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ANIAK RIVER SONAR PROJECT REPORT
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by

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ABSTRACT

The Aniak River sonar project provided daily estimates of fish passage from 21 June through 28 July, 1996. User-configurable sonar continuously sampled the entire width of the river between the transducers, except for short periods when the equipment was moved or serviced. An estimated 302,106 fish passed upstream through the ensonified area during the period of operation. The passage was distinctly bimodal; the initial peak daily passage of 21,035 fish occurred on 4 July, and a second daily peak of 17,002 fish occurred on 20 July. The four and five year age classes of Aniak River chum salmon comprised 65.4% and 31.2% 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 harvests from 1988-1995 averaged 526,191 chum salmon (Table 1). Exvessel value from in-river harvests of chum salmon during the same period averaged $1.14 million (Francisco et al. 1989, 1990, 1991, 1992, 1993, 1994, 1995; Burkey et al. 1996). Also during that time, an average 103,764 chum salmon were estimated to have been harvested annually for subsistence purposes (Table 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 the single largest producer 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 averages approximately 9 days (Burkey et al. 1996). Because of its proximity to the Kuskokwim River commercial and subsistence fisheries, the Aniak River sonar project can provide a timely estimate of the number of chum salmon escaping to spawn in that river.

The chum salmon biological escapement goal (BEG) for the Aniak River was set at 250,000 fish in 1983, based on data provided by the Aniak River sonar project (Schneiderhan 1984). Established in 1980, Aniak River escapement data were collected using an echo counting and processing transceiver manufactured by Bendix Corporation[1]. Data were collected with a single transceiver located on the right bank and expanded to estimate total fish passage using a variety of techniques (Schneiderhan 1989). Aniak River sonar fish abundance estimates are not apportioned to species. Early gillnet and beach seine test fishing investigations indicate that the abundance of fish species other than chum salmon is insufficient to compromise the utility of passage estimates for making chum salmon management decisions (Schneiderhan 1981, 1982a, 1982b, 1984, 1985).

The Aniak River chum salmon stock had record low escapements in 1992 and 1993. The estimated escapement for the Aniak River sonar project was only 34 percent of the BEG in 1992 and 6 percent of the BEG in 1993 (Francisco et al. 1994). As a result of these low escapements, the Aniak stock is not expected to have harvestable surpluses in 1996 or 1997. Special management measures to achieve, or minimize shortfalls from, the BEG during these return years will depend on escapement data provided by the Aniak River sonar project.

In 1996, the Aniak River sonar project was redesigned to provide full river ensonification, with periodic net sampling to monitor broad changes in species composition, corroborate

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

acoustically detected abundance trends, and obtain age, sex, and length (ASL) samples of chum salmon.

The Objectives of the 1996 Aniak River sonar project were:

1) Establish a new sonar data collection site, including fabrication of new tent facilities, approximately 19 km upstream from the mouth of the Aniak River confluence with the mainstem Kuskokwim River.
2) 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 20 June through 28 July.
3) Provide daily fish passage estimates in the Aniak River to fishery managers in Bethel.
4) Periodically drift a suite of gillnets to qualitatively monitor general trends in species composition, and to corroborate sonar abundance trends.
5) Collect and archive ASL samples from migrating chum salmon near the sonar site.

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

In order to accomplish our objective of full river ensonification, we relocated the sonar site downstream approximately 1.5 km from the historical site (Schneiderhan 1985) (Figure 2). Upon arrival, we constructed a wall tent platform and frame on the right bank to house the electronic equipment. The river at the sonar site is characterized by broad meanders with large gravel bars on the inside bend and cutbanks with exposed soil, tree roots and snags on the outside bend. Numerous transects were conducted in the immediate vicinity of the sonar site using a Lowrance model X-16 chart recording portable fathometer to determine the exact 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 13.7 m, while the left bank slopes gradually to the thalweg at roughly 24.4 m (Figure 3).

Hydroacoustic Data Acquisition

Equipment

Sonar equipment for the right bank of the Aniak River included: 1) a Biosonics model 102 (SN 89-020) 120/420 kHz echosounder configured to transmit and receive at 120 kHz; 2) an International Transducer Co. (I.T.C.) model 5398 (SN 002) user configurable 120 kHz elliptical beam transducer configured for dual beam use as Case II (4°x9° narrow, 12°x22° wide beam); 3) two 304.8 m (1000 ft) Belden model 8412 transducer cables (SN 605K, 606K); and 4) a Biosonics model 111 (SN 041) thermal chart recorder. A Nicolet model 310 (SN 4865) digital storage oscilloscope 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 304.8 m of Belden 9934 pan and tilt cable. A set of digital panel meters provided readings, accurate to within ± 0.3 degrees, for the horizontal and vertical axes positions.

Left-bank sonar equipment included: 1) a Biosonics model 102 (SN 89-021) 120/420 kHz echosounder configured to transmit and receive at 120 kHz; 2) an International Transducer Co. (I.T.C.) model 5398 (SN 009) user configurable 120 kHz elliptical beam transducer configured for dual beam use as Case I (2°x5° narrow, 4°x9° wide beam); 3) two 304.8 m (1000 ft) Belden model 8412 transducer cables (SN 701A, 702A); and 4) a Biosonics model 111 (SN 053) thermal chart recorder.

We mounted the left bank transducer on an aluminum tripod and remotely aimed it with a Remote Oceans Systems (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 m x 3.7 m (10 ft x 12 ft) portable wall tent on the right bank and powered by a single Honda model EM-3500 independently grounded generator. Transducer and rotator cables for the left bank 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, seven 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 rotated through shifts of 0800-1630 and 1630-2400 h until 10 July, when the schedule was altered to 0000-0800, 0800-1600, and 1600-2400 h. During those shifts crew members

identified and tallied fish traces from chart recordings. 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 were summarized by 15 minute subsample and range intervals. Range intervals were 2 m wide on the right bank and 5 m wide on the left bank. Completed data forms were transported to the main camp throughout the day, and entered into Quattro Pro Version 5.0 electronic spreadsheets by the project leader. Chart recorder output constituted the only record of detected echoes and fish passage. Chart recordings were annotated for date, time, and bank, and catalogued for storage.

Project activities were recorded in a project log book. The log book 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 120 kHz. We used a 40 log(R) time varied gain (TVG) and a 5 kHz frequency bandwidth filter for both banks. We set the left bank transmit pulse width at 0.4 ms, and varied the right bank transmit pulse width from 0.4 ms to 0.2 ms to minimize cross-talk between transducers. Maximum range was 35 m on the left bank and 15 m on the right bank. The left bank chart recorder threshold was set at 0.6 volts (-44.6 dB) during all sampling activities. The right bank threshold was set at 0.5 volts (-42.2 dB) on the second day of operation for the duration of the season. Three printer thresholds, corresponding to intensities of gray-line, on the Biosonics MDL 111 thermal printer were factory set at 6 dB intervals. Left bank printer thresholds corresponded to target strengths of -44.6 dB, -38.6 dB, and -32.6 dB (gray scale 1, 2, and 3 respectively). Right bank printer thresholds were -42.2 dB, -36.2 dB, and -30.2 dB.

Threshold levels and target strength levels 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

Aiming, Deployment

The transducers were positioned in the river as nearly perpendicular to the current as possible. The wide axis of each beam was oriented as close to the horizontal position and as near the bottom of the river as possible to maximize target residence time in the beam. Transducers were placed offshore, 3 m from the right bank, and 12.5 m from the left bank. Weirs extended from shore to several meters beyond the transducers to prevent fish from passing undetected behind the transducers and to minimize detections in the nearfield (MacLennan and Simmonds 1992). Daily visual inspections confirmed proper placement and orientation of the transducers.

Hydroacoustic Equipment Checks

Both sonar systems were bench calibrated in May, 1996. We estimated background noise levels in the field at several range intervals for each sonar system several times each week. Noise levels were estimated by measuring the average peak voltage in four separate range intervals on the oscilloscope. Selected range intervals were separated by noise peaks caused by structure.

Bottom Profiles and Stream Measurements

Numerous bottom profiles were recorded outward from both banks using a Lowrance X-16 chart recording fathometer prior to choosing exact deployment sites. On 3 July, paired depth at range measurements were made on both banks using the Lowrance fathometer and a Laser Atlanta model Advantage (SN 10365) optical laser range finder (Figure 3). Measurements were made at 2-3 m intervals, from each transducer to the opposite shore.

Climatological and Hydrologic Measurements

Ambient air temperature was measured once per day using a min/max Fahrenheit scale thermometer. Water level was recorded daily on the right bank at the site using a staff gauge to register daily river levels. Water temperature was sampled once per day using a standard Celsius scaled thermometer. Standard secchi disk readings were taken once per day and recorded in the camp log.

