2005 CHINOOK SALMON SONAR ENUMERATION ON THE BIG SALMON RIVER

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Prepared For: The Yukon River Panel
Restoration and Enhancement Fund

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ABSTRACT

A long range dual frequency identification sonar (DIDSON-LR) was used to enumerate the chinook salmon escapement to the Big Salmon River in 2005. In addition, run timing and diel migration patterns were determined. The sonar site was located on the Big Salmon River 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 an ensonified field 40 m wide that completely covered the water column within the fish passage opening.

A total of 5,618 (5,584 counted plus 34 extrapolated) targets identified as chinook salmon was counted past the sonar station between July 15 and August 28, 2005. A peak daily migration of 346 fish occurred on August 2, and 90% of the run had passed the station on August 12. The cumulative daily run pattern exhibited a normal distribution.

The 2005 Big Salmon sonar project demonstrated that the DIDSON-LR sonar unit produced observable images of fish swimming through the ensonified field at distances up to 40 m. The resolution of target images was poor at ranges >20 m 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. In addition, the Big Salmon chinook counts were concordant with the 2005 DFO derived upper Yukon River chinook escapement estimates.

INTRODUCTION

The use of sonar and hydro-acoustic techniques has become an established tool used by researchers and fisheries managers to enumerate and obtain population estimates of fish species within a variety of habitats. At many locations, including Pilot station on the Yukon River system, sonar has been used to enumerate and obtain other migration data on all species of salmon since 1978. While hydroacoustics as a physical science dates back over a century, fisheries sonar has developed only over the last four decades and is a relatively new field in aquatic sciences. Until 2002, fisheries sonar technology, particularly with regard to enumerating migrating salmon, have used dual and split beam apparatus. For the enumeration of migrating salmon these systems have limitations (Rawson et al. 1998; Daum et al. 1998). In particular, streambed morphology, turbulence, high fish densities, schooling and milling behaviour, and species mis-identification can significantly impair the precision of sonar derived population estimates

In 2002, a unique high definition sonar was developed by the Applied Physics Laboratory at the University of Washington. The DIDSON (**D**ual frequency **ID**entification **SON**ar) sonar technology is a surrogate for optical systems in that it uses acoustic "lenses' to obtain unambiguous, almost photographic quality images in dark and/or turbid water. The DIDSON sonar represents a quantum leap in high definition sonar in that it produces clear video type images in real time. The DIDSON operates at two frequencies (1.8 MHz and 1.0 MHz – standard unit; 1.2 Mhz and 700 Khz. - long range unit). Instead of one or two beams the DIDSON sonar uses 96 (Standard) or 48 (Long Range) beams spaced 0.6° apart. Along with the multiple beams the unit uses acoustic lenses which produce relatively sharp images of objects, depending on the size and sonic reflectivity, from 1 m to over 60 m in range. The sonar is small, rugged, and requires only 30 watts power at 24 volts DC (Appendix 1). The sonar images are digitized and can be stored on computer files for archiving and reviewing.

Designed principally for military use, it quickly became apparent that the technology was suited for many applications including the detection of migrating salmon. During the 2003 and 2004 field seasons, fish and wildlife monitoring agencies in Alaska and Canada used the DIDSON apparatus on an experimental basis to enumerate migrating salmon at several sites. 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 (Galbreath and Barber 2005, Holmes et al. 2005, Maxwell et al. 2004). The DIDSON units were found to be reliable, required a minimum of operator training, and provided accurate counts of migrating salmon.

Based on chinook telemetry studies and annual DFO aerial index counts, 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.

Yukon River chinook are harvested in subsistence, sport, and commercial fisheries in both Alaska and Canada. Obtaining accurate estimates of spawning escapements are required for the proper management of the Yukon River chinook stocks. As the Big Salmon River stocks contribute a significant share of the total upper Yukon River chinook escapement, accurate counts of chinook entering the drainage would provide a valuable index to estimate total annual upper Yukon River chinook escapements. Traditional salmon weirs can 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. It was thought that the use of sonar would allow for enumeration of migrating chinook while minimizing negative impacts on fish behaviour and providing un-restricted recreational access to the river.

In early 2005 a proposal was prepared by J. Wilson and Associates and submitted to the Yukon River Panel Restoration and Enhancement (R&E) fund to install and operate a DIDSON sonar station on the Big Salmon River. The objective of the project was to enumerate the 2005 chinook salmon escapement into the system. The proposal was accepted and funding for the 2005 project was received from the R&E fund.

Study Area

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

Objectives

The objectives of the 2005 Big Salmon River sonar project were:

1. To select a suitable sonar site and establish a field camp on the Big Salmon River.
2. To construct two partial weirs to constrict the passage of migrating chinook to a 35 m opening.

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[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.

