2010 Klondike River DIDSON Sonar

CRE-16-10

Prepared For: The Yukon River Panel
Restoration and Enhancement Fund

Prepared By: Brian Mercer

B. Mercer & Associates Ltd.
Box 20046
Whitehorse, Yukon
Y1A 7A2

March 2011

ABSTRACT

During July and August 2010 a project was conducted to enumerate Chinook salmon entering the Klondike River watershed using a DIDSON™ high resolution sonar. A similar project was previously conducted in 2009. The sonar site on the Klondike River was located approximately 3.5 km upstream of the confluence with the Yukon River. Fabrication of camp and weir materials occurred in June 2010. Transport of equipment and personnel from Whitehorse to Dawson City occurred on July 2 and camp construction and placement of diversion weirs at the sonar site commenced July 3. Sonar operation began on July 5 and continued through to August 17. Carcass pitches were conducted August 15, 16, 17, and 21. The camp and weirs were dismantled and removed August 22. The sonar was inoperative for 30.3 hours July 23-24 due to a problem with the power supply unit and again for 5.3 hours on July 27 as a result of battery charging problems. The Chinook counts during the outages were estimated using the mean hourly counts from the 24 hour periods before and after the sonar outage. The project ended before the run was completely finished and an estimate of fish passing after the sonar was removed was determined using a linear regression based on the final 15 days of sonar counts. A total of 737 Chinook salmon was counted by sonar and 38 were estimated to have passed while the sonar was inoperative and 28 were estimated to have passed after the project was completed. The final 2010 Klondike River Chinook escapement was estimated to be 803. The 2010 Klondike River Chinook escapement represented 2.4 % of the upper Yukon River Chinook spawning escapement estimate. The carcass pitches yielded age, sex, and length (ASL) samples from 20 Chinook.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

Monitoring of key spawning streams is an important stock assessment and salmon management tool that supplies information for the establishment and monitoring of salmon escapement goals. 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. Enumeration 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 important for run reconstruction and the establishment of scientifically based escapement objectives.

DIDSON high resolution sonar units have been used successfully on the Big Salmon River (2005-2010) and the Klondike River (2009-2010) 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 is accessible;
2. It has documented significant Chinook escapements;
3. No other salmon or fish species are present in the system that are of similar size and/or exhibit similar migration behaviour;
4. The Chinook stock is considered to be genetically unique and identifiable using the existing GSI database;
5. 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;
6. 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.

Fixed-location, side-view sonar techniques are 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 barrier to water craft. Since 2002 the DIDSON apparatus has been used for enumeration of several species of salmon in a broad range of environments (Galbreath and Barber 2005, Holmes et al. 2006, Maxwell et al. 2004, Enzenhofer et al., 2010). In general, the DIDSON units have been found to be reliable, require a limited amount of 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).

[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.

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 km from the river mouth (Mercer & Eiler 2004). Approximately 50% of Chinook salmon entering the Yukon River from the Bering Sea are destined for spawning grounds in Canada (Eiler et al. 2004, 2006). Canadian origin fish contribute approximately 47% to 67% of the total U.S. commercial and subsistence fisheries (Templin et al. 2005; cited in Daum and Flannery 2009). In 3 of the past 4 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 2009).

The Klondike River is located in north central Yukon and flows in a southwesterly direction from its headwaters to the 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 typical intra and inter-annual variation. Records collected over the period 1965 to 2009 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 typically around 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 2010 Klondike River sonar project were:

