

2016 Chinook Salmon Sonar Enumeration on the Big Salmon River

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ABSTRACT

A long range dual frequency identification sonar (LR DIDSON) was used to enumerate the Chinook salmon escapement to the Big Salmon River in 2016. The sonar was operated on the Big Salmon River for its twelfth year at the same site used for the 2005 to 2015 projects. Sonar operation began on July 11 and continued through to August 19. A total of 6,691 targets identified as Chinook salmon was counted during the period of operation and a further 70 Chinook were interpolated to have passed after sonar operations ceased, bringing the total escapement estimate to 6,761. The first Chinook salmon passing the Big Salmon sonar station was observed on July 11, the first day of operations. The peak daily count of 430 fish occurred on July 28, at which date 42% of the estimated run had passed the sonar station. Approximately 90% of the run had passed the station by August 9. Based on the 2016 Big Salmon sonar count and above border escapement estimates from the Eagle sonar project, the Big Salmon run comprised approximately 9.8% of the total above border escapement. Drift tangle netting to examine for the presence of non-Chinook targets was conducted. A total of 52 drifts were conducted over the period August 7 – 14. Two female Chinook were captured. No other fish species were captured in the tangle net operation. An ARIS sonar utilising high resolution settings was deployed concurrently with the DIDSON sonar for a period of 69 hours as a means of testing the LR DIDSON target identification. Carcass samples were collected between Aug 23 and Aug 25 over approximately 145 km of the Big Salmon River system; yielding 136 Chinook salmon samples. Of the total, 84 (63%) were female and 52 (37%) were male. The mean fork length (MEF) of females and males sampled was 831 mm and 757 mm, respectively. Complete age data was determined from 107 of the Chinook sampled; the remaining 29 samples yielded partial or no ages due to regenerate scales. Age 5 was the dominant age class of females (39%), followed by age 4 (17%) and age 6 (1%). Of the males, age 5 was the dominant age class (22%), followed by age 6 (10%), age 2 (2%) and age 4 and 7 (1%).

INTRODUCTION

The 2016 Big Salmon sonar project marks the twelfth year Chinook salmon enumeration has been conducted on this system by Metla Environmental Inc. (MEI). The DIDSON and ARIS sonar units used on the Big Salmon and other escapement enumeration projects have been found to be reliable and to provide accurate counts of migrating salmon (Enzhofer et al. 2010, Holmes et al. 2006, Mercer & Wilson 2006 - 2016). Due to high seasonal flows and wilderness recreation use of the Big Salmon system, the utilization of traditional salmon weir techniques on this river is not feasible. For these reasons a multiple beam sonar was selected as a 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. This report is a summary of the results of the 2016 project.

Based on the 2005 – 2016 sonar operations, the Big Salmon River has been shown to be a significant contributor to upper Yukon River Chinook production. The 2005 -2016 average Big Salmon sonar count is 5,507 (range 1,329 to 10,071). These counts represented an average of 10.2% of the total average upper Yukon River Chinook spawning escapement estimate for these years (JTC 2016).

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 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 was conducted to obtain age, sex and length data from the 2016 Big Salmon Chinook escapement. This information provides important biological baseline data on the health of the stock as well as information used in constructing future pre-season run forecasts.

In 2015 a juvenile chinook mark/recapture and outmigration study was initiated by Fisheries and Oceans Canada (DFO) on the Big Salmon River system. This study was continued in 2016. One of the goals of the project is to begin to develop a baseline of Chinook outmigration timing and juvenile abundance in a river with monitored adult returns. Information on juvenile production and life history will assist with interpretation of stock recruitment models and could contribute to the restoration and management of Canadian-origin Chinook salmon stocks. The project is aimed at examining juvenile Chinook outmigration timing, relative abundance, age, growth and stock composition on the Big Salmon River. The existing Big Salmon sonar camp has been used as a base for the project. In addition, personnel associated with the sonar program have assisted with the juvenile assessment 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 km², 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. It is accessible by either boat or float plane.

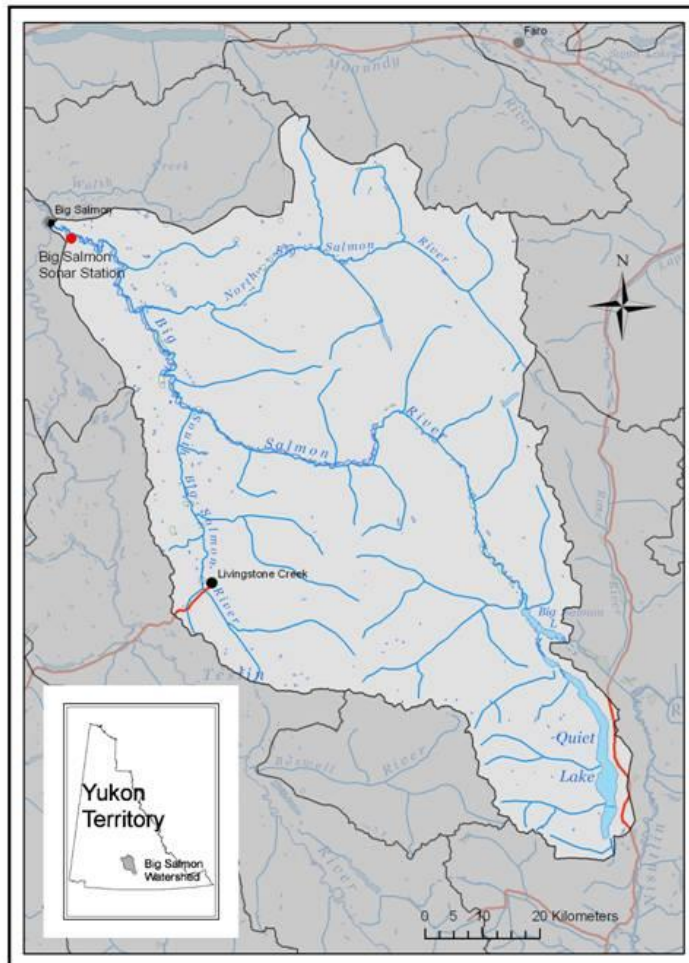


Figure 1. Big Salmon River Watershed and location of the 2016 Big Salmon sonar station.

Objectives

The objectives of the 2016 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. In addition document egg retention of female spawners and the principal recovery locations of spawned out fish.
3. Continue to investigate the possible presence of other co-migrating species at the sonar site that could be mis-identified as Chinook salmon.
4. Provide material, logistical and technical support to a DFO initiated juvenile Chinook assessment project.

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 physical characteristics of the river at this site have not changed over the 12 years of sonar operation. It is anticipated that this site will continue to be used as long as the sonar program operates.

Permits

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.

Camp and Sonar Station Set-up

Project mobilization began on July 10. Initial access to the project site and transportation of associated equipment and supplies was by boat from Little Salmon Village. Other supplies and personnel were transported from Whitehorse via floatplane. Subsequent camp access, crew changes, and delivery of supplies and fuel were accomplished either by riverboat or floatplane.

A five year licence of occupation was granted to the contractor in 2009 by the Yukon Territorial Government Lands Branch for the sonar camp (lower Big Salmon River, N 61°52' 45'', W 134° 53' 08''). This precluded the requirement of annual land use permits and allowed for the construction of upgraded and more permanent facilities at this site. This licence was renewed in 2014.

Diversion Fence Construction

At the onset of the project, 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 2). Fence structures were constructed as in previous years using conduit panels and metal tripods stored on site. Placement of the fence structures was completed by July 11.

