2009 Klondike River DIDSON Sonar

CRE-16-09

Prepared For: The Yukon River Panel
Restoration and Enhancement Fund

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ABSTRACT

As a result of a sonar feasibility study conducted in July 2008 and May 2009 on the Klondike River watershed, a suitable site was identified for the deployment of a DIDSON™ sonar unit. The purpose of the study was to determine the feasibility of obtaining accurate enumeration of Chinook salmon escapement into the drainage. In 2008 a proposal to conduct a sonar project to enumerate the 2009 Klondike River Chinook salmon escapement was submitted to the Yukon River Panel (YRP) Restoration and Enhancement Fund and accepted. The identified sonar site on the Klondike River is located approximately 3.5 km upstream of the confluence with the Yukon River. Fabrication of required weir and camp materials occurred in June 2009. Transport of equipment from Whitehorse to Dawson City occurred on July 2. The construction and placement of diversion weirs and camp setup at the sonar site commenced on July 3. Sonar operation began on July 6 and continued through to August 15. Due to a component malfunction the sonar was inoperable for approximately 78 hours from July 18 – 21. During this time 27 hours of visual counts were conducted over three days and an expanded estimate of Chinook salmon passage was obtained for this period. A total of 5,147 Chinook salmon was estimated to have entered the Klondike River drainage in 2009 based on sonar counts, expanded visual counts, and an end of the run extrapolation. The 2009 Klondike River Chinook escapement represented 7.8 % of the Eagle sonar station total upper Yukon River Chinook spawning escapement estimate of 65,278.

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INTRODUCTION

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

From 2005 through 2009, a DIDSON LR sonar unit has been successfully used to enumerate annual Chinook salmon escapements into the Big Salmon River in the upper Yukon River watershed (Mercer & Wilson, 2005 through 2009). In 2008 and 2009 a feasibility study was conducted on the Klondike River system to identify potential sites for deployment of a DIDSON sonar unit. A suitable site was identified that could provide an accurate count of Chinook salmon escapements into the drainage. Due to high flow rates, First Nation concerns, and recreational use of the Klondike River, the use of a traditional counting weir on this river is not feasible. For these reasons the DIDSON sonar was considered a relatively low-impact, non-intrusive method of enumerating annual Chinook escapements into the Klondike River system. The use of sonar allows for enumeration of migrating Chinook salmon while minimizing negative impacts on fish behaviour and providing unrestricted recreational use of the river. 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 weir structures and too turbid for visual observations.

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

1. It is accessible;
2. It has documented significant Chinook escapements;
3. The Chinook stock is considered to be genetically unique and identifiable;
4. 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;
5. The Chinook stock is one of the earlier temporal segments of the above border Yukon River Chinook run.

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[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.

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

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 are destined for spawning grounds in Canada (Eiler et al. 2004, 2006). Canadian origin fish contribute approximately 47% to 67% of the total U.S. commercial and subsistence fisheries (Templin et al. 2005; cited in Daum and Flannery 2009). In recent years above border Chinook escapements have been less than bilaterally agreed escapement goals, leading to closures and restrictions on commercial and aboriginal fisheries.

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. The Klondike River and its tributaries have been impacted by placer mining activities.

