Fishery Data Series No. 05-30

Sonar Estimation of Chum Salmon Passage in the Aniak River, 2004

by

Malcolm S. McEwen

June 2005

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

Symbols and Abbreviations

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Weights and measures (metric)

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

Weights and measures (English)

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

Time and temperature

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

Physics and chemistry

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

General

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

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 changes including changing from the original Bendix sonar to dual-beam and in 2004 to a high frequency imaging sonar (DIDSON). 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 25 through July 31, 2004. During this period, an estimated 673,445 fish (SE 18,897) passed through the ensonified area, the majority of which are assumed to be chum salmon *Oncorhynchus keta*. The peak passage of 30,946 fish occurred on July 19 and the 50% passage date occurred on July 15. Age-0.2, -0.3, and -0.4 chum salmon comprised 24.4%, 43.2% and 32.1% of the escapement estimate, respectively.

Key words: Aniak River, chum salmon, *Oncorhynchus keta*, DIDSON, hydroacoustic, 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*. Commercial chum salmon harvests in Districts 1 (W-1) and 2 (W-2) from 1992–2001 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). 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).

Management of the Kuskokwim fishery resource requires timely estimates of run strength and escapement. Past sonar escapement estimates and aerial survey indices of abundance suggest the Aniak River is one of the largest producers of chum salmon in the Kuskokwim River drainage (Francisco et al. 1995). Prior tagging studies suggest travel time of chum salmon migrating from the upper end of District 1 to the Aniak River sonar site is about 7 or 8 days (ADF&G 1961, 1962). Because of its proximity (Figure 1) to the Kuskokwim River commercial and subsistence fisheries, the Aniak River sonar project can provide management staff with timely estimates of fish passage.

Aniak River escapement data were collected using an echo counting and processing transceiver manufactured by Bendix Corporation[1] from 1980 to 1995. 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 counts (Schneiderhan 1985). The second counter was deployed

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

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. In addition to the expansion of daily totals, sonar estimates were extrapolated for salmon escapement occurring before and after the operational period.

In the early 1980's, gillnet test fishing provided species apportionment and age, sex, and length (ASL) information of chum and Chinook salmon. 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. Supporting the decision to abandon chum salmon ASL data collection was previous age and sex composition data that indicated Aniak River chum salmon results were similar to commercial catch results from the lower Kuskokwim River districts (Schneiderhan 1988).

Salmon escapement objectives for the Aniak River were tentatively set at 250,000 chum 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).

Species apportionment activities were discontinued in 1986 because of inadequate sample sizes (Schneiderhan 1988). Early gillnet and beach seine test fishing 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 the absence of species apportionment data, 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, 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). 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, this is used in situations where a BEG cannot be estimated due to the absence of a stock specific catch estimate (ADF&G 2004). The SEG was revised to 210,000 to 370,000 fish.

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. 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. The SEG of 210,000 to 370,000 estimated fish counts was carried forward to the redesigned sonar project.

Sonar operations from 1997 to 2002 remained essentially unchanged since 1996. In 2003, the sonar sampling protocol changed. The Alaska Department of Fish and Game (ADF&G) implemented three 4-hour sampling periods instead of sampling 24-hours per day. This sampling protocol was continued in 2004. Preparations to transition to a new dual frequency identification sonar (DIDSON) were initiated in 2003 (Sandall and Pfisterer *In prep*) and 2004 saw replacement of the dual-beam system with the DIDSON sonar. A timetable of developmental changes for the sonar project is presented in Appendix A1.

A species apportionment feasibility study was conducted in 2001 and 2002. This study attempted to determine if test fishing with gillnets could provide an acceptable method of apportioning sonar counts to fish species. The results indicated that test fishing was not an acceptable method apportioning sonar counts on this river system, and the study was discontinued in 2003 (M. S. McEwen, Commercial Fisheries Biologist, ADF&G, Fairbanks; personal communication).

OBJECTIVES

The primary objectives for the 2004 field season are outlined in the following list:

1. Collect fish abundance data with user-configurable sonar equipment over three 4-hour shifts on both banks throughout the bulk of the chum salmon migration (approximately June 21 through July 31).
2. Provide daily estimates of fish passage to fishery managers in Bethel by 0800 hours the following morning.
3. 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).

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 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.

At the sonar site the river 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. The river substrate at the sonar site is fine, smooth gravel, sand, and silt. The right bank river bottom slopes steeply to the thalweg at about 10–30 m, while the left bank slopes gradually to the thalweg at roughly 25–65 m depending on water level.

HYDROACOUSTIC DATA ACQUISITION

Equipment

Two DIDSON units (SN 24 and SN 23) were deployed at the Aniak sonar site, one for each bank. The sonar operated at one of two frequencies, 1 MHz or 1.8 MHz depending on range requirements. The DIDSON was mounted on an aluminum tripod and remotely aimed with a set of HTI rotators allowing movement in 2 axes. A Remote Oceans 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 running version 4.47 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) Firewire Direct RAID (redundant array of independent drives) drive was connected to the laptop for storing of all data from both banks. The RAID drive kept redundant copies of the data on 2 separate hard drives 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. An Ethernet cable routed data from the breakout box to a wireless data access point, which transferred the data across the river to a wireless data access receiver. An Ethernet cable routed data to the same hub as the right bank and then to the controlling laptop.

