

BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES FOR 1998

by

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and

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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 1998. 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 295,470,850 from Kvichak River, 78,791,125 from Egegik River, and 12,624,441 from Ugashik River. Age-1. smolt, the progeny of 1996 spawners, predominated at Kvichak River (65%), Egegik River (64%), and Ugashik River (82%). The remainders were largely age-2. smolt, the progeny of 1995 spawners.

KEYWORDS: smolt, sockeye salmon, *Oncorhynchus nerka*, Bristol Bay, Kvichak River, Egegik River, Ugashik River, sonar, smolt emigration estimate, outmigration timing, age-length-weight relationship

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 1978 to 1997 the commercial catch in Bristol Bay averaged 25.4 million sockeye salmon (K. Weiland, 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 pre-season 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 (sonar) equipment.

Hydroacoustic equipment was used to estimate sockeye salmon smolt numbers on Kvichak River from 1971 through 1998; Wood River from 1975 to 1990; Naknek River from 1982 to 1986 and 1993 to 1994; Egegik River from 1982 through 1998; Ugashik River from 1983 to 1991 and 1993 to 1998; 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; Weolington et al. 1990, 1991; Crawford et al. 1992; Crawford and Cross 1992, 1994a, 1994b, 1995a, 1995b, 1996, 1997, 1998).

Hydroacoustic equipment developed by Bendix Corporation² 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 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

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

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 bank³ (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.

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, encompassing 88%-90% of the total 134-m river cross section. In comparison, the three arrays of the upward-looking sonar encompassed about 7.5% of the river. The spatial distributions 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.

The smolt migration on Ugashik River was not monitored in 1992 (Crawford and Cross 1992). 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; the City of Pilot Point, Lake and Peninsula Borough, and ADF&G in 1995; the Lake and Peninsula Borough, and ADF&G in 1996; and the City of Pilot Point, Lake and Peninsula Borough, and ADF&G in 1997 and 1998 allowed for

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.

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. These organizations also wanted a continuation of the historical Ugashik River sockeye salmon smolt database 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 was summarized in Crawford and Cross (1995b).

Upward-looking sonar studies were conducted on Kvichak, Egegik, and Ugashik Rivers in 1998 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 1998; 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 Corporation², Model 5095 transducers that 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. A single 12-volt battery recharged by a pair of 43 watt, 2.9 amp solar panels, powered each smolt counting system.

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 1998 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, snow, 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.

Site location and equipment changes that have been made over the years to improve our ability to enumerate annual sockeye salmon smolt outmigrations using sonar are summarized in Crawford and Cross (1996, 1997, 1998).

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 134 m wide at this site. Three transducer arrays referred to as *inshore*, *center*, and *offshore*, were anchored 49 m, 70 m, and 98 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 was 108 m wide at this site. The inshore, center and offshore arrays were anchored 40 m, 55 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 44 m wide, only two arrays have been used. The inshore and offshore arrays were anchored 27 m and 32 m from the right bank (Figure 4).

Appendices A.1 to A.3 summarize river widths and locations of arrays at each river from 1989-1998.

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*. The velocity index at Kvichak River was measured at the center array and the velocity index at Ugashik River was measured at inshore array. At Egegik River, a buoyed flow meter anchored downriver of the center 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 Gurley², 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 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 were taken over each array at specified intervals and velocity correction factors (vcf_i) were then calculated:

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

where

$$\begin{aligned} v_i &= \text{velocity over array } i, \text{ and} \\ v_{index} &= \text{velocity over the velocity index array.} \end{aligned}$$

Adjustments to daily counts ($ac_{i,z}$) were then made for differences in river velocity:

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

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 several hours before and after the missing count.

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:

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

where

$$\begin{aligned} d_{i,z} &= \text{average water depth over array } i \text{ on day } z, \text{ and} \\ bw &= \text{transducer beam width in degrees (9° for all transducers).} \end{aligned}$$

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 (Appendix A.1, A.2, and A.3). 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). However, due to the changing water levels and faster river velocities at Kvichak River in 1998, the crew noticed that the schools of smolt seemed to be passing further away from the inshore bank. Therefore the inshore limit dead zone (e.g., the shallow or slack water area of the river that extends outward from the right river bank where little or no smolt passage was recorded or observed) was extended from 40' to 50' (Appendix A.1). 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:

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

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 salmon 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 1998 smolt occurred in 1996 for age-1. smolt, 1995 for age-2. smolt, and 1994 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 up to a maximum of 600 smolt each day for length and weight and up to 100 of those smolt for age (Bue and Eggers 1989).

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.

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.

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:

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

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

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

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

Estimation of Smolt Numbers

Numbers of smolt by age 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 ($S\hat{P}C$):

$$S\hat{P}C = \frac{BPC}{\hat{W}} , \quad 8$$

where BPC = biomass (g) per count.

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

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

The estimated contribution of age j smolt on day z ($\hat{N}_{j,z}$) was estimated by:

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

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

$$\hat{N}_{tot} = \sum \hat{N}_z , \quad 11$$

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

$$\hat{N}_{j,tot} = \sum \hat{N}_{j,z} . \quad 12$$

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 (°C) were recorded at 0800 and 2000 hours daily.

RESULTS

Kvichak River

A local resident reported that the ice on Lake Iliamna began breaking up during the third week in April (Dan Salmon, Igiugig resident, personal communication). On April 24, an estimated 5 mile by 20 mile sheet of ice was wedged at the outlet of Lake Iliamna. A strong SW wind on April 25-26 broke the ice free at the outlet and blew it back up the lake where it melted in place. The average reported break-up date for Lake Iliamna between 1971 and 1997 was May 14 (Appendix B.1). The lake ice break-up in 1998 was 19 d earlier than average.

ADF&G's Kvichak smolt personnel arrived in Igiugig on the evening of May 15; there was no ice in Lake Iliamna or the Kvichak River. From May 16-17, the crew observed no smolt or birds (e.g., Arctic terns *Sterna paradisaea*) feeding on smolt. The smolt counter was activated at 2400 hours on May 17 and it immediately began registering smolt counts. The smolt passage rate during the first 12 h of sonar operation ranged from 5 to 700 thousand smolt per hour for a daily total of 3.2 million smolt.

The first three fyke net sets on May 19 caught no sockeye salmon smolt (Appendix C.1). The fourth fyke net set, fished from 2400 hours on May 19 to 0150 hours on May 20, caught 500 sockeye smolt. All were age-2. See Appendices C.2 to C.4 for a complete summary of the 1998 Kvichak River fyke net catch by date, species, hour, and time fished. In addition to sockeye salmon smolt, other species captured in the fyke net were: threespine stickleback *Gasterosteus aculeatus*, ninespine stickleback *Pungitius pungitius*, pink salmon fry *Oncorhynchus gorboscha*, juvenile chinook salmon *O. tshawytscha*, juvenile lamprey (sp), juvenile coho salmon *O. kisutch*, broad whitefish *Coregonus nasus*, sculpin *Cottus sp.*, juvenile rainbow trout *Salmo gairdneri*, and juvenile northern pike *Esox lucius*.

River velocity measurements over the center index array, which were used to adjust the sonar counter firing rate, ranged from 1.2 to 1.5 m/s (4.0 to 5.0 ft/sec). The average river velocity in 1998 of 1.4 m/s (4.5 ft/sec) was slightly more than the recent 10-year average at the Kvichak River sonar site (Appendix D.1). Velocity correction factors (m/s) used for the three arrays were as follows:

Smolt Days	Inshore	Center	Offshore
May 17 - May 30	0.97	1.00	0.97
May 31 - June 09	0.94	1.00	0.95
June 10 - June 11	0.97	1.00	0.99
June 12	0.86	1.00	0.95

A total of 8,580,962 sonar counts were recorded at the Kvichak River counting site from May 17 to June 12, 1998 (Table 1). This year the sonar counts were distributed evenly over all three sonar arrays (inshore = 32%, center = 34%, and offshore = 34%). Daily sonar counts were highest from May 20 to May 29 when 77% of the total counts were recorded. The peak daily sonar count of 1,431,360 occurred on May 20. Over the course of the entire sampling season, 69% of the total sonar counts were obtained between 2000 hours and 0500 hours (Table 2); the peak hourly passage rate of 252,429 sonar counts per hour occurred at 2300 hours on May 29.

Based on sonar an estimated 295,470,850 sockeye salmon smolt migrated from Kvichak River in 1998 (Table 3). Age-1. smolt (1996 brood year) comprised 65% of the total smolt estimate and they were the predominant age class from May 23 to June 12. Age-2. smolt (1995 brood year) comprised the largest percentage of the daily counts from May 17-19 and on May 22. The highest daily smolt counts occurred on May 21. The smolt per count estimates based on mean smolt weights ranged from 3.5 to 6.3 with an average of 4.9 smolt per count (Table 4).

Age, weight, and length data were collected from 1,562 sockeye salmon smolt in 1998 (Table 5). All smolt sampled were age 1. or 2. Mean length was 90 mm for age-1. smolt and 112 mm for age-2. smolt. Mean weight was 6.7 g for age-1. smolt and 11.9 g for age-2. smolt. An additional 7,024 smolt were measured for length only (Table 6). The discriminating length calculated to differentiate age-1. from age-2. smolt was 100.53 mm.

Two hundred twenty-nine depth measurements were recorded for smolt schools passing over Kvichak River sonar arrays between May 17 and June 12 (Table 7). Schools passed at an average depth range of 33 cm to 89 cm below the surface. Average water depth over the sonar arrays ranged from 270 cm to 274 cm during the peak smolt passage. The difference in the depth of smolt passage by hour over each sonar array is shown in Figure 5.

River and weather conditions were recorded at the counting site from May 18 to June 13 (Table 8). There was no disabled time from lake-ice flows in the Kvichak River in 1998 and the weather was excellent for counting smolt. The smolt counter was disabled for 55.9 h (<9%) of the 636 h it operated in 1998 due to weather (Figure 6). Hail, rain squalls, strong NE winds, and wave action were the primary causes. Smolt days with 6 or more hours of disabled time due to weather were 5/19 (7 h), 5/26 (11 h), 6/04 (8 h), 6/06 (12 h), and 6/07 (9 h). Mean water temperature during the project was 6.3°C (range 2.0°C to 9.5°C). Mean daily water temperature during the peak of the smolt migration on May 20 was 3.5°C.

In 1998, the Kvichak River smolt sonar was also disabled for an additional 26.7 h due to boat traffic (Figure 7). Prior to the opening of the rainbow trout sport fishing season at 0001 hours on June 8th disable time due to boat traffic averaged 0.7 h/d. After the sport fish opening, disable time due to

boat traffic increased to an average of 2.5 h/d. Peak passage times for boat traffic were 0900, 1100, 1200, and 1800 hours.

Egegik River

Local pilots reported that the eastern half of Becharof Lake was ice-free during the second week of March and that the entire lake was ice-free by April 4 (R. Russell, ADF&G retired, personal communication). This was 18 d earlier than the 1975-1997 average reported break-up date for Becharof Lake of April 22 (Appendix B.2).

Starting on May 8, a seismic swarm of tectonic earthquakes were felt in King Salmon, Dillingham, Egegik, and Pilot Point (AEIC and AVO 1998). It began with five earthquakes that occurred between 4:30 PM and 10:59 PM Alaska Daylight Time (ADT) on May 8. The magnitude (M) of the initial earthquakes ranged from M 5.2 to M 4.7 and they were followed by dozens of smaller ones (e.g., M 2.0 to M 4.7 range) over the next four-to-five weeks. Epicenters of the earthquakes were located beneath the SW side of Becharof Lake, approximately 10-20 km (6-12 mi) NW of Ukinrek Maars⁴, and near the southern end of the Bruin Bay fault. Alaska Volcano Observatory scientists observed no signs of volcanic activity or surface breakage when they conducted an overflight of the swarm location on May 9th.

The first two Egegik River smolt crewmembers flew to the study site on the evening of May 15. There were no observations of smolt or birds feeding on smolt prior to the installation of the Egegik River smolt sonar counter at 2400 hours on May 18. There were very few smolt passing (mostly small isolated schools) during the first week of sonar operation; the first daily sonar count greater than 100,000 occurred on May 25.

The fyke net was installed and fished nightly from May 20-28, but few smolt ($n \leq 50$) were caught until after midnight on May 29 (Appendix C.5). From then on the fyke net routinely caught more than 100 smolt per set. For a complete summary of the 1998 Egegik River fyke net catch by date, species, hour, and time fished see Appendices C.6 to C.8. In addition to sockeye salmon smolt, the following other species were also captured in the fyke net: chum salmon fry *Oncorhynchus keta*, pink salmon fry, juvenile coho salmon, sculpin (sp), stickleback (sp), and juvenile lamprey (sp).

River velocities at the counting site ranged from 0.6 to 1.0 m/s (2.0 to 3.1 ft/sec). The river velocities at the center array were higher than the 1984-1997 average of 2.1 ft/sec (Appendix D.2). In 1998, 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:

⁴ Ukinrek Maars formed between March 30 and April 10, 1977 as a result of magmatic intrusion into water-saturated glacial till 2 km south of Gas Rocks on the south shore of Becharof Lake (Alaska Volcano Observatory 1998). During this 10-day period, violent explosions produced steam and ash plumes as high as 6,500 m and light ash fall as far as 160 km to the north. Carbon dioxide gas has been emitting continuously from Gas Rocks, beneath Becharof Lake, long before the Maars formed.

Smolt Days	Index Buoy	Inshore	Center	Offshore
May 18 - May 23	1.00	1.00	1.29	1.32
May 24 - May 30	1.00	0.86	1.06	1.07
May 31 - Jun 05	1.00	0.84	1.00	1.06
Jun 06 - Jun 10	1.00	0.80	1.03	1.07

A total of 5,354,020 sonar counts were recorded at the Egegik River counting site from May 18 to June 10, 1998 (Table 9). Sonar counts were most numerous over the center array (43%) followed by the offshore (38%) and inshore (19%) arrays. Daily sonar counts were highest from May 26-June 2. Eighty-three percent of the total sonar count was recorded during this eight-day period. The peak daily sonar count of 1,223,241 occurred on May 29. Over the course of the season, the largest hourly sonar counts were recorded from 2300 hours to 0700 hours (Table 10); 80% of all smolt counts were obtained during these times.

An estimated 78,791,125 sockeye salmon smolt migrated from Egegik River in 1998 based on sonar counts (Table 11). Age-1. smolt (1996 brood year) comprised 64% of the total smolt estimate and they were the predominant age class from May 18 to June 10. Age-2. smolt (1995 brood year) comprised 35% of the total smolt estimate. Age-3. smolt (1994 brood year) composed 1% of the total smolt estimate. Mean weight of smolt varied from 9.8 to 12.3 g per smolt (Table 12), resulting in an average 3.7 smolt per count adjustment factor to expand sonar counts.

Age, weight, and length data were collected from 1,261 sockeye salmon smolt in 1998 (Table 13). Age-1., -2., and -3. smolt were sampled. Mean length was 105 mm for age-1. smolt, 121 mm for age-2. smolt, and 132 mm for age-3. smolt. Mean weight was 9.0 g for age-1. smolt, 13.7 g for age-2. smolt, and 16.2 g for age-3. smolt. An additional 3,631 smolt were measured for length only (Table 14). Age-1. smolt were separated from age-2. smolt using a discriminating length of 117.31 mm.

Sixty depth measurements were recorded for smolt schools passing over Egegik River sonar arrays during peak smolt passages between May 27 and June 5 (Table 15). Most schools passed from 35 cm to 132 cm below the surface. Average water depth over the sonar arrays at this site ranged from 310 cm to 387 cm. The depth of smolt passage by hour for each array is shown in Figure 8.

River and weather conditions were recorded at the counting site from May 19 to June 11 (Table 16). The weather at the Egegik River sonar site was good for counting smolt in 1998. The smolt counter was disabled due to weather for 67.1 hours (12%) of the 564 hours it operated (Figure 9). Rain squalls and wave actions from strong SE winds were the primary causes. Smolt days with 6 or more hours of disabled time due to weather were: 5/25 (18 h), 5/26 (14 h), 6/04 (8 h), and 6/7 (24 h). Mean water temperature during the season was 4.9°C (range 2.5°C to 7.0°C). Mean daily water temperature during the peak of the smolt outmigration on May 29 was 5.0°C.

In 1998, the Egegik River smolt sonar was disabled for 0.3 h due to boat traffic.

Ugashik River

Local pilots reported that Upper Ugashik Lake and Lower Ugashik Lake were completely ice free by April 4 (R. Russell, ADF&G retired, King Salmon, personal communication). This was 17 d earlier than April 23, the 1976-1997 average reported break-up date of for these lakes (Appendix B.3).

In 1998, the first two Ugashik smolt crewmembers arrived at the study site in the evening on May 15 and the remaining crewmember arrived the next morning. There were no observations of smolt or gulls and terns actively feeding on smolt prior to the activation of the smolt sonar counter at 2400 hours on May 17 (C. Vicary, ADF&G, Ugashik Smolt Project, personal communication). Sonar counts during the first seven days of sonar operation were very low.

The first sockeye salmon smolt (n=104) were caught in the fyke net fished from 2336 hours to 0055 hours on May 19 (Appendix C.9). Complete summaries of the 1998 Ugashik River fyke net catch by date, species, hour, and time fished are presented in Appendices C.10 to C.12. Other species captured in the fyke net were: juvenile coho salmon, juvenile chinook salmon, stickleback (sp), and smelt (sp).

River velocity measurements over the inshore index array ranged from 1.9 to 2.6 m/s (6.3 to 8.6 ft/sec). By early June, the river velocities were the second highest recorded at the Ugashik River sonar site since 1983 (Appendix D.3). The average velocity in 1998 was 18% greater than the 1983-1997 average of 1.9 m/sec (6.2 ft/sec). 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 17 - May 23	1.00	1.03
May 24 - May 30	1.00	1.09
May 31 - Jun 05	1.00	1.01
Jun 06 - Jun 12	1.00	1.03

A total of 1,309,451 sonar counts were recorded at the Ugashik River sonar counting site from May 17 to June 12, 1998 (Table 17). Most counts (70%) were recorded over the offshore array. Daily sonar counts were highest from June 1-8 and June 12. Sixty-four percent of the total counts were recorded on these days. The peak daily sonar count of 211,915 occurred on June 5. Over the entire sampling season, 67% of all smolt counts were recorded between 2200 hours and 0400 hours with peak passages occurring between 2400 hours and 0300 hours (Table 18).

Based on sonar counts an estimated 12,624,441 sockeye salmon smolt migrated from Ugashik River in 1998 (Table 19). Age-1. smolt (1996 brood year) comprised 82% of the total smolt estimate and they were the predominant age class throughout the sampling period. Age-2. smolt (1995 brood year) composed 18% of the total migration and they were most numerous on June 1 and from May 22-27. Mean weights of smolt ranged from 6.5 to 9.4 g per smolt (Table 20), resulting in an average 5.5 smolt per count adjustment factor for expansion of sonar counts.

Age, weight, and length data were collected from 459 sockeye salmon smolt in 1998 (Table 21). Mean length was 91 mm for age-1. smolt and 110 mm for age-2. smolt. Mean weight was 6.4 g for age-1. smolt and 11.1 g for age-2. smolt. An additional 2,413 sockeye salmon smolt were sampled for length only (Table 22). A discriminating length of 103.5 mm was calculated to differentiate age-1. smolt from age-2. smolt at Ugashik River.

Fifty-one depth measurements were recorded for smolt schools passing over Ugashik River sonar arrays between May 24 and June 12 (Table 23). Schools passed at an average depth of 9 cm to 53 cm below the surface. Average water depth over the sonar arrays at this site ranged from 287 cm to 305 cm during the peak smolt passage. The depth of smolt passage by hour for each array shown in Figure 10.

River and weather conditions were recorded at the counting site from May 18 to June 13 (Table 24). The weather was generally fair for enumerating sockeye salmon smolt emigrating from Upper and Lower Ugashik Lakes in 1998. The smolt counter was disabled for 148.0 h (23%) of the 636 h it operated in 1998 due to weather (Figure 11). Snow, hail, rain squalls, wave action, and entrained air in the water column from strong SE, ESE, and E winds were the primary causes. Smolt days with 6 or more hours of disabled time due to weather were: 5/22 (7 h), 5/25 (24 h), 5/26 (21 h), 5/29 (16 h), 6/04 (19 h), 6/06 (9 h), 6/07 (21 h), and 6/10 (13 h). Average water temperature was 5.5°C (range 3.5°C to 7.5°C). The mean water temperature during the peak of the smolt outmigration, on June 5, was 6.5°C.

During 1998, Ugashik River smolt sonar counters were also disabled for 7.4 h due to equipment problems (Figure 12) and 2.9 h due to boat-and-floatplane traffic.

DISCUSSION

Kvichak River

The 1998 smolt outmigration estimate of 295,470,850 smolt is the fourth largest smolt outmigration estimate ever recorded at the Kvichak River sonar site (Appendices E.1 and E.2). Four out of the last five years have had smolt outmigrations greater than the 1983-1997 average of 165,835,183 smolt. All smolt outmigration estimates since 1994 have been composed primarily of age-1. smolt.

Comparing the percent of the total adjusted sonar count by smolt day for 1998 with the 1988-1997 mean it appears that the timing of the peak count was 7 d early (Figure 13). A comparison of the 1998 cumulative percent of the total adjusted sonar count by smolt day with the 1988-1997 mean shows that the timing for the front end (25%) of the smolt outmigration was 4 d early, the mid-point (50%) of the smolt outmigration was 5 d early, and the later portion (75%) of the smolt outmigration was 6 d early (Figure 14).

During past outmigrations the proportion of age-2. smolt have been higher early in the season. Therefore, since break-up was 19 d early in 1998 and we have no smolt counts for the first 20 days of the open-water season, we must wait until the age-2.2 adult sockeye salmon return to the Kvichak River in 2000 to find out whether the current estimate of age-2. smolt for the 1995 brood year was accurate or if the majority of age-2. smolt passed the sonar site prior to the start of the 1998 project.

The graph of the percent of the total adjusted sonar count by hour for 1998 is similar to the graph of the 1988-1997 mean count per hour (Figure 15). Some minor differences were fewer smolt passed from 0800 hours to 1900 hour this year and more smolt passed between 2000 hours and 0400 hours with the exception of 0200 hours.

Age-1. smolt in 1998 were 3% longer and 14% heavier than the 1955-1997 mean (Table 25). Age-2. smolt were 5% longer and 14% heavier than the 1955-1997 mean.

The mean water temperature in 1998 was 5% warmer (NSC) than the 1963-1997 mean of 5.9°C (Table 26). The mean daily water temperature when the Kvichak River sonar project began this year was 1.6°C colder than the recent 14-year average of 4.6°C (Appendix F.1). On May 25, the peak of the 1998 smolt passage, the mean daily water temperature was 2.1°C colder than the 1984-1997 mean. For other climatological factors that may have affected the freshwater survival of smolt that outmigrated in 1998 see Appendix G.

The most recent brood year of sockeye salmon which spawned in the Kvichak River drainage and has had all of its offspring outmigrate from freshwater spawning and rearing areas to the marine environment is brood year 1994. A comparison of total smolt outmigration estimates by age with the 1994 brood year escapement of 8,337,840 sockeye salmon showed a freshwater survival rate of approximately 44.47 smolt per spawner (Table 27). Since we expect no catch of age-3. smolt at Kvichak River in 1999, the freshwater survival rate for the 1995 brood year escapement of 10,038,720 sockeye salmon should remain at 37.14 smolt per spawner. Smolt-per-spawner estimates for 1994 and 1995 were both greater than the recent ten-year average for Kvichak River; mean production from brood years 1984-1993 was 27.29 smolt per spawner.

Nineteen ninety-one (1991) was the most recent brood year of sockeye salmon to have all age groups of adults return from the marine environment to the Kvichak River drainage to spawn. A comparison of smolt outmigration estimates by age with corresponding adult returns for brood years 1982-1991 (Table 28) shows an average marine survival (i.e. adult salmon returns per smolt) of 0.14 for age-1. smolt and 0.18 for age-2. smolt. For brood year 1992, the last adult sockeye salmon (e.g., ages 2.3 and 3.3) will return to the Kvichak River in 1999 as 7-year-old fish. Since 7-year-old fish historically compose < 1% of the total sockeye salmon return to the Kvichak River, it would be appropriate to note that the average marine survival for brood year 1992 age-1. (0.01) and age-2. smolt (0.07) are both well below the 1982-1991 averages.

A comparison of the age composition of sockeye salmon smolt from the Kvichak River with the freshwater age composition of the total adult returns shows close comparison for brood years 1984, 1985, 1988, and 1990 (Figure 16). For example in brood year 1984, 20% of the smolt were estimated to be age-1. and 80% of the smolt were estimated to be age-2. Analysis of the freshwater

age of the total adult return for the 1984 brood year showed 19% age-1. and 81% age-2. However, the freshwater age relationship between smolt and adults does not always hold true. In brood years 1982, 1986, 1987, and 1989, estimates of smolt age composition were significantly higher for age-1. smolt and lower for age-2. smolt than adult returns (Table 29). Similarly, in brood years 1983 and 1991, smolt age composition showed lower percentages of age-1. and greater percentages of age-2. smolt than the age composition of the adult return.

If the fyke net catches a representative sample of outmigrating smolt and smolt survival rates by age are equal, then you would expect the freshwater age composition of the smolt to match the freshwater age composition of the total adult return from corresponding brood years. However, there is strong evidence that survival rates are higher for the larger age-2. smolt than for the smaller age-1. smolt (Table 28). Differences in freshwater age composition between smolt and their corresponding adult return can be attributed to a number of factors including: (1) differential survival rates of smolt by age; (2) errors in estimates of smolt age composition; (3) errors in estimates of adult total return age composition; and (4) inaccurate estimates of numbers of smolt by age due to not counting the early or late portions of the outmigration.

To determine if there were any major changes in the way fyke net data were collected at the 1998 Kvichak River smolt project, fyke net data from 1996 (Appendices C.13 to C.15) and 1997 (Appendices C.16 to C.18) were summarized and compared to the current year (Appendices C.2 to C.4). Based on this comparison, the fyke net was fished less time per day in 1998 (6.7 h /d average) than in 1996 (9.3 h/d average) or 1997 (12.9 h/d average). However, the overall catch of sockeye salmon smolt in 1998 (n = 31,887) was greater than or comparable to the other two years in which more effort was expended in trying to catch smolt. By spending less time fishing during hours with lower smolt abundance (e.g., 0700-2100 hours), it appears that the fyke net sampling strategy employed in 1998 was more efficient.

Egegik River

The 1998 Egegik River smolt outmigration estimate was 44% larger than the 1983-1997 average of 54,606,535 smolt (Appendices E.3 and E.4). Three of the last five years have had smolt outmigrations greater than or equal to the 1983-1997 average, however 1996 and 1997 were well below average. Age-1. smolt have been the predominant age class outmigrating from the Egegik River in three of the last five years.

Comparing the percent of the total adjusted sonar count by smolt day for 1998 with the 1988-1997 mean, the timing of the peak count in 1998 appeared to be 4 d later than average (Figure 17). A comparison of the cumulative percent of the total adjusted sonar count by smolt day for 1998 with the 1988-1997 mean shows that the timing for the front end (25%) of the smolt outmigration was 4 d late, the mid-point (50%) of the smolt outmigration was 3 d late, and the later portion (75%) of the smolt outmigration was 2 d later than average (Figure 18).

To see if the earthquake activity beneath Becharof Lake in May-June 1998 effected outmigrating sockeye salmon smolts, AEIC (1998) and NEIC (1998) earthquake data (Appendix H.1) were

compared with hourly smolt sonar counts at Egegik River (Appendices H.2 to H.10). This exercise produced no apparent relationship. Although we are unable to detect any immediate effect, it may be interesting to see if this earthquake activity has any effect on Becharof Lake smolt production in future years.

The graph of the percent of the total adjusted sonar count by hour for 1998 was similar to the 1988-1997 mean, however it peaked at 2400 hours rather than 0300 hours (Figure 19).

Age-1. smolt in 1998 were slightly longer and weighed 7% less than the 1939-1997 mean (Table 30). Age-2. smolt were also slightly longer than the historical mean and weighed 4% less; age-3. smolt were the same length and weighed 20% less.

The mean water temperature in 1998 was 25% colder than the 1981-1997 average of 6.5 °C (Table 31). The mean daily water temperature when the Egegik River sonar was activated was 0.3 °C cooler than the 1984-1997 average (Appendix F.2). During the peak smolt passage on May 29, the mean daily water temperature remained 0.3 °C colder than the 1984-1997 average of 5.6 °C. The colder water temperature this year may have contributed to the later timing of the 1998 smolt outmigration. Other climatological factors that may have affected the freshwater survival of 1998 smolt are discussed in Appendix G.

In the Egegik River drainage, the most recent brood year of sockeye salmon that has spawned and outmigrated as smolt from freshwater to the marine environment is brood year 1994. A comparison of total smolt outmigration estimates by age with the 1994 brood year escapement of 1,897,932 sockeye salmon showed a freshwater survival rate of approximately 19.95 smolt per spawner (Table 32). Since we expect age-3. smolt to comprise < 3% of the total smolt outmigration at Egegik River in 1999, the freshwater survival rate for the 1995 brood year escapement of 1,265,862 sockeye salmon should remain at 31.36 smolt per spawner. Smolt-per-spawner estimates for 1994 and 1995 were both below the recent ten-year average for Egegik River; mean production from brood years 1984-1993 was 39.78 smolt per spawner.

Nineteen ninety-one (1991) was the most recent brood year of sockeye salmon to have all age groups of adults return from the marine environment to the Egegik River drainage to spawn. A comparison of smolt outmigration estimates by age with corresponding adult returns for brood years 1982-1991 (Table 33) shows an average marine survival (i.e. adult salmon returns per smolt) of 0.22 for age-1. smolt and 0.32 for age-2. smolt. For brood year 1992, the last adult sockeye salmon (e.g., ages 2.3 and 3.3) will return to the Egegik River in 1999 as 7-year-old fish. Seven year old fish historically composed < 1% of the total sockeye salmon return to the Egegik River, therefore the average marine survival for brood year 1992 age-1. (0.03) and age-2. smolt (0.16) will remain well below the 1982-1991 averages.

A comparison of the age composition of outmigrating sockeye salmon smolt at Egegik River with the freshwater age composition of the total adult returns shows similarities ($\pm 15\%$) for brood years 1982, 1984, 1985, 1988, 1989, 1990 and 1991 (Figure 20, Table 34). However, as we saw at Kvichak River, the smolt to adult freshwater age relationship does vary. In brood year 1983, 1986, and 1987, smolt age composition showed a higher percentage of age-1. smolt and a lower percentage of age-2. smolt than the adult returns. Only two brood years, 1988 and 1991, had smolt

age compositions with lower percentages of age-1. and higher percentages of age-2. smolt than the corresponding adult returns.

Ugashik River

The 1998 smolt outmigration of 12,624,441 smolt is the second lowest estimate recorded at the Ugashik River smolt sonar site (Appendices E.5 and E.6). All smolt outmigrations from Ugashik River in the last five years have been smaller than the 1983-1997 average of 66,221,793 smolt. Three of the last five years have had smolt outmigrations composed primarily of age-1. smolt.

Comparing the percent of the total adjusted sonar count by smolt day for 1998 with the 1988-1997 mean, it appears that the timing of the peak counts was 7 d late (Figure 21). A comparison of the cumulative percent of the total adjusted sonar count by smolt day with the 1988-1997 mean shows that the timing for the front end (25%) of the smolt outmigration was 5 d late, the mid-point (50%) of the smolt outmigration was 6 d late, and the later portion (75%) of the smolt outmigration was 3 d later than average (Figure 22). Judging from the gentle slope of the cumulative curve during the first 7 d of the project, we probably counted most of the smolt on the front end of the outmigration. The steep slope of the cumulative curve on the last day of the project indicates we probably missed some smolt on the back end of the outmigration. However, even with a few extra smolt added to the back end of the outmigration, this years smolt outmigration estimate is still well below the historical average. The graph of the percent of the total adjusted sonar count by hour for 1998 was very similar to the graph of the 1988-1997 mean count per hour (Figure 23).

The dominant age groups of adult sockeye salmon from the 1998 smolt outmigration will return in 2000 (ages 1.2 and 2.2 fish) and 2001 (ages 1.3 and 2.3 fish).

Age-1. smolt in 1998 were the same length as the 1958-1997 mean, but weighed 8% less (Table 35). Age-2. smolt were 1% shorter and weighed 8% less than the 1958-1997 mean.

The mean water temperature in 1998 was 9% colder than the 1983-1997 mean of 6.0 °C (Table 36). The average daily water temperature when the sonar was activated this year was 3.5 °C which is 0.7 °C colder than the 1984-1997 average (Appendix F.3). At the peak of the 1998 smolt passage on June 5 the mean daily water temperature was 6.0 °C, the same as the 1984-1997 average. See Appendix G for other climatological factors that may have affected the freshwater survival of smolt that outmigrated in 1998.

In the Ugashik River drainage, 1994 is the most recent brood year of sockeye salmon that has spawned and outmigrated as smolt from freshwater to the marine environment. A comparison of total smolt outmigration estimates by age with the 1994 brood year escapement of 1,080,858 sockeye salmon showed a freshwater survival rate of approximately 2.17 smolt per spawner (Table 37). Since we expect no catch of age-3. smolt at Ugashik River in 1999, the freshwater survival rate for the 1995 brood year escapement of 1,304,058 sockeye salmon should remain at 12.74 smolt per spawner. Smolt-per-spawner estimates for 1994 and 1995 were both well below than the recent

ten-year average for Ugashik River; mean production from brood years 1984-1993 was 80.93 smolt per spawner.

Nineteen ninety-one (1991) was the most recent brood year of sockeye salmon to have all age groups of adults return from the marine environment to the Ugashik River drainage to spawn. A comparison of smolt outmigration estimates by age with corresponding adult returns for brood years 1982-1991 (Table 38) shows an average marine survival (i.e. adult salmon returns per smolt) of 0.07 for age-1. smolt and 0.13 for age-2. smolt. For brood year 1992, the last adult sockeye salmon (e.g., ages 2.3 and 3.3) will return to the Ugashik River in 1999 as 7-year-old fish. Seven-year-old fish historically make up < 1% of the total sockeye salmon return to the Ugashik River. Therefore, the average marine survival for age-1. smolt from brood year 1992 (0.03) should remain at less than half of the 1982-1991 average for Ugashik River and the average marine survival of age-2. smolt (0.12) will almost equal the 1982-1991 average.

A comparison of the age composition of outmigrating smolt at Ugashik River with the freshwater age composition of the total adult salmon return showed similarities ($\pm 5\%$) for brood years 1983, 1988, and 1991 (Figure 24, Table 39). In brood year 1985, age composition estimates from outmigrating smolt showed a lower percentage of age-1. smolt and a higher percentage of age-2. smolt compared to returning adults. In brood years, 1982, 1984, 1986, and 1987 smolt age composition data showed higher percentages of age-1. smolt and lower percentages of age-2. smolt compared to adult returns.

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Table 1. Sonar counts by smolt day and array at the sockeye salmon smolt counting site on Kvichak River, 1998.

Smolt Day ^a	Sonar Count			
	Transducer Array			Total
	Inshore	Center	Offshore	
5/17 ^b	47,255	46,353	36,395	130,003
5/18 ^c	90,263	75,208	50,111	215,582
5/19 ^c	92,564	103,184	118,004	313,752
5/20 ^d	529,066	471,510	430,784	1,431,360
5/21	556,650	462,534	346,168	1,365,352
5/22	79,624	110,060	74,315	263,999
5/23	6,519	5,754	4,291	16,564
5/24	59,335	84,876	145,413	289,624
5/25	476,010	508,762	410,344	1,395,116
5/26 ^c	105,340	129,997	178,905	414,242
5/27 ^c	71,211	92,071	97,229	260,511
5/28	17,510	27,301	40,224	85,035
5/29 ^c	217,687	355,469	535,860	1,109,016
5/30	31,049	39,752	26,408	97,209
5/31	1,330	1,781	1,988	5,099
6/01	96,481	91,682	159,167	347,330
6/02	81,415	85,043	104,638	271,096
6/03	42,942	43,215	31,218	117,375
6/04 ^c	12,513	13,180	16,227	41,920
6/05 ^c	4,073	7,476	16,265	27,814
6/06 ^c	6,750	7,054	10,576	24,380
6/07 ^{c^e}	7,579	14,355	34,574	56,508
6/08 ^e	25,391	32,224	40,475	98,090
6/09 ^e	7,162	5,018	7,921	20,101
6/10 ^e	37,825	41,001	41,917	120,743
6/11 ^{c^e}	15,175	11,079	6,925	33,179
6/12 ^e	10,041	7,560	12,361	29,962
Total	2,728,760	2,873,499	2,978,703	8,580,962
Percent	31.8	33.5	34.7	

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

^b Sonar counter was activated at 2400 hours on May 17.

^c Sonar counts interpolated for one or more arrays for the following periods:

- 1100-1159 hours on smolt day 5/18 due to hail
- 1200-1859 hours on smolt day 5/19 due to hail and rain
- 2100-2259 and 2400-1159 hours on smolt day 5/26 due to rain and high NE winds
- 0900-1159 hours on smolt day 5/28 due to high NE wind and waves
- 1200-1259 hours on smolt day 5/29 due to high NE wind and waves
- 2000-0359 hours on smolt day 6/04 due to high NE wind, waves, and rain
- 2400-1159 hours on smolt day 6/06 due to high NNE wind and rain
- 1200-1759 and 2000-2259 hours on smolt day 6/07 due to high NNE winds
- 1400-1659 hours on smolt day 6/10 due to high NNE winds
- 1400-1659 hours on smolt day 6/11 due to rain

^d Peak daily smolt passage for 1998.

^e Rainbow trout *Salmo gairdneri* sport fishing season opened at 0001 hours on June 8. Increased boat traffic during this period caused 13.3 h of sonar disabled time. The smolt days with the highest disabled time from boat traffic were: 6/09 (3.6 h), 6/10 (2.3 h), and 6/08 (2.2 h). The hours with the the highest disabled time from boat traffic were: 0900 (2.0 h) 1100 (1.9 h), 1200 (1.9 h), and 1800 (2.0 h).

Table 2. Sonar counts by hour and array at the sockeye salmon smolt counting site on Kvichak River, 1998.

Sonar Operating Period	Hour	Sonar Count				Hourly Percent
		Transducer Array			Total	
		Inshore	Center	Offshore		
	1200	55,029	57,143	25,257	137,429	1.60
	1300	60,067	60,334	49,207	169,608	1.98
	1400	56,489	68,432	54,636	179,557	2.09
	1500	75,021	61,265	45,022	181,307	2.11
	1600	59,290	79,639	44,949	183,878	2.14
	1700	68,175	72,196	68,863	209,234	2.44
	1800	98,849	84,659	66,923	250,430	2.92
	1900	96,483	88,505	59,320	244,308	2.85
	2000	196,012	112,396	64,019	372,427	4.34
Smolt	2100	225,319	133,252	65,049	423,619	4.94
Days	2200	236,907	208,486	141,716	587,109	6.84
5/17	2300 ^b	156,796	205,326	308,726	670,847	7.82
to	2400 ^c	183,673	261,006	294,802	739,481	8.62
6/12	0100 ^c	161,047	249,291	363,287	773,625	9.02
	0200 ^c	169,068	244,127	322,802	735,997	8.58
	0300 ^c	205,686	237,567	266,392	709,645	8.27
	0400 ^c	247,813	175,541	160,297	583,651	6.80
	0500 ^c	164,882	103,455	91,043	359,380	4.19
	0600 ^b	67,791	82,631	94,472	244,894	2.85
	0700	46,560	64,322	100,838	211,720	2.47
	0800	20,605	59,399	88,345	168,349	1.96
	0900	23,001	53,161	64,191	140,354	1.64
	1000	29,202	52,383	77,034	158,619	1.85
	1100	24,995	58,986	61,512	145,494	1.70
Total		2,728,760	2,873,498	2,978,703	8,580,961	100.00

^a Daylight hours unless indicated otherwise

^b Twilight hours

^c Hours of darkness

Table 3. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Kvichak River, 1998.

Smolt Day ^a	Age 1.			Age 2.			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5/17	748,566	23.1	748,566	2,497,600	76.9	2,497,600	3,246,166	3,246,166
5/18	1,240,379	23.1	1,988,945	4,138,542	76.9	6,636,142	5,378,921	8,625,087
5/19	1,815,189	23.1	3,804,134	6,056,405	76.9	12,692,547	7,871,594	16,496,681
5/20	23,633,066	53.4	27,437,200	20,631,901	46.6	33,324,448	44,264,967	60,761,648
5/21	30,528,281	65.0	57,965,481	16,409,420	35.0	49,733,868	46,937,701	107,699,349
5/22	2,772,076	38.7	60,737,557	4,398,322	61.3	54,132,190	7,170,398	114,869,747
5/23	337,362	61.2	61,074,919	213,793	38.8	54,345,983	551,155	115,420,902
5/24	5,923,201	61.2	66,998,120	3,753,650	38.8	58,099,633	9,676,851	125,097,753
5/25	37,343,185	72.6	104,341,305	14,114,972	27.4	72,214,605	51,458,157	176,555,910
5/26	10,491,306	70.0	114,832,611	4,489,853	30.0	76,704,458	14,981,159	191,537,069
5/27	6,368,803	68.0	121,201,414	2,997,084	32.0	79,701,542	9,365,887	200,902,956
5/28	2,143,009	68.6	123,344,423	980,455	31.4	80,681,997	3,123,464	204,026,420
5/29	28,140,728	68.6	151,485,151	12,874,762	31.4	93,556,759	41,015,490	245,041,910
5/30	3,181,221	81.2	154,666,372	736,538	18.8	94,293,297	3,917,759	248,959,669
5/31	165,682	81.2	154,832,054	38,360	18.8	94,331,657	204,042	249,163,711
6/01	11,329,253	81.2	166,161,307	2,623,029	18.8	96,954,686	13,952,282	263,115,993
6/02	10,023,418	87.5	176,184,725	1,426,682	12.5	98,381,368	11,450,100	274,566,093
6/03	4,619,606	89.2	180,804,331	559,905	10.8	98,941,273	5,179,511	279,745,604
6/04	938,256	66.4	181,742,587	474,993	33.6	99,416,266	1,413,249	281,158,853
6/05	626,839	66.4	182,369,426	317,338	33.6	99,733,604	944,177	282,103,030
6/06	544,835	66.4	182,914,261	275,823	33.6	100,009,427	820,658	282,923,688
6/07	1,273,621	66.4	184,187,882	644,771	33.6	100,654,198	1,918,392	284,842,080
6/08	2,526,187	73.4	186,714,069	915,484	26.6	101,569,682	3,441,671	288,283,751
6/09	517,742	73.4	187,231,811	187,628	26.6	101,757,310	705,370	288,989,121
6/10	3,151,241	73.4	190,383,052	1,142,003	26.6	102,899,313	4,293,244	293,282,365
6/11	862,482	73.4	191,245,534	312,561	26.6	103,211,874	1,175,043	294,457,408
6/12	743,867	73.4	191,989,401	269,575	26.6	103,481,449	1,013,442	295,470,850
	191,989,401	65.0		103,481,449	35.0		295,470,850	

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

Table 4. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Kvichak River, 1998.

Smolt Day ^a	Mean Weight of Smolt (g)	Smolt per Count
5/17	11.9	3.5
5/18	11.9	3.5
5/19	11.9	3.5
5/20	9.6	4.3
5/21	8.6	4.8
5/22	10.9	3.8
5/23	9.0	4.6
5/24	9.0	4.6
5/25	8.0	5.2
5/26	8.3	5.0
5/27	8.3	5.0
5/28	8.1	5.1
5/29	8.1	5.1
5/30	7.3	5.7
5/31	7.3	5.7
6/01	7.3	5.7
6/02	6.9	6.0
6/03	6.6	6.3
6/04	8.7	4.8
6/05	8.7	4.8
6/06	8.7	4.8
6/07	8.7	4.8
6/08	8.2	5.0
6/09	8.2	5.0
6/10	8.2	5.0
6/11	8.2	5.0
6/12	8.2	5.0

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

Table 5. Mean fork length and weight of sockeye salmon smolt captured by fyke net, Kvichak River, 1998.

Smolt Day ^a	Age 1.					Age 2.				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5/19	93	7.3	7.3	1.17	11	117	15.5	14.1	5.28	89
5/20	91	9.4	6.6	2.75	60	114	17.6	12.7	5.81	39
5/21	91	9.9	6.9	2.36	44	114	13.8	12.7	5.07	56
5/22	90	12.6	7.7	3.60	57	113	14.2	13.5	4.75	43
5/23	91	6.8	7.5	2.31	41	110	12.2	11.9	2.84	9
5/24	92	16.7	7.3	3.61	59	112	14.3	11.9	4.50	41
5/25	90	10.2	6.8	2.39	76	111	16.1	11.3	4.14	23
5/26	90	8.0	6.8	2.20	77	109	13.2	11.3	3.94	17
5/27	90	12.9	6.9	2.85	62	114	17.2	12.6	4.84	38
5/28	89	14.7	6.0	2.72	34	110	14.6	10.2	3.56	14
5/29	90	13.0	5.9	4.11	78	112	10.7	11.1	3.49	21
5/31	87	11.5	6.2	2.78	59	111	10.9	11.2	3.77	11
6/01	88	8.7	6.0	2.07	81	109	8.7	10.7	2.55	19
6/02	86	15.4	5.7	2.94	91	109	8.3	11.0	2.45	9
6/03	86	14.1	5.9	2.73	99	110	0.0	11.1	0.00	1
6/05	89	13.2	6.4	2.71	53	112	8.3	11.7	3.04	7
6/07	94	5.2	7.4	1.02	11	116	10.3	13.9	3.34	29
6/08	91	7.9	6.8	1.84	35	112	9.3	11.8	2.51	5
6/10	90	9.9	7.0	2.21	25	102	14.7	11.0	2.61	5
6/11	90	5.1	6.6	1.26	29	115	8.9	11.7	2.72	4
Total Mean	90		6.7		1,082	112		11.9		480

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

Table 6. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Kvichak River, 1998.

Smolt Day ^b	Age 1. ^a				Age 2. ^a			
	Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size	Mean Length (mm)	Std. Error	Estimated Mean Weight (g)	Sample Size
5/19	90	14.3	6.7	148	116	25.4	13.2	401
5/20	90	17.9	6.6	364	115	23.9	13.1	286
5/21	90	16.7	6.5	468	113	20.8	12.4	217
5/22	92	13.7	7.0	172	115	24.3	13.1	348
5/23	89	11.6	6.4	103	111	1.2	11.7	4
5/24	91	13.8	6.8	211	112	19.2	12.2	159
5/25	89	21.1	6.4	466	111	20.2	11.8	134
5/26	89	14.6	6.5	275	111	21.6	11.9	94
5/27	88	18.9	6.3	266	111	15.7	11.8	97
5/28	88	15.8	6.3	106	111	10.2	11.9	23
5/29	90	17.5	6.6	349	111	19.3	11.8	170
5/30	88	12.2	6.3	96	112	4.6	12.0	13
6/01	88	16.0	6.2	435	110	15.1	11.4	76
6/02	88	22.0	6.2	499	109	9.7	11.2	25
6/03	85	20.1	5.7	429	108	10.2	11.1	11
6/05	88	10.7	6.3	33	109	0.6	11.3	3
6/07	92	13.6	7.0	188	114	17.3	12.6	78
6/08	91	13.7	6.9	134	112	16.7	12.2	40
6/09	87	4.1	6.1	4	115	6.9	13.1	5
6/10	91	12.0	6.8	79	109	6.8	11.2	15
Total Mean	89		6.5	4,825	112		12.1	2,199

^a Length-weight parameters by age group and discriminating length used to separate ages from May 19 through June 10 were:

Age 1. $a = -10.3248$ $b = 2.7113$ $r^2 = 0.6404$ $n = 1,082$

Age 2. $a = -9.9532$ $b = 2.6344$ $r^2 = 0.7374$ $n = 480$

Discriminating Length = 100.53 mm

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

Table 7. Depth of sockeye salmon smolt passage at Kvichak River sonar site, May 17 to June 12, 1998.

	Depth of Passage (cm)									
	Inshore Array ^a		Center Array ^b		Offshore Array ^c		All Combined Smolt Schools			
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Minimum	9	35	5	48	6	45	5	35	5	35
Mean	32	85	30	85	37	96	33	89	33	89
Maximum	90	176	90	160	110	180	110	180	110	180
n	74	74	79	79	76	76	229	229	229	229

^a Average depth of inshore array on smolt day 5/20 was 273 cm.

^b Average depth of center array on smolt day 5/20 was 274 cm.

^c Average depth of offshore array on smolt day 5/20 was 270 cm.

Table 8. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Kvichak River, 1998.

Date	Cloud Cover ^a		Precipitation (mm)	Wind Direction & Velocity (km/h)		Air Temperature (°C)		Water Temperature (°C)		Water Clarity ^b
	0800	2000		0800	2000	0800	2000	0800	2000	
5/18	4	4	-	NE 40	SE 08	4.0	5.0	3.0	3.0	murky
5/19	3	3	3.8	SW 0-08	SE 05	8.0	6.0	3.5	2.5	murky
5/20	4	3	trace	0	N 08	6.0	8.0	2.0	4.0	clear
5/21	4	2	0.0	S 0-08	N 05	6.0	9.0	3.0	4.0	clear
5/22	4	3	trace	SE 08	NE 06	4.0	9.0	3.0	4.5	clear
5/23	4	4	14.0	SE 16	SE 40	-	3.0	-	3.5	clear
5/24	3	1	trace	0	NE 11	2.0	12.0	2.0	6.0	clear
5/25	1	4	trace	0	W 05	6.0	10.5	3.2	5.5	clear
5/26	4	4	trace	SE 08	E 32	5.0	8.0	4.0	7.0	clear
5/27	3	4	3.3	E 56-64	SE 08	9.0	11.0	5.5	7.0	clear
5/28	3	3	-	0	NNE 13-18	7.0	14.0	4.5	7.5	murky
5/29	3	4	-	NNE 16-32	NE 27	9.0	9.0	6.0	7.5	murky
5/30	4	4	trace	0	SE 16	7.0	9.0	5.5	6.0	murky
5/31	4	4	4.3	SE 16	NE 08	7.0	9.0	6.0	7.0	murky
6/01	4	2	5.3	0	N 08	6.0	12.0	6.0	6.0	clear
6/02	4	1	0.0	0	N 16	7.0	11.0	6.5	8.5	clear
6/03	4	4	1.3	N 08	N 06	6.0	9.0	8.0	8.5	clear
6/04	4	4	1.3	N 10	NE 40	7.0	9.0	7.0	8.5	clear
6/05	3	3	17.3	NNW 16	NE 05	8.0	11.0	9.0	9.0	murky
6/06	4	4	0.0	0	NE 16	8.0	11.0	8.0	9.5	murky
6/07	4	3	18.0	NNE 32-48	N 24	8.0	10.0	9.0	9.0	murky
6/08	4	4	0.0	NE 24	NE 11	8.0	9.0	8.5	8.0	murky
6/09	4	3	2.5	SE 08	SE 16	7.0	9.0	8.0	9.0	murky
6/10	4	4	0.0	0	NE 14	6.0	11.0	6.5	8.5	murky
6/11	4	3	10.2	N 11	NE 10	8.0	9.0	8.0	9.0	clear
6/12	4	4	13.2	0	SE 11	7.5	9.0	8.0	7.5	murky
6/13	3	-	-	0	-	7.0	-	6.0	-	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 Water clarity at 0800 hours

Table 9. Sonar counts by smolt day and array at the sockeye salmon smolt counting site on Egegik River, 1998.

