Fishery Data Series No. 09-23

Sonar Estimation of Chum Salmon Passage in the Aniak River, 2007

by

Malcolm S. McEwen

April 2009

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)

Measures (fisheries)

fork length	FL
mideye to fork	MEF
mideye to tail fork	METF
standard length	SL
total length	TL

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 SERIES NO. 09-23

SONAR ESTIMATION OF CHUM SALMON PASSAGE IN THE ANIAK RIVER, 2007

by
Malcolm S. McEwen
Alaska Department of Fish and Game, Division of Commercial Fisheries, Fairbanks

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

April 2009

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.

Malcolm S. McEwen,
Alaska Department of Fish and Game, Division of Commercial Fisheries,
1300 College Road, Fairbanks, Alaska 99701-1599, USA

This document should be cited as:

McEwen, M. S. 2009. Sonar estimation of chum salmon passage in the Aniak River, 2007. Alaska Department of Fish and Game, Fishery Data Series No. 09-23, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

The Aniak River sonar project has provided daily fish passage estimates for most years since 1980. During this time, the project has undergone important modifications including changing from the original Bendix sonar to dual-beam in 1996 and to a high frequency imaging sonar (DIDSON) in 2004. In 2007, the project maintained the sampling schedule adopted in 2003 in which the sonar operated for three 4-hour blocks each day (0000–0400, 0800–1200, and 1600–2000 hours). The Aniak River sonar project was operational from June 24 through July 31, 2007. During this period, an estimated 699,178 fish (SE 16,947) passed through the ensonified area, the majority of which are assumed to be chum salmon *Oncorhynchus keta*. The peak passage of 57,586 fish occurred on July 14 and the 50% passage date occurred on July 18. Age-0.2, -0.3, -0.4 and -0.5 chum salmon comprised 2.2%, 66.6%, 29.7% and 1.5% of the escapement estimate, respectively.

Key words: Aniak River, DIDSON, chum salmon, hydroacoustic, Kuskokwim River, *Oncorhynchus keta*, sonar

INTRODUCTION

HISTORY

The Kuskokwim River subsistence and potential commercial salmon fishery in June and July is directed toward the harvest of chum salmon *Oncorhynchus keta* and Chinook salmon *O. tshawytscha*. From 1996 to 2005, an average of 54,841 chum salmon were harvested annually for subsistence purposes in the Kuskokwim area (Linderman and Bergstrom 2006). Commercial chum salmon harvests in Districts 1 (W-1) and 2 (W-2) from 1995 to 2005 averaged 56,279 fish, from 2001 to 2003 no market existed for chum salmon in the Kuskokwim River fishery, and only modest commercial fisheries were prosecuted from 2004 to 2006 (Linderman and Bergstrom 2006).

Timely estimates of run strength and escapement are important to management of the Kuskokwim River fishery. Based on past sonar escapement estimates and aerial survey indices of abundance, the Aniak River is believed to be one of the largest producers of chum salmon in the Kuskokwim River drainage (Francisco et al. 1995). Prior tagging studies have shown that chum salmon migrate from the upper end of District 1 to the Aniak River sonar site in about 7 or 8 days (ADF&G 1961, 1962). Because of the Aniak River's proximity to the Kuskokwim River commercial and subsistence fisheries (Figure 1), the Aniak River sonar project provides timely estimates of chum salmon passage.

The Aniak River sonar project began operating in 1980 and has undergone numerous changes in equipment and methodologies. From 1980 to 1995, Aniak River escapement data were collected using an echo counting and processing transceiver manufactured by Bendix Corporation[1]. Data were collected with a single transceiver mounted on an 18.3 m artificial substrate located on the right bank and expanded to estimate total fish passage beyond the ensonified range (Schneiderhan 1989). Cumulative adjusted daily totals were subjectively estimated to be 150% of the actual count for the initial years of operation. Behavior of chum salmon observed during aerial spawning surveys of the Aniak River, and visual observations of fish migration patterns reported for the Anvik River (Buklis 1981) lead to the supposition that on the order of two-thirds of the run passed through the ensonified portion of the river. A second sonar counter was temporarily operated for a few days in 1984 to refine the expansion factor applied to the daily

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

counts (Schneiderhan 1985). The second counter was deployed 1.5 km downstream from the existing counter and alternately operated on each bank. The proportions between daily counts at the historical site and each bank of the downstream site over a 16 day period resulted in a new expansion factor of 162%. This expansion factor was used from 1984 through 1995 to readjust the estimated counts from 1980–1983. In addition to the expansion of daily totals, sonar estimates were extrapolated for salmon escapement occurring before and after the operational period.

In 1996, the Aniak River sonar project was redesigned to provide full river ensonification with user-configurable sonar equipment operating 24 hours per day on both banks throughout the chum salmon migration. A new sonar data collection site was established 1.5 km downstream from the historical site. Seasonal sonar estimates were not extrapolated for salmon escapement before or after the operational period. Sonar operations from 1997 to 2002 remained essentially unchanged. During the winter of 2002 different sonar sampling regimes were explored in order to reduce operational costs. It was found sampling an alternating 4 hours on, 4 hours off schedule presented the least overall error (+/- 2.7%) with a moderate amount of daily variability. In 2003, instead of sampling 24 hours per day the project implemented an alternating 4 hours on, 4 hours off sampling period (Sandall and Pfisterer 2006). Preparations to transition to a dual frequency identification sonar (DIDSON) were also initiated in 2003 (Sandall and Pfisterer 2006) and in 2004, the dual-beam system was replaced with the DIDSON. Sonar operations in 2007 were consistent with the changes made in 2003, 2004.

Examination of the relationship of counts made in 2003 using BioSonics and DIDSON equipment has shown a density dependent relationship, with the BioSonics estimates approximately 70% of those derived using DIDSON (Sandall and Pfisterer 2006). Using the density dependent relationship, the fish estimates from 1980 to 2003 have been adjusted to equivalent DIDSON estimates (Carl Pfisterer, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication; Figure 2).

In the early 1980s, sonar counts were apportioned to chum or Chinook salmon using catch information from test gillnets. Schneiderhan (1988) determined that the abundance of other fish species was insufficient to compromise the utility of passage estimates for making chum salmon management decisions and, because of this determination, species apportionment activities were discontinued in 1986. A 1995 Aniak River sonar test fish feasibility study indicated that a species apportionment program was logistically feasible at the current site (Knuepfer 1995). The primary impediment to implementing such a program was a lack of funding. In response to extremely poor returns of chum and coho salmon in 1997 and 1998 the federal government (Western Alaska Fisheries Disaster) made funds available for Kuskokwim River salmon fisheries research and management (Fair 2000). In 2001 and 2002, through these funds, a new species apportionment feasibility study was conducted. This study attempted to determine if test fishing with gillnets could provide an acceptable method of apportioning sonar counts to fish species. The results were similar to earlier efforts indicating that drift gillnetting was not an acceptable method and was unnecessary for apportioning sonar counts on this river system, prompting termination of the study in 2003 (McEwen 2006).

Although fish passage estimates were not apportioned by species, periodic net sampling was employed to monitor broad changes in species composition, corroborate acoustically detected abundance trends, and obtain chum salmon age, sex and length (ASL) samples. From 1981 through 1985, attempts at beach seine test fishing and carcass sampling proved unsuccessful at obtaining adequate sample sizes for ASL determination. In 1986, ASL sampling activities were discontinued to decrease operating costs when it was noted that the Aniak River chum salmon ASL data were similar to the commercial catch results from the lower Kuskokwim River districts (Schneiderhan, 1988). In 1996, beach seining procedures were reexamined and a method was devised to provide large enough samples to estimate ASL for chum salmon. ASL sampling continues to be an important component of the project.

Escapement objectives for the Aniak River have undergone a number of modifications since the project's inception. Salmon escapement objectives were tentatively set at 250,000 chum salmon and 25,000 Chinook salmon in 1981, and formally established in 1982. The chum salmon objective was derived subjectively by relating historical sonar passage estimates to trends in harvest and aerial survey indices (Schneiderhan 1982b). In 1983, a review of the escapement objective based upon sonar estimates and other escapement indices suggested that the 1980–1981 Aniak River sonar estimates likely represented record escapements, and much smaller escapements would probably provide adequate future spawning stocks and a sustainable harvest (Schneiderhan 1984). With the discontinuation of species apportionment in 1985, the sonar-based escapement objective was changed from species-specific objectives to 250,000 estimated fish counts (Schneiderhan 1985). After the implementation of the Salmon Escapement Goal Policy in 1992, the Aniak River escapement objective was termed a biological escapement goal (BEG; Buklis 1993). During the winter of 2003 and 2004, the Arctic-Yukon-Kuskokwim (AYK) escapement goal team recommended a sustainable escapement goal (SEG) of 210,000 to 370,000 chum salmon fish. In 2007, the SEG was revised upward to 220,000 to 480,000 (Brannian et al. 2006). The SEG is defined as a level of escapement, indicated by an index or an escapement estimate, that is known to provide for sustained yield over a 5 to 10 year period and is used in situations where a BEG cannot be estimated due to the absence of a stock specific catch estimate (Brannian et al. 2006). A timetable of changes for the sonar project is presented in Appendix A1.

