ANIAK RIVER SONAR PROJECT REPORT
1999

by

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REGIONAL INFORMATION REPORT[1] NO. 3A00-10

Alaska Department of Fish and Game
Division of Commercial Fisheries, AYK Region
333 Raspberry Road
Anchorage, AK 99518

January 2000

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ACKNOWLEDGMENTS

Commercial Fisheries Division staff who provided assistance with inseason operation and maintenance of the field camp and all aspects of data collection were Sean Palmer, Timothy Drumhiller, Doug Lieb, and Jason Westdahl. William Hoffman of the Association of Village Council Presidents also provided assistance with inseason operation and maintenance of the field camp and all aspects of data collection. Additionally, Thomas Vania was instrumental in camp setup, including the initialization of hydroacoustic data acquisition. Larry DuBois provided age class results of scale samples. Steve Parry and Suzanne Maxwell provided project oversight, technical support, and review of this report. Larry Buklis, Dan Huttunen, and Doug Molyneaux also provided critical review of this report.

OFFICE OF EQUAL OPPORTUNITY STATEMENT

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ABSTRACT

The Aniak River sonar project provided daily estimates of fish passage from 1 July through 3 August, 1999. 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 177,771 fish passed through the ensonified area during the period of operation. The peak daily passage of 10,613 fish occurred on 25 July, and the 50% passage date occurred on 20 July. The four and five-year age classes of Aniak River chum salmon comprised an estimated 59.6% and 39.9% of the escapement estimate, respectively.

INTRODUCTION

The Kuskokwim River commercial salmon fishery in June and July is directed toward the harvest of chum salmon *Oncorhynchus keta*. Commercial chum salmon harvests from 1988-1998 averaged 428,581 fish (Appendix A.1) and the exvessel value from in-river harvests averaged approximately $830 thousand (Burkey et al. 1999). The 1999 commercial harvest for chum salmon was 23,006 fish valued at $17 thousand. From 1988 to 1998, an average 91,237 chum salmon were harvested annually for subsistence purposes (Appendix A.2).

Management of the fishery resource requires timely estimates of run strength and escapement. Past sonar escapement estimates and aerial survey indices of abundance suggest that the Aniak River is one of the largest producers of chum salmon in the Kuskokwim drainage (Francisco et al. 1995). Prior tagging studies suggest that travel time of chum salmon migrating from the upper end of District 1 to the Aniak River sonar site is about seven or eight days (ADF&G 1961 and 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 supposition that on the order of two-thirds of the run passed through the ensonified portion of the river.

A second sonar counter was temporarily operated for a few days in 1984 to refine the expansion factor applied to the daily counts (Schneiderhan 1985). The second counter was deployed 1.5 km downstream from the existing counter and alternately operated on each bank. The proportions between daily counts at the historical site and each bank of the downstream site over a 16-day period resulted in a new expansion factor of 162%. This expansion factor was used from 1984 through 1995. In addition to the expansion of daily totals, sonar estimates were extrapolated for salmon escapement occurring before and after the operational period.

In the early 1980's, gillnet test fishing provided species apportionment and age, sex, and length (ASL) information of chum and chinook salmon (*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 decrease

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

operating costs. Supporting the decision to abandon chum salmon ASL data collection was previous age and sex composition data that indicated Aniak River chum salmon results were similar to commercial catch results from the lower Kuskokwim River districts (Schneiderhan 1988).

Salmon escapement objectives for the Aniak River were tentatively set at 250,000 chum and 25,000 chinook salmon in 1981, and formally established in 1982. The chum salmon objective was derived subjectively by relating historical sonar passage estimates to trends in harvest and aerial survey indices (Schneiderhan 1982b). In 1983, a review of the escapement objective based upon sonar estimates and other escapement indices suggested that the 1980-81 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 due to inadequate sample sizes (Schneiderhan 1988). Early gillnet and beach seine test fishing investigations indicated that 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, 1982b, 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). With the implementation of the Salmon Escapement Goal Policy, the Aniak River escapement objective was termed 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. Season sonar estimates were not extrapolated for salmon escapement that occurred before and after the operational period. A new sonar data collection site was established 1.5 km downstream from the historical site (Figure 1). 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.

Project operations in 1999 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.3.

The 1999 Aniak River sonar project objectives were to:

1) Collect fish abundance data with user-configurable sonar equipment 24 hours per day on both banks throughout the bulk of the chum salmon migration, from approximately 22 June through 31 July.
2) Provide daily fish passage estimates to fishery managers in Bethel.
3) Periodically drift a suite of gillnets to qualitatively monitor general trends in species composition, and to corroborate acoustically detected fish abundance trends.
4) Collect and archive ASL samples from chum salmon captured in beach seines.

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 (Figure 2). The Aniak River originates in the Aniak Lake basin about 145 km east and 32 km south of Bethel, Alaska. It flows north for nearly 129 km, where it joins the Kuskokwim River 1.6 km upstream from the community of Aniak.

The river at the sonar site is characterized by broad meanders, with large gravel bars on the inside bends and cutbanks 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 101-034) 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 2842A04372) digital storage oscilloscope (DSO) was 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 it with 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 89-020) 120/420 kHz echosounder configured to transmit and receive at 420 kHz; 2) a 3^{o}x10^{o} Biosonics dual beam 420 kHz elliptical transducer; 3) two 304.8 m (1000 ft) Belden model 8412 cables (SN 701A, 702A); and 4) a Biosonics model 111 (SN 111-88-041) 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 215) 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 orange flagging to allow safe boat passage.

Sampling Procedures

We conducted single beam acoustic sampling on both banks continuously 24 h per day, 7 days per week, except for short periods of time in which 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 h. For consistency, crew members were trained to distinguish between fish traces and non-fish traces, such as those from debris and bottom. The number of fish traces was summed 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 Excel97 electronic spreadsheets by the project leader. Daily estimates were transmitted via single side band radio to area managers at 0730 h 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 then 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; 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 and left bank transmit pulse width at 0.4 ms and later changed the left bank transmit pulse width to 0.3 ms on 4 July for less than 24 hours, and then back to 0.4 ms for the remainder of the season. Maximum sampling range was 40 m on the right bank and 90 m on the left bank. Minimum sampling range was 14 m on the right bank and 60 m on the left bank. Three printer thresholds, corresponding to intensities of gray-line were factory set at 6 dB intervals. Right bank chart recorder thresholds were set at -39.8, -33.8, and -27.8 dB during all sampling activities. The first left bank threshold was initially set at -39.9 dB, then changed to -40.0 dB on 8 July for the remainder of the season, with corresponding second and third thresholds at -34 and -28 dB.

Thresholds were calculated as follows:

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

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

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

Transducer Deployment

The transducers were positioned in the river perpendicular to current flow. 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 5 to 9 m from the right bank, and 10 to 19 m from the left bank. Daily visual inspections confirmed proper placement and orientation of the transducers.

Weirs extended from shore 3 to 8 m beyond the transducers to prevent chum salmon from passing undetected behind the transducers and to minimize detections in the near field (MacLennan and Simmonds 1992). The gap between weir pickets, 4.4 cm (1 ¾ in), was selected to divert chum salmon but allow passage of small, resident, non-target species.

Hydroacoustic Equipment Checks

Both sonar systems were bench calibrated in May, 1999 (Appendix B.1). We estimated noise levels in situ at three range intervals for the right bank sonar system and at five intervals for the left bank sonar system by measuring the average peak voltage (256 pings) on the DSO. For our purposes, we defined noise as any unwanted signal including boundary and volume

reverberation, electronic noise, and ambient background noise. Structure reverberation peaks separated the selected range intervals.

Bottom Profiles and Stream Measurements

We recorded numerous bottom profiles outward from both banks using the chart recording fathometer prior to choosing exact deployment sites. On 29 June, we made paired depth and range measurements in 2 to 3 m intervals from each transducer to the opposite shore on both banks using the fathometer and a Laser Atlanta model Advantage (SN 10365) optical laser range finder.

Climatological and Hydrologic Measurements

In 1999, we measured ambient air temperature, and water conductivity and temperature once per day using an Extech model 34165 Conductivity/Temperature meter. Standard secchi disk readings were taken daily. Water level was recorded daily on the right bank at the site using a staff gauge..

In 1998, we established a benchmark to reference daily water level measurements and to be able to make valid comparisons between years. The benchmark at the southeast corner of the sonar tent platform is indicated by a black rectangular mark. We used the laser range finder to measure distance and angle from the benchmark to the staff gauge.

Analytical Methods

Abundance Estimation

Actual sonar counts in a spreadsheet are computed by time/space and summed for each bank. Counts are assumed to represent all fish passing the sonar site.

Missing Data

Generator maintenance, sonar equipment adjustments and malfunctions occasionally resulted in missing sonar data. 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. Data missing from more than 10 minutes were estimated from the average relative distribution (proportions) of passage rates 45 minutes before and after the missing block of data on that bank. When more than one hour of data were missed on both banks, the average

proportions of passage rates were pooled from six hours before and after the missing block of data on that bank respectively. A right bank/left bank average proportion of passage rates was used to estimate fish passage when one of the sonar systems remained operational while the other was down for more than one hour. The number of fish traces tallied for both banks was summed with estimates for missing data to provide daily total fish passage estimates.

Species Composition Verification

Equipment and Procedures

We fished two gillnets periodically at 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. We used a 13.6 cm (5-3/8") mesh multifilament net measuring 18.3 m (10 fathoms) long by 3.1 m (10 feet) deep and a 7.0 cm (2-3/4") mesh multifilament net measuring 18.3 m (10 fathoms) long by 1.5 m (five feet) deep. Each net was drifted at least once on each bank during the sampling period (Figure 3). Most drifts were approximately 2-3 minutes in duration. 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, and unharmed fish were released back into the river.

ASL Sampling

Equipment and Procedures

The gravel bar in front of the sonar camp was used as the sampling site for the second consecutive year. We 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. We moved the skiff straight offshore until all of the lead line was deployed and the seine started to peel out of the tote. We then drove 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 we 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 4). 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 mid-eye to the fork of the tail. All data 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 one or two 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 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 by age and sex.

RESULTS

Hydroacoustic Data Acquisition

Sampling Procedures

Sonar project activities commenced on 16 June and ended on 5 August 1999. Hydroacoustic sampling began mid-day on 30 June on both banks with the first full 24-hour period occurring on

July 1. A later than normal spring break-up caused high water in mid-June, which delayed the planned startup date by about one week (Appendix A.4). With few exceptions, the equipment ran continuously until sampling ended at midnight on 3 August. Passage estimates were available to fishery managers in Bethel at 0730 hours and 1700 hours daily. In addition to regular maintenance, a total of 15 hours (less than 2%) on the left bank and 12 hours on the right bank of sampling time were missed due to paper jams, system diagnostic tests, moving the tripod, or aiming the transducer to compensate for changing water levels throughout the season.

Signal to noise ratios (SNR's) of approximately 10 dB on the right bank and 18 dB on the left bank were common. Higher noise levels occurred on the right and left bank over narrow range intervals where the beam grazed high points in the river bottom with SNR's around 3 dB. Data collection at these points however, was not unduly corrupted since only a small range was affected.

Bottom Profiles and Stream Measurements

The river width on 29 June at the sonar site was 105 m and the maximum depth was 4.2 m (Figure 5). The thalweg was located 30 m from the right bank and 75 m from the left bank. Cross talk 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 177,771 fish, with 59% passing on the right bank and 41% passing on the left bank (Table 1). A comparison of daily estimated passage between banks is presented in Figure 6 with a linear regression fit line. The significant ($p<0.001$) relationship indicates that left and right bank passages are correlated to one another. The peak daily passage of 10,613 fish occurred on 25 July (Figure 7). The 25%, 50%, and 75% quartile dates of passage were 12 July, 20 July, and 26 July (Table 1).

We examined the hourly fish count data for evidence of daily patterns of movement during 7-day periods of data collection. All time periods displayed fish passage increasing at night and declining during the day (Figure 8). This tendency was more pronounced than the 1998 estimates, but similar to the 1996 and 1997 passage estimates (Vania and Huttunen 1997, Vania 1998, Vania 1999).

Seasonal range distributions of targets that passed the site peaked at 5-10 m from the right bank transducer (Figure 9) and at 11-20 m from the left bank transducer (Figure 10). Less than 1% of the right bank targets passed through the outer 15 meters of the right bank sampling range (Table 2). The outer 10 meter sampling range on the left bank accounted for less than 1% of the left

bank passage estimates (Table 3). As the season progressed, the fish passage distribution on the left bank demonstrated an increasingly inshore movement.

Species Composition Verification

We conducted gillnet drifts lasting two to three minutes during three sampling periods to verify dominant species presence (Table 4). Sonar fish passage rates during these sampling periods ranged from 136 to 284 fish per hour. We made a total of 24 drifts, 9 with 13.6 cm mesh gillnets and 15 with 7.0 cm mesh gillnets. The total catch consisted of 22 chum salmon, 1 chinook salmon, 1 pink salmon (*O. gorbuscha*), 9 longnose suckers (*Catostomus catostomus*), and 3 humpback whitefish (*Coregonus clupeaformis*).

ASL Sampling

We made a total of 101 beach seine sets and obtained 1,003 ASL samples from migrating chum salmon (Table 5). The 0.3 and 0.4 age classes for chum salmon comprised an estimated 59.6% and 39.9% of the Aniak River escapement estimate in 1999, respectively (Table 6). The percentages of 0.3 and 0.4 age class chum salmon were similar to the 1996 and 1997 seasons, but differed from the 1998 season that demonstrated an exceptionally low percentage of 0.4 fish (Appendix A.5).

DISCUSSION

Hydroacoustic Data Acquisition

Sampling Procedures

For the 1999 season, we changed from the 120 kHz counter frequency used since 1996 to 420 kHz. One benefit was that the 420 kHz transducers are much smaller in size, allowing us greater flexibility with changing water levels. This meant less sampling time lost from moving weirs and tripods, and reaiming. 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, beneficial in the fast Aniak River waters.

In the past, chart recordings displayed evidence of fish occasionally passing within the near field. The 420 kHz transducers have a shorter near field (~1.0 m) than the 120 kHz transducers (~10.0 m), which reduces the likelihood of fish passing through this zone. Higher frequency transducers are characterized by greater attenuation. However, the short sampling ranges employed at the site minimize the effect of transmission loss at this higher frequency.

Fish Passage Estimates

For 1999, the mid-point of the run occurred on 20 July, five days later than the average for years dating back to 1996 when we implemented the use of user configurable sonar (Appendix A.6). Peak passage occurred on 25 July with 10,613 fish, which is considerably smaller than the average peak passage of 17,400 dating back to 1996. The 1999 total passage of 177,771 was well below the 250,000 BEG, and it was the lowest reported passage since user configurable sonar has been in use on the Aniak River (Appendix A.7).

The comparison of daily left bank percent passage rates for years 1996 through 1999 show the daily and seasonal changes in fish migration patterns at the sonar site (Figure 11). A comparison between water level and percent passage by bank may explain some of this variation. Water level measurements are relative only to the year in which they were taken for 1996 and 1997, and thus cannot be directly compared. For 1998 and 1999 however, water levels were set to a permanent benchmark. An analysis of each season indicates an inverse relationship between left bank percent passage and water level with correlation coefficients ranging from –0.38 in 1999 to –0.75 in 1998 (Figure 12). A large gravel bar below the right bank transducer becomes exposed at lower water levels and appears to divert a higher percentage of fish through the left bank ensonified range.