1. To build and transport additional deflection weir structures to the project site.

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

3. To recover and sample for age, sex, and length (ASL), moribund and dead Chinook salmon.

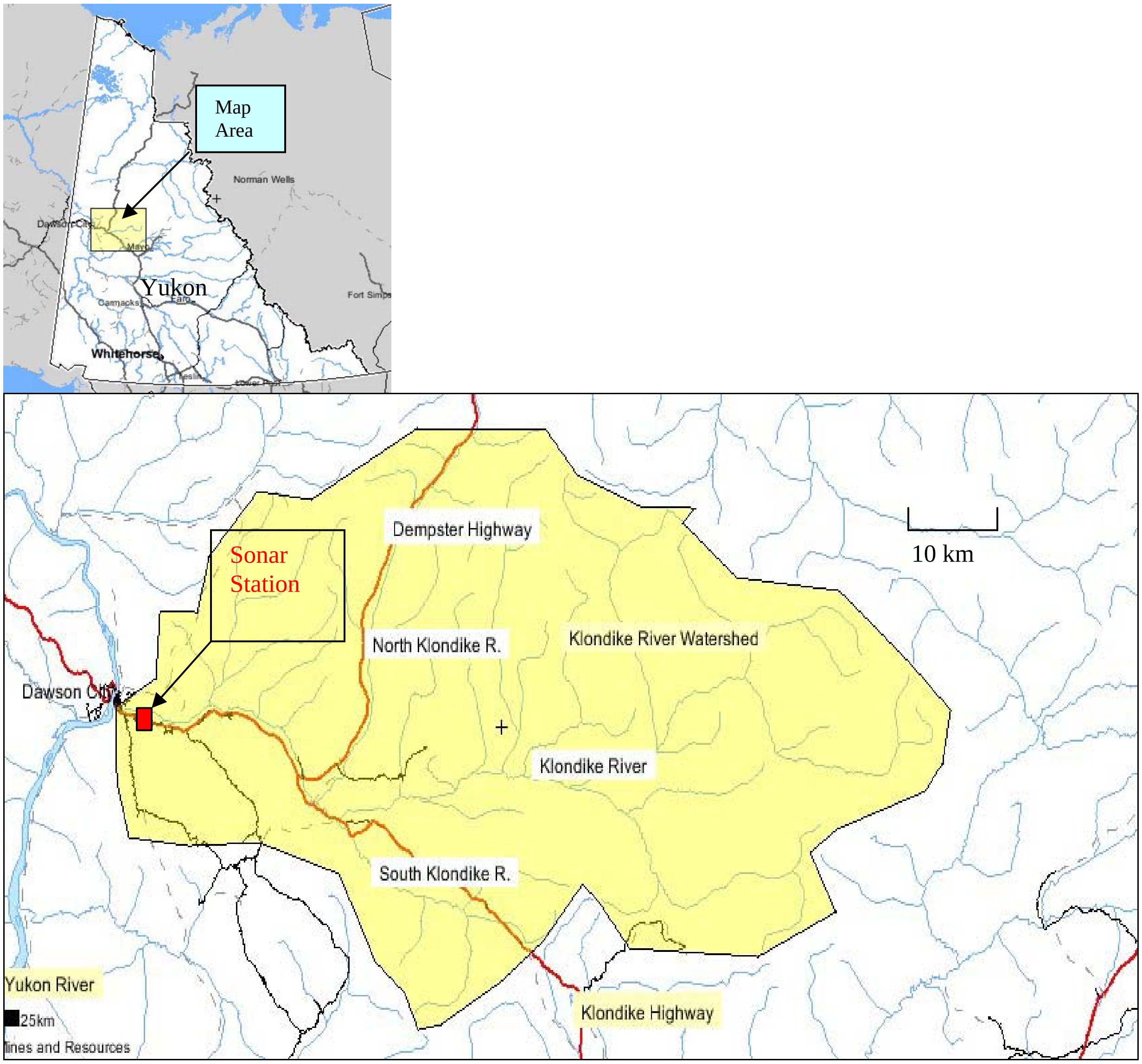

Figure 1. Klondike River watershed.

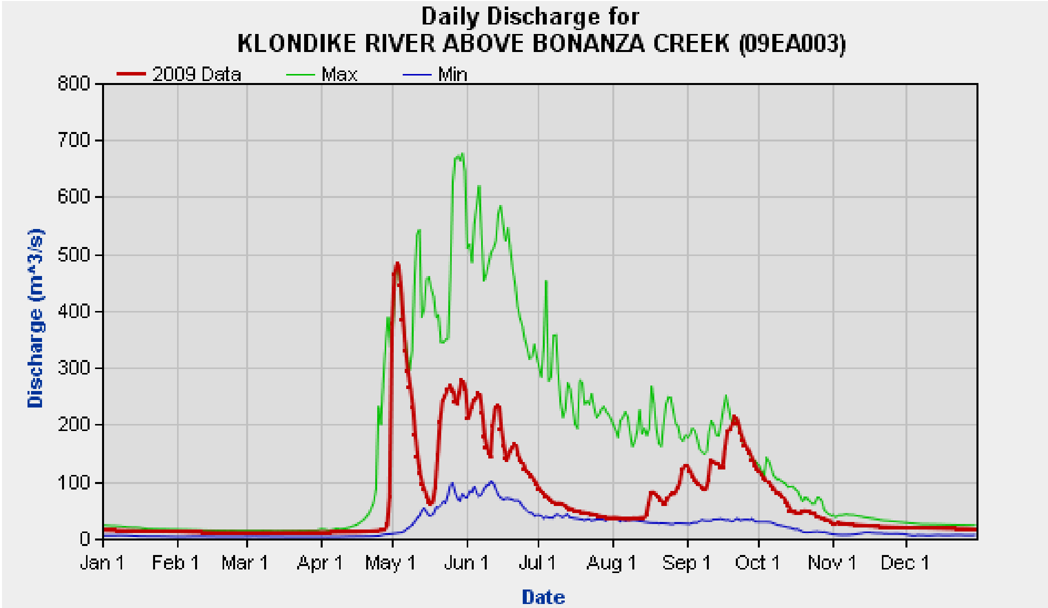

Figure 2. Daily minimum and maximum and mean discharge rates for Klondike River, above Bonanza Creek, from 1965 through 2009.
Source: Water Survey Board of Canada

METHODS

Site Selection

A location for the Klondike River sonar project was identified in the 2008 – 2009 Klondike River feasibility study (Mercer 2009). This site was used during the 2009 project and again in 2010. The site is located approximately 3.5 km upstream from the confluence with the Yukon River (Figure 1), and was selected and retained for the 2010 project 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 as well as acoustic shadows.
6. The river width and depth allows for installation of partial deflection weirs on either side 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 so that 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.

Weir Materials

In addition to the existing weir materials from the 2009 project, an additional three metal weir tripods were constructed in Whitehorse and transported to the project site. Ten conduit weir panels were fabricated at the project site. These materials along with the weir components used in 2009 were used to construct the deflection weirs for the 2010 sonar project. The newly fabricated metal tripods were larger and heavier than the standard tripods constructed in 2009 and were deployed in the deeper sections of the river.

Camp, Sonar Station, and Weir Construction

Construction of the camp and sonar station was initiated on July 3. All supplies and equipment were transported by truck from Whitehorse to Dawson City. The camp was located 15 m from the south bank of the river and comprised of two wall tents, one serving as living quarters and the other the sonar and computer station (Figure 3).

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 4 and completed on July 6. The weir materials were moved and installed using a jet boat. Prefabricated panels of electrical conduit were placed on the tripod structures to create the diversion fence in the deeper sections of the river (Figure 4). 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.

Figure 3. 2010 Klondike River sonar station camp, looking downstream.

