Fishery Data Series No. 06-33

Sonar Estimation of Chum Salmon Passage in the Aniak River, 2002

by

Malcolm S. McEwen

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:
McEwen, M. S. 2006. Sonar estimation of chum salmon passage in the Aniak River, 2002. Alaska Department of Fish and Game, Fishery Data Series No. 06-33, Anchorage.

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ABSTRACT

The Aniak River sonar project provided daily estimates of fish passage from 26 June through 31 July, 2002. User-configurable sonar continuously sampled the entire width of the river between the transducers, except for short periods when equipment was moved or serviced. An estimated 362,812 fish passed through the ensonified area during the period of operation. The peak daily passage of 18,532 fish occurred on 17 July, and the 50% passage date occurred on 13 July. Age-0.4 and-0.5 chum salmon *Oncorhynchus keta* comprised an estimated 77% and 20% of the escapement estimate, respectively. A total of 2,939 fish, 85% of which were chum salmon, were captured at the site during a total of 662 drifts with gillnets.

Key words: Aniak River, chum salmon, *Oncorhynchus keta*, Bendix, hydroacoustic, sonar, escapement, Kuskokwim River, age-sex-length, ASL

INTRODUCTION

HISTORY

The Kuskokwim River commercial salmon fishery in June and July is directed toward the harvest of chum salmon *Oncorhynchus keta*. From 1992 to 2001, commercial chum salmon harvests in districts W-1 and W-2 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). During the same time period, an average 66,017 chum salmon were harvested annually for subsistence purposes in the Kuskokwim drainage (Ward et al. 2003).

Management of the chum salmon fishery resource requires timely estimates of run strength and escapement. 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 area (Francisco et al. 1995; Figure 1). Tagging studies suggest travel time of chum salmon from the upper end of District 1 to the Aniak River sonar site at 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 data were collected from 1980 to 1995 using a single echo counting and processing transceiver manufactured by Bendix Corporation.[1] The transceiver was mounted on an 18.3 m artificial substrate located on the right bank. The counts were 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 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 in 1984 to refine the expansion factor applied to the daily counts (Schneiderhan 1985). The second counter was deployed 1.5 km downstream from the existing counter and alternately operated on each bank. The proportions 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.

[1] Use of vendor names does not constitute product endorsement by Alaska Department of Fish and Game (ADF&G).

In the early 1980s, gillnet test fishing provided species apportionment and age, sex, and length (ASL) information of chum salmon and Chinook salmon *O. tshawytscha*. 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 reduce operating costs because it was noted that the Aniak River chum salmon ASL data was similar to the commercial catch results from the lower Kuskokwim River districts (Schneiderhan 1988).

The 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 in 1992, the Aniak River escapement objective was termed a biological escapement goal (BEG) (Buklis 1993).

Salmon escapement objectives for the Aniak River were set at 250,000 chum salmon and 25,000 Chinook salmon in 1981, and formally established in 1982. The chum salmon objective was derived subjectively by relating historical sonar passage estimates to trends in harvest and aerial survey indices (Schneiderhan 1982b). In 1983, a review of the escapement objective based upon sonar estimates and other escapement indices suggested that the 1980–1981 Aniak River sonar estimates likely represented record escapements, and much smaller escapements would probably provide adequate future spawning stocks and a sustainable harvest (Schneiderhan 1984).

The Aniak River sonar project was redesigned in 1996 to provide full river ensonification with user-configurable sonar equipment operating 24 hours per day on both banks throughout the chum salmon migration. Seasonal sonar estimates were not extrapolated for salmon escapement before or after the operational period. The new sonar data collection site was established 1.5 km downstream from the historical site (Figure 2). 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.

Although the Aniak River supports anadromous and resident fish populations of several different species, the sonar estimates are not apportioned to species. However, recent beach seine sampling conducted near the sonar site to obtain ASL samples of chum salmon included significant numbers of several non-targeted resident and anadromous species that were detectable by the sonar. The degree to which these non-target species compromise the effectiveness of the sonar project is unknown.

A 1995 Aniak River sonar test fish feasibility study indicated that a species apportionment program is logistically feasible at the current site (Knuepfer 1995). The primary impediment to implementing such a program has been a lack of sufficient budgetary resources. In response to extremely poor returns of chum and coho salmon in 1997 and 1998, the federal government made funds available for Kuskokwim River salmon fisheries research and management. This funding source supported the development of a species apportionment study to complement the Aniak River sonar project.

A species apportionment program was added to the project in 2001 and continued in 2002. The goal of the species apportionment program is to estimate the proportion of each species passing the sonar site. These catches will be used in developing net selectivity curves and ultimately allow us to estimate the actual passage of chum salmon up the Aniak River.

Sonar operations in 2002 remained essentially unchanged since 1996. The BEG of 250,000 estimated fish counts was carried forward to the redesigned sonar project, but will be reassessed as more information is gathered. A timetable of developmental changes for the sonar project is presented in Appendix A.

OBJECTIVES

The primary objectives for the 2002 field season remained the same as previous seasons. These objectives are outlined in the following list:

1. Estimate fish abundance in the Aniak River using user-configurable sonar equipment 24 hours per day on both banks throughout the bulk of the chum salmon migration, from approximately 21 June through 31 July.
2. Provide daily fish passage estimates to fishery managers in Bethel by 0800 hours the following morning.
3. Estimate age, sex, and length (ASL) composition of the total chum salmon escapements to the Aniak River from a minimum of 2 to 3 pulse samples collected from each third for 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).
4. Drift gillnets twice daily to sample the fish species present in the river. The goal is to ascertain whether the site is suitable for drift gillnetting and if catches will be sufficient to apportion sonar counts to species. This will be determined based on our ability to sample an area with the nets which corresponds to a high target count (> 60%) with the sonar.

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

Sonar equipment for the right bank of the Aniak River included: 1) a Biosonics model 101 (SN 101-021) 120/420 kHz echosounder configured to transmit and receive at 420 kHz; 2) a 4 ^{o}x15 ^{o} Biosonics single beam 420 kHz elliptical transducer (SN 16-420-4x15-007); 3) a 152.4 m (500 ft) Belden model 8412 cable (SN 503Y); and 4) a Biosonics model 111 (SN 111-88-041) thermal chart recorder. A Hewlett Packard model 54501A (SN 2842A04372) digital storage oscilloscope (DSO) and a Nicolet 310 (SN 88DO4365) were used to examine signals from both the left and right bank systems.

We mounted the right bank transducer on an aluminum tripod and remotely aimed using a Remote Oceans Systems (R.O.S.) model PT-25 (SN 1064) air-filled, dual-axis rotator. We controlled rotator movements with a R.O.S. model PTC-1 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 102 (SN 102-89-020) 120/420 kHz echosounder configured to transmit and receive at 420 kHz; 2) a 3^{o}x10^{o} (S/N 09-420-4x15-004) Biosonics dual beam 420 kHz elliptical transducer; 3) two 304.8 m (1000 ft) Belden model 8412 cables (SN 601K, 602K); and 4) a Biosonics model 111 (SN 111-89-053) thermal chart recorder.

We 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. We controlled left bank rotator movements 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 pink flagging to allow safe boat passage.

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 entire river was ensonified by using the right bank transducer to sample outwards 15 – 20 m and the left bank transducer to sample 40 m.

Partial weirs were erected perpendicular to the current and extended from the shore 3 – 10 m beyond the transducers. 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

Throughout the season, 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 right bank had a steep gradient from shore to the thalweg (Figure 3). The left bank gradient was fairly shallow with a small hump close to shore (Figure 4). This hump was a minor obstruction at high water, but was not an issue once the river stage dropped. The thalweg was approximately (3m) deep and located closer to the right bank.

Sampling Procedures

Single beam acoustic sampling was conducted on both banks continuously 24 hours per day; 7 days per week, except for short periods when the generator was serviced and transducer adjustments were made. 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. Crew members identified and tallied fish traces on chart recordings while rotating through shifts of 0000–0800, 0800–1600, and 1600–2400 hours. For consistency, crewmembers were trained to distinguish between fish traces and non-fish traces, such as from debris and bottom. The number of fish traces was summed within range intervals and 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 Excel (2000) electronic spreadsheets by the project leader. Daily estimates were transmitted via single side band radio to area managers 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.

All project activities were recorded 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. We set the right bank transmit pulse width at 0.2 milliseconds (ms) and the left bank transmit pulse width at 0.4 ms. The right bank sampling range was 20 m and the left bank sampling range varied from 30 – 40 m. Three printer thresholds, corresponding to intensities of gray were factory set at 6 dB intervals. Chart recorder thresholds for both banks were set at -40, -34,
and -28 dB during all sampling activities. These thresholds remained unchanged throughout the season.

Thresholds were calculated as follows:

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

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.

Climatological and Hydrologic Measurements

During the season, we measured ambient air temperature, water conductivity, and water temperature once per day using an Extech model 34165 Conductivity/Temperature meter. Standard secchi disk readings, water level, min/max air temperature, and wind direction were also recorded daily. The water level was measured using a staff gauge placed in front of the sonar tent on right bank.

In previous years, a benchmark was used for absolute water level measurements. That benchmark degraded and was unusable during the 2002 season. Consequently, this season's measurements reflect relative water levels and should not be compared to previous years.

ANALYTICAL METHODS

Abundance Estimation

The reported sonar estimates were calculated using an Excel spreadsheet. The raw counts were entered into the worksheet in 15-minute blocks for each spatial strata ensonified and then summed for each bank. The estimates are assumed to represent all fish passing the sonar site.

