2020 Big Salmon River Chinook Salmon Sonar Enumeration Project

Prepared for: The Yukon River Panel
Restoration and Enhancement Fund
CRE-41-20

February 2021

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ABSTRACT

A multiple beam sonar unit was used to enumerate the Chinook salmon escapement to the Big Salmon River in 2020. The sonar was operated on the Big Salmon River for the sixteenth consecutive year at the same site used since 2005. Sonar operation began on July 16 and continued without interruption through August 25. A total escapement of 1,634 Chinook salmon was estimated to have passed the sonar site in 2020. The first Chinook salmon passing the Big Salmon sonar station was observed on July 17, the second day of operations. Fifty percent of the run had passed the sonar by August 8 and 90% by August 20. Based on the 2020 Big Salmon sonar count and preliminary above border escapement estimates from the Eagle sonar project, the Big Salmon run comprised approximately 5.3% of the total above border Yukon River Chinook Salmon escapement. The carcass pitch resulted in the collection of only 9 Chinook carcasses due to rising water levels and poor visibility from high turbidity and a low escapement.

INTRODUCTION

The 2020 Big Salmon River sonar project marks the sixteenth year that Chinook salmon (*Oncorhynchus tshawytscha*) enumeration has been conducted on this system by Metla Environmental Inc. (MEI). This report is a summary of the results of the 2020 project.

The overall goal of the Big Salmon Chinook program is to provide stock assessment information that will improve the ability of Canadian and U.S. salmon management agencies to manage Yukon River Chinook salmon. Quantifying Chinook escapement into upper Yukon River index streams allows for an independent (from Eagle sonar project estimates) assessment of total above border Chinook escapements. Using accurate Chinook escapement enumeration of select tributaries combined with genetic stock information (GSI), it is possible to generate upper Yukon River Chinook spawning escapement estimates within quantified statistical parameters.

In addition to the sonar operation, carcass sampling has been conducted to obtain age, sex and length data from Big Salmon Chinook escapements. This information provides important ongoing biological baseline data on the health of the stock as well as information used in constructing future pre-season run forecasts.

A four-year juvenile Chinook salmon study was conducted by DFO on the Big Salmon system between 2015 and 2018. The Big Salmon sonar camp belonging to MEI was used as a base for the juvenile Chinook study over those years. The Big Salmon sonar project will continue to provide supportive data quantifying the adult returns from previous years of the juvenile Chinook out-migrant study. The juvenile out-migrant study corroborates the JTC Research objective of developing scientifically-based escapement objectives for Canadian-origin salmon. Continued annual Chinook escapement estimates into the Big Salmon system will be an important component of the data set required to complete the juvenile Chinook study.

Based on the 2005 – 2020 sonar operations, the Big Salmon River has been shown to be a significant contributor to upper Yukon River Chinook production. The 2005 - 2019 average Big Salmon sonar count is 5,379 (range 1,329 to 10,078). These counts represented an average of 10.2% (range 8.3% - 15.8%) of the total average upper Yukon River Chinook spawning escapement estimate for these years (JTC 2019). However, the 2020 Big Salmon Chinook escapement was the lowest proportion (4.9%) of the total estimated above border Chinook escapement that has been recorded to date.

Study Area

The Big Salmon River flows in a north-westerly direction from the headwaters at Quiet and Big Salmon lakes to its confluence with the Yukon River (Figure 1). The river and its tributaries drain an area of approximately 6,760 km^2, predominantly from the Big Salmon Range of the Pelly Mountains. Major tributaries of the Big Salmon River include the North Big Salmon River and the South Big Salmon River. The Big Salmon River can be accessed by boat either from Quiet Lake on the South Canol Road, from the Yukon River on the Robert Campbell and Klondike Highways, or from Lake Laberge via the Thirty Mile and Yukon rivers. The sonar site is at a remote location, approximately 130 air kilometers from Whitehorse.

