2011 Teslin River DIDSON Sonar Feasibility Study

CRE-01N-11

Prepared For: The Yukon River Panel
Restoration and Enhancement Fund

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February 2012

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ABSTRACT

B. Mercer & Associates Ltd. conducted a study on the mainstem Teslin River in 2011 to determine the feasibility of operating DIDSON™ high resolution sonars for the purpose of enumerating migrating adult Chinook salmon. The objectives of the study were to identify a suitable sonar site and operate two sonars at the site for a period of 14 days during the peak period of Chinook migration. Additionally, a Chinook carcass pitch was planned for the upper mainstem Teslin River to obtain genetic tissue samples as well as age, sex and length data. A suitable site was identified on the lower mainstem Teslin River and two sonars were operated at the site from August 3 through August 16. Except for partial operation on the first and last day, the sonars were operated continuously 24 hours per day. Over this period a total of 3,401 targets identified as up-stream migrating Chinook salmon was counted using the sonar apparatus. A peak daily count of 345 was obtained on August 10. An average of 10.5 fish per hour (range 5.5 – 14.4) was counted over the course of the project. Approximately 96% of the counted fish were observed by the north bank sonar, indicating Chinook passage at the site was significantly skewed to the north side of the river. The study indicated it would be possible to obtain an accurate estimate of the Chinook spawning escapement into the Teslin River system if sonar(s) were deployed throughout the migration period. A Chinook carcass pitch conducted September 3 through 5 yielded 176 ASL samples and 55 DNA tissue samples. The carcass pitch confirmed the occurrence of relatively high densities of spawning Chinook in the mainstem Teslin River system.

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1. INTRODUCTION

Background

The Yukon River system encompasses a drainage area of approximately 854,000 km^2 and contributes to important aboriginal, subsistence and commercial fisheries in the U.S. and Canada. Of the five species of salmon entering the Yukon River, adult Chinook salmon travel the farthest upstream and have been documented at the furthest headwaters of the Teslin system in the McNeil River, 3,300 km from the river mouth (Mercer & Eiler 2004). Approximately 50% of Chinook salmon entering the Yukon River from the Bering Sea are typically destined for spawning grounds in Canada (Eiler et al. 2004, 2006; JTC 2010). 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).

Canadian and U.S. fishery managers of the Yukon River Joint Technical Committee (JTC) as well as members of the Yukon River Panel (YRP) recognize that obtaining accurate estimates of spawning escapements is required for the management of Yukon River Chinook (*Onchorynchus tshawytscha)* stocks. The enumeration of genetically distinct stocks, coupled with a representative genetic stock identification (GSI) sampling program can also be used to obtain independent drainage wide above border Chinook escapement estimates[1]. Quantified Chinook escapements and biological information on the stock is important for post-season run reconstruction, pre-season run forecasts and the establishment of long term biologically based escapement goals.

The Teslin River system has been identified, potentially, as a discrete Conservation Unit (CU) under the Fisheries and Oceans Canada (DFO) Wild Salmon Policy (WSP), (DFO 2007). One of the long term goals of the WSP is the establishment of biologically based escapement goals for all species of salmon within designated conservation units. A sufficiently long time series data set of salmon escapements coupled with stock recruitment modelling is the primary recognized method for the establishment of biologically based escapement goals. Currently, there is no in-season monitoring specific to Teslin River Chinook. Stock assessment of Teslin River origin Chinook is limited to annual spawning ground aerial index surveys of the upper Nisutlin River system conducted by DFO Whitehorse.

Teslin River origin Chinook are an important contributor to aboriginal fisheries in the upper Yukon watershed, and are of particular importance to the Teslin Tlingit Council. Monitoring of Teslin River Chinook will assist in achieving long term management and escapement objectives for the Teslin Tlingit Council.

[1] For the purposes of this report border escapement is defined as the number of Chinook salmon estimated to have crossed the Canada/U.S. border into the Upper Yukon River drainage minus the total Canadian harvest. Representative GSI sampling of upper Yukon River Chinook stocks occurs at the Eagle sonar site near the Canada/U.S. border in Alaska.

DIDSON Sonar

Fixed-location, side-view sonar techniques are currently the only means of obtaining in-season abundance estimates for anadromous fish stocks in rivers that are too wide for conventional weir structures, too turbid for visual observations and where weir emplacements would be a navigational impediment to water craft. Since 2002, the DIDSON™ high resolution sonar apparatus has been used for enumeration of several species of salmon in a broad range of environments (Galbreath and Barber 2005, Holmes et al. 2006, Maxwell et al. 2004, Enzenhofer et al., 2010). In general, the DIDSON units have been found to be reliable, do not require extensive operator training and provide accurate counts of migrating salmon. The detection and counting of migrating salmon with a properly positioned DIDSON imaging sonar is as accurate as visual counts of fish migrating through an enumeration fence in a clear water river (Holmes et al., 2006). Within the upper Yukon drainage DIDSON sonar has been used on the Big Salmon River (Mercer & Wilson, 2005-2011) and the Klondike River (Mercer, 2009-2011) to enumerate annual Chinook salmon escapements into these systems.

The deployment configuration of the sonar is dependent on the characteristics of the particular site, species involved, and the project objectives. The DIDSON sonar produces an ensonified field 29° wide in the horizontal plane and, depending on the transducer lens configuration, from 1° to 12° deep in the vertical plane. The maximum ensonified distance that DIDSON sonar (with an 8° lens) can detect migrating Chinook is 40 m. With a horizontally aligned 8° transducer lens the maximum ensonifiable depth at 40 m is 5.6 m. For the accurate enumeration of fish it is essential that the sonar is aimed so the beams completely ensonify the area through which fish are migrating. In addition, the bathymetric profile must preclude the presence of acoustic shadows or turbulence (air entrained water) that could mask fish targets. Species identification and/or apportionment should also be unambiguous.

Unlike split beam sonar the DIDSON sonar produces a real time image of the target. This imaging capability can allow for the identification of the species based on size, form and swimming characteristics. When mounted in a horizontal configuration the DIDSON sonar provides information on distance the target is from the sonar but not the depth of the target within the water column.

Study Area

The Teslin River system has a drainage area of 36,500 km^2 that straddles the Yukon and B.C. border (Figure 1). Teslin Lake is the largest water body in the system with a surface area of approximately 354 km^2. Teslin Lake is fed by several drainages in the upper system and discharges at its outlet into the mainstem Teslin River. The lower mainstem Teslin River has a mean annual discharge volume of 869 m^3/sec (range 1080 – 643 m^3/sec; Water survey of Canada, Station 09AF001; Figure 2).

The lower mainstem Teslin River area is remote with no highway access. Access to the area is by riverboat from Lake Laberge or Johnson's Crossing (approximately 100 and

145 river km respectively) or by floatplane with a direct distance of approximately 95 km from Whitehorse, Yukon.

