2008 Klondike River DIDSON Sonar Feasibility Study

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Restoration and Enhancement Fund

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TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

A study was conducted in July 2008 and May 2009 to determine the feasibility of using a DIDSON sonar unit to enumerate Chinook salmon entering the Klondike River watershed. It was known from past radio telemetry studies that Chinook Salmon entered the Klondike River system from the mainstem Yukon River from late June through to the beginning of August. Investigators were on site on the Klondike River from July 2 through July 8, 2008 and May 19 and 20, 2009. Using a skiff with an outboard jet, potential sonar sites were examined from the mouth of the Klondike River to a point 10 km upstream from the confluence with the Yukon River. Two principal factors were considered to identify potential sonar sites: 1) The site had to satisfy the required criteria for successful sonar deployment, and 2) It had to have road access. Only two potential sites were identified that met these criteria. Site one was located 4.5 km upstream from the confluence with the Yukon River. Site 2 was located 2 km upstream of the river mouth. At the time of examination in 2008 the Klondike system was experiencing above average flows. Site 1 and Site 2 had a wetted river width of approximately 55m and 65m. At both sites partial weirs on both sides of the river would have to be deployed to for complete ensonification of a 40m wide migration corridor. Site 1 had a narrower wetted width, more laminar flow, and was considered the optimal site for sonar deployment. A DIDSON LR sonar unit was deployed at sites 1 and 2 for 28 and 8 hours respectively over 3 days. River bottom and cross sectional profiles were obtained for both sites. Two targets identified as Chinook Salmon were observed at site 2 on July 6. It was concluded that two sites exist for DIDSON sonar deployment on the lower reaches of the Klondike River, with Site 1 the preferred choice. Given average seasonal water conditions it was concluded that complete ensonification of a 40 m width of the Klondike River could occur at this site and a complete count of migrating Chinook salmon could be achieved.

INTRODUCTION

The Yukon River system encompasses a drainage of approximately 854,000 km^2 and provides important aboriginal, subsistence and commercial fisheries in U.S. and Canada. Of the five species of salmon entering the Yukon River, adult Chinook salmon *Onchorynchus tshawytscha* travel the farthest upstream and have been documented at its furthest headwaters, 3,200 Km from the river mouth (Mercer & Eiler 2004). Approximately 50% of Chinook salmon entering the Yukon River are destined for spawning grounds in Canada (Eiler et al. 2004, 2006). Canadian origin fish contribute approximately 47% to 67% of the total U.S. commercial and subsistence fisheries (Templin et al. 2005; cited in Daum and Flannery 2009). In recent years above border escapements have been less than set management goals leading to closures and restrictions on commercial and aboriginal fisheries.

The Yukon River Panel (YRP) as well as Canadian and U.S. fisheries managers have recognized that obtaining accurate estimates of spawning escapements is required for the management of the Yukon River Chinook stocks. In the 2007 YRP Framework statement, determination of escapement estimates is ranked as a high priority as there is strong public and Joint Technical Committee (JTC) interest in quantifying escapement information. In it's "2008 and near term priorities" the YRP Restoration and Enhancement (R&E) Fund Budget Priorities Subcommittee recommended as a first priority "Stock Escapement Monitoring of the Canadian tributaries" and the implementation of escapement monitoring projects for selected Canadian tributaries. Monitoring of key spawning streams (index streams) is ranked as an important management strategy that contributes data for the establishment and monitoring of escapement goals. Escapement enumeration of genetically distinct stocks coupled with baseline genetic stock index (GSI) information can also be used to calculate drainage wide above border Chinook spawner escapement estimates[1]. This information is important for run reconstruction and the establishment of scientifically based escapement objectives.

Development of the DIDSON (**D**ual frequency **Id**entification **SON**ar) sonar technology occurred at the Applied Physics Laboratory at the University of Washington. Developed for U.S. military applications, it was first utilized in 2002. It quickly became apparent that the DIDSON technology was suited for many applications including the detection of migrating salmon. Subsequently, researchers have found the DIDSON apparatus to be superior, in certain applications, to other sonar systems for the enumeration of migrating salmon. Since 2002 the DIDSON apparatus has been used for enumeration of several species of salmon in a broad range of environments (Galbreath and Barber 2005, Holmes et al. 2005, Maxwell et al. 2004).

From 2005 through 2008, a DIDSON LR sonar unit has been used to successfully enumerate annual Chinook salmon escapements into the Big Salmon River in the upper Yukon River watershed (Mercer & Wilson 2006, 2007). In general the DIDSON units

[1] Border escapement is the number of potential spawners estimated to have entered the Upper Yukon River drainage into Canada.

have been found to be reliable, require a limited amount of operator training, and provide accurate counts of migrating salmon.

The Klondike River is considered to be a candidate as a Chinook salmon escapement index stream using high definition sonar because:

1. It is accessible;
2. Has documented significant Chinook escapements;
3. Recognized as a genetically unique and identifiable Chinook stock;
4. Has discharge volumes too high for a conventional salmon counting fence but low enough during periods of Chinook passage to allow complete ensonification of a fish passage channel 40m or less in width;
5. The Klondike River Chinook stock appears to be one of earlier temporal segments of the above border Yukon River Chinook run.

