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Alaska Department of Fish and Game
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Bristol Bay Sockeye Salmon Smolt Studies for 1991

by

Drew L. Crawford

and

Beverly A. Cross

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ABSTRACT

Numbers of sockeye salmon *Oncorhynchus nerka* smolt emigrating to sea from three rivers in Bristol Bay, Alaska, in 1991 were estimated from sonar counts and age-weight-length samples. 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 121,454,182 from Kvichak River, 94,077,988 from Egegik River, and 73,769,877 from Ugashik River. Age-1. smolt, the progeny of 1989 spawners, predominated from Kvichak River (71.8%). Age-2. smolt, the progeny of 1988 spawners, predominated from Egegik River (94.8%) and Ugashik River (64.7%).

KEY WORDS: Smolt, sockeye salmon, *Oncorhynchus nerka*, smolt migration, sonar, Bristol Bay, Kvichak River, Egegik River, Ugashik River

INTRODUCTION

The Bristol Bay Management Area includes all waters east of a line from Cape Newenham to Cape Menshikof (Figure 1) and supports the largest sockeye salmon *Oncorhynchus nerka* fishery in the world. From 1982 to 1991 the commercial catch in Bristol Bay averaged 23.4 million sockeye salmon (ADF&G 1992). To effectively manage this fishery, managers need accurate abundance forecasts of returning adults and other information to determine optimum spawning escapement goals. Estimates of outmigrating smolt numbers are currently used as an index of production for adult salmon; this improves the accuracy of preseason forecasts and aids in setting goals for optimum numbers of spawners.

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

Hydroacoustic equipment has been used to estimate sockeye salmon smolt numbers on Kvichak River from 1971 to 1991; Wood River from 1975 to 1990; Naknek River from 1982 to 1986; Egegik River from 1982 to 1991; Ugashik River from 1983 to 1991; Nuyakuk River from 1983 to 1989; and Togiak River in 1989 (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 and Yuen 1984; Bue and Fried 1987; Bue 1986a, 1986b; Bue et al. 1988; Cross et al. 1990; Woolington et al. 1990; Woolington et al. 1991, Crawford et al. 1992).

Hydroacoustic equipment developed by Bendix Corporation¹ was tested on Kvichak River in 1969 (McCurdy and Paulus 1972; 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 and 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).

¹ Use of a company's name does not constitute endorsement.

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 was 6.4 m from the east bank (total river width = 100 m), smolt passing the Egegik River sonar primarily used a 73-m corridor 12.2 m from the west bank (total river width = 104 m), Ugashik River smolt used a 21- m corridor which began 7.0 m from the south bank (total river width = 43 m). Side-scanning sonar was not an effective tool for collecting lateral smolt distribution data on the Wood River (Cross et al. 1990; Woolington et al. 1990, 1991). Therefore, lateral smolt distribution was assumed to be a function of river width and depth, measured and recorded when tidal influence was minimal. Based on those measurements, Wood River smolt were assumed to migrate within a 94 m corridor which began 3.3 m from the north bank.

The monitoring of smolt migrations was discontinued on Naknek River in 1986 (Bue et al. 1988), on Togiak River in 1988 (Woolington et al. 1990), on Nuyakuk River in 1989 (Woolington et al. 1991), on Wood River in 1990, and on Ugashik River following the 1991 sampling season due to budget cuts.

In 1990, a single narrow-beam side-looking sonar unit was used from 29-31 May to determine the lateral limits of smolt migratory 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. Upward facing sonar arrays were located 30 m, 65 m, and 92 m from the right bank. The daily proportion of passage between the inshore and offshore arrays varied from 71.7 to 83.2% of the total during the three days of data collection. An average of 1.4% of the total daily smolt passage occurred between the right bank and the inshore array and an average of 20.0% passed beyond the offshore array. The distribution of these emigrating smolt varied considerably between nights, however the cumulative peak distribution occurred at 57 m from the right bank. The results of this study were encouraging, so it was expanded in 1991 to evaluate the feasibility of using side-looking sonar to enumerate Kvichak River sockeye salmon smolt outmigrations. Results of this study will be reported by Huttunen and Skvorc (*In press*).

Upward-looking sonar studies were conducted on Kvichak, Egegik, and Ugashik Rivers in 1991 to: (1) estimate numbers of outmigrating sockeye smolt; using hydroacoustic equipment; (2) describe smolt migration patterns; (3) collect smolt age, weight, and length data; and (4) record climatological and hydrological parameters which may affect migratory behavior.

METHODS

Hydroacoustic Equipment

Bendix Corporation constructed all hydroacoustic systems used to estimate smolt numbers in Bristol Bay river systems. Transducers were housed in 3.03-m long arrays set on the river bottom and connected by

coaxial cable to a control unit located on shore. Transducer arrays used on Egegik and Ugashik Rivers housed ten upward-facing transducers. In 1991 seven upward-facing transducers were used on each Kvichak River array.

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.

Hydroacoustic systems were factory calibrated to record one count when a specified fish biomass passed through each transducer beam during a given period; these fish biomass units were 41.5 g for Egegik and Ugashik, 83.0 g for Kvichak Rivers. 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. Most smolt migrate within the upper portion of the water column. The equipment was set to record counts to within 1 - 2 cm of the water surface to avoid counting debris or entrapped air.

Sources of false counts, e.g., boats, wind, rain, debris, etc., were noted and the hydroacoustic equipment 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. The Kvichak and Egegik River smolt counters each monitored three transducer arrays. The Ugashik River unit monitored two arrays.

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

Project Locations

The 1991 Kvichak River counting site was located 6 km below the outlet of Lake Iliamna (Figure 1); it was moved to this location in 1989, approximately 1 km downstream from the site used during the previous 15 years (Woolington et al. 1991). The Kvichak River was 134 m wide at this site. Three transducer arrays referred to as *inshore*, *center*, and *offshore*, were anchored 56 m, 78 m, and 97 m from the right bank (right and left bank as determined by facing downstream). Array placement was improved in 1991 by utilizing lateral smolt distribution data reported by Huttunen and Skvorc (1991).

Arrays on Egegik and Ugashik Rivers were placed in locations similar to previous years. The Egegik River counting site was located 4 km below the outlet of Becharof Lake where the river is 107 m wide. The inshore, center, and offshore arrays were anchored 40 m, 55 m, and 67 m, respectively, from the left bank.

The Ugashik River counting site was located 50 m below the outlet of Lower Ugashik Lake. Because the channel is only 43 m wide, only two arrays have been used. The inshore and offshore arrays were anchored 26 m and 30 m from the right bank.

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 over one array referred to as the *velocity index array*. Because velocities of Egegik River are influenced by tides, a Marsh-McBirney² flow meter was anchored directly behind the velocity index array, and the smolt counter was adjusted every 15 - 30 min to account for changes in river velocity. Velocities of the Kvichak and Ugashik Rivers are more stable than the other rivers, and velocities at these sites were measured periodically with a Gurley³ flow meter and the counters adjusted accordingly. To account for differences in river velocities between the index array and the remaining arrays, readings over each array were taken at specified intervals and velocity correction factors were then calculated:

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

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

where

- vcf_i = velocity correction factor for array i ,
- v_i = velocity over array i , and
- v_{index} = velocity over the velocity index array.

Using these correction factors, adjustments for differences in river velocity were made to daily counts for each array:

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

where

- $ac_{i,z}$ = adjusted counts for array i on day z , and
- $c_{i,z}$ = counts for array i on day z .

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

The width of river monitored by each array depended on array length (3.03 m), water depth over the array, and transducer signal beam width:

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

where

- $l_{i,z}$ = width of river monitored by array i on day z ,
- $d_{i,z}$ = 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. Estimates of the inshore and offshore limits of smolt passage were obtained with side-scanning hydroacoustic equipment. At sites where three arrays were used, 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); and third array to offshore limit of smolt passage (D_4).

The biomass of fish passing the counting site was estimated as follows:

where

- \hat{B}_z = estimated biomass on day z ,
- D_i = the distance for interval i , and

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

na = number of transducer arrays used.

Age, Weight, and Length Estimation

Data on age, weight, and length of sockeye smolt were obtained from samples captured in fyke nets. Smolt weight in grams and length in millimeters from tip-of-snout to fork-of-tail were measured; age was determined from visual observations of scales mounted on glass slides. Smolt were designated as age 1., 2., or 3. depending on the number of freshwater annuli. Parent year escapements for 1991 smolt outmigrations were 1989 for age-1. smolt, 1988 for age-2. smolt, and 1987 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, which is strongly correlated with age, has been shown to differ 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. Weight and age of smolt are strongly correlated to length: to reduce the time and cost of data collection, all smolt collected each day, up to a maximum of 600, were measured for length, whereas only 100 of those smolt were weighed and sampled for age (Bue and Eggers 1989).

Weight was estimated for those 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 (Ricker 1975), weights were estimated for those smolt measured only for length:

$$W_j = \alpha L_j^\beta, \quad (5)$$

where

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

Age was estimated for those smolt measured only for length using an age-length key (Bue and Eggers 1989). The age-length 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.

Due to the variability of age and size composition estimates among subsamples, e.g., fyke net catches, taken the same day, daily mean weight and age proportions 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

- \hat{W} = estimated mean weight of smolt during a sample period,
- m = number of subsamples collected during a sampling period,
- w_k = observed weights from subsample k ,
- 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

- \hat{P}_j = estimated proportion of age j during a sample period, and
- $n_{j,k}$ = number of observations of age j in subsample k .

Estimation of Smolt Numbers

Numbers of smolt by age were estimated by combining biomass estimates with estimates of age and weight composition. Mean weight of smolt was used to convert estimates of biomass per count into estimates of smolt per count:

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

where

- $S\hat{P}C$ = estimated number of smolt per sonar count, and
- BPC = biomass (g) per count.

The estimated number of smolt per day was the product of smolt per count and estimated biomass:

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

where

\hat{N}_z = estimated number of smolt in population on day z .

The estimated number of smolt for each day were then apportioned into age classes:

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

where

$\hat{N}_{j,z}$ = estimated number of smolt of age j on day z .

Finally, daily estimates of smolt numbers were summed to provide season totals of smolt passing the site:

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

and

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

where

\hat{N}_{tot} = estimated total number of smolt which passed site during season, and

$\hat{N}_{j,tot}$ = estimated number of smolt of age j which passed the sonar site during the season.

Climatological Data Collection

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

RESULTS

Kvichak River

A total of 1,511,301 sonar counts were recorded at the Kvichak River counting site from 22 May to 16 June 1991 (Table 1). More counts were recorded over the inshore array (47.3%) than over the center (28.5%) or offshore (24.2%) arrays. Daily sonar counts were highest from 30 May to 7 June when 84.5% of the total counts were recorded. Over the course of the entire sampling season, sonar counts were highest between 0200 hours and 0400 hours (Figure 2); sonar counts during the remaining hours were lower but fairly steady.

No signs of smolt were observed in Kvichak River by the crew prior to the start of the project. The earliest reports of smolt came from boat travelers from Kakhonak village who reported seeing large schools of smolt in open water areas of Lake Iliamna near Big Mountain on 20 May (D. Salmon, Alaska Department of Fish and Game, Igiugig, personal communication). The arrays were set in the river at the sonar site on 22 May and counting began at 2400 hours the same day. On the afternoon of 23 May a fyke net set in Kvichak River above the sonar site for 1 h (between ice flows) produced no catch. From 22 May to 26 May, the smolt counter was disabled for most of each day due to ice flowing in the river, however no smolt or signs of smolt, e.g., flocks of birds feeding on smolt, were observed. Between 27 May and 29 May, the smolt counter was shut down completely due to large ice flows in the river. The first signs of smolt in Kvichak River occurred on the morning of 30 May; the counter began counting smolt between intermittent ice flows at 0200 hours and later that morning the crew observed a flock of Arctic terns *Sterna paradisaea* feeding heavily on smolt in a shallow riffle below the ADF&G boat launch at Igiugig. Prior to this time, individual and small groups of predatory terns and gulls were present but were not observed actively fishing. The last report of ice in the river occurred at 2129 hours on 1 June. The peak daily sonar count of 247,672 occurred on 4 June.