Analytical Methods

Fish Passage Estimates

Fish traces were tallied in 2 m range intervals for the right bank and 5 m intervals for the left bank in 15 minute intervals directly from the chart recordings. Data were collected on both banks 24 hours per day, 7 days per week, except for brief and infrequent periods when the sonar equipment was not operational. The full width of the river between transducers was ensonified and fish traces were not apportioned for species. No attempts were made to determine direction of travel. The number of fish traces tallied for both banks was summed with estimates for missing data to provide total fish passage estimates.

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 existing passage rate subsample for that period was applied to the full time interval. Data missing from more than 10 minutes of a 15 minute interval were estimated from the average relative distribution (proportions) of passage rates 45 minutes prior to and following 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 6 hours prior to and following 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.

Species Composition Verification

Equipment and Procedures

We fished two gillnets periodically at times determined inseason to monitor species composition and corroborate the presence or absence of fish traces. 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 9.1 m (5 fathoms) long by 1.5 m (5 feet) deep.

Nets were fished during periods of acoustically determined low fish passage to avoid fish mortality and verify low abundance. Each net was drifted at least one time at two stations, one on each bank, during the sampling period (Figure 4). 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 from shore toward midstream, 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

A 46 m x 3 m (150 ft x 10 ft) green 7.0 cm mesh beach seine was used to obtain ASL samples of chum salmon. One end of the seine was anchored to shore while the other end was towed out toward mid-river and turned downstream with a skiff. The net and skiff typically drifted downstream approximately 18 m before the set was closed. All captured non-salmon fish were identified, tallied by species, fin clipped, and released. Chum salmon were placed in a live box for sampling, while other salmon were tallied by species, fin clipped, and released. 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.

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). A pulse sampling design was followed in which intensive sampling was conducted for one or two days followed by several days without sampling. The goal of each pulse was 200 chum salmon scales (Bromaghin 1993). All ASL data were sent to the Bethel ADF&G office for analysis by the Kuskokwim Area research biologist. 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 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 number 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 4 June and ended on 31 July 1996. Hydroacoustic sampling began on 21 June on the left bank, and on 25 June on the right bank. With few exceptions, the equipment ran continuously, 24 hours per day, 7 days per week, until sampling ended at 8:14 pm on 28 July. Passage estimates were available to fishery managers in Bethel at 7:30 am and 5:00 pm daily.

Data acquisition was interrupted for several minutes 3 times each day for generator refueling and maintenance. In addition to regular maintenance, a total of 16 hours of sampling time were missed on the left bank due to moving the tripod or reaiming the transducer to compensate for changing river conditions throughout the season. Moving the tripod, reaiming the transducer and damaged transducer cables accounted for 24 hours (less than 3 %) of missed sampling time on the right bank over the course of the season.

Typical ambient background noise levels measured -76.8 dB over most of the counting range on both banks and signal to noise ratios (SNR) of 26.0 dB were common on the right bank and 32.2 dB on the left bank. Higher noise levels, -43.1 dB and -49.4 dB, occurred on the right and left bank at narrow points where the beam grazed the river bottom. Lower SNR's (0.9 dB and 4.8 dB) at these points did not affect data collection. SNR's were generally maintained above 25 dB.

Bottom Profiles and Stream Measurements

Stream measurements were calculated using a Laser Atlanta model Advantage optical laser range finder with paired magnetic direction output capacity and a Lowrance model X-16 chart recording fathometer on 3 July. Water level at this time was below normal. The river width at the sonar site was 61.9 m and the maximum depth was 2.1m (Figure 5). The right bank transducer was positioned at a 169° magnetic heading and the left bank transducer was at a 334° magnetic heading. Total distance between transducers measured 46.3 m. Total ensonification range between transducers was 46.5 m. With respect to the left bank transducer, the right bank transducer was positioned approximately 50 feet downstream. Cross talk between transducers was observed on the left bank 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.

Analytical Methods

Fish Passage Estimates

Total passage during project sampling activities was estimated at 302,106 fish, with 63 percent passing on the right bank and 37 percent passing on the left bank (Table 3). A comparison of daily estimated passage between banks is presented in Figure 6. The pattern of daily passage was distinctly bimodal. The first peak of 21,035 fish occurred on 4 July and the second peak of 17,002 fish occurred on 20 July (Figure 7). The 25%, 50%, and 75% quartile dates of passage were 4 July, 9 July and 20 July (Table 3).

We examined the hourly fish count data for evidence of daily patterns of movement during 7 day periods of data collection. During each time period, fish passage increased at night and declined during the day, though less markedly as the season progressed (Figure 8). Overall, seasonal range distributions of targets that passed the site peaked at 7.5 m from the right bank transducer and at 13 m from the left bank transducer (Figure 9).

Species Composition Verification

We conducted drifts during five sampling periods using drift gillnet gear to verify dominant species presence (Table 4). Sampling periods occurred when fish passage was

less than 500 fish per hour and drift duration averaged two to three minutes. We made a total of 45 drifts, of which 28 were made with 13.6 cm mesh gillnets and 17 were made with 7.0 cm mesh gillnets. The total catch consisted of 11 chum salmon, 3 chinook salmon (*O. tshawytscha*), 1 sockeye salmon (*O. nerka*), 4 longnose sucker (*Catostomus catostomus*), and 1 northern pike (*Esox lucius*).

ASL Sampling

We made a total of 137 beach seine sets to obtain ASL samples of migrating chum salmon (Table 5). In all, we collected data from 459 chum salmon samples for analysis by the Kuskokwim Area research biologist. The overall age composition of Aniak River chum salmon was typical of other Kuskokwim chum salmon populations, where the 0.3 age class dominates the return, followed by the 0.4 age class (Francisco et al. 1995). The 0.3 and 0.4 age classes comprised 65.4 % and 31.2 %, of the escapement estimate, respectively (Table 6). The tendency seen at Aniak River of age 0.4 chum dominating at the onset of the season and age 0.3 chum becoming progressively more dominant through the course of the season is a common pattern in the Kuskokwim drainage (Molyneaux and DuBois 1997).

DISCUSSION

Hydroacoustic Data Acquisition

Sampling Procedures

The transducers used at the Aniak River sonar project are very large due to their narrow beam width and low frequency (120 kHz). To submerge the left bank transducer, it was necessary to deploy it approximately 12.5 m offshore. Constructing and maintaining a weir to prevent fish passing undetected behind the transducer was difficult and time consuming. The option of using a smaller 420 kHz transducer, should be considered. The uncertainty of transmission loss at this higher frequency is lessened by the shorter ranges ensonified at the site.

Species Composition Verification

The Aniak River supports fish populations of several different species. Resident and migratory species passed the sonar site during the period of data collection. While we are aware of this situation, past and current efforts indicate that the abundance of fish other than chum salmon is insufficient to compromise the utility of passage estimates for making

chum salmon management decisions. Given the limitation of fiscal resources, implementation of a complete species apportionment program does not seem warranted.

ASL Sampling

Based on the low escapement estimate in 1992, a weak return of 0.3 age class Aniak River chum salmon was anticipated. The strong return of 0.3 age class in 1996, 65.4% of the 302,106 fish escapement estimate, was not expected.

The techniques used to obtain ASL samples were designed to maximize the capture of chum salmon with the equipment on hand. Therefore, assumptions about relative species abundance from beach seine data are unwarranted. The beach seine sampling area was located 1.5 km upstream of the sonar site and only the extreme nearshore portion of the river was fished for ASL samples. No attempt should be made to expand or use this data for quantitative species apportionment information.

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Table 1. Lower Kuskokwim River, District 1 and the middle Kuskokwim River, District 2, combined commercial salmon harvest and estimated exvessel value, 1988-1995.[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	42,747	479,856	464	749,182	1,315,466
	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	8,835	27,008	610,739	64	43,337	689,883
	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
Average	Fish	37,470	71,026	559,574	13,156[b]	526,191	1,201,907
(1988-1994)	Value	$402,646	$482,725	$2,423,886	$4,435[b]	$1,143,662	$4,455,496

[a] Does not include test fish sales.
[b] Even years only.

Table 2. Lower Kuskokwim River, District 1 and the middle Kuskokwim River, District 2, and the Upper Kuskokwim River combined subsistence salmon harvest, 1988-1995.

Kuskokwim In-River Subsistence Salmon Harvest					
Year	Chinook	Sockeye	Coho	Chum	Total
1988[a]	70,358	29,945	36,451	149,655	286,409
1989	80,603	34,286	52,980	137,587	305,456
1990	83,949	35,473	42,062	122,977	284,461
1991	84,792	52,346	52,090	93,439	282,667
1992	63,789	30,943	37,661	92,771	225,164
1993	86,088	48,260	31,794	59,911	226,053
1994	91,989	36,387	31,839	70,005	230,220
1995	99,730	28,595	40,087	69,837	238,249
Average (1988-1994)	80,224	38,234	40,697	103,764	262,919

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

Table 3. Daily and cumulative estimates of fish passage at the Aniak River sonar site, 1996.

