2020 Klondike River Chinook Salmon Sonar

Prepared For
Tr'ondëk Hwëch'in
PO Box 599
Dawson City, YT Y0B 1G0

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

Tr'ondëk Hwëch'in
Department of Natural Resources
PO Box 599
Dawson City, YT Y0B 1G0

EDI Contact
Ben Schonewille, B.Sc., R.P. Bio.
Fish and Wildlife Biologist

EDI Project
20Y0177
March 2021

ENVIRONMENTAL DYNAMICS INC.
Down to Earth Biology

This page is intentionally blank.

EXECUTIVE SUMMARY

In 2020, EDI Environmental Dynamics Inc. (EDI) and Tr'ondëk Hwëch'in First Nation (TH) conducted their first year of the Chinook salmon sonar enumeration project on a new site in the Klondike River. Sonar projects on the Klondike River had been previously conducted by B. Mercer & Associates Ltd. from 2009 to 2011. The 2020 project took place on a site surveyed by EDI in 2019, east of the Klondike River bridge on the North Klondike Highway and approximately 3 km southeast of central Dawson City, Yukon Territory.

The objectives of this project were to:

- enumerate adult Chinook salmon migrating up the Klondike River;
- conduct test netting to confirm sonar counts;
- collect age, sex and length data from captured Chinook; and
- build capacity for sonar operation and fisheries research projects for TH citizens in Dawson City.

Local TH Technicians assisted with fieldwork for the program and received technical training on sonar operation and fisheries data management. Set netting could not be conducted to determine the extent of adult freshwater fish during the period of sonar operations.

An ARIS Explorer 1200 multi-beam sonar system was installed in the Klondike River, 2 km upstream of the Yukon River and Klondike River confluence, to enumerate salmon between July 2 and August 14, 2020. A total of 461 Chinook salmon were counted during the period of operation. Sonar data indicated that adult freshwater fish were present and numerous, relative to the amount of migrating Chinook salmon. Sonar repositioning and movement, equipment maintenance and updates resulted in 18 hours of missing data which required interpolation. However, interpolation did not change the estimated number of Chinook salmon travelling upstream. A run expansion of the Chinook sonar counts was conducted for pre- and post-program periods and an additional 9 Chinook salmon are estimated to have migrated past the sonar site after operations ceased on August 14. Including run expansion data, a final interpolated estimate of 470 Chinook salmon migrated upstream past the Klondike River sonar site in 2020.

ACKNOWLEDGEMENTS

Funding for this year's in-season project was provided by the Yukon River Panel Restoration and Enhancement Fund (YRP R&E Fund). Newmont Goldcorp's community investment program and the Pacific Salmon Foundation's Community Salmon Program, along with YRP R&E Fund generously donated funds to support the expensive purchase of the sonar unit as well as the site feasibility studies that occurred in 2019. Natasha Ayoub and Alice McCulley of the Tr'ondëk Hwëch'in Government provided general project direction and assistance with logistics.

AUTHORSHIP

Team members from EDI Environmental Dynamics Inc. who contributed to preparing this report include:

Evan Warren, B.T. .... Primary Author

Scott Cavasin, A.B.T. .... Technical Review

Ben Schonewille, B.Sc., R.P.Bio. .... Senior Review

Joel MacFabe and Scott Cavasin of EDI were the lead sonar technicians for the field component of the project. Additional field assistants included Devon O'Connor, Evan Warren and Emma Tom Tom of EDI, Derek Scheffen and Tamara Dickson of TH.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PHOTOGRAPHS

LIST OF APPENDIX PHOTOGRAPHS

1 INTRODUCTION

Tr'ondëk Hwëch'in (TH) citizens are physically, culturally, and spiritually connected to the Yukon River salmon fishery. This fishery has been a major contributor to the traditional economy since time immemorial and the Tr'ondëk Hwëch'in, or People of the River, have historically focused salmon harvest at the confluence of the Yukon and Klondike Rivers, or Tr'ochëk. As a primary stakeholder in subsistence and commercial salmon fisheries, TH has a vested interest in the health of salmon stocks found within their Traditional Territory. Chinook salmon (*Oncorhynchus tshawytscha*; also referred to herein as Chinook) in the Klondike River have faced declining populations for several decades and TH has been involved with and supported salmon restoration projects in their Traditional Territory.

The Klondike River Chinook Restoration Plan (EDI Environmental Dynamics Inc. and Tr'ondek Hwech'in 2018) specifies that the re-establishment of the sonar on the Klondike River is a high priority task for TH. Sonar enumeration of Klondike Chinook will provide an indicator of Chinook escapement, with TH becoming more actively involved in restoration. The long-term operation of this sonar is desirable for tracking future changes in abundance. The Klondike stock is also known to migrate relatively early compared to other stocks in the Yukon River, which makes them more vulnerable to harvest, as many of the spawners move through the lower Yukon River before managers have strong confidence in escapement numbers.

1.1 BACKGROUND

In 2008, a Klondike River Sonar Feasibility Study was completed by B. Mercer & Associates Ltd. A candidate site was located approximately 4 km upstream from the confluence with the Yukon River (Mercer 2010). From 2009 to 2011, the sonar was operated at the Klondike River site during which time the escapement ranged from 1,181 to 5,147 spawners (Mercer 2009, 2010, 2011, 2012).

In 2019, EDI was retained by TH to conduct a reconnaissance level survey of the Klondike River and locate a candidate site for the sonar project for the annual enumeration of adult Chinook salmon migrating up the Klondike River. The original site operated by Mercer was ruled out due to its proximity to privately owned land. An additional site, located 2 km upstream of the Klondike River bridge, was previously documented by Mercer, but stream bed profile made the site unsuitable and a shallow gravel bar obscured the far bank. A third site located immediately downstream of the Klondike River bridge, 2 km upstream from the confluence with the Yukon River, on the right downstream bank, and located on TH Settlement land parcel C-4B within the TH assets compound was recommended for investigation by TH personnel. The third site was selected for the sonar project for its combination of accessibility, existing infrastructure such as road, packed gravel surface, storage, proximity to town, river characteristics, morphology and ease of sonar operation, which make it ideal as a long-term sonar site.

1.2 OBJECTIVES

Tr'ondëk Hwëch'in secured funding in 2019 to purchase an ARIS sonar to be used on the Klondike River to enumerate Chinook spawners and conduct site reconnaissance to set the stage for full-scale operations of the sonar during the summer of 2020. TH is committed to Chinook salmon stock restoration in the Klondike River, and the annual operation of the sonar will be important to establish a current baseline of escapement which will help determine the effectiveness of long-term restoration efforts that are planned for on the Klondike River.

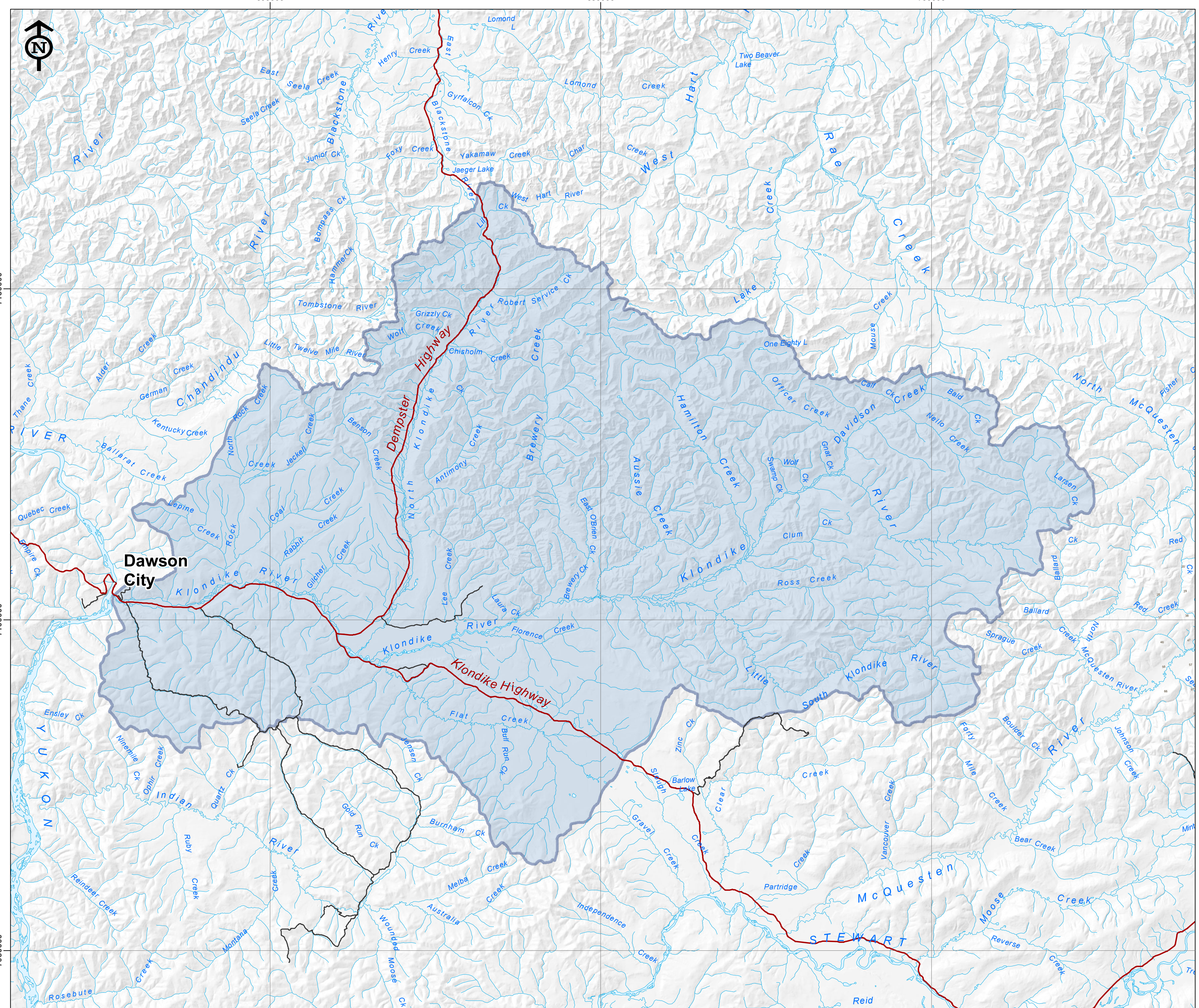
The primary objectives of the 2020 Klondike River Chinook salmon sonar program were to:

