Fishery Data Series No. 07-86

Sonar Estimation of Chum Salmon Passage in the Aniak River, 2005

by

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December 2007

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)

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

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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 imaging sonar (DIDSON) in 2004. In 2005, 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 23 through July 31, 2005. During this period, an estimated 1,171,977 fish (SE 28,821) passed through the ensonified area, the majority of which are assumed to be chum salmon *Oncorhynchus keta*. The peak passage of 76,652 fish occurred on July 14 and the 50% passage date occurred on July 15. Age-0.2, -0.3, and -0.4 chum salmon comprised 5.4%, 89.5% and 5.0% 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 fisheries in June and July are directed toward the harvest of chum salmon *Oncorhynchus keta* and Chinook salmon *O. tshawytscha.* From 1992 to 2001, an average of 66,017 chum salmon were harvested annually for subsistence purposes in the Kuskokwim area (Ward et al. 2003). Commercial chum salmon harvests in Districts 1 (W-1) and 2 (W-2; Figure 1) from 1992 to 2001 averaged 234,629 fish, while no commercial fishing for chum salmon occurred in 2002 due to depressed runs and difficulty in securing a buyer (Ward et al. 2003).

Timely estimates of run strength and escapement are important to management of the Kuskokwim 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 for management purposes.

The Aniak River sonar project began operating in 1980 and has undergone numerous changes in equipment and methodology since that time. 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) led 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 counts (Schneiderhan 1985). The second counter was deployed 1.5 km downstream from the existing counter and alternately operated on each bank. The proportions

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

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 and to readjust the 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 dual-beam 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. In 2003, in an effort to streamline the project and save money, the project implemented three 4-hour sampling periods instead of sampling 24-hours per day (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 2005 were consistent with the changes made in 2003 and 2004.

Examination of the past relationship of counts made using BioSonics and DIDSON equipment have 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 Fish Biologist, ADF&G, Fairbanks; personal communication; Table 1). This year's estimate is a 60% increase over the 2003 adjusted DIDSON count of 477,544 and 43% increase over the 2004 DIDSON count of 672,931, but is below the 1980 adjusted estimate of 1,600,032.

In the early 1980s, sonar counts were apportioned to chum or Chinook salmon using catch information from test gillnets. Species apportionment activities were discontinued in 1986 due to inadequate sample sizes (Schneiderhan 1988) and because these early gillnet and beach seine investigations indicated the abundance of fish species other than chum salmon was insufficient to compromise the utility of passage estimates for making chum salmon management decisions (Schneiderhan 1981, 1982a, b, 1984, 1985). In 2001 and 2002, 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. These results prompted 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 ASL samples. From 1981 to 1985, attempts at beach seine test fishing and carcass sampling proved unsuccessful at obtaining adequate sample sizes for ASL data. 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. In 1981 salmon escapement objectives were tentatively set at 250,000 chum salmon and 25,000 Chinook salmon; in 1982, these objectives were formally adopted. The chum salmon objective was derived subjectively by relating historical sonar passage estimates to trends in harvest and aerial survey indices (Schneiderhan 1982 b). 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 salmon (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 updated the Aniak River escapement objective to a Sustainable Escapement Goal (SEG) setting the range at 210,000 to 370,000 fish. 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 (ADF&G 2004). A timetable of developmental changes for the sonar project is presented in Appendix A1.

OBJECTIVES

The objective of the Aniak River sonar project is to estimate the chum salmon abundance and obtain the age, sex, and length composition of the run, along with collecting climatic and hydrological data. These objectives are outlined in the following list:

1. Estimate fish abundance in the Aniak River, with user-configurable sonar equipment, by sampling in 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 2–3 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 on state land in Section 5 of T16N, R56W (Seward Meridian), approximately 19 km upstream from the mouth of the Aniak River, and is 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 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.

HYDROACOUSTIC DATA ACQUISITION

Equipment

Two DIDSON units (SN 23 and SN 161) were deployed at the Aniak sonar site, 1 for each bank. The sonar units operated at 1 of 2 frequencies, 700 kHz or 1.4 MHz, depending on range requirements. Each DIDSON was mounted on an aluminum tripod and remotely aimed with a set of HTI rotators allowing movement in 2 axes. A Remote Ocean Systems (R.O.S.) model PTC-1 (SN 104) pan and tilt control unit connected to the rotator with 152.4 m of Belden model 9934 cable and provided horizontal and vertical positioning accurate to within ± 0.3º.

Each DIDSON was controlled by a laptop computer running version 4.54 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 EM-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 gigabyte (GB) RAID (redundant array of independent drives) enclosure were connected to the laptop for storing of all data from both banks. The enclosure was configured as RAID 1 which stores 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 EM-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.

Transducer Deployment

The transducers were attached to aluminum tripod's deployed on each bank, and oriented perpendicular to the current. The wide axis of each elliptical beam was oriented horizontally and positioned close to the river bottom to maximize residence time of targets in the beam. Transducers were placed offshore 4–10 m from the right bank, and 10–20 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 was ensonified by using the right bank transducer to sample outwards 20 m and the left bank transducer to sample outward 20 m.

Partial weirs were erected perpendicular to the current and extended from the shore out 1–3 m beyond the transducers. These devices moved chum salmon, Chinook salmon, and other large fish offshore and in front of the transducers to prevent 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.

Bottom Profiles and Stream Measurements

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, and the stability of the site, we were able to use the same location. The river substrate at the sonar site is fine, smooth gravel, sand, and silt. The left bank slopes gradually to the thalweg at roughly 25–65 m (Figure 3), while the right bank river bottom slopes steeply to the thalweg at about 10–30 m (Figure 4), depending on water level.

Sampling Procedures

Sonar project activities on both banks commenced on June 23 at 0800 hours and ran until 2000 hours on July 31, 2005. 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. 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. 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 and size. All fish were counted except for very small fish, which are assumed not to be salmon. A single fisheries technician operated and monitored equipment at the sonar site which entails identifying and tallying fish traces on echogram recordings while rotating through shifts occurring from 0000–0400, 0800–1200, and 1600–2000 hours. To ensure accurate data collection, crew members were trained to distinguish between fish traces and non-fish traces, such as those from debris and bottom. The number of fish traces were summed over 15-minute periods and recorded onto forms. Completed data forms were entered into a spreadsheet and checked over by the crew leader. 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 all project activities in a project logbook. The logbook was used to document daily 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 and Thresholds

Sound pulses were generated by the sonar at center frequencies of 1.1 MHz. 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 frequencies of 1.1 MHz, 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 out to a range of 20 m. All data were recorded on a laptop computer (one for each bank) and the files were saved to a single dual RAID drive.