Date	Left Bank	Right Bank	Daily Total	Cumulative Total	Percent Passage	Water Level (cm)
21-Jun	261	643 [a]	904	904	0	63.5
22-Jun	770	1,898 [a]	2,668	3,572	1	
23-Jun	1,034	2,549 [a]	3,583	7,155	2	58.4
24-Jun	1,001	2,467 [a]	3,468	10,623	4	
25-Jun	696	1,459	2,155	12,778	4	59.1
26-Jun	606	1,450	2,056	14,834	5	63.5
27-Jun	1,941	4,843	6,784	21,618	7	64.1
28-Jun	2,252	6,216	8,468	30,086	10	62.9
29-Jun	1,868	2,684	4,552	34,638	11	62.2
30-Jun	2,169	7,973	10,142	44,780	15	
1-Jul	508	687	1,195	45,975	15	56.5
2-Jul	3,307	7,559	10,866	56,841	19	49.5
3-Jul	4,697	5,576	10,273	67,114	22	47.5
4-Jul	8,462	12,573	21,035	88,149	29	40.6
5-Jul	6,633	10,469	17,102	105,251	35	37.5
6-Jul	6,213	5,788	12,001	117,252	39	32.4
7-Jul	4,507	4,640	9,147	126,399	42	
8-Jul	5,920	6,307	12,227	138,626	46	25.4
9-Jul	5,247	8,433	13,680	152,306	50	25.4
10-Jul	2,669	2,995	5,664	157,970	52	22.2
11-Jul	1,210	1,762	2,972	160,942	53	20.2
12-Jul	1,987	4,109	6,096	167,038	55	25.4
13-Jul	2,233	7,108	9,341	176,379	58	40.6
14-Jul	1,604	3,629	5,233	181,612	60	49.5
15-Jul	2,007	5,901	7,908	189,520	63	61
16-Jul	1,496	5,099	6,595	196,115	65	57.4
17-Jul	1,505	2,911	4,416	200,531	66	52
18-Jul	3,083	3,770	6,853	207,384	69	48.5
19-Jul	4,253	4,992	9,245	216,629	72	48.5
20-Jul	7,244	9,758	17,002	233,631	77	48.5
21-Jul	6,777	9,360	16,137	249,768	83	51
22-Jul	4,404	7,338	11,742	261,510	87	53.5
23-Jul	4,149	7,681	11,830	273,340	90	68.5
24-Jul	2,758	5,408	8,166	281,506	93	65
25-Jul	2,458	4,415	6,873	288,379	95	63
26-Jul	2,042	3,317	5,359	293,738	97	59.5
27-Jul	1,095	1,922	3,017	296,755	98	64
28-Jul [b]	1,643	3,708	5,351	302,106	100	81.5
Total	112,709	189,397	302,106	302,106		

[a] Estimated from the ratio of right bank estimates to left bank estimates from 6/25 to7/2.

[b] Counts ended at 2014hrs on 7/28.

Table 4. Aniak River sonar catch results using drift gillnets, 1996.

Date	# of Drifts	Mesh (cm)	Chum	King	Sockeye	Sucker	Pike
6/28/96	4	13.6	3	0	0	0	0
7/11/96	5	13.6	2	0	1	0	0
7/11/96	4	7.0	0	0	0	0	0
7/20/96	4	13.6	3	2	0	0	0
7/20/96	5	7.0	0	0	0	1	0
7/22/96	8	13.6	2	0	0	0	0
7/22/96	4	7.0	0	1	0	0	1
7/24/96	7	13.6	1	0	0	0	0
7/24/96	4	7.0	0	0	0	3	0

Table 5. Aniak River catch results using beach seine gear, 1996.

Date	Location	# of Sets	Chum	King	Pink	Sockeye	Coho	Whitefish	Sucker	Pike	Char	Rainbow	**Total Catch**
6/28/96	Site A	3	0	0	0	0	0	0	2	1	0	0	**3**
7/1/96	Site B	15	4	0	0	0	0	2	3	1	0	0	**10**
7/2/96	Site B	5	101	2	0	2	0	0	0	0	0	0	**105**
7/2/96	Site B	4	0	0	0	0	0	0	0	0	0	0	**0**
7/4/96	Site B	3	5	0	0	0	0	0	0	0	0	0	**5**
7/6/96	Site B	15	50	2	2	2	0	6	0	1	0	0	**63**
7/7/96	Site B	3	30	2	0	0	0	0	1	0	0	0	**33**
7/9/96	Site B	18	59	0	2	2	0	6	3	0	0	0	**72**
7/11/96	Site B	16	11	0	0	1	0	3	2	2	2	0	**21**
7/15/96	Site B	15	22	0	0	0	0	2	1	0	0	0	**25**
7/16/96	Site B	4	6	0	0	0	0	2	0	0	0	1	**9**
7/16/96	Site C	12	104	1	5	9	0	17	3	0	2	0	**141**
7/20/96	Site C	10	111	2	11	2	0	2	19	0	6	0	**153**
7/20/96	Site C	8	88	3	8	1	0	0	1	0	1	0	**102**
7/23/96	Site C	6	32	1	7	4	2	2	6	0	1	0	**55**

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 1996.

Year	Sample Dates (Stratum Dates)	Sample Size	Sex	Age Class 0.2 Esc.	0.2 %	0.3 Esc.	0.3 %	0.4 Esc.	0.4 %	0.5 Esc.	0.5 %	Total Esc.	Total %
1996	7/1 - 2	78	M	0	0.0	15,822	17.9	12,431	14.1	2,260	2.6	30,513	34.6
	(6/21 - 7/4)		F	0	0.0	32,773	37.2	24,863	28.2	0	0.0	57,636	65.4
			Subtotal	0	0.0	48,595	55.1	37,294	42.3	2,260	2.6	88,149	100.0
	7/5 - 8	35	M	0	0.0	14,422	28.6	8,653	17.1	0	0.0	23,075	45.7
	(7/6 - 7)		F	0	0.0	15,864	31.4	11,538	22.9	0	0.0	27,402	54.3
			Subtotal	0	0.0	30,286	60.0	20,191	40.0	0	0.0	50,477	100.0
	7/10 - 11	59	M	0	0.0	8,014	18.6	5,829	13.6	0	0.0	13,843	32.2
	(7/9 - 14)		F	0	0.0	21,129	49.2	8,014	18.6	0	0.0	29,143	67.8
			Subtotal	0	0.0	29,143	67.8	13,843	32.2	0	0.0	42,986	100.0
	7/16	120	M	0	0.0	6,937	36.7	1,892	10.0	158	0.8	8,987	47.5
	(7/15 - 17)		F	473	2.5	7,883	41.7	1,577	8.3	0	0.0	9,932	52.5
			Subtotal	473	2.5	14,820	78.3	3,468	18.3	158	0.8	18,919	100.0
	7/19 - 20	167	M	1,216	1.2	37,710	37.1	7,299	7.2	608	0.6	46,834	46.1
	(7/18 - 28)		F	3,649	3.6	37,102	36.5	12,165	12.0	1,825	1.8	54,741	53.9
			Subtotal	4,866	4.8	74,813	73.7	19,463	19.2	2,433	2.4	101,575	100.0
	Season	459	M	1,216	0.4	82,905	27.4	36,104	12.0	3,026	1.0	123,252	40.8
			F	4,122	1.4	114,751	38.0	58,156	19.3	1,825	0.6	178,854	59.2
			Total	5,339	1.8	197,657	65.4	94,260	31.2	4,851	1.6	302,106	100.0