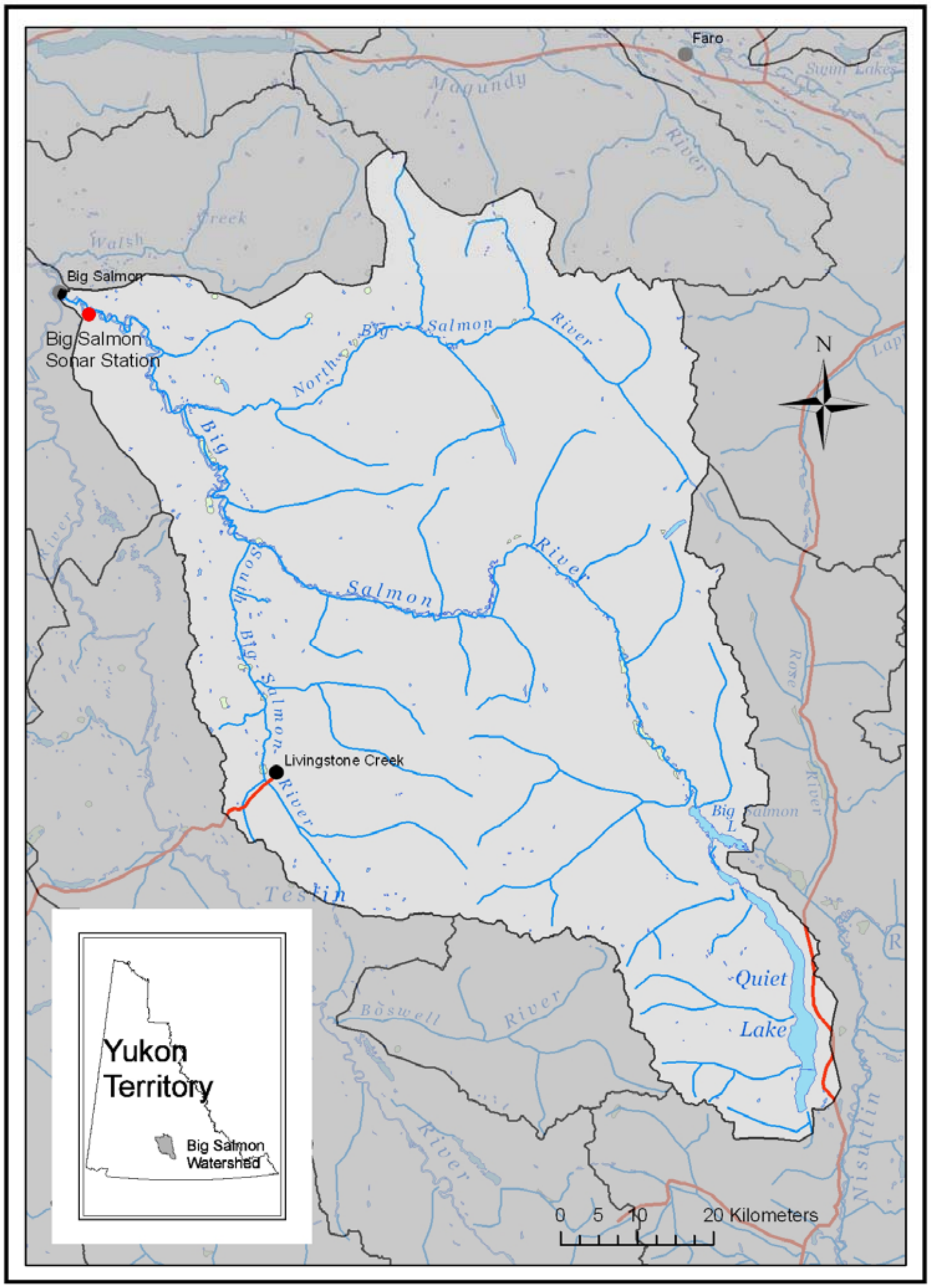

Figure 1. Big Salmon River Watershed and location of the 2005 Big Salmon sonar station.

3. To set up a DIDSON-LR sonar unit to enumerate chinook salmon migrating upstream through the opening and obtain information on the total run size and diel migration patterns.

METHODS

Site selection

On June 4, an overflight of the lower Big Salmon River was conducted, using a fixed wing aircraft, to locate a suitable site for the sonar station and camp. The site selected was located approximately 1.5 km upstream from the confluence with the Yukon River. This site was chosen for the following reasons:

- It was located below the lower limit of known chinook spawning and a sufficient distance upstream of the mouth to avoid straying mainstem Yukon/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 a suitable campsite located on the south bank where wall tent frames could be constructed within close proximity to the sonar set-up.
- The site was accessible by boat allowing supplies and materials to be brought to the site.

