2008 CHINOOK SALMON SONAR ENUMERATION ON THE BIG SALMON RIVER

CRE-41-08

Prepared For: The Yukon River Panel
Restoration and Enhancement Fund

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ABSTRACT

A long range dual frequency identification sonar (DIDSON-LR) was used to enumerate the Chinook salmon escapement to the Big Salmon River in 2008, as well as determine associated run timing, and diel migration patterns. This was the fourth year of sonar operation at this site. The sonar site was located on the Big Salmon River at the same location as in previous years, approximately 1.5 km upstream of the confluence with the Yukon River. Sonar operation began on July 13; however, placement of partial weir structures used to restrict fish passage through a 34 m opening was delayed until August 9 due to unusually high water conditions. Prior to the weir placement on August 9, fish migrating outside the ensonified area would have gone undetected. A total of 1,329 targets identified as Chinook salmon was counted past the sonar station between July 13 and August 25, 2008. The peak daily migration of 122 fish occurred on August 11, and 90% of the run had passed the station on August 17. The total count was expanded by 102 fish to account for passage of undetected Chinook that migrated outside of the ensonified area of the river. The estimated total escapement into the Big Salmon drainage was 1,431 Chinook. A carcass pitch was conducted over approximately 100 km of the Big Salmon River, however, persistent high and turbid water conditions made it difficult to locate and retrieve carcasses. Only 13 Chinook carcasses were collected as a result. Of the 13 fish sampled, 6 were female and 7 were male. The mean fork length of females and males sampled was 837.3 mm and 776.9 mm, respectively. Age data was determined from 10 fish sampled. Age 1.4 (European) was the dominant age class representing 80% of the sample while age 1.3 and 1.5 each represented 10%. No spaghetti tags were observed or recovered from the sampled fish. A total of 13 DNA (axillary appendage) samples was collected.

INTRODUCTION

In 2005, a sonar enumeration program was initiated on the Big Salmon River using a DIDSON (Dual frequency Identification SONAR). In 2005, 2006 and 2007, the Big Salmon River sonar counts were 5,618, 7,308 and 4,452. These counts represented approximately 18%, 20% and 10.6% of the total upper Yukon River spawning escapement point estimate in 2005, 2006 and 2007, respectively (JTC 2009).

Due to high flow rates, First Nation concerns, and wilderness recreational use in the Big Salmon River, the use of traditional salmon weir techniques on this river is not feasible. For these reasons the DIDSON sonar was considered as a relatively low impact, non-intrusive method of enumerating annual Chinook escapements to the Big Salmon River system. The use of sonar allows for enumeration of migrating Chinook salmon while minimizing negative impacts on fish behaviour and providing un-restricted recreational use of the river.

The Yukon River Panel (YRP) has indicated that obtaining accurate estimates of spawning escapements is required for the management of the Yukon River Chinook stocks. In the 2007 YRP Framework, determination of escapement estimates is ranked as a high priority as there is strong public and Joint Technical Committee (JTC) interest in quantifying escapement information. This information is important for run reconstruction and the establishment of scientifically based escapement objectives.

Researchers have found the DIDSON apparatus to be superior to other sonar systems for many applications aimed at enumerating migrating salmon (Galbreath and Barber 2005, Holmes et al. 2005). In general, the DIDSON units have been found to be reliable, require a minimum of operator training, and provide accurate counts of migrating salmon (Holmes et al. 2006, Mercer & Wilson 2006, 2007, and 2008).

A proposal to continue sonar operations on the Big Salmon River using a DIDSON sonar unit as well as conduct a Chinook carcass pitch was submitted by J. Wilson and Associates to the Yukon River Panel Restoration and Enhancement (R&E) fund in January 2008. The proposal was accepted and financial support was received from the R&E fund.

Study Area

The Big Salmon River flows in a north-westerly direction from its headwaters at the Quiet and Big Salmon lakes chain 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 from Quiet Lake along the Canol Road, from the Yukon River on the Robert Campbell and Klondike Highways, or from Lake Laberge via the Thirty Mile and Yukon rivers.

