2006 CHINOOK SALMON SONAR ENUMERATION ON THE BIG SALMON RIVER

CRE-41-06

Prepared For: The Yukon River Panel
Restoration and Enhancement Fund

Prepared By: B. Mercer and J.K. Wilson

J. Wilson & Associates
Box 20263
Whitehorse, Yukon
Y1A 7A2

February, 2007

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

ABSTRACT

A long range dual frequency identification sonar (DIDSON-LR) was used to enumerate the chinook salmon escapement to the Big Salmon River in 2006, as well as determine associated run timing, and diel migration patterns. This was the second year of sonar operation at this site. The sonar site was located on the Big Salmon River at the same location as in 2005, approximately 1.5 km upstream of the confluence with the Yukon River. Partial weirs placed on both sides of the river were used to restrict fish passage through a 34 m opening. The sonar was configured to provide a 29º conical ensonified field, 40 m wide that covered the water column within the fish passage opening.

A total of 7,308 (7,298 counted plus 10 extrapolated) targets identified as chinook salmon was counted past the sonar station between July 15 and August 23, 2006. A peak daily migration of 496 fish occurred on August 5, and 90% of the run had passed the station on August 12. The cumulative daily run pattern exhibited a normal distribution. The 2006 run timing was approximately 3 days later than was observed in 2005.

The 2006 Big Salmon sonar project, as in the previous year, demonstrated that the DIDSON-LR sonar unit could produce observable images of fish swimming through the ensonified field at distances up to 40 m. At ranges >20 m, however, the resolution of target images was poor and the relative size of the targets beyond this distance could only be determined qualitatively. The results indicated that migrating chinook salmon were readily distinguishable from resident fish species by the relative size of the image and difference in swimming behaviour. The fish images produced total counts that correlated well with past chinook salmon passage data from the Big Salmon River and were concordant with the 2006 DFO derived upper Yukon River chinook escapement estimates.

A carcass pitch was conducted over the total length of the Big Salmon River that yielded 234 chinook carcasses. Each carcass was sexed, and sampled for age determination, size and DNA analysis. Spaghetti tags were retrieved and the date of retrieval and tag number recorded. Of the 234 fish sampled, 110 (47%) were male and 124 (53%) were female. The mean fork length of males and females sampled was 825 mm and 891 mm, respectively. Ninety percent of the sampled fish were from the 1-3 and 1-4 age classes. A total of 5 spaghetti tags was collected.

INTRODUCTION

The use of the DIDSON (**D**ual frequency **ID**entification **SON**ar) sonar technology is becoming a widely accepted tool for enumerating salmon populations Since its development at the Applied Physics Laboratory at the University of Washington in 2002, it quickly became apparent that the DIDSON technology was suited for many applications including the detection of migrating salmon. It was found that the DIDSON apparatus exceeded expectations in this role and was thought to be superior to both the Bendix dual beam and Hydroacoustics Technology Inc. (HTI) split beam systems for most applications aimed at enumerating migrating salmon (Galbreath and Barber 2005, Holmes et al. 2005, Maxwell et al. 2004). The DIDSON units were found to be reliable, require a minimum of operator training, and provide accurate counts of migrating salmon (Holmes et al. 2006).

Based on chinook telemetry studies, annual DFO aerial index counts, and the 2005 Big Salmon sonar enumeration project, the Big Salmon River has been demonstrated to be a significant contributor to upper Yukon River chinook production. During three years of telemetry studies from 2002 through 2004, this system accounted for 9.2%, 10.4 % and 16.4% of the radio tags located in the upper Yukon River drainage[1] (Mercer 2005, Mercer and Eiler 2004, Osborne et al. 2003). Spawning escapement estimates into the Big Salmon River drainage, based on the three consecutive years of telemetry results, were 2,014, 13,126, and 4,224, respectively. In 2005, the Big Salmon River sonar count was 5,618, approximately 18% of the total upper Yukon River spawning escapement point estimate in 2005 (JTC 2006).

Yukon River chinook are harvested in subsistence, First Nation, sport, and commercial fisheries in both Alaska and Canada. Obtaining accurate estimates of spawning escapements is required for the proper management of the Yukon River chinook stocks. As the Big Salmon River stock contributes a significant share of the total upper Yukon River chinook escapement, accurate counts of chinook entering the drainage can provide a valuable index for the estimation of the total annual upper Yukon River chinook escapement.

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

A proposal to install and operate a DIDSON sonar station on the Big Salmon River for a second year, as well as conduct a chinook carcass pitch on the system was submitted by J.

[1] This is the proportional distribution of radio tags entering the Big Salmon River that had passed the telemetry stations at the Canada/U.S. border. In this report the upper Yukon River refers to the portion of the Yukon River drainage within Canada, excluding the Porcupine River system.

Wilson and Associates to the Yukon River Panel Restoration and Enhancement (R&E) fund in January 2006. The proposal was accepted and financial support received from the R&E fund.

Study Area

The Big Salmon River flows in a north-westerly direction from its headwaters at the Quiet and Big Salmon lakes chain to its confluence with the Yukon River (Figure 1). The river and its tributaries drain an area of approximately 6,760 km^2, predominantly from the Big Salmon Range of the Pelly Mountains. Major tributaries of the Big Salmon River include the North Big Salmon River and the South Big Salmon River. The Big Salmon River can be accessed by boat from Quiet Lake along the Canol Road, from the Yukon River on the Robert Campbell and Klondike Highways, or from Lake Laberge via the 30 Mile and Yukon rivers.

Objectives

The objectives of the 2006 Big Salmon River sonar project were:

1. To re-establish a field camp on the Big Salmon River at the location used in 2005.
2. To construct two partial weirs to constrict the passage of migrating chinook to a 30 m opening.
3. To set up a DIDSON-LR sonar unit to enumerate chinook salmon migrating upstream through the opening and obtain information on run timing and diel migration patterns.
4. To conduct a chinook salmon carcass sampling pitch throughout the Big Salmon River system to obtain information on the age, sex and size structure of the run, retrieve spaghetti tags and obtain tissue samples for DNA analysis