ANALYTICAL METHODS

Abundance Estimation

The estimate of daily passage $\left(\hat{y}_{dz}\right)$ on day *d*, and bank *z* was calculated as follows:

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

where r_{dzp} is the hourly passage rate for period p calculated by summing the 16 individual 15-minute observations y, collected over the 4-hour period and dividing by the total number of hours.

The average hourly passage rate for the day ($\hat{r}_{dz}$) is estimated by summing the passage rates for the 3 periods and dividing by the number of periods (3):

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

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

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

The total daily passage is estimated by adding the daily passage for both banks. Note that the same result is obtained by summing the individual 15-minute samples and multiplying by the reciprocal of the fraction of the day sampled (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 would overestimate the variance of the total since sonar counts were highly autocorreltated (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:

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

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

The new sampling scheme helped to minimize sonar down time. However, sometimes generator maintenance, sonar equipment adjustments, and malfunctions resulted in missing sonar counts. The crew used different methodologies to make up for these incomplete counts, depending on the amount of time that was missed.

If more than 5 minutes were missed at the beginning of a shift, the shift was lengthened by the amount of time that was missed. If less than 5 minutes were missed at the beginning of a shift, the passage rate for the period within that interval was used to estimate passage for the un-sampled portion of the interval.

In the middle of a shift, if less than 10 minutes of a 15 minute interval were missed; the passage rate for the period within that interval was used to estimate passage for the un-sampled portion of the interval. If counts were missed for more than 10 minutes, the crew followed an ad hoc approach to estimation by initially preparing various plots of both banks passage depending on the amount of time missed. The goal of these plots was to produce a general picture of the run for that day so that an interpolation routine could be chosen that was appropriate for the real-time trends as depicted in the figures. These interpolations included averaging the passage rates for varying amounts of time before and after the missing data or performing regressions with varying start and stop points around the missing data. The crew also took into account the other bank's trends for the same time period and sometimes used this data in the regression to estimate the missing data.

On rare occasions more than 30 minutes were missed in the middle of a shift. In these instances, the crew extended the length of the shift by the amount of time missed.

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 became unusable do 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 of 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 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 pulse sampling design whereby intensive sampling was conducted for 1 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 to obtain 210 chum salmon scales (L. Dubois, Commercial Fish Biologist, ADF&G, Anchorage; personal communication). All ASL data were sent to the Bethel Alaska Department of Fish and Game (ADF&G) office for analysis by research staff. Ages were reported using European notation, in which 2 digits, separated by a decimal, refer to the number of freshwater and marine annuli. The total age from the time of egg deposition is the sum of the 2 digits plus 1.

To estimate the age and sex composition of chum salmon escapement in the Aniak River, daily passage estimates were temporarily stratified. Each stratum consisted of several days of fish passage and 1 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, conductivity, and secchi visibility were measured 1 time per day between 0800 and 1200 hours. Water temperature and conductivity were sampled in the middle of the river using an Extech model 34165 Conductivity/Temperature meter. Secchi depth was also measured at the middle of the river using a standard 20 cm radius secchi disk. A technician submerged the disk until it disappeared from sight before raising it back to the surface. As soon as the disk was visible again, the technician noted the depth before repeating this 2 more times and averaging the results to produce the recorded depth. At the main camp, the air temperature was recorded several times each day from a digital thermometer and general wind direction was noted.

The crew used a staff gauge to measure the water level. The benchmark used prior to 2002 degraded and became unusable, and consequently, readings are not comparable across years.

RESULTS

FISH PASSAGE ESTIMATES

Of the 1,171,977 (SE 28,821) fish estimated to have passed during the 2005 season, 50.7% of the fish passed on the left bank and 49.3% passed on the right bank (Table 2). This passage estimate is the second highest since the inception of the project in 1980, when 1,600,032 chum salmon were estimated to have passed the sonar site. Figure 5 shows the daily passage rates by bank along with the cumulative season estimate. The peak total daily passage of 76,652 fish occurred on July 14 (Table 2) and represented the highest daily passage for the season. The 25%, 50%, and 75% quartile dates of passage were July 8, July 15, and July 22 respectively (Table 2). Fish passage quartiles are approximately average compared with data from 2002–2004 (Figure 6).

MISSING DATA

A total of 1.2 hours (0.08%) on the left bank and 0.25 hours (0.02%) on the right bank of sampling time were 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 47 beach seine sets were completed and from these, 1,100 ASL samples from migrating chum salmon were obtained. Of those samples, 940 scales were analyzed postseason, with 89.5% falling in the 0.3 age class, 5.4% comprising the 0.2 age class, 5.0% in the 0.4 age class, and the remaining 0.1 % in the 0.5 age class (Table 3). Age-0.3 fish remained constant throughout the run accounting for 87% to 92% of the run during all strata. Age 0.4 chum salmon came in strong at the beginning of the run (11%–13%) and then tapered off as age 0.2 fish came in stronger in the second half of the run (6%–8%). For all age classes, male fish were present in greater proportions early in the season while females began to dominate the catch in the second half of the season.

Every captured fish was examined for the presence or absence of tags and secondary marks. Six tagged chum salmon were recovered during ASL sampling. Three extra days (9 sets) of seining were conducted in a further attempt to collect additional tags. These samplings resulted in the capture of 686 additional chum salmon and of these, 5 tags were recovered. This data was given to Doug Molyneaux and is reported in the annual Salmon Age, Sex, and Length catalog for the Kuskokwim Area.

ENVIRONMENTAL INFORMATION

Climate and River Measurements

Water levels steadily went down throughout the summer except for a brief period at the beginning of July when it rained; otherwise, it was a hot and dry summer with the lowest water levels coming at the end of July (Figure 7). Water temperatures varied from 11ºC (June 23) to 14ºC (July 9) over the operational period of the project (Figure 8). Data collection with the secchi disk and conductivity meter was incomplete. Daily air temperatures fluctuated between a minimum of 6.1ºC (July 27) and 15ºC (July 17) over the project operational period (Figure 8).