Missing Data

Generator maintenance, sonar equipment adjustments, and malfunctions occasionally resulted in missing sonar counts. We used different methodologies depending on the amount of time missed. When 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.

SPECIES COMPOSITION VERIFICATION

Equipment and Procedures

In past seasons, the crew has periodically fished 2 gillnets at various times, determined inseason, to qualitatively monitor general trends in species composition and corroborate the presence or absence of fish as a reference to observed trends in the number of fish. This activity was unnecessary during 2001 and 2002 because a species apportionment feasibility study was conducted.

SPECIES APPORTIONMENT

Equipment and Procedures

The species apportionment program was conducted by drifting 5 different gillnet mesh sizes, once at 0800 hours and again at 1400 hours. The mesh sizes included 18.4 cm (7-1/4"), 16.5 cm (6-1/2"), 13.6 cm (5-3/8"), 10.2 cm (4.0"), and 7.0 cm (2-3/4") net size. All gillnets were constructed using multifilament mesh and measured 18.3 m (10 fathoms) long by 3.1 m (10 feet) deep. Each net was drifted for approximately 2-3 minutes on each bank during the sampling period (Figure 5). The procedure for gillnet fishing was to deploy the net off the bow of a skiff moving from midstream toward shore, then drift downstream with the net perpendicular to shore. The net was pulled into the boat at the end of the drift, and the fish were removed, identified, sexed, and the length was measured. Unharmed fish were then released back into the river. For each drift we recorded the start out (SO), full out (FO), start in (SI), and full in (FI) times. The duration of each drift was then calculated as: duration = [(FO – SO)/2] + (SI-FO) + [(FI – SI)/2].

ASL SAMPLING

Equipment and Procedures

The gravel bar in front of the sonar camp was used as the sampling site for the third consecutive year. The crew used 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, we stacked the seine in a plastic fish tote and placed it in the stern of a skiff. We attached the opposite end of the seine 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 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 (Figure 6). We drifted the entire seine in this formation for approximately 100 m before we pulled in the lead line and closed 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 millimeter from mideye to the tail fork. All chum salmon had the adipose fin clipped so that they were not sampled twice if caught again. All measurements were recorded in a “rite-in-the-rain” notebook and later transcribed to standard mark-sense forms.

We followed a stratified random 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 (Larry DuBois, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). All ASL data were sent to the Bethel ADF&G office for analysis by research staff. 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 the 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 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.

RESULTS

HYDROACOUSTIC DATA ACQUISITION

Sampling Procedures

Sonar project activities commenced on 26 June and ended on 31 July. Hydroacoustic sampling for right bank began at 2026 hours on 26 June with the first full 24-hour period occurring on the following day. Left bank sonar was operational on 30 June at 1630 hours. With few exceptions, the equipment ran continuously until sampling ended at midnight on 31 July. Passage estimates were available to fishery managers in Bethel at 0730 and 1700 hours daily. A total of 2.5 hours (0.5%) on the left bank and 2.7 hours (0.54%) on the right bank of sampling time were missed because of regular maintenance, paper jams, system diagnostic tests, moving the tripod, or aiming the transducer to compensate for changing water levels throughout the season.

Relatively low signal to noise ratios (SNR) occurred on the right and left bank over narrow range intervals where the beam grazed high points in the river bottom. The SNR in those instances were about 3dB. Sonar counts at these points were not unduly corrupted since only a small range was affected.

Bottom Profiles, Stream Measurements, and Climatology Measurements

Water levels steadily went down throughout the season (Figure 7). The daily air temperature fluctuated between a minimum of 2°C (27 July) and 15°C (3 July) over the project operational period (Figure 8). The daily water temperature fluctuated between 10C (1 July) and 14C (24 July) (Figure 8). The secchi depth ranged between 50 cm and 138 cm with an average of 90.8 cm. The thalweg was located 29 m from the right bank and 68 m from the left bank. Crosstalk between transducers was observed on the chart recordings, but did not interfere with data acquisition. When transducers were repositioned to compensate for changing water levels, the ensonified range was adjusted accordingly.

FISH PASSAGE ESTIMATES

Total passage during project sampling activities was estimated at 362,812 fish, with 55% passing on the right bank and 45% passing on the left bank (Table 1). A comparison of daily estimated passage between banks is presented in Figure 9 with the cumulative season estimate. The peak daily passage of 19,321 fish occurred on 11 July (Table 1). The 25%, 50%, and 75% quartile dates of passage were 6 July, 13 July, and 19 July respectively (Table 1; Figure 10).

We examined the hourly fish count data for evidence of daily patterns of movement. All time periods displayed fish passage increasing at night and declining during the day (Figure 11). During the time period 2000 to 0700 hours, 60% of the migrating chum salmon passed by the sonar compared with 40% passed by from 0800 to 1900 hours.

SPECIES APPORTIONMENT PROGRAM

Each of the 5 different gillnet mesh sizes were drifted twice daily, once at 0800 hours and then again at 1400 hours from 26 June to 31 July. Sonar fish passage rates during these test fishing periods ranged from 47 to 805 fish per hour. A total of 662 drifts were performed over a total fishing time of 16 hrs and 18 minutes, resulting in a total catch of 2485 chum salmon, 230 Chinook salmon, 51 sockeye salmon *O. nerka*, 4 Coho salmon *O. kisutch*, 50 pink salmon *O. gorbuscha*, 37 humpback whitefish *Coregonus pidschian*, 23 Dolly Varden *Salvelinus malma*, 3 sheefish *Stenodus leucichthys*, and 56 longnose suckers *Catostomus catostomus* (Table 2). Overall, chum salmon accounted for 85% of the fish captured in the gillnets.

AGE, SEX, AND LENGTH SAMPLING

A total of 66 beach seine sets obtained 805 ASL samples from migrating chum salmon (Table 3; Figure 12). The 0.3 and 0.4 age classes for chum salmon comprised an estimated 77% and 20% respectively of the Aniak River escapement in 2002, (Table 3). The age-0.3 fish were the dominant age class throughout the run, starting at 67% of the run and going to a high of 84%. The age-0.4 fish came in strong comprising 32% of the run but then decreased in numbers throughout the season to only comprising 10% of the run at the end (Figure 12). Comparing this to the historical record the percentage of chum salmon returning by age since 1994 shows that age-0.3 fish make up the bulk of the entire run at (70.7%) followed by age-0.4 (26.9%)fish, then age-0.2 (1.8%) and- 0.5 (0.6%) chum salmon. Of the 66 beach seine sets, chum salmon comprised 84%, suckers 7%, and pinks 5%. Other species caught were Chinook, coho, sockeye salmon, whitefish, and Dolly Varden (Table 4).

DISCUSSION

HYDROACOUSTIC DATA ACQUISITION

Sampling Procedures

During the 2002 season, the crew continued the use of the 420 kHz transducer instead of the 120 kHz model that was used before 1999. One continued benefit was that the 420 kHz transducers are much smaller in size, allowing greater flexibility with changing water levels. This meant less sampling time lost from moving weirs and tripods, and re-aiming. In addition, the smaller transducers can be placed in shallower water and because of a shorter near field; they can accommodate a relatively short weir length, which is beneficial in the fast Aniak River waters.

The Aniak River sonar site is approximately 97 m from left bank to right bank where the hydroacoustic data acquisition occurs, dependent on water level. Higher frequencies, such as 420 kHz, experience greater attenuation than lower frequencies. Because of the short ranges ensonified at this site, we do not think the higher frequency compromised our ability to detect fish, and any potential for decreased detection is likely more than offset by the shorter nearfield of the 420 kHz transducer.

Fish Passage Estimates

The estimated passage for 2002 was the highest since 1994 when 388,162 fish passed by the sonar (Figure 13). Comparison of 2002 run timing with the historical 25% and 50% median passage being average and progressing to 75% being a few days early(Figure 14). The 2002 daily passage followed a roughly sinusoidal pattern with peaks separated in time by 4 to 5 days (Figure 9). Fish were distributed fairly evenly between the left and right banks. In previous years, passage has been biased to one bank or the other, and often this bias changed as water levels changed. We believe the consistently low water level observed this year resulted in the fish being evenly distributed along both banks.

Species Apportionment

The species apportionment program, which began in 2001, will not continue after 2002. A primary reason for discontinuing is that it is not possible to drift nets in the areas of highest fish passage. For the left bank 90% of the fish passed within the first couple of sectors of the sonar, each sector is approximately 5.6m wide (Figure 15). For right bank (Figure 16) 98% of the fish passed within the first couple of sectors of the sonar, each sector is approximately 5m wide (Figure 16). The width of each sector was determined by the ensonified area, divided by the number of sectors sampled. For the left bank we sampled out 40 to 50m and had 8 sectors. For right bank we sampled out 20m and had 4 sectors. We were unable to deploy the nets close enough to the weirs to sample this important area. The crew could not risk snagging the net on a weir panel or the sonar; therefore, staff doesn't regard the catch as representative of the actual run composition. In addition, submerged debris in front of the transducer forced the crew to anchor the boat at the end of each drift causing the net to flag, which allowed fish to escape. The majority of the gillnet catch was comprised of chum salmon (84.5%), Chinook salmon (7.8%), and suckers (1.9%) (Table 2). This is consistent with the proportion of chum salmon in the seine catches (86.3%); however, the remainder of the catch percentage differed with Chinook salmon comprising 0.4% and suckers comprising 6.6% (Table 4). This is similar to 2001 where 82% of the overall catch was chum salmon (Leib 2002). Given the consistently high proportion of chum salmon observed during the apportionment portion of the project, staff doesn't consider the small increase in the accuracy and precision of the estimates as adequate to continue the apportionment program considering the expense, difficulty, and unacceptable mortality associated with drift gillnetting.

