Fishery Data Series No. 06-32

Sonar Estimation of Chum Salmon Passage in the Aniak River, 2003

by

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and

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June 2006

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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June 2006

This investigation was funded through State of Alaska General Funds. The Association of Village Council Presidents (AVCP) provided the project with a technician.

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

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This document should be cited as:
Sandall, H. D. and C. T. Pfisterer. 2006. Sonar estimation of chum salmon passage in the Aniak River, 2003. Alaska Department of Fish and Game, Fishery Data Series No. 06-32, Anchorage.

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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 is in the process of migrating to a high frequency imaging sonar (DIDSON). This season, the project adopted a new sampling protocol 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 28 June through 31 July in 2003. During this period, an estimated 393,396 fish (SE 7,871) passed through the ensonified area. The peak passage of 23,208 fish occurred on 14 July and the 50% passage date occurred on 17-July. The escapement estimate was primarily comprised of age-0.3 fish (80.6%), while age -0.4 (17.9%), -0.5 (1.1%) and -0.2 (0.4%) classes were also present. Side-by-side comparisons of counts obtained with the BioSonics and DIDSON equipment suggest undercounting with the BioSonics at high densities.

Key words: Aniak River, chum salmon, DIDSON, hydroacoustic, sonar

INTRODUCTION

HISTORY

The Kuskokwim River subsistence and potential commercial salmon fishery in June and July are directed toward the harvest of chum salmon *Oncorhynchus keta* and Chinook salmon *O. tshawytscha*. Commercial chum salmon harvests in districts W-1 and W-2 from 1992 to 2001 averaged 234,629 while there was no commercial fishing for chum salmon in 2002 and 2003 due to depressed runs and difficulty in securing a buyer (Ward et al. 2003). From 1992 to 2001, an average 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 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 approximately 7 or 8 days (ADF&G 1961, 1962). Because of its proximity to the Kuskokwim River commercial and subsistence fisheries, the Aniak River sonar project can provide management 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 on the Aniak River, and visual observations of fish migration patterns reported for the Anvik River (Buklis 1981) lead to the assumption 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

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[1] The use of vendor names does not constitute product endorsement by ADF&G.

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 1980s, 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 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).

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; 1982 a, 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 renamed a biological escapement goal (BEG) (Buklis 1993).

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 ASL samples of chum salmon. The BEG of 250,000 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. Alaska Department of Fish and Game (ADF&G) implemented three, 4-hour sampling periods instead of sampling for 24 hours per day. This protocol provided similar estimates to the 24-hour counts (Appendix A1) and resulted in reduced crew size. A timetable of developmental changes for the sonar project is presented in Appendix D1.

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 of apportioning sonar counts on this river system, and the study was discontinued in 2003 (McEwen *In prep*).

OBJECTIVES

The primary objectives for the 2003 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 21 June through 31 July).
2. Provide daily estimates of fish passage to fishery managers in Bethel by 0800 hours the following morning.
3. Estimate age-sex-length (ASL) composition of the total chum salmon escapements to the Aniak River from a minimum of three pulses, sampled 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).

In addition to these primary objectives, ADF&G began testing a new DIDSON imaging sonar at this site by pursuing this list of objectives:

1. Perform a 1 to 3 year comparison of passage estimates generated by the imaging and dual-beam systems to determine what corrections will be necessary to allow using historical data in conjunction with the new imaging estimates for making management decisions.
2. Assess the ability of the imaging sonar to discern different species by determining what species can be separated, how well they can be differentiated, and over what ranges these differences can be distinguished.

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 DNR permit # 13916 (Figure 1). The main camp is situated at 61° 30.163’ N, 159° 22.464’ W. The Aniak River originates in the Aniak Lake basin approximately 145 km east and 32 km south of Bethel, Alaska. It flows north for nearly 129 km, where it joins the Kuskokwim River 1.6 km upstream from the community of Aniak.

The 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. 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 approximately 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

Sonar equipment for the right bank of the Aniak River included: 1) a BioSonics model 102 (SN 10-021) 120/420 kHz echosounder configured to transmit and receive at 420 kHz; 2) a 4°x15° BioSonics single beam 420 kHz elliptical transducer (SN 16-420-4x15-006); 3) a 152.4 m (500 ft) Belden model 8412 cable (SN 703A); and 4) a BioSonics model 111 (SN 111-89-053) thermal chart recorder. A Hewlett Packard model 54501A (SN 2930A11300) digital storage oscilloscope (DSO) was used to examine signals from both the left and right bank systems.

The crew mounted the right bank transducer on an aluminum tripod and remotely aimed it with a Remote Oceans Systems (R.O.S.) model PT-25 (SN 1064) air-filled, dual-axis rotator. The rotator movements were controlled with a 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. A set of digital panel meters provided horizontal and vertical position readings, accurate to within ± 0.3 degrees.

Left bank sonar equipment included: 1) a BioSonics model 101 (SN 101-034) 120/420 kHz echosounder configured to transmit and receive at 420 kHz; 2) a 3°x10° (SN 09-420-3x107x21-004) BioSonics dual beam 420 kHz elliptical transducer; 3) a 304.8 m (1000 ft) Belden model 8412 cable (SN 601K); and 4) a BioSonics model 111 (SN 111-89-053) thermal chart recorder.

The crew mounted the left bank transducer on an aluminum tripod and remotely aimed it with a R.O.S. model PT-25 (SN 214) oil-filled, dual-axis rotator. The left bank rotator movements were controlled with the same R.O.S. PTC-1 controller used for the right bank. All electronic equipment was housed in a 3.0 x 3.7 m (10 x 12 ft) portable wall tent on the right bank and powered by a single Honda model EM-3500 independently grounded generator. Left bank cables were attached to a 6.4 mm (1/4 in) steel cable suspended 3 m above the river. The cable bundle was marked with neon survey flagging to alert passing boats.

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 frequently to accommodate fluctuating water levels. The majority of the river was ensonified by using the right bank transducer to sample outwards 15–20 m and the left bank transducer to sample 40–50 m.

Partial weirs were erected perpendicular to the current and extended from the shore out 1–3 m beyond the transducers (Figure 2). These devices moved the chum salmon, Chinook salmon, and other large fish offshore and in front of the transducers to prevent the 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, non-target species.

Bottom Profiles and Stream Measurements

The crew performed numerous bottom profile surveys of both banks with a chart recording fathometer. These charts were used to select the best deployment site and to verify that the site was stable throughout the season. The left bank gradient was fairly shallow and constant (Figure 3), whereas the right bank had a steep gradient from shore to the thalweg (Figure 4) that measured approximately 3 m deep and was located closer to the right bank than left bank. 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 16 June and ended on 2 August 2003. Hydroacoustic sampling began at 0001 hours on 28 June on both banks and ran every day until 2000 hours on 31 July. The water level was the limiting factor for starting counts. The water must be low enough to deploy the partial weirs and to reveal an acceptable bottom profile for aiming the sonar. Passage estimates were available to fishery managers in Bethel at 0730 hours daily.

We conducted single beam acoustic sampling 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 previous seasons when sampling occurred 24 hours per day. Inseason analysis consisted of visually scanning the echograms for fish traces and anomalous detections to verify consistent aim. A single fisheries technician operated and monitored equipment at the sonar site. Crewmembers identified and tallied fish traces on chart recordings while rotating through shifts of 0000–0400, 0800–1200, and 1600–2000 hours. For consistency, crewmembers 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 within range intervals over 15-minute periods and recorded onto forms. Range intervals were 2–5 m wide on the right bank and 5–10 m wide on the left bank. Completed data forms were transported to the main camp throughout the day and entered into a spreadsheet by the project leader. Daily estimates were transmitted via single side band radio or satellite phone to area managers in Bethel at 0730 hours the following morning. Chart recorder output constituted the only record of detected echoes and fish passage. Chart recordings were annotated for date, time, and bank, and subsequently catalogued for storage.

We 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 echosounders at a center frequency of 420 kHz. We applied a 40 log (R) time-varied gain (TVG) function and a 5 kHz frequency bandwidth filter for all data on both banks. On both banks, the transmit pulse width was set to 0.4 ms and the transmit power setting was –6 dB. The right bank sampling range was 16–20 m and the left bank sampling range varied from 30–40 m. The right bank chart recorder paper speed was set at 1/16 mm/ping and the left bank was set at 1/8 mm/ping. Three printer thresholds, corresponding to receive signal intensities, were factory set in 6 dB intervals. The three grey levels make it possible to determine relative signal amplitude over the 18 dB range. Chart recorder thresholds were set at -40, -34, and -28 dB during all sampling activities. The lowest threshold was approximately 10 dB than the theoretical on-axis target strength of a chum salmon (length 450 mm), calculated using Love's equation (Love 1977). Lowering the threshold by 10 dB allows for detection across the nominal beam width (6 dB) and variability (~4 dB) induced by fish aspect and noise corruption. Both banks' thresholds remained unchanged throughout the season. Thresholds were calculated as follows:

$$TS_{dB} = V_o - SL - G_X - G_R - 2B\theta \tag{1}$$

where:

TS_{dB} = target strength in dB

V_o = Volts out in dB

SL = transmitted source level in dB

G_X = through-system gain in dB

G_R = receiver gain in dB

$2B\theta$ = two-way beam pattern factor in dB

Attenuation (α) was assumed to be negligible at the ensonification ranges sampled.

ANALYTICAL METHODS

Abundance Estimation

The reported sonar estimates are calculated using an Excel spreadsheet. The raw counts are entered into the worksheet in 15-minute blocks for each spatial strata ensonified, and then summed for each bank to represent 12 hours of sampling. Those counts were multiplied by 2 to give the daily passage estimate by bank. These estimates are assumed to represent all fish passing the sonar site.

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

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

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). 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. r_{dzp} is calculated as:

$$r_{dzp} = \frac{\sum_{s=1}^{16} y_{dzps}}{4} \tag{3}$$

Finally, since the passage estimates are assumed independent between zones and among days, the total variance was estimated as the sum of the variances:

$$\hat{V}ar(\hat{y}) = \sum_{d}\sum_{z}\hat{V}ar(\hat{y}_{dz}) \tag{4}$$

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. We used different methodologies to make up for these incomplete counts depending on the amount of time that was missed.

If more than five minutes were missed at the beginning of a shift, we lengthened the shift by the amount of time that was missed. If less than five 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, we 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 we could choose an interpolation routine 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. We also took into account the other bank's trends for the same time period and sometimes used this data in our regression to estimate the missing data.

On rare occasions, more than 30 minutes were missed in the middle of a shift. In these instances, we 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 other banks from the sonar camp was used as the sampling site. This bar has been used intermittently for the last few years, but was used exclusively in 2003. The crew fished a 3 x 46 m (10 x 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 it in the stern of a skiff. The opposite end of the seine was attached to a pulley designed to pivot from the side of the skiff to the stern. As the skiff moved offshore, orientated upstream, the end of the 30 m lead was held in place by a crewmember on shore. The skiff was 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, keying on the development of the kype, roundness of the belly, and the presence or absence of an ovipositor. Length was measured to the nearest five millimeter step from mideye to tail fork. All measurements were recorded in a "rite-in-the-rain" notebook and later transcribed to standard mark-sense forms.

We 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 200 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 two 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 two digits plus one.

To estimate the age and sex composition of the 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 the 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 two or three times per day corresponding to the sonar shifts. Water temperature and conductivity was sampled in the middle of the river using a digital multi-purpose 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 two more times and averaging the results to produce the recorded depth. At the main camp, the air temperature was recorded several times each day using a thermometer, and general wind direction was noted.

We used a staff gauge to note water level. The previous benchmark used prior to 2002 degraded and became unusable. Consequently, only readings from 2002 and 2003 are comparable.

DIDSON VS BIOSONICS COMPARISON

Equipment

One DIDSON unit (SN 24) was deployed at the Aniak Sonar site. This sonar operated at one of two frequencies, 1 MHz or 1.8 MHz, and was set automatically by the software depending upon range requirements. At ranges less than 10 m, the DIDSON operated at 1.8 MHz and at ranges greater than 10m it operated at 1 MHz.

We mounted the DIDSON on an aluminum tripod and remotely aimed it with rotators manufactured by Hydroacoustic Technologies Inc. allowing movement in two axes. We controlled rotator movements with a 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. The rotator controller provided horizontal and vertical position readings, accurate to within ± 0.3 degrees.

The sonar was controlled by DIDSON software loaded on a Dell laptop. A 152.4 m long DIDSON cable carried power and data between a “breakout box” and the DIDSON unit in the water. Ethernet cabling routed data between the breakout box and the laptop. All data was archived on recordable DVDs.