Smolt Day ^a	Sonar Count			
	Transducer Array			Total
	Inshore	Center	Offshore	
5/18 ^b	2,279	377	1,692	4,348
5/19	155	1,759	3,204	5,118
5/20	44	47	298	389
5/21	74	772	948	1,794
5/22	184	160	380	724
5/23	43	83	189	315
5/24	118	249	73	440
5/25 ^c	51,204	94,208	15,282	160,694
5/26 ^c	69,037	139,510	194,325	402,872
5/27	177,107	294,578	46,707	518,392
5/28 ^c	99,283	361,738	638,040	1,099,061
5/29 ^d	285,713	581,097	356,431	1,223,241
5/30	37,858	91,576	198,586	328,020
5/31	67,392	166,651	78,344	312,387
6/01	42,276	136,648	79,158	258,082
6/02	58,562	122,709	136,525	317,796
6/03	52,702	71,887	21,346	145,935
6/04 ^c	22,944	63,429	63,300	149,673
6/05	22,521	72,254	79,160	173,935
6/06 ^c	8,813	33,041	29,047	70,901
6/07 ^c	11,163	36,550	35,981	83,694
6/08 ^c	7,063	27,461	15,759	50,283
6/09	3,169	11,449	20,248	34,866
6/10	2,777	5,685	2,598	11,060
Total	1,022,481	2,313,918	2,017,621	5,354,020
Percent	19.1	43.2	37.7	

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

^b Sonar counter was activated at 2400 hours on May 18.

^c Sonar counts interpolated for one or more arrays for the following periods:

1500-0859 hours on smolt day 5/25 due to high SE winds and intermittent rain

1300-1459, 1800-1859, and 2300-0959 hours on smolt day 5/26 due to high E and SE winds and rain

1400-1559 hours on smolt day 5/28 due to high SE winds

2200-0659 hours on smolt day 6/04 due to high SE winds and wave action.

0900-1159 hours on smolt day 6/06 due to high SE winds and wave action.

1200-1159 hours on smolt day 6/07 due to high SE winds and wave action.

1200-1659 hours on smolt day 6/08 due to high SE winds, wave action, and rain.

^d Peak daily smolt passage for 1998.

Table 10. Sonar counts by hour and array at the sockeye salmon smolt counting site on Egegik River, 1998.

Sonar Operating Period	Hour	a	Sonar Count				Hourly Percent
			Transducer Array			Total	
			Inshore	Center	Offshore		
	1200		19,806	34,598	4,322	58,726	1.10
	1300		13,810	18,018	12,437	44,265	0.83
	1400		13,514	43,352	31,869	88,736	1.66
	1500		35,915	35,276	15,610	86,800	1.62
	1600		25,876	51,428	9,691	86,995	1.62
	1700		11,439	26,705	23,459	61,603	1.15
	1800		12,715	37,256	39,601	89,571	1.67
	1900		32,002	27,275	9,669	68,946	1.29
	2000		27,351	32,278	7,108	66,736	1.25
Smolt Days	2100		31,060	28,858	6,160	66,078	1.23
	2200		35,842	68,703	10,429	114,974	2.15
5/18 to 6/10	2300	b	66,780	217,010	42,623	326,413	6.10
	2400	c	148,691	292,448	442,443	883,582	16.50
	0100	c	31,911	199,322	360,270	591,504	11.05
	0200	c	22,304	207,681	310,086	540,071	10.09
	0300	c	19,511	243,394	339,811	602,716	11.26
	0400	c	35,330	192,611	205,290	433,232	8.09
	0500	c	176,752	129,343	73,940	380,034	7.10
	0600	b	93,314	119,973	32,897	246,183	4.60
	0700		64,137	181,929	16,434	262,500	4.90
	0800		34,838	48,720	7,916	91,474	1.71
	0900		15,404	13,547	6,943	35,893	0.67
	1000		27,321	18,960	4,538	50,819	0.95
	1100		26,862	45,234	4,074	76,170	1.42
Total			1,022,482	2,313,917	2,017,620	5,354,019	100.00

^a Daylight hours unless indicated otherwise

^b Twilight hours

^c Hours of darkness

Table 11. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Egegik River, 1998.

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
5/18	50,420	59.5	50,420	33,260	39.3	33,260	1,059	1.3	1,059	84,739	84,739
5/19	52,025	59.5	102,445	34,319	39.3	67,579	1,092	1.3	2,151	87,436	172,175
5/20	4,144	59.5	106,589	2,734	39.3	70,313	87	1.3	2,238	6,965	179,140
5/21	18,040	59.5	124,629	11,900	39.3	82,213	379	1.3	2,617	30,319	209,459
5/22	7,793	59.5	132,422	5,141	39.3	87,354	163	1.3	2,780	13,097	222,556
5/23	3,262	59.5	135,684	2,152	39.3	89,506	68	1.3	2,848	5,482	228,038
5/24	3,808	59.5	139,492	2,512	39.3	92,018	80	1.3	2,928	6,400	234,438
5/25	1,464,597	59.5	1,604,089	966,142	39.3	1,058,160	30,768	1.3	33,696	2,461,507	2,695,945
5/26	3,600,771	59.5	5,204,860	2,375,298	39.3	3,433,458	75,646	1.3	109,342	6,051,715	8,747,660
5/27	4,598,717	59.5	9,803,577	3,033,607	39.3	6,467,065	96,611	1.3	205,953	7,728,935	16,476,595
5/28	9,275,988	59.5	19,079,565	6,119,034	39.3	12,586,099	194,873	1.3	400,826	15,589,895	32,066,490
5/29	10,406,393	59.7	29,485,958	6,784,124	38.9	19,370,223	249,390	1.4	650,216	17,439,907	49,506,397
5/30	2,918,035	61.9	32,403,993	1,730,079	36.7	21,100,302	65,997	1.4	716,213	4,714,111	54,220,508
5/31	2,717,722	61.9	35,121,715	1,611,315	36.7	22,711,617	61,467	1.4	777,680	4,390,504	58,611,012
6/01	2,388,848	66.0	37,510,563	1,164,188	32.2	23,875,805	68,076	1.9	845,756	3,621,112	62,232,124
6/02	3,033,601	66.0	40,544,164	1,478,403	32.2	25,354,208	86,450	1.9	932,206	4,598,454	66,830,578
6/03	1,836,769	77.3	42,380,933	506,317	21.3	25,860,525	33,992	1.4	966,198	2,377,078	69,207,656
6/04	2,163,380	84.0	44,544,313	375,545	14.6	26,236,070	36,833	1.4	1,003,031	2,575,758	71,783,414
6/05	2,472,476	84.0	47,016,789	429,202	14.6	26,665,272	42,095	1.4	1,045,126	2,943,773	74,727,187
6/06	996,366	83.2	48,013,155	184,348	15.4	26,849,620	17,129	1.4	1,062,255	1,197,843	75,925,030
6/07	1,020,737	76.1	49,033,892	293,056	21.9	27,142,676	26,812	2.0	1,089,067	1,340,605	77,265,635
6/08	604,241	76.1	49,638,133	173,479	21.9	27,316,155	15,871	2.0	1,104,938	793,591	78,059,226
6/09	420,501	76.1	50,058,634	120,727	21.9	27,436,882	11,045	2.0	1,115,983	552,273	78,611,499
6/10	136,768	76.1	50,195,402	39,266	21.9	27,476,148	3,592	2.0	1,119,575	179,626	78,791,125
	50,195,402	63.7		27,476,148	34.9		1,119,575	1.4		78,791,125	

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

Table 12. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Egegik River, 1998.

Smolt Day ^a	Mean Weight of Smolt (g)	Smolt per Count
5/18	11.9	3.5
5/19	11.9	3.5
5/20	11.9	3.5
5/21	11.9	3.5
5/22	11.9	3.5
5/23	11.9	3.5
5/24	11.9	3.5
5/25	11.9	3.5
5/26	11.9	3.5
5/27	11.9	3.5
5/28	11.9	3.5
5/29	12.3	3.4
5/30	11.9	3.5
5/31	11.9	3.5
6/01	11.7	3.6
6/02	11.7	3.6
6/03	10.7	3.9
6/04	9.8	4.2
6/05	9.8	4.2
6/06	9.9	4.2
6/07	10.5	4.0
6/08	10.5	4.0
6/09	10.5	4.0
6/10	10.5	4.0

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

Table 13. Mean fork length and weight of sockeye salmon smolt captured by fyke net, Egegik River, 1998.

Smolt Day ^a	Age 1.					Age 2.					Age 3.				
	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
5/19	108		9.2		1	135	5.2	19.1	2.18	8	130		18.3		1
5/21	106	11.0	10.1	0.49	5	134	12.1	18.8	5.33	21					0
5/25	106	11.7	8.9	2.70	5	123	14.0	13.2	4.03	14					0
5/27	108	10.5	9.5	2.95	44	127	9.4	15.2	3.10	6					0
5/28	102	20.0	8.4	4.57	69	115	18.6	11.5	5.39	30					0
5/29	105	12.7	9.6	5.17	46	126	29.0	15.5	10.89	54					0
5/30	105	16.4	9.4	3.62	69	118	23.4	12.8	8.45	29	133	4.8	15.3	0.30	2
5/31	108	14.1	10.0	4.45	52	122	24.4	13.9	8.92	45	133	9.5	16.7	3.92	2
6/01	105	15.8	9.0	4.28	70	118	22.0	12.6	7.28	29	132		14.5		1
6/02	108	20.3	9.7	5.43	76	122	18.8	14.2	6.46	22					0
6/03	106	15.0	9.2	4.62	80	121	14.8	13.6	4.88	19					0
6/05	103	14.1	8.4	3.81	94	114	5.9	10.8	1.63	5					0
6/06	102	12.9	8.2	3.33	91	119	17.1	12.7	4.63	9					0
6/08	103	15.3	8.6	4.77	66	124	21.0	14.6	7.21	8					0
6/09	103	14.7	8.2	3.69	92	109	10.7	9.5	2.64	7					0
6/10	101	12.6	7.9	3.30	80	115	13.5	11.0	2.67	9					0
Total Mean	105		9.0		940	121		13.7		315	132		16.2		6

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

Table 14. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Egegik River, 1998.

Smolt Day ^b	Age 1. ^a				Age 2. ^a			
	Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size	Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size
5/28	105	24.4	8.8	258	125	16.6	14.8	36
5/29	107	25.1	9.3	386	127	22.1	15.4	147
5/30	106	20.3	9.2	163	126	16.9	15.0	50
5/31	106	23.4	9.2	352	128	24.4	15.7	175
6/01	107	15.9	9.3	190	124	11.1	14.3	32
6/02	105	18.7	8.9	74	126	15.0	15.0	35
6/03	105	26.9	8.8	485	125	17.4	14.6	53
6/05	102	24.4	8.2	525	124	10.9	14.5	19
6/06	102	24.4	8.2	562	125	12.8	14.8	22
6/09	103	14.3	8.5	66	123		13.8	1
Total Mean	105		8.9	3,061	125		14.8	570

^a Length-weight parameters by age group and discriminating length used to separate ages were:

Age 1. $a = -10.7149$ $b = 2.7682$ $r^2 = 0.7198$ $n = 940$

Age 2. $a = -11.0498$ $b = 2.8415$ $r^2 = 0.8229$ $n = 315$

Discriminating Length = 117.31 mm

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

Table 15. Depth of sockeye salmon smolt passage at Egegik River sonar site, May 27 to June 5, 1998.

	Depth of Passage (cm)											
	Inshore Array ^a		Center Array ^b		Offshore Array ^c		All Combined					
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
Minimum	8	32	4	48	3	83	3	32	3	3	3	32
Mean	41	129	46	145	17	123	35	132	17	17	35	132
Maximum	120	216	176	280	28	153	176	280	28	28	176	280
n	11	11	28	28	21	21	21	21	21	21	60	60

^a Average depth of inshore array on smolt day 5/28 was 310 cm.

^b Average depth of center array on smolt day 5/28 was 374 cm.

^c Average depth of offshore array on smolt day 5/28 was 387 cm.

Table 16. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Egegik River, 1998.

Date	Cloud Cover ^a		Precipitation (mm)	Wind Direction & Velocity (km/h)		Air Temperature (°C)		Water Temperature (°C)		Water Clarity ^b
	0800	2000		0800	2000	0800	2000	0800	2000	
5/19	3	3	-	SE 08	W 06	3.3	8.0	4.0	5.0	clear
5/20	4	4	7.6	NW 11	NW 21	1.1	6.0	3.0	5.0	clear
5/21	4	3	2.5	SSE 29	SW 16	2.2	5.0	4.0	5.0	clear
5/22	4	4	1.3	E 13	S 16	4.4	5.0	4.5	5.0	clear
5/23	4	4	4.3	SSW 24	SW 16	2.0	3.0	4.5	4.0	clear
5/24	4	1	-	0	S 10	1.0	9.0	2.5	5.5	clear
5/25	2	3	-	E 27	SE 56	4.0	7.0	3.0	4.5	clear
5/26	4	4	2.5	E 56	SE 24	5.0	6.0	4.0	5.0	clear
5/27	4	4	2.3	E 51	SE 24	6.0	6.0	4.0	4.0	clear
5/28	2	2	-	E 19	SE 24	5.0	8.0	3.0	6.0	clear
5/29	4	4	1.0	0	SE 40	8.0	7.0	4.0	6.0	clear
5/30	3	4	4.1	E 27	SE 11	5.0	6.0	4.5	6.0	clear
5/31	3	4	2.5	SE 08	SE 40	6.0	6.0	5.0	6.0	clear
6/01	4	2	6.6	SE 32	0	4.0	6.0	4.0	6.0	clear
6/02	3	2	-	0	SE 24	5.0	10.0	4.0	7.0	clear
6/03	4	4	5.8	SE 24	SE 32	6.0	6.0	5.0	6.0	clear
6/04	3	3	0.0	SE 32	SE 40	5.0	6.0	4.0	6.0	clear
6/05	3	4	-	SE 40	SE 32	7.0	6.0	4.0	5.0	clear
6/06	3	4	-	SE 15	SE 16	6.0	7.0	4.0	7.0	clear
6/07	3	-	-	SE 40	-	8.0	-	5.0	-	clear
6/08	4	4	6.4	SE 48	SE 32	6.0	6.0	4.0	6.0	clear
6/09	4	4	3.1	SW 16	S 08	-	7.0	5.0	7.0	clear
6/10	1	3	-	SE 16	SE 32	5.0	6.0	5.0	7.0	clear
6/11	4	-	-	SE 32	-	6.0	-	6.0	-	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 Water clarity at 0800 hours

Table 17. Sonar counts by smolt day and array at the sockeye salmon smolt counting site on Ugashik River, 1998.

Smolt Day ^a	Sonar Count		
	Transducer Array		Total
	Inshore	Offshore	
5/17 ^b	356	2,720	3,076
5/18 ^c	163	1,147	1,310
5/19	936	5,122	6,058
5/20 ^c	197	1,366	1,563
5/21	762	4,421	5,183
5/22 ^c	616	4,284	4,900
5/23	164	945	1,109
5/24 ^c	3,919	23,979	27,898
5/25 ^c	5,741	26,308	32,049
5/26 ^c	8,664	39,052	47,716
5/27	12,325	52,868	65,193
5/28 ^c	7,029	36,355	43,384
5/29 ^c	8,824	33,651	42,475
5/30 ^c	5,003	14,662	19,665
5/31 ^c	11,588	30,965	42,553
6/01 ^c	12,678	38,619	51,297
6/02 ^c	17,766	53,881	71,647
6/03 ^c	7,140	41,382	48,522
6/04 ^c	31,677	84,830	116,507
6/05 ^c	84,338	127,577	211,915
6/06 ^c	30,277	65,068	95,345
6/07 ^c	26,714	58,163	84,877
6/08	20,346	32,247	52,593
6/09	12,268	13,949	26,217
6/10 ^c	28,754	34,380	63,134
6/11	17,816	16,578	34,394
6/12	37,598	71,273	108,871
Total	393,659	915,792	1,309,451
Percent	30.1	69.9	

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

^b The sonar counter was activated at 2400 hours on May 17.

^c Sonar counts interpolated for one or more arrays for the following periods:

1400-1459 hours on smolt day 5/18 due to heavy rain showers
 1600-1759 and 2400-2459 hours on smolt day 5/20 due to NW wind, choppy waves, and rain showers
 0300-0959 hours on smolt day 5/22 due to rain, hail, and snow
 1100-1159 hours on smolt day 5/24 due to high SE winds
 1200-1159 hours on smolt day 5/25 due to high SE winds and breaking waves
 1200-0830 hours on smolt day 5/26 due to high SE and ESE winds
 2200-2359 and 1000-1159 hours on smolt day 5/28 due to high ESE winds
 1200-0359 hours on smolt day 5/29 due to high ESE winds and waves
 1600-1630 hours on smolt day 5/30 due to abnormal sonar counter printout
 0100-0259 and 0400-0459 hours on smolt day 5/31 due to SE wind and rain
 1600-1859 hours on smolt day 6/01 due to W wind and wave action
 0300-0359 hours on smolt day 6/02 due to E wind and rain
 0500-0359 and 0900-1159 hours on smolt day 6/03 due to high ESE wind, breaking waves, and rain
 1200-0559 and 0900-0959 hours on smolt day 6/04 due to high ESE and SE wind, waves, and rain
 1600-2159 hours on smolt day 6/05 due to smolt counter problems and installation of backup counter
 0400-1159 hours on smolt day 6/06 due to high ESE and SE wind, waves, and rain
 1200-0859 hours on smolt day 6/07 due to high SE wind, waves, and rain
 1600-0459 hours on smolt day 6/10 due to high E and ESE wind, breaking waves, and rain

Table 18. Sonar counts by hour and array at the sockeye salmon smolt counting site on Ugashik River, 1998.

Sonar Operating Period	Sonar Count				Hourly Percent
	Hour ^a	Transducer Array		Total	
		Inshore	Offshore		
	1200	6,217	7,467	13,684	1.05
	1300	9,137	12,482	21,619	1.65
	1400	9,552	8,636	18,189	1.39
	1500	9,786	11,154	20,940	1.60
	1600	8,088	10,082	18,171	1.39
	1700	10,905	20,347	31,253	2.39
	1800	10,699	20,376	31,075	2.37
	1900	11,738	37,064	48,802	3.73
	2000	13,167	28,254	41,420	3.16
Smolt	2100	12,682	29,932	42,614	3.25
Days	2200	15,223	55,597	70,821	5.41
5/17	2300 ^b	15,810	72,327	88,137	6.73
to	2400 ^c	38,123	157,656	195,778	14.95
6/12	0100 ^c	46,147	139,076	185,223	14.15
	0200 ^c	35,926	96,416	132,343	10.11
	0300 ^c	45,659	87,357	133,015	10.16
	0400 ^c	33,789	42,319	76,108	5.81
	0500 ^c	12,178	12,471	24,649	1.88
	0600 ^b	9,403	17,423	26,826	2.05
	0700	8,482	11,432	19,915	1.52
	0800	8,214	8,162	16,376	1.25
	0900	7,204	9,264	16,468	1.26
	1000	6,565	9,283	15,848	1.21
	1100	8,964	11,214	20,178	1.54
Total		393,659	915,791	1,309,450	100.00

^a Daylight hours unless indicated otherwise.

^b Twilight hours

^c Hours of darkness

Table 19. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Ugashik River, 1998.

Smolt Day ^a	Age 1.			Age 2.			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5/17	28,909	91.2	28,909	2,786	8.8	2,786	31,695	31,695
5/18	12,403	91.2	41,312	1,195	8.8	3,981	13,598	45,293
5/19	58,431	91.2	99,743	5,631	8.8	9,612	64,062	109,355
5/20	14,855	91.2	114,598	1,431	8.8	11,043	16,286	125,641
5/21	49,732	91.2	164,330	4,792	8.8	15,835	54,524	180,165
5/22	31,130	73.7	195,460	11,086	26.3	26,921	42,216	222,381
5/23	7,114	73.7	202,574	2,533	26.3	29,454	9,647	232,028
5/24	185,947	73.7	388,521	66,218	26.3	95,672	252,165	484,193
5/25	219,521	73.7	608,042	78,174	26.3	173,846	297,695	781,888
5/26	328,619	73.7	936,661	117,026	26.3	290,872	445,645	1,227,533
5/27	447,511	73.7	1,384,172	159,366	26.3	450,238	606,877	1,834,410
5/28	403,572	88.2	1,787,744	53,992	11.8	504,230	457,564	2,291,974
5/29	403,761	88.2	2,191,505	54,018	11.8	558,248	457,779	2,749,753
5/30	190,942	88.2	2,382,447	25,545	11.8	583,793	216,487	2,966,240
5/31	399,006	88.2	2,781,453	53,381	11.8	637,174	452,387	3,418,627
6/01	208,541	53.6	2,989,994	180,819	46.4	817,993	389,360	3,807,987
6/02	516,711	82.2	3,506,705	111,585	17.8	929,578	628,296	4,436,283
6/03	328,818	82.2	3,835,523	71,009	17.8	1,000,587	399,827	4,836,110
6/04	863,657	82.2	4,699,180	186,509	17.8	1,187,096	1,050,166	5,886,276
6/05	1,692,650	82.2	6,391,830	365,533	17.8	1,552,629	2,058,183	7,944,459
6/06	735,836	82.2	7,127,666	158,906	17.8	1,711,535	894,742	8,839,201
6/07	657,447	82.2	7,785,113	141,977	17.8	1,853,512	799,424	9,638,625
6/08	420,893	82.2	8,206,006	90,893	17.8	1,944,405	511,786	10,150,411
6/09	218,607	82.2	8,424,613	47,208	17.8	1,991,613	265,815	10,416,226
6/10	526,671	82.2	8,951,284	113,736	17.8	2,105,349	640,407	11,056,633
6/11	295,852	82.2	9,247,136	63,890	17.8	2,169,239	359,742	11,416,375
6/12	1,085,206	89.8	10,332,342	122,860	10.2	2,292,099	1,208,066	12,624,441
	10,332,342	81.8		2,292,099	18.2		12,624,441	

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

Table 20. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Ugashik River, 1998.

Smolt Day ^a	Mean Weight of Smolt (g)	Smolt per Count
5/17	6.5	6.4
5/18	6.5	6.4
5/19	6.5	6.4
5/20	6.5	6.4
5/21	6.5	6.4
5/22	7.8	5.3
5/23	7.8	5.3
5/24	7.8	5.3
5/25	7.8	5.3
5/26	7.8	5.3
5/27	7.8	5.3
5/28	6.8	6.1
5/29	6.8	6.1
5/30	6.8	6.1
5/31	6.8	6.1
6/01	9.4	4.4
6/02	8.2	5.1
6/03	8.2	5.1
6/04	8.2	5.1
6/05	8.2	5.1
6/06	8.2	5.1
6/07	8.2	5.1
6/08	8.2	5.1
6/09	8.2	5.1
6/10	8.2	5.1
6/11	8.2	5.1
6/12	7.0	6.0

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

Table 21. Mean fork length and weight of sockeye salmon smolt captured by fyke net, Ugashik River, 1998.

Smolt Day ^a	Age 1.					Age 2.				
	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5/19	92	10.1	6.5	1.98	8	113	1.8	11.9	0.18	2
5/20	89	9.1	6.1	1.19	16	106	5.0	9.1	1.69	4
5/21	90	7.5	5.9	2.20	36	119	13.1	13.9	4.93	4
5/23	91	3.2	6.0	1.13	10					0
5/24	90	6.3	6.0	1.71	18	104	9.5	9.8	2.68	2
5/25	85	21.0	5.1	4.66	15					0
5/27	87	7.9	5.4	1.70	30	121	10.0	15.2	2.68	20
5/28	94	8.1	6.6	2.12	16	107	7.2	9.9	3.20	4
5/30	85	8.6	5.0	1.79	10					0
5/31	92	8.4	5.9	2.09	46	110	4.4	10.0	2.21	4
6/01	93	15.0	6.6	2.85	49	116	12.1	12.9	4.05	50
6/02	94	11.3	7.4	2.96	21	114	7.6	12.6	2.27	9
6/08	93	10.5	6.8	2.38	9	97		6.7		1
6/09	94	6.4	7.1	1.89	10					0
6/11	95	5.9	8.1	1.63	18	109	3.0	10.4	0.42	2
6/12	92	10.2	7.5	2.43	43	104	3.0	10.8	0.89	2
Total Mean	91		6.4		355	110		11.1		104

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

Table 22. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Ugashik River, 1998.

Smolt Day ^b	Age 1. ^a				Age 2. ^a			
	Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size	Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size
5/19	91	11.2	6.3	70	111	10.6	11.5	24
5/20	89	8.9	6.0	81	121		14.6	1
5/21	89	14.5	5.9	221	110	10.2	11.1	10
5/24	87	19.5	5.5	178	110	6.1	11.1	7
5/27	90	16.8	6.2	94	118	20.4	13.7	163
5/28	92	10.9	6.5	126	112	14.9	11.7	24
5/31	92	17.5	6.5	250	111	14.6	11.4	26
6/01	96	17.5	7.5	275	112	19.8	11.8	272
6/02	93	14.2	6.9	43	116	22.9	13.1	57
6/08	91	12.3	6.3	117	109	2.5	10.8	4
6/09	95	11.7	7.3	49	105		9.4	1
6/11	96	11.9	7.3	173	104	1.1	9.4	6
6/12	90	17.6	6.2	139	106	2.4	9.7	2
Total Mean	92		6.5	1,816	111		11.5	597

^a Length-weight parameters by age group and discriminating length used to separate ages were:

Age 1. $a = -12.2682$ $b = 3.1231$ $r^2 = 0.75$ $n = 355$

Age 2. $a = -12.3401$ $b = 3.1327$ $r^2 = 0.88$ $n = 104$

Discriminating Length = 103.5 mm

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

Table 23. Depth of sockeye salmon smolt passage at Ugashik River sonar site, May 24 to June 12, 1998.

	Depth of Passage (cm)					
	Inshore Array ^a Smolt Schools		Offshore Array ^b Smolt Schools		All Combined Smolt Schools	
	Top	Bottom	Top	Bottom	Top	Bottom
Minimum	0	25	0	25	0	25
Mean	11	50	7	56	9	53
Maximum	25	75	22	92	23	83
n	19	19	32	32	51	51

^a Average depth of inshore array on smolt day 6/05 was 287 cm.

^b Average depth of offshore array on smolt day 6/05 was 305 cm.

Table 24. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Ugashik River, 1998.

Date	Cloud Cover ^a		Precipitation (mm)	Wind Direction & Velocity (km/h)		Air Temperature (°C)		Water Temperature (°C)		Water Clarity ^b
	0800	2000		0800	2000	0800	2000	0800	2000	
5/18	3	4	6.4	E 10	W 16	5.0	4.0	3.5	4.0	clear
5/19	4	3	trace	SW 10	W 11	2.0	4.0	4.0	4.0	clear
5/20	4	4	6.4	NW 06	NW 19	3.0	5.0	4.0	4.0	clear
5/21	4	4	15.2	SW 16	W 13	4.0	5.0	4.0	4.0	clear
5/22	4	4	2.5	W 19	W 27	3.0	4.0	4.0	4.0	clear
5/23	4	4	8.9	W 24	W 19	1.0	2.0	4.0	4.0	clear
5/24	4	1	-	0	SE 11	1.0	10.0	3.5	5.0	clear
5/25	2	3	-	SE 24	SE 45	7.0	7.0	5.0	6.0	clear
5/26	3	4	-	SE 24	E 32	6.0	6.0	5.0	6.0	lt brown
5/27	3	4	2.5	SE 32	SE 16	7.0	7.0	5.0	5.0	lt brown
5/28	2	3	-	E 08	ESE 24	7.0	7.0	5.0	7.5	clear
5/29	3	4	-	E 19	ESE 48	7.0	7.0	7.0	6.5	clear
5/30	2	4	trace	ESE 24	W 0-08	6.0	7.0	5.5	5.0	clear
5/31	4	4	1.3	0	S 13	6.0	8.0	5.0	5.5	lt brown
6/01	4	3	1.3	E 29	W 16	5.0	12.0	6.5	6.0	lt brown
6/02	5	3	-	0	SE 24	5.0	10.0	5.0	6.0	clear
6/03	4	3	2.5	E 16	SE 32	7.0	8.0	7.0	7.0	clear
6/04	3	4	2.8	SE 27	ESE 35	8.0	8.0	7.5	7.0	lt brown
6/05	3	3	1.0	SE 37	ESE 24	9.0	7.0	6.0	6.0	lt brown
6/06	4	4	-	E 14	E 23	6.0	9.0	6.0	7.0	lt brown
6/07	4	2	trace	SE 48	E 64	10.0	9.0	7.0	7.0	lt brown
6/08	4	4	1.0	SE 32	SE 16	6.0	9.0	6.0	6.0	brown
6/09	5	4	2.5	SW 10	0	6.0	7.0	5.5	6.0	lt brown
6/10	2	4	trace	NE 05	ESE 40	7.0	7.0	5.5	6.0	clear
6/11	4	2	1.0	SE 08	0	7.0	11.0	6.0	6.0	clear
6/12	4	3	1.3	SW 10	N 0-08	7.0	13.0	5.0	6.0	clear
6/13	4	-	-	0	-	7.0	-	6.0	-	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 Water clarity at 0800 hours

Table 25. Age composition of total migration and mean fork length and weight by age class for sockeye salmon smolt, Kvichak River, 1955-1998.

Year of Migration	Age 1.			Age 2.			Age 3.			Total Estimate *			
	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)
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
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	<1	102	9.1	136,733,218
1987	1985	3	82	4.5	1984	97	96	7.0	1983	<1	97	8.5	342,686,918
1988	1986	13	86	5.6	1985	87	99	8.3	1984	<1	107	9.8	100,173,692
1989	1987	95	85	5.5	1986	5	108	10.8	1985	<1	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
1995	1993	95	87	6.2	1992	5	103	9.8	1991	0	—	—	220,892,127
1996	1994	74	89	6.5	1993	26	110	11.3	1992	0	—	—	373,166,532
1997	1995	74	88	6.8	1994	26	105	10.6	1993	0	—	—	363,397,663
Mean			87	5.9			107	10.4			107	10.9	
1998	1996	65	90	6.7	1995	35	112	11.9	1994	0	—	—	295,470,850
% Difference from Mean			3	14			5	14					

* Estimates of smolt numbers from 1955 to 1970 based on fyke net catches; estimates of smolt numbers from 1971 to 1998 based on hydroacoustic techniques.

Table 26. Water temperatures at sockeye salmon smolt counting site, Kvichak River, 1963-1998.

Year	Sample Period	Water Temperature (°C)		
		Minimum	Mean	Maximum
1963	May 16 - June 14	2.2	5.5	8.9
1964	May 18 - June 14	0.0	2.6	5.6
1965	May 17 - June 11	0.0	4.4	8.9
1966	May 16 - June 26	0.0	4.7	11.1
1967	May 17 - June 20	1.1	6.9	9.4
1968	May 12 - June 12	3.3	5.4	8.3
1969	May 16 - June 18	0.3	3.9	7.8
1970	May 13 - June 07	2.8	6.8	11.1
1971	May 17 - June 20	1.1	2.4	3.3
1972	May 18 - June 18	0.6	2.9	5.0
1973	May 15 - June 14	2.9	4.9	8.9
1974	May 13 - June 09	3.0	6.2	8.0
1975	May 17 - June 15	2.0	3.8	8.0
1976	May 18 - June 19	2.0	3.9	9.5
1977	May 17 - June 14	3.0	6.4	9.5
1978	May 19 - June 09	5.0	7.6	11.0
1979	June 01 - June 10	8.0	8.6	10.0
1980	May 16 - June 18	1.5	5.5	9.0
1981	May 15 - June 09	7.0	8.2	10.0
1982	May 14 - June 15	2.5	4.9	8.5
1983	May 19 - June 14	5.2	7.9	10.5
1984	May 19 - June 11	5.5	7.9	10.0
1985	May 23 - June 20	2.0	4.6	7.0
1986	May 18 - June 12	1.0	4.6	7.0
1987	May 21 - June 13	4.5	6.7	9.0
1988	May 17 - June 17	3.0	7.1	11.0
1989	May 19 - June 16	3.0	5.8	8.8
1990	May 22 - June 15	3.5	7.3	9.5
1991	May 23 - June 17	1.0	4.8	8.5
1992	May 22 - June 14	5.0	7.8	10.0
1993	May 19 - June 12	4.0	6.6	11.0
1994	May 22 - June 16	1.5	6.1	11.0
1995	May 21 - June 14	4.0	8.1	12.5
1996	May 17 - June 13	5.0	8.1	13.0
1997	May 17 - June 13	5.0	8.8	13.0
Mean		2.9	5.9	9.2
1998	May 18 - June 13	2.0	6.2	9.5
% Difference from Mean		-31.0	4.6	2.8

Table 27. Sockeye salmon spawning escapement, total number of smolt produced by age class, percent of total smolt production composed by age class, and number of smolt produced per spawner for 1956-1996 brood years, Kvichak River.

Brood Year	Total Spawning Escapement ^a	Number of Smolt Produced						Per Spawner
		Age 1.	(%) ^b	Age 2.	(%) ^b	Age 3.	(%) ^b	
<u>Estimates of smolt numbers based upon fyke net catches</u>								
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	0.22
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	0.85
1963	338,760	64,377	73	23,377	27	0	87,754	0.26
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						
<u>Estimates of smolt numbers based upon hydroacoustic techniques</u>								
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	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	108,355,892	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	22,505,268	150,421,026	66	76,244,773	34	0	226,665,799	10.07
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	8	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	0	64,672,348	13.68
1993	4,025,166	209,857,983	69	96,434,554	31	0	306,292,537	76.09
1994	8,337,840	276,731,978	75	94,049,964	25	0	370,781,942	44.47
1995	10,038,720	269,347,699	72	103,481,449	28	c	372,829,148 ^c	37.14 ^c
1996	1,450,578	191,989,401				c		
1984-1993 Max	10,490,670	209,857,983	83	331,384,545	92	43,135	414,898,140	76.09
1984-1993 Avg	5,727,347	69,158,560	49	90,454,056	51	7,348	159,619,965	27.29
1984-1993 Min	1,179,322	11,178,398	8	6,830,717	17	0	19,957,080	12.31

^a Kvichak River tower count only. Does not include aerial survey index counts from Branch River.

^b Percent of total smolt production.

^c Incomplete returns from brood year escapements.

Table 28. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1952-1996 brood years, Kvichak River.

Brood Year	Total Spawning Escapement ^a	Age 1.			Age 2.		
		Number of Smolt	Adult Returns ^b	Adult Returns per Smolt	Number of Smolt	Adult Returns ^b	Adult Returns per Smolt
<u>Estimates of smolt numbers based upon fyke net catches.</u>							
1952	-	-	-	-	241,870	3,610,258	^c
1953	-	18,198	152,165	^c	47,373	424,627	^c
1954	-	30,287	109,965	^c	8,654	659,246	^c
1955	-	22,253	351,240	^c	66,679	1,132,813	^c
1956	9,443,318	3,267,274	31,253,977	^c	2,777,960	7,773,131	^c
1957	2,842,810	85,916	488,844	^c	552,603	3,591,552	^c
1958	534,785	61,400	124,250	^c	10,126	161,253	^c
1959	680,000	26,038	328,287	^c	72,180	217,593	^c
1960	14,630,000	1,130,820	1,877,221	^c	4,116,093	53,360,190	^c
1961	3,705,849	113,338	524,416	^c	1,603,464	2,971,816	^c
1962	2,580,884	458,122	256,253	0.56	1,748,178	5,083,162	^c
1963	338,760	64,377	98,571	^c	23,377	1,008,242	^c
1964	957,120	252,384	2,647,042	^c	222,528	3,093,042	^c
1965	24,325,926	2,866,214	10,349,415	^c	5,475,362	34,671,692	^c
1966	3,775,184	648,321	1,594,186	^c	541,017	4,657,432	^c
1967	3,216,208	594,327	621,690	^c	298,282	900,307	^c
1968	2,557,440	185,356	332,177	^c	-	-	^c
<u>Estimates of smolt numbers based upon hydroacoustic techniques</u>							
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	^c
1973	226,554	-	1,606,766	^c	3,031,287	818,529	0.27
1974	4,433,844	108,326,892	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	1,773,442	0.03
1984	10,490,670	83,470,460	4,455,429	0.05	331,384,545	19,478,848	0.06
1985	7,211,046	11,178,398	2,313,349	0.21	87,004,194	15,069,258	0.17
1986	1,179,322	13,126,363	1,791,108	0.14	6,830,717	2,722,727	0.40
1987	6,065,880	146,603,154	6,706,260	0.05	41,434,534	5,229,846	0.13
1988	4,065,216	46,569,569	4,982,204	0.11	34,266,421	4,961,033	0.14
1989	8,317,500	87,187,761	3,829,838	0.04	61,317,308	22,259,220	0.36
1990	6,970,020	18,172,700	2,740,515	0.15	204,626,879	22,351,542	0.11
1991	4,222,788	21,781,009	3,927,301	0.18	30,207,268	871,782	0.03
1992	4,725,864	53,638,204	656,610	0.01	11,034,144	730,567 ^d	0.07 ^d
1993	4,025,166	209,857,983	1,778,374 ^d		96,434,554	623,072 ^d	
1994	8,337,840	276,731,978	1,803,862 ^d		94,049,964	29,290 ^d	
1995	10,038,720	269,347,699	16,953 ^d		103,481,449	^d	
1996	1,450,578	191,989,401	^d				
1982-1991 Max	10,490,670	146,603,154	11,612,066	0.49	331,384,545	22,351,542	0.40
1982-1991 Avg	5,322,726	50,357,385	4,335,321	0.14	85,226,997	9,538,094	0.18
1982-1991 Min	1,134,840	11,178,398	995,144	0.02	1,937,408	663,241	0.03

^a Kvichak River tower count only. Does not include aerial survey index counts from Branch River.

^b Includes estimates of adult returns through 1998.

^c Insufficient smolt samples collected to perform this calculation.

^d Future adult returns will increase these values.

Table 29. Comparison of the age composition of outmigrating sockeye salmon smolt at Kvichak River with the freshwater age composition of their total adult returns by brood year, 1981-1991.

Smolt Outmigration Year	Brood Years	Freshwater Age	Proportion of Total		Difference	Comments
			Smolt	Adult		
1983	1981	Age 1.	0.15	0.48	-0.33	Ice problems - (5/19-5/22), intermittent
	1980	Age 2.	-	-		
1984	1982	Age 1.	0.96	0.60	0.36	No ice problems noted.
	1981	Age 2.	0.85	0.52	0.33	
1985	1983	Age 1.	0.31	0.87	-0.56	Ice problems - 5/22-6/02, 6/06 intermittent, 6/3-6/5 continuous
	1982	Age 2.	0.04	0.40	-0.36	
1986	1984	Age 1.	0.20	0.19	0.01	No ice problems noted.
	1983	Age 2.	0.69	0.13	0.56	
1987	1985	Age 1.	0.11	0.13	-0.02	No ice problems noted.
	1984	Age 2.	0.80	0.81	-0.01	
1988	1986	Age 1.	0.66	0.40	0.26	No ice problems noted.
	1985	Age 2.	0.89	0.87	0.02	
1989	1987	Age 1.	0.78	0.56	0.22	No ice problems noted.
	1986	Age 2.	0.34	0.60	-0.26	
1990	1988	Age 1.	0.58	0.50	0.08	Ice problems prior to 5/21.
	1987	Age 2.	0.22	0.44	-0.22	
1991	1989	Age 1.	0.59	0.15	0.44	Ice problems - 5/22-5/26 intermittent, 5/27-5/29 continuous.
	1988	Age 2.	0.41	0.50	-0.09	
1992	1990	Age 1.	0.08	0.11	-0.03	Ice problems - 5/19-5/22 continuous, 5/24-5/26 and 5/31 intermittent.
	1989	Age 2.	0.41	0.85	-0.44	
1993	1991	Age 1.	0.42	0.82	-0.40	No ice problems. River ice-free 10 d before sonar activated.
	1990	Age 2.	0.92	0.89	0.03	
1994	1992	Age 1.	-	-		Ice problems - 5/17- 5/28 continuous.
	1991	Age 2.	0.58	0.18	0.40	

Table 30. Age composition of total migration and mean fork length and weight by age class for sockeye salmon smolt, Egegik River, 1939-1998.

Year of Migration	Age 1.				Age 2.				Age 3.				Total Estimate ^a
	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)	
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	87	6.1	1987	93	105	10.5	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
1995	1993	13	103	9.3	1992	87	112	11.6	1991	0	126	14.9	57,385,790
1996	1994	71	106	10.5	1993	26	124	16.1	1992	3	141	21.4	31,270,793
1997	1995	45	103	9.5	1994	54	117	13.4	1993	1	135	18.4	27,050,113
Mean			103	9.7			117	14.2			132	20.1	
1998	1996	64	105	9.0	1995	35	121	13.7	1994	1	132	16.2	78,791,125
% Difference from Mean			2	-7			4	-4			0	-20	

^a No estimate of smolt numbers for 1939-1981 fyke net catches; estimates of smolt numbers from 1982-1998 based on hydroacoustic techniques.

Table 31. Water temperatures at sockeye salmon smolt counting site, Egegik River, 1981-1998.

Year	Sample Period	Water Temp (C°)		
		Minimum	Mean	Maximum
1981	May 15 - June 08	7.0	8.2	10.0
1982	May 15 - June 16	2.5	4.9	8.5
1983	May 18 - June 10	5.2	7.9	10.5
1984	May 17 - June 11	5.5	7.9	10.0
1985	May 17 - June 12	2.0	4.6	7.0
1986	May 19 - June 12	1.0	4.6	7.0
1987	May 18 - June 13	4.5	6.7	9.0
1988	May 19 - June 14	3.0	7.1	11.0
1989	May 21 - June 10	3.0	5.8	8.8
1990	May 20 - June 11	3.5	7.3	9.5
1991	May 21 - June 12	1.0	4.8	8.5
1992	May 21 - June 12	5.0	7.8	10.0
1993	May 18 - June 09	4.0	6.6	11.0
1994	May 21 - June 10	1.5	6.1	11.0
1995	May 21 - June 13	2.0	7.0	12.5
1996	May 19 - June 13	2.0	5.8	10.5
1997	May 19 - June 10	3.5	7.9	13.0
Mean		3.3	6.5	9.9
1998	May 19 - June 11	2.5	4.9	7.0
% Difference from Mean		-24.4	-24.9	-29.1

Table 32. Sockeye salmon spawning escapement, total number of smolt produced by age class, percent of total smolt production composed by age class, and number of smolt produced per spawner for 1978-1996 brood years, Egegik River.

Brood Year	Total Spawning Escapement ^a	Number of Smolt Produced						Total	Per Spawner
		Age 1.	(% ^b)	Age 2.	(% ^b)	Age 3.	(% ^b)		
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	0	66,179,555	62.38
1981	694,680	2,242,326	6	32,235,734	93	52,852	0	34,530,912	49.71
1982	1,034,628	17,234,269	60	11,434,848	40	564	0	28,669,681	27.71
1983	792,282	54,585,828	64	29,984,140	35	85,087	0	84,655,055	106.85 ^c
1984	1,165,320	14,016,441	24	45,386,536	76	80,931	0	59,483,908	51.05
1985	1,095,192	4,397,087	26	12,758,135	74	81,150	0	17,236,372	15.74
1986	1,151,750	36,122,149	57	27,347,612	43	0	0	63,469,761	55.11
1987	1,272,978	72,458,024	58	52,299,487	42	396,423	0	125,153,934	98.32 ^c
1988	1,612,680	3,795,739	4	89,162,038	96	361,128	0	93,318,905	57.87
1989	1,610,916	4,519,527	21	17,338,786	79	37,254	0	21,895,567	13.59
1990	2,191,362	6,048,364	14	37,719,609	86	19,196	0	43,787,169	19.98
1991	2,786,880	20,203,545	34	39,158,743	66	11,242	0	59,373,530	21.30
1992	1,945,332	54,909,050	52	49,962,265	47	1,067,697	1	105,939,012	54.46
1993	1,516,980	7,412,283	47	8,089,658	52	202,218	1	15,704,159	10.35
1994	1,897,932	22,113,438	58	14,630,756	39	1,119,575	3	37,863,769	19.95
1995	1,265,862	12,217,139	31	27,476,148 ^d	69			39,693,287 ^d	31.36 ^d
1996	1,076,460	50,195,402							
1984-1993 Max	2,786,880	72,458,024	58	89,162,038	96	1,067,697	1	125,153,934	98.32
1984-1993 Avg	1,634,939	22,388,221	34	37,922,287	66	225,724	0	60,536,232	39.78
1984-1993 Min	1,095,192	3,795,739	4	8,089,658	42	0	0	15,704,159	10.35

^a Egegik River tower count only. Does not include aerial survey index counts from Shosky Creek or King Salmon River.

^b Percent of total smolt production

^c Smolt outmigration estimates for brood years with unusually high smolt per spawner ratios may be artificially low. During these years smolt may have passed undetected before, during, or after the operational dates of the smolt sonar.

^d Incomplete returns from brood year escapements.

Table 33. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1978-1996 brood years, Egegik River.

Brood Year	Age 1.				Age 2.			Age 3.		
	Total Spawning Escapement ^a	Number of Smolt	Adult Returns ^b	Adult Returns per Smolt	Number of Smolt	Adult Returns ^b	Adult Returns per Smolt	Number of Smolt	Adult Returns ^b	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	
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 ^c	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	^d
1983	792,282	54,585,828	4,520,747	0.08	30,036,716	6,086,667	0.20	85,087	37,683	0.44 ^c
1984	1,165,320	14,160,585	1,597,084	0.11	45,386,536	11,665,474	0.26	80,931	256,616	^d
1985	1,095,192	4,397,087	1,980,826	0.45 ^c	12,758,135	5,652,082	0.44 ^c	81,150	25,976	0.32 ^d
1986	1,151,750	36,122,149	5,676,245	0.16	27,347,612	8,520,337	0.31	0	120,388	^d
1987	1,272,978	72,458,024	5,548,894	0.08	52,299,487	20,199,111	0.39	396,423	193,309	0.49 ^c
1988	1,612,680	3,795,739	1,695,748	0.45	89,162,038	16,775,951	0.19	361,128	412,775	^d
1989	1,610,916	4,519,527	974,486	0.22	17,338,786	10,076,582	0.58 ^c	37,245	201,466	^d
1990	2,191,362	6,048,364	1,273,444	0.21	37,719,609	14,413,565	0.38	19,196	51,024	^d
1991	2,786,880	20,203,545	5,385,263	0.27	39,158,743	5,751,033	0.15	11,242	29,987 ^e	^d
1992	1,945,332	54,909,050	1,461,902	0.03	49,962,265	8,169,742 ^e	0.16 ^e	1,067,697	55,602 ^e	
1993	1,516,980	7,412,283	1,083,190 ^e	0.15 ^e	8,089,658	917,834 ^e		202,218	0 ^e	
1994	1,897,932	22,113,438	376,114 ^e		14,630,756	65,227 ^e		1,119,575		
1995	1,265,862	12,217,139	6,988 ^e		27,476,148					
1996	1,076,460	50,195,402								
1982-1991 Max	2,786,880	72,458,024	5,676,245	0.45	89,162,038	20,199,111	0.58	396,423	412,775	0.49
1982-1991 Avg	1,471,399	23,352,512	3,152,606	0.22	36,264,251	10,258,834	0.32	107,297	134,196	0.42
1982-1991 Min	792,282	3,795,739	974,486	0.08	11,434,848	3,447,534	0.15	0	12,739	0.32

^a Egegik River tower count only. Does not include aerial survey index counts from Shosky Creek or King Salmon River.

^b Includes estimates of adult returns through 1998.

^c Smolt outmigration estimates for brood years with unusually high adult return per smolt ratios may be artificially low. During these years smolt may have passed undetected before, during, or after the operational dates of the smolt sonar.

^d Insufficient Age 3. smolt sampled to perform this calculation.

^e Future adult returns will increase these values.

Table 34. Comparison of the age composition of outmigrating sockeye smolt at Egegik River with the freshwater age composition of their total adult returns by brood year, 1981-1991.

Smolt Outmigration Year	Brood Year	Freshwater Age	Proportion of Total		Difference	Comments
			Smolt	Adult		
1983	1981	Age 1.	0.06	0.24	-0.18	No ice problems noted.
	1980	Age 2.	-	-		
1984	1982	Age 1.	0.60	0.45	0.15	No ice problems noted.
	1981	Age 2.	0.93	0.76	0.17	
1985	1983	Age 1.	0.64	0.42	0.22	Ice present - 5/17-5/22 intermittent
	1982	Age 2.	0.40	0.54	-0.14	
1986	1984	Age 1.	0.24	0.12	0.12	Ice present - 5/19-5/25 intermittent
	1983	Age 2.	0.35	0.57	-0.22	
1987	1985	Age 1.	0.26	0.26	0.00	No ice problems noted.
	1984	Age 2.	0.76	0.86	-0.10	
1988	1986	Age 1.	0.57	0.40	0.17	No ice problems noted.
	1985	Age 2.	0.74	0.74	0.00	
1989	1987	Age 1.	0.58	0.21	0.37	No ice problems noted.
	1986	Age 2.	0.43	0.60	-0.17	
1990	1988	Age 1.	0.04	0.09	-0.05	Fair Weather - 118 h disabled time
	1987	Age 2.	0.42	0.78	-0.36	
1991	1989	Age 1.	0.21	0.09	0.12	Ice problems - 5/17-5/18 continuous.
	1988	Age 2.	0.96	0.89	0.07	
1992	1990	Age 1.	0.14	0.08	0.06	No ice problems noted.
	1989	Age 2.	0.79	0.90	-0.11	
1993	1991	Age 1.	0.34	0.48	-0.14	No ice problems noted.
	1990	Age 2.	0.86	0.92	-0.06	
1994	1992	Age 1.	-	-		Excellent Weather - no disabled time.
	1991	Age 2.	0.66	0.52	0.14	

Table 35. Age composition of total migration and mean fork length and weight by age class for sockeye salmon smolt, Ugashik River, 1958-1998.