Once the site was selected, application was made to Yukon Energy, Mines & Resources, Lands Branch for a land use permit to establish a camp on the lower Big Salmon River. A permit was granted on June 30 and can be renewed in 2006 and 2007. Approval was also granted to cut and remove timber on Territorial Lands for the purposes of clearing a site and the use of fue wood by the Whitehorse District Forestry office.

Application was made to Transport Canada, Marine Branch, Navigable Waters Protection for approval to install partial fish diversion fences in a navigable waterway. Approval was granted on June 27.

Camp Construction and Sonar Station

Construction of the camp and sonar station was initiated on July 5. All construction materials for the camp, equipment, sonar apparatus, and diversion fences were transported to the site by riverboat. Camp access, crew changes, and delivery of supplies was also accomplished via riverboat and supplemented by floatplane from Whitehorse. An initial load of camp construction materials was transported to the site by riverboat departing from Lake Laberge. All subsequent supplies were taken to Carmacks by truck and loaded onto the boat from the boat ramp in Carmacks or from a pullout along the Robert Campbell Highway near Little Salmon Village.

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 constructed using a 5m x 5m "weatherall" free standing wall tent placed on a plywood platform. The sleeping quarters were constructed using a 14' X 16' canvas wall tent placed on a plywood platform and wooden frame.

Two diversion fences were constructed on opposite sides of the river to divert shoreline migrating chinook salmon through the ensonified area (Figure 2). Diversion fences were constructed using prefabricated panels of electrical conduit. Tripods and stringers used to support the panels were constructed on-site using tree poles cut locally and 8" spikes. The south bank fence extended approximately 6 m from the bank and the north bank fence approximately 20 m from the bank. This provided 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. Also, in accordance with Transport Canada, Navigable Waters Protection requirements, a warning sign was posted 200 m upstream of the station to alert boaters of the partial obstruction ahead.

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 weir on south bank.

Sonar and computer software configuration

The DIDSON sonar 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. DIDSON sonar unit mounted on adjustable stand.

The mounted sonar unit and stand was placed next to the south bank, in the river immediately upstream of the diversion fence in approximately 0.7 m of water. 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 tree onshore.

The DIDSON transducer lens was positioned to a depth of approximately 15 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 5). If the transducer angle were set higher reflections from surface turbulence would produce interference in the sonar recordings.

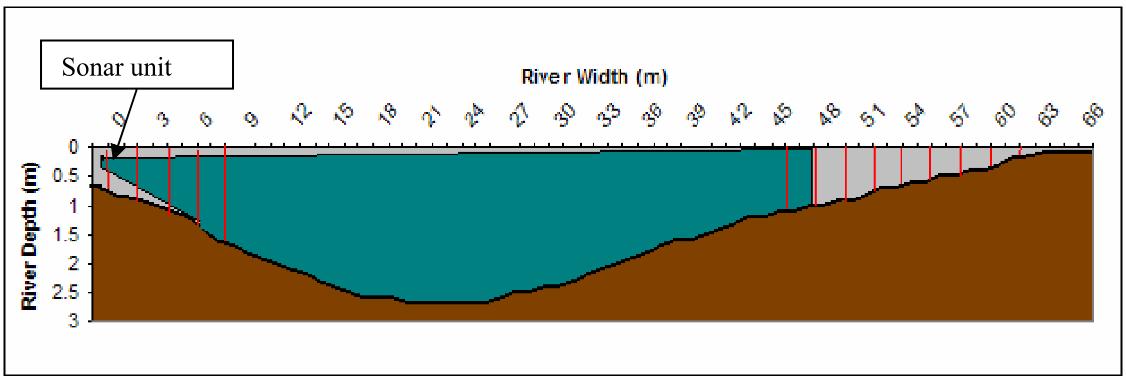

Figure 5. Schematic diagram of river profile and sonar and weir configuration.
Red bars denote weir structures and blue the ensonified portion of the water column.
Note: Vertical scale is exaggerated.

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. For the duration of the project the receiver gain was set at –40 dB, the window start at 5.86 m, window length at 40 m, and auto frequency was enabled. 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 that 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.

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.

During the initial recording period from August 12 – 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. Objects included a sandbag tied with a rope and a canoe paddle held vertically beneath the boat. On August 6 the sonar unit was temporarily set up for 3 hours on the north bank of the river to determine if fish moving at the outer target detection range were being missed.

Sonar data collection

Sonar imagery 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 the collected files 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 or 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 DIDSON software has a target measurement feature that can be used to estimate the size of the observed fish. The minimum size used to identify chinook was 55 cm. However, 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 below. Chinook images were visually counted using a hand counter and the total count of 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.

