Fishery Data Series No. 12-47

Sonar Estimation of Fall Chum Salmon Abundance in the Sheenjek River, 2010

by

Roger D. Dunbar

September 2012

Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Dual frequency identification sonar was used to estimate chum salmon *Oncorhynchus keta* escapement in the Sheenjek River from August 18 to September 24, 2010. The sonar-estimated escapement through September 24 was 22,062 chum salmon. There were several extreme high water events that necessitated removal of the sonar equipment from the river and relocation of the camp to prevent damage or loss. Extreme erosion prevented operation of the sonar on the left bank the entire season. The current biological escapement goal is based only on right bank passage. The right bank estimate was 56% below the low end of the Sheenjek River biological escapement goal of 50,000 to 104,000 chum salmon. Median passage while the sonar was operating was observed on September 14. Peak single day passage was observed on September 17, when an estimated 1,548 fish passed the sonar site. A diel migration pattern showed most chum salmon passed the sonar site during periods of darkness or suppressed light. Range of ensonification was considered adequate for most fish that passed. The passage estimate should be considered conservative since it does not include fish migrating beyond the counting range (including along the left bank) or fish present before the sonar equipment was in operation. Only 64 vertebrae samples for age determination were collected because of low salmon passage. Female chum salmon comprised 53% of the sample and 47% were male.

Key words: chum salmon, *Oncorhynchus keta*, DIDSON, sonar, hydroacoustics, escapement, enumeration, Yukon River, Porcupine River, Sheenjek River.

INTRODUCTION

Five species of anadromous Pacific salmon *Oncorhynchus* spp. are found in the Yukon River drainage. However, chum salmon *O. keta* are the most abundant and occur in genetically distinct summer and fall runs (Seeb et al. 1995; Wilmot et al. 1992). Fall chum salmon are larger, spawn later, and are less abundant than summer chum salmon. Spawning occurs in upper portions of the drainage in spring-fed streams, which usually remain ice-free during the winter (Buklis and Barton 1984). Major fall chum salmon spawning areas occur within the Tanana, Chandalar, and Porcupine River systems, as well as portions of the upper Yukon River in Canada (Figure 1). The Sheenjek River (66°47.02′N, 144°27.82′W) is one of the most important producers of fall chum salmon in the Yukon River drainage. Located above the Arctic Circle, it heads in glacial ice fields of the Romanzof Mountains, a northern extension of the Brooks Range, and flows southward approximately 400 km to its terminus on the Porcupine River (Figure 2).

INRIVER FISHERIES

Fall chum salmon are harvested for commercial and subsistence uses. Commercial harvest is permitted along the entire Yukon River in Alaska and in the lower portion of the Tanana River. No commercial harvest is permitted in any other tributaries of the drainage including the Koyukuk and Porcupine River systems. Although commercial harvest occurs in the Canadian portion of the Yukon River near Dawson, most fish are taken commercially in the lower river, downstream of the village of Anvik. Subsistence use of fall chum salmon is greatest throughout the upper river drainage, upstream of the village of Koyukuk.

Although the Alaska commercial fishery for Yukon River fall chum salmon developed in the early 1960s, annual harvests remained relatively low through the mid-1970s. Estimated total inriver utilization (U.S. and Canada commercial and subsistence) of Yukon River fall chum salmon was below 300,000 fish per year before the mid-1970s (JTC 2009). Inriver commercial fisheries became more fully developed during the late 1970s and early 1980s. Harvest peaked in 1981 at 677,257 fish (JTC 2009). In the mid-1980s, management strategies were implemented to reduce commercial exploitation on fall chum stocks and to improve low escapements observed throughout the drainage during the early 1980s.

Yukon River fall chum salmon runs improved somewhat between 1994 and 1996. Poor salmon runs to Western Alaska between 1997 and 2003 resulted in partial or total closures to commercial and subsistence fishing in Alaska and Canadian portions of the drainage during those years. Limited commercial fishing for fall chum was allowed from 2003 through 2009. In 2010, limited commercial fishing of fall chum salmon was allowed in Canada, while no fall chum salmon commercial fishing was allowed in Alaska. Subsistence harvest of fall chum in 2003 was also limited while the subsistence harvest in 2004 was unrestricted except within the Canadian portion of the Porcupine River. There were no restrictions on subsistence harvest from 2005 through 2008. In 2009 and 2010, the subsistence harvest was limited in Alaska and Canada.

ESCAPEMENT ASSESSMENT

Between 1960 and 1980, some portions of Yukon River fall chum salmon runs were estimated from mark–recapture studies (Buklis and Barton 1984). Aside from these tagging studies, and aerial assessment of selected tributaries that have been conducted since the early 1970s, comprehensive escapement estimation studies were sporadic and limited to only 2 streams: the Delta River (Tanana River drainage) and the Fishing Branch River (Porcupine River drainage). In the early 1980s, comprehensive escapement assessment studies intensified on major spawning tributaries throughout the drainage.

The Sheenjek River is one of the most intensely monitored fall chum salmon spawning streams in Yukon River drainage. Escapement observations date back to 1960 when United States Fish and Wildlife Service (USFWS) reported chum salmon spawning in September. Between 1974 and 1981, escapement observations in the Sheenjek River were limited to aerial surveys flown in late September and early October (Barton 1984). Beginning in 1981, escapements were monitored using Bendix[1] fixed-location, single-beam, side-looking sonar systems (Dunbar 2004). However, an early segment of the fall chum salmon run was not measured prior to 1991 because the project typically started around August 25, after that portion of the run had passed. Beginning in 1991, the project startup was changed to start about 2 weeks earlier to include the early segment of the run. The sonar-estimated escapements for 1986 through 1990 have been expanded to include estimated early fish passage (Barton 1995). Termination of sonar counting was consistent between 1981 and 2010, averaging September 24, except in 2000 when the project was terminated early because of extremely low water (Barton 2002).

The Sheenjek River sonar project has undergone a number of changes in recent years. The project originally operated Bendix single-beam sonar equipment and, although the Bendix sonar functioned well, the manufacturer ceased production in the mid-1990s and no longer supports the system. In 2000, Alaska Department of Fish and Game (ADF&G) purchased a Hydroacoustic Technology, Incorporated (HTI) model 241 split-beam echosounder for use on the Sheenjek River. In 2000 and 2002, the new split-beam system was deployed alongside the existing single-beam sonar and produced comparable results (Dunbar 2004). In 2003 and 2004, the split-beam sonar system was used exclusively to enumerate chum salmon in the Sheenjek River.

Historically, because of unfavorable conditions for transducer placement on the left bank[2], only the right bank of the Sheenjek River has been used to estimate fish passage, except for 1985 through 1987 when single-beam sonar was tested on the left bank. Drift gillnet studies in the

[1] Reference to trade names does not imply endorsement by the Alaska Department of Fish and Game.
[2] Left and right bank refers to the bank on the left or right side of the river when looking downstream.

early 1980s suggested that distribution of migrant chum salmon was primarily concentrated on the right bank of the river at the current sonar site, with a small but unknown proportion passing on the left bank (Barton 1985). In 2002, ADF&G began experimenting with a new Dual frequency identification sonar (DIDSON), manufactured by Sound Metrics Corporation, for counting salmon in small rivers. This system appeared to be more accurate, easy to use, with the ability to operate across substrate profiles unacceptable for single-beam or split-beam systems (Maxwell and Gove 2004). The uneven substrate on left bank of the Sheenjek River was selected as an ideal candidate for experimenting with this system. In 2003, a DIDSON was deployed on the previously unmonitored left bank. Using DIDSON data it was estimated that approximately 33% of the fish were migrating up the left bank (Dunbar 2006). Given this surprisingly large number, it was proposed that DIDSON be deployed on both banks in the future. In 2004 and 2005, DIDSON and HTI split-beam sonar were deployed side-by-side on the right bank and found that DIDSON estimates were 20% higher than the split-beam estimates (Dunbar and Pfisterer 2009). Since 2005, only DIDSON has been the deployed to estimate chum salmon escapement on both banks of the Sheenjek River. The transition from split-beam to DIDSON has gone smoothly and this equipment should continue to provide accurate escapement estimates in future years.

Escapement estimates averaged 98,607 fall chum salmon from 1981 to 2009 and 178,391 fall chum salmon during the most recent 5-year period of 2005–2009 (Table 1). This increase in the average escapement over the last 5 years can be attributed to the extraordinarily large run (561,863 fall chum salmon) in 2005. From 1992 through 2000 the Sheenjek River biological escapement goal (BEG) was set at 64,000 fall chum salmon. This goal was based upon aerial survey and hydroacoustic data collected between 1974 and 1990 (Buklis 1993). In 2001, ADF&G completed a review of the escapement goals for Yukon River fall chum salmon stocks, including the Sheenjek River. Based on this review of long term escapement, catch, and age composition data, the BEG for the Sheenjek River was given a range of 50,000 to 104,000 fall chum salmon on the right bank (Figure 3; Eggers 2001).