OBJECTIVES

The objectives of the Aniak River sonar project are to:

1. Estimate fish abundance in the Aniak River with user-configurable sonar equipment by sampling three 4-hour shifts per day on both banks throughout the bulk of the chum salmon migration (approximately June 21 through July 31).
2. Estimate age, sex, and length (ASL) composition of the total Aniak River chum salmon escapements from a minimum of 2 to 3 pulse samples collected from each third of the run, such that simultaneous 95% confidence intervals of age composition in each pulse are no wider than 0.20 (α=0.05 and d=0.10).
3. Monitor selected climatic and hydrological parameters daily at the project site for use as baseline data.

METHODS

Site Description

The Aniak River sonar project site is located in Section 5 of T16N, R56W (Seward Meridian), approximately 19 km upstream from the mouth of the Aniak River on state land and permitted by Alaska Department of Natural Resources (DNR) permit # 13916. The main camp is situated at 61° 30.163’ N, 159° 22.464’ W (Figure 3). The Aniak River originates in the Aniak Lake basin about 145 km east and 32 km south of Bethel, Alaska. It flows north for nearly 129 km, where it joins the Kuskokwim River 1.6 km upstream from the community of Aniak.

The Aniak river, at the sonar site, is characterized by broad meanders, with large gravel bars on the inside bends and cut banks with exposed soil, tree roots, and snags on the outside bends. Numerous transects were conducted in the immediate vicinity of the sonar site, using a Lowrance model X-16 chart recording fathometer to determine the best location to deploy the sonar transducers. As with past years, we were able to use the same location, due to the site’s stability. The river substrate at the sonar site is fine, smooth gravel, sand, and silt. The left bank slopes gradually to the thalweg at roughly 35–45 m, while the right bank river bottom slopes steeply to the thalweg at about 5–10 m, depending on water level.

Hydroacoustic Data Acquisition

Equipment

Two DIDSON units were deployed at the Aniak sonar site, a long range DIDSON on the left bank, and a standard on the right bank. The left bank DIDSON was mounted on an aluminum tripod and manually aimed. The right bank DIDSON was mounted on an aluminum tripod and remotely aimed with a set of Hydroacoustic Technology Inc. (HTI) rotators allowing movement in 2 axes. A Remote Ocean Systems pan and tilt control unit was connected to the rotators and provided horizontal and vertical positioning accurate to within ± 0.3º.

Each DIDSON was controlled by a laptop computer running either version 5.09 or 5.11 of the DIDSON software. A 152.4 m cable transferred power and data between a “breakout box” and the DIDSON unit in the water. For the right bank, a Honda model EU-2000 generator provided power for all equipment. An Ethernet cable routed data between the breakout box and a 10/100 BT hub and then to a laptop computer. A 250 GB RAID enclosure was connected to the laptop for storing all data from both banks (Figure 4). The enclosure was configured as RAID 1, allowing redundant copies of the data on 2 separate hard drives within the enclosure in the event one of the mechanisms failed.

The left bank sonar electronic equipment was housed in a 3.0 by 3.7 m (10 by 12 ft) portable wall tent and the equipment was powered by a single Honda model EU-1000 generator. A wireless Ethernet router (D-Link DWL-2100AP) transferred the data from the left bank DIDSON to the controlling laptop on the right bank where the data were saved to the RAID drive (Figure 4).

Transducer Deployment

The transducers were attached to an aluminum tripod deployed on each bank, and oriented perpendicular to the current. The wide axis of each beam was oriented horizontally and positioned close to the river bottom to maximize residence time of targets in the beam. Transducers were placed offshore 4 to 10 m from the right bank, and 10 to 20 m from the left bank. Daily visual inspections confirmed proper placement and orientation of the transducers and alerted operators as to when the transducers needed to be repositioned to accommodate changing water levels. The majority of the river (72%–88% depending on water level) was ensonified by sampling both the right and left banks out to 20 m.

Partial weirs were erected perpendicular to the current and extended from the shore out to 1–3 m beyond the transducers. These weirs moved chum salmon, Chinook salmon, and other large fish offshore preventing them from passing undetected behind the transducers. The 4.4 cm gap between weir pickets was selected to divert large fish (primarily chum and Chinook salmon) while allowing passage of small, resident, non-target species, (suckers, *Catostomus sp.*, whitefish, *Coregonus*, and rainbow trout, *O. mykiss)*.

Sampling Procedures

Sonar project activities commenced on June 24 and ended on July 31, 2007. Hydroacoustic sampling began at 0800 hours on June 24 on right and left bank and ran every day until 2000 hours on July 31. Passage estimates were available to fishery managers in Bethel at 0730 hours daily.

Acoustic sampling was conducted on both banks for three 4 hour shifts, 7 days per week, except for short periods when the generator was serviced or transducer adjustments were made. This sampling was consistent with the 2003 and 2004 field seasons but was a significant change from seasons prior to 2003 when sampling occurred 24 hours per day. Three fishery technicians operated and monitored equipment at the sonar site while rotating through shifts (one person per shift) occurring from 0000–0400, 0800–1200, and 1600–2000 hours. The technicians identified and tallied fish traces from the echogram recordings. All fish were counted except for very small fish, which are assumed not to be salmon. The number of fish traces were then summed over 15 minute periods and recorded onto forms. Completed data forms were entered into a spreadsheet and checked over by the crew leader. All data was saved to the RAID drive in 15 minute intervals during the 4 hour shift for later review as an echogram and/or video. All counting was done manually using the echogram by marking fish traces with the computer mouse. The video was used to verify fish target and fish size. Daily estimates were transmitted via single side band radio or satellite phone to area managers in Bethel at 0730 hours the following morning.

The crew recorded project activities in a project logbook. The logbook was used to document daily events of sonar activities and system diagnostics. During each shift, crew members were required to: 1) read the log from the previous shift; 2) sign the log book, including date and time of arrival and departure; 3) record equipment problems, factors contributing to problems, and resolution of problems; 4) record equipment setting adjustments and their purpose; 5) record observations concerning weather, wildlife, boat traffic, etc.; and 6) record visitors to the site, including their arrival and departure times.

Equipment Settings

The DIDSON is a high frequency, multi-beam sonar with a unique acoustic lens system designed to focus the beam to create high resolution images. Sound pulses were generated by the sonar at center frequencies of 1.1 MHz for the standard DIDSON and 1.2 MHz for the long range DIDSON. DIDSON simultaneously transmits on, and then receives from sets of 12 beams. Images or frames are built in sequences of these sets of pings. At the operational frequencies used, 48 beams (4 sets of 12) 0.6° apart from each other on a horizontal plane are utilized to form the image. The right bank and left bank both sampled at a range from 0.83 m to 20 m and the frame rate was set to 4 pings per second.

ANALYTICAL METHODS

Abundance Estimation

Daily passage $\hat{y}_{dz}$ on day *d*, and bank *z* was estimated by first calculating the hourly passage rate r_{dzp} for each period *p*:

$$r_{dzp} = \frac{\sum_{s=1}^{16} y_{dzps}}{4}, \tag{1}$$

where the rate is calculated by summing the 16 individual 15 minute observations *s*, collected during the 4 hour sample period, and dividing by the total number of hours. The average hourly passage rate for the day $\hat{r}_{dz}$ is then estimated from the passage rates for the 3 periods,

$$\hat{r}_{dz} = \frac{\sum_{p=1}^{3} r_{dzp}}{3}. \tag{2}$$

Finally, the daily passage for bank *z* is estimated by multiplying the average hourly passage rate by 24 (the number of hours in the day):

$$\hat{y}_{dz} = 24\hat{r}_{dz}. \tag{3}$$

The total daily passage is estimated by adding the daily passage for both banks. Note that the same result is obtained by summing all of the individual 15 minute samples collected in one 24h period and multiplying by the reciprocal of the fraction of the day sampled (i.e. 24/12=2).

Sonar sampling periods, each 4 hours in duration, were spaced at regular (systematic) intervals. Treating the systematically sampled sonar counts as a simple random sample may overestimate the variance of the total since sonar counts can be highly auto correlated (Wolter 1985). To accommodate these data characteristics, a variance estimator based on the squared differences of successive observations was utilized. This estimator was adapted from the estimator used at the Yukon River sonar project (Pfisterer 2002). The variance for the passage estimate for bank *z* on day *d* was estimated as:

$$\hat{V}_{y_{dz}} = 24^2 \cdot \frac{1 - f_{dz}}{n_{dz}} \cdot \frac{\sum_{p=2}^{n_{dz}} \left(r_{dzp} - r_{dz,p-1}\right)^2}{2\left(n_{dz} - 1\right)}, \tag{4}$$

where n_{dz} is the number of periods sampled in the day (3) and f_{dz} is the fraction of the day sampled (12/24=0.5). Finally, since the passage estimates are assumed independent between zones and among days, the total variance was estimated as the sum of the variances:

$$\hat{V}ar(\hat{y}) = \sum_{d}\sum_{z}\hat{V}ar(\hat{y}_{dz}). \tag{5}$$

Missing Data

Depending on the amount of time that was missed, the crew used different methodologies to make up for incomplete or missing counts.

If less than 10 minutes were missed the passage rate for the period within that interval was used to estimate passage for the non-sampled portion of the interval.

$$P = x_i(15/m_c) \tag{6}$$

Where 15 is the number of minutes in a complete sample and m_c is the number of minutes in sample that where actually counted, x_i is the number of fish counted.

