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BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES FOR 1999



by

Drew L. Crawford

Regional Information Report¹ No. 2A00-18

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

March 2000

¹Contribution 00-18 from the Anchorage regional office. The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate needs for up-to-date information, reports in this series may contain preliminary data.

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AUTHOR

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^a Kvichak River smolt sonar

^b Egegik River smolt sonar

^c Ugashik River smolt sonar

^d Lead Crewmember

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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 1999. 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 143,543,215 from Kvichak River, 8,592,482 from Egegik River, and 10,631,613 from Ugashik River. Age-1. smolt, the progeny of 1997 spawners, predominated at Kvichak River (92%) and Ugashik River (99%). Age-2. smolt, the progeny of 1996 spawners, predominated at Egegik River (89%).

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 1979 to 1998 the commercial catch in Bristol Bay averaged 25.5 million sockeye salmon (ADF&G 1999). 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 information is used to prepare preseason forecasts of adult returns and aids in setting goals for optimum numbers of spawners.

This report summarizes upward-looking smolt sonar studies conducted on the Kvichak, Egegik, and Ugashik Rivers in 1999. The purpose of these studies were 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.

Background

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 the total number of smolts. To improve estimates of smolt numbers, the department began experimenting with and using hydroacoustic (sonar) equipment in the 1970's.

Hydroacoustic equipment was used to estimate sockeye salmon smolt numbers on Kvichak River from 1971 through 1999; Wood River from 1975 to 1990; Naknek River from 1982 to 1986 and 1993 to 1994; Egegik River from 1982 through 1999; Ugashik River from 1983 to 1991 and 1993 to 1999; Nuyakuk River from 1983 to 1989; and Togiak River in 1988 (Russell 1972; Parker 1974a, 1974b; Krasnowski 1975; Randall 1976, 1977, 1978; Newcome 1978; Yuen 1980a, 1980b; Clark and Robertson 1980; Bucher 1980, 1981, 1982, 1983, 1984, 1986a, 1986b, 1987; Bergstrom and Yuen 1981; Yuen and Wise 1982; Eggers 1984; Eggers and Yuen 1984; Bue 1986a, 1986b; Bue and Fried 1987; Bue et al. 1988; Cross et al. 1990; Woolington et al. 1990, 1991; Crawford et al. 1992; Crawford and Cross 1992, 1994a, 1994b, 1995a, 1995b, 1996, 1997, 1998, 1999).

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 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).

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

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

The results of the 1990 study were encouraging, so in 1991 it was expanded to evaluate the feasibility of using side-looking sonar to enumerate outmigrating Kvichak River sockeye salmon smolt. Huttunen and Skvorc (1992) estimated, based on 81 h of horizontal-aspect echo-integration data collected June 2-14, that 44,972,864 smolt passed through the sonar site during the counting period. This compared well to an upward-looking sonar estimate of 43,525,980 smolt for the same hours of operation. The maximum single-beam listening range for the side-looking sonar varied from 118 m to 120 m, ensonifying 88%-90% of the total 134-m river cross section. In comparison, the three arrays of the upward-looking sonar ensonified 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

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

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.

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 last year ADF&G funded the entire Ugashik smolt project was 1991; in 1992 the smolt migration on Ugashik River was not monitored (Crawford and Cross 1992). The Ugashik River smolt study was resumed to measure the freshwater production, the size and age structure of smolt from recent sockeye salmon spawning escapements, and to continue using smolt data for preparing preseason forecasts of adult salmon returns. Various cooperative agreements between ADF&G and the City of Pilot Point and the Lake and Peninsula Borough funded the Ugashik smolt project from 1993-1999 (e.g., 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; the City of Pilot Point, Lake and Peninsula Borough, and ADF&G in 1997 and 1998; and the Lake and Peninsula Borough and ADF&G in 1999).

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).

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 1999; all projects used 1982 or 1983 model smolt counters. Transducers used to transmit and receive sound pulses at each sonar site were housed in 3.0-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, where two arrays were used 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 1999 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 is approximately 134 m wide at this site. Three transducer arrays referred to as *inshore*, *center*, and *offshore*, were anchored 49 m, 70 m, and 82 m from the right bank (Figure 2).

The Egegik River counting site was located 4 km below the outlet of Becharof Lake (Figure 1); it has been operated at this location since 1982 (Eggers and Yuen 1984). Egegik River is 112 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 1989-1999.

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 downstream of 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 (e.g., hourly at Egegik and every 7-10 days at Kvichak and Ugashik) and velocity correction factors (vcf_i) were then calculated:

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

where

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

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

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

Arrays were placed perpendicular to the river current; distances from each array to a reference point on one river bank were measured to the nearest foot (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 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. Since then 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 50' to 60' (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 1999 smolt occurred in 1997 for age-1. smolt, 1996 for age-2. smolt, and 1995 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 to 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}_{jtot}) was

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

Smolt Fin Clips for DNA Analysis

In 1999, the Kvichak River smolt crew collected sockeye salmon smolt fin clip samples for a DNA analysis that will be conducted by the ADF&G genetics laboratory in Anchorage. Genetics lab personnel will summarize results from these analyses in a separate report.

The sampling goal for this genetics study was to obtain at least one fin clip from each smolt that was sampled for age-weight-length (AWL) data. For sockeye salmon smolt that were in good condition and able to be released alive, one pelvic fin was collected with a sharp pair of dissecting scissors. For dead smolt, the entire caudal fin was collected plus some muscle tissue at the base. Between samples, the scissors were wiped off with a paper towel to prevent contamination of subsequent samples.

All smolt fin clip samples were collected, preserved, and shipped according to procedures outlined by the ADF&G genetics lab (Sue Merkouris, ADF&G Genetics, personal communication).

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. Arrays that received the highest counts were monitored most often.

Climatological Data Collection

Climatological data were recorded at each smolt sonar 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. Wind direction, wind velocity, and air temperature data were measured with a West Marine², Model 332356 weather monitor. Precipitation data was collected with a direct-read rain gauge graduated from 0.1 mm to 15.0 mm. Water temperatures were collected with a mercury pocket thermometer graduated in 1° increments from -10°C to +110°C.

RESULTS

Kvichak River

ADF&G's Kvichak smolt personnel arrived in Igiugig on the afternoon of May 17. Most of Lake Iliamna was still covered with 90-100 cm of white ice, there was about 350-375 m of open water at the lake outlet in front of Igiugig, and open water in the Kvichak River.

By May 21, the ice on Lake Iliamna had deteriorated to the point that it was no longer safe to land a plane or travel on the ice (Tim LaPort, Iliamna Air Taxi, personal communication). Open holes appeared in the ice around islands, at the mouth of the Newhalen River, and at the outlet by Igiugig. There was open water in the main channel of the Kvichak River from Igiugig to Kvichak Bay.

On the afternoon of May 28, the main body of Lake Iliamna was still frozen, the ice was dark and rotten, and there was open water in Knutson Bay and Pedro Bay on the NE shore. That evening, NE winds at 20+ mph began to break up the ice on Lake Iliamna and blow it towards the outlet. By 0830 hours on May 29 the wind had shifted to SE 30, the lake ice jammed at the outlet by Igiugig, and the water level in the Kvichak River dropped about 0.6 m. Later that morning the ice jam broke and bank-to-bank ice flowed down the Kvichak River all day. That evening the wind shifted to E 25 and by morning on May 30 the lake ice was jammed at the outlet again. On May 31, westerly winds blew the remaining ice back toward the center of the lake, an estimated 8 km from the outlet. The remaining ice in Lake Iliamna subsequently melted in place and/or was broken up by wind and wave action.

The average reported break-up date for Lake Iliamna between 1971 and 1998 was May 13 (Appendix B.1). The lake ice break-up in 1999 was 15 d later than average.

Although the threat posed by the massive quantities of ice in the still frozen Lake Iliamna prevented us from deploying our sonar equipment prior to June 1, open water in Kvichak River allowed us to set and fish our fyke net to gauge the relative presence or absence of smolt. From smolt day 5/20

to 5/27 the fyke net was fished for one hour or more each night between 2400 hours and 0230 hours (Appendix C.1). Only 5 sockeye salmon smolt were caught during this period, all were age-1. . The first fyke net catch greater than 100 sockeye salmon smolt occurred on smolt day 5/31. See Appendices C.2 to C.4 for a complete summary of the 1999 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: three-spine stickleback *Gasterosteus aculeatus*, nine-spine stickleback *Pungitius pungitius*, pink salmon fry *Oncorhynchus gorbuscha*, sculpin *Cottus sp.*, and whitefish (*sp.*).

The smolt counter was activated at 2400 hours on June 1. The smolt passage rate during the first 36 h of sonar operation was very low. Hourly passage rates ranged from 0 to 34 thousand smolt per hour.

River velocity measurements over the center index array, which were used to adjust the sonar counter firing rate, ranged from 1.1 to 1.4 m/s (3.6 to 4.6 ft/sec). The average river velocity in 1999 of 1.3 m/s (4.1 ft/sec) was slightly less than the recent 10-year average at the Kvichak River sonar site (Appendices D.1 and D.2). Velocity correction factors (m/s) used for the three arrays were as follows:

| Smolt Days | Inshore | Center | Offshore |
|-------------------|---------|--------|----------|
| Jun 01 - Jun 02 | 0.99 | 1.00 | 0.80 |
| Jun 03 - June 10 | 0.90 | 1.00 | 0.97 |
| June 11 - June 15 | 0.93 | 1.00 | 0.97 |
| June 16 | 0.90 | 1.00 | 1.01 |

A total of 3,406,524 sonar counts were recorded at the Kvichak River counting site from June 1 to June 16, 1999 (Table 1). This year the sonar counts were slightly higher over the center (36%) and offshore (35%) sonar arrays than the inshore sonar array (29%). Daily sonar counts were highest from June 4 to June 8 when 53% of the total counts were recorded. The peak daily sonar count of 444,670 occurred on June 4. Over the course of the entire sampling season, 56% of the total sonar counts were obtained between 2000 hours and 0600 hours (Table 2); the peak hourly passage rate of 86,321 sonar counts per hour occurred at 0400 hours on June 9.

Based on sonar an estimated 143,543,215 sockeye salmon smolt migrated from Kvichak River in 1999 (Table 3). Age-1. smolt (1997 brood year) comprised 92% of the total smolt estimate and they were the predominant age class from June 1 to June 16. Age-2. smolt (1996 brood year) were most numerous from June 1 to June 3 but they never comprised more than 28% of the total smolt estimate. The highest daily smolt counts occurred on June 4 and June 8. The smolt per count estimates based on mean smolt weights ranged from 5.4 to 7.6 with an average of 6.4 smolt per count (Table 4).

Age, weight, and length data were collected from 1,117 sockeye salmon smolt in 1999 (Table 5). All smolt sampled were age 1. or 2. Mean length was 86 mm for age-1. smolt and 108 mm for age-2. smolt. Mean weight was 5.8 g for age-1. smolt and 10.3 g for age-2. smolt. An additional 6,215 smolt were measured for length only (Table 6). The discriminating length calculated to differentiate age-1. from age-2. smolt was 96.74 mm.

Fin clip samples were collected from 1,111 sockeye salmon smolt at the Kvichak River smolt sonar site in 1999 for DNA analysis that will be performed and reported by the ADF&G genetics laboratory in Anchorage.

Eighty-five depth measurements were recorded for smolt schools passing over Kvichak River sonar arrays between June 2 and June 15 (Table 7). Schools passed at an average depth range of 42 cm to 106 cm below the surface. Average water depth over the sonar arrays ranged from 277 cm to 286 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 23 to June 17 (Table 8). The 1999 deployment of Kvichak River smolt sonar gear was delayed due to the late breakup of the ice on Lake Iliamna. Since the smolt counter was activated after most of the lake ice had passed the sonar site, there was only 1.4 h of disabled time from lake-ice floes in the river. After the smolt sonar was activated, the weather was excellent for counting smolt. The smolt counter was disabled for 8.3 h (2%) of the 372 h it operated in 1999 due to weather (Figure 6). Rain squalls, strong NE winds, and wave action were the primary causes. The only smolt day with 3 or more hours of disabled time due to weather was 6/10 (3 h). Mean water temperature during the project was 2.9°C (range 0.0°C to 8.0°C). Mean daily water temperatures during the peak of the smolt migration ranged from 2.0°C to 4.5°C.

In 1999, the Kvichak River smolt sonar was also disabled for an additional 28.0 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 2.6 h/d. Most boat traffic occurred from 0900 to 1800 hours with peak passages at 1100, 1700, and 1800 hours.

Egegik River

Becharof Lake was still completely ice covered when the first Egegik River smolt crewmembers flew to the study site on the evening of May 17. The ice near the outlet of the lake appeared dark and rotten. The main channel of Egegik River was open from the outlet of the lake as far as the eye could see. Some shelf ice remained along the left bank from the outlet to the upper end of the lagoon. There was some ice in the river; it was very rotten and it crumbled upon contact.

On May 25, PenAir pilots reported seeing a few holes in the ice on Becharof Lake, but most of the lake remained ice covered. A pilot reported on May 28 that the ice had broken up on Becharof Lake, there was still lots of ice in the lake, and some open water was visible in the southwest corner. Subsequent strong winds from the northeast and then the southwest pushed much of the remaining ice toward the outlet of the lake. From that day on through the end of the project, every time the wind picked up, more ice was dumped from the lake into the river causing problems for smolt sampling and smolt counting operations downstream.

May 28 is the latest break-up date that we have ever recorded for Becharof Lake. The average break-up date for Becharof Lake from 1976 to 1998 was April 20 (Appendix B.2). The lake ice break-up in 1999 was 38 d later than average.

A fyke net installed and fished nightly from May 19-26 caught only two sockeye salmon smolt (Appendix C.5). There were no observations of smolt or birds feeding on smolt prior to the first smolt catch (n=1) in the fyke at 0157 hours on May 26. From May 27 to June 08, fyke netting was severely restricted due to persistent floes of ice in the river at night. During this time the fyke net was fished successfully on June 4, June 5, and June 8 but few sockeye salmon smolt (n<250 fish/d) were caught. For a complete summary of the 1999 Egegik River fyke net catch by date, species, hour, and time fished see Appendices C.5 to C.8. In addition to sockeye salmon smolt, the following other species were also captured in the fyke net: sculpin (sp), stickleback (sp), juvenile chinook salmon *Oncorhynchus tshawytscha*, juvenile coho salmon *Oncorhynchus kisutch*, and chum salmon fry *Oncorhynchus keta*.

The Egegik River smolt sonar counter was activated at 1200 hours on May 21. Sonar counts and fyke net catch data indicate that smolt passage during the first two weeks of sonar operations was negligible; the first daily sonar count greater than 100,000 occurred on June 8 concurrent with heavy ice floes (Table 9).

River velocities at the counting site ranged from 0.4 to 0.7 m/s (1.4 to 2.3 ft/sec). The river velocities at the center array were equal to the 1984-1998 average of 2.1 ft/sec (Appendices D.3 and D.4). In 1999, the smolt counter was calibrated according to the water velocities at an index buoy set downstream from the center array. Velocity correction factors (m/s) used for three arrays were:

| Smolt Days | Index Buoy | Inshore | Center | Offshore |
|-----------------|------------|---------|--------|----------|
| May 24 - May 30 | 1.00 | 0.75 | 0.97 | 1.07 |
| May 31 - Jun 06 | 1.00 | 0.83 | 1.04 | 1.08 |
| Jun 07 - Jun 13 | 1.00 | 0.82 | 1.04 | 1.05 |

A total of 763,829 sonar counts were recorded at the Egegik River counting site from May 21 to June 13, 1999 (Table 9). Sonar counts were most numerous over the offshore array (52%) followed by the center (38%) and inshore (10%) arrays. Daily sonar counts were highest on June 8 and June 9. Eighty-five percent of the total sonar count was recorded during this two-day period. The peak daily sonar count of 334,812 occurred on June 9. Over the course of the season, the largest hourly sonar counts were recorded from 2300 hours to 0500 hours (Table 10); 87% of all smolt counts were obtained during these times.

An estimated 8,592,482 sockeye salmon smolt migrated from Egegik River in 1999 based on sonar counts (Table 11). Age-2. smolt (1996 brood year) comprised 89% of the total smolt estimate from May 21 to June 13. Age-1. smolt (1997 brood year) and age-3. smolt (1995 brood year) composed 9% and 2% of the total smolt estimate, respectively. A mean weight of 16.4 g per smolt (Table 12) resulted in an average 2.5 smolt per count adjustment factor to expand sonar counts.

Age, weight, and length data were collected from 221 sockeye salmon smolt in 1999 (Table 13). Age-1., -2., and -3. smolt were sampled. Mean length was 107 mm for age-1. smolt, 127 mm for age-2. smolt, and 140 mm for age-3. smolt. Mean weight was 9.9 g for age-1. smolt, 16.5 g for age-2. smolt, and 19.2 g for age-3. smolt. An additional 205 smolt were measured for length only (Table 14). Age-1. smolt were separated from age-2. smolt using a discriminating length of 124.55 mm.

Thirty-seven depth measurements were recorded for smolt schools passing over Egegik River sonar arrays during peak smolt passages from June 4-13 (Table 15). Most schools passed from 78 cm to 163 cm below the surface. Average water depth over the sonar arrays at this site ranged from 296 cm to 378 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 21 to June 14 (Table 16). The primary factor that hindered smolt counting and smolt sampling in 1999 was the persistent floe of ice in the Egegik River from Becharof Lake. The smolt counter was disabled due to ice for only 74.4 hours, however, counts from 235.0 hours (41%) of the 576 hours it operated were adjusted or deleted due to false counts from ice (Figure 9). Smolt days with 6 or more hours of counts that were effected by ice were: 5/27 (10 h), 5/28 (14 h), 5/29 (11 h), 5/31 (15 h), 6/01 (17 h), 6/07 (22 h), 6/08 (16 h), 6/09 (15 h), 6/10 (24 h), 6/11 (24 h), 6/12 (24 h), and 6/13 (24 h). By comparison, other weather conditions did not present much of a problem for smolt counting at the Egegik River site in 1999. The smolt counter was disabled due to weather for only 21.8 hours (Figure 10). Snow, rain squalls, and wave actions from strong NE winds were the primary causes. The only smolt day with 6 or more hours of disabled time due to weather was 6/06 (14 h). Mean water temperature during the season was 2.2°C (range 0.0°C to 8.0°C). Mean daily water temperature during the peak of the smolt count on June 9 was 1.8°C.

In 1999, the Egegik River smolt sonar was disabled for 1.5 h due to boat traffic associated with measuring water velocities or adjusting equipment.

Ugashik River

Upper and Lower Ugashik Lakes were still ice covered when the first two Ugashik smolt crewmembers arrived at the study site mid-morning on May 17. There were pressure ridges on the lakes and the ice was soft, dark, and wet. The Ugashik River was open below the outlet of Lower Ugashik Lake. The crew saw a few swans and scoters near the outlet of the lake but there were no observations of smolt or gulls and terns actively feeding on smolt.

On the afternoon of May 18, with a southwest wind blowing 10-15 mph, pieces of the lake ice started breaking off at the outlet and flowing down the river. At this time, the bulk of the ice in the lake remained intact. By 0800 hours on May 19 the wind had shifted to the east at 10 mph and the lake ice started to break-up. For the next 5 days there were alternating periods of heavy ice followed by periods of little or no ice in the river. The last reported observation of ice in the river occurred at 0700 hours on May 23.

May 19 is the latest break-up date that we have recorded for Upper and Lower Ugashik Lakes. This was 26 d later than April 21, the 1977-1998 average reported break-up date of for these lakes (Appendix B.3).

A fyke net fished from 0035 hours to 0105 hours on May 20 (smolt day 5/19) caught no smolt (Appendix C.9). The first sockeye salmon smolt (n=19) were caught in the fyke net fished from 2354 hours to 0110 hours on May 23. Complete summaries of the 1999 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: sculpin (sp), pink salmon fry, sticklebacks (sp), and smelt (sp).

The Ugashik River smolt sonar counter was activated at 1300 hours on May 26. Fyke net catch data and sonar counts indicated little or no smolt passage at the smolt sonar site prior to May 29. The first daily sonar counts greater than 100,000 occurred on June 9.

River velocity measurements over the inshore index array ranged from 1.7 to 2.3 m/s (5.6 to 7.6 ft/sec). The average velocity in 1999 was 8% greater than the 1983-1998 average of 1.9 m/sec (6.2 ft/sec) (Appendix D.5 and D.6). 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 24 - May 30 | 1.00 | 0.91 |
| May 31 - Jun 06 | 1.00 | 0.97 |
| Jun 07 - Jun 10 | 1.00 | 1.01 |
| Jun 11 - Jun 12 | 1.00 | 0.93 |

A total of 985,388 sonar counts were recorded at the Ugashik River sonar counting site from May 26 to June 12, 1999 (Table 17). Most counts (88%) were recorded over the offshore array. Daily sonar counts were highest from June 9-11. Sixty-four percent of the total counts were recorded on these days. The peak daily sonar count of 373,797 occurred on June 10. Over the entire sampling season, 86% of all smolt counts were recorded between 1800 hours and 0200 hours with peak passages occurring between 2400 hours and 0200 hours (Table 18).

Based on sonar counts an estimated 10,631,613 sockeye salmon smolt migrated from Ugashik River in 1999 (Table 19). Age-1. smolt (1997 brood year) comprised 99% of the total smolt estimate and they were the predominant age class throughout the sampling period. Age-2. smolt (1996 brood year) composed 1% of the total migration and they were most numerous from June 1-5. Mean weights of smolt ranged from 6.0 to 7.3 g per smolt (Table 20), resulting in an average 6.1 smolt per count adjustment factor for expansion of sonar counts.

Age, weight, and length data were collected from 385 sockeye salmon smolt in 1999 (Table 21). Mean length was 91 mm for age-1. smolt and 125 mm for age-2. smolt. Mean weight was 6.8 g for age-1. smolt and 17.5 g for age-2. smolt. An additional 2,266 sockeye salmon smolt were sampled for length only (Table 22). A discriminating length of 108.5 mm was calculated to differentiate age-1. smolt from age-2. smolt at Ugashik River.

Fifteen depth measurements were recorded for smolt schools passing over Ugashik River sonar arrays between May 26 and June 12 (Table 23). Schools passed at an average depth of 7 cm to 66 cm below the surface. Average water depth over the sonar arrays at this site ranged from 270 cm to 303 cm during the peak smolt passage. The depth of smolt passage by hour for each array is shown in Figure 11.

River and weather conditions were recorded at the counting site from May 18 to June 13 (Table 24). Ice floes in the Ugashik River and/or the threat posed to sonar gear by ice from Lower Ugashik Lake prevented the deployment of the Ugashik River smolt sonar equipment prior to May 26. Other weather conditions were good for enumerating sockeye salmon smolt emigrating from Upper and Lower Ugashik Lakes in 1999. The smolt counter was disabled for 62.3 h (14%) of the 431 h it operated in 1999 due to weather (Figure 12). Snow, rain squalls, wave action, and entrained air in the water column from strong E and ENE winds were the primary causes. Smolt days with 6 or more hours of disabled time due to weather were: 5/28 (11 h), 5/29(10 h), 6/06 (15 h), and 6/09 (18 h). Average water temperature was 2.6°C (range 1.0°C to 6.0°C). The mean water temperature during the peak of the smolt outmigration, on June 10, was 5.0°C.

During 1999, Ugashik River smolt sonar counters were also disabled for 4.0 h due to boat-or-floatplane traffic (Figure 13).

DISCUSSION

Kvichak River

The 1999 smolt outmigration estimate of 143,543,215 smolt is the eighth largest smolt outmigration estimate recorded at the Kvichak River sonar site (Appendices E.1 and E.2). This is 17% less than the 1983-1998 average of 173,937,412 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 1999 with the 1989-1998 mean it appears that the timing of the peak count was 8 d later (Figure 14). A comparison of the 1999 cumulative percent of the total adjusted sonar count by smolt day with the 1989-1998 mean shows that the timing for the front end (25%) of the smolt outmigration was 12 d later, the mid-point (50%) of the smolt outmigration was 11 d later, and the later portion (75%) of the smolt outmigration was 9 d later (Figure 15).

Historically, the proportion of age-2. smolt has been highest early in the season. This was also true in 1999, with age-2. smolt 10-28% of the fyke net catch during the first week of June. Thereafter, age-2. smolt generally comprised less than 10% of the fyke net catch.

The sequence of break-up events in 1999 allowed the crew to travel freely on the Kvichak River by boat and fish their fyke net prior to the break-up of the ice on Lake Iliamna. Nightly fyke net sets from May 21-27 produced no smolt catches. The first fyke net catch greater than 500 smolt occurred on May 31. There did not appear to be any smolt passage prior to this time.

The graph of the percent of the total adjusted sonar count by hour for 1999 was similar to the graph of the 1989-1998 mean count per hour (Figure 16). However, this year the 2400 hours counts were lower than average and the peak hourly counts, which normally occurred from 0100 hours to 0300 hours, were shifted to the 0400 hours to 0600 hours time slot.

Age-1. smolt in 1999 were 2% shorter and 1% lighter than the 1955-1998 mean (Table 25). Age-2. smolt were 1% longer and 1% lighter than the 1955-1998 mean.

The mean water temperature in 1999 was 3°C colder (NSC) than the 1963-1998 mean of 5.9°C (Table 26). The mean daily water temperature when the Kvichak River sonar project began this year was 4.0°C colder than the recent 15-year average of 4.5°C (Appendix F.1). On June 4, the peak of the 1999 smolt passage, the mean daily water temperature was 3.8°C colder than the 1984-1998 mean. For other climatological factors that may have affected the freshwater survival of smolt that outmigrated in 1999 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 1995. A comparison of total smolt outmigration estimates by age with the 1995 brood year escapement of 10,038,720 sockeye salmon showed a freshwater survival rate of approximately 37.1 smolt per spawner (Table 27). Since we expect no catch of age-3. smolt at Kvichak River in 2000, the freshwater survival rate for the 1996 brood year escapement of 1,450,578 sockeye salmon should remain at 141.0 smolt per spawner. Smolt-per-spawner estimates for 1995 and 1996 were both greater than the recent ten-year average for Kvichak River; mean production from brood years 1985-1994 was 27.8 smolt per spawner. The smolt per spawner estimate for 1996 is the highest we have on record for any eastside Bristol Bay river and it is almost twice as high as any smolt per spawner estimate that we have calculated for Kvichak River before.

Nineteen ninety-two (1992) 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 1983-1992 (Table 28) shows an average marine survival (i.e. adult salmon returns per smolt) of 0.14 for age-1. smolt and 0.15 for age-2. smolt. For brood year 1993, the last adult sockeye salmon (e.g., ages 2.4 and 3.3) will return to the Kvichak River in 2000 as 7-year-old fish. Since 7-year-old fish historically compose < 1% of the total sockeye salmon return to the Kvichak River, the average marine survival for brood year 1993 age-1. (0.01) and age-2. smolt (0.01) are both well below the 1983-1992 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 17). 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 1986, 1987, 1989, and 1992 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.

Egegik River

The 1999 Egegik River smolt outmigration estimate was 653% smaller than the 1983-1998 average of 56,118,072 smolt (Appendices E.3 and E.4). Three of the last five years have had smolt outmigration estimates below the 1983-1998 average; 1996, 1997, and 1999 smolt estimates were all well below average. In the last five years, age-2. smolt have been the predominant age class outmigrating from the Egegik River in 1995, 1997, and 1999.

The 1999 smolt outmigration estimate for Egegik River should be considered a minimum estimate due to the late break-up of Becharof Lake, persistent ice problems, and colder than normal water temperatures. After the smolt sonar counter was shut down at 1159 hours on June 14, ice continued to flow past the Egegik River smolt sonar site through June 19 and the last few pieces of ice flowed by on June 20. No ice was observed in the river after June 20.

Visual observations of smolt passage in the Egegik River after the smolt sonar counter was shut down in 1999 suggest that the smolt outmigration timing was later than usual and that the smolt continued to outmigrate from Becharof Lake after the smolt crew left (Table 30).

Comparing the percent of the total adjusted sonar count by smolt day for 1999 with the 1989-1998 mean, the timing of the peak count appeared to be 14 d later than average (Figure 18). A comparison of the cumulative percent of the total adjusted sonar count by smolt day for 1999 with the 1989-1998 mean shows that the timing for the front end (25%) of the smolt outmigration was 14 d late, the mid-point (50%) of the smolt outmigration was 13 d late, and the later portion (75%) of the smolt outmigration was 10 d later than average (Figure 19).

The graph of the percent of the total adjusted sonar count by hour for 1999 was similar to the 1989-1998 mean (Figure 20).

Age-1. smolt in 1999 were 4% longer and 3% heavier than the 1939-1998 mean (Table 31). Age-2. smolt were also 9% longer than the historical mean and weighed 16% more; age-3. smolt were 6% longer and weighed 4% less.

The mean water temperature in 1999 was 4.2 °C colder than the 1981-1998 average of 6.4 °C (Table 32). The mean daily water temperature when the Egegik River sonar was activated was 2.3°C colder than the 1984-1998 average (Appendix F.2). During the peak smolt passage on June 9, the mean daily water temperature was 5.1°C colder than the 1984-1998 average of 5.6°C. The colder water temperature this year may have contributed to the later timing of the 1999 smolt outmigration. Other climatological factors that may have affected the freshwater survival of 1999 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 1995. A comparison of total smolt outmigration estimates by age with the 1995 brood year escapement of 1,265,862 sockeye salmon showed a freshwater survival rate of approximately 31.5 smolt per spawner (Table 33). Since we expect age-3. smolt to comprise < 3% of the total smolt outmigration at Egegik River in 2000, the freshwater survival rate for the 1996 brood year escapement of 1,076,460 sockeye salmon should remain at 53.7 smolt per spawner. The smolt-per-spawner estimate for 1995 was below and 1996 was above the recent ten-year average for Egegik River; mean production from brood years 1985-1994 was 36.6 smolt per spawner.

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 was 1992. A comparison of smolt outmigration estimates by age with corresponding adult returns for brood years 1983-1992 (Table 34) shows an average marine survival (i.e. adult salmon returns per smolt) of 0.20 for age-1. smolt and 0.31 for age-2. smolt. For brood year 1993, the last adult sockeye salmon (e.g., ages 2.4 and 3.3) will return to the Egegik River in 2000 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 1993 age-1. (0.15) and age-2. (0.24) smolt will be below the 1983-1992 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 1984, 1985, 1988, 1989, 1990 and 1991 (Figure 21, Table 35). 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. Three brood years, 1988, 1991, and 1992, 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 1999 smolt outmigration of 10,631,631 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 six years have been smaller than the 1983-1998 average of 62,648,636 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 1999 with the 1989-1998 mean, it appears that the timing of the peak counts was 6 d to 16 d late (Figure 22). A comparison of the cumulative percent of the total adjusted sonar count by smolt day with the 1989-1998 mean shows that the timing for the front end (25%) of the smolt outmigration was 11 d late, the mid-point (50%) of the smolt outmigration was 11 d late, and the later portion (75%) of the smolt outmigration was 6 d later than average (Figure 23). Judging from the low fyke net catches prior to May 29 (Appendix C.12), we probably counted most of the smolt on the front end of the outmigration. The steep slope of the cumulative curve on the last several days of the project indicates we probably missed some smolt on the back end of the outmigration. However, even if we add an additional 25-50% to the back end of the outmigration, this years smolt outmigration estimate is still well below the historical average. With the exception of an increase in counts at 1800 hours, the graph of the percent of the total adjusted sonar count by hour for 1999 was similar to the graph of the 1989-1998 mean count per hour (Figure 24). The increased counts at 1800 hours this year resulted from multiple large schools of smolt passing the smolt site during this hour on smolt day 6/10.

The dominant age groups of adult sockeye salmon from the 1999 smolt outmigration will return in 2001 (ages 1.2 and 2.2 fish) and 2002 (ages 1.3 and 2.3 fish).

Age-1. smolt in 1999 were the same length as the 1958-1998 mean, but weighed 2% less (Table 36). Age-2. smolt were 12% longer and weighed 45% more than the 1958-1998 mean.

The mean water temperature in 1999 was 3.5 °C colder than the 1983-1998 mean of 6.1 °C (Table 37). The average daily water temperature when the sonar was activated this year was 1.5 °C which is 2.7 °C colder than the 1984-1998 average (Appendix F.3). At the peak of the 1999 smolt passage on June 10 the mean daily water temperature was 5.0 °C, 1.0°C less than the 1984-1998 average. See Appendix G for other climatological factors that may have affected the freshwater survival of smolt that outmigrated in 1999.

In the Ugashik River drainage, 1995 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 1995 brood year escapement of 1,304,058 sockeye salmon showed a freshwater survival rate of approximately 12.7 smolt per spawner (Table 38). Since we expect no catch of age-3. smolt at Ugashik River in 2000, the freshwater survival rate for the 1996 brood year escapement of 667,518 sockeye salmon should remain at 15.6 smolt per spawner. Smolt-per-spawner estimates for 1995 and 1996 were both well below the recent ten-

year average for Ugashik River; mean production from brood years 1985-1994 was 75.2 smolt per spawner.

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 was 1992. A comparison of smolt outmigration estimates by age with corresponding adult returns for brood years 1983-1992 (Table 39) 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 1993, the last adult sockeye salmon (e.g., ages 2.4 and 3.3) will return to the Ugashik River in 2000 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 1993 (0.09) will be slightly above the 1983-1992 average for Ugashik River and the average marine survival of age-2. smolt (0.31) is well above the 1983-1992 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 25, Table 40). 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 1984, 1986, 1987, and 1992 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, 1999.

| Smolt Day ^a | Transducer Array | | | Total |
|------------------------|------------------|------------------|------------------|------------------|
| | Inshore | Center | Offshore | |
| 5/20 ^b | | | | |
| 5/21 | | | | |
| 5/22 | | | | |
| 5/23 ^c | | | | |
| 5/24 | | | | |
| 5/25 | | | | |
| 5/26 | | | | |
| 5/27 | | | | |
| 5/28 ^d | | | | |
| 5/29 ^d | | | | |
| 5/30 ^d | | | | |
| 5/31 ^{d,e} | | | | |
| 6/01 ^{d,f} | 1,326 | 2,182 | 1,394 | 4,902 |
| 6/02 | 5,227 | 7,453 | 10,966 | 23,646 |
| 6/03 | 39,912 | 30,515 | 19,431 | 89,858 |
| 6/04 ^g | 64,300 | 158,078 | 222,292 | 444,670 |
| 6/05 | 164,348 | 114,384 | 89,274 | 368,006 |
| 6/06 | 86,928 | 101,069 | 77,221 | 265,218 |
| 6/07 ^{h,i} | 83,738 | 116,070 | 98,867 | 298,675 |
| 6/08 | 121,012 | 170,538 | 135,670 | 427,220 |
| 6/09 | 52,320 | 64,668 | 64,223 | 181,211 |
| 6/10 ^h | 21,138 | 29,329 | 27,380 | 77,847 |
| 6/11 | 64,779 | 123,107 | 118,277 | 306,163 |
| 6/12 | 86,896 | 125,524 | 112,600 | 325,020 |
| 6/13 | 67,288 | 79,384 | 98,363 | 245,035 |
| 6/14 ^h | 83,044 | 92,061 | 92,266 | 267,371 |
| 6/15 | 17,678 | 15,403 | 11,975 | 45,056 |
| 6/16 | 14,895 | 11,116 | 10,615 | 36,626 |
| Total | 974,829 | 1,240,881 | 1,190,814 | 3,406,524 |
| Percent | 28.6 | 36.4 | 35.0 | |

- ^a Smolt day began at 1200 hours and ended at 1159 hours the next calendar day.
- ^b Fyke net fished for 1.0 h or more daily from this date forward when conditions permitted.
- ^c First smolt (n=1) captured in the fyke net
- ^d Problems with lake ice in the river during the following periods:
 1900-1159 hours (17 h) on smolt day 5/28 due to ice jam and heavy ice flows
 1200-1159 hours (24 h) on smolt day 5/29 due to ice jam and heavy ice flows
 1200-0459 hours (17 h) on smolt day 5/30 due to heavy ice flows
 0600-1159 hours (6 h) on smolt day 5/31 due to intermittent to steady ice flows
 1800-0259 hours (9 h) on smolt day 6/01 due to occasional to heavy ice flows
- ^e First major smolt catch (n=568) in the fyke net.
- ^f Sonar counter was activated at 2400 hours on June 1, 1999.
- ^g Peak daily smolt passage estimate for 1999.
- ^h Sonar interpolated for one or more arrays for the following periods:
 0300-0500 hours (3 h) on smolt day 6/07 due to steady rain
 1600-1900 hours (4 h) on smolt day 6/10 due to high winds (NE 15-30)
 1100 hours (1 h) on smolt day 6/10 due to crew taking water velocity measurements
 1100 hours (1 h) on smolt day 6/14 due to wind (NE 15-20) and small whitecaps
- ⁱ Rainbow trout *Salmo gairdneri* sport fishing season opened at 0001 hours on June 8. Increased boat traffic after this opener produced 23.5 hours of sonar disabled time.

Table 2. Sonar counts by hour and array at the sockeye salmon smolt counting site on Kvichak River, 1999.

| Sonar Operating Period | Hour | a | Sonar Count | | | Total | Hourly Percent |
|------------------------------|------|---|------------------|-----------|-----------|-----------|-------------------|
| | | | Transducer Array | | | | |
| | | | Inshore | Center | Offshore | | |
| | 1200 | | 26,557 | 35,316 | 39,711 | 101,584 | 2.98 |
| | 1300 | | 32,738 | 57,643 | 71,577 | 161,958 | 4.75 |
| | 1400 | | 51,911 | 78,077 | 61,314 | 191,302 | 5.62 |
| | 1500 | | 53,056 | 63,073 | 47,222 | 163,351 | 4.80 |
| | 1600 | | 48,443 | 52,658 | 32,329 | 133,430 | 3.92 |
| | 1700 | | 37,653 | 39,628 | 37,870 | 115,151 | 3.38 |
| | 1800 | | 25,047 | 33,018 | 31,851 | 89,916 | 2.64 |
| | 1900 | | 36,166 | 40,839 | 37,031 | 114,036 | 3.35 |
| | 2000 | | 36,787 | 63,448 | 43,567 | 143,802 | 4.22 |
| Smolt | 2100 | | 34,745 | 60,165 | 62,674 | 157,584 | 4.63 |
| Days | 2200 | | 46,213 | 69,088 | 70,367 | 185,668 | 5.45 |
| 6/01 | 2300 | b | 38,951 | 58,155 | 57,861 | 154,967 | 4.55 |
| to | 2400 | c | 20,614 | 30,724 | 27,201 | 78,539 | 2.31 |
| 6/16 | 0100 | c | 35,727 | 56,617 | 53,171 | 145,515 | 4.27 |
| | 0200 | c | 45,854 | 61,564 | 91,369 | 198,787 | 5.84 |
| | 0300 | c | 68,862 | 49,524 | 55,211 | 173,597 | 5.10 |
| | 0400 | c | 105,617 | 90,534 | 76,675 | 272,826 | 8.01 |
| | 0500 | c | 61,846 | 78,653 | 87,030 | 227,529 | 6.68 |
| | 0600 | b | 46,991 | 52,098 | 52,048 | 151,137 | 4.44 |
| | 0700 | | 30,884 | 44,785 | 34,926 | 110,595 | 3.25 |
| | 0800 | | 22,586 | 33,960 | 34,045 | 90,591 | 2.66 |
| | 0900 | | 23,770 | 24,616 | 20,617 | 69,003 | 2.03 |
| | 1000 | | 22,712 | 31,995 | 30,340 | 85,047 | 2.50 |
| | 1100 | | 21,099 | 34,703 | 34,807 | 90,609 | 2.66 |
| Total | | | 974,829 | 1,240,881 | 1,190,813 | 3,406,522 | 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, 1999.

| Smolt Day ^a | Age 1. | | | Age 2. | | | All Ages | |
|------------------------|-------------|---------|------------------|------------|---------|------------------|-------------|------------------|
| | Number | Percent | Cumulative Total | Number | Percent | Cumulative Total | Daily Total | Cumulative Total |
| 6/01 | 113,072 | 72.4 | 113,072 | 43,040 | 27.6 | 43,040 | 156,112 | 156,112 |
| 6/02 | 563,585 | 72.4 | 676,657 | 214,525 | 27.6 | 257,565 | 778,110 | 934,222 |
| 6/03 | 2,167,147 | 72.4 | 2,843,804 | 824,910 | 27.6 | 1,082,475 | 2,992,057 | 3,926,279 |
| 6/04 | 16,609,514 | 89.5 | 19,453,318 | 1,956,900 | 10.5 | 3,039,375 | 18,566,414 | 22,492,693 |
| 6/05 | 13,090,764 | 89.5 | 32,544,082 | 1,542,327 | 10.5 | 4,581,702 | 14,633,091 | 37,125,784 |
| 6/06 | 9,201,608 | 88.9 | 41,745,690 | 1,144,252 | 11.1 | 5,725,954 | 10,345,860 | 47,471,644 |
| 6/07 | 10,788,499 | 90.2 | 52,534,189 | 1,170,817 | 9.8 | 6,896,771 | 11,959,316 | 59,430,960 |
| 6/08 | 17,235,303 | 94.7 | 69,769,492 | 958,830 | 5.3 | 7,855,601 | 18,194,133 | 77,625,093 |
| 6/09 | 7,536,722 | 93.7 | 77,306,214 | 507,596 | 6.3 | 8,363,197 | 8,044,318 | 85,669,411 |
| 6/10 | 3,217,659 | 93.7 | 80,523,873 | 216,708 | 6.3 | 8,579,905 | 3,434,367 | 89,103,778 |
| 6/11 | 12,741,675 | 93.7 | 93,265,548 | 858,148 | 6.3 | 9,438,053 | 13,599,823 | 102,703,601 |
| 6/12 | 13,503,937 | 93.7 | 106,769,485 | 909,487 | 6.3 | 10,347,540 | 14,413,424 | 117,117,025 |
| 6/13 | 9,317,985 | 88.4 | 116,087,470 | 1,223,914 | 11.6 | 11,571,454 | 10,541,899 | 127,658,924 |
| 6/14 | 11,707,494 | 96.4 | 127,794,964 | 440,989 | 3.6 | 12,012,443 | 12,148,483 | 139,807,407 |
| 6/15 | 1,949,736 | 95.0 | 129,744,700 | 103,482 | 5.0 | 12,115,925 | 2,053,218 | 141,860,625 |
| 6/16 | 1,597,788 | 95.0 | 131,342,488 | 84,802 | 5.0 | 12,200,727 | 1,682,590 | 143,543,215 |
| | 131,342,488 | 91.5 | | 12,200,727 | 8.5 | | 143,543,215 | |

^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, 1999.

| Smolt Day ^a | Mean Weight of Smolt (g) | Smolt per Count |
|------------------------|--------------------------|-----------------|
| 5/23 | 7.6 | 5.4 |
| 5/24 | 7.6 | 5.4 |
| 5/25 | 7.6 | 5.4 |
| 5/26 | 7.6 | 5.4 |
| 5/27 | 7.6 | 5.4 |
| 5/28 | 7.6 | 5.4 |
| 5/29 | 7.6 | 5.4 |
| 5/30 | 7.6 | 5.4 |
| 5/31 | 7.6 | 5.4 |
| 6/01 | 7.3 | 5.7 |
| 6/02 | 7.3 | 5.7 |
| 6/03 | 7.3 | 5.7 |
| 6/04 | 6.2 | 6.7 |
| 6/05 | 6.2 | 6.7 |
| 6/06 | 6.3 | 6.6 |
| 6/07 | 6.2 | 6.7 |
| 6/08 | 5.7 | 7.2 |
| 6/09 | 5.6 | 7.4 |
| 6/10 | 5.6 | 7.4 |
| 6/11 | 5.6 | 7.4 |
| 6/12 | 5.6 | 7.4 |
| 6/13 | 6.0 | 7.0 |
| 6/14 | 5.5 | 7.5 |
| 6/15 | 5.4 | 7.6 |
| 6/16 | 5.4 | 7.6 |

^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, 1999.

| Smolt Day ^a | Age 1. | | | | | Age 2. | | | | |
|------------------------|------------------|------------|-----------------|------------|--------------------------|------------------|------------|-----------------|------------|--------------------------|
| | Mean Length (mm) | Std. Error | Mean Weight (g) | Std. Error | Sample Size ^b | Mean Length (mm) | Std. Error | Mean Weight (g) | Std. Error | Sample Size ^b |
| 5/22 | 88 | 2.4 | 5.8 | 0.65 | 2 | | | | | 0 |
| 5/23 | | | | | 0 | | | | | 0 |
| 5/24 | 90 | 1.6 | 7.2 | 0.79 | 3 | | | | | 0 |
| 5/25 | | | | | 0 | | | | | 0 |
| 5/26 | | | | | 0 | | | | | 0 |
| 5/27 | | | | | 0 | | | | | 0 |
| 5/28 | | | | | 0 | | | | | 0 |
| 5/29 | | | | | 0 | | | | | 0 |
| 5/30 | | | | | 0 | | | | | 0 |
| 5/31 | 89 | 8.9 | 6.6 | 2.02 | 34 | 114 | 18.1 | 12.0 | 3.67 | 33 |
| 6/01 | | | | | 0 | | | | | 0 |
| 6/02 | | | | | 0 | | | | | 0 |
| 6/03 | 87 | 9.9 | 6.0 | 2.08 | 81 | 112 | 11.9 | 11.8 | 3.44 | 18 |
| 6/04 | 88 | 10.7 | 5.6 | 2.20 | 73 | 110 | 14.3 | 10.7 | 4.52 | 25 |
| 6/05 | 87 | 11.2 | 5.4 | 2.32 | 92 | 109 | 16.4 | 10.6 | 4.06 | 8 |
| 6/06 | 87 | 10.7 | 5.5 | 2.23 | 90 | 107 | 12.1 | 9.9 | 3.01 | 10 |
| 6/07 | 87 | 10.7 | 5.5 | 2.34 | 84 | 110 | 14.4 | 10.7 | 2.89 | 13 |
| 6/08 | 87 | 11.3 | 5.8 | 2.30 | 81 | 106 | 13.6 | 9.6 | 3.17 | 18 |
| 6/09 | 88 | 8.5 | 6.4 | 1.93 | 13 | 109 | 4.1 | 10.9 | 0.86 | 4 |
| 6/10 | | | | | 0 | | | | | 0 |
| 6/11 | 84 | 8.0 | 5.2 | 1.23 | 33 | 108 | 5.9 | 9.9 | 1.13 | 2 |
| 6/12 | 83 | 11.7 | 5.0 | 2.02 | 85 | 108 | 10.5 | 9.9 | 2.81 | 15 |
| 6/13 | 85 | 13.2 | 6.0 | 2.75 | 92 | 106 | 13.7 | 10.2 | 3.66 | 8 |
| 6/14 | 85 | 11.1 | 5.5 | 2.51 | 92 | 110 | 7.7 | 10.6 | 1.57 | 8 |
| 6/15 | 82 | 12.2 | 5.2 | 2.80 | 99 | 100 | | 7.8 | | 1 |
| Total Mean | 86 | | 5.8 | | 954 | 108 | | 10.3 | | 163 |

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

^b Also tried to collect one fin clip sample from each smolt sampled for age-weight-length (AWL) data for DNA analysis by the ADF&G genetics lab in Anchorage.