It will take several more years of data collection to determine how best to treat the historical estimates that are based only on the right bank. In 2009, 39% of the fish migrated on the formerly unmonitored left bank, compared to 16% in 2008, 40% in 2007, and 39% in 2005 and 2006 (Dunbar 2010). Only the right bank estimate will be used to evaluate whether the current BEG is obtained, until a new BEG that includes data from both banks is determined.

STUDY AREA

This project site is located approximately 10 km upstream from the mouth of the Sheenjek River (Figure 2). While created by glaciers, the Sheenjek River has numerous clearwater tributaries. Water clarity in the lower river is somewhat unpredictable, but generally clearest during periods of low water. Historically, the water level begins to drop in late August or early September. Upwelling ground water composes a significant portion of the river flow volume, especially in winter. It is in these spring areas that fall chum salmon spawn, particularly within the lower 160 km.

OBJECTIVES

Objectives for the 2010 Sheenjek River sonar project were to:

1. Estimate daily and seasonal passage of chum salmon escapement using fixed, side looking DIDSON systems.
2. Collect a minimum of 30–35 vertebrae samples per week, up to 180 for the season, to estimate age and sex composition of the spawning chum salmon population, such that simultaneous 95% confidence intervals of age composition are no wider than 0.20 (α=0.05 and d=0.10).
3. Collect selected climate and hydrologic data daily at the project site.

METHODS

HYDROACOUSTIC EQUIPMENT

The 2010 season was marked by extreme flooding that caused the sonar to be installed later than normal on the right bank and not at all on the left bank. One DIDSON unit was deployed on August 18 on the right bank of the Sheenjek River at the historic sonar site (Figures 4 and 5). The DIDSON (long range) operated at 1.2 MHz, its high frequency option, with a viewing angle of 29° in the horizontal axis, 14° in the vertical axis, and a range of 20 m. The DIDSON was mounted on an H-shaped stand equipped with a manual crank-style rotator to facilitate aiming (Figure 6). A 152 m cable carried power and data between the DIDSON unit in the water and the topside breakout box housed with all surface electronics in a 10x12 wall tent. All electronics were powered with a portable 1000 W generator run continuously.

Sampling was accomplished with DIDSON software running on a laptop computer. After establishing the parameters that maximize sonar effectiveness, the system was left to operate 24 hours per day. Sonar data were collected in twenty-four 60-minute digital samples per day by the DIDSON data acquisition software. Files were transferred to, and stored on, an external hard drive enclosure, configured for RAID 1 data storage. Files were later examined and edited by the field crew to produce an estimate of fish passage. The crew, consisting of 2 technicians, monitored the sonar and interpreted the data during 6 to 7 hour shifts twice daily.

SITE SELECTION AND TRANSDUCER DEPLOYMENT

The gently-sloping river bottom and small cobble at the historic right bank counting location was adequate for ensonification. A bottom profile was obtained after initial transducer placement at the counting location by stretching a rope across the river and measuring water depth at one meter increments with a calibrated pole. The transducer and manual crank-style rotator were mounted on a stand made of aluminum pipe and deployed from the right bank. The stand was secured in place with sandbags and designed to permit raising and lowering of the transducer by sliding up or down along 2 riser pipes that extended above the water. Technicians adjusted the aim by viewing the video image and relaying aiming instructions to a technician at the transducer stand via handheld VHF radio. The transducer was deployed in water ranging from 0.5 to 1.0 m in depth, and aimed perpendicular to the current along the natural substrate. An attempt was made to ensure the transducer was deployed at a location where there was sufficient current, i.e., area without eddies or slack water where fish milling behavior can occur.

Technicians used an artificial acoustic target during deployment to ensure transducer aim was low enough to prevent salmon from passing undetected beneath the acoustic beam. The target, an airtight 300 ml weighted plastic bottle, with a volume less than that of a chum salmon, and easily discernible with the DIDSON, was allowed to drift downstream along the river bottom and through the acoustic beam. Drifts were made at multiple ranges in order to verify target detection at all ranges of interest. Beam aim adjustment and target drifts were repeated until a satisfactory result was achieved.

A fish lead was constructed shoreward from the transducer on the right bank to prevent upstream salmon passage inshore of the transducer. The fish lead was constructed of 5 cm by 5 cm by 1.2 m high galvanized chain-link fencing attached to 2.5 m metal "T" stakes. The lead was positioned to guide fish beyond the nearfield of the sonar transducer. Whenever a transducer was relocated because of rising or falling water level, the beam was re-aimed to ensure proper ensonification, and the lead was repositioned as appropriate.

SONAR COUNT ADJUSTMENTS

Data collected by the DIDSON were transferred to another computer for counting and editing using the echogram viewer program Echotastic (C. Pfisterer, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication). Upstream migrating fish were counted by marking each fish track on the echogram (Figure 7). Upstream direction of travel was verified using the video feature of the program. Counts were saved as text files and recorded on a count form. Brief interruptions in sampling intermittently occurred when routine maintenance (i.e. silt removal) or relocation of the transducer was required. Long term interruptions also occurred when flooding or hazardous conditions forced removal of equipment.

Whenever a portion of a sample was missing, passage was estimated by expansion based on the known portion of the sample. The number of minutes in a complete sample period (60) was divided by the number of minutes counted *m*, and then multiplied by the number of fish counted *x* in that period *i*. Passage y_i was estimated as:

$$\hat{y}_i = (60/m_i)x_i \tag{1}$$

If data from one or more complete sample periods were missing, passage for that portion of the day y_m was estimated by averaging passage from the sample periods immediately before (y_b) and after (y_a) the missing sample period(s), and then multiplying by the number of sample periods missed *n* :

$$\hat{y}_m = \left(\frac{y_b + y_a}{2}\right)n \tag{2}$$

If data from one or more complete days x_d were missing, passage for each missing day y_d was estimated using simple linear interpolation, based on the known passage y_b for the day immediately before the missing days and passage y_a for the day immediately after (x_a) the missing day(s).

$$\hat{y}_d = y_b + x_d\left(\frac{y_a - y_b}{x_a}\right) \tag{3}$$

As an example, if data from 9 days were missing, for the estimated passage on the third missing day (*d*=3), x_d=3, and x_a = 10.

The proportion of fish other than fall chum salmon in the daily counts was assumed insignificant based upon historic visual counting tower observations and test fishing records collected at the site. After editing was complete, an estimate of daily and cumulative fish passage was produced and forwarded to the Fairbanks ADF&G office via satellite telephone. The estimates produced during the field season were further scrutinized postseason and adjusted as necessary.

TEMPORAL AND SPATIAL DISTRIBUTIONS

Fish range distributions were examined postseason by importing text files containing all fish track information into *R* (R Development Core Team[3] 2009) where the fish counts were binned by range. Microsoft® Excel was used to plot the binned data and investigate the spatial distribution of fish passing the sonar site. Histograms of passage by hour were also created in Microsoft® Excel to investigate diel patterns of migration.

SAMPLE FISHING

Regionwide standards have been set for the sample size needed to describe the age composition of a salmon population. These standards apply to the period or stratum in which the sample is collected. These goals are based on a 1 in 10 chance (precision) of not having the true age proportion (p_i) within the interval $p_i \pm 0.05$ for all i ages (accuracy).

Vertebrae collections are the preferred method of aging Yukon River fall chum salmon when in close proximity to their natal streams (Clark 1986[4]). As described in Bromaghin (1993), a sample size of 150 chum salmon is needed, assuming 2 major age classes with minor ages pooled, and no unreadable vertebrae. Allowing for 20% unreadable vertebrae, the Sheenjek River sample size goal was set at 30 chum salmon per week up to a maximum of 180 for the season.

A beach seine was periodically fished at the sonar site to collect adult salmon for age and sex composition. The beach seine (3-inch stretch measure) is 30 m in length by 55 meshes deep (~3 m) and appropriate for collecting a representative sample. Chum salmon were collected with the beach seine, enumerated by sex using external characteristics, and measured to the nearest 5 mm, from mideye to tail fork. Additionally, 3 vertebrae are taken from each fish for age determination. Vertebrae samples were given to ADF&G research staff in Fairbanks for age determination.

CLIMATE AND HYDROLOGIC OBSERVATIONS

A water level gauge was installed at the sonar site and monitored daily, with readings made to the nearest centimeter. Surface water temperature was measured approximately 30 cm below the surface daily, with a HOBO U22™ water temperature data logger, and a pocket thermometer. The data logger was suspended from a float tied to the water level gauge and set to record 6 times a day. Minimum and maximum air temperatures, and wind velocity and direction were measured daily with a Weather Wizard III weather station. Other daily observations included occurrence of precipitation and percent cloud cover. Climate and hydrologic observations were recorded at approximately 1800 hours daily.

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[3] R Development Core Team. 2009. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, available for download: http://www.R-project.org

[4] Clark, R. A. Sources of variability in three ageing structures for Yukon River fall chum salmon (*Oncorhynchus keta Walbaum*) escapement samples. Alaska Department of Fish and Game, Division of Sport Fish, (1986 Region III unpublished report), Fairbanks.