Sampling

Sampling was conducted on both banks and targeted representative passage rates for each bank. We monitored the passage rates by examining the BioSonics charts and moving the DIDSON unit to the bank that was displaying the desired passage. Generally, the DIDSON was left on one bank for several days, and paired 15-minute samples were collected over those time periods, and then expanded to obtain hourly passage rates.

The accuracy of length measurements made using a DIDSON was examined by tethering fish of various species and lengths. Fish were positioned at 5, 9 and 12 m with data collected using window lengths of 10 and 20 m.

Analysis

Paired hourly passage rates obtained using the BioSonics and DIDSON equipment were compared using standard linear regression techniques (Mendenhall and Sincich 1996). The data were transformed using the natural logarithm to correct for unequal variability in the residuals. The results of this relationship will be used to compare future data collected with the DIDSON to the historical data from the project.

Operator effects were examined by comparing the full model (with operators) against the reduced model using the *anova* function in the statistical software package R (R Development Core Team 2004). The operator effect will not be applied to historical data since this analysis is specific only to the operators present this season. Although this effect will not be applied to historical data, the information helps to better understand potential sources of variability. For each bank, the full model was:

$$\ln(D) = \beta_0 + \beta_1 \ln(B) + \beta_2 O_1 + \beta_3 O_2 \tag{5}$$

The reduced model was:

$$\ln(D) = \beta_0 + \beta_1 \ln(B) \tag{6}$$

Which simplifies to:

$$D = e^{\beta_0} B^{\beta_1} \tag{7}$$

Where *B* is the BioSonics count, *D* is the DIDSON count, the β terms are the fitted coefficients, and O_1 and O_2 are the categorical variables denoting two of the three operators.

RESULTS

FISH PASSAGE ESTIMATES

Although past drift gillnetting at the site has shown the vast majority of the fish passing the site to be chum salmon (Lieb 2002), we recognize other species are also present and therefore report passage estimates as total fish, not exclusively chum salmon. The 2003 season's estimated fish passage of 363,396 (se = 7,871) counts included 51% of the fish passing on the right bank and 49% passing on the left bank (Table 1). This passage estimate represents a record since the project reorganized operations in 1996 and is the fifth highest since the project's inception in 1980 (Figure 5). Figure 6 shows the daily passage rates by bank along with the cumulative season estimate. The peak total daily passage of 23,208 counts occurred on 14 July (Table 1) and represented record daily passage since the project was redesigned in 1996. The 25%, 50%, and 75% quartile dates of passage were 10 July, 17 July, and 24 July respectively (Figure 7).

The passage estimate for 2003 was similar to 2002, although the 2003 run timing lagged a few days behind 2002. Both the 2002 and 2003 runs were earlier than previous years (Figure 8). All targets on the right bank, and 92% of targets on left bank were detected within 20 m of the transducer (Figure 9).

MISSING DATA

A total of 4.2 hours (1.0%) on the left bank and 2.9 hours (0.7 %) on the right bank of sampling time were missed because of maintenance, paper jams, system diagnostic tests, moving the tripod, or aiming the transducer to compensate for changing water levels throughout the season.

ASL SAMPLING

We made a total of 41 beach seine sets and obtained 1120 ASL samples from migrating chum salmon. Out of those samples, 930 scale samples were analyzed post season with 80.6% falling in the 0.3 age class, 17.9% comprising the 0.4 age class, 1.1 % were in the 0.5 age class, with the remaining 0.4% in the 0.2 age class (Table 2; Figure 10). The age-0.4 fish came in strong at the beginning of the run and then tapered off as the age-0.3 fish came in stronger in the second half of the run. The age-0.2 and -0.5 fish remained at low levels throughout the season.

ENVIRONMENTAL INFORMATION

Water levels fluctuated over a range of approximately 1.3 m during the season (Figure 11). A high water event occurred during the first week of July that caused high debris loads in the river. The lowest levels came toward the end of July before rebounding prior to dismantling camp.

Water temperatures varied from 11° C to 22° C over the course of the operational period (Figure 12). Water temperature generally increased over the season reaching a high of 21.9° C on 22 July before plunging to a low of 11.5° C on 24 July. Daily air temperatures fluctuated between a minimum of 0.7° C and a maximum of 28.8° C over the operational period of the project (Figure 13).

DIDSON VS BIOSONICS COMPARISON

Sampling was conducted from 5 July through 28 July and a total of 117.75 hours of paired BioSonics and DIDSON data was collected. This data included 266, 15-minute samples for the left bank, and 205, 15-minute samples for the right bank. Of these samples, 42 were chosen for the left bank and 28 for the right bank for analysis. The samples were chosen to enable comparison across as broad a range of counts as possible while spanning a large period of operation. It was important to span the period of operation to account for changes in water level and aim across the season.

Fifteen minute BioSonics and DIDSON counts, expanded to hourly rate, were compared over the same time periods on both the right and left banks (Figure 14). The natural logarithm transformation alleviated the heterogeneity as evidenced by the residual plots (Figure 15). Both banks showed a significant correlation between the counts derived from the different equipment at $p<0.001$. In addition, the slopes of the least squares regressions for the 2 banks were significantly different from each other ($p<0.05$). The simplified model fit for the left bank was $DIDSON=0.603BioSonics^{1.115}$ (adjusted $R^2=0.896$) and for the right bank it was $DIDSON=0.614BioSonics^{1.145}$ (adjusted $R^2=0.852$).

The effect of the operator on marking the BioSonics charts was significant on the left bank ($p<0.001$, adjusted $R^2=0.942$) while there was no evidence of operator effect on the right bank (Tables 3 and 4). Figure 16 shows the natural logarithm of the BioSonics counts versus the natural logarithm of the DIDSON counts by operator of the BioSonics equipment. Also shown on the graph are the fitted values for the full models that include operator effects.

For the length measurement investigation, a total of 15 fish were tethered with the following breakdown by species: 7 chum salmon, 5 suckers *Catostomus* sp., 2 Dolly Varden *Salvelinus malma* and 1 whitefish *Coregonus* sp. Analysis of this data will be reported in a future document.

DISCUSSION

FISH PASSAGE ESTIMATES

Sampling Procedures

In 2003, the sampling schedule was changed from 24-hour counts to 12-hour counts separated into three 4-hour shifts. This sampling scheme worked well, resulting in reduced crew size and other operational savings. We feel the low coefficient of variation for the season (2.2%) was an acceptable trade-off for the benefits provided. The analysis of the efficacy of this sampling change is presented in Appendix A1.

Fish Passage Estimates

The chum salmon run on the Aniak exhibited average characteristics this season although the overall passage was higher this year than in any other year since 1996. However, the small difference between total passage for 2003 and 2002 is insignificant when taking into account the sampling change and associated variability in estimates for 2003. The 2003 run timing was about average, and the cumulative counts increased steadily throughout the season.

Similar to 2002, the 2003 daily passage followed a rough sinusoidal pattern with peaks separated in time by 4 or 5 days (Figure 6). At this time, there is no explanation for this feature, but it will be interesting to examine future year's counts for this behavior and to note any major changes in the fishery.

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. In 2003, the right bank morphology changed considerably, which may have played a role in the uncommonly even distribution of fish between banks.

The distribution of fish by range was similar to previous years, with the majority of fish passing within 20 m of each bank.

ASL SAMPLING

The techniques used to obtain ASL samples were designed to maximize the capture of chum salmon with the equipment available. The beach seine sampling area is located approximately 2.5 km upstream of the sonar site. In previous years, beach seining was conducted off the gravel bar directly in front of the main camp. In 2003, we conducted all beach seining activities on the left bank gravel bar directly upstream of the main camp. This gravel bar provided a better drift of the net, had fewer snags, and helped to produce more efficient sampling.

As in past years, this 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 Sonar beach seining 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.

The age distribution of the catch in 2003 did not exhibit any anomalies. The 2003 catch was similar to 2002 in that the age-0.3 and 0.4 fish made up 98.5% of the run (80.6% and 17.9% respectively). The age-0.2 and -0.5 fish made up the other 1.5% of the run (0.4% and 1.1% respectively). The age-0.3 fish were the dominant age class for the entire run except at the end of June when the age-0.4 class made up 54.5% of the run. 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

The right bank gravel bar morphology change was the most significant environmental feature in 2003. The shift in structure affected the flow of water past the right bank and likely impacted the path that fish traveled. In addition, the bottom profile was different than in past years and made it more difficult to achieve an acceptable aim.

Air and water temperatures were moderate and the overall weather was pleasant, which helped to prevent problems with data collection. Water levels prevented installation of the sonar until late June, although data collection began on a date close to the historical average startup date for this site. In the future, DIDSON equipment may allow an even earlier start. A high water event in early July caused several moves of the sonar equipment, and almost forced temporary removal of the equipment.

DIDSON VS BIOSONICS COMPARISON

The discrepancy between the BioSonics and DIDSON estimates is due in part to two primary sources of error, termed “Aiming Error” and “Counting Error”. Aiming error involves inconsistency in BioSonics aiming because of different sonar operators and changing river bottom profiles across years. Each time a variable changes, the BioSonics may do a better or worse job at ensonifying the whole water column. Even if the aim is deemed acceptable, it may not do a perfect job at seeing over small ridges or into shallow pits. Fish traveling in these small features can be missed by the BioSonics equipment. This source of error is quite variable as the river bottom is in constant flux and sonar operators change within and across seasons. This error is much reduced (although still present) for DIDSON since the imaging allows the beam to be aimed closer to the bottom to better detect fish. The DIDSON is deployed in a similar manner as the BioSonics, however, even with a very low aim, the bottom remains distinct (although visible) from migrating fish in the video. In addition, the 12° vertical beam of the DIDSON allows it to be aimed closer to the bottom without compromising vertical coverage.

Counting error arises from differing fish densities, different sonar setting, and technician counting idiosyncrasies. At high fish passage, it is difficult to identify and separate individual fish on the BioSonics charts due to slow ping rates and paper speeds. This leads to a density dependent bias in the BioSonics counts. In one particular instance, 4 fish were counted in a group of fish on the BioSonics chart (Figure 17) while the DIDSON video showed 14 fish actually passing. We believe this was the primary cause of the differences observed. Another source of counting error is differences in interpretation of the charts between operators. Although this affect was negligible on the right bank, it was significant on the left bank. There were insufficient resources to study this effect in detail but it is clear this must be considered for a complete understanding of the counting error.

Maxwell and Gove (2004) observed a similar disparity between split-beam and DIDSON counts. They noted a range dependant bias in the split-beam counts that they attributed to signal degradation at high densities. In our study, we were simply unable to separate densely packed fish as they blended together on the chart.

It is difficult to determine the exact cause of the overall disparity between the DIDSON and BioSonics counts. This project was not designed, nor do we have the resources, to fully ascertain the exact cause; rather, the goal was to gain an understanding about how estimates generated by the new equipment compare with historical estimates. Because of the consistency of the data acquisition settings across years, the relationship between the counts observed this season is likely a reasonable representation of what would have been observed in past seasons and will be used to make cross-year comparisons in the future.

CONCLUSION

Operations at the Aniak River sonar project went smoothly in 2003. Passage estimates were relayed to managers daily and the sample size objectives of the ASL sampling were met. Passage at the site was comparable to 2002 and exceeded the BEG for the project. The newly implemented sampling scheme has led to more streamlined operations and will allow for reduced project expenses in the future.

The DIDSON sonar worked very well at this project and will be the ideal choice to replace the aging BioSonics dual-beam equipment. The estimates produced by the imaging sonar do not appear to have the same density limitations and we believe more accurately reflect the true passage. Escapement goals for the Aniak River will need to be reexamined in light of this difference but ultimately the transition should prove beneficial to the management of the Aniak River chum salmon stocks. We are still hopeful that the DIDSON will provide at least limited species separation based on length and the results of this work will be published once the analysis is complete.

ACKNOWLEDGEMENTS

The authors wish to thank the seasonal ADF&G staff of Brian Lathem, Naomi Brodersen, and Ian Dixen, along with Dana Diehl of the Association of Village Council Presidents, for the collection of the data. The Kuskokwim Native Association and Dave Cannon provided invaluable logistical assistance in Aniak.

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TABLES AND FIGURES

Table 1.–Daily fish passage estimates, Aniak River Sonar, 2003.