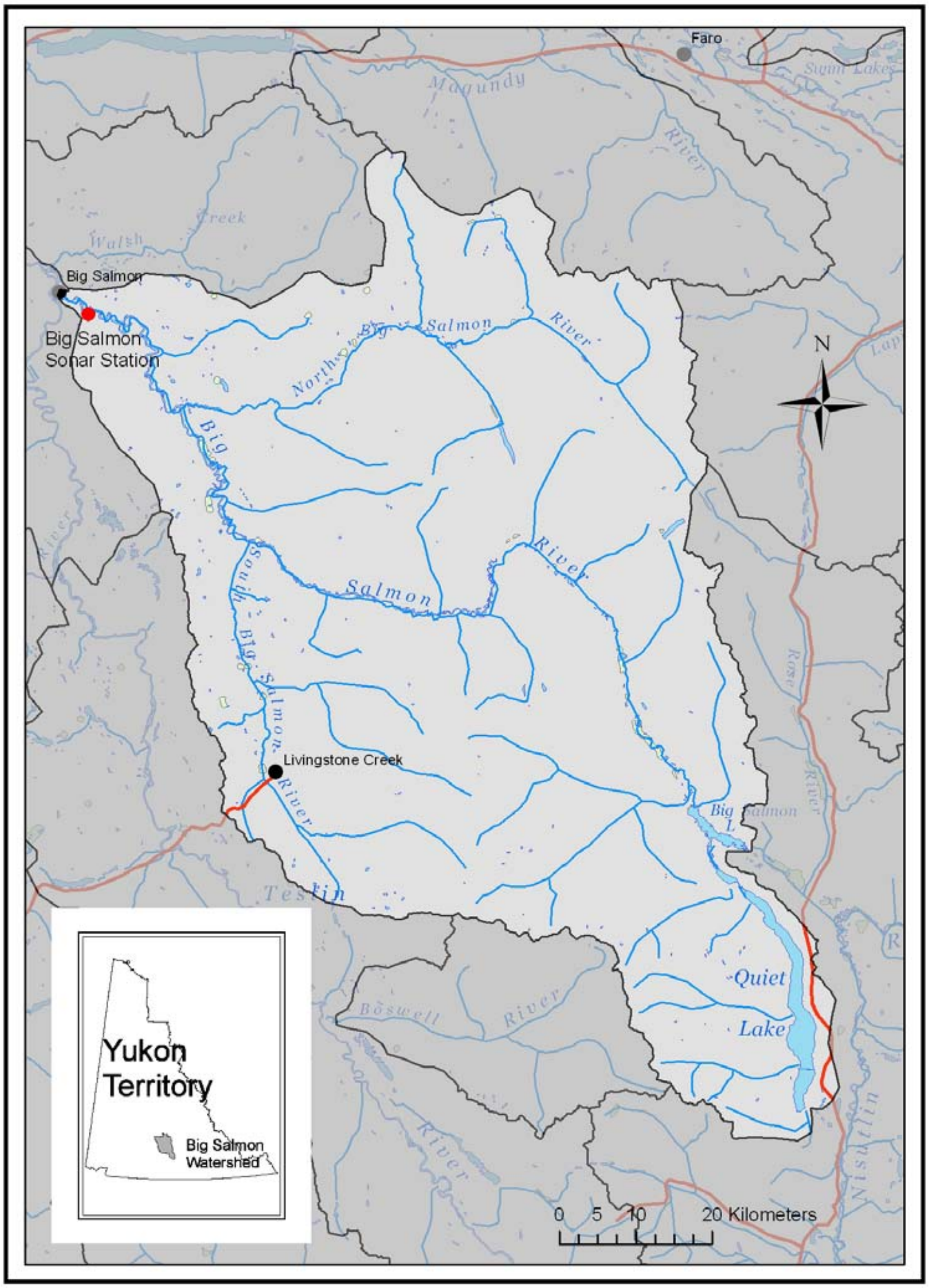

Figure 1. Big Salmon River Watershed and location of the 2006 Big Salmon sonar station.

METHODS

Site selection

The site utilized in 2005 was considered to be the optimal location for the sonar station in 2006. This site, located approximately 1.5 km upstream from the confluence with the Yukon River (Figure 1), was retained for the following reasons:

- It was a sufficient distance upstream of the mouth to avoid straying UpperYukon/Teslin River chinook.
- The site was 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 would have a clear view of the in-stream structures.
- The flow was laminar and swift enough to preclude milling or ‘holding’ behaviour by migrating fish.
- Bottom substrates consisted of gravel and cobble evenly distributed along the width of the river.
- The stream bottom profile would allow for complete ensonification of the water column.
- There was the existing campsite located on the south bank where wall tent frames were already constructed within close proximity to the sonar set-up.
- The site was accessible by boat and floatplane.

Camp and Sonar Station setup

An application was submitted to Yukon Energy, Mines & Resources, Lands Branch, for a land use permit to establish the sonar camp on the lower Big Salmon River in 2005. A permit was granted for use in 2005 and 2006 with the option of renewal for one more year. If the project continues beyond 2007 at this site a permanent land use lease will be required. Approval was also granted by the Whitehorse District Forestry office to cut and remove timber on Territorial lands for the purposes of clearing and the use of fuel wood.

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

Construction of the camp and sonar station was initiated on July 10. Materials for the camp, equipment, sonar apparatus, and additions to the existing diversion fence were transported from Whitehorse to Carmacks. These were then transported to the sonar site by riverboat and floatplane. Subsequent camp access, crew changes, and delivery of supplies was also accomplished via riverboat and supplemented by floatplane from Whitehorse.

As in 2005, the camp was comprised of two wall tents: one to house a kitchen/eating area and computer station and another for sleeping quarters. The kitchen and computer station was located 6 m from the south bank of the river and constructed using a 5m x 5m "weatherall" free standing wall tent placed on a plywood platform. The sleeping quarters was situated 70 m from the shore and constructed using a 14' X 16' canvas wall tent placed on a plywood platform and wooden frame (Figure 3).

Two diversion fences were constructed on opposite sides of the river to divert shoreline migrating chinook salmon through the ensonified area (Figures 2 and 3). The diversion fences were constructed using prefabricated panels of electrical conduit. Tripods and stringers from the 2005 project were re-used and additional tripods were constructed on-site in 2006 using locally cut tree poles and 8" spikes. The diversion fence on the north bank was extended into the shallower reaches using "vexar" plastic mesh that was anchored with rebar driven into the stream bottom. The upper margin of the "vexar" was fastened to 2-inch PVC pipe to provide flotation and create a fence that self adjusted to fluctuating water levels. The south bank fence extended approximately 7 m from the bank and the north bank fence approximately 25 m from the bank providing a 34 m opening for fish passage. Light activated flashing beacon lights were secured to each diversion fence to mark the in-stream extent of weirs. A warning sign was also posted 200 m upstream of the station to alert boaters of the partial obstruction ahead in accordance with Transport Canada, Navigable Waters Protection requirements.

Figure 2. Partial weirs and 34 m opening for fish passage viewed from the south bank.

Figure 3. Aerial view of sonar station camp and partial weirs.

Sonar and computer software configuration

The configuration of the DIDSON sonar unit was similar to that used in 2005. The unit was mounted on an adjustable stand constructed of 2-inch steel galvanized pipe similar in design to those used at other DIDSON sonar projects (Galbreath and Barber 2005). The stand consisted of two T-shaped legs 120 cm in height connected by a 90 cm crossbar (Figure 4). The sonar unit was bolted to a steel plate suspended from the cross bar that was connected to the stand with adjustable fittings (Kee Klamps™). The adjustable clamps allowed the sonar unit to be raised or lowered according to fluctuating water levels as well as rotation of the transducer lens to adjust the beam angle.

Figure 4. Sonar unit and stand in position.

The mounted sonar unit and stand was placed next to the south bank immediately upstream of the diversion fence in approximately 0.7 m of water (Figure 5). The “feet” of the stand were secured to the stream bottom using sandbags. A 6 mm stainless steel safety cable was affixed to the sonar unit and fastened to a buried anchor onshore.

Figure 5. Sonar unit and stand in position.