RESULTS

River and Sonar Counting Conditions

In 2010, the right bank transducer was deployed in approximately the same location on the point bar that has been used in recent years. The river bottom at the counting location dropped abruptly from the left bank at a rate of 36 cm/m (bottom slope ≈ 19.6°) to the thalweg approximately 12 m from shore, and then sloped gently up toward the right-bank point bar at a rate of approximately 8 cm/m (bottom slope ≈ 4.8°; (Figure 8). River width measured 63 m. Much of the nearshore zone along the left cutbank was scoured clean of fallen trees and other woody vegetation from the flooding that occurred early in the season, while the right bank consisted of small cobble with no debris. In past years, the left cutbank was cluttered with fallen trees and other woody vegetation.

The water level was moderately high upon arrival at the project site on August 6. Over the next two days, while setting up camp, the water level steadily increased (based on visual observation, gauge not installed). On the morning of August 9 the water level was at flood stage, prompting the relocation of the camp to high ground, where the crew remained for the next 8 days. On August 17 the camp was again set up on the gravel bar, and the sonar equipment and stream gauge were installed the next day. With respect to the initial reading of the water gauge upon deployment on August 18, the water level gained 1 cm the first day. On the evening of August 19 the water level abruptly began to rise again. On August 20 the sonar equipment and most of the camp was again removed from the gravel bar. Over the next few days the water level climbed to 49 cm above the initial reading. (Figure 9, Appendix A1). From August 22 to August 25 the water level decreased to 21 cm before increasing once more to 51 cm above the initial reading on August 27. From that point on the water level gradually dropped until, by September 24, it was 114 cm below the initial reading. Sonar equipment was reinstalled on August 30. Water temperature at the project site ranged from 2.0°C to 12.3°C, and averaged 8.7°C.

Fluctuations in water level affected placement of the transducer with respect to shore. As the water level dropped the transducer was moved out away from shore and when the water level increased the transducer was moved in toward shore. While no attempt was made to estimate fish passage beyond the counting range, occasional expansions or interpolations of sonar counts were made to estimate fish passage for periods when data were missing because of flood conditions (prompting transducer removal), system failures, and routine maintenance or moving the transducer.

Abundance Estimation and Adjustments

The 2010 sonar-estimated escapement for the right bank was 22,062 fall chum salmon for the 38-day period from August 18 through September 24 (Table 2). A total of 269.2 hours of sampling time on the right bank were missed because of routine maintenance, system diagnostic tests, system malfunction, moving and aiming the transducer, or flooding (Table 3). Most of the missed time was from August 20 through August 29 when the project site was flooded. Extreme erosion prevented operation of the sonar on the left bank the entire season.

Temporal and Spatial Distribution

Chum salmon were present in the river when right bank sonar counting was initiated on August 18, as evidenced by the 141 fish estimated passing that day. The largest passage estimate of

1,548 fish occurred on September 17 (Table 2 and Figure 10). An estimated 580 chum salmon passed the project site on September 24, the final day of sonar operation.

The diel pattern of migration of Sheenjek River chum salmon typically observed in most years (Dunbar 2004) was observed again in 2010 (Figure 11). Overall, upstream migration was heaviest in periods of darkness or suppressed light, with fish moving in greater numbers close to shore. On average, the period of greatest upstream migration occurred between 1900 hours and 0800 hours. The period of minimal passage was 1200 hours, while the highest average passage occurred at 0100 hours.

Most migrating chum salmon were shore-oriented, passing through the nearshore portion of the acoustic beam. Approximately 74% of the fish counted were passing through the first 10 m of the counting range (Figure 8). The first few meters had fewer fish due to the placement of the fish lead in relation to the transducer.

AGE AND SEX COMPOSITION

Sampling activities were curtailed most of the season because of flooding. There were 25 seine hauls made at the sonar site, river kilometer (rkm) 10, from September 15 through September 23. A total of 64 chum salmon, 34 (53%) females and 30 (47%) males were collected for sampling (Table 4). Four of the samples came from carcasses collected between rkm 10 and rkm 20. Age, sex, and length compositions estimated from samples collected, can be found in Schumann and DuBois (2011).

DISCUSSION

ESCAPEMENT ESTIMATE

This was the sixth season that DIDSON was used to estimate fall chum salmon passage in the Sheenjek River. Although flooding prevented deployment of the left bank sonar, and much time was missed on the right bank, when deployed, the DIDSON performed well with no major technical difficulties or failures. Procedures used for counting DIDSON files worked well for estimating salmon passage at the site. All data files were processed in a reasonable amount of time. Factors affecting termination of sonar counting in 2010 included logistics associated with closing down camp, and impending winter weather.

The 2010 sonar estimated escapement was 22,062 chum salmon, for the 38-day period August 18 through September 24. The right bank estimate of was 56% below the low end of the BEG of 50,000 to 104,000 chum salmon. Since 1992 the right bank estimate has been used to assess the BEG because it was the only bank monitored. Until more data is collected, the right bank estimate will continue to be used for assessing the BEG. The fact that the DIDSON estimates may be 20% higher than split-beam estimates must also be taken into consideration when evaluating whether or not the BEG has been met. Because of prior experience with large runs producing poorly, this low escapement was not unexpected. The high parent year escapements of 561,863 in 2005 (returning age 0.4 fish) and 160,178 in 2006 (returning age 0.3 fish) had poor returns in 2009 and again this season.

Drift gillnet studies conducted in the 1980s concluded that only a small proportion of the salmon pass on the left bank. In 2003, preliminary work with the DIDSON on both banks at the sonar site indicated as many as 33% of the fish migrated on the left bank. In 2009, 39% of the fish migrated on the formerly unmonitored left bank, compared to 39% in 2005 and 2006, 40% in

2007, and 16% in 2008. Continued estimation of salmon passage on both banks should yield more accurate information on the total escapement to the Sheenjek River. Although it was not possible to operate on the left bank in 2010, we plan to install sonar on that bank in 2011.

The 2010 season was characterized by a low even-year fall chum salmon run to the Yukon River. Commercial fishing opportunity was restricted to directed coho salmon fishing that included a small incidental catch of fall chum salmon. Subsistence and personal use opportunities were slightly restricted. With these restrictions most drainages met escapement goals. The Canadian mainstem Yukon River met the spawning escapement goal, whereas the Fishing Branch River fell short of its goal. The Chandalar and Tanana river goals were also met. The Sheenjek River produced one of the weakest returns in the Yukon River drainage.

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TABLES AND FIGURES

Table 1.–Operational dates, and escapement estimates of fall chum salmon in the Sheenjek River, 1981–2010.

Year	Starting Date	Ending Date	Project Duration	Sonar Estimate	Expanded Estimate
1981	8/31	9/24	25	74,560	
1982	8/31	9/22	23	31,421	
1983	8/29	9/24	27	49,392	
1984	8/30	9/25	27	27,130	
1985 [a]	9/2	9/29	28	152,768	
1986 [a]	8/17	9/24	39	83,197 [b]	84,207
1987 [a]	8/25	9/24	31	140,086	153,267
1988	8/21	9/27	38	40,866	45,206
1989	8/24	9/25	33	79,116	99,116
1990	8/22	9/28	38	62,200	77,750
1991	8/9	9/24	47	86,496	
1992	8/9	9/20	43	78,808	
1993	8/8	9/28	52	42,922	
1994	8/7	9/28	53	150,565	
1995	8/10	9/25	47	241,855	
1996	7/30	9/24	57	246,889	
1997	8/9	9/23	46	80,423	
1998	8/17	9/30	45	33,058	
1999	8/10	9/23	45	14,229	
2000	8/8	9/12	36	18,652 [c]	30,084
2001	8/11	9/23	44	53,932	
2002	8/9	9/24	47	31,642	
2003	8/9	9/26	49	38,321 [d]	44,047
2004	8/8	9/25	49	37,878	
2005 [a]	8/10	9/24	46	438,253 [d]	561,863
2006 [a]	8/9	9/24	47	160,178	
2007 [a]	8/11	9/24	45	65,435	
2008 [a]	8/9	9/24	47	42,842 [d]	50,353
2009 [a]	8/15	9/24	41	46,926 [e]	54,126
2010	8/18	9/24	38	22,062	
1981-09	8/15	9/24	41	91,381	98,607
2005-09	8/10	9/24	45	150,727	178,391

[a] Sonar estimate is based on counts from both right and left bank sonar operations, all other years are right bank estimates only.

[b] Sonar–estimated escapement in these years was subsequently expanded to include fish passing prior to sonar operations (Barton 1995). Expansions for 1986–1988 and 1990 were based upon run timing data collected in the nearby Chandalar River. The 1989 estimate was expanded based upon aerial survey observations made in the Sheenjek River prior to sonar operations in that year.

[c] Sonar-estimated escapement was expanded to include fish passing after sonar operations terminated (Barton 2002). Expansions for 2000 were based upon average run time data from the Sheenjek River 1986–1999.

[d] Sonar-estimated escapement was expanded to include fish passing after sonar operations terminated. Expansions for 2003, 2005 and 2008 were based upon run time data from the Rampart Rapids tag recovery fish wheel (Dunbar 2006; Dunbar and Pfisterer 2009; Dunbar 2009).