Table 6. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Kvichak River, 1999.

| 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 |
| 5/31 | 86 | 12.8 | 5.7 | 248 | 111 | 20.0 | 11.1 | 85 |
| 6/01 | | | | 0 | | | | 0 |
| 6/02 | 88 | 13.5 | 5.9 | 200 | 111 | 26.0 | 11.0 | 156 |
| 6/03 | 88 | 13.2 | 5.9 | 299 | 109 | 16.9 | 10.6 | 53 |
| 6/04 | 88 | 11.6 | 5.8 | 109 | 111 | 15.5 | 10.9 | 23 |
| 6/05 | 87 | 14.3 | 5.7 | 493 | 111 | 44.2 | 11.4 | 49 |
| 6/06 | 87 | 14.7 | 5.7 | 553 | 108 | 20.1 | 10.4 | 66 |
| 6/07 | 87 | 15.5 | 5.7 | 648 | 108 | 18.1 | 10.4 | 82 |
| 6/08 | 85 | 16.9 | 5.4 | 612 | 106 | 14.0 | 9.9 | 26 |
| 6/09 | | | | 0 | | | | 0 |
| 6/10 | | | | 0 | | | | 0 |
| 6/11 | | | | 0 | | | | 0 |
| 6/12 | 83 | 18.0 | 5.1 | 565 | 107 | 9.7 | 10.0 | 21 |
| 6/13 | 84 | 18.4 | 5.3 | 576 | 106 | 18.8 | 9.9 | 102 |
| 6/14 | 84 | 16.7 | 5.3 | 660 | 104 | 11.5 | 9.5 | 27 |
| 6/15 | 82 | 19.1 | 4.9 | 533 | 109 | 14.6 | 10.5 | 29 |
| Total Mean | | | | 5,496 | 719 | | | |
| 86 | | 5.5 | | 108 | | 10.5 | | |

^a Length-weight parameters by age group and discriminating length used to separate ages from May 31 to June 15 were:

Age 1. $a = -9.3278$ $b = 2.4767$ $r^2 = 0.6087$ $n = 954$

Age 2. $a = -9.1565$ $b = 2.4505$ $r^2 = 0.8258$ $n = 163$

Discriminating Length = 96.74 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, June 2-15, 1999.

| | Depth of Passage (cm) | | | | | | | |
|---------|---|--------|--|--------|--|--------|-------------------------------|--------|
| | Inshore Array ^a Smolt Schools | | Center Array ^b Smolt Schools | | Offshore Array ^c Smolt Schools | | All Combined Smolt Schools | |
| | Top | Bottom | Top | Bottom | Top | Bottom | Top | Bottom |
| Minimum | 1 | 30 | 20 | 40 | 10 | 50 | 1 | 30 |
| Mean | 40 | 93 | 48 | 111 | 38 | 113 | 42 | 106 |
| Maximum | 160 | 180 | 140 | 180 | 80 | 165 | 160 | 180 |
| n | 17 | 17 | 36 | 36 | 32 | 32 | 85 | 85 |

^a Average depth of inshore array on smolt day 6/04 was 286 cm.

^b Average depth of center array on smolt day 6/04 was 280 cm.

^c Average depth of offshore array on smolt day 6/04 was 277 cm.

Table 8. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Kvichak River, 1999.

| Date | Cloud Cover ^a | | Precipitation ^b (mm) | Wind Direction & Velocity (km/h) | | Air Temperature (°C) | | Water Temperature (°C) | | Water Clarity ^c |
|------|--------------------------|------|------------------------------------|--|--------|-------------------------|------|---------------------------|------|-------------------------------|
| | 0800 | 2000 | | 0800 | 2000 | 0800 | 2000 | 0800 | 2000 | |
| 5/23 | 4 | 2 | trace | 0 | NE 06 | 8.0 | 10.0 | 3.0 | 4.0 | clear |
| 5/24 | 3 | 3 | trace | W 08 | 0 | 7.0 | 9.0 | 2.5 | 3.5 | clear |
| 5/25 | 4 | 4 | trace | SW 16 | SW 24 | 1.5 | 8.0 | 2.0 | 2.0 | clear |
| 5/26 | 4 | 4 | 0.0 | WSW 32 | SW 16 | 0.0 | 7.0 | 1.5 | 2.0 | clear |
| 5/27 | 4 | 3 | 0.0 | SW 08 | SW 16 | 2.0 | 6.5 | 2.0 | 2.0 | clear |
| 5/28 | 4 | 4 | 0.0 | 0 | E 16 | 8.5 | 6.0 | 2.0 | 0.0 | clear |
| 5/29 | 4 | 4 | trace | SE 48 | E 08 | 2.0 | 3.0 | 0.0 | 0.0 | clear |
| 5/30 | 4 | 3 | 10.2 | 0 | NW 16 | 4.0 | 5.0 | 0.0 | 0.5 | clear |
| 5/31 | 4 | 3 | trace | W 08 | 0 | 3.0 | 6.0 | 0.0 | 0.5 | clear |
| 6/01 | 4 | 4 | trace | 0 | W 08 | 1.5 | 8.0 | 0.0 | 1.0 | clear |
| 6/02 | 4 | 4 | 12.7 | SE 23 | SE 24 | 3.0 | 4.0 | 0.5 | 1.0 | clear |
| 6/03 | 4 | 4 | 7.1 | SE 13 | SE 08 | 4.0 | 6.0 | 0.5 | 2.0 | clear |
| 6/04 | 1 | 1 | 0.0 | W 16 | W 16 | 5.0 | 12.0 | 1.0 | 3.0 | clear |
| 6/05 | 4 | 1 | 0.0 | S 14 | 0 | 3.0 | 17.0 | 2.0 | 4.0 | clear |
| 6/06 | 3 | 4 | 0.0 | 0 | SW 16 | 9.0 | 14.0 | 2.0 | 5.0 | clear |
| 6/07 | 4 | 4 | na | 0 | N 08 | 6.0 | 6.0 | 2.5 | 5.0 | clear |
| 6/08 | 4 | 4 | na | 0 | N 08 | 7.0 | 7.0 | 3.0 | 6.0 | murky |
| 6/09 | 4 | 3 | 6.1 | N 08 | N 16 | 7.0 | 11.0 | 3.0 | 6.0 | murky |
| 6/10 | 3 | 3 | 0.0 | NE 24 | N 32 | 7.0 | 11.0 | 4.0 | 8.0 | murky |
| 6/11 | 4 | 3 | 0.0 | NNE 14 | N 16 | 8.0 | 15.0 | 4.0 | 6.0 | murky |
| 6/12 | 4 | 2 | 5.6 | N 04 | N 04 | 9.0 | 13.0 | 5.0 | 5.0 | murky |
| 6/13 | 4 | 3 | 0.0 | N 04 | NE 16 | 8.0 | 15.0 | 5.0 | 6.0 | murky |
| 6/14 | 4 | 4 | 0.0 | NNW 16 | NNW 08 | 9.0 | 9.0 | 5.0 | 5.5 | clear |
| 6/15 | 4 | 4 | 0.0 | NNE 13 | NNW 08 | 10.0 | 11.0 | 6.0 | 5.0 | clear |
| 6/16 | 4 | 4 | trace | NW 08 | N 08 | 9.0 | 13.0 | 7.0 | na | clear |
| 6/17 | 3 | na | na | NE 08 | na | 7.5 | na | 7.0 | na | na |

^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 na = not available

^c Water clarity at 0800 hours

Table 9. Sonar counts by smolt day and array at the sockeye salmon smolt counting site on Egegik River, 1999.

| Smolt Day ^a | Sonar Count | | | Total |
|------------------------|------------------|---------|----------|---------|
| | Transducer Array | | | |
| | Inshore | Center | Offshore | |
| 5/19 ^b | | | | |
| 5/20 | | | | |
| 5/21 ^c | 0 | 50 | 65 | 115 |
| 5/22 | 34 | 25 | 183 | 242 |
| 5/23 | 152 | 124 | 265 | 541 |
| 5/24 ^{d,e} | 5 | 40 | 37 | 82 |
| 5/25 ^{e,f} | 46 | 38 | 92 | 176 |
| 5/26 ^f | 76 | 72 | 66 | 214 |
| 5/27 ^d | 56 | 50 | 0 | 106 |
| 5/28 ^d | 79 | 11 | 14 | 104 |
| 5/29 | 51 | 62 | 27 | 140 |
| 5/30 ^d | 0 | 120 | 27 | 147 |
| 5/31 ^{d,e} | 193 | 46 | 49 | 288 |
| 6/01 ^d | 313 | 289 | 639 | 1,241 |
| 6/02 | 1 | 666 | 1,883 | 2,550 |
| 6/03 ^{d,e} | 849 | 8,717 | 2,811 | 12,377 |
| 6/04 ^f | 39 | 484 | 7,509 | 8,032 |
| 6/05 ^f | 110 | 1,862 | 400 | 2,372 |
| 6/06 ^e | 4 | 10,366 | 6,404 | 16,774 |
| 6/07 ^d | 59 | 905 | 867 | 1,831 |
| 6/08 ^{d,f} | 5,091 | 96,510 | 214,848 | 316,449 |
| 6/09 ^{d,e} | 68,473 | 141,875 | 124,464 | 334,812 |
| 6/10 ^e | 0 | 0 | 0 | 0 |
| 6/11 ^e | 0 | 0 | 0 | 0 |
| 6/12 ^e | 1,323 | 5,118 | 11,586 | 18,027 |
| 6/13 ^d | 3,717 | 21,731 | 21,761 | 47,209 |
| Total | 80,671 | 289,161 | 393,997 | 763,829 |
| Percent | 10.5 | 37.9 | 51.6 | |

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

^b Fyke net fished for 1-2 h per night from this smolt day on whenever conditions permitted.

^c Sonar counter was activated at 1200 hours on May 21.

^d False counts recorded on one or more arrays during the following periods:

1900-1959, 2100-0359, and 0600-0759 hours on smolt day 5/27 from floating ice (n=7,874)

2100-2259 and 0300-0859 hours on smolt day 5/28 from floating ice (n=17,678)

1400-1459 (wind & waves, n=4,722), 2000-2059 (boat, n=1,896), and 0800-0959 and 1100-1159 (floating ice, n=1,247)

hours on smolt day 5/30

1300-1459, 2300-0059, 0600-0759, and 1000-1059 hours on smolt day 5/31 from floating ice (n=4,590)

1200-1359 (rain, n=627), 1400-1459 (boat, n=2,446), 2000-2259 and 0300-0959 (ice, n=21,5224) hours on smolt day 6/01

0300-0459 and 0600-0859 hours on smolt day 6/03 from floating ice (n=19,320)

1200-1959 and 2200-1159 hours on smolt day 6/07 from floating ice (n=37,205)

1200-1359, 1500-2359, 0800-1159 hours on smolt day 6/08 from floating ice (n=11,945)

1200-1959 and 0600-0659 hours on smolt day 6/09 from floating ice sheets (n=39,206)

1200-2359 hours on smolt day 6/13 from floating ice (n=99,707)

^e Sonar counter disabled for the following periods. Insufficient signs of smolt to warrant interpolation of counts.

0941-1008 hours on smolt day 5/24 due to heavy snow

intermittently from 0345-1059 hours on smolt day 5/25 due to heavy snow

0100-0559 hours on smolt day 5/31 due to heavy ice passage

0500-0559 hours on smolt day 6/03 due to heavy ice passage

1300-0459 (wind, wave, and rain) and 0900-1159 (heavy ice passage) hours on smolt day 6/06

0700-1159 hours on smolt day 6/09 due to heavy ice floes

1200-1159 hours on smolt day 6/10 due to heavy ice floes

1200-0459 hours on smolt day 6/11 due to heavy ice floes

1300-0859 hours on smolt day 6/12 due to heavy ice floes

^f Able to fish fyke net and capture sockeye salmon smolt on the following occasions:

0044-0157 hours on smolt day 5/25 - caught (n=1) smolt

0036-0200 hours on smolt day 5/26 - caught (n=1) smolt

0031-0208 hours on smolt day 6/04 - caught (n=162) smolt

0014-0223 hours on smolt day 6/05 - caught (n=17) smolt

0152-0156, 0224-0244, 0247-0302, and 0304-0319 hours on smolt day 6/08 - caught (n=246) smolt

Table 10. Sonar counts by hour and array at the sockeye salmon smolt counting site on Egegik River, 1999.

| Sonar Operating Period | Hour ^a | Sonar Count | | | Total | Hourly Percent |
|------------------------|-------------------|------------------|---------|----------|---------|----------------|
| | | Transducer Array | | | | |
| | | Inshore | Center | Offshore | | |
| | 1200 | 128 | 2,177 | 329 | 2,634 | 0.34 |
| | 1300 | 315 | 14 | 399 | 728 | 0.10 |
| | 1400 | 973 | 968 | 1,181 | 3,122 | 0.41 |
| | 1500 | 5 | 1,673 | 1,639 | 3,317 | 0.43 |
| | 1600 | 64 | 115 | 8 | 187 | 0.02 |
| | 1700 | 32 | 763 | 29 | 824 | 0.11 |
| | 1800 | 28 | 2,625 | 426 | 3,079 | 0.40 |
| | 1900 | 993 | 13,104 | 1,703 | 15,800 | 2.07 |
| | 2000 | 976 | 7,021 | 3,999 | 11,996 | 1.57 |
| Smolt Days | 2100 | 1,090 | 12,140 | 8,764 | 21,994 | 2.88 |
| | 2200 | 262 | 8,379 | 4,223 | 12,864 | 1.68 |
| 5/21 to 6/13 | 2300 ^b | 16,644 | 5,243 | 10,426 | 32,313 | 4.23 |
| | 2400 ^c | 20,415 | 29,083 | 44,438 | 93,936 | 12.30 |
| | 0100 ^c | 3,995 | 38,943 | 95,375 | 138,313 | 18.11 |
| | 0200 ^c | 8,456 | 24,597 | 52,083 | 85,136 | 11.15 |
| | 0300 ^c | 17,170 | 65,167 | 75,220 | 157,557 | 20.63 |
| | 0400 ^c | 7,250 | 35,180 | 63,920 | 106,350 | 13.92 |
| | 0500 ^c | 313 | 34,342 | 15,865 | 50,520 | 6.61 |
| | 0600 ^b | 133 | 2,113 | 2,139 | 4,385 | 0.57 |
| | 0700 | 6 | 105 | 27 | 138 | 0.02 |
| | 0800 | 1 | 13 | 5 | 19 | 0.00 |
| | 0900 | 6 | 981 | 8,370 | 9,357 | 1.23 |
| | 1000 | 742 | 3,587 | 2,978 | 7,307 | 0.96 |
| | 1100 | 674 | 828 | 451 | 1,953 | 0.26 |
| Total | | 80,671 | 289,161 | 393,997 | 763,829 | 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, 1999.

| Smolt Day ^a | Age 1. | | | Age 2. | | | Age 3. | | | All Ages | |
|------------------------|---------|---------|------------------|-----------|---------|------------------|---------|---------|------------------|-------------|------------------|
| | Number | Percent | Cumulative Total | Number | Percent | Cumulative Total | Number | Percent | Cumulative Total | Daily Total | Cumulative Total |
| 5/21 | 111 | 9.0 | 111 | 1,099 | 88.7 | 1,099 | 29 | 2.3 | 29 | 1,239 | 1,239 |
| 5/22 | 259 | 9.0 | 370 | 2,547 | 88.7 | 3,646 | 67 | 2.3 | 96 | 2,873 | 4,112 |
| 5/23 | 545 | 9.0 | 915 | 5,356 | 88.7 | 9,002 | 141 | 2.3 | 237 | 6,042 | 10,154 |
| 5/24 | 77 | 9.0 | 992 | 765 | 88.7 | 9,767 | 20 | 2.3 | 257 | 862 | 11,016 |
| 5/25 | 179 | 9.0 | 1,171 | 1,764 | 88.7 | 11,531 | 46 | 2.3 | 303 | 1,989 | 13,005 |
| 5/26 | 206 | 9.0 | 1,377 | 2,028 | 88.7 | 13,559 | 53 | 2.3 | 356 | 2,287 | 15,292 |
| 5/27 | 95 | 9.0 | 1,472 | 935 | 88.7 | 14,494 | 24 | 2.3 | 380 | 1,054 | 16,346 |
| 5/28 | 104 | 9.0 | 1,576 | 1,024 | 88.7 | 15,518 | 27 | 2.3 | 407 | 1,155 | 17,501 |
| 5/29 | 132 | 9.0 | 1,708 | 1,298 | 88.7 | 16,816 | 34 | 2.3 | 441 | 1,464 | 18,965 |
| 5/30 | 125 | 9.0 | 1,833 | 1,231 | 88.7 | 18,047 | 32 | 2.3 | 473 | 1,388 | 20,353 |
| 5/31 | 307 | 9.0 | 2,140 | 3,025 | 88.7 | 21,072 | 79 | 2.3 | 552 | 3,411 | 23,764 |
| 6/01 | 1,326 | 9.0 | 3,466 | 13,034 | 88.7 | 34,106 | 344 | 2.3 | 896 | 14,704 | 38,468 |
| 6/02 | 2,726 | 9.0 | 6,192 | 26,793 | 88.7 | 60,899 | 707 | 2.3 | 1,603 | 30,226 | 68,694 |
| 6/03 | 11,454 | 9.0 | 17,646 | 112,553 | 88.7 | 173,452 | 2,971 | 2.3 | 4,574 | 126,978 | 195,672 |
| 6/04 | 9,090 | 9.0 | 26,736 | 89,322 | 88.7 | 262,774 | 2,358 | 2.3 | 6,932 | 100,770 | 296,442 |
| 6/05 | 2,152 | 9.0 | 28,888 | 21,151 | 88.7 | 283,925 | 558 | 2.3 | 7,490 | 23,861 | 320,303 |
| 6/06 | 16,433 | 9.0 | 45,321 | 161,475 | 88.7 | 445,400 | 4,263 | 2.3 | 11,753 | 182,171 | 502,474 |
| 6/07 | 1,804 | 9.0 | 47,125 | 17,730 | 88.7 | 463,130 | 468 | 2.3 | 12,221 | 20,002 | 522,476 |
| 6/08 | 328,274 | 9.0 | 375,399 | 3,225,609 | 88.7 | 3,688,739 | 85,162 | 2.3 | 97,383 | 3,639,045 | 4,161,521 |
| 6/09 | 334,118 | 9.0 | 709,517 | 3,283,028 | 88.7 | 6,971,767 | 86,678 | 2.3 | 184,061 | 3,703,824 | 7,865,345 |
| 6/10 | | | 709,517 | | | 6,971,767 | | | 184,061 | | 7,865,345 |
| 6/11 | | | 709,517 | | | 6,971,767 | | | 184,061 | | 7,865,345 |
| 6/12 | 18,806 | 9.0 | 728,323 | 184,792 | 88.7 | 7,156,559 | 4,878 | 2.3 | 188,939 | 208,476 | 8,073,821 |
| 6/13 | 46,788 | 9.0 | 775,111 | 459,736 | 88.7 | 7,616,295 | 12,137 | 2.3 | 201,076 | 518,661 | 8,592,482 |
| | 775,111 | 9.0 | | 7,616,295 | 88.7 | | 201,076 | 2.3 | | 8,592,482 | |

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

^b No smolt estimates on these smolt days. Sonar counter disabled due to heavy floes of lake ice in the river.

Table 12. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Egegik River, 1999.

| Smolt Day ^a | Mean Weight of Smolt (g) | Smolt per Count |
|------------------------|--------------------------|-----------------|
| 5/21 | 16.4 | 2.5 |
| 5/22 | 16.4 | 2.5 |
| 5/23 | 16.4 | 2.5 |
| 5/24 | 16.4 | 2.5 |
| 5/25 | 16.4 | 2.5 |
| 5/26 | 16.4 | 2.5 |
| 5/27 | 16.4 | 2.5 |
| 5/28 | 16.4 | 2.5 |
| 5/29 | 16.4 | 2.5 |
| 5/30 | 16.4 | 2.5 |
| 5/31 | 16.4 | 2.5 |
| 6/01 | 16.4 | 2.5 |
| 6/02 | 16.4 | 2.5 |
| 6/03 | 16.4 | 2.5 |
| 6/04 | 16.4 | 2.5 |
| 6/05 | 16.4 | 2.5 |
| 6/06 | 16.4 | 2.5 |
| 6/07 | 16.4 | 2.5 |
| 6/08 | 16.4 | 2.5 |
| 6/09 | 16.4 | 2.5 |
| 6/10 | 16.4 | 2.5 |
| 6/11 | 16.4 | 2.5 |
| 6/12 | 16.4 | 2.5 |
| 6/13 | 16.4 | 2.5 |

^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, 1999.

| 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 | | | | | | | | | | | | | | | |
| 5/20 | | | | | | | | | | | | | | | |
| 5/21 | | | | | | | | | | | | | | | |
| 5/22 | | | | | | | | | | | | | | | |
| 5/23 | | | | | | | | | | | | | | | |
| 5/24 | | | | | | | | | | | | | | | |
| 5/25 | | | | | | 114 | | 12.4 | | 1 | | | | | |
| 5/26 | | | | | | 134 | | 17.0 | | 1 | | | | | |
| 5/27 | | | | | | | | | | | | | | | |
| 5/28 | | | | | | | | | | | | | | | |
| 5/29 | | | | | | | | | | | | | | | |
| 5/30 | | | | | | | | | | | | | | | |
| 5/31 | | | | | | | | | | | | | | | |
| 6/01 | | | | | | | | | | | | | | | |
| 6/02 | | | | | | | | | | | | | | | |
| 6/03 | | | | | | | | | | | | | | | |
| 6/04 | 104 | | 10.2 | | 1 | 131 | 19.5 | 18.7 | 8.39 | 91 | 139 | 7.0 | 21.0 | 3.81 | 5 |
| 6/05 | | | | | | 128 | 14.3 | 18.0 | 6.23 | 16 | 144 | | 14.7 | | 1 |
| 6/06 | | | | | | | | | | | | | | | |
| 6/07 | | | | | | | | | | | | | | | |
| 6/08 | 110 | 6.8 | 9.5 | 0.11 | 3 | 127 | 20.4 | 16.5 | 7.19 | 97 | 138 | 6.9 | 21.8 | 3.79 | 5 |
| 6/09 | | | | | | | | | | | | | | | |
| 6/10 | | | | | | | | | | | | | | | |
| 6/11 | | | | | | | | | | | | | | | |
| 6/12 | | | | | | | | | | | | | | | |
| 6/13 | | | | | | | | | | | | | | | |
| Total Mean | 107 | | 9.9 | | 4 | 127 | | 16.5 | | 206 | 140 | | 19.2 | | 11 |

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

^b Fyke net fished for 1-2 hours each night, no sockeye salmon smolt caught.

^c Fyke net fished briefly (< 15 min); net had to be pulled early due to heavy floes of lake ice in the river. No smolt caught.

^d Fyke net not fished. Too much lake ice in the river to make a set.

Table 14. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Egegik River, 1999.

| 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 |
| 6/04 | 119 | 5.7 | 9.5 | 9 | 132 | 11.5 | 18.5 | 53 |
| 6/08 | 117 | 16.7 | 9.5 | 47 | 131 | 16 | 18.3 | 96 |
| Total Mean | 118 | | 9.5 | 56 | 132 | | 18.4 | 149 |

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

Age 1. $a = 3.2797$ $b = -0.2156$ $r^2 = 0.1086$ $n = 4$

Age 2. $a = -9.6076$ $b = 2.5638$ $r^2 = 0.7116$ $n = 206$

Discriminating Length = 124.55 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, June 4-13, 1999.

| | Depth of Passage (cm) | | | | | | | |
|---------|---|--------|--|--------|--|--------|-------------------------------|--------|
| | Inshore Array ^a Smolt Schools | | Center Array ^b Smolt Schools | | Offshore Array ^c Smolt Schools | | All Combined Smolt Schools | |
| | Top | Bottom | Top | Bottom | Top | Bottom | Top | Bottom |
| Minimum | 16 | 56 | 0 | 40 | 0 | 90 | 0 | 40 |
| Mean | 59 | 111 | 80 | 187 | 94 | 191 | 78 | 163 |
| Maximum | 100 | 140 | 180 | 280 | 240 | 296 | 240 | 296 |
| n | 5 | 5 | 13 | 13 | 19 | 19 | 37 | 37 |

^a Average depth of inshore array on smolt day 6/08 was 296 cm.

^b Average depth of center array on smolt day 6/08 was 357 cm.

^c Average depth of offshore array on smolt day 6/08 was 378 cm.

Table 16. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Egegik River, 1999.

| Date | Cloud Cover ^a | | Precipitation (mm) | Wind Direction & Velocity (km/h) | | Air Temperature ^b (°C) | | Water Temperature (°C) | | Water Clarity ^c |
|------|--------------------------|------|-----------------------|--|---------|--------------------------------------|------|---------------------------|------|-------------------------------|
| | 0800 | 2000 | | 0800 | 2000 | 0800 | 2000 | 0800 | 2000 | |
| 5/21 | 2 | 3 | 0.0 | 0 | E 16 | 5.0 | 10.0 | 2.0 | 3.0 | clear |
| 5/22 | 2 | 3 | 0.0 | ENE 08 | ENE 21 | 4.0 | 5.0 | 2.0 | 2.5 | clear |
| 5/23 | 1 | 2 | trace | E 10 | WSW 26 | 2.0 | 10.0 | 2.0 | 4.0 | clear |
| 5/24 | 5 | 3 | 0.0 | S 24 | S 32 | 1.0 | 3.0 | 2.0 | 4.0 | clear |
| 5/25 | 5 | 4 | 0.0 | S 24 | SSW 27 | 0.0 | 1.0 | 1.5 | 3.0 | clear |
| 5/26 | 4 | 4 | 0.0 | SW 16 | SSW 26 | 0.0 | 2.0 | 1.0 | 3.0 | clear |
| 5/27 | 4 | 2 | 0.0 | S 18 | 0 | 0.0 | 1.0 | 1.0 | 3.0 | clear |
| 5/28 | 3 | 4 | 0.0 | 0 | ENE 32 | 0.0 | 3.0 | 1.0 | 3.0 | clear |
| 5/29 | 4 | 4 | 15.7 | NE 40 | E 29 | 3.0 | 4.0 | 0.5 | 1.0 | lt brown |
| 5/30 | 4 | 3 | 9.1 | SW 18 | S 32-40 | 3.0 | 3.0 | 1.0 | 4.0 | clear |
| 5/31 | 4 | 4 | trace | SSE 08 | NE 16 | 1.0 | 5.0 | 1.0 | 4.0 | clear |
| 6/01 | 4 | 4 | 6.1 | ENE 32 | E 13 | 3.0 | 5.0 | 1.0 | 1.0 | lt brown |
| 6/02 | 4 | 4 | 1.0 | SSE 14 | E 24 | 3.0 | 4.0 | 1.0 | 2.0 | clear |
| 6/03 | 4 | 3 | 0.0 | SSE 18 | S 24 | 2.0 | 4.0 | 2.0 | 4.5 | clear |
| 6/04 | 3 | 3 | 0.0 | 0 | SW 15 | 4.0 | 3.0 | 2.0 | 5.0 | clear |
| 6/05 | 5 | 1 | trace | S 08 | W 16 | 0.0 | 10.0 | 2.5 | 8.0 | clear |
| 6/06 | 3 | 4 | 0.3 | NE 39 | E 56 | 4.0 | 8.0 | 3.0 | 8.0 | clear |
| 6/07 | 4 | 4 | 0.8 | E 16 | 0 | 5.0 | 5.0 | 3.5 | 1.0 | clear |
| 6/08 | 4/5 | 4 | 15.7 | S 0-08 | 0 | 4.0 | 9.0 | 2.5 | 4.0 | clear |
| 6/09 | 4 | 4 | 6.9 | 0 | E 32 | na | 7.0 | 2.5 | 1.0 | clear |
| 6/10 | 3 | 3 | 0.0 | E 27 | E 32 | 6.0 | 8.0 | 0.0 | 1.0 | clear |
| 6/11 | 3 | 3 | 0.0 | E 19 | 0 | 6.0 | 7.0 | 0.0 | 1.0 | white ice |
| 6/12 | 3 | 3 | 4.8 | 0 | 0 | 8.0 | 10.0 | 0.0 | 1.0 | white ice |
| 6/13 | 3 | 3 | 0.0 | NNW 19 | E 13 | 9.0 | 11.0 | 0.0 | 1.0 | white ice |
| 6/14 | 3 | na | na | NNE 19 | na | 8.0 | na | 1.0 | na | white ice |

^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 na = not available

^c Water clarity at 0800 hours

Table 17. Sonar counts by smolt day and array at the sockeye salmon smolt counting site on Ugashik River, 1999.

| Smolt Day ^a | Sonar Count | | |
|------------------------|------------------|----------|---------|
| | Transducer Array | | Total |
| | Inshore | Offshore | |
| 5/17 ^b | 0 | 0 | 0 |
| 5/18 ^c | 0 | 0 | 0 |
| 5/19 ^d | 0 | 0 | 0 |
| 5/20 ^e | 0 | 0 | 0 |
| 5/21 ^f | 0 | 0 | 0 |
| 5/22 ^g | 0 | 0 | 0 |
| 5/23 ^h | 0 | 0 | 0 |
| 5/24 ⁱ | 0 | 0 | 0 |
| 5/25 ⁱ | 0 | 0 | 0 |
| 5/26 ^j | 85 | 140 | 225 |
| 5/27 | 32 | 511 | 543 |
| 5/28 ^k | 8,081 | 16,934 | 25,015 |
| 5/29 ^k | 28,493 | 63,518 | 92,011 |
| 5/30 | 283 | 62 | 345 |
| 5/31 | 2,610 | 4,429 | 7,039 |
| 6/01 ^k | 3,883 | 21,485 | 25,368 |
| 6/02 | 7,151 | 17,969 | 25,120 |
| 6/03 | 4,218 | 7,716 | 11,934 |
| 6/04 | 5,269 | 18,399 | 23,668 |
| 6/05 | 4,563 | 10,767 | 15,330 |
| 6/06 ^k | 7,718 | 17,964 | 25,682 |
| 6/07 | 5,539 | 58,327 | 63,866 |
| 6/08 | 10,290 | 19,652 | 29,942 |
| 6/09 ^k | 8,047 | 115,092 | 123,139 |
| 6/10 ^k | 21,093 | 352,704 | 373,797 |
| 6/11 | 2,600 | 130,665 | 133,265 |
| 6/12 | 1,188 | 7,911 | 9,099 |
| Total | 121,143 | 864,245 | 985,388 |
| Percent | 12.3 | 87.7 | |

- ^a Sample day began at 1200 hours and ended at 1159 hours the next calendar day.
- ^b Lower Ugashik Lake still ice covered; lake ice was soft, dark, and wet. There was open water at the Ugashik River sonar site with a few scattered small pieces of ice.
- ^c Some bigger chunks of lake ice break off and drift downriver by late afternoon. Drift ice increased and by morning there was a steady flow of ice moving downriver.
- ^d Heavy floes of lake ice continued to move past the sonar site until late evening. Ice floes stopped shortly before midnight. A fyke net fished for 0.5 hours caught no smolt.
- ^e Little or no ice in the river in the early afternoon. Moderate-to-heavy ice floes in the river from 1600-0200 hours next morning. Fyke net not fished due to too much ice.
- ^f Heavy ice floes in the river from 1200-0800 hours the next morning. Fyke net not fished due to too much ice.
- ^g Less ice in the river in early afternoon. Bank-to-bank ice floes from 1600-0100 hours, tapered off by 0800 hours. Fyke net not fished due to too much ice.
- ^h WNW wind pushed remaining ice to the far end of Lower Ugashik Lake. Little or no ice reported in the river at the sonar site thereafter. Fyke net fished for 1.0 hour caught 19 sockeye salmon smolt.
- ⁱ No ice in river. Sonar counter not deployed due to uncertainty about the remaining ice in the lake. Fyke net caught 75 and 12 sockeye salmon smolt on smolt days 5/24 and 5/25 respectively.
- ^j The sonar counter was activated at 1300 hours on smolt day 5/26.
- ^k Sonar counts interpolated for one or more arrays for the following periods:
 1700-0459 hours on smolt day 5/28 due to high ENE wind, waves, and rain
 1200-1659 hours on smolt day 5/29 due to high ESE wind, waves, and rain
 0300-0459 hours on smolt day 5/29 due to heavy snow
 0500-0659 hours on smolt day 5/29 due to high WSW wind, mixed rain and snow
 1600-1759 hours on smolt day 6/01 due to plane and boat traffic
 1900-2059 hours on smolt day 6/01 due to hard rain and boat traffic
 1500-0659 hours on smolt day 6/06 due to high easterly wind, waves, and rain
 1900-1159 hours on smolt day 6/09 due to high easterly wind and waves
 1200-1759 hours on smolt day 6/10 due to high easterly wind and waves

Table 18. Sonar counts by hour and array at the sockeye salmon smolt counting site on Ugashik River, 1999.

| Sonar Operating Period | Hour | Sonar Count | | | Hourly Percent |
|------------------------------|------|---------------------|------------------|---------|-------------------|
| | | ^a | Transducer Array | | |
| | | Inshore | Offshore | Total | |
| | 1200 | 1,878 | 3,317 | 5,195 | 0.53 |
| | 1300 | 2,526 | 4,840 | 7,365 | 0.75 |
| | 1400 | 1,198 | 4,817 | 6,015 | 0.61 |
| | 1500 | 1,668 | 3,137 | 4,805 | 0.49 |
| | 1600 | 2,846 | 5,505 | 8,351 | 0.85 |
| | 1700 | 793 | 6,401 | 7,194 | 0.73 |
| | 1800 | 13,526 | 100,599 | 114,125 | 11.58 |
| | 1900 | 1,786 | 50,678 | 52,463 | 5.32 |
| | 2000 | 3,181 | 41,429 | 44,610 | 4.53 |
| Smolt | 2100 | 2,899 | 46,067 | 48,966 | 4.97 |
| Days | 2200 | 4,127 | 41,393 | 45,520 | 4.62 |
| 5/26 | 2300 | ^b 1,308 | 28,655 | 29,962 | 3.04 |
| to | 2400 | ^c 18,147 | 113,449 | 131,596 | 13.35 |
| 6/12 | 0100 | ^c 21,614 | 222,501 | 244,115 | 24.77 |
| | 0200 | ^c 14,395 | 122,032 | 136,427 | 13.85 |
| | 0300 | ^c 16,401 | 21,314 | 37,716 | 3.83 |
| | 0400 | ^c 4,319 | 17,696 | 22,014 | 2.23 |
| | 0500 | ^c 3,061 | 8,880 | 11,941 | 1.21 |
| | 0600 | ^b 965 | 6,599 | 7,563 | 0.77 |
| | 0700 | 380 | 943 | 1,322 | 0.13 |
| | 0800 | 1,465 | 2,298 | 3,763 | 0.38 |
| | 0900 | 312 | 1,633 | 1,946 | 0.20 |
| | 1000 | 633 | 2,518 | 3,151 | 0.32 |
| | 1100 | 1,718 | 7,547 | 9,265 | 0.94 |
| Total | | 121,144 | 864,246 | 985,389 | 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, 1999.

| Smolt Day ^a | Age 1. | | | Age 2. | | | All Ages | |
|------------------------|------------|---------|------------------|--------|---------|------------------|-------------|------------------|
| | Number | Percent | Cumulative Total | Number | Percent | Cumulative Total | Daily Total | Cumulative Total |
| 5/26 | 2,439 | 99.1 | 2,439 | 21 | 0.9 | 21 | 2,460 | 2,460 |
| 5/27 | 4,568 | 99.1 | 7,007 | 41 | 0.9 | 62 | 4,609 | 7,069 |
| 5/28 | 261,785 | 99.1 | 268,792 | 2,350 | 0.9 | 2,412 | 264,135 | 271,204 |
| 5/29 | 951,765 | 99.1 | 1,220,557 | 8,546 | 0.9 | 10,958 | 960,311 | 1,231,515 |
| 5/30 | 4,858 | 99.1 | 1,225,415 | 43 | 0.9 | 11,001 | 4,901 | 1,236,416 |
| 5/31 | 77,908 | 99.1 | 1,303,323 | 699 | 0.9 | 11,700 | 78,607 | 1,315,023 |
| 6/01 | 237,193 | 96.4 | 1,540,516 | 8,857 | 3.6 | 20,557 | 246,050 | 1,561,073 |
| 6/02 | 249,143 | 96.6 | 1,789,659 | 8,849 | 3.4 | 29,406 | 257,992 | 1,819,065 |
| 6/03 | 123,489 | 96.6 | 1,913,148 | 4,386 | 3.4 | 33,792 | 127,875 | 1,946,940 |
| 6/04 | 225,070 | 96.6 | 2,138,218 | 7,994 | 3.4 | 41,786 | 233,064 | 2,180,004 |
| 6/05 | 152,376 | 96.6 | 2,290,594 | 5,412 | 3.4 | 47,198 | 157,788 | 2,337,792 |
| 6/06 | 292,288 | 99.3 | 2,582,882 | 2,030 | 0.7 | 49,228 | 294,318 | 2,632,110 |
| 6/07 | 646,332 | 99.3 | 3,229,214 | 4,490 | 0.7 | 53,718 | 650,822 | 3,282,932 |
| 6/08 | 355,053 | 99.3 | 3,584,267 | 2,466 | 0.7 | 56,184 | 357,519 | 3,640,451 |
| 6/09 | 1,377,700 | 100.0 | 4,961,967 | 0 | 0.0 | 56,184 | 1,377,700 | 5,018,151 |
| 6/10 | 4,171,058 | 100.0 | 9,133,025 | 0 | 0.0 | 56,184 | 4,171,058 | 9,189,209 |
| 6/11 | 1,342,366 | 100.0 | 10,475,391 | 0 | 0.0 | 56,184 | 1,342,366 | 10,531,575 |
| 6/12 | 100,038 | 100.0 | 10,575,429 | 0 | 0.0 | 56,184 | 100,038 | 10,631,613 |
| | 10,575,429 | 99.5 | | 56,184 | 0.5 | | 10,631,613 | |

^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, 1999.

| Smolt Day ^a | Mean Weight of Smolt (g) | Smolt per Count |
|------------------------|--------------------------|-----------------|
| 5/26 | 7.1 | 5.8 |
| 5/27 | 7.1 | 5.8 |
| 5/28 | 7.1 | 5.8 |
| 5/29 | 7.1 | 5.8 |
| 5/30 | 7.1 | 5.8 |
| 5/31 | 7.1 | 5.8 |
| 6/01 | 7.1 | 5.9 |
| 6/02 | 7.3 | 5.7 |
| 6/03 | 7.3 | 5.7 |
| 6/04 | 7.3 | 5.7 |
| 6/05 | 7.3 | 5.7 |
| 6/06 | 6.6 | 6.2 |
| 6/07 | 6.6 | 6.2 |
| 6/08 | 6.6 | 6.2 |
| 6/09 | 6.0 | 7.0 |
| 6/10 | 6.0 | 7.0 |
| 6/11 | 6.0 | 7.0 |
| 6/12 | 6.0 | 7.0 |

^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, 1999.

| 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 |
| 5/29 | 89 | 15.6 | 6.5 | 3.44 | 49 | 110 | | 11.5 | | 1 |
| 5/30 | | | | | | | | | | |
| 5/31 | 90 | 12.1 | 6.3 | 2.36 | 49 | 128 | | 18.7 | | 1 |
| 6/01 | 90 | 12.4 | 6.5 | 2.88 | 60 | | | | | 0 |
| 6/02 | | | | | | | | | | |
| 6/03 | 92 | 9.5 | 7.2 | 2.33 | 26 | 131 | 7.4 | 20.7 | 2.66 | 4 |
| 6/04 | 95 | 11.0 | 8.3 | 4.13 | 17 | 129 | 9.1 | 19.1 | 3.87 | 3 |
| 6/05 | 91 | 11.0 | 6.9 | 2.43 | 50 | | | | | 0 |
| 6/06 | | | | | | | | | | |
| 6/07 | 88 | 14.7 | 6.3 | 3.26 | 40 | | | | | 0 |
| 6/08 | 93 | 8.1 | 7.3 | 2.10 | 25 | | | | | 0 |
| 6/09 | | | | | | | | | | |
| 6/10 | 90 | 14.1 | 6.3 | 2.93 | 60 | | | | | 0 |
| Total Mean | 91 | | 6.8 | | 376 | 125 | | 17.5 | | 9 |

^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, 1999.

| 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 |
| 5/23 | 95 | 9.2 | 7.6 | 19 | | | | 0 |
| 5/24 | 92 | 16.9 | 7.0 | 73 | 121 | 14.3 | 16.2 | 2 |
| 5/25 | 97 | 6.2 | 8.2 | 12 | | | | 0 |
| 5/26 | 93 | 3.8 | 7.2 | 4 | | | | 0 |
| 5/27 | 95 | | 7.5 | 1 | | | | 0 |
| 5/28 | | | | 0 | | | | 0 |
| 5/29 | 91 | 21.7 | 6.8 | 161 | 120 | 5.9 | 15.4 | 2 |
| 5/30 | 88 | 12.1 | 6.2 | 7 | | | | 0 |
| 5/31 | 91 | 20.3 | 6.7 | 221 | 136 | 4.2 | 22.7 | 2 |
| 6/01 | 90 | 21.3 | 6.6 | 434 | 123 | 16.8 | 16.7 | 23 |
| 6/02 | 84 | 17.4 | 5.7 | 4 | | | | 0 |
| 6/03 | 93 | 14.7 | 7.1 | 106 | 121 | 12.0 | 16.2 | 12 |
| 6/04 | 95 | 18.8 | 7.6 | 151 | 119 | 10.5 | 15.4 | 7 |
| 6/05 | 91 | 20.8 | 6.7 | 311 | 159 | 42.8 | 41.3 | 2 |
| 6/06 | 90 | 6.4 | 6.5 | 5 | | | | 0 |
| 6/07 | 87 | 19.8 | 6.0 | 208 | 124 | | 16.9 | 1 |
| 6/08 | 90 | 15.2 | 6.6 | 146 | 119 | 11.3 | 15.4 | 4 |
| 6/09 | | | | 0 | | | | 0 |
| 6/10 | 89 | 21.3 | 6.4 | 327 | | | | 0 |
| 6/11 | 75 | 14.6 | 4.0 | 6 | | | | 0 |
| 6/12 | 77 | 16.4 | 4.4 | 15 | | | | 0 |
| Total Mean | 90 | | 6.6 | 2,211 | 127 | | 19.6 | 55 |

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

Age 1. $a = -10.7498$ $b = 2.8021$ $r^2 = 0.77$ $n = 376$

Age 2. $a = -11.6497$ $b = 3.0038$ $r^2 = 0.97$ $n = 9$

Discriminating Length = 108.5 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 26 to June 12, 1999.

| | 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 | 60 | 0 | 43 | 0 | 51 |
| Mean | 5 | 64 | 9 | 67 | 7 | 66 |
| Maximum | 10 | 68 | 17 | 85 | 13 | 76 |
| n | 3 | 3 | 12 | 12 | 15 | 15 |

^a Average depth of inshore array on smolt day 6/10 was 270 cm.

