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Alaska Department of Fish and Game
Division of Commercial Fisheries
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Origins of Sockeye Salmon In 1991 Eastside Bristol Bay Fisheries Based On Linear Discriminant Function Analysis of Scale Patterns

by

Barry L. Stratton

and

James D. Miller

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ABSTRACT

Stock composition of the 1991 commercial sockeye salmon *Oncorhynchus nerka* harvests in Naknek-Kvichak, Egegik, and Ugashik Districts, Bristol Bay, Alaska, were estimated with scale pattern analyses and age composition. Scale measurements from age-1.3 and -2.2 sockeye salmon escapement samples were used to build discriminant functions which allowed the stock composition of these age groups in the commercial catch to be estimated. Stock origins for other age groups were estimated by combining age-1.3 and -2.2 scale pattern analyses with escapement age compositions. Most sockeye salmon harvested had originated from rivers within the fishing district; however, harvest of outside stocks occurred in every district. Of the estimated 10,522,495 sockeye salmon caught in Naknek-Kvichak District, 58.5% were from Naknek River, 31.8% from Kvichak River, 7.0% from Egegik River, and 2.7% from Ugashik River. The estimated 6,796,454 sockeye salmon caught in Egegik District were composed of the following stocks: 75.8% Egegik, 10.6% Naknek, 6.9% Ugashik, and 6.7% Kvichak Rivers. The estimated Ugashik District harvest of 2,945,499 sockeye salmon was 53.4% Ugashik River, 20.0% Naknek River, 14.1% Kvichak River, and 12.5% Egegik River origin. Estimated exploitation rates were 48.7% for Ugashik River, 50.0% for Kvichak River, 67.6% for Naknek River, and 69.2% for Egegik River stocks.

KEY WORDS: Sockeye salmon *Oncorhynchus nerka*, Bristol Bay, scale pattern analysis, linear discriminant analysis, stock composition, exploitation rate

INTRODUCTION

To facilitate discrete stock management, the Bristol Bay sockeye salmon *Oncorhynchus nerka* fishery is restricted to districts located near the mouths of major spawning streams (Figure 1). However, the close proximity of these spawning streams and annual variation in migratory routes causes stock mixing in the fisheries.

The Bristol Bay Management Area is divided into two general fisheries, the East and West Side. The Eastside fishery is composed of Naknek-Kvichak, Egegik, and Ugashik Districts (Figure 1); the West Side fishery includes Nushagak and Togiak Districts. Naknek-Kvichak District is subdivided into Naknek and Kvichak Sections.

From 1956 to present, stock composition estimates from Naknek-Kvichak District harvests have been based on escapement age composition estimates from Kvichak, Alagnak (Branch), and Naknek Rivers. Total runs of sockeye salmon to Egegik and Ugashik Rivers were estimated by adding the district catch to the district escapement. This standard method assumes (1) that all fish harvested in a district were returning to rivers within that district, and (2) equal exploitation among stocks. Complete results of the standard method have been summarized and published in separate reports (Stratton 1990, 1991). Bernard (1983) evaluated the biases inherent with this procedure.

More recently a second method based on linear discriminant function analysis of scale patterns has been used as well as the standard method. Use of this method began when decreased catches of sockeye salmon in Naknek-Kvichak District in 1985 and 1986 prompted concerns that these fish were being intercepted in Egegik and Ugashik Districts where catches were large (Figure 2). Straty (1975), after conducting a tagging study from 1955 to 1957, concluded that Eastside sockeye salmon stocks mixed in all Eastside districts and that Westside stocks were not present in appreciable numbers in Eastside districts. Examining the 1985 Eastside commercial catches, Fried and Yuen (1985) found that scale pattern analysis could accurately identify major Eastside sockeye salmon stocks. Scale pattern studies were expanded and stock compositions of Eastside district catches were recently estimated by Burns (1991) for the 1983 and 1984 runs; estimates for 1986 to 1990 have also been completed (Bue et al. 1986; Cross and Stratton 1989; Cross and Stratton 1991; Cross et al. 1992; Stratton et al. 1992).

Objectives of this ongoing investigation of Eastside sockeye salmon runs include (1) estimation of stock composition in Eastside commercial sockeye salmon harvests; (2) estimation of total run by river; and (3) comparison of run estimates by river obtained from scale pattern analyses with the standard method. For this report, the objectives were specific to the 1991 run.

METHODS

Catch and Escapement Estimation

Commercial catch statistics in this report were compiled from final ADF&G fish ticket summaries. Sockeye salmon escapement estimates were based on visual counts made from towers on the banks of Kvichak, Naknek, Egegik, and Ugashik Rivers (ADF&G 1992).

Age Composition Estimation

European notation (Koo 1962) was used to record ages; numerals preceding the decimal refer to number of freshwater annuli, numerals following the decimal refer to number of marine annuli. Total age from time of egg deposition (brood year) is the sum of these numbers plus one. Complete methods and results of sampling Bristol Bay sockeye salmon catches and escapements have been summarized and published in separate reports (e.g., Stratton 1990, 1991) and the 1991 results in Stratton and Crawford (1992).

Catch Composition Estimation

Linear discriminant function analysis (Fisher 1936) of scale patterns combined with age composition data were used to determine sockeye salmon stock origins in the 1991 Eastside harvests. Sockeye salmon harvested from selected setnet beaches in Naknek-Kvichak and Egegik Districts were also sampled in 1991 and classified to river of origin.

Scale Measurements

Scale impressions were projected at 100X magnification onto a digitizing tablet using equipment similar to that described by Ryan and Christie (1976). Measurements were taken along the anterior-posterior axis to standardize each scale. This axis is approximately 20° ventral of the long axis and perpendicular to the sculptured (anterior) field (Figure 3). Distances between growth rings (circuli) were measured to the nearest 0.01 in, and number of circuli were counted from (1) center of scale focus to outside edge of first freshwater annulus (first freshwater annular zone), (2) outside edge of first freshwater annulus to outside edge of second freshwater annulus (second freshwater annular zone), (3) outside edge of last freshwater annulus to end of freshwater growth (freshwater plus growth zone), if present, and (4) outside edge of last freshwater circulus to outer edge of first ocean annulus (first marine annular zone). Total distance from the outside edge of first ocean annulus to outside edge of second ocean annulus (second marine annular zone) was recorded for age-1.3 sockeye salmon. A total of 75 variables for age-1.2 and -1.3 samples, and 108 for age-2.2 samples were computed from distance measurements and circuli counts (Appendix A.1).

Linear Discriminant Analysis

Escapement samples from Kvichak, Naknek, Egegik, and Ugashik Rivers provided known-origin scales to build linear discriminant functions (LDF). Commercial catch samples provided scales of unknown origin. Escapement samples collected in 1991 were used to classify 1991 commercial catches in age-specific LDF models.