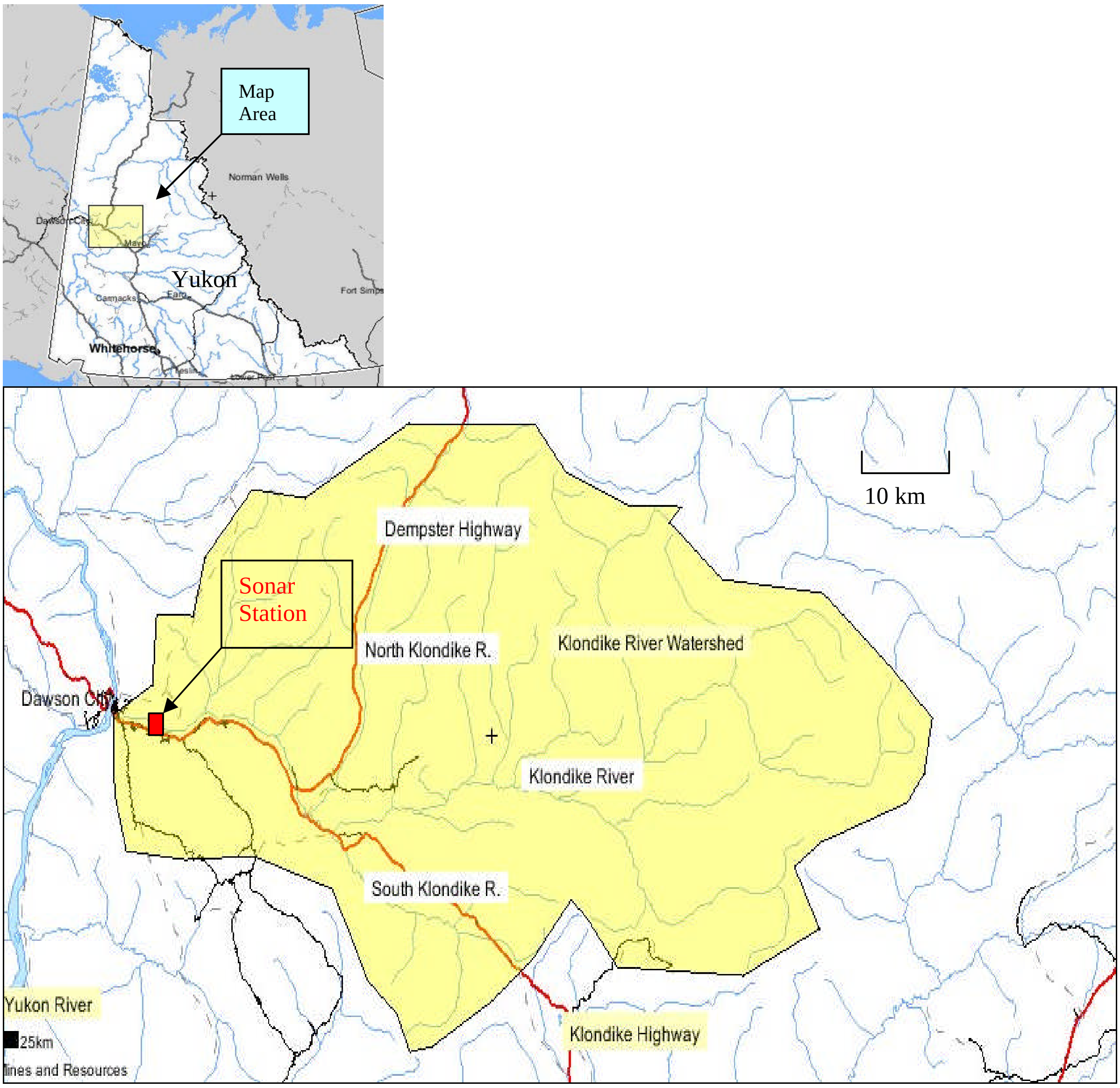

Figure 1. Klondike River watershed.

Maximum and minimum discharge rates exhibit typical inter-annual variation and as well as being variable from year to year. Records range from a maximum discharge rate of 679 m^3/s and a minimum of 4.51 m^3/s with a mean discharge rate of 63.2 m^3/s. Mean peak discharge rates occur around June 1, with a mean discharge rate of 275 m^3/s (Figure 2). At the beginning of the sonar operation in early July, mean discharge rates are typically in the range of 130 m^3/s, approximately 45% of peak discharge rates.

Fish species documented in the Klondike River system include Chinook and Chum salmon (*Oncoryhncus tshawytscha* and *O. keta),* Grayling (*Thymallus thymallus),* Burbot (*Lota lota*), Inconnu (*Stenodus leucichthys),* Round Whitefish (*Prosopium* *cylindraceum*), slimy sculpin (*Cottus cognatus*), and longnose sucker (*Catostomus catostomus*) (DFO FISS database).

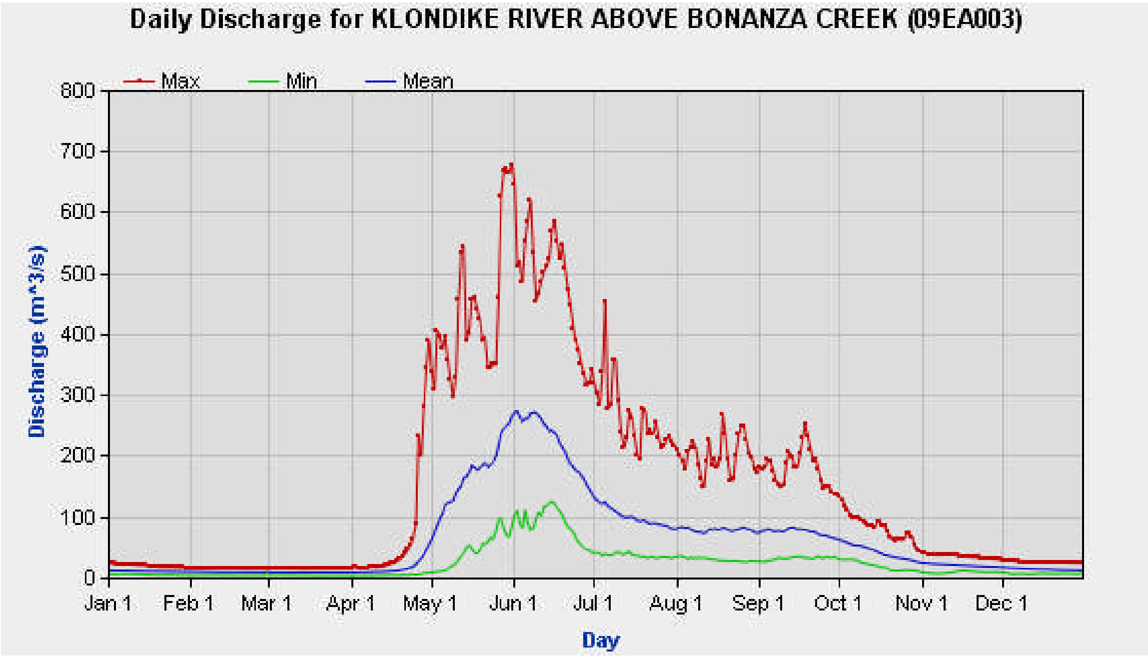

Figure 2. Daily minimum and maximum and mean discharge rates for Klondike River from 1965 through 2007. (Source: Water Survey Board of Canada)

