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ANIAK RIVER SALMON ESCAPEMENT STUDY, 1988

By

D. J. Schneiderhan

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ABSTRACT

The Bendix side scan sonar was operated from 23 June to 31 July, 1988. The total sonar-based estimate of chum salmon escapement for the Aniak River was 401,511. The cumulative proportion model of chum salmon passage was updated to include all years, 1980 - 1988. The relationship (R^2=.73, P<0.05, df=7) for all years (n=9) between Aniak River chum salmon escapement estimates and chum salmon CPUE in District 1 of the Kuskokwim River was significant (.05), though considerably deteriorated from previous years. The mean date of chum salmon passage was similar to historic mean dates (12.4 July, s=9.3 days). The average sector and average diel count distributions were typical.

Daily noon water temperatures ranged from 8 C to 14 C (mean = 11.9 C). Daily noon air temperatures ranged from 13 C to 23 C (mean = 18.6 C).

INTRODUCTION

Description of the Area

The Aniak River originates in the Aniak Lake basin about 90 miles east and 20 miles south of Bethel, Alaska. It flows north for nearly 80 miles where it joins the Kuskokwim River one mile above the village of Aniak. The uppermost portion of the river is characterized by swift, clear water which descends from Aniak Lake at about 800 feet elevation to about 450 feet elevation in the vicinity of the confluence of Atsaksovluk Creek, a distance of about 35 miles. The character of the river and its substrate begins to change in that area. The swift, clear water becomes increasingly turbid as it flows in the shallower gradients of the middle and lower river valley where the substrate grades into finer gravels, sands, and silts. The main features of the river from this area to the mouth are the broad meanders with large gravel bars on the inside bend and cutbanks with exposed soil, tree roots and snags on the outside bend. Downstream navigation in the middle and lower reaches of the Aniak River can be hazardous due numerous snags and sweepers which may be encountered.

The Aniak River sonar project is located in section 5 of T16N, R56W (Seward Meridian) approximately 12 miles upstream from the mouth of the Aniak River (Figure 1).

Project History

The Kuskokwim River produces abundant quantities of Pacific salmon (*Oncorhynchus* spp.). Subsistence and commercial fishermen who live along the Kuskokwim River place major cultural and economic importance upon harvests of chum (*O. keta*) and chinook salmon (*O. tschawytscha*). The expanding human population in the Kuskokwim area is producing increasing pressure on the salmon resource to provide cash and subsistence food and to maintain the accustomed lifestyle of the native people. Increasing demand for the resource is accompanied by growing interest in more efficient harvest technique and equipment. The combination of all of these factors in other fisheries has proven to be a forewarning of the potential for resource overexploitation. It is one of the primary aims of fishery management to protect fishery stocks from overexploitation while optimizing their potential value and limiting the adverse political, economic and cultural effects caused by stock depletion.

Acquisition of timely chum salmon escapement data from Kuskokwim River tributaries provides a basis for inseason management of the fishery and a means of evaluating management efficiency. In 1978 and 1979, the Kwethluk and Kasigluk Rivers were chosen to evaluate the feasibility of using Bendix side scan sonar equipment for providing estimates of chinook and chum salmon escapements. These rivers were chosen for their proximity to the important commercial fishery near Bethel, e.g. District 1 (Figure 2).

The Kwethluk and Kasigluk Rivers proved to be unsuitable for sonar operation. The Kwethluk contained large quantities of debris which caused an unacceptable amount of indeterminant false counts (Schneiderhan 1979). The Kasigluk salmon escapements were too small to allow accurate sonar calibration (Schneiderhan 1980).

Evidence of the importance of Aniak River salmon production has accumulated since 1954 (Schneiderhan 1983) when the first efforts were made by biologists to quantify the extent of salmon spawning in Kuskokwim River tributaries. Because of a history of significantly larger counts of spawning salmon compared to other Kuskokwim tributaries, the Aniak was chosen in 1980 for a sonar feasibility study (Figure 3). The purpose of the study was to assess the implementation of the Bendix side scan sonar to index adult salmon escapements. The first three years of operation (1980-82) resulted in data which agreed with trends of commercial chum salmon CPUE, and the project entered its current fully operational phase. Early reports (Schneiderhan 1981, 1982, 1982a, 1984, 1988) provide details of the project history.

Description of the Resource

Since 1980, sonar-based escapement estimates have ranged from 115 thousand to over one million salmon of which 5 to 10 percent are thought to be chinook, and the remainder mostly chum salmon. These and other observations suggest that in the Kuskokwim drainage the Aniak River is one of the two most important producers of chum and chinook salmon. Although the contribution of Aniak River chum salmon to total Kuskokwim River chum salmon production is not known, it is believed that it may be as much as 10% to 25% of the drainage-wide total.

Quantitatively, little is known about Aniak salmon species other than chum, although in many years aerial surveys provide an index of chinook salmon abundance in the clearwater areas. Early attempts to apportion sonar counts using test fishing techniques indicate that probably less than 10% of the sonar count may be attributed to chinook salmon (Schneiderhan 1981, 1982, 1982a). Coho salmon (*O. kisutch*) spawn and rear (Schneiderhan 1981, Sundberg pers. comm.) in relative abundance in the Aniak River drainage. Sockeye salmon (*O. nerka*) have been sighted in small schools by experienced aerial observers (Schneiderhan 1983, 1987), while pink salmon (O. gorbuscha) have been infrequently captured in gill nets or beach seines in the Aniak (Schneiderhan 1981).

Management of the commercial and subsistence chum salmon fisheries benefits from timely knowledge of spawning escapement performance. The chum salmon resource has traditionally been the major fisheries resource in the Kuskokwim River. It provides a significant cash income to most Kuskokwim River commercial fishermen and is of major importance to the Kuskokwim subsistence economy. Currently, there is only one other intensive escapement monitoring activity in the drainage, the Kogrukluk River weir on the upper Holitna River drainage. A major strength of the Aniak Sonar project is an established database consisting of eight consecutive years of comparable sonar data. The database provides a migration timing model consisting of cumulative daily proportions which are used on a daily basis during the migration to forecast total season escapement.

The Aniak sonar project is the nearest of the two upriver escapement monitoring projects to the lower river commercial and subsistence fisheries. Because of its proximity to the main Kuskokwim River fisheries, the project is able to provide a timely indication of chum salmon escapement magnitudes while the fishery remains in progress. It also provides an index of relative annual chum salmon escapement abundance upon which escapement index objectives are based.

Project Objectives

The primary objective of the Aniak River sonar project is to acquire daily and seasonal indexes of adult chum salmon passage at the sonar site. Supplemental to this is the objective of using the chum indexes to provide analytical tools for the inseason management of the chum salmon commercial fishery on the lower Kuskokwim River. These objectives are accomplished by:

1. Estimating daily chum salmon migrations in the Aniak River using Bendix side scan sonar equipment.

2. Estimating timing statistics of the chum salmon passage at the sonar site.

3. Examining sites and techniques which have the potential for improving the accuracy or precision of the project results.

Prior to 1986 the project had the objective of determining the age, sex and size composition of chinook and chum salmon from drift gill net and carcass samples. That objective was deleted from the project operation in 1986 in order to decrease expenditures. The early work also had the objective of indexing chinook salmon escapements by apportioning counts using the results of test fishing at the project site. That objective was also dropped in 1986 after it was evident that test fishing techniques were incapable of providing adequate sample sizes.

METHODS

Types of Data Collected

The sonar data sheet was the primary data recording form. Each form accepted a day of sonar data from a single sonar counter. Daily sonar counts were automatically output on the built-in printer. These data were then transferred to the sonar data sheet on a daily basis. The sonar data sheet served as a worksheet for estimating the daily chum salmon escapement. The estimates were usually calculated after the last of the daily counts were made at 2400 hours. The estimate was relayed to the area management biologist in Bethel via single side band radio at 0730 hours following the day the counts were made.

The field calibration log was used to maintain a record of sonar calibration data. The result of each calibration was an agreement ratio (AR) which was transferred to the sonar data sheet and used as a factor in estimating the daily chum salmon escapement.

The side scan counter log was used to record changes to the physical or electronic settings of the sonar equipment which may have affected performance.

Data which was regularly relayed to the Department of Fish and Game office in Bethel was recorded on the radio data log. This included the date, adjusted daily site A sonar count, and the daily estimated end-of-season escapement.

Weather and hydrologic conditions were recorded on the climatological and stream observations form. The data was recorded daily at noon.

Sonar Operation

A two person crew installed and operated a Bendix side scan sonar counter at the primary sonar location, e.g. site A (Figure 1). Sonar operation began on 23 June and concluded on 31 July. Daily salmon magnitude indexes were obtained from sonar counts which had been adjusted using standardized calibration procedures. Comparable site A sonar data exists for all years of sonar operation, e.g. 1980 through 1988.

An additional sonar unit was operated at the site to provide data useful for evaluating various operating modes and locations in the near vicinity.

The sonar counters were operated continuously except for short periods when the equipment was moved or malfunctioning. Sonar counters were calibrated at 0600, 1200, 1800, and 2400 hours each day, or more often if necessary.

A 1981 model Bendix side scan sonar was installed and operated (Bendix Corp. 1981) without substrate at site A. Operation was identical to prior years in all respects except for the elimination of the substrate. Sonar calibration was performed by a practiced observer using an oscilloscope to visually display real time echo-generated electronic patterns from the sonar receiver. The observer applied criteria developed through experience and training to discern and count the oscilloscope patterns which were generated by migrating salmon during a minimum fifteen minute time period. The sonar count during the same period of time was compared to the oscilloscope count as:

$$\mathbf{AR} = \frac{\textbf{OSCILLOSCOPE COUNT}}{\textbf{SONAR COUNT}}$$

where AR > 1 and AR < 1 indicated that the sonar was proportionally under- and overcounting, respectively.

The fish velocity control, which sets the sonar ping rate, was initially set at 0.571 s/ft when the sonar was installed (Bendix 1981). After the daily 2400 hours calibration, the sonar ping rate was adjusted if the daily average AR value was less than 0.8 or greater than 1.2. The ping rate adjustment was proportional to the deviation of the average AR from 1.0.

The sonar counts were subtotaled for each six hour period. The subtotals were multiplied by the end-of-period AR value to adjust for the observed sonar error during that period. The sum of adjusted six hour sonar counts was the daily adjusted count which was the essential product of the sonar operation and represented the best estimate of daily salmon passage through the sonar counting range.

Inseason estimation of total escapement was conducted in the field by the project crewleader using an electronic calculator. The daily estimate of the total-season escapement magnitude was calculated as the most recent cumulative adjusted daily count multiplied by an expansion factor of 1.62 to account for salmon which passed outside of the sonar counting range. The result of that operation was then divided by the corresponding cumulative proportion from the inseason forecast model. The accuracy of these daily estimates depended on how well the current year escapement time series matched that of the model chosen as the most probable representative type. In practice, three models representing early, normal (mean) and late migration timing were followed simultaneously, and the estimates from the one which demonstrated the best fit with current season data was used by the management biologist along with other catch and escapement indicators for regulating the chum salmon harvest in District 1.

At the end of the season, daily proportions were calculated as the daily adjusted count divided by the sum of all daily adjusted counts. These data were then used as a basis for calculating the mean date of migration and its standard deviation using techniques presented by Mundy (1982) for Yukon River chinook salmon.

Final post season data analysis involved entry of the data into spreadsheets where all adjustment and estimation calculations were examined and repeated. Counts on days when the sonar was not operated but for which historic data existed were estimated as

$$x = \frac{a\,b}{c}$$

where x represented the expanded count to be estimated, a was the sum of the known expanded counts, b was the historic daily proportion on the day of the count to be estimated, and c was the sum of historic daily proportions on days with known expanded counts. This process resulted in an estimated count for each day for which historic data existed.

The estimated total escapement and the commercial chum salmon CPUE in Kuskokwim District 1 was regressed for all years of sonar operation.

Sonar sector distribution was calculated as the average by sector of the daily sonar counts for the season. The average sector count was used to graphically illustrate the average sonar sector distributions. A similar procedure was used to analyze hourly sonar count distributions.

Most analyses of the sonar data were performed after the completion of the field season in either the Bethel or Anchorage office. Analyses were performed using Lotus 1-2-3 (TM Lotus Developement

Corp.) software running on a Compaq Deskpro 286 (TM Compaq Computer Corp.) microcomputer or other IBM (TM International Business Machines) compatible computer.

Meteorologic and Hydrologic

Environmental factors were measured daily at noon. Measurements were made of air and water temperatures, and relative stream levels. Type of precipitation, amount of cloud cover, wind direction and velocity, and water color were subjectively estimated and coded using instructions printed on the form.

RESULTS

Site A Sonar

Sonar site A provided uninterrupted daily adjusted salmon counts during the operating period in 1988. The cumulative adjusted count was 239,454 (Table 1). Adjustment ratios used to correct these counts averaged 0.82 for the season (Table 2). The normal timing model was selected from the average of 1980-1984 time series data to provide proportions for nonoperating days. Expansion to account for salmon swimming outside of the sonar range (EF = 1.62), and expansion for nonoperating days resulted in an estimated total escapement of 401,511 (Table 3). Time series data for 1980-1984 was used because the database was not current during the 1988 season. A current time series database through 1988 was prepared for presentation in this report and is included in the appendices.