If data from one or more complete samples was missing, counts were interpolated by averaging counts from samples before and after the missing sample(s) as follows:

$$P = \left(1/n\sum_{i=1}^{n} x_i\right)\begin{Bmatrix} s = 1, n = 4 \\ s = 2, n = 6 \\ s = 3, n = 8 \end{Bmatrix} \tag{7}$$

Where n is the number of samples used for interpolation (half before and half after missing sample(s)), x_i is the count for each sample i, and s is the number of missed samples.

If more than 4 samples were missed, an XY Scatter plot was calculated using the fish counts for the day from both left bank and right bank. The linear regression-line equation was then used to calculate missing fish counts:

$$P_i = a + bx_i \tag{8}$$

Where a and b are the regression coefficients, x equals the count for sample i on the opposite bank and P_i is the estimated passage for missing sample i.

ASL Sampling

Equipment and Procedures

The gravel bar just upstream and on the opposite bank from the sonar camp was used as the sampling site over the past several years. Prior to 2003 the gravel bar in front of camp was used for collecting ASL samples, but this site became unusable due to snags. In recent years the gravel bar just upstream has been used exclusively because it has few snags, which allows the net to drift smoothly and has led to more efficient sampling. The crew fished a 3 by 46 m (10 by 150 ft) green 7.0 cm mesh beach seine to obtain ASL samples from chum salmon. After attaching a 30 m line to one end of the seine, the seine was stacked in a plastic fish tote and placed in the stern of a skiff. The crew attached the opposite end of the seine to a pulley designed to pivot from the side of the skiff from the bow to the stern. As the skiff moved offshore, orientated upstream, the end of the 30 m lead was held in place by a crew member on shore. The skiff moved straight offshore until all of the lead line was deployed and the seine started to peel out of the tote. The driver maneuvered the skiff upstream and inshore, deploying the entire length of the seine. When the skiff reached the shore, the seine was released from the pulley and allowed to drift downstream while the crew guided it next to the shore. The lead was pulled in just enough to form a hook shape to the offshore end of the seine. The crew drifted the entire seine in this formation for approximately 100 m before the lead line was pulled in to close the set.

All captured fish except chum salmon were tallied by species, fin clipped, recorded and released. Chum salmon were placed in a live box for sampling. One scale was taken from the preferred area of each chum salmon for use in age determination (INPFC 1963). Scales were wiped clean and mounted on gum cards. Sex was determined by visually examining external morphological characteristics, such as kype development, roundness of the belly, and the presence or absence of an ovipositor. Length was measured to the nearest 5 mm from mid eye to tail fork. Fish that were sampled had the adipose fin clipped so that they were not sampled twice if recaptured. All measurements were recorded in a “rite-in-the-rain” notebook and later transcribed to standard mark-sense forms.

The crew followed a pulse sampling design whereby intensive sampling was conducted for one or 2 days followed by several days without sampling. The sampling goal was to obtain data from a sufficient number of fish, within a given period of time, which would allow us to estimate the true age composition of the escapement with simultaneous 95% confidence intervals in each pulse (Molyneaux and Dubois 1996). The goal of each sampling pulse was 210 chum salmon scales (L. Dubois, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). All ASL data were sent to the Bethel ADF&G office for analysis by research staff.

To estimate the age and sex composition of chum salmon escapement in the Aniak River, daily passage estimates were temporally stratified. Each stratum consisted of several days of fish passage and one pulse sample. Within each stratum, estimates of age and sex composition were applied to the sum of the chum salmon passage to generate an estimate of the number of fish in each age-sex category. The numbers of fish were summed by age-sex category over all strata to estimate the total season passage.

ENVIRONMENTAL MEASUREMENTS

Water temperature was measured at the sonar site using a HOBO pro v-2 water temperature logger which electronically recorded the temperature 4 times per day. The data was downloaded to a laptop computer at the end of the season. At the main camp, the air temperature was recorded several times each day from a digital thermometer, and general weather and wind direction was noted. The crew used a staff gauge to measure the water level. The benchmark, located at the sonar site, degraded and became unusable in 2002; consequently, readings are not comparable across years.

RESULTS

FISH PASSAGE ESTIMATES

During the 2007 season 699,178 (SE 16,947) fish are estimated to have passed the sonar site. Of those, 47.6% passed on the left bank and 52.4% passed on the right bank (Table 1). Figure 5 shows the daily passage rates by bank along with the cumulative season estimate. The peak total daily passage of 57,586 occurred on July 14 (Table 1). The 25%, 50%, and 75% quartile dates of passage were July 11, July 18, and July 24 respectively. The 2007 run timing was about 5 days later, then the historical record (Figure 6).

MISSING DATA

A total of 18.6 hours (4.0%) on the left bank and 9.0 hours (2.0%) on the right bank of sampling time were missed. On July 3, 4, 5, 9, 11 the computer program and wireless system on left bank went down at various times for a total of 9 hours. On July 22–23 the left bank computer program and wireless system went down and we missed 8 hours of data collection. On July 3–4 there were problems with the right bank computer program and we missed 2 hours. On July 7 there were computer problems and we missed 5 hours. We did regression analysis using available data from both banks for these days to account for the missed time. Other sampling time was missed because of maintenance, system diagnostic tests, moving the tripod, or aiming the transducer to compensate for changing water levels throughout the season.

ASL SAMPLING

A total of 36 beach seine sets were completed and from these, 812 ASL samples from migrating chum salmon were obtained. Of those samples, 669 scales were analyzed post season with 66.6% falling in the 0.3 age class, 29.7% comprising the 0.4 age class, 2.2% in the 0.2 age class and 1.5% in the 0.5 age class (Table 2). Age 0.3 chum salmon increased steadily throughout the run from 51.9% at the beginning to 74.3% at the end. Age 0.4 chum salmon came in strong at the beginning of the run (42.8%) and decreased to 20.6% by the end of the run. Age 0.2 fish increased as the run progressed and age 0.5 fish decreased as the run progressed. Female chum salmon accounted for 55.6% of the overall run.

ENVIRONMENTAL INFORMATION

Climate and River Measurements

Water levels steadily went up for the first half of the season due to wet rainy conditions, and then decreased during the second half due to dryer conditions, to the lowest levels of the season at the end of July (Figure 7). Daily air temperatures fluctuated between 7 ºC (July 18) and 14 ºC (July 8) over the project operational period (Figure 8). Water temperatures were measured 6 times per day (0200, 0600, 1000, 1400, 1800, 2200) the lowest average temperature by time was 8.8°C at 0600 the highest average temperature was 13.5°C at 2200 (Figure 9). The average water temperature over the operational period of the project was 11.2°C (Figure 8).

DISCUSSION

When we arrived at the sonar site in mid June the water level was high, but didn't cause any delay in getting the sonar in the water and conducting the ASL sampling. We had the sonar in the water on 24 June which is 2 days ahead of schedule. The ASL sampling started at the beginning of July.

FISH PASSAGE ESTIMATES

We were able to meet objective one of collecting fish abundance data using sonar. The estimated passage for 2007 was the fourth highest since the projects inception in 1980 (Figure 10). The fish count was similar to 2004 with this year running a couple of days behind (Figure 11). When compared to the historical record, this year's run was 4 to 5 days behind the historical average (Figure 6). This year's estimate is above the 10 year average (1996–2006) of 529,121 and is similar to the 2004 escapement of 673,445, which is the first year of using DIDSON. Similar to 2002 through 2006, the 2007 daily passages followed a roughly sinusoidal pattern with peaks separated in time by 4 or 5 days (Figure 5). Fish were distributed fairly evenly between left and right bank. In previous years, passage has been biased to one bank or the other, and often this bias changed as water levels changed. When the water level is low a gravel bar becomes exposed down stream of the sonar on right bank. Fair (2000) noted that when this gravel bar becomes exposed during low water a high percentage of the fish are diverted over to left bank.

ASL Sampling

We were able to meet objective 2 of collecting the age, sex and length samples from the Aniak River chum salmon escapement. The age distribution of the catch in 2007 didn't exhibit any anomalies. As in past years, the 2007 chum salmon run was predominantly age 0.3 (66.6%) and 0.4 (29.7%) fish. The age 0.3 fish were the dominant age class for the entire run with females dominating this age class (38.3%). The age 0.4 fish had more males then females overall, but the females were dominant in the first and third strata. For the overall run, female fish accounted for 55.6% of the run. They were in greater proportions than males during the first and forth strata and equal proportions during the second and third strata.

ENVIRONMENTAL INFORMATION

We were able to meet objective 3, of monitoring selected climatic and hydrological parameters daily at the project site. When we arrived the water level was moderate to high but we were able to install the water height gage and electronic water temperature sensors in a timely fashion. Water levels continued to rise through the first half of the season due to rain, but then went steadily down during the second half (Figure 7). Air and water temperatures were moderate (Figure 8).

ACKNOWLEDGEMENTS

The author wishes to thank seasonal ADF&G staff including Jody Lozori, Samuel Roy, Kaitlyn Meade and Zach Force for the collection of hydroacoustic and ASL data. The Kuskokwim Native Association and David Orabutt provided invaluable logistical assistance in Aniak. Bruce McIntosh, Regional Sonar Biologist, provided project oversight, technical support, and review of this report. This project was operated using State of Alaska General Funds.

REFERENCES CITED

ADF&G (Alaska Department of Fish and Game). 1961. Kuskokwim River salmon tagging studies, 1961. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Salmon Stock Separation Report No. 1, Anchorage.

ADF&G (Alaska Department of Fish and Game). 1962. Kuskokwim River salmon tagging studies, 1962. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Salmon Stock Separation Report No. 2, Anchorage.