Figure 4. Sonar transducer unit and mounting stand.

Sonar and Computer Software Configuration

The 2010 Klondike River sonar project was scheduled to begin approximately 15 days before another YRP sonar project on the Big Salmon River. The 2010 operational plan included the use of the LR DIDSON unit belonging to the YRP[2] for the first 15 days of the Klondike project. The rationale for this was to reduce the overall sonar rental costs. For the remaining 35 days of the Klondike project a standard DIDSON unit was rented from Sound Metrics Corporation.

[2] This LR-DIDSON unit was purchased by the 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 for the 2009 project (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 4). The sonar unit was bolted to a steel plate suspended from the cross bar that was connected to the stand with adjustable fittings (Kee Klamps™). The adjustable clamps allowed the sonar unit to be raised or lowered according to fluctuating water levels as well as enabled rotation of the transducer lens to adjust the beam direction.

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

As in 2009, it was planned for the 2010 project to use an 8° concentrator lens 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 2010 the concentrator lens was used only when the YRP LR DIDSON unit was in operation. When the rental unit arrived on July 17 it was discovered that the lens was not pre-drilled as required to accommodate the 8° lens. A replacement pre-drilled lens was obtained from Sound Metrics on July 21 but by that time the water level had risen to the point where the 8° beam depth was no longer deep enough to ensonify the entire water column (Figure 6). For this reason, the decision was made to continue using the standard lens for the remainder of the project.

The DIDSON sonar produces an ensonified field 29° wide in the horizontal plane and with the standard lens, 12° 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, which 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 unit had a compass and inclinometer that displayed the tilt and azimuth of the sonar beams on the computer screen.

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 typically set at 4 frames per second, which was the highest frame rate the computers could process with a window length setting of 40 m. Two laptop computers were used for the project, one recording the DIDSON files and one for reviewing the files. All files were saved on the recording computer as well as backed up on a 500 GB external hard drive.

Figure 5. Partial weir structures in place at the Klondike River sonar station, 2010.

Figure 6. Weir structures in high water conditions, Klondike River sonar site, 2010.

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 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. This allowed observers to quickly review files, particularly during long periods when no targets were observed. When necessary, the recording was stopped when a fish was observed and replayed at a slower rate for positive identification. The target measurement feature of the DIDSON software was used to estimate the size of the observed fish when required. The minimum size used to classify Chinook salmon was approximately 50 cm, although there were very few Chinook salmon targets in this size range. 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 documented in telemetry studies of Yukon River Chinook (Eiler et al. 2006). The number of identified strays detected is typically low and in the 2010 Klondike project only one Chinook was observed returning downstream.

Visual Counts

During the 2009 Klondike project the clear water conditions allowed visual counting of Chinook salmon passing the sonar station. However, in 2010 visual counts were not obtainable as a result of the deep and turbid water conditions.

[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.

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 lengths (to the nearest 0.5cm) were also recorded for each recovered fish. The crew made day trips upriver on August 14 through 17 and on August 21, searching for spent Chinook and carcasses.

RESULTS

Chinook Enumeration and Run Timing

The Klondike River sonar was operational starting July 5 at 19:00. The first Chinook salmon passing the sonar station was observed on July 8. Daily and cumulative counts are presented in Table 2. The estimated 2010 Chinook salmon escapement in the Klondike River drainage was 803. Of this total, 737 Chinook salmon were counted by sonar and 38 were estimated to have passed while the sonar was inoperative. A further 28 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 linear regression formula $y = -0.5643x + 14.381$. This formula was derived from the daily counts of the final 15 days of sonar operation. The peak daily count of 89 fish occurred on July 20 at which time 33% of the run had passed the sonar station. On July 22, 50% of the run had passed the sonar station and on August 9, 90% had passed (Figure 7). The 2010 daily counts exhibited a normal distribution skewed somewhat to the front end of the run. The bi-modality exhibited in the 2010 daily counts was not evident in the 2009 run pattern. This may have been a result of delayed migration due to the rising water levels that peaked on July 24 (Appendix 1 and Figure 9).

On July 23 at approximately 9:30 the sonar stopped working. After trouble shooting it was determined the 24 volt power supply unit had malfunctioned. The device was not repairable on site and a replacement was ordered from Sound Metrics Corporation the following morning. A temporary 24 volt power supply was constructed using two 12 volt deep cycle batteries connected in series. A charge was maintained on the batteries using a standard battery charger. This temporary power unit was used for 4 days until the replacement power supply unit was received on July 28.

During this period the sonar was not in operation for 30.3 hours from July 23 at 9:40 through to 15:40 on July 24. The sonar was also inoperative for 4.3 hours on July 27 as a result of battery charging problems. An estimate of the number of fish that passed the station when the sonar was not working was calculated for both time periods. The missing counts were obtained by calculating the mean number of fish per hour observed 24 hours before and 24 hours after the sonar outage. This mean hourly count was expanded by the number of hours the sonar was not in operation to obtain the total daily counts (Appendix 2). It was estimated that 29 fish passed during the first 30.3 hour outage. A total of 9 Chinook was estimated to have passed during the 4.3 hour second outage (Table 1).