DISCUSSION

Operations at the Aniak River sonar went smoothly in 2005. Fish passage at the site was the second highest on record and exceeded the SEG for the project, the sample size objectives of the ASL sampling were met, and the air and water temperatures were moderate and the overall weather was pleasant, which helped to prevent problems with data collection.

FISH PASSAGE ESTIMATES

We were able to meet the first objective of collecting fish abundance data using sonar. The estimated fish passage for 2005 was the second highest since the projects inception in 1980 (Figure 9). In 2005 the run timing was a couple of days behind the average (Figure 10) when compared to the historical record. The fish count was slightly higher through the first quarter (July 7) when compared with the previous 3 years (Figure 11), and then starting around July 8, the first of 3 large pulses each lasting 6 days came up the river. During each of these pulses, there was an average of 300,000 fish. Similar to 2002 thru 2004, the 2005 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; this has occurred over the last couple of years. 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 on the 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 the second objective, of estimating the age, sex, and length composition of the Aniak River chum salmon escapement. The 2005 catch was predominantly age-0.3 chum salmon (89.5%) or approximately 1 million fish. This continued the strong showing from the previous year when, as age-0.2 fish, they accounted for 24.4% (164,472 chum) of the overall run (McEwen 2005). While this is a big percentage difference between years, on average the age-0.2 fish contribute less then 3% (0.3% in 2003 and 2.8% in 2002) to the overall run. The age-0.4 chum accounted for 43.2% (290,861 chums; McEwen 2005) last year but fell off precipitously this year with 5% (41,285) returning to spawn (Table 3). Even though this is a small percentage of the overall run this year the actual number of fish returning is a good showing considering 2000 was a disastrous year for chum salmon returning to the Aniak River.

Environmental Information

We were able to meet the third objective of monitoring selected climatic and hydrological parameters daily at the project site. Air and water temperatures were moderate and the overall weather was pleasant, which helped to prevent problems with sonar data collection and beach seining for ASL samples. Due to the hot, dry summer the water level steadily decreased throughout the season prompting frequent movement of the left bank sonar. The right bank sonar was moved less frequently due to the steeper bank which allowed for a deeper deployment closer to shore.

ACKNOWLEDGEMENTS

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TABLES AND FIGURES

Table 1.–Density dependent relationship between BioSonics and DIDSON counts between 1980 and 2005.

Year	BioSonics Passage [a]	DIDSON Passage [b]	Percent of DIDSON
1980	1,094,094	1,600,032	68.38%
1981	500,348	649,849	76.99%
1982	408,397	529,758	77.09%
1983	135,442	166,452	81.37%
1984	251,771	317,688	79.25%
1985	217,376	273,306	79.54%
1986	177,808	219,770	80.91%
1987	165,523	204,834	80.81%
1988	380,094	485,077	78.36%
1989	236,998	295,993	80.07%
1990	198,939	246,813	80.60%
1991	287,816	366,687	78.49%
1992	71,439	87,467	81.68%
1993	12,708	15,278	83.18%
1994	366,276	474,356	77.22%
1995	ND	ND	ND
1996	316,767	402,195	78.76%
1997	231,807	289,654	80.03%
1998	278,534	351,792	79.18%
1999	173,363	214,429	80.85%
2000	144,157	177,384	81.27%
2001	323,076	408,830	79.02%
2002	370,272	472,346	78.39%
2003	372,559	477,544	78.02%
2004	518,117	672,931	76.99%
2005	828,257	1,151,505	71.93%

Note: ND means "no date."

[a] Biosonics passage estimates for years 2004–2005 are based on hourly counts relationship established in 2003.

[b] DIDSON passage estimates for years 1980–2003 are values estimated using daily relationships from 1997–2003.

Table 2.–Daily fish passage estimates, Aniak River sonar, 2005.

Date	Left Bank	Right Bank	Daily Total	Cumulative Total	LB % Passage	RB % Passage
6/23	3,379	4,185	7,564	7,564	44.7%	55.3%
6/24	3,868 [a]	3,195	7,063	14,627	54.8%	45.2%
6/25	3,290 [a]	2,419	5,709	20,336	57.6%	42.4%
6/26	1,540	2,798	4,338	24,675	35.5%	64.5%
6/27	2,500	3,008	5,508	30,183	45.4%	54.6%
6/28	2,795	3,830	6,625	36,808	42.2%	57.8%
6/29	4,177	5,365	9,542	46,350	43.8%	56.2%
6/30	4,672	7,435	12,107	58,457	38.6%	61.4%
7/01	2,026	2,979	5,005	63,461	40.5%	59.5%
7/02	5,359	8,096	13,455	76,917	39.8%	60.2%
7/03	12,600	12,735	25,334	102,251	49.7%	50.3%
7/04	7,637	11,435	19,072	121,323	40.0%	60.0%
7/05	10,143	13,057	23,200	144,523	43.7%	56.3%
7/06	12,494	11,134	23,628	168,151	52.9%	47.1%
7/07	17,771	15,760	33,531	201,682	53.0%	47.0%
7/08	15,888	15,901	31,789	233,472	50.0%	50.0%
7/09	21,858	16,292	38,150	271,622	57.3%	42.7%
7/10	28,801	23,506	52,307	323,929	55.1%	44.9%
7/11	22,839	22,428	45,267	369,195	50.5%	49.5%
7/12	12,396	18,303	30,699	399,894	40.4%	59.6%
7/13	20,407	18,092	38,499	438,393	53.0%	47.0%
7/14	38,949	37,703	76,652	515,045	50.8%	49.2%
7/15	30,309	25,196	55,505	570,550	54.6%	45.4%
7/16	22,102	19,444	41,545	612,096	53.2%	46.8%
7/17	24,379	22,678	47,057	659,153	51.8%	48.2%
7/18	16,952	17,328	34,280	693,434	49.5%	50.5%
7/19	11,840	15,332	27,172	720,606	43.6%	56.4%
7/20	25,520	24,538	50,058	770,664	51.0%	49.0%
7/21	36,227	33,136	69,363	840,027	52.2%	47.8%
7/22	30,897	31,324	62,221	902,249	49.7%	50.3%
7/23	18,411	19,712	38,123	940,371	48.3%	51.7%
7/24	20,515	20,228	40,743	981,114	50.4%	49.6%
7/25	15,231	17,340	32,571	1,013,686	46.8%	53.2%
7/26	11,055	10,636	21,691	1,035,376	51.0%	49.0%
7/27	17,446	14,931	32,377	1,067,753	53.9%	46.1%
7/28	18,949	14,336	33,285	1,101,038	56.9%	43.1%
7/29	13,457	10,807	24,264	1,125,302	55.5%	44.5%
7/30	10,873	8,459	19,332	1,144,634	56.2%	43.8%
7/31	14,792	12,551	27,343	1,171,977	54.1%	45.9%
Season Totals	594,345	577,632	1,171,977		50.7%	49.3%

Note: The large box indicates the central 50% of the run (second and third quartiles). The small box indicates the median passage date (mean quartile).

