Fishery Data Series No. 10-98

Using Hydroacoustic Methods to Enumerate Migrating Salmon in the Copper River, Miles Lake Sonar Project, 2007

by

Sonya El Mejjati,

Jenefer Bell,

Jeremy Botz,

April Faulkner,

and

Suzanne Maxwell

December 2010

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

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

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

FISHERY DATA REPORT NO. 10-98

USING HYDROACOUSTIC METHODS TO ENUMERATE MIGRATING SALMON IN THE COPPER RIVER, MILES LAKE SONAR PROJECT, 2007

by

Sonya El Mejjati, Jenefer Bell, and Jeremy Botz
Alaska Department of Fish and Game, Division of Commercial Fisheries, Cordova
and
April Faulkner and Suzanne Maxwell
Alaska Department of Fish and Game, Division of Commercial Fisheries, Soldotna

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

December 2010

ADF&G Fishery Data Series was established in 1987 for the publication of Division of Sport Fish technically oriented results for a single project or group of closely related projects, and in 2004 became a joint divisional series with the Division of Commercial Fisheries. Fishery Data Series reports are intended for fishery and other technical professionals and are available through the Alaska State Library and on the Internet: http://www.sf.adfg.state.ak.us/statewide/divreports/html/intersearch.cfm This publication has undergone editorial and peer review.

Sonya El Mejjati, Jenefer Bell, and Jeremy Botz
Alaska Department of Fish and Game, Division of Commercial Fisheries,
P.O. Box 669, Cordova, Alaska 99574
and
April Faulkner and Suzanne Maxwell
Alaska Department of Fish and Game, Division of Commercial Fisheries,
43961 Kalifornsky Beach Road, Suite B, Soldotna, Alaska 99669

This document should be cited as:
El Mejjati, S., J. Bell, J. Botz, A. Faulkner, and S. Maxwell. 2010. Using hydroacoustic methods to enumerate migrating salmon in the Copper River, Miles Lake sonar project 2007. Alaska Department of Fish and Game, Fishery Data Series No. 10-98, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

The Miles Lake sonar project is a long-term assessment project designed to obtain estimates of adult salmon *Oncorhynchus* spp. in the Copper River to assist biologists in managing commercial sockeye salmon *O. nerka* harvests. In 2007, a Bendix counter was used along the north bank. Along the south bank, salmon passage estimates were obtained from dual-frequency identification sonar (DIDSON). Using the 2 systems, the project estimated an escapement of 919,601 salmon in 2007, 10% more than the 10-year average and 17% above the upper end of the inriver goal. North bank sonar operations began May 19. The south bank sonar operated for the first 6 days (May 20-26) at an alternative site due to heavy snow and ice, rather than the traditional concrete pad. Run timing was later than average and one early fishing period was closed due to low sonar estimates. The majority of salmon (88%) were counted along the south bank. Range data, available only from the south bank DIDSON, showed that 94% of fish passed within 10 m of the transducer, indicating the 20-m ensonified range along this shore was adequate. Paired data between the Bendix counter and DIDSON were collected for the third season on the north bank. Preliminary results from a cross-river study using a mobile DIDSON are also included, but both studies will be reported elsewhere.

Key words: Copper River, sonar, Pacific salmon, Bendix counter, dual-frequency identification sonar, DIDSON, hydroacoustic, Miles Lake, *Oncorhynchus* spp., sockeye salmon, escapement

INTRODUCTION

The Miles Lake sonar project is a long-term assessment project designed to provide annual estimates of escapement for sockeye salmon *Oncorhynchus nerka* in the Copper River. Copper River sockeye salmon are harvested in Prince William Sound (PWS) by commercial and subsistence fishermen and inriver in subsistence, sport, and personal use fisheries. Annual escapement estimates from the sonar project are used to set escapement goals and forecast run strength. The daily escapement estimates are used inseason to determine harvest schedules that open and close fisheries (Lewis et al. 2008).

Copper River sockeye salmon are comprised of (a) delta stocks that spawn below the sonar site and are monitored primary by aerial surveys (Botz et al. 2008, Appendix A10), (b) upriver stocks that spawn north of the Chugach Mountains, and (c) hatchery salmon propagated in the Gulkana River. Both wild and hatchery sockeye salmon stocks migrate past the sonar site, the hatchery component producing 17.6% (1997–2006 average) of the upriver stocks (Botz et al. 2008; Appendix A2) since the early 1970s. In 1996, the Alaska Board of Fisheries (BOF) directed the Alaska Department of Fish & Game (ADF&G) to manage the Copper River District commercial salmon fishery to achieve a biological escapement goal (BEG - the escapement that provides the greatest potential for maximum sustained yield) of 300,000 sockeye salmon into the Copper River, with additional fish beyond the goal to allow for subsistence, personal use, and sport fish harvests, and hatchery brood and surplus for the Gulkana Hatchery (Copper River District Salmon Management Plan 5 AAC 24.360). Because stock-specific catch information needed to establish a BEG was not available, Bue et al. (2002) determined a sustained escapement goal (SEG - a level of escapement indicated by an index or escapement estimate known to provide for sustained yield over a 5-10 year period) was more appropriate which was set at 300,000–500,000 natural sockeye salmon. An annual inriver goal is established each year that incorporates the SEG, upriver harvest forecasts, and hatchery brood stock.

Monitoring of salmon escapement in the Copper River began in 1978 using a Bendix[1] counter (Gaudet 1983, 1990; Bendix Corp. 1980, 1984) installed on the south bank of the river at the

[1] Product names used in this report are included for scientific completeness but do not constitute a product endorsement.

outlet of Miles Lake. The following year, Bendix counters were installed on both banks. Hydroacoustic methods were selected for this project because they could provide daily escapement estimates and be placed reasonably close to the PWS commercial fisheries. Weirs and towers could only operate far upriver, while mark–recapture and similar studies could not provide daily estimates of abundance. Bendix counters are automated, echo-counting, single-beam sonars designed to count shore-based migrating salmon in rivers. The counters have been used to assess salmon runs in several Alaskan rivers including the Kenai, Kasilof, Yentna, Crescent, Nushagak, Sheenjek and Anvik Rivers (Westerman and Willette 2007; Brazil 2007; Dunbar 2003; Dunbar and Pfisterer 2004). Currently, these projects have either replaced, or are in the process of replacing, the aging Bendix counters with dual-frequency identification sonars (DIDSONs). Significant changes to the Miles Lake sonar project are documented in Appendix A1.

The DIDSON is multiple beam sonar that produces high resolution, video-like images (Belcher et al. 2002; sample fish images at http://www.soundmetrics.com). At close range, DIDSON fish images resemble the actual fish shape. Farther offshore, the images become more blob-like, but are still easily detected because of their upstream movement. Unlike the Bendix counter, the DIDSON's narrow multiple beams and wide view field allow the user to determine the fish's direction of travel and individuals from multiple fish traveling side-by-side or head-to-tail. The DIDSON was first verified for the purpose of counting migrating salmon in 2002 by comparing Bendix and DIDSON counts to visual counts from an observation tower in a clear river (Maxwell and Gove 2004, 2007), and later by comparing DIDSON and weir counts (Holmes et al. 2006). The comparison showed strong levels of agreement between each sonar method and the visual count. The DIDSON's effective range in the turbid Copper River was approximately 17m (Maxwell and Gove 2004, 2007). The standard-range DIDSON (SR DIDSON) evaluated in the comparison study was selected for use on the south bank of the Copper River, where the nearshore current is strong and fish migration is expected to be close to the shoreline. Along the north bank, where the main current flow is farther offshore, an instrument that ensonified a longer range was needed. Sound Metrics Corporation developed a lower frequency, long-range DIDSON (LR DIDSON) to fill this need.

A comparison study was conducted between the Bendix and DIDSON at the Miles Lake site. Along the south bank, the SR DIDSON was set next to the Bendix counter and paired data were collected during the 2003 and 2004 field seasons. Because counts from the 2 sonars were very similar, DIDSON became the primary escapement tool in 2005 and subsequent years. Along the north bank, a LR DIDSON was paired with the Bendix counter in 2005 through 2007.

Sonar systems are generally not capable of distinguishing one species of salmon from another. The Miles Lake sonar project does not have an on-site apportion program to separate the sonar counts into species. Most sonar projects in Alaska have on-site programs that use drift gillnetting, beach seining, or fish wheels to apportion the sonar estimates to species (Brazil 2007; Pfisterer 2002; Westerman and Willette 2007). These methods were attempted at the Miles Lake site, but few fish were captured (Brady 1986; Morstad et al. 1991). Although the target species of the Miles Lake project is sockeye salmon, other salmon species are present, but probably low in numbers. For example, the 10-year average of subsistence and personal use harvests from the upper Copper River is 95.1% sockeye salmon 3.5% Chinook *O. tshawytscha*, 1.4% coho *O. kisutch*, and less than 1% pink *O. gorbuscha* and chum *O. keta* salmon (Botz et al. 2008, Appendix F5). Sport fishing and aerial survey data also support the assertion that most salmon migrating up the Copper River are sockeye salmon (Botz et al. 2008). The primary apportionment need at the Miles Lake site is between sockeye and Chinook salmon, which overlap in run timing but end prior to any significant coho salmon passage (Botz et al. 2008). This apportionment need is met by subtracting Chinook salmon estimates obtained from upriver mark–recapture studies from the Miles Lake sonar estimates (Evenson and Wuttig 2000; Savereide and Evenson 2002; Savereide 2005; van den Broek et al. 2008). Prior to 1998, sockeye salmon were apportioned from subsistence and personal use harvest compositions (Steve Moffitt, Commercial Fisheries Biologist, Cordova; personal communication; Botz et al. 2008, Appendix F5).

During the 2007 field season, the Miles Lake sonar project produced daily estimates of salmon passage using a DIDSON along the south bank and Bendix counter along the north bank of the Copper River. In addition, paired DIDSON and Bendix data were collected along the north bank during 2007, the third year of paired data collection along this bank.

OBJECTIVES

The primary objectives of the Miles Lake sonar project report are:

1. Estimate adult salmon passage rates in the Copper River.
2. Determine the accuracy of the salmon passage estimates by analyzing river bottom profiles and on-site fish behavior.
3. Collect a third season of paired DIDSON and Bendix salmon estimates along the north bank and report preliminary results (final results to be included in a separate report).

METHODS

Study Area

The sonar project is located downriver of the Million Dollar Bridge at the outlet of Miles Lake, mile 48 of the Copper River Highway (Figures 1 and 2) and is the closest single-channel site to the Copper River commercial fishing district located 53 km downriver (Figure 3). The Copper River is approximately 360 m wide at the sonar site, is highly turbid, measuring beyond 1000 nephelometric turbidity units (Maxwell and Gove 2004), carries a sediment load averaging 69 million tons/year, and has a mean annual discharge of 1,625 m^3/s (Brabets 1997). The site is not tidally influenced, but water level can fluctuate 5 m or more during the summer due to upriver snowmelt, rainfall, and glacial melt (Faulkner and Maxwell 2008; Smith and Lewis 2006). The downriver Childs Glacier occasionally creates wave action and surges in water level displacing the transducer mounts at the site, and ice calves from the upriver Miles Glacier frequently flow past the site. When heavy ice floes pass nearshore, the sonars are pulled from the water to prevent damage to the transducers.

The Million Dollar Bridge underwent repairs from 2003 until the end of June in 2005 to raise a collapsed span on the north bank. A work pad was built in the river around the bridge abutment just upriver of the north bank sonar site. The work pad created a large back eddy extending downriver and significantly changing flow patterns, pushing the current 40 m offshore. There has been no evaluation of the affect of the work pad on salmon movement and sonar operations.

The ideal river bottom for sonar sampling is linear in the offshore direction with laminar flows and a fine substrate material. Along the south bank of the sonar site, the river bottom is nonlinear with large cobble and boulders. Currently, a concrete pad along the south bank is used for deploying the DIDSON. The pad, in use since 2001is 27.4 x 5 m with a 13% grade and has an embedded iron rail used to slide the weir along (Smith and Lewis 2006). This pad replaced an older concrete pad located 50 m upriver that was damaged by icebergs. Originally, the Bendix counters were installed with 18.3 m aluminum tubes as substrates (Roberson et al. 1982). Although the aluminum tube provided a smooth, linear surface for the transducer beam, it was difficult to manage in the strong current along the south bank and was replaced after the first field season with the first concrete pad (Roberson et al. 1982). Along the north bank, the offshore slope is more linear and the substrate is made up of sand and small cobble. The natural substrate is used for deployment. In past years, grading has been done during low water conditions in the fall to make the slope more linear. The original aluminum tube substrates were discontinued in 1986 (Morstad et al. 1991).

Sonar operations

South Bank

A SR DIDSON (SN 22) was deployed along the south bank. This DIDSON has 2 frequency options: 1.8 MHz with 96 - 0.3°x14° beams limited to a 12 m range, and 1.1 MHz with 48 - 0.4°x14° beams limited to a 40 m range, both with a 29° field of view. The DIDSON was mounted on an H-shaped mount and positioned horizontally for sampling (Figure 4) and vertically for river bottom profiling (Figure 5). An aluminum cylinder protected the DIDSON from ice floes. The DIDSON was tilted with an automated Hydroacoustic Technology, Inc. model 661H rotator with relative feedback and controlled with a laptop computer. We obtained absolute tilt information from an Applied Geomechanics, Inc. Model 802 attitude sensor aligned with the DIDSON beam and calibrated with a bubble level prior to deployment. Tilt and roll sensor data were displayed with the ZAGI33 program. The cabling from the transducer to the topside box consisted of a 15.2 m (50 ft) cable, a thinnet converter, and an additional 152.4 m (500 ft) cable. The equipment was powered with a 12V system that included solar panels, a generator, batteries, and inverters (Figure 6). The mount was deployed nearshore on the concrete substrate with the sonar beam directed perpendicular to the current flow. The transducer was kept at a relatively constant water depth by moving the mount as water level fluctuated. The nearshore end of the rail in the substrate was considered the zero mark, and numbers painted every 10 ft were used to track the transducer's position along the substrate. To prevent fish from passing undetected between shore and the DIDSON's start range, a weir (metal, chain-linked, A-frame connected to a floating net; Figure 7) was positioned 0.3–0.6 m downriver of the transducer and extended from shore to 1.8–2.4 m beyond the transducer.

The DIDSON software, v5.07.03, was used to collect and process data. The timer data entry function was set to automatically record 10 min/h files at the top of the hour using the parameters: low frequency, 40 dB receiver gain, 0.82 m start range, 20 m window length (range), the default focal length, and a sampling rate of 8 frames per second (fps), the highest frame rate possible without losing frames. For counting sockeye salmon, sample designs of 10-min/h have been tested and proven satisfactory (Becker 1962; Seibel 1967). Sound speed, calculated from the water temperature (Simmonds and MacLennan 2005), was inputted into the DIDSON initialization file, varying 1411-1418 m/s across the field season. Image files were processed using the background subtraction feature to remove static background structure, leaving only the objects in motion (Figure 8). Upriver and downriver fish were counted manually from the recorded files using separate tally counters. For an accurate count the frame rate was adjusted depending on fish passage rates: it was set at real time speed (8 fps) or slower at high fish passage (200+ fish/10 min), 2x recorded speed (16 fps) at medium passage (100–200 fish/10 min), and 3x recorded speed (24 fps) at low passage (0–100 fish/10 min). During playback, threshold was set low (2 dB) to avoid reducing fish detection and intensity was 47 dB to brighten fish targets without over brightening the volume reverberation.

After subtracting the downriver counts, counts were expanded from the 10-min files to produce hourly estimates. If files were unexpectedly shortened, the actual minutes were used in the expansion. Counts were interpolated if 1 hour was missed by averaging the counts from 2 hours before and 2 hours following the missed sample. If 2 hours were missed, 3 hours before and after were averaged; for 3 missed hours, 4 hours before and after were averaged, and so on. The hourly counts were summed to obtain a daily salmon passage estimate. A variance was calculated based on the 10-min sample design using the V5 variance estimator described by Reynolds et al. (2007). Missed data were interpolated prior to calculating the variance. Data were written to external drives and archived on DVDs.

All fish targets were manually marked on DIDSON echograms (Figure 9) to obtain range and time data. The DIDSON echograms were extracted from the center beam only. The range of each fish, frame number, time, and the cumulative number of marked fish per file were exported to a text file.

North Bank

A 1985 model, 16-sector, automated Bendix counter (Figure 10) was used for sampling along north bank, collecting paired data with an LR DIDSON (SN 159). Bendix counter specifications include a 515 kHz frequency, 100 µs pulse width beam that alternately transmits 4° and 2° beams sampling a nearshore and offshore range. On May 27, the Bendix counter stopped receiving signal and was replaced by a spare counter of the same model with the same specifications. A Tektronix model 323 oscilloscope was used for aiming and visual counting. The Bendix transducer was mounted to a portable tripod (Figure 10) and deployed nearshore approximately 4 m from the shoreline with the beam directed offshore perpendicular to the river's current along the natural river bottom. A weir was not used because it has long been assumed that the slower current causes the majority of fish to pass farther offshore. Large fluctuations in water level, wave action, and periods of heavy ice floes required frequent repositioning of the transducer. The tilt angle of the transducer was manually adjusted, and the transducer was panned upriver and downriver by shifting the tripod in the desired direction.

Aiming the transducer, changing the threshold, and setting the range were all interrelated, i.e., changing one parameter affects the others. The selection of each parameter was dependent on the river bottom slope, water level, suspended sediment levels, ice floes, and fish distribution within the river. All echoes that pass threshold are counted by the Bendix counter, thus parameters are set so fish echoes exceed the threshold and false counts (non-fish echoes, which include echoes from all other sources) remain below threshold. Ideally, the transducer beam is aimed so bottom reflections remain below threshold and the intensity of the bottom reflections are similar across the sampling range. The threshold was modified by increasing or decreasing the sensitivity (power output level) of the sonar signal, in effect, widening or narrowing the beam. The threshold was adjusted in response to changes in water level, acoustic noise caused by debris or ice, or if positioning of the transducer affected the count (i.e., the threshold was raised if noise levels were high and lowered if desired targets were sub-threshold). The start and end counting ranges were set to maximize the counting range and restricted if false counts increased above the counting threshold. A counting range of 22.9 m, dead range of 0.3 m, ping rate of 1.345 s/m, and sensitivity of 116 V were the parameters used throughout the season.

Counting occurred manually. Although the Bendix counter produces automated counts, the count accuracy depends on frequent calibrations, which are difficult at the low fish passage rates observed along this bank. Because fish are counted manually, sector (range) data were unavailable. Manual counts were made by observing voltage spikes from the transducer on an oscilloscope and counting the spikes (fish) that crossed a minimum voltage level (approximately 4 V). For most of the field season, voltage spikes were counted for 30 min, 6 times daily with counting periods starting at 0500, 0900, 1200, 1600, 1900 and 2300 hours, unless environmental challenges necessitated either shortening the sampling time or missing a sample period. For the first few days of the field season, counting was done in 30-min/h increments across a continuous 8-h block from 0900 to 1700 hours to allow the crew to work together during the initial set up period.

Daily passage estimates for north bank (P_{NBd}) were obtained by expanding the oscilloscope counts (C) by the number of minutes sampled within each hour (t), then summing, and expanding by the number of periods sampled each day (p):

$$P_{NBd} = \left[\sum_{i=1}^{n} C_i \bullet \frac{60}{t} \right] \bullet \frac{24}{p} \tag{1}$$

The daily passage estimates were summed across the days sampled (d) to produce an annual estimate of escapement for the north bank (P_{NB}):

$$P_{NB} = \sum_{j=1}^{d} P_{NBd} \tag{2}$$

The LR DIDSON was positioned on the downriver side of the Bendix transducer (Figure 11). This DIDSON has low (0.7 MHz) and high (1.2 MHz) frequency options that are range dependent. The low frequency beam widths are 0.8°x14°, the high frequency 0.5°x14°; both have 48 beams spanning a 29° field of view. The LR DIDSON was mounted on an H-frame similar to the one used for the SR DIDSON, and tilted using an Remote Ocean Systems (ROS) rotator with relative feedback. An internal Honeywell sensor within the DIDSON provided absolute tilt, roll, and compass feedback. Two range strata were sampled, a high frequency, nearshore strata from 1 to 20 m and a low frequency, offshore strata from 15-35 m offshore. The DIDSON window length increments by doubling making it impossible to start at 1 m and end at 15 m, so the nearshore strata was only counted out to 15 m to avoid overlapping counts. Sampling parameters for both range strata included a 40 dB receiver gain and frame rates set as high as possible without losing frames, 8 fps nearshore and 5 fps offshore.

The 30-min/h LR DIDSON nearshore counts were paired with Bendix counts. Both estimates were expanded to a daily count for the final comparison.

PROFILES AND AIMING

Profiles of the river bottom in the region of the sonar beam were produced using the SR and LR DIDSONs on south bank and the LR DIDSON on north bank following methods described by Maxwell and Smith (2007). We obtained profiles perpendicular to the shoreline (or current flow) starting from nearshore and extending to the maximum range of the sonar. The profiles served 2 functions. The primary function was to find an optimum aim for each transducer that would lay the sonar beam along the river bottom across the sampling range. An aiming protocol to accomplish this requires exporting information from the DIDSON to plot the river bottom profile, using sensor data from a tilt sensor to determine the tilt angle of the transducer, measuring the position of the transducer, and then modeling the optimal aim of the transducer in relation to the river bottom (Faulkner and Maxwell 2009). The second reason for obtaining river bottom profiles is to determine whether the river bottom and river conditions are suitable for sonar sampling. Inaccuracies can occur in the count if the sonar beam cannot be laid smoothly along the river bottom or if the sonar is range limited due to slope changes or high turbidity.

ENVIRONMENTAL DATA

Environmental data were collected daily. Water level (elevation above mean sea level) was measured at 0630 and 1830 hours each day using a U.S. Geological Survey gauge mounted on the Million Dollar Bridge. Water and air temperatures were measured and the degree of cloud cover estimated.

DATA ANALYSES AND REPORTING

The DIDSON and Bendix counts were recorded on paper data forms then entered into Microsoft Excel worksheets. The prior day's counts, current day's counts through 0600 hours (0000–0500 hours), and water level were reported daily at 0930 hours to fishery managers.

Daily and cumulative salmon passage estimates summed across both banks were plotted in a time series and compared against anticipated and historical estimates. Anticipated daily and cumulative counts were generated for the duration of the field season and compared daily to the sonar estimates of salmon passage. A forecast of salmon returns each year was applied to the average run-timing curve to generate these anticipated passage estimates (Steve Moffitt, Commercial Fisheries Biologist, Cordova; personal communication).

Migrating fish behavior was analyzed by examining bank preferences, hourly passage rate, upriver and downriver movement, and offshore range distributions. Bank preferences were observed by plotting a time series of daily counts by bank and determining the percentage of total monthly fish passage per bank. Data from across the field season were aggregated by hour to examine diurnal patterns. The remaining behavior analyses were confined to the south bank, as these data were not available from the north bank's Bendix counter. Upriver and downriver fish movements were plotted on a daily time series, and the total and daily percentages of downriver-moving fish were determined. Exported data from DIDSON echograms provided the distance from the transducer (range) and time of passage for each marked fish. From the range information, a range distribution was plotted across the field season. A least squares regression variables was used to determine whether water level effects run timing.

Quality Control Measures

Several quality control measures were put in place at this site. Regional sonar staff ensured the field crew was properly trained in the set up and daily operations of both sonars, and in the interpretation of DIDSON images and voltage spikes from the Bendix system. The crew leader carried out quality control by spot checking counts made by technicians, especially new technicians, and retraining when necessary. In addition, the crew leader or a second technician rechecked the data entry daily.

RESULTS

Data Collection

Ice and snow prevented sonar deployment on the south bank's concrete substrate at the start of the field season so a temporary alternate site 395 m downriver was selected. About a week after initial deployment, the substrate was free of ice and snow so the DIDSON was redeployed near the 90 m mark on the substrate. The more exposed north shore presented no early deployment problems. The sonars along both banks were moved inshore or offshore as water levels changed, keeping the water level at the transducer relatively constant (43 cm at south bank; the lens center 17 cm from the river bottom). The 2007 schedule of events included:

- May 19, 0900 hours – north bank data collection began with the Bendix counter
- May 20, 2200 hours – south bank data collection at alternate site began with DIDSON
- May 25, 0500 hours – north bank LR DIDSON data collection began paired with Bendix counter
- May 26, 0000 hours – south bank DIDSON moved from alternate site to concrete substrate
- May 27 – south bank weir deployed
- August 4 – last day of sampling for both banks

Profiles and Aiming

River bottom profiles were made of each sampling site (Figure 12). The profiles of the alternate south bank site and north bank site were created in 2007, the concrete pad and beyond profile in 2005. The alternate south bank site profile was created from DIDSON images collected at one time with the zero point representing the position of the transducer (Figure 12a). The other 2 profiles (Figures 12b, 12c) were created from DIDSON images collected at different times during the season, with the zero points representing the final position of the transducer at the highest water stage. The profiles were merged together based on measurements made from each transducer position to a fixed point on the shoreline.

The slope of the alternate south bank site was mostly linear out to 15 m where the outline of a prominent obstruction was recorded; the region beyond was relatively flat out to the maximum detected range (Figure 12a). The concrete pad is shown as a straight line in the profile, which becomes uneven at the end of the pad and then flattens (Figure 12b). The north bank slope is relatively smooth along its entire length, and at first glance appears to be a single slope. The dotted line (Figure 12c) shows how the slope becomes flatter at a range approximately 32 m from the transducer's position.

The optimal tilt angle for the SR DIDSON was -13.8° at the alternate south bank site and -8.2º at the concrete pad. For the north bank LR DIDSON, the tilt angle was decreased as water levels increased and the transducer was moved up the bank with steeper slope grades. Selected aims ranged from -2.6º at the start of the season to -7.8º at the highest water stage. The Bendix transducer did not have a tilt sensor, so the selected tilt angles were unknown. The 2 beams shown in Figure 12c are the near and offshore Bendix beams.

SALMON PASSAGE ESTIMATES

Salmon passage estimates for the 2007 field season totaled 919,601 fish at Miles Lake. Daily estimates were substantially higher than anticipated estimates during most of the field season, although the run timing was a few days later (Figure 13). Two primary peaks were observed in the daily estimates; the first with counts exceeding 35,000 fish/d from May 30 to June 3, peaking on June 2 with 36,204 fish, and the second from July 4 to 6 with counts over 25,000 fish/d, peaking July 5 with 28,116 fish. Approximately 50% of the total escapement passed the sonar site by June 22. The cumulative escapement surpassed minimum anticipated escapement levels after June 2 and remained above this level for the rest of the season (Figure 14). The cumulative escapement estimate exceeded the lower boundary of the escapement goal range (566,918) June 30 and the upper boundary (763,561) July 14.

Although the run timing was later than the historical average (1978–2006), the 2007 escapement estimate surpassed the average historical estimate by May 28 and was generally higher through the remainder of the field season (Figure 15). The cumulative escapement was below the 10-year (1997–2006) average until June 2 then it rose above and remained higher for the rest of the season (Figure 16).

The south bank estimate of 808,122 ± 4,832 salmon (V5 variance estimator s.e.; Reynolds et al. 2007) accounted for 87.9% of the total escapement (Figure 17), with 111,479 fish estimated along the north bank. By month, the percentages of fish along the north bank were lowest in May (5.2%) and highest in July (16.1%), with a lower percentage compared to the historical average in May, and higher in both June and July (Table 1). August was excluded because there were so few days sampled.

SALMON MIGRATION BEHAVIOR

Fish passage rate by hour and month showed no obvious trends along either bank, but was most variable in May (Figures 18, 19). The lowest percentage of fish passage observed with the north bank Bendix counter occurred at 0900 hours in May, while in June, this was the hour of greatest fish passage. The least variation in daily passage was observed in July with the hourly counts more evenly spread across the day. The south bank DIDSON counts showed a smoother distribution across the day compared to the north bank with each hour's count fluctuating narrowly within 3–5% of the total south bank fish passage.

From the south bank DIDSON, direction of fish travel was obtained. These data were not available from the Bendix counter, and are not yet available from the LR DIDSON. Less than 6%, on average, of all fish counted on the south bank were observed moving downriver, with the largest percentage of downriver fish (17.3%) observed July 2 (Figure 20). Although upriver fish passage contained major peaks and valleys within the counts, downriver passage started off low, increased, and then remained relatively constant across the remaining season.

Range data was also collected with the south bank DIDSON. Along the south bank, most salmon (94%) passed the site nearshore within 10 m of the transducer (Figure 21). The majority of fish (51%) passed between 2 and 4 m from the transducer where peak passage occurred at 3 m. Beyond 10 m, fish passage dropped dramatically and within the last 2 m of sampling range (19–20 m), less than 0.06% of total fish passage was observed. At the alternate south bank site (May 20–26), 57.9% of fish were counted within the first 4 m, 91.1% within 10 m, and less than 0.08% in the outer 2 m (19–20 m).

ENVIRONMENTAL DATA

The water level in the Copper River trended with the 1982–2006 historical average overall; it rose rapidly until mid-June then slowly increased during the remainder of the field season (Figure 22). Average monthly water levels were between 40.1 and 42.8 m. The water level fluctuated 3.57 m throughout the field season with a low of 39.49 m in late May and a high of 43.07 m in late July. Water temperature increased rapidly until mid-June then stabilized, ranging from 3.1° C in late May to 11.1° C in late June (Appendix A5).

No relationship was observed between daily water level and daily salmon passage estimates (R^2=0.025; Figure 23).

Supporting data for each section are provided in Appendices A2–A10.

DISCUSSION

The sonar estimate of 919,601 salmon was higher than the 10-year average (825,463 salmon; Lewis et al. 2008, Appendix A8), and surpassed the upper end of the inriver goal (566,918–763,561 salmon). Additionally, commercial harvests of Copper River sockeye salmon were above normal, 31.2% higher than the 10-year average (Lewis et al. 2008). This suggests the 2007 sockeye salmon run was larger than average.

The late deployment of the south bank sonar and early low daily counts resulted in management actions that canceled a fishing period during the first week of commercial fishing. However, fishing resumed according to schedule the following week (Lewis et al. 2008). The late deployment of the south bank sonar likely had little effect on the overall estimate. Only 75 fish were estimated for the south bank count the first full sampling day, May 21, and daily passage estimates remained below 1,000 fish until May 24 (Appendix A2).

There are several factors that can affect the accuracy of the sonar estimates: 1) missed sampling periods, 2) image quality, 3) changes in the river bottom profile, 4) position and aim of the transducer, 4) environmental conditions, and 5) fish migrating behavior.

Sampling periods are missed when equipment or environmental problems arise. For most of the field season, sonar counts were collected according to pre-determined schedules with few missed periods. The largest block of missed data occurred during the move from the alternate site on the south bank to the concrete substrate when 6 sample periods were missed. An additional 3 h were missed June 6 and 1 h June 24. The north bank system was down only a couple of hours on 2 days, May 27 and July 7. All missed counts were interpolated. The low number of missed sampling periods probably had little effect on the overall estimate.

The quality of the DIDSON images along the south bank was very good. The background subtraction algorithm made the fish stand out strongly against the mostly black background (Figure 8). Fish passage rates at this site are generally low enough that individual fish can be counted accurately without being occluded by neighboring fish. On the north bank, the oscilloscope provided the visual information from the Bendix counter. Passage rates are very slow on this side of the river and no overlapping of voltage spikes occurs on the oscilloscope. The important factors in producing a good signal from the Bendix counter depend on an aim that skims the bottom but does not have obstructions that produce false counts, and voltage spikes from fish that reach a much higher threshold than voltage return from the river bottom. The challenge with this system comes from the need for frequent re-aiming as water levels change, and movement of the transducer from floating ice. The crew was able to successfully meet the challenges this year and few problems occurred while aiming the Bendix transducer.

PROFILES AND AIMING

One of the most important factors in a riverine sonar system is the river bottom profile and the relationship of the transducer to the river bottom (Maxwell and Smith 2007). For optimum ensonification of the sampling region, the transducer beam must be able to flow along a linear river bottom encountering few or no obstructions. The south bank alternate site was a reasonable sampling site with a relatively smooth profile that extended 15 m offshore (Figure 12a). The rise in the river bottom at 15 m is likely an obstruction and not a change in slope. If this was a change in slope, the region beyond would have been undetected by the sonar beam, but the river bottom beyond was clearly visible in DIDSON images.

A degree of uncertainty exists when sampling off the south bank with the transducer placed at the very end of the concrete substrate, which is often the situation at the start of the field season when the water level is low. Beyond the substrate, there is a dip in the river bottom where fish may pass undetected. This dip is not viewable in the profile (Figure 12b) because of the small scale of the figure. This dip is probably caused by the current encountering the end of the concrete pad and washing away the rocks and gravel immediately beyond. Past the dip, the bottom slope is detectable by the sonar, so there is only a small region affected for a short period of time until the water level rises and the transducer is moved farther up the concrete pad. Profiles are not completed every field season at this site because of the stability of the concrete pad. However, when sampling beyond the substrate, a new profile is worth doing to determine how the region beyond the concrete pad has changed. From profiles done across years (Figure 12b) differences have been observed in this region.