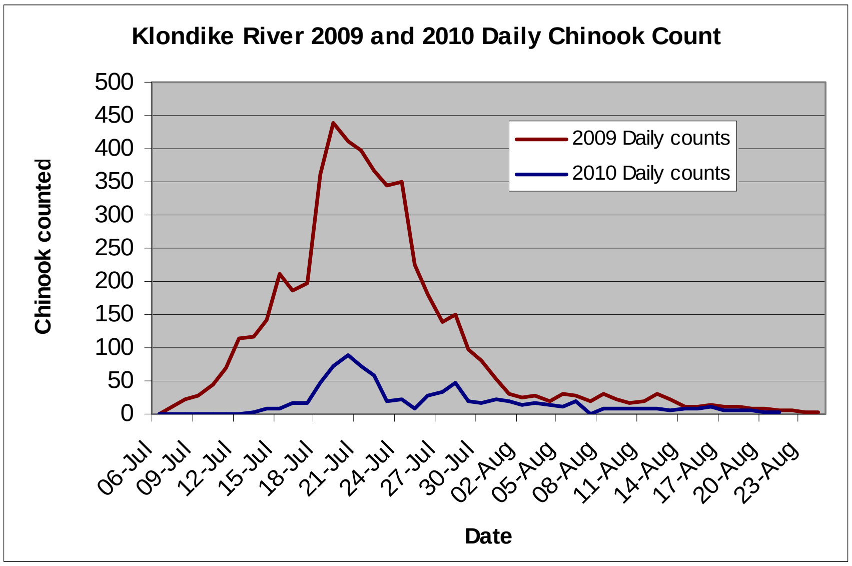

Figure 7. Daily DIDSON sonar counts of Chinook salmon passing the Klondike River sonar station in 2009 and 2010.

Diel Migration

The hourly sonar counts of Chinook passing the Klondike River sonar station are presented in Appendix 2 and illustrated in Figure 8. Hourly counts illustrated in Figure 8 do not include the days when complete 24 hour counts were not obtained (July 23, 24, 27 and August 17). There was no statistically significant difference observed in total hourly counts (Single factor ANOVA, tested for homogeneity of variance: df=23, F=0.43, F*crit.* = 1.54, α=0.05, *p*=0.99).

A statistically significant diurnal pattern was noted in the 2009 run pattern, with peak hourly counts at 05:00 and 06:00. With only two years of data, however, it is not known if a diel migration pattern is typical of the Klondike River Chinook.

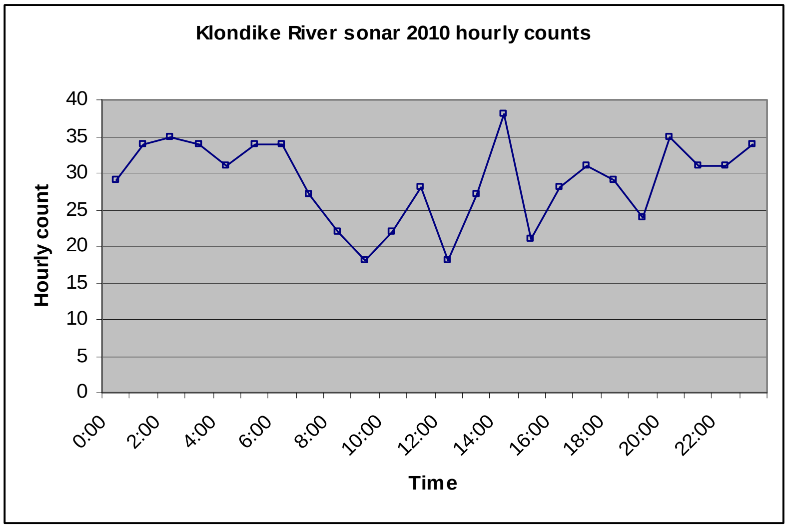

Figure 8. Total hourly counts of Chinook salmon passing the Klondike River sonar station in 2010.

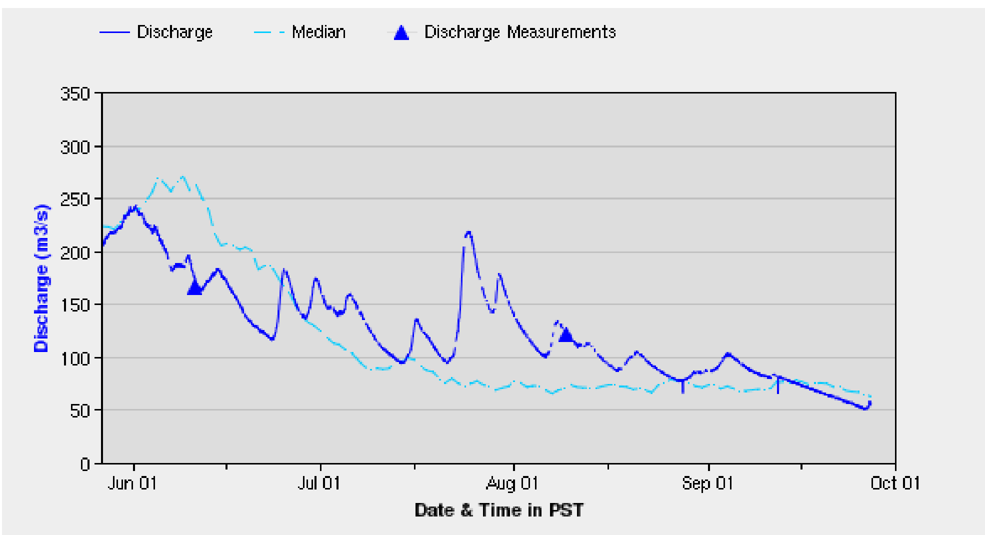

Figure 9. Daily 2010 and median (1965 – 2009) discharge rates of the Klondike River, June 1 – October 1. (Source: Water Survey Board of Canada).

