2012 CHINOOK SALMON SONAR ENUMERATION ON THE BIG SALMON RIVER

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Prepared for: The Yukon River Panel
Restoration and Enhancement Fund

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ABSTRACT

A long range dual frequency identification sonar (DIDSON) was used to enumerate the Chinook salmon (*Onchorynchus tshawytscha)* escapement to the Big Salmon River in 2012. The sonar was operated on the Big Salmon River for its eighth year at the same site used for the 2005 to 2011 projects; approximately 1.5 km upstream of the confluence of the Yukon River. The camp and sonar station set-up was initiated on July 14. Sonar operation began on July 18 and operated continuously through to August 24. A total of 2,553 targets identified as Chinook salmon was counted during the period of operation. Extrapolation of the final 6 days of the run yielded an additional 41 fish to bring the total estimated escapement to 2,594. The 2012 sonar count was the second lowest observed over the eight year duration of the project. GSI stock composition estimates indicated the Big Salmon River escapement represented 6.7 % of the upper Yukon River preliminary Eagle sonar spawning escapement estimate of 32,658. The first Chinook salmon passing the Big Salmon sonar station was observed on July 25. The peak daily count of 235 fish occurred on August 8, at which time 50% of the run had passed the sonar station; 90% of the run had passed the station on August 17. The peak of the run was approximately 7 days later than average which was consistent with run timing observed at other escapement monitoring projects on the upper Yukon drainage. A carcass pitch was conducted over approximately 145 km of the Big Salmon River, yielding 47 sampled Chinook. Of these, 27 (57.4%) were female and 20 (42.6%) were male. The mean fork length of females and males sampled was 840.9 mm and 795.8 mm, respectively. The DFO scale lab determined ages from 40 Chinook sampled. Age-6 (80%) was the dominant age class, followed by age-5 fish (20%).

INTRODUCTION

A project to enumerate the Chinook salmon escapement into the Big Salmon River drainage was initiated in 2005 using a DIDSON™ (Dual frequency Identification SONAR). The 2012 project is the eighth year Chinook enumeration has been conducted on this system. The DIDSON units have been found to be reliable, do not require extensive operator training, and provide accurate counts of migrating salmon (Enzhofer et al. 2010, Holmes et al. 2006, Mercer & Wilson 2006 - 2012). Due to high flows and wilderness recreation use of the Big Salmon River, the utilization of traditional salmon weir techniques on this river is not feasible. For these reasons the DIDSON sonar was selected as a relatively low impact, non-intrusive method of accurately 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.

Based on the 2005 – 2012 sonar operations, the Big Salmon River has been shown to be a significant contributor to upper Yukon River Chinook production. The 2005 -2011 average sonar count is 5,285 with a range from 1,329 (2008) to 9,261 (2009). These counts represented an average of 11.5% of the total upper Yukon River spawning escapement point estimate for these years (JTC 2012 and unpublished DFO data).

The goal of the program is to provide stock assessment information that will enhance the ability of salmon management agencies to manage Yukon River Chinook salmon. Quantifying Chinook escapement into upper Yukon River index streams allows for independent (from Pilot station and Eagle sonar project estimates) assessment of total above border Chinook escapements. Accurate Chinook escapement enumeration of select tributaries combined with stock composition information could generate upper Yukon River Chinook spawning escapement estimates within quantified statistical parameters.

In addition to the sonar operation, carcass sampling was conducted to obtain age, sex and length data from the 2012 Big Salmon Chinook escapement. This information provides important biological baseline data on the health of the stocks as well as information used in constructing future pre-season run forecasts.

A proposal to continue sonar operations and a Chinook dead pitch on the Big Salmon River was submitted by J. Wilson and Associates to the Yukon River Panel Restoration and Enhancement (R&E) fund in January 2012. The proposal was accepted and financial support was received from the R&E fund. This report is a summary of the 2012 project.

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 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. The sonar site is approximately 130 air kilometers from Whitehorse.

Objectives

The objectives of the 2012 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 high resolution DIDSON 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 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 characteristics of the river at this site have not changed over the 8 years of sonar operation. It is anticipated that this site will continue be used as long as the sonar program operates.

Permits

A five year licence of occupation (with option of renewal) was granted in 2009 by the Yukon Territorial Government (YTG) Lands Branch for the sonar camp on the lower Big Salmon River. This precluded the requirement of annual land use permits and allowed for the construction of upgraded and more permanent facilities at this site.