Relationship with W-1 CPUE

The relationship (R^2=.73, P<0.05, df=7) between Aniak River chum salmon escapement estimates and chum salmon CPUE in District 1 (Figure 4), the lower Kuskokwim River, was significant (.05). Annual data and regression statistics for the years 1980 through 1988 appear in Appendix A.

Daily Count Magnitude and Timing

The distribution of daily counts followed patterns typical of previous years (Figure 5). Characteristically, counts leveled out at an intermediate level near the end of the operating period (Figure 5 includes estimated counts for the periods before 23 June and after 31 July). This was thought to be an artifact caused by the difficulty of properly calibrating the sonar as salmon behavior changed and swimming speeds slowed near the end of the spawning period. Also, coho salmon were thought to begin passing the sonar at that time and may have contributed to elevated counts. The mean date of passage was 12.4 July (s = 9.3 days). Peak daily escapement estimate was 18,045 on July 5.

Sector Distribution

The sector distribution was typical of other years. The largest counts occurred in sectors 1-5 while the smallest counts were in the outermost sectors. A discontinuity was apparent between sectors 8 and 9. This has been widely reported for the Bendix side scan sonar and appears to be related to the counting logic criteria which is a built-in characteristic of the equipment (Figure 6, Appendix B).

Diel Distribution

The hourly pattern of sonar count fluctuations was typical of all other years (Figure 7, Appendix C). The diel distribution of counts was characterized by relatively low counts around noon gradually increasing to relatively high counts at midnight and the early morning hours, and then declining to low counts by the following noon.

Meteorologic and Hydrologic

High stream levels and flow rates occurred at the start of operations. Relatively good weather in late June continued through most of July with only brief periods of thunderstorm or rain activity. Dry weather in July resulted in numerous forest fires in the Yukon and Kuskokwim River drainages. Heavy smoke on 3 July was caused by a large fire in the lower Yukon drainage. Lighter smoke haze occurred on other days during the operating period.

Daily noon water temperatures in the Aniak River ranged from 8 C at the start of operation to 14 C on 22 and 23 July (mean = 11.9 C). Daily noon air temperatures ranged from 13 to 23 C with a mean of 18.6 C. Relative stream levels, daily water temperatures and weather conditions appear in Table 4.

DISCUSSION

Sonar

Inseason Escapement Estimates

Time series of the 1980 through 1984 average cumulative proportions of daily sonar counts (Table 3) were used to generate inseason estimates of the end-of-season total chum salmon escapement. The average cumulative proportion series was calculated as the average cumulative proportion for each date for the years 1980 through 1984. The late cumulative proportion series represents the minimum cumulative proportion for each date from the baseline data, while the early cumulative proportion series represents the maximum cumulative proportion for each date from the baseline data. During the 1988 season, only the years 1980 through 1984 were included in the database. The database has since been updated to include all years through 1988 (Appendices D, E, and F). A graph of the 1980 through 1984 average cumulative proportions would appear similar to that of the 1980 through 1988 data depicted in Figure 8.

Inseason estimates of total season escapement were made using cumulative adjusted sonar counts to date and the baseline (1980-84) time series of cumulative proportions (Table 3). The trends of those estimates was closely monitored to detect which appeared to stabilize. As one of the three estimates appeared to stabilize at a particular level, it was chosen as the most reasonable estimate of the final season chum salmon escapement. If subsequently a different estimate became more stable, it was used.

The most stable series of 1988 estimates was derived from the normal series of the 1980-1984 baseline model (Table 3). Therefore, the results from this model provided the best estimate of final season escapement and provided input for the inseason management process.

The average, maximum, and minimum daily cumulative proportion statistics were updated after the season to include the years 1985 through 1988. That database appears as Appendices D, E, and F. Figure 8 graphically illustrates the resulting daily cumulative proportion statistics.

Escapement Trend

The chum salmon escapement objective for the project (250,000) was established in 1983. It was thought to represent a realistic escapement expectation based on four years of sonar escapement data and nearly 30 years of intermittent aerial survey counts. Escapement estimates since that time continue to support the objective as capable of providing adequate returns and escapements (Figure

9). Relatively low escapements in 1983 and 1984 produced the very large return in 1988. Assuming a reasonable accuracy for the sonar escapement estimates, this may be due to a dramatic change in mortality factors, i.e. high seas interception; or it may indicate that perceived low escapements are routinely capable of producing large returns, e.g. lower spawning density increases survival; or both. Certainly, the record escapements of 1980 and 1981 did not produce the large returns expected in 1984 and 1985. Differential mortality is the obvious cause, but the dynamics of the many mortality factors are largely unknown for Kuskokwim River salmon stocks.

Fish Velocity Setting

The sonar ping rate is set under the assumption of a static salmon swimming speed when in reality swimming speed varies with time of day and other factors. The six hour calibration intervals (0600, 1200, 1800, 2400 hours) were chosen for operational expediency as well as considerations of daily migration rate fluctuations. Calibrations (AR values), which vary from 1.0, are used to adjust the previous six hour total count when intraday variations occur. Swimming speed may also vary on a longer term with the stage of the migration. The average AR, when less than 0.8 or greater than 1.2, is used to reset the sonar ping rate to compensate for a multiday trend in swimming speed.

Relationship with W-1 CPUE

Prior to 1984 regulation of exploitation rates was the primary means of managing the commercial salmon fisheries in District 1. The fishery manager limited the timing and duration of commercial openings to achieve a preselected "quideline harvest level". That management approach resulted in chum salmon escapement magnitudes which were more or less proportional to returns. Chum CPUE in District 1 was also proportional to return strength; consequently, the relationship between chum CPUE and Aniak River escapement was very close (R^2=.98, $P<0.05$, df=4).

Beginning in 1984, the salmon fisheries were managed to achieve escapement objectives which were established for escapement monitoring projects. Initial management efforts in 1984 through 1987 continued to prove nearly as conservative as those in prior years. This was primarily due to the smaller returns of chinook and chum salmon which were detected inseason in catch and escapement statistics during that period. The relationship between chum CPUE and Aniak River escapement through 1987 deteriorated only slightly (R^2=.92, $P<0.05$, df=6) and remained significant (.05).

In 1988 very large chum returns were detected early in the season, and the fishery manager responded by increasing the number of open commercial periods and allowing openings to occur throughout the month of July. A record chum salmon harvest resulted (1.3 million fish), while escapements appeared to be only moderately larger than recent years. Chum salmon (and chinook) escapement objectives were achieved or exceeded throughout the drainage; however, the relationship between chum CPUE and Aniak escapement estimates deteriorated substantially (R^2=.73, P<0.05, df=7) though continuing to be significant (.05).

Two things occurred in 1988 that did not jointly happen in prior years. First, the chum salmon fishery was managed by escapement objective, and second, large returns and frequent openings produced large catches which approached the fleet's and processors' maximum capacity, thus reaching maximum efficiency and preventing subsequent rises in CPUE. The combination of these two factors substantially altered the usual relationship between return, CPUE, and Aniak escapement.

It is interesting to note that Bethel Test Fish Project results appear to indicate that the District 1 commercial fleet harvests 80 to 90 percent of the chum salmon present in the district during each six hour opening (Huttunen pers. comm.). This is compelling proof that an upper limit for CPUE exists well within reach of the commercial fleet. This implies that spawning ground escapements must be provided by adequate inter-period duration. It further implies that more efficient gear would add little to the harvest magnitude.

Even though the relationship between W-1 chum CPUE and Aniak chum escapement estimates has deteriorated substantially in recent years, it continues to be a significant relationship, and it may continue to be a useful interpretive tool when the limitations of CPUE as an indicator of catch efficiency and return strength are kept firmly in mind.

An interesting aside to this discussion is provided by Bethel test fish project results. It appears that under the new management regimen the commercial harvest is liable to reach the limiting factor of tendering and processing efficiency in years with large chum salmon returns (Huttunen pers. comm.). This further renders CPUE inoperable as a measure of harvest efficiency or of total chum returns above processing capacity. This may suggest that processors need only increase capacity to increase profits. However, only in years of unusually large returns would it be more profitable. In other years, increased capacity above a certain point would be realized as over-capitalization which may manifest as a substantial drain on profits. Also, beyond the limit of increased processing capacity, awaits the limit imposed by a fixed fleet size.

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Table 1. Adjusted daily site A sonar counts, Aniak River, 1988.

Date	DAILY COUNT BY PERIOD 0600	1200	1800	2400	ADJUSTMENT RATIO 0600	1200	1800	2400	ADJUSTED COUNT
15-Jun									
16-Jun									
17-Jun									
18-Jun									
19-Jun									
20-Jun									
21-Jun									
22-Jun									
23-Jun	243	227	364	458	1.00	1.00	0.48	0.45	851.4
24-Jun	329	307	367	745	1.00	1.00	0.63	0.84	1495.2
25-Jun	622	353	882	1260	0.90	0.75	0.72	0.70	2332.9
26-Jun	1159	874	767	1537	1.21	0.87	0.97	1.22	4796.2
27-Jun	1360	933	704	989	0.89	0.94	1.13	1.24	4112.6
28-Jun	1499	655	639	545	0.76	2.25	0.87	1.08	3750.5
29-Jun	722	510	539	1106	0.71	0.48	1.10	1.21	2688.8
30-Jun	667	695	671	801	1.53	0.83	1.20	2.06	4054.6
01-Jul	1731	2856	2707	2188	0.91	1.11	0.95	1.05	9599.9
02-Jul	2094	1049	932	1548	0.83	0.91	1.02	1.47	5909.8
03-Jul	1780	1134	1334	1480	0.77	1.72	2.04	1.50	8264.0
04-Jul	5146	4094	2614	3128	0.49	0.50	0.90	0.76	9299.9
05-Jul	2947	2847	2642	3445	0.86	1.06	0.76	1.04	11138.6
06-Jul	2240	1719	1666	1734	0.86	0.72	0.79	0.92	6091.3
07-Jul	1574	980	1199	1834	0.64	0.71	0.78	0.97	4422.1
08-Jul	2237	1087	1618	1820	1.22	0.77	1.08	1.31	7698.2
09-Jul	2320	2399	2314	2736	1.49	0.77	0.82	1.10	10200.2
10-Jul	2947	1787	2394	3113	0.98	0.83	0.83	0.90	9134.2
11-Jul	2716	2093	1932	3239	0.68	0.82	0.67	0.80	7452.6
12-Jul	2319	1423	1000	1365	1.01	1.07	1.35	1.83	7726.3
13-Jul	2075	1248	948	2745	1.14	1.18	1.07	0.82	7114.6
14-Jul	2642	1449	1186	2393	0.90	0.89	1.30	1.05	7720.1
15-Jul	3892	1630	1050	1618	0.88	1.56	1.89	1.23	9924.2
16-Jul	3255	2213	1811	3982	0.71	0.72	0.72	0.72	8064.4
17-Jul	4299	2384	2164	2250	0.96	0.62	1.28	1.07	10774.4
18-Jul	4044	1427	832	1277	1.11	1.24	0.94	1.71	9219.6
19-Jul	2156	1100	1452	2424	0.76	0.88	0.88	1.17	6739.0
20-Jul	2191	1227	1114	1545	0.82	0.92	1.27	1.40	6508.0
21-Jul	1804	1055	1068	1702	1.10	0.51	0.78	0.95	4979.5
22-Jul	2389	1366	1634	2548	1.05	0.58	0.77	0.95	6979.7
23-Jul	2996	1789	2041	2623	0.63	0.44	0.54	0.87	6033.7
24-Jul	2241	1256	1072	1662	0.84	1.27	1.45	1.23	7083.1
25-Jul	2439	1076	999	2138	0.97	0.78	0.80	0.66	5416.9
26-Jul	1799	622	798	1529	0.56	1.17	0.75	0.58	3213.3
27-Jul	1587	1206	1273	2033	0.57	1.17	0.26	1.21	5109.6
28-Jul	1419	902	1120	2480	0.54	0.50	0.27	1.04	4089.1
29-Jul	2112	764	1411	1317	0.53	0.43	0.52	0.52	2864.3
30-Jul	780	694	855	914	0.67	1.50	0.40	2.25	3959.5
31-Jul	824	768	923	987	0.36	0.37	1.00	1.00	2493.4
01-Aug									
02-Aug									
03-Aug									
04-Aug									
05-Aug									
06-Aug									
Average	2092.2	1338.4	1308.6	1877.9	0.867	0.919	0.923	1.100	Total 239,454

Table 2. Scheduled daily sonar calibration data, site A, Aniak River, 1988.