Cross section distribution

The distribution pattern of the migrating Chinook as detected by the sonar is presented in Figure 10. The distribution of Chinook passing the station is skewed to the south bank of the river where the sonar unit is located. This distribution is likely a result of Chinook orientating to the deeper section of the river along the South bank. The weir structure on the North side of the river extended into the 44-47.5 range which may account for the low number of fish observed in the outer range. Although the range frequency distribution was not determined during the 2009 project, subjective observation by the technicians suggests the pattern was similar to that observed in 2010.

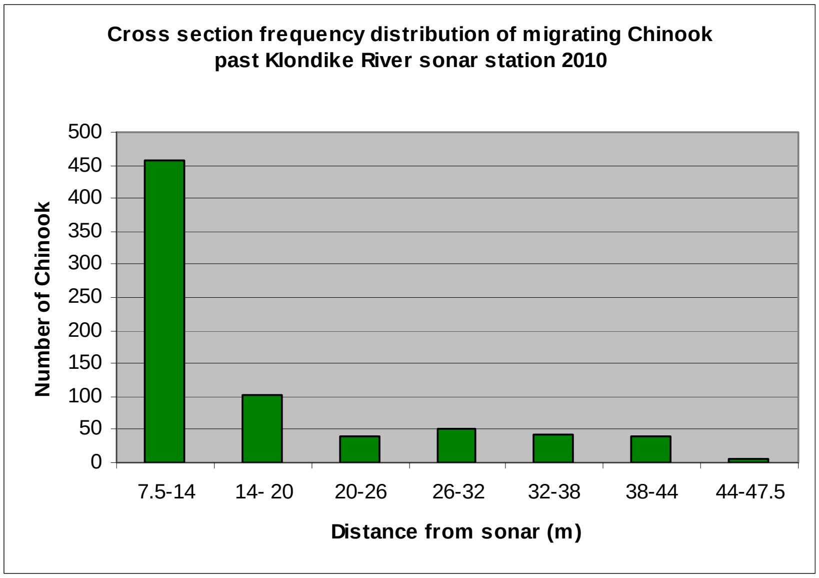

Figure 10. 2010 Klondike River Chinook range/frequency in cross section profile.

Table 1. 2010 Klondike River Chinook ASL summary.

Sex	European age*	Data	Total
F	13	Average of MEF	81.0
		Average of POH	73.5
	14	Average of MEF	91.1
		Average of POH	81.5
	15	Average of MEF	98.5
		Average of POH	88.0
	M4	Average of MEF	n/a
		Average of POH	80.5
F Count			5
M	12	Average of MEF	57.0
		Average of POH	48.5
	13	Average of MEF	74.9
		Average of POH	66.0
	14	Average of MEF	90.8
		Average of POH	79.5
	1F	Average of MEF	83.5
		Average of POH	75.0
	M3	Average of MEF	80.3
		Average of POH	71.0
	M4	Average of MEF	78.0
		Average of POH	66.5
M Count			15
Total Average of MEF			79.1
Total Average of POH			70.3

*Scale age analysis was conducted under the aegis of DFO Whitehorse by the Pacific Biological Station Fish Ageing Lab, Nanaimo. British Columbia. European age format; e.g. 1.3 denotes 1 year freshwater residence and 3 year marine residence.

Table 2. 2010 daily and cumulative counts of Klondike River Chinook salmon.[4]

Date	Daily Count	Cum. Count	Remarks
06-Jul	0	0	
07-Jul	0	0	
08-Jul	1	1	
09-Jul	1	2	
10-Jul	1	3	
11-Jul	0	3	
12-Jul	1	4	
13-Jul	3	7	
14-Jul	9	16	
15-Jul	7	23	
16-Jul	16	39	
17-Jul	18	57	
18-Jul	46	103	
19-Jul	71	174	
20-Jul	89	263	
21-Jul	71	334	
22-Jul	58	392	
23-Jul	20	412	Sonar off for 14.5 hours; 14 added to daily count
24-Jul	22	434	Sonar off for 16 hours; 15 fish added to daily count
25-Jul	9	443	
26-Jul	27	470	
27-Jul	32	502	Sonar off 4.5 hrs; 9 added to daily count
28-Jul	46	548	
29-Jul	19	567	
30-Jul	18	585	
31-Jul	22	607	
01-Aug	20	627	
02-Aug	14	641	
03-Aug	17	658	
04-Aug	14	672	
05-Aug	12	684	
06-Aug	19	703	
07-Aug	1	704	
08-Aug	8	712	
09-Aug	9	721	
10-Aug	7	728	
11-Aug	7	735	
12-Aug	8	743	
13-Aug	6	749	
14-Aug	8	757	
15-Aug	8	765	
16-Aug	10	775	
17-Aug	5	780	Daily counts based on extrapolation Aug.17-Aug. 25
18-Aug	5	785	
19-Aug	4	789	
20-Aug	4	793	
21-Aug	3	796	
22-Aug	3	799	
23-Aug	2	801	
24-Aug	1	802	
25-Aug	1	803	

[4] Grey shaded cells denote daily counts obtained using expanded counts based on the number of fish per hour derived from the mean of the 24 hour counts before and after the sonar outage. Yellow shaded cells are extrapolated daily estimates after the project was finished.

Carcass Pitch

A total of 20 dead or moribund Chinook was recovered during the carcass pitch. Of these, 3 were pre-spawn dead Chinook recovered on the weir. Five female (20%) and 15 (80%) male carcasses were sampled. Age, length, and sex data is summarized in Table 1 and complete data is presented in Appendix 3. Age 1.3[5] was the dominant age class, followed by age 1.4. Due to the prevailing high water conditions, the number of recovered carcasses was low and it is unlikely the ASL data is representative of the population.