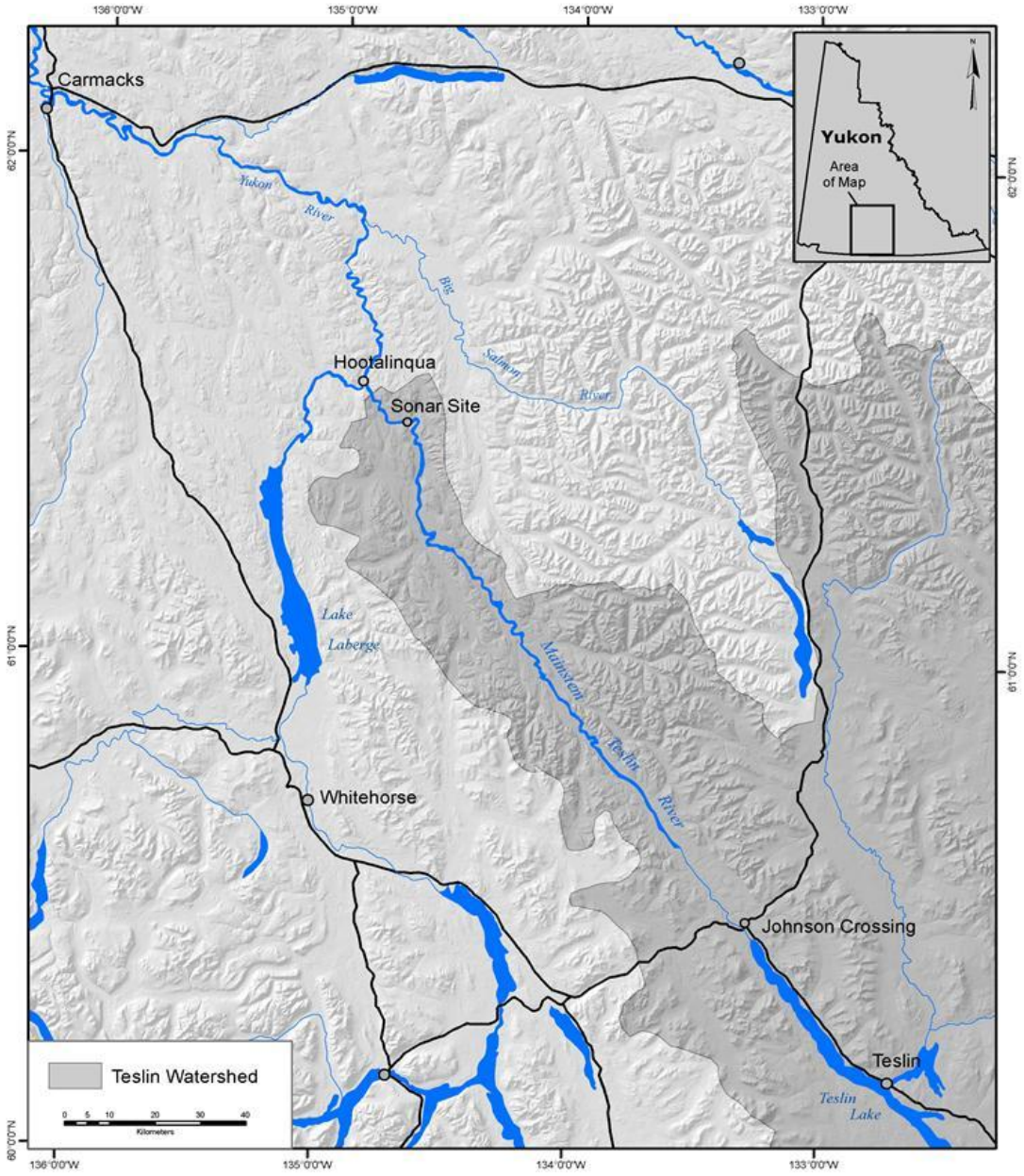

Figure 1. Mainstem Teslin River and sonar site.
Digital map data source: Yukon Government spatial data collection. www.geomaticsyukon.ca.

Fish species documented in the mainstem Teslin River system include, but are likely not limited to, Chinook and Chum salmon (*Oncorhynchus tshawytscha* and *O. keta),* Grayling (*Thymallus thymallus),* Burbot (*Lota lota*), Inconnu (*Stenodus leucichthys),* Round Whitefish (*Prosopium cylindraceum*), slimy sculpin (*Cottus cognatus*) and longnose sucker (*Catostomus catostomus*) (DFO FISS database).

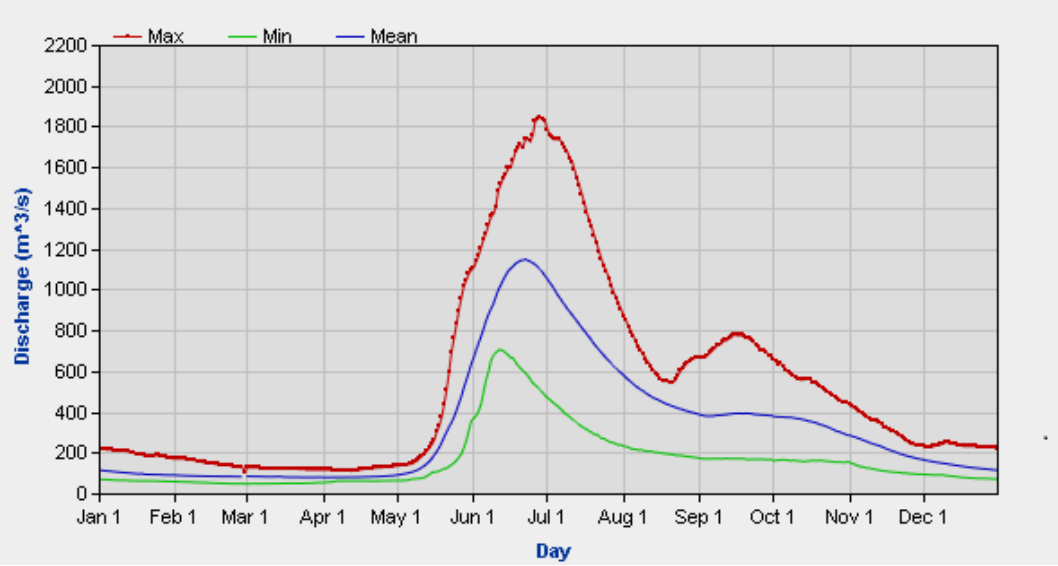

Figure 2. Daily minimum, maximum and mean discharge rates for mainstem Teslin River at station 09AF001[2] from December 1955 through January 1973. Source: Water Survey Board of Canada.

A three year radio telemetry study conducted on Yukon River Chinook from 2002 through 2004 indicated that the Teslin River system received on average 17.5% (range 15% - 20%) of the total Canadian origin Chinook in the Yukon River watershed (Mercer et al. 2004, 2005; Osborne et al. 2003). Based on this radio telemetry data, approximately 80% of the radio tagged Chinook entering the Teslin River watershed were located in the mainstem Teslin River (Appendix 1). The remaining 20% were located throughout several headwater systems draining into Teslin Lake. This proportional distribution within the Teslin system was consistent over the three years of the study. The Chinook stock proportions in other upper Yukon River basin as indicated by the telemetry results have been corroborated by subsequent sonar enumeration projects on the Klondike and Big Salmon rivers (Mercer and Wilson 2005-2011). Genetic stock identification (GSI) data collected at the Eagle sonar site is also congruent with the stock proportions observed in the three years of telemetry data (JTC 2010). Preliminary 2011 GSI data indicate Teslin origin Chinook comprised approximately 24% of the total above border Yukon River Chinook escapement in 2011 (Unpublished data, DFO Whitehorse).

2. OBJECTIVES

The objectives of the 2011 Teslin River sonar project were to:

1. Conduct a survey of the lower mainstem Teslin River to identify a potential site(s) for the deployment of two DIDSON sonars. The ideal site(s) would allow ensonification of the entire cross section of the river enabling enumeration of all passing Chinook salmon.

[2] This station, decommissioned in 1973, was located 300 m downstream of sonar site 1.

2. Operate two DIDSON sonars over the period August 3 through 16 inclusive at the chosen site(s) in order to enumerate migrating adult Chinook salmon.

3. Conduct Chinook sampling on the mainstem Teslin River to obtain age, sex and length (ASL) data as well as genetic stock identification samples from post spawn fish.

3. METHODS

Site Selection

Potential DIDSON sonar sites on the lower mainstem Teslin River should possess the following characteristics:

- Have a total wetted width of 90 m or less.
- Possess a river cross section profile that would allow complete ensonification of the water column with a maximum thalweg depth of 6 m.
- Be free of substrate irregularities such as large cobble or rock outcrops that could create acoustic shadows and/or turbulence where fish could pass undetected.
- Have laminar flow characteristics where migrating Chinook would pass directly through the ensonified zone and not be prone to milling or holding behavior.
- Be located within 15 km of the confluence of the Yukon and Teslin Rivers and therefore downstream of the principal documented spawning areas in the mainstem Teslin.

During the period June 23 through June 27 the project manager and a technician surveyed the lower mainstem Teslin River for potential sonar sites. The survey was conducted using a 6m riverboat powered by an outboard jet. The wetted river width of potential sites was determined to the nearest meter using a laser range finder. Cross section bathymetric profiles were obtained using mechanical soundings and a Biosonics™ DTX hydroacoustic apparatus.

Sonar deployment and operation

The 2011 operational plan was to place a sonar unit on each side of the river at the selected site. The sonar units would be aimed across the river to ensonify the Chinook migration corridor. Using a window length of 40 m for each sonar would result in a total ensonified distance of 80 m across the river.

Two standard range DIDSON sonar units were rented from Sound Metrics Corporation (Manufacturer of DIDSON sonars) for the period August 1 through August 17. In addition, two Tranzeo™ wireless routers were ordered and purchased in mid-May. The routers enable wireless transmission from the sonar unit to the linked computer that controls and receives the sonar data. The sonars, computers, and other apparatus were powered throughout the project using two 2000 watt Honda generators, one on each side of the river.

Two sonar stands were fabricated in Whitehorse prior to the start of the project. Each stand was constructed of 2-inch, schedule 80 steel pipe consisting of two T-shaped legs 120 cm in height, connected by a 90 cm crossbar (Figure 3). The sonar unit was bolted to a steel plate suspended from the cross bar that was connected to the stand with adjustable clamps. The adjustable clamps allowed the sonar unit to be raised or lowered according to fluctuating water levels as well as enabling rotation of the transducer lens to adjust the beam direction.

