BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES FOR 1995

by

Drew L. Crawford

and

Beverly A. Cross

Regional Information Report[1] No. 2A96-10

Alaska Department of Fish and Game
Division of Commercial Fisheries Management and Development
Regional Office
333 Raspberry Road
Anchorage, Alaska 99518-1599

February 1996

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[1]Contribution 96-10 from the Anchorage regional office. The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate needs for up-to-date information, reports in this series may contain preliminary data.

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[a] Ugashik River Smolt Project
[b] Kvichak River Smolt Project
[c] Egegik River Smolt Project
[d] Crew leader

PROJECT SPONSORSHIP

The Ugashik River smolt project was financed through cooperative agreements with the City of Pilot Point (COOP-95-084), the Lake and Peninsula Borough (COOP-95-085), and the State of Alaska, Department of Fish and Game, Division of Commercial Fisheries Management and Development.

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ABSTRACT

Numbers of sockeye salmon *Oncorhynchus nerka* smolt emigrating to sea from three rivers in Bristol Bay, Alaska, were estimated from sonar counts and age-weight-length samples from mid-May to mid-June in 1995. Hydroacoustic equipment was used to estimate total smolt biomass, and age-weight-length samples were used to convert biomass estimates into numbers of smolt by age group. Estimated numbers of smolt emigrating were 220,892,127 from Kvichak River, 57,385,790 from Egegik River, and 22,234,137 from Ugashik River. Age-1. smolt, the progeny of 1993 spawners, predominated at Kvichak River (95%). Age-2. smolt, the progeny of 1992 spawners, predominated at Egegik River (87%), and Ugashik River (69%).

KEYWORDS: smolt, sockeye salmon, *Onchorhynchus nerka*, smolt emigration, sonar, vertical distribution of passage, winter ice cover, bird predators, Bristol Bay, Kvichak River, Egegik River, Ugashik River

INTRODUCTION

The Bristol Bay Management Area includes all waters east of a line from Cape Newenham to Cape Menshikof (Figure 1) and supports the largest sockeye salmon *Oncorhynchus nerka* fishery in the world. From 1986 to 1995 the commercial catch in Bristol Bay averaged 28.6 million sockeye salmon (R.B. Russell, ADF&G, King Salmon, personal communication). To effectively manage this fishery, managers need accurate abundance forecasts of returning sockeye salmon and precise estimates of optimum spawning escapement goals. Estimates of outmigrating smolt numbers are currently used as an index of production for adult salmon; this improves the accuracy of preseason forecasts and aids in setting goals for optimum numbers of spawners.

Fyke nets were used to estimate smolt numbers on Kvichak River from 1956 to 1970; on Naknek River from 1956 to 1978; on Egegik River during 1957, 1969, and 1978; on Ugashik River from 1955 to 1965, 1967 to 1970, and 1972 to 1975; and on Wood River from 1955 to 1966 (Burgner and Koo 1954; Rietze and Spangler 1958; Kerns 1961; Burgner 1962; Jaenicke 1963, 1968; Church 1963; Church and Nelson 1963; Nelson 1964, 1965a, 1965b, 1966a, 1966b, 1969; Marriott 1965; Nelson and Jaenicke 1965; Pennoyer and Seibel 1965; Pennoyer 1966; Pennoyer and Stewart 1967, 1969; Robertson 1967; Siedelman 1967, 1969; Paulus and McCurdy 1969, 1972; Van Valin 1969a, 1969b; Shroeder 1972a, 1972b, 1974a; McCurdy and Paulus 1972a, 1972b; Paulus 1972; McCurdy 1974a, 1974b; Bill 1975, 1976, 1977; Pella and Jaenicke 1978; Yuen 1978). Although fyke net sampling provided information on age, size, and relative abundance of smolt, it did not provide an accurate estimate of total smolt numbers. To improve estimates of smolt numbers, the department began experimenting with and using hydroacoustic equipment.

Hydroacoustic equipment was used to estimate sockeye salmon smolt numbers on Kvichak River from 1971 through 1995; Wood River from 1975 to 1990; Naknek River from 1982 to 1986 and 1993 to 1994; Egegik River from 1982 through 1995; Ugashik River from 1983 to 1991 and 1993 to 1995 Nuyakuk River from 1983 to 1989; and Togiak River in 1988 (Russell 1972; Parker 1974a, 1974b; Krasnowski 1975; Randall 1976, 1977, 1978; Newcome 1978; Yuen 1980a, 1980b; Clark and Robertson 1980; Bucher 1980, 1981, 1982, 1983, 1984, 1986a, 1986b, 1987; Bergstrom and Yuen 1981; Yuen and Wise 1982; Eggers 1984; Eggers and Yuen 1984; Bue 1986a, 1986b; Bue and Fried 1987; Bue et al. 1988; Cross et al. 1990; Woolington et al. 1990, 1991; Crawford et al. 1992; Crawford and Cross 1992, 1994a, 1994b,1995).

Hydroacoustic equipment developed by Bendix Corporation[2] was tested on Kvichak River in 1969 (McCurdy and Paulus 1972b; Paulus and Parker 1974). Further testing and modification of this prototype resulted in the construction of smolt counters for use on Wood (Krasnowski 1976, 1977) and Kvichak Rivers (Randall 1977) in 1975 and 1976. Hydroacoustic equipment for counting smolt was tested on Ugashik River from 1973 to 1975 (Schroeder 1974b, 1975; Sanders 1976). Smolt studies on Naknek, Egegik, Ugashik, and Nuyakuk Rivers were limited to occasional fyke

[2] Use of a company's name does not constitute endorsement.

net sampling to obtain age and size data from 1975 to 1982 (Huttunen 1980; Eggers 1984; Minard 1984). An experimental two-array sonar system similar to the one used on Kvichak River was tested on Egegik River during 1981 (Bue 1982). Smolt enumeration projects using modified counters began on Naknek and Egegik Rivers in 1982 (Huttunen 1984; Bue 1984) and on Ugashik and Nuyakuk Rivers in 1983 (Fried et al. 1987; Minard and Frederickson 1987).

Side-scanning sonar was used in 1985 and 1986 to determine the lateral distribution of smolt passing each of the respective sonar sites. Bue et al. (1988) reported that most smolt passing the Kvichak River sonar site stayed within a 68-m corridor that began 6.4 m from the left bank[3] (total river width = 100 m). Smolt passing the Egegik River sonar primarily used a 73-m corridor beginning 12.2 m from the left bank (total river width = 104 m). Ugashik River smolt used a 21-m corridor which began 7.0 m from the left bank (total river width = 43 m). Side-scanning sonar was not an effective tool for collecting lateral smolt distribution data on Wood River (Cross et al. 1990; Woolington et al. 1990, 1991). Therefore, lateral smolt distribution was assumed to be a function of river width and depth, measured and recorded when tidal influence was minimal. Based on those measurements, Wood River smolt were assumed to migrate within a 94-m corridor which began 3.3 m from the left bank.

Due to budget cuts, the monitoring of smolt migrations was discontinued on Naknek River in 1986 (Bue et al. 1988), on Togiak River in 1988 (Woolington et al. 1990), on Nuyakuk River in 1989 (Woolington et al. 1991), and on Wood River in 1990 (Crawford et al. 1992).

In 1990 a single narrow-beam, side-looking sonar unit was used from May 29 to 31 to determine the lateral limits of smolt distribution at the Kvichak River sonar site (Huttunen and Skvorc 1991); most smolt migrated between 40 and 100 m offshore from the right bank. The total river width at the site was 136 m.

The results of the 1990 study were encouraging, so in 1991 it was expanded to evaluate the feasibility of using side-looking sonar to enumerate outmigrating Kvichak River sockeye salmon smolt. Huttunen and Skvorc (1992) estimated, based on 81 h of horizontal-aspect echo-integration data collected June 2-14, that 44,972,864 smolt passed through the sonar site during the counting period. This compared well to an upward-looking sonar estimate of 43,525,980 smolt for the same hours of operation. The maximum single-beam listening range for the side-looking sonar varied from 118 m to 120 m, ensonifying 88%-90% of the total 134-m river cross section. In comparison, the three arrays of the historical upward-looking sonar ensonified roughly 7.5% of the river. The spacial distribution of smolt on a nightly basis were highly dynamic; side-looking estimates peaked at ranges from 64 m on June 12 to 118 m on June 7. Whereas the distribution of upward-looking estimates also varied between nights, the largest estimates were typically from the inshore array at 56 m from the right bank. No side-looking sonar smolt studies have been conducted since 1991 due to lack of funding.

[3] In this report the location of projects and the placement of equipment are referenced to the right and left bank of the respective river as determined by facing downstream at the study site.

Due to budget cuts, the smolt migration on Ugashik River was not monitored in 1992 (Crawford and Cross 1992). However, approval of cooperative agreements between the City of Pilot Point and ADF&G in 1993; the Lake and Peninsula Borough and ADF&G in 1994; and the City of Pilot Point, Lake and Peninsula Borough, and ADF&G in 1995 allowed for continued enumeration of sockeye salmon smolt with hydroacoustic equipment on Ugashik River. The Ugashik River smolt study was resumed to measure the freshwater production and the size and age structure of smolt from recent sockeye salmon spawning escapements. Also each of these organizations wanted a continuation of the historical Ugashik River sockeye salmon smolt data base that had been collected annually (except for 1992) since 1983.

In 1993, approval of a cooperative agreement between the National Park Service and the Alaska Department of Fish and Game (ADF&G) allowed for continued enumeration of sockeye salmon smolt with hydroacoustic equipment on Naknek River in 1993 and 1994. The primary impetus for resuming the Naknek River smolt study was to measure freshwater production from the record sockeye salmon escapement (3.6 million fish) that entered the Naknek River drainage to spawn during the 1991 commercial fishermen strike. This study was concluded in 1994 and the Naknek River smolt migration study was not funded in 1995.

Upward-looking sonar studies were conducted on Kvichak, Egegik, and Ugashik Rivers in 1995 to: (1) estimate numbers of outmigrating sockeye salmon smolt; (2) describe smolt migration patterns; (3) collect smolt age, weight, and length data; and (4) record climatological and hydrological parameters which might affect migratory behavior.

METHODS

For step-by-step procedures on the installation, operation, maintenance, troubleshooting, and retrieval of smolt sonar and sampling equipment; plus detailed instructions on data collection, recording, and reporting techniques see Crawford and Tilly (1995).

Hydroacoustic Equipment

Bendix Corporation constructed all hydroacoustic systems used to estimate smolt numbers in Bristol Bay river systems in 1995; all projects used 1982 or 1983 model smolt counters. Transducers used to transmit and receive sound pulses at each sonar site were housed in two-to-three 3.03-m long arrays set on the river bottom and connected by coaxial cable to a control unit located on shore. Three arrays were used at each sonar site except Ugashik River. Only two arrays were used at Ugashik River due to a narrow channel width. Each array had 10 upward-facing single-element International Transducer Corporation[2], Model 5095 transducers which operate at a frequency of 235 Khz and a half power beamwidth angle of 9°. Detected echoes from each transducer were accumulated in the smolt counter and a printer produced a hard copy of totaled counts by array at prescribed intervals which were summed and recorded hourly on a field data collection form. Each smolt counting system was powered by a single 12-volt battery recharged by a pair of 43 watt, 2.9 amp solar panels.

Hydroacoustic equipment to monitor smolt outmigrations was operated on Kvichak, Egegik, and Ugashik Rivers from mid-May to mid-June. The smolt outmigrations in Kvichak, Egegik, and Ugashik Rivers generally peak during late May or early June and drop off by mid-June. All arrays at each project site were removed from the water at the end of the field season.

All hydroacoustic systems used in 1995 were factory calibrated to record one count whenever 41.5 g of biomass passed through each transducer beam during a given period. Because most smolt migrate within the upper portion of the water column, individual arrays were calibrated independently, which allowed the operator to set the counting range as near the surface as possible. The equipment was set to record counts to within 1-2 cm of the water surface to avoid counting debris or entrapped air.

Sources of false counts, e.g., boats, wind, rain, debris, were noted and the hydroacoustic equipment was disabled whenever false-count conditions were detected. Known false counts were subtracted from hourly totals, and linear interpolations were used to estimate counts missed while equipment was disabled. The control unit automatically recorded and stored the length of time the system was disabled. Manual control was available for adjusting printing intervals for accumulated counts, transducer pulse rate, and the portion of the water column monitored. Transducer signal characteristics were visually monitored with an oscilloscope.

In 1989, the Kvichak River smolt counting system was relocated and modified so that one smolt counter on the right bank monitored three arrays and a second smolt counter on the left bank monitored a fourth array to account for the greater river width and depth at the new site. Analysis of the 1989 data (Woolington et al. 1991) revealed no advantages to using a three- versus four-array system; therefore, in 1990 only three arrays and one counter were used. The offshore transducer cables were also extended 100 ft to help enumerate smolt in the deep, fast water near the left bank. In addition, Al Menin of Bendix Corporation modified the Kvichak counter in 1989 and 1990 to enable counting in the deeper water at the new site. As a result of these changes, a new depth setting factor of 1.79 and a new formula, Water Depth = (Depth Setting * 1.79) + 3.0 ft, were introduced in 1990 to convert depth settings on the smolt counter to actual river depths. The additional 3.0 ft is an electronic blanking range that is built into the Kvichak River counter to account for near-field effects. For a detailed discussion of near-field effects, refer to MacLennan and Simmonds (1992).

Between the 1992 and 1993 field seasons, several hydroacoustic equipment changes were made. Due to uncorrectable problems with the modified Kvichak counter's Practical Automation, Inc.[2], Model C4-265 moduprint printer, use of this counter and its seven-transducer-per-array system was discontinued after 1992. In 1993 the modified Kvichak counter (Bendix, 1976 model) and arrays were replaced by a Bendix, 1982 model counter with three 10-transducer arrays which had been used on the Naknek River from 1982 to 1986. Prior to the field season, sonar consultant Al Menin, extended each of the ten offshore array cables (standard length = 330 ft) an additional 85 ft for use at the wider Kvichak River site in 1993 and he also installed 10 new 150 Uh inductors in the offshore array components of the smolt counter to tune them for the additional cable length. A Bendix, 1982 model smolt counter with three 10-transducer arrays was also used at Naknek River smolt in 1993. This unit had originally been used on Nuyakuk River from 1983 to 1989. Therefore since 1993, all smolt projects have used 1982 or 1983 model smolt counters with 10-transducer arrays.

In 1994, Al Menin added a three-way switch to the Ugashik River smolt counter which enable the operator to select shorter printout intervals (e.g., 1.875 printouts per minute or 3.750 printouts per minute) when the smolt are running strong.

Project Locations

The Kvichak River counting site was located 6 km below the outlet of Lake Iliamna (Figure 1); it was moved to this location in 1989, approximately 1 km downstream from the site used during the previous 15 years (Woolington et al. 1991). The Kvichak River was 135 m wide at this site. Three transducer arrays referred to as *inshore, center,* and *offshore*, were anchored 61 m, 72 m, and 100 m from the right bank (Figure 2). Array placement was improved by using lateral smolt distribution data reported by Huttunen and Skvorc (1991, 1992).

The Egegik River counting site was located 4 km below the outlet of Becharof Lake (Figure 1); it has been operated at this location since 1982 (Eggers and Yuen 1984). Egegik River is 114 m wide at this site. The inshore, center, and offshore arrays were anchored 37 m, 53 m, and 67 m from the left bank (Figure 3).

The Ugashik River counting site was located 50 m below the outlet of Lower Ugashik Lake (Figure 1). Because this river-section is only 43 m wide, only two arrays have been used. The inshore and offshore arrays were anchored 24 m and 30 m from the right bank (Figure 4).

Estimation of Smolt Numbers

The process of estimating smolt numbers was divided into three steps: (1) determining total fish biomass emigrating past the study site; (2) sampling the emigrating fish population to estimate species, age, weight, and length composition; and (3) converting fish biomass into numbers of smolt by age and species.

Biomass Estimation

Fish biomass was estimated using continually monitored hydroacoustic equipment. The signal pulse rate of the smolt counter was set to correspond with the river velocity measured at a location referred to as the *velocity index*. In most instances, the velocity at one of the arrays was used as the velocity index. At Egegik River, a buoyed flow meter anchored downriver of the inshore array was used as the velocity index.

Estimation of River Velocities and Adjustments to Sonar Counts. River velocities at the Kvichak and Ugashik River sites were nearly constant; thus velocities were measured once a week with a Gurley[2], Model 622 flow meter and the counter was adjusted accordingly.

River velocities at the Egegik River site were influenced by tides, therefore river velocities were measured continuously by a Gurley, Model 622 or Model 625, flow meter anchored directly behind the velocity index array, and smolt counts were adjusted every 15-30 min to account for changes in river velocity. To account for differences in river velocities between the velocity index and the arrays (i) readings over each array were taken at specified intervals and velocity correction factors (vcf_i) were then calculated:

$$vcf_i = \frac{v_i}{v_{index}}, \qquad 1$$

where

v_i = velocity over array i, and
v_{index} = velocity over the velocity index array.

Using these correction factors, adjustments to daily counts ($ac_{i,z}$) were made for differences in river velocity:

$$ac_{i,z} = c_{i,z}(vcf_i), \qquad 2$$

where $c_{i,z}$ = counts for array i on day z.

Ideally, all sonar arrays monitored fish biomass 24 h/d, so daily counts for each array represented actual sonar counts. If an array was not monitored during an hour, counts were linearly interpolated using estimated counts from the previous and following hours.

Expansion of Biomass Estimates. The width of the section of river ($l_{i,z}$) monitored by array i on day z depended on array length (3.03 m), water depth over the array, and transducer signal beam width:

$$l_{i,z} = 3.03 + 2\left(d_{i,z} \tan\frac{bw}{2}\right), \qquad 3$$

where

$d_{i,z}$ = water depth over array i on day z, and
bw = transducer beam width in degrees (9^0 for all transducers).

Arrays were placed perpendicular to the river current; distances from each array to a reference point on one river bank were measured to the nearest foot. Estimates of the inshore and offshore limits of smolt passage were made based on past studies with side-scanning hydroacoustic equipment (Bue et al. 1988; Huttunen and Skvorc 1991, 1992). Distances were calculated between inshore limit of smolt passage to first array (D_1); first to second array (D_2); second to third array (D_3) at sites where three arrays were used; and offshore array to offshore limit of smolt passage (D_4).

The estimated biomass of fish ($\hat{B}_z$) passing the counting site on day z was calculated as follows:

$$\hat{B}_z = \frac{1}{2} D_1 \left(\frac{ac_{1,z}}{l_{1,z}} \right) + \sum_{i=2}^{na} \left[\frac{1}{2} D_i \left(\frac{ac_{i-1,z}}{l_{i-1,z}} + \frac{ac_{i,z}}{l_{i,z}} \right) + \frac{1}{2} D_{na+1} \left(\frac{ac_{na,z}}{l_{na,z}} \right) \right] , \quad 4$$

where

D_i = the distance for interval i, and
na = number of transducer arrays used.

Age, Weight, and Length Estimation

Data on age, weight, and length of sockeye smolt were obtained from samples captured in a fyke net. Smolt weight in grams and length, from tip-of-snout to fork-of-tail, in millimeters were measured; age was determined from visual observations of scales mounted on glass slides. European ages -- 1., 2., or 3. depending on the number of freshwater annuli -- were used. Parent year escapements that produced 1995 smolt occurred in 1993 for age-1. smolt, 1992 for age-2. smolt, and 1991 for age-3. smolt.

Sample size goals for Kvichak, Egegik, and Ugashik Rivers were 400 smolt/d. Based on binomial proportions for the two major age groups, a sample size of 400 smolt would simultaneously estimate the percentage of each age class within 5% of the true percentage 95% of the time (Goodman 1965; Cochran 1977). When the daily goal of 400 smolt was not obtained, samples from subsequent days were combined until a total of at least 400 was reached.

Mean length of smolt differs among fyke net samples from a single day (Minard and Brandt 1986). Thus, to ensure that daily age composition estimates were representative of the population, attempts were made daily to obtain 100 smolt from each of six different fyke net catches. Because weight and age of smolt are strongly correlated to length, the time and cost of data collection was reduced by measuring all smolt collected each day: up to a maximum of 600 for length and weighing and sampling up to 100 of those smolt for age (Bue and Eggers 1989).

Weight was estimated for smolt measured only for length using a least squares linear regression. Based on paired weight-length data obtained from smolt sampled for age, weight, and length, we estimated weights (W_j) of age j smolt measured only for length as explained by (Ricker 1975):

$$W_j = \alpha L_j^{\beta} , \quad 5$$

where

L_j = fork length of an age j smolt, and
α and β = parameters which determine the y-axis intercept and the slope of the line.

Age was estimated for smolt measured only for length using an age-length key (Bue and Eggers 1989). The key used length to categorize age-1. or -2. sockeye salmon smolt by determining a discriminant length that minimized classification error. This discriminant length was chosen such that the number of age-1. smolt classified as age-2. smolt was equal to the number of age-2. smolt classified as age-1. smolt. Age-3 smolt were not included in this analysis because too few samples were collected.

Due to the variability of age and size composition estimates among subsamples (e.g., fyke net catches) taken the same day, daily mean weight ($\hat{W}$) and age proportions ($\hat{P}_j$) were estimated as the mean of subsampled values:

$$\hat{W} = \frac{\sum_{k=1}^{m}\left(\frac{\sum w_k}{n_k}\right)}{m}, \qquad 6$$

where

m = number of subsamples collected during a sampling period,
w_k = observed weights from subsample k, and
n_k = number of observations in subsample k; and

$$\hat{P}_j = \frac{\sum_{k=1}^{m}\left(\frac{n_{j,k}}{n_k}\right)}{m}, \qquad 7$$

where $n_{j,k}$ = number of observations of age j in subsample k.

Estimation of Smolt Numbers

Numbers of smolt by age ($\hat{SPC}$) were estimated by combining biomass estimates with estimates of age and weight composition. Mean weight of smolt was used to convert estimates of biomass per count into estimates of smolt per count:

$$\hat{SPC} = \frac{BPC}{\hat{W}}, \qquad 8$$

where BPC = biomass (g) per count.

The estimated number of smolt passing the counting site ($\hat{N}_z$) each day (z) was computed:

$$\hat{N}_z = \hat{B}_z\,(S\hat{P}C) \quad . \qquad 9$$

The estimated number ($\hat{N}_{j,z}$) of age j smolt on day z were then apportioned:

$$\hat{N}_{j,z} = \hat{N}_z(\hat{P}_j). \qquad 10$$

Finally, daily estimates of smolt numbers were summed: the seasonal total of all smolt passing the sonar site ($\hat{N}_{tot}$) was

$$\hat{N}_{tot} = \Sigma \hat{N}_z \qquad 11$$

and the estimated number of age j smolt that passed the site during the season ($\hat{N}_{jtot}$) was

$$\hat{N}_{jtot} = \Sigma \hat{N}_{j,z} \quad . \qquad 12$$

Vertical Distribution of Smolt Passage

Monitoring of vertical distribution of passing smolt schools was conducted with an oscilloscope during the 2 weeks of peak smolt passage. Vertical distribution of smolt was monitored for approximately 1 h during each 8-h shift. Observers recorded the top and bottom depth (in centimeters) of passing smolt schools and spread their hour of monitoring throughout their shift and among all arrays. The arrays that received the highest counts were monitored most.

Climatological Data Collection

Climatological data were recorded at each counting site. Observations of sky conditions and measurements of wind direction, wind velocity (km/h), daily precipitation (mm), air and water temperatures (^{o}C) were recorded at 0800 and 2000 hours daily.

RESULTS

Kvichak River

A total of 5,120,393 sonar counts were recorded at the Kvichak River counting site from May 21 to June 13, 1995 (Table 1). More counts were recorded over the offshore array (44%) than over the inshore (26%) or center (30%) arrays (Figure 5). Daily sonar counts were highest from May 21 to May 27 when 74% of the total counts were recorded (Figures 6, 7). The peak daily sonar count of 936,415 occurred on May 22. Over the course of the entire sampling season, 37% of the total sonar counts were obtained between 2200 hours and 0300 hours (Figure 8); the remaining counts were spread fairly evenly throughout the day.

Local residents reported that the east end of Lake Iliamna was 30-40% ice free with black ice visible at Igiugig on May 1 and 95% of the lake was open by May 13 (R. Russell, ADF&G, King Salmon, personal communication). The average reported break-up date for Lake Iliamna between 1971 and 1993 was May 15 (Appendix A.1).