Frequency distribution plots for principal scale variables for each growth zone were examined. Differences between mean number of circuli and size of selected growth zones for males and females were compared using Student *t*-tests. Scale variable selection for each discriminant model was made using a forward stepping procedure with partial *F*-statistics as criteria for entry or removal of variables (Enslein et al. 1977). This process was continued until model accuracy ceased improving. The equality of variance-covariance matrices were tested using an *F*-statistic described by Box (1949). A nearly unbiased estimate of overall classification accuracy for each LDF was determined with a "leaving-one-out procedure" (Lachenbruch 1967).

Construction of Age-1.2 Models. A four-way linear discriminant model was constructed from scale measurements of age-1.2 sockeye salmon entering Kvichak, Naknek, Egegik, and Ugashik Rivers. Models were built with age-1.2 scale samples from each 1991 escapement weighted by run strength through time.

Construction of Age-1.3 Models. A four-way linear discriminant model was constructed from scale measurements of age-1.3 sockeye salmon entering Kvichak, Naknek, Egegik, and Ugashik Rivers. Scale samples from each 1991 escapement weighted by run strength through time were used to build discriminant models. Frequency distribution plots of the total size of freshwater growth zones for Kvichak, Naknek, and Ugashik River stocks were similar (Figure 4). Therefore, all Kvichak, Naknek, and Ugashik River samples were pooled. A two-way linear discriminant model was built using scales from Egegik and a pooling of Kvichak, Naknek, and Ugashik.

Classification of Age-1.3 Sockeye Salmon. Linear discriminant models were used to assign unknown samples to river of origin. Proportion by stock estimates in the catches derived from the model were adjusted for misclassification error with the procedure of Cook and Lord (1978). The adjusted proportions were assumed to reflect true stock composition. Variance and 90% confidence intervals around adjusted estimates were computed using the procedure of Pella and Robertson (1979).

The number of age-1.3 sockeye salmon for stock *i* in a specific catch stratum, ($\hat{C}_{i,1.3}$) was calculated as

$$\hat{C}_{i,1.3} = \hat{C} \hat{P}_{1.3} \hat{S}_{i,1.3}, \quad (1)$$

where:

\hat{C} = estimated catch of sockeye salmon in a fishery at a given time,

$\hat{P}_{1.3}$ = estimated proportion of age-1.3 sockeye salmon in the catch, and

$\hat{S}_{i,3}$ = estimated proportion of age-1.3 sockeye salmon of stock i in the catch.

In this procedure, the variance about catch (\hat{C}) is not evaluated. Consequently, a conditional variance of the estimated age-1.3 sockeye salmon catch ($V[\hat{C}_{i,3}]$) for each stock in a specific fishery at a given time was calculated as described by Goodman (1960). This provided an exact variance of a product conditional on catch:

$$V[\hat{C}_{i,3}] = C^2 V[\hat{P}_{1,3} \hat{S}_{i,3}], \quad (2)$$

$$V[\hat{P}_{1,3} \hat{S}_{i,3}] = V[\hat{P}_{1,3}] \hat{S}_{i,3}^2 + V[\hat{S}_{i,3}] \hat{P}_{1,3}^2 - V[\hat{S}_{i,3}] V[\hat{P}_{1,3}] \quad (3)$$

Contributions for each stock through time for a specific fishery were added to estimate total contribution to that fishery. The variance of the total contribution was calculated by summing the variances for each period. The contributions by stock to each fishery were added to produce the total contribution by stock to the Eastside age-1.3 sockeye salmon harvest. The variance of the total contribution by stock was calculated as the sum of the variances for each fishery.

Construction of Age-2.2 Models. A four-way linear discriminant model was built from scale measurements of age-2.2 sockeye salmon entering Kvichak, Naknek, Egegik, and Ugashik Rivers. Scale samples weighted by run strength through time were used to build the discriminant models. Frequency distribution plots of the total size of freshwater growth zones for Kvichak and Naknek River stocks were similar (Figure 5). Therefore, all Kvichak and Naknek River samples were pooled. A three-way linear discriminant model was built using scales from Egegik, Ugashik, and Kvichak/Naknek Rivers pooled.

Classification of Age-2.2 Sockeye Salmon. The three-way linear discriminant model was used to classify 1991 district catches of age-2.2 sockeye salmon. A catch sample was reclassified with a two-way model if the adjusted proportion was ≤ 0 for one of the stocks in the three-way model. Procedures for the age-2.2 analysis were the same as those used for the age-1.3 analysis.

Separation of Kvichak/Naknek/Ugashik Age-1.3 Catch

Proportions of age-1.3 sockeye salmon classified to the Kvichak/Naknek/Ugashik aggregate were separated to their respective river based on scale pattern estimates for age-2.2 sockeye salmon and age composition of escapements:

$$\hat{S}_{i1.3} = \hat{S}_{p1.3} \frac{\hat{S}_{i2.2} \frac{\hat{T}_{i1.3}}{\hat{T}_{i2.2}}}{\sum_{i=1}^n \left(\hat{S}_{i2.2} \frac{\hat{T}_{i1.3}}{\hat{T}_{i2.2}} \right)}, \quad (4)$$

$$\hat{S}_{i2.2} = \frac{\hat{C}_{i2.2}}{\hat{C}_{2.2}}, \quad (5)$$

$$\hat{T}_{i2.2} = \frac{\hat{E}_{i2.2}}{\hat{E}_i}, \quad (6)$$

where:

$\hat{S}_{i1.3}$ = estimated proportion of age-1.3 sockeye salmon of stock i (Kvichak, Naknek, or Ugashik) in the catch,

$\hat{S}_{p1.3}$ = estimated proportion of age-1.3 sockeye salmon of Kvichak/Naknek/Ugashik pooled stocks in the catch,

$\hat{S}_{i2.2}$ = estimated proportion of age-2.2 sockeye salmon in stock i in the catch,

$\hat{T}_{i1.3}$ = estimated proportion of age-1.3 sockeye salmon in stock i escapement,

$\hat{T}_{i2.2}$ = estimated proportion of age-2.2 sockeye salmon in stock i escapement,

$\hat{C}_{i2.2}$ = estimated number of age-2.2 sockeye salmon of stock i in the catch,

$\hat{C}_{2.2}$ = estimated numbers of age-2.2 sockeye salmon in the catch,

$\hat{E}_{i2.2}$ = estimated number of age-2.2 sockeye salmon in stock i escapement,

\hat{E}_i = number of sockeye salmon in stock i escapement, and

n = number of stocks.