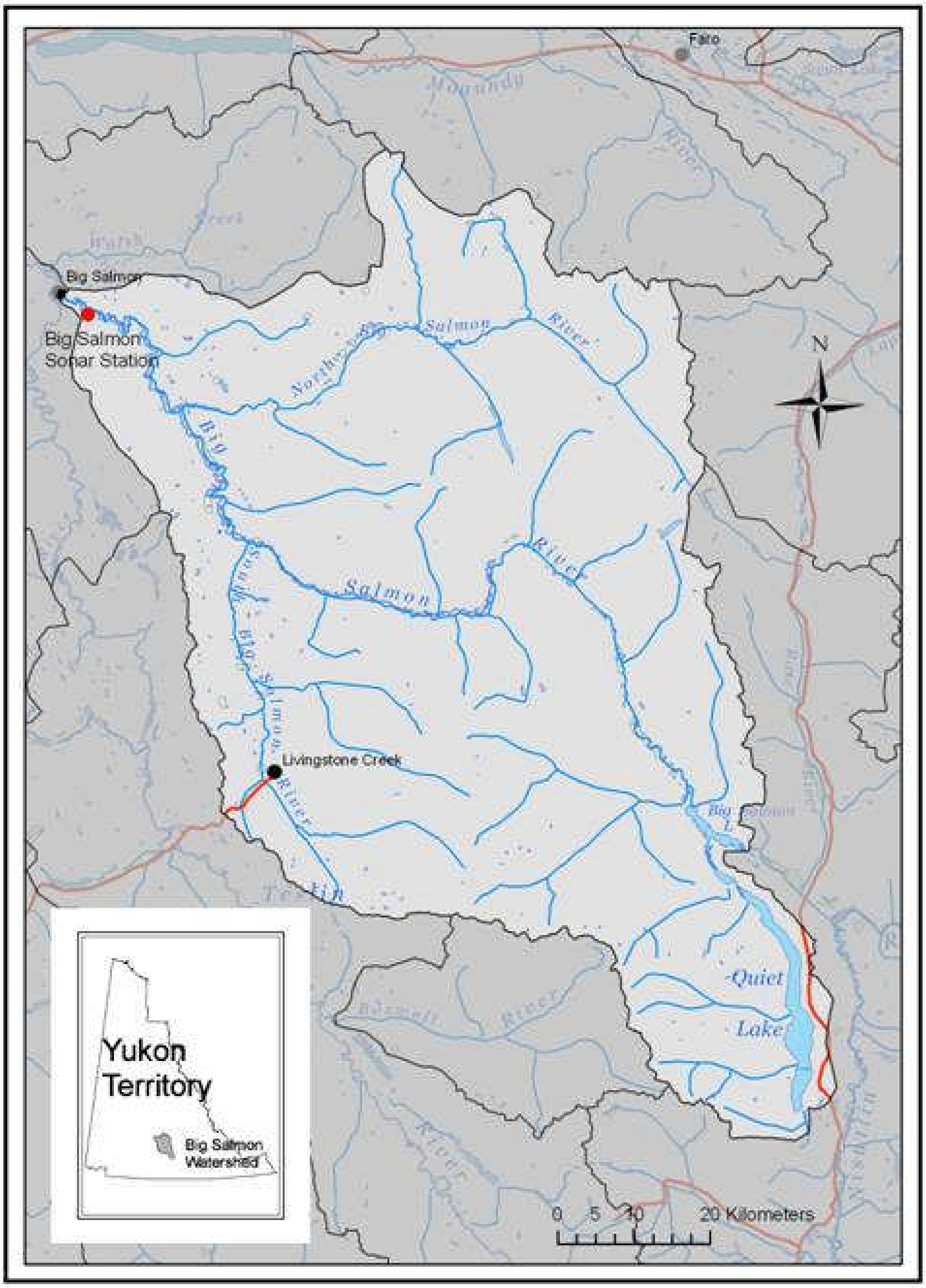

Figure 1. Big Salmon River Watershed and location of the 2008 Big Salmon sonar station.

Objectives

The objectives of the 2008 Big Salmon River sonar project were:

1. To operate a sonar station on the Big Salmon River to enumerate the Chinook salmon escapement and obtain information on run timing and diel migration patterns.

2. To conduct spawning ground sampling for age-sex-length data and genetic material from post-spawn fish and recover spaghetti tags.

METHODS

Site Selection

Sonar operations were set up at the same site 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 UpperYukon/Teslin River Chinook salmon.
- 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.

Permits

In 2005, an application was submitted to Yukon Energy, Mines & Resources, Lands Branch, for a land use permit to establish the sonar camp on the lower Big Salmon River. A permit was granted for use in 2005 and 2006 and extended in 2007 and 2008.

An application was submitted to Transport Canada (Marine Branch), Navigable Waters Protection for approval to install partial fish diversion fences in a navigable waterway in 2005. Approval was granted for ongoing annual sonar operations as described in the original application.

Weir Materials

Prefabricated metal tripods and cross pieces used in a past R&E project were obtained from storage in Dawson City. Six tripods were obtained for this purpose. These were transported to the sonar site by riverboat prior to starting the project. These tripods were intended to replace the existing wooden tripods on the north bank of the river.

Camp and Sonar Station Set-up

Construction of the camp and sonar station was initiated on July 12. Materials for the camp, equipment, sonar apparatus, and additions to the existing diversion fence were transported from Whitehorse to Little Salmon Village. These were then transported to the sonar site by riverboat and floatplane. Subsequent camp access, crew changes, and delivery of supplies was also accomplished via riverboat and supplemented by floatplane from Whitehorse.

As in previous years, the camp was comprised of two wall tents: one to house a kitchen/eating area and computer station and another for sleeping quarters. The kitchen and computer station was located 6 m from the south bank of the river and constructed using a 5m x 5m “weatherall” free standing wall tent placed on a plywood platform. The sleeping quarters was situated 70 m from the shore and constructed using a 14’ X 16’ canvas wall tent placed on a plywood platform and wooden frame (Figure 3).

Weir Construction

Construction of a partial weir to divert shoreline migrating Chinook salmon into the ensonified area was delayed because of extremely high water levels. Weir construction was initiated on August 9 after water levels had lowered enough to enable complete installation.

The diversion weirs were constructed on opposite sides of the river as in previous years (Figures 3 and 4). As well as the metal tripods, wooden tripods and stringers from the 2006 project were re-used. Prefabricated panels of electrical conduit were placed on the tripod structures to create the diversion fence. The partial weir on the north bank was extended into the shallower reaches using “vexar” plastic mesh that was anchored with rebar driven into the stream bottom (Figure 4). The upper margin of the “vexar” was fastened to 5-inch PVC pipe to provide flotation and create a fence that self adjusted to fluctuating water levels. The south bank fence extended approximately 7 m from the bank and the north bank fence approximately 25 m from the bank providing a 35 m opening for fish passage. Light activated flashing beacon lights were secured to each diversion fence to mark the in-stream extent of weirs. A warning sign was also posted 200 m upstream of the station to alert boaters of the partial obstruction ahead in accordance with Transport Canada, Navigable Waters Protection requirements.

Figure 2. Flood conditions on July 14 viewed from the south bank at the weir placement site.