[a] Counts extrapolated for equipment repair.

Table 3.–Age and sex composition of chum salmon, Aniak River sonar, 2005.

			Age 0.2			Age 0.3			Age 0.4			Age 0.5			Total		
2005 Sample Date (Strata)	Sample size		Number fish	Sample count	%	Number fish	Sample count	%	Number fish	Sample count	%	Number fish	Sample count	%	Number fish	Sample count	%
6/23-26	46	M	0		0.0	15,091	23	50.0	3,924	6	13.0	0		0.0	19,015	29	63.0
(23-27 June)		F	0		0.0	11,168	17	37.0			0.0	0		0.0	11,168	17	37.0
		Subtotal	0		0.0	26,259	40	87.0	3,924	6	13.0	0		0.0	30,183	46	100
6/30-7/2	191	M	911	2	1.0	46,299	97	50.8	7,656	16	8.4	0		0.0	54,866	115	60.2
28-June to		F	1,914	4	2.1	31,990	67	35.1	2,370	5	2.6	0		0.0	36,274	76	39.8
4-Jul		Subtotal	2,825	6	3.1	78,289	164	85.9	10,025	21	11.0	0		0.0	91,140	191	100
7/8-9	177	M	0		0.0	148,476	106	59.9	9,667	7	3.9	0		0.0	158,143	113	63.8
5-11 July		F	9,915	7	4.0	75,601	54	30.5	4,214	3	1.7	0		0.0	89,730	64	36.2
		Subtotal	9,915	7	4.0	224,077	160	90.4	13,881	10	5.6	0		0.0	247,873	177	100
7/14-15	176	M	1,945	1	0.6	151,095	82	46.6	1,945	1	0.6	0		0.0	154,986	84	47.7
12-18 July		F	23,994	13	7.4	143,637	78	44.3	1,621	1	0.5	0		0.0	169,252	92	52.3
		Subtotal	25,939	14	8.0	294,732	160	90.9	3,567	2	1.1	0		0.0	324,238	176	100
7/20-21	173	M	3,843	2	1.2	153,721	83	48.0	1,922	1	0.6	1,922	1	0.6	161,407	87	50.3
19-25 July		F	14,732	8	4.6	140,591	76	43.9	3,523	2	1.1	0		0.0	158,845	86	49.7
		Subtotal	18,575	10	5.8	294,312	159	91.9	5,444	3	1.7	1,922	1	0.6	320,252	173	100
7/28-29	177	M	1,741	2	1.1	68,857	77	43.5	1,741	2	1.1	0		0.0	72,339	81	45.8
26-31 July		F	10,764	12	6.8	72,497	81	45.8	2,691	3	1.7	0		0.0	85,952	96	54.2
		Subtotal	12,505	14	7.9	141,354	158	89.3	4,432	5	2.8	0		0.0	158,291	177	100
Season	940	M	8,441	7	0.7	583,539	468	49.8	26,855	33	3.5	1,922	1	0.1	620,756	509	54.1
		F	61,318	44	4.7	475,484	373	39.7	14,418	14	1.5	0		0.0	551,221	431	45.9
		Total	69,759	51	5.4	1,059,023	841	89.5	41,273	47	5.0	1,922	1	0.1	1,171,977	940	100