[e] Sonar-estimated escapement was expanded to include fish passing after sonar operations terminated. Expansion was based upon run time data from the Rampart Rapids tag recovery fish wheel (Bonnie Borba, Commercial Fisheries Biologist, ADF&G, Fairbanks, personal communication).

Table 2.–Sonar-estimated passage of fall chum salmon in the Sheenjek River, 2010.

	Daily			Cumulative			% of Total
Date	Right Bank	Left Bank	Total	Right Bank	Left Bank	Total	Passage
8/18 [a, b]	141	ND	141	141	ND	141	0.01
8/19	175	ND	175	316	ND	316	0.01
8/20 [b, c]	246	ND	246	562	ND	562	0.03
8/21 [c, d]	256	ND	256	818	ND	818	0.04
8/22 [c, d]	266	ND	266	1,084	ND	1,084	0.05
8/23 [c, d]	277	ND	277	1,361	ND	1,361	0.06
8/24 [c, d]	287	ND	287	1,648	ND	1,648	0.07
8/25 [c, d]	297	ND	297	1,945	ND	1,945	0.09
8/26 [c, d]	307	ND	307	2,252	ND	2,252	0.10
8/27 [c, d]	317	ND	317	2,569	ND	2,569	0.12
8/28 [c, d]	328	ND	328	2,897	ND	2,897	0.13
8/29 [c, d]	338	ND	338	3,235	ND	3,235	0.15
8/30 [e]	348	ND	348	3,583	ND	3,583	0.16
8/31	307	ND	307	3,890	ND	3,890	0.18
9/1	328	ND	328	4,218	ND	4,218	0.19
9/2	349	ND	349	4,567	ND	4,567	0.21
9/3	291	ND	291	4,858	ND	4,858	0.22
9/4	279	ND	279	5,137	ND	5,137	0.23
9/5	288	ND	288	5,425	ND	5,425	0.25 [f]
9/6	255	ND	255	5,680	ND	5,680	0.26
9/7	340	ND	340	6,020	ND	6,020	0.27
9/8	340	ND	340	6,360	ND	6,360	0.29
9/9	464	ND	464	6,824	ND	6,824	0.31
9/10	537	ND	537	7,361	ND	7,361	0.33
9/11	788	ND	788	8,149	ND	8,149	0.37
9/12	928	ND	928	9,077	ND	9,077	0.41
9/13	1,069	ND	1,069	10,146	ND	10,146	0.46
9/14	1,160	ND	1,160	11,306	ND	11,306	0.51 [g]
9/15	1,120	ND	1,120	12,426	ND	12,426	0.56
9/16	1,064	ND	1,064	13,490	ND	13,490	0.61
9/17	1,548	ND	1,548	15,038	ND	15,038	0.68
9/18	1,310	ND	1,310	16,348	ND	16,348	0.74
9/19	1,391	ND	1,391	17,739	ND	17,739	0.80
9/20	1,231	ND	1,231	18,970	ND	18,970	0.86
9/21	1,107	ND	1,107	20,077	ND	20,077	0.91
9/22	801	ND	801	20,878	ND	20,878	0.95
9/23	604	ND	604	21,482	ND	21,482	0.97
9/24 [h]	580	ND	580	22,062	ND	22,062	1.00

Note: Sonar did not operate on the left bank in 2010. ND = no data.

[a] Right bank DIDSON operational starting at 1600.

[b] Counts extrapolated to 24 hours based on partial counts.

[c] Sonar operations suspended due to high water.

[d] Counts interpolated.

[e] Sonar operations resume.

[f] Single boxed area identifies central half of the observed run.

[g] Bold box identifies the observed midpoint.

[h] Last day of sonar operation.

Table 3.–Number of minutes by bank that were either expanded or interpolated to calculate the hourly passage estimate, 2010.

Date	Right Bank	Left Bank
8/18	960	ND
8/19	2	ND
8/20	960	ND
8/21	1,440	ND
8/22	1,440	ND
8/23	1,440	ND
8/24	1,440	ND
8/25	1,440	ND
8/26	1,440	ND
8/27	1,440	ND
8/28	1,440	ND
8/29	1,440	ND
8/30	7	ND
8/31	0	ND
9/1	4	ND
9/2	302	ND
9/3	534	ND
9/4	0	ND
9/5	2	ND
9/6	2	ND
9/7	23	ND
9/8	1	ND
9/9	90	ND
9/10	1	ND
9/11	2	ND
9/12	2	ND
9/13	3	ND
9/14	177	ND
9/15	97	ND
9/16	11	ND
9/17	2	ND
9/18	2	ND
9/19	0	ND
9/20	2	ND
9/21	2	ND
9/22	1	ND
9/23	2	ND
9/24	2	ND
Total	16,153 (269.2 h)	ND

Note: Sonar did not operate on the left bank in 2010. ND = no data.

Table 4.–Sheenjek River sample fishing (beach seine) results, 2010.

Date	Location (rkm)[a]	Number of Sets	Chum Salmon Captured: Female		Male		Total	Arctic Grayling	Northern Pike	Whitefish spp.
9/15	10	4	7		3		10	2	1	0
9/17	10-22	4	3		8		11	2	1	0
9/19	10	4	2		1		3	1	1	1
9/20	10	5	5		3		8	0	1	0
9/22	10	4	11		7		18	2	1	0
9/23	10	4	6		8		14	8	3	0
Total		25	34	(53%)	30	(47%)	64	15	8	1

[a] Locations are river kilometer(rkm). The sonar site is at rkm 10.

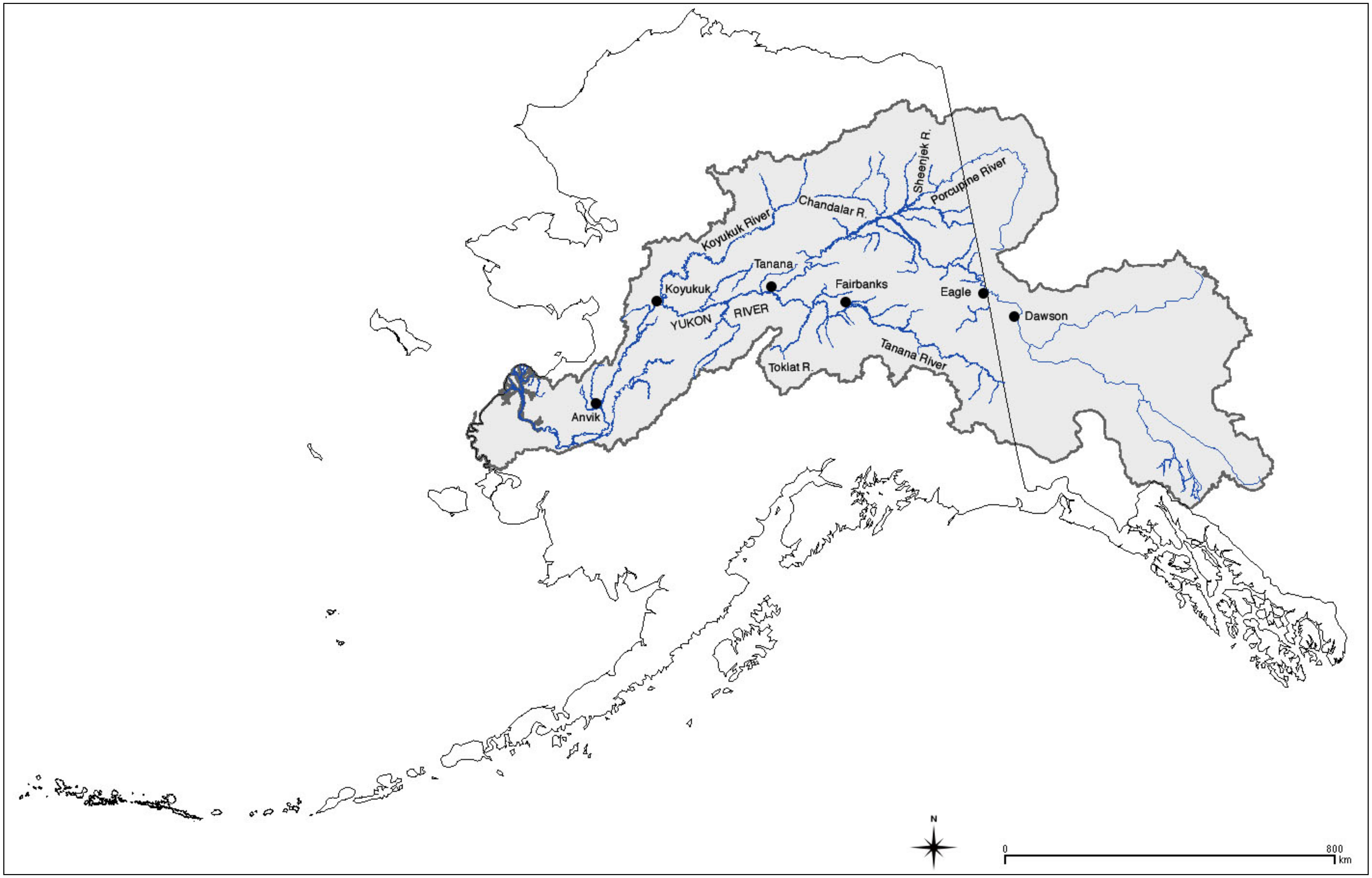


Figure 1.–The Yukon River drainage showing selected locations.