We have never attached a tilt sensor to the Bendix transducer on the north bank. For comparison purposes, the Bendix counts obtained during the comparison years needed to be collected in the same fashion as the historical counts. The position of the Bendix beam shown in Figure 12c is an approximation based on the fact that technicians try to place the lower edge of the beam along the river bottom during aiming. This process can be tricky as the technician tries to balance the beam between the bottom and surface of the river column without encountering any above-threshold signal along the sampling range. It is unlikely a technician would push the beam too deep into the bottom. Unless the river bottom is completely non-reflective, an aim that is too low would produce false counts, i.e., unwanted echoes counted as fish targets. What is more probable is the beam is raised too high above the river bottom to avoid obstructions higher than bottom. This scenario can result in fish passing without being detected. The extent of this problem is largely unknown, and comparing Bendix counts with DIDSON (below) indicates that the Bendix system does experience detection problems.

Profiling the river bottom along the north bank has been done every season to determine the best placement and optimum aim for the LR DIDSON, and redone when water levels significantly increase. During the 2007 field season, the crew was able to follow the aiming protocol to achieve optimum aims for the LR DIDSON during the initial set up and following changes in water level or disturbances to the transducer mounts. This year's profiles and the modeled aims suggest fish detection was high within the ensonified regions (Figure 12c).

SALMON MIGRATION BEHAVIOR

Studies in fish energetics have shown that in strong current flows salmon reduce energy expenditures by migrating nearshore and close to the river bottom where the current velocity is lessened (Brett 1995; Hughes 2004; Standen et al. 2004; Webb 1995). At the Miles Lake site, the current flow is strong along the south bank, but a back eddy exists along the north bank. The south bank offshore range distribution indicates that few, if any, fish travel beyond the maximum effective range of the sonar at either the alternate site or the concrete pad but, the effective ensonification range can vary along this bank. While performing profiles of the river bottom (and concrete pad), we have been able to detect the river bottom out to 18 m from shore during normal water levels, but one profile collected during high water showed the bottom signal greatly diminished after 11 m. The reduction in range is likely related to the higher silt content carried by the river during high water that scatters the sonar pulse. Although range reduction occurs during high water events, the higher water may also move fish closer to shore as they migrate. Since the majority of fish (94%) were observed within 10 m of the transducer (Figure 21), the effects of high water on fish passage counts are minimal. Historically, the north bank range information from the Bendix counter showed salmon migrated farther offshore; this is likely caused by the reduced current flow along this bank. Without recent information, the effects of the bridge work on fish migration along the north bank are difficult to assess. Range information from the LR DIDSON, when it becomes available, may help answer questions regarding fish distribution along this bank.

Traditionally, the percentage of the total fish passage observed along the north bank is low. In 2007, north bank fish passage was 12% which is similar to percentages from prior years (Table 1). This low percentage may be partly due to the effects of the Childs Glacier located downstream along the north bank. The glacier is actively calving and it extends to the edge of the river. The similarity in north bank fish passage percentages across years also indicates the bridge work conducted in 2003–2005 may not have substantively affected fish passage. The construction work permanently altered the flow patterns along the north bank creating the large, nearshore, back eddy. There was concern fish may have moved approximately 40 m offshore to the region where the current flow begins, beyond the sonar's range. If fish have been pushed farther offshore along this bank, the numbers are so few that the effects are negligible. A more pressing concern for this side of the river is the fact that a weir has never been used to prevent fish from passing inshore of the transducer. It has always been assumed that the slower current along this shore and the shallower bottom keeps fish offshore. This is an assumption that still requires evaluation. At the Miles Lake site, there are shallower places in the river that might be conducive to fish travel. To address the possibility that salmon are moving outside the ensonified range, a mobile DIDSON was mounted to the side of a boat and transects were conducted, stopping and sampling at selected intervals across the river. The complete study and results will be published in a separate report, but preliminary results are in Figure 24. One cross-river transect was completed in 2005 and 8 in 2006. In 2005, 65 fish were observed during the single transect with the majority (73.5%) within 10 m of shore. No fish were observed outside the ensonified ranges of the shore-based sonars. In 2006, 303 fish were observed with the mobile DIDSON with the majority (96% in May and 93% in June) within 10 m of shore. When compared against the shore-based sonars 7 fish (2.4%) would have been outside the sampling ranges. From these results, we are confident fish are not traveling in the middle of the river; however, a small increase to the outer range of the sonar may increase the accuracy of the sonar estimates.

There was no diurnal pattern observed in salmon migration at the Miles Lake site (Figure 19). This contrasts with rivers in the Upper Cook Inlet area where salmon passage rates decrease from 0200 to 0500 hours and increase from 1800 to 2200 hours (Westerman and Willette 2007). Variations in daily migration behavior of salmon may be caused by how far the site is from the river mouth, the size and depth of the river, and turbidity. The Upper Cook Inlet sonar sites are closer to the river mouths and a residual pattern from salmon entering the river during specific tidal stages may affect the migrating timing at the sonar sites. Farther upriver, these patterns may diminish. Predation by bears, which may drive fish offshore, is not likely a factor at the Miles Lake site where the river is deep and turbid, making fishing by bears or people difficult. The lack of any clear pattern in the hourly plots from the north bank suggests the sampling regime (6 h/day) was sufficient, and the hours selected for sampling did not bias the estimate.

SPECIES APPORTIONMENT

The Miles Lake project escapement estimate was apportioned between Chinook and sockeye salmon post-season. A total of 46,349 Chinook salmon (van den Broek et al. 2008) were subtracted from the 2007 Miles Lake sonar estimate leaving 873,252 sockeye salmon, or 95% sockeye salmon and 5% Chinook salmon (Steve Moffitt, Commercial Fisheries Biologist, Cordova; personal communications). Upriver subsistence and personal use harvests indicate the proportion of Chinook salmon may be even smaller; 2007 harvests consisted of 3.0% Chinook, 95.7% sockeye, and 1.3% coho salmon and other species (Lewis et al. 2008).

Although most sonar systems are not capable of identifying individual salmon species, there is new evidence that DIDSON length measures can be used to distinguish between fish species with distinct length curves, i.e., frequency curves of length measures that either don't overlap or are predominantly bimodel (Burwen et al. 2007). It is unknown whether the Copper River Chinook and sockeye salmon have distinct length curves. More information is needed to determine whether an on-site apportionment program can be built around DIDSON length measures of fish at this site.

DIDSON-BENDIX COMPARISON

The paired LR DIDSON and Bendix counts from the north bank were tallied and estimates from the last 3 years were compared. Paired data were collected along the south bank from 2003 to 2004. Comparison results are preliminary and will be published in a separate report along with similar results from several rivers across Central Region. For the south bank, the Bendix estimates were within the 95% confidence intervals of the sampled DIDSON estimates for both years. Along the north bank, DIDSON counts were 1.47%, 1.12%, and 1.14% higher than Bendix counts in 2005, 2006, and 2007, respectively. The best model for converting the north bank's historical Bendix estimates to DIDSON equivalents was a single multiplier of 1.303, although this conversion factor may change as the analysis proceeds. Because the estimates from the 2 sonars along the south bank were so similar, the Bendix counter was replaced with a DIDSON starting in 2005, with no changes made to either the daily estimates or escapement goals. The north bank counts may require the Bendix historical estimates and SEGs be adjusted to fit the new DIDSON system.

CONCLUSIONS AND RECOMMENDATIONS

The primary conclusions from the 2007 field season:

1. Sonar estimates were above average (10% higher than the 10-year average).
2. Run timing was several days late compared to historical run timing.
3. One early fishing period was closed due to the late run timing.
4. Confidence in data collection was high based on few missed sampling periods, quality DIDSON fish images, the use of an alternate south bank site to avoid a start up delay, and a stringent aiming protocol used to determine the optimal transducer aim.
5. Salmon migrated predominantly along the south bank (88%), within 10 m of the transducer (south bank), and exhibited no obvious diurnal pattern (both banks).
6. River bottom profiles and environmental conditions indicated fish detection was high within ensonified regions.
7. Preliminary comparison results showed Bendix and DIDSON south bank estimates were similar, but north bank estimates required an increase in the Bendix estimates by a factor of 1.303 to make the 2 estimates similar.

Changes scheduled to take place next year (2008) include replacing the north bank Bendix counter with a LR DIDSON and developing a weir for the north bank. The escapement goals will be reassessed when preliminary comparison results are finalized. Because north bank estimates make up a small percentage of the total Miles Lake sonar estimate, we expect the north bank changeover to DIDSON to have little effect on fishery management decisions. We will begin developing a weir on north bank and evaluate range distributions from the LR DIDSON before and after use of the weir to determine whether or not a weir is needed.

ACKNOWLEDGEMENTS

The Miles Lake sonar crew deserves special recognition for their dedication to the project: Donald Malherek and Roger Johnson. Glenn Hollowell (ADF&G Area Management Biologist) assisted in setup and supervision of the field camp. Glenn also gave his building expertise and assistance in building a new cook shack for the camp. Lowell Fair provided editorial support.

REFERENCES CITED

Becker, C. D. 1962. Estimating red salmon escapements by sample counts from observation towers. U.S. Fish and Wildlife Service Fishery Bulletin 61(192):355–369.

Belcher, E. O., W. Hanot, and J. Burch. 2002. Dual-Frequency identification sonar. Pages 187-192 [*In*]: Proceedings of the 2002 International Symposium on underwater technology. Tokyo, Japan, April 16-19.

Bendix Corporation. 1980. Installation and operation manual for side scan salmon counter (1980 model). Bendix Corporation Oceanics Division Report SP-78-017, Sylmar, California.

Bendix Corporation. 1984. Installation and operation manual for long range side scan herring counter with rock inhibitor. Bendix Corporation Oceanics Division, Sylmar, California.

Botz, J., R. Brenner, G. Hollowell, B. Lewis, and S. Moffitt. 2008. 2006 Prince William Sound Area finfish management report. Alaska Department of Fish and Game, Fishery Management Report No. 08-30, Anchorage.

Brabets, T. P. 1997. Geomorphology of the Lower Copper River, Alaska. U.S. Geological Survey Professional Paper 1581.

Brady, J. 1986. Copper River hydroacoustic salmon enumeration studies, 1984 and 1985. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report No. 183, Juneau.

Brazil, C. 2007. Sonar enumeration of Pacific salmon into the Nushagak River, 2003. Alaska Department of Fish and Game, Commercial Fisheries Division, Fishery Data Series No. 07-37, Anchorage.

Brett, J. R. 1995. Energetics. Pages 3-68 [*In*]: C. Groot, L. Margolis, and W.C. Clarke, editors. Physiological Ecology of Pacific Salmon. University of British Columbia Press, Vancouver, B.C.

Bue, B. G., J. J. Hasbrouck, and M. J. Evenson. 2002. Escapement goal review of Copper and Bering rivers, and Prince William Sound Pacific Salmon Stocks. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A02-35, Anchorage.

Burwen, D. L., S. J. Fleischman, and J. D. Miller. 2007. Evaluation of a dual-frequency imaging sonar for estimating fish size in the Kenai River. Alaska Department of Fish and Game, Fishery Data Series No. 07-44, Anchorage.

Dunbar, R. 1999. Copper River hydroacoustic salmon enumeration studies, 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A99-23, Anchorage.

Dunbar, R. 2001. Copper River hydroacoustic salmon enumeration studies, 2000 and 2001. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 2A01-13, Anchorage.

Dunbar, R. 2003. Anvik River sonar chum salmon escapement study, 2003. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A03-14, Anchorage.

Dunbar, R., and C. T. Pfisterer. 2004. Sonar estimation of fall chum salmon abundance in the Sheenjek River, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A04-10, Anchorage.

Evenson, M. J., and Wuttig, K. G. 2000. Inriver abundance, spawning distribution, and migratory timing of Copper River Chinook salmon in 1999. Alaska Department of Fish and Game, Fishery Data Series No. 00-32, Anchorage.

Faulkner, A. V. and S. L. Maxwell. 2008. Copper River hydroacoustic salmon enumeration studies, Miles Lake sonar project, 2005–2006. Alaska Department of Fish and Game, Fishery Data Series No. 08-37, Anchorage.

Faulkner, A. V. and S. L. Maxwell. 2009. An aiming protocol for fish-counting sonars using river bottom profiles from a Dual-frequency Identification Sonar (DIDSON). Alaska Department of Fish and Game, Fishery Manuscript No. 09-03, Anchorage.

Gaudet, D. M. 1983. 1981 Bendix counter manual. Alaska Department of Fish and Game, Division of Commercial Fisheries, Juneau.

REFERENCES CITED (Continued)

Gaudet, D. M. 1990. Enumeration of migrating salmon populations using fixed-location sonar counters. Rapp. P.-V. Reun. Cons. Int. Explor. Mer. 189:197-209.

Holmes, J. A., M. W. Cronkite, H. J. Enzenhofer, and T. J. Mulligan. 2006. Accuracy and precision of fish-count data from a “Dual-frequency Identification Sonar” (DIDSON) imaging system. ICES J. of Marine Science, 63:543-555.

Hughes, N. F. 2004. The wave-drag hypothesis: an explanation for size-based lateral segregation during the upstream migration of salmonids. Canadian Journal of Fisheries and Aquatic Sciences 61:103-109.

Lewis, B., J. Botz, R. Brenner, G. Hollowell, and S. Moffitt. 2008. 2007 Prince William Sound Area Finfish Management Report. Alaska Department of Fish and Game, Fishery Data Series No. 08-53, Anchorage.

Maxwell, S. L., and N. E. Gove. 2004. The feasibility of estimating migrating salmon passage rates in turbid rivers using a dual-frequency identification sonar (DIDSON) 2002. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report 2A04-05, Anchorage.

Maxwell, S. L., and N. E. Gove. 2007. Assessing a dual-frequency identification sonars’ fish-counting accuracy, precision, and turbid river range capability. Journal of the Acoustical Society of America 122(6):3364-3377.

Maxwell, S. L., and A. V. Smith. 2007. Generating river bottom profiles with a dual-frequency identification sonar (DIDSON). North American Journal of Fisheries Management 27:1294-1309.

Merritt, M. F., and K. Roberson. 1983. Copper River sockeye salmon sonar enumeration studies, 1982. Alaska Department of Fish and Game, Division of Commercial Fisheries, Glennallen.

Merritt, M. F. and K. Roberson. 1984. 1983 Copper River sockeye and Chinook salmon sonar enumeration studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Prince William Sound Data Report No. 84-20, Glennallen.

Morstad, S., E. Biggs, and J. Brady. 1991. Copper River hydroacoustic salmon enumeration studies, 1986 and 1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report 2C91-03, Anchorage.

Morstad, S. 1992. Copper River hydroacoustic salmon enumeration studies, 1988 through 1991. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report 2A92-29, Anchorage.

Morstad, S. 1993. Copper River hydroacoustic salmon enumeration studies, 1992. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report 2A93-07, Anchorage.

Morstad, S. 1994. Copper River hydroacoustic salmon enumeration studies, 1993 and 1994. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report 2A94-25, Anchorage.

Morstad, S. 1997. Copper River hydroacoustic salmon enumeration studies, 1995 and 1996. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report 2A97-04, Anchorage.

Morstad, S. 1999. Copper River hydroacoustic salmon enumeration studies, 1997 and 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Informational Report 2A99-04, Anchorage.

Pfisterer, C. T. 2002. Estimation of Yukon River salmon passage in 2001 using hydroacoustic methodologies. Regional Information Report 3A02-24. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.

Roberson, K. 1978. A review of progress on the Copper River sonar project. Alaska Department of Fish & Game, Division of Commercial Fisheries, Glennallen.

Roberson, K., M. F. Merritt, and P. J. Fridgen. 1982. Copper-Prince William Sound sockeye salmon catalog and inventory. Alaska Department of Fish and Game, Annual Technical Report AFC-61-4, Anchorage.

REFERENCES CITED (Continued)

Reynolds, J. H., C. A. Woody, N. E. Gove, and L. F. Fair. 2007. Efficiently estimating salmon escapement uncertainty using systematically sampled data. Pages 121-129 [*In*]: C. A. Woody, editor. Sockeye salmon ecology, evolution, and management. American Fisheries Society Symposium No. 54, Bethesda, MD.

Savereide, J. W. and M. J. Evenson. 2002. Inriver abundance, spawning distribution, and migratory timing of Copper River Chinook salmon in 2001. Alaska Department of Fish and Game, Fishery Data Series No. 02-28, Anchorage.

Savereide, J. W. 2005. Inriver abundance, spawning distribution, and run timing of Copper River Chinook salmon, 2002–2004. Alaska Department of Fish and Game, Fishery Data Series No. 05-50, Anchorage.

Seibel M. C. 1967. The use of expanded ten-minute counts as estimates of hourly salmon migration past counting towers on Alaskan rivers. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 101, Juneau.

Simmonds, E. J., and D. N. MacLennan. 2005. Fisheries acoustics: theory and practice. Blackwell Science Ltd., Oxford, UK.

Smith, A. V., and B. Lewis. 2006. Copper River hydroacoustic salmon enumeration studies 2002-2004. Alaska Department of Fish and Game, Fishery Data Series No. 06-41, Anchorage.

Standen, E. M., S. G. Hinch, and P. S. Rand. 2004. Influence of river speed on path selection by migrating adult sockeye salmon (*Oncorhynchus nerka*). Can. J. Fish. Aquat. Sci. 61: 905-912.

van den Broek, K. M., J. J. Smith, and G. Wade. 2008. Estimating the inriver abundance of Copper River Chinook and sockeye salmon, 2008 Annual Report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 07-503), Anchorage.

Webb, P. W. 1995. Locomotion. Pages 71-99 [*In*]: C. Groot, L. Margolis, and W.C. Clarke, editors. Physiological Ecology of Pacific Salmon. University of British Columbia Press, Vancouver, B.C.

Westerman, D. L., and T. M. Willette. 2007. Upper Cook Inlet salmon escapement studies 2006. Alaska Department of Fish and Game, Fishery Data Series No. 07-82, Anchorage.

TABLES AND FIGURES

Table 1.–North and south bank sonar escapement estimates by month from the Miles Lake sonar site at the Copper River, 1998–2007.

May				
Year	North	South	% North	%South
1998 [a]	ND	ND		
1999	870	15,791	5.2	94.8
2000	14,137	29,326	32.5	67.5
2001	36,208	167,774	17.8	82.2
2002	2,602	51,027	4.9	95.1
2003	12,692	99,319	11.3	88.7
2004	8,688	180,067	4.6	95.4
2005	24,920	176,793	12.4	87.6
2006	17,932	104,708	14.6	85.4
2007	6,039	110,832	5.2	94.8
Average	13,788	103,960	12.0	88.0
June				
Year	North	South	% North	%South
1998	9,495	386,319	2.4	97.6
1999	15,494	374,716	4.0	96.0
2000	27,303	285,101	8.7	91.3
2001	16,856	321,235	5.0	95.0
2002	17,519	305,983	5.4	94.6
2003	25,776	349,375	6.9	93.1
2004	10,768	320,346	3.3	96.7
2005	62,290	362,407	14.7	85.3
2006	64,704	462,174	12.3	87.7
2007	48,504	415,344	10.5	89.5
Average	29,871	358,300	7.3	92.7
July				
Year	North	South	% North	%South
1998	12,636	258,399	4.7	95.3
1999	23,105	389,923	5.6	94.4
2000	11,892	213,214	5.3	94.7
2001	41,186	236,327	14.8	85.2
2002	27,169	415,590	6.1	93.9
2003	29,744	183,637	13.9	86.1
2004	2,068	147,577	1.4	98.6
2005	44,984	183,730	19.7	80.3
2006	48,322	261,866	15.6	84.4
2007	50,056	261,330	16.1	83.9
Average	29,116	255,159	10.3	89.7

[a] North bank wasn't deployed until June 5.

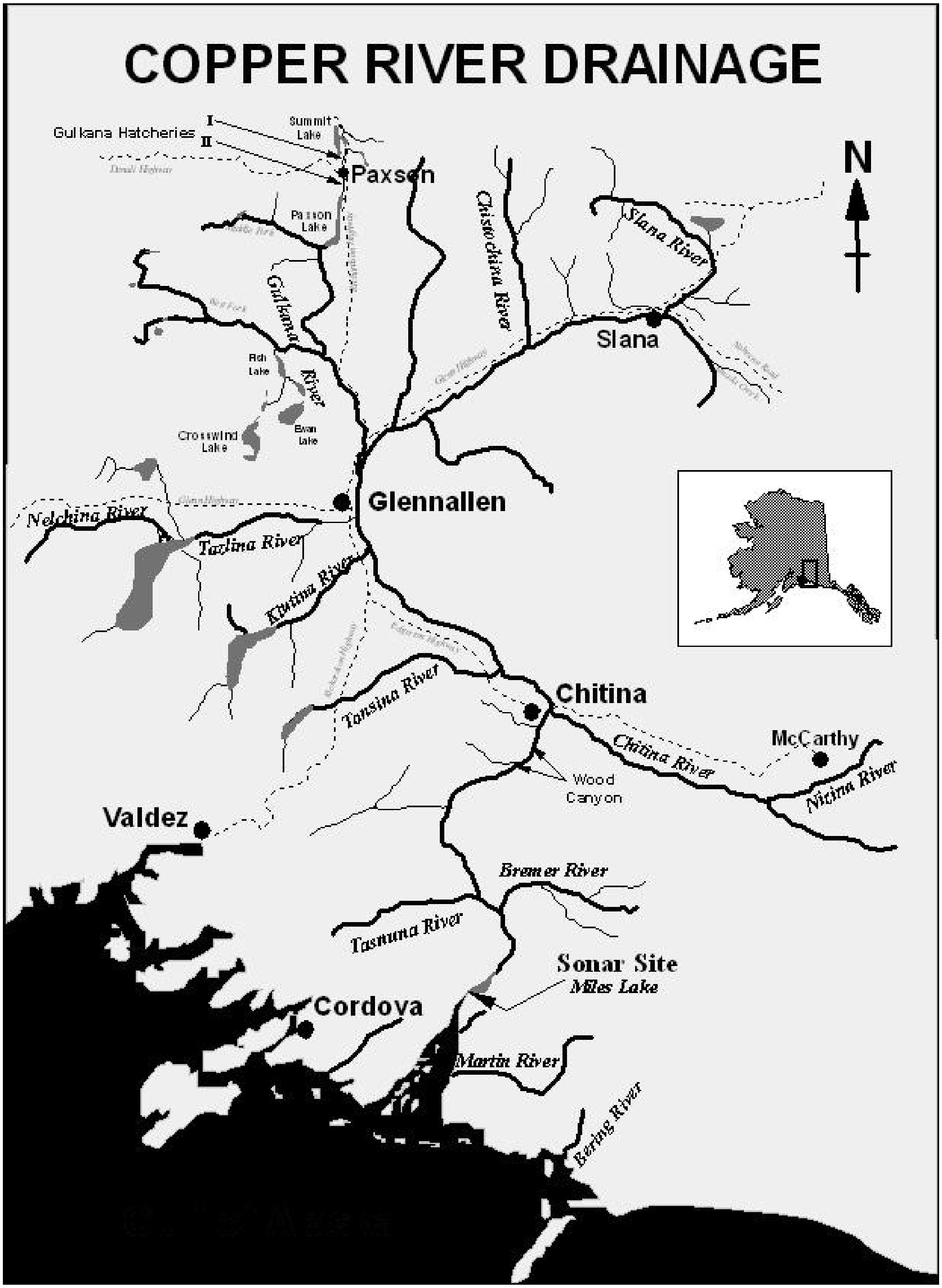
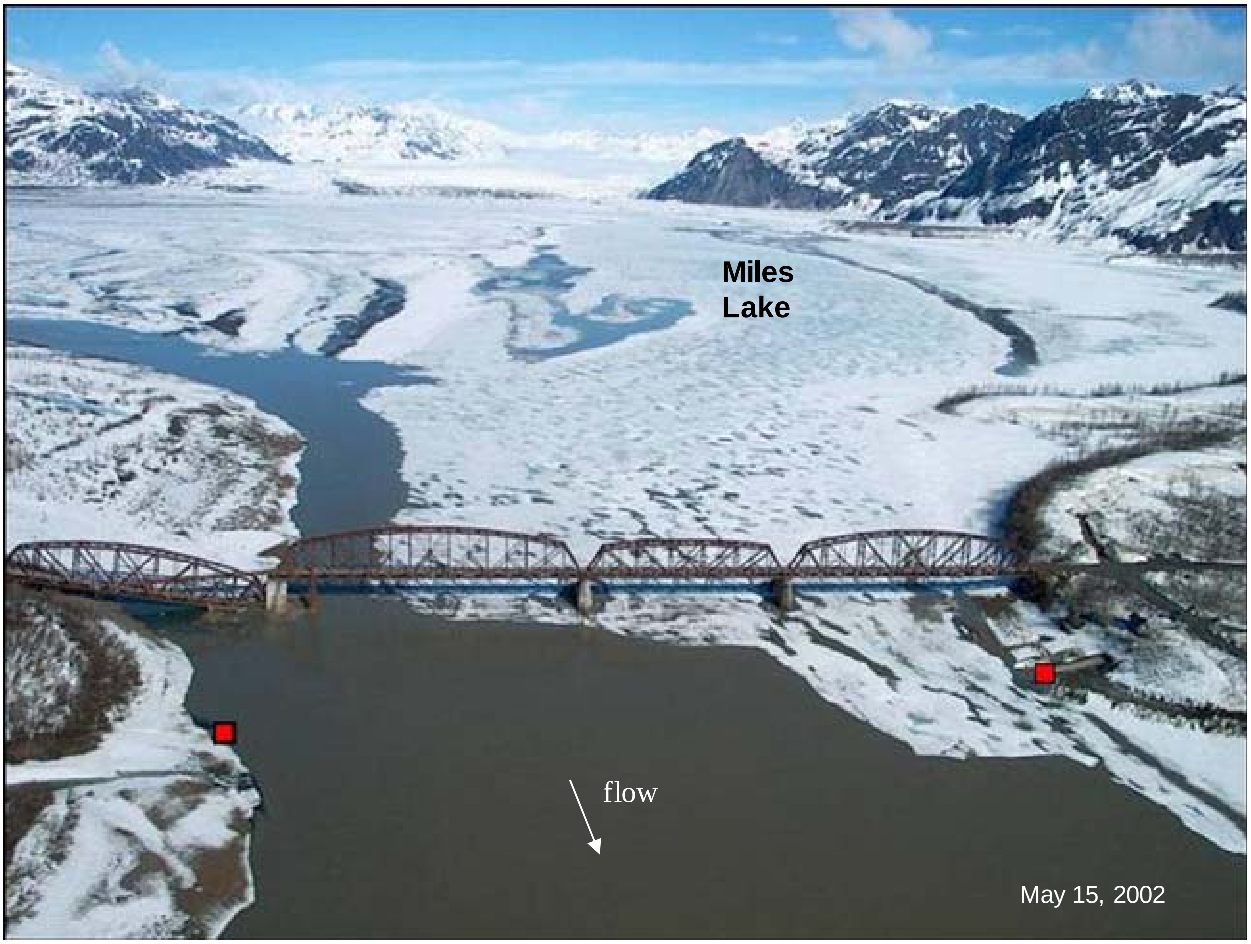


Figure 1.–The Copper River drainage showing the Miles Lake sonar site.



Note: The north and south bank deployment sites are indicated by a square marker, with the concrete substrate visible along the south bank.

Figure 2.–The Copper River at mile 48 of the Copper River Highway showing the Million Dollar Bridge and the collapsed span on the north bank (left).

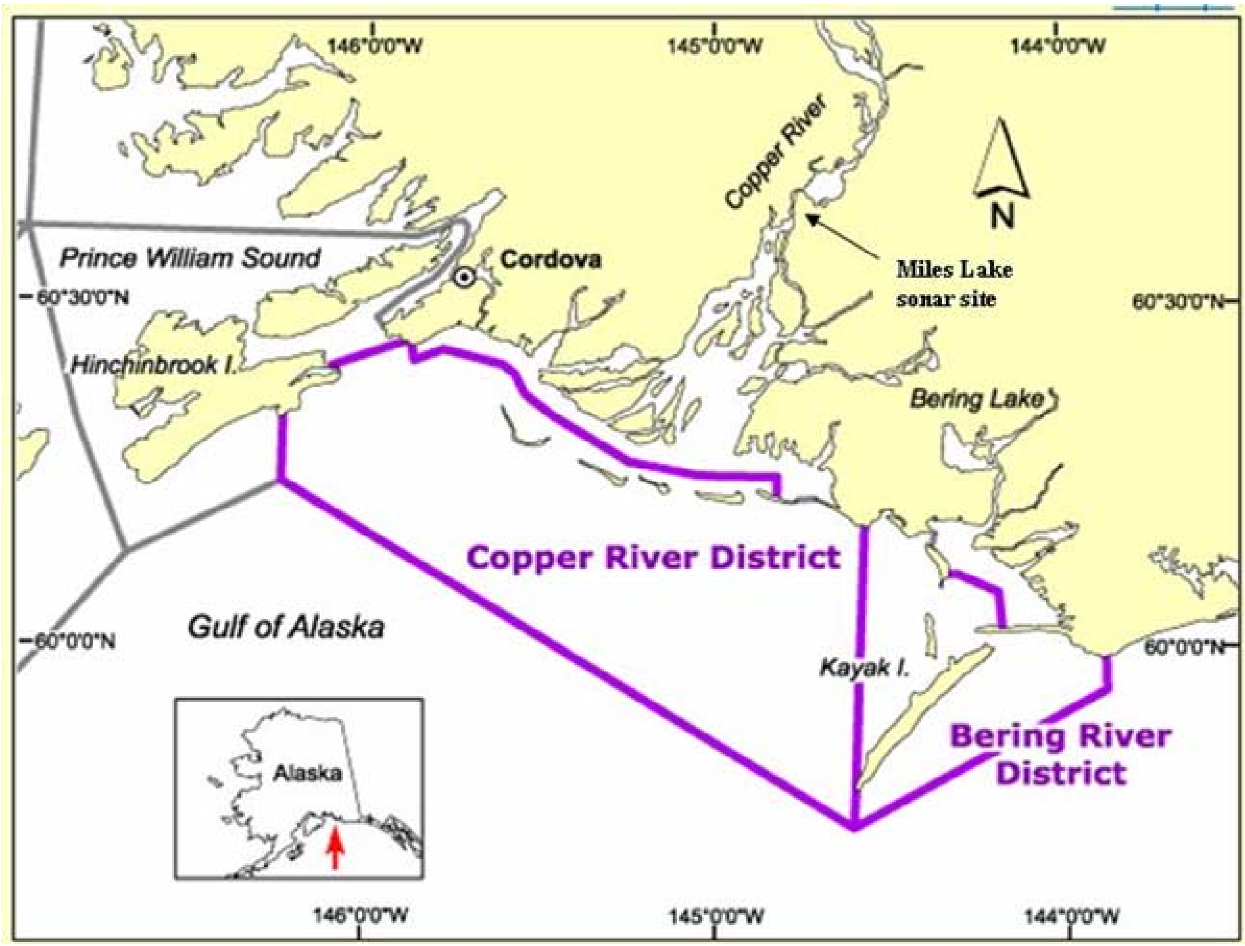


Figure 3.–The location of the Miles Lake sonar site 53 km upriver of the Copper River District commercial salmon fishery.

Figure 4.–A DIDSON positioned horizontally for estimating salmon passage, encased in an aluminum cylinder, attached to a single-axis, automated rotator mounted to an aluminum H-mount, with an attached tilt and roll sensor along the Copper River’s south bank, Miles Lake sonar.

Figure 5.–A DIDSON mounted vertically to record river bottom profiles along the Copper River, Miles Lake sonar.