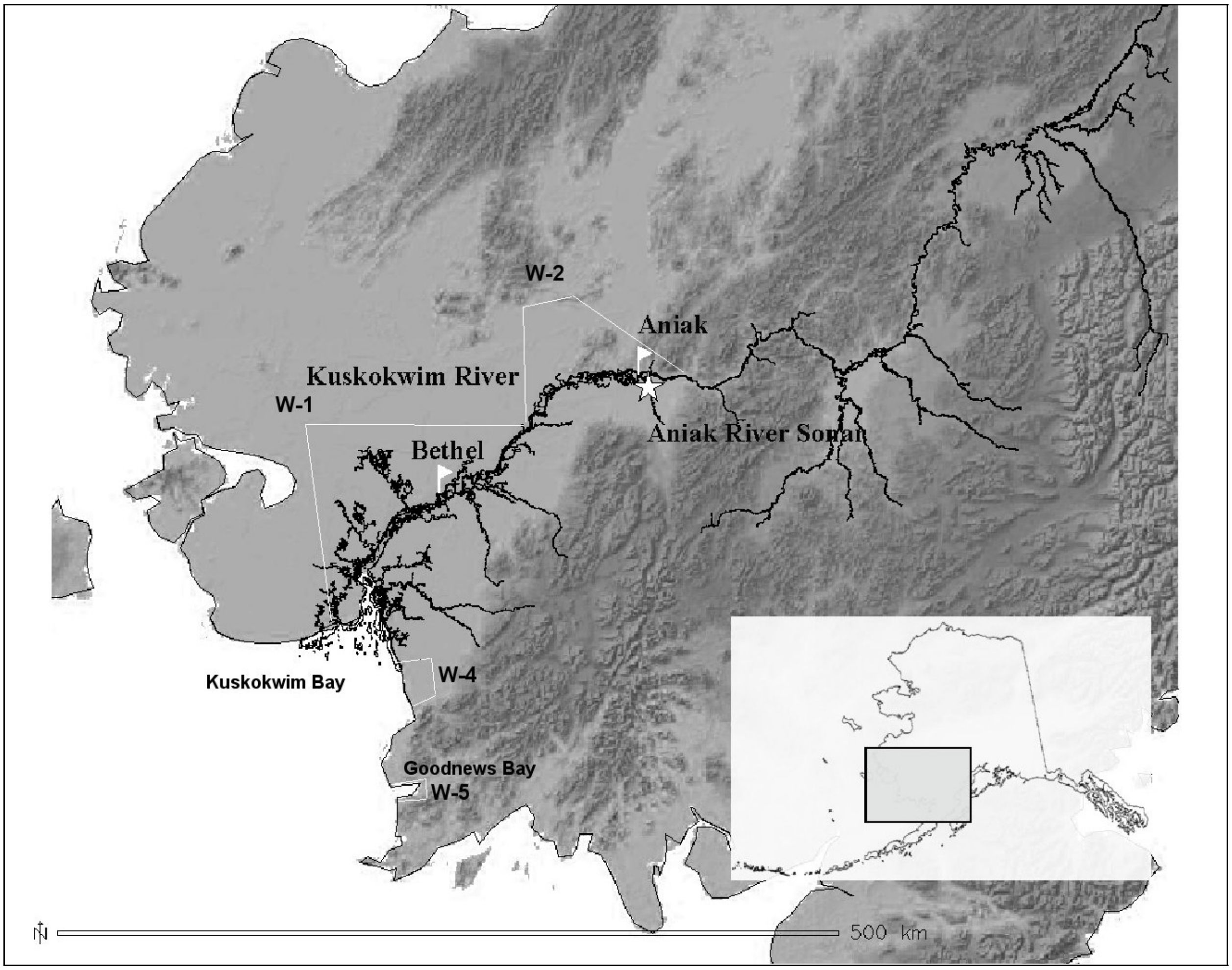

Figure 1.–Kuskokwim River Area, with lower river fishing districts (W-1,W-2,W-4,W-5) delineated.

Figure 2.–Location of Aniak River sonar site, 2005.

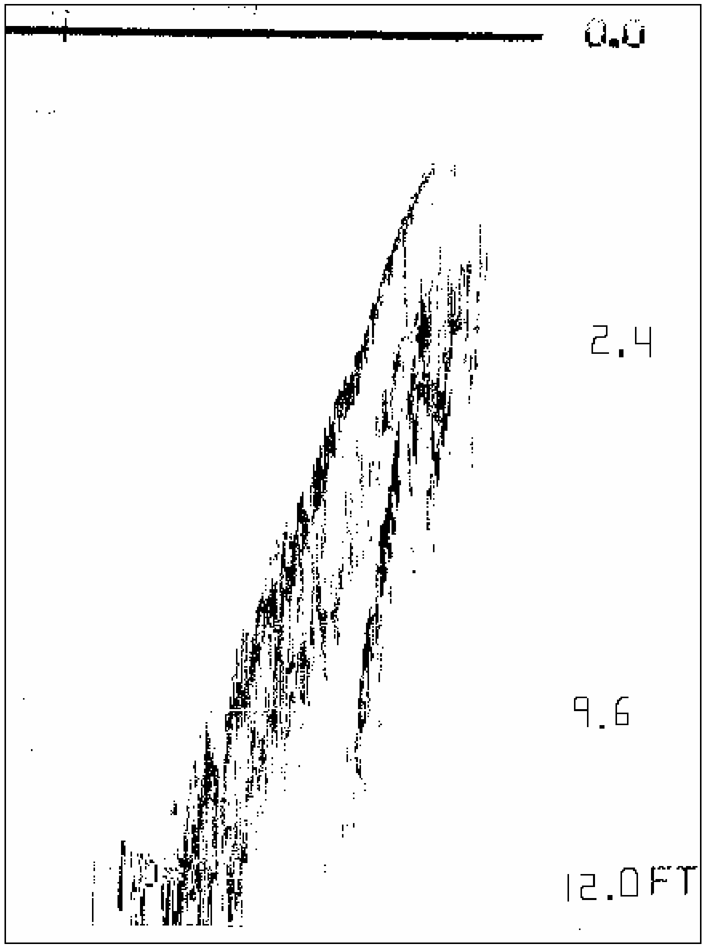

Figure 3.–Left bank bottom profile, Aniak River sonar, 2005.

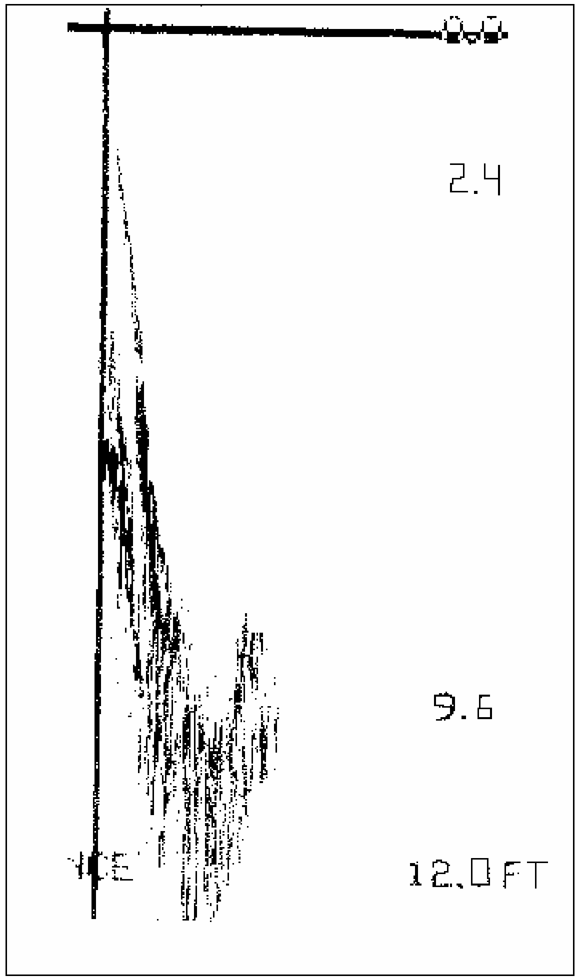

Figure 4.–Right bank bottom profile, Aniak River sonar, 2005.