Two 8° concentrator lenses were purchased from Sound Metrics Corporation and mounted on the standard transducer lens of each sonar unit. The concentrator lens reduces the vertical ensonified field from 14° to 8°. The reduced field size increases the acoustic energy reflected and reduces interference from surface and bottom reverberation as well as overall acoustical "noise". This results in an increase in the resolution of all target images and, more importantly, increases the resolution and detection of targets in the outer range of the ensonified area where reflected acoustic energy is lowest.

The DIDSON transducer lens was positioned to a depth of approximately 12 cm below the surface of the river and angled downward approximately 3º from horizontal. This resulted in the upper edge of the ensonified field of view remaining parallel to the surface of the river. The sonars have an incorporated compass and inclinometer that displays the tilt and azimuth of the sonar beams on the computer display.

Figure 3. Sonar unit mounted on stand (Photo from 2006 Big Salmon sonar project).

The receiver gain was set at –40 dB, the window start at 5.0 m, window length at 40 m, and auto frequency was enabled for the duration of the project. With a 40 m window length the default operating frequency is 1.1 Mhz. Threshold settings were set at 3 dB and intensity at 40 dB. The recording frame rate was set at 4 frames per second. Two laptop computers were used for the project, one designated for each sonar. All files were saved on the recording computer as well as backed up on a 2.0 TB external hard drive.

Chinook Enumeration

A temporary camp was set up at the selected site on the north bank of the river on July 18th and 19th. The camp structure consisted of a 5 m x 5 m "Weatherall" tent with a plywood floor. Materials for the camp were transported to the site using a river boat and

float equipped aircraft. On August 1st and 2nd personnel, equipment, fuel and supplies were transported to the selected sonar site.

On August 3 the sonars were put in position on each side of the river (Figure 4). Recording of files began at 13:00 for the sonar located on the north bank (NB) of the river and at 17:00 for the unit situated on the south bank (SB). The NB sonar was operated continuously until 15:20 on August 16. The SB sonar was operated continuously until 13:40 on August 14. Initially the computer controlling and receiving data from the SB sonar was positioned on the south bank and directly connected via ethernet cable to the sonar. On August 5 the two wireless routers were installed allowing the SB computer to be operated from the camp by wireless transmission.

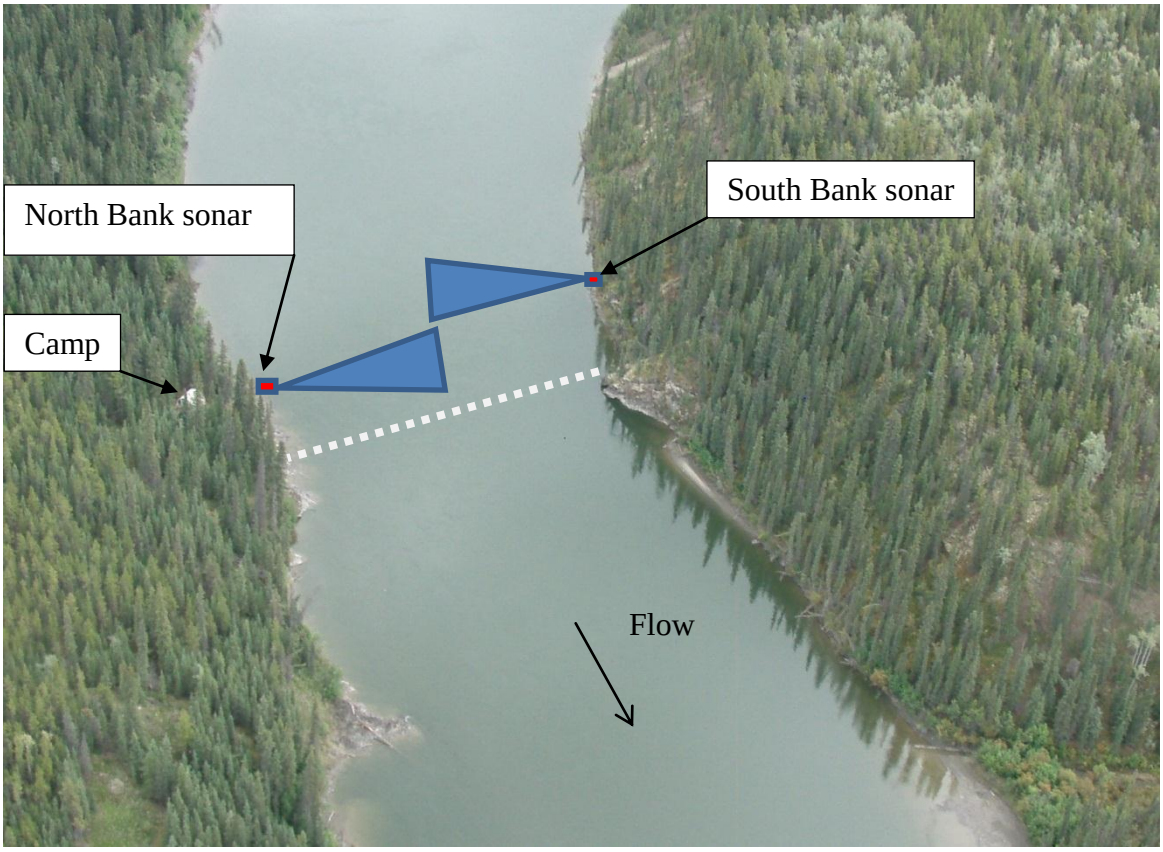

Figure 4. Aerial view of Site 1 depicting the camp, sonar locations and schematic representation of ensonified portions of the river during the 2011 Teslin Feasibility study. Note: Blue triangles denote approximate ensonified regions of the river. White dotted line is bathymetric profile transect. Position of SB sonar is after being moved upstream on August 9.

During the project the sonar data was collected continuously and stored automatically in pre-programmed, 20 minute date stamped files. This resulted in an accumulation of 72 files over a 24 hour period. These files were subsequently reviewed the following day and backed up on an external hard drive.

To optimize target detection during file review, the background subtraction feature was used to remove the static river bottom structure. The intensity (brightness) was set at 40 dB and threshold (sensitivity) at 3dB. The playback speed depended on the preference and experience of the observer, but was generally set between 40 and 60 frames per second, approximately 10 - 15 times the recording rate. When necessary, the file review was stopped when a target was observed and replayed at a slower rate to aid in identifying passing fish. All targets identified as Chinook were visually counted and entered into an excel spreadsheet. The position of each Chinook observed within the cross section profile of the river was recorded in 5 m increments. This provided information on the spatial pattern of migrating Chinook within the ensonified area of the river. A record was maintained of each 20 minute file count as well as hourly, daily and cumulative counts. The data from each sonar was combined and entered daily into a master spreadsheet.

Target Identification and Species Apportionment

Fish identification and species apportionment was based on size, form and swimming behaviour of detected sonar targets. The minimum size used to classify Chinook salmon for the project was 55 cm. The target measurement feature of the DIDSON software was used to estimate the size of the observed fish when required. With adequate training it has been demonstrated that DIDSON sonar operators are able to differentiate, with a high degree of accuracy, between resident fish species and migrating salmon (Enzenhofer et al. 2010). Blind trials comparing both visual and DIDSON sonar counts of Chinook on the Klondike River demonstrated that trained sonar operators detected and correctly identified 100% of the visually observed (n=106) Chinook passing the Station (Mercer 2010).

Co-migrating Chum salmon could be incorrectly identified as migrating Chinook due to similar migratory behaviour and size overlap. Fall Chum salmon are documented spawning in the mainstem Teslin River (DFO FISS database). Test fishing at the Eagle sonar station from 2007 through 2009 captured the first fall Chum Salmon on August 8, 9, and 19 respectively (Crane and Dunbar, 2009 and 2011). The first Chum salmon captured during the 2011 gillnet sampling at the Eagle sonar test fishing site was on August 3 (Elizabeth MacDonald, DFO Whitehorse, Per. Comm.). The river distance from Eagle Alaska to the Teslin sonar site is approximately 780 km. Mean migration rates for upper Yukon River fall Chum have been documented at approximately 40 km/day (Boyce 1999). This suggests the Chinook migration would be complete before the arrival of fall Chum in the system. GSI sampling at the Eagle sonar site in 2011indicated Teslin Chum accounted for only 0.7% (std. dev. 0.4) of the total above border fall Chum escapement (DFO Whitehorse, unpublished data).

Permits

Given the short nature of the project a land use permit from YTG Lands Branch was not required for the project. A 2011 fish collection licence was obtained from DFO to collect dead and moribund Chinook from the Teslin River watershed.

Carcass Pitch

The carcass pitch on the upper mainstem Teslin River was conducted by a crew of two technicians. Access to Chinook spawning areas was by a river boat powered by a 60 hp outboard jet. The crew accessed the river at the Johnson's Crossing boat ramp located approximately 4 km downstream from the outlet of Teslin Lake (Figure 1). Only dead or moribund fish were collected. Collection was by hand and by an extendable spear.