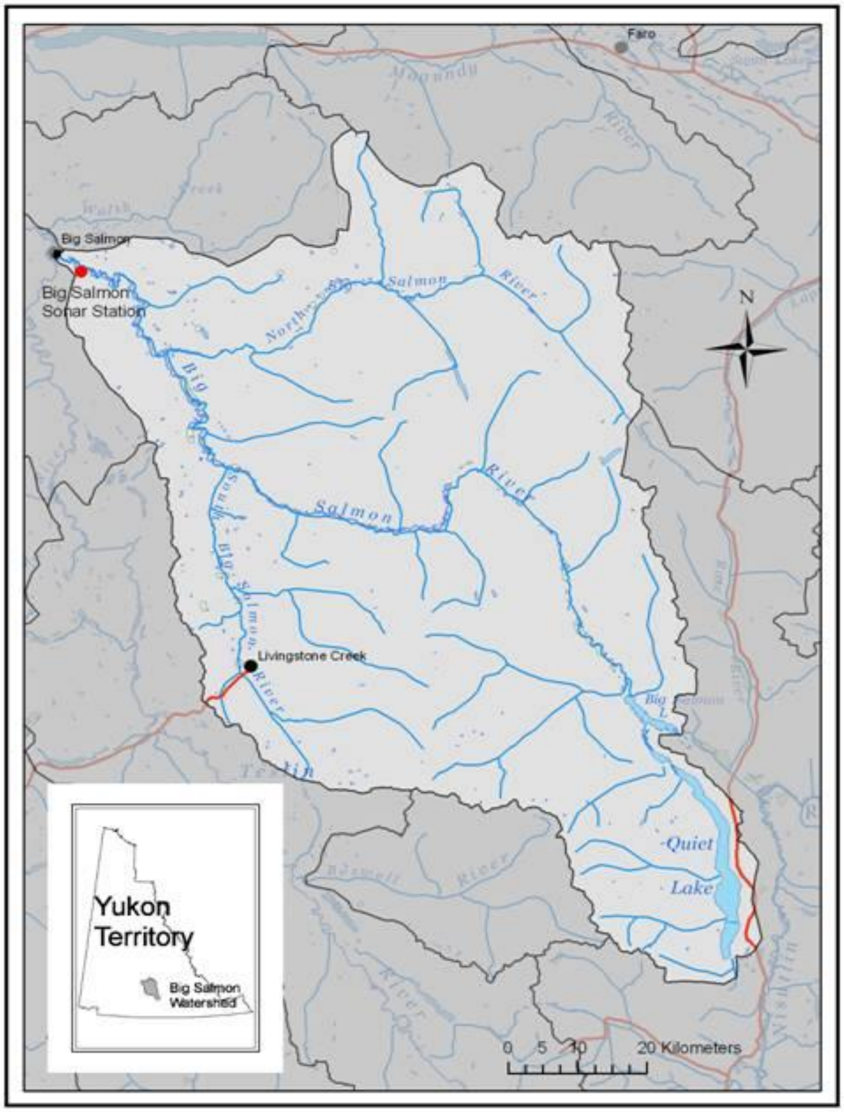

Figure 1. Big Salmon River Watershed and location of the 2020 Big Salmon sonar station.

Objectives

The objectives of the 2020 Big Salmon River sonar project were:

1. To provide an accurate count of the total Chinook salmon escapement in the Big Salmon River using a multiple beam sonar unit.

2. To conduct a carcass pitch on the Big Salmon River to obtain age-sex-length (ASL) data from as many post-spawned Chinook as possible with a target goal of 5% of the total run.

METHODS

Site selection

Sonar operations were set up at the same site on the lower Big Salmon River used since 2005. This site, located approximately 1.5 km upstream from the confluence with the Yukon River (Figure 1), was initially selected for the following reasons:

- It is a sufficient distance upstream of the mouth to avoid straying or milling Chinook salmon destined for other headwater spawning sites.
- The site is in a relatively straight section of the river and far enough downstream from any bends in the river so that recreational boaters using the river have a clear view of the in-stream structures.
- The river flow is laminar and swift enough to preclude milling or 'holding' behaviour by migrating fish.
- Bottom substrates consist of gravel and cobble evenly distributed along the width of the river.
- The stream bottom profile allows for complete ensonification of the water column.
- The site is accessible by boat and floatplane.

The physical characteristics of the river at this site have not changed over the 16 years of sonar operation. It is anticipated that this site will continue to be used as long as the sonar program operates.

Camp and Sonar Station Set-up

Supplies and crew were mobilized from Whitehorse, YT. This entailed driving to a boat launch site on the Yukon River situated 3 km downstream of Little Salmon Village on the Robert Campbell Highway. From the boat launch a riverboat was used to access the sonar station site. Subsequent camp access, crew changes, and delivery of supplies were accomplished by riverboat and floatplane from Whitehorse. Mobilization to the sonar station was initiated on July 14. The sonar apparatus was operational beginning 19:30 on July 16.

River Profile

A boat mounted Biosonics DTX split beam sonar, aimed 90° down from the surface, was used to obtain a cross section profile of the river bottom at the sonar site. Data was collected from three bank to bank transects of the river. These transects were located 5m upstream, at the center and 5m downstream of the anticipated sonar beam. The bottom profile was similar for all three transects. The cross-section profile where the sonar was deployed is presented in Figure 2. The cross-section profile of the river bottom at the sonar station has remained relatively unchanged since the project started in 2005. This site had a bottom profile the most conducive to complete ensonification of the water column.

Diversion Fence Construction

Partial fence structures were placed in the river to divert migrating Chinook salmon into a 36 m migration corridor in the center of the river (Figure 3). The weir was constructed using conduit panels and metal tripods that were stored on site. The fences were constructed as detailed in previous years reports (Mercer & Wilson 2020).

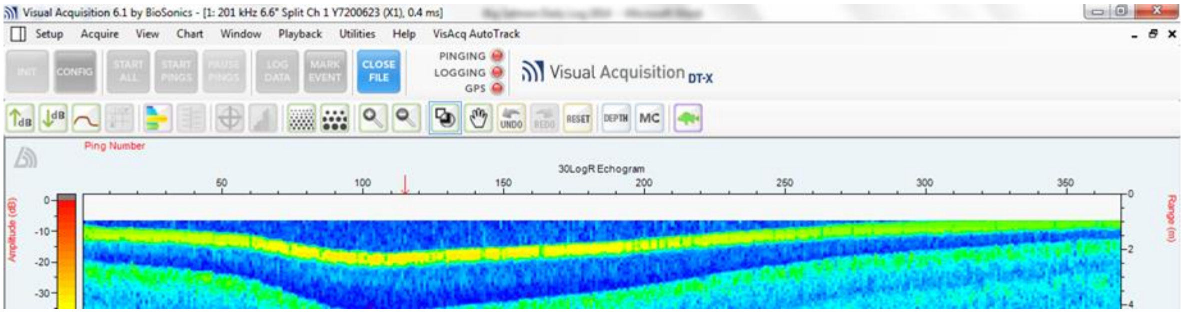

Figure 2. Cross section profile of Big Salmon River at sonar site using a Biosonics DTX split beam echo-sounder.

Note: Top of yellow line is river bottom, thalweg = 1.97 m. Transect view looking down river. The near field of the transducer prevents readings at depths less than 1m as indicated by the white band.