RESULTS

Chinook Counts and Run Timing

Scheduled 24 hr recording began on July 15 at 9:00 A.M. Two days prior to this, during testing and calibration trials, the sonar apparatus was set up and operated for at least 5 hours each day. No chinook images were observed during this time. Chinook were not observed moving through the ensonified area until July 15 at 12:20. A total of 5,584 targets identified as chinook salmon was counted past the sonar station between July 15 and August 23, after which the project was terminated. The peak daily count of 346 fish occurred on August 2, and 90% of the run had past the station on August 12. The daily and cumulative run patterns exhibited a normal distribution as illustrated in Figures 8 and 9.

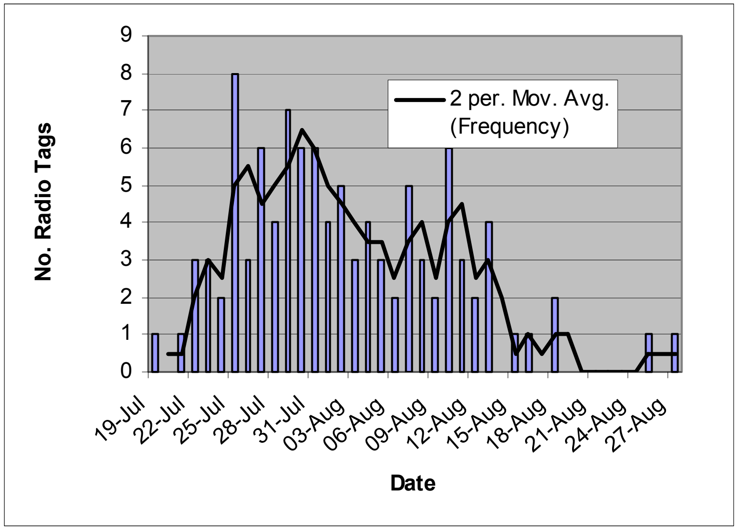

Figure 6. Aggregate daily count of radio tags past the Big Salmon River telemetry tower 2002 – 2004.

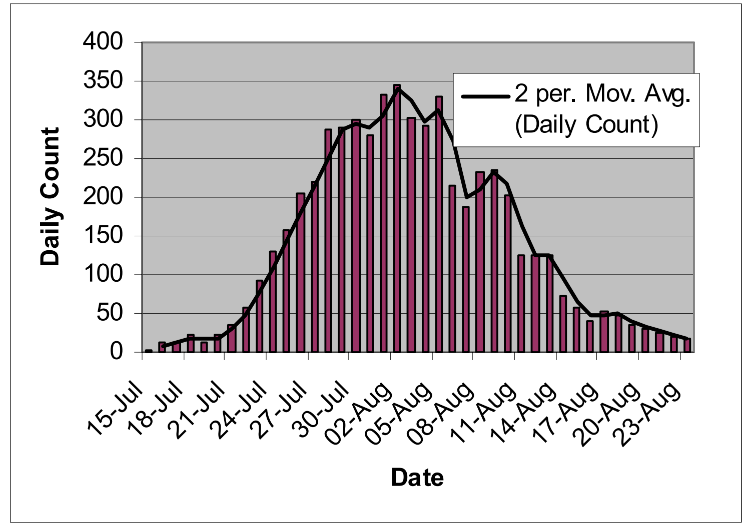

Figure 8. Daily count of chinook salmon counted at the Big Salmon River sonar station in 2005.

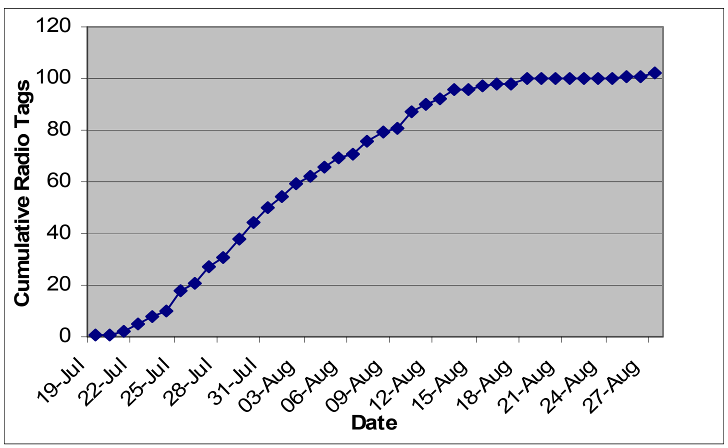

Figure 7. Cumulative count of aggregate radio tags past the Big Salmon River telemetry tower 2002 – 2004.