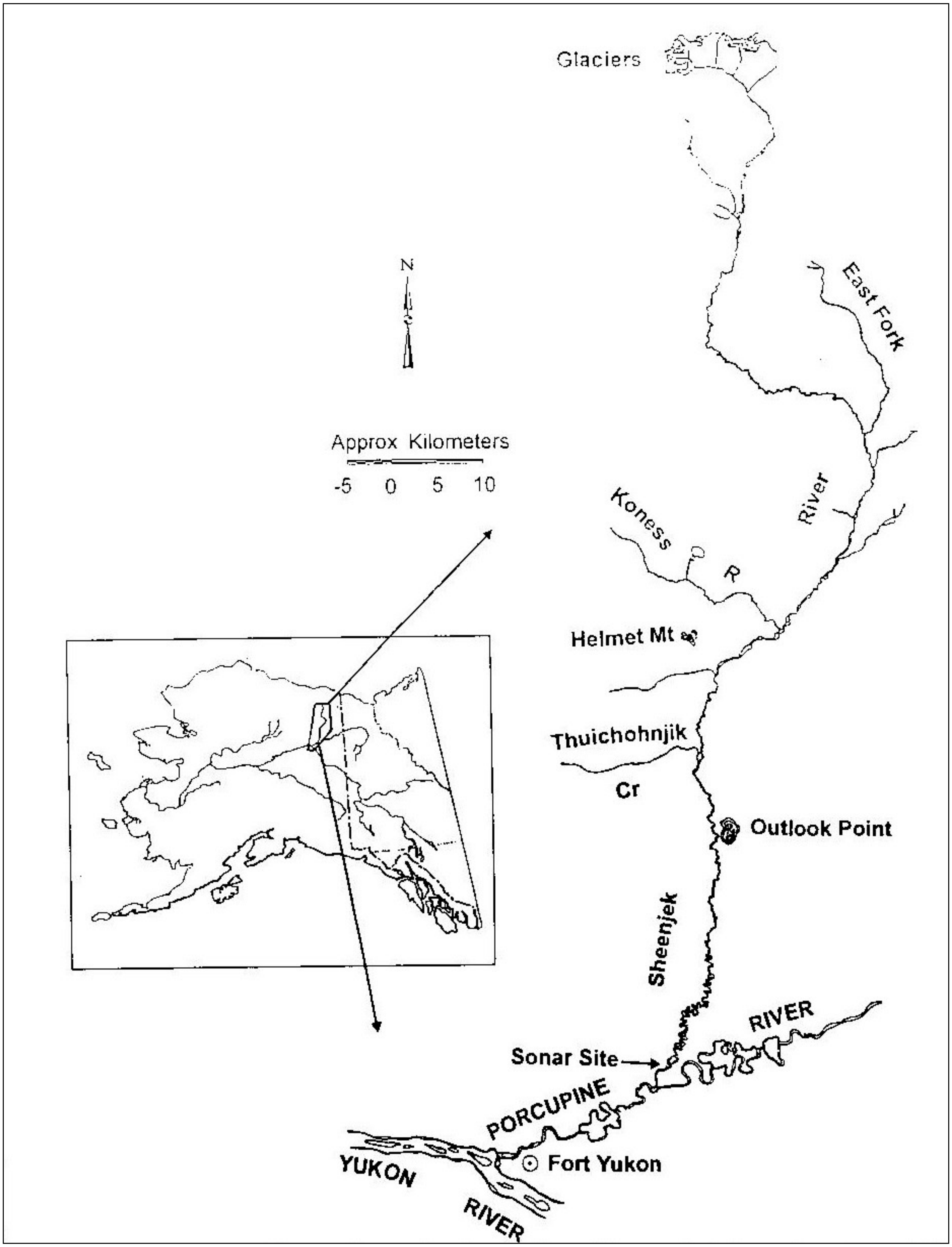
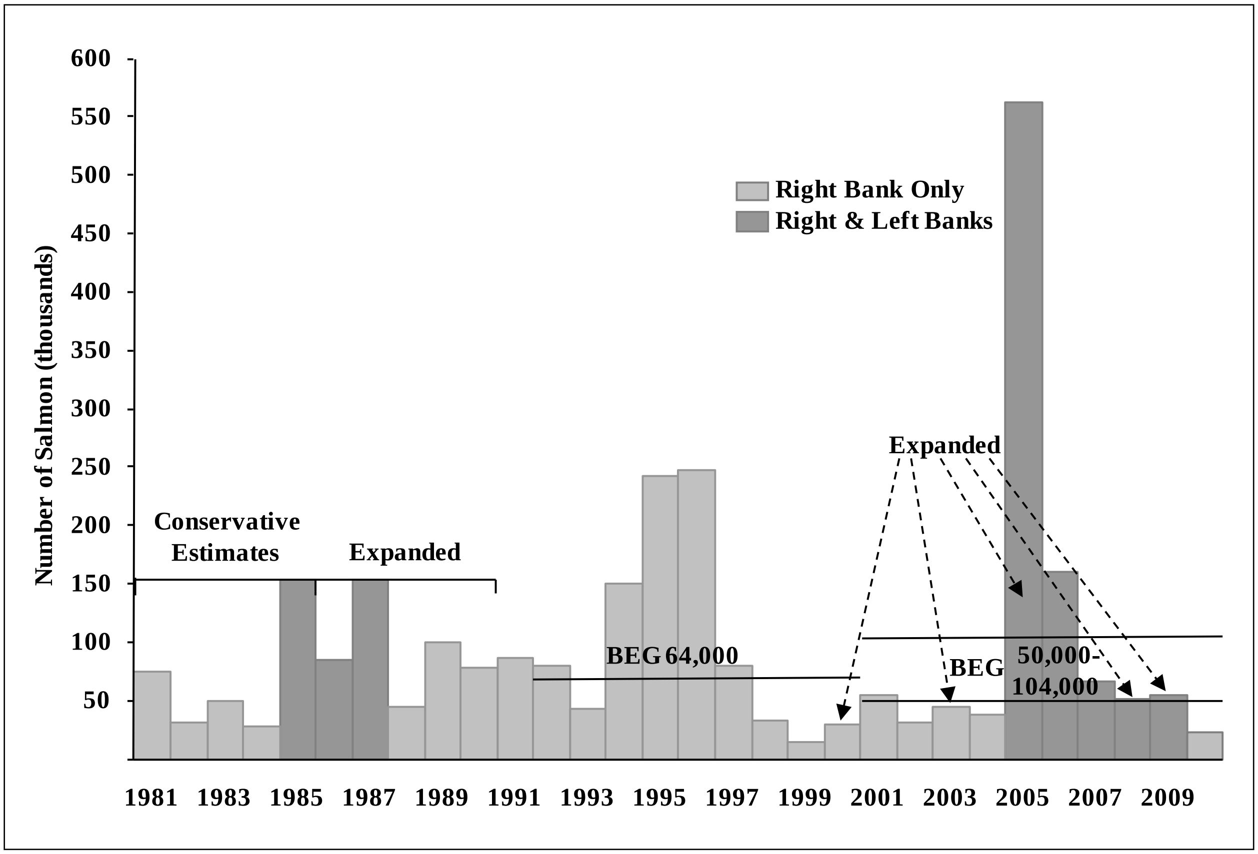


Figure 2.–The Sheenjek River drainage.



Note: Although the total escapement estimates for 2007 through 2009 were greater than the low end of the current biological escapement goal (BEG), the BEG was not achieved because it was based on right bank estimates only.

Figure 3.–Sonar-estimated escapement and BEG (horizontal lines) of fall chum salmon in the Sheenjek River, 1981–2010.