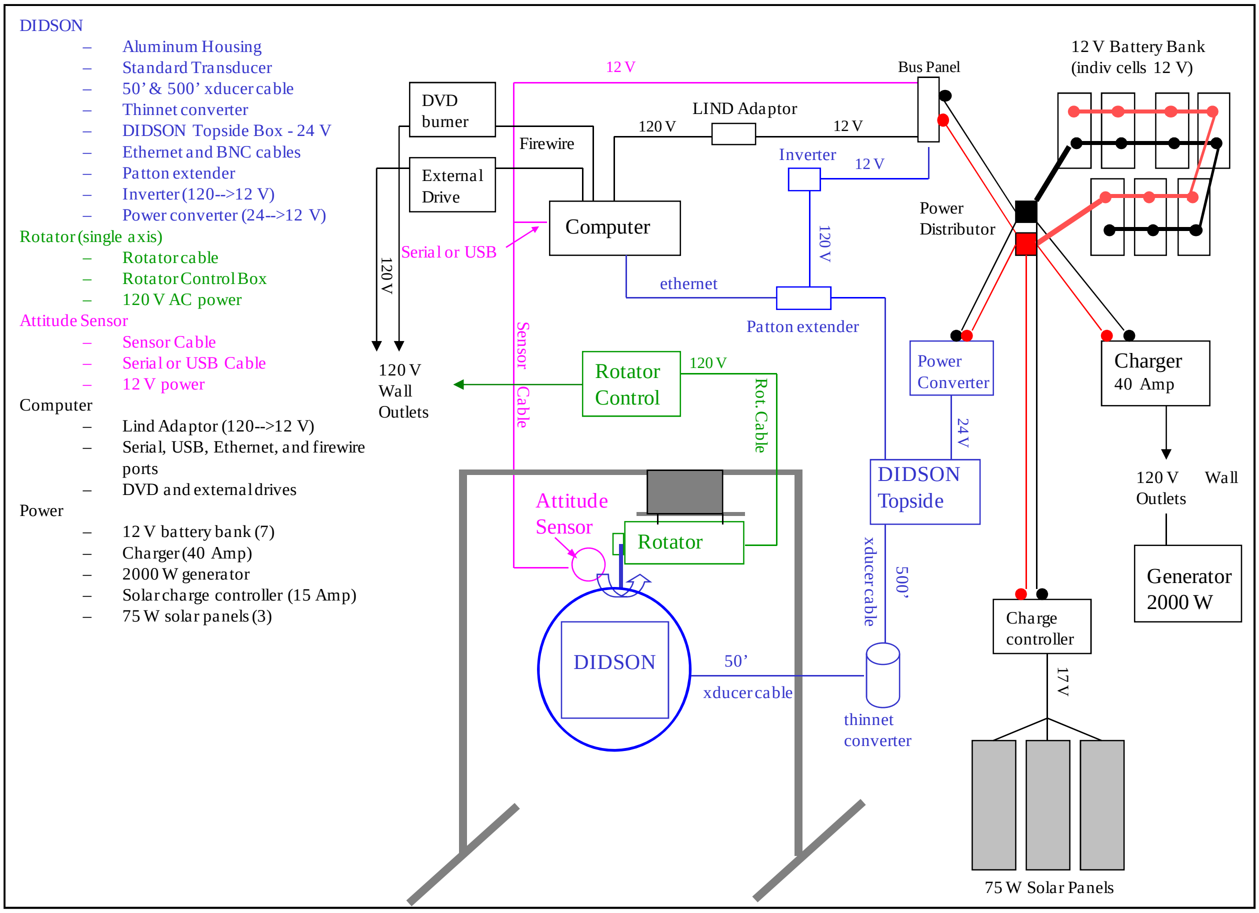


Figure 6.–Diagram of the DIDSON setup along the Copper River's south bank, Miles Lake sonar, 2007.

Figure 7.–The south bank weir on the downriver side of the DIDSON at the Copper River, Miles Lake sonar.

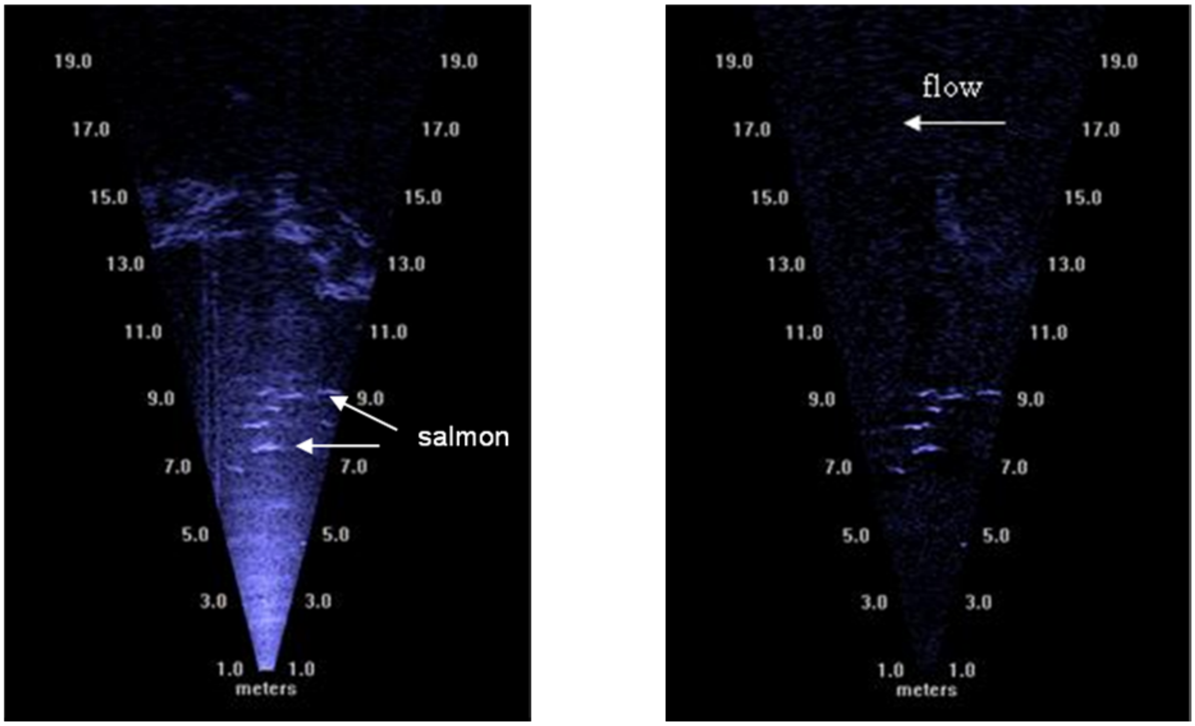


Figure 8.–A raw DIDSON image of migrating salmon (left) and the same image processed using the DIDSON's background subtraction algorithm (right), Copper River south bank, Miles Lake sonar, June 8, 2005.

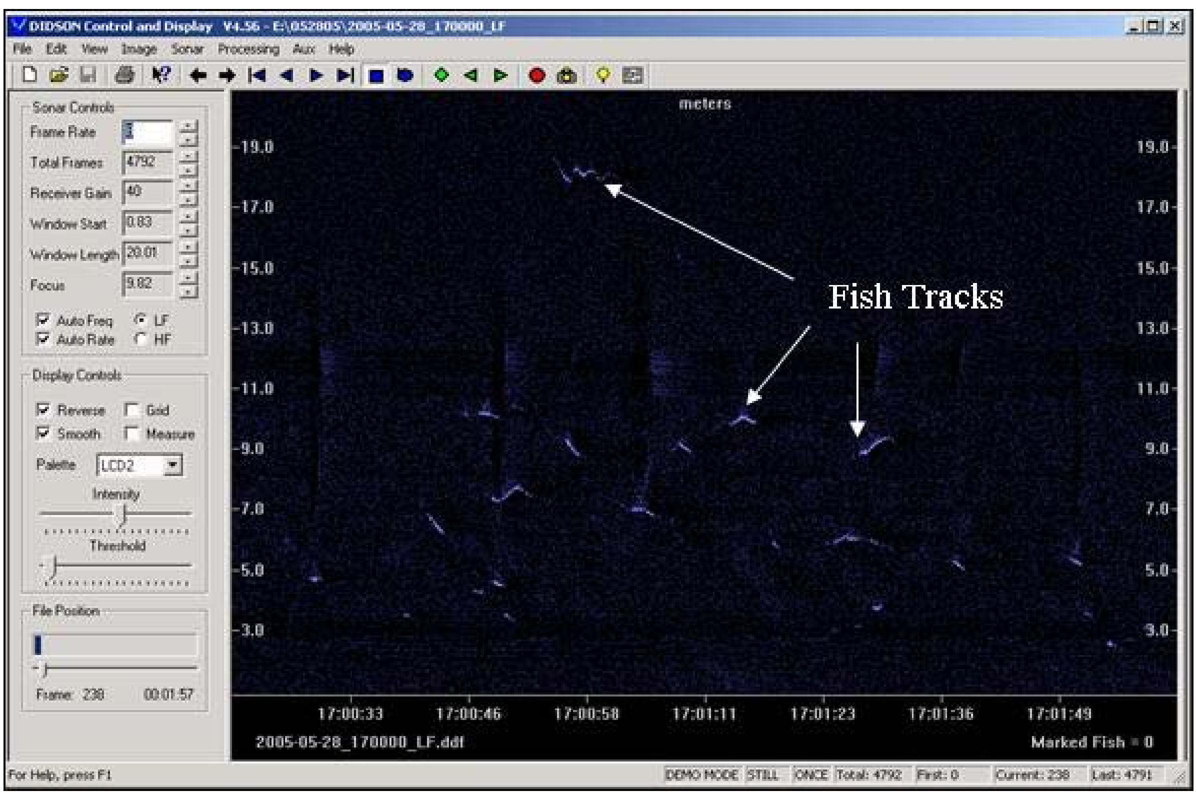


Figure 9.–A DIDSON echogram processed using the DIDSON background subtraction algorithm, Copper River south bank, Miles Lake sonar, 2005.

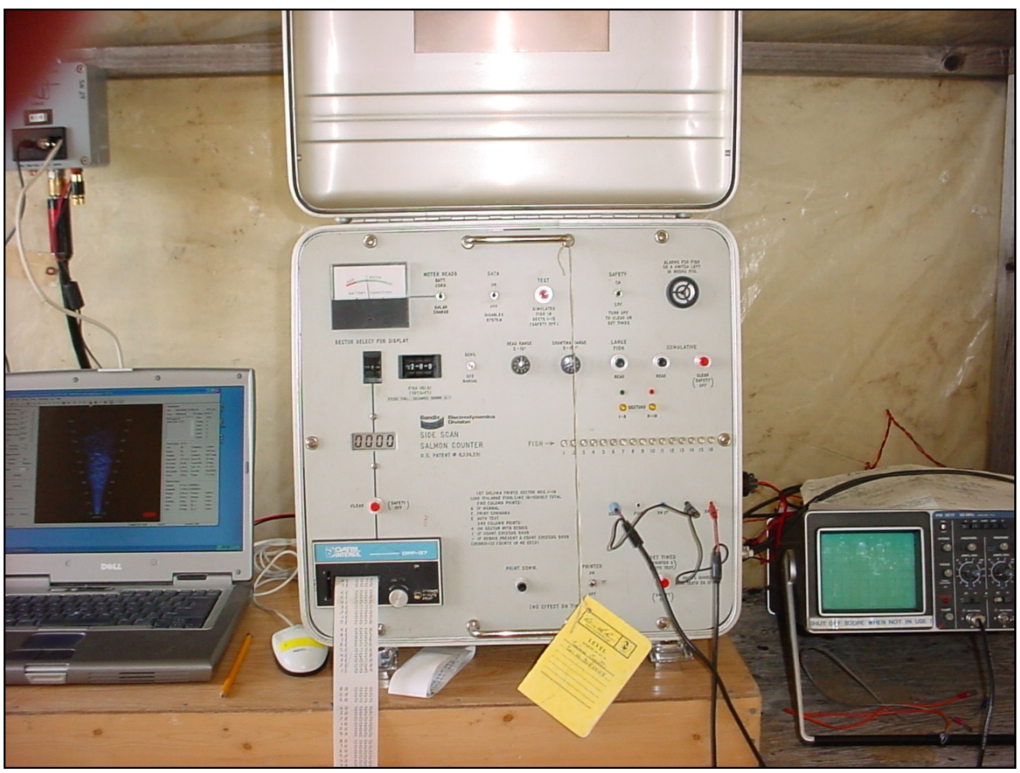


Figure 10.–The Bendix transducer mounted to an aluminum tripod (top) used along the Copper River's north bank and a Bendix counter (bottom), Miles Lake sonar, 2007.

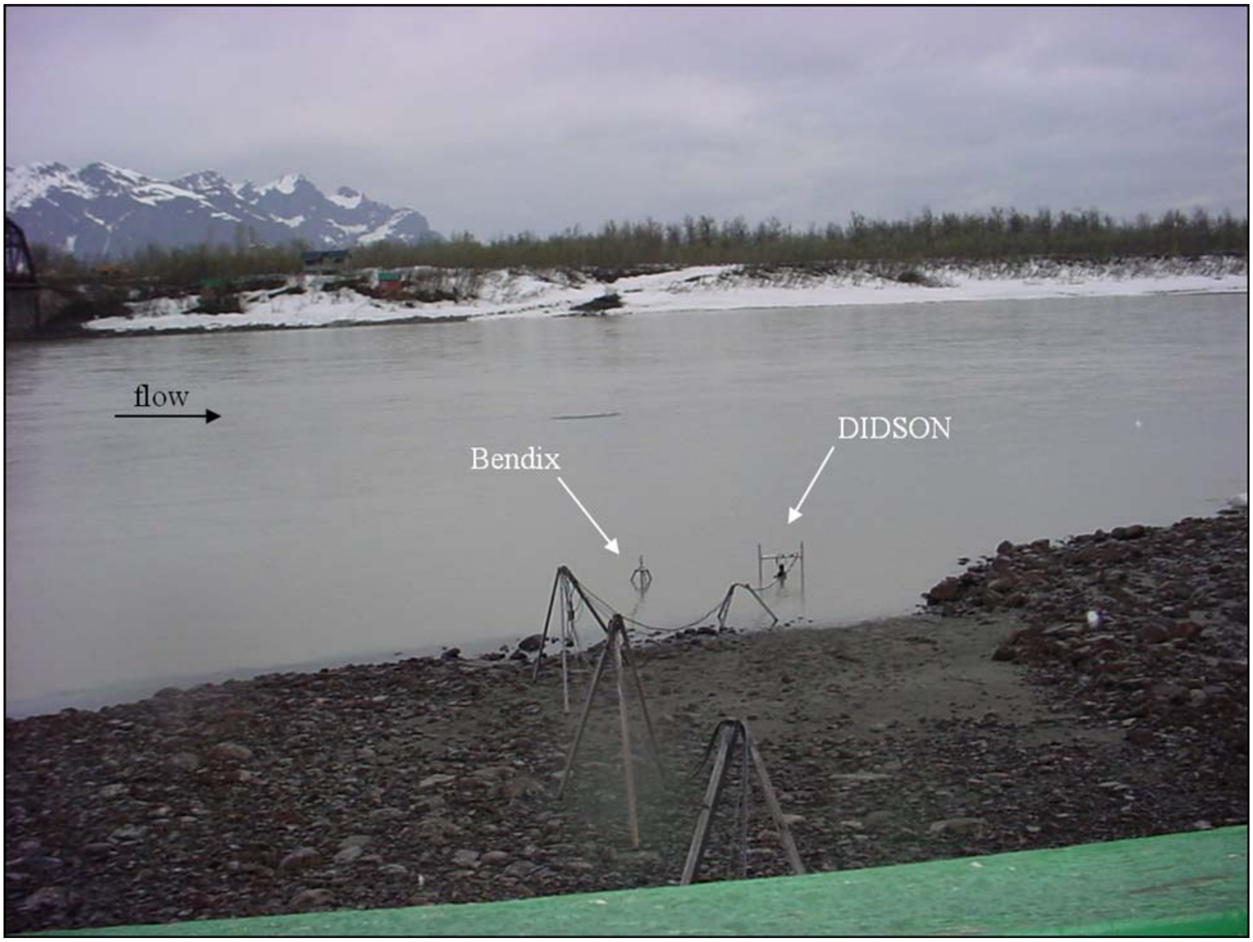
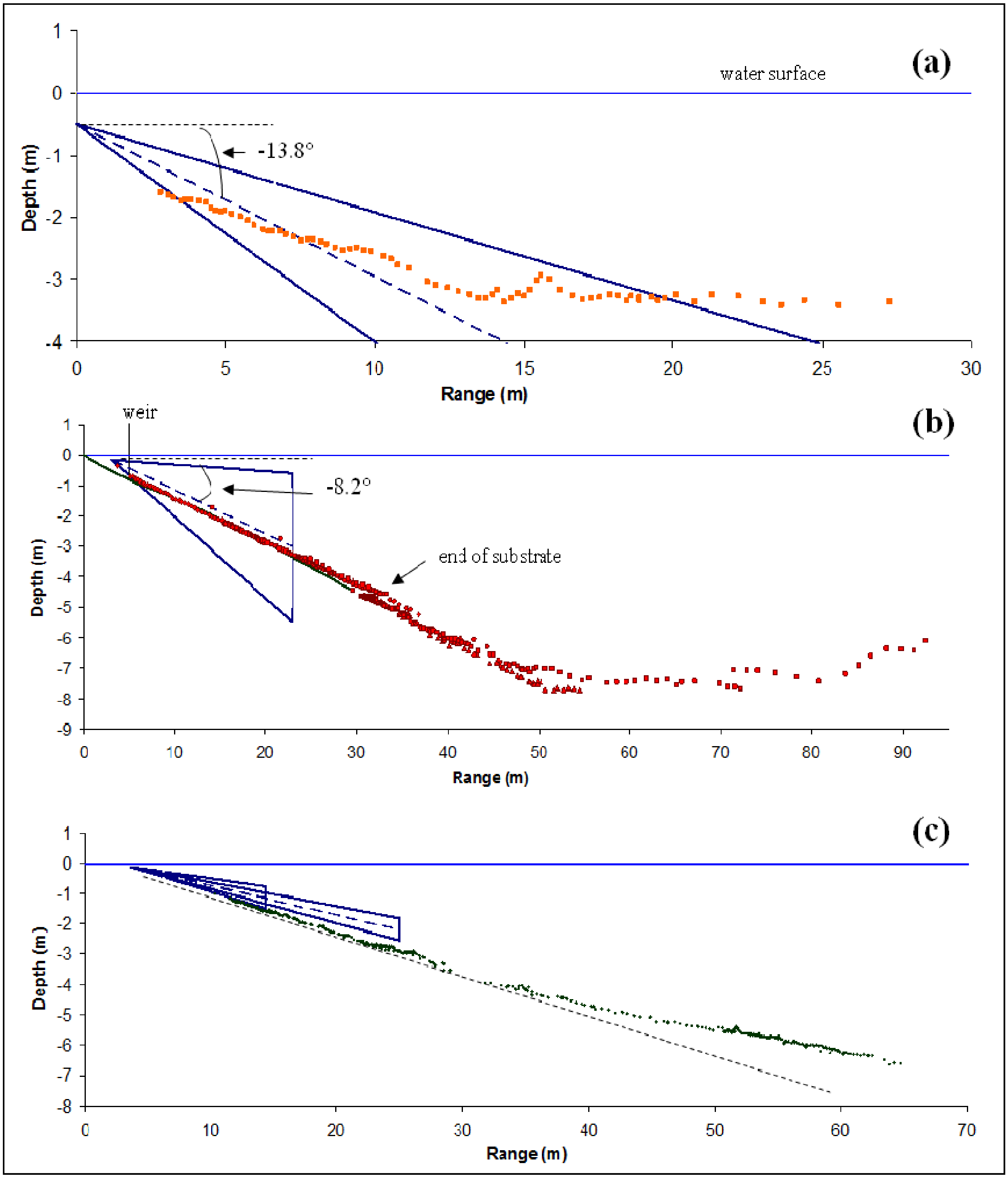


Figure 11.–The Bendix transducer and LR DIDSON deployed side-by-side at the Copper River north bank, Miles Lake sonar, 2005.



Note: Profiles (b) and (c) were created with DIDSON at multiple positions merged based on each transducer position measured from a fixed point along the shore. Tilt angles for the DIDSONs are shown in (a) and (b). The tilt angle for the Bendix beams (c) is unknown.

Figure 12.–River bottom profiles of the Copper River south bank's alternate site (a) and concrete pad and beyond (b) and the north bank site (c), Miles Lake sonar site.

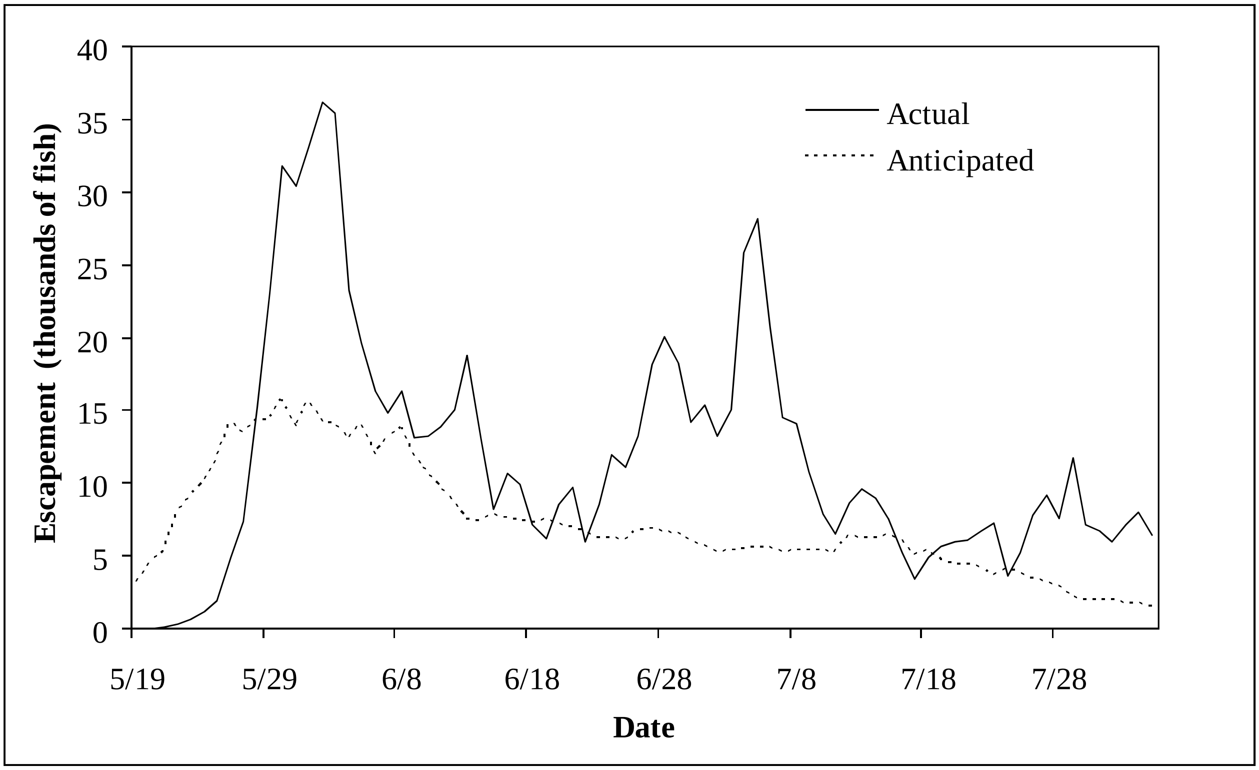


Figure 13.–Daily actual and anticipated salmon escapement estimates for the Copper River, Miles Lake sonar, 2007.

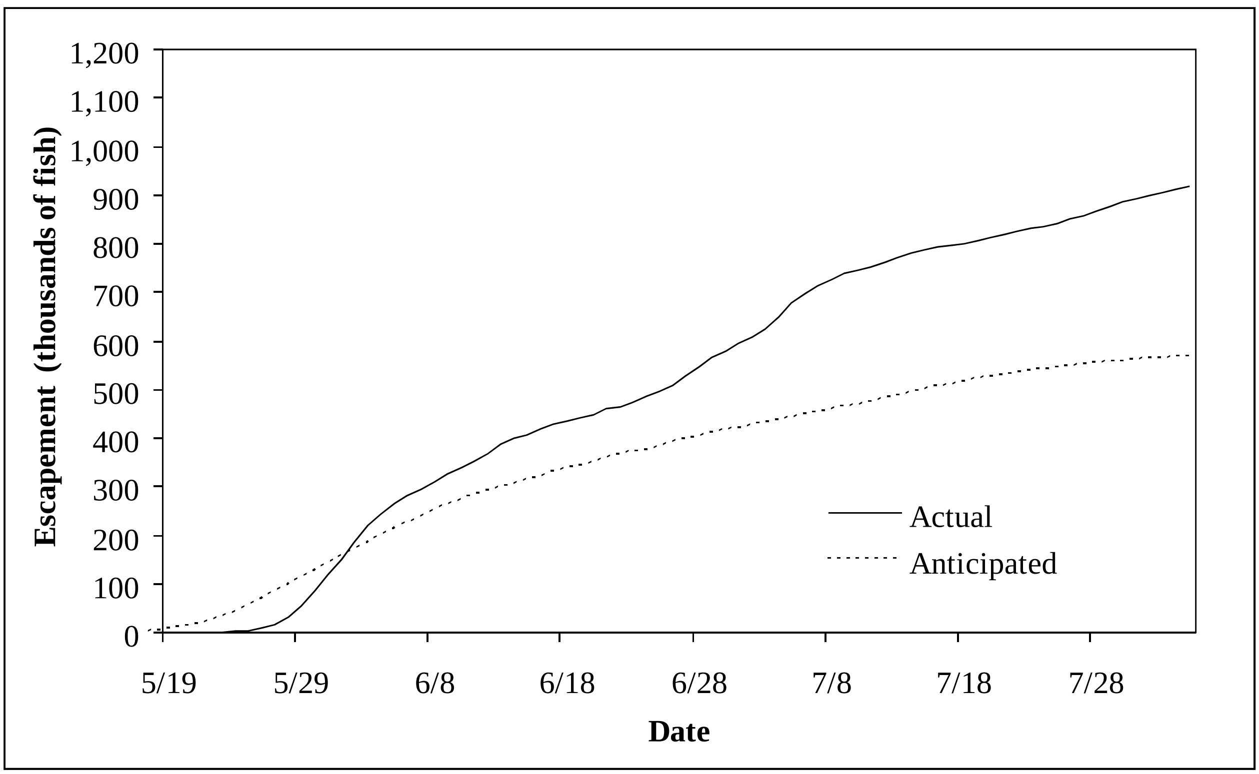


Figure 14.–Cumulative actual and anticipated salmon escapement estimates for the Copper River, Miles Lake sonar, 2007.

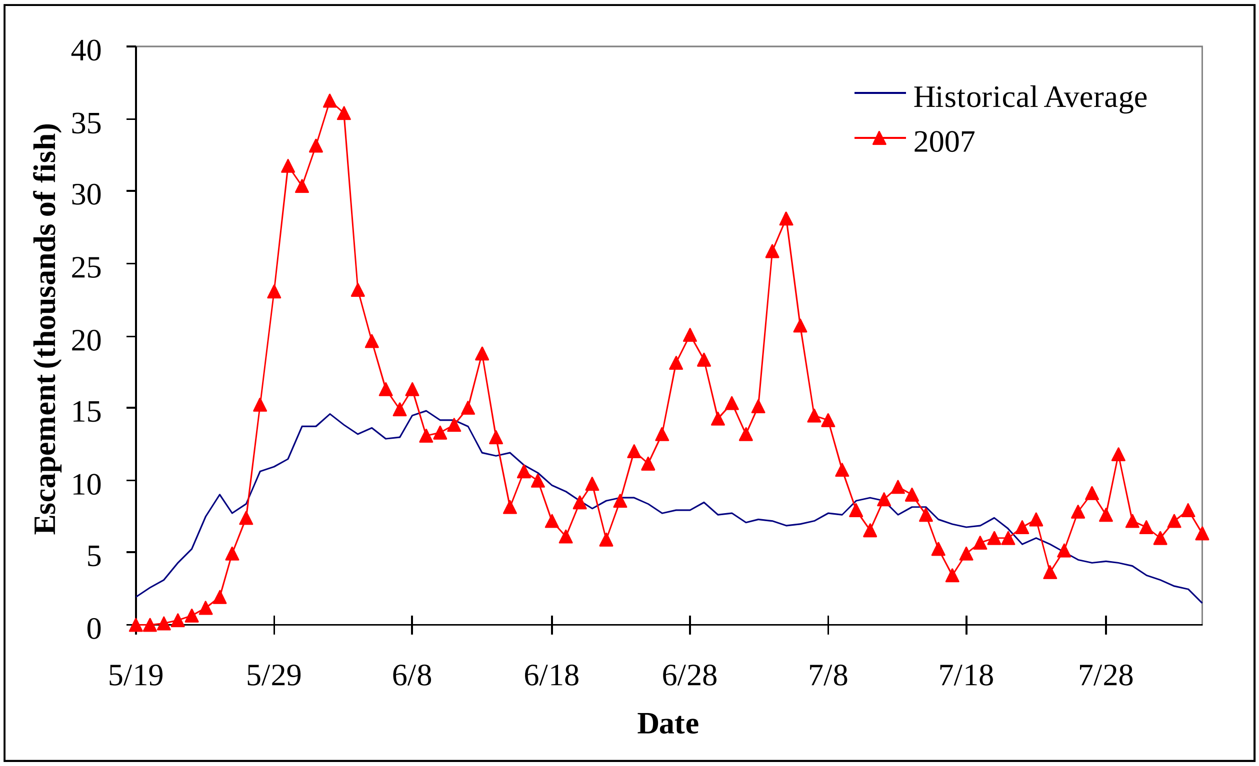


Figure 15.–Daily salmon escapement estimates from 2007 compared against the historical average (1978–2006) for the Copper River, Miles Lake sonar.

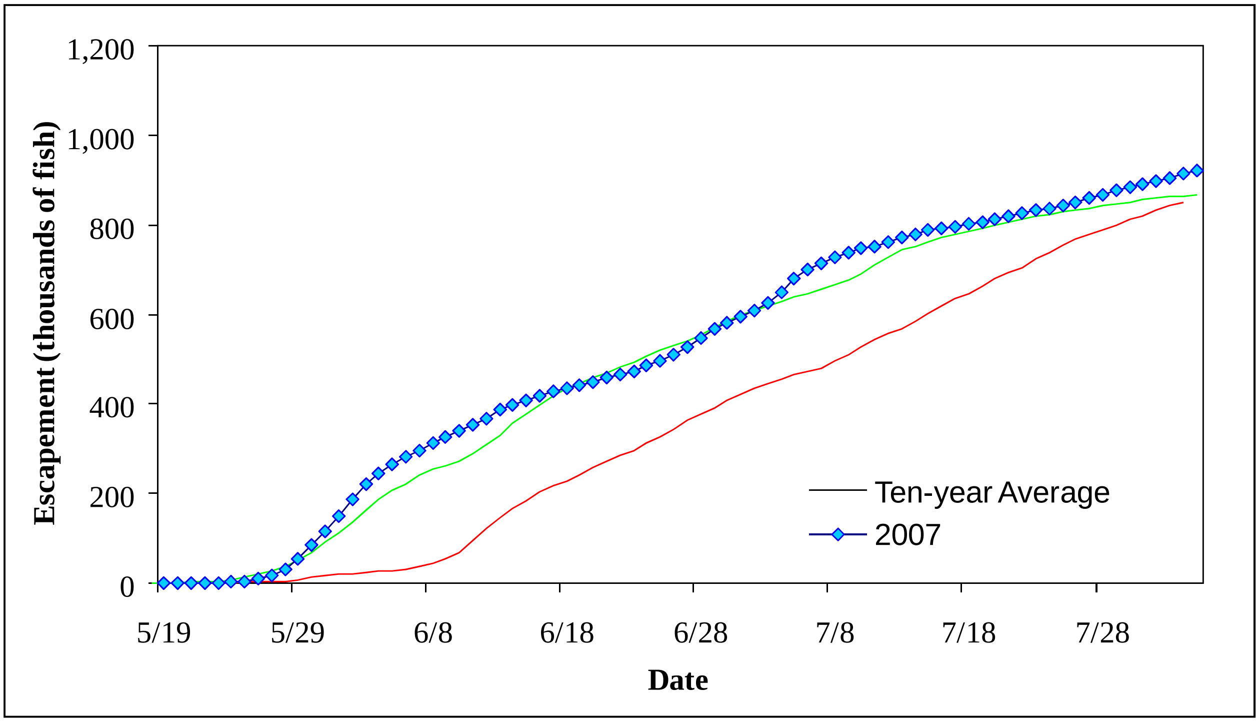


Figure 16.–Cumulative salmon escapement estimates from 2007 compared against the 10-year cumulative average (1998–2007) for the Copper River, Miles Lake sonar.