^b Average depth of offshore array on smolt day 6/10 was 303 cm.

Table 24. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Ugashik River, 1999.

| Date | Cloud Cover ^a | | Precipitation (mm) | Wind Direction & Velocity (km/h) | | Air Temperature ^l (°C) | | Water Temperature (°C) | | Water Clarity ^c |
|------|--------------------------|------|-----------------------|--|-----------|--------------------------------------|------|---------------------------|------|-------------------------------|
| | 0800 | 2000 | | 0800 | 2000 | 0800 | 2000 | 0800 | 2000 | |
| 5/18 | 5 | 4 | 0.0 | SW 13 | 0 | 2.2 | na | 1.0 | 1.0 | clear |
| 5/19 | 1 | 1 | 0.0 | E 16 | E 16 | 6.1 | na | 1.0 | 1.0 | clear |
| 5/20 | 1 | 2 | 0.0 | NE 08 | NE 16 | 7.2 | na | 1.5 | 1.0 | clear |
| 5/21 | 3 | 2 | 0.0 | 0 | SE 16 | 4.4 | na | 1.0 | 1.0 | clear |
| 5/22 | 2 | 2 | trace | 0 | 0 | 6.1 | na | 1.0 | 1.0 | clear |
| 5/23 | 3 | 3 | trace | 0 | 0 | 4.4 | na | 1.0 | 1.0 | clear |
| 5/24 | 5 | 4 | trace | SW 32 | 0 | 0.6 | na | 2.0 | 1.0 | clear |
| 5/25 | 4 | 4 | trace | SW 24 | 0 | -0.6 | na | 1.0 | 1.0 | clear |
| 5/26 | 4 | 4 | trace | SW 24 | WSW 19 | -0.6 | 2.8 | 1.0 | 2.0 | clear |
| 5/27 | 4 | 2 | trace | SW 16 | E 0-08 | 2.2 | 4.4 | 1.0 | 1.0 | clear |
| 5/28 | 4 | 4 | trace | 0 | ENE 40 | 3.3 | 3.9 | 1.5 | 1.0 | clear |
| 5/29 | 4 | 4 | 2.0 | ENE 24 | E 24 | 2.2 | 5.0 | 4.0 | 4.0 | lt brown |
| 5/30 | 4 | 1 | 11.0 | WSW 35 | SW 32-40 | 3.3 | 3.9 | 2.0 | 3.0 | murky |
| 5/31 | 4 | 4 | 1.0 | S 08 | NE 0-08 | 3.3 | 4.4 | 2.0 | 4.0 | clear |
| 6/01 | 4 | 4 | 4.5 | SE 19 | WSW 16 | 3.3 | 6.1 | 3.0 | 3.0 | clear |
| 6/02 | 4 | 4 | 4.0 | SW 11 | WSW 32 | 4.4 | 3.9 | 4.5 | 2.0 | clear |
| 6/03 | 4 | 4 | 1.0 | SW 16 | WSW 29 | 1.7 | 3.3 | 4.0 | 2.0 | clear |
| 6/04 | 4 | 4 | 0.0 | SW 24 | WSW 29 | 2.2 | 2.8 | 3.0 | 2.0 | clear |
| 6/05 | 4 | 2 | 0.0 | W 0-08 | WSW 24 | 1.1 | 8.3 | 2.5 | 3.0 | clear |
| 6/06 | 3 | 4 | 5.0 | NE 0-08 | E 39 | 7.8 | 5.6 | 2.5 | 6.0 | clear |
| 6/07 | 5 | 4 | 20.0 | SE 32 | W 16 | 5.0 | 4.4 | 5.0 | 5.0 | clear |
| 6/08 | 4 | 4/5 | 5.0 | SW 08 | SE 0-08 | 3.9 | 5.6 | 2.5 | 3.0 | clear |
| 6/09 | 5 | 4 | 1.0 | 0 | ENE 40-56 | 4.4 | 6.7 | 2.5 | 4.0 | clear |
| 6/10 | 3 | 4 | 0.0 | E 45 | E 24 | 6.7 | 7.2 | 5.0 | 5.0 | murky |
| 6/11 | 4 | 4 | 0.0 | SE 16 | SE 19 | 6.1 | 6.1 | 5.0 | 5.5 | lt brown |
| 6/12 | 4 | 4 | 1.0 | NE 08 | NE 08 | 6.1 | 10.0 | 5.0 | 6.0 | clear |
| 6/13 | 4 | na | na | 0 | na | 8.3 | na | 4.0 | na | 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 na = not available

^c 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, 1955-1999.

| 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) |
| 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 |
| 1998 | 1996 | 65 | 90 | 6.7 | 1995 | 35 | 112 | 11.9 | 1994 | 0 | — | — | 295,470,850 |
| Mean | | | 87 | 5.9 | | | 107 | 10.4 | | | 108 | 11.2 | |
| 1999 | 1997 | 92 | 86 | 5.8 | 1996 | 8 | 108 | 10.3 | 1995 | 0 | — | — | 143,543,215 |
| % Difference from Mean | | | -2 | -1 | | | 1 | -1 | | | | | |

^a Estimates of smolt numbers from 1955 to 1970 based on fyke net catches; estimates of smolt numbers from 1971 to present based on hydroacoustic techniques.

Table 26. Water temperatures at sockeye salmon smolt counting site, Kvichak River, 1963-1999.

| 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 |
| 1998 | May 18 - June 13 | 2.0 | 6.2 | 9.5 |
| Mean | | 2.9 | 5.9 | 9.3 |
| 1999 | May 23 - June 17 | 0.0 | 2.9 | 8.0 |
| Difference from Mean | | -2.9 | -3.0 | -1.3 |

Table 27. Sockeye salmon spawning escapement, total number of smolt produced by age class, percent of total smolt production by each age class, and number of smolt produced per spawner for 1968-1997 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 | |
| 1968 | | | | 5,959,383 | | 0 | - | - |
| 1969 | 8,394,204 | 85,723,430 | 61 | 54,159,340 | 39 | 0 | 139,882,770 | 16.7 |
| 1970 | 13,935,306 | 464,219 | < 1 | 191,842,930 | 98 | 2,918,768 | 195,225,917 | 14.0 |
| 1971 | 2,387,392 | 5,123,400 | 19 | 21,423,246 | 81 | 0 | 26,546,646 | 11.1 |
| 1972 | 1,009,962 | 2,740,610 | | - | | - | - | - |
| 1973 | 226,554 | - | | 3,031,287 | | 0 | - | - |
| 1974 | 4,433,844 | 108,356,892 | 49 | 114,269,848 | 51 | 0 | 222,626,740 | 50.2 |
| 1975 | 13,140,450 | 78,308,251 | 27 | 213,364,470 | 73 | 0 | 291,672,721 | 22.2 |
| 1976 | 1,965,282 | 32,226,544 | 55 | 26,423,348 | 45 | 0 | 58,649,892 | 29.8 |
| 1977 | 1,341,144 | 28,758,191 | 73 | 10,410,467 | 27 | 0 | 39,168,658 | 29.2 |
| 1978 | 4,149,288 | 182,442,540 | 85 | 32,294,536 | 15 | 0 | 214,737,076 | 51.8 |
| 1979 | 11,218,434 | 219,928,232 | 71 | 89,300,703 | 29 | 0 | 309,228,935 | 27.6 |
| 1980 | 22,505,268 | 150,421,026 | 66 | 76,244,773 | 34 | 0 | 226,665,799 | 10.1 |
| 1981 | 1,754,358 | 6,549,125 | 15 | 37,595,987 | 85 | 0 | 44,145,112 | 25.2 |
| 1982 | 1,134,840 | 51,893,988 | 96 | 1,937,408 | 4 | 2,065 | 53,833,461 | 47.4 |
| 1983 | 3,569,982 | 23,590,443 | 31 | 53,260,693 | 69 | 123,975 | 76,975,111 | 21.6 |
| 1984 | 10,490,670 | 83,470,460 | 20 | 331,384,545 | 80 | 43,135 | 414,898,140 | 39.5 |
| 1985 | 7,211,046 | 11,178,398 | 11 | 87,004,194 | 89 | 30,345 | 98,212,937 | 13.6 |
| 1986 | 1,179,322 | 13,126,363 | 66 | 6,830,717 | 34 | 0 | 19,957,080 | 16.9 |
| 1987 | 6,065,880 | 146,603,154 | 78 | 41,434,534 | 22 | 0 | 188,037,688 | 31.0 |
| 1988 | 4,065,216 | 46,569,569 | 58 | 34,266,421 | 42 | 0 | 80,835,990 | 19.9 |
| 1989 | 8,317,500 | 87,187,761 | 59 | 61,317,308 | 41 | 0 | 148,505,069 | 17.9 |
| 1990 | 6,970,020 | 18,172,700 | 8 | 204,626,879 | 92 | 0 | 222,799,579 | 32.0 |
| 1991 | 4,222,788 | 21,781,009 | 42 | 30,207,268 | 58 | 0 | 51,988,277 | 12.3 |
| 1992 | 4,725,864 | 53,638,204 | 83 | 11,034,144 | 17 | 0 | 64,672,348 | 13.7 |
| 1993 | 4,025,166 | 209,857,983 | 69 | 96,434,554 | 31 | 0 | 306,292,537 | 76.1 |
| 1994 | 8,337,840 | 276,731,978 | 75 | 94,049,964 | 25 | 0 | 370,781,942 | 44.5 |
| 1995 | 10,038,720 | 269,347,699 | 72 | 103,481,449 | 28 | 0 | 372,829,148 | 37.1 |
| 1996 | 1,450,578 | 191,989,401 | 94 | 12,200,727 | 6 | ^c | 204,190,128 ^c | 140.8 ^c |
| 1997 | 1,497,432 | 131,342,488 | | ^c | | ^c | ^c | ^c |
| 1985-1994 Max | 8,337,840 | 276,731,978 | 83 | 204,626,879 | 92 | 30,345 | 370,781,942 | 76.1 |
| 1985-1994 Avg | 5,512,064 | 88,484,712 | 55 | 66,720,598 | 45 | 3,035 | 155,208,345 | 27.8 |
| 1985-1994 Min | 1,179,322 | 11,178,398 | 8 | 6,830,717 | 17 | 0 | 19,957,080 | 12.3 |

^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 1968-1997 brood years, Kvichak River.

| Brood Year | Total Spawning Escapement ^a | Age 1. | | | Age 2. | | |
|---------------|--|-----------------|----------------------------|-------------------------|-----------------|----------------------------|-------------------------|
| | | Number of Smolt | Adult ^b Returns | Adult Returns per Smolt | Number of Smolt | Adult ^b Returns | Adult Returns per Smolt |
| 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 | 0.03 ^c |
| 1973 | 226,554 | - | 1,606,766 | 0.00 ^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 | 871,783 | 0.03 |
| 1992 | 4,725,864 | 53,638,204 | 656,610 | 0.01 | 11,034,144 | 730,567 | 0.07 |
| 1993 | 4,025,166 | 209,857,983 | 1,785,575 | 0.01 | 96,434,554 | 1,178,783 ^d | 0.01 ^d |
| 1994 | 8,337,840 | 276,731,978 | 2,976,624 ^d | | 94,049,964 | 3,728,795 ^d | |
| 1995 | 10,038,720 | 269,347,699 | 7,609,634 ^d | | 103,481,449 | 0 ^d | |
| 1996 | 1,450,578 | 191,989,401 | 0 ^d | | 12,200,727 | 0 ^d | |
| 1997 | 1,497,432 | 131,342,488 | 0 ^d | | | | |
| 1983-1992 Max | 10,490,670 | 146,603,154 | 11,612,066 | 0.49 | 331,384,545 | 22,351,542 | 0.40 |
| 1983-1992 Avg | 5,681,829 | 50,531,806 | 4,301,468 | 0.14 | 86,136,670 | 9,544,827 | 0.15 |
| 1983-1992 Min | 1,179,322 | 11,178,398 | 656,610 | 0.01 | 6,830,717 | 730,567 | 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 1999.

^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, 1981-1992.

| Smolt Outmigration Year | Brood Years | Freshwater Age | Proportion of Total | | | Comments |
|-------------------------------|----------------|-------------------|---------------------|-------|------------|---|
| | | | Smolt | Adult | Difference | |
| 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. | 0.83 | 0.47 | 0.36 | Ice problems - 5/17- 5/28 continuous. |
| | 1991 | Age 2. | 0.58 | 0.18 | 0.40 | |
| 1995 | 1993 | Age 1. | 0.69 | 0.60 | 0.09 | Ice problems - 5/17- 5/21 continuous. |
| | 1992 | Age 2. | 0.17 | 0.52 | -0.35 | |

Table 30. Visual observations made at the Egegik River smolt sonar site by ADF&G personnel from June 15-20, 1999.

| Date | Hour | Observation ^a |
|------|-----------|---|
| 6/15 | 1900 | Lots of birds feeding activity in the Egegik River at the rapids below Becharof Lake. They were catching smolt regularly. I could also see smolt schools passing among the ice floes. |
| 6/16 | 1400 | Same as yesterday. Lots of smolt. |
| 6/18 | 1600 | Large flocks of gulls actively feeding in Egegik Lagoon, just downstream from the smolt sonar tent platform. The gulls were too far away to determine what they were actually feeding on, however I suspect they were eating smolt. This went on for several hours. |
| 6/19 | 0001-0400 | While working the night shift at Egegik Tower, I saw schools of smolt on the surface of the water near the middle of the river as I motored my boat across the river between counting towers. There was no wind and the surface of the water was flat calm. I did not see any smolt schools from the counting tower because the tower lights do not illuminate the middle of the river. |
| 6/20 | 0001-0400 | When I was crossing the river, I only saw one smolt school tonight. However the wave action generated by a slight breeze made it harder to see smolt. |

^a Visual observations were made by ADF&G Fish and Wildlife Technician Tom Kerns, who worked at the Egegik Smolt and Egegik Tower projects and stayed at the Egegik cabin during the transition between these projects.

Table 31. Age composition of total migration and mean fork length and weight by age class for sockeye salmon smolt, Egegik River, 1939-1999.

| 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 |
| 1998 | 1996 | 64 | 105 | 9.0 | 1995 | 35 | 121 | 13.7 | 1994 | 1 | 132 | 16.2 | 78,791,125 |
| Mean | | | 103 | 9.7 | | | 117 | 14.2 | | | 132 | 19.9 | |
| 1999 | 1997 | 9 | 107 | 9.9 | 1996 | 87 | 127 | 16.5 | 1995 | 2 | 140 | 19.2 | 8,592,482 |
| % Difference from Mean | | | 4 | 3 | | | 9 | 16 | | | 6 | -4 | |

^a No estimate of smolt numbers for 1939-1981 fyke net catches; estimates of smolt numbers from 1982-1999 based on hydroacoustic techniques.

Table 32. Water temperatures at sockeye salmon smolt counting site, Egegik River, 1981-1999.

| 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 |
| 1998 | May 19 - June 11 | 2.5 | 4.9 | 7.0 |
| Mean | | 3.3 | 6.4 | 9.7 |
| 1999 | May 21 - June 14 | 0.0 | 2.2 | 8.0 |
| Difference from Mean | | -3.3 | -4.2 | -1.7 |

Table 33. Sockeye salmon spawning escapement, total number of smolt produced by age class, percent of total smolt production composed by each age class, and number of smolt produced per spawner for 1978-1997 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 62.4 | |
| 1981 | 694,680 | 2,242,326 | 6 | 32,235,734 | 93 | 52,852 | 0 | 34,530,912 49.7 | |
| 1982 | 1,034,628 | 17,234,269 | 60 | 11,434,848 | 40 | 564 | 0 | 28,669,681 27.7 | |
| 1983 | 792,282 | 54,585,828 | 64 | 29,984,140 | 35 | 85,087 | 0 | 84,655,055 106.8 ^c | |
| 1984 | 1,165,320 | 14,016,441 | 24 | 45,386,536 | 76 | 80,931 | 0 | 59,483,908 51.0 | |
| 1985 | 1,095,192 | 4,397,087 | 26 | 12,758,135 | 74 | 81,150 | 0 | 17,236,372 15.7 | |
| 1986 | 1,151,750 | 36,122,149 | 57 | 27,347,612 | 43 | 0 | 0 | 63,469,761 55.1 | |
| 1987 | 1,272,978 | 72,458,024 | 58 | 52,299,487 | 42 | 396,423 | 0 | 125,153,934 98.3 ^c | |
| 1988 | 1,612,680 | 3,795,739 | 4 | 89,162,038 | 96 | 361,128 | 0 | 93,318,905 57.9 | |
| 1989 | 1,610,916 | 4,519,527 | 21 | 17,338,786 | 79 | 37,254 | 0 | 21,895,567 13.6 | |
| 1990 | 2,191,362 | 6,048,364 | 14 | 37,719,609 | 86 | 19,196 | 0 | 43,787,169 20.0 | |
| 1991 | 2,786,880 | 20,203,545 | 34 | 39,158,743 | 66 | 11,242 | 0 | 59,373,530 21.3 | |
| 1992 | 1,945,332 | 54,909,050 | 52 | 49,962,265 | 47 | 1,067,697 | 1 | 105,939,012 54.5 | |
| 1993 | 1,516,980 | 7,412,283 | 47 | 8,089,658 | 52 | 202,218 | 1 | 15,704,159 10.4 | |
| 1994 | 1,897,932 | 22,113,438 | 58 | 14,630,756 | 39 | 1,119,575 | 3 | 37,863,769 20.0 | |
| 1995 | 1,265,862 | 12,217,139 | 31 | 27,476,148 | 68 | 201,076 | 1 | 39,894,363 31.5 | |
| 1996 | 1,076,460 | 50,195,402 | 87 | 7,616,295 | 13 | | | 57,811,697 ^d 53.7 ^d | |
| 1997 | 1,104,004 | 775,111 | | | | | | | |
| 1985-1994 Max | 2,786,880 | 72,458,024 | 58 | 89,162,038 | 96 | 1,119,575 | 3 | 125,153,934 98.3 | |
| 1985-1994 Avg | 1,708,200 | 23,197,921 | 37 | 34,846,709 | 62 | 329,588 | 1 | 58,374,218 36.7 | |
| 1985-1994 Min | 1,095,192 | 3,795,739 | 4 | 8,089,658 | 39 | 0 | 0 | 15,704,159 10.4 | |

^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 34. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1978-1997 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 |
| 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 | ^d |
| 1992 | 1,945,332 | 54,909,050 | 1,461,902 | 0.03 | 49,962,265 | 8,185,162 | 0.16 | 1,067,697 | 71,455 ^e | |
| 1993 | 1,516,980 | 7,412,283 | 1,093,536 | 0.15 | 8,089,658 | 1,910,621 ^e | 0.24 ^e | 202,218 | 4,601 ^e | |
| 1994 | 1,897,932 | 22,113,438 | 1,360,867 ^e | 0.06 ^e | 14,630,756 | 4,311,034 ^e | | 1,119,575 | 0 ^e | |
| 1995 | 1,265,862 | 12,217,139 | 3,180,061 ^e | | 27,476,148 | 3,765 ^e | | 201,076 | | |
| 1996 | 1,076,460 | 50,195,402 | 655 ^e | | 7,616,295 | | | | | |
| 1997 | 1,104,004 | 77,511 | | | | | | | | |
| 1983-1992 Max | 2,786,880 | 72,458,024 | 5,676,245 | 0.45 | 89,162,038 | 20,199,111 | 0.58 | 1,067,697 | 412,775 | 0.49 |
| 1983-1992 Avg | 1,562,469 | 27,119,990 | 3,011,464 | 0.20 | 40,116,993 | 10,732,596 | 0.31 | 214,010 | 140,068 | 0.42 |
| 1983-1992 Min | 792,282 | 3,795,739 | 974,486 | 0.03 | 12,758,135 | 5,652,082 | 0.15 | 0 | 25,976 | 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 1999.

^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 35. 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, 1981-1992.

| 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. | 0.52 | 0.15 | 0.37 | Excellent Weather - no disabled time. |
| | 1991 | Age 2. | 0.66 | 0.52 | 0.14 | |
| 1995 | 1993 | Age 1. | - | - | | Ice problems - 5/19-5/21 and 0100-0500 hours on 5/23; good weather thereafter |
| | 1992 | Age 2. | 0.47 | 0.84 | -0.37 | |

Table 36. Age composition of total migration and mean fork length and weight by age class for sockeye salmon smolt, Ugashik River, 1958-1999.

| 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 |
| 1998 | 1996 | 82 | 91 | 6.4 | 1995 | 18 | 110 | 11.1 | 1994 | - | - | - | 12,624,441 |
| Mean | | | 91 | 6.9 | | | 112 | 12.0 | | | 128 | 17.9 | |
| 1999 | 1997 | 99 | 91 | 6.8 | 1996 | 1 | 125 | 17.5 | 1995 | - | - | - | 10,631,631 |
| % Difference from Mean | | | 0 | -2.1 | | | 12 | 45.4 | | | | | |

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

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

Table 37. Water temperatures at sockeye salmon smolt counting site, Ugashik River, 1983-1999.

| 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 |
| 1998 | May 18 - June 13 | 3.5 | 5.5 | 7.5 |
| Mean | | 3.5 | 6.1 | 8.7 |
| 1999 | May 18 - June 13 | 1.0 | 2.6 | 6.0 |
| Difference from Mean | | -2.5 | -3.4 | -2.7 |

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

Table 38. 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 1979-1997 brood years, Ugashik River.

| Brood Year | Total Spawning Escapement ^a | Number of Smolt Produced | | | | | 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 85.9 |
| 1982 | 1,157,526 | 75,491,249 | 78 | 21,407,762 | 22 | 0 | 96,899,011 83.7 |
| 1983 | 1,000,614 | 12,693,628 | 46 | 15,186,101 | 54 | 1,677 | 27,881,406 27.9 |
| 1984 | 1,241,418 | 37,890,152 | 64 | 21,483,727 | 36 | 9,598 | 59,383,477 47.8 |
| 1985 | 998,232 | 5,461,821 | 14 | 33,238,739 | 86 | 0 | 38,700,560 38.8 |
| 1986 | 1,001,492 | 182,719,678 | 85 | 32,278,743 | 15 | 0 | 214,998,421 214.7 |
| 1987 | 668,964 | 94,019,379 | 71 | 38,789,387 | 29 | 0 | 132,808,766 198.5 |
| 1988 | 642,972 | 14,837,960 | 24 | 47,713,086 | 76 | - ^c | 62,551,046 ^d 97.3 ^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 26.1 |
| 1992 | 2,173,692 | 24,305,081 | 61 | 15,272,807 | 39 | 0 | 39,577,888 18.2 |
| 1993 | 1,389,534 | 6,961,330 | 83 | 1,429,625 | 17 | 0 | 8,390,955 6.0 |
| 1994 | 1,080,858 | 1,147,187 | 49 | 1,199,949 | 51 | 0 | 2,347,136 2.2 |
| 1995 | 1,304,058 | 14,319,834 | 86 | 2,292,099 | 14 | 0 | 16,611,933 12.7 |
| 1996 | 667,518 | 10,332,342 | 99 | 56,184 | 1 | ^d | 10,388,526 ^d 15.6 ^d |
| 1997 | 618,396 | 10,545,429 | | ^d | | ^d | ^d ^d |
| 1985-1994 Max | 2,457,306 | 182,719,678 | 91 | 47,713,086 | 86 | | 214,998,421 214.7 |
| 1985-1994 Avg | 1,282,439 | 45,982,309 | 60 | 20,895,933 | 40 | | 70,428,984 75.2 |
| 1985-1994 Min | 642,972 | 1,147,187 | 14 | 1,199,949 | 9 | | 2,347,136 2.2 |

^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.

Table 39. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1979-1997 brood years, Ugashik River.

| Brood Year | Total Spawning Escapement ^a | Age 1. | | | Age 2. | | | Age 3. | | |
|---------------|--|-----------------|----------------------------|-------------------------|------------------------|----------------------------|-------------------------|-----------------|----------------------------|-------------------------|
| | | 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 |
| 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 | ^c | 0 | 9,880 | ^c |
| 1990 | 730,038 | ^d | 1,057,589 | ^c | 12,415,518 | 3,535,731 | 0.28 | 0 | 1,733 | ^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 | 1,837,467 | 0.12 | 0 | 1,181 ^e | |
| 1993 | 1,389,534 | 6,961,330 | 630,341 | 0.09 | 1,429,625 ^f | 445,332 ^e | 0.31 ^e | 0 | 0 ^e | |
| 1994 | 1,080,858 | 1,147,187 | 670,874 ^e | ^c | 1,199,949 | 703,906 ^e | | 0 | | |
| 1995 | 1,304,058 | 14,319,834 | 2,833,731 ^e | | 2,292,099 | 1,181 ^e | | | | |
| 1996 | 667,518 | 10,332,342 | 0 ^e | | 56,184 | | | | | |
| 1997 | 618,396 | 10,575,429 | | | | | | | | |
| 1983-1992 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 |
| 1983-1992 Avg | 1,259,603 | 50,701,783 | 1,812,454 | 0.07 | 24,678,183 | 2,883,889 | 0.13 | 1,253 | 8,937 | ^c |
| 1983-1992 Min | 642,972 | 5,461,821 | 784,551 | 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 1999.

^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.

Table 40. 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, 1981-1992.

| Smolt Outmigration Year | Brood Year | Freshwater Age | Proportion of Total | | | Comments |
|-------------------------------|---------------|-------------------|---------------------|--------------|------------|--|
| | | | Smolt | Adult | Difference | |
| 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 | 0.30 | | Good Weather - 42 h disabled time |
| | 1991 | Age 2. | 0.09 | 0.15 | -0.06 | |
| 1995 | 1993 | Age 1. | 0.83 | ^d | | Excellent Weather - 21 h disabled time |
| | 1992 | Age 2. | 0.39 | 0.70 | -0.31 | |

^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 adult returns from brood year escapement.

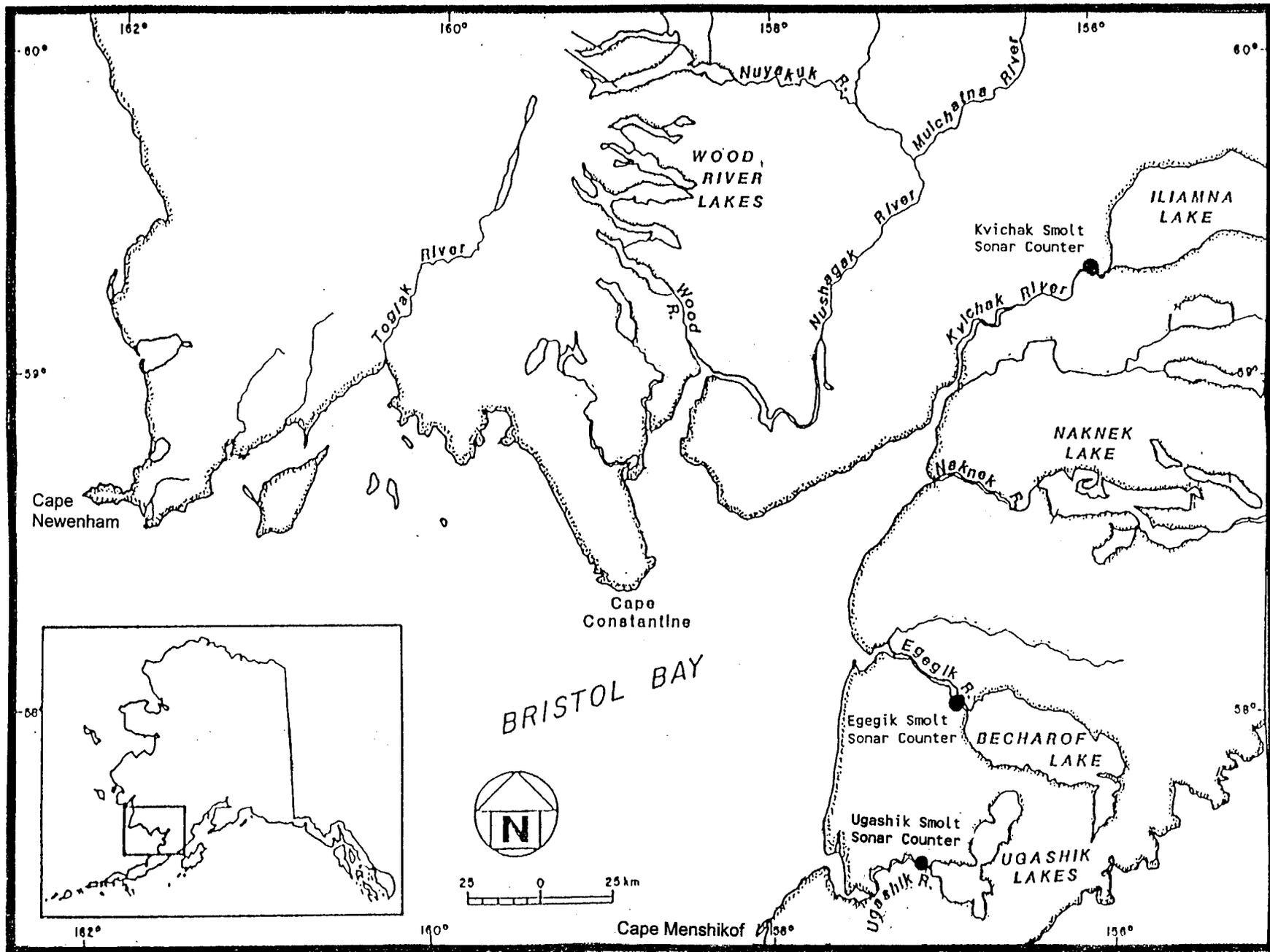


Figure 1. Locations of major rivers and smolt sonar counting sites in the Bristol Bay Management Area.

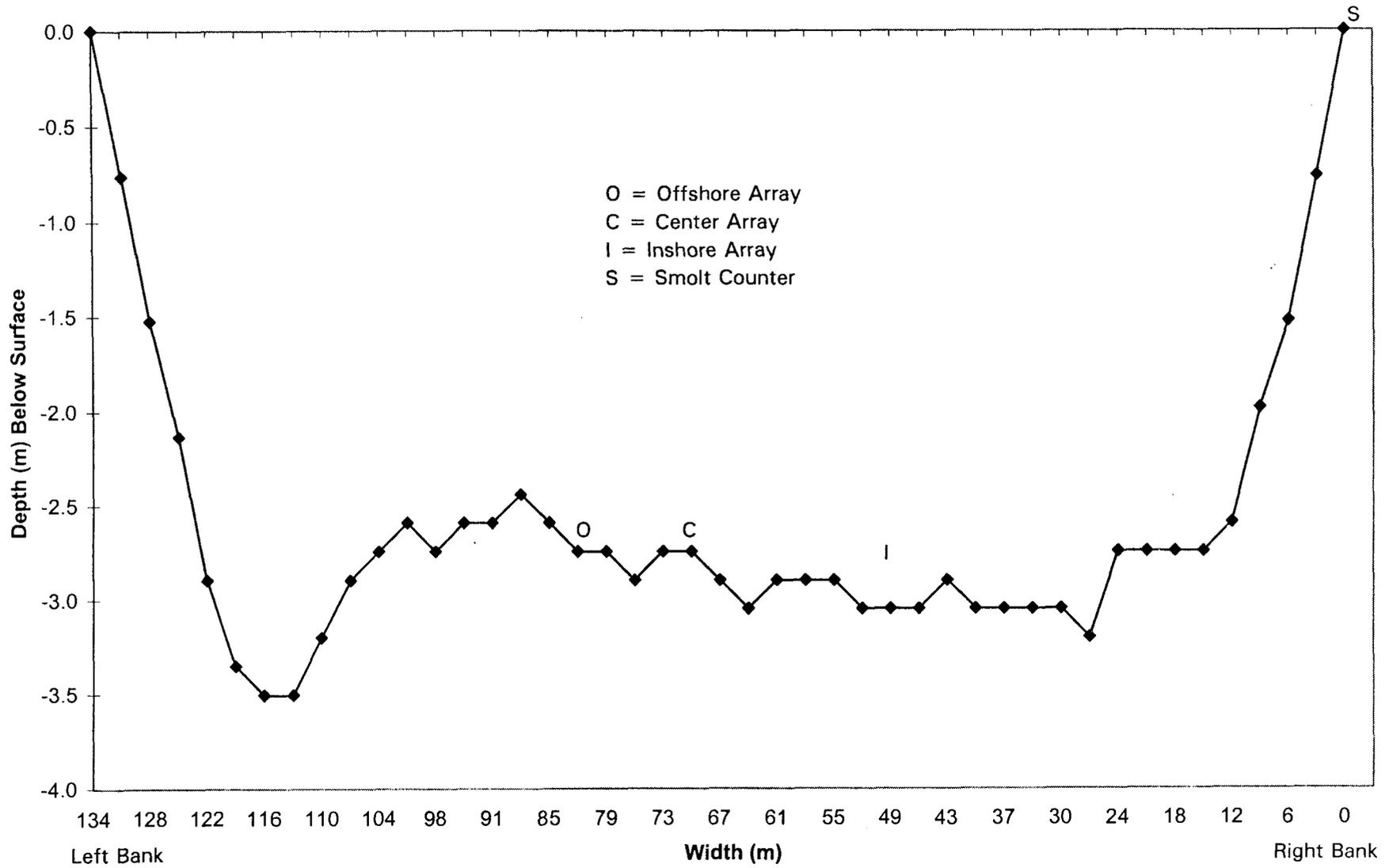


Figure 2. River bottom profile and sonar array placement at Kvichak River smolt sonar site, 1999.

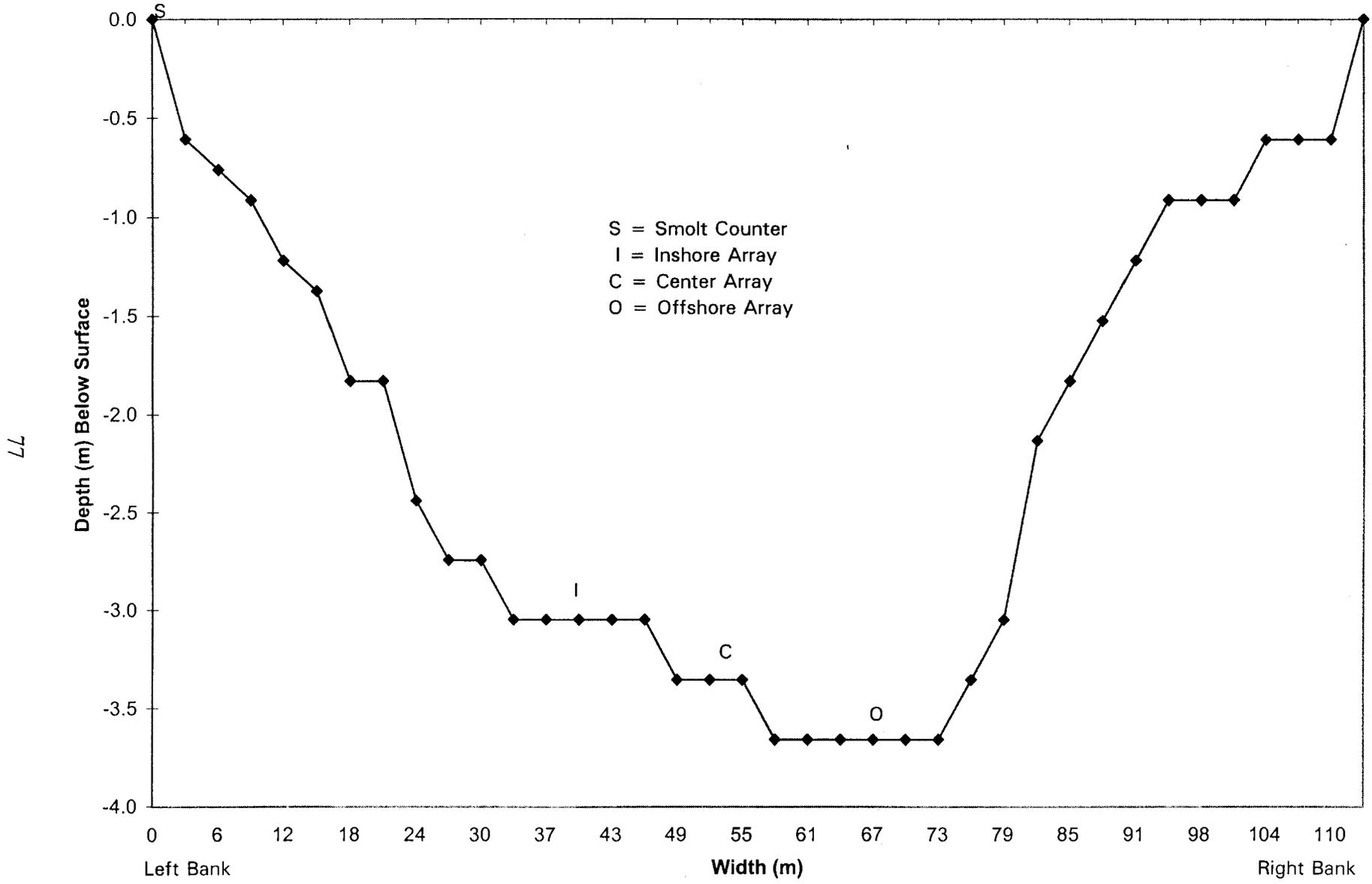


Figure 3. River bottom profile and sonar array placement at Egegik River smolt sonar site, 1999.

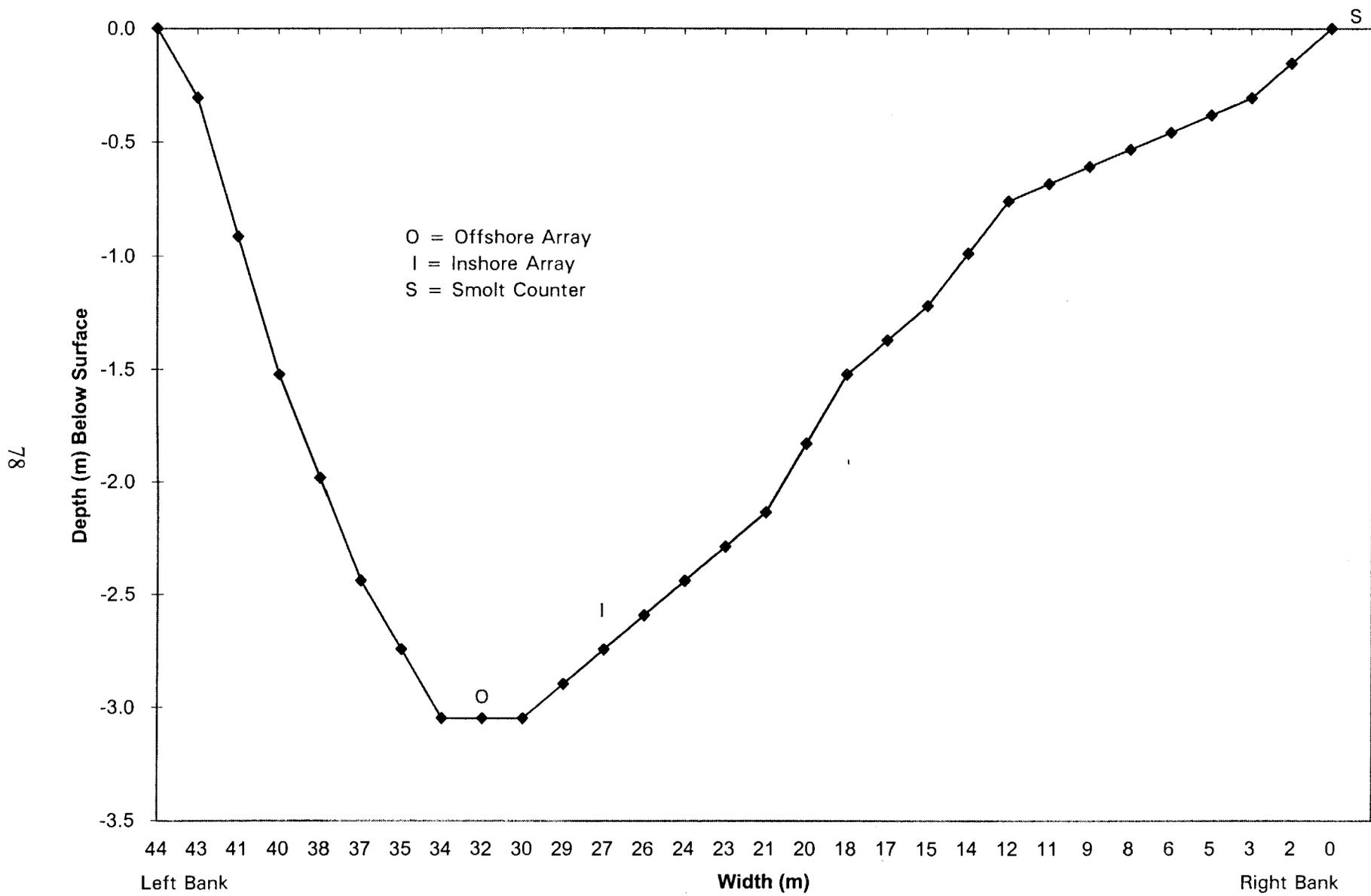


Figure 4. River bottom profile and sonar array placement at Ugashik River smolt sonar site, 1999.