- develop an accurate, in-season stock assessment tool to estimate the annual passage rates for Chinook salmon in the Klondike River;
- determine run apportionment for Chinook salmon in the Klondike River compared to sonar counts on the mainstem and other rivers;
- confirm run timing in comparison with Eagle sonar mainstem counts;
- provide educational opportunities at the sonar to highlight the importance of the Chinook salmon run in the community through community engagement;
- build local capacity, through technical training and full-time employment for local TH citizens throughout the program;
- conduct test netting to confirm the type of fish species in the sonar count data; and,
- collect age, sex and length data from Chinook salmon captured during test netting.

1.3 STUDY AREA

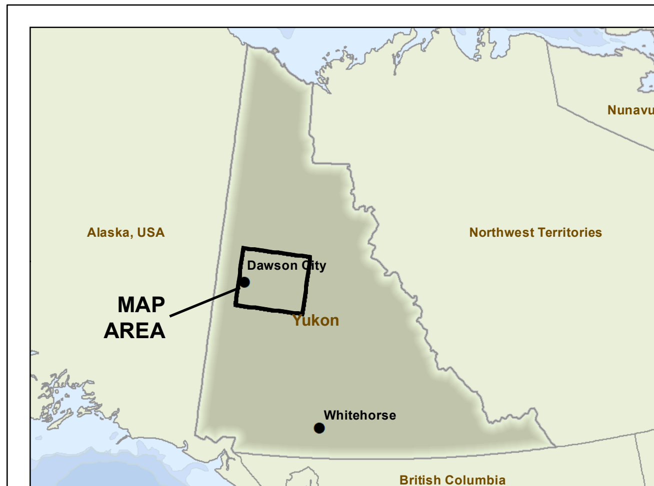
The Klondike is a large tributary in the Yukon River Watershed (Map 1). It flows into the Yukon River just upstream of Dawson City, Yukon. The Klondike River has several tributaries, the largest of which is the North Klondike River that also contains a spawning population of Chinook salmon. Map 2 illustrates the location of the 2020 Klondike River Chinook salmon sonar program.

Map 1. Overview of the Klondike River Watershed



Legend

- Highway
- Secondary Road
- Klondike River Watershed



0 5 10 15 20 25
Kilometres

Map Scale = 1:600,000 (printed on 11 x 17)
Map Projection: NAD 1983 UTM Zone 7N

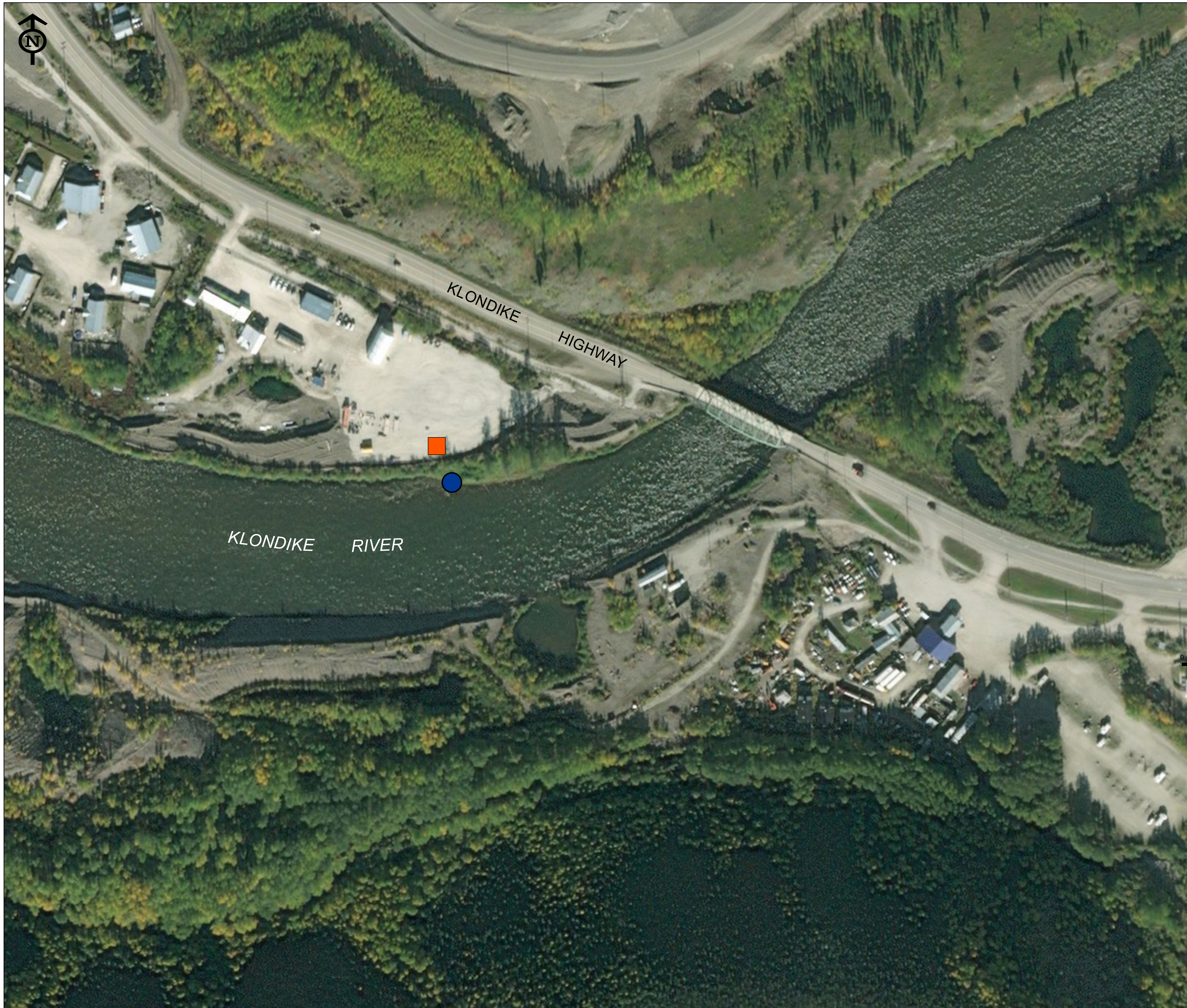
Data Sources
Digital Elevation Model and 1:250,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) www.geomaticsyukon.ca.