ADF&G's Kvichak Smolt personnel arrived in Igiugig late in the evening on May 17, but were unable to count smolt with sonar in the Kvichak River prior to 2400 hours May 21 due to ice in the river from Lake Iliamna's spring breakup. No observations were reported of birds feeding on smolt in Kvichak River prior to the start of the project. However when the smolt counter was activated at 2400 hours on May 21, it immediately began registering high counts (e.g., 34,000 to 105,000 counts/h). The smolt passage rate during the first 12 h of sonar operation ranged from 1.5 to 4.6 million smolt per hour and equaled a total of 34.9 million smolt. Based on the high rate of passage the first day of counting a substantial number of smolt could have passed the Kvichak smolt counting site before counting began. The first fyke net set fished from 2100 hours May 22 to 0015 hours May 23 caught only 150 sockeye salmon smolt which indicated a relatively low abundance (CPUE=1) of smolt in the river. The age composition of the first fyke net catch was 94% age-1. and 6% age-2. smolt.

Equipment problems contributed to 29 hours of sonar counter disabled time in 1995 which required interpolation of sonar counts. Twenty-two hours of disabled time (e.g., 1200-2400 hours on May 26; and 2400 hours on June 3 to 0800 hours on June 4) were caused by portions of the inshore and center arrays being silted in with sand, gravel, cobble, and debri. This unusually high sediment movement in the river was attributed to eroding action of wind driven waves on gravel bars upstream from the sonar site. An additional 7 hours of disabled time (e.g., 0700-0900 hours on May 25; 1800-1900 on June 3; 1900 hours on June 4; and 1600 hours on June 5) were due to an intermittant printer problem.

Problems with lake ice flows in the Kvichak River from the breakup of Lake Iliamna's winter ice cover inhibited boat travel and camp setup between May 18 and May 20. At 1100 hours on May 21, the crew reported that they were still dodging 1 ft diameter chunks of black ice in the river,

however they were able to set anchors and buoys for their arrays that morning and set out their arrays later that evening. No further problems with ice were reported after May 21.

High easterly winds gusting in excess of 56 km/h from 0500 hours to 1100 hours on May 23 accounted for 6 hours of diasabled time which were not able to be interpolated.

River velocity measurements over the center index array, which were used to adjust the sonar counter firing rate, ranged from 1.2 m/s to 1.5 m/s. Velocity correction factors (m/s) used for the three arrays were as follows:

Smolt Days	Inshore	Center	Offshore
May 21 - May 28	1.01	1.00	0.84
May 29 - June 07	0.98	1.00	0.87
June 08 - June 12	0.93	1.00	0.94
June 13	0.96	1.00	0.97

Based on sonar counts an estimated 220,892,127 sockeye salmon smolt migrated from Kvichak River in 1995 (Table 2).. Age-1. smolt (1993 brood year) comprised 95% of the total smolt estimate and they predominated throughout the operation of the project. Age-2. smolt (1992 brood year) were most numerous during the first week of sonar operations and peaked on May 27. Since the highest daily smolt counts occurred on the first two days of sonar operation, May 21-22, it is highly likely that an undetermined portion of the outmigration passed the site prior to gear deployment and were not counted. Therefore, the 1995 smolt outmigration estimate for the Kvichak River should be considered a conservative estimate. Based on trends in past outmigrations, the proportion of age-2. smolt are higher early in the season. As for the age-2. smolt, we will have to wait until the age-2.2 adults return to the Kvichak River in 1997 to find out whether the current estimate of age-2. smolt for the 1992 brood year is good or if the majority of age-2. smolt passed the sonar site prior to the start of the 1995 project. Mean weight of smolt were generally small (5.9 g to 6.7 g) throughout the season (NSC). The smolt per count estimate decreased and then increased (Table 3). Total production from the 1991 spawning escapement of 4,222,788 sockeye salmon was 12.31 smolt per spawner (Table 4). The 1991 smolt production from Kvichak was 54% less than the recent ten-year average; mean production from brood years 1981-1990 was 26.50 smolt per spawner. Marine survival (i.e. adult salmon returns per smolt) has averaged 13% for age-1. smolt and 17% for age-2. smolt for the 1979-1988 brood years (Table 5).

Age, weight, and length data were collected from 1,207 sockeye salmon smolt in 1995 (Table 6). All smolt sampled were age 1. or 2. Mean weight was 6.2 g for age-1. smolt and 9.8 g for age-2. smolt. Mean length was 87 mm for age-1. smolt and 103 mm for age-2. smolt. Age-1. and -2. smolt in 1995 were 0% to 4% shorter in length and 7% heavier to 6% lighter in weight than the 1955-1994 average (Table 7). An additional 5,997 smolt were measured for length only (Table 8).

Fifty-nine depth measurements were recorded for smolt schools passing over Kvichak River sonar arrays between May 21 and June 7 (Table 9). Schools passed at an average depth range of 9 cm to 121 cm below the surface. The water depth over the sonar arrays ranged from 258 cm to 304 cm

during the peak smolt passage. Data, although limited, suggest that depth of smolt passage may have varied diurnally (Figure 9). During daylight, smolt schools tended to travel at greater depths below the surface than during darkness.

River and weather conditions were recorded at the counting site from May 21 to June 14 (Table 10). Extensive lake ice in the river prevented smolt counting with sonar prior to May 22. High easterly winds on or before May 26 and June 4 were attributed for movement of sand and gravel on the river bottom which silted in portions of the center array and required it to be pulled up and cleaned on each of these dates. The smolt counter was not disabled for any other weather related reasons. Mean water temperature during the project was 8.1 °C (range 4.0 °C to 12.5 °C), which was warmer (NSC) than the 1963-1994 mean of 5.7 °C (Table 11). Mean daily water temperature during the peak of the smolt migration was 6.0 °C on May 22.

Egegik River

A total of 3,571,414 sonar counts were recorded at the Egegik River counting site from May 21 to June 12, 1995 (Table 12). Sonar counts were most numerous over the center array (58%) followed by the offshore (34%) and inshore (8%) arrays (Figure 10). Daily sonar counts were highest from May 22-25 (Figures 11, 12). Seventy-five percent of the total sonar count were recorded during this four-day period. The peak daily sonar count of 1,188,519 occurred on May 23. Over the course of the season, most sonar counts were recorded between 2400 hours and 0600 hours (Figure 13); 69% of all smolt counts were obtained during these times.

Local pilots reported that Becharof Lake was 98% ice-free by April 28 and there was only one pan of ice left in the lake by Gas Rocks (R. Russell, ADF&G, King Salmon, personal communication). Between 1975 and 1993 the earliest reported break-up date for Becharof Lake was April 1 in 1991 and the latest was May 20 in 1982 (Appendix A.2). The break-up date for 1995 compares closely with the historical average date of April 24.

The first two Egegik River smolt crew members arrived at the study site via boat from Egegik Village late in the afternoon on May 17. Late in the afternoon on May 18 a strong SE wind ($\geq$64 km/h) began to blow. By the next morning a large ice jam (approximatey 100 m wide by 800 m long) had lodged at the outlet of Becharof Lake (F. Tilly, ADF&G, Egegik River Smolt Project, personal communication). From May 19 through May 21 the high winds persisted and ice jams clogged the rapids in Egegik River above the ADF&G cabin, restricting the flow of the river, and lowering the water level about 3 ft. Many large chunks of ice were grounded on the numerous boulders and shallow gravel bars in the rapids area. Smaller pieces of ice refloated on each high tide and filled the river below with heavy flows of ice. No observations of smolt or birds feeding on smolt were observed prior to the startup of the Egegik River smolt sonar counter at 1100 hours on May 22 (Smolt Day - May 21). However, as soon as the smolt counter was activated it began registering counts from large, dense schools of smolt (e.g., 36,000 to 60,000 counts/h on the center and offshore arrays) passing at depths of 100-180 cm below the surface. Swimming at these depths

the smolt apparently did not attract the attention of predatory birds (Appendix B) which are often observed fishing at smolt sonar and fyke net sites. Therefore the lack of bird activity was not a good indicator of early smolt outmigration activity this year. The first smolt catches (n=150) in the fyke net were made between 0011 hours and 0044 hours on May 23.

River velocities at the counting site ranged from 0.7-0.8 m/s. Historically, the inshore array has been used as the index array at this site. However, from 1992 to 1994 the center array was used as the index array because the water velocity at the center array was faster and more smolt were passing over it. In 1995, the smolt counter was calibrated according to the water velocities at an index buoy set downstream from the center array. Velocity correction factors (m/s) used for three arrays were:

Smolt Days	Index Buoy	Inshore	Center	Offshore
May 21 - May 31	1.00	0.66	1.02	1.14
Jun 01 - Jun 07	1.00	0.67	1.09	1.19
Jun 08 - Jun 11	1.00	0.67	1.07	1.13
Jun 12	1.00	0.65	1.00	1.12

An estimated 57,385,790 sockeye salmon smolt migrated from Egegik River in 1995 based on sonar counts (Table 13). Since large dense schools of smolt were already present when the smolt counter was first activated this year, the 1995 smolt outmigration estimate should be considered a minimum estimate. Age-2. smolt composed 87% of the total migration. The daily percentage of age-2. smolt ranged from 63% to 95% during the migration. Mean weight of smolt generally decreased over the season (Table 14), resulting in an increase in the estimated number of smolt per count (NSC). Total production from the 1991 spawning escapement of 2,786,880 sockeye salmon was 21.30 smolt per spawner (Table 15). The 1991 smolt production from Egegik was below average; mean production for brood years 1981-1990 was 49.59 smolt per spawner. Smolt outmigration estimates for brood years with unusually high smolt per spawner ratios (e.g, 1983 and 1987) may be artifically low. During these years smolt may have passed undetected before, during, or after the operational dates of the smolt sonar. Average marine survival has been 25% for age-1. smolt for the 1980-1989 brood years and 25% for age-2. smolt for the 1979-1988 brood years (Table 16).

Age, weight, and length data were collected from 1,305 sockeye salmon smolt in 1995 (Table 17). Age-1., -2., and -3. smolt were sampled. Mean weight was 9.3 g for age-1., 11.6 g for age-2. smolt, and 14.9 g for age-3. smolt. Mean length was 103 mm for age-1. smolt, 112 mm for age-2. smolt, and 126 mm for age-3. smolt. In comparison to the 1939-1994 average, age-1. smolt were average in length and weight, age-2. smolt were average in length and 19% lighter, and age-3. smolt were average in length and 28% lighter (Table 18). An additional 3,361 smolt were measured for length only (Table 19).

Ninety-one depth measurements were recorded for smolt schools passing over Egegik River sonar arrays during peak smolt passages between May 21 and June 09 (Table 20). Most schools passed

from 33 cm to 137 cm below the surface. Water depth over the sonar arrays at this site ranged from 273 cm to 375 cm. Figure 14 shows the depth of smolt passage by hour for each array.

River and weather conditions were recorded at the counting site from May 21 to June 13 (Table 21). Problems with ice in Egegik River from Becharof Lake's spring breakup delayed camp set up and the installation of sonar gear from May 19 through May 21. From 0100-0500 hours on May 23 (Smolt Day-May 22) sonar counts were discounted because they high winds, heavy rain, and lake ice flowing in the river made it impossible to differentiate smolt counts. After this there was very little down time for the Egegik River smolt sonar during 1995. Mean water temperature during the season was 7.0 °C (range 2.0 °C to 12.5 °C), which was slightly higher NSC) than the 1981-1994 average of 6.5 °C (Table 22). Mean daily water temperature during the peak of the smolt outmigration on May 23 was 5.0 °C.

Ugashik River

A total of 3,027,734 sonar counts were recorded at the Ugashik River sonar counting site from May 22 to June 12, 1995 (Table 23). Most counts (83%) were recorded over the offshore array (Figure 15). Daily sonar counts were highest from May 23 to May 30 when 85% of the total counts were recorded (Figures 16,17). The peak daily sonar count of 588,254 occurred on May 25. Over the entire sampling season, 78% of all smolt counts were recorded between 2200 hours and 0400 hours (Figure 18).

Local pilots reported the ice on Upper and Lower Ugashik Lakes broke up by April 28 (R. Russell, ADF&G, King Salmon, personal communication). This corresponds closely with the average reported break-up date of April 24 for these lakes (Appendix A.3). Ugashik was the only smolt project that did not encounter problems with lake ice in the river from the spring break-up in 1995.

No signs of smolt were observed prior to the startup of this project, however when the sonar counter was activated at 2400 hours on May 22 a low passage of smolt (e.g., 1,200 to 17,000 counts/h) was detected during the first several hours of operation. Therefore an undetermined number of smolt passed the Ugashik River smolt counting site before the project began. The first sockeye salmon smolt (n=130) were caught in the fyke net fished from 0032 hours to 0036 hours on May 24.

The weather was generally favorable for enumerating sockeye salmon smolt emigrating from Upper and Lower Ugashik Lakes in 1995. High winds and waves caused the sonar counter to be disabled 21 h this year. Nine hours of this disable time were estimated by interpolation: 1600 hours and 1800-2000 hours on June 3 due to W winds and entrained air from wave action, 1600 hours on June 5 due to SW wind and breaking waves, and 1500-1900 hours on June 9 due to W winds. An additional 12 h of weather related disable time (e.g., 0400-1100 hours and 2300 hours on May 23 due to SE wind, 1200-1300 hours on June 4 due to heavy rain, and 1900-2100 hours on June 11 due to NW winds) were not estimated by interpolation. For comparison, the Ugashik River

smolt counter was disabled on one or more arrays for 264 h in 1993 due to weather-related events and 162 h of these counts were adjusted by interpolation.

An additional 8 h of disable time were attributed to other causes (e.g., 0800-1100 hours on May 25 to pull and reset the anchors for the inshore array, 2200 hours on June 1 due to boat traffic, 1600 hours on June 4 due to velocity measurments, and 1300-1400 hours on June 8 due to electrical interference from radio transmissions).

River velocity measurements over the inshore index array ranged from 2.1 m/s to 2.9 m/s. Velocity correction factors (m/s) used to adjust the sonar counter firing rate for the two arrays were as follows:

Smolt Days	Inshore	Offshore
May 22 - May 27	1.00	1.01
May 28 - Jun 03	1.00	1.04
Jun 04 - Jun 08	1.00	0.97
Jun 09 - Jun 12	1.00	0.93

An estimated 22,234,137 sockeye salmon smolt migrated from Ugashik River in 1995 (Table 24). Age-2. smolt (1992 brood year) composed 69% of the total migration. Age-1. smolt (1993 brood year) were less numerous prior to May 29 (12.8% to 32.5%) and more thereafter (31.4% to 49.9%) as the outmigration progressed. The estimated number of smolt per sonar count ranged from 3.7 to 4.6 (Table 25).

This project was not operated in 1992, therefore we were unable to measure the total smolt production from the 1989 spawning escapement of 1,681,302 sockeye salmon or the 1990 spawning escapement of 730,038 sockeye salmon because outmigrating smolt from these brood years (e.g., 1989, age-2. smolt; 1990, age-1. smolt) were not enumerated (Table 26). The total smolt production of age-1. and -2. smolt from the 1992 spawning escapement of 2,173,692 sockeye salmon was 39,577,888 smolt; this equates to a smolt per spawner value of 18.21. Marine survival has averaged 7% for age-1. smolt for the 1981-88 brood years and 12% for age-2. smolt for the 1980-87 brood years (Table 27).

Age, weight, and length data were collected from 939 sockeye salmon smolt in 1995 (Table 28). Mean weight was 7.8 g for age-1. smolt and 11.1 g for age-2. smolt. Mean length was 93 mm for age-1. smolt and 106 mm for age-2. smolt. Age-1. smolt were 2% larger than the 1958-1994 average length and 15% heavier; age-2. smolt were 5% shorter and 8% lighter than average (Table 29). An additional 3,213 sockeye salmon smolt were sampled for length only (Table 30).

One hundred thirty depth measurements were recorded for smolt schools passing over Ugashik River sonar arrays between May 22 and June 7 (Table 31). Schools passed at an average depth of 20 cm to 79 cm below the surface. Water depth over the sonar arrays at this site ranged from 274 cm to 328 cm during the peak smolt passage. Figure 19 shows the depth of smolt passage by hour for each array.

River and weather conditions were recorded at the counting site from May 23 to June 12 (Table 32). Weather was not a major problem at Ugashik River smolt in 1995, however sonar counts were interpolated for one or more arrays due to high winds and/or breaking waves: 1600 hours, 1800-2000 hours on June 3; 1600 hours on June 5; and 1500-1900 hours on June 9. Average water temperature was 6.2 °C (range 4.0 °C to 9.0 °C), which was slightly warmer (NSC) than the 1983-94 average of 6.1 °C (Table 33). The mean water temperature during the peak of the smolt outmigration -- May 25 -- was 5.0 °C.

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Table 1. Sonar counts recorded from three arrays at the sockeye salmon smolt counting site on Kvichak River, 1995.

Smolt Day [a]	Sonar Count by Transducer Array			
	Inshore	Center	Offshore	Total
5/21 [b]	232,425	276,599	281,093	790,117
5/22 [c]	156,771	248,924	530,720	936,415
5/23 [d]	36,109	54,777	245,347	336,233
5/24 [e]	43,159	45,780	80,181	169,120
5/25	155,269	129,963	264,948	550,180
5/26 [e]	60,379	73,783	103,937	238,099
5/27 [d]	197,087	252,211	311,017	760,315
5/28	36,614	48,640	45,501	130,755
5/29	13,687	15,598	17,187	46,472
5/30	5,275	8,047	9,111	22,433
5/31	31,832	42,619	34,824	109,275
6/01 [e]	53,413	42,139	30,808	126,360
6/02	51,737	39,057	52,855	143,649
6/03 [d e]	133,368	86,374	124,656	344,398
6/04 [e]	26,378	41,799	37,822	105,999
6/05 [e]	13,274	22,864	15,984	52,122
6/06 [e]	24,400	18,100	8,296	50,796
6/07 [e f]	32,641	28,882	20,437	81,960
6/08	22,056	26,661	25,904	74,621
6/09	5,238	5,777	5,444	16,459
6/10	2,196	1,234	1,125	4,555
6/11	5,648	6,309	6,584	18,541
6/12	2,463	3,011	3,391	8,865
6/13	1,516	692	446	2,654
Total	1,342,935	1,519,840	2,257,618	5,120,393
Percent	26.2	29.7	44.1	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] All center array counts from 2400 hours May 21 to 2400 hours May 26 were multiplied by 1.11 to account for a bad transducer #8. Thereafter transducer #8 was replaced and it worked well for the remainder of the project.

[c] Disable time due to high easterly winds not able to be interpolated:

0500-1100 hours on May 23 (Smolt Day-May 22)

[d] Fyke net cath per unit effort (CPUE) data indicate higher smolt passages during the following times:

0135-0145 and 2015-2020 hours on May 23, fyke net CPUE(s) = 40 and 33
1800-1820 hours on May 27, fyke net CPUE = 25
1455-1510 hours on June 3, fyke net CPUE = 33

[e] Data interpolated for one or more arrays for the following time periods:

0700-0900 hours on May 25 (Smolt Day-May 24) due to printer problems
1200-2400 hours on May 26 due to inshore and center arrays being silted in with sand, gravel, cobble < 2" diameter, and debri. Unusually high substrate movement in the river was attributed to eroding wave action upstream from high easterly winds.
2000 hours on June 1 due to boat traffic
1800-1900 hours on June 3 due to printer problems
2400 hours on June 3 to 0800 hours on June 4 (Smolt Day-Jun 3) due to gravel silting in and inhibiting center array counts
1900 hours on June 4 due to printer problems
1600 hours on June 5 due to printer problems
0600-1600 hours on June 7 (Smolt Days-Jun 6 & Jun 7) due to printer problems

[f] Sport fishing season for rainbow trout opens at 0001 hours on June 8. Increased boat traffic.

Table 2. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Kvichak River, 1995.

	Age 1.			Age 2.			All Ages	
Smolt Day [a]	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5/21	34,030,442	97.4	34,030,442	911,997	2.6	911,997	34,942,439	34,942,439
5/22	39,015,155	97.4	73,045,597	1,045,585	2.6	1,957,582	40,060,740	75,003,179
5/23	11,638,504	90.0	84,684,101	1,287,422	10.0	3,245,004	12,925,926	87,929,105
5/24	6,697,457	91.8	91,381,558	597,453	8.2	3,842,457	7,294,910	95,224,015
5/25	22,103,349	91.8	113,484,907	1,971,750	8.2	5,814,207	24,075,099	119,299,114
5/26	8,993,341	92.4	122,478,248	737,605	7.6	6,551,812	9,730,946	129,030,060
5/27	28,714,967	92.4	151,193,215	2,355,112	7.6	8,906,924	31,070,079	160,100,139
5/28	5,480,613	95.4	156,673,828	265,469	4.6	9,172,393	5,746,082	165,846,221
5/29	1,965,595	95.4	158,639,423	95,209	4.6	9,267,602	2,060,804	167,907,025
5/30	803,924	88.8	159,443,347	100,988	11.2	9,368,590	904,912	168,811,937
5/31	3,957,541	88.8	163,400,888	497,142	11.2	9,865,732	4,454,683	173,266,620
6/01	5,751,893	98.0	169,152,781	116,188	2.0	9,981,920	5,868,081	179,134,701
6/02	6,517,216	97.1	175,669,997	196,718	2.9	10,178,638	6,713,934	185,848,635
6/03	15,801,976	97.1	191,471,973	476,973	2.9	10,655,611	16,278,949	202,127,584
6/04	4,921,568	99.2	196,393,541	41,190	0.8	10,696,801	4,962,758	207,090,342
6/05	2,224,191	97.6	198,617,732	54,459	2.4	10,751,260	2,278,650	209,368,992
6/06	2,343,381	97.6	200,961,113	57,378	2.4	10,808,638	2,400,759	211,769,751
6/07	3,686,011	97.6	204,647,124	90,252	2.4	10,898,890	3,776,263	215,546,014
6/08	3,076,527	97.5	207,723,651	79,856	2.5	10,978,746	3,156,383	218,702,397
6/09	682,550	97.5	208,406,201	17,716	2.5	10,996,462	700,266	219,402,663
6/10	196,810	97.5	208,603,011	5,108	2.5	11,001,570	201,918	219,604,581
6/11	769,952	97.5	209,372,963	19,985	2.5	11,021,555	789,937	220,394,518
6/12	366,271	97.5	209,739,234	9,507	2.5	11,031,062	375,778	220,770,296
6/13	118,749	97.5	209,857,983	3,082	2.5	11,034,144	121,831	220,892,127
	209,857,983	95.0		11,034,144	5.0		220,892,127	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Kvichak River, 1995.

Smolt Day [a]	Mean Weight of Smolt (g)	Smolt per Count
5/21	6.1	6.8
5/22	6.1	6.8
5/23	6.7	6.2
5/24	6.2	6.7
5/25	6.2	6.7
5/26	6.5	6.4
5/27	6.5	6.4
5/28	6.1	6.8
5/29	6.1	6.8
5/30	6.6	6.3
5/31	6.6	6.3
6/01	6.0	6.9
6/02	5.9	7.0
6/03	5.9	7.0
6/04	5.6	7.4
6/05	6.0	6.9
6/06	6.0	6.9
6/07	6.0	6.9
6/08	6.4	6.5
6/09	6.4	6.5
6/10	6.4	6.5
6/11	6.4	6.5
6/12	6.4	6.5
6/13	6.4	6.5

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 4. Sockeye salmon spawning escapement, total number of smolt produced by age class, percent of total smolt production composed by each age class, and number of smolt produced per spawner for 1956-1993 brood years, Kvichak River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age 1. (%)[a]	Age 2. (%)[a]	Age 3. (%)[a]	Total	Per Spawner
		Estimates of smolt numbers based upon fyke net catches				
1956	9,443,318	3,267,274 (54)	2,777,960 (46)	0	6,045,234	0.64
1957	2,842,810	85,916 (13)	552,603 (87)	0	638,519	0.23
1958	534,785	61,400 (86)	10,126 (14)	0	71,526	0.13
1959	680,000	26,038 (27)	72,180 (73)	0	98,218	0.14
1960	14,630,000	1,130,820 (22)	4,116,093 (78)	0	5,246,913	0.36
1961	3,705,849	113,338 (7)	1,603,464 (93)	0	1,716,802	0.46
1962	2,580,884	458,122 (21)	1,748,178 (79)	0	2,206,300	0.86
1963	338,760	64,377 (73)	23,377 (27)	0	87,754	0.27
1964	957,120	252,384 (53)	222,528 (47)	0	474,912	0.50
1965	24,325,926	2,866,214 (34)	5,475,362 (66)	0	8,341,576	0.34
1966	3,775,184	648,321 (55)	541,017 (45)	0	1,189,338	0.32
1967	3,216,208	594,327 (67)	298,282 (33)	0	892,609	0.28
1968	2,557,440	185,356				
		Estimates of smolt numbers based upon hydroacoustic techniques				
1968			5,959,383	0	-	-
1969	8,394,204	85,723,430 (61)	54,159,340 (39)	0	139,882,770	16.66
1970	13,935,306	464,219 (<1)	191,842,930 (98)	2,918,768 (1)	195,225,917	14.01
1971	2,387,392	5,123,400 (19)	21,423,246 (81)	0	26,546,646	11.12
1972	1,009,962	2,740,610	-	-	-	-
1973	226,554	-	3,031,287	0	-	-
1974	4,433,844	108,356,892 (49)	114,269,848 (51)	0	222,626,740	50.21
1975	13,140,450	78,308,251 (27)	213,364,470 (73)	0	291,672,721	22.20
1976	1,965,282	32,226,544 (55)	26,423,348 (45)	0	58,649,892	29.84
1977	1,341,144	28,758,191 (73)	10,410,467 (27)	0	39,168,658	29.21
1978	4,149,288	182,442,540 (85)	32,294,536 (15)	0	214,737,076	51.75
1979	11,218,434	219,928,232 (71)	89,300,703 (29)	0	309,228,935	27.56
1980	17,505,268	150,421,026 (62)	76,244,773 (38)	0	226,665,799	12.95
1981	1,754,358	6,549,125 (15)	37,595,987 (85)	0	44,145,112	25.16
1982	1,134,840	51,893,988 (96)	1,937,408 (4)	2,065	53,833,461	47.44
1983	3,569,982	23,590,443 (31)	53,260,693 (69)	123,975	76,975,111	21.56
1984	10,490,670	83,470,460 (20)	331,384,545 (80)	43,135	414,898,140	39.55
1985	7,211,046	11,178,398 (11)	87,004,194 (89)	30,345	98,212,937	13.62
1986	1,179,322	13,126,363 (66)	6,830,717 (34)	0	19,957,080	16.92
1987	6,065,880	146,603,154 (78)	41,434,534 (22)	0	188,037,688	31.00
1988	4,065,216	46,569,569 (58)	34,266,421 (42)	0	80,835,990	19.88
1989	8,317,500	87,187,761 (59)	61,317,308 (41)	0	148,505,069	17.85
1990	6,970,020	18,172,700 (08)	204,626,879 (92)	0	222,799,579	31.97
1991	4,222,788	21,781,009 (42)	30,207,268 (58)	0	51,988,277	12.31
1992	4,725,864	53,638,204 (83)	11,034,144 (17)		64,672,348	13.68 [b]
1993	4,025,166	209,857,983				[b]
Max 81-90	10,490,670	146,603,154 (96)	331,384,545 (92)	123,975	414,898,140	47.44
Avg 81-90	5,057,883	48,832,196 (44)	85,965,869 (56)	19,952	134,820,017	26.50
Min 81-90	1,134,840	6,549,125 (8)	1,937,408 (4)	0	19,957,080	13.62

[a] Percent of total smolt production

[b] Preliminary total. Incomplete returns from brood year escapements.