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

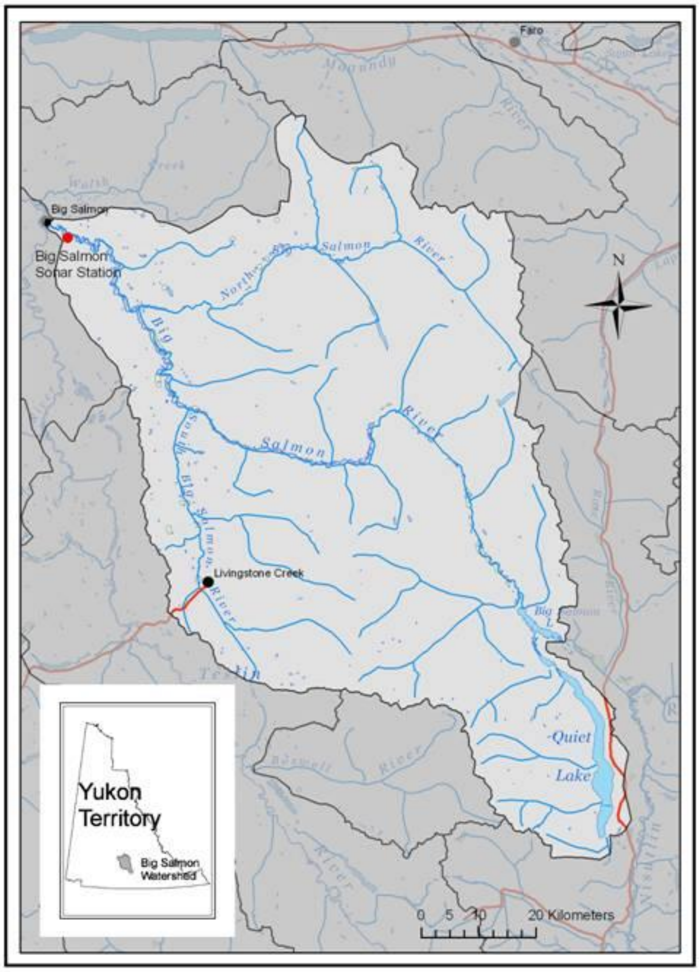

Figure 1. Big Salmon River Watershed and location of the 2012 Big Salmon sonar station.

Camp and Sonar Station Set-up

Construction of the camp and sonar station was initiated on July 14. Equipment and supplies were transported by truck from Whitehorse and loaded onto a boat and floatplane at Little Salmon Village for transport to the site. Subsequent camp access, crew changes, and delivery of supplies were accomplished either by riverboat or floatplane.

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 30 m from the south bank and constructed using a 14’ X 16’ canvas wall tent placed on a plywood platform and wooden frame (Figure 2).

In 2010, construction of a cabin was initiated at the sonar site to replace the wall tents. The cabin was clad to weather at the end of the 2011 season which enabled secure storage of some camp equipment on site. Cabin construction continued during the 2012 season and is expected to be completed and usable by personnel during the 2013 season.

Weir construction

At the onset of the project, fence structures are placed in the river to divert shoreline migrating Chinook salmon into a 36 m migration corridor in the center of the river (Figure 2). The start of the project, however, was marked by record high water levels on the Yukon and Big Salmon rivers which delayed the placement of partial fence structures on either side of the river. After water levels had lowered sufficiently, construction of the fence extending from the north bank was started on July 25 but could not be completed until July 30 when the water levels receded enough to allow final placement of the fence. The fence structure extending from the south bank in deeper water was completed on August 1. Fence structures were constructed as in previous years using conduit panels and metal tripods stored on site (Figure 3).

Figure 2. Aerial view of sonar station camp and partial weirs, (photo from 2006 project).
Blue outline denotes ensonified portion of the river.

Sonar and Computer Software Configuration

Due to the high water conditions at the start of the season, the sonar stand used in previous years was not usable and a different stand was fabricated to allow the sonar unit to be operated in the deeper water. This stand consisted of two 2-inch steel galvanized pipe connected by an adjustable crossbar. The sonar unit was bolted to a steel plate suspended from the cross bar that

Figure 3. Construction of partial weir on south side of river. (Photo 2011)

was connected to the stand with adjustable fittings (Kee Klamps™). The entire stand was secured to the bank by 2 steel pipes running to the bank and secured with rebar driven into the ground (Figure 4). The sonar unit was placed next to the south bank at the site used in previous sonar operations (Figure 5).

A concentrator lens has been attached to the sonar unit during its operation since 2009. This lens reduces the vertical ensonified field from 14° to 8°, increasing the resolution of all target images. However, due to the high water levels at the beginning of this season and required depth of the ensonified water column, the concentrator lens was not applied until July 24 when water levels had lowered sufficiently to enable complete ensonification of the water column.
The DIDSON sonar produces an ensonified field 29° wide in the horizontal plane and with the concentrator lens, 8° deep in the vertical plane. The DIDSON 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 the surface of the river (Figure 6).

Due to the high water levels encountered during portions of the 2012 project it was necessary to tilt the sonar unit on the horizontal plane to ensure the entire near shore water column was ensonified. Using an 8° lens on a sonar unit deployed horizontally results in a beam depth of 1.05 m at a distance of 7.5 m from the sonar. Since the water depth at a distance of 7.5 m from the sonar unit reached a maximum of 1.5 m, it was necessary during certain periods of the project to tilt the sonar to increase the depth of the ensonified vertical plane. A table was prepared using simple trigonometry formulae to enable the sonar operators to determine the sonar tilt requirements for given water depths and sonar window start lengths (Appendix 2). The maximum tilt of the sonar did not exceed 10° from horizontal.

Once the sonar was in place and positioned, the primary sonar unit settings and software were configured. 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. 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 laptop computers were used for the project, one recording the DIDSON files and one for reviewing the files. All files were saved and placed on a backup 500 GB external hard drive.

Figure 4. Fabricated sonar stand used in high water.

Figure 5. Sonar transducer unit and mounting stand in position. (Photo 2011)

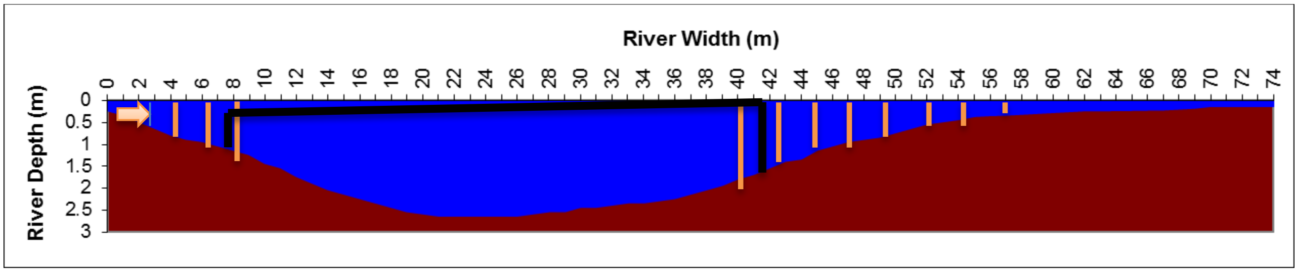

Figure 6. Schematic diagram of river cross section profile and sonar and weir configuration. Orange bars denote weir structures, arrow the sonar and the area outlined in black the ensonified portion of the water column. Note: Not to scale.