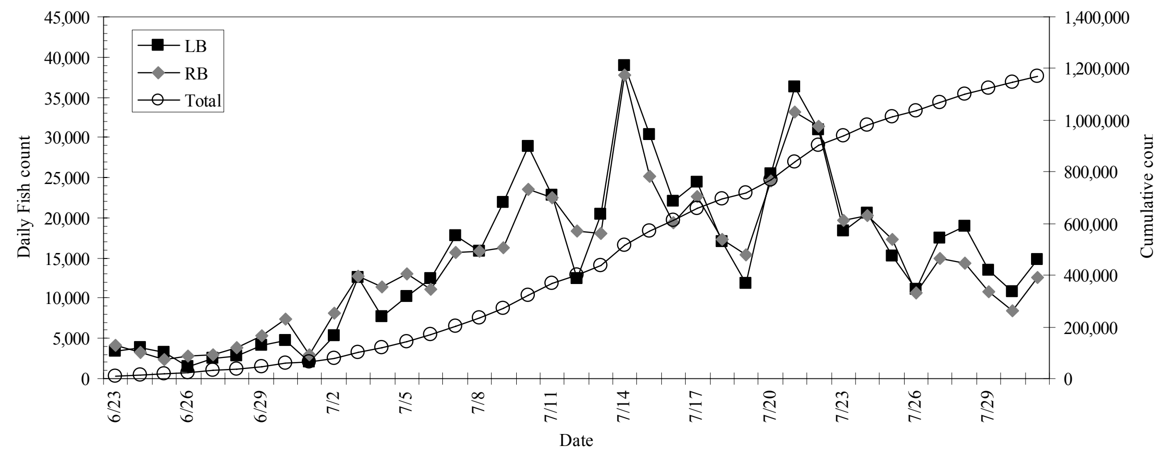

Figure 5.–Daily and cumulative passage estimates, Aniak River sonar, 2005.

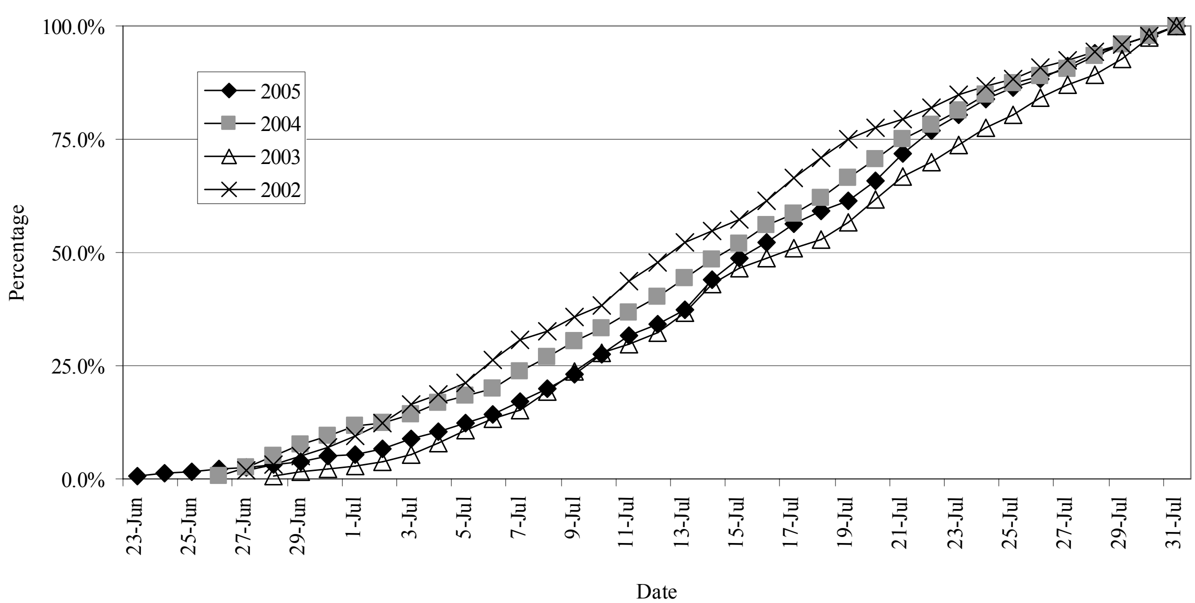

Figure 6.–Fish passage quartiles, Aniak River sonar, 2002–2005.

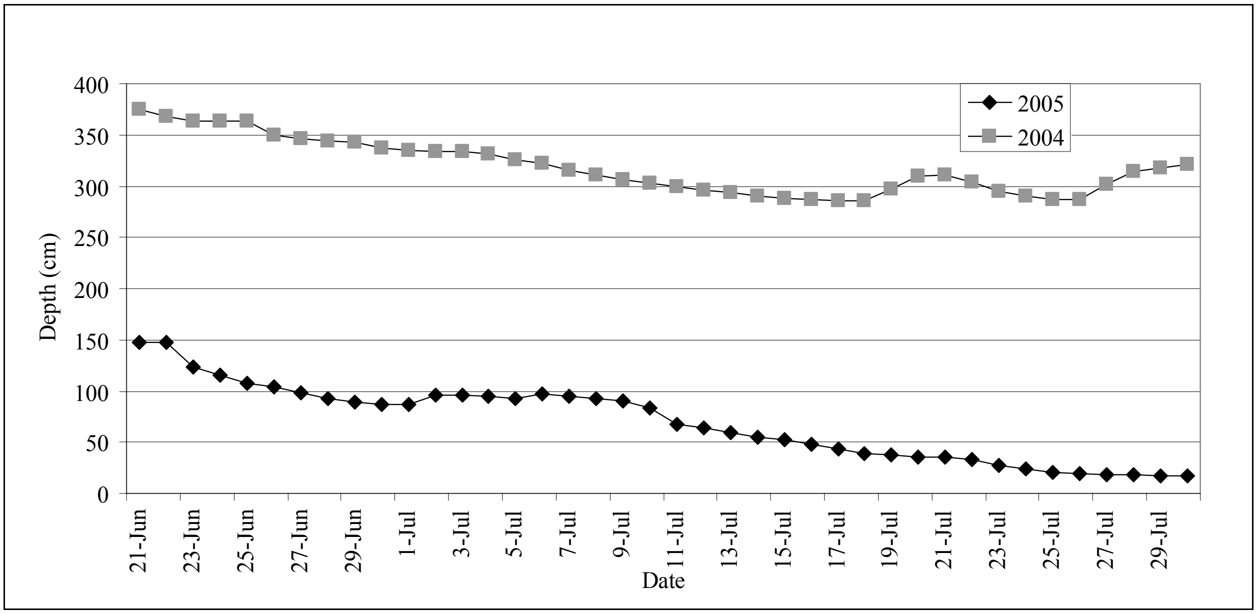

Figure 7.–Water level, Aniak River sonar, 2004–2005.