Due to high flow rates, First Nation concerns, and recreational use of the Klondike River the use of a weir on this river is not feasible. For these reasons the DIDSON sonar was considered a relatively low impact, non-intrusive method of enumerating annual Chinook escapements into the Klondike 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. Fixed-location, side-looking sonar techniques are the only means of obtaining in-season abundance estimates for anadromous fish stocks in rivers that are too wide for weir structures and too turbid for visual observations.

Researchers have found the DIDSON apparatus to be superior to other sonar systems for many applications aimed at enumerating migrating salmon including within the upper Yukon River watershed (Galbreath and Barber 2005, Holmes et al. 2005, Mercer & Wilson 2005, 2006, and 2007). The DIDSON units have been found to be generally reliable, require a minimum of operator training, and when deployed in a proper manner will provide accurate counts of migrating salmon.

A proposal to conduct a DIDSON feasibility study on the Klondike River was submitted by B. Mercer & Associates and the Tr'ondëk Hwëch'in First Nation to the Yukon River Panel Restoration and Enhancement (R&E) fund in January 2008. The proposal was accepted and financial support was received from the R&E fund

Study Area

The Klondike River is located in the north central Yukon and flows in a south-westerly direction from its headwaters to it’s confluence with the Yukon River at Dawson City (Figure 1). The river and its tributaries drain an area of approximately 7,800 km^2.

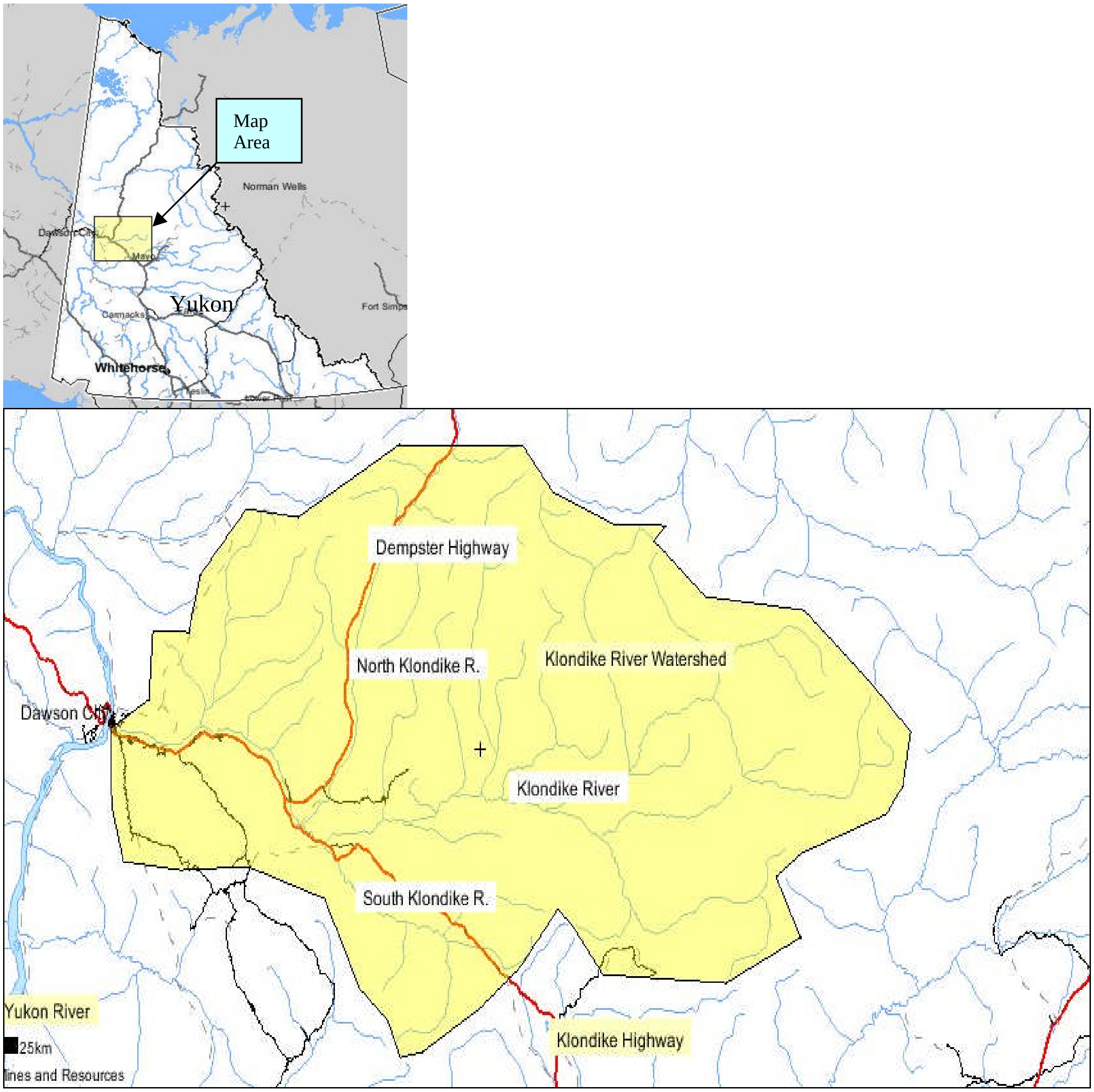

Figure 1. Klondike River watershed.