OBJECTIVES

The objectives of the 2009 Klondike River sonar project were:

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

2. To establish a temporary camp and sonar station at the identified project site.

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

METHODS

Site Selection

The location of the sonar project was the one identified in the 2008 – 2009 Klondike River feasibility study (Mercer 2009). This site, located approximately 3.5 km upstream from the confluence with the Yukon River (Figure 1), 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.
2. The site is a sufficient distance upstream of the mouth to avoid detection 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. In addition, laminar flow is conducive to active 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 is not so wide as to preclude ensonification of the total width where Chinook migration will occur. Both standard and Long Range (LR) DIDSON sonar units can detect Chinook size targets to a maximum range of approximately 40m. For this to occur,sites that are wider than 40m should allow 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

An application was submitted to Yukon Energy, Mines & Resources, Lands Branch for a licence of occupation on vacant crown land at the identified sonar station site. Given the short nature of the project the agency concluded a licence of occupation was not required for 2009. Notification of the project was given to the City of Dawson as the sonar site is within municipal boundaries.

An application was submitted to Transport Canada (Marine Branch), Navigable Waters Protection for approval to install the partial fish diversion fences in a navigable waterway.

Weir Materials

Three metal tripods and 7 prefabricated conduit panels were constructed in Whitehorse and transported to the project site. These materials along with unused weir equipment from another R&E project were used to construct the deflection weirs for the 2009 sonar project. The newly fabricated metal tripods were larger and stronger than the surplus weir equipment and were deployed in the deeper sections of the river.

Camp and Sonar Station Set-up

Construction of the camp and sonar station was initiated on July 5. 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 a single wall tent which served as living quarters and computer station. (Figure 3).

Figure 3. Klondike River sonar station camp, looking upstream.

Weir Construction

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 6 and completed by July 7. 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 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 4. Partial weir structures in place at the Klondike River sonar station, 2009.

Sonar and Computer Software Configuration

The 2009 Klondike River sonar project was scheduled to begin approximately 10 days before the Big Salmon sonar project. The 2009 operational plan included the use of the LR DIDSON unit belonging to the YRP[2] for the first 10 days of the Klondike project. The rationale for this was to reduce the overall sonar rental costs. For the remaining 27 days of the Klondike project a standard DIDSON unit was rented from Ocean Marine Industries Inc.

The set up and configuration of the DIDSON sonar unit was similar to that used for the Big Salmon River project (Mercer and Wilson 2009). 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 5). 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 enabling rotation of the transducer lens to adjust the beam direction.

For the 2009 Klondike River project 8° concentrator lenses were acquired from Sound Metrics Corp. for mounting on both the rental and YRP sonar units. The existing lenses of the LR DIDSON units were machine drilled in order to attach the concentrator lens. The 8° concentrator lens reduces the vertical ensonified field from 14° to 8°. The reduced field increases the acoustic energy reflected from the targets in the field and increases the resolution of targets in the farther reaches of the ensonified area.

[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).

Figure 5. Sonar transducer 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 0.8 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.

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, which resulted in the ensonified field of view remaining parallel to the surface of the river (Figure 6).

Once the sonar was in place and properly positioned, the primary sonar unit settings and software were configured. These settings included the window start length, the ensonified window length, and the frame rate. The receiver gain was set at –40 dB, the window start at 6.5 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 5 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 6. DIDSON sonar in position at the Klondike River sonar site, 2009.

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 obtained from a nearby residence. A 35 m, #12 electrical supply line incorporating a voltage surge protection device was connected from the residence to the operation tent.

Sonar Data Collection

Once operation 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 30 and 40 frames per second, approximately 8 to 10 times the recording rate. This allowed observers to quickly review files, particularly during long periods when no targets were observed. When necessary, the recording was stopped when a fish was observed and replayed at a slower rate for positive identification. The target measurement feature of the DIDSON software was used to estimate the size of the observed fish. 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. Fish identified as Chinook salmon moving downstream were subtracted from the file total. A record of each 20 minute file count as well as hourly, daily and cumulative counts was maintained throughout the run.

Visual Counts

The clear water conditions encountered in 2009 allowed visual counting of Chinook salmon passing the sonar station. The initial purpose for obtaining visual counts was to quantify the precision of visual versus sonar counts as a means of truthing the sonar counts. The laminar flow and lack of surface turbulence at the sonar station typically provided reasonable and standardized viewing conditions. Visual counts were obtained using an observer station situated on a placer tailings pile adjacent to and 10 m above the south bank of the river. Hand held radios provided communication between the observer and the sonar operator for real time comparisons between visual and sonar target recognition. The image illustrated in Figure 4 was obtained from the visual counting station. Visual counts were obtained during the period 09:00 –21:00, however, records were kept only for the number of hours observations occurred on a given day and not the specific timing of the visual counts. Visual counts were not conducted when visibility was impaired such as during windy or heavy overcast conditions[3].