Tissue samples were collected from fish that were moribund or were considered to have been dead less than four hours as determined by the absence of rigor mortis and the presence of red gills. Two axillary appendage clips were obtained from each selected fish and placed in separate bottles containing 95% denatured ethanol. Five scales were obtained from all recovered fish. As well, post-orbital hypural (POH) and mid-eye fork (MEF) lengths to 0.5 cm and the sex were recorded for all recovered fish.

4. RESULTS

Site selection

Three potential sonar sites were identified in a 24 km reach of the Mainstem Teslin River upstream from the confluence with the Yukon River at Hootalinqua (Figure 5). These sites were initially identified and selected for further investigation based on having wetted river widths of 100m or less. The lower (24 km upstream of Hootalinqua) mainstem portion of the Teslin River has an estimated mean wetted width of approximately 150 m, (range 78m to 260m).

Site 1.
Location: 61°29'26.37"N; 134°45'25.24"W

Of the three sites initially identified, further investigation indicated Site 1 was considered the most suitable for the deployment of DIDSON sonar to enumerate migrating Chinook. This assessment was based on a river width of 91 m, a laminar flow, and an appropriate cross section bathymetric profile that would allow near complete ensonification of the river using two sonars (Figures 3 and 6). The narrowing of the river at this site is due to the occurrence of an erosion resistant bedrock outcrop visible on both banks and extending under the river. The thalweg depth of this site on June 26 was 6.0 m. The surface flow 5 m out from the north and south banks was approximately 1.3 m/sec. During the sonar operation the water depth was approximately 0.9 m lower than when measurements were taken on June 26. Site 1 was chosen for the operational phase of the project.

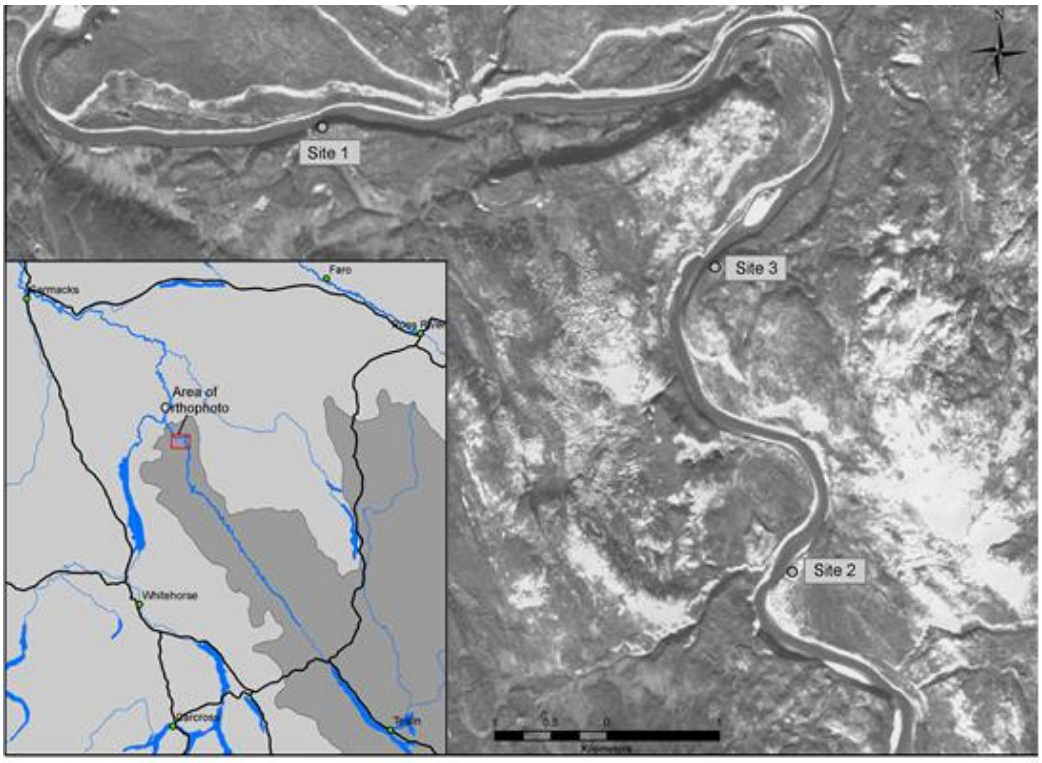

Figure 5. Location of identified potential sonar sites on the lower mainstem Teslin River.
Digital orthophoto source: Yukon Government spatial data collection. www.geomaticsyukon.ca.

Figure 6. Site 1, view from north bank looking across river showing bedrock outcrops.

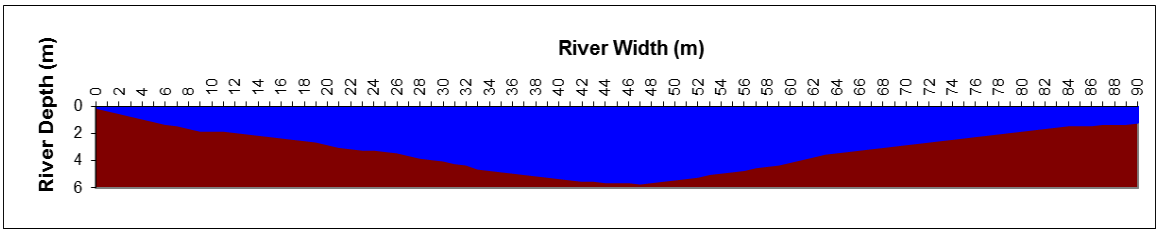

Figure 7. Schematic bathymetric profile of sonar Site 1, measured June 27, 2011.

Site 2.
Location: 61°27'18.33"N; 134°40'47.93"W

Site 2 had a total wetted width of 98 m as measured on June 28. The river at this location did not appear to be constricted by any obvious physiographic structure (Figure 7). The lower current velocity, cobble substrate, and bathymetric slope profile on the east side of the river would allow for the deployment of an extensive deflection weir to narrow the fish migration corridor to 80 m or less. Laminar flow exists at this site and the maximum thalweg depth measured on June 28 was 5.8 m. However, the bathymetric profile indicates the thalweg is located in a depression which would likely result in a proportion of the water column at the bottom of the river that could not be completely ensonified. It is probable that some Chinook would migrate in this region. The preliminary investigation at this site was limited as it was not considered as suitable as Site 1.

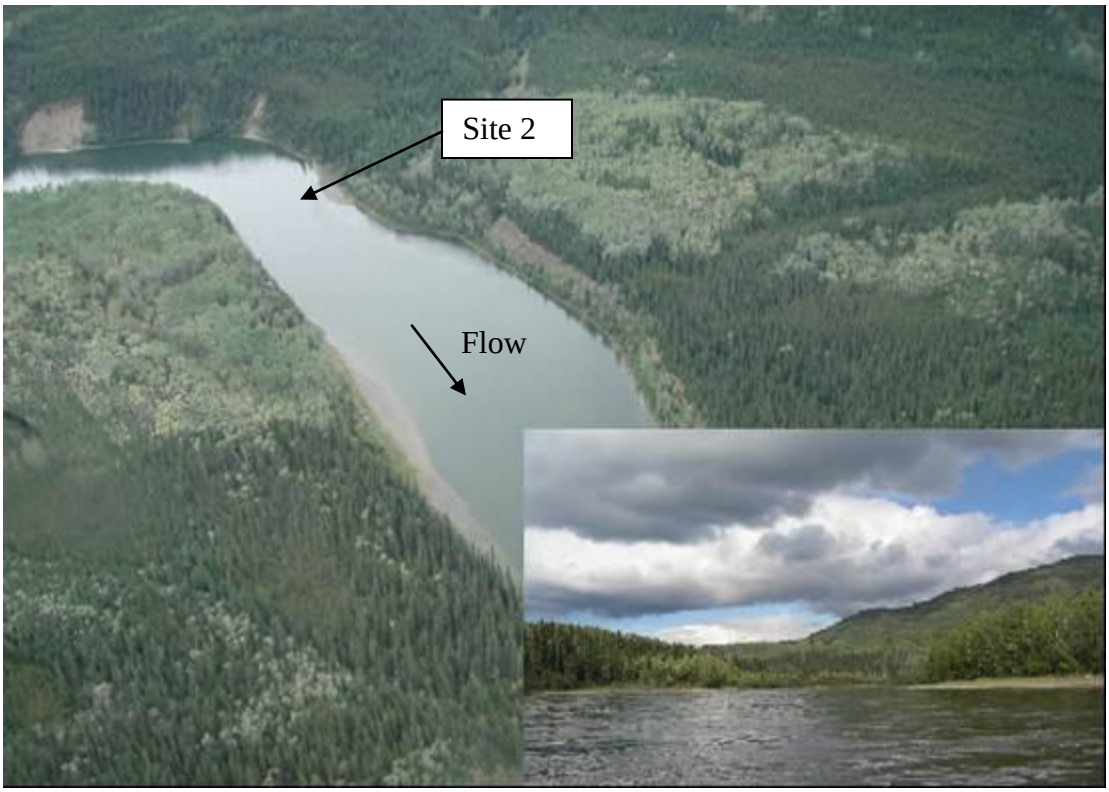

Figure 8. Aerial view of Site 2. Inset photo looking downstream through Site 2.