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

Disclaimer
EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

Drawn: MP	Checked: EW/BSc	Date: 2020-12-16

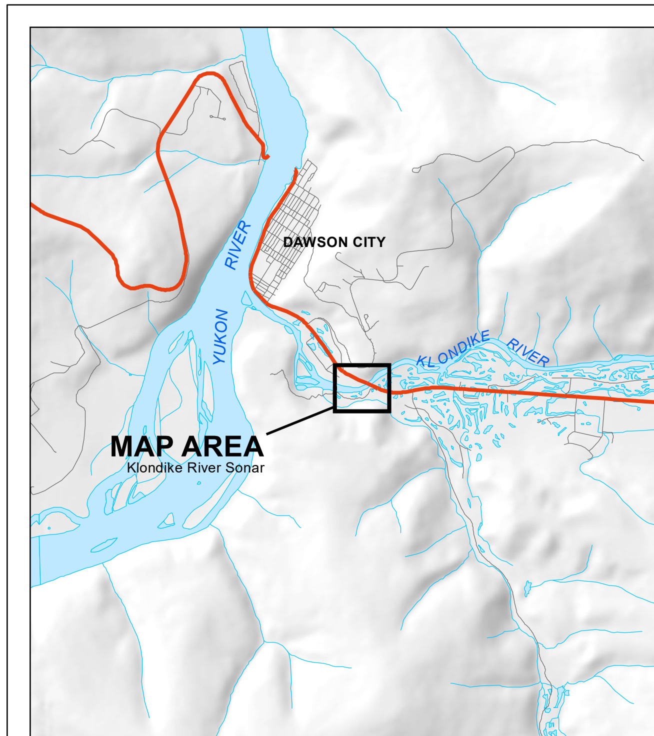
Path: ...\2020\20Y0177_KlondikeRiverSonar\Mapping\Reporting\Map1_Overview_20201216.mxd



Map 2. Klondike River Chinook Salmon Sonar Program - Site Location

Legend

- Sonar Camp
- Sonar Transducer



0 50 100 150 200 250
Metres

Map Scale = 1:2,398 (printed on 11 x 17)
Map Projection: NAD 1983 UTM Zone 7N

Data Sources
Digital Elevation Model and 1:250,000 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., 2019 was obtained using Garmin GPS technology.

Aerial imagery provided by Great River Air. (Collected August 8 - 10, 2018).

Disclaimer
EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

Drawn: CT	Checked: BSc	Date: 2020-12-18

Path: L:\PROJECTS\2020\20Y0177_KlondikeRiverSonar\Mapping\Reporting\Map2_ProjectSites_20201216.mxd

2 METHODS

2.1 FIELD CREW AND CAMP SETUP

The TH carpentry crew constructed the sonar camp, which included the clearing of brush and placement of crushed rock to form an approximately 4 m wide gravel path from the assets compound to allow for safe and easy access to the north bank of the Klondike River and the sonar equipment. In addition, two 3.7 m x 3.7 m (i.e., 12 ft x 12 ft) shed-roof style framed cabins (uninsulated) were constructed on the east end of the TH assets compound to house sonar equipment and provide office space, a rudimentary kitchen and sleeping area for staff who were present 24-hours per day.

A crew of three team members set up the field camp on June 30, 2020. This crew consisted of two Tr'ondëk Hwëch'in summer student technicians and one experienced sonar technician from EDI. The sonar camp was powered by a single 3000-watt gas-powered Honda generator, provided by TH Government, which supplied energy for a full-sized fridge and two laptops, as well as the ARIS unit. A propane camp stove and blue jugs were used for food and water on site (Appendix Photo 3). The efficiency and design of the Klondike sonar camp contributed immensely to the project's success. Construction of the two cabins on a movable skid foundation will allow TH to use the buildings for future years of operation, with the potential for repurposing the cabins at the project's conclusion.

Following the initial setup, two EDI technicians and two local TH technicians conducted the day-to-day operations of the field program, with off-site support from EDI biologists in Whitehorse. EDI and TH staff operated on a rotation schedule, with at least one EDI and TH technician on site at all times for the duration of the project.

2.2 SONAR DEPLOYMENT

On July 1, 2020, an ARIS Explorer 1200 multi-beam sonar system was deployed on the right downstream bank of the Klondike River. The sonar system consisted of a sonar transducer, power/data cable and a command module, which was located on shore and provided control of the system power as well as interfacing with a laptop computer via WIFI. The transducer was mounted on an aluminum 'goal-post' type mount (Photo 1), which was custom built by EDI in Whitehorse for this project. The mount allowed for easy adjustments of pitch and depth within the water column. Sonar data were transmitted from the sonar command module to a laptop computer by wireless Ethernet bridge, to allow for data capture and review.

This sonar setup allowed for ensonification up to a maximum of 80 m of river channel. The total distance ensonified over the season did not exceed 70 m; this allowed for the entire channel to be ensonified by a single ARIS explorer unit.

Photo 1. Photo from shore showing the transducers aluminum 'goal post' type mount, which allowed for adjustment of pitch, pan and angle.

2.2.1 TARGET TESTING

At the onset of sonar operation, target testing was conducted to make sure that targets in all areas of the water column were covered adequately by the sonar beam. In the 2020 season, target testing consisted of one crew member watching the sonar screen in real-time, while the other crew member, in waders, walked on the opposite bank from the sonar transducer. With no access to a jetboat, target testing was limited to water depths safe for technicians to wade in on either bank directly in front of the sonar. As a result, the center of the channel was not target tested. Once target testing was completed, major gaps in sonar coverage were noted and adjustments to the sonar's aim were made.

2.2.2 FISH DEFLECTION FENCE

To prevent fish from migrating behind the sonar or outside 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 and extended into deeper water and supported by T-rail type stakes, which were pounded into the riverbed to secure the fence (Photo 1). After the fence was erected, field staff weighted the bottom of the fence into the riverbed material with rocks, to make sure no small salmon could pass underneath the fence. The approximate total length of the fence extended 4 to 7 m into the Klondike River, depending on water levels. The fence was deployed approximately 1 m downstream of the sonar transducers, and a minimum of 2 m ahead of the sonar transducer. This placement of the transducer and fence was used to make sure 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 and measured.

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 sonar and to record all collected sonar data. The relevant settings of this software used during this project are shown in Table 1. The sonar was set to record data continuously (24 hours a day), and all data were recorded to a NAS Drive. Data recorded to the NAS drive were stored on two 4 TB drives, which were configured in a mirrored RAID-array, to provide data redundancy. This array made sure that all recorded sonar data were secured in the event of a hard drive failure.

The sonar system was powered on after the initial set up was complete, sonar aim was checked, and fine-scale pitch and depth adjustments were made to optimize the sonar positioning. Periodic adjustments were made to sonar positioning throughout the field program, primarily in response to changing water levels. Sonar data were collected from July 2, 2020, to August 14, 2020. A total of 18 hours were not recorded throughout the program. Much of these missing data were due to sonar adjustments and movements in response to changing water levels and equipment maintenance and updates, resulting in intermittent missing hours of data collection as opposed to one consecutive event.

Table 1. Summary of ARIS Explorer 1200 data collection parameter values and settings used during 2020 Klondike River Chinook salmon sonar program.

Parameter	Sonar
Model	ARIS Explorer 1200
Frequency Low/High (kHz)	High (1.8 MHz)/Low (1.1 MHz)
Beam Width (Horizontal/Vertical)	8º H/14º V
Window Range	30 m

2.3 ENUMERATION OF CHINOOK SALMON

Sonar data were reviewed using Echotastic version 3.0b8, a software package developed by Carl Pfisterer of the Alaska Department of Fish and Game (ADF&G). 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 configurations described above to enumerate riverine fish, the series of horizontal lines through the echogram indicates ensonification of the river bottom. The echogram image generated by Echotastic can be confirmed with the use of the video window (Photo 2).

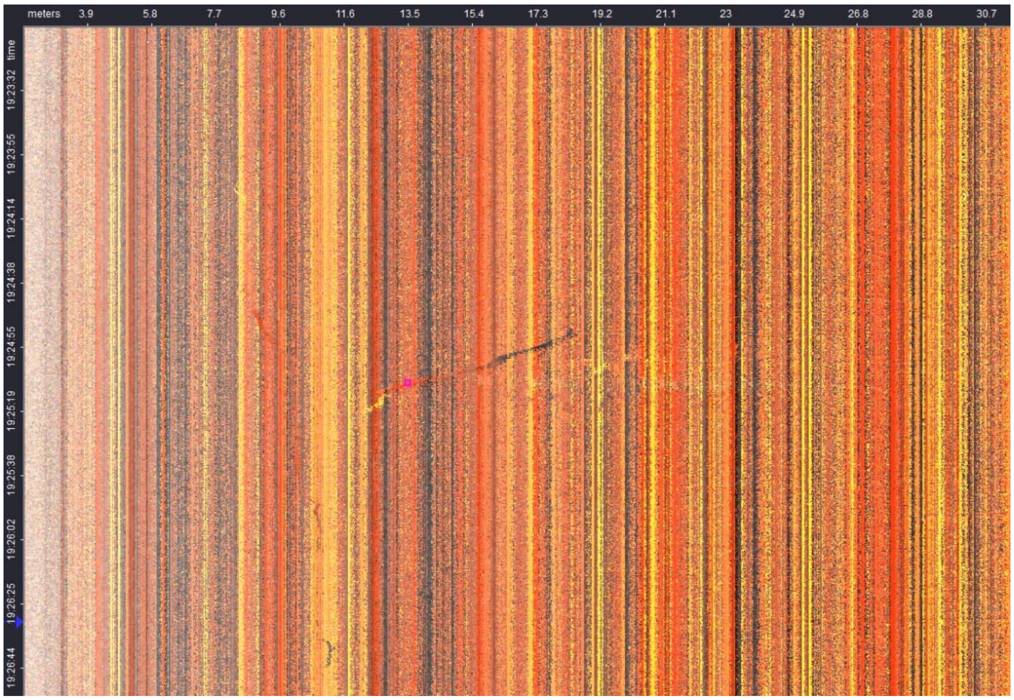


Photo 2. **Echotastic echogram window showing a suspected salmon traveling upstream with characteristic shadow cast. Image is from the Klondike River sonar unit, July 2020.**

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 2020 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 2020 Klondike 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 objects

Processing Option	Setting Used	Explanation of Setting	Rationale
Lower Threshold	-50 dB	Displays all sonar data stronger than -50 dB	Excludes sonar signals of lower intensity from the echogram and reduces noise from image
Colour Background	White	Displays sonar data against a white 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 oriented parallel to the river current (Photo 2). 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 the 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 echogram in Photo 2.