Date	Left Bank	Right Bank	Daily Total	Cumulative Total	LB % Passage	RB % Passage
6/28	1,340	1,528	2,868	2,868	47	53
6/29	1,206	1,610	2,816	5,684	43	57
6/30	868	990	1,858	7,542	47	53
7/01	1,244	1,864	3,108	10,650	40	60
7/02	1,740	1,846	3,586	14,236	49	51
7/03	2,232	3,054	5,286	19,522	42	58
7/04	4,204	5,524	9,728	29,250	43	57
7/05	4,246	5,294	9,540	38,790	45	55
7/06	3,762	6,006	9,768	48,558	39	61
7/07	2,700	4,446	7,146	55,704	38	62
7/08	6,886	7,064	13,950	69,654	49	51
7/09	6,868	9,632	16,500	86,154	42	58
7/10 [a]	5,556	9,176	14,732	100,886	38	62
7/11	3,314	3,706	7,020	107,906	47	53
7/12	5,420	4,460	9,880	117,786	55	45
7/13	8,342	7,152	15,494	133,280	54	46
7/14	11,544	11,664	23,208	156,488	50	50
7/15	6,150	6,596	12,746	169,234	48	52
7/16	3,946	3,834	7,780	177,014	51	49
7/17 [a]	3,962	3,844	7,806	184,820	51	49
7/18	3,836	3,032	6,868	191,688	56	44
7/19	8,872	5,816	14,688	206,376	60	40
7/20	10,972	6,924	17,896	224,272	61	39
7/21	9,370	8,580	17,950	242,222	52	48
7/22	7,128	5,070	12,198	254,420	58	42
7/23	7,830	6,184	14,014	268,434	56	44
7/24 [a]	7,110	6,280	13,390	281,824	53	47
7/25	6,028	4,092	10,120	291,944	60	40
7/26	7,380	6,464	13,844	305,788	53	47
7/27	5,674	4,414	10,088	315,876	56	44
7/28	4,804	3,042	7,846	323,722	61	39
7/29	7,062	6,620	13,682	337,404	52	48
7/30	7,844	9,358	17,202	354,606	46	54
7/31	5,062	3,728	8,790	363,396	58	42
Season Totals	184,502	178,894	363,396			

[a] Quartiles of the cumulative total.

Table 2.–Age and sex composition of chum salmon, Aniak River Sonar, 2003.

			Age Class									
			0.2		0.3		0.4		0.5		Total	
2003 Sample Date (strata)	Sample Size		No. Estimated	%	No. Estimated	%	No. Estimated	%	No. Estimated	%		
June 25, 27, 28	55	M	0	0	2,331	30.9	2,743	36.3	0	0	5,074	67.3
(6/28-30)		F	0	0	1,097	14.6	1,371	18.2	0	0	2,468	32.7
		Subtotal	0	0	3,428	45.5	4,114	54.5	0	0	7,542	100
July 2-4	141	M	291	0.7	13,381	32.6	8,727	21.3	1,164	2.8	23,562	57.4
(7/1-6)		F	0	0	11,927	29.1	5,527	13.5	0	0	17,454	42.6
		Subtotal	291	0.7	25,308	61.7	14,254	34.8	1,164	2.8	41,016	100
July 8,9	243	M	0	0	29,628	42.8	12,535	18.1	855	1.3	43,018	62.1
(7/7-12)		F	570	0.8	17,948	25.9	6,837	9.9	854	1.2	26,210	37.9
		Subtotal	570	0.8	47,576	68.7	19,372	28	1,709	2.5	69,228	100
14-Jul	146	M	459	0.7	26,171	39	5,051	7.5	0	0	31,680	47.3
(7/13-17)		F	0	0	30,762	45.9	4,132	6.2	459	0.7	35,354	52.7
		Subtotal	459	0.7	56,933	84.9	9,183	13.7	459	0.7	67,034	100
20-Jul-21	180	M	0	0	35,568	36.7	3,772	3.9	0	0	39,341	40.6
(7/18-24)		F	0	0	49,041	50.5	8,084	8.3	539	0.6	57,663	59.4
		Subtotal	0	0	84,609	87.2	11,856	12.2	539	0.6	97,004	100
26-Jul-27	165	M	0	0	32,629	40	2,966	3.6	0	0	35,595	43.6
(7/25-31)		F	0	0	42,516	52.1	3,461	4.3	0	0	45,977	56.4
		Subtotal	0	0	75,145	92.1	6,427	7.9	0	0	81,572	100
Season	930	M	750	0.2	139,709	38.4	35,794	9.8	2,018	0.6	178,270	49.1
		F	570	0.2	153,291	42.2	29,412	8.1	1,853	0.5	185,126	50.9
		Total	1,320	0.4	293,000	80.6	65,206	17.9	3,871	1.1	363,396	100

Table 3.–Deviance table testing the significance of operator effects on the left bank.

	Res DF	RSS	DF	Sum of Sq	F Statistic	Pr(>F)
Model 1	25	0.771				
Model 2	23	0.332	2	0.439	15.212	6.18E-05

Model 1: ln(DIDSON) = ln(BioSonics)+B
Model 2: ln(DIDSON) = ln(BioSonics)+O1+O2+B

Table 4.–Deviance table testing the significance of operator effects on the right bank.

	Res DF	RSS	DF	Sum of Sq	F Statistic	Pr(>F)
Model 1	26	1.267				
Model 2	24	1.097	2	0.170	1.855	0.178

Model 1: ln(DIDSON) = ln(BioSonics)+B
Model 2: ln(DIDSON) = ln(BioSonics)+O1+O2+B

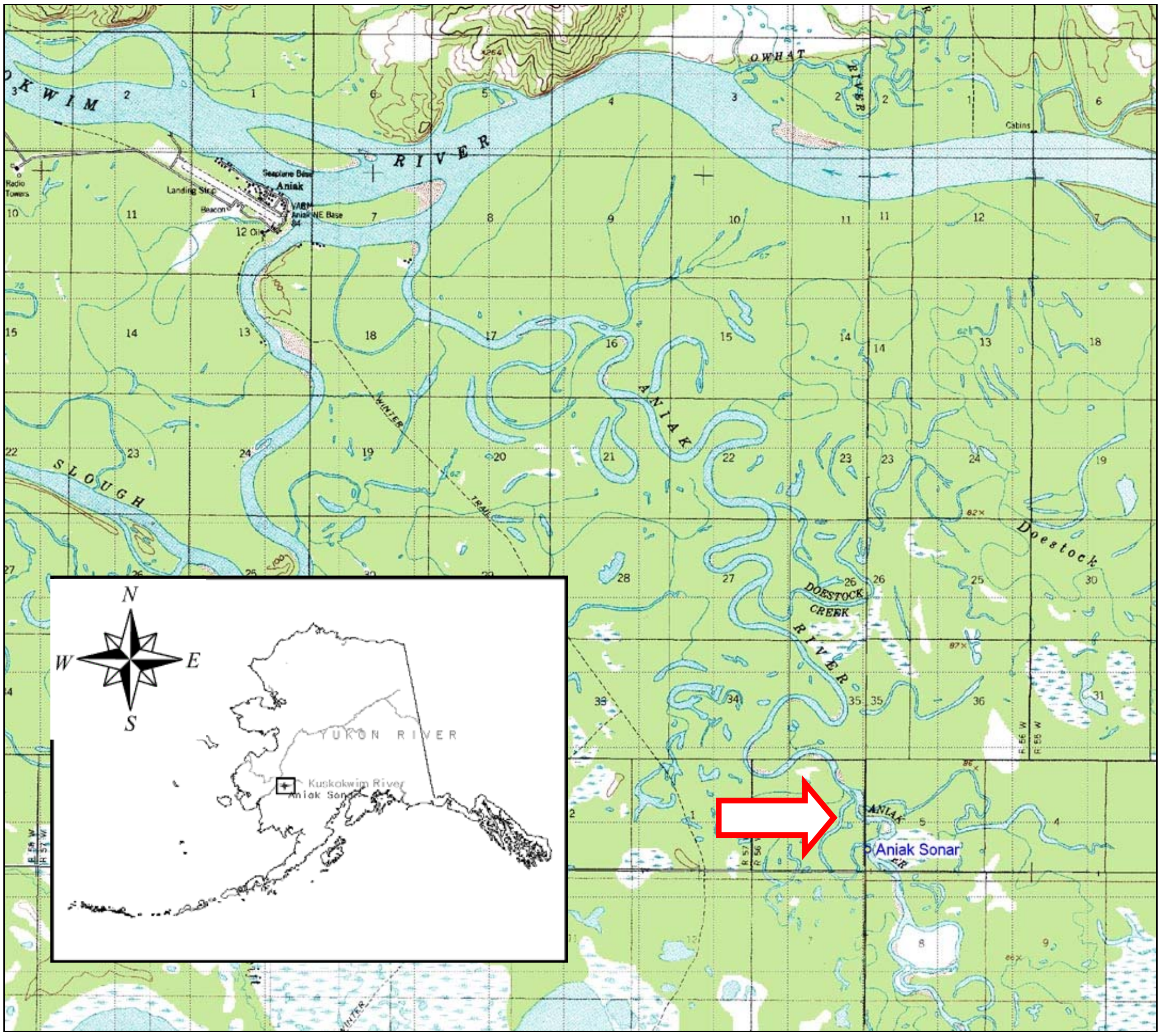


Figure 1.–Location of the Aniak River Sonar site, 2003.

Figure 2.–Aniak River Sonar site, 2003.

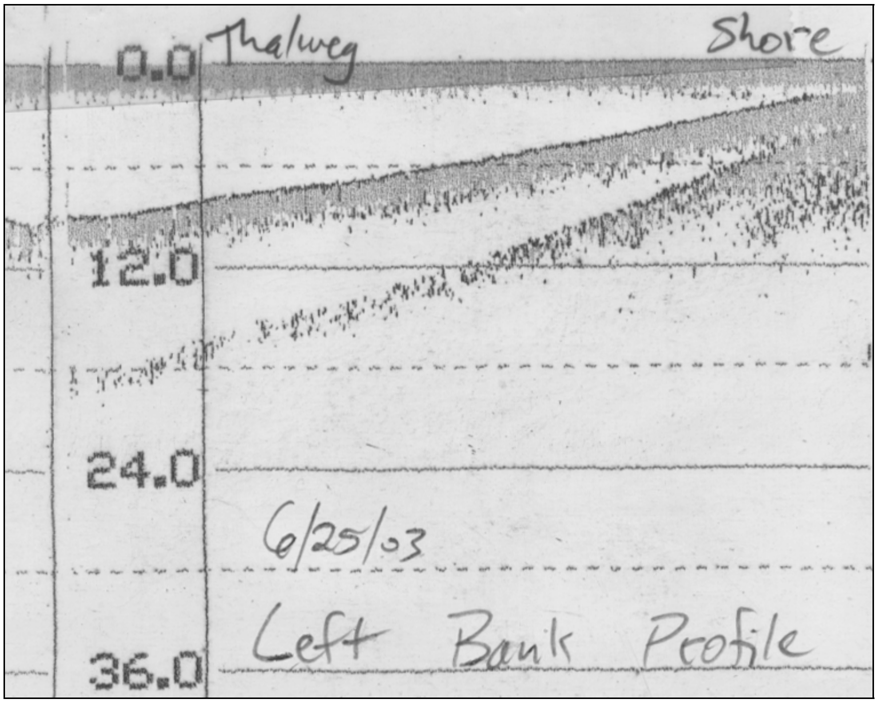


Figure 3.–Left bank bottom profile, Aniak River Sonar, 2003.

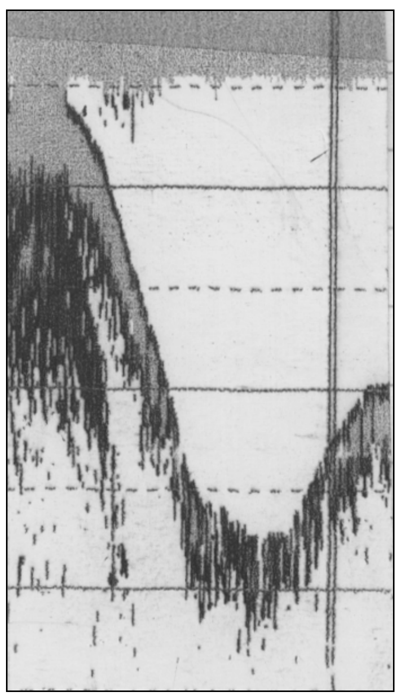


Figure 4.–Right bank bottom profile, Aniak River Sonar, 2003.