Two assumptions were made: (1) age composition of Kvichak, Naknek, and Ugashik River escapements represented the catch age composition; and (2) exploitation of age-1.3 sockeye salmon within Kvichak, Naknek, and Ugashik Rivers was equal to exploitation of age-2.2 sockeye salmon within those rivers.

Separation of Kvichak/Naknek Age-2.2 Catch

The age-2.2 sockeye salmon catch proportion classified to the Kvichak/Naknek group was separated to each river based on age composition of the escapements:

$$\hat{S}_{i2.2} = \hat{S}_{p2.2} \frac{\hat{E}_{i2.2}}{\hat{E}_{p2.2}}, \quad (7)$$

where:

$\hat{S}_{p2.2}$ = estimated proportion of age-2.2 sockeye salmon of Kvichak/Naknek pooled stocks in the catch, and

$\hat{E}_{p2.2}$ = estimated number of age-2.2 sockeye salmon in Kvichak and Naknek River pooled escapement.

Other Age Group Stock Composition Estimation

Estimates of stock composition for sockeye salmon of other ages harvested in Eastside districts were based on scale pattern estimates for age-1.3 and -2.2 sockeye salmon, and the ratio of age-1.3 and -2.2 sockeye salmon to sockeye salmon of other age groups within the respective escapements:

$$\hat{S}_y = \frac{\hat{S}_{i(1.3,2.2)} \frac{\hat{T}_y}{\hat{T}_{i(1.3,2.2)}}}{\sum_{i=1}^n \left(\hat{S}_{i(1.3,2.2)} \frac{\hat{T}_y}{\hat{T}_{i(1.3,2.2)}} \right)}, \quad (8)$$

$$\hat{S}_{i(1.3,2.2)} = \frac{\hat{C}_{i1.3} + \hat{C}_{i2.2}}{\hat{C}_{1.3} + \hat{C}_{2.2}}, \quad (9)$$

$$\hat{T}_{i(1.3,2.2)} = \frac{\hat{E}_{i1.3} + \hat{E}_{i2.2}}{\hat{E}_i}, \quad (10)$$

where:

T_{ij} = estimated proportion of age j sockeye salmon in stock i escapement,

$T_{i(1.3,2.2)}$ = estimated proportion of combined age-1.3 and age-2.2 sockeye salmon of stock i in the escapement,

$C_{i1.3}$ = estimated number of age-1.3 sockeye salmon of stock i in the catch,

$C_{1.3}$ = estimated number of age-1.3 sockeye salmon in the catch, and

$E_{i1.3}$ = estimated number of age-1.3 sockeye salmon in stock i escapement.

Run Size Estimation

Sockeye salmon run size to each river was estimated by adding estimates of catch by stock to escapement estimates. For each river, we computed the percentage (1) harvested within the natal district, (2) harvested outside the natal district, and (3) that escaped. Finally, run size estimates from scale pattern analysis were compared with estimates from the standard method.

RESULTS

Catch and Escapement

Eastside commercial fishermen harvested an estimated 20,264,448 sockeye salmon in 1991 (Table 1). This was slightly greater than the 1981–90 average catch of 19.4 million. The 10,522,495 sockeye salmon caught in Naknek-Kvichak District accounted for 52.0% of the Eastside harvest; commercial harvests in Egegik were 6,796,454 or 33.5% of the Eastside harvest and in Ugashik were 2,945,499 or 14.5%.

Sockeye salmon escapements in 1991 were estimated to be 4,222,788 in Kvichak River, 3,578,508 in Naknek River, 2,786,880 in Egegik River, and 2,457,306 in Ugashik River (Table 2).

Age Composition

Four age groups made up 99.4% of the Eastside sockeye salmon catch: age 1.2 was 12.8%, age 1.3 was 47.9%, age 2.2 was 23.1%, and age 2.3 was 15.6% (Table 3). Naknek-Kvichak District catch was 50.0% age 1.3. Egegik District catch was 40.2% age 1.3 and 35.8% age 2.2. Ugashik District catch was 47.1% age 1.3 and 29.3% age 2.2.

Age composition of sockeye salmon escapements varied among runs (Table 4). Kvichak River escapement was 61.2% age-1.2 sockeye salmon. Naknek River escapement was 62.4% age 1.3. Egegik River escapement was 48.2% age 2.2 and 31.2% age 1.3. Ugashik River escapement was 38.4% age 1.3 and 38.1% age 2.2.

Classification Models

Age 1.2

Scale characteristics which differed the most among age-1.2 sockeye salmon stocks were variables 22, 27, and 65 (Tables 5, 6). Overall classification accuracy for the four-way age-1.2 model was 66.2%. Individual classification accuracies were 80.0% for Egegik, 76.0% for Kvichak, 64.0% for Ugashik, and 44.8% for Naknek. Because of small sample sizes and poor model accuracy, this model was not used to classify any age-1.2 catches to river of origin.

Age 1.3

We used t-statistics to test for differences in mean circuli number and major growth zone size between males and females within each stock (Table 7). Significant differences ($\alpha = 0.05$) between sexes were only found for the size of the second ocean growth zone for Ugashik River ($t = 2.89$, $P \approx 0.005$, d.f. = 98). Because no growth zones were consistently different between sexes for all stocks, samples of males and females were combined to build the models.

Scale variables were similar between Kvichak, Naknek, and Ugashik samples, and the four-way model could not accurately differentiate between these stocks (Tables 7–9; Figure 4). Egegik stocks were distinct (Figure 6). Therefore, Kvichak, Naknek, and Ugashik samples were pooled and compared to Egegik River samples in a two-way model. Scale measurements that provided the greatest discrimination among age-1.3 sockeye salmon in the two-way model were variables 15, 91, and 18.

Estimated overall classification accuracy for the two-way, age-1.3 model was 94.7% (Table 9). Individual classification accuracy was high, >94%, for both groups.

Age 2.2

To test male-female differences in mean circuli number and major growth zone size within each stock t-statistics were computed (Table 10). Significant differences ($\alpha = 0.05$) between sexes were found for the size of the second freshwater growth zone for Kvichak River ($t = 2.68$, $P \approx 0.005$, d.f. = 148), and in the size of the first ocean growth zone for Egegik ($t = 2.69$, $P \approx 0.005$, d.f. = 198) and Ugashik ($t = 2.33$, $P \approx 0.01$, d.f. = 198) Rivers. Because no growth zones were consistently different between sexes for all stocks, samples of males and females were combined to build the models.

Scale variables were similar between Kvichak and Naknek samples; the four-way model could not accurately differentiate between these stocks (Tables 11, 12; Figure 5). Egegik and Ugashik stocks were distinct (Figure 7). Kvichak and Naknek samples were pooled and compared to Egegik and Ugashik River samples in a three-way model. Scale measurements that provided the greatest discrimination among age-2.2 groups in the three-way model were variables 64, 8, and 36.