Figure 3. Partial weirs and 34 m opening for fish passage viewed from the south bank.

Figure 4. Aerial view of sonar station camp and partial weirs.

Sonar and Computer Software Configuration

The configuration of the DIDSON sonar unit was similar to that used in previous years at this site. The unit was mounted on an adjustable stand constructed of 2-inch steel galvanized pipe similar in design to those used at other DIDSON sonar projects (Galbreath and Barber 2005). 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 rotation of the transducer lens to adjust the beam angle.

Due to flood conditions during sonar set-up, it was not possible to place the sonar unit at the site used in previous years. The unit was set-up temporarily in a protected eddy in close proximity to the camp where it could be monitored closely. By July 21, water levels had lowered somewhat enabling the sonar unit to be placed at the usual site. Due to the large debris load in the river and concern over the security of the sonar apparatus, the sonar was operational only 12 hours per day until July 22 after which water levels moderated enough that normal placement and 24 hour operation could begin. For the duration of the project the sonar device was installed on the submerged adjustable mounting platform and secured to a tree onshore using a 6 mm stainless steel safety cable.

The mounted sonar unit and stand was placed next to the south bank immediately upstream of the diversion fence in approximately 1.0 m of water (Figure 6). The “feet” of the stand were secured to the stream bottom using sandbags. A 6 mm stainless steel safety cable was affixed to the sonar unit and fastened to a buried anchor onshore.

Figure 5. Sonar transducer unit and mounting stand.

Figure 6. Sonar transducer unit and mounting stand in position.

The DIDSON sonar produces an ensonified field 29° wide in the horizontal plane and 12° deep in the vertical plane. The DIDSON transducer lens was positioned to a depth of approximately 12 cm below the surface of the river and angled downward approximately 4º from horizontal which resulted in the ensonified cone of water remaining parallel to the surface of the river (Figure 7).

Once the sonar was in place and properly positioned, the primary sonar unit settings and software were configured. These settings included the window start length, the ensonified window length, and the frame rate. The receiver gain was set at –40 dB, the window start at 5.86 m, window length at 40 m, and auto frequency enabled for the duration of the project. Threshold settings were set at 3 dB and intensity at 40 dB. The recording frame rate was typically set at 4 frames per second, which was the highest frame rate the computers could process with a window length setting of 40 m. Two Toshiba laptop computers were used for the project, one recording the DIDSON files and one for reviewing the files.

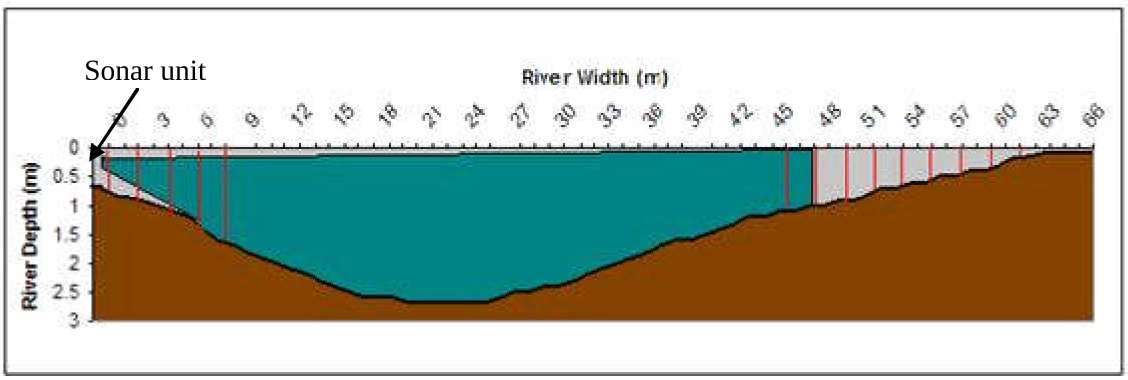

Figure 7. Schematic diagram of river profile and sonar and weir configuration. Red bars denote weir structures and blue the ensonified portion of the water column. Note: Vertical scale is exaggerated.

The sonar system was powered by two sets of 6 gel cell batteries connected in two parallel circuits to create a 12 volt power source. The battery banks were charged by 6 solar panels and a backup 2.4 kW generator. An 800 watt inverter was used to obtain 110 volt AC from the batteries to supply power for the computers and the sonar unit. A rotating solar panel platform was constructed in 2008 (Figure 8). This allowed the panels to be manually rotated during the day to directly face the sun thereby increasing the efficiency of the solar panel array.

Sonar Data Collection

After operation was normalized on July 22 the sonar data was collected continuously and stored automatically in pre-programmed 20 minute files each specifying time and date. This resulted in an accumulation of 72 files over a 24 hour period. These files were subsequently reviewed the following morning and stored on the active PC as well as backed up on an external hard drive. All files collected from the project were archived on external hard drives.

Figure 8. Solar panels mounted on rotating piece of local folk art.

To optimize target detection during file review, the background subtraction feature was used to remove static images such as the river bottom and weir structures. The intensity (brightness) was set at 40 dB and threshold (sensitivity) at 3dB. The playback speed depended on the preference and experience of the observer, but was generally set between 30 and 40 frames per second, approximately 8 to 10 times the recording rate. This allowed observers to quickly review files, particularly during long periods when no targets were observed. When necessary, the recording was stopped when a fish was observed and replayed at a slower rate for positive identification. The target measurement feature of the DIDSON software was used to estimate the size of the observed fish. The minimum size used to identify Chinook salmon was approximately 50 cm, although there was some subjective interpretation regarding identification and categorization of the smaller fish observed. Review of the data files indicate that less than 1% of the observed Chinook salmon was in the 50 cm size range. Chinook salmon images were visually counted using a hand counter and the total count from each file was entered into an excel spreadsheet. Fish identified as Chinook salmon moving downstream were subtracted from the file total. A record of each 20 minute file count as well as hourly, daily and cumulative counts was maintained throughout the run.

