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Bristol Bay Sockeye Salmon Smolt Studies for 1990

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ABSTRACT

Numbers of sockeye salmon *Oncorhynchus nerka* smolt emigrating to sea from four rivers in Bristol Bay, Alaska, in 1990 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 88,004,103 from Kvichak River, 56,095,226 from Egegik River, 53,627,347 from Ugashik River, and 28,246,633 from Wood River. Age-1. smolt, the progeny of 1988 spawners, predominated from Kvichak River (52.9%) and Wood River (98.4%). Age-2. smolt, the progeny of 1987 spawners, predominated from Egegik River (93.2%) and Ugashik River (72.3%).

KEY WORDS: Smolt, sockeye salmon, *Oncorhynchus nerka*, smolt emigration, sonar, Bristol Bay, Kvichak River, Egegik River, Ugashik River, Wood River, *Triaenophorus crassus*

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 1981 to 1990 the commercial catch in Bristol Bay averaged 23.4 million sockeye salmon (ADF&G 1991). 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 the Kvichak River from 1956 to 1970; on the Naknek River from 1956 to 1978; on the Egegik River during 1957, 1969, and 1978; on the Ugashik River from 1955 to 1965, 1967 to 1970, and 1972 to 1975; and on the Wood River from 1955 to 1966 (Kerns 1961; Rietze and Spangler 1958; Jaenicke 1968; Pella and Jaenicke 1978; Burgner and Koo 1954; Burgner 1962). 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 the Kvichak River from 1971 to 1990; on the Wood River from 1975 to 1990; on the Naknek River from 1982 to 1986; on the Egegik River from 1982 to 1990; on the Ugashik River from 1983 to 1990; and on the Nuyakuk River from 1983 to 1989 (Russell 1972; Parker 1974a, 1974b; Krasnowski 1975; Randall 1976, 1977, 1978; Yuen 1980a, 1980b; Bergstrom and Yuen 1981; Yuen and Wise 1982; Eggers and Yuen 1984; Bue 1986; Bue and Fried 1987; Bue et al. 1988; Cross et al. 1990; Woolington et al. 1990; Woolington et al. 1991).

Hydroacoustic equipment developed by Bendix Corporation[1] was tested on the 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 the Wood (Krasnowski 1976) and Kvichak Rivers (Randall 1977) in 1975 and 1976. Hydroacoustic equipment for counting smolt was tested on the Ugashik River from 1973 to 1975 (Schroeder 1974b and 1975; Sanders 1976). Smolt studies on the 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 the Kvichak River was tested on the Egegik River during 1981 (Bue 1982). Smolt enumeration projects using modified counters began on the Naknek and Egegik Rivers in 1982 (Huttunen 1984; Bue 1984) and on the 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 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

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

width = 104 m); Ugashik River smolt used a 21-m corridor 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 emigrations was discontinued on the Naknek River in 1986 (Bue et al. 1988) and on the Nuyakuk River in 1989 (Woolington et al. 1991) due to lack of funding.

Studies were conducted on the Kvichak, Egegik, Ugashik, and Wood Rivers in 1990 to (1) estimate, using hydroacoustic equipment, numbers of seaward migrating sockeye smolt; (2) describe smolt emigration patterns; (3) collect age, weight, and length data for smolt; 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 the Egegik, Ugashik, and Wood Rivers housed 10 upward-facing transducers. In 1990, seven upward-facing transducers were used on each Kvichak River array, and the seven downstream-facing transducers on each array were disconnected based on advice from former project leaders and a Bendix[2] sonar technician.

Hydroacoustic equipment to monitor smolt outmigrations was operated on the Kvichak, Egegik, and Ugashik Rivers from mid-May to mid-June and on the Wood River from late May to early August. The Wood River counter was operated for a longer period because smolt from this multi-lake system tend to outmigrate in smaller schools over a longer period of time. Smolt outmigrations in the Kvichak, Egegik, and Ugashik Rivers, on the other hand, 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 unit were 26.9 g for Wood, 41.5 g for Egegik and Ugashik, 83.0 g for Kvichak. Because most smolt migrate within the upper portion of the water column, individual arrays were calibrated independently, which allowed the operator to set the

counting range as near the surface as possible. The equipment was set to record counts to within 1 - 2 cm of the water surface to avoid counting debris or entrapped air.

Sources of false counts (e.g., boats, wind, rain, debris, 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 Wood and Ugashik River units monitored two arrays. A switch box was added to the Wood River system which allowed a combination of any two of the four arrays to be monitored by the counter.

In 1989 the Kvichak River smolt counting system was relocated and modified so that one smolt counter on the right bank monitored three arrays and a second smolt counter on the left bank monitored a fourth array to account for the greater river width and depth at the new site. Analyses of the 1989 data (Woolington et al.'s 1991) revealed no advantages to using a three- versus a four-array system; therefore, in 1990 only three arrays and one counter were used. The offshore transducer cables were also extended 30.5 m 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, Water Depth = (Depth Setting) (1.79) + 3.0 feet were introduced this year 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 1990 counting site on the Kvichak River 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 136 m wide at this site. Three transducer arrays referred to as *inshore, center,* and *offshore*, were anchored 30 m, 65 m, and 92 m from the right bank (right bank and the left bank as determined when facing downstream). Array placement was improved in 1990 by first measuring water velocities to determine the edge of the slow water from the right bank (inshore) and then placing the inshore array beyond this slow water edge in the faster current.

Arrays on the Egegik, Ugashik, and Wood 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 104

m wide. The inshore, center, and offshore arrays were anchored 40 m, 55 m, and 67 m from the left bank.

The Ugashik River counting site was located 50 m below the outlet of Lower Ugashik Lake. Because the channel width is only 43 m wide, only two arrays have been used. The inshore and offshore arrays were anchored 26 m and 31 m from the right bank. On June 4, heavy storm runoff moved the Ugashik River arrays 0.6 m downstream; both arrays were returned to their original locations after the storm.

The Wood River counting site was located 1 km below the outlet of Lake Aleknagik. where the river is 109 m wide. Arrays I, II, III, and IV were anchored 13 m, 24 m, 46 m, and 64 m from the right bank. Due to decreasing water levels, arrays I and II were moved offshore an additional 0.3 m and 1.2 m, respectively, on July 10 because the original locations became too shallow.

Estimation of Smolt Numbers

The process of estimating smolt numbers was divided into three steps: (1) determining total fish biomass migrating past the study site; (2) sampling the migrating 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 and Wood Rivers are influenced by tides, a Marsh-McBirney[2] flow meter was anchored directly behind the velocity index array, the smolt counters were adjusted every 15 to 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 Gurley 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:

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

where

vcf_i = velocity correction factor for array i,

v_i = velocity over array i, and

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

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:

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

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 except those at Wood River monitored fish biomass 24 h/d, so daily counts for each array represented actual sonar counts. The Wood River counter was designed to simultaneously control only two of the four arrays used. Array I, the index array, was continuously monitored. The other three arrays were each monitored for 15-min periods each hour. Consequently, total daily counts for array I were known, whereas those for arrays II, III, and IV were estimated from the 15-min counting periods:

$$\hat{hc}_{i,z,k} = \sum_{l=1}^{p} (pc_{i,z,k,l}\, \frac{4}{p}) \quad , \text{ and} \tag{3}$$

$$\hat{e}_{i,z,k} = \sum_{l=1}^{24} \hat{hc}_{i,z,k} \quad , \tag{4}$$

where

$\hat{hc}_{i,z,k}$ = hourly count for array i, day z, and hour k,
$pc_{i,z,k,l}$ = sonar counts for array i, day z, hour k, and counting period l, and
p = the number of 15-min periods that array i was monitored during hour k and day z, and
$\hat{e}_{i,z,k}$ = estimated counts for array i, day z, and hour k.

If an array was not monitored during an hour, counts were linearly interpolated using estimated counts from the previous and following hours. Estimated $\hat{e}_{i,z}$ for Wood River was used in equation (2).

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:

$$l_{i,z} = 3.03 + 2\, (d_{i,z} \tan \frac{bw}{2}) \quad , \tag{5}$$

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 the 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:

$$\hat{B}_z = \frac{1}{2} D_1 \left(\frac{ac_{1,z}}{l_{1,z}}\right) + \sum_{i=2}^{na} \frac{1}{2} D_i \left(\frac{ac_{i-1,z}}{l_{i-1,z}} + \frac{ac_{i,z}}{l_{i,z}}\right) + \frac{1}{2} D_{na+1} \left(\frac{ac_{na,z}}{l_{na,z}}\right) , \quad (6)$$

where

$\hat{B}_z$ = estimated biomass on day z,
D_i = the distance for interval i, and
na = number of transducer arrays used.

Age, Weight, and Length Estimation

Data on age, weight, and length of sockeye smolt were obtained from samples captured in fyke nets. Smolt weight in grams and length in mm 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 1990 smolt outmigrations were 1988 for age-1. smolt, 1987 for age-2. smolt, and 1986 for age-3. smolt.

Sample size goals for the 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).

Age-1. smolt are preponderant each year in the Wood River emigration, averaging 93.7% from 1982 to 1988; consequently, the sample goal was lower. Furthermore, because Wood River smolt emigration patterns made it difficult to consistently collect large quantities of smolt, only 120 smolt were collected each day. All 120 smolt/d were sampled for age, weight, and length. Smolt from subsequent days were pooled into a sample of 200. Based on binomial proportions for the two age groups, a sample size of 200

smolt would simultaneously estimate the percentage of each age class within 5% of the true percentage points at least 95% of the time (Goodman 1965; Cochran 1977). For each Wood River smolt examined for age, weight, and length data in 1990, the presence or absence of *T. crassus* was determined by gross external examination for small bumps underneath the skin.

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:

$$W_j = \alpha L_j^{\beta} \quad , \tag{7}$$

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:

$$\hat{W} = \frac{\sum_{k=1}^{m} \left(\frac{\sum W_k}{n_k} \right)}{m} \quad , \tag{8}$$

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, and

n_k = number of observations in subsample k; and

$$\hat{P}_j = \frac{\sum_{k=1}^{m} \left(\frac{n_{j,k}}{n_k} \right)}{m} \quad , \tag{9}$$

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:

$$\hat{SPC} = \frac{BPC}{\hat{W}} , \tag{10}$$

where

$\hat{SPC}$ = 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:

$$\hat{N}_z = \hat{B}_z \hat{SPC} , \tag{11}$$

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:

$$\hat{N}_{j,z} = \hat{N}_z \hat{P}_j , \tag{12}$$

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:

$$\hat{N}_{tot} = \sum \hat{N}_z , \text{ and} \tag{13}$$

$$\hat{N}_{jtot} = \sum \hat{N}_{j,z} , \tag{14}$$

where

$\hat{N}_{tot}$ = estimated total number of smolt which passed site during season, and
$\hat{N}_{jtot}$ = 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 1,335,420 sonar counts were recorded at the Kvichak River counting site from May 21 to June 14, 1990 (Table 1). More counts were recorded over the offshore (41.0%) and center arrays (37.7%) than over the inshore array (21.3%). Daily sonar counts were highest from May 22 to May 28 when 61.6% of the total counts were recorded.

Because the peak daily sonar count occurred on May 22 -- the second day of sonar operations -- it is possible that the smolt outmigration had begun before the project began. The spring weather was unusually warm and most of Lake Iliamna was clear of ice by early May. An easterly wind pushed the remaining lake ice into the Kvichak River and prevented installation of the sonar gear until May 21. Villagers from Igiugig reported seeing smolt in the river before the smolt project started. Therefore, the 1990 Kvichak River smolt outmigration estimate should be considered a minimal estimate.

Side-looking sonar information collected from May 29 to 31, 1990 (Huttunen and Skvorc 1990) indicated that most smolt migrated between 40 and 100 m offshore from the right bank. The daily passage between the inshore and offshore arrays varied from 71.7 to 83.2% of the total daily smolt passage during the 3 d of data collection; an average of 1.4% passed between the right bank and the inshore array, and an average of 20.0% passed beyond the offshore array.

River velocity measurements over the center index array ranged from 1.5 m/s to 1.7 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 23	0.83	1.00	0.90
May 24 - June 2	0.83	1.00	0.99
June 3 - June 10	0.77	1.00	0.99
June 11 - June 15	0.78	1.00	0.98

An estimated 88,004,103 sockeye salmon smolt migrated from the Kvichak River in 1990 based on sonar counts (Table 2). Age-1. smolt (1988 brood year) composed 52.9% of the total emigration. The daily percentage of age-1. smolt increased and the daily percentage of age-2. smolt decreased during the 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 1986 spawning escapement of 1,179,322 sockeye salmon was 16.92 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 2,316 sockeye salmon smolt in 1990 (Table 6). All smolt were age-1. or age-2. and no age-3. smolt were present. Mean weights of age-1. smolt were 6.1 g and age-2. 10.5 g; mean lengths of age-1. smolt were 87 mm and of age-2. smolt 105 mm. Age-1. and age-2. smolt from the Kvichak River in 1990 were smaller (NSC) in length and greater than or equal in weight compared to the 1955-89 average (Table 7). An additional 12,203 smolt were measured for length only (Table 8).

River and weather conditions were recorded at the counting site from May 22 to June 15 (Table 9). Except for the lake ice in early May, project operations were not greatly affected by weather conditions in 1990. Mean water temperature during the project was 7.3° C (range 3.5-9.5°C), which was warmer (NSC) than the 1963-89 mean of 5.6°C (Table 10). Mean water temperature during the peak of the smolt emigration was 3.5°C on May 22 and 5.8°C from May 27 to 28.

Egegik River

A total of 4,864,570 sonar counts were recorded at the Egegik River counting site from May 19 to June 11, 1990 (Table 11). Most counts (57.5%) occurred over the center array. Daily sonar counts were highest from May 23 to 26 when 74.7% of the total counts were recorded.

River velocity at the counting site ranged from 0.6 to 0.8 m/s over the sonar arrays. Velocity correction factors for the inshore, center, and offshore arrays were:

	Inshore	Center	Offshore
May 19 - May 26	1.00	1.12	1.13
May 27 - June 2	1.00	1.32	1.24
June 3 - June 12	1.00	1.17	1.09

An estimated 56,095,226 sockeye salmon smolt migrated from the Egegik River in 1990 based on sonar counts (Table 12). Age-2. smolt composed 93.2% of the total emigration. The daily percentage of age-2. smolt decreased during the emigration (NSC). The mean weight of smolt decreased over the season,

consequently the estimated number of smolt per count increased (Table 13;NSC). The total smolt production from the 1986 spawning escapement of 1,151,320 sockeye salmon was 55.13 smolt per spawner (Table 14). This was the second highest production from a single brood year recorded from this project following 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 1,363 sockeye salmon smolt in 1990 (Table 16). All smolt sampled were age-1. or age-2. and no age-3. smolt were present. Mean weights of age-1. were 9.6 g and of age-2. smolt 14.5 g; mean lengths of age-1. smolt were 102 mm and of age-2. smolt 118 mm. Age-1. and age-2. smolt showed slight size differences from the historical average (NSC; Table 17); age-1. smolt were slightly shorter and lighter, and age-2. smolt were slightly lighter. An additional 6,313 smolt were measured for length only (Table 18). Mean smolt length remained similar throughout the 1990 field season; one discriminating length (106 mm) was used to determine proportions of age groups.