During the sonar operation phase of the project Site 2 was investigated again. On August 15 the SB sonar was moved from Site 1 and deployed at Site 2 on the east bank for a period of 5 hours. The DIDSON sonar imagery of the river bottom confirmed the presence of a non-ensonified portion of the water column at a distance 35 m from the east bank. Additional bathymetric profiling may yield a location at this site where complete ensonification of the water column may be possible. This site would require the full deployment of two sonars over the course of the Chinook run and a deflection weir on the east bank.

Site 3.
Location: 61°28'48.11"N; 134°41'33.01"W

Site 3 had the narrowest river width (78 m) observed in the study area. The river constriction at this location is caused by an erosion resistant rock outcrop on the west side of the river (Figure 9). However, with a maximum depth of 10m, a near vertical cross sectional profile on the west bank, and the presence of strong eddies immediately above and below the rock outcrop the site was not considered suitable for the deployment of any type of sonar. The characteristics of this site suggest it would be a good location for test fishing with set nets.

Figure 9. Site 3. View from west bank looking across river at narrowest point.

Chinook Enumeration and Migration Patterns

A total of 3,401 assumed Chinook salmon was counted passing the sonar site during the period August 3 through 16 (Table 1). Of this total, the NB sonar counted 3,300 (97%) of the passing Chinook and the SB sonar, 101 (3%). Total daily counts ranged from 193 to 325 with a mean daily count of 258 (Figure 7). The highest count during the project occurred on August 10. It is possible this could have been the peak of the run but the consistency of counts (excluding partial day counts on August 3 and 16) during the project precludes positive identification of a run peak. There was an observable but non-significant ($R^2 = 0.15$) linear decrease in daily counts over the course of the project.

The cross sectional distribution pattern of the migrating Chinook is presented in Figure 7. The distribution of Chinook passing the station was significantly skewed to the north bank of the river. After 3 days of observing the relatively low Chinook counts of the SB sonar, the two sonar units were inter-changed to determine if the low SB counts could have been due to faulty equipment. However, interchanging the sonars did not significantly alter the SB counts.

During the first 6 days of SB sonar operation a pattern of turbulence was observed at the 20 m and 25 m range. A DIDSON sonar was not used during the initial site evaluation and consequently this bottom turbulence was not detected. The bathymetric profile of the site was determined upstream of the SB sonar ensonified area. It is suspected the turbulence was due to bottom protrusions associated with the bedrock outcropping at the site. Surface flow patterns did not indicate the presence of turbulence lower in the water column.

Table 1. 2011 Daily counts of Teslin River Chinook salmon.
Note: Grey cells denote partial day of sonar operation

	South Bank Sonar			North Bank Sonar			Total Daily Count
Date	Daily Count	Fish/hour	% of Daily Total	Daily count	Fish/hour	% of Daily Total	
03-Aug	0	0.00	0.0%	98	4.08	100.0%	98
04-Aug	0	0.00	0.0%	325	13.54	100.0%	325
05-Aug	9	0.38	3.4%	253	10.54	96.6%	262
06-Aug	2	0.08	1.0%	206	8.58	99.0%	208
07-Aug	0	0.00	0.0%	274	11.42	100.0%	274
08-Aug	2	0.08	0.7%	265	11.04	99.3%	267
09-Aug	13	0.54	4.5%	277	11.54	95.5%	290
10-Aug	21	0.88	6.1%	324	13.50	93.9%	345
11-Aug	18	0.75	6.8%	246	10.25	93.2%	264
12-Aug	19	0.79	7.2%	245	10.21	92.8%	264
13-Aug	9	0.38	4.5%	193	8.04	95.5%	202
14-Aug	8	0.33	3.3%	235	9.79	96.7%	243
15-Aug				228	9.50	100.0%	228
16-Aug				131	5.46	100.0%	131
Total/mean	101	0.38	0.03	3300	10.66	0.97	3401

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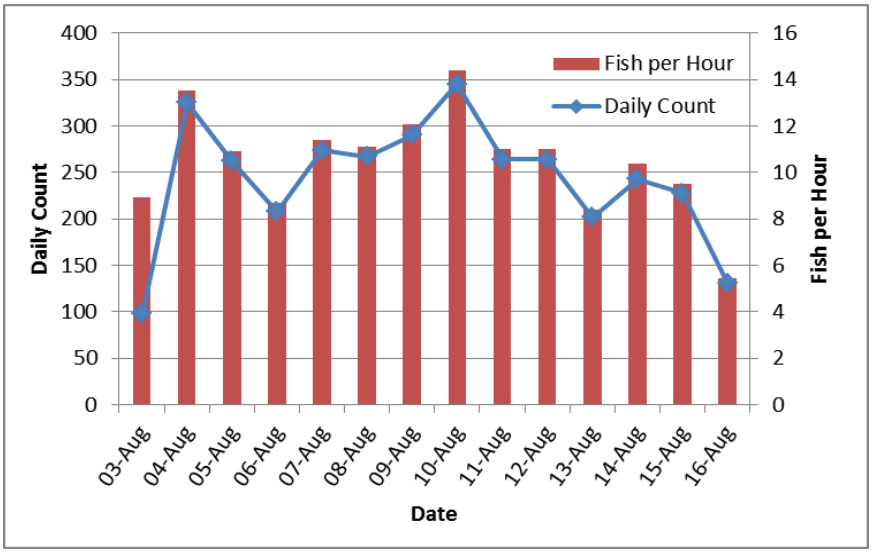

Figure 10. 2011 Teslin River Chinook daily and fish per hour counts.
Note: August 3 and August 16 are partial day counts.

Due to concern that the observed turbulence could mask fish targets, the SB sonar was moved upstream 35 m on August 9. Subjective evaluation indicated an observable reduction in turbulence at this upper site. The SB daily counts increased significantly (t-test: $t = 4.18$; $p = 0.0024$; df = 9) after the sonar was moved upstream. However, after the move the SB daily counts were still only 5.7% of the NB daily counts (Table 1). It is not known if the increase in SB sonar counts was a result of better detection conditions (less turbulence) and/or the result of Chinook moving back into the south side of the river after transiting the zone of increased flow and turbulence downstream of the sonars.

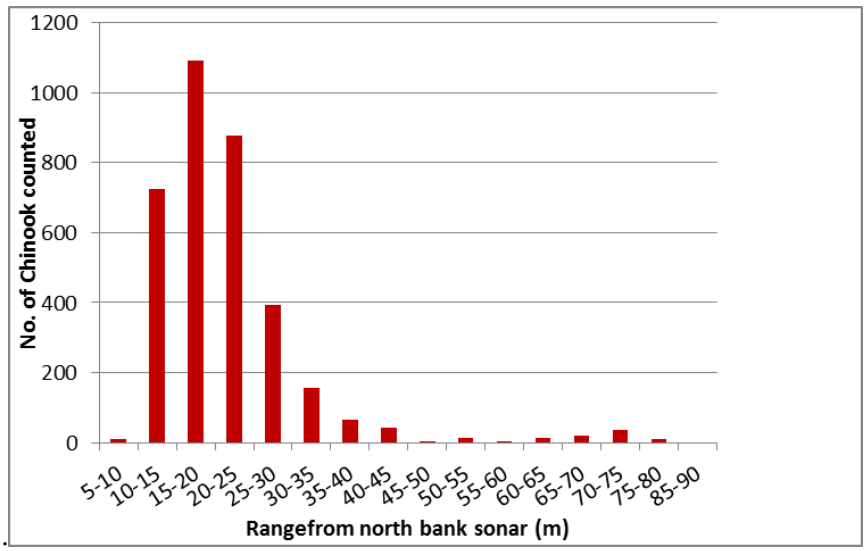

Figure 11. 2011 Teslin River Chinook range/frequency in cross section profile.
Note: Distance from the NB sonar.

Target Identification and Species Apportionment

During the project, resident fish species (as well as other observed targets such as waterfowl and beaver) were readily distinguished from migrating Chinook based on size, form and swimming behaviour. Resident fish species were detected by the sonars throughout the course of the project. In order to accurately measure resident fish lengths both sonars were operated for 1 hour each on August 7 and 10 at a reduced window length of 10 m. Reducing the sonar window length to less than 10 m changes several sonar operating parameters leading to an increase in image resolution and thereby increasing the precision of the fish measurements. During the four hours of short range sonar operation 56 assumed resident fish were measured using the DIDSON measuring software. The estimated size of the resident fish ranged from 100 to 510 mm (mean 180 mm; std. dev. 5.4 mm). The smallest Chinook MEF length observed from the Teslin 2011 carcass pitch results was 530 mm (range 530 – 1030 mm; mean 792 mm; std. dev. 988 mm) (Appendix 2 and 3). Figure 9 illustrates a length frequency histogram of the sonar estimated size of presumed resident fish and the measured MEF length of 2011 sampled mainstem Teslin Chinook.