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 six 80 watt solar panels and a backup 2.0 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 allowed the panels to be manually rotated to directly face the sun thereby increasing the efficiency of the solar panel array.

Sonar Data Collection

Sonar recording began on July18 and continued until August 24. Sonar data was collected continuously and stored automatically in pre-programmed, 20 minute date stamped files. This resulted in an accumulation of 72 files over a 24 hour period. These files were subsequently reviewed the following day and stored on the active PC as well as backed up on the external hard drive.

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 40 and 50 frames per second, approximately 8 to 10 times the recording rate. When necessary, the recording was stopped when a fish was observed and replayed at a slower rate for positive identification. Chinook salmon images were visually counted using a hand counter and the total count from each file was entered into an excel spreadsheet. A record of each 20 minute file count as well as hourly, daily and cumulative counts was maintained throughout the run.

The target measurement feature of the DIDSON software was used when required to estimate the size of the observed fish. All fish 50 cm and larger were categorized as Chinook. The smallest sampled Big Salmon Chinook during the 2011 dead pitch was 52 cm. The largest target categorized as a resident fish based on size and swimming behaviour was approximately 30 cm.

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 number of assumed strays detected is typically low and in 2012 amounted to 74 or 2.9% of the total run.

[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.

Cross Section Distribution

The position of each Chinook observed within the cross section profile of the river was recorded in 5 m increments. This provided a range frequency histogram illustrating the cross sectional pattern of migrating Chinook.

Carcass Pitch

The upper reaches of the Big Salmon River were accessed using a 6.0 m open skiff powered by a 60 hp outboard jet motor. The crew made one extended trip upriver on August 24 through 26 searching for dead and moribund Chinook. Carcass pitch efforts extended from the camp approximately 145 river kilometers to the first logjam located 20 km downstream from Big Salmon Lake.

The carcass pitch involved collecting dead and moribund Chinook using a spear and sampling each fish. Carcass sampling consisted of collecting five scales per fish and placing them in prescribed scale cards. The sex and mid-eye-fork and post-orbital hypural lengths (to the nearest 0.5cm) were also recorded for each recovered fish.

RESULTS

Chinook Salmon Counts

The first Chinook salmon was observed on July 25 at16:40. The peak passage was on August 8, and 90% of the run had passed the station on August 17. Daily and cumulative counts are presented in Appendix 1 and Figure 7. A total of 2,553 targets identified as Chinook salmon was counted past the sonar station from July 18 through to August 24. Because the sonar was removed before the run was totally complete, the counts were estimated for an additional 7 days through extrapolation of the last 7 days of the sonar counts based on the polynomial regression $y = 0.5678x^2 - 13.811x + 87.503$. This added 41 fish to bring the total count to 2,594.

The start of the run on July 25 was 6 days prior to the final installment of both deflection weirs. Comparison of the slopes of the first 7 days of sonar counts in 2012 and the average of 2005 – 2011 indicates no statistical difference between them. Therefore, while it is probable that a few Chinook migrated outside of the ensonified range of the sonar during the first 6 days of operation, it is not possible to quantify the number. Given that the total count for this period was only 56 fish and approximately 75% of the water column was ensonified it is likely the number of missed fish was low.

The daily counts exhibited a normal distribution. The run timing was approximately 7 days later than average run timing observed in the previous 7 years. Daily counts from 2005 through 2012 are in Appendix 5.

Cross Section Distribution

The cross sectional distribution pattern of the migrating Chinook as detected by the sonar is presented in Figure 8. The largest proportion of fish migrated near the south bank in deeper water at a distance of 10-20 meters from the sonar. The distribution of migrating Chinook in 2012 was similar to 2011 but unlike the 2010 distribution where the majority of fish moved through the centre of the river 20-30 meters from the sonar. This was likely due to the lower water conditions in 2010. It should be noted the distribution likely does not reflect the typical in-river migration pattern as the weir structures channel the fish into the 36 m wide opening.

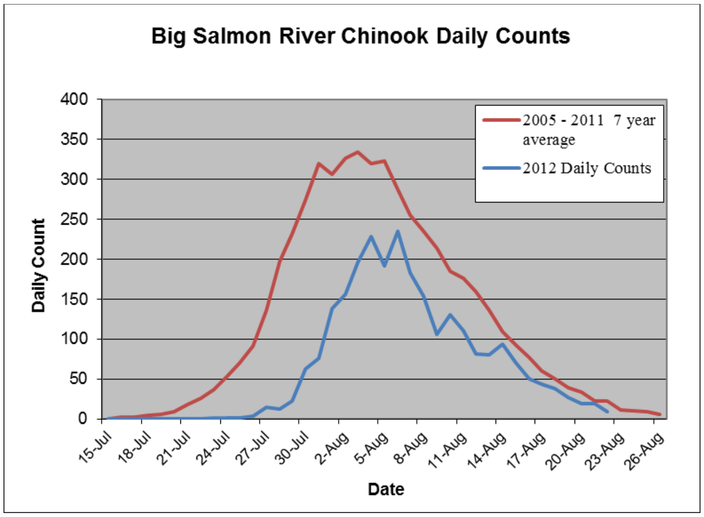

Figure 7. Daily counts of Chinook salmon passing the Big Salmon River sonar station in 2005 through 2012.