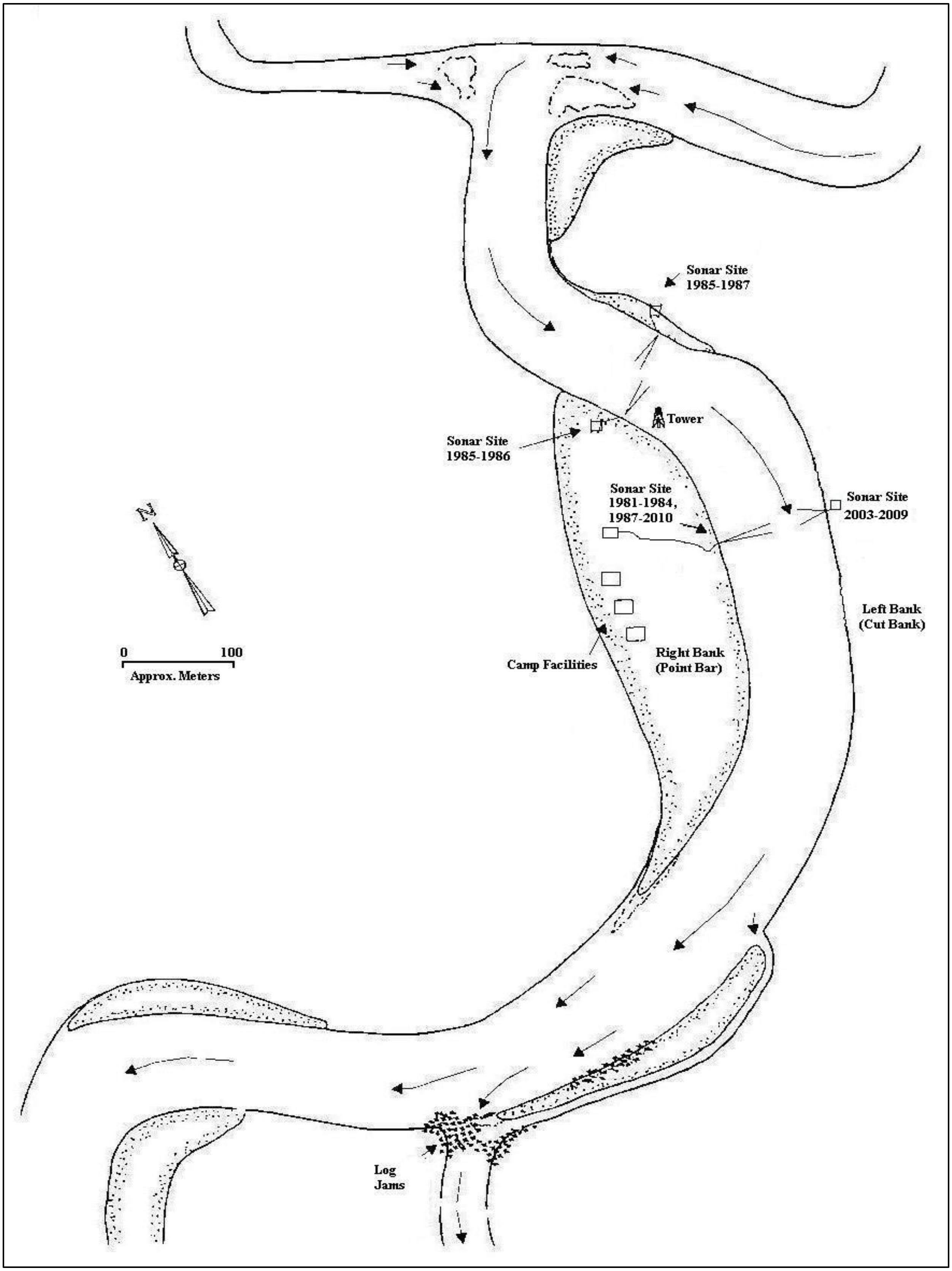


Figure 4.–The Sheenjek River sonar project site.

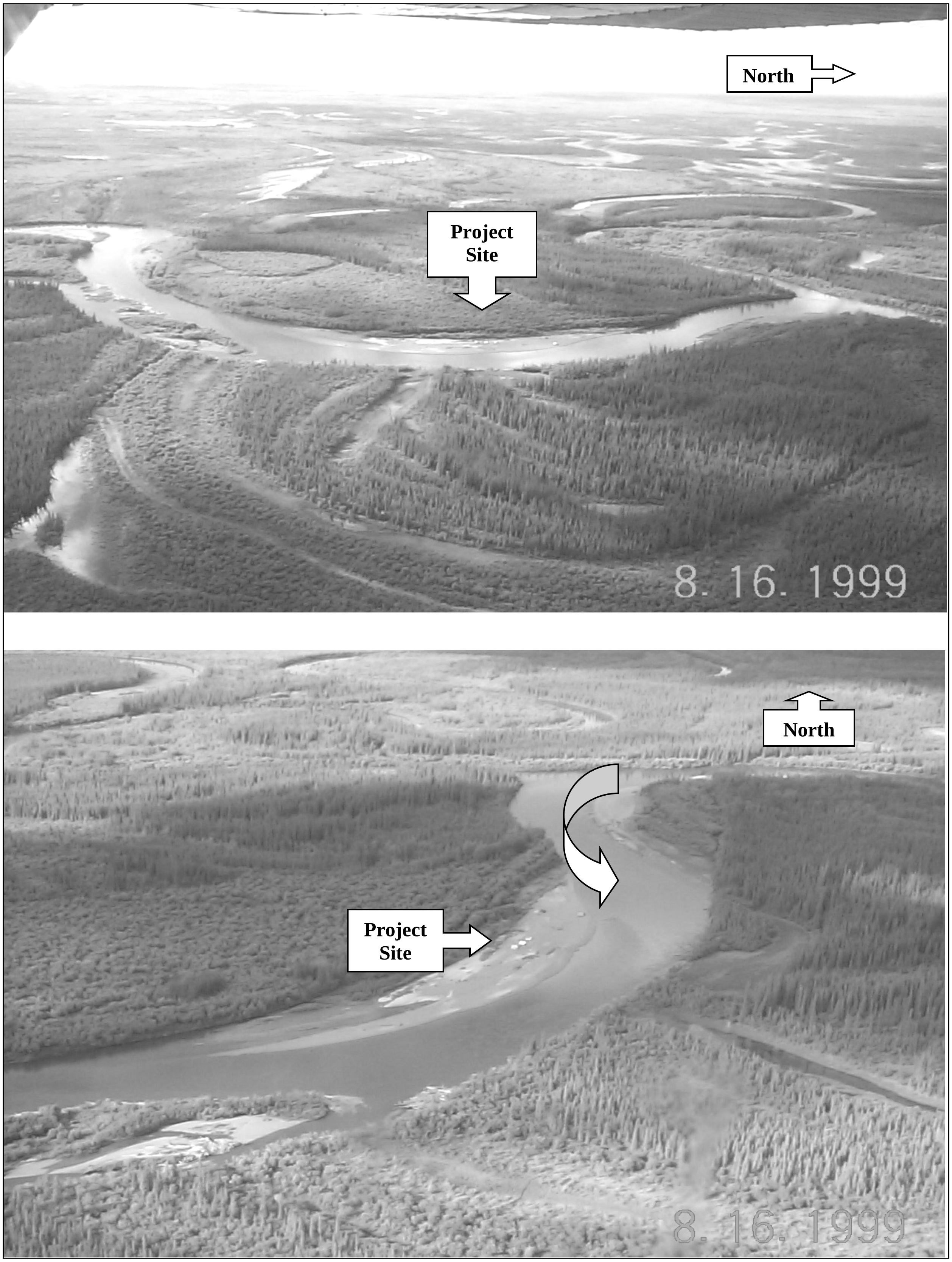


Figure 5.–Aerial photographs of the Sheenjek River sonar project site taken August 16, 1999.

Figure 6.–DIDSON attached to H-style mount with manual rotator prior to deployment.