Instream debris (non-fish target) can be distinguished from fish targets because debris is always moving downstream 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 2020 season, sonar technicians completed a comprehensive training module, created in 2016 by Fisheries and Oceans Canada (DFO) biologist Elizabeth MacDonald. This training module was comprised of example data files and practice enumeration tests to develop the ability of the sonar technicians 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.

Training was supervised by the EDI project technician and all team members were tested on the training files to make sure that they could efficiently 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 or unclear data files were encountered during the review process. Both size and speed were considered in determining if sonar targets were Chinook or freshwater fish, targets less than 50 cm were disregarded. Team members 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 (red or yellow) 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 as they possess the opposite colour spectrum orientation to those fish moving downstream (Photo 2).

Once technicians were confident that a detected acoustic target was a migrating salmon, the salmon target in question was marked on the Echotastic echogram on site. This was done by left-clicking on the location of the fish on the echogram window and marking the upstream migration 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 and a paper backup copy. Saved marks on the Echotastic echogram were then exported as a text file for post-season processing and data analysis.

2.3.5 INTERPOLATION OF THE COUNT DATA

During the operation of the sonar program, routine equipment maintenance resulted in periods when sonar data were not collected. These periods of missing data range from 6 hours to 1 hour. For in-season reporting, missing data were interpolated by multiplying raw daily counts by the percentage of the day that was missing. For example, if five hours of data were missing, data were interpolated by taking an average of the preceding and following five hours of count data. This method provided a simple means for the field staff to generate preliminary adjusted counts in time for in-season updates delivered to fisheries managers.

Post season (i.e., in this report), missing data were interpolated using different methods. The post-season methods of interpolation for periods when a portion 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 were being interpolated. All these 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 (ms) was

divided by the number of minutes counted (mi), and then multiplied by the number of fish counted (x) in that period (i). Passage (yi) was estimated as:

$$\hat{y}_i = \left(m_s / m_i \right) x_i$$

If data from one or more complete sample periods were missing, passage for that portion of the day (ym) was estimated by averaging passage from the [equivalent number of] sample periods immediately before (yb) and after (ya) 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]:

$$\hat{y}_m = \left(\frac{y_b + y_a}{2} \right) n$$

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

2.3.6 SONAR DATA QUALITY ASSURANCE/QUALITY CONTROL AND RELIABILITY

To provide a high-quality data set, quality assurance/quality control (QA/QC) measures were implemented for review of the sonar files during the field component of the program and post season.

In the field, sonar technicians reviewed a subset of each other's count data for quality assurance and control. Each day, approximately 10% of the daily files (i.e., a minimum of three files per day) were re-opened without saved fish marks and re-counted by a second technician on site. 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 formula employed by DFO (Mather 2018, pers. comm. available upon request). Some subjectivity exists when interpreting sonar target data and differences in interpretation between technicians are expected; therefore, it is important that the counting and review process is standardized among technicians and sonar programs to provide the most accurate and consistent data.

Post-season analysis was also 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 2018, pers. comm.).

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

$$\boldsymbol{Var(\hat{y}) = \frac{\Sigma(x_i - x)^2}{(n-1)}}$$

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.

The 95% confidence interval for the Chinook salmon estimate was calculated by multiplying the standard deviation by ±1.96.

2.4 TEST NETTING

The 2020 test netting program was not initiated due to several factors, including very low Chinook returns to the Klondike River, higher than average water levels, lack of access to a jetboat, along with a lack of TH elder support voiced during an emergency in-season meeting called to consult with the Elders Council. Test netting was intended to confirm species counted by the sonar station. Inconnu, Arctic grayling and chum salmon (*Oncorhynchus keta* also referred to herein as chum) are suspected to be present in addition to Chinook; these species were excluded from the count based on size and behaviour below a fish length threshold of 0.5 m and directed 0.52 m/s travel. In future years of the project, test netting is planned, and the design of this project component will be discussed pre-season with DFO.

3 RESULTS

3.1 SONAR DATA

3.1.1 RAW WEEKLY SONAR COUNTS

A raw total of 466 upstream fish were identified from the collected sonar data over the duration of the sonar program (Table 3). The net weekly 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. The peak of the run occurred during the week of July 12 to 18 with a net upstream total of 159, approximately 34% of the total run.

Table 3. Raw weekly counts of salmon at the Klondike River sonar site from July 2 to August 15, 2020, appended with missing hours of data.

Program Week	Upstream	Downstream	Net Upstream Total
July 2–4[A]	4	0	4
July 5–11[B]	60	0	60
July 12–18[C]	162	3	159
July 19–25[D]	81	0	81
July 26–August 1[E]	87	1	86
August 2–8	47	1	46
August 9–14	25	0	25
Total	**466**	**5**	**461**

[A] Missing 6 hours of data; [B] Missing 1 hour of data; [C] Missing 5 hours of data; [D] Missing 1 hour of data; [E] Missing 5 hours of data.

Daily counts suggest the sonar site was in operation before the onset of the Chinook migration. On the first day of counting (July 2), no Chinook salmon were recorded. The first Chinook was not recorded until July 4, and the total count for the following days continued to rise. Although the data indicate the peak (July 12 to 18) of the Chinook run had passed, the daily counts show Chinook salmon were still migrating past the sonar site after the program operations ceased. On August 14, the final day of sonar operation, a total of five upstream salmon were counted.

3.1.2 SONAR DATA QUALITY ASSURANCE/QUALITY CONTROL AND RELIABILITY

A total of 1027 files were collected through the season, 176 sonar files were re-counted for QA/QC purposes. Of the re-counted files, 24 (13.6%) differed from the original count of salmon. Typically, the targeted difference in the original versus the QA/QC files is less than a 10% difference; therefore, additional QA/QC was completed post-season on113 sonar files selected for a third count to tighten the confidence interval and investigate how this may have affected the overall total estimated Chinook salmon counts.

The total number of fish counted in the original files was 63; the total number of salmon counted during the in-season QA/QC was 39; and a total of 55 salmon were counted during the post-season QA/QC. This means that during the first round of QA/QC, there was a difference of 24 and a difference of 8 during the second round of QA/QC. The APE for the data set was 10.92% meaning the mean difference in the original count versus the two QA/QC counts was 10.92%.

It is important to note that discrepancies between counters is expected. However, during the season when discrepancies were noted in association with one technician and given the low number of returning salmon, it was decided that the senior technician on-site would recount the files. Typically, during QA/QC the reported numbers are not changed but, after discussions between the project biologist, senior technician and the TH Natural Resource Analyst, it was decided that the counts should be adjusted. The senior technician on site recounted files from July 10 to 17 and adjusted the reported count accordingly. After more training was done on July 26 and 27 with technicians on sonar review, the count accuracy increased for the remainder of the season. Post season, the QA/QC files were updated to replace the original count, altering the reported figure of 404 to 461 upstream salmon.

4 DISCUSSION

4.1 INTERPOLATION OF RUN DATA

4.1.1 INTERPOLATION OF MISSING COUNT DATA

Interpolation of 18 hours of missing sonar data was required. Much of these missing data were due to sonar repositioning and movement, equipment maintenance and updates. Interpolation was conducted according to the methods outlined in Section 2.3.6 and interpolated net upstream sonar counts were calculated for each week of the program (Table 4). Daily interpolated count data are included in Appendix Table 1.

After interpolating, no additional estimated salmon were believed to have passed the sonar site during missing hours of operations. Subsequently, a total of 461 salmon were estimated to have passed the sonar site between July 2 and August 14, 2020 (Table 4).

Table 4. Interpolated net upstream weekly counts of Chinook salmon at the Klondike River sonar site between July 2 and August 15, 2020.

Program Week	Upstream	Interpolated Upstream	Interpolated Net Upstream Total
July 2 - 4	4	0	4
July 5 - 11	60	0	60
July 12 - 18	159	-	159
July 19 - 25	81	0	81
July 26 - Aug 1	86	0	86
Aug 2 - 8	46	-	46
Aug 9 - 14	25	-	25
Total	**461**	**0**	**461**

4.1.2 CHUM SALMON RUN OVERLAP

Chum salmon are known to travel and spawn in the mainstem of the Yukon River. To accurately estimate the escapement of Chinook salmon within the Klondike River, an estimate of total chum salmon that passed the sonar site must be subtracted from the total count of Chinook salmon, due to the potential for chum to be present and co-migrate with the Chinook in early to late August.