Three of the past four seasons have experienced left bank passage percentages between 37% and 41%. The exception was 53% in 1997, a notoriously dry summer in the Kuskokwim Area, with water levels notably low on the Aniak River.

Species Composition Verification

Although the Aniak River supports anadromous and resident fish populations of several different species, the sonar estimates are not apportioned to species. Gillnet and beach seine test fishing investigations in the early 1980's indicated that the abundance of fish other than chum salmon was insufficient to compromise the utility of passage estimates for making chum salmon management decisions. However, recent beach seine sampling conducted near the sonar site to obtain ASL samples of chum salmon has included significant numbers of several non-target

resident and anadromous species that are 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 has made available funds for Kuskokwim River salmon fisheries research and management. This funding source will support the development of a species apportionment study to complement the Aniak River sonar project. Development requires a multi-year commitment and funding has been provided for three field seasons starting in 2000. Estimates of passage by species are not expected to be available until after the final year of data collection. Coupled with the Kuskokwim River sonar project near Bethel, the apportioned Aniak River sonar escapement would provide fishery managers information on the proportionate contribution of Aniak River chum salmon stocks to the total Kuskokwim River chum salmon escapement.

A secondary consideration to implementing a species apportionment program has been the potential for unacceptable levels of collateral fish mortality due to additional netting and fish handling.

In 1998, we retained fish captured from two drift gillnet operations in a live box to observe the effects of netting and handling. Extraordinary care was given in handling the first catch, which we retained for six hours. All of the salmon (18 chum, 2 sockeye, and 1 coho) appeared healthy and vigorously swam away when released. The remaining fish, two whitefish and one inconnu died. These fish appeared healthy when placed in the live box and may have sustained fatal injury while in the live box.

The second catch was handled in a manner more consistent with a typical test fishing operation with less care given to the fish while the speed of the operation increased. We retained this catch for five hours, which consisted of 24 chum salmon, 2 chinook salmon, 2 pink salmon, and 1 longnose sucker. All of the fish except two chum salmon survived and swam away upon release.

It appears that some mortality can be expected, but with short drift periods and careful handling, we may be able to keep the fish mortality to a minimum. Below the current site, there is a bend in the river that collects large amounts of large woody debris. For a successful gillnetting operation at this location, much time and effort will be required to remove the debris prior to fishing. If it's not possible to remove the vast majority of the debris, it will be necessary to pull the net into the boat at the end of the drift to prevent hooking the snags with the net. With such a strategy, fish survival will likely be minimal.

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 1.5 km upstream of the sonar site and only the extreme nearshore portion of the river was fished. While these data provide valuable biological ASL information on the chum salmon escapement, they are insufficient to provide quantitative species apportionment information.

Fish Tethering

We conducted a fish tethering experiment for a rough estimate of target strength on suckers, whitefish, and chum salmon. Fish used in the experiment were captured in the beach seine, held overnight in a live box, and then transported to the sonar site in a large tote the next day.

To begin the experiment, we anchored the boat in the sonar beam. Next, a line was lowered into the water with a 10-pound lead weight attached. Using the lead ball, we found the location in the beam producing the maximum amplitude echo corresponding to the on-axis position. Next, we attached a 3 m (10 ft) section of monofilament line to the lead ball and tested to make sure we weren't getting the TS of the lead weight. We then attached a fish to the monofilament line using a single hook. Placing the fish on-axis, we recorded voltage estimates using the DSO. To verify that echoes were from the tethered fish, the target was displaced in and out of the beam and noted on the chart output. Biologists kept in contact using a hand-held radio. All tethered fish were visible and swam downstream of the lead ball with the fishing line taut.

Target strength average measurements were made using the display average function (128 pings) on the DSO. The average target strength measurement for suckers and whitefish was approximately -33 dB, well within the project's sampling threshold of -40 dB. The small and large chum salmon target strength's averaged approximately -34 and -31 dB respectively.

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 due to a lack of project documentation and the inability of the Bendix equipment 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.

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TABLES

Table 1. Daily and cumulative estimates of fish passage at the Aniak River sonar site, 1999.

Date	Left Bank	Right Bank	Daily Total	Cumulative Total	LB % Passage	RB % Passage	Percent Passage	Water Level [a]
1-Jul	571	733	1,303	1,303	0.44	0.56	1%	179
2-Jul	737	1,196	1,933	3,236	0.38	0.62	2%	183
3-Jul	582	1,069	1,651	4,887	0.35	0.65	3%	190
4-Jul	691	1,009	1,700	6,588	0.41	0.59	4%	203
5-Jul	866	1,738	2,604	9,192	0.33	0.67	5%	217
6-Jul	894	2,673	3,567	12,758	0.25	0.75	7%	227
7-Jul	880	3,645	4,525	17,283	0.19	0.81	10%	222
8-Jul	1,300	3,528	4,828	22,111	0.27	0.73	12%	230
9-Jul	1,446	3,295	4,741	26,852	0.30	0.70	15%	237
10-Jul	1,810	4,058	5,868	32,720	0.31	0.69	18%	238
11-Jul	1,878	3,423	5,301	38,021	0.35	0.65	21%	244
12-Jul	2,120	4,215	6,334	44,355	0.33	0.67	25%	253
13-Jul	1,615	3,710	5,325	49,680	0.30	0.70	28%	262
14-Jul	977	2,949	3,926	53,606	0.25	0.75	30%	257
15-Jul	1,634	3,620	5,254	58,860	0.31	0.69	33%	263
16-Jul	1,961	3,299	5,260	64,120	0.37	0.63	36%	265
17-Jul	2,730	3,959	6,689	70,809	0.41	0.59	40%	267
18-Jul	2,973	2,931	5,904	76,713	0.50	0.50	43%	273
19-Jul	2,971	3,384	6,355	83,068	0.47	0.53	47%	278
20-Jul	3,488	4,382	7,870	90,938	0.44	0.56	51%	272
21-Jul	2,545	3,380	5,925	96,863	0.43	0.57	54%	272
22-Jul	2,137	2,510	4,647	101,510	0.46	0.54	57%	278
23-Jul	3,712	4,377	8,089	109,599	0.46	0.54	62%	280
24-Jul	4,838	5,203	10,041	119,640	0.48	0.52	67%	284
25-Jul	4,990	5,623	10,613	130,253	0.47	0.53	73%	283
26-Jul	2,988	3,325	6,313	136,566	0.47	0.53	77%	284
27-Jul	1,922	1,653	3,575	140,141	0.54	0.46	79%	287
28-Jul	2,777	3,149	5,926	146,066	0.47	0.53	82%	292
29-Jul	2,998	3,191	6,189	152,255	0.48	0.52	86%	292
30-Jul	2,873	3,125	5,998	158,253	0.48	0.52	89%	296
31-Jul	3,089	2,970	6,059	164,312	0.51	0.49	92%	300
1-Aug	2,498	2,676	5,173	169,485	0.48	0.52	95%	306
2-Aug	1,788	2,222	4,009	173,495	0.45	0.55	98%	309
3-Aug	1,472	2,804	4,276	177,771	0.34	0.66	100%	313
Total	**72,749**	**105,022**	**177,771**	**177,771**	**0.41**	**0.59**		

[a] Measured centimeters below benchmark.

Table 2. Estimated right bank daily fish passage per range strata, Aniak River sonar, 1999.

	Right Bank Strata					
	1	2	3	4	5	6
	Distance from right bank transducer (m)					
	0-5	6-10	11-15	16-20	21-25	26-30
1-Jul	170	517	14	8	3	0
2-Jul	478	695	10	1	3	7
3-Jul	407	629	7	4	4	6
4-Jul	350	647	4	3	4	1
5-Jul	1,000	577	21	0	8	2
6-Jul	2,091	495	71	2	0	0
7-Jul	2,936	637	72	0	0	0
Week Total	7,432	4,197	199	18	22	16
Passage	62.5%	35.3%	1.7%	0.2%	0.2%	0.1%
8-Jul	2,755	654	117	2	0	0
9-Jul	2,625	554	113	3	0	0
10-Jul	3,126	789	143	0	0	0
11-Jul	2,538	788	95	2	0	0
12-Jul	2,365	1,662	176	1	0	0
13-Jul	2,427	924	148	0	0	0
14-Jul	2,390	443	116	0	0	0
Week Total	18,226	5,814	908	8	0	0
Passage	73.0%	23.3%	3.6%	0.0%	0.0%	0.0%
15-Jul	2,786	474	137	0	0	0
16-Jul	2,804	397	98	0	0	0
17-Jul	3,165	548	109	4	0	0
18-Jul	2,163	642	82	0	0	0
19-Jul	2,517	729	131	1	0	0
20-Jul	2,972	1,136	266	5	0	0
21-Jul	2,191	807	377	5	0	0
Week Total	18,598	4,733	1,200	15	0	0
Passage	75.8%	19.3%	4.9%	0.1%	0.0%	0.0%
22-Jul	1,468	742	277	14	0	0
23-Jul	1,371	1,772	252	134	163	0
24-Jul	2,896	1,712	586	9	0	0
25-Jul	3,400	1,620	602	1	0	0
26-Jul	1,723	1,141	416	2	0	0
27-Jul	436	926	288	0	0	0
28-Jul	736	1,850	469	7	1	0
Week Total	12,030	9,763	2,890	167	164	0
Passage	48.1%	39.0%	11.6%	0.7%	0.7%	0.0%
29-Jul	901	1,789	492	1	0	0
30-Jul	847	1,802	474	2	0	0
31-Jul	731	1,615	563	1	0	0
1-Aug	697	1,482	428	24	0	0
2-Aug	1,067	864	180	44	0	0
3-Aug	1,433	1,190	109	0	0	0
Week Total	5,676	8,742	2,246	72	0	0
Passage	33.9%	52.2%	13.4%	0.4%	0.0%	0.0%
Season Total	**61,962**	**33,249**	**7,443**	**280**	**186**	**16**
Passage	**60.1%**	**32.2%**	**7.2%**	**0.3%**	**0.2%**	**0.0%**

Table 3. Estimated left bank daily fish passage per range strata, Aniak River sonar, 1999.

	Left Bank Strata						
	1	2	3	4	5	6	7
	Distance from right bank transducer (m)						
	0-10	11-20	21-30	31-40	41-50	51-60	61-70
1-Jul	26	160	89	36	103	141	15
2-Jul	24	195	130	46	118	179	43
3-Jul	24	146	108	39	83	147	30
4-Jul	24	147	75	31	75	215	23
5-Jul	17	111	91	50	159	406	32
6-Jul	3	163	101	51	189	372	15
7-Jul	5	133	110	66	150	389	27
Week Total	123	1,055	704	319	877	1,849	185
Passage	2.4%	20.6%	13.8%	6.2%	17.2%	36.2%	3.6%
8-Jul	10	377	175	78	238	407	15
9-Jul	22	460	206	99	267	376	16
10-Jul	54	568	244	139	276	518	11
11-Jul	57	670	287	116	217	317	4
12-Jul	230	797	141	92	263	326	0
13-Jul	362	690	86	60	190	227	0
14-Jul	184	418	84	78	213	0	0
Week Total	919	3,980	1,223	662	1,664	2,171	46
Passage	8.6%	37.3%	11.5%	6.2%	15.6%	20.4%	0.4%
15-Jul	488	661	118	85	273	4	0
16-Jul	640	809	168	81	262	1	0
17-Jul	841	1,247	191	101	298	0	0
18-Jul	1,256	1,156	195	94	232	0	0
19-Jul	1,399	1,124	195	93	160	0	0
20-Jul	1,596	1,263	222	146	259	2	0
21-Jul	1,015	1,006	223	151	148	0	0
Week Total	7,235	7,266	1,312	751	1,632	7	0
Passage	39.7%	39.9%	7.2%	4.1%	9.0%	0.0%	0.0%
22-Jul	565	1,146	231	118	67	0	0
23-Jul	1,371	1,772	252	134	163	0	0
24-Jul	1,244	2,702	487	220	185	0	0
25-Jul	1,748	2,525	354	189	174	0	0
26-Jul	1,040	1,505	199	79	163	0	0
27-Jul	603	1,039	193	41	44	0	0
28-Jul	785	1,610	213	86	83	0	0
Week Total	7,356	12,299	1,929	867	879	0	0
Passage	31.5%	52.7%	8.3%	3.7%	3.8%	0.0%	0.0%
29-Jul	892	1,588	204	99	117	0	0
30-Jul	964	1,519	198	80	112	0	0
31-Jul	908	1,807	244	91	39	0	0
1-Aug	900	1,183	172	168	68	0	0
2-Aug	715	864	101	30	1	0	0
3-Aug	489	539	342	73	21	5	3
Week Total	4,868	7,500	1,261	541	358	5	3
Passage	33.5%	51.6%	8.7%	3.7%	2.5%	0.0%	0.0%
Season Total	**20,501**	**32,100**	**6,429**	**3,140**	**5,410**	**4,032**	**234**
Passage	**28.6%**	**44.8%**	**9.0%**	**4.4%**	**7.6%**	**5.6%**	**0.3%**

Table 4. Aniak River sonar catch results using drift gillnets, 1999.

Date	Time of Day	# of Drifts	Mesh (cm)	Chum	King	Pink	Sucker	Whitefish
7/27/99	1800-1820	3	13.6	2	0	0	0	0
Fish Passage – 136/h.								
7/27/99	1840-1900	2	7.0	0	0	0	0	0
Fish Passage – 136/h.								
7/30/99	1300-1400	2	13.6	4	1	0	0	0
Fish Passage – 229/h.								
7/30/99	1415-1430	7	7.0	6	0	0	7	3
Fish Passage – 229/h.								
7/30/99	2315-2400	6	13.6	9	0	0	0	0
Fish Passage – 284/h.								
7/31/99	0015-0045	4	7.0	1	0	1	2	0
Fish Passage – 284/h.								
Total		**24**		**22**	**1**	**1**	**9**	**3**

Table 5. Aniak River sonar catch results using beach seine gear, 1999.