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 elliptical beam was oriented horizontally and positioned close to the river bottom to maximize target residence time 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. The transducers needed to be repositioned several times to accommodate lowering 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 fish from passing undetected behind the transducers and to minimize detections in the near field. 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, nontarget species.

Bottom Profiles and Stream Measurements

Numerous bottom profile surveys of both banks were performed with a chart recording fathometer. These charts were used to select the best deployment site and to verify that the site was stable. The left bank gradient was fairly shallow and constant (Figure 3), whereas the right bank had a steep gradient from shore to the thalweg that measured approximately 3 m deep and was located closer to the right bank than left bank (Figure 4). The right bank displayed a significantly different morphology from previous years. A large deposit of gravel had widened the bar and changed the bank profile.

Sampling Procedures

Sonar project activities commenced on June 25 and ended on July 31, 2004. Hydroacoustic sampling began at 0800 hours on June 25 on both banks 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 and transducer adjustments were made. This was a significant change from seasons prior to 2003 when sampling occurred 24 hours per day. Inseason analysis consisted of visually scanning the echograms and video for fish traces and anomalous detections to verify consistent aim. A single fisheries technician operated and monitored equipment at the sonar site. Crew members identified and tallied fish traces on echogram recordings while rotating through 0000–0400, 0800–1200, and 1600–2000 hours shifts. For consistency, 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 was 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. All data were recorded onto a separate hard drive and backed up daily.

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 and Thresholds

Sound pulses were generated by the sonar at center frequencies of 0.7, 1.1, 1.4 or 1.8 MHz depending upon model and sampling range. 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 1.8 MHz mode uses 96 beams (8 sets of 12) at 0.3° apart from each other on a horizontal plane. The long range DIDSON which can see out to 60m, operates at two frequencies 0.700 MHz, 48 beams at 0.8° apart from each other on a horizontal plane, and the 1.2 MHz, 48 beams, 0.5° apart from each other on a horizontal plane.

The right bank and left bank both sampled out to a range of 20 m. All data was 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 $(\hat{y}_{dz})$ 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 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 unsampled 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 unsampled 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 chose 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. This bar has been used intermittently in the past, but has been used exclusively in the last couple of years including this year. This gravel bar provides a better drift of the net, had fewer snags, and helped to produce 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 step from mid eye to tail fork. 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 to precisely estimate the true age composition of the escapement during that time (Molyneaux and Dubois 1996). The goal of each sampling pulse was 210 chum salmon scales (Bromaghin 1993). All ASL data were sent to the Bethel 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 one.

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 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, conductivity, and secchi visibility was measured one time per day between 0800–1200 hours. Water temperature and conductivity was 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 note water level. The previous benchmark used prior to 2002 degraded and became unusable. Consequently, only readings from 2002, 2003 and 2004 are comparable.

RESULTS

Fish Passage Estimates

Of the 673,445 (SE 18,897) fish estimated to have passed during the 2004 season, 50.1% of the fish passed on the left bank and 49.9% passed on the right bank (Table 1). This passage estimate is the highest since the project reorganized operations in 1996 and has only been exceeded once since the inception of the project in 1980, when 1,169,470 chum salmon were estimated in 1980. Figure 5 shows the daily passage rates by bank along with the cumulative season estimate. The peak total daily passage of 30,946 counts occurred on July 19 (Table 1) and represented record daily passage. The 25%, 50%, and 75% quartile dates of passage were July 8, July 15, and July 21 respectively (Table 1). With a record run in 2004, the fish passage quartiles are average compared with data from 2002–2003 (Figure 6). The overall fish count for 2004 when compared with the previous 2 years (Figure 7) was slightly higher through the first quarter (July 8). Starting around July 11 the first of 2 large pulses came up the river, each pulse lasting 6 days. During each of these pulses approximately 150,000 fish came up the river.

MISSING DATA

A total of 10.9 hours (2.0%) on the left bank and 5.7 hours (1.0 %) 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. Most of the hours missed on left bank were due to debugging the wireless system early in the season.

ASL SAMPLING

A total of 29 beach seine sets were completed and from these, 1,915 ASL samples from migrating chum salmon were obtained. Out of those samples, 1,130 scale samples were analyzed post season with 43.2% falling in the 0.3 age class, 32.1% comprising the 0.4 age class, 24.4% in the 0.2 age class, with the remaining 0.3 % in the 0.5 age class (Table 2; Figure 8). Age-0.3 fish remained constant throughout the run. Age-0.4 chum salmon came in strong at the beginning of the run and then tapered off as age-0.2 fish came in stronger in the second half of the run.

ENVIRONMENTAL INFORMATION

Climate and River Measurements

Water levels steadily went down due to a hot and dry summer and came up briefly near the end of the season (Figure 9). The lowest levels came toward the end of July, but began to come up as camp was being disassembled. Water temperatures varied from 11ºC (July 5) to 14ºC (July 11) over the operational period of the project (Figure 10). The secchi depth remained consistent over the project operational period; the depth averaged 1.3 m (SD 0.1). Daily air temperatures fluctuated between a minimum of 6.1ºC (July 5) and 23.1ºC (June 27) over the project operational period (Figure 10).

DISCUSSION

In 2004, the sampling schedule remained the same as last year with three 4-hour shifts. This sampling scheme worked well, resulting in reduced crew size and other operational savings. This was especially helpful considering the storage requirements of the DIDSON. The data for the entire season was approximately 300 GB and would have been at least twice the amount had the project operated 24 hours per day.