River velocity measurements over the center index array ranged from 1.3 m/s to 1.4 m/s and were used to adjust the sonar counter firing rate. Velocity correction factors for the three arrays were:

	Inshore	Center	Offshore
May 22 - May 31	0.96	1.00	0.91
June 1 - June 9	0.97	1.00	0.94
June 10 - June 16	0.95	1.00	0.94

An estimated 121,454,182 sockeye salmon smolt migrated from the Kvichak River in 1991 based on sonar counts (Table 2). Age-1. smolt (1989 brood year) composed 71.8% of the total migration. The daily percentage of age-1. and -2. smolt fluctuated somewhat during the 1991 migration, however the overall trend was that the percentage of age-1. smolts increased and the percentage of age-2. smolt decreased during project operations (NSC = nonstatistical comparison). During this time mean weight of smolt

generally decreased, and consequently, the estimated number of smolt per count increased (Table 3). The total production from the 1987 spawning escapement of 6,065,880 sockeye salmon was 31.00 smolt per spawner (Table 4). Average marine survival ,e.g., adult salmon returns per smolt, has been 11.4% for age-1. smolt for the 1969-86 brood years and 12.6% for age-2. smolt for the 1968-85 brood years (Table 5).

Age, weight, and length data were collected from 1,442 sockeye salmon smolt in 1991 (Table 6). All smolt sampled were age 1. or 2. and no age-3. smolt were present. Mean weights of age-1. smolt were 5.5 g and age-2. smolt were 9.9 g; mean lengths of age-1. smolt were 85 mm and of age-2. smolt 105 mm. Age-1. and -2. smolt from the Kvichak River in 1991 were smaller (NSC) in length and weight compared to the 1955-90 average (Table 7). An additional 8,271 smolt were measured for length only (Table 8).

River and weather conditions were recorded at the counting site from 22 May to 16 June (Table 9). Although smolt counting began on 22 May heavy flows of lake ice in the river caused extensive disabled time from 22-29 May and actual smolt counts were not detected until 30 May. From then on, the smolt counter operated effectively 95% of the time with only 20 h of disabled time for 408 h of operation. This disabled time was primarily caused by high easterly winds, with gusts up to 40 km/h. Mean water temperature during the project was 4.8° C (range 1.0-8.5°C), which was cooler (NSC) than the 1963-90 mean of 5.6°C (Table 10). Mean water temperature during the peak of the smolt migration was 4.8°C on 4 June.

Egegik River

A total of 7,339,625 sonar counts were recorded at the Egegik River counting site from May 21 to June 11, 1991 (Table 11). Most counts (43.6%) occurred over the center array. Daily sonar counts were highest from May 25 to 28 when 50.2% of the total counts were recorded. Over the course of the entire sampling season, sonar counts were highest between 0200 hours and 0400 hours (Figure 3); 90% of all smolt count were obtained between 1600 hours and 0500 hours.

River velocity at the counting site ranged from 0.5 to 0.9 m/s over the sonar arrays. Velocity correction factors for the inshore, center, and offshore arrays were:

	Inshore	Center	Offshore
May 20 - May 28	1.00	1.27	1.18
May 29 - June 4	1.00	1.49	1.42
June 5 - June 11	1.00	1.28	1.26

An estimated 94,077,988 sockeye salmon smolt migrated from Egegik River in 1991 based on sonar counts (Table 12). Age-2. smolt composed 94.8% of the total migration. The daily percentage of age-2.

smolt fluctuated between a high of 99.6% and a low of 84.4% during the out migration. The mean weight of smolt decreased over the season (Table 13), consequently the estimated number of smolt per count increased (NSC). The total smolt production from the 1987 spawning escapement of 1,272,978 sockeye salmon was 98.32 smolt per spawner (Table 14). The 1991 smolt production from Egegik is about average; the mean production for brood years 1980-88 was 58.28 smolt per spawner. The highest smolt production was 106.84 smolt per spawner in 1983. Average marine survival has been 25.7% for age-1. smolt for the 1980-85 brood years and 26.0% for age-2. smolt for the 1979-84 brood years (Table 15).

Age, weight, and length data were collected from 1,215 sockeye salmon smolt in 1991 (Table 16). Age-1., -2., and -3. smolt were sampled. Mean weights of age-1. smolt were 10.3 g, age-2. smolt 15.6 g, and age-3. smolt 24.4 g; mean lengths of age-1. smolt were 102 mm, age-2. smolt 118 mm, and age-3. smolt 140 mm. All age smolt showed slight size differences from the historical average (NSC; Table 17); age-1. smolt were average in length but heavier, age-2. smolt were slightly longer and heavier, and age-3. smolt were substantially longer and heavier. An additional 5,802 smolt were measured for length only (Table 18).

River and weather conditions were recorded at the counting site from 21 May to 12 June (Table 19). Heavy ice flows from Becharof Lake choked the Egegik River at the counting site on 17-18 May; thereafter there were no further problems with ice. However, frequent high winds primarily from the SE caused the smolt counter to be disabled for 133 h of the 522 h that this project was conducted in 1991. Sonar counts were adjusted for 55 h of disabled time by interpolation. The mean water temperature during the season was 6.4°C (range 4.0-10.0°C), which was slightly higher (NSC) than the 1981-90 average of 6.0°C (Table 20). The mean water temperature during the peak of the smolt outmigration -- May 25 to May 28 -- was 5.3°C.

Ugashik River

A total of 9,549,448 sonar counts were recorded at the Ugashik River sonar counting site from 20 May to 13 June, 1991 (Table 21). Most counts (54.5%) were recorded over the inshore array. Daily sonar counts were highest from 29 May to 6 June when 77.7% of the total counts were recorded. During the course of the entire sampling season sonar counts were highest between 2400 hours and 0300 hours (Figure 4); 91% of all smolt count were obtained between 1600 hours and 0400 hours.

River velocities varied from 1.6 to 2.5 m/s. Velocity correction factors used for inshore and offshore arrays were:

	Inshore	Offshore
May 20 - May 27	0.72	1.00
May 28 - June 4	1.08	1.00
June 5 - June 13	0.95	1.00

An estimated 73,769,877 sockeye salmon smolt migrated from Ugashik River in 1991 based on sonar counts (Table 22). Age-2. smolt, 1988 brood year, composed 64.7% of the total migration. The percentage of age-2. smolt varied somewhat in May (26.7-83.3%), however during June the percentage of age 2.'s decreased steadily (88.3-14.8%). The estimated number of smolt per sonar count ranged from 3.6 to 5.7 (Table 23). The total smolt production from the 1987 spawning escapement of 668,964 sockeye salmon was 198.68 smolt per spawner (Table 24). This was more than twice the average production (83.13 smolt/spawner) calculated for the 1981- 86 brood years. Average marine survival has been 9.6% for age-1. smolt for the 1981-85 brood years and 13.8% for age-2. smolt for the 1980-84 brood years (Table 25).

Age, weight, and length data were collected from 1,866 sockeye salmon smolt in 1991 (Table 26). Mean weights of age-1. smolt were 7.7 g, and age-2. smolt 11.6 g; mean lengths of age-1. smolt were 92 mm and of age-2. smolt 107 mm. Age-1. smolt were about average in length but slightly heavier and age-2. smolt were smaller (NSC) than the 1958-90 average (Table 27). An additional 8,621 sockeye salmon smolt were sampled for length only (Table 28).

Age, weight, and length data from a small sample (n=29) of chinook salmon *Oncorhynchus tshawytscha* smolt captured in the fyke net on 9 June are presented in Appendix A.1.

River and weather conditions were recorded at the counting site from 20 May to 14 June (Table 29). Wind inhibited counting on 24-29 May, 31 May, 1-4 June, and 7-11 June. However, unfavorable smolt counting conditions (187 h of disabled time out of 594 h in operation) usually prevailed for only part of these days. Therefore, 96 h of disabled time were adjusted by interpolation. Average water temperature was 5.9°C (range 4.0-8.5°C), which was similar (NSC) to the 1983-90 average of 6.0°C (Table 30). The mean water temperature during the peak of the smolt outmigration -- May 29 to June 6 -- was 5.5°C.

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Table 1. Sonar counts recorded from three arrays at the sockeye salmon smolt counting site on Kvichak River, 1991.

Sonar Counts				
Transducer Array				
Date ^a	Inshore	Center	Offshore	Total
5/22 ^b	173	12	230	415
5/23 ^b	117	58	37	212
5/24 ^b	199	190	82	471
5/25 ^b	60	18	41	119
5/26 ^b	1	4	0	5
5/27 ^c	0	0	0	0
5/28 ^c	0	0	0	0
5/29 ^c	0	0	0	0
5/30	59,914	40,979	13,682	114,575
6/31	54,302	53,280	14,364	121,946
6/01	59,803	42,857	11,850	114,510
6/02 ^d	56,573	16,358	11,106	84,037
6/03 ^d	102,662	48,759	30,679	182,100
6/04	119,766	64,785	63,121	247,672
6/05	33,255	26,464	27,716	87,435
6/06	24,432	22,621	62,589	109,642
6/07	89,216	56,407	69,043	214,666
6/08 ^d	18,554	11,797	11,946	42,297
6/09	8,140	7,931	16,287	32,358
6/10	11,380	5,937	4,173	21,490
6/11	19,011	11,794	10,135	40,940
6/12	26,824	6,791	6,479	40,094
6/13	4,163	1,534	1,767	7,464
6/14 ^d	5,105	6,067	5,062	16,234
6/15	11,972	3,157	3,132	18,261
6/16	9,839	2,968	1,551	14,358
Total	715,461	430,768	365,072	1,511,301
Percent	47.3	28.5	24.2	

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

^b Smolt counter disabled form most of the day due to ice flowing in the river.

^c Smolt counter disabled all day due to extremely heavy concentrations of ice flowing in the river.

^d Interpolated data for one or more arrays for the following hours and dates:

1000-2400 hours on June 3
 0100-0159 hours on June 4
 2000-2059 hours on June 8
 2200-2259 hours on June 14

Table 2. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Kvichak River, 1991.

Date ^a	Age 1.			Age 2.			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5/22	17,787	59.3	17,787	12,218	40.7	12,218	30,005	30,005
5/23	9,335	59.3	27,122	6,412	40.7	18,630	15,747	45,752
5/24	19,406	59.3	46,528	13,330	40.7	31,960	32,736	78,488
5/25	5,175	59.3	51,703	3,555	40.7	35,515	8,730	87,218
5/26 ^b	179	59.3	51,882	123	40.7	35,638	302	87,520
5/30	5,013,982	59.3	5,065,864	3,444,152	40.7	3,479,790	8,458,134	8,545,654
5/31	5,077,219	59.3	10,143,083	3,487,590	40.7	6,967,380	8,564,809	17,110,463
6/01	8,453,182	82.4	18,596,265	1,811,762	17.7	8,779,142	10,264,944	27,375,407
6/02	6,674,480	81.3	25,270,745	1,533,193	18.7	10,312,335	8,207,673	35,583,080
6/03	12,626,246	77.9	37,896,991	3,586,191	22.1	13,898,526	16,212,437	51,795,517
6/04	14,562,096	73.2	52,459,087	5,323,328	26.8	19,221,854	19,885,424	71,680,941
6/05	3,868,898	61.3	56,327,985	2,444,577	38.7	21,666,431	6,313,475	77,994,416
6/06	3,613,289	51.8	59,941,274	3,359,480	48.2	25,025,911	6,972,769	84,967,185
6/07	9,597,423	61.9	69,538,697	5,902,291	38.1	30,928,202	15,499,714	100,466,899
6/08	3,239,786	84.8	72,778,483	580,716	15.2	31,508,918	3,820,502	104,287,401
6/09	2,432,664	88.1	75,211,147	329,843	11.9	31,838,761	2,762,507	107,049,908
6/10	1,688,783	85.2	76,899,930	293,822	14.8	32,132,583	1,982,605	109,032,513
6/11	3,270,744	87.8	80,170,674	453,628	12.2	32,586,211	3,724,372	112,756,885
6/12	3,192,403	82.9	83,363,077	658,040	17.1	33,244,251	3,850,443	116,607,328
6/13	567,095	82.9	83,930,172	116,893	17.1	33,361,144	683,988	117,291,316
6/14	1,071,058	82.3	85,001,230	230,981	17.7	33,592,125	1,302,039	118,593,355
6/15	1,219,989	76.4	86,221,219	376,228	23.6	33,968,353	1,596,217	120,189,572
6/16	966,542	76.4	87,187,761	298,068	23.6	34,266,421	1,264,610	121,454,182
	87,187,761	71.8		34,266,421	28.2		121,454,182	

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

^b The smolt counter was disabled from May 27 through May 29 due to heavy concentrations of ice flowing in the river. No visible signs of smolt or birds feeding on smolt were observed during this time.