Brannian, L. K., M. J. Evenson, and J. R. Hilsinger. 2006. Escapement goal recommendations for select Arctic-Yukon-Kuskokwim region salmon stocks, 2007. Alaska Department of Fish and Game, Fishery Manuscript No. 06-07, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fms06-07.pdf

Buklis, L. S. 1981. Yukon River salmon studies. Project No. AFC-63-4, Anadromous Fish Conservation Act. NOAA National Marine Fisheries Service. Technical report for period July 1, 1980 to June 30, 1981, Anchorage.

Buklis, L. S. 1993. Documentation of Arctic-Yukon-Kuskokwim region salmon escapement goals in effect as of the 1992 fishing season. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 3A93-03, Anchorage.

Fair, L. 2000. Aniak River Sonar Project Report 1999. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A00-10, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.2000.10.pdf

Francisco, K. R., C. A. Anderson, C. Burkey Jr., M. Fogarty, D. B. Molyneaux, C. Utermohle, and K. Vaught. 1995. Annual management report for the subsistence and commercial fisheries of the Kuskokwim Area, 1994. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A95-15, Anchorage.

INPFC (International North Pacific Fisheries Commission). 1963. Annual Report, 1961. Vancouver, British Columbia.

Knuepfer, G. 1995. Aniak River sonar test fishing feasibility report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A95-34, Anchorage.

Linderman, J. C. Jr., and D. J. Bergstrom. 2006. Kuskokwim River Chinook and chum salmon stock status and Kuskokwim area fisheries; a report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Special Publication No. 06-35, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/sp06-35.pdf

McEwen, M. S. 2006. Sonar estimation of chum salmon passage in the Aniak River 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fishery Data Series No. 06-33, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds06-33.pdf

Molyneaux, D., and L. Dubois. 1996. Salmon age, sex and length catalog for the Kuskokwim area, 1995 progress report. Alaska Department of Fish and Game, Division of Commercial Fisheries Management and Development, Regional Information Report 3A96-31, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/RIR.3A.1996.31.pdf

REFERENCES CITED (Continued)

Pfisterer, C. T. 2002. Estimation of Yukon River salmon passage in 2001 using hydroacoustic methodologies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 3A02-24, Anchorage. http://www.sf.adfg.state.ak.us/FedAidpdfs/RIR.3A.2002.24.pdf

Sandall, H., and C. T. Pfisterer. 2006. Sonar estimation of chum salmon passage in the Aniak River, 2003. Alaska Department of Fish and Game, Division of Commercial Fisheries, Fishery Data Series No. 06-32, Anchorage. http://www.sf.adfg.state.ak.us/FedAidPDFs/fds06-32.pdf

Schneiderhan, D. J. 1982b. 1982 Aniak River sonar studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Escapement Report No. 26, Anchorage.

Schneiderhan, D. J. 1984. 1983 Aniak River sonar studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, AYK Region, Kuskokwim Escapement Report No. 32, Anchorage.

Schneiderhan, D. J. 1985. 1984 Aniak River sonar studies. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kuskokwim Escapement Report No. 36, Anchorage.

Schneiderhan, D. J. 1988. Aniak River salmon escapement study, 1985-1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A88-17, Anchorage.

Schneiderhan, D. J. 1989. Aniak River salmon escapement studies, 1989. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 3A89-23, Anchorage.

Wolter, K. M. 1985. Introduction to Variance Estimation. Springer-Verlag, New York.

TABLES AND FIGURES

Table 1.–Daily and cumulative fish passage estimates for left and right banks, percent passage for left and right banks and cumulative passage, Aniak River Sonar, 2007.

Date	Left Bank	Right Bank	Daily Total	Cumulative Total	LB % Passage	RB % Passage	Cumulative percent passage
24-Jun	357	278	635	635	0.1%	0.1%	0.1%
25-Jun	659	1,084	1,743	2,377	0.2%	0.3%	0.3%
26-Jun	706	689	1,396	3,773	0.2%	0.2%	0.5%
27-Jun	1,010	1,067	2,076	5,849	0.3%	0.3%	0.8%
28-Jun	888	1,054	1,942	7,791	0.3%	0.3%	1.1%
29-Jun	894	1,193	2,087	9,878	0.3%	0.3%	1.4%
30-Jun	1,576	1,472	3,048	12,926	0.5%	0.4%	1.8%
1-Jul	3,080	3,420	6,500	19,426	0.9%	0.9%	2.8%
2-Jul	2,184	4,624	6,808	26,234	0.7%	1.3%	3.8%
3-Jul	2,590	3,478	6,068	32,302	0.8%	0.9%	4.6%
4-Jul	9,636	10,581	20,217	52,519	2.9%	2.9%	7.5%
5-Jul	12,203	16,284	28,487	81,006	3.7%	4.4%	11.6%
6-Jul	3,559	6,152	9,711	90,717	1.1%	1.7%	13.0%
7-Jul	1,661	3,897	5,558	96,275	0.5%	1.1%	13.8%
8-Jul	6,805	9,892	16,697	112,973	2.0%	2.7%	16.2%
9-Jul	15,463	19,109	34,573	147,545	4.6%	5.2%	21.1%
10-Jul	7,458	11,200	18,658	166,203	2.2%	3.1%	23.8%
11-Jul	6,743	11,194	17,938	184,141	2.0%	3.1%	26.3%
12-Jul	5,004	9,656	14,660	198,801	1.5%	2.6%	28.4%
13-Jul	22,336	25,992	48,328	247,129	6.7%	7.1%	35.3%
14-Jul	27,128	30,458	57,586	304,715	8.2%	8.3%	43.6%
15-Jul	3,291	4,468	7,759	312,474	1.0%	1.2%	44.7%
16-Jul	3,548	4,407	7,955	320,429	1.1%	1.2%	45.8%
17-Jul	8,549	10,028	18,577	339,006	2.6%	2.7%	48.5%
18-Jul	16,304	16,692	32,996	372,002	4.9%	4.6%	53.2%
19-Jul	15,346	15,260	30,606	402,608	4.6%	4.2%	57.6%
20-Jul	7,762	11,494	19,256	421,864	2.3%	3.1%	60.3%
21-Jul	9,296	11,320	20,616	442,480	2.8%	3.1%	63.3%
22-Jul	7,308	10,540	17,848	460,328	2.2%	2.9%	65.8%
23-Jul	24,953	14,934	39,887	500,215	7.5%	4.1%	71.5%
24-Jul	19,502	17,328	36,830	537,045	5.9%	4.7%	76.8%
25-Jul	11,715	11,752	23,467	560,511	3.5%	3.2%	80.2%
26-Jul	20,856	18,088	38,944	599,455	6.3%	4.9%	85.7%
27-Jul	16,874	14,358	31,232	630,687	5.1%	3.9%	90.2%
28-Jul	12,996	12,174	25,170	655,857	3.9%	3.3%	93.8%
29-Jul	7,344	6,992	14,336	670,193	2.2%	1.9%	95.9%
30-Jul	8,089	6,768	14,857	685,050	2.4%	1.8%	98.0%
31-Jul	7,158	6,970	14,128	699,178	2.2%	1.9%	100.0%
Season Totals	332,832	366,347	699,178		47.6%	52.4%	

Note: The large box indicates the central 50% of the run (second and third quartiles). Historic median passage date is 12 July.

Table 2.–Age and sex composition of chum salmon for 4 sampling strata, Aniak River Sonar, 2007.

			Age									
			0.2		0.3		0.4		0.5		Total	
Date (Strata)	Sample Size	Sex	Number Fish	%	Number Fish	%	Number Fish	%	Number Fish	%	Number Fish	%
2007												
7/3,5,7		M	0	0.0	17,511	15.5	22,369	19.8	4,180	3.7	44,059	39.0
(6/22-7/8)		F	565	0.5	41,122	36.4	25,984	23.0	1,243	1.1	68,914	61.0
	187	Subtotal	565	0.5	58,633	51.9	48,352	42.8	5,423	4.8	112,973	100.0
7/10,11,13		M	0	0.0	62,843	31.5	38,903	19.5	1,197	0.6	102,943	51.6
(7/9-15)		F	0	0.0	65,237	32.7	31,322	15.7	0	0.0	96,559	48.4
	159	Subtotal	0	0.0	128,080	64.2	70,225	35.2	1,255	0.6	199,502	100.0
7/18-19		M	0	0.0	51,010	34.5	18,925	12.8	1,035	0.7	70,970	48.0
(7/16-22)		F	5,027	3.4	50,862	34.4	20,995	14.2	0	0.0	76,884	52.0
	148	Subtotal	5,027	3.4	101,871	68.9	39,921	27.0	1,035	0.7	147,854	100.0
7/24,26		M	1,433	0.6	66,878	28.0	24,602	10.3	0	0.0	92,913	38.9
(7/23-31)		F	8,121	3.4	110,588	46.3	24,602	10.3	2,627	1.1	145,937	61.1
	175	Subtotal	9,554	4.0	177,466	74.3	49,203	20.6	2,627	1.1	238,850	100.0
Season		M	1,398	0.2	197,868	28.3	104,877	15.0	6,293	0.9	310,435	44.4
		F	13,984	2.0	267,786	38.3	102,779	14.7	4,195	0.6	388,744	55.6
	669	Total	15,382	2.2	465,653	66.6	207,656	29.7	10,488	1.5	699,179	100.0

Note: Number of fish per strata and age class is based on the sonar estimate per strata multiplied by percent of fish in an age class and stratum.