Carcass Pitch

The upper reaches of the Big Salmon River were accessed using a 5.5m open skiff powered by a 60 hp outboard jet motor. The crew made one trip upriver on August 24/25 searching for spent Chinook and carcasses. Carcass pitch efforts extended from the camp approximately 100 river kilometers to the first logjam located 20 km downstream from Big Salmon Lake.

Carcass sampling consisted of collecting five scales per fish placed in prescribed scale cards, noting presence of spaghetti tags and recording sex and post-orbital hypural and mid-eye-fork lengths (to the nearest 0.5cm).

RESULTS

Chinook Salmon Counts and Run Timing

The first Chinook salmon was observed on July 19 at 20:00. The peak passage was on August 11, and 90% of the run had passed the station on August 17. Daily and cumulative counts are presented in Table 1. A total of 1,329 targets identified as Chinook salmon was counted past the sonar station from July 16 through to August 25. The peak daily count of 122 fish occurred on August 11 at which time 53% of the run had passed the sonar station. The daily counts exhibited a less pronounced peak in 2008 compared to previous years (Figure 9), however, the cumulative daily run pattern exhibited the same normal distribution as occurred in 2005 through 2007 (Figure 10).

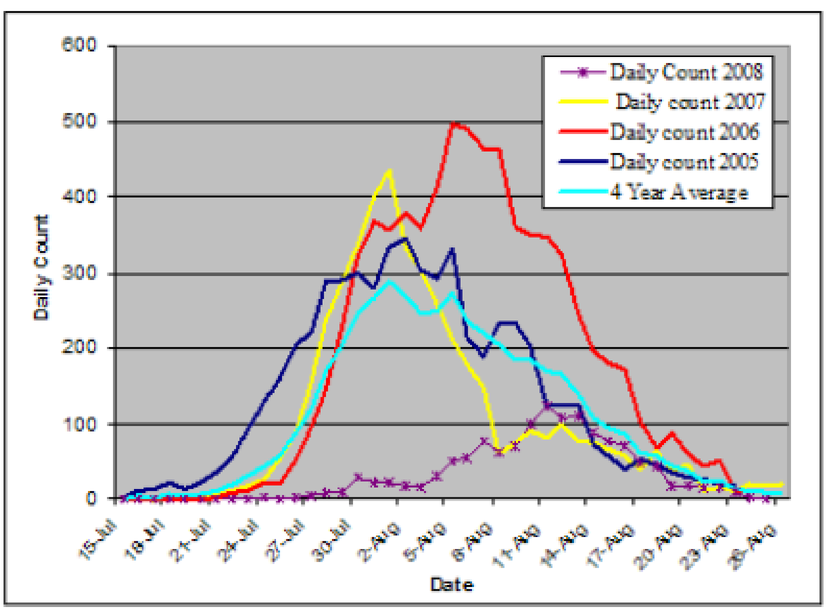

Figure 9. Daily counts of Chinook salmon passing the Big Salmon River sonar station in 2005, 2006, 2007, and 2008.

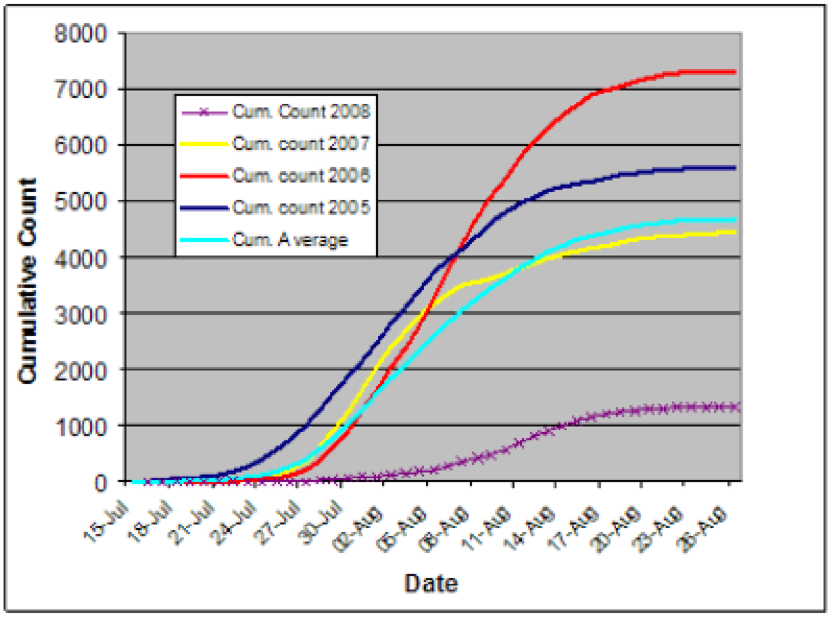

Figure 10. Cumulative counts of Chinook salmon passing the Big Salmon River sonar station in 2005, 2006, 2007, and 2008.

The 2008 peak run timing was approximately 10 days later than the average observed in the previous four years at this site. Later than average run timing was observed in other Upper Yukon systems and was likely a result of the 2008 protracted high water event.