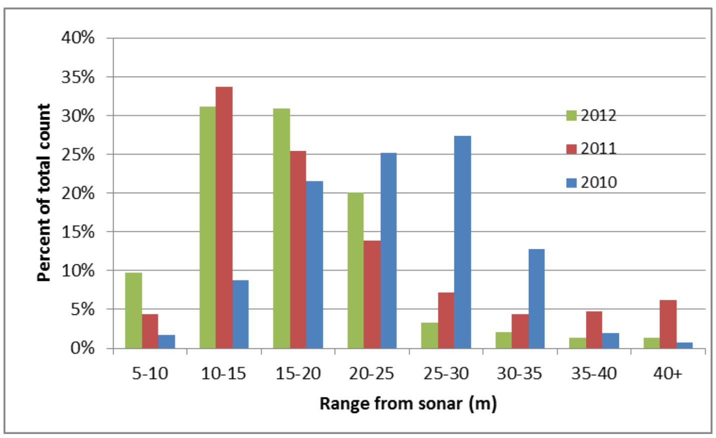

Figure 8. 2010 - 2012 Big Salmon River Chinook range/frequency in cross section profile.

Above border Chinook spawning escapement estimates

The 2012 Eagle sonar project on the Yukon River downstream of the Canada/U.S. border yielded a spawning escapement[2] estimate of 32,658 Chinook salmon (DFO Whitehorse unpublished data 2012). Genetic stock identification (GSI) samples were also obtained at this site using drift nets. The GSI data provides information on the stock composition of the total above border Chinook escapement. The 2012 mean un-weighted proportional contribution of the Big Salmon River stock to the Chinook border escapement based on analysis of the GSI samples was 6.7%, SD 2.8

[2] Spawning escapement is the Eagle sonar count minus the catches in the U.S. above the sonar station and in the Canadian fisheries.

(DFO Whitehorse unpublished data). Using Big Salmon sonar counts and the proportion of Big Salmon origin stock derived from the GSI sampling, the 2012 expanded Chinook border escapement estimate would be 38,104 (95% CI: 20,926 – 210,991). The 2012 Big Salmon Chinook contribution to the above border Chinook escapement based on GSI sampling is within the range predicted by the Eagle sonar count. However, given the low stock proportion (6.7%) and relatively large SD, the expanded escapement estimate has limited value for stock assessment purposes.

Table 1. Estimated proportion of Big Salmon River Chinook and Yukon River Chinook border escapement, 2002 through 2012.

Year	Method	Estimated % proportion of border escapement based on telemetry or GSI sampling	Big Salmon sonar count	Escapement based on Eagle sonar count or mark/recapture	Escapement based on Big Salmon sonar count and GSI stock proportion
2002	Telemetry	9.2	n/a	n/a	n/a
2003	Telemetry	15.1	n/a	n/a	n/a
2004	Telemetry	10.0	n/a	n/a	n/a
2005	Fishwheel GSI Sampling	10.8	5,618	67,985 [c]	52,019
2006	Fishwheel GSI Sampling	9.7	7,308	62,630 [c]	75,340
2007	Fishwheel GSI Sampling	10.6	4,506	34,904 [b]	42,509
2008	Fishwheel GSI Sampling	9.3	1,431	33,883 [b]	15,387
2009	Gillnet GSI Sampling	16.9	9,261	65,278 [b]	54,799
2010	Gillnet GSI Sampling	11.7	3,817	32,010 [b]	32,624
2011	Gillnet GSI Sampling	9.2	5,156	50,780 [a]	56,043
2012	Gillnet GSI Sampling	6.7	2,594	32,658 [a]	38,104
Mean		10.8	5,282	49,781	45,853
Std. Dev.		2.9	2,319	14,776	17,991

[a] Preliminary Eagle sonar above border spawning escapement estimate (DFO Whitehorse, unpublished data).
[b] Eagle sonar estimate (JTC 2012 preliminary).
[c] Mark/recapture estimate (JTC 2012 preliminary).
Sources: Osborne et al. 2003; Mercer and Eiler 2004; Mercer 2005; JTC reports 2005 through 2010; unpublished DFO Whitehorse data.

Carcass Pitch

A total of 47 dead or moribund Chinook was recovered during the carcass pitch. Of the fish sampled, 27 (57.4%) were female and 20 (42.6%) were male. Mean length at age data for male and female Chinook sampled is presented in Table 2. The mean mid-eye fork length of females and males sampled was 841 mm and 792 mm, respectively. The length frequency of Chinook sampled is presented in Figure 9. Complete age data[3] was determined from 45 of the Chinook sampled; the remaining 2 samples yielded partial ages or no ages due to regenerate scales. Age-

[3] Scale age analysis was conducted for DFO Whitehorse by the Pacific Biological Station, fish ageing lab in Nanaimo, British Columbia.

6 (1.4) [4] was the predominant age class comprising 83% of the sample, followed by age-5 (1.3) fish (17%). Complete age, length and sex data is presented in Appendix 4.

Table 2. Age, length, and sex of Chinook sampled from the Big Salmon River, 2012.

