Fishery Data Series No. 13-17

Sonar Estimation of Chum Salmon Passage in the Aniak River, 2010

by

Malcolm S. McEwen

April 2013

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

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

Mathematics, statistics

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

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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 dual imaging sonar (DIDSON) in 2004. In 2010, 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 26 through July 31, 2010. During this period, an estimated 429,643 fish (SE 9,939) passed through the ensonified area, the majority of which are assumed to be chum salmon *Oncorhynchus keta*. The peak passage of 24,696 fish occurred on July 16 and the 50% passage date occurred on July 16. Age-0.2, -0.3, -0.4 and -0.5 chum salmon comprised 7.9%, 70.7%, 21.0%, and 0.5% of the escapement estimate, respectively.

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

INTRODUCTION

HISTORY

The Kuskokwim River subsistence and commercial salmon fishery in June and July is directed toward the harvest of chum salmon *Oncorhynchus keta* and Chinook salmon *O. tshawytscha.* From 2000 to 2009, an average of 52,067 chum salmon were harvested annually for subsistence purposes in the Kuskokwim area (Estensen et al. 2009). Commercial chum salmon harvests in Districts W-1 and W-2 (Figure 1) from 2005 to 2009 averaged 46,316 fish. No market existed for chum salmon in the Kuskokwim River fishery from 2001 to 2003, and only modest commercial fisheries were prosecuted from 2004 to 2006 (Estensen et al. 2009).

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, 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 during this time. From 1980 to 1995, Aniak River escapement data were collected using an echo counting and processing transceiver manufactured by Bendix Corporation.[1] 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. In 2003, instead of sampling 24 hours per day, the project implemented the alternating schedule (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 2010 were consistent with the changes made in 2003 and 2004. McEwen (2010) presents a complete history of the project. A timetable of developmental changes for the sonar project is presented in Appendix A1.

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

OBJECTIVES

The objectives of the Aniak River sonar project are to:

1. Estimate chum salmon abundance in the Aniak River using DIDSON sonar from June 26 through July 31.
2. Collect a minimum of 210 chum salmon samples during each of 3 to 4 stratum throughout the season to estimate the age, sex, and length (ASL) composition of the Aniak River chum salmon passage, such that simultaneous 95% confidence intervals of age composition in each sample 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 permit # 13916. The main camp is situated at 61° 30.163' N, 159° 22.464' W (Figure 2). 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 bathymetric profile 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 river bottom slopes gradually to the thalweg at roughly 63–68 m, while the right bank river bottom slopes steeply to the thalweg at about 17–22 m, depending on water level.

HYDROACOUSTIC DATA ACQUISITION

Equipment

Two DIDSON units were deployed at the Aniak sonar site, one for each bank. The sonar units operated at 1.1 MHz on the right bank and 1.2 MHz on the left 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 HTI rotators allowing movement in two axes. A Remote Ocean Systems model 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 version 5.11 of the DIDSON software to acquire data. A 152.4 m cable transferred power and data between a "topside 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 topside box and a laptop computer. A RAID enclosure was connected to the laptop (Figure 3) for saving of all data.

The enclosure was configured as RAID 1, allowing redundant copies of the data on two separate hard drives within the enclosure in the event one of the mechanisms failed.

The left bank electronic equipment was housed in a portable canvas 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 was saved to a RAID drive.

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 7 to 12 m from the right bank, and 15 to 20 m from the left bank. Daily visual inspections confirmed proper placement and orientation of the transducers and alerted operators when the transducers needed to be repositioned to accommodate changing water levels. The majority of the width of the river (80%–86% 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 1–3 m beyond the transducers. These weirs moved chum salmon, Chinook salmon, and other large fish offshore and in front of the transducers, 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, (longnose sucker *Catostomus catostomus*, whitefish *Coregonus* spp., and rainbow trout *O. mykiss).*

Sampling Procedures

Sonar project activities commenced on June 26 and ended on July 31, 2010. Hydroacoustic sampling began at 0800 June 26 of the right and left bank, and ran every day until 2000 on July 31. Daily estimates were transmitted via single side band radio or satellite phone to area managers in Bethel at 1000 the following morning.

Acoustic sampling was conducted on both banks for three 4 hour shifts each day, 7 days per week, except for short periods when the generator was serviced or transducer adjustments were made. This sampling was consistent with the past 4 seasons, based on changes made during 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 at 0000–0400, 0800–1200, and 1600–2000 hours. The technicians identified and tallied fish traces from the echogram recordings using in-house developed software (Carl Pfisterer, Commercial Fisheries Biologist, ADF&G, Fairbanks, personal communication). 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 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 and marking fish traces with the computer mouse. The video was used to verify fish target, fish size and direction of travel.

The crew recorded all 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 operated on the right bank and 1.2 MHz for the long range DIDSON used on the left bank. DIDSON simultaneously transmits on, and then receives from every fourth beam. Images or frames are built in sequences of these sets of pings. At the frequencies utilized, 48 beams (4 sets of 12) 0.6° apart from each other on a horizontal plane are composited to form the image. The right bank and left bank both sampled at a range from 0.83 m to 20 m and a rate of 4 frames 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 min observations *s*, collected during the 4 h 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 min samples collected in one 24 h period and multiplying by the reciprocal of the fraction of the day sampled (i.e., 24 / 12 = 2).

Sonar sampling periods 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 autocorrelated (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:

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

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 methods to make up for incomplete or missing counts.

If less than 10 minutes were missed in a sample, the count was expanded by the inverse of the fraction sampled:

$$\hat{y}_s = x_s \left(15 / m_c\right), \tag{6}$$

where 15 is the number of minutes in a complete sample, m_c is the number of minutes in the sample that were actually counted, and x_s 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:

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

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

If more than 4 samples were missed, an XY scatterplot with a regression line was plotted using the known fish counts for the day from both left bank and right bank. The linear regression equation was then used to calculate missing fish counts for each missing sample *s*:

$$\hat{y}_s = a + bx_s \quad , \tag{8}$$

where *a* and *b* are the regression coefficients, *x* equals the count for sample *s* on the opposite bank and $\hat{y}_s$ is the estimated passage for missing sample *s*.