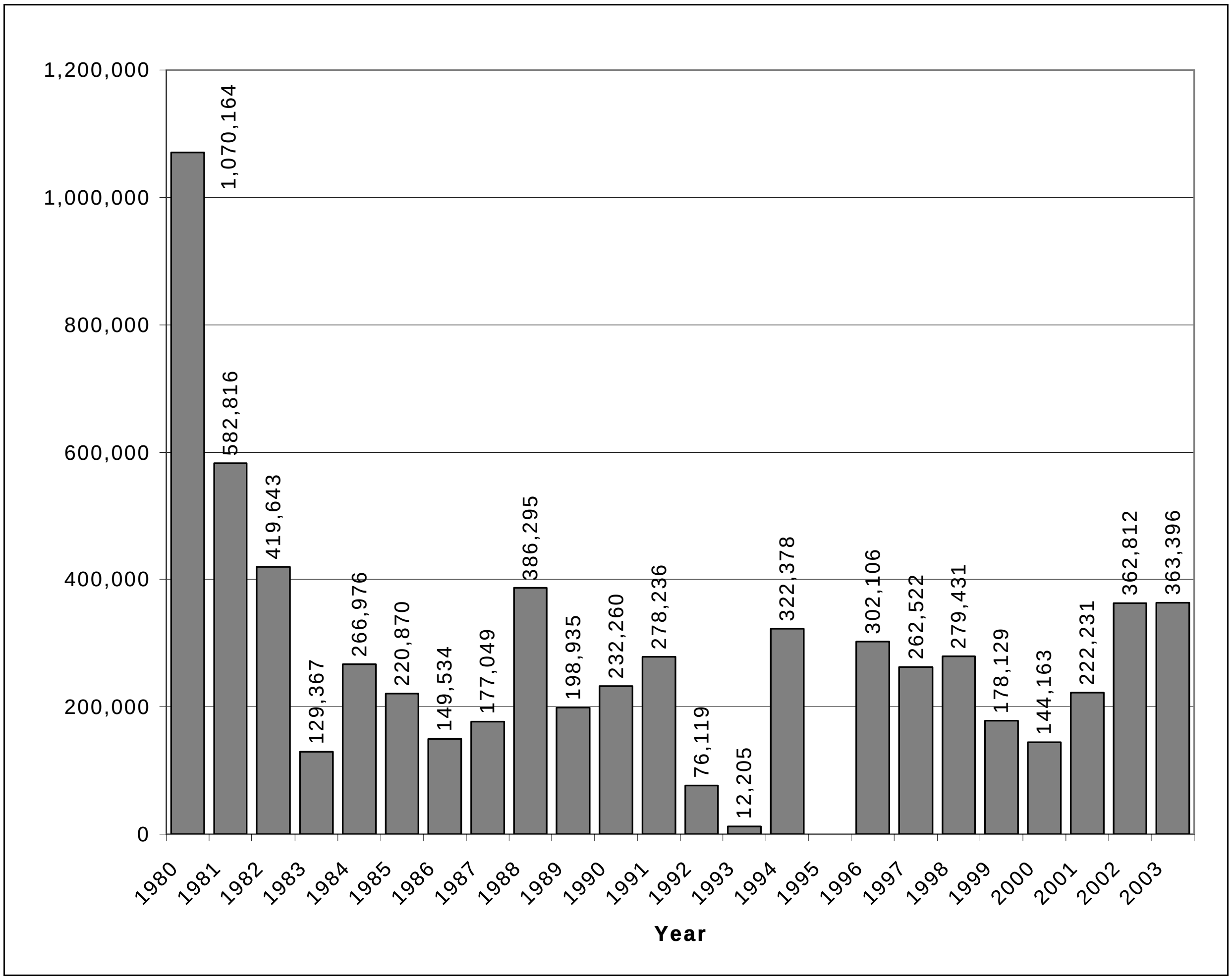


Figure 5.–Historical passage estimates for the Aniak River sonar project, 1980–2003.

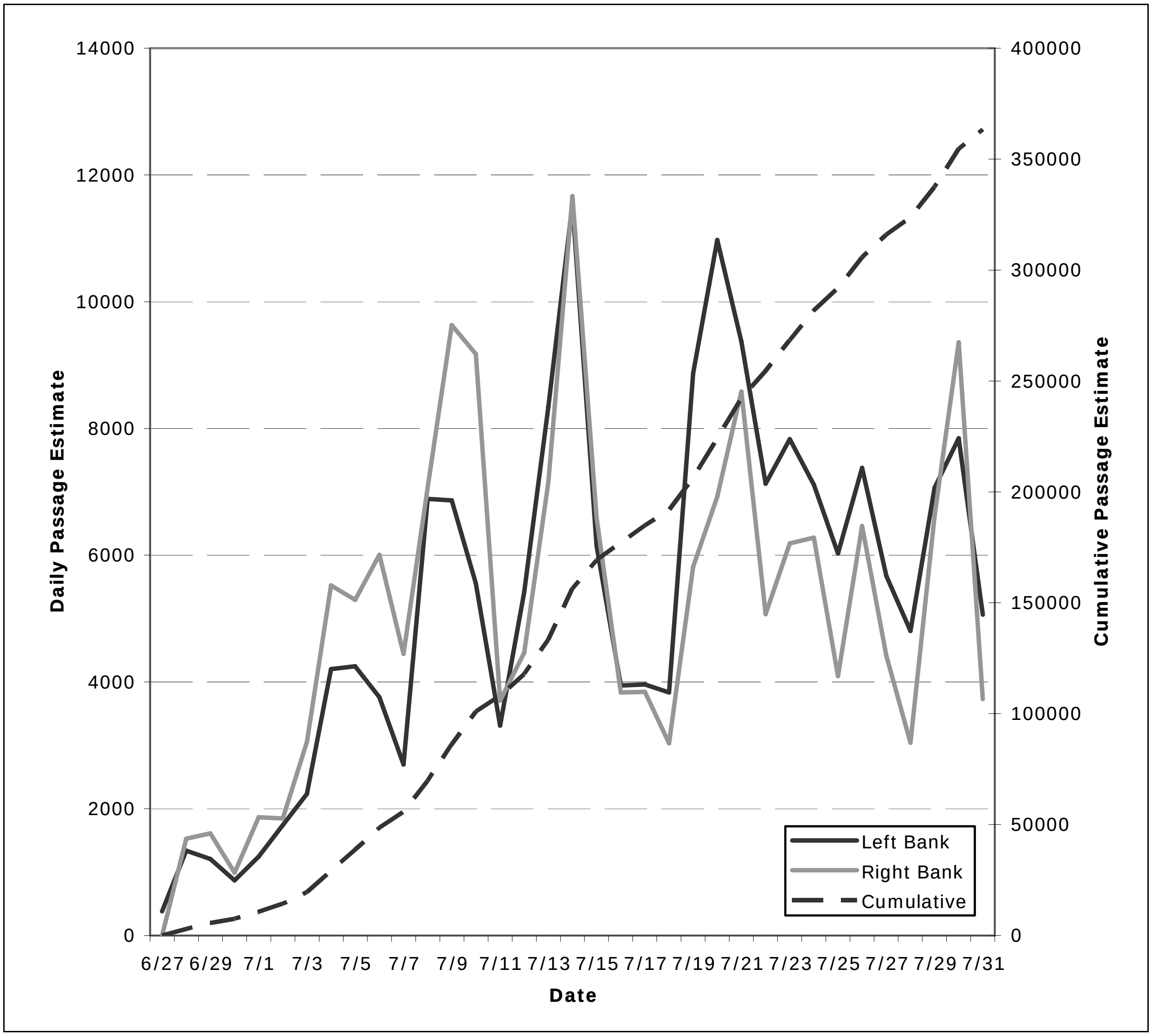


Figure 6.–Daily and cumulative passage estimates, Aniak River Sonar, 2003.

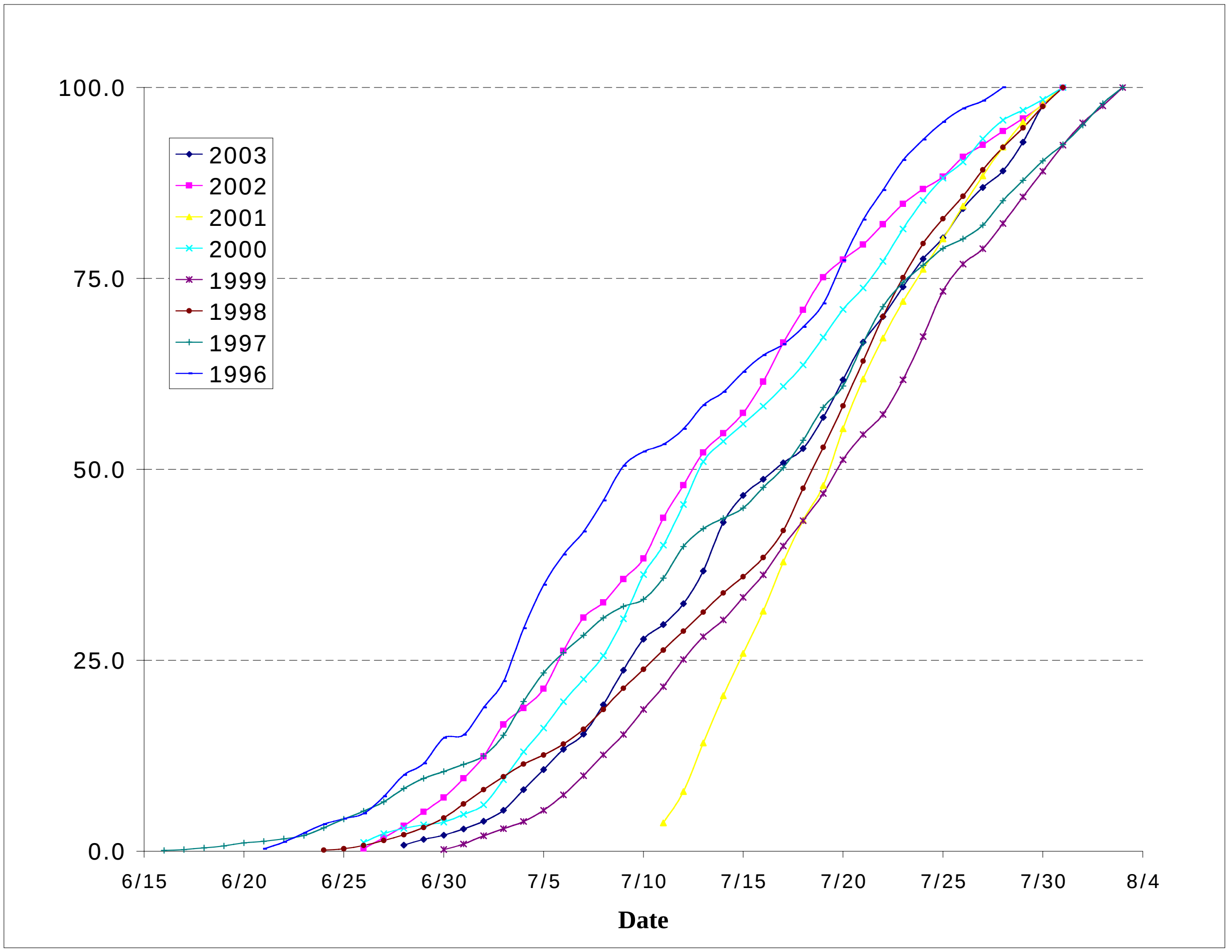


Figure 7.–Fish passage quartiles, Aniak River Sonar, 1996–2003.