DISCUSSION

A total of 803 Chinook salmon was estimated to have entered the Klondike River drainage based on sonar counts, estimated counts during sonar outage, and an end of the run extrapolation. The 2010 Klondike River Chinook escapement estimate represented 2.5% of the total upper Yukon River spawning escapement[6] estimate of 32,010 obtained from the Eagle sonar station[7] count and Canadian harvest figures (DFO Whitehorse, unpublished data). The 2010 Klondike River proportion (2.5%) of the total upper Yukon River Chinook escapement is significantly below that obtained from the 2009 sonar count (7.8%) and the proportional distribution of radio tagged Chinook in the Klondike system observed during two years of Yukon River radio telemetry studies conducted in 2003 (6.8%) and 2004 (7.8%) (Mercer 2010, Mercer and Eiler 2004, Mercer 2005).

The run timing of Chinook entering the Klondike system in 2010 was similar to that observed during the 2009 sonar project (Figure 7). The run timing from the 2003 and 2004 telemetry data (Mercer 2009), and corroborated by the 2010 and 2009 sonar counts, suggests the Klondike River Chinook stock exhibits earlier run timing than most upper Yukon River stocks. As a result of this early run timing, sonar counts of the Klondike River Chinook stock can provide an early in-season index of the Canadian origin Upper Yukon River Chinook run.

Chinook Genetic Stock Identification (GSI) samples are collected over the total Chinook run passing the Eagle sonar station. Using the 467 GSI samples collected in 2010 at the Eagle sonar site and existing base line GSI information on individual Upper Yukon River Chinook stocks, estimates of the proportional contribution these stocks made to the total 2010 Chinook border escapement can be calculated. If the escapement of a distinct and identifiable Chinook stock is quantified, the proportional contribution can be expanded to obtain an estimate of the total border escapement. This can be used as an independent means of evaluating the accuracy of the Eagle sonar Chinook counts. As an example, the 2010 mean weighted proportional contribution of the Big Salmon River stock based on

---

[5] European age format; e.g. 1.3 denotes 1 year freshwater residence and 3 year marine residence.
[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.

GSI samples obtained from drift net sampling at the Eagle sonar site was 11.7%, (SD 2.4) (DFO Whitehorse, unpublished data). Using Big Salmon sonar counts and the proportion of Big Salmon origin stocks derived from the Eagle GSI sampling, the expanded border escapement would be 32,624 (95% CI +/- 9,350). The Eagle sonar count is within this range and the point estimate is very similar to the 2010 Upper Yukon Chinook spawning escapement (32,010) based on the Eagle sonar count. The range of escapement estimates based on expanded Big Salmon sonar counts and GSI stock proportions have been concordant with the Eagle sonar counts since that project began (Mercer and Wilson 2006 – 2010).

Unlike the Big Salmon GSI stock proportion and sonar counts, the 2010 Klondike sonar counts are not concordant with the Eagle sonar count and Klondike GSI proportions. As occurred in 2009 (Mercer 2010), the 2010 proportional contribution of Klondike River Chinook based on the Eagle GSI samples was significantly lower than the proportion derived from the sonar counts. The 2010 GSI sampling indicated the Klondike Chinook represented 0.3% (SD 0.6) of the Upper Yukon Chinook run whereas the sonar counts indicated 2.5%; a differential factor of 8.3. While the low 2010 Klondike GSI proportion does correspond with a relatively low sonar count, it is evident that the GSI based stock proportions obtained in 2009 and 2010 are likely biased low. This apparent discrepancy is discussed in detail in the 2009 Klondike River sonar report (Mercer 2010).

The high and turbid water conditions on the Klondike system during the course of the 2010 sonar project were atypical (Figure 9), and contrasted with the relatively low water levels experienced in 2009 (Figure 2). The 2010 conditions made installation and maintenance of the weirs difficult. In addition, they prevented visual counting and reduced the effectiveness of the carcass recovery efforts. Notwithstanding the water conditions of 2010 and the estimated counts when the sonar was inoperative for 35 hours, the project supervisor believed that the sonar counts obtained were accurate and that passing Chinook were not missed by the sonar. It would be preferable to deploy an 8º concentrator lens at this site when water conditions permit, however, the standard lens is capable of detecting Chinook targets at the outer range (37 m) of the ensonified migration corridor (Maxwell et al. 2004).

While corroborative visual counts are desirable, the DIDSON sonar units when properly positioned and operated have repeatedly demonstrated their ability to provide accurate counts of migrating salmon in a range of conditions and sites (Enzenhofer et al. 2010; Holmes et al. 2006). One of the purposes for obtaining visual counts is to compare and quantify the visual versus sonar counts in order to truth the precision of the sonar counts. In 2009, the laminar flow and lack of surface turbulence at the Klondike sonar site provided reasonable and standardized viewing conditions. The visual counts from 2009 indicated that 100% of the 196 Chinook observed visually were also detected by the sonar (Mercer 2010).

A total of 48 hours (126 files over the period July 20 -26) of the 2010 Klondike River sonar counts was independently reviewed prior to preparation of this report. This was done to quantify the variance between file readers as well as determine the overall accuracy of the counts. Both the reviewers and the on-site personnel obtained a total count of 106 fish from these files. However, although the total file counts were equal, each group of readers missed two Chinook. Although it would be incorrect to conclude that 2% of all passing Chinook are missed by all reviewers it is likely the variance is in that range. At the Big Salmon River project reviewers produced the same counts 98% and 99% of the time (Mercer and Wilson 2005 and 2006). Other DIDSON projects involving salmon enumeration have observed similar concordance and based on the coefficient of variation, counts of individual passage events varied <3% of the time (Holmes et al. 2006). Typically the variance is inversely proportional to the count. Reviewing files in which no fish passage occurs requires greater effort to stay focused on the task. The relatively low 2010 Klondike sonar count could contribute to a higher variance between reviewers.