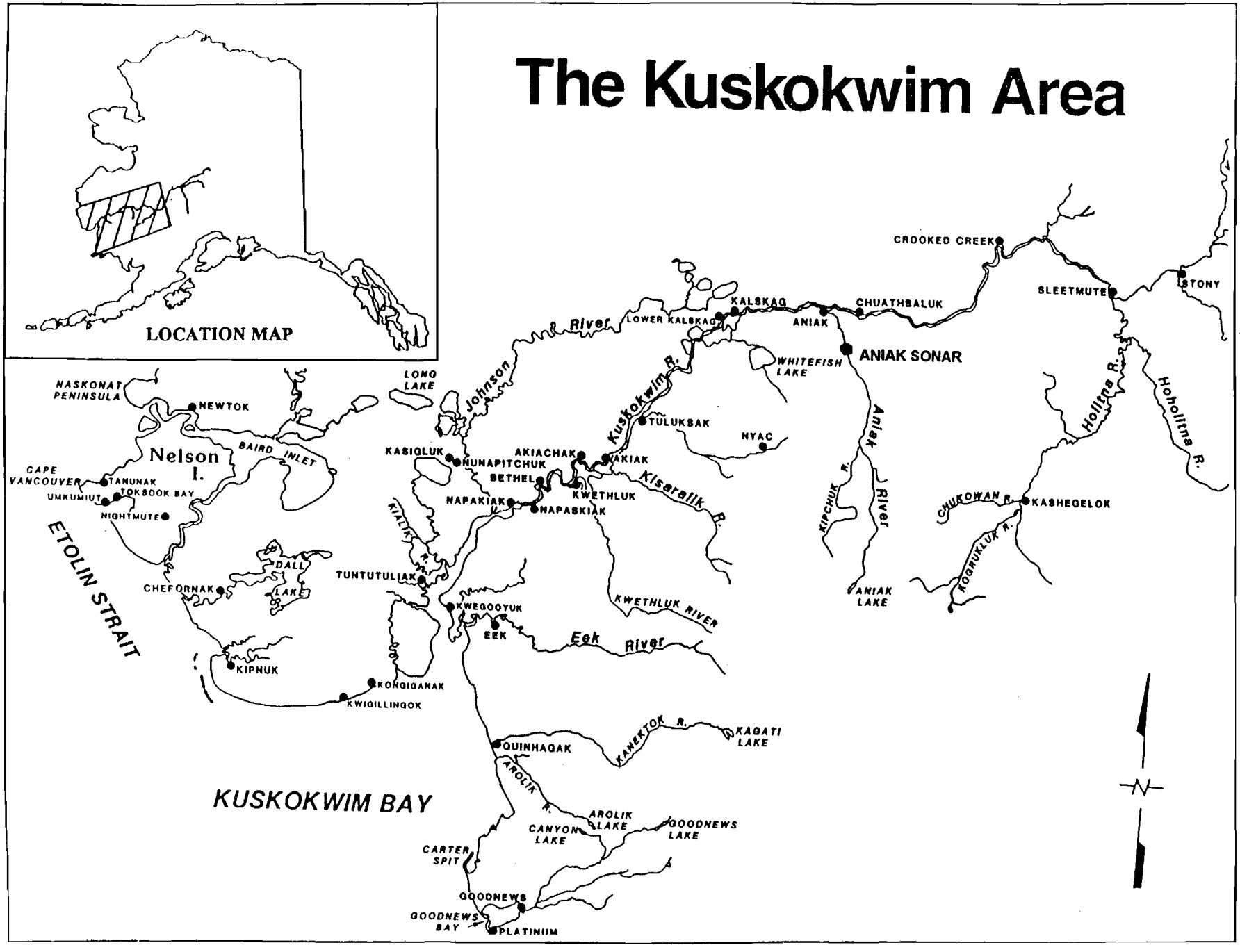


Figure 1. Map of the Kuskokwim Area.

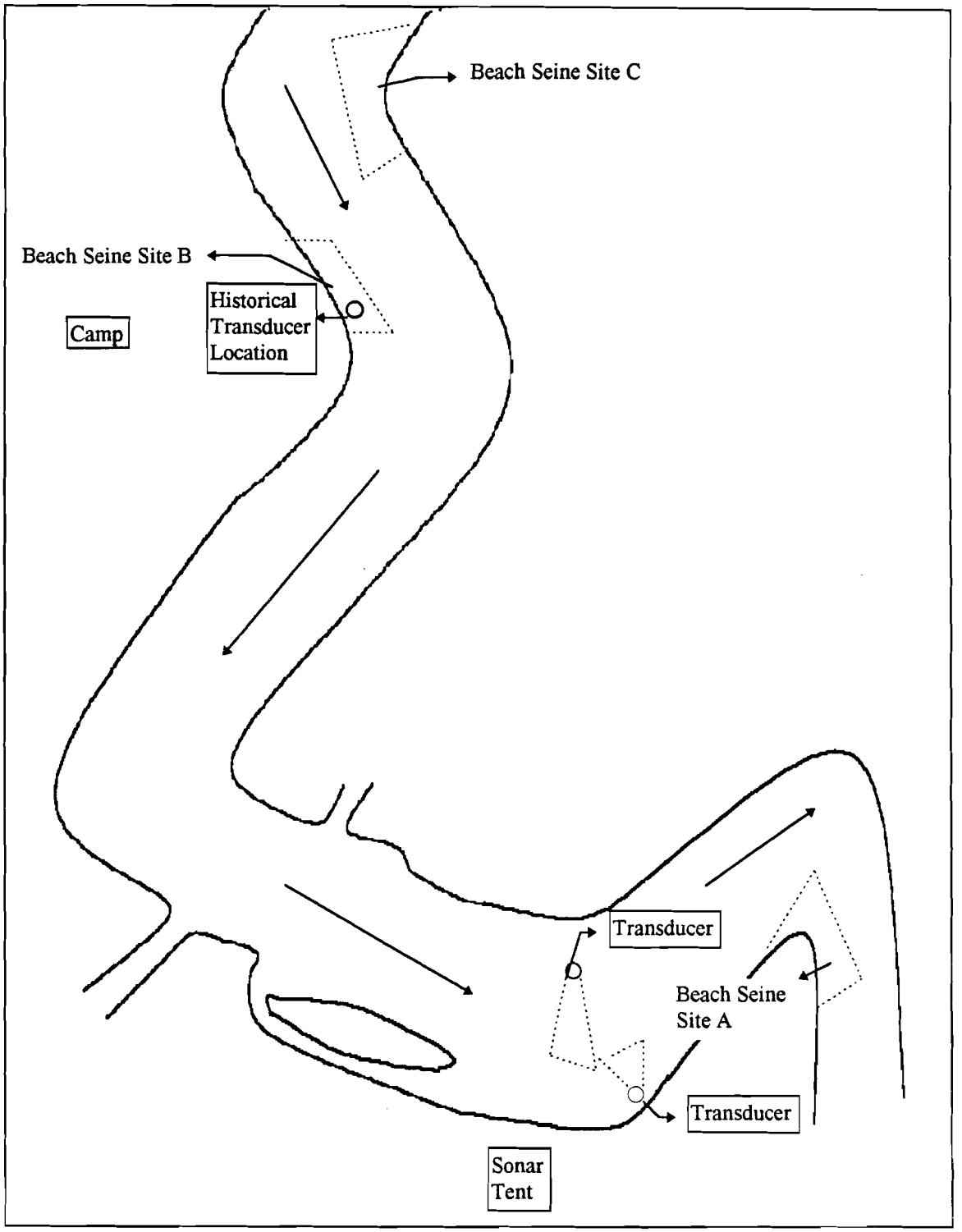
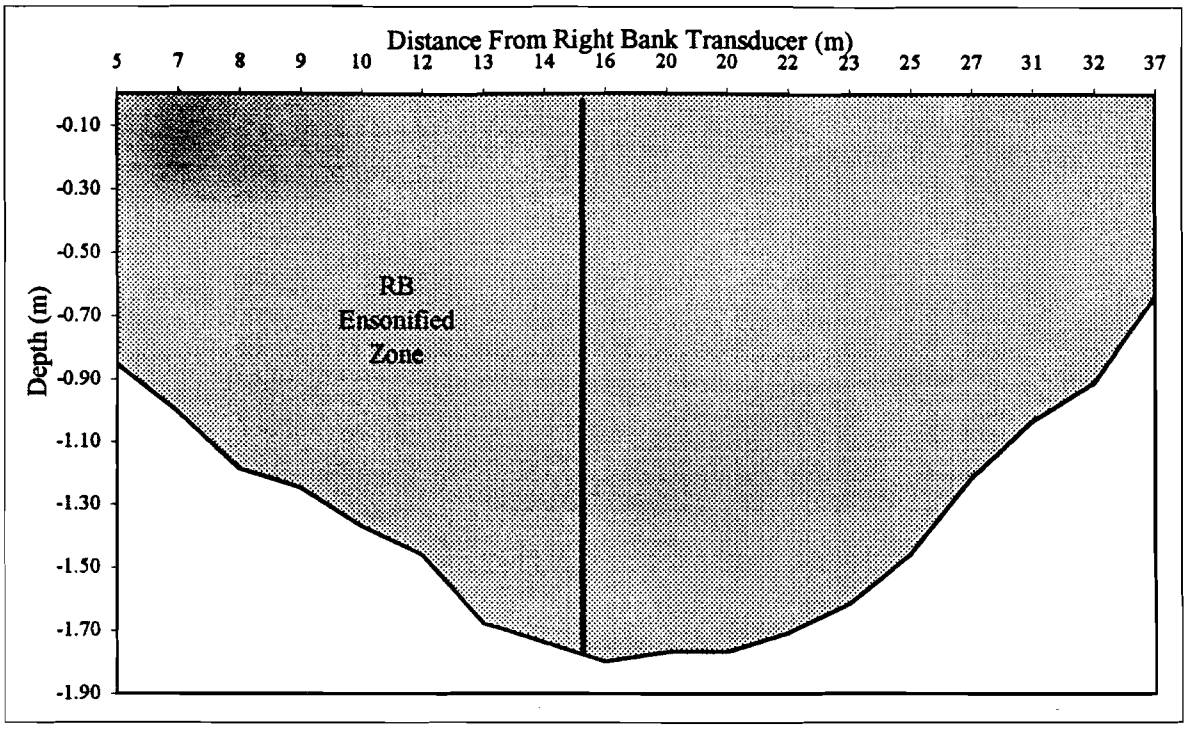


Figure 2. Aniak River sonar site map, 1996.