Year of Migration	Age 1.				Age 2.				Age 3.				Total Estimate ^a
	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)	
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
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
1995	1993	31	93	7.8	1992	69	106	11.1	1991	-	-	-	22,234,137
1996	1994	44	101	9.9	1993	56	114	13.5	1992	-	-	-	2,576,812
1997	1995	92	92	7.9	1994	8	109	12.1	1993	-	-	-	15,519,783
Mean			91	7.0			112	12.1			128	17.9	
1998	1996	82	91	6.4	1995	18	110	11.1	1994	-	-	-	12,624,441
% Difference from Mean			0	-8.1			-1	-8.0					

^a No estimates of smolt numbers from 1958-1982 fyke net catches; estimates of smolt numbers from 1983-1991 and 1993-1998 based on hydroacoustic techniques.

^b Project not operated in 1992. No smolt data collected.

Table 36. Water temperatures at sockeye salmon smolt counting site, Ugashik River, 1983-1998.

Year	Sample Period	Water Temp (C°)		
		Minimum	Mean	Maximum
1983	May 23 - June 11	6.0	7.3	8.5
1984	May 20 - June 17	4.8	6.3	8.5
1985	May 17 - June 09	-1.0	4.3	7.0
1986	May 23 - June 28	2.0	5.6	7.0
1987	May 17 - June 13	4.0	5.9	9.0
1988	May 17 - June 13	3.5	6.6	10.0
1989	May 21 - June 16	3.0	5.8	8.8
1990	May 21 - June 14	3.0	5.9	8.0
1991	May 20 - June 14	4.0	5.9	8.5
1992	^a			
1993	May 18 - June 11	5.0	6.5	9.0
1994	May 20 - June 13	4.5	6.5	10.0
1995	May 23 - June 12	4.0	6.2	9.0
1996	May 19 - June 13	3.0	5.6	7.5
1997	May 10 - June 13	3.5	7.1	12.0
Mean		3.5	6.0	8.5
1998	May 18 - June 13	3.5	5.5	7.5
% Difference from Mean		-0.7	-9.2	-12.0

^a Project not operated in 1992. No data collected.

Table 37. 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 1979-1996 brood years, Ugashik River.

Brood Year	Total Spawning Escapement ^a	Number of Smolt Produced			Total	Per Spawner		
		Age 1. (% ^b)	Age 2. (% ^b)	Age 3. (% ^b)				
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	1,001,492	182,719,678	85	32,278,743	15	0	214,998,421	214.68
1987	668,964	94,019,379	71	38,789,387	29	0	132,808,766	198.53
1988	642,972	14,837,960	24	47,713,086	76	- ^c	62,551,046 ^d	97.28 ^d
1989	1,681,302	26,056,791		- ^c		0	^d	^d
1990	730,038	- ^c		12,415,518		0	^d	^d
1991	2,457,306	58,331,556	91	5,725,543	9	0	64,057,099	26.07
1992	2,173,692	24,305,081	61	15,272,807	39	0	39,577,888	18.21
1993	1,389,534	6,961,330	83	1,429,625 ^e	17	0	8,390,955	6.04
1994	1,080,858	1,147,187 ^e	49	1,199,949	51	0	2,347,136	2.17
1995	1,304,058	14,319,834	86	2,292,099	14	^d	16,611,933 ^d	12.74 ^d
1996	667,518	10,332,342		^d		^d	^d	^d
1984-1993 Max	2,457,306	182,719,678	91	47,713,086	86		214,998,421	214.68
1984-1993 Avg	1,298,495	50,064,861	62	23,149,686	38		77,558,527	80.93
1984-1993 Min	642,972	5,461,821	14	1,429,625	9		8,390,955	6.04

^a Ugashik River tower count only. Does not include aerial survey index counts from King Salmon River or Dog Salmon River.

^b Percent of total smolt production.

^c No smolt data collected in 1992, therefore smolt production data for the 1988 (Age 3.), 1989 (Age 2.), and 1990 (Age 1.) brood years are incomplete.

^d Incomplete returns from brood year escapements.

^e Need adult returns through 1999 to validate this smolt estimate.

Table 38. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1979-1996 brood years, Ugashik River.

Brood Year	Total Spawning Escapement ^a	Age 1.			Age 2.			Age 3.		
		Number of Smolt	Adult Returns ^b	per Smolt	Number of Smolt	Adult Returns ^b	per Smolt	Number of Smolt	Adult Returns ^b	per Smolt
1979	1,700,904		3,960,210			2,045,642		0		^c
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	^c
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	957,765	0.06	1,677	957	^c
1984	1,241,418	37,890,152	1,052,692	0.03	21,483,727	4,399,295	0.20	9,598	6,732	^c
1985	998,232	5,461,821	1,233,686	0.23	33,238,739	1,454,422	0.04	0	0	
1986	1,001,492	182,719,678	3,001,968	0.02	32,278,743	3,639,400	0.11	0	4,459	^c
1987	668,964	94,019,379	2,478,649	0.03	38,789,387	4,215,483	0.11	0	34,612	^c
1988	642,972	14,837,960	1,193,721	0.08	47,713,086	4,426,031	0.09	^d	29,819	^c
1989	1,681,302	26,056,791	1,104,400	0.04	^d 3,449,364	^c		0	9,880	^c
1990	730,038	^d	1,057,589	^c	12,415,518	3,535,731	0.28	0	1,733 ^e	^c
1991	2,457,306	58,331,556	5,221,704	0.09	5,725,543	923,928	0.16	0	0 ^e	
1992	2,173,692	24,305,081	784,551	0.03	15,272,807	1,827,685 ^e	0.12 ^e	0	0 ^e	
1993	1,389,534	6,961,330	612,895 ^e	0.09 ^e	1,429,625 ^f	247,054 ^e		0		
1994	1,080,858	1,147,187 ^f	342,729 ^e		1,199,949	11,585 ^e				
1995	1,304,058	14,319,834	17,541 ^e		2,292,099					
1996	667,518	10,332,342								
1982-1991 Max	2,457,306	182,719,678	5,221,704	0.23	47,713,086	4,426,031	0.28	9,598	34,612	^c
1982-1991 Avg	1,157,986	56,389,135	1,848,648	0.07	25,359,845	2,834,666	0.13	1,253	8,819	^c
1982-1991 Min	642,972	5,461,821	995,579	0.02	5,725,543	923,928	0.04	0	0	^c

^a Ugashik River tower count only. Does not include aerial survey index counts from King Salmon River or Dog Salmon River.

^b Includes estimates of adult returns through 1998.

^c Insufficient smolt data to complete this calculation.

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

^e Future adult returns will increase these values.

^f Need adult returns through 1999 to validate this smolt estimate.

Table 39. Comparison of the age composition of outmigrating sockeye salmon smolt at Ugashik River with the freshwater age composition of their total adult returns by brood year, 1981-1991.

Smolt Outmigration Year	Brood Year	Freshwater Age	Proportion of Total		Difference	Comments
			Smolt	Adult		
1983	1981	Age 1.	0.27	0.57	-0.30	No ice or weather problems noted.
	1980	Age 2.	-	-		
1984	1982	Age 1.	0.78	0.46	0.32	No ice or weather problems noted.
	1981	Age 2.	0.73	0.43	0.30	
1985	1983	Age 1.	0.46	0.51	-0.05	Ice present - 5/17-5/21 intermittent
	1982	Age 2.	0.22	0.54	-0.32	
1986	1984	Age 1.	0.64	0.19	0.45	No ice or weather problems noted.
	1983	Age 2.	0.54	0.49	0.05	
1987	1985	Age 1.	0.14	0.46	-0.32	No ice or weather problems noted.
	1984	Age 2.	0.36	0.81	-0.45	
1988	1986	Age 1.	0.85	0.45	0.40	No ice or weather problems noted.
	1985	Age 2.	0.86	0.54	0.32	
1989	1987	Age 1.	0.71	0.37	0.34	No ice or weather problems noted.
	1986	Age 2.	0.15	0.55	-0.40	
1990	1988	Age 1.	0.24	0.21	0.03	Poor Weather - 199 h disabled time
	1987	Age 2.	0.29	0.63	-0.34	
1991	1989	Age 1.	^a	0.24		Poor Weather - 187 h disabled time
	1988	Age 2.	0.76	0.78	-0.02	
1992	1990	Age 1.	^b	0.23		No smolt data.
	1989	Age 2.	^b	0.76		
1993	1991	Age 1.	0.91	0.85	0.06	Bad Weather - 264 h disabled time
	1990	Age 2.	^c	0.77		
1994	1992	Age 1.	0.61	^d		Good Weather - 42 h disabled time
	1991	Age 2.	0.09	0.15	-0.06	

^a Unable to calculate the proportion of Age-1. Smolt for brood year 1989 because the Age-2 smolt for brood year 1989 were not counted in 1992.

^b The Ugashik Smolt project was not operated in 1992; no smolt data collected that year.

^c Unable to calculate the proportion of Age-2. smolt for brood year 1990 because the Age-1 smolt for brood year 1990 were not counted in 1992.

^d Incomplete returns from brood year escapement.

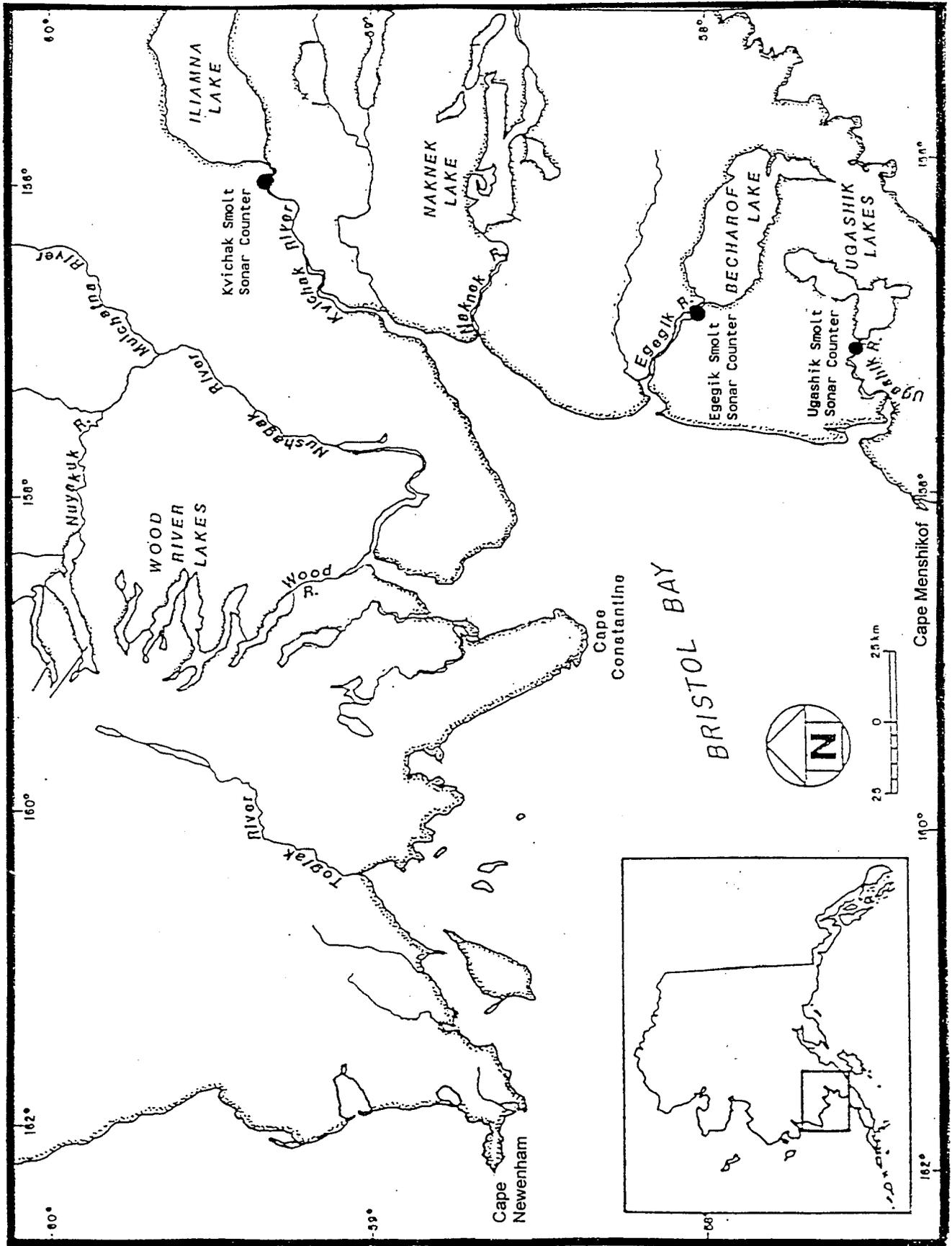


Figure 1. Bristol Bay Management Area with major rivers and locations of smolt sonar counting sites, 1998.

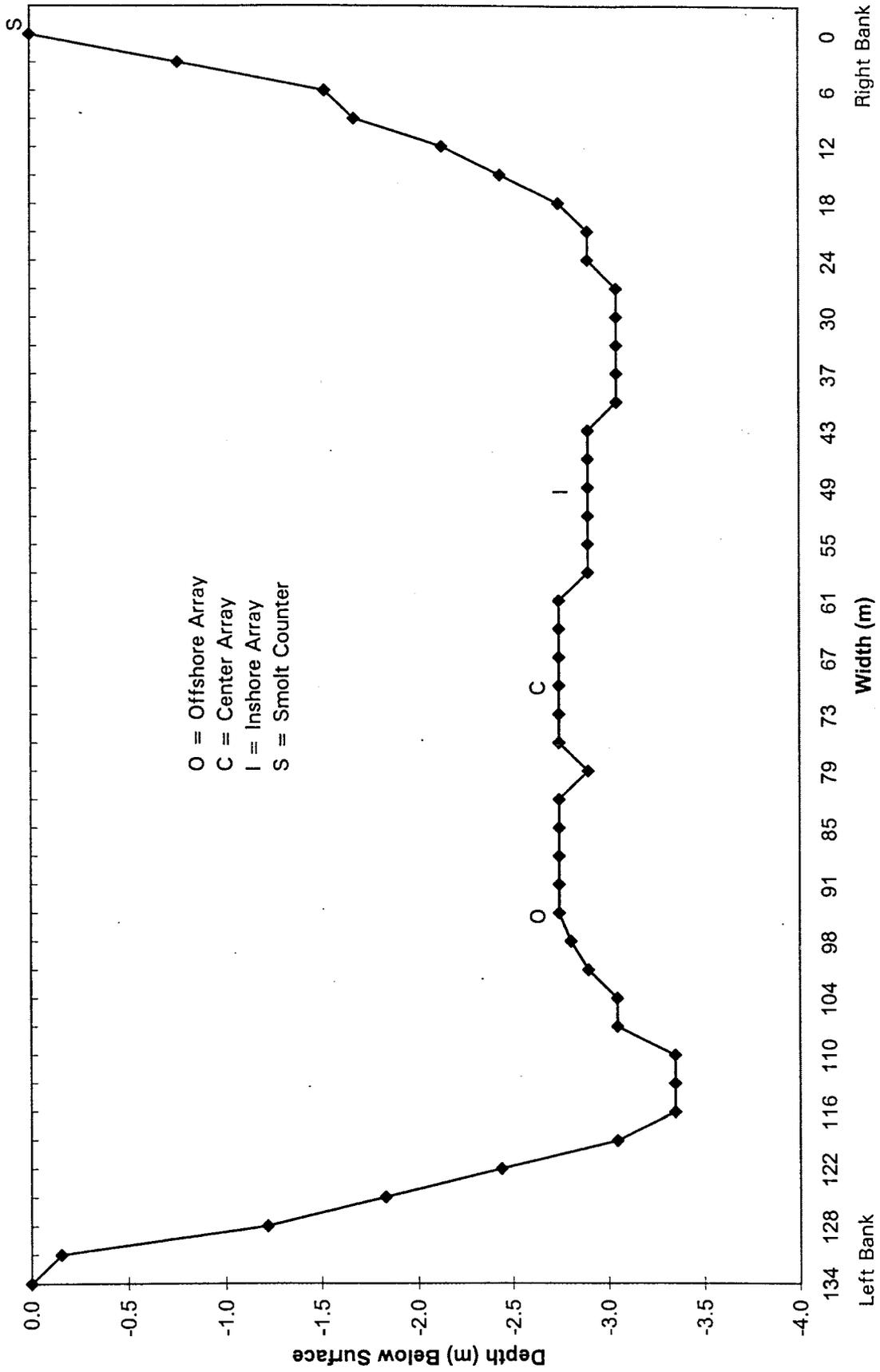


Figure 2. River bottom profile and sonar array placement at Kvichak River smolt sonar site, 1998.

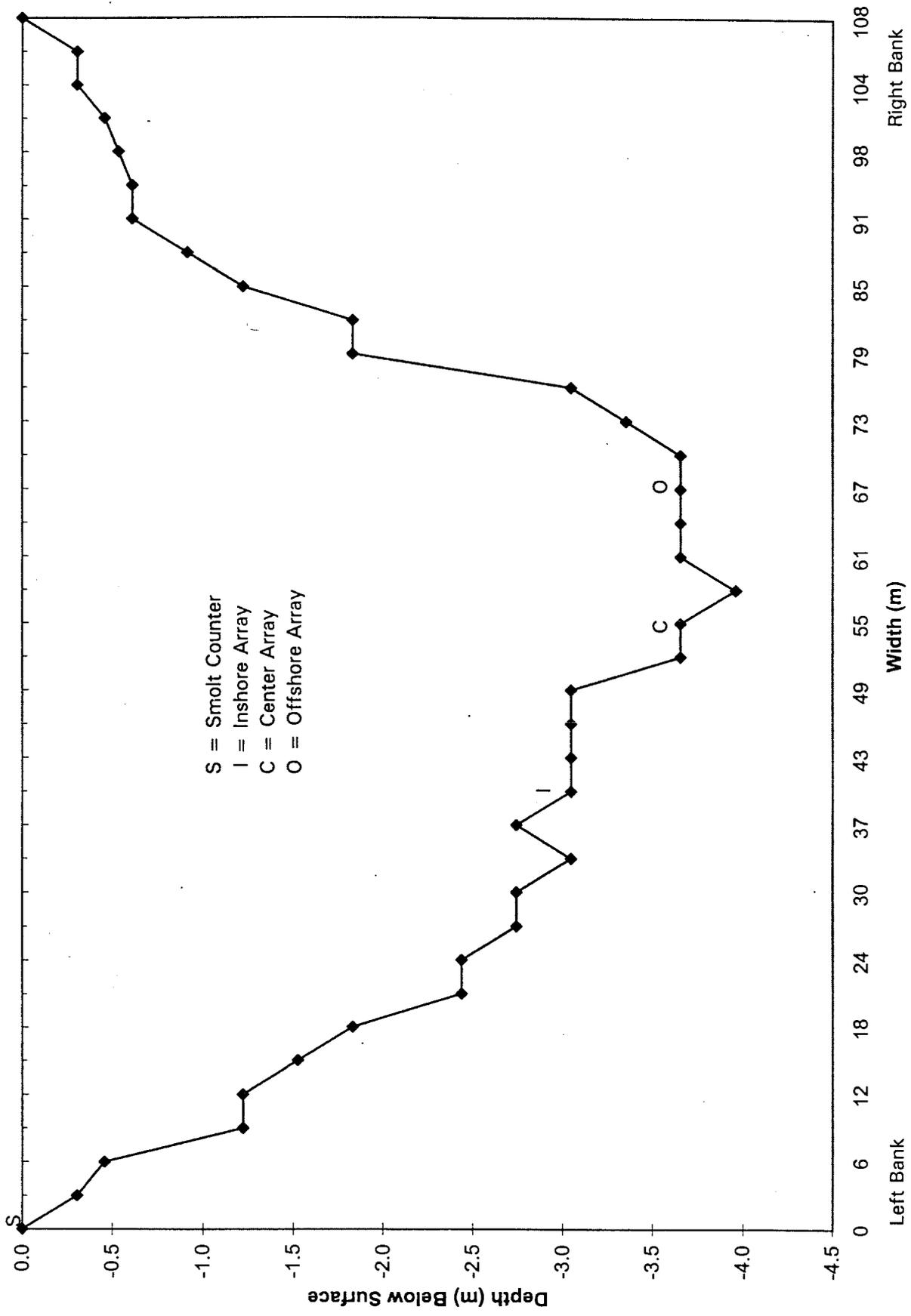


Figure 3. River bottom profile and sonar array placement at Egegik River smolt sonar site, 1998.

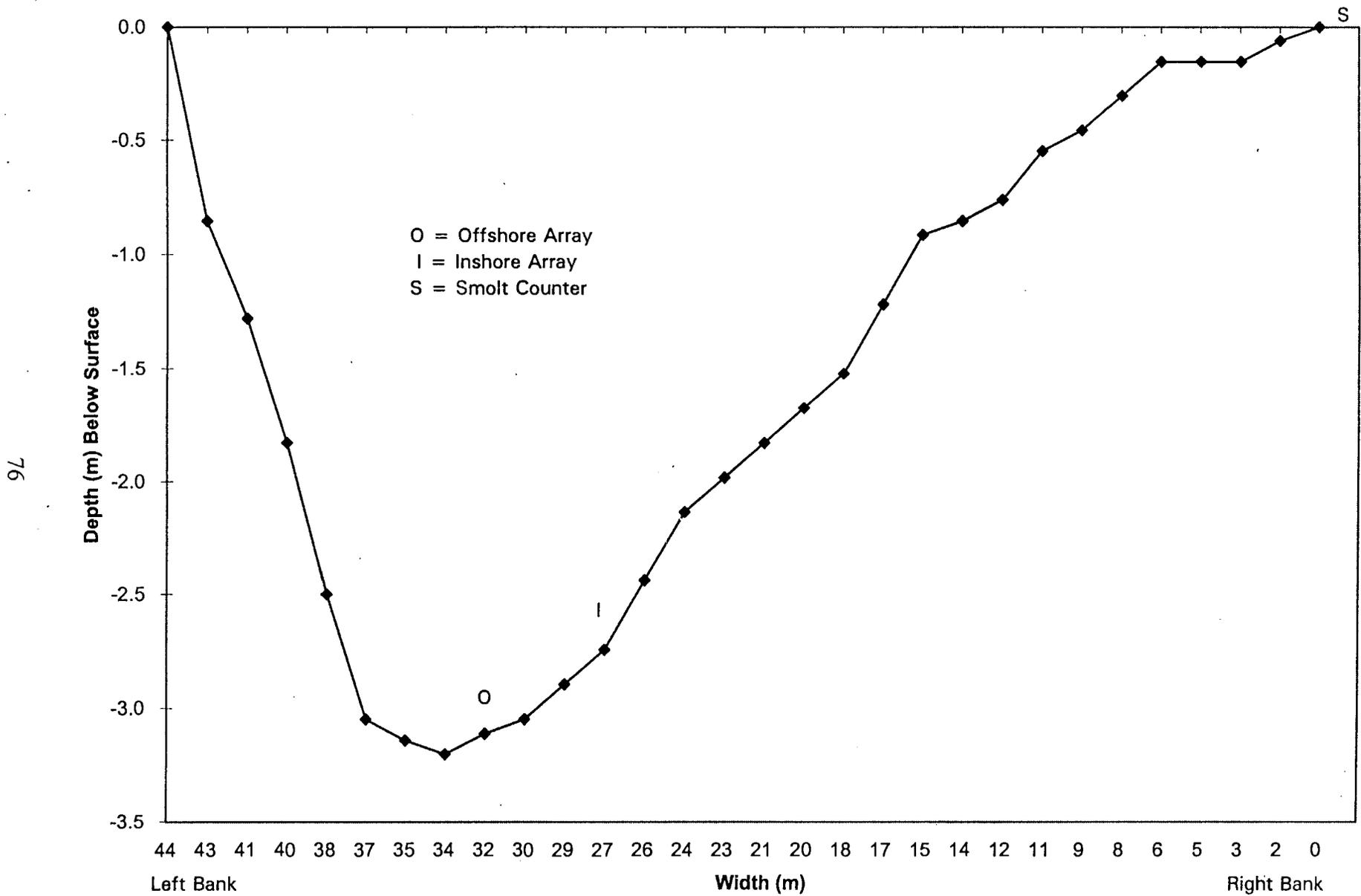


Figure 4. River bottom profile and sonar array placement at Ugashik River smolt sonar site, 1998.

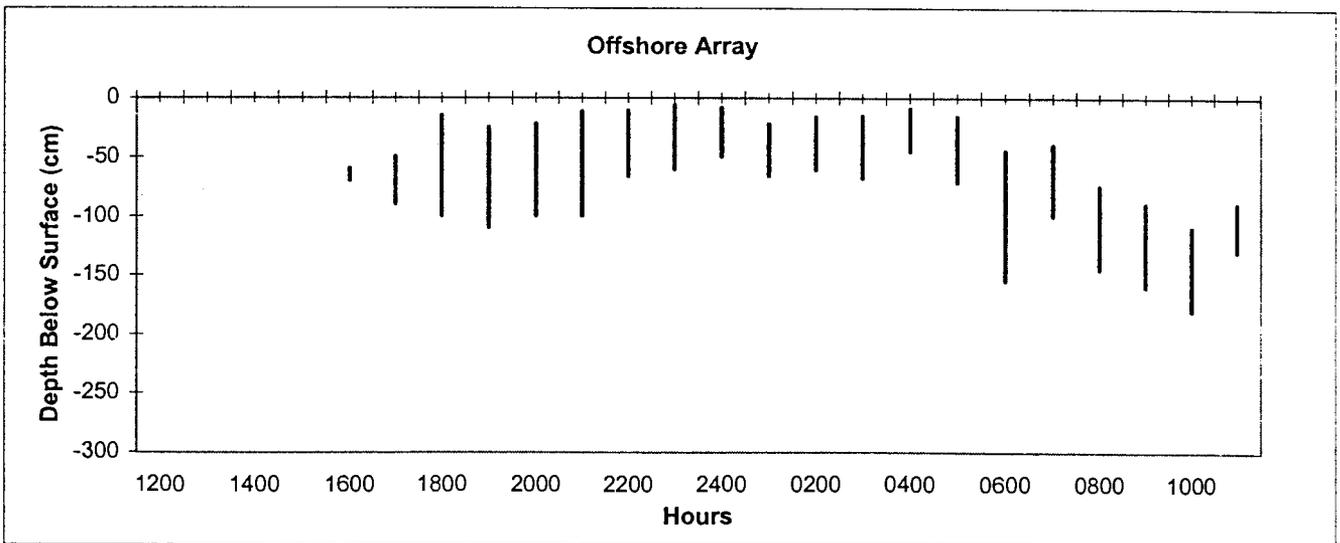
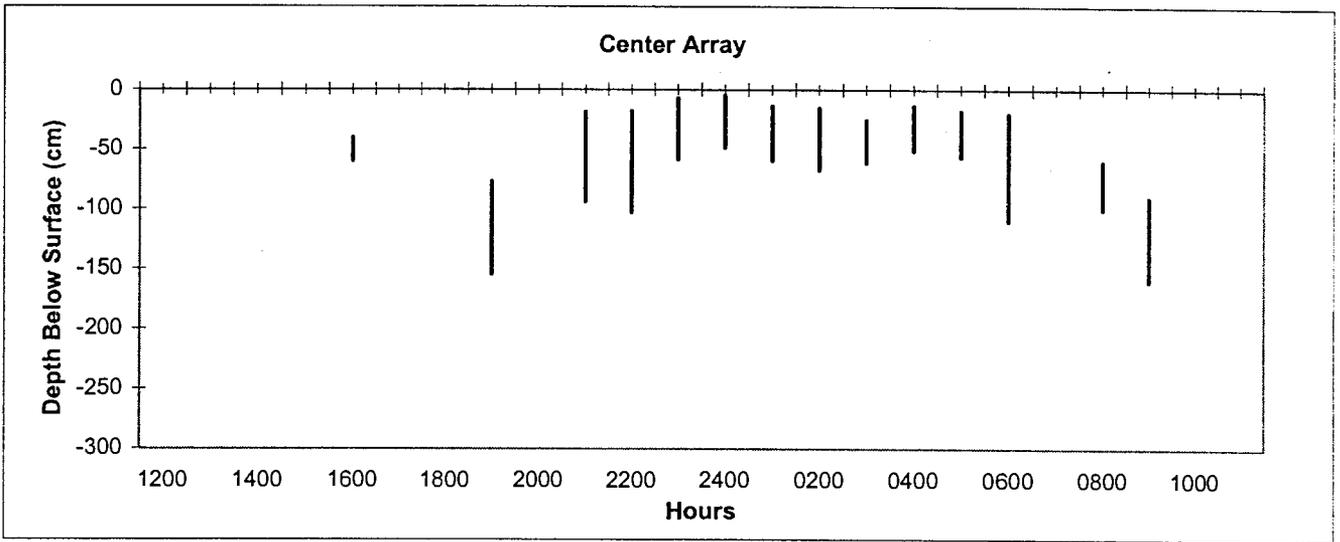
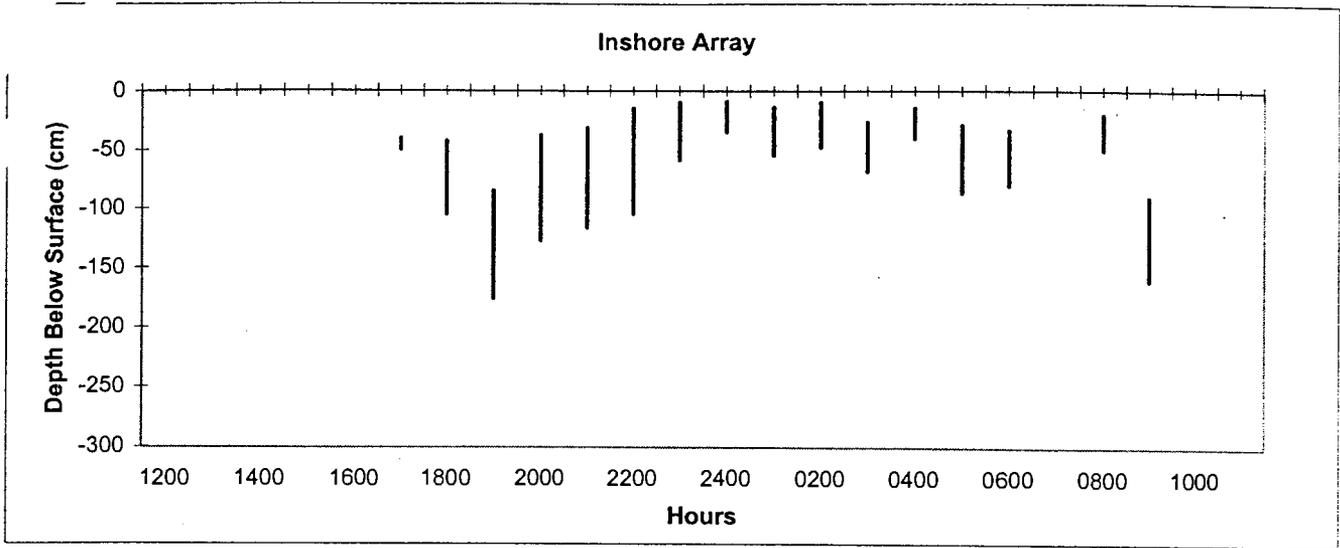


Figure 5. Depth of smolt passage data summarized by hour, Kvichak River, May 17 to June 12, 1998.

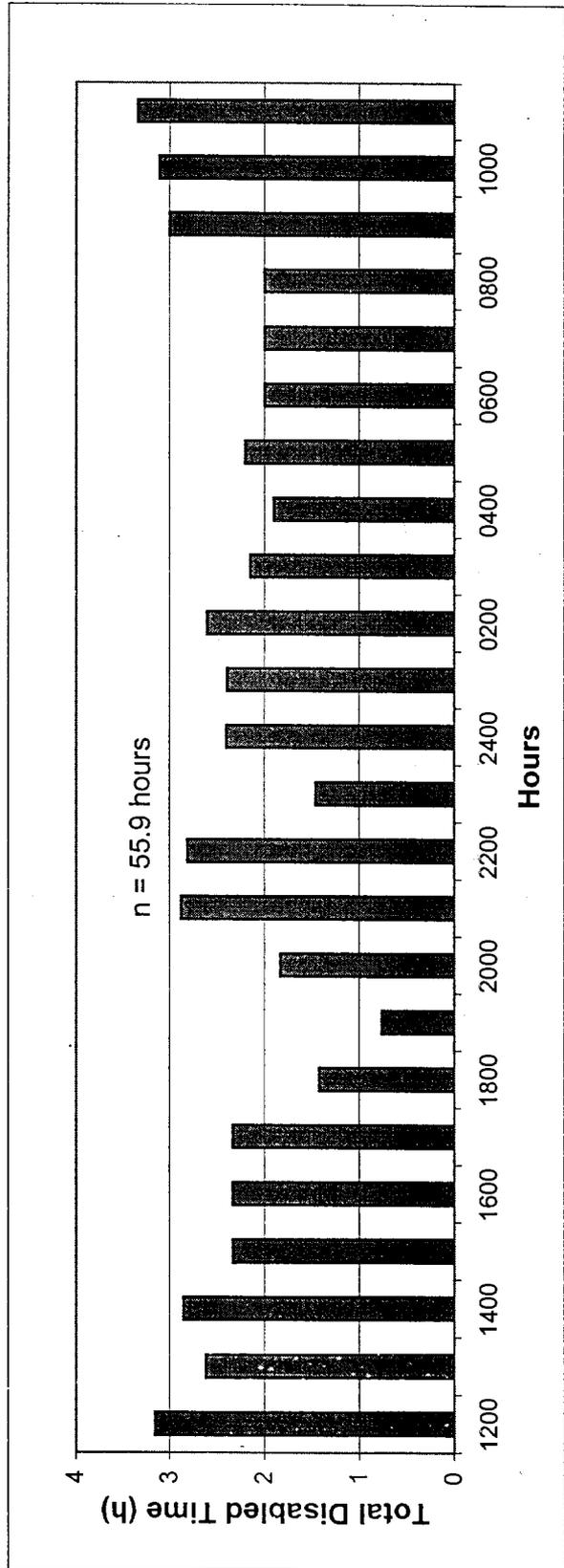
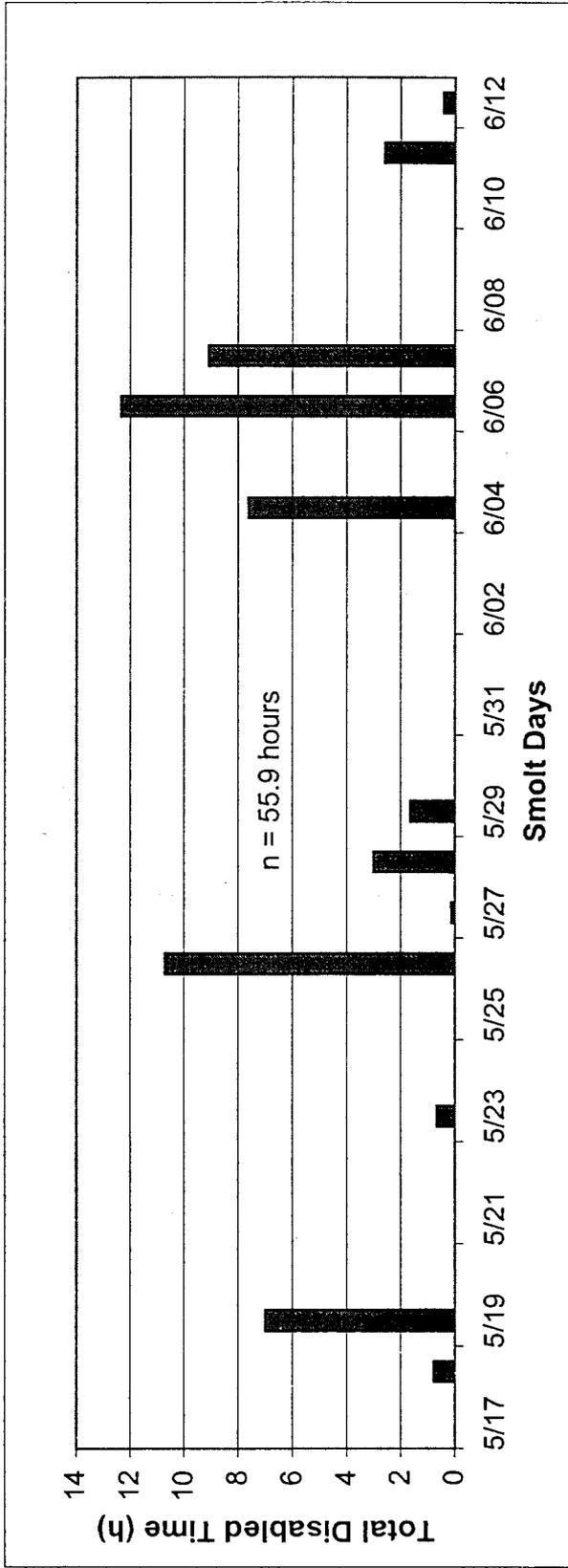


Figure 6. Kvichak River smolt sonar total disabled time due to weather by smolt day and hour, May 17 to June 12, 1998.

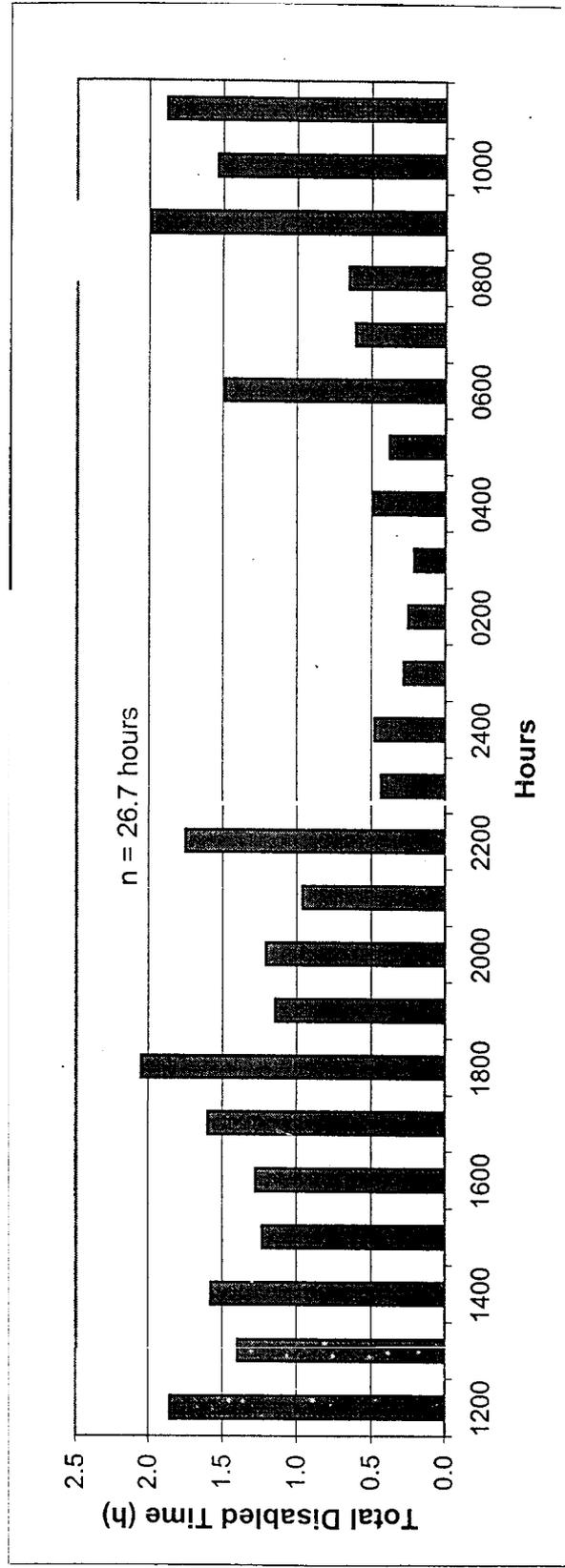
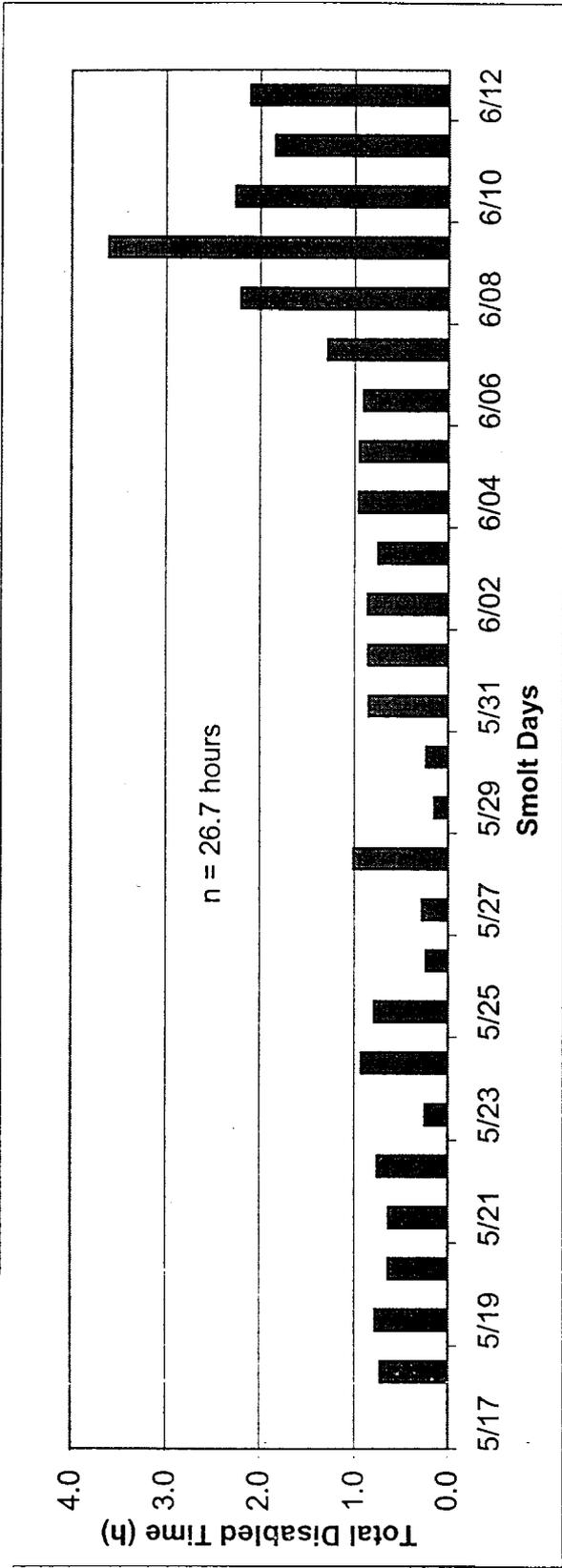


Figure 7. Kvichak River smolt sonar total disabled time due to boat traffic by smolt day and hour, May 17 to June 12, 1998.

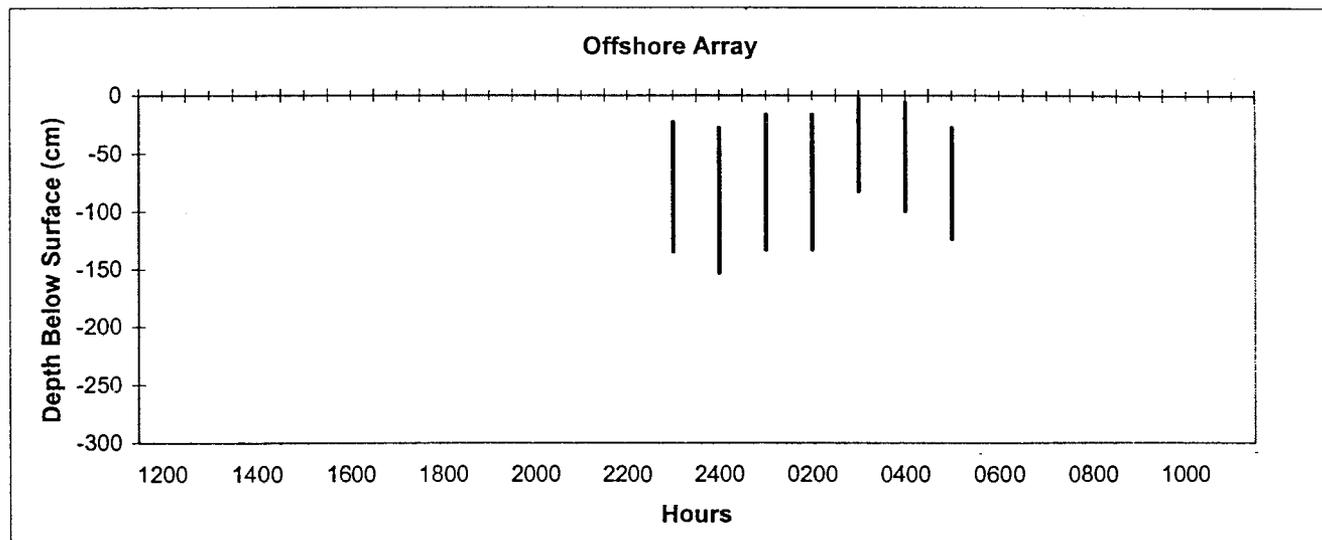
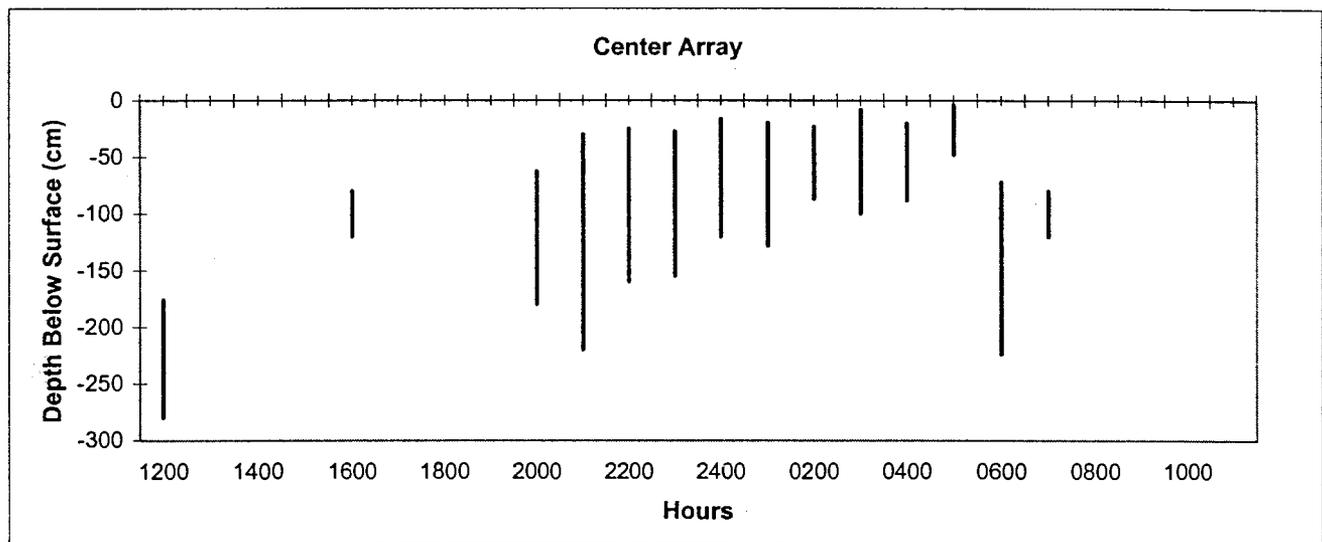
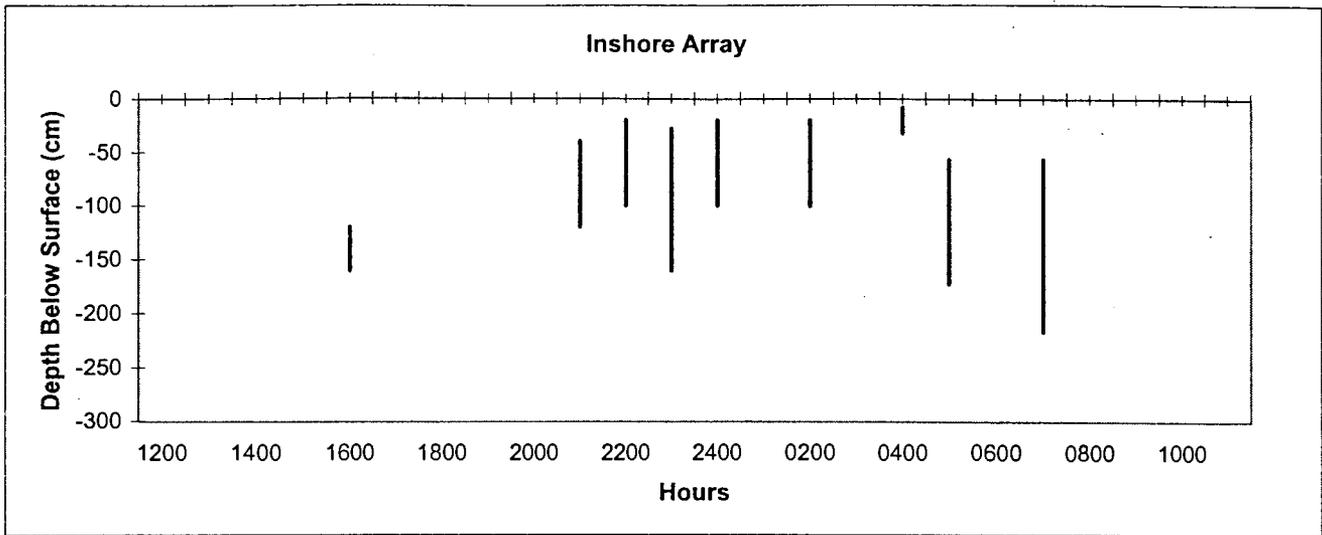


Figure 8. Depth of smolt passage data summarized by hour, Egegik River, May 27 to June 5, 1998.