River and weather conditions were recorded at the counting site from May 20 to June 11 (Table 19). There was no ice from Becharof Lake at the Egegik counting site in 1990. However, frequent high winds primarily from the SE caused the smolt counter to be shut down for 118 of the 570 hours that this project was conducted in 1990. Sonar counts were adjusted for 53 h of down time by interpolation. The mean water temperature during the season was 5.4°C (range 2.5-10.0°C), which was slightly lower (NSC) than the 1981-89 average of 6.0°C (Table 20). The mean water temperature during the peak of the smolt outmigration -- May 23 to May 26 -- was 4.1°C.

Ugashik River

A total of 7,023,316 sonar counts were recorded at the Ugashik River sonar counting site from May 20 to June 13, 1990 (Table 21). Most counts were recorded over the offshore array (69.8%). Daily sonar counts were highest from May 25 to June 1 when 79.8% of the total counts were recorded.

River velocities varied from 1.9 to 2.3 m/s. Velocity correction factors used for inshore and offshore arrays were:

	Inshore	Offshore
May 20 - May 28	0.92	1.00
May 29 - June 4	0.92	1.00
June 5 - June 12	0.92	1.00
June 13 - June 14	0.91	1.00

An estimated 53,627,347 sockeye salmon smolt migrated from the Ugashik River in 1990 based on sonar counts (Table 22). Age-2. smolt, 1987 brood year, composed 72.3% of the total emigration. The

percentage of age-2. smolt generally decreased over the season. The estimated number of smolt per sonar count ranged from 3.0 to 5.2 (Table 23). The total smolt production from the 1986 spawning escapement of 1,001,493 sockeye salmon was 214.68 smolt per spawner (Table 24). This was much greater than the average production of 56.81 smolt per spawner calculated for the 1981 to 1985 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 1,398 sockeye salmon smolt in 1990 (Table 26). Mean weights of age-1. smolt were 7.4 g and age-2. smolt 11.9 g; mean lengths of age-1. smolt were 92 mm and of age-2. smolt 109 mm. Age-1. smolt were similar to, and age-2. smolt smaller (NSC) than, the 1958-88 average (Table 27). An additional 7,394 smolt were sampled for length only (Table 28).

River and weather conditions were recorded at the counting site from May 21 to June 14 (Table 29). Wind, snow, and rain inhibited counting on May 21 to May 25, May 27 to May 31, June 3 to June 7, June 9, and June 13 to June 14. However, unfavorable smolt counting conditions -- totalling 199 hours out of 588 hours in operation -- usually prevailed for only part of these days. Therefore, 109 hours of smolt counter down time were able to be adjusted by interpolation. Average water temperature was 5.9°C (range 3.0-8.0°C), which was slightly cooler (NSC) than the 1983-89 average of 6.0°C (Table 30). The mean water temperature during the peak of the smolt outmigration -- May 25 to June 1 -- was 6.3°C.

Wood River

A total of 930,973 sonar counts were recorded at the Wood River counting site from May 31 to August 6 (Table 31). The highest count for a single day occurred on August 2. Observations of birds feeding on smolt in the vicinity of the Wood River sonar site prior to May 31 indicate that smolt probably began outmigrating prior to the deployment of the sonar equipment (J.D. Woolington, Alaska Department of Fish and Game, Dillingham, personal communication). Consequently, the total number of sonar counts and resulting smolt emigration estimate should be considered a minimum. The distribution of counts over the four arrays was 22.0% array I, 33.1% array II, 29.0% array III, and 15.9% array IV. This pattern was similar to that observed in past years (Table 32).

River velocity at the counting site ranged from 0.70 m/s to 1.2. m/s over the index (inshore) array. Velocity correction factors used for the remaining three arrays were calculated 11 times during the season (Table 33).

An estimated 28,246,633 sockeye salmon smolt migrated from the Wood River in 1990 based on sonar counts (Table 34). Age-1. smolt, 1987 brood year, composed 98.4% of the total. Mean weight of the age-1. smolt generally increased over the season, and the estimated number of smolt per sonar count decreased (Table 35).

Rogers (1988) found late season migrants from Wood River were typically larger than smolt sampled earlier in the season.

The total smolt production from the 1986 spawning escapement of 818,652 sockeye salmon was 53.02 smolt per spawner (Table 36). Production from the 1973-85 brood years has ranged from a low of 12.29 smolt per spawner for the 1980 brood year to a high of 111.83 smolt per spawner for the 1977 brood year. Average marine survival has been 7.1% for age-1. smolt for the 1973-85 brood years, and 6.5% for age-2. smolt for the 1972-84 brood years (Table 37).

Age, weight, and length data were collected from 2,411 sockeye salmon smolt in 1990 (Table 38). Mean weights of age-1. smolt were 8.4 g and age-2. smolt 10.2 g; mean lengths of age-1. smolt were 92 mm and age-2. smolt 101 mm. Mean length and weight of smolt in 1990 were larger than the 1951-1989 average (NSC;Table 39).

River and weather conditions were recorded at the counting site from June 1 to August 7 (Table 40). Mean water temperature during the season was 9.3 °C (range 4.0-17.0°C), similar (NSC) to the 1975-88 average of 8.1 °C (Table 41). From mid-July to the end of the project, low water in the river caused counting problems because large clumps of aquatic vegetation were churned up by passing boats and barges. These mats of vegetation floated back and forth with the tide and produced false counts. Therefore, the smolt counter was turned off from one to three hours whenever vegetation mats were observed or suspected.

The incidence of parasitism of Wood River sockeye salmon smolt by the cestode *Triaenophorus crassus* has been documented since 1948. Burgner (1962) recorded internal observations of the cestodes cysts from 1948 to 1958. In discussing the relationship between growth rate and survival of young sockeye salmon, Burgner (1962) suggested that parasitism might be a factor contributing to slow growth rates which might result in greater freshwater mortality. Burgner (1962) found the plerocercoid stage of the cestode *T. crassus* to be a common parasite of Wood River smolt, although its effect on survival was unknown. Beginning in 1961 (Nelson 1964) all smolts measured for length frequency and age studies have been examined externally for the presence or absence of *T. crassus* cysts, which appear as small bumps beneath the skin surface. Krasnowski (1976) compared the length frequency distributions for smolt showing external signs of *T. crassus* with those showing no signs; he concluded that *T. crassus* may not have a deleterious effect on sockeye salmon smolt growth. Interest in the annual incidence of *T. crassus* in smolts continued, and since 1978 its incidence has been determined for age-1. and -2. smolt (Clark and Robertson 1980). Woolington et al. (1990) reported that between 1978 and 1987 an average of 27.8% of age-1. smolt and 40.9 percent of age-2. smolt sampled at Wood River were infected with *T. crassus*.

Infection by *T. crassus* occurred in 39.6% of 2,362 age-1. smolt that were examined and in 40.8% of 49 age-2. smolt (Table 42). Table 43 compares the mean lengths and mean weights for age-1. and age-2. smolt that showed external signs of *T. crassus* and those that did not. The mean lengths and weights for smolt infected by *T. crassus* was similar to the smolt that were not infected; which supports Krasnowski's (1976) findings that *T. crassus* does not seem to adversely effect sockeye salmon smolt growth.

The average incidence of *T. crassus* in Wood River sockeye salmon smolt from 1978 to 1989 was 32.0% for age-1. smolt and 41.7% for age-2. smolt (Table 44).

A comparison of the percent age of *T. crassus* infected sockeye salmon smolt at Wood River by age with the percent age of marine survival -- e.g., adult returns per smolt times 100 -- for the 1975-1986 brood years did not show any relationship between smolt infected with *T. crassus* and their marine survival (Table 45, Figures 2 and 3).

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Table 1. Sonar counts recorded from three arrays at the sockeye salmon smolt counting site on Kvichak River, 1990.

Date [a]	Sonar Counts			
	Transducer Array			
	Inshore	Center	Offshore	Total
5/21	723	2,509	6,806	10,038
5/22	65,418	97,701	58,861	221,980
5/23	16,230	3,258	40,909	60,397
5/24 [b]	7,560	14,308	28,075	49,943
5/25 [b]	3,610	9,671	23,871	37,152
5/26	20,335	51,976	38,641	110,952
5/27 [b]	12,657	85,677	95,526	193,860
5/28 [b]	60,867	51,191	36,843	148,901
5/29	8,179	13,754	11,766	33,699
5/30 [b]	15,750	12,139	14,239	42,128
5/31	2,840	8,700	9,456	20,996
6/01 [b]	1,215	8,808	10,311	20,334
6/02	4,059	10,804	20,634	35,497
6/03	3,668	12,636	27,478	43,782
6/04 [b]	2,286	4,458	11,920	18,664
6/05	1,889	3,013	3,710	8,612
6/06 [b]	5,988	4,741	8,915	19,644
6/07	3,628	10,862	16,201	30,691
6/08	4,260	11,579	9,980	25,819
6/09	9,833	19,309	23,584	52,726
6/10	8,927	17,102	16,796	42,825
6/11	3,363	12,188	10,409	25,960
6/12	8,292	16,306	13,608	38,206
6/13	8,135	13,112	7,189	28,436
6/14 [b]	4,307	7,596	2,275	14,178
Total	284,019	503,398	548,003	1,335,420
Percent	21.3	37.7	41.0	

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

[b] Interpolated data for one or more arrays for the following hours and dates:
1800 hours on May 24
1200-1800 hours on May 25
1500 hours on May 27
1400 hours on May 28
1400-2000 hours on May 30
0800 hours on June 1
0100-0200 hours on June 4
0800 hours on June 6
1300 and 2100 hours on June 14

Table 2. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Kvichak River, 1990.

Date [a]	Age 1. Number	Age 1. Percent	Age 1. Cumulative Total	Age 2. Number	Age 2. Percent	Age 2. Cumulative Total	All Ages Daily Total	All Ages Cumulative Total
5/21	63,921	12.4	63,921	451,156	87.6	451,156	515,077	515,077
5/22	1,369,891	12.4	1,433,812	9,668,719	87.6	10,119,875	11,038,610	11,553,687
5/23	198,754	6.6	1,632,566	2,799,049	93.4	12,918,924	2,997,803	14,551,490
5/24	326,406	12.5	1,958,972	2,295,332	87.6	15,214,256	2,621,738	17,173,228
5/25	538,212	25.4	2,497,184	1,582,402	74.6	16,796,658	2,120,614	19,293,842
5/26	2,708,957	40.1	5,206,141	4,046,548	59.9	20,843,206	6,755,505	26,049,347
5/27	3,767,423	32.1	8,973,564	7,954,491	67.9	28,797,697	11,721,914	37,771,261
5/28	6,226,114	60.3	15,199,678	4,099,116	39.7	32,896,813	10,325,230	48,096,491
5/29	2,124,741	79.0	17,324,419	563,443	21.0	33,460,256	2,688,184	50,784,675
5/30	2,369,839	73.6	19,694,258	849,613	26.4	34,309,869	3,219,452	54,004,127
5/31	1,214,575	73.6	20,908,833	435,438	26.4	34,745,307	1,650,013	55,654,140
6/01	1,493,637	82.7	22,402,470	311,580	17.3	35,056,887	1,805,217	57,459,357
6/02	2,401,804	80.7	24,804,274	575,516	19.3	35,632,403	2,977,320	60,436,677
6/03	2,870,953	78.3	27,675,227	797,059	21.7	36,429,462	3,668,012	64,104,689
6/04	1,481,775	86.6	29,157,002	228,491	13.4	36,657,953	1,710,266	65,814,955
6/05	625,205	83.2	29,782,207	125,882	16.8	36,783,835	751,087	66,566,042
6/06	1,138,099	75.4	30,920,306	370,516	24.6	37,154,351	1,508,615	68,074,657
6/07	1,252,076	59.5	32,172,382	851,546	40.5	38,005,897	2,103,622	70,178,279
6/08	1,308,427	70.4	33,480,809	550,398	29.6	38,556,295	1,858,825	72,037,104
6/09	3,358,672	80.9	36,839,481	792,962	19.1	39,349,257	4,151,634	76,188,738
6/10	2,636,244	80.2	39,475,725	651,253	19.8	40,000,510	3,287,497	79,476,235
6/11	1,801,886	85.4	41,277,611	307,803	14.6	40,308,313	2,109,689	81,585,924
6/12	2,613,464	84.9	43,891,075	463,371	15.1	40,771,684	3,076,835	84,662,759
6/13	2,047,724	86.0	45,938,799	332,520	14.0	41,104,204	2,380,244	87,043,003
6/14	630,770	65.6	46,569,569	330,330	34.4	41,434,534	961,100	88,004,103
	46,569,569	52.9		41,434,534	47.1		88,004,103	

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

Table 3. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Kvichak River, 1990.

Date [a]	Mean Weight of Smolt (g)	Smolt per Count
5/21	10.6	7.8
5/22	10.6	7.8
5/23	11.5	7.2
5/24	10.8	7.7
5/25	10.1	8.2
5/26	9.1	9.2
5/27	9.4	8.9
5/28	7.8	10.7
5/29	6.9	12.0
5/30	7.1	11.7
5/31	7.1	11.7
6/01	6.4	13.0
6/02	6.7	12.3
6/03	6.8	12.2
6/04	6.2	13.4
6/05	6.3	13.2
6/06	7.1	11.7
6/07	8.2	10.2
6/08	7.6	10.9
6/09	7.0	11.9
6/10	7.0	11.9
6/11	6.7	12.3
6/12	6.7	12.4
6/13	6.3	13.2
6/14	7.7	10.8

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

Table 4. Sockeye salmon spawning escapement, total number of smolt produced by age class, percent of total smolt production composed by each age class, and number of smolt produced per spawner for 1956-1988 brood years, Kvichak River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced								Total	Per Spawner
		Age 1.	(%[a])	Age 2.	(%[a])	Age 3.	(%[a])				
		Estimates of smolt numbers based upon fyke net catches									
1956	9,443,318	3,267,274	(54)	2,777,960	(46)	0				6,045,234	0.64
1957	2,842,810	85,916	(13)	552,603	(87)	0				638,519	0.23
1958	534,785	61,400	(86)	10,126	(14)	0				71,526	0.13
1959	680,000	26,038	(27)	72,180	(73)	0				98,218	0.14
1960	14,630,000	1,130,820	(22)	4,116,093	(78)	0				5,246,913	0.36
1961	3,705,849	113,338	(7)	1,603,464	(93)	0				1,716,802	0.46
1962	2,580,884	458,122	(21)	1,748,178	(79)	0				2,206,300	0.86
1963	338,760	64,377	(73)	23,377	(27)	0				87,754	0.27
1964	957,120	252,384	(53)	222,528	(47)	0				474,912	0.50
1965	24,325,926	2,866,214	(34)	5,475,362	(66)	0				8,341,576	0.34
1966	3,775,184	648,321	(55)	541,017	(45)	0				1,189,338	0.32
1967	3,216,208	594,327	(67)	298,282	(33)	0				892,609	0.28
1968	2,557,440	185,356									
		Estimates of smolt numbers based upon sonar techniques									
1968				5,959,383		0				-	-
1969	8,394,204	85,723,430	(61)	54,159,340	(39)	0				139,882,770	16.66
1970	13,935,306	464,219	(<1)	191,842,930	(98)	2,918,768	(1)			195,225,917	14.01
1971	2,387,392	5,123,400	(19)	21,423,246	(81)	0				26,546,646	11.12
1972	1,009,962	2,740,610		-		-				-	-
1973	226,554	-		3,031,287		0				-	-
1974	4,433,844	108,356,892	(49)	114,269,848	(51)	0				222,626,740	50.21
1975	13,140,450	78,308,251	(27)	213,364,470	(73)	0				291,672,721	22.20
1976	1,965,282	32,226,544	(55)	26,423,348	(45)	0				58,649,892	29.84
1977	1,341,144	28,758,191	(73)	10,410,467	(27)	0				39,168,658	29.21
1978	4,149,288	182,442,540	(85)	32,294,536	(15)	0				214,737,076	51.75
1979	11,218,434	219,928,232	(71)	89,300,703	(29)	0				309,228,935	27.56
1980	17,505,268	150,421,026	(62)	76,244,773	(38)	0				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)					188,037,688	19.46[b]
1988	4,065,216	46,569,569									

[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 1952-1988 brood years, Kvichak River.