The DIDSON transducer lens was positioned to a depth of approximately 12 cm below the surface of the river. The angle of the sonar beam was set at approximately -4° which resulted in the entire length of the upper edge of the ensonified cone of water remaining parallel to the surface of the river (Figure 6). If the transducer angle was set higher reflections from surface turbulence would produce interference in the sonar recordings.

Once the sonar was in place and properly positioned, the primary sonar unit settings and software were configured. These settings included the window start length, the ensonified window length, and the frame rate. As occurred in 2005, the receiver gain was set at –40 dB, the window start at 5.86 m, window length at 40 m, and auto frequency enabled for the duration of the project. Threshold settings were set at 3 dB and intensity at 40 dB. The recording frame rate was typically set at 4 frames per second, which was the highest frame rate the computers could process with a window length setting of 40 m. Two Toshiba laptop computers were used for the project, one recording the DIDSON files and one for reviewing the files.

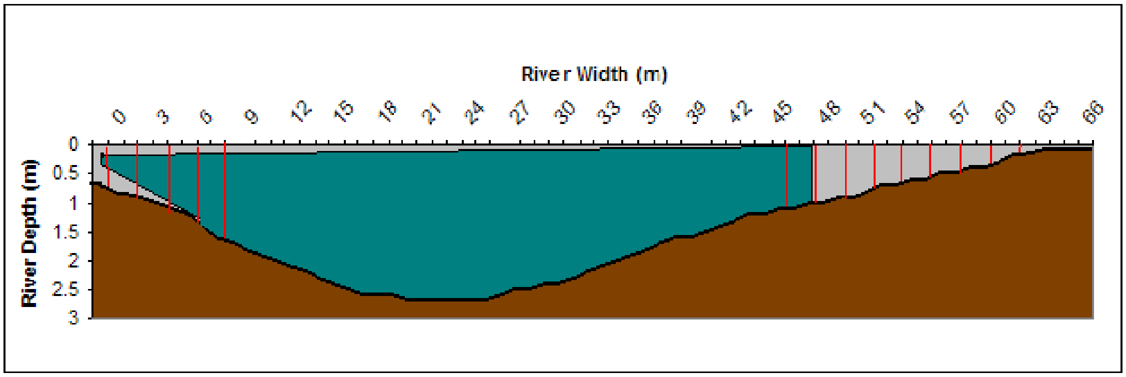

Figure 6. Schematic diagram of river profile and sonar and weir configuration.
Red bars denote weir structures and blue the ensonified portion of the water column.
Note: Vertical scale is exaggerated.

The sonar system was powered by 6 gel cell batteries connected in two parallel circuits to create a 12 volt power source. The battery bank was charged by 4 solar panels and a backup 2.4 kw generator. An 800 watt inverter was used to obtain 110 volt AC from the batteries to supply power for the computers and the sonar unit. The battery bank, solar panels and tower components used for this project were retrieved from a DFO telemetry tower located near Hootalinqua on the 30 Mile River. Two additional solar panels that were surplus from past telemetry projects were obtained from DFO Whitehorse.

After completing the setup of the apparatus on August 14, the range of the sonar as well as the target identification capability was tested by dragging objects beneath a boat across the ensonified portion of the river.

Sonar data collection

As occurred in 2005, the sonar data was collected continuously and stored automatically in pre-programmed 20 minute files each specifying time and date. This resulted in an accumulation of 72 files over a 24 hour period. These files were subsequently reviewed the following morning and stored on the active PC as well as backed up on an external hard drive. All files collected from the project were archived on external hard drives.

To optimize target detection during file review, the background subtraction feature was used to remove static images such as the river bottom and weir structures. The intensity (brightness) was set at 40 dB and threshold (sensitivity) at 3dB. The playback speed depended on the preference and experience of the observer, but was generally set between 30 and 40 frames per second, approximately 8 to 10 times the recording rate. This allowed observers to quickly review files, particularly during long periods when no targets were observed. When necessary, the recording was stopped when a fish was observed and replayed at a slower rate for positive identification. The target measurement feature of the DIDSON software was used to estimate the size of the observed fish. The minimum size used to identify chinook was 55 cm, although there was a certain amount of subjective interpretation regarding identification and categorization of the smaller fish. Typically resident fish species exhibited markedly different behaviour than the migrating chinook. The subjective interpretation of target identity is discussed in further detail below. Chinook images were visually counted using a hand counter and the total count from each file was entered into an excel spreadsheet. Fish identified as chinook moving downstream were subtracted from the file total. A record of each 20 minute file as well as hourly, daily and cumulative counts was maintained throughout the run.

Carcass Pitch

Chinook carcass sampling was conducted throughout the total length of the Big Salmon River from Quiet Lake to the confluence of the Yukon River over the period August 24 through September 1, 2006. In addition, approximately 10 km of the lower reaches of the North Big Salmon River were surveyed for carcasses on the first trip. Low water conditions and the steep gradient prevented access to the upper reaches of the North Big Salmon River. Access to the system was gained using an open 5 m skiff powered by a 60 hp outboard jet motor. Each round trip took approximately 4 days to complete.

In addition to dead chinook found on the stream banks and in back eddies, post-spawn moribund fish were collected using a barbed spear on a 3m extension pole. Carcass sampling consisted of collecting five scales per fish placed in prescribed scale cards, noting presence of spaghetti tags, recording sex and post-orbital hypural and lengths (to the nearest 0.5cm). Opercula tissue samples were also obtained from each carcass and preserved in a fixative of 95% ethanol for future DNA analysis.

RESULTS

Chinook Counts and Run Timing

Scheduled 24 hr recording began on July 15 at 18:00. The first chinook was observed at 23:00 on July 15. A total of 7,308 targets identified as chinook salmon was counted past the sonar station from July 15 through to August 23 (Appendix 1). A total of 6 chinook was counted during the first 12 hours of sonar recordings on August 23 before terminating sonar operations. The count for August 23 was extrapolated to 12 to provide an estimate for the total day. Since the sonar was removed before the run was entirely complete, daily counts after the sonar was removed were extrapolated. The extrapolated count was estimated using a polynomial regression ($y = 0.8011x^2 - 25.841x + 187.31$) based on the previous 9 daily counts. Based on the extrapolation, the run would have continued until August 24 with an additional 10 fish, bringing the season total to 7,308. The decline in the latter part of the run appeared to be steeper than was apparent in 2005. However, had the sonar been operating for a few days longer it is possible the decline would not have been as marked.

The peak daily count of 496 fish occurred on August 5 at which time 50% of the run had passed the sonar station. By August 14, 90% of the run had passed. The cumulative daily run pattern exhibited the same normal distribution as occurred in 2005. The run timing, however, was approximately 3 days later relative to the run timing in 2005 (Figures 7 and 8). In 2005, 50% of the run had passed the station by August 2 and 90% by August 12.