Carcass Pitch

A total of 178 dead or moribund Chinook was recovered during the carcass pitch. Of these, 172 were aged based on scale analysis. Age, length and sex data of the sampled Chinook is summarized in Table 2 and presented in Appendix 2. Females and males comprised 56 (33%) and 116 (67%) respectively of the 172 fish sampled. Age 1.3 and age 1.4 were the dominant age classes for males and females respectively. The dead pitch sampling occurred over a three day period from September 3 – 5. It is probable the ASL data is not representative of the 2011 mainstem Teslin Chinook escapement as the sampling was not temporally representative of the entire post spawn mortality event.

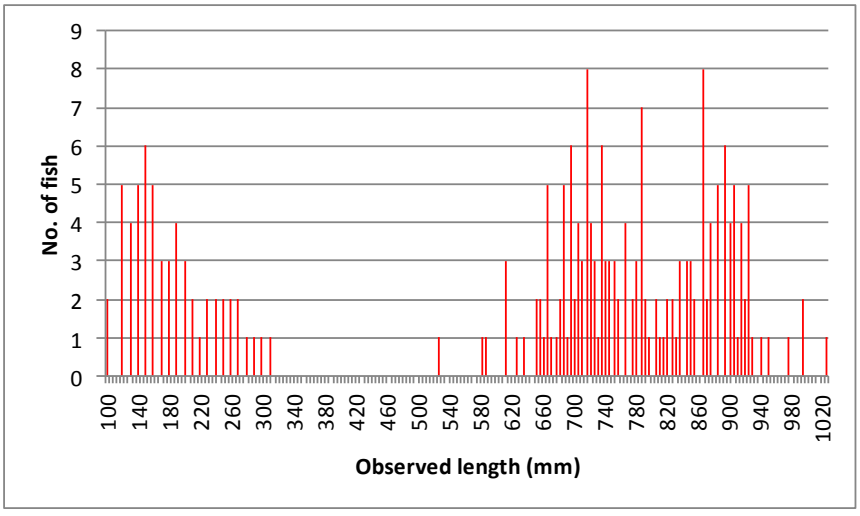

Figure 12. Length frequency histogram of resident fish and sampled 2011 mainstem Teslin Chinook.

Table 2. Age, sex, and length summary of sampled 2011 mainstem Teslin Chinook.

Age	Data	Female	Male	Total
12	Count of Age	0	6	6
	Average MEF (mm)		623	623
13	Count of Age	6	61	67
	Average MEF (mm)	789	724	731
14	Count of Age	41	25	66
	Average MEF (mm)	871	843	860
15	Count of Age	4	2	6
	Average MEF (mm)	918	890	908
1F	Count of Age	0	4	4
	Average MEF (mm)		764	764
M2	Count of Age	0	1	1
	Average MEF (mm)		530	530
M3	Count of Age	1	9	10
	Average MEF (mm)	890	726	742
M4	Count of Age	4	8	12
	Average MEF (mm)	909	863	878
Total Count		56	116	172
Total Average MEF (mm)		868	758	792

5. DISCUSSION AND RECOMMENDATIONS

The results of this project demonstrated the feasibility of using DIDSON sonar to enumerate Chinook escapements into the Teslin River drainage. Nevertheless, obtaining an accurate escapement estimates will be somewhat more challenging than other DIDSON sonar projects conducted on upper Yukon River tributaries.

Appendix 4 illustrates the passage of 86 Teslin origin radio tagged Chinook that were recorded migrating past the Teslin River telemetry station[3] in 2003. The 2003 Teslin Chinook telemetry data indicate that 36% (31/86) of the radio tagged fish passed the station during the period Aug 4 through 16. Applying an expansion factor to the 2011 sonar count of 3,301 based on this proportion (36%) would yield a total 2011 Teslin Chinook escapement of 9,169. This expanded count is not inconsistent with the 2011 Yukon River Chinook GSI sample data and the 2011 above border Eagle sonar Chinook estimate. The GSI sampling at the Eagle sonar site indicated that Teslin drainage Chinook comprised approximately 25% of the total above border escapement estimate of 50,780 Chinook salmon (DFO Whitehorse unpublished data 2012).

The absence of a defined temporal run pattern during the 2011 project prevented the development of a Teslin Chinook escapement estimate based on the 14 days of daily counts. The radio telemetry data (Appendix 4) is consistent with the 2011 Teslin sonar

[3] The Teslin telemetry station was located 28 km downstream of the sonar site.

counts in that it suggests a protracted run with no defined peak. This pattern is unlike that observed at the Big Salmon and Klondike sonar projects where the Chinook daily counts exhibit a normalized distribution with a defined peak (Mercer 2011; Mercer and Wilson 2011).

As with other DIDSON sonar projects on upper Yukon River tributaries, the results of this project indicate differentiation between migrating Chinook and resident mainstem Teslin River fish species is possible. The size classes of presumed resident species did not overlap with those of sampled Chinook. Catches of resident fish species in the size range of migrating Chinook during test fishing at the Eagle sonar site are very low (< 1% of combined Chum and Chinook; Crane and Dunbar, 2009 and 2011). There is no reason to expect the riverine habitats of the mainstem Teslin would contain larger resident species than are found in the Yukon River at the Canada/US border. However, the presence of resident mainstem Teslin fish in the size classes of Yukon Chinook salmon and/or the presence of co-migrating Chum later in the season cannot be discounted. Limited test fishing with appropriate sized gillnets at the sonar site over the course of the project, while not definitive, may provide some quantitative information on the relative abundance of larger resident fish in the mainstem Teslin. Test fishing may also yield information on the presence/absence of co-migrating Chum during the latter stages of the Chinook run.

Only 3% of the migrating Chinook were detected on the south side of the river. It is possible the spatially skewed distribution of migrating Chinook at the sonar site may be due to the disturbed laminar flow and turbulence observed on the south side of the river. Chinook spatial migration patterns within a river are not random. Research has demonstrated that to increase energetic efficiency migrating salmon will orient to those parts of the river with the lower and more uniform laminar flows (Quinn 2005). If the proportion of Chinook migrating on the south side of the river at Site 1 is consistently small and does not exhibit significant inter or intra-annual variance it may be possible to obtain an accurate escapement estimate using only one sonar. Quantification of the relative proportions, and their variance, would allow development of an expansion factor which could be applied to the total counts of the sonar operated on the north bank.

The following recommendations are suggested if a comprehensive mainstem Teslin Chinook enumeration project is conducted in the future:

1. Sonar operations should occur from July 15 through to September 2 to adequately cover the run.
2. Dead pitch collection should occur from approximately August 25 through September 10 for representative biological sampling of the mainstem Teslin Chinook escapement.
3. A second sonar should be operated concurrently from the south bank of the river for a minimum of 15 days during the middle of the run. This would be needed to determine the proportional contribution of Chinook migrating on the south side of the river.
4. Short (5 m) diversion weirs would be required downstream of both the SB and NB sonars to deflect migrating Chinook from the near field of the sonar into the ensonified portion of the River.

5. A limited test fishing program using both drift and set nets of the appropriate mesh sizes should be conducted in conjunction with the sonar project. There is no evidence that Chinook recognition/species apportionment will be a concern, however, limited test fishing will help remove any perceived uncertainty.

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ACKNOWLEDGEMENTS

Several individuals contributed to the 2011 Teslin River sonar project. Jane Wilson assisted with the sonar site evaluation and provided editorial support for this report. Clive Osbourne and David Macdonald assisted with the camp setup and sonar operation. Funding for this project was provided by the Yukon River Panel Restoration and Enhancement Fund.

