2011 Klondike River Sonar Project

CRE-16-11

Prepared For: The Yukon River Panel
Restoration and Enhancement Fund

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February 2011

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ABSTRACT

During July and August 2011 a project was conducted to enumerate Chinook salmon entering the Klondike River watershed using a DIDSON™ high resolution sonar. The sonar site was located on the Klondike River approximately 3.5 km upstream of the confluence with the Yukon River at the same location used for the project in 2009 and 2010. Sonar operation began on July 5 and continued through to August 14. Carcass pitches were conducted on the Klondike system on August 4, 8, 11, and 14. The camp and weirs were dismantled and removed from the site on August 18. The sonar was inoperative due to technical problems for 11 hours July 6-7, and 4 hours on both July 19 and August 5. The Chinook counts during the outages were estimated using the mean hourly counts from the 24 hour periods before and after the sonar outage. A total of 29 fish was estimated to have passed the station when the sonar was inoperative. The total sonar count including the number of fish estimated during sonar outages was 1,311 salmon. The daily counts of passing salmon displayed a normal distribution with peak passage on July 24 and a decline in daily counts until August 2, after which daily counts began to increase. It is believed that the daily count increase after August 2 was due to Chum salmon entering the system. As there is a size overlap it was not possible to distinguish with certainty between Chum and Chinook within the overlapping size range. An estimate of Chinook passage after August 3 was obtained by incorporating a Chum subtraction factor using an exponential regression based on 8 days of sonar counts from July 28 to August 3. The final 2011 Klondike River Chinook escapement was estimated to be 1,181. This represented 2.3 % of the upper Yukon River Chinook spawning escapement estimate based on the 2011 Eagle sonar above border Chinook estimate of 50,780. The Klondike Chinook carcass pitch yielded 48 Chinook from which age, sex, and length (ASL) data was obtained. DNA tissue samples were collected from 36 of the Chinook retrieved.

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INTRODUCTION

Canadian and U.S. fisheries managers as well as 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. Quantifying escapements into index spawning streams is a useful stock assessment and management tool to define and monitor Chinook escapement goals. Escapement estimates of genetically distinct stocks coupled with baseline genetic stock index (GSI) information can also be used to calculate independent drainage wide above border Chinook spawner escapement estimates[1]. This information is used for post-season run reconstruction and the establishment of long term escapement objectives.

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™ 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 DIDSON imaging sonar is as accurate as visual counts of fish migrating through an enumeration fence in a clear water river, providing the apparatus is aimed so that the beams completely ensonify the area through which fish are migrating and there are no acoustic blind spots at the surface or bottom (Holmes et al., 2006). Within the upper Yukon drainage DIDSON sonar has been used on the Big Salmon River (2005-2011) and the Klondike River (2009-2011) to enumerate annual Chinook salmon escapements into these systems.

The Klondike River is a suitable Chinook salmon escapement index stream using high definition sonar because:

1. It has documented significant Chinook escapements;
2. It 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;
3. The Chinook stock is one of the earlier temporal segments of the above border Yukon River Chinook run allowing for timely in-season run estimates.

Study Area

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 its furthest headwaters, 3,200

[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.

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). In 3 of the past 5 years, above border Chinook escapements have been less than the bilaterally agreed escapement goal leading to closures and restrictions on commercial and aboriginal fisheries in Canada (JTC 2011).

The Klondike River is located in north central Yukon and flows in a southwesterly direction from its headwaters to its confluence with the Yukon River at Dawson City (Figure 1). The river and its tributaries drain an area of approximately 7,800 km^2. 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 Ogilvie 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 major tributaries include the South Klondike River and Hunker Creek.

Maximum and minimum Klondike River discharge rates exhibit intra and inter-annual variation typical of the area. Records collected over the period 1965 to 2011 range from a maximum discharge rate of 679 m^3/s to a minimum of 4.51 m^3/s with a mean discharge rate of 63.2 m^3/s (Water survey of Canada). Peak discharge rates occur around June 1, with a mean peak discharge rate of 275 m^3/s (Figure 2). At the beginning of sonar operations in early July mean discharge rates are 130 m^3/s; approximately 45% of peak discharge rates.

Fish species documented in the Klondike River system include 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).

OBJECTIVES

The objectives of the 2011 Klondike River sonar project were:

1. To enumerate the Chinook salmon escapement into the Klondike River drainage using a DIDSON sonar.

2. To recover moribund and dead Chinook salmon from the Klondike drainage and sample for age, sex, and length (ASL), as well as collect tissue samples for baseline genetic analysis.

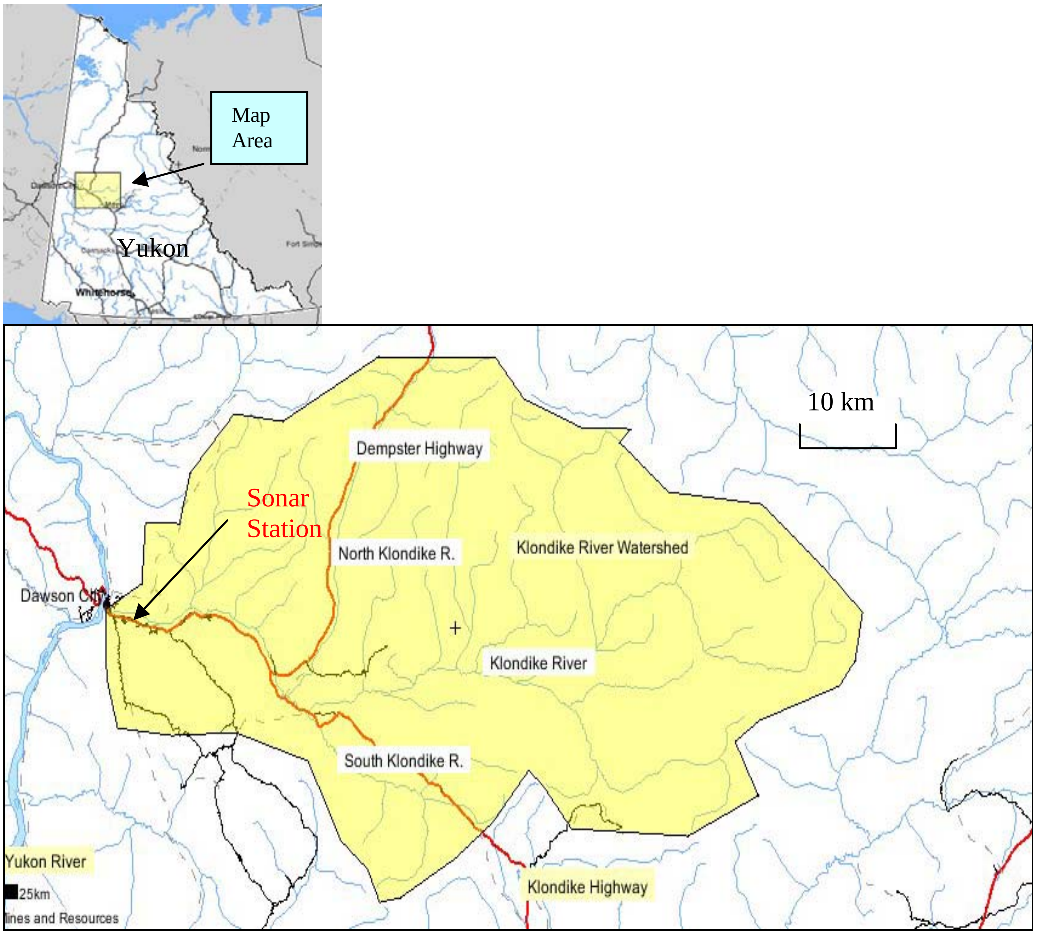

Figure 1. Klondike River watershed.