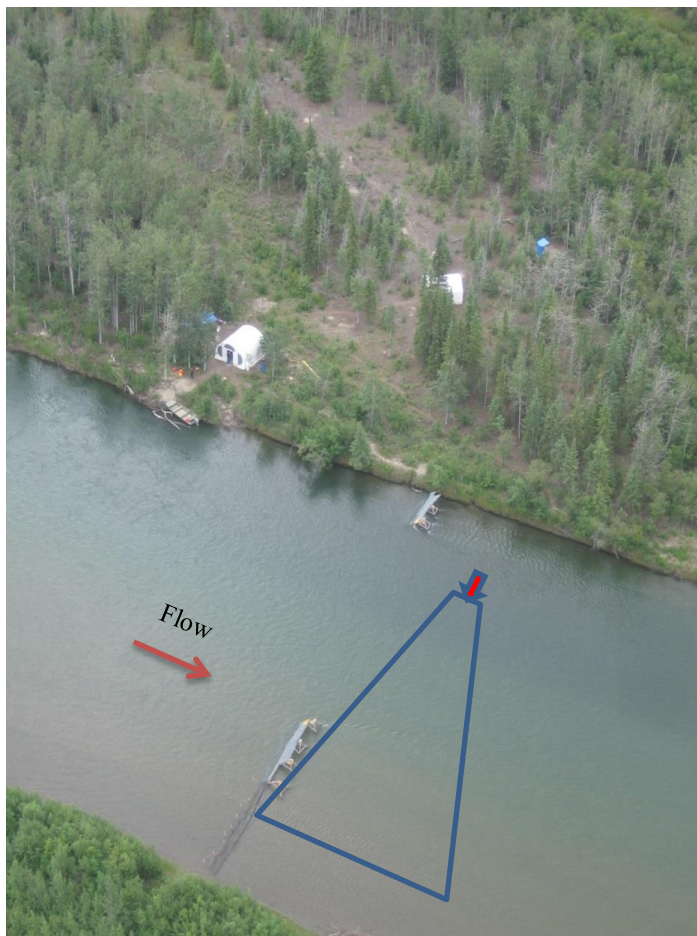


Figure 2. Aerial view of sonar station camp and partial weirs, (photo from 2010 project). Blue outline denotes ensounded portion of the river.

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 DIDSON sonar beams. The bottom profile was similar for all three transects. The cross section profile where the sonar was deployed is presented in Figure 3. The cross section profile of the river bottom has remained relatively unchanged since the project started in 2005.

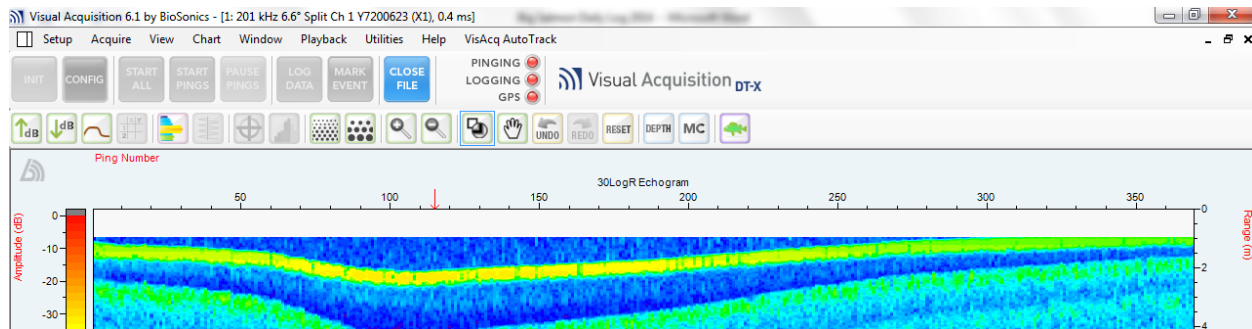


Figure 3. Cross section profile of Big Salmon River at sonar site using a Biosonics DTX split beam echo-sounder.

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 1 m as indicated by the white band.

DIDSON Sonar and Software Configuration

The sonar unit was placed next to the south bank at the same location used in previous sonar operations (Figures 4). 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. 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 system was powered by one set of 6 – 6 volt 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. 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. An 800 watt inverter was used to obtain 110 volt AC from the batteries to supply power for the computers and the sonar unit.

The DIDSON sonar with a standard lens produces an ensonified field 29° wide in the horizontal plane and 12° in the vertical plane. An 8° concentrator lens was used for the 2016 project. This lens reduces the vertical ensonified field from 14° to 8°, resulting in an increase in the resolution of the target images. The DIDSON transducer lens was positioned at a depth of approximately 12 cm below the surface of the river and angled downward approximately 3° from horizontal resulting in the ensonified field of view remaining parallel to the surface of the river.



Figure 4. Sonar transducer unit and mounting stand in position (2011 Photo).

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. A table, using simple trigonometry formulae, enabled the sonar crew to determine the beam depth for given water depths and sonar window start lengths. Care was taken to insure the sonar beam contacted the river bottom before the end of the deflection fence to insure the entire migration corridor was ensonified.

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 2 TB external hard drive.

DIDSON Sonar Data Collection

Sonar recording began on July 11 and continued until August 19. 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 echotastic software program was used to review most of the files recorded. The echogram view and sonar view platform were used concurrently to review the files. The sonar view 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. The data 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 collected throughout the project.

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 Big Salmon Chinook sampled during the 2016 carcass pitch was 60.0 cm. The largest target categorized as a resident fish based on size and swimming behaviour was approximately 40 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 temporary¹ 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 2016 amounted to 92 fish or 1.4% of the total run.

As in previous years short interruptions in data collection due to equipment malfunctions, power failures and other technical difficulties are inevitable. All stoppages or gaps in recording coverage were documented. Potentially missed fish were added to the counts by extrapolation 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 extrapolation 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 m th 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 extrapolated counts were included in the total daily counts reported over the course of the project.

Precision of Fish Counts

It is standard practice in salmon enumeration sonar projects to review a sub-set of recorded data 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 file counts was measured by double reviewing a sub-set of all the files recorded. Precision in this case refers to the repeatability of a count between different individuals for the same data file. Files for review were randomly selected from each day of sonar operation. The re-count from each file was recorded for comparison with the original.

The average percent error (APE) 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:

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.

$$APE = \frac{1}{N} \sum_{j=1}^N \left[\frac{1}{R} \sum_{i=1}^R \frac{|X_{ij} - \bar{X}_j|}{\bar{X}_j} \right] \times 100$$

where N is the number of events counted by R observers, X_{ij} is the i th count of the j th event and \bar{X}_j is the average count of the j th event.

However, because of the relatively low number of fish per hour in most of the Big Salmon sonar files, the percent error could be over-estimated. For example, if the first counter observed 2 upstream fish and the second counter missed one, the APE would be as high as 33%. This is due to the leverage that small numerical differences in low counts have on the overall calculation of APE. For this reason, the average percent error for this project was calculated using files with fish counts ≥ 5 fish/ file.

As well as calculating APE, a sample variance estimator based on the absolute difference between readers was used to quantify the correlation of the counts and the net variability between readers.

Range 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. The range of the target was determined by where the target passed through the center axis of the sonar beam.

Species identification and target testing

Two methods were employed during the 2016 project to examine if co-migrating species were present at the sonar site that could be mis-identified as Chinook salmon. Drift netting was conducted in an attempt to sample the larger fish species present at the sonar site. As well, an ARIS sonar with high resolution settings was deployed concurrent with the LR DIDSON sonar to obtain accurate measurements of a sub-set of the fish passing the station.

Drift netting operations were carried out at the site over the latter part of the run. Operations were conducted between 12:00 and 22:00 hrs. The net was a 16.25 cm mesh gillnet, 30 m long by 2.0 m deep. The net was deployed perpendicular to the current from a river boat and allowed to drift from above the deflection weirs through the ensonified migration corridor to a point downstream of the sonar station. Total length of the drifts varied between 150 -500 meters. All fish species captured were identified and measured.

An ARIS 1800 sonar was deployed 5 m upstream of the LR DIDSON sonar site to track the passage of fish through the migration corridor from August 2 at 15:20 through August 5 at 12:00. The clocks in each sonar were synchronized. Fish passing through the beams of each of the sonars would be identifiable by the time of passage and the distance from the sonar. The ARIS sonar was configured with a window length of 16 m, a frame rate of 6 frames/second, a 2000 sample rate and a frequency of 1.8 Mhz. These settings resulted in the capture of high resolution images from a subset of the fish passing the sonar station. All fish targets ≥ 50 cm were

measured² and marked using ARISfish software. ARISfish automatically enters pertinent data such as time, frame, fish size and range from a fish marked in the sonar view into a .csv format file. The data from each 20 minute file was exported into a master excel spreadsheet after each file was reviewed.

Fish length measurements using a LR DIDSON with a window length of 40 m are not considered accurate (Burwen et al. 2010; Tuser et al. 2014). Work conducted by MEI at other sonar projects has indicated that it is possible to obtain high resolution images and measurements of fish using an ARIS sonar with the aforementioned settings (Mercer 2017). This work indicated that when using an ARIS sonar with the above settings the mean error of length measurements of the fish was 3.1 cm (95% CI +/- 4.9 cm). The purpose of obtaining accurate measurements was to determine if the fish that were identified as Chinook using the high resolution ARIS images were also identified as Chinook using the DIDSON sonar. The intent was to use the comparisons as a proxy for target testing.

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 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. All sampling data and scale cards were submitted to DFO Whitehorse stock assessment; scales were subsequently read by the Pacific Biological Station fish ageing lab.