SEX	Age	Data	Total	%
Female	1.3	Average of MEF (mm)	775	
		Count of AGE *	1	2%
	1.4	Average of MEF (mm)	844	
		Count of AGE *	25	56%
F Average of MEF (mm)			841	
F Count of AGE *			26	58%
Male	1.3	Average of MEF (mm)	713	
		Count of AGE *	7	16%
	1.4	Average of MEF (mm)	839	
		Count of AGE *	12	27%
M Average of MEF (mm)			792	
M Count of AGE *			19	42%
Total Average of MEF (mm)			821	
Total Count of AGE *			45	1

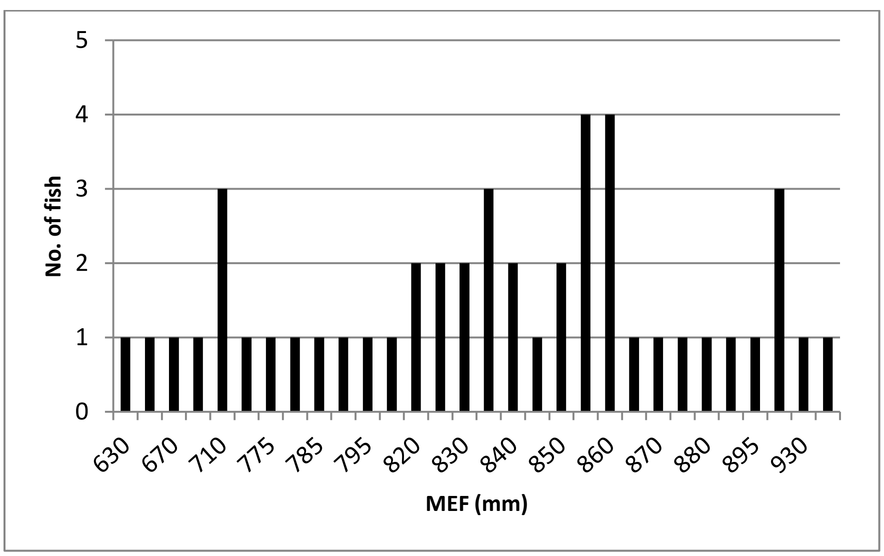

Figure 9. Length/frequency histogram of Big Salmon Chinook sampled in 2012.

[4] European age format; e.g. 1.3 denotes a 5 year old fish with 1+ years freshwater residence and 3 years marine residence.

DISCUSSION

Water levels were very high during the initial phase of the project. July 2012 hydrometric data from a station on the Yukon River, 150 km downstream from the mouth of the Big Salmon, indicated flows were at record levels for that month. The peak discharge at this station in July 2012 was 4,110 m^3/s, the highest recorded in the previous 63 years. The average 2012 July discharge was 3,480 m^3/s, 43% higher than the 63 year mean of 2,420 m^3/s (Water survey of Canada; Wade Hanna per. comm.).

The 2002 through 2004 Yukon River telemetry program yielded stock proportions of Chinook in upper Yukon River tributaries based on observed radio tag distributions. It should be noted that the inter-annual variance[5] of the relative stock proportions within all the larger tributaries was low and consistent over the 3 years of the telemetry program (J. Eiler per. Comm.). The telemetry derived stock proportions for Blind Creek and the Big Salmon and Teslin Rivers are presented in Appendix 6. Using the combined 2012 counts (6,186) from these three projects and the mean sum of the telemetry derived stock proportions (32.8%, SD 1.6) yields a 2012 upper Yukon Chinook escapement estimate of 18,860 (95% CI 17,231- 20,899). This estimate is significantly below the 32,656 escapement estimate derived from the Eagle sonar count.

As occurred in previous years and evidenced by the 2005 – 2011 mean daily counts, the daily sonar counts in 2012 exhibited a normal distribution (Figure 7). This suggests the probability is low that other co-migrating fish species misidentified as Chinook are present in the system when the sonar is in operation. Resident fish species (as well as other aquatic organisms such as waterfowl and beaver) are readily distinguished from migrating Chinook based on size, form, and behaviour. Due to similar migratory behaviour and size overlap with smaller Chinook, the only likely species that could be confused with Chinook are Chum salmon. The presence of co-migrating fall Chum salmon entering the system at the end of the Chinook migration period would be problematic and would decrease the accuracy of the Chinook escapement estimate. However, the presence of Chum salmon has not been documented in the Big Salmon system (DFO Whitehorse FISS database) and none have been observed during the eight years of carcass recovery. Test fishing at the Eagle sonar station from 2007 through 2009 captured the first Chum Salmon on August 8, 9, and 19 respectively (Crane and Dunbar, 2009 and 2011). The first Chum salmon counted in 2012 at the Eagle sonar sites was on August 23 (JTC 2012 *in prep.* preliminary data). The river distance from Eagle Alaska to the Big Salmon sonar site is approximately 700 km. Mean migration rates for upper Yukon River fall Chum have been documented at approximately 40 km/day (Boyce 1999). This suggests the Teslin Chinook migration would have been complete before the arrival of fall Chum in the system.

If sampling is not done throughout the die off period the samples collected may not be representative of the population structure. Efforts were made to obtain ASL samples representative of the total escapement but it is not known if the samples collected were representative of the aggregate escapement. The planning for the first carcass recovery trip in

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[5]Between-year differences observed during 2002-2004 were analyzed using a multivariate test for proportions. No significant differences were detected within the groups (SSB = 0.0048, p = 0.80), suggesting that the stock compositions were comparable during the three years of the study. A similar pattern occurred within regional areas, with equivalent composition estimates observed for most of the larger individual stocks. Only the Little Salmon River showed significant inter-annual differences based on 95% confidence intervals, with a higher proportion of the return to this tributary in 2003 than in the other two years of the study. It should also be noted that 95% of the radio tagged fish tracked into the upper Yukon system were accounted for either in fisheries or in terminal areas.

2012 was based on run timing in 2012 and previous years. Each carcass recovery effort involves a 3-4 day, 240 km round trip. For reasons of economy, efficient use of personnel, and to maximize the number of samples obtained, the carcass sampling is timed to coincide with the period of maximum die off. The number of samples collected in 2012 was lower than expected as a result of the below average escapement and possibly a shift to a later die off period as a result of the delayed run timing.