Brood Year	Total Spawning Escapement	Age 1. Number of Smolt	Age 1. Adult[a] Returns	Age 1. Adult Returns per Smolt	Age 2. Number of Smolt	Age 2. Adult[a] Returns	Age 2. Adult Returns per Smolt
		Estimates of smolt numbers based upon fyke net catches					
1952	-	-			241,870	3,610,258	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	-		
		Estimates of smolt numbers based upon sonar techniques					
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	8,353,688	0.08	114,269,848	17,797,272	0.16
1975	13,140,450	78,308,251	6,919,726	0.09	213,364,470	31,164,419	0.15
1976	1,965,282	32,226,544	6,132,602	0.19	26,423,348	4,431,287	0.17
1977	1,341,144	28,758,191	2,910,136	0.10	10,410,467	307,905	0.03
1978	4,149,288	182,442,540	2,989,871	0.02	32,294,536	2,169,833	0.07
1979	11,218,434	219,928,232	20,631,921	0.09	89,300,703	21,194,617	0.24
1980	22,505,268	150,421,026	4,536,972	0.03	76,244,773	8,527,417	0.11
1981	1,754,358	6,549,125	1,034,266	0.16	37,595,987	1,097,260	0.03
1982	1,134,840	51,893,988	991,104	0.02	1,937,408	662,863	0.34
1983	3,569,982	23,590,443	11,613,889	0.49	53,260,693	1,771,787	0.03
1984	10,490,670	83,470,460	4,476,802	0.05	331,384,545	19,490,377	0.06
1985	7,211,046	11,178,398	2,312,507	0.21	87,004,194	13,404,347	0.15[b]
1986	1,179,322	13,126,363	693,391	0.05[b]	6,830,717	0	0.00[b]
1987	6,065,880	146,603,154	3,530	0.00[b]	41,434,534	0	0.00[b]
1988	4,065,216	46,569,569					

[a] Includes return estimates 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, 1990.

	Age 1.					Age 2.				
Date [a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5/22	92	15.1	7.1	3.18	12	107	12.1	11.6	3.43	91
5/23	93	13.9	7.1	3.81	10	111	13.1	11.6	4.00	91
5/24	88	10.7	7.1	2.38	8	110	14.8	12.0	5.29	97
5/25	88	18.2	6.5	4.54	33	108	12.8	11.5	3.56	65
5/26	88	12.4	5.9	2.56	45	108	11.9	10.8	3.68	63
5/27	84	14.4	6.1	3.36	27	108	12.9	11.0	2.83	74
5/28	86	11.2	5.7	2.05	67	105	11.8	10.3	3.29	49
5/29	86	11.4	5.5	2.30	94	103	13.1	9.7	2.68	11
5/31	86	16.7	5.6	3.33	96	109	14.4	10.8	3.71	15
6/01	83	14.3	5.5	2.91	92	104	5.3	10.5	1.54	13
6/02	86	17.1	5.9	4.54	95	104	9.0	10.4	2.49	10
6/03	86	12.5	6.0	3.10	88	105	8.4	10.8	2.55	14
6/04	84	11.5	5.4	2.16	105					0
6/05	83	14.3	5.3	3.14	94	105	7.9	10.9	2.33	10
6/06	86	19.8	6.0	4.71	80	105	14.5	10.3	3.53	8
6/07	91	17.4	6.7	3.98	70	105	14.0	10.2	3.68	32
6/08	90	18.6	6.5	3.88	81	107	13.2	10.4	3.17	21
6/09	88	16.2	6.3	3.43	92	106	5.4	10.9	1.76	9
6/10	88	14.5	6.1	3.46	100	102	0.6	9.7	0.83	2
6/11	86	11.0	6.2	2.09	101					0
6/12	87	13.8	6.2	3.02	109	102	6.8	8.8	2.94	5
6/13	84	12.2	5.6	2.38	101	108	1.2	10.4	1.78	2
6/14	85	11.4	6.4	2.36	31	104	5.0	10.2	1.89	3
Totals					1,631					685
Means	87		6.1			105		10.5		

[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, 1955-1990.

Year of Migration	Age 1. Percent of Total Estimate	Age 1. Mean Length (mm)	Age 1. Mean Weight (g)	Age 2. Percent of Total Estimate	Age 2. Mean Length (mm)	Age 2. Mean Weight (g)	Age 3. Percent of Total Estimate	Age 3. Mean Length (mm)	Age 3. Mean Weight (g)	Total Estimate [a]	References
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. Percent of Total Estimate	Age 1. Mean Length (mm)	Age 1. Mean Weight (g)	Age 2. Percent of Total Estimate	Age 2. Mean Length (mm)	Age 2. Mean Weight (g)	Age 3. Percent of Total Estimate	Age 3. Mean Length (mm)	Age 3. Mean Weight (g)	Total Estimate [a]	References
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)
Mean		88	5.8		108	10.5		107	10.9		
1990	53	87	6.1	47	105	10.5	0	-	-	88,004,103	

[a] Estimates of smolt numbers for 1955-1970 based on fyke net catches; estimates of smolt numbers for 1971-1990 based on hydroacoustic techniques.

Table 8. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Kvichak River, 1990.

Date [b]	Estimated Age 1. [a] Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size	Estimated Age 2. [a] Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size
5/22	88	14.9	6.3	68	108	19.8	11.1	473
5/23	90	9.5	6.6	34	112	19.8	12.0	518
5/24	88	15.4	6.2	84	109	21.7	11.4	481
5/25	88	13.5	6.1	143	109	20.2	11.4	377
5/26	88	16.5	6.2	247	107	19.3	10.9	306
5/27	85	19.3	5.6	208	107	18.0	11.0	340
5/28	86	17.8	5.8	388	105	13.7	10.6	176
5/29	86	18.5	5.8	523	105	10.4	10.6	52
5/30	85	12.3	5.6	91	105	7.7	10.5	9
5/31	85	19.4	5.7	426	108	15.4	11.1	122
6/01	83	20.9	5.3	571	103	5.8	10.0	18
6/02	85	19.4	5.6	515	105	10.0	10.4	36
6/03	84	17.1	5.5	489	106	11.3	10.6	51
6/04	83	17.5	5.4	522	100	0.0	9.2	1
6/05	83	17.9	5.3	493	105	12.4	10.4	15
6/06	85	21.0	5.7	368	106	13.0	10.7	49
6/07	88	20.9	6.2	352	106	16.4	10.7	167
6/08	87	19.7	6.1	424	106	17.7	10.8	100
6/09	86	22.2	5.9	502	104	9.1	10.3	37
6/10	87	19.0	6.0	486	104	10.5	10.2	48
6/11	86	18.6	5.9	519	102	4.5	9.7	9
6/12	86	19.5	5.9	637	101	4.6	9.6	11
6/13	84	17.7	5.4	537	102	4.3	9.8	4
6/14	85	16.3	5.7	168	102	1.9	9.7	8
Totals				8,795				3,408
Means	86		5.8		105		10.5	

[a] Length-weight parameters by age group and discriminating length used to seperate ages for May 22 through June 14 were:

Age 1. $a = -10.06$ $b = 2.65$ $r^2 = 0.77$ $n = 1,632$
Age 2. $a = -8.45$ $b = 2.32$ $r^2 = 0.66$ $n = 685$

Discriminating Length = 98.57 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, 1990.

Date	Cloud Cover[a] 0800	Cloud Cover[a] 2000	Wind Velocity (km/h) 0800	Wind Velocity (km/h) 2000	Air Temp. (°C) 0800	Air Temp. (°C) 2000	Water Temp. (°C) 0800	Water Temp. (°C) 2000	Precipitation (mm)	Water Clarity[b]
5/22	3	4	0-08 SW	8-16 E	12.0	8.0	3.0	4.0	1.5	lt brown
5/23	4	3	0-08 E	0-08 E	7.0	8.0	4.0	4.0	trace	lt brown
5/24	3	3	8-24 E	8-24 E	7.0	11.5	4.0	5.0	0.0	lt brown
5/25	4	3	24-32 E	24-32 E	8.0	10.0	4.0	5.0	trace	murky
5/26	4	3	16-24 E	16-24 E	7.0	16.0	5.0	6.5	0.0	dk brown
5/27	4	3	0-08 E	8-16 E	11.5	9.0	6.0	5.5	0.0	murky
5/28	3	4	8-16 E	16 E	10.0	11.0	5.0	6.5	0.0	brown
5/29	3	2	8-16 E	16 E	9.5	11.0	6.0	6.5	0.0	brown
5/30	3	1	8-24 NE	48 NE	9.0	12.0	6.0	8.0	0.0	lt brown
5/31	1	1	8-24 NE	5-08 var	9.0	14.5	7.0	7.0	0.0	murky
6/01	1	1	0-08 SW	8-16 E	8.0	19.0	7.5	9.5	0.0	murky
6/02	2	1	0-08 NE	calm	10.5	19.0	8.5	9.5	0.0	murky
6/03	4	1	calm	0-08 SW	13.5	22.0	9.0	9.0	trace	murky
6/04	1	1	calm	0-08 SW	9.0	24.0	9.0	10.0	0.0	clear
6/05	5	1	8-16 SW	16-24 SW	11.0	20.0	9.0	9.5	0.0	lt brown
6/06	5	1	8-24 SW	8-24 SW	7.0	16.0	9.0	8.5	0.0	clear
6/07	4	1	8-24 SW	8-16 SW	5.0	14.5	8.5	7.5	0.0	clear
6/08	4	1	8-16 SW	0-08 SW	6.0	15.0	7.0	8.0	trace	clear
6/09	5	4	0-08 SW	calm	6.5	10.0	7.5	8.0	1.8	clear
6/10	3	3	8-16 E	8-16 E	9.0	10.5	7.5	8.0	0.8	clear
6/11	3	3	calm	8-16 W	9.5	10.0	8.0	9.0	0.0	clear
6/12	3	4	calm	calm	9.0	14.0	8.5	9.0	trace	clear
6/13	4	3	0-08 E	24-40 E	10.5	13.5	8.5	9.0	18.3	murky
6/14	4	3	0-08 SW	32-40 SW	9.5	12.0	9.0	9.0	3.8	murky
6/15	2		8-16 SW		9.0		9.0		-	murky

[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, 1963-1990.

Year	Sample Period	Water Temperature (°C) Minimum	Maximum	Mean	References
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)
	Mean	2.7	8.7	5.6	
1990	May 22 - Jun 15	3.5	9.5	7.3	

Table 11. Sonar counts recorded from three arrays at the sockeye salmon smolt counting site on Egegik River, 1990.

Date [a]	Sonar Counts: Transducer Array: Inshore	Center	Offshore	Total
5/19	98	468	454	1,020
5/20	41	230	271	542
5/21	669	600	28	1,297
5/22 [b]	18,463	170,283	85,074	273,820
5/23 [b]	66,616	459,338	170,775	696,729
5/24	66,165	470,188	397,469	933,822
5/25 [b]	114,706	881,609	545,687	1,542,002
5/26 [b]	89,507	209,077	164,630	463,214
5/27 [b]	21,700	56,778	44,705	123,183
5/28 [b]	35,968	150,029	63,703	249,700
5/29 [b]	13,450	129,601	31,194	174,245
5/30 [b]	3,319	42,483	11,143	56,945
5/31	6,223	61,206	15,257	82,686
6/01 [b]	15,840	46,240	11,047	73,127
6/02 [b]	14,045	37,110	7,865	59,020
6/03	1,434	14,616	8,729	24,779
6/04	1,749	13,472	5,787	21,008
6/05 [b]	1,635	2,314	2,006	5,955
6/06 [b]	1,519	8,804	6,144	16,467
6/07	337	957	1,018	2,312
6/08	362	518	488	1,368
6/09 [b]	6,714	34,296	3,575	44,585
6/10	6,656	4,948	1,750	13,354
6/11	675	1,871	844	3,390
Total	487,891	2,797,036	1,579,643	4,864,570
Percent	10.0	57.5	32.5	

[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:

1900 hours on May 22
0100-0700 hours on May 23
0400, 1000-1100, 1300, 1600-1700 hours on May 25
0900, 1000, 1200, 1400, 2000, 2300 hours on May 26.
0700, 0800, 1700, 1800, 2000-2300 hours on May 27.
0600-1700, 1900 hours on May 28.
1000-1700 hours on May 29.
0700-2300 hours on May 30.
1200-1400, 1700-1800 hours on June 1.
1500-1600 hours on June 2.
1500, 2200 hours on June 5.
1200, 1400-1500, 1700 hours on June 6.
1200, 1400-1700, 2000, 2200 hours on June 9.

Table 12. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Egegik River, 1990.

	Age 1.			Age 2.			All Ages	
Date [a]	Number	Percent	Cumulative Total	Number	Percent	Cumulative Total	Daily Total	Cumulative Total
5/19	82	0.8	82	10,692	99.2	10,692	10,774	10,774
5/20	43	0.8	125	5,585	99.2	16,277	5,628	16,402
5/21	127	0.8	252	16,408	99.2	32,685	16,535	32,937
5/22	22,034	0.8	22,286	2,839,581	99.2	2,872,266	2,861,615	2,894,552
5/23	56,359	0.8	78,645	7,263,073	99.2	10,135,339	7,319,432	10,213,984
5/24	309,388	3.1	388,033	9,834,492	96.9	19,969,831	10,143,880	20,357,864
5/25	887,416	5.1	1,275,449	16,478,860	94.9	36,448,691	17,366,276	37,724,140
5/26	224,438	4.2	1,499,887	5,081,437	95.8	41,530,128	5,305,875	43,030,015
5/27	187,296	11.4	1,687,183	1,457,097	88.6	42,987,225	1,644,393	44,674,408
5/28	377,522	11.4	2,064,705	2,936,983	88.6	45,924,208	3,314,505	47,988,913
5/29	342,715	14.3	2,407,420	2,053,896	85.7	47,978,104	2,396,611	50,385,524
5/30	119,293	15.4	2,526,713	655,841	84.6	48,633,945	775,134	51,160,658
5/31	172,466	15.4	2,699,179	948,172	84.6	49,582,117	1,120,638	52,281,296
6/01	191,610	18.2	2,890,789	860,040	81.8	50,442,157	1,051,650	53,332,946
6/02	234,397	27.7	3,125,186	611,803	72.3	51,053,960	846,200	54,179,146
6/03	97,149	29.9	3,222,335	228,091	70.1	51,282,051	325,240	54,504,386
6/04	110,618	37.9	3,332,953	181,019	62.1	51,463,070	291,637	54,796,023
6/05	34,241	37.9	3,367,194	56,033	62.1	51,519,103	90,274	54,886,297
6/06	86,683	37.9	3,453,877	141,852	62.1	51,660,955	228,535	55,114,832
6/07	11,382	34.9	3,465,259	21,260	65.1	51,682,215	32,642	55,147,474
6/08	7,181	34.9	3,472,440	13,413	65.1	51,695,628	20,594	55,168,068
6/09	227,735	34.9	3,700,175	425,363	65.1	52,120,991	653,098	55,821,166
6/10	78,211	34.9	3,778,386	146,083	65.1	52,267,074	224,294	56,045,460
6/11	17,353	34.9	3,795,739	32,413	65.1	52,299,487	49,766	56,095,226
	3,795,739	6.8		52,299,487	93.2		56,095,226	

[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, 1990.