In addition to collection of ASL data, information was collected on the egg retention of the sampled females. The principal locations of the recovered carcasses and moribund fish were also recorded.

RESULTS

Chinook Salmon Counts

The 2016 Big Salmon Chinook run timing was earlier than the previous 10 year average for this stock (Figure 5). The first Chinook salmon was observed on July 11, on the first day of operations. The peak daily count of 430 fish occurred on July 28, at which date 42% of the estimated run had passed the sonar station. The run reached 50% passage on July 30, four days earlier than the previous 10 year average for 50% passage. Ninety percent of the run had passed the station by August 9, four days earlier than the 10 year average. Daily and cumulative counts are presented in Appendix 1 and Figure 5. Annual counts from 2005 through 2016 are illustrated in Figure 6 and listed in Appendix 2.

² Depending on the number of viable frames captured up to 10 separate measurements could be taken for an individual fish in order to select the best image and largest measurement.

A total of 6,691 targets identified as Chinook salmon was counted past the sonar station from July 11 through to August 19. Because the sonar was removed before the run was totally complete, an interpolation was used to estimate the number of Chinook that passed the station in after sonar operations were stopped. This was done through regression analysis of the previous 10 days of the sonar counts based on the logarithmic regression $y = -37.95\ln(x) + 109.22$. This added 70 fish to bring the total 2016 count to 6,761.

Short interruptions in sonar recording due to maintenance or power interruptions resulted in a total of 3 hours recording loss. A total of 5 fish was extrapolated for these periods. An additional 30 hours of sonar downtime occurred from 07:20 on Jul 25 to 13:40 on July 26. This occurred as a result of a focusing issue with the sonar. After consultation with Sound Metrics and software and firmware upgrades the issue was resolved. A total of 56 fish was extrapolated over this period.

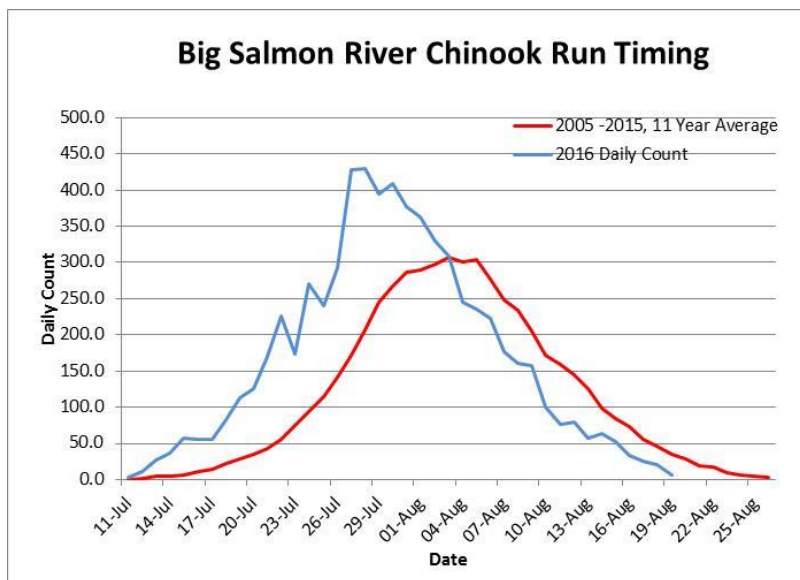


Figure 5. Daily counts of Chinook salmon passing the Big Salmon River sonar station in 2016 and 2005 through 2015.

Precision of Counts

Of the 2,826 sonar files recorded and analysed, a total of 195 (6.9%) were reviewed by a second observer (Table 1). Of the 195 files reviewed, a total of 60 files (31%) exhibited a discrepancy of the total file count between readers. Of the 60 files that exhibited an inconsistency between readers, an additional 19 fish were observed and 11 fish missed in the second review. This yields a net gain of 8 fish for the 352 files that were reviewed representing 0.6% of the fish counted in the first iteration. Expansion of the net gain in this subset of files to cover the total number of files recorded would result in a possible total of 90 Chinook that may not have been observed or correctly identified and therefore not counted.

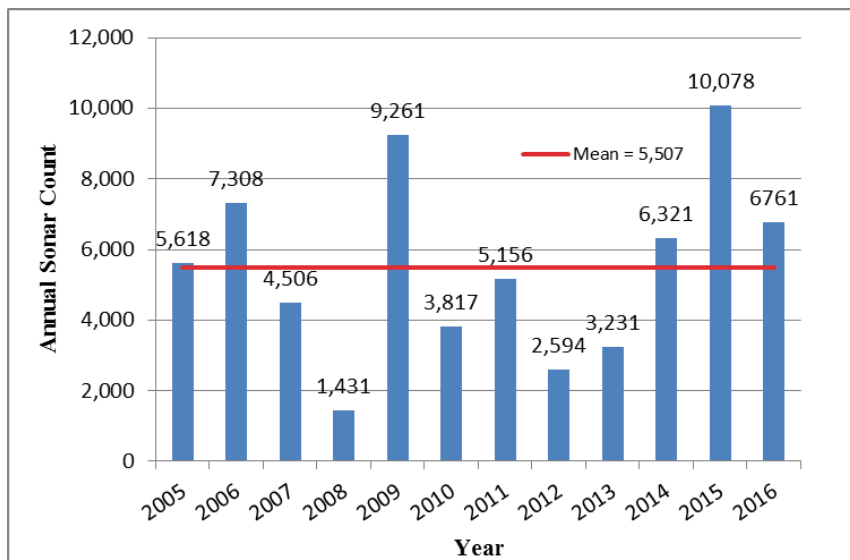


Figure 6. Annual sonar counts for Big Salmon sonar project 2005 – 2016.

Figure 7 illustrates the relationship between counts of 2 different file readers using daily pooled original (reader 1) and reviewed files (reader 2). The Pearson correlation between the readers is high ($R(23) = 0.99$, $p < 0.001$).

The average percent error (APE) was calculated for the 56 reviewed files that had fish counts ≥ 5 fish/file. The APE for this subset was 0.06%.

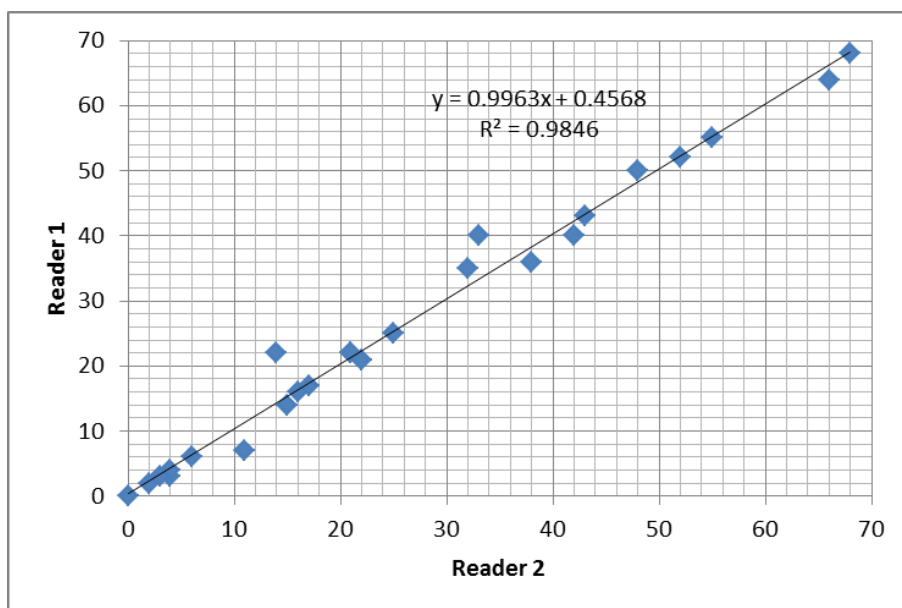


Figure 7. Linear regression between daily pooled sonar file counts examined by two separate readers.

Note: Data points are daily pooled initial file counts (y axis) and reviewed file counts (x axis).

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

	Count	%
Total files recorded during project	2,826	
Total files double reviewed	195	6.9%
Total fish counted first iteration	660	
Total fish counted first iteration	669	
Total files with + variance	32	16.4%
Total files with - variance	29	14.9%
Total Files with variance	61	31.3%
Net difference	9	1.4%

Range Distribution

The cross sectional distribution of migrating Chinook at the sonar site over the period 2011 – 2015 and 2016 is presented in Figure 8.³ As occurred in previous years the largest proportion of fish migrated near the south bank in deeper water at a distance of 15-20 meters from the sonar. The water levels experienced in 2016 were considered below average which may account for the typical migration pattern. The water levels and temperatures recorded during the project are listed in Appendix 3.