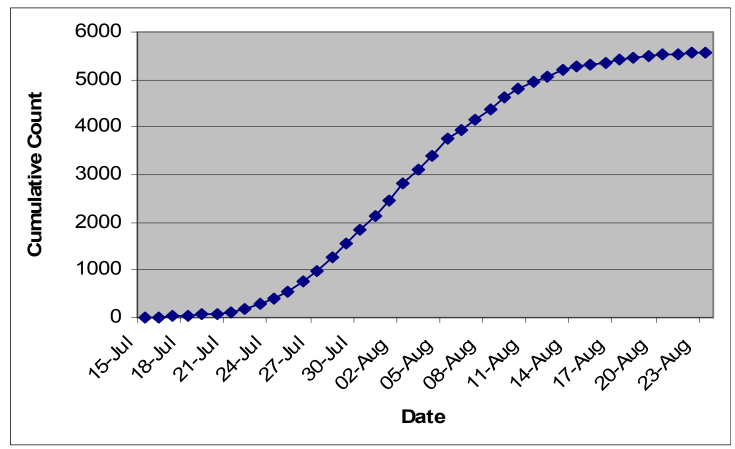

Figure 9. Cumulative count of chinook salmon counted at the Big Salmon River sonar station in 2005.

A total of 17 chinook was counted on the last day of sonar recordings. Since the sonar was removed before the end of the run, daily counts were extrapolated for 5 days after the sonar was removed. The extrapolated count was estimated using a polynomial regression ($y = 0.1742x^2 - 7.4621x + 73.833$) based on the previous 10 daily counts (Figure 10). This extrapolation resulted in the run continuing until August 28 with an additional 34 fish, bringing the season total to 5,618.

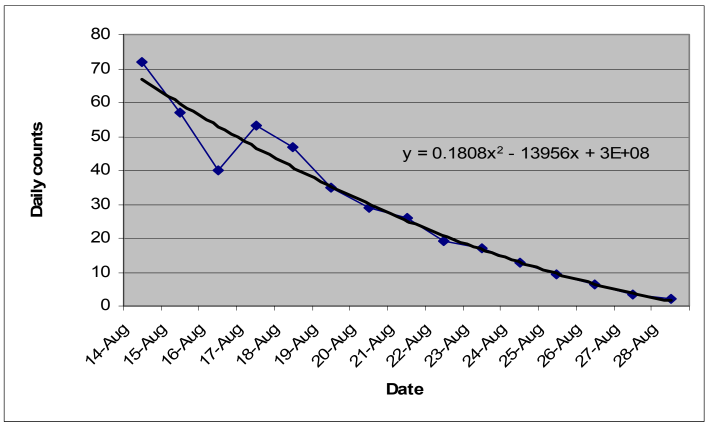

Figure 10. Extrapolation of the Big Salmon River sonar counts from August 24 through August 28.

Diel Migration

Figure 11 illustrates the diel migration pattern of the migrating chinook counted at the Big Salmon sonar station. There was no significant difference in the hourly migration pattern (Single factor ANOVA, tested for homogeneity of variance: df=23, F=0.656, α=0.05, *p*=0.88). However, there was a non-significant indication of higher rates of fish passage at 21:00 and lower rates between 02:00-03:00.

Diel migration patterns have been noted at other sonar and fish enumeration projects (Galbreath and Barber, 2005). However, migration patterns are often stock and system specific and can be influenced by variables such as counting structures (weirs) and fishing effects. Yukon River chinook have some of the highest daily migration rates recorded for chinook salmon (Spencer et al. 2002). The long distances travelled by Yukon River chinook may be a factor in these high migration rates. In 2002, the daily average migration rate of radio tagged upper Yukon River chinook was 47.6 km/day with the Big Salmon stocks averaging 46.1 km/day (Osborne et al. 2003). These rates suggest that migration may be continuous with little resting or milling behaviour. Definitive determination of the existence of diel migration patterns may require several years of data sets.

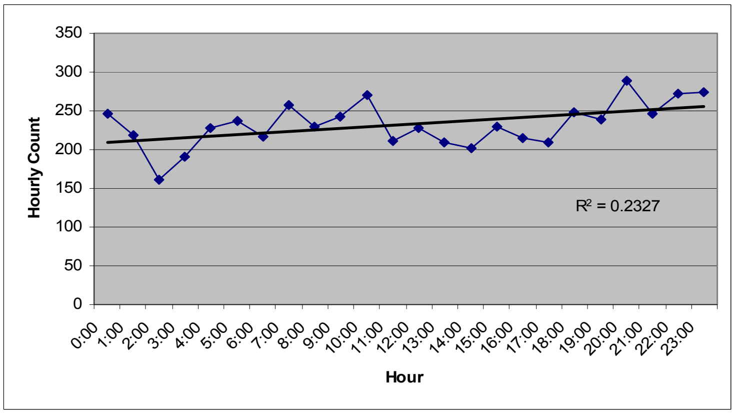

Figure 11. Total hourly counts of chinook salmon passing the Big Salmon River sonar station in 2005.