Estimated overall classification accuracy for the three-way, age-2.2 model was 82.0% (Table 12). Individual classification accuracy was high for both Egegik (86.9%) and Ugashik (86.3%), and lower, 72.9%, for Kvichak/Naknek pooled. Overall classification accuracy for the two-way models ranged from 91.6% to 96.7%.

Estimates of Catch Composition

Age 1.3

Of the estimated 5,578,187 age-1.3 sockeye salmon caught in Naknek-Kvichak District, 92.7% originated within the district and 7.3% from outside the district (Figure 8). Of the estimated 2,731,394 age-1.3 sockeye salmon caught in Egegik District, 69.1% originated from Egegik River and 30.9% were produced outside the district (Figure 9). The estimated catch of age-1.3 sockeye salmon in Ugashik District was 1,386,278; 54.4% originated in Ugashik River and 45.6% from outside the district (Figure 10). The 90% confidence intervals by group are presented in Tables 13 and 14.

Age 2.2

Of the estimated 1,376,419 age-2.2 sockeye salmon caught in Naknek-Kvichak District, 68.0% originated within the district and 32.0% from outside the district (Figure 11). Of the estimated 2,430,675 age-2.2 sockeye salmon caught in Egegik District, 90.4% originated from Egegik River and 9.6% were produced outside the district (Figure 12). The estimated catch of age-2.2 sockeye salmon in Ugashik District was 862,575; 67.4% originated in Ugashik River and 32.6% from stocks outside the district (Figure 13). The 90% confidence intervals by group are presented in Tables 15 and 16.

All Ages

The Naknek-Kvichak District harvest was composed of an estimated 6,150,889 sockeye salmon from Naknek River, 3,346,858 from Kvichak River, 737,686 from Egegik River, and 287,062 from Ugashik River (Table 17). Estimated stock contributions to the Naknek-Kvichak District total catch were 58.5% for Naknek, 31.8% for Kvichak, 7.0% for Egegik, and 2.7% for Ugashik Rivers (Figure 14). On north Naknek beaches, stock composition of setnet harvests between Libbyville and Pederson Point were similar (NSC = nonstatistical comparison) to harvests between Pederson Point and the inside district marker (Table 18). However, stock composition of harvests differed greatly (NSC) between north Naknek beach

study areas and the south Naknek beach study area. Egegik River sockeye salmon were the largest component of south Naknek beach catches, whereas Naknek River sockeye salmon were the largest component of north Naknek beach catches. However, because beach samples were taken on different dates, it is not known whether stock composition estimates differed due to sample location or time.

Of the sockeye salmon caught in Egegik District, an estimated 5,149,567 were from Egegik River, 722,984 from Naknek River, 467,047 from Ugashik River, and 456,856 from Kvichak River (Table 19). Estimated stock contributions to the Egegik District total catch were 75.8% Egegik, 10.6% Naknek, 6.9% Ugashik, and 6.7% Kvichak Rivers (Figure 15). All sampled setnet catches had higher percentages of Egegik River sockeye salmon than the total Egegik District catch, which was primarily harvested by driftnets (Table 20).

The Ugashik District catch was composed of an estimated 1,575,514 sockeye salmon from Ugashik River, 588,469 from Naknek River, 414,305 from Kvichak River, and 367,211 from Egegik River (Table 21). Estimated stock contribution to the total Ugashik District sockeye salmon catch were 53.4% from Ugashik River, 20.0% from Naknek River, 14.1% from Kvichak River, and 12.5% from Egegik River (Figure 16).

Harvest Distribution

Of the estimated 4,218,019 Kvichak River sockeye salmon harvested in 1991, 79.4% were taken in Naknek-Kvichak, 10.8% in Egegik, and 9.8% in Ugashik Districts (Table 22). Of the estimated 7,462,342 Naknek River sockeye salmon harvested, 82.4% were taken in Naknek-Kvichak District, 9.7% in Egegik District, and 7.9% in Ugashik District. Of the estimated 6,254,464 Egegik River sockeye salmon harvested, 82.3% were taken in Egegik District, 11.8% in Naknek-Kvichak District, and 5.9% in Ugashik District. Of the estimated 2,329,623 Ugashik River sockeye salmon harvested, 67.7% were taken in Ugashik District, 12.3% in Naknek-Kvichak District, and 20.0% in Egegik District.

An estimated 2,182,614 sockeye salmon destined for Kvichak and Naknek Rivers were harvested outside their natal district, whereas Naknek-Kvichak District fishermen caught 1,024,748 sockeye salmon bound for other districts. Therefore, Naknek-Kvichak District fishermen had a potential net loss of 1,157,866 sockeye salmon. The number of Egegik River sockeye salmon harvested in other districts was 1,104,897, whereas fishermen in Egegik District caught 1,646,887 sockeye salmon bound for other districts. Therefore, Egegik District fishermen realized a net gain of 541,990 sockeye salmon. An estimated 754,109 Ugashik River sockeye salmon were harvested outside Ugashik District, whereas 1,369,985 sockeye salmon from other rivers were caught in Ugashik District. Therefore, Ugashik District fishermen had a net gain of 615,876 sockeye salmon.

Run By River System

Run Distribution

The 1991 Kvichak River run was estimated to be 8,440,807 sockeye salmon: 50.0% escaped, 39.7% were harvested in Naknek-Kvichak District, and 10.3% were harvested in other districts (Tables 23, 24; Figure 17). The 1991 Naknek River run was estimated to be 11,040,850 sockeye salmon: 32.4% escaped, 55.7% were harvested in Naknek-Kvichak District, and 11.9% were harvested in other districts (Figure 18). The 1991 Egegik River run was estimated to be 9,041,344 sockeye salmon: 30.8% escaped, 57.0% were harvested in Egegik District, and 12.2% were harvested in other districts (Figure 19). The 1991 Ugashik River run was estimated to be 4,786,929: 51.3% escaped, 32.9% were harvested in Ugashik District, and 15.8% were harvested in other districts (Figure 20).

Exploitation Rates

The Ugashik River run was exploited outside the natal district at a 15.8% rate which was slightly higher than Egegik (12.2%), Naknek (11.9%), or Kvichak (10.3%) Rivers. Total exploitation rates based on harvests inside and outside the natal district were 48.7% for Ugashik River, 50.0% for Kvichak River, 67.6% for Naknek River, and 69.2% for Egegik River (Tables 23, 24; Figures 17–20).