Due to the extreme high water levels experienced at the beginning of the project, the partial weir structures on each side of the river were not deployed until August 9. From July 19, when the first Chinook was observed, through to August 9 a total of 484 Chinook was counted past the site. During this period the ensonified area of the river was the same as during past years, extending from a 5 meter start point on the south side of the river 40 meters across to the north bank (Figure 7). Without the partial weirs on each bank it is probable that some Chinook were migrating undetected between the sonar and the 5 m start window (near field) and beyond the 40 m range of the set ensonified window length. Throughout the 2008 sonar operation the distance from the sonar unit to where fish passage occurred was recorded for 1,162 of the 1,329 Chinook counted past the site. In an attempt to quantify the number of Chinook that passed undetected from July 19 through August 9 a comparison was made of the proportion of Chinook migrating in the 5 to 10 m range and the 40 to 45 m range both before and after the partial weirs was installed. The relative proportions of fish migrating within each 5 m sectional width of the river are presented in figures 11(a) and (b) and Appendix 3. There was a significant difference in the proportion of Chinook detected in both the 5m to 10m range and greater than 40 m range before and after the installation of the weir. After weir installation on August 9 the combined proportion of fish detected in these two areas increased from 29% to 50% (Table 2, Figures 11 (a) and 11(b)). This was an increase of 21% of the total count after the weirs were installed. The assumption is that this difference was due to the non-detection of Chinook migrating outside the ensonified area of the river. Using this expansion factor of 21% and applying it to the cumulative count up to and including August 9 the pre-weir count was increased by 102 fish from 484 to 586; resulting in a total expanded count for the season of 1,431.

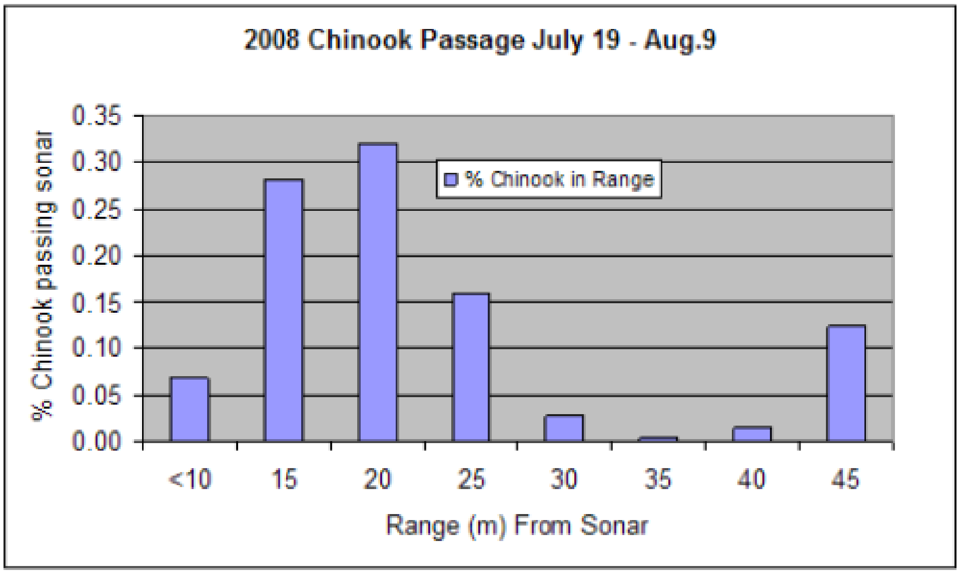

Figure 11(a). Chinook passage within ensonified cross section of river before weirs installed.

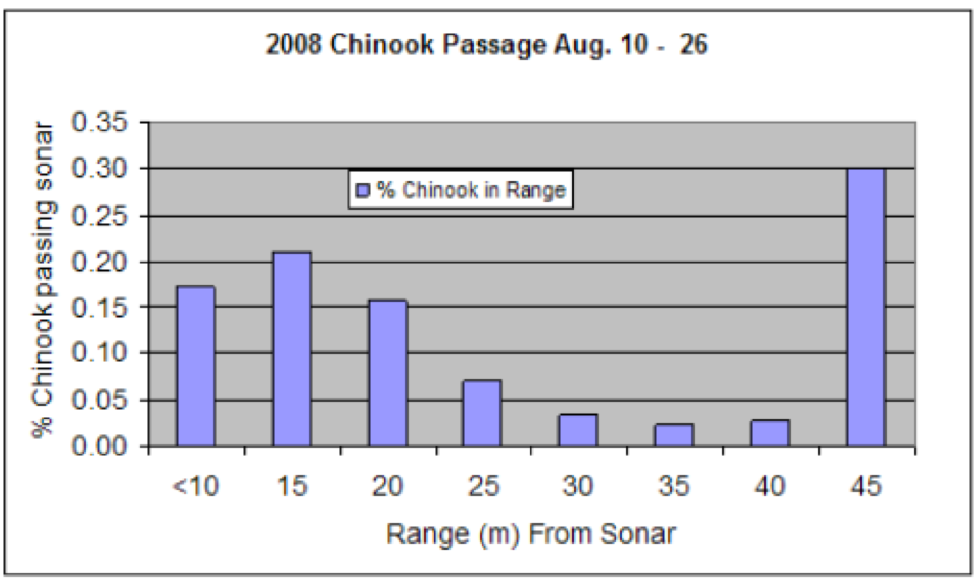

Figure 11(b). Chinook passage within ensonified cross section of river after weirs installed.

Table 1. 2008 daily and cumulative counts of Chinook salmon at the Big Salmon River sonar site.