Species Apportionment

During the 2010 season at the Aniak sonar project, daily passage estimates were reported inseason without any apportionment for species. Postseason adjustments were made for the unusually large pink salmon *O. gorbuscha* returns through applying the results of the test fish catches made on the right bank during the course of regular ASL sampling. Estimated proportions prior to July 5 were considered 100% chum salmon. Days without observations were interpolated.

Daily passage estimates *y* by species *a* were apportioned to either pink or chum salmon by applying the estimated proportion *p* to the unadjusted daily passage estimate for each bank *z*:

$$\hat{y}_{dza} = \hat{y}_{dz} \cdot \hat{p}_{dza} \quad . \tag{9}$$

With only 2 species apportioned for, the variance of the proportion follows the binomial distribution:

$$Var(\hat{p}_{dza}) = \hat{p}_{dza} \cdot (1 - \hat{p}_{dza})/(n-1) \,, \tag{10}$$

and the variance of the species passage estimate was calculated as:

$$\hat{V}ar(\hat{y}_{dza}) = \hat{y}_{dz}^2 \cdot \hat{V}ar(\hat{p}_{dza}) + \hat{p}_{dza}^2 \cdot \hat{V}ar(\hat{y}_{dz}) - \hat{V}ar(\hat{y}_{dz}) \cdot \hat{V}ar(\hat{p}_{dza}) \,. \tag{11}$$

Total daily passage by species was estimated by summing both banks,

$$\hat{y}_{da} = \sum_z \hat{y}_{dza} \,, \tag{12}$$

and passage estimates were summed over both banks and all days to obtain a seasonal estimate for species y_a

$$\hat{y}_a = \sum_d \sum_z \hat{y}_{dza} \,. \tag{13}$$

Finally, passage estimates were assumed independent between banks and among days, so the variance of their sum was estimated by the sum of their variances:

$$\hat{V}ar\left(\hat{y}_a\right)=\sum_d \sum_z \hat{V}ar\left(\hat{y}_{dza}\right) , \tag{14}$$

and, assuming normally distributed errors, 90% confidence intervals were calculated as,

$$\hat{y}_a \pm 1.645\sqrt{\hat{V}ar(\hat{y}_a)} . \tag{15}$$

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 mideye 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 systematic sampling design whereby intensive sampling was conducted 3 days each week (Monday, Tuesday, and Thursday, or until the sample size goal of n = 210 was reached). The sampling goal of n = 210 was set such that simultaneous 95% confidence intervals of age composition in each weekly period were no wider than 0.20 ($\alpha = 0.05$ and $d = 0.10$) (Molyneaux and Dubois 1996). All scales and 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 to correspond with ASL sampling periods. 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 number of fish were then 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 water temperature logger which electronically recorded the temperature 4 times per day. The data were 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 2010 season 429,643 (SE 9,939) salmon are estimated to have passed the sonar site. Of those, 35.0% passed on the left bank and 65.0% passed on the right bank (Table 1). After postseason adjustment an estimated 345,076 were chum salmon and 84,567 (19.7%) were pink salmon. Figure 4 shows the daily passage rates by bank along with the cumulative season estimate. The peak total daily passage of 24,696 occurred on July 16 (Table 1). The 25%, 50%, and 75% quartile dates of passage were July 10, July 16, and July 23 respectively. The 2010 run timing was similar to the historical median (Figure 5).

MISSING DATA

Total sampling times of 14.8 hours on the left bank and 4.8 hours on the right bank were missed because of maintenance, system diagnostic tests, moving the tripod, or aiming the transducer to compensate for changing water levels throughout the season. The left bank sonar had mechanical trouble and there were no counts on June 27 from midnight to 1730.

ASL SAMPLING

A total of 21 beach seine sets were completed and, from these, 615 ASL samples from migrating chum salmon were obtained. Of those samples, 553 scales were analyzed postseason, with 70.7% falling in the 0.3 age class, 21.0% in the 0.4 age class, 7.9% in the age-0.2 class, and 0.5% in the age-0.5 class (Table 2). Age-0.3 chum salmon increased steadily throughout the run from 69.0% at the beginning to 75.2% at the end. Age-0.4 chum salmon came in strong at the beginning of the run (22.0%) and decreased to 18.6% by the end of the run. Female chum salmon accounted for 56.6% of the overall run.

ENVIRONMENTAL INFORMATION

Climate and River Measurements

Water levels decreased steadily for most of the season due to sunny clear conditions. Late in the season, rain caused the water level to steadily rise (Figure 6). Daily air temperatures fluctuated between 10.6ºC (July 23) and 23.3ºC (July 12) over the project operational period (Figure 7).

Water temperatures fluctuated between 10.1 ºC (June 28) and 21.7ºC (July 12) (Figure 7). The average water and air temperature over the operational period of the project was 13.6°C and 16.3ºC respectively.

DISCUSSION

When staff arrived at the sonar site in late June the water level was high, but this did not cause any delay in getting the sonar in the water and conducting the ASL sampling. We had the sonar in the water on June 26. The ASL sampling started at the beginning of July.

Fish Passage Estimates

We were able to meet objective one, collecting fish abundance data using sonar. The estimated passage for 2010 was below the long term running average (Figure 8). The fish count was similar to the 2 preceding years (Figure 9). The chum salmon run timing on the Aniak River closely resembled the other escapement projects on the Kuskokwim River; overall, the chum salmon were between 0 and 4 days later than the median (Table 3). Similar to 2002 through 2009, the 2010 daily passage estimates followed a roughly sinusoidal pattern with peaks separated in time by 4 or 5 days (Figure 4). During the ASL sampling, 132 pink salmon were captured, comprising between 3.5% (July 7) and 41.2% (July 25) of the combined chum and pink salmon sample. During the 21 days that ASL sampling took place (July 5–25) approximately 316,845 salmon passed by the sonar and, of those, 57,027 were pink salmon. While the project assumes that 80% to 85% of the overall run is chum salmon, we have not seen this many pink salmon captured during ASL sampling. In reviewing the DIDSON data to see if there was a way for the technicians to differentiate the chum from the pink salmon, there was not enough difference in size or swimming to differentiate using just the sonar.