The Big Salmon program has been ongoing for eight consecutive years. There is value in maintaining an upper Yukon Chinook escapement monitoring project that provides accurate data over a long time series. The Big Salmon sonar project should continue because:

- It has proven to be a viable and consistent means of obtaining accurate escapement counts as well as age, sex and length data of Chinook salmon returning to the Big Salmon River.
- The Big Salmon stock comprises on average 11% of the total upper Yukon Chinook escapement; the fourth highest stock composition behind the Yukon Mainstem, the Pelly and the Teslin systems.
- The Big Salmon stock is discrete and separates out relatively well within the upper Yukon Chinook GSI database.
- There is now one full generation of escapement data for the Big Salmon stock. Continuation of the project will provide ensuing recruitment information on those escapements. The development of biologically based escapement goals is typically based on stock recruitment modelling. These models are based on escapement estimates incorporating a long time series.
- Big Salmon escapement information coupled with stock composition data can provide an independent annual estimate of the total above border Chinook spawning escapement.

ACKNOWLEDGEMENTS

Several people contributed to the 2012 Big Salmon River sonar project. Bob Gransden, Sandy Johnston, Al Macleod and John Bylenga worked as technicians on the project. Bob Gransden and John Bylenga played an especially valuable role during camp and cabin construction and demobilization and freighting of materials. The carcass pitch was ably conducted by David McDonald and Bob Gransden.

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Appendix 1. 2012 daily and cumulative counts of Chinook salmon at the Big Salmon River sonar site.

DATE	DAILY COUNT	CUMULATIVE	SONAR OPERATION TIME/COMMENTS
July 18	0	0	start sonar 20:40
July 19	0	0	
July 20	0	0	
July 21	0	0	
July 22	0	0	
July 23	0	0	
July 24	0	0	
July 25	1	1	first fish @ 16:40
July 26	1	2	
July 27	1	3	
July 28	3	6	
July 29	15	21	
July 30	12	33	
July 31	23	56	far weir in
Aug 1	62	118	near weir in
Aug 2	76	194	
Aug 3	138	332	
Aug 4	156	488	
Aug 5	196	684	
Aug 6	228	912	
Aug 7	192	1104	
Aug 8	235	1339	
Aug 9	183	1522	
Aug 10	154	1676	
Aug 11	106	1782	
Aug 12	130	1912	
Aug 13	110	2022	
Aug 14	81	2103	
Aug 15	80	2183	
Aug 16	94	2277	
Aug 17	70	2347	
Aug 18	50	2397	
Aug 19	44	2441	
Aug 20	38	2479	
Aug 21	27	2506	
Aug 22	19	2525	
Aug 23	19	2544	
Aug 24	9	2553	sonar pulled 8:00

Appendix 2. Sonar beam depth at tilt angles 0° – 45° and with start window lengths 6.67m and 7.5m.

8 Degree Lens								
Horizontal Beam			6.67 m start window			7.5 m start window		
Distance From Sonar (m)	Depth of Beam (m)	Width of Beam (m)	Tilt Degree @ 6.67m from sonar	Depth Added (m)	TOTAL DEPTH @ 6.67m (m)	Tilt Degree @ 7.5m from sonar	Depth Added (m)	TOTAL DEPTH @ 7.5m (m)
2.00	0.28	1.03	1.00	0.06	0.99	1.00	0.07	1.00
3.00	0.42	1.55	2.00	0.12	1.05	2.00	0.14	1.07
4.00	0.56	2.07	3.00	0.18	1.11	3.00	0.20	1.13
5.00	0.70	2.59	4.00	0.24	1.17	4.00	0.27	1.20
6.00	0.84	3.10	5.00	0.30	1.23	5.00	0.34	1.27
6.67	0.93	3.45	6.00	0.36	1.29	6.00	0.41	1.34
7.00	0.98	3.62	7.00	0.42	1.35	7.00	0.48	1.41
7.50	1.05	3.88	8.00	0.48	1.41	8.00	0.55	1.48
8.00	1.12	4.14	9.00	0.55	1.48	9.00	0.61	1.54
9.00	1.26	4.66	10.00	0.61	1.54	10.00	0.68	1.61
10.00	1.40	5.17	11.00	0.67	1.60	11.00	0.75	1.68
11.00	1.54	5.69	12.00	0.73	1.66	12.00	0.82	1.75
12.00	1.68	6.21	13.00	0.80	1.73	13.00	0.90	1.83
13.00	1.82	6.72	14.00	0.86	1.79	14.00	0.97	1.90
14.00	1.96	7.24	15.00	0.92	1.85	15.00	1.04	1.97
15.00	2.10	7.76	16.00	0.99	1.92	16.00	1.11	2.04
16.00	2.24	8.28	17.00	1.05	1.98	17.00	1.19	2.12
17.00	2.38	8.79	18.00	1.12	2.05	18.00	1.26	2.19
18.00	2.52	9.31	19.00	1.19	2.12	19.00	1.34	2.27
19.00	2.66	9.83	20.00	1.26	2.19	20.00	1.41	2.34
20.00	2.80	10.34	21.00	1.32	2.25	21.00	1.49	2.42
21.00	2.94	10.86	22.00	1.39	2.32	22.00	1.57	2.50
22.00	3.08	11.38	23.00	1.46	2.39	23.00	1.65	2.58
23.00	3.22	11.90	24.00	1.54	2.47	24.00	1.73	2.66
24.00	3.36	12.41	25.00	1.61	2.54	25.00	1.81	2.74
25.00	3.50	12.93	26.00	1.68	2.61	26.00	1.89	2.82
26.00	3.64	13.45	27.00	1.76	2.69	27.00	1.98	2.91
27.00	3.78	13.97	28.00	1.83	2.76	28.00	2.06	2.99
28.00	3.92	14.48	29.00	1.91	2.84	29.00	2.15	3.08
29.00	4.06	15.00	30.00	1.99	2.92	30.00	2.24	3.17
30.00	4.20	15.52	31.00	2.07	3.00	31.00	2.33	3.26
31.00	4.34	16.03	32.00	2.16	3.09	32.00	2.42	3.35
32.00	4.48	16.55	33.00	2.24	3.17	33.00	2.52	3.45
33.00	4.62	17.07	34.00	2.33	3.26	34.00	2.62	3.55
34.00	4.76	17.59	35.00	2.42	3.35	35.00	2.72	3.65
35.00	4.89	18.10	36.00	2.51	3.44	36.00	2.82	3.75
36.00	5.03	18.62	37.00	2.60	3.53	37.00	2.92	3.85
37.00	5.17	19.14	38.00	2.70	3.63	38.00	3.03	3.96
38.00	5.31	19.65	39.00	2.79	3.72	39.00	3.14	4.07
39.00	5.45	20.17	40.00	2.89	3.82	40.00	3.26	4.19
40.00	5.59	20.69	41.00	3.00	3.93	41.00	3.37	4.30
41.00	5.73	21.21	42.00	3.11	4.04	42.00	3.49	4.42
42.00	5.87	21.72	43.00	3.22	4.15	43.00	3.62	4.55
43.00	6.01	22.24	44.00	3.33	4.26	44.00	3.75	4.68
44.00	6.15	22.76	45.00	3.45	4.38	45.00	3.88	4.81
45.00	6.29	23.28						