DATE	DAILY COUNT	CUMULATIVE	SONAR OPERATION TIME/COMMENTS
July 16	0	0	8 hrs
17	0	0	12 hrs
18	0	0	12 hrs
19	1	1	12 hrs 40 min
20	0	1	12 hrs 40 min
21	0	1	12 hrs 40 min
22	0	1	24 hrs (Starting 8:00 a.m.)
23	1	2	24 hrs
24	2	4	24 hrs
25	1	5	24 hrs
26	3	8	24 hrs
27	5	13	24 hrs
28	9	22	24 hrs
29	9	31	24 hrs
30	29	60	24 hrs
31	21	81	24 hrs
Aug-01	23	104	24 hrs
2	18	122	24 hrs
3	16	138	24 hrs
4	31	169	24 hrs
5	51	220	24 hrs
6	55	275	24 hrs
7	78	353	24 hrs
8	61	414	24 hrs
9	70	484	24 hrs, partial weir installed
10	98	582	24 hrs
11	122	704	24 hrs
12	107	811	24 hrs
13	109	920	24 hrs
14	89	1009	24 hrs
15	78	1087	24 hrs
16	70	1157	24 hrs
17	49	1206	24 hrs
18	45	1251	24 hrs
19	17	1268	24 hrs
20	18	1286	24 hrs
21	15	1301	24 hrs
22	16	1317	24 hrs
23	9	1326	24 hrs
24	2	1328	24 hrs
25	1	1329	Shut down 6:00 p.m.

Table 2. Expansion factor applied to proportional cross section distribution.

	Cumulative count	Proportion <5m and >40m	Proportion >5m and <40m	Proportion undetected	Number undetected	Expanded count
Before weir installed	484	29%	71%	21%	102	586
After weir installed	845	50%	50%			845
			Total Expanded count			**1,431**

Table 3. Expanded 2008 above border and Big Salmon Chinook escapement estimates based on sonar counts and GSI proportions.

Sample site (n)		**Bio-Island (305)**	**Eagle (453)**	**Eagle rerun (311)**
GSI proportion % (SE)		9.3% (6.0)	1.1% (1.9)	2.6% (2.9)
Expanded total escapement based on Big Salmon sonar count		15,387	130,091	55,038
upper (95% CI)		18,614	221,782	84,919
lower (95% CI)		12,160	38,400	25,158
Estimated Big Salmon escapement[1] based on Eagle sonar and GSI			374	884
upper (95% CI)			1,272	1,932
lower (95% CI)			0	0

[1.] This is the estimated escapement to the Big Salmon River using the above border escapement of 34,008 (Eagle sonar count minus catches), and the Eagle re-run GSI proportional data.
Note: The eagle rerun GSI proportion data are used to determine expansion factors in this report as they are more concordant with the Bio-Island sampling data. The estimates based on the total Eagle sampling regime are presented in Table 3 for comparative purposes. See discussion below.

Diel Migration

As occurred in previous years at this site, there was no significant diel migration pattern observed in the Chinook salmon migration in the Big Salmon River (Single factor ANOVA, tested for homogeneity of variance: df=23, F=0.35, α=0.05, p=0.99). The lack of diel migration patterns by Yukon River Chinook salmon may be due to the long distances traveled and high daily travel rates. It may require several years of data to determine if a diel migration pattern is present.

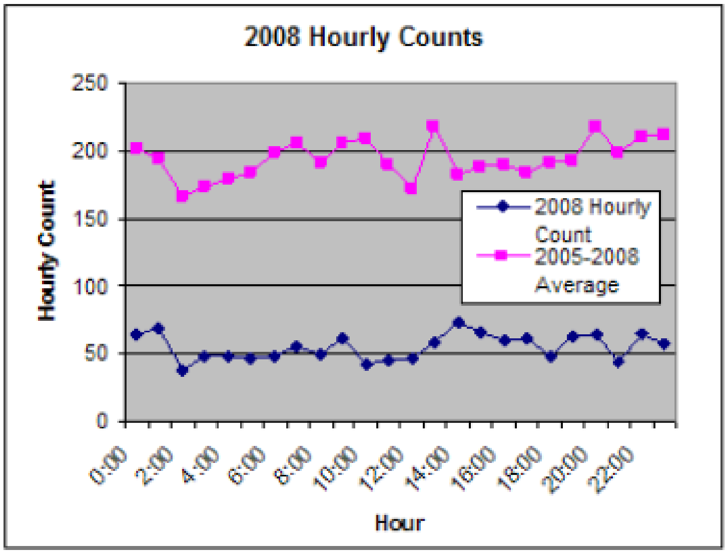

Figure 12. Total hourly counts of Chinook salmon passing the Big Salmon River sonar station in 2005, 2006, 2007, and 2008.

Carcass Pitch

A total of 13 carcasses was recovered during the carcass pitch. This was significantly lower than in previous year's efforts. The low numbers were attributable to the high and turbid water conditions. As the water conditions continued to deteriorate at the end of the project no further effort was made to recover carcasses. The age, length and sex data from these fish are presented in Appendix 2. A total of 13 DNA (axillary appendage) samples was collected.

DISCUSSION

The 2008 Eagle sonar project on the Yukon River yielded a border[1] escapement estimate of 34,008 Chinook salmon (JTC 2009). In 2008 genetic stock identification (GSI) samples were collected using drift nets at the Eagle sonar site and from Chinook captured at the Bio-Island fish wheels. The proportions of Big Salmon origin Chinook varied significantly between the samples taken at each site (Table 2). The proportional contribution of the Big Salmon River stock based on GSI samples obtained from drift net sampling at the Eagle sonar site was significantly lower (2.6%, SE 2.9) and had greater variance than the proportion (9.3%, SE 6.0) derived from samples collected at the Bio-Island fish wheel site. Using both the Eagle and Big Salmon sonar counts the proportion

[1] Border escapement is the number of potential spawners estimated to have passed the Canada/U.S. border and entered the Upper Yukon River drainage in Canada. The 2008 Eagle sonar Chinook count of 38,097 was adjusted by subtracting the local U.S subsistence catch of 690 Chinook and the Canadian commercial and aboriginal harvest of 3,339 Chinook (JTC 2009).

of Big Salmon origin stocks in the above border escapement would be 4.2%. This proportion is within the SE ranges of both sampling data sets.