It is suspected that chum salmon were not present during the 2020 sonar operation; however, to further support this idea, the run timing of chum salmon in 2020 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 Klondike River sonar site is approximately 170 km upstream of the Eagle sonar site. The travel rate for chum salmon has been estimated at 25 miles per day (40.2 km/day; ADFG 2020). Based on this information, the first arrival of chum at the Klondike River sonar site was estimated to be approximately August 31. Given that the last day of sonar operation was August 14, there is a very low probability that chum were counted by the sonar units. Therefore, it was assumed that all net upstream sonar targets counted and estimated were Chinook salmon. It is also important to note that local and traditional knowledge support an understanding that the chum run in the Klondike River is very low, and potentially non-existent. This knowledge, coupled with the differences in timing of migration, increases our confidence that the Klondike River sonar counts will not likely be impacted from chum salmon numbers migrating into and through the Traditional Territory. Future test netting efforts will confirm species assumptions and continue to be a key supporting element to this project and obtaining accurate Chinook counts.

4.1.3 FINAL CHINOOK SALMON PASSAGE ESTIMATE

The 2020 Klondike River sonar program ran for 44 days. Chinook salmon were first observed on the third day of sonar counting (July 4) and still observed to be infrequently migrating past the sonar site on August 14, when operations ceased. To gather an estimate of the total escapement of Chinook salmon in the Klondike River, a post-season estimate was calculated as part of the goals of the program.

The final passage date of Chinook for the Klondike River sonar was chosen by comparing the Chinook counts recorded at the Eagle sonar site. The peak in daily counts at the Klondike River sonar site generally occurred approximately three days after the peak daily count at the Eagle sonar site. The Chinook count ended at the Eagle sonar site on August 27, 2020, with a daily count of 98 Chinook (ADFG 2020). Using the second-order polynomial equation below (MacDonald pers. comm. 2017), the final daily count from the Eagle sonar was extrapolated to determine the date of the final Chinook passage at the Klondike sonar site. After extrapolation, it is estimated that the final Chinook passage at Eagle sonar was September 6, 2020. The distance from the Eagle sonar site to the Klondike River sonar site is approximately 170 km, resulting in approximately three travel days. The final passage of Chinook at the Klondike River sonar site is estimated to be no later than September 9, 2020.

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

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 nine Chinook salmon are estimated to have passed by the sonar site after operations ceased (Table 5). Additionally, no salmon are suspected to have passed the sonar site prior to operation on July 2. With this being the case, the run expansion is minimal and shows that the duration of the sonar program captured the majority of the 2020 Klondike Chinook salmon run. Therefore, the total interpolated upstream run (including post-season expansion) for July 2, 2020 – September 6, 2020 was 470. Using the formulas explained in Sections 2.3.5 and 2.3.6, the confidence interval was calculated for the sonar counts (Appendix Table 2). The total confidence interval is ±11 salmon with 95% confidence.

Table 5. Extrapolated daily Chinook salmon counts at the Klondike River sonar site between August 14 and August 23, 2020.

Date	Extrapolated Net Upstream Total
August 15	3
August 16	3
August 17	2
August 18	1
August 19	0
August 20	0
August 21	0
August 22	0
August 23	0

4.2 KLONDIKE 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 first year of operation for this program, the data presented in the following sections cannot yet be used to determine long-term trends; however, they are presented here as baseline information with the intention that these components will be further developed in future years.

4.2.1 RUN TIMING AND STRENGTH

Upstream Chinook salmon were recorded at the Klondike River sonar site on the second day of sonar recording (July 4), with a total of four upstream migrating Chinook salmon counted. Given that no fish were counted on the first day of operation, we are confident the 2020 project captured the start of the Klondike River Chinook salmon run. The daily counts began to spike around July 12 and remained steady between July 19 to August 1 before decreasing consistently throughout the remainder of the run (Figure 1). On the final day of sonar operation (August 14), five Chinook salmon were recorded, indicating the project captured the majority of the run. The Klondike sonar was successful in capturing a comprehensive data set for the 2020 Chinook salmon run and post-season expansion accounted for a very small portion (1.9%) of the total run estimate.

The daily cumulative upstream Chinook salmon count was low compared to Mercer's 2009, 2010 and 2011 study in the Klondike River, and accounted for approximately 0.01% of the Chinook run counted at the Eagle sonar (Figure 2). This run apportionment appears to be very low in comparison to past estimates that indicate up to 8% of the Yukon River Chinook salmon run may spawn in the Klondike River (Department of Fisheries and Oceans 2015). Future years of sonar operation on the Klondike River will be an important part of understanding current species apportionment trends as well as contributing to our understanding of overall run timing and peak spawning times.

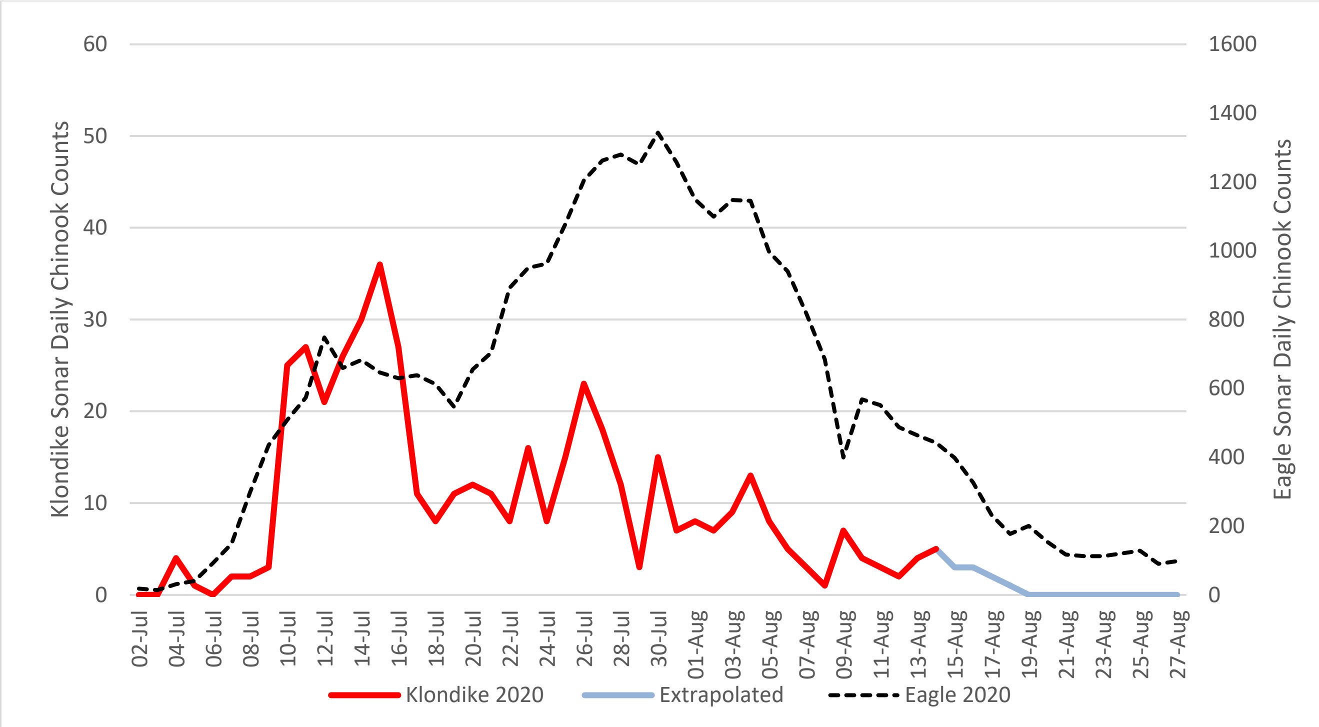


Figure 1. Daily upstream Chinook salmon counts at the Klondike River Chinook sonar site and Eagle sonar site in 2020, including post season run expansion extrapolation.