Date [a]	Mean Weight of Smolt (g)	Smolt per Count
5/19	16.4	2.5
5/20	16.4	2.5
5/21	16.4	2.5
5/22	16.4	2.5
5/23	16.4	2.5
5/24	15.7	2.6
5/25	15.1	2.8
5/26	15.7	2.6
5/27	14.7	2.8
5/28	14.7	2.8
5/29	13.9	3.0
5/30	14.2	2.9
5/31	14.2	2.9
6/01	14.0	3.0
6/02	13.0	3.2
6/03	12.9	3.2
6/04	12.5	3.3
6/05	12.5	3.3
6/06	12.5	3.3
6/07	12.5	3.3
6/08	12.5	3.3
6/09	12.5	3.3
6/10	12.5	3.3
6/11	12.5	3.3

[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 1978-1988 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)		124,757,511	98.00[b]
1988	1,612,680	3,795,739				

[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 1978-1988 brood years, Egegik River.

		Age 1.			Age 2.			Age 3.		
Brood Year	Total Spawning Escapement	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt	Number of Smolt	Adult[a] Returns	Adult Returns per Smolt
1978	895,698	-	907,413		-	8,310,922		225,522	33,756	0.15
1979	1,032,042	-	1,246,161		14,287,075	4,737,895	0.33	0	0	0.00
1980	1,060,860	49,457,563	3,027,613	0.06	16,524,563	5,502,662	0.33	197,429	7,888	0.04
1981	694,680	2,242,326	1,532,938	0.68	32,235,734	4,875,574	0.15	52,852	16,104	0.30
1982	1,034,628	17,234,269	2,901,187	0.17	11,434,848	3,442,382	0.30	564	12,655	22.44
1983	792,282	54,585,828	4,507,190	0.08	29,984,140	6,016,215	0.20	85,087	36,905	0.43[b]
1984	1,165,320	14,016,441	1,572,383	0.11	45,386,536	11,341,791	0.25[b]	80,931	210,246	2.60[b]
1985	1,095,192	4,397,087	1,930,592	0.44[b]	12,758,135	4,294,556	0.34[b]	81,150	0	0.00[b]
1986	1,151,320	36,122,149	1,847,679	0.05[b]	27,347,612	10,211	0.00[b]	0	0	0.00[b]
1987	1,272,978	72,458,024	0	0.00[b]	52,299,487		0.00[b]			
1988	1,612,680	3,795,739								

[a] Includes return estimates 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, 1990.

	Age 1.					Age 2.				
Date [a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5/23					0	121	21.5	16.1	8.01	100
5/24	101	9.1	9.4	2.43	6	120	38.4	15.0	7.11	92
5/25	105	7.8	10.7	1.85	10	118	21.5	14.8	7.46	89
5/26	105	9.1	10.3	1.57	6	120	21.2	15.4	7.89	93
5/28	103	6.3	10.0	1.15	4	121	21.8	16.0	7.99	96
5/29	100	7.0	9.2	1.71	17	119	20.6	14.6	7.44	72
5/30	100	8.7	8.9	2.06	23	117	18.8	13.9	6.37	76
5/31	101	11.1	9.1	2.88	33	118	19.0	14.0	6.88	67
6/01	101	7.3	9.0	1.81	12	119	23.8	14.5	8.05	88
6/02	103	14.7	9.8	3.01	28	117	20.1	14.1	6.91	72
6/03	102	7.7	9.2	2.17	44	117	22.7	13.7	7.57	56
6/05	100	9.4	9.3	2.09	38	118	18.2	14.1	6.37	43
6/06	102	19.9	9.6	4.69	40	116	23.1	13.1	8.03	60
6/09	103	9.9	9.7	2.42	45	116	20.3	13.3	6.03	53
Totals					306					1,057
Means	102		9.6			118		14.5		

[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 the Egegik River, 1939-1990.

Year of Migration	Sample Dates	Sample Size	Age 1. Mean Length	Age 1. Mean Weight	Age 2. Mean Length	Age 2. Mean Weight	Age 3. Mean Length	Age 3. Mean Weight	References
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 (1986)
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)
Mean			103	9.9	118	14.9	132	21.0	
1990	May 19 - Jun 11	1,363	102	9.6	118	14.5	-	-	

[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, 1990.

Date [b]	Estimated Age 1. [a] Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size	Estimated Age 2. [a] Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size
5/23	101	3.1	9.3	5	125	27.8	16.5	534
5/24	98	33.9	9.0	17	124	30.7	16.1	545
5/25	102	6.0	9.6	28	121	32.5	15.3	521
5/26	102	5.0	9.6	25	123	30.2	16.0	515
5/28	102	10.4	9.5	82	120	31.9	15.0	461
5/29	102	9.1	9.4	80	118	31.6	14.4	402
5/30	101	7.7	9.4	55	119	28.4	14.6	199
5/31	102	8.6	9.5	61	121	34.7	15.4	541
6/01	101	11.6	9.4	130	120	32.2	14.9	426
6/02	102	10.8	9.5	179	117	30.9	13.9	362
6/03	101	11.0	9.4	173	117	32.4	14.1	351
6/06	101	11.1	9.3	146	117	25.6	13.9	166
6/09	102	8.8	9.5	131	114	23.4	13.1	178
Totals				1,112				5,201
Means	101		9.4		120		14.9	

[a] Length-weight parameters by age group and discriminating length used to separate ages for May 23 through June 9 were:

Age 1. $a = -7.8202$ $b = 2.1746$ $r^2 = 0.74$ $n = 306$
Age 2. $a = -9.5422$ $b = 2.5547$ $r^2 = 0.80$ $n = 957$

Discriminating Length = 106.46 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, 1990.

Date	Cloud Cover[a] 0800	Cloud Cover[a] 2000	Wind Velocity (km/h) 0800	Wind Velocity (km/h) 2000	Air Temp. (°C) 0800	Air Temp. (°C) 2000	Water Temp. (°C) 0800	Water Temp. (°C) 2000	Precipitation (mm)	Water Clarity[b]
5/20	5	4	08-16 SSW	24-32 W	9.0	3.0	3.0	4.0	trace	clear
5/21	3	4	16 W	8-16 WNW	4.0	4.0	2.5	3.5	trace	clear
5/22	3	4	32 SE	48-56 SE	8.0	5.0	3.0	4.0	trace	clear
5/23	3	4	16 SE	24-32 SE	5.5	8.0	3.0	5.0	3.8	clear
5/24	4	4	16-24 SE	32 SE	7.0	7.2	4.0	4.5	0.0	clear
5/25	3	3	24 SE	24-32 SE	7.0	8.0	3.5	4.5	trace	clear
5/26	3	3	8-24 SE	24-32 SE	9.0	8.0	3.5	5.0	trace	clear
5/27	3	4	8 SE	16-24 NE	9.0	9.4	4.0	5.0	trace	clear
5/28	3	3	0-08 NE	24-32 SE	8.0	9.2	4.0	5.0	trace	clear
5/29	4	3	0-08 NE	8-16 SE	8.0	11.7	4.5	6.5	2.0	clear
5/30	2	3	32 SE	32 SE	8.0	7.2	5.0	6.0	0.0	clear
5/31	3	2	0-08 SE	8-16 SE	8.0	11.1	4.5	6.5	0.0	clear
6/01	1	1	calm	16 S	15.5	12.8	4.0	8.0	0.0	clear
6/02	3	2	calm	24 N	8.0	15.5	4.5	8.0	0.0	clear
6/03	5	3	calm	0-08 NW	10.0	15.5	4.5	8.5	trace	clear
6/04	5	1	8 SW	0-08 NE	9.0	15.5	6.0	10.0	0.0	clear
6/05	5	3	0-08 W	16-24 SW	7.0	11.7	6.0	9.0	0.0	clear
6/06	5	4	16 SW	24 SW	5.5	11.5	5.0	9.0	trace	clear
6/07	5	4	8 W	16 W	4.5	8.9	5.0	7.0	0.8	clear
6/08	4	2	8 W	calm	4.5	10.0	5.0	7.0	0.0	clear
6/09	4	4	16 SE	32 SE	7.0	8.3	5.0	6.0	trace	clear
6/10	4	4	8-16 SE	0-08 SE	8.0	12.2	5.0	8.0	1.0	clear
6/11	4	3	calm	8-16 NW	9.0	12.8	5.0	8.5	0.0	clear

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

[b] Water clarity at 0800 hours

Table 20. Water temperatures at sockeye salmon smolt counting site, Egegik River, 1981-1990.

Year	Sample Period	Water Temperature (°C) Minimum	Maximum	Mean	Reference
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 (1986)
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)
	Mean	3.3	9.0	6.0	
1990	May 20 - Jun 11	2.5	10.0	5.4	

Table 21. Sonar counts recorded from two arrays at the sockeye salmon smolt counting site on Ugashik River, 1990.

Date [a]	Sonar Counts: Transducer Array: Inshore	Sonar Counts: Transducer Array: Offshore	Sonar Counts: Total
5/20 [b]	778	355	1,133
5/21	561	742	1,303
5/22 [c]	5,723	8,278	14,001
5/23 [c]	6,792	19,303	26,095
5/24 [c]	23,387	27,266	50,653
5/25 [c]	34,796	217,397	252,193
5/26	63,269	285,705	348,974
5/27 [c]	26,106	98,435	124,541
5/28	59,979	400,836	460,815
5/29	789,919	1,040,661	1,830,580
5/30 [c]	251,958	740,471	992,429
5/31 [c]	29,892	639,166	669,058
6/01	115,843	806,712	922,555
6/02	78,559	60,479	139,038
6/03 [c]	52,719	59,473	112,192
6/04	39,489	24,930	64,419
6/05 [c]	79,464	33,286	112,750
6/06 [c]	54,366	21,015	75,381
6/07 [c]	124,394	26,673	151,067
6/08	42,218	13,084	55,302
6/09 [c]	18,611	86,340	104,951
6/10	146,953	226,848	373,801
6/11	10,455	11,876	22,331
6/12	11,839	8,877	20,716
6/13	55,773	41,265	97,038
Total	2,123,843	4,899,473	7,023,316
Percent	30.2	69.8	

[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 0400 hours on May 20th. Therefore, all inshore array counts from May 20 through the end of the season 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:
2300-2400 hours on May 22
0100-0800 hours on May 23
1500-1700, 1900-2100 hours on May 24
1000 hours on May 25
1200-2200 hours on May 27
0600-2400 hours on May 30
0100-0600, 0800-1700 hours on May 31
1200-1400 hours on June 3
1800-2400 hours on June 5
0100-0800, 1200-1400, 1600-1800, 2000-2100, 2400 hours on June 6
0100-0800 hours on June 7
1200-2200 hours on June 9

Table 22. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Ugashik River, 1990.

Date [a]	Age 1. Number	Age 1. Percent	Age 1. Cumulative Total	Age 2. Number	Age 2. Percent	Age 2. Cumulative Total	All Ages Daily Total	All Ages Cumulative Total
5/20	613	7.8	613	7,262	92.2	7,262	7,875	7,875
5/21	636	7.8	1,249	7,530	92.2	14,792	8,166	16,041
5/22	6,993	7.8	8,242	82,777	92.2	97,569	89,770	105,811
5/23	11,872	7.8	20,114	140,539	92.2	238,108	152,411	258,222
5/24	21,129	6.5	41,243	303,934	93.5	542,042	325,063	583,285
5/25	90,329	6.5	131,572	1,299,361	93.5	1,841,403	1,389,690	1,972,975
5/26	190,304	8.7	321,876	2,004,667	91.3	3,846,070	2,194,971	4,167,946
5/27	37,234	4.7	359,110	749,967	95.3	4,596,037	787,201	4,955,147
5/28	132,783	4.7	491,893	2,674,488	95.3	7,270,525	2,807,271	7,762,418
5/29	1,932,816	14.4	2,424,709	11,526,907	85.6	18,797,432	13,459,723	21,222,141
5/30	1,169,799	16.3	3,594,508	6,020,120	83.7	24,817,552	7,189,919	28,412,060
5/31	713,997	16.3	4,308,505	3,674,434	83.7	28,491,986	4,388,431	32,800,491
6/01	2,516,623	35.4	6,825,128	4,588,468	64.6	33,080,454	7,105,091	39,905,582
6/02	456,120	35.4	7,281,248	831,628	64.6	33,912,082	1,287,748	41,193,330
6/03	580,048	52.7	7,861,296	521,239	47.3	34,433,321	1,101,287	42,294,617
6/04	314,821	48.6	8,176,117	332,426	51.4	34,765,747	647,247	42,941,864
6/05	570,893	48.6	8,747,010	602,818	51.4	35,368,565	1,173,711	44,115,575
6/06	383,458	48.6	9,130,468	404,902	51.4	35,773,467	788,360	44,903,935
6/07	795,604	48.6	9,926,072	840,095	51.4	36,613,562	1,635,699	46,539,634
6/08	453,794	67.9	10,379,866	215,025	32.1	36,828,587	668,819	47,208,453
6/09	686,235	67.9	11,066,101	325,165	32.1	37,153,752	1,011,400	48,219,853
6/10	2,801,208	71.1	13,867,309	1,140,269	28.9	38,294,021	3,941,477	52,161,330
6/11	148,410	66.2	14,015,719	75,740	33.8	38,369,761	224,150	52,385,480
6/12	143,882	66.2	14,159,601	73,429	33.8	38,443,190	217,311	52,602,791
6/13	678,359	66.2	14,837,960	346,197	33.8	38,789,387	1,024,556	53,627,347
	14,837,960	27.7		38,789,387	72.3		53,627,347	

[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, 1990.

Date [a]	Mean Weight of Smolt (g)	Smolt per Count
5/20	13.8	3.0
5/21	13.8	3.0
5/22	13.8	3.0
5/23	13.8	3.0
5/24	13.8	3.0
5/25	13.8	3.0
5/26	12.3	3.4
5/27	12.5	3.3
5/28	12.5	3.3
5/29	11.8	3.5
5/30	11.1	3.7
5/31	11.1	3.7
6/01	9.8	4.2
6/02	9.8	4.2
6/03	8.9	4.7
6/04	9.2	4.5
6/05	9.2	4.5
6/06	9.2	4.5
6/07	9.2	4.5
6/08	8.0	5.2
6/09	8.0	5.2
6/10	8.0	5.2
6/11	8.7	4.8
6/12	8.7	4.8
6/13	8.7	4.8

[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 1979-1988 brood years, Ugashik River.

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

[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 1979-1988 brood years, Ugashik River.