Comparison of Run Estimates

Run estimates based on the standard method cannot be directly compared to those based on scale pattern analysis because the Branch River stock was not included in linear discriminant models. Therefore, standard run estimates were adjusted so that the Naknek-Kvichak District catch was only divided between Kvichak and Naknek Rivers. Naknek River had the greatest difference in estimated run size between the two methods (Table 25). The standard method estimate for the Naknek River run was 922,734 sockeye salmon less than that obtained from scale pattern analysis. Estimates for Ugashik River differed by 615,876, the standard method estimate being higher. Estimates for Egegik River differed by 541,990, the standard method estimate again being higher. The standard method estimate of run size for Kvichak River was 235,132 lower than that obtained from scale pattern analysis. In general, harvests of stocks outside their natal districts in 1991 resulted in the standard method over-estimating runs to Egegik and Ugashik Rivers and under-estimating runs to Kvichak and Naknek Rivers.

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Table 1. Sockeye salmon commercial catch by district and date for the East Side of Bristol Bay, 1991.

Date	Catch ^a			Total
	Naknek-Kvichak	Egegik	Ugashik	
6/04-6/14	5,679	347	367	6,393
6/16	1,062			1,062
6/17	1,830	85	158	2,073
6/18	2,480		1,490	3,970
6/19	3,578		2,851	6,429
6/20	5,617		6,841	12,458
6/21	6,019	7,150	869	14,038
6/22-6/29	6,845	23,939		30,784
6/30	365,925	260,462		626,387
7/01	753,123	787,948		1,541,071
7/02	827,889	604,612		1,432,501
7/03	787,995	577,550	1,845	1,367,390
7/04	1,376,582	531,664	96,473	2,004,719
7/05	519,091	566,861	206,522	1,292,474
7/06	452,199	88,234	132,948	673,381
7/07	699,644	391,227	188,502	1,279,373
7/08	729,157	477,330	1,800	1,208,287
7/09	670,012	483,142	524,847	1,678,001
7/10	756,015	310,730	425,215	1,491,960
7/11	793,425	556,783	221,512	1,571,720
7/12	344,189	207,760	220,603	772,552
7/13	220,165	172,721	163,169	556,055
7/14	139,729	190,934	194,025	524,688
7/15	158,066	87,839	128,529	374,434
7/16	284,189	112,830	111,266	508,285
7/17	250,182	41,447	33,299	324,928
7/18	147,371	62,578	51,035	260,984
7/19	66,012	59,514	48,040	173,566
7/20	4,538	42,418	35,838	82,794
7/21	1,519	49,815	44,702	96,036
7/22-7/27	123,412	83,942	88,909	296,263
7/29-8/02	13,807	12,759	12,194	38,760
8/05-8/10	4,604	1,952	1,289	7,845
8/12-9/03	545	1,881	361	2,787
Total	10,522,495	6,796,454	2,945,499	20,264,448
Percent	52.0	33.5	14.5	100.0

^a Blanks indicate a district was closed.

Table 2. Sockeye salmon escapement by river and date for the East Side of Bristol Bay, 1991.

Date	Kvichak River		Naknek River		Egegik River		Ugashik River	
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative
06/22	42	42						
06/23	30	72	588	588	2,142	2,142		
06/24	0	72	792	1,380	7,452	9,594		
06/25	60	132	96	1,476	1,728	11,322		
06/26	594	726	104,316	105,792	24,210	35,532		
06/27	2,844	3,570	102,576	208,368	10,974	46,506		
06/28	45,960	49,530	113,226	321,594	16,866	63,372		
06/29	75,210	124,740	326,316	647,910	23,352	86,724		
06/30	152,598	277,338	504,216	1,152,126	47,358	134,082		
07/01	310,830	588,168	669,858	1,821,984	115,764	249,846		
07/02	312,918	901,086	517,218	2,339,202	156,450	406,296		
07/03	354,504	1,255,590	295,194	2,634,396	300,438	706,734	186	186
07/04	325,824	1,581,414	244,176	2,878,572	305,238	1,011,972	114	300
07/05	343,572	1,924,986	30,366	2,908,938	326,586	1,338,558	246	546
07/06	215,718	2,140,704	8,274	2,917,212	345,588	1,684,146	204	750
07/07	66,822	2,207,526	8,220	2,925,432	343,284	2,027,430	1,344	2,094
07/08	69,090	2,276,616	12,132	2,937,564	142,194	2,169,624	206,874	208,968
07/09	77,946	2,354,562	132,282	3,069,846	68,844	2,238,468	203,916	412,884
07/10	278,598	2,633,160	73,836	3,143,682	37,368	2,275,836	63,720	476,604
07/11	446,826	3,079,986	25,224	3,168,906	45,756	2,321,592	20,352	496,956
07/12	379,860	3,459,846	25,398	3,194,304	85,896	2,407,488	264,186	761,142
07/13	179,508	3,639,354	16,050	3,210,354	54,942	2,462,430	570,204	1,331,346
07/14	83,712	3,723,066	39,258	3,249,612	151,068	2,613,498	224,910	1,556,256
07/15	97,656	3,820,722	151,968	3,401,580	96,612	2,710,110	484,884	2,041,140
07/16	86,838	3,907,560	18,012	3,419,592	12,366	2,722,476	139,578	2,180,718
07/17	89,874	3,997,434	28,032	3,447,624	8,688	2,731,164	31,296	2,212,014
07/18	64,428	4,061,862	27,102	3,474,726	10,326	2,741,490	22,488	2,234,502
07/19	53,070	4,114,932	10,920	3,485,646	11,118	2,752,608	20,754	2,255,256
07/20	30,270	4,145,202	26,256	3,511,902	11,358	2,763,966	33,942	2,289,198
07/21	24,432	4,169,634	41,844	3,553,746	10,488	2,774,454	24,816	2,314,014
07/22	26,520	4,196,154	24,762	3,578,508	12,426	2,786,880	46,530	2,360,544
07/23	26,634	4,222,788					51,000	2,411,544
07/24							16,236	2,427,780
07/25							9,996	2,437,776
07/26							7,446	2,445,222
07/27							5,910	2,451,132
07/28							6,174	2,457,306
Total	4,222,788		3,578,508		2,786,880 ^a		2,457,306 ^b	

^a An additional 45 sockeye salmon were counted in the King Salmon River drainage, bringing the Egegik District sockeye salmon escapement total to 2,786,925.

^b An additional 12,500, 12,195, and 15 sockeye salmon were counted in Dog Salmon River, King Salmon River, and Grassy Creek, bringing the Ugashik District sockeye salmon escapement total to 2,482,016.

Table 3. Sockeye salmon age composition by brood year in the commercial catch for the East Side of Bristol Bay, 1991.