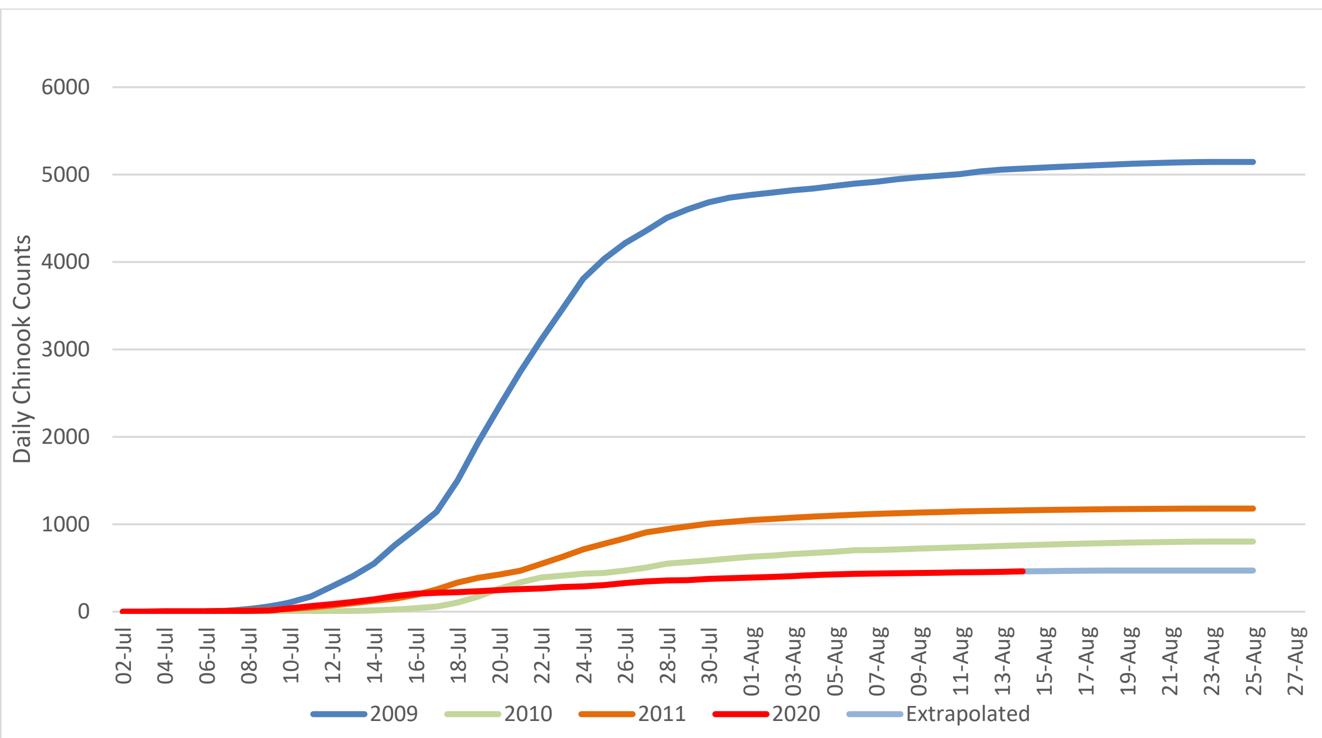


Figure 2. Daily cumulative net upstream Chinook salmon counts at the Klondike River sonar site in 2020, including a comparison of daily cumulative counts from 2009, 2010 and 2011 (previous data from Mercer 2009, 2010, 2011, 2012.)

4.2.2 CHINOOK SALMON BANK ORIENTATION

The review of collected sonar data using Echotastic software produces a text file record, which includes a measurement of the distance of each fish target from the sonar transducer. This information can be used to detect patterns in fish movements; for example, whether salmon are bank orientated at a particular location within the river (Table 6). The target range data were graphed to investigate potential patterns in the movement of Chinook as they passed through the zone of ensonification (Figure 3). Several factors may affect the spatial migration patterns of Chinook salmon including river discharge, water clarity, and water temperature. A 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.

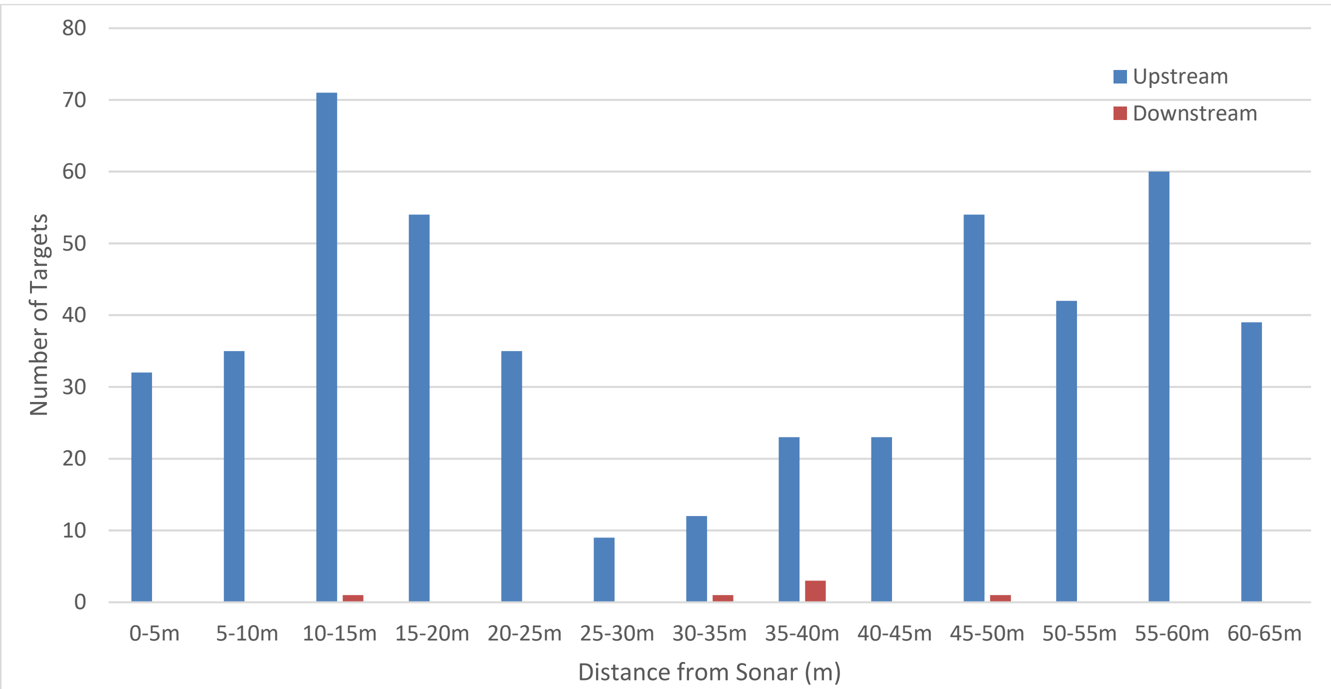


Figure 3. Range of upstream and downstream moving fish targets detected on the right bank of the Klondike Sonar site in 2020.

The target range data suggest that Chinook counts were more frequent within approximately 20 m from either bank. The highest frequency of suspected Chinook were counted at ranges 10 to 15 m from the right downstream bank, and 55 to 60 m from the right downstream bank, (or 5 to 10 m from the left downstream bank) (Table 6). The fewest fish targets were counted in the center of the channel, between 25 to 30 m from the right downstream bank. These data show a fairly even split on either bank, which may have been due to the higher than average water conditions experienced during the run.. Higher water may have kept fish from traveling in the middle of the stream.

Table 6. Upstream and downstream bank orientation of Chinook salmon captured during sonar operation in 2020.

Target Range	Upstream		Downstream	
	Number of Targets	Proportion of Total Targets (%)	Number of Targets	Proportion of Total Targets (%)
0–5m	32	6.54	0	0.00
5–10m	35	7.16	0	0.00
10–15m	71	14.52	1	16.67
15–20m	54	11.04	0	0.00
20–25m	35	7.16	0	0.00
25–30m	9	1.84	0	0.00
30–35m	12	2.45	1	16.67
35–40m	23	4.70	3	50.00
40–45m	23	4.70	0	0.00
45–50m	54	11.04	1	16.67
50–55m	42	8.59	0	0.00
55–60m	60	12.27	0	0.00
60–65m	39	7.98	0	0.00
Total	**489**	**100.00**	**6**	**100.00**

*Total Value includes QA/QC counted fish, and potential miss clicks resulting in a higher total count than raw/interpolated fish targets.

4.2.3 KLONDIKE 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 are recorded at a Water Survey of Canada gauging station on the Klondike River, approximately 0.2 km upstream from the sonar camp (Station Number 09EA003; Government of Canada 2020). This station has been operating on a continuous basis measuring flow and water level since 2011 and no major watercourses enter the Klondike 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 the summer months. The available water level data recorded from the water survey station from 2016 to 2020 were reviewed to investigate the water levels during the operation of the sonar between July to August (Figure 4).