Table 5. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1952-1993 brood years, Kvichak River.

Brood Year	Total Spawning Escapement	Age 1. Number of Smolt	Age 1. Adult[a] Returns	Age 1. Adult Returns per Smolt	Age 2. Number of Smolt	Age 2. Adult[a] Returns	Age 2. Adult Returns per Smolt
		Estimates of smolt numbers based upon fyke net catches					
1952	-	-			241,870	3,610,258	[b]
1953	-	18,198	152,165	[b]	47,373	424,627	[b]
1954	-	30,287	109,965	[b]	8,654	659,246	[b]
1955	-	22,253	351,240	[b]	66,679	1,132,813	[b]
1956	9,443,318	3,267,274	31,253,977	[b]	2,777,960	7,773,131	[b]
1957	2,842,810	85,916	488,844	[b]	552,603	3,591,552	[b]
1958	534,785	61,400	124,250	[b]	10,126	161,253	[b]
1959	680,000	26,038	328,287	[b]	72,180	217,593	[b]
1960	14,630,000	1,130,820	1,877,221	[b]	4,116,093	53,360,190	[b]
1961	3,705,849	113,338	524,416		1,603,464	2,971,816	[b]
1962	2,580,884	458,122	256,253	0.56	1,748,178	5,083,162	[b]
1963	338,760	64,377	98,571	[b]	23,377	1,008,242	[b]
1964	957,120	252,384	2,647,042	[b]	222,528	3,093,042	[b]
1965	24,325,926	2,866,214	10,349,415	[b]	5,475,362	34,671,692	[b]
1966	3,775,184	648,321	1,594,186	[b]	541,017	4,657,432	[b]
1967	3,216,208	594,327	621,690	[b]	298,282	900,307	
1968	2,557,440	185,356	332,177		-		
		Estimates of smolt numbers based upon hydroacoustic techniques					
1968	2,557,440	-			5,959,383	209,138	0.04
1969	8,394,204	85,723,430	449,791	0.01	54,159,340	4,824,026	0.09
1970	13,935,306	464,219	56,778	0.12	191,842,930	15,351,498	0.08
1971	2,387,392	5,123,400	337,314	0.07	21,423,246	2,489,981	0.12
1972	1,009,962	2,740,610	436,837	0.16	-	1,504,435	[b]
1973	226,554	-	1,606,766	[b]	3,031,287	818,529	0.27
1974	4,433,844	108,356,892	8,353,542	0.08	114,269,848	17,796,617	0.16
1975	13,140,450	78,308,251	6,920,452	0.09	213,364,470	31,164,576	0.15
1976	1,965,282	32,226,544	6,132,390	0.19	26,423,348	4,431,284	0.17
1977	1,341,144	28,758,191	2,912,441	0.10	10,410,467	309,369	0.03
1978	4,149,288	182,442,540	2,991,655	0.02	32,294,536	2,151,024	0.07
1979	11,218,434	219,928,232	20,621,724	0.09	89,300,703	21,516,038	0.24
1980	22,505,268	150,421,026	4,534,253	0.03	76,244,773	8,508,770	0.11
1981	1,754,358	6,549,125	1,019,361	0.16	37,595,987	1,098,376	0.03
1982	1,134,840	51,893,988	995,144	0.02	1,937,408	663,241	0.34
1983	3,569,982	23,590,443	11,612,066	0.49	53,260,693	1,773,436	0.03
1984	10,490,670	83,470,460	4,455,429	0.05	331,384,545	19,441,947	0.06
1985	7,211,046	11,178,398	2,311,147	0.21	87,004,194	14,991,491	0.17
1986	1,179,322	13,126,363	1,804,257	0.14	6,830,717	2,721,114	0.40
1987	6,065,880	146,603,154	6,710,655	0.05	41,434,534	5,217,874	0.13
1988	4,065,216	46,569,569	4,979,438	0.11	34,266,421	4,901,646	0.14
1989	8,317,500	87,187,761	3,802,200	0.04	61,317,308	22,236,201	0.36[c]
1990	6,970,020	18,172,700	2,728,898	0.15[c]	204,626,879	21,345,277	0.10[c]
1991	4,222,788	21,781,009	2,699,376	0.12[c]	30,207,268	1,673	0.00[c]
1992	4,725,864	53,638,204	0	0.00[c]	11,034,144		
1993	4,025,166	209,857,983					
Max 79-88	22,505,268	219,928,232	20,621,724	0.49	331,384,545	21,516,038	0.40
Avg 79-88	6,919,502	75,333,076	5,904,347	0.13	75,925,998	8,083,393	0.17
Min 79-88	1,134,840	6,549,125	995,144	0.02	1,937,408	663,241	0.03

[a] Includes estimates of returns through 1995.

[b] Insufficient smolt samples collected to perform this calculation.

[c] Future adult returns will increase these values.

Table 6. Mean fork length and weight of sockeye salmon smolt captured in fyke nets, Kvichak River, 1995.

	Age 1.					Age 2.				
Smolt Day [a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5/22	86	15.6	6.4	4.01	95	99	11.0	9.7	3.53	7
5/23	89	13.7	6.8	3.31	91	107	11.5	11.1	3.97	11
5/24	87	13.8	6.0	3.16	48	108	6.9	10.4	1.68	6
5/25	85	16.7	5.5	3.37	99	104	2.7	10.0	0.72	3
5/26	90	12.1	6.6	2.94	53	107	5.0	10.8	1.70	7
5/27	87	14.0	6.6	3.29	96	101	6.7	9.8	1.51	6
5/28	90	6.7	6.1	1.50	14	107	12.9	10.4	3.13	3
5/29	85	14.4	6.0	3.31	99	103	7.2	9.8	2.31	3
5/31	88	13.8	6.3	3.16	84	106	12.8	10.7	3.91	19
6/01	85	10.8	6.3	2.81	102					0
6/03	85	11.3	5.6	2.57	99	95		7.9		1
6/04	83	14.0	5.4	2.91	100	94		6.2		1
6/05	85	7.0	6.1	1.32	18	94	8.3	8.4	1.13	2
6/07	86	11.4	5.9	2.72	99	104		9.2		1
6/08	88	10.1	6.7	1.83	19	111		12.1		1
6/11	88	7.0	6.6	1.35	20					0
Total					1,136					71
Mean	87		6.2			103		9.8		

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 7. Age composition of total migration and mean fork length and weight by age class for sockeye salmon smolt, Kvichak River, 1955-1995.

	Age 1.				Age 2.				Age 3.				
Year of Migration	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Total Estimate [a]
1955	1953	7	89	-	1952	93	-	-	1951	0	-	-	260,068
1956	1954	39	92	-	1953	61	116	-	1952	0	-	-	77,660
1957	1955	72	96	7.3	1954	28	120	14.4	1953	0	-	-	30,907
1958	1956	98	84	4.6	1955	2	114	-	1954	0	-	-	3,333,953
1959	1957	3	80	-	1956	97	99	7.6	1955	0	-	-	2,863,876
1960	1958	10	91	6.3	1957	90	108	10.3	1956	0	-	-	614,003
1961	1959	72	92	6.8	1958	28	117	13.1	1957	0	-	-	36,164
1962	1960	94	82	4.3	1959	6	110	9.9	1958	0	-	-	1,203,000
1963	1961	3	83	4.8	1960	97	98	7.5	1959	0	-	-	4,229,431
1964	1962	22	87	5.2	1961	78	108	9.8	1960	0	-	-	2,061,586
1965	1963	4	90	6.8	1962	96	109	11.3	1961	0	-	-	1,812,555
1966	1964	92	94	7.4	1963	8	114	12.6	1962	0	-	-	275,761
1967	1965	93	86	5.9	1964	7	118	14.2	1963	0	-	-	3,088,742
1968	1966	11	88	5.5	1965	89	104	9.2	1964	0	-	-	6,123,683
1969	1967	52	92	5.7	1966	48	109	10.6	1965	0	-	-	1,135,344
1970	1968	38	91	6.0	1967	62	110	11.0	1966	0	-	-	483,638
1971	1969	93	90	5.8	1968	7	111	11.1	1967	0	-	-	91,682,813
1972	1970	1	80	4.2	1969	99	106	10.0	1968	0	-	-	54,623,559
1973	1971	3	86	5.1	1970	97	97	8.3	1969	0	-	-	196,966,331
1974	1972	9	96	8.3	1971	79	111	13.1	1970	12	124	17.5	27,082,626
1975	1973	63	98	8.4	1972	37	122	16.4	1971	0	-	-	15,632,531
1976	1974	97	88	5.8	1973	3	121	14.2	1972	0	-	-	111,388,180
1977	1975	38	86	5.5	1974	62	106	10.1	1973	0	-	-	192,578,099
1978	1976	12	88	6.0	1975	88	97	7.8	1974	0	-	-	245,591,014
1979	1977	51	90	6.0	1976	49	109	10.3	1975	0	-	-	55,181,540
1980	1978	94	88	5.9	1977	6	110	10.7	1976	0	-	-	192,853,007
1981	1979	89	85	5.4	1978	11	108	10.2	1977	0	-	-	252,222,769
1982	1980	58	84	5.1	1979	39	103	9.1	1978	0	-	-	239,721,729
1983	1981	8	80	4.9	1980	92	98	8.5	1979	0	-	-	82,793,899
1984	1982	58	90	6.8	1981	42	104	10.0	1980	0	-	-	89,489,975

-Continued-

Table 7. (p 2 of 2)

	Age 1.				Age 2.				Age 3.				
Year of Migration	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Total Estimate [a]
1985	1983	92	85	5.3	1982	8	102	9.2	1981	0	-	-	25,527,851
1986	1984	61	84	5.5	1983	39	107	10.4	1982	0	102	9.1	136,733,218
1987	1985	3	82	4.5	1984	97	96	7.0	1983	0	97	8.5	342,686,918
1988	1986	13	86	5.6	1985	87	99	8.3	1984	0	107	9.8	100,173,692
1989	1987	95	85	5.5	1986	5	108	10.8	1985	0	105	9.5	153,464,216
1990	1988	53	87	6.1	1987	47	105	10.5	1986	0	-	-	88,004,103
1991	1989	72	85	5.5	1988	28	105	9.9	1987	0	-	-	121,454,182
1992	1990	23	84	5.6	1989	77	100	9.3	1988	0	_	_	79,490,008
1993	1991	10	86	6.0	1990	90	97	8.2	1989	0	_	_	226,407,888
1994	1992	64	84	5.7	1991	36	102	9.5	1990	0	_	_	83,845,472
Mean			87	5.8			107	10.4			107	10.9	
1995	1993	95	87	6.2	1992	5	103	9.8	1991	0	_	_	220,892,127

[a] Estimates of smolt numbers for 1955 to 1970 based on fyke net catches; estimates of smolt numbers for 1971 to 1995 based on hydroacoustic techniques.

Table 8. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Kvichak River, 1995.

	Estimated Age 1. [a]				Estimated Age 2. [a]			
Smolt Day [b]	Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size	Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size
5/22	86	17.7	5.9	498	101	4.0	9.5	9
5/23	87	19.5	6.3	468	103	11.8	9.8	57
5/24	86	21.3	6.0	246	106	16.0	10.7	64
5/25	85	23.8	5.8	503	103	11.6	9.9	19
5/26	89	11.6	6.6	183	104	14.3	10.2	33
5/27	86	18.8	6.0	524	100	8.2	9.3	15
5/28	88	13.2	6.3	78	105	8.9	10.3	13
5/29	85	20.0	5.8	506	102	11.9	9.8	15
5/31	86	19.9	6.1	457	104	13.1	10.2	56
6/01	85	18.4	5.9	504	100	5.4	9.3	9
6/03	85	20.3	5.9	473	101	5.6	9.5	15
6/04	84	20.3	5.6	513				0
6/05	86	12.7	6.0	86	102	3.7	9.8	4
6/07	85	17.0	5.8	383	101	3.1	9.5	6
6/08	86	10.9	6.0	32				0
6/11	88	13.8	6.5	226	100	1.2	9.2	2
Total				5,680				317
Mean	86		6.0		102		9.8	

[a] Length-weight parameters by age group and discriminating length used to separate ages from May 22 to June 11 were:

Age 1. $a = -10.7665$ $b = 2.8154$ $r^2 = 0.6992$ $n = 1{,}136$
Age 2. $a = -8.4747$ $b = 2.3211$ $r^2 = 0.6927$ $n = 71$

Discriminating Length = 97.72 mm

[b] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 9. Depth of sockeye salmon smolt passage at Kvichak River sonar site, May 21 to June 7, 1995.

	Depth of Passage (cm)							
	Inshore Array[a] Smolt Schools		Center Array[b] Smolt Schools		Offshore Array[c] Smolt Schools		All Combined Smolt Schools	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Mean	17	107	6	117	5	138	9	121
Minimum	0	40	0	80	0	90	0	70
Maximum	81	170	30	143	20	250	44	188
n	16	16	18	18	25	25	59	59

[a] Average depth of inshore array on smolt day 5/22 was 258 cm.

[b] Average depth of center array on smolt day 5/22 was 304 cm.

[c] Average depth of offshore array on smolt day 5/22 was 281 cm.

Table 10. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Kvichak River, 1995.

Date	Cloud Cover [a] 0800	Cloud Cover [a] 2000	Wind Direction [b] & Velocity (km/h) 0800	Wind Direction [b] & Velocity (km/h) 2000	Air Temperature (°C) 0800	Air Temperature (°C) 2000	Water Temperature (°C) 0800	Water Temperature (°C) 2000	Percipitation (mm)	Water Clarity [c]
5/21	0	3	-	E 15	-	9.5	-	7.0	-	-
5/22	2	4	E 08	E 16-24	5.0	10.0	5.0	7.0	trace	murky
5/23	4	3	E 32+	E 16-32	5.0	12.0	6.0	7.0	1.0	murky
5/24	1	3	0	0	3.0	12.5	4.0	7.0	0.0	brown
5/25	4	4	E 0-08	E 0-08	4.0	10.5	5.0	7.0	0.0	clear
5/26	3	-	E 16	-	5.0	-	6.0	-	1.8	murky
5/27	3	4	0	E 0-08	4.0	10.0	5.0	8.0	0.0	brown
5/28	3	2	E 19	E 16-24	6.0	10.0	6.0	7.0	0.0	lt brown
5/29	3	3	E 0+	E 0-08	5.0	10.0	5.0	6.5	0.0	clear
5/30	4	3	0	W 0-08	4.0	10.5	5.0	7.0	0.5	clear
5/31	4	3	0	E 8-16	6.0	9.5	6.5	7.5	3.0	lt brown
6/01	2	2	0	E 8-16	6.0	10.0	7.0	7.5	trace	clear
6/02	2	2	E 8-11	E 8-16	5.5	14.0	6.0	8.5	0.0	clear
6/03	2	2	E 08	0	7.0	15.5	8.0	8.5	trace	clear
6/04	3	3	0	E 16-24	8.0	13.0	8.0	9.0	0.0	clear
6/05	3	2	0	E 8-16	7.0	14.0	7.5	8.5	0.0	clear
6/06	3	2	0	E 24-32	11.0	12.0	8.0	8.5	0.0	clear
6/07	4	3	0	E 16	5.0	13.5	7.0	8.0	trace	lt brown
6/08	3	3	E 0-08	var. 0-16	7.0	13.5	9.0	9.5	0.0	lt brown
6/09	5	2	0	NE 0-08	4.0	16.0	9.0	11.0	0.0	lt brown
6/10	4	3	0	0	10.0	18.0	9.5	11.0	0.0	clear
6/11	2	1	0	NW 8-18	11.0	25.0	10.0	12.0	0.6	clear
6/12	1	1	0	NW 0-08	10.0	24.0	11.0	12.0	0.0	clear
6/13	1	3	NW 0-08	N 6-11	10.0	18.5	11.0	12.5	0.0	clear
6/14	4	-	0	-	8.0	-	11.0	-	0.0	clear

[a] 1 = Cloud cover not more than 1/10
2 = Cloud cover not more than 1/2
3 = Cloud cover more than 1/2
4 = Completely overcast
5 = Fog

[b] var. = variable wind

[c] Water clarity at 0800 hours

Table 11. Water temperatures at sockeye salmon smolt counting site, Kvichak River, 1963-1995.

Year	Sample Period	Water Temperature (°C)		
		Minimum	Maximum	Mean
1963	May 16 - Jun 14	2.2	8.9	5.5
1964	May 18 - Jun 14	0.0	5.6	2.6
1965	May 17 - Jun 11	0.0	8.9	4.4
1966	May 16 - Jun 26	0.0	11.1	4.7
1967	May 17 - Jun 20	1.1	9.4	6.9
1968	May 12 - Jun 12	3.3	8.3	5.4
1969	May 16 - Jun 18	0.3	7.8	3.9
1970	May 13 - Jun 07	2.8	11.1	6.8
1971	May 17 - Jun 20	1.1	3.3	2.4
1972	May 18 - Jun 18	0.6	5.0	2.9
1973	May 15 - Jun 14	2.9	8.9	4.9
1974	May 13 - Jun 09	3.0	8.0	6.2
1975	May 17 - Jun 15	2.0	8.0	3.8
1976	May 18 - Jun 19	2.0	9.5	3.9
1977	May 17 - Jun 14	3.0	9.5	6.4
1978	May 19 - Jun 09	5.0	11.0	7.6
1979	Jun 01 - Jun 10	8.0	10.0	8.6
1980	May 16 - Jun 18	1.5	9.0	5.5
1981	May 15 - Jun 09	7.0	10.0	8.2
1982	May 14 - Jun 15	2.5	8.5	4.9
1983	May 19 - Jun 14	5.2	10.5	7.9
1984	May 19 - Jun 11	5.5	10.0	7.9
1985	May 23 - Jun 20	2.0	7.0	4.6
1986	May 18 - Jun 12	1.0	7.0	4.6
1987	May 21 - Jun 13	4.5	9.0	6.7
1988	May 17 - Jun 17	3.0	11.0	7.1
1989	May 19 - Jun 16	3.0	8.8	5.8
1990	May 22 - Jun 15	3.5	9.5	7.3
1991	May 23 - Jun 17	1.0	8.5	4.8
1992	May 22 - Jun 14	5.0	10.0	7.8
1993	May 19 - Jun 12	4.0	11.0	6.6
1994	May 22 - Jun 16	1.5	11.0	6.1
	Mean	2.7	8.9	5.7
1995	May 21 - Jun 14	4.0	12.5	8.1

Table 12. Sonar counts recorded from three arrays at the sockeye salmon smolt counting site on Egegik River, 1995.

Smolt Day [a]	Sonar Count by Transducer Array			
	Inshore	Center	Offshore	Total
5/21 [b]	9,257	36,202	60,418	105,877
5/22 [c]	178,396	396,358	140,151	714,905
5/23 [d]	29,334	661,970	497,215	1,188,519
5/24	1,300	8,401	79,676	89,377
5/25	39,431	561,661	93,351	694,443
5/26	3,906	61,168	101,317	166,391
5/27	450	20,972	21,781	43,203
5/28	9,497	94,536	85,637	189,670
5/29	15,365	110,603	6,411	132,379
5/30	1,690	63,867	8,774	74,331
5/31	697	5,628	17,988	24,313
6/01	1,379	7,399	12,258	21,036
6/02	95	1,530	2,985	4,610
6/03	208	3,232	1,553	4,993
6/04	176	1,766	4,150	6,092
6/05	376	2,792	6,169	9,337
6/06	2,418	3,680	9,330	15,428
6/07	3,167	1,963	30,778	35,908
6/08	3,164	7,574	24,637	35,375
6/09	458	3,587	6,067	10,112
6/10	326	754	1,027	2,107
6/11	260	642	933	1,835
6/12	249	583	341	1,173
Total	301,599	2,056,868	1,212,947	3,571,414
Percent	8.4	57.6	34.0	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] The sonar counter was activated at 1100 hours May 22, therefore the total smolt count for smolt day May 21 represents only one hour of sonar counts.

[c] From 0100-0500 hours on May 23 (Smolt Day May 22) sonar operators reported that they believed there was a large passage of smolt, however the combination of high SE winds, heavy rain, and lake ice flowing in the river at this time, made it impossible to differentiate smolt. Therefore hourly sonar counts for this time period were discounted and it was not possible to interpolate these data.

[d] Fyke net catch per unit effort (CPUE) data indicates peak smolt passage at the following time:

0117-0118 hours on May 24 (Smolt Day-May 23), fyke net CPUE = 2,000

Table 13. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Egegik River, 1995.

Smolt Day [a]	Age 1.			Age 2.			Age 3.			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5/21	190,870	10.5	190,870	1,620,048	89.5	1,620,048	0		0	1,810,918	1,810,918
5/22	1,128,646	10.5	1,319,516	9,579,572	89.5	11,199,620	0		0	10,708,218	12,519,136
5/23	2,047,757	10.5	3,367,273	17,380,685	89.5	28,580,305	0		0	19,428,442	31,947,578
5/24	331,676	17.6	3,698,949	1,556,067	82.4	30,136,372	0		0	1,887,743	33,835,321
5/25	492,787	5.3	4,191,736	8,864,561	94.6	39,000,933	11,242	0.1	11,242	9,368,590	43,203,911
5/26	534,474	16.9	4,726,210	2,631,842	83.1	41,632,775	0		11,242	3,166,316	46,370,227
5/27	133,678	16.9	4,859,888	658,253	83.1	42,291,028	0		11,242	791,931	47,162,158
5/28	576,294	16.9	5,436,182	2,837,774	83.1	45,128,802	0		11,242	3,414,068	50,576,226
5/29	283,116	14.1	5,719,298	1,731,947	86.0	46,860,749	0		11,242	2,015,063	52,591,289
5/30	426,678	34.9	6,145,976	796,246	65.1	47,656,995	0		11,242	1,222,924	53,814,213
5/31	173,196	34.9	6,319,172	323,210	65.1	47,980,205	0		11,242	496,406	54,310,619
6/01	149,168	34.9	6,468,340	278,371	65.1	48,258,576	0		11,242	427,539	54,738,158
6/02	33,412	34.9	6,501,752	62,352	65.1	48,320,928	0		11,242	95,764	54,833,922
6/03	32,537	34.9	6,534,289	60,719	65.1	48,381,647	0		11,242	93,256	54,927,178
6/04	44,587	34.9	6,578,876	83,206	65.1	48,464,853	0		11,242	127,793	55,054,971
6/05	68,154	34.9	6,647,030	127,186	65.1	48,592,039	0		11,242	195,340	55,250,311
6/06	110,312	34.9	6,757,342	205,859	65.1	48,797,898	0		11,242	316,171	55,566,482
6/07	277,252	34.9	7,034,594	517,395	65.1	49,315,293	0		11,242	794,647	56,361,129
6/08	267,719	36.9	7,302,313	458,595	63.1	49,773,888	0		11,242	726,314	57,087,443
6/09	74,437	36.9	7,376,750	127,509	63.1	49,901,397	0		11,242	201,946	57,289,389
6/10	14,936	36.9	7,391,686	25,585	63.1	49,926,982	0		11,242	40,521	57,329,910
6/11	13,078	36.9	7,404,764	22,403	63.1	49,949,385	0		11,242	35,481	57,365,391
6/12	7,519	36.9	7,412,283	12,880	63.1	49,962,265	0		11,242	20,399	57,385,790
	7,412,283	12.9		49,962,265	87.1		11,242	.02		57,385,790	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 14. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolts, Egegik River, 1995.