District	Sample Size		1988		1987		1986			1985		1984		Total	
			0.2	0.3	1.2	2.1	0.4	1.3	2.2	1.4	2.3	3.2	2.4		3.3
Naknek/ Kvichak	5,684	Numbers	1,822	33,410	1,623,144		1,822	5,578,187	1,376,419	18,913	1,881,730		441	6,607	10,522,495
		Percent	0.0 ^a	0.3	15.4		0.0 ^a	53.0	13.1	0.2	17.9		0.0 ^a	0.1	100.0
		SE	2,018	10,301	64,008		2,018	85,354	58,145	7,987	65,051		500	3,394	
Egegik	5,913	Numbers	116	8,172	624,174	4,696		2,731,394	2,430,675	8,466	940,375	5,896	11,264	31,226	6,796,454
		Percent	0.0 ^a	0.1	9.2	0.1		40.2	35.8	0.1	13.8	0.1	0.2	0.5	100.0
		SE	124	3,604	28,155	2,125		47,919	46,146	2,936	35,048	2,304	3,667	6,084	
Ugashik	3,023	Numbers		6,149	338,013		246	1,386,278	862,575	4,272	344,166			3,800	2,945,499
		Percent		0.2	11.5		0.0 ^a	47.1	29.3	0.2	11.7			0.1	100.0
		SE		2,887	21,075		395	32,590	29,755	3,978	21,914			2,274	
Total	14,620	Numbers	1,938	47,731	2,585,331	4,696	2,068	9,695,859	4,669,669	31,651	3,166,271	5,896	11,705	41,633	20,264,448
		Percent	0.0 ^a	0.2	12.8	0.0 ^a	0.0 ^a	47.9	23.1	0.2	15.6	0.0 ^a	0.1	0.2	100.0

^a Represented < 0.1%

Table 4. Sockeye salmon age composition by brood year in the escapement for the East Side of Bristol Bay, 1991.

River	Sample Size	1988		1987		1986			1985			1984		Total		
		0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	1.4	2.3	3.2	2.4		3.3	
Kvichak	3,425	Numbers	8,338	4,390	38,318	2,583,669	30,307	566	337,769	677,990	1,281	539,115	1,045		4,222,788	
		Percent	0.2	0.1	0.9	61.2	0.7	0.0 ^a	8.0	16.1	0.0 ^a	12.8	0.0 ^a		100.0	
Naknek	3,052	Numbers			5,991	207,414	3,695		2,234,203	617,121	23,784	485,429		871	3,578,508	
		Percent			0.2	5.8	0.1		62.4	17.3	0.7	13.6		0.0 ^a	100.0	
Egegik	3,770	Numbers		1,127	532	230,173	58,964		868,132	1,341,991	532	276,584	1,495	1,432	5,918	2,786,880
		Percent		0.0 ^a	0.0 ^a	8.3	2.1		31.2	48.2	0.0 ^a	9.9	0.1	0.1	0.2	100.0
Ugashik	3,027	Numbers	484	1,497	2,171	455,629	10,233		944,598	935,364		107,330			2,457,306	
		Percent	0.0 ^a	0.1	0.1	18.5	0.4		38.4	38.1		4.4			100.0	

^a Represented < 0.1%

Table 5. Mean and standard error of age-1.2 scale variables used to construct a linear discriminant function for the East Side of Bristol Bay, 1991.

Variable Number	Variable Name	Kvichak		Naknek		Egegik		Ugashik	
		Mean ^a	SE						
<u>First Freshwater Annular Zone</u>									
6	C0-C8	129.48	0.886	122.92	0.955	126.94	0.792	121.29	0.756
22	C2-C8/S1FW	0.49	0.003	0.43	0.005	0.37	0.003	0.43	0.004
27	S1FW/NC1FW	13.92	0.099	12.64	0.087	12.99	0.080	12.63	0.081
<u>Freshwater and Plus Growth Zones</u>									
65	NC1FW+NC2FW+NCPG	13.31	0.133	15.60	0.176	17.19	0.127	14.59	0.132
<u>First Marine Annular Zone</u>									
91	EFW-C6/S10Z	0.25	0.004	0.24	0.005	0.29	0.003	0.23	0.003
108	MAX DIST/S10Z	0.07	0.001	0.07	0.001	0.07	0.001	0.06	0.001

^a Scale images projected at 100x magnification and measured at 0.01 in; therefore, variable means are in 0.0001 in.

Table 6. Classification matrix from a discriminant analysis of age-1.2 sockeye salmon sampled from Kvichak, Naknek, Egegik, and Ugashik Rivers, 1991.

Actual Group Of Origin	Sample Size	Classified Group of Origin (%)			
		<u>Kvichak</u>	<u>Naknek</u>	<u>Egegik</u>	<u>Ugashik</u>
Kvichak	96	<u>76.0</u>	10.4	0.0	13.5
Naknek	96	11.5	<u>44.8</u>	21.9	21.9
Egegik	100	5.0	10.0	<u>80.0</u>	5.0
Ugashik	100	14.0	17.0	5.0	<u>64.0</u>

Mean classification accuracy = 66.2%
 Variables used: 22,27,65,91,108,6
 Box's Test of Variance-Covariance Equality^a
 F-statistic = 2.21
 df = 63, 351731
 P = 0.000

^a The equality of the variance-covariance matrices tested with a procedure described by Box (1949).

Table 7. Mean, variance, and t-statistic comparing males and females for selected scale variables of age-1.3 sockeye salmon sampled from Kvichak, Naknek, Egegik, and Ugashik Rivers, 1991.