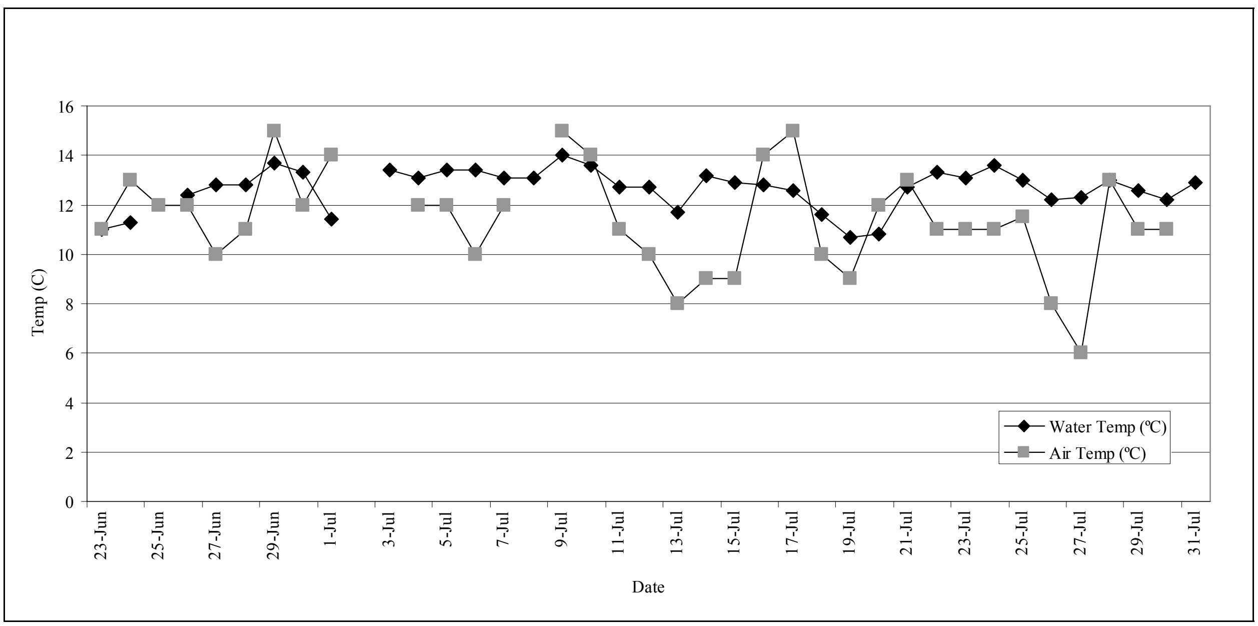

Figure 8.–Air and water temperatures, Aniak River sonar, 2005.

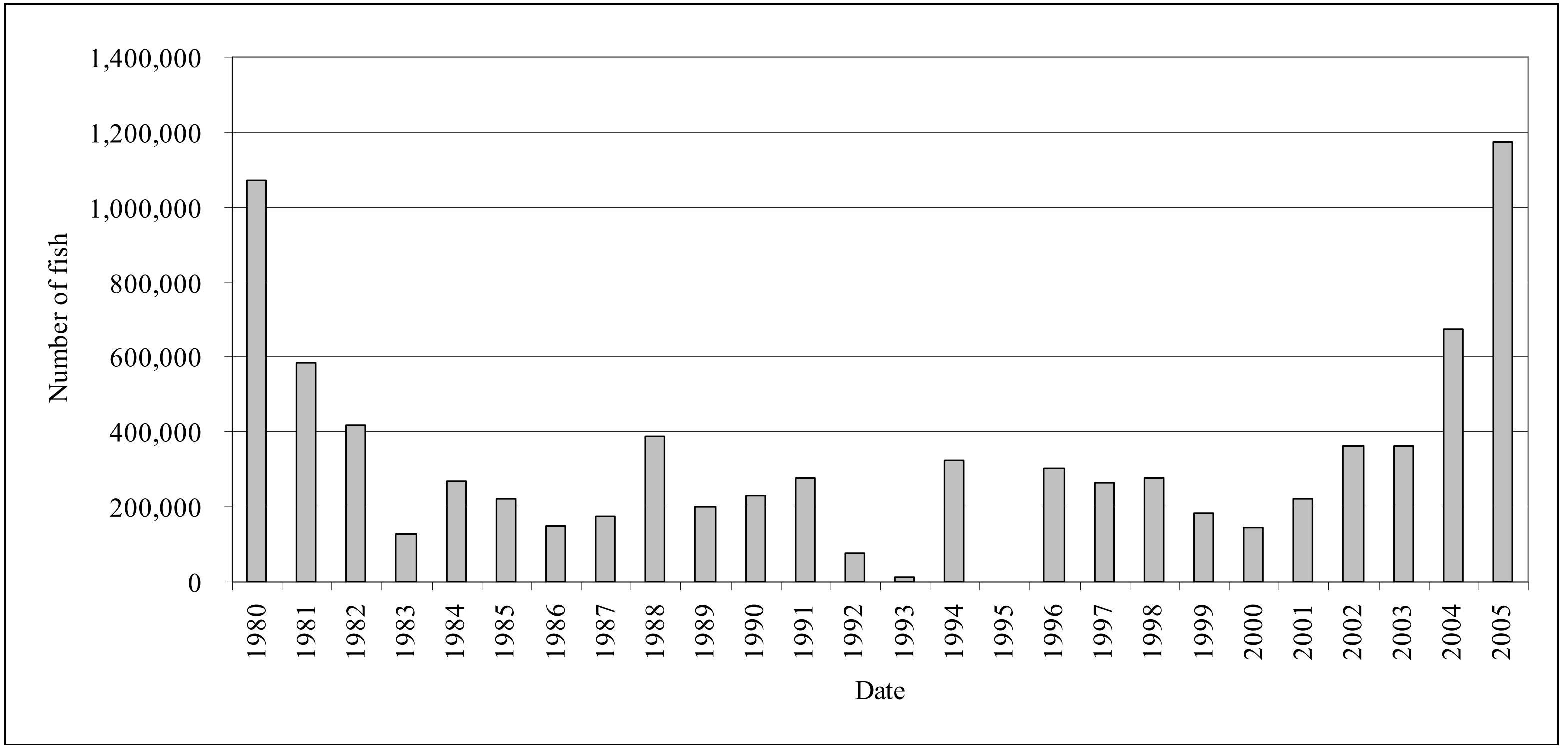

Figure 9.–Historical fish passage, Aniak River sonar project, 1980–2005.