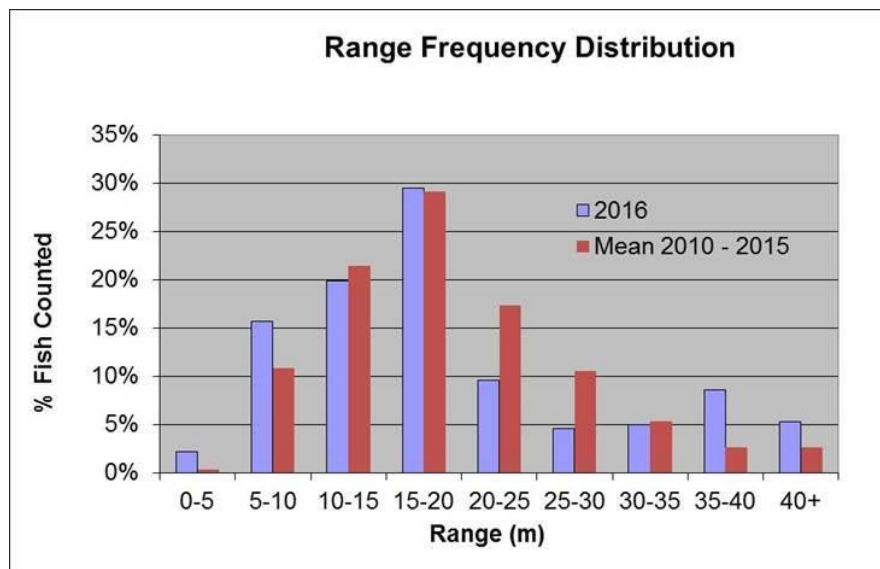


Figure 8. 2016 Big Salmon River Chinook range/frequency in cross section profile.

Note: The 0 – 5m range from the sonar has a deflection fence in place.

³ It should be noted the distribution does not reflect the typical in-river migration pattern as the weir structures channel the fish into the 36 m wide opening.

Species Identification

A total of 46 tangle/gill net drifts were successfully conducted over the period August 7 to August 14. Six additional drift attempts were terminated or truncated when the net became entangled in a snag and/or did not deploy properly. The total in-water drift time over the entire period was 173 minutes, with individual sets ranging from 0.5 to 7.0 minutes. Drift tangle net set locations, deployment times and capture results are presented in Appendix 3. The total tangle net captures included two female Chinook captured on August 11 at 15:06 and on August 12 at 22:12. This resulted in a catch per unit effort (CPUE) of 1 Chinook/ 86.5 minutes drift time. Two additional hits on the net likely indicated Chinook striking the net but not captured. No fish other than Chinook were captured.

A total of 294 fish passing the station between 15:20 on August 2 and 12:00 on August 5 was detected and measured using the ARIS sonar. This subset represented 27% of the 1,111 Chinook counted past the station by the DIDSON sonar. The lengths of these fish ranged from 52 cm to 104 cm. A length frequency histogram of this subset is illustrated in Appendix 4.

Carcass Pitch

A total of 136 dead or moribund Chinook was recovered during the carcass pitch. Of the fish sampled, 84 (62%) were female and 52 (38%) were male. The mean fork length (MEF) of females and males sampled was 831 mm and 757 mm, respectively. The length frequency of Chinook sampled is presented in Figure 8. Complete age data⁴ was determined from 107 of the Chinook sampled; the remaining 29 samples yielded partial or no ages due to regenerate scales. Females were predominately age-6 (1.4)⁵ (39%) and males predominantly age-5 (1.3) (22%). Mean length and age data is presented in Table 2.

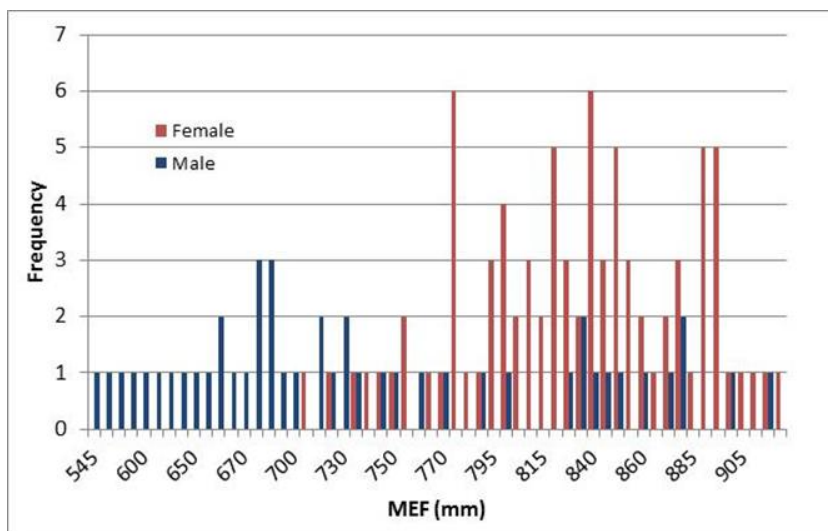


Figure 9. Length/frequency histogram of Big Salmon Chinook sampled in 2016.

⁴ Scale age analysis was conducted for DFO Whitehorse by the Pacific Biological Station, sclerochronology lab in Nanaimo, British Columbia.

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

Of the 72 females examined (in which egg retention could be determined),⁶ five (6.9%) were not fully spawned out. The estimated egg retention in these five fish ranged from 50% – 100%. Complete age, length and sex data as well as egg retention and principal recovery locations are presented in Appendix 4.

Table 2. Age, length, and sex of Chinook sampled from the Big Salmon River, 2016.

SEX	AGE	Mean MEF	Count	%
Female	1.3	810	20	17%
	1.4	844	47	39%
	1.5	880	1	1%
	M3	778	2	2%
	M4	837	5	4%
Female total		833	75	63%
Male	1.1	605	3	3%
	1.2	685	1	1%
	1.3	716	26	22%
	1.4	885	8	7%
	1.5	990	1	1%
	M3	765	3	3%
	M4	910	2	2%
Male total		757	44	37%
Total		805	119	100%

DISCUSSION

The 2016 Big Salmon sonar project was successful in enumerating the Chinook salmon passing the station throughout the course of the run. Other than the 30 hour period of the DIDSON sonar focus issue no other significant problems were encountered with the sonar and related equipment. Water levels at the sonar station were below average with the exception of a high water event on July 25-26 after a period of heavy rains. Overall the weir structures remained in place and the migration corridor of 36 m was maintained.

The comparison of the counts of files reviewed by two different individuals exhibited a relatively high degree of precision between both reviewers. However, the precision was somewhat lower than has been observed in past years. This may be due to the presence of two technicians engaged on the project with no previous sonar file reading experience. Repeated counts of the files were observed to produce the same counts 69% of the time for the 195 files reviewed. Average percent error of all the reviewed files was low (0.21%), but as mentioned, higher than was observed in the previous two years. As occurred in 2014 and 2015, the reviewed file counts resulted in a net gain of fish. This would suggest that the 2016 sonar count could be biased low by a factor of approximately 1.4% of the total count (90 Chinook).

The drift tangle/gill net operations yielded 2 female Chinook. The average Chinook sonar count on the days the fish were caught was 3.25 Chinook/hour. The CPUE of 0.69 Chinook per hour is

⁶ No assessment for egg retention was possible for 12 females examined due to partial decomposition or predation.

consistent with the passage rate observed. The 16.25 cm mesh size of the net would likely preclude the capture of fish < 60 cm. A more definitive test netting regime would entail the use of variable mesh sized nets and increased effort. Test netting at the peak of the run would also result in larger catch sizes.

The ARIS sonar measurements of fish passing the station were not within the range of observed measurements of Chinook sampled during the 2016 carcass pitch (Appendix 4). The carcass pitch lengths were skewed to larger size classes and the ARIS lengths to smaller size classes. This is consistent with known sampling bias associated with dead pitch sample results; with larger fish and females over represented (Mears and Dubois, 2009; Zou 2002). As with the test netting results the sub-set of ARIS sonar measurements does not confirm the absence of co-migrating species that could be mis-identified as Chinook.