River	Sex		NC1FW	S1FW	NCPG	SPGZ	NC10Z	S10Z	S20Z	
Kvichak River	Male	Sample Size	55	55	52	52	55	55	55	
		Mean	11.89	153.95	1.69	18.00	23.60	399.16	337.25	
		Variance	2.88	289.83	0.45	70.71	4.21	915.88	2,450.86	
	Female	Sample Size	39	39	36	36	39	39	39	
		Mean	11.64	151.74	1.72	17.08	23.13	388.28	324.90	
		Variance	1.66	208.93	0.55	47.56	3.85	1,070.94	1,630.57	
	Combined	Sample Size	100	100	96	96	100	100	100	
		Mean	11.76	152.87	1.68	17.45	23.46	395.76	332.65	
		Variance	2.29	243.08	0.58	72.63	4.33	1,002.47	2,028.31	
	T-Statistic			0.77	0.66	-0.20	0.54	1.12	1.66	1.28
	Naknek River	Male	Sample Size	55	55	54	54	55	55	55
			Mean	12.07	150.55	2.15	23.46	24.58	418.02	338.75
Variance			3.74	589.25	0.62	84.89	5.95	1,716.39	1,314.56	
Female		Sample Size	45	45	44	44	45	45	45	
		Mean	12.58	156.29	2.30	24.39	23.84	409.33	326.40	
		Variance	3.48	561.66	0.82	104.10	5.73	1,376.82	1,339.02	
Combined		Sample Size	100	100	98	98	100	100	100	
		Mean	12.30	153.13	2.24	24.19	24.25	414.11	333.19	
		Variance	3.65	579.29	0.69	89.92	5.93	1,566.99	1,350.26	
T-Statistic			-1.32	-1.19	-0.86	-0.47	1.52	1.09	1.69	
Egegik River		Male	Sample Size	89	89	85	85	89	89	89
			Mean	16.26	211.54	1.54	17.52	22.51	408.08	311.16
	Variance		1.74	393.02	0.39	41.46	3.18	1,341.51	2,044.95	
	Female	Sample Size	111	111	109	109	111	111	111	
		Mean	16.50	214.02	1.55	15.66	22.27	402.15	299.43	
		Variance	1.71	316.35	0.43	50.97	3.78	1,267.08	2,307.97	
	Combined	Sample Size	200	200	194	194	200	200	200	
		Mean	16.39	212.92	1.55	15.88	22.38	404.79	304.65	
		Variance	1.73	350.19	0.41	46.63	3.51	1,302.34	2,214.19	
	T-Statistic			-1.27	-0.93	-0.10	1.88	0.88	1.15	1.76
	Ugashik River	Male	Sample Size	48	48	48	48	48	48	48
			Mean	11.54	142.81	1.96	20.90	23.42	398.06	345.75
Variance			1.57	229.86	0.81	100.10	5.06	1,626.53	2,320.53	
Female		Sample Size	52	52	51	51	52	52	52	
		Mean	11.96	148.46	1.88	19.76	23.15	395.83	320.65	
		Variance	2.27	390.80	0.75	81.58	4.64	1,062.42	1,477.25	
Combined		Sample Size	100	100	99	99	100	100	100	
		Mean	11.76	145.75	1.92	20.31	23.28	396.90	332.70	
		Variance	1.96	318.49	0.77	89.95	4.81	1,320.76	2,021.46	
T-Statistic			-1.51	-1.59	0.43	0.59	0.60	0.31	2.89 ^a	

^a Significant at $\alpha = 0.05$

Table 8. Mean and standard error of age-1.3 scale variables used to construct linear discriminant functions for the East Side of Bristol Bay, 1991.

Variable Number	Variable Name	Kvichak		Naknek		Egegik		Ugashik	
		Mean ^a	SE						
<u>First Freshwater Annular Zone</u>									
9	C2-C8	72.13	0.721	67.81	0.728	76.38	0.648	66.45	0.627
11	C4-C8	45.67	0.497	41.82	0.569	48.86	0.442	41.19	0.476
14	C2-E1FW	103.64	1.612	104.43	2.322	161.07	1.611	96.86	1.671
15	C4-E1FW	77.17	1.647	78.42	2.237	133.55	1.546	71.60	1.609
18	C0-C6/S1FW	0.66	0.008	0.64	0.009	0.49	0.004	0.66	0.006
19	C0-C8/S1FW	0.80	0.008	0.77	0.009	0.60	0.005	0.80	0.007
27	S1FW/NC1FW	13.12	0.119	12.48	0.091	12.98	0.083	12.43	0.093
28	NC 1ST 3/4	6.80	0.132	7.25	0.145	10.31	0.091	6.85	0.112
<u>Freshwater and Plus Growth Zones</u>									
66	S1FW+S2FW+SPGZ	169.27	1.642	176.53	2.325	226.25	1.560	165.86	1.868
<u>First Marine Annular Zone</u>									
89	C15-E10Z	131.45	3.787	147.57	4.122	103.41	2.785	134.35	3.836
91	EFW-C6/S10Z	0.23	0.004	0.22	0.004	0.29	0.003	0.23	0.004
103	(C(NC-6)-E10Z)/S10Z	0.22	0.004	0.21	0.004	0.21	0.003	0.23	0.004

^a Scale images projected at 100x magnification and measured at 0.01 in; therefore, variable means are in 0.0001 in.

Table 9. Classification matrices from discriminant analyses of age-1.3 sockeye salmon sampled from Kvichak, Naknek, Egegik, and Ugashik Rivers, 1991.

Actual Group Of Origin	Sample Size	Classified Group of Origin (%)			
		<u>Kvichak</u>	<u>Naknek</u>	<u>Egegik</u>	<u>Ugashik</u>
Kvichak	91	<u>63.7</u>	15.4	1.1	19.8
Naknek	99	15.2	<u>51.5</u>	5.1	28.3
Egegik	112	2.7	8.0	<u>88.4</u>	0.9
Ugashik	100	23.0	27.0	1.0	<u>49.0</u>

Mean classification accuracy = 63.2%
 Variables used: 14,66,19,9,27,103,89
 Box's Test of Variance-Covariance Equality^a
 F-statistic = 6.43
 df = 84, 346493
 P = 0.055

Actual Group Of Origin	Sample Size	Classified Group of Origin (%)	
		<u>Egegik</u>	<u>Other^b</u>
Egegik	200	<u>94.5</u>	5.5
Other	299	5.0	<u>95.0</u>

Mean classification accuracy = 94.7%
 Variables used: 15,91,18,11,28
 Box's Test of Variance-Covariance Equality
 F-statistic = 13.08
 df = 15, 729408
 P = 0.000

^a The equality of the variance-covariance matrices tested with a procedure described by Box (1949).

^b Samples from Kvichak, Naknek, and Ugashik Rivers were combined.

Table 10. Mean, variance, and t-statistic comparing males and females for selected scale variables of age-2.2 sockeye salmon sampled from Kvichak, Naknek, Egegik, and Ugashik Rivers, 1991.