DISCUSSION

There is a high degree of concordance between the 2005 Big Salmon River chinook sonar counts and the aggregate 2002 – 2004 passage of radio tagged chinook past the Big Salmon telemetry tower[2] (Figures 7 – 10). Based on the radio tag passage during these years, the first and last tags passed the telemetry tower on July 19 and August 27. The peak passage was on July 31, and 90% of the radio tags had passed the tower by August 12. The first chinook counted by the sonar station in 2005 was on July 15, with the final fish counted (based on extrapolation) on August 28. The peak daily chinook sonar count was on August 2. As occurred with the aggregate radio tag count, 90% of the total 2005 chinook count had also passed the sonar station on August 12.

The 2005 Big Salmon sonar count could be used as an index to estimate upper Yukon River spawning escapements. Yukon River chinook telemetry studies during the years 2002 through 2004 indicated that the Big Salmon River stocks comprised 9.2%, 10.4%, and 16.4%, respectively, of the upper Yukon River spawning escapement (Osborne et al. 2003, Mercer and Eiler 2004, Mercer 2005). In 2005, the DFO mark recapture estimate for the Canada/U.S. above border escapement was calculated to be 42,254 (95% C.I. 32,970 – 51,520). After deducting the total Canadian harvest the spawning ground escapement point estimate was 31,565 (JTC 2006, in prep.). Based on this estimate, the 2005 Big Salmon sonar count of 5,618 would have represented 17.8% of the total upper Yukon River 2005 spawning ground escapement. Using the telemetry derived proportional distributions, the expanded total Canadian spawning ground escapement based on the 2005 Big Salmon River sonar count would range from 34,255 – 61,065. This escapement estimate is higher than the DFO mark recapture estimates, however, the 2005 DFO estimate was thought to be biased low. This assumption is based on the relatively high 2005 catch per unit effort in the commercial chinook fisheries as well as the chinook population estimates derived from sonar counts in the U.S. portion of the Yukon River (JTC 2006, in prep.).

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

DFO Whitehorse is in the process of building 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 2005 Big Salmon sonar counts could be in doubt due to three possible sources of error:

1. Mis-identification of co-migrating fish species resulting in a higher total chinook count.
2. Mis-identification of migrating chinook (classifying chinook as resident fish) resulting in a lower total chinook count.
3. Not detecting all migrating chinook passing the site resulting in a count biased low.

Based on First Nation, subsistence, commercial fishing, and unpublished DFO data chinook are the only salmon species known to be present during the period that Big Salmon origin chinook enter the headwater tributaries. It is very probable the larger fish migrating past the sonar site were all chinook salmon. Typically those fish targets identified[3] 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 were typically larger (>60 cm) and exhibited strong positive rheotaxis. They typically transversed the ensonified portion of the river quickly and directly lateral to the flow. It was not unusual to observe the migrating chinook clustered in groups of 2 – 5 fish (Figure 12). The normal distribution pattern of the daily counts as well as the close correlation with the radio telemetry data suggests there was a relatively low rate of mis-identification of resident fish species. While it is possible that larger resident fish could co-migrate with the Big Salmon chinook stocks, the absence of significant non-chinook by-catches in the upper Yukon River First Nation fisheries (M.E. Jarvis, Aboriginal Fisheries Coordinator DFO Whitehorse, per. Comm.), suggests this is not likely.

It is probable that some smaller chinook were 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 of 40cm – 60cm. The low image resolution associated with the LF-DIDSON settings combined with the presence of chinook jacks less than 55cm suggest that some mis-identification of small chinook likely 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 2005

[3] Using the target size calibration feature of the DIDSON software program.

Big Salmon chinook run was relatively low[4]. As well, the number of possible errors flagged by the sonar operators while reading the files was low. A total of 78 undersize fish were identified in the 2,765 files reviewed and only 6 were labeled as questionable by the file reviewers.