Based on expansion of proportional GSI data from samples collected at the Eagle sonar site, the Big Salmon River escapement count of 1,431 yielded an above border escapement of 55,038 (95% CI +/- 29,880). However, based on the Bio-Island GSI sample data the above border escapement estimate would be 15,387 (95% CI +/- 3,227). The 2008 Bio-Island derived Big Salmon origin proportion (9.3%) is consistent with proportional contributions observed from this site in 2005 through 2007 (10.8%, 9.7%, and 10.6% respectively; Mercer & Wilson 2007). The 2005 – 2007 Bio-Island GIS proportions are also concordant with those obtained from previous radio telemetry studies which ranged from 9.2% to 16.4% (Osborne et al. 2003, Mercer and Eiler 2004, Mercer 2005).

The 2008 Bio-Island GSI sample set was collected over 3 weeks from July 20 through August 9, whereas the total sample set from the Eagle site was collected over 6 weeks from July 6 through August 16. A sub-set of Eagle GSI samples from the July 20 to August 9 (re-run in Table 3 above) was presented for comparison with the Bio-Island sample set. The high variance observed in the Eagle sonar site GSI samples resulted in such wide confidence intervals in the population estimates that the information extracted has questionable stock assessment and management value. Unlike previous years the Big Salmon sonar project in 2008 did not produce total Chinook salmon counts that correlated well with the Eagle sonar counts and GSI data. Although not in the purview of this report to examine these data, the variance in proportionate GSI values at the Eagle site and the variance between sample sites may be due, in part, to imprecision in the Upper Yukon River GSI database and/or non representative sampling resulting from the 2008 high water event and the different sample collection methods at both sites. Sampling techniques should be refined in the future to ensure representative sampling occurs and the variance within the sample set is reduced.

The accuracy of the Big Salmon sonar counts has been discussed in detail in previous Big Salmon River sonar reports (Mercer and Wilson 2006, 2007, and 2008). The prolonged high water events in 2008 precluded installation of the partial weirs and this likely resulted in the passage of undetected Chinook within the near field and beyond the 40m window length of the ensonified area. Attempts were made to quantify the number of undetected Chinook with the result that the total estimated escapement into the Big Salmon drainage was expanded by 7.8% (102 fish) from the actual count of 1,329 to a final total of 1,431.

The extreme flood events experienced on the Big Salmon watershed and through out the upper Yukon River drainage in 2008 resulted in the delay of the weir installation and precipitated the collapse and loss of most of the weir components at the end of the project. Continuing high water precluded retrieval of any weir material during the prescribed project duration. Project personnel returned to the site on October 15 to attempt to retrieve some of the lost weir material. Five weir panels and all the metal tripods were recovered at this time. Unfortunately water conditions were still unseasonably high and turbid which precluded the recovery of the remaining weir materials. It is anticipated the project proponents will attempt to retrieve the remaining weir panels in mid-May 2009. The metal tripods procured from a previous R&E project were not large enough to withstand the high water conditions seen in 2008. To avoid this problem in the future, five new larger metal tripods will be constructed similar to those used by B. Mercer & Associates in drainages on the Taku River system in Northern B.C. The tripods will be constructed and transported to the site along with necessary replacement weir panels.

Recommendations:

It is recommended for the 2009 sonar project that:

1. Larger metal tripods be used for the weir construction.
2. Refinements be considered for GIS sample collection.

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ACKNOWLEDGEMENTS

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Appendix 1. 2008 Big Salmon River water and weather conditions.