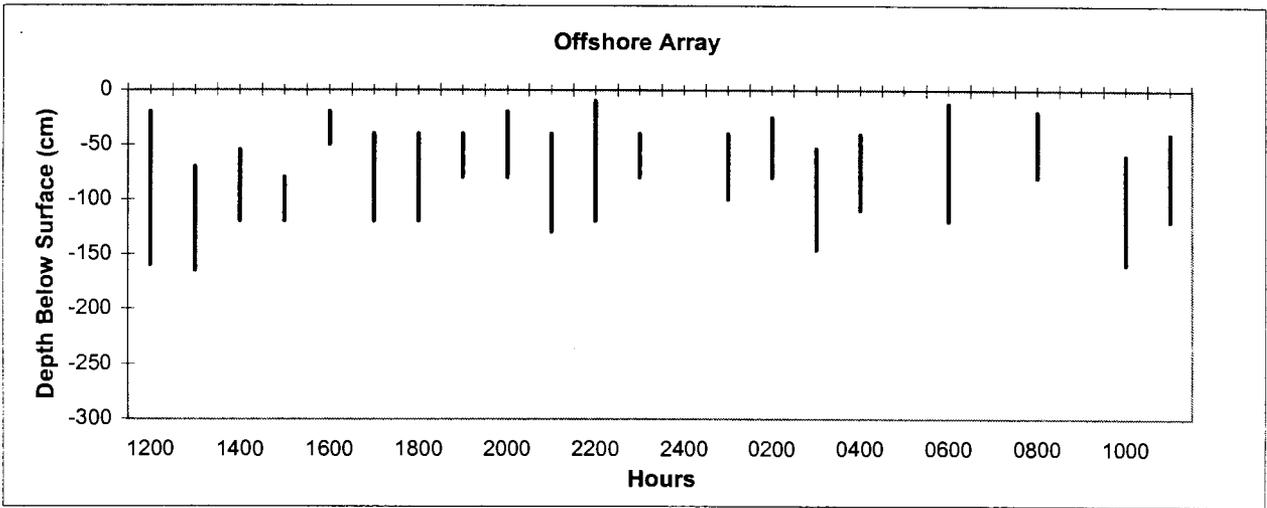
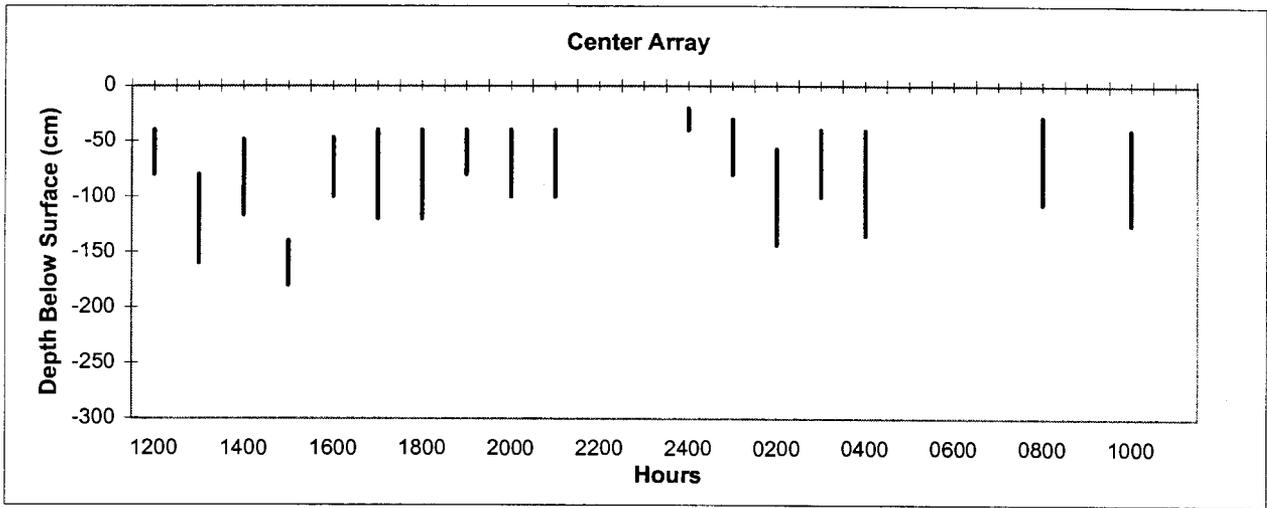
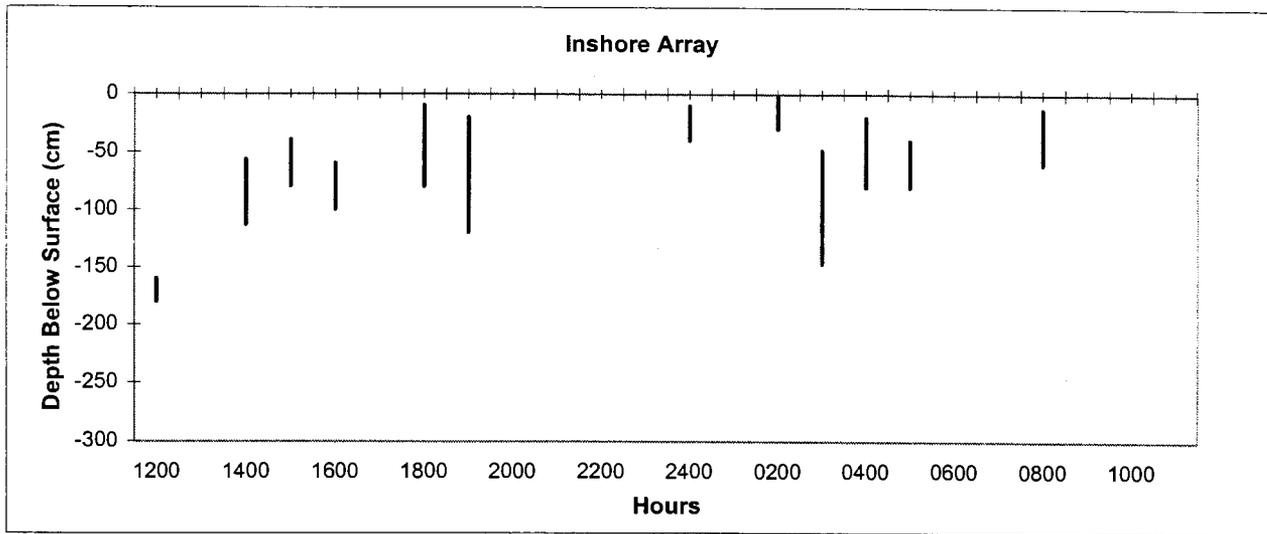


Figure 5. Depth of smolt passage data summarized by hour, Kvichak River, June 2-15, 1999.

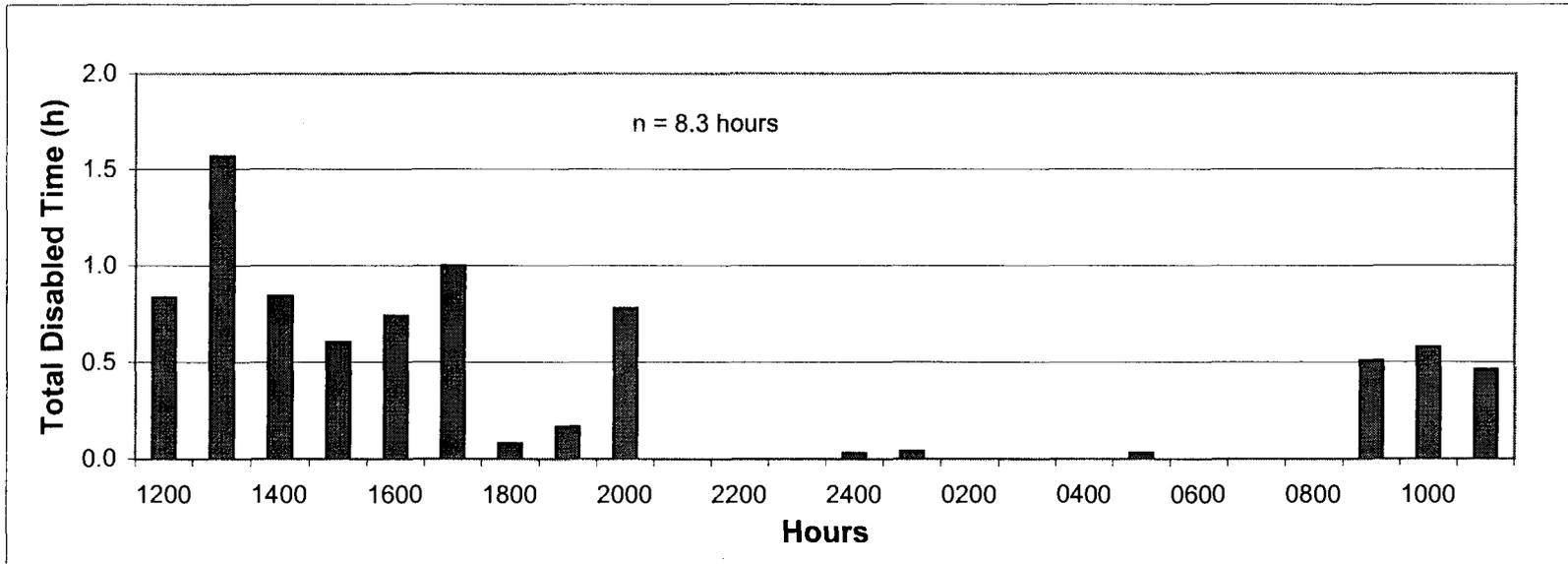
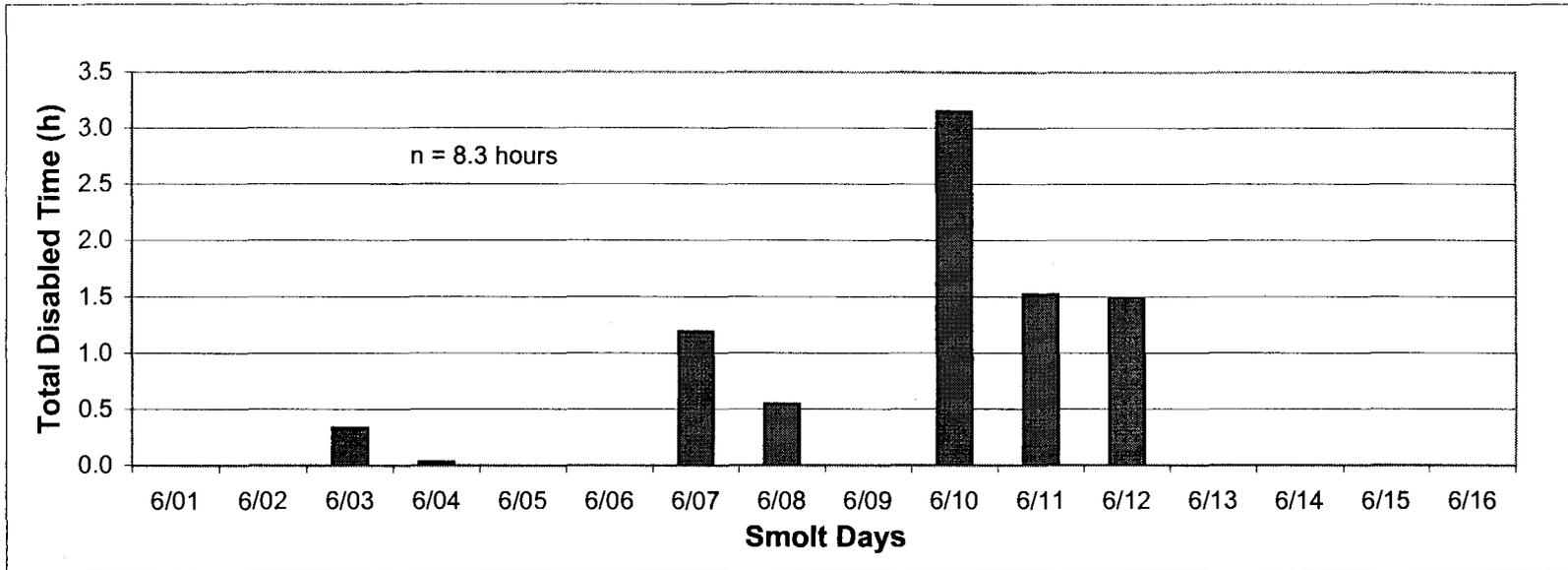


Figure 6. Kvichak River smolt sonar total disabled time due to weather by smolt day and hour, June 1-16, 1999.

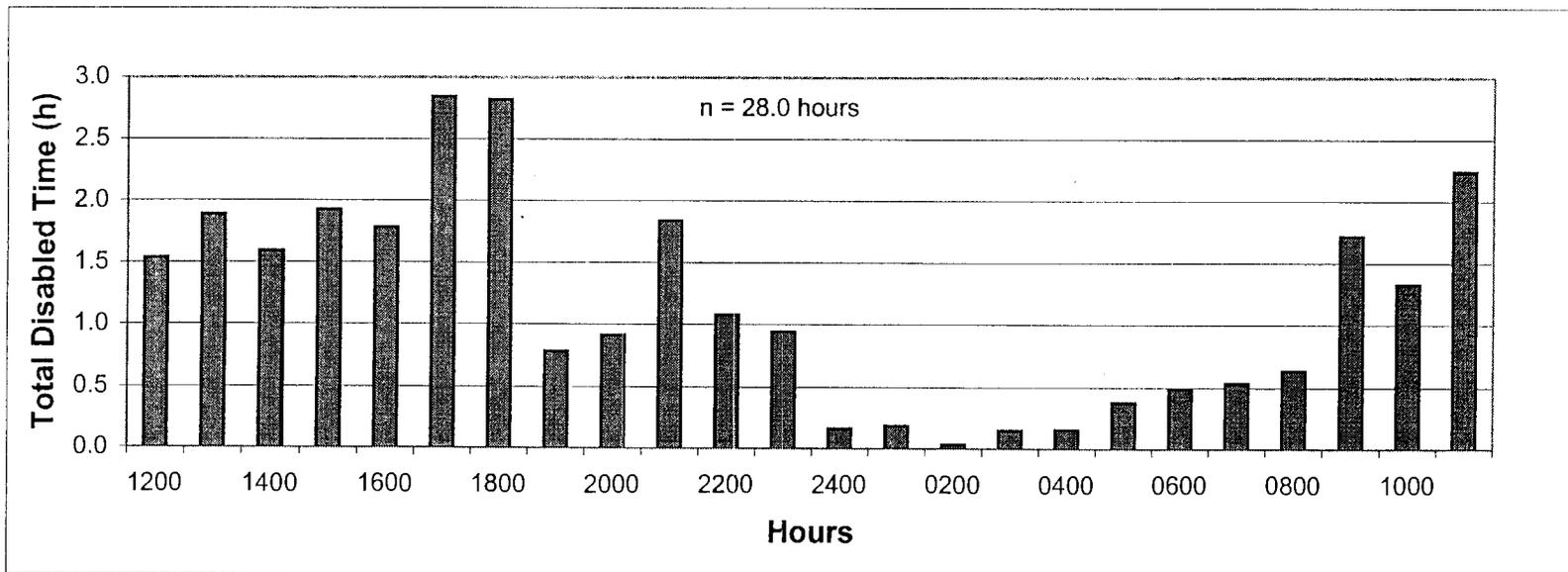
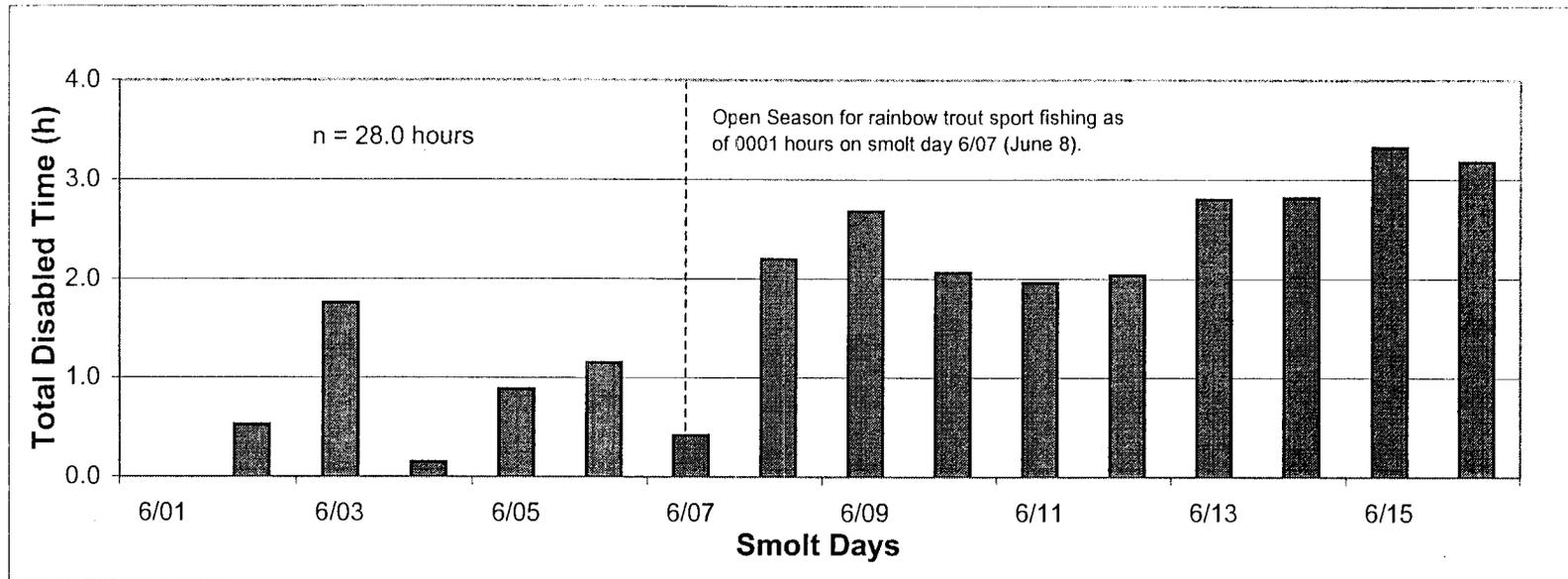


Figure 7. Kvichak River smolt sonar total disabled time due to boat traffic by smolt day and hour, June 1-16, 1999.

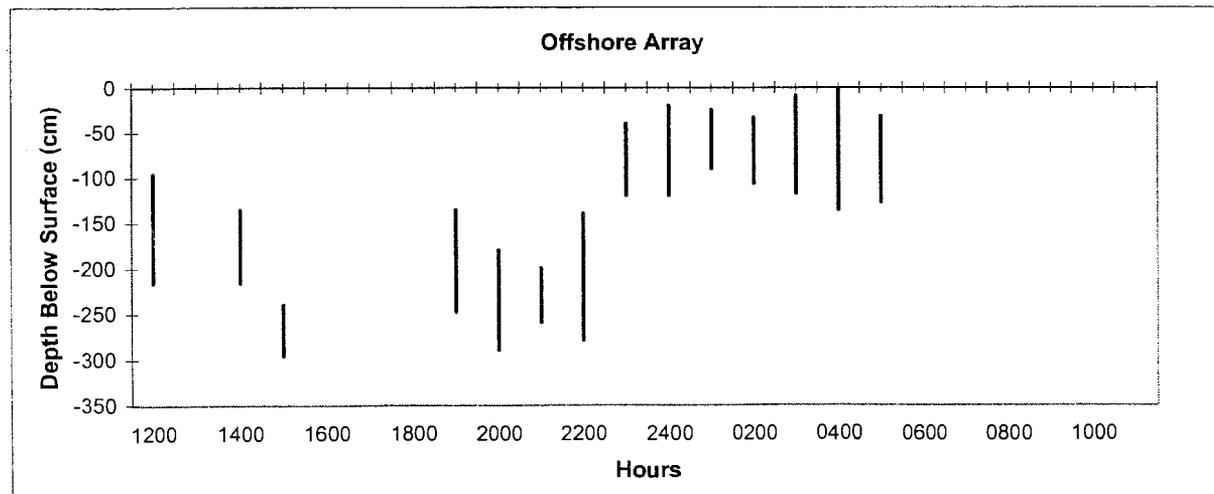
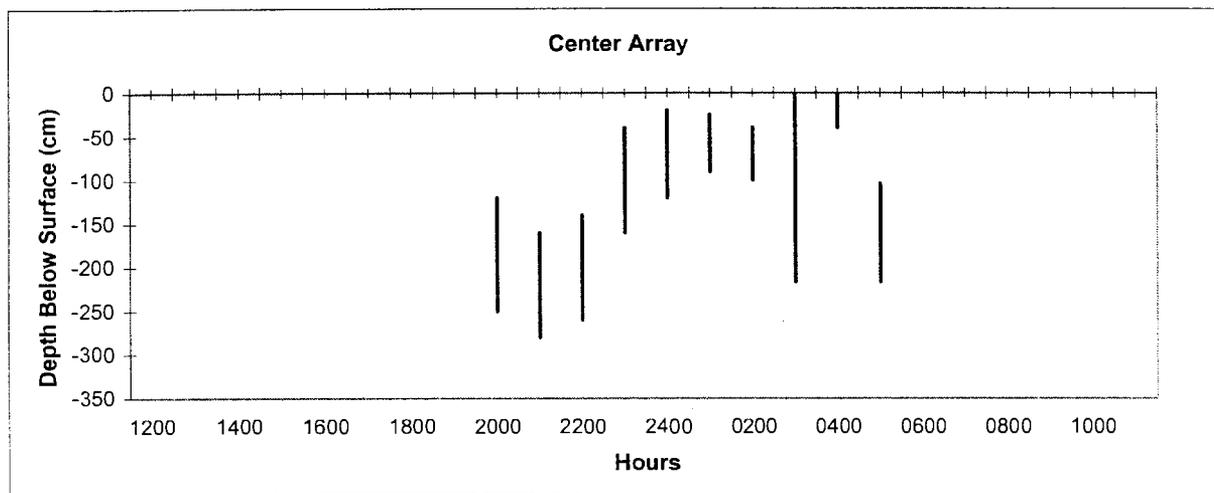
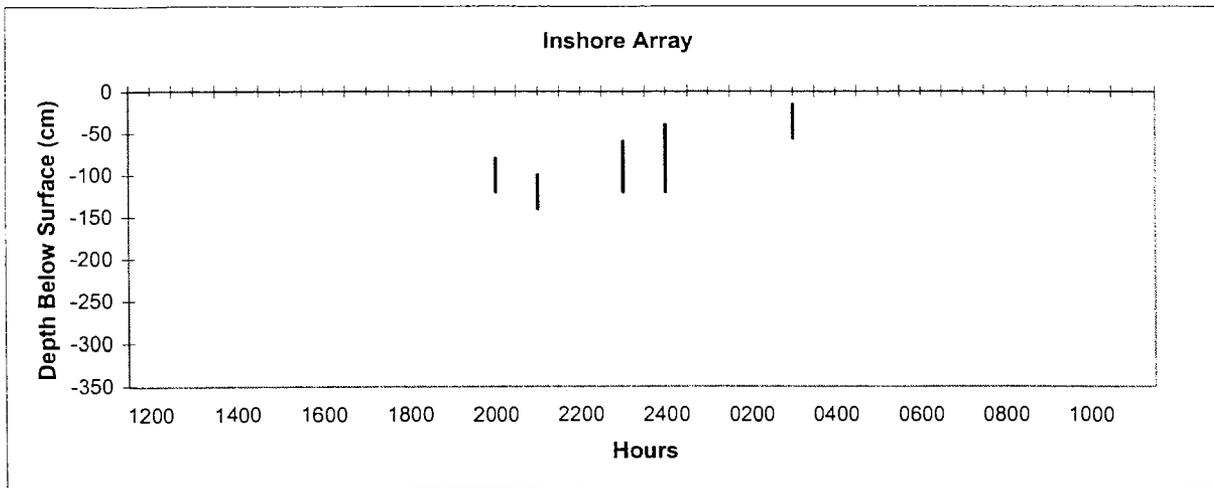


Figure 8. Depth of smolt passage data summarized by hour, Egegik River, June 4-13, 1999.

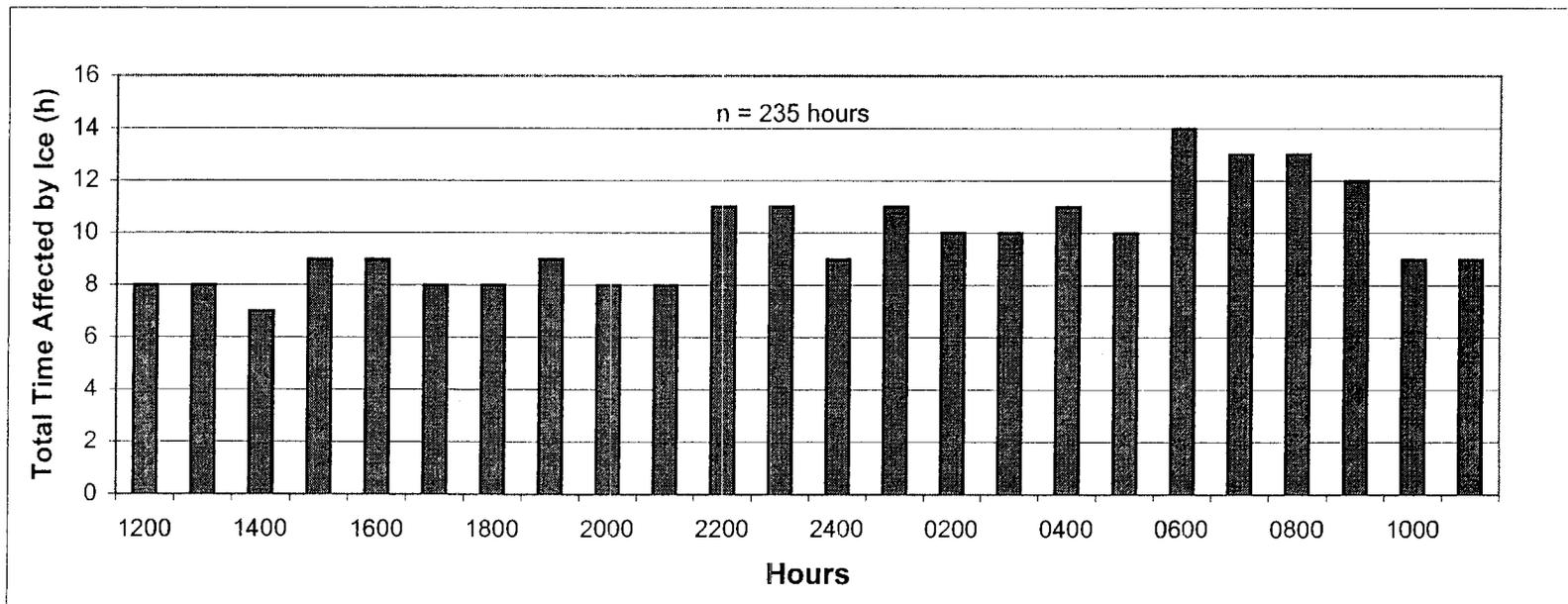
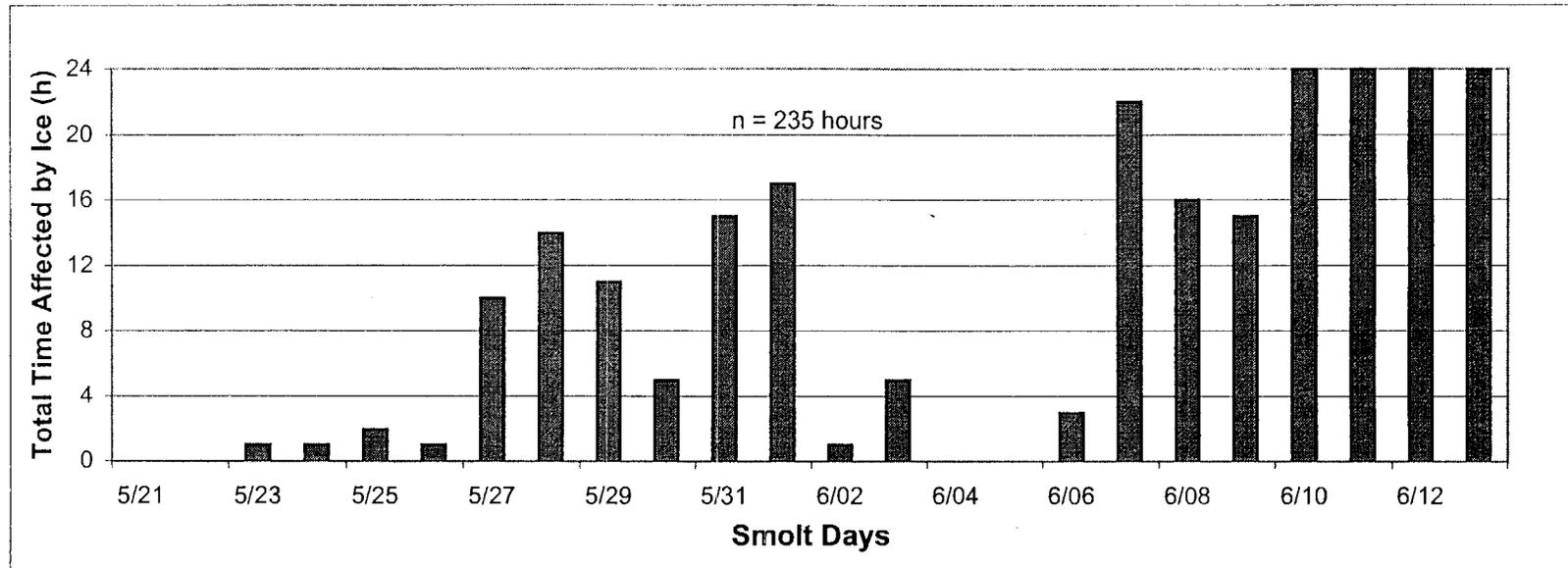


Figure 9. Egegik River smolt sonar total time affected by ice by smolt day and hour, May 21 to June 13, 1999.

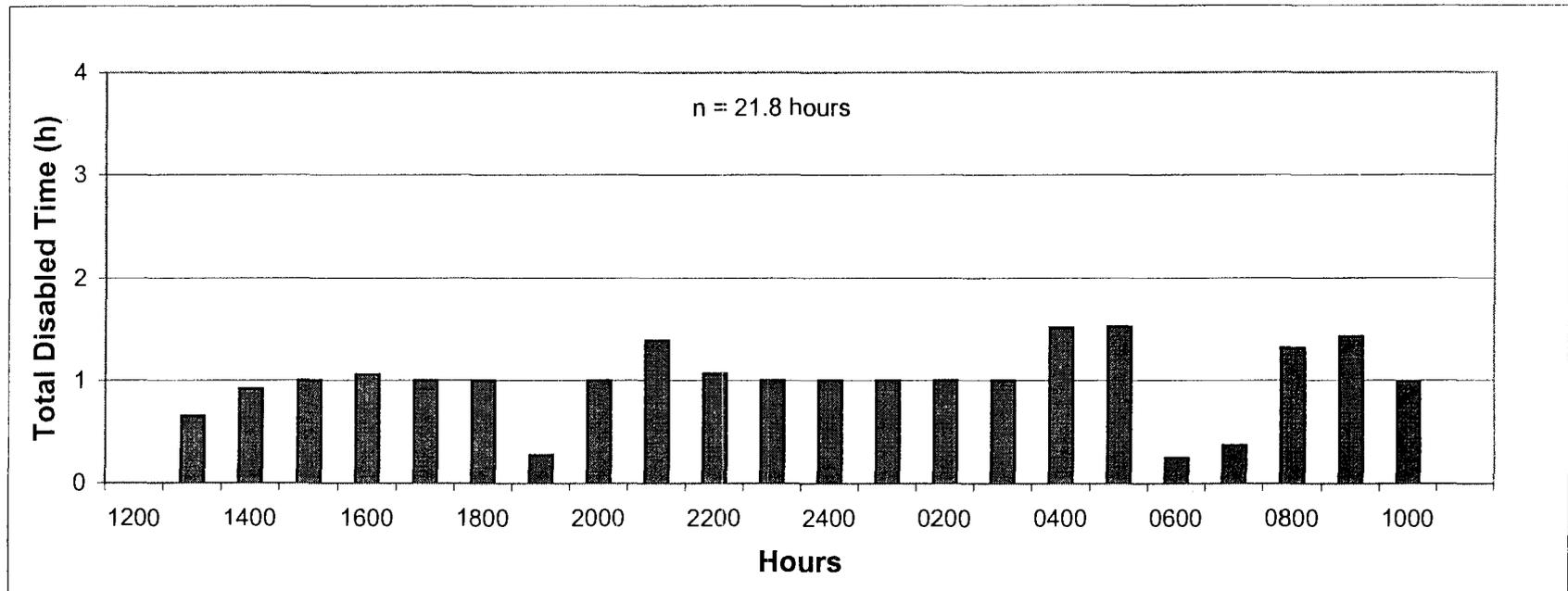
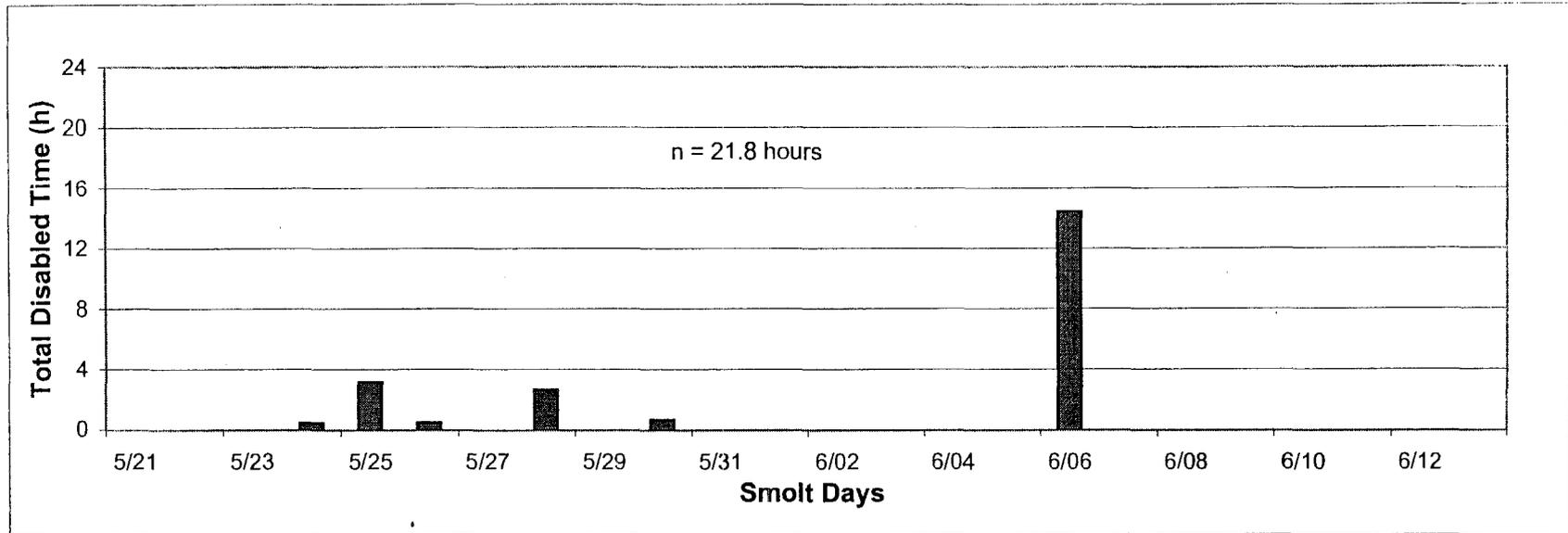


Figure 10. Egegik River smolt sonar total disabled time due to weather by smolt day and hour, May 21 to June 13, 1999.

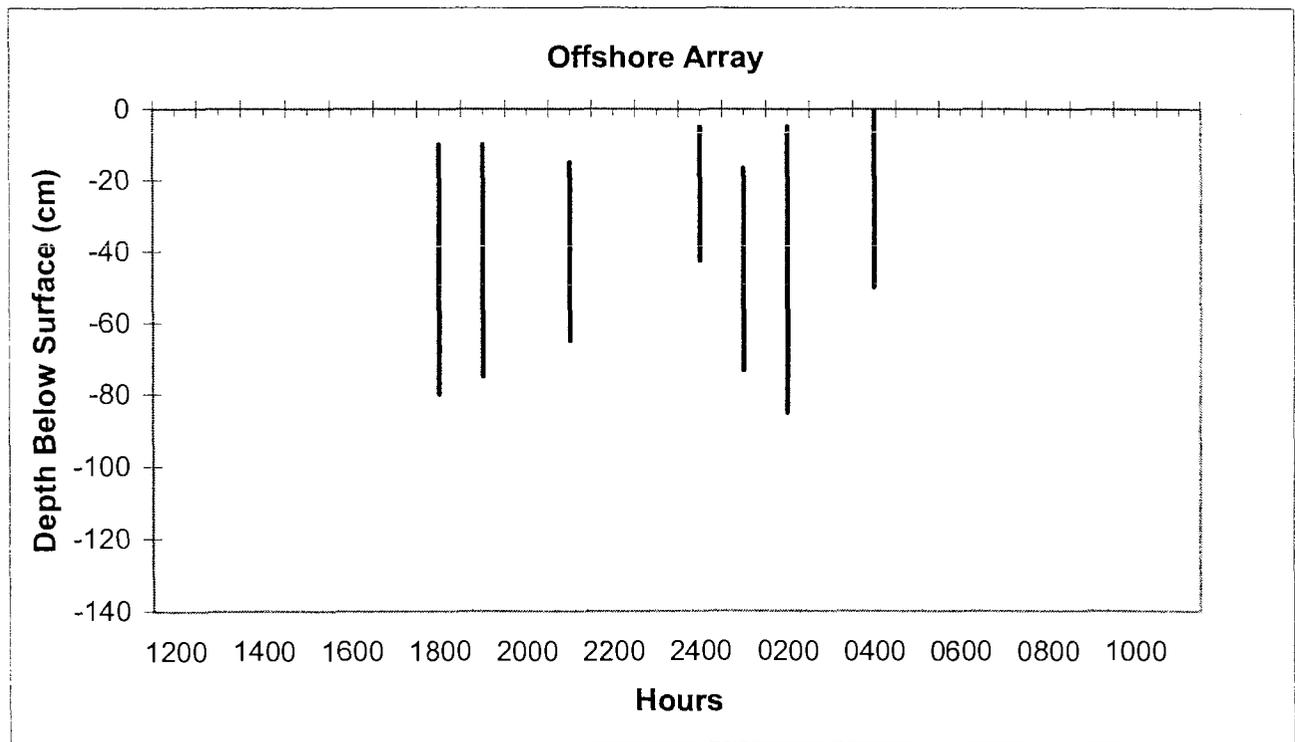
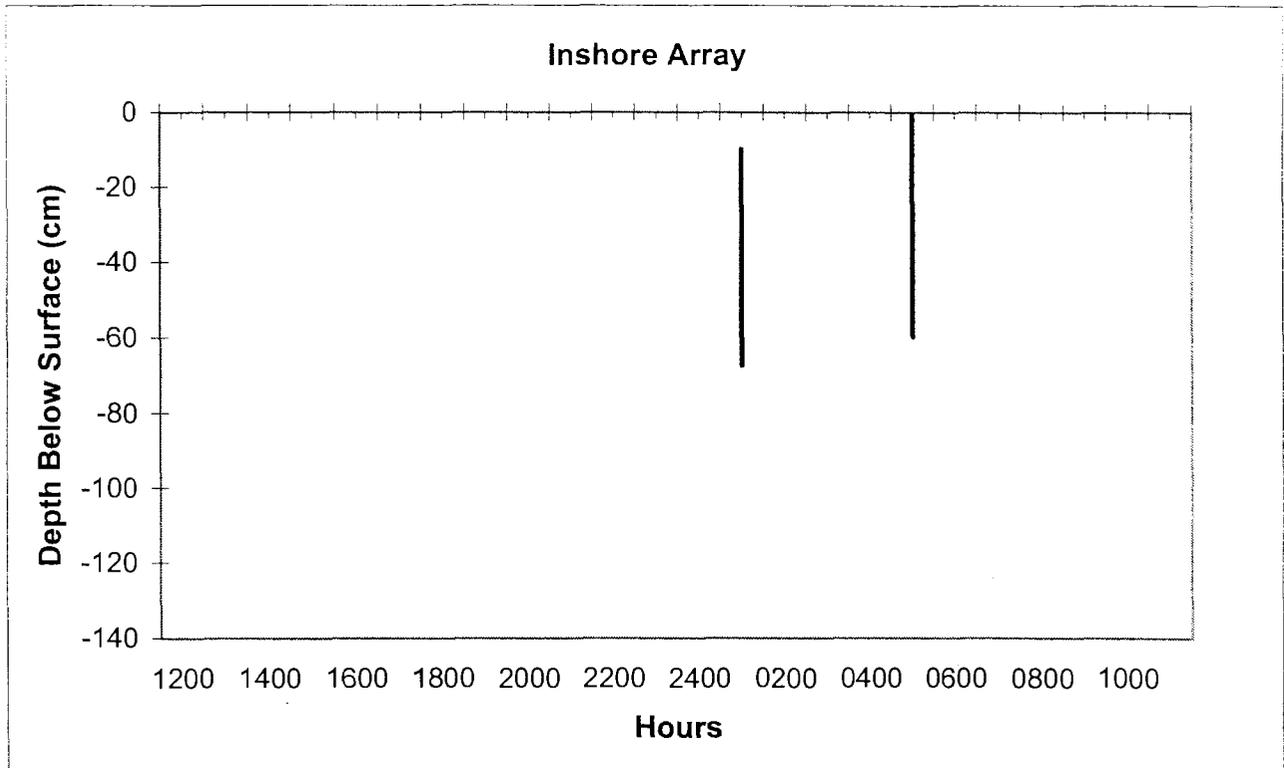


Figure 11. Depth of smolt passage data summarized by hour, Ugashik River, May 26 to June 12, 1999.

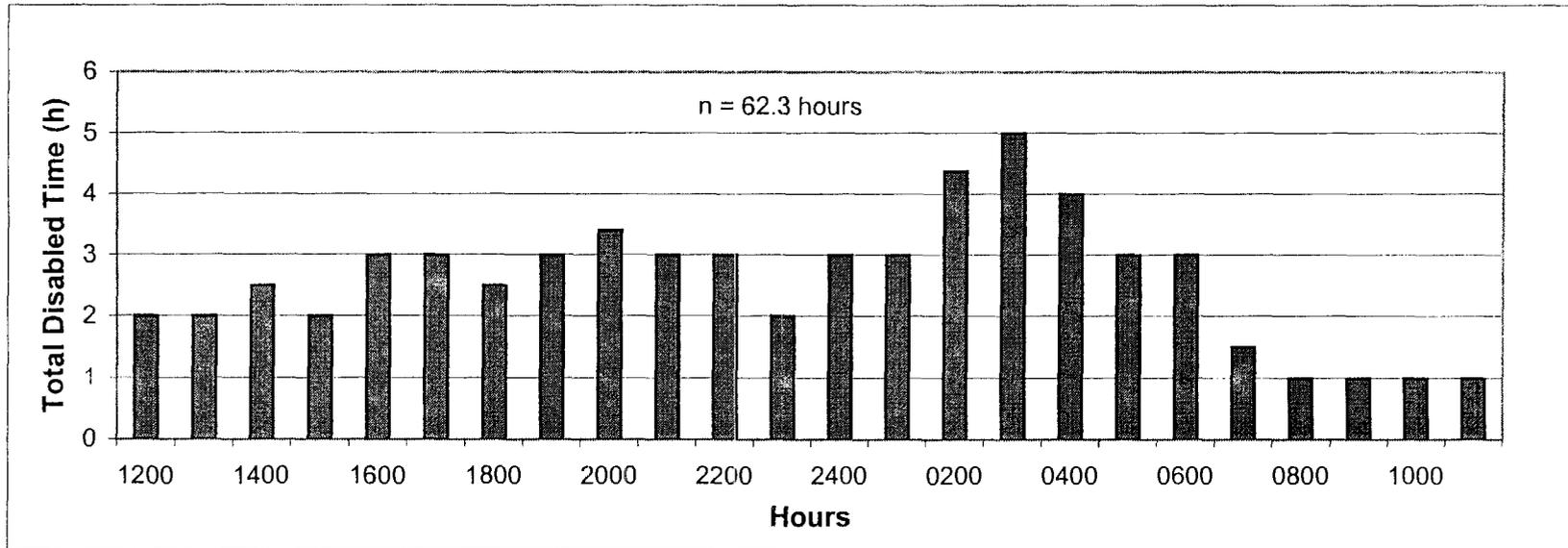
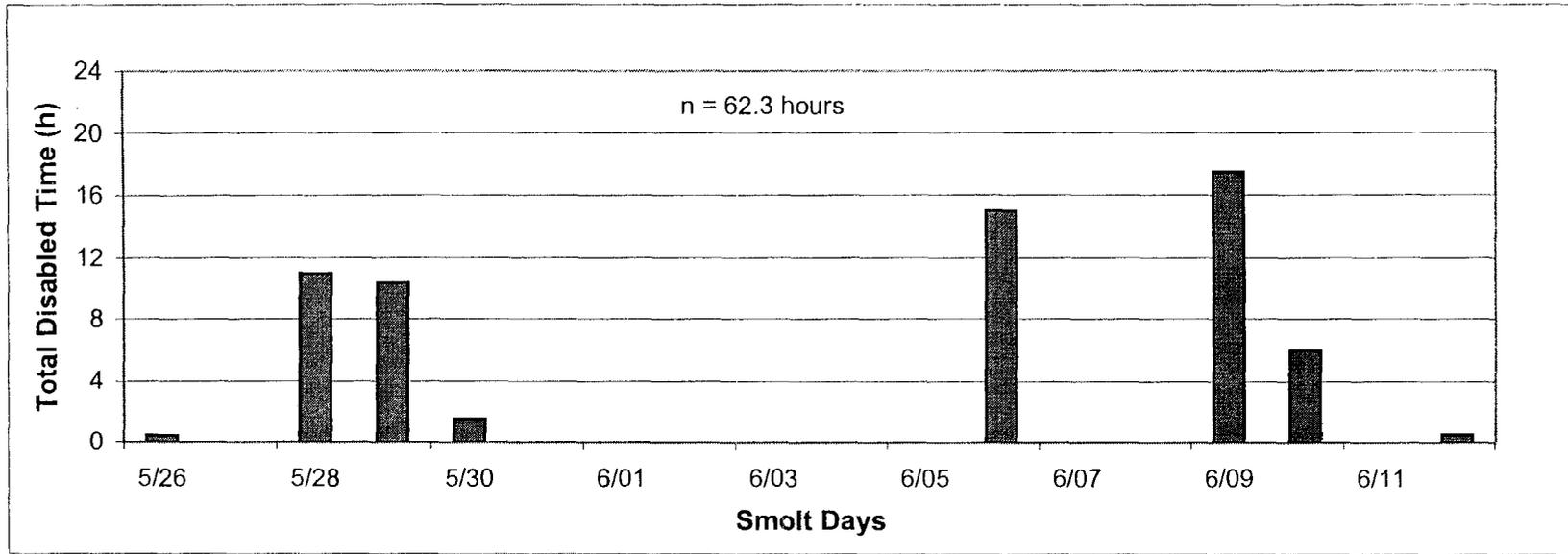


Figure 12. Ugashik River smolt sonar total disabled time due to weather by smolt day and hour, May 26 to June 12, 1999.