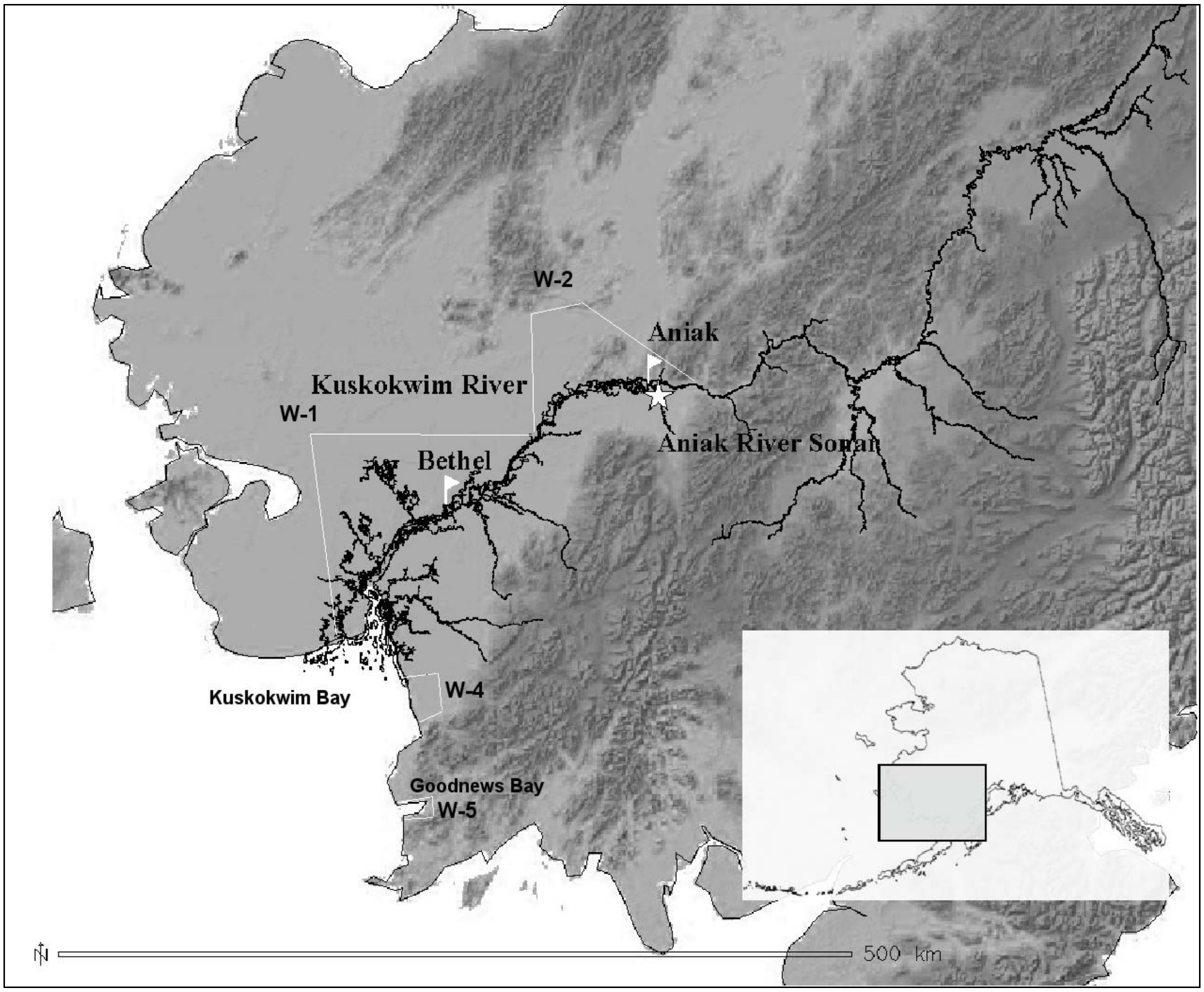

Figure 1.–Kuskokwim River Area, with lower river fishing districts (W-1, W-2, W-4, W-5) delineated.

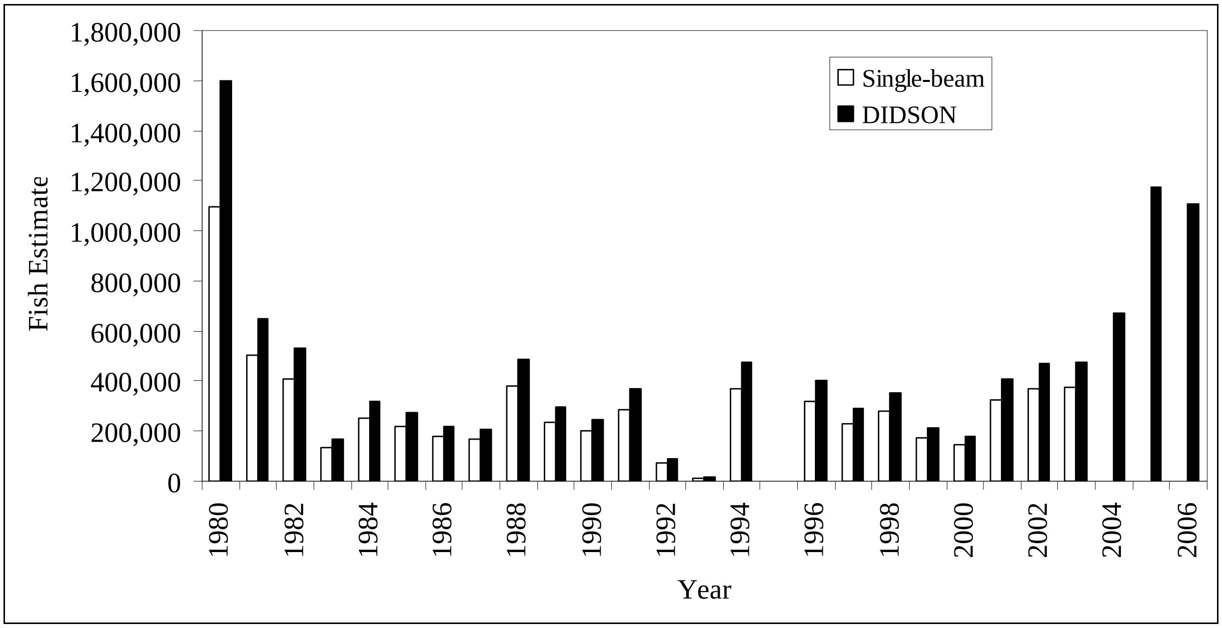

Figure 2.–Historical sonar passage from 1980 to 2006 Aniak River Sonar. From 1980 to 1994 Bendix sonar was used, from 1996 to 2003 BioSonics sonar was used. Bendix and BioSonic sonar counts from 1980 to 1994 and 1996 to 2003 were adjusted to DIDSON equivalent. No data 1995.

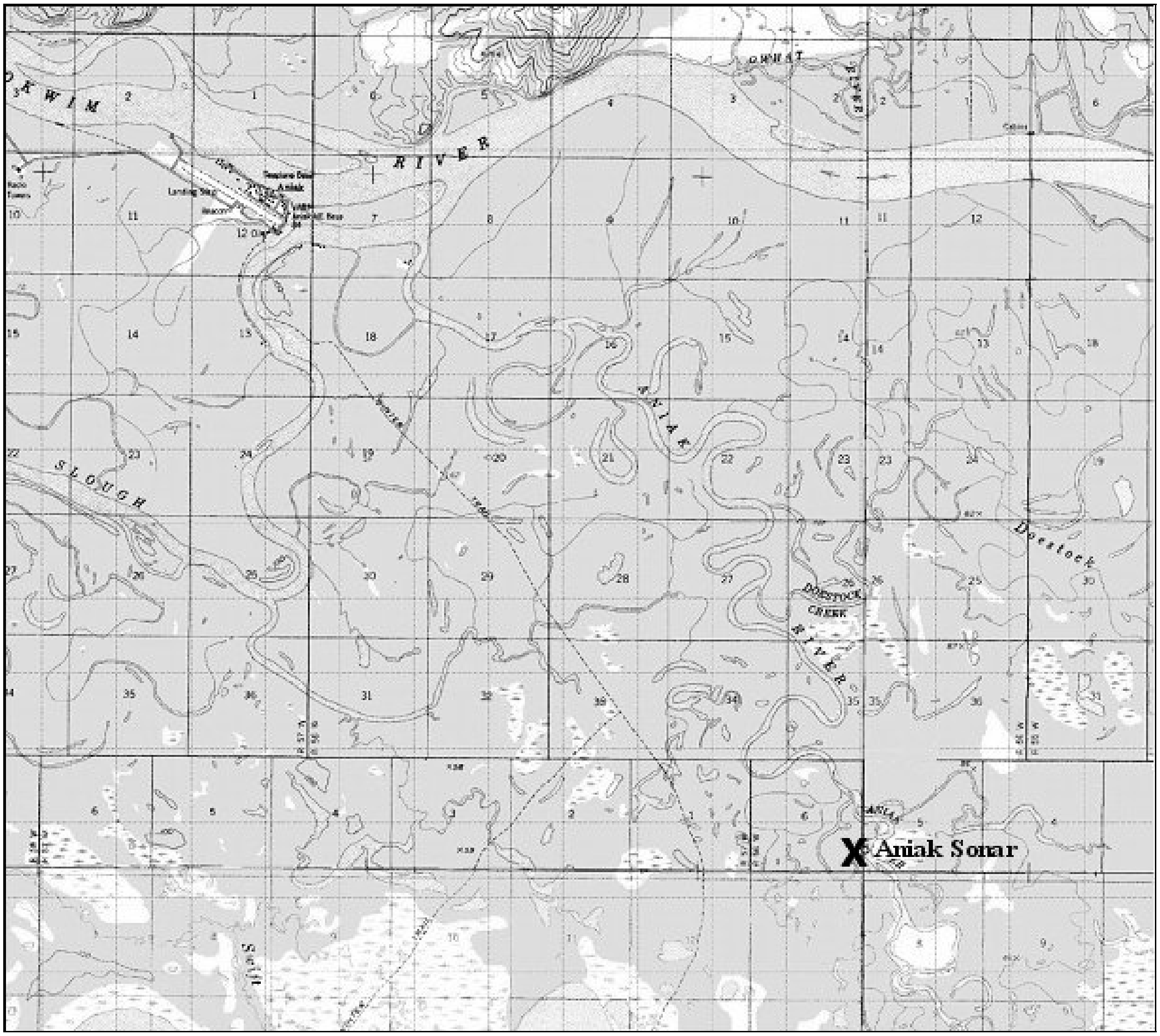

Figure 3.–Location of Aniak River Sonar site, 2007.