AGE, SEX, AND LENGTH 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 areas are located 1.5 km and 2.5 km upstream of the sonar site. Although ASL determination provides valuable biological information on the chum salmon escapement, it is insufficient to provide quantitative species apportionment information. The age distribution of the 2002 catch followed the historical average with the age-0.3 chum salmon dominating the entire run and the older age-0.4 fish coming back before the younger age-0.2 fish. 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.

HISTORICAL DATA

In 1996, the Aniak River sonar project was redesigned and operations were significantly altered from past operations dating to 1980. Estimates prior to 1996 are difficult to substantiate because project documentation is lacking and the Bendix equipment is unable to verify aim. Comparisons between escapement estimates generated from these two very different types of project operations could lead to misinterpretation and should not be made. The established BEG of 250,000 fish for the Aniak River sonar project 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 the seasonal ADF&G staff of Heath Sandall, Brian Latham, Rebekah Smith, Naomi Brodersen, Ron Jensen, Jaya Tressler, and Ian Dickson, 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. Carl Pfisterer, AYK Sonar Coordinator, provided project oversight, technical support, and review of this report.

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TABLES AND FIGURES

Table 1.–Daily and cumulative estimates of fish passage in the Aniak River, 2002.

Date	Left Bank	Right Bank	Daily Total	Cumulative Total	LB % Passage	RB % Passage
25-Jun	-	-	-	-	-	-
26-Jun	407	727	1,134	1,134	0.36	0.64
27-Jun	1,906	3,404	5,310	6,444	0.36	0.64
28-Jun	2,013	3,594	5,607	12,051	0.36	0.64
29-Jun	2,359	4,213	6,572	18,623	0.36	0.64
30-Jun	2,243	4,629	6,872	25,495	0.33	0.67
1-Jul	3,175	5,969	9,144	34,639	0.35	0.65
2-Jul	3,802	6,621	10,423	45,062	0.36	0.64
3-Jul	5,236	9,833	15,069	60,131	0.35	0.65
4-Jul	3,059	4,759	7,818	67,949	0.39	0.61
5-Jul	4,666	4,551	9,217	77,166	0.51	0.49
6-Jul [a]	8,756	9,169	17,925	95,091	0.49	0.51
7-Jul	5,981	9,839	15,820	110,911	0.38	0.62
8-Jul	3,551	3,712	7,263	118,174	0.49	0.51
9-Jul	4,581	6,483	11,064	129,238	0.41	0.59
10-Jul	4,541	5,234	9,775	139,013	0.46	0.54
11-Jul	7,867	11,454	19,321	158,334	0.41	0.59
12-Jul	6,079	9,400	15,479	173,813	0.39	0.61
13-Jul [a]	5,533	10,018	15,551	189,364	0.36	0.64
14-Jul	3,677	5,502	9,179	198,543	0.40	0.60
15-Jul	4,770	4,873	9,643	208,186	0.49	0.51
16-Jul	6,206	8,612	14,818	223,004	0.42	0.58
17-Jul	8,703	9,829	18,532	241,536	0.47	0.53
18-Jul	8,592	6,974	15,566	257,102	0.55	0.45
19-Jul [a]	8,026	7,489	15,515	272,617	0.52	0.48
20-Jul	4,301	4,053	8,354	280,971	0.51	0.49
21-Jul	3,621	3,621	7,242	288,213	0.50	0.50
22-Jul	4,771	4,826	9,597	297,810	0.50	0.50
23-Jul	5,198	4,421	9,619	307,429	0.54	0.46
24-Jul	4,065	3,080	7,145	314,574	0.57	0.43
25-Jul	3,733	2,064	5,797	320,371	0.64	0.36
26-Jul	5,536	3,946	9,482	329,853	0.58	0.42
27-Jul	3,233	2,386	5,619	335,472	0.58	0.42
28-Jul	3,912	2,647	6,559	342,031	0.60	0.40
29-Jul	3,341	2,672	6,013	348,044	0.56	0.44
30-Jul	3,458	3,147	6,605	354,649	0.52	0.48
31-Jul	3,838	4,325	8,163	362,812	0.47	0.53

[a] quartile of the cumulative total.

Table 2.–Gillnet catch data by species, Aniak River sonar, 2002.

Date	Chinook	Sockeye	Coho	Pink	Summer Chum	Whitefish	Sheefish	Char/Dolly Varden	Sucker	Other
6/26	13	0	0	0	34	0	0	0	1	1
6/27	12	1	0	1	30	0	0	0	3	0
6/28	2	2	0	0	20	1	1	0	5	0
6/29	9	0	0	0	18	0	0	0	3	0
6/30	14	1	0	0	53	0	0	0	0	0
7/01	6	0	0	0	40	0	0	0	1	0
7/03	22	4	0	2	91	1	0	0	0	0
7/04	12	3	0	2	66	0	0	0	0	0
7/05	6	2	0	1	34	0	0	0	0	0
7/06	7	4	0	3	109	0	0	0	2	0
7/07	10	2	0	4	63	1	0	0	1	0
7/08	9	2	0	4	57	3	1	1	3	0
7/09	7	7	0	1	59	0	0	0	0	0
7/10	7	5	0	3	54	0	0	0	0	0
7/11	9	2	0	1	99	1	0	2	1	0
7/12	6	4	0	1	119	2	0	0	1	0
7/13	4	3	0	2	71	3	0	0	2	0
7/14	6	2	0	1	49	0	1	2	1	0
7/15	4	1	0	0	99	0	0	1	3	1
7/17	18	0	0	0	132	2	0	2	1	0
7/18	8	0	0	0	98	2	0	2	1	0
7/19	4	2	0	1	96	2	0	3	1	0
7/20	3	2	0	1	60	1	0	4	1	0
7/21	7	0	1	2	62	1	0	1	3	0
7/22	4	1	0	2	69	1	0	0	1	0
7/23	6	0	0	0	186	0	0	0	2	1
7/24	7	0	0	3	106	0	0	1	2	0
7/25	2	0	1	1	62	5	0	1	4	0
7/26	1	0	0	3	52	3	0	0	6	0
7/27	0	1	1	5	93	3	0	0	1	0
7/28	1	0	0	1	53	1	0	1	2	0
7/29	0	0	1	0	89	1	0	0	3	0
7/30	2	0	0	3	69	1	0	0	1	0
7/31	2	0	0	2	93	2	0	2	0	0
Season Totals	**230**	**51**	**4**	**50**	**2,485**	**37**	**3**	**23**	**56**	**3**

Table 3.–Age and sex composition of chum salmon, Aniak River sonar, 2002.

			Age									
			0.2		0.3		0.4		0.5		Total	
2002 Sample Data (Strata)	Sample Size (No. of Fish)		No. Fish [a]	No. Sample	No. Fish [a]	No. Sample	No. Fish [a]	No. Sample	No. Fish [a]	No. Sample	No. Fish [a]	%
6/30, 7/01, 7/03	97	M	796	1	31,821	40	14,319	18	0	0	46,936	61%
(6/26 – 7/5)		F	0	0	19,888	25	10,342	13	0	0	30,230	39%
		Subtotal	796	1	51,709	65	24,661	31	0	0	77,166	100%
7/08	174	M	0	0	34,986	75	12,595	28	0	0	47,581	59%
(7/6 – 7/11)		F	466	1	23,791	50	9,330	20	0	0	33,587	41%
		Subtotal	466	1	58,777	125	21,925	48	0	0	81,168	100%
7/14, 7/15	184	M	905	2	36,627	81	7,235	17	0	0	44,766	54%
(7/12 – 7/17)		F	452	2	3,462	73	4,522	19	0	0	38,436	46%
		Subtotal	1,357	4	70,089	154	11,757	36	0	0	83,202	100%
7/20, 7/21	174	M	757	2	22,343	59	3,787	10	0	0	26,887	41%
(7/18 – 7/23)		F	2,651	7	32,947	87	3,408	9	0	0	39,006	59%
		Subtotal	3,408	9	55,290	146	7,195	19	0	0	65,893	100%
7/25	176	M	1,573	5	20,769	66	2,203	7	0	0	24,545	44%
(7/24 – 7/31)		F	2,832	9	24,230	76	3,461	11	315	2	30,838	56%
		Subtotal	4,405	14	44,999	142	5,664	18	315	2	55,383	100%
Season	805	M	4,031	8	146,546	322	40,139	89	0	0	190,716	53%
		F	6,401	16	134,317	298	31,063	72	315	1	172,096	47%
		Total	10,432	24	280,863	620	71,202	161	315	1	362,812	100%

[a] Estimated escapement in numbers of fish.

Table 4.–Beach seine catch by species, Aniak River sonar, 2002.