The issue of co-migrating species that could be mis-identified as Chinook has been discussed at length in previous reports on this project (Mercer & Wilson 2013, 2012). The species identification issue was raised again in 2016 in an internal memorandum to YRP and DFO. The concern centred on the defensibility of the Big Salmon sonar counts with regard to species apportionment, and also with regard to abundance estimation (including target testing). This memorandum prompted the ARIS sonar measurements and tangle net operations at the Big Salmon project in 2016. The evidence presented in earlier reports, including the very high improbability of other salmon species (Chum) being present during the Chinook migration period, as well as the drift net results from 2016, does not lend support to the presence of fish at the sonar site that could be mis-identified as migrating Chinook. Using drift netting to assign species apportionment is standard protocol in systems where mixed salmon species are present. However, where a single salmon species is being enumerated and where there is no evidence that resident species within the size range of Chinook are present, the utility of continuing to search for fish for which no evidence exists must be questioned. The project manager is prepared to continue with tangle net operations with multi size mesh in future years if the program continues. However, given that the sonar crew is assisting with the juvenile Chinook study concurrent with the sonar project, constraints do exist on the deployment of personnel to conduct extensive drift net operations.

Obtaining accurate measurements of a sub-set of the Big Salmon Chinook could provide additional information on the age class of the escapement into the system. Mixture modeling techniques have been developed to quantify age and species composition of fish stocks using multiple beam sonar (Key et al. 2016, Gurney et al. 2014). It is recommended these techniques be explored if the Big Salmon program continues.

The ARIS (Adaptive Resolution Imaging Sonar) sonar is considered the second generation of multiple beam sonars manufactured by Sound Metrics Corporation. While the underlying beam-forming techniques involving the use of acoustic lenses are similar for both units, significant refinements to the ARIS hardware and software as well as specialized fish counting and measuring software make it a more versatile and user friendly platform for detecting and counting migrating salmon (Key et al. 2016). With DIDSON the number of samples (pixels) is fixed at 512. The DIDSON window length parameter can only be set at multiple discrete values (2.5m, 5m, 10m, 20m, etc.) and the sample number is fixed. ARIS images can attain a finer downrange resolution than DIDSON. With ARIS, The number of samples in a beam is operator controlled and is variable from 128 to a maximum of 4,000 samples (pixels). In addition the Window Length is user selectable. This allows the user to collect data over a longer window

length but increases the number of samples per beam to compensate. The use of an ARIS 1800 sonar and related ARISfish software rather than the current LR DIDSON for the Big Salmon project would provide better downrange resolution of the fish targets and speed up the process of reviewing the data.

The 2016 Eagle sonar project on the Yukon River downstream of the Canada/U.S. border yielded a total count of 72,239 Chinook. The above border spawning escapement⁷ estimate was 68,798 (JTC 2016). Based on both the Big Salmon and Eagle Chinook sonar counts, the Big Salmon stock contributed 9.8% of the total above border Chinook escapement in 2016.

Genetic stock identification (GSI) samples were also obtained at the Eagle sonar site using drift nets. The GSI data provides information on the stock composition of the total above border Chinook escapement. The 2016 un-weighted contribution of the Big Salmon River stock to the total Chinook above border escapement based on analysis of the GSI samples was 9.0%, (SD 1.8%) (DFO Whitehorse unpublished data). The 2016 proportional contribution of the Big Salmon River stock to the Chinook above border escapement based on analysis of the GSI samples was within the range observed from 2005 through 2015 (mean 9.4%; range 2.4% - 16.9%).

Appendix 8 illustrates the relationship between the Eagle sonar counts and the Big Salmon sonar counts from 2005 through 2016. As expected there is a correlation between the annual Big Salmon sonar counts and the JTC above border escapement estimates (Pearson corr. $R(10) = .88$, $p < 0.001$).

An independent above border Chinook escapement estimate can be obtained by expansion of the Big Salmon sonar count using the 2016 Big Salmon GSI stock proportion. Using this method yields an above border escapement point estimate of 75,122 (95% CI: 54,088 – 123,601). Over the period 2005 – 2016 there has been no significant correlation between the Big Salmon Chinook sonar counts and the calculated Big Salmon escapement estimates derived from the Eagle sonar count and GSI proportions (Pearson $R(10) = 0.48$, $p > 0.05$). This has been discussed in previous reports (Mercer and Wilson, 2015).

A longer time series data set and the elimination of suspected outlier years may increase the predictive precision of using GSI data to estimate Chinook stock groups. The Big Salmon stock is a relatively small component of the total above border escapement. Using the GSI method with aggregate stocks (Teslin plus Big Salmon stock) has been demonstrated to yield somewhat better predictive results (Mercer 2016).

The 2016 carcass pitch component of the project was planned with an extension of the carcass pitch period by approximately 4 days over that of previous years. The expansion of the carcass pitch effort was initiated to reduce the level of sampling bias associated with carcass sampling. This potential sampling bias has been discussed at length in previous reports (Mercer and Wilson 2015; Mears and Dubois, 2009; Zou 2002). Because of the earlier than average run timing, carcass sampling was initiated earlier than usual with sampling beginning August 15. However, it was evident after the first day of sampling that few carcasses were available and the crew returned to the sonar station the following day. An extended carcass sampling trip was conducted August 21 through 25.

⁷ Spawning escapement is the Eagle sonar count minus the catches in the U.S. above the sonar station and in the Canadian fisheries.

A DFO juvenile Chinook salmon study was initiated in 2015 on the Big Salmon system and continued in 2016. As in 2015, the Big Salmon sonar camp belonging to MEI was used as a base for the juvenile Chinook study. During the operation of the sonar project one of the sonar technicians assisted on the DFO juvenile Chinook project. This did not unduly affect sonar operations and if both projects are conducted again in 2017 a similar arrangement could be made.

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Appendix 1. 2016 daily and cumulative counts of Chinook salmon at the Big Salmon River sonar site.

DATE	DAILY COUNT	CUMULATIVE	COMMENTS
11-Jul	3	3	Sonar recording starts at 7:50
12-Jul	11	14	
13-Jul	27	41	
14-Jul	36	77	
15-Jul	57	134	
16-Jul	56	190	
17-Jul	56	246	
18-Jul	82	328	
19-Jul	113	441	
20-Jul	126	567	
21-Jul	171	738	
22-Jul	226	964	
23-Jul	174	1138	
24-Jul	271	1409	
25-Jul	240	1649	
26-Jul	292	1941	
27-Jul	428	2369	
28-Jul	430	2799	peak daily count
29-Jul	394	3193	
30-Jul	409	3602	
31-Jul	377	3979	
01-Aug	362	4341	
02-Aug	329	4670	
03-Aug	309	4979	
04-Aug	245	5224	
05-Aug	235	5459	
06-Aug	222	5681	
07-Aug	177	5858	
08-Aug	161	6019	
09-Aug	157	6176	
10-Aug	101	6277	
11-Aug	77	6354	
12-Aug	79	6433	
13-Aug	58	6491	
14-Aug	63	6554	
15-Aug	52	6606	
16-Aug	33	6639	
17-Aug	26	6665	
18-Aug	20	6685	
19-Aug	6	6691	sonar recording stops 13:52

Appendix 2. Daily and average Chinook counts in the Big Salmon River, 2005-2016.