Appendix 3. 2012 Big Salmon River water and weather conditions.

DATE	TIME	AIR TEMP. (ºC)	WATER TEMP. (ºC)	WATER LEVEL (cm)	COMMENTS
16-Jul				113	
17-Jul				120	rain
18-Jul	8:00 AM	7.0		134	cloudy showers clearing later in day
19-Jul	8:00 AM	8.0	9.5	130	mostly sunny, with haze in morning
20-Jul	8:00 AM	6.0	10.0	115	sunny with some clouds and wind in evening
21-Jul	7:50 AM	8.0	11.0	106	sunny, hot 25 in the shade
22-Jul	8:00 AM	8.0	11.5	102	sunny
23-Jul	8:00AM	7.0	12.5	97	mostly cloudy, thunder and showers at night
24-Jul	8:05AM	9.0	12.0	92	Mostly cloudy with sunny breaks, light rain at night
25-Jul	8:05AM	13.0	12.0	89	Cloudy in morning clearing by evening
26-Jul	7:57 AM	2.0	11.0	86	Sunny
27-Jul	8:00 AM	5.0	12.0	81	Cloudy with sunny breaks, thunder showers in evening
28-Jul	8:00 AM	12.0	12.0	79	Clouds clearing early in morning to mostly sunny day
29-Jul	7:55 AM	8.0	11.5	79	Sunny
30-Jul	8:10 AM	13.0	11.5	73	mostly sunny, with haze in morning
31-Jul	8:01 AM	8.0	11.0	67	mix of sun and cloud, clearing in evening
01-Aug	8:00 AM	4.0	10.0	63	Sunshine
02-Aug	8:05 AM	11.0	10.5	59	Overcast, no rain
03-Aug	7:55 AM	7.0	10.0	55	Overcast, light showers all day
04-Aug	8:00 AM	4.0	9.0	53	Foggy morning, sunny, clouding in evening
05-Aug	8:02 AM	4.0	9.5	50	Cloudy with showers
06-Aug	8:00 AM	8.0	9.5	47	mix of sun and cloud, clearing in evening
07-Aug	8:02 AM	11.0	10.0	44	Cloudy with sunny breaks.
08-Aug	8:02 AM	13.0	11.0	41	Mostly sunny, thunder and lightning at 11pm
09-Aug	8:05 AM	10.0	12.0	41	Cool cloudy showers all day
10-Aug	7:55 AM	7.0	10.5	48	Mix of sun and cloud, small shower in evening.
11-Aug	7:50 AM	8.0	10.0	68	Cloudy morning clearing by afternoon.
12-Aug	8:10 AM	9.0	10.5	57	Sunny morning; thundershowers mid afternoon
13-Aug	8:10 AM	7.0	10.0	51	Mix sun and cloud, heavy shower in late afternoon
14-Aug	7:55 AM	4.0	10.0	54	Clear overnight, foggy morning and sunny all day.
15-Aug	8:10 AM	3.0	10.0	49	Sunny all day
16-Aug	8:15 AM	8.0	10.0	44	Sunny all day
17-Aug	8:10 AM	4.0	10.0	40	Mix of sun and cloud
18-Aug	8:00 AM	8.0	11.0	38	Showers in morning, clearing in afternoon
19-Aug	8:05 AM	2.0	9.5	45	Cool cloudy morning, sunny afternoon
20-Aug	7:57 AM	0.0	9.0	42	Sunny all day clouding over in evening
21-Aug	7:53 AM	4.0	9.5	37	Mostly sunny clouding over with showers at night
22-Aug	8:00 AM	7.0	10.5	33	Mix sun & cloud during day, rain in evening and night.
23-Aug	8:10 AM	10.0	11.0	32	

Appendix 4. Age, sex, and length of sampled Chinook on the Big Salmon River, 2012.