FISH PASSAGE ESTIMATES

The estimated passage for 2004 was the highest since 1981. The 2004 run timing was about average, and the cumulative counts increased steadily throughout the season. Similar to 2002 and 2003, the 2004 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. The consistently low water level observed this year is believed to have resulted in fish being evenly distributed along both banks.

ASL Sampling

As in past years, ASL sampling is not used, and should not be used, for any level of species apportionment. With the advent of a Kuskokwim River mainstem tagging study, the Aniak

River sonar beach seining project has provided a tag recapture location. Every captured fish is examined for the presence or absence of tags and secondary marks. The beach seining technique is very efficient at capturing fish, and can be relied upon to capture large numbers of samples. Five tagged chum salmon were recovered during ASL sampling. Two extra days of seining were conducted in a further attempt to collect additional tags. This sampling resulted in the capture of 630 additional fish and of these one tag was recovered from a sockeye salmon *O. nerka*.

The age distribution of the 2004 catch had a strong show of age-0.4 chum salmon during the first half of the run which tapered off as age-0.2 fish came in strong during the last half of the run. Age-0.3 chum salmon remained constant during the entire run (Table 2; Figure 8). In contrast to 2002 and 2003, where the run was composed mostly of age 0.3 (81.1 to 80.6%) and age 0.4 (18.3 to 17.9%) and very few age 0.2 chums (0.6 to 0.4%) (Lieb 2002; Sandall and Pfisterer *In prep*). 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.

ENVIRONMENTAL INFORMATION

Air and water temperatures were moderate and the overall weather was pleasant, which helped to prevent problems with data collection. 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.

Past examination of the relationship of counts made using BioSonics and DIDSON equipment have shown that the BioSonics estimates are about 70% of those derived using a DIDSON (Sandall and Pfisterer *In prep*). Using the relationship observed in 2003, the estimated count would have been approximately 516,000 had the older BioSonics equipment been utilized. This is a 40% increase over the 2003 count of 363,396, and the 2002 count of 362,812. The established SEG of 210,000 to 370,000 (ADF&G 2004) chum salmon for the Aniak River should be considered as interim under the redesigned sonar project. The goal will need to be reassessed as more information is gathered.

ACKNOWLEDGEMENTS

The author wishes to thank seasonal ADF&G staff including Holly Carroll and Naomi Brodersen along with Dana Diehl of the Association of Village Council Presidents for the collection of data. Brian Latham and Heath Sandall for coming out to Aniak to help set up camp and the hydroacoustics. The Kuskokwim Native Association and Dave Cannon provided invaluable logistical assistance in Aniak. Carl Pfisterer, AYK Sonar Supervisor, provided project oversight, technical support, and review of this report.

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TABLES AND FIGURES

Table 1.–Daily fish passage estimates, Aniak River sonar, 2004.

Date	Left Bank	Right Bank	Daily Total	Cumulative Total	LB % Passage	RB % Passage
6/25	118	396	514	514	23%	77%
6/26	2,207	1,567	3,774	4,288	58%	42%
6/27	6,727	5,382	12,108	16,396	56%	44%
6/28	7,542	9,412	16,954	33,350	44%	56%
6/29	7,739	9,485	17,224	50,574	45%	55%
6/30	6,167	7,131	13,297	63,872	46%	54%
7/1	6,524	7,618	14,142	78,013	46%	54%
7/2	2,622	3,361	5,982	83,995	44%	56%
7/3	4,790	6,476	11,266	95,261	43%	57%
7/4	6,610	10,046	16,656	111,917	40%	60%
7/5	4,664	8,083	12,747	124,664	37%	63%
7/6	5,142	5,018	10,160	134,824	51%	49%
7/7	13,274	12,688	25,962	160,786	51%	49%
7/8 [a]	10,712	10,714	21,426	182,212	50%	50%
7/9	13,322	9,824	23,146	205,358	58%	42%
7/10	9,936	9,104	19,040	224,398	52%	48%
7/11	11,294	11,042	22,336	246,734	51%	49%
7/12	10,468	13,842	24,310	271,045	43%	57%
7/13	10,831	15,787	26,618	297,662	41%	59%
7/14	11,498	16,240	27,738	325,400	41%	59%
7/15 [a]	8,916	15,218	24,134	349,534	37%	63%
7/16	12,976	14,354	27,330	376,864	47%	53%
7/17	7,930	8,972	16,902	393,766	47%	53%
7/18	10,791	12,991	23,782	417,549	45%	55%
7/19	15,722	15,224	30,946	448,495	51%	49%
7/20	14,351	13,190	27,541	476,036	52%	48%
7/21 [a]	17,344	12,072	29,416	505,452	59%	41%
7/22	11,466	9,668	21,134	526,586	54%	46%
7/23	12,626	8,996	21,622	548,208	58%	42%
7/24	13,282	9,871	23,153	571,361	57%	43%
7/25	9,096	7,792	16,888	588,249	54%	46%
7/26	5,754	4,943	10,698	598,947	54%	46%
7/27	6,259	5,024	11,283	610,230	55%	45%
7/28	10,477	7,030	17,507	627,737	60%	40%
7/29	10,702	7,816	18,518	646,255	58%	42%
7/30	8,218	4,436	12,654	658,909	65%	35%
7/31	9,614	4,922	14,536	673,445	66%	34%
Season Totals	337,711	335,733	673,445			

[a] quartiles of the cumulative total.