Date	Time of Day	# of Sets	Avg. Fish Passage	Chum	King	Pink	SK[a]	Coho	WF[a]	Sucker	Pike	DV[a]	RB[a]	GL[a]	IN[a]	**Total Catch**	**Chum %**
7/03	2200-2400	8	98	21	1	0	1	0	4	11	3	0	0	0	1	**42**	**50**
7/04	2200-0030	8	135	38	2	0	0	0	3	8	1	0	1	1	1	**55**	**69**
7/05	2030-2230	8	159	52	2	0	0	0	7	17	0	0	0	1	1	**80**	**65**
7/06	2100-2300	5	239	61	4	0	2	0	5	15	1	0	0	0	0	**88**	**69**
7/10	2200-0030	8	336	95	4	0	5	0	13	17	0	0	0	0	1	**135**	**70**
7/11	2215-0030	8	360	114	4	0	3	0	12	22	2	0	0	0	0	**157**	**73**
7/12	2200-2245	2	292	27	1	0	0	0	4	18	0	0	0	0	0	**50**	**54**
7/16	2215-2330	4	295	49	0	0	4	0	7	9 (4 recaps)	0	2	2	0	1	**74**	**66**
7/17	2130-0045	8	292	99	0	1	7	0	14	16	1	0	3	1	0	**142**	**70**
7/18	2100-2245	4	256	38	2	0	2	0	7	3	0	0	0	0	0	**52**	**73**
7/22	2200-0115	8	547	127	3	2	1	0	27	29	2	1	0	0	1	**192**	**66**
7/23	2100-2345	6	364	75	3	11	0	0	19	23 (1 recap)	1	3	0	0	0	**132**	**56**
7/27	2245-0100	8	325	80	1	9	0	1	38	50 (4 recaps)	5	8	0	0	0	**192**	**42**
7/28	2200-0030	8	337	74 (1 recap)	1	6	0	0	33 (1 recap)	23 (1 recap)	0	8	0	0	0	**145**	**51**
7/29	2200-0030	8	399	53	1	10	0	0	54	12 (1 recap)	0	4	1	0	0	**135**	**39**
	Total	**101**		**1,003**	**29**	**39**	**25**	**1**	**247**	**273**	**15**	**26**	**7**	**3**	**6**	**1,674**	**60**
	%			**59.9**	**1.7**	**2.3**	**1.5**	**0.1**	**14.8**	**16.3**	**0.9**	**1.6**	**0.4**	**0.2**	**0.4**	**100.0**	

[a] WF = Whitefish DV = Dolly Varden RB = Rainbow Trout GL = Grayling IN = Inconnu SK = Sockeye

Table 6. Age and sex of beach seine caught chum salmon from Aniak River escapement samples, collected near the sonar site and applied to passage estimates by time stratum in 1999.

Sample Dates (Stratum Dates)	Sample Size	Sex	Age Class 0.2 Esc.	%	0.3 Esc.	%	0.4 Esc.	%	0.5 Esc.	%	Total Esc.	%
7/3	151	Male	0	0.0	3,661	16.5	8,054	36.4	146	0.7	11,861	53.6
(7/1 - 7/8)		Female	0	0.0	4,686	21.2	5,564	25.2	0	0.0	10,250	46.4
		Subtotal	0	0.0	8,347	37.7	13,618	61.6	146	0.7	22,111	100.0
7/10	182	Male	0	0.0	7,441	23.6	8,653	27.5	0	0.0	16,094	51.1
(7/9- 7/14)		Female	0	0.0	7,960	25.3	7,441	23.6	0	0.0	15,401	48.9
		Subtotal	0	0.0	15,401	48.9	16,094	51.1	0	0.0	31,495	100.0
7/16 - 7/18	175	Male	0	0.0	10,026	26.9	7,253	19.4	213	0.6	17,492	46.9
(7/15 - 7/20)		Female	213	0.6	12,586	33.7	7,039	18.9	0	0.0	19,839	53.1
		Subtotal	213	0.6	22,612	60.6	14,292	38.3	213	0.6	37,331	100.0
7/22-7/23	187	Male	0	0.0	12,194	31.0	6,307	16.0	0	0.0	18,501	47.1
(7/21 - 7/25)		Female	0	0.0	15,558	39.6	5,256	13.4	0	0.0	20,814	52.9
		Subtotal	0	0.0	27,752	70.6	11,563	29.4	0	0.0	39,315	100.0
7/27 - 7/29	192	Male	0	0.0	12,622	26.6	7,177	15.1	247	0.5	20,047	42.2
(7/26 - 8/3)		Female	0	0.0	19,304	40.6	8,167	17.2	0	0.0	27,471	57.8
		Subtotal	0	0.0	31,926	67.2	15,344	32.3	247	0.5	47,518	100.0
Season	887	Male	0	0.0	45,944	25.8	37,444	21.1	607	0.3	83,995	47.2
		Female	213	0.1	60,094	33.8	33,468	18.8	0	0.0	93,775	52.8
		Total	213	0.1	106,038	59.6	70,912	39.9	607	0.3	177,771	100.0

FIGURES

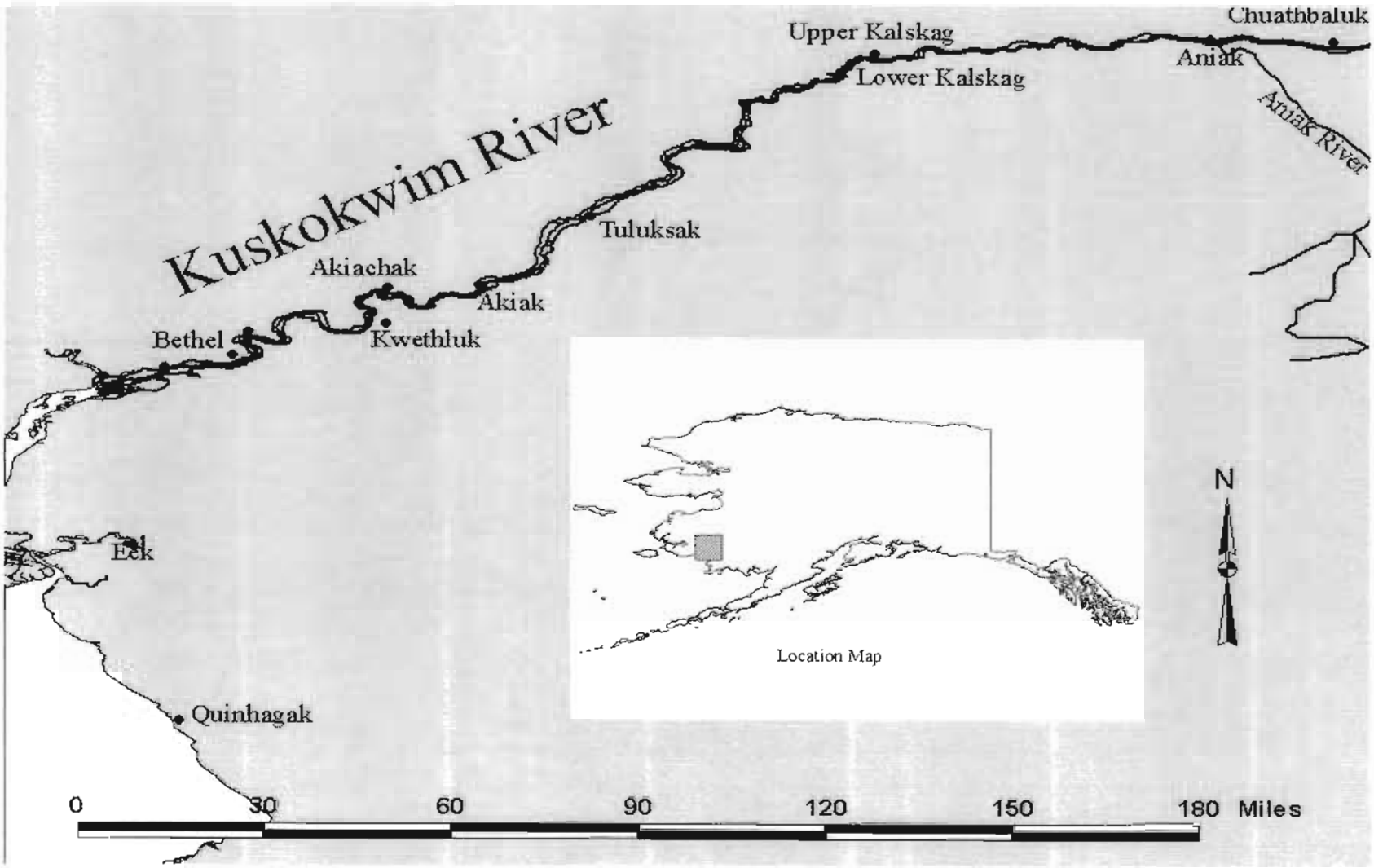


Figure 1. Map of the Kuskokwim Area.

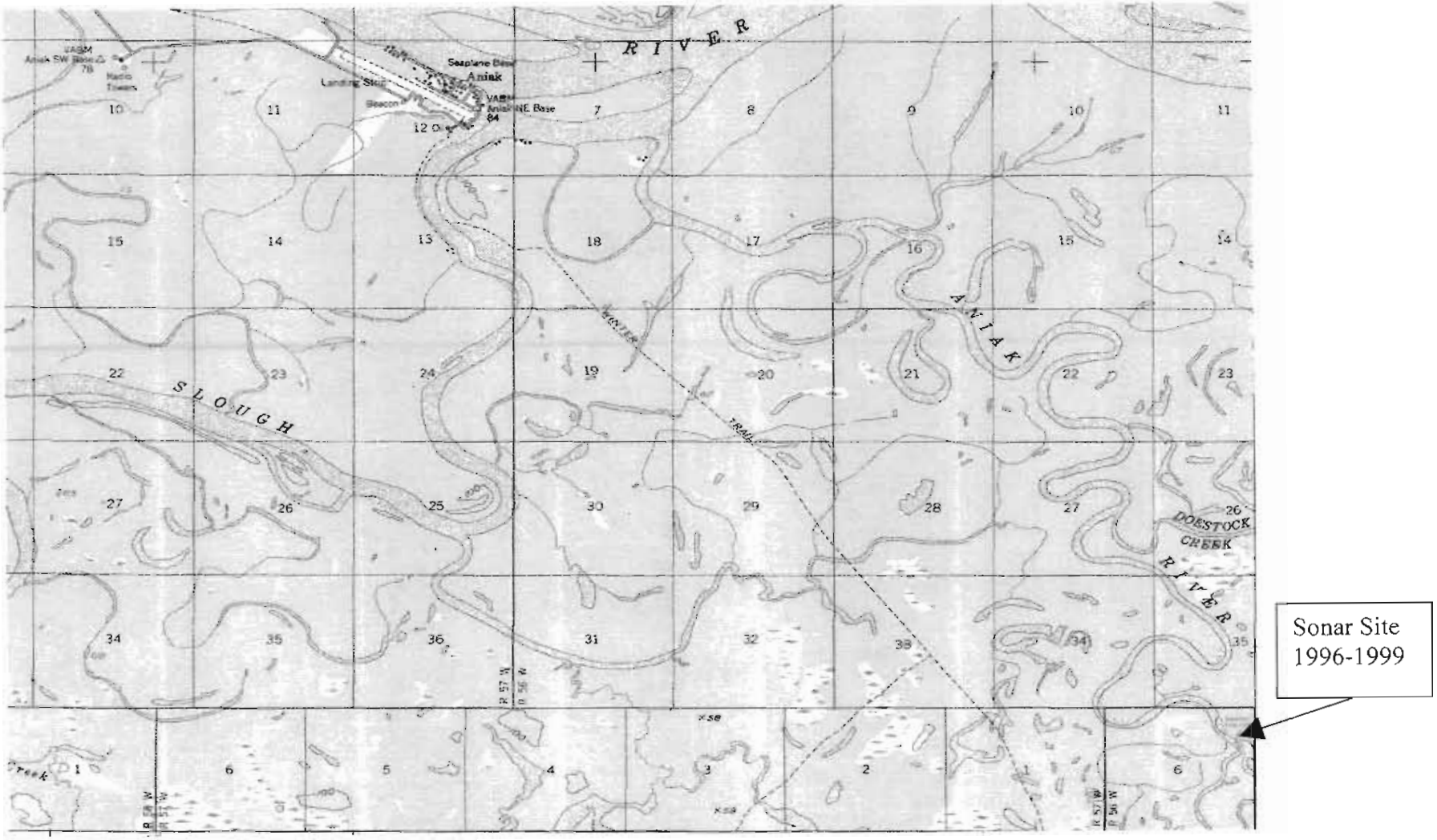


Figure 2. Aniak River sonar site map, 1999.

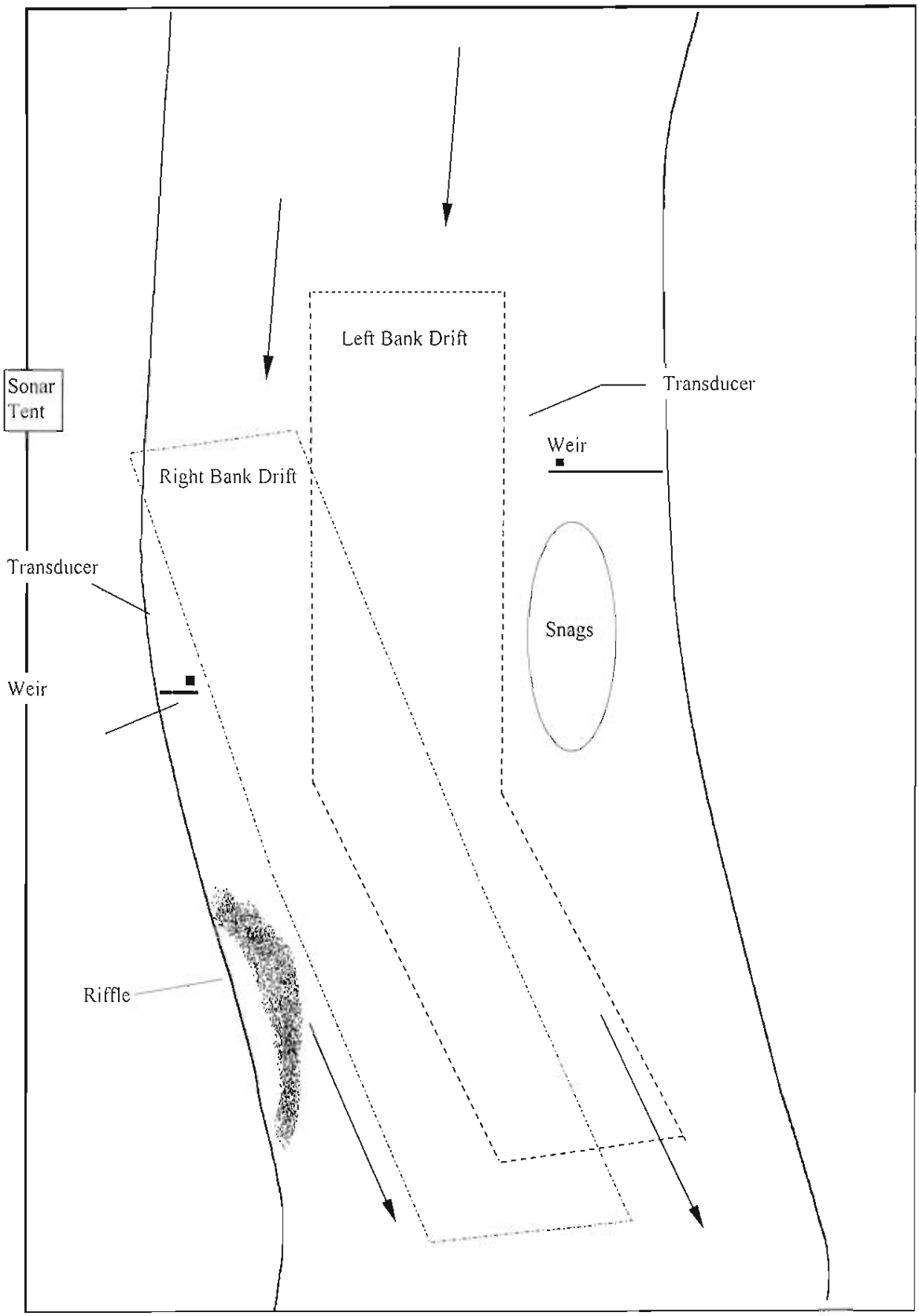


Figure 3. Aniak River drift gillnet stations, 1999.