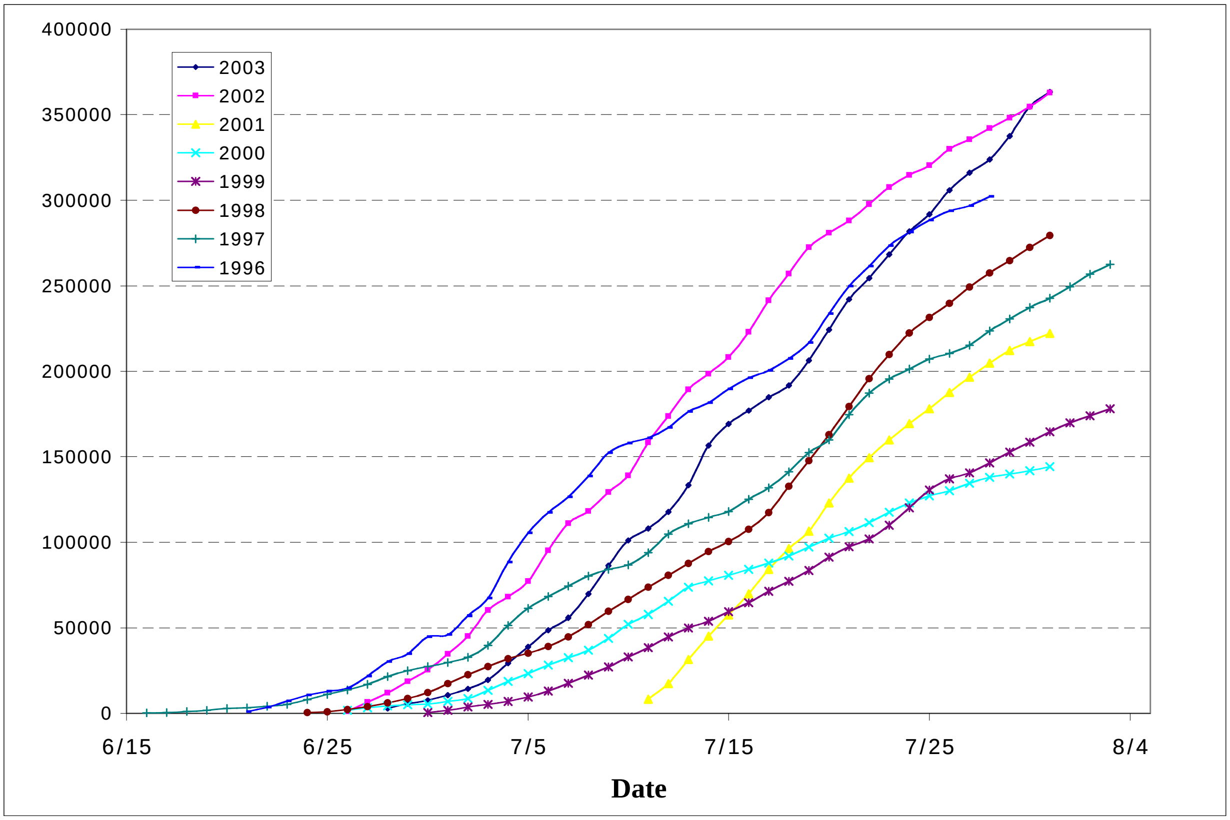


Figure 8.–Cumulative fish passage estimates, Aniak River Sonar, 1996–2003.

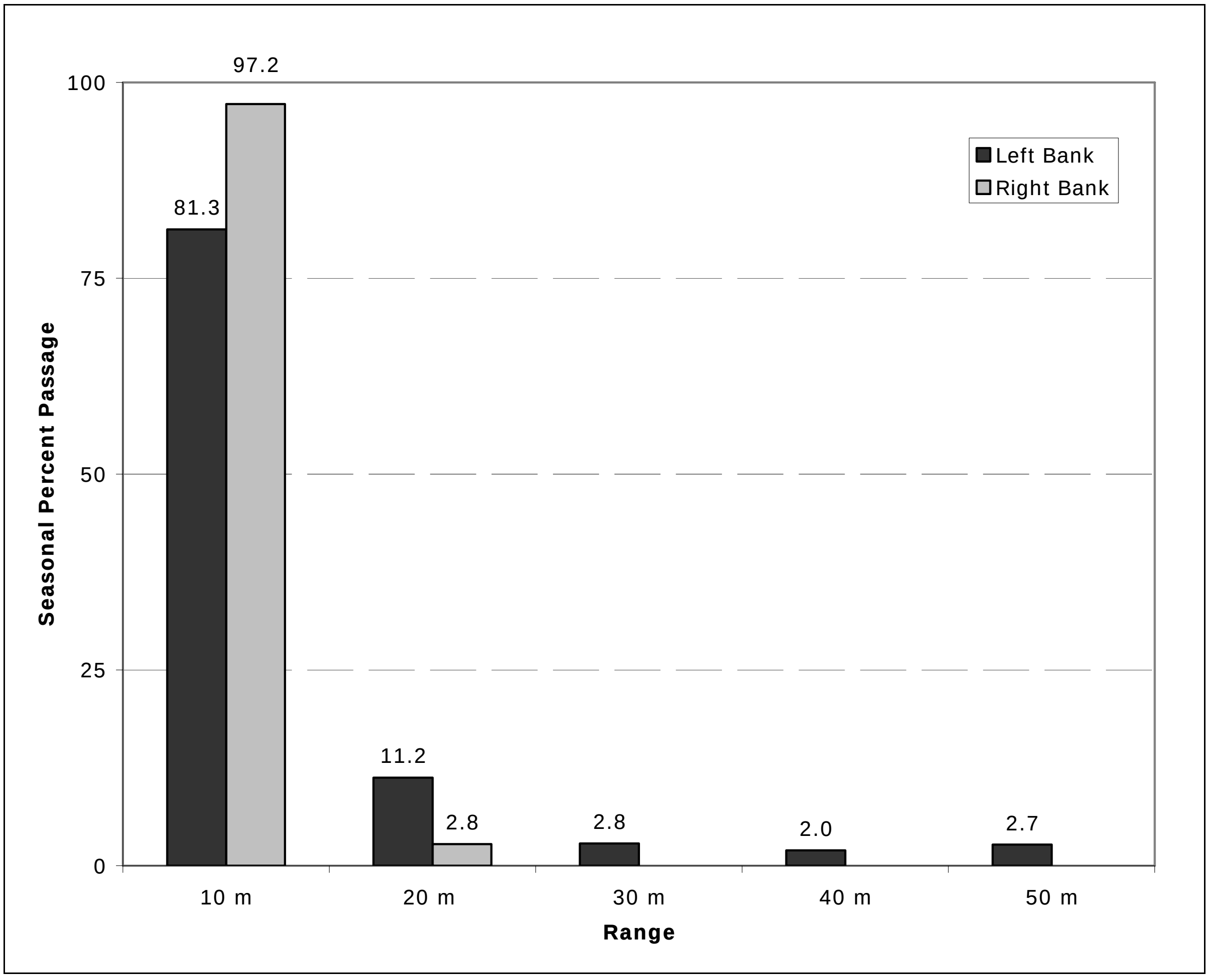


Figure 9.–Distribution of targets by range, Aniak River Sonar, 2003.

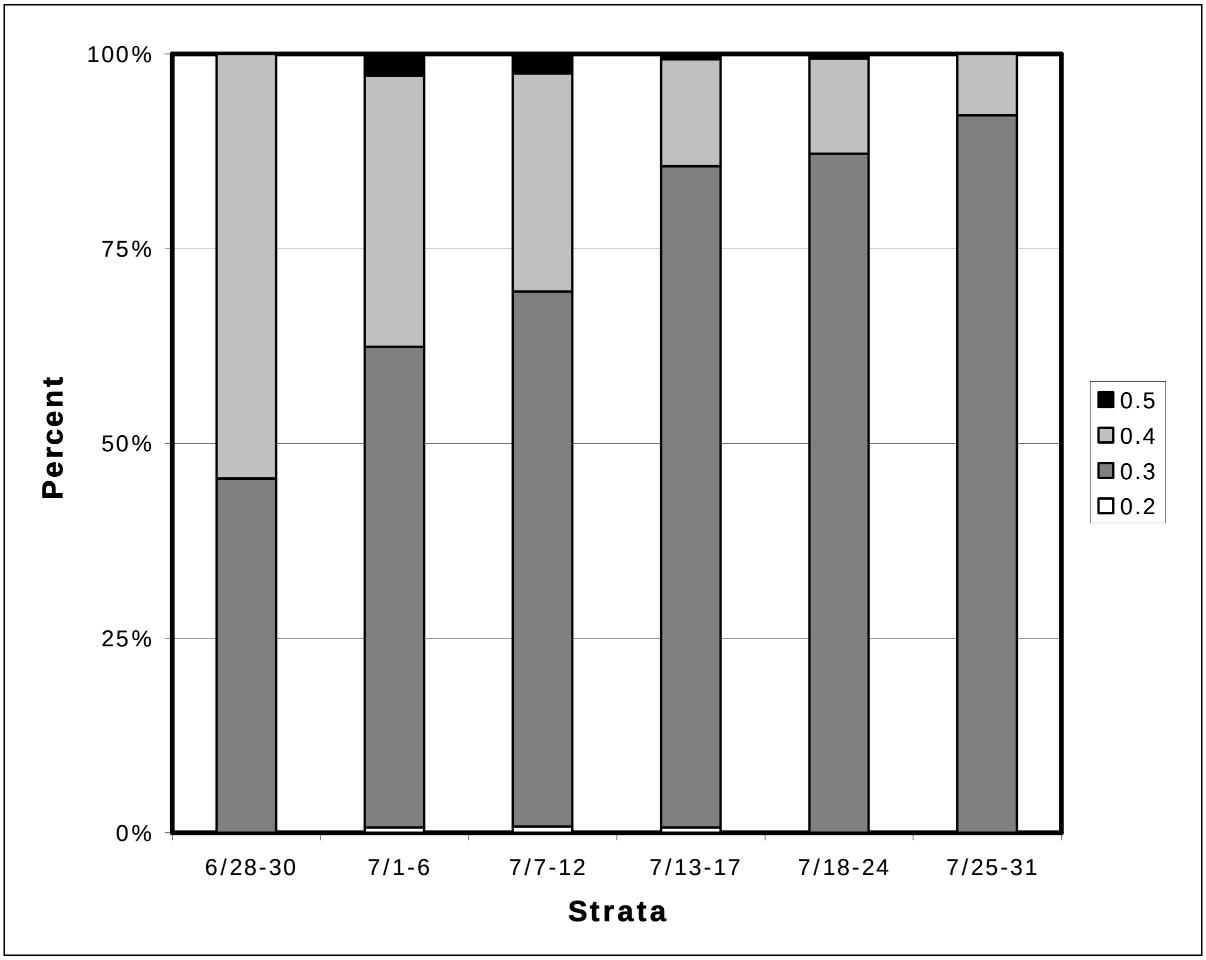


Figure 10.–Age composition of chum salmon, Aniak River Sonar, 2003.

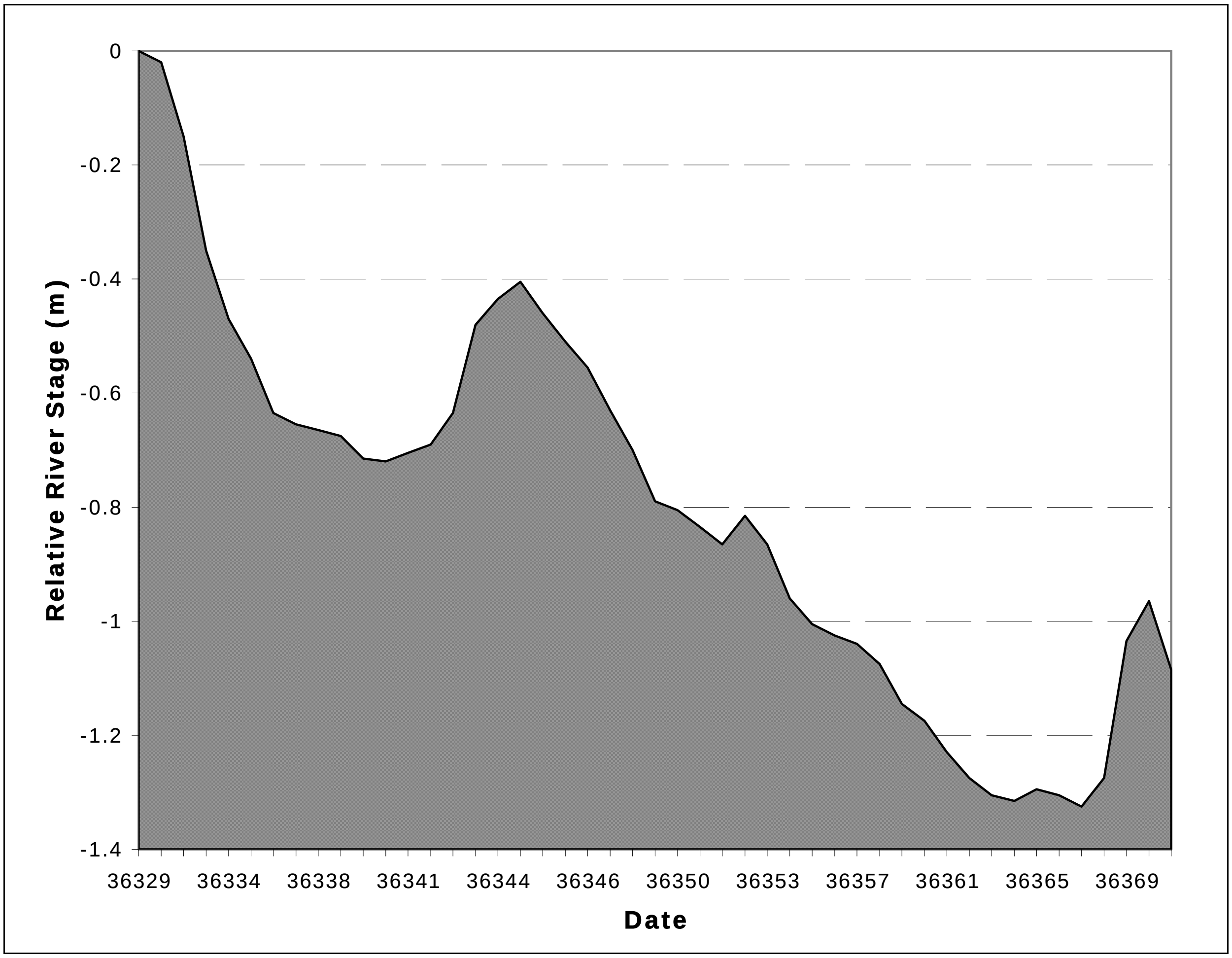


Figure 11.–Relative river stage, Aniak River sonar, 2003.