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Kvichak River, 1991.

Date ^a	Mean Weight of Smolt (g)	Smolt per Count
5/22	7.8	10.6
5/23	7.8	10.6
5/24	7.8	10.6
5/25	7.8	10.6
5/26 ^b	7.8	10.6
5/30	7.8	10.6
5/31	7.8	10.6
6/01	6.4	12.9
6/02	6.4	13.1
6/03	6.7	12.5
6/04	7.1	11.7
6/05	7.5	11.1
6/06	8.0	10.4
6/07	7.6	10.9
6/08	6.2	13.5
6/09	6.0	13.8
6/10	6.2	13.3
6/11	6.1	13.6
6/12	6.4	13.0
6/13	6.4	13.0
6/14	6.4	12.9
6/15	6.9	12.0
6/16	6.9	12.0

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

^b The smolt counter was disabled from May 27 through May 29 due to heavy concentrations of ice flowing in the river.

Table 4. Sockeye salmon spawning escapement, total number of smolt produced by age class, percent of total smolt production composed by each age class, and number of smolt produced per spawner for 1956-1989 brood years, Kvichak River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age 1. (%) ^a	Age 2. (%) ^a	Age 3. (%) ^a	Total	Per Spawner
<u>Estimates of smolt numbers based upon fyke net catches</u>						
1956	9,443,318	3,267,274 (54)	2,777,960 (46)	0	6,045,234	0.64
1957	2,842,810	85,916 (13)	552,603 (87)	0	638,519	0.23
1958	534,785	61,400 (86)	10,126 (14)	0	71,526	0.13
1959	680,000	26,038 (27)	72,180 (73)	0	98,218	0.14
1960	14,630,000	1,130,820 (22)	4,116,093 (78)	0	5,246,913	0.36
1961	3,705,849	113,338 (7)	1,603,464 (93)	0	1,716,802	0.46
1962	2,580,884	458,122 (21)	1,748,178 (79)	0	2,206,300	0.86
1963	338,760	64,377 (73)	23,377 (27)	0	87,754	0.27
1964	957,120	252,384 (53)	222,528 (47)	0	474,912	0.50
1965	24,325,926	2,866,214 (34)	5,475,362 (66)	0	8,341,576	0.34
1966	3,775,184	648,321 (55)	541,017 (45)	0	1,189,338	0.32
1967	3,216,208	594,327 (67)	298,282 (33)	0	892,609	0.28
1968	2,557,440	185,356				
<u>Estimates of smolt numbers based upon sonar techniques</u>						
1968			5,959,383	0	-	-
1969	8,394,204	85,723,430 (61)	54,159,340 (39)	0	139,882,770	16.66
1970	13,935,306	464,219 (<1)	191,842,930 (98)	2,918,768 (1)	195,225,917	14.01
1971	2,387,392	5,123,400 (19)	21,423,246 (81)	0	26,546,646	11.12
1972	1,009,962	2,740,610	-	-	-	-
1973	226,554	-	3,031,287	0	-	-
1974	4,433,844	108,356,892 (49)	114,269,848 (51)	0	222,626,740	50.21
1975	13,140,450	78,308,251 (27)	213,364,470 (73)	0	291,672,721	22.20
1976	1,965,282	32,226,544 (55)	26,423,348 (45)	0	58,649,892	29.84
1977	1,341,144	28,758,191 (73)	10,410,467 (27)	0	39,168,658	29.21
1978	4,149,288	182,442,540 (85)	32,294,536 (15)	0	214,737,076	51.75
1979	11,218,434	219,928,232 (71)	89,300,703 (29)	0	309,228,935	27.56
1980	17,505,268	150,421,026 (62)	76,244,773 (38)	0	199,172,858	12.95
1981	1,754,358	6,549,125 (15)	37,595,987 (85)	0	44,145,112	25.16
1982	1,134,840	51,893,988 (96)	1,937,408 (4)	2,065	53,833,461	47.44
1983	3,569,982	23,590,443 (31)	53,260,693 (69)	123,975	76,975,111	21.56
1984	10,490,670	83,470,460 (20)	331,384,545 (80)	43,135	414,898,140	39.55
1985	7,211,046	11,178,398 (11)	87,004,194 (89)	30,345	98,212,937	13.62
1986	1,179,322	13,126,363 (66)	6,830,717 (34)	0	19,957,080	16.92
1987	6,065,880	146,603,154 (78)	41,434,534 (22)	0	188,037,688	31.00
1988	4,065,216	46,569,569 (58)	34,266,421 (42)		80,835,990	19.88 ^b
1989	8,317,500	87,187,761				

^a Percent of total smolt production

^b Preliminary total

Table 5. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1952-1989 brood years, Kvichak River.

Brood Year	Total Spawning Escapement	Age 1.			Age 2.		
		Number of Smolt	Adult ^a Returns	Adult Returns per Smolt	Number of Smolt	Adult ^a Returns	Adult Returns per Smolt
<u>Estimates of smolt numbers based upon fyke net catches</u>							
1952	-	-	-	-	241,870	3,610,258	14.93
1953	-	18,198	152,165	8.36	47,373	424,627	8.96
1954	-	30,287	109,965	3.63	8,654	659,246	76.18
1955	-	22,253	351,240	15.78	66,679	1,132,813	16.99
1956	9,443,318	3,267,274	31,253,977	9.57	2,777,960	7,773,131	2.80
1957	2,842,810	85,916	488,844	5.69	552,603	3,591,552	6.50
1958	534,785	61,400	124,250	2.02	10,126	161,253	15.92
1959	680,000	26,038	328,287	12.61	72,180	217,593	3.01
1960	14,630,000	1,130,820	1,877,221	1.66	4,116,093	53,360,190	12.96
1961	3,705,849	113,338	524,416	4.63	1,603,464	2,971,816	1.85
1962	2,580,884	458,122	256,253	0.56	1,748,178	5,083,162	2.91
1963	338,760	64,377	98,571	1.53	23,377	1,008,242	43.13
1964	957,120	252,384	2,647,042	10.49	222,528	3,093,042	13.90
1965	24,325,926	2,866,214	10,349,415	3.61	5,475,362	34,671,692	6.33
1966	3,775,184	648,321	1,594,186	2.46	541,017	4,657,432	8.61
1967	3,216,208	594,327	621,690	1.05	298,282	900,307	3.02
1968	2,557,440	185,356	332,177	1.79	-	-	-
<u>Estimates of smolt numbers based upon sonar techniques</u>							
1968	2,557,440	-	-	-	5,959,383	209,105	0.04
1969	8,394,204	85,723,430	449,876	0.01	54,159,340	4,823,046	0.09
1970	13,935,306	464,219	56,805	0.12	191,842,930	15,350,282	0.08
1971	2,387,392	5,123,400	337,402	0.07	21,423,246	2,490,225	0.12
1972	1,009,962	2,740,610	436,664	0.16	-	1,504,342	-
1973	226,554	-	1,607,253	-	3,031,287	818,392	0.27
1974	4,433,844	108,356,892	8,357,781	0.08	114,269,848	17,915,045	0.16
1975	13,140,450	78,308,251	6,885,486	0.09	213,364,470	31,159,431	0.15
1976	1,965,282	32,226,544	6,142,993	0.19	26,423,348	4,426,365	0.17
1977	1,341,144	28,758,191	2,910,838	0.10	10,410,467	309,453	0.03
1978	4,149,288	182,442,540	2,991,867	0.02	32,294,536	2,150,899	0.07
1979	11,218,434	219,928,232	20,620,672	0.09	89,300,703	21,516,056	0.24
1980	22,505,268	150,421,026	4,533,524	0.03	76,244,773	8,508,632	0.11
1981	1,754,358	6,549,125	1,019,204	0.16	37,595,987	1,097,336	0.03
1982	1,134,840	51,893,988	992,574	0.02	1,937,408	662,963	0.34
1983	3,569,982	23,590,443	11,616,100	0.49	53,260,693	1,784,972	0.03
1984	10,490,670	83,470,460	4,479,884	0.05	331,384,545	19,490,377	0.06
1985	7,211,046	11,178,398	2,314,507	0.21	87,004,194	14,948,347	0.17 ^b
1986	1,179,322	13,126,363	1,770,391	0.13 ^b	6,830,717	1,425,000	0.21 ^b
1987	6,065,880	146,603,154	424,330	0.00 ^b	41,434,534	30,000	0.00 ^b
1988	4,065,216	46,569,569	-	-	34,266,421	-	-
1989	8,317,500	87,187,761	-	-	-	-	-

^a Includes estimates of returns through 1990.

^b Future adult returns will increase these values.

Table 6. Mean fork length and weight of sockeye salmon smolt captured in fyke nets, Kvichak River, 1991.

Date ^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
5/31	84	0.0	4.9	0.00	1	112	14.4	11.3	4.39	19
6/01	87	9.6	5.9	1.99	61	109	19.8	10.8	5.17	53
6/02	85	10.1	5.3	1.81	90	105	16.8	9.4	3.62	12
6/03	84	11.2	5.1	2.03	90	98	14.2	8.2	2.94	12
6/04	84	12.0	5.2	2.31	86	103	18.0	9.2	3.78	14
6/05	86	18.7	6.2	4.35	81	108	14.4	10.7	4.01	21
6/06	84	10.5	5.6	2.17	67	108	16.3	11.0	4.77	35
6/07	86	12.6	6.1	2.85	58	107	10.4	10.7	3.05	45
6/08	87	21.5	6.0	4.61	64	105	17.1	9.9	4.72	20
6/09	83	12.4	5.2	1.83	95	104	5.8	9.2	1.90	7
6/10	83	10.7	5.3	2.07	100	98	0.0	8.1	0.00	1
6/11	85	11.1	5.5	1.85	97	109	8.5	9.7	1.70	4
6/12	84	12.1	5.3	2.27	102					0
6/13	84	6.2	5.2	0.96	17					0
6/14	84	12.0	5.2	2.05	61					0
6/15	84	12.2	5.5	2.55	79	106	17.6	10.1	4.21	6
6/16	86	6.2	5.6	1.22	42	106	4.2	10.5	2.68	2
Totals					1,191					251
Means	85		5.5			105		9.9		

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

Table 7. Age composition of total migration and mean fork length and weight by age class for sockeye salmon smolt, Kvichak River, 1955-1991.

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

-Continued-

Table 7. (p 2 of 2)

Year of Migration	Age 1.			Age 2.			Age 3.			Total Estimate ^a	References
	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)	Percent of Total Estimate	Mean Length (mm)	Mean Weight (g)		
1981	89	85	5.4	11	108	10.2	0	-	-	252,222,769	Yuen and Wise (1982)
1982	58	84	5.1	39	103	9.1	0	-	-	239,721,729	Bill (1984)
1983	8	80	4.9	92	98	8.5	0	-	-	82,793,899	Bill et al. (1987)
1984	58	90	6.8	42	104	10.0	0	-	-	89,489,975	Bill (1986a)
1985	92	85	5.3	8	102	9.2	0	-	-	25,527,851	Bill (1986b)
1986	61	84	5.5	39	107	10.4	0	102	9.1	136,733,218	Bue et al. (1988)
1987	3	82	4.5	97	96	7.0	0	97	8.5	342,686,918	Cross et al. (1990)
1988	13	86	5.6	87	99	8.3	0	107	9.8	100,173,692	Woolington et al. (1990)
1989	95	85	5.5	5	108	10.8	0	105	9.5	153,464,216	Woolington et al. (1991)
1990	53	87	6.1	47	105	10.5	0	-	-	88,004,103	Crawford et al. (1992)
Mean		88	5.8		108	10.5		107	10.9		
1991	72	85	5.5	28	105	9.9	0	-	-	121,454,182	

^a Estimates of smolt numbers for 1955-1970 based on fyke net catches; estimates of smolt numbers for 1971-1991 based on hydroacoustic techniques.

Table 8. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Kvichak River, 1991.