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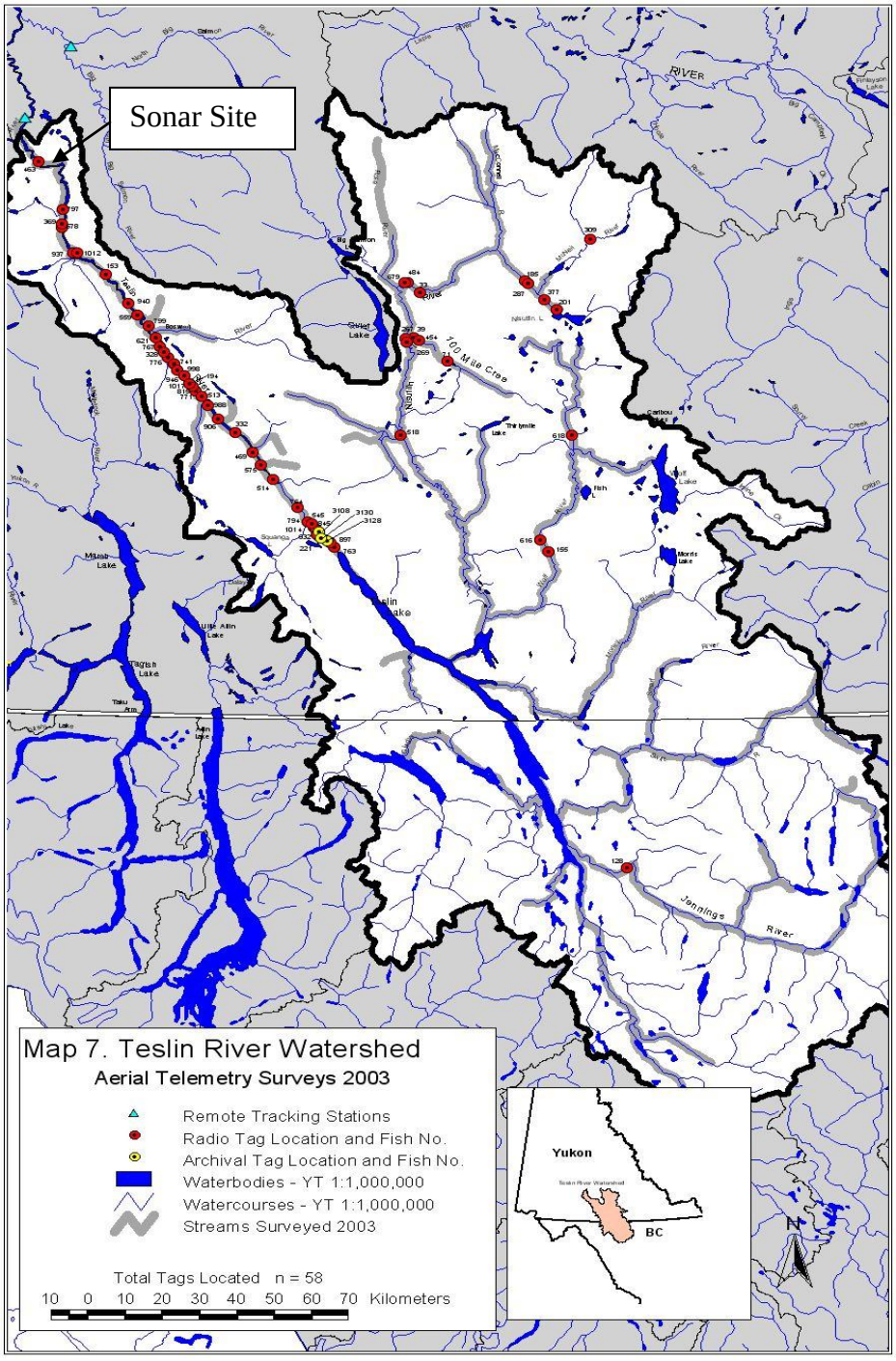
Appendix 1. Location of radio tagged Chinook during peak spawning in the Teslin River drainage in 2003.
Source: Mercer and Eiler, 2004.



Appendix 2. 2011 Mainstem Teslin River carcass pitch data.

DATE	FISH #	SEX	MEF (mm)	POHL (mm)	Gilbert age	European Age	DNA sample	SCALE BOOK#	BOOK #	SCALE #
3-Sep	1	M	700	600	52	13	Y	71235	1	1-41
3-Sep	2	M	700	605	52	13	Y	71235	1	2-42
3-Sep	3	F	870	750	62	14		71235	1	3-43
3-Sep	4	M	720	625	52	13	Y	71235	1	4-44
3-Sep	5	F	910	810	62	14	Y	71235	1	5-45
3-Sep	6	F	910	800	62	14		71235	1	6-46
3-Sep	7	F	860	730	62	14	Y	71235	1	7-47
3-Sep	8	F	890	785	62	14	Y	71235	1	8-48
3-Sep	9	F	855	750	62	14		71235	1	9-49
3-Aug	10	F	905	795	62	14		71235	1	10-50
3-Sep	11	F	NA	765	62	14		71236	2	1-41
3-Sep	12	F	825	715	62	14		71236	2	2-42
3-Sep	13	M	715	630	52	13		71236	2	3-43
3-Sep	14	F	790	695	62	14	Y	71236	2	4-44
3-Sep	15	M	1030	885	62	14		71236	2	5-45
3-Sep	16	M	NA	560	52	13	Y	71236	2	6-46
3-Sep	17	M	690	595	52	13	Y	71236	2	7-47
3-Sep	18	M	680	580	52	13		71236	2	8-48
3-Sep	19	F	870	765	62	14		71236	2	9-49
3-Sep	20	M	760	650	52	13	Y	71236	2	10-50
3-Sep	21	F	875	750	62	14	Y	71237	3	1-41
3-Sep	22	M	730	640	52	13		71237	3	2-42
3-Sep	23	M	720	620	52	13	Y	71237	3	3-43
3-Sep	24	M	780	685	52	13		71237	3	4-44
3-Sep	25	F	770	660	62	14		71237	3	5-45
3-Sep	26	M	720	640	3M	M3		71237	3	6-46
3-Sep	27	M	745	645	52	13	Y	71237	3	7-47
3-Sep	28	F	900	790	62	14		71237	3	8-48
3-Sep	29	M	675	580	52	13	Y	71237	3	9-49
3-Sep	30	M	870	745	4M	M4		71237	3	10-50
3-Sep	31	M	825	730	52	13		71238	4	1-41
3-Sep	32	M	710	610	52	13		71238	4	2-42
3-Sep	33	M	790	690	62	14		71238	4	3-43
3-Sep	34	M	745	650				71238	4	4-44
3-Sep	35	M	720	620	52	13	Y	71238	4	5-45
3-Sep	36	M	NA	585	52	13		71238	4	6-46
3-Sep	37	M	640	555	S2	1F		71238	4	7-47
3-Sep	38	M	705	610	52	13	Y	71238	4	8-48
3-Sep	39	M	660	565	62	14		71238	4	9-49
3-Sep	40	M	720	620	52	13		71238	4	10-50
3-Sep	41	F	890	775	62	14		71239	5	1-41
4-Sep	42	F	930	805				71239	5	2-42
4-Sep	43	F	880	775	62	14	Y	71239	5	3-43
4-Sep	44	F	855	755	62	14		71239	5	4-44
4-Sep	45	M	725	625	52	13		71239	5	5-45
4-Sep	46	M	710	615	52	13		71239	5	6-46
4-Sep	47	F	875	765	62	14	Y	71239	5	7-47

DATE	FISH #	SEX	MEF (mm)	POHL (mm)	Gilbert age	European Age	DNA sample	SCALE BOOK#	BOOK #	SCALE #
4-Sep	48	F	870	765	52	13		71239	5	8-48
4-Sep	49	F	NA	775	62	14		71239	5	9-49
4-Sep	50	F	910	800	4M	M4		71239	5	10-50
4-Sep	51	M	730	620	S2	1F	Y	71240	6	1-41
4-Sep	52	M	785	695	52	13		71240	6	2-42
4-Sep	53	F	790	690	52	13	Y	71240	6	3-43
4-Sep	54	M	585	515	42	12	Y	71240	6	4-44
4-Sep	55	F	840	735	62	14	Y	71240	6	5-45
4-Sep	56	M	785	670	52	13	Y	71240	6	6-46
4-Sep	57	M	715	620	52	13	Y	71240	6	7-47
4-Sep	58	M	740	640	62	14	Y	71240	6	8-48
4-Sep	59	F	930	810	62	14	Y	71240	6	9-49
4-Sep	60	M	910	780	4M	M4		71240	6	10-50
4-Sep	61	M	900	760	4M	M4		71241	7	1-41
4-Sep	62	F	835	740	4M	M4	Y	71241	7	2-42
4-Sep	63	M	690	605	52	13		71241	7	3-43
4-Sep	64	M	810	710	3M	M3		71241	7	4-44
4-Sep	65	M	920	785	62	14		71241	7	5-45
4-Sep	66	F	NA	790	62	14	Y	71241	7	6-46
4-Sep	67	F	830	745	62	14		71241	7	7-47
4-Sep	68	M	750	670	4M	M4		71241	7	8-48
4-Sep	69	F	900	795	62	14		71241	7	9-49
4-Sep	70	M	670	590	52	13		71241	7	10-50
4-Sep	71	F	920	795	72	15		71242	8	1-41
4-Sep	72	F	855	760	62	14	Y	71242	8	2-42
4-Sep	73	F	870	780	62	14		71242	8	3-43
4-Sep	74	M	795	695	62	14		71242	8	4-44
4-Sep	75	F	900	805	72	15		71242	8	5-45
4-Sep	76	F	1000	880	4M	M4		71242	8	6-46
4-Sep	77	F	880	785	62	14		71242	8	7-47
4-Sep	78	F	930	830	72	15		71242	8	8-48
4-Sep	79	F	870	775	62	14		71242	8	9-49
4-Sep	80	M	670	580	52	13		71242	8	10-50
4-Sep	81	M	700	630	52	13		71243	9	1-41
4-Sep	82	F	860	765	62	14		71243	9	2-42
4-Sep	83	M	740	665	52	13		71243	9	3-43
4-Sep	84	M	590	510	42	12		71243	9	4-44
4-Sep	85	M	755	665	52	13		71243	9	5-45
4-Sep	86	F	NA	800	62	14	Y	71243	9	6-46
4-Sep	87	M	935	815	4M	M4		71243	9	7-47
4-Sep	88	M	670	595	3M	M3		71243	9	8-48
4-Sep	89	M	705	620	42	12		71243	9	9-49
4-Sep	90	F	920	820	72	15		71243	9	10-50
4-Sep	91	M	925	805	62	14		71244	10	1-41
4-Sep	92	M	850	735	62	14	Y	71244	10	2-42
4-Sep	93	M	685	605	S2	1F		71244	10	3-43
4-Sep	94	M	770	675	3M	M3		71244	10	4-44
4-Sep	95	M	930	805	62	14		71244	10	5-45
4-Sep	96	M	740	655	52	13		71244	10	6-46