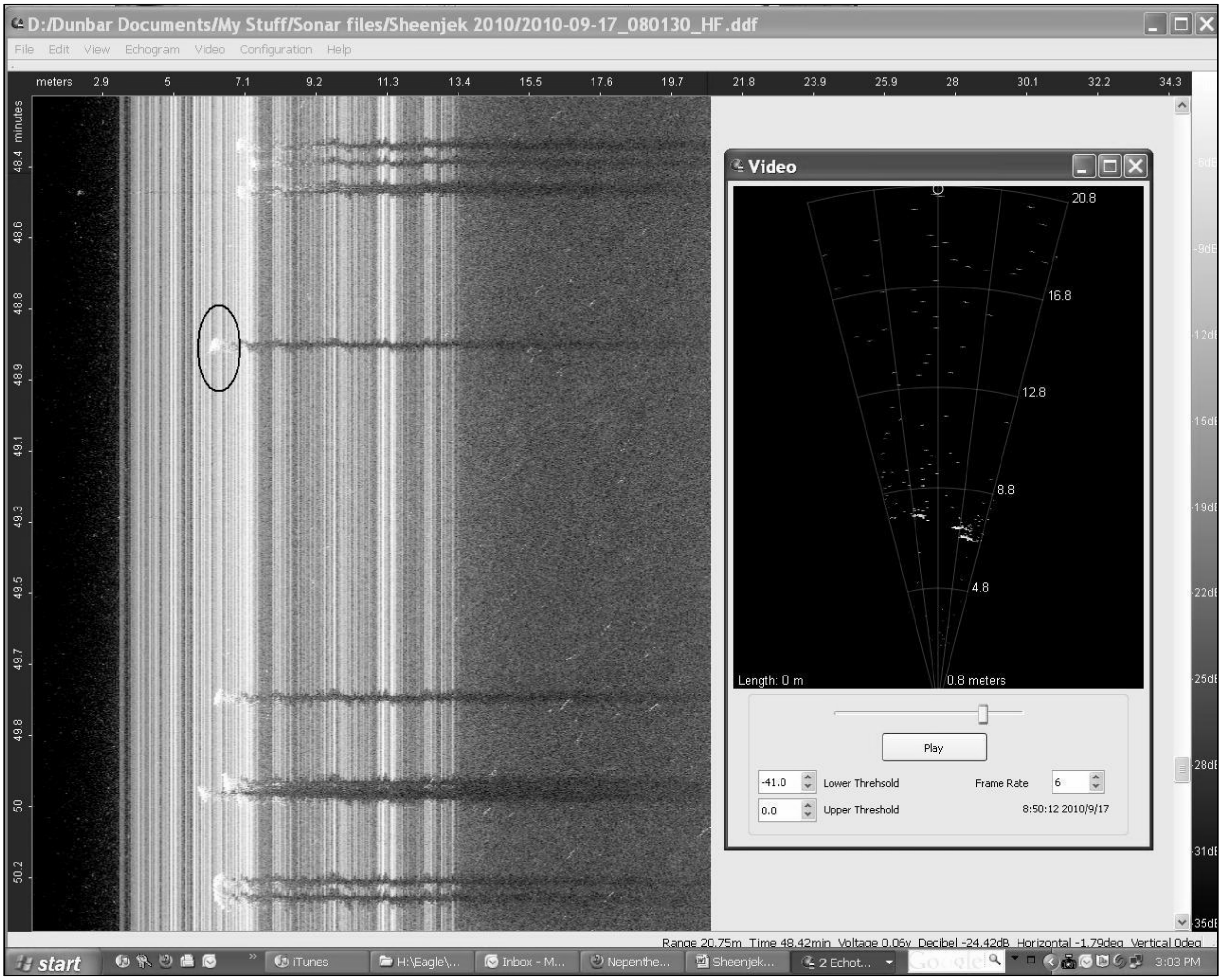
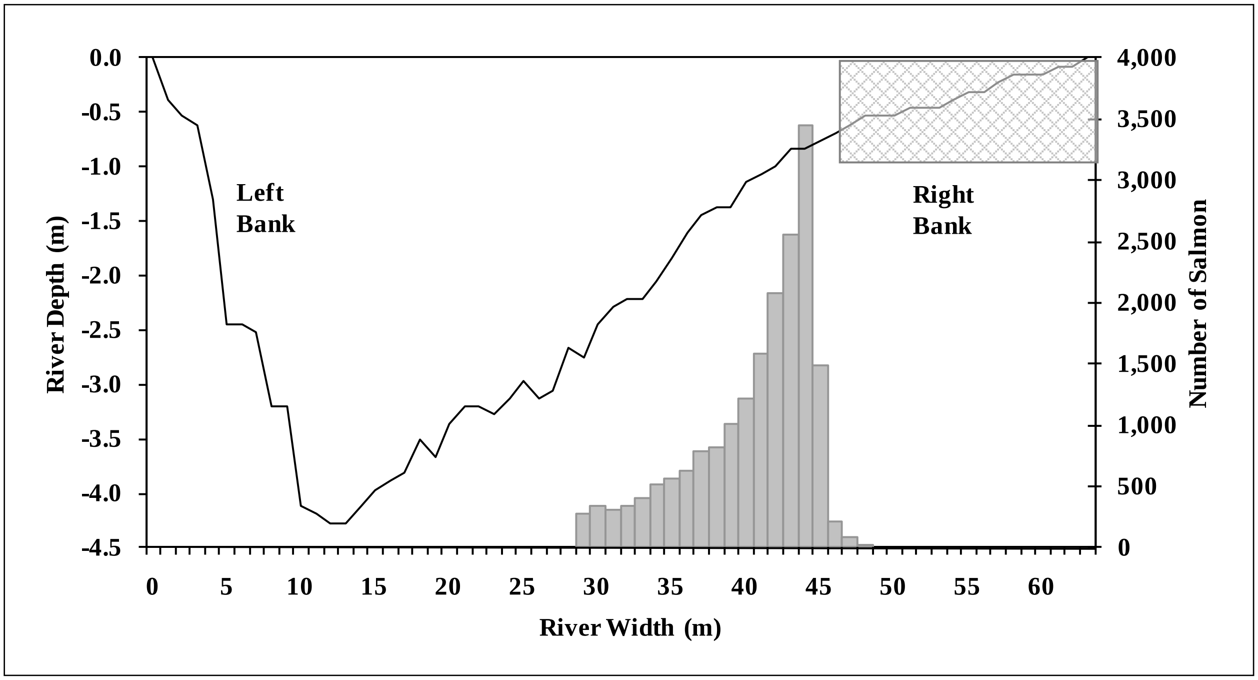


Figure 7.–Screenshot of echogram with oval around representative fish, and video image.



Note: Cross hatch represents portion of river blocked by fish lead and vertical bars represent horizontal distribution of upstream fall chum salmon passage through ensonified zone of the Sheenjek River, 2010.

Figure 8.–Depth profile (downstream view) at the project site.

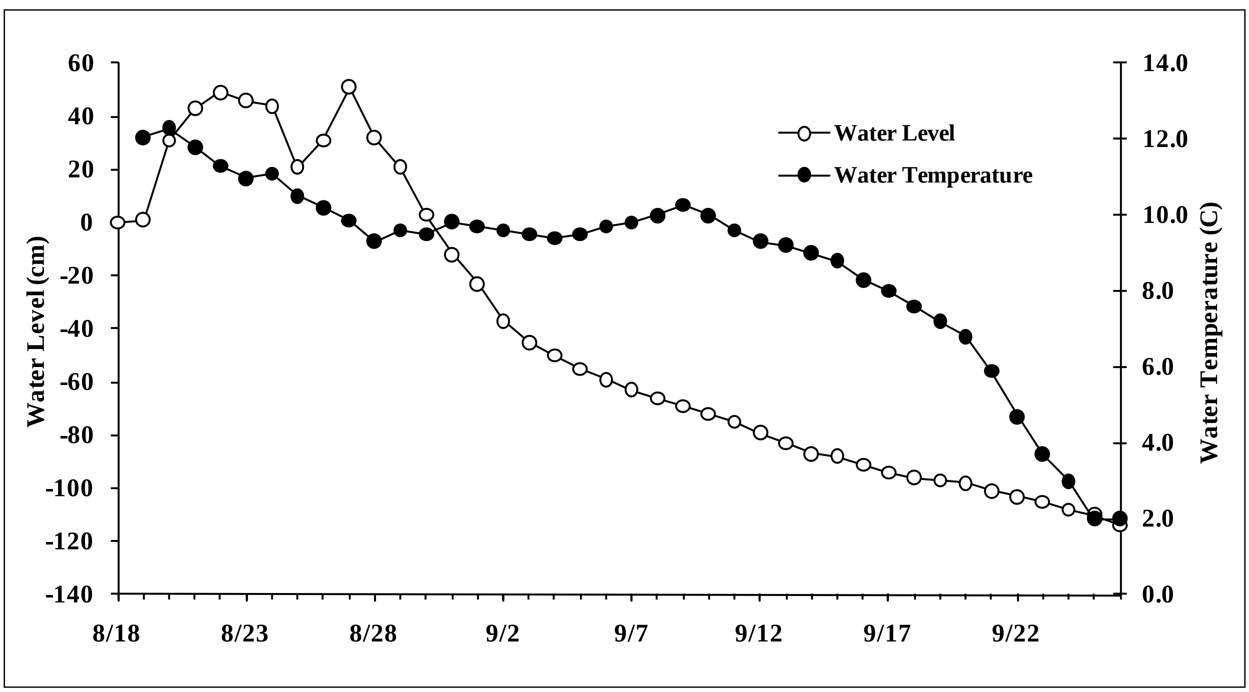
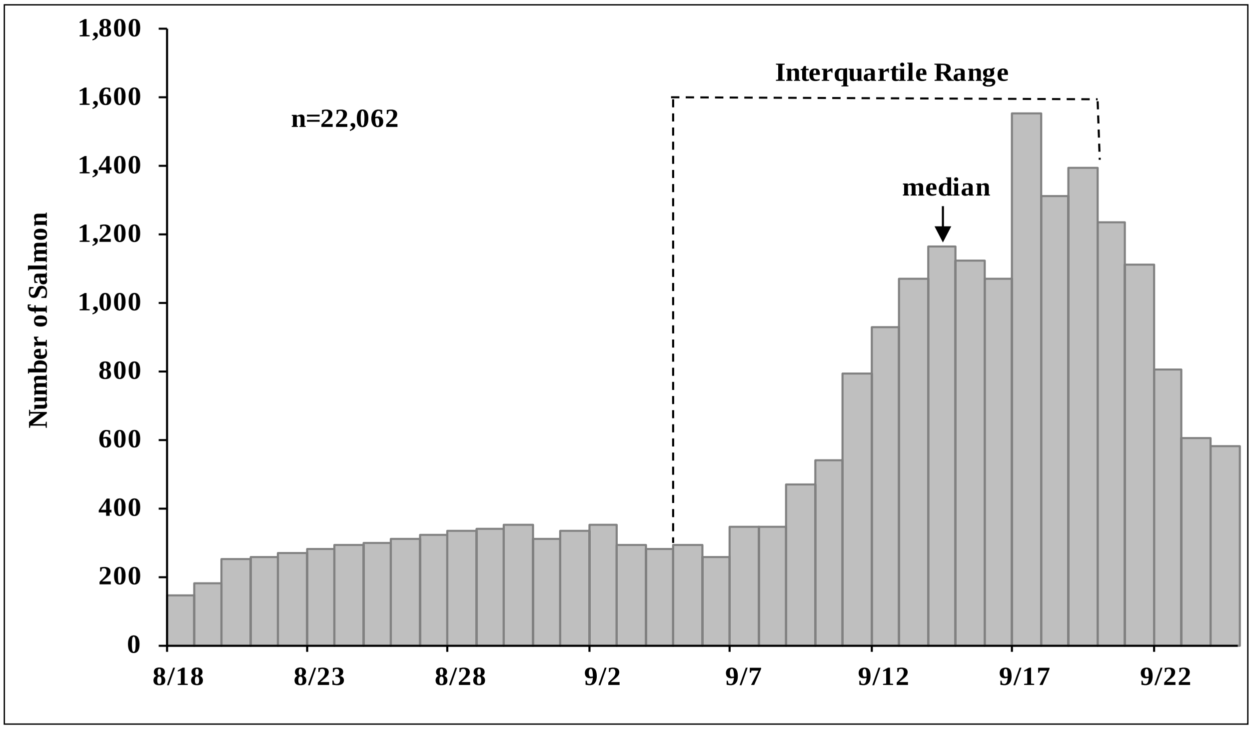


Figure 9.–Changes in daily water level relative to August 18, and water temperature measured at the Sheenjek River sonar project site, 2010.