Smolt Day [a]	Mean Weight of Smolt (g)	Smolt per Count
5/21	12.1	3.4
5/22	12.1	3.4
5/23	12.1	3.4
5/24	10.8	3.9
5/25	13.0	3.2
5/26	11.0	3.8
5/27	11.0	3.8
5/28	11.0	3.8
5/29	11.2	3.7
5/30	10.7	3.9
5/31	10.7	3.9
6/01	10.7	3.9
6/02	10.7	3.9
6/03	10.7	3.9
6/04	10.7	3.9
6/05	10.7	3.9
6/06	10.7	3.9
6/07	10.7	3.9
6/08	10.5	3.9
6/09	10.5	3.9
6/10	10.5	3.9
6/11	10.5	3.9
6/12	10.5	3.9

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 15. Sockeye salmon spawning escapement, total number of smolt produced by age class, percent of total smolt production composed by each age class, and number of smolt produced per spawner for 1978-1993 brood years, Egegik River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced						
		Age 1.	(%)[a]	Age 2.	(%)[a]	Age 3.	Total	Per Spawner
1978	895,698	-		-		225,522	-	-
1979	1,032,042	-		14,287,075		0	-	-
1980	1,060,860	49,457,563	(75)	16,524,563	(25)	197,429	66,179,555	62.38
1981	694,680	2,242,326	(7)	32,235,734	(93)	52,852	34,530,912	49.71
1982	1,034,628	17,234,269	(60)	11,434,848	(40)	564	28,669,681	27.71
1983	792,282	54,585,828	(65)	29,984,140	(35)	85,087	84,655,055	106.84
1984	1,165,320	14,016,441	(24)	45,386,536	(76)	80,931	59,483,908	51.05
1985	1,095,204	4,397,087	(26)	12,758,135	(74)	81,150	17,236,372	15.74
1986	1,151,320	36,122,149	(57)	27,347,612	(43)	0	63,469,761	55.13
1987	1,272,978	72,458,024	(58)	52,299,487	(42)	396,423	125,153,934	98.32
1988	1,612,680	3,795,739	(4)	89,162,038	(96)	361,128	93,318,905	57.87
1989	1,610,916	4,519,527	(21)	17,338,786	(79)	37,254	21,895,567	13.59
1990	2,191,362	6,048,364	(14)	37,719,609	(86)	19,196	43,787,169	19.98
1991	2,786,880	20,203,545	(34)	39,158,743	(66)	11,242	59,372,530	21.30
1992	1,945,332	54,909,050	(52)	49,962,265	(48)		104,871,315[b]	53.91[b]
1993	1,516,980	7,412,283						
Max 81-90	2,191,362	72,458,024		89,162,038		396,423	125,153,934	106.85
Avg 81-90	1,262,136	21,541,975		35,566,693		111,459	57,220,126	49.59
Min 81-90	694,680	2,242,326		11,434,848		0	17,236,372	13.59

[a] Percent of total smolt production

[b] Preliminary total

Table 16. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1978-1993 brood years, Egegik River.

		Age 1.			Age 2.			Age 3.		
Brood Year	Total Spawning Escapement	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt
1978	895,698	-	908,379		-	8,264,740		225,522	33,395	0.15
1979	1,032,042	-	1,239,273		14,287,075	4,705,018	0.33	0	0	0.00
1980	1,060,860	49,457,563	3,035,494	0.06	16,524,563	5,519,025	0.33	197,429	7,730	0.04
1981	694,680	2,242,326	1,508,516	0.67	32,235,734	4,785,803	0.15	52,852	16,119	0.30
1982	1,034,628	17,234,269	2,873,325	0.17	11,434,848	3,447,534	0.30	564	12,739	[b]
1983	792,282	54,585,828	4,520,747	0.08	29,984,140	6,085,720	0.20	85,087	37,329	0.44
1984	1,165,320	14,016,441	1,596,859	0.11	45,386,536	11,482,531	0.25	80,931	249,131	[b]
1985	1,095,192	4,397,087	1,951,334	0.44	12,758,135	5,558,244	0.44	81,150	26,295	0.32
1986	1,151,320	36,122,149	5,664,220	0.16	27,347,612	8,549,130	0.31	0	116,845	[b]
1987	1,272,978	72,458,024	5,550,526	0.08	52,299,487	20,140,758	0.39	396,423	201,328	0.51
1988	1,612,680	3,795,739	1,910,599	0.50	89,162,038	16,780,162	0.19	361,128	411,139[c]	[b]
1989	1,610,916	4,519,527	1,065,313	0.24	17,338,786	10,136,548[c]	0.58	37,245	167,945[c]	[b]
1990	2,191,362	6,048,364	1,276,129[c]	0.21	37,719,609	9,672,236[c]	0.26	19,196	628[c]	
1991	2,786,880	20,203,545	1,384,244[c]	0.07	39,158,743	19,886[c]	0.00	11,242		
1992	1,945,332	54,909,050	125[c]	0.00	49,962,265					
1993	1,516,980	7,412,283								
Max	2,786,880	72,458,024	5,664,220	0.67	89,162,038	20,140,758	0.39	396,423	249,131	0.51
Avg	1,366,197	26,814,443	2,652,049	0.25	33,971,398	8,210,788	0.25	110,626	70,091	0.32
Min	694,680	2,242,326	908,379	0.06	11,434,848	558,244	0.04	0	0	0.04

[a] Includes estimates of returns through 1995.

[b] Insufficient Age 3. smolt sampled to perform this calculation.

[c] Future adult returns will increase these values.

Table 17. Mean fork length and weight of sockeye salmon smolt captured in fyke nets, Egegik River, 1995.

	Age 1.					Age 2.					Age 3.				
Smolt Day [a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5/22	99	7.7	8.5	1.90	5	111	8.9	11.9	2.87	20					0
5/23	103	4.6	9.1	0.84	4	120	25.7	13.7	8.60	93					0
5/24	103	9.2	8.9	2.86	15	113	22.9	11.1	6.66	83					0
5/25					0	121	22.3	14.3	8.32	99	126		14.9		1
5/26	103	6.9	8.9	2.06	11	114	16.0	11.4	5.05	39					0
5/27	104		9.1		1	111	11.6	11.2	3.38	19					0
5/28	102	9.4	8.8	2.40	13	111	16.7	11.1	6.02	87					0
5/29	103	6.2	8.7	2.06	12	114	22.1	11.6	6.90	88					0
5/30	104	9.6	9.2	2.98	26	111	19.3	10.9	5.95	46					0
5/31	102	6.2	9.2	1.93	26	111	19.9	11.2	6.24	74					0
6/01	103	11.0	8.8	2.97	25	112	16.6	11.1	5.12	48					0
6/02	102	4.5	9.0	1.35	6	109	10.9	11.0	4.81	11					0
6/03	109		10.7		2	116	4.6	13.2	0.99	4					0
6/04	106	7.7	11.0	2.46	4	114	16.6	12.2	4.53	5					0
6/05	104	8.9	8.6	3.08	19	112	13.4	10.3	3.91	19					0
6/06	104	8.5	9.6	2.51	18	111	14.0	11.1	4.91	33					0
6/07	103	8.6	9.1	2.96	30	110	17.5	10.5	5.55	70					0
6/08	103	7.6	8.7	2.11	27	107	14.7	9.9	3.89	73					0
6/09	103	10.5	9.3	3.97	35	109	17.9	10.9	5.68	65					0
6/10	104	6.3	9.8	1.69	18	110	13.7	11.3	4.40	15					0
6/11	105	8.8	11.3	2.80	7	109	11.2	12.8	4.23	9					0
Total					304					1,000					1
Mean	103		9.3			112		11.6			126		14.9		

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 18. Age composition of total migration and mean fork length and weight by age class for sockeye salmon smolt, Egegik River, 1939-1995.

	Age 1.				Age 2.				Age 3.				
Year of Migration	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Total Estimate [a]
1939	1937	-	96	-	1936	-	105	-	1935	-	-	-	-
1956	1954	-	101	-	1953	-	116	-	1952	-	123	-	-
1957	1955	-	107	-	1954	-	120	-	1953	-	130	-	-
1959	1957	-	99	-	1956	-	116	-	1955	-	123	-	-
1960	1958	-	106	-	1957	-	115	-	1956	-	140	-	-
1969	1967	-	99	-	1966	-	119	-	1965	-	115	-	-
1977	1975	-	110	11.3	1974	-	116	13.3	1973	-	-	-	-
1978	1976	-	104	10.1	1975	-	122	15.4	1974	-	130	18.1	-
1981	1979	-	105	9.1	1978	-	122	16.6	1977	-	128	19.1	-
1982	1980	77	104	9.2	1979	23	130	17.1	1978	0	145	23.5	63,970,160
1983	1981	12	101	9.3	1980	88	116	13.6	1979	0	-	-	18,766,889
1984	1982	35	106	10.1	1981	65	112	12.2	1980	0	134	20.2	49,667,432
1985	1983	83	106	10.4	1982	17	123	16.8	1981	0	138	24.1	66,073,548
1986	1984	32	101	9.0	1983	68	122	15.7	1982	0	140	22.6	44,197,865
1987	1985	9	107	11.6	1984	91	114	14.1	1983	0	128	18.9	49,868,710
1988	1986	74	103	10.2	1985	26	117	14.3	1984	0	136	21.2	48,961,215
1989	1987	73	99	8.9	1986	27	119	15.4	1985	0	135	21.1	99,886,786
1990	1988	7	102	9.6	1987	93	118	14.5	1986	0	-	-	56,095,226
1991	1989	5	102	10.3	1988	95	118	15.6	1987	0	140	24.4	94,095,226
1992	1990	26	104	10.2	1989	73	112	12.4	1988	1	127	17.6	23,748,278
1993	1991	35	102	9.3	1990	65	112	12.2	1989	0	138	22.1	57,960,399
1994	1992	58	104	9.6	1991	42	118	13.7	1990	0	125	14.6	94,086,989
Mean			102	9.7			117	14.3			132	20.6	
1995	1993	13	103	9.3	1992	87	112	11.6	1991	0	126	14.9	57,385,790

[a] No estimates of smolt numbers from 1939-1981 fyke net catches; estimates of smolt numbers for 1982-1995 based on hydroacoustic techniques.

Table 19. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Egegik River, 1995.

Smolt Day [b]	Estimated Age 1. [a] Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size	Estimated Age 2. [a] Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size
5/22	101	6.5	8.6	69	113	27.1	11.6	289
5/23	102	5.7	8.7	39	117	35.0	12.7	553
5/24	101	7.0	8.6	97	112	25.7	11.2	464
5/25	101	6.0	8.5	17	119	33.1	13.3	532
5/27	101	2.4	8.4	4	115	18.6	12.2	51
5/28	100	8.4	8.4	98	113	27.4	11.4	447
5/29	101	7.3	8.6	73	114	26.6	11.7	485
5/31				0	108		10.0	1
6/01	102	2.4	8.7	2	119		13.0	1
6/07	100	3.7	8.4	9	112	16.1	11.4	13
6/08	101	4.1	8.7	34	109	14.1	10.5	49
6/09	102	2.6	8.7	12	110	8.6	10.7	22
Totals				454				2,907
Means	101		8.6		113		11.6	

[a] Length-weight parameters by age group and discriminating length used to seperate ages from May 22 to June 9 were:

Age 1. $a = -11.1001$ $b = 2.8673$ $r^2 = 0.5989$ $n = 304$
Age 2. $a = -10.5556$ $b = 2.7457$ $r^2 = 0.7816$ $n = 1{,}000$

Discriminating Length = 104.42 mm

[b] Sample day began at 1200 hrs and ended at 1159 hrs the next calendar day

Table 20. Depth of sockeye salmon smolt passage at Egegik River sonar site, May 21 to June 9, 1995.

	Depth of Passage (cm)							
	Inshore Array[a] Smolt Schools		Center Array[b] Smolt Schools		Offshore Array[c] Smolt Schools		All Combined Smolt Schools	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Mean	18	133	45	150	35	129	33	137
Minimum	0	60	0	100	3	38	1	66
Maximum	40	184	120	224	80	256	80	221
n	4	4	38	38	49	49	91	91

[a] Average depth of inshore array on smolt day 5/23 was 273 cm.

[b] Average depth of center array on smolt day 5/23 was 337 cm.

[c] Average depth of offshore array on smolt day 5/23 was 375 cm.

Table 21. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Egegik River, 1995.

Date	Cloud Cover [a] 0800	Cloud Cover [a] 2000	Wind Direction [b] & Velocity (km/h) 0800	Wind Direction [b] & Velocity (km/h) 2000	Air Temperature (°C) 0800	Air Temperature (°C) 2000	Water Temperature (°C) 0800	Water Temperature (°C) 2000	Percipitation (mm)	Water Clarity [c]
5/21	-	-	-	-	-	-	2.0	-	-	-
5/22	3	4	SE 16	SE 48	-	7.0	3.5	5.0	trace	clear
5/23	4	2	SE 48	SE 56	5.5	7.0	5.0	5.0	trace	clear
5/24	1	1	SE 32	SE 08	5.0	9.0	4.0	6.5	0.0	clear
5/25	3	4	0	0	3.8	10.0	4.0	6.0	2.5	clear
5/26	2	3	SE 32	SE 32	6.0	8.0	4.5	6.5	0.5	clear
5/27	3	4	NW 24	0	6.0	15.0	4.0	8.0	trace	clear
5/28	3	3	SE 24	SE 08	7.0	12.0	5.5	8.0	0.0	clear
5/29	4	4	SE 32	SE 32	5.5	9.5	5.0	7.0	trace	clear
5/30	3	3	E 16-24	SE 32	6.0	7.0	4.5	6.5	0.0	clear
5/31	3	2	E 24-32	SE 32	5.0	8.0	4.5	7.0	0.0	clear
6/01	3	3	E 16-24	0	5.5	13.0	5.5	8.5	trace	clear
6/02	3	3	NE 0-08	SE 08	7.0	11.0	5.5	9.0	5.3	clear
6/03	3	4	NW 0-08	N 24	7.0	13.0	6.0	10.0	0.0	clear
6/04	4	4	NW 24-32	SE 24	8.0	12.0	7.0	8.0	0.0	clear
6/05	5	2	0	SE 32	7.5	12.0	7.0	10.0	1.0	clear
6/06	1	3	var. 0-08	SE 16	8.5	12.0	7.0	10.0	trace	clear
6/07	4	3	NE 8-16	SE 16	7.5	12.0	8.0	10.0	3.0	clear
6/08	3	2	SE 24-32	SE 11	8.0	13.0	8.0	11.0	0.0	clear
6/09	3	2	0	NW 11	8.5	14.0	8.0	10.0	1.5	clear
6/10	3	3	SE 0-08	NW 16	8.0	15.5	7.5	10.0	0.0	clear
6/11	1	1	SW 5-08	W 24	10.0	21.0	8.0	12.0	0.0	clear
6/12	1	1	NW 0-02	NW 08	13.0	20.0	8.5	12.5	0.0	clear
6/13	1	-	SE 8-11	- -	10.0	-	8.0	-	-	clear

[a] 1 = Cloud cover not more than 1/10
2 = Cloud cover not more than 1/2
3 = Cloud cover more than 1/2
4 = Completely overcast
5 = Fog

[b] var. = variable winds

[c] Water clarity at 0800 hours

Table 22. Water temperatures at sockeye salmon smolt counting site, Egegik River, 1981-1995.

Year	Sample Period	Water Temperature (°C)		
		Minimum	Maximum	Mean
1981	May 15 - Jun 08	5.0	9.0	7.3
1982	May 15 - Jun 16	0.0	5.0	2.9
1983	May 18 - Jun 10	5.0	9.5	7.0
1984	May 17 - Jun 11	5.0	10.0	7.6
1985	May 17 - Jun 12	2.5	7.5	4.2
1986	May 19 - Jun 12	2.2	7.5	7.2
1987	May 18 - Jun 13	3.9	11.0	6.6
1988	May 19 - Jun 14	3.0	10.1	6.4
1989	May 21 - Jun 10	3.0	11.0	5.2
1990	May 20 - Jun 11	2.5	10.0	5.4
1991	May 21 - Jun 12	4.0	10.0	6.4
1992	May 21 - Jun 12	3.5	10.0	6.8
1993	May 18 - Jun 09	5.0	10.0	7.2
1994	May 21 - Jun 10	3.0	9.0	5.8
	Mean	3.4	9.4	6.5
1995	May 21 - Jun 13	2.0	12.5	7.0

Table 23. Sonar counts recorded from two arrays at the sockeye salmon smolt counting site on Ugashik River, 1995.

Smolt Day [a]	Sonar Counts: Transducer Array: Inshore	Sonar Counts: Transducer Array: Offshore	Sonar Counts: Total
5/22 [b]	7,497	32,665	40,162
5/23 [b]	39,066	215,915	254,981
5/24	39,156	397,216	436,372
5/25 [c]	122,963	465,291	588,254
5/26	32,277	232,828	265,105
5/27	74,137	217,752	291,889
5/28	107,189	285,965	393,154
5/29	13,159	107,488	120,647
5/30	32,417	170,792	203,209
5/31	6,539	104,144	110,683
6/01 [d]	8,160	95,169	103,329
6/02	12,173	82,026	94,199
6/03 [d]	4,509	25,035	29,544
6/04 [d]	2,340	2,984	5,324
6/05 [d]	2,186	30,713	32,899
6/06	2,445	19,439	21,884
6/07	2,362	11,885	14,247
6/08 [d]	1,783	11,493	13,276
6/09 [d]	1,745	2,246	3,991
6/10	1,230	1,332	2,562
6/11 [b]	852	1,008	1,860
6/12	149	14	163
Total	514,334	2,513,400	3,027,734
Percent	17.0	83.0	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

[b] Sonar counter disable, but counts not able to be interpolated on the following hours and dates:

0400-1100 hours on May 23 (Smolt Day-May 22) due to wind
2300 hours on May 23 due to wind
1900-2100 hours on Jun 11 due to wind

[c] All offshore array counts from 2400 hours May 25 till the end of the project were multiplied by 1.11 to account for a bad transducer #8.

[d] Sonar counts interpolated for one or more arrays on the following hours and dates:

2200 hours on June 1 due to boat traffic.
1600 hours, 1800-2000 hours on June 3 due to wind.
1600 hours on June 4 due to river velocity measurements.
1600 hours on June 5 due to breaking waves.
1300-1400 hours on June 8 due to electrical interference.
1500-1900 hours on June 9 due to wind.

Table 24. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Ugashik River, 1995.

	Age 1.			Age 2.			All Ages	
Smolt Day [a]	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5/22	64,683	23.8	64,683	207,096	76.2	207,096	271,779	271,779
5/23	407,040	23.8	471,723	1,303,212	76.2	1,510,308	1,710,252	1,982,031
5/24	923,655	30.3	1,395,378	2,129,751	69.7	3,640,059	3,053,406	5,035,437
5/25	1,317,552	30.3	2,712,930	3,037,993	69.7	6,678,052	4,355,545	9,390,982
5/26	220,006	12.8	2,932,936	1,497,455	87.2	8,175,507	1,717,461	11,108,443
5/27	257,433	12.8	3,190,369	1,752,192	87.2	9,927,699	2,009,625	13,118,068
5/28	1,010,983	32.5	4,201,352	2,100,692	67.5	12,028,391	3,111,675	16,229,743
5/29	487,861	49.9	4,689,213	489,229	50.1	12,517,620	977,090	17,206,833
5/30	841,363	49.9	5,530,576	843,722	50.1	13,361,342	1,685,085	18,891,918
5/31	245,263	31.4	5,775,839	534,837	68.6	13,896,179	780,100	19,672,018
6/01	375,904	46.3	6,151,743	436,510	53.7	14,332,689	812,414	20,484,432
6/02	352,481	46.3	6,504,224	409,311	53.7	14,742,000	761,792	21,246,224
6/03	111,141	46.3	6,615,365	129,061	53.7	14,871,061	240,202	21,486,426
6/04	21,920	46.3	6,637,285	25,455	53.7	14,896,516	47,375	21,533,801
6/05	112,658	46.3	6,749,943	130,822	53.7	15,027,338	243,480	21,777,281
6/06	76,947	46.3	6,826,890	89,354	53.7	15,116,692	166,301	21,943,582
6/07	51,716	46.3	6,878,606	60,054	53.7	15,176,746	111,770	22,055,352
6/08	47,322	46.3	6,925,928	54,951	53.7	15,231,697	102,273	22,157,625
6/09	16,338	46.3	6,942,266	18,973	53.7	15,250,670	35,311	22,192,936
6/10	10,606	46.3	6,952,872	12,316	53.7	15,262,986	22,922	22,215,858
6/11	7,633	46.3	6,960,505	8,863	53.7	15,271,849	16,496	22,232,354
6/12	825	46.3	6,961,330	958	53.7	15,272,807	1,783	22,234,137
	6,961,330	31.3		15,272,807	68.7		22,234,137	

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 25. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Ugashik River, 1995.

Smolt Day [a]	Mean Weight of Smolt (g)	Smolt per Count
5/22	11.3	3.7
5/23	11.3	3.7
5/24	10.2	4.1
5/25	10.2	4.1
5/26	11.2	3.7
5/27	11.2	3.7
5/28	10.0	4.1
5/29	9.1	4.6
5/30	9.1	4.6
5/31	10.2	4.1
6/01	9.2	4.5
6/02	9.2	4.5
6/03	9.2	4.5
6/04	9.2	4.5
6/05	9.2	4.5
6/06	9.2	4.5
6/07	9.2	4.5
6/08	9.2	4.5
6/09	9.2	4.5
6/10	9.2	4.5
6/11	9.2	4.5
6/12	9.2	4.5

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 26. Sockeye salmon spawning escapement, total number of smolt produced by age class, percent of total smolt production composed by each age class, and number of smolt produced per spawner for 1979-1993 brood years, Ugashik River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced									
		Age 1.	(%)[a]	Age 2.	(%)[a]	Age 3.	(%)[a]	Total	Per Spawner
1979	1,700,904	-		-		0		-	
1980	3,321,384	-		12,736,379		26,384		-	
1981	1,326,762	31,297,432	(27)	82,656,993	(73)	0		113,954,425	85.89
1982	1,157,526	75,491,249	(78)	21,407,762	(22)	0		96,899,011	83.71
1983	1,000,614	12,693,628	(46)	15,186,101	(54)	1,677		27,881,406	27.86
1984	1,241,418	37,890,152	(64)	21,483,727	(36)	9,598		59,383,477	47.84
1985	998,232	5,461,821	(14)	33,238,739	(86)	0		38,700,560	38.77
1986	1,001,493	182,719,678	(85)	32,278,743	(15)	0		214,998,421	214.68
1987	668,964	94,119,379	(71)	38,789,387	(29)	0		132,908,766	198.68
1988	642,972	14,837,960	(24)	47,713,086	(76)	b		62,551,046	97.28
1989	1,681,302	26,056,791		b		0		-	-
1990	730,038	b		12,415,518		0		-	-
1991	2,457,306	58,331,556	(91)	5,725,543	(09)	0		64,057,099	26.07
1992	2,173,692	24,305,081	(61)	15,272,807	(39)			39,577,888	18.21
1993	1,389,534	6,961,330							
Max	3,321,384	182,719,678		82,656,993		26,384		214,998,421	214.68
Avg	1,435,901	47,505,505		28,242,065		3,138		85,081,210	83.88
Min	642,972	5,461,821		5,725,543		0		27,881,406	18.21

[a] Percent of total smolt production

[b] No Ugashik River smolt enumeration project conducted in 1992. Therefore smolt production data for the 1988, 1989, and 1990 brood years are incomplete because no smolt data were collected in 1992.

Table 27. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1979-1993 brood years, Ugashik River.