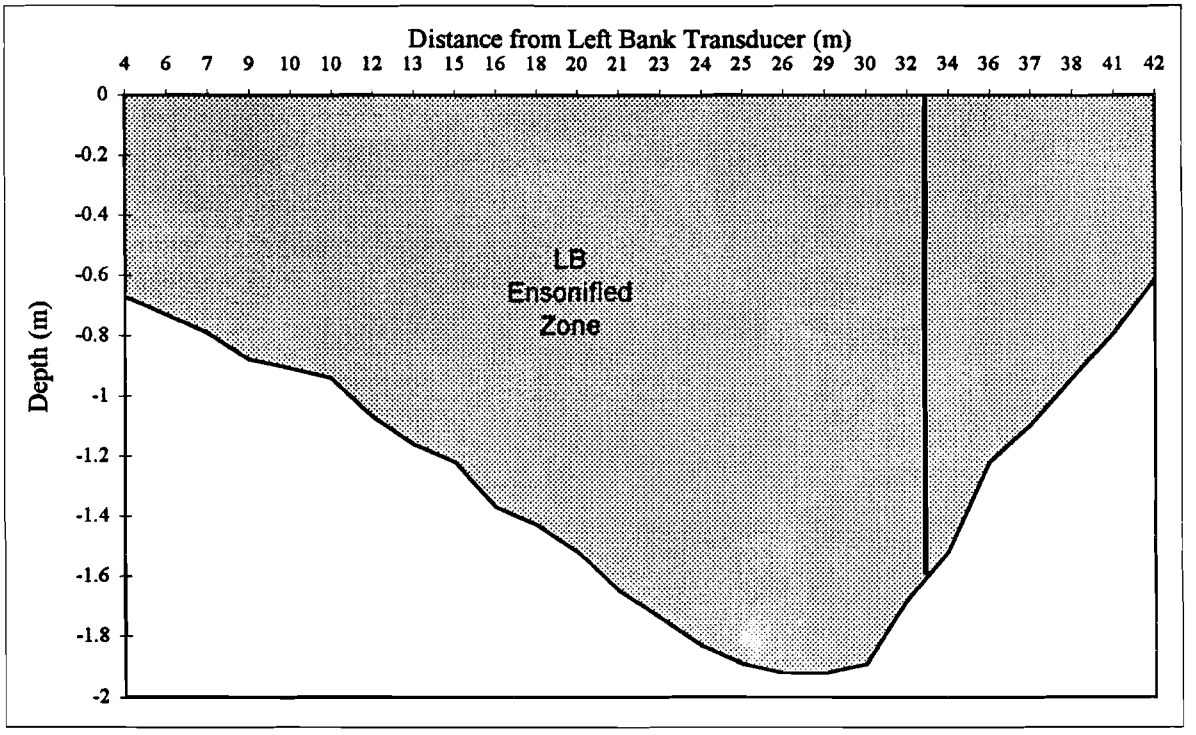


Figure 3. Aniak River bottom profile at the sonar site, 1996.

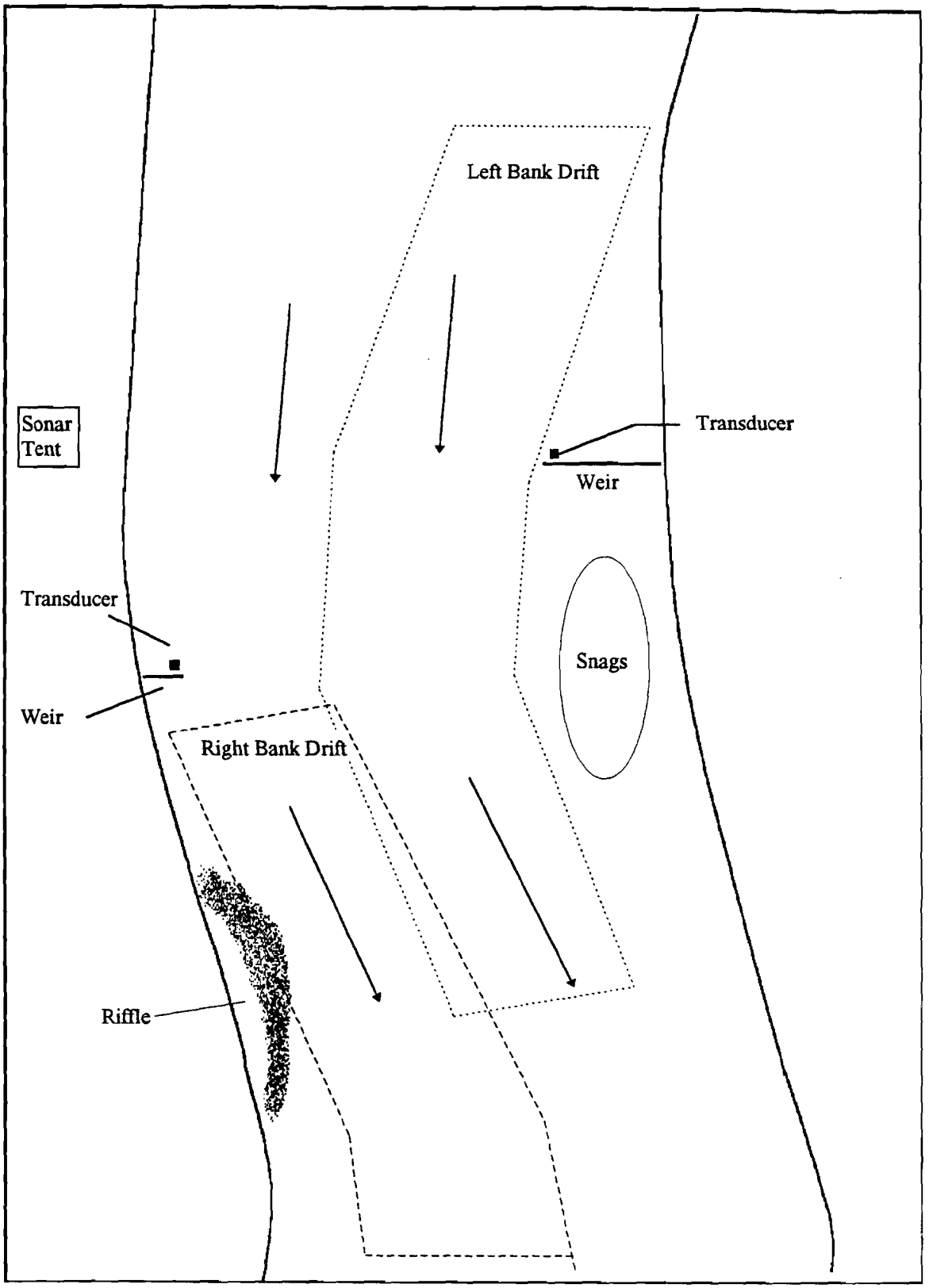


Figure 4. Aniak River drift gillnet stations, 1996.