ASL Sampling

We were able to meet objective 2, collecting the ASL samples from the Aniak River chum salmon escapement. The age distribution of the catch in 2010 did not exhibit any anomalies. As in past years, the age-0.3 and -0.4 class has comprised between 94 to 99% of the overall run except in 2004, when a strong 0.2 age class returned to spawn and only 75% were age-0.3 or -0.4.

Environmental Information

We were able to meet objective 3, 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 steadily went down through the first half of the season. Due to rain (mostly in the headwaters), water levels leveled out during the second half (Figure 6) of the season and began to rise at the end of the season. Air and water temperatures were moderate (Figure 7).

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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.

Estensen, J. L., D. B. Molyneaux, and D. J. Bergstrom. 2009. Kuskokwim River Salmon Stock Status and Kuskokwim area fisheries, 2009; a report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Special Publication No. 09-21, Anchorage.

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, BC.

McEwen, M. S. 2010. Sonar estimation of chum salmon passage in the Aniak River, 2009. Alaska Department of Fish and Game, Fishery Data Series No. 10-95, Anchorage.

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.

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 3A02-24, Anchorage.

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.

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, and cumulative percent passage, Aniak River sonar, 2010.

Date	Left Bank	Right Bank	Daily pink	Daily chum	Daily Total	Cumulative Total	Cumulative percent passage
26 Jun	666	1,164		1,830	1,830	1,830	0.4%
27 Jun	1,858[a]	1,838		3,696	3,696	5,525	1.3%
28 Jun	714	1,142		1,856	1,856	7,381	1.7%
29 Jun	648	1,322		1,970	1,970	9,351	2.2%
30 Jun	808	2,680		3,488	3,488	12,839	3.0%
1 Jul	1,720	5,924		7,644	7,644	20,483	4.8%
2 Jul	1,466	5,545		7,011	7,011	27,495	6.4%
3 Jul	1,598	5,796		7,394	7,394	34,888	8.1%
4 Jul	2,136	8,890		11,026	11,026	45,914	10.7%
5 Jul	2,694	5,876	816	7,754	8,570	54,484	12.7%
6 Jul	2,556	6,328	846	8,038	8,884	63,368	14.7%
7 Jul	2,902	5,356	295	7,963	8,258	71,626	16.7%
8 Jul	2,974	6,630	343	9,261	9,604	81,230	18.9%
9 Jul	5,994	11,614	1,914	15,694	17,608	98,838	23.0%
10 Jul	3,740	8,869	1,371	11,239	12,609	111,448	25.9%
11 Jul	5,580	12,058	1,917	15,721	17,638	129,086	30.0%
12 Jul	5,652	11,122	1,823	14,951	16,774	145,860	33.9%
13 Jul	6,488	15,236	2,172	19,552	21,724	167,584	39.0%
14 Jul	3,614	6,306	992	8,928	9,920	177,504	41.3%
15 Jul	8,950	13,924	3,486	19,388	22,874	200,378	46.6%
16 Jul	10,834	13,862	3,763	20,933	24,696	225,074	52.4%
17 Jul	9,596	15,069	8,131	16,534	24,665	249,739	58.1%
18 Jul	3,912	8,698	4,157	8,453	12,610	262,349	61.1%
19 Jul	5,308	10,038	3,456	11,890	15,346	277,695	64.6%
20 Jul	2,932	5,764	1,959	6,737	8,696	286,391	66.7%
21 Jul	6,360	8,102	1,640	12,822	14,462	300,853	70.0%
22 Jul	6,946	11,295	2,069	16,172	18,241	319,094	74.3%
23 Jul	4,874	10,096	5,067	9,903	14,970	334,064	77.8%
24 Jul	4,814	8,912	4,646	9,080	13,726	347,790	80.9%
25 Jul[b]	5,464	9,506	6,164	8,806	14,970	362,760	84.4%
26 Jul	3,016	5,074	3,331	4,759	8,090	370,850	86.3%
27 Jul	4,188	5,950	4,174	5,964	10,138	380,988	88.7%
28 Jul	4,004	9,660	5,626	8,038	13,664	394,652	91.9%
29 Jul	3,844	4,390	3,390	4,843	8,234	402,885	93.8%
30 Jul	5,598	7,630	5,447	7,781	13,228	416,113	96.9%
31 Jul	6,121	7,409	5,571	7,959	13,530	429,643	100.0%
Season Totals	150,568	279,075	84,567	345,076	429,643		

Note: The large box indicates the central 50% of the run.

[a] DIDSON had mechanical trouble and there were no counts from midnight to 1730; total daily count is interpolated.

[b] Pink salmon estimate was calculated from percentage of pink salmon on last day of age, sex, and length seining on July 25, 2010.

Table 2.–Age and sex composition of chum salmon for 3 sampling strata, Aniak River sonar, 2010.

				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	%
2010	7/5, 7, 9, 13	229	M	970	10.0	32,982	43.0	12,126	49.0	0	0.0	46,077	41.5
	(6/26-7/13)		F	8,730	90.0	43,652	57.0	12,611	51.0	0	0.0	64,994	58.5
			Subtotal	9,701	9.0	76,634	69.0	24,736	22.0	0	0.0	111,071	100.0
	7/15, 17, 19	219	M	4,137	40.0	46,542	59.2	11,377	46.8	0	0.0	62,056	54.8
	(7/15-21)		F	6,206	60.0	32,062	40.8	12,928	53.2	0	0.0	51,196	45.2
			Subtotal	10,343	9.1	78,604	69.4	24,305	21.5	0	0.0	113,252	100.0
	7/21, 23, 25	105	M	1,955	14.3	54,752	36.8	21,510	52.4	0	0.0	78,217	38.1
	(7/20-31)		F	11,733	85.7	93,861	63.2	19,554	47.6	1,955	100.0	127,103	61.9
			Subtotal	13,688	4.8	148,613	75.2	41,064	18.6	1,955	1.4	205,320	100.0
	Season	553	M	7,063	20.9	134,276	44.2	45,012	50.0	0	0.0	186,351	43.4
			F	26,669	79.1	169,575	55.8	45,093	50.0	1,955	100.0	243,292	56.6
			Total	33,731	7.9	303,851	70.7	90,106	21.0	1,955	0.5	429,643	100.0

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

Table 3.–Run timing for chum salmon at escapement projects along Kuskokwim River 2010.