Brood Year	Total Spawning Escapement	Age 1. Number of Smolt	Age 1. Adult[a] Returns	Age 1. Adult Returns per Smolt	Age 2. Number of Smolt	Age 2. Adult[a] Returns	Age 2. Adult Returns per Smolt	Age 3. Number of Smolt	Age 3. Adult[a] Returns	Age 3. Adult Returns per Smolt
1979	1,700,904	-	3,963,182		-	2,004,153		0	0	
1980	3,321,384	-	3,463,594		12,736,379	4,193,843	0.33	26,384	2,627	0.10
1981	1,326,762	31,297,432	4,171,203	0.13	82,656,993	3,173,571	0.04	0	1,679	0.00
1982	1,157,526	75,491,249	1,132,268	0.02	21,407,762	1,338,487	0.06	0	0	0.00
1983	1,000,614	12,693,628	987,416	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	1,221,160	0.22[b]	33,238,739	969,828	0.03[b]	0	0	0.00[b]
1986	1,001,493	182,719,678	502,225	0.00[b]	32,278,743	745	0.00[b]	0	0	0.00[b]
1987	668,964	94,019,379	493	0.00[b]	38,789,387					
1988	642,972	14,837,960								

[a] Includes return estimates 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, 1990.

	Age 1.					Age 2.				
Date [a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
5/22	102	0.0	9.6	0.00	1	117	4.9	13.9	1.96	6
5/23	95	26.2	7.6	5.54	6	119	14.2	15.0	5.80	94
5/24	96	10.8	8.7	2.69	17	113	10.5	13.2	4.01	31
5/25	94	13.4	7.5	2.99	4	116	15.9	13.9	5.57	96
5/26	95	8.3	8.4	2.15	14	109	16.2	12.7	5.98	86
5/28	101	0.6	10.1	0.71	2	110	18.9	12.5	5.71	98
5/29	90	19.1	7.2	4.45	24	108	15.5	11.7	4.88	76
5/31	93	15.3	8.4	3.20	14	107	13.8	11.9	4.34	86
6/01	93	13.1	7.6	2.76	14	108	13.6	11.2	4.00	36
6/02	90	15.5	6.9	3.39	46	106	14.2	10.5	3.73	53
6/03	88	20.9	6.8	5.45	45	104	9.9	10.9	3.30	55
6/06	90	12.6	7.3	3.47	32	104	10.2	10.7	2.76	18
6/07	88	15.1	6.3	3.38	60	108	20.0	11.8	7.92	34
6/08	87	10.8	6.0	2.62	76	107	16.7	11.6	6.10	24
6/09	89	13.6	6.4	3.27	75	104	11.0	10.6	4.18	25
6/10	89	15.0	6.0	3.55	75	109	23.6	11.5	8.48	25
6/11	87	8.2	5.9	1.70	26	110	12.6	11.9	4.80	4
6/13	86	4.3	6.2	1.04	18	102	10.7	9.4	2.20	2
Totals					549					849
Means	92		7.4			109		11.9		

[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 the Ugashik River, 1958-1990.

Year of Migration	Sample Dates	Sample Size	Age 1. Mean Length	Age 1. Mean Weight	Age 2. Mean Length	Age 2. Mean Weight	Age 3. Mean Length	Age 3. Mean Weight	References
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 (1986)
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)
Mean			91	6.7	113	12.1	128	17.9	
1990	May 23 - Jun 16	1,398	92	7.4	109	11.9	-	-	

Table 28. Mean fork length and estimated mean weight for age-1. and -2. sockeye salmon smolt, Ugashik River, 1990.

Date [b]	Estimated Age 1. [a] Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size	Estimated Age 2. [a] Mean Length (mm)	Std. Error	Estimated Weight (g)	Sample Size
5/23	91	14.9	7.1	38	116	27.3	14.3	504
5/24	93	6.3	7.3	14	112	11.5	12.8	39
5/25	94	4.3	7.6	3	117	28.7	14.4	509
5/26	93	11.1	7.5	37	110	27.6	12.4	519
5/28	94	8.4	7.5	17	110	24.9	12.5	491
5/29	88	21.7	6.5	92	110	28.2	12.3	507
5/31	90	19.4	6.7	105	107	24.6	11.4	494
6/01	92	14.5	7.2	80	106	19.2	11.2	265
6/02	90	19.2	6.7	252	105	19.2	10.9	308
6/03	88	21.7	6.2	381	105	18.5	10.8	253
6/04	94	5.1	7.7	14	107	14.1	11.4	90
6/06	90	16.2	6.7	109	105	13.5	10.8	82
6/07	88	21.2	6.2	280	106	22.6	11.1	221
6/08	87	14.2	6.1	183	105	16.0	10.9	98
6/09	88	17.5	6.2	492	105	17.5	10.8	142
6/10	88	18.1	6.2	496	106	20.4	11.1	117
6/11	86	11.6	5.9	61	109	16.2	12.3	8
6/13	86	9.3	5.9	91	103	1.8	10.3	2
Totals				2,745				4,649
Means	90		6.7		108		11.8	

[a] Length-weight parameters by age group and discriminating length used to seperate ages for May 23 through June 13 were:

Age 1. $a = -11.58$ $b = 2.99$ $r^2 = 0.85$ $n = 572$
Age 2. $a = -9.96$ $b = 2.65$ $r^2 = 0.85$ $n = 856$

Discriminating Length = 98.53 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, 1990.

Date	Cloud Cover[a] 0800	Cloud Cover[a] 2000	Wind Velocity (km/h) 0800	Wind Velocity (km/h) 2000	Air Temp. (°C) 0800	Air Temp. (°C) 2000	Water Temp. (°C) 0800	Water Temp. (°C) 2000	Percipitation (mm)	Water Clarity[b]
5/21	4	2	24 SW	16 SW	1.0	2.0	3.0	3.0	trace	clear
5/22	4	4	32 NE	40-48 SE	3.5	4.0	4.0	4.0	0.8	clear
5/23	4	4	24 SE	32 SE	5.0	5.5	5.0	5.0	0.0	clear
5/24	3	4	24 SE	24-32 SE	5.0	9.0	5.0	6.0	0.0	lt. brown
5/25	4	4	24 SE	24 SE	7.0	6.0	6.0	6.5	0.0	clear
5/26	4	4	32 SE	16-24 SE	5.0	10.0	6.0	6.0	0.0	lt. brown
5/27	4	4	24 SE	32 E	6.0	10.0	5.5	7.5	0.3	lt. brown
5/28	4	4	calm	8 E	7.0	12.0	6.0	6.5	0.3	lt. brown
5/29	4	4	calm	calm	6.0	12.0	7.0	-	1.0	lt. brown
5/30	3	4	40 SE	48 SE	5.0	8.0	7.0	6.5	2.5	lt. brown
5/31	4	3	16 SE	13 SE	6.0	6.0	6.0	6.0	1.0	lt. brown
6/01	1	2	calm	16-24 SE	7.0	13.0	5.0	7.5	0.0	clear
6/02	2	2	calm	3 SE	9.0	10.0	7.0	7.5	0.0	clear
6/03	3	3	16 SE	16 W	7.0	20.0	7.0	6.5	0.0	clear
6/04	5	1	8 SE	2-08 W	6.0	19.0	5.0	5.5	0.0	clear
6/05	5	1	8-16 SW	24 SW	4.0	19.0	5.0	6.0	0.0	clear
6/06	4	4	8-16 W	8-16 W	4.0	13.0	4.5	6.0	1.3	clear
6/07	4	4	16 SW	8 W	3.0	10.0	4.5	4.5	1.3	clear
6/08	4	2	0-08 SW	0-08 SW	2.5	9.5	4.0	5.0	0.0	clear
6/09	5	3	calm	40 SE	3.0	11.0	4.5	7.0	0.0	clear
6/10	4	4	0-08 SE	16 SE	7.0	10.0	6.0	7.0	1.3	lt. brown
6/11	4	3	3 var.	calm	6.0	11.0	7.0	7.5	0.0	clear
6/12	5	4	calm	16 SE	7.0	14.0	6.0	7.0	0.0	clear
6/13	4	4	16-24 E	24-32 SE	7.0	13.0	7.0	8.0	10.2	lt. brown
6/14	4		40-48 W		5.0	12.0	7.0		11.7	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, 1983-1990.

Year	Sample Period	Water Temperature (°C) Minimum	Maximum	Mean	Reference
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 (1986)
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)
	Mean	3.2	8.4	6.0	
1990	May 21 - Jun 14	3.0	8.0	5.9	

Table 31. Sonar counts recorded from four arrays at the sockeye salmon smolt counting site on the Wood River, 1990.

Date [a]	Sonar Counts: Transducer Arrays I	II	III	IV	Total
5/31	659	720	741	833	2,953
6/01	1,090	1,508	446	324	3,368
6/02 [b]	892	642	581	519	2,634
6/03 [b]	4,908	2,739	4,533	3,226	15,406
6/04	7,280	6,049	2,821	1,548	17,698
6/05	5,053	10,285	1,179	1,645	18,162
6/06	2,126	3,762	1,634	1,006	8,528
6/07	8,180	3,430	1,853	1,546	15,009
6/08	7,892	2,916	1,896	1,186	13,890
6/09	891	1,398	967	414	3,670
6/10	490	1,727	814	173	3,204
6/11	1,953	4,687	2,339	527	9,506
6/12	1,210	5,015	5,933	2,451	14,609
6/13	581	1,766	4,027	3,306	9,680
6/14	1,154	2,686	5,430	929	10,199
6/15	989	3,409	3,566	605	8,569
6/16	883	7,688	2,394	792	11,757
6/17	854	337	3,910	1,180	6,281
6/18	840	2,968	3,020	1,590	8,418
6/19	4,031	11,265	8,814	1,076	25,186
6/20	2,137	7,326	9,312	2,728	21,503
6/21	2,545	3,382	3,286	1,851	11,064
6/22	1,660	3,797	2,977	1,146	9,580
6/23	2,427	7,028	2,791	1,988	14,234
6/24	1,583	2,561	1,472	2,215	7,831
6/25	1,417	7,344	4,035	1,187	13,983
6/26	1,247	5,431	3,335	4,577	14,590
6/27	3,552	17,222	2,615	3,597	26,986
6/28	6,117	17,520	5,981	2,426	32,044
6/29	2,343	8,821	3,332	1,688	16,184
6/30	647	4,391	2,269	1,691	8,998
7/01 [b]	954	2,766	2,137	598	6,455
7/02 [b]	814	2,614	1,642	1,566	6,636
7/03	3,032	2,944	3,197	2,481	11,654
7/04	2,477	2,253	3,508	3,855	12,093
7/05	909	1,781	1,150	2,230	6,070
7/06	6,032	4,349	5,252	3,431	19,064
7/07	1,718	6,447	4,961	2,425	15,551
7/08	2,634	5,822	6,930	2,520	17,906
7/09	4,342	9,071	7,561	5,702	26,676
7/10	9,327	8,556	5,952	3,612	27,447
7/11	3,901	2,821	2,578	1,506	10,806
7/12	2,980	3,183	5,221	1,778	13,162
7/13	3,908	3,589	4,345	4,027	15,869
7/14	6,322	8,750	9,777	1,378	26,227

-Continued-

Table 31. (p. 2 of 2)

Date [a]	Sonar Counts				
	Transducer Arrays				
	I	II	III	IV	Total
7/15	7,363	3,946	5,154	2,688	19,151
7/16	7,052	1,278	2,398	2,273	13,001
7/17	3,478	5,558	9,680	4,805	23,521
7/18	4,003	3,947	4,152	2,362	14,464
7/19	4,774	6,118	6,060	4,305	21,257
7/20	2,976	3,827	3,906	4,361	15,070
7/21	1,405	1,059	1,800	1,890	6,154
7/22	2,923	2,193	5,151	2,974	13,241
7/23	2,250	2,094	1,673	697	6,714
7/24	2,425	3,615	2,510	2,765	11,315
7/25	2,078	1,472	872	1,545	5,967
7/26	1,707	1,874	2,121	1,687	7,389
7/27	1,981	2,089	7,215	5,638	16,923
7/28	1,416	1,587	2,555	983	6,541
7/29	2,708	2,653	1,927	1,323	8,611
7/30	2,196	2,151	2,349	1,279	7,975
7/31	2,008	2,988	2,574	1,966	9,536
8/01	2,695	6,500	5,943	3,530	18,668
8/02	5,163	8,804	18,615	4,980	37,562
8/03	5,232	5,943	4,331	2,146	17,652
8/04	5,965	4,504	5,273	2,718	18,460
8/05	3,332	5,099	7,316	3,160	18,907
8/06	3,043	3,591	3,636	1,284	11,554
Total	205,154	307,656	269,725	148,438	930,973
Percent	22.0	33.1	29.0	15.9	

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

[b] Interpolated data: 1200-2400 hours on June 2, Array IV only
0001-1159 hours on June 3, Array IV only
0500-1159 hours on July 1, All Arrays
1200-2300 hours on July 2, All Arrays

Table 32. Percentage of total unexpanded sonar counts recorded over each array, Wood River, 1975-1990.

	Percentage of Sonar Counts				
	Transducer Array				
Year	I	II	III	IV	References
1975[a]	68.6	31.4	-	-	Krasnowski (1976)
1976	49.0	30.2	11.7	9.1	Krasnowski (1977)
1977	36.0	24.4	20.8	18.8	Newcome (1978)
1978	28.6	29.7	25.6	16.1	Clark and Robertson (1980)
1979	17.0	27.1	33.1	22.8	Bucher (1980)
1980	34.1	35.2	20.5	10.2	Bucher (1981)
1981	39.2	24.8	24.9	11.1	Bucher (1982)
1982	38.2	31.3	15.9	14.6	Bucher (1984)
1983	31.6	29.9	23.5	15.0	Bucher (1987)
1984	23.9	36.7	22.2	17.2	Bucher (1986a)
1985	34.2	36.3	18.5	11.0	Bucher (1986b)
1986	34.2	36.3	18.5	11.0	Bue et al. (1988)
1987	30.9	32.3	20.8	16.0	Cross et al. (1990)
1988	18.0	35.1	26.5	20.5	Woolington et al. (1990)
1989	23.3	29.0	23.0	24.7	Woolington et al. (1991)
Mean[b]	31.3	31.3	21.8	15.6	
1990	22.0	33.1	29.0	15.9	

[a] Only two transducer arrays used.

[b] Data from 1975 omitted.

Table 33. Velocity correction factors used at Wood River, 1990.

Date	Velocity Correction Factor [a]			
	Array I[b]	Array II	Array III	Array IV
Jun 11 - Jun 15	1.00	1.16	1.16	1.25
Jun 16 - Jun 20	1.00	0.97	0.99	1.11
Jun 21 - Jun 25	1.00	1.16	1.16	1.01
Jun 26 - Jun 30	1.00	1.33	1.28	1.24
Jul 01 - Jul 05	1.00	1.21	1.21	1.19
Jul 06 - Jul 09	1.00	1.59	1.50	1.45
Jul 10 - Jul 14	1.00	1.09	1.00	1.21
Jul 15 - Jul 19	1.00	1.08	0.96	1.15
Jul 20 - Jul 24	1.00	1.07	0.99	0.99
Jul 25 - Jul 29	1.00	1.14	1.17	1.18
Jul 30 - Aug 06	1.00	1.13	1.16	1.19

[a] $\text{Velocity Correction Factor} = \frac{\text{Desired Array Water Velocity (fps)}}{\text{Index Array Water Velocity (fps)}}$

[b] Array I (Inshore) = Index Array

Table 34. Daily number of sockeye salmon smolt emigrating seaward estimated with hydroacoustic equipment, Wood River, 1990.