DATE	FISH #	SEX	MEF (mm)	POHL (mm)	Gilbert age	European Age	DNA sample	SCALE BOOK#	BOOK #	SCALE #
4-Sep	97	M	710	615	52	13		71244	10	7-47
4-Sep	98	M	915	790	4M	M4		71244	10	8-48
4-Sep	99	M	720	630	3M	M3	Y	71244	10	9-49
4-Sep	100	M	730	640	52	13	Y	71244	10	10-50
4-Sep	101	M	930	795	62	14		71245	11	1-41
4-Sep	102	M	870	765	62	14		71245	11	2-42
4-Sep	103	M	905	805	62	14	Y	71245	11	3-43
4-Sep	104	M	810	700	62	14	Y	71245	11	4-44
4-Sep	105	M	700	620	52	13		71245	11	5-45
4-Sep	106	M	NA	595	52	13		71245	11	6-46
4-Sep	107	M	980	850	62	14		71245	11	7-47
4-Sep	108	F	925	815	62	14	Y	71245	11	8-48
4-Sep	109	F	NA	770	62	14	Y	71245	11	9-49
4-Sep	110	F	900	795	62	14		71245	11	10-50
4-Sep	111	M	1000	870	S2	1F		71246	12	1-41
4-Sep	112	F	920	815	62	14	Y	71246	12	2-42
4-Sep	113	F	785	685	52	13	Y	71246	12	3-43
4-Sep	114	M	840	725	52	13		71246	12	4-44
4-Sep	115	F	870	770	62	14	Y	71246	12	5-45
4-Sep	116	F	850	760	62	14		71246	12	6-46
4-Sep	117	M	740	655	52	13		71246	12	7-47
4-Sep	118	F	890	790	4M	M4		71246	12	8-48
4-Sep	119	M	880	775	72	15		71246	12	9-49
4-Sep	120	M	725	640	52	13		71246	12	10-50
4-Sep	121	F	815	720	62	14		71247	13	1-41
4-Sep	122	M	955	835	62	14		71247	13	2-42
4-Sep	123	F	840	735				71247	13	3-43
4-Sep	124	F	905	825	62	14		71247	13	4-44
4-Sep	125	F	890	800	62	14		71247	13	5-45
4-Sep	126	M	850	740	62	14	Y	71247	13	6-46
4-Sep	127	M	670	590	3M	M3		71247	13	7-47
5-Sep	128	M	945	820	62	14		71247	13	8-48
5-Sep	129	F	905	790	62	14		71247	13	9-49
5-Sep	130	M	790	695	4M	M4		71247	13	10-50
5-Sep	131	M	740	645	62	14	Y	71248	14	1-41
5-Sep	132	M	615	545	42	12		71248	14	2-42
5-Sep	133	M	630	560	42	12		71248	14	3-43
5-Sep	134	M	725	620	62	14	Y	71248	14	4-44
5-Sep	135	M	755	660	62	14	Y	71248	14	5-45
5-Sep	136	F	780	675	52	13	Y	71248	14	6-46
5-Sep	137	M	740	640	52	13	Y	71248	14	7-47
5-Sep	138	M	690	595	52	13	Y	71248	14	8-48
5-Sep	139	F	800	700	62	14	Y	71248	14	9-49
5-Sep	140	M	795	685	52	13	Y	71248	14	10-50
5-Sep	141	F	790	685	52	13		71249	15	1-41
5-Sep	142	M	900	790	72	15	Y	71249	15	2-42
5-Sep	143	M	830	720	4M	M4		71249	15	3-43
5-Sep	144	M	670	580	52	13		71249	15	4-44
5-Sep	145	M	715	625	62	14		71249	15	5-45

DATE	FISH #	SEX	MEF (mm)	POHL (mm)	Gilbert age	European Age	DNA sample	SCALE BOOK#	BOOK #	SCALE #
5-Sep	146	F	720	640	52	13		71249	15	6-46
5-Sep	147	M	710	620	52	13	Y	71249	15	7-47
5-Sep	148	M	880	770	62	14		71249	15	8-48
5-Sep	149	M	695	605	52	13		71249	15	9-49
5-Sep	150	M	760	645	3M	M3		71249	15	10-50
5-Sep	151	M	615	530	42	12		71250	16	1-41
5-Sep	152	M	755	670	52	13		71250	16	2-42
5-Sep	153	M	770	670	52	13		71250	16	3-43
5-Sep	154	M	735	650	52	13		71250	16	4-44
5-Sep	155	M	910	790	62	14		71250	16	5-45
5-Sep	156	M	725	635	52	13		71250	16	6-46
5-Sep	157	F	890	775	3M	M3	Y	71250	16	7-47
5-Sep	158	M	750	655	52	13		71250	16	8-48
5-Sep	159	M	820	715	62	14		71250	16	9-49
5-Sep	160	M	700	610	52	13		71250	16	10-50
5-Sep	161	M	615	535	52	13	Y	75951	17	1-41
5-Sep	162	M	770	675	52	13		75951	17	2-42
5-Sep	163	M	665	595	52	13		75951	17	3-43
5-Sep	164	M	745	660	52	13		75951	17	4-44
5-Sep	165	M	790	705	52	13		75951	17	5-45
5-Sep	166	M	690	605	52	13		75951	17	6-46
5-Sep	167	M	790	685	52	13		75951	17	7-47
5-Sep	168	M	700	610	52	13	Y	75951	17	8-48
5-Sep	169	M	690	610	3M	M3		75951	17	9-49
5-Sep	170	M	655	575	52	13		75951	17	10-50
5-Sep	171	M	655	575	62	14		75952	18	1-41
5-Sep	172	M	720	630	3M	M3		75952	18	2-42
5-Sep	173	M	685	595	52	13		75952	18	3-43
5-Sep	174	M	750	660	52	13	Y	75952	18	4-44
5-Sep	175	M	660	590	52	13		75952	18	5-45
5-Sep	176	M	530	465	2M	M2		75952	18	6-46

*Scale age analysis will be conducted for DFO Whitehorse by the Pacific Biological Station Fish Ageing Lab, Nanaimo, British Columbia.

Appendix 3. Sonar measured lengths of presumed resident fish, Teslin River 2011.

Fish no	Length (cm)	Fish no	Length (cm)	Sample Statistics	
1	14	29	19	Mean	18.3
`2	16	30	19	Standard Error	0.7
3	17	31	16	Median	17.0
4	15	32	26	Mode	15.0
5	12	33	22	Standard Deviation	5.4
6	13	34	13	Sample Variance	29.5
7	13	35	15	Kurtosis	-0.5
8	12	36	14	Skewness	0.6
9	15	37	27	Range	21.0
10	16	38	21	Minimum	10.0
11	10	39	25	Maximum	31.0
12	18	40	23	Count	57
13	16	41	28	Confidence Level(95.0%)	1.4
14	13	42	12		
15	18	43	15		
16	19	44	15		
17	20	45	16		
18	12	46	25		
19	20	47	27		
20	23	48	30		
21	24	49	20		
22	21	50	14		
23	10	51	17		
24	14	52	29		
25	15	53	12		
26	31	54	26		
27	14	55	24		
28	17	56	18		
		57	19		

Appendix 4. Daily count of radio tagged Chinook (n=86) passing the Teslin telemetry station in 2003.

Note: Black line is a 5 day moving average; Source: Mercer and Eiler , 2003