Table 2.–Age and sex composition of chum salmon, Aniak River sonar, 2004.

2004 Sample Date (Strata)	Sample size (No. of fish)		Age 0.2 No. fish [a]	%	0.3 No. fish [a]	%	0.4 No. fish [a]	%	0.5 No. fish [a]	%	Total No fish [a]	%
6/28/1930	184	M	913	1.1	13,238	15.7	35,150	41.8	0	0	49,301	58.7
6/25–7/2		F	1,826	2.2	12,326	14.7	20,542	24.5	0	0	34,694	41.3
		Subtotal	2,739	3.3	25,564	30.4	55,692	66.3	0	0	83,995	100.0
7/4/2005	182	M	2,159	2.2	24,824	25.3	21,046	21.4	540	0.5	48,568	49.5
7/3/2008		F	5,396	5.5	25,363	25.8	18,888	19.3	0	0	49,648	50.5
		Subtotal	7,555	7.7	50,187	51.1	39,934	40.7	540	0.5	98,216	100.0
7/10/2011	180	M	11,545	10.0	35,277	30.6	33,994	29.4	0	0	80,816	70.0
7/9/2013		F	4,490	3.9	18,600	16.1	11,545	10.0	0	0	34,635	30.0
		Subtotal	16,035	13.9	53,877	46.7	45,539	39.4	0	0	115,451	100.0
7/16/2017	196	M	22,317	14.8	40,786	27.0	20,778	13.8	1,539	1.0	85,420	56.6
7/14/2019		F	20,008	13.3	27,704	18.4	17,700	11.7	0	0	65,412	43.4
		Subtotal	42,325	28.1	68,490	45.4	38,478	25.5	1,539	1.0	150,832	100
7/22/2023	189	M	31,056	22.2	26,620	19.1	17,007	12.2	0	0	74,683	53.4
7/20/2025		F	23,662	17.0	34,014	24.3	7,394	5.3	0	0	65,071	46.6
		Subtotal	54,718	39.2	60,634	43.4	24,401	17.5	0	0	139,754	100
7/28/2029	199	M	14,984	17.6	15,412	18.1	5,137	6.0	0	0	35,534	41.7
7/26/1931		F	26,116	30.6	16,697	19.6	6,850	8.1	0	0	49,662	58.3
		Subtotal	41,100	48.2	32,109	37.7	11,987	14.1	0	0	85,196	100
Season	1,130	M	82,974	12.3	156,157	23.2	133,113	19.8	2,079	0.3	374,323	55.6
		F	81,498	12.1	134,704	20.0	82,919	12.3	0	0	299,121	44.4
		Total	164,472	24.4	290,861	43.2	216,032	32.1	2,079	0.3	673,444	100

[a] Estimated escapement in numbers of fish.