REFERENCES

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

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

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

Enzenhofer, H.J., Cronkite, G.M.W., and Holmes, J.A. 2010. Application of DIDSON imaging sonar at Qualark Creek on the Fraser River for enumeration of adult pacific salmon: An operational manual. Can. Tech. Rep. Fish. Aquat. Sci. 2869: iv + 37 p.

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

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

Joint Technical Committee (JTC) of the Yukon River US/Canada Panel. 2009. Yukon River Salmon 2009 Season Summary and 2010 Season Outlook. Fisheries and Oceans Canada, Stock Assessment and Fisheries Management Section, Yukon and Transboundary Area. Whitehorse, Yukon Territory.

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

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

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

Mercer B. 2009. 2008 Klondike River DIDSON Sonar Feasibility Study Unpublished report for Yukon River Panel, CRE project 16-08.

Mercer B. and J. Wilson, 2005 through 2010. Chinook Salmon Sonar Enumeration on the Big Salmon River. Unpublished reports for Yukon River Panel CRE project 41.

Water Survey of Canada. Archived hydrometric data. http://www.wsc.ec.gc.ca/applications/H2O/ reporteng.cfm?station=09EA003 &report=daily&year=2009.

Acknowledgements

Several individuals capably contributed to the 2010 Klondike sonar project. Project supervisor Bob Gransden and technician Sarah Wesche conducted the daily operational activities associated with the project as well as the setup and dismantling of the sonar station. Jim Mercer fabricated the additional weir materials and assisted with the weir placement. Jane Wilson assisted with the initial camp and weir construction, reviewed files, and helped edit this report. Lowell Tait assisted with the carcass pitch and dismantling of the weir and camp.

Appendix 1. Air and water temperatures and relative water levels at the Klondike River sonar station, 2010.

Date	Time	Air Temp.	Water Temp.	Water Level -cm	Comments
08-Jul	740 AM		10	72.4	Staff gauge set at 730 PM Water temp 13.5 degrees Hot and sunny all day
09-Jul	742 AM	16	11	68.6	Clear and sunny
10-Jul	815 AM	14	11.5	64.1	Mostly cloudy, with rain at night
11-Jul	745 AM	15	11	61.6	Cloudy with clearing in evening
12-Jul	740 AM	14	10.5	59.7	Cloudy in morning clearing in afternoon
13-Jul	745 AM	16	11	57.2	Sunny in morning afternoon thundershowers
14-Jul	745 AM	18	11.5	56.5	Cloudy in morning clearing in afternoon
15-Jul	800AM	16	11	62.2	Mix of sun and cloud showers at night
16-Jul	800AM		11.5	77.5	Mix of sun and cloud
17-Jul	800AM	10	10	72.4	Mostly cloudy with occasional showers
18-Jul	800AM	16	9	69.9	Mostly sunny
19-Jul	745AM	17	11	63.5	Mostly cloudy
20-Jul	730AM	16	11	59.1	Mostly cloudy with occasional showers
21-Jul	730AM	13	11	62.2	Mix of sun and cloud
22-Jul	900AM	16	11	61.0	Cloudy with steady rain, and rain all night
23-Jul	730AM	16	10.5	82.6	Cloudy with some rain at night
24-Jul	900AM		10.5	116.8	Mostly cloudy clearing in evening
25-Jul	800AM	13	9	109.2	Showers in the morning clearing in afternoon
26-Jul	700AM	9	9	96.5	Sunny, with thundershowers in early evening
27-Jul			10	88.9	Mix of sun and cloud with high wind in afternoon
28-Jul	730AM	15	10.5	83.8	Mix of sun and cloud
29-Jul	730AM	16	10	106.7	Mix of sun and cloud
30-Jul	730AM	13	10	96.5	Mostly sunny
31-Jul	800AM	15	10.5	86.4	Mostly sunny
01-Aug	800AM	15	11	81.3	Mostly sunny
02-Aug	730AM	14	11.5	76.2	Mostly sunny with haze
03-Aug	730AM	13	11.5	71.1	Mostly sunny
04-Aug	700AM	12	12	66.0	Sunny, hot
05-Aug	700AM	14	12.5	63.5	Clouding over rain beginning in early evening
06-Aug				62.2	Following rain all night, light rain all day ending early evening
07-Aug	800AM	13	10.5	74.9	Mostly sunny with isolated showers in late afternoon
08-Aug	745AM	11	10.5	78.7	Mostly sunny with isolated showers in late afternoon
09-Aug	730AM	11	10	74.9	Mix of sun and cloud
10-Aug	730AM	13	10.5	71.1	Mix of sun and cloud, with showers at night
11-Aug	730AM	12	10	69.9	Clear in morning isolated showers in the afternoon
12-Aug	710AM	9	10	68.6	Mix of sun and cloud
13-Aug	730AM	13	10.5	66.0	Mix of sun and cloud
14-Aug	715AM	13	11	63.5	Cloudy in morning clearing in afternoon
15-Aug	700AM	11	11	61.0	Clear and sunny
16-Aug	730AM	12	11.5	58.4	Clear and sunny
17-Aug	800AM	16	12	55.9	Clouding over rain beginning in early evening

Appendix 2. Hourly Chinook counts at Klondike sonar station 2010. Shaded cells denote hours sonar was inoperative.