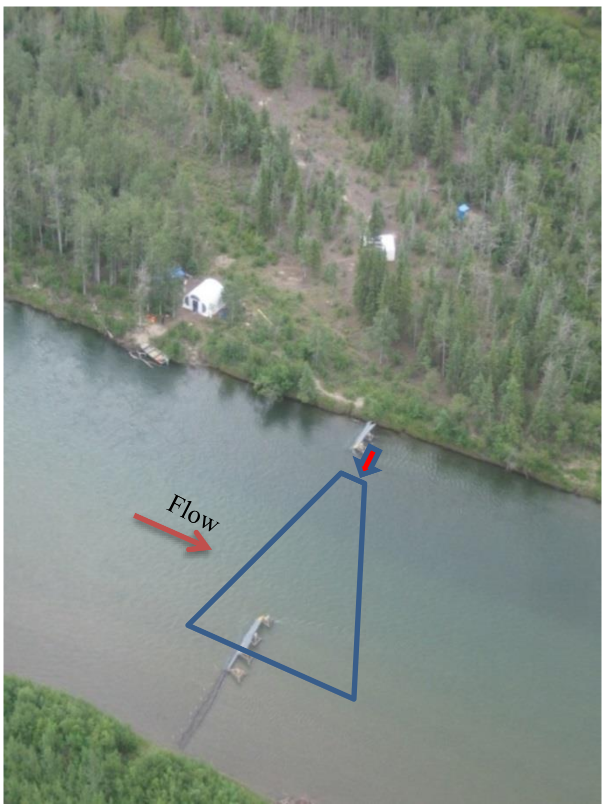

Figure 3. Aerial view of sonar station camp and partial weirs, (photo from 2010 project).

Blue outline denotes ensonified portion of the river.

ARIS 1800 Sonar, Placement and Software Configuration

An ARIS model 1800 sonar, owned by MEI and manufactured by Sound Metrics Corporation, was used for the 2020 Big Salmon sonar project. Sound Metrics are currently the primary manufacturers of multi-beam sonars employed for enumerating migrating salmon in riverine environments.

The sonar unit was mounted on an adjustable stand constructed of 2-inch steel galvanized pipe. The stand consisted of two T-shaped legs 120 cm in height connected by a 90 cm crossbar (Figure 4). The sonar unit was bolted to a steel plate suspended from the cross bar that was connected to the stand with adjustable fittings (Kee Klamps™). The adjustable clamps allowed the sonar unit to be raised or lowered according to fluctuating water levels as well as enabling rotation of the transducer lens to adjust the beam angle.

The sonar unit was placed in the river 1.5m upstream of the south bank diversion fence and remained in this position for the duration of the project. The ARIS sonar with a standard lens produces an ensonified field 29° wide in the horizontal plane and 14° in the vertical plane. An 8° concentrator lens was used for the 2020 project. This lens reduces the vertical ensonified field from 14° to 8°, resulting in an increase in the resolution of the target images. The ARIS transducer lens was positioned at a depth of approximately 12 cm below the surface of the river and angled downward approximately 3º from horizontal resulting in the ensonified field of view remaining parallel to the surface of the river. Daily adjustments to the sonar aiming configuration were performed in response to fluctuating water levels.

Figure 4. Sonar transducer unit and mounting stand.

The sonar system was powered by a battery bank of five – 12 volt gel cell batteries connected in parallel to create a 12 volt power source. The battery bank was charged by six 80 watt solar panels and supplemented by a battery charger powered by a 2.0 kW generator. An 800 watt inverter was used to obtain 110 volt AC from the batteries to supply continuous power for the computers and the sonar unit as well as domestic power for the camp. An uninterruptible power supply (UPS) was used to protect the equipment from power surges and occasional power interruptions. As well, an alarm system was installed on the recording computer to alert personnel to power or data transmission interruptions.

For optimal resolution of the ensonified targets within the migration corridor the following ARIS sonar settings were used: a) Low frequency (1.1 Mhz), b) 96 sub-beam array, c) Frame rate of 4 frames/sec. and d) Samples per beam set at 2000. The computer equipment used to interface with the sonar consisted of two workstation laptop computers and one HDMI 25 inch video monitor. The computers used I-7 processors, 256 GB SSHD plus a 1TB HDD and 16 GB of RAM. This processing capability allowed the technicians to read the files concurrent with continuous uninterrupted recording of the data. A third computer was used as a standby machine and for the internet connection.

Sonar Data Collection

The sonar data was collected continuously over the course of the project and stored automatically in pre-programmed, 20 minute date stamped files using the ARIScope software. This resulted in the accumulation of 72 files over a 24 hour period. The files were stored on the recording laptop computer and transferred each day to a 5 TB external hard drive. Each 20 minute file required approximately 250 Mb of hard disc space. It is MEI policy to maintain the ARIScope files on the external hard drive for a minimum of 3 years after the project is completed.

The ARISFish software program was used for reading the recorded files and the inputting of data. File reading typically occurred the day following recording. All 72 files from each day were read. Files were read using a combination of the sonar view platform and echogram view of each file. When the examiner identified a target on the echogram the sonar view was used to observe and measure the fish when required. To optimize target detection in both sonar and echogram view, the background subtraction feature was used to remove the static images such as the river bottom and weir structures. ARISFish software inputs the targets selected by the reader into a comma-separated values (CSV) file. Data from the CSV file was inputted into an excel spreadsheet incorporating the counts from each file into hourly and daily counts as well as upstream and downstream movements. Total daily fish counts were derived from the net upstream passage of fish. The target measurement feature of the ARISFish software was used when required to estimate the size of the observed fish and when required to differentiate Chinook salmon from resident fish species. All fish 50 cm and larger were categorized as Chinook. Fish moving downstream identified as live Chinook were subtracted from each file total. It is assumed Chinook migrating downstream were strays. Straying of migrating salmon is not unusual and temporary[1] straying has been documented in telemetry studies of Yukon River Chinook (Eiler et al. 2006). The proportion of suspected straying Chinook at the sonar site is typically low (< 2%).

Short interruptions in data collection due to equipment maintenance, power interruptions and other technical difficulties are inevitable. All stoppages or gaps in recording coverage were documented. Potentially missed fish were added to the counts by interpolation based on the mean number of fish per hour counted 12 hours before and after the outage. If complete files were missed the Chinook passage was estimated by interpolation of the average file count over the 12 hour period before and after the missing sample event as follows:

$$P_m = \frac{X_a + X_b}{2}$$

Where m is mth missing value, X_a is the mean file count prior to the missing sample event and X_b is the mean file count of the sample after the missing file(s). The interpolated counts were included in the total daily counts reported over the course of the project.