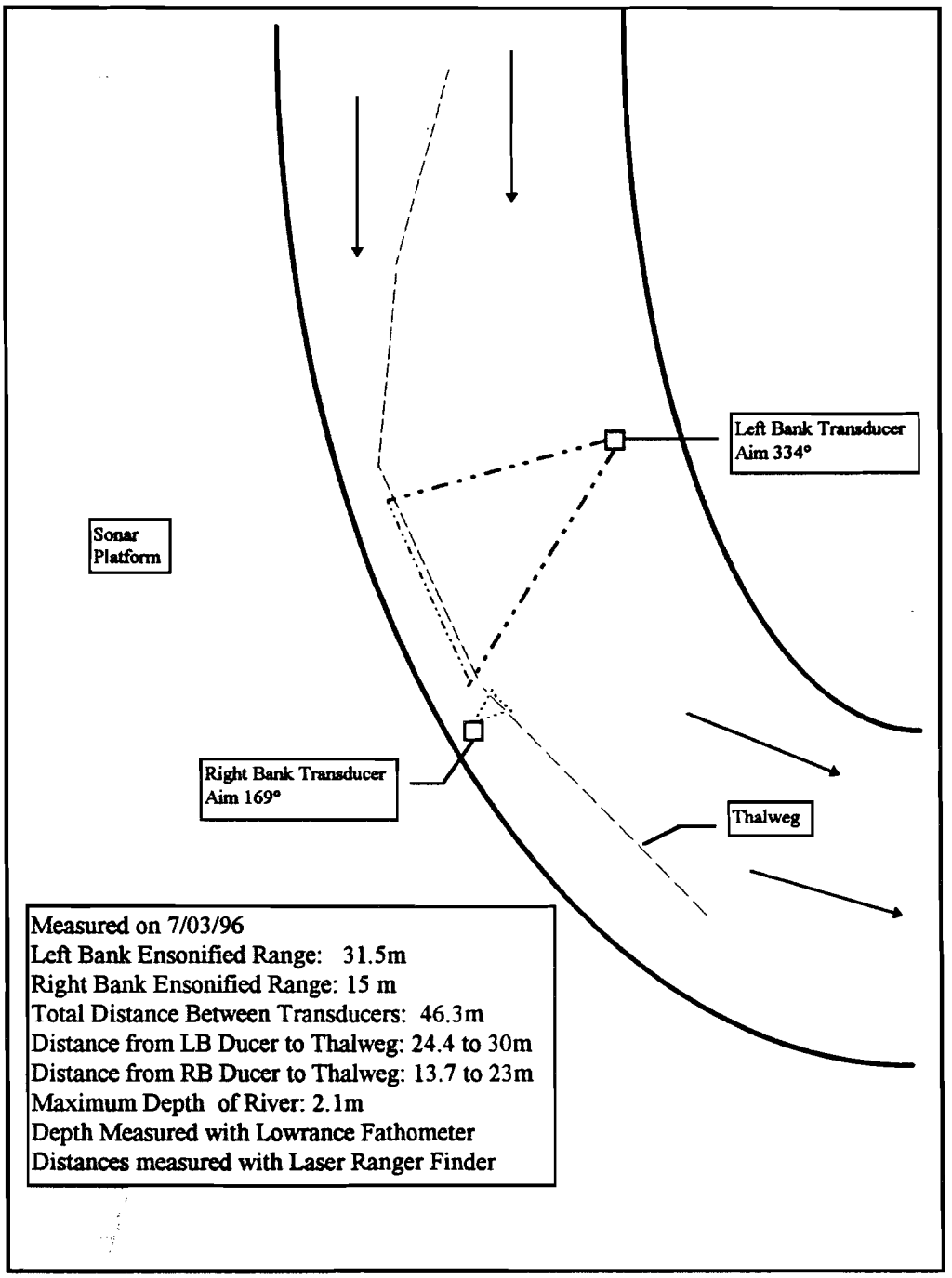


Figure 5. Aniak River sonar site stream measurements, 1996.

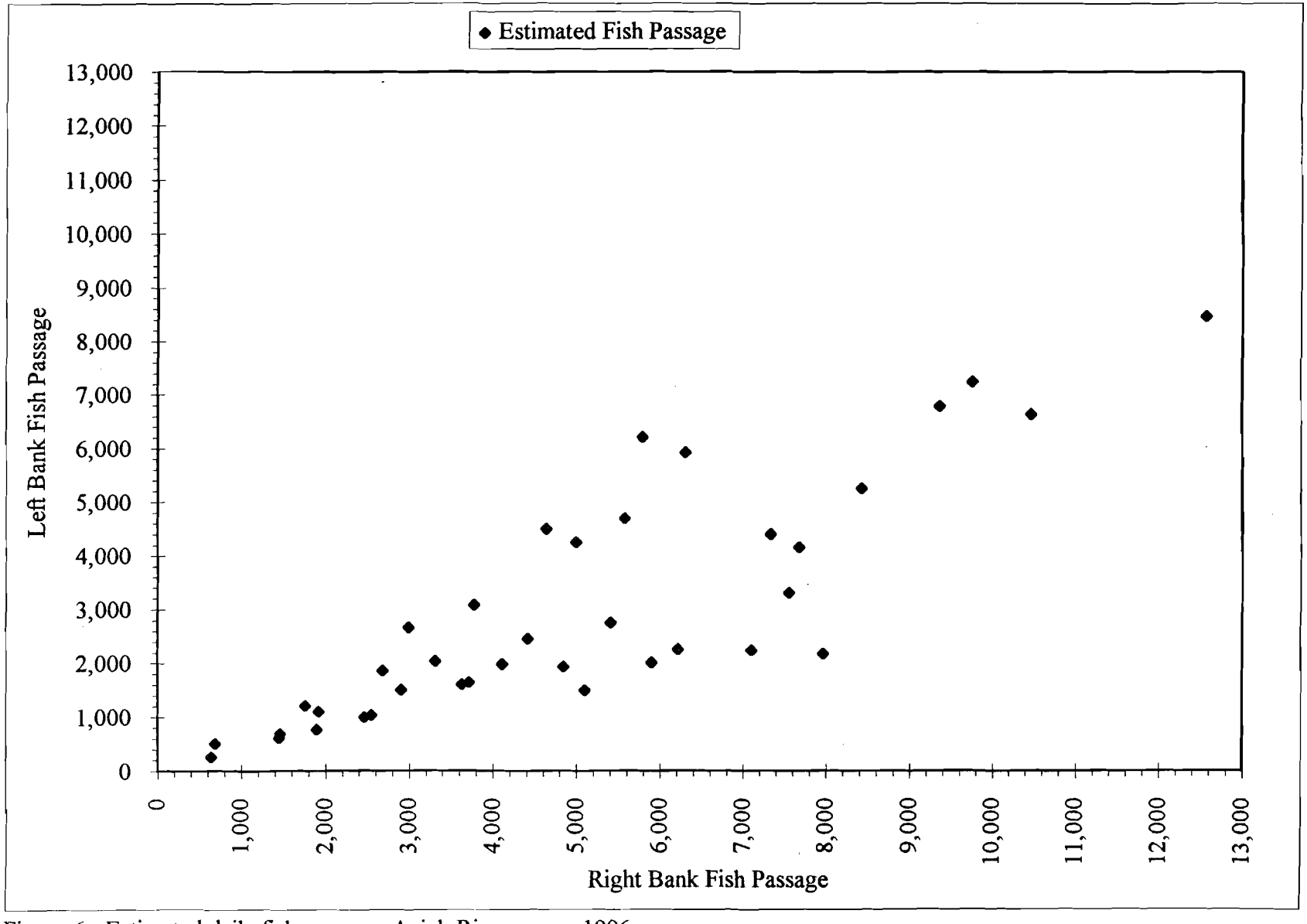


Figure 6. Estimated daily fish passage, Aniak River sonar, 1996.