Date	12:00:00 AM	1:00:00 AM	2:00:00 AM	3:00:00 AM	4:00:00 AM	5:00:00 AM	6:00:00 AM	7:00:00 AM	8:00:00 AM	9:00:00 AM	10:00:00 AM	11:00:00 AM	12:00:00 PM	1:00:00 PM	2:00:00 PM	3:00:00 PM	4:00:00 PM	5:00:00 PM	6:00:00 PM	7:00:00 PM	8:00:00 PM	9:00:00 PM	10:00:00 PM	11:00:00 PM
06-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
07-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
08-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	1	0
09-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1	0	0	0	0	0
10-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
11-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
12-Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0		0	0	0	0	0	0
13-Jul	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
14-Jul	0	0	1	0	0	0	2	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1
15-Jul	1	1	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	2	0	0
16-Jul	3	1	0	1	0	0	1	0	0	0	1	1	1	1	1	1	0	0	2	0	1	0	0	1
17-Jul	1	0	0	0	2	1	0	0	3	2	1	1	0	0	0	0	0	0	3	0	2	2	0	0
18-Jul	1	1	0	2	0	2	2	0	1	0	0	3	1	5	2	2	1	5	2	1	2	5	4	4
19-Jul	1	0	5	3	9	6	6	5	1	0	0	3	3	2	3	2	1	2	3	7	2	0	5	2
20-Jul	2	0	3	5	4	6	1	2	2	3	1	3	1	3	4	6	8	8	1	7	13	3	1	2
21-Jul	1	0	6	2	5	2	5	4	3	2	5	2	4	4	5	3	0	1	1	2	0	4	5	5
22-Jul	1	7	4	3	1	5	3	4	2	0	3	5	4	0	2	3	2	2	2	2	1	1	0	1
23-Jul	1	1	3	1	0	0	0	0	0	0														
24-Jul																		0	1	1	2	1	1	1
25-Jul	1	2	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0
26-Jul	3	3	0	2	1	1	2	0	0	1	2	1	0	1	1	0	1	2	1	0	0	1	0	4
27-Jul	3	0	3	2	0	0	0	0	1	1	0							0	1	2	5	0	1	1
28-Jul	3	3	3	1	0	0	0	0	1	0	3	1	1	0	4	0	5	1	1	2	3	1	2	0
29-Jul	0	4	3	1	1	2	3	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	1
30-Jul	3	0	0	0	3	0	1	0	0	2	1	1	0	0	0	0	0	0	0	0	2	3	0	2
31-Jul	0	2	2	0	1	0	0	1	1	1	1	0	0	1	3	0	2	1	1	1	1	1	0	2
01-Aug	0	2	0	3	0	1	1	1		3	0	1		0	0	0	1	1	2	1	1	0	1	1
02-Aug	0	1	2	1	0	1	1	0	0	1	0	0	1	0	1	2	0	0	0	0	0	2	1	0
03-Aug	1	0	0	0	1	0	0	1	0	1	1	3	1	1	2	0	0	3	0	0	1	1	0	0
04-Aug	2	0	1	1	0	2	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	2	2
05-Aug	0	0	0	1	0	1	3	1	0	0	0	0	0	1	0	1	1	0	1	0	1	0	0	1
06-Aug	1	0	0	3	0	1	0	1	0	0	0	1	0	2	1	0	1	1	2	1	2	1	1	0
07-Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
08-Aug	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	2	1	0
09-Aug	0	1	0	1	0	0	0	2	0	1	0	0	0	0	0	0	0	1	3	0	0	0	0	0
10-Aug	0	0	1	0	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1
11-Aug	0	1	1	0	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0
12-Aug	1	1	0	1	-1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1
13-Aug	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0
14-Aug	0	1	0	1	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
15-Aug	1	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	2	0
16-Aug	0	0	1	0	1	0	0	0	3	0	0	0	0	1	1	0	1	0	1	0	0	0	1	0
17-Aug	2	1	1	0	0	0	0																	
Grand Total	29	34	35	34	31	34	34	27	22	18	22	28	18	27	38	21	28	31	29	24	35	31	31	34

Appendix 2 continued.

Time period	July 23-24	July 27
Total hours inoperative	30.3	4.3
Mean fish per hour 24 hours before and after outage	0.97	2.15
Expanded count during outage	**29**	**9**

Appendix 3. 2010 Klondike River carcass pitch data.

Fish no.	Sex	MEF	POH	European age*	Scale book #	Scale row	DNA Sample	Comments
1	F	88.2	78.4	14	82331	1	Y	Pre-spawn mort on weir
2	F	81.0	73.5	13		2	Y	Pre-spawn mort on weir
3	M	63.5	55.5	13		3	Y	Pre-spawn mort on weir
4	M	71.0	63.0	M3		4	Y	
5	M	82.5	74.5	13		5	Y	Carcass on weir
6	M	71.5	63.5	13		6	Y	
7	M	89.5	79.0	M3		7	Y	
8	M	91.5	79.5	13		8	Y	
9	F	94.0	84.5	14		9	Y	
10	F	n/a	80.5	M4		10	N	
11	F	98.5	88.0	15	82332	1	Y	
12	M	60.5	52.0	12		2	Y	
13	M	61.5	53.5	13		3	Y	
14	M	79.0	70.0	13		4	Y	
15	M	89.0	78.0	14		5	Y	
16	M	92.5	81.0	14		6	Y	
17	M	78.0	66.5	M4		7	Y	
18	M	75.0	65.5	13		8	Y	
19	M	53.5	45.0	12		9	Y	
20	M	83.5	75.0	1F		10	Y	

*Scale age analysis was conducted under the aegis of DFO Whitehorse by the Pacific Biological Station Fish Ageing Lab, Nanaimo, British Columbia. European age format; e.g. 1.3 denotes 1 year freshwater residence and 3 year marine residence.