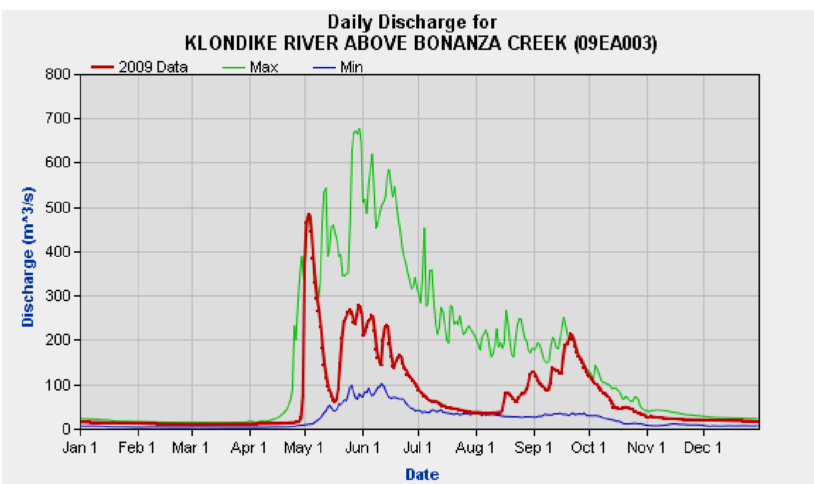

Figure 2. Daily minimum and maximum and mean discharge rates for Klondike River, above Bonanza Creek, from 1965 through 2011. Source: Water Survey Board of Canada.

METHODS

Site Selection

A location for the Klondike River sonar project was identified during a 2008 Klondike River feasibility study (Mercer 2009). This site was used for the sonar projects from 2009 through 2011. The site is located approximately 3.5 km upstream from the confluence with the Yukon River (Figure 1) and was selected for the following reasons:

1. The site is located as close as practical to the mouth of the system and below documented Chinook Spawning habitat.
2. The site is a sufficient distance upstream from the mouth to minimize the presence of straying Chinook salmon from other upper Yukon River stocks.
3. The river channel is straight and non-braided with a laminar flow. Laminar flow results in less background acoustic noise allowing for better fish detection, particularly those fish migrating near the river bottom. Laminar flow is also conducive to active linear migration rather than holding/milling behaviour.
4. The profile of the river bottom at the site is relatively planar allowing for complete ensonification of the water column with an absence of acoustic "shadows".
5. The substrate is free of large boulders which can create turbulence and acoustic noise and shadows.
6. The river width and depth allows for installation of partial deflection weirs on both sides of the river to constrict the salmon migration corridor to 40m or less.
7. The site is in a relatively straight section of the river and recreational boaters using the river have a clear view and adequate reaction time to avoid the in-stream structures.
8. The site has road access which is logistically easier for camp set up and power grid access.

Permits

Given the short nature of the project a land use permit from YTG Lands Branch was not required. Notification of the project activities was given to the City of Dawson as the sonar site is within municipal boundaries.

An application was submitted to and approved by Transport Canada (Marine Branch), Navigable Waters Protection, to install the partial fish diversion fences in a navigable waterway. A permit was issued for ongoing annual sonar operations as described in the original application.

A 2011 fish collection licence was obtained from DFO to collect dead and moribund Chinook from the Klondike River watershed.

Sonar Station and Weir Construction

Construction of the camp and sonar station was initiated on July 2. The materials used for the deflection weirs were stored at the Yukon Territorial Government (YTG) Department of Environment compound at Dawson City after completion of the 2010 project. All supplies and camp equipment were transported by truck from Whitehorse to Dawson City. The camp was located 15 m from the south bank of the river and was comprised of two wall tents, one serving as living quarters and the other as the sonar and computer station (Figure 3).

Figure 3. 2011 Klondike River sonar station camp, looking downstream.

Construction of partial weirs on either side of the river to divert shoreline migrating Chinook salmon into the mid-section of the river was initiated on July 3 and completed on July 5. Due to the high water levels in the Klondike watershed in July 2011 most of the weir materials were moved and placed using a river boat (Figures 4 and 5). The weir design was the same as used in 2010. Metal tripods were placed in the river 3.5 m apart. Wooden cross ties were placed between the tripods and prefabricated panels of electrical conduit were placed on the tripod structures. The panels were inter-locked using single conduit to create two seamless diversion fences (Figure 6). Light activated flashing beacon lights were secured to each diversion fence to mark the in-stream extent of the weirs. A warning sign was also posted 200 m upstream of the station to alert boaters of the partial obstruction in accordance with Transport Canada, Navigable Waters Protection requirements. Due to the high water in early July it was impossible to construct the outboard 2 m of the diversion fence on north side of the river. This portion of the fence was installed July 14 when the water levels had moderated.

Figure 4. Transporting fence tripods.

Figure 5. Placing tripods and cross ties for diversion fence on south side of river.

Sonar and Computer Software Configuration

The 2011 Klondike River sonar project was scheduled to begin approximately 15 days before a separate sonar project on the Big Salmon River. The 2011 Klondike River sonar operational plan included the use of the LR DIDSON unit belonging to the YRP[2] for the first 15 days of the project. The rationale for this was to reduce the overall sonar rental costs. For the remaining 40 days of the Klondike project a standard DIDSON unit was rented from Sound Metrics Corporation.

[2] This LR-DIDSON unit was purchased by the Yukon River Panel (YRP) in 2005 and is currently dedicated for the ongoing Big Salmon River sonar project (CRE – 41).

The set up and configuration of the DIDSON sonar unit was the same as that used during previous sonar projects at this site (Mercer 2010). The unit was mounted on an adjustable stand constructed of 2-inch, schedule 80 steel pipe. The stand consisted of two T-shaped legs, 120 cm in height, connected by a 90 cm crossbar (Figure 7). The sonar unit was bolted to a steel plate suspended from a 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 enabled rotation of the transducer lens to adjust the beam direction.

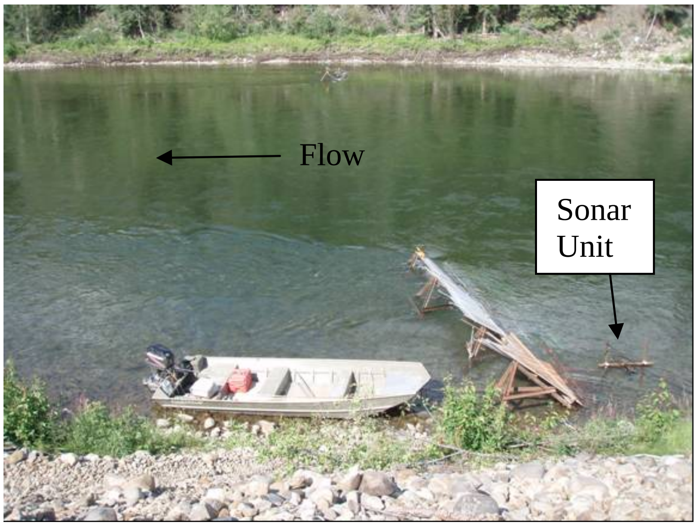

Figure 6. Partial weir structures in place at the Klondike River sonar station.