Date ^b	Estimated Age 1. ^a				Estimated 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	88	7.1	6.0	36	111	18.3	11.6	108
6/01	87	15.6	5.8	454	107	26.2	10.5	222
6/02	85	16.5	5.5	531	103	13.4	9.3	40
6/03	84	16.9	5.4	541	104	15.6	9.6	49
6/04	84	16.3	5.4	480	109	19.7	10.9	70
6/05	85	16.4	5.5	448	107	21.2	10.5	100
6/06	85	17.7	5.5	419	105	25.1	10.0	202
6/07	85	17.4	5.5	376	106	19.2	10.1	261
6/08	86	14.2	5.7	265	107	20.3	10.4	124
6/09	84	18.8	5.3	598	104	12.1	9.7	30
6/10	84	16.9	5.3	609	104	6.0	9.5	6
6/11	84	14.9	5.3	551	103	10.7	9.5	24
6/12	84	14.5	5.4	558	108	8.0	10.7	8
6/13	83	9.4	5.2	89	114	7.5	12.1	5
6/14	84	15.2	5.3	300	107	14.4	10.5	24
6/15	84	16.7	5.4	504	105	13.6	10.0	31
6/16	86	13.5	5.6	194	101	7.0	8.9	14
Totals								
Means	85		5.5	6,953	106		10.2	1,318

^a Length-weight parameters by age group and discriminating length used to separate ages from May 31 through June 16 were:

Age 1. $a = -9.7883$ $b = 2.5833$ $r^2 = 0.74$ $n = 1,190$
Age 2. $a = -9.9371$ $b = 2.6244$ $r^2 = 0.75$ $n = 232$

Discriminating Length = 95.19 mm

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

Table 9. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Kvichak River, 1991.

Date	Cloud Cover ^a		Wind Velocity (km/h)		Air Temp (°C)		Water Temp (°C)		Precipitation (mm)	Water Clarity ^b
	0800	2000	0800	2000	0800	2000	0800	2000		
5/22	1	1	0-08 SW	3-12 SW	12.0	25.0	2.0	2.0	-	clear
5/23	1	1	8-13 W	calm	11.0	26.0	2.0	3.0	0.0	clear
5/24	1	3	0-05 W	8-16 W	7.0	15.0	2.0	3.5	0.0	clear
5/25	4	4	0-05 SW	0-08 E	7.0	7.0	4.0	2.5	0.3	clear
5/26	4	4	0-05 E	8-16 E	12.0	7.5	3.0	2.5	3.3	dk brown
5/27	4	3	5-13 E	0-08 W	11.0	11.0	1.0	1.0	0.3	clear
5/28	4	3	0-08 SW	0-08 SW	8.0	7.0	1.0	1.0	8.1	clear
5/29	4	4	0-08 SW	0-08 S	6.0	11.0	2.0	2.0	4.6	clear
5/30	4	3	8-24 SW	16-32 SW	8.0	13.0	4.0	2.0	0.5	clear
5/31	4	2	8-24 SW	8-24 SW	7.0	13.0	5.0	3.5	0.0	clear
6/01	1	3	0-08 SW	calm	6.0	15.0	4.0	4.0	0.0	clear
6/02	4	4	8-24 NE	32-40 E	8.0	11.0	4.0	4.0	0.0	murky
6/03	4	3	8-24 NE	0-08 W	8.0	14.0	4.0	4.5	0.3	brown
6/04	4	4	8-16 NE	0-08 E	9.0	14.0	4.5	5.0	0.0	clear
6/05	3	3	0-08 E	0-08 W	10.5	14.0	5.0	6.0	0.8	clear
6/06	3	2	0-08 W	0-08 E	10.0	10.5	5.5	7.0	2.0	clear
6/07	2	2	0-08 E	32-40 E	8.5	9.0	6.5	6.5	0.0	clear
6/08	2	2	8-24 E	calm	7.0	19.0	6.5	8.0	0.0	clear
6/09	1	2	0-08 SW	16-24 SW	9.0	14.0	8.0	8.5	0.0	clear
6/10	4	3	8-25 SW	16-24 SW	6.5	12.0	7.5	8.0	0.0	clear
6/11	5	3	0-08 SW	calm	5.0	25.0	7.0	8.0	0.0	clear
6/12	5	3	calm	0-08 E	11.0	18.0	7.0	8.0	2.8	clear
6/13	5	3	8-16 SW	16-24 SW	11.5	15.0	7.5	7.5	0.0	clear
6/14	3	3	8-24 SW	16-24 SW	9.5	13.0	7.0	7.5	0.0	clear
6/15	4	4	calm	8-16 SW	6.0	13.0	6.0	7.0	0.5	clear
6/16	4	-	calm	-	7.0	-	7.0	-	-	clear

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

- ^b Water clarity at 0800 hours

Table 10. Water temperatures at sockeye salmon smolt counting site, Kvichak River, 1963-1991.

Year	Sample Period	Water Temperature (°C)			References
		Minimum	Maximum	Mean	
1963	May 16 - Jun 14	2.2	8.9	5.5	Marriott (1965)
1964	May 18 - Jun 14	0.0	5.6	2.6	Pennoyer and Seibel (1965)
1965	May 17 - Jun 11	0.0	8.9	4.4	Pennoyer (1966)
1966	May 16 - Jun 26	0.0	11.1	4.7	Pennoyer and Stewart (1967)
1967	May 17 - Jun 20	1.1	9.4	6.9	Pennoyer and Stewart (1969)
1968	May 12 - Jun 12	3.3	8.3	5.4	Paulus and McCurdy (1969)
1969	May 16 - Jun 18	0.3	7.8	3.9	McCurdy and Paulus (1972)
1970	May 13 - Jun 07	2.8	11.1	6.8	Paulus and McCurdy (1972)
1971	May 17 - Jun 20	1.1	3.3	2.4	Russell (1972)
1972	May 18 - Jun 18	0.6	5.0	2.9	Parker (1974a)
1973	May 15 - Jun 14	2.9	8.9	4.9	Parker (1974b)
1974	May 13 - Jun 09	3.0	8.0	6.2	Krasnowski (1975)
1975	May 17 - Jun 15	2.0	8.0	3.8	Randall (1976)
1976	May 18 - Jun 19	2.0	9.5	3.9	Randall (1977)
1977	May 17 - Jun 14	3.0	9.5	6.4	Randall (1978)
1978	May 19 - Jun 09	5.0	11.0	7.6	Yuen (1980a)
1979	June 1 - Jun 10	8.0	10.0	8.6	Yuen (1980b)
1980	May 16 - Jun 18	1.5	9.0	5.5	Bergstrom and Yuen (1981)
1981	May 15 - Jun 09	7.0	10.0	8.2	Yuen and Wise (1982)
1982	May 14 - Jun 15	2.5	8.5	4.9	Bill (1984)
1983	May 19 - Jun 14	5.2	10.5	7.9	Bill et al. (1987)
1984	May 19 - Jun 11	5.5	10.0	7.9	Bill (1986a)
1985	May 23 - Jun 20	2.0	7.0	4.6	Bill (1986b)
1986	May 18 - Jun 12	1.0	7.0	4.6	Bue et al. (1988)
1987	May 21 - Jun 13	4.5	9.0	6.7	Cross et al. (1990)
1988	May 17 - Jun 17	3.0	11.0	7.1	Woolington et al. (1990)
1989	May 19 - Jun 16	3.0	8.8	5.8	Woolington et al. (1991)
1990	May 22 - Jun 15	3.5	9.5	7.3	Crawford et al. (1992)
	Mean	2.7	8.7	5.6	
1991	May 23 - Jun 17	1.0	8.5	4.8	

Table 11. Sonar counts recorded from three arrays at the sockeye salmon smolt counting site on Egegik River, 1991.

Sonar Counts				
Transducer Array				
Date ^a	Inshore	Center	Offshore	Total
5/21	0	0	0	0
5/22	0	0	0	0
5/23	0	0	0	0
5/24	16,492	60,727	60,603	137,822
5/25	28,261	707,379	621,438	1,357,078
5/26 ^b	78,555	202,610	96,179	377,344
5/27 ^b	171,807	391,304	411,289	974,400
5/28 ^b	250,616	346,382	377,149	974,147
5/29 ^b	31,780	31,205	18,924	81,909
5/30 ^b	71,708	78,295	74,593	224,596
5/31 ^b	47,697	106,218	35,854	189,769
6/01 ^b	45,578	58,616	22,432	126,626
6/02 ^b	55,959	113,762	38,229	207,950
6/03 ^b	367,356	248,045	81,426	696,827
6/04	150,694	257,865	75,070	483,629
6/05	140,481	213,249	118,734	472,464
6/06 ^b	53,570	88,008	73,670	215,248
6/07	98,676	76,781	67,168	242,625
6/08 ^b	131,190	150,204	140,416	421,810
6/09	40,751	56,758	15,788	113,297
6/10	8,723	12,162	12,881	33,766
6/11	688	3,511	4,119	8,318
Total	1,790,582	3,203,081	2,345,962	7,339,625
Percent	24.4	43.6	32.0	

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

^b Data interpolated for one or more arrays on the following hours and dates:

0800, 1000 hours on May 26
 1200, 2100 hours on May 27
 0700, 0800, 1000 hours on May 28
 0700, 1000, 1100, 1700-2000 hours on May 29
 1100-1900, 2000-2200 hours on May 30
 0700 hours on May 31
 0600, 1000, 1200-1400, 1700-1800 hours on June 1
 1000-1100, 1300, 1500 hours on June 2
 0100-0400, 0700 hours on June 3
 0600-0900, 2000 hours on June 6
 1100 hours on June 8

Table 12. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Egegik River, 1991.

Date ^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	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	0	0.0	0	0	0.0	0	0	0.0	0	0	0
5/24	0	0.0	0	1,376,347	99.6	1,376,347	5,666	0.4	5,666	1,382,013	1,382,013
5/25	0	0.0	0	13,118,192	99.6	14,494,539	54,006	0.4	59,672	3,172,198	14,554,211
5/26	0	0.0	0	3,943,590	98.9	18,438,129	45,878	1.2	105,550	13,989,468	18,543,679
5/27	77,143	0.7	77,143	10,740,348	98.9	29,178,477	47,807	0.4	153,357	10,865,298	29,408,977
5/28	727,525	5.7	804,668	12,043,878	94.0	41,222,355	37,144	0.3	190,501	12,808,547	42,217,524
5/29	31,548	2.7	836,216	1,121,837	96.7	42,344,192	6,495	0.6	196,996	11,159,880	43,377,404
5/30	86,003	2.7	922,219	3,058,172	96.7	45,402,364	17,706	0.6	214,702	3,161,881	46,539,285
5/31	71,241	2.7	993,460	2,533,267	96.7	47,935,631	14,667	0.6	229,369	2,619,175	49,158,460
6/01	53,932	2.9	1,047,392	1,830,105	96.7	49,765,736	8,326	0.4	237,695	1,892,363	51,050,823
6/02	60,873	2.1	1,108,265	2,844,176	97.7	52,609,912	7,572	0.3	245,267	2,912,621	53,963,444
6/03	212,342	2.1	1,320,607	9,921,175	97.7	62,531,087	26,415	0.3	271,682	10,159,932	64,123,376
6/04	1,195,425	15.2	2,516,032	6,658,085	84.4	69,189,172	37,085	0.5	308,767	17,890,595	72,013,971
6/05	919,337	13.4	3,435,369	5,926,526	86.2	75,115,698	30,254	0.4	339,021	6,876,117	78,890,088
6/06	295,928	9.9	3,731,297	2,664,550	89.2	77,780,248	25,680	0.9	364,701	2,986,158	81,876,246
6/07	237,779	6.5	3,969,076	3,433,449	93.3	81,213,697	9,570	0.3	374,271	3,680,798	85,557,044
6/08	403,845	6.5	4,372,921	5,831,382	93.3	87,045,079	16,253	0.3	390,524	6,251,480	91,808,524
6/09	107,774	6.5	4,480,695	1,556,224	93.3	88,601,303	4,337	0.3	394,861	1,668,335	93,476,859
6/10	31,473	6.5	4,512,168	454,461	93.3	89,055,764	1,266	0.3	396,127	487,200	93,964,059
6/11	7,359	6.5	4,519,527	106,274	93.3	89,162,038	296	0.3	396,423	113,929	94,077,988
	4,519,527	4.8		89,162,038	94.8		396,423	0.4		94,077,988	

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

Table 13. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Egegik River, 1991.