[1] Radio tagged Chinook were documented entering a tributary and subsequently retreating to the mainstem river and continuing their migration further up the system. Since the sonar station is located 1.5 km upstream from the confluence of the Yukon River the presence of straying Chinook could be expected.

Precision of Fish Counts

It is the practice in some salmon enumeration sonar projects, particularly those with high rates of daily passage, to read and count salmon from a sub-set of recorded data files and apply an expansion factor to obtain a total estimate of fish passage. The variance associated with this expansion method can be quantified and incorporated into the total fish passage estimate (Enzenhofer et al., 2010). For the Big Salmon sonar project, all recorded files were reviewed in their entirety so there was no variance associated with the expansion of a sub-set of a file data.

The precision of the Chinook counts is measured by reviewing a sub-set of all the files recorded and read. Precision in this case refers to the repeatability of a count between different individuals for the same data file or aggregate of data files. Files for review were randomly selected from 13 days of sonar operation, over the periods August 3 through August 15, inclusive. The re-count from each reviewed file was recorded for comparison with the original.

The Coefficient of Variation (CV) method was used to quantify the repeatability (precision) of counts, particularly those counts with high fish passage rates (Enzenhofer *et. al*, 2010). This formula is expressed as:

$$CV = \sqrt{\frac{\sum_{i=1}^{R}(X_{ij} - \overline{X}_j)^2}{\overline{X}_j^{\,2}}} \quad \text{x} \quad 100$$

where Xij is the ith count of the jth event and Xj is the average count of the jth event.

Because of the relatively low number of fish counted per hour in most of the Big Salmon sonar files, the CV values could be distorted. For example, if the first counter observed 2 upstream fish and the second counter observed one, the CV would be as high as 50%. This is due to the leverage that small numerical differences in low counts have on the overall calculation of CV. For this reason, during previous Big Salmon sonar projects only files that had a total Chinook count of 7 fish or higher were used to determine the precision of counts. In 2020, the escapement and resultant fish passage was below average and few files had counts greater than 7 fish/file. As a result, the CV method was not used with the 2020 project data.

As well as calculating CV, a sample variance estimator based on the absolute difference between readers is typically used to quantify the correlation of the counts and the net variability between readers. To accomplish this the relationship was plotted between counts of 2 different file readers using original daily aggregate file counts (reader 1) and reviewed aggregate file counts (reader 2).

Range Distribution

The ARISFish software recorded the distance (m) from the sonar for each target selected and marked as a Chinook salmon. This range value was inputted into the CSV file. This provided data to construct a range frequency histogram illustrating the cross-sectional distribution of migrating Chinook.

Carcass Pitch

Access to Chinook spawning areas on the river was via a riverboat powered by a 60 hp outboard jet. Carcass pitch efforts extended from the sonar station to a point approximately 75 river kilometers upstream.

The carcass pitch involved collecting dead and moribund Chinook and sampling each fish for age, length and sex (ASL). Length measurements (mid-eye to fork and post orbital to hypural) were recorded to the nearest 0.5 cm. Five scales were taken from each fish and placed on scale cards for age determination. All sampling data and scale cards were submitted to DFO Whitehorse. Scale age analysis was conducted by the sclero-chronology lab, Pacific Biological Station, Nanaimo, British Columbia.

RESULTS

Chinook Salmon Counts

The first Chinook salmon was observed on July 17, on the second day of operations. The run reached 50% passage on August 8 and 90% of the run had passed the station by August 20. Daily and cumulative counts are presented in Appendix 1 and Figure 5.

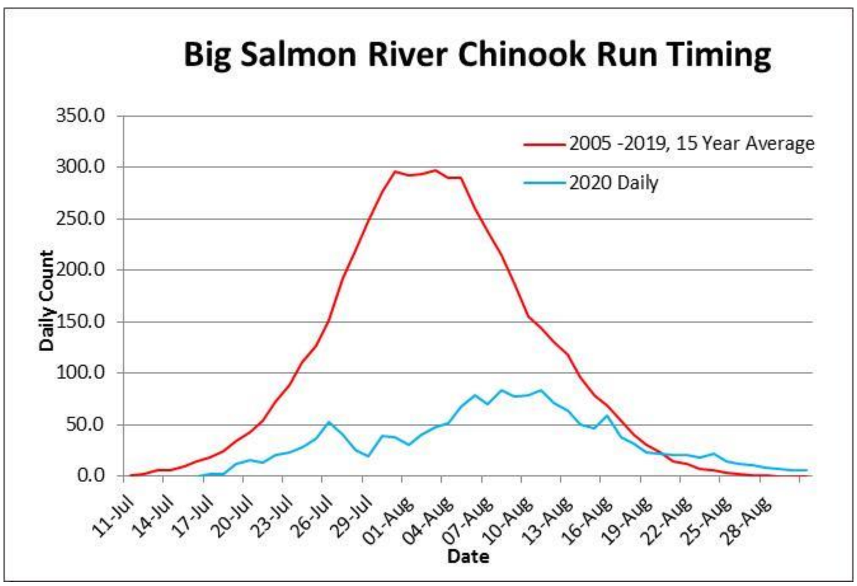

Figure 5. Daily counts of Chinook salmon passing the Big Salmon River sonar station in 2020 and average daily counts 2005 through 2019.

A total of 1,574 targets identified as Chinook salmon was counted past the sonar station from July 16 through to August 25. Because sonar operation stopped before the run was completely over, an estimate was obtained of the number of Chinook that passed the station after sonar operations were suspended. This was done through regression analysis using the final 10 days of the sonar counts and the logarithmic equation y=-17.16ln(x) + 52.815. This interpolation[2] added 60 fish to bring the total count to 1,634. A total of 6 Chinook salmon (0.4% of the total escapement) was recorded moving downstream during the 2020 project.

Short interruptions in sonar recording due to maintenance or technical difficulties resulted in a total of 10.9 hrs recording time loss. A total of 7 fish was interpolated for the recording time loss. The interpolated counts were included in the total daily counts reported over the course of the project.