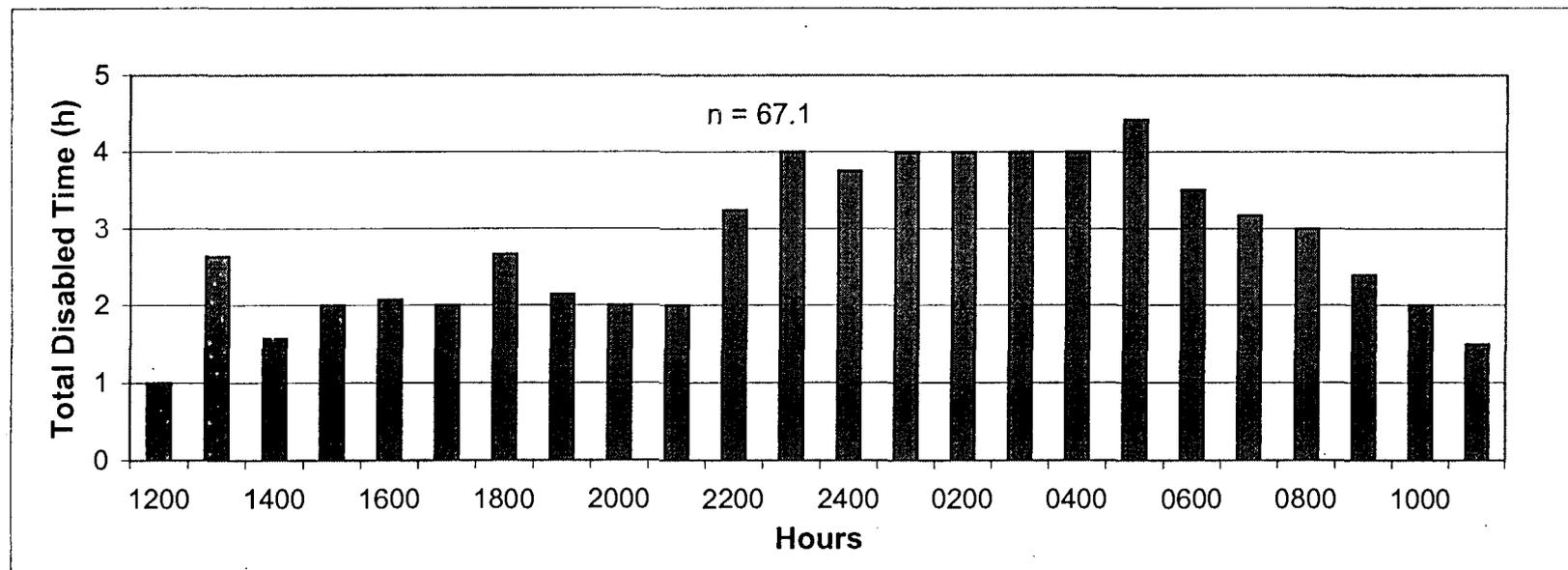
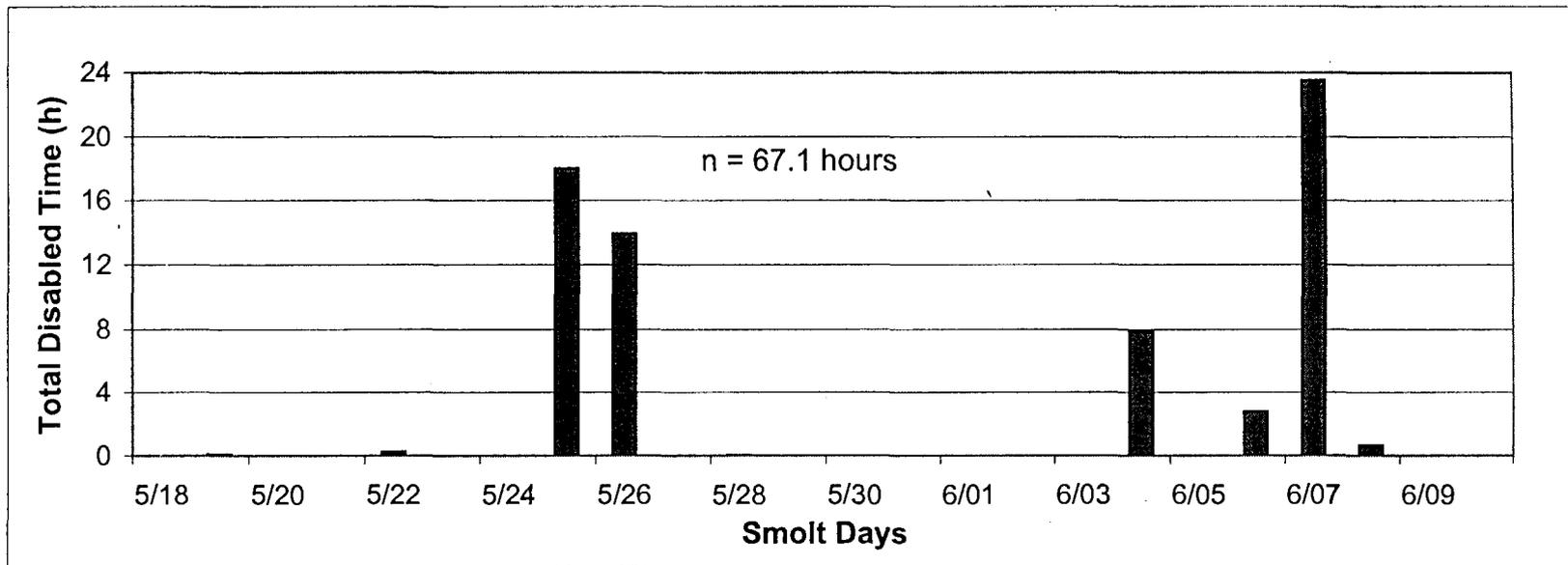


Figure 9. Egegik River smolt sonar total disabled time due to weather by smolt day and hour, May 18 to June 10, 1998.

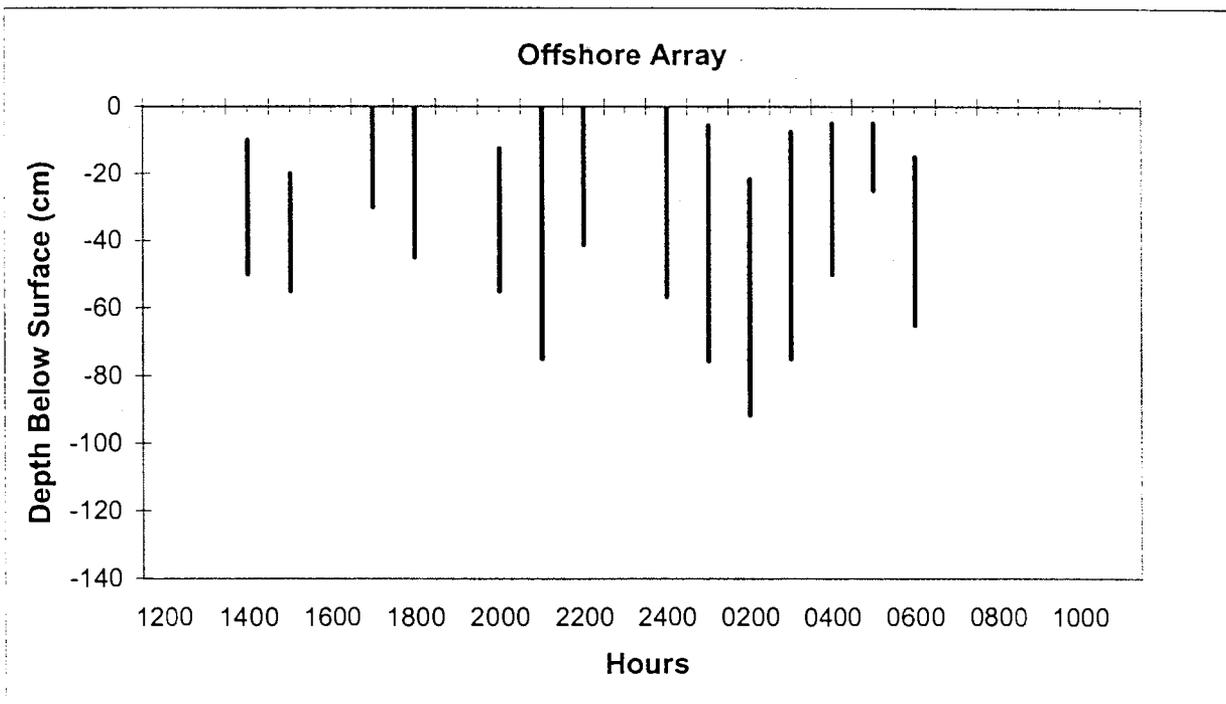
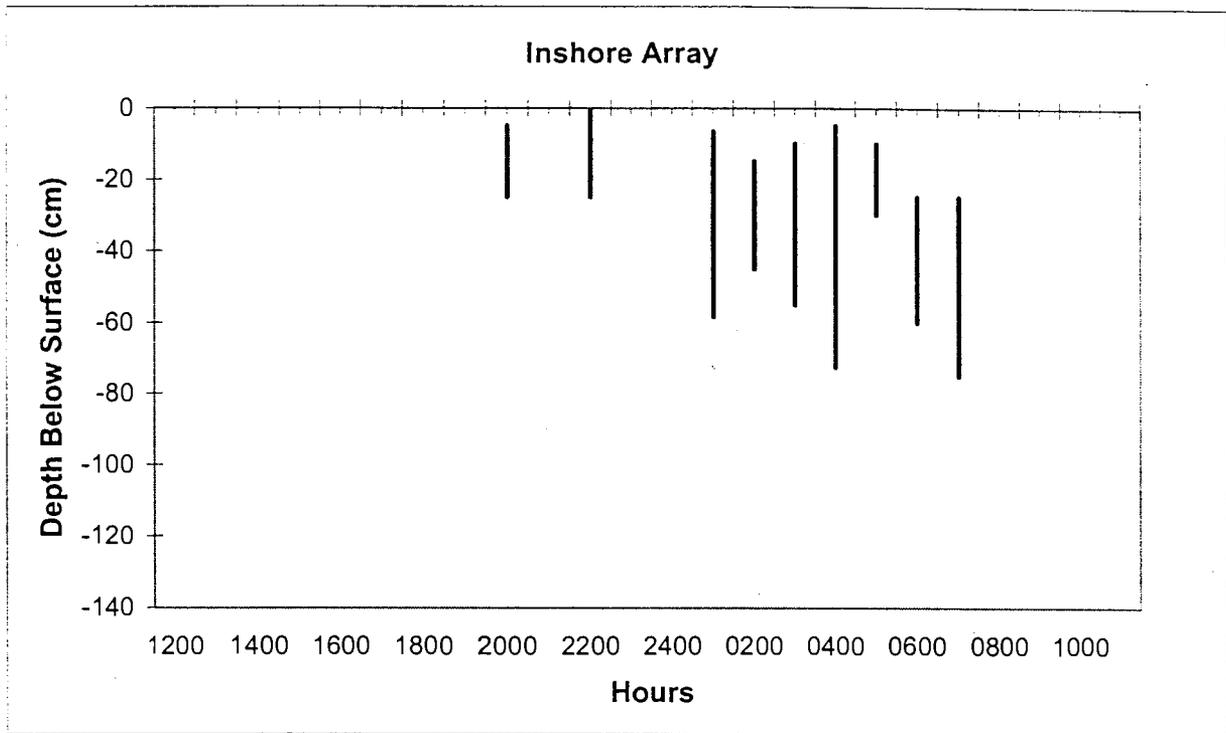


Figure 10. Depth of smolt passage data summarized by hour, Ugashik River, May 24 to June 12, 1998.

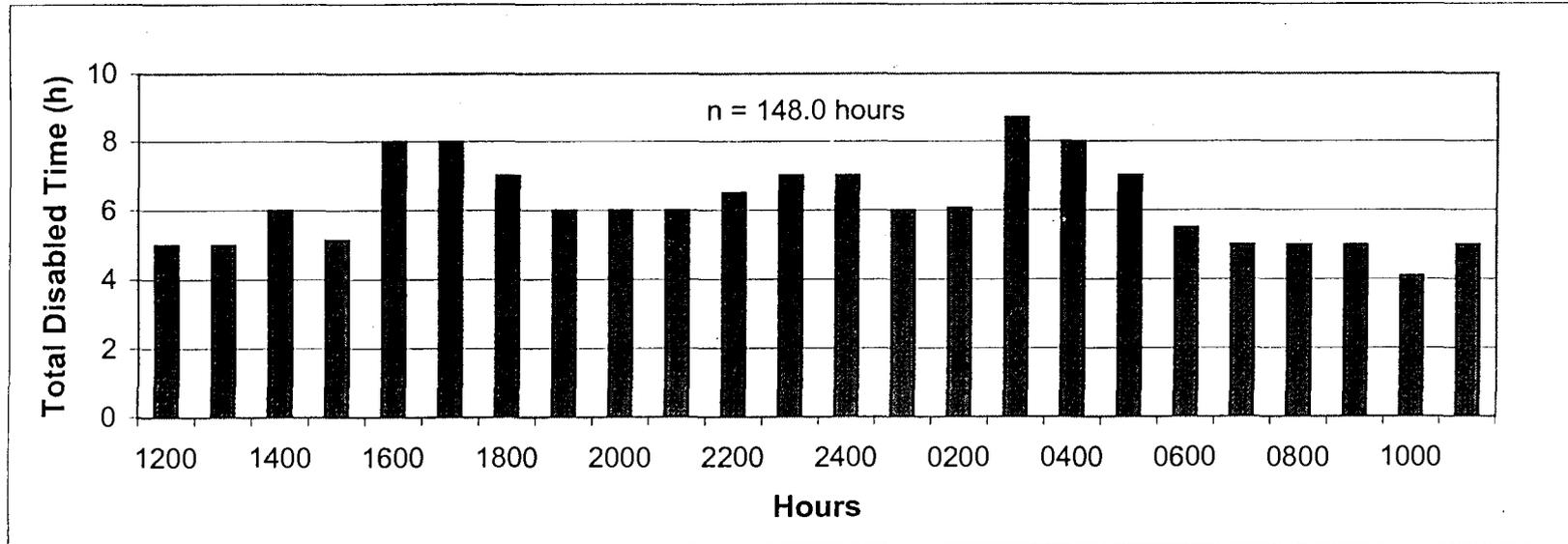
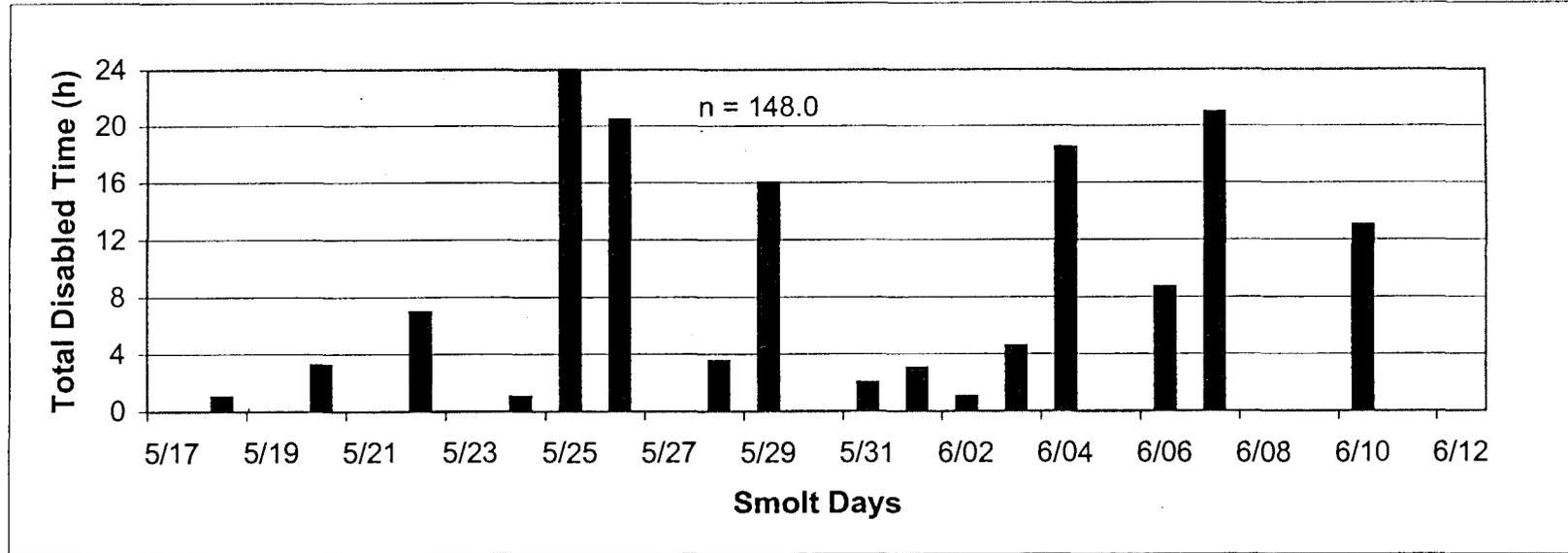


Figure 11. Ugashik River smolt sonar total disabled time due to weather by smolt day and hour, May 17 to June 12, 1998.

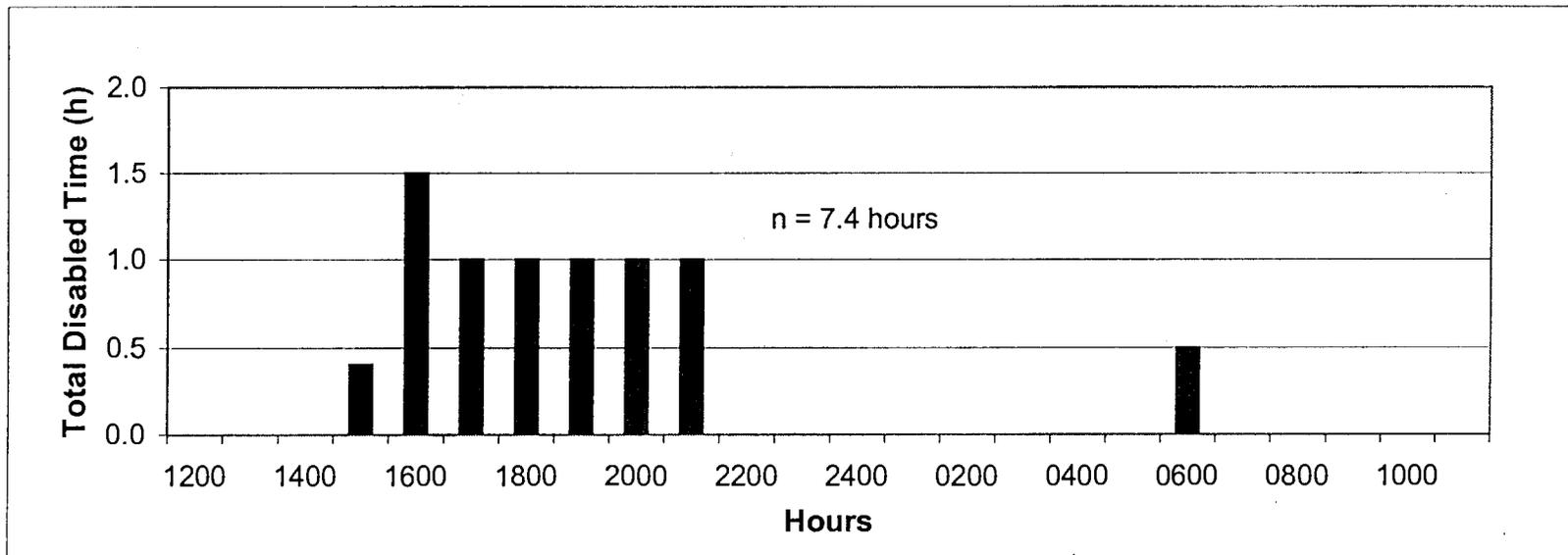
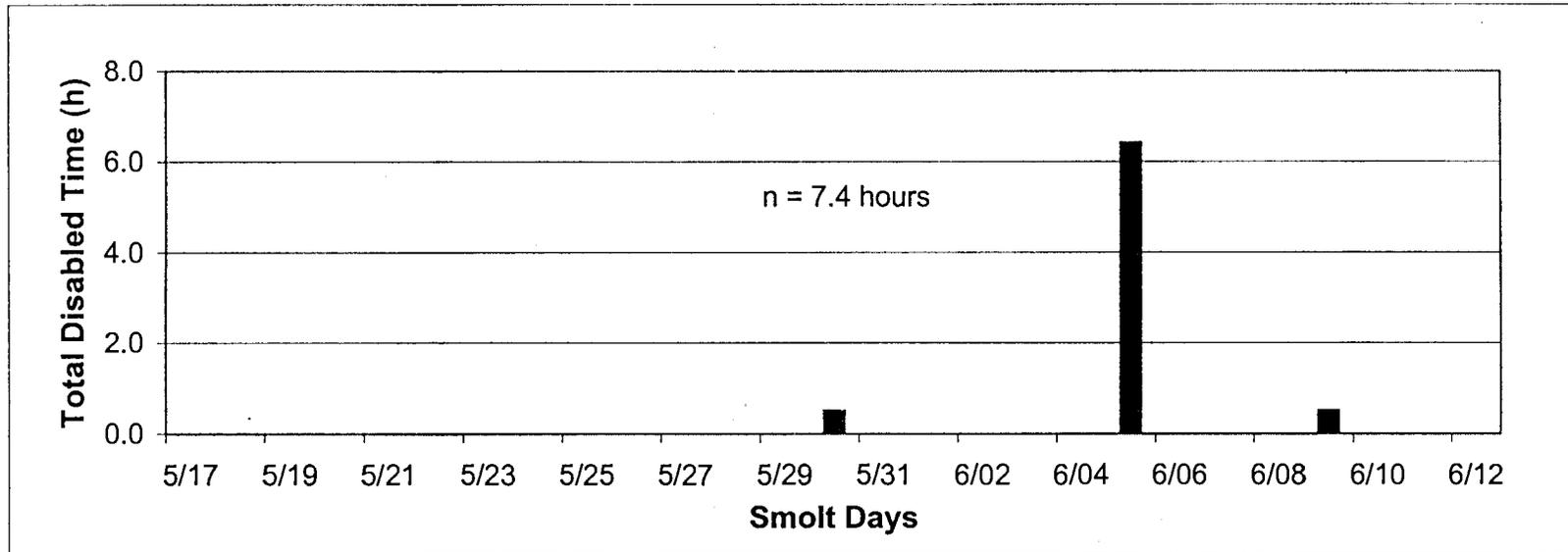


Figure 12. Ugashik River smolt sonar total disabled time due to equipment problems by smolt day and hour, May 17 to June 12, 1998.

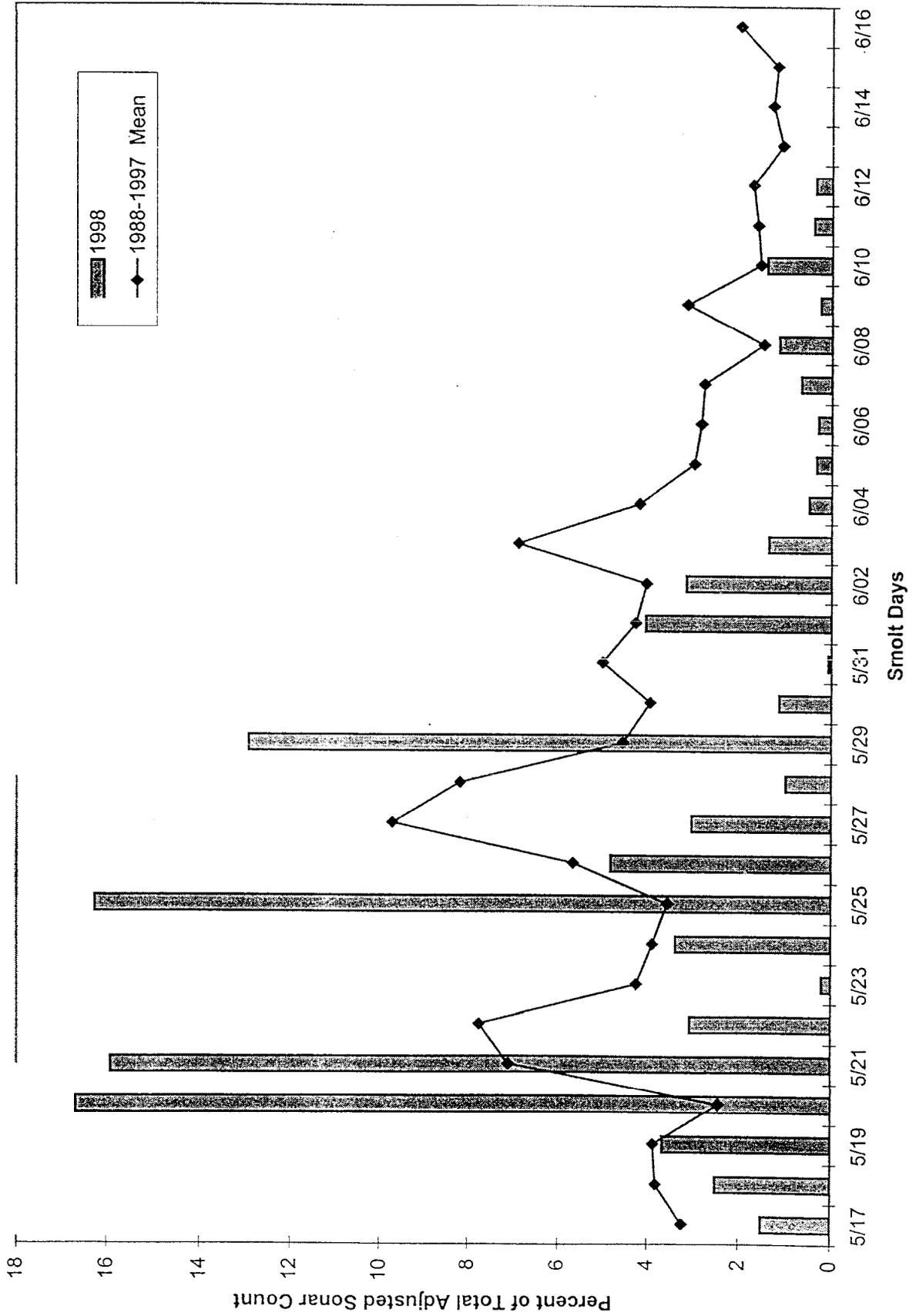


Figure 13. Comparison of the percent of the 1998 total adjusted sonar counts by smolt day at Kvichak River smolt sonar with the 1988-1997 mean.

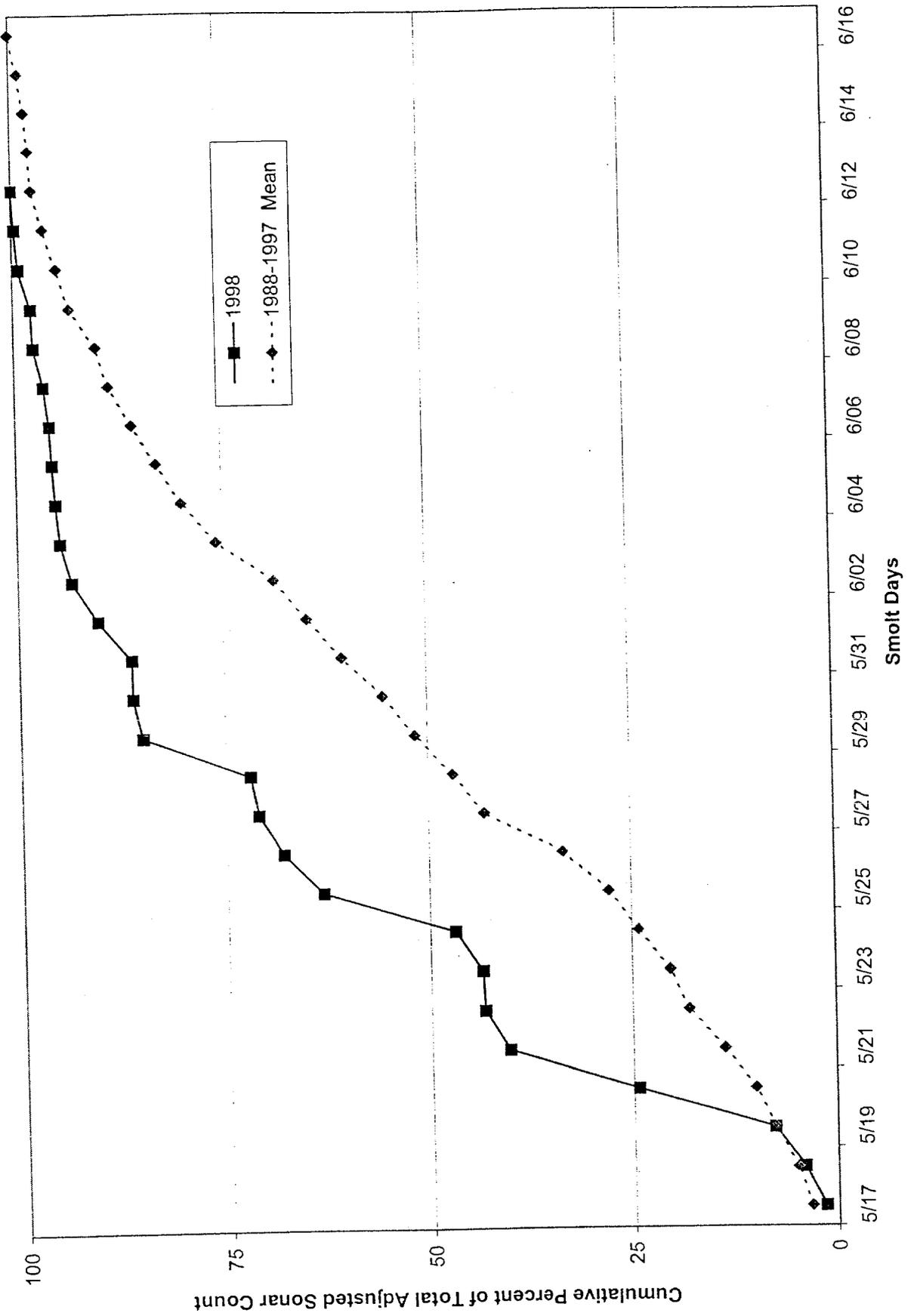


Figure 14. Comparison of the cumulative percent of the 1998 total adjusted sonar counts by smolt day at Kvichak River smolt sonar with the 1988-1997 mean.

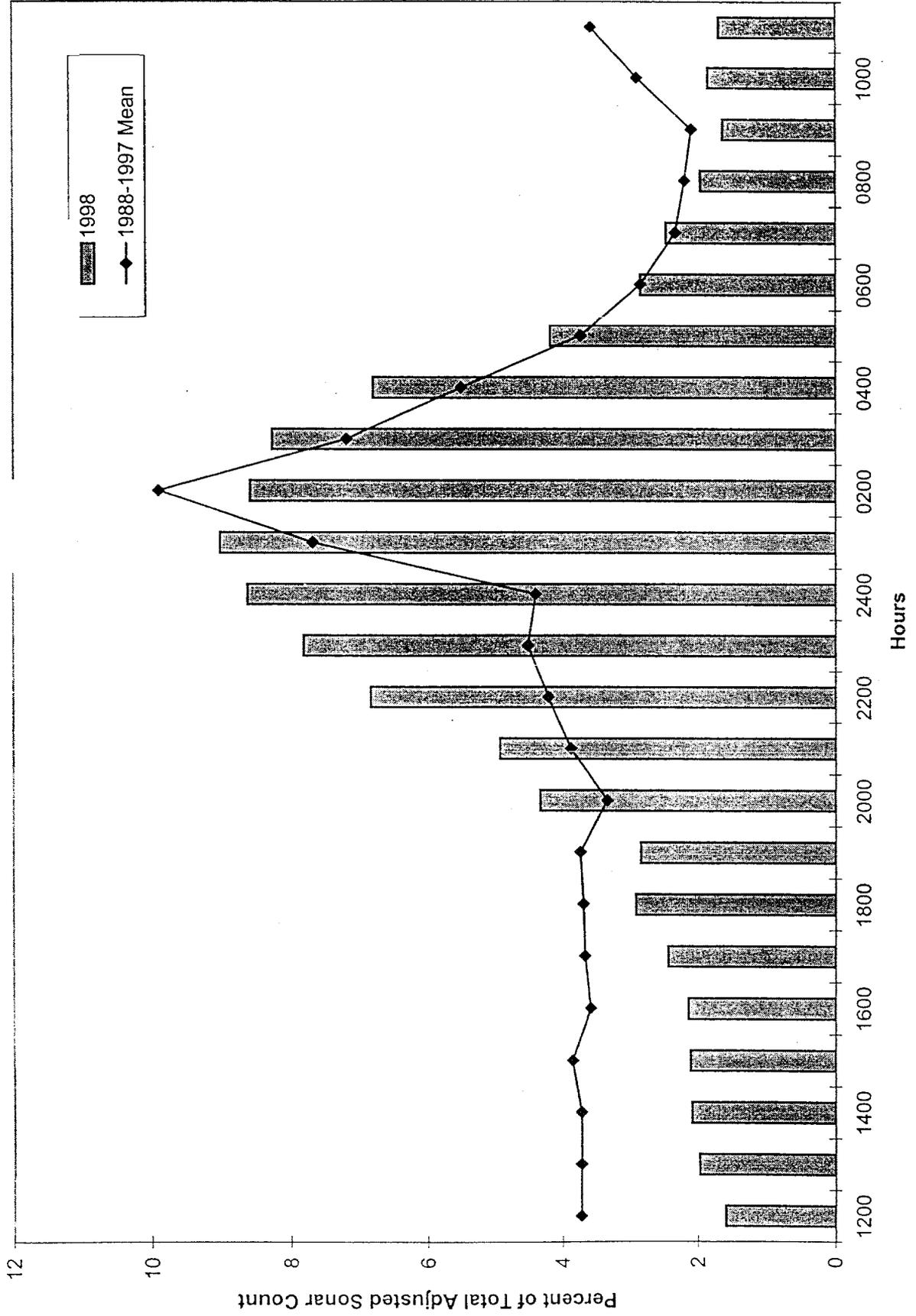


Figure 15. Comparison of the percent of the 1998 total adjusted sonar counts by hour at Kvichak River smolt sonar with the 1988-1997 mean.

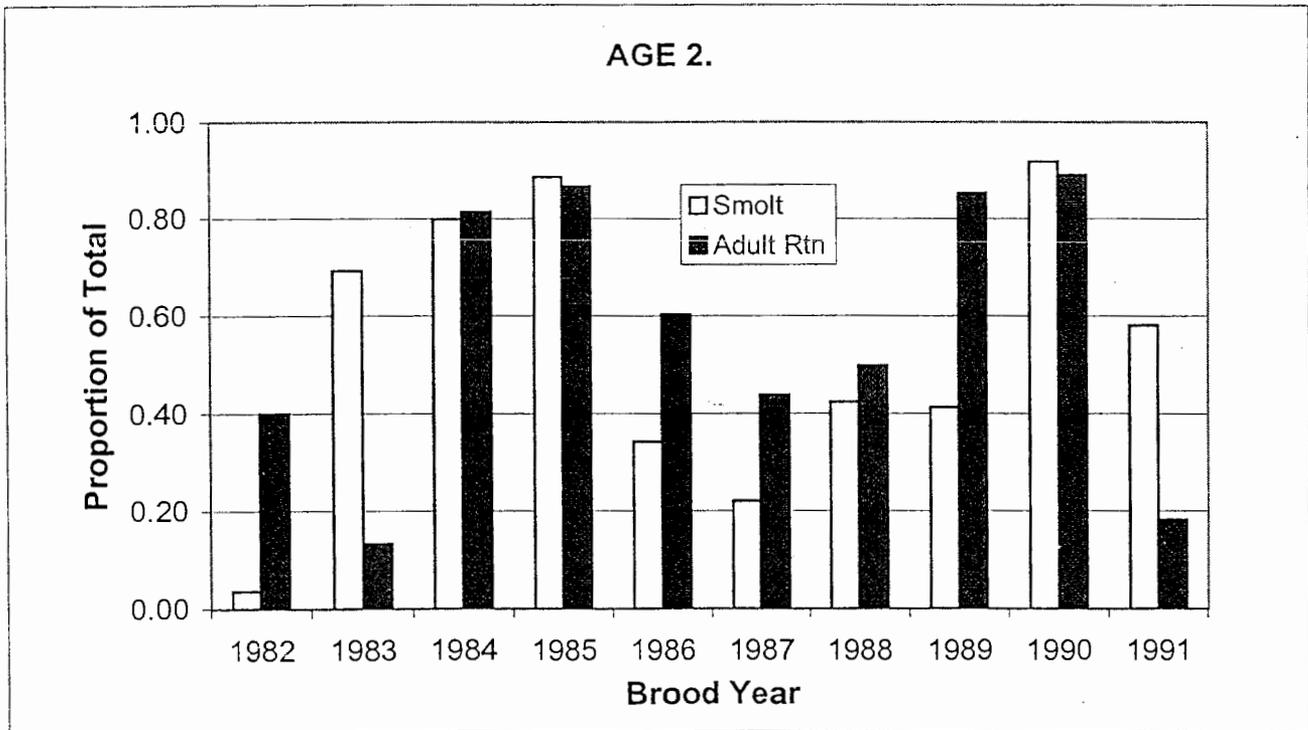
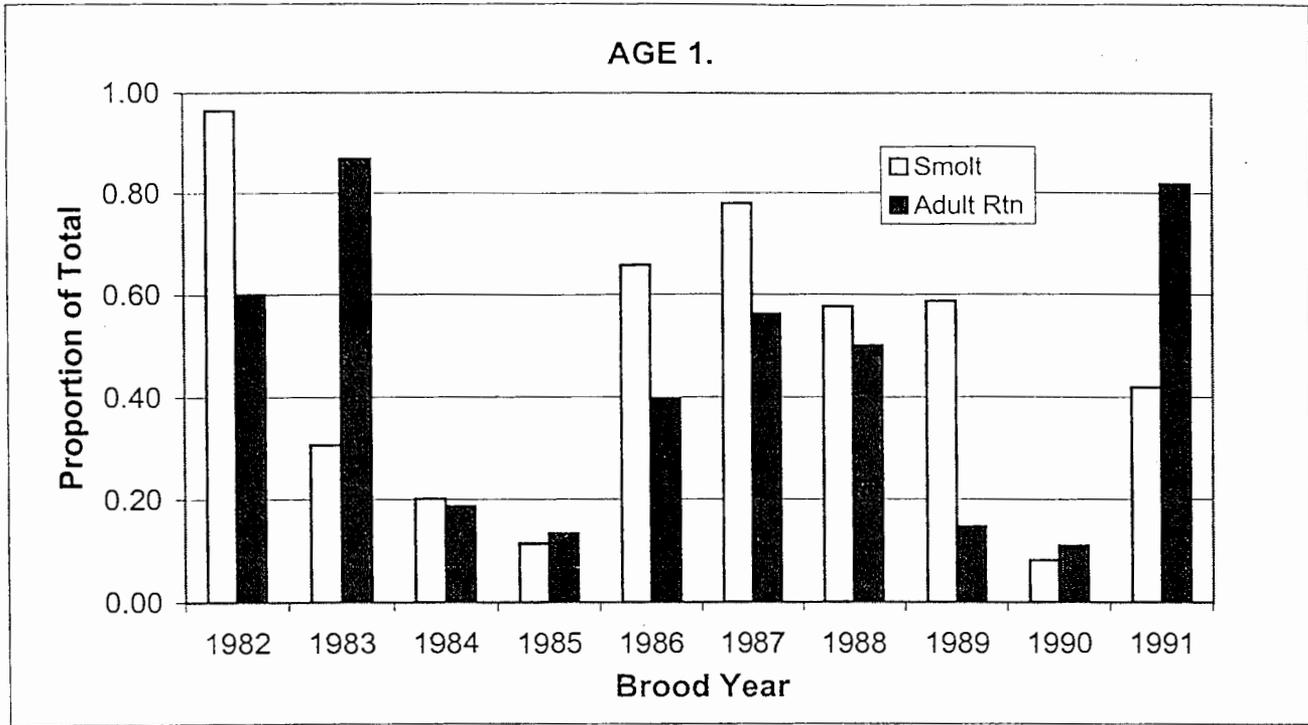


Figure 16. Comparison of the age composition of outmigrating sockeye salmon smolt at Kvichak River with the freshwater age composition of the total adult returns by brood year, 1982-1991.

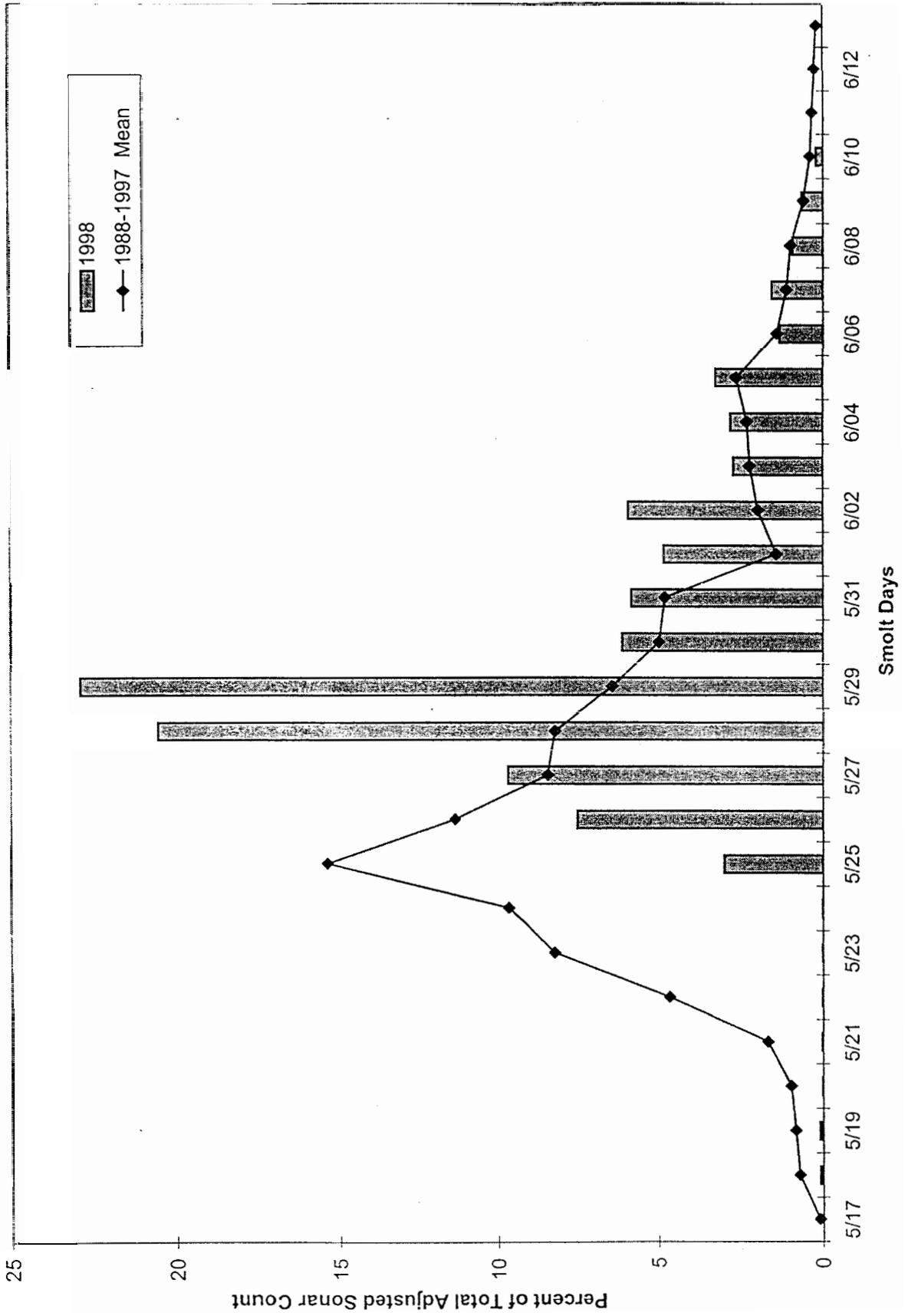


Figure 17. Comparison of the percent of the 1998 total adjusted sonar counts by smolt day at Egegik River smolt sonar with the 1988-1997 mean.

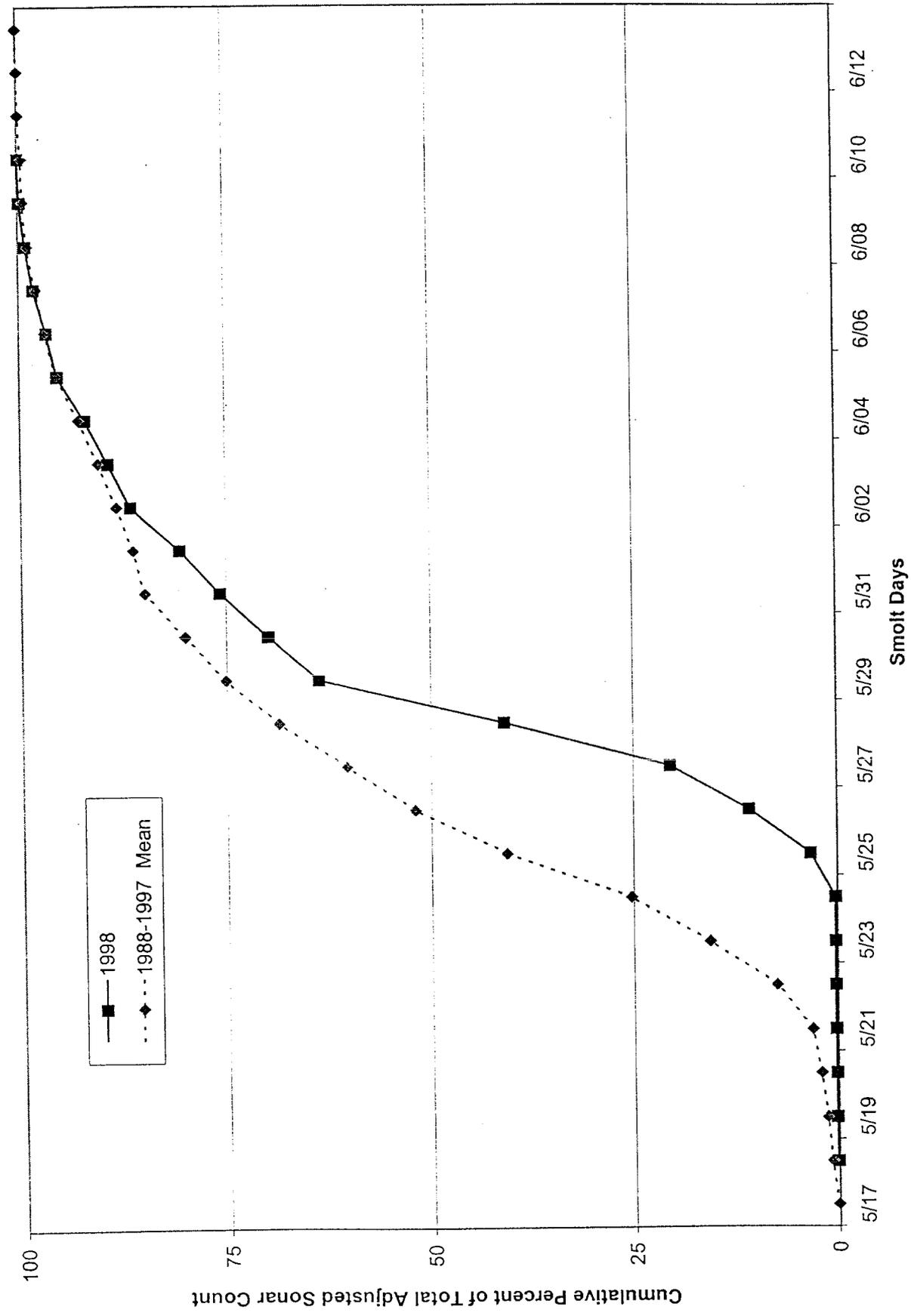


Figure 18. Comparison of the cumulative percent of the 1998 total adjusted sonar counts by smolt day at Egegik River smolt sonar with the 1988-1997 mean.

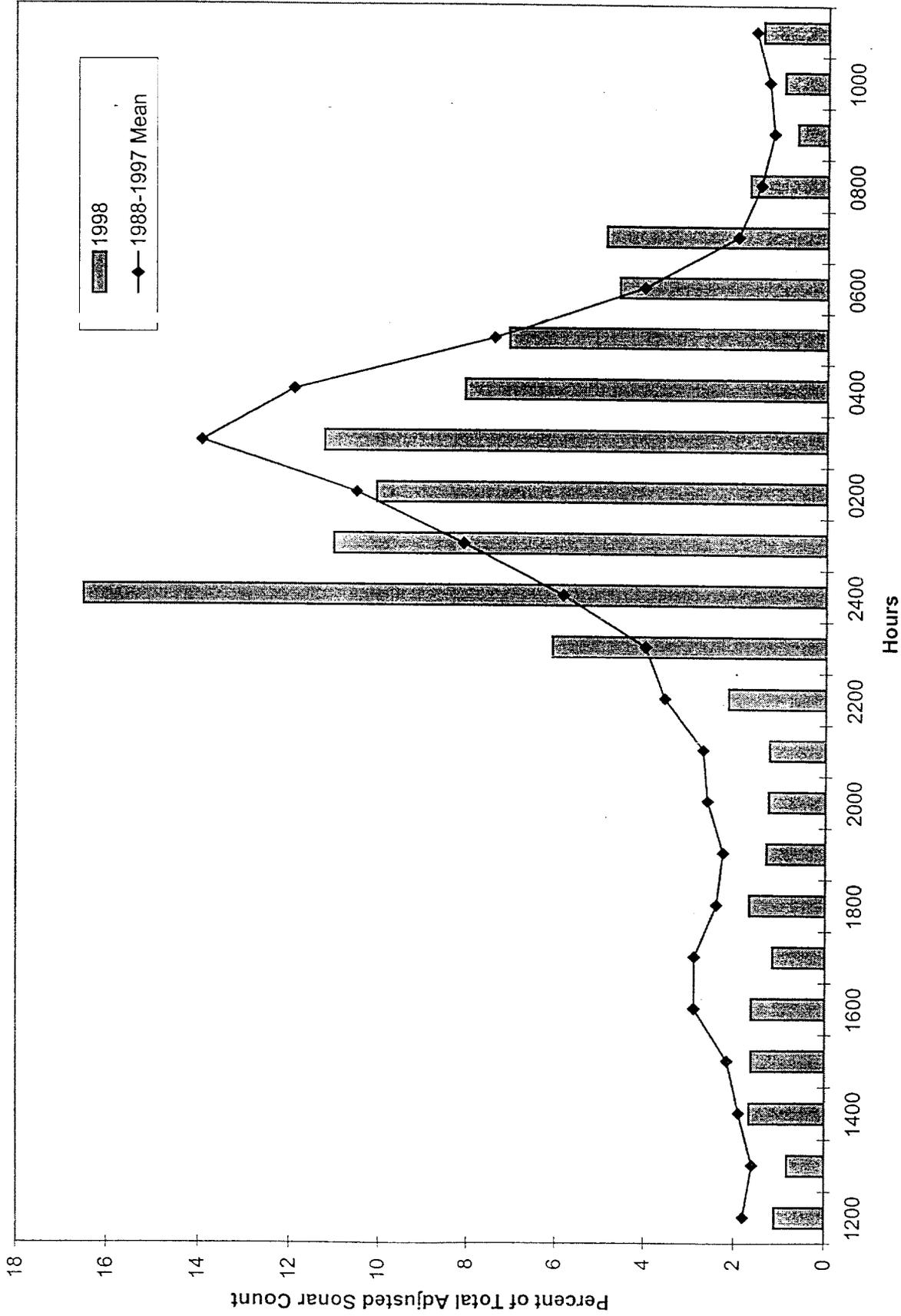


Figure 19. Comparison of the percent of the 1998 total adjusted sonar counts by hour at Egegik River smolt sonar with the 1988-1997 mean.