Date	Chinook	Sockeye	Coho	Pink	Chum	Whitefish	Dolly Varden	Sucker
06/30	0	0	0	1	49	4	0	17
07/01	0	0	0	7	26	4	0	24
07/03	3	0	0	12	107	4	0	21
07/09	1	3	0	14	301	1	0	6
07/14	0	0	0	7	106	2	12	4
07/15	0	1	0	21	98	0	2	5
07/20	0	0	0	2	120	2	5	5
07/21	1	0	0	2	92	0	3	2
07/26	0	0	0	4	219	6	0	5
Season Totals	**5**	**4**	**0**	**70**	**1,118**	**23**	**22**	**89**

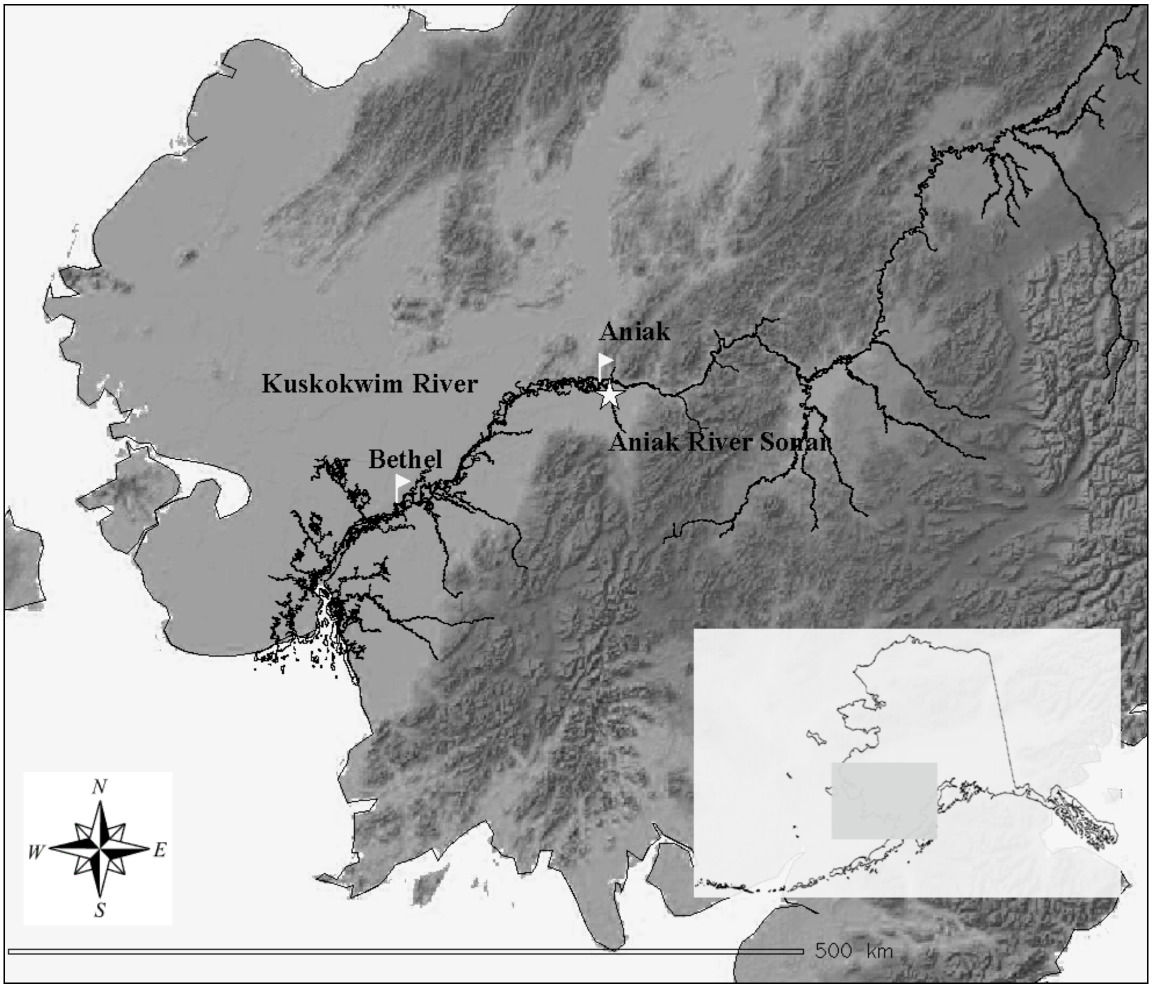


Figure 1.–Kuskokwim River area.

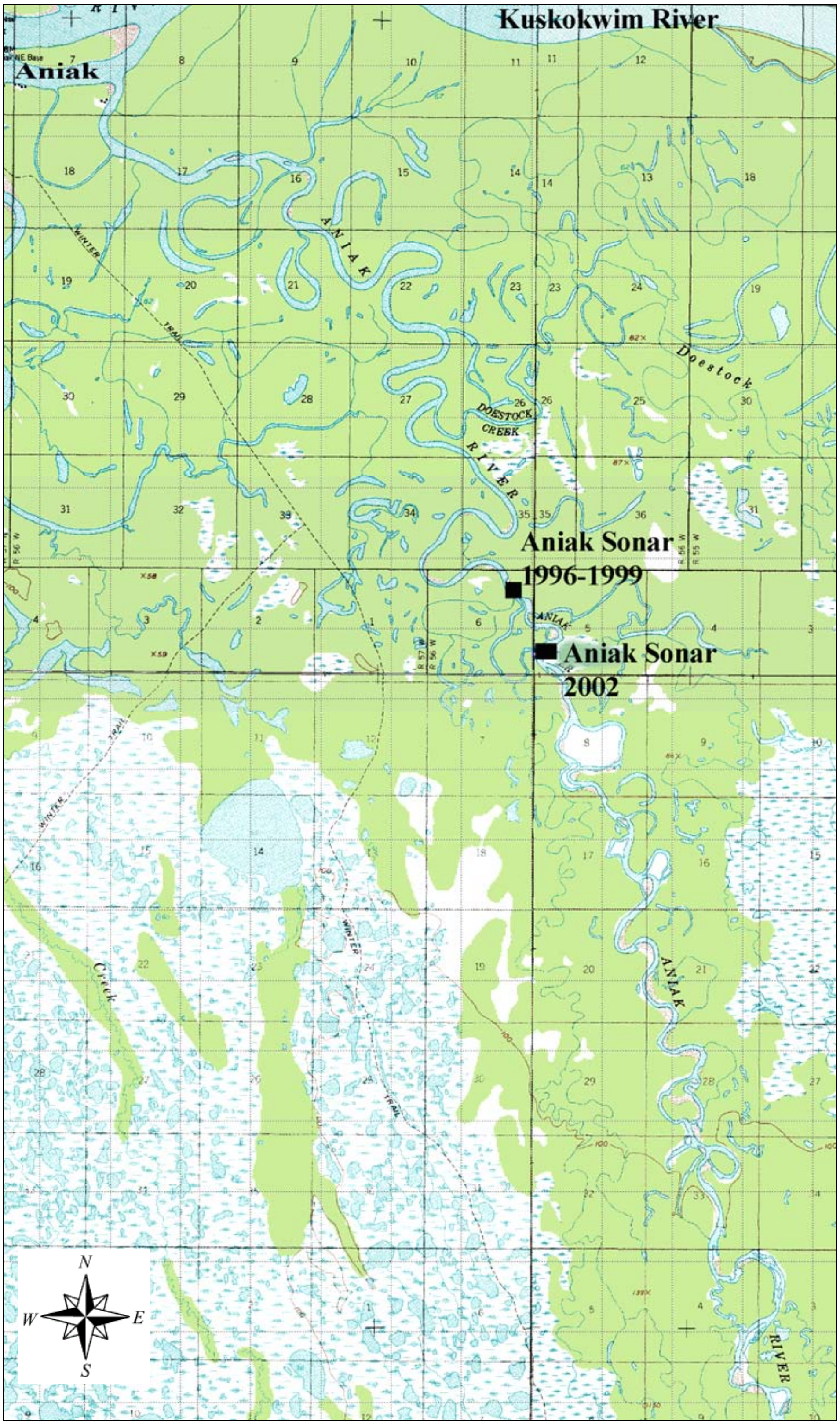
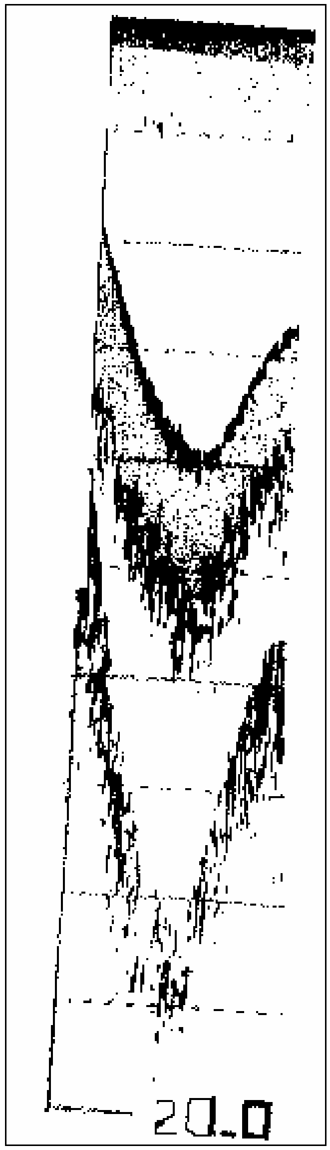
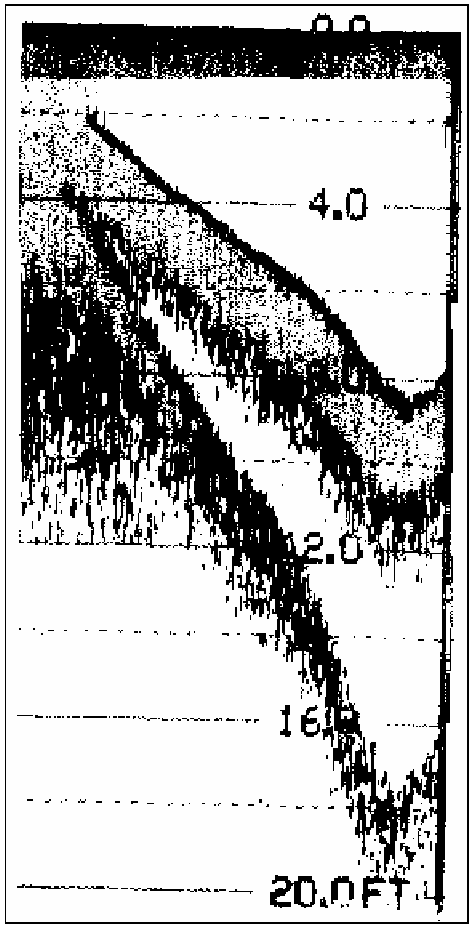


Figure 2.–Location of Aniak River sonar site, 2002.