Date	0600 Counts Scope	0600 Counts Sonar	A.R.[a]	1200 Counts Scope	1200 Counts Sonar	A.R.[a]	1800 Counts Scope	1800 Counts Sonar	A.R.[a]	2400 Counts Scope	2400 Counts Sonar	A.R.[a]	Daily Average A.R.
15-Jun													
16-Jun													
17-Jun													
18-Jun													
19-Jun													
20-Jun													
21-Jun													
22-Jun													
23-Jun							13	27	0.48	9	20	0.45	0.915
24-Jun	6	6	1.00	13	13	1.00	24	38	0.63	16	19	0.84	0.974
25-Jun	26	29	0.90	9	12	0.75	28	39	0.72	55	79	0.70	0.711
26-Jun	34	28	1.21	40	46	0.87	38	39	0.97	71	58	1.22	0.994
27-Jun	59	66	0.89	15	16	0.94	26	23	1.13	124	100	1.24	0.907
28-Jun	28	37	0.76	9	4	2.25	13	15	0.87	27	25	1.08	0.864
29-Jun	25	35	0.71	16	33	0.48	33	30	1.10	47	39	1.21	0.854
30-Jun	52	34	1.53	19	23	0.83	53	44	1.20	99	48	2.06	1.289
01-Jul	139	152	0.91	113	102	1.11	86	91	0.95	129	123	1.05	0.746
02-Jul	48	58	0.83	40	44	0.91	49	48	1.02	113	77	1.47	0.982
03-Jul	46	60	0.77	55	32	1.72	98	48	2.04	167	111	1.50	1.359
04-Jul	79	162	0.49	77	154	0.50	110	122	0.90	103	135	0.76	0.543
05-Jul	111	129	0.86	92	87	1.06	97	128	0.76	99	95	1.04	0.704
06-Jul	51	59	0.86	71	98	0.72	55	70	0.79	48	52	0.92	0.699
07-Jul	43	67	0.64				53	68	0.78	136	140	0.97	0.764
08-Jul	61	50	1.22	47	61	0.77	71	66	1.08	134	102	1.31	0.978
09-Jul	119	80	1.49	74	96	0.77	87	106	0.82	102	93	1.10	0.757
10-Jul	80	82	0.98	59	71	0.83	88	106	0.83	111	124	0.90	0.728
11-Jul	78	114	0.68	32	39	0.82	110	164	0.67	102	128	0.80	0.596
12-Jul	69	68	1.01	73	68	1.07	46	34	1.35	84	46	1.83	1.037
13-Jul	56	49	1.14	47	40	1.18	91	85	1.07	103	125	0.82	0.876
14-Jul	61	68	0.90	55	62	0.89	52	40	1.30	136	129	1.05	0.883
15-Jul	78	89	0.88	42	27	1.56	89	47	1.89	150	122	1.23	1.060
16-Jul	48	68	0.71	59	82	0.72	95	132	0.72	168	233	0.72	0.666
17-Jul	64	67	0.96	84	136	0.62	86	67	1.28	173	161	1.07	0.845
18-Jul	61	55	1.11	41	33	1.24	48	51	0.94	116	68	1.71	1.092
19-Jul	54	71	0.76	30	34	0.88	46	52	0.88	88	75	1.17	0.797
20-Jul	51	62	0.82	23	25	0.92	33	26	1.27	119	85	1.40	0.990
21-Jul	33	30	1.10	31	61	0.51	43	55	0.78	104	109	0.95	0.780
22-Jul	46	44	1.05	35	60	0.58	74	96	0.77	119	125	0.95	0.766
23-Jul	72	115	0.63	42	96	0.44	59	109	0.54	161	186	0.87	0.559
24-Jul	47	56	0.84	14	11	1.27	64	44	1.45	139	113	1.23	1.063
25-Jul	70	72	0.97	25	32	0.78	24	30	0.80	48	73	0.66	0.570
26-Jul	39	70	0.56	7	6	1.17	18	24	0.75	70	52	0.58	0.763
27-Jul	29	51	0.57	21	18	1.17	48	183	0.26	74	61	1.21	0.524
28-Jul	36	67	0.54	5	10	0.50	39	143	0.27	57	55	1.04	0.444
29-Jul	37	70	0.53	10	23	0.43	28	54	0.52	40	77	0.52	0.442
30-Jul	20	30	0.67	6	4	1.50	4	10	0.40	27	12	2.25	1.036
31-Jul	21	58	0.36	10	27	0.37							0.365
01-Aug													
02-Aug													
03-Aug													
04-Aug													
05-Aug													
06-Aug													
Average	54.7	66.0	0.864	38.9	48.3	0.922	55.8	67.2	0.921	96.5	91.4	1.102	0.8185

a Adjustment ratio is the oscilloscope count divided by the sonar count.

Table 3. Chum salmon escapement estimation for 1988 using side scan sonar migration timing data from the years 1980-1984, Aniak River, Alaska.

	Normal Timing		Late Timing		Early Timing			
Date	Daily Prop.	Cum. Prop.	Daily Prop.	Cum. Prop.	Daily Prop.	Cum. Prop.	Adjusted Count	Estimated Daily Escapem't [a]
15-Jun	0.00021	0.00021	0.00000	0.00000	0.00105	0.00105	0.0	84.3
16-Jun	0.00151	0.00172	0.00000	0.00000	0.00604	0.00709	0.0	606.3
17-Jun	0.00150	0.00322	0.00000	0.00000	0.00698	0.01407	0.0	602.3
18-Jun	0.00137	0.00459	0.00000	0.00000	0.00586	0.01993	0.0	550.1
19-Jun	0.00244	0.00703	0.00000	0.00000	0.00730	0.02723	0.0	979.7
20-Jun	0.00184	0.00887	0.00000	0.00000	0.00460	0.03183	0.0	738.8
21-Jun	0.00327	0.01214	0.00000	0.00000	0.00240	0.03423	0.0	1312.9
22-Jun	0.00426	0.01640	0.00048	0.00048	0.00494	0.03917	0.0	1710.4
23-Jun	0.00579	0.02219	0.00035	0.00083	0.00533	0.04450	851.4	1379.3
24-Jun	0.00623	0.02842	0.00028	0.00111	0.00744	0.05194	1495.2	2422.2
25-Jun	0.00761	0.03603	0.00026	0.00137	0.00704	0.05898	2332.9	3779.2
26-Jun	0.01223	0.04826	0.00065	0.00202	0.01875	0.07773	4796.2	7769.8
27-Jun	0.01480	0.06306	0.00168	0.00370	0.03390	0.11163	4112.6	6662.5
28-Jun	0.01534	0.07840	0.00126	0.00496	0.02971	0.14134	3750.5	6075.9
29-Jun	0.01660	0.09500	0.00207	0.00703	0.01421	0.15555	2688.8	4355.8
30-Jun	0.01491	0.10991	0.00677	0.01380	0.00967	0.16522	4054.6	6568.4
01-Jul	0.02119	0.13110	0.01131	0.02511	0.02875	0.19397	9599.9	15551.9
02-Jul	0.02853	0.15963	0.01489	0.04000	0.02403	0.21800	5909.8	9573.8
03-Jul	0.03569	0.19532	0.02961	0.06961	0.06474	0.28274	8264.0	13387.6
04-Jul	0.04857	0.24389	0.04150	0.11111	0.07010	0.35284	9299.9	15065.8
05-Jul	0.03364	0.27753	0.02119	0.13230	0.01399	0.36683	11138.6	18044.5
06-Jul	0.03669	0.31422	0.03881	0.17111	0.01153	0.37836	6091.3	9867.9
07-Jul	0.02961	0.34383	0.02077	0.19188	0.02029	0.39865	4422.1	7163.8
08-Jul	0.02909	0.37292	0.01405	0.20593	0.03133	0.42998	7698.2	12471.1
09-Jul	0.03818	0.41110	0.03165	0.23758	0.06977	0.49975	10200.2	16524.4
10-Jul	0.03585	0.44695	0.03264	0.27022	0.03690	0.53665	9134.2	14797.4
11-Jul	0.03775	0.48470	0.03572	0.30594	0.03852	0.57517	7452.6	12073.2
12-Jul	0.03615	0.52085	0.03783	0.34377	0.03744	0.61261	7726.3	12516.6
13-Jul	0.03807	0.55892	0.04551	0.38928	0.04124	0.65385	7114.6	11525.7
14-Jul	0.03778	0.59670	0.02560	0.41488	0.04707	0.70092	7720.1	12506.5
15-Jul	0.03647	0.63317	0.02472	0.43960	0.03687	0.73779	9924.2	16077.1
16-Jul	0.03237	0.66554	0.03526	0.47486	0.02454	0.76233	8064.4	13064.4
17-Jul	0.03123	0.69677	0.04363	0.51849	0.03126	0.79359	10774.4	17454.4
18-Jul	0.03494	0.73171	0.07171	0.59020	0.03505	0.82864	9219.6	14935.7
19-Jul	0.02975	0.76146	0.05634	0.64654	0.02031	0.84895	6739.0	10917.2
20-Jul	0.02654	0.78800	0.02057	0.66711	0.01847	0.86742	6508.0	10543.0
21-Jul	0.02256	0.81056	0.02385	0.69096	0.01557	0.88299	4979.5	8066.7
22-Jul	0.02634	0.83690	0.02918	0.72014	0.02517	0.90816	6979.7	11307.1
23-Jul	0.02288	0.85978	0.03165	0.75179	0.01676	0.92492	6033.7	9774.5
24-Jul	0.02393	0.88371	0.03344	0.78523	0.02004	0.94496	7083.1	11474.6
25-Jul	0.02137	0.90508	0.02279	0.80802	0.01571	0.96067	5416.9	8775.4
26-Jul	0.01745	0.92253	0.02438	0.83240	0.01411	0.97478	3213.3	5205.5
27-Jul	0.01553	0.93806	0.02220	0.85460	0.01384	0.98862	5109.6	8277.5
28-Jul	0.01572	0.95378	0.02030	0.87490	0.01138	1.00000	4089.1	6624.3
29-Jul	0.01153	0.96531	0.01578	0.89068			2864.3	4640.2
30-Jul	0.00986	0.97517	0.01198	0.90266			3959.5	6414.4
31-Jul	0.00677	0.98194	0.01482	0.91748			2493.4	4039.3
01-Aug	0.00442	0.98636	0.01434	0.93182			0.0	1774.7
02-Aug	0.00279	0.98915	0.01394	0.94576			0.0	1120.2
03-Aug	0.00381	0.99296	0.01902	0.96478			0.0	1529.8
04-Aug	0.00326	0.99622	0.01644	0.98122			0.0	1308.9
05-Aug	0.00378	1.00000	0.01878	1.00000			0.0	1517.7

Escapement Objective = 250,000 Estimated Total Escapement => 401,511

a Daily escapements for the periods June 15-22 and August 1-5 were estimated from historic daily proportions for a normal migration. All other daily estimates were determined from adjusted daily counts as listed in Table 1. Daily escapement estimates represent adjusted sonar counts which have been expanded by a factor of 1.62 to account for salmon which swim outside of the ensonified water column.

Table 4. Site A meteorologic and hydrologic observations, 1988.

Date	Time[a]	Cloud Cover (%)	Precip.[b]	Wind (Dir/mph)[b]	Air Temp. (C.)	H2O Temp. (C.)	H2O Level (mm)
15-Jun							
16-Jun							
17-Jun							
18-Jun							
19-Jun							
20-Jun							
21-Jun							
22-Jun							
23-Jun	1510	100	A	SW/5	13	8	4530
24-Jun	1200	10	0	SW<5	15	8	4430
25-Jun	1150	10	0	WNW/5	18	10	4270
26-Jun	1205	75	0	WNW/5	15	11	4090
27-Jun	1220	75	A	SW<5	19	11	4000
28-Jun	1220	75	0	NW<5	20	11	4000
29-Jun	1240	10	0	N<5	18	10	4020
30-Jun	1155	10	0	N<5	21	11	4030
01-Jul	1205	100	0	N<5	19	12	3890
02-Jul	1155	75	0	NW<5	22	11	3940
03-Jul	1150	SMOKE	0	SW<5	18	11	4010
04-Jul	1150	50	0	S/5	21	12	4000
05-Jul	1150	75	0	SW<5	19	12	3930
06-Jul	1150	100	A	SW/8	18	11	3820
07-Jul	1220	75	0	S/5	19	10	3710
08-Jul	1156	75	0	NW<5	18	11	3590
09-Jul	1150	100	A	SW/5	19	12	3500
10-Jul	1155	75	F	SE/8	23	12	3430
11-Jul	1158	75	F	SW<5	19	12	3410
12-Jul	1150	75	F	W<5	17	12	3510
13-Jul	1155	10	0	NW/8	18	12	3460
14-Jul	1150	75	0	NW<5	23	13	3480
15-Jul	1154	10	0	SW<5	20	14	3450
16-Jul	1150	10	0	NW/8	18	13	3430
17-Jul	1155	75	0	0	18	13	3340
18-Jul	1150	100	0	S<5	20	13	3260
19-Jul	1145	10	0	0	21	13	3180
20-Jul	1150	10	0	NW<5	22	13	3140
21-Jul	1155	50	0	NW<5	20	13	3080
22-Jul	1200	10	0	NW<5	22	14	3010
23-Jul	1155	75	0	NW/8	17	14	2950
24-Jul	1150	10	0	0	18	13	2890
25-Jul	1150	100	B	SE/5	16	13	2850
26-Jul	1150	100	0	SW<5	14	12	2820
27-Jul	1150	50	0	S/5	18	12	2750
28-Jul	1150	50	0	S/5	19	13	2690
29-Jul	1150	100	B	0	14	12	2660
30-Jul	1200	100	B	N<5	17	12	2670
31-Jul	1210	10	0	S/8	19	13	2680

a Using the 24 hour clock.

b Codes: A = intermittent rain; B = steady rain; F = thunderstorms; N, S, E, W, etc. = compass points; < = less than.