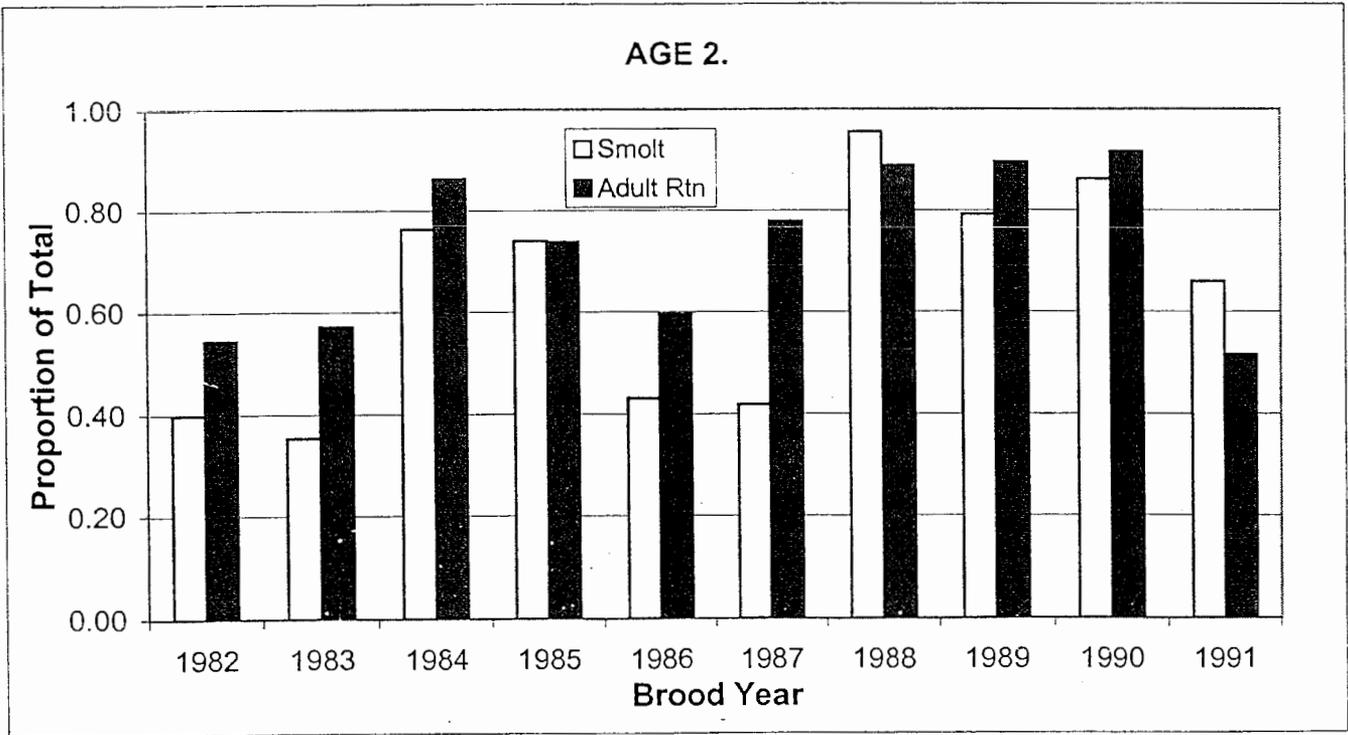
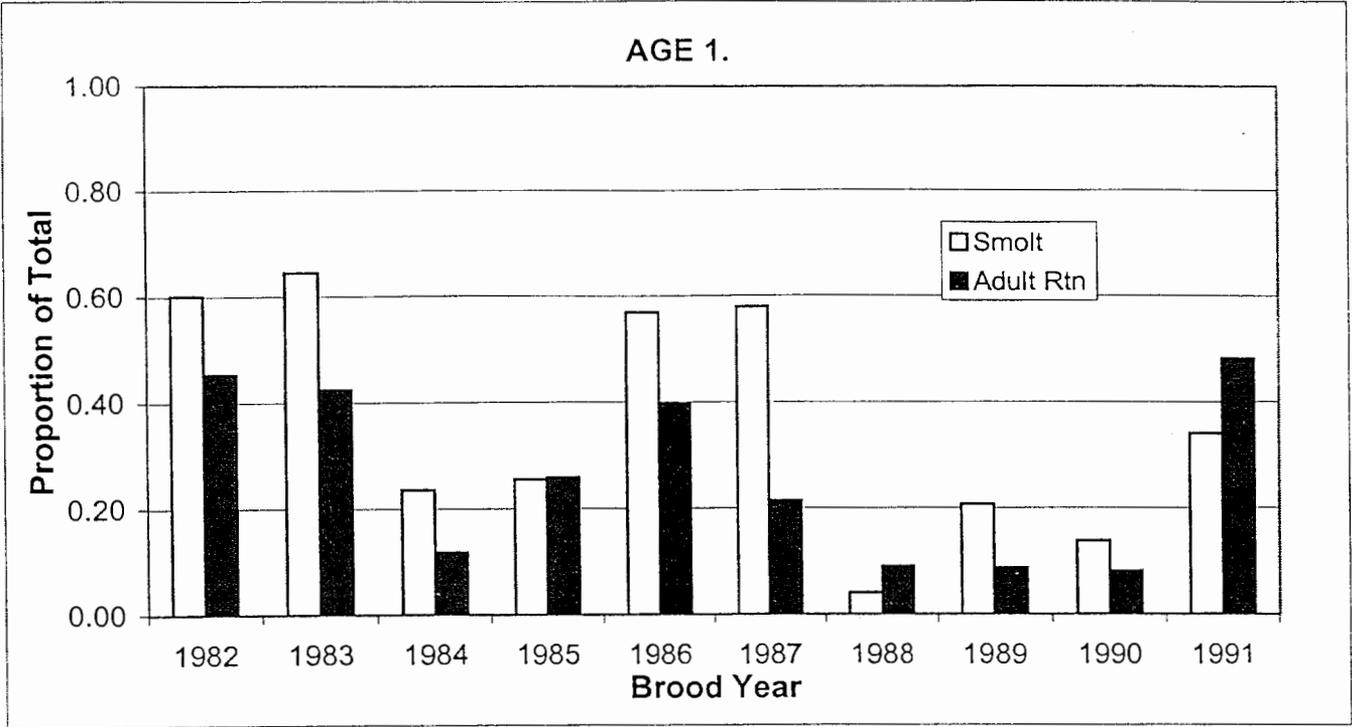


Figure 20. Comparison of the age composition of outmigrating sockeye salmon smolt at Egegik River with the freshwater age composition of the total adult returns by brood year, 1982-1991.

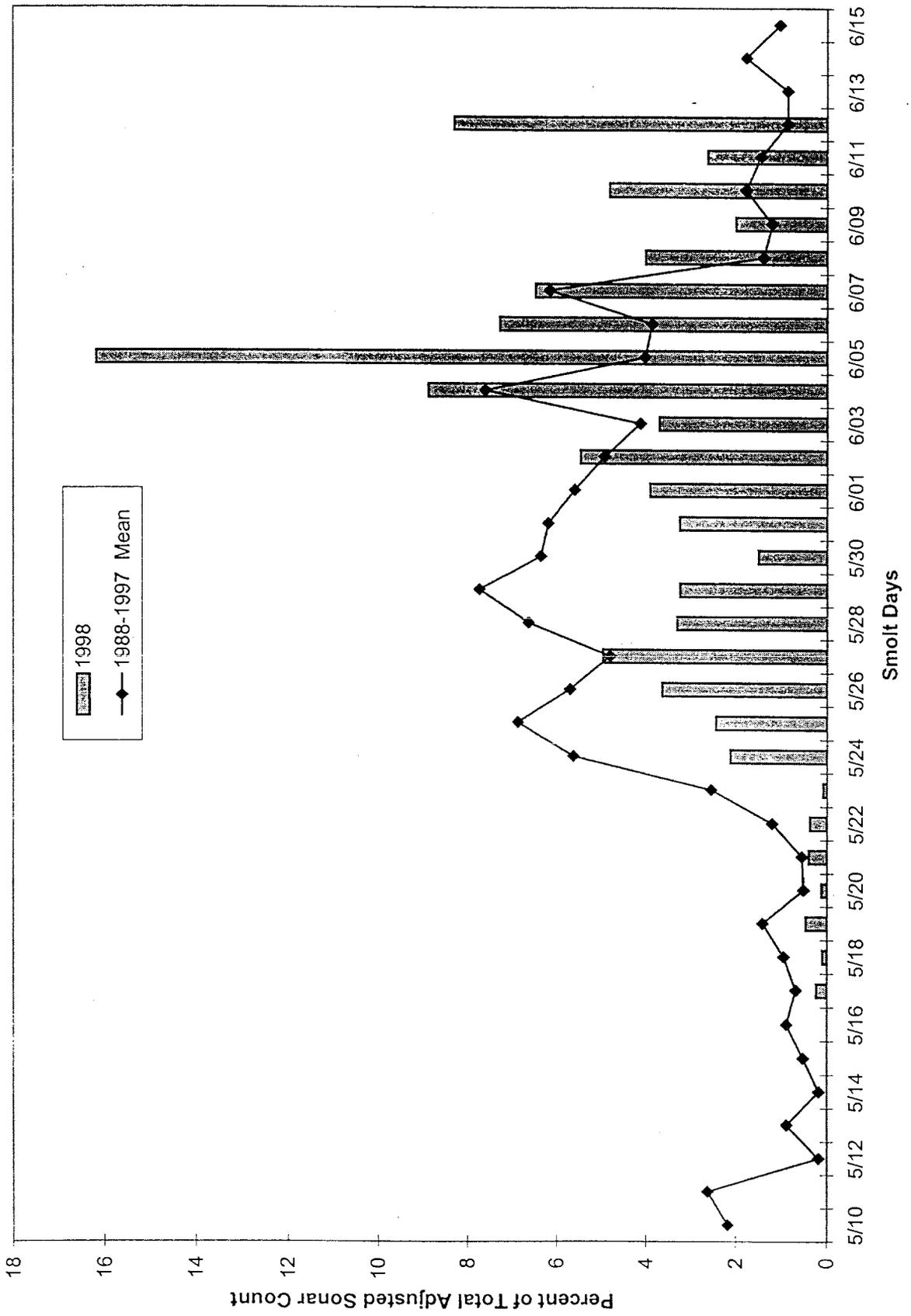


Figure 21. Comparison of the percent of the 1998 total adjusted sonar counts by smolt day at Ugashik River smolt sonar with the 1988-1997 mean.

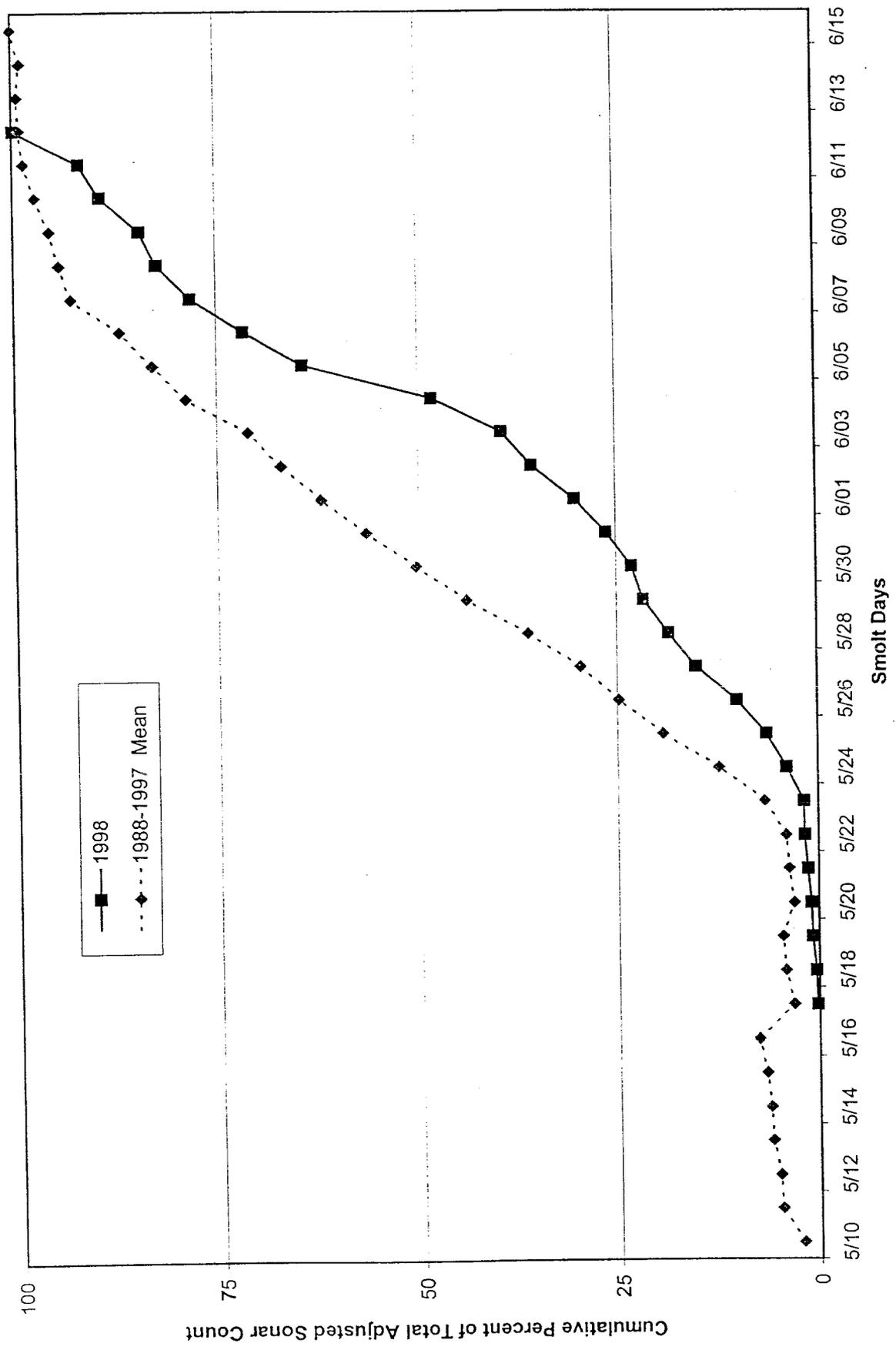


Figure 22. Comparison of the cumulative percent of the 1998 total adjusted sonar counts by smolt day at Ugashik River smolt sonar with the 1988-1997 mean.

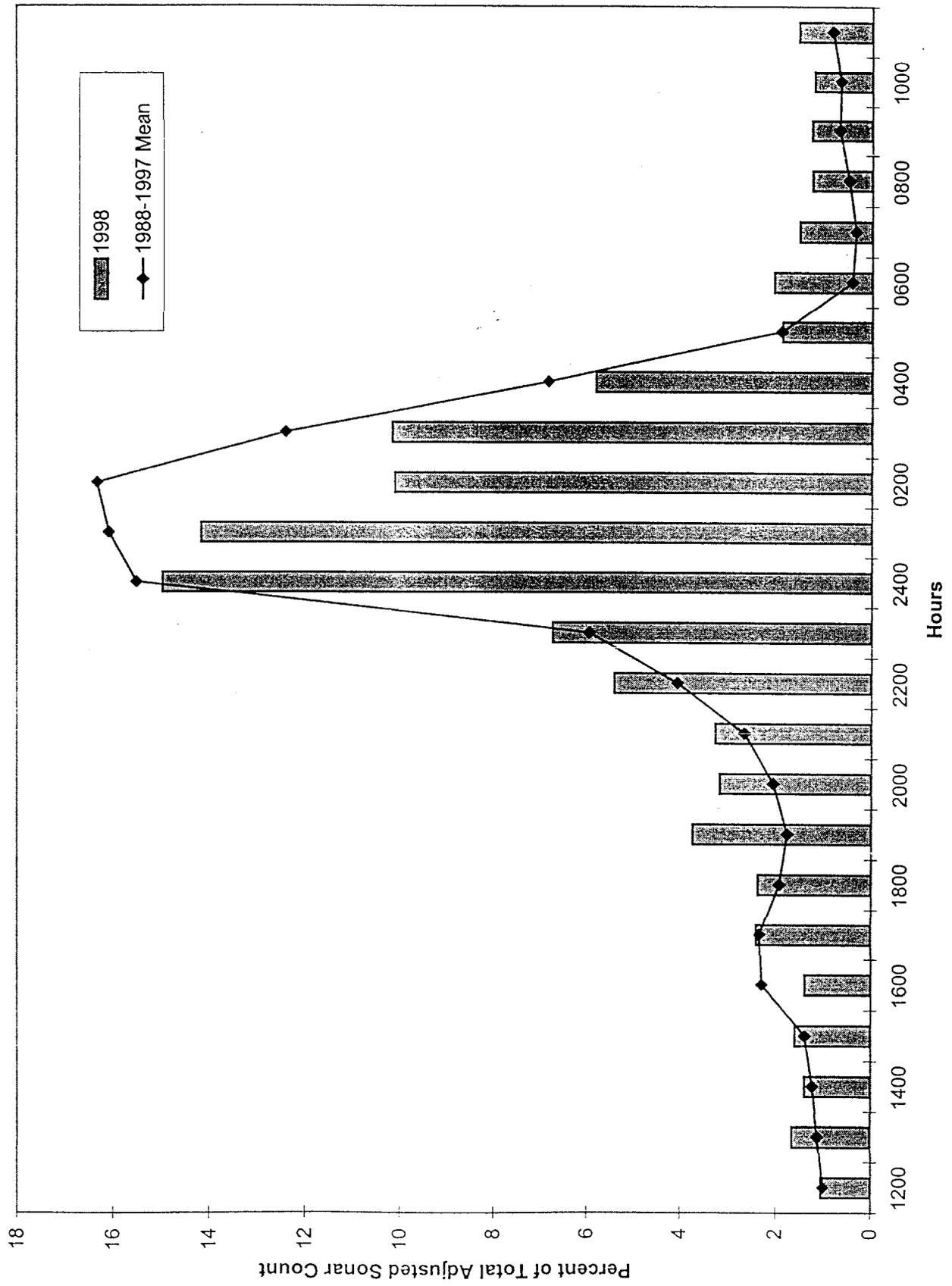


Figure 23. Comparison of the percent of the 1998 total adjusted sonar counts by hour at Ugashik River smolt sonar with the 1988-1997 mean.

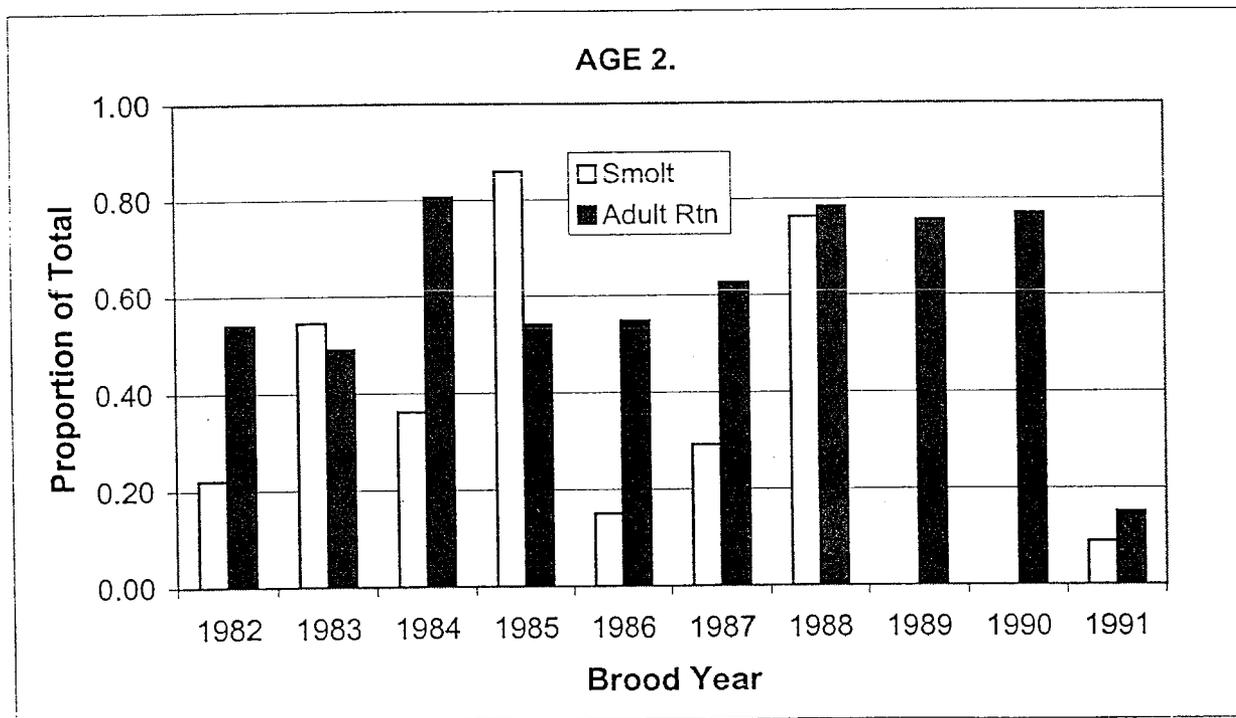
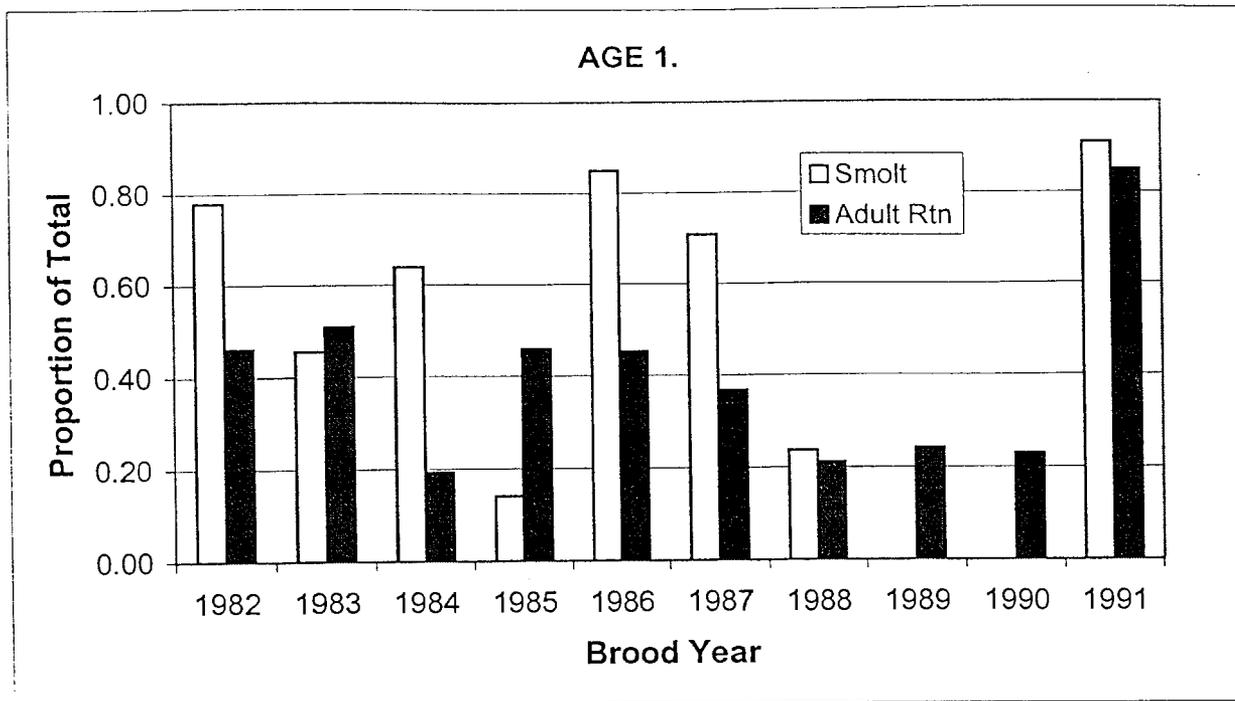


Figure 24. Comparison of the age composition of outmigrating sockeye salmon smolt at Ugashik River with the freshwater age composition of the total adult returns by brood year, 1982-1991.

Appendix A.1. River width and distance between arrays at Kvichak River smolt sonar site^a, 1989-1998.

Year	Distance (ft)						
	Left Bank Shore	Offshore Limit Dead Zone	Offshore Array	Center Array	Inshore Array	Inshore Limit Dead Zone	Right Bank Shore
1989 ^b	404	389	237	180	75	40	0
1990	445	419 ^c	315	220	138	16 ^c	0
1991	439	413	318	255	185	16	0
1992	422	358	280	222	162	16	0
1993	410	380	304	230	170	40	0
1994	439	409	298	229	189	40	0
1995	442	410	328 ^d	236	200	40	0
1996	423	393	328	279 ^e	171	40	0
1997	415	385	305	262	205	60	0
1998	440	410	315	227	155	50	0
1989-97 Max	445	419	328	279	205	60	0
1989-97 Avg	427	395	301	235	166	34	0
1989-97 Min	404	358	237	180	75	16	0

^a The Kvichak River smolt sonar site was located 6 km downstream from the outlet of Lake Iliamna from 1989-1997. The current site is 1 km downstream from the 1973-1988 smolt sonar site.

^b From 1989-1994 the cables for all sonar arrays were 330' long.

^c Source - Huttunen and Skvorc (1991)

^d Offshore array cables extended from 330' to 415' prior to the 1995 field season to improve array placement and safety during deployment.

^e Center array cables extended from 330' to 415' prior to the 1996 field season to improve array placement and safety during deployment.

Appendix A.2. River width and distance between arrays at Egegik River smolt sonar site^a, 1989-1998.

Year	Distance (ft)						
	Left Bank Shore	Inshore Limit Dead Zone	Inshore Array	Center Array	Offshore Array	Offshore Limit Dead Zone	Right Bank Shore
1989	0	30	130	180	220	270	340
1990	0	30	130	180	220	270	340
1991	0	30	130	180	220	280	350
1992	0	70	140	180	240	330	360
1993	0	52	140	190	230	310	380
1994	0	40	130	180	220	296	366
1995	0	30	120	175	220	305	375
1996	0	40	130	180	220	293	367
1997	0	55	130	180	220	270	350
1998	0	30	130	180	220	280	354
1989-97 Max	0	70	140	190	240	330	380
1989-97 Avg	0	42	131	181	223	292	359
1989-97 Min	0	30	120	175	220	270	340

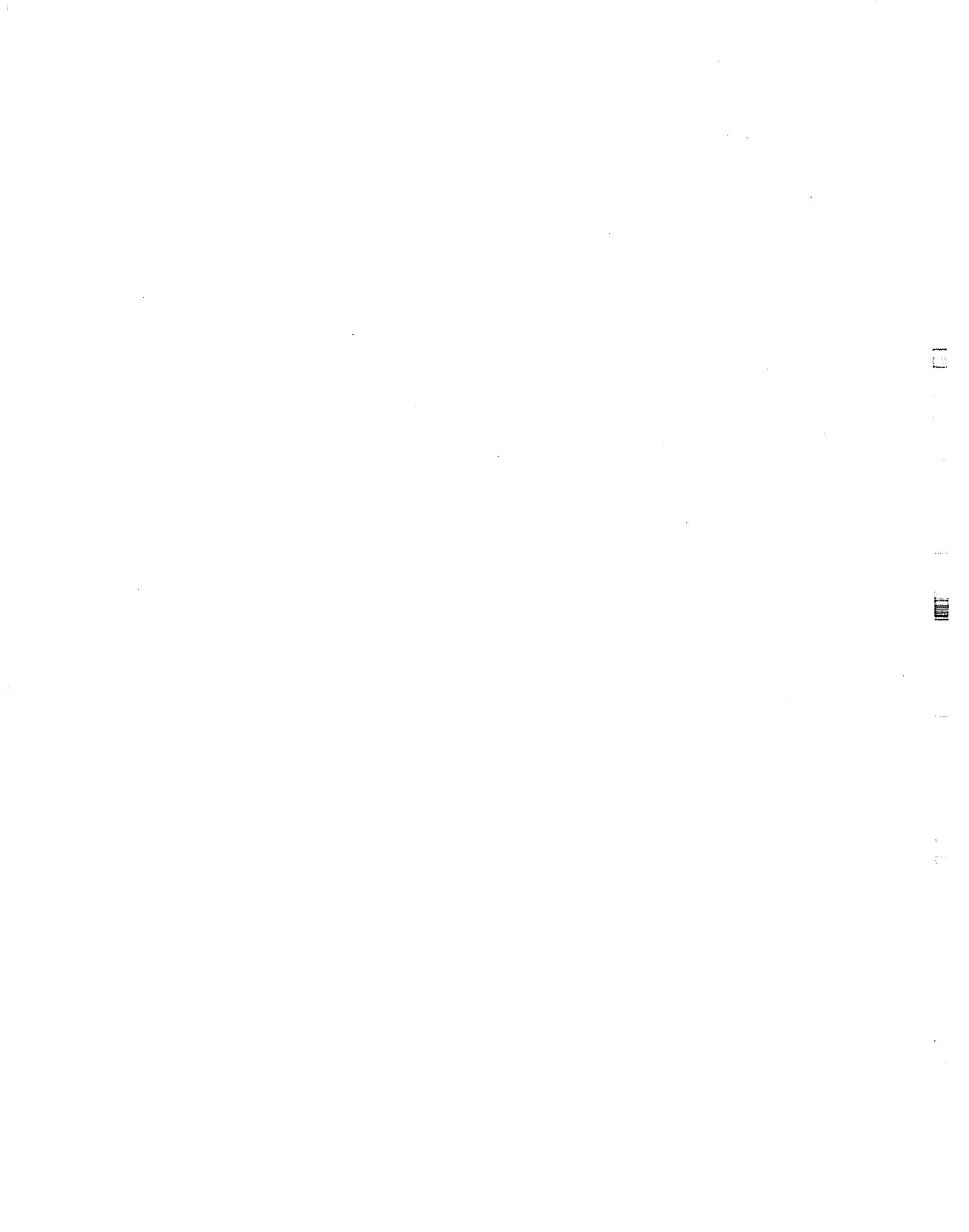
^a The Egegik River smolt sonar site was located 4 km downstream from the outlet of Becharof Lake, 1982-1998.

Appendix A.3. River width and distance between arrays at Ugashik River smolt sonar site^a, 1988-1998.

Year	Distance (ft)					
	Left Bank Shore	Offshore Limit Dead Zone	Offshore Array	Inshore Array	Inshore Limit Dead Zone	Right Bank Shore
1988	160		96	75		0
1989	140	110	91	75	40	0
1990	142	122	101	86	40	0
1991	140	120	99	85	40	0
1992 ^b						
1993	140	115	100	85	40	0
1994	140	120	105	89	40	0
1995	140	120	100	80	40	0
1996	135	115	100	85	35	0
1997	138	125	106	88	35	0
1998	145	125	107	90	45	0
1989-97 Max	142	125	106	89	40	0
1989-97 Avg	139	118	100	84	39	0
1989-97 Min	135	110	91	75	35	0

^a The Ugashik River smolt sonar site was located 50 m downstream from the outlet of Lower Ugashik Lake, 1988-1998.

^b Due to budget cuts, the smolt outmigration was not monitored on the Ugashik River in 1992.



Appendix B.1. Ice-cover dates for Lake Iliamna, 1970-1998.

Winter of	Freeze-up Date ^a		Break-up Date ^a		Total Days of Ice Cover	Comments ^a
	(dd-mmm)	Julian Day	(dd-mmm)	Julian Day		
1969-1970	1-Jan	1				
1970-1971	7-Jan	7	16-Jun	167	160	Long, cold winter.
1971-1972			5-Jun	157		
1972-1973			25-May	145		
1973-1974			21-May	141		
1974-1975	26-Dec	-5	4-Jun	155	160	
1975-1976			7-May	128		
1976-1977	4-Feb	35	2-May	122	87	Partially open 30-Mar
1977-1978			11-May	131		80% open 02-May
1978-1979			3-May	123		50% open 28-Apr
1979-1980			3-May	124		
1980-1981						
1981-1982	9-Jan	9	25-May	145	136	Started to reopen 10-Feb
1982-1983						
1983-1984						Still open 19-Dec
1984-1985	11-Feb	42	5-Jun	157	114	50% open 29-May
1985-1986	18-Jan	18	12-May	132	114	
1986-1987	13-Feb ^b	44	23-Mar	86	38	Still not frozen up by 13-Feb
1987-1988	26-Jan	26				Began re-opening 24-Feb; 75% open 01-Apr
1988-1989	13-Jan	13				50% open 20-Apr
1989-1990	9-Jan	9	22-May	142	133	
1990-1991	7-Jan	7				
1991-1992	27-Jan	27	4-May	125	98	
1992-1993	22-Jan	22	3-May	123	101	
1993-1994	16-Feb	47	5-May	125	78	Ice jammed along west shore; trickled out until 29-May
1994-1995	11-Jan ^b	11	22-May	142	131	Lake frozen briefly, 19-Dec, then reopened. Lake 95% open by 13-May
1995-1996	12-Jan	12	5-May	125	114	
1996-1997	23-Dec ^c	-9	8-May ^d	127	136	
1997-1998	5-Jan	5	26-Apr	116	111	
Minimum	23-Dec		23-Mar		38	
Average	17-Jan		14-May		114	
Maximum	16-Feb		16-Jun		160	

^a Most data is anecdotal, provided by pilots from local air charter companies (R. Russell, ADF&G retired, King Salmon, personal communication).

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

^c Mostly frozen 18-Dec, except several large holes.

^d Lake Iliamna was still ice covered on the evening of May 6. Subsequent southerly and westerly winds over the next several days caused the ice to break up, blow up the lake, and melt in place. By May 10 the lake was ice-free at Igiugig.

Appendix B.2. Ice-cover dates for Becharof Lake, 1976-1998.

Winter of	Freeze-up Date ^a		Break-up Date ^a		Total Days of Ice Cover	Comments ^a
	(dd-mmm)	Julian Day	(dd-mmm)	Julian Day		
1975-1976			6-Apr	97		
1976-1977			6-Apr	96		Island Arm still frozen. Main basin opened earlier.
1977-1978						
1978-1979						
1979-1980						
1980-1981			13-May	133		May have opened earlier.
1981-1982			20-May	140		Still open 15-Dec. May have opened earlier than 20-May.
1982-1983	18-Jan	18				50% open 31-Mar
1983-1984	16-Jan ^b	16	16-May	137		Still open 16-Jan
1984-1985	11-Feb	42	3-May	123	81	
1985-1986	26-Feb	57	27-Apr	117	60	Still open 30-Jan
1986-1987	12-Mar ^b	71				Still open 12-Mar
1987-1988	24-Mar ^b	84				Still open 24-Mar
1988-1989	17-Jan	17	27-Apr	117	100	
1989-1990	21-Feb	52	25-Apr	115	63	
1990-1991	4-Feb	35	1-Apr	91	56	
1991-1992	27-Jan	27	10-May	131	104	
1992-1993	23-Jan	23	31-Mar	90	67	
1993-1994	25-Feb	56	4-Apr	94	38	
1994-1995	24-Jan	24	28-Apr	118	94	Wind driven ice lense blocked lake outlet on 19-May & 20-May
1995-1996	8-Jan	8	28-Mar	87	80	
1996-1997	13-Dec ^c	-18	19-Apr ^d	109	127	
1997-1998	6-Jan	6	4-Apr	94	88	
Minimum	13-Dec		28-Mar		38	
Average	3-Feb		22-Apr		79	
Maximum	24-Mar		20-May		127	

^a Most data is anecdotal, provided by pilots from local air charter companies (R. Russell, ADF&G retired, King Salmon, personal communication).

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

^c Mostly frozen on 13-Dec except a small section of shoreline near Whale Mt and two small sections in the NW half of the lake.

^d In a 19-Apr satellite photo the lake appears to be completely ice free (1 °C), scattered patches of windblown ice remain along the NE & W end of lake.

Appendix B.3. Ice-cover dates for Upper and Lower Ugashik Lakes, 1977-1998.

Winter of	Freeze-up Date ^a		Break-up Date ^a		Total Days of Ice Cover	Comments ^a
	(dd-mmm)	Julian Day	(dd-mmm)	Julian Day		
1976-1977			6-Apr	96		
1977-1978						
1978-1979						
1979-1980						
1980-1981						Still open 16-Dec
1981-1982			12-May	132		
1982-1983	18-Jan	18				Partially open 31-Mar
1983-1984	16-Jan ^b	16				
1984-1985	11-Feb	42	14-May	134	92	
1985-1986	26-Feb	57	9-May	129	72	
1986-1987	12-Mar ^b	71				
1987-1988	9-Dec	-22	24-Mar	84	106	
1988-1989	17-Jan	17	10-May	130	113	
1989-1990	21-Feb	52	25-Apr	115	63	
1990-1991	8-Jan	8				
1991-1992	27-Jan	27	4-May	125	98	
1992-1993	20-Jan	20	31-Mar	90	70	
1993-1994	16-Feb	47	8-Apr	98	51	
1994-1995	24-Jan	24	28-Apr	118	94	
1995-1996	8-Jan	8	15-Apr	105	98	
1996-1997	13-Dec ^c	-18	26-Apr ^d	116	134	
1997-1998	5-Jan	5	4-Apr	94	89	
Minimum	9-Dec		24-Mar		51	
Average	24-Jan		23-Apr		90	
Maximum	12-Mar		14-May		134	

^a Most data is anecdotal, provided by pilots from local air charter companies (R. Russell, ADF&G retired, King Salmon, personal communication).

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

^c Mostly frozen on 13-Dec except SW shoreline of Upper Ugashik Lake by Blue Mt and the NW shore of Lower Ugashik Lake between the outlet and the Narrows.

^d Upper Ugashik Lake ice free by 24-Apr. Lower Ugashik Lake 90% open by 26-April. Lake ice flows cleared in Ugashik River about May 4.



Appendix C.1. Kvichak River smolt fyke net catch log, 1998.

Smolt Day	Cod End No.	Time ^a		Total Time Fished (min)		Smolt Catch		CPUE ^b
		Set	Pulled	per Set	per Smolt Day	per Set	per Smolt Day	
5/19		1955	2105	70		0		0
		2105	2245	100		0		0
		2245	2400	75		0		0
	001	2400	0150	110		500		5
	002	0155	0315	80		390		5
	003	0347	0420	33		250		8
	004	0425	0445	20		200		10
	005	0450	0525	35		150		4
	006	0530	0630	60	583	500	1,990	8
5/20	007	2350	2356	6		250		42
	008	2358	0027	29		112		4
	009	0030	0057	27		113		4
	010	0059	0145	46		100		2
	011	0242	0323	41		150		4
	012	0326	0614	168	317	1,200	1,925	7
	5/21		1825	1945	80		0	
		1945	2035	50		0		0
		2035	2150	75		0		0
		2150	2332	102		0		0
013		2333	2338	5		500		100
014		2339	2353	14		250		18
015		2355	0006	11		93		8
016		0007	0030	23		1,000		43
017		0033	0044	11		400		36
	018	0046	0102	16	387	198	2,441	12
5/22	019	1738	2230	292		500		2
	020	2235	0016	101		500		5
	021	0018	0114	56		300		5
	022	0119	0220	61		200		3
	023	0225	0355	90		100		1
	024	0357	0505	68	668	300	1,900	4
	5/23		2220	2400	100		0	
		0001	0300	179		0		0
025		0300	0400	60		157		3
		0400	0620	140	479	0	157	0
5/24		2210	2330	80		0		0
	026	2330	0133	123		280		2
	027	0139	0255	76		100		1
		0255	0430	95		0		0
	028	0430	0600	90	464	400	780	4
5/25	029	1816	1924	68		500		7
	030	1925	2021	56		400		7
	031	2023	2130	67		1,000		15
	032	2132	2227	55		118		2
		2229	2330	61		0		0
	033	2330	0040	70		1,000		14
	034	0043	0145	62	439	2,000	5,018	32
5/26	035	2206	2337	91		121		1
	036	2339	0040	61		200		3
	037	0045	0125	40		350		9
	038	0132	0300	88	280	2,000	2,671	23

Appendix C.1. (p 2 of 3)

Smolt Day	Cod End No.	Time ^a		Total Time Fished (min)		Smolt Catch		CPUE ^b
		Set	Pulled	per Set	per Smolt Day	per Set	per Smolt Day	
5/27	039	2204	2310	66		155		2
	040	2315	0030	75		240		3
	041	0035	0215	100		150		2
	042	0218	0348	90		98		1
	043	0350	0541	111	442	65	708	1
5/28	044	0030	0135	65		109		2
	045	0137	0610	273	338	1,284	1,393	5
5/29	046	0009	0010	1		2,000		2000
	047	0030	0031	1		200		200
	048	0033	0035	2		500		250
	049	0036	0038	2		200		100
	050	0039	0040	1		200		200
	051	0041	0043	2	9	2,000	5,100	1000
5/30		0014	0210	116		0		0
		0210	0330	80		2		0
		0330	0630	180	376	0	2	0
5/31	052	0002	0157	115		40		0
		0157	0300	63		20		0
		0300	0428	88		40		0
	053	0429	0600	91	357	40	140	0
6/01		1830	2115	165		0		0
	054	2115	2235	80		75		1
		2236	2335	59		0		0
	055	2335	0024	49		150		3
	056	0024	0115	51		2,000		39
	057	0118	0121	3		200		67
	058	0122	0126	4		250		63
059	0127	0220	53	464	1,000	3,675	19	
6/02	060	1800	1945	105		500		5
		1946	2045	59		6		0
	061	2046	2227	101		135		1
		2228	2336	68		20		0
		2337	0030	53		0		0
	062	0030	0208	98		35		0
	063	0209	0325	76		15		0
		0325	0429	64		30		0
	064	0429	0525	56		80		1
	065	0525	0615	50	730	1,500	2,321	30
6/03	066	1825	2126	181		200		1
		2127	2235	68		6		0
		2236	2336	60		25		0
	067	2336	0103	87		35		0
	068	0103	0215	72		65		1
		0215	0314	59		30		1
	069	0314	0420	66		70		1
		0420	0623	123	716	300	731	2
6/04						0		
6/05	071	0009	0132	83		4		0
		0132	0225	53		4		0
		0225	0416	111		15		0
	072	0416	0606	110	357	100	123	1
6/06		2400	0120	80		2		0
		0120	0600	280	360	0	2	0

Appendix C.1. (p 3 of 3)

Smolt Day	Cod End No.	Time ^a		Total Time Fished (min)		Smolt Catch		CPUE ^b
		Set	Pulled	per Set	per Smolt Day	per Set	per Smolt Day	
6/07	074	0009	0118	69		95		1
	075	0119	0212	53		180		3
	076	0213	0316	63		98		2
	077	0318	0608	170	355	19	392	0
6/08	078	0006	0117	71		63		1
		0118	0220	62		15		0
		0221	0324	63		12		0
		0325	0420	55		4		0
	079	0425	0531	66		90		1
	080	0531	0615	44	361	38	222	1
6/09		0001	0130	89		5		0
		0130	0250	80		1		0
		0250	0420	90		1		0
		0420	0530	70		0		0
	081	0530	0615	45	374	1	8	0
6/10	082	0001	0138	97		15		0
		0139	0242	63		45		1
	083	0243	0348	65		75		1
		0348	0520	92	317	2	137	0
6/11	084	0001	0216	135		6		0
		0216	0345	89		45		1
		0345	0520	95	319	0	51	0
Max					730	2,000	5,100	2,000
Avg					413	255	1,329	36
Min					9	0	0	0

^a Military time - 24 hour clock (hhmm).

^b CPUE = catch per unit effort

Appendix C.2. Kvichak River fyke net catches by species and smolt day, May 19 to June 11, 1998.

Smolt Day	Time Fished (h)	Catch Estimate (No. of Fish)											
		Sockeye Smolt	Sticklebacks ^a (Species)	Chinook Smolt	Coho Smolt	Chum Fry	Pink Fry	Lamprey ^b (Species)	Whitefish ^c (Species)	Smelt ^d (Species)	Rainbow Trout (juv)	Sculpin ^e (Species)	Northern Pike (juv)
5/19	10.0	1,990	0	0	0	0	0	0	0	0	0	0	0
5/20	6.4	1,925	0	0	0	0	0	0	0	0	0	0	0
5/21	6.6	2,441	3	0	0	0	0	0	0	0	0	0	0
5/22	11.4	1,900	0	0	0	0	0	0	0	0	0	0	0
5/23	8.0	157	0	0	0	0	0	0	0	0	0	0	0
5/24	7.8	780	0	0	0	0	0	0	0	0	0	0	0
5/25	7.5	5,018	0	0	0	0	0	0	0	0	0	0	0
5/26	4.9	2,671	0	0	0	0	0	0	1	0	0	0	0
5/27	7.6	708	0	0	0	0	20	0	0	0	0	0	0
5/28	5.7	1,393	0	3	2	0	10	0	0	0	0	0	0
5/29	0.5	5,100	0	0	0	0	0	0	0	0	0	0	0
5/30	6.3	2	50	0	0	0	0	0	0	0	0	1	0
5/31	6.0	140	25	0	0	0	6	0	0	0	0	0	0
6/01	7.8	3,675	0	0	0	0	0	0	0	0	0	0	0
6/02	12.3	2,321	83	2	0	0	0	1	0	0	0	0	0
6/03	12.0	731	25	1	0	0	1	1	0	0	0	0	0
6/04	0.0	0	0	0	0	0	0	0	0	0	0	0	0
6/05	5.8	123	105	0	0	0	3	2	1	0	1	0	1
6/06	6.0	2	5	0	0	0	1	0	0	0	0	1	0
6/07	6.0	392	0	0	0	0	1	0	0	0	0	0	0
6/08	6.2	222	137	0	0	0	0	0	0	0	0	0	0
6/09	6.3	8	320	0	0	0	0	0	0	0	0	0	0
6/10	5.3	137	7	0	0	0	0	1	0	0	0	0	0
6/11	5.0	51	50	0	0	0	0	0	0	0	0	0	0
Total	161.3	31,887	810	6	2	0	42	5	2	0	1	2	1
Max	12.3	5,100	320										
Avg	6.7	1,329	34										
Min	0.0	0	0										

^a Most were threespine sticklebacks, however some ninespine sticklebacks were also caught.

^b Species not identified, however Morrow (1980) reported that both Pacific lamprey and Arctic lamprey are found in the Bristol Bay area.

^c The first was an adult humpback whitefish. The second was an unidentified whitefish juvenile, about the same size as a sockeye smolt.

^d Species not determined, but Morrow (1980) lists rainbow smelt, pond smelt, and eulachon as possibilities.

^e Species unknown, however slimy sculpin and coastrange sculpin both occur in freshwater lakes and streams in Bristol Bay (Morrow 1980).

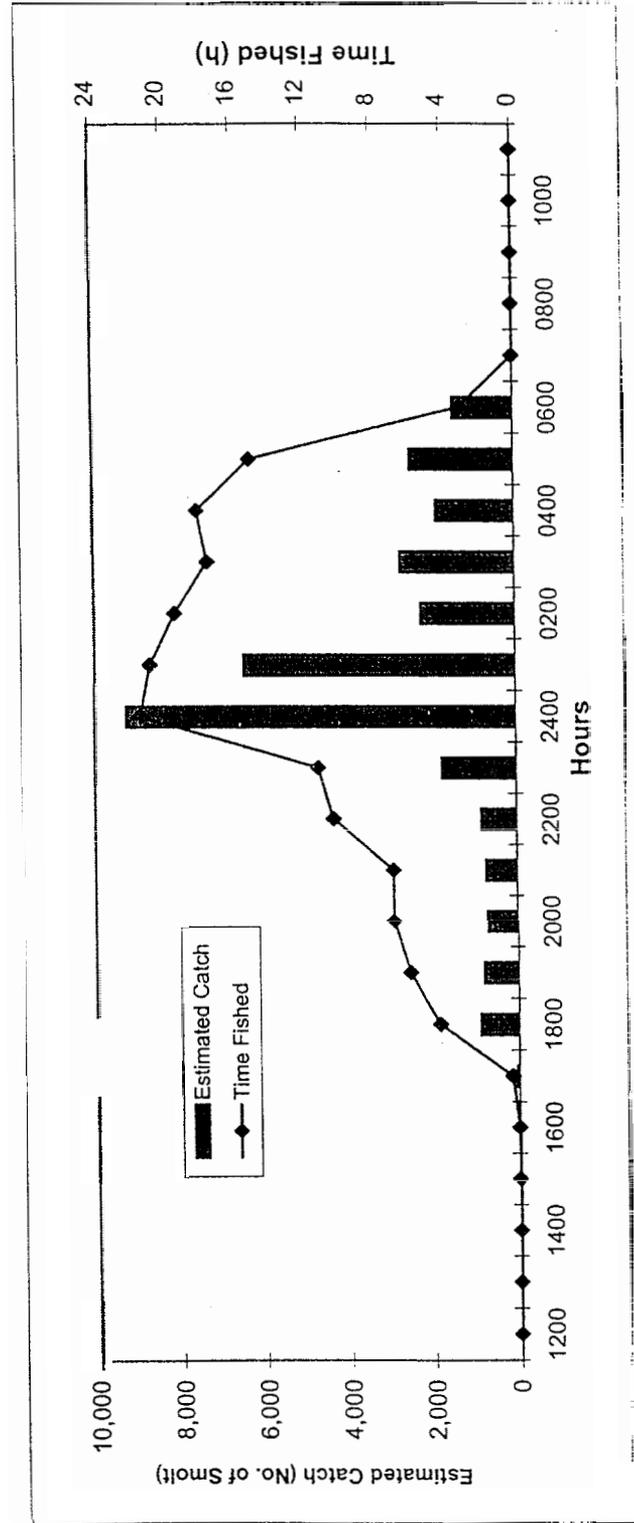
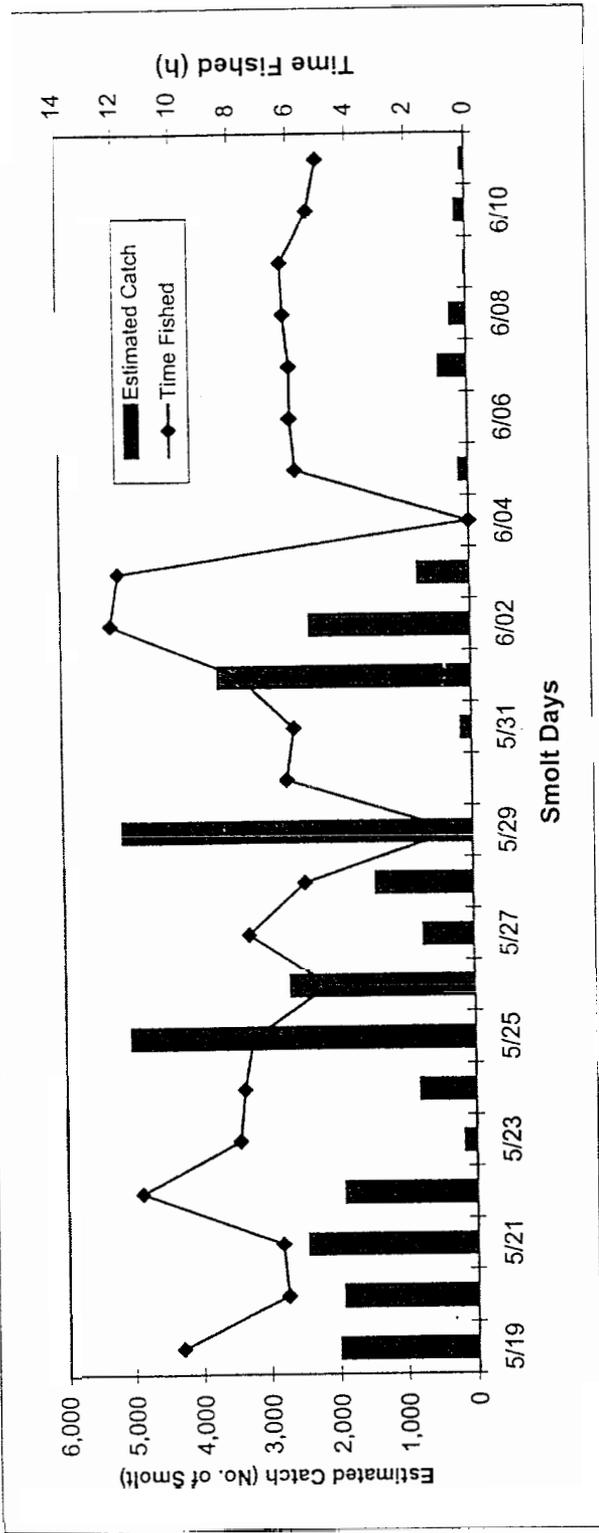
Appendix C.3. Kvichak River fyke net catches by species and hour, May 19 to June 11, 1998.