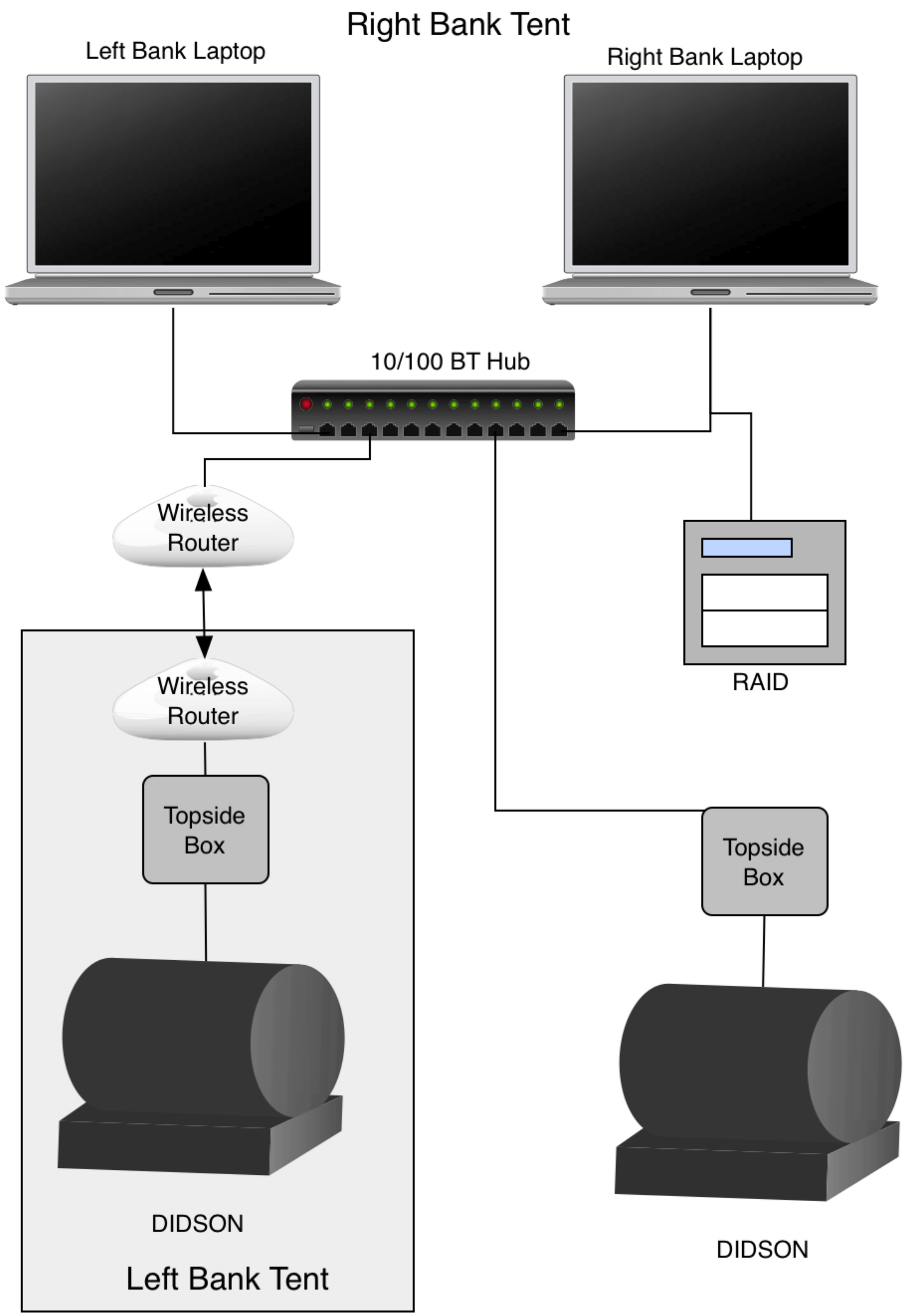

Figure 4.–DIDSON Sonar equipment schematic, Aniak River Sonar, 2007.

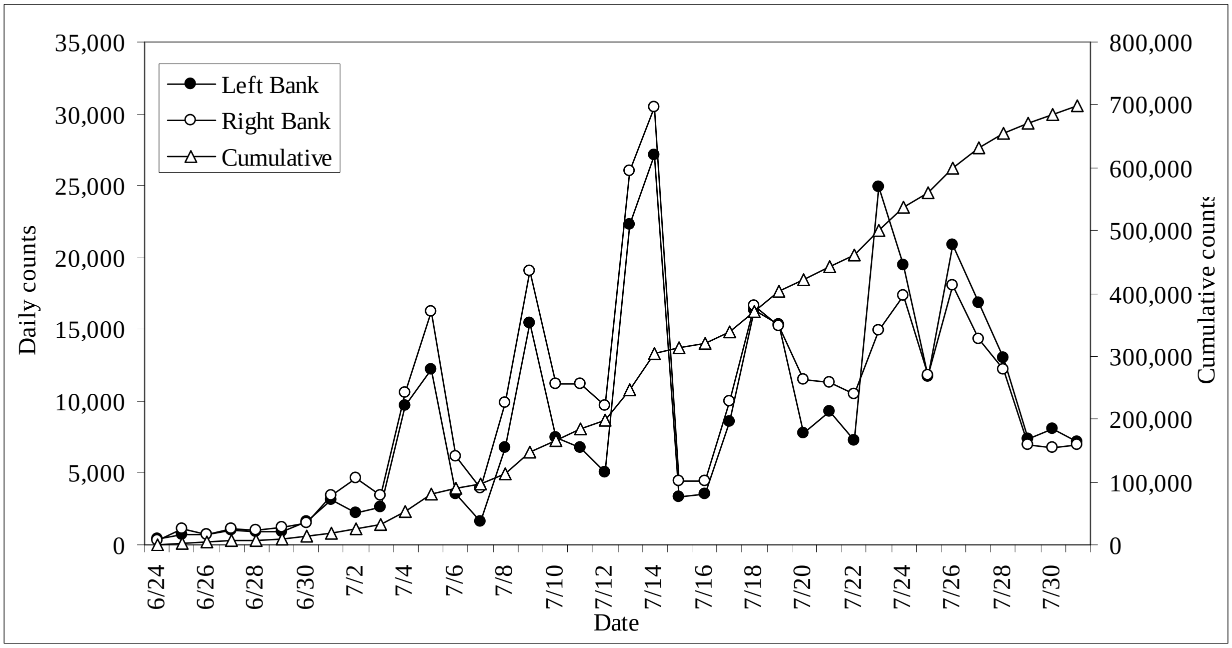

Figure 5.–Daily passage estimates on left bank, right bank and cumulative passage estimates at Aniak River Sonar, 2007.

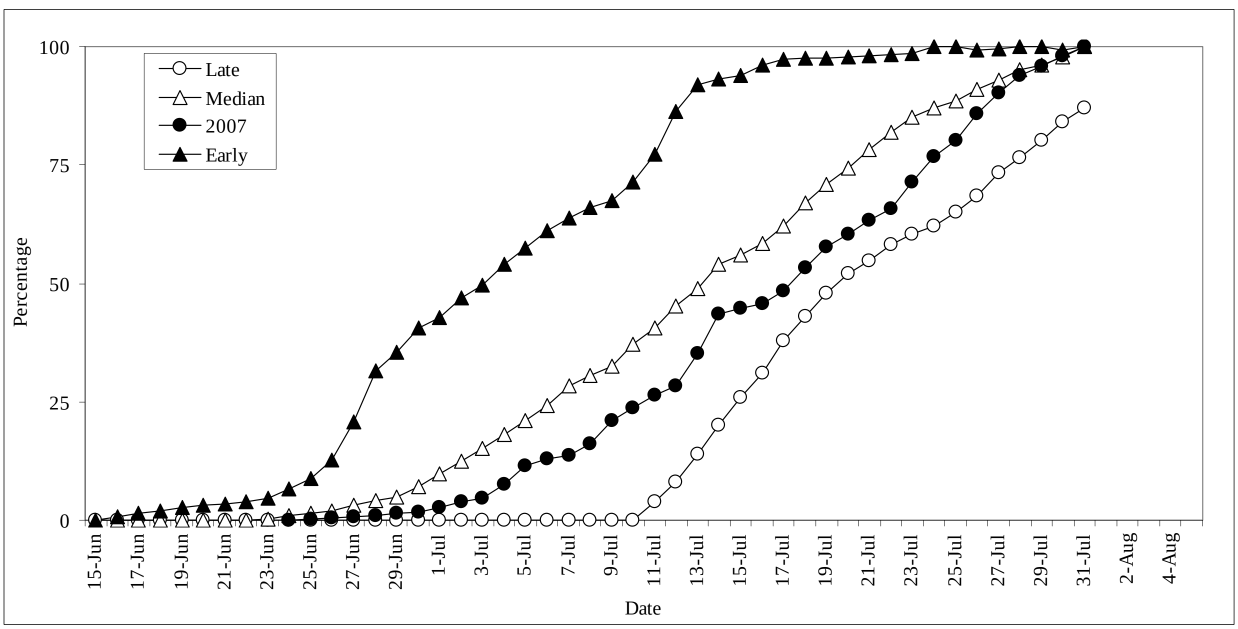

Figure 6.–Historical run timing 1980–2006, Aniak River Sonar. Early, late, and median values were derived from the maximum, minimum and median cumulative percentages across all years, respectively.