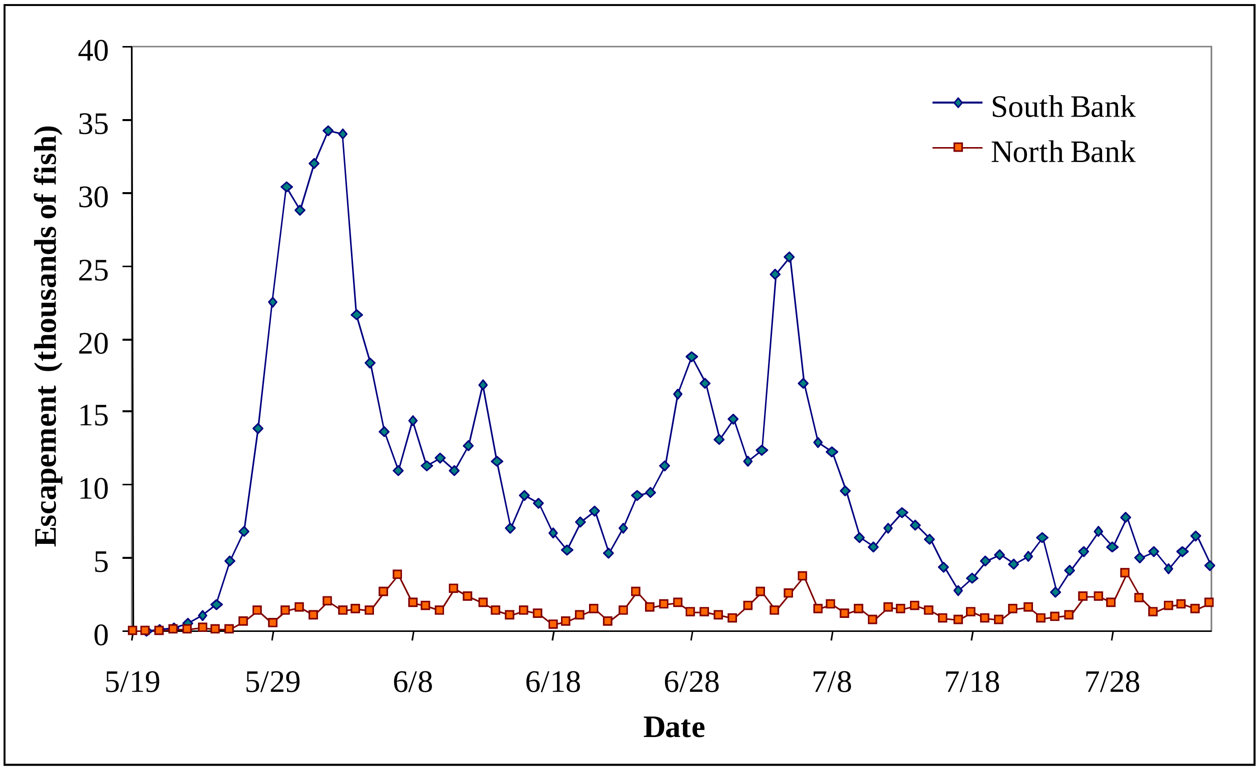
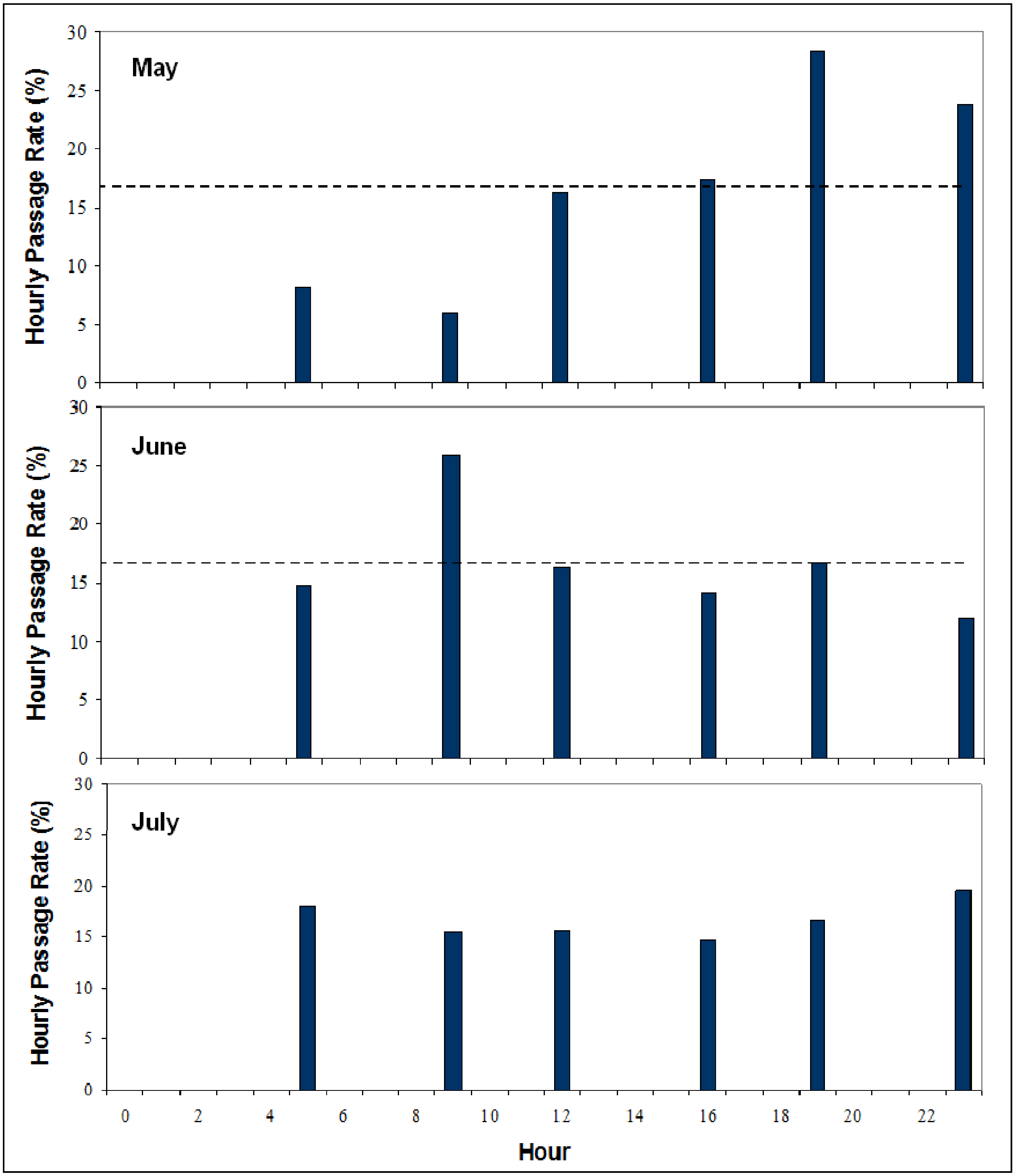
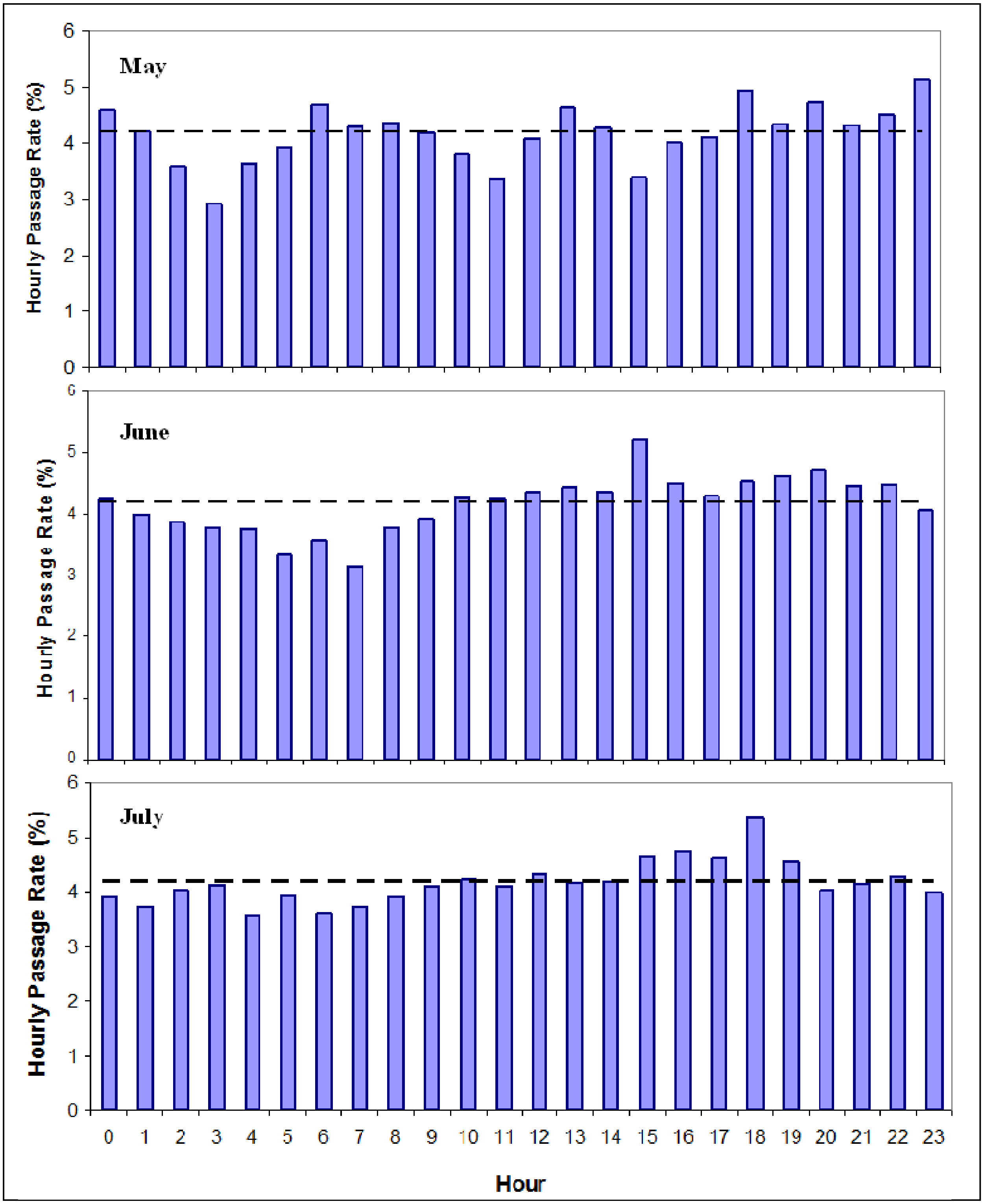


Figure 17.–Daily salmon escapement estimates for the Copper River by bank, Miles Lake sonar, 2007.



Note: The dotted line represents a (hypothetical) constant passage rate.

Figure 18.–Hourly salmon passage rates by month from Bendix counts along the Copper River's north bank, Miles Lake sonar, 2007.



Note: The dotted line represents a (hypothetical) constant passage rate.

Figure 19.–Hourly salmon passage rates by month from DIDSON counts along the Copper River's south bank, Miles Lake sonar, 2007.

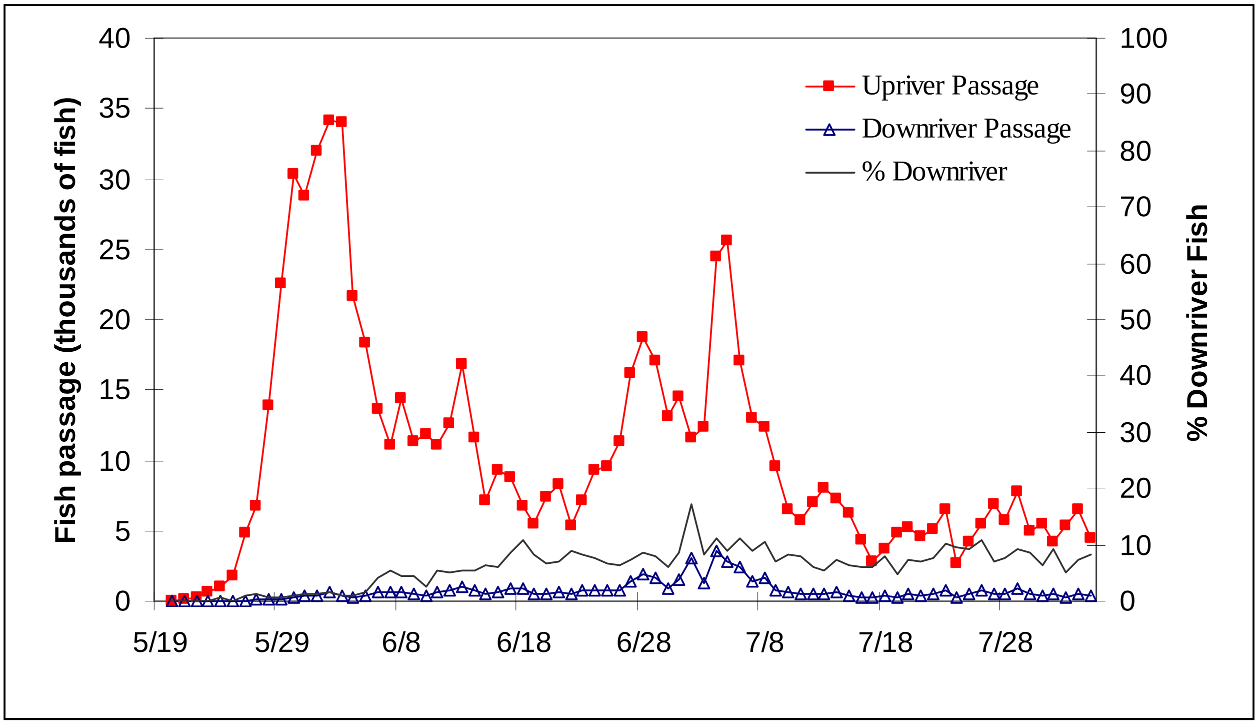


Figure 20.–Daily salmon escapement estimates and percentage of downriver fish for the Copper River's south bank, Miles Lake sonar, 2007.

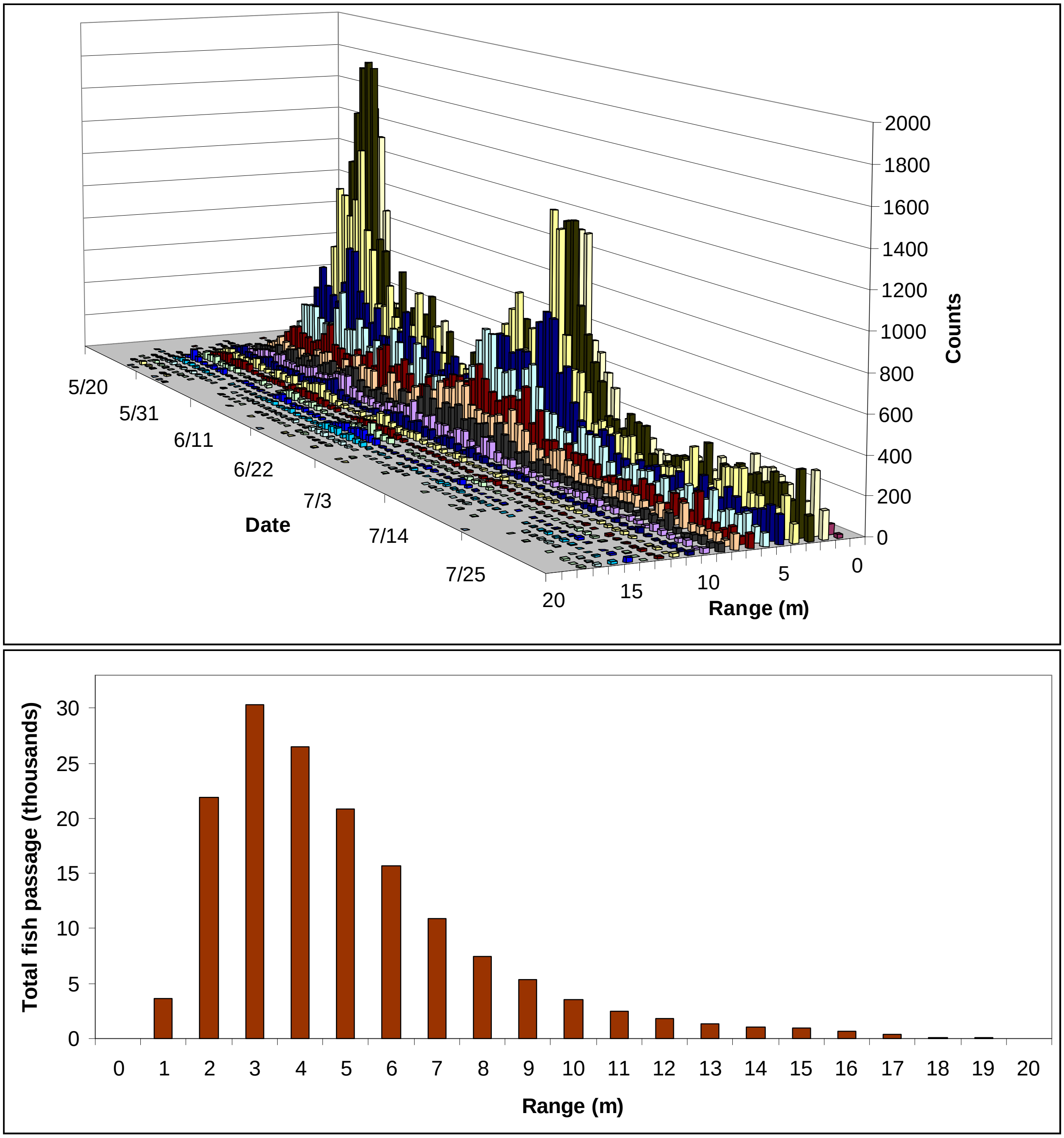


Figure 21.–Range distribution of Copper River south bank salmon escapement by day (top) and total fish passage by range (bottom), Miles Lake sonar, 2007.

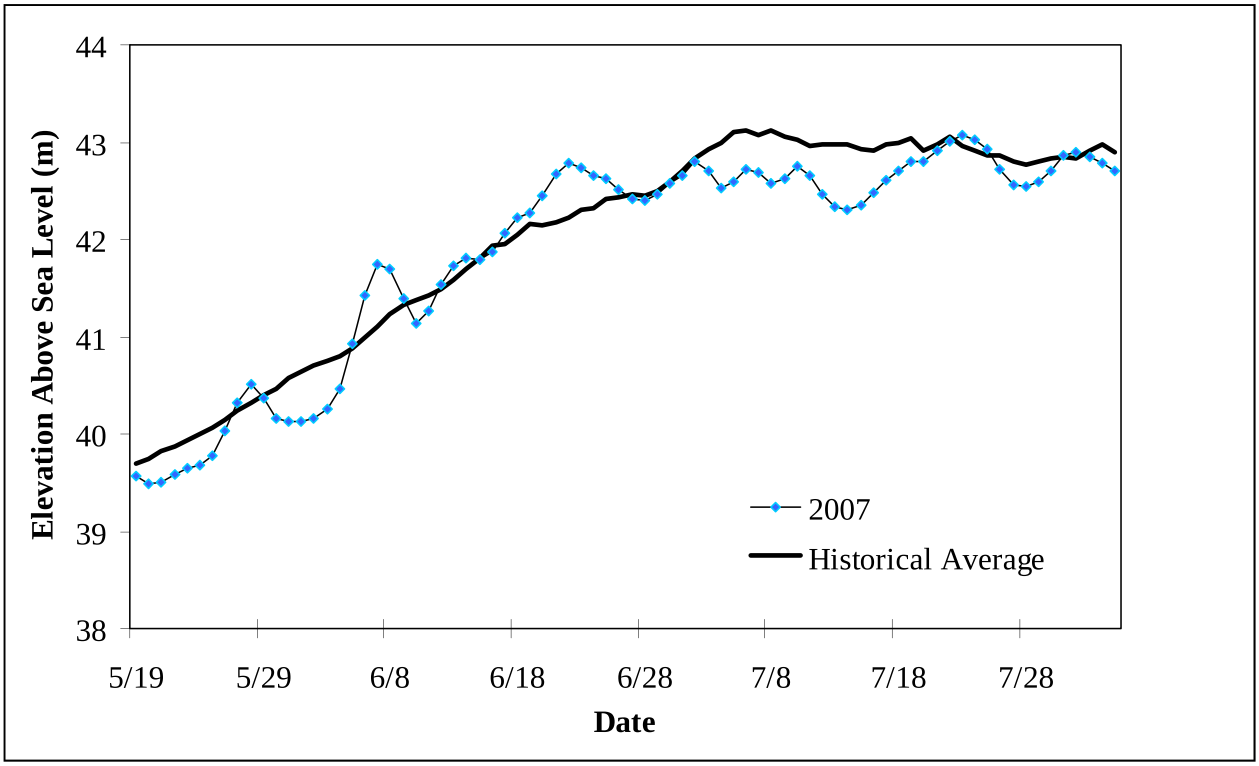


Figure 22.–Water level (elevation above sea level) for 2007 compared against the historical average (1982–2006) for the Copper River, Miles Lake sonar.

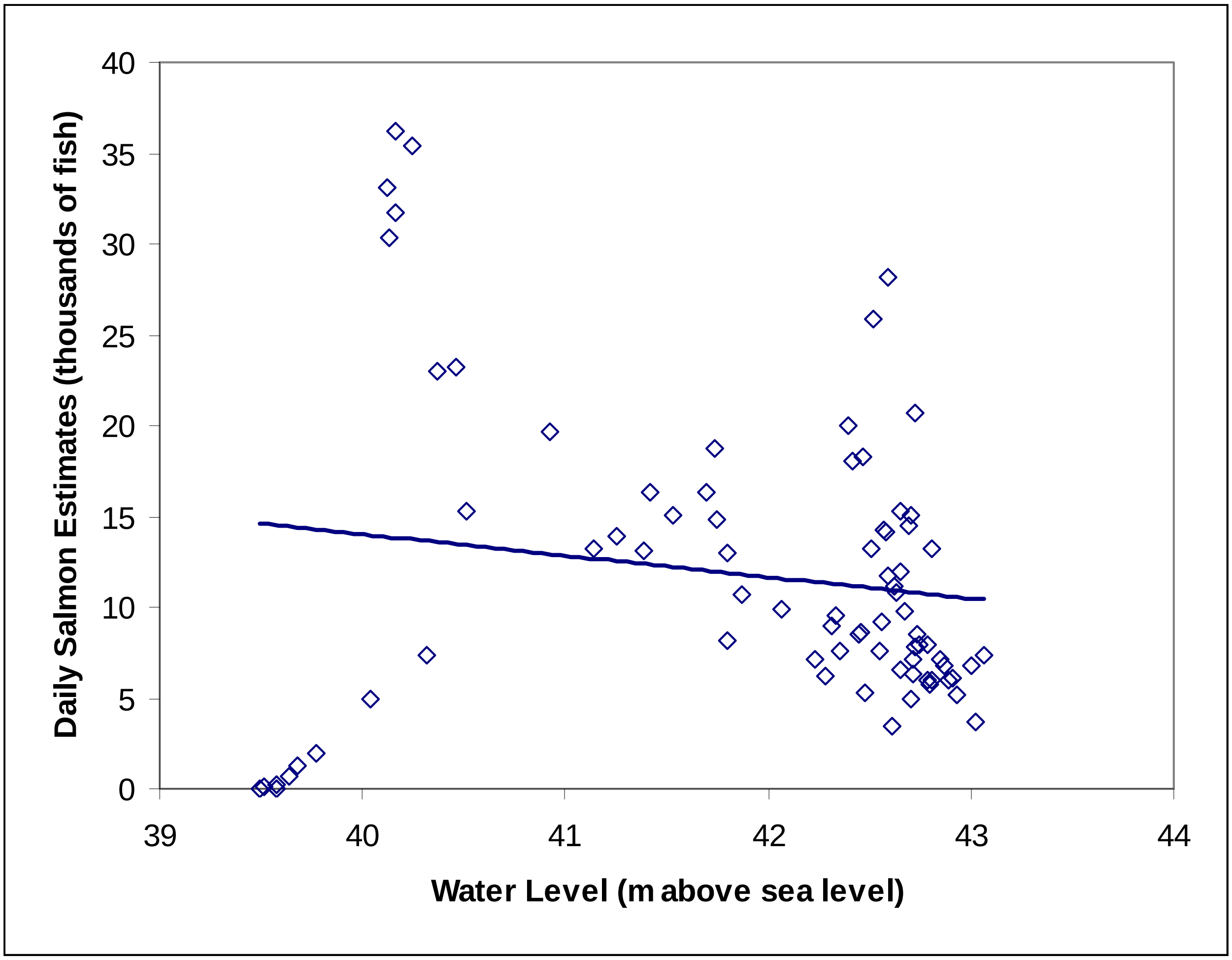


Figure 23.–Water levels compared against fish passage for the Copper River, Miles Lake sonar, 2007.

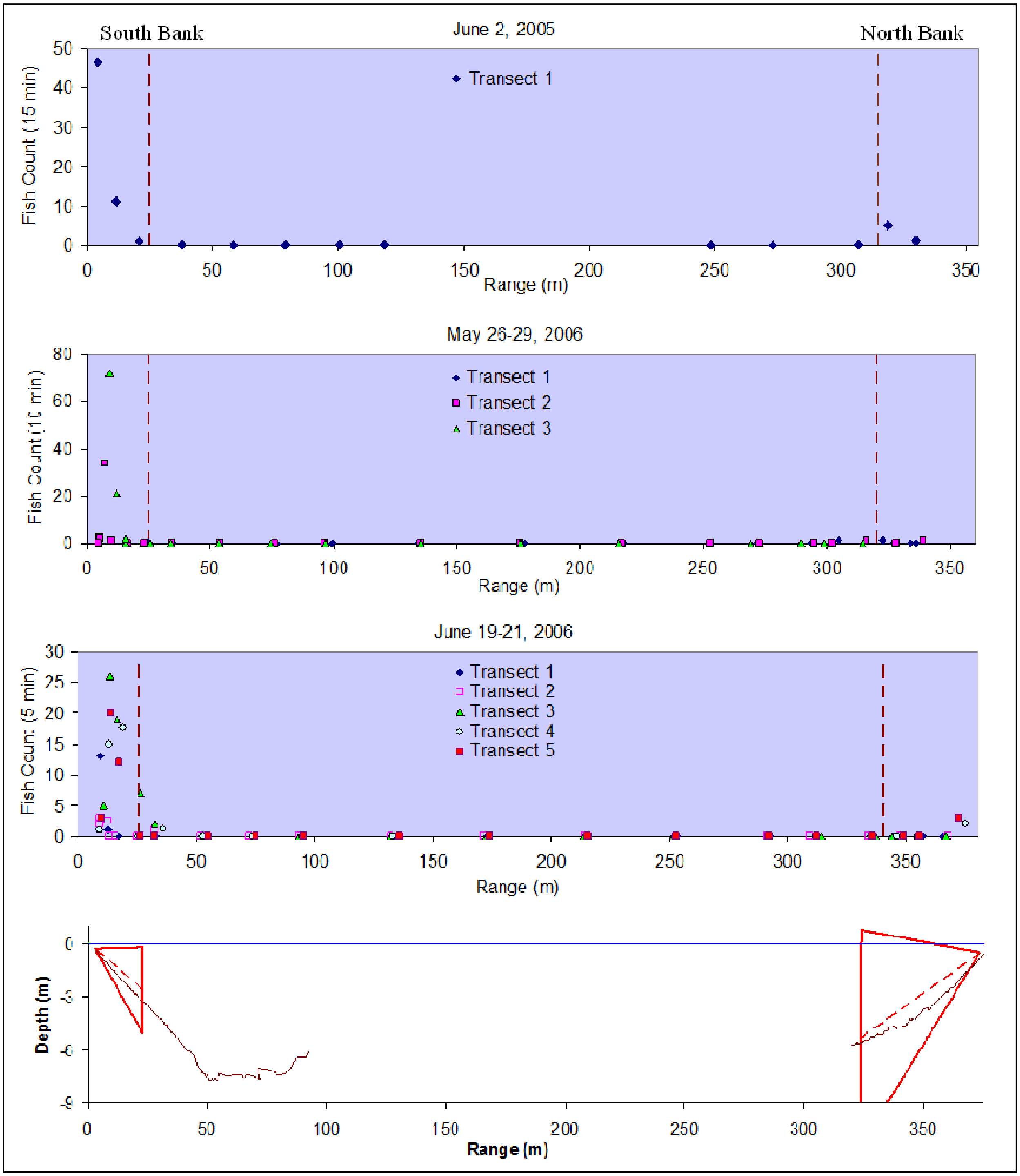


Figure 24.–The Copper River's cross-river fish distribution at the Miles Lake sonar site, obtained using a mobile DIDSON during 3 time periods (top 3 plots); the vertical dotted lines mark the offshore edges of the shore-based DIDSON beams, and the bottom plot shows the outline of those beams along with the river bottom profile.

APPENDIX A

Appendix A1.–Timetable of operation and major changes at the Miles Lake sonar project operated to estimate adult salmon escapement, 1978-2007.

Year	Event

1978

- Sonar project conducted by the Alaska Department of Fish and Game (ADF&G) (Roberson 1978) with federal funding (1978-1981) from the National Marine Fisheries Service under the Anadromous Fish Conservation Act to estimate adult salmon *Oncorhynchus spp.* escapement.
  - Deployed a 1978 model Bendix sonar counter along the south bank (SB).
  - Directed the Bendix transducer beam along an 18.3 m long x 20.3 cm wide aluminum tube substrate positioned perpendicular to current flow.
  - Calibrated counter every 6 h for a total of 4 h/day.
  - Recorded raw amplified echoes received by the transducer on audio cassette tapes for 3.75 min/h (1978-1983).
- Operated 2 fish wheels to assess species composition, provide index of fish passage, and obtain age and length samples (Roberson 1978).
- Conducted a tagging study using gillnets in the commercial fishery; note: no tagged fish recovered at the Miles Lake site, 89% recovered in the commercial fishery zone (Roberson 1978).
- October – Constructed a permanent 26.5 m long, 14% grade, concrete substrate with embedded railroad iron along the SB. The transducer mount was fit to the rail and moved up or down depending on water level.

1979

- Deployed a 1978 model Bendix counter along both south and north banks (Roberson et al. 1982).
  - Aluminum tube substrates used along both banks during low water; moved SB transducer to concrete substrate as water level reached high enough for deployment.
  - Calibrated both counters every 6 h for a total of 4 h/day per counter.

1980

- No significant changes from previous year (Roberson et al. 1982).

1981

- Graded the NB substrate prior to the ’81 season (Roberson et al. 1982).

1982

- Sonar project supported solely by ADF&G.
- Recorded river level relative to the SB permanent substrate offshore end twice a day.
- Measured water velocity along the length of the SB permanent substrate with a Gurley current flow meter (Merritt and Roberson 1983)

1983

- Grading on NB prior to and after season during low water levels. A 2° slope with a steep drop-off offshore was changed to a consistent 6° slope (Merritt and Roberson 1984).

1984

- Test fishing program at the sonar site with set and drift gillnets from 1984-1987 (Brady 1986; Morstad et al. 1991). Few fish were captured and the program was ended.

-continued-

1984

- In the fall, the NB site was graded with a D-8 Caterpillar tractor. The natural substrate was built up 3 ft nearshore and graded down 3 ft offshore, generating a uniform slope of ~7% extending ~235 ft in front of the shed (Brady 1986). Done to provide an improved surface for substrateless deployments.

1985

- 1978 model Bendix counters used, a modified 1981 model with long range capability deployed for a portion of the season (Brady 1986).
- Sonar deployment over natural river bottom first tried on NB.

1986

- Sonar project (Morstad et al. 1991).
    - A modified 1981 and a new 1985 model Bendix counter used on the SB (each used for half of the season). New 1984 and 1985 model Bendix counters used on the NB (each used for half of the season).
    - Water level now measured at a U.S. Geological Survey gauge mounted on the Million Dollar Bridge, Copper River height relative to elevation above sea level.
    - NB transducer deployed on natural substrate. Aluminum tubes no longer used.
    - Automated rotator tested on NB.
- Test fishing program – beach seining first tried, but few fish were captured (Morstad et al. 1991).
- On the NB, 2 transducers were compared for 3 days at separate sites using a new Bendix 1984 model counter. Data was recorded alternatively for each transducer in 30-min periods. (Morstad et al. 1991).
- Efforts made to map the river bottom at the sonar and test fishing sites using a portable Lowrance echosounder, (Morstad et al. 1991).

1987

- A 1985 model Bendix counter was used on both banks until July 27 when the NB unit was moved to the SB to replace a malfunctioning counter and a 1978 model was used on NB; NB automated rotator malfunctioned mid-season, so transducer was manually adjusted (Morstad et al. 1991).
- Examined the river bottom around the steel piling adjacent to the partially collapsed bridge span on NB with a portable echosounder.

1988

- 1985 model Bendix counters used on the SB and NB with two 1981 counters available as spares (Morstad 1992).
- Calibrated counters every 2 h (SB) and every 4 h (NB) for 30 min or until 100 fish were counted.

1989-1991

- No significant changes from previous year (Morstad 1992).