Note: depth in feet.

Figure 3.–Right bank profile, Aniak River sonar, 2002.



Note: depth in feet.

Figure 4.–Left bank profile, Aniak River sonar, 2002.

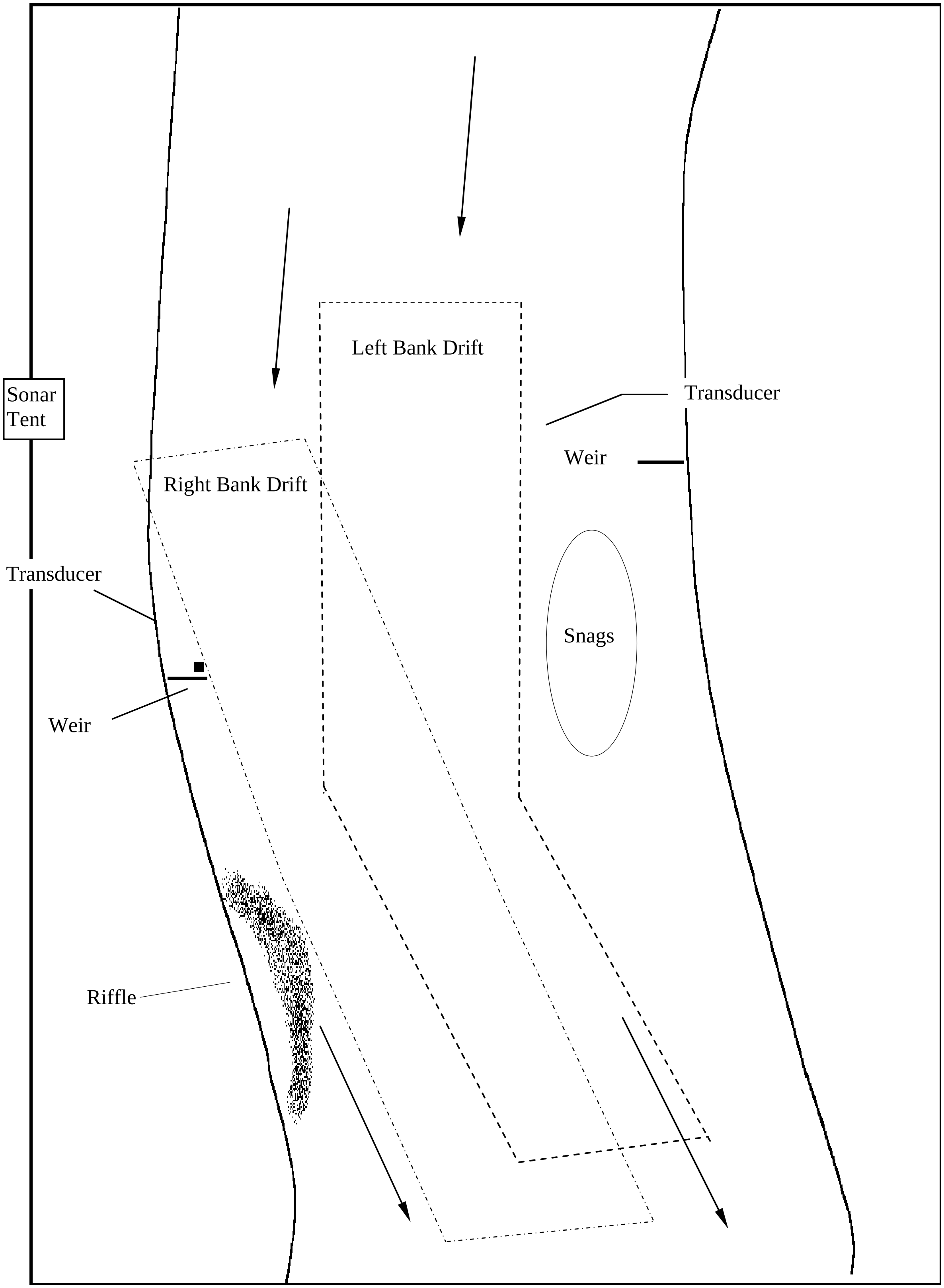


Figure 5.–Drift gillnet stations, Aniak River, 2002.

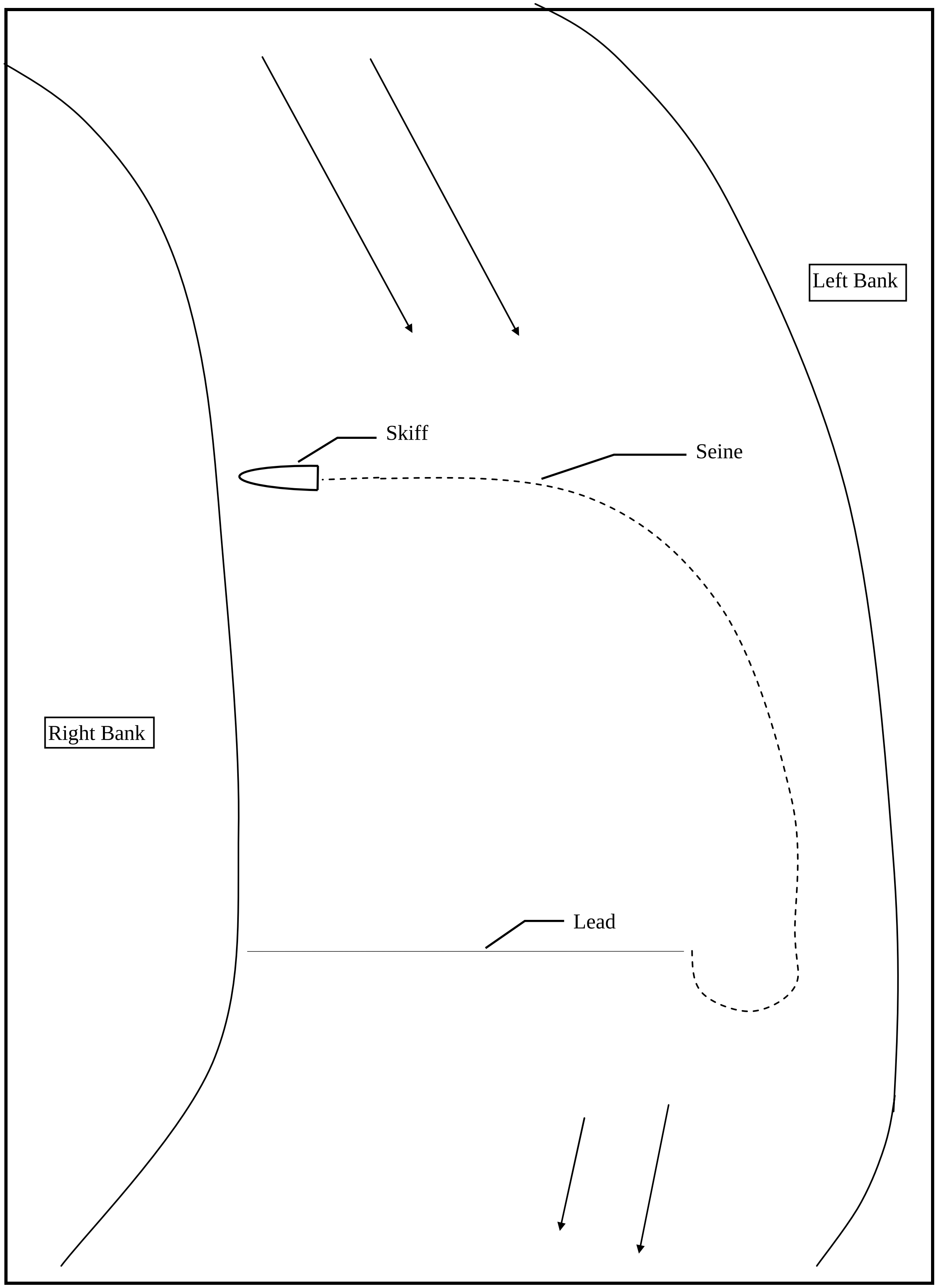


Figure 6.–Beach seine deployment method, Aniak River, 2002.