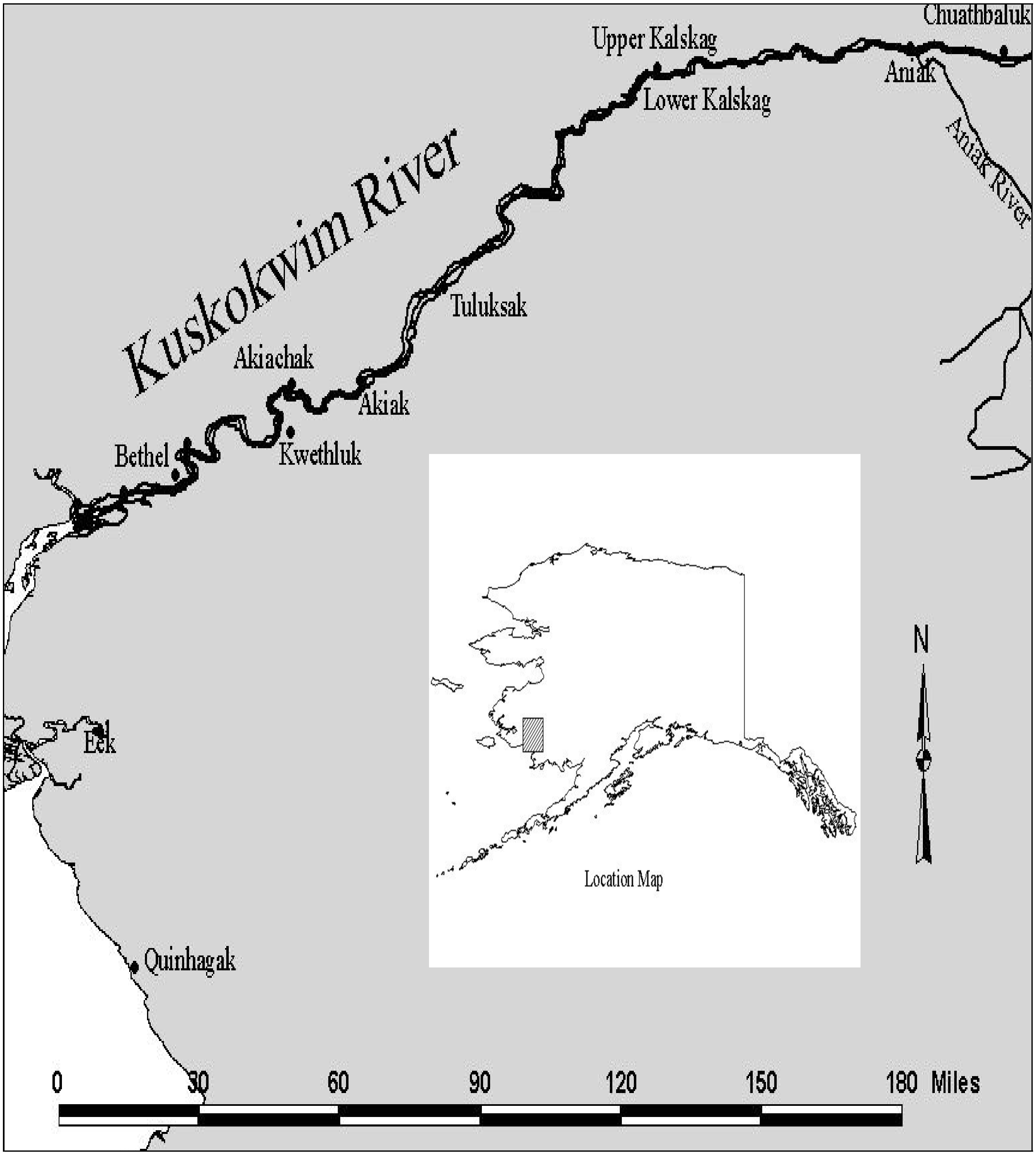

Figure 1.–Kuskokwim River Area.

Figure 2.–Location of Aniak River sonar site, 2004.

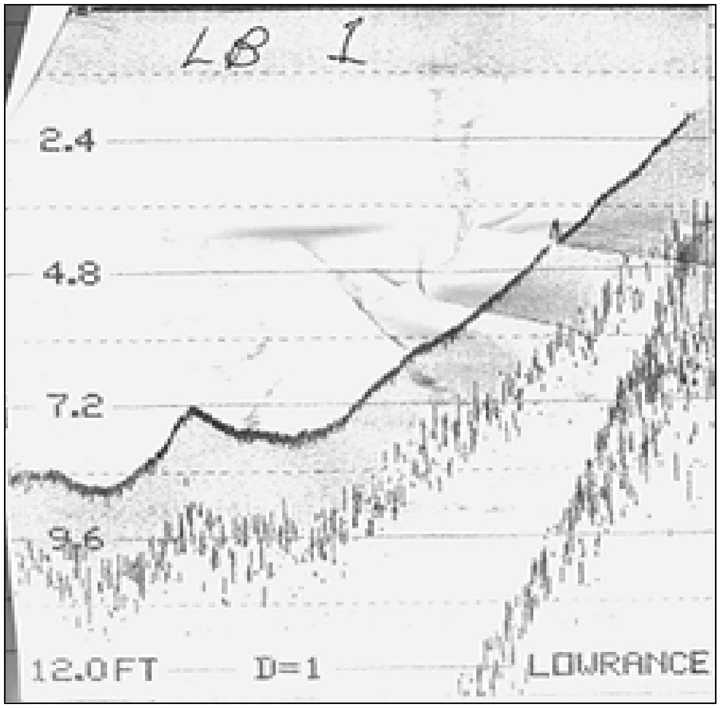

Figure 3.–Left bank bottom profile, Aniak River sonar, 2004.

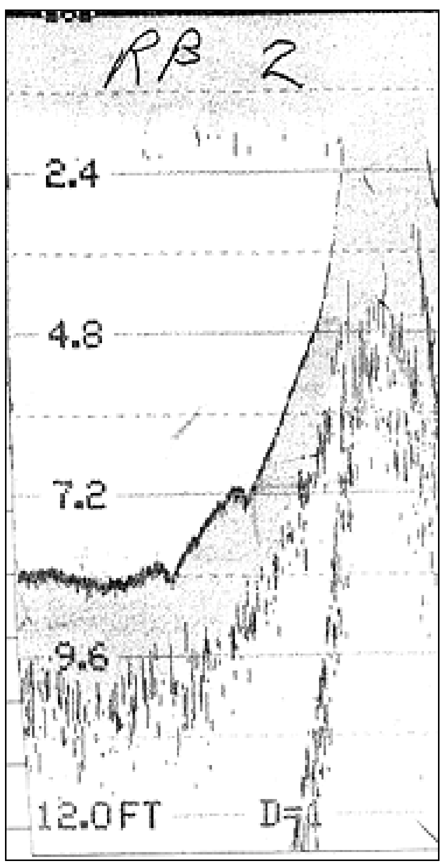

Figure 4.–Right bank bottom profile, Aniak River sonar, 2004.