Date ^a	Mean Weight of Smolt (g)	Smolt per Count
5/21	19.5	2.1
5/22	19.5	2.1
5/23	19.5	2.1
5/24	19.5	2.1
5/25	19.5	2.1
5/26	19.1	2.2
5/27	17.9	2.3
5/28	15.6	2.7
5/29	16.4	2.5
5/30	16.4	2.5
5/31	16.4	2.5
6/01	15.5	2.7
6/02	16.5	2.5
6/03	16.5	2.5
6/04	14.2	2.9
6/05	14.5	2.9
6/06	15.1	2.7
6/07	14.5	2.9
6/08	14.5	2.9
6/09	14.5	2.9
6/10	14.5	2.9
6/11	14.5	2.9

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

Table 14. 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 1978-1989 brood years, Egegik River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age 1. (%) ^a	Age 2. (%) ^a	Age 3.	Total	Per Spawner
1978	895,698	-	-	225,522	-	-
1979	1,032,042	-	14,287,075	0	-	-
1980	1,060,860	49,457,563 (75)	16,524,563 (25)	197,429	66,179,555	62.38
1981	694,680	2,242,326 (7)	32,235,734 (93)	52,852	34,530,912	49.71
1982	1,034,628	17,234,269 (60)	11,434,848 (40)	564	28,669,681	27.71
1983	792,282	54,585,828 (65)	29,984,140 (35)	85,087	84,655,055	106.84
1984	1,165,320	14,016,441 (24)	45,386,536 (76)	80,931	59,483,908	51.05
1985	1,095,204	4,397,087 (26)	12,758,135 (74)	81,150	17,236,372	15.74
1986	1,151,320	36,122,149 (57)	27,347,612 (43)	0	63,469,761	55.13
1987	1,272,978	72,458,024 (58)	52,299,487 (42)	396,423	125,153,934	98.32
1988	1,612,680	3,795,739 (4)	89,162,038 (96)		92,957,777	57.64 ^b
1989	1,610,916	4,519,527				

^a Percent of total smolt production

^b Preliminary total

Table 15. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1978-1989 brood years, Egegik River.

Brood Year	Total Spawning Escapement	Age 1.			Age 2.			Age 3.		
		Number of Smolt	Adult ^a Returns	Adult Returns per Smolt	Number of Smolt	Adult ^a Returns	Adult Returns per Smolt	Number of Smolt	Adult ^a Returns	Adult Returns per Smolt
1978	895,698	-	908,417		-	8,264,377		225,522	33,395	0.15
1979	1,032,042	-	1,239,014		14,287,075	4,704,934	0.33	0	0	0.00
1980	1,060,860	49,457,563	3,034,510	0.06	16,524,563	5,540,893	0.33	197,429	7,888	0.04
1981	694,680	2,242,326	1,536,974	0.68	32,235,734	4,876,605	0.15	52,852	16,104	0.30
1982	1,034,628	17,234,269	2,906,356	0.17	11,434,848	3,443,152	0.30	564	12,655	22.44
1983	792,282	54,585,828	4,508,139	0.08	29,984,140	6,016,215	0.20	85,087	36,905	0.43
1984	1,165,320	14,016,441	1,572,383	0.11	45,386,536	11,354,791	0.25	80,931	210,246	2.60 ^b
1985	1,095,192	4,397,087	1,940,592	0.44	12,758,135	5,535,556	0.34 ^b	81,150	0	0.00 ^b
1986	1,151,320	36,122,149	5,539,679	0.05 ^b	27,347,612	4,029,211	0.00 ^b	0	0	0.00 ^b
1987	1,272,978	72,458,024	892,000	0.00 ^b	52,299,487	64,000	0.00 ^b	396,423		
1988	1,612,680	3,795,739			89,162,038					
1989	1,610,916	4,519,527								

^a Includes estimates of returns through 1990.

^b Future adult returns will increase these values.

Table 16. Mean fork length and weight of sockeye salmon smolt captured in fyke nets, Egegik River, 1991.

Date ^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
5/25					0	128	24.4	19.6	11.01	95	140	0.6	24.1	1.96	2
5/26					0	126	28.3	19.1	12.16	94	143	7.0	27.2	2.55	6
5/27	101	0.6	10.1	0.24	2	123	28.3	18.0	12.30	98	144		26.3		1
5/28	101	4.4	10.3	1.28	7	117	25.5	14.9	9.76	93					0
5/31	103	5.1	10.7	0.86	5	117	21.6	15.7	9.31	92	141	11.3	21.9	4.94	2
6/01	102	6.2	9.9	1.34	8	116	20.5	14.0	7.77	87	141		23.1		1
6/02	103	3.9	10.4	1.61	7	117	22.1	14.5	9.74	91					0
6/03	103	2.1	10.5	0.35	4	121	23.4	16.2	8.93	96					0
6/04	99	8.2	9.9	2.93	9	114	21.1	13.9	7.97	70	146		29.5		1
6/05	102	7.8	10.5	2.06	12	113	19.3	13.7	7.38	86	138		21.9		1
6/06	101	6.8	9.8	2.03	11	116	23.9	14.7	8.79	84	133	16.6	21.3	8.88	4
6/07	100	5.6	9.6	1.90	9	117	20.4	15.3	7.95	39					0
6/08	104	5.5	11.2	1.52	12	113	20.5	13.7	7.39	86					0
Totals					86					1,111					18
Means	102		10.3			118		15.6			140		24.4		

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

Table 17. Mean fork length and weight of sockeye salmon smolt sampled from Egegik River, 1939-1991.

Year of Migration	Sample Dates	Sample Size	Age 1.		Age 2.		Age 3.		References
			Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	
1939	-	-	96	-	105	-	-	-	USF&WS (unpublished)
1956	-	386	101	-	116	-	123	-	"
1957	-	236	107	-	120	-	130	-	"
1959	-	281	99	-	116	-	123	-	"
1960	-	159	106	-	115	-	140	-	"
1969	-	67	99	-	119	-	115	-	Paulus (1972)
1977	May 27 - May 29	299	110	11.3	116	13.3	-	-	ADF&G (unpublished)
1978	May 19 - May 22	319	104	10.1	122	15.4	130	18.1	Huttunen (1980)
1981	May 15 - Jun 06	549	105	9.1	122	16.6	128	19.1	Bue (1982)
1982	May 27 - Jun 15	881	104	9.2	130	17.1	145	23.5	Bue (1984)
1983 ^a	May 17 - Jun 09	2,631	101	9.3	116	13.6	-	-	Fried et al. (1987)
1984 ^a	May 10 - Jun 10	3,602	106	10.1	112	12.2	134	20.2	Fried et al. (1986)
1985 ^a	May 24 - Jun 05	5,427	106	10.4	123	16.8	138	24.1	Bue (1986c)
1986	May 18 - Jun 11	1,120	101	9.0	122	15.7	140	22.6	Bue et al. (1988)
1987	May 18 - Jun 13	1,953	107	11.6	114	14.1	128	18.9	Cross et al. (1990)
1988	May 18 - Jun 13	1,595	103	10.2	117	14.3	136	21.2	Woolington et al. (1990)
1989	May 27 - Jun 06	661	99	8.9	119	15.4	135	21.1	Woolington et al. (1991)
1990	May 19 - Jun 11	1,263	102	9.6	118	14.5	-	-	Crawford et al. (1992)
Mean			102	9.6	117	14.6	132	21.0	
1991	May 25 - Jun 8	1,263	102	10.3	118	15.6	140	24.4	

^a Age, weight, and length samples pooled with estimated weight by age from length samples.

Table 18. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Egegik River, 1991.

Date ^b	Estimated Age 1. ^a				Estimated Age 2. ^a			
	Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size	Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size
5/25				0	129	38.8	19.5	605
5/26				0	128	40.4	18.9	516
5/27	100	3.2	9.8	3	124	44.0	17.6	516
5/28	100	5.1	10.0	34	118	38.9	15.3	490
5/31	101	4.3	10.0	15	120	38.4	16.0	510
6/01	101	3.9	10.2	12	117	35.4	15.1	496
6/02	102	0.6	10.4	2	116	22.4	14.7	51
6/03	100	2.7	9.9	7	121	39.0	16.5	499
6/04	100	7.8	9.8	97	114	34.8	13.9	413
6/05	100	8.5	9.8	84	115	33.0	14.4	428
6/06	99	8.2	9.8	59	117	38.1	15.0	466
6/07	99	3.7	9.6	4	115	14.2	14.3	18
6/08	101	3.1	10.1	20	114	32.3	14.0	457
Totals				337				5,465
Means	100		9.9		119		15.8	

^a Length-weight parameters by age group and discriminating length used to separate ages from May 25 through June 8 were:

Age 1. a = -9.0011 b = 2.4492 r² = 0.63 n = 83
 Age 2. a = -10.2187 b = 2.7089 r² = 0.82 n = 1,110

Discriminating Length = 103.09 mm

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

Table 19. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Egegik River, 1991.

Date	Cloud Cover ^a		Wind Velocity (km/h)		Air Temp. (°C)		Water Temp. (°C)		Precipitation (mm)	Water Clarity ^b
	0800	2000	0800	2000	0800	2000	0800	2000		
5/21	-	1	-	16-24 WSW	-	13.2	-	10.0	0.0	clear
5/22	1	1	0-08 NW	-	9.0	14.8	4.0	10.0	0.0	clear
5/23	1	1	0-08 NW	0-08 NW	9.0	16.5	4.0	10.0	0.0	clear
5/24	1	1	8-16 NW	16-24 SW	8.0	9.0	4.0	8.0	0.0	clear
5/25	3	2	32-40 SE	40-48 SW	9.0	6.5	5.0	6.5	0.0	clear
5/26	3	4	32-40 SE	24-32 SE	5.0	5.0	4.0	5.0	0.8	clear
5/27	3	4	0-08 SE	8-16 SE	4.0	7.5	5.0	5.5	2.5	clear
5/28	4	3	0-08 SE	24-32 W	5.0	9.5	5.0	6.0	29.7	clear
5/29	4	4	8-16 W	8 SW	5.0	6.5	5.0	6.0	0.3	clear
5/30	4	4	8-16 SE	0-08 E	4.0	9.0	5.0	6.0	0.8	clear
5/31	4	4	8-16 SW	24-32 NW	5.0	5.0	5.0	5.0	2.0	clear
6/01	4	4	8-16 SW	0-08 W	4.5	8.0	4.0	6.0	0.0	clear
6/02	2	3	16 SE	40-48 SE	9.0	6.0	4.0	7.0	0.0	clear
6/03	4	4	48 SE	32-48 SE	5.0	5.0	4.5	6.0	0.0	clear
6/04	4	-	24 SW	-	5.0	-	7.0	-	0.0	clear
6/05	4	3	0-08 SE	calm	6.0	9.5	6.0	10.0	3.3	clear
6/06	5	2	0-05 SE	10-19 SE	5.5	9.0	6.0	9.0	0.0	clear
6/07	1	1	0-05 SW	16 E	10.0	9.0	6.0	9.0	0.0	clear
6/08	1	4	8-16 SE	32-40 E	15.0	7.0	8.0	7.0	trace	clear
6/09	2	3	0-05 SE	8 E	11.0	11.0	7.5	10.0	0.0	clear
6/10	4	4	8-16 SE	0-08 SW	7.0	7.0	7.0	8.0	0.0	clear
6/11	4	4	0-08 SE	0-08 SW	5.5	7.0	7.0	7.0	0.0	clear
6/12	4	-	0-05 SE	-	4.0	-	6.0	-	-	clear

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

- ^b Water clarity at 0800 hours

Table 20. Water temperatures at sockeye salmon smolt counting site, Egegik River, 1981-1991.

Year	Sample Period	Water Temperature (°C)			Reference
		Minimum	Maximum	Mean	
1981	May 15 - Jun 08	5.0	9.0	7.3	Bue (1982)
1982	May 15 - Jun 16	0.0	5.0	2.9	Bue (1984)
1983	May 18 - Jun 10	5.0	9.5	7.0	Fried et al. (1987)
1984	May 17 - Jun 11	5.0	10.0	7.6	Fried et al. (1986)
1985	May 17 - Jun 12	2.5	7.5	4.2	Bue (1986c)
1986	May 19 - Jun 12	2.2	7.5	7.2	Bue et al. (1988)
1987	May 18 - Jun 13	3.9	11.0	6.6	Cross et al. (1990)
1988	May 19 - Jun 14	3.0	10.1	6.4	Woolington et al. (1990)
1989	May 21 - Jun 10	3.0	11.0	5.2	Woolington et al. (1991)
1990	May 20 - Jun 11	2.5	10.0	5.4	Crawford et al. (1992)
	Mean	3.2	9.1	6.0	
1991	May 21 - Jun 12	4.0	10.0	6.4	

Table 21. Sonar counts recorded from two arrays at the sockeye salmon smolt counting site on the Ugashik River, 1991.