Project	Run Timing		Difference (days)	Distance from River mouth (Km)
	1999-2009 Median date	2010 Median date		
Kwethluk River weir	17 Jul	17 Jul	0	190
Tuluksak River weir	20 Jul	20 Jul	0	222
Aniak River sonar	14 Jul	16 Jul	2	323
George River weir	15 Jul	16 Jul	1	453
Tatlawiksuk River weir	14 Jul	15 Jul	1	568
Kogrukluk River weir	17 Jul	21 Jul	4	710
Takotna River weir	14 Jul	18 Jul	4	835

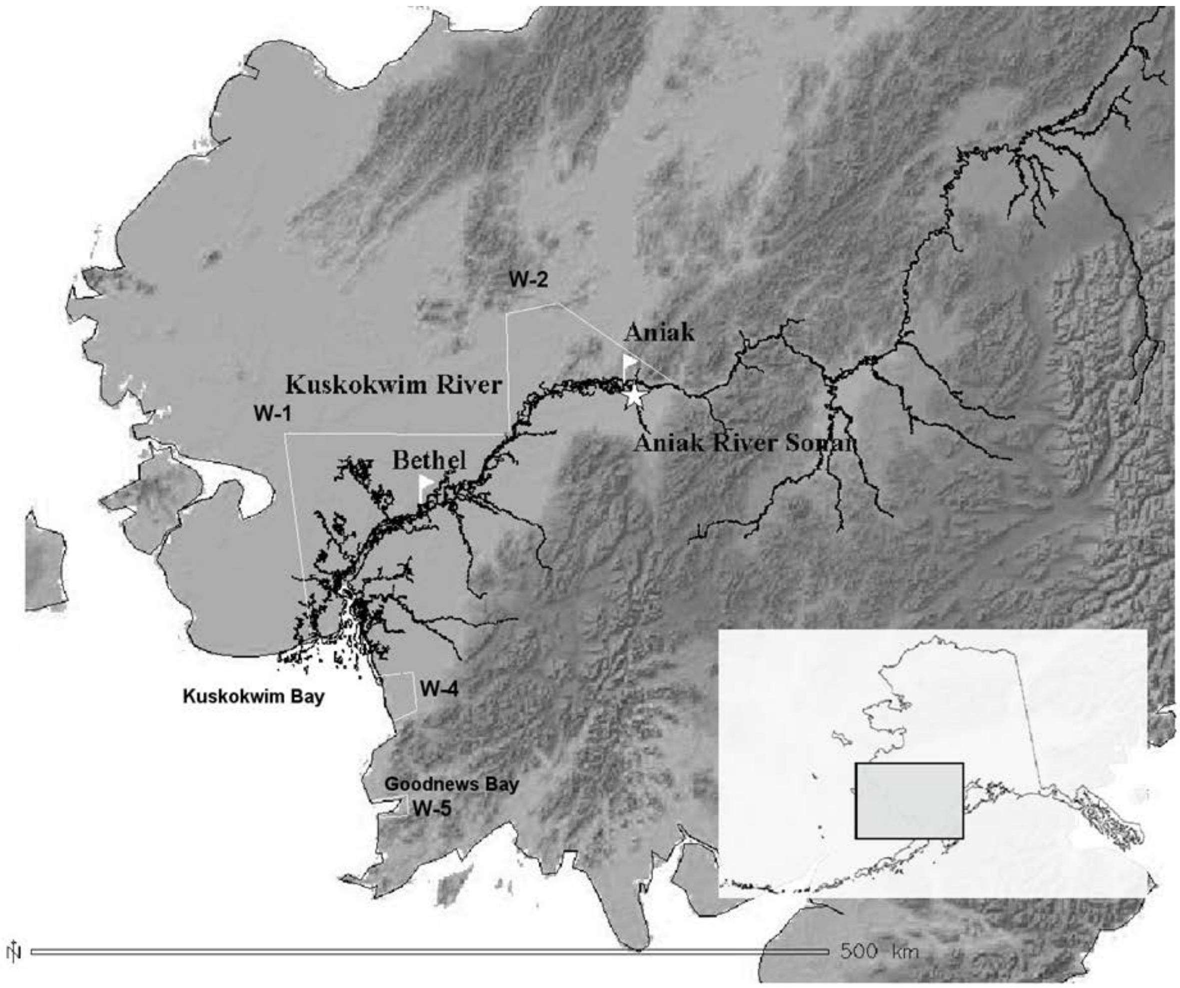


Figure 1.–Kuskokwim River Area, with lower river fishing districts (W-1, W-2, W-4, W-5) delineated.