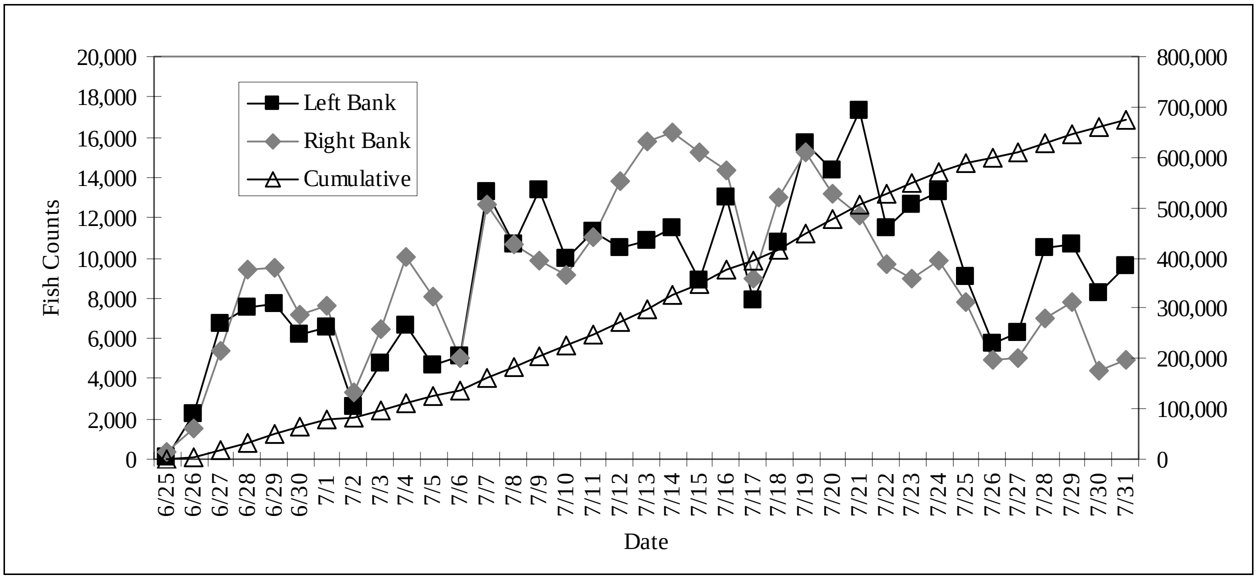

Figure 5.–Daily and cumulative passage estimates at Aniak River sonar, 2004.

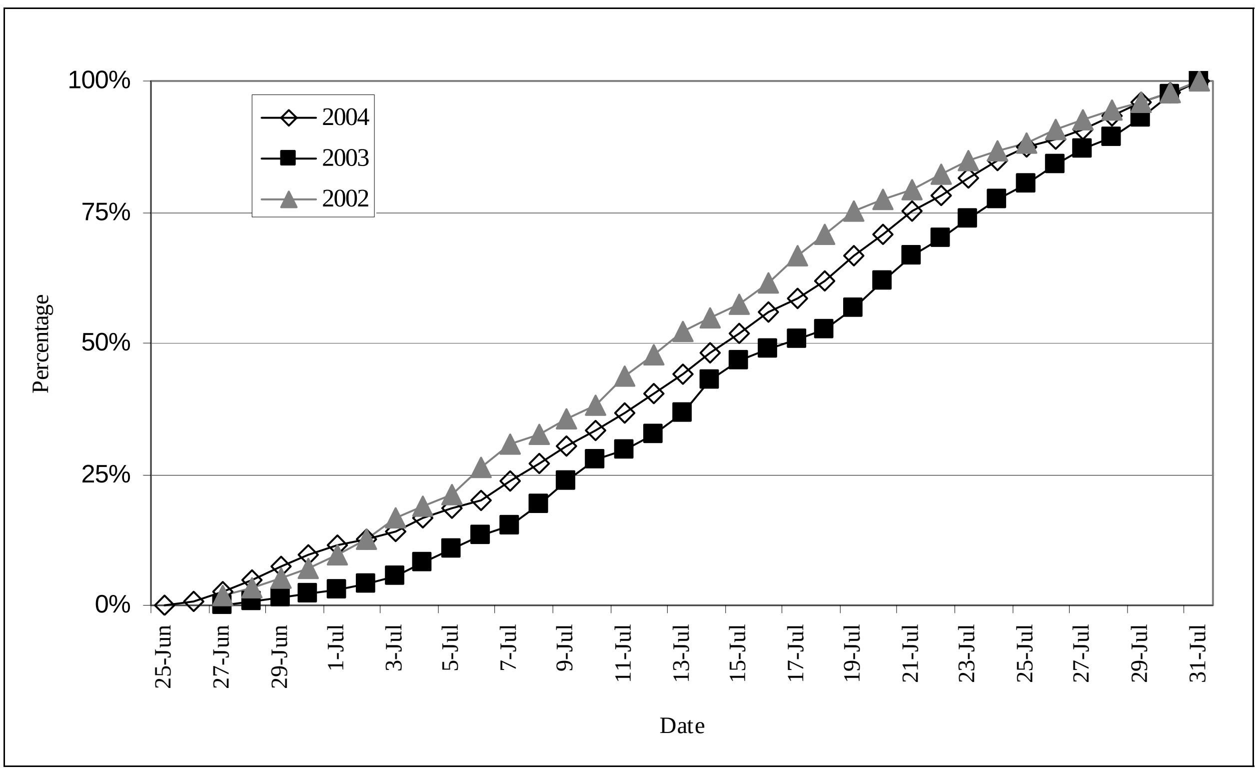

Figure 6.–Fish passage quartiles, Aniak River sonar, 2002–2004.