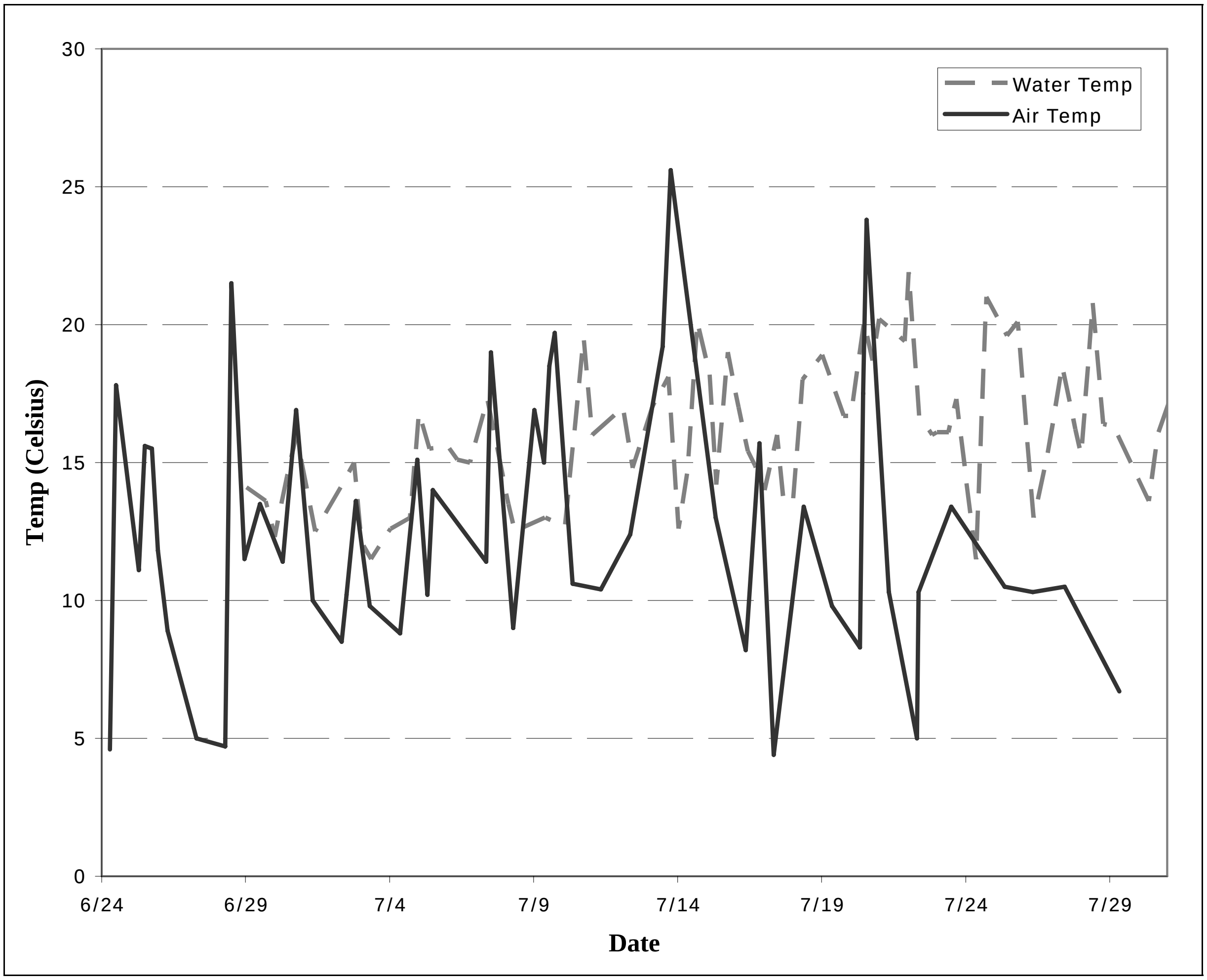


Figure 12.–Air and water temperatures (°C), Aniak River Sonar, 2003.

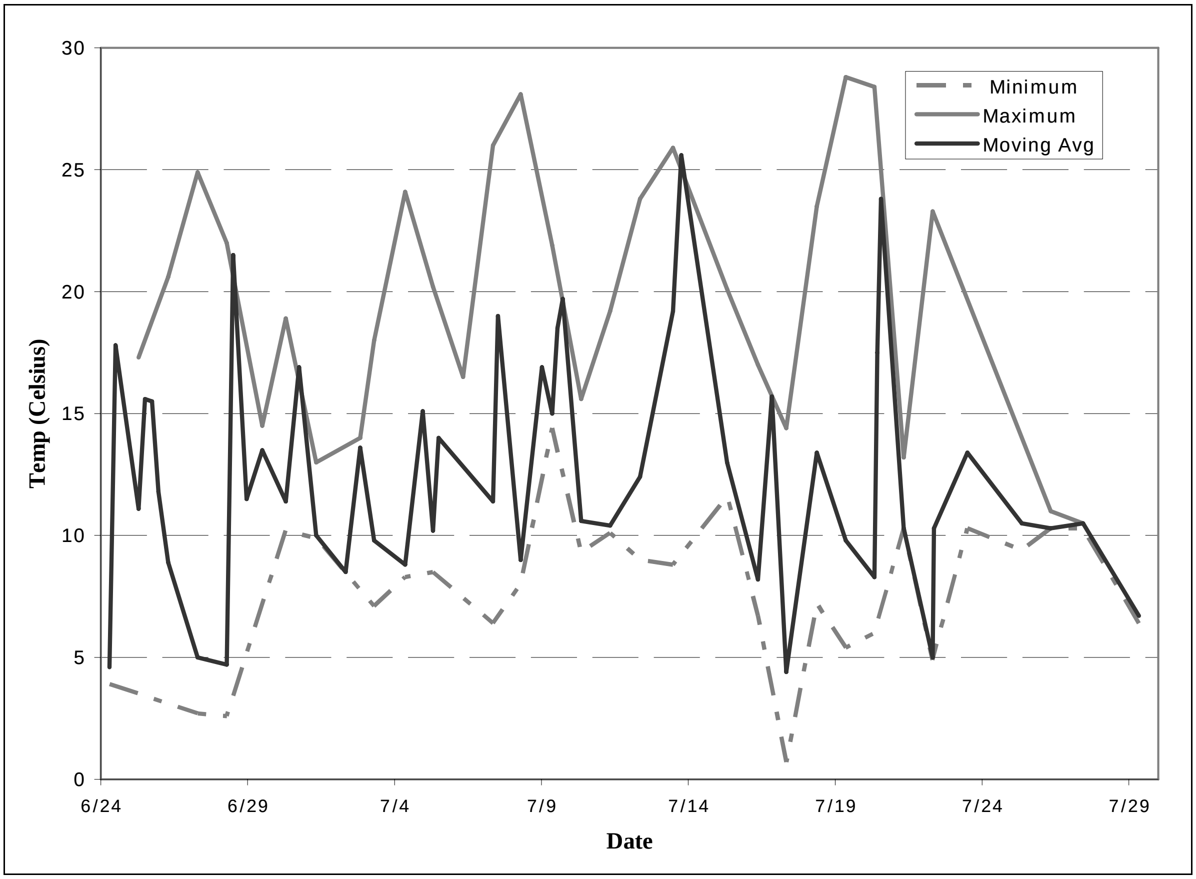
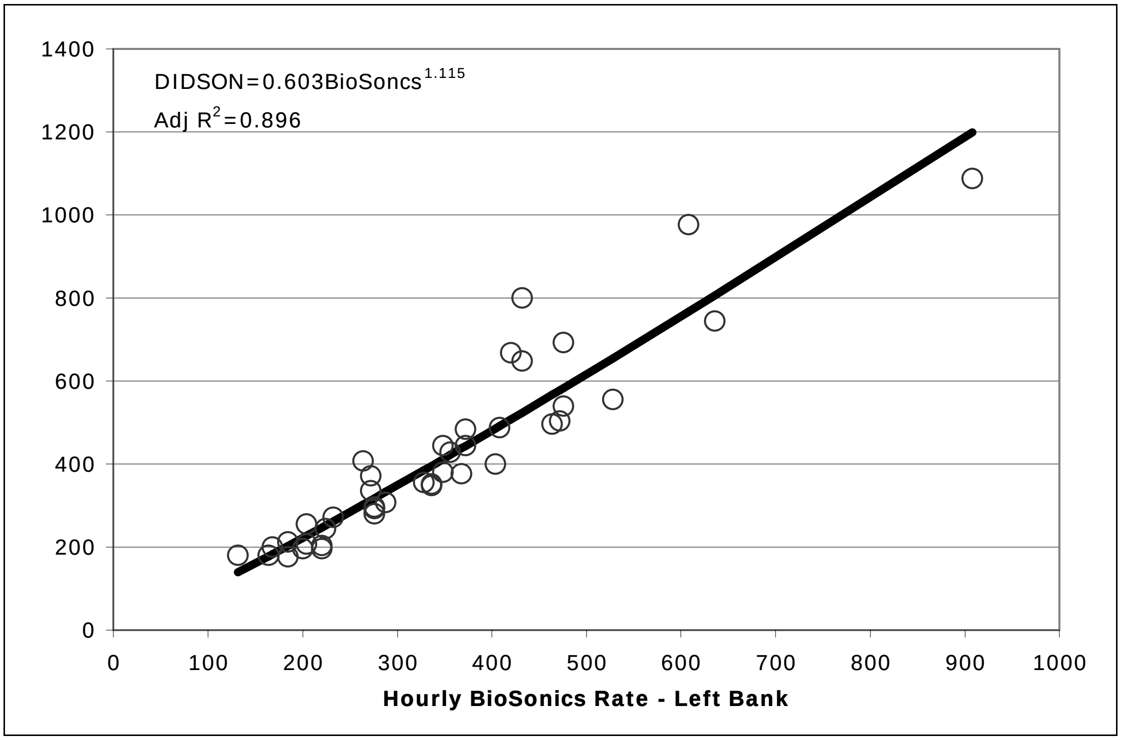


Figure 13.–Air temperature (°C), Aniak River Sonar, 2003.