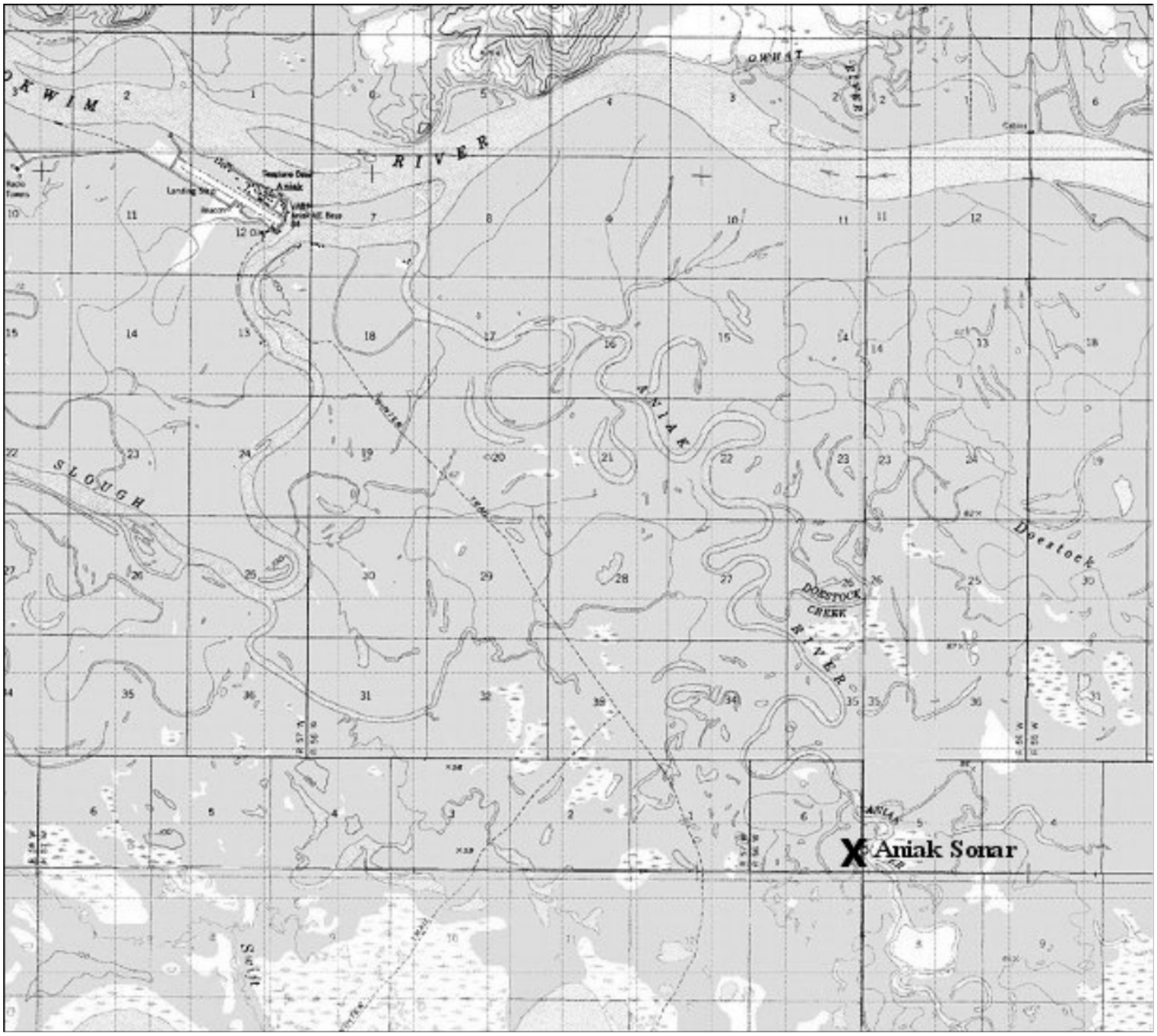


Figure 2.–Location of Aniak River sonar site, 2010.