Date [a]	Age 1. Number	Age 1. Percent	Age 1. Cumulative Total	Age 2. Number	Age 2. Percent	Age 2. Cumulative Total	All Ages Daily Total	All Ages Cumulative Total
5/31	117,126	98.3	117,126	2,013	1.7	2,013	119,139	119,139
6/01	108,154	98.3	225,280	1,859	1.7	3,872	110,013	229,152
6/02	93,564	98.3	318,844	1,608	1.7	5,480	95,172	324,324
6/03	565,928	98.3	884,772	9,728	1.7	15,208	575,656	899,980
6/04	548,608	98.3	1,433,380	9,430	1.7	24,638	558,038	1,458,018
6/05	586,855	98.3	2,020,235	10,088	1.7	34,726	596,943	2,054,961
6/06	295,140	98.3	2,315,375	5,073	1.7	39,799	300,213	2,355,174
6/07	440,512	98.3	2,755,887	7,572	1.7	47,371	448,084	2,803,258
6/08	398,531	98.3	3,154,418	6,850	1.7	54,221	405,381	3,208,639
6/09	144,459	98.4	3,298,877	2,304	1.6	56,525	146,763	3,355,402
6/10	124,857	98.4	3,423,734	1,991	1.6	58,516	126,848	3,482,250
6/11	364,689	98.4	3,788,423	5,816	1.6	64,332	370,505	3,852,755
6/12	664,887	98.4	4,453,310	10,605	1.6	74,937	675,492	4,528,247
6/13	462,408	97.6	4,915,718	11,564	2.4	86,501	473,972	5,002,219
6/14	415,525	97.6	5,331,243	10,392	2.4	96,893	425,917	5,428,136
6/15	335,905	97.6	5,667,148	8,401	2.4	105,294	344,306	5,772,442
6/16	382,893	97.6	6,050,041	9,576	2.4	114,870	392,469	6,164,911
6/17	241,953	97.6	6,291,994	6,051	2.4	120,921	248,004	6,412,915
6/18	311,847	97.6	6,603,841	7,799	2.4	128,720	319,646	6,732,561
6/19	807,697	97.6	7,411,538	20,200	2.4	148,920	827,897	7,560,458
6/20	343,440	99.7	7,754,978	1,137	0.3	150,057	344,577	7,905,035
6/21	367,394	99.7	8,122,372	1,216	0.3	151,273	368,610	8,273,645
6/22	319,485	99.7	8,441,857	1,057	0.3	152,330	320,542	8,594,187
6/23	468,918	99.7	8,910,775	1,552	0.3	153,882	470,470	9,064,657
6/24	271,374	99.7	9,182,149	898	0.3	154,780	272,272	9,336,929
6/25	472,118	99.7	9,654,267	1,563	0.3	156,343	473,681	9,810,610
6/26	626,058	99.7	10,280,325	2,072	0.3	158,415	628,130	10,438,740
6/27	871,881	94.0	11,152,206	55,454	6.0	213,869	927,335	11,366,075
6/28	990,392	94.0	12,142,598	62,992	6.0	276,861	1,053,384	12,419,459
6/29	565,827	99.7	12,708,425	1,588	0.3	278,449	567,415	12,986,874
6/30	344,604	99.7	13,053,029	967	0.3	279,416	345,571	13,332,445
7/01	216,135	99.7	13,269,164	606	0.3	280,022	216,741	13,549,186
7/02	219,699	100.0	13,488,863	0	0.0	280,022	219,699	13,768,885
7/03	364,928	100.0	13,853,791	0	0.0	280,022	364,928	14,133,813
7/04	413,650	100.0	14,267,441	0	0.0	280,022	413,650	14,547,463
7/05	213,811	100.0	14,481,252	0	0.0	280,022	213,811	14,761,274
7/06	651,834	97.1	15,133,086	19,398	2.9	299,420	671,232	15,432,506
7/07	597,033	97.1	15,730,119	17,767	2.9	317,187	614,800	16,047,306
7/08	676,313	97.1	16,406,432	20,127	2.9	337,314	696,440	16,743,746
7/09	1,022,794	97.1	17,429,226	30,438	2.9	367,752	1,053,232	17,796,978
7/10	630,410	97.1	18,059,636	18,761	2.9	386,513	649,171	18,446,149
7/11	247,344	97.1	18,306,980	7,360	2.9	393,873	254,704	18,700,853
7/12	326,048	97.1	18,633,028	9,703	2.9	403,576	335,751	19,036,604
7/13	400,804	97.1	19,033,832	11,927	2.9	415,503	412,731	19,449,335
7/14	627,582	97.1	19,661,414	18,676	2.9	434,179	646,258	20,095,593
7/15	397,464	99.5	20,058,878	1,836	0.5	436,015	399,300	20,494,893
7/16	258,178	99.5	20,317,056	1,193	0.5	437,208	259,371	20,754,264
7/17	571,988	99.5	20,889,044	2,643	0.5	439,851	574,631	21,328,895
7/18	321,975	99.5	21,211,019	1,487	0.5	441,338	323,462	21,652,357
7/19	498,227	99.5	21,709,246	2,302	0.5	443,640	500,529	22,152,886
7/20	356,900	99.5	22,066,146	1,649	0.5	445,289	358,549	22,511,435

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Table 34. (p. 2 of 2)

Date [a]	Age 1. Number	Age 1. Percent	Age 1. Cumulative Total	Age 2. Number	Age 2. Percent	Age 2. Cumulative Total	All Ages Daily Total	All Ages Cumulative Total
7/21	146,273	99.5	22,212,419	675	0.5	445,964	146,948	22,658,383
7/22	306,021	99.5	22,518,440	1,414	0.5	447,378	307,435	22,965,818
7/23	135,677	99.5	22,654,117	627	0.5	448,005	136,304	23,102,122
7/24	258,717	99.5	22,912,834	1,195	0.5	449,200	259,912	23,362,034
7/25	145,778	99.5	23,058,612	673	0.5	449,873	146,451	23,508,485
7/26	191,386	99.5	23,249,998	884	0.5	450,757	192,270	23,700,755
7/27	501,778	99.5	23,751,776	2,318	0.5	453,075	504,096	24,204,851
7/28	166,107	100.0	23,917,883	0	0.0	453,075	166,107	24,370,958
7/29	201,608	100.0	24,119,491	0	0.0	453,075	201,608	24,572,566
7/30	192,654	100.0	24,312,145	0	0.0	453,075	192,654	24,765,220
7/31	242,782	100.0	24,554,927	0	0.0	453,075	242,782	25,008,002
8/01	486,155	100.0	25,041,082	0	0.0	453,075	486,155	25,494,157
8/02	982,762	100.0	26,023,844	0	0.0	453,075	982,762	26,476,919
8/03	404,543	100.0	26,428,387	0	0.0	453,075	404,543	26,881,462
8/04	485,497	100.0	26,913,884	0	0.0	453,075	485,497	27,366,959
8/05	566,303	100.0	27,480,187	0	0.0	453,075	566,303	27,933,262
8/06	313,371	100.0	27,793,558	0	0.0	453,075	313,371	28,246,633
	27,793,558	98.4		453,075	1.6		28,246,633	

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

Table 35. Adjustment factors used to expand sonar counts into estimated numbers of sockeye salmon smolt, Wood River, 1990.

Date [a]	Mean Weight of Smolt (g)	Smolt per Count	Date [a]	Mean Weight of Smolt (g)	Smolt per Count
5/31	6.3	6.6	7/04	8.3	5.0
6/01	6.3	6.6	7/05	8.3	5.0
6/02	6.3	6.6	7/06	8.6	4.9
6/03	6.3	6.6	7/07	8.6	4.9
6/04	6.3	6.6	7/08	8.6	4.9
6/05	6.3	6.6	7/09	8.6	4.9
6/06	6.3	6.6	7/10	8.6	4.9
6/07	6.3	6.6	7/11	8.6	4.9
6/08	6.3	6.6	7/12	8.6	4.9
6/09	5.6	7.4	7/13	8.6	4.9
6/10	5.6	7.4	7/14	8.6	4.9
6/11	5.6	7.4	7/15	10.2	4.1
6/12	5.6	7.4	7/16	10.2	4.1
6/13	6.0	6.9	7/17	10.2	4.1
6/14	6.0	6.9	7/18	10.2	4.1
6/15	6.0	6.9	7/19	10.2	4.1
6/16	6.0	6.9	7/20	10.2	4.1
6/17	6.0	6.9	7/21	10.2	4.1
6/18	6.0	6.9	7/22	10.2	4.1
6/19	6.0	6.9	7/23	10.2	4.1
6/20	7.0	5.9	7/24	10.2	4.1
6/21	7.0	5.9	7/25	10.2	4.1
6/22	7.0	5.9	7/26	10.2	4.1
6/23	7.0	5.9	7/27	10.2	4.1
6/24	7.0	5.9	7/28	10.2	4.1
6/25	7.0	5.9	7/29	10.2	4.1
6/26	7.0	5.9	7/30	10.2	4.1
6/27	7.6	5.4	7/31	10.2	4.1
6/28	7.6	5.4	8/01	10.2	4.1
6/29	7.5	5.5	8/02	10.2	4.1
6/30	7.5	5.5	8/03	10.2	4.1
7/01	7.5	5.5	8/04	8.8	4.7
7/02	8.3	5.0	8/05	8.8	4.7
7/03	8.3	5.0	8/06	8.8	4.7

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

Table 36. Sockeye salmon spawning escapements, 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 1972-1988 brood years, Wood River.

Brood Year	Total Spawning Escapement	Number of Smolt Produced				
		Age 1. (%)[a]	Age 2. (%)[a]	Age 3.	Total	Per Spawner
1972	430,602	-	5,900,000	0	-	-
1973	330,474	27,950,000 (85)	4,800,000 (15)	0	32,750,000	99.24
1974	1,708,836	101,400,000 (89)	12,550,000 (11)	0	113,950,000	66.64
1975	1,270,116	60,750,000 (88)	8,400,000 (12)	0	69,150,000	54.45
1976	817,008	46,600,000 (90)	5,127,868 (10)	0	51,727,868	63.31
1977	561,828	60,838,182 (97)	1,993,345 (3)	0	62,831,527	111.83
1978	2,267,238	46,302,587 (58)	33,196,940 (42)	0	79,499,527	35.06
1979	1,706,352	64,330,507 (92)	4,706,853 (8)	0	69,037,360	40.46
1980	2,969,040	32,354,984 (89)	4,133,901 (11)	0	36,488,885	12.29
1981	1,233,318	19,594,247 (93)	1,378,417 (7)	0	20,972,664	17.01
1982	976,470	22,332,474 (83)	4,692,859 (17)	0	27,025,333	27.68
1983	1,360,968	31,948,110 (98)	597,724 (2)	2,592	32,548,426	23.92
1984	1,002,792	27,466,684 (92)	2,335,723 (8)	0	29,802,407	29.72
1985	939,000	29,039,259 (97)	971,516 (3)	0	30,010,775	31.96
1986	818,652	39,828,021 (92)	3,575,054 (8)	0	43,403,075	53.02
1987	1,337,172	37,653,986 (99)	453,075 (1)		38,107,061	28.50[b]
1988	866,778	27,793,558				

[a] Percent of total smolt production

[b] Preliminary total

Table 37. Sockeye salmon spawning escapements, smolt production, adult returns, and smolt survival (number of adults produced per smolt), for 1972-1988 brood years, Wood River.

Brood Year	Total Spawning Escapement	Age 1. Number of Smolt	Age 1. Adult[a] Returns	Age 1. Adult Returns per Smolt	Age 2. Number of Smolt	Age 2. Adult[a] Returns	Age 2. Adult Returns per Smolt
1972	430,602	-	1,430,065		5,900,000	59,353	0.01
1973	330,474	27,950,000	1,364,992	0.05	4,800,000	118,476	0.02
1974	1,708,836	101,400,000	4,661,537	0.05	12,550,000	496,546	0.04
1975	1,270,116	60,750,000	3,617,378	0.06	8,400,000	1,141,143	0.14
1976	817,008	46,600,000	4,895,420	0.11	5,127,868	867,507	0.17
1977	561,828	60,838,182	3,399,952	0.06	1,993,345	116,606	0.06
1978	2,267,238	46,302,587	2,546,030	0.05	33,196,940	742,252	0.02
1979	1,706,352	64,330,507	4,497,413	0.07	4,706,853	46,750	0.01
1980	2,969,040	32,354,984	1,585,416	0.05	4,133,901	187,961	0.05
1981	1,233,318	19,594,247	1,815,951	0.09	1,378,417	179,333	0.13
1982	976,470	22,332,474	1,471,659	0.07	4,692,859	149,409	0.03
1983	1,360,968	31,948,110	3,098,001	0.10	597,724	90,606	0.15
1984	1,002,792	27,466,684	1,960,754	0.07	2,335,723	53,921	0.02
1985	939,000	29,039,259	2,560,969	0.09	971,516	29,554	0.03[b]
1986	818,652	39,828,021	1,216,728	0.03[b]	3,575,054	0	0.00[b]
1987	1,337,172	37,653,986			453,075		
1988	866,778	27,793,558					

[a] Includes return estimates through 1990.

[b] Future adult returns will increase these values.

Table 38. Mean fork length and weight of sockeye salmon smolt captured in fyke nets, Wood River, 1990.

	Age 1.					Age 2.				
Date [a]	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size	Mean Length (mm)	Std. Error	Mean Weight (g)	Std. Error	Sample Size
6/04	83	15.3	6.7	2.83	29					0
6/05	84	8.9	6.0	1.89	59	109	0.6	10.4	0.12	2
6/08	82	15.3	5.9	2.50	110	86	1.2	6.2	0.12	2
6/09	81	15.8	5.3	3.44	72	87	0.0	6.1	0.00	1
6/10	82	9.2	5.3	1.94	38	110	0.0	12.0	0.00	1
6/11	83	9.6	5.4	1.97	67					0
6/12	82	7.6	5.2	1.54	49	86	1.2	5.8	0.65	2
6/14	82	12.2	5.3	2.89	46					0
6/15	82	8.5	5.1	1.57	26					0
6/16	86	19.1	6.5	3.28	81	101	8.0	10.0	2.03	9
6/19	84	9.7	6.0	2.10	44	98	0.0	7.8	0.00	1
6/20	86	13.1	6.8	3.18	75	101	0.0	9.2	0.00	1
6/25	87	13.8	7.0	3.48	116					0
6/26	87	13.6	7.4	3.51	118					0
6/27	85	20.6	6.7	4.06	119					0
6/28	96	30.2	9.4	7.66	96	99	13.8	9.9	3.68	21
6/29	86	15.7	7.4	4.25	117					0
7/01	88	21.4	8.4	5.49	117	113	0.0	15.3	0.00	1
7/02	92	19.3	9.3	5.63	120					0
7/03	90	11.9	8.6	3.04	39					0
7/05	88	16.2	8.5	4.34	77					0
7/06	92	16.8	8.7	4.85	25	112	0.0	12.0	0.00	1
7/07	94	3.2	8.3	1.10	4					0
7/08	95	17.3	9.5	4.93	113	114	12.5	16.8	5.31	3
7/09	95	9.3	8.2	2.98	10	99	3.6	9.3	0.71	2
7/12	92	7.4	7.8	1.76	9					0
7/13	93	7.0	8.5	2.00	6					0
7/14	98	17.2	10.4	4.07	118					0
7/19	99	8.7	10.9	2.68	23	106	0.0	11.9	0.00	1
7/20	99	5.8	10.0	2.23	9					0
7/21	100	12.8	11.4	4.41	32					0
7/22	99	11.4	10.6	3.15	15					0
7/24	99	11.6	11.0	3.77	59					0
7/25	98	9.6	9.6	3.14	21					0
7/26	101	9.1	10.8	2.31	9					0
7/27	101	14.4	10.8	4.61	59					0
7/29	99	9.3	9.8	2.43	6					0
7/31	99	11.2	10.5	3.48	25					0
8/01	102	13.4	11.1	3.31	19					0
8/02	101	15.8	11.5	5.98	120					0
8/03	103	14.6	11.8	4.64	58					0
8/05	103	7.8	11.0	2.29	8					0
Totals					2,363					48
Means	92		8.4			101		10.2		

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

Table 39. Age composition of total migration and mean fork length and weight by age class, for sockeye salmon smolt, Wood River, 1951-1990.