The Klondike River watershed is a dendritic drainage system typical of un-glaciated terrain of moderate relief. The North Klondike River with origins in the Olgilvie Mountains drains an area of approximately 1100 km^2 and is the major tributary of the system. It joins the Klondike River 25 km upstream from its mouth. Other significant tributaries include the South Klondike River and Hunker Creek. The Klondike River and its tributaries have been significantly impacted by placer mining activities.

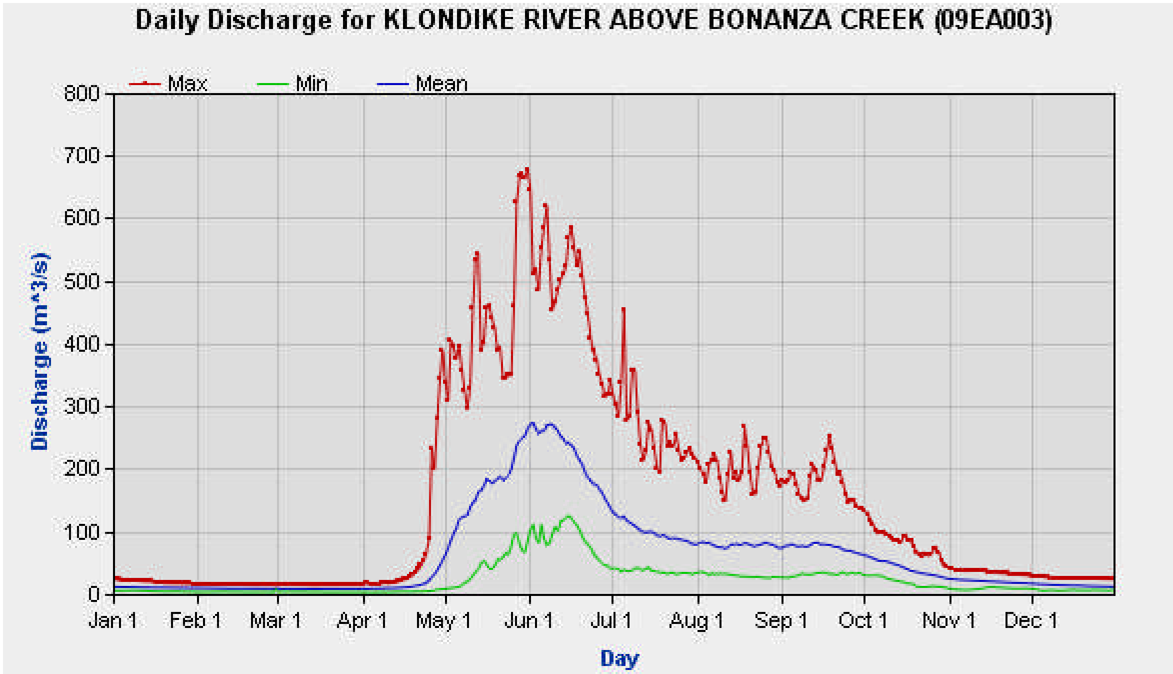

Figure 2. Daily minimum and maximum discharge rates for Klondike River from 1965 through 2007. (Source: Water survey Board of Canada)

Maximum and minimum discharge rates are highly variable and records range from 679 m^3/s and 4.51 m^3/s respectively with a mean discharge rate of 63.2 m^3/s. Peak discharge rates typically occur on June 1, with a mean discharge rate of 275 m^3/s (Figure 2). At the beginning of the proposed sonar operation on July 1 mean discharge rates are typically in the range of 130 m^3/s.

Fish species documented in the Klondike River system include Chinook and Chum salmon (*Oncoryhncus tshawytscha* and *O. keta),* Grayling (*Thymallus thymallus),* Burbot (*Lota lota*), Innconnu (*Stenodus leucichthys),* Round Whitefish (*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus*), and longnose sucker (*Catostomus catostomus*) (DFO FISS database). As a result of extensive placer mining and other impacts on the Klondike system, numerous studies and agency reports have focused on the aquatic resources of the drainage. It is probable that grayling both historically and presently are the numerically dominant resident fish species present in the system (DFO FISS database).

OBJECTIVES

The objectives of the 2008 Klondike River sonar feasibility project were:

1. To investigate the run timing and spawning distribution of Chinook salmon within the Klondike watershed to define operational parameters.

2. To identify potential DIDSON sonar sites on the Klondike River that would allow for complete enumeration of Chinook escapements into the system. Collection of stream widths and profiles at potential sonar sites.
3. To operate an LR DIDSON sonar at the identified sites.
4. Identify permits and authorizations required to operate a sonar station at the identified site(s).

RESULTS

1. Run Timing and Spawning Distribution of Klondike River Chinook

Some research has been conducted on documenting the presence and distribution of returning adult Chinook Salmon in the Klondike system. Radio telemetry studies on the total Yukon River drainage conducted from 2002 through 2004 suggest the Klondike system contributed to approximately 5% - 7% of the above border Chinook salmon escapement in the upper Yukon River system (Osborne et al. 2003, Mercer and Eiler 2004, Mercer 2005). Expanding the calculated radio tag ratios from the three year study period the number of Chinook annually entering the Klondike system during this period was estimated to have ranged from 2,020 to 4,480, approximately 5% - 8% of the total estimated Chinook escapement into the Canadian portion of the Yukon River Basin. GSI information collected from 2006 through 2008 at the DFO Bio-Island Fish Wheels indicate that the Klondike River stock comprised from 2.0% up to 6.2% of the total upper Yukon River Chinook escapement (JTC reports 2006 – 2008).