DATE	FISH #	SEX	MEF (mm)	POHL (mm)	AGE*
24-Aug	1	M	860	765	RG
24-Aug	2	M	710	620	1.3
24-Aug	3	M	905	800	M4
24-Aug	4	M	930	820	1.4
24-Aug	5	M	710	605	1.3
24-Aug	6	F	785	680	1.4
24-Aug	7	F	835	750	RG
24-Aug	8	M	810	710	1.4
24-Aug	9	F	905	795	1.4
24-Aug	10	M	830	720	1.4
24-Aug	11	F	875	775	1.4
24-Aug	12	F	860	770	1.4
24-Aug	13	F	775	675	1.3
24-Aug	14	M	710	625	1.3
24-Aug	15	M	835	715	1.4
24-Aug	16	F	845	750	1.4
24-Aug	17	M	715	625	1.3
24-Aug	18	F	885	795	1.4
24-Aug	19	F	855	750	1.4
24-Aug	20	F	820	720	1.4
25-Aug	21	M	670	585	1.3
25-Aug	22	M	630	555	1.4
25-Aug	23	M	870	760	1.4
25-Aug	24	F	860	770	1.4
25-Aug	25	F	895	685	1.4
25-Aug	26	F	840	750	1.4
25-Aug	27	F	850	760	1.4
25-Aug	28	F	880	765	1.4
25-Aug	29	F	825	740	1.4
25-Aug	30	F	950	775	1.4
25-Aug	31	F	855	760	1.4
25-Aug	32	M	655	580	1.3
25-Aug	33	F	780	710	1.4
25-Aug	34	F	830	755	M4
25-Aug	35	F	825	730	M4
25-Aug	36	F	855	745	1.4
25-Aug	37	F	855	770	1.4
25-Aug	38	F	860	765	1.4
26-Aug	39	M	850	750	1.4
26-Aug	40	F	680	615	1.4
26-Aug	41	F	835	740	1.4
26-Aug	42	M	865	760	1.4
26-Aug	43	M	840	730	M4
26-Aug	44	M	820	710	1.3
26-Aug	45	M	905	790	1.4
26-Aug	46	M	795	695	M4
26-Aug	47	F	790	715	1.4

*European age format; e.g. 1.3 denotes a 5 year old fish with 1+ years freshwater residence and 3 years marine residence
No Ages:
RG = regenerate scale (center is missing from scale)
Partial Ages:
M=marine stage

Appendix 5. Daily and average Chinook counts in the Big Salmon River, 2005-2012.

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 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			2		**3**
18-Jul	23	0	2	0	0		7	0	**5**
19-Jul	13	0	5	1	11		13	0	**6**
20-Jul	23	1	5	0	22	0	15	0	**8**
21-Jul	36	3	7	0	47	7	24	0	**16**
22-Jul	58	8	11	0	68	14	24	0	**23**
23-Jul	92	11	18	1	85	12	43	0	**33**
24-Jul	130	21	26	2	135	7	44	0	**46**
25-Jul	158	20	52	1	201	12	50	1	**62**
26-Jul	204	53	88	3	226	14	56	1	**81**
27-Jul	219	95	153	5	346	27	105	1	**119**
28-Jul	287	146	237	9	498	46	160	3	**173**
29-Jul	290	230	287	9	532	83	192	15	**205**
30-Jul	299	321	337	29	594	123	218	12	**242**
31-Jul	279	368	400	21	808	141	218	23	**282**
01-Aug	333	357	435	23	578	159	260	62	**276**
02-Aug	346	379	331	18	715	182	313	76	**295**
03-Aug	303	358	304	16	725	216	417	138	**310**
04-Aug	292	413	258	31	595	226	426	156	**300**
05-Aug	331	496	210	51	559	215	396	196	**307**
06-Aug	214	490	178	55	452	221	400	228	**280**
07-Aug	188	464	147	78	364	227	317	192	**247**
08-Aug	232	464	59	61	295	242	294	235	**235**
09-Aug	234	360	74	70	270	248	243	183	**210**
10-Aug	203	349	90	98	209	183	160	154	**181**
11-Aug	124	348	82	122	183	207	170	106	**168**
12-Aug	126	324	98	107	146	174	143	130	**156**
13-Aug	125	243	77	109	118	181	100	110	**133**
14-Aug	72	196	74	89	117	134	85	81	**106**
15-Aug	57	180	66	78	65	114	89	80	**91**
16-Aug	40	172	56	70	55	82	63	94	**79**
17-Aug	53	104	40	49	63	80	35	70	**62**
18-Aug	47	69	64	45	55	53	20	50	**50**
19-Aug	35	87	37	17	43	40	18	44	**40**
20-Aug	29	59	47	18	35	24	21	38	**34**
21-Aug	26	45	11	15	28	18	11	27	**23**
22-Aug	19	50	16	16	14	38	2	19	**22**
23-Aug	17	12	23	9	4	24	2	19	**14**
24-Aug	13	10	17	2		20		14	**13**
25-Aug	9		14	1		17		9	**10**
26-Aug	6		14			6		6	**8**
27-Aug	4		13					5	**7**
28-Aug	2		11					3	**5**
29-Aug			9					2	**6**
30-Aug			8					1	**5**
31-Aug			6						**6**
01-Sep			4						**4**
02-Sep			3						**3**
TOTAL:	**5618**	**7308**	**4506**	**1329**	**9261**	**3817**	**5156**	**2584**	

Appendix 6. Estimated proportions of Blind Creek, Big Salmon and Teslin River Chinook in upper Yukon River Chinook escapements based on observed radio tag distributions 2002 – 2004.

Year	**Blind Creek**	**Big Salmon**	**Teslin**	**Total**
2002	1.8	9.2	19.8	30.8
2003	1.4	15.1	18.1	34.6
2004	2.2	10.0	20.8	33.0
Mean	**1.8**	**11.4**	**19.6**	**32.8**
SD	0.3	2.6	1.1	1.6

Data source: Osborne et al. 2003, Mercer and Eiler 2004, Mercer 2005.