Figure 7. Sonar unit and mounting stand.

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

As occurred in 2009 and 2010, an 8° concentrator lens was mounted on the standard sonar lens. The concentrator lens, which is used for shallow water applications, reduces the vertical ensonified field from 14° to 8°. The reduced field size increases the acoustic energy reflected from the targets in the field. In addition, the smaller field 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. In 2011 the concentrator lens was used for the duration of the project.

The DIDSON sonar produces an ensonified field 29° wide in the horizontal plane and with the concentrator lens, 8° deep in the vertical plane. 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 ensonified field of view remaining parallel to the surface of the river. The angle of the YRP DIDSON unit was calibrated twice daily using a digital inclinometer. The rental sonar had an incorporated compass and inclinometer that displayed the tilt and azimuth of the sonar beams on the computer screen.

Due to the high water levels encountered during portions of the 2011 project it was necessary to tilt the sonar unit on the horizontal plane to ensure the entire near shore water column was ensonified. Using an 8° lens on a sonar unit deployed horizontally results in a beam depth of 1.05 m at a distance of 7.5 m from the sonar. Since the water depth at a distance of 7.5 m from the sonar unit reached a maximum of 2.1 m, it was necessary during certain periods of the project to tilt the sonar to increase the depth of the ensonified vertical plane. A table was prepared using trigonometry formulae to enable the sonar operators to determine the sonar tilt requirements for given water depths and sonar window start lengths (Appendix 1).

Once the sonar was in place and properly positioned, the primary sonar unit settings and software were configured. The receiver gain was set at –40 dB, the window start at 7.5 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 set at 4 frames per second, which was the highest frame rate the computers could process with a window length setting of 40 m. Two laptop computers were used for the project, one for recording the DIDSON files and the other for reviewing the files. All files were saved on the recording computer as well as backed up on a 500 GB external hard drive. These files will be saved for three years after project completion.

The camp, computers, and sonar unit were powered using 120 V AC power. The power was supplied from the local Yukon Electrical Co. grid and rented from a nearby resident. A 35 m, #12 wire electrical supply line incorporating a voltage surge protection device was connected from the residence to the sonar operation tent.

Sonar Data Collection

Once the project began, 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 stored on the active PC as well as backed up on the external hard drive.

To optimize target detection during file review, the background subtraction feature was used to remove static images such as the river bottom and weir structures. The intensity (brightness) was set at 40 dB and threshold (sensitivity) at 3dB. The 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.

Figure 8. Weir structures in high water conditions, Klondike River sonar site.

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 to aid in identifying passing fish. The target measurement feature of the DIDSON software was used to estimate the size of the observed fish when required. The minimum size used to classify Chinook salmon was approximately 55 cm. The targets identified as Chinook were visually counted using a hand counter and the total count from each file was entered into an excel spreadsheet. A record of each 20 minute file count as well as hourly, daily and cumulative counts was maintained throughout the run.

Fish moving downstream identified as live Chinook were subtracted from each file total. Straying of migrating salmon is not unusual and temporary[3] straying has been

[3] Radio tagged Chinook were documented entering a drainage and subsequently retreating to the main stem river and continuing their migration further up the system. Since the sonar station is located 3 km upstream from the confluence of the Yukon River the presence of straying Chinook could be expected.

documented in telemetry studies of Yukon River Chinook (Eiler et al. 2006). The number of identified strays detected is typically low. During the 2011 Klondike project five Chinook salmon were observed returning downstream and were assumed to be strays.

Cross section distribution

The position of each Chinook observed within the cross section profile of the river was recorded in 5 m increments. This provided a range frequency histogram illustrating the cross sectional pattern of migrating Chinook.

Carcass Pitch

The upper reaches of the Klondike River were accessed using a 6.0 m open skiff powered by a 40 hp outboard jet motor. The carcass pitch involved collecting dead and moribund Chinook using a spear and sampling each fish. Carcass sampling consisted of collecting five scales per fish and placing them in prescribed scale cards. The sex and mid-eye fork and post orbital-hypural lengths (to the nearest 0.5cm) were also recorded for each recovered fish. The crew made a total of four day trips upriver on August 4th, 8th, 11th and 14th searching for moribund Chinook and carcasses.

RESULTS

Chinook Enumeration and Run Timing

The Klondike River sonar was operational starting July 5 at 15:40. The first Chinook salmon were observed passing the sonar station on July 6 at 11:20. Daily and cumulative counts are presented in Table 1 and hourly counts in Appendix 3. The estimated 2011 Chinook salmon escapement in the Klondike River drainage was 1,181. Of this total, 1,131 Chinook salmon were counted by sonar and 30 were estimated to have passed while the sonar was inoperative. A further 20 Chinook were estimated to have passed the sonar station after the project ended. This estimate was obtained by extrapolating the daily counts an additional 9 days using the exponential regression formula $y = 39.21^{-0.12x}$. This formula was derived from the daily counts over 8 days from July 27 to August 4. This time period was also used to obtain a subtraction formula (discussed below) to account for probable passing Chum salmon after Aug 3. The peak daily count of 86 Chinook occurred on July 24 at which time 60% of the run had passed the sonar station. On July 22, 50% of the run had passed the sonar station and on August 2, 90% had passed. As occurred in 2009 and 2010 the 2011 daily counts approximated a normal distribution skewed somewhat to the front end of the run.

Table 1. Daily and cumulative counts of Klondike River Chinook salmon, 2011.

Date	Total daily count	Daily Count Chinook	Cum. Chinook Count	Remarks
05-Jul	0	0	0	
06-Jul	5	5	5	Grey denotes periods of sonar outages
07-Jul	3	3	8	
08-Jul	5	5	13	
09-Jul	7	7	20	
10-Jul	10	10	30	
11-Jul	16	16	46	
12-Jul	24	24	70	
13-Jul	27	27	97	
14-Jul	27	27	124	
15-Jul	23	23	147	
16-Jul	45	45	192	
17-Jul	62	62	254	
18-Jul	79	79	333	
19-Jul	54	54	387	
20-Jul	37	37	424	
21-Jul	44	44	468	
22-Jul	78	78	546	
23-Jul	79	79	625	
24-Jul	86	86	711	
25-Jul	65	65	776	
26-Jul	62	62	838	
27-Jul	67	67	905	
28-Jul	38	38	943	
29-Jul	33	33	976	
30-Jul	30	30	1006	
31-Jul	21	21	1027	
01-Aug	19	19	1046	
02-Aug	13	13	1059	
03-Aug	21	15	1074	Yellow denotes daily counts less estimated Chum passing station
04-Aug	18	13	1087	Blue denotes Daily Chinook and Chum sonar counts
05-Aug	23	12	1099	
06-Aug	19	10	1110	
07-Aug	17	9	1119	
08-Aug	23	8	1127	
09-Aug	25	7	1134	
10-Aug	23	6	1141	
11-Aug	24	6	1147	
12-Aug	35	5	1152	
13-Aug	21	5	1156	
14-Aug	3	4	1160	Aug. 14 is partial daily count; sonar removed at 14;00
15-Aug		4	1164	Green denotes extrapolated Chinook counts after the project ended
16-Aug		3	1167	
17-Aug		3	1170	
18-Aug		2	1172	
19-Aug		2	1174	
20-Aug		2	1176	
21-Aug		2	1178	
22-Aug		2	1179	
23-Aug		1	1181	

The sonar was inoperative due to technical problems for 11 hours July 6-7, and 4 hours on both July 19 and Aug. 5. The Chinook counts during the outages were estimated using the mean hourly counts from the 24 hour periods before and after the sonar outage. A total of 30 fish were estimated to have passed the station when the sonar was inoperative. The outages that occurred on July 6-7 and July 19 were due to power failures in the electrical grid. On August 4 the memory capacity of the recording computer was maximized and stopped recording files. As this fault occurred in the middle of the night it was not immediately detected by the operator.