The 2020 Big Salmon sonar estimate was the 2nd lowest in the 16 years it has been operational at this site and was below the recent ten-year average (2010–2019) of 5,266 fish.

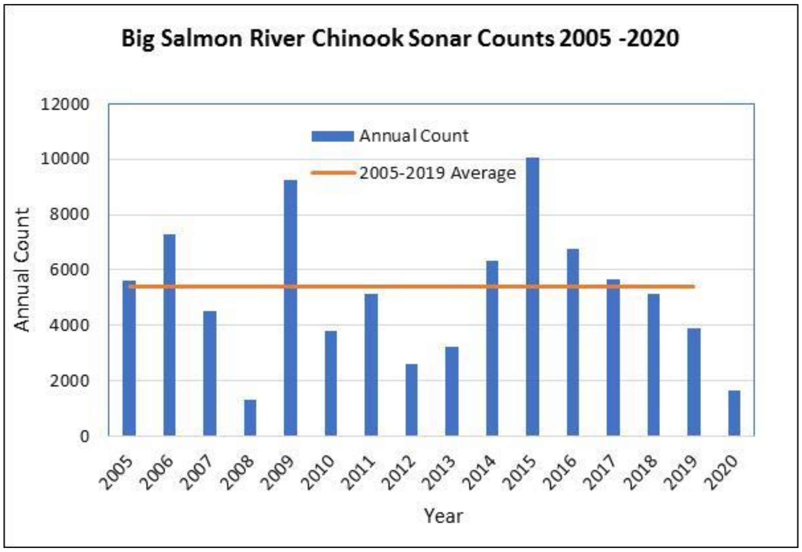

Figure 6. Annual Chinook sonar counts and 2005 – 2019 average for Big Salmon sonar project 2005 – 2020.

Precision of Counts

Of the 2,899 sonar files recorded and analysed, a total of 61 was reviewed by a second reader (Table 1). A total of 175 fish was counted in the 61 files by the first reviewer. Of the 61files reviewed by a second reader, 3 files (4.9%) exhibited a discrepancy in the count between readers (Appendix 3). The three files yielded a total of 3 less fish. There was a net difference between the total number of fish counted in the first iteration and the subsequent review of 3 fish.

The Pearson correlation between the separate file reviewers = 0.97, (R 61; $p<0.001$).

Due to the low 2020 escapement and hence relatively low number of fish counted in each file it was not possible to obtain meaningful coefficient of variation (CV) statistics between file readers. However, overall, it can be concluded that there was a high level of concordance between file readers during the 2020 project.

[2] The interpolation is based on the assumption of an inferred daily count of zero, 10 days after the last day of sonar operation.

Table 1. Double reviewed files and calculated difference between counts.

	Count	%
Total files recorded during project	2,899	
Total files double reviewed	61	2.1%
Total fish counted first iteration	175	
Total fish counted second iteration	172	
Total files with + divergence	0	
Total files with - divergence	3	4.9%
Total Files with divergence	3	1.7%
Net difference in target count	-3	-2%

Range Distribution

The cross-sectional pattern of migrating Chinook at the sonar site in 2020 is presented in Figure 8.[3] Unlike that which occurred in the previous years there was a not a bi-modal range distribution. In 2020 there was a single peak distribution at approximately 8 meters from the sonar. There was a small increase in numbers around 19 m which demarks the thalweg of the river. It is probable the cross-sectional range distribution of Chinook at the sonar site varies inter-annually, likely as a result of prevailing water levels. The relatively skewed cross section pattern observed in 2020 may have been a result of the above average water levels experienced throughout the project.

Carcass Pitch

The carcass pitch was initiated on August 27 but was terminated the following day due to poor visibility resulting from rising water levels and high turbidity. As a consequence, the number of carcasses recovered was low (9). Mean lengths of mid eye to tail fork (METF) for female and male samples were 795 mm and 776 mm, respectively.

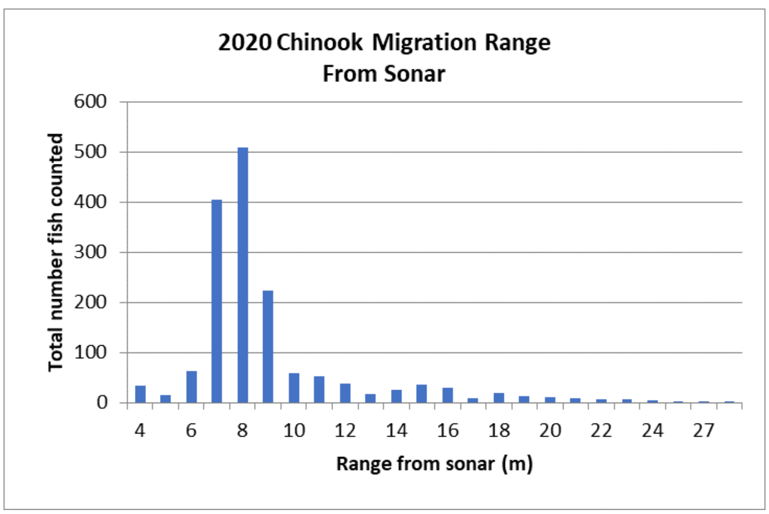

Figure 8. 2020 Big Salmon River Chinook range/frequency in cross section profile.
Note: The 0 – 4m range from the sonar has a deflection fence in place.

[3] The distribution observed from sonar data may not reflect the natural in-river migration pattern at this location as the weir structures channel the fish from an 80 m wide into a 36 m wide corridor.

DISCUSSION

The 2020 Big Salmon sonar project was successful in enumerating the Chinook salmon passing the sonar station throughout the course of the run. There were challenges associated with high water and the removal of debris (logs, stumps etc.) on the weirs but the sonar and weirs were installed as per the usual operational timing and the diversion weirs remained intact and were functional throughout the project. The sonar recorded continuously over the course of the project with no significant interruptions.