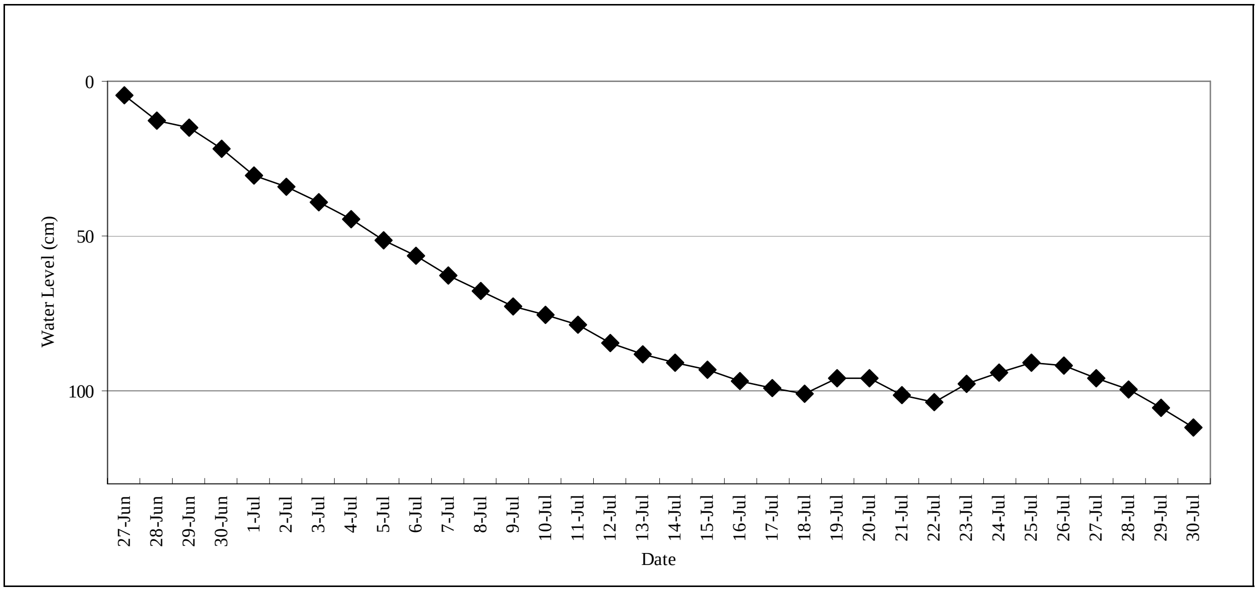


Figure 7.–Water level, Aniak River sonar, 2002.

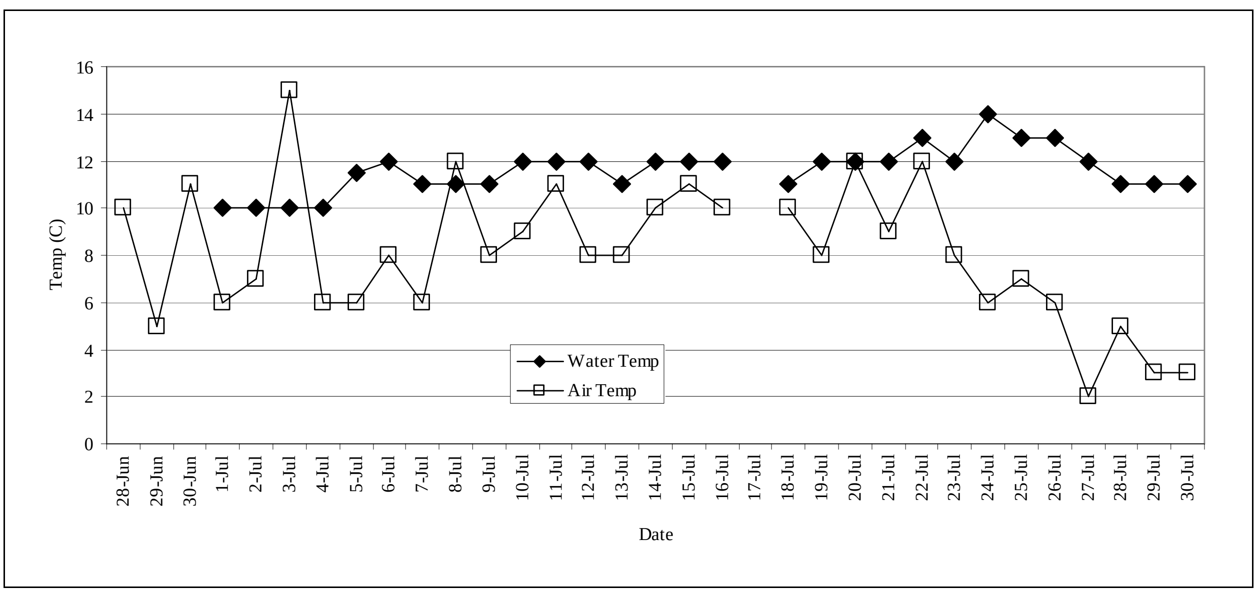


Figure 8.–Air and water temperatures, Aniak River sonar, 2002.

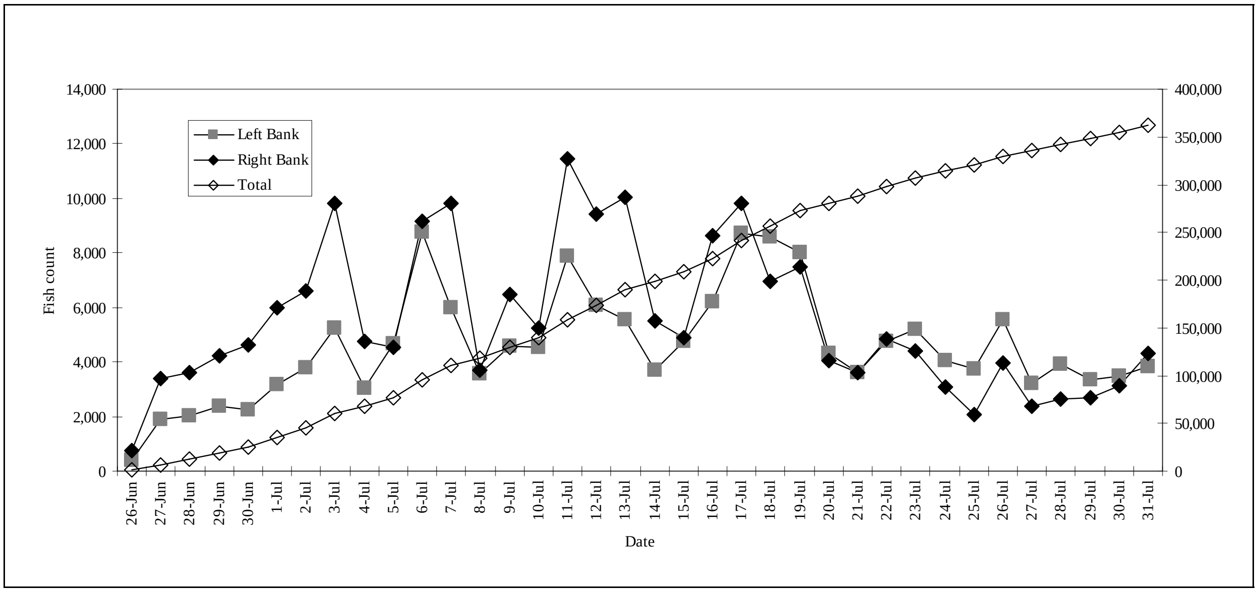


Figure 9.–Daily and cumulative fish passage estimates, Aniak River Sonar, 2002.

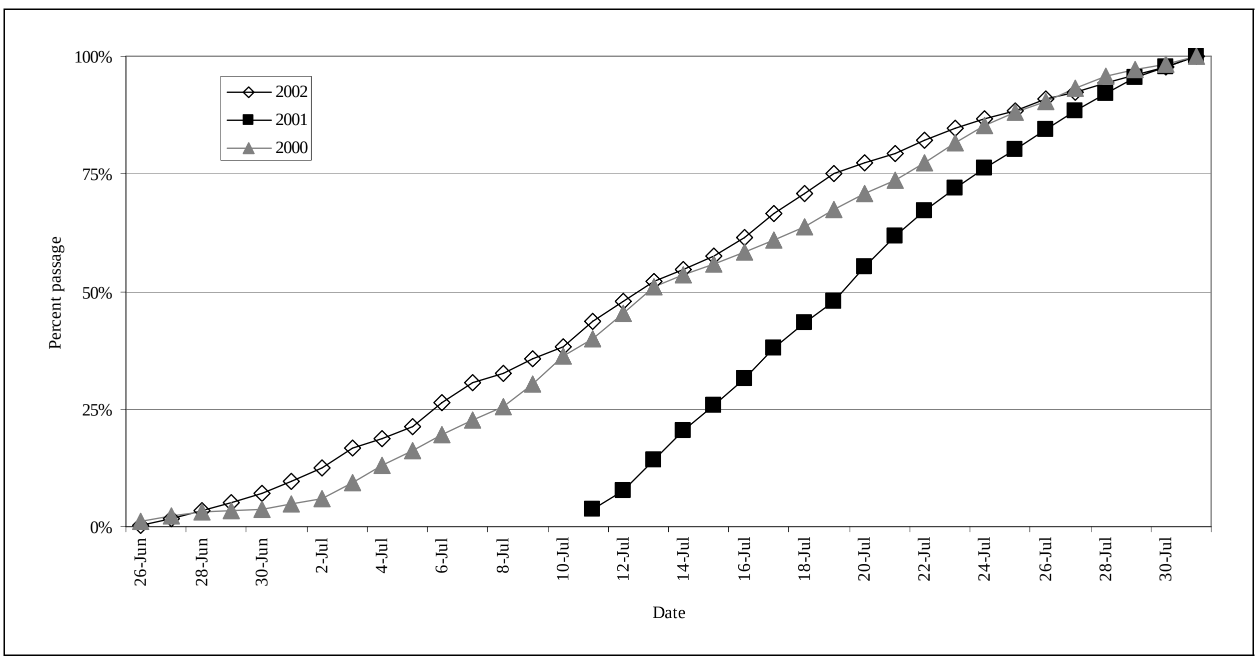


Figure 10.–Fish passage quartiles, Aniak River Sonar, 2000–2002.