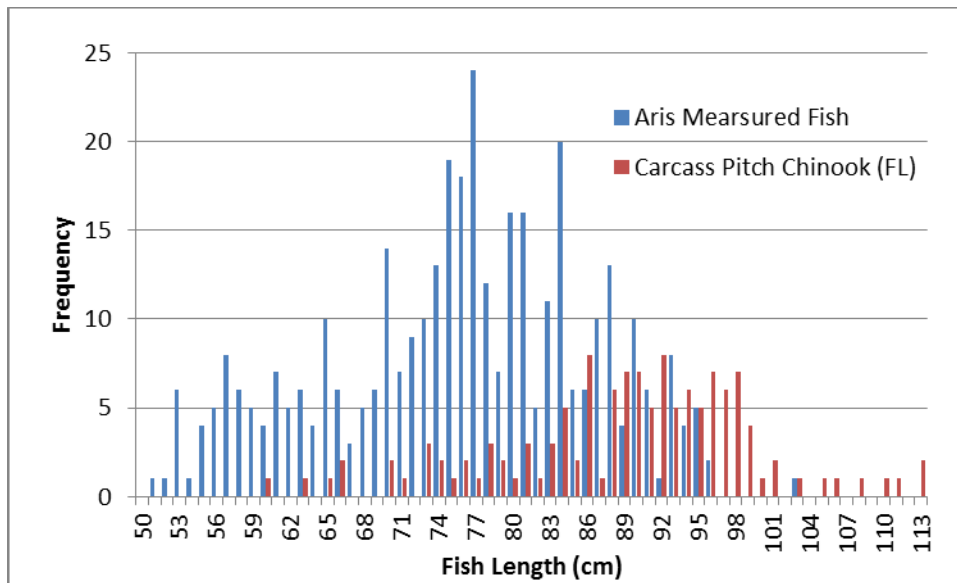
DATE	Daily Count 2005	Daily Count 2006	Daily Count 2007	Daily Count 2008	Daily Count 2009	Daily Count 2010	Daily Count 2011	Daily Count 2012	Daily Count 2013	Daily Count 2014	Daily Count 2015	Daily Count 2016	Daily Average
11-Jul										2		3	3
12-Jul										18		11	15
13-Jul	0									52		27	26
14-Jul	0									52		36	29
15-Jul	2	1								64	5	57	26
16-Jul	12	0	2	0					0	90	17	56	22
17-Jul	13	1	0	0			2		0	115	25	56	24
18-Jul	23	0	2	0	0		7	0	0	170	39	82	29
19-Jul	13	0	5	1	11		13	0	0	199	72	113	39
20-Jul	23	1	5	0	22	0	15	0	0	236	81	126	42
21-Jul	36	3	7	0	47	7	24	0	1	229	117	171	54
22-Jul	58	8	11	0	68	14	24	0	1	284	148	226	70
23-Jul	92	11	18	1	85	12	43	0	2	345	217	174	83
24-Jul	130	21	26	2	135	7	44	0	4	343	312	271	108
25-Jul	158	20	52	1	201	12	50	1	3	356	411	240	125
26-Jul	204	53	88	3	226	14	56	1	11	372	538	292	155
27-Jul	219	95	153	5	346	27	105	1	25	421	494	428	193
28-Jul	287	146	237	9	498	46	160	3	44	307	531	430	225
29-Jul	290	230	287	9	532	83	192	15	86	380	588	394	257
30-Jul	299	321	337	29	594	123	218	12	83	330	586	409	278
31-Jul	279	368	400	21	808	141	218	23	150	256	492	377	294
01-Aug	333	357	435	23	578	159	260	62	196	207	568	362	295
02-Aug	346	379	331	18	715	182	313	76	220	207	485	329	300
03-Aug	303	358	304	16	725	216	417	138	264	192	441	309	307
04-Aug	292	413	258	31	595	226	426	156	262	190	451	245	295
05-Aug	331	496	210	51	559	215	396	196	261	170	452	235	298
06-Aug	214	490	178	55	452	221	400	228	225	120	469	222	273
07-Aug	188	464	147	78	364	227	317	192	191	114	449	177	242
08-Aug	232	464	59	61	295	242	294	235	195	96	397	161	228
09-Aug	234	360	74	70	270	248	243	183	156	68	348	157	201
10-Aug	203	349	90	98	209	183	160	154	132	61	246	101	166
11-Aug	124	348	82	122	183	207	170	106	134	50	217	77	152
12-Aug	126	324	98	107	146	174	143	130	113	46	187	79	139
13-Aug	125	243	77	109	118	181	100	110	101	25	201	58	121
14-Aug	72	196	74	89	117	134	85	81	77	30	126	63	95
15-Aug	57	180	66	78	65	114	89	80	65	24	113	52	82
16-Aug	40	172	56	70	55	82	63	94	57	24	91	33	70
17-Aug	53	104	40	49	63	80	35	70	34	17	65	26	53
18-Aug	47	69	64	45	55	53	20	50	32	15	54	20	44
19-Aug	35	87	37	17	43	40	18	44	21		28	6	34
20-Aug	29	59	47	18	35	24	21	38	28		10		31
21-Aug	26	45	11	15	28	18	11	27	20				22
22-Aug	19	50	16	16	14	38	2	19	10				20
23-Aug	17	12	23	9	4	24	2	19	14				14
24-Aug	13	10	17	2		20		14	11				12
25-Aug	9		14	1		17		9	6				9
26-Aug	6		14			6		6	4				7
27-Aug	4		13					5	2				6
28-Aug	2		11					3	1				4
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	3242	6321	10071	6691	

Note: Stippled values were obtained through extrapolation of counts. Shaded areas denote start and end of sonar recording

Appendix 3. Big Salmon 2016 tangle netting results.

Date	Time Net In	Time Net Out	Time deployed (sec)	Drift distance (m)	Comments
Aug-07	1424h15s	1425h16s	61	200	
Aug-07	1433h55s	1436h01s	126	250	
Aug-07	1447h31s	1449h44s	133	300	
Aug-07	1457h55s	1459h54s	119	300	
Aug-07	1513h15s	1515h40s	145	300	
Aug-07	1523h53s	1525h15s	82	300	
Aug-07	1528h49s	1531h39s	170	300	
Aug-07	1535h02s	1538h00s	178	300	
Aug-07	1550h50s	1553h39s	169	300	
Aug-07	1605h15s	1608h08s	173	300	
Aug-08	1606h15s	1609h02s	167	305	
Aug-08	1617h53s	1621h08s	195	310	
Aug-08	1630h12s	1631h10s	58	175	
Aug-08	1635h29s	1638h10s	161	300	
Aug-08	1647h00s	1647h30s	30	500	Net tangled
Aug-08	1658h47s	1705h45s	418	500	
Aug-09	1430h10s	1431h45s	95	220	Possible hit but no capture
Aug-09			0	20	Net did not deploy
Aug-09	1440h48s	1443h40s	172	300	
Aug-09	1448h40s	1452h35s	235	370	
Aug-09	1457h43s	1500h40s	177	350	
Aug-09	1504h53s	1508h05s	192	280	
Aug-09	1521h35s	1527h30s	355	500	Possible hit but no capture
Aug-10	1205h44s	1209h53s	249	450	
Aug-10	1221h06s	1225h38s	212	450	
Aug-10	1235h58s	1239h39s	221	400	
Aug-10					Snagged net on deployment
Aug-10	1306h10s	1309h00s	170	400	
Aug-10	1315h30s	1318h05s	155	350	
Aug-10	1323h31s	1327h48s	223	400	
Aug-10	1331h25s	1333h00s	155	150	Net pulled parallel to flow
Aug-10	1335h30s	1341h04s	334	400	
Aug-10	1345h57s	1349h23s	206	400	
Aug-11	1503h54s	1506h30s	156	350	Female Chinook - MEF:85cm - FL:92.5cm
Aug-11	1517h13s	1521h12s	239	350	
Aug-11	1524h40s	1527h55s	195	300	
Aug-12	1313h15s	1317h18s	243	300	
Aug-12	1320h24s	1325h00s	276	370	
Aug-12	1328h05s	1332h02s	237	320	
Aug-12	1336h20s	1339h48s	208	300	
Aug-12	1343h15s	1347h54s	279	400	
Aug-12	2151h19s	2155h40s	261	290	
Aug-12	2159h24s	2204h30s	306	310	
Aug-12	2209h27s	2212h16s	169	250	Female Chinook - MEF:76cm - FL:81cm
Aug-13	2050h55s	2056h10s	315	380	
Aug-13	2100h27s	2105h55s	328	460	
Aug-13	2109h58s	2113h13s	195	300	
Aug-13	2116h43s	2121h00s	257	370	
Aug-13	2124h30s	2129h05s	275	400	
Aug-14	1629h00s	1634h00s	300	390	
Aug-14	1638h35s	1643h40s	305	400	
Aug-14	1648h00s	1653h20s	320	400	

Appendix 4. Length frequency histogram of sampled Big Salmon Chinook (Fork Length) and ARIS sonar derived measurements.



Appendix 5. 2016 Big Salmon River water and weather conditions.