There was a high degree of precision between file readers for the files reviewed. However, there was a net difference between reviewers of 1.7% (3/175), with 3 fish missed by the second reviewer. The 3 missed fish were considered faint targets and were missed by the least experienced personnel.

The ARIS sonar is considered the second generation of multiple beam sonars manufactured by Sound Metrics Corporation. The ARIS 1800 sonar and ARISFish software provides better downrange resolution of the fish targets and increases efficiency when reviewing the data compared to the DIDSON sonar. It is recommended the ARIS sonar continue to be used on this project rather than the LR DIDSON previously used from 2005 through 2015.

The 2020 Eagle sonar project on the Yukon River downstream of the Canada/U.S. border yielded a total count of 33,550 Chinook. The above border Chinook spawning escapement[4] estimate was 30,967 (DFO Whitehorse, unpublished data). Based on the Big Salmon and Eagle Chinook sonar counts, the Big Salmon stock contributed 5.3% of the total above border Chinook escapement in 2020. Over the period 2005 -2020 the contribution of the Big Salmon Chinook stock to the upper Yukon Chinook production has ranged from 4.8% to 15.8% Appendix 6(a). A comparison of Big Salmon River Chinook sonar counts and the JTC above border Chinook escapement estimates based on Eagle sonar counts (2005 – 2020) is illustrated in Appendix 6 (b). There is a positive relationship between Eagle sonar escapement estimates and the Big Salmon sonar counts, with a Pearson correlation of 0.84, (R 16) $p<0.001$).

A DFO juvenile Chinook salmon research project was conducted on the Big Salmon River from 2014 through 2018. The adult salmon returns from this period are expected to occur through to 2023. Annual Big Salmon sonar Chinook escapement estimates would continue to contribute to this juvenile Chinook research project.

[4] Spawning escapement is the Eagle sonar count minus the catches in the U.S. upstream of the sonar station and in the Canadian fisheries.

ACKNOWLEDGEMENTS

Several people contributed to the successful operation of the 2020 Big Salmon River sonar project. Ross Zeleznik capably worked as the senior technician for the duration of the sonar operation. Nicholas Starr provided assistance with weir construction, the carcass pitch and demobilization. Ross McBee assisted with data review on site. Peter Etherton assisted with initial freighting of gear, camp set-up and weir construction. The project was funded by the Yukon River Restoration and Enhancement Fund. DFO funded the age analysis of the carcass samples.

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Appendix 1. 2020 daily and cumulative counts of Chinook salmon at the Big Salmon River sonar site.

DATE	DAILY COUNT	CUMULATIVE	COMMENTS
16-Jul	0	0	Sonar installed at 19:30
17-Jul	2	2	Far weir made fish tight 15:30
18-Jul	2	4	
19-Jul	12	16	
20-Jul	15	31	
21-Jul	13	44	
22-Jul	21	65	
23-Jul	23	88	
24-Jul	28	116	
25-Jul	37	153	
26-Jul	53	206	
27-Jul	40	246	
28-Jul	25	271	
29-Jul	19	290	
30-Jul	39	329	
31-Jul	38	367	
01-Aug	30	397	
02-Aug	40	437	
03-Aug	48	485	
04-Aug	51	536	
05-Aug	67	603	
06-Aug	79	682	
07-Aug	70	752	
08-Aug	83	835	peak daily count
09-Aug	77	912	
10-Aug	79	991	
11-Aug	83	1074	
12-Aug	71	1145	
13-Aug	64	1209	
14-Aug	50	1259	
15-Aug	46	1305	
16-Aug	59	1364	
17-Aug	38	1402	
18-Aug	32	1434	
19-Aug	23	1457	
20-Aug	22	1479	
21-Aug	21	1500	
22-Aug	20	1520	
23-Aug	18	1538	
24-Aug	22	1560	
25-Aug	14	1574	Last full day of recording
26-Aug	12	1586	
27-Aug	10	1596	
28-Aug	9	1605	
29-Aug	8	1613	
30-Aug	6	1619	
31-Aug	5	1624	
01-Sept	4	1628	
02-Sept	3	1631	
03-Sept	2	1633	
04-Sept	1	1634	Final estimate based on interpolation

Shaded cells denote daily interpolated counts based on the previous 10 days of sonar counts using the logarithmic equation $y = -17.16\ln(x) + 52.815$.

Appendix 2. Daily and average Chinook counts in the Big Salmon River, 2005-2020.