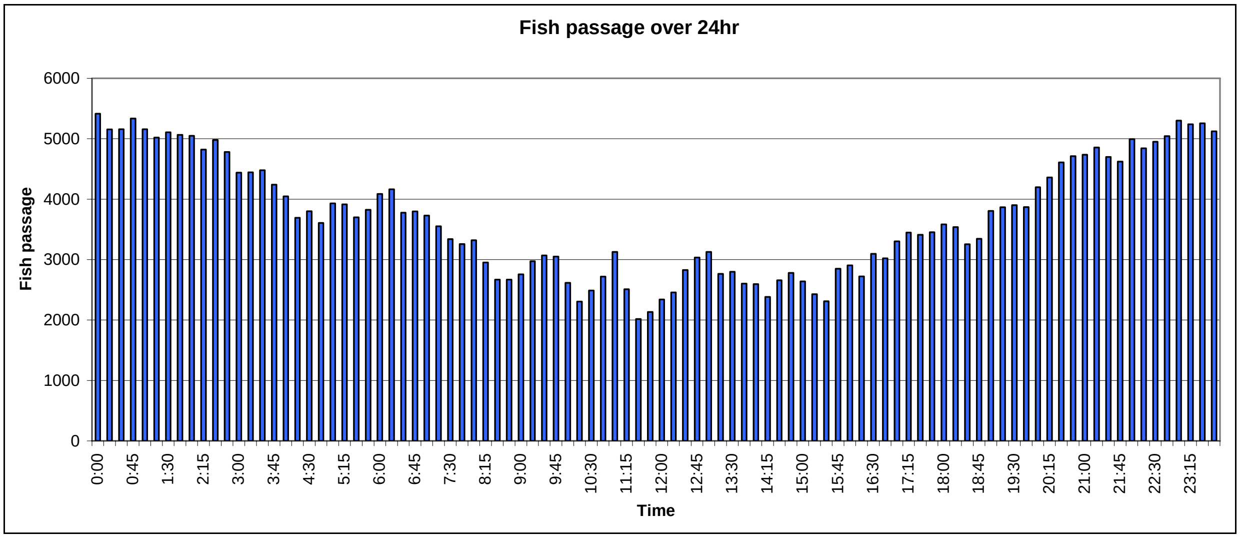


Figure 11.–Hourly fish passage, Aniak River sonar, 2002.

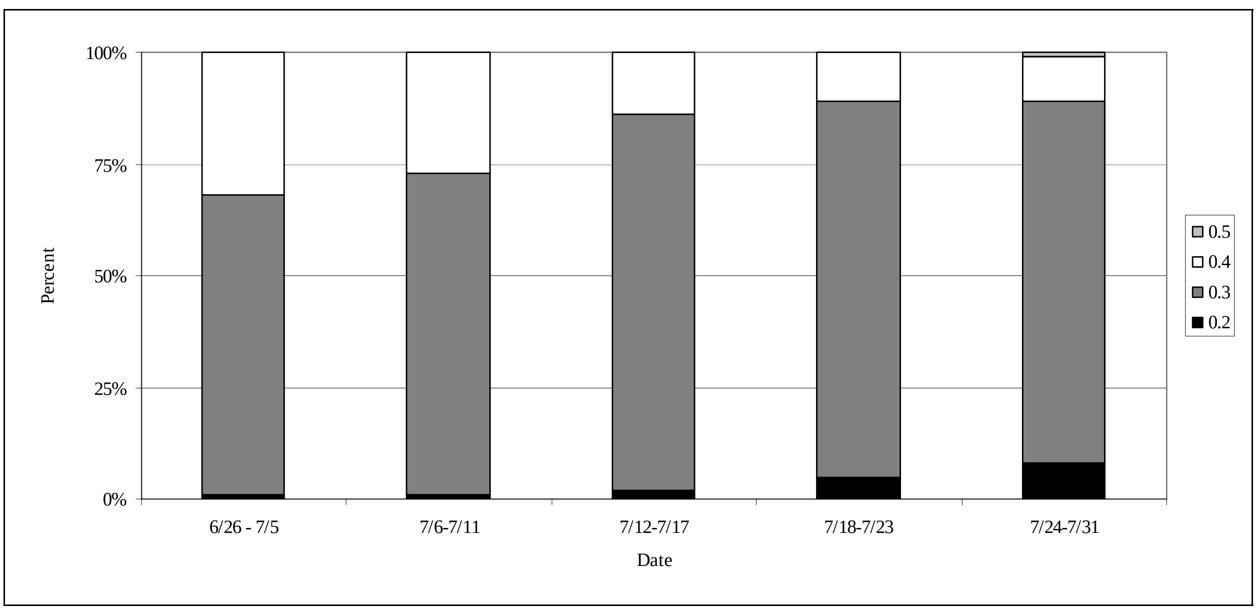


Figure 12.–Age composition of chum salmon, Aniak River sonar, 2002.

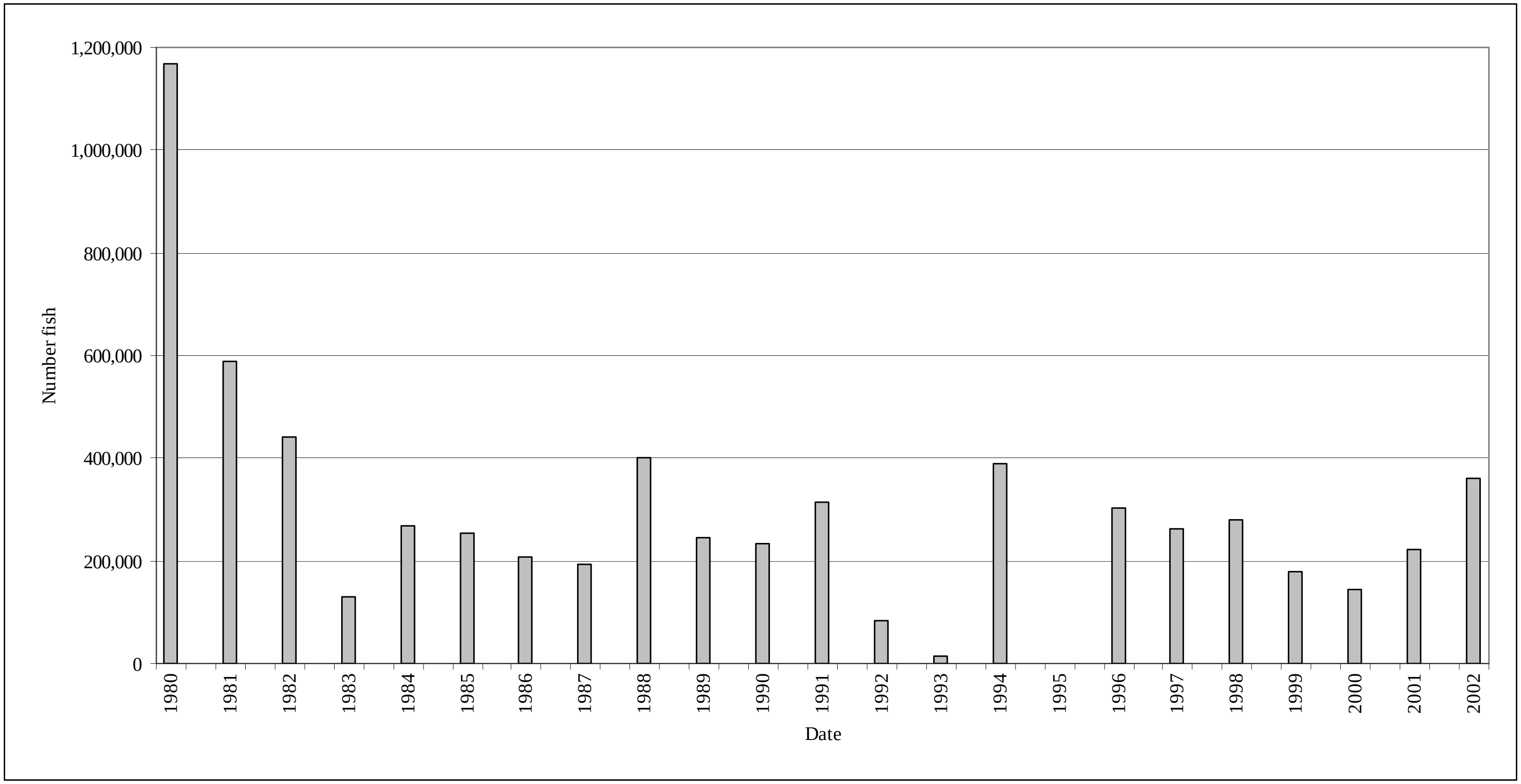


Figure 13.–Population estimate, Aniak River sonar, 1980–2002.