RESULTS

Chinook Enumeration and Run Timing

The Klondike River sonar was operational starting July 6 at 19:00. The first Chinook salmon passing the sonar station was observed on July7 at 03:00. Daily and cumulative counts are presented in Table 1. The estimated 2009 Chinook salmon escapement in the Klondike River drainage was 5,147. A total of 5,078 Chinook salmon was counted passing the sonar station from July 6 through to August 15. A further 69 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 a linear regression formula of $y = -1.4727x + 30.473$ which was derived from the daily counts of the final 10 days of sonar operation. The peak daily count of 438 fish occurred on July 19 at which time 38% of the run had passed the sonar station. On July 21, 50% of the run had passed and 90% of the run had passed the station on August 7 (Figure 7). The daily counts exhibited a normal distribution typical of run patterns observed in two other ongoing upper Yukon River Chinook escapement projects at the Big Salmon sonar station (Mercer and Wilson 2009) and a weir at Blind Creek (Wilson 2009).

On July 18 at approximately 18:00 a significant electrical storm passed over the sonar station. Immediately following a close lightning strike the sonar was observed to have

[3] Four hours of visual counts were obtained on July 15 when windy conditions prevailed. These counts were not used to determine sonar/visual counts.

Table 1. 2009 daily and cumulative counts of Chinook salmon at the Klondike River sonar site.[4]

Date	Daily count	Cum Count	Comments
06-Jul	0	0	Sonar starts at 19:00
07-Jul	11	11	
08-Jul	21	32	
09-Jul	28	60	
10-Jul	45	105	
11-Jul	69	174	
12-Jul	115	289	
13-Jul	117	406	
14-Jul	142	548	
15-Jul	212	760	
16-Jul	186	946	
17-Jul	196	1142	
18-Jul	360	1502	Sonar malfunction at 18:00
19-Jul	438	1940	
20-Jul	410	2350	
21-Jul	396	2746	Sonar repaired at 23:00
22-Jul	367	3113	
23-Jul	344	3457	
24-Jul	351	3808	
25-Jul	226	4034	
26-Jul	181	4215	
27-Jul	140	4355	
28-Jul	150	4505	
29-Jul	98	4603	
30-Jul	80	4683	
31-Jul	53	4736	
01-Aug	31	4767	
02-Aug	26	4793	
03-Aug	28	4821	
04-Aug	19	4840	
05-Aug	30	4870	
06-Aug	27	4897	
07-Aug	20	4917	
08-Aug	30	4947	
09-Aug	21	4968	
10-Aug	18	4986	
11-Aug	20	5006	
12-Aug	30	5036	
13-Aug	21	5057	
14-Aug	11	5068	
15-Aug	10	5078	
16-Aug	13	5091	Extrapolated counts August 16 to
17-Aug	12	5103	Aug 24 using linear regression
18-Aug	10	5114	$y = -1.4727x + 30.473$
19-Aug	9	5123	
20-Aug	8	5130	
21-Aug	6	5137	
22-Aug	5	5141	
23-Aug	3	5145	
24-Aug	2	5147	

[4] Grey shaded cells denote daily counts obtained using expanded observer visual counts. Yellow shaded cells are extrapolated estimates using linear regression derived from counts from the previous 10 days.

stopped functioning. Either due to the shock of the sonic wave or an electrical surge[5] the electrical storm appeared to have caused a malfunction in the power module of the sonar

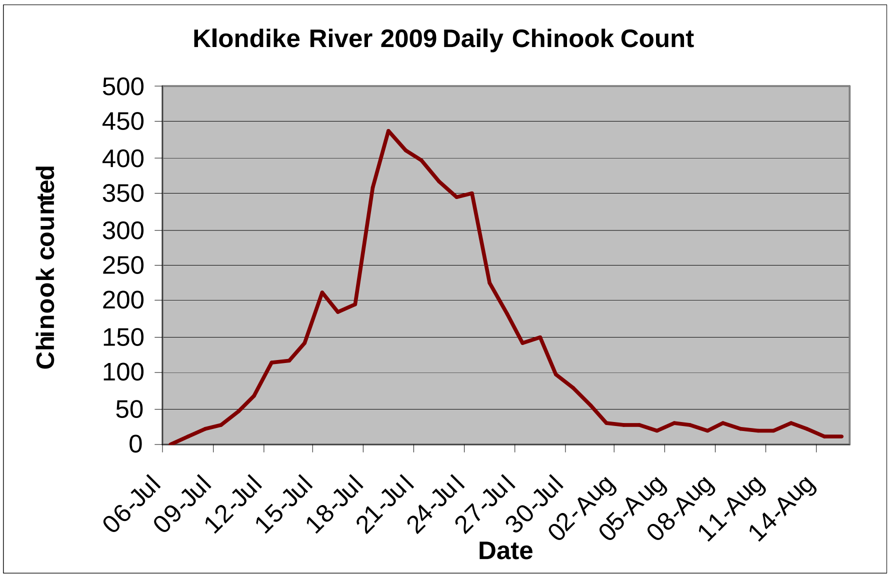

Figure 7. Daily DIDSON sonar counts of Chinook salmon passing the Klondike River sonar station from July 6 through August 15, 2009.

unit. As the malfunction occurred on a Saturday it was not possible to contact DIDSON technical support until the following Monday, July 20. Consultation with technicians from Sound Metrics Corporation on July 20 resulted in a probable diagnosis of the problem and another power module and spare fuses were priority shipped from Lake Forest Park, Washington U.S. via Fedex® to the contractor in Whitehorse, Yukon. On July 21 the components arrived in Whitehorse and the contractor flew to Dawson City with the replacement module and fuses. These were installed and the sonar was back in operation at 23:00 on July 21.