DATE	Daily Count 2005	Daily Count 2006	Daily Count 2007	Daily Count 2008	Daily Count 2009	Daily Count 2010	Daily Count 2011	Daily Count 2012	Daily Count 2013	Daily Count 2014	Daily Count 2015	Daily Count 2016	Daily Count 2017	Daily Count 2018	Daily Count 2019	Daily Count 2020	Daily Average
11-Jul										2		3					**3**
12-Jul										18		11					**15**
13-Jul	0									52		27					**26**
14-Jul	0									52		36			2		**23**
15-Jul	2	1								64	5	57		1	20		**21**
16-Jul	12	0	2	0					0	90	17	56	11	4	24	0	**18**
17-Jul	13	1	0	0			2		0	115	25	56	22	2	41	2	**21**
18-Jul	23	0	2	0	0		7	0	0	170	39	82	19	2	20	2	**24**
19-Jul	13	0	5	1	11		13	0	0	199	72	113	32	13	38	12	**35**
20-Jul	23	1	5	0	22	0	15	0	0	236	81	126	58	23	46	15	**41**
21-Jul	36	3	7	0	47	7	24	0	1	229	117	171	82	38	47	13	**51**
22-Jul	58	8	11	0	68	14	24	0	1	284	148	226	144	51	48	21	**69**
23-Jul	92	11	18	1	85	12	43	0	2	345	217	174	197	71	54	23	**84**
24-Jul	130	21	26	2	135	7	44	0	4	343	312	271	235	91	45	28	**106**
25-Jul	158	20	52	1	201	12	50	1	3	356	411	240	211	118	66	37	**121**
26-Jul	204	53	88	3	226	14	56	1	11	372	538	292	212	136	66	53	**145**
27-Jul	219	95	153	5	346	27	105	1	25	421	494	428	281	168	106	40	**182**
28-Jul	287	146	237	9	498	46	160	3	44	307	531	430	243	242	113	25	**208**
29-Jul	290	230	287	9	532	83	192	15	86	380	588	394	192	273	164	19	**233**
30-Jul	299	321	337	29	594	123	218	12	83	330	586	409	317	326	159	39	**261**
31-Jul	279	368	400	21	808	141	218	23	150	256	492	377	432	310	168	38	**280**
01-Aug	333	357	435	23	578	159	260	62	196	207	568	362	390	272	183	30	**276**
02-Aug	346	379	331	18	715	182	313	76	220	207	485	329	363	265	164	40	**277**
03-Aug	303	358	304	16	725	216	417	138	264	192	441	309	341	270	170	48	**282**
04-Aug	292	413	258	31	595	226	426	156	262	190	451	245	309	333	159	51	**275**
05-Aug	331	496	210	51	559	215	396	196	261	170	452	235	241	303	230	67	**276**
06-Aug	214	490	178	55	452	221	400	228	225	120	469	222	181	264	184	79	**249**
07-Aug	188	464	147	78	364	227	317	192	191	114	449	177	181	248	230	70	**227**
08-Aug	232	464	59	61	295	242	294	235	195	96	397	161	115	168	198	83	**206**
09-Aug	234	360	74	70	270	248	243	183	156	68	348	157	116	100	174	77	**180**
10-Aug	203	349	90	98	209	183	160	154	132	61	246	101	84	93	158	79	**150**
11-Aug	124	348	82	122	183	207	170	106	134	50	217	77	85	114	134	83	**140**
12-Aug	126	324	98	107	146	174	143	130	113	46	187	79	72	99	115	71	**127**
13-Aug	125	243	77	109	118	181	100	110	101	25	201	58	80	131	106	64	**114**
14-Aug	72	196	74	89	117	134	85	81	77	30	126	63	65	103	126	50	**93**
15-Aug	57	180	66	78	65	114	89	80	65	24	113	52	53	72	75	46	**77**
16-Aug	40	172	56	70	55	82	63	94	57	24	91	33	51	76	60	59	**68**
17-Aug	53	104	40	49	63	80	35	70	34	17	65	26	54	66	44	38	**52**
18-Aug	47	69	64	45	55	53	20	50	32	15	54	20	40	65	46	32	**44**
19-Aug	35	87	37	17	43	40	18	44	21	14	28	10	32	54	37	23	**34**
20-Aug	29	59	47	18	35	24	21	38	28	11	10	18	10	52	28	22	**28**
21-Aug	26	45	11	15	28	18	11	27	20	9	7	15	25	36	17	21	**21**
22-Aug	19	50	16	16	14	38	2	19	10	6		12	22	31	8	20	**19**
23-Aug	17	12	23	9	4	24	2	19	14	3		9	19	24	1	18	**13**
24-Aug	13	10	17	2		20		14	11	1		6	16	20		22	**13**
25-Aug	9		14	1		17		9	6			4	13	15		14	**10**
26-Aug	6		14			6		6	4			2	10	10		12	**8**
27-Aug	4		13					5	2				8	5		10	**7**
28-Aug	2		11					3	1				5	1		9	**5**
29-Aug			9					2					3			8	**6**
30-Aug			8					1								6	**5**
31-Aug			6													5	**6**
01-Sep			4													4	**4**
02-Sep			3													3	**3**
03-Sep																2	**2**
04-Sep																1	**1**
TOTAL:	**5618**	**7308**	**4506**	**1329**	**9261**	**3817**	**5156**	**2584**	**3242**	**6321**	**10078**	**6761**	**5672**	**5159**	**3874**	**1634**	**5145**

Note: Stippled areas are interpolated counts. Shaded areas denote start and end of sonar recording

Appendix 3. Precision of counts by two ARISfish file reviewers.

File #	Reviewer #1	Reviewer #2	Difference
1	4	4	0
2	4	4	0
3	3	3	0
4	3	3	0
5	3	3	0
6	4	4	0
7	2	2	0
8	3	3	0
9	4	4	0
10	3	3	0
11	3	3	0
12	3	3	0
13	3	3	0
14	4	4	0
15	4	4	0
16	3	3	0
17	3	3	0
18	2	2	0
19	3	3	0
20	5	5	0
21	1	1	0
22	2	2	0
23	3	3	0
24	3	3	0
25	1	1	0
26	2	2	0
27	3	3	0
28	4	4	0
29	4	4	0
30	2	2	0
31	2	2	0
32	2	2	0
33	2	2	0
34	3	3	0
35	2	2	0
36	3	3	0
37	2	2	0
38	4	4	0
39	5	5	0
40	4	4	0
41	3	3	0
42	3	3	0
43	3	3	0
44	3	2	-1
45	2	2	0
46	1	1	0
47	3	3	0
48	3	3	0
49	2	2	0
50	3	3	0
51	4	4	0
52	3	3	0
53	3	2	-1
54	3	2	-1
55	2	2	0
56	2	2	0
57	2	2	0
58	4	4	0
59	2	2	0
60	2	2	0
61	2	2	0

Appendix 4. Sex, length and age of sampled Chinook on the Big Salmon River, 2020.