Based on radio telemetry studies of Yukon River Chinook from 2002 through 2004, the passage of Klondike River bound Chinook observed at the Canada/US border indicate that Chinook typically enter the system in early July[2] (Figure 3). The radio telemetry data indicate that peak migration occurs in mid-July. If the Klondike River Chinook run timing pattern is similar to that observed at the Big Salmon River sonar site the run will occur over approximately 5 weeks and typically be symmetrically distributed around the peak (Figure 4). However, the 2003-2005 telemetry data suggest the Klondike River Chinook run peak may be skewed to the latter half of the run. However, this could be an artifact of radio tag induced behaviour and a relatively small data set. The Chinook run into Blind Creek on the upper Pelly River system typically extends over a period of 30 days with a symmetric peak mid-way through the run (Figure 5).

Based on data from these upper Yukon River stock assessment sites it is probable the Klondike River Chinook enter the system from early July through to mid-August. Protraction of the run is likely dependent on run strength, with larger returns extending over a somewhat longer migration period.

[2] The Canada/US border is approximately 100 km downstream of the mouth of the Klondike River. Average migration rates of radio tagged Yukon River Chinook were approximately 50 km/day (B. Mercer & J.H. Eiler 2004; B. Mercer 2005; Osborne et al. 2003). The assumption is that Klondike origin Chinook would enter the Klondike River approximately 2 days after passing the border.

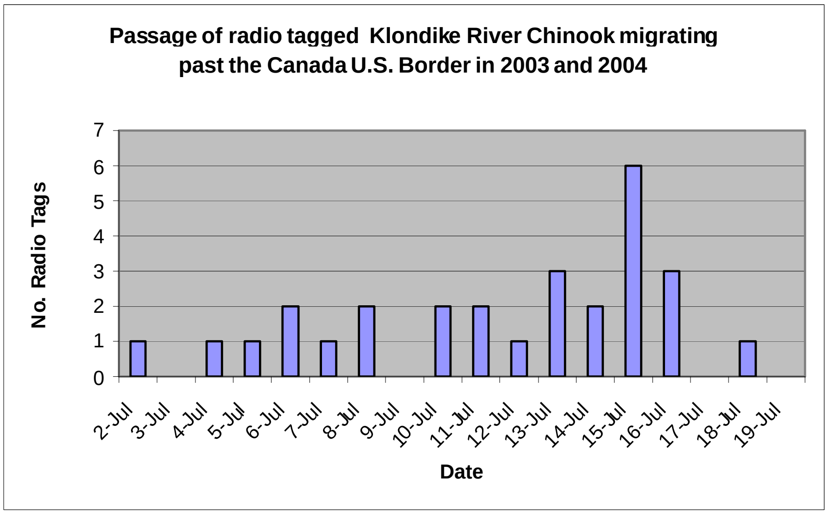

Figure 3. Date of passage past the Canada/US border of radio tagged Chinook returning to the Klondike River in 2003 and 2004.
Source: (B. Mercer & J.H. Eiler 2004; B. Mercer 2005).

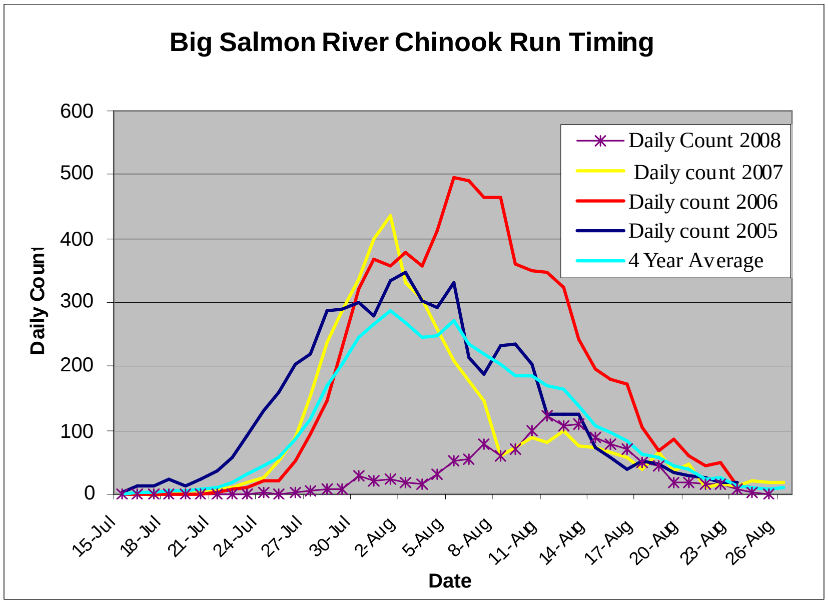

Figure 4. Run timing of Big Salmon River Chinook passing the Big Salmon River sonar site 2005 through 2008.