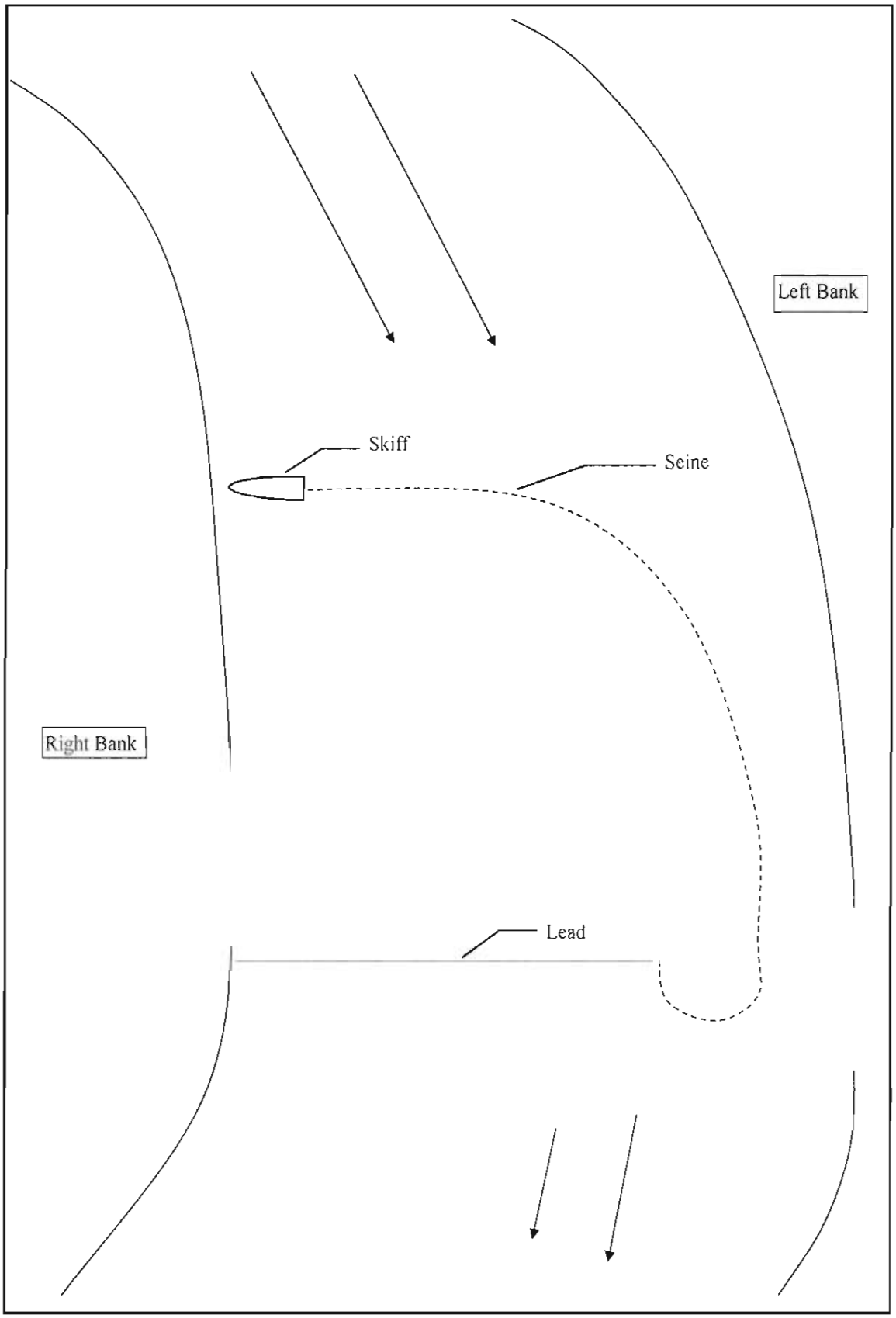


Figure 4. Beach seine deployment method, Aniak River, 1999.

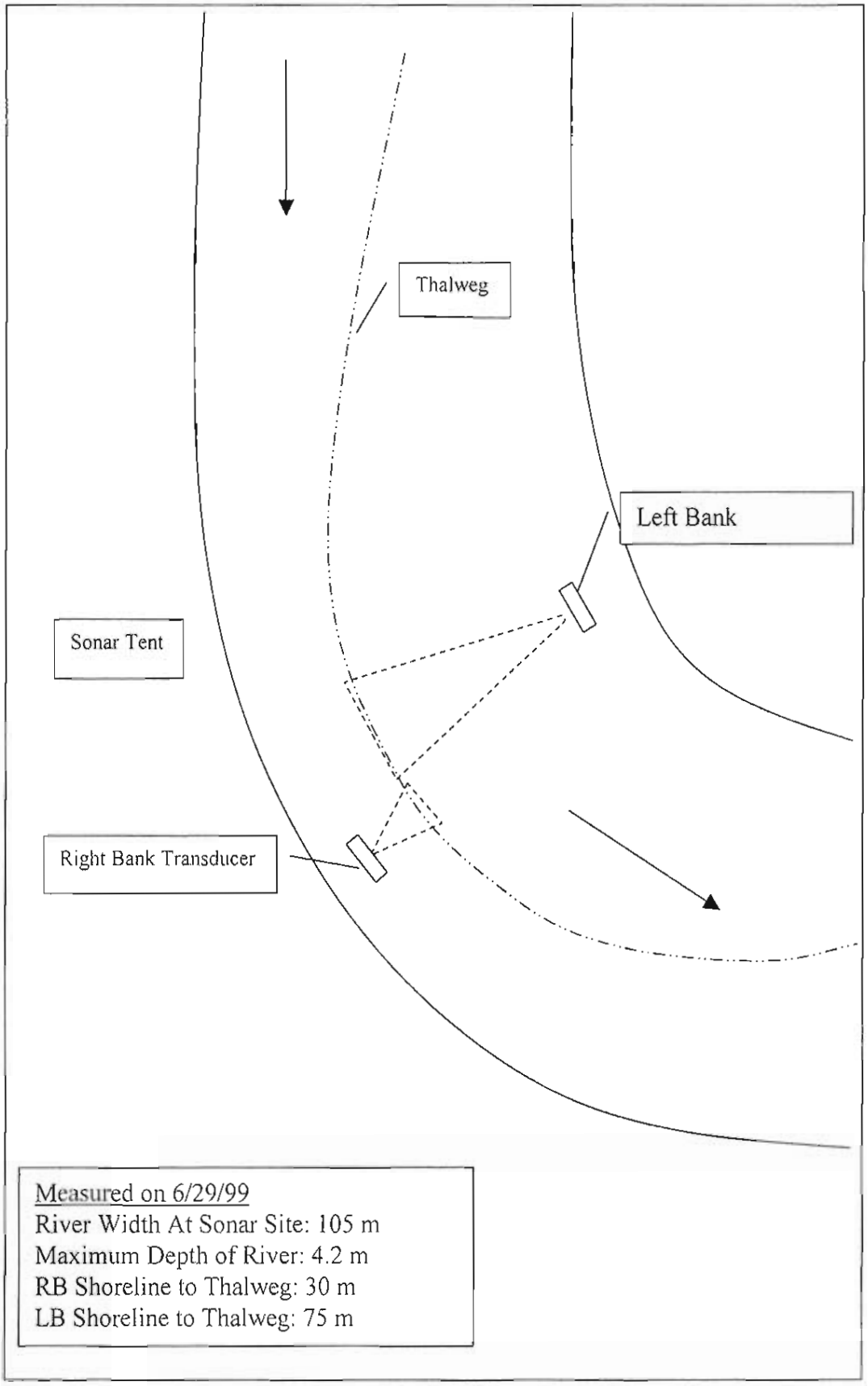


Figure 5. Aniak River sonar site stream measurements, 1999.

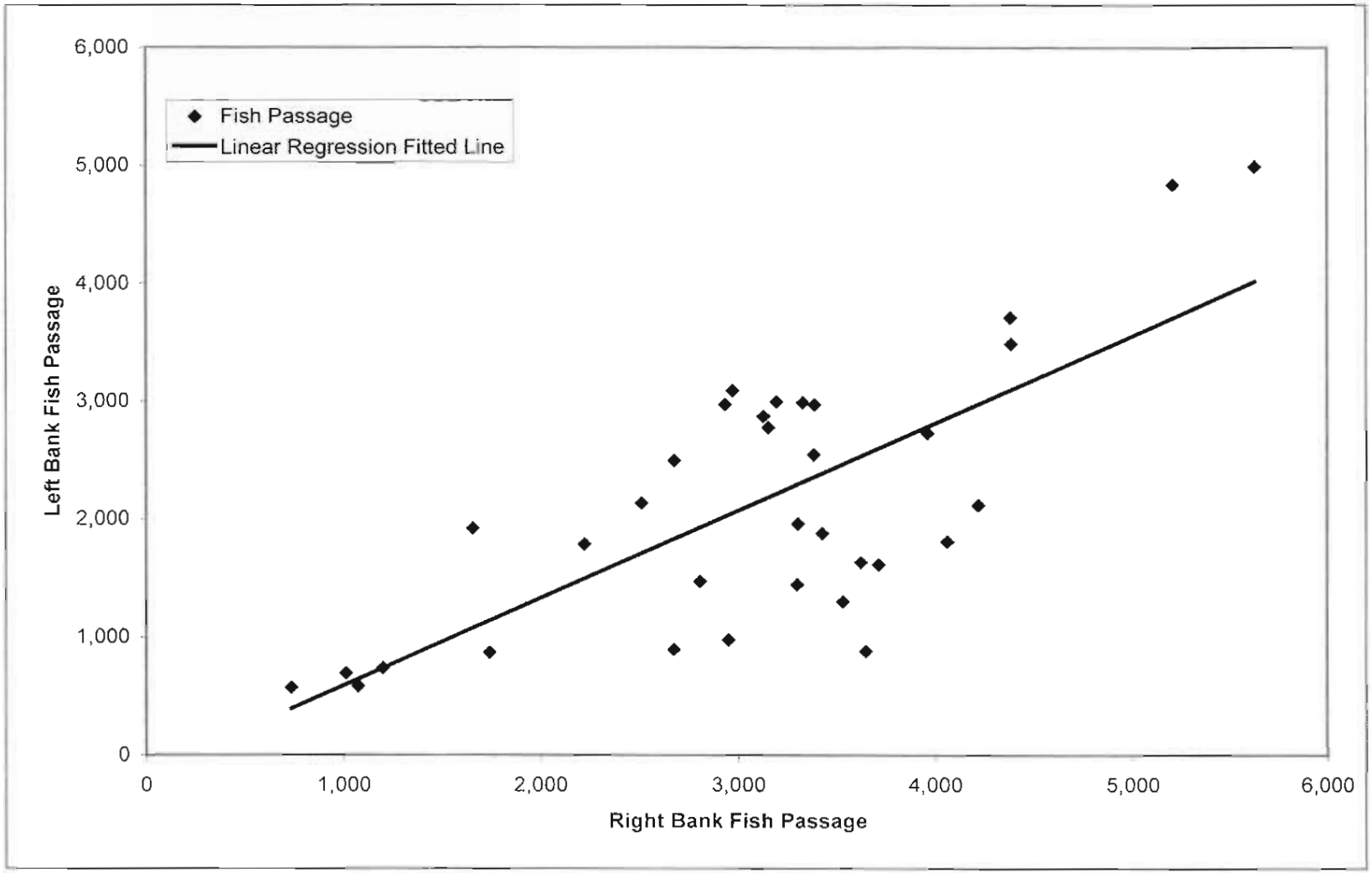


Figure 6. A comparison of daily estimated fish passage between banks, Aniak River sonar, 1999.

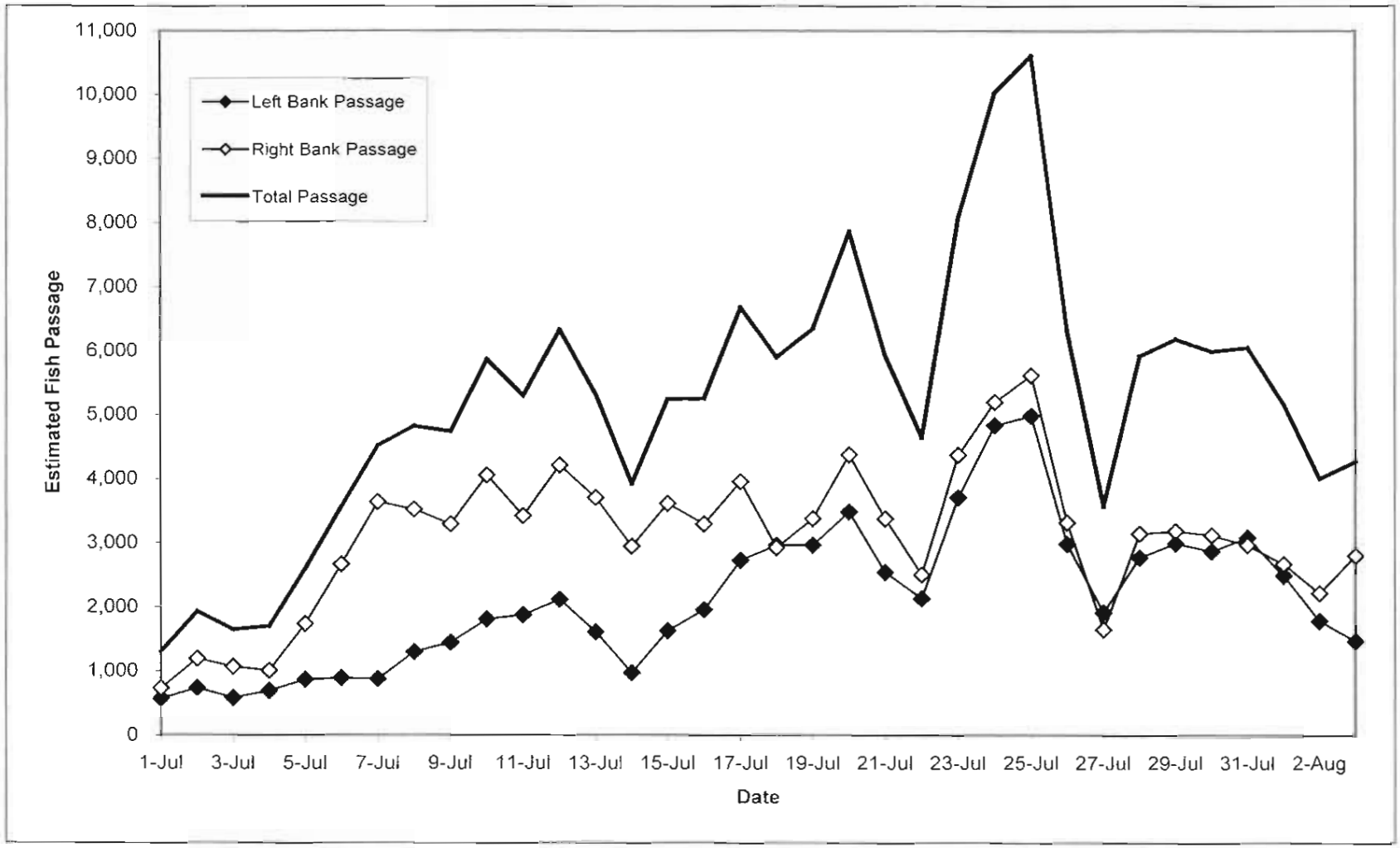


Figure 7. Estimated daily fish passage, Aniak River, 1999.