1992

- Calibrated counters every 3 h (SB) and every 4 h (NB) for 30 min or until 100 fish were counted (Morstad 1993).

1993

- No significant changes from previous year (Morstad 1994).

-continued-

1994

- SB aluminum tube no longer used during low water (Morstad 1994). Deployed transducer on a tripod and manually counted fish for 30 min every hour expanding to an hourly count until the transducer was mounted on the rail of the concrete substrate.

1995

- Lower portion of the SB concrete substrate damaged by an iceberg requiring a higher water level before transferring transducer from tripod to concrete substrate (Morstad 1997).

1996-2000

- No significant changes from previous year (Morstad 1997, 1999; Dunbar 1999, 2001).

2001

- Last day of counting set at July 31 (2001-2006) (Dunbar 2001); the end date has varied from July 25 to August 9 since 1978.
- In October, a 26.5 x 5 m concrete substrate was constructed on SB, 30 m downriver from old substrate.

2002

- A 1978 model Bendix counter was used on NB (Smith and Lewis 2006).
- Preliminary testing of DIDSON sonar on the new SB concrete substrate (Maxwell and Gove 2004).
- A new SB sonar shack was constructed.

2003

- A 1985 model Bendix counter was used on NB (Smith and Lewis 2006).
    - Visual oscilloscope only counts conducted on the NB for 30-min, 6 times daily; no sector (range) data available (2003-2007).
- SB - Year 1 of 2-year comparison study between standard-range (SR) DIDSON and Bendix counter .

2004

- SB - Year 2 of 2-year SR DIDSON vs. Bendix comparison study.
- Construction crews raised the collapsed span of the Million Dollar Bridge (upriver of the NB site) during the field season. A construction pad around the NB bridge abutment and a temporary bridge leading to it was installed, altering the NB flow pattern (Smith and Lewis 2006).

2005

- SB - SR DIDSON first used for management purposes, installed on the new concrete pad (Faulkner and Maxwell 2008).
- NB - Year 1 of 3-year long-range (LR) DIDSON vs. Bendix comparison study.
- Cross-river tests conducted with a mobile DIDSON.
- Million Dollar Bridge construction pad (upriver of NB site) no longer visible on surface and temporary bridge removed before the season; construction ended in June.

-continued-

Appendix A1.–Page 4 of 4.

2006

- NB - Year 2 of 3-year LR DIDSON vs. Bendix comparison study.
- Cross-river tests conducted with a mobile DIDSON.
- Phone and internet connection established at the sonar site.

2007

- NB - Year 3 of 3-year LR DIDSON vs. Bendix comparison study.
- Deployed SB DIDSON 395 m downriver of the concrete substrate from May 20-26 because of shore ice.
- Last day of counting extended to August 4 because of higher fish passage during this time period.

Appendix A2.–Salmon escapement estimates from the Miles Lake sonar site at the Copper River, 2007.

Date		Water Level (m)	North Bank	South Bank	Daily	Cumulative	Minimum Escapement Objective Daily	Minimum Escapement Objective Cumulative	0600 Count	Anticipated Daily
16 May		ND	ND	ND	ND	ND	378	378	ND	ND
17 May		ND	ND	ND	ND	ND	599	977	ND	ND
18 May		ND	ND	ND	ND	ND	1,798	2,776	ND	ND
19 May	[a]	39.58	0	ND	0	0	3,157	5,933	ND	ND
20 May	[a, b]	39.49	0	6	6	6	4,599	10,532	ND	ND
21 May	[a]	39.51	48	75	123	129	5,192	15,725	12	48
22 May	[a]	39.58	72	204	276	405	7,989	23,713	24	96
23 May	[a]	39.64	114	579	693	1,098	9,116	32,830	144	576
24 May	[a]	39.68	162	1,056	1,218	2,316	10,063	42,892	174	696
25 May		39.78	112	1,788	1,900	4,216	11,484	54,376	432	1,728
26 May	[c]	40.04	112	4,800	4,912	9,128	14,167	68,543	1,074	4,296
27 May		40.32	595	6,774	7,369	16,497	13,409	81,952	852	3,408
28 May		40.51	1,336	13,896	15232	31,729	14,261	96,212	2,832	11,328
29 May		40.36	496	22,512	23,008	54,737	14,316	110,528	4,746	18,984
30 May		40.17	1,376	30,378	31,754	86,491	15,627	126,155	6,924	27,696
31 May		40.13	1,616	28,764	30,380	116,871	13,707	139,862	8,802	35,208
1 Jun		40.12	1,080	32,022	33,102	149,973	15,725	155,587	6,036	24,144
2 Jun		40.16	2,016	34,188	36,204	186,177	14,218	169,805	7,998	31,992
3 Jun		40.25	1,352	34,020	35,372	221,549	14,088	183,893	8,034	32,136
4 Jun		40.46	1,520	21,690	23,210	244,759	12,992	196,886	5,658	22,632
5 Jun		40.93	1,360	18,318	19,678	264,437	14,123	211,009	6,030	24,120
6 Jun		41.42	2,656	13,677	16,333	280,770	11,998	223,006	3,369	13,475
7 Jun		41.74	3,824	11,034	14,858	295,628	13,160	236,166	3,216	12,864
8 Jun		41.70	1,904	14,382	16,286	311,914	13,782	249,949	3,114	12,456
9 Jun		41.39	1,752	11,352	13,104	325,018	11,870	261,819	3,414	13,656
10 Jun		41.14	1,384	11,880	13,264	338,282	10,636	272,455	3,390	13,560
11 Jun		41.26	2,856	11,022	13,878	352,160	9,710	282,166	3,198	12,792
12 Jun		41.53	2,368	12,654	15,022	367,182	8,588	290,753	2,466	9,864
13 Jun		41.73	1,944	16,840	18,784	385,966	7,489	298,242	4,294	17,175
14 Jun		41.80	1,432	11,592	13,024	398,990	7,313	305,554	3,714	14,856
15 Jun		41.79	1,088	7,074	8,162	407,152	7,738	313,292	1,854	7,416
16 Jun		41.87	1,376	9,264	10,640	417,792	7,544	320,837	1,740	6,960
17 Jun		42.06	1,160	8,778	9,938	427,730	7,470	328,306	3,102	12,408
18 Jun		42.23	456	6,720	7,176	434,906	7,234	335,541	1,926	7,704
19 Jun		42.28	656	5,507	6,163	441,069	7,468	343,008	1,638	6,552
20 Jun		42.45	1,088	7,428	8,516	449,585	7,101	350,109	1,878	7,512
21 Jun		42.67	1,504	8,232	9,736	459,321	6,915	357,024	2,196	8,784
22 Jun		42.78	608	5,340	5,948	465,269	6,628	363,652	1,686	6,744
23 Jun		42.73	1,440	7,092	8,532	473,801	6,194	369,846	2,028	8,112
24 Jun		42.65	2,680	9,300	11,980	485,781	6,148	375,995	2,994	11,976
25 Jun		42.62	1,600	9,510	11,110	496,891	6,058	382,053	2,502	10,008
26 Jun		42.50	1,864	11,340	13,204	510,095	6,758	388,811	2,076	8,304

-continued-

Appendix A2.–Page 2 of 2.

Date	Water Level (m)	North Bank	South Bank	Daily	Cumulative	Minimum Escapement Objective Daily	Minimum Escapement Objective Cumulative	0600 Count	Anticipated Daily
27 Jun	42.41	1,888	16,200	18,088	528,183	6,789	395,600	2,856	11,424
28 Jun	42.40	1,248	18,762	20,010	548,193	6,627	402,226	4,536	18,144
29 Jun	42.47	1,280	17,010	18,290	566,483	6,487	408,713	5,706	22,824
30 Jun	42.57	1,120	13,116	14,236	580,719	5,983	414,696	3,672	14,688
1 Jul	42.66	832	14,478	15,310	596,029	5,651	420,347	4,020	16,080
2 Jul	42.81	1,664	11,574	13,238	609,267	5,221	425,568	4,008	16,032
3 Jul	42.71	2,656	12,420	15,076	624,343	5,337	430,906	3,174	12,696
4 Jul	42.52	1,424	24,414	25,838	650,181	5,416	436,322	5,172	20,688
5 Jul	42.59	2,520	25,596	28,116	678,297	5,500	441,822	9,708	38,832
6 Jul	42.73	3,728	17,010	20,738	699,035	5,550	447,372	6,330	25,320
7 Jul	42.69	1,536	12,948	14,484	713,519	5,243	452,616	2,520	10,080
8 Jul	42.58	1,800	12,306	14,106	727,625	5,302	457,917	3,474	13,896
9 Jul	42.63	1,176	9,582	10,758	738,383	5,370	463,287	2,298	9,192
10 Jul	42.75	1,456	6,450	7,906	746,289	5,299	468,586	2,010	8,040
11 Jul	42.65	736	5,784	6,520	752,809	5,217	473,804	1,398	5,592
12 Jul	42.46	1,600	7,062	8,662	761,471	6,407	480,211	1,824	7,296
13 Jul	42.34	1,480	8,070	9,550	771,021	6,147	486,357	2,112	8,448
14 Jul	42.31	1,664	7,302	8,966	779,987	6,223	492,581	2,022	8,088
15 Jul	42.35	1,376	6,246	7,622	787,609	6,447	499,028	1,674	6,696
16 Jul	42.48	848	4,392	5,240	792,849	6,075	505,102	1,398	5,592
17 Jul	42.61	696	2,760	3,456	796,305	5,008	510,110	588	2,352
18 Jul	42.70	1,240	3,666	4,906	801,211	5,283	515,393	684	2,736
19 Jul	42.80	864	4,830	5,694	806,905	4,678	520,071	1,710	6,840
20 Jul	42.80	744	5,244	5,988	812,893	4,356	524,427	1,554	6,216
21 Jul	42.91	1,520	4,536	6,056	818,949	4,367	528,794	1,488	5,952
22 Jul	43.00	1,648	5,124	6,772	825,721	4,193	532,987	1,602	6,408
23 Jul	43.07	856	6,444	7,300	833,021	3,670	536,658	1,500	6,000
24 Jul	43.03	984	2,652	3,636	836,657	4,091	540,749	1,194	4,776
25 Jul	42.93	1,040	4,152	5,192	841,849	3,821	544,570	864	3,456
26 Jul	42.72	2,400	5,418	7,818	849,667	3,378	547,948	2,250	9,000
27 Jul	42.56	2,304	6,858	9,162	858,829	3,174	551,122	2,340	9,360
28 Jul	42.55	1,872	5,742	7,614	866,443	2,929	554,051	1,014	4,056
29 Jul	42.59	3,952	7,818	11,770	878,213	2,161	556,212	2,106	8,424
30 Jul	42.71	2,200	4,962	7,162	885,375	1,909	558,121	1,674	6,696
31 Jul	42.87	1,240	5,490	6,730	892,105	1,963	560,084	642	2,568
1 Aug	42.89	1,720	4,266	5,986	898,091	1,886	561,971	1,182	4,728
2 Aug	42.85	1,784	5,394	7,178	905,269	1,739	563,710	1,230	4,920
3 Aug	42.78	1,456	6,516	7,972	913,241	1,723	565,433	2,316	9,264
4 Aug	42.71	1,920	4,440	6,360	919,601	1,485	566,918	1,854	7,416

[a] North bank Bendix deployed on 19 May. Counts were collected for 8 hours each day and expanded to 24 hours up to the 24 May, after which date, counts were scheduled for 6 hours daily and expanded to 24 hours.

[b] South bank DIDSON deployed 395m downriver of substrate and operated for 2 h on May 20; counts not expanded. May 21 is the first complete day of sampling on the south bank.

[c] South bank DIDSON moved to substrate on 26 May.

Appendix A3.–Daily salmon escapement estimates from the Miles Lake sonar site at the Copper River, 1978–2007.

Date	1978[a]	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
09 May													
10 May													
11 May													
12 May													
13 May													
14 May													
15 May													
16 May													
17 May				5,372								732	
18 May		381	218	9,665								3,660	
19 May		487	167	11,409			725				313	6,588	
20 May		847	221	10,733			1,924				877	6,935	
21 May		1,199	88	9,729			1,986				1,440	4,834	1,121
22 May		1,916	391	7,558			5,124			482	2,256	4,030	4,843
23 May		2,901	594	6,214		3,310	5,042			1,601	5,078	6,472	7,177
24 May		3,402	494	12,985	90	8,620	4,486			1,805	11,033	7,448	11,923
25 May		2,397	713	12,816	493	11,587	3,120		611	3,888	9,979	4,658	14,333
26 May	502	4,927	1,057	6,383	1,023	10,575	4,645		1,694	6,976	8,946	8,318	11,337
27 May	837	6,821	2,115	2,842	12,091	8,661	5,836		2,092	12,176	13,247	13,143	12,060
28 May	1,047	2,768	1,693	2,560	47,303	8,456	4,978	1,031	3,384	16,022	14,201	13,880	7,434
29 May	661	3,905	1,080	2,160	19,671	6,380	7,126	417	2,738	14,485	10,022	10,677	9,176
30 May	3,241	7,482	1,903	11,822	8,781	8,296	4,951	599	3,173	17,757	6,806	5,375	9,541
31 May	2,549	8,655	3,620	21,126	11,389	17,123	4,278	1,758	4,150	18,540	7,586	7,316	10,343
01 Jun	2,616	4,078	5,257	18,415	15,385	18,428	8,536	3,462	7,001	16,350	5,205	7,041	10,026
02 Jun	2,811	3,465	7,061	23,771	17,213	14,414	8,483	6,726	20,638	14,385	3,558	5,234	9,909
03 Jun	1,837	3,536	7,437	16,716	13,383	13,137	9,730	10,691	20,237	17,666	4,626	6,867	8,576
04 Jun	3,256	2,778	8,996	9,755	12,355	15,357	12,496	24,272	26,626	14,632	7,877	8,555	7,572
05 Jun	2,970	4,352	9,746	10,478	14,806	19,110	16,728	30,507	27,934	10,962	6,755	7,512	10,173
06 Jun	3,318	6,453	5,407	11,975	15,585	14,069	18,097	32,953	14,527	4,322	8,895	7,719	10,410
07 Jun	3,808	7,031	2,093	13,585	12,506	19,309	18,515	27,256	9,658	5,755	9,096	12,693	11,137
08 Jun	3,275	11,078	1,349	14,412	8,430	16,094	26,619	30,925	24,938	6,366	11,322	14,565	7,637
09 Jun	2,252	7,985	3,543	15,694	7,017	11,415	20,476	29,702	28,242	7,922	14,641	9,440	9,905
10 Jun	3,475	5,205	7,301	12,856	7,599	8,009	19,275	12,010	29,952	11,553	15,216	12,126	11,660
11 Jun	2,490	4,426	12,032	7,877	7,879	9,563	17,237	11,826	25,418	11,194	16,255	9,663	16,181
12 Jun	2,082	2,227	11,584	4,844	8,587	13,292	21,706	8,231	16,503	6,506	14,959	8,256	23,929

-continued-

Appendix A3.–Page 2 of 6.

Date	1978[a]	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
13 Jun	2,419	3,903	7,600	3,556	9,932	13,444	12,072	6,829	11,453	4,053	10,751	10,626	24,448
14 Jun	2,835	2,563	5,661	5,228	12,551	13,831	5,981	6,800	11,393	8,053	9,382	13,548	14,302
15 Jun	2,913	3,351	7,308	7,071	12,677	15,915	10,291	8,825	8,747	5,485	9,910	9,922	8,390
16 Jun	2,782	3,473	5,655	6,885	13,595	7,938	13,930	9,347	10,099	5,516	6,484	8,889	10,112
17 Jun	2,779	4,640	7,189	6,467	12,030	5,671	19,809	6,270	8,772	5,406	4,910	10,020	12,695
18 Jun	2,261	3,911	6,741	4,565	6,544	5,689	12,850	3,738	9,050	4,815	6,469	11,131	8,052
19 Jun	3,035	3,413	2,391	2,985	4,369	6,461	7,474	3,251	7,910	3,983	7,855	8,345	9,763
20 Jun	3,035	1,954	3,597	2,891	3,352	7,382	9,258	2,423	7,240	3,933	7,952	7,575	9,315
21 Jun	2,515	2,223	4,142	3,446	3,346	8,124	7,159	2,061	6,741	3,924	5,770	7,169	10,292
22 Jun	2,068	2,585	3,954	3,997	4,467	8,005	5,522	2,763	9,026	5,779	6,985	8,868	10,157
23 Jun	2,841	2,865	3,896	4,363	7,031	7,528	5,913	3,369	8,010	10,111	7,699	5,850	10,166
24 Jun	2,616	1,877	5,217	4,651	6,329	6,009	6,741	2,950	6,968	15,708	5,582	3,927	9,340
25 Jun	2,130	3,013	5,104	3,398	4,903	5,226	6,503	1,585	5,731	16,517	5,597	2,996	10,010
26 Jun	1,771	1,973	3,595	2,412	4,416	5,638	4,385	2,381	5,410	12,476	6,378	3,426	6,812
27 Jun	2,178	1,315	3,421	2,507	2,732	4,738	7,224	3,035	5,153	7,010	6,559	3,240	9,234
28 Jun	1,103	1,697	4,324	2,949	2,174	4,771	6,728	2,264	5,022	5,644	6,259	6,302	6,881
29 Jun	1,604	1,450	3,845	3,421	2,130	4,304	4,453	2,147	3,578	6,836	8,220	6,490	4,499
30 Jun	1,632	1,899	3,465	2,378	2,313	6,146	6,449	2,139	3,771	4,636	6,497	7,354	3,975
01 Jul	1,587	2,651	3,559	2,723	2,190	6,106	8,226	2,620	3,584	2,012	5,602	7,930	4,323
02 Jul	2,533	2,524	3,365	2,606	4,420	6,113	7,554	2,608	3,152	3,406	4,680	5,296	5,067
03 Jul	2,527	2,859	4,104	2,548	5,751	6,026	8,581	1,819	2,311	4,096	4,222	4,976	4,682
04 Jul	2,980	3,806	2,934	4,094	5,245	6,943	6,515	3,536	1,805	7,100	3,532	7,369	5,665
05 Jul	2,269	3,008	2,879	4,256	4,995	5,347	6,662	3,254	1,499	4,351	3,304	10,739	7,998
06 Jul	1,623	1,996	3,025	3,476	6,300	3,973	5,449	4,664	2,808	3,393	3,510	10,024	7,749
07 Jul	1,152	892	3,291	3,863	6,171	4,209	4,040	3,627	2,991	5,617	4,324	10,236	5,700
08 Jul	831	2,091	2,995	3,774	3,990	4,080	3,906	3,893	2,860	6,616	8,499	11,113	5,192
09 Jul	947	3,190	2,817	3,449	2,210	3,353	3,210	6,827	3,077	6,352	5,167	10,761	5,153
10 Jul	1,252	4,209	3,642	2,942	2,070	3,644	2,927	10,607	5,435	8,585	6,347	9,506	6,620
11 Jul	841	3,684	5,763	2,271	1,980	4,454	3,608	5,457	5,115	5,322	7,620	8,453	5,402
12 Jul	341	3,262	4,788	2,468	3,420	4,541	4,280	6,329	5,042	5,757	7,881	11,953	9,338
13 Jul	167	3,144	1,725	2,265	4,032	4,543	4,582	5,252	3,696	6,583	7,087	9,329	11,432
14 Jul	290	4,124	1,679	2,596	4,339	5,819	6,573	6,113	3,530	6,439	7,012	10,270	8,206
15 Jul	275	3,535	1,743	3,691	4,714	6,496	5,521	5,024	4,699	5,722	6,924	12,283	8,309

-continued-

Appendix A3.–Page 3 of 6.

Date	1978[a]	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
16 Jul	538	5,175	2,515	2,580	3,561	6,970	6,755	5,339	2,227	6,259	5,457	10,897	6,093
17 Jul	304	3,555	3,419	780	2,925	6,327	4,955	5,960		4,467	4,877	8,903	6,259
18 Jul	284	3,760	5,878	8,633	3,413	4,326	4,736	5,110		4,620	3,857	11,811	5,726
19 Jul	321	3,344	5,613	20,975	4,296	3,703	3,140	4,560		4,127	4,583	10,567	5,975
20 Jul	238	2,716	5,060	20,511	3,920	3,988	3,389	8,176		3,634	4,483	10,169	4,315
21 Jul	81	2,583	3,826	15,741	4,049	4,463	3,204	4,128		2,441	3,964	8,639	2,534
22 Jul	18	2,012	3,173	6,566	3,871	4,881	3,780	3,158		1,273	2,797	8,908	2,457
23 Jul	15	1,915	2,143	5,787	3,099	3,603	3,205	2,870		1,002	3,429	8,103	3,901
24 Jul	40	2,182	1,353	5,063	3,061	3,903	2,198	2,162		625	3,900	6,250	2,883
25 Jul	13	1,112	1,623	3,391	3,374	4,535	1,937	2,449		2,014	4,023	5,303	2,050
26 Jul		771	1,256	2,493	2,596	3,839	1,687	1,974		368	4,142	5,706	2,257
27 Jul		318	1,198	2,451	2,247	3,687	1,391	2,191		626	3,920	5,699	2,885
28 Jul		387	698	2,785	2,375	5,234	1,004	2,839		2,494	3,452	4,926	1,934
29 Jul		365	400	3,686	1,426	4,138	891	2,813		2,341	3,476	4,150	2,808
30 Jul		491	470	3,814	963	3,512	938	2,790		2,075	2,423	2,519	2,462
31 Jul		703	353	3,802	1,176	1,835	1,093	1,848		2,226	1,920	1,551	2,550
01 Aug		758	825	3,396	511	1,912	1,047	1,070		2,726	1,438	2,299	3,839
02 Aug		379	1,034	2,304	942	2,211	1,088	703		1,299	1,098	1,744	5,249
03 Aug		227	764	1,913	494	2,088	1,213			1,702			
04 Aug		286	708	1,297	581	2,897	1,118			1,499			
05 Aug		173	758	1,181	122		1,009			518			
06 Aug		103	877	1,170			533						
07 Aug		76	615										
08 Aug			166										
09 Aug			239										
Total	107,011	237,173	276,538	534,263	467,306	545,724	536,806	436,313	457,421	480,917	488,398	607,797	581,859

-continued-

Appendix A3.–Page 4 of 6.

Date	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
09 May															192			192
10 May															451			451
11 May															626			626
12 May														0	1,179	0		393
13 May													81	24	1,377	18		375
14 May													403	150	1,046	24		406
15 May					499						371	70	656	296	1,673	72		520
16 May					479		64				55	4	1,218	412	1,676	78		498
17 May				448	547		88				61	8	1,616	419	4,286	102		1,140
18 May				686	522	84	136	158		337	572	4	1,447	821	5,608	18		1,520
19 May				952	1,295	72	168	254		456	1,156	13	3,506	1,864	5,386	18	0	1,833
20 May			9,503	955	3,028	130	486	173		358	1,128	37	3,408	1,579	6,762	72	6	2,458
21 May	1,087		13,677	1,610	3,504	338	464	1,477		474	1,527	578	5,432	4,960	10,619	0	123	3,012
22 May	1,717		22,706	2,422	2,808	1,023	1,742	1,277		462	4,565	823	3,878	8,761	15,069	0	276	4,093
23 May	3,161		28,425	3,558	4,301	1,766	2,744	1,327	960	600	7,925	1,509	5,472	16,588	8,878	138	693	5,057
24 May	2,465		31,980	2,897	2,473	1,330	12,196	3,582	480	936	19,752	2,612	12,083	17,130	13,866	627	1218	7,227
25 May	3,046		38,581	4,083	1,841	1,363	26,923	5,851	600	1,237	27,684	3,637	13,101	17,520	21,169	1,639	1900	8,695
26 May	3,274		23,647	3,282	3,032	2,192	27,389	5,608	372	1,049	24,816	2,958	3,997	18,890	18,344	2,706	4912	7,602
27 May	3,893	1,226	12,885	2,855	3,806	4,790	31,978	9,011	859	2,584	20,514	4,004	5,885	17,863	13,369	5,590	7369	8,290
28 May	3,389	1,431	17,476	3,047	7,168	12,856	46,182	10,275	1,129	3,220	17,616	5,171	9,881	23,347	14,552	7,710	15232	10,815
29 May	3,933	2,362	13,156	2,888	9,878	12,008	46,539	11,226	2,457	9,864	29,292	9,052	12,777	24,625	20,294	17,990	23008	11,328
30 May	4,417	5,736	8,478	1,966	12,779	10,861	37,554	18,442	6,194	12,452	30,091	11,021	10,038	20,647	17,306	34,122	31754	12,120
31 May	9,362	7,931	16,686	4,616	10,755	19,994	46,197	23,018	3,610	9,434	17,228	12,036	17,132	12,859	17,986	51,716	30380	14,312
01 Jun	16,833	6,610	16,473	9,423	8,980	25,530	31,557	21,312	2,200	10,357	14,730	13,969	17,278	13,731	16,741	51,138	33102	14,392
02 Jun	21,151	7,919	22,831	7,767	9,428	25,977	30,744	24,206	1,964	9,366	16,755	15,421	13,437	17,281	13,637	47,734	36204	15,316
03 Jun	17,808	11,535	14,591	3,137	5,647	27,265	18,078	25,724	2,466	11,536	11,992	26,287	13,164	12,750	11,502	52,220	35372	14,517
04 Jun	14,557	7,921	17,585	6,143	6,745	22,231	17,562	25,530	2,562	5,751	12,080	21,334	12,371	10,136	9,922	34,778	23210	13,498
05 Jun	18,673	9,295	25,779	5,265	5,895	18,009	16,188	19,064	2,835	6,782	18,250	21,473	9,446	15,350	14,008	16,594	19678	13,821
06 Jun	11,688	14,552	25,643	12,100	9,236	11,310	19,985	14,130	1,827	9,518	15,597	15,831	10,820	16,448	10,558	19,494	16333	12,960
07 Jun	8,440	16,734	18,068	16,732	8,044	16,743	22,612	18,601	6,459	7,538	19,494	14,660	14,472	6,320	12,412	16,914	14858	13,051
08 Jun	9,471	17,729	20,762	18,022	5,738	26,585	33,969	13,719	7,270	6,951	10,421	12,234	16,359	12,844	17,564	14,210	16286	14,571
09 Jun	11,665	20,719	24,997	18,042	5,479	35,684	37,078	7,325	9,270	4,511	11,676	14,239	17,415	14,948	15,192	12,476	13104	14,735
10 Jun	8,565	23,430	19,794	17,588	8,054	31,792	34,180	10,494	14,853	7,720	9,661	10,522	13,951	13,160	12,748	16,360	13264	14,079
11 Jun	8,104	18,591	11,119	12,272	11,950	29,085	30,941	18,471	27,063	10,033	8,094	11,372	20,849	10,232	18,002	11,486	13878	14,119
12 Jun	12,688	14,096	18,322	13,008	7,274	35,637	19,119	17,681	26,485	10,735	10,638	9,946	19,046	13,418	17,186	8,600	15022	13,720

-continued-

Appendix A3.–Page 5 of 6.

Date	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
13 Jun	9,066	18,257	12,872	9,081	8,945	27,036	13,364	21,718	24,872	9,651	13,805	5,648	12,562	15,066	11,761	11,316	18784	12,163
14 Jun	9,236	20,456	8,357	15,639	14,021	14,958	16,080	28,281	19,622	7,212	11,321	8,903	12,290	8,558	14,364	16,350	13024	11,693
15 Jun	14,967	23,957	13,351	11,679	11,853	15,548	23,220	20,869	17,196	8,106	7,764	9,162	10,867	10,834	16,692	19,732	8162	11,825
16 Jun	14,367	13,914	14,247	14,227	19,732	13,809	16,989	17,261	18,802	6,588	7,558	6,853	13,021	12,561	13,692	10,880	10640	10,995
17 Jun	10,129	14,509	7,621	11,445	19,918	10,298	21,801	20,761	16,021	6,926	8,887	6,985	13,447	8,083	9,998	10,088	9938	10,450
18 Jun	11,051	14,893	4,921	17,223	17,938	7,359	22,092	18,535	10,660	10,602	6,596	5,910	13,506	9,337	11,634	12,452	7176	9,590
19 Jun	12,921	12,324	6,324	19,392	16,025	15,303	12,711	11,618	13,007	14,016	7,403	5,651	10,030	12,940	10,184	17,884	6163	9,171
20 Jun	14,146	19,480	4,900	11,498	16,863	12,071	7,844	11,500	14,696	12,533	6,357	4,709	6,823	14,740	6,044	14,728	8516	8,579
21 Jun	8,750	16,882	3,536	11,699	15,430	7,570	8,389	12,276	14,102	12,793	6,651	4,811	5,741	12,853	8,138	15,386	9736	8,055
22 Jun	7,830	9,452	2,864	13,305	9,862	10,851	17,553	10,788	14,745	16,790	5,424	4,882	11,773	9,513	13,754	15,466	5948	8,499
23 Jun	6,358	7,234	5,069	18,686	5,320	15,544	7,705	10,907	10,268	18,769	10,062	6,185	10,110	10,533	21,442	10,428	8532	8,760
24 Jun	5,963	6,319	6,071	24,282	7,357	10,226	5,310	13,521	16,915	15,829	11,313	5,847	10,697	10,255	19,311	9,282	11980	8,946
25 Jun	7,660	6,675	4,321	14,140	9,211	7,963	5,460	13,001	14,040	16,160	12,153	6,723	10,890	7,922	19,924	14,206	11110	8,476
26 Jun	9,500	7,180	2,718	12,204	9,989	8,668	7,985	11,217	15,151	9,410	14,073	6,950	10,149	7,080	19,022	10,958	13204	7,884
27 Jun	10,355	6,266	3,370	14,146	16,025	10,255	12,011	10,722	20,545	11,287	12,247	8,325	7,590	5,485	14,339	8,270	18088	8,256
28 Jun	10,810	8,084	4,361	9,213	13,673	9,195	10,427	12,822	14,967	13,457	11,772	11,947	12,164	6,778	13,584	9,622	20010	8,300
29 Jun	10,439	9,258	4,976	15,859	9,723	12,621	10,409	15,851	14,841	13,509	14,155	14,027	14,779	5,905	16,686	9,756	18290	8,802
30 Jun	9,113	7,416	8,384	10,845	4,402	13,091	13,741	14,681	14,506	7,968	11,162	12,696	10,104	6,053	14,656	8,070	14236	7,793
01 Jul	7,303	7,120	7,639	10,359	5,730	15,487	12,724	13,646	16,067	10,348	13,612	10,146	10,183	9,350	11,636	9,568	15310	7,978
02 Jul	5,109	5,591	5,720	9,802	5,218	13,066	13,566	11,432	10,944	10,346	14,223	10,134	10,377	8,613	5,898	12,224	13238	7,294
03 Jul	6,335	4,641	5,145	9,965	4,851	12,949	15,430	11,036	13,013	11,001	13,016	10,826	8,570	8,551	9,036	14,024	15076	7,599
04 Jul	6,680	5,413	5,527	8,782	4,291	12,956	14,618	8,549	10,206	13,219	13,978	11,923	5,589	8,228	6,260	10,176	25838	7,792
05 Jul	5,845	4,424	6,339	6,196	7,787	8,829	13,448	9,625	9,216	10,357	11,522	12,029	5,222	8,814	9,407	8,996	28116	7,558
06 Jul	6,213	6,987	6,431	9,544	8,172	8,818	11,024	8,757	6,864	8,592	7,861	19,951	8,221	6,758	10,283	9,840	20738	7,435
07 Jul	6,222	7,361	9,229	9,921	6,620	9,007	11,534	10,018	6,696	8,244	5,569	26,061	10,223	8,364	10,916	6,900	14484	7,449
08 Jul	7,069	5,758	10,386	7,947	4,272	8,424	13,736	9,350	16,340	8,554	9,620	32,912	7,022	10,150	8,202	5,620	14106	7,977
09 Jul	6,453	11,937	11,105	9,391	6,845	7,802	7,877	11,307	14,377	9,264	11,612	28,918	6,076	7,173	5,460	7,568	10758	7,681
10 Jul	4,610	9,139	9,566	14,539	14,846	9,792	13,757	13,562	15,599	11,399	11,384	24,974	4,710	6,126	5,212	10,598	7906	8,517
11 Jul	4,477	8,380	7,364	13,656	9,368	10,608	16,698	17,782	17,119	12,297	14,544	29,471	9,420	5,702	5,376	11,410	6520	8,672
12 Jul	4,818	7,959	6,819	16,223	6,467	11,805	10,159	17,661	13,049	10,694	16,183	28,299	6,617	8,350	4,676	10,824	8662	8,622
13 Jul	3,969	6,741	5,615	13,924	5,978	10,829	9,249	16,079	10,242	9,181	14,178	24,478	5,927	5,767	3,016	11,930	9550	7,683
14 Jul	7,498	8,574	7,673	13,333	9,602	9,959	12,908	8,263	16,721	9,333	11,104	29,038	6,367	4,635	3,480	10,078	8966	8,151
15 Jul	7,550	8,971	6,112	10,161	11,587	9,465	15,751	10,882	17,549	6,699	10,746	26,652	3,497	4,864	7,432	10,508	7622	8,166

-continued-

Appendix A3.–Page 6 of 6.