Hour	Time Fished (h)	Catch Estimate (No. of Fish)											
		Sockeye Smolt	Sticklebacks (Species)	Chinook Smolt	Coho Smolt	Chum Fry	Pink Fry	Lamprey (Species)	Whitefish (Species)	Smelt (Species)	Rainbow Trout (juv)	Sculpin (Species)	Northern Pike (juv)
1200	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1300	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1400	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1500	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1600	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1700	0.4	50	0	0	0	0	0	0	0	0	0	0	0
1800	4.4	880	0	0	0	0	0	0	0	0	0	0	0
1900	6.1	798	1	0	0	0	0	0	0	0	0	0	0
2000	7.0	698	2	2	0	0	0	0	0	0	0	0	0
2100	7.0	716	0	0	0	0	0	0	0	0	0	0	0
2200	10.3	817	0	0	0	0	0	0	0	0	0	0	0
2300	11.2	1,736	1	0	0	0	0	0	0	0	0	0	0
2400	21.3	9,216	41	0	1	0	12	0	1	0	1	1	0
0100	20.8	6,422	94	2	1	0	23	0	0	0	0	0	0
0200	19.3	2,196	188	0	0	0	7	0	0	0	0	1	0
0300	17.4	2,695	228	1	0	0	0	3	0	0	0	0	1
0400	18.0	1,821	152	0	0	0	0	0	0	0	0	0	0
0500	15.0	2,438	84	1	0	0	0	2	1	0	0	0	0
0600	3.1	1,404	19	0	0	0	0	0	0	0	0	0	0
0700	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0800	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0900	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1000	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1100	0.0	0	0	0	0	0	0	0	0	0	0	0	0
Total	161.3	31,887	810	6	2	0	42	5	2	0	1	2	1

^a Daylight hours unless indicated otherwise

^b Twilight hours

^c Hours of darkness



Appendix C.4. Kvichak River fyke net estimated catch and time fished by smolt day and 998.

Appendix C.5. Egegik River smolt fyke net catch log, 1998.

Smolt Day	Cod End No.	Time ^a		Total Time Fished (min)		Smolt Catch		CPUE ^o
		Set	Pulled	per Set	per Smolt Day	per Set	per Smolt Day	
5/19	001	0135	0230	55	55	10	10	0
5/20		0035	0200	85	85	0	0	0
5/21	002	0110	0205	55	55	26	26	0
5/22		0105	0210	65	65	0	0	0
5/23		0037	0205	88	88	0	0	0
5/24		0042	0202	80	80	0	0	0
5/25	003	0016	0204	108	108	20	20	0
5/26					0		0	
5/27	004	0026	0206	100	100	50	50	1
5/28	005	0029	0152	83		73		1
	006	0153	0209	16		95		6
	007	0209	0238	29		115		4
	008	0238	0300	22	150	111	394	5
5/29	009	0044	0105	21		150		7
	010	0106	0110	4		120		30
	011	0111	0130	19		120		6
	012	0131	0156	25		105		4
	013	0157	0210	13		170		13
	014	0211	0215	4	86	240	905	60
5/30	015	0024	0136	72		100		1
	016	0138	0212	34		100		3
	017	0212	0246	34	140	113	313	3
5/31	018	0039	0119	40		130		3
	019	0121	0149	28		140		5
	020	0150	0203	13		90		7
	021	0203	0216	13		130		10
	022	0217	0230	13		135		10
	023	0231	0239	8	115	125	750	16
6/01	024	0042	0137	55		129		2
	025	0137	0230	53		78		1
	026	0231	0252	21	129	115	322	5
6/02	027	0055	0229	94		136		1
	028	0230	0251	21	115	73	209	3
6/03	029	0050	0110	20		156		8
	030	0111	0122	11		128		12
	031	0123	0137	14		168		12
	032	0138	0146	8		119		15
	033	0147	0210	23		113		5
	034	0212	0225	13	89	132	816	10
6/04					0		0	
6/05	035	0050	0110	20		101		5
	036	0111	0122	11		228		21
	037	0123	0137	14		150		11
	038	0138	0146	8		175		22
	039	0147	0210	23		185		8
	040	0212	0225	13	89	160	999	12

Smolt Day	Cod End No.	Time ^a		Total Time Fished (min)		Smolt Catch		CPUE ^b
		Set	Pulled	per Set	per Smolt Day	per Set	per Smolt Day	
6/06	041	0044	0056	12		146		12
	042	0058	0103	5		112		22
	043	0104	0112	8		161		20
	044	0113	0121	8		169		21
	045	0122	0126	4		140		35
	046	0129	0135	6	43	210	938	35
6/07					0		0	
6/08	047	0056	0252	116	116	74	74	1
6/09	048	0055	0159	64		130		2
	049	0202	0255	53	117	64	194	1
6/10	050	0053	0250	117	117	89	89	1
Max				117	150	240	999	60
Avg				36	84	113	266	9
Min				4	0	0	0	0

^a Military time - 24 hour clock (hhmm).

^b CPUE = catch per unit effort

Appendix C.6. Egegik River fyke net catches by smolt day and species, May 19 to June 10, 1998.

Smolt Day	Time Fished (h)	Catch Estimate (No. of Fish)											
		Sockeye Smolt	Sticklebacks (Species)	Chinook Smolt	Coho Smolt	Chum Fry	Pink Fry (Species)	Lamprey (Species)	Whitefish (Species)	Smelt (Species)	Rainbow Trout (juv)	Sculpin (Species)	Northern Pike (juv)
5/19	0.9	10	1	0	0	2	0	0	0	0	0	2	0
5/20	1.4	0	1	0	0	6	0	0	0	0	0	6	0
5/21	0.9	26	0	0	0	5	0	0	0	0	0	2	0
5/22	1.1	11	0	0	0	0	0	0	0	0	0	4	0
5/23	1.5	0	2	0	0	1	1	0	0	0	0	1	0
5/24	1.3	0	1	0	0	8	5	0	0	0	0	3	0
5/25	1.8	20	0	0	0	0	0	0	0	0	0	0	0
5/26	0.0	0	0	0	0	0	0	0	0	0	0	0	0
5/27	1.7	50	1	0	0	0	5	0	0	0	0	0	0
5/28	2.5	394	0	0	0	7	0	0	0	0	0	3	0
5/29	1.5	905	0	0	0	0	0	0	0	0	0	0	0
5/30	2.3	313	0	0	0	0	0	0	0	0	0	0	0
5/31	2.0	750	0	0	0	0	0	0	0	0	0	0	0
6/01	2.2	322	0	0	0	0	0	0	0	0	0	0	0
6/02	1.9	209	0	0	0	0	0	0	0	0	0	0	0
6/03	1.6	816	0	0	0	0	0	0	0	0	0	0	0
6/04	0.0	0	0	0	0	0	0	0	0	0	0	0	0
6/05	1.6	999	0	0	0	0	0	0	0	0	0	0	0
6/06	0.9	938	0	0	2	0	0	0	0	0	0	0	0
6/07	0.0	0	0	0	0	0	0	0	0	0	0	0	0
6/08	1.9	74	0	0	1	0	0	0	0	0	0	0	0
6/09	1.9	194	0	0	1	0	0	1	0	0	0	0	0
6/10	2.0	89	0	0	4	0	0	0	0	0	0	0	0
Total	32.9	6,120	6	0	8	29	11	1	0	0	0	21	0
Max	2.5	999											
Avg	1.4	266											
Min	0.0	0											

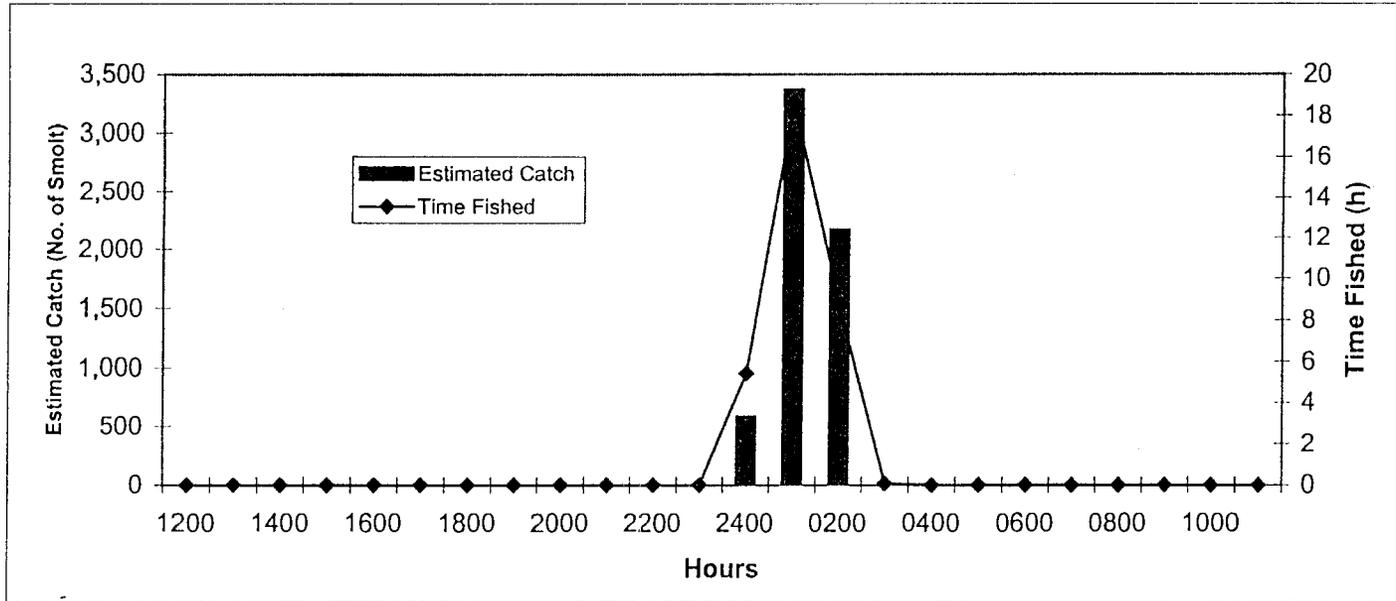
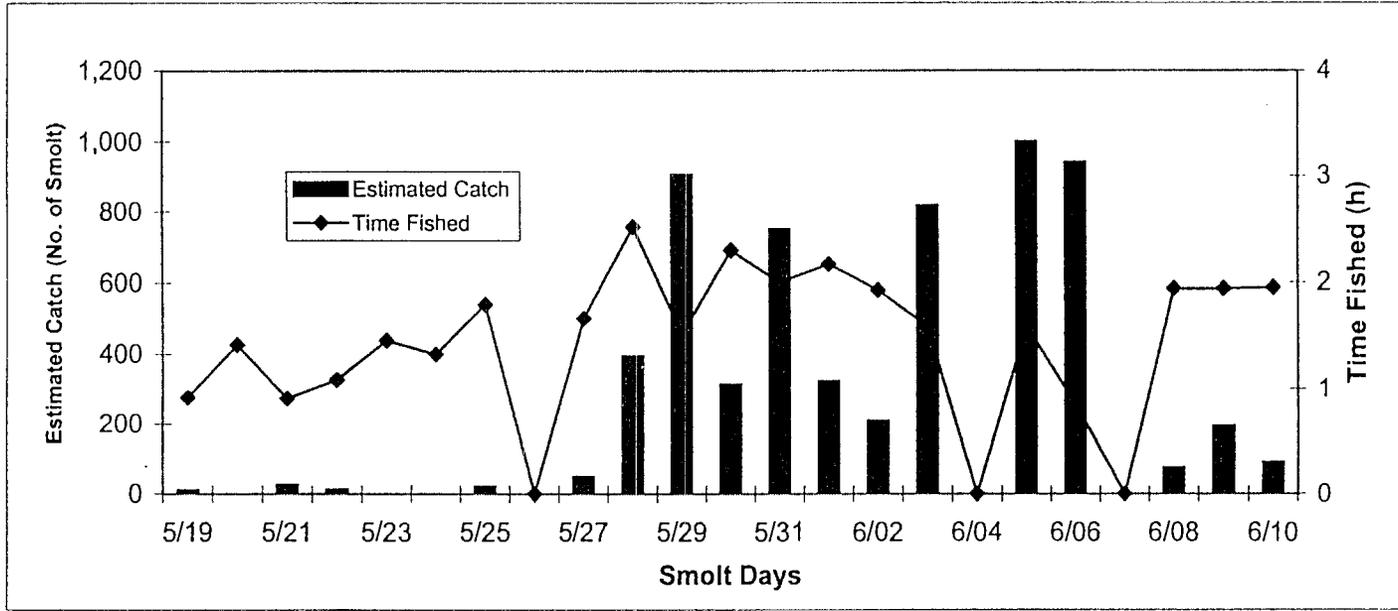
Appendix C.7. Egegik River fyke net catches by hour and species, May 19 to June 10, 1998.

Hour ^a	Time Fished (h)	Catch Estimate (No. of Fish)											
		Sockeye Smolt	Sticklebacks (Species)	Chinook Smolt	Coho Smolt	Chum Fry	Pink Fry	Lamprey (Species)	Whitefish (Species)	Smelt (Species)	Rainbow Trout (juv)	Sculpin (Species)	Northern Pike (juv)
1200	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1300	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1400	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1500	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1600	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1700	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1800	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1900	0.0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0.0	0	0	0	0	0	0	0	0	0	0	0	0
2100	0.0	0	0	0	0	0	0	0	0	0	0	0	0
2200	0.0	0	0	0	0	0	0	0	0	0	0	0	0
2300 ^b	0.0	0	0	0	0	0	0	0	0	0	0	0	0
2400 ^c	5.5	580	1	0	1	8	3	0	0	0	0	5	0
0100 ^c	18.6	3,370	5	0	5	20	8	0	0	0	0	13	0
0200 ^c	8.7	2,170	0	0	2	1	0	1	0	0	0	3	0
0300 ^c	0.1	0	0	0	0	0	0	0	0	0	0	0	0
0400 ^c	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0500 ^c	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0600 ^b	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0700	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0800	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0900	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1000	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1100	0.0	0	0	0	0	0	0	0	0	0	0	0	0
Total	32.9	6,120	6	0	8	29	11	1	0	0	0	21	0

^a Daylight hours unless indicated otherwise.

^b Twilight hours

^c Hours of darkness



Appendix C.8. Egegik River fyke net estimated catch and time fished by smolt day and hour, 1998.



Appendix C.9. Ugashik River smolt fyke net catch log, 1998.

Smolt Day	Cod End No.	Time ^a		Total Time Fished (min)		Smolt Catch		CPUE ^b
		Set	Pulled	per Set	per Smolt Day	per Set	per Smolt Day	
5/19	001	2336	0055	79	79	104	104	1
5/20	002	2320	0025	65		102		2
	003	0030	0050	20	85	3	105	0
5/21	004	2315	0020	65		102		2
	005	0025	0035	10		119		12
	006	0040	0055	15	90	50	271	3
5/22				0	0			
5/23	007	2320	0100	100	100	10	10	0
5/24	008	2315	2345	30		119		4
	009	2350	0105	75	105	86	205	1
5/25	010	2325	0050	85	85	15	15	0
5/26				0	0			
5/27	011	2325	0012	47		93		2
	012	0017	0032	15		107		7
	013	0037	0053	16	78	107	307	7
5/28	014	2323	2349	26		108		4
	015	2354	0051	57	83	63	171	1
5/29	016	2334	0051	77	77	0	0	0
5/30	017	2320	0055	95	95	10	10	0
5/31	018	2320	2341	21		100		5
	019	2346	0028	42		106		3
	020	0034	0051	17	80	120	326	7
6/01	021	2330	2334	4		110		28
	022	2340	2356	16		107		7
	023	0001	0019	18		300		17
	024	0025	0032	7		111		16
	025	0037	0044	7		200		29
	026	0049	0053	4	56	200	1,028	50
6/02	027	2330	2350	20		104		5
	028	2355	0051	56	76	26	130	0
6/03	029	2320	0050	90	90	2	2	0
6/04				0	0			
6/05	030	2315	0055	100	100	3	3	0
6/06	031	2310	0055	105	105	0	0	0
6/07				0	0			
6/08	032	2310	0100	110	110	150	150	1
6/09	033	2315	0100	105	105	60	60	1
6/10				0	0			
6/11	034	2315	2340	25		68		3
	035	2345	0022	37		90		2
	036	0027	0052	25	87	47	205	2
6/12	037	2315	2355	40		130		3
	038	2400	0055	55	95	64	194	1
Max				110	110	300	1028	50
Avg				41	71	87	165	6
Min				0	0	0	0	0

^a Military time - 24 hour clock (hhmm).

^b CPUE = catch per unit effort

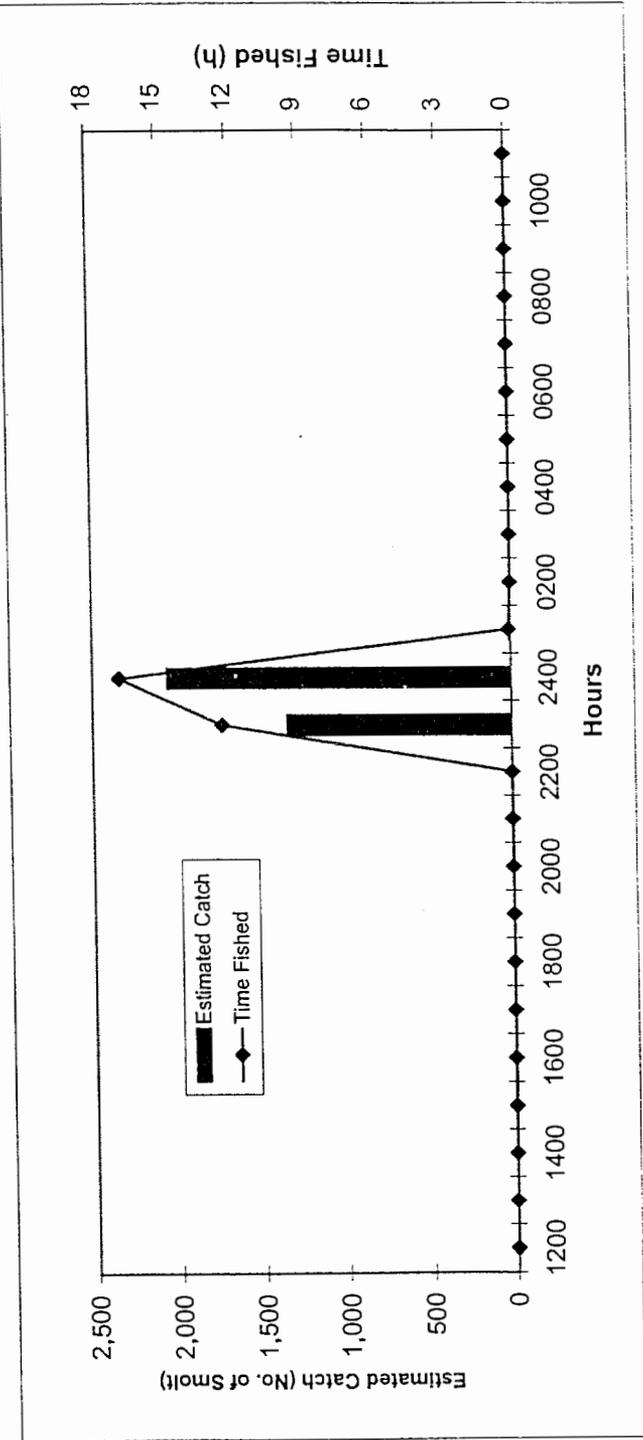
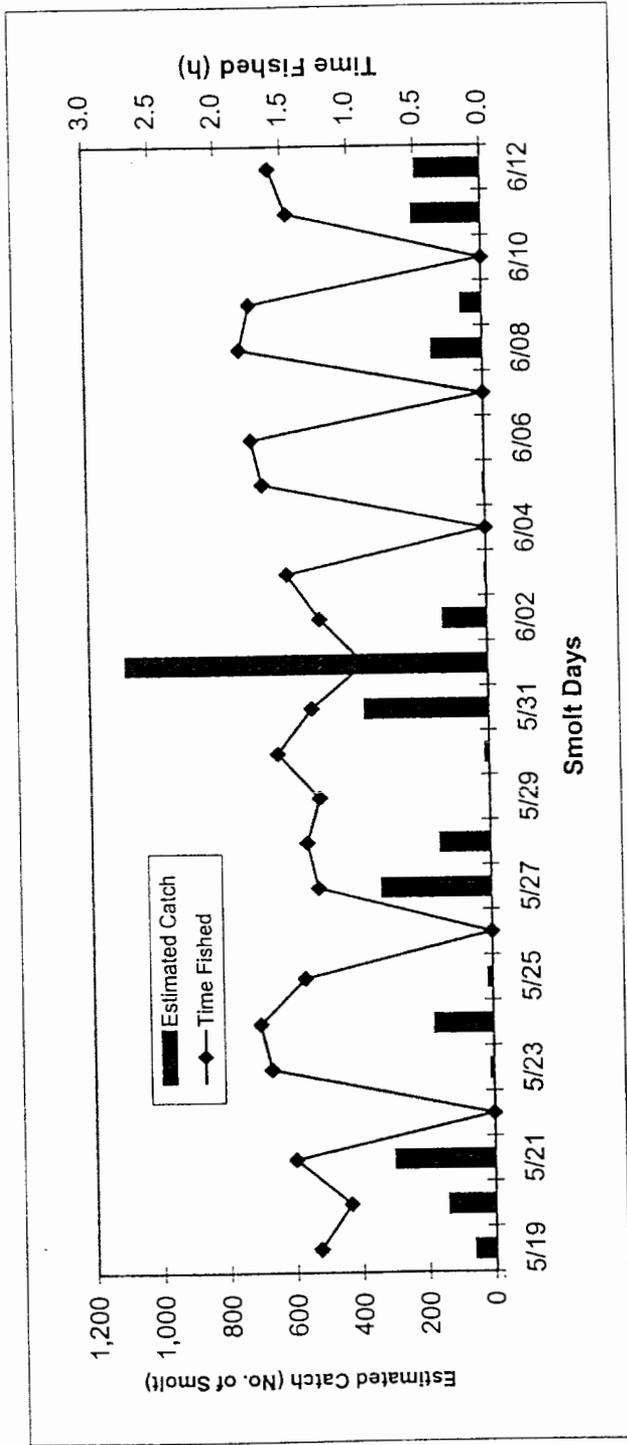
Appendix C.11. Ugashik River fyke net catches by hour and species, May 19 to June 12, 1998.

Hour ^a	Time Fished (h)	Catch Estimate (No. of Fish)											
		Sockeye Smolt	Sticklebacks (Species)	Chinook Smolt	Coho Smolt	Chum Fry	Pink Fry	Lamprey (Species)	Whitefish (Species)	Smelt (Species)	Rainbow Trout (juv)	Sculpin (Species)	Northern Pike (juv)
1200	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1300	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1400	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1500	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1600	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1700	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1800	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1900	0.0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0.0	0	0	0	0	0	0	0	0	0	0	0	0
2100	0.0	0	0	0	0	0	0	0	0	0	0	0	0
2200	0.0	0	0	0	0	0	0	0	0	0	0	0	0
2300 ^b	12.4	1,333	0	0	1	0	0	0	0	0	0	0	0
2400 ^c	16.8	2,049	1	1	1	0	0	0	0	1	0	0	0
0100 ^c	0.1	5	0	0	0	0	0	0	0	0	0	0	0
0200 ^c	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0300 ^c	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0400 ^c	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0500 ^c	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0600 ^b	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0700	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0800	0.0	0	0	0	0	0	0	0	0	0	0	0	0
0900	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1000	0.0	0	0	0	0	0	0	0	0	0	0	0	0
1100	0.0	0	0	0	0	0	0	0	0	0	0	0	0
Total	29.4	3,387	1	1	2	0	0	0	0	1	0	0	0

^a Daylight hours unless indicated otherwise.

^b Twilight hours

^c Hours of darkness



Appendix C.12. Ugashik River fyke net estimated catch and time fished by smolt day and hour, 1998.

Appendix C.13. Kvichak River fyke net catches by smolt day and species, May 19 to June 11, 1996.

Smolt Day	Time Fished (h)	Catch Estimate (No. of Fish)									
		Sockeye Smolt	Sticklebacks (Species)	Chinook Smolt	Coho Smolt	Chum Fry	Pink Fry	Lamprey (Species)	Whitefish (Species)	Smelt (Species)	Rainbow Trout (juv)
5/19	12.3	176	120	0	0	4	3	1	1	0	0
5/20	6.0	2,100	29	0	0	0	0	1	0	0	0
5/21	8.7	315	2	0	0	0	0	0	0	0	0
5/22	13.5	0	370	0	0	0	0	1	0	0	0
5/23	0.0	0	0	0	0	0	0	0	0	0	0
5/24	6.3	0	200	0	0	0	0	0	0	0	0
5/25	13.3	1,551	6	0	0	0	0	0	0	0	0
5/26	2.9	1,550	0	0	0	0	0	0	0	0	0
5/27	6.1	4,100	0	0	0	0	0	0	0	0	0
5/28	2.5	1,950	0	0	0	0	0	0	0	0	0
5/29	8.8	1,165	3	4	0	0	2	0	0	0	0
5/30	5.5	1,720	0	0	0	0	0	0	0	0	0
5/31	6.4	2,700	0	0	0	0	0	0	0	0	0
6/01	6.2	1,800	0	2	0	0	0	0	0	0	0
6/02	9.8	1,202	0	0	0	0	0	0	0	0	0
6/03	15.3	46	0	1	0	0	0	0	0	0	0
6/04	15.3	450	0	0	0	0	0	0	0	0	0
6/05	11.5	33	0	0	0	0	0	0	0	0	0
6/06	13.3	386	0	7	0	0	1	0	0	1	0
6/07	14.8	170	0	0	0	0	0	1	0	0	0
6/08	14.5	730	0	12	0	0	0	0	0	0	0
6/09	6.1	1,861	0	0	12	0	0	0	0	0	1
6/10	10.8	332	0	0	0	0	0	0	0	0	0
6/11	14.6	280	1	0	0	0	0	1	0	0	1
Total	224.3	24,617	731	26	12	4	6	5	1	1	2
Max	15.3	4,100									
Avg	9.3	1,026									
Min	0.0	0									

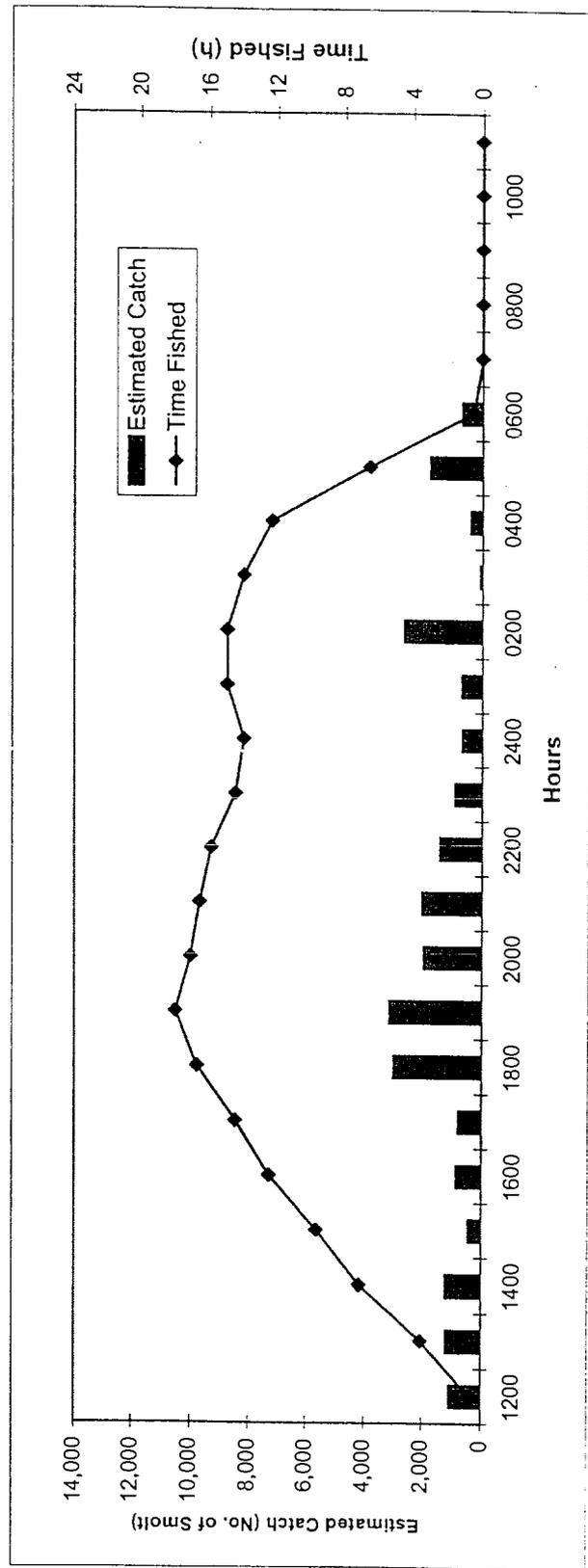
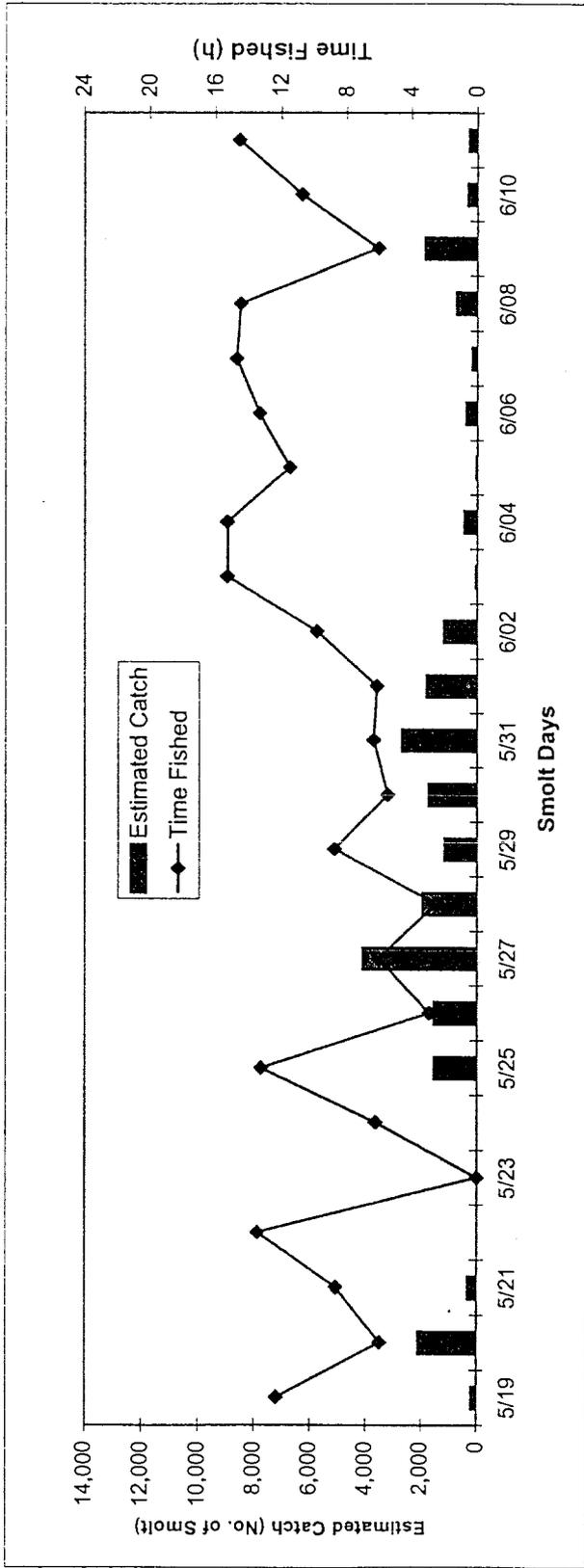
Appendix C.14. Kvichak River fyke net catches by hour and species, May 19 to June 11, 1996.

Hour	Time Fished (h)	Catch Estimate (No. of Fish)									
		Sockeye Smolt	Sticklebacks (Species)	Chinook Smolt	Coho Smolt	Chum Fry	Pink Fry	Lamprey (Species)	Whitefish (Species)	Smelt (Species)	Rainbow Trout (juv)
1200	1	1,052	0	0	0	0	0	0	0	0	0
1300	4	1,169	0	0	0	0	0	0	0	0	0
1400	7	1,192	0	0	0	0	0	0	0	0	1
1500	10	419	1	0	12	0	0	0	0	0	0
1600	13	823	2	0	0	0	1	0	0	0	0
1700	15	752	11	0	0	0	1	0	0	0	0
1800	17	3,003	7	1	0	0	0	0	0	0	0
1900	18	3,147	7	1	0	0	0	0	0	0	0
2000	17	1,941	29	1	0	0	0	0	0	0	0
2100	17	2,008	27	2	0	0	1	1	0	0	0
2200	16	1,406	42	3	0	0	1	1	0	0	1
2300	^b 15	891	86	2	0	0	1	0	0	0	0
2400	^c 14	653	128	2	0	0	0	0	0	0	0
0100	^c 15	664	140	2	0	0	1	0	0	1	0
0200	^c 15	2,640	75	0	0	0	0	2	0	0	0
0300	^c 14	65	62	3	0	4	0	0	0	0	0
0400	^c 12	381	66	4	0	0	0	0	1	0	0
0500	^c 7	1,744	48	5	0	0	0	1	0	0	0
0600	^b 1	667	0	0	0	0	0	0	0	0	0
0700	0	0	0	0	0	0	0	0	0	0	0
0800	0	0	0	0	0	0	0	0	0	0	0
0900	0	0	0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0	0	0	0
1100	0	0	0	0	0	0	0	0	0	0	0
Total	224	24,617	731	26	12	4	6	5	1	1	2

^a Daylight hours unless indicated otherwise.

^b Twilight hours

^c Hours of darkness



Appendix C.15. Kvichak River fyke net estimated catch and time fished by smolt day and hour, 1996.

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Appendix C.16. Kvichak River fyke net catches by smolt day and species, May 18 to June 12, 1997.

Smolt Day	Time Fished (h)	Catch Estimate (No. of Fish)									
		Sockeye Smolt	Sticklebacks (Species)	Chinook Smolt	Coho Smolt	Chum Fry	Pink Fry	Lamprey (Species)	Whitefish (Species)	Smelt (Species)	Rainbow Trout (juv)
5/18	9.5	4,200	0	0	0	0	0	0	0	0	0
5/19	8.5	8,000	0	0	0	0	0	0	0	0	0
5/20	9.5	550	0	0	0	0	0	0	0	0	0
5/21	9.5	2,350	0	0	0	0	0	0	0	0	0
5/22	14.2	2,380	12	0	0	0	0	0	0	0	0
5/23	3.1	1,450	0	0	0	0	0	0	0	0	0
5/24	14.0	3,800	0	0	0	0	0	0	0	0	0
5/25	13.2	1,725	42	1	0	0	108	1	0	0	0
5/26	17.2	2,150	0	0	0	0	0	0	0	0	0
5/27	17.5	1,550	0	0	0	0	0	0	0	0	0
5/28	17.0	1,050	0	0	0	0	0	0	0	0	0
5/29	18.3	550	14	5	0	0	0	1	0	0	0
5/30	4.0	0	0	0	0	0	0	0	0	0	0
5/31	16.3	1,900	2	0	0	0	202	0	0	0	0
6/01	4.0	2,400	0	0	0	0	0	0	0	0	0
6/02	10.5	1,400	0	0	0	0	74	0	0	0	0
6/03	15.3	300	0	0	2	0	2	0	0	0	0
6/04	20.0	403	10	0	0	0	197	10	1	0	0
6/05	17.0	375	0	0	0	0	145	2	0	0	0
6/06	16.8	1,141	0	0	0	0	6	0	0	0	0
6/07	17.0	7	0	0	0	0	325	0	0	0	0
6/08	8.0	666	0	0	0	0	0	0	0	0	0
6/09	15.7	371	0	0	0	0	45	1	0	0	0
6/10	8.8	11,650	0	0	0	0	0	0	0	0	0
6/11	13.8	3	0	9	0	0	0	1	0	0	0
6/12	17.5	3	0	0	0	0	27	0	0	0	0
Total	336	50,374	80	15	2	0	1,131	16	1	0	0
Max	20.0	11,650									
Avg	12.9	1,937									
Min	3.1	0									

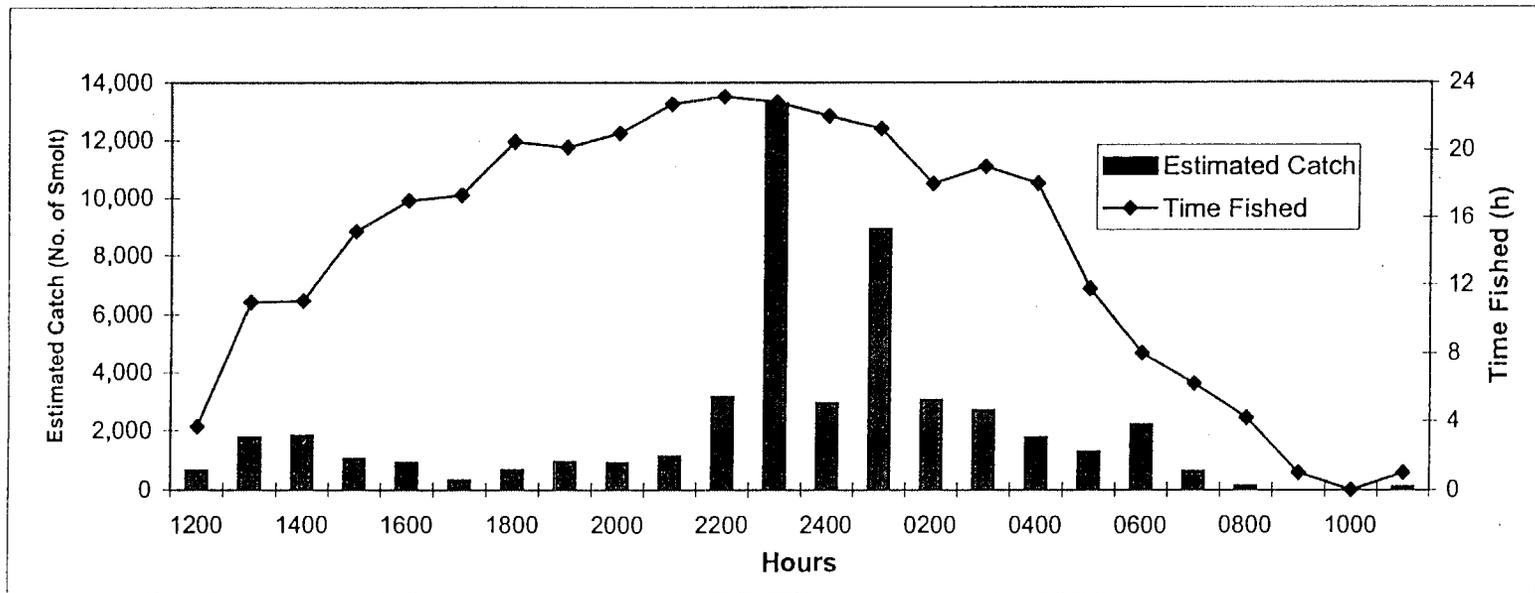
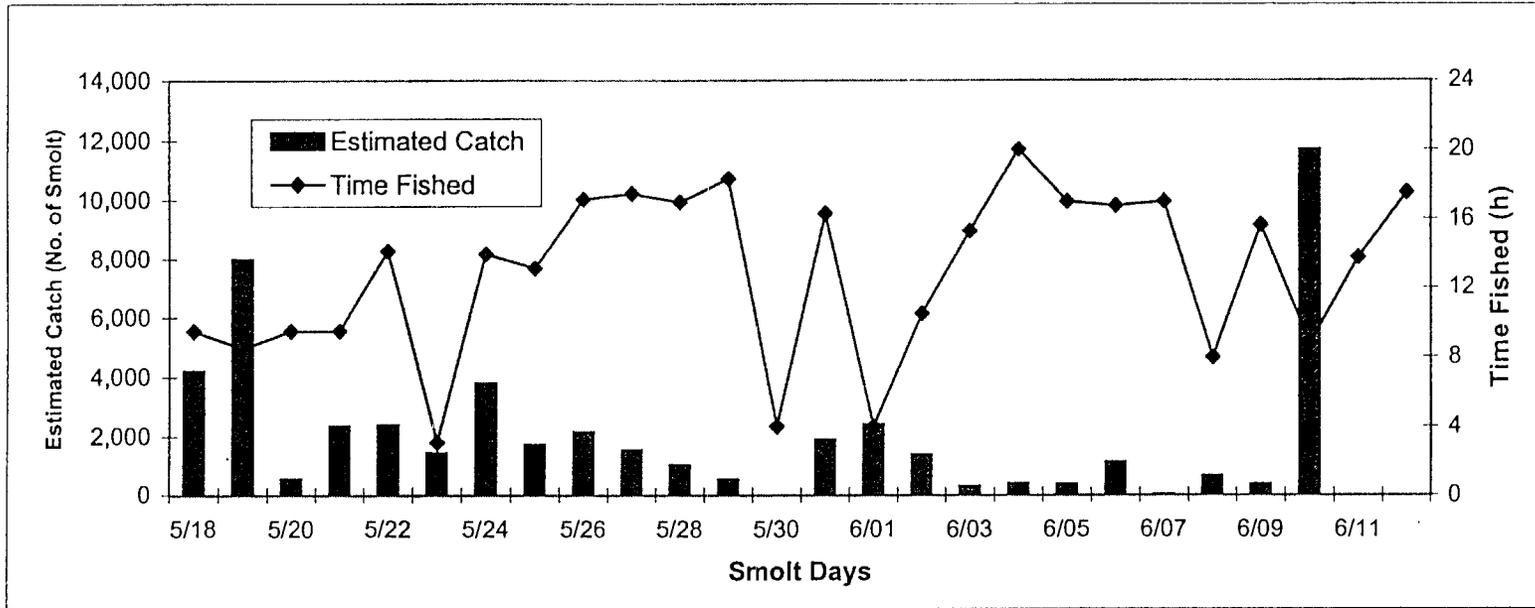
Appendix C.17. Kvichak River fyke net catches by hour and species, May 18 to June 12, 1997.

Hour	Time Fished (h)	Catch Estimate (No. of Fish)									
		Sockeye Smolt	Sticklebacks (Species)	Chinook Smolt	Coho Smolt	Chum Fry	Pink Fry	Lamprey (Species)	Whitefish (Species)	Smelt (Species)	Rainbow Trout (juv)
1200	4	663	0	5	0	0	14	0	0	0	0
1300	11	1,777	0	0	0	0	47	0	0	0	0
1400	11	1,829	0	0	0	0	31	0	0	0	0
1500	15	1,056	0	0	0	0	96	0	0	0	0
1600	17	917	0	0	0	0	171	0	0	0	0
1700	17	330	0	0	0	0	81	0	0	0	0
1800	21	689	0	0	0	0	32	0	0	0	0
1900	20	963	1	0	1	0	52	1	0	0	0
2000	21	912	2	0	1	0	49	1	0	0	0
2100	23	1,152	2	0	0	0	87	1	0	0	0
2200	23	3,143	5	0	0	0	59	1	0	0	0
2300	^b 23	13,258	7	0	0	0	2	2	1	0	0
2400	^c 22	2,924	7	0	0	0	1	2	0	0	0
0100	^c 21	8,917	7	0	0	0	213	3	0	0	0
0200	^c 18	3,031	7	0	0	0	65	2	0	0	0
0300	^c 19	2,687	7	9	0	0	8	2	0	0	0
0400	^c 18	1,763	3	0	0	0	8	1	0	0	0
0500	^c 12	1,284	32	0	0	0	33	0	0	0	0
0600	^b 8	2,195	0	1	0	0	39	0	0	0	0
0700	6	628	0	0	0	0	22	0	0	0	0
0800	4	146	0	0	0	0	21	0	0	0	0
0900	1	0	0	0	0	0	0	0	0	0	0
1000	0	0	0	0	0	0	0	0	0	0	0
1100	1	110	0	0	0	0	0	0	0	0	0
Total	336	50,374	80	15	2	0	1,131	16	1	0	0

^a Daylight hours unless indicated otherwise.

^b Twilight hours

^c Hours of darkness



Appendix C.18. Kvichak River fyke net estimated catch and time fished by smolt day and hour, 1997.



Appendix D.1. Kvichak River water velocity at the center smolt sonar array, 1987-1998.

Date	Water Velocity (ft/sec)												
	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1988-1997 Average
5/16													
5/17											3.12	4.04	3.12
5/18							4.20			3.52			3.86
5/19			3.96										3.96
5/20													
5/21	4.96								4.82				4.82
5/22		5.38		5.01	4.27								4.89
5/23				4.99		3.43		4.27					4.23
5/24													
5/25													
5/26											3.27		3.27
5/27							4.35			3.63			3.99
5/28			3.95										3.95
5/29						3.53			4.72				4.13
5/30													
5/31		5.50										4.01	5.50
6/01					4.47								4.47
6/02				5.37									5.37
6/03											3.45		3.45
6/04								4.33		3.59			3.96
6/05													
6/06													
6/07						3.89							3.89
6/08		5.80							4.88				5.34
6/09							4.59						4.59
6/10			4.27	5.44	4.69							4.78	4.80
6/11													
6/12													
6/13							4.61	4.35		3.67	3.53	5.01	4.04
6/14													
6/15									4.90				4.90
Max		5.80	4.27	5.44	4.69	3.89	4.61	4.35	4.90	3.67	3.53	5.01	5.80
Avg	4.96	5.56	4.06	5.20	4.48	3.62	4.44	4.32	4.83	3.60	3.34	4.46	4.34
Min		5.38	3.95	4.99	4.27	3.43	4.20	4.27	4.72	3.52	3.12	4.01	3.12

Appendix D.2. Egegik River water velocity at the center smolt sonar array, 1984-1998.

Date	Water Velocity (ft/sec)															1984-1997 Average
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	
5/16																
5/17				2.15						2.37						
5/18					2.63										2.57	
5/19							2.50									
5/20	1.89					2.00		2.00					1.50	1.80		
5/21		1.16	1.83							2.30	2.68					
5/22									1.58							
5/23																
5/24									1.70			2.62			2.42	
5/25					3.16								1.25	1.75		
5/26			1.53	2.14			2.68									
5/27											2.28					
5/28						2.09				2.30						
5/29								2.75								
5/30																
5/31									2.02				1.28	1.67	2.47	
6/01			1.76	2.30	2.90							2.75				
6/02							2.73									
6/03	1.82									2.30		2.43				
6/04						2.30										
6/05								2.85								
6/06		1.16													3.03	
6/07													0.90	1.72		
6/08												2.68				
6/09									1.98		2.25					
6/10			1.67	2.51	2.83											
6/11																
6/12												2.40				
6/13		1.32														
6/14																
6/15																
Max	1.89	1.32	1.83	2.51	3.16	2.30	2.73	2.85	2.02	2.37	2.68	2.75	1.50	1.80	3.03	3.16
Avg	1.86	1.21	1.70	2.28	2.88	2.13	2.64	2.53	1.82	2.32	2.41	2.61	1.23	1.74	2.62	2.10
Min	1.82	1.16	1.53	2.14	2.63	2.00	2.50	2.00	1.58	2.30	2.25	2.40	0.90	1.67	2.42	0.90

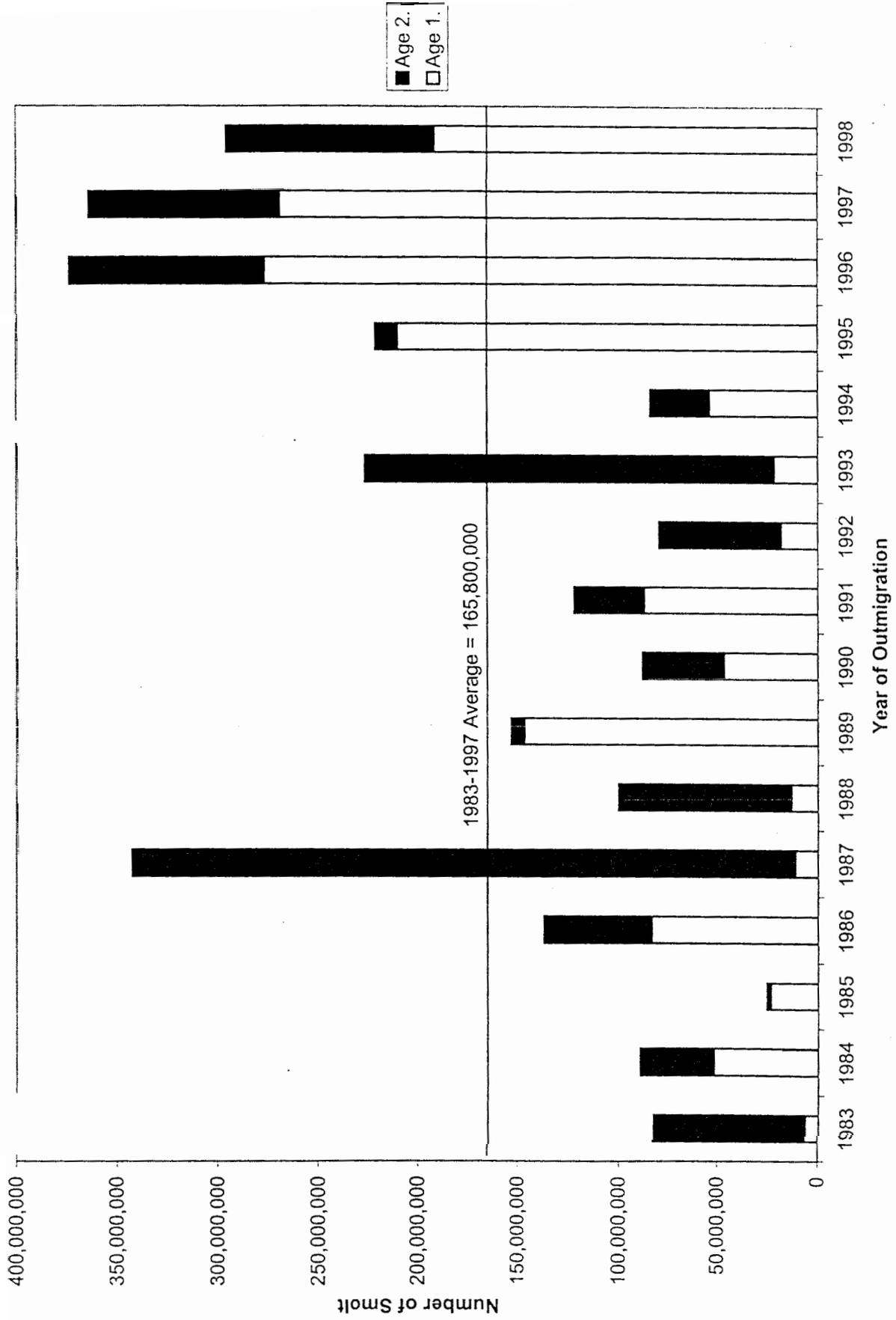
Appendix D.3. Ugashik River water velocity at the inshore smolt sonar array, 1983-1998.