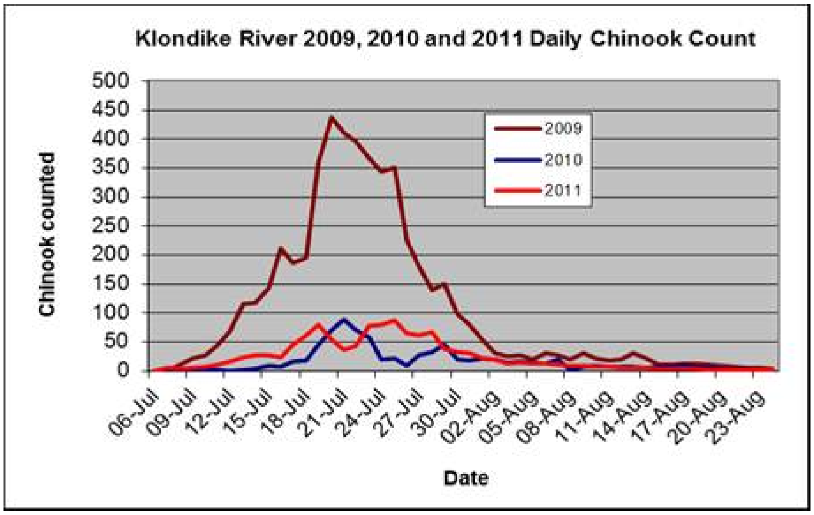

Figure 9. Daily DIDSON sonar counts of Chinook salmon passing the Klondike River sonar station in 2009, 2010 and 2011.

Temporal and Spatial Migration

The hourly sonar counts of Chinook passing the Klondike River sonar station are presented in Appendix 2 and illustrated in Figure 10. Hourly counts illustrated in Figure 10 do not include the days when complete 24 hour counts were not obtained. A statistically significant diel pattern was noted in the 2009 run pattern with peak hourly counts at 05:00 and 06:00, however, as occurred in 2010, there was no statistically significant difference observed in the 2011 total hourly counts (Single factor ANOVA, tested for homogeneity of variance: df=23, F=1.08, F*crit.* = 1.55, α=0.05, *p*=0.99).

The cross sectional distribution pattern of the migrating Chinook as detected by the sonar is presented in Figure 11. As occurred in 2010 the distribution of Chinook passing the station is skewed to the south bank of the river where the sonar unit is located. This distribution may be a result of Chinook orientating to the deeper section of the river along the south bank.

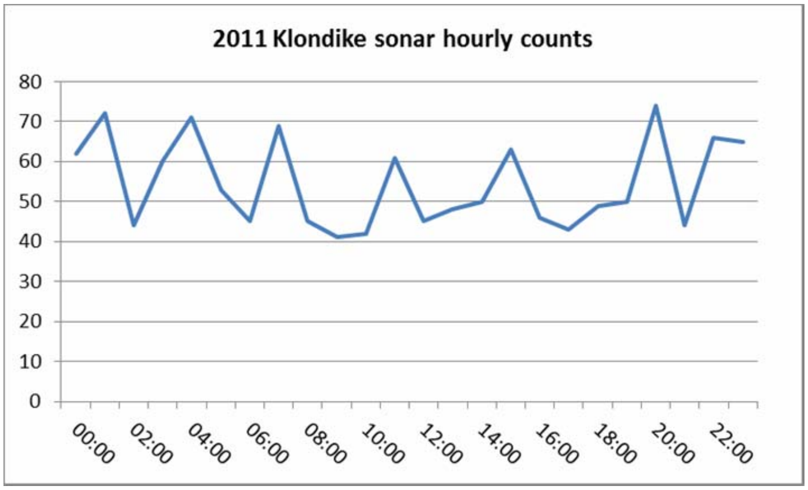

Figure 10. Total hourly counts of Chinook salmon passing the Klondike River sonar station in 2011.

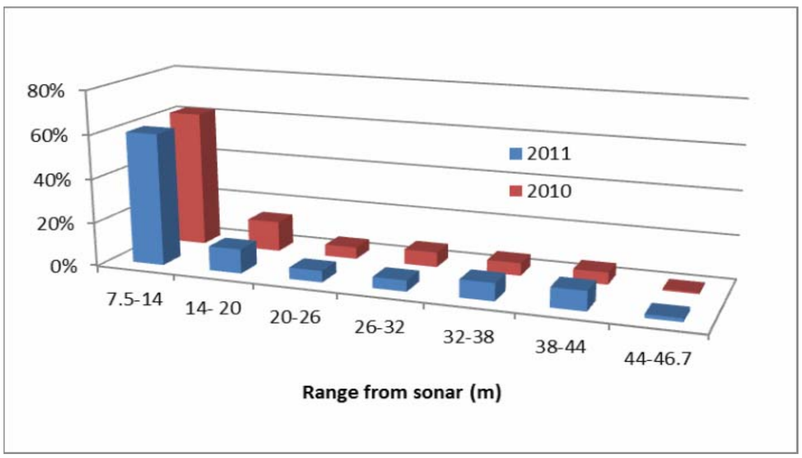

Figure 11. 2010 and 2011 Klondike River Chinook range/frequency in cross section profile.

Carcass Pitch

A total of 48 dead or moribund Chinook was recovered and sampled during the carcass pitch. Of these, 15 were female (33%) and 33 (67%) were male. Complete ages were determined for 42 fish. Age, length, and sex data is tabled in Appendix 3 and summarized in Table 2. Age 1.4 was the dominant age class at 52.3% of the total. Age 1.3 comprised 40.5% of the fish sampled and age 1.5 and 1.2 made up 4.8% and 2.4% respectively.

Table 2. Age, sex, and length summary of sampled 2011 Klondike River Chinook.

SEX	Age[a]	Data	Total	Percent
Female	1.3	Average of MEF (mm)	800	
		Count of Age	4	9.5%
	1.4	Average of MEF (mm)	914	
		Count of Age	8	19.0%
	1.5	Average of MEF (mm)	945	
		Count of Age	2	4.8%
F Average of MEF (mm)			893	
F Count of Age			14	33.3%
Male	1.2	Average of MEF (mm)	520	
		Count of Age	1	2.4%
	1.3	Average of MEF (mm)	741	
		Count of Age	13	31.0%
	1.4	Average of MEF (mm)	863	
		Count of Age	14	33.3%
M Average of MEF (mm)			794	
M Count of Age			28	66.7%
Total Average of MEF (mm)			822	
Total Count of Age			42	

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

Chum salmon subtraction

The presence of Chum salmon entering the system during the 2011 sonar project was suspected based on the increasing daily counts after August 3 and the increased proportion of smaller targets observed at the end of the run. Over the course of a run the daily counts of other upper Yukon River Chinook stocks typically exhibit a normal distribution and an increase in daily counts at the end of the run is atypical (Mercer and Wilson 2011; Wilson 2010). The presence of co-migrating Chum was verified with the collection of a dead Chum during the carcass recovery upriver of the sonar site on August 14. Figure 12 illustrates the daily counts of all salmon targets detected passing the sonar. It is assumed that both Chum and Chinook were present after August 3 based on the rising daily counts, however this assumption was not tested.