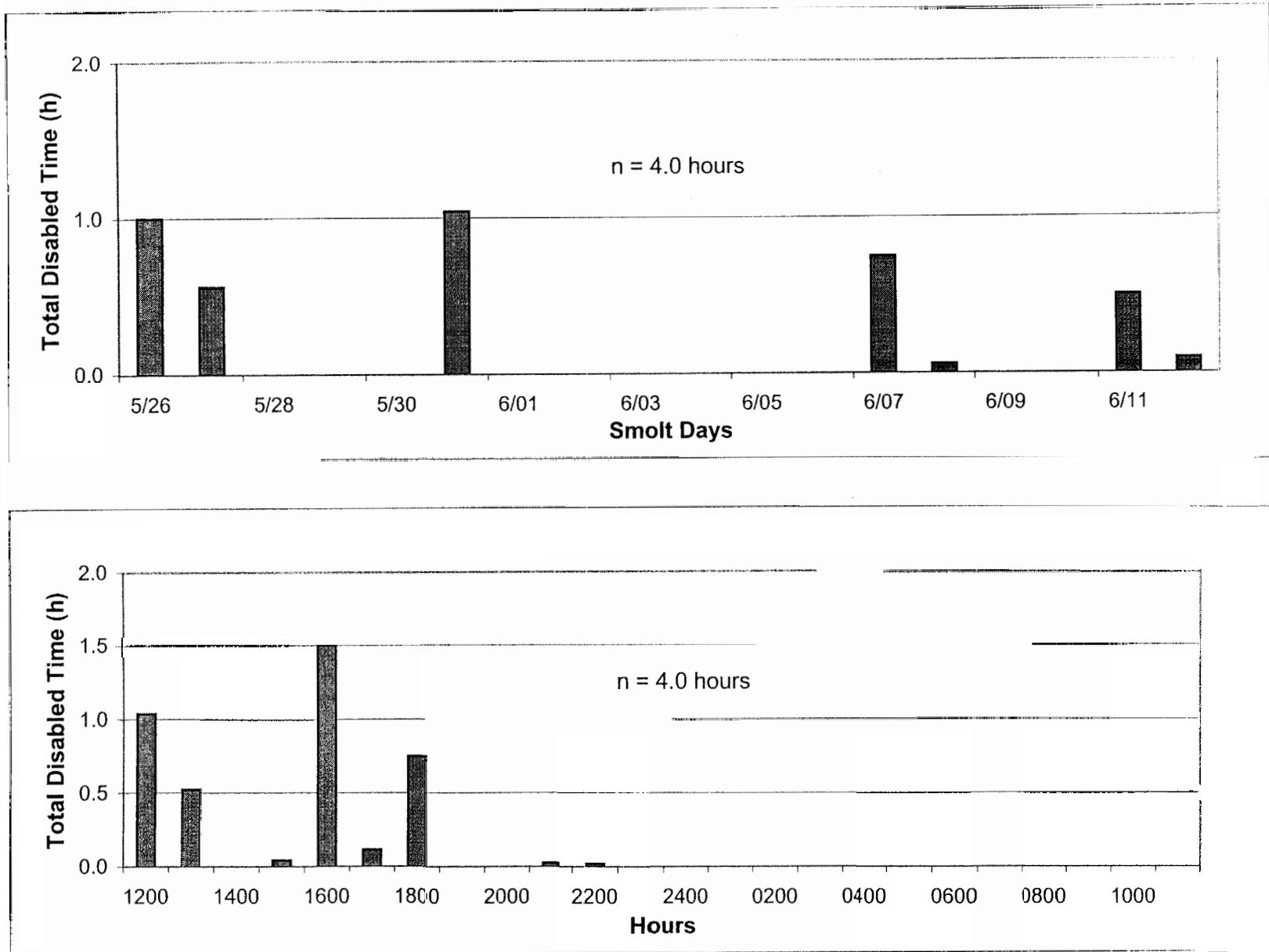


Figure 13. Ugashik River smolt sonar total disabled time due to boat or float plane traffic by smolt day and hour, May 26 to June 12, 1999

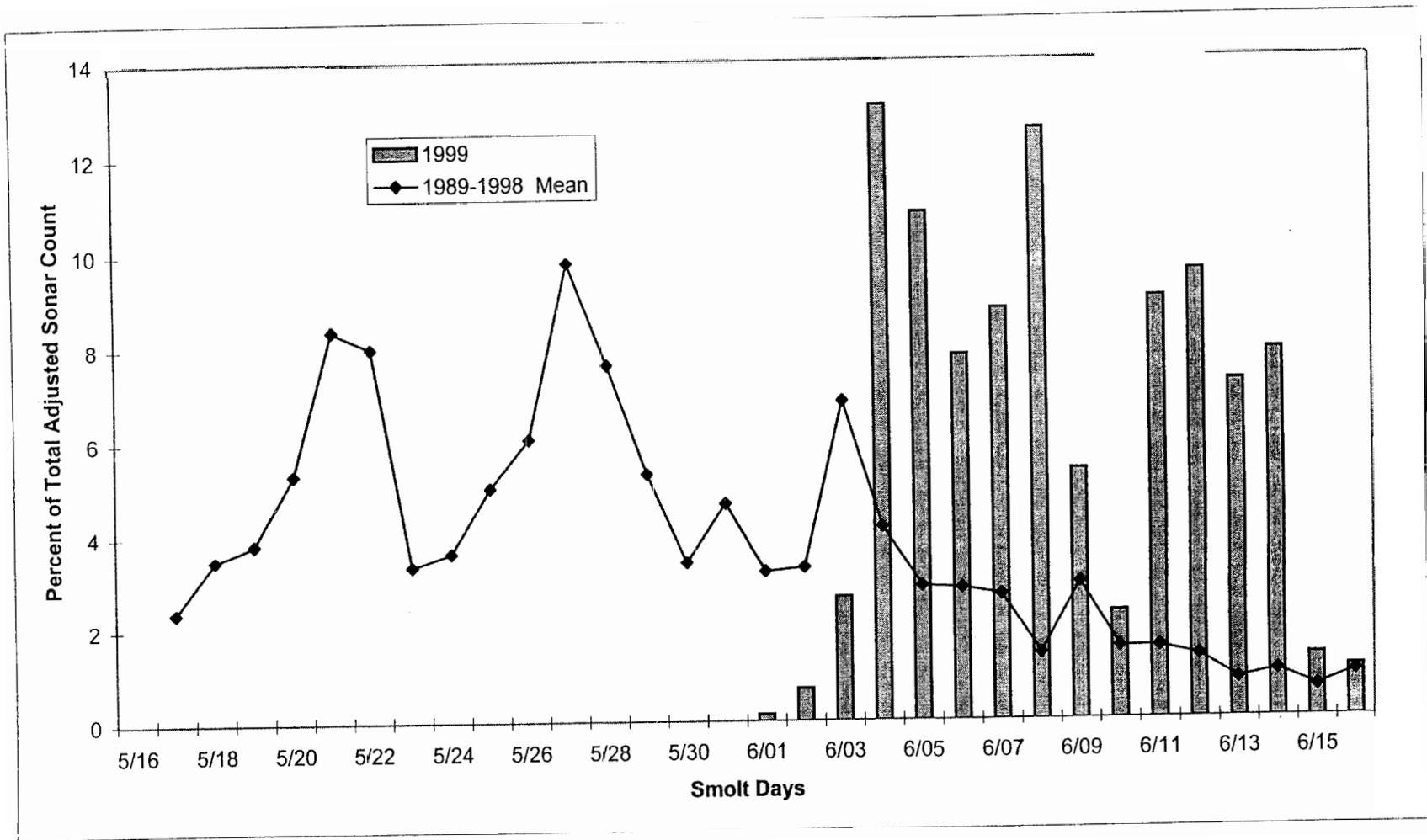


Figure 14. Comparison of the percent of the 1999 total adjusted sonar counts by smolt day at Kvichak River smolt sonar with the 1989-1998 mean.

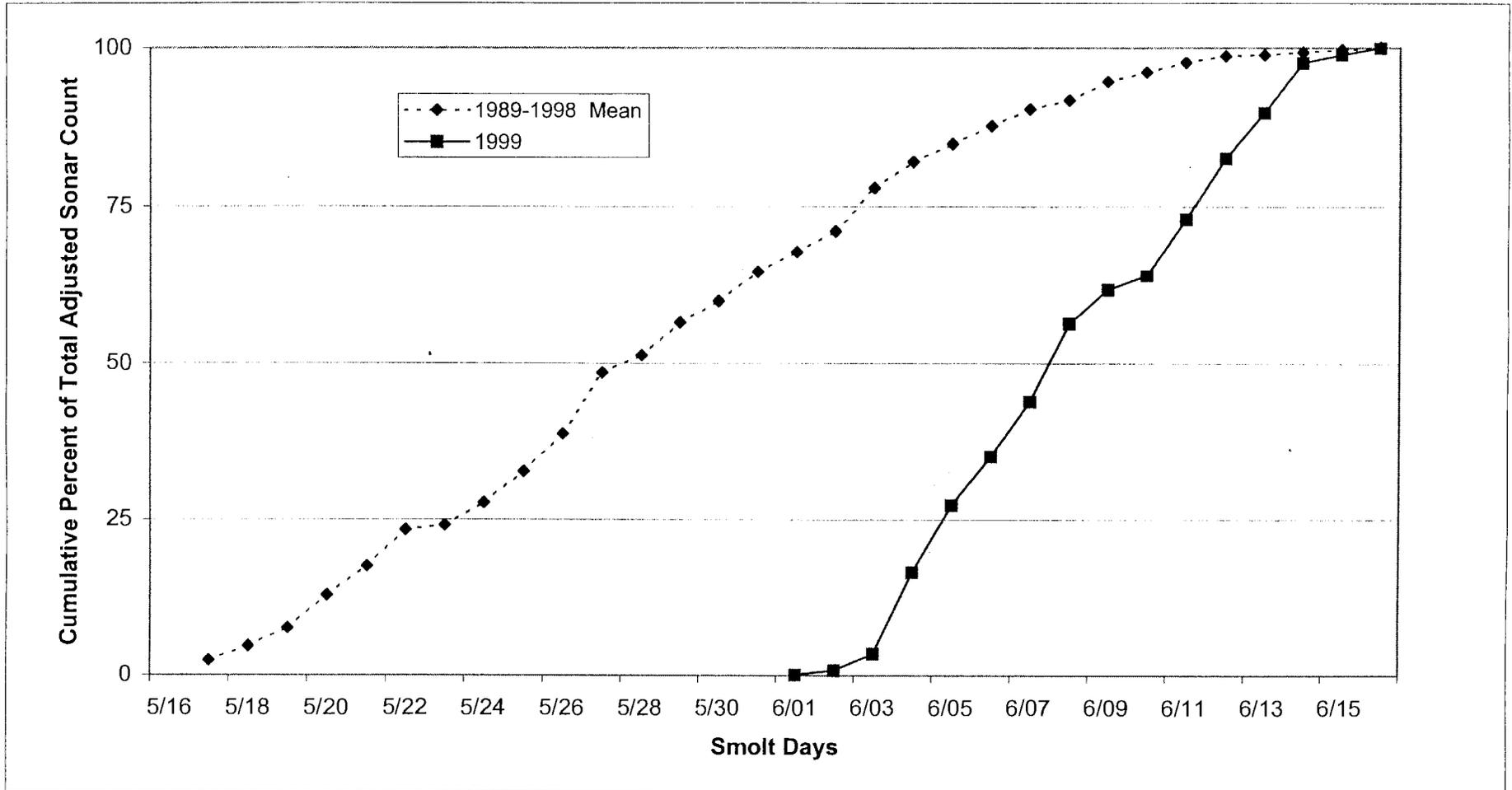


Figure 15. Comparison of the cumulative percent of the 1999 total adjusted sonar counts by smolt day at Kvichak River smolt sonar with the 1989-1998 mean.

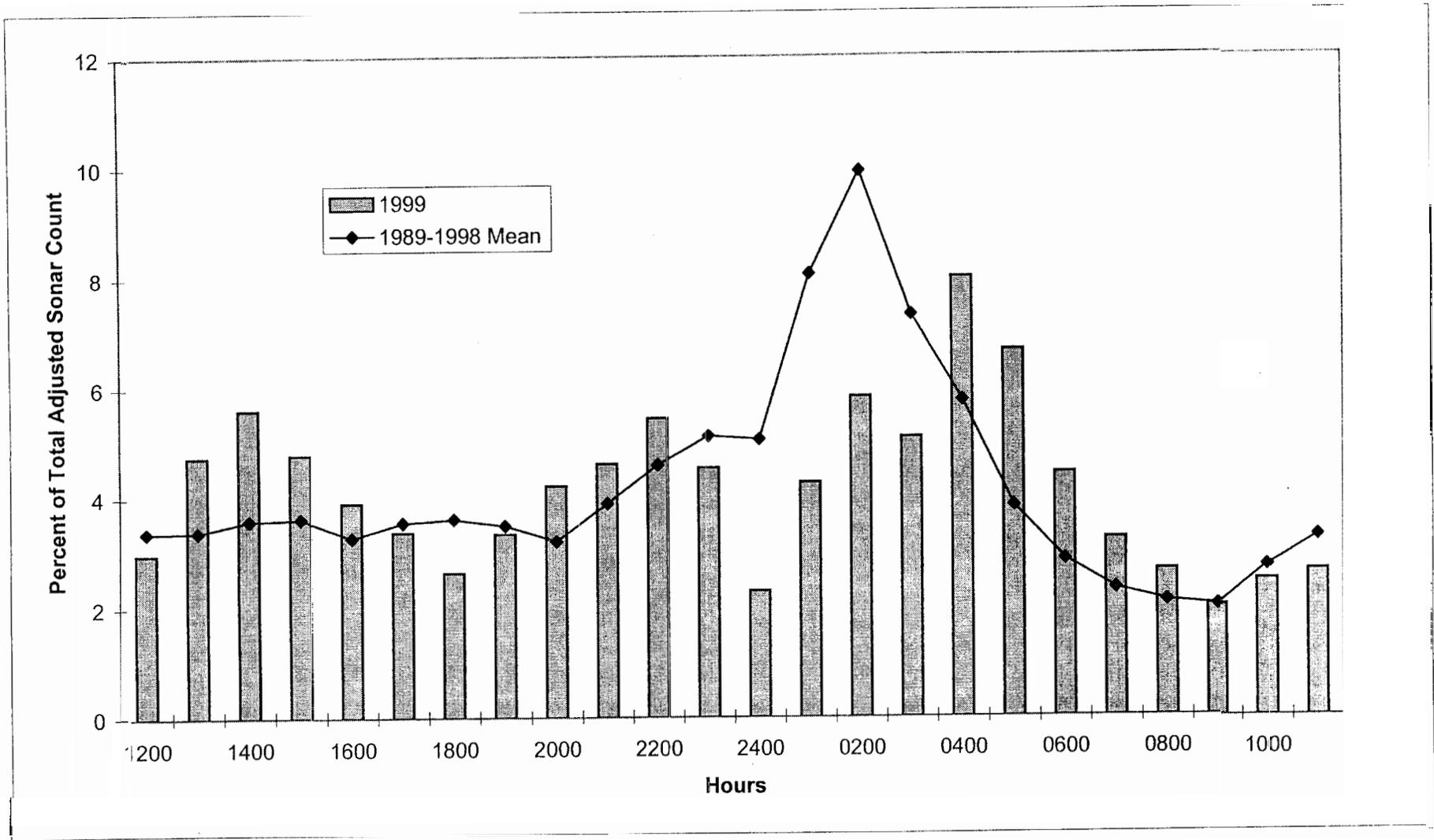


Figure 16. Comparison of the percent of the 1999 total adjusted sonar counts by hour at Kvichak River smolt sonar with the 1989-1998 mean.

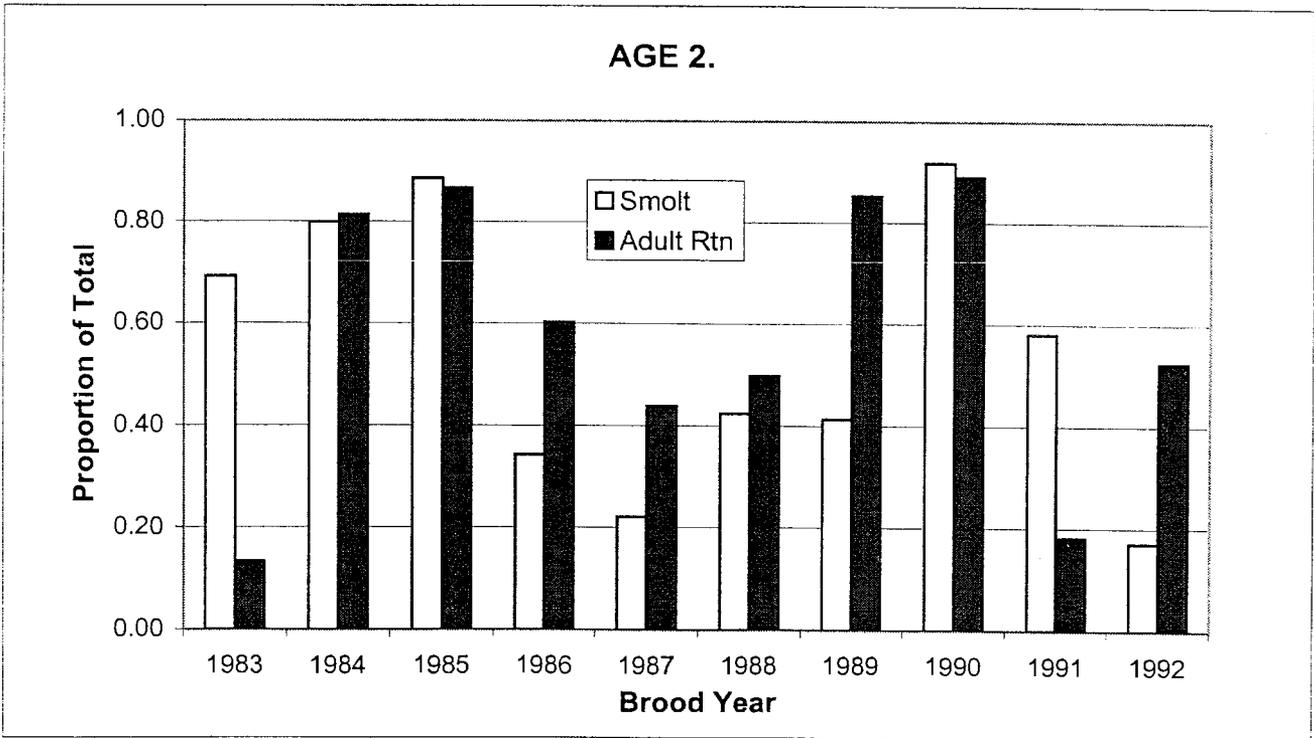
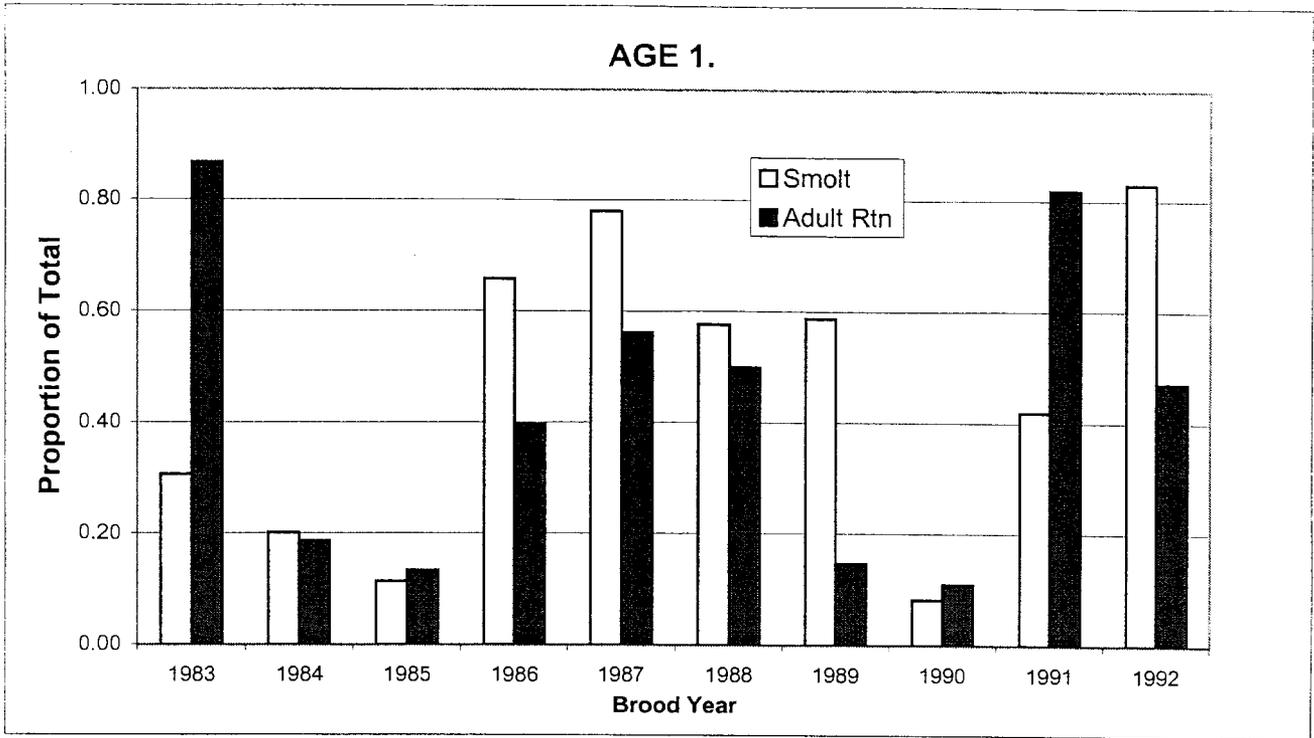


Figure 17. Comparison of the age composition of outmigrating sockeye salmon smolt at Kvichak River with the freshwater age composition of the total adult returns by brood year, 1983-1992.

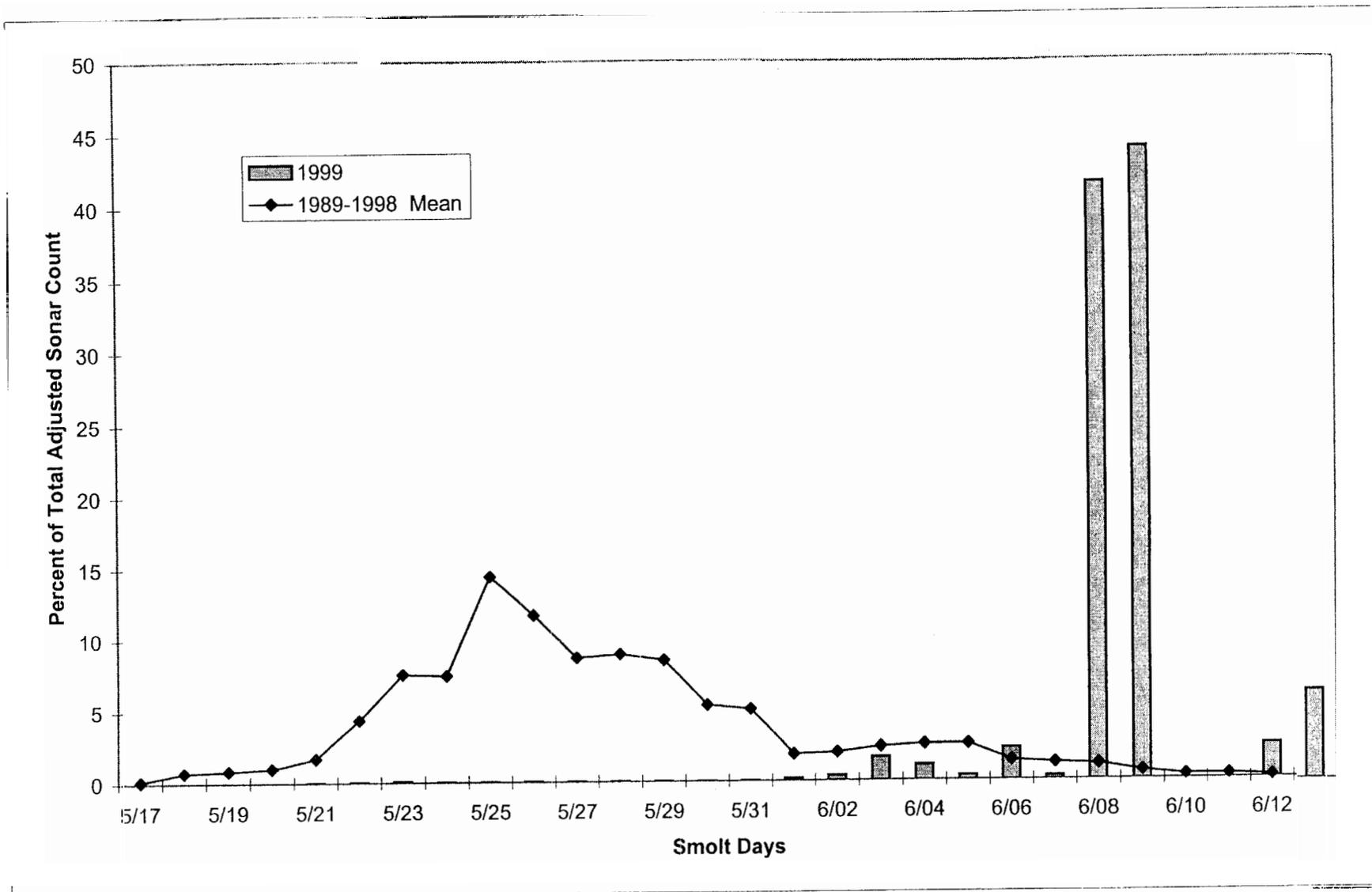


Figure 18. Comparison of the percent of the 1999 total adjusted sonar counts by smolt day at Egegik River smolt sonar with the 1989-1998 mean.

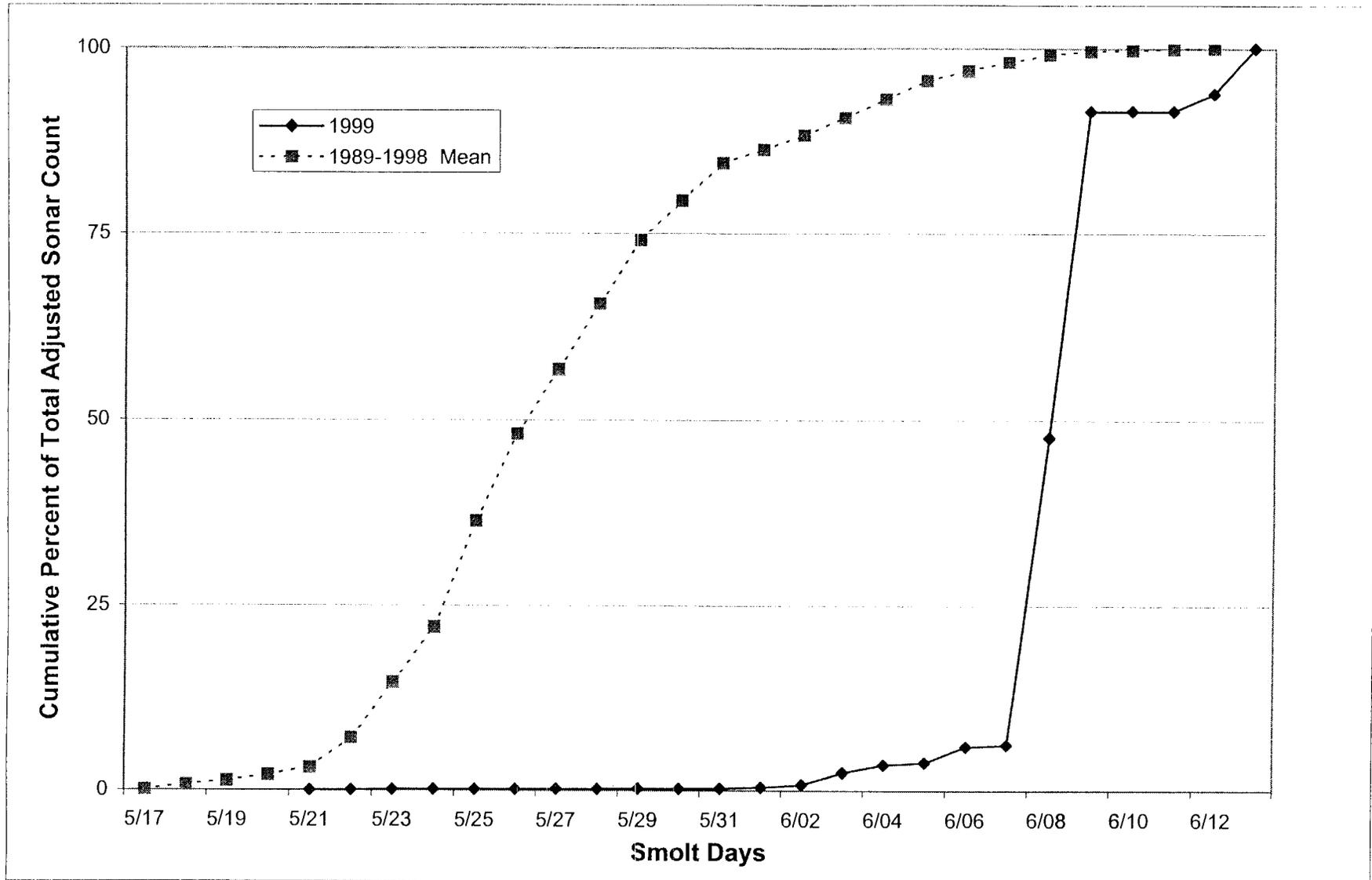


Figure 19. Comparison of the cumulative percent of the 1999 total adjusted sonar counts by smolt day at Egegik River smolt sonar with the 1989-1998 mean.

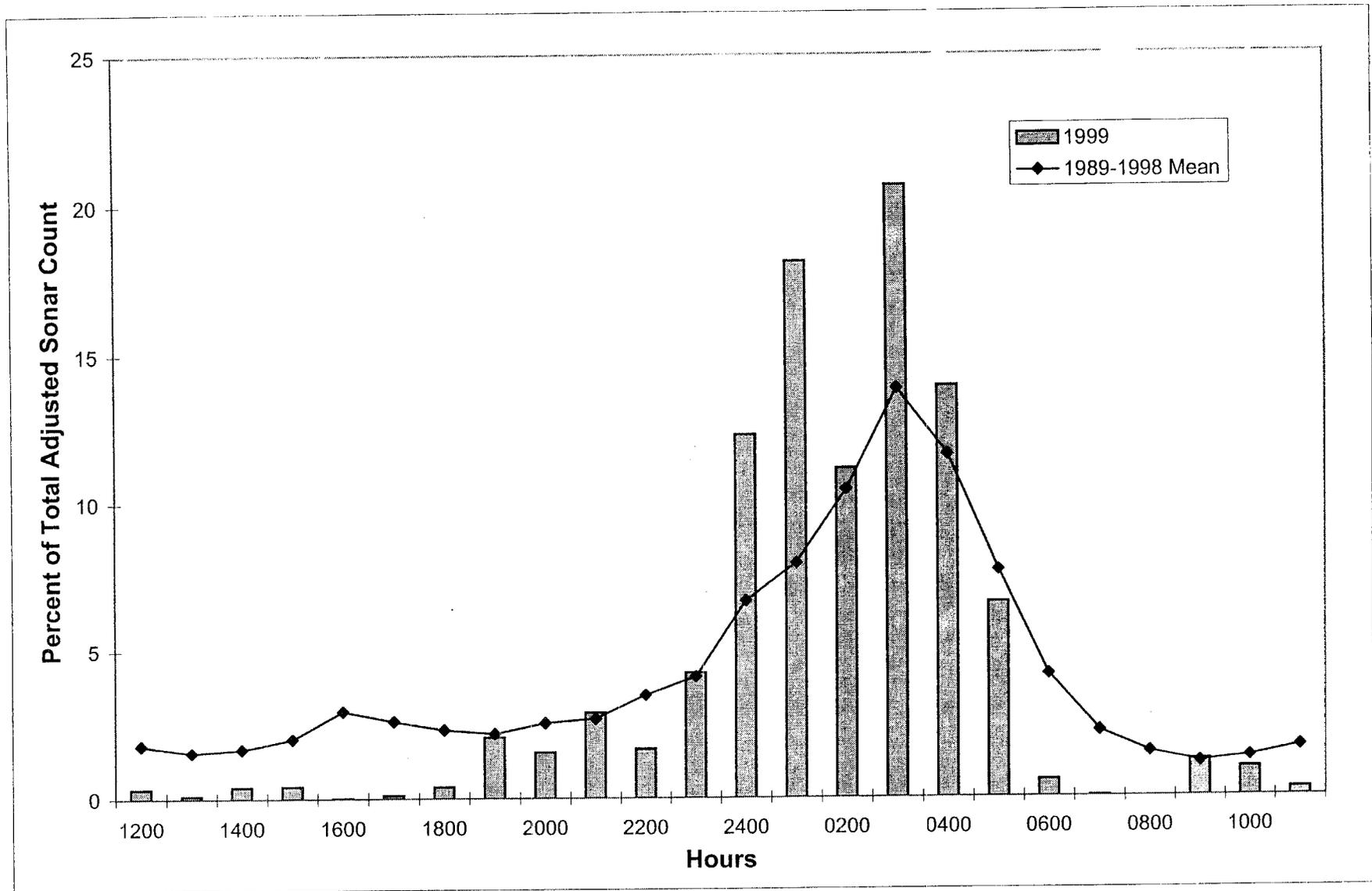


Figure 20. Comparison of the percent of the 1999 total adjusted sonar counts by hour at Egegik River smolt sonar with the 1989-1998 mean.

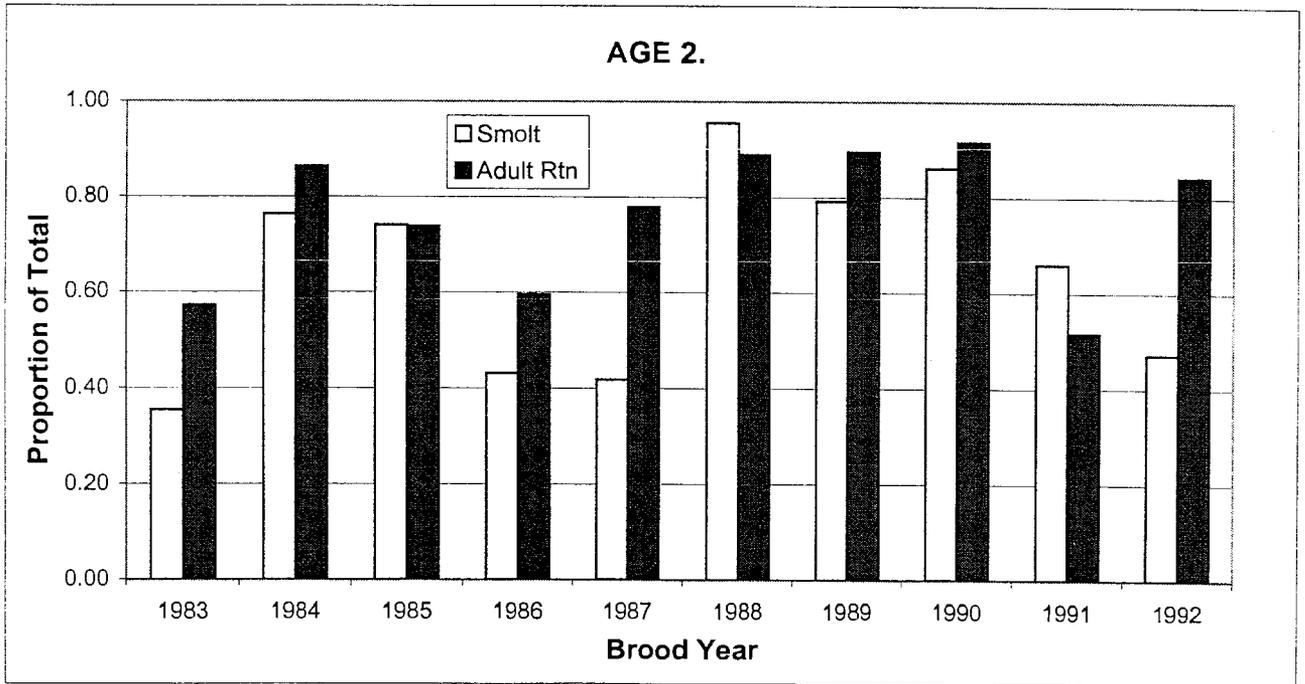
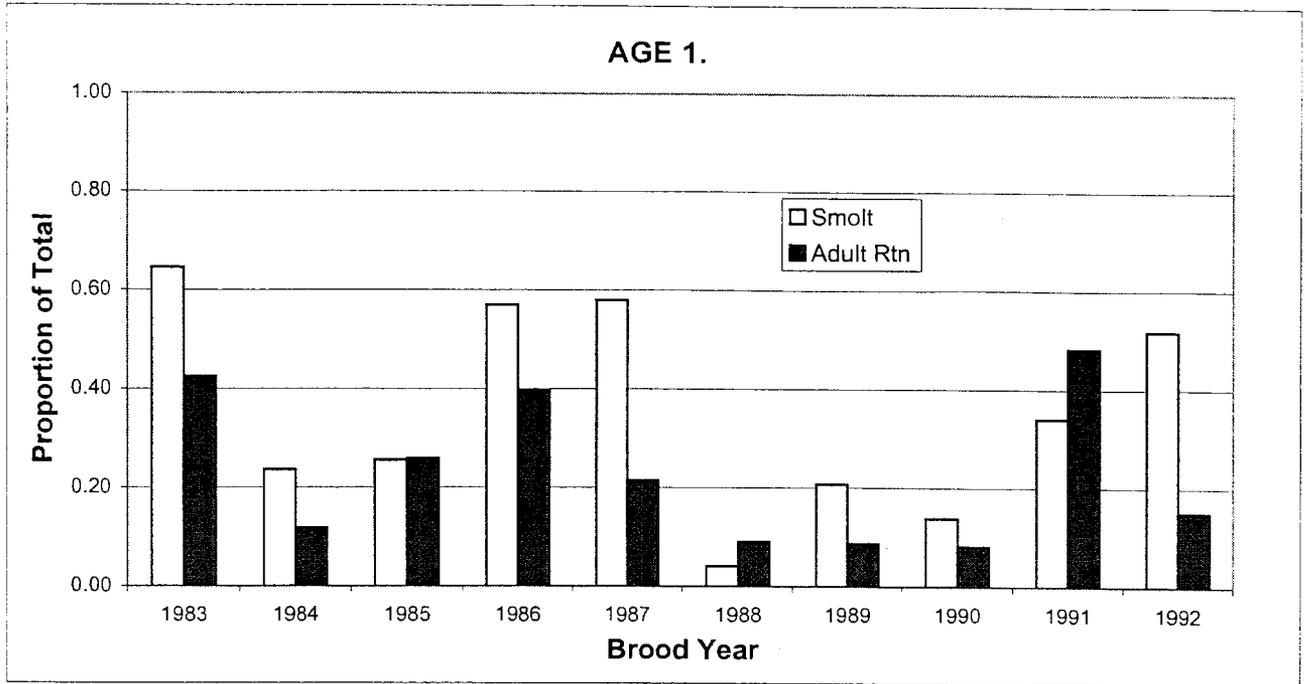


Figure 21. Comparison of the age composition of outmigrating sockeye salmon smolt at Egegik River with the freshwater age composition of the total adult returns by brood year, 1983-1992.

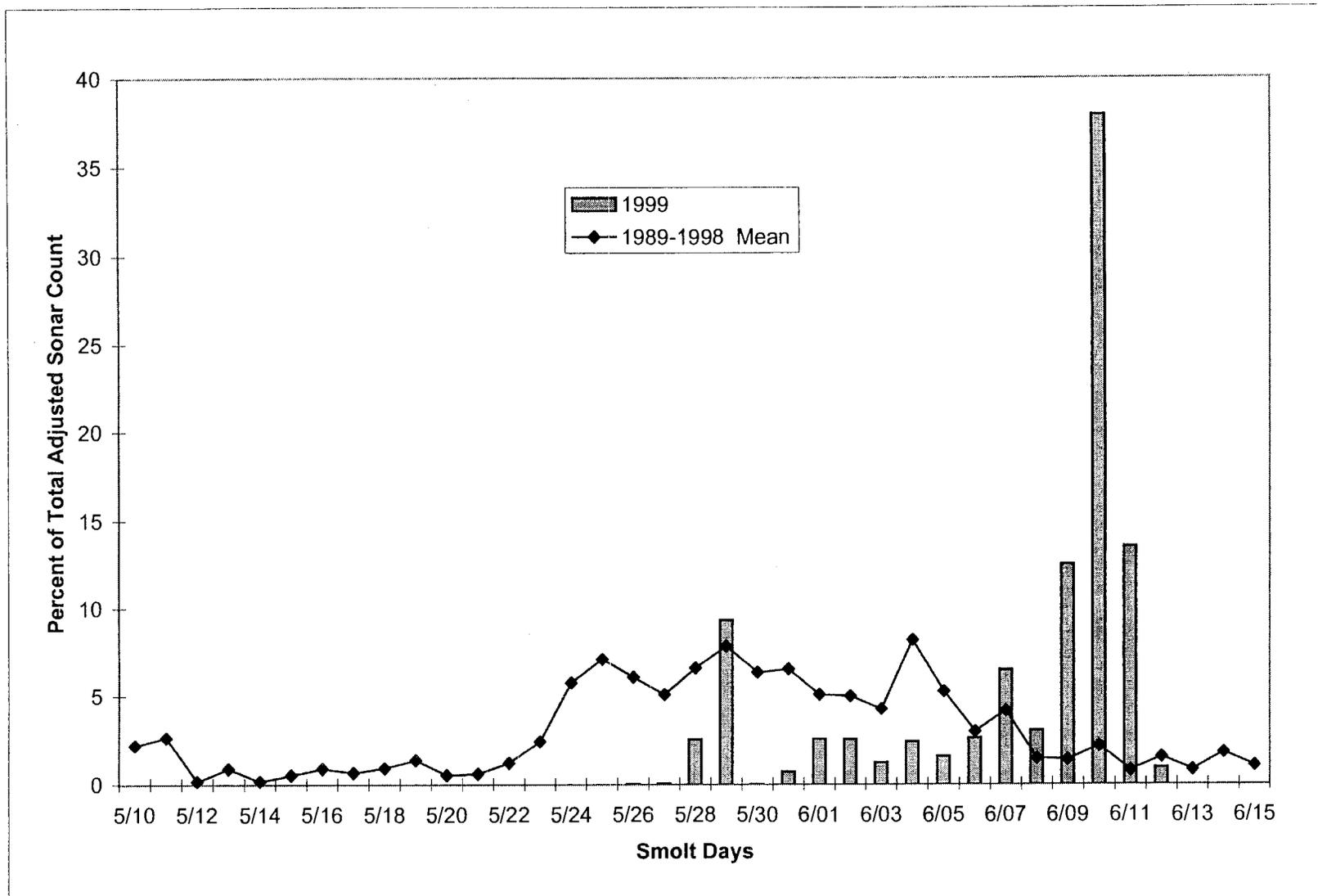


Figure 22. Comparison of the percent of the 1999 total adjusted sonar counts by smolt day at Ugashik River smolt sonar with the 1989-1998 mean.