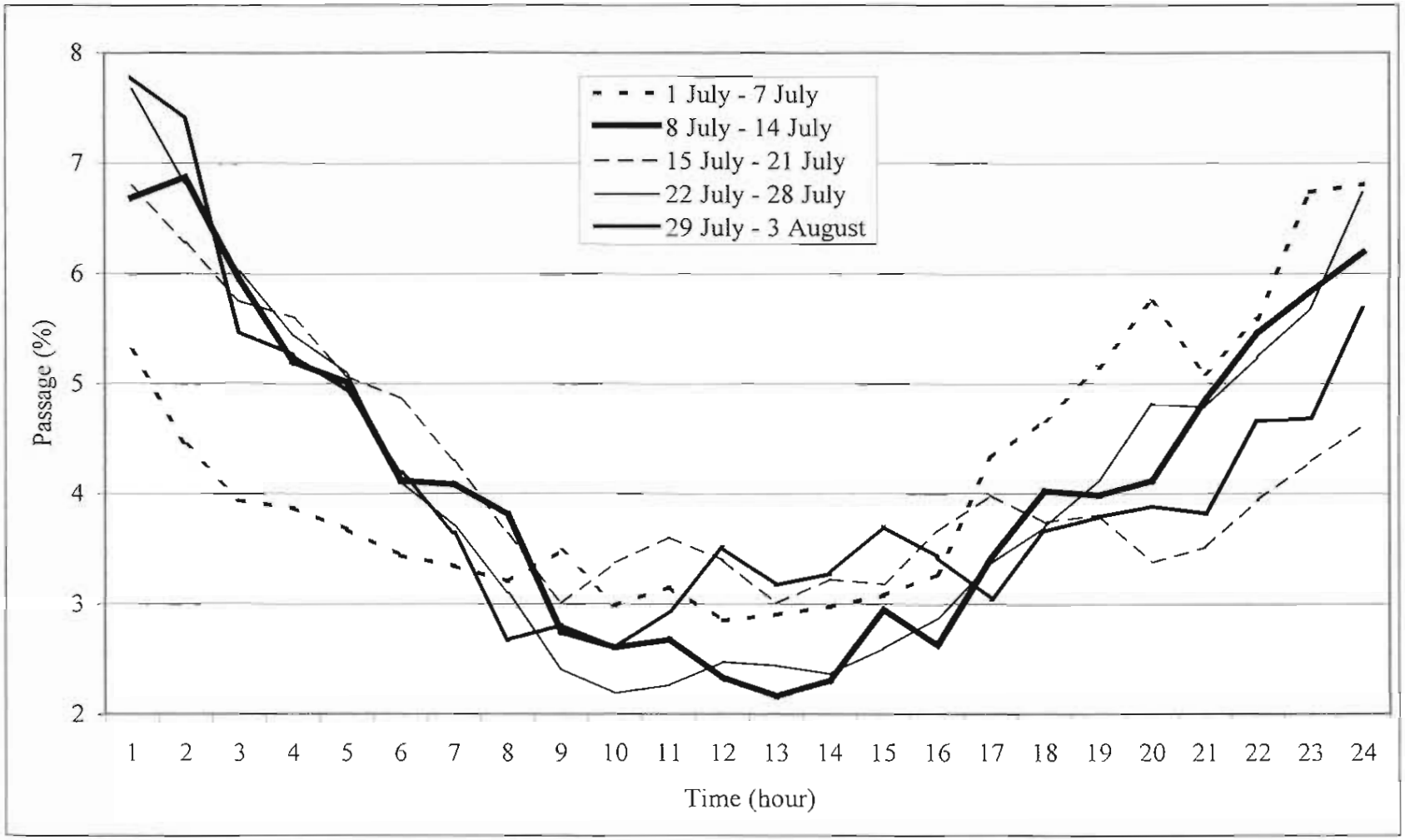


Figure 8. Diel distributions of fish detections, Aniak River, 1999.

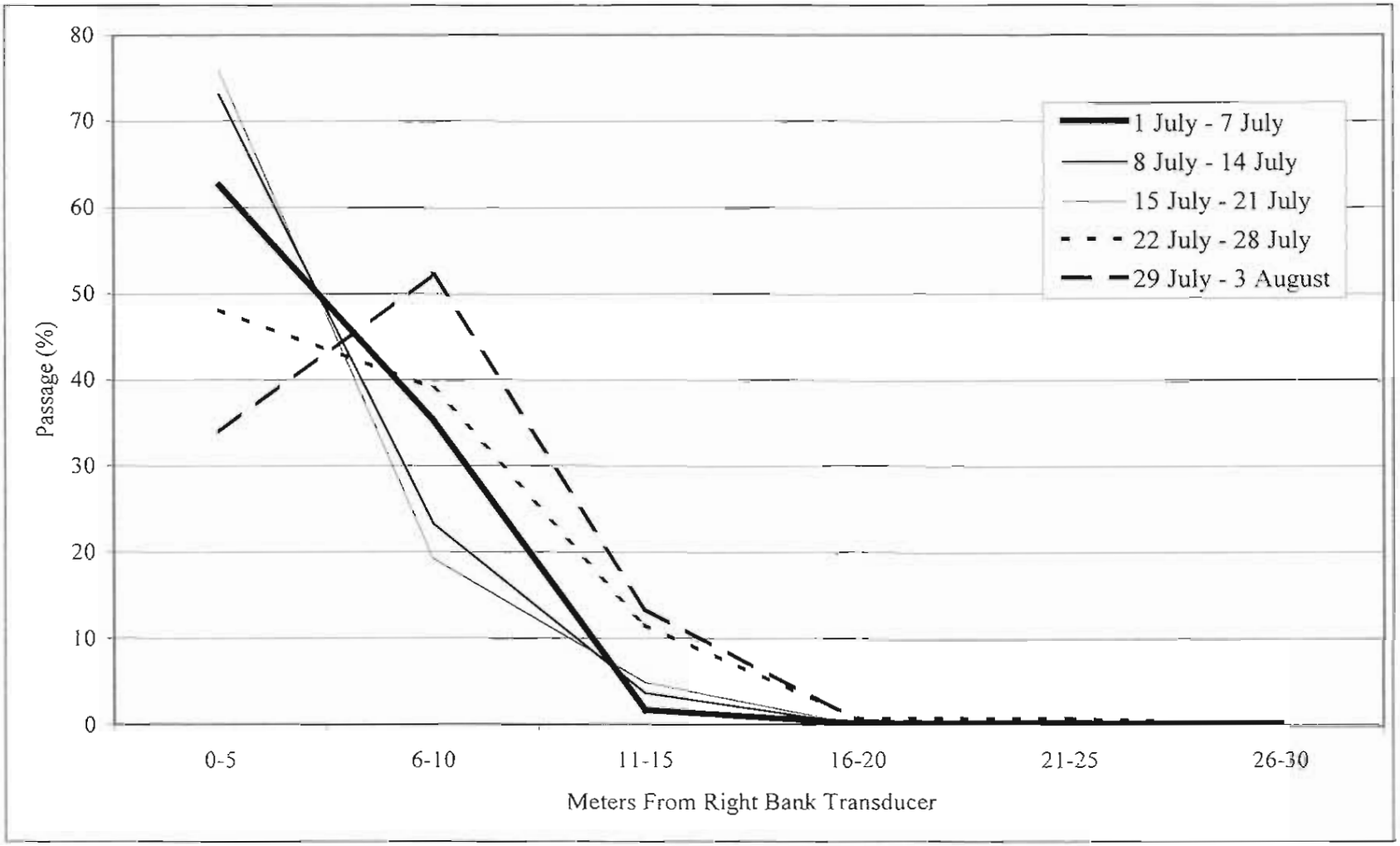


Figure 9. Right bank horizontal range distributions of fish passage, Aniak River sonar, 1 July – 3 August, 1999.

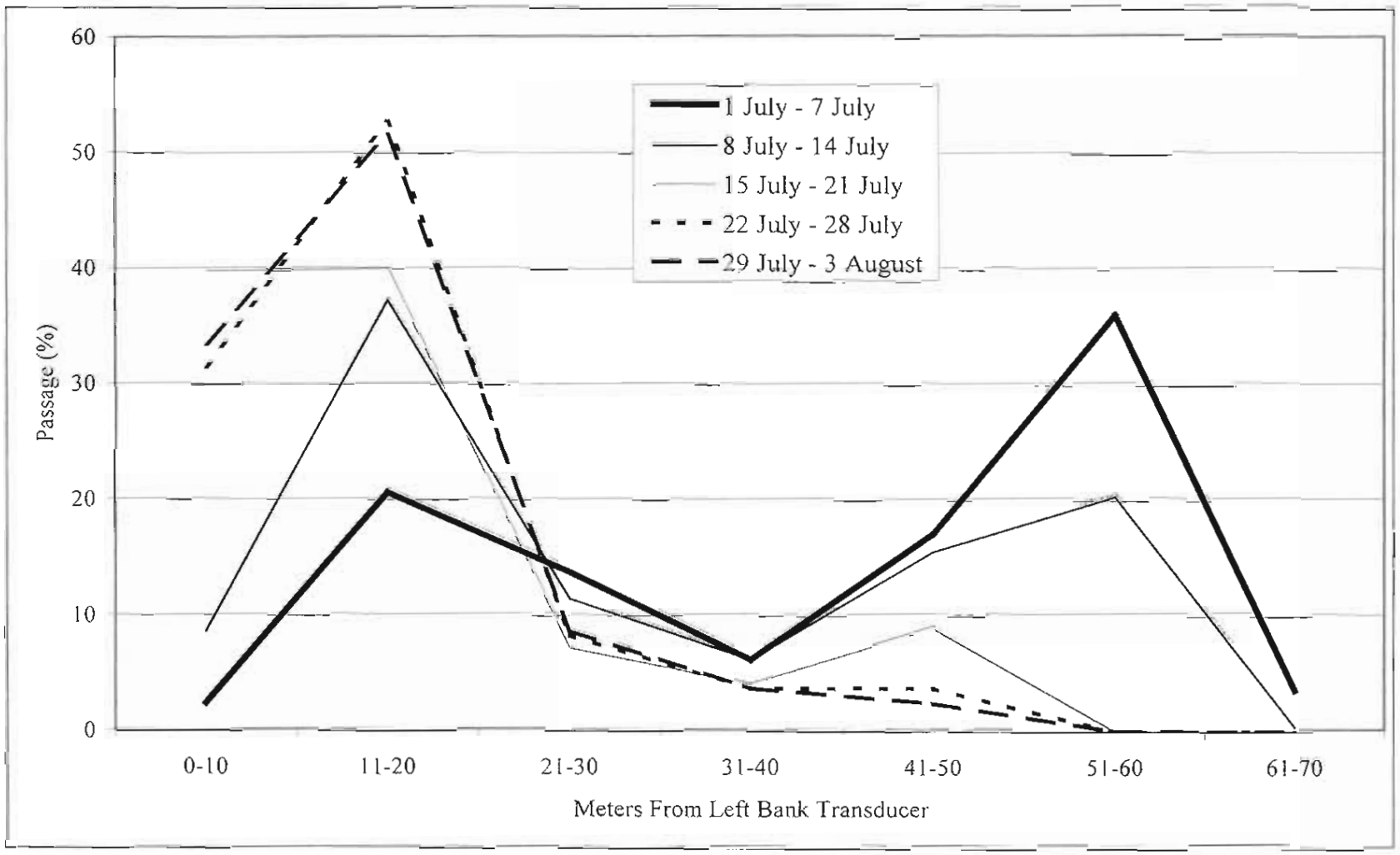


Figure 10. Left bank horizontal range distributions of fish passage, Aniak River sonar, 1 July - 3 August, 1999.

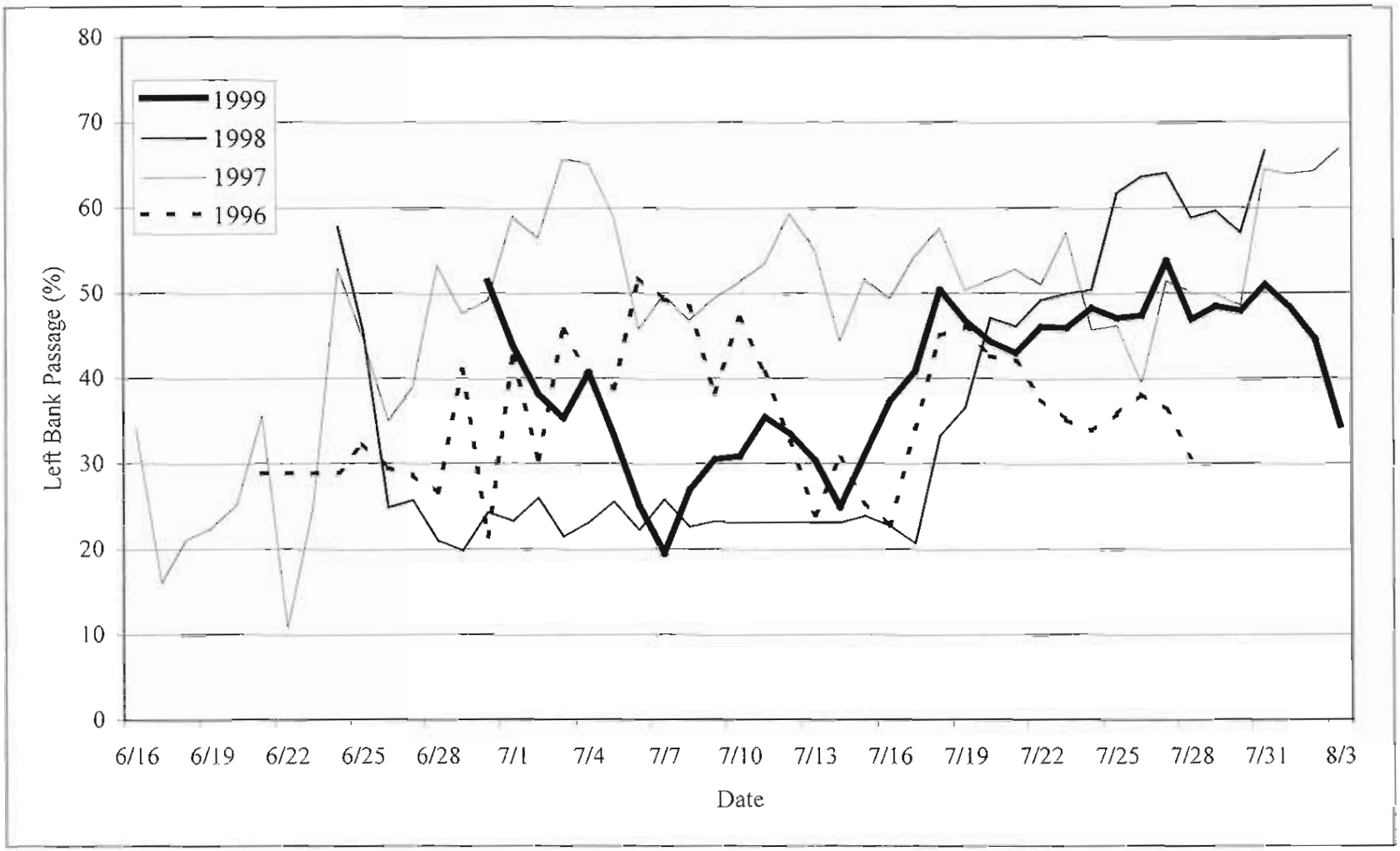


Figure 11. Daily left bank percent passage rates for Aniak River sonar, 1996-1999.