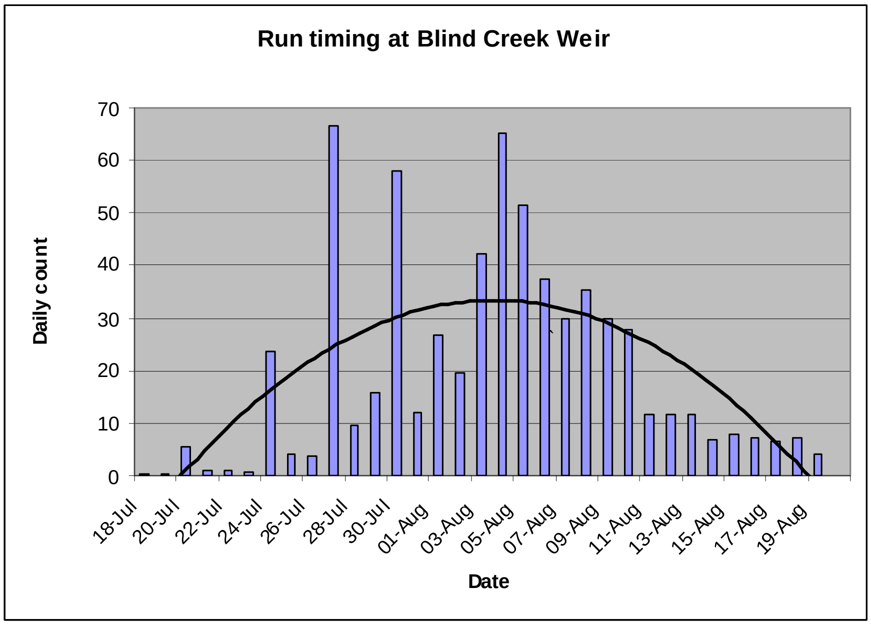

Figure 5. Eight year average run timing of Chinook salmon passing through the Blind Creek weir from 1998-2007.
(Source J. Wilson and Associates unpublished data).

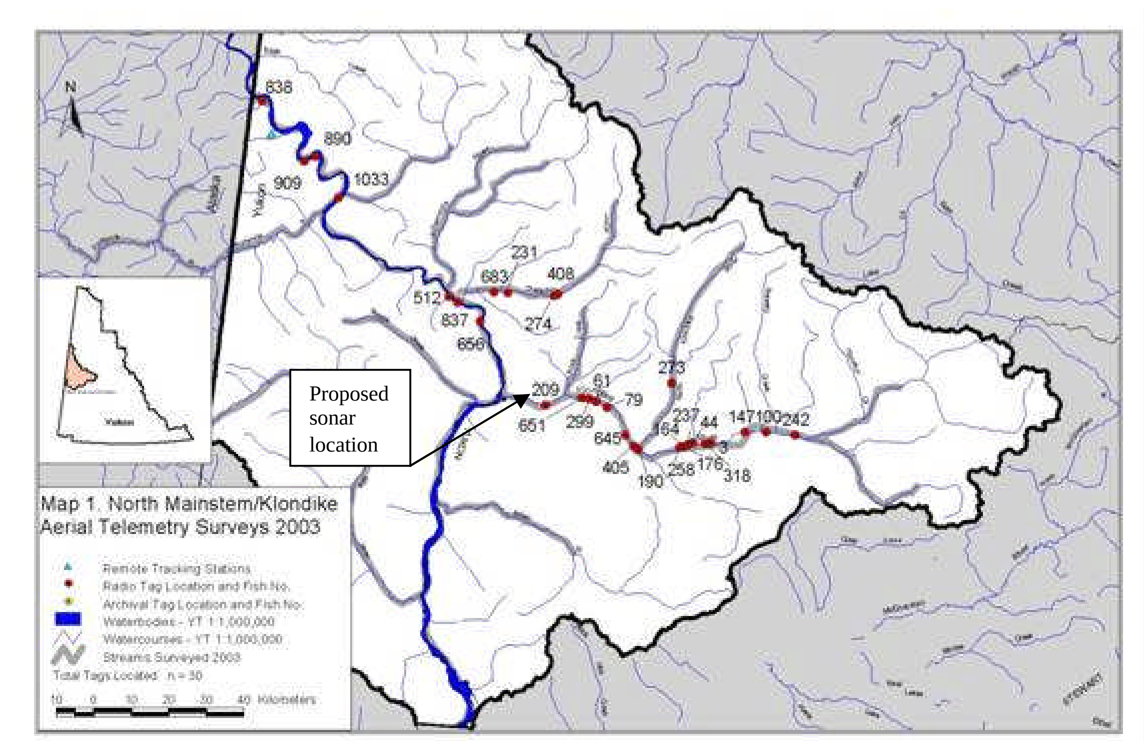

Figure 6. Location of radio tagged Chinook during peak spawning in the Klondike River watershed, 2003. (Source: Osborne and Mercer, 2003).

The spawning distribution of Klondike River Chinook has not been fully mapped and documented. However anecdotal and ancillary information on spawning distribution is available. Data from radio telemetry studies conducted from 2002 through 2004 documented the location of radio tagged Chinook during peak spawning periods. Figure 6 illustrates the location of radio tagged Chinook located in 2003 within the Klondike River watershed. A Yukon River basin-wide radio telemetry study was conducted for three years from 2003 through 2005. During the three years of telemetry studies all the 65 radio tagged Chinook that were located in the Klondike River system during the peak spawning period were located upstream of the identified sonar sites. The radio tag locations in Figure 6 were observed at peak spawning and it is likely reflective of the general Chinook spawning habitat usage in the watershed. However, the locations of the radio tagged Chinook likely does not define the absolute spawning limits and range. It is probable some fish may utilize spawning habitat within the watershed outside the location the radio tagged fish were observed.