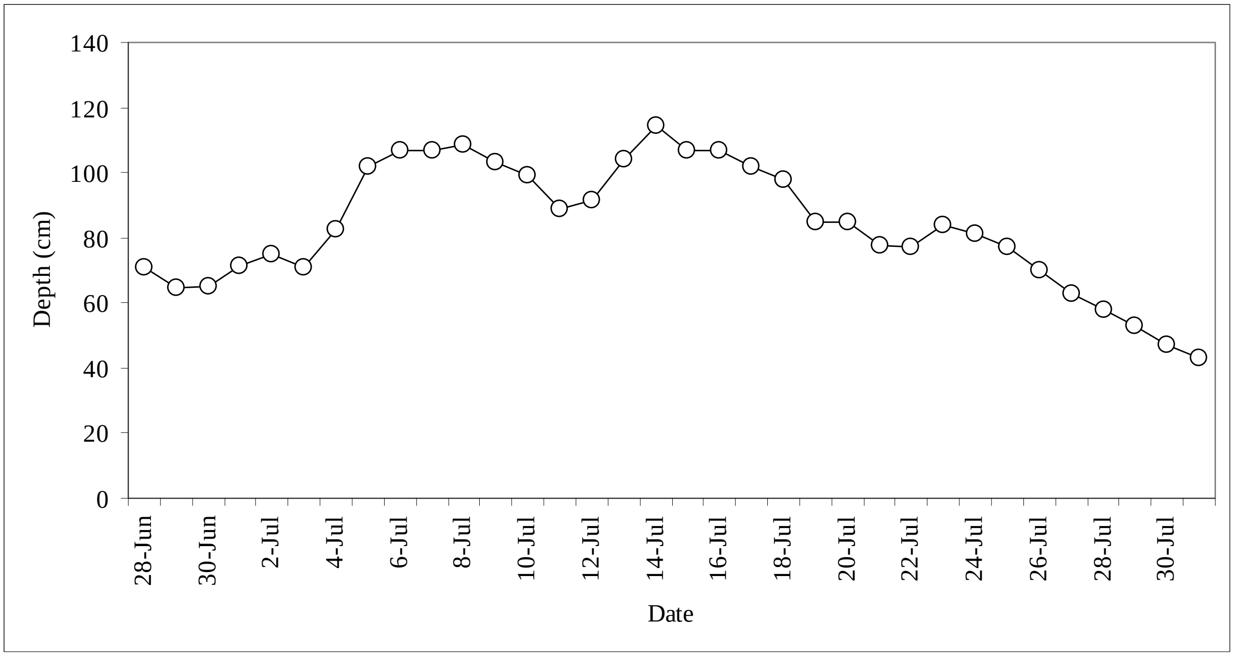

Figure 7.–Water level Aniak River Sonar, 2007.

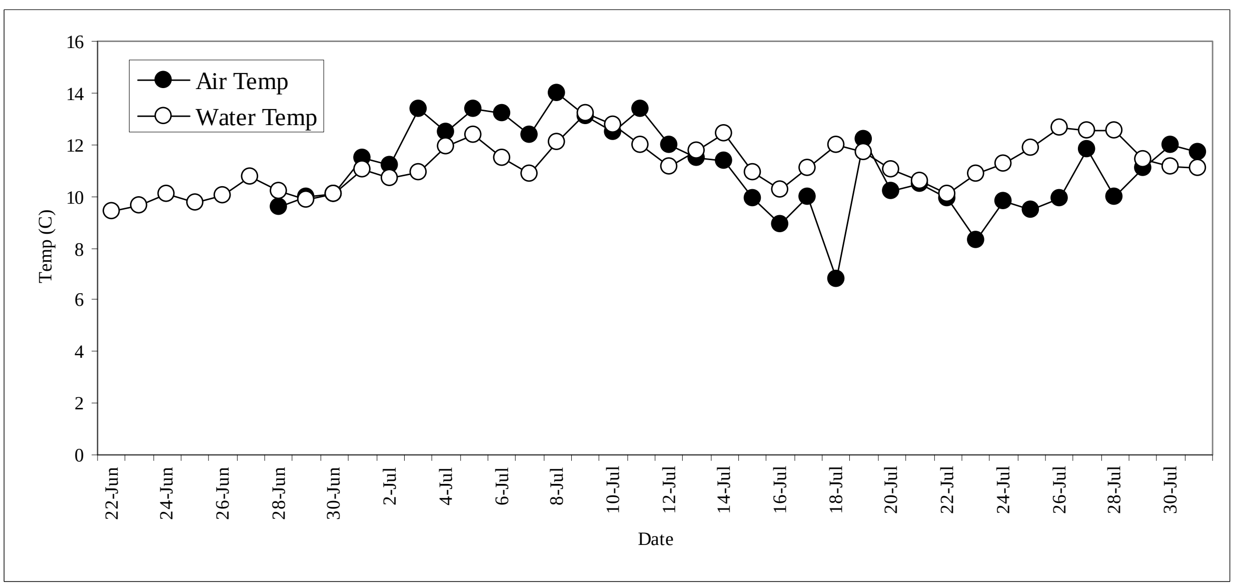

Figure 8.–Air and water temperatures, Aniak River Sonar, 2007.

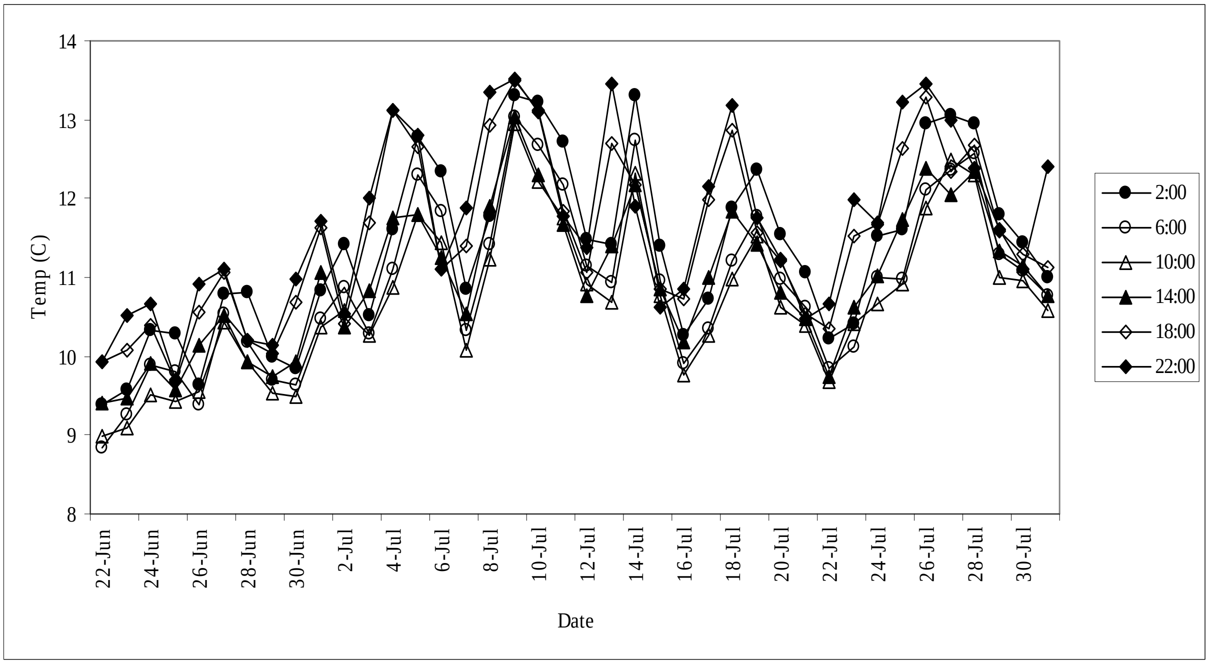

Figure 9.–Daily water temperature by time, Aniak River sonar, 2007.