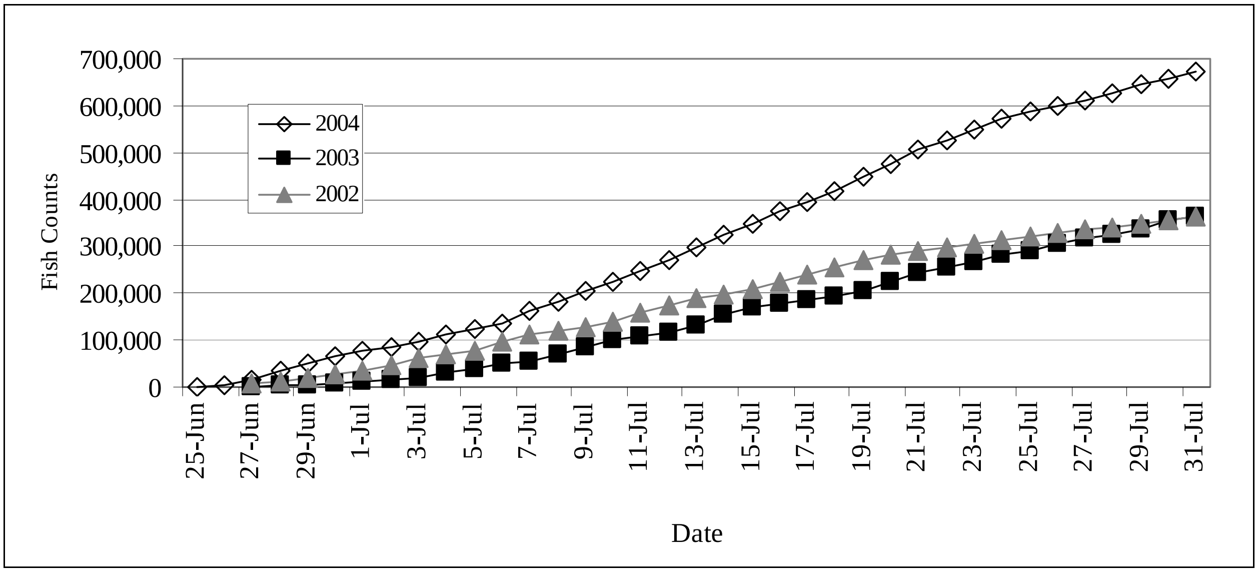

Figure 7.–Cumulative fish passage estimates, Aniak River sonar, 2002–2004.

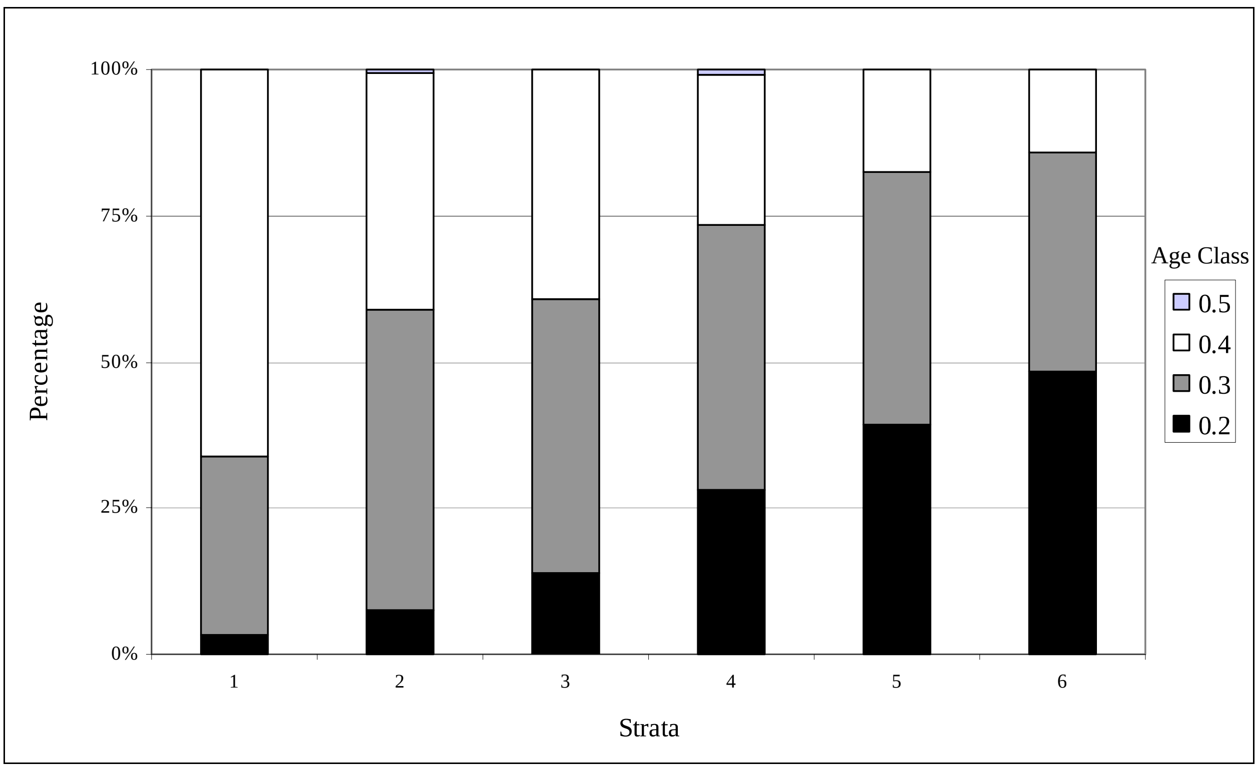

Figure 8.–Age composition of chum salmon, Aniak River sonar, 2004.