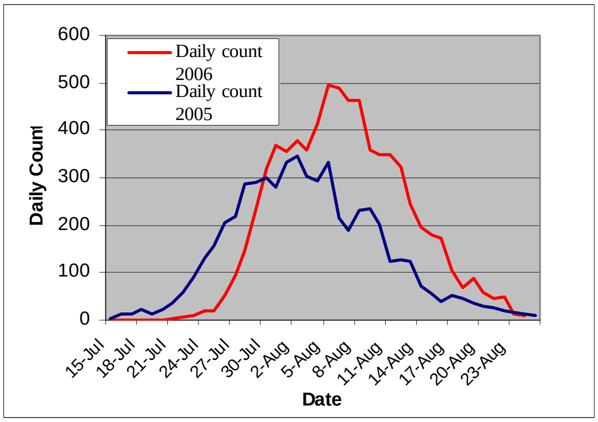

Figure 7. Daily count of chinook salmon counted at the Big Salmon River sonar station in 2005 and 2006.

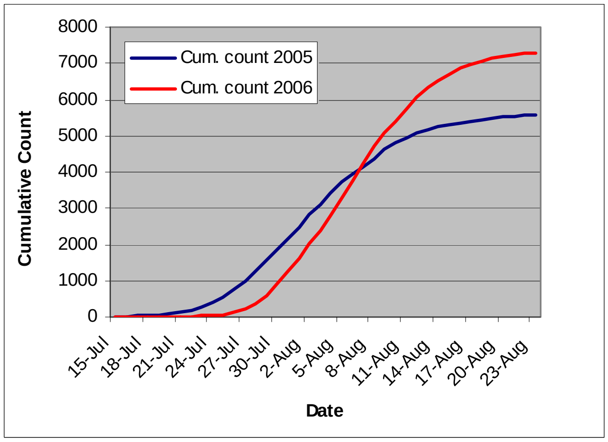

Figure 8. Cumulative count of chinook salmon counted at the Big Salmon River sonar station in 2005 and 2006.

Diel Migration

There was no significant diel migration pattern observed in the chinook migration in the Big Salmon River. (Single factor ANOVA, tested for homogeneity of variance: df=23, F=0.35, α=0.05, p=0.99). This was similar to the findings in 2005 (Figure 9). Diel migration patterns have been recorded at other sonar and fish enumeration projects (Galbreath and Barber, 2005). The lack of diel migration patterns by Yukon River chinook may be due to the long distances traveled and high daily travel rates. Yukon

River chinook have some of the highest daily migration rates recorded for chinook salmon (Spencer et al. 2002). The determination of a diel migration pattern in the Big Salmon River will likely require several years of data.

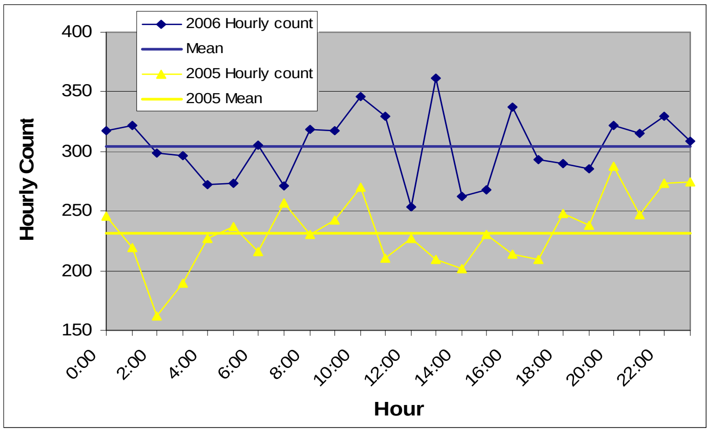

Figure 9. Total hourly counts of chinook salmon passing the Big Salmon River sonar station in 2005 and 2006.

Carcass Pitch

A total of 234 chinook salmon carcasses was retrieved and sampled on the Big Salmon River during the period August 25 through September 1, 2006. The results of the carcass sampling are detailed in Appendix 2.

Of the 234 fish sampled, 110 (47%) were male and 124 (53%) were female. The mean fork length of the males and females sampled was 825 mm and 891 mm, respectively. Ninety percent of the sampled fish were comprised of 1·3 and 1·4 age classes. Males represented the highest proportion of the 1·2 and 1·3 age classes, whereas females composed the majority of the 1·4 age class. The sex ratios and length data are summarised in Table 1 and Figure 11.

Five spaghetti tags were recovered during the carcass pitch, three of which were attached to carcasses. Two spaghetti tags were found lying loose on the bank near scavenged carcasses. The spaghetti tag numbers are listed in Appendix 3.

A total of 234 tissue samples was collected for DNA analysis and submitted to DFO Whitehorse.

Table 1. Size and age structure of Big Salmon River chinook carcasses sampled in 2006.

Sex	Age	Data	Total	% of Total
F	13	Count of Age	23	13%
		Average of FL (mm)	869	
	14	Count of Age	71	40%
		Average of FL (mm)	897	
	15	Count of Age	2	1%
		Average of FL (mm)	998	
F Count of Age			96	54%
F Average of FL (mm)			892	
M	12	Count of Age	12	7%
		Average of FL (mm)	602	
	13	Count of Age	49	28%
		Average of FL (mm)	810	
	14	Count of Age	19	11%
		Average of FL (mm)	989	
	15	Count of Age	2	1%
		Average of FL (mm)	949	
M Count of Age			82	46%
M Average of FL (mm)			825	
Total Count of Age			178	100%
Total Average of FL (mm)			861	

.

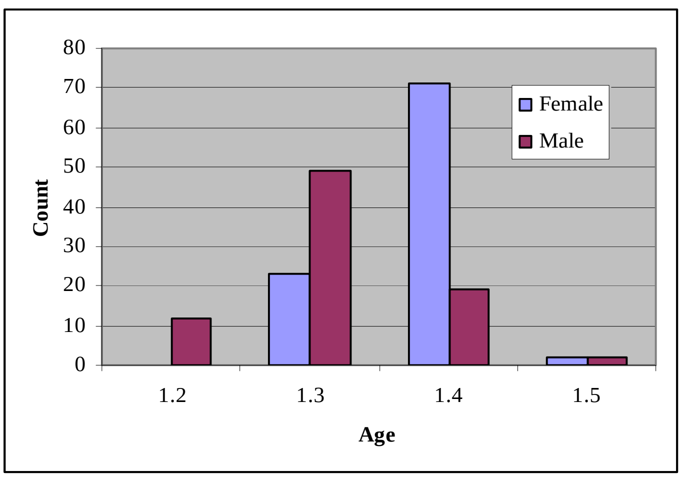

Figure 10. Age class structure of Big Salmon River chinook carcasses sampled in 2006.

DISCUSSION

The 2006 DFO mark recapture point estimate for the Canada/U.S. above border chinook escapement is 36,748 (P. Milligan, DFO Whitehorse, stock assessment biologist, per.

comm.). Based on this estimate, the 2006 Big Salmon sonar count of 7,308 would have represented 19.9% of the total Upper Yukon River 2006 spawning ground escapement. Using telemetry derived proportional distributions that ranged from 9.2% – 16.4% (Osborne et al. 2003, Mercer and Eiler 2004, Mercer 2005), the expanded total Canadian spawning ground escapement point estimate, based on the 2006 Big Salmon River sonar count, would range from 44,560 – 79,434.