Date	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
16 Jul	9,671	7,683	6,880	7,955	5,935	11,311	13,956	9,184	18,232	6,578	12,307	19,787	487	2,836	6,964	7,910	5240	7,243
17 Jul	9,668	6,718	5,175	7,642	10,858	11,586	15,111	7,378	16,641	7,079	9,818	16,585	179	1,324	5,774	9,984	3456	6,817
18 Jul	7,340	8,807	5,398	7,063	10,642	7,234	9,864	6,583	11,424	5,357	10,923	13,483	176	846	8,188	12,926	4906	6,666
19 Jul	7,513	8,615	6,782	4,675	8,164	6,373	11,268	6,183	15,295	4,991	9,764	7,116	156	821	10,582	12,484	5694	6,817
20 Jul	10,681	7,102	7,417	3,922	7,003	5,609	11,374	6,934	16,077	5,907	6,908	7,514	14,414	1,364	9,808	13,480	5988	7,314
21 Jul	10,268	4,898	7,844	7,756	5,354	7,439	9,976	7,790	16,398	6,958	4,230	8,817	13,714	2,527	7,476	10,090	6056	6,664
22 Jul	9,702	4,612	9,241	13,476	4,596	7,282	6,749	7,347	8,527	3,684	2,916	9,067	6,521	2,550	8,250	7,926	6772	5,590
23 Jul	9,017	5,426	14,012	14,447	4,256	6,734	7,037	5,953	19,218	3,529	1,826	10,731	7,437	3,020	7,852	8,564	7300	6,049
24 Jul	4,245	3,821	12,723	10,424	4,255	8,883	5,211	4,768	16,497	4,241	3,952	5,093	10,757	3,778	10,990	11,930	3636	5,477
25 Jul	3,066	2,984	9,048	13,043	3,310	9,120	3,593	5,366	16,581	5,655	4,477	3,206	7,984	2,338	9,768	10,002	5192	5,054
26 Jul	4,422	3,412	6,406	5,897	3,190	7,536	3,478	3,806	14,188	6,617	5,125	871	9,613	2,988	8,094	7,846	7818	4,586
27 Jul	3,884	3,619	7,465	4,888	5,196	4,834	4,270	3,512	8,621	5,017	9,652	2,170	10,832	2,961	5,668	6,934	9162	4,475
28 Jul	4,793	3,205	5,972	5,467	5,093	8,560	4,489	4,430	9,649	3,021	8,117	4,173	6,897	2,287	5,632	9,958	7614	4,553
29 Jul	5,354	3,954	6,116	3,996	5,973	7,389	3,318	3,843	10,491	2,084	7,602	3,309	5,777	1,682	5,432	12,494	11770	4,539
30 Jul	4,711	3,872	6,503	3,156	6,281	5,481	3,254	5,199	13,213	2,605	8,051	1,960	5,031	3,353	6,062	9,962	7162	4,225
31 Jul	2,901	3,855	5,539	3,686	5,039	3,915	2,579	4,810	7,974	2,255	6,305	3,061	5,385	3,525	5,884	7,434	6730	3,569
01 Aug			4,560	4,014	3,425	4,065	4,396	3,189	13,039	2,253							5986	3,237
02 Aug			4,209		1,589	4,253	4,709	3,490	10,531	2,324							7178	2,965
03 Aug						4,383	5,014	2,974	7,482	1,947							7972	2,936
04 Aug						5,082		2,004									6360	1,985
05 Aug						6,929												1,336
06 Aug						5,424												1,621
07 Aug																		346
08 Aug																		166
09 Aug																		239
Total	579,435	601,952	833,387	715,577	599,265	906,239	1,148,079	866,957	850,951	587,497	833,569	819,794	700,543	669,514	855,125	959,705	919,601	640,157

[a] Sonar deployed only on south bank; counts later expanded to include number of salmon that would have passed on north bank according to consequent years.

Appendix A4.–Cumulative daily salmon escapement estimates from the Miles Lake sonar site at the Copper River, 1978–2007.

Date	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
09 May													
10 May													
11 May													
12 May													
13 May													
14 May													
15 May													
16 May													
17 May				5,372								732	
18 May		381	218	15,037								4,392	
19 May		868	385	26,446			725				313	10,980	
20 May		1,715	606	37,179			2,649				1,190	17,915	
21 May		2,914	694	46,908			4,635				2,630	22,749	1,121
22 May		4,830	1,085	54,466			9,759			482	4,886	26,779	5,964
23 May		7,731	1,679	60,680		3,310	14,801			2,083	9,964	33,251	13,141
24 May		11,133	2,173	73,665	90	11,930	19,287			3,888	20,997	40,699	25,064
25 May		13,530	2,886	86,481	583	23,517	22,407		611	7,776	30,976	45,357	39,397
26 May	502	18,457	3,943	92,864	1,606	34,092	27,052		2,305	14,752	39,922	53,675	50,734
27 May	1,339	25,278	6,058	95,706	13,697	42,753	32,888		4,397	26,928	53,169	66,818	62,794
28 May	2,386	28,046	7,751	98,266	61,000	51,209	37,866	1,031	7,781	42,950	67,370	80,698	70,228
29 May	3,047	31,951	8,831	100,426	80,671	57,589	44,992	1,448	10,519	57,435	77,392	91,375	79,404
30 May	6,288	39,433	10,734	112,248	89,452	65,885	49,943	2,047	13,692	75,192	84,198	96,750	88,945
31 May	8,837	48,088	14,354	133,374	100,841	83,008	54,221	3,805	17,842	93,732	91,784	104,066	99,288
01 Jun	11,453	52,166	19,611	151,789	116,226	101,436	62,757	7,267	24,843	110,082	96,989	111,107	109,314
02 Jun	14,264	55,631	26,672	175,560	133,439	115,850	71,240	13,993	45,481	124,467	100,547	116,341	119,223
03 Jun	16,101	59,167	34,109	192,276	146,822	128,987	80,970	24,684	65,718	142,133	105,173	123,208	127,799
04 Jun	19,357	61,945	43,105	202,031	159,177	144,344	93,466	48,956	92,344	156,765	113,050	131,763	135,371
05 Jun	22,327	66,297	52,851	212,509	173,983	163,454	110,194	79,463	120,278	167,727	119,805	139,275	145,544
06 Jun	25,645	72,750	58,258	224,484	189,568	177,523	128,291	112,416	134,805	172,049	128,700	146,994	155,954
07 Jun	29,453	79,781	60,351	238,069	202,074	196,832	146,806	139,672	144,463	177,804	137,796	159,687	167,091
08 Jun	32,728	90,859	61,700	252,481	210,504	212,926	173,425	170,597	169,401	184,170	149,118	174,252	174,728
09 Jun	34,980	98,844	65,243	268,175	217,521	224,341	193,901	200,299	197,643	192,092	163,759	183,692	184,633
10 Jun	38,455	104,049	72,544	281,031	225,120	232,350	213,176	212,309	227,595	203,645	178,975	195,818	196,293
11 Jun	40,945	108,475	84,576	288,908	232,999	241,913	230,413	224,135	253,013	214,839	195,230	205,481	212,474
12 Jun	43,027	110,702	96,160	293,752	241,586	255,205	252,119	232,366	269,516	221,345	210,189	213,737	236,403

-continued-

Appendix A4.–Page 2 of 6.

Date	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
13 Jun	45,446	114,605	103,760	297,308	251,518	268,649	264,191	239,195	280,969	225,398	220,940	224,363	260,851
14 Jun	48,281	117,168	109,421	302,536	264,069	282,480	270,172	245,995	292,362	233,451	230,322	237,911	275,153
15 Jun	51,194	120,519	116,729	309,607	276,746	298,395	280,463	254,820	301,109	238,936	240,232	247,833	283,543
16 Jun	53,976	123,992	122,384	316,492	290,341	306,333	294,393	264,167	311,208	244,452	246,716	256,722	293,655
17 Jun	56,755	128,632	129,573	322,959	302,371	312,004	314,202	270,437	319,980	249,858	251,626	266,742	306,350
18 Jun	59,016	132,543	136,314	327,524	308,915	317,693	327,052	274,175	329,030	254,673	258,095	277,873	314,402
19 Jun	62,051	135,956	138,705	330,509	313,284	324,154	334,526	277,426	336,940	258,656	265,950	286,218	324,165
20 Jun	65,086	137,910	142,302	333,400	316,636	331,536	343,784	279,849	344,180	262,589	273,902	293,793	333,480
21 Jun	67,601	140,133	146,444	336,846	319,982	339,660	350,943	281,910	350,921	266,513	279,672	300,962	343,772
22 Jun	69,669	142,718	150,398	340,843	324,449	347,665	356,465	284,673	359,947	272,292	286,657	309,830	353,929
23 Jun	72,510	145,583	154,294	345,206	331,480	355,193	362,378	288,042	367,957	282,403	294,356	315,680	364,095
24 Jun	75,126	147,460	159,511	349,857	337,809	361,202	369,119	290,992	374,925	298,111	299,938	319,607	373,435
25 Jun	77,256	150,473	164,615	353,255	342,712	366,428	375,622	292,577	380,656	314,628	305,535	322,603	383,445
26 Jun	79,027	152,446	168,210	355,667	347,128	372,066	380,007	294,958	386,066	327,104	311,913	326,029	390,257
27 Jun	81,205	153,761	171,631	358,174	349,860	376,804	387,231	297,993	391,219	334,114	318,472	329,269	399,491
28 Jun	82,308	155,458	175,955	361,123	352,034	381,575	393,959	300,257	396,241	339,758	324,731	335,571	406,372
29 Jun	83,912	156,908	179,800	364,544	354,164	385,879	398,412	302,404	399,819	346,594	332,951	342,061	410,871
30 Jun	85,544	158,807	183,265	366,922	356,477	392,025	404,861	304,543	403,590	351,230	339,448	349,415	414,846
01 Jul	87,131	161,458	186,824	369,645	358,667	398,131	413,087	307,163	407,174	353,242	345,050	357,345	419,169
02 Jul	89,664	163,982	190,189	372,251	363,087	404,244	420,641	309,771	410,326	356,648	349,730	362,641	424,236
03 Jul	92,191	166,841	194,293	374,799	368,838	410,270	429,222	311,590	412,637	360,744	353,952	367,617	428,918
04 Jul	95,171	170,647	197,227	378,893	374,083	417,213	435,737	315,126	414,442	367,844	357,484	374,986	434,583
05 Jul	97,440	173,655	200,106	383,149	379,078	422,560	442,399	318,380	415,941	372,195	360,788	385,725	442,581
06 Jul	99,063	175,651	203,131	386,625	385,378	426,533	447,848	323,044	418,749	375,588	364,298	395,749	450,330
07 Jul	100,215	176,543	206,422	390,488	391,549	430,742	451,888	326,671	421,740	381,205	368,622	405,985	456,030
08 Jul	101,046	178,634	209,417	394,262	395,539	434,822	455,794	330,564	424,600	387,821	377,121	417,098	461,222
09 Jul	101,993	181,824	212,234	397,711	397,749	438,175	459,004	337,391	427,677	394,173	382,288	427,859	466,375
10 Jul	103,245	186,033	215,876	400,653	399,819	441,819	461,931	347,998	433,112	402,758	388,635	437,365	472,995
11 Jul	104,086	189,717	221,639	402,924	401,799	446,273	465,539	353,455	438,227	408,080	396,255	445,818	478,397
12 Jul	104,427	192,979	226,427	405,392	405,219	450,814	469,819	359,784	443,269	413,837	404,136	457,771	487,735
13 Jul	104,594	196,123	228,152	407,657	409,251	455,357	474,401	365,036	446,965	420,420	411,223	467,100	499,167
14 Jul	104,884	200,247	229,831	410,253	413,590	461,176	480,974	371,149	450,495	426,859	418,235	477,370	507,373
15 Jul	105,159	203,782	231,574	413,944	418,304	467,672	486,495	376,173	455,194	432,581	425,159	489,653	515,682
16 Jul	105,697	208,957	234,089	416,524	421,865	474,642	493,250	381,512	457,421	438,840	430,616	500,550	521,775
17 Jul	106,001	212,512	237,508	417,304	424,790	480,969	498,205	387,472		443,307	435,493	509,453	528,034

-continued-

Appendix A4.–Page 3 of 6.

Date	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
18 Jul	106,285	216,272	243,386	425,937	428,203	485,295	502,941	392,582		447,927	439,350	521,264	533,760
19 Jul	106,606	219,616	248,999	446,912	432,499	488,998	506,081	397,142		452,054	443,933	531,831	539,735
20 Jul	106,844	222,332	254,059	467,423	436,419	492,986	509,470	405,318		455,688	448,416	542,000	544,050
21 Jul	106,925	224,915	257,885	483,164	440,468	497,449	512,674	409,446		458,129	452,380	550,639	546,584
22 Jul	106,943	226,927	261,058	489,730	444,339	502,330	516,454	412,604		459,402	455,177	559,547	549,041
23 Jul	106,958	228,842	263,201	495,517	447,438	505,933	519,659	415,474		460,404	458,606	567,650	552,942
24 Jul	106,998	231,024	264,554	500,580	450,499	509,836	521,857	417,636		461,029	462,506	573,900	555,825
25 Jul	107,011	232,136	266,177	503,971	453,873	514,371	523,794	420,085		463,043	466,529	579,203	557,875
26 Jul		232,907	267,433	506,464	456,469	518,210	525,481	422,059		463,411	470,671	584,909	560,132
27 Jul		233,225	268,631	508,915	458,716	521,897	526,872	424,250		464,037	474,591	590,608	563,017
28 Jul		233,612	269,329	511,700	461,091	527,131	527,876	427,089		466,531	478,043	595,534	564,951
29 Jul		233,977	269,729	515,386	462,517	531,269	528,767	429,902		468,872	481,519	599,684	567,759
30 Jul		234,468	270,199	519,200	463,480	534,781	529,705	432,692		470,947	483,942	602,203	570,221
31 Jul		235,171	270,552	523,002	464,656	536,616	530,798	434,540		473,173	485,862	603,754	572,771
01 Aug		235,929	271,377	526,398	465,167	538,528	531,845	435,610		475,899	487,300	606,053	576,610
02 Aug		236,308	272,411	528,702	466,109	540,739	532,933	436,313		477,198	488,398	607,797	581,859
03 Aug		236,535	273,175	530,615	466,603	542,827	534,146			478,900			
04 Aug		236,821	273,883	531,912	467,184	545,724	535,264			480,399			
05 Aug		236,994	274,641	533,093	467,306		536,273			480,917			
06 Aug		237,097	275,518	534,263			536,806						
07 Aug		237,173	276,133										
08 Aug			276,299										
09 Aug			276,538										

-continued-

Date	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
09 May															192			192
10 May															643			643
11 May															1,269			1,269
12 May															2,448	0		1,224
13 May													81		3,825	18		1,308
14 May													484		4,871	42		1,799
15 May					499						371	71	1,140	470	6,544	114		1,316
16 May					978		64				426	73	2,358	882	8,219	192		1,649
17 May				448	1,525		152				487	77	3,974	1,301	12,505	294		2,442
18 May				1,134	2,047	84	288	158		337	1,059	79	5,421	2,122	18,113	312		3,199
19 May				2,086	3,342	156	456	412		793	2,215	96	8,927	3,986	23,500	330	0	4,527
20 May			9,503	3,041	6,370	286	942	585		1,151	3,343	130	12,335	5,565	30,261	402	6	6,759
21 May	1,087		23,180	4,651	9,874	624	1,406	2,062		1,625	4,870	705	17,767	10,525	40,880	402	129	9,156
22 May	2,804		45,886	7,073	12,682	1,647	3,148	3,339		2,087	9,435	1,530	21,645	19,286	55,949	402	405	12,851
23 May	5,965		74,311	10,631	16,983	3,413	5,892	4,666	960	2,687	17,360	3,034	27,117	35,874	64,827	540	1098	16,880
24 May	8,430		106,291	13,528	19,456	4,743	18,088	8,248	1,440	3,623	37,112	5,646	39,200	53,004	78,693	1,167	2316	23,458
25 May	11,476		144,872	17,611	21,297	6,106	45,011	14,099	2,040	4,860	64,796	9,280	52,301	70,524	99,862	2,806	4216	31,284
26 May	14,750		168,519	20,893	24,329	8,298	72,400	19,707	2,412	5,909	89,612	12,236	56,298	89,414	118,206	5,512	9128	37,769
27 May	18,643	1,226	181,404	23,748	28,135	13,088	104,378	28,718	3,271	8,493	110,126	16,245	62,183	107,277	131,576	11,102	16497	44,756
28 May	22,032	2,657	198,880	26,795	35,303	25,944	150,560	38,993	4,400	11,713	127,742	21,418	72,064	130,624	146,128	18,812	31729	54,079
29 May	25,965	5,019	212,036	29,683	45,181	37,952	197,099	50,219	6,857	21,577	157,034	30,473	84,841	155,249	166,422	36,802	54737	65,408
30 May	30,382	10,755	220,514	31,649	57,960	48,813	234,653	68,661	13,051	34,029	187,125	41,587	94,879	175,896	183,728	70,924	86491	77,530
31 May	39,744	18,686	237,200	36,265	68,715	68,807	280,850	91,679	16,661	43,463	204,353	53,629	112,011	188,755	201,714	122,640	116871	91,843
01 Jun	56,577	25,296	253,673	45,688	77,695	94,337	312,407	112,991	18,861	53,820	219,083	67,604	129,289	202,486	218,455	173,778	149973	106,235
02 Jun	77,728	33,215	276,504	53,455	87,123	120,314	343,151	137,197	20,825	63,186	235,838	83,019	142,726	219,767	232,092	221,512	186177	121,551
03 Jun	95,536	44,750	291,095	56,592	92,770	147,579	361,229	162,921	23,291	74,722	247,830	109,306	155,890	232,517	243,594	273,732	221549	136,068
04 Jun	110,093	52,671	308,680	62,735	99,515	169,810	378,791	188,451	25,853	80,473	259,910	130,640	168,261	242,653	253,516	308,510	244759	149,566
05 Jun	128,766	61,966	334,459	68,000	105,410	187,819	394,979	207,515	28,688	87,255	278,160	152,113	177,707	258,003	267,524	325,104	264437	163,387
06 Jun	140,454	76,518	360,102	80,100	114,646	199,129	414,964	221,645	30,515	96,773	293,757	167,944	188,527	274,451	278,082	344,598	280770	176,347
07 Jun	148,894	93,252	378,170	96,832	122,690	215,872	437,576	240,246	36,974	104,311	313,251	182,604	202,999	280,771	290,494	361,512	295628	189,398
08 Jun	158,365	110,981	398,932	114,854	128,428	242,457	471,545	253,965	44,244	111,262	323,672	194,838	219,358	293,615	308,058	375,722	311914	203,970
09 Jun	170,030	131,700	423,929	132,896	133,907	278,141	508,623	261,290	53,514	115,773	335,348	209,077	236,773	308,563	323,250	388,198	325018	218,705
10 Jun	178,595	155,130	443,723	150,484	141,961	309,933	542,803	271,784	68,367	123,493	345,009	219,599	250,724	321,723	335,998	404,558	338282	232,784
11 Jun	186,699	173,721	454,842	162,756	153,911	339,018	573,744	290,255	95,430	133,526	353,103	230,971	271,573	331,955	354,000	416,044	352160	246,904
12 Jun	199,387	187,817	473,164	175,764	161,185	374,655	592,863	307,936	121,915	144,261	363,741	240,917	290,619	345,373	371,186	424,644	367182	260,624

-continued-

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
13 Jun	208,453	206,074	486,036	184,845	170,130	401,691	606,227	329,654	146,787	153,912	377,546	246,565	303,181	360,439	382,947	435,960	385966	272,787
14 Jun	217,689	226,530	494,393	200,484	184,151	416,649	622,307	357,935	166,409	161,124	388,867	255,468	315,471	368,997	397,311	452,310	398990	284,480
15 Jun	232,656	250,487	507,744	212,163	196,004	432,197	645,527	378,804	183,605	169,230	396,631	264,630	326,338	379,831	414,003	472,042	407152	296,306
16 Jun	247,023	264,401	521,991	226,390	215,736	446,006	662,516	396,065	202,407	175,818	404,189	271,483	339,359	392,392	427,695	482,922	417792	307,301
17 Jun	257,152	278,910	529,612	237,835	235,654	456,304	684,317	416,826	218,428	182,744	413,076	278,468	352,806	400,475	437,693	493,010	427730	317,751
18 Jun	268,203	293,803	534,533	255,058	253,592	463,663	706,409	435,361	229,088	193,346	419,672	284,378	366,312	409,812	449,327	505,462	434906	327,341
19 Jun	281,124	306,127	540,857	274,450	269,617	478,966	719,120	446,979	242,095	207,362	427,075	290,029	376,342	422,752	459,511	523,346	441069	336,512
20 Jun	295,270	325,607	545,757	285,948	286,480	491,037	726,964	458,479	256,791	219,895	433,432	294,738	383,165	437,492	465,555	538,074	449585	345,091
21 Jun	304,020	342,489	549,293	297,647	301,910	498,607	735,353	470,755	270,893	232,688	440,083	299,549	388,906	450,345	473,693	553,460	459320	353,146
22 Jun	311,850	351,941	552,157	310,952	311,772	509,458	752,906	481,543	285,638	249,478	445,507	304,431	400,679	459,858	487,447	568,926	465268	361,645
23 Jun	318,208	359,175	557,226	329,638	317,092	525,002	760,611	492,450	295,906	268,247	455,569	310,616	410,789	470,391	508,889	579,354	473800	370,405
24 Jun	324,171	365,494	563,297	353,920	324,449	535,228	765,921	505,971	312,821	284,076	466,882	316,463	421,486	480,646	528,199	588,636	485780	379,351
25 Jun	331,831	372,169	567,618	368,060	333,660	543,191	771,381	518,972	326,861	300,236	479,035	323,186	432,376	488,568	548,124	602,842	496890	387,827
26 Jun	341,331	379,349	570,336	380,264	343,649	551,859	779,366	530,189	342,012	309,646	493,108	330,136	442,525	495,648	567,146	613,800	510094	395,711
27 Jun	351,686	385,615	573,706	394,410	359,674	562,114	791,377	540,911	362,557	320,933	505,355	338,461	450,115	501,133	581,485	622,070	528182	403,967
28 Jun	362,496	393,699	578,067	403,623	373,347	571,309	801,804	553,733	377,524	334,390	517,127	350,408	462,279	507,911	595,069	631,692	548192	412,267
29 Jun	372,935	402,957	583,043	419,482	383,070	583,930	812,213	569,584	392,365	347,899	531,282	364,435	477,058	513,816	611,755	641,448	566482	421,069
30 Jun	382,048	410,373	591,427	430,327	387,472	597,021	825,954	584,265	406,871	355,867	542,444	377,131	487,162	519,869	626,411	649,518	580719	428,862
01 Jul	389,351	417,493	599,066	440,686	393,202	612,508	838,678	597,911	422,938	366,215	556,056	387,277	497,345	529,219	638,047	659,086	596028	436,840
02 Jul	394,460	423,084	604,786	450,488	398,420	625,574	852,244	609,343	433,882	376,561	570,279	397,411	507,722	537,832	643,945	671,310	609266	444,134
03 Jul	400,795	427,725	609,931	460,453	403,271	638,523	867,674	620,379	446,895	387,562	583,295	408,237	516,292	546,383	652,981	685,334	624342	451,733
04 Jul	407,475	433,138	615,458	469,235	407,562	651,479	882,292	628,928	457,101	400,781	597,273	420,160	521,881	554,611	659,241	695,510	650180	459,525
05 Jul	413,320	437,562	621,797	475,431	415,349	660,308	895,740	638,553	466,317	411,138	608,795	432,189	527,103	563,425	668,648	704,506	678296	467,082
06 Jul	419,533	444,549	628,228	484,975	423,521	669,126	906,764	647,310	473,181	419,730	616,656	452,140	535,324	570,183	678,931	714,346	699034	474,517
07 Jul	425,755	451,910	637,457	494,896	430,141	678,133	918,298	657,328	479,877	427,974	622,225	478,201	545,547	578,547	689,847	721,246	713518	481,967
08 Jul	432,824	457,668	647,843	502,843	434,413	686,557	932,034	666,678	496,217	436,528	631,845	511,113	552,569	588,697	698,049	726,866	727624	489,944
09 Jul	439,277	469,605	658,948	512,234	441,258	694,359	939,911	677,985	510,594	445,792	643,457	540,031	558,645	595,870	703,509	734,434	738382	497,625
10 Jul	443,887	478,744	668,514	526,773	456,104	704,151	953,668	691,547	526,193	457,191	654,841	565,005	563,355	601,996	708,721	745,032	746288	506,142
11 Jul	448,364	487,124	675,878	540,429	465,472	714,759	970,366	709,329	543,312	469,488	669,385	594,476	572,775	607,698	714,097	756,442	752808	514,814
12 Jul	453,182	495,083	682,697	556,652	471,939	726,564	980,525	726,990	556,361	480,182	685,568	622,775	579,392	616,048	718,773	767,266	761470	523,436
13 Jul	457,151	501,824	688,312	570,576	477,917	737,393	989,774	743,069	566,603	489,363	699,746	647,253	585,319	621,815	721,789	779,196	771020	531,119
14 Jul	464,649	510,398	695,985	583,909	487,519	747,352	1,002,682	751,332	583,324	498,696	710,850	676,291	591,686	626,450	725,269	789,274	779986	539,270
15 Jul	472,199	519,369	702,097	594,070	499,106	756,817	1,018,433	762,214	600,873	505,395	721,596	702,943	595,183	631,314	732,701	799,782	787608	547,436
16 Jul	481,870	527,052	708,977	602,025	505,041	768,128	1,032,389	771,398	619,105	511,973	733,903	722,730	595,670	634,150	739,665	807,692	792848	554,678
17 Jul	491,538	533,770	714,152	609,667	515,899	779,714	1,047,500	778,776	635,746	519,052	743,721	739,315	595,849	635,474	745,439	817,676	796304	564,850

-continued-

Appendix A4.–Page 6 of 6.

Date	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
18 Jul	498,878	542,577	719,550	616,730	526,541	786,948	1,057,364	785,359	647,170	524,409	754,644	752,798	596,025	636,320	753,627	830,602	801,210	571,516
19 Jul	506,391	551,192	726,332	621,405	534,705	793,321	1,068,632	791,542	662,465	529,400	764,408	759,914	596,181	637,141	764,209	843,086	806,904	578,332
20 Jul	517,072	558,294	733,749	625,327	541,708	798,930	1,080,006	798,476	678,542	535,307	771,316	767,428	610,595	638,505	774,017	856,565	812,892	585,646
21 Jul	527,340	563,192	741,593	633,083	547,062	806,369	1,089,982	806,266	694,940	542,265	775,546	776,245	624,309	641,032	781,493	866,655	818,948	592,310
22 Jul	537,042	567,804	750,834	646,559	551,658	813,651	1,096,731	813,613	703,467	545,949	778,462	785,312	630,830	643,582	789,743	874,581	825,720	597,900
23 Jul	546,059	573,230	764,846	661,006	555,914	820,385	1,103,768	819,566	722,685	549,478	780,288	796,043	638,267	646,602	797,595	883,145	833,020	603,949
24 Jul	550,304	577,051	777,569	671,430	560,169	829,268	1,108,979	824,334	739,182	553,719	784,240	801,136	649,024	650,380	808,585	895,075	836,656	609,426
25 Jul	553,370	580,035	786,617	684,473	563,479	838,388	1,112,572	829,700	755,763	559,374	788,717	804,342	657,008	652,718	818,353	905,077	841,848	614,479
26 Jul	557,792	583,447	793,023	690,370	566,669	845,924	1,116,050	833,506	769,951	565,991	793,842	805,213	666,621	655,706	826,447	912,923	849,666	637,189
27 Jul	561,676	587,066	800,488	695,258	571,865	850,758	1,120,320	837,018	778,572	571,008	803,494	807,383	677,453	658,667	832,115	919,857	858,828	641,664
28 Jul	566,469	590,271	806,460	700,725	576,958	859,318	1,124,809	841,448	788,221	574,029	811,611	811,556	684,350	660,954	837,747	929,815	866,442	646,217
29 Jul	571,823	594,225	812,576	704,721	582,931	866,707	1,128,127	845,291	798,712	576,113	819,213	814,865	690,127	662,636	843,179	942,309	878,212	650,755
30 Jul	576,534	598,097	819,079	707,877	589,212	872,188	1,131,381	850,490	811,925	578,718	827,264	816,825	695,158	665,989	849,241	952,271	885,374	654,981
31 Jul	579,435	601,952	824,618	711,563	594,251	876,103	1,133,960	855,300	819,899	580,973	833,569	819,886	700,543	669,514	855,125	959,705	892,104	658,550
01 Aug			829,178	715,577	597,676	880,168	1,138,356	858,489	832,938	583,226							898,090	624,221
02 Aug			833,387		599,265	884,421	1,143,065	861,979	843,469	585,550							905,268	622,377
03 Aug						888,804	1,148,079	864,953	850,951	587,497							913,240	639,717
04 Aug						893,886		866,957									919,601	575,163
05 Aug						900,815												490,006
06 Aug						906,239												497,985
07 Aug																		256,653
08 Aug																		276,299
09 Aug																		276,538

Appendix A5.–Environmental data from the Miles Lake sonar site at the Copper River, 2007. Water Level is the elevation above sea level.

Date	Hour	Water Level (m)	Water Temp (C)	Air Temp (F)	Air Temp (C)	Cloud Cover [a]	Comments
19 May	11:50	39.58				1	
20 May	13:55	39.49				1	
21 May	13:00	39.51				1	
22 May	10:00	39.58	3.1	30.2	-1.0	5	fog
23 May	16:50	39.64				5	fog
24 May	8:05	39.68				5	fog
	16:00	39.71				5	fog
25 May	6:05	39.78	4.0	30.9	-0.6	5	
	18:00	39.89		39.2	4.0	4	
26 May	6:10	40.04	4.0	32.0	0.0	5	
	18:30	40.19		37.4	3.0	5	
27 May	6:30	40.32	3.3	29.3	-1.5	4	
	18:30	40.49		35.6	2.0	4	
28 May	6:30	40.51	3.5	30.2	-1.0	4	
	18:30	40.44		33.8	1.0	5	
29 May	6:30	40.36	4.1	30.2	-1.0	5	
	18:30	40.24		32.0	0.0	5	
30 May	6:30	40.17	4.6	28.4	-2.0	5	
	18:30	40.12		30.2	-1.0	6	
31 May	6:30	40.13	4.7	30.2	-1.0	5	
	18:30	40.14		35.6	2.0	5	
1 Jun	6:30	40.12	4.8	28.4	-2.0	5	
	18:30	40.13	6.4	37.4	3.0	4	
2 Jun	6:30	40.16	5.2	30.2	-1.0	3	
	18:30	40.20	6.3	37.4	3.0	4	
3 Jun	6:30	40.25	5.7	32.0	0.0	4	
	18:30	40.34	7.0	41.9	5.5	4	
4 Jun	6:30	40.46	6.4	37.4	3.0	5	
	18:30	40.71	7.0	38.3	3.5	6	
5 Jun	6:30	40.93	6.1	37.4	3.0	4	
	18:30	41.20	7.6	40.1	4.5	3	
6 Jun	6:30	41.42	6.5	32.0	0.0	5	mist/fog
	18:30	41.67	7.4	36.5	2.5	5	cold wind, dust up river
7 Jun	6:30	41.74	6.6	30.2	-1.0	5	windy
	18:30	41.78	7.3	32.0	0.0	6	
8 Jun	6:30	41.70	6.7	28.4	-2.0	6	
	18:30	41.60	6.9	33.8	1.0	5	
9 Jun	6:30	41.39	6.2	31.1	-0.5	3	windy
	18:30	41.25	8.5	45.5	7.5	1	strong wind from up river
10 Jun	6:30	41.14	6.3	37.4	3.0	1	
	18:30	41.17	8.8	50.0	10.0	1	
11 Jun	6:30	41.26	7.2	32.9	0.5	1	
	18:30	41.46	9.2	43.7	6.5	3	sunny most of day
12 Jun	6:30	41.53	8.2	32.0	0.0	5	
	18:30	41.68	9.3	36.5	2.5	4	

-continued-

Appendix A5.–Page 2 of 4.