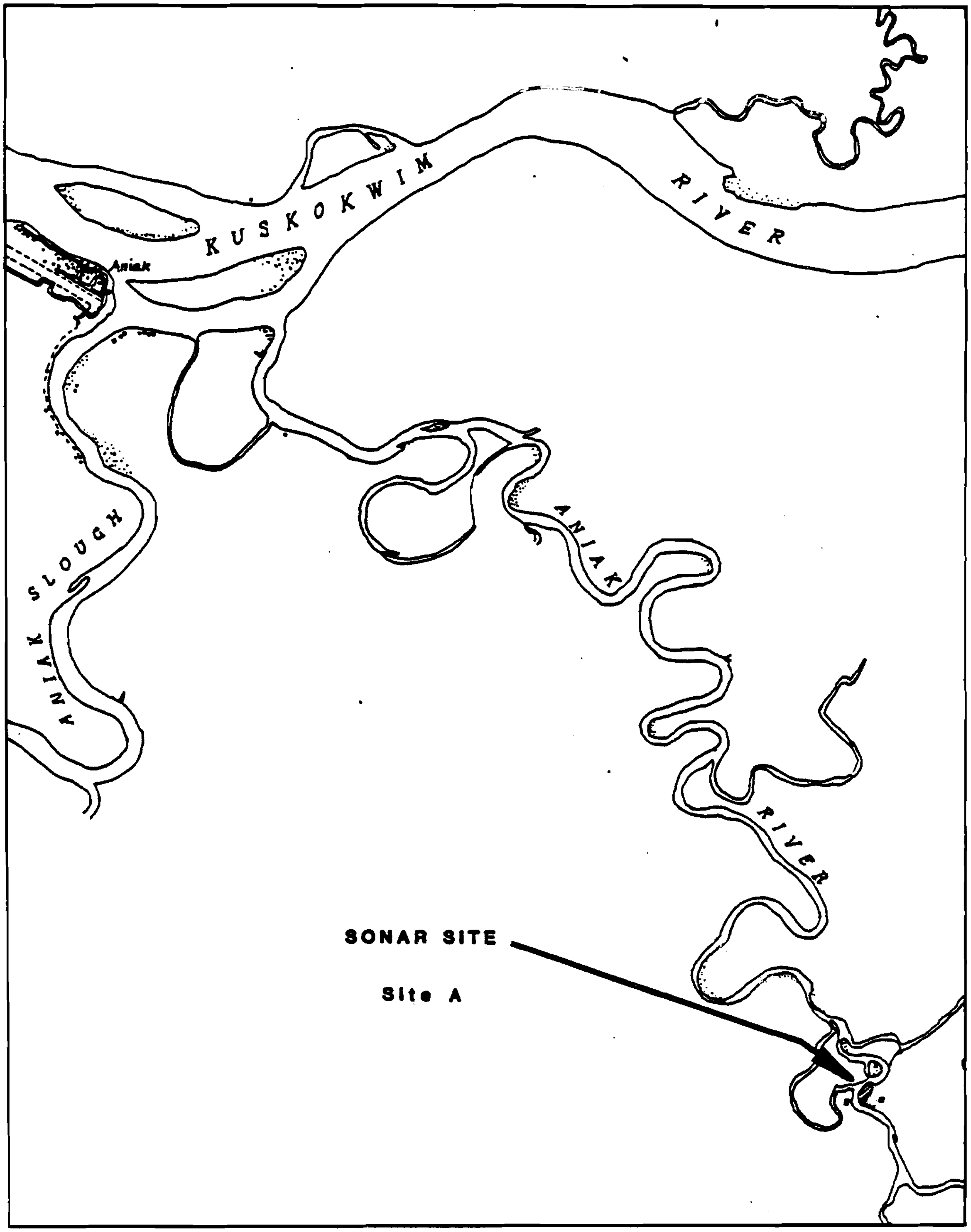

Figure 1. Map of the Aniak Sonar site and vicinity, 1988.

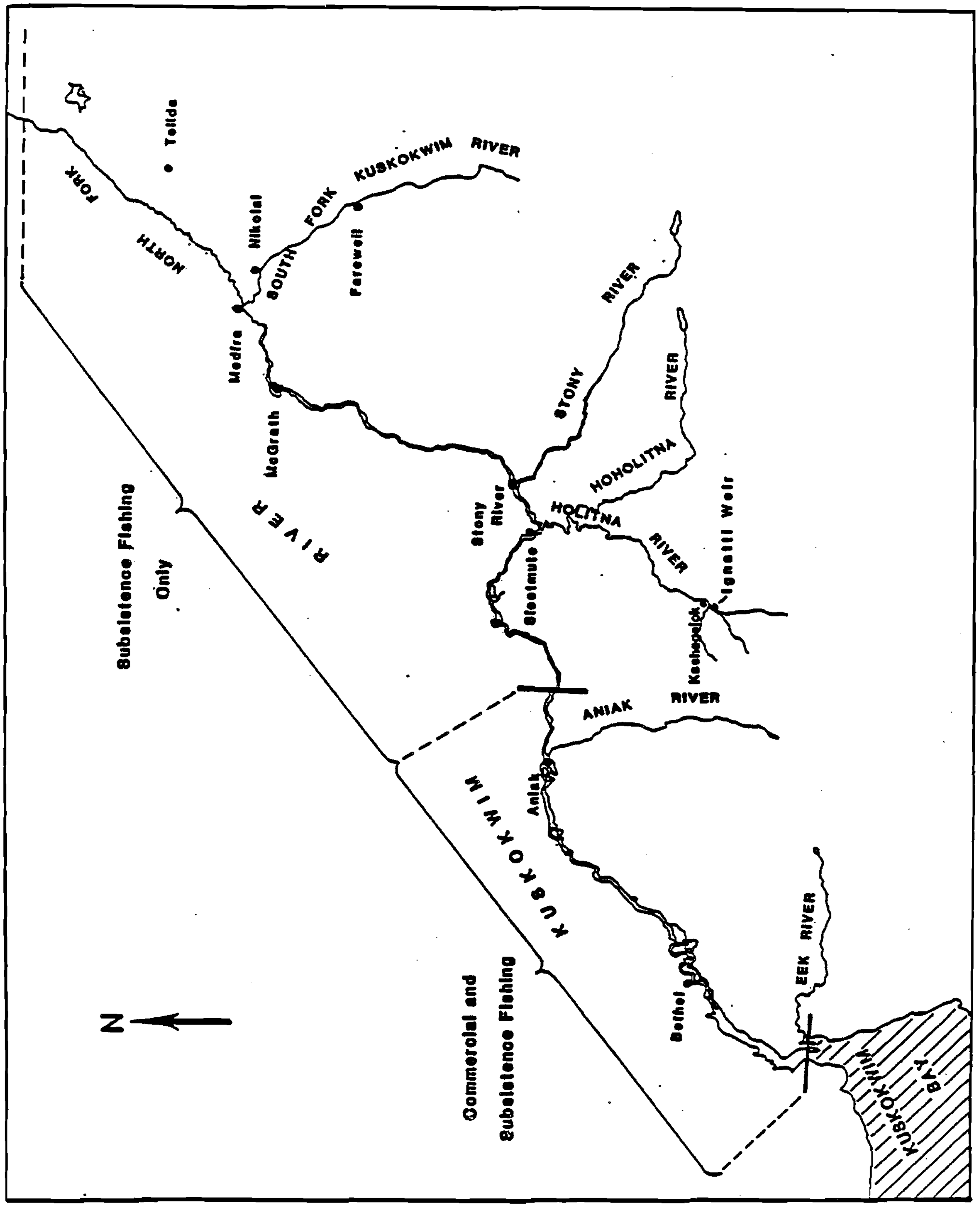

Figure 2. Map of the Kuskokwim area.

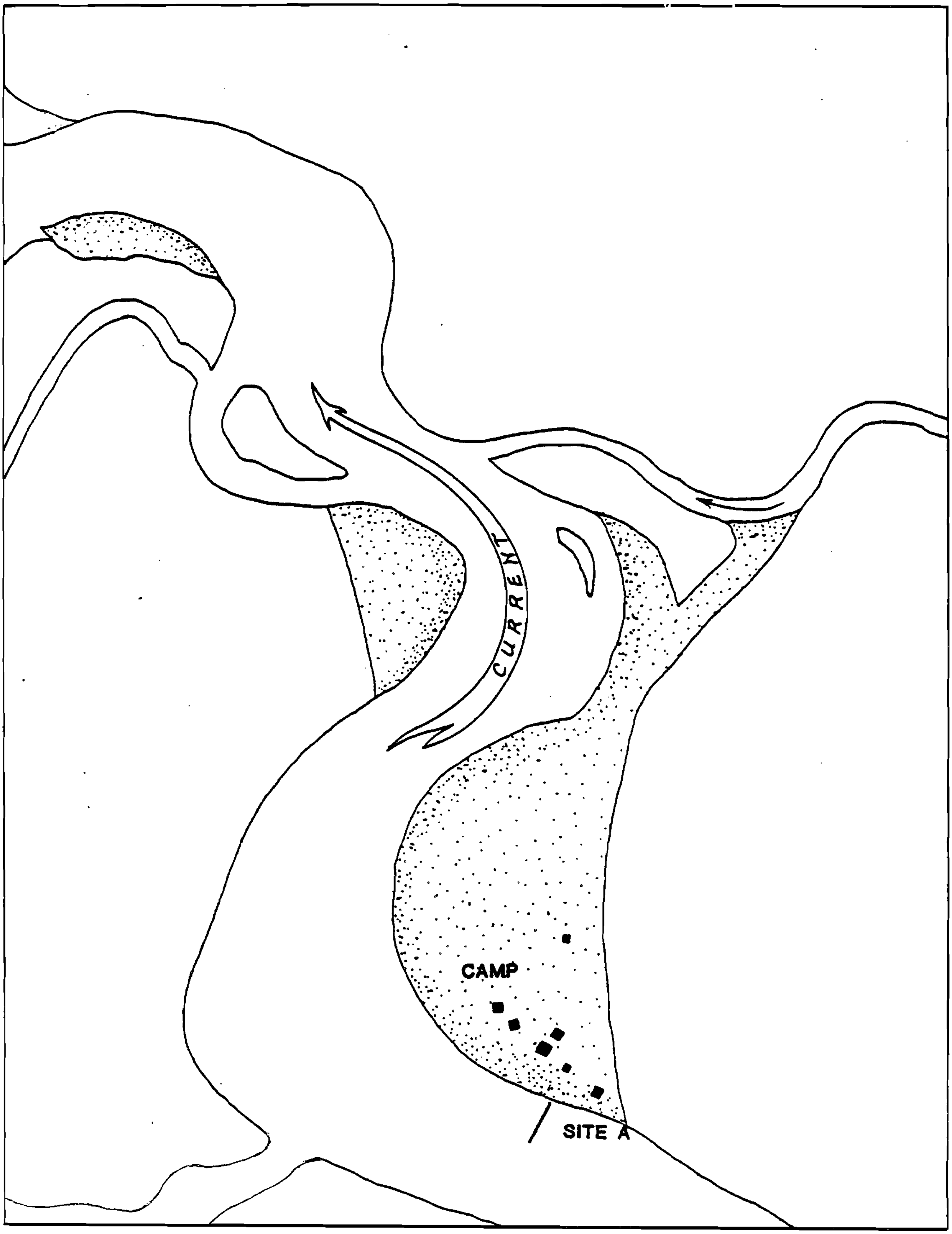

Figure 3. Map of the Aniak Sonar site, 1988.