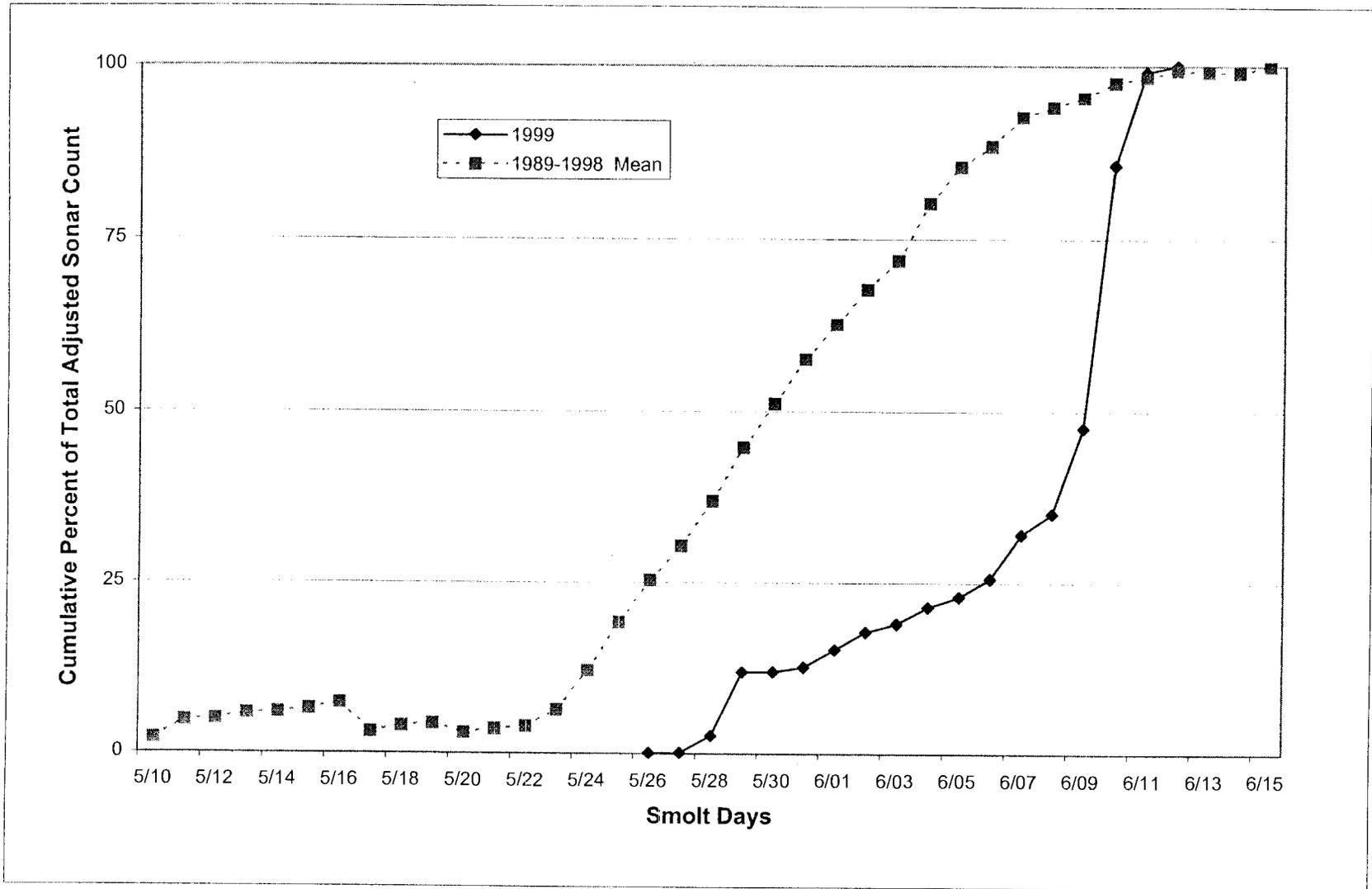


Figure 23. Comparison of the cumulative percent of the 1999 total adjusted sonar count by smolt day at Ugashik River smolt sonar with the 1989-1998 mean.

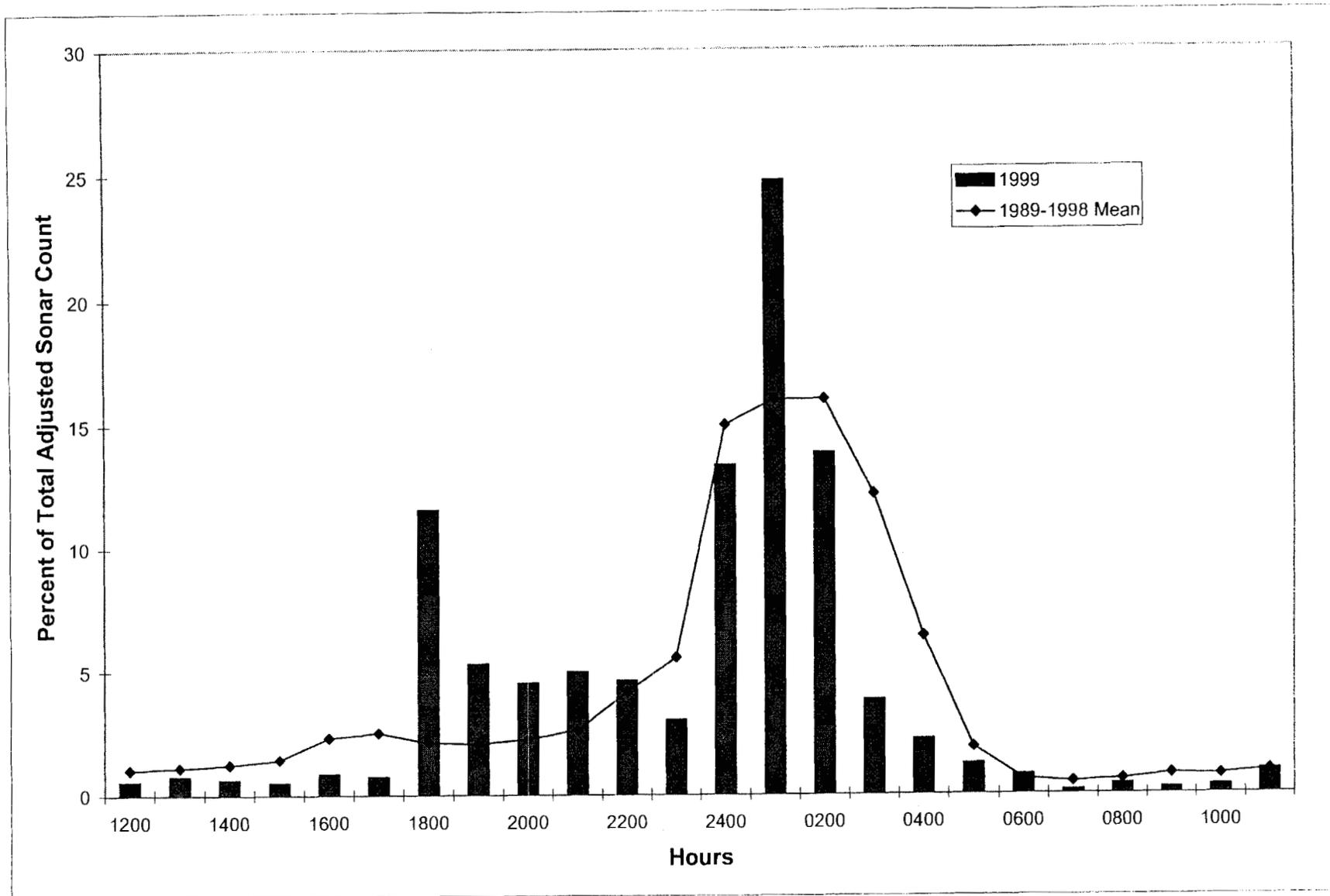


Figure 24. Comparison of the percent of the 1999 total adjusted sonar counts by hour at Ugashik River smolt sonar with the 1989-1998 mean.

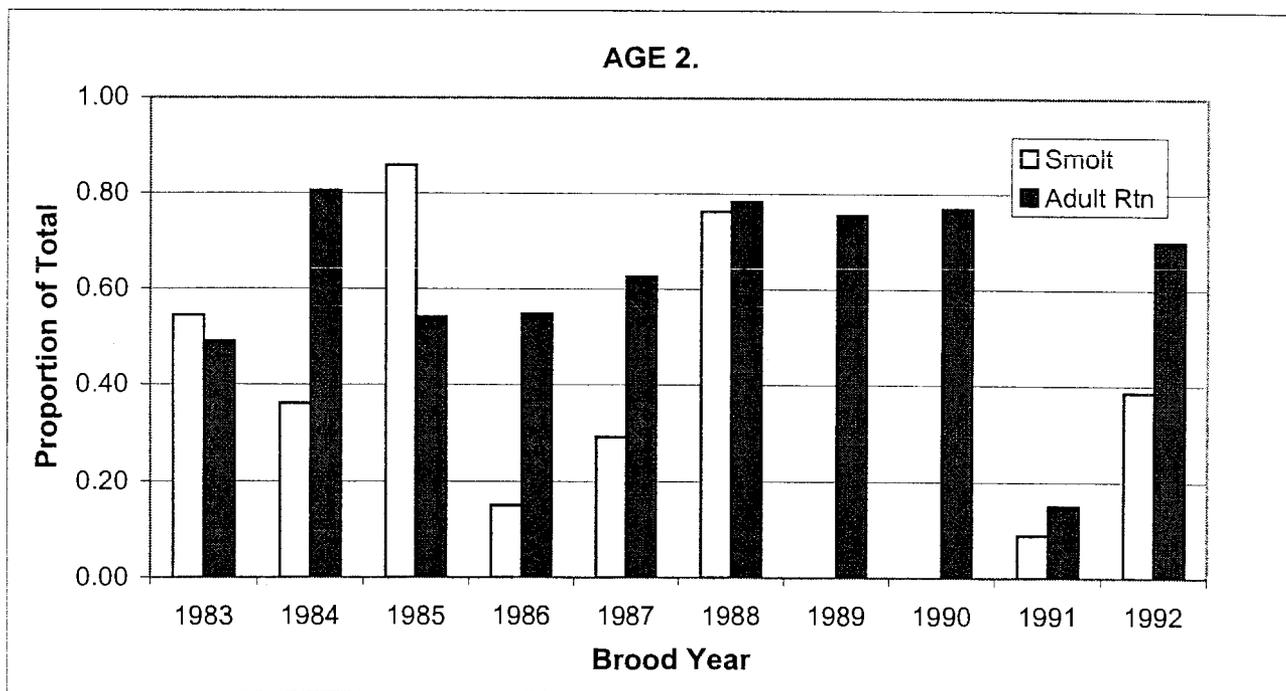
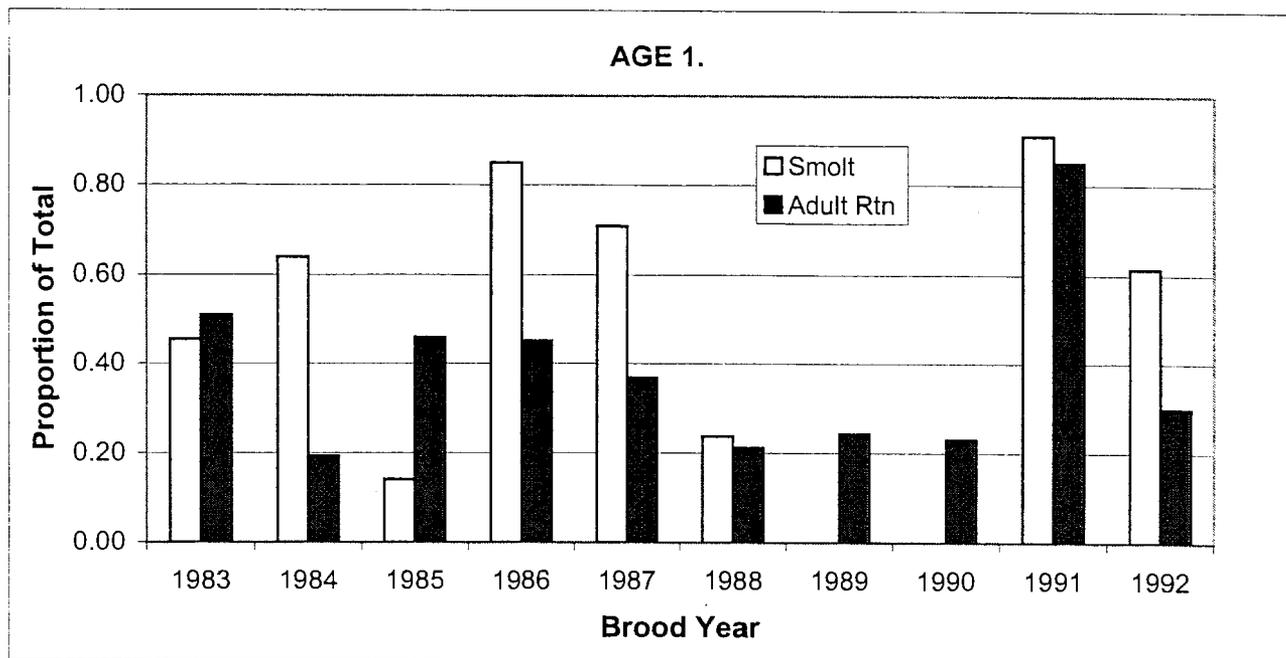


Figure 25. Comparison of the age composition of outmigrating sockeye salmon smolt at Ugashik River with the freshwater age composition of the total adult returns by brood year, 1983-1992.



Appendix A.1. River width and distance between arrays at Kvichak River smolt sonar site^a, 1989-1999.

| 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 |
| 1999 | 440 | 410 | 265 | 225 | 158 | 60 | 0 |
| 1989-98 Max | 445 | 419 | 328 | 279 | 205 | 60 | 0 |
| 1989-98 Avg | 428 | 397 | 303 | 234 | 165 | 36 | 0 |
| 1989-98 Min | 404 | 358 | 237 | 180 | 75 | 16 | 0 |

^a Since 1989, the Kvichak River smolt sonar site has been located 6 km downstream from the outlet of Lake Iliamna. 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, 1989-1999.

| 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 |
| 1999 | 0 | 40 | 130 | 180 | 220 | 300 | 366 |
| 1989-98 Max | 0 | 70 | 140 | 190 | 240 | 330 | 380 |
| 1989-98 Avg | 0 | 41 | 131 | 181 | 223 | 290 | 358 |
| 1989-98 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, 1982-1999.

Appendix A.3. River width and distance between arrays at Ugashik River smolt sonar site^a, 1988-1999.

| Year | Distance (ft) | | | | | |
|-------------------|-----------------|---------------------------------------|----------------|---------------|--------------------------------------|------------------|
| | Left Bank Shore | Offshore Limit Dead Zone ^b | Offshore Array | Inshore Array | Inshore Limit Dead Zone ^b | Right Bank Shore |
| 1988 | 160 | na | 96 | 75 | na | 0 |
| 1989 | 140 | 110 | 91 | 75 | 40 | 0 |
| 1990 | 142 | 122 | 101 | 86 | 40 | 0 |
| 1991 | 140 | 120 | 99 | 85 | 40 | 0 |
| 1992 ^c | | | | | | |
| 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 |
| 1999 | 143 | 125 | 103 | 88 | 40 | 0 |
| 1989-98 Max | 145 | 125 | 107 | 90 | 45 | 0 |
| 1989-98 Avg | 140 | 119 | 101 | 85 | 39 | 0 |
| 1989-98 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, 1988-1999.

^b na = not available

^c 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, 1970-1999.

| 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 | 01-Jan | 1 | | | | |
| 1970-1971 | 07-Jan | 7 | 16-Jun | 167 | 160 | Long, cold winter. |
| 1971-1972 | | | 05-Jun | 157 | | |
| 1972-1973 | | | 25-May | 145 | | |
| 1973-1974 | | | 21-May | 141 | | |
| 1974-1975 | 26-Dec | -5 | 04-Jun | 155 | 160 | |
| 1975-1976 | | | 07-May | 128 | | |
| 1976-1977 | 04-Feb | 35 | 02-May | 122 | 87 | Partially open 30-Mar |
| 1977-1978 | | | 11-May | 131 | | 80% open 02-May |
| 1978-1979 | | | 03-May | 123 | | 50% open 28-Apr |
| 1979-1980 | | | 03-May | 124 | | |
| 1980-1981 | | | | | | |
| 1981-1982 | 09-Jan | 9 | 25-May | 145 | 136 | Started to reopen 10-Feb |
| 1982-1983 | | | | | | |
| 1983-1984 | | | | | | Still open 19-Dec |
| 1984-1985 | 11-Feb | 42 | 05-Jun | 156 | 114 | 50% open 29-May |
| 1985-1986 | 18-Jan | 18 | 12-May | 132 | 114 | |
| 1986-1987 | 13-Feb ^b | 44 | 23-Mar | 82 | 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 | 09-Jan | 9 | 22-May | 142 | 133 | |
| 1990-1991 | 07-Jan | 7 | | | | |
| 1991-1992 | 27-Jan | 27 | 04-May | 125 | 98 | |
| 1992-1993 | 22-Jan | 22 | 03-May | 123 | 101 | |
| 1993-1994 | 16-Feb | 47 | 05-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 | 05-May | 126 | 114 | |
| 1996-1997 | 23-Dec ^c | -8 | 08-May ^d | 128 | 136 | |
| 1997-1998 | 05-Jan | 5 | 26-Apr | 116 | 111 | |
| 1998-1999 | 30-Dec | -1 | 28-May | 148 | 149 | |
| 1970-1998 Min | 23-Dec | | 23-Mar | | 38 | |
| 1970-1998 Avg | 16-Jan | | 13-May | | 114 | |
| 1970-1998 Max | 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, 1976-1999.

| 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 | | | 06-Apr | 97 | | |
| 1976-1977 | | | 06-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 | 03-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 | 04-Feb | 35 | 01-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 | 04-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 | 08-Jan | 8 | 28-Mar | 88 | 80 | |
| 1996-1997 | 13-Dec ^c | -18 | 19-Apr ^d | 109 | 127 | |
| 1997-1998 | 06-Jan | 6 | 04-Apr | 94 | 88 | |
| 1998-1999 | 05-Feb ^e | 36 | 28-May | 148 | 112 | Accumulated of ice at the lake outlet caused ice problems in the river from 27-May to 18-June. |
| 1976-1998 Min | 13-Dec | | 28-Mar | | 38 | |
| 1976-1998 Avg | 01-Feb | | 20-Apr | | 83 | |
| 1976-1998 Max | 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.

^e Estimated freeze-up date. West half of lake frozen on 08-Jan. Average temperatures in King Salmon were below -18°C (0°F) from 28-Jan to 12-Feb. The coldest days occurred from 30-Jan to 05-Feb with average daily temperatures of -29 to -34°C (-20 to -29 °F).

Appendix B.3. Ice-cover dates for Upper and Lower Ugashik Lakes, 1977-1999.

| 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 | | | 06-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 | 09-May | 129 | 72 | |
| 1986-1987 | 12-Mar ^b | 71 | | | | |
| 1987-1988 | 09-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 | 08-Jan | 8 | | | | |
| 1991-1992 | 27-Jan | 27 | 04-May | 125 | 98 | |
| 1992-1993 | 20-Jan | 20 | 31-Mar | 90 | 70 | |
| 1993-1994 | 16-Feb | 47 | 08-Apr | 98 | 51 | |
| 1994-1995 | 24-Jan | 24 | 28-Apr | 118 | 94 | |
| 1995-1996 | 08-Jan | 8 | 15-Apr | 106 | 98 | |
| 1996-1997 | 13-Dec ^c | -18 | 26-Apr ^d | 116 | 134 | |
| 1997-1998 | 05-Jan | 5 | 04-Apr | 94 | 89 | |
| 1998-1999 | 22-Jan | 22 | 19-May | 139 | 117 | |
| <hr/> | | | | | | |
| 1977-1998 Min | 09-Dec | | 24-Mar | | 51 | |
| 1977-1998 Avg | 23-Jan | | 21-Apr | | 90 | |
| 1977-1998 Max | 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 4-May.



Appendix C.1. Kvichak River smolt fyke net catch log, 1999.

| 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 | |
| 5/20 | | 2130 | 2148 | 18 | | 0 | | 0 |
| | | 0128 | 0229 | 61 | 79 | 0 | 0 | 0 |
| 5/21 | | 0055 | 0156 | 61 | 61 | 0 | 0 | 0 |
| 5/22 | 001 | 0105 | 0206 | 61 | 61 | 2 | 2 | 0 |
| 5/23 | | 0134 | 0236 | 62 | 62 | 0 | 0 | 0 |
| 5/24 | 002 | 0037 | 0205 | 88 | 88 | 3 | 3 | 0 |
| 5/25 | | 0025 | 0127 | 62 | 62 | 0 | 0 | 0 |
| 5/26 | | 0010 | 0115 | 65 | 65 | 0 | 0 | 0 |
| 5/27 | | 0015 | 0117 | 62 | 62 | 0 | 0 | 0 |
| 5/28 | | | | | | | | |
| 5/29 | | | | | | | | |
| 5/30 | | | | | | | | |
| 5/31 | 003 | 2205 | 2305 | 60 | | 18 | | 0 |
| | 004 | 0035 | 0104 | 29 | | 150 | | 5 |
| | 005 | 0106 | 0122 | 16 | | 200 | | 13 |
| | 006 | 0124 | 0136 | 12 | 117 | 200 | 568 | 17 |
| 6/01 | | | | | | | | |
| 6/02 | 007 | 2335 | 0044 | 69 | | 250 | | 4 |
| | 008 | 0045 | 0250 | 125 | | 90 | | 1 |
| | 009 | 0251 | 0427 | 96 | | 150 | | 2 |
| | 010 | 0428 | 0545 | 77 | 367 | 50 | 540 | 1 |
| 6/03 | 011 | 2339 | 0024 | 45 | | 550 | | 12 |
| | 012 | 0025 | 0103 | 38 | | 2,000 | | 53 |
| | 013 | 0105 | 0116 | 11 | | 160 | | 15 |
| | 014 | 0118 | 0220 | 62 | | 60 | | 1 |
| | | 0221 | 0320 | 59 | 215 | 0 | 2,770 | 0 |
| 6/04 | 015 | 2331 | 0014 | 43 | | 100 | | 2 |
| | 016 | 0015 | 0056 | 41 | | 100 | | 2 |
| | | 0057 | 0414 | 197 | 281 | 10 | 210 | 0 |
| 6/05 | 017 | 1727 | 1815 | 48 | | 200 | | 4 |
| | 018 | 1818 | 2151 | 213 | | 160 | | 1 |
| | 019 | 2154 | 2251 | 57 | | 200 | | 4 |
| | 020 | 2254 | 2315 | 21 | | 300 | | 14 |
| | 021 | 2321 | 2324 | 3 | | 100 | | 33 |
| | 022 | 2350 | 0014 | 24 | 366 | 50 | 1,010 | 2 |
| 6/06 | 023 | 1712 | 1715 | 3 | | 150 | | 50 |
| | 024 | 1716 | 1718 | 2 | | 200 | | 100 |
| | | 1719 | 1721 | 2 | | 0 | | 0 |
| | 025 | 1814 | 1837 | 23 | | 200 | | 9 |
| | 026 | 1912 | 1940 | 28 | | 65 | | 2 |
| | 027 | 2014 | 2212 | 118 | | 80 | | 1 |
| | 028 | 2216 | 2322 | 66 | 242 | 50 | 745 | 1 |
| | | | | | | | | |
| 6/07 | 029 | 1815 | 1824 | 9 | | 170 | | 19 |
| | 030 | 1827 | 1917 | 50 | | 200 | | 4 |
| | 031 | 1921 | 2011 | 50 | | 600 | | 12 |
| | 032 | 2014 | 2036 | 22 | | 75 | | 3 |
| | 033 | 2039 | 2042 | 3 | | 100 | | 33 |
| | 034 | 2046 | 2052 | 6 | 140 | 200 | | 33 |

| 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 | |
| 6/08 | 035 | 1518 | 1924 | 246 | | 110 | | 0 |
| | 036 | 1928 | 2055 | 87 | | 100 | | 1 |
| | 037 | 2230 | 2329 | 59 | | 100 | | 2 |
| | 038 | 0333 | 0427 | 54 | | 70 | | 1 |
| | 039 | 0610 | 0705 | 55 | | 600 | | 11 |
| | 040 | 0707 | 0711 | 4 | 505 | 250 | 1,230 | 63 |
| 6/09 | 041 | 2145 | 2250 | 65 | 65 | 20 | 20 | 0 |
| 6/10 | | | | | | | | |
| 6/11 | 042 | 1409 | 1531 | 82 | | 15 | | 0 |
| | 043 | 2209 | 2253 | 44 | 126 | 20 | 35 | 0 |
| 6/12 | 044 | 2218 | 2302 | 44 | | 700 | | 16 |
| | 045 | 2302 | 2327 | 25 | | 800 | | 32 |
| | 046 | 0000 | 0010 | 10 | | 750 | | 75 |
| | 047 | 0010 | 0021 | 11 | | 350 | | 32 |
| | 048 | 0120 | 0130 | 10 | | 350 | | 35 |
| | 049 | 0131 | 0140 | 9 | 109 | 200 | 3,150 | 22 |
| 6/13 | 050 | 1430 | 1454 | 24 | | 100 | | 4 |
| | 051 | 1455 | 1519 | 24 | | 100 | | 4 |
| | 052 | 1520 | 1530 | 10 | | 80 | | 8 |
| | 053 | 1534 | 1609 | 35 | | 300 | | 9 |
| | 054 | 1611 | 1636 | 25 | | 70 | | 3 |
| | 055 | 1638 | 1644 | 6 | 124 | 150 | 800 | 25 |
| 6/14 | 056 | 1409 | 1451 | 42 | | 150 | | 4 |
| | 057 | 1514 | 1536 | 22 | | 200 | | 9 |
| | 058 | 1539 | 1611 | 32 | | 100 | | 3 |
| | 059 | 1613 | 1641 | 28 | | 150 | | 5 |
| | 060 | 1643 | 1652 | 9 | | 150 | | 17 |
| | 061 | 1710 | 1725 | 15 | 148 | 115 | 865 | 8 |
| 6/15 | | 2219 | 0115 | 176 | | 20 | | 0 |
| | 062 | 0116 | 0245 | 89 | | 100 | | 1 |
| | | 0300 | 0528 | 148 | | 0 | | 0 |
| | 063 | 0530 | 0605 | 35 | | 200 | | 6 |
| | 064 | 0606 | 0716 | 70 | | 57 | | 1 |
| | 065 | 0718 | 0846 | 88 | | 2,000 | | 23 |
| | | 0848 | 0946 | 58 | | 30 | | 1 |
| | 066 | 0947 | 1147 | 120 | 784 | 200 | 2,607 | 2 |
| Max | | | | | 784 | 2,000 | 3,150 | 100 |
| Avg | | | | | 199 | 209 | 766 | 11 |
| Min | | | | | 61 | 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 20 to June 15, 1999.

| Smolt Day | Time Fished (h) | Catch Estimate (No. of Fish) | | | | | | | | | | | |
|-----------|-----------------|------------------------------|-------------------------------------|---------------|------------|----------|----------|-------------------|----------------------------------|-----------------|---------------------|--------------------------------|---------------------|
| | | Sockeye Smolt | Sticklebacks ^a (Species) | Chinook Smolt | Coho Smolt | Chum Fry | Pink Fry | Lamprey (Species) | Whitefish ^b (Species) | Smelt (Species) | Rainbow Trout (juv) | Sculpin ^c (Species) | Northern Pike (juv) |
| 5/20 | 1.3 | 0 | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/21 | 1.0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 5/22 | 1.0 | 2 | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 5/23 | 1.0 | 1 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/24 | 1.5 | 3 | 6 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 |
| 5/25 | 1.0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/26 | 1.1 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 5/27 | 1.0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 5/28 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/29 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/30 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/31 | 2.0 | 568 | 45 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/01 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/02 | 6.2 | 540 | 42 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |
| 6/03 | 3.7 | 2,770 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/04 | 4.7 | 210 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/05 | 6.8 | 1,010 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/06 | 4.1 | 745 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/07 | 2.8 | 1,345 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/08 | 9.0 | 1,230 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/09 | 1.1 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/10 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/11 | 2.1 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/12 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/13 | 2.3 | 800 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/14 | 2.3 | 1,365 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/15 | 13.2 | 807 | 420 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 69.1 | 11,451 | 558 | 0 | 0 | 0 | 15 | 0 | 1 | 0 | 0 | 7 | 0 |
| Max | 13.2 | 2,770 | 420 | | | | | | | | | | |
| Avg | 2.6 | 424 | 21 | | | | | | | | | | |
| Min | 0.0 | 0 | 0 | | | | | | | | | | |

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

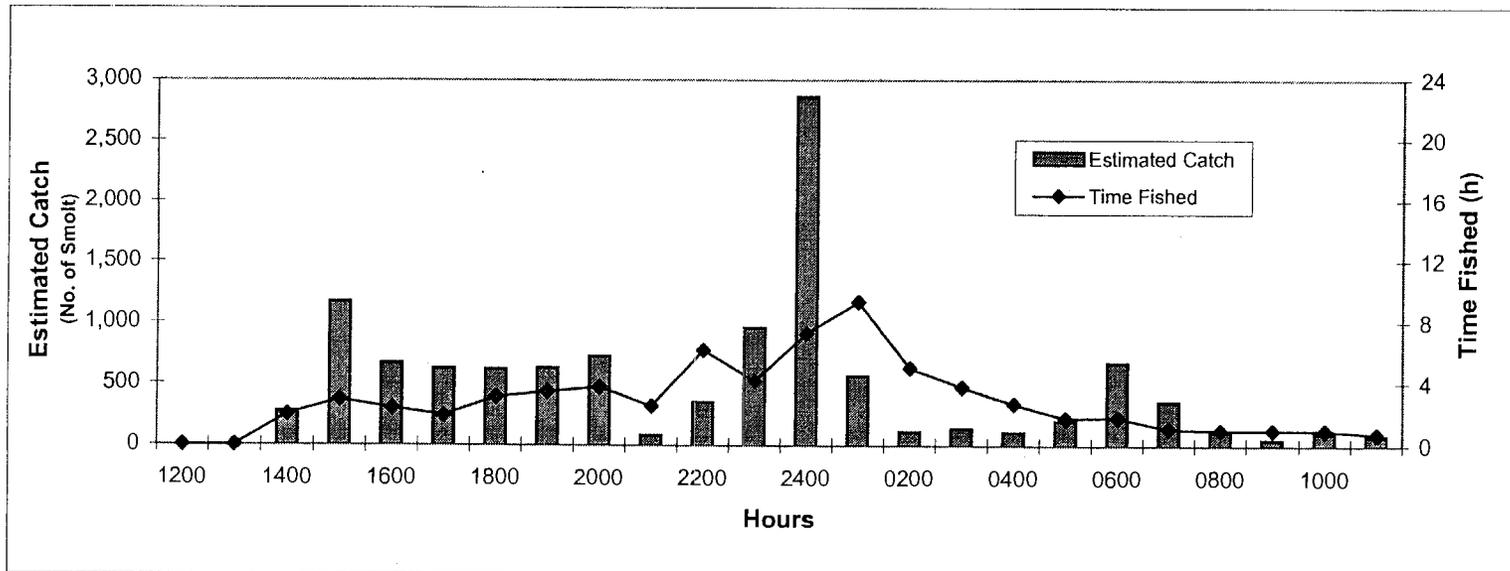
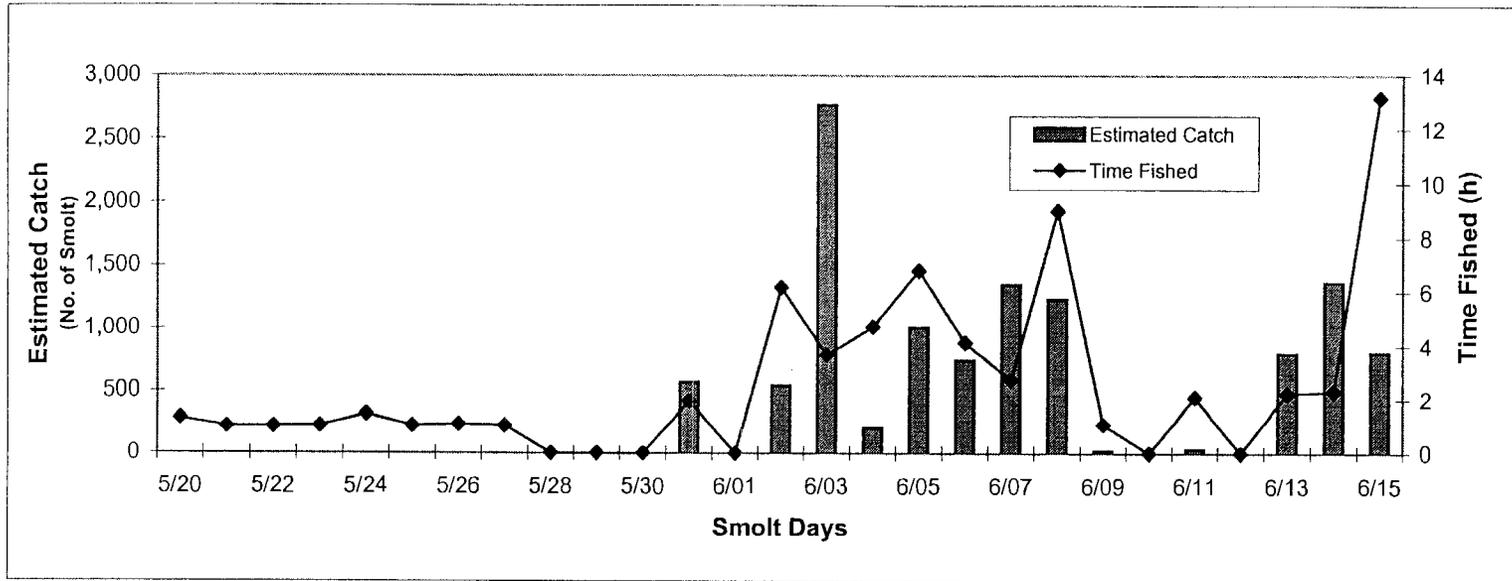
^b Species not identified.

^c 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 20 to June 15, 1999.

| 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 | 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 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1400 | 2.0 | 279.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1500 | 3.0 | 1165.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1600 | 2.4 | 665.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1700 | 2.0 | 623.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1800 | 3.1 | 616.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1900 | 3.5 | 629.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2000 | 3.8 | 721.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2100 | 2.6 | 80.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2200 | 6.2 | 353.1 | 9.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2300 ^b | 4.2 | 960.5 | 4.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2400 ^c | 7.3 | 2861.0 | 38.0 | 0.0 | 0.0 | 0.0 | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.0 | 0.0 |
| 0100 ^c | 9.3 | 570.0 | 49.0 | 0.0 | 0.0 | 0.0 | 8.0 | 0.0 | 1.0 | 0.0 | 0.0 | 4.0 | 0.0 |
| 0200 ^c | 5.0 | 114.0 | 14.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0300 ^c | 3.8 | 138.0 | 123.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0400 ^c | 2.7 | 107.0 | 129.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0500 ^c | 1.8 | 201.0 | 72.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0600 ^b | 1.8 | 673.0 | 47.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0700 | 1.1 | 357.0 | 32.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0800 | 1.0 | 111.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0900 | 1.0 | 48.0 | 16.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1000 | 1.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1100 | 0.8 | 76.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Total | 69.1 | 11,451 | 558 | 0 | 0 | 0 | 15 | 0 | 1 | 0 | 0 | 7 | 0 |

^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 hour, 1999.

Appendix C.5. Egegik River smolt fyke net catch log, 1999.

| 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 | | 0013 | 0200 | 107 | 107 | 0 | 0 | 0 |
| 5/20 | | 0034 | 0200 | 86 | 86 | 0 | 0 | 0 |
| 5/21 | | 0031 | 0201 | 90 | 90 | 0 | 0 | 0 |
| 5/22 | | 0021 | 0200 | 99 | 99 | 0 | 0 | 0 |
| 5/23 | | 0050 | 0215 | 85 | 85 | 0 | 0 | 0 |
| 5/24 | | 0037 | 0130 | 53 | 53 | 0 | 0 | 0 |
| 5/25 | 001 | 0044 | 0157 | 73 | 73 | 1 | 1 | 0 |
| 5/26 | 002 | 0036 | 0200 | 84 | 84 | 1 | 1 | 0 |
| 5/27 | | | | | | | | |
| 5/28 | | | | | | | | |
| 5/29 | | | | | | | | |
| 5/30 | | 0019 | 0026 | 7 | 7 | 0 | 0 | 0 |
| 5/31 | | | | | | | | |
| 6/01 | | | | | | | | |
| 6/02 | | | | | | | | |
| 6/03 | | | | | | | | |
| 6/04 | 003 | 0031 | 0056 | 85 | | 118 | | 1 |
| | 004 | 0059 | 0208 | 69 | 154 | 44 | 162 | 1 |
| 6/05 | 005 | 0014 | 0223 | 129 | 129 | 17 | 17 | 0 |
| 6/06 | | | | | | | | |
| 6/07 | | | | | | | | |
| 6/08 | 006 | 0152 | 0156 | 4 | | 29 | | 7 |
| | 007 | 0224 | 0244 | 20 | | 85 | | 4 |
| | 008 | 0247 | 0302 | 15 | | 85 | | 6 |
| | 009 | 0304 | 0319 | 15 | 54 | 47 | 246 | 3 |
| Max | | | | 129 | 154 | 118 | 246 | 7 |
| Avg | | | | 64 | 85 | 27 | 36 | 1 |
| Min | | | | 4 | 7 | 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 13, 1999.

| 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) | Sculpin (Species) | Northern Pike (juv) |
| 5/19 | 1.8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 5/20 | 1.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 5/21 | 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/22 | 1.7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/23 | 1.4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/24 | 0.9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/25 | 1.2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/26 | 1.4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 5/27 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/28 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/29 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/30 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/31 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/01 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/02 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/03 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/04 | 1.6 | 162 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 5 | 0 |
| 6/05 | 2.1 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 |
| 6/06 | 0.0 | 0 | 0 | 0 | 0 | 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 | 1.0 | 246 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/09 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/10 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/11 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/12 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/13 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 16.0 | 427 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 14 | 0 |
| Max | 2.1 | 246 | | | | | | | | | | | |
| Avg | 0.6 | 16 | | | | | | | | | | | |
| Min | 0.0 | 0 | | | | | | | | | | | |

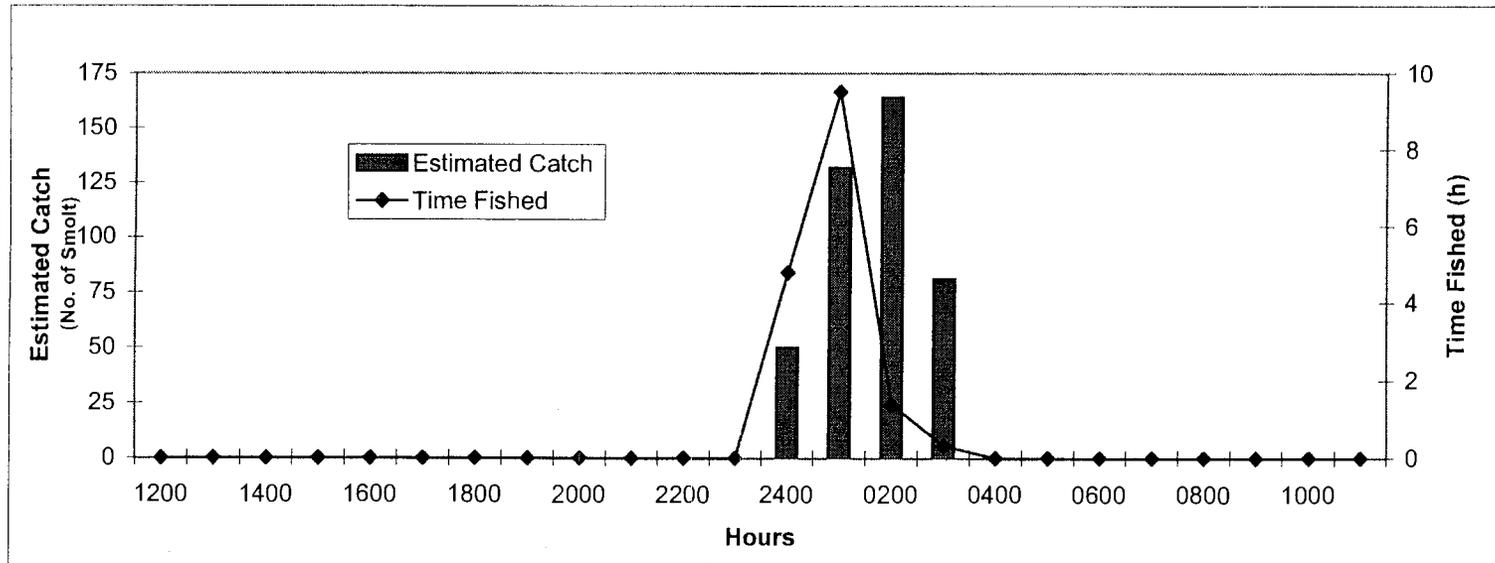
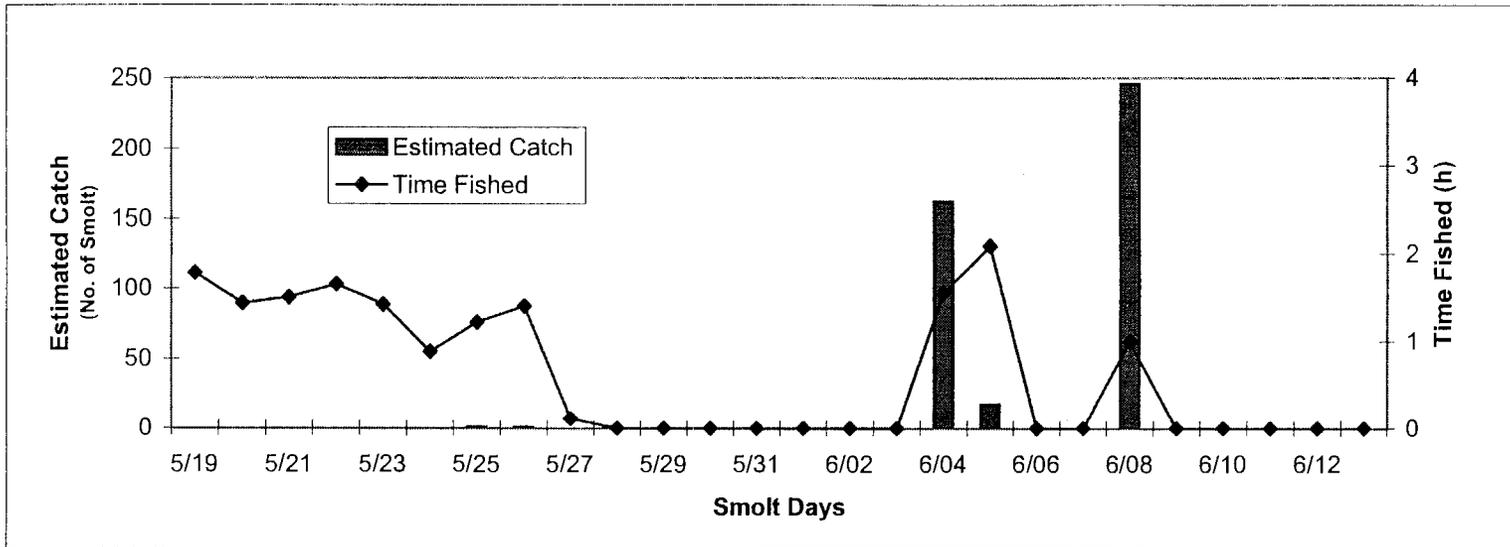
Appendix C.7. Egegik River fyke net catches by hour and species, May 19 to June 13, 1999.

| 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 | 4.8 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 |
| 0100 ^c | 9.5 | 132 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 8 | 0 |
| 0200 ^c | 1.4 | 164 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 0300 ^c | 0.3 | 81 | 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 | 16.0 | 427 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 0 | 14 | 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, 1999.