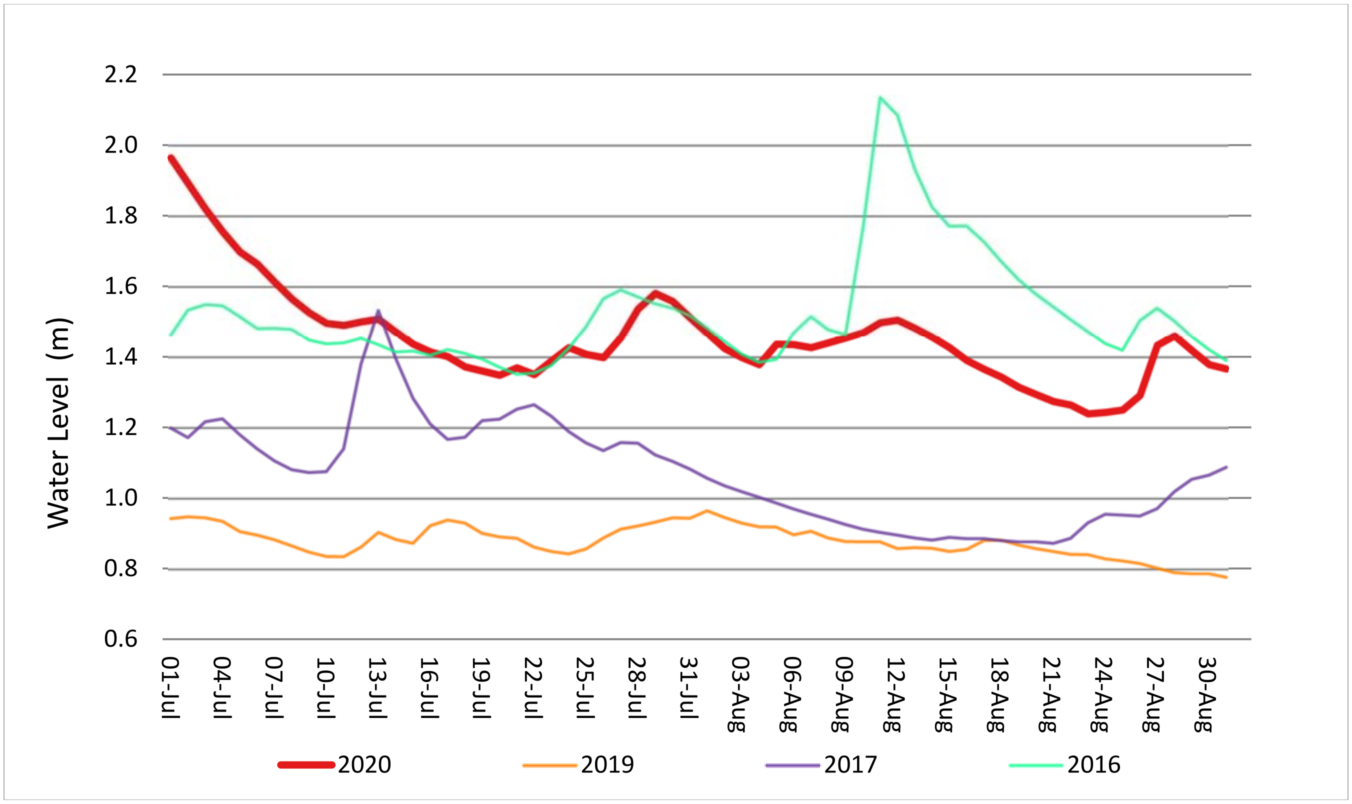


Figure 4. Water levels from Canada weather station upstream of Klondike River Chinook salmon sonar program, including 2016, 2017 and 2019.

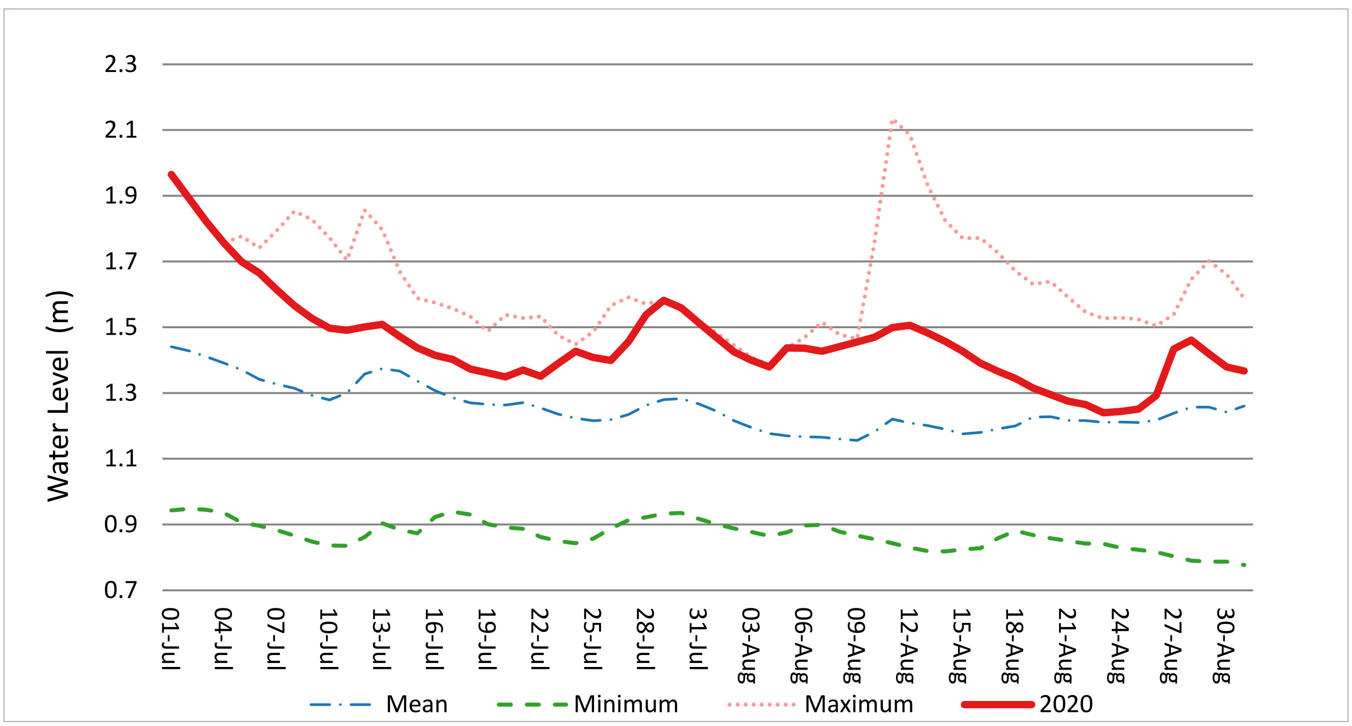


Figure 5. Water levels from Canada weather station upstream of Klondike River Chinook salmon sonar program, graphed over the duration of program activity.

Water levels observed at the sonar site included some of the highest water levels among the earliest years available for water levels at this station (Figure **5**, Figure 4). Water levels peaked in June and declined steadily during the first week of sonar operation, before it reached its lowest point of the program between July 19 and July 22, 2020. The highest level observed during operation of the sonar site was between July 1 to July 7.

4.3 DEVELOPMENT OF LOCAL CAPACITY

The project was staffed primarily by Dawson-based personnel, including two Dawson locals employed through EDI's summer student program and two local TH technicians. In total, 91% of the sonar operation was completed by Dawson-based personnel. The program created local employment, training opportunities and offered 44 days of fish related work for two local TH technicians.

Notable community interest and engagement were generated by posting daily updates on the TH Klondike River Chinook Sonar Facebook page (the page currently has 47 followers and 42 page likes). Local community engagement also included a TH Elders 'Salmon Welcoming' prayer ceremony on July 13, 2020, which was open to TH citizens and staff. Additionally, a site visit, project background and information session was provided to the TH Natural Resources staff and the public on July 30. Covid-19 safety precautions were put in place to protect sonar staff and visitors. A short video documentary for the local Dawson City news was filmed on site and included an interview with a TH-employed technician. The video included explanations of the sonar equipment, the project's importance to the TH citizen and the daily routines during operation of the Klondike Sonar site.

Later in the season, TH employed technicians were operating the station without the presence of an EDI technician, from 8 am to 5 pm. An EDI technician arrived in the evening and remained overnight to allow TH staff to return home every evening. A large part of the project's success this year was a result of TH's enthusiasm and resources allocated to employing strong, engaged local support. The program provided in-season passage estimates to TH and DFO.

4.4 RECOMMENDATIONS

The 2020 Klondike River Chinook salmon sonar program was successful in meeting most goals and objectives as outlined in the project proposal submitted to the Yukon River Panel Restoration and Enhancement Fund. Despite some challenges with high water and low salmon returns, which prevented test netting, the project was a success. Recommendations for future Klondike River Chinook salmon sonar programs are outlined below.

- Increase collaboration between TH and EDI to enhance local capacity in other roles and responsibilities in addition to the field program (i.e., TH technician involvement in field preparation and post-field reporting.)

- Dedicate more time for sonar training of technicians prior to the initial start of the program. The training of sonar technicians will be important to allow technicians to distinguish between freshwater fish and migrating Chinook salmon.
- Discuss with DFO and TH government funding for purchase or rental of a jetboat for the purposes of target testing and net testing. Conducting a test netting program will require more consistent and continuous use of a jetboat, experienced workers and suitable netting locations. This may also increase the number of workers needed to maintain full 24-hour occupancy at the sonar camp. The use of a boat and more workers would increase the cost of future projects.
- Consider switching to electricity from the Dawson City electrical grid to run the sonar project. This option would be ideal to limit the use of generators, which have proven to be costly regarding maintenance, fuel and oil. A generator should be kept on site, with the intent of providing backup power in the event of a power outage and reduce the potential for lost data.
- Continue to improve the data QA/QC protocols by making sure 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.
- Increase community involvement by encouraging more site visits by locals, including youth and Elders, to the sonar camp.