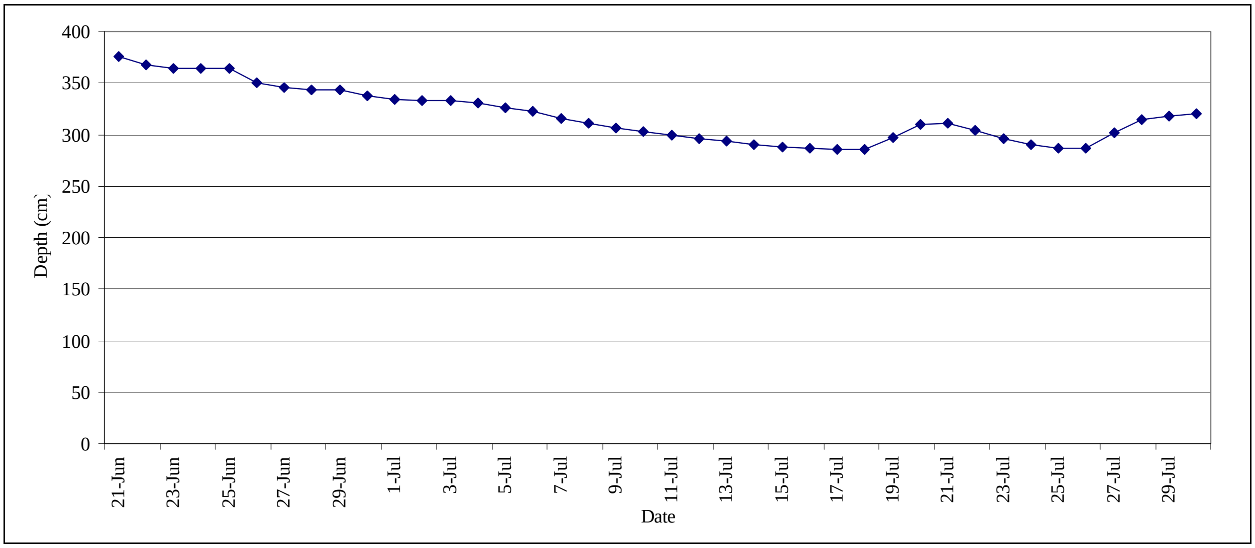

Figure 9.–Water level, Aniak River sonar 2004.

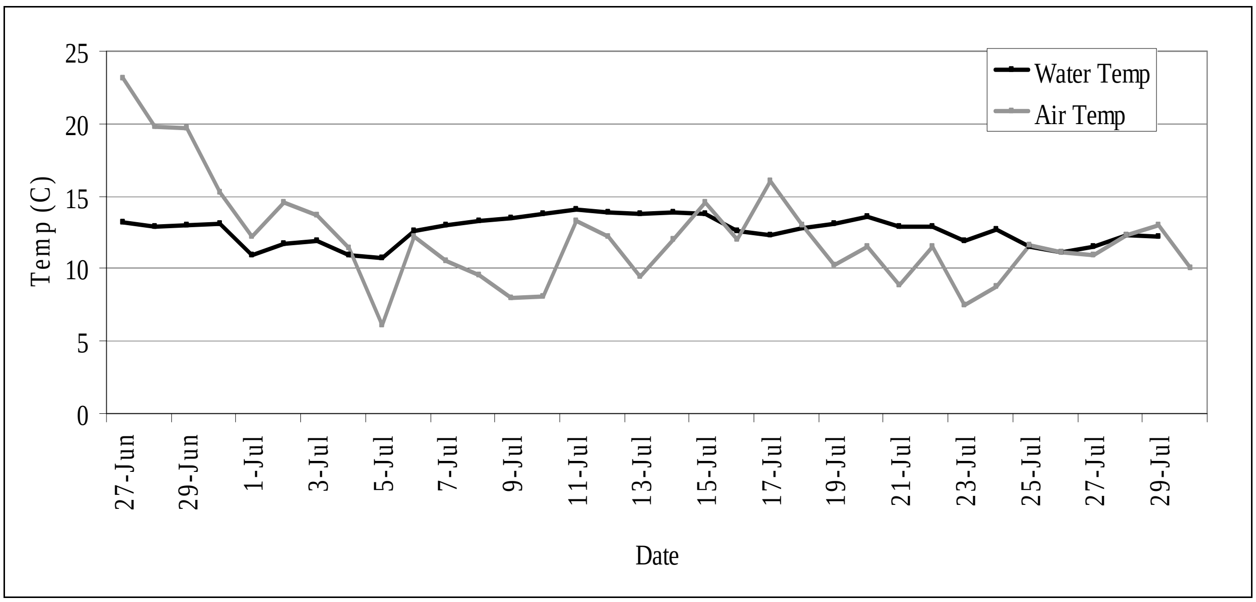

Figure 10.–Air and water temperatures, Aniak River sonar, 2004.

APPENDIX A. PROJECT HISTORY

Appendix A1.–Timetable of developmental changes of the Aniak River sonar project, 1980–2004.

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 insonified 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 crew
2002	• Sonar operations remain the same as years 1996–2001 • Species Apportionment Program operates for last season with similar methodology to 2001. This project will be discontinued in the future
2003	• Sonar operations undergo a significant sampling change • Instead of sampling both banks 24 hours per day, 3 4-hour periods were sampled on each bank • The total counts for both banks, for the 3 periods, were multiplied by 2 to provide the daily passage estimate • DIDSON sonar was tested at the site and efforts were underway to migrate from BioSonics to DIDSON • Switched over to DIDSON exclusively for both banks
2004	• Sampling continued same as last year