Date	Water Velocity (ft/sec)															1983-1997	
	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992 ^a	1993	1994	1995	1996	1997	1998	Average
5/05															4.99		4.99
5/06																	
5/07																	
5/08																	
5/09																	
5/10																	
5/11																	
5/12																	
5/13																	
5/14																	
5/15																	
5/16															5.13		5.13
5/17					5.17	7.15					7.84					6.30	6.72
5/18																	
5/19														3.91	5.01		4.46
5/20									6.23	5.78		7.60					6.54
5/21																	
5/22	8.00			3.16			4.13						9.48				6.19
5/23			4.10												4.86		4.48
5/24																6.49	
5/25	7.63										8.34						7.99
5/26												7.78		4.52			6.15
5/27																	
5/28		5.56						6.73	7.82				8.93				7.26
5/29															4.82		4.82
5/30								4.90									4.90
5/31				3.89												7.74	3.89
6/01											8.19						8.19
6/02								5.12				7.23		4.45			5.60
6/03																	
6/04			4.93					6.17	6.84				8.72		4.88		6.31
6/05										7.70							7.70
6/06																8.59	
6/07																	
6/08											8.34						8.34
6/09												7.04	7.53	4.47			6.35
6/10																	
6/11				3.80													3.80
6/12								6.51	6.67								6.59
6/13																	
6/14					4.94												4.94
6/15						6.95											6.95
Max	8.00	5.56	4.93	3.89	5.17	7.15	6.51	6.84	7.82		8.34	7.78	9.48	4.52	5.13	8.59	9.48
Avg	7.82	5.56	4.51	3.62	5.06	7.05	5.37	6.62	7.10		8.18	7.41	8.67	4.34	4.95	7.28	6.16
Min	7.63	5.56	4.10	3.16	4.94	6.95	4.13	6.23	5.78		7.84	7.04	7.53	3.91	4.82	6.30	3.16

^a Project not conducted in 1992 due to lack of funding. No data collected.

Appendix E.1. Total smolt outmigration estimates for Kvichak River by outmigration year, 1983-1998.

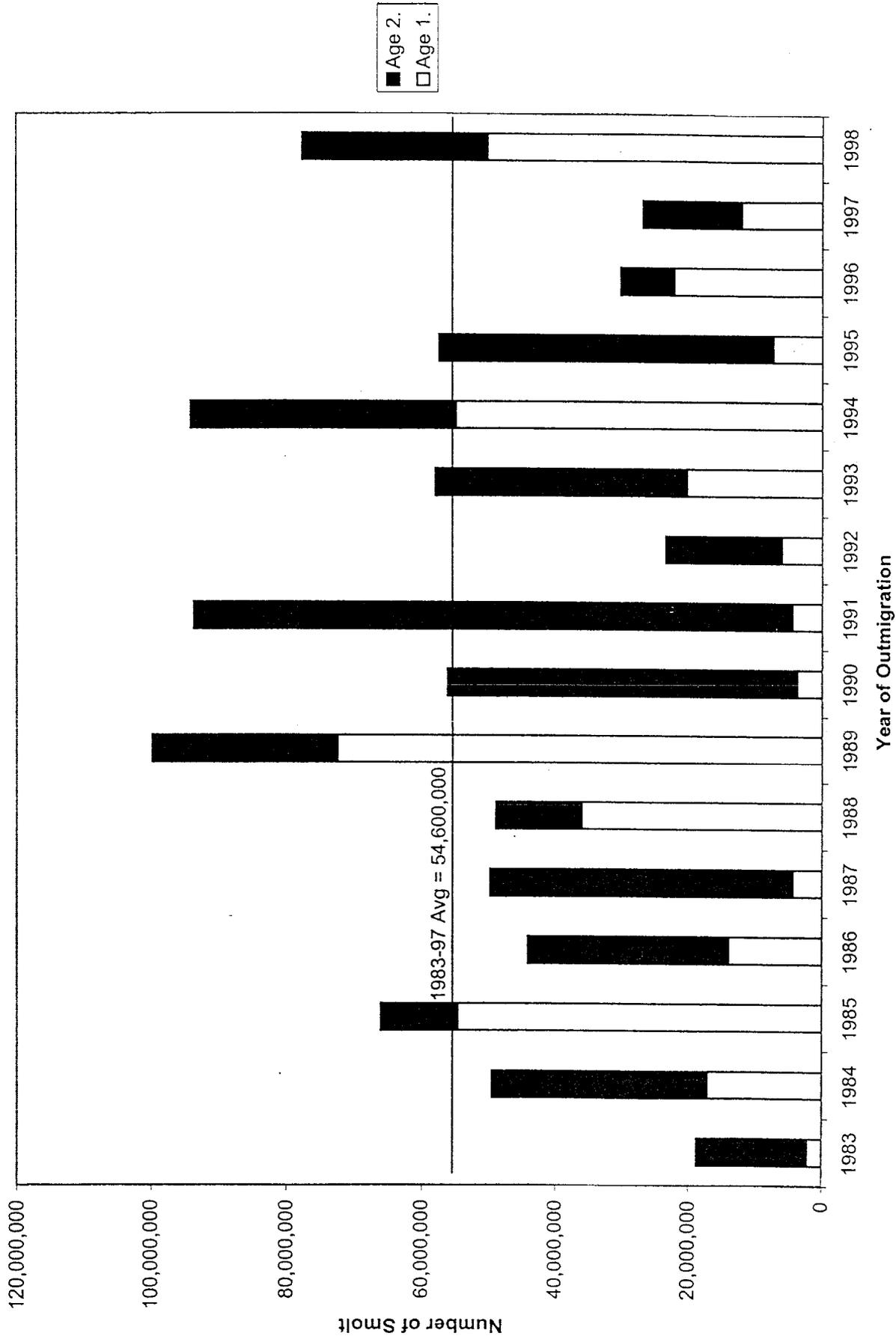
Year of Outmigration	Operating Dates	Total Days Operated	Cumulative Percent by Date			Peak Daily		Total Smolt Estimate	Total Smolt Estimate	Comments
			10%	50%	90%	Date	Smolt Estimate			
1983	5/19-6/13	26	5/23	5/26	6/05	5/24	14,258,463	82,793,899	Ice Problems - 5/19-5/22 intermittent	
1984	5/18-6/10	24	5/21	5/27	6/05	5/27	13,184,162	89,489,975		
1985	5/22-6/19	29	6/06	6/10	6/17	6/09	6,059,204	25,527,851	Ice Problems - 5/22-6/02, 6/06 intermittent, 6/03-6/05 continuous	
1986	5/21-6/12	23	5/28	6/05	6/06	6/06	58,591,781	136,733,218		
1987	5/21-6/13	24	5/24	5/28	6/09	5/28	45,657,674	342,686,918		
1988	5/22-6/16	26	5/23	6/01	6/13	6/01	15,490,767	100,173,692		
1989	5/19-6/15	28	5/29	6/03	6/10	6/03	26,318,761	153,464,216	New Site Location - 1 km downstream from 1974-1988 site	
1990	5/21-6/14	25	5/22	5/25	6/10	5/27	11,721,914	88,004,103	Ice Problems - prior to 5/21	
1991	5/22-6/16	26	5/30	5/28	6/10	6/04	19,885,424	121,454,182	Ice Problems - 5/22-5/26 intermittent, 5/27-5/29 continuous	
1992	5/23-6/13	22	5/25	5/22	6/03	5/28	18,838,144	79,490,008	Ice Problems - 5/19-5/22 continuous, 5/24-5/26, 5/31 intermittent	
1993	5/18-6/11	25	5/19	5/24	5/31	5/31	44,155,479	226,407,888		
1994	5/28-6/15	19	5/31	6/05	6/11	6/05	11,705,421	83,845,472	Ice Problems - 5/17-5/28 continuous	
1995	5/21-6/13	24	5/21	5/25	6/03	5/22	40,060,740	220,892,127	Ice Problems - 5/17-5/21 continuous	
1996	5/18-6/12	26	5/24	5/28	5/31	5/28	78,544,749	373,166,532		
1997	5/17-6/12	27	5/19	5/24	6/01	5/22	44,778,344	363,397,663		
1983-97 Max		29	6/06	6/10	6/17	6/09	78,544,749	373,166,532		
1983-97 Avg		25	5/25	5/29	6/06	5/30	29,950,068	165,835,183		
1983-97 Min		19	5/19	5/22	5/31	5/21	6,059,204	25,527,851		
1998	5/17-6/12	27	5/20	5/25	6/01	5/21	46,937,701	295,470,850		



Appendix E.2. Age composition of smolt outmigration estimates for Kvichak River by outmigration year, 1983-1998.

Appendix E.3. Total smolt outmigration estimates for Egegik River by outmigration year, 1983-1998.

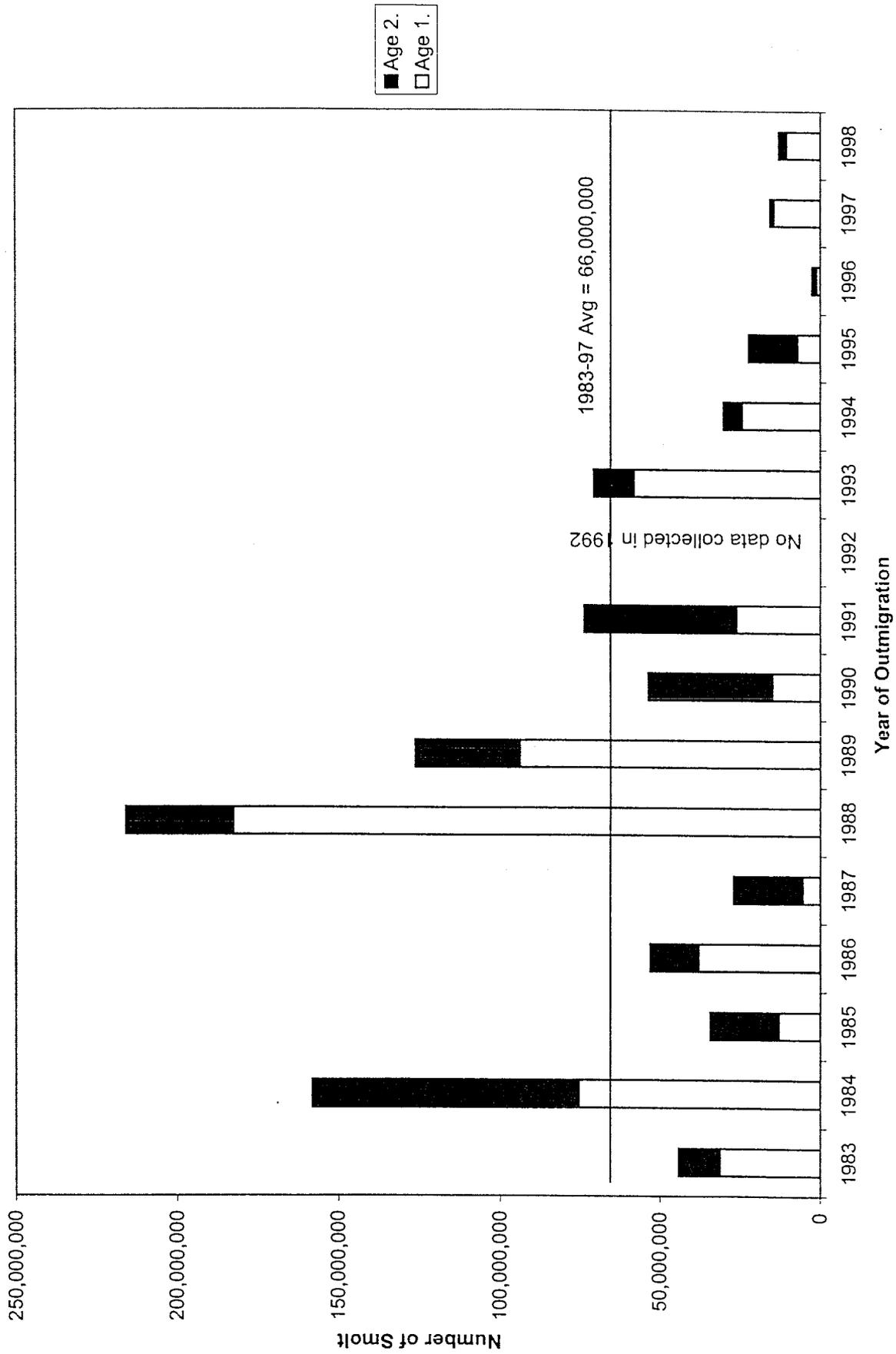
Year of Outmigration	Operating Dates	Total Days Operated	Cumulative Percent by Date			Peak Daily		Total Smolt Estimate	Comments
			10%	50%	90%	Date	Smolt Estimate		
1983	5/17-6/10	25	5/21	5/27	5/31	5/29	5,377,393	18,766,889	
1984	5/19-6/10	23	5/26	5/26	5/30	5/26	23,006,014	49,667,432	
1985	5/19-6/11	24	5/27	5/29	6/01	5/27	24,392,451	66,073,548	Ice Present - 5/17-5/22 intermittent
1986	5/18-6/11	25	5/27	5/29	6/03	5/29	10,079,789	44,197,865	Ice Present - 5/19-5/25 intermittent
1987	5/19-6/13	26	5/21	5/24	6/08	5/22	9,088,350	49,868,710	
1988	5/18-6/13	27	5/23	5/26	6/05	5/24	9,963,520	48,961,215	
1989	5/20-6/09	21	5/25	5/27	5/31	5/27	21,494,695	99,886,786	
1990	5/19-6/11	24	5/23	5/25	5/29	5/25	17,366,276	56,095,226	Fair Weather - 118 h disabled time
1991	5/21-6/11	22	5/25	5/28	6/07	6/04	17,890,595	94,077,988	Ice Problems - 5/17-5/18 continuous
1992	5/22-6/11	21	5/26	5/27	6/02	5/26	7,935,493	23,748,278	
1993	5/17-6/08	23	5/20	5/24	5/27	5/25	11,674,298	57,960,399	
1994	5/21-6/09	20	5/24	5/31	6/05	5/31	14,215,785	94,086,989	
1995	5/21-6/12	23	5/22	5/23	5/29	5/23	19,428,442	57,385,790	Ice Problems - 5/19-5/21 continuous
1996	5/19-6/12	25	5/24	5/25	5/29	5/24	10,043,411	31,270,793	
1997	5/18-6/09	23	5/24	5/28	5/31	5/29	4,881,168	27,050,113	Excellent Weather - 1 hr disabled time
1983-97 Max		27	5/27	5/31	6/08	6/04	24,392,451	99,886,786	
1983-97 Avg		23	5/23	5/26	6/01	5/26	13,789,179	54,606,535	
1983-97 Min		20	5/20	5/23	5/27	5/22	4,881,168	18,766,889	
1998	5/18-6/10	24	5/26	5/29	6/04	5/29	17,439,907	78,791,125	Good Weather - 67 hr disabled time



Appendix E.4. Age composition of smolt outmigration estimates for Egegik River by outmigration year, 1983-1998.

Appendix E.5. Total smolt outmigration estimates for Ugashik River by outmigration year, 1983-1998.

Year of Outmigration	Operating Dates	Total Days Operated	Cumulative Percent by Date			Peak Daily		Total Smolt Estimate	Comments
			10%	50%	90%	Date	Smolt Estimate		
1983	5/21-6/16	27	5/26	6/01	6/13	6/07	5,355,409	44,033,811	
1984	5/22-6/16	26	5/24	6/01	6/08	6/01	26,771,956	158,174,626	
1985	5/22-6/17	27	5/24	6/05	6/11	6/04	5,498,113	34,101,390	Ice Present - 5/17-5/21 intermittent
1986	5/21-6/13	24	5/30	6/02	6/10	5/30	9,142,549	53,076,253	
1987	5/17-6/13	28	5/21	6/03	6/06	6/03	4,944,521	26,947,225	
1988	5/17-6/13	28	5/28	6/06	6/10	6/07	55,816,902	215,968,015	
1989	5/22-6/15	25	5/25	5/31	6/09	5/25	22,376,115	126,298,122	
1990	5/20-6/13	25	5/26	5/30	6/07	5/29	13,459,723	53,627,347	Poor Weather - 199 h disabled time
1991	5/20-6/13	25	5/25	6/02	6/06	6/02	11,905,863	73,769,877	Poor Weather - 187 h disabled time
1992		0							
1993	5/17-6/11	26	5/26	5/30	6/06	5/26	12,360,357	70,747,074	Bad Weather - 264 h disabled time
1994	5/20-6/12	24	5/28	6/04	6/07	6/04	6,914,049	30,030,624	Good Weather - 44 h disabled time
1995	5/22-6/12	22	5/24	5/26	6/01	5/25	4,355,545	22,234,137	Excellent Weather - 21 h disabled time
1996	5/19-6/11	24	5/25	5/30	6/04	6/04	627,517	2,576,812	Fair Weather - 105 h disabled time
1997	5/10-6/12	34	5/18	5/24	5/30	5/24	4,065,127	15,519,783	Good/Excellent Weather - 31 h disabled time
1983-97 Max		34	5/30	6/06	6/13	6/07	55,816,902	215,968,015	
1983-97 Avg		24	5/25	5/31	6/06	5/31	13,113,839	66,221,793	
1983-97 Min		0	5/18	5/24	5/30	5/24	627,517	2,576,812	
1998	5/17-6/12	27	5/27	6/05	6/11	6/05	2,058,183	12,624,441	Poor/Fair Weather - 148 h disabled time



Appendix E.6. Age composition of smolt outmigration estimates for Ugashik River by outmigration year, 1983-1998.



Appendix F.1. Comparison of Kvichak River mean water temperatures at the start of the smolt sonar project and at the time of peak smolt passage, 1984-1998.

Year	Sonar Startup			Peak Smolt Passage	
	Smolt Day	Mean Water Temperature °C		Smolt Day	Mean Water Temperature °C
1984	18-May	5.5	^a	27-May	6.8
1985	22-May	3.8	^b	9-Jun	5.8
1986	21-May	4.5		6-Jun	7.0
1987	21-May	4.5		28-May	5.9
1988	22-May	3.8		1-Jun	5.7
1989	19-May	4.0		3-Jun	6.0
1990	21-May	3.5	^c	27-May	5.8
1991	22-May	2.0		4-Jun	4.8
1992	23-May	6.3		28-May	7.5
1993	18-May	4.5	^d	31-May	7.8
1994	28-May	4.0		5-Jun	6.0
1995	21-May	6.0		22-May	6.0
1996	18-May	7.0		28-May	7.5
1997	17-May	5.5		22-May	7.0
Max		7.0			7.8
Avg		4.6			6.5
Min		2.0			4.8
1998	18-May	3.0		25-May	4.4

^a Water temperature recorded May 19, 1984.

^b Water temperature recorded May 23, 1985.

^c Water temperature recorded May 22, 1990.

^d Water temperature recorded May 19, 1993.

Appendix F.2. Comparison of Egegik River mean water temperatures at the start of the smolt sonar project and at the time of peak smolt passage, 1984-1998.

Year	Sonar Startup		Peak Smolt Passage	
	Smolt Day	Mean Water Temperature °C	Smolt Day	Mean Water Temperature °C
1984	19-May	7.0	26-May	7.5
1985	19-May	2.5	27-May	4.0
1986	18-May	3.0	29-May	4.7
1987	19-May	5.5	22-May	4.0
1988	18-May	4.9	24-May	5.8
1989	20-May	3.5	27-May	4.2
1990	19-May	3.5	25-May	3.8
1991	21-May	7.0	4-Jun	8.0
1992	22-May	7.0	26-May	6.8
1993	17-May	6.5	25-May	6.5
1994	21-May	4.0	31-May	5.8
1995	21-May	4.3	23-May	5.0
1996	19-May	4.8	24-May	5.3
1997	19-May	4.0	29-May	7.5
Max		7.0		8.0
Avg		4.8		5.6
Min		2.5		3.8
1998	18-May	4.5	29-May	5.3

^a Water temperature recorded May 19, 1986.

^b Water temperature recorded May 19, 1988.

^c Water temperature recorded May 21, 1989.

^d Water temperature recorded May 20, 1990.

^e Water temperature recorded May 23, 1992.

^f Water temperature recorded May 18, 1993.

^g Water temperature recorded May 22, 1995.

Appendix F.3. Comparison of Ugashik River mean water temperatures at the start of the smolt sonar project and at the time of peak smolt passage, 1984-1998.

Year	Sonar Startup		Peak Smolt Passage	
	Smolt Day	Mean Water Temperature °C	Smolt Day	Mean Water Temperature °C
1984	22-May	4.8	1-Jun	6.5
1985	22-May	1.5	4-Jun	5.3
1986	21-May	4.0	30-May	5.0
1987	17-May	5.5	3-Jun	6.3
1988	17-May	3.5	7-Jun	7.3
1989	22-May	4.0	25-May	4.0
1990	20-May	3.0	29-May	6.3
1991	20-May	4.0	2-Jun	5.5
1992 ^a				
1993	17-May	6.0	26-May	7.0
1994	20-May	5.0	4-Jun	7.0
1995	22-May	4.5	25-May	5.0
1996	19-May	4.0	4-Jun	7.0
1997	10-May	5.0	24-May	6.5
Max		6.0		7.3
Avg		4.2		6.0
Min		1.5		4.0
1998	17-May	3.5	5-Jun	6.0

^a Project not conducted. No data collected.

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APPENDIX G. CLIMATOLOGICAL FACTORS AFFECTING FRESHWATER SURVIVAL

The freshwater survival of salmon eggs, fry, and smolt from the 1995 and 1996 brood years were probably affected by several climatic factors outlined below; however, we have no direct information indicating the magnitude or direction of the effect.

Air Temperature

According to air temperature data collected by the National Weather Service (1995; 1996; 1997; 1998a,b,c,d,e,f) the overall annual temperatures for King Salmon and vicinity from July through June in 1995-1996, 1996-1997, and 1997-1998 were 2.3 °F, 0.4 °F, and 1.4 °F warmer than the 30-year mean (Appendix G.1).

Average monthly temperatures for the same time periods are shown in (Appendix G.2). Some colder months which may have impacted salmon eggs, fry, and smolt in the Kvichak, Egegik, and Ugashik River drainage were November 1995 (4.6 °F below average), February, October, and December 1996 (1.6 °F, 3.7 °F, and 11.0 °F below average), January, March, October, and December 1997 (2.4 °F, 2.9 °F, 5.4 °F, and 9.4 °F below average), and January 1998 (2.6 °F below average). The remaining months appear to be at or above the 30-year mean temperatures, which would have been favorable for the development and survival of juvenile salmon.

During the winter of 1995-1996 there were 125 d between October and April with average daily air temperatures less than or equal to 32 °F and 17 d with average daily temperatures less than 0 °F (Appendix G.3). During this same time period, there were 88 d with average daily air temperatures greater than 32 °F which would be favorable for the production of salmon eggs and fry for the 1995 brood year. Below normal temperatures, which may have contributed to increased mortality, were most prevalent in mid-late November (11 d), early December (4 d), mid-January (9 d), and early February (12 d).

The winter of 1996-1997, with the exception of February, was colder than the prior year. Between October 1996 and April 1997, there were 136 d with average daily air temperatures less than or equal to 32 °F and 22 d with average daily temperatures less than 0 °F (Appendix G.4). This winter had 76 d with average daily air temperatures greater than 32 °F which would be favorable for the production of salmon eggs and fry for the 1996 brood year. Below normal temperatures which may have contributed to reduced freshwater survival of juvenile sockeye salmon occurred from late November to early January (30 d), late-January to early February (5 d), and mid-March (6 d).

Air temperatures during the winter of 1997-1998 were milder than 1996-1997, but not as warm as 1995-1996. Between October 1997 and April 1998 there were 130 d with average daily air temperatures less than or equal to 32 °F and 15 d with average daily temperatures less than 0 °F (Appendix G.5). This milder weather, especially in March and April, may have created more favorable rearing conditions for age-2. smolt from the 1995 brood year and age-1. smolt from the

1996 brood year. The winter of 1997-1998 had 82 d with average daily air temperatures greater than 32 °F which would be favorable for the production of salmon eggs and fry for the 1997 brood year. Below normal temperatures predominated from mid-October to early November (14 d), late November to early December (6 d), and mid-December to mid- January (22 d).

Precipitation

Precipitation data collected by the National Weather Service (1995; 1996; 1997; 1998a,b,c,d,e,f) for King Salmon and vicinity from July through June in 1995-1996, 1996-1997, and 1997-1998 were 1.7 in, 7.1 in, and 0.2 in less than the 30-year mean annual precipitation of 19.1 in (Appendix G.6).

Average monthly precipitations during the 1995-1996 season were less than the 30-year mean in 8 out of 12 months (Appendix G.7). The months in which low precipitation may have had the greatest impacts upon freshwater survival of sockeye salmon in east side Bristol Bay river systems were August, October, November, December, and March. The average monthly precipitation for August was 4.73 in, 57% greater than the 30-year mean. The average monthly precipitation for October, November, December, and March were 1.46 in, 0.13 in, 0.14 in, and 0.38 in respectively. The precipitation for these months was 30%, 92%, 90%, and 60% less than the 30-year mean. It is unknown how this increase followed by decreases in precipitation may have effected the age-2. (1995 brood year) eggs and fry.

Average monthly precipitations during the 1996-1997 season were less than the 30-year mean in all 12 months (Appendix G.7). The months in which precipitation probably did not impact the freshwater survival of sockeye salmon in east side Bristol Bay river systems were August, September, and February. The average monthly precipitations, for the remaining 9 months, were well below the 30-year mean. Low water levels may have reduced access to and availability of suitable adult salmon spawning habitat and juvenile rearing habitat. Lower than usual precipitation in the spring may also have dewatered some smaller tributaries and prevented fry from entering rearing areas in the lakes.

Average monthly precipitations during the 1997-1998 season were greater than or equal to the 30-year mean in 6 out of 12 months (Appendix G.7). The months in which precipitation probably had the greatest impact upon freshwater survival of sockeye salmon in east side Bristol Bay river systems were August, September, May, and June. The average monthly precipitations for these months were 25%, 32%, 133%, and 37% greater than the 30-year means. The increase in precipitation may have caused some flooding however we have no direct information that significant flooding occurred.

Snowfall

Snowfall data collected for King Salmon and vicinity by the National Weather Service (1995; 1996; 1997; 1998a,b,c,d,e,f) from July through June in 1995-1996, 1996-1997, and 1997-1998 were 20.5 in less, 23.6 in less, and 4.2 in more than the 30-year mean annual snowfall of 46.3 in. (Appendix G.8).

Snowfall during the winter of 1995-1996 season was sparse (Appendix G.9). The average monthly snowfalls for October, November, December, January, and March were 38%, 66%, 83%, 69%, and 76% respectively, below the 30-year mean. Snowfalls in March, April, and May were normal. It is unknown how the lack of insulating snow in the early half of the winter may have affected the incubating salmon eggs (1995 brood year) in east side Bristol Bay streams and lakes.

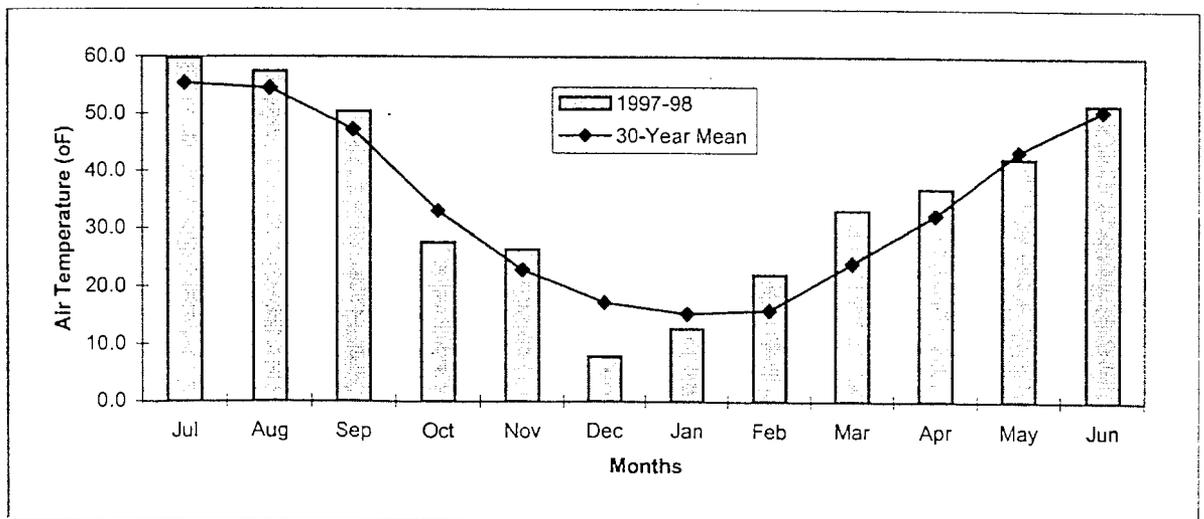
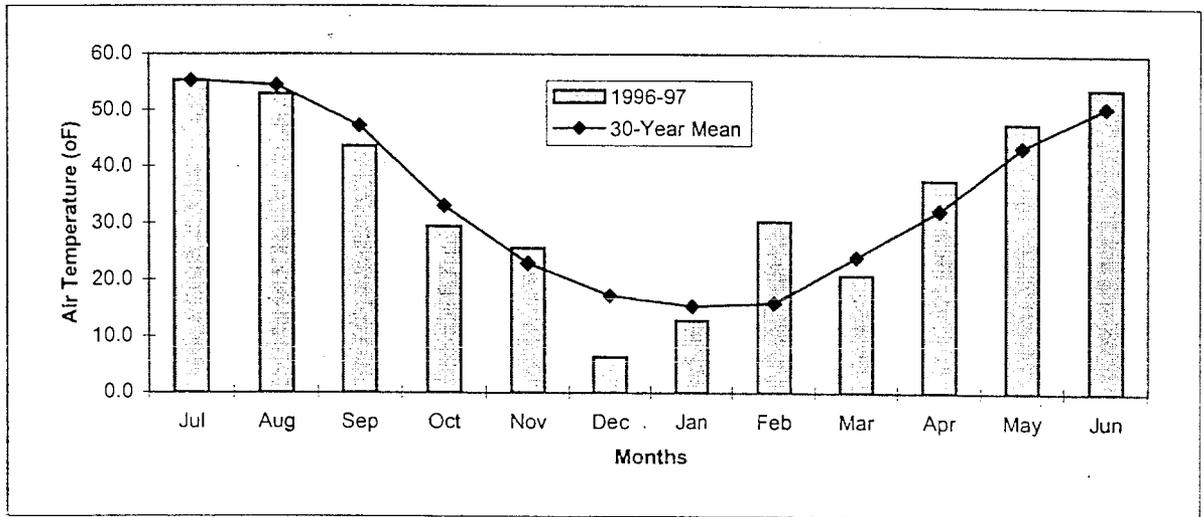
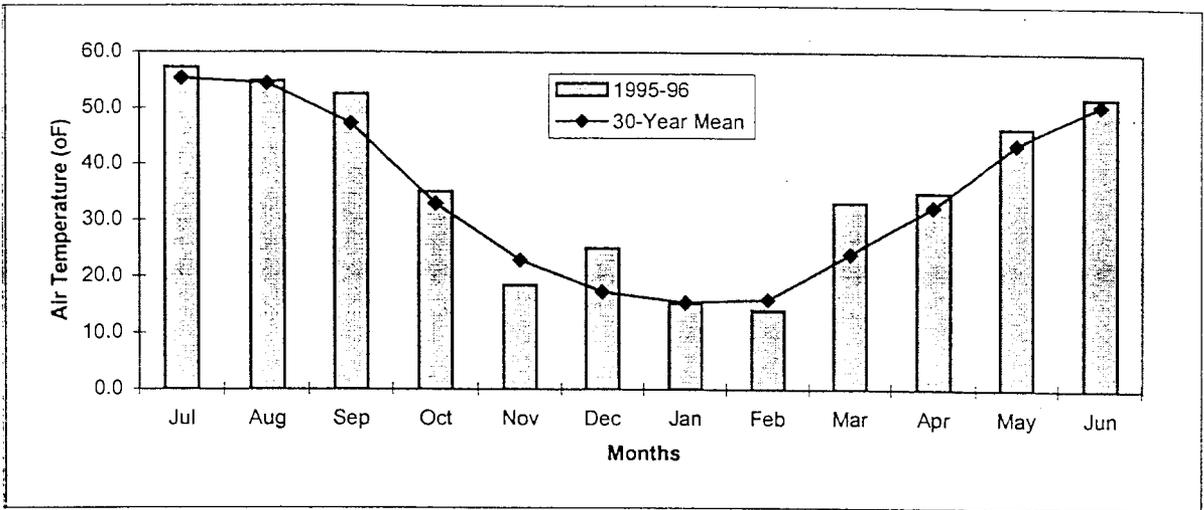
Average monthly snowfalls during the winter of 1996-1997 were also well below normal (Appendix G.9). The average monthly snowfalls during October, December, and February were slightly less than normal, but were probably adequate to provide an insulating layer to protect developing salmon eggs and emerging fry (1996 brood year) from sharp changes in temperature. Despite little or no snowfall in November and well below average snowfall in January, March, and April, the negative effects caused by lack of insulating snow in the later months may have been canceled out by the average and above average air temperatures (Appendix G.2).

During the winter of 1997-1998 most of the snow fell early with above normal snowfalls in November (10.4 in), December (13.1 in), and January (17.3 in) (Appendix G.9). The monthly snowfall for the remainder of the winter was below normal, however the insulating qualities of the early snowfall probably protected rearing fry which would emigrate from the lake systems in the spring as age-1. and age-2. smolt.

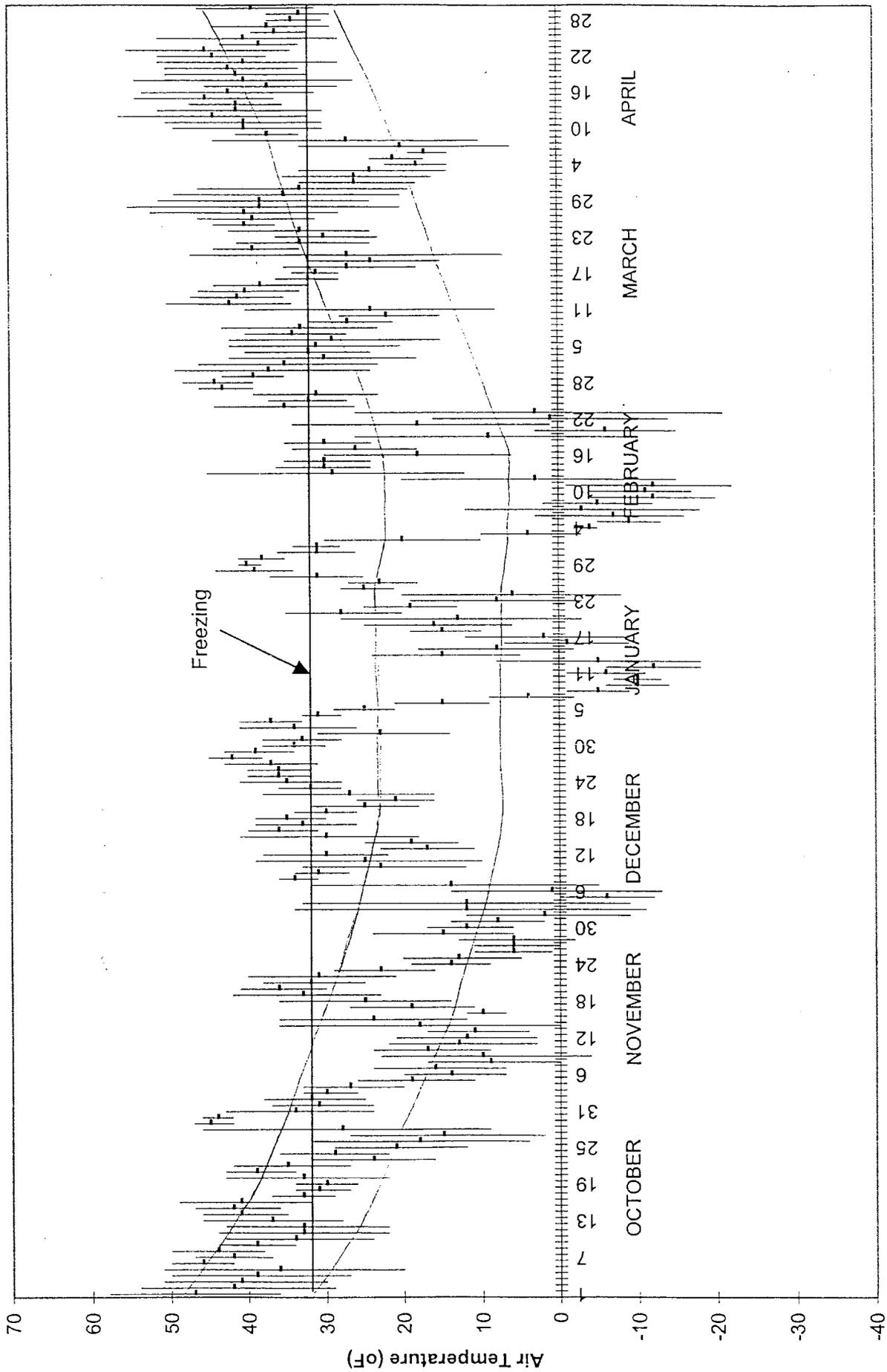
Appendix G.1. Average monthly air temperature for King Salmon, July 1968 to June 1998.

Smolt Year	Air Temperature (°F) ^a												Average Annual
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
1968-69	55.5	54.6	43.3	28.4	26.2	3.4	6.9	12.8	26.3	34.4	44.1	52.5	32.4
1969-70	54.3	50.9	48.1	38.8	17.0	26.2	-0.3	26.4	30.5	29.8	44.8	51.1	34.8
1970-71	52.7	51.7	44.8	29.3	29.3	11.6	-2.6	12.2	7.8	26.8	37.7	47.3	29.1
1971-72	54.5	54.9	46.8	34.3	21.6	18.6	6.7	6.2	1.8	2.1	40.9	46.6	27.9
1972-73	55.2	54.4	45.5	36.0	25.4	16.2	1.8	19.5	19.3	35.9	42.9	51.4	33.6
1973-74	55.6	54.6	47.2	34.1	24.7	17.9	9.5	0.4	23.2	35.6	45.5	51.2	33.3
1974-75	55.4	57.0	50.6	33.4	20.1	8.0	4.7	3.9	14.5	25.0	39.4	47.1	29.9
1975-76	54.7	53.6	47.1	32.4	12.7	10.2	12.3	7.3	15.3	29.5	39.5	46.9	30.1
1976-77	53.2	53.1	45.3	31.5	24.2	19.3	34.4	30.1	18.8	25.7	39.5	50.5	35.5
1977-78	54.3	56.8	47.0	31.7	14.1	10.6	28.6	24.8	25.6	37.5	45.2	49.5	35.5
1978-79	54.2	57.1	47.7	36.5	30.0	28.0	30.1	6.2	30.3	39.6	47.3	52.0	38.3
1979-80	57.8	56.0	50.0	39.4	29.4	4.5	9.0	20.7	27.6	36.4	41.7	48.9	35.1
1980-81	55.1	51.1	47.0	35.2	26.3	5.3	29.8	21.9	34.4	35.8	46.8	50.3	36.6
1981-82	55.1	54.8	44.9	33.2	23.4	13.3	17.0	12.8	23.9	25.5	40.3	48.9	32.8
1982-83	51.5	52.3	46.2	28.1	26.1	24.0	11.9	18.7	33.2	36.5	46.6	53.8	35.7
1983-84	57.4	54.1	45.5	28.8	30.1	27.2	17.4	-2.1	36.3	29.2	43.0	52.3	34.9
1984-85	53.7	53.5	48.0	30.1	22.5	24.7	32.6	10.6	22.6	20.8	39.9	47.4	33.9
1985-86	54.3	52.4	47.4	26.7	25.1	34.2	16.9	22.1	21.5	28.1	42.1	49.9	35.1
1986-87	53.7	52.2	48.8	36.1	26.3	30.6	21.1	24.3	29.8	32.3	42.8	49.3	37.3
1987-88	55.9	57.0	45.4	37.5	16.5	9.4	25.6	26.6	24.8	31.1	44.5	52.8	35.6
1988-89	56.8	53.5	45.8	30.9	13.9	20.8	-2.9	28.8	23.6	36.1	42.0	51.6	33.4
1989-90	56.3	57.1	51.7	36.7	18.1	19.5	16.8	-1.8	25.4	39.3	45.8	51.4	34.7
1990-91	56.0	55.9	47.5	31.5	17.3	20.4	17.5	14.2	25.7	36.4	44.5	50.4	34.8
1991-92	55.2	53.7	50.7	37.2	23.1	15.1	17.7	3.1	22.0	32.4	42.7	52.6	33.8
1992-93	55.6	53.9	41.0	31.7	23.5	19.2	15.0	22.7	31.1	41.0	48.3	53.1	36.3
1993-94	57.9	56.0	48.6	38.1	29.6	24.6	21.2	14.3	19.5	36.0	45.4	51.7	36.9
1994-95	55.7	55.9	48.6	29.9	19.3	14.3	19.5	23.1	17.4	40.3	46.4	53.2	35.3
1995-96	57.3	54.8	52.5	35.1	18.4	25.0	15.2	14.0	33.1	34.9	46.5	52.0	36.6
1996-97	55.3	52.9	43.6	29.4	25.6	6.3	12.8	30.3	20.8	37.7	47.8	54.0	34.7
1997-98	59.8	57.4	50.4	27.6	26.4	7.8	12.7	22.1	33.1	36.9	42.3	51.7	35.7
Max	59.8	57.4	52.5	39.4	30.1	34.2	34.4	30.3	36.3	41.0	48.3	54.0	38.3
30-Year Mean	55.3	54.4	47.2	33.0	22.9	17.2	15.3	15.9	24.0	32.3	43.5	50.7	34.3
Min	51.5	50.9	41.0	26.7	12.7	3.4	-2.9	-2.1	1.8	2.1	37.7	46.6	27.9

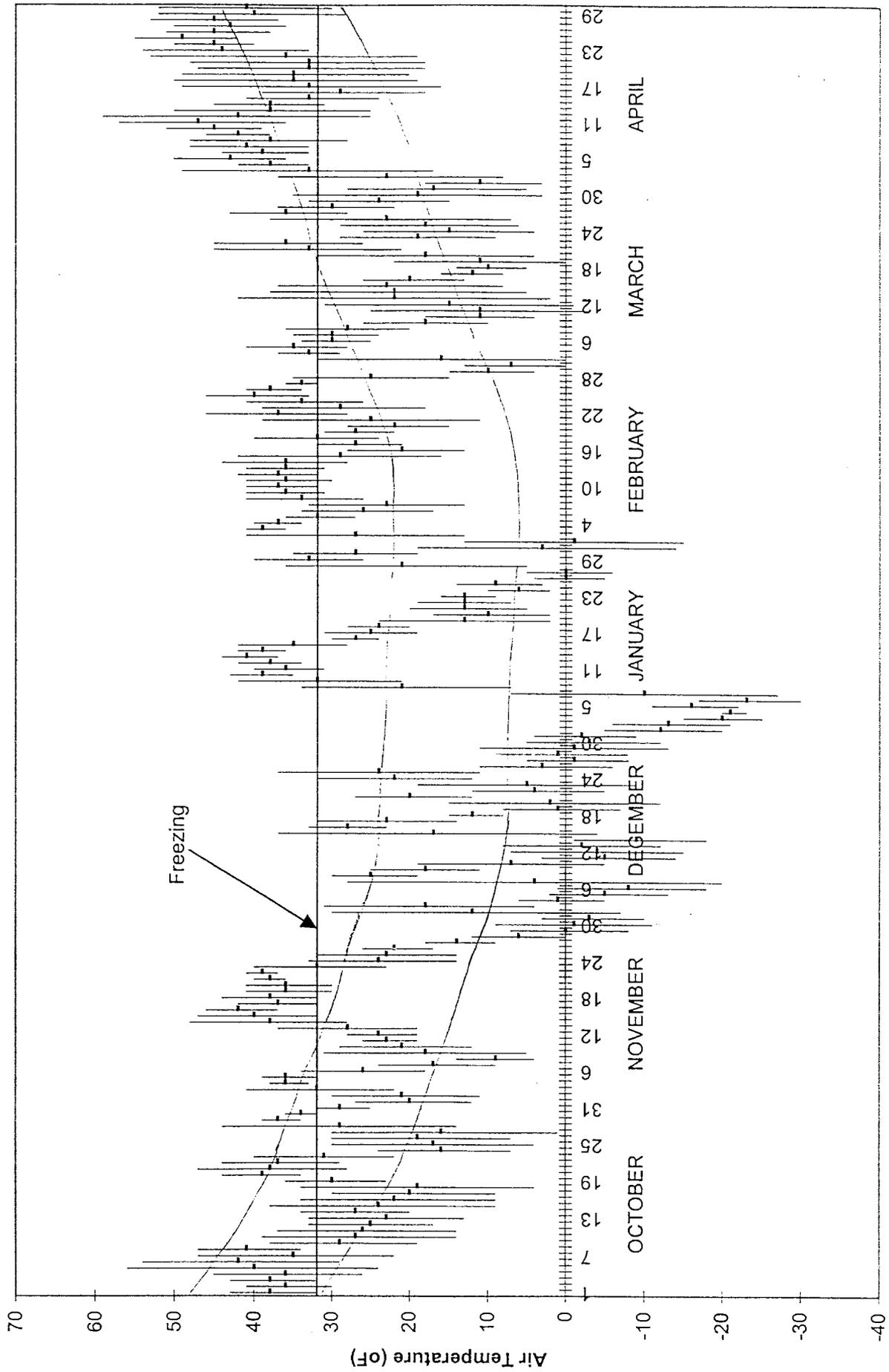
^a Source - National Weather Service (1996; 1997; 1998a,b,c,d,e,f)



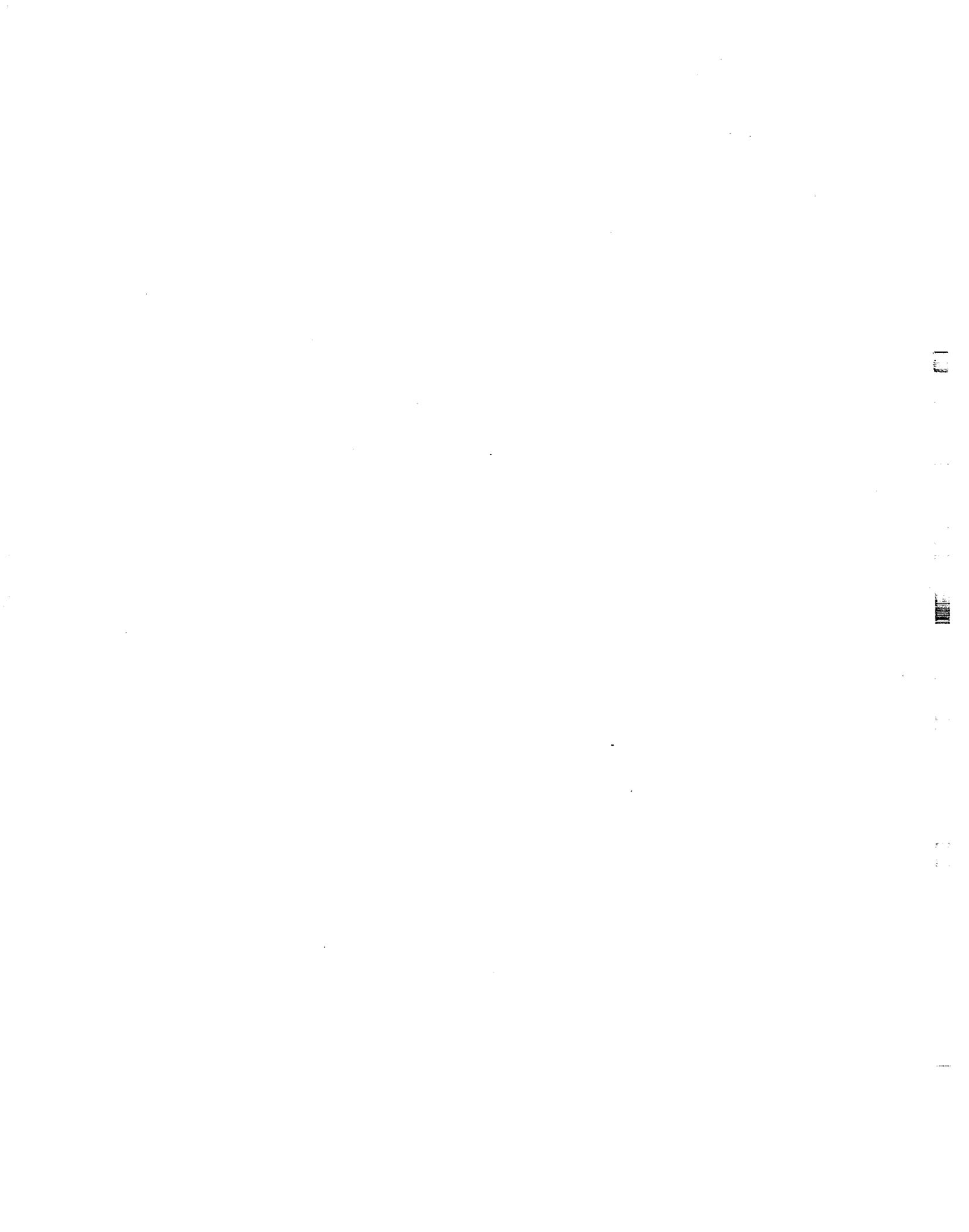
Appendix G.2. Comparison of monthly air temperature to the 30-year mean at King Salmon, July 1995 to June 1998.