Appendix C.9. Ugashik River smolt fyke net catch log, 1999.

| 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 | | 0035 | 0105 | 30 | 30 | 0 | 0 | 0 |
| 5/20 | | | | | | | | |
| 5/21 | | | | | | | | |
| 5/22 | | | | | | | | |
| 5/23 | 001 | 2354 | 0110 | 16 | 16 | 19 | 19 | 1 |
| 5/24 | 002 | 0025 | 0135 | 70 | 70 | 75 | 75 | 1 |
| 5/25 | 003 | 2315 | 0023 | 68 | 68 | 12 | 12 | 0 |
| 5/26 | 004 | 2320 | 0047 | 87 | 87 | 4 | 4 | 0 |
| 5/27 | 005 | 2340 | 0055 | 75 | 75 | 1 | 1 | 0 |
| 5/28 | | 2330 | 0030 | 60 | 60 | 0 | 0 | |
| 5/29 | 006 | 2318 | 0018 | 60 | | 99 | | 2 |
| | 007 | 0023 | 0045 | 22 | 82 | 114 | 213 | 5 |
| 5/30 | 008 | 2330 | 0050 | 80 | 102 | 7 | 121 | 0 |
| 5/31 | 009 | 2330 | 0030 | 60 | | 200 | | 3 |
| | 010 | 0035 | 0044 | 69 | | 150 | | 2 |
| | 011 | 0049 | 0105 | 16 | 145 | 59 | 409 | 4 |
| 6/01 | 012 | 2324 | 2337 | 13 | | 106 | | 8 |
| | 013 | 2345 | 2354 | 9 | | 200 | | 22 |
| | 014 | 0001 | 0016 | 15 | | 110 | | 7 |
| | 015 | 0031 | 0036 | 5 | | 300 | | 60 |
| | 016 | 0041 | 0051 | 10 | 52 | 100 | 816 | 10 |
| 6/02 | 017 | 2327 | 0047 | 80 | 80 | 4 | 4 | 0 |
| 6/03 | 018 | 2323 | 0040 | 77 | | 117 | | 2 |
| | 019 | 0045 | 0055 | 10 | 87 | 27 | 144 | 3 |
| 6/04 | 020 | 2323 | 0042 | 79 | | 107 | | 1 |
| | 021 | 0047 | 0105 | 18 | 97 | 70 | 177 | 4 |
| 6/05 | 022 | 2320 | 2343 | 23 | | 300 | | 13 |
| | 023 | 2350 | 0040 | 50 | | 106 | | 2 |
| | 024 | 0045 | 0054 | 9 | 82 | 200 | 606 | 22 |
| 6/06 | 025 | 2340 | 0040 | 60 | 60 | 5 | 5 | 0 |
| 6/07 | 026 | 2318 | 2335 | 17 | | 68 | | 4 |
| | 027 | 2340 | 0053 | 73 | | 300 | | 4 |
| | 028 | 0058 | 0105 | 7 | 97 | 53 | 421 | 8 |
| 6/08 | 029 | 2328 | 0024 | 56 | | 150 | | 3 |
| | 030 | 0029 | 0043 | 74 | | 100 | | 1 |
| | 031 | 0048 | 0056 | 68 | 198 | 2 | 252 | 0 |
| 6/09 | | | | | | | | |
| 6/10 | 032 | 2324 | 0055 | 91 | | 30 | | 0 |
| | 033 | 0153 | 0204 | 11 | | 250 | | 23 |
| | 034 | 0209 | 0212 | 3 | | 400 | | 133 |
| | 035 | 0217 | 0220 | 3 | 108 | 150 | 830 | 50 |
| 6/11 | 036 | 2348 | 0100 | 12 | 12 | 6 | 6 | 1 |
| 6/12 | 037 | 2332 | 0055 | 83 | 83 | 15 | 15 | 0 |
| Max | | | | 91 | 198 | 400 | 830 | 133 |
| Avg | | | | 43 | 83 | 106 | 207 | 11 |
| Min | | | | 3 | 12 | 0 | 0 | 0 |

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

^b CPUE = catch per unit effort

Appendix C.10. Ugashik River fyke net catches by smolt day and species , May 19 to June 12, 1999.

| Smolt Day | Time Fished (h) | Catch Estimate (No. of Fish) | | | | | | | | | | | |
|-----------|-----------------|------------------------------|-------------------------------------|---------------|------------|----------|----------|-------------------|---------------------|-----------------|---------------------|-------------------|---------------------|
| | | Sockeye Smolt | Sticklebacks (Species) ^a | Chinook Smolt | Coho Smolt | Chum Fry | Pink Fry | Lamprey (Species) | Whitefish (Species) | Smelt (Species) | Rainbow Trout (juv) | Sculpin (Species) | Northern Pike (juv) |
| 5/19 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| 5/20 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/21 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/22 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/23 | 1.3 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 |
| 5/24 | 1.2 | 75 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 20 | 0 |
| 5/25 | 1.1 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/26 | 1.5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 |
| 5/27 | 1.3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/28 | 1.0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/29 | 1.4 | 213 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/30 | 1.3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5/31 | 1.4 | 273 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/01 | 0.9 | 516 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/02 | 1.4 | 4 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 8 | 0 |
| 6/03 | 1.5 | 144 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/04 | 1.6 | 177 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/05 | 1.4 | 364 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/06 | 1.0 | 5 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/07 | 1.6 | 249 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6/08 | 1.3 | 175 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6/09 | 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/10 | 1.8 | 389 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/11 | 1.2 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6/12 | 1.4 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 26.9 | 2,648 | 3 | 0 | 0 | 0 | 24 | 0 | 0 | 2 | 0 | 53 | 0 |
| Max | 1.8 | 516 | | | | | | | | | | | |
| Avg | 1.1 | 106 | | | | | | | | | | | |
| Min | 0.0 | 0 | | | | | | | | | | | |

^a Both threespine sticklebacks and ninespine sticklebacks were present.

Appendix C.11. Ugashik River fyke net catches by hour and species, May 19 to June 12, 1999.

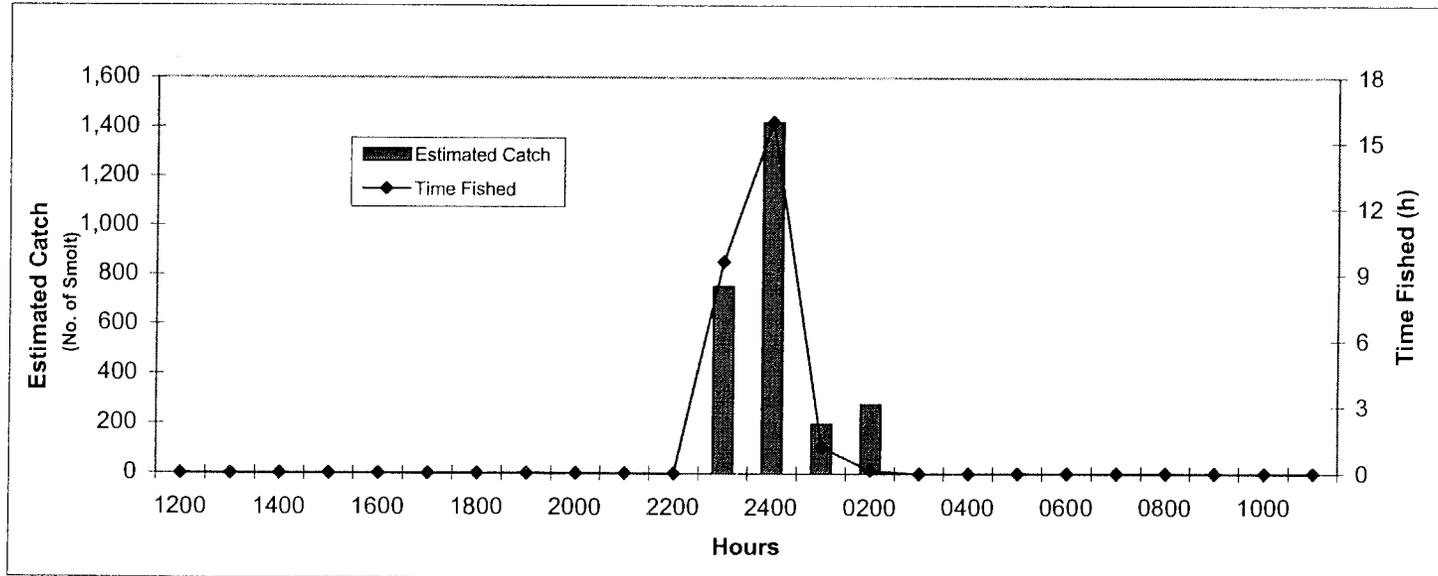
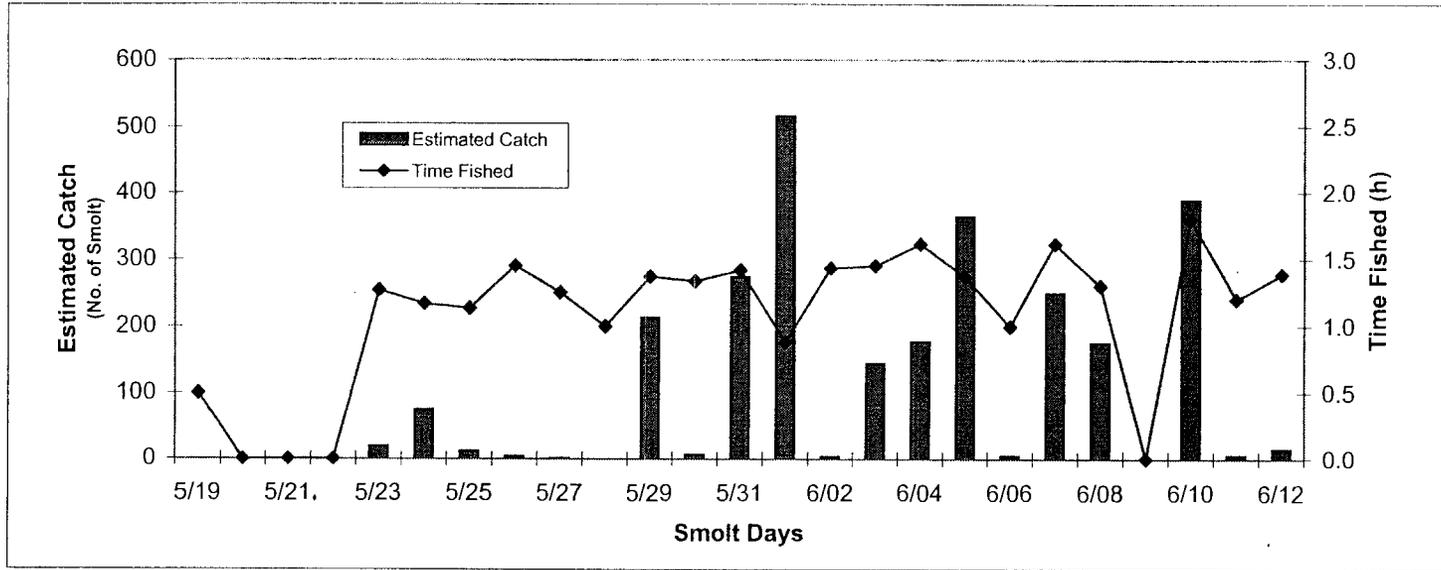
| Hour | Time Fished (h) ^a | Catch Estimate (No. of Fish) | | | | | | | | | | | |
|--------------|------------------------------|------------------------------|-------------------------------------|---------------|------------|----------|-----------|-------------------|---------------------|-----------------|---------------------|-------------------|---------------------|
| | | Sockeye Smolt | Sticklebacks (Species) ^b | 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 | ^c 9.6 | 754 | 0 | 0 | 0 | 0 | 9 | 0 | 0 | 1 | 0 | 11 | 0 |
| 2400 | ^d 16.0 | 1,418 | 3 | 0 | 0 | 0 | 14 | 0 | 0 | 1 | 0 | 31 | 0 |
| 0100 | ^d 1.2 | 197 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 11 | 0 |
| 0200 | ^d 0.2 | 279 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0300 | ^d 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0400 | ^d 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0500 | ^d 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0600 | ^c 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 | 26.9 | 2,648 | 3 | 0 | 0 | 0 | 24 | 0 | 0 | 2 | 0 | 53 | 0 |

^a Daylight hours unless indicated otherwise.

^b Both threespine sticklebacks and ninespine sticklebacks were present.

^c Twilight hours

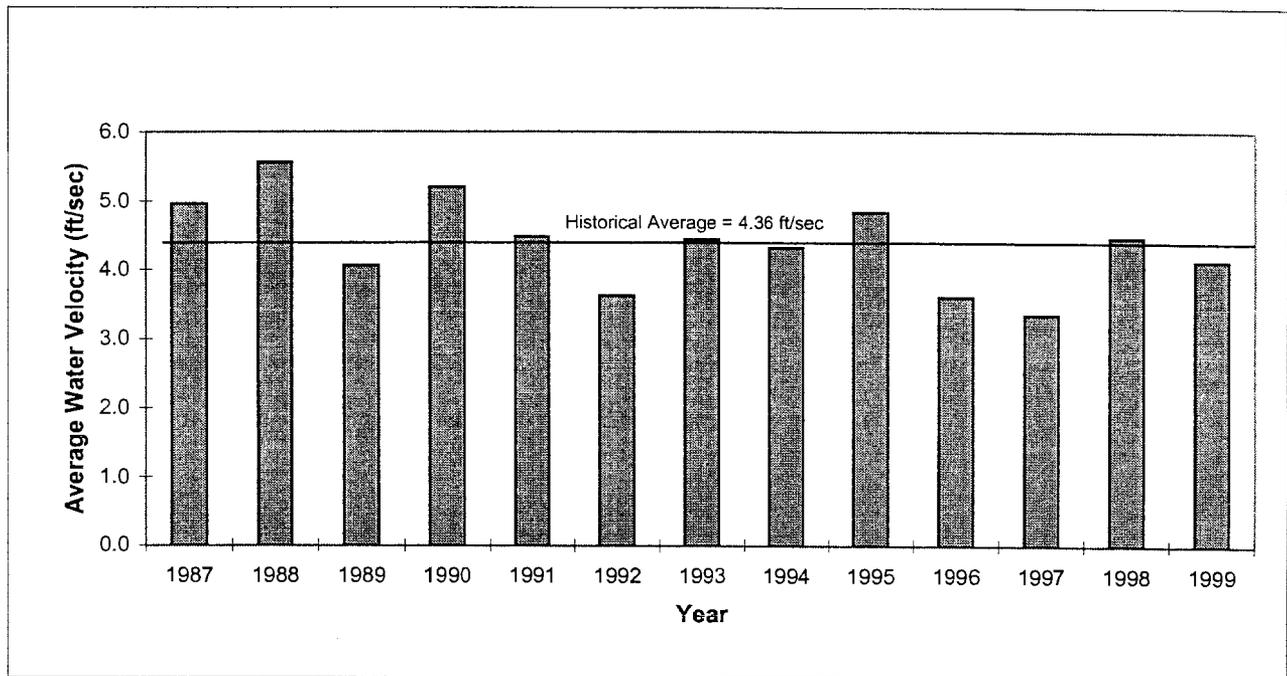
^d Hours of darkness



Appendix C.12. Ugashik River fyke net estimated catch and time fished by smolt day and hour, 1999.

Appendix D.1. Kvichak River water velocity at the center smolt sonar array, 1987-1999.

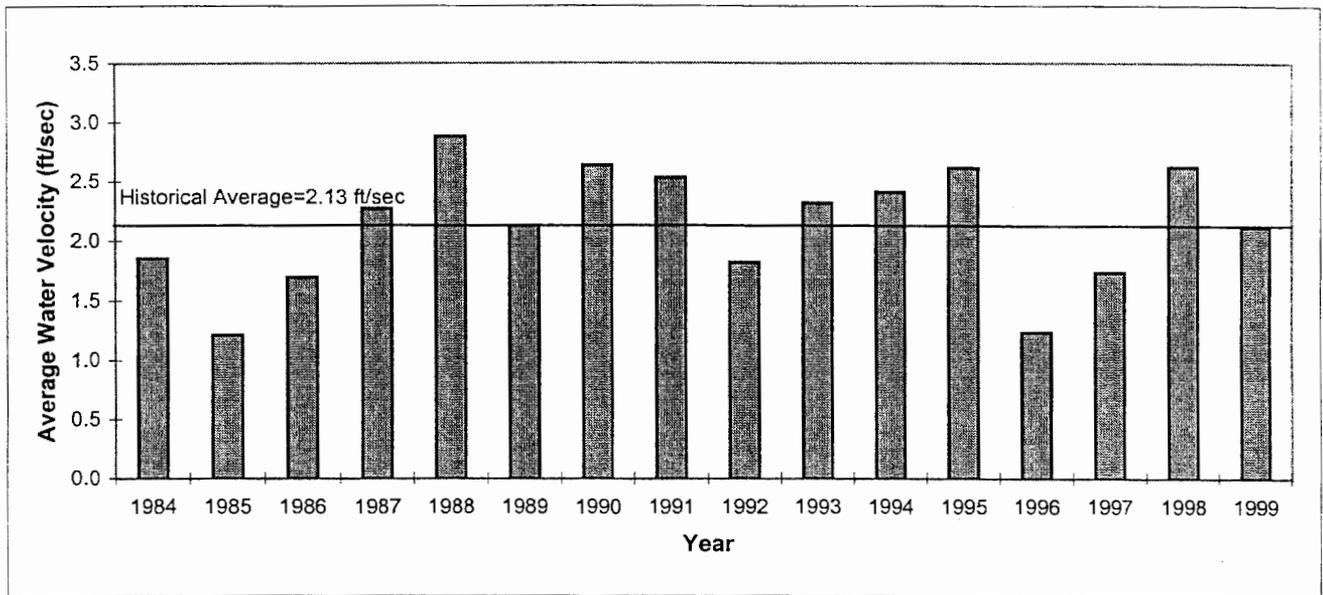
| Date | Water Velocity (ft/sec) | | | | | | | | | | | | | 1988-1998 |
|------|-------------------------|------|------|------|------|------|------|------|------|------|------|------|------|-----------|
| | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | Average |
| 5/16 | | | | | | | | | | | | | | |
| 5/17 | | | | | | | | | | | 3.12 | 4.04 | | 3.58 |
| 5/18 | | | | | | 4.20 | | | 3.52 | | | | | 3.86 |
| 5/19 | | | 3.96 | | | | | | | | | | | 3.96 |
| 5/20 | | | | | | | | | | | | | | |
| 5/21 | 4.96 | | | | | | | 4.82 | | | | | | 4.89 |
| 5/22 | | 5.38 | | 5.01 | 4.27 | | | | | | | | 3.57 | 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 | | 4.76 |
| 6/01 | | | | | 4.47 | | | | | | | | | 4.47 |
| 6/02 | | | | 5.37 | | | | | | | | | | 5.37 |
| 6/03 | | | | | | | | | | | 3.45 | | 3.93 | 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 | | | | | | | | | | | | | 4.39 | |
| 6/12 | | | | | | | | | | | | | | |
| 6/13 | | | | | | | 4.61 | 4.35 | | 3.67 | 3.53 | 5.01 | | 4.23 |
| 6/14 | | | | | | | | | | | | | | |
| 6/15 | | | | | | | | | 4.90 | | | | | 4.90 |
| 6/16 | | | | | | | | | | | | | 4.60 | |
| Max | | 5.80 | 4.27 | 5.44 | 4.69 | 3.89 | 4.61 | 4.35 | 4.90 | 3.67 | 3.53 | 5.01 | 4.60 | 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 | 4.12 | 4.36 |
| Min | | 5.38 | 3.95 | 4.99 | 4.27 | 3.43 | 4.20 | 4.27 | 4.72 | 3.52 | 3.12 | 4.01 | 3.57 | 3.12 |



Appendix D.2. Average water velocity at Kvichak River smolt sonar center array, May 15 to June 15, 1987-1999.

Appendix D.3. Egegik River water velocity at the center smolt sonar array, 1984-1999.

| Date | Water Velocity (ft/sec) | | | | | | | | | | | | | | | 1984-1998 Average | |
|------|-------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|----------------------|------|
| | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | | 1999 |
| 5/16 | | | | | | | | | | | | | | | | | |
| 5/17 | | | | 2.15 | | | | | | 2.37 | | | | | | | 2.26 |
| 5/18 | | | | | 2.63 | | | | | | | | | | 2.57 | | 2.60 |
| 5/19 | | | | | | | 2.50 | | | | | | | | | | 2.50 |
| 5/20 | 1.89 | | | | | 2.00 | | 2.00 | | | | | 1.50 | 1.80 | | | 1.84 |
| 5/21 | | 1.16 | 1.83 | | | | | | | 2.30 | 2.68 | | | | | | 1.99 |
| 5/22 | | | | | | | | | 1.58 | | | | | | | | 1.58 |
| 5/23 | | | | | | | | | | | | | | | | | |
| 5/24 | | | | | | | | | 1.70 | | | 2.62 | | | 2.42 | 1.85 | 2.25 |
| 5/25 | | | | | 3.16 | | | | | | | | 1.25 | 1.75 | | | 2.05 |
| 5/26 | | | 1.53 | 2.14 | | | 2.68 | | | | | | | | | | 2.12 |
| 5/27 | | | | | | | | | | | 2.28 | | | | | | 2.28 |
| 5/28 | | | | | | 2.09 | | | | 2.30 | | | | | | | 2.20 |
| 5/29 | | | | | | | | 2.75 | | | | | | | | | 2.75 |
| 5/30 | | | | | | | | | | | | | | | | | |
| 5/31 | | | | | | | | | 2.02 | | | | 1.28 | 1.67 | 2.47 | 2.20 | 1.86 |
| 6/01 | | | 1.76 | 2.30 | 2.90 | | | | | | | 2.75 | | | | | 2.43 |
| 6/02 | | | | | | | 2.73 | | | | 2.43 | | | | | | 2.58 |
| 6/03 | 1.82 | | | | | | | | | 2.30 | | | | | | | 2.06 |
| 6/04 | | | | | | 2.30 | | | | | | | | | | | 2.30 |
| 6/05 | | | | | | | | 2.85 | | | | | | | | | 2.85 |
| 6/06 | | 1.16 | | | | | | | | | | | | | 3.03 | | 2.10 |
| 6/07 | | | | | | | | | | | | 0.90 | 1.72 | | | 2.30 | 1.31 |
| 6/08 | | | | | | | | | | | | 2.68 | | | | | 2.68 |
| 6/09 | | | | | | | | 1.98 | | 2.25 | | | | | | | 2.12 |
| 6/10 | | | 1.67 | 2.51 | 2.83 | | | | | | | | | | | | 2.34 |
| 6/11 | | | | | | | | | | | | | | | | | |
| 6/12 | | | | | | | | | | | | 2.40 | | | | | 2.40 |
| 6/13 | | 1.32 | | | | | | | | | | | | | | | 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 | 2.30 | 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 | 2.12 | 2.13 |
| 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 | 1.85 | 0.90 |

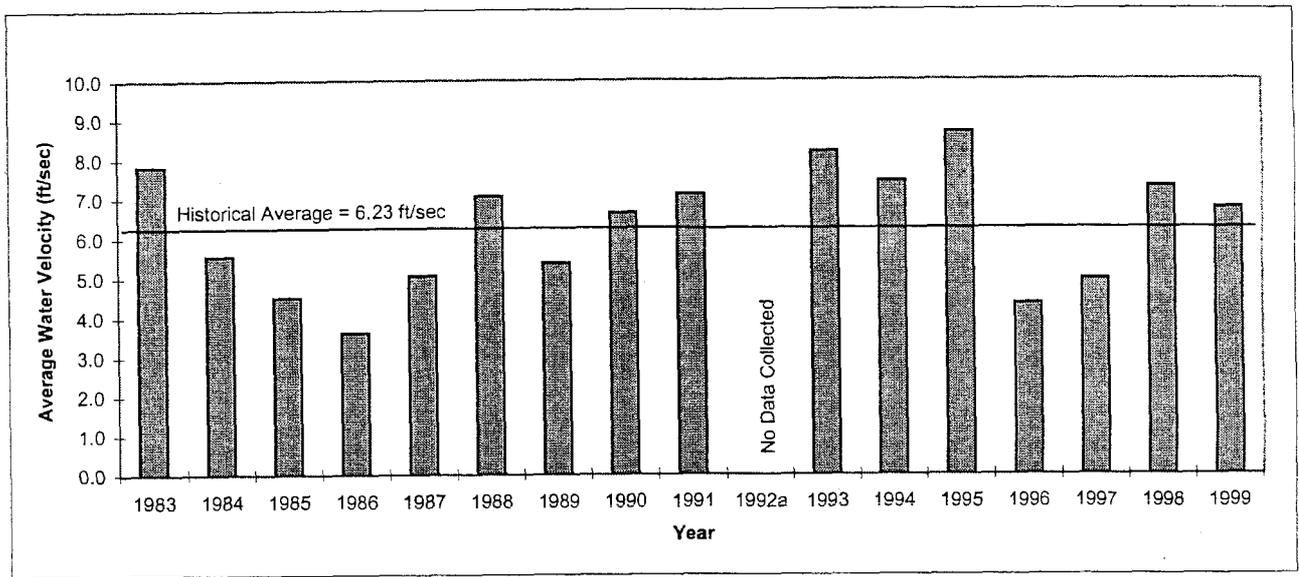


Appendix D.4. Average water velocity at Egegik River smolt sonar center array, May 15 to June 15, 1984-1999.

Appendix D.5. Ugashik River water velocity at the inshore smolt sonar array, 1983-1999.

| Date | Water Velocity (ft/sec) | | | | | | | | | | | | | | | | | 1983-1998 |
|------|-------------------------|------|------|------|------|------|------|------|------|-------------------|------|------|------|------|------|------|------|-----------|
| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 ^a | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 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 | | 6.62 |
| 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 | 6.12 | |
| 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 | 6.30 | 5.82 |
| 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 | | | | | | | | | | | | | | | | | 6.91 | |
| 6/08 | | | | | | | | | | | 8.34 | | | | | | | 8.34 |
| 6/09 | | | | | | | | | | | | 7.04 | 7.53 | 4.47 | | | | 6.35 |
| 6/10 | | | | | | | | | | | | | | | | | | |
| 6/11 | | | | 3.80 | | | | | | | | | | | | | 7.60 | 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 | 7.60 | 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 | 6.73 | 6.23 |
| 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 | 6.12 | 3.16 |

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

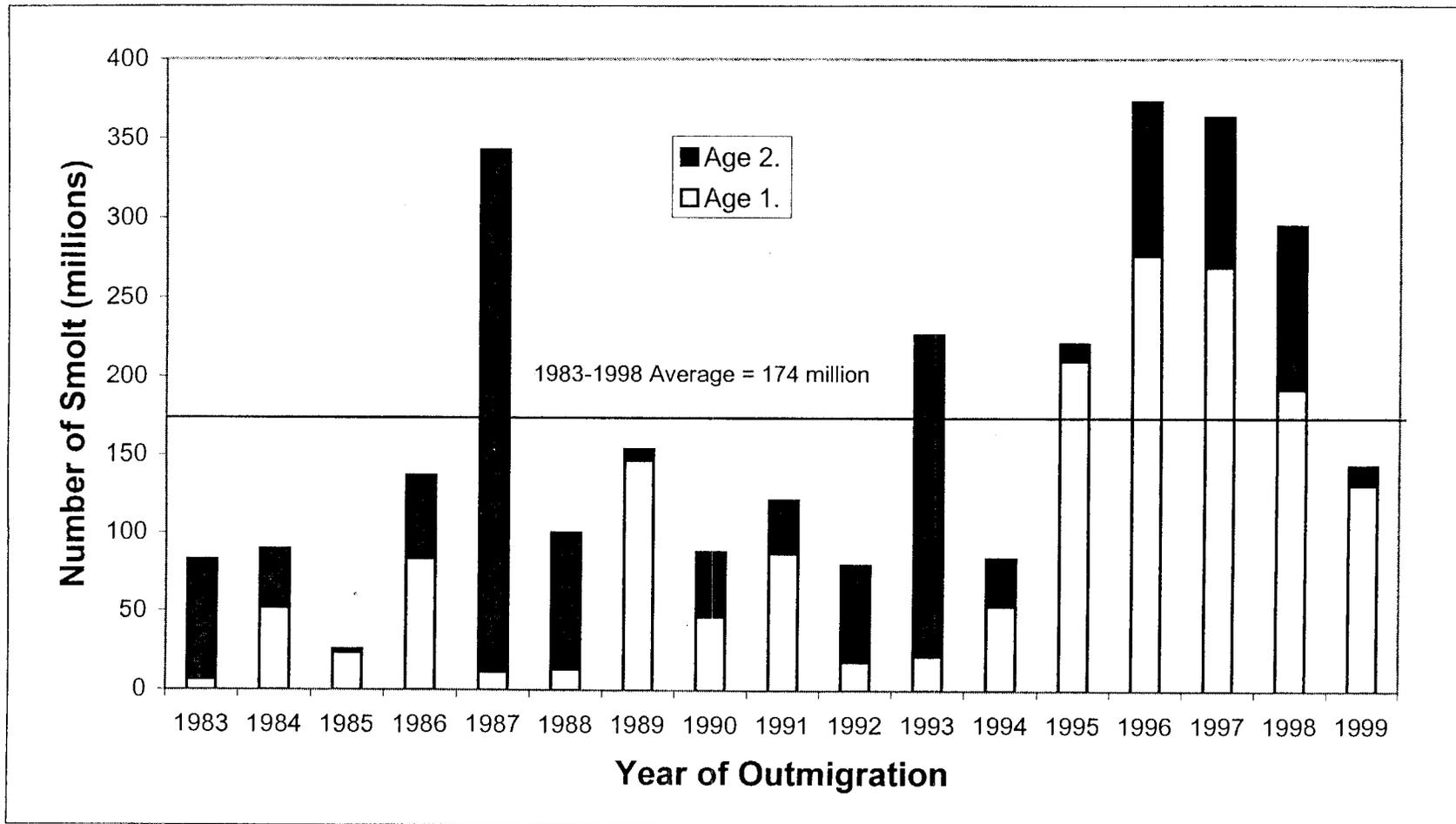


Appendix D.6. Average water velocity at Ugashik River smolt sonar inshore array, May 15 to June 15, 1983-1999.

Appendix E.1. Total smolt outmigration estimates for Kvichak River by outmigration year, 1983-1999.

| 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 | | |
| 1998 | 5/17-6/12 | 27 | 5/20 | 5/25 | 6/01 | 5/21 | 46,937,701 | 295,470,850 | | |
| 1983-98 Max | | 29 | 6/06 | 6/10 | 6/17 | 6/09 | 78,544,749 | 373,166,532 | | |
| 1983-98 Avg | | 25 | 5/24 | 5/28 | 6/06 | 5/29 | 31,011,796 | 173,937,412 | | |
| 1983-98 Min | | 19 | 5/19 | 5/22 | 5/31 | 5/21 | 6,059,204 | 25,527,851 | | |
| 1999 ^a | 6/01-6/16 | 16 | 6/04 | 6/08 | 6/14 | 6/04 | 18,566,414 | 143,543,215 | Ice Problems - 5/17-5/31 continuous threat from frozen lake | |

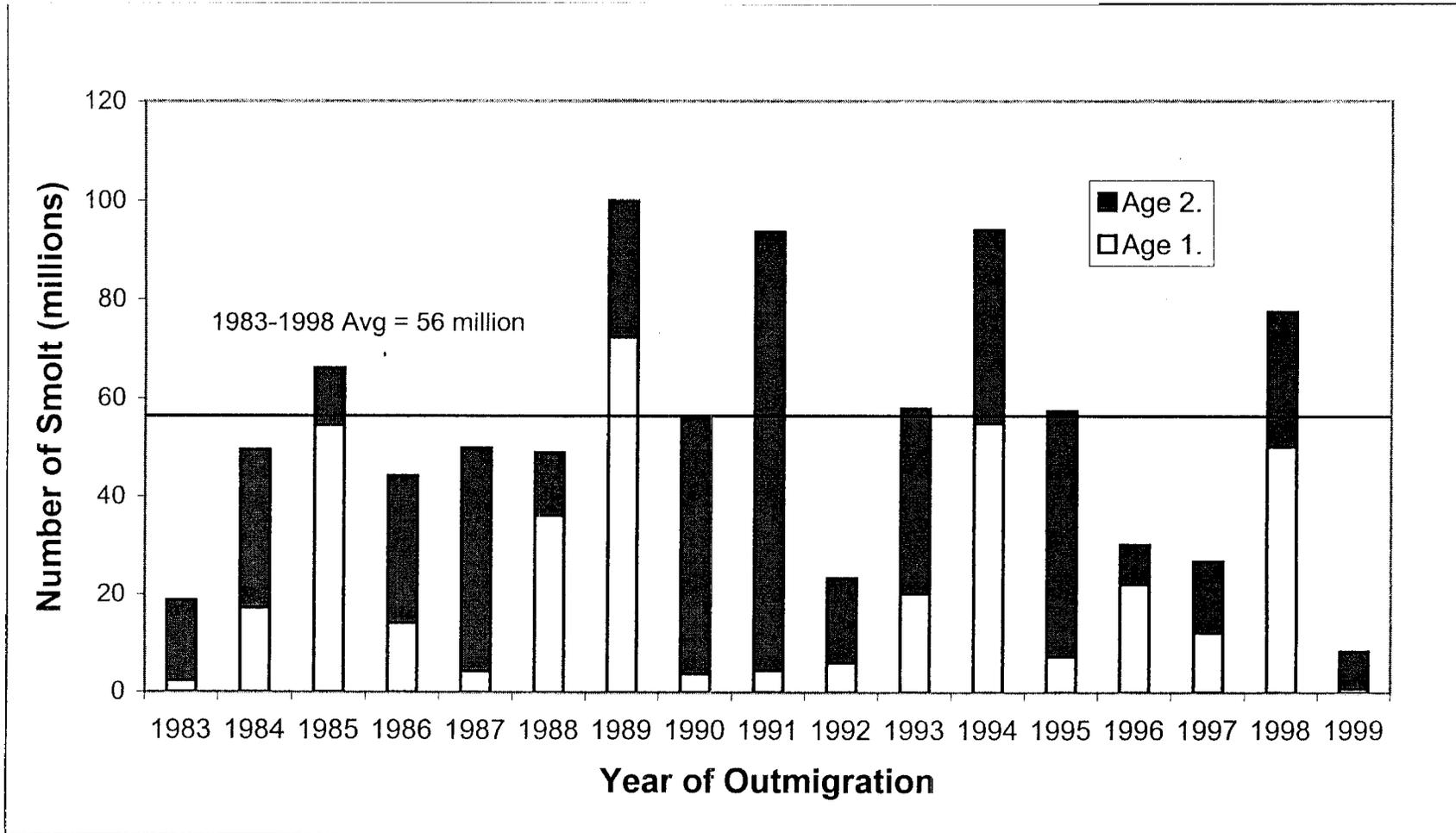
^a Preliminary smolt outmigration estimates.



Appendix E.2. Age composition of smolt outmigration estimates for Kvichak River by outmigration year, 1983-1999.

Appendix E.3. Total smolt outmigration estimates for Egegik River by outmigration year, 1983-1999.

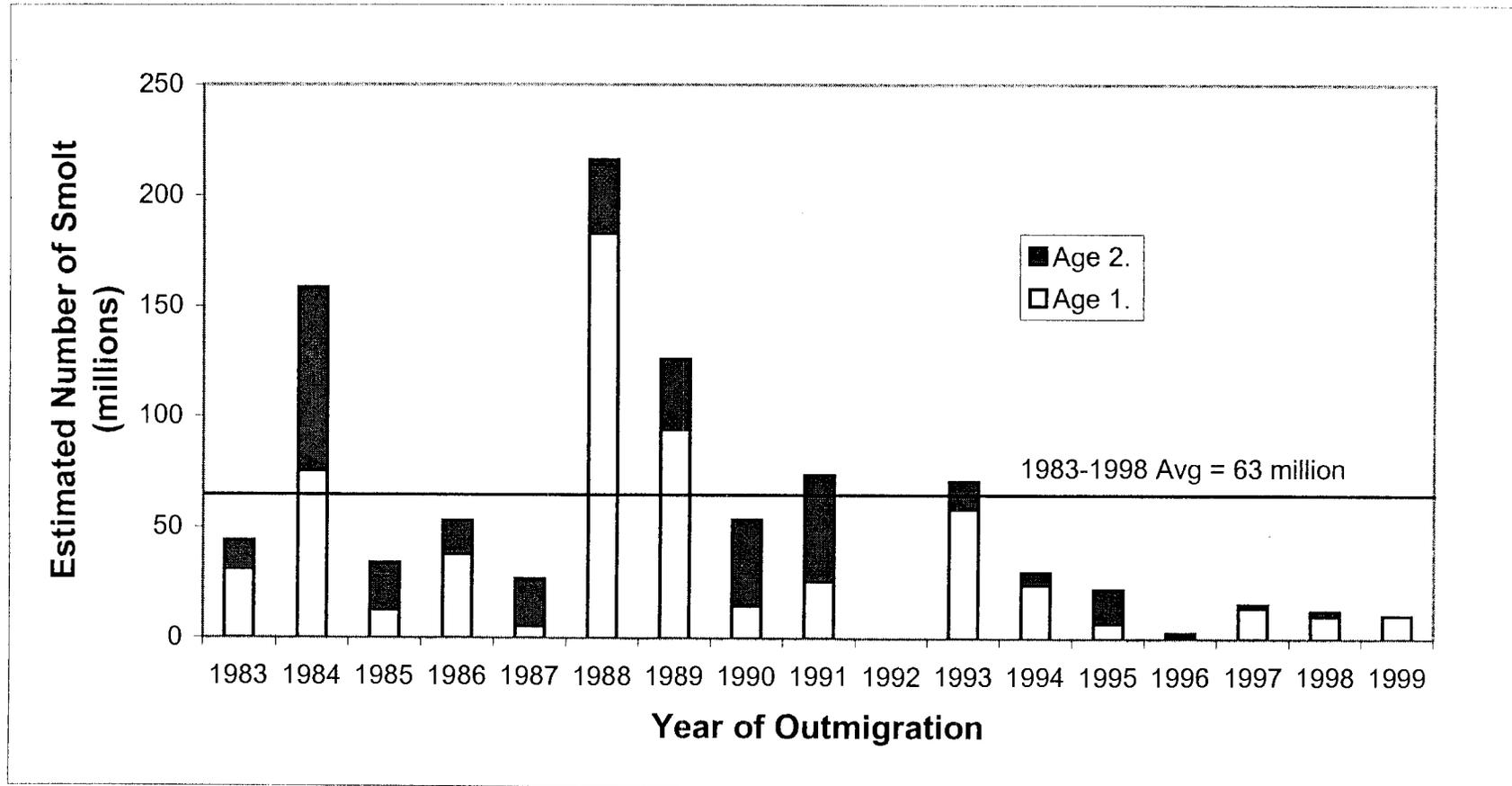
| Year of Outmigration | Operating Dates | Total Days Operated | Cumulative Percent by Date | | | Peak Daily | | Total Smolt Estimate | Comments |
|----------------------|-----------------|---------------------|----------------------------|------|------|------------|----------------|----------------------|---|
| | | | 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 |
| 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 |
| 1983-98 Max | | 27 | 5/27 | 5/31 | 6/08 | 6/04 | 24,392,451 | 99,886,786 | |
| 1983-98 Avg | | 24 | 5/24 | 5/26 | 6/01 | 5/26 | 14,017,349 | 56,118,072 | |
| 1983-98 Min | | 20 | 5/20 | 5/23 | 5/27 | 5/22 | 4,881,168 | 18,766,889 | |
| 1999 | 5/21-6/13 | 24 | 5/23 | 6/09 | 6/09 | 6/09 | 3,703,824 | 8,592,482 | Ice Problems - 5/27-6/06 intermittent, 6/07-6/13 continuous |



Appendix E.4. Age composition of smolt outmigration estimates for Egegik River by outmigration year, 1983-1999.

Appendix E.5. Total smolt outmigration estimates for Ugashik River by outmigration year, 1983-1999.

| 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 | Intermittent ice floes - 5/17-5/21 |
| 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 |
| 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 |
| 1983-98 Max | | 34 | 5/30 | 6/06 | 6/13 | 6/07 | 55,816,902 | 215,968,015 | |
| 1983-98 Avg | | 25 | 5/25 | 5/31 | 6/07 | 5/31 | 12,376,795 | 62,648,636 | |
| 1983-98 Min | | 0 | 5/18 | 5/24 | 5/30 | 5/24 | 627,517 | 2,576,812 | |
| 1999 | 5/17-6/12 | 27 | 5/29 | 6/10 | 6/11 | 6/10 | 4,171,058 | 10,631,631 | Intermittent to heavy ice floes - 5/18-5/23; Good Weather - 62 h disabled time |



Appendix E.6. Age composition of smolt outmigration estimates for Ugashik River by outmigration year, 1983-1999.



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, 1984-1999.

| 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 | 09-Jun | 5.8 |
| 1986 | 21-May | 4.5 | | 06-Jun | 7.0 |
| 1987 | 21-May | 4.5 | | 28-May | 5.9 |
| 1988 | 22-May | 3.8 | | 01-Jun | 5.7 |
| 1989 | 19-May | 4.0 | | 03-Jun | 6.0 |
| 1990 | 21-May | 3.5 | c | 27-May | 5.8 |
| 1991 | 22-May | 2.0 | | 04-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 | | 05-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 |
| 1998 | 18-May | 3.0 | | 25-May | 4.4 |
| Max | | 7.0 | | | 7.8 |
| Avg | | 4.5 | | | 6.3 |
| Min | | 2.0 | | | 4.4 |
| 1999 | 01-Jun | 0.5 | | 04-Jun | 2.5 |

^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, 1984-1999.

| 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 ^a | 29-May | 4.7 |
| 1987 | 19-May | 5.5 | 22-May | 4.0 |
| 1988 | 18-May | 4.9 ^b | 24-May | 5.8 |
| 1989 | 20-May | 3.5 ^c | 27-May | 4.2 |
| 1990 | 19-May | 3.5 ^d | 25-May | 3.8 |
| 1991 | 21-May | 7.0 | 04-Jun | 8.0 |
| 1992 | 22-May | 7.0 ^e | 26-May | 6.8 |
| 1993 | 17-May | 6.5 ^f | 25-May | 6.5 |
| 1994 | 21-May | 4.0 | 31-May | 5.8 |
| 1995 | 21-May | 4.3 ^g | 23-May | 5.0 |
| 1996 | 19-May | 4.8 | 24-May | 5.3 |
| 1997 | 19-May | 4.0 | 29-May | 7.5 |
| 1998 | 18-May | 4.5 | 29-May | 5.3 |
| Max | | 7.0 | | 8.0 |
| Avg | | 4.8 | | 5.6 |
| Min | | 2.5 | | 3.8 |
| 1999 | 21-May | 2.5 | 09-Jun | 0.5 |

^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, 1984-1999.

| Year | Sonar Startup | | Peak Smolt Passage | |
|-------------------|---------------|---------------------------|--------------------|---------------------------|
| | Smolt Day | Mean Water Temperature °C | Smolt Day | Mean Water Temperature °C |
| 1984 | 22-May | 4.8 | 01-Jun | 6.5 |
| 1985 | 22-May | 1.5 | 04-Jun | 5.3 |
| 1986 | 21-May | 4.0 | 30-May | 5.0 |
| 1987 | 17-May | 5.5 | 03-Jun | 6.3 |
| 1988 | 17-May | 3.5 | 07-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 | 02-Jun | 5.5 |
| 1992 ^a | | | | |
| 1993 | 17-May | 6.0 | 26-May | 7.0 |
| 1994 | 20-May | 5.0 | 04-Jun | 7.0 |
| 1995 | 22-May | 4.5 | 25-May | 5.0 |
| 1996 | 19-May | 4.0 | 04-Jun | 7.0 |
| 1997 | 10-May | 5.0 | 24-May | 6.5 |
| 1998 | 17-May | 3.5 | 05-Jun | 6.0 |
| Max | | 6.0 | | 7.3 |
| Avg | | 4.2 | | 6.0 |
| Min | | 1.5 | | 4.0 |
| 1999 | 26-May | 1.5 | 10-Jun | 5.0 |

^a Project not conducted. No data collected.