Similar to the 2005 project results, there was a high degree of concordance between the 2006 Big Salmon River chinook sonar counts and the aggregate 2002 – 2004 passage of radio tagged chinook past the Big Salmon telemetry tower[2] (Mercer and Wilson 2006). Based on the radio tag passage during these years, the first and last tags passed the telemetry tower on July 19 and August 27, respectively. The peak passage was on July 31, and 90% of the radio tags had passed the tower by August 12. The 2006 chinook run was somewhat later than the aggregate radio tag timing with the peak of the run on August 5, although the timing when 90% had passed was the same (August 12) for the sonar count and the aggregate radio tag passage.

DFO, ADF&G and the USF&WS are in the process of developing a baseline genetic database for upper Yukon River chinook stocks. Genetic analysis of a representative sample of chinook salmon at the Canada/U.S. border could yield data regarding the proportional contribution of the Big Salmon River stock. This coupled with the Big Salmon River sonar counts could yield accurate total spawning escapement estimates for upper Yukon River chinook.

The veracity of the Big Salmon sonar counts was discussed in detail in the 2005 Big Salmon River sonar report (Mercer and Wilson 2005). It was postulated that the greatest likelihood of error would have been mis-identification of the smaller size classes of chinook. It is probable that some smaller chinook could have been mis-identified as resident species based on size alone. This would result in the total count being biased low. While the size determinant for chinook identification was set at 55cm there is a certain degree of subjective interpretation by the file readers regarding identification of fish in the size range between 40cm – 60cm (Figure 11). The low image resolution associated with the LR-DIDSON settings combined with the presence of chinook jacks less than 55cm suggest that some mis-identification of small chinook could have occurred. It is difficult to quantify the possible error, however it is probable the number of mis-identified small chinook is low. This statement is based on the assumption that the total number of jack chinook in the 2006 Big Salmon chinook run was relatively low based on the ratio (7%) of jack chinook (age class 1-2) that were obtained in the carcass pitch. The mean fork length of the sampled age 1-2 chinook was 60 mm with only 2 fish (<1%) less than 55 cm. The targets identified as resident fish were considerably smaller (approximately 20 - 40 cm) than the average chinook size and exhibited markedly different behaviour than migrating chinook. The resident fish tended to remain in the ensonified area for longer periods displaying random swimming movements often perpendicular to the flow. Those fish identified as chinook exhibited strong positive rheotaxis, traveling through the ensonified portion of the river quickly and lateral to the flow.

[2] The Big Salmon telemetry tower was located approximately 10 km upstream of the sonar station.

One complication encountered during the 2006 project was the presence of what was assumed to be a spawning pair of chinook in the mid-section of the river immediately upstream of the ensonified portion of the stream. These fish were first detected on August 15 and were visible sporadically for the next 7 days. Their presence made counting upstream moving fish somewhat more difficult as they tended to move in and out of the ensonified area. However, with the subtraction of chinook targets moving downstream it was thought that the counts during this period were an accurate reflection of the chinook that moved upstream. It was also noted that there was increased activity of smaller resident fish in association with the spawning pair.

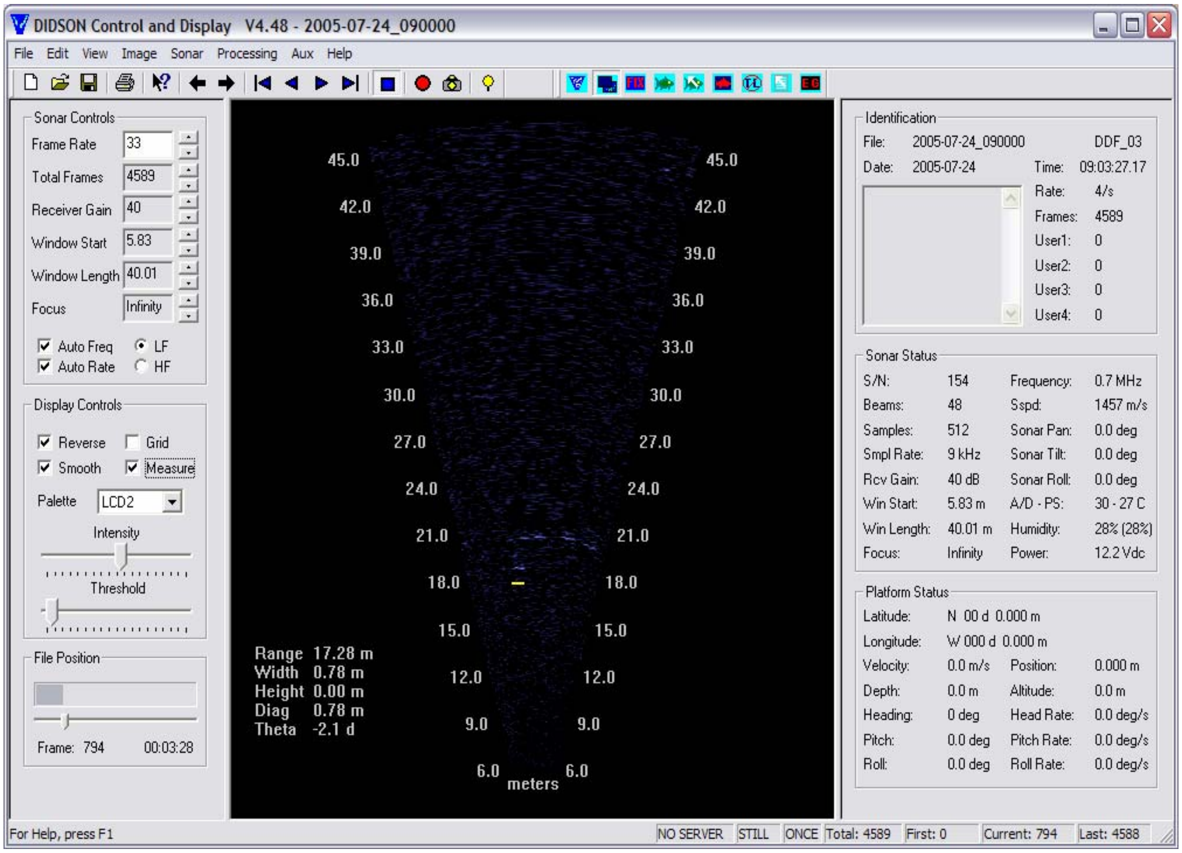

Figure 11. DIDSON display window illustrating sonar settings.
Note: Five Big Salmon River chinook salmon located between 18 m and 20 m within the ensonified field. The yellow bar below the closest fish denotes the estimated length of the target i.e. 0.78 m.

Based on previous assessments of the DIDSON-LR sonar unit and experimentation at the Big Salmon sonar site, it is known that the sonar unit is capable of detecting chinook size (and smaller) targets out to a range of 40m - 70m. Experiments in Lake Washington indicated the DIDSON-LR was capable of detecting 10 mm plastic spheres and 38 mm tungsten carbide spheres at a range of 60 m (Maxwell et al. 2004). Other experiments have shown strong corroboration between visual and DIDSON sonar counts (Galbreath and Barber 2005; Holmes et al. 2005 and 2006).

It is assumed that all chinook that passed through the ensonified area of the Big Salmon River were detected and counted. Results from both the 2005 and 2006 Big Salmon River sonar operations have shown a high concordance between observer counts. This was demonstrated by a random review of 20 sonar files from both the 2005 and 2006 Big Salmon River sonar operations. The independent blind counts demonstrated a 99% concordance with the counts in the archived files. In addition, the river bottom profile at the Big Salmon sonar site would not have resulted in sonic shadows or “blind areas”.