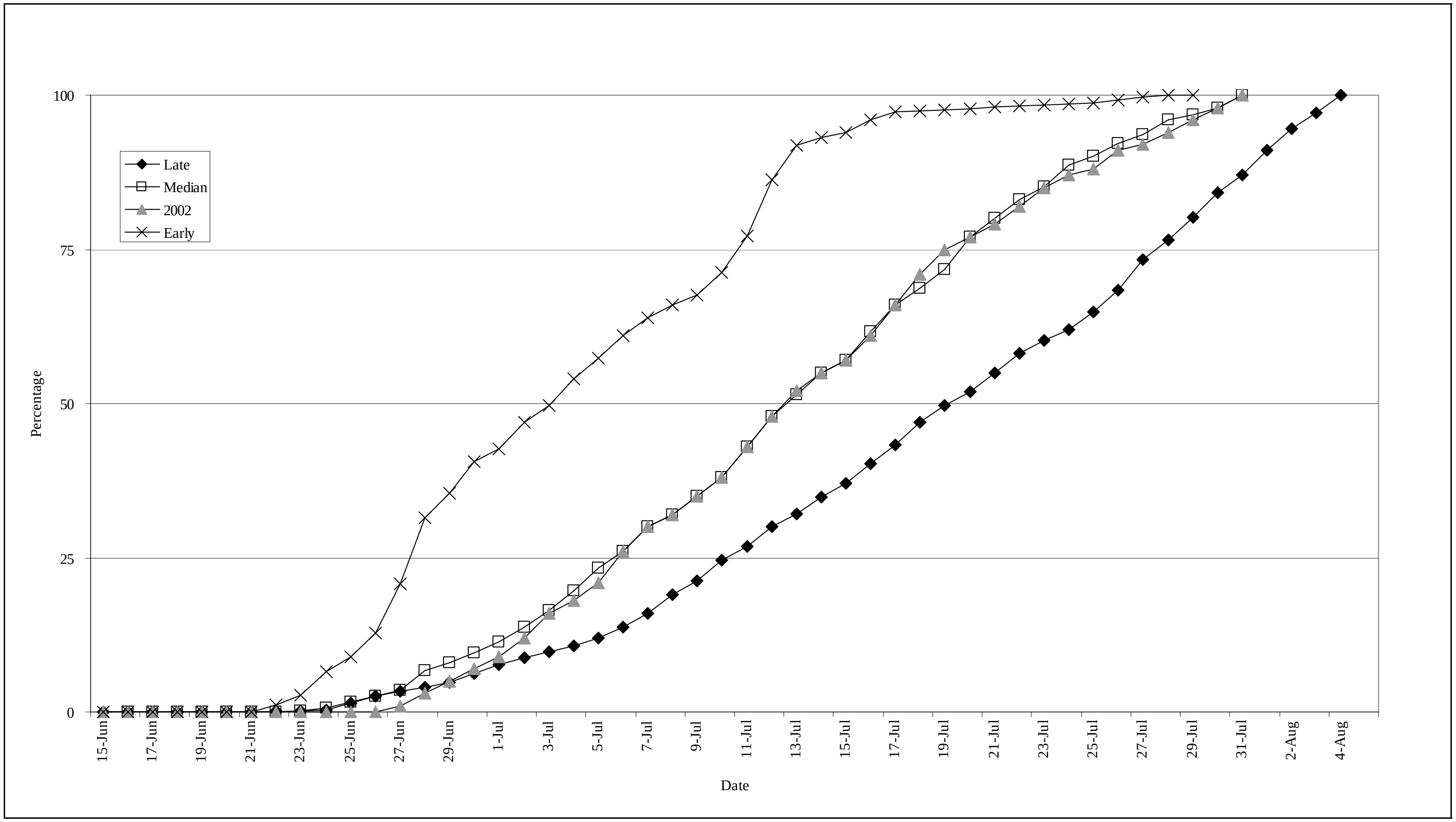
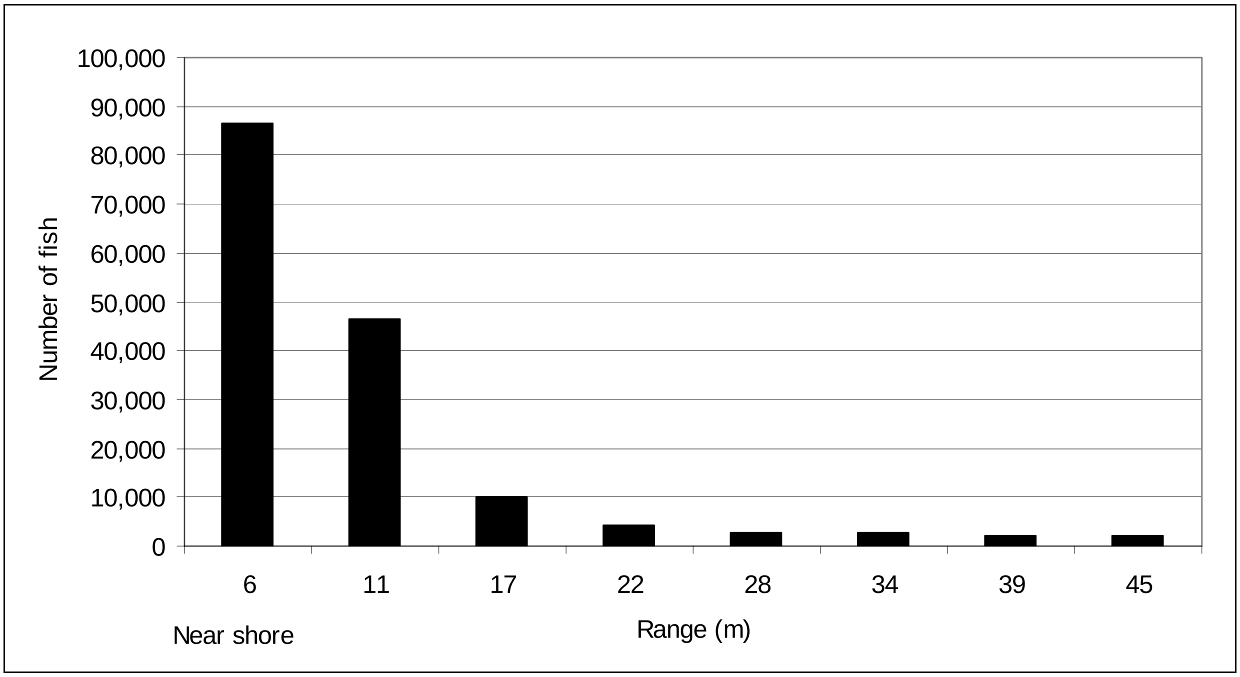
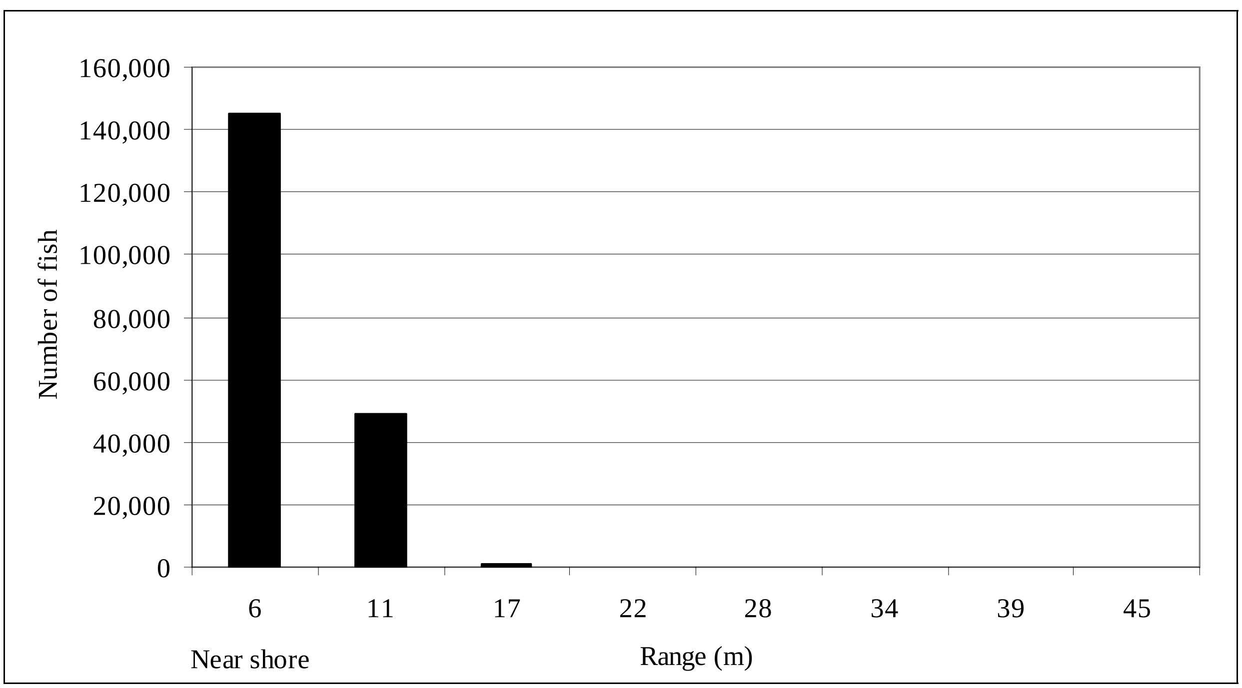


Figure 14.–Historical early, late, and median percent passage at Aniak River sonar, 1980–2002.



Note: Each range is maximum distance from shore.

Figure 15.–Left bank adjusted sonar estimates by range.



Note: Each range is maximum distance from shore.

Figure 16.–Right bank adjusted sonar estimates by range.

APPENDIX A: PROJECT HISTORY

Appendix A1.–Timetable of developmental changes at the Aniak River sonar project, 1980–2002.

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, 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 king 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 king 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 king salmon • Sonar estimates are not extrapolated for pre- and post-season salmon escapement (1983–1984, 1990, 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
1985	• Cumulative adjusted daily sonar estimates expanded by 162% to account for salmon passing outside the ensonified area • 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

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YEAR	EVENT
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
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
2002	• Species Apportionment Program is added to the project, which involved test fishing twice daily and expanding crew • Sonar operations remain the same as years 1996–2001 • Species apportionment program operates for second season with similar methodology to 2001