APPENDIX G. CLIMATOLOGICAL FACTORS THAT MAY HAVE AFFECTED THE FRESHWATER SURVIVAL OF 1999 SMOLT

The freshwater survival of salmon eggs, fry, and smolt from the 1996 and 1997 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 (1996; 1997; 1998, 1999a,b,c,d,e,f) the overall annual temperatures for King Salmon and vicinity from July through June in 1996-1997 and 1997-1998 were 0.4 °F and 1.4 °F warmer than the 30-year mean (Appendix G.1) and 1998-1999 was -2.6 °F colder than the 30-year mean.

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 October and December 1996 (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), January, August, and December 1998 (2.6 °F, 2.6 °F, and 7.8 °F below average) and January, February, March, and May 1999 (4.4 °F, 11.2 °F, 9.6 °F and 3.3°F below average). The remaining months were at or above the 30-year mean temperatures, which would have been favorable for the development and survival of juvenile salmon.

The winter of 1996-1997, with the exception of February, was colder than the prior year. Between October 1996 and April 1997, there were 135 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.3). This winter had 77 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. Between October 1997 and April 1998 there were 130 d with average daily air temperatures less than or equal to 32 °F and 16 d with average daily temperatures less than 0 °F (Appendix G.4). This milder weather, especially in March and April, may have created more favorable rearing conditions for 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).

Air temperatures during the winter of 1998-1999 were much more severe than 1996-1997 or 1997-1998. Between October 1998 and April 1999 there were 142 d with average daily air temperatures less than or equal to 32 °F and 45 d with average daily temperatures less than 0 °F (Appendix G.5).

The winter of 1998-1999 had only 70 d with average daily air temperatures greater than 32 °F which may have slowed development of salmon eggs and fry from the 1998 brood year. Below normal temperatures predominated from late November to mid-December (18 d), late December to early January (10 d), mid-January to mid- February (22 d) and late February to mid-March (19d).

Precipitation

Precipitation data collected by the National Weather Service (1996; 1997; 1998; 1999a,b,c,d,e,f) for King Salmon and vicinity from July through June in 1996-1997, 1997-1998, and 1998-1999 were 7.3 in less, 0.4 in less, and 1.0 in more than the 30-year mean annual precipitation of 19.4 in (Appendix G.6).

Average monthly precipitation's 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 precipitation's 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 precipitation 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 precipitation's for these months were 25%, 32%, 133%, and 37% greater than the 30-year means. The increase in precipitation may have caused some flooding, although we have no direct information that significant flooding occurred.

Average monthly precipitation's during the 1998-1999 season fluctuated above and below the 30-year mean (Appendix G.7). The average monthly precipitations for August, September, and October were 3.59 in, 3.28 in, and 3.96 in; 21%, 22%, and 88% greater than the 30-year mean. This increased precipitation in the fall may have caused some flooding which could decrease freshwater survival of eggs from the 1998 brood year due to scouring and siltation of salmon redds. The months in which low precipitation may have impacted freshwater survival of sockeye salmon in east side Bristol Bay river systems were December, January, March, and April. The precipitation for these months was 40%, 53%, 58%, and 36% less than the 30-year mean. It is unknown how this increase followed by decreases in precipitation may have effected the age-1. (1997 brood year) and age-2. (1996 brood year) fry.

Snowfall

Snowfall data collected for King Salmon and vicinity by the National Weather Service (1996; 1997; 1998, 1999a,b,c,d,e,f) from July through June in 1996-1997, 1997-1998, and 1998-1999 were 23.6 in less, 4.2 in more, 8.3 in more than the 30-year mean annual snowfall of 46.3 in. (Appendix G.8).

Average monthly snowfalls during the winter of 1996-1997 were 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).

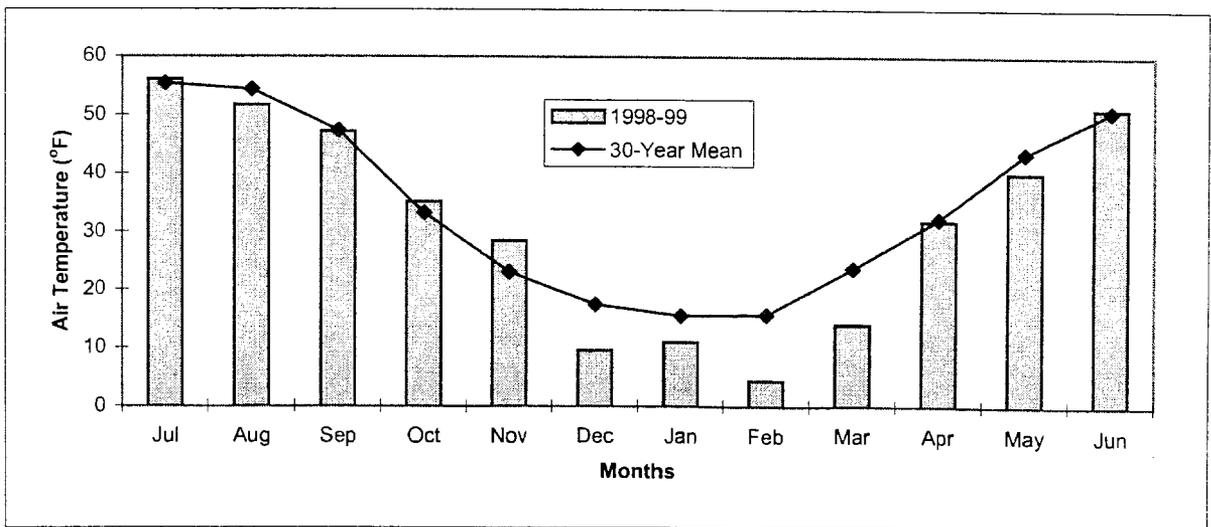
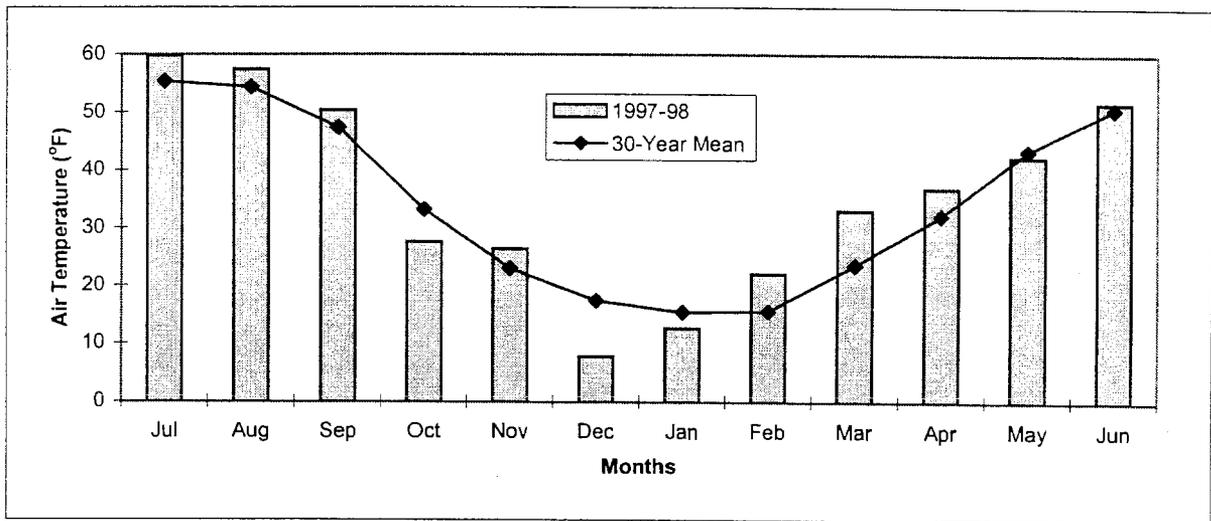
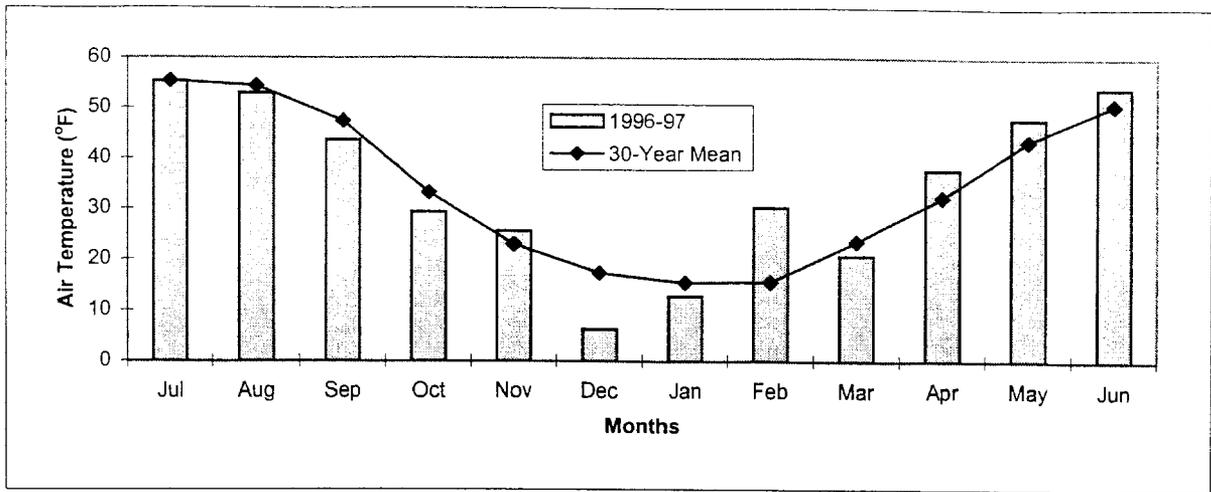
During the winter of 1997-1998 most of the snow fell early with above normal snowfalls in November (10.4 in), December (13.1 in), and January (17.3 in) (Appendix G.9). The monthly snowfall for the remainder of the winter was below normal, however the insulating qualities of the early snowfall probably protected developing eggs (1997 brood year) and rearing age-1. and -2. fry (1996 and 1995 brood years) from exposure to severe temperatures.

Overall, snowfall during the winter of 1998-1999 season was above normal (Appendix G.9). The total monthly snowfalls for October, February, and April were 206%, 198%, and 230% respectively, above the 30-year mean. The warm spell that occurred in late October and early November melted most if not all of the October snow. Snowfalls in November, December, January, and March were below normal. It is unknown how the lack of insulating snow in the early half of the winter may have affected the incubating salmon eggs (1998 brood year) and rearing fry in east side Bristol Bay streams and lakes.

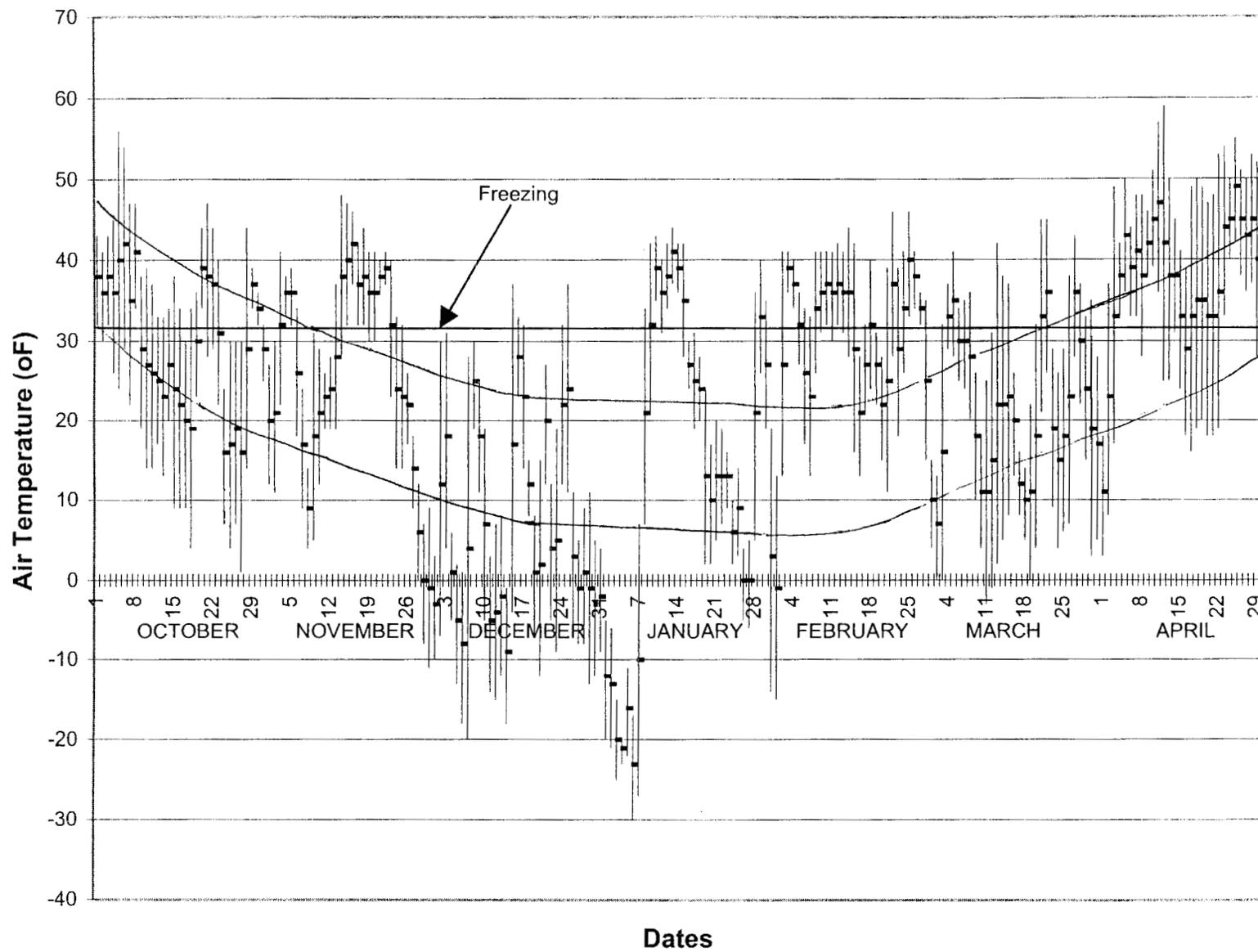
Appendix G.1. Average monthly air temperature for King Salmon, July 1969 to June 1999.

| Smolt Year | Air Temperature (°F) ^a | | | | | | | | | | | | Average Annual |
|--------------|-----------------------------------|------|------|------|------|------|------|------|------|------|------|------|----------------|
| | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | |
| 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 |
| 1998-99 | 56.1 | 51.7 | 47.2 | 35.1 | 28.4 | 9.6 | 11.0 | 4.4 | 14.0 | 31.8 | 40.1 | 51.0 | 31.7 |
| 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 | 55.4 | 54.3 | 47.4 | 33.2 | 22.9 | 17.4 | 15.4 | 15.6 | 23.6 | 32.2 | 43.4 | 50.7 | 34.3 |
| Min | 51.5 | 50.9 | 41.0 | 26.7 | 12.7 | 4.5 | -2.9 | -2.1 | 1.8 | 2.1 | 37.7 | 46.6 | 27.9 |

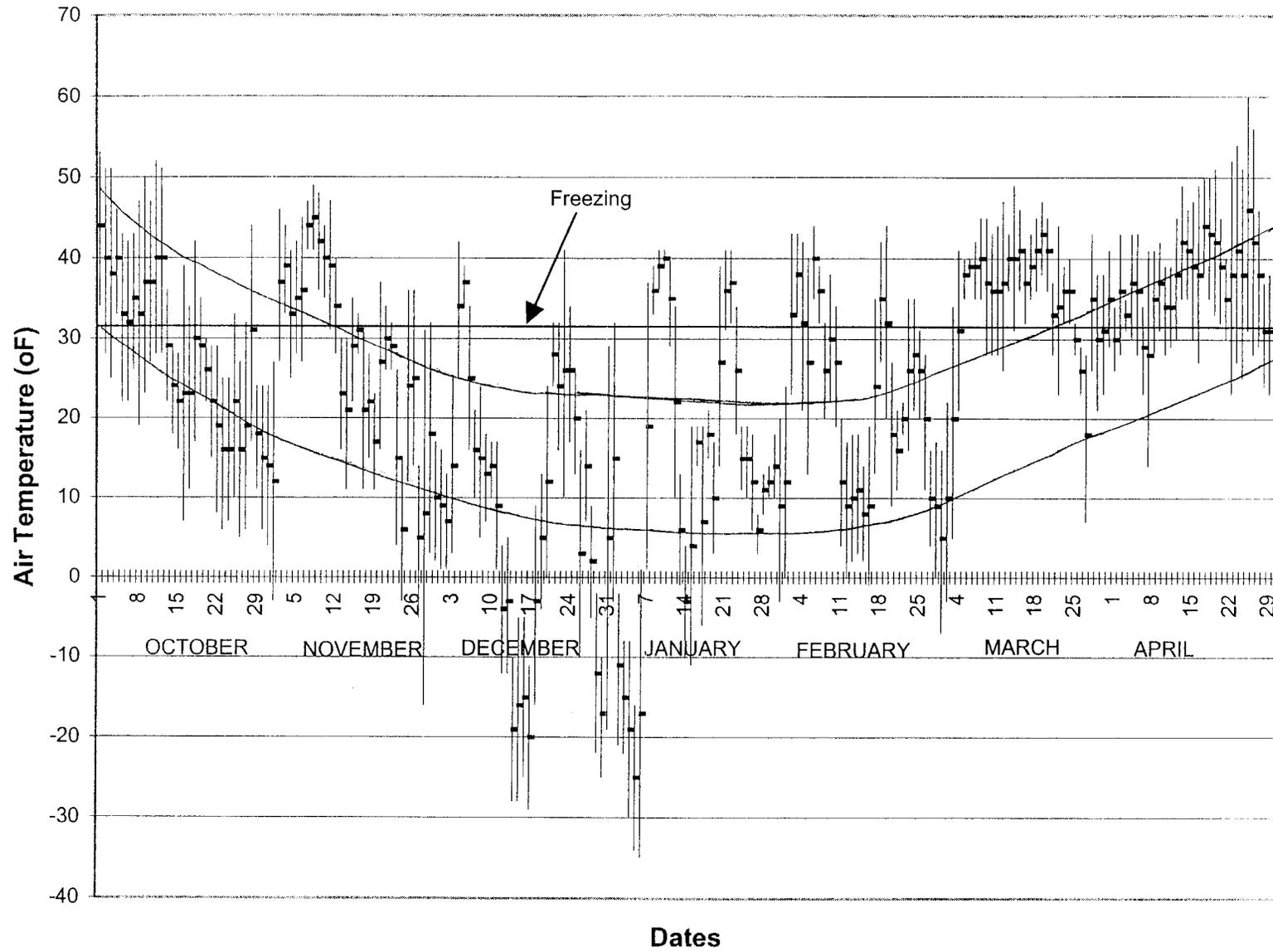
^a Source - National Weather Service (1996; 1997; 1998; 1999a,b,c,d,e,f)



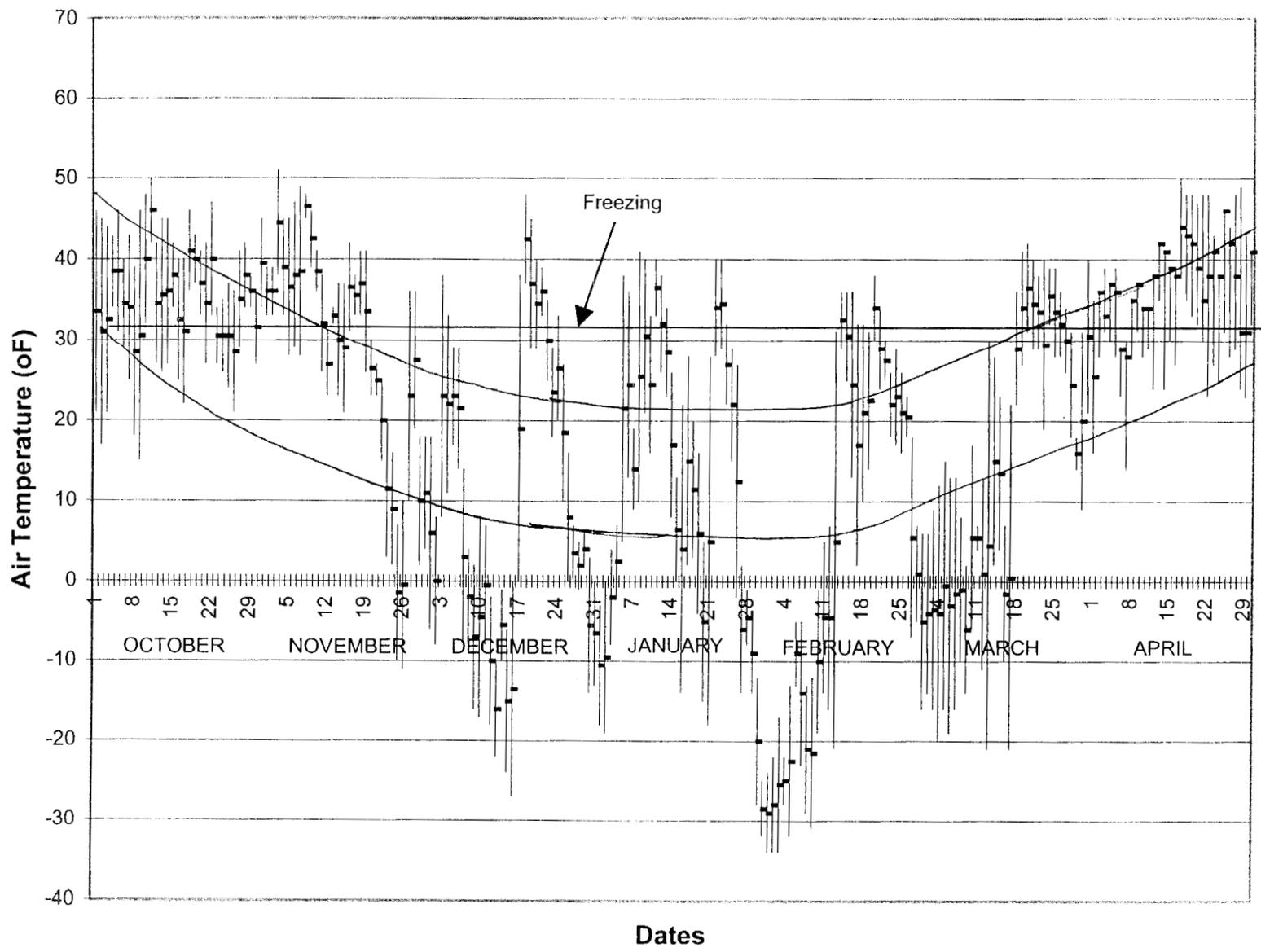
Appendix G.2. Comparison of monthly air temperature to the 30-year mean at King Salmon, July 1996 to June 1999.



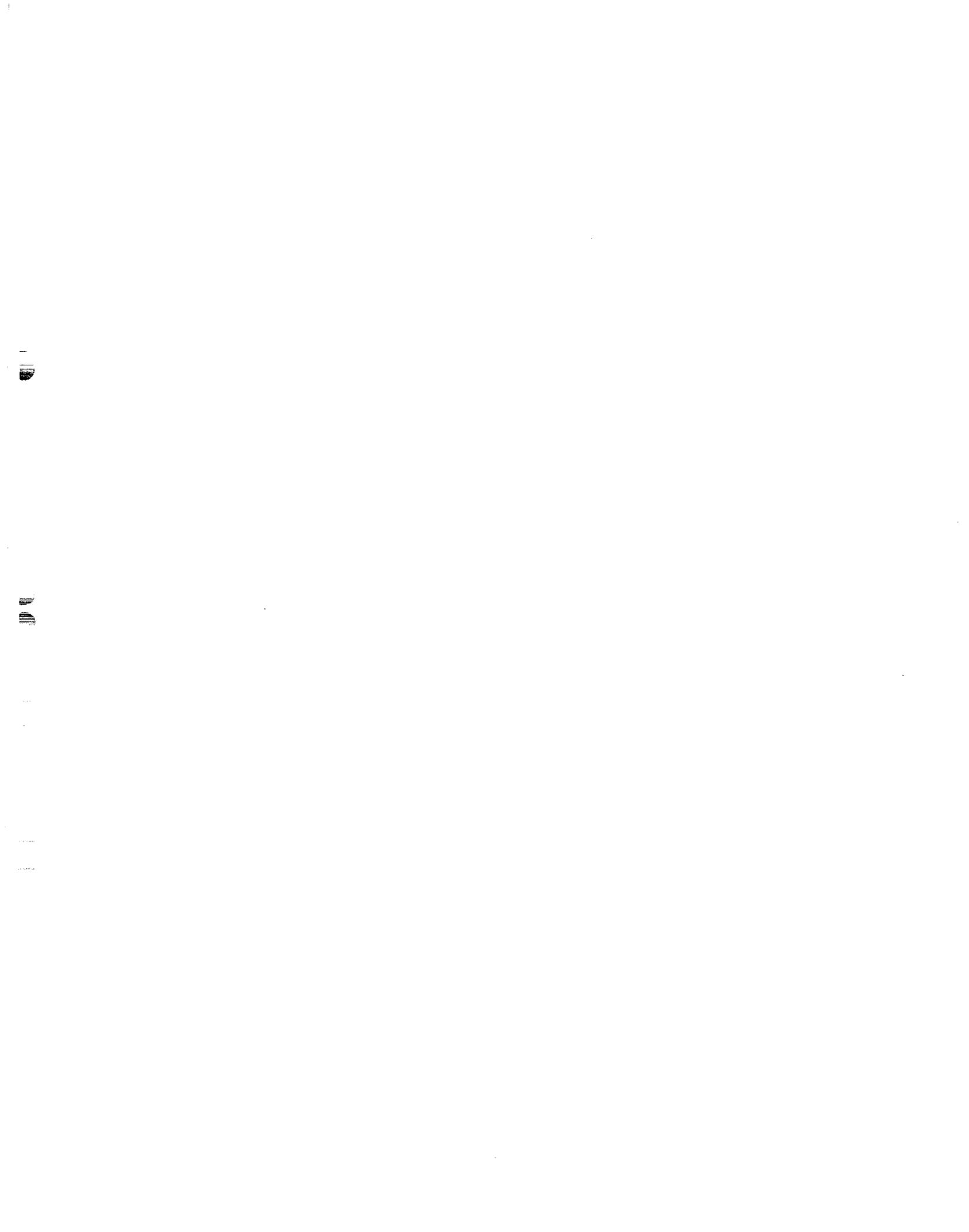
Appendix G.3. Daily air temperatures (normal, mean and extreme) for King Salmon, October 1996 to April 1997.



Appendix G.4. Daily air temperature (normal, mean and extreme) for King Salmon, October 1997 to April 1998.



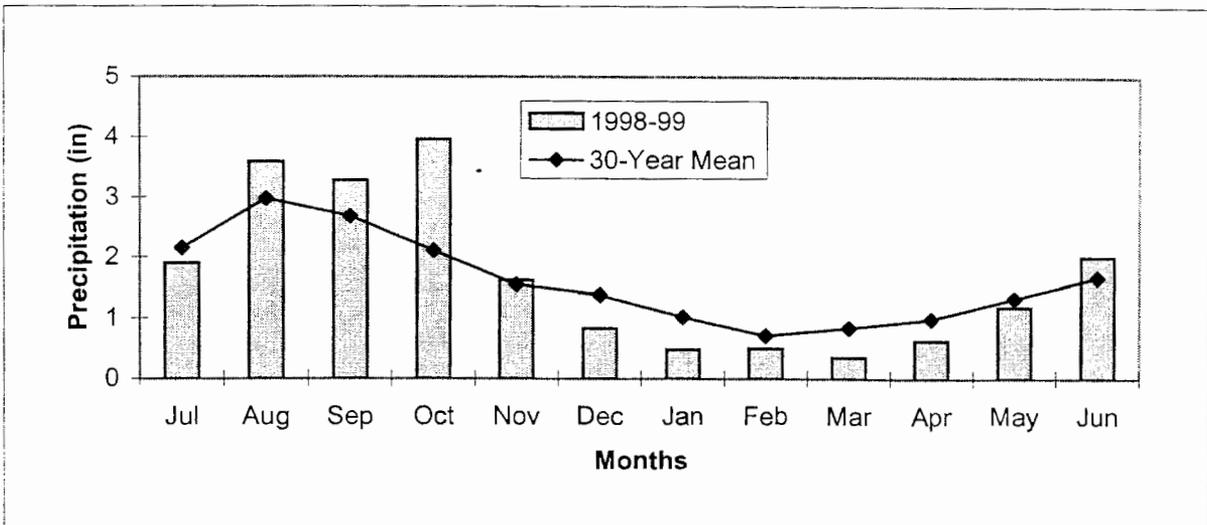
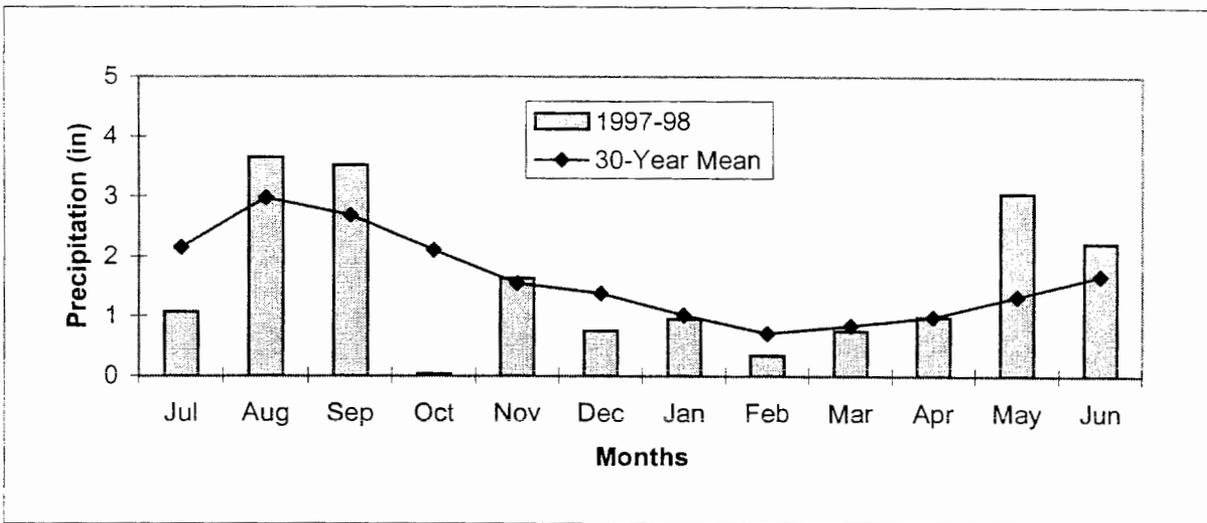
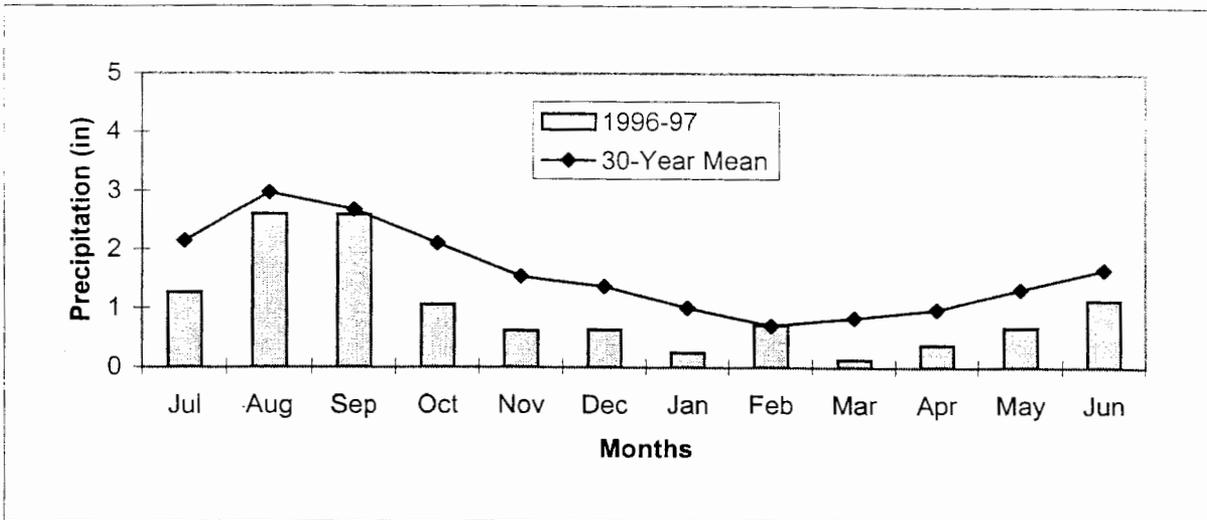
Appendix G.5. Daily air temperatures (normal, mean and extreme) for King Salmon, October 1998 to April 1999.



Appendix G.6. Average monthly precipitation for King Salmon, July 1969 to June 1999.

| Smolt Year | Precipitation (in) ^a | | | | | | | | | | | | Total Annual |
|---------------|---------------------------------|------|------|------|------|------|------|------|------|------|------|------|-----------------|
| | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | |
| 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 |
| 1998-99 | 1.90 | 3.59 | 3.28 | 3.96 | 1.62 | 0.83 | 0.48 | 0.50 | 0.35 | 0.63 | 1.18 | 2.01 | 20.33 |
| Max | 5.08 | 4.73 | 5.90 | 3.96 | 3.35 | 3.65 | 2.38 | 2.26 | 1.99 | 2.65 | 3.05 | 3.04 | 26.23 |
| 30-Year Mean | 2.15 | 2.97 | 2.68 | 2.10 | 1.54 | 1.37 | 1.01 | 0.71 | 0.84 | 0.98 | 1.32 | 1.67 | 19.35 |
| 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; 1998; 1999a,b,c,d,e,f)



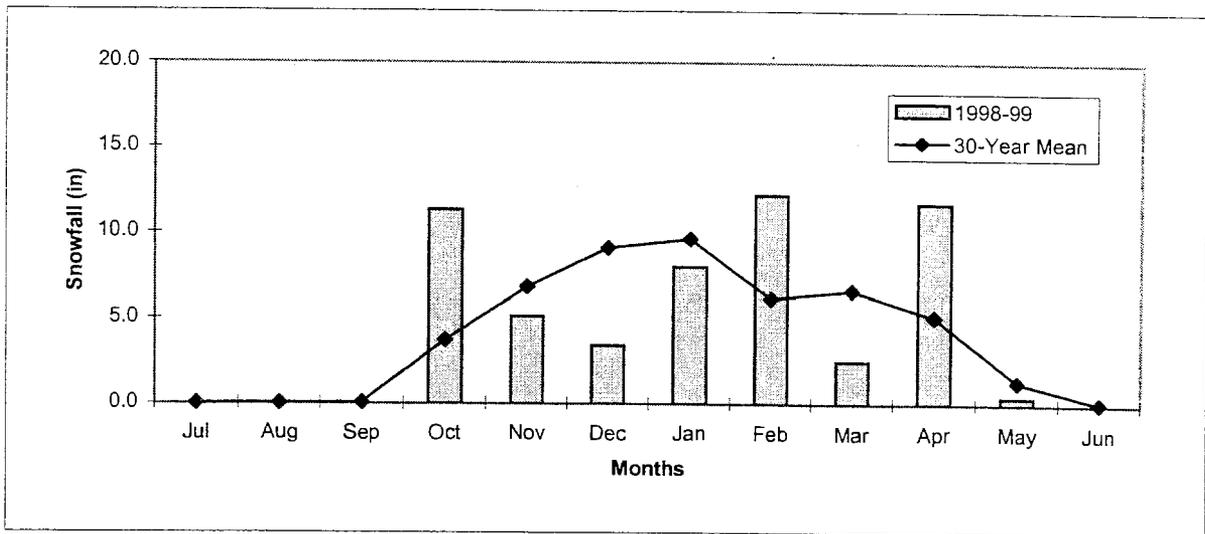
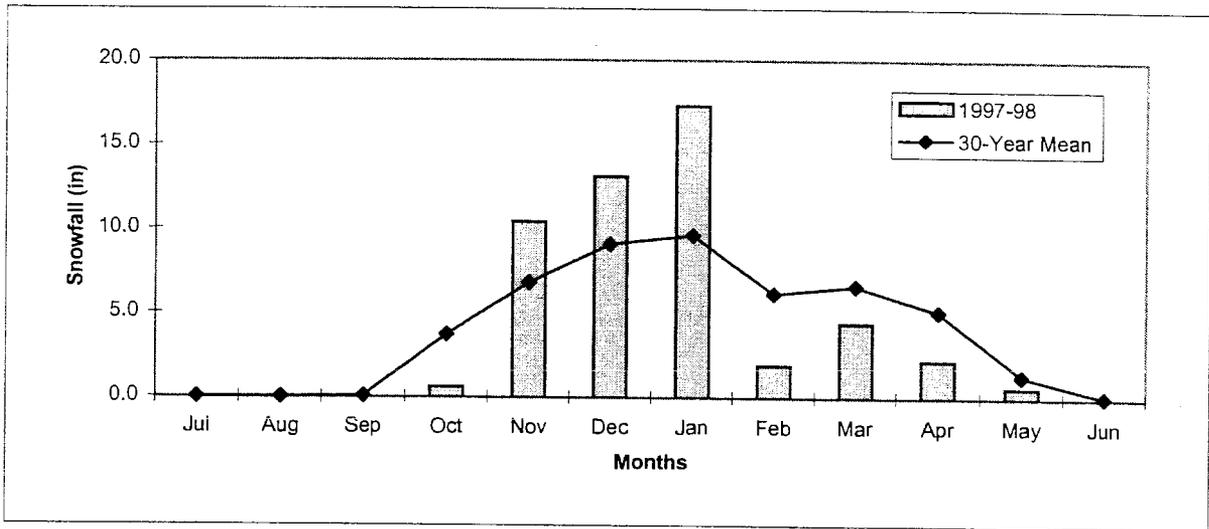
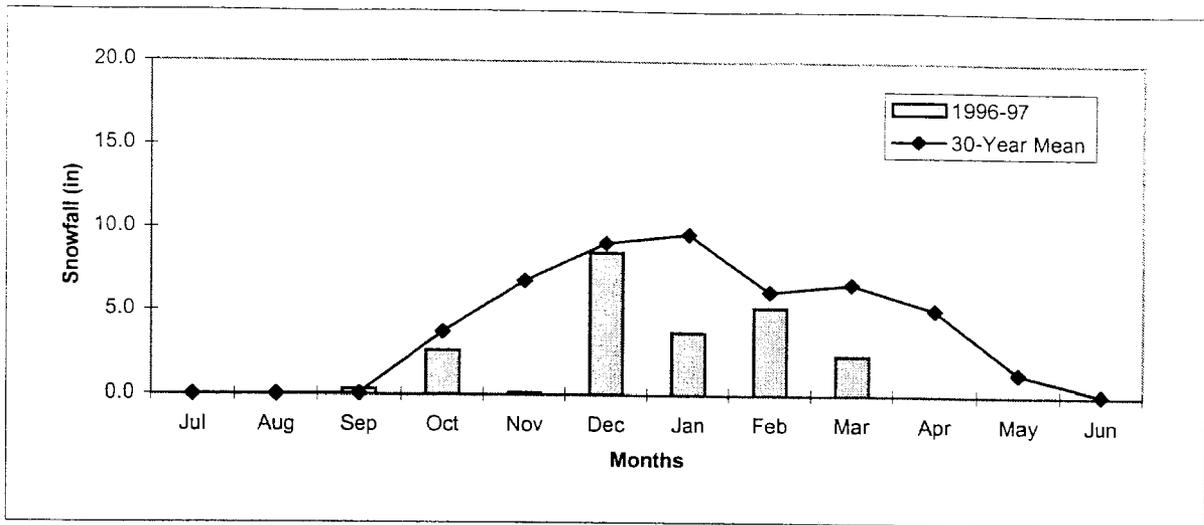
Appendix G.7. Comparison of monthly precipitation to the 30-year mean at King Salmon, July 1996 to June 1999.

Appendix G.8. Average monthly snowfall for King Salmon, July 1969 to June 1999.

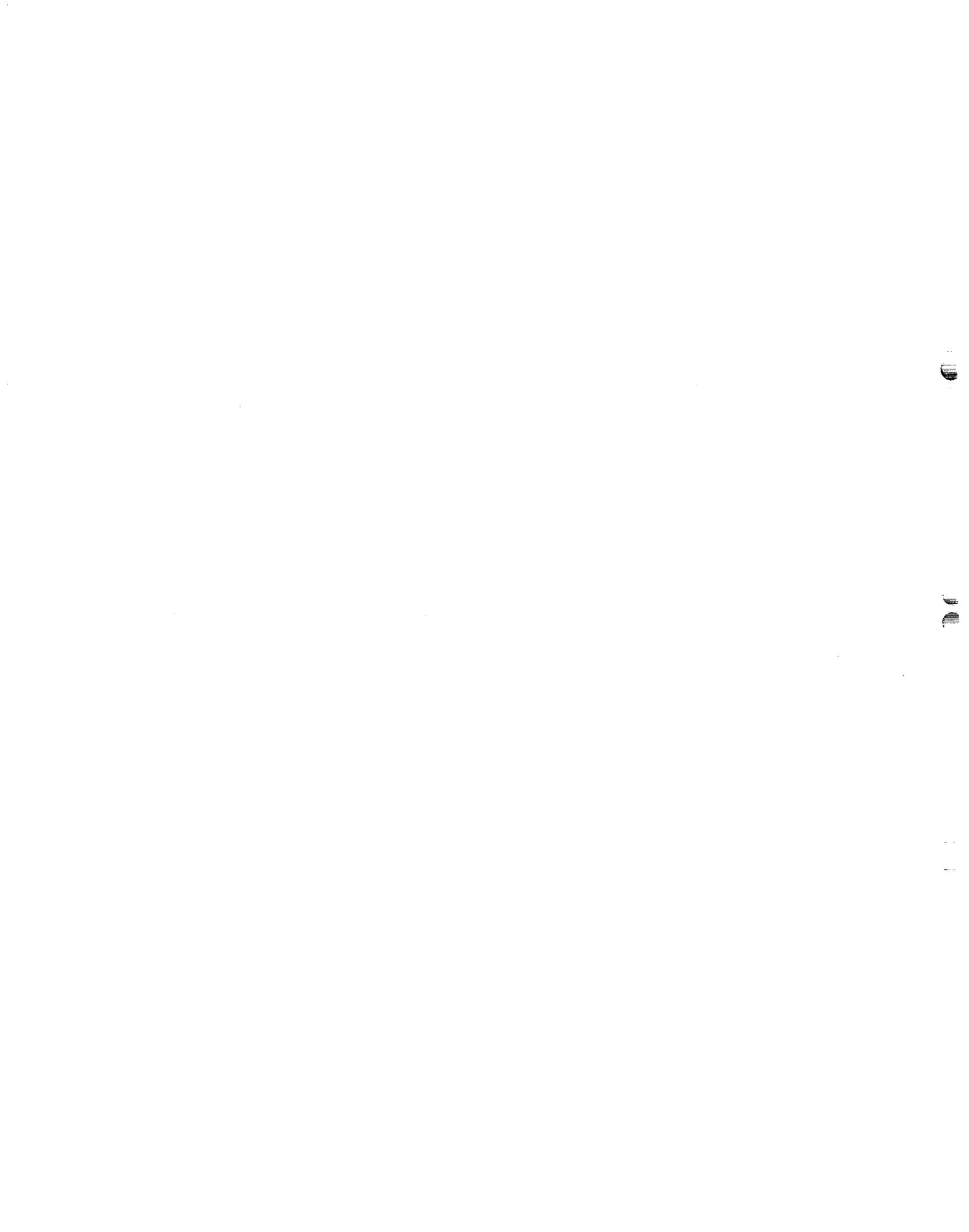
| Smolt Year | Snowfall (in) ^{a b} | | | | | | | | | | | | Total Annual |
|---------------|------------------------------|-----|-----|------|------|------|------|------|------|------|-----|-----|-----------------|
| | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | |
| 1969-70 | 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 |
| 1998-99 | 0.0 | T | T | 11.3 | 5.1 | 3.4 | 8.0 | 12.2 | 2.5 | 11.7 | 0.4 | T | 54.6 |
| 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 | 0.0 | 3.7 | 6.8 | 9.1 | 9.6 | 6.2 | 6.6 | 5.1 | 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; 1998, 1999a,b,c,d,e,f)

^b T = trace



Appendix G.9. Comparison of monthly snowfall to the 30-year mean at King Salmon, July 1996 to June 1999.



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