In 2005, it was recommended that efforts should be made to reduce the ensonified window length to 20 m in future projects at this site. When operated at HF the maximum window length setting is 20 m. The window start length can be set at 13 m which would allow high resolution viewing out to 33 m. Operating at HF would result in increased precision in estimating the size of the targets and theoretically increase the precision and confidence of the total chinook counts, particularly with regard to the smaller size classes. However, in order to reduce the window length to 20 m this year, the diversion weir would have to have been extended a further 15 m in-stream. The water levels encountered when the diversion fences were installed were too high to consider extending the fence on the south bank a further 15 m. The fence was extended approximately 3 m using additional fence materials transported to the site in 2006. Because of the river depth and velocity in the mid-section of the river, specialized fish weir structures (such as a resistance board weir) would have to be used and installed during low water conditions in May in order to extend the diversion fences beyond their current limit. Since there appears to be little ambiguity regarding species identification, however, the additional expense associated with installing a resistance board weir is not likely warranted.

As in 2005, the 2006 Big Salmon sonar project demonstrated that the DIDSON sonar unit produced observable images of fish swimming through the ensonified field at distances up to 40 m. These images produced total counts that correlated well with past fish passage data and the 2006 upper Yukon River chinook escapement estimates. The DIDSON sonar proved to be a low impact, non-intrusive method of enumerating the Big Salmon system chinook escapement while allowing unhindered passage for boaters and canoeists traveling the river.

Recommendations:

It is recommended that for future sonar projects at this site that:

1. It should be determined whether there are suitable weir materials that could be used to extend the fence at the current site and reduce the ensonified window length. These materials could possibly be retrieved from other R&E projects that are no longer in operation. Reducing the ensonified window length could allow for high resolution viewing and result in increased precision in estimating the size of the targets.

2. In the event that chinook salmon happen to spawn in close proximity to the ensonified area they should be removed from the area, if possible, by angling. The

3. Evidence from the 2006 carcass pitch on the Big Salmon River indicates that peak post-spawn mortality likely occurs around August 25. Future carcass pitches on the Big Salmon River should begin prior to August 25 and be conducted over the entire post-spawn mortality period in order to obtain a larger sample size and a sample set more representative of the run.

4. Arrangements should be made to have a fuel cache at Big Salmon Lake for use during the carcass pitch. This would eliminate the necessity to return to Carmacks for refueling and thereby economize on fuel usage.

REFERENCES

Galbreath, P.F. and P.E. Barber. Validation of a Long-Range Dual Frequency Identification Sonar for Fish Passage Enumeration in the Methow River. Unpublished report for the PSC Southern Fund project. 2005.

Holmes, J. A., Cronkite, G. M. W., Enzenhofer, H. J., and Mulligan, T. J. 2006. Accuracy and precision of fish-count data from a ''dual-frequency identification sonar'' (DIDSON) imaging system. ICES Journal of Marine Science, 63: 543e555.

Holmes, J.A., G.M.W. Cronkite, H.J. Enzenhofer, and T.J. Mulligan. Accuracy and Precision of Fish Count Data from a Dual Frequency Identification Sonar (DIDSON) Imaging System. 2005. Unpublished report for the PSC Southern Boundary Restoration and Enhancement Fund. 2005.

Joint Technical Committee (JTC) of the Yukon River US/Canada Panel. Draft Report, 2007. Yukon River Salmon 2006 Season Summary and 2007 Season Outlook. Fisheries and Oceans Canada, Stock Assessment and Fisheries Management Section, Yukon and Transboundary Area. Whitehorse, Yukon Territory.

Maxwell, S., D. Burwen, and C. Pfisterer. Testing the Range Limitations of the Long Range and Standard Versions of the Dual Frequency Identification Sonar (DIDSON). Draft report. Regional Information Report No. 2A04-XX April 2004.

Mercer B. and J. Wilson, 2006. 2005 Chinook Salmon sonar enumeration on the Big Salmon River. Unpublished report for Yukon River Panel RE project 41-05.

Mercer, B. and J Eiler, 2004. Distribution and Abundance of Radio Tagged Chinook Salmon in the Canadian Portion of the Yukon River Watershed as Determined by 2003 Aerial Telemetry Surveys. RE project 77-03, Yukon River Panel.

Mercer, B. 2005. Distribution and Abundance of Radio Tagged Chinook Salmon in the Canadian Portion of the Yukon River Watershed as Determined by 2004 Aerial Telemetry Surveys. RE project 77-04, Yukon River Panel.

Osborne, C.T., B. Mercer, and J.H. Eiler, 2003. Radio Telemetry Tracking of Chinook Salmon in the Canadian Portion of the Yukon River Watershed – 2002. RE project 78-02, Yukon River Panel.

Spencer, T.R., R.S. Chappel, J.H. Eiler, and T. Hamazaki. Estimation of Abundance and Distribution of Chinook Salmon in the Yukon River Using Mark-Recapture and Radio Telemetry in 2000 and 2001. ADF&G (Alaska Department of Fish and Game), 2002. Regional Information Report No. 3A02-37.

ACKNOWLEDGEMENTS

Several people contributed to the operational success of the 2006 Big Salmon River sonar project. Robert Gransden and Jim Mercer worked as technicians on the project and played an especially valuable role during camp construction and demobilization and freighting of materials. Ross Mercer ably provided riverboat pilotage and assisted with the carcass pitch sampling. Special acknowledgement is again due to Dawn and Don Marino of Carmacks for their support and storage of equipment.

Appendix 1. 2006 Big Salmon River sonar chinook counts and water conditions.

Date	Daily Count	Cumulative Count	Water Temp.	Relative Water Level
15-Jul	1	1	16.0°C	40cm
16-Jul	0	1	17.5°C	35cm
17-Jul	1	2	16.0°C	31cm
18-Jul	0	2	14.0°C	29cm
19-Jul	0	2	15.0°C	26cm
20-Jul	1	3	16.0°C	23cm
21-Jul	3	6	15.0°C	21cm
22-Jul	8	14	14.0°C	18cm
23-Jul	11	25	17.0°C	14cm
24-Jul	21	46	13.0°C	12cm
25-Jul	20	66	18.0°C	48cm
26-Jul	53	119	14.0°C	48cm
27-Jul	95	214	13.0°C	49cm
28-Jul	146	360	13.0°C	49cm
29-Jul	230	590	13.0°C	47cm
30-Jul	321	911	14.0°C	43cm
31-Jul	368	1279	12.0°C	41cm
01-Aug	357	1636	13.0°C	39cm
02-Aug	379	2015	14.0°C	40cm
03-Aug	358	2373	12.0°C	39cm
04-Aug	413	2786	8.0°C	37cm
05-Aug	496	3282	10.0°C	35cm
06-Aug	490	3772	10.0°C	35cm
07-Aug	464	4236	10.0°C	33cm
08-Aug	464	4700	11.5°C	33cm
09-Aug	360	5060	13.0°C	35cm
10-Aug	349	5409	11.0°C	33cm
11-Aug	348	5757	12.0°C	30cm
12-Aug	324	6081	11.0°C	30cm
13-Aug	243	6324	11.0°C	36cm
14-Aug	196	6520	08.5°C	37cm
15-Aug	180	6700	11.0°C	34cm
16-Aug	172	6872	14.0°C	32cm
17-Aug	104	6976	12.0°C	31cm
18-Aug	69	7045	12.0°C	34cm
19-Aug	87	7132	13.0°C	31cm
20-Aug	59	7191	16.0°C	29cm
21-Aug	45	7236	11.0°C	26.5cm
22-Aug	50	7286	11.0°C	24.5cm
23-Aug	12	7298	11.0°C	24.5cm
24-Aug	10	7308	n/a	n/a

Note: Shaded values were obtained through extrapolation of counts from previous 9 days.