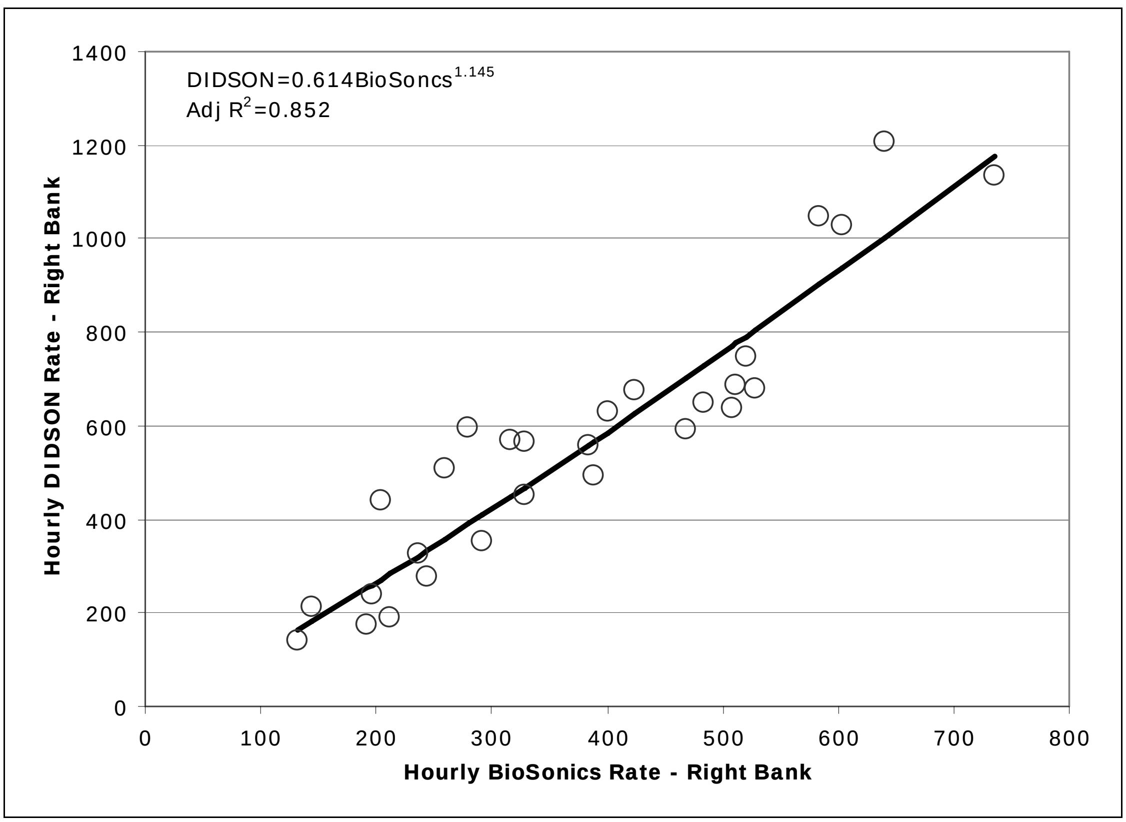


Figure 14.–Comparison of BioSonics and DIDSON counts on the left (top) and right (bottom) banks of the Aniak River, 2003**.**

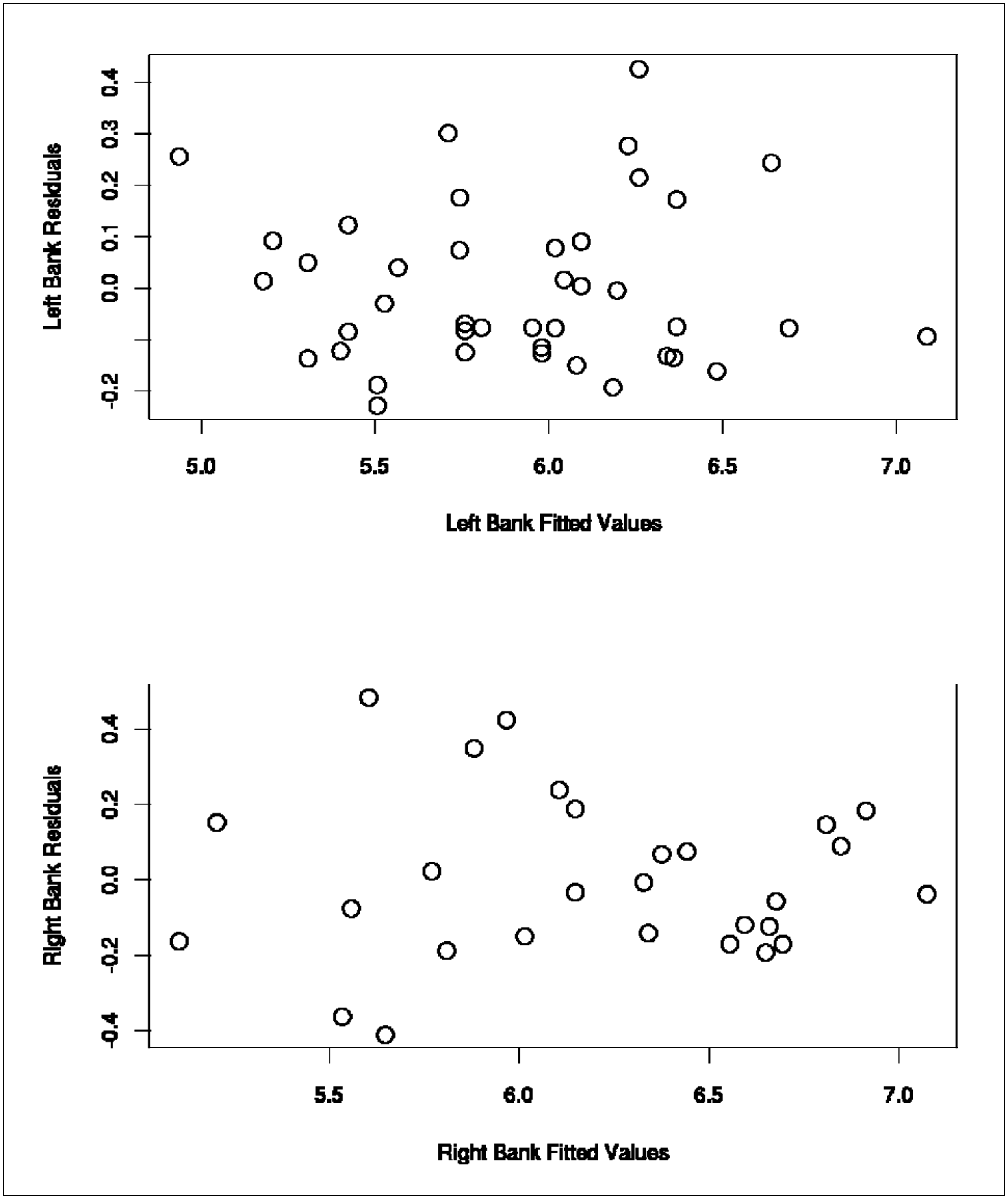


Figure 15.–Residuals for BioSonics and DIDSON comparison on the left (top) and right (bottom) banks of the Aniak River, 2003**.**

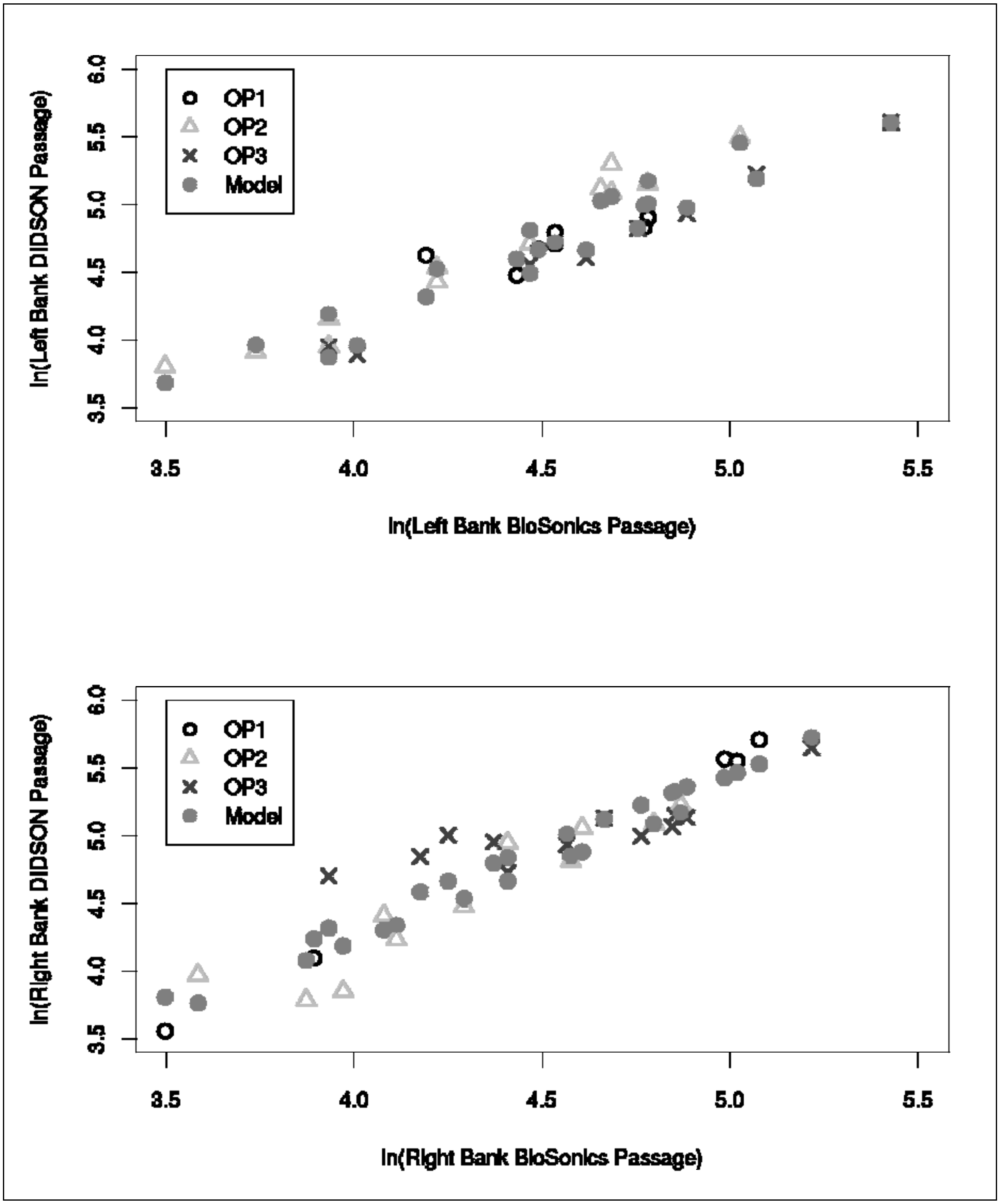
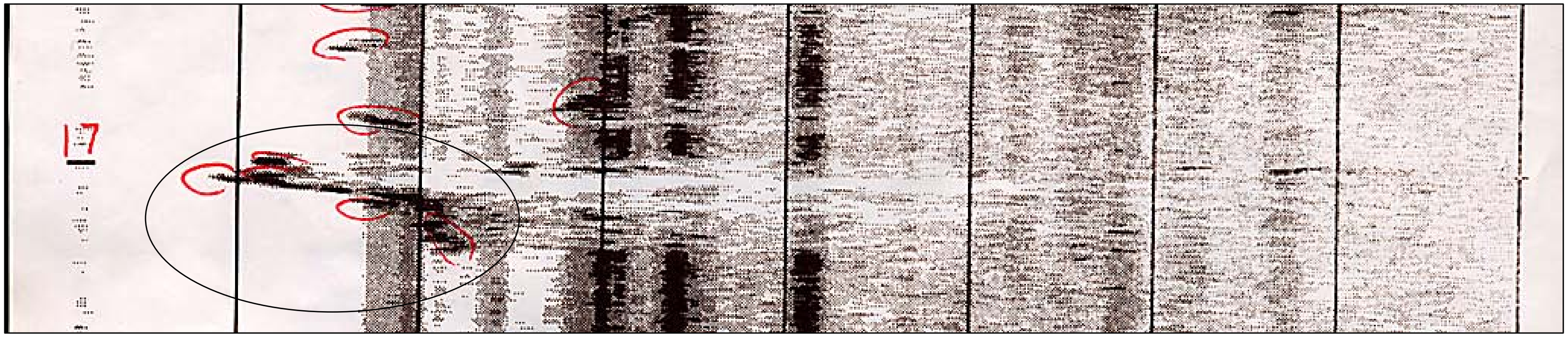


Figure 16.–Comparison of DIDSON and BioSonics by operator.



Note: 4 fish were counted in the highlighted oval.

Figure 17.–BioSonics chart with markings by technicians.

APPENDIX A. SAMPLING VERSUS 24 HOUR COUNTS

Appendix A1.–BioSonics Subsampling Analysis.

From 1996–2002, the Aniak River sonar project operated the sonar 24 hours per day, 7 days per week and used the full day's counts for the daily passage estimate. In an effort to streamline the project and to save money, we will be modifying the sampling protocol to operate for three 4-hour periods per day. This practice will result in the ability to reduce the crew size by one technician for 2003 and by two technicians for 2004. This could result in a cost savings for the project of 21% the first year and 37% the second year.

We conducted a study of the data covering 1997–2002 to devise a sampling regime that would minimize uncertainty, variability, and error in our estimates while at the same time providing a logistically feasible schedule. We initially explored the 2002 data and analyzed four different sampling regimes (Appendix B1):

- the top 15 minutes of each hour
- 4 hours on/4 hours off
- 6 hours on/2 hours off
- 8 hours on/8 hours off

The latter three options provide shifts that would be logistically feasible for crew scheduling and operations. The top 15 minutes regime would only be feasible if we convert to DIDSON in the future. From this initial examination, the 4 on/4 off schedule presented the least overall error with a moderate amount of daily variability. The other two options provided a less acceptable level of seasonal error (Appendix C1).