DATE	TIME	AIR TEMP. (°C)	WATER TEMP. (°C)	WATER LEVEL (cm)	COMMENTS
11-Jul	9:00	16	12	31	clear except for 2hr storm in afternoon
12-Jul	8:30	15	10	30	clear except for 2hr storm in afternoon
13-Jul	15:00	15	20	29	overcast morning, clearing day, storm afternoon, clearing evening
14-Jul	9:30	15	12	31	clear in morning thunder midday clear in afternoon and evening
15-Jul	10:30	15	16	29	clear in morning light rain for a short time then clear again
16-Jul	9:00	15	12	35	clear in morning light rain in afternoon then clear
17-Jul	9:30	16	14	34	overcast in morning, sun and cloud throughout day
18-Jul	11:30	16	18	32	overcast in morning and throughout day
19-Jul	9:00	15	13	29	scattered clouds with breeze in morning and throughout day
20-Jul	9:00	14	10	29	slight overcast throughout day with light showers in afternoon
21-Jul	10:00	13	12	29	rain and cloud all day and night
22-Jul	8:30	12	10	33	rain in morning and throughout day
23-Jul	9:00	11	10	45	rain all day with some breaks of just cloud
24-Jul	8:30	11	10	65	rain for first half of day then clearing in evening showing lighter clouds
25-Jul	8:00	11	9	80	cloudy and overcast throughout
26-Jul	8:00	11	9	74	sun and cloud
27-Jul	8:00	11	8	58	sun and cloud
28-Jul	8:00	12	13	58	sun and cloud all day except for short storm in early afternoon.
29-Jul	8:00	12	9	51	rain overnight then cloudy morning, clearing in mid-day
30-Jul	8:00	11	9	52	rain overnight then cloudy morning, clearing in mid-day for sunshine!
31-Jul	8:00	11	8	55	sun and cloud
01-Aug	8:00	13	8	48	sunny all day
02-Aug	8:00	13	7	43	sunny all day
03-Aug	8:00	15	12	39	sun and cloud
04-Aug	8:00	14	9	36	sunny all day
05-Aug	8:00	14	8	36	mostly overcast
06-Aug	8:00	15	12	32	overcast then sun and cloud in afternoon
07-Aug	8:00	14	11	30	clear and sunny all day
08-Aug	8:00	14	12	29	rain on and off with rain overnight
09-Aug	8:00	14	11	28	mostly rain and overcast, rain overnight
10-Aug	8:00	12	9	30	sunny with some clouds, rain overnight
11-Aug	8:00	13	10	31	mostly sunny
12-Aug	8:00	13	13	29	sunny with some clouds
13-Aug	8:00	13	11	26	sun and cloud
14-Aug	8:00	13	13	24	sun and cloud
15-Aug	8:00	12	12	21	sun and cloud with wind
16-Aug	8:00	12	9	19	rain in afternoon, then clearing, wind in evening with rain at night
17-Aug	8:00	11	6	18	rain in early morning then sun and cloud
18-Aug	8:00	11	4	16	clear in morning then rain in mid-day and evening
19-Aug	8:00	11	5	18	cloudy all day with rain in afternoon and evening
20-Aug	8:00				cloudy in morning

Appendix 6 (a). Age, sex, and length of sampled Chinook on the Big Salmon River, 2016.

DATE	FISH #	SEX	% Spawned (Females)	FL (mm)	MEF (mm)	POHL (mm)	AGE*	Recovery Site
7-Aug	1	F	100	87.0	80.0	69.5	1.4	CAMP
15-Aug	2	M		98.5	88.0	76.0	1.4	1
15-Aug	3	F	100	99.5	89.5	80.0	1.3	1
15-Aug	4	M		84.0	74.5	64.5	M3	1
15-Aug	5	M		83.0	73.0	62.5	1.3	1
15-Aug	6	M		77.0	68.5	60.0	1.3	1
15-Aug	7	F	100	84.0	77.0	65.5	M4	1
15-Aug	8	M		78.5	71.5	62.0	1.3	1
15-Aug	9	F	100	98.0	88.5	79.0	1.4	1
15-Aug	10	M		73.5	65.5	57.5	1F	1
11-Aug	11	F	100	NM	NM	NM	1F	CAMP
11-Aug	12	F	100	94.0	85.0	75.5	1.3	CAMP
11-Aug	13	F	100	83.0	75.5	64.0	no age	CAMP
11-Aug	14	M		70.0	62.0	54.5	1.3	CAMP
21-Aug	15	F	50	86.0	78.0	69.5	1.4	2
21-Aug	16	M		82.5	73.0	64.5	1.3	2
21-Aug	17	F	100	89.5	81.0	72.5	1.4	2
21-Aug	18	M		93.5	83.0	72.5	1.3	2
21-Aug	19	M		65.5	59.0	51.5	1.3	2
21-Aug	20	F	100	89.0	81.5	72.5	M4	2
16-Aug	21	M		113.0	99.0	86.0	1.5	2
16-Aug	22	F	100	92.0	84.5	75.0	1.4	2
16-Aug	23	F	100	96.0	88.0	77.5	1.5	2
16-Aug	24	F	100	89.5	81.0	71.0	1F	2
16-Aug	25	F	100	92.0	84.0	74.0	1.4	2
16-Aug	26	M		70.0	62.5	53.0	1.3	2
21-Aug	27	F	100	91.5	84.0	74.0	1.4	2
21-Aug	28	F	100	88.5	79.5	70.5	1.3	2
22-Aug	29	M		108.0	93.5	83.0	1.4	2
22-Aug	30	M		95.5	83.5	74.0	M3	2
22-Aug	31	F	100	84.5	76.5	67.5	1.3	2
22-Aug	32	F	100	94.0	85.0	75.5	1.4	2
22-Aug	33	F	50	80.0	73.5	64.5	1.3	2
22-Aug	34	M		75.5	67.0	59.0	1.3	2
22-Aug	35	F	0	83.5	75.5	66.5	no age	2
22-Aug	36	F	100	86.5	80.0	72.0	1.4	2
22-Aug	37	F	100	93.5	85.5	76.0	1.4	3
22-Aug	38	M		73.5	66.0	57.0	1.3	3
22-Aug	39	M		74.0	66.0	58.5	no age	3
22-Aug	40	F	100	90.0	82.0	73.0	1.4	3
22-Aug	41	F	100	96.0	88.0	78.5	1.4	3
22-Aug	42	F	100	91.5	83.5	75.0	1.4	3
22-Aug	43	F	100	91.5	83.0	72.5	1.3	3
22-Aug	44	F	100	92.5	83.5	76.5	no age	3
22-Aug	45	F	100	95.0	87.0	77.0	1.4	3
22-Aug	46	M		84.5	75.0	64.0	1.3	3
22-Aug	47	F	50	92.0	84.0	74.5	1.4	3
22-Aug	48	F	100	90.0	81.5	73.0	1.4	3
22-Aug	49	F	100	88.0	79.5	70.0	1.3	3
22-Aug	50	F	100	101.0	92.0	82.5	1.4	3

DATE	FISH #	SEX	% Spawned (Females)	FL (mm)	MEF (mm)	POHL (mm)	AGE*	Recovery Site
22-Aug	51	M		66.5	59.5	52.5	1.1	3
22-Aug	52	F	100	85.5	78.0	70.0	1.4	3
22-Aug	53	M		77.5	68.5	60.0	1.2	3
22-Aug	54	F	100	85.0	78.0	69.5	1.4	3
22-Aug	55	F	100	92.5	84.0	74.5	1.4	3
22-Aug	56	F	100	97.5	90.0	79.0	1.4	4
22-Aug	57	F	100	94.5	85.0	75.0	1.4	4
22-Aug	58	F	100	91.5	83.0	73.5	1F	4
22-Aug	59	F	100	82.0	75.0	66.5	1.4	4
22-Aug	60	F	0	88.0	80.5	71.0	1.3	4
23-Aug	61	M		60.0	54.5	47.5	1F	5
23-Aug	62	M		79.0	70.0	61.0	1.3	5
23-Aug	63	M		113.5	99.5	85.0	1.4	5
23-Aug	64	M		63.5	57.0	50.5	1.1	5
23-Aug	65	M		76.5	69.0	60.0	1.3	5
23-Aug	66	M		96.0	85.0	73.0	1.3	5
23-Aug	67	F	N/A	95.0	85.5	75.0	1.4	5
23-Aug	68	F	100	92.5	84.0	73.5	1.3	5
23-Aug	69	M		97.0	86.0	74.0	1.4	5
23-Aug	70	F	100	87.0	79.0	70.0	1.3	5
23-Aug	71	F	100	86.0	78.0	69.5	1.4	5
23-Aug	72	M		71.0	64.0	56.0	1.3	5
23-Aug	73	F	100	84.0	71.0	67.5	M3	5
23-Aug	74	F	100	98.5	89.5	79.0	1.4	5
23-Aug	75	F	100	90.0	83.0	73.0	M4	5
23-Aug	76	F	N/A	93.0	84.5	75.0	1.4	5
23-Aug	77	M		86.0	77.0	69.0	1.3	5
23-Aug	78	F	100	92.5	86.0	75.0	1.4	6
23-Aug	79	M		110.5	95.5	85.0	1.4	6
23-Aug	80	M		95.5	84.5	74.0	1.3	6
23-Aug	81	F	N/A	90.0	82.0	73.5	1.4	6
23-Aug	82	F	N/A	98.0	90.5	80.0	1.4	6
23-Aug	83	F	100	92.0	84.0	74.5	1.4	6
23-Aug	84	M		103.0	92.0	80.0	M4	6
23-Aug	85	F	100	88.0	80.0	71.5	1.4	6
23-Aug	86	M		95.0	84.0	73.0	1.4	6
23-Aug	87	F	100	89.0	81.0	70.5	1.3	6
23-Aug	88	F	100	94.0	85.5	75.5	1F	6
23-Aug	89	M		99.0	87.5	76.5	1.3	6
23-Aug	90	F	100	96.5	89.0	77.5	1.4	6
23-Aug	91	F	100	86.5	78.5	70.5	1.4	6
23-Aug	92	M		100.5	88.0	77.0	1.4	6
23-Aug	93	M		81.5	72.5	63.0	1.3	6
23-Aug	94	F	100	93.0	85.0	75.0	1.4	7
23-Aug	95	F	100	89.0	79.5	68.5	1.4	7
23-Aug	96	F	100	97.5	89.0	79.5	1.3	7
23-Aug	97	F	N/A	97.5	89.0	78.5	1.4	7
23-Aug	98	F	100	101.5	92.5	82.5	1.3	7
23-Aug	99	F	100	93.0	85.0	79.5	1F	7
23-Aug	100	F	100	97.5	89.5	78.5	1.4	7