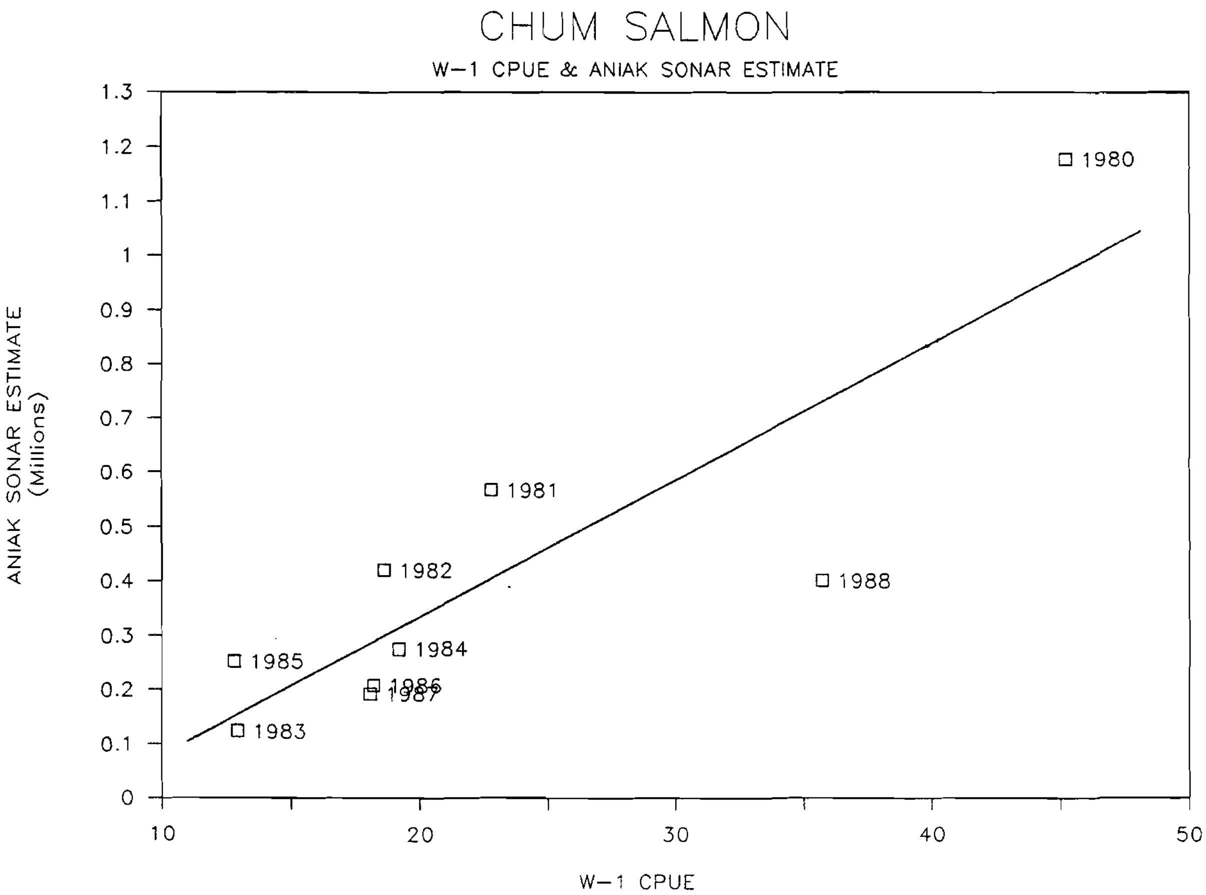

Figure 4. Relationship between annual Aniak Sonar escapement estimates and District 1 commercial chum salmon catch per unit effort, 1980-1988.

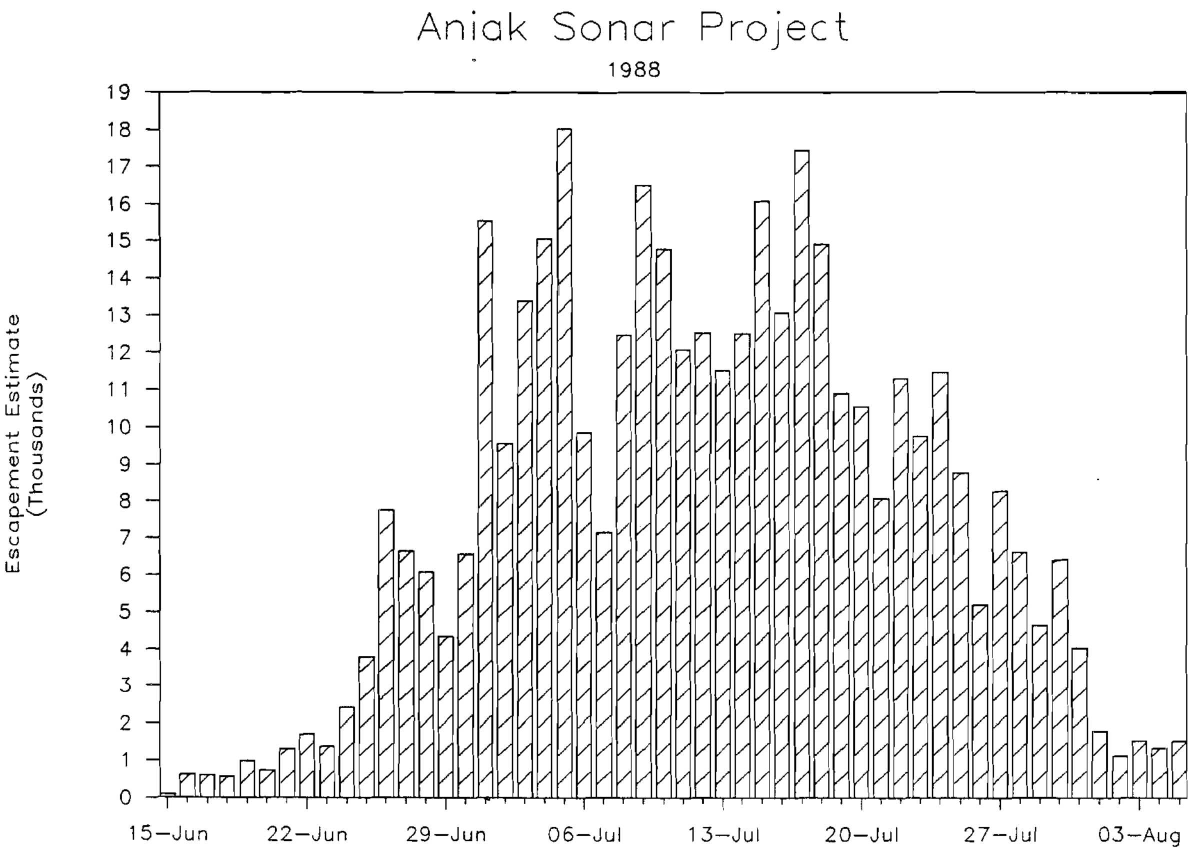

Figure 5. Daily chum salmon escapement estimates for the Aniak River, 1988. Counts for 15-22 June and 1-5 August were estimated based on historic timing data.

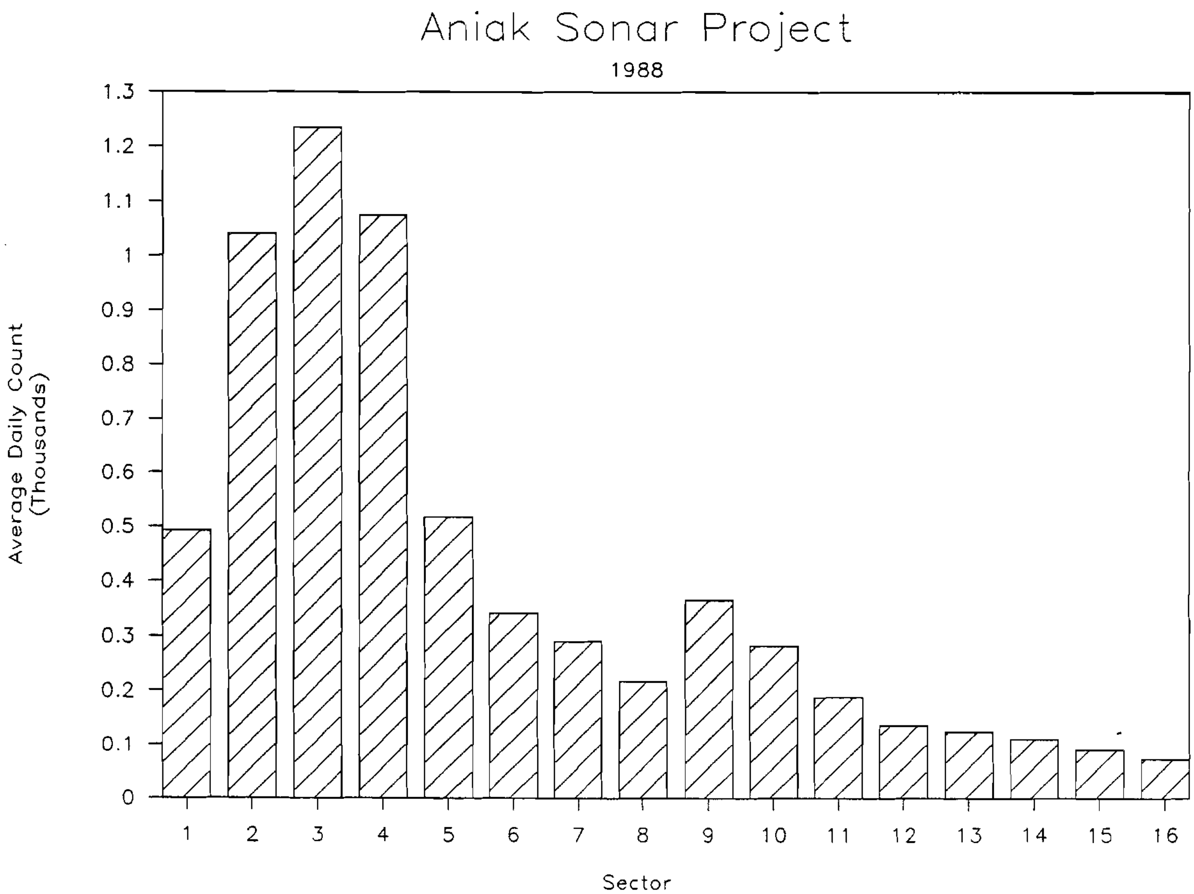

Figure 6. Average daily sonar sector count distributions, Aniak Sonar project, 1988.

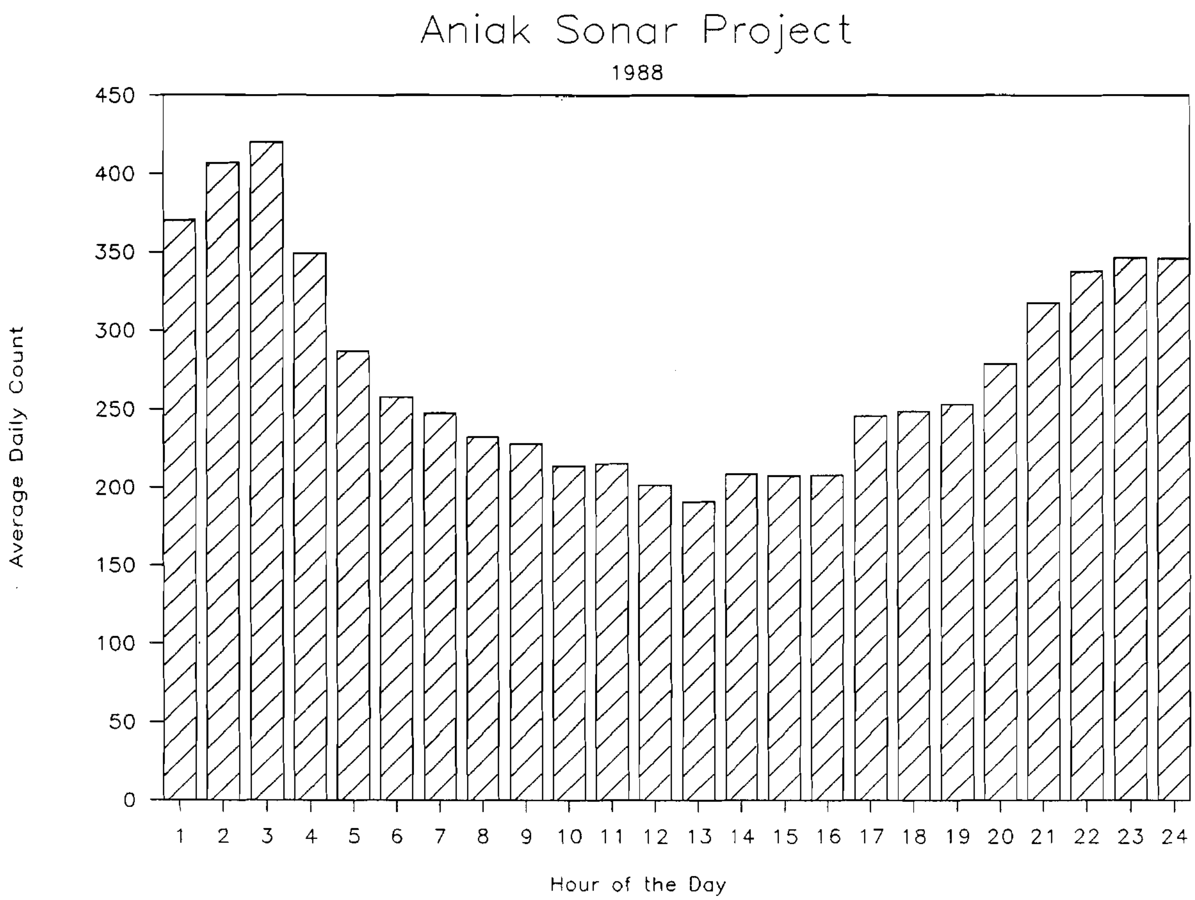

Figure 7. Average daily diel count distributions, Aniak Sonar project, 1988.