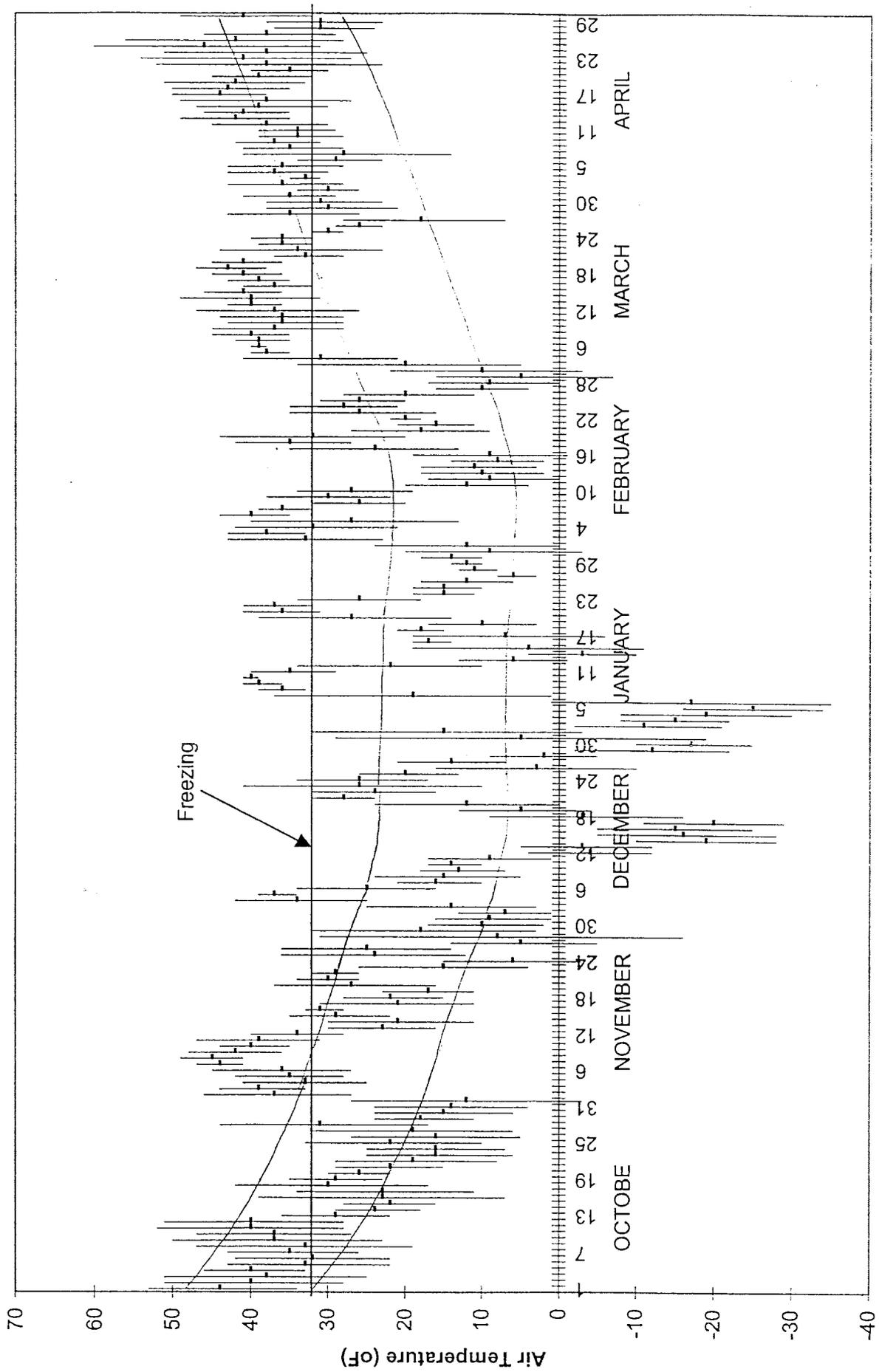


Appendix G.3. Daily air temperatures (normal, mean and extreme) for King Salmon, October 1995 to April 1996.



Appendix G.4. Daily air temperatures (normal, mean and extreme) for King Salmon, October 1996 to April 1997.



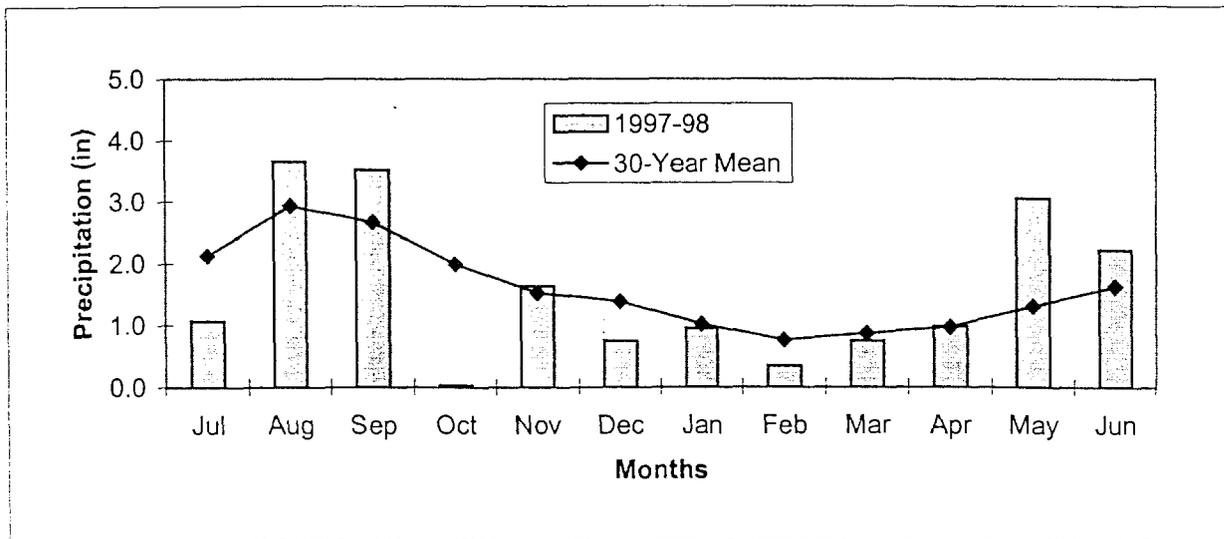
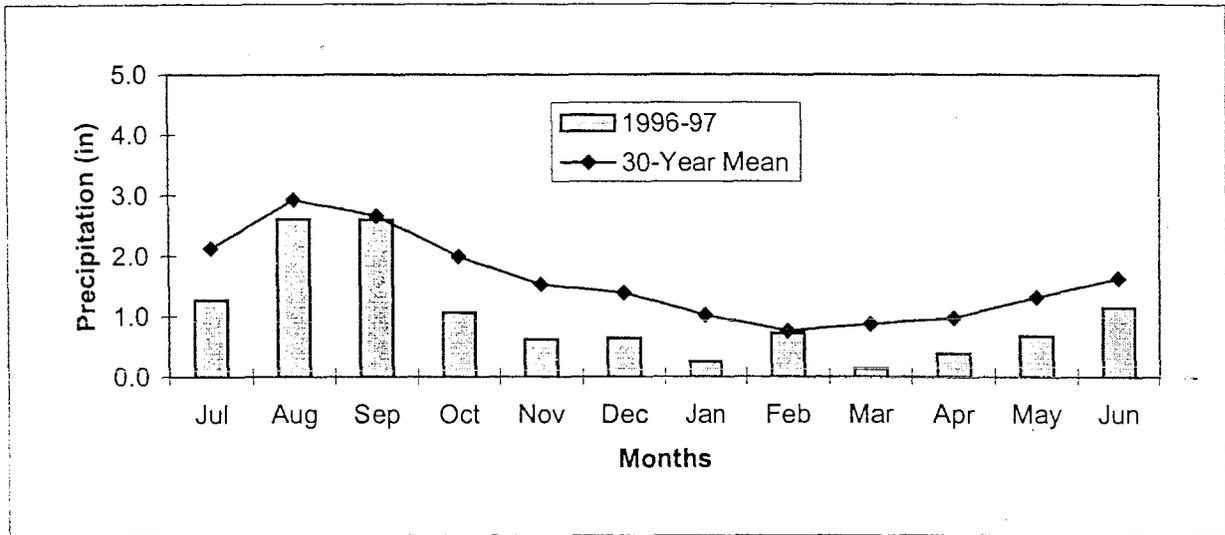
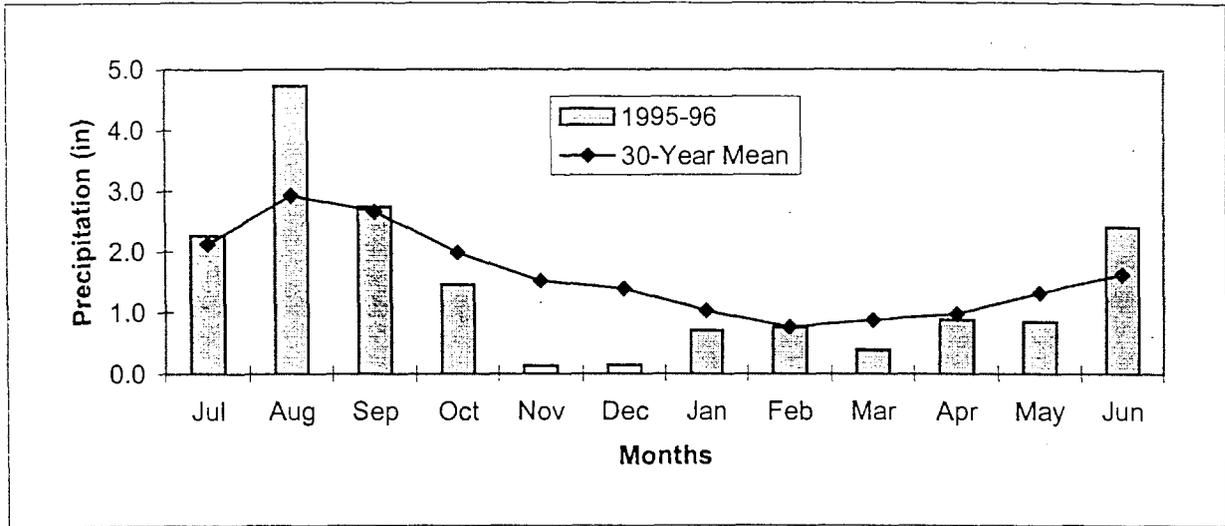


Appendix G.5. Daily air temperatures (normal, mean and extreme) for King Salmon, October 1997 to April 1998.

Appendix G.6. Average monthly precipitation for King Salmon, July 1968 to June 1998.

Smolt Year	Precipitation (in) ^a												Total Annual
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
1968-69	1.14	2.20	2.70	0.51	0.91	1.25	0.65	1.94	1.19	0.30	0.79	0.56	14.14
1969-70	2.19	3.42	1.28	2.33	1.84	0.57	0.50	0.45	1.81	1.80	0.41	1.13	17.73
1970-71	2.87	4.31	1.59	2.24	0.79	1.33	0.45	1.62	0.27	0.84	1.43	1.48	19.22
1971-72	3.25	4.30	3.40	2.72	1.13	3.42	1.30	0.21	0.17	1.37	1.29	1.62	24.18
1972-73	1.08	1.95	2.95	2.57	1.35	0.59	0.62	0.11	1.25	0.43	1.83	1.48	16.21
1973-74	2.43	3.80	1.41	1.52	0.97	1.10	0.86	0.55	1.27	1.18	0.57	2.40	18.06
1974-75	2.01	3.19	1.56	2.90	1.20	1.23	2.14	0.76	0.93	2.65	0.86	2.69	22.12
1975-76	0.74	1.05	3.90	2.10	0.46	1.38	1.24	0.97	0.78	0.58	1.47	1.34	16.01
1976-77	2.60	1.71	2.64	0.81	2.06	1.77	0.85	1.35	1.99	1.68	1.72	0.99	20.17
1977-78	1.60	3.16	2.58	3.29	0.58	1.04	0.70	0.28	0.26	0.58	0.98	2.81	17.86
1978-79	1.66	2.03	1.87	2.84	1.77	3.65	1.00	0.29	0.39	1.20	0.46	1.80	18.96
1979-80	2.24	2.50	0.91	2.71	2.89	1.09	1.46	0.83	1.51	0.42	1.61	2.19	20.36
1980-81	2.97	2.36	2.00	2.46	1.19	0.49	1.76	2.26	1.83	0.49	0.73	2.27	20.81
1981-82	2.17	3.93	1.82	1.59	1.31	0.59	1.48	0.15	1.37	1.20	1.55	3.04	20.20
1982-83	1.98	1.99	5.14	1.41	0.83	1.37	0.42	0.25	0.22	2.22	1.37	1.20	18.40
1983-84	1.53	2.33	2.36	2.82	0.98	0.48	1.17	0.55	0.44	0.43	1.08	1.59	15.76
1984-85	1.30	2.41	0.89	0.57	1.00	1.79	0.95	0.73	1.27	0.34	1.16	1.23	13.64
1985-86	1.31	3.24	2.64	2.29	3.35	1.58	1.33	0.19	0.24	0.98	1.01	0.93	19.09
1986-87	2.44	3.22	4.03	2.50	1.91	0.65	2.38	0.54	0.55	0.81	1.74	1.49	22.26
1987-88	1.94	2.73	2.99	2.47	2.75	1.07	0.56	0.75	0.74	1.02	2.95	1.11	21.08
1988-89	2.73	2.88	2.17	1.68	1.52	1.60	0.84	0.93	0.19	0.99	2.32	1.10	18.95
1989-90	3.04	3.15	5.90	2.86	1.58	1.31	1.44	1.61	1.71	0.89	1.52	1.22	26.23
1990-91	5.08	2.02	2.75	2.38	2.10	3.26	0.55	0.58	1.56	0.86	1.24	1.63	24.01
1991-92	1.02	1.79	2.10	1.99	1.34	1.26	0.79	0.92	1.40	0.19	0.74	2.53	16.07
1992-93	3.02	4.73	1.35	1.11	1.45	1.77	1.48	0.35	0.26	0.50	0.70	0.50	17.22
1993-94	1.01	3.21	4.53	1.98	3.00	2.15	1.35	1.22	0.91	1.35	1.74	1.71	24.16
1994-95	3.77	3.17	3.46	2.41	2.98	2.28	0.35	0.49	0.17	1.51	1.44	0.81	22.84
1995-96	2.27	4.73	2.74	1.46	0.13	0.14	0.70	0.75	0.38	0.87	0.84	2.41	17.42
1996-97	1.27	2.61	2.60	1.06	0.62	0.64	0.25	0.72	0.13	0.38	0.67	1.14	12.09
1997-98	1.07	3.65	3.52	0.03	1.63	0.75	0.95	0.34	0.75	0.98	3.05	2.22	18.94
Max	5.08	4.73	5.90	3.29	3.35	3.65	2.38	2.26	1.99	2.65	3.05	3.04	26.23
30-Year Mean	2.12	2.93	2.66	1.99	1.52	1.39	1.02	0.76	0.86	0.97	1.31	1.62	19.14
Min	0.74	1.05	0.89	0.03	0.13	0.14	0.25	0.11	0.13	0.19	0.41	0.50	12.09

^a Source - National Weather Service (1996; 1997; 1998a,b,c,d,e,f)



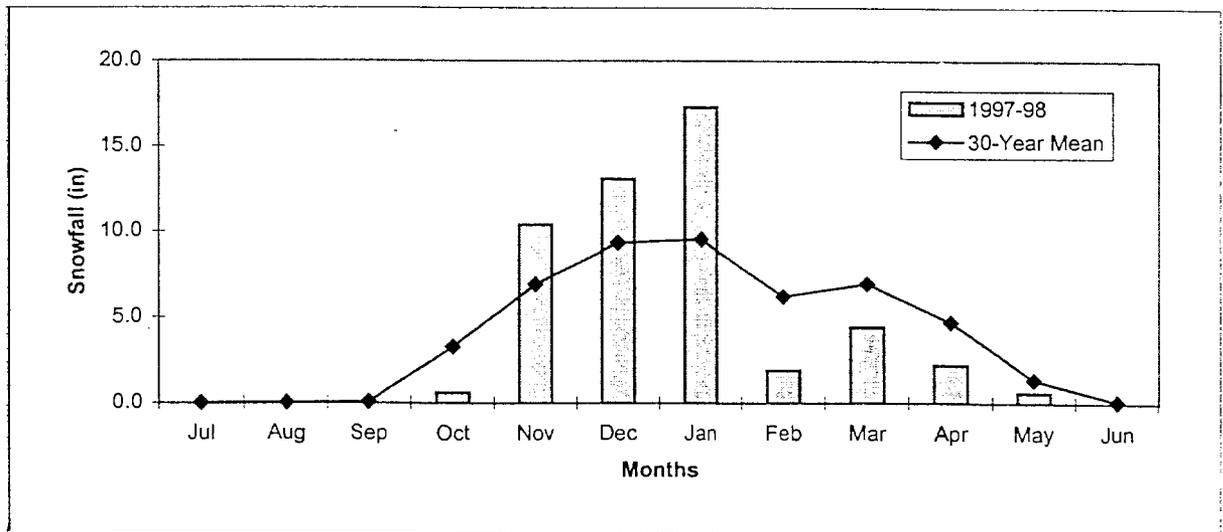
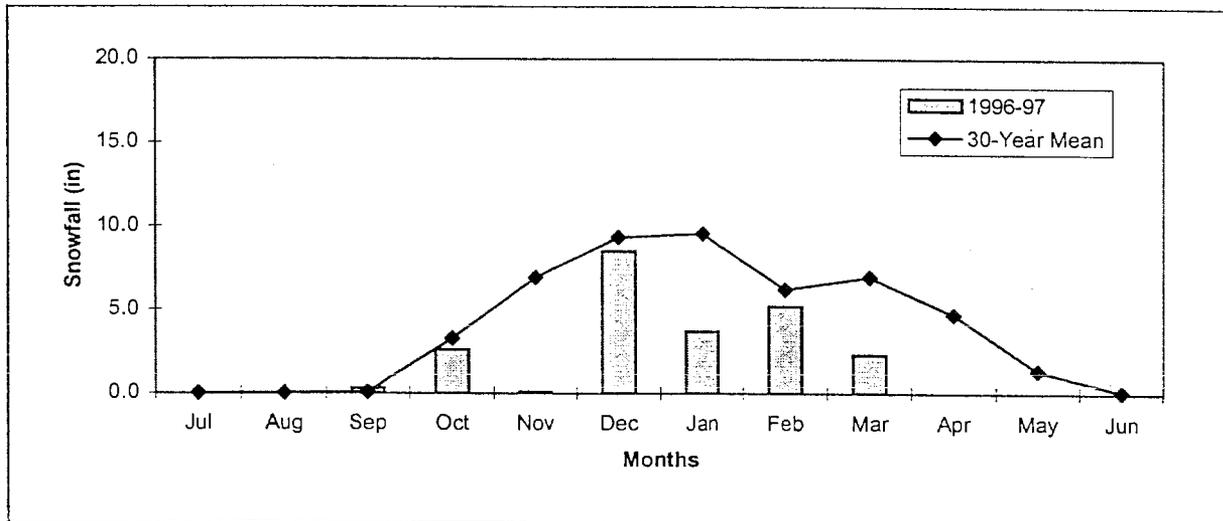
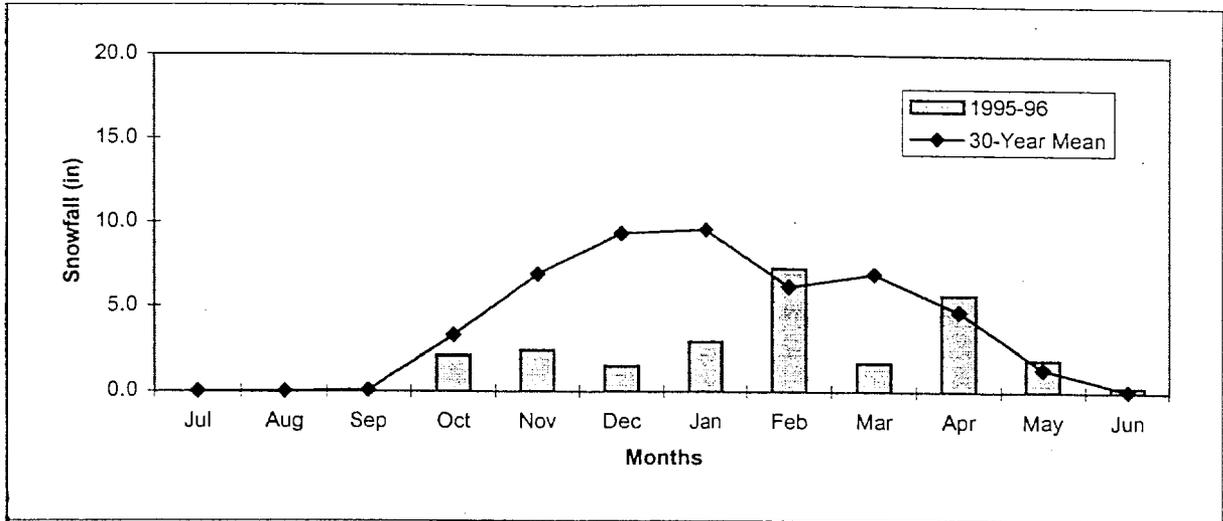
Appendix G.7. Comparison of monthly precipitation to the 30-year mean at King Salmon, July 1995 to June 1998.

Appendix G.8. Average monthly snowfall for King Salmon, July 1968 to June 1998.

Smolt Year	Snowfall (in) ^{a,b}												Total Annual
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
1968-69	0.0	0.0	0.3	0.3	8.9	10.8	6.1	13.9	12.3	1.1	T	0.0	53.7
1969-70	0.0	0.0	0.0	T	16.1	1.5	11.1	4.6	6.4	5.5	T	0.0	45.2
1970-71	0.0	0.0	T	8.3	1.4	8.6	4.3	15.2	1.6	8.9	2.5	T	50.8
1971-72	0.0	0.0	0.0	7.9	3.9	15.1	11.7	2.1	1.9	8.7	0.1	1.3	52.7
1972-73	0.0	0.0	T	0.8	8.0	2.1	3.0	0.8	8.1	2.2	0.6	0.0	25.6
1973-74	0.0	0.0	T	2.0	2.1	12.7	11.9	5.3	4.6	5.1	T	0.0	43.7
1974-75	0.0	0.0	0.0	T	4.3	10.9	19.1	6.3	8.7	14.3	2.9	0.0	66.5
1975-76	0.0	0.0	0.0	0.8	3.9	13.9	12.0	3.2	6.7	6.2	3.2	0.0	49.9
1976-77	0.0	0.0	0.0	2.0	10.9	11.0	2.1	11.9	20.0	4.6	T	0.0	62.5
1977-78	0.0	0.0	T	4.3	5.3	4.5	3.9	3.7	2.2	0.6	T	0.0	24.5
1978-79	0.0	0.0	0.0	1.0	2.2	14.1	4.4	0.2	1.1	T	T	0.0	23.0
1979-80	0.0	0.0	0.0	T	8.5	9.7	11.5	11.1	9.0	T	0.8	0.0	50.6
1980-81	0.0	0.0	0.0	0.3	6.1	6.8	10.5	11.3	15.8	0.6	T	T	51.4
1981-82	0.0	0.0	0.5	0.3	4.8	5.9	5.7	T	8.3	8.3	T	0.0	33.8
1982-83	0.0	0.0	0.0	2.8	2.0	2.9	4.0	2.0	T	6.0	0.1	0.0	19.8
1983-84	0.0	0.0	T	9.9	2.3	2.8	8.4	5.5	T	4.0	0.3	0.0	33.2
1984-85	0.0	0.0	0.0	3.4	7.3	3.8	3.7	6.4	8.9	3.4	6.1	0.0	43.0
1985-86	0.0	0.0	0.0	2.5	9.3	3.6	13.5	1.8	2.5	9.8	1.3	0.0	44.3
1986-87	0.0	0.0	0.0	2.3	2.5	4.8	24.7	2.7	2.7	9.4	T	0.0	49.1
1987-88	0.0	0.0	T	0.1	13.2	8.9	3.3	10.1	9.4	4.4	1.2	0.0	50.6
1988-89	0.0	0.0	T	3.4	12.7	9.2	14.9	3.7	5.1	1.5	2.1	0.0	52.6
1989-90	0.0	0.0	T	0.4	12.3	12.4	14.9	20.3	13.5	3.4	0.2	0.0	77.4
1990-91	0.0	0.0	T	15.7	6.7	18.9	3.1	4.3	14.0	2.8	0.0	0.0	65.5
1991-92	0.0	0.0	0.0	T	9.0	9.4	7.2	8.6	8.7	0.5	T	T	43.4
1992-93	0.0	0.0	T	0.9	7.9	8.0	30.6	5.5	5.2	1.8	T	T	59.9
1993-94	0.0	0.0	0.1	2.0	5.1	28.4	11.0	3.2	7.7	5.6	0.2	0.1	63.4
1994-95	0.0	0.0	0.0	8.4	17.9	16.0	5.9	2.0	2.0	0.4	0.1	0.1	52.8
1995-96	0.0	0.0	0.0	2.1	2.4	1.5	2.9	7.3	1.7	5.7	1.9	0.3	25.8
1996-97	0.0	0.0	0.3	2.6	0.1	8.5	3.7	5.2	2.3	T	T	0.0	22.7
1997-98	0.0	0.0	0.0	0.6	10.4	13.1	17.3	1.9	4.4	2.2	0.6	0.0	50.5
Max	0.0	0.0	0.5	15.7	17.9	28.4	30.6	20.3	20.0	14.3	6.1	1.3	77.4
30-Year Mean	0.0	0.0	0.1	3.3	6.9	9.3	9.5	6.2	7.0	4.7	1.3	0.1	46.3
Min	0.0	0.0	0.0	0.1	0.1	1.5	2.1	0.2	1.1	0.4	0.0	0.0	19.8

^a Source - National Weather Service (1996; 1997; 1998a,b,c,d,e,f)

^b T = trace



Appendix G.9. Comparison of monthly snowfall to the 30-year mean at King Salmon, July 1995 to June 1998.



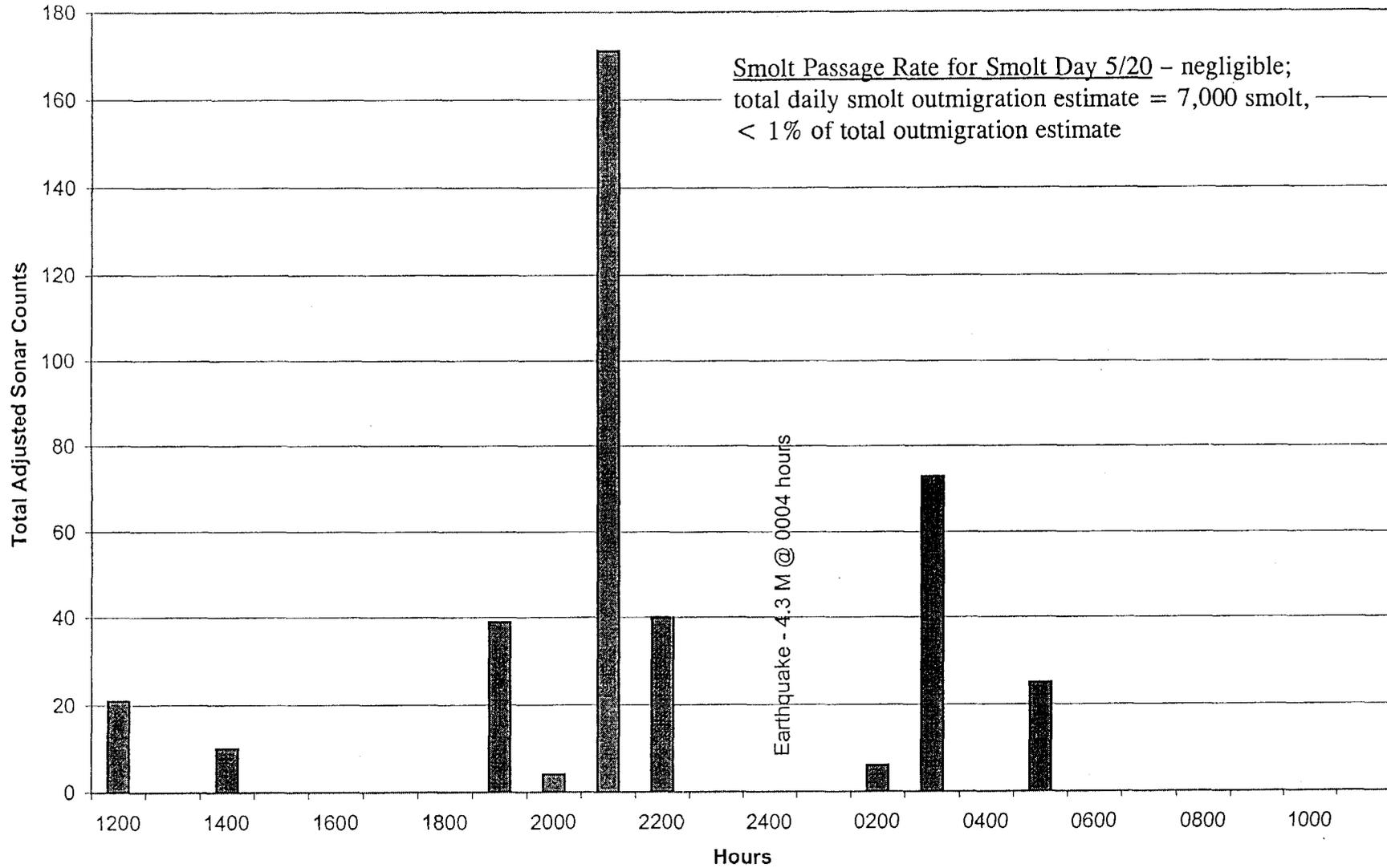
Appendix H.1. Earthquake activity under and around the SW end of Becharof Lake, May 8 to June 16, 1998 ^a.

Universal Coordinated Time ^b		Alaska Daylight Time ^c		Latitude	Longitude	Depth (km)	Magnitude (ml)
Date	Time (hhmm)	Date	Time (hhmm)				
5/09	0030	5/08	1630	57.89 N	156.82 W	0.0	5.2
	0037		1637	57.92 N	156.76 W	0.0	3.8
	0059		1659	57.90 N	156.41 W	0.0	5.1
	0146		1746	57.97 N	156.59 W	0.0	2.8
	0147		1747	57.89 N	156.82 W	0.0	4.3
	0354		1954	57.95 N	156.62 W	0.0	3.6
	0356		1956	57.98 N	156.96 W	0.0	5.3
	0450		2050	57.90 N	156.68 W	0.0	2.9
	0458		2058	57.99 N	156.93 W	0.0	4.9
	0659		2259	57.93 N	156.83 W	0.0	5.0
	1559	5/09	0759	57.87 N	156.77 W	0.0	4.5
5/10	0446		2046	57.95 N	156.76 W	0.0	3.0
	0948	5/10	0148	57.81 N	156.72 W	0.0	4.4
	1313		0513	57.97 N	156.63 W	0.0	2.5
	2105		1305	57.99 N	156.69 W	0.0	4.0
	2116		1316	57.97 N	156.71 W	0.0	4.0
	2307		1507	57.89 N	156.64 W	1.9	2.7
5/11	1931	5/11	1131	57.93 N	156.80 W	0.0	4.5
5/12	0005		1605	57.97 N	156.77 W	1.0	3.6
	0038		1638	58.04 N	156.45 W	0.0	3.3
	0114		1714	58.08 N	156.83 W	0.0	2.1
	0551		2151	57.92 N	156.92 W	25.0	4.2
	2132	5/12	1332	57.97 N	156.70 W	0.0	4.2
5/15	1611	5/15	0811	57.98 N	156.81 W	6.3	2.6
	2010		1210	57.90 N	156.69 W	0.1	2.2
5/16	0638		2238	57.99 N	156.69 W	0.0	2.6
	0856	5/16	0056	57.94 N	156.82 W	0.0	3.6
	0951		0151	57.90 N	156.68 W	0.0	3.1
	1044		0244	57.92 N	156.63 W	0.0	3.8
	1141		0341	57.92 N	156.64 W	0.0	3.9
	1918		1118	57.91 N	156.68 W	5.3	2.8
5/17	0051		1651	57.96 N	156.80 W	0.0	2.8
	1436	5/17	0636	58.01 N	156.70 W	0.0	3.5
	1642		0842	57.93 N	156.74 W	0.0	2.1
5/18	1857	5/18	1057	57.91 N	156.79 W	0.0	4.7
5/21	0804	5/21	0004	57.96 N	156.85 W	0.0	4.3
	2210		1410	57.93 N	156.68 W	2.9	2.3
5/22	1129	5/22	0329	57.97 N	156.81 W	0.0	4.0
	2240		1440	57.91 N	156.70 W	0.0	3.0
	2240		1440	57.99 N	156.75 W	0.0	3.0
5/23	0350		1950	58.03 N	156.76 W	0.5	3.0
5/24	0059	5/23	1659	57.98 N	156.68 W	2.5	2.0
5/26	1040	5/26	0240	57.96 N	156.81 W	9.9	2.8
	2338		1538	58.00 N	156.81 W	5.0	2.2
5/30	0724	5/29	2324	57.97 N	156.87 W	18.7	2.4
6/02	0603	6/01	2203	58.01 N	156.82 W	7.5	2.5
6/04	0109	6/03	1709	57.95 N	156.82 W	0.0	4.3
	0220		1820	57.93 N	156.81 W	0.0	3.1
	0424		2024	57.91 N	156.71 W	3.6	2.2
	1346	6/04	0546	57.97 N	156.78 W	0.5	3.9
6/16	0812	6/16	0012	57.69 N	155.83 W	1.0	3.4

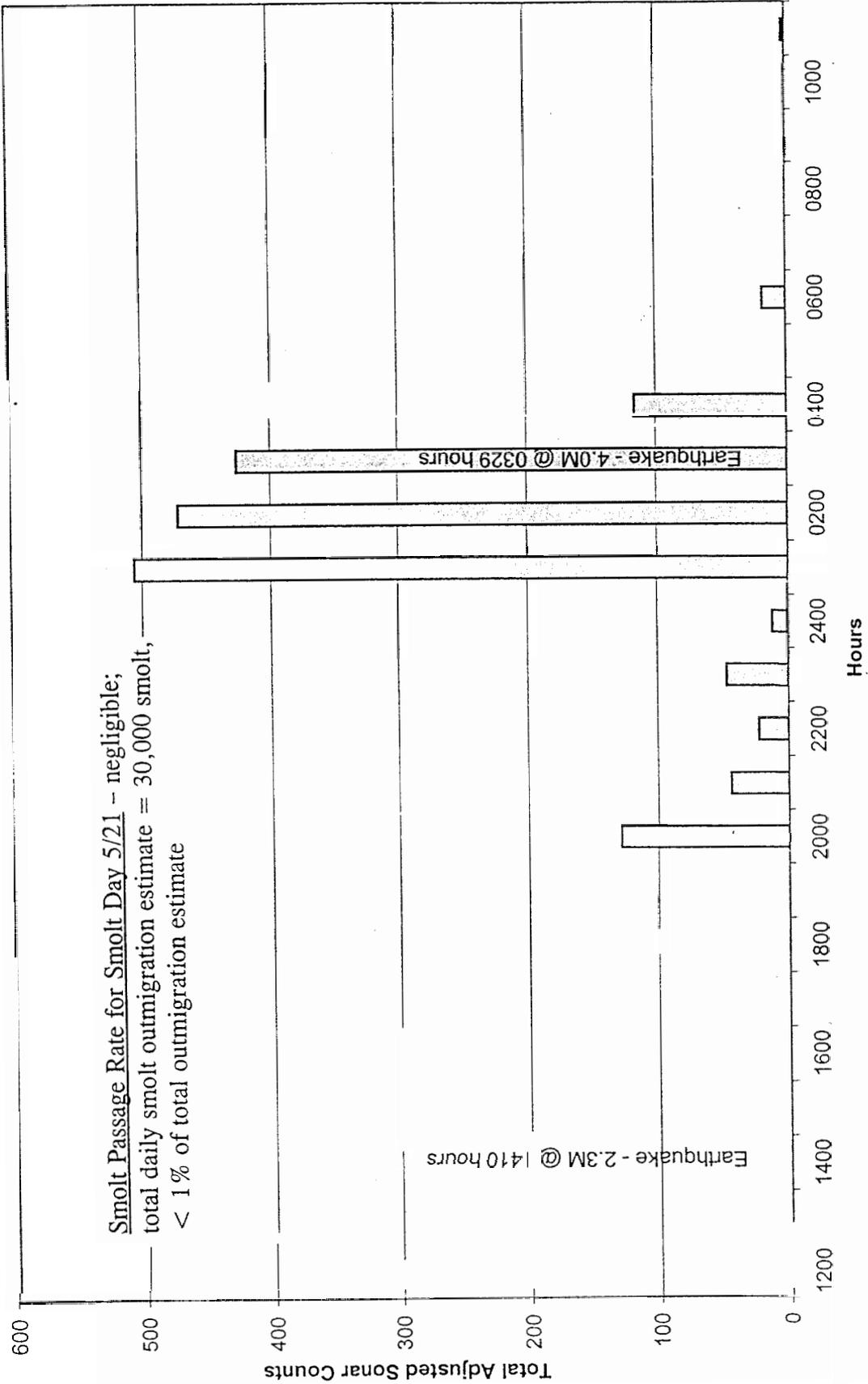
^a Source - AEIC (1998) and NEIC (1998)

^b Universal Coordinated Time (UTC), previously known as Greenwich Mean Time (GMT)

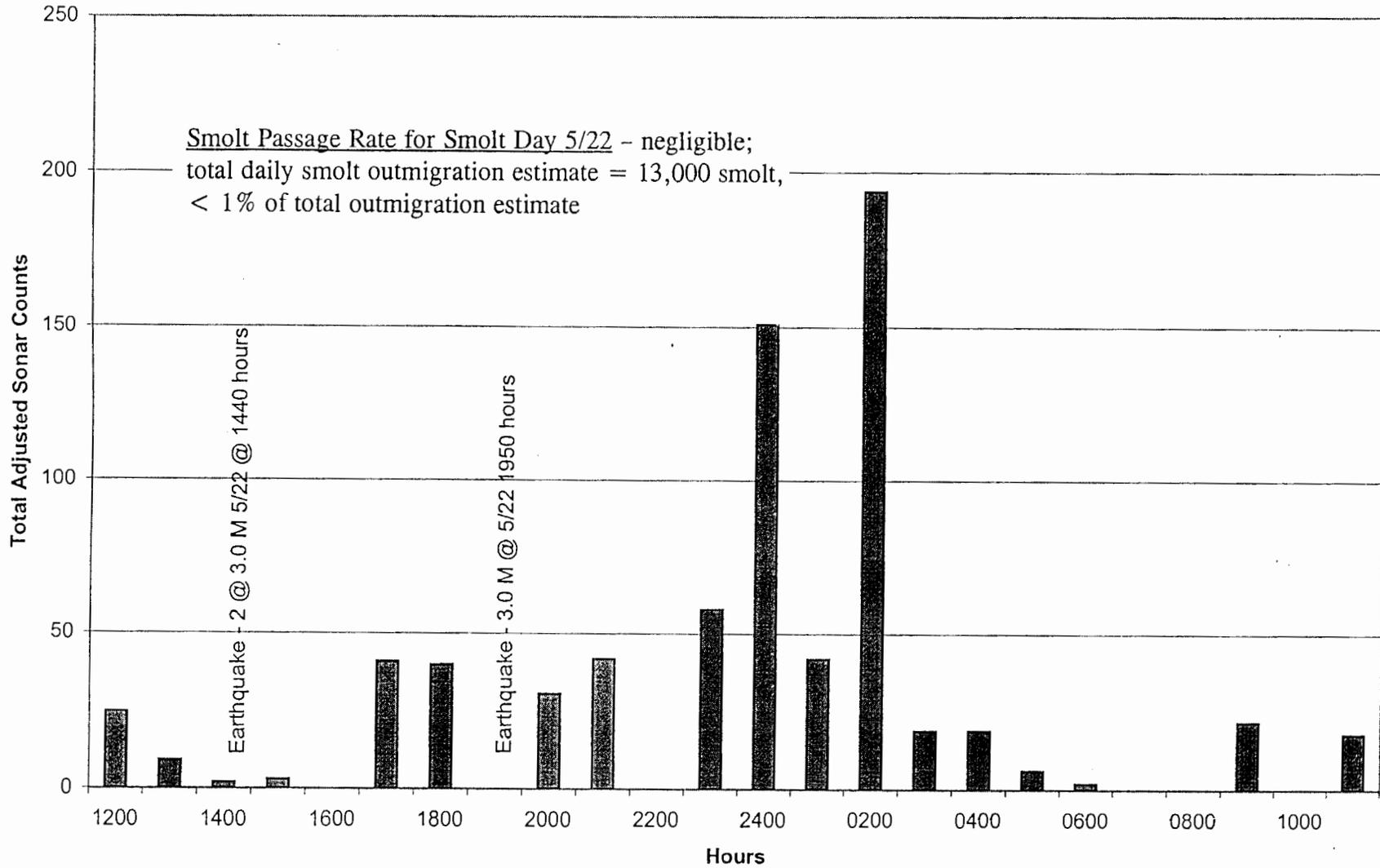
^c Alaska Daylight Time (ADT); ADT = UTC - 8 hours



Appendix H.2. Comparison of total adjusted sonar counts by hour at Egegik River smolt sonar with corresponding seismic data from the Alaska Earthquake Information Center (1998) for smolt day 5/20.

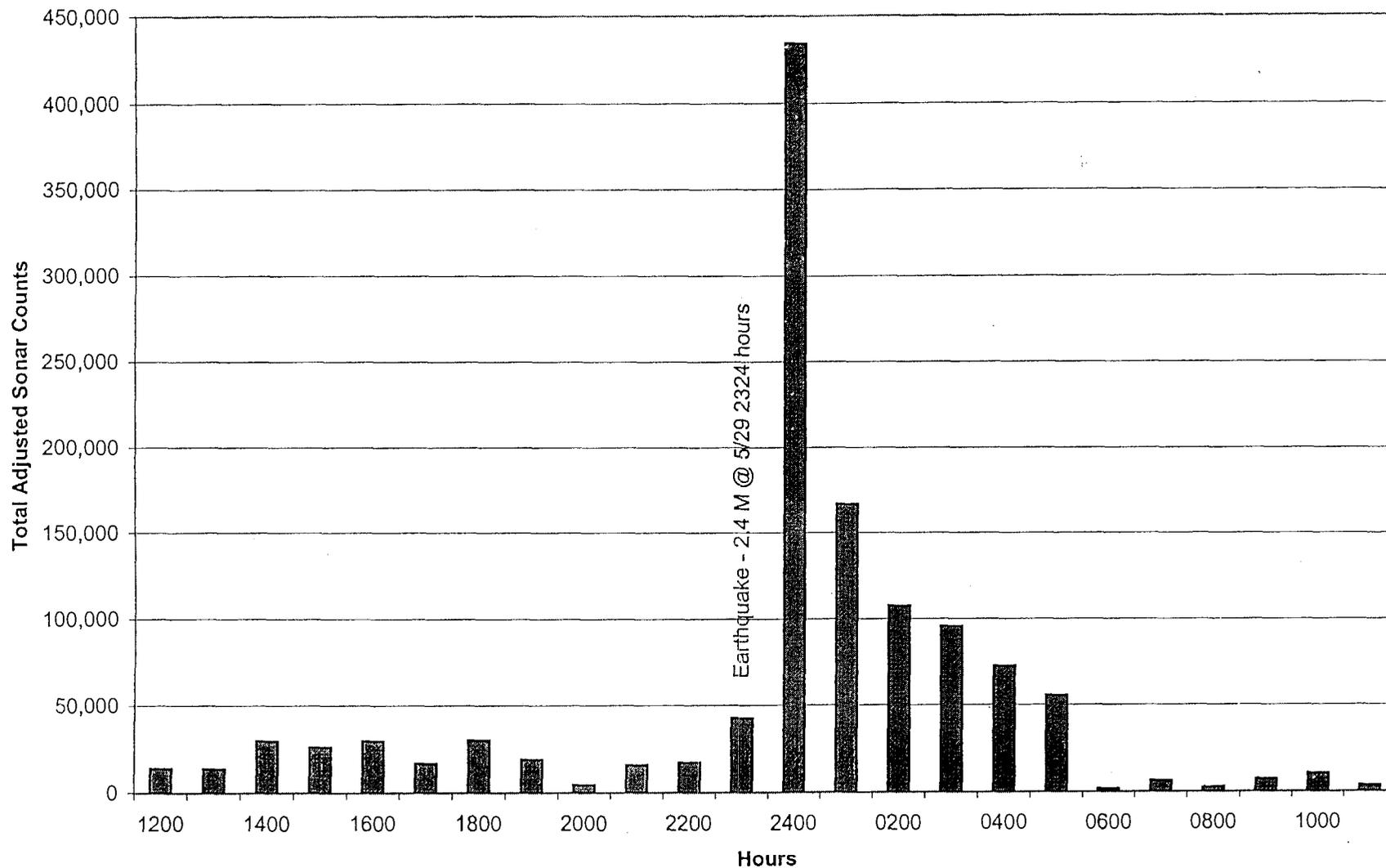


Appendix H.3. Comparison of total adjusted sonar counts by hour at Egegik River smolt sonar with corresponding seismic data from the Alaska Earthquake Information Center (1998) for smolt day 5/21.



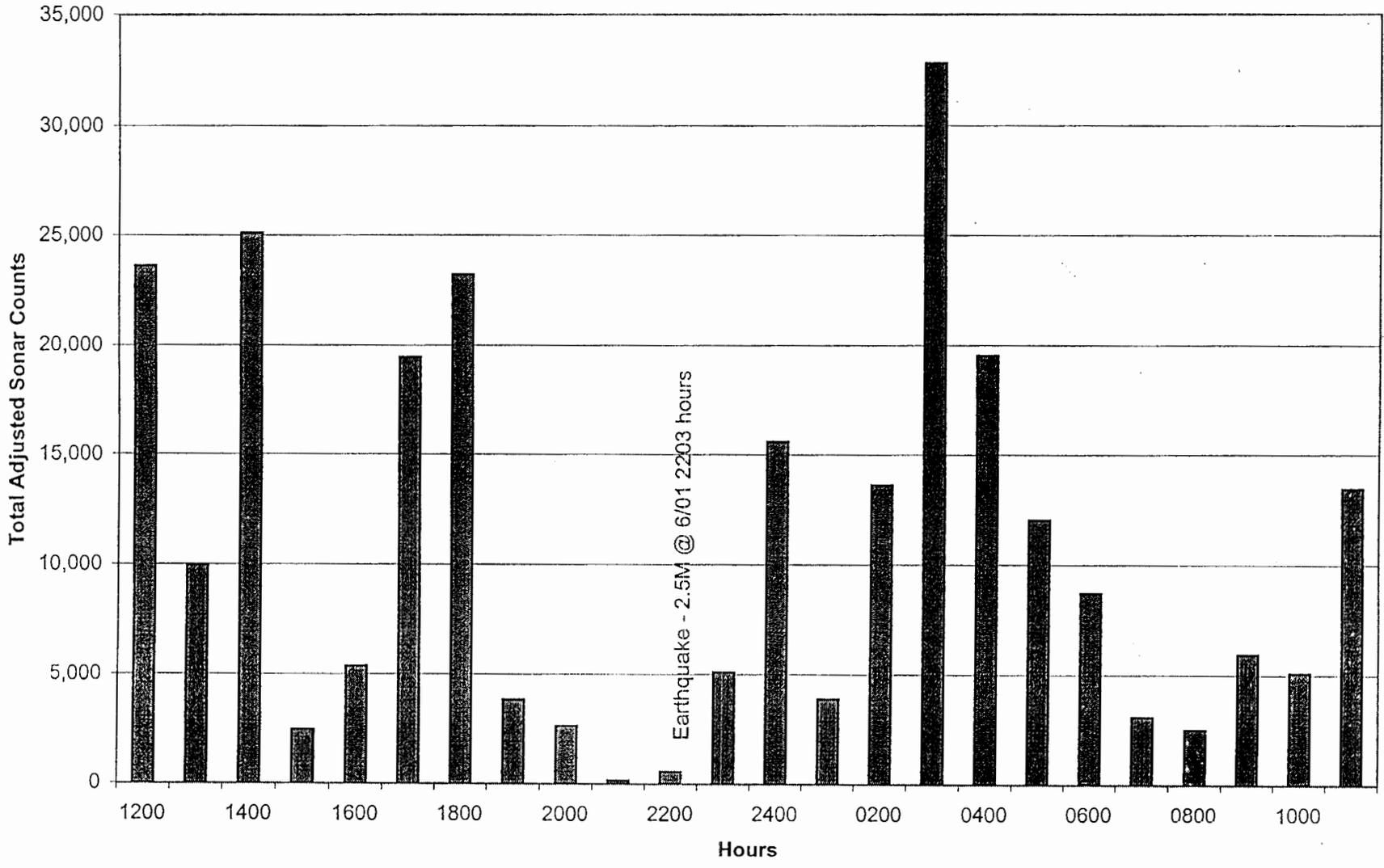
Appendix H.4. Comparison of total adjusted sonar counts by hour at Egegik River smolt sonar with corresponding seismic data from the Alaska Earthquake Information Center (1998) for smolt day 5/22.

Smolt Passage Rate for Smolt Day 5/29 - peak passage;
 total daily smolt outmigration estimate = 17,440,000 smolt,
 23% of total outmigration estimate



Appendix H.6. Comparison of total adjusted sonar counts by hour at Egegik River smolt sonar with corresponding seismic data from the Alaska Earthquake Information Center (1998) for smolt day 5/29.

Smolt Passage Rate for Smolt Day 6/01 – low passage;
total daily smolt outmigration estimate = 3,621,000 smolt,
5% of total outmigration estimate



Appendix H.7. Comparison of total adjusted sonar counts by hour at Egegik River smolt sonar with corresponding seismic data from the Alaska Earthquake Information Center (1998) for smolt day 6/01.

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