Date	Hour	Water Level (m)	Water Temp (C)	Air Temp (F)	Air Temp (C)	Cloud Cover [a]	Comments
13 Jun	6:30	41.73	8.2	32.0	0.0	5	
	18:30	41.83	9.4	41.9	5.5	5	
14 Jun	6:30	41.80	8.5	33.8	1.0	5	
	18:30	41.82	8.8	36.5	2.5	5	cold
15 Jun	6:30	41.79	8.4	32.0	0.0	5	
	18:30	41.86	9.9	43.7	6.5	3	
16 Jun	6:30	41.87	8.9	32.9	0.5	5	
	18:30	41.98	9.5	39.2	4.0	5	
17 Jun	6:30	42.06	8.9	32.0	0.0	5	very foggy can't see Childs
	18:30	42.20	9.1	33.3	0.7	5	
18 Jun	6:30	42.23	8.7	33.8	1.0	5	
	18:30	42.28	9.2	37.4	3.0	5	
19 Jun	6:30	42.28	8.5	33.8	1.0	5	
	18:30	42.35	10.6	44.6	7.0	1	
20 Jun	6:30	42.45	9.1	36.5	2.5	2	
	18:30	42.60	10.8	51.8	11.0	3	
21 Jun	6:30	42.67	9.5	34.7	1.5	5	foggy
	18:30	42.76	9.9	42.8	6.0	5	
22 Jun	6:30	42.78	9.2	33.8	1.0	5	
	18:30	42.78	9.6	40.6	4.8	5	
23 Jun	6:30	42.73	8.8	34.7	1.5	5	
	18:30	42.69	9.6	42.8	6.0	4	
24 Jun	6:30	42.65	9.0	34.7	1.5	5	
	18:30	42.68	9.7	41.0	5.0	5	
25 Jun	6:30	42.62	9.0	33.8	1.0	5	
	18:30	42.58	10.0	41.0	5.0	4	
26 Jun	6:30	42.50	8.8	32.9	0.5	5	
	18:30	42.46	10.0	42.8	6.0	3	
27 Jun	6:30	42.41	9.1	34.7	1.5	3	
	18:30	42.43	10.8	46.4	8.0	1	
28 Jun	6:30	42.40	9.3	42.8	6.0	1	
	18:30	42.43	11.1	44.6	7.0	1	
29 Jun	6:30	42.47	9.6	34.7	1.5	3	
	18:30	42.53	10.3	44.6	7.0	4	
30 Jun	6:30	42.57	9.5	41.0	5.0	5	
	18:30	42.61	9.7	41.0	5.0	5	
1 Jul	6:30	42.66	8.8	35.6	2.0	6	
	18:30	42.74	9.4	41.0	5.0	4	
2 Jul	6:30	42.81	8.1	33.8	1.0	5	
	18:30	42.82	8.8	40.1	4.5	4	
3 Jul	6:30	42.71	8.0	33.8	1.0	5	
	18:30	42.60	8.7	41.9	5.5	4	
4 Jul	6:30	42.52	7.8	42.8	6.0	1	
	18:30	42.58	9.0	41.0	5.0	5	
5 Jul	6:30	42.59	8.4	33.8	1.0	6	
	18:30	42.67	9.1	41.0	5.0	4	

-continued-

Appendix A5.–Page 3 of 4.

Date	Hour	Water Level (m)	Water Temp (C)	Air Temp (F)	Air Temp (C)	Cloud Cover [a]	Comments
6 Jul	6:30	42.73	8.5	33.8	1.0	4	
	18:30	42.78	9.2	41.0	5.0	3	
7 Jul	6:30	42.69	8.8	42.8	6.0	5	
	18:30	42.66	9.1	41.0	5.0	4	
8 Jul	6:30	42.58	8.0	37.4	3.0	5	
	18:30	42.61	9.1	41.0	5.0	4	
9 Jul	6:30	42.63	8.8	34.7	1.5	5,6	mixed overcast and rain
	20:00	42.73	9.1	35.6	2.0	5, 6	drizzle
10 Jul	6:30	42.75	8.2	34.7	1.5	6	
	18:30	42.72	8.3	35.6	2.0	6	
11 Jul	6:30	42.65	7.6	32.0	0.0	4	
	18:30	42.57	8.1	39.2	4.0	5	
12 Jul	6:30	42.46	7.5	33.8	1.0	1	
	18:30	42.41	8.9	39.2	4.0	5	
13 Jul	6:30	42.34	8.3	32.0	0.0	4	sunny earlier
	18:30	42.34	9.6	42.8	6.0	5	
14 Jul	6:30	42.31	8.7	35.6	2.0	5	
	18:30	42.36	9.9	41.0	5.0	4	
15 Jul	6:30	42.35	8.6	34.7	1.5	1	
	18:30	42.45	10.7	46.4	8.0	1	
16 Jul	6:30	42.48	9.1	38.3	3.5	1	
	18:30	42.58	11.0	50.9	10.5	1	
17 Jul	6:30	42.61	9.8	41.0	5.0	5	
	18:30	42.69	9.9	42.8	6.0	5	
18 Jul	6:30	42.70	9.1	35.6	2.0	4	
	18:30	42.78	10.0	41.0	5.0	5	
19 Jul	6:30	42.80	9.1	34.7	1.5	3	
	18:30	42.82	10.4	44.6	7.0	3	
20 Jul	6:30	42.80	9.0	35.6	2.0	5	rain earlier
	18:30	42.89	9.7	41.0	5.0	5	drizzle
21 Jul	6:30	42.91	9.2	34.7	1.5	5	
	18:30	43.01	9.8	41.0	5.0	5	foggy
22 Jul	6:30	43.00	8.9	35.6	2.0	5	
	18:30	43.03	9.3	41.0	5.0	6	20:00 rd wash out 41 mile
23 Jul	6:30	43.07	8.9	38.3	3.5	5	rain earlier
	18:30	43.05	8.8	39.2	4.0	5	
24 Jul	6:30	43.03	8.2	32.9	0.5	5	
	18:30	43.00	8.6	41.0	5.0	5	
25 Jul	6:30	42.93	7.9	34.7	1.5	5	
	18:30	42.87	8.3	41.0	5.0	5	
26 Jul	6:30	42.72	7.7	34.7	1.5	5	
	18:30	42.62	8.4	38.3	3.5	5	
27 Jul	6:30	42.56	7.6	32.9	0.5	5	
	18:30	42.56	8.3	40.1	4.5	5	

-continued-

Appendix A5.–Page 4 of 4.

Date	Hour	Water Level (m)	Water Temp (C)	Air Temp (F)	Air Temp (C)	Cloud Cover [a]	Comments
28 Jul	6:30	42.55	7.6	33.8	1.0	3	
	18:30	42.59	9.1	46.4	8.0	1	
29 Jul	6:30	42.59	8.2	34.7	1.5	5	dense fog
	18:30	42.64	8.7	43.7	6.5	5	
30 Jul	6:30	42.71	8.5	37.4	3.0	5	
	18:30	42.82	9.6	41.9	5.5	5	
31 Jul	6:30	42.87	8.8	34.7	1.5	6	
	18:30	42.92	9.3	41.0	5.0	5	
1 Aug	6:30	42.89	8.7	34.7	1.5	5	
	18:30	42.89	9.2	41.9	5.5	5	
2 Aug	6:30	42.85	8.5	34.7	1.5	5	
	18:30	42.84	9.0	41.0	5.0	5	
3 Aug	6:30	42.78	8.5	35.6	2.0	5	
	18:30	42.78	9.3	42.8	6.0	5	
4 Aug	6:30	42.71	8.5	34.7	1.5	5, 6	
	18:30	42.70	8.2	35.6	2.0	6	

[a] Cloud Cover:

1 – sunny, bright

2 – sunny, hazy

3 – p. cloudy (<50%)

4 – m. cloudy (>50%)

5 – overcast

6– rain

Appendix A6.–Historical Copper River water levels at the Miles Lake sonar site, 1982–2007.

	Elevation Above Sea Level (m)											
Date	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
10 May												
11 May												
12 May												
13 May												
14 May												
15 May						38.99		40.05				
16 May								40.04				
17 May						39.09		40.01				
18 May					39.19	39.10		40.01				
19 May					39.31	39.05	39.70	40.06				
20 May			39.05		38.97	39.05	39.62	40.07				41.12
21 May			39.08		38.95	39.10	39.65	40.02	40.79	39.42		41.26
22 May			39.31		39.19	39.14	39.65	40.14	40.92	39.52	39.62	41.40
23 May			39.45		39.29	39.21	39.60	40.23	40.81	39.70	39.68	41.39
24 May		39.39	39.48		39.37	39.28	39.61	40.27	40.63	39.96		41.38
25 May		39.39	39.57		39.38	39.29	39.64	40.16	40.48	40.17	39.92	41.54
26 May		39.36	39.61		39.46	39.36	39.67	40.17	40.48	40.33	40.10	41.68
27 May		39.37	39.71		39.54	39.46	39.75	40.27	40.58	40.41	40.30	41.67
28 May		39.39	39.75	40.28	39.60	39.46	39.78	40.42	40.77	40.51	40.55	41.65
29 May		39.38	39.61	40.34	39.77	39.48	39.82	40.60	41.00	40.55	40.73	41.77
30 May	39.62	39.44	39.55	40.31	39.97	39.45	39.87	41.00	41.47	40.56	40.94	41.93
31 May		39.58	39.47	40.18	39.96	39.48	40.00	41.49	41.72	40.58	40.97	42.11
01 Jun		39.94	39.46	40.03	39.97	39.76	40.12	41.82	41.00	40.51	41.13	42.35
02 Jun	40.03	40.64	39.42	39.90	39.96	39.98	40.14	41.87	42.03	40.42	41.22	42.37
03 Jun	40.31	41.00	39.39	39.88	39.97	40.33	40.16	41.70	42.18	40.32	41.34	42.40
04 Jun	40.60	40.94	39.45	39.95	39.90	40.36	40.26	41.70	42.26	40.31	41.50	42.49
05 Jun	40.72	40.94	39.61	40.18	39.88	40.30	40.32	42.02	42.45	40.38	41.56	42.53
06 Jun	40.83	40.89	39.75	40.44	39.98	40.43	40.35	42.11	42.67	40.42	41.52	42.60
07 Jun	40.71	40.82	40.04	40.36	40.19	40.73	40.61	42.06	42.81	40.47	41.38	42.74
08 Jun	40.69	40.82	40.34	40.11	40.43	40.88	40.82	42.00	42.98	40.55	41.53	42.68
09 Jun		40.85	40.36	40.03	40.46	40.69	41.15	41.89	42.96	40.60	41.62	42.35
10 Jun	41.50	40.84	40.36	40.06	40.36	40.64	41.48	41.92	42.85	40.58	41.73	42.03
11 Jun		40.82	40.43	40.01	40.24	40.54	41.80	41.80	42.63	40.71	41.91	41.84
12 Jun		40.84	40.56	40.01	40.13	40.38	42.00	41.65	42.47	40.87	42.17	41.84

-continued-

	Elevation Above Sea Level (m)											
Date	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
13 Jun		40.81	40.68	40.11	40.22	40.34	42.19	41.73	42.44	41.06	42.48	41.86
14 Jun		40.67	40.84	40.13	40.33	40.37	42.36	41.78	42.61	41.31	42.74	41.94
15 Jun	41.27	40.71	40.97	40.16	40.62	40.36	42.45	42.03	42.66	41.53	42.89	42.08
16 Jun		40.60	41.07	40.13	41.05	40.36	42.64	42.13	42.58	41.77	43.01	42.35
17 Jun	41.06	40.75	41.05	40.13	41.58	40.44	42.80	42.02	42.52	42.00	42.97	42.58
18 Jun	40.93	40.88	40.89	40.36	41.83	40.57	42.99	41.94	42.39	42.10	42.85	42.61
19 Jun		40.97	40.97	40.49	41.88	40.51	42.90	42.02	42.15	42.04	42.63	42.57
20 Jun	41.16	41.31	41.15	40.49	41.89	40.43	42.56	42.09	42.03	42.05	42.47	42.60
21 Jun	41.50	41.58	41.31	40.51	41.71	40.36	42.32	42.15	41.91	42.53	42.58	42.46
22 Jun	41.54	41.85	41.66	40.34	41.54	40.70	42.53	42.22	41.92	43.14	42.91	42.50
23 Jun		41.95	41.76	40.39	41.43	41.18	42.25	42.34	41.93	43.69	42.99	42.52
24 Jun	41.35	42.01	41.99	40.46	41.29	41.27	41.82	42.48	42.01	44.02	42.90	42.58
25 Jun		42.19	42.35	40.74	41.11	41.23	41.73	42.84	42.02	44.03	42.66	42.64
26 Jun	41.62	42.43	42.60	40.79	41.00	41.10	41.68	43.13	42.09	43.83	42.42	43.00
27 Jun		42.44	42.75	40.77	40.97	40.98	41.68	43.11	42.31	43.64	42.26	42.75
28 Jun	42.39	42.43	42.58	40.97	41.17	41.28	41.55	43.01	42.59	43.57	42.44	42.61
29 Jun		42.60	42.37	41.20	41.52	41.00	41.79	42.98	42.96	43.66	42.68	42.57
30 Jun	42.90	42.55	42.14	41.43	41.62	41.53	41.79	43.03	43.27	43.78	42.99	42.60
01 Jul	42.81	42.43	41.88	41.86	41.96	42.37	41.73	43.10	43.49	43.87	43.28	42.65
02 Jul		42.24	41.94	42.32	42.37	42.83	41.82	43.31	43.78	43.90	43.61	42.61
03 Jul	42.57	42.33	41.91	42.55	42.61	42.85	41.99	43.49	43.76	43.77	44.15	42.62
04 Jul	42.18	42.51	41.91	42.62	42.70	42.91	42.29	43.41	43.71	43.76	44.35	42.55
05 Jul		42.60	41.96	42.62	42.85	43.04	42.51	43.43	43.71	43.53	44.53	42.63
06 Jul		42.67	41.86	42.67	43.03	43.16	42.66	43.38	43.74	43.24	44.55	42.59
07 Jul	41.92	42.70	42.06	42.85	43.11	43.12	42.95	43.42	43.85	43.07	44.38	42.53
08 Jul		42.84	42.29	42.93	43.13	42.93	43.08	43.43	43.75	43.08	44.19	42.34
09 Jul		42.81	42.52	42.75	43.03	42.33	43.06	43.50	43.51	43.22	43.71	42.08
10 Jul		42.82	42.72	42.55	42.70	42.52	42.94	43.63	43.14	43.49	43.39	42.50
11 Jul	42.72	42.72	42.62	42.52	42.62	42.49	42.72	43.74	42.81	43.22	43.34	42.82
12 Jul		42.55	42.47	42.55	42.76	42.50	42.53	43.95	42.58	43.04	43.48	43.07
13 Jul		42.14	42.32	42.62	42.80	42.53	42.72	44.07	42.51	42.94	43.72	43.16
14 Jul		41.98	42.19	42.60	42.78	42.41	42.73	44.03	42.42	42.92	43.65	43.45
15 Jul		41.80	42.16	42.55	42.51	42.47	42.66	43.82	42.37	42.85	43.42	43.61
16 Jul	42.44	41.95	42.06	42.44	42.35	42.43	42.64	43.51	42.28	42.82	43.41	43.76

-continued-

Appendix A6.–Page 3 of 6.

	Elevation Above Sea Level (m)											
Date	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
17 Jul		42.10	41.96	42.42		42.47	42.72	43.20	42.12	42.96	43.27	44.04
18 Jul	42.35	42.23	41.83	42.49		42.35	43.03	43.14	42.50	42.86	43.19	44.14
19 Jul		42.46	41.96	42.49		42.36	43.18	43.30	42.78	42.50	43.16	44.07
20 Jul	42.39	42.55	41.99	42.60		42.63	43.18	43.47	43.06	42.17	43.16	43.82
21 Jul		42.53	41.76	42.90		42.78	43.24	43.58	43.28	42.11	43.31	43.85
22 Jul		42.48	41.63	42.88	43.53	43.36	43.53	43.32	43.57	42.27	43.34	43.87
23 Jul	42.09	42.27	41.61	42.62	43.41	43.51	43.40	43.14	43.62	42.41	43.14	43.44
24 Jul	42.58	42.30	41.66	42.37	43.34	43.39	43.38	43.00	43.72	42.70	42.92	43.29
25 Jul	42.72	42.30	41.86	42.24		43.17	43.04	42.91	43.83	42.87	42.84	43.19
26 Jul	42.98	42.20	42.06	42.24	42.77	43.01	42.70	42.86	43.75	42.97	43.11	43.21
27 Jul	43.13	42.10	42.19	41.99	42.45	43.02	42.54	42.81	43.25	42.95	43.26	43.29
28 Jul	43.09	42.23	42.29	41.99	42.22	43.16	42.58	42.75	42.90	42.90	43.18	43.33
29 Jul		42.51	42.29	42.11	42.01	43.23	42.58	42.87	43.15	42.82	42.99	43.43
30 Jul		42.68	42.39	42.24	41.94	43.29	42.43	42.96	43.46	42.77	42.88	43.49
31 Jul		42.76	42.34	42.39	41.98	43.26	42.38	43.13	43.51	42.65	42.81	43.53
01 Aug		42.79	42.39	42.55		43.07	42.31	43.29	43.51			43.60
02 Aug	43.90	42.66	42.32	42.98		42.98	42.33	43.37	43.51			43.40
03 Aug	43.84	42.61	42.34	44.35		42.92	42.48					
04 Aug		42.55	42.34	45.09		42.93	42.81					
05 Aug		42.62	42.42			42.88						
06 Aug			42.42									
07 Aug			42.42									
08 Aug			42.42									

-continued-

	Elevation Above Sea Level (m)														
Date	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
10 May												39.88			39.88
11 May	39.03							39.17				40.05			39.42
12 May								39.25		39.81	40.28	40.20			39.88
13 May	39.12				39.32			39.18		39.16	40.25	40.41			39.57
14 May	39.18				38.74			39.20		39.10	40.01	40.54	39.28		39.44
15 May	39.26	40.71	40.33	39.65				39.08	39.89	39.06	40.36	40.66	39.04		39.76
16 May	39.33		40.07	39.65	38.76		39.32	39.06	39.84	39.07	40.39	40.86	39.42		39.65
17 May	39.43		39.77	39.49	38.80		39.31	39.18	40.02	39.08	40.42	41.00	39.63		39.63
18 May	39.53	40.27	39.60	39.44	38.85		39.35	39.27	39.76	39.11	40.42	41.11	39.79		39.65
19 May	39.76	40.09	39.57	39.35	39.00		39.44	39.28	39.91	39.15	40.44	41.05	39.89	39.58	39.68
20 May	40.17	39.65	39.60	39.28	39.06		39.57	39.36	40.04	39.17	40.60	41.06	40.02	39.49	39.73
21 May	40.35	39.87	39.55	39.29	39.08		39.57	39.50	40.24	39.17	40.79	41.13	39.74	39.51	39.81
22 May	40.19	39.90	39.55	39.62	39.04	39.45	39.57	39.52	40.40	39.18	40.95	41.18	39.77	39.58	39.86
23 May	40.07	39.98	39.62	40.08	39.09	39.34	39.52	39.45	40.69	39.21	41.11	41.20	39.91	39.64	39.92
24 May	40.12	40.08	39.75	40.49	39.13	39.35	39.47	39.37	40.78	39.31	41.23	41.37	40.14	39.68	39.98
25 May	40.17	40.31	39.85	40.50	39.16	39.43	39.49	39.36	40.89	39.52	41.40	41.41	40.38	39.78	40.05
26 May	40.05	40.71	39.87	40.40	39.28	39.44	39.52	39.43	41.07	39.66	41.64	41.46	40.65	40.04	40.14
27 May	40.03	41.06	39.89	40.27	39.58	39.46	39.51	39.51	41.29	39.80	41.64	41.51	40.93	40.32	40.24
28 May	40.11	41.04	39.95	40.22	39.91	39.44	39.65	39.64	41.41	40.01	41.42	41.55	41.30	40.51	40.33
29 May	40.08	41.04	39.98	40.22	40.26	39.53	39.74	39.83	41.33	40.16	41.39	41.53	41.39	40.36	40.40
30 May	40.22	40.88	40.11	40.40	40.64	39.54	39.85	40.02	41.33	40.29	41.39	41.52	41.23	40.17	40.45
31 May	40.23	40.69	40.29	40.42	41.09	39.42	39.99	40.20	41.46	40.33	41.34	41.56	41.20	40.13	40.56
01 Jun	40.21	40.54	40.51	40.40	41.27	39.37	40.09	40.38	41.53	40.45	41.46	41.57	41.36	40.12	40.61
02 Jun	40.22	40.45	40.96	40.45	41.25	39.55	40.17	40.57	41.35	40.49	41.49	41.57	41.26	40.16	40.69
03 Jun	40.27	40.37	41.08	40.45	41.21	39.55	40.28	40.74	41.17	40.46	41.42	41.55	41.24	40.25	40.73
04 Jun	40.30	40.26	41.18	40.37	41.42	39.56	40.44	40.95	41.12	40.43	41.35	41.52	41.45	40.46	40.79
05 Jun	40.40	40.22	41.22	40.57	41.45	39.65	40.64	41.01	41.04	40.46	41.33	41.63	41.67	40.93	40.89
06 Jun	40.52	40.22	41.08	41.06	41.55	39.87	40.93	41.04	41.02	40.71	41.52	41.78	41.64	41.42	41.01
07 Jun	40.75	40.29	40.90	41.42	41.54	40.13	41.27	41.32	41.22	40.98	41.68	41.84	41.40	41.74	41.13
08 Jun	40.88	40.45	40.97	41.49	41.96	40.52	41.38	41.28	41.28	41.23	42.18	41.92	41.27	41.70	41.24
09 Jun	40.97	40.63	41.08	41.45	42.50	40.84	41.83	41.25	41.40	41.29	42.43	41.87	41.31	41.39	41.33
10 Jun	41.10	40.81	41.03	41.45	42.86	41.16	41.85	41.34	41.39	41.35	42.43	41.88	41.36	41.14	41.37
11 Jun	41.38	41.35	40.88	41.46	42.63	41.37	41.91	41.58	41.39	41.61	42.31	42.03	41.62	41.26	41.42
12 Jun	41.55	42.09	40.70	41.44	42.25	41.45	41.94	41.86	41.35	41.93	42.07	42.25	42.00	41.53	41.49

-continued-

	Elevation Above Sea Level (m)														
Date	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
13 Jun	41.74	42.71	40.54	41.45	41.89	41.64	42.10	42.12	41.25	42.25	41.84	42.39	42.25	41.73	41.59
14 Jun	42.00	43.04	40.51	41.51	41.71	41.96	42.30	42.22	41.18	42.53	41.67	42.53	42.40	41.80	41.70
15 Jun	42.44	43.22	40.47	41.51	41.65	42.19	42.43	42.26	41.38	42.67	41.73	42.74	42.59	41.79	41.80
16 Jun	42.82	43.33	40.43	41.49	41.72	42.35	42.43	42.38	41.76	42.48	41.87	42.96	42.88	41.87	41.94
17 Jun	43.11	43.09	40.50	41.48	41.82	42.50	42.34	42.57	42.05	42.25	42.02		43.14	42.06	41.95
18 Jun	43.26	42.67	40.72	41.41	41.96	42.66	42.17	42.82	42.30	42.17	42.35	43.26	43.20	42.23	42.06
19 Jun	43.25	42.62	40.97	41.52	42.08	42.83	42.07	43.01	42.63	42.08	42.74	43.52	43.20	42.28	42.16
20 Jun	43.02	42.65	41.14	41.69	42.24	42.73	42.03	43.14	42.65	42.12	43.21	43.69	43.05	42.45	42.15
21 Jun	42.89	42.68	41.35	41.67	42.21	42.62	41.90	43.26	42.61	42.12	43.60	43.86	42.80	42.67	42.20
22 Jun	42.72	42.65	41.48	41.73	42.25	42.42	41.68	43.35	42.49	41.99	43.87	43.72	42.51	42.78	42.25
23 Jun	42.85	42.67	41.70	42.03	42.27	42.26	41.49	43.37	42.43	42.00	43.97	43.29	42.36	42.73	42.31
24 Jun	43.16	42.85	42.03	42.43	42.19	42.12	41.50	43.49	42.43	42.05	44.07	43.04	42.28	42.65	42.33
25 Jun	43.34	42.60	42.28	42.72	42.12	42.07	41.74	43.56	42.41	42.15	44.25	42.96	42.10	42.62	42.42
26 Jun	43.39	42.22	42.43	42.99	42.24	42.20	42.11	43.43	42.41	42.09	44.33	43.01	42.16	42.50	42.43
27 Jun	43.06	42.35	42.43	43.28	42.37	42.37	42.39	43.42	42.36	41.93	44.42	43.08	42.15	42.41	42.47
28 Jun	42.54	42.11	42.25	43.28	42.38	42.32	42.74	43.43	42.18	41.71	44.48	43.11	42.02	42.40	42.44
29 Jun	42.20	42.20	41.82	43.66	42.40	42.27	43.07	43.42	42.09	41.73	44.48	43.13	42.06	42.47	42.49
30 Jun	42.05	42.35	41.51	43.71	42.46	42.34	43.35	43.44	42.22	41.84	44.42	43.22	42.16	42.57	42.59
01 Jul	42.08	42.53	41.43	43.75	42.65	42.38	43.39	43.43	42.33	42.09	44.28	43.43	42.32	42.66	42.70
02 Jul	42.34	42.76	41.44	43.71	42.90	42.47	43.39	43.38	42.44	42.40	44.17	43.64	42.40	42.81	42.84
03 Jul	42.47	42.98	41.56	43.70	43.16	42.59	43.41	43.41	42.43	42.69	44.08	43.64	42.52	42.71	42.92
04 Jul	42.48	43.16	41.71	43.65	43.36	42.87	43.42	43.59	42.49	42.84	44.04	43.60	42.69	42.52	42.97
05 Jul	42.55	43.23	41.90	43.71	43.44	43.10	43.43	43.56	42.71	43.09	43.96	43.41	42.89	42.59	43.08
06 Jul	42.55	43.40	41.95	43.76	43.48	43.19	43.49	43.38	42.71	43.15	43.73	43.26	43.13	42.73	43.10
07 Jul	42.44	43.60	41.99	43.71	43.47	43.09	43.41	43.17	42.46	43.04	43.61	43.37	43.50	42.69	43.06
08 Jul	42.23	43.75	42.11	43.72	43.31	43.00	43.37	42.98	42.39	43.12	43.72	43.55	43.51	42.58	43.09
09 Jul	42.24	43.71	42.21	43.46	42.87	42.95	43.41	42.81	42.47	43.42	43.89	43.77	43.48	42.63	43.03
10 Jul	42.38	43.58	42.28	43.22	42.53	42.85	43.40	42.76	42.47	43.60	44.01	43.90	43.29	42.75	43.02
11 Jul	42.34	43.53	42.24	43.18	42.43	42.73	43.31	42.67	42.66	43.62	43.92	43.88	43.08	42.65	42.95
12 Jul	42.43	43.61	42.03	43.24	42.63	42.78	43.10	42.58	42.75	43.65	43.98	44.04	43.20	42.46	42.96
13 Jul	42.52	43.51	41.98	43.17	42.62	42.85	42.96	42.50	42.69	43.68	44.10	44.16	43.26	42.34	42.96
14 Jul	42.63	43.40	42.02	43.14	42.58	42.86	43.03	42.38	42.54	43.82	44.15	44.16	43.44	42.31	42.94
15 Jul	42.78	43.35	42.11	43.11	42.65	42.78	42.99	42.36	42.50	44.02	44.23	43.75	43.56	42.35	42.91
16 Jul	42.98	43.30	42.01	43.05	42.60	43.07	42.99	42.43	42.61	44.26	44.30	43.54	43.53	42.48	42.89

-continued-

	Elevation Above Sea Level (m)														
Date	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
17 Jul	42.99	43.01	41.91	43.04	42.66	43.41	43.17	42.51	42.71	44.48	44.43	43.75	43.27	42.61	42.97
18 Jul	42.97	43.01	42.10	42.97	42.61	43.43	43.31	42.64	42.98	44.63	44.60	43.56	42.89	42.70	42.98
19 Jul	43.06	43.12	42.30	42.93	42.51	43.29	43.37	42.82	43.27	44.48	44.63	43.09	42.70	42.80	43.03
20 Jul	42.68	43.10	42.44	42.90	41.78	42.93	43.29	43.06	43.22	43.54	44.30	42.88	42.64	42.80	42.90
21 Jul	42.73	43.17	42.47	42.87	42.33	42.93	43.12	43.45	43.02	43.65	43.95	42.93	42.64	42.91	42.98
22 Jul	42.44	43.32	42.53	42.65	42.44	42.96	43.04	43.89	42.95	43.91	43.81	43.06	42.62	43.00	43.06
23 Jul	42.21	43.59	42.53	42.66	42.42	42.96	42.84	44.24	42.91	43.79	43.85	42.85	42.59	43.07	42.97
24 Jul	42.13	43.74	42.46	42.66	42.33	42.52	42.80	44.17	43.12	43.45	43.57	42.76	42.52	43.03	42.92
25 Jul	42.26	43.42	42.56	42.75	42.17	42.29	42.69	43.82	43.63	43.27	43.37	42.74	42.66	42.93	42.86
26 Jul	42.40	43.16	42.67	42.85	42.28	42.13	42.57	43.62	44.03	43.09	43.17	42.84	42.84	42.72	42.85
27 Jul	42.68	42.89	42.65	42.85	42.36	42.13	42.55	43.41	43.59	42.90	43.12	42.99	42.85	42.56	42.79
28 Jul	42.76	42.72	42.65	43.28	42.31	42.34	42.59	43.29	43.06	42.64	43.21	43.11	42.73	42.55	42.76
29 Jul	42.83	42.38	42.75	43.63	42.18	42.50	42.69	43.23	43.02	42.58	43.55	43.14	42.70	42.59	42.79
30 Jul	42.94	42.31	42.88	43.80	42.18	42.59	42.49	43.15	43.32	42.57	43.60	42.97	42.78	42.71	42.83
31 Jul	43.28	42.33	43.21	43.81	42.15	42.41	42.52	43.06	43.30	42.58	43.37	42.56	43.01	42.87	42.85
01 Aug	42.96	42.33	43.13	43.65	42.28	42.48	42.26							42.89	42.84
02 Aug	43.17	42.33	42.92	43.45	42.35	42.70	42.26							42.85	42.91
03 Aug	43.52		42.51	43.34	42.38	43.17	42.28							42.78	42.96
04 Aug			42.35		42.16	43.46	42.42							42.71	42.88
05 Aug			42.29												42.55
06 Aug			42.11												42.26
07 Aug			41.91												42.16
08 Aug															42.42

Appendix A7.–The number of minutes per hour the oscilloscope was monitored at the Miles Lake north bank sonar site at the Copper River, May 19–August 4, 2007.

	Hour																							
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
19 May										30	30	30	30	30	30	30	30							
20 May										30	30	30	30	30	30	30	30							
21 May										30	30	30	30	30	30	30	30							
22 May										30	30	30	30	30	30	30	30							
23 May										30	30	30	30	30	30	30	30							
24 May										30	30	30	30	30	30	30	30							
25 May						30				30			30				30			30				30
26 May						30				30			30			30				30				30
27 May						30				30			ND				30			30				30
28 May						30				30			30			30				30				30
29 May						30				30			30			30				30				30
30 May						30				30			30				30			30				30
31 May						30				30			30			30				30				30
1 Jun						30				30			30			30				30				30
2 Jun						30				30			30				30			30				30
3 Jun						30				30			30			30				30				30
4 Jun						30				30			30			30				30				30
5 Jun						30				30			30			30				30				30
6 Jun						30				30			30				30			30				30
7 Jun						30				30			30				30			30				30
8 Jun						30				30			30				30			30				30
9 Jun						30				30			30				30			30				30
10 Jun						30				30			30				30			30				30
11 Jun						30				30			30				30			30				30
12 Jun						30				30			30				30			30				30
13 Jun						30				30			30				30			30				30
14 Jun						30				30			30				30			30				30
15 Jun						30				30			30				30			30				30
16 Jun						30				30			30				30			30				30
17 Jun						30				30			30				30			30				30
18 Jun						30				30			30				30			30				30
19 Jun						30				30			30				30			30				30
20 Jun						30				30			30				30			30				30
21 Jun						30				30			30				30			30				30
22 Jun						30				30			30				30			30				30

-continued-

	Hour																							
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
23 Jun						30				30			30				30			30				30
24 Jun						30				30			30				30			30				30
25 Jun						30				30			30				30			30				30
26 Jun						30				30			30				30			30				30
27 Jun						30				30			30				30			30				30
28 Jun						30				30			30				30			30				30
29 Jun						30				30			30				30			30				30
30 Jun						30				30			30				30			30				30
1 Jul						30				30			30				30			30				30
2 Jul						30				30			30				30			30				30
3 Jul						30				30			30				30			30				30
4 Jul						30				30			30				30			30				30
5 Jul						30				30			30				30			30				30
6 Jul						30				30			30				30			30				30
7 Jul						30				30			30				30			30				ND
8 Jul						30				30			30				30			30				30
9 Jul						30				30			30				30			30				30
10 Jul						30				30			30				30			30				30
11 Jul						30				30			30				30			30				30
12 Jul						30				30			30				30			30				30
13 Jul						30				30			30				30			30				30
14 Jul						30				30			30				30			30				30
15 Jul						30				30			30				30			30				30
16 Jul						30				30			30				30			30				30
17 Jul						30				30			30				30			30				30
18 Jul						30				30			30				30			30				30
19 Jul						30				30			30				30			30				30
20 Jul						30				30			30				30			30				30
21 Jul						30				30			30				30			30				30
22 Jul						30				30			30				30			30				30
23 Jul						30				30			30				30			30				30
24 Jul						30				30			30				30			30				30
25 Jul						30				30			30				30			30				30
26 Jul						30				30			30				30			30				30
27 Jul						30				30			30				30			30				30
28 Jul						30				30			30				30			30				30

-continued-

Appendix A7.–Page 3 of 3.