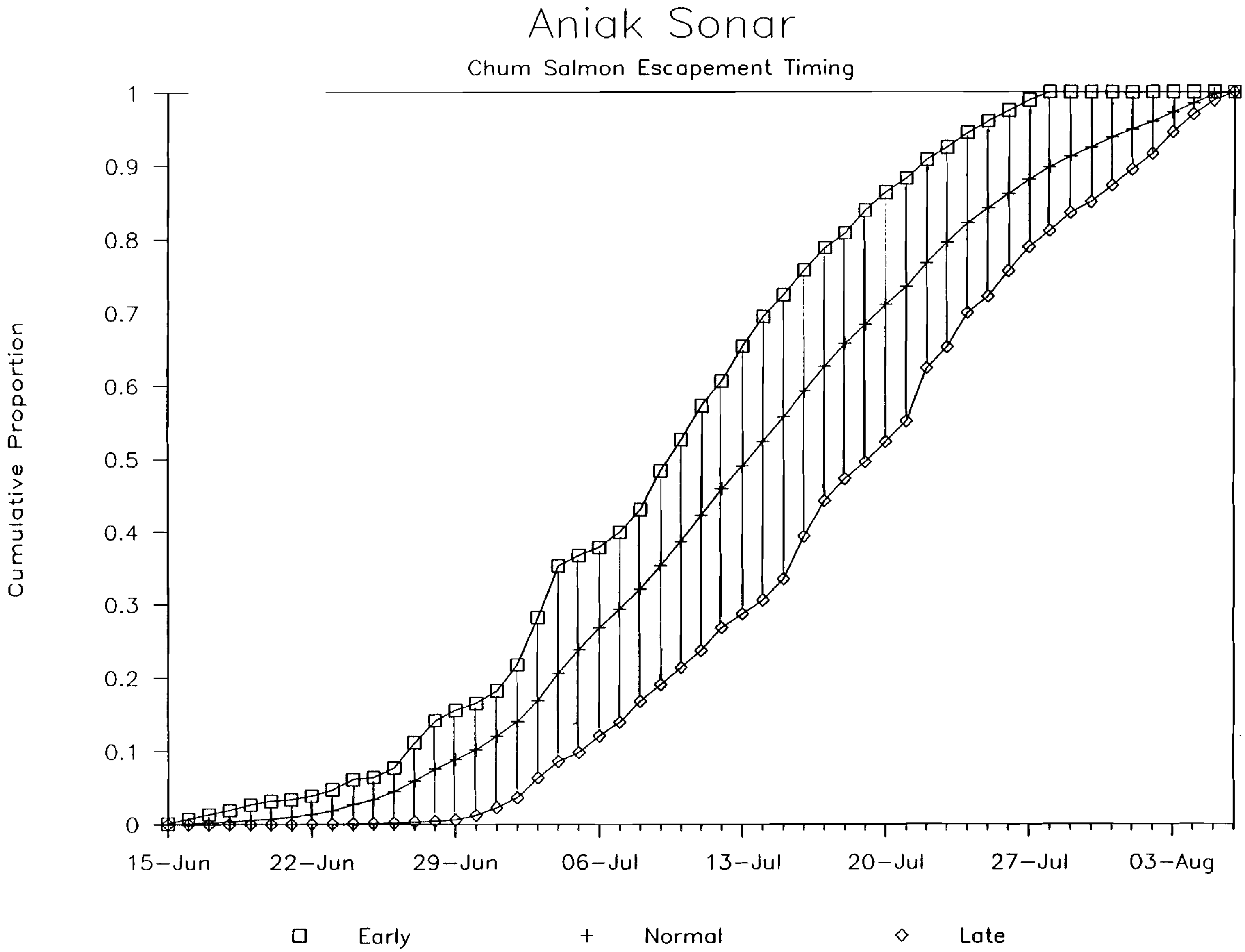

Figure 8. Average, late, and early chum salmon migration timing based on historic data, Aniak Sonar project, 1980-1988.

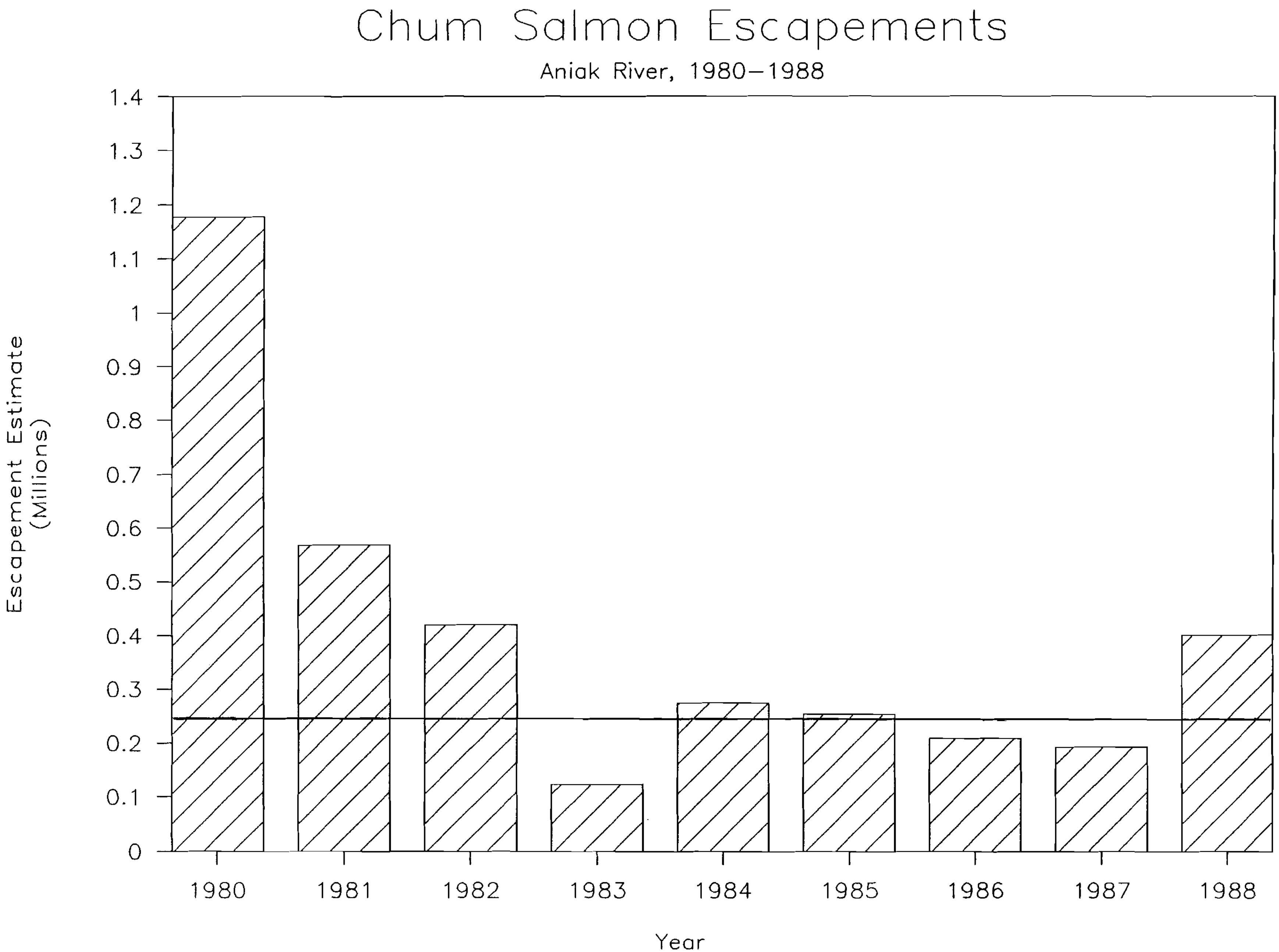

Figure 9. Annual Aniak River chum salmon escapement estimates, 1980-1988.

Appendix A. Historic progression of linear regression computations using sonar generated chum salmon escapement estimates for the Aniak River and chum salmon cumulative season commercial catch per unit effort for District 1 of the Kuskokwim River.

DATA

YEAR	ANIAK ESC. EST. (Y)	W-1 CPUE (X)
1980	1178589	45.2
1981	568426	22.8
1982	420364	18.6
1983	124058	12.9
1984	275261	19.2
1985	253048	12.8
1986	209080	18.2
1987	193464	18.1
1988	401511	35.7

REGRESSION OUTPUT [a]

Year	Constant	Std Err of Y Est	R Squared	N	D.F.	X Coef.	Std Err of Coef.
1982	-88240	21523	0.999	3	1	28084	1064
1983	-200178	77333	0.980	4	2	31077	3157
1984	-245301	88007	0.965	5	3	31956	3518
1985	-205826	85101	0.960	6	4	30834	3159
1986	-240235	96969	0.940	7	5	31466	3571
1987	-268059	102209	0.924	8	6	31990	3739
1988	-171786	177443	0.734	9	7	25409	5787

a Regression output was generated using the built-in regression function in the Lotus 1-2-3 (copyright Lotus Developement Corporation) spreadsheet software.

Appendix B. Daily site A sonar counts by sector, Aniak River, 1988.

	Sector															
Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
15-Jun																
16-Jun																
17-Jun																
18-Jun																
19-Jun																
20-Jun																
21-Jun																
22-Jun																
23-Jun	12	30	131	53	51	42	87	67	102	66	48	18	8	0	0	0
24-Jun	24	22	97	121	168	162	169	229	316	234	156	34	17	7	3	0
25-Jun	55	226	304	326	216	160	428	521	428	251	137	56	22	2	1	0
26-Jun	254	852	769	510	303	147	347	381	429	240	82	28	12	1	2	0
27-Jun	585	1085	635	416	237	174	145	229	325	88	60	5	0	0	0	0
28-Jun	413	959	695	351	177	124	115	150	213	97	42	5	0	0	0	0
29-Jun	302	746	574	357	217	158	118	83	185	92	43	8	0	0	0	0
30-Jun	248	737	731	338	116	60	133	112	170	101	44	15	2	0	0	0
01-Jul	232	1690	2266	2097	1082	480	345	120	364	273	180	121	72	75	50	28
02-Jul	237	1664	1299	1012	380	162	139	74	183	119	97	76	70	51	41	22
03-Jul	387	1475	1059	944	394	224	219	74	240	203	118	87	101	75	73	54
04-Jul	2078	3760	2447	2314	946	726	524	474	568	509	213	182	140	66	43	39
05-Jul	1119	3382	2692	1945	679	360	315	290	355	302	171	35	81	48	31	31
06-Jul	632	1459	1361	1197	526	410	335	304	363	345	145	95	83	42	39	38
07-Jul	769	989	955	737	527	485	345	194	208	148	72	42	36	30	28	26
08-Jul	245	738	1053	922	723	741	604	385	504	320	149	103	126	68	48	42
09-Jul	21	234	1297	1632	1555	1534	1009	538	749	479	200	154	146	81	61	80
10-Jul	1209	2170	1671	1410	850	796	593	308	442	271	154	108	100	67	42	50
11-Jul	3516	4012	1148	450	101	104	112	74	89	98	42	70	62	37	34	32
12-Jul	1738	1445	1341	937	222	127	69	45	43	30	24	34	19	14	10	9
13-Jul	111	613	2945	1642	451	214	164	128	150	164	999	77	117	66	39	39
14-Jul	155	585	2198	1745	840	556	380	199	273	222	125	100	82	67	96	50
15-Jul	256	903	2262	2232	968	487	594	147	165	105	64	57	76	65	50	60
16-Jul	406	916	2685	2582	1257	749	584	326	395	400	261	216	149	115	143	77
17-Jul	45	637	2384	3591	1521	864	411	222	341	265	162	147	129	133	119	126
18-Jul	21	552	2388	2079	843	367	204	156	173	168	141	146	124	79	74	66
19-Jul	97	516	1793	1759	558	239	217	161	251	268	271	248	232	151	212	161
20-Jul	60	266	1112	1630	535	187	168	131	253	276	322	244	235	221	217	220
21-Jul	416	762	922	1047	454	189	130	193	351	274	211	155	155	139	100	134
22-Jul	1026	1714	1033	788	434	299	211	107	532	545	297	218	251	239	131	112
23-Jul	1246	2235	1197	702	459	293	262	201	867	716	318	251	264	209	121	103
24-Jul	526	1157	1145	651	330	257	169	114	409	448	213	226	215	199	123	61
25-Jul	381	1166	1284	809	376	211	170	154	482	416	271	170	199	277	147	140
26-Jul	165	389	714	600	323	182	196	163	389	293	177	283	236	341	186	110
27-Jul	77	280	666	730	430	320	316	421	729	606	323	299	262	286	219	135
28-Jul	32	159	452	533	441	262	311	222	741	708	360	371	350	344	307	333
29-Jul	93	78	347	447	295	266	462	419	820	481	345	389	320	363	319	156
30-Jul	13	20	113	183	145	156	126	302	536	269	246	333	233	194	203	170
31-Jul	1	26	71	105	70	64	101	72	139	111	62	102	129	186	213	143
01-Aug																
02-Aug																
03-Aug																
04-Aug																
05-Aug																
06-Aug																
Average	492	1042	1237	1075	518	342	290	218	366	282	188	136	124	111	90	73

Appendix C. Daily site A sonar counts by hour, Aniak River, 1988.