Date ^a	Sonar Counts		
	Transducer Array		Total
	Inshore	Offshore	
5/20	311	26	337
5/21 ^b	32,116	14,093	46,209
5/22	178,938	273,998	452,936
5/23	78,917	78,401	157,318
5/24 ^c	63,020	130,100	193,120
5/25 ^c	62,713	115,606	178,319
5/26 ^c	20,012	41,717	61,729
5/27 ^c	5,350	3,481	8,831
5/28 ^c	134,625	39,590	174,215
5/29 ^c	1,056,222	341,964	1,398,186
5/30	309,289	94,233	403,522
5/31 ^c	453,229	312,317	765,546
6/01 ^c	83,994	100,134	184,128
6/02 ^c	797,899	952,769	1,750,668
6/03 ^c	262,337	490,235	752,572
6/04 ^c	119,265	371,230	490,495
6/05	687,462	470,110	1,157,572
6/06	256,195	263,421	519,616
6/07 ^c	30,649	74,786	105,435
6/08 ^c	10,637	7,122	17,759
6/09 ^c	307,069	66,264	373,333
6/10 ^c	133,632	47,200	180,832
6/11 ^c	66,627	21,059	87,686
6/12	53,815	8,180	61,995
6/13	0	27,089	27,089
Total	5,204,323	4,345,125	9,549,448
Percent	54.5	45.5	

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

^b A malfunctioning transducer (#3) on the inshore array was unplugged at 1900 hours on May 21. Therefore, all inshore array counts were multiplied by 1.11 to account for the unplugged transducer.

^c Data interpolated for one or more arrays on the these hours and dates:

- 1400-1800 and 2100 hours on May 24
- 0100-0700 and 0900-1000 hours on May 25
- 0700-1000 and 2200-2400 hours on May 26
- 0100 hours on May 27
- 2200-2300 hours on May 28
- 0200-0800 and 1000 hours on May 29
- 0800-2200 hours on May 31
- 0500-0600 hours on June 1
- 2300-2400 hours on June 2
- 0100-0600 and 0800-2000 hours on June 3
- 0700 and 2000-2200 hours on June 4
- 1800 hours on June 7
- 1200-1300 hours on June 8
- 2200 hours on June 9
- 0500-1100 hours on June 10
- 0800-1100 and 1800-2100 hours on June 11

Table 22. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Ugashik River, 1991.

Date ^a	Age 1.			Age 2.			All Ages	
	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5/20	1,353	59.9	1,353	906	40.1	906	2,259	2,259
5/21	228,908	59.9	230,261	153,306	40.1	154,212	382,214	384,473
5/22	2,812,948	59.9	3,043,209	1,883,909	40.1	2,038,121	4,696,857	5,081,330
5/23	1,243,656	73.3	4,286,865	453,010	26.7	2,491,131	1,696,666	6,777,996
5/24	1,103,821	51.5	5,390,686	1,037,857	48.5	3,528,988	2,141,678	8,919,674
5/25	834,697	44.7	6,225,383	1,034,306	55.3	4,563,294	1,869,003	10,788,677
5/26	152,860	25.8	6,378,243	439,162	74.2	5,002,456	592,022	11,380,699
5/27	17,906	25.8	6,396,149	51,443	74.2	5,053,899	69,349	11,450,048
5/28	276,306	25.8	6,672,455	793,820	74.2	5,847,719	1,070,126	12,520,174
5/29	1,662,847	19.7	8,335,302	6,769,442	80.3	12,617,161	8,432,289	20,952,463
5/30	549,361	22.1	8,884,663	1,942,074	77.9	14,559,235	2,491,435	23,443,898
5/31	828,671	16.7	9,713,334	4,124,537	83.3	18,683,772	4,953,208	28,397,106
6/01	145,187	11.7	9,858,521	1,096,794	88.3	19,780,566	1,241,981	29,639,087
6/02	1,391,795	11.7	11,250,316	10,514,068	88.3	30,294,634	11,905,863	41,544,950
6/03	1,989,809	31.9	13,240,125	4,249,793	68.1	34,544,427	6,239,602	47,784,552
6/04	1,342,584	31.9	14,582,709	2,867,464	68.1	37,411,891	4,210,048	51,994,600
6/05	2,893,760	31.9	17,476,469	6,180,433	68.1	43,592,324	9,074,193	61,068,793
6/06	2,798,640	57.1	20,275,109	2,100,940	42.9	45,693,264	4,899,580	65,968,373
6/07	728,983	64.2	21,004,092	405,797	35.8	46,099,061	1,134,780	67,103,153
6/08	119,784	71.5	21,123,876	47,676	28.5	46,146,737	167,460	67,270,613
6/09	2,202,561	71.5	23,326,437	876,652	28.5	47,023,389	3,079,213	70,349,826
6/10	1,279,659	77.2	24,606,096	377,930	22.8	47,401,319	1,657,589	72,007,415
6/11	634,602	78.9	25,240,698	170,118	21.1	47,571,437	804,720	72,812,135
6/12	482,105	85.2	25,722,803	83,679	14.8	47,655,116	565,784	73,377,919
6/13	333,988	85.2	26,056,791	57,970	14.8	47,713,086	391,958	73,769,877
	26,056,791	35.3		47,713,086	64.7		73,769,877	

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

Table 23. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Ugashik River, 1991.

Date ^a	Mean Weight of Smolt (g)	Smolt per Count
5/20	9.7	4.3
5/21	9.7	4.3
5/22	9.7	4.3
5/23	8.7	4.8
5/24	9.5	4.4
5/25	9.9	4.2
5/26	11.1	3.8
5/27	11.1	3.8
5/28	11.1	3.8
5/29	11.3	3.7
5/30	11.0	3.8
5/31	11.4	3.6
6/01	11.6	3.6
6/02	11.6	3.6
6/03	10.0	4.2
6/04	10.0	4.2
6/05	10.0	4.2
6/06	8.8	4.7
6/07	8.6	4.9
6/08	8.3	5.0
6/09	8.3	5.0
6/10	7.9	5.3
6/11	7.8	5.3
6/12	7.3	5.7
6/13	7.3	5.7

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

Table 24. 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 1979-1989 brood years, Ugashik River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced					Total	Per Spawner
		Age 1.	(%) ^a	Age 2.	(%) ^a	Age 3.		
1979	1,700,904	-		-		0	-	
1980	3,321,384	-		12,736,379		26,384	-	
1981	1,326,762	31,297,432	(27)	82,656,993	(73)	0	113,954,425	85.89
1982	1,157,526	75,491,249	(78)	21,407,762	(22)	0	96,899,011	83.71
1983	1,000,614	12,693,628	(46)	15,186,101	(54)	1,677	27,881,406	27.86
1984	1,241,418	37,890,152	(64)	21,483,727	(36)	9,598	59,383,477	47.84
1985	998,232	5,461,821	(14)	33,238,739	(86)	0	38,700,560	38.77
1986	1,001,493	182,719,678	(85)	32,278,743	(15)	0	214,998,421	214.68
1987	668,964	94,119,379	(71)	38,789,387	(29)	0	132,908,766	198.68
1988	642,972	14,837,960	(24)	47,713,086	(76)		62,551,046	97.28 ^b
1989	1,610,916	26,056,791						

^a Percent of total smolt production

^b Preliminary total

Table 25. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt) for 1979-1989 brood years, Ugashik River.

Brood Year	Total Spawning Escapement	Age 1.			Age 2.			Age 3.		
		Number of Smolt	Adult ^a Returns	Adult Returns per Smolt	Number of Smolt	Adult ^a Returns	Adult Returns per Smolt	Number of Smolt	Adult ^a Returns	Adult Returns per Smolt
1979	1,700,904	-	3,955,342		-	2,031,003		0	0	0.00
1980	3,321,384	-	3,490,984		12,736,379	4,244,354	0.33	26,384	2,627	0.10
1981	1,326,762	31,297,432	4,200,008	0.13	82,656,993	3,173,830	0.04	0	1,679	0.00
1982	1,157,526	75,491,249	1,134,226	0.02	21,407,762	1,339,087	0.06	0	0	0.00
1983	1,000,614	12,693,628	987,614	0.08	15,186,101	958,251	0.06	1,677	970	0.58
1984	1,241,418	37,890,152	1,051,938	0.03	21,483,727	4,397,856	0.20 ^b	9,598	1,491	0.16 ^b
1985	998,232	5,461,821	1,226,160	0.22	33,238,739	1,441,828	0.04 ^b	0	0	0.00 ^b
1986	1,001,493	182,719,678	2,947,225	0.02 ^b	32,278,743	1,936,745	0.06 ^b	0	0	0.00 ^b
1987	668,964	94,019,379	839,493	0.01 ^b	38,789,387	10,000				
1988	642,972	14,837,960								
1989	1,681,302									

^a Includes estimates of returns through 1990.

^b Future adult returns will increase these values.

Table 26. Mean fork length and weight of sockeye salmon smolt captured in fyke nets, Ugashik River, 1991.

Date ^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
5/20	90	11.1	7.2	2.65	20	114	12.1	14.0	4.66	10
5/21	98	15.9	9.0	3.40	15	115	14.3	14.0	5.42	34
5/22	93	13.5	7.9	3.78	85	111	14.4	12.8	4.60	15
5/23	94	16.3	7.9	4.06	88	104	11.5	10.8	3.13	12
5/24	86	27.7	6.4	4.96	58	109	15.6	12.0	6.67	41
5/25	94	14.9	8.3	3.92	35	110	15.3	12.3	6.23	63
5/26	98	9.5	9.0	2.20	7	109	9.6	11.6	4.05	43
5/27					0	109	13.4	12.9	3.95	22
5/28	101	0.0	9.9	0.77	2	108	14.7	12.5	4.55	96
5/29	93	4.2	8.9	2.59	6	110	13.3	12.2	4.61	93
5/30	97	6.2	8.2	1.44	5	107	12.2	11.5	5.04	91
5/31	98	9.8	9.4	3.23	5	108	12.8	12.2	3.80	93
6/01					0	110	11.0	11.8	3.21	50
6/02	82	1.8	6.6	0.54	2	109	17.8	12.8	4.47	98
6/03	96	7.4	9.1	1.32	7	107	13.3	11.6	3.20	43
6/05	95	13.4	8.4	3.42	18	103	14.6	10.6	4.28	80
6/06	91	11.1	7.3	2.93	25	105	15.5	11.3	5.88	73
6/07	86	20.2	6.4	4.53	63	98	20.9	9.8	7.51	27
6/09	88	16.7	6.9	4.36	73	104	18.6	11.3	6.19	26
6/10	90	10.5	6.5	2.22	63	104	17.4	10.2	5.85	35
6/11	89	13.8	6.7	2.60	84	104	16.6	10.1	3.96	15
6/12	89	13.9	6.5	2.76	41	103	15.8	10.3	4.41	6
6/13	88	16.4	6.2	3.78	85	101	7.4	9.5	2.37	13
Totals					787					1,079
Means	92		7.7			107		11.6		

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

Table 27. Mean fork length and weight of sockeye salmon smolt sampled from Ugashik River, 1958-1991.