There is likely a size overlap of Klondike Chinook and Chum salmon making it difficult to distinguish between the smaller size classes of migrating Chinook and the co-migrating Chum. Size information for 2011 Klondike Chum is unknown, however 2011 data from Kluane Lake Chum[4] samples was used to compare size classes between Chinook and fall Chum. Figure 13 depicts a post orbital-hypural (POH) size[5] frequency histogram of 2011 Kluane Chum and Klondike Chinook. The Klondike Chinook POH size classes from 620 mm and below overlap with the Chum and represent 30% of the total Klondike Chinook

[4] Kluane Lake Chum are a lake spawning stock from the headwaters of the White river, a major upper Yukon River tributary. Data source: Unpublished DFO Whitehorse data.

[5] Post orbital-hypural lengths (POH) were used for comparative purposes as the mid-eye fork lengths of Klondike Chinook were unreliable due to typical post-spawning caudal fin abrasion.

sampled in 2011. The carcass pitch size data may not be representative of the total run but the evidence suggests there is some size overlap between the species.

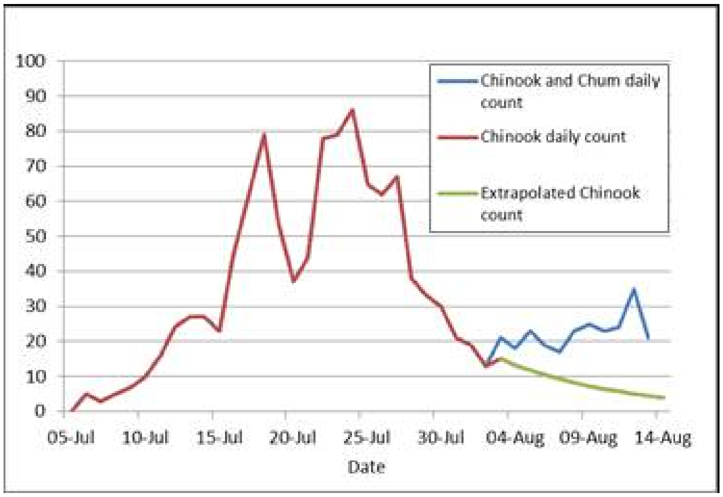

Figure 12. Daily absolute and extrapolated salmon counts from the 2011 Klondike River sonar operation.

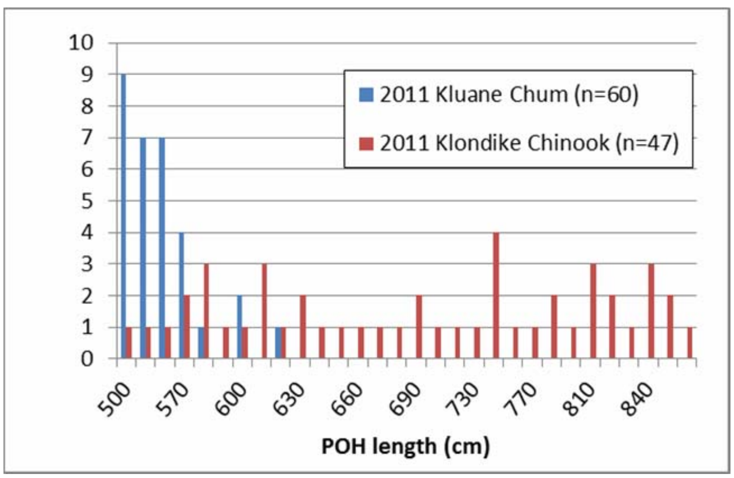

Figure 13. Length frequency histogram of Kluane Lake Chum and Klondike River Chinook sampled in 2011.
Note: Chum size classes below 50 cm are not illustrated.

A chum subtraction factor was applied to the final 10 days of sonar counts (August 4-13) by extrapolating the previous 8 days sonar counts using the exponential regression formula $y = 39.21^{-0.12x.}$. The estimated Chum and Chinook daily count differential is illustrated in Figure 12. Daily sonar counts without the Chum subtraction factor applied are listed in Table 1. A total of 152 Chum was estimated to have been counted passing the station from August 4 through 14.

Table 3. Estimated proportion of Klondike River Chinook and Yukon River Chinook border escapement, 2009 through 2011.

Year	Method	Estimated % proportion of border escapement based on telemetry or GSI sampling	Klondike sonar count	Border Escapement based on Eagle sonar count	Above border escapement based on expansion of Klondike sonar count and GSI stock proportion
2003	Telemetry	6.8	n/a	n/a	n/a
2004	Telemetry	7.8	n/a	n/a	n/a
2009	Gillnet GSI Sampling	3.3	5,147	65,278	155,969
2010	Gillnet GSI Sampling	0.3	803	32,010	267,666
2011	Gillnet GSI Sampling	4.8	1,181	50,780	24,604
Mean		4.6	2,377	49,356	149,413
Std. Dev.		2.7	1,965	13,619	99,338

Source: JTC 2010, Mercer 2010, Mercer and Eiler 2004, Mercer 2005.

DISCUSSION

Based on the sonar count and an end of run extrapolation, a total of 1,181 Chinook salmon was estimated to have entered the Klondike River drainage in 2011. The 2011 Klondike Chinook escapement is higher than the observed escapement in 2010 (803) but substantially lower than that recorded in 2009 (5,147), (Table 3). The 2011 Klondike escapement estimate represented 2.3% of the total upper Yukon River spawning escapement[6] estimate of 50,780 obtained from the Eagle sonar station[7].

Along with sonar counts, genetic stock identification (GSI) samples are also obtained using drift nets at the Eagle sonar site. The GSI data provides information on the proportional contribution of 23 separate identified stocks to the total above border Chinook escapement. The 2011 mean weighted proportional contribution of the Klondike River stock to the Chinook border escapement based on analysis of the GSI samples was 4.8%, (std. dev. 1.4%; DFO Whitehorse unpublished data). Using the GSI stock proportions and Eagle sonar estimate the contribution of Klondike origin Chinook to the total above border escapement would be 2,437 (95% C.I. 3,504 – 1,371). This is significantly higher than the 2011 Klondike sonar estimate of 1,181. This suggests either the Klondike and/or Eagle sonar counts or the Klondike GSI stock proportions are inaccurate. Since the start of the Klondike sonar program in 2009 the Klondike sonar counts and GSI stock proportions have not been concordant with the Eagle sonar counts (Table 3). The reasons for this are unclear but could be related to the present Klondike River GSI stock separation capability as discussed in previous reports (Mercer 2010 and 2011). It should be noted that the Big Salmon River sonar counts have been congruent

[6] Border escapement is the number of potential spawners estimated to have passed the Canada/U.S. border and entered the Upper Yukon River drainage in Canada. Upper Yukon River spawning escapement is the border escapement less the Canadian harvest.
[7] The Eagle sonar station is located on the Yukon River in Alaska 120 km downstream from the mouth of the Klondike River.

with the Eagle sonar counts and GSI data for six of the seven years since 2005 (Mercer and Wilson 2012).