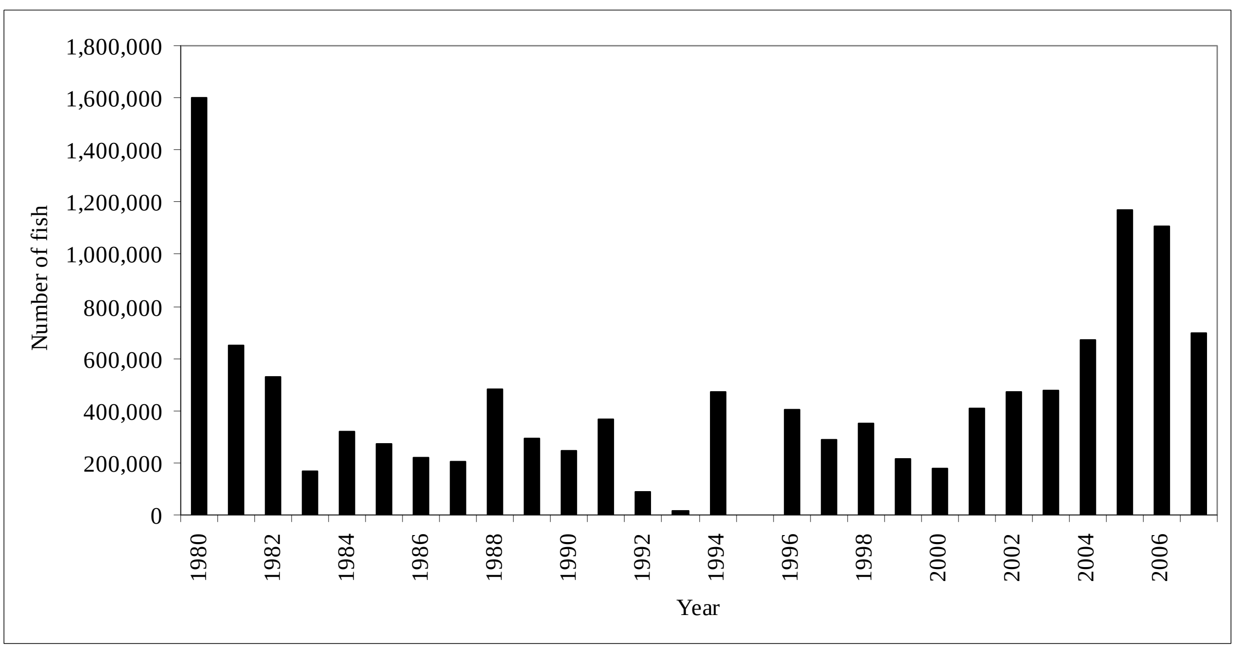

Figure 10.–Corrected historical passage at the Aniak River Sonar project, 1980 to 2007.

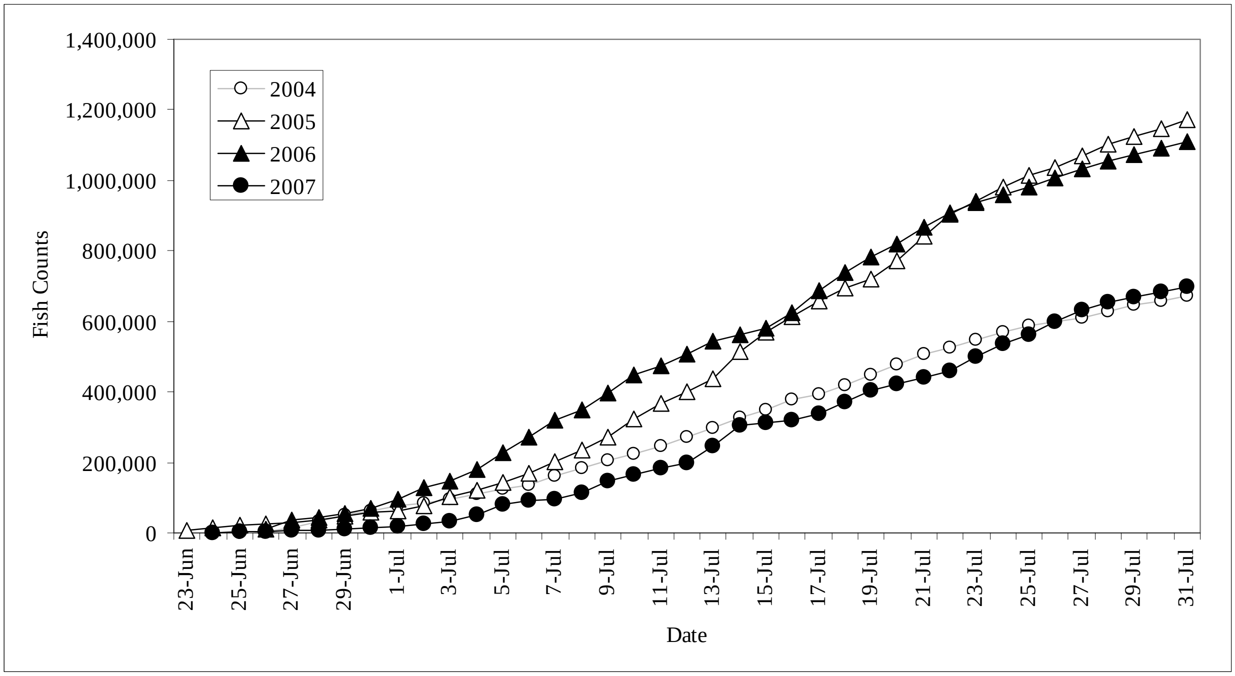

Figure 11.–Cumulative fish passage estimates, Aniak River sonar, 2004 to 2007.

APPENDIX A PROJECT HISTORY

Appendix A1.–Timetable of developmental changes of the Aniak River sonar project, 1980–2007.

Year	Event
1980	• Aniak River sonar project established • 1978 model, non-configurable Bendix sonar counter used with 60 ft. artificial substrate • Single bank operation (1980–1995) • Cumulative adjusted daily sonar estimates expanded by 150% to account for salmon passing outside the ensonified area • Sonar estimates are extrapolated for pre- and postseason salmon escapement (1980–1982, 1985–1989, and 1991–1996) • Gillnet test fishing to provide species apportionment and ASL information • Three correction factor calibrations per day averaged to adjust daily estimates
1981	• 1981 model, non-configurable Bendix sonar counter used with 60 ft artificial substrate • A tentative escapement goal of 250,000 chum and 25,000 Chinook salmon is established for the Aniak River • Gillnet and beach seine test fishing to provide species apportionment and ASL information
1982	• Sonar equipment unchanged • Escapement goals for AYK Region updated; 250,000 chum and 25,000 Chinook salmon escapement goal is established for the Aniak River • Gillnet test fishing to provide species apportionment and ASL information • Four correction factor calibrations applied to 6 hour time periods to adjust daily estimates
1983	• Sonar equipment unchanged • Review of escapement goal based upon sonar estimates indicated 1980–1981 Aniak River • Sonar estimates likely represented unusual record escapements, and much smaller escapements would probably provide adequate future spawning stocks as well as catches for user groups • Goal remains 250,000 chum and 25,000 Chinook salmon • Sonar estimates are not extrapolated for preseason and postseason salmon escapement (1983–1984, 1990, 1996–1997)
1984	• Sonar equipment unchanged • No apportionment of estimates made due to insufficient test gillnets catches • In the absence of sufficient species apportionment data, the sonar based escapement objective would be 250,000 estimated salmon counts • Cumulative adjusted daily sonar estimates expanded by 162% to account for salmon passing outside the ensonified area
1985	• Sonar equipment unchanged • Gillnet test fishing and carcass samples provide ASL information
1986	• Sonar equipment unchanged • ASL sampling activities are discontinued to decrease operating costs • Species apportionment activities are discontinued due to inadequate sample sizes

-continued-

Appendix A1.–Page 2 of 2.

Year	Event
1988	• Sonar operations eliminated use of the 60 ft artificial substrate • Sampling range unknown
1989	• Sonar operations same as 1988
1990	• No formal project documentation (1990–1995)
1993	• Fire destroys 1981 model Bendix sonar counter • Replaced with a 1978 model Bendix sonar counter • Historic data in Kuskokwim Area Management Report is adjusted to reflect 162% expansion factor applied to 1980–1983 season estimates
1994	• Sonar operations continue with 1978 model counter
1995	• Sonar operations continue with 1978 model counter • Reliable escapement estimates are not generated
1996	• Established a new sonar data collection site 1.5 km downstream from the historical site • Project operations redesigned to provide full river ensonification with user-configurable sonar equipment 24 hours per day on both banks • Periodic net sampling to monitor broad changes in species composition, corroborate acoustically detected abundance trends, and obtain ASL samples of chum salmon • Sonar estimates are not extrapolated for preseason and postseason salmon escapement (1996–1997) • Regional Information Report documents project operations and data collection activities
1997–2000	• Project operations remain the same as 1996 for years 1997 through 2000
2001	• Sonar operations remain the same as 1996 for years 1997 through 2001 • Species Apportionment Program is added to the project, which involved test fishing twice daily and expanding the crew size
2002	• Sonar operations remain the same as years 1996–2001 • Species apportionment program operates for last season with similar methodology to 2001.
2003	• Sampled three 4 hour periods on each bank instead of operating 24-hours/day. • Species apportionment discontinued • DIDSON sonar was tested at the site in preparation to migrate from BioSonics to DIDSON • Escapement goal updated: SEG to provide a range of 210,000 – 370,000 fish
2004-2007	• Operated DIDSON exclusively on both banks