Visual counts were obtained over 9 days before and after the sonar malfunction. This was done in order to quantify the precision of visual versus sonar counts. Over this period a total of 23.8 hours was spent collecting visual counts for comparison with the sonar counts (Appendix 1). Visual counts on average detected 66% of the Chinook counted from the sonar files. In every instance, Chinook detected visually during this period were also detected by the sonar. The sonar/visual counts yielded a mean expansion factor of 1.43 (Std. Dev. = 0.11; 95% CI 1.36 – 1.50) that could be used for obtaining an estimate of the Chinook passing the station based on visual counts only. With the exclusion of visual counts obtained under windy conditions and poor visibility on July 15, the ratio of visual/sonar counts was relatively consistent over the 9 day sampling period exhibiting a relatively low variance of 0.10.

[5] Surge protection was in place for all the electronic components used on the project. Technical staff from Sound Metrics Corp. noted that damage to the DIDSON power module from electrical storms had been observed in the past (Drew Hubbard, Sound Metrics Corp. per. Comm.).

The daily counts obtained for July 19, 20, and 21 were based on expansion of the visual counts obtained during those days. Visual counts were acquired during the day between 09:00 and 21:00, during periods of maximum light conditions. The diel migration data indicates that significantly higher numbers of Chinook passed the station during the hours 01:00 to 07:00, a time when visual counts were not performed. Therefore, in order to obtain the most accurate daily escapement estimates a second expansion factor based on the differential diel migration pattern must also be used. This expansion factor (1.28 x total expanded daily count) was obtained by stratifying the sonar counts into two 12 hour time periods: 09:00 – 21:00 and 21:00 – 09:00. Hourly sonar counts over the total project indicated that 61% of the sonar counted Chinook passed during the 21:00 – 09:00 interval compared to 39% passing during the period 09:00 – 21:00 (Appendix 2).

Due to the equipment malfunction the operation of the sonar was disrupted for 78 hours. In order to obtain daily estimates of the number of Chinook passing the sonar station during this time, visual counts were conducted for a period of 1.67 hours on July 18 and approximately 9 hours during each of the following three days (Appendix 3). During this period the expanded counts per hour of Chinook passing the station averaged 14.06/hour (range 13.30 – 14.58). Using the two expansion formulae applied to visual daily fish per hour counts it was estimated that a total of 1,370 (95% CI +/- 65) Chinook passed the sonar station during the 78 hours the sonar unit was inoperable. The total daily counts for this period presented in Table 1 were obtained by using the total expanded visual counts on July 19 and 20, and the expanded visual counts plus the actual sonar counts on the two partial days (July 18 and 21) the sonar was operational (Appendix 3).

Diel Migration Pattern

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 6, 18, 19, 20, 21, and August 15). Statistically significant differences were observed in total hourly counts (Single factor ANOVA, tested for homogeneity of variance: df=23, F=2.32, $F_{crit.} = 1.54$, α=0.05, p=0.00045). The highest hourly counts were observed between 00:00 and 06:00, with a peak at 04:00, and the lowest were between 17:00 and 19:00.

With only one year of data it is not known if this diel migration pattern is typical of the Klondike River Chinook. It could possibly be adaptive migratory behaviour particular to Chinook entering the clear water conditions exhibited in the Klondike watershed in July and August 2009. A diel migration pattern has not been observed in 5 years of DIDSON sonar operation on the Big Salmon River drainage; a system which typically exhibits more turbid conditions (Mercer and Wilson 2009).