The run timing of Chinook entering the Klondike system in 2011 was similar to that observed during the 2009 and 2010 projects. The run timing exhibited from 2009 through 2011 suggests the Klondike River Chinook stock enters the system earlier than other upper Yukon River stocks. This is supported by the GSI sampling proportions observed over the course of the Chinook run at the Eagle sonar site.

The relatively high and turbid water conditions on the Klondike system during the earlier portion of the 2011 project made installation of the weirs difficult. In addition, it prevented visual corroboration of sonar counts and somewhat reduced the effectiveness of the carcass recovery efforts. Above average flows have occurred during the Klondike Chinook migration period for three out of the past four consecutive years.

The DIDSON sonar units when properly positioned and operated have demonstrated their ability to provide accurate counts of migrating salmon in a range of conditions and sites. In 2009, the low and clear water conditions at the Klondike sonar site provided good conditions for visual observance of passing Chinook. The visual counts from 2009 indicated that 100% of the Chinook observed visually were also detected by the sonar (Mercer 2010).

The presence of co-migrating Chum salmon entering the system at the end of the Chinook migration period is somewhat problematic and decreases the accuracy of the end of run extrapolation and the total escapement estimate. As noted above there is a size overlap of Yukon River Chum and Chinook. There is no technique using the current Klondike sonar methodology to differentiate, with certainty, the smaller Chinook sonar targets from the co-migrating Chum. Research has been conducted using DIDSON sonar to measure tail beat frequencies in order to differentiate between Sockeye and Chinook (Mueller et al., 2010). This study concluded that species recognition was possible based on tail beat frequency regardless of fish size. This technique will be further explored in 2012 to differentiate co-migrating Chinook and Chum entering the Klondike system.

It is possible there is not a significant temporal overlap of migrating fall Chum and Chinook in the Klondike system every year. The 2009 and 2010 Klondike sonar count data did not display an increase in daily counts at the end of the run. Test fishing at the Eagle sonar station[8] from 2007 through 2009 captured the first Chum Salmon on August 8, 9, and 19 respectively (Crane and Dunbar, 2009 and 2011). This suggests the Klondike Chinook run is typically close to completion before the arrival of fall Chum in the system. The presence of co-migrating Chum at the end of the Klondike Chinook run would likely be dependent on the strength and timing of the fall Chum run in a given year. The 2011 Yukon River fall Chum above border escapement was estimated to be 200,000 based on the Eagle sonar count. This escapement is considerably above the previous 30 year and 5 year escapement averages of 103,000 and 170,000 respectively

[8] The Eagle sonar station is located approximately 100 km downstream of the mouth of the Klondike River. Based on Yukon River Chinook telemetry data the average Chinook travel time from Eagle to the Klondike River is approximately 48 hours.

(JTC, 2010). The first Chum salmon captured in 2011 at the Eagle sonar test fishing site was on August 3 (Elizabeth MacDonald, DFO Whitehorse, Per. Comm.). This is earlier than occurred the previous 3 years and may be related to the above average escapement in 2011.

If this project continues the potential presence of co-migrating fall Chum in the latter portion of the Chinook run will have to be considered. It may be possible to conduct test netting near the sonar site in an attempt to quantify species composition and/or the presence of co-migrating Chum. This technique may indicate the presence of Chum in the system but not yield valid species composition results due to size selectivity and/or species specific migration patterns. The additional effort associated with gill netting for species apportionment may not be warranted given that at least 90% of the Chinook are likely to have passed before the Chum enter the system. The 2011 estimated Klondike Chum passage of 152 fish over the period August 4 to August 14 results in an average passage rate of approximately 0.5 Chum/hour. At these passage rates considerable fishing effort would be required to obtain meaningful species apportionment data.

Due to inter-annual variability in escapements observed over the past three years, the Klondike River Chinook sonar project cannot yet provide an early in-season indicator of the total above border Yukon River Chinook escapement. If this project is conducted in subsequent years it will continue to provide escapement information, biological (ASL) data, and may eventually assist in the establishment of a biologically based Klondike Chinook escapement goal for the system. If the Yukon River Panel considers the program has long term value it would be of benefit if the project were granted multiple year funding status. This would allow for better long range planning, retention of experienced personnel, and could result in overall cost savings as equipment and rentals could be amortized over a longer period.

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Acknowledgements

Several individuals capably contributed to the 2011 Klondike sonar project. Project supervisor Bob Gransden and technician Manon Fontaine conducted the daily operational activities associated with the project as well as the setup and dismantling of the sonar station and carcass pitch. Jim Mercer assisted with the weir placement. Jane Wilson reviewed this report. YTG Department of the Environment has provided storage space for weir materials at their Dawson yard.

Appendix 1. Sonar beam depth at tilt angles 0° – 45° and with start window lengths 6.67m and 7.5m.

8 Degree Lens								
Horizontal Beam			6.67 m start window			7.5 m start window		
Distance From Sonar (m)	Depth of Beam (m)	Width of Beam (m)	Tilt Degree @ 6.67m from sonar	Depth Added (m)	TOTAL DEPTH @ 6.67m (m)	Tilt Degree @ 7.5m from sonar	Depth Added (m)	TOTAL DEPTH @ 7.5m (m)
2.00	0.28	1.03	1.00	0.06	0.99	1.00	0.07	1.00
3.00	0.42	1.55	2.00	0.12	1.05	2.00	0.14	1.07
4.00	0.56	2.07	3.00	0.18	1.11	3.00	0.20	1.13
5.00	0.70	2.59	4.00	0.24	1.17	4.00	0.27	1.20
6.00	0.84	3.10	5.00	0.30	1.23	5.00	0.34	1.27
6.67	0.93	3.45	6.00	0.36	1.29	6.00	0.41	1.34
7.00	0.98	3.62	7.00	0.42	1.35	7.00	0.48	1.41
7.50	1.05	3.88	8.00	0.48	1.41	8.00	0.55	1.48
8.00	1.12	4.14	9.00	0.55	1.48	9.00	0.61	1.54
9.00	1.26	4.66	10.00	0.61	1.54	10.00	0.68	1.61
10.00	1.40	5.17	11.00	0.67	1.60	11.00	0.75	1.68
11.00	1.54	5.69	12.00	0.73	1.66	12.00	0.82	1.75
12.00	1.68	6.21	13.00	0.80	1.73	13.00	0.90	1.83
13.00	1.82	6.72	14.00	0.86	1.79	14.00	0.97	1.90
14.00	1.96	7.24	15.00	0.92	1.85	15.00	1.04	1.97
15.00	2.10	7.76	16.00	0.99	1.92	16.00	1.11	2.04
16.00	2.24	8.28	17.00	1.05	1.98	17.00	1.19	2.12
17.00	2.38	8.79	18.00	1.12	2.05	18.00	1.26	2.19
18.00	2.52	9.31	19.00	1.19	2.12	19.00	1.34	2.27
19.00	2.66	9.83	20.00	1.26	2.19	20.00	1.41	2.34
20.00	2.80	10.34	21.00	1.32	2.25	21.00	1.49	2.42
21.00	2.94	10.86	22.00	1.39	2.32	22.00	1.57	2.50
22.00	3.08	11.38	23.00	1.46	2.39	23.00	1.65	2.58
23.00	3.22	11.90	24.00	1.54	2.47	24.00	1.73	2.66
24.00	3.36	12.41	25.00	1.61	2.54	25.00	1.81	2.74
25.00	3.50	12.93	26.00	1.68	2.61	26.00	1.89	2.82
26.00	3.64	13.45	27.00	1.76	2.69	27.00	1.98	2.91
27.00	3.78	13.97	28.00	1.83	2.76	28.00	2.06	2.99
28.00	3.92	14.48	29.00	1.91	2.84	29.00	2.15	3.08
29.00	4.06	15.00	30.00	1.99	2.92	30.00	2.24	3.17
30.00	4.20	15.52	31.00	2.07	3.00	31.00	2.33	3.26
31.00	4.34	16.03	32.00	2.16	3.09	32.00	2.42	3.35
32.00	4.48	16.55	33.00	2.24	3.17	33.00	2.52	3.45
33.00	4.62	17.07	34.00	2.33	3.26	34.00	2.62	3.55
34.00	4.76	17.59	35.00	2.42	3.35	35.00	2.72	3.65
35.00	4.89	18.10	36.00	2.51	3.44	36.00	2.82	3.75
36.00	5.03	18.62	37.00	2.60	3.53	37.00	2.92	3.85
37.00	5.17	19.14	38.00	2.70	3.63	38.00	3.03	3.96
38.00	5.31	19.65	39.00	2.79	3.72	39.00	3.14	4.07
39.00	5.45	20.17	40.00	2.89	3.82	40.00	3.26	4.19
40.00	5.59	20.69	41.00	3.00	3.93	41.00	3.37	4.30
41.00	5.73	21.21	42.00	3.11	4.04	42.00	3.49	4.42
42.00	5.87	21.72	43.00	3.22	4.15	43.00	3.62	4.55
43.00	6.01	22.24	44.00	3.33	4.26	44.00	3.75	4.68
44.00	6.15	22.76	45.00	3.45	4.38	45.00	3.88	4.81
45.00	6.29	23.28						