Year of Migration	Sample Dates	Sample Size	Age 1.		Age 2.		Age 3.		References
			Mean Length	Mean Weight	Mean Length	Mean Weight	Mean Length	Mean Weight	
1958	-	-	93	6.4	112	11.7	-	-	Pella and Jaenicke (1978)
1959	-	-	90	6.1	120	13.5	-	-	"
1960	-	-	90	6.6	104	11.0	-	-	"
1961	-	-	90	6.7	112	12.2	-	-	"
1962	May 12 - Jun 28	1,070	88	6.1	112	12.3	-	-	Jaenicke (1963)
1963	May 05 - Jun 26	921	90	6.1	104	9.6	-	-	Nelson and Jaenicke (1965)
1964	May 15 - Jun 20	4,042	92	6.9	118	12.7	-	-	Nelson (1965a)
1965	May 13 - Jun 20	3,296	94	6.9	114	12.5	-	-	Nelson (1966a)
1967	May 15 - Jun 12	966	88	6.0	113	12.2	-	-	Nelson (1969)
1968	May 13 - Jun 24	6,727	93	6.5	113	10.7	-	-	Siedelman (1969)
1969	May 23 - Jun 06	567	97	7.5	121	14.5	-	-	Schroeder (1972a)
1970	May 15 - Jun 10	907	97	7.7	125	15.9	-	-	Schroeder (1972b)
1972	May 28 - Jun 20	615	81	5.0	112	11.2	129	14.3	Schroeder (1974a)
1973	May 17 - Jun 12	1,189	93	7.2	113	11.9	132	20.1	Schroeder (1974b)
1974	May 17 - Jun 17	355	94	7.4	119	13.6	-	-	Schroeder (1975)
1975	Jun 03 - Jun 13	-	96	7.2	116	13.0	125	16.7	Sanders (1976)
1982	Jun 06 - Jun 08	512	88	6.3	113	13.0	138	22.5	Eggers (1984)
1983	May 21 - Jun 16	9,502	89	7.6	111	13.2	-	-	Fried et al. (1987)
1984	May 23 - Jun 16	4,810	87	6.8	102	10.3	103	11.7	Fried et al. (1986)
1985	May 22 - Jun 17	3,473	94	8.3	107	11.8	-	-	Bue (1986c)
1986	May 21 - Jun 14	1,555	87	5.8	114	10.9	-	-	Bue et al. (1988)
1987	May 18 - Jun 12	2,190	94	7.9	107	11.1	138	24.1	Cross et al (1990)
1988	May 17 - Jun 14	2,581	87	5.7	109	10.8	128	15.6	Woolington et al. (1990)
1989	May 23 - Jun 15	1,898	90	6.5	108	10.7	-	-	Woolington et al. (1991)
1990	May 23 - Jun 16	1,392	90	6.7	108	11.8	-	-	Crawford et al. (1992)
Mean			91	6.7	112	12.1	128	17.9	
1991	May 20 - Jun 13	1,866	92	7.7	107	11.6	-	-	

Table 28. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Ugashik River, 1991.

Date ^b	Estimated Age 1. ^a				Estimated Age 2. ^a			
	Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size	Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size
5/21	96	6.9	8.3	36	113	22.9	13.4	130
5/22	93	17.8	7.7	387	105	20.3	11.0	127
5/23	92	21.6	7.5	401	106	22.6	11.3	162
5/24	93	15.2	7.7	205	108	25.8	11.8	258
5/25	91	28.8	7.3	221	107	23.2	11.6	299
5/26	94	8.8	8.0	42	107	15.6	11.7	49
5/27	98	0.6	8.9	2	110	11.7	12.5	48
5/28	92	5.9	7.4	2	107	14.5	11.6	125
5/29	93	14.7	7.8	72	109	24.8	12.0	454
5/30	92	13.9	7.6	84	108	22.4	11.9	430
5/31	95	10.9	8.2	46	109	24.1	12.0	466
6/01	95	3.5	8.0	4	109	16.5	12.2	154
6/02	93	9.3	7.7	33	108	24.0	11.9	478
6/03	96	3.9	8.3	6	105	12.0	11.1	44
6/05	93	15.9	7.8	190	104	16.4	10.8	430
6/06	88	32.2	6.7	326	105	19.5	11.1	226
6/07	89	29.9	7.0	271	104	14.5	10.7	138
6/09	90	24.2	7.1	459	104	14.6	10.6	180
6/10	89	23.1	6.9	436	104	13.6	10.6	99
6/11	89	21.8	6.8	474	103	14.4	10.6	111
6/12	86	20.0	6.3	183	104	8.4	10.8	18
6/13	88	13.7	6.5	276	105	9.9	10.9	39
Totals				4156				4465
Means	92		7.5		107		11.5	

^a Length-weight parameters by age group and discriminating length used to separate ages for May 20 through June 14 were:

Age 1. a = -10.86 b = 2.84 r² = 0.88 n = 787
 Age 2. a = - 9.52 b = 2.56 r² = 0.73 n = 1,079

Discriminating Length = 99.17 mm

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

Table 29. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Ugashik River, 1991.

Date	Cloud Cover ^a		Wind Velocity (km/h)		Air Temp. (°C)		Water Temp. (°C)		Precipitation (mm)	Water Clarity ^b
	0800	2000	0800	2000	0800	2000	0800	2000		
5/20	3	2	-	24 SW	-	7.0	-	4.5	0.0	clear
5/21	2	1	8-16 SE	16 SW	-	11.0	4.0	5.3	0.0	clear
5/22	5	1	calm	3 S	14.0	14.0	4.5	5.5	0.0	clear
5/23	1	1	calm	16 S	19.0	16.0	5.0	6.7	0.0	clear
5/24	1	1	calm	40 E	15.0	9.0	4.8	7.3	0.0	clear
5/25	4	3	32-48 SE	8 S	5.0	10.0	6.0	8.0	0.0	lt. brown
5/26	4	4	48 SE	32 SE	5.0	12.0	7.0	7.0	0.0	clear
5/27	3	4	8 S	48 SE	6.0	4.0	5.5	6.0	trace	lt. brown
5/28	5	3	8 SE	48 W	5.0	6.0	5.5	5.0	4.0	lt. brown
5/29	4	4	16 W	8-16 W	5.0	4.0	5.0	5.0	4.0	clear
5/30	5	5	8-16 W	32 W	6.0	4.0	5.0	5.0	11.0	clear
5/31	4	4	16-32 W	32-48 W	5.0	2.0	4.5	4.0	13.0	clear
6/01	4	1	16-24 W	calm	3.0	7.0	4.0	4.5	14.0	clear
6/02	4	4	8-16 SE	48-64 SE	5.0	6.0	4.5	7.0	0.0	clear
6/03	4	4	64-80 SE	24-32 SE	6.0	4.0	6.0	6.0	4.0	lt. brown
6/04	4	3	24-32 SE	16-24 SE	5.0	5.0	5.0	7.0	0.0	lt. brown
6/05	4	3	0-08 E	calm	5.0	6.0	6.0	7.0	1.0	lt. brown
6/06	3	1	0-08 W	8-16 SE	6.0	8.0	5.5	8.5	0.0	clear
6/07	2	2	0-08 E	16-24 E	9.0	10.0	7.5	7.5	0.0	clear
6/08	3	4	8-16 E	24-32 E	7.0	9.0	7.0	7.5	0.0	clear
6/09	3	3	0-08 NE	0-08 NE	7.0	10.0	7.0	8.0	0.0	clear
6/10	3	4	8-24 S	8-16 SW	8.0	9.0	6.0	7.0	0.0	clear
6/11	4	4	8-24 SW	8-16 W	5.0	7.0	5.5	6.0	0.0	clear
6/12	5	1	0-05 S	calm	5.0	10.0	6.0	6.5	0.0	clear
6/13	5	1	8 S	16-24 SW	5.0	11.0	5.5	7.0	0.0	clear
6/14	5	-	16-40 SW	-	4.5	-	6.0	-	-	clear

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

- ^b Water clarity at 0800 hours

Table 30. Water temperatures at sockeye salmon smolt counting site, Ugashik River, 1983-1991.

Year	Sample Period	Water Temperature (°C)			Reference
		Minimum	Maximum	Mean	
1983	May 23 - Jun 11	6.0	8.5	7.3	Fried et al. (1987)
1984	May 20 - Jun 17	4.8	8.5	6.3	Fried et al. (1986)
1985	May 17 - Jun 09	-1.0	7.0	4.3	Bue (1986c)
1986	May 23 - Jun 28	2.0	7.0	5.6	Bue et al. (1988)
1987	May 17 - Jun 13	4.0	9.0	5.9	Cross et al. (1990)
1988	May 17 - Jun 13	3.5	10.0	6.6	Woolington et al. (1990)
1989	May 21 - Jun 16	3.0	8.8	5.8	Woolington et al. (1991)
1990	May 21 - Jun 14	3.0	8.0	5.9	Crawford et al. (1992)
	Mean	3.2	8.4	6.0	
1991	May 20 - Jun 14	4.0	8.5	5.9	

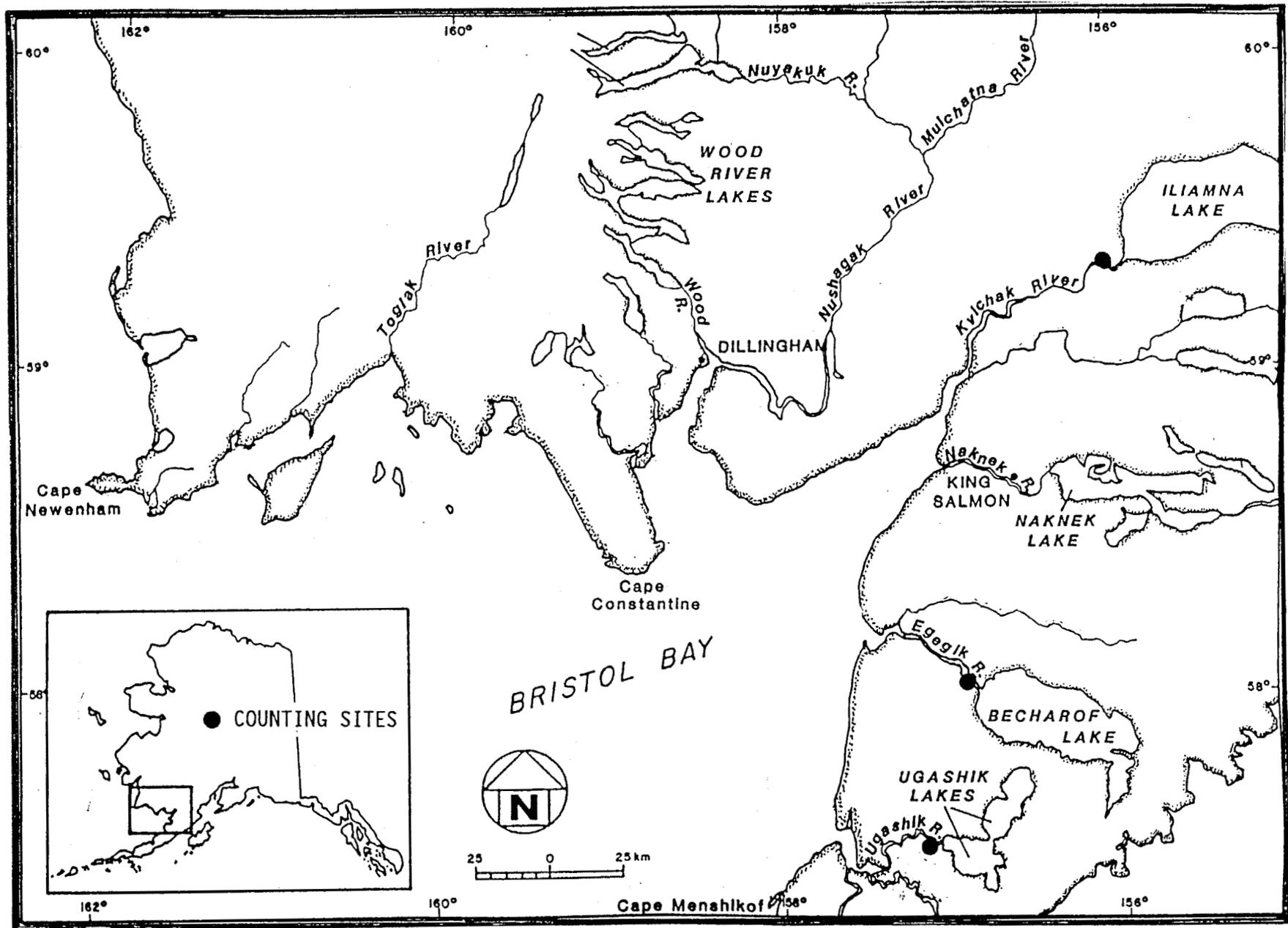


Figure 1. Bristol Bay Management Area with major rivers and location of smolt counting projects, 1991.