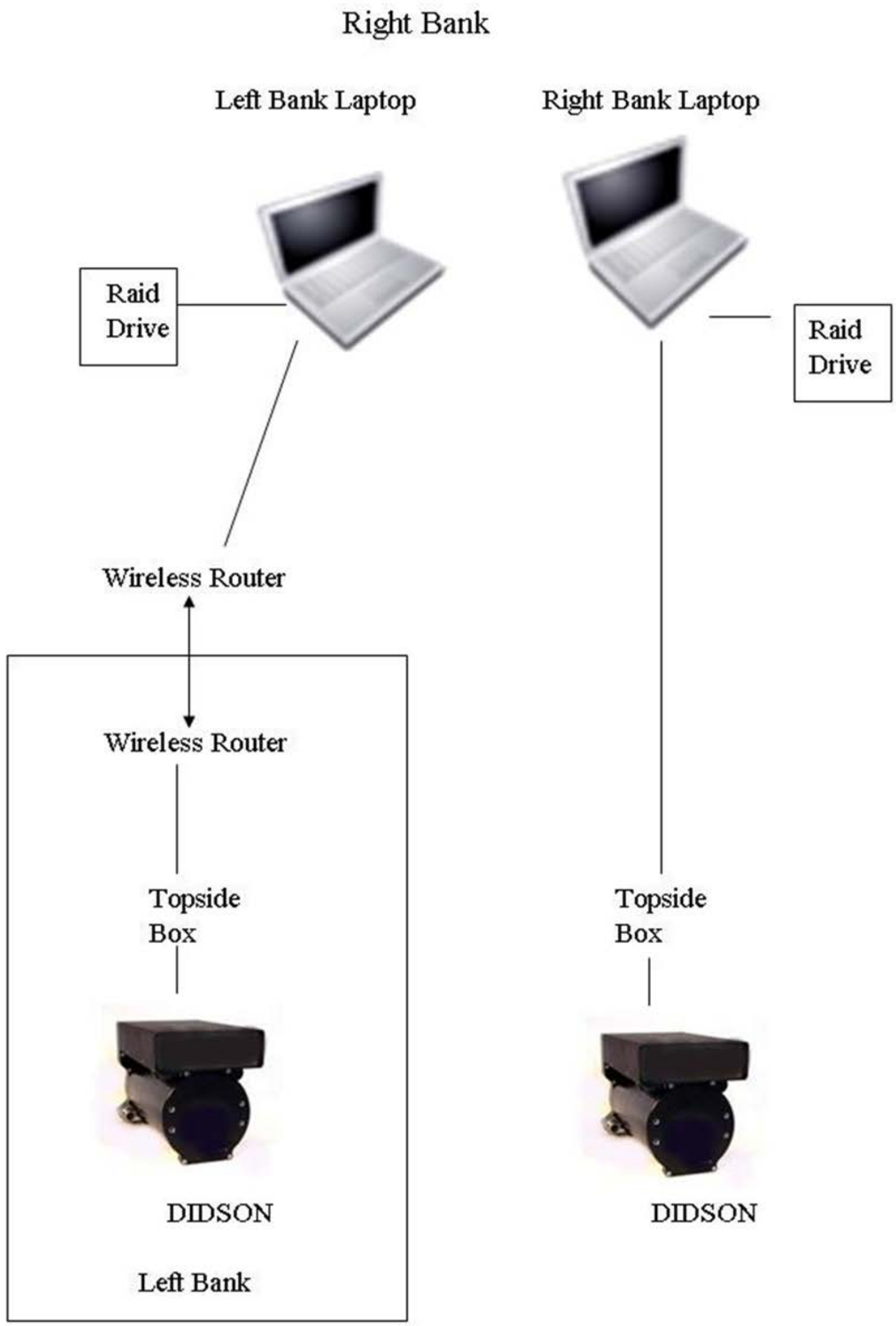


Figure 3.–DIDSON sonar equipment schematic, Aniak River sonar, 2010.

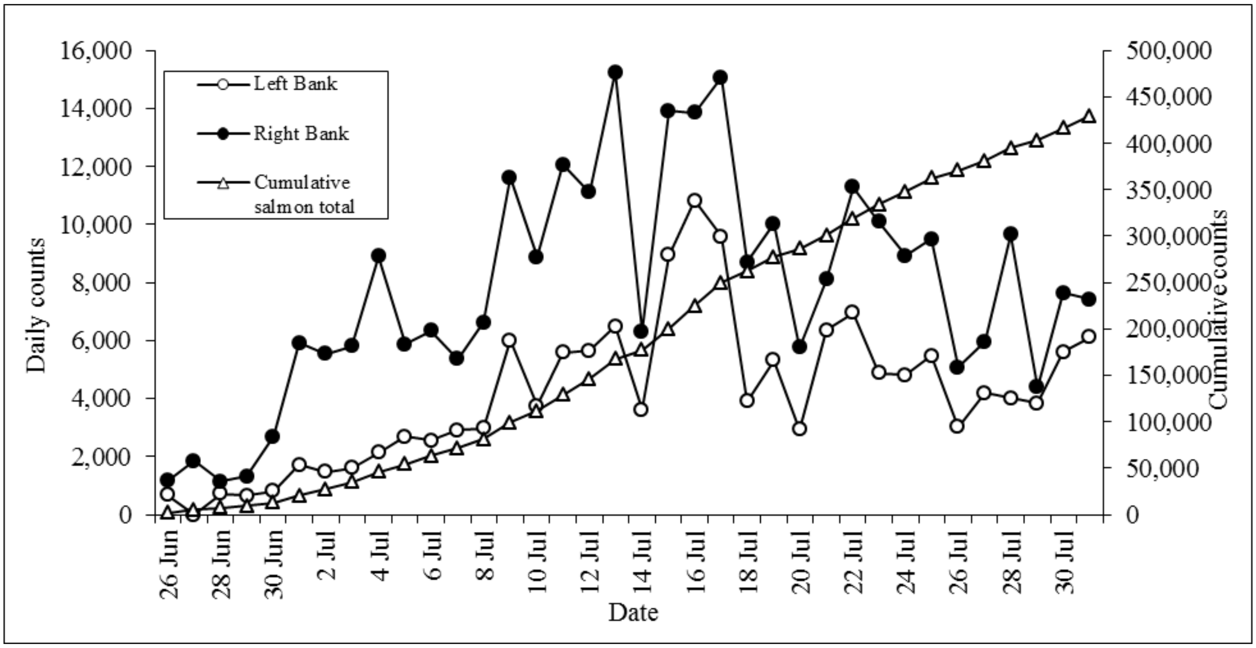
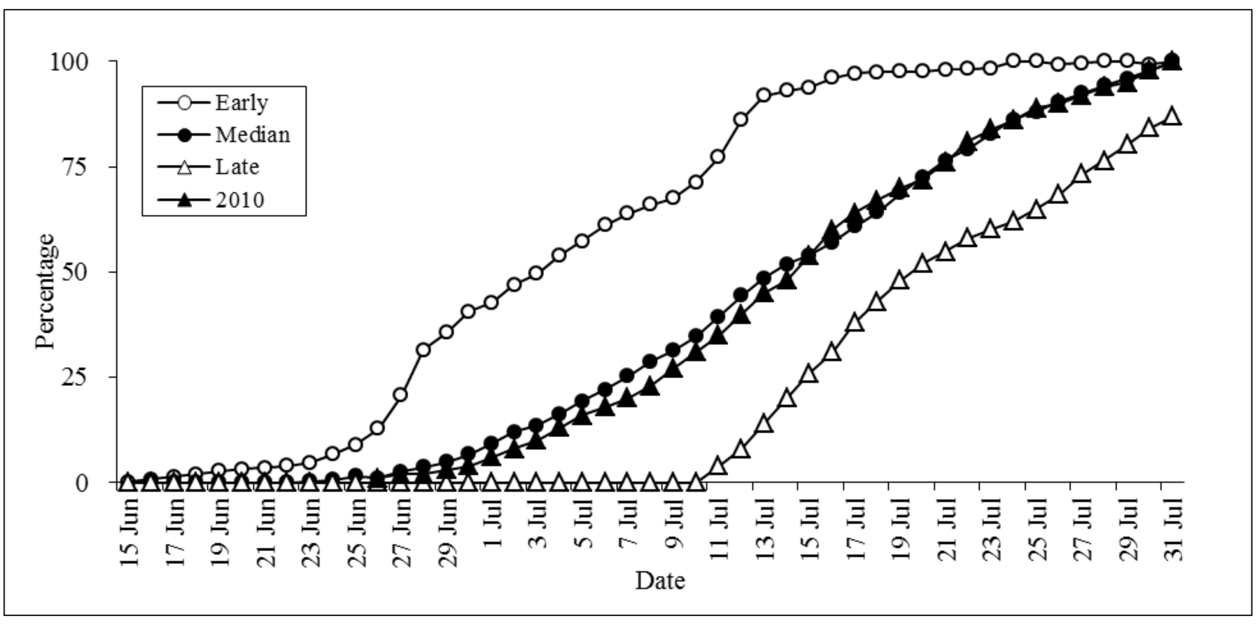


Figure 4.–Daily passage estimates on left bank, right bank and cumulative passage estimates for chum and pink salmon at Aniak River sonar, 2010.