Appendix 2. Water temperature and levels at the Klondike sonar station, 2011.

Date	Time	Air Temp.	Water Temp.	Water Level - cm	Water Level - inches	Comments
05-Jul				101.6	**40**	
06-Jul				96.52	38	
07-Jul				104.14	41	Morning rain clearing in afternoon
08-Jul	7:30 AM	13	9	109.22	43	Mostly sunny
09-Jul	7:30 AM	12	9.5	107.95	42.5	Light morning rain, clearing, thunder showers late in day
10-Jul	7:20 AM	13	9.5	104.14	41	mix of sun and cloud, thundershowers in afternoon
11-Jul	8:00 AM	11	10	96.52	38	Mostly sunny
12-Jul	7:40 AM	15	10	88.9	35	Overcast clearing to partly cloudy,warm humid night
13-Jul	7:30 AM	18	10	83.82	33	mix of sun and cloud, thundershowers in afternoon
14-Jul	7:30 AM	15	10.5	80.01	31.5	mix of sun and cloud, thundershowers in afternoon
15-Jul	7:40 AM	15	10	81.28	32	overcast with light rain in AM
16-Jul	7:40 AM	14	10	74.93	29.5	overcast
17-Jul	7:35 AM	12	10	71.12	28	mix of sun and cloud, thundershowers in afternoon
18-Jul	7:30 AM	12	10	66.675	26.25	Mostly sunny, heavy thundershower in afternoon
19-Jul	8:00 AM	14	10	71.1	28	Steady light rain starting midnight ends at noon
20-Jul	8:00 AM	12	9	78.7	31	Clear and sunny, water level reaches 12 inches
21-Jul	7:15: AM	9	10	78.7	31	Clear and sunny
22-Jul	7:35 AM	10	10	72.4	28.5	Clear and sunny
23-Jul	7:35 AM	12	11	66.0	26	Clear and sunny
24-Jul	7:40 AM	15	11	62.2	24.5	Mix of sun and cloud, showers late evening
25-Jul	8:00 AM	15	11	58.4	23	Cloudy with showers -light
26-Jul	8:00 AM	13	11	55.9	22	Cloudy with showers, clearing in afternoon
27-Jul	7:45 AM	11	11	54.6	21.5	Mostly sunny, occasional showers
28-Jul	8:10 AM	14	11	54.6	21.5	Cloudy with sunny breaks
29-Jul	7:45 AM	15	11	55.9	22	Mix of sun and cloud late day shower
30-Jul	8:05 AM	13	11	55.9	22	Mix of sun and cloud, isolated shower in late afternoon
31-Jul	7:50 AM	12	11	57.2	22.5	Mix of sun and cloud
01-Aug	8:00 AM	13	10	61.0	24	Mostly sunny with isolated showers in afternoon
02-Aug	7:30 AM	12	10	58.4	23	Mostly sunny
03-Aug	8:05AM	12	10	55.9	22	Mostly sunny

Date	Time	Air Temp.	Water Temp.	Water Level - cm	Water Level - inches	Comments
04-Aug	7:30 AM	15	11	52.1	20.5	Mostly sunny,cloudy afternoon
05-Aug	8:05 AM	12	11	48.3	19	Sunny AM,cloudy PM light showers after midnight.
06-Aug	8:15 AM	11	10.5	45.7	18	Showers in AM, clearing later in day
07-Aug	8:00 AM	10	9	45.7	18	Mix of sun and cloud
08-Aug	7:30 AM	10	9	45.7	18	Mix of sun and cloud
09-Aug	8:00 AM	9	8	43.2	17	clear in AM clouding over evening shower
10-Aug	8:10 AM	8	8.5	40.6	16	mostly cloudy, afternoon showers
11-Aug	7:30 AM	7	9	39.4	15.5	Mostly sunny
12-Aug	8:30 AM	9	8	38.0	15	Mix of sun and cloud
13-Aug	9:30 AM	8	8.5	37.0	15	clear in AM clouding over evening shower
14-Aug	10:30 AM	7	9	37.0	15	mostly cloudy, afternoon showers

Appendix 3. Hourly Chinook counts at Klondike sonar station 2011.

Note: After August 2 counts include probable Chum salmon. Shaded cells denote hours sonar was inoperative.