	Hour																							
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
29 Jul						30				30			30				30			30				30
30 Jul						30				30			30				30			30				30
31 Jul						30				30			30				30			30				30
1 Aug						30				30			30				30			30				30
2 Aug						30				30			30				30			30				30
3 Aug						30				30			30				30			30				30
4 Aug						30				30			30				30			30				30

Appendix A8.–Salmon escapement estimate during visual monitoring of the oscilloscope by half hour at the Miles Lake sonar site at the Copper River north bank, May 19–August 4, 2007.

	Hour																							
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
19 May										0	0	0	0	0	0	0	0							
20 May										0	0	0	0	0	0	0	0							
21 May										0	1	1	0	0	0	1	5							
22 May										2	1	0	1	1	2	3	2							
23 May										3	0	0	2	4	2	3	5							
24 May										5	2	2	3	0	0	5	10							
25 May						4				0			0				2			5				3
26 May						3				4			4			1				1				1
27 May						5				9			ND				5			16				27
28 May						17				5			23			45				22				55
29 May						4				2			22			5				4				25
30 May						10				7			34				37			61				23
31 May						14				15			30			25				87				31
1 Jun						5				44			4			12				33				37
2 Jun						73				100			17				11			20				31
3 Jun						36				79			17			11				11				15
4 Jun						62				55			26			13				25				9
5 Jun						19				92			34			13				5				7
6 Jun						25				56			180				49			12				10
7 Jun						44				159			110				80			47				38
8 Jun						20				28			68				66			26				30
9 Jun						49				82			25				9			34				20
10 Jun						21				61			25				20			28				18
11 Jun						30				87			62				86			72				20
12 Jun						24				85			68				70			27				22
13 Jun						37				75			40				62			12				17
14 Jun						27				17			33				39			37				26
15 Jun						22				18			27				35			24				10
16 Jun						20				41			38				53			7				13
17 Jun						49				57			7				9			12				11
18 Jun						11				20			5				2			4				15
19 Jun						11				14			6				13			11				27
20 Jun						18				15			1				4			73				25
21 Jun						20				36			50				6			38				38
22 Jun						16				17			7				7			19				10

-continued-

Appendix A8.–Page 2 of 3.

	Hour																							
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
23 Jun						18				12			26				27			77				20
24 Jun						39				93			20				37			99				47
25 Jun						29				44			37				20			39				31
26 Jun						19				30			14				34			74				62
27 Jun						10				63			12				63			73				15
28 Jun						13				63			17				3			6				54
29 Jun						101				19			7				4			18				11
30 Jun						28				13			9				3			48				39
1 Jul						17				22			11				7			3				44
2 Jul						66				34			24				21			37				26
3 Jul						52				31			37				45			126				41
4 Jul						30				19			55				8			32				34
5 Jul						111				72			23				69			26				14
6 Jul						131				98			102				9			41				85
7 Jul						36				37			40				11			36				ND
8 Jul						35				103			27				15			16				29
9 Jul						31				21			30				17			18				30
10 Jul						7				38			19				46			28				44
11 Jul						9				23			23				7			16				14
12 Jul						45				14			51				50			24				16
13 Jul						40				31			11				60			35				8
14 Jul						16				40			12				13			101				26
15 Jul						13				48			37				17			14				43
16 Jul						30				19			10				15			14				18
17 Jul						9				14			11				12			12				29
18 Jul						18				31			12				23			39				32
19 Jul						47				10			7				18			10				16
20 Jul						8				6			20				23			21				15
21 Jul						33				15			42				59			30				11
22 Jul						8				14			90				20			33				41
23 Jul						10				10			16				7			12				52
24 Jul						33				15			11				25			30				9
25 Jul						21				20			9				16			16				48
26 Jul						48				12			41				52			66				81
27 Jul						49				13			38				85			33				70
28 Jul						22				68			30				11			23				80

-continued-

Appendix A8.–Page 3 of 3.

	Hour																							
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
29 Jul						75				57			50				97			36				179
30 Jul						65				17			41				31			68				53
31 Jul						3				11			45				26			42				28
1 Aug						8				38			12				19			68				70
2 Aug						25				42			23				41			24				68
3 Aug						13				21			28				52			33				35
4 Aug						54				17			32				37			50				50

Appendix A9.–Expanded hourly and daily visual escapement estimates at the Miles Lake sonar site at the Copper River north bank, May 19–August 4, 2007.

	Hour																									
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL	DAILY
19 May										0	0	0	0	0	0	0	0								0	0
20 May										0	0	0	0	0	0	0	0								0	0
21 May										0	2	2	0	0	0	2	10								16	48
22 May										4	2	0	2	2	4	6	4								24	72
23 May										6	0	0	4	8	4	6	10								38	114
24 May										10	4	4	6	0	0	10	20								54	162
25 May						8				0			0				4			10				6	28	112
26 May						6				8			8			2				2				2	28	112
27 May						10				18			ND				10			32				54	124	595
28 May						34				10			46			90				44				110	334	1,336
29 May						8				4			44			10				8				50	124	496
30 May						20				14			68				74			122				46	344	1,376
31 May						28				30			60			50				174				62	404	1,616
1 Jun						10				88			8			24				66				74	270	1,080
2 Jun						146				200			34				22			40				62	504	2,016
3 Jun						72				158			34			22				22				30	338	1,352
4 Jun						124				110			52			26				50				18	380	1,520
5 Jun						38				184			68			26				10				14	340	1,360
6 Jun						50				112			360				98			24				20	664	2,656
7 Jun						88				318			220				160			94				76	956	3,824
8 Jun						40				56			136				132			52				60	476	1,904
9 Jun						98				164			50				18			68				40	438	1,752
10 Jun						42				122			50				40			56				36	346	1,384
11 Jun						60				174			124				172			144				40	714	2,856
12 Jun						48				170			136				140			54				44	592	2,368
13 Jun						74				150			80				124			24				34	486	1,944
14 Jun						54				34			66				78			74				52	358	1,432
15 Jun						44				36			54				70			48				20	272	1,088
16 Jun						40				82			76				106			14				26	344	1,376
17 Jun						98				114			14				18			24				22	290	1,160
18 Jun						22				40			10				4			8				30	114	456
19 Jun						22				28			12				26			22				54	164	656
20 Jun						36				30			2				8			146				50	272	1,088
21 Jun						40				72			100				12			76				76	376	1,504
22 Jun						32				34			14				14			38				20	152	608

-continued-

Appendix A9.–Page 2 of 3.

	Hour																									
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL	DAILY
23 Jun						36				24			52				54			154				40	360	1,440
24 Jun						78				186			40				74			198				94	670	2,680
25 Jun						58				88			74				40			78				62	400	1,600
26 Jun						38				60			28				68			148				124	466	1,864
27 Jun						20				126			24				126			146				30	472	1,888
28 Jun						26				126			34				6			12				108	312	1,248
29 Jun						202				38			14				8			36				22	320	1,280
30 Jun						56				26			18				6			96				78	280	1,120
1 Jul						34				44			22				14			6				88	208	832
2 Jul						132				68			48				42			74				52	416	1,664
3 Jul						104				62			74				90			252				82	664	2,656
4 Jul						60				38			110				16			64				68	356	1,424
5 Jul						222				144			46				138			52				28	630	2,520
6 Jul						262				196			204				18			82				170	932	3,728
7 Jul						72				74			80				22			72				ND	320	1,536
8 Jul						70				206			54				30			32				58	450	1,800
9 Jul						62				42			60				34			36				60	294	1,176
10 Jul						14				76			38				92			56				88	364	1,456
11 Jul						18				46			46				14			32				28	184	736
12 Jul						90				28			102				100			48				32	400	1,600
13 Jul						80				62			22				120			70				16	370	1,480
14 Jul						32				80			24				26			202				52	416	1,664
15 Jul						26				96			74				34			28				86	344	1,376
16 Jul						60				38			20				30			28				36	212	848
17 Jul						18				28			22				24			24				58	174	696
18 Jul						36				62			24				46			78				64	310	1,240
19 Jul						94				20			14				36			20				32	216	864
20 Jul						16				12			40				46			42				30	186	744
21 Jul						66				30			84				118			60				22	380	1,520
22 Jul						16				28			180				40			66				82	412	1,648
23 Jul						20				20			32				14			24				104	214	856
24 Jul						66				30			22				50			60				18	246	984
25 Jul						42				40			18				32			32				96	260	1,040
26 Jul						96				24			82				104			132				162	600	2,400
27 Jul						98				26			76				170			66				140	576	2,304
28 Jul						44				136			60				22			46				160	468	1,872

-continued-

Appendix A9.–Page 3 of 3.

	Hour																									
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	TOTAL	DAILY
29 Jul						150				114			100				194			72				358	988	3,952
30 Jul						130				34			82				62			136				106	550	2,200
31 Jul						6				22			90				52			84				56	310	1,240
1 Aug						16				76			24				38			136				140	430	1,720
2 Aug						50				84			46				82			48				136	446	1,784
3 Aug						26				42			56				104			66				70	364	1,456
4 Aug						108				34			64				74			100				100	480	1,920
Total	0	0	0	0	0	4,342	0	0	0	5,416	8	6	4,362	10	8	274	3,884	0	0	4,840	0	0	0	4,664	27,814	111,479

Appendix A10.–Copper River south bank sonar escapement estimates by hour at the Miles Lake sonar site at the Copper River, May 20–August 4, 2007.

	Hour																								
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
20 May	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6	0	6
21 May	0	0	0	12	0	0	0	0	0	0	12	3	0	0	0	0	6	12	0	0	0	6	0	24	75
22 May	6	0	6	12	0	0	0	6	0	12	0	6	6	6	18	18	12	6	36	24	12	12	6	0	204
23 May	30	30	42	6	24	12	18	0	30	21	24	30	42	42	6	24	42	18	6	12	36	54	18	12	579
24 May	18	12	12	84	24	24	6	0	24	42	12	42	108	72	66	72	24	48	78	36	78	72	66	36	1,056
25 May	24	42	72	42	114	90	72	72	84	54	36	108	72	114	78	36	66	66	66	66	30	72	138	174	1,788
26 May	234	210	132	156	150	156	168	180	288	120	78	228	222	138	192	234	138	276	348	312	348	204	90	198	4,800
27 May	72	126	234	18	108	234	312	372	306	300	342	162	240	246	408	342	432	276	576	216	402	342	252	456	6,774
28 May	438	354	372	282	582	600	666	558	570	522	552	654	342	720	570	372	396	732	780	816	852	852	972	342	13,896
29 May	984	1044	684	498	654	834	726	792	732	822	858	732	984	1020	900	1002	1182	822	996	1302	1206	996	1344	1398	22,512
30 May	1362	1506	864	498	1512	1062	1626	1332	1338	1494	1968	1500	1356	1674	1194	216	678	1140	1092	1374	1482	1176	1062	1872	30,378
31 May	1908	1344	1554	1632	852	1344	1584	1452	1458	1230	330	258	1140	1110	1302	1446	1458	1158	1512	666	804	1002	1050	1170	28,764
1 Jun	1074	942	1014	1080	984	882	960	1446	1734	1842	1758	1278	1068	1464	1794	1548	1008	888	1662	1482	1518	1500	1590	1506	32,022
2 Jun	1344	1386	1188	1110	1392	702	1446	174	1620	1590	1656	744	1560	2124	906	2394	1668	1380	1674	1674	1614	1566	1710	1566	34,188
3 Jun	1278	1302	1032	1176	1410	1404	1494	1632	1272	1242	1194	1458	2220	1656	1722	1848	1524	1386	1398	1494	1206	1152	1254	1266	34,020
4 Jun	1110	1014	744	726	786	534	252	228	900	936	1020	1218	996	972	1140	1272	1494	1194	1044	624	852	1026	1038	570	21,690
5 Jun	1098	996	1056	1188	744	720	630	618	714	384	768	768	948	858	798	906	600	546	690	822	678	624	576	588	18,318
6 Jun	522	570	534	481	481	481	384	462	228	558	648	600	690	492	612	852	552	840	492	738	648	582	660	570	13,677
7 Jun	528	456	294	492	534	384	438	348	276	294	534	366	396	468	498	474	402	486	600	600	498	456	474	738	11,034
8 Jun	516	480	306	522	498	552	612	582	948	588	750	822	828	504	516	726	714	690	312	588	720	738	582	288	14,382
9 Jun	558	210	540	510	468	540	618	174	324	360	390	450	708	270	492	594	414	618	540	462	600	576	630	306	11,352
10 Jun	516	552	558	546	408	558	534	300	504	360	594	456	456	528	522	618	720	306	420	528	498	474	552	372	11,880
11 Jun	462	372	540	522	498	444	222	324	240	342	462	318	360	360	540	636	516	564	552	432	702	600	576	438	11,022
12 Jun	180	468	162	390	606	372	264	546	510	582	138	330	252	432	672	774	768	816	719	720	834	774	749	596	12,654
13 Jun	795	528	637	771	577	541	618	366	474	744	1014	804	684	630	990	1050	750	630	756	762	864	552	600	702	16,840
14 Jun	696	642	492	600	486	474	522	396	402	594	522	522	294	540	396	564	330	336	408	450	312	576	792	246	11,592
15 Jun	240	318	282	258	198	294	204	198	408	330	258	300	372	342	288	354	300	336	318	414	342	144	270	306	7,074
16 Jun	186	282	288	222	240	282	354	444	420	474	528	462	498	276	228	258	456	624	756	744	588	432	144	78	9,264
17 Jun	366	468	456	378	348	498	426	384	492	282	360	534	294	270	264	378	336	180	294	288	498	276	444	264	8,778
18 Jun	576	336	276	240	192	174	270	420	282	204	174	294	204	228	282	420	240	192	276	222	216	336	276	390	6,720
19 Jun	318	210	258	234	282	204	54	174	144	162	210	209	114	156	132	174	216	138	294	336	288	450	324	426	5,507
20 Jun	300	348	402	300	126	186	312	198	360	258	234	240	306	336	294	144	156	474	648	360	408	324	366	348	7,428

-continued-

Appendix A10.–Page 2 of 3.

	Hour																								
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
21 Jun	468	468	354	162	246	258	336	360	312	246	216	366	378	372	354	438	378	354	384	378	294	348	426	336	8,232
22 Jun	534	216	240	138	186	180	168	180	222	210	132	162	216	222	204	162	168	252	120	156	300	312	342	318	5,340
23 Jun	294	408	312	312	258	228	252	180	228	216	204	210	204	138	204	276	306	402	342	78	534	390	528	588	7,092
24 Jun	426	312	636	420	288	444	390	588	258	432	336	372	282	450	210	540	408	402	468	168	282	486	378	324	9,300
25 Jun	390	456	492	282	264	270	384	432	378	324	318	522	666	528	252	318	426	240	276	468	516	504	300	504	9,510
26 Jun	306	324	384	324	246	264	336	282	234	264	444	756	768	864	540	612	600	444	384	654	732	624	414	540	11,340
27 Jun	372	540	606	378	402	438	516	186	408	486	984	930	774	768	912	900	1140	810	828	1080	630	750	702	660	16,200
28 Jun	798	516	486	732	1212	636	840	714	468	840	798	798	546	750	1152	1050	930	816	816	876	774	522	630	1062	18,762
29 Jun	942	1056	984	552	462	498	600	438	426	648	588	912	642	786	624	834	564	888	732	756	1044	864	726	444	17,010
30 Jun	498	420	510	684	762	462	378	276	480	504	486	486	438	672	618	570	582	648	624	828	576	522	588	504	13,116
1 Jul	624	714	750	618	660	450	648	1020	882	630	552	444	426	408	426	432	618	450	570	468	414	594	666	1014	14,478
2 Jul	522	318	414	594	858	510	468	432	306	324	450	450	642	594	366	546	450	480	582	450	444	510	564	300	11,574
3 Jul	390	522	432	390	360	456	372	336	402	402	402	456	468	384	540	654	852	714	798	420	522	504	804	840	12,420
4 Jul	504	672	1302	810	534	990	816	954	1128	690	1188	1428	1176	1554	1032	966	924	1158	1260	1218	720	936	1434	1020	24,414
5 Jul	1230	840	1356	2100	1026	1824	804	798	1188	1368	1782	1116	996	888	720	1116	594	798	1014	744	708	1158	792	636	25,596
6 Jul	414	744	738	1032	798	1032	894	636	666	588	582	858	732	690	696	588	696	762	744	690	612	564	648	606	17,010
7 Jul	228	408	330	318	372	432	738	426	408	1002	822	588	408	660	540	636	600	378	636	660	534	486	636	702	12,948
8 Jul	750	348	528	474	498	456	456	1002	618	600	282	648	702	294	264	576	768	468	342	306	852	384	354	336	12,306
9 Jul	216	324	342	432	288	324	318	294	462	318	390	258	264	348	420	588	582	762	750	672	330	318	228	354	9,582
10 Jul	288	252	600	300	252	234	366	210	150	270	306	162	204	246	450	366	276	306	240	150	66	288	222	246	6,450
11 Jul	174	216	204	258	240	198	192	174	180	240	126	186	222	156	138	222	282	222	162	420	360	600	384	228	5,784
12 Jul	228	264	234	162	48	348	174	180	162	246	234	342	270	294	354	288	402	396	348	354	372	360	474	528	7,062
13 Jul	276	444	222	270	114	306	264	192	228	426	390	312	630	276	486	348	396	408	384	330	450	354	240	324	8,070
14 Jul	408	186	366	282	324	264	168	102	276	276	282	402	366	468	384	342	342	366	480	246	396	114	264	198	7,302
15 Jul	348	234	204	282	336	114	54	174	126	360	336	132	330	168	228	408	510	342	294	276	366	204	132	288	6,246
16 Jul	354	228	48	168	174	66	156	126	192	234	144	156	372	78	168	198	120	198	216	252	222	120	246	156	4,392
17 Jul	102	54	78	72	78	96	78	114	168	72	66	66	96	66	114	96	150	372	216	138	138	234	54	42	2,760
18 Jul	36	90	126	42	102	72	96	156	24	72	96	114	120	204	216	318	336	192	276	282	204	198	198	96	3,666
19 Jul	240	198	162	168	228	150	72	132	210	270	228	102	252	156	144	306	222	186	192	462	234	228	144	144	4,830
20 Jul	138	282	264	222	366	186	294	270	162	174	252	216	138	150	186	156	162	252	300	150	288	216	132	288	5,244
21 Jul	222	180	126	102	264	198	222	204	174	180	192	114	228	216	222	234	156	246	330	144	150	144	156	132	4,536
22 Jul	360	180	306	288	180	192	132	222	228	120	186	360	324	282	198	84	204	384	246	174	66	192	174	42	5,124
23 Jul	324	144	132	342	180	258	366	228	246	336	204	126	180	204	516	234	210	264	774	306	288	306	162	114	6,444

-continued-

	Hour																								
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
24 Jul	156	144	84	192	156	66	60	96	150	126	24	96	90	144	150	66	90	72	180	54	120	114	96	126	2,652
25 Jul	84	144	96	114	66	108	138	150	186	114	234	162	120	150	138	528	234	186	234	192	210	168	108	288	4,152
26 Jul	564	498	264	144	78	126	66	90	150	84	174	186	108	150	264	228	246	246	372	264	264	228	396	228	5,418
27 Jul	138	504	312	288	162	348	348	240	192	168	234	234	222	528	708	492	234	330	330	156	84	192	198	216	6,858
28 Jul	156	168	126	108	72	120	180	198	204	318	252	354	240	228	216	192	234	126	282	558	234	228	546	402	5,742
29 Jul	498	240	174	72	114	108	150	216	348	294	306	312	270	426	318	438	792	306	552	642	312	414	294	222	7,818
30 Jul	138	120	162	108	216	150	192	180	252	270	162	150	486	210	198	216	276	252	336	360	108	270	108	42	4,962
31 Jul	114	96	36	36	216	108	108	174	138	168	156	150	222	264	186	240	456	444	540	390	468	234	282	264	5,490
1 Aug	306	282	168	108	126	96	228	270	204	162	210	192	180	198	144	108	174	180	180	222	144	174	132	78	4,266
2 Aug	264	90	138	72	114	252	294	276	204	264	228	198	180	306	180	276	234	390	282	276	216	210	210	240	5,394
3 Aug	336	294	324	378	354	474	204	204	234	378	180	186	210	144	108	186	228	342	264	192	282	366	258	390	6,516
4 Aug	372	210	126	210	180	108	144	132	216	114	228	198	156	144	168	144	180	198	192	546	132	90	126	126	4,440
Total	34,269	31,896	31,309	30,526	29,738	29,480	30,252	28,422	31,560	32,571	33,810	32,864	34,704	35,274	34,476	38,262	36,330	35,610	39,215	37,170	36,126	34,968	35,507	33,782	808,122

Appendix A11.–Copper River south bank 10-min escapement estimates by range at the Miles Lake sonar site, May 20–August 4, 2007.

	Range (m)																				
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
20 May			1																		
21 May		5	1		1																
22 May	2	11	6	3	2	1		1			1										
23 May	5	25	20	11	3	8	1	1			2	1		1			1				
24 May		33	46	36	13	11	15	2		1	1	5	1	1			1				
25 May	3	39	55	45	9	3	8	2	2	3	5	3	2			5	2	2	1		
26 May		27	77	91	147	122	82	43	36	30	30	32	16	12	10	2	4	4	3	1	
27 May	1	13	89	120	145	170	168	109	57	36	22	41	40	22	13	18	12	7	2	1	
28 May	1	47	269	358	336	386	284	155	99	47	27	60	49	35	45	63	20	10	18	20	1
29 May		240	610	704	645	523	295	168	79	54	46	36	39	47	38	33	18	18	11	8	1
30 May		430	874	1175	1013	422	300	139	67	82	59	32	37	55	43	16	15	8	5	3	
31 May		137	1,088	1,479	983	375	241	128	58	53	62	34	37	32	26	8	12	11	2		
1 Jun	4	219	1,509	1,760	870	349	223	114	79	81	57	48	39	47	27	23	9	3	2	4	
2 Jun	4	238	1,347	1,802	979	478	237	138	62	95	72	60	60	50	29	18	13	16	3	8	3
3 Jun	2	93	911	1,773	1,283	697	341	188	65	54	46	44	37	44	27	30	7	10	4		1
4 Jun	2	45	190	753	815	691	449	260	114	83	46	34	22	19	8	5	3	4	1		1
5 Jun	3	55	370	693	707	460	239	151	109	68	39	41	16	14	4	3	1	2			
6 Jun		18	220	400	393	402	250	143	128	112	60	44	46	14	6	2		1			
7 Jun		15	214	375	393	297	328	123	66	69	65	47	41	21	10	14	3				
8 Jun		17	327	604	526	398	286	128	59	96	81	43	36	28	26	12	3	2			
9 Jun		23	267	369	352	245	187	177	126	122	56	39	56	28	16	7	2				
10 Jun	1	30	311	413	302	252	239	156	92	71	65	57	19	10		8	3	4	1		
11 Jun	1	16	169	279	311	270	218	191	178	99	71	64	51	38	6	3	6	2	1		
12 Jun		21	300	403	345	311	230	121	135	134	100	69	53	30	24	8	3	1	3		

-continued-

	Range (m)																				
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
13 Jun		23	368	522	546	441	349	238	131	138	108	85	71	44	41	23	10	7	2		
14 Jun		15	151	242	303	309	284	275	130	79	113	103	79	42	42	41	15	6	3	1	
15 Jun		4	75	214	217	194	142	162	44	56	61	50	51	46	21	29	20	5			
16 Jun		14	155	353	390	279	183	186	71	52	51	33	48	32	18	14	9	4			
17 Jun	2	12	93	168	249	339	317	231	162	71	38	29	24	35	33	17	11	4	3		
18 Jun		17	101	161	154	274	245	161	122	62	43	26	18	21	25	21	24	6	6	1	
19 Jun		12	80	176	140	183	165	105	94	47	31	13	10	20	14	13	14	5	1		
20 Jun	1	25	174	287	230	235	173	131	91	46	30	15	11	4	8	14	9	4	4		
21 Jun		20	133	221	213	292	190	189	140	124	63	35	25	8	5	12	15	14	2		
22 Jun		5	92	167	170	195	168	120	92	59	53	25	13	15	7	5	10	1	2		2
23 Jun		13	114	173	159	220	150	173	147	84	85	55	30	24	13	13	16	5			
24 Jun		7	95	146	195	273	193	218	166	131	88	57	63	29	20	29	35	21	7	3	
25 Jun		6	59	98	165	205	223	259	227	208	132	72	64	42	27	43	34	24	11	1	
26 Jun		13	94	190	329	286	316	265	206	152	78	66	39	31	30	30	38	22	1		
27 Jun		40	311	622	553	457	471	248	222	111	75	51	30	40	67	49	19	12	2		
28 Jun		51	322	586	649	516	549	276	271	157	96	72	30	43	41	54	37	10	3		
29 Jun	1	46	338	492	752	517	533	374	261	146	68	52	36	26	32	38	26	18	5	3	
30 Jun		26	221	309	452	438	359	307	169	178	73	55	44	16	30	32	24	8			
1 Jul		30	404	549	581	468	351	249	158	112	49	26	20	7	6	8	7	3			
2 Jul		41	419	651	482	472	381	214	153	133	84	52	16	8		5	1				
3 Jul		44	355	438	427	364	280	251	154	119	88	58	27	16	10	6	8	2	4	1	
4 Jul	3	207	1,147	1,199	1,265	661	414	271	177	136	50	37	18	12	8	5	3	2		1	
5 Jul	4	235	1,138	1,213	1,172	731	451	264	147	81	35	21	11	12	10	4		1			
6 Jul		55	570	764	611	706	343	351	235	167	100	50	28	12	4	9	4	1			

-continued-

	Range (m)																				
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7 Jul		39	519	621	440	425	228	167	172	122	93	34	23	12	11	6	4	5			
8 Jul	1	34	423	485	438	475	228	253	151	100	50	34	11	17	6	13	12	5	2		
9 Jul		43	354	396	345	296	170	110	96	57	35	13	9	9	7	9	5	1			
10 Jul		7	147	225	192	214	161	122	84	79	44	21	11	9	4	3	1				
11 Jul		35	217	222	225	173	118	91	57	38	13	6	4	1	2	4	1				
12 Jul		23	97	188	205	171	218	135	110	68	37	21	19	13	18	7	10	3			
13 Jul		26	163	282	188	213	195	103	128	58	28	29	17	13	16	29	12	4			
14 Jul	1	38	161	251	186	200	197	113	90	45	21	27	11	23	24	14	7	4	1		
15 Jul		23	116	249	205	118	163	99	81	42	20	12	9	11	12	7	9	2			
16 Jul		28	108	117	125	107	99	93	52	42	27	12	5	9	7	2	5	1			
17 Jul		14	74	73	69	87	45	44	45	31	13	6	2	5	2	1	7	2			
18 Jul		16	81	111	86	132	104	67	56	38	25	13	10	6	2	5	6	6	1		
19 Jul		17	124	157	113	117	136	68	58	49	30	21	9	6	3	4	3		3		
20 Jul		22	161	173	126	136	121	80	66	55	41	18	13	11	1		3	2			
21 Jul		22	142	177	137	103	136	65	43	21	27	12	3	3	3	2	2		1		
22 Jul		18	123	174	193	116	96	118	59	37	35	25	17	3	5		1				
23 Jul		36	208	288	276	157	132	106	62	33	22	30	14	8	3	2					
24 Jul		10	43	71	84	81	78	68	50	44	31	13	3	3	1	2	1				1
25 Jul		19	198	213	119	100	108	46	18	19	8	4	2	1	3	2	2				
26 Jul	1	16	162	189	157	188	147	114	72	51	24	19	14	10	5	3	4	3	1		
27 Jul		65	289	248	241	138	121	100	52	40	20	11	12	2	13	4	11	2			
28 Jul		39	237	210	251	109	110	60	31	28	14	8	11		12	6	6	6	1		
29 Jul	1	34	253	232	267	179	173	172	123	83	38	28	17	10	9	15	11	8			
30 Jul		29	228	204	160	148	85	52	39	25	25	10	10	5	4	4	5	4			
31 Jul		38	204	272	164	110	111	52	43	16	21	5	2	5			1		1		

-continued-

Appendix A11.–Page 4 of 4.

	Range (m)																				
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1 Aug		28	139	236	126	122	104	41	40	31	20	9	3	5	3	2	1	1			
2 Aug		45	152	167	138	140	129	72	50	42	31	19	10	11	5	9	6	3	9		
3 Aug		51	322	335	215	176	81	40	31	28	11	9	2	4	1			4	1		
4 Aug		19	144	127	95	148	67	72	79	42	27	19	19	12	2	25	15	11	6		

Appendix A12.–Copper River south bank 10–min escapement estimates by range as percent of total at the Miles Lake sonar site, May 20–August 4, 2007.

	Range (m)																				
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
20 May			1.0																		
21 May		0.7	0.1		0.1																
22 May	0.1	0.4	0.2	0.1	0.1	0.0		0.0			0.0										
23 May	0.1	0.3	0.3	0.1	0.0	0.1	0.0	0.0			0.0	0.0		0.0			0.0				
24 May		0.2	0.3	0.2	0.1	0.1	0.1	0.0		0.0	0.0	0.0	0.0	0.0			0.0				
25 May	0.0	0.2	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0		
26 May		0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
27 May	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
28 May	0.0	0.0	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 May		0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30 May		0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
31 May		0.0	0.2	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
1 Jun	0.0	0.0	0.3	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2 Jun	0.0	0.0	0.2	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 Jun	0.0	0.0	0.2	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
4 Jun	0.0	0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
5 Jun	0.0	0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
6 Jun		0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0		0.0			
7 Jun		0.0	0.1	0.2	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
8 Jun		0.0	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
9 Jun		0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
10 Jun	0.0	0.0	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0		
11 Jun	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
12 Jun		0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

-continued-

Date	Range (m)																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
13 Jun		0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
14 Jun		0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
15 Jun		0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
16 Jun		0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
17 Jun	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
18 Jun		0.0	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
19 Jun		0.0	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
20 Jun	0.0	0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
21 Jun		0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
22 Jun		0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0
23 Jun		0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
24 Jun		0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
25 Jun		0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
26 Jun		0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
27 Jun		0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
28 Jun		0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
29 Jun	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
30 Jun		0.0	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
1 Jul		0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
2 Jul		0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0				
3 Jul		0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
4 Jul	0.0	0.0	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	
5 Jul	0.0	0.0	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0			
6 Jul	0.0	0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
7 Jul	0.0	0.0	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			

-continued-

Appendix A12.–Page 3 of 4.

Date	Range (m)																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
8 Jul	0.0	0.0	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
9 Jul		0.0	0.2	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
10 Jul		0.0	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
11 Jul		0.0	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
12 Jul		0.0	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
13 Jul		0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
14 Jul	0.0	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
15 Jul		0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
16 Jul		0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
17 Jul		0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
18 Jul		0.0	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
19 Jul		0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0		
20 Jul		0.0	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0		0.0	0.0			
21 Jul		0.0	0.2	0.2	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0		
22 Jul		0.0	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0		0.0				
23 Jul		0.0	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					
24 Jul		0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0				0.0
25 Jul		0.0	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
26 Jul	0.0	0.0	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
27 Jul		0.0	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
28 Jul		0.0	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		
29 Jul	0.0	0.0	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
30 Jul		0.0	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
31 Jul		0.0	0.2	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0		0.0		
1 Aug		0.0	0.2	0.3	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			

-continued-

Appendix A12.–Page 4 of 4.

	Range (m)																				
Date	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2 Aug		0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
3 Aug		0.0	0.2	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0		
4 Aug		0.0	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		