Appendix 2. 2006 Big Salmon carcass pitch sampling results.

								European	Age
DATE	**FISH #**	**SEX**	**FL (mm)**	**POH (mm)**	**SCALE BOOK#**	**BOOK #**	**SCALE #**	**Age**	**Code**
25-Aug	1	F	833	679	51801	1	1-41	13	
	2	F	914	752	51801	1	2-42	14	
	3	F	902	729	51801	1	3-43	14	
	4	M	620	499	51801	1	4-44	12	
	5	M	784	628	51801	1	5-45	1F	RS
	6	F	912	722	51801	1	6-46	14	
	7	M	780	625	51801	1	7-47		RG
	8	F	903	727	51801	1	8-48	14	
	9	M	783	616	51801	1	9-49	13	
	10	M	811	624	51801	1	10-50	13	
	11	F	916	742	51802	2	1-41	1F	RS
	12	F	956	784	51802	2	2-42	14	
	13	M	1034	850	51802	2	3-43	13	
	14	F	840	881	51802	2	4-44	14	
	15	F	902	712	51802	2	5-45	14	
	16	F	897	726	51802	2	6-46	14	
	17	M	730	575	51802	2	7-47	13	
	18	M	698	550	51802	2	8-48	13	
	19	F	771	627	51802	2	9-49	M3	RG
	20	F	866	695	51802	2	10-50	14	
	21	F	927	764	51803	3	1-41		RG
	22	M	989	793	51803	3	2-42	14	
	23	M	848	662	51803	3	3-43	13	
	24	M	573	451	51803	3	4-44	12	
	25	F	832	687	51803	3	5-45	M4	RG
	26	F	891	718	51803	3	6-46	14	
	27	F	905	735	51803	3	7-47	M4	RG
	28	M	994	768	51803	3	8-48	14	
	29	F	874	704	51803	3	9-49	14	
	30	M	1097	841	51803	3	10-50	14	
	31	F	889	733	51804	4	1-41	14	
	32	F	841	687	51804	4	2-42	M4	RG
	33	M	971	774	51804	4	3-43	13	
	34	F	936	761	51804	4	4-44	14	
	35	F	896	742	51804	4	5-45	13	
	36	M	785	641	51804	4	6-46	13	
	37	M	838	666	51804	4	7-47		RG
	38	F	849	696	51804	4	8-48	14	
	39	F	988	824	51804	4	9-49	M4	RG
	40	F	810	642	51804	4	10-50	13	
	41	M	587	485	51805	5	1-41	13	
	42	M	635	499	51805	5	2-42	12	
	43	F	812	848	51805	5	3-43	13	
	44	M	867	690	51805	5	4-44	M3	W

								European	Age
DATE	**FISH #**	**SEX**	**FL (mm)**	**POH (mm)**	**SCALE BOOK#**	**BOOK #**	**SCALE #**	**Age**	**Code**
	45	M	1055	842	51805	5	5-45	M4	RG
	46	M	634	517	51805	5	6-46	12	
	47	M	754	607	51805	5	7-47	13	
	48	M	1022	831	51805	5	8-48	14	
	49	M	768	622	51805	5	9-49	13	
	50	M	985	791	51805	5	10-50	15	
25-Aug	51	M	1057		51806	6	1-41	M4	RG
	52	M	783		51806	6	2-42	1F	RS
	53	F	817		51806	6	3-43	13	
	54	F	1008		51806	6	4-44	1F	RS
	55	F	788		51806	6	5-45	14	
	56	M	824		51806	6	6-46	M3	RG
	57	M	1009		51806	6	7-47	14	
	58	M	896		51806	6	8-48	M4	RG
	59	F	957		51806	6	9-49	14	
	60	F	897		51806	6	10-50	M4	RG
	61	F	997		51807	7	1-41		RG
	62	M	664		51807	7	2-42	12	
	63	M	746		51807	7	3-43	13	
	64	M	765		51807	7	4-44	13	
26-Aug	65	M	800		51807	7	5-45	13	
	66	M	719		51807	7	6-46	M3	RG
	67	F	849		51807	7	7-47	14	
	68	M	757		51807	7	8-48	M3	RG
	69	F	860		51807	7	9-49	14	
	70	F	929		51807	7	10-50	14	
	71	F	948		51808	8	1-41	24	
	72	F	1018		51808	8	2-42	14	
	73	M	814		51808	8	3-43	13	
	74	M	694		51808	8	4-44	13	
	75	F	824		51808	8	5-45	14	
	76	F	908		51808	8	6-46	14	
	77	M	1002		51808	8	7-47	13	
	78	F	858		51808	8	8-48	13	
	79	F	829		51808	8	9-49	14	
	80	F	969		51808	8	10-50	14	
	81	M	1091		51809	9	1-41	14	
	82	M	734		51809	9	2-42	13	
	83	F	943		51809	9	3-43	13	
	84	M	1004		51809	9	4-44	14	
	85	F	913		51809	9	5-45	14	
	86	M	767		51809	9	6-46	13	
	87	M	876		51809	9	7-47	13	
	88	M	637		51809	9	8-48	12	
	89	F	852		51809	9	9-49	M4	RG
	90	M	719		51809	9	10-50	13	