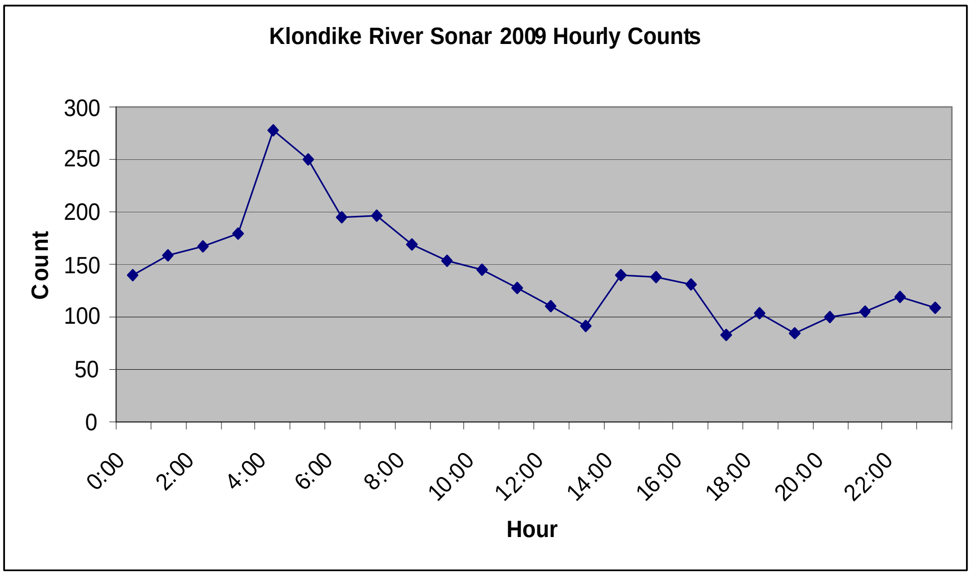

Figure 8. Total hourly counts of Chinook salmon passing the Klondike River sonar station in 2009.

DISCUSSION

A total of 5,147 Chinook salmon was estimated to have entered the Klondike River drainage based on sonar counts, expanded visual counts and an end of the run extrapolation. The 2009 Klondike River Chinook escapement represented 7.8 % of the total upper Yukon River spawning escapement[6] estimate of 65, 278 that was obtained from the Eagle sonar station count and Canadian harvest figures (JTC 2009). The 2009 Klondike River proportion of the total upper Yukon River Chinook is concordant with 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 and Eiler 2004, Mercer 2005).

The run timing of Chinook entering the Klondike system in 2009 was similar to the run timing of radio tagged fish observed in the 2003 and 2004 telemetry studies (Figure 9). This telemetry data, corroborated by the 2009 sonar counts, suggests the Klondike River Chinook stock exhibits earlier run timing than most upper Yukon River stocks. The early run timing and relatively large proportional contribution of the Klondike River Chinook stock supports the assumption that it is a suitable index system for Upper Yukon River Chinook stock assessment.

Chinook Genetic Stock Identification (GSI) samples are collected over the total Chinook run at the Eagle sonar station located in Alaska, approximately 120 km downstream of the mouth of the Klondike River. Using the 646 GSI samples collected in 2009 at the

[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.

Eagle sonar site, along with previously collected base line GSI information on Upper Yukon River Chinook stocks, estimates of the proportional contribution these stocks made to the total 2009 Chinook border escapement can be calculated (JTC 2009). If the escapement of a distinct and GSI 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 testing the veracity of the Eagle sonar Chinook estimates. For example, the 2009 mean weighted proportional contribution of the Big Salmon River stock based on GSI samples obtained from drift net sampling at the Eagle sonar site was 16.9%, (SD 3.6) (JTC 2009). Using the 2009 Big Salmon sonar counts and the proportion of Big Salmon origin stocks derived from the Eagle GSI sampling, the expanded border escapement point estimate would be 54,875 (95% CI +/- 17,923). This is within the range of the 2009 Eagle sonar border passage estimate of 69,575 (Mercer and Wilson 2009).

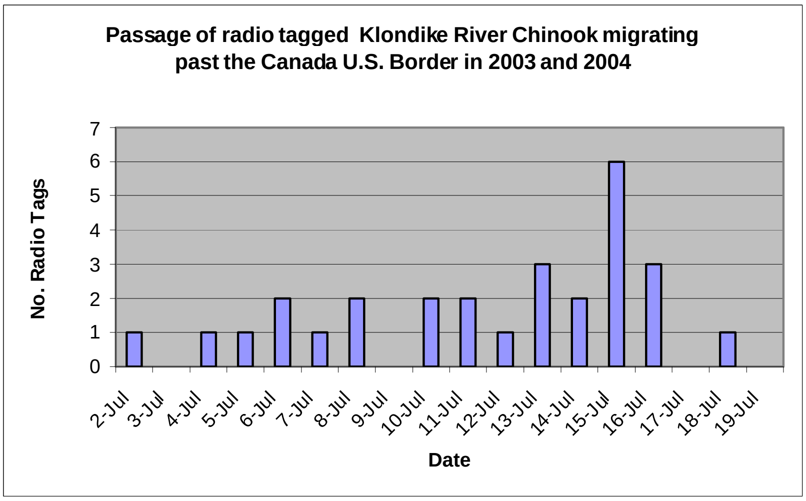

Figure 9. Date of passage past the Canada/US border of radio tagged Chinook returning to the Klondike River in 2003 and 2004.
Source: (B. Mercer & J.H. Eiler 2004; B. Mercer 2005).