Date	00:00:00	01:00:00	02:00:00	03:00:00	04:00:00	05:00:00	06:00:00	07:00:00	08:00:00	09:00:00	10:00:00	11:00:00	12:00:00	13:00:00	14:00:00	15:00:00	16:00:00	17:00:00	18:00:00	19:00:00	20:00:00	21:00:00	22:00:00	23:00:00	Grand Total
06-Jul												1		1		1	1								4
07-Jul																			2				1		3
08-Jul	1	1				1					1		1												5
09-Jul	1		1		1					1					1		1						1		7
10-Jul		1				1						2	1		2				1				1	1	10
11-Jul		2	2	1	1										1	4	2				2			1	16
12-Jul		1	2	1			1	1	2	1		1	1	3	1	3							2		20
13-Jul	1		1		1	1	1	3	2	1	2	2	2		1	1	1	1	2		1	-1	2	2	27
14-Jul	2	3		1	2	3	1		2			1				1			3	4	1			3	27
15-Jul	2	1	1		3	1			2	2			1	1		1	2		2		2		1	1	23
16-Jul		4	2	2	4		4	2	1	1	1	5	1	2		2			3	2	2	1	2	4	45
17-Jul		2	1	2	2	1	9	1	1	5	2	4	3	2	1	3		2	3	4		1	7	6	62
18-Jul	8	4		4	5	1		1	4	2	1	4	2	3	5	3	6	4		1	6	4	7	4	79
19-Jul	3	3	1	5				20	2	2	2	1	2	1	2	3	1	2	1	1		1	1		54
20-Jul	3	2	2	2	2		2	1	1	1		3	2	2		2		1	2	3	2	1	1	2	37
21-Jul	2	6			1	1	3	3	1	1		5			2	2	1	1	3	3	3	3	1	2	44
22-Jul	1	9	4	3	4	3	4		3	1	3	2	3	2	5	4	6	5	1	2	5	2	4	2	78
23-Jul	5	2	3	2	6	3	1	8		4	6	1	3	4	3	4	2	3	2	1	3	2	5	6	79
24-Jul	2	6	4	4	6	9	1	9	2	1	3	6	4	1		5	4	2	4	2	1	4	4	2	86
25-Jul	3	3		2	5	5	1	2	2	3	4	2	4	4	4	4	3	4	1	3	1		3	2	65
26-Jul	6	1	1	3	3	2	3	1	3	2	1	2	4	5	2	1		1	3	6	5	3	3	1	62
27-Jul	3	5	3	5	5	3	2	3	4	3	1	3	3	2	1	3	2		2	3	4	3	3	1	67
28-Jul					6	3	1			1		1	3	2	1		5	5	1	1	3	2	2	1	38
29-Jul	5	2	1	2		2	2	2	1	1	1	1	1	1	3	4					2	2			33
30-Jul	1		2	4	1		3	3		1	1		1			1	2				2	1	4	3	30
31-Jul	2	2	2			2		2	1	1		1	1	1	3	2					1	1		1	23
01-Aug	1	1	2	1	1	1		2	2			2		2				1	2	1					19
02-Aug				2		1				1	1						2	1		1				4	13
03-Aug	1	1			1				1	2	1	3		1	3	2	1				3		1		21
04-Aug	1	1	1		2		1			1		1			1	2	2	2	1			1		1	18
05-Aug	1	1	1	1	1	2		1			1	2			1						5	4	1	1	23
06-Aug	1		1	2	2			1				1		2	1			3			2	1		2	19
07-Aug	1	1										2	1			2		1	2		4		2	1	17
08-Aug		3		1		1	1		2		1				1			1		3	4	1	1	3	23
09-Aug	3		1	1	1		1		2	1	2			1			2		1	2		2	1	4	25
10-Aug				2	2		3		1		1			3	1	2		2			1	1	1	3	23
11-Aug	1	1	3	2	2	2			2		1	1						1	3		3	2			24
12-Aug	1		2	4		2				1	1			1					4	7	6	1	4	1	35
13-Aug		3		1	1	2		3	1		4	1	1	1	2							1			21
14-Aug															2	1									3
05-Jul																									
Grand Total	62	72	44	60	71	53	45	69	45	41	42	61	45	48	50	63	46	43	49	50	74	44	66	65	1308

Appendix 4. 2011 Klondike River carcass pitch age, sex, and length data.

DATE	FISH #	SEX	MEF (mm)	POH	Gilbert-Rich Age	European Age	DNA Sample	SCALE BOOK#	BOOK #	SCALE #
4-Aug	1	M	965	845	62	14	Yes	82333	1	1-41
4-Aug	2	M	NA	635	52	13	No	82333	1	2-42
4-Aug	3	F	1000	0	72	15	Yes	82333	1	3-43
4-Aug	4	M	835	740	52	13	Yes	82333	1	4-44
4-Aug	5	M	NA	690	62	14	Yes	82333	1	5-45
4-Aug	6	M	680	610	52	13	Yes	82333	1	6-46
8-Aug	7	M	660	570	52	13	No	82333	1	7-47
8-Aug	8	M	1000	870	62	14	Yes	82333	1	8-48
8-Aug	9	F	NA	770	62	14	Yes	82333	1	9-49
8-Aug	10	M	660	580	52	13	Yes	82333	1	10-50
8-Aug	11	M	705	610	52	13	Yes	82334	2	1-41
8-Aug	12	M	NA	510	2M	M2	No	82334	2	2-42
8-Aug	13	F	760	650	52	13	No	82334	2	3-43
8-Aug	14	M	795	685	62	14	Yes	82334	2	4-44
8-Aug	15	M	NA	745	62	14	Yes	82334	2	5-45
8-Aug	16	M	520	455	42	12	Yes	82334	2	6-46
8-Aug	17	M	690	595	52	13	Yes	82334	2	7-47
8-Aug	18	M	NA	630	52	13	No	82334	2	8-48
8-Aug	19	M	NA	570	52	13	Yes	82334	2	9-49
8-Aug	20	M	NA	625	52	13	Yes	82334	2	10-50
8-Aug	21	F	NA	580	62	14	No	82335	3	1-41
11-Aug	22	M	1030	890	52	13	Yes	82335	3	2-42
11-Aug	23	F	NA	830	52	13	No	82335	3	3-43
11-Aug	24	M	970	850	4M	M4	No	82335	3	4-44
11-Aug	25	F	NA	780	52	13	Yes	82335	3	5-45
11-Aug	26	M	665	580	62	14	Yes	82335	3	6-46
11-Aug	27	M	850	740	62	14	Yes	82335	3	7-47
11-Aug	28	M	NA	550	62	14	Yes	82335	3	8-48
11-Aug	29	M	NA	660	4M	M4	Yes	82335	3	9-49
11-Aug	30	F	840	740	52	13	Yes	82335	3	10-50
11-Aug	31	M	725	620	52	13	Yes	82336	4	1-41
11-Aug	32	M	690	605	S2	1F	Yes	82336	4	2-42
11-Aug	33	F	940	840	62	14	Yes	82336	4	3-43
11-Aug	34	F	805	700	4M	M4	No	82336	4	4-44
11-Aug	35	M	890	780	62	14	Yes	82336	4	5-45
11-Aug	36	F	NA	820	62	14	Yes	82336	4	6-46
14-Aug	37	M	940	820	62	14	No	82336	4	7-47
14-Aug	38	M	680	590	52	13	Yes	82336	4	8-48
14-Aug	39	F	905	805	62	14	Yes	82336	4	9-49
14-Aug	40	M	970	840	62	14	No	82336	4	10-50
14-Aug	41	F	890	805	72	15	Yes	82337	5	1-41
14-Aug	42	M	840	730	62	14	Yes	82337	5	2-42
14-Aug	43	M	740	670	62	14	Yes	82337	5	3-43
14-Aug	44	M	950	840	4M	M4	Yes	82337	5	4-44
14-Aug	45	F	NA	na	62	14	Yes	82337	5	5-45
14-Aug	46	F	910	805	62	14	Yes	82337	5	6-46
14-Aug	47	M	840	740	62	14	Yes	82337	5	7-47
14-Aug	48	F	900	785	62	14	Yes	82337	5	8-48
Mean Female			883	708						
Mean Male			803	680						
Count Female			15							
Count Male			33							

Scale age analysis is conducted for DFO Whitehorse by the Pacific Biological Station Fish Ageing Lab, Nanaimo, British Columbia.
M2 and M4 denote partial ages obtained.