KVICHAK RIVER

Sockeye Salmon Smolt

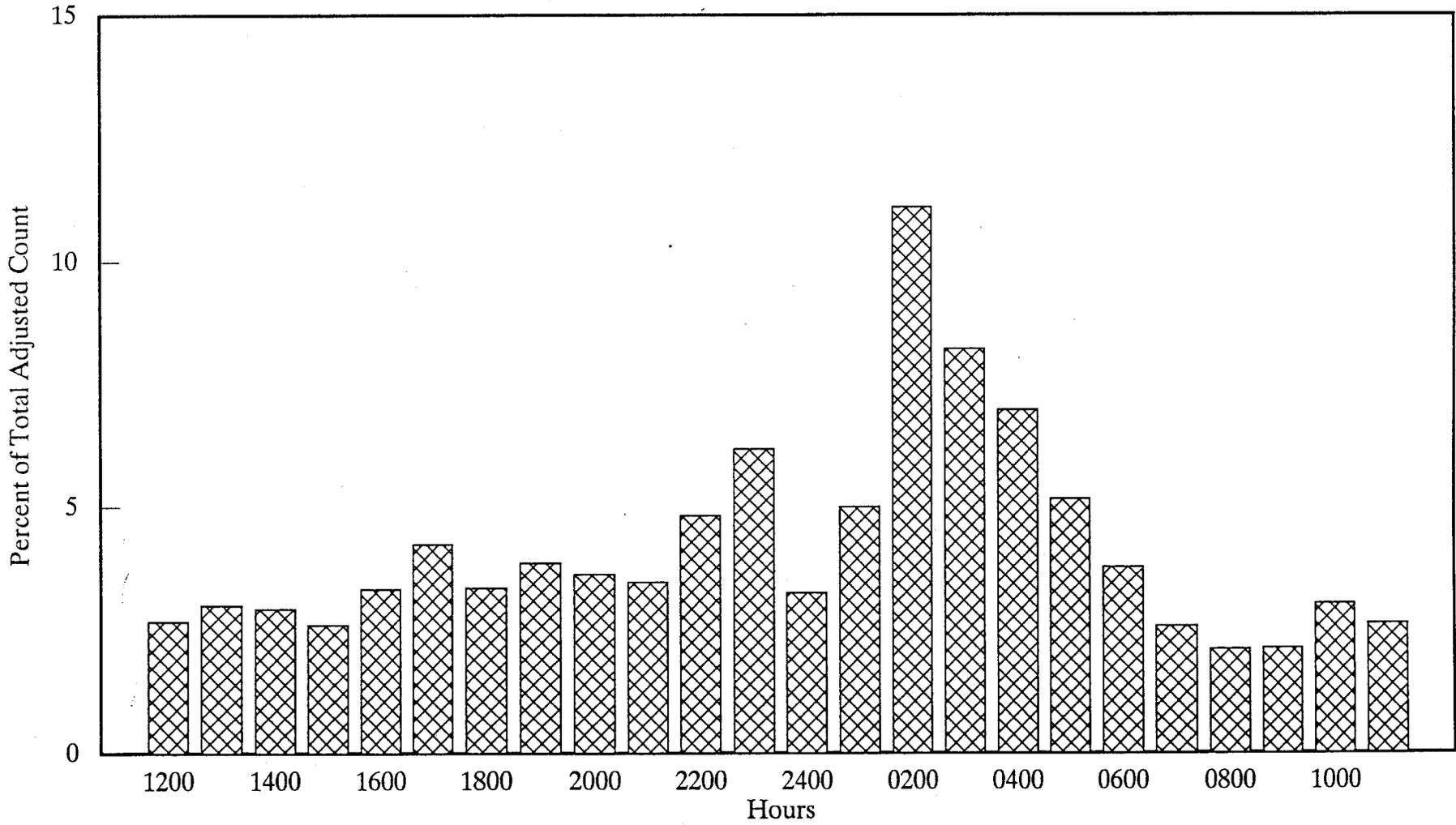


Figure 2. Percent of the total adjusted sonar count summarized by hour, Kvichak River smolt project, May 22 through June 16, 1991.

EGEGIK RIVER

Sockeye Salmon Smolt

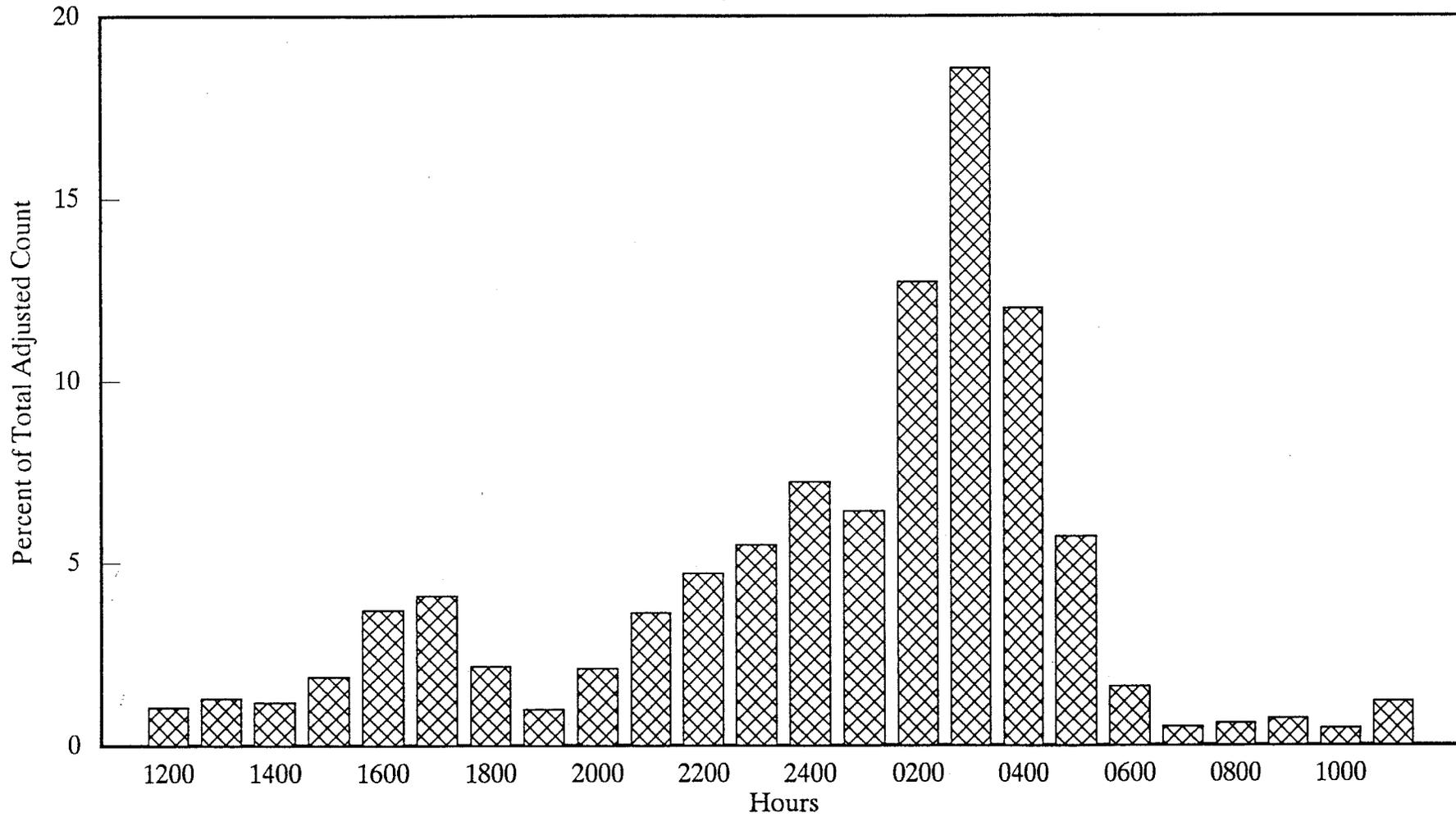


Figure 3. Percent of the total adjusted sonar count summarized by hour, Egegik River smolt project, May 21 through June 11, 1991.

UGASHIK RIVER

Sockeye Salmon Smolt

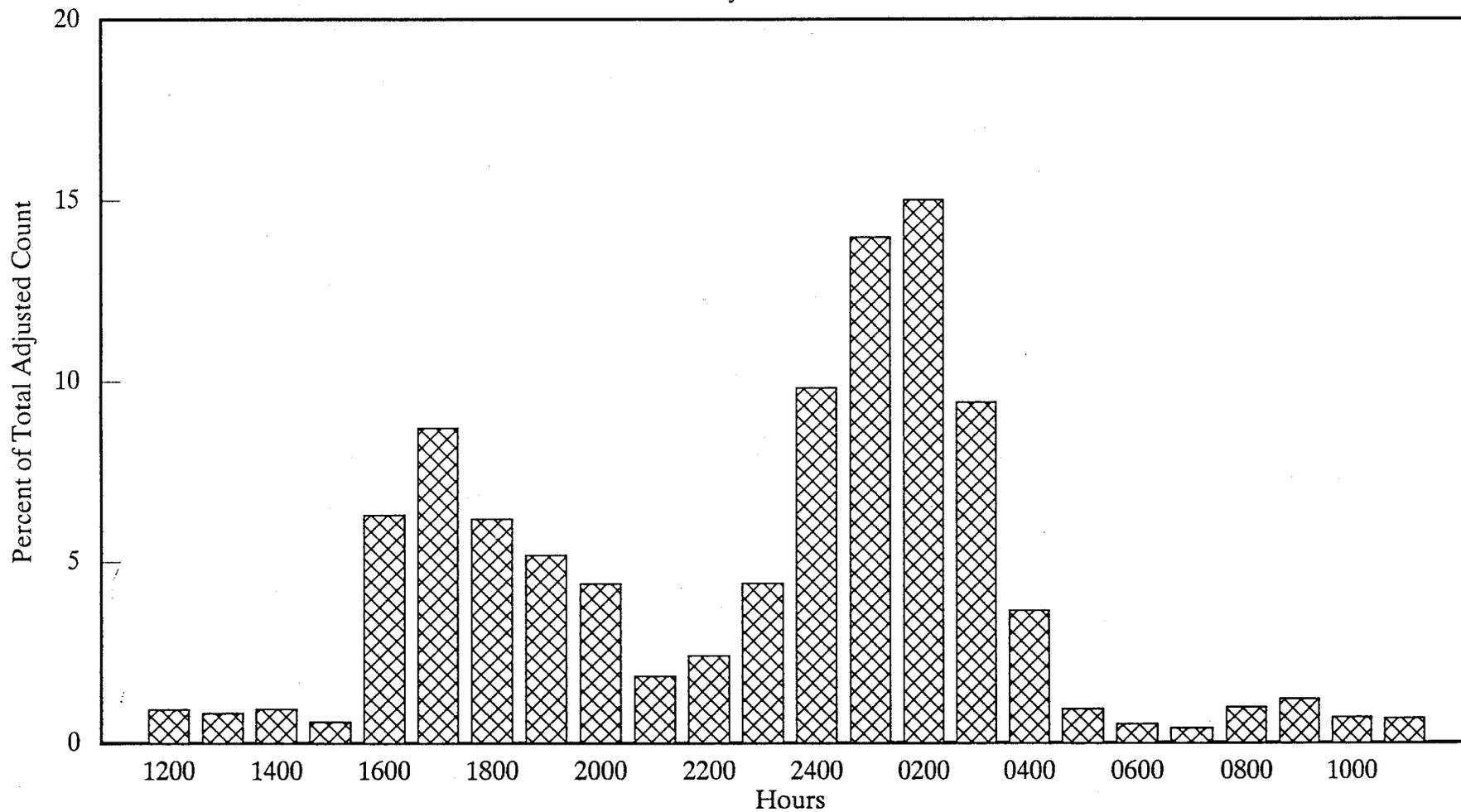


Figure 4. Percent of the total adjusted sonar count summarized by hour, Ugashik River smolt project, May 20 through June 13, 1991.

Appendix A.1. Ugashik River chinook salmon smolt
age-weight-length data, 1991.

Sampling Date	Age	Weight (g)	Length ^a (mm)
6/09	1.	20.1	125
	1.	38.6	151
	1.	46.4	164
	1.	38.8	159
	1.	53.6	171
	1.	27.4	136
	1.	24.5	131
	1.	17.9	117
	1.	17.8	120
	1.	18.4	120
	1.	21.0	129
	1.	24.7	137
	1.	26.6	130
	1.	16.0	114
	1.	21.4	126
	1.	30.7	145
	1.	47.1	161
	1.	19.5	121
	1.	40.6	153
	1.	27.7	140
1.	43.7	160	
1.	35.7	148	
1.	25.5	128	
1.	22.0	124	
1.	28.4	137	
1.	41.1	158	
1.	57.8	175	
1.	33.4	152	
1.	38.5	155	
Range		16.0 - 57.8	114 - 175
Mean		31.2	141
Standard Deviation		11.5	17

^a Tip-of-snout to fork-of-tail measurement.

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