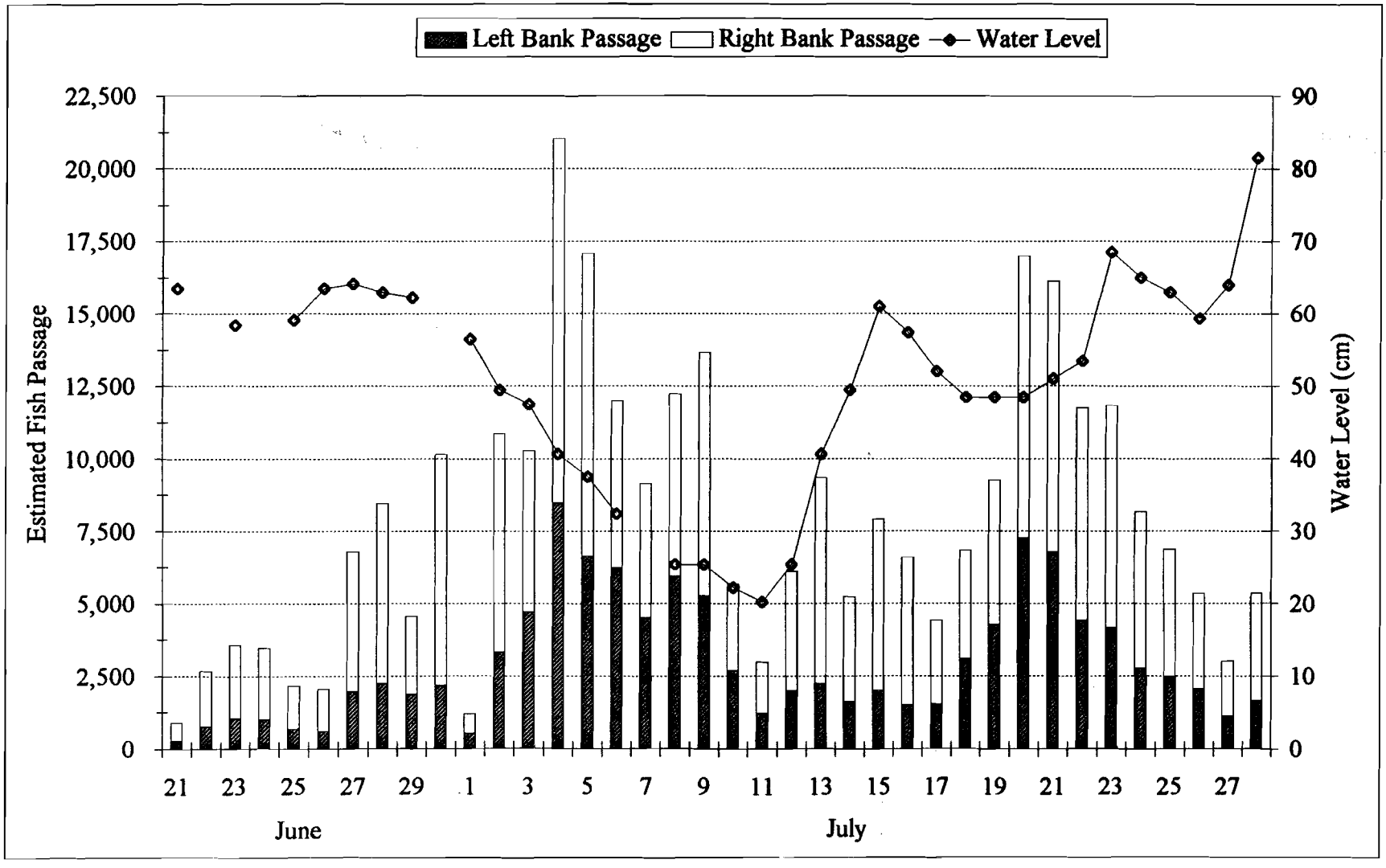


Figure 7. Estimated daily fish passage and measured water levels, Aniak River, 1996

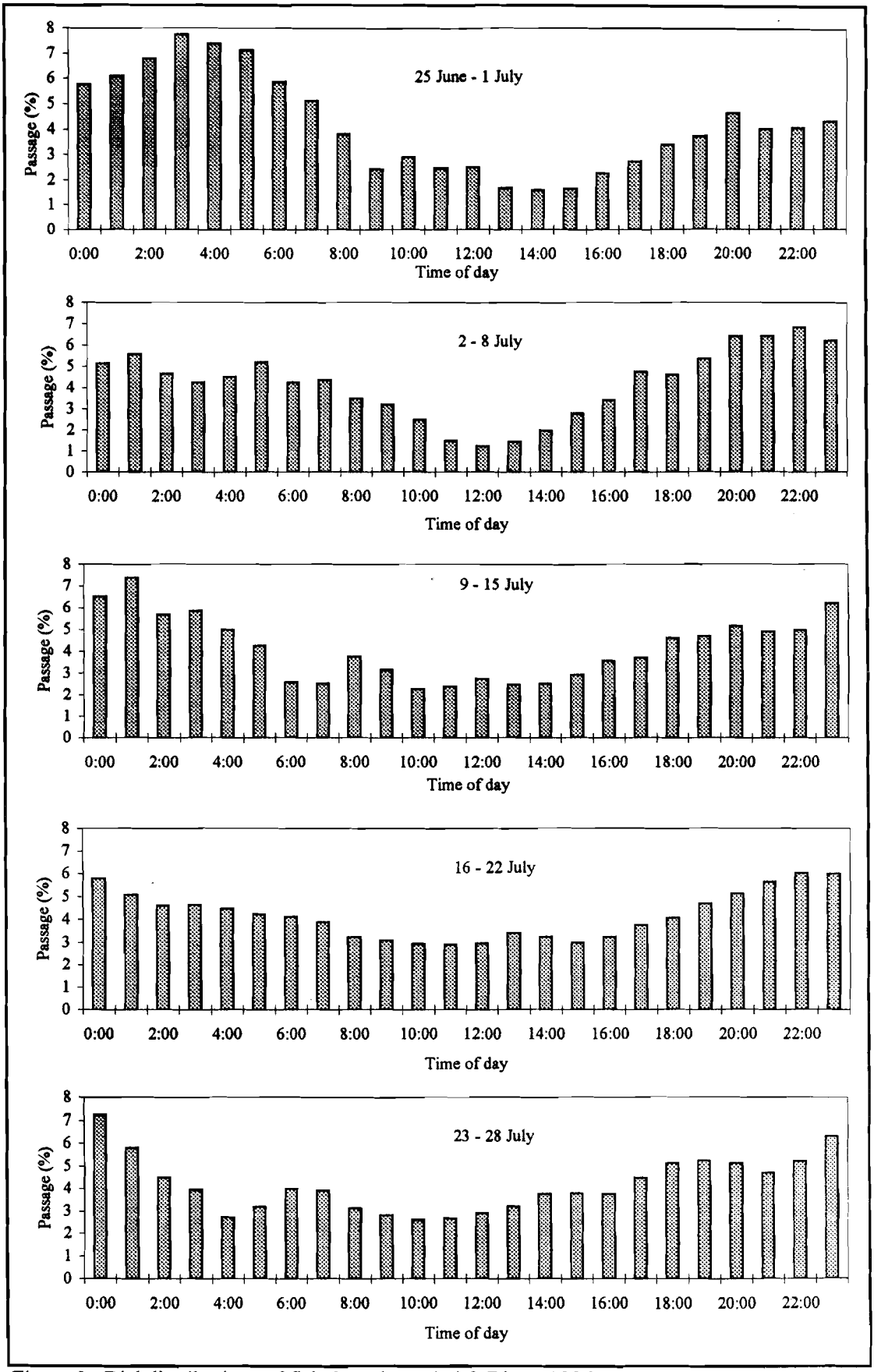


Figure 8. Diel distributions of fish detections, Aniak River, 1996.