		Age 1.			Age 2.			Age 3.		
Brood Year	Total Spawning Escapement	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt
1979	1,700,904	-	3,960,210		-	2,045,642		-	0	[d]
1980	3,321,384	-	3,503,629		12,736,379	4,262,289	0.33	26,384	2,600	0.10
1981	1,326,762	31,297,432	4,241,375	0.14	82,656,993	3,215,237	0.04	0	1,682	[d]
1982	1,157,526	75,491,249	1,146,491	0.02	21,407,762	1,345,244	0.06	0	0	
1983	1,000,614	12,693,628	995,579	0.08	15,186,101	957,859	0.06	1,677	957	[d]
1984	1,241,418	37,890,152	1,052,811	0.03	21,483,727	4,394,930	0.20	9,598	5,707	[d]
1985	998,232	5,461,821	1,233,687	0.23	33,238,739	1,465,357	0.04	0	0	
1986	1,001,493	182,719,678	3,055,686	0.03	32,278,743	3,681,875	0.11	0	4,478	[d]
1987	668,964	94,019,379	2,501,539	0.03	38,789,387	4,271,781	0.11	0	34,988	[d]
1988	642,972	14,837,960	1,204,275	0.08[b]	47,713,086[c]	4,475,380[b]	0.09[b]	-[c]	29,260[b]	[d]
1989	1,681,302	26,056,791[c]	1,116,433[b]	0.04[b]	-	3,442,534[b]	[d]	0	5,136[b]	[d]
1990	730,038	-[c]	1,041,906[b]	[d]	12,415,518	2,322,286[b]		0	0[b]	
1991	2,457,306	58,331,556	2,017,827[b]		5,725,543	1,313[b]		0		
1992	2,173,692	24,305,081	2,878[b]		15,272,807					
1993	1,389,534	6,961,330								
Max	3,321,384	182,719,678	4,241,375	0.23	82,656,993	4,475,380	0.33	26,384	34,988	0.10
Avg	1,435,901	47,505,505	2,182,883	0.07	28,242,065	3,011,559	0.12	3,424	5,601	0.05
Min	642,972	5,461,821	995,579	0.02	5,725,543	957,859	0.04	0	0	0.00

[a] Includes estimates of returns through 1995.

[b] Future adult returns will increase these values.

[c] No Ugashik River smolt enumeration project conducted in 1992. Therefore smolt estimates for the 1988, 1989, and 1990 brood years are incomplete because no smolt data were collected in 1992.

[d] Insufficient smolt data to complete this calculation.

Table 28. Mean fork length and weight of sockeye salmon smolt captured in fyke nets, Ugashik River, 1995.

	Age 1.					Age 2.				
Smolt Day [a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5/23	100	12.3	9.7	2.42	25	113	16.8	13.8	5.38	75
5/24	96	12.6	8.6	3.21	45	105	14.3	11.0	4.05	55
5/25	100	10.1	9.6	3.01	14	107	13.4	11.6	4.41	85
5/26	99	1.8	9.2	.00	2	108	11.6	11.1	3.64	48
5/27	101	1.2	9.8	.18	2	109	20.6	12.3	6.16	98
5/28	90	16.4	6.9	3.44	28	105	16.2	10.9	3.83	72
5/29	83	7.8	5.7	1.42	4	110	14.4	11.9	4.54	26
5/30	92	20.1	7.5	4.21	68	104	12.3	10.5	3.76	32
5/31	86	14.4	6.2	3.37	23	106	20.7	11.1	6.41	75
6/01	86	13.0	6.1	2.41	29	100	12.9	9.1	3.09	15
6/02	93	8.3	7.3	1.49	2	107	10.0	11.4	2.93	16
6/05	88	12.3	7.0	2.81	48	97	16.4	8.8	3.65	52
Total					290					649
Mean	93		7.8			106		11.1		

[a] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 29. Age composition of total migration and mean fork length and weight by age class for sockeye salmon smolt, Ugashik River, 1958-1995.

	Age 1.				Age 2.				Age 3.				
Year of Migration	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Brood Year	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Total Estimate [a]
1958	1956	-	93	6.4	1955	-	112	11.7	1954	-	-	-	-
1959	1957	-	90	6.1	1956	-	120	13.5	1955	-	-	-	-
1960	1958	-	90	6.6	1957	-	104	11.0	1956	-	-	-	-
1961	1959	-	90	6.7	1958	-	112	12.2	1957	-	-	-	-
1962	1960	-	88	6.1	1959	-	112	12.3	1958	-	-	-	-
1963	1961	-	90	6.1	1960	-	104	9.6	1959	-	-	-	-
1964	1962	-	92	6.9	1961	-	118	12.7	1960	-	-	-	-
1965	1963	-	94	6.9	1962	-	114	12.5	1961	-	-	-	-
1967	1965	-	88	6.0	1964	-	113	12.2	1963	-	-	-	-
1968	1966	-	93	6.5	1965	-	113	10.7	1964	-	-	-	-
1969	1967	-	97	7.5	1966	-	121	14.5	1965	-	-	-	-
1970	1968	-	97	7.7	1967	-	125	15.9	1966	-	-	-	-
1972	1970	-	81	5.0	1969	-	112	11.2	1968	-	129	14.3	-
1973	1971	-	93	7.2	1970	-	113	11.9	1969	-	132	20.1	-
1974	1972	-	94	7.4	1971	-	119	13.6	1970	-	-	-	-
1975	1973	-	96	7.2	1972	-	116	13.0	1971	-	125	16.7	-
1982	1980	-	88	6.3	1979	-	113	13.0	1978	-	138	22.5	-
1983	1981	71	89	7.6	1980	29	111	13.2	1979	-	-	-	44,033,811

-Continued-

Table 29. (p 2 of 2)

Year of Migration	Age 1. Brood Year	Age 1. Percent of Total Estimate	Age 1. Mean Length (mm)	Age 1. Mean Weight (g)	Age 2. Brood Year	Age 2. Percent of Total Estimate	Age 2. Mean Length (mm)	Age 2. Mean Weight (g)	Age 3. Brood Year	Age 3. Percent of Total Estimate	Age 3. Mean Length (mm)	Age 3. Mean Weight (g)	Total Estimate [a]
1984	1982	48	87	6.8	1981	52	102	10.3	1980	0	103	11.7	158,174,626
1985	1983	37	94	8.3	1982	63	107	11.8	1981	-	-	-	34,101,390
1986	1984	71	87	5.8	1983	29	114	10.9	1982	-	-	-	53,076,253
1987	1985	20	94	7.9	1984	80	107	11.1	1983	0	138	24.1	26,947,225
1988	1986	85	87	5.7	1985	15	109	10.8	1984	0	128	15.6	215,968,015
1989	1987	74	90	6.5	1986	26	108	10.7	1985	-	-	-	126,298,122
1990	1988	28	90	6.7	1987	72	108	11.8	1986	-	-	-	53,627,347
1991	1989	35	92	7.7	1988	65	107	11.6	1987	-	-	-	73,769,877
1992 [b]	1990	-	-	-	1989	-	-	-	1988	-	-	-	-
1993	1991	83	92	8.0	1990	17	109	12.5	1989	-	-	-	70,747,074
1994	1992	81	89	6.7	1991	19	109	11.2	1990	-	-	-	30,030,624
Mean			91	6.8			112	12.1			128	17.9	
1995	1993	31	93	7.8	1992	69	106	11.1	1991	-	-	-	22,234,137

[a] No estimates of smolt numbers from 1958-1982 fyke net catches; estimates of smolt numbers for 1983-1991 and 1993-1995 based on hydroacoustic techniques.

[b] Project not operated in 1992. No smolt data collected.

Table 30. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Ugashik River, 1995.

	Estimated Age 1. [a]				Estimated Age 2. [a]			
Smolt Day [b]	Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size	Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size
5/23	92	18.4	7.5	134	109	29.4	12.1	472
5/24	93	13.2	7.8	44	105	18.8	10.9	113
5/25	90	27.7	7.1	171	106	21.3	11.0	378
5/26	97		8.5	1	109	16.9	11.9	117
5/27	93	21.1	7.9	103	105	25.7	10.9	422
5/28	88	31.7	6.9	205	106	24.8	11.2	355
5/29	77	30.3	4.9	84	105	12.5	10.8	39
5/30	90	26.0	7.3	91	103	11.7	10.4	81
5/31	90	19.8	7.2	126	104	18.8	10.7	179
6/01	86	11.5	6.3	27	103	5.4	10.4	2
6/05	90	14.1	7.2	62	101	1.2	9.7	7
Total				1,048				2,165
Mean	90		7.1		105		10.9	

[a] Length-weight parameters by age group and discriminating length used to seperate ages were:

Age 1. $a = -10.3599$ $b = 2.7330$ $r^2 = 0.92$ $n = 290$
Age 2. $a = -9.8637$ $b = 2.6286$ $r^2 = 0.88$ $n = 649$

Discriminating Length = 98.53 mm

[b] Sample day began at 1200 hours and ended at 1159 hours the next calendar day.

Table 31. Depth of sockeye salmon smolt passage at Ugashik River sonar site, May 22 to June 7, 1995.

	Depth of Passage (cm)					
	Inshore Array[a] Smolt Schools		Offshore Array[b] Smolt Schools		All Combined Smolt Schools	
	Top	Bottom	Top	Bottom	Top	Bottom
Mean	18	72	22	86	20	79
Minimum	0	50	0	38	0	44
Maximum	30	88	47	125	38	107
n	35	35	95	95	130	130

[a] Average depth of inshore array on smolt day 5/25 was 274 cm.

[b] Average depth of offshore array on smolt day 5/25 was 328 cm.

Table 32. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Ugashik River, 1995.

Date	Cloud Cover [a]		Wind Direction [b] & Velocity (km/h)				Air Temperature (°C)		Water Temperature (°C)		Percipitation (mm)	Water Clarity [c]
	0800	2000	0800		2000		0800	2000	0800	2000		
5/23	2	2	SE	48	SE	24-32	5.0	6.0	4.5	5.0	0.0	brown
5/24	1	1	SE	08	SE	16	8.0	7.0	4.5	6.0	0.0	lt brown
5/25	1	2		0		0	10.0	9.0	5.0	5.0	0.0	clear
5/26	2	2	SE	32	E	32	6.0	6.0	5.5	6.0	0.0	clear
5/27	2	3	W	10	E	24	7.0	7.0	5.0	5.0	0.0	clear
5/28	4	1	var.	08	E	24	4.0	7.0	4.0	5.0	0.0	clear
5/29	4	3	S	08	SE	24	5.0	7.0	6.0	6.0	0.0	clear
5/30	3	1	SE	08	SE	24	4.0	7.0	6.5	7.0	0.0	clear
5/31	1	3	SE	8-16	SE	32	4.0	8.0	6.5	8.0	0.0	clear
6/01	3	3	SE	8-16	E	5	5.0	7.0	7.0	7.5	5.0	clear
6/02	1	3	SE	08	SE	8	4.5	8.0	7.0	7.0	4.0	clear
6/03	1	3	SE	08	W	16-32	-	12.0	6.0	6.5	trace	clear
6/04	3	3	NW	16	W	08-16	8.0	11.0	5.0	6.5	trace	clear
6/05	5	3		0	S	24-32	3.0	10.0	5.0	7.0	0.0	clear
6/06	1	3	E	16	ESE	24	7.0	10.0	5.0	8.0	0.0	clear
6/07	4	3	SE	16	SE	16	6.0	8.0	7.0	7.0	2.0	clear
6/08	3	2	SE	10	SE	16	8.0	9.0	7.0	9.0	0.0	clear
6/09	3	2	W	08	NW	16	11.0	19.0	7.0	7.0	trace	clear
6/10	5	3	SW	19	W	16	6.0	12.0	7.0	7.0	trace	clear
6/11	4	1	SW	16	NW	21	3.0	17.0	5.5	7.5	0.0	clear
6/12	1	-	W	08	-	-	13.0	-	5.5	-	-	clear

[a] 1 = Cloud cover not more than 1/10
2 = Cloud cover not more than 1/2
3 = Cloud cover more than 1/2
4 = Completely overcast
5 = Fog

[b] var. = variable winds

[c] Water clarity at 0800 hours

Table 33. Water temperatures at sockeye salmon smolt counting site, Ugashik River, 1983-1995.

Year	Sample Period	Water Temperature (°C)		
		Minimum	Maximum	Mean
1983	May 23 - Jun 11	6.0	8.5	7.3
1984	May 20 - Jun 17	4.8	8.0	6.3
1985	May 17 - Jun 09	-1.0	7.0	4.3
1986	May 23 - Jun 28	2.0	7.0	5.6
1987	May 17 - Jun 13	4.0	9.0	5.9
1988	May 17 - Jun 13	3.5	10.0	6.6
1989	May 21 - Jun 16	3.0	8.8	5.8
1990	May 21 - Jun 14	3.0	8.0	5.9
1991	May 20 - Jun 14	4.0	8.5	5.9
1992[a]	-	-	-	-
1993	May 18 - Jun 11	5.0	9.0	7.3
1994	May 20 - Jun 13	4.5	10.0	6.5
	Mean	3.5	8.6	6.1
1995	May 23 - Jun 12	4.0	9.0	6.2

[a] Project not operated in 1992, no data collected.

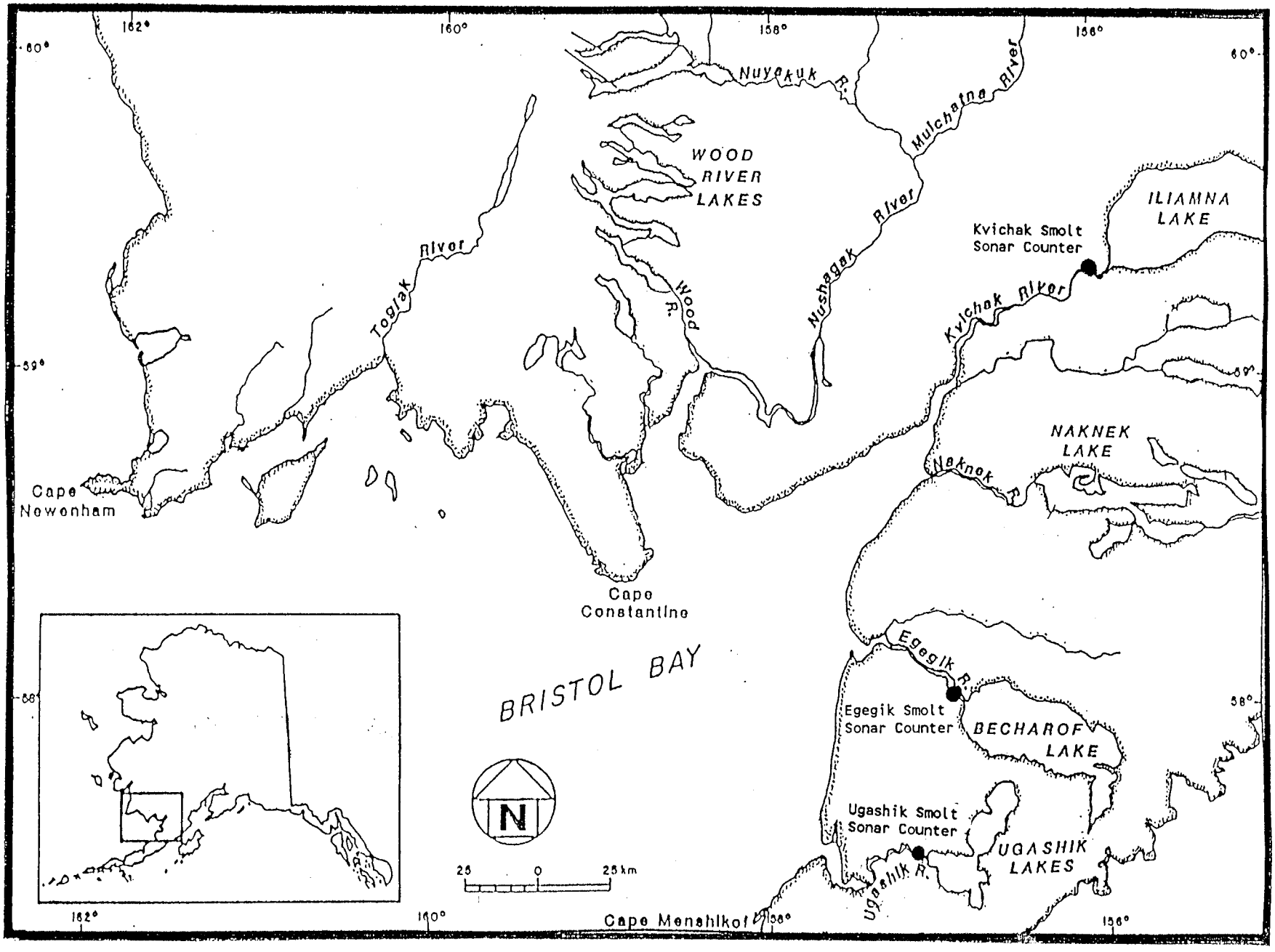


Figure 1. Bristol Bay Management Area with major rivers and locations of smolt counting projects, 1995.

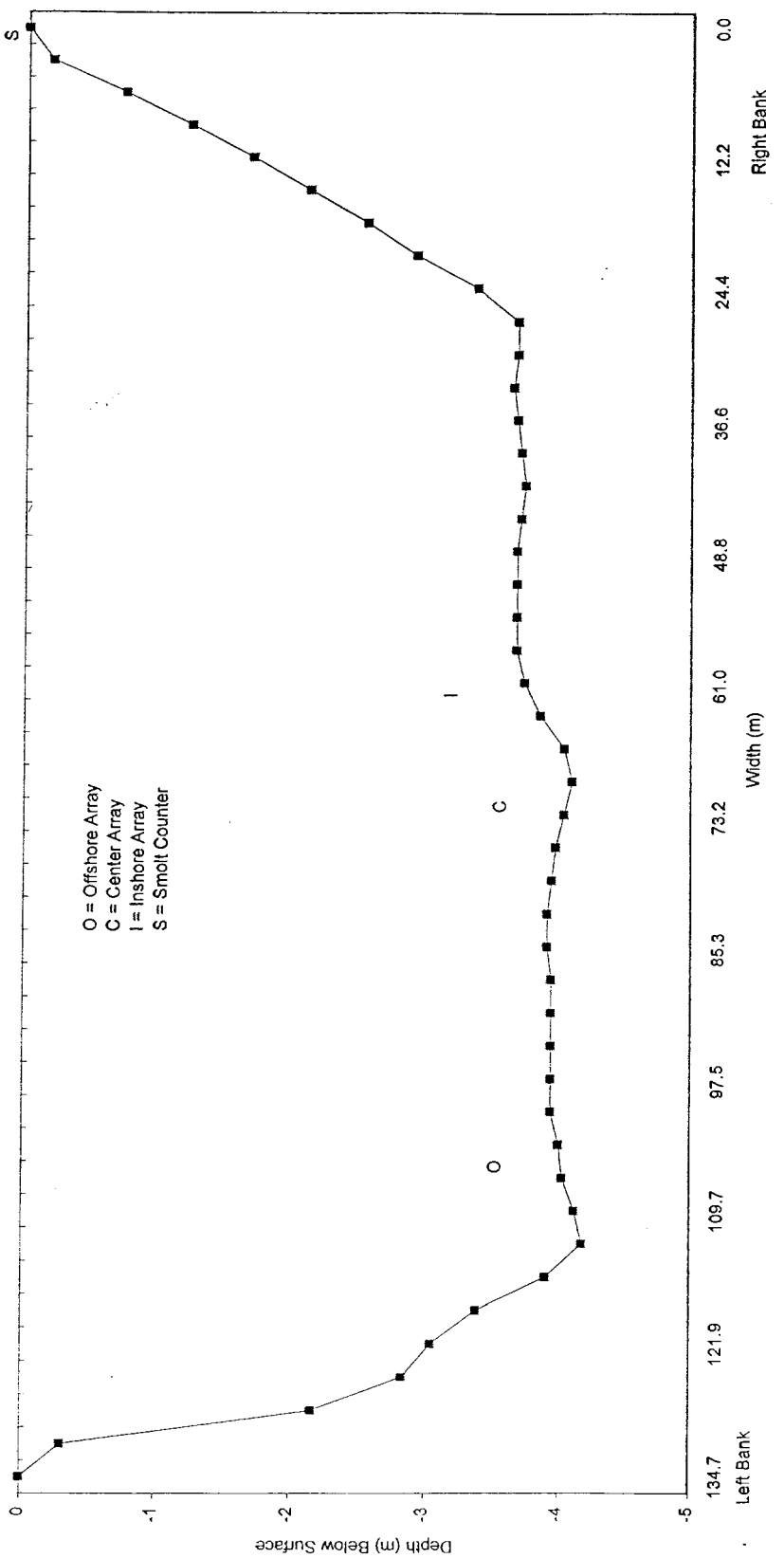


Figure 2. River bottom profile and sonar array placement at Kvichak River smolt site, 1995.

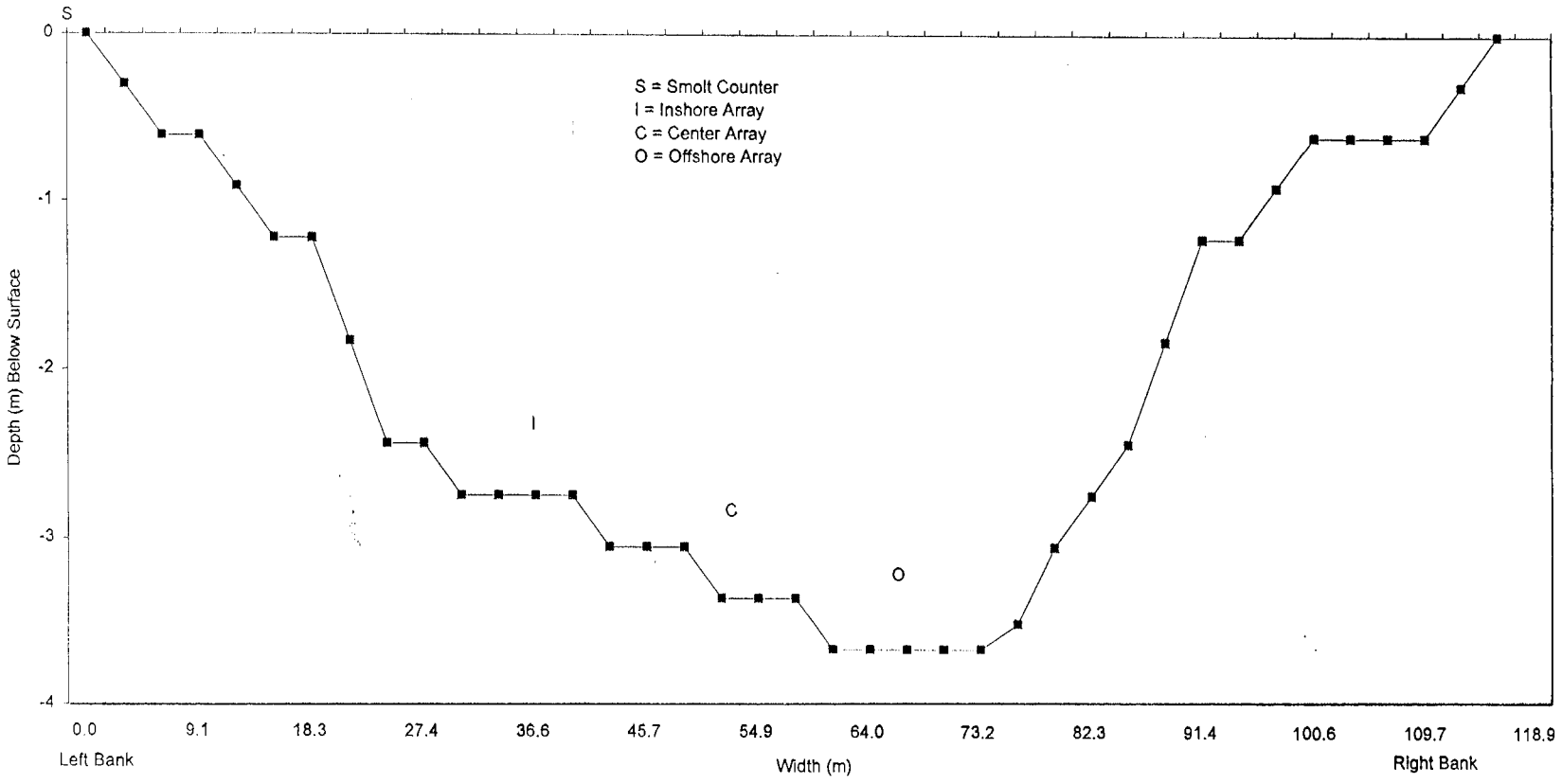


Figure 3. River bottom profile and sonar array placement at Egegik River smolt site, 1995.