The mean weighted proportional contribution of the Klondike River stock based on 2009 GSI samples obtained from drift net sampling at the Eagle sonar site was 4.3%, (SD 4.8) (JTC 2009). Using this GSI stock proportion and the Klondike River escapement estimate of 5,147, the 2009 expanded border escapement point estimate would be 119,000, significantly higher than the actual Eagle sonar estimate of 69,575. Since the 2009 Big Salmon sonar counts are considered reliable (Mercer and Wilson 2009) and the GSI data is concordant with the Eagle sonar count it is plausible to consider that the estimated Klondike Chinook GSI stock proportions may be biased low. From 2006 through 2009 GSI based Klondike River stock proportions based on sampling at Eagle sonar station and the Bio-Island fish wheels averaged 4.1% (range 2.0% - 5.9%). This is significantly lower than was observed in both the telemetry studies and the 2009 sonar data. Conversely the Chandindu River, a relatively small tributary to the Yukon River located approximately 30 km downstream from the mouth of the Klondike, exhibits a relatively high GSI stock proportion with a 2006 – 2009 mean of 8.8% (range 6.8% -

11.2%, DFO data, Whitehorse). However, 5 years of Chinook weir counts[7] obtained on the Chandindu system averaged only 138 Chinook (range 4 – 239, JTC 2009). These low weir counts are incongruent with the assumption that the Chandindu system contributes an average of 8.8% to the total Upper Yukon River Chinook escapement. It is possible the GSI sampling techniques at the Eagle sonar site are not representative.[8] However, if that were correct then the Chandindu GSI proportions would likely be low as well, but they are not. It is possible the baseline GSI data for the Klondike and Chandindu Rivers is incomplete or erroneous resulting in at least partial mis-identification of these two stocks. In order to try and resolve this apparent discrepancy it is suggested that the baseline GSI data from these two systems be re-examined. Additional baseline GSI samples from the two systems may need to be obtained and incorporated in the Yukon River Chinook GSI data base. The value of the Klondike River as a Chinook index system would be enhanced if accurate and concordant GSI based stock proportion data were available.

Water conditions on the Klondike system during the course of the 2009 sonar project were very clear, in contrast with the high turbidity observed in 2008 (Mercer 2009). These clear water conditions allowed the crew to obtain visual counts of the passing Chinook. It is important to note that all of the 116 Chinook counted visually were also concurrently observed and correctly identified using the sonar apparatus. While not definitive, this suggests that while the sonar was operational, all or nearly all of the Chinook passing the sonar station were detected, positively identified, and counted.

Regrettably the sonar malfunction occurred at the peak of the 2009 Klondike Chinook run. This malfunction was considered to be unusual and the experience of the 2009 project should not preclude consideration of using similar equipment in future projects at this site. Typically DIDSON sonar units have been demonstrated to be reliable, robust, and relatively trouble free in a wide range of field conditions.

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[7] The Chandindu River weir operated 5 years from 1998 – 2003, except for 2002. It is probable that in some years only partial counts were obtained due to high water events (Pat Milligan per. Comm.. DFO Whitehorse).

[8] It has been postulated that because the GSI samples are collected relatively close to the natal stream (< 120 km) the Klondike stock are more bank oriented than other Upper Yukon stocks and thus are not as likely to be caught in the Eagle drift net sampling. However the Chandindu River is even closer to the sampling site so it would also be expected to be biased low.

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Appendix 1. DIDSON sonar and visual counts of Chinook passing the Klondike River sonar station, 2009.

Date	Visual observation time in hours	Didson counted Chinook	Observer counted Chinook		Ratio Didson versus observer	Sonar Fish/hour passed	Comments
13-Jul	5	19	13		1.46	3.80	
15-Jul	4	32	13		2.46	8.00	Very windy, data from this day not used for calculating expansion factor
16-Jul	5	29	22		1.32	5.80	Observer misses 2 of 4 downstream
18-Jul	1	14	9		1.56	14.00	
23-Jul	2.67	27	18		1.50	10.11	
24-Jul	2.33	32	25		1.28	13.73	
25-Jul	1.67	13	10		1.30	7.78	During observations made in evening for 1 hour observer notes some wind, misses 3 of 4 salmon
26-Jul	0.67	3	2		1.50	4.48	Good conditions
29-Jul	1.5	6	4		1.50	4.00	Didson misses downstream salmon, moves at an angle to sonar.
				Mean	1.43		
				Std. Dev.	0.11		
Total	23.84	175	116	**95% CI**	(1.36-1.50)		

Appendix 2. Hourly counts and expansion factor based on differential diel migration. Shaded cells denote days sonar was wholly or partially inoperative.