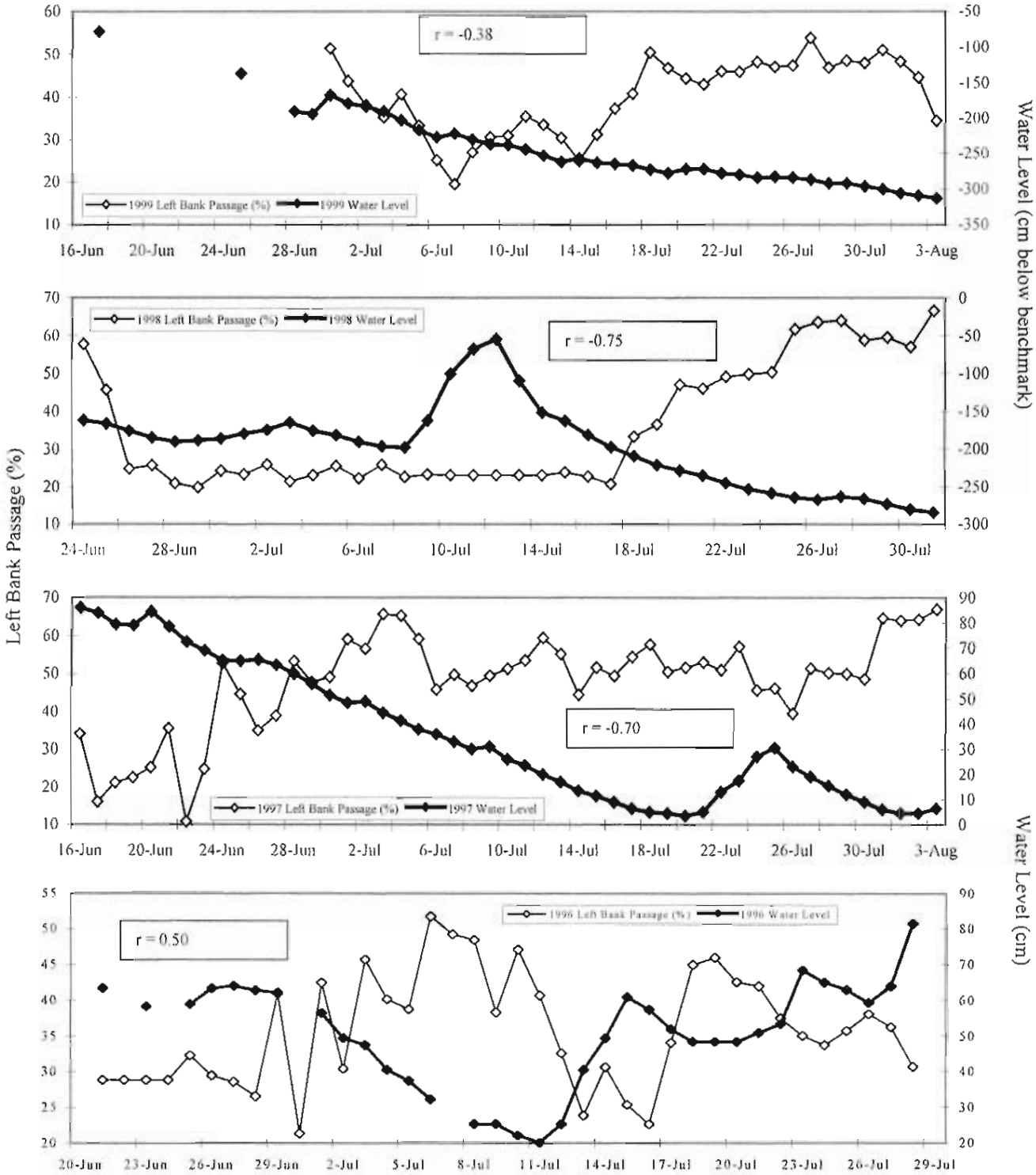


Figure 12. Daily left bank percent passage rate and water level for Aniak River sonar, 1996-1999.

APPENDICES

APPENDIX A

Appendix A. 1. Lower Kuskokwim River, District 1 and the middle Kuskokwim River, District 2, combined commercial salmon harvest and estimated exvessel value, 1988-1999[a].

Kuskokwim In-River Commercial Salmon Harvest

Year		Chinook	Sockeye	Coho	Pink	Chum	Total
1988	Fish	55,716	92,025	524,296	10,825	1,381,674	2,064,536
	Value	$974,664	$950,181	$4,570,505	$5,495	$3,781,449	$10,282,296
1989	Fish	43,217	42,712	479,856	464	749,182	1,315,431
	Value	$490,410	$376,775	$1,875,097	$80	$1,305,284	$4,047,646
1990	Fish	53,759	84,870	410,332	3,397	461,624	1,013,982
	Value	$435,052	$619,442	$1,639,224	$1,893	$824,067	$3,519,678
1991	Fish	37,778	108,946	500,935	378	431,802	1,079,839
	Value	$320,733	$512,858	$1,431,976	$157	$836,144	$3,101,868
1992	Fish	46,872	92,218	666,170	7,451	344,603	1,157,314
	Value	$397,894	$590,293	$2,150,242	$1,381	$760,934	$3,900,744
1993	Fish	8,735	27,008	610,786	64	43,337	689,930
	Value	$72,812	$140,824	$2,297,772	$59	$114,127	$2,625,594
1994	Fish	16,211	49,365	724,689	30,949	271.115	1,092,329
	Value	$126,961	$188,704	$3,002,387	$8,973	$383,630	$3,710,655
1995	Fish	30,846	92,500	471,461	93	605,918	1,200,818
	Value	$309,088	$460,982	$1,358,656	$50	$746,478	$2,875,254
1996[b]	Fish	6,973	33,512	935,510	1,621	200,298	1,177,914
	Value	$23,672	$97,622	$1,835,208	$744	$170,988	$2,128,234
1997	Fish	10,441	21,989	130,803	2	17,026	180,261
	Value	$36,888	$64,926	$315,650	$1	$19,522	$436,987
1998	Fish	17,359	60,906	210,481	92	207,809	496,647
	Value	$74,396	$209,870	$516,552	$55	$183,386	$984,259
1999	Fish	4,705	16,976	25,593	2	23,006	70,282
	Value	$23,337	$64,000	$54,052	$0	$16,794	$158,183
Avg.	Fish	29,810	64,186	515,029	5,031	428,581	1,042,636
(1988-1998)	Value	$296,597	$382,952	$1,908,479	$1,717	$829,637	$3,419,383

[a] Does not include test fish sales.
[b] Does not include roe sales.

Appendix A. 2. Lower Kuskokwim River, District 1 and the middle Kuskokwim River, District 2 and the Upper Kuskokwim River combined subsistence salmon harvest, 1988-1998.

Kuskokwim In-River Subsistence Salmon Harvest

Year	Chinook	Chum	Sockeye	Coho	Total
1988[a]	70,943	151,967	30,775	38,387	292,072
1989	81,176	139,687	35,224	52,918	309,005
1990	85,979	126,508	36,276	44,791	293,554
1991	85,554	93,075	52,984	50,370	281,983
1992	64,795	96,491	32,067	40,168	233,521
1993	87,512	59,396	49,349	31,737	227,994
1994	93,242	72,025	37,159	33,050	235,476
1995	96,436	67,862	27,791	36,277	228,366
1996	78,063	88,965	34,213	32,741	233,982
1997	81,577	39,970	40,077	29,032	190,656
1998	86,115	67,665	37,578	27,239	218,597
Average (1988-1998)	82,854	91,237	37,590	37,883	249,564

[a] Beginning in 1988, estimate based on new formula, data not comparable to previous years.

Appendix A. 3. Timetable of developmental changes at the Aniak River sonar project, 1980-1999.

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 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 1980-81 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 king salmon. • Sonar estimates are not extrapolated for pre- and post-season salmon escapement (1983-84, 90, 96-97)
1984	• Sonar equipment unchanged • No apportionment of estimates made due to insufficient test gillnet 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.

-Continued-

Appendix A.3. (Page 2 of 2)

YEAR	EVENT
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 (1990-95)
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 1980-83 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 (1996-97) • Regional Information Report documents project operations and data collection activities
1999	• Project operations remain the same as 1996 for years 1997 through 1999.

Appendix A. 4. Climatological and hydrologic measurements, Aniak River sonar site, 1999.

Date	Time	Water (C)	Air (C)	Secchi (m)	H_2O Level - Below benchmark (cm)	Conduct	Air (c) (min)	Air (c) (max)	General Conditions (sunny, overcast, intermittent rain, heavy rain, etc....)
1-Jul	0830	11.4	14.3	0.75	179	79.3	12	17	
2-Jul	0800	11.7	10.8	0.8	183	81.4	8	17	Overcast, scattered rain showers
3-Jul	0900	9.9	10.3	0.8	190	82.6	3	11	Overcast, wind 5-15
4-Jul	0800	10.6	10.8	0.9	203	81.2	14	16	Overcast
5-Jul	0800	11.7	12.5	1	217	81.8	14	20	Mostly cloudy, winds W @ 5-10
6-Jul	0800	11.6	13.7	1	227	80.8	7	20	Mostly cloudy, no wind
7-Jul	0815	12.3	12.8	0.9	222	81.9	12	22	Overcast, winds W @ 10-15
8-Jul	0830	12.9	11.7	1.1	230	83.9	4	20	Mostly sunny, no wind
9-Jul	0900	12.5	15.4	1.1	237	84.7	2	23	Partly cloudy, winds W @ 5
10-Jul	0800	12.8	8	0.8	238	84.7	8	24	Mostly cloudy, occasional rain, no wind
11-Jul	0800	12.7	5	0.7	244	85.5	2	22	Mostly sunny, light variable winds
12-Jul	0830	13	8	0.75	253	84.8	4	24	Mostly sunny, no wind
13-Jul	0800	12.5	11	0.7	262	84.9	4	23	Mostly sunny, no wind
14-Jul	0830	14.6	8	0.9	257	83.6	7	16	Mostly cloudy, winds S @ 5
15-Jul	0820	14.1	8	1	263	84.9	5	17	Overcast, light rain, no wind
16-Jul	0815	11.2	11.8	0.9	265	87.8	8	14	Overcast, rain, no wind
17-Jul	0930	11.3	10.9	0.75	267	89.4	4	13	Overcast, no wind
18-Jul	0810	11.4	10.5	0.75	273	89.4	4	19	Overcast, no wind
19-Jul	0810	11.1	12.7	0.8	278	88.1	7	13	Overcast, rain, no wind
20-Jul	0930	10.8	8.7	0.75	272	88.3	3	12	Overcast, light rain, winds E @ 20
21-Jul	0805	10.3	8.2	0.55	272	86.3	3	12	Overcast, occasional rain, winds S @ 10-15
22-Jul	0900	9.3	10	1.25	278	90.9	2	15	Mostly sunny, no wind
23-Jul	0810	12.7	12.8	1.75	280	88.1	6	20	Overcast, winds N @ 5
24-Jul	0930	11.2	18	1.75	284	85	2	22	Overcast, no wind
25-Jul	0800	12.3	12.5	1.85	283	90.8	5	20	Overcast, winds W @ 15
26-Jul	0805	11.3	10.5	2	284	97.3	8	17	Overcast, no wind
27-Jul	0800	9.7	10.3	2	287	96.4	9	16	Overcast, light rain, winds SW @ 10
28-Jul	0900	10.1	9	1.9	292	93.3	14	24	Overcast, no wind
29-Jul	0825	9.8	10.1	1.9	292	95.2	7	19	Overcast, winds W @ 15
30-Jul	0820	10.7	14.5	2	296	91.5	3	14	Overcast, no wind
31-Jul	0830	11.3	14.1	1.5	300	94.1	3	14	Overcast, winds N @ 15-20
1-Aug	0830	11.8	10.8	1.4	306	95.5	4	13	Overcast, no wind
2-Aug	0820	10.5	11.2	1.7	309	95.2	2	10	Partly cloudy, no wind
3-Aug	0810	11.6	11.5	1.2	313	96.5	5	19	Mostly cloudy, winds S @ 15

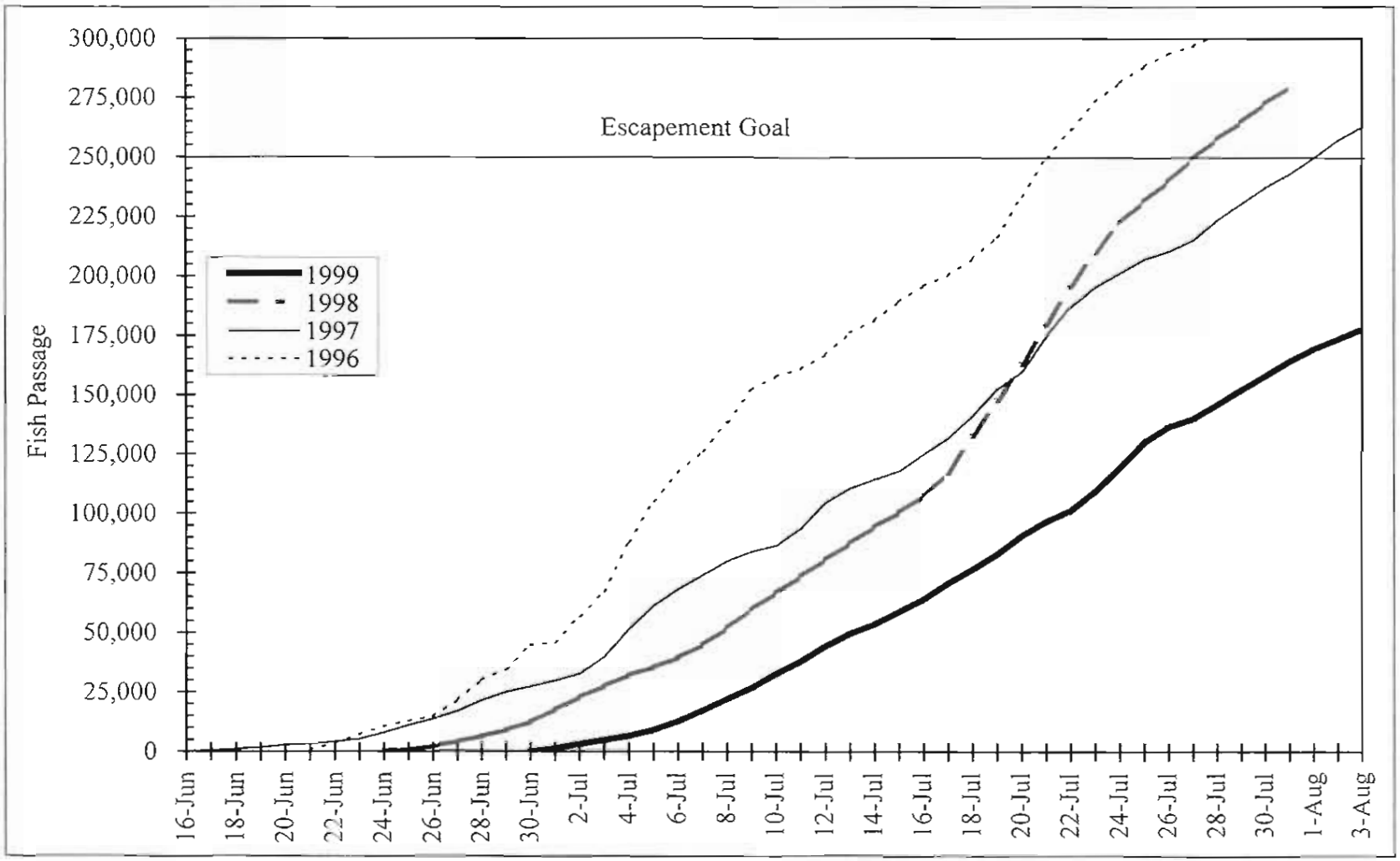
Appendix A. 6. Daily and cumulative estimates of fish passage at the Aniak River sonar site, 1996-1999.