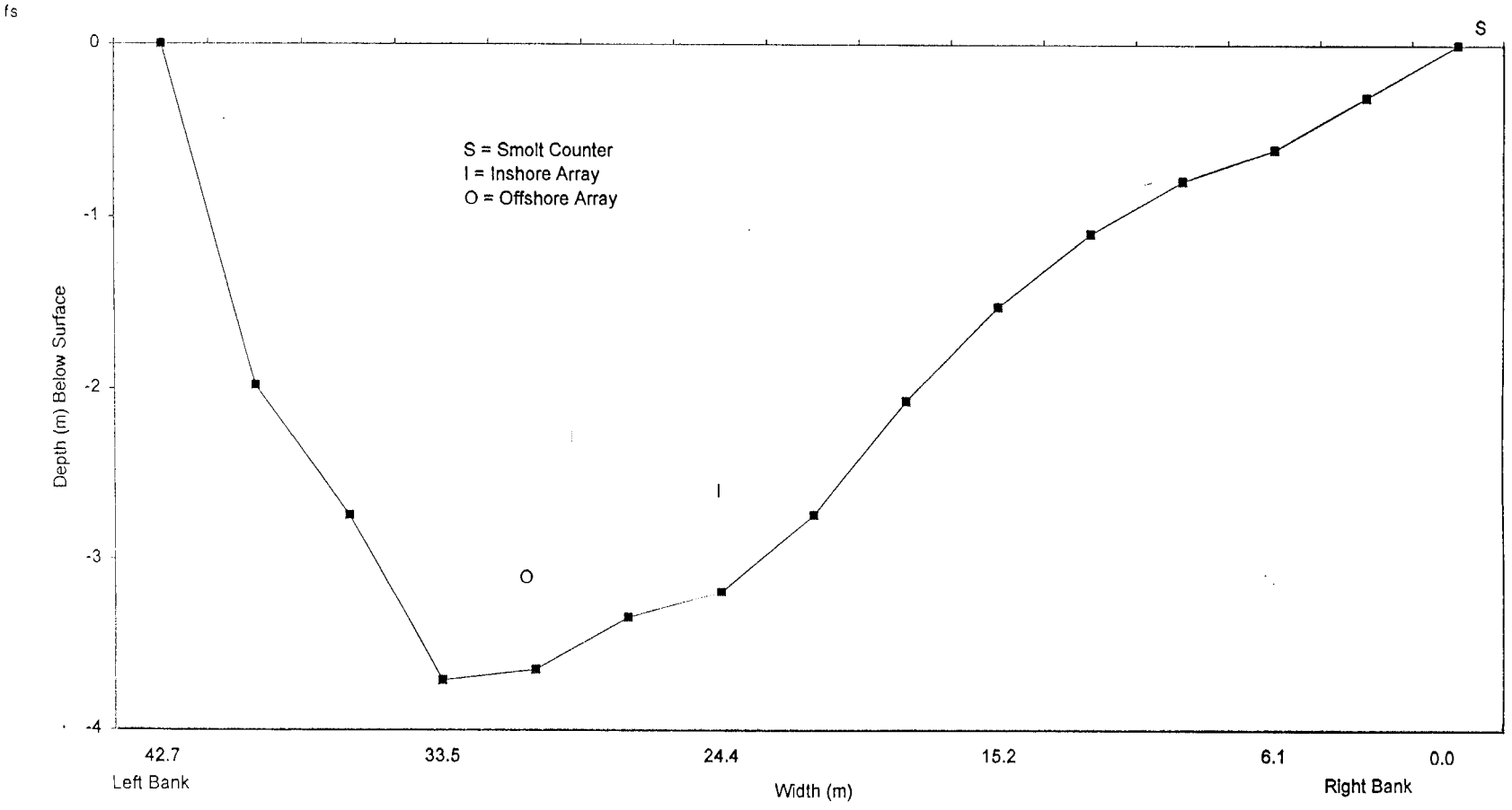


Figure 4. River bottom profile and sonar array placement at Ugashik River smolt site, 1995.

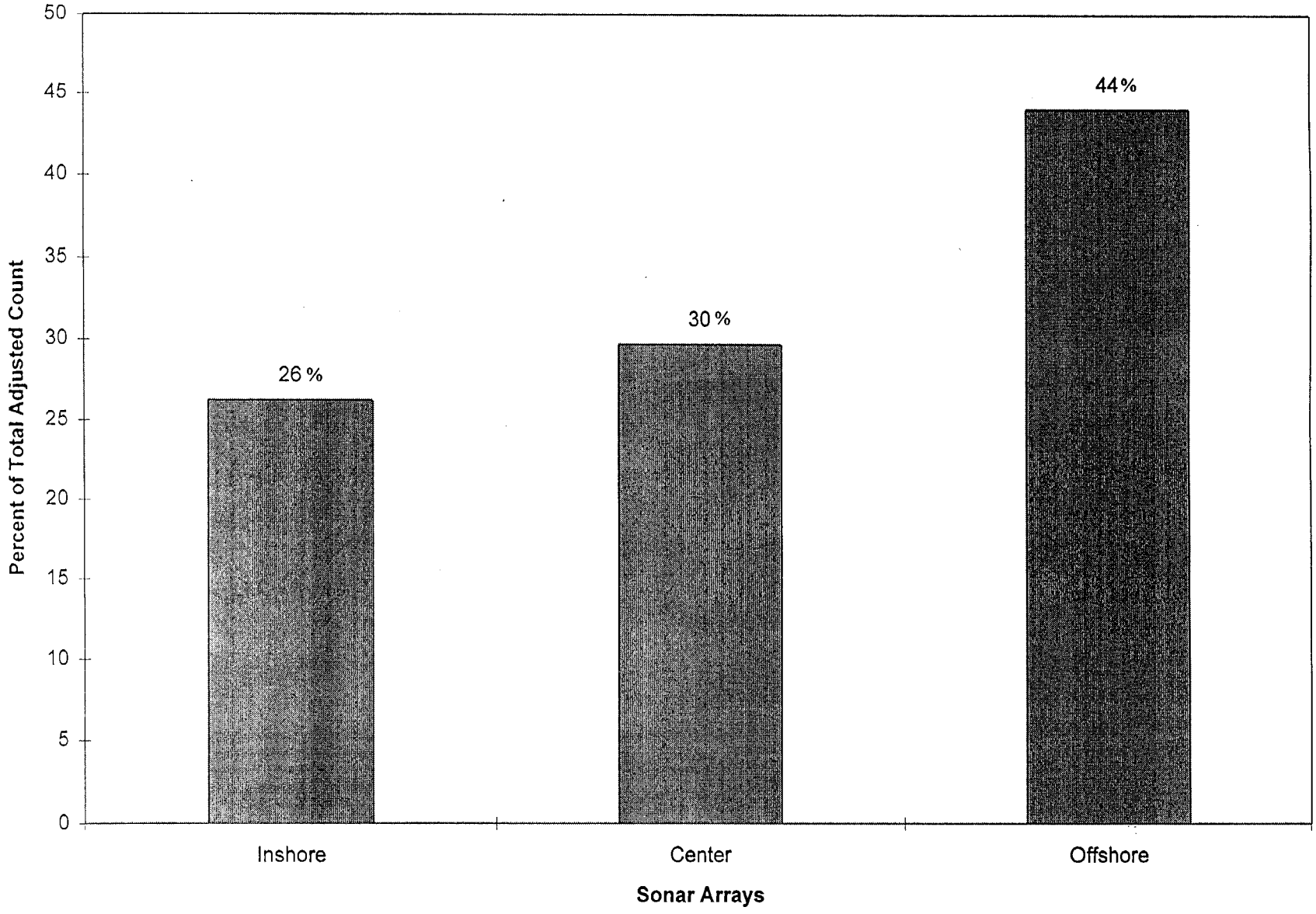


Figure 5. Lateral distribution of Kvichak River smolt sonar counts, 1995.

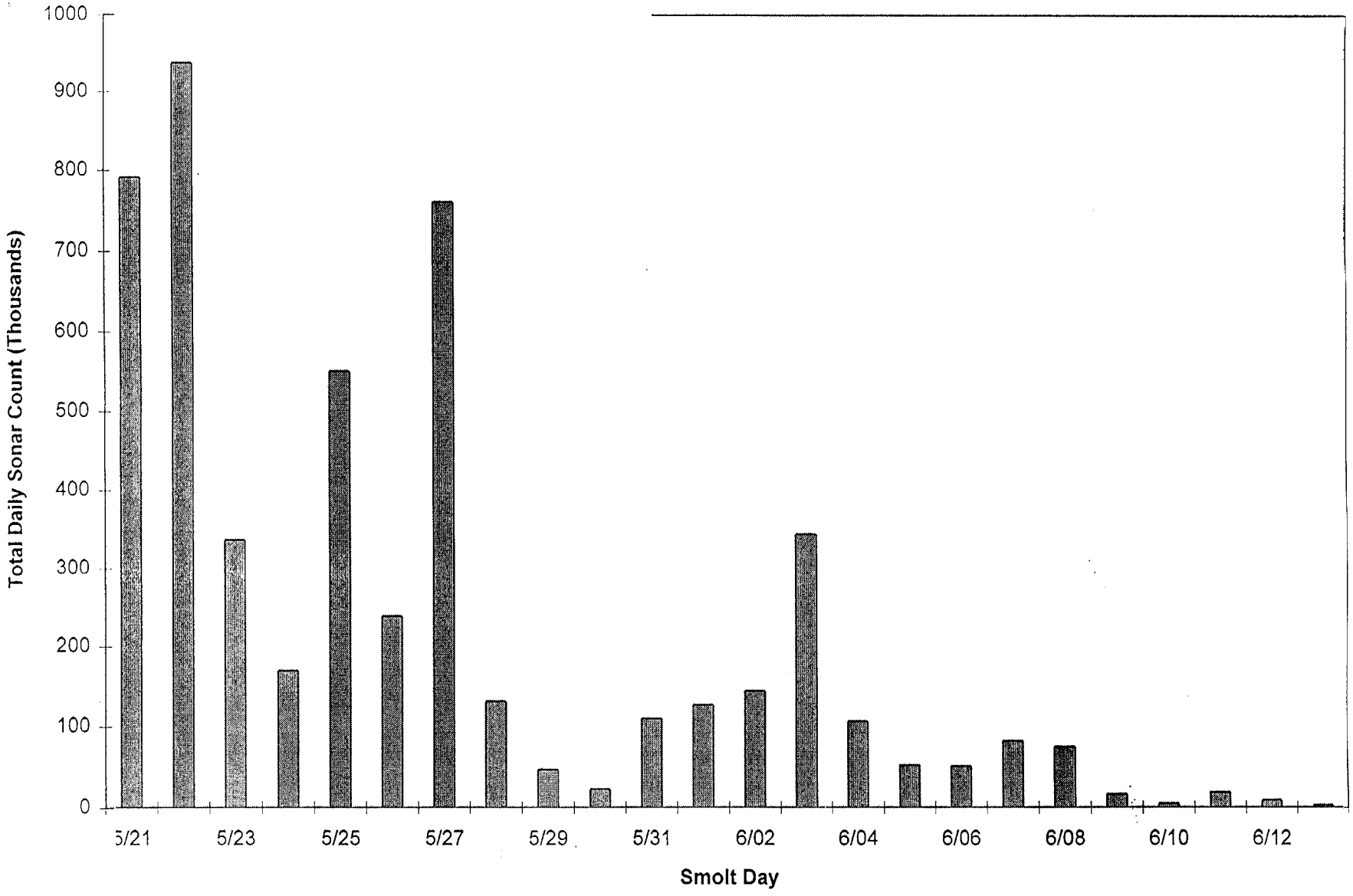


Figure 6. Total daily sonar counts at Kvichak River smolt project, May 21 to June 13, 1995.

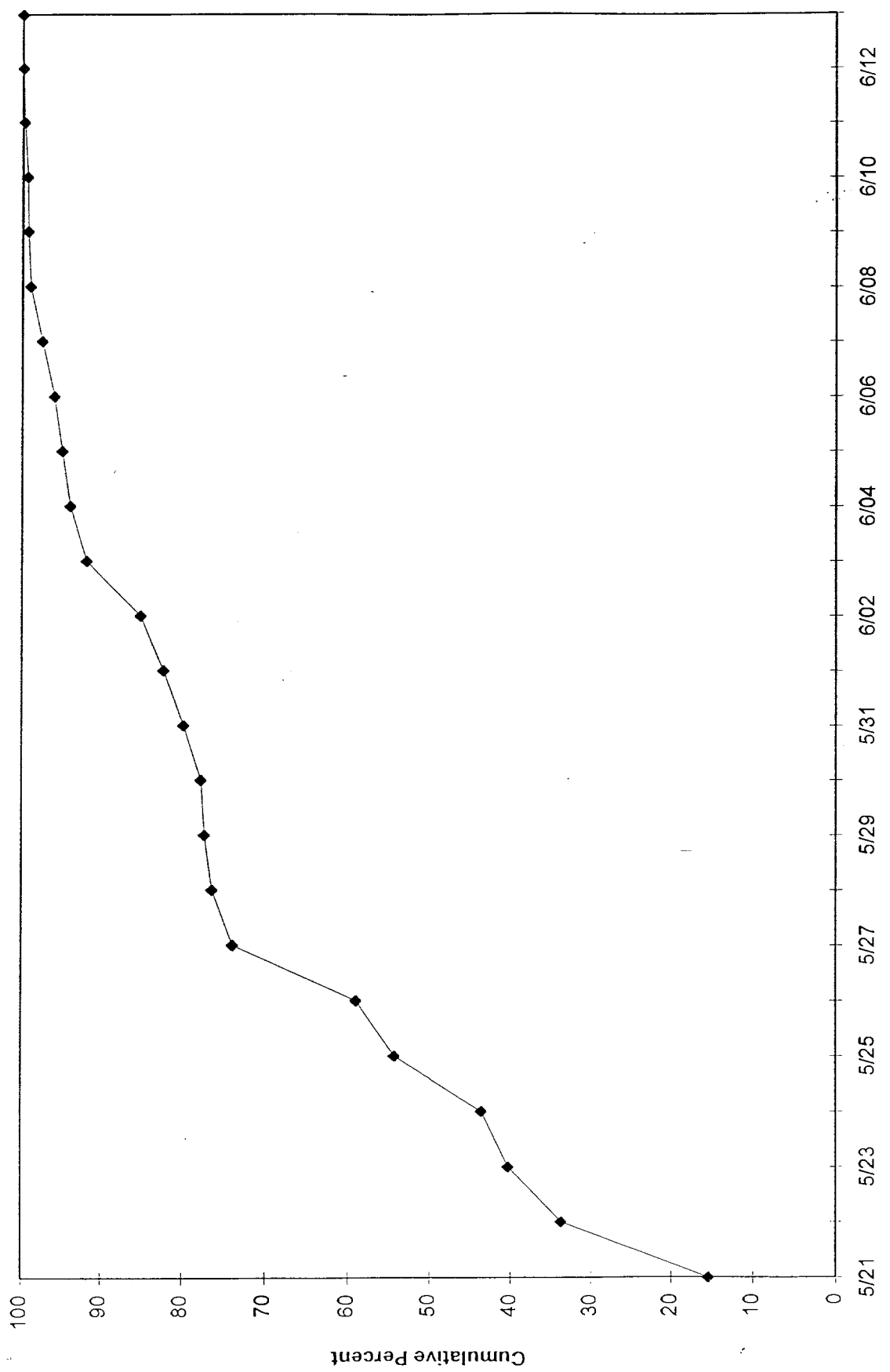


Figure 7. Kvichak River smolt sonar count, cumulative percent by smolt day, May 21 to June 13, 1995.

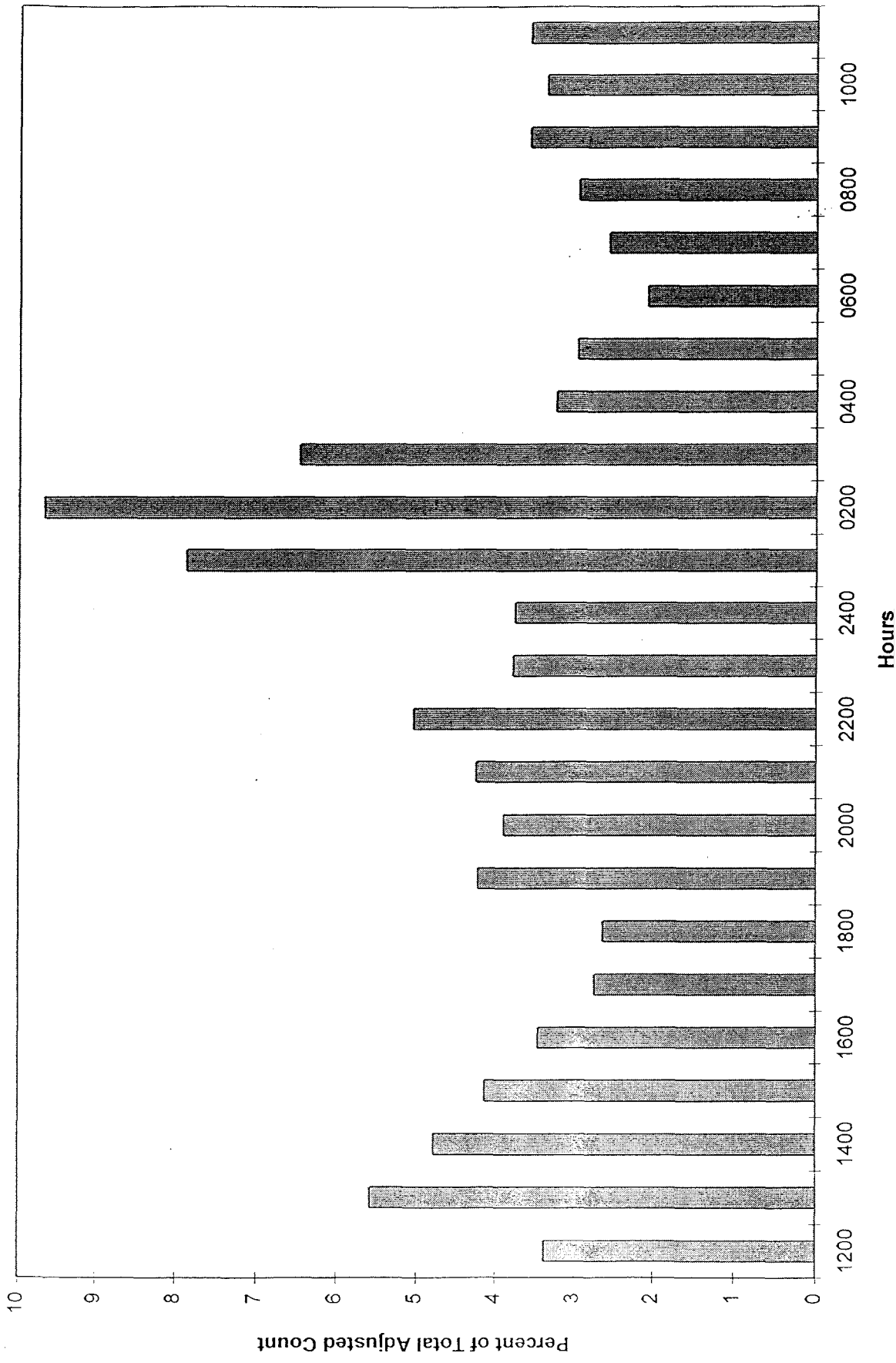
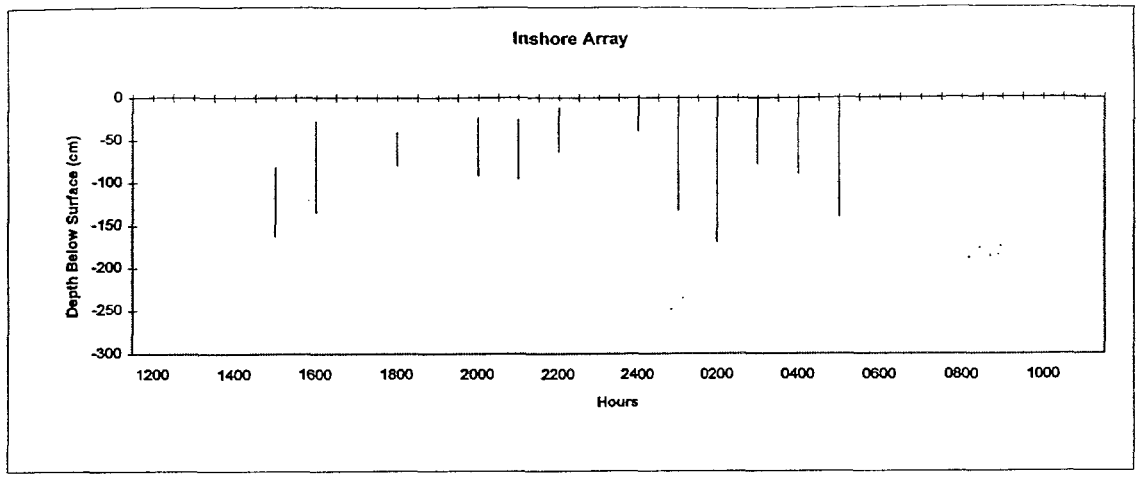
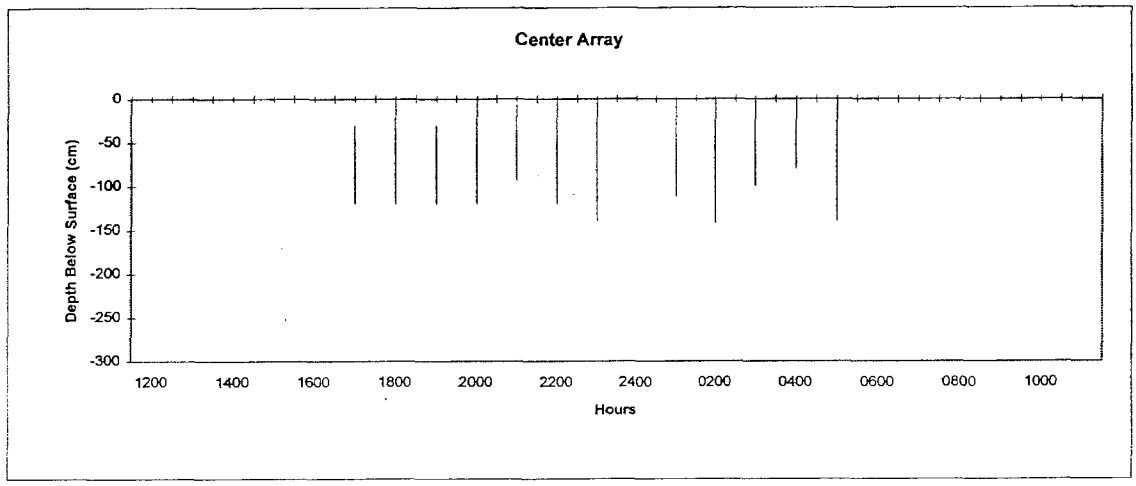


Figure 8. Percent of the total adjusted sonar count summarized by hour, Kvichak River smolt project, May 21 to June 13, 1995.





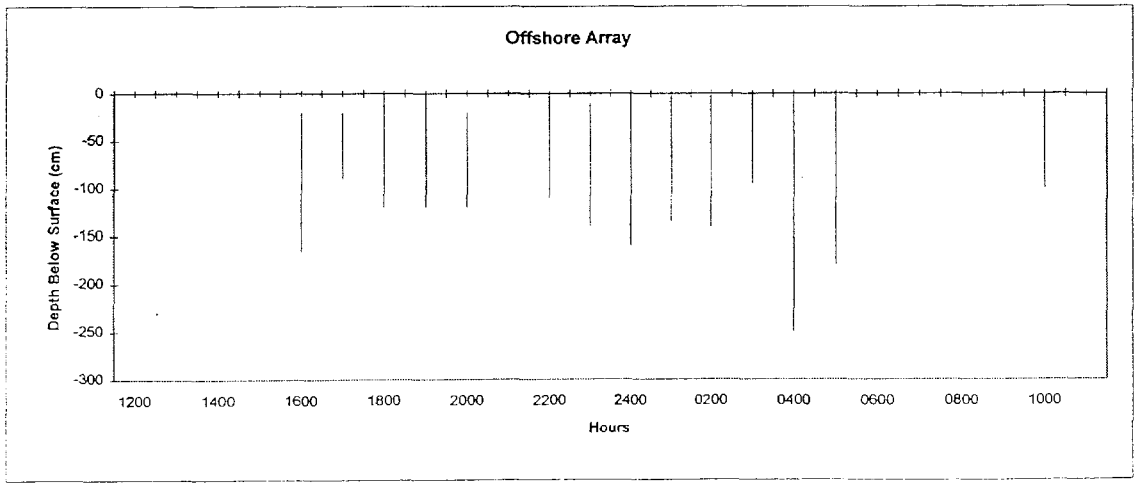


Figure 9. Depth of smolt passage data summarized by hour, Kvichak River, May 21 to June 7, 1995.