DATE	FISH #	SEX	% Spawned (Females)	FL (mm)	MEF (mm)	POHL (mm)	AGE*	Recovery Site
23-Aug	101	F	100	78.5	72.5	63.0	1.3	7
23-Aug	102	F	100	90.5	82.0	72.0	1.4	7
23-Aug	103	F	100	96.0	87.5	78.5	1.4	7
23-Aug	104	F	100	86.5	78.0	69.0	1.3	7
23-Aug	105	F	100	88.5	80.5	71.5	1.4	7
23-Aug	106	F	100	99.5	89.0	79.0	M4	7
24-Aug	107	F	N/A	90.5	82.0	72.5	1.3	8
24-Aug	108	F	100	88.0	80.0	70.5	1.3	8
24-Aug	109	F	100	98.0	89.5	79.0	1.4	8
24-Aug	110	F	N/A	94.0	87.5	76.5	1.4	8
24-Aug	111	M		74.0	66.5	59.0	NA	8
24-Aug	112	F	100	98.0	89.0	79.0	1.4	8
24-Aug	113	M		82.5	73.5	64.5	1.4	8
24-Aug	114	F	N/A	96.5	88.0	78.5	M4	8
24-Aug	115	M		86.0	76.0	66.0	1.3	8
24-Aug	116	F	N/A	99.0	91.0	80.0	1.4	8
24-Aug	117	M		111.5	96.0	84.0	1F	8
24-Aug	118	F	N/A	81.5	74.0	66.0	1.3	8
24-Aug	119	M		104.0	90.0	78.5	M4	8
24-Aug	120	M		66.0	60.0	52.5	1.3	8
24-Aug	121	M		77.5	69.0	61.0	1.3	8
24-Aug	122	M		77.5	69.0	60.0	1.3	8
24-Aug	123	F	100	91.5	84.5	74.0	M3	8
24-Aug	124	F	100	98.0	89.5	78.5	1.4	8
24-Aug	125	M		78.5	69.5	61.0	1.3	8
24-Aug	126	M		96.5	83.5	73.0	1F	8
24-Aug	127	M		89.0	79.0	69.5	1.3	8
24-Aug	128	M		106.5	94.0	81.5	1F	9
24-Aug	129	M		79.5	71.5	64.0	M3	9
25-Aug	130	M		90.0	80.0	69.5	1F	10
25-Aug	131	F	100	86.5	78.0	69.5	1F	10
25-Aug	132	M		76.5	68.5	58.5	1.3	10
25-Aug	133	F	N/A	94.0	86.0	76.0	1.3	10
25-Aug	134	F	N/A	89.5	82.0	73.5	1.4	10
25-Aug	135	F	100	81.5	74.5	65.5	1.3	10
25-Aug	136	M		73.5	65.0	57.0	1.1	10

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

No age = scales regenerate (center is missing from scale) or resorbed (growth at scale margin is missing)

M = Marine stage

F = Freshwater stage

N/A = Partially decomposed or consumed, no assessment.

NM = no measurement obtained due to partial decomposition

Appendix 6 (b). Primary locations of sampled carcasses and moribund fish recovered on the Big Salmon River, 2016.

Recovery Site	* GPS Coordinates
1	N 61° 45' 44.7"
	W 134° 36' 57.4"
2	N 61° 39' 29.9"
	W 134° 31' 14.3"
3	N 61° 37' 50.7"
	W 134° 29' 29.7"
4	N 61° 36' 23.8"
	W 134° 26' 26.8"
5	N 61° 32' 58.8"
	W 134° 10' 01.1"
6	N 61° 31' 52.9"
	W 133° 56' 12.6"
7	N 61° 31' 58.6"
	W 133° 55' 29.6"
8	N 61° 36' 14.0"
	W 133° 48' 01.4"
9	N 61° 35' 57.5"
	W 133° 42' 38.3"
10	N 61° 52' 43.4"
	W 134° 53' 24.5"

Appendix 7. Estimated proportion of Big Salmon River Chinook and Yukon River Chinook border escapement, 2002 through 2015.

Year	Method	Estimated % proportion of border escapement based on telemetry or GSI sampling	Big Salmon sonar count	Border escapement based on Eagle sonar count or mark/recapture	Border escapement ^d 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
2013	Gillnet GSI Sampling	6.6	3,239	28,669	49,136
2014	Gillnet GSI Sampling	2.4	6,321	63,331	263,375
2015	Gillnet GSI Sampling	9.7	10,078	82,674	103,896
2016	Gillnet GSI Sampling	9.0	6,762	68,798	75,122
Mean		11.3	4,770	45,422	61,757
Std. Dev.		3	2,278	15,259	65,681

^a Eagle sonar above border spawning escapement estimate (DFO Whitehorse, unpublished data).

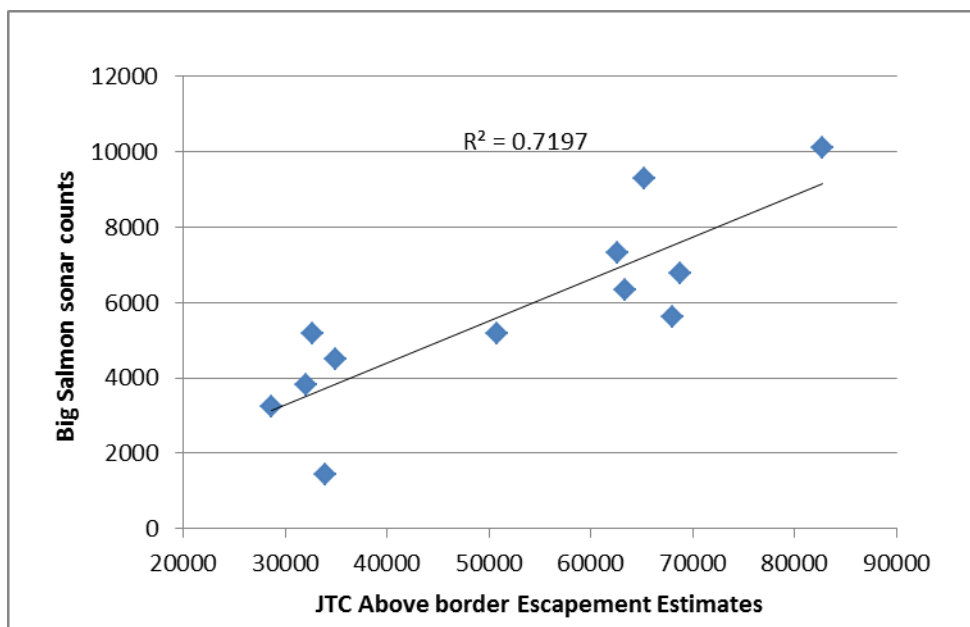
^b Eagle sonar estimate (JTC 2012 and Unpublished DFO Whitehorse data).

^c Mark/recapture estimate (JTC 2012).

^d Point estimate

Sources: Osborne et al. 2003; Mercer and Eiler 2004; Mercer 2005; JTC reports 2005 through 2012; unpublished DFO Whitehorse data.

Appendix 8. Big Salmon sonar counts and the JTC above border escapement estimates based on Eagle sonar counts, 2005 – 2016.



Appendix 9. Big Salmon Chinook sonar counts and Big Salmon Chinook escapement estimates based on Eagle sonar counts and GSI data, 2005 – 2015.