	1999 Season Estimates				1998 Season Estimates				1997 Season Estimates				1996 Season Estimates			
Date	Left Bank	Right Bank	Daily Total	% Pass.	Left Bank	Right Bank	Daily Total	% Pass.	Left Bank	Right Bank	Daily Total	% Pass.	Left Bank	Right Bank	Daily Total	% Pass.
16-Jun									74	143	217	0%				
17-Jun									52	272	324	0%				
18-Jun									119	445	564	0%				
19-Jun									155	535	690	1%				
20-Jun									248	737	985	1%				
21-Jun									205	371	576	1%	261	643	904	0%
22-Jun									92	760	852	2%	770	1,898	2,668	1%
																2%
23-Jun									270	821	1,091	2%	1,034	2,549	3,583	
24-Jun					231	169	400	0%	1,412	1,261	2,673	3%	1,001	2,467	3,468	4%
25-Jun					227	270	497	0%	1,344	1,667	3,011	4%	696	1,459	2,155	4%
26-Jun					292	884	1,176	1%	964	1,789	2,753	5%	606	1,450	2,056	5%
27-Jun					470	1,360	1,830	1%	1,238	1,940	3,178	6%	1,941	4,843	6,784	7%
28-Jun					447	1,689	2,136	2%	2,445	2,145	4,590	8%	2,252	6,216	8,468	10%
29-Jun					520	2,106	2,626	3%	1,663	1,822	3,485	10%	1,868	2,684	4,552	11%
30-Jun					841	2,626	3,467	4%	1,151	1,193	2,344	10%	2,169	7,973	10,142	15%
1-Jul	571	733	1,303	1%	1,209	3,992	5,201	6%	1,455	1,011	2,466	11%	508	687	1,195	15%
2-Jul	737	1,196	1,933	2%	1,353	3,864	5,217	8%	1,650	1,270	2,920	12%	3,307	7,559	10,866	19%
3-Jul	582	1,069	1,651	3%	1,008	3,702	4,710	10%	4,621	2,420	7,041	15%	4,697	5,576	10,273	22%
4-Jul	691	1,009	1,700	4%	1,072	3,576	4,648	11%	7,628	4,070	11,698	20%	8,462	12,573	21,035	29%
5-Jul	866	1,738	2,604	5%	839	2,451	3,290	13%	5,760	3,986	9,746	23%	6,633	10,469	17,102	35%
6-Jul	894	2,673	3,567	7%	885	3,103	3,988	14%	3,199	3,783	6,982	26%	6,213	5,788	12,001	39%
7-Jul	880	3,645	4,525	10%	1,409	4,059	5,468	16%	2,984	3,014	5,998	28%	4,507	4,640	9,147	42%
8-Jul	1,300	3,528	4,828	12%	1,622	5,560	7,182	19%	2,770	3,152	5,922	31%	5,920	6,307	12,227	46%
9-Jul	1,446	3,295	4,741	15%	1,798	5,939	7,737	21%	1,975	2,016	3,991	32%	5,247	8,433	13,680	50%
10-Jul	1,810	4,058	5,868	18%	1,609[a]	5,370	6,979	24%	1,272	1,207	2,479	33%	2,669	2,995	5,664	52%
11-Jul	1,878	3,423	5,301	21%	1,609[a]	5,370	6,979	26%	3,849	3,350	7,199	36%	1,210	1,762	2,972	53%
12-Jul	2,120	4,215	6,334	25%	1,609[a]	5,370	6,979	29%	6,466	4,429	10,895	40%	1,987	4,109	6,096	55%
13-Jul	1,615	3,710	5,325	28%	1,609[a]	5,370	6,979	31%	3,366	2,738	6,104	42%	2,233	7,108	9,341	58%
14-Jul	977	2,949	3,926	30%	1,609[a]	5,370	6,979	34%	1,632	2,040	3,672	44%	1,604	3,629	5,233	60%
15-Jul	1,634	3,620	5,254	33%	1,410	4,509	5,919	36%	1,779	1,665	3,444	45%	2,007	5,901	7,908	63%
16-Jul	1,961	3,299	5,260	36%	1,604	5,473	7,077	38%	3,515	3,602	7,117	48%	1,496	5,099	6,595	65%
17-Jul	2,730	3,959	6,689	40%	2,021	7,773	9,794	42%	3,704	3,109	6,813	50%	1,505	2,911	4,416	66%
18-Jul	2,973	2,931	5,904	43%	5,163	10,363	15,526	48%	5,392	3,977	9,369	54%	3,083	3,770	6,853	69%
19-Jul	2,971	3,384	6,355	47%	5,466	9,485	14,951	53%	5,668	5,568	11,236	58%	4,253	4,992	9,245	72%
20-Jul	3,488	4,382	7,870	51%	7,151	8,035	15,186	58%	3,826	3,591	7,417	61%	7,244	9,758	17,002	77%
21-Jul	2,545	3,380	5,925	54%	7,560	8,849	16,409	64%	7,833	6,971	14,804	67%	6,777	9,360	16,137	83%
22-Jul	2,137	2,510	4,647	57%	7,997	8,274	16,271	70%	6,339	6,105	12,444	71%	4,404	7,338	11,742	87%
23-Jul	3,712	4,377	8,089	62%	7,120	7,151	14,271	75%	4,760	3,584	8,344	74%	4,149	7,681	11,830	90%
24-Jul	4,838	5,203	10,041	67%	6,285	6,195	12,480	80%	2,714	3,234	5,948	77%	2,758	5,408	8,166	93%
25-Jul	4,990	5,623	10,613	73%	5,572	3,466	9,038	83%	2,654	3,098	5,752	79%	2,458	4,415	6,873	95%
26-Jul	2,988	3,325	6,313	77%	5,244	3,003	8,247	86%	1,290	1,974	3,264	80%	2,042	3,317	5,359	97%
27-Jul	1,922	1,653	3,575	79%	6,177	3,473	9,650	89%	2,428	2,296	4,724	82%	1,095	1,922	3,017	98%
28-Jul	2,777	3,149	5,926	82%	4,842	3,392	8,234	92%	4,251	4,231	8,482	85%	1,643	3,708	5,351	100%
29-Jul	2,998	3,191	6,189	86%	4,263	2,892	7,155	95%	3,457	3,464	6,921	88%				
30-Jul	2,873	3,125	5,998	89%	4,465	3,361	7,826	98%	3,273	3,465	6,738	90%				
31-Jul	3,089	2,970	6,059	92%	4,616	2,313	6,929	100%	3,568	1,959	5,527	92%				
1-Aug	2,498	2,676	5,173	95%					4,340	2,451	6,791	95%				
2-Aug	1,788	2,222	4,009	98%					4,750	2,646	7,396	98%				
3-Aug	1,472	2,804	4,276	100%					3,707	1,838	5,545	100%				
Total	72,749	105,022	177,771		109,224	170,207	279,431		139,307	123,215	262,522		112,709	189,397	302,106	

[a] Sonar not operational, passage estimated using the average passage from 8-9 July & 15-16 July.

Appendix A. 5. Historic age class of beach seine caught chum salmon from Aniak River escapement samples, collected near the sonar site and applied to passage estimates by time stratum, 1996-1999.

Year	Stratum Dates	Sample Size	Age Class 0.2 Esc.	0.2 %	0.3 Esc.	0.3 %	0.4 Esc.	0.4 %	0.5 Esc.	0.5 %	Total Esc.
1999	7/1 – 7/8	151	0	0.0	8,347	37.7	13,618	61.6	146	0.7	22,111
1998	6/24 - 7/05	72	0	0.0	29,332	83.3	5,377	15.3	489	1.4	35,198
1997	6/16 - 7/06	139	491	0.7	31,886	46.8	35,319	51.8	491	0.7	68,186
1996	6/21 - 7/04	78	0	0.0	48,595	55.1	37,294	42.3	2,260	2.6	88,149
1999	7/9 – 7/14	182	0	0.0	15,401	48.9	16,094	51.1	0	0.0	31,495
1998	7/06 - 7/12	165	0	0.0	35,425	78.2	9,611	21.2	275	0.6	45,311
1997	7/07 - 7/13	169	252	0.6	28,224	66.3	13,356	31.4	756	1.8	42,588
1996	7/06 - 7/14	94	0	0.0	59,429	63.6	34,034	36.4	0	0.0	93,463
1999	7/15 – 7/20	175	213	0.6	22,612	60.6	14,292	38.3	213	0.6	37,331
1998	7/13 - 7/18	220	0	0.0	44,671	85.5	7,603	14.5	0	0.0	52,274
1997	7/14 - 7/17	138	610	2.9	11,896	56.5	8,540	40.6	0	0.0	21,046
1996	7/15 - 7/17	120	473	2.5	14,820	78.3	3,468	18.3	158	0.8	18,919
1999	7/21 – 7/25	187	0	0.0	27,752	70.6	11,563	29.4	0	0.0	39315
1998	7/19 - 7/22	204	308	0.5	56,966	90.7	5,235	8.3	308	0.5	62,817
1997	7/18 - 7/22	124	446	0.8	39,669	71.8	14,709	26.6	446	0.8	55,270
1998	7/23 - 7/27	210	511	1.0	49,340	91.9	3,835	7.1	0	0.0	53,686
1997	7/23 - 7/26	156	598	2.6	16,883	72.4	5,827	25.0	0	0.0	23,308
1996	7/18 - 7/28	167	4,866	4.8	74,813	73.7	19,463	19.2	2,433	2.4	101,575
1999	7/26 – 8/3	192	0	0.0	31,926	67.2	15,344	32.3	247	0.5	47,518
1998	7/28 - 7/31	173	0	0.0	28,227	93.6	1,917	6.4	0	0.0	30,144
1997	7/27 - 8/03	127	1,231	2.4	43,505	83.5	7,388	14.2	0	0.0	52,124
1999	Season	1,003	213	0.1	106,038	59.6	70,912	39.9	607	0.3	177,771
1998	Season	1,044	819	0.3	243,961	87.3	33,579	12.0	1,071	0.4	279,430
1997	Season	853	3,628	1.4	172,063	65.5	85,138	32.4	1,693	0.6	262,522
1996	Season	459	5,339	2.0	197,657	65.0	94,260	31.0	4,851	2.0	302,106



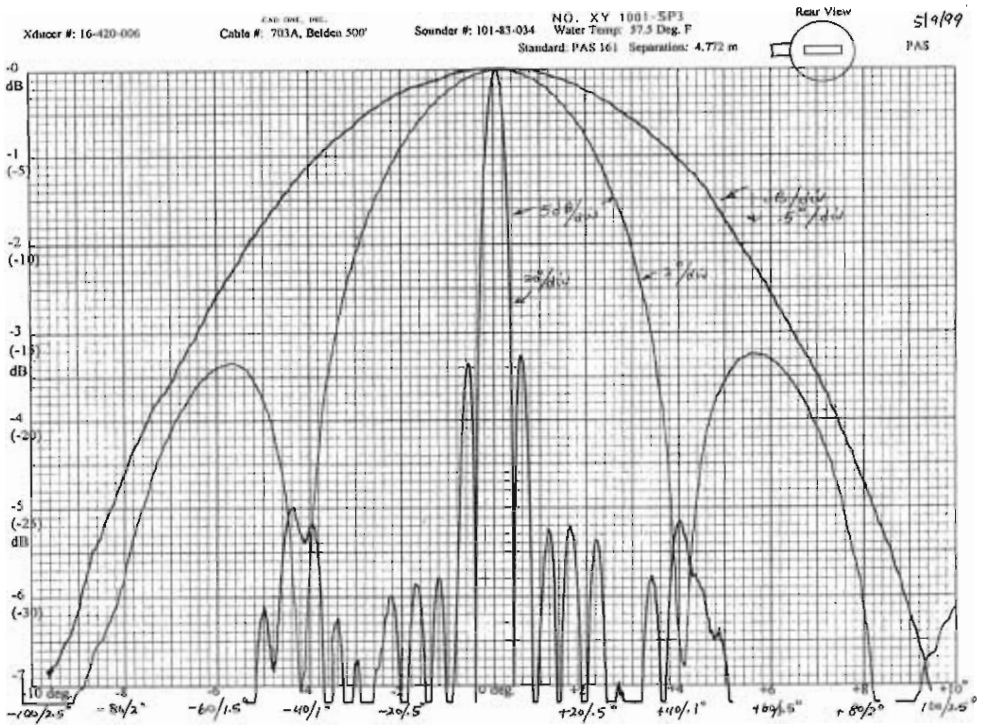
Appendix A. 7. Estimated cumulative fish passage, Aniak River sonar, 1996-1999.

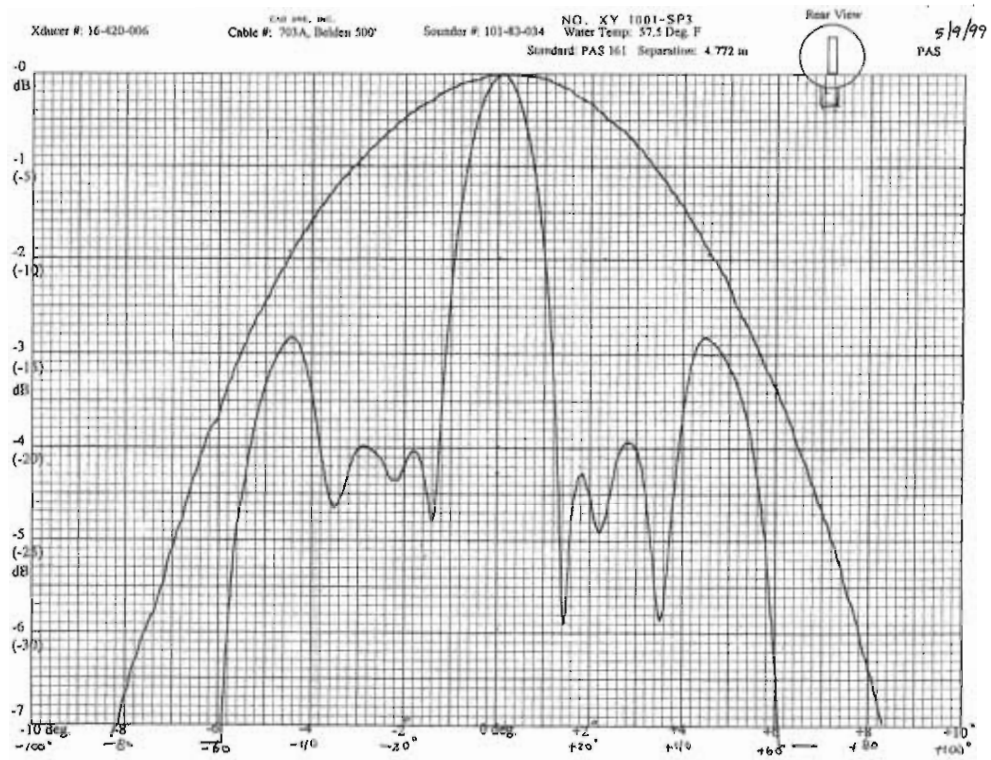
APPENDIX B

Appendix B. 1. BioSonics bench calibration data; calibrated 9 May, 1999.