Note: Early, late, and median values were derived from the maximum, minimum and median cumulative percentages across all years, respectively.

Figure 5.–Historical run timing 1980–2010, Aniak River sonar.

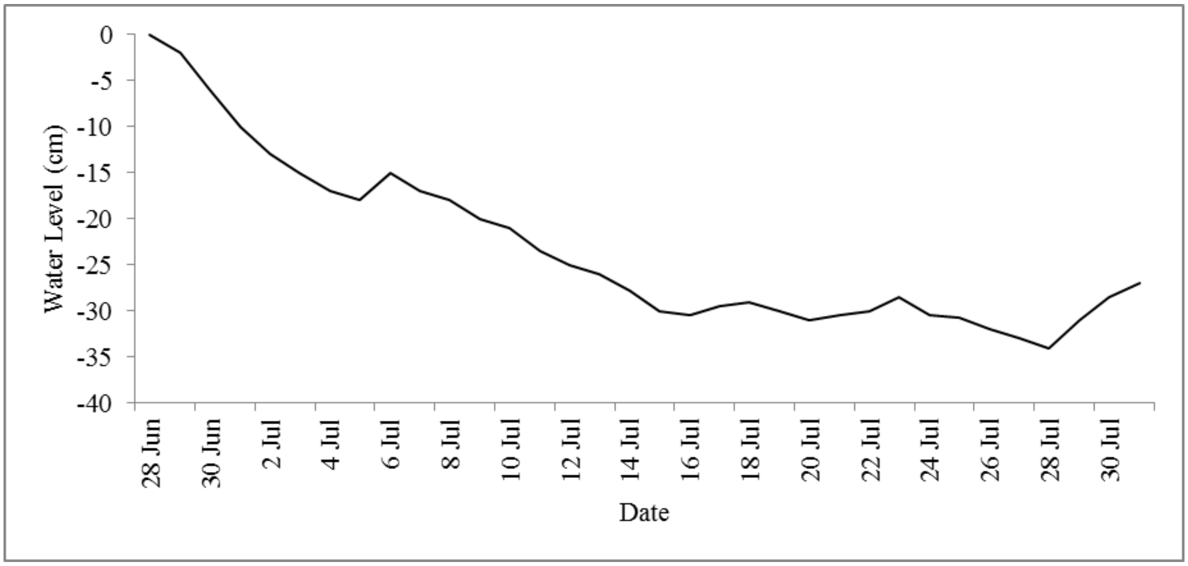


Figure 6.–Water level Aniak River sonar, 2010.