5 REFERENCES

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.

Department of Fisheries and Oceans. 2015. Distribution and Estimated Proportional Contribution of Canadian-origin Chinook Salmon Stocks in Upper Yukon River Sub-Drainages.

EDI Environmental Dynamics Inc. and Tr'ondek Hwech'in. 2018. Klondike River Chinook salmon stock restoration plan, v2.0. Prepared for the Yukon River Panel. Whitehorse, Yukon. 94 pp.

Mather, V. 2018. Whitehorse fishway and Takhini sonar preliminary Chinook salmon counts. Email from Communication from Vesta Mather to Ben Shonewille, EDI Environmental Dynamics Inc. October 6, 2018 email.

Mercer, B. 2009. Klondike River DIDSON sonar feasability study (2008). Prepared by Mercer and Associates for the Yukon River Panel. 22 pp.

Mercer, B. 2010. 2009 Klondike River DIDSON sonar. Prepared for the Yukon River Panel. B. Mercer and Associates Ltd., Whitehorse Yukon. 29 pp.

Mercer, B. 2011. 2010 Klondike River DIDSON sonar. Prepared for the Yukon River Panel. B. Mercer and Associates Ltd., Whitehorse Yukon. 30 pp.

Mercer, B. 2012. 2011 Klondike River sonar project. Prepared for the Yukon River Panel. B. Mercer and Associates Ltd., Whitehorse, Yukon. 31 pp.

APPENDICES

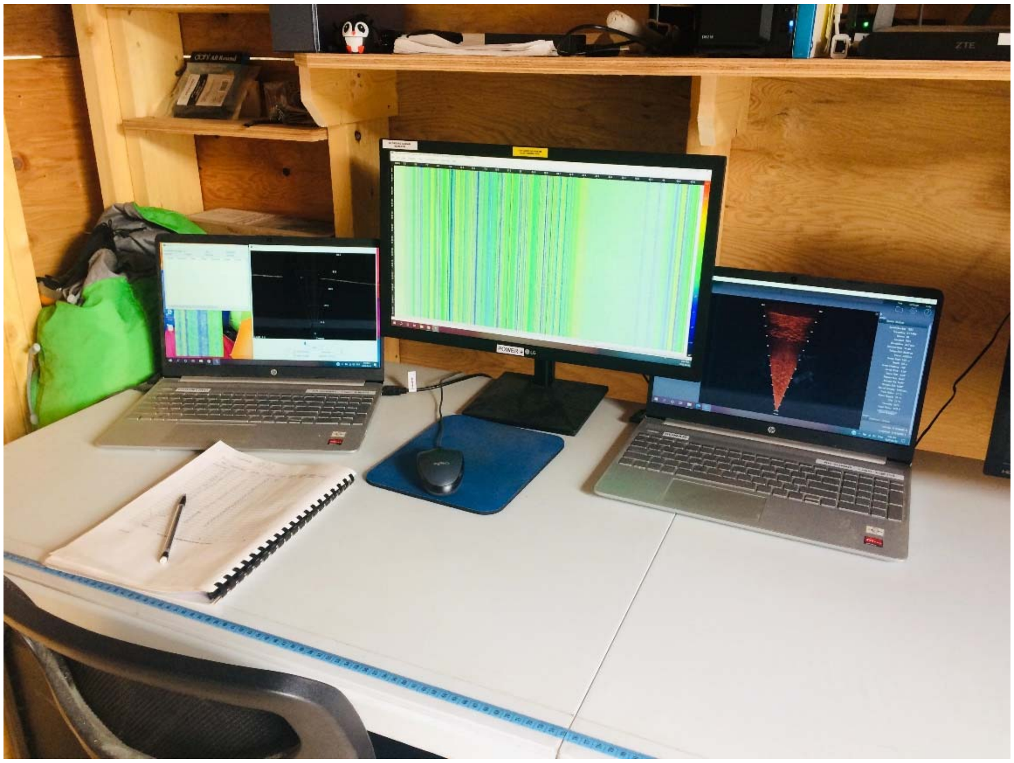
APPENDIX A PHOTOGRAPHS

Appendix Photo 1. **Two shed roof framed cabins constructed by TH carpentry crew for the 2020 Klondike River Sonar project.**

Appendix Photo 2. **Photo from riverbank access of two framed cabins constructed by TH carpentry crew for the 2020 Klondike River Sonar project.**

Appendix Photo 3. Inside of the working cabin for the Klondike River Sonar project. Kitchen space on the left and sonar counting computers on the right.

Appendix Photo 4. Sonar counting equipment set up, including counting laptop (left), sonar recording laptop (right) and router connecting wirelessly to ARIS sonar system (top shelf).



Appendix Photo 5. Counting laptop with active files, left and middle monitor, and sonar recording laptop on right connected wirelessly to the ARIS sonar system.

Appendix Photo 6. Path down to sonar with gravel laid down allowing easy and safe access to the Klondike River bank and sonar unit.

Appendix Photo 7. Klondike River sonar unit, showing white top box and fish exclusion fencing on the right downstream bank of the Klondike River.

Appendix Photo 8. Inside of Klondike River Sonar top box, with power controller for ARIS sonar unit and connection to the router for wireless delivery of sonar data to counting laptops.

Appendix Photo 9. TH citizen and Dawson City local, Derek Scheffen cleaning the deflection fence of downstream debris at Klondike Sonar site.

Appendix Photo 10. Photo taken by Roberta Joseph of TH, during the Elder salmon prayer and welcoming ceremony preformed at Klondike River Sonar site on July 13, 2020.

Appendix Photo 11. Photo taken by Roberta Joseph of TH, during the Elder salmon prayer and welcoming ceremony preformed at Klondike River Sonar site on July 13, 2020.

Appendix Photo 12. A meeting held at the Klondike River Sonar camp for the TH Natural Resource Department and the public on July 30, 2020.

APPENDIX B RAW AND INTERPOLATED RIVER DAILY SONAR COUNTS

Appendix Table 1. Daily raw, interpolated and expanded sonar counts from the 2020 Klondike River Chinook salmon sonar program.

Date	Raw Upstream	Raw Downstream	Upstream Interpolated	New Total Upstream	Cumulative Total
02-Jul	0	0	0	0	0
03-Jul	0	0	0	0	0
04-Jul	4	0	0	4	4
05-Jul	1	0	0	1	5
06-Jul	0	0	0	0	5
07-Jul	2	0	0	2	7
08-Jul	2	0	0	2	9
09-Jul	3	0	0	3	12
10-Jul	25	0	0	25	37
11-Jul	27	0	0	27	64
12-Jul	21	0	0	21	85
13-Jul	26	0	0	26	111
14-Jul	30	0	0	30	141
15-Jul	36	0	0	36	177
16-Jul	29	2	0	27	204
17-Jul	11	0	0	11	215
18-Jul	9	1	0	8	223
19-Jul	11	0	0	11	234
20-Jul	12	0	0	12	246
21-Jul	11	0	0	11	257
22-Jul	8	0	0	8	265
23-Jul	16	0	0	16	281
24-Jul	8	0	0	8	289
25-Jul	15	0	0	15	304
26-Jul	23	0	0	23	327
27-Jul	18	0	0	18	345
28-Jul	12	0	0	12	357
29-Jul	3	0	0	3	360
30-Jul	15	0	0	15	375
31-Jul	8	1	0	7	382
01-Aug	8	0	0	8	390
02-Aug	8	1	0	7	397
03-Aug	9	0	0	9	406
04-Aug	13	0	0	13	419
05-Aug	8	0	0	8	427
06-Aug	5	0	0	5	432
07-Aug	3	0	0	3	435

Date	Raw Upstream	Raw Downstream	Upstream Interpolated	New Total Upstream	Cumulative Total
08-Aug	1	0	0	1	436
09-Aug	7	0	0	7	443
10-Aug	4	0	0	4	447
11-Aug	3	0	0	3	450
12-Aug	2	0	0	2	452
13-Aug	4	0	0	4	456
14-Aug	5	0	0	5	461
15-Aug	-	-	3	3	464
16-Aug	-	-	3	3	467
17-Aug	-	-	2	2	469
18-Aug	-	-	1	1	470
19-Aug	-	-	0	0	470
Total	**466**	**5**	**9**	**470**	**470**

Appendix Table 2. Results from average percent error, variance, standard deviation and confidence intervals for Chinook salmon counts.

Location	APE	Variance	SD	CI
Right Bank	10.92	23.35	5.85	11.47

APE = average percent error; SD = standard deviation; CI = confidence intervals.