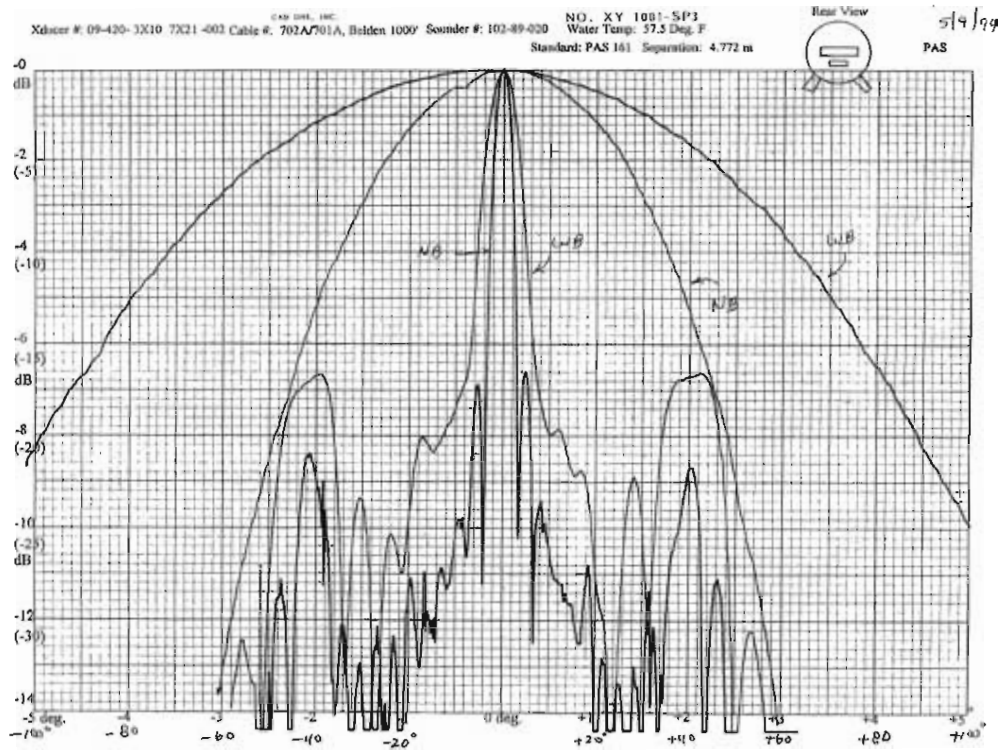
Sounder:	101-034	102-020
Cables (S/N):	500' Belden 703A	1,000' Belden 701A/702A
Transducer:	Biosonics 16-420-006	Biosonics 09-420-002
Receiver Gain L	0	0
Standard Volts In	3	3
Vdet NB 40	1.915	2.320
G1 NB 40	-189.760	-185.090
Vdet WB 40	N/A	7.405
G1 WB 40	N/A	-175.010
-13 dB Vrms	-19.94	-17.83
-13 dB SL	206.52	208.63
-10 dB Vrms	-17.05	-15.26
-10 dB SL	209.41	211.20
-6 dB Vrms	-13.38	-11.97
-6 dB SL	213.08	214.49
-3 dB Vrms	-10.87	9.62
-3 dB SL	215.59	216.84
0 dB Vrms	-8.79	N/A
0 dB SL	217.67	N/A

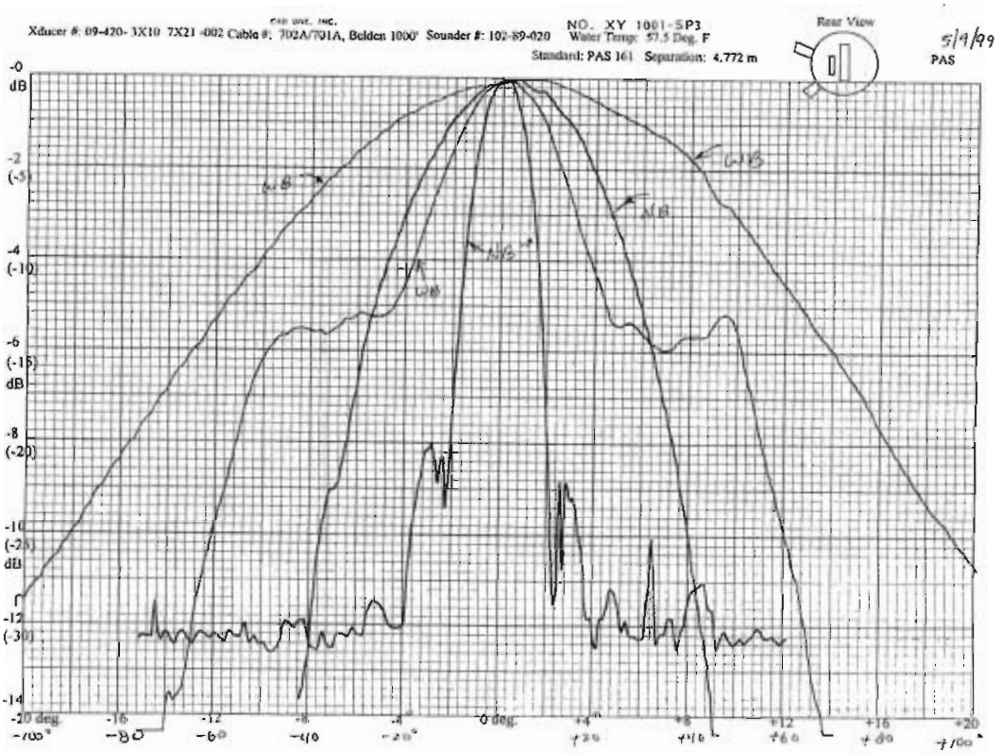
Appendix B. 2. Polar plots for Biosonics transducer (S/N 16-420-006).





Appendix B. 3. Polar plots for Biosonics transducer (S/N 09-420-002).





APPENDIX C

Appendix C. 1. State of Alaska, Department of Natural Resources Land Use Permit for the Aniak River sonar project.

STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF LAND, SOUTHCENTRAL REGION
3601 C STREET, SUITE 1080
ANCHORAGE, AK 99503-5937
PHONE: (907) 269-8542; FAX (907) 269-8913

1999 LAND USE PERMIT VALIDATION
(Commercial, Recreation)
Under AS 38.05.850

Permit # LAS 13916

ADF&G, Commercial Fisheries Management & Development Division, Aniak River Sonar Project is issued this 1999 land use permit validation authorizing:

(a) the establishment and use of a temporary seasonal tent camp and off-season cache (per Attachment A) on a parcel of state-owned land located within:

NW1/4 SW1/4 of Section: 05 Township: 16 North Range: 56 West Seward Meridian

The authorized 1999 seasonal camp term is June 1, 1999 through August 10, 1999, unless earlier terminated at the state's discretion.

Natural Resource Manager — 4/20/99 Date

*The permittee is responsible for conducting the permitted activities in accordance with original, amended and/or new land use permit stipulations attached to the multi-year (seasonal) land use permit and applicable guidelines set forth in 11 AAC 96.140.

*The permittee is responsible for obtaining authorizations required by other agencies for the permitted activity.

*The permittee is responsible for maintaining a current address with the division during the term of the multi-year (seasonal) land use permit.

DIVISION OF LAND
APR 20 1999

LAND USE PERMIT

LAS 13916

PERMITTEE : ADF&G
Aniak River Sonar Project

Seasonal Camp
Permit Term: 06/01/1999 through 08/10/1999

4/20/99
DNR AUTHORIZED SIGNATURE

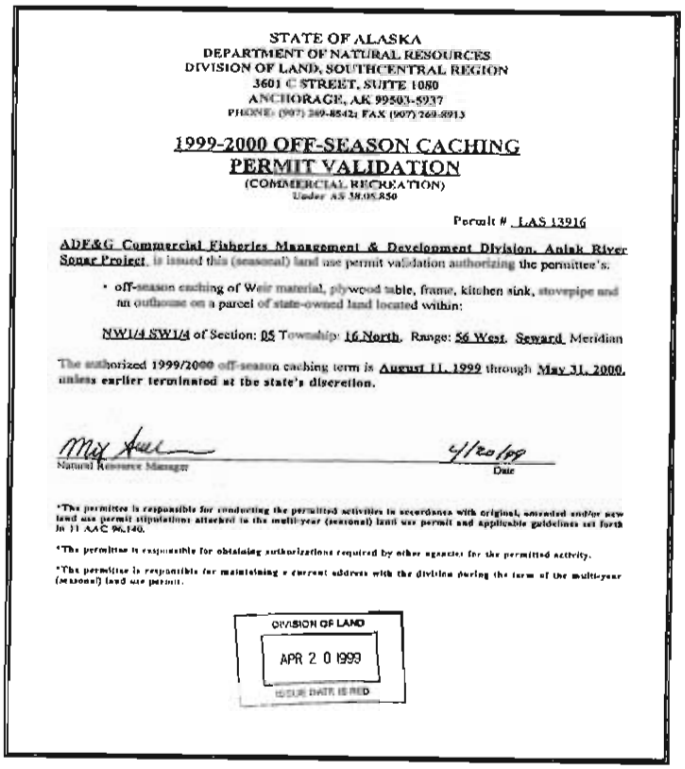
Alaska Department of NATURAL RESOURCES

This permit must be posted in a conspicuous location visible from the most common access route. Only permit posters with

Division of Land and Water
Southcentral Region
3601 C Street, Suite 1080
Anchorage, Alaska 99503-5937
269-8554.

Township	Range	Section/Other
16 North	56 West	NW1/4 SW1/4 Sec. 05 Seward Meridian

Appendix C. 2. State of Alaska, Department of Natural Resources Caching Permit for the Aniak River sonar project.



STATE OF ALASKA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF LAND, SOUTHCENTRAL REGION
3601 C STREET, SUITE 1080
ANCHORAGE, AK 99503-5937
PHONE: (907) 269-8542; FAX (907) 269-8913

1999-2000 OFF-SEASON CACHING
PERMIT VALIDATION
(COMMERCIAL RECREATION)
Under AS 38.05.850

Permit # LAS 13916

ADF&G Commercial Fisheries Management & Development Division, Aniak River Sonar Project is issued this (seasonal) land use permit validation authorizing the permittee's:

- off-season caching of Weir material, plywood table, frame, kitchen sink, stovepipe and an outhouse on a parcel of state-owned land located within:

NW1/4 SW1/4 of Section: 05 Township: 16 North, Range: 56 West, Seward Meridian

The authorized 1999/2000 off-season caching term is August 11, 1999 through May 31, 2000, unless earlier terminated at the state's discretion.

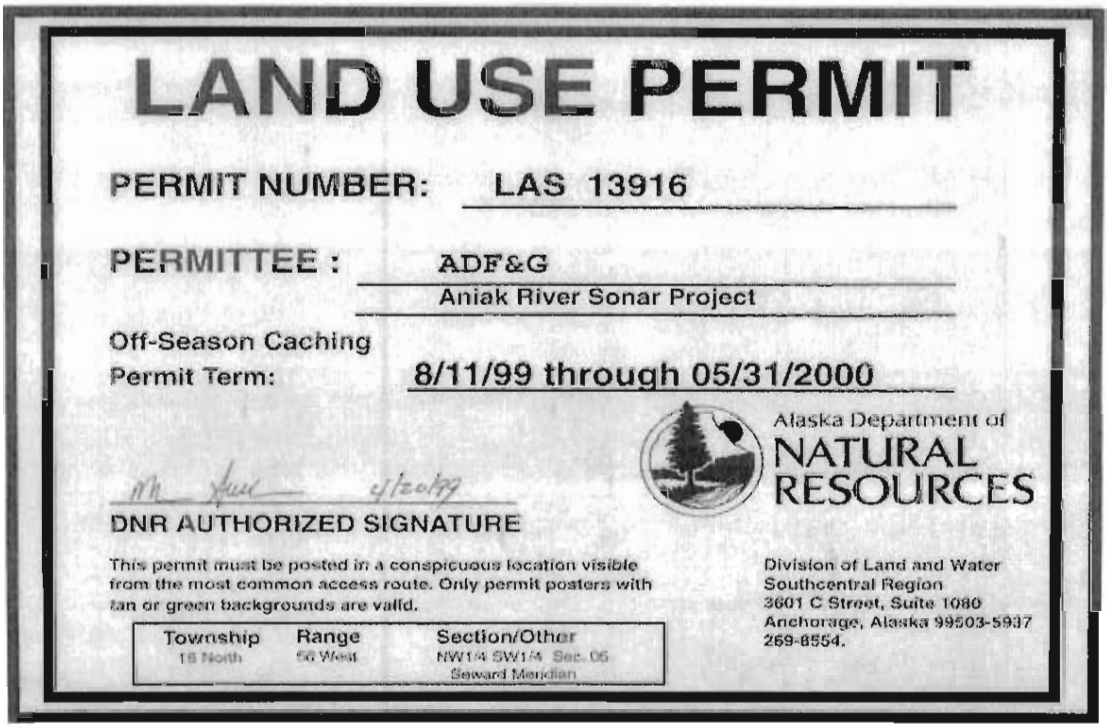
Natural Resource Manager — Date 4/20/99

*The permittee is responsible for conducting the permitted activities in accordance with original, amended and/or new land use permit stipulations attached to the multi-year (seasonal) land use permit and applicable guidelines set forth in 11 AAC 96.140.

*The permittee is responsible for obtaining authorizations required by other agencies for the permitted activity.

*The permittee is responsible for maintaining a current address with the division during the term of the multi-year (seasonal) land use permit.

DIVISION OF LAND
APR 20 1999
ISSUE DATE IS RED



LAND USE PERMIT

PERMIT NUMBER: LAS 13916

PERMITTEE : ADF&G
Aniak River Sonar Project

Off-Season Caching
Permit Term: 8/11/99 through 05/31/2000

Alaska Department of
NATURAL
RESOURCES

4/20/99
DNR AUTHORIZED SIGNATURE

This permit must be posted in a conspicuous location visible from the most common access route. Only permit posters with tan or green backgrounds are valid.

Township	Range	Section/Other
16 North	56 West	NW1/4 SW1/4 Sec. 05 Seward Meridian

Division of Land and Water
Southcentral Region
3601 C Street, Suite 1080
Anchorage, Alaska 99503-5937
269-8554.