	Hour of the Day																							
Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
15-Jun																								
16-Jun																								
17-Jun																								
18-Jun																								
19-Jun																								
20-Jun																								
21-Jun																								
22-Jun																								
23-Jun	67	41	22	46	55	11	31	30	47	58	21	40	16	18	41	32	148	108	74	104	64	45	73	98
24-Jun	91	56	30	62	75	15	42	40	64	78	29	54	22	25	56	43	108	113	90	81	139	158	149	128
25-Jun	109	99	69	117	134	94	99	42	45	21	61	85	86	163	128	151	207	147	151	230	205	198	270	206
26-Jun	283	190	229	190	146	121	129	148	154	161	161	121	169	169	68	68	135	158	170	149	308	351	301	258
27-Jun	216	218	265	258	254	149	220	235	110	154	151	63	129	110	118	135	116	96	78	73	140	133	260	305
28-Jun	386	301	278	188	167	179	119	138	140	145	62	51	35	51	98	192	166	97	71	99	84	90	87	114
29-Jun	129	128	157	129	93	86	85	83	112	78	77	75	104	82	51	72	116	114	88	115	127	275	313	188
30-Jun	131	146	114	87	86	103	94	108	142	138	106	107	100	90	118	123	115	125	165	112	132	142	115	135
01-Jul	199	222	291	327	343	349	526	537	455	486	380	472	403	544	399	427	535	399	339	284	344	383	378	460
02-Jul	437	481	377	321	249	229	218	211	180	145	119	176	149	153	141	149	182	158	144	215	299	306	301	283
03-Jul	311	345	311	256	271	286	210	211	209	100	224	180	140	188	255	230	221	300	197	245	264	292	264	218
04-Jul	748	832	1074	984	811	697	683	805	729	697	644	536	441	343	359	522	498	451	435	437	533	612	565	546
05-Jul	545	556	561	449	415	421	519	487	683	364	382	412	374	447	485	385	490	461	533	585	660	609	590	468
06-Jul	467	538	482	285	258	210	236	270	269	254	406	284	345	244	245	263	349	220	355	221	333	251	292	282
07-Jul	265	220	364	285	203	237	242	149	189	142	139	119	249	142	200	143	166	299	245	288	289	315	414	283
08-Jul	458	481	435	343	227	293	281	185	178	128	167	148	247	371	211	223	289	277	316	234	302	309	319	340
09-Jul	382	354	439	397	353	395	338	359	389	455	419	439	395	388	396	365	366	404	447	572	385	440	434	458
10-Jul	449	608	571	539	403	377	308	256	337	310	274	302	343	240	377	421	542	471	403	606	492	501	527	584
11-Jul	557	575	459	385	354	386	314	406	351	360	357	305	182	234	283	271	309	653	538	470	446	607	646	532
12-Jul	564	483	382	372	290	228	218	180	211	271	277	266	227	283	180	149	70	91	133	135	351	312	241	193
13-Jul	272	389	427	429	298	260	199	254	276	207	192	120	147	159	122	151	174	195	322	368	514	537	470	534
14-Jul	512	594	554	444	329	209	259	189	236	215	289	261	191	190	181	212	212	200	194	312	389	386	555	557
15-Jul	574	904	819	734	459	402	391	316	281	228	205	209	197	198	184	159	170	142	154	134	183	271	436	440
16-Jul	578	602	797	651	278	349	396	388	339	308	366	416	304	299	302	235	187	484	521	560	544	659	745	953
17-Jul	829	827	798	609	808	428	337	314	392	464	418	459	404	325	284	421	389	341	344	380	410	352	310	454
18-Jul	668	896	1260	438	438	344	289	230	265	256	256	131	131	152	217	99	84	149	204	118	214	287	272	182
19-Jul	391	614	418	302	213	218	193	212	155	156	184	200	165	250	252	246	308	231	316	367	362	381	570	428
20-Jul	302	484	396	387	358	264	238	199	234	235	141	180	142	194	163	241	192	182	192	234	287	246	256	330
21-Jul	385	307	413	303	173	223	159	116	195	185	184	216	154	150	163	149	225	227	215	274	272	304	294	343
22-Jul	413	496	540	362	326	252	183	234	194	260	290	205	187	248	231	268	301	399	432	370	496	385	425	440
23-Jul	512	588	558	511	408	419	359	418	273	249	238	252	323	276	432	252	398	360	371	370	393	485	456	548
24-Jul	474	322	349	401	314	381	223	165	178	200	342	148	85	188	162	171	250	216	166	275	379	259	253	330
25-Jul	451	498	480	449	335	226	207	243	139	274	103	110	121	133	142	241	187	175	209	317	491	425	263	433
26-Jul	269	271	402	413	265	179	212	131	43	56	121	59	58	60	222	89	204	165	206	316	174	341	279	213
27-Jul	256	288	306	224	230	283	199	302	233	179	187	106	82	302	183	194	280	232	321	248	380	380	361	343
28-Jul	276	219	312	264	171	177	305	119	122	79	142	135	58	325	163	161	146	267	355	541	366	477	395	346
29-Jul	264	468	327	432	413	208	238	128	94	53	69	182	284	178	155	168	350	276	210	146	332	196	272	161
30-Jul	132	141	133	117	95	162	134	77	118	74	140	151	123	105	152	143	193	139	77	134	139	222	169	173
31-Jul	99	93	190	138	97	207	205	144	132	109	81	97	133	113	164	154	208	150	83	145	150	240	183	187
01-Aug																								
02-Aug																								
03-Aug																								
04-Aug																								
05-Aug																								
06-Aug																								
Average	371	407	420	349	287	258	247	232	228	214	215	202	191	208	207	208	246	248	253	279	317	337	346	345

Appendix D. Historic daily cumulative proportions of the chum salmon escapement at the Aniak River sonar site.

Date	1980	1981	1982	1983	1984	1985	1986	1987	1988	Late	Normal	Early
15-Jun	0.00000	0.00103	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00021	0.00000	0.00014	0.00103
16-Jun	0.00000	0.00151	0.00018	0.00000	0.00709	0.00000	0.00000	0.00000	0.00172	0.00000	0.00117	0.00709
17-Jun	0.00000	0.00199	0.00165	0.00000	0.01407	0.00000	0.00000	0.00000	0.00322	0.00000	0.00233	0.01407
18-Jun	0.00000	0.00300	0.00375	0.00000	0.01993	0.00000	0.00000	0.00000	0.00459	0.00000	0.00348	0.01993
19-Jun	0.00000	0.00464	0.00687	0.00324	0.02723	0.00000	0.00000	0.00000	0.00703	0.00000	0.00544	0.02723
20-Jun	0.00000	0.00715	0.01126	0.00527	0.03183	0.00000	0.00000	0.00000	0.00887	0.00000	0.00715	0.03183
21-Jun	0.00000	0.01060	0.01720	0.00948	0.03423	0.00000	0.00000	0.00526	0.01214	0.00000	0.00988	0.03423
22-Jun	0.00043	0.01420	0.02107	0.01763	0.03917	0.00211	0.00069	0.01421	0.01640	0.00043	0.01399	0.03917
23-Jun	0.00076	0.02362	0.02188	0.02747	0.04754	0.00521	0.00120	0.02680	0.01984	0.00076	0.01937	0.04754
24-Jun	0.00101	0.03928	0.02325	0.03668	0.05194	0.01056	0.00161	0.06152	0.02587	0.00101	0.02797	0.06152
25-Jun	0.00125	0.05833	0.02932	0.04373	0.05695	0.01381	0.00705	0.06476	0.03528	0.00125	0.03450	0.06476
26-Jun	0.00185	0.07142	0.04756	0.05090	0.07773	0.01650	0.01045	0.07278	0.05463	0.00185	0.04487	0.07773
27-Jun	0.00339	0.08660	0.06046	0.06035	0.11163	0.02042	0.03201	0.08916	0.07123	0.00339	0.05947	0.11163
28-Jun	0.00454	0.10463	0.07537	0.07205	0.14134	0.02738	0.06299	0.10541	0.08636	0.00454	0.07556	0.14134
29-Jun	0.00643	0.14035	0.08887	0.08838	0.15555	0.03385	0.07148	0.11789	0.09721	0.00643	0.08889	0.15555
30-Jun	0.01263	0.15841	0.10876	0.10717	0.16522	0.04038	0.08430	0.12263	0.11357	0.01263	0.10145	0.16522
01-Jul	0.02293	0.18195	0.14036	0.12945	0.18032	0.04859	0.09408	0.12964	0.15230	0.02293	0.11996	0.18195
02-Jul	0.03656	0.20337	0.18729	0.14820	0.21800	0.05532	0.10555	0.13192	0.17614	0.03656	0.14026	0.21800
03-Jul	0.06365	0.22060	0.22972	0.16998	0.28274	0.07198	0.12491	0.15064	0.20949	0.06365	0.16930	0.28274
04-Jul	0.10163	0.24300	0.27648	0.22909	0.35284	0.08573	0.14960	0.17325	0.24701	0.08573	0.20651	0.35284
05-Jul	0.12102	0.29458	0.30992	0.27446	0.36683	0.09831	0.16631	0.22527	0.29195	0.09831	0.23874	0.36683
06-Jul	0.15654	0.33264	0.34338	0.33368	0.37836	0.12092	0.17941	0.25370	0.31653	0.12092	0.26835	0.37836
07-Jul	0.17555	0.35990	0.37231	0.38248	0.39865	0.13938	0.19781	0.28536	0.33437	0.13938	0.29398	0.39865
08-Jul	0.18840	0.38177	0.41029	0.42024	0.42998	0.16805	0.22364	0.30516	0.36543	0.16805	0.32144	0.42998
09-Jul	0.21737	0.40549	0.48341	0.45769	0.45044	0.19069	0.24027	0.32798	0.40659	0.19069	0.35332	0.48341
10-Jul	0.24724	0.42239	0.51827	0.52558	0.47519	0.21422	0.27361	0.35920	0.44344	0.21422	0.38657	0.52558
11-Jul	0.27993	0.45602	0.55466	0.57257	0.50871	0.23775	0.29733	0.41553	0.47351	0.23775	0.42178	0.57257
12-Jul	0.31454	0.48874	0.59003	0.60619	0.54747	0.26873	0.32988	0.47911	0.50468	0.26873	0.45882	0.60619
13-Jul	0.35619	0.50819	0.61898	0.65381	0.59436	0.28789	0.35325	0.50260	0.53339	0.28789	0.48985	0.65381
14-Jul	0.37962	0.53462	0.67347	0.69425	0.63288	0.30621	0.38429	0.54396	0.56454	0.30621	0.52376	0.69425
15-Jul	0.40224	0.55393	0.70830	0.72404	0.70431	0.33550	0.41092	0.57308	0.60458	0.33550	0.55743	0.72404
16-Jul	0.43451	0.57771	0.73149	0.75784	0.74800	0.39362	0.44755	0.60368	0.63712	0.39362	0.59239	0.75784
17-Jul	0.47444	0.59989	0.76102	0.78811	0.77708	0.44237	0.47111	0.64082	0.68059	0.44237	0.62616	0.78811
18-Jul	0.54006	0.61719	0.79397	0.80819	0.80763	0.47226	0.49247	0.67064	0.71779	0.47226	0.65780	0.80819
19-Jul	0.59859	0.63944	0.81332	0.83944	0.81822	0.49583	0.51140	0.69293	0.74498	0.49583	0.68379	0.83944
20-Jul	0.64355	0.65978	0.83077	0.86383	0.83834	0.52358	0.53785	0.72546	0.77124	0.52358	0.71049	0.86383
21-Jul	0.67421	0.68338	0.84187	0.88298	0.86289	0.55155	0.57980	0.74895	0.79133	0.55155	0.73522	0.88298
22-Jul	0.70756	0.71223	0.85827	0.90815	0.88646	0.62472	0.63253	0.76340	0.81949	0.62472	0.76809	0.90815
23-Jul	0.74519	0.74354	0.86703	0.92496	0.90200	0.70483	0.65345	0.78104	0.84383	0.65345	0.79621	0.92496
24-Jul	0.78083	0.77661	0.87747	0.94495	0.91820	0.72553	0.69998	0.80845	0.87241	0.69998	0.82271	0.94495
25-Jul	0.81795	0.79915	0.88684	0.96067	0.93607	0.74852	0.72224	0.81784	0.89427	0.72224	0.84262	0.96067
26-Jul	0.84314	0.82326	0.89997	0.97478	0.94730	0.76715	0.75752	0.83818	0.90723	0.75752	0.86206	0.97478
27-Jul	0.85719	0.84522	0.91108	0.98862	0.96178	0.79504	0.78964	0.85465	0.92785	0.78964	0.88123	0.98862
28-Jul	0.87892	0.86529	0.91992	1.00000	0.97559	0.81204	0.81901	0.86862	0.94435	0.81204	0.89819	1.00000
29-Jul	0.89973	0.88090	0.93026	1.00000	0.98382	0.83643	0.84184	0.88794	0.95590	0.83643	0.91298	1.00000
30-Jul	0.91508	0.89275	0.94104	1.00000	0.99296	0.85084	0.85917	0.90243	0.97188	0.85084	0.92513	1.00000
31-Jul	0.92963	0.90741	0.95233	1.00000	1.00000	0.87283	0.88061	0.91729	0.98194	0.87283	0.93800	1.00000
01-Aug	0.94334	0.92159	0.95969	1.00000	1.00000	0.89493	0.90136	0.93166	0.98636	0.89493	0.94877	1.00000
02-Aug	0.95623	0.93537	0.97000	1.00000	1.00000	0.91641	0.92153	0.94563	0.98915	0.91641	0.95937	1.00000
03-Aug	0.96842	0.95418	0.97869	1.00000	1.00000	0.94572	0.94904	0.96470	0.99296	0.94572	0.97263	1.00000
04-Aug	0.97978	0.97035	0.98660	1.00000	1.00000	0.97106	0.97283	0.98118	0.99622	0.97035	0.98422	1.00000
05-Aug	0.99030	0.98902	0.99370	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	0.98902	0.99700	1.00000
06-Aug	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

Note: "late", "normal", and "early" data is calculated as the minimum, average, and maximum, respectively, of the cumulative proportions on that date.