2. Site Selection

The criteria used to identify potential DIDSON sonar sites on the Klondike River that would allow for complete enumeration of Chinook escapements into the system are:

1. Site is located as close as practical to the mouth of the system or below all known Chinook Spawning.
2. Site is a sufficient distance upstream of the mouth to avoid detection of straying Chinook salmon from other upper Yukon River stocks.
3. A straight non-braided channel with laminar flow. Laminar flow results in less background acoustic noise allowing for better fish detection, particularly those fish migrating near the river bottom. In addition straight laminar flow is conducive to a zone of active migration rather than holding/milling behaviour.
4. A relatively planar bottom profile allowing for complete ensonification of the water column so there are no areas within an acoustic "shadow".
5. Substrate should be free of large boulders which can create turbulence and acoustic noise and additional acoustic shadows.
6. The river width should not be so wide as to preclude ensonification of the total width where Chinook migration will occur. Both standard and Long Range (LR) DIDSON sonar units can detect Chinook size targets to a maximum range of approximately 40m. For this to occur the sites that are wider than 40m should allow for installation of partial weirs on either side of the river to constrict the migration to 40m or less.
7. The site is in a relatively straight section of the river so that recreational boaters using the river have a clear view and adequate reaction time to avoid the in-stream structures.
8. Road access to the sonar station site is logistically easier for camp set up and re-supply.

The Klondike river from it's confluence with the Yukon river to a point 10 km upstream is typically 75m – 85m in width and characterized by almost continuous series of contiguous riffles. Mean depth is approximately 0.6 m and mean flow rates are typically 1m/second. Braiding with one or more side channels is common and it is estimated approximately 20% of the river in the examined area is braided. The lower Klondike River alluvial plain has been significantly altered through placer mine dredging operations. The south side of the alluvial plain is interspersed with numerous dredge ponds which limits access to the Klondike River proper in this area (Figures 7 and 8).

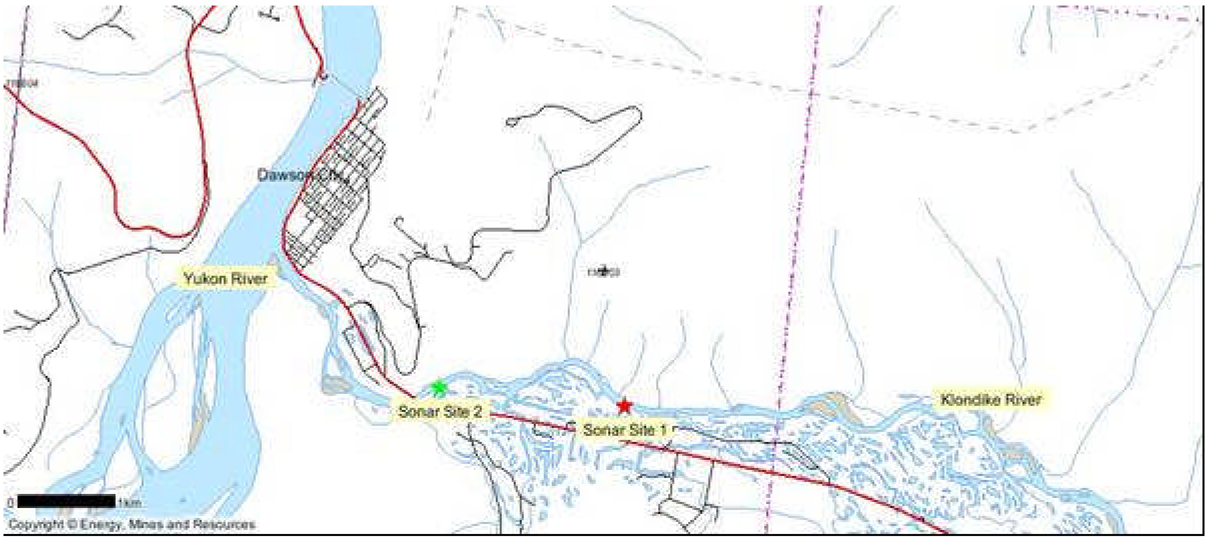

Figure 7. Lower Klondike River and potential sonar station sites.

Figure 8. Lower Klondike River valley, east view above sonar site 2.

Due to the braided, shallow, and turbulent nature of the Klondike River in the area examined as well as access difficulties, only two potential sonar station sites were identified. Sites 1 and 2 are located approximately 4 km and 2 km upstream from the confluence with the Yukon River (Figure 7). Both sites possess most of the criteria listed above allowing for complete enumeration of Klondike River Chinook escapements. However, of these two sites, site 1 was identified as having the most suitable characteristics that would allow for complete and unambiguous sonar counts of migrating Chinook salmon. For the purposes of this report, Site 1 has been identified as the primary site possessing all the required criteria listed above. Site 2 is designated a secondary site and is identified here for contingency purposes and will receive limited analysis.