DATE	FISH #	SEX	MEF (mm)	POHL (mm)	AGE*
25-Aug	1	F	830	720	1.4
27-Aug	2	M	680	605	1.3
27-Aug	3	F	750	665	1.3
27-Aug	4	M	900	835	M3
27-Aug	5	F	720	635	M3
27-Aug	6	M	620	530	1.1
27-Aug	7	F	880	755	1.4
27-Aug	8	M	905	790	M3
27-Aug	9	F	795	690	1.3

*European age format; e.g. 1.3 denotes a 5 year old fish with 1+ years freshwater residence and 3 years marine residence
M = Marine stage

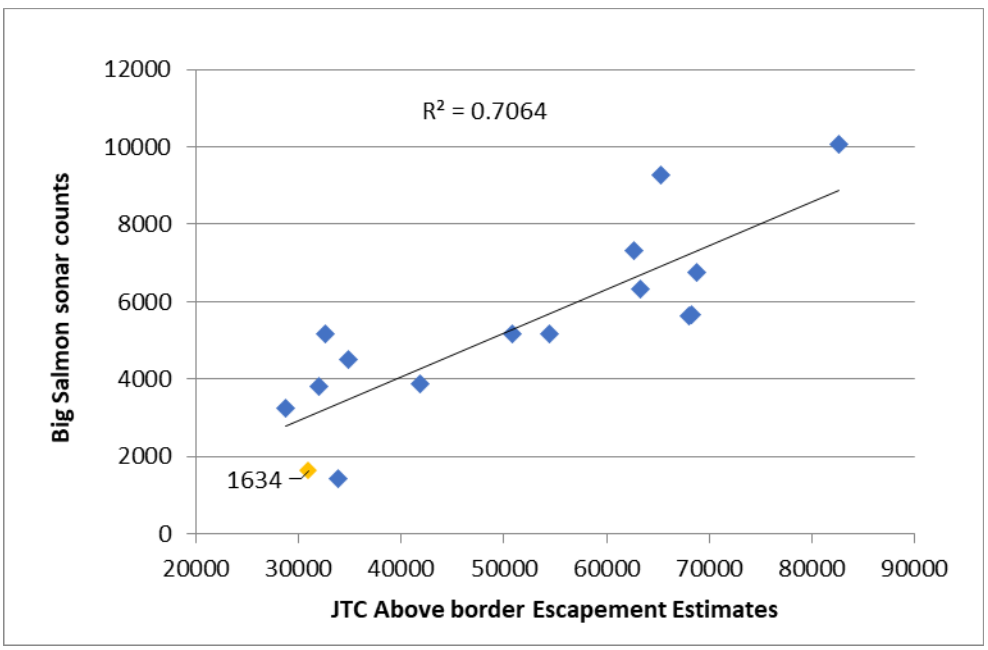
Appendix 5. 2020 Big Salmon River Environmental Conditions – Recorded at 0900h Daily

DATE	AIR TEMP. (ºC)	WATER TEMP. (ºC)	WATER LEVEL (cm)	COMMENTS
17-Jul	-	-	-	Clear, Sunny
18-Jul	12	12	41	Mixed cloud/ overcast
19-Jul	13	11.5	36	Mixed cloud and sun
20-Jul	12	11.5	34	overcast with intermittent showers
21-Jul	12	11.5	35	overcast, heavy showers in evening
22-Jul	12	11.5	46	Foggy morning, overcast day
23-Jul	11	11.5	52	Foggy morning, overcast day
24-Jul	7	9.5	54	Mix sun and cloud
25-Jul	13	10.5	44	Mix sun and cloud
26-Jul	8	11	43	Overcast, steady rain
27-Jul	7	10	45	Overcast, steady rain
28-Jul	10	9	61	Heavy, steady rain
29-Jul	10	9	69	Overcast, steady rain
30-Jul	10	9	70	Bright, sunny morning
31-Jul	11	10.5	59	Bright sunny, hot day
01-Aug	11	11.5	51	Mix of sun and clouds, hot afternoon
02-Aug	12	11.5	46	Sun, brief clouds and showers
03-Aug	8	10.5	41	Mix of sun and clouds
04-Aug	10	10.5	37	partly cloudy
05-Aug	7	10	35	Sunny, with some cloud cover
06-Aug	10	10.5	31	cloudy with rain
07-Aug	12	10	30	Mix sun and cloud
08-Aug	8	10	27	cloudy with rain
09-Aug	5	9	26	Overcast, steady rain showers
10-Aug	10	9.5	28	Sun, with patches of cloud and rain
11-Aug	10	9	27	Overcast, light showers
12-Aug	10	10	26	cloudy with rain
13-Aug	10	10	28	overcast
14-Aug	8	9	37	overcast
15-Aug	9	10	34	overcast
16-Aug	9	9.5	33	Sunny, with some cloud cover
17-Aug	9	10	44	Sunny and clear
18-Aug	4	9	41	Foggy morning followed by clear skies
19-Aug	6	9	39	Overcast morning, light rains
20-Aug	2	7.5	38	Fogged in morning, bright, sunny day
21-Aug	9	9	35	Overcast and calm
22-Aug	9	9.5	34	Foggy morning, clear and hot afternoon
23-Aug	11	10	31	Overcast, intermittent rain
24-Aug	11	10	32	Overcast. Heavy rain
25-Aug	9	10	36	Overcast morning, calm sunny afternoon.

Appendix 6 (a). Big Salmon River Chinook sonar counts, % contribution and the JTC above border Chinook escapement estimates based on Eagle sonar counts, 2005 – 2020.

year	Above Border Chinook Escapement	Big Salmon Sonar Counts	% contribution of Big Salmon Stock to Total Above Border YR Chinook Production
2020	30,967	1,634	5.3%
2019	41,786	3,874	9.3%
2018	54,474	5,159	9.5%
2017	68,315	5,672	8.3%
2016	68,798	6,761	9.8%
2015	82,674	10,078	12.2%
2014	63,331	6,321	10.0%
2013	28,669	3,242	11.3%
2012	32,658	5,156	15.8%
2011	50,780	5,156	10.2%
2010	32,010	3,817	11.9%
2009	65,278	9,261	14.2%
2008	33,883	1,431	4.2%
2007	34,904	4,506	12.9%
2006	62,630	7,308	11.7%
2005	67,985	5,618	8.3%

Appendix 6 (b). Comparison of Big Salmon River Chinook sonar counts and the JTC above border Chinook escapement estimates based on Eagle sonar counts, 2005 – 2020.



Note: Yellow data point is 2020 value.