Year of Migration	Age 1. Percent of Total Estimate	Age 1. Mean Length (mm)	Age 1. Mean Weight (g)	Age 2. Percent of Total Estimate	Age 2. Mean Length (mm)	Age 2. Mean Weight (g)	Total Estimate [a]	References
1951	80.0	91	-	20.0	-	-	-	Univ. Washington (unpub.)
1952	99.0	87	-	1.0	-	-	-	"
1953	95.3	86	-	4.7	103	-	-	"
1954	95.8	87	-	4.2	107	-	-	"
1955	98.0	85	-	2.0	102	-	-	"
1956	78.4	82	-	21.6	95	-	-	"
1957	80.7	77	-	19.3	93	-	-	"
1958	65.0	82	-	35.0	102	-	-	"
1959	93.5	88	-	6.5	105	-	-	"
1960	99.4	88	-	0.6	114	-	-	"
1961	93.0	82	-	7.0	102	-	-	Church (1963)
1962	86.0	80	-	14.0	98	-	-	Church and Nelson (1963)
1963	84.3	83	-	15.7	102	-	-	Nelson (1964)
1964	98.8	84	-	1.2	104	-	-	Nelson (1965b)
1965	92.0	86	-	8.0	106	-	-	Nelson (1966b)
1966	94.3	77	-	5.7	101	-	-	Siedelman (1967)
1975	86.0	83	-	14.0	98	-	33,850,000	Krasnowski (1976)
1976	95.5	84	-	4.5	95	-	106,200,000	Krasnowski (1977)
1977	82.9	71	3.5	17.1	98	9.3	73,300,000	Newcome (1978)
1978	84.7	79	-	15.3	90	-	55,000,000	Clark and Robertson (1980)
1979	92.2	90	7.6	7.8	100	10.1	65,966,050	Bucher (1980)
1980	96.0	78	4.0	4.0	95	6.8	48,295,932	Bucher (1981)
1981	66.1	88	6.3	33.9	96	8.4	97,527,446	Bucher (1982)
1982	87.3	79	4.7	12.7	98	8.4	37,061,837	Bucher (1984)
1983	82.6	86	6.5	17.4	98	9.2	23,728,252	Bucher (1987)
1984	94.2	92	7.8	5.8	97	8.7	23,710,947	Bucher (1986a)
1985	87.2	92	7.2	12.8	91	7.1	36,640,969	Bucher (1986b)
1986	97.9	87	5.9	2.1	101	9.2	54,661,948	Bue et al. (1988)
1987	92.6	86	5.8	7.4	100	8.7	36,227,371	Cross et al. (1990)
1988	97.0	87	6.3	3.0	100	9.2	40,799,537	Woolington et al. (1990)
1989	91.3	91	7.8	8.7	98	9.1	41,229,040	Woolington et al. (1991)
	Mean	84	6.1		100	8.2		
1990	98.4	92	8.4	1.6	101	10.2	28,246,633	

[a] Estimates of smolt numbers for 1951-1966 based on fyke net catches; estimates for 1975-1990 based on hydroacoustic techniques.

Table 40. Climatological and hydrological observations made at sockeye salmon smolt counting site at 0800 and 2000 hours, Wood River, 1990.

Date	Cloud Cover[a]		Wind Velocity (km/h)		Air Temp. (°C)		Water Temp. (°C)		Precipitation (mm)	Water Clarity
	0800	2000	0800	2000	0800	2000	0800	2000		
6/01	1	1	-	8 N	10.0	22.0	4.0	6.0	0.0	clear
6/02	2	2	calm	calm	10.0	20.0	4.0	6.0	0.0	clear
6/03	3	1	calm	calm	9.0	20.0	4.0	6.0	0.0	clear
6/04	5	1	5-08 S	calm	8.0	21.0	4.5	6.0	0.0	clear
6/05	1	1	calm	8-12 S	10.0	27.0	5.0	6.5	0.0	clear
6/06	1	1	calm	8 N	9.0	28.0	6.0	6.5	0.0	clear
6/07	5	1	calm	8 N	10.0	27.0	5.0	6.5	0.0	clear
6/08	5	1	calm	8-16 S	10.0	27.0	5.0	6.5	0.0	clear
6/09	4	4	calm	8 S	9.0	24.0	5.0	6.0	0.0	clear
6/10	4	4	calm	calm	10.0	20.0	5.0	6.0	0.5	clear
6/11	4	3	calm	calm	10.0	21.0	5.0	6.0	0.0	clear
6/12	5	3	calm	calm	10.0	20.0	5.0	6.0	0.0	clear
6/13	4	4	8 N	8 S	10.0	20.0	5.0	6.0	10.0	clear
6/14	4	2	calm	8 S	7.0	17.0	5.0	5.0	0.0	clear
6/15	4	4	calm	8-16 S	8.0	20.0	5.0	5.0	7.0	clear
6/16	4	4	calm	8 S	8.0	12.0	5.0	5.0	0.0	clear
6/17	4	2	calm	8 S	8.0	17.0	5.0	5.0	0.0	clear
6/18	4	3	calm	calm	9.0	14.0	5.5	5.0	0.0	clear
6/19	4	4	calm	8 N	9.0	14.0	5.5	5.5	7.0	clear
6/20	1	3	8-16 S	8 S	9.0	20.0	6.0	5.5	0.0	clear
6/21	2	2	8-16 SW	8 SW	9.0	20.0	6.0	6.0	0.0	clear
6/22	4	3	calm	8 SW	6.0	22.0	8.0	10.5	0.0	clear
6/23	1	1	calm	8 SW	8.0	22.0	9.0	9.0	0.0	clear
6/24	1	1	calm	8 SW	9.0	26.0	9.0	9.5	0.0	clear
6/25	3	3	calm	8 SW	9.0	26.0	5.5	6.0	0.0	clear
6/26	5	4	calm	calm	7.0	15.0	7.5	8.0	0.0	clear
6/27	2	1	calm	8 SW	9.0	24.0	6.0	7.0	0.0	clear
6/28	1	1	calm	8 SW	9.0	26.0	6.5	8.0	0.0	clear
6/29	1	1	calm	8 SW	10.0	25.0	5.5	8.0	0.0	clear
6/30	3	2	calm	16-32 SW	9.0	19.0	5.5	8.5	0.0	clear
7/01	3	2	calm	8 SW	9.0	25.0	5.5	8.0	0.0	clear
7/02	1	2	calm	16-32 SW	10.0	26.0	7.0	8.0	0.0	clear
7/03	1	1	calm	8-16 SW	10.0	28.0	7.0	12.0	0.0	clear
7/04	4	2	8-16 N	8-16 N	8.0	20.0	7.0	10.0	0.0	clear
7/05	4	4	calm	8 N	9.0	13.0	7.0	10.0	0.0	clear
7/06	4	3	calm	8 N	8.0	17.0	7.0	9.5	0.0	clear
7/07	4	4	calm	8 N	8.0	15.0	12.0	12.0	3.0	clear
7/08	4	3	calm	8 N	8.0	18.0	12.0	12.0	5.0	clear
7/09	1	3	8-16 S	8 S	9.0	24.0	12.0	12.0	2.0	clear
7/10	4	2	calm	8 S	10.0	25.0	12.0	13.5	0.0	clear
7/11	5	3	8-16 S	8 S	8.0	21.0	12.0	13.0	0.0	clear
7/12	3	4	calm	calm	9.0	19.0	12.0	13.0	0.0	clear
7/13	4	3	calm	calm	14.0	20.0	11.0	13.0	0.0	clear
7/14	3	3	calm	8 S	15.0	22.0	12.0	13.5	0.0	clear
7/15	5	1	8 S	8 S	15.0	25.0	12.0	13.5	0.0	clear
7/16	1	1	calm	8 S	14.0	26.0	13.0	13.5	0.0	clear
7/17	1	1	8 S	8-16 S	14.0	26.0	13.0	14.5	0.0	clear
7/18	5	1	calm	8-16 S	14.0	28.0	13.0	14.5	0.0	clear
7/19	5	1	calm	8-16 S	13.0	26.0	13.0	17.0	0.0	clear
7/20	5	2	calm	8-16 S	14.0	22.0	14.5	15.0	0.0	clear

-Continued-

Table 40. (p 2 of 2).

Date	Cloud Cover[a] 0800	Cloud Cover[a] 2000	Wind Velocity (km/h) 0800	Wind Velocity (km/h) 2000	Air Temp. (°C) 0800	Air Temp. (°C) 2000	Water Temp. (°C) 0800	Water Temp. (°C) 2000	Precipitation (mm)	Water Clarity
7/21	3	4	8-16 S	calm	15.0	21.0	14.5	14.0	0.0	clear
7/22	2	2	calm	calm	14.0	25.0	14.0	14.5	0.0	clear
7/23	4	4	8-16 S	8-16 S	15.0	24.0	14.0	14.0	0.0	clear
7/24	4	4	8-16 S	calm	12.0	17.0	14.0	14.0	20.0	clear
7/25	4	4	8 S	calm	13.0	15.0	12.0	13.0	8.0	clear
7/26	4	2	calm	8 N	14.0	16.0	12.0	11.0	30.0	clear
7/27	4	4	16-32 N	8-32 N	10.0	16.0	11.0	10.5	15.0	clear
7/28	4	2	calm	calm	12.0	15.0	10.5	10.5	10.0	clear
7/29	4	3	calm	8-16 N	10.0	13.0	10.5	10.5	14.0	clear
7/30	4	1	8-16 N	8 S	10.0	14.0	10.5	10.5	2.0	clear
7/31	4	4	calm	8-16 S	11.0	14.0	10.5	10.5	7.0	clear
8/01	4	4	calm	8 S	10.0	15.0	10.5	10.5	17.0	clear
8/02	4	4	8 S	calm	10.0	20.0	11.0	12.0	0.5	clear
8/03	1	1	calm	calm	9.0	26.0	12.0	14.5	0.0	clear
8/04	2	3	calm	24 S	8.0	26.0	13.0	14.5	0.0	clear
8/05	2	2	8-16 N	calm	7.0	22.0	13.0	14.5	0.0	clear
8/06	5	2	calm	calm	4.0	20.0	13.0	14.5	0.0	clear
8/07	4		calm	-	7.0	-	13.5	-	0.0	clear

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

Table 41. Water temperatures at the sockeye salmon smolt counting site, Wood River, 1975-1990.

Year	Sample Period	Water Temperature (° C) Minimum	Maximum	Mean	Reference
1975	May 29 - Jul 19	2.0	9.5	5.0	Krasnowski (1976)
1976	Jun 09 - Aug 07	2.0	14.0	8.0	Krasnowski (1977)
1977	Jun 09 - Aug 08	4.5	15.5	9.0	Newcome (1978)
1978	May 28 - Aug 09	5.0	16.0	9.0	Clark and Robertson (1980)
1979	May 30 - Aug 02	4.5	16.0	9.0	Bucher (1980)
1980	May 30 - Aug 15	4.5	18.0	9.0	Bucher (1981)
1981	May 27 - Aug 13	5.4	17.5	11.4	Bucher (1982)
1982	May 27 - Aug 10	2.2	12.0	6.4	Bucher (1984)
1983	May 28 - Jul 26	4.4	12.8	8.7	Bucher (1987)
1984	May 22 - Jul 27	4.4	16.7	10.8	Bucher (1986a)
1985	Jun 06 - Aug 08	2.2	10.6	6.3	Bucher (1986b)
1986	May 23 - Jul 17	3.0	10.5	6.1	Bue et al. (1988)
1987	May 23 - Aug 05	4.0	16.0	6.8	Cross et al. (1988)
1988	Jun 03 - Aug 01	3.5	15.5	8.8	Woolington et al. (1990)
1989	Jun 09 - Aug 07	5.0	12.5	9.3	Woolington et al. (1991)
	Mean	3.8	14.2	8.1	
1990	Jun 01 - Aug 07	4.0	17.0	9.3	

Table 42. Infection of age-1. and -2. Wood River sockeye salmon smolt by the cestode *Triaenophorus crassus*, 1990.

	Age 1.		Age 2.			Age 1.		Age 2.	
Date	Number Examined	Number Infected	Number Examined	Number Infected	Date	Number Examined	Number Infected	Number Examined	Number Infected
6/04 [a]	29	24	0	0	7/06	25	5	1	1
6/05	59	48	2	2	7/07	4	1	0	0
6/08	110	80	2	1	7/08	113	14	3	1
6/09	72	62	1	1	7/09	10	2	2	2
6/10	38	0	1	0	7/12	9	0	0	0
6/11	67	55	0	0	7/13	6	2	0	0
6/12	49	42	2	2	7/14	118	19	0	0
6/14	46	27	0	0	7/19	23	5	1	0
6/15	26	13	0	0	7/20	9	1	0	0
6/16	81	39	9	4	7/21	32	2	0	0
6/19	44	23	1	1	7/22	15	0	0	0
6/20	75	44	1	1	7/24	59	15	0	0
6/25	116	69	0	0	7/25	21	5	0	0
6/26	118	71	0	0	7/26	9	0	0	0
6/27	119	88	0	0	7/27	59	9	0	0
6/28 [b]	96	9	21	3	7/29	6	0	0	0
6/29	117	19	0	0	7/31	25	5	0	0
7/01	117	38	1	1	8/01	19	3	0	0
7/02	120	26	0	0	8/02	120	36	0	0
7/03	39	10	0	0	8/03	57	14	1	0
7/05	77	9	0	0	8/05	8	1	0	0
					Total	2,362	935	49	20
					Percent		39.6		40.8

[a] From June 4 through June 27, zeros were recorded next to each smolt which did not have any signs of *T. crassus* and a number (e.g., 1, 2, or 3) was recorded next to each smolt which exhibited visual external signs of *T. crassus*.

[b] From June 28 through August 5, numbers were only recorded next to smolt which exhibited signs of *T. crassus* infection. For the purpose of this analysis, blanks were interprated as smolt which were examined for signs of *T. crassus* but exhibited no signs of infection.

Table 43. Comparison of mean length and weight data by age for Wood River sockeye salmon smolt which did or did not exhibit signs of the cestode *Triaenophorus crassus*, June 4 to June 27, 1990.