Appendix E. Historic daily proportions of estimated chum salmon escapements at the Aniak River sonar site.

Date	1980	1981	1982	1983	1984	1985	1986	1987	1988
15-Jun	0.00000	0.00103	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00021
16-Jun	0.00000	0.00048	0.00018	0.00000	0.00709	0.00000	0.00000	0.00000	0.00151
17-Jun	0.00000	0.00048	0.00146	0.00000	0.00698	0.00000	0.00000	0.00000	0.00150
18-Jun	0.00000	0.00101	0.00211	0.00000	0.00586	0.00000	0.00000	0.00000	0.00137
19-Jun	0.00000	0.00163	0.00311	0.00324	0.00729	0.00000	0.00000	0.00000	0.00244
20-Jun	0.00000	0.00251	0.00439	0.00203	0.00461	0.00000	0.00000	0.00000	0.00184
21-Jun	0.00000	0.00345	0.00595	0.00421	0.00240	0.00000	0.00000	0.00526	0.00327
22-Jun	0.00043	0.00360	0.00387	0.00815	0.00494	0.00211	0.00069	0.00895	0.00426
23-Jun	0.00033	0.00942	0.00081	0.00984	0.00837	0.00310	0.00051	0.01259	0.00344
24-Jun	0.00025	0.01566	0.00137	0.00920	0.00440	0.00535	0.00041	0.03472	0.00603
25-Jun	0.00024	0.01905	0.00607	0.00705	0.00502	0.00325	0.00544	0.00324	0.00941
26-Jun	0.00060	0.01309	0.01824	0.00718	0.02078	0.00269	0.00340	0.00802	0.01935
27-Jun	0.00154	0.01519	0.01290	0.00944	0.03390	0.00392	0.02156	0.01638	0.01659
28-Jun	0.00116	0.01803	0.01491	0.01171	0.02971	0.00696	0.03098	0.01625	0.01513
29-Jun	0.00189	0.03572	0.01351	0.01633	0.01421	0.00647	0.00849	0.01248	0.01085
30-Jun	0.00619	0.01805	0.01989	0.01878	0.00967	0.00653	0.01282	0.00474	0.01636
01-Jul	0.01030	0.02354	0.03160	0.02228	0.01510	0.00821	0.00978	0.00700	0.03873
02-Jul	0.01363	0.02142	0.04693	0.01876	0.03768	0.00673	0.01147	0.00228	0.02384
03-Jul	0.02709	0.01723	0.04243	0.02178	0.06474	0.01666	0.01936	0.01872	0.03334
04-Jul	0.03798	0.02240	0.04676	0.05911	0.07010	0.01375	0.02469	0.02261	0.03752
05-Jul	0.01939	0.05158	0.03344	0.04537	0.01399	0.01257	0.01672	0.05202	0.04494
06-Jul	0.03552	0.03806	0.03346	0.05922	0.01154	0.02261	0.01310	0.02844	0.02458
07-Jul	0.01901	0.02726	0.02894	0.04880	0.02029	0.01846	0.01839	0.03166	0.01784
08-Jul	0.01285	0.02188	0.03798	0.03777	0.03133	0.02867	0.02583	0.01979	0.03106
09-Jul	0.02897	0.02372	0.07312	0.03744	0.02046	0.02264	0.01663	0.02283	0.04116
10-Jul	0.02987	0.01690	0.03486	0.06790	0.02475	0.02353	0.03334	0.03122	0.03685
11-Jul	0.03269	0.03363	0.03639	0.04698	0.03351	0.02353	0.02372	0.05633	0.03007
12-Jul	0.03461	0.03273	0.03537	0.03362	0.03876	0.03098	0.03255	0.06358	0.03117
13-Jul	0.04165	0.01945	0.02895	0.04762	0.04689	0.01916	0.02337	0.02349	0.02871
14-Jul	0.02343	0.02643	0.05448	0.04044	0.03851	0.01831	0.03104	0.04136	0.03115
15-Jul	0.02262	0.01931	0.03483	0.02979	0.07144	0.02929	0.02664	0.02911	0.04004
16-Jul	0.03227	0.02378	0.02319	0.03380	0.04369	0.05812	0.03663	0.03060	0.03254
17-Jul	0.03992	0.02218	0.02953	0.03027	0.02907	0.04876	0.02356	0.03714	0.04347
18-Jul	0.06562	0.01730	0.03295	0.02009	0.03055	0.02989	0.02136	0.02982	0.03720
19-Jul	0.05853	0.02225	0.01935	0.03124	0.01059	0.02357	0.01893	0.02229	0.02719
20-Jul	0.04496	0.02034	0.01745	0.02439	0.02012	0.02774	0.02645	0.03253	0.02626
21-Jul	0.03066	0.02359	0.01109	0.01915	0.02456	0.02797	0.04194	0.02349	0.02009
22-Jul	0.03335	0.02885	0.01640	0.02517	0.02356	0.07317	0.05273	0.01445	0.02816
23-Jul	0.03762	0.03131	0.00877	0.01682	0.01555	0.08012	0.02093	0.01764	0.02434
24-Jul	0.03564	0.03307	0.01043	0.01999	0.01620	0.02070	0.04653	0.02742	0.02858
25-Jul	0.03712	0.02255	0.00937	0.01572	0.01787	0.02299	0.02226	0.00938	0.02186
26-Jul	0.02520	0.02411	0.01313	0.01411	0.01123	0.01862	0.03527	0.02034	0.01296
27-Jul	0.01405	0.02195	0.01111	0.01384	0.01448	0.02789	0.03212	0.01647	0.02062
28-Jul	0.02173	0.02007	0.00884	0.01138	0.01382	0.01700	0.02937	0.01397	0.01650
29-Jul	0.02081	0.01561	0.01033	0.00000	0.00822	0.02439	0.02283	0.01933	0.01156
30-Jul	0.01535	0.01184	0.01078	0.00000	0.00914	0.01441	0.01733	0.01449	0.01598
31-Jul	0.01455	0.01466	0.01130	0.00000	0.00704	0.02199	0.02144	0.01485	0.01006
01-Aug	0.01371	0.01419	0.00736	0.00000	0.00000	0.02210	0.02075	0.01437	0.00442
02-Aug	0.01288	0.01378	0.01031	0.00000	0.00000	0.02148	0.02017	0.01397	0.00279
03-Aug	0.01219	0.01881	0.00870	0.00000	0.00000	0.02931	0.02752	0.01906	0.00381
04-Aug	0.01136	0.01616	0.00791	0.00000	0.00000	0.02534	0.02379	0.01648	0.00326
05-Aug	0.01053	0.01867	0.00710	0.00000	0.00000	0.02894	0.02717	0.01882	0.00378
06-Aug	0.00970	0.01098	0.00630	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

Appendix F. Historic daily estimates of chum salmon escapement at the Aniak River sonar site.

Date	1980	1981	1982	1983	1984	1985	1986	1987	1988
15-Jun		609.1							84.3
16-Jun		281.9	81.0		1893.8				606.3
17-Jun		283.5	648.0		1863.0				602.3
18-Jun		596.2	931.5		1564.9				550.1
19-Jun		962.3	1377.0	419.6	1947.2				979.7
20-Jun		1479.1	1944.0	262.4	1229.6				738.8
21-Jun		2034.7	2630.9	544.3	639.9			1015.7	1312.9
22-Jun	508.7	2119.0	1710.7	1054.6	1318.7	534.6	145.2	1727.7	1710.4
23-Jun	382.3	5553.4	358.0	1273.3	2234.0	783.7	105.9	2429.5	1379.3
24-Jun	293.2	9225.9	605.9	1190.7	1174.5	1354.0	84.7	6702.0	2422.2
25-Jun	280.3	11228.2	2686.0	912.1	1339.7	821.5	1137.2	625.2	3779.2
26-Jun	698.2	7712.8	8072.5	928.3	5546.9	680.4	711.2	1547.7	7769.8
27-Jun	1798.2	8948.9	5705.6	1221.5	9049.3	992.9	4507.6	3161.8	6662.5
28-Jun	1351.1	10622.3	6595.0	1514.7	7933.1	1761.5	6478.3	3136.4	6075.9
29-Jun	2209.7	21050.3	5976.2	2112.5	3794.0	1637.5	1774.6	2409.3	4355.8
30-Jun	7244.6	10638.5	8799.8	2430.0	2580.7	1652.8	2680.4	914.7	6568.4
01-Jul	12047.9	13873.7	13980.6	2882.0	4032.2	2078.1	2045.1	1351.3	15551.9
02-Jul	15940.8	12621.4	20765.2	2426.8	10060.2	1702.0	2397.5	440.6	9573.8
03-Jul	31684.0	10155.8	18775.8	2817.2	17283.8	4215.4	4047.5	3613.2	13387.6
04-Jul	44415.5	13201.4	20687.4	7646.4	18714.2	3480.7	5162.4	4363.6	15065.8
05-Jul	22675.1	30396.1	14795.5	5869.3	3734.1	3181.8	3494.8	10040.8	18044.5
06-Jul	41538.4	22425.7	14805.2	7661.0	3079.6	5721.3	2739.5	5488.6	9867.9
07-Jul	22229.6	16062.3	12802.9	6313.1	5417.3	4671.4	3845.8	6110.5	7163.8
08-Jul	15030.4	12892.0	16804.3	4885.9	8364.1	7254.7	5400.7	3820.4	12471.1
09-Jul	33874.2	13975.7	32351.4	4843.8	5462.6	5728.9	3477.8	4405.7	16524.4
10-Jul	34932.1	9956.5	15422.4	8783.6	6608.0	5954.8	6970.6	6026.0	14797.4
11-Jul	38235.2	19817.5	16102.8	6078.2	8947.3	5955.1	4958.5	10872.8	12073.2
12-Jul	40477.3	19284.5	15649.2	4349.7	10348.6	7839.4	6805.2	12271.1	12516.6
13-Jul	48708.5	11459.9	12811.0	6160.9	12519.4	4848.9	4886.6	4533.7	11525.7
14-Jul	27395.8	15574.7	24107.2	5231.0	10282.1	4634.6	6489.2	7983.9	12506.5
15-Jul	26457.8	11380.5	15412.7	3854.0	19072.3	7412.3	5569.7	5619.5	16077.1
16-Jul	37742.8	14013.0	10259.5	4372.4	11664.0	14706.5	7658.1	5905.9	13064.4
17-Jul	46686.8	13071.8	13065.3	3915.5	7761.4	12338.3	4926.1	7168.5	17454.4
18-Jul	76745.9	10194.7	14578.4	2598.5	8156.7	7562.7	4465.1	5755.8	14935.7
19-Jul	68443.4	13112.3	8563.3	4041.9	2826.9	5965.6	3957.8	4302.5	10917.2
20-Jul	52585.2	11986.4	7722.5	3155.8	5371.9	7020.6	5531.1	6278.9	10543.0
21-Jul	35858.7	13902.8	4908.6	2477.0	6556.1	7077.7	8769.4	4534.6	8066.7
22-Jul	39003.1	17001.9	7256.0	3256.2	6290.5	18515.2	11025.1	2788.4	11307.1
23-Jul	43999.2	18450.2	3878.3	2175.7	4150.4	20274.2	4375.1	3404.1	9774.5
24-Jul	41677.7	19487.0	4617.0	2585.5	4325.4	5238.0	9728.6	5291.9	11474.6
25-Jul	43412.8	13285.6	4147.2	2033.1	4770.9	5818.0	4654.3	1811.0	8775.4
26-Jul	29466.2	14209.0	5810.9	1825.7	2997.0	4712.0	7374.8	3926.0	5205.5
27-Jul	16430.0	12935.7	4915.1	1790.1	3865.3	7058.8	6715.4	3179.4	8277.5
28-Jul	25411.3	11829.2	3912.3	1472.6	3688.7	4301.2	6140.7	2695.7	6624.3
29-Jul	24335.6	9201.6	4571.6		2195.1	6172.8	4773.4	3730.7	4640.2
30-Jul	17956.1	6979.0	4770.9		2439.7	3645.9	3623.9	2796.4	6414.4
31-Jul	17010.0	8637.8	4997.7		1880.8	5563.8	4483.0	2867.1	4039.3
01-Aug	16038.0	8360.8	3254.6			5592.4	4337.8	2774.3	1774.7
02-Aug	15066.0	8119.4	4560.3			5436.4	4216.8	2696.9	1120.2
03-Aug	14256.0	11085.7	3847.5			7417.5	5753.5	3679.7	1529.8
04-Aug	13284.0	9525.6	3499.2			6411.4	4973.0	3180.5	1308.9
05-Aug	12312.0	11003.0	3142.8			7323.9	5680.9	3633.3	1517.7
06-Aug	11340.0	6470.3	2786.4						
Total	1169470	589286	442461	129367	266976	253051	209080	193013	401511

Note: all daily estimated escapements are derived by multiplying the daily adjusted sonar count by an expansion factor of 1.62. Reference to data expanded by 1.5 will reveal different calculated daily escapement estimates and season totals.