Date	Time	Air Temp.	Water Temp.	Water Level	Comments
16-Jul	8:30 AM	8.0		134	Steady rain on the night of the 14th river up from 45 cm. Sunny weather today
17-Jul	8:00 AM	13.0	8.0	122	Clear and Sunny, clouding over late evening, light showers at night
18-Jul	8:30 AM	14.0	9.5	112	Overcast, with occasional showers
19-Jul	9:00 AM	12.0	9.0	106	Overcast, with wind and showers heavy at times
20-Jul	9:00 AM	10.0	8.5	105	Cloudy with occasional showers and sunny breaks, light rain at night
21-Jul	9:00 AM	11.0	8.0	100	Cloudy with light rain, partial clearing in the afternoon
22-Jul	9:30 AM	13.0	8.0	106	Overcast,clearing overnight
23-Jul	9:20 AM	12.0	7.5	99	Clear in early morning becoming overcast, clearing again in the late evening
24-Jul	9:00 AM	9.0	6.5	93	Clear overnight but high cloud cover in morning,developing into light rain overnight
25-Jul	9:00 AM	12.0	8.0	90	Partial clearing in morning with fog, light rain at night
26-Jul	9:30 AM	13.0	9.0	88	Overcast, but clearing later in the day
27-Jul	9:00 AM	10.0	9.0	86	High overcast clearing to mostly sunny
28-Jul	9:05 AM	10.0	8.5	82	Clear and Sunny
29-Jul	9:10 AM	12.0	8.5	77	Overcast, clearing in the late evening. Staff guage reset, prior readings adjusted
30-Jul	9:00 AM	10.0	8.5	71	Clear in early morning, light rain developing in afternoon. Rain heavy at times all night
31-Jul	9:00 AM	10.0	8.5	71	Rain clearing in early morning, around 7,developing again in early evening
01-Aug	9:30 AM	12.0	9.0	80	Light rain previous night, clearing in morning to a sunny day
02-Aug	9:00 AM	12.0	9.0	84	Overcast, clearing around 10 AM to a sunny warm day
03-Aug	9:00 AM	13.0	9.5	76	Sunny with cloudy periods and a spot of rain
04-Aug	9:00 AM	11.0	9.0	70	Mostly sunny
05-Aug	9:00 AM	10.0	9.5	66	Mostly sunny
06-Aug	9:30 AM	14.0	10.5	62	Overcast, with occasional showers
07-Aug	9:00 AM	13.0	10.5	59	Overcast
08-Aug	9:10 AM	14.0	10.5	57	Sun and cloud mixed
09-Aug	9:05 AM	11.0	10.0	66	Mostly cloudy with thundershowers, clearing in the evening
10-Aug	9:00 AM	6.0	9.0	67	Foggy, clearing to a mostly sunny day
11-Aug	9:00 AM	7.0	9.0	64	Clear and sunny
12-Aug	9:00 AM	10.0	9.5	57	Overcast with showers
13-Aug	11:00AM	17.0	9.5	53	Cloudy with sunny breaks and moderate wind
14-Aug	9:10 AM	13.0	9.5	52	Cloudy with sunny breaks and moderate wind
15-Aug	9:30 AM	12.0	9.0	50	Cloudy with sunny breaks
16-Aug	9:00 AM	8.0	8.5	48	Sunny, clouding over to thundershower in evening
17-Aug	10:00 AM	12.0	9.0	45	Overcast with showers, clearing in late afternoon, steady rain at night
18-Aug	9:15 AM	10.0	9.0	51	Overcast with showers
19-Aug	9:20AM	7.0	8.5	73	Mostly clear with hazy overcast
20-Aug	9:00 AM	10.0	8.5	62	Cloudy
21-Aug	9:20AM	10.0	8.5	54	Cloudy with light rain
22-Aug	9:20 AM	12.0	8.5	54	Cloudy with showers
23-Aug	9:10 AM	11.0	8.5	56	Sun and cloud mixed light rain at night
24-Aug	9:45 AM	11.0	9.0	57	Overcast; Bob and Marcus leave upriver for dead pitch
25-Aug	9:30 AM	9.0	8.5	78	Raining steady since 1PM yesterday, no breaks

Appendix 2. 2008 Big Salmon River Chinook salmon carcass pitch sampling results.

DATE	FISH #	SEX	MEF (mm)	POHL (mm)	AGE*	Code
23-Aug	1	M	747	675	M4	RG
24-Aug	2	M	835	740	14	
24-Aug	3	M	869	748	14	
24-Aug	4	M	749	665	14	
24-Aug	5	F	797	707	14	
24-Aug	6	M	668	573	13	
24-Aug	7	M	728	624	M3	RG
24-Aug	8	F	838	756	14	
24-Aug	9	M	842	743	14	
24-Aug	10	F	855	765	M4	RG
24-Aug	11	F	830	752	14	
24-Aug	12	F	859	780	14	
24-Aug	13	F	845	743	15	

* European age
Code: RG – regenerate scale (centre is missing from scale)

Appendix 3. Daily and average Chinook salmon counts in the Big Salmon River, 2005-2008.

DATE	Daily Count 2005	Daily Count 2006	Daily Count 2007	Daily Count 2008	Daily Average
13-Jul	0				**0**
14-Jul	0				**0**
15-Jul	2	1			**2**
16-Jul	12	0	2	0	**4**
17-Jul	13	1	0	0	**4**
18-Jul	23	0	2	0	**6**
19-Jul	13	0	5	1	**5**
20-Jul	23	1	5	0	**7**
21-Jul	36	3	7	0	**12**
22-Jul	58	8	11	0	**19**
23-Jul	92	11	18	1	**31**
24-Jul	130	21	26	2	**45**
25-Jul	158	20	52	1	**58**
26-Jul	204	53	88	3	**87**
27-Jul	219	95	153	5	**118**
28-Jul	287	146	237	9	**170**
29-Jul	290	230	287	9	**204**
30-Jul	299	321	337	29	**247**
31-Jul	279	368	400	21	**267**
01-Aug	333	357	435	23	**287**
02-Aug	346	379	331	18	**269**
03-Aug	303	358	304	16	**245**
04-Aug	292	413	258	31	**249**
05-Aug	331	496	210	51	**272**
06-Aug	214	490	178	55	**234**
07-Aug	188	464	147	78	**219**
08-Aug	232	464	59	61	**204**
09-Aug	234	360	74	70	**185**
10-Aug	203	349	90	98	**185**
11-Aug	124	348	82	122	**169**
12-Aug	126	324	98	107	**164**
13-Aug	125	243	77	109	**139**
14-Aug	72	196	74	89	**108**
15-Aug	57	180	66	78	**95**
16-Aug	40	172	56	70	**85**
17-Aug	53	104	40	49	**62**
18-Aug	47	69	64	45	**56**
19-Aug	35	87	37	17	**44**
20-Aug	29	59	47	18	**38**
21-Aug	26	45	11	15	**24**
22-Aug	19	50	16	16	**25**
23-Aug	17	12	23	9	**15**
24-Aug	13	10	17	2	**11**
25-Aug	9		14	1	**8**
26-Aug	6		14		**10**
27-Aug	4		13		**9**
28-Aug	2		11		**7**
29-Aug			9		**9**
30-Aug			8		**8**
31-Aug			6		**6**
01-Sep			4		**4**
02-Sep			3		**3**
TOTAL:	**5618**	**7308**	**4506**	**1329**	**4690**

Note: shaded areas denote sonar operation start and end date – values in dotted areas were obtained through extrapolation of counts