		Age 1. [a]		Age 2. [a]	
T. crassus		Length (mm)	Weight (g)	Length (mm)	Weight (g)
Present	Sample Size (n = 685)			Sample Size (n = 12)	
	Range	60-101	3.4-11.1	85-110	5.2-11.7
	Mean	85	6.0	98	9.0
Absent	Sample Size (n = 323)			Sample Size (n = 6)	
	Range	64-102	3.5-12.7	87-105	6.3-10.0
	Mean	85	6.0	98	8.8

[a] *T. crassus* data collected at Wood River from June 28 to August 4, 1990 was not used in this analysis due to ambiguity in the data collection and recording practices.

Table 44. Infection of Wood River sockeye salmon smolt by the cestode *Triaenophorus crassus*, 1978-1990.

Year	Percent Infected		References
	Age 1.	Age 2.	
1978	15.1	40.5	Clark and Robertson (1980)
1979	10.0	30.8	Bucher (1980)
1980	11.1	17.3	Bucher (1981)
1981	28.2	35.6	Bucher (1982)
1982	10.0	21.2	Bucher (1984)
1983	43.1	73.6	Bucher (1987)
1984	41.1	45.7	Bucher (1986a)
1985	35.7	41.5	Bucher (1986b)
1986	40.8	45.6	Bue et al. (1988)
1987	42.6	57.8	Cross et al. (1990)
1988	40.8	46.4	Woolington et al. (1990)
1989	65.6	44.9	Woolington et al. (1991)
Mean	32.0	41.7	
1990	39.6	40.8	

Table 45. Number of sockeye salmon smolt outmigrants from Wood River by brood year, percent of smolt infected with *Triaenophorus crassus*, number of smolt outmigrants infected with *T. crassus*, adult returns per spawner, and percent marine survival (adult returns per smolt X 100), 1975-1986.

	Age 1.					Age 2.				
Brood Year	Number of Smolt Outmigrants	% of Smolt Infected wi/ T.crassus	No. of Infected Smolt	Adult Returns per Smolt	Percent Marine Survival	Number of Smolt Outmigrants	% of Smolt Infected wi/ T.crassus	No. of Infected Smolt	Adult Returns per Smolt	Percent Marine Survival
1975	60,750,000	[a]	[a]	[a]		8,400,000	40.5	3,402,000	0.14	14
1976	46,600,000	15.1	7,036,600	0.11	11	5,127,868	30.8	1,579,383	0.17	17
1977	60,838,182	10.0	6,083,818	0.06	6	1,993,345	17.3	344,849	0.06	6
1978	46,302,587	11.1	5,139,587	0.05	5	33,196,940	35.6	11,818,111	0.02	2
1979	64,330,507	28.2	18,141,203	0.07	7	4,706,853	21.2	997,853	0.01	1
1980	32,354,984	10.0	3,235,498	0.05	5	4,133,901	73.6	3,042,551	0.05	5
1981	19,594,247	43.1	8,445,120	0.09	9	1,378,417	45.7	629,937	0.13	13
1982	22,332,474	41.1	9,178,647	0.07	7	4,692,859	41.5	1,947,536	0.03	3
1983	31,948,110	35.7	11,405,475	0.1	10	597,724	45.6	272,562	0.15	15
1984	27,466,684	40.8	11,206,407	0.07	7	2,335,723	57.8	1,350,048	0.02	2
1985	29,039,259	42.6	12,370,724	0.09	9	971,516	46.4	450,783	0.03	3
1986	39,828,021	40.8	16,249,833	0.03	3	3,575,054	44.9	1,605,199	[a]	[a]

[a] Percent of smolt infection with *T. crassus* by age not available.

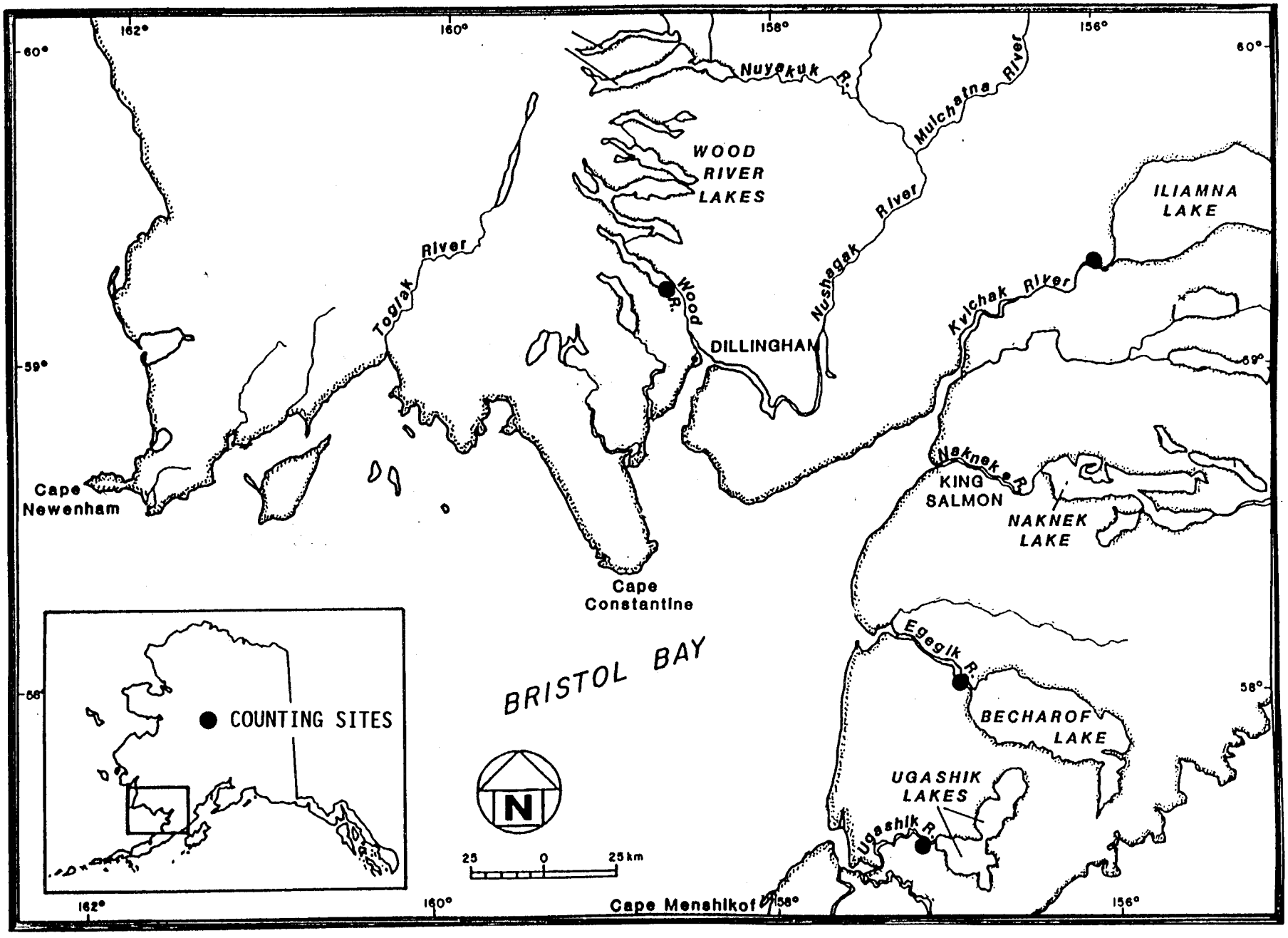

Figure 1. Bristol Bay Management Area with major rivers and locations of smolt counting projects, 1990.

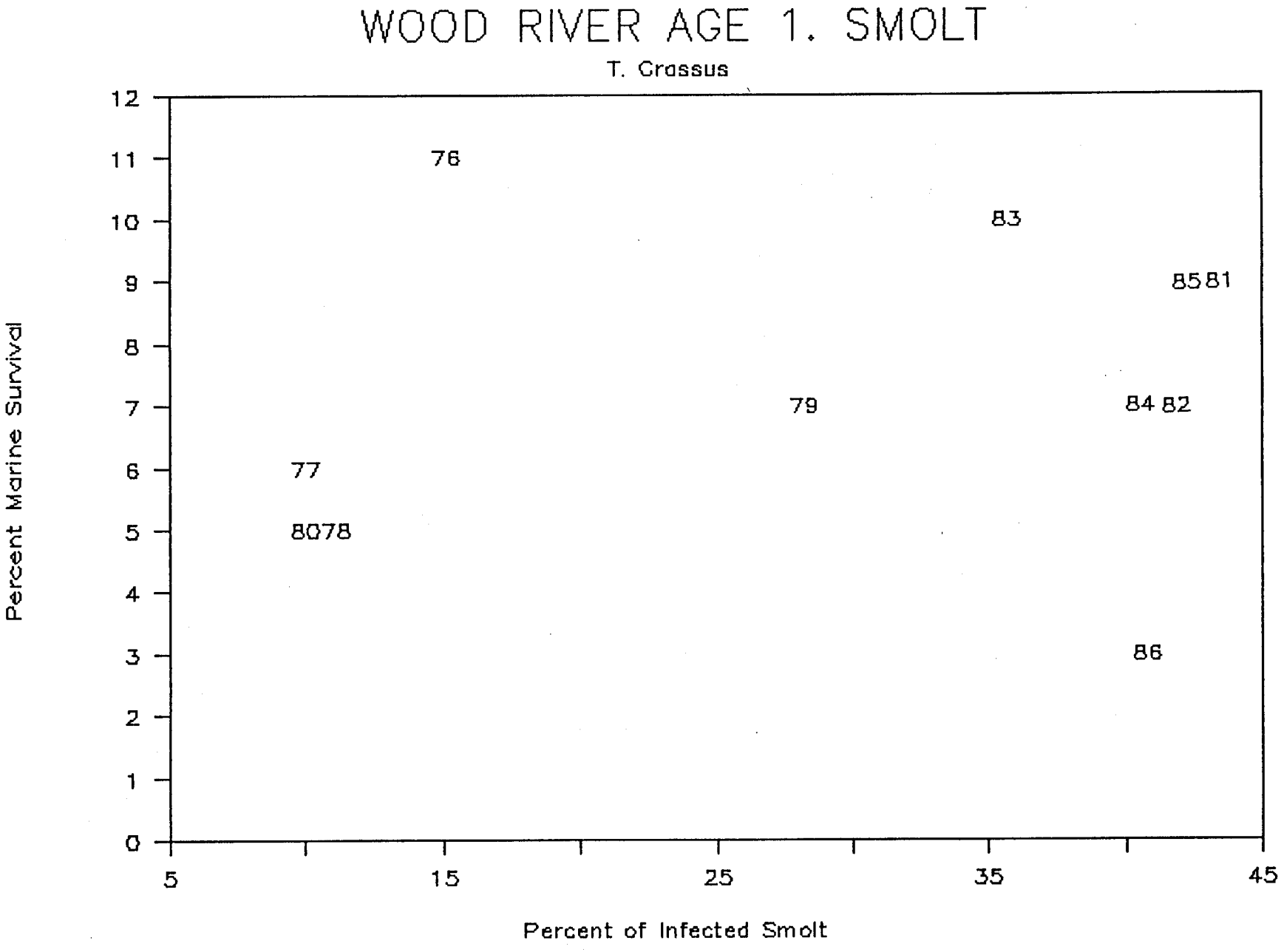

Figure 2. Comparison of the percent of age-1. sockeye salmon smolt outmigrants at Wood River with the percent of marine survival (adult returns per smolt X 100), 1976-1986.

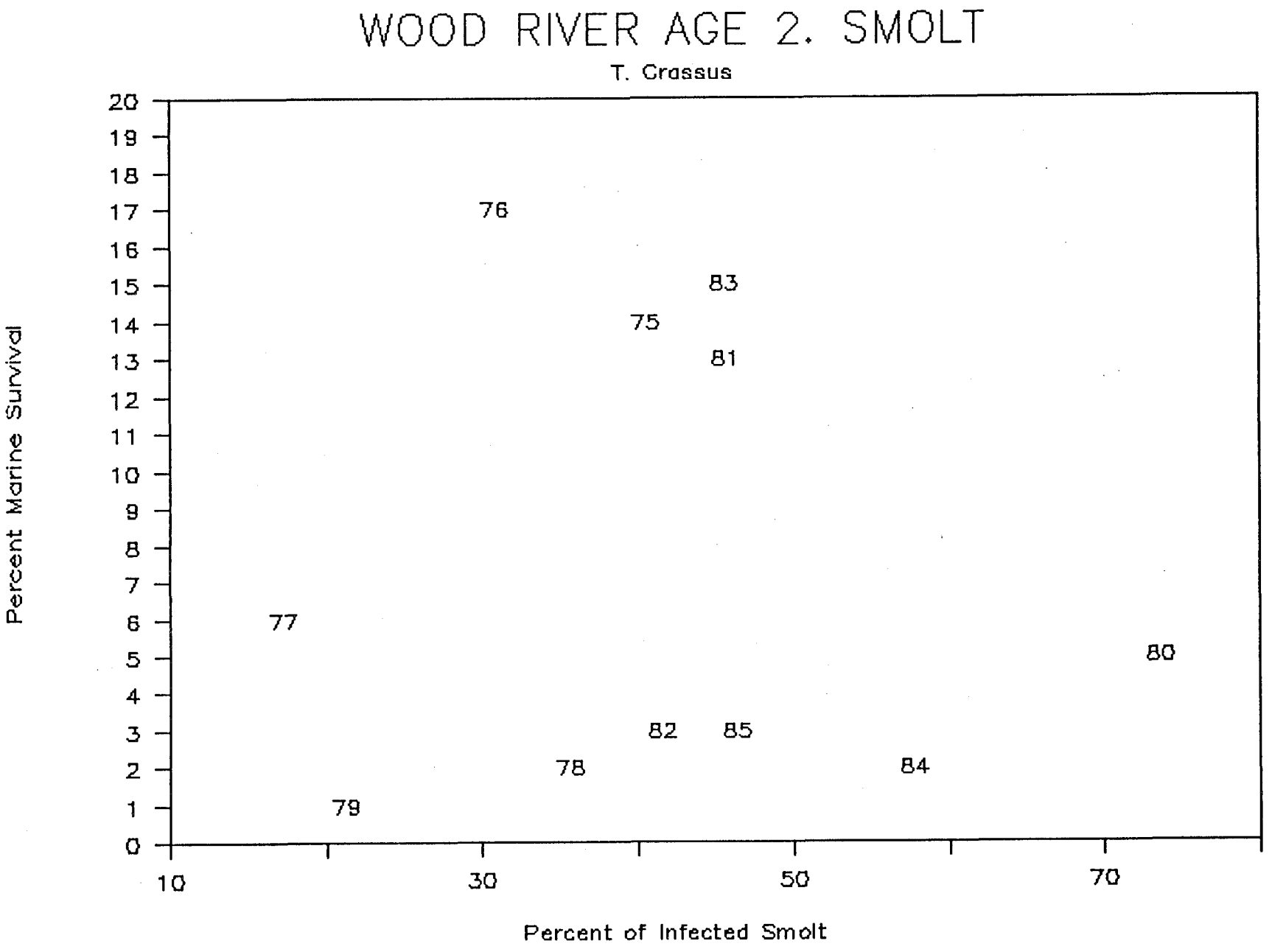

Figure 3. Comparison of the percent of age-2. sockeye salmon smolt outmigrants at Wood River with the percent of marine survival (adult returns per smolt X 100), 1975-1985.