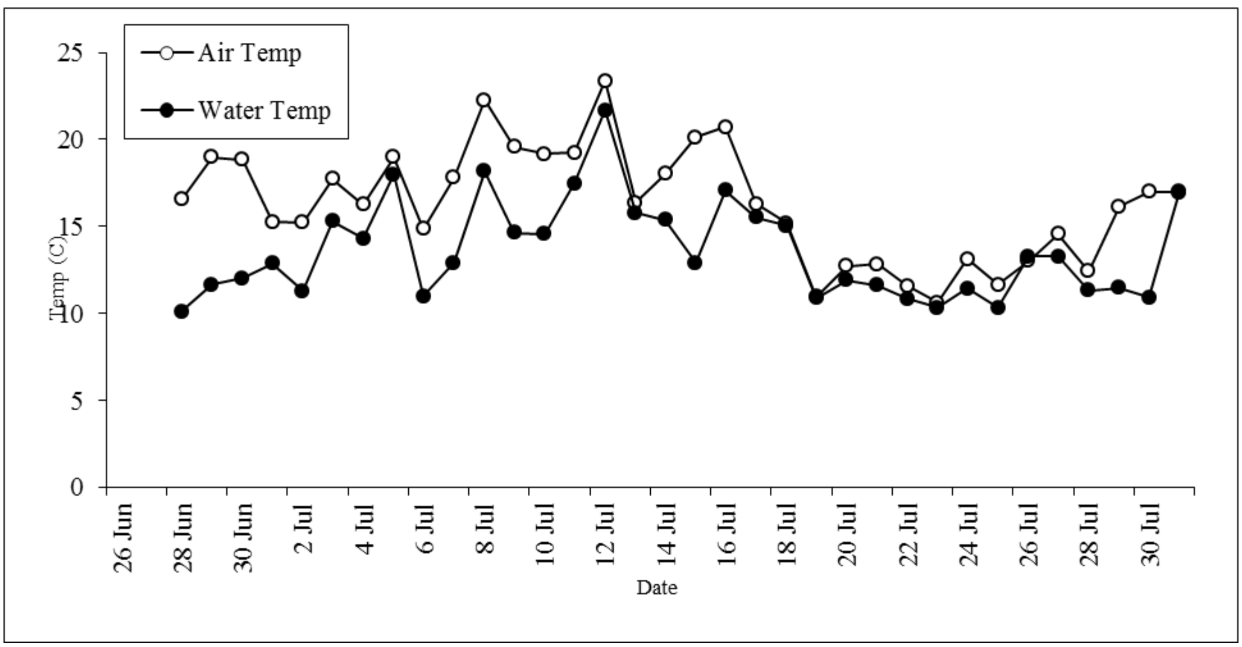
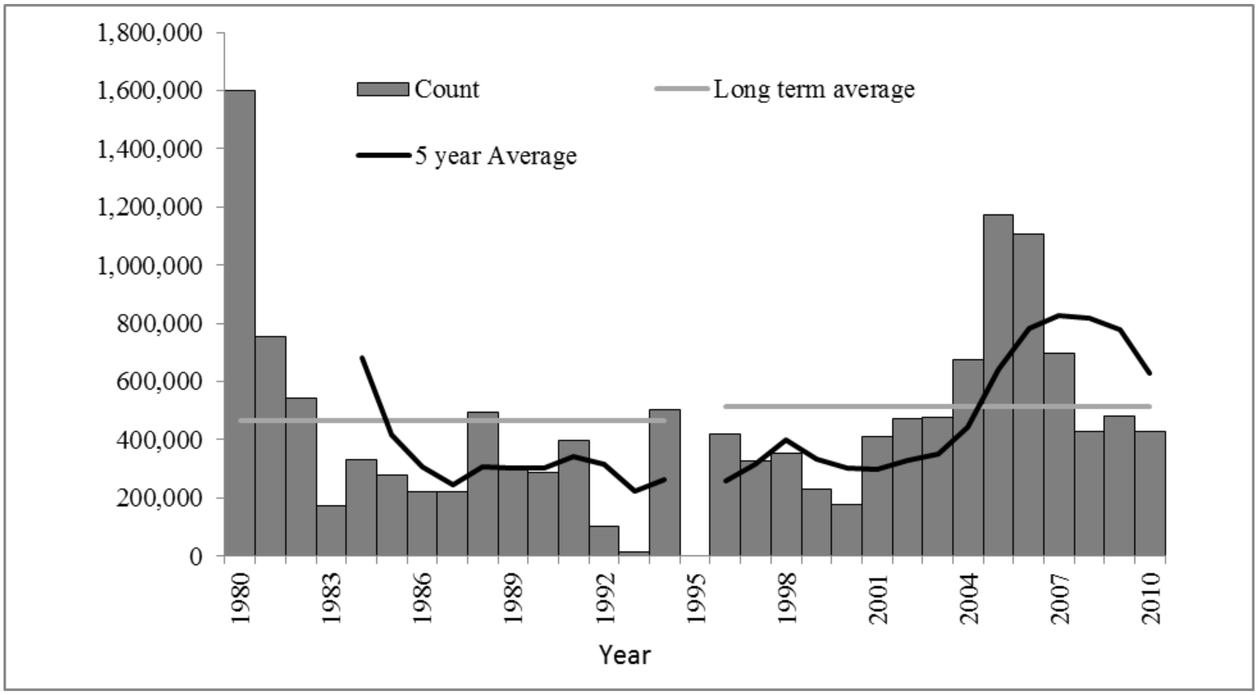
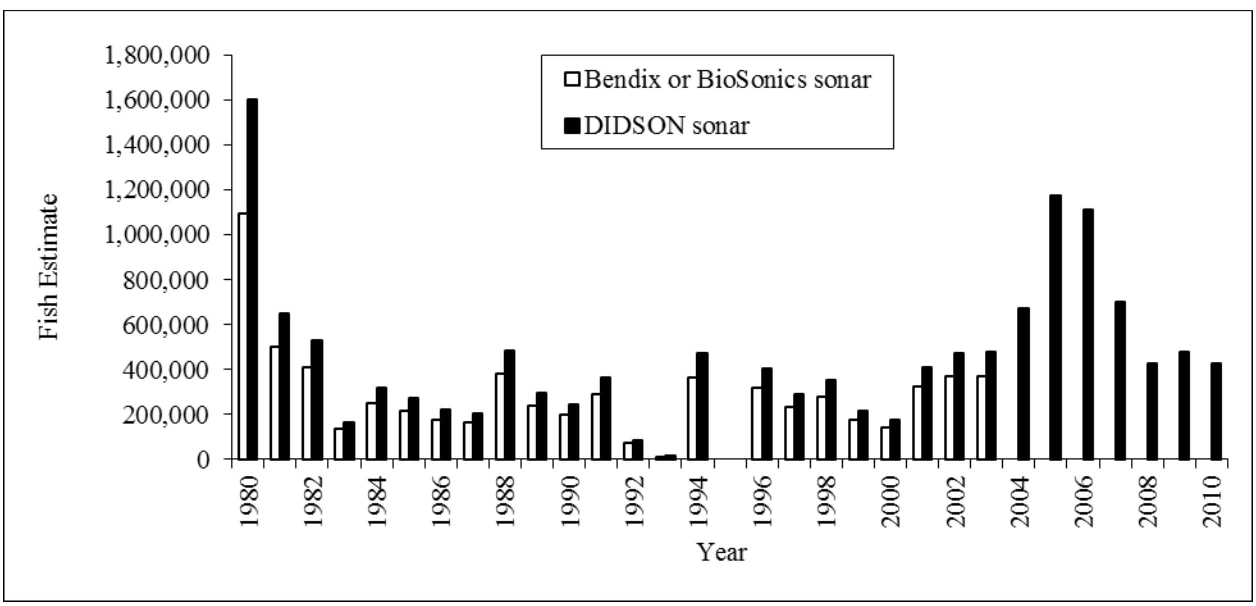


Figure 7.–Air and water temperatures, Aniak River sonar, 2010.



Note: No data collected in 1995.

Figure 8.–Corrected historical passage with long term average 1980 to 1994 and 1996 to present, and the 5 year average, at the Aniak River sonar project, 1980 to 2010.



Note: From 1980 to 1994 Bendix sonar was used, from 1996 to 2003 BioSonics sonar was used, from 2004 to present DIDSON sonar used. Bendix and BioSonics sonar counts from 1980 to 1994 and 1996 to 2003 were adjusted to DIDSON equivalent. No data 1995.

Figure 9.–Historical sonar passage from 1980 to 2010 Aniak River sonar.

APPENDIX A: PROJECT HISTORY

Appendix A1.–Timetable of developmental changes of the Aniak River sonar project, 1980–2010.

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 post-season 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

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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
2004-2006	• Operated DIDSON exclusively on both banks
2007	• Operated DIDSON exclusively on both banks • Escapement goal updated: SEG revised to a range of 220,000 to 480,000 fish
2008-2010	• Operated DIDSON exclusively on both banks