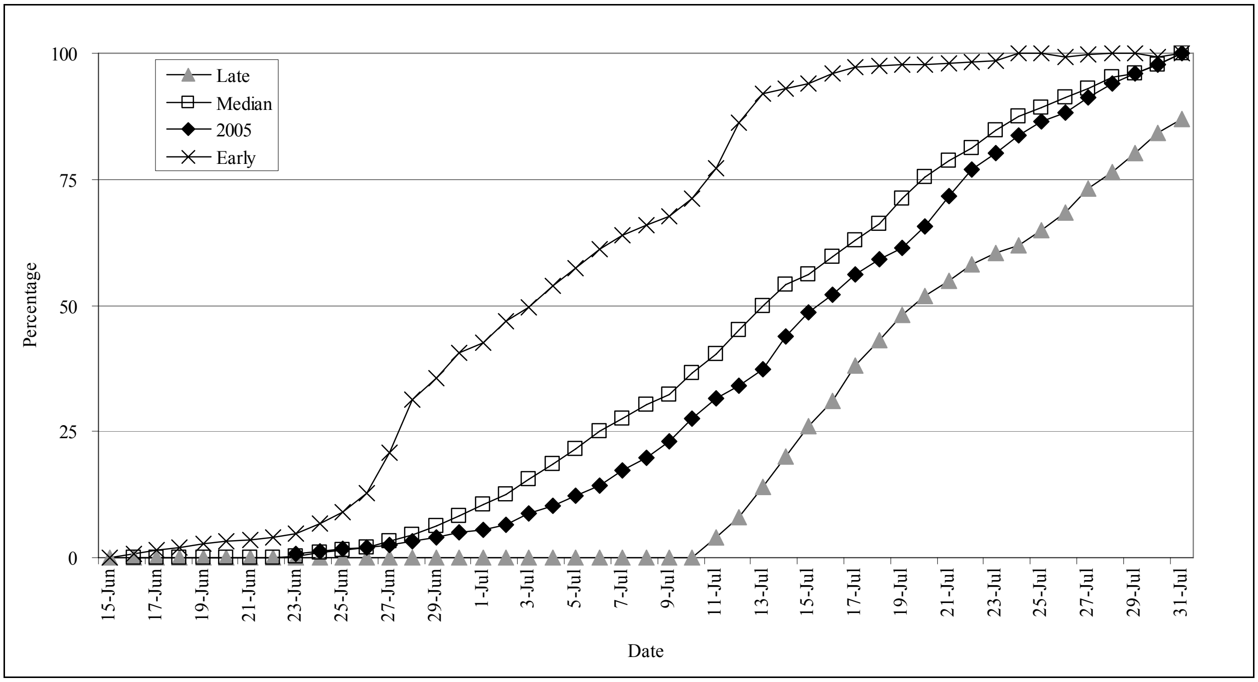

Figure 10.–Historical run timing, Aniak River Sonar, 1980–2005.

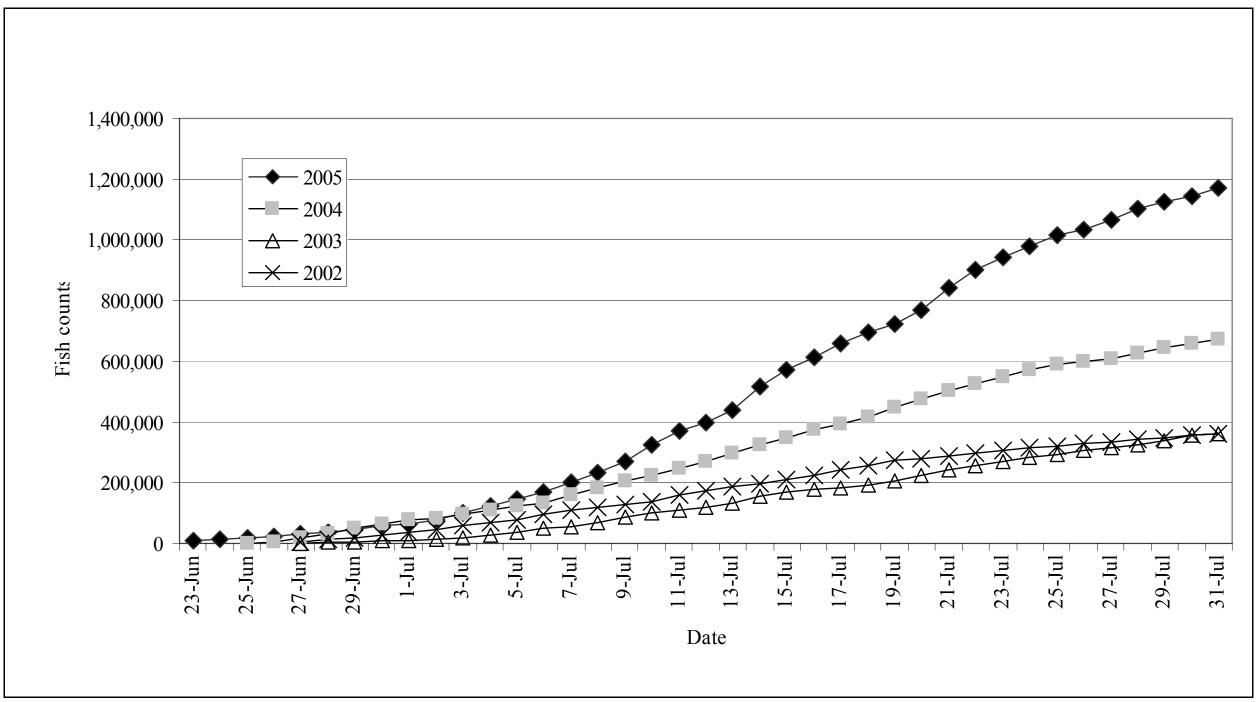

Figure 11.–Cumulative fish passage estimates, Aniak River sonar, 2002–2005.

APPENDIX A. PROJECT HISTORY

Appendix A1.–Timetable of developmental changes of the Aniak River sonar project, 1980–2005.

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 insonification 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	• Operated DIDSON exclusively on both banks