Note: August 20 counts are extrapolated to 24 hours based on partial counts, while counts from August 21 through August 29 are interpolated.

Figure 10.–Fall chum salmon sonar counts by day at Sheenjek River sonar site, August 18 through September 24, 2010.

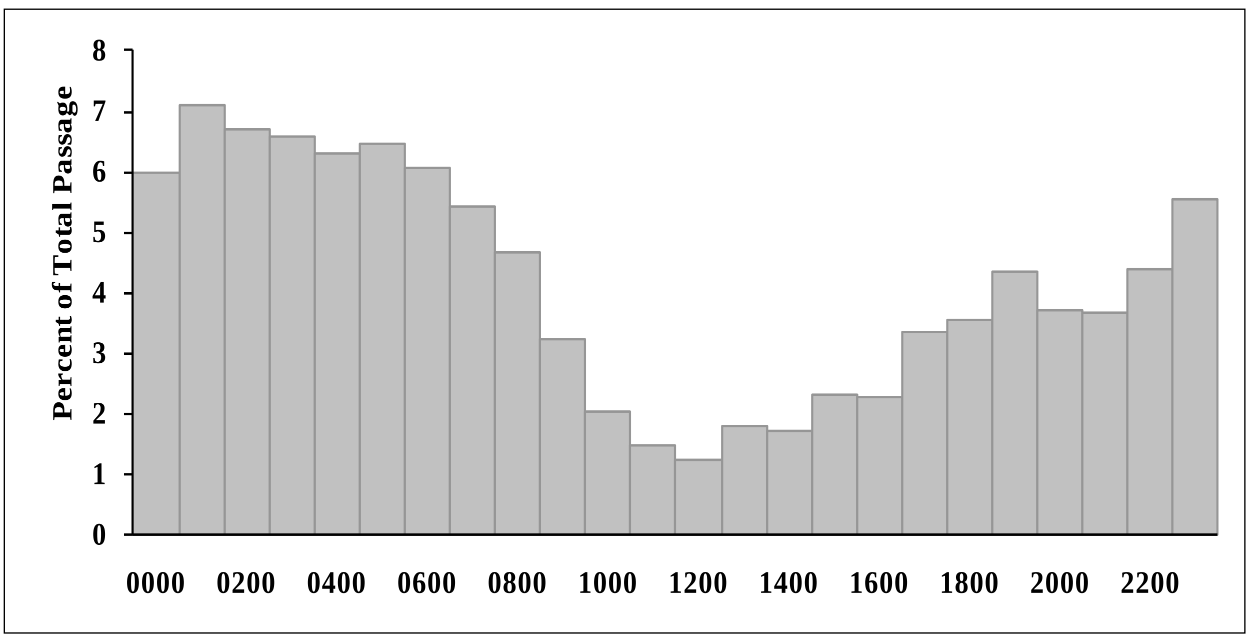


Figure 11.–Diel migration pattern of fall chum salmon on the right bank of the Sheenjek River, 2010.

APPENDIX A. CLIMATE AND HYDROLOGIC OBSERVATIONS

Appendix A1.–Climate and hydrologic observations at the Sheenjek River sonar project site, 2010.

			Wind		Temperature (C°)			Water Level (cm)		
						Air				
Date	Precipitation (code)[a]	Cloud Cover (code)[b]	Direction	Velocity (mph)	Water Surface[c]	Minimum	Maximum	± 24 h Change	Relative to Zero Datum	Water Color (code)[d]
8/12	ND	S	NE	1	ND	ND	22	ND	ND	D
8/13	ND	S	NE	3	ND	13	20	ND	ND	D
8/14	ND	S	NE	3	ND	9	22	ND	ND	D
8/15	ND	C	NE	10	ND	12	26	ND	ND	D
8/16	ND	C	NE	5	ND	15	26	ND	ND	D
8/17	ND	B	SW	2	ND	13	24	ND	ND	D
8/18	ND	B	SW	12	ND	10	21	zero datum	0	C
8/19	A	O	SW	1	12.0	9	16	1	1	C
8/20	A	C	ENE	7	12.3	10	18	30	31	D
8/21	A	B	E	7	11.8	5	18	12	43	D
8/22	A	B	NNE	0	11.3	8	18	6	49	D
8/23	A	B	SW	0	11.0	5	21	-3	46	D
8/24	B	B	N	3	11.1	9	17	-2	44	C
8/25	A	S	NW	3	10.5	5	17	-23	21	C
8/26	A	B	NE	4	10.2	6	17	10	31	C
8/27	A	S	SSW	0	9.9	1	19	20	51	C
8/28	A	S	S	0	9.3	1	22	-19	32	C
8/29	A	C	SSW	0	9.6	2	21	-11	21	C
8/30	A	S	NNE	5	9.5	2	20	-18	3	C
8/31	A	B	N	3	9.8	6	20	-15	-12	C
9/01	A	B	NNW	2	9.7	5	19	-11	-23	C
9/02	A	B	N	5	9.6	1	20	-14	-37	B
9/03	A	F	NW	0	9.5	1	19	-8	-45	B
9/04	A	O	E	0	9.4	2	19	-5	-50	B
9/05	B	O	SSW	1	9.5	9	16	-5	-55	B
9/06	A	S	SSW	0	9.7	10	19	-4	-59	B
9/07	A	O	S	1	9.8	7	19	-4	-63	B
9/08	A	B	ENE	1	10.0	10	18	-3	-66	B
9/09	A	B	NNE	17	10.3	6	21	-3	-69	B
9/10	A	C	N	4	10.0	8	22	-3	-72	B
9/11	A	C	SW	1	9.6	1	19	-3	-75	A

-continued-

Appendix A1.–Page 2 of 2.

					Temperature (C°)			Water Level (cm)		
		Cloud								Water
	Precipitation	Cover	Wind		Water	Air		± 24 h	Relative to	Color
Date	(code)[a]	(code)[b]	Direction	Velocity (mph)	Surface[c]	Minimum	Maximum	Change	Zero Datum	(code)[d]
9/12	A	C	SW	0	9.3	4	20	-4	-79	A
9/13	A	F	NW	0	9.2	4	24	-4	-83	A
9/14	A	C	NNE	0	9.0	3	19	-4	-87	A
9/15	A	C	N	0	8.8	-1	16	-1	-88	A
9/16	A	S	ENE	0	8.3	-1	17	-3	-91	A
9/17	B	C	NNE	3	8.0	4	13	-3	-94	A
9/18	A	C	NE	1	7.6	-2	13	-2	-96	A
9/19	A	C	N	0	7.2	-3	14	-1	-97	A
9/20	A	C	N	4	6.8	-1	14	-1	-98	A
9/21	A	C	NE	10	5.9	-2	12	-3	-101	A
9/22	A	C	NNE	4	4.7	-6	6	-2	-103	A
9/23	A	S	NNE	6	3.7	-6	6	-2	-105	A
9/24	A	C	N	3	3.0	-9	4	-3	-108	A
9/25	A	S	NNE	2	2	-11	4	-2	-110	A
9/26	F	D	N	3	2	-4	2	-4	-114	A
Average					8.7	4	4			

Note: ND = no data.

[a] Precipitation code for the preceding 24-hr period: A = none; B = intermittent rain; C = continuous rain; D = snow and rain mixed; E = light snowfall; F = continuous snowfall; G = thunderstorm w/ or w/o precipitation.

[b] Cloud cover code: C = ceiling and visibility unlimited (CAVU); S = scattered (<60%); B = broken (60–90%); O = overcast (100%); F = fog or thick haze or smoke.

[c] Water temperature collected 30 cm below surface with HOBO data logger from 8/19 through 9/24, and pocket thermometer on 9/25 and 9/26.

[d] Water color code: A = clear; B = slightly murky or glacial; C = moderately murky or glacial; D = heavily murky or glacial; E = brown, tannic acid stain.