Date/Hour	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
7-Jul-09	0	0	0	3	3	0	0	1	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0
8-Jul-09	0	0	1	0	0	1	2	2	1	0	2	0	2	0	1	1	1	1	0	1	0	1	3	1
9-Jul-09	0	0	3	0	1	2	5	0	0	0	1	2	2	4	0	0	0	3	1	1	1	0	1	1
10-Jul-09	0	0	1	0	3	2	2	3	0	1	2	0	0	4	5	1	2	1	4	7	1	3	1	2
11-Jul-09	4	1	2	3	3	4	4	3	5	5	7	2	2	2	3	3	4	1	1	6	1	1	0	2
12-Jul-09	2	4	5	4	6	15	2	12	1	3	9	7	4	2	4	3	2	12	2	2	1	4	5	4
13-Jul-09	14	11	4	5	11	4	2	3	3	5	4	5	3	1	9	3	3	6	3	0	1	3	8	6
14-Jul-09	2	1	14	5	6	11	9	8	10	4	6	4	5	8	4	9	6	3	1	2	5	12	5	3
15-Jul-09	8	21	11	7	12	12	6	12	10	7	8	10	7	6	9	5	12	1	7	2	4	13	12	10
16-Jul-09	13	8	9	7	12	13	12	14	3	4	6	2	7	1	7	11	18	9	4	12	4	4	2	4
18-Jul-09	11	15	13	25	20	32	17	11	17	16	15	6	11	11	11	6	15	7						
19-Jul-09	0	0																						
20-Jul-09	0	0																						
21-Jul-09	0	0																						5
17-Jul-09	4	7	9	15	33	23	8	8	7	5	9	7	2	17	9	9	9	1	0	0	1	0	8	5
22-Jul-09	7	11	15	10	20	21	25	13	12	27	25	26	20	6	14	14	12	8	12	6	17	13	19	14
23-Jul-09	11	12	13	20	24	28	18	7	24	22	10	13	8	3	14	20	10	6	19	8	16	10	14	14
24-Jul-09	23	9	15	17	16	22	12	12	24	19	5	14	7	8	12	20	24	8	11	16	22	20	8	7
25-Jul-09	11	11	10	6	11	5	18	18	16	9	9	11	13	7	20	11	6	7	10	0	2	1	4	10
26-Jul-09	3	4	7	4	12	13	15	20	11	7	12	3	11	14	10	2	6	3	10	0	3	2	7	2
27-Jul-09	2	11	10	7	19	20	9	13	12	2	5	1	2	4	1	3	3	0	0	6	2	4	2	2
28-Jul-09	7	11	11	11	22	14	17	14	2	8	10	7	2	2	2	2	1	1	0	2	2	0	2	0
29-Jul-09	0	4	4	11	14	11	8	11	5	4	3	3	0	0	4	4	0	3	2	2	2	1	1	0
30-Jul-09	1	0	3	9	12	6	5	6	7	5	3	2	0	0	2	3	1	1	9	1	1	1	1	1
31-Jul-09	0	1	1	3	3	4	2	10	6	5	1	0	3	0	2	2	0	1	1	0	2	1	1	4
1-Aug-09	2	6	1	2	6	1	2	1	1	2	0	0	2	0	0	0	0	0	1	0	2	0	1	1
2-Aug-09	0	1	1	3	4	1	2	0	2	0	2	0	0	0	4	2	1	0	0	0	3	0	0	0
3-Aug-09	2	1	1	3	1	1	1	0	0	1	0	0	1	0	1	0	2	0	3	4	1	1	2	2
4-Aug-09	0	2	0	3	3	0	1	2	2	1	0	2	-1	1	0	0	1	0	1	1	0	0	0	0
5-Aug-09	2	3	1	4	3	0	2	1	0	2	0	0	2	0	1	0	3	1	1	1	0	1	2	0
6-Aug-09	4	2	0	1	3	0	0	0	2	0	0	1	1	0	1	4	2	1	0	1	1	1	2	0
7-Aug-09	3	1	6	0	2	1	2	0	0	0	2	1	0	0	0	0	0	1	0	0	0	0	-1	2
8-Aug-09	1	0	1	7	2	1	1	2	1	1	0	1	2	1	0	0	1	1	2	1	2	2	0	0
9-Aug-09	1	3	1	4	3	1	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	3	1	0
10-Aug-09	2	1	2	1	1	2	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	4

Appendix 2 continued.

Date/Hour	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
11-Aug-09	2	6	1	1	3	1	0	0	0	0	1	0	0	0	0	1	1	1	0	0	1	0	1	0
12-Aug-09	1	3	2	1	1	6	2	0	0	1	1	1	2	0	0	0	0	1	-1	0	0	2	3	4
13-Aug-09	2	1	1	1	2	1	0	0	0	1	0	1	0	0	0	4	0	0	0	0	2	1	1	3
14-Aug-09	3	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	2	1
15-Aug-09	3	2	1	1	0	2	0	1																
Sum	151	174	180	204	298	282	212	208	186	169	159	133	122	102	151	144	146	90	104	84	100	106	119	114

Time period	09:00-21:00	21:00-09:00
Total hourly count	1359	2115
%	39%	61%
Diel expansion factor	1.28 * expanded visual count	
X = 1.28	(X * 2718 = 3474)	

Appendix 3. 2009 Klondike River expanded visual and total counts when the sonar was inoperative.

Date	Visual observation time in hours	Observer counted Chinook	Expanded observer count	Estimated Fish/hour	Hours sonar not operating	Total visual expanded count	Adjusted for diel increase (1.28)	Total daily count	Comments
18-Jul	1.66	17	24	14.58	7	102	131	360	Sonar down at 18:00 following lightning strike. Total =131 expanded + 259 sonar count.
19-Jul	8.83	88	126	14.25	24	342	438	438	sonar inoperative 24 hours
20-Jul	8.84	83	119	13.36	24	321	410	410	sonar inoperative 24 hours
21-Jul	9.25	80	123	13.30	23	306	391	396	Sonar operational at 23:00. Total = 391 expanded count + 5 sonar count. Some wind during day, expansion factor of 1.54 used is mean of all observation days including July 15.
			Mean	**14.06**	**78**	**1070**	**1370**	**1604**	**Total**
			Std.dev.	**0.64**		**95% CI**	+/- 65		
			95%CI	**0.63**					