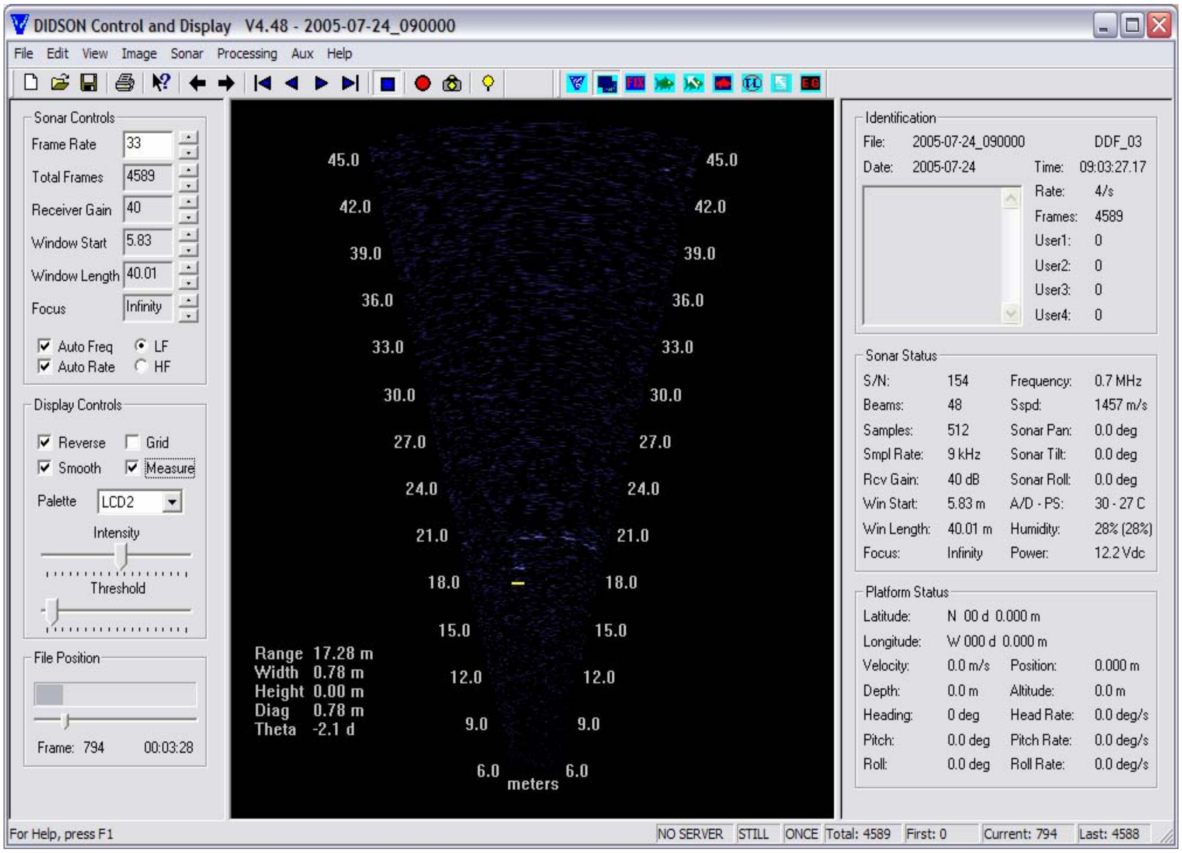

Figure 12. DIDSON display window illustrating sonar settings.
Note: Five Big Salmon River chinook salmon located between 18 m and 20 m within the ensonified field. The yellow bar below the closest fish denotes the estimated length of the target i.e. 0.78 m.

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 exhibited strong corroboration between visual and DIDSON sonar counts (Galbreath and Barber 2005; Holmes et al. 2005). Typically there is high precision or concordance between observers doing the manual counting. This was demonstrated by a random review of 20 of the 2005 Big Salmon River sonar files. The independent blind counts demonstrated a 98% concordance with the counts in the archived files. In addition, the

[4] The age class structure of chinook can be stock and year specific however the proportion of chinook <60cm at another upper Yukon Headwater tributary in 2005 was 7% and the proportion <50cm was 1% (n= 161 sampled; Wilson in prep. 2006). At the DFO fish wheels near the Canada/U.S. border the 2005 proportion of the population that was <50 cm was only 0.4% (n = 6/1341; JTC 2006 in prep.).

river bottom profile at the Big Salmon sonar site should not have resulted in sonic shadows or “blind areas”. Therefore, for the 2005 Big Salmon sonar project it is assumed that the chinook that passed through the ensonified portion of the river were detectable and were counted.

At the range used during the 2005 Big Salmon River sonar project (5.86 m window start and 40 m window length) the level of resolution was adequate for making counts of fish passage but inadequate for making more than a qualitative estimate of fish size. This was particularly evident with targets located between 25 m and 40 m. At HF settings the beam width is 5 degrees and at LF settings the beam width is 8 degrees. Therefore while the decreased frequency at LF settings increase operational range there is a concomitant decrease in resolution. The DIDSON-LR emits sound waves with a 0.6 degree spacing. At 10 m the cross-range width of the field is 5 m and the distance between the sound beams is 5 m/48 = 5 cm. At twice the distance (20 m) the distance between beams is 10 cm and at 40 m the distance is 20 cm. Thus at distances of 30 m or greater the maximum number of beams intercepting an 80 cm fish would be three. The higher the number of beams striking the target the greater the lateral resolution on the computer screen as it provides more information for the software to describe the shape of the image. As the window length increases, the ability of the observer to estimate the size and form of the target decreases. The start window length of the DIDSON-LR is variable but the operating window length is only variable in multiples of 100% (i.e. window lengths of 5, 10, 20, and 40 meters). It is recommended that in future projects at this site efforts should be made to reduce the ensonification window length to 20 m. When operated at HF the maximum window length setting is 20 m although the start length window can be set at 13 m, which would allow high resolution viewing out to 33 m. This 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. In order to reduce the window length to 20 m the diversion weir would have to be extended a further 15 m to create a 20 m ensonified gap for fish passage. At the present sonar site this may only be possible using specialized weir materials that could withstand the seasonal water depth and flows.