The next step in our analysis applied the 4 on/4 off schedule to the 1997–2002 data. This information is displayed in Appendices A1 and B1 and summarized in Appendices A1 and C1. The analysis shows that a 4 on/4 off schedule would result in a maximum seasonal error of roughly +/- 2.7%. The daily variability is larger, but oscillates between over and under counts for the duration of the season.

The 4 on/4 off shifts cover the time periods of 0000–0400, 0800–1200, and 1600–2000 hours. We also looked at moving these periods to different parts of the day, but these specific times provided the best results. We believe that the cause for this is that these times do the best job at representatively sampling the diel variations.

APPENDIX B: ANALYSIS OF SUBSAMPLING REGIMES

Appendix B1.–Analysis of four different subsampling regimes for the 2002 Aniak Biosonics data.

Date	Actual	Top 15 min.	No. diff	% diff	4 on/4 off	No. diff	% diff	6 on/2 off	No. diff	% diff	8 on/8 off	No. diff	% diff
26-Jun	1,134	855	-279	25	0	-1,134	100	641	-493	43			
27-Jun	5,310	5,678	368	-7	3,292	-2,018	38	3,191	-2,119	40			
28-Jun	5,607	5,853	246	-4	3,448	-2,159	39	3,293	-2,314	41			
29-Jun	6,572	6,522	-50	1	4,182	-2,390	36	4,400	-2,172	33			
30-Jun	6,872	6,360	-512	7	6,420	-452	7	6,429	-443	6	7,776	904	-13
1-Jul	9,144	9,640	496	-5	9,144	0	0	8,679	-465	5	7,509	-1,635	18
2-Jul	10,423	10,588	165	-2	11,554	1,131	-11	10,196	-227	2	12,146	1,723	-17
3-Jul	15,069	15,672	603	-4	15,510	441	-3	14,063	-1,006	7	16,482	1,413	-9
4-Jul	7,818	7,384	-434	6	6,504	-1,314	17	6,359	-1,459	19	8,811	993	-13
5-Jul	9,217	9,376	159	-2	9,208	-9	0	9,121	-96	1	6,030	-3,187	35
6-Jul	17,925	18,864	939	-5	16,704	-1,221	7	16,818	-1,107	6	18,395	4,69.5	-3
7-Jul	15,820	16,544	724	-5	17,608	1,788	-11	14,561	-1,259	8	11,784	-4,036	26
8-Jul	7,263	7,376	113	-2	6,442	-821	11	6,490	-773	11	8,499	1,236	-17
9-Jul	11,064	10,940	-124	1	9,596	-1,468	13	10,437	-627	6	6,624	-4,440	40
10-Jul	9,775	9,716	-59	1	9,130	-645	7	9,039	-736	8	11,837	2,062	-21
11-Jul	19,321	20,552	1,231	-6	18,134	-1,187	6	16,389	-2,932	15	19,944	623	-3
12-Jul	15,479	16,476	997	-6	16,596	1,117	-7	14,891	-588	4	17,501	2,022	-13
13-Jul	15,551	16,084	533	-3	17,426	1,875	-12	15,379	-172	1	13,110	-2,441	16
14-Jul	9,179	9,332	153	-2	9,530	351	-4	8,702	-477	5	9,996	817	-9
15-Jul	9,643	10,032	389	-4	9,384	-259	3	8,933	-710	7	7,323	-2,320	24
16-Jul	14,818	14,976	158	-1	14,830	12	0	13,944	-874	6	14,967	149	-1
17-Jul	18,532	19,124	592	-3	18,152	-380	2	16,606	-1,926	10	14,544	-3,988	22
18-Jul	15,566	15,772	206	-1	14,726	-840	5	14,298	-1,268	8	18,909	3,343	-21
19-Jul	15,515	16,632	1,117	-7	16,694	1,179	-8	15,423	-92	1	9,027	-6,488	42
20-Jul	8,354	8,196	-158	2	8,990	636	-8	8,276	-78	1	9,966	1,612	-19
21-Jul	7,242	7,616	374	-5	7,338	96	-1	6,949	-293	4	2,982	-4,260	59
22-Jul	9,597	8,964	-633	7	9,862	265	-3	9,018	-579	6	11,033	1,436	-15
23-Jul	9,619	9,256	-363	4	9,380	-239	2	9,113	-506	5	5,832	-3,787	39

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Date	Actual	Top 15 min.	No. diff	% diff	4 on/4 off	No. diff	% diff	6 on/2 off	No. diff	% diff	8 on/8 off	No. diff	% diff
24-Jul	7,145	6,632	-513	7	7,456	311	-4	6,725	-420	6	8,628	1,483	-21
25-Jul	5,797	5,704	-93	2	6,008	211	-4	5,621	-176	3	2,901	-2,896	50
26-Jul	9,482	9,668	186	-2	8,958	-524	6	8,363	-1,119	12	10,983	1,501	-16
27-Jul	5,619	5,752	133	-2	5,518	-101	2	5,353	-266	5	3,555	-2,064	37
28-Jul	6,559	7,324	765	-12	6,082	-477	7	6,428	-131	2	80,14.5	14,55.5	-22
29-Jul	6,013	6,364	351	-6	5,954	-59	1	5,960	-53	1	2,670	-3,343	56
30-Jul	6,605	6,800	195	-3	5,820	-785	12	5,981	-624	9	83,86.5	1,782	-27
31-Jul	8,163	8,236	73	-1	7,508	-655	8	7,640	-523	6	2,649	-5,514	68

Note: The Actual column represents 24-hour counts (sum of both banks) and the other shaded columns represent the counts multiplied by the appropriate factor.

Summary	Top 15 Minutes	4 on/4 off	6 on/2 off	8 on/8 off
Total Difference for the Season (%)	2.3	0.6	6.4	7.4
Seasonal Average of the Daily Difference (no. of fish)	243	-63	-688	-793
Seasonal Sum of Difference in Counts (no. of fish)	7,763	-2,023	-22,005	-25,378
Minimum Daily Difference (%)	-12	-12	1	-27
Maximum Daily Difference (%)	7	17	19	68
Average Daily Difference (%)	-2	1	6	8
Range of Daily Differences for the Season (%)	19	39	19	95

APPENDIX C: SAMPLING RESULTS (4 HOURS ON/4 HOURS OFF)

Appendix C1.–Results of sampling 4 hours on/4 hours off and multiplying the summed 12-hour counts by two.

	2002		2001		2000		1999		1998		1997	
Date	**No. diff**	**% diff**	**No. diff**	**% diff**	**No. diff**	**% diff**	**No. diff**	**% diff**	**No. diff**	**% diff**	**No. diff**	**% diff**
17-Jun											3	1
18-Jun											-38	-12
19-Jun											-48	-9
20-Jun											-54	-8
21-Jun											-57	-6
22-Jun											26	5
23-Jun											-26	-3
24-Jun											-113	-10
25-Jun									12	3	-365	-14
26-Jun									-7	-1	-183	-6
27-Jun					14	1			-128	-11	1	0
28-Jun					-35	-2			14	1	-320	-10
29-Jun					36	4			-68	-3	-80	-2
30-Jun					-16	-2			-40	-2	179	5
1-Jul	-452	-7			256		-80	-23	-9	0	308	13
2-Jul	0	0			89	6	-106	-8	-99	-2	-484	-20
3-Jul	1,131	11			72	4	-51	-3	267	5	-306	-10
4-Jul	441	3			-329	-7	29	2	-148	-3	-753	-11
5-Jul	-1,314	-17			310	6	-100	-6	280	6	-954	-8
6-Jul	-9	0			-480	-11	86	3	-132	-4	-150	-2
7-Jul	-1,221	-7			208	4	93	3	-90	-2	-22	0
8-Jul	1,788	11			252	6	13	0	-136	-2	-82	-1
9-Jul	-821	-11			-327	-7	-490	-10	-226	-3	254	4
10-Jul	-1,468	-13			-675	-10	79	2	-477	-6	479	12
11-Jul	-645	-7			-428	-5	246	4			51	2
12-Jul	-1,187	-6	-1,124	-14	355	6	-49	-1			11	0
13-Jul	1,117	7	1,169	13	-1,254	-16	-59	-1			-241	-2
14-Jul	1,875	12	339	2	1,155	14	381	7			1552	25
15-Jul	351	4	922	7	695	18	326	8			394	11

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Date	2002		2001		2000		1999		1998		1997	
	No diff	**% diff**	**No. diff**	**% diff**	**No. diff**	**% diff**	**No. diff**	**% diff**	**No. diff**	**% diff**	**No. diff**	**% diff**
16-Jul	-259	-3	602	5	-310	-9	98	2	757	13	184	5
17-Jul	12	0	1,044	8	141	4	220	4	-443	-6	-229	-3
18-Jul	-380	-2	1,087	8	-115	-3	663	10	-1,194	-12	-425	-6
19-Jul	-840	-5	1,413	12	-695	-17	222	4	-1,792	-12	-777	-8
20-Jul	1,179	8	113	1	-415	-8	165	3	-647	-4	-682	-6
21-Jul	636	8	103	1	319	6	522	7	484	3	-107	-1
22-Jul	96	1	52	0	187	5	455	8	589	4	-1,024	-7
23-Jul	265	3	630	5	128	3	-473	-10	-583	-4	1,076	9
24-Jul	-239	-2	596	6	19	0	273	3	-927	-6	304	4
25-Jul	311	4	-458	-5	540	10	293	3	818	7	216	4
26-Jul	211	4	300	3	401	9	89	1	-714	-8	1,814	32
27-Jul	-524	-6	-851	-9	205	7	945	15			278	9
28-Jul	-101	-2	320	4	176	4	-165	-5	-514	-5	-638	-14
29-Jul	-477	-7	-209	-2	381	11	296	5	-158	-2	-628	-7
30-Jul	-59	-1	359	5	217	11	91	1	-373	-5	249	4
31-Jul	-785	-12	-67	-1	76	4	310	5	460	6	30	0
1-Aug	-655	-8	-93	-2	42	2	303	5	-705	-10	929	17

Note: No. diff refers to the difference between 12-hour estimates and 24-hour counts.

Summary	**2002**	**2001**	**2000**	**1999**	**1998**	**1997**
Total Difference for the Season (%)	-0.6	2.7	0.8	2.7	-2.6	-0.2
Seasonal Average of the Daily Difference (No. of fish)	-63	297	33	145	-185	-10
Seasonal Sum of Difference in Counts (No. of fish)	-2,023	6,247	1,195	4,625	-5,929	-448
Minimum Daily Difference (%)	-17	-14	-17	-23	-12	-20
Maximum Daily Difference (%)	12	13	18	15	13	32
Average Daily Difference (%)	-1	2	1	1	-2	-0.5
Range of Daily Differences for the Season (%)	29	27	35	38	25	51

APPENDIX D. TIMETABLE OF DEVELOPMENTAL CHANGES AT THE ANIAK RIVER SONAR PROJECT

Appendix D1.–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 (1980–95) • 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 (1980–82, 85–89, 91–96) • 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 1980–81 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 pre- and post-season salmon escapement (1983–1984, 90, 1996–1997)

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YEAR	EVENT
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
1988	• Sonar operations eliminated use of the 60 ft artificial substrate. Sampling range unknown
1989	• Sonar operations same as 1988
1990	• No formal project documentation (1990–1995)
1993	• Fire destroys 1981 model Bendix sonar counter. Replaced with a 1978 model Bendix sonar counter • Historic data in Kuskokwim Area Management Report is adjusted to reflect 162% expansion factor applied to 1980–1983 season estimates
1994	• Sonar operations continue with 1978 model counter
1995	• Sonar operations continue with 1978 model counter • Reliable escapement estimates are not generated
1996	• Established a new sonar data collection site 1.5 km downstream from the historical site • Project operations redesigned to provide full river ensonification, with user-configurable sonar equipment 24 hours per day on both banks • Periodic net sampling to monitor broad changes in species composition, corroborate acoustically detected abundance trends, and obtain ASL samples of chum salmon • Sonar estimates are not extrapolated for pre- and post-season salmon escapement (1996–1997) • Regional Information Report documents project operations and data collection activities

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YEAR	EVENT
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, three 4-hour periods were sampled on each bank. The total counts for both banks, for the three periods were multiplied by two to provide the daily passage estimate. • DIDSON sonar was tested at the site and efforts were underway to migrate from BioSonics to DIDSON.