Site 1

Site 1 is located approximately 4 km upstream from the confluence with the Yukon River. The site is accessible of a side branch of prospector road which accesses the Klondike Highway 6 km east of Dawson City. The sonar site borders on private leased residential land to the west and titled property within the Dredge Pond subdivision on the south-east. A 100m strip of crown land river easement is located on the south side of the river at the site. Beyond the easement on the north side of the river is Tr'ondëk Hwëch'in settlement land.

This site is the only reach on the lower Klondike system with sufficient depth to produce even laminar flows. The site is situated at the downstream end of a straight 0.8 km reach of the Klondike River (Figures 9 and 10). The flow rates at this location are approximately 0.8m/second. The flow rates are relatively uniform across the river and within 100m downstream and 800m upstream. Eddies and cross currents appear to be absent.

The wetted river width is 55m at the water levels observed during the survey in and May 2009. The wetted width in July 2009 was approximately 58m during unusually high water. The cross section profile of the site is illustrated in Figure 11. The deepest section of the river is approximately 2m at seasonal levels. The bottom profile is relatively planar with more gradual sloping on the south bank.

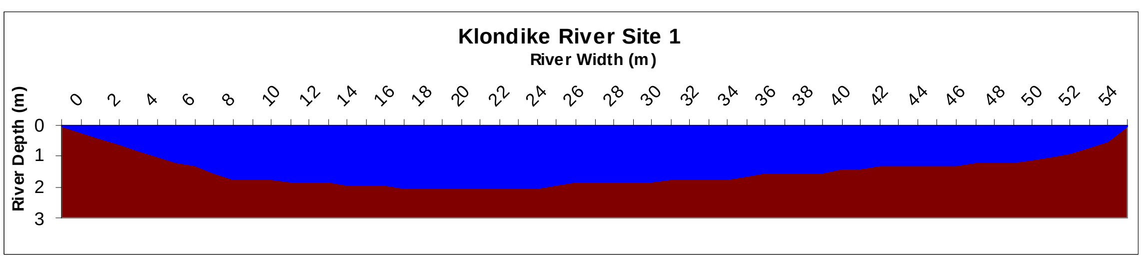

Figure 9. Cross section profile of the Klondike River at sonar site 1.

The substrate at site is primarily cobble with some sand in the interstices near shore. The cobble size varies from 5cm to 20cm in diameter. None of the substrate material appears large enough to conceal acoustical targets the size of Chinook salmon.

Figure 10. Sonar site 1 looking downstream.

Figure 11. Sonar site 1 looking upstream.

Site 2

Site 2 is located approximately 2 km upstream of the Yukon River mouth and 100m upstream of the Klondike highway bridge. The site is accessible from the Klondike Highway using an un-maintained 4 wheel drive track. An abandoned squatter's shack is located adjacent to the Klondike River at this site. The south side of the sonar site is within the easement for the Klondike Highway bridge abutment.

The site is located at the downstream end of a 200m reach of the river (Figure 12). The flow rates are approximately 1.2m/second being slightly greater in midstream. The wetted width is approximately 65 m with a maximum depth of 1.2m at seasonal water levels.

Figure 12. Site 2 looking downstream from the south bank.

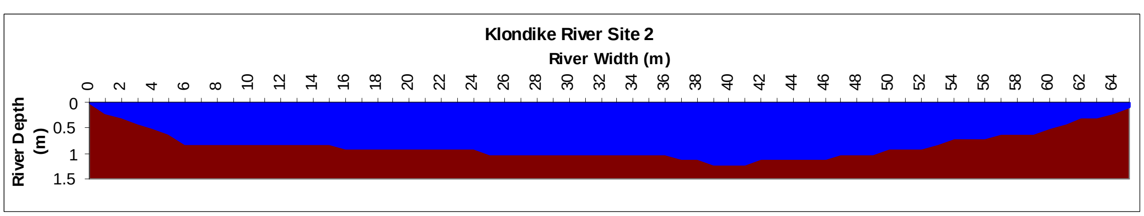

Figure 13. Cross section river profile at site 2. (Note: vertical scale exaggerated)

The cross section profile of the river at site 2 is illustrated in Figure 13. The bottom profile is relatively flat with gradual slopes up to each shore. The substrate at site 2 is cobble ranging in size from 5 up to 30cm in diameter.

3. DIDSON Sonar Operation

A LONG RANGE (LR) DIDSON sonar unit was deployed at both sites on July 6 and 7, 2008. The unit was deployed on the south bank at each site using the same mounting apparatus and in the standard manner the unit is deployed at the Big Salmon sonar site (Mercer and Wilson 2005-2007).

The DIDSON transducer lens was positioned to a depth of approximately 12 cm below the surface of the river and angled downward approximately 4º from horizontal which resulted in the ensonified cone of water remaining parallel to the surface of the river. Once the sonar was in place and properly positioned, the primary sonar unit settings and software were configured. These settings included the window start length, the ensonified window length, and the frame rate. The receiver gain was set at –40 dB, the window start at 5.86 m, window length at 40 m, and auto frequency enabled for the duration of the project. Threshold settings were set at 3 dB and intensity at 40 dB. The recording frame rate was typically set at 4 frames per second. A Toshiba laptop computer was used for recording and reviewing the DIDSON files. The window start length was varied from 5m – 40 m. During the extended operation period at each site the window length was set at 40m, which was the expected operating range that would be used to completely ensonify the supposed migration window.