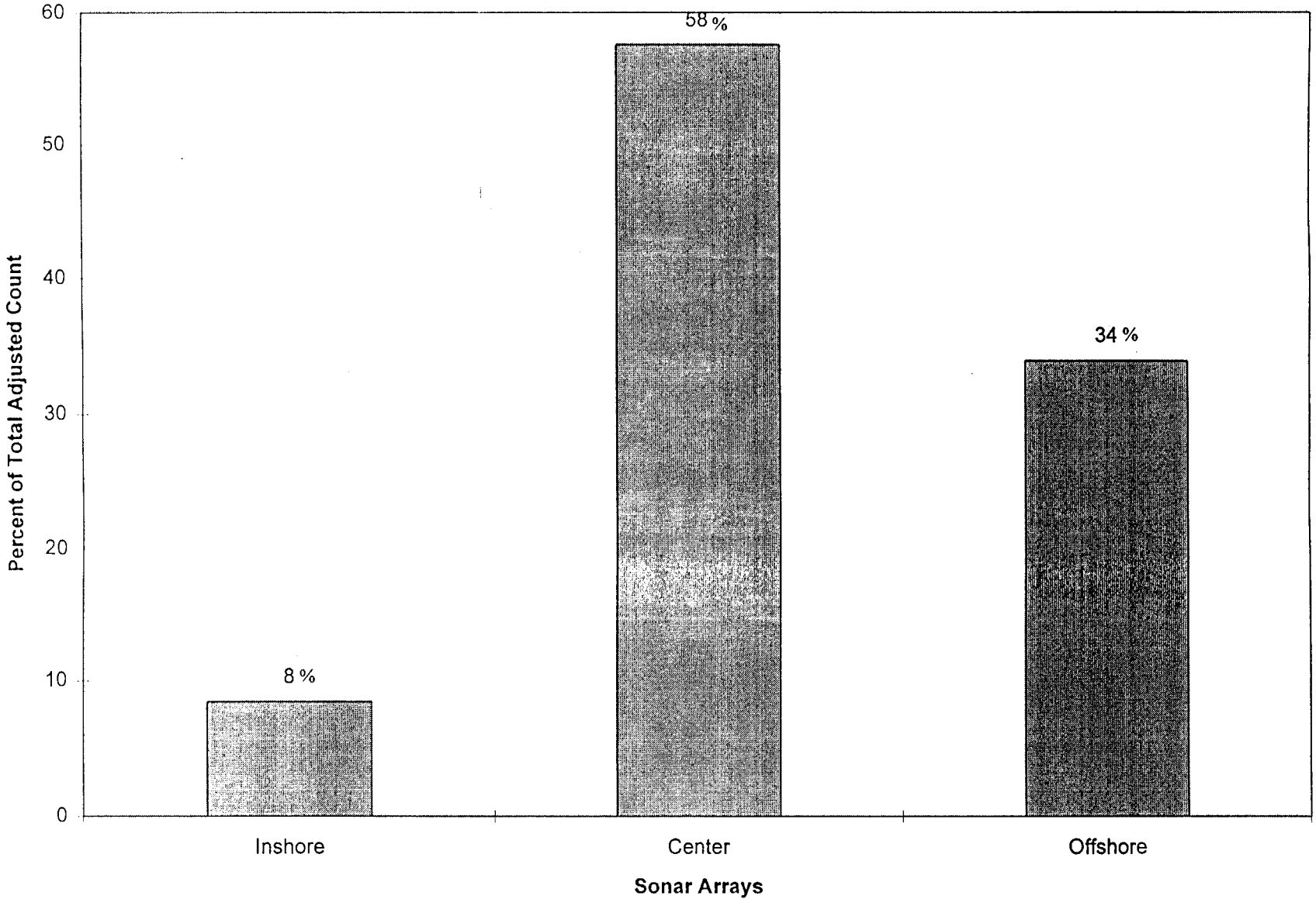


Figure 10. Lateral distribution of Egegik River smolt sonar counts, 1995.

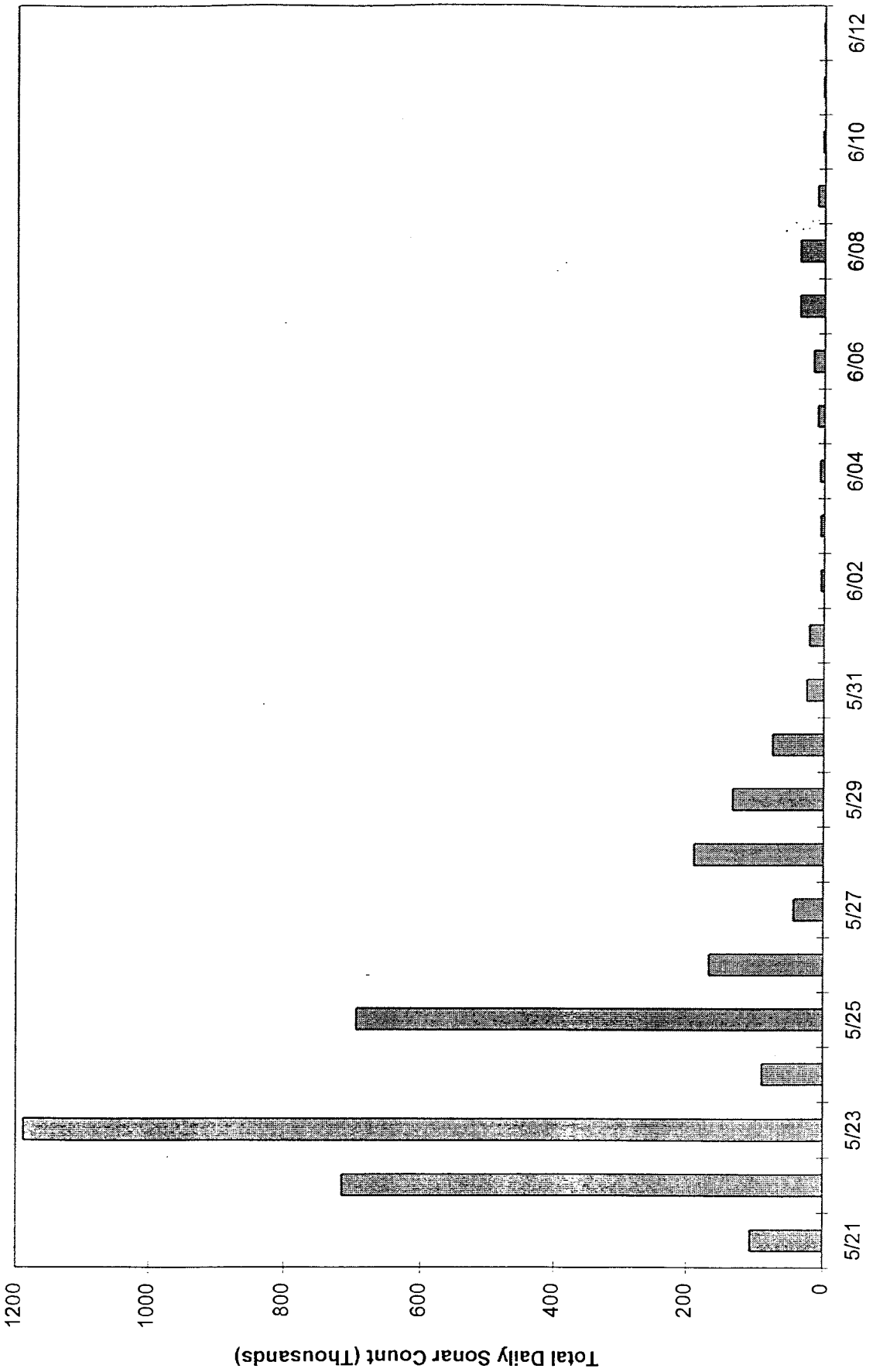


Figure 11. Total daily sonar counts at Egegik River smolt project, May 21 to June 12, 1995.

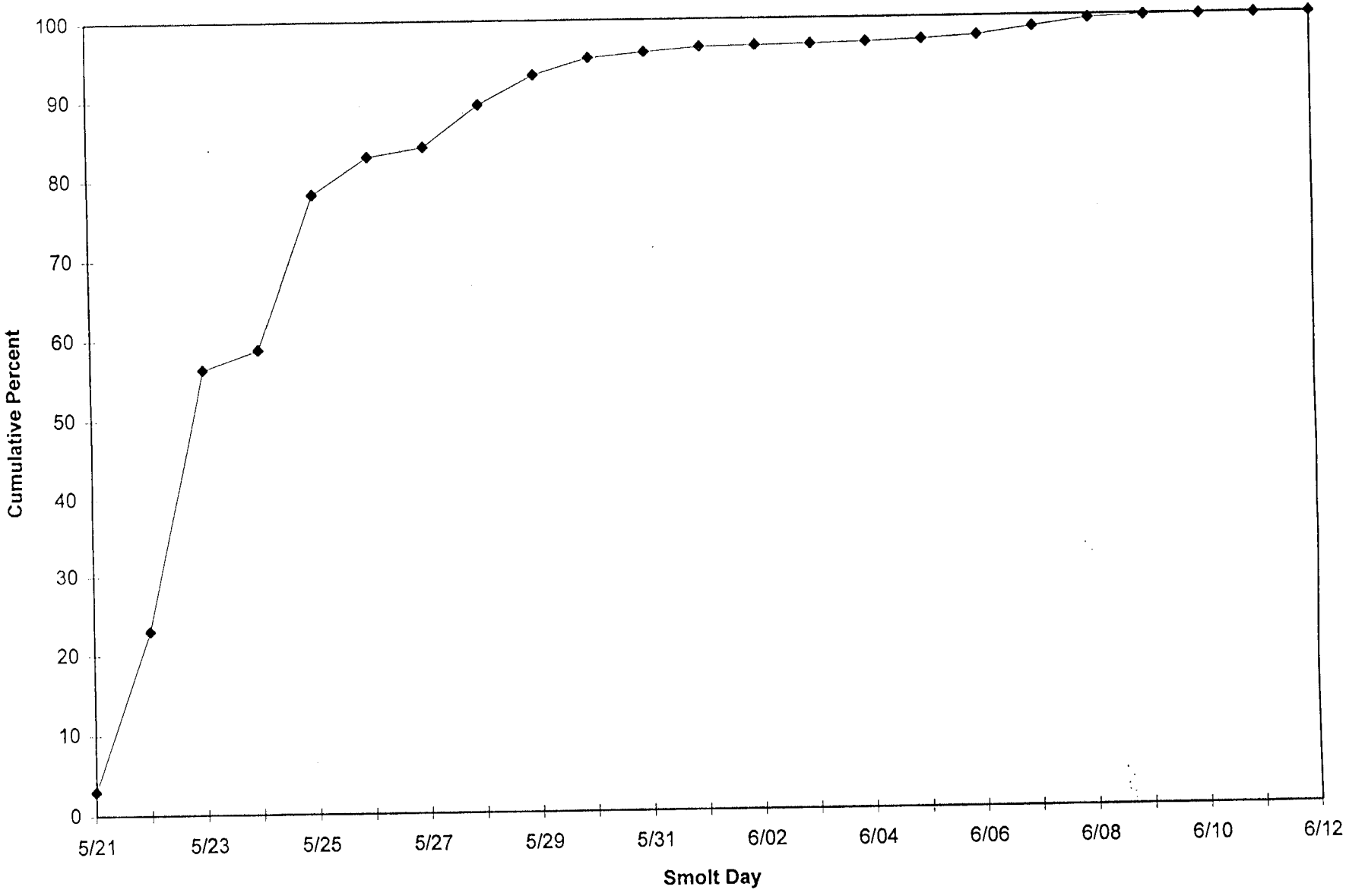


Figure 12. Egegik River smolt sonar count, cumulative percent by smolt day, May 21 to June 12, 1995.

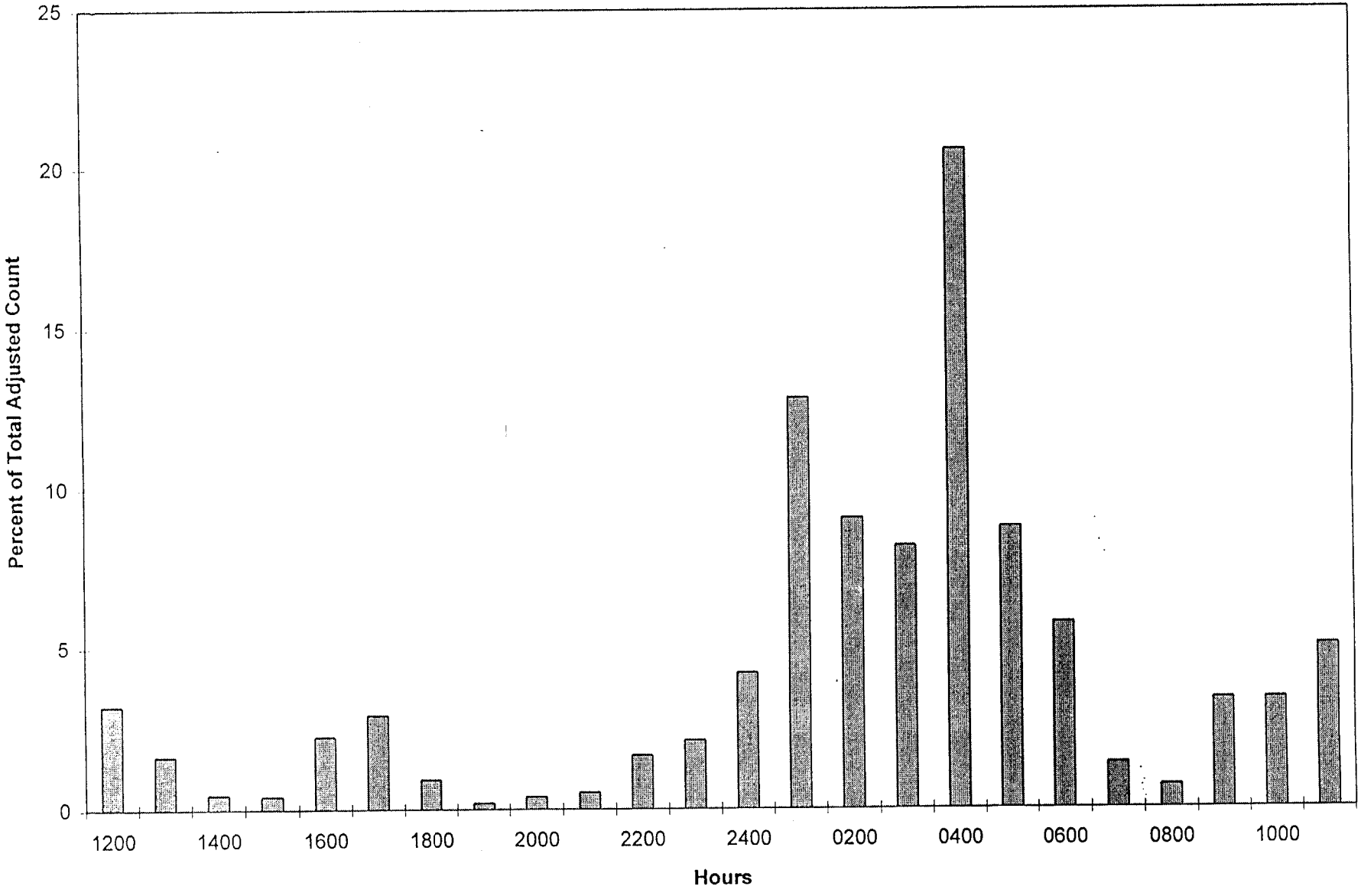
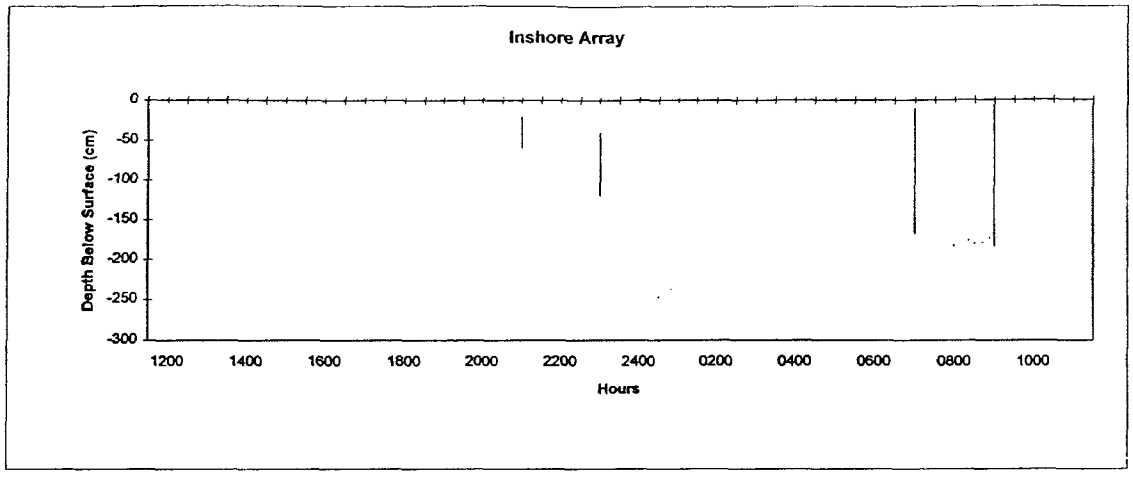
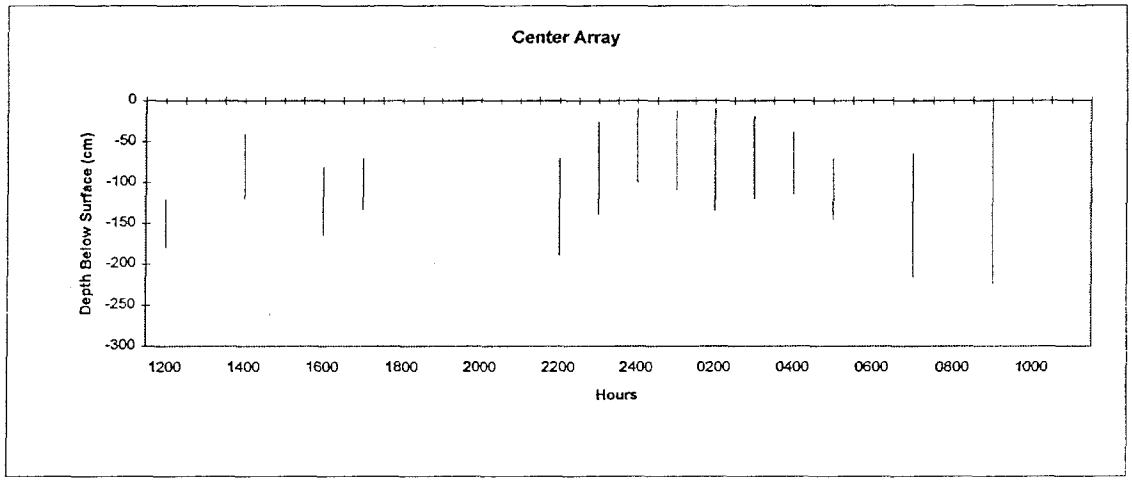


Figure 13. Percent of the total adjusted sonar count summarized by hour, Egegik River smolt project, May 21 to June 12, 1995.





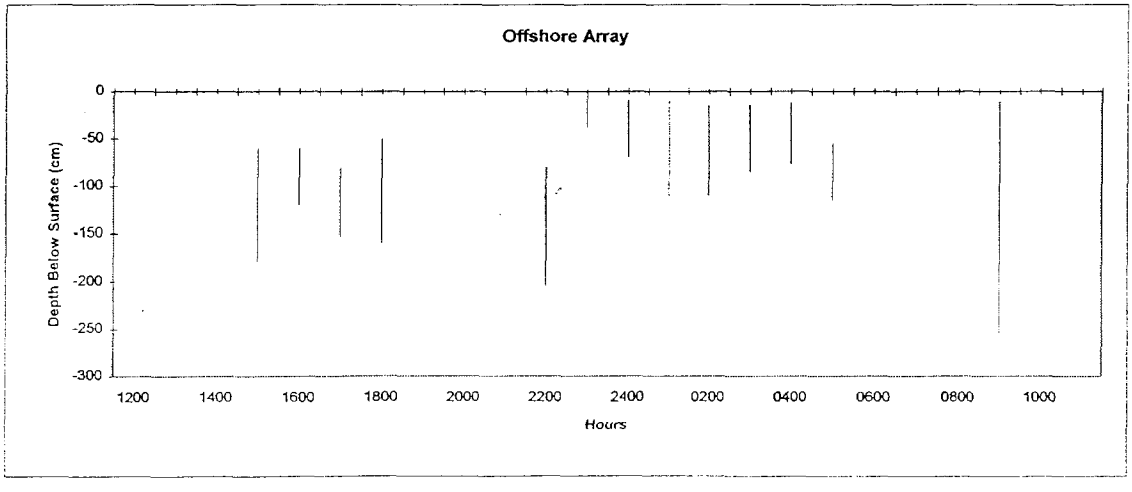


Figure 14. Depth of smolt passage data summarized by hour, Egegik River, May 21 to June 9, 1995.

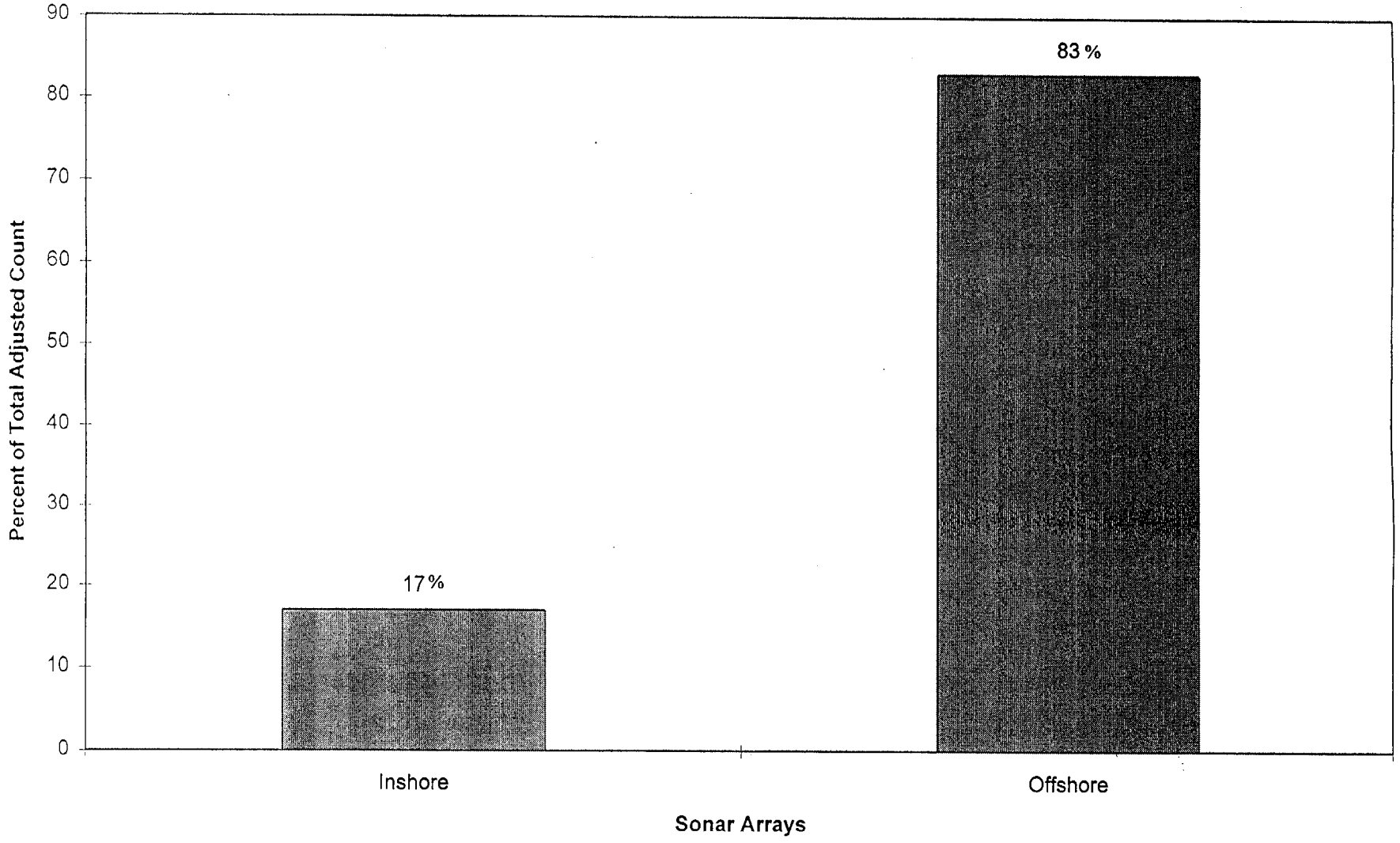


Figure 15. Lateral distribution of Ugashik River smolt sonar counts, 1995.