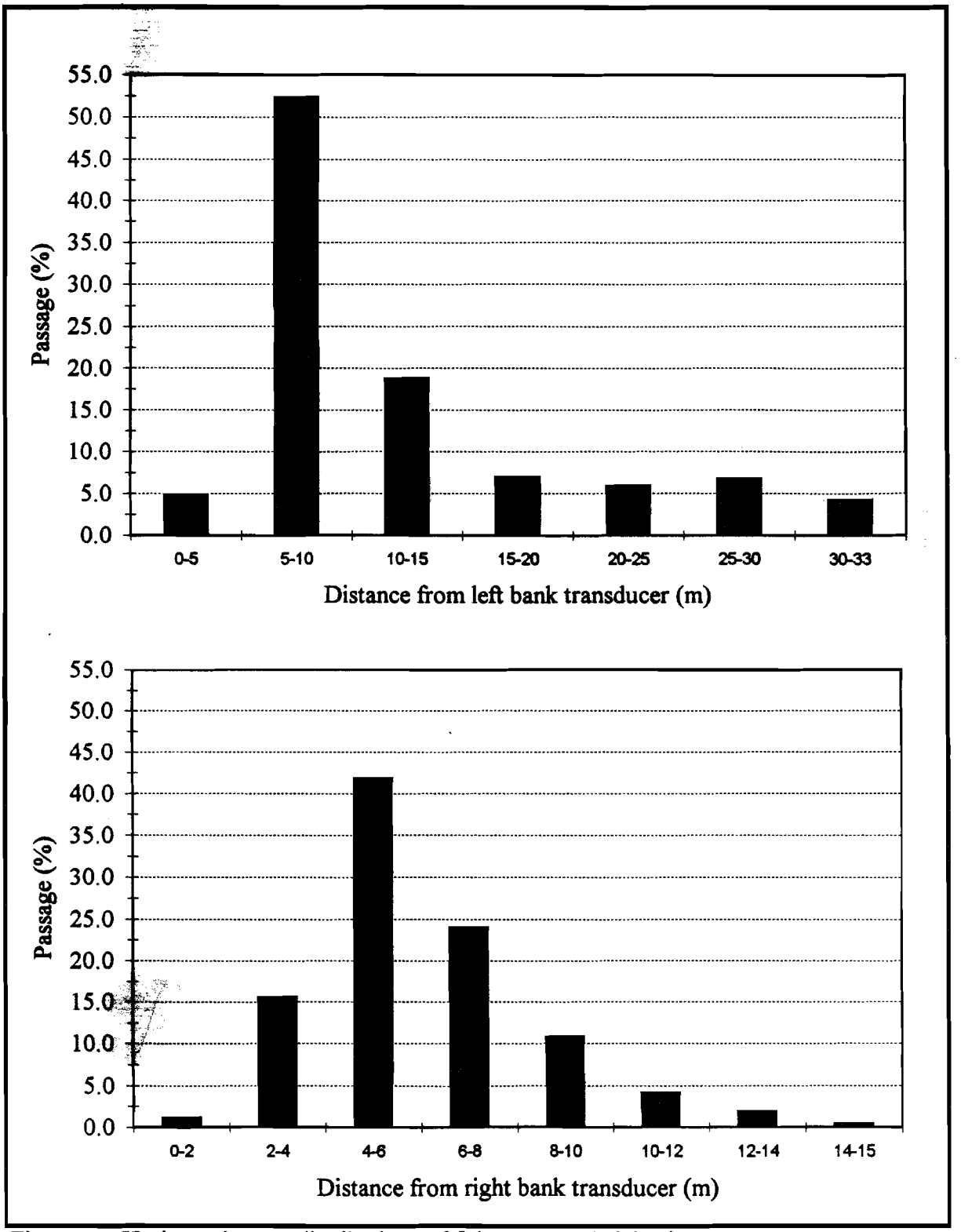
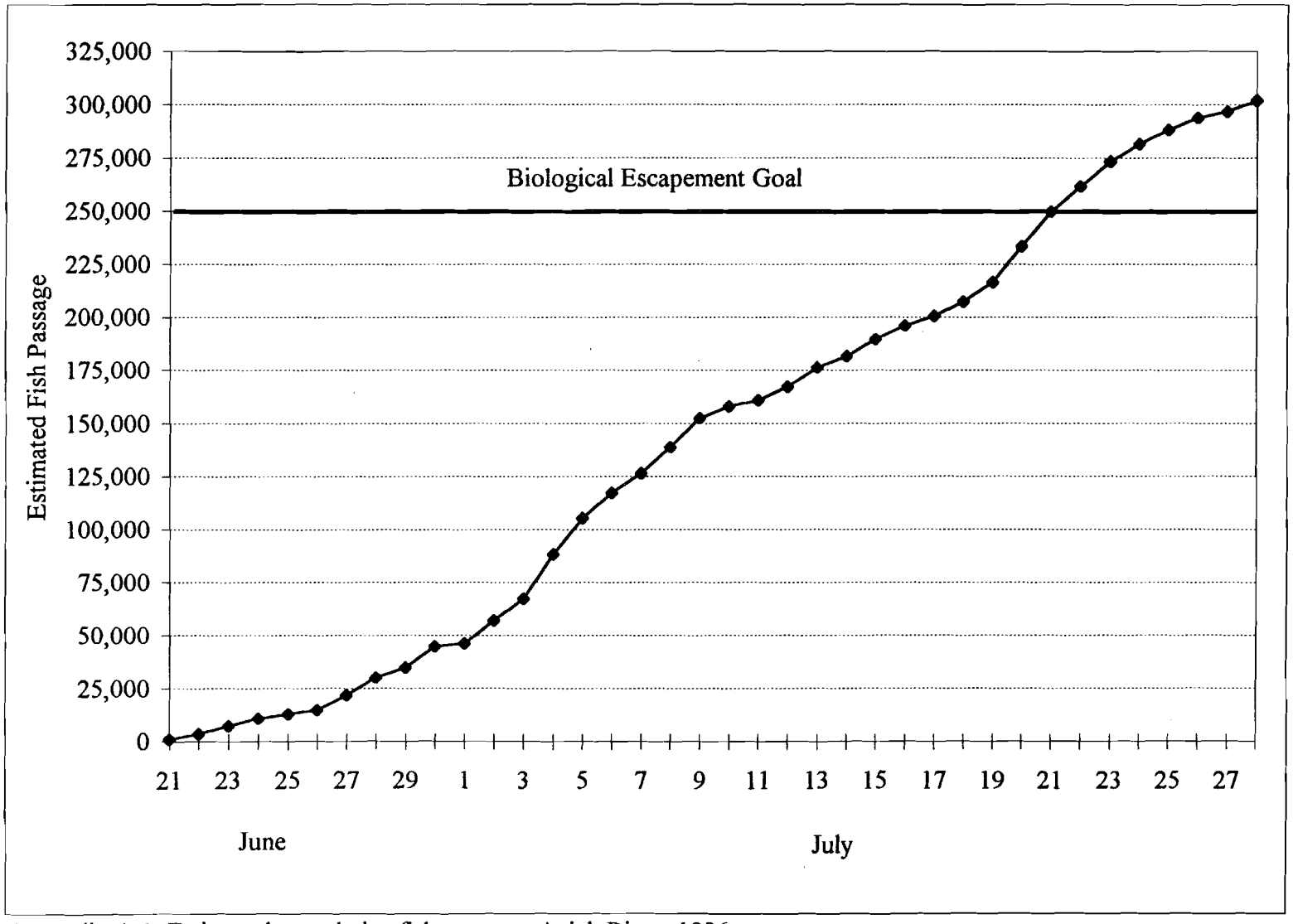


Figure 9. Horizontal range distributions of fish passage, Aniak River sonar, 25 June - 28 July, 1996.

APPENDIX A



Appendix A.1 Estimated cumulative fish passage, Aniak River, 1996.

Appendix A.2 Climatological and hydrologic measurements, Aniak River sonar site, 1996.

Date	Time	Water (C)	Air (C)	Secchi (cm)	Water Level (cm)	Rain (mm)	Wind Velocity/Dir.	Comments
20-Jun	0920	8	N/A	N/A	N/A	N/A	10-15/SW	Overcast w/ intermittent rain
21-Jun	1312	10	N/A	N/A	63.5	N/A	N/A	Overcast w/ intermittent rain
22-Jun	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
23-Jun	0755	11	10	167	58.4	N/A	calm	clear
24-Jun	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
25-Jun	1020	11	N/A	167	59.1	N/A	N/A	
26-Jun	0800	9	N/A	167	63.5	N/A	N/A	
27-Jun	0823	10	N/A	167	64.1	N/A	N/A	
28-Jun	0800	10	N/A	137	62.9	N/A	N/A	
29-Jun	0850	9	N/A	167	62.2	N/A	N/A	
30-Jun	0815	10	N/A	N/A	N/A	N/A	10-15/E	Overcast
1-Jul	0800	9	N/A	152	56.5	N/A	N/A	
2-Jul	0815	10	N/A	152	49.5	N/A	N/A	
3-Jul	0722	10.5	N/A	167	47.5	N/A	N/A	
4-Jul	0810	12	21	N/A	40.6	N/A	10-15	Partly cloudy w/ evening rain
5-Jul	0800	11.5	21	N/A	37.5	N/A	10-15	Sunny a.m., evening thunder shower
6-Jul	1600	13	21	137	32.4	N/A	5-10	Partly cloudy a.m., sunny evening
7-Jul	N/A	N/A	27	N/A	N/A	N/A	0-5	Sunny a.m. w/ late evening rain
8-Jul	0810	12	25	N/A	25.4	0	0-5	Mostly sunny
9-Jul	0825	12	21	N/A	25.4	N/A	0-5	Overcast w/ intermittent rain
10-Jul	0800	12	N/A	N/A	22.2	N/A	N/A	Overcast w/ intermittent rain
11-Jul	0815	10	13	N/A	20.2	2.5	5-10	Overcast/evening rain
12-Jul	0815	9.5	18	N/A	25.4	10.2	10-20/SE	Rain/overcast
13-Jul	0900	10	16	N/A	40.6	5.1	5-10/SE	Rain/overcast
14-Jul	0830	10	N/A	N/A	49.5	N/A	5-10/SE	Early a.m. rain, sunny afternoon
15-Jul	N/A	N/A	28	N/A	61	0	5-10/SE	Mostly sunny
16-Jul	0800	9.5	17	N/A	57.4	10.2	5-10/S	Rain
17-Jul	0940	10	18	N/A	52	N/A	5-10/NW	Rain
18-Jul	0805	10	N/A	N/A	48.5	5.1	5-10/NW	Scattered showers
19-Jul	0800	10	28	N/A	48.5	N/A	N/A	Light a.m. rain, sunny evening
20-Jul	1000	10	27	N/A	48.5	0	0-5/SW	Sunny all day
21-Jul	0820	10.5	26	N/A	51	0	0-5/SW	Sunny all day
22-Jul	0825	10.5	21	N/A	53.5	0	0-5/SW	Partly cloudy
23-Jul	0820	10.5	21	N/A	68.5	0	15-20/SW	Partly cloudy
24-Jul	0900	12	23	N/A	65	0	5-10/S	Partly cloudy
25-Jul	0815	10.5	20	N/A	63	N/A	N/A	Overcast w/ intermittent rain
26-Jul	0850	14	19	N/A	59.5	38.1	10-15/S	Heavy rain
27-Jul	0815	N/A	18	N/A	64	7.6	5-10/W	Overcast w/ heavy p.m. rain
28-Jul	0850	N/A	N/A	N/A	81.5	N/A	N/A	