In summary, the 2005 Big Salmon sonar project demonstrated that the DIDSON sonar unit produced observable images of fish swimming through the ensonified field at distances to 40 m. These images produced total counts that correlated well with past fish passage data and the 2005 upper Yukon River chinook escapement estimates. There is no evidence from the sonar operation and the data collected to indicate the sonar counts were not reflective of the 2005 Big Salmon chinook escapement. The DIDSON sonar proved to be a low impact, non-intrusive method of enumerating the Big Salmon system chinook escapement. The in-stream structures associated with the sonar project did not present a navigational hazard for boaters and canoeists traveling the river.

Operation of the sonar project in 2006 along with representative carcass sampling should provide valuable escapement, age and sex structure, and baseline genetic data on the Big Salmon River chinook stocks. This will further increase the usefulness of these data as an index of the total upper Yukon River chinook escapement.

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Appendix 1. DIDSON-LR (Long Range DIDSON) Specifications.

Detection Mode	
Operating Freq:	0.70 MHz
Beamwidth (two-way):	0.8° H by 12° V
Number of Beams:	48
Range Settings:	
Start Range:	0.75 m to 23.25 m in 0.75 m intervals
Window Length:	9 m, 18 m, 36 m , 72 m
Range-bin size relative to window:	17 mm, 35 mm, 70 mm, 140 mm
Pulse length relative to window length:	23 µs, 46 µs, 92 µs, 184 µs
Identification Mode	
Operating Freq:	1.2 MHz
Beamwidth (two-way):	0.5° H by 12° V
Number of Beams:	48
Range Settings:	
Start Range:	0.38 m to 11.63 m in 0.38 m increments
Window Length:	2.25 m, 4.5 m, 9 m, 18 m
Range-bin separation:	4.4 mm, 9 mm, 18 mm, 36mm
Both Modes	
Max frame rate (window length dependent):	2-10 Frames/s
Field of view:	29°
Remote focus:	1 m to maximum range
Power Consumption:	30 Watts typical
Image Uplink:	Ethernet and NTSC Video
Dimensions:	30.7 cm long by 20.6 cm high by 17.1 cm wide
Depth rating:	150 m (500 feet)
Weight in air:	7.3 kg (16.1 lb.)
Weight in water:	0.8 kg negative (1.8 lb.)

Appendix 2. Big Salmon River sonar 2005 chinook counts and water conditions.

Date	Daily Count	Cumulative Count	Water Temp.	Relative Water Level
13-Jul	0	0	13˚C	31
14-Jul	0	0	12˚C	30
15-Jul	2	2	10.5˚C	27
16-Jul	12	14	13˚C	24
17-Jul	13	27	11˚C	22
18-Jul	23	50	9˚C	25
19-Jul	13	63	7˚C	48
20-Jul	23	86	10˚C	41
21-Jul	36	122	6˚C	41
22-Jul	58	180	7˚C	36
23-Jul	92	272	5˚C	30
24-Jul	130	402	7˚C	26
25-Jul	158	560	9˚C	28
26-Jul	204	764	10˚C	30
27-Jul	219	983	10˚C	27
28-Jul	287	1270	11˚C	25
29-Jul	290	1560	10˚C	25
30-Jul	299	1859		27
31-Jul	279	2138	8˚C	29
01-Aug	333	2471	10˚C	29
02-Aug	346	2817	10˚C	26
03-Aug	303	3120	11˚C	21
04-Aug	292	3412	13˚C	20
05-Aug	331	3743	13˚C	19
06-Aug	214	3957	9˚C	19
07-Aug	188	4145	8.5˚C	17
08-Aug	232	4377	10.5˚C	20
09-Aug	234	4611	5˚C	16
10-Aug	203	4814	7˚C	14
11-Aug	124	4938	8˚C	10
12-Aug	126	5064	6˚C	8
13-Aug	125	5189	5˚C	7
14-Aug	72	5261	7˚C	6
15-Aug	57	5318	5˚C	5
16-Aug	40	5358	7˚C	3
17-Aug	53	5411	10˚C	0
18-Aug	47	5458	13˚C	0
19-Aug	35	5493	10˚C	2
20-Aug	29	5522	8˚C	5
21-Aug	26	5548	2˚C	9
22-Aug	19	5567	7˚C	11
23-Aug	17	5584	5˚C	9
24-Aug	13	5597		
25-Aug	9	5606		
26-Aug	6	5612		
27-Aug	4	5616		
28-Aug	2	5618		

Note: Shaded values were obtained through extrapolation of counts from previous 10 days.