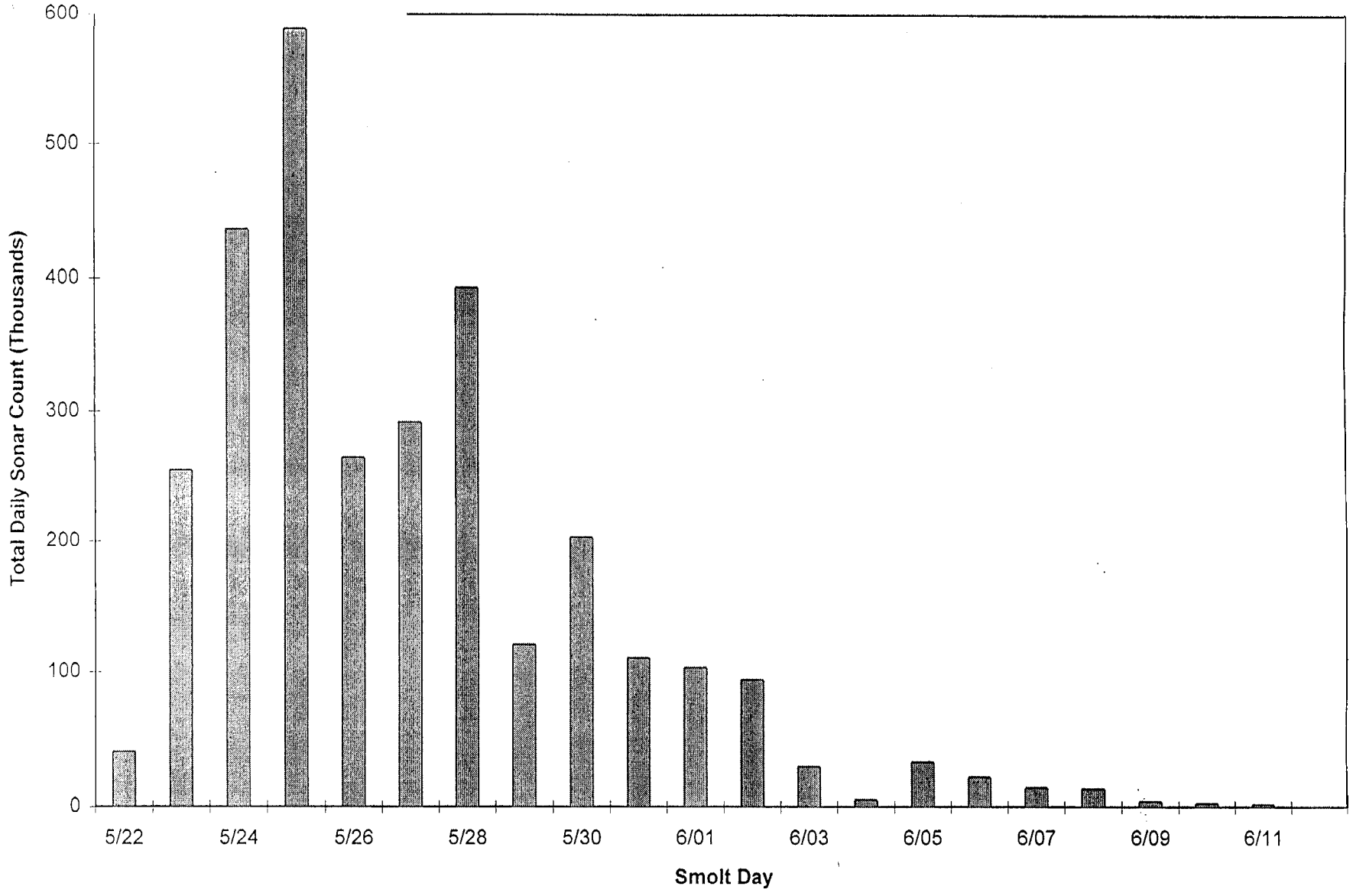


Figure 16. Total daily sonar counts at Ugashik River smolt project, May 22 to June 12, 1995.

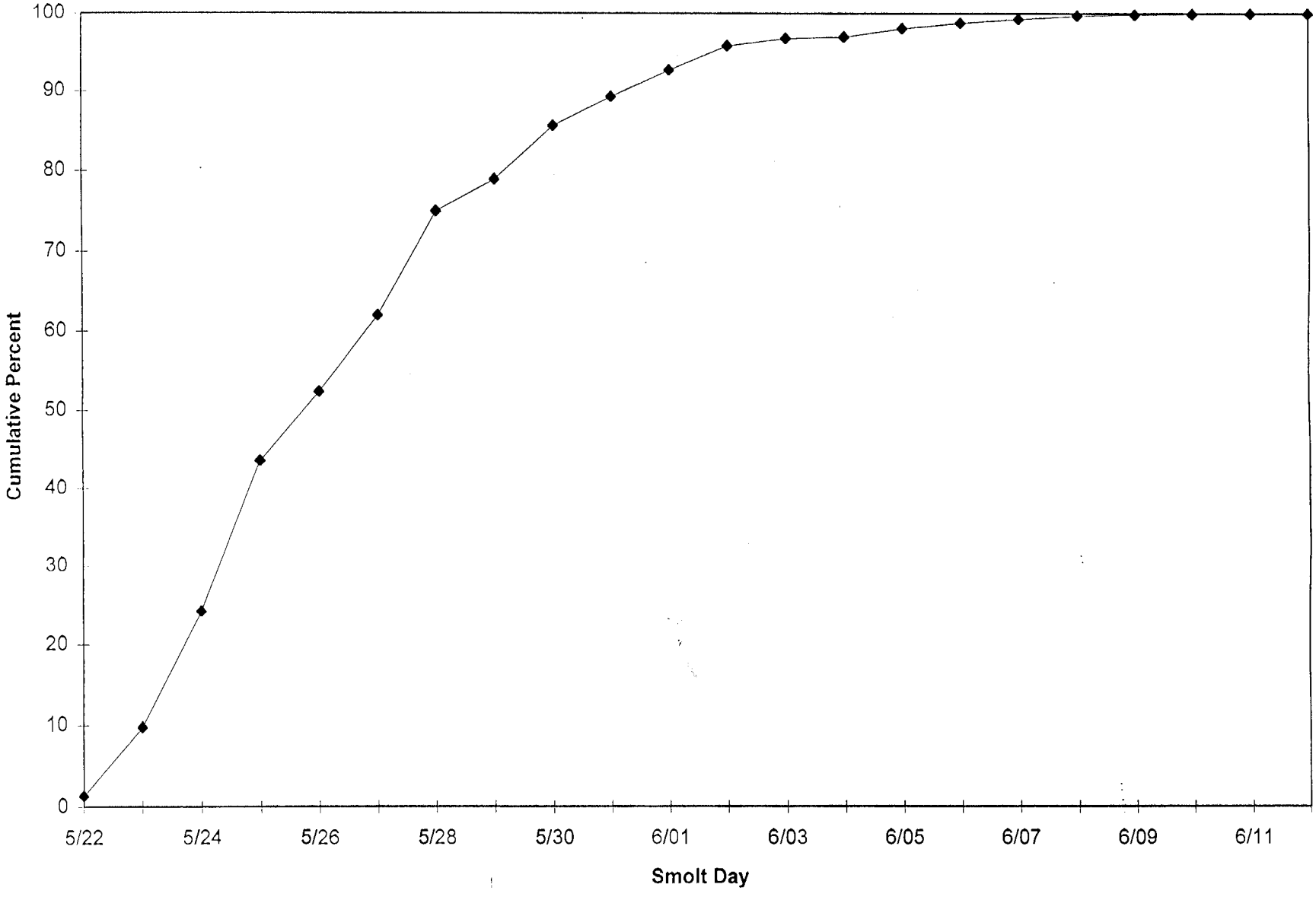


Figure 17. Ugashik River smolt sonar count, cumulative percent by smolt day, May 22 to June 12, 1995.

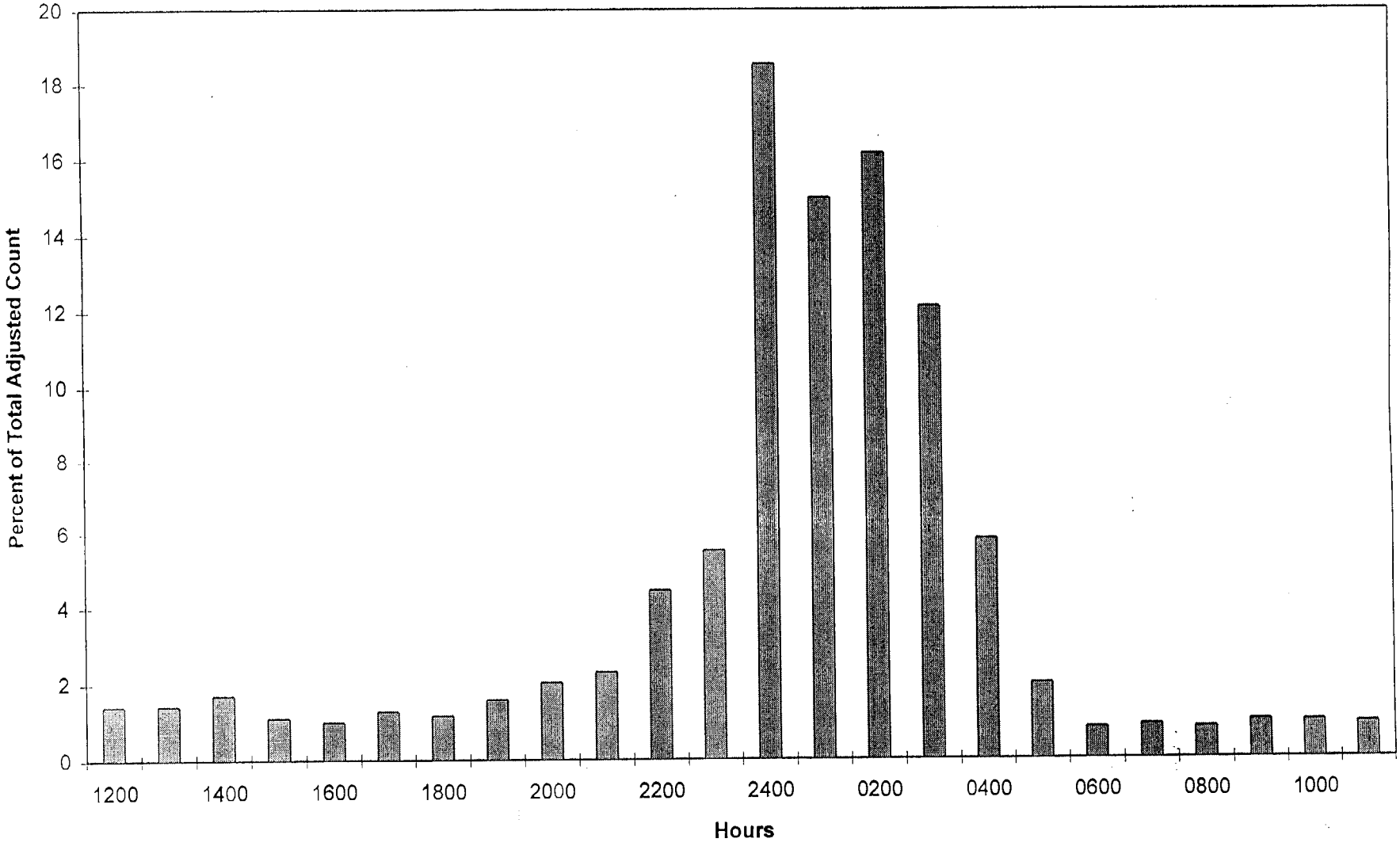
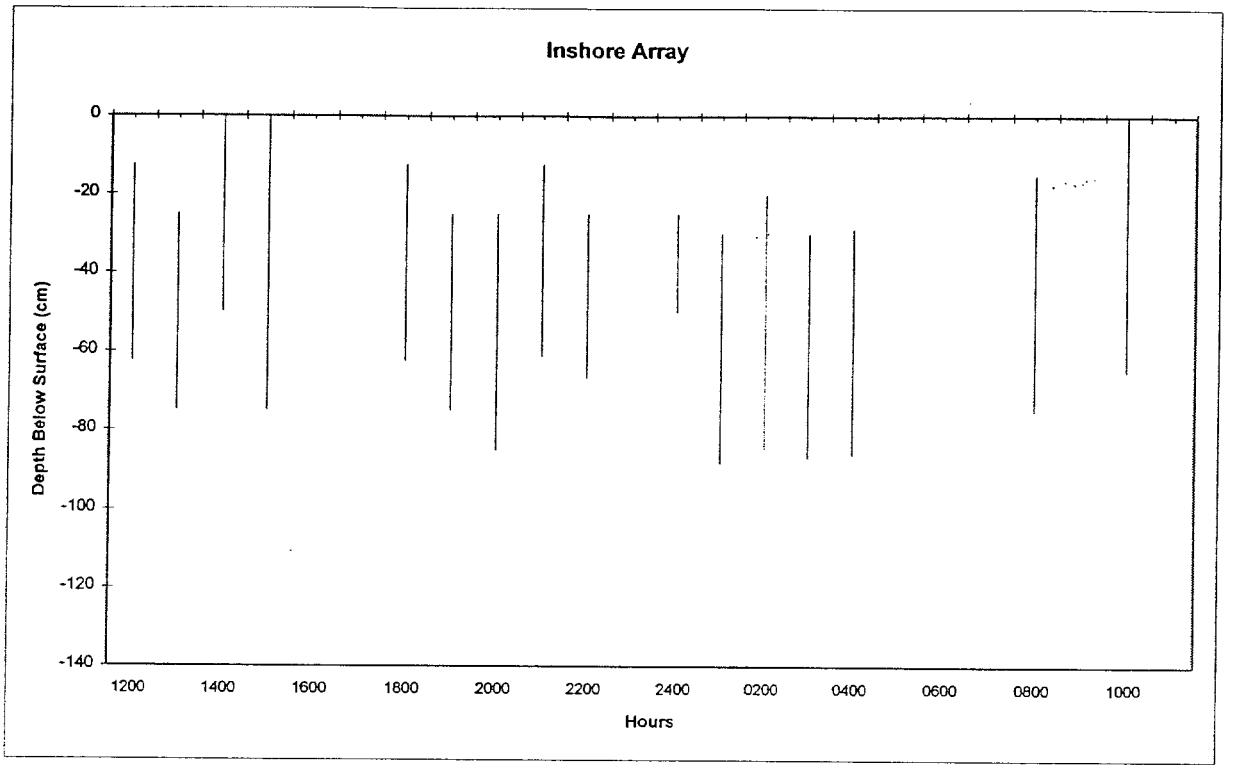


Figure 18. Percent of the total adjusted sonar count summarized by hour, Ugashik River smolt project, May 22 to June 12, 1995.



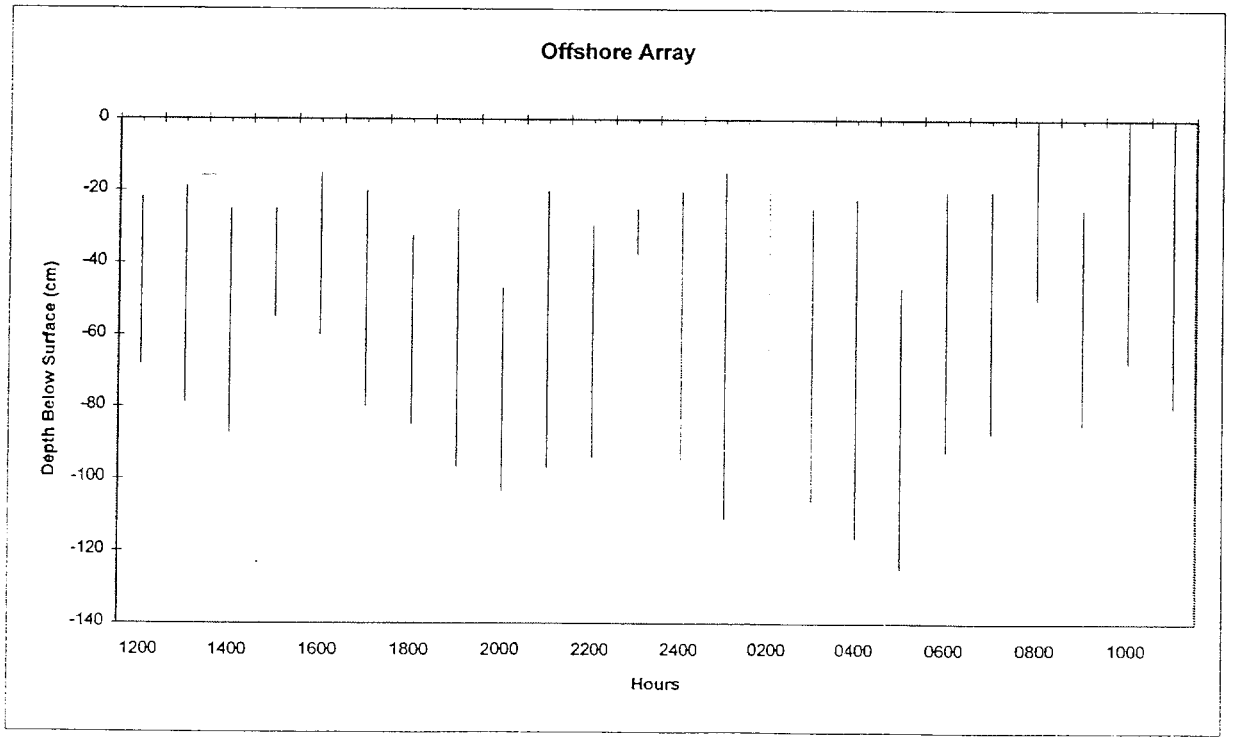


Figure 19. Depth of smolt passage data summarized by hour, Ugashik River, May 22 to June 07, 1995.

Appendix A.1. Ice covered data for Lake Iliamna, 1970 - 1995.

Winter Of	Freeze-up Date [a] (dd/mmm)	Julian Day	Break-up Date [a] (dd/mmm)	Julian Day	Total Days of Ice Cover	Comments [a]
1969-70	01-Jan	1				
1970-71	07-Jan	7	16-Jun	167	159	Long, cold winter.
1971-72			05-Jun	157		
1972-73			25-May	145		
1973-74			21-May	141		
1974-75	26-Dec	5	04-Jun	155	158	
1975-76			07-May	128		
1976-77	04-Feb	35	02-May	122	88	Partially open 30- Mar
1977-78			11-May	131		80% open 02-May
1978-79			03-May	123		50% open 28-Apr
1979-80			03-May	124		
1980-81						
1981-82	09-Jan	9	25-May	145	136	Started to reopen 10-Feb
1982-83						
1983-84						Still open 19-Dec
1984-85	11-Feb	42	05-Jun	157	114	50% open 29-May
1985-86	18-Jan	18	12-May	132	114	
1986-87	13-Feb [b]	44	23-Mar	86	40	Still not frozen up by 13-Feb
1987-88	26-Jan	26				Began re-opening 24-Feb; 75% open 01-Apr
1988-89	13-Jan	13				50% open 20-Apr
1989-90	09-Jan	9	22-May	142	133	
1990-91	07-Jan	7				
1991-92	27-Jan	27	04-May	125	97	
1992-93	22-Jan	22	03-May	123	101	
1993-94	16-Feb	47	05-May	125	79	Ice jammed along west shore; trickled out until May 29
1994-95	11-Jan [b]	11	22-May	142	131	Lake frozen briefly, Dec 19, then reopened. Lake 95% open by May 13
Total		323		2570		
Min	26-Dec		23-Mar		40	
Avg	20-Jan	20	15-May	135	113	
Max	16-Feb		16-Jun		159	

[a] Most data is anecdotal, provided by pilots from local air charter companies (R. Russell, Alaska Department of Fish and Game, King Salmon, personal communication).

[b] Last date area was observed with open water; may have frozen over even later.

Appendix A.2. Ice covered data for Becharof Lake, 1970 - 1995.

Winter Of	Freeze-up Date [a] (dd/mmm)	Julian Day	Break-up Date [a] (dd/mmm)	Julian Day	Total Days of Ice Cover	Comments [a]
1969-70						
1970-71						Long, cold winter.
1971-72						
1972-73						
1973-74						
1974-75						
1975-76			06-Apr	97		
1976-77			06-Apr	96		Island Arm still frozen. Main basin opened earlier.
1977-78						
1978-79						
1979-80						
1980-81			13-May	133		May have opened earlier.
1981-82			20-May	140		Still open 15-Dec. May have opened earlier than 20-May.
1982-83	18-Jan	18				50% open 31-Mar
1983-84	16-Jan [b]	16	16-May	137		Still open 16-Jan
1984-85	11-Feb	42	03-May	123	82	
1985-86	26-Feb	57	27-Apr	117	61	Still open 30-Jan
1986-87	12-Mar [b]	71				Still open 12-Mar
1987-88	24-Mar [b]	84				Still open 24-Mar
1988-89	17-Jan	17	27-Apr	117	100	
1989-90	21-Feb	52	25-Apr	115	64	
1990-91	04-Feb	35	01-Apr	91	57	
1991-92	27-Jan	27	10-May	131	103	
1992-93	23-Jan	23	31-Mar	90	68	
1993-94	25-Feb	56	04-Apr	94	39	
1994-95	24-Jan	24	28-Apr	118	94	
Total		522		1599		
Min	16-Jan		01-Apr		39	
Avg	9-Feb	40	24-Apr	114	74	
Max	24-Mar		20-May		103	

[a] Most data is anecdotal, provided by pilots from local air charter companies (R. Russell, Alaska Department of Fish and Game, King Salmon, personal communication).

[b] Last date area was observed with open water; may have frozen over even later.

Appendix A.3. Ice covered data for Upper and Lower Ugashik Lakes, 1970 - 1995.

Winter Of	Freeze-up Date [a] (dd/mmm)	Julian Day	Break-up Date [a] (dd/mmm)	Julian Day	Total Days of Ice Cover	Comments [a]
1969-70						
1970-71						Long, cold winter.
1971-72						
1972-73						
1973-74						
1974-75						
1975-76						
1976-77			06-Apr	96		
1977-78						
1978-79						
1979-80						
1980-81						Still open 16-Dec
1981-82			12-May	132		
1982-83	18-Jan	18				Partially open 31-Mar
1983-84	16-Jan [b]	16				
1984-85	11-Feb	42	14-May	134	93	
1985-86	26-Feb	57	09-May	129	73	
1986-87	12-Mar [b]	71				
1987-88	09-Dec	22	24-Mar	84	105	
1988-89	17-Jan	17	10-May	130	113	
1989-90	21-Feb	52	25-Apr	115	64	
1990-91	08-Jan	8				
1991-92	27-Jan	27	04-May	125	97	
1992-93	20-Jan	20	31-Mar	90	71	
1993-94	16-Feb	47	08-Apr	98	52	
1994-95	24-Jan	24	28-Apr	118	94	
Total		421		1251		
Min	09-Dec		24-Mar		52	
Avg	01-Feb	32	24-Apr	114	85	
Max	12-Mar		14-May		113	

[a] Most data is anecdotal, provided by pilots from local air charter companies (R. Russell, Alaska Department of Fish and Game, King Salmon, personal communication).

[b] Last date area was observed with open water; may have frozen over even later.

APPENDIX B. SMOLT AND PREDATORY BIRD OBSERVATIONS

The Egegik River smolt crew reported that they did not observe any birds actually catching smolt at their sonar site in 1995. However the following birds were observed fishing in the general area (presumably for smolt): red-breasted mergansers *Mergus serrator*, common mergansers *Mergus merganser*, and Arctic loons *Gavia arctica*. Arctic terns *Sterna paradisaea* were occasionally observed diving on and capturing smolt at the fyke net site below the outlet of Becharof Lake. Overall, bird activity was not a good indicator of the presence or absence of smolt at the Egegik River smolt project in 1995.

The Ugashik River smolt crew reported that observations of Mew gulls *Larus canus* and Glaucous-wing gulls *Larus glaucescens* actively fishing at their sonar site were a good indicator of the presence or absence of smolt and their relative abundance. Typically, if there were no gulls feeding there were no smolt counts on the sonar. Two-to-three gulls fishing at the site equated to a moderate smolt passage and 10 to 12 gulls actively feeding indicated a major passage of smolt. Arctic terns maintained a constant presence at the Ugashik sonar site. During periods of peak smolt passages, a pair of parasitic jaegers *Stercorarius parasiticus* were frequently observed chasing gulls and terns in attempts to steal their smolt catch. Ducks such as Oldsquaw *Clangula byemalis,* and mergansers *sp.* were regularly observed feeding in the side channels below the sonar site. Surf scoters *Melanitta perspicillata* and loons *sp.* usually fished in Lower Ugashik Lake and would occasionally move toward the outlet of the lake just prior to peak passages of smolt.

Due to early difficulties with ice and later recurring equipment problems, few reports were received from the Kvichak River smolt crew on bird activity in 1995. No observations were reported of birds feeding on smolt prior to the start of the project, however as soon as the sonar was activated it began registering high counts immediately. Therefore the lack of bird feeding activity at Igiugig was not a good indicator of the presence or absence of smolt this year. During the peak of the smolt passage, the crew reported seeing Arctic terns and mergansers *sp.* actively feeding (presumably on smolt) at the sonar site.