The DIDSON sonar performed as expected at both sites. Using identical sonar settings at each site it was found the background acoustical noise at site 2 was higher than was observed at site 1. This was expected and is a result of higher turbulence and more air entrained water at Site 2. At the lower frequency settings (higher resolution and ensonified window < 20m) resident fish were observed. The very turbid conditions encountered in July 2008 precluded visual confirmation, but from their size and behaviour it is probable they were resident Grayling. Two larger targets were observed at Site 2 on July 6 and these were assumed to be Chinook salmon. The small number of observed Chinook targets was likely due to deployment during the early stages of the run.

4. Permitting

A sonar project at either site will require the construction of partial weirs on each bank of the river. At Site 2 the weirs would total approximately 25m and at Site 1 approximately 15m. These partial weir structures would not pose a threat to navigation on the river; however application will need to be made to Transport Canada (Marine Branch), Navigable Waters Protection for approval to install partial fish diversion fences in a navigable waterway. It is very probable the permits would be issued for either site conditional to placement of warning signs upstream of the structures and posting notification for local users.

The requirement for land use permits would be determined by the type of structures used at the sonar station and the duration the structures would be in place. If the structures are temporary and will not be left in place after the seasonal operation it is expected land use permits will not be needed. Initial enquires indicate permission could be obtained from the Yukon Ministry of Transportation for temporary use of the bridge abutment lands at Site 2.

Both potential sonar sites are within the boundaries of Dawson City. Discussion with municipal staff did not provide clarity on the requirement for research permits within city limits. The implication from city representatives was that if a permit was required for the purposes of a sonar station operation it would not be an issue.

DISCUSSION

Due to the turbulent, shallow nature of the lower 10 km of the lower Klondike River as well as difficulty of access, the lower section of the river does not offer many potential DIDSON sonar sites. Of the two potential DIDSON sonar station sites that were identified on the Klondike River during field examinations in July 2008 and May 2009 Site 1 is considered to have the best potential of yielding accurate in-season escapement counts.

At Site 1:

1. The water flow is laminar and turbulence is minimal.
2. The river profile characteristics will allow for partial weir construction on each bank of the stream with complete ensonification of the migration corridor and no acoustic shadows.
3. It is sufficient distance upstream of the Yukon River confluence to avoid detection of straying from other upper Yukon River salmon stocks.
4. The location is downstream of the principal spawning habitat.
5. The sonar station and weir structures are at the downstream end of .8 km reach of the river allowing adequate reaction time for recreational users to avoid the partial weir structures.
6. There is road access to the sonar station site with available crown easement land along the south river bank.

Given the slope characteristics on both the south and north sides of the river at Site 1, placement of partial weir structures is possible. Approximately 15 m of weir structure would be required to narrow the ensonified migration corridor to 40m or less. A typical tripod and picket weir structure should be sufficient diversion fences. However, it is suggested that robust 2.5m high rigid metal tripods be used as the water levels can rise dramatically in mid-summer during protracted periods of rain. It is anticipated the sonar station would be located on the south bank with nearby access from the road.

The property owner adjacent to Site was interviewed and appeared to be amenable to using a small portion of the property for parking vehicles and during the setup and removal of the sonar station. The property owner was also amenable to providing grid electricity to the sonar station from a nearby structure.

For the initial year of operation and to ensure a complete and accurate count of the Klondike River Chinook escapement the project should be operational from July 1 through to August 15. With experience on the system these dates may altered.

Notwithstanding unforeseen extreme water conditions it was concluded that at Site 1 using DIDSON sonar equipment, complete ensonification of a 40 m width of the Klondike River could occur throughout the Chinook migration period and a complete count of Klondike River Chinook salmon escapements could be achieved.

REFERENCES

Daum, D.W.and B.G. Flannery. 2009. Canadian origin Chinook salmon rearing in non-natal U.S. tributary streams of the Yukon River, Alaska, 2006-2007. Alaska Fisheries Technical Report No. 102, May 2009.

Eiler, J.H., T.R. Spencer, J.J. Pella, and M.M. Masuda, and R.R. Holder. 2004. Distribution and movement patterns of Chinook salmon returning to the Yukon River Basin in 2000 – 2002. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-AFSC-148.

Eiler, J.H., .R. Spencer, J.J. Pella, and M.M. Masuda. 2006. Stock composition, run timing, and movement patterns of Chinook salmon returning to the Yukon River Basin 2004. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-AFSC-165.

Galbreath, P.F. and P.E. Barber. Validation of 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.

Joint Technical Committee (JTC) of the Yukon River US/Canada Panel. 2006 and 2007. Yukon River Salmon 200- Season Summary and 200- Season Outlook. Fisheries and Oceans Canada, Stock Assessment and Fisheries Management Section, Yukon and Transboundary Area. Whitehorse, Yukon Territory.

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. CRE project 77-04, Yukon River Panel.

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. Unpublished report for CRE project 77-03, Yukon River Panel.

Mercer B. and J. Wilson, 2007, 2006, and 2005 Chinook Salmon Sonar Enumeration on the Big Salmon River. Unpublished reports for Yukon River Panel CRE project 41.

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. CRE project 78-02, Yukon River Panel.