								European	Age
DATE	FISH #	SEX	FL (mm)	POH (mm)	SCALE BOOK#	BOOK #	SCALE #	Age	Code
	91	M	603		51810	10	1-41	12	
	92	F	855		51810	10	2-42	14	
	93	F	809		51810	10	3-43	M3	W
	94	M	813		51810	10	4-44	13	
	95	F	989		51810	10	5-45	14	
	96	F	913		51810	10	6-46	14	
	97	F	816		51810	10	7-47	M3	RG
	98	M	748		51810	10	8-48	13	
	99	F	829		51810	10	9-49	14	
	100	M	816		51810	10	10-50	13	
26-Aug	101	F	884		51811	11	1-41	14	
	102	M	783		51811	11	2-42	13	
	103	F	881		51811	11	3-43	M4	RG
	104	M	827		51811	11	4-44	M3	RG
	105	M	752		51811	11	5-45	13	
	106	F	977		51811	11	6-46	14	
	107	M	1058		51811	11	7-47	14	
	108	M	884		51811	11	8-48	13	
	109	F	905		51811	11	9-49	24	
	110	F	795		51811	11	10-50	14	
	111	F	840		51812	12	1-41	14	
	112	M	776		51812	12	2-42	13	
	113	M	797		51812	12	3-43		RS
	114	F	952		51812	12	4-44	14	
	115	M	806		51812	12	5-45	13	
	116	M	791		51812	12	6-46	13	
	117	F	831		51812	12	7-47	13	
	118	M	793		51812	12	8-48	13	
	119	M	569		51812	12	9-49	12	
	120	M	614		51812	12	10-50	12	
	121	M	678		51813	13	1-41	M2	RG
	122	M	821		51813	13	2-42		RG
	123	F	909		51813	13	3-43	M3	RG
	124	M	757		51813	13	4-44	13	
	125	F	864		51813	13	5-45	14	
	126	M	882		51813	13	6-46	14	
	127	M	934		51813	13	7-47	M4	RG
	128	F	882		51813	13	8-48	14	
	129	M	852		51813	13	9-49	14	
	130	F	907		51813	13	10-50	14	
	131	F	879		51814	14	1-41	14	
	132	F	951		51814	14	2-42	1F	RS
	133	M	1022		51814	14	3-43	14	
	134	M	843		51814	14	4-44	M3	RG
	135	F	923		51814	14	5-45	14	
	136	M	845		51814	14	6-46	13	

								European	Age
DATE	**FISH #**	**SEX**	**FL (mm)**	**POH (mm)**	**SCALE BOOK#**	**BOOK #**	**SCALE #**	**Age**	**Code**
	137	F	939		51814	14	7-47	M4	RG
	138	M	904		51814	14	8-48	13	
	139	F	955		51814	14	9-49	14	
	140	F	853		51814	14	10-50	14	
	141	F	977		51815	15	1-41	14	
	142	F	830		51815	15	2-42	14	
	143	F	814		51815	15	3-43	13	
	144	F	918		51815	15	4-44	14	
27-Aug	145	F	826		51815	15	5-45	13	
	146	F	870		51815	15	6-46	14	
	147	F	948		51815	15	7-47	14	
	148	F	819		51815	15	8-48	1F	RS
	149	M	881		51815	15	9-49	13	
	150	F	931		51815	15	10-50	14	
27-Aug	151	F	819		51816	16	1-41	13	
	152	M	763		51816	16	2-42	13	
	153	M	1049		51816	16	3-43	14	
	154	F	907		51816	16	4-44	14	
	155	M	1015		51816	16	5-45	13	
	156	F	940		51816	16	6-46	14	
	157	F	884		51816	16	7-47	1F	RS
	158	F	920		51816	16	8-48	14	
	159	M	717		51816	16	9-49	13	
	160	F	843		51816	16	10-50	M4	RG
	161	M	913		51817	17	1-41	15	
	162	F	954		51817	17	2-42	15	
	163	F	845		51817	17	3-43	14	
	164	M	633		51817	17	4-44	M2	RG
	165	M	704		51817	17	5-45	13	
	166	M	510		51817	17	6-46	12	
	167	M	902		51817	17	7-47	M3	W
	168	M	840		51817	17	8-48	M3	W
30-Aug	169	F	966		51817	17	9-49	14	
	170	M	1101		51817	17	10-50	13	
	171	F	840		51818	18	1-41	M4	RG
	172	M	1062		51818	18	2-42	14	
	173	M	789		51818	18	3-43	13	
	174	M	981		51818	18	4-44	14	
	175	F	852		51818	18	5-45	M3	RG
	176	F	855		51818	18	6-46		RS
	177	M	832		51818	18	7-47	14	
	178	M	826		51818	18	8-48	13	
	179	F	943		51818	18	9-49	13	
	180	F	900		51818	18	10-50	13	
	181	M	915		51819	19	1-41	M3	RG
	182	F	950		51819	19	2-42	14	

								European	Age
DATE	**FISH #**	**SEX**	**FL (mm)**	**POH (mm)**	**SCALE BOOK#**	**BOOK #**	**SCALE #**	**Age**	**Code**
	183	F	884		51819	19	3-43	14	
	184	M	844		51819	19	4-44	14	
	185	F	1042		51819	19	5-45	15	
	186	F	837		51819	19	6-46	14	
	187	F	966		51819	19	7-47	14	
	188	F	899		51819	19	8-48	13	
	189	F	915		51819	19	9-49	13	
	190	F	832		51819	19	10-50	13	
	191	F	908		51820	20	1-41	13	
	192	F	897		51820	20	2-42	14	
	193	F	932		51820	20	3-43	14	
	194	F	871		51820	20	4-44	13	
	195	F	866		51820	20	5-45	14	
	196	M	753		51820	20	6-46	M3	RG
	197	M	823		51820	20	7-47	13	
	198	F	890		51820	20	8-48	M3	RG
	199	M	927		51820	20	9-49	13	
	200	M	521		51820	20	10-50	12	
30-Aug	201	M	853		51821	21	1-41	13	
	202	F	840		51821	21	2-42	13	
	203	F	840		51821	21	3-43	14	
	204	F	821		51821	21	4-44	M4	RG
	205	F	875		51821	21	5-45	14	
	206	M	1016		51821	21	6-46	14	
31-Aug	207	F	866		51821	21	7-47	13	
	208	F	857		51821	21	8-48	14	
	209	M	800		51821	21	9-49	13	
	210	F	960		51821	21	10-50	14	
	211	M	750		51822	22	1-41	13	
	212	M	586		51822	22	2-42	M3	RG
	213	M	1035		51822	22	3-43	1F	RS
	214	F	980		51822	22	4-44	14	
	215	F	869		51822	22	5-45	13	
	216	F	935		51822	22	6-46	14	
	217	F	859		51822	22	7-47	14	
	218	M	870		51822	22	8-48	1F	RS
	219	F	941		51822	22	9-49	14	
	220	M	1029		51822	22	10-50	14	
1-Sep	221	F	927		51823	23	1-41	M4	RG
	222	F	732		51823	23	2-42	14	
	223	M	780		51823	23	3-43	13	
	224	M	646		51823	23	4-44	12	
	225	M	680		51823	23	5-45	M3	RG
	226	M	939		51823	23	6-46	M3	RG
	227	F	940		51823	23	7-47	13	
	228	F	865		51823	23	8-48	14	

								European	Age
DATE	FISH #	SEX	FL (mm)	POH (mm)	SCALE BOOK#	BOOK #	SCALE #	Age	Code
	229	F	911		51823	23	9-49	14	
	230	M	821		51823	23	10-50	13	
	231	M	721		51824	24	1-41	M3	RG
	232	F	864		51824	24	2-42	14	
	233	M	960		51824	24	3-43	14	
	234	F	947		51824	24	4-44	13	

Note: RG = regenerate scale (center is missing from scale)
RS = resorbed scale (growth from margin is missing)

Appendix 3. 2006 Big Salmon River carcass pitch recovered spaghetti tag numbers.

TAG #	DATE RECOVERED	COMMENTS
Z 00509	Aug 25	attached to Female
Z 00151	Aug 26	lying loose
Z 00267	Aug 27	lying loose by scavenged carcass
Z 00977	Aug 30	attached to female carcass
Z 00119	Aug 31	lying loose by scavenged carcass