River	Sex		S1FW	S2FW	SPGZ	S1FW+S2FW+ SPGZ	S1OZ	
Kvichak River	Male	Sample Size	65	65	55	65	65	
		Mean	129.98	105.78	10.71	244.83	404.46	
		Variance	258.36	153.64	17.06	398.30	1,445.03	
	Female	Sample Size	80	80	69	80	80	
		Mean	130.73	100.44	10.78	240.35	399.18	
		Variance	192.38	133.36	19.58	212.61	1,028.68	
	Combined	Sample Size	150	150	125	150	150	
		Mean	130.73	102.79	10.73	242.46	401.27	
		Variance	230.40	146.96	18.23	296.88	1,178.28	
	T-Statistic			-0.30	2.68 ^a	-0.09	1.56	0.91
	Naknek River	Male	Sample Size	58	58	54	58	58
			Mean	129.69	101.52	12.15	242.52	392.14
Variance			413.83	228.75	29.07	576.39	1,771.14	
Female		Sample Size	92	92	87	92	92	
		Mean	130.51	102.51	14.05	245.22	396.46	
		Variance	431.84	353.45	36.00	409.21	1,152.14	
Combined		Sample Size	150	150	141	150	150	
		Mean	130.19	102.51	13.32	245.22	394.79	
		Variance	422.21	305.90	21.38	475.06	1,385.66	
T-Statistic			-0.24	-0.34	-1.90	-0.74	-0.69	
Egegik River		Male	Sample Size	80	80	65	80	80
			Mean	169.91	111.51	10.40	289.88	405.56
	Variance		553.30	150.51	16.03	568.44	1,364.05	
	Female	Sample Size	119	119	97	119	119	
		Mean	166.37	111.87	9.98	286.38	391.41	
		Variance	511.61	144.16	8.98	490.37	1,292.23	
	Combined	Sample Size	200	200	162	200	200	
		Mean	167.66	111.58	10.15	287.45	396.94	
		Variance	529.90	149.98	11.77	541.68	1,361.04	
	T-Statistic			1.07	-0.21	0.76	1.06	2.69 ^a

-Continued-

Table 10. (p 2 of 2).

River	Sex		S1FW	S2FW	SPGZ	S1FW+S2FW+ SPGZ	S1OZ	
Ugashik River	Male	Sample Size	88	88	73	88	88	
		Mean	113.86	105.75	11.41	229.08	400.35	
		Variance	152.28	177.50	18.08	234.33	1,623.43	
	Female	Sample Size	112	112	88	112	112	
		Mean	112.25	106.36	10.96	227.61	387.96	
		Variance	158.08	171.29	15.47	230.85	1,215.39	
	Combined	Sample Size	200	200	165	200	200	
		Mean	112.96	106.09	11.16	228.26	393.42	
		Variance	155.40	173.24	16.57	231.75	1,425.67	
	T-Statistic			0.91	-0.32	0.71	0.68	2.33 ^a

^a Significant at $\alpha = 0.05$

Table 11. Mean and standard error of age-2.2 scale variables used to construct linear discriminant functions for the East Side of Bristol Bay, 1991.

Variable Number	Variable Name	Kvichak		Naknek		Egegik		Ugashik	
		Mean ^a	SE						
<u>First Freshwater Annular Zone</u>									
5	C0-C6	98.16	0.685	95.89	0.749	101.01	0.626	87.75	0.490
8	C2-C6	48.64	0.442	47.53	0.472	51.09	0.413	41.22	0.322
10	C4-C6	22.93	0.250	22.08	0.265	24.07	0.222	18.90	0.182
16	C0-C2/S1FW	0.38	0.005	0.38	0.004	0.30	0.003	0.42	0.003
25	(C(NC-4)-E1FW)/S1FW	0.27	0.004	0.27	0.005	0.21	0.002	0.29	0.003
27	S1FW/NC1FW	13.41	0.098	13.00	0.091	12.83	0.068	12.24	0.066
<u>Second Freshwater Annular Zone</u>									
36	E1FW-C8	91.15	0.581	86.44	0.612	96.04	0.517	92.71	0.524
42	C(NC-4)-E2FW	34.79	0.362	34.35	0.402	40.29	0.336	35.88	0.305
47	E1FW-C4/S2FW	0.48	0.006	0.45	0.006	0.43	0.004	0.47	0.005
50	C2-C4/S2FW	0.25	0.003	0.23	0.004	0.22	0.002	0.25	0.003
54	C4-C8/S2FW	0.41	0.003	0.40	0.004	0.44	0.003	0.41	0.002
55	(C(NC-4)-E2FW)/S2FW	0.34	0.005	0.34	0.006	0.37	0.004	0.34	0.004
<u>Freshwater and Plus Growth Zones</u>									
64	S1FW+S2FW	233.52	1.379	232.70	1.809	279.23	1.693	219.05	1.093
66	S1FW+S2FW+SPGZ	242.46	1.407	245.22	1.780	287.45	1.646	228.26	1.076
67	S1FW/S1FW+S2FW+SPGZ	0.54	0.004	0.53	0.005	0.58	0.003	0.50	0.003
<u>First Marine Annular Zone</u>									
76	EFW-C15	310.00	1.694	309.91	1.524	308.12	1.307	304.61	1.518
78	C3-C9	142.67	1.097	142.48	1.055	141.38	0.817	136.11	0.873
86	C(NC-3)-E10Z	39.54	0.483	39.33	0.448	36.82	0.361	38.42	0.358
96	C3-C9/S10Z	0.36	0.003	0.36	0.003	0.36	0.003	0.35	0.002
102	C9-C15/S10Z	0.28	0.002	0.30	0.002	0.29	0.002	0.30	0.002
104	(C(NC-3)-E10Z)/S10Z	0.10	0.001	0.10	0.001	0.09	0.001	0.10	0.001

^a Scale images projected at 100x magnification and measured at 0.01 in; therefore, variable means are in 0.0001 in.

Table 12. Classification matrices from discriminant analyses of age-2.2 sockeye salmon sampled from Kvichak, Naknek, Egegik, and Ugashik Rivers, 1991.

Actual Group Of Origin	Sample Size	Classified Group of Origin (%)			
		<u>Kvichak</u>	<u>Naknek</u>	<u>Egegik</u>	<u>Ugashik</u>
Kvichak	149	<u>54.4</u>	23.5	5.4	16.8
Naknek	146	21.9	<u>55.5</u>	7.5	15.1
Egegik	198	3.5	8.1	<u>85.9</u>	2.5
Ugashik	197	10.7	9.1	0.0	<u>80.2</u>

Mean classification accuracy = 69.0%
 Variables used: 64,36,27,54,78,67,10,102
 Box's Test of Variance-Covariance Equality^a
 F-statistic = 2.82
 df = 108, 910839
 P = 0.000

Actual Group Of Origin	Sample Size	Classified Group of Origin (%)		
		<u>Kvichak/Naknek^b</u>	<u>Egegik</u>	<u>Ugashik</u>
Kvichak/Naknek	295	<u>72.9</u>	6.1	21.0
Egegik	198	8.1	<u>86.9</u>	5.1
Ugashik	197	13.7	0.0	<u>86.3</u>

Mean classification accuracy = 82.0%
 Variables used: 64,8,36,54,78,27,96,42,104,25
 Box's Test of Variance-Covariance Equality
 F-statistic = 3.19
 df = 110, 1029022
 P = 0.020

-Continued-

Table 12. (p 2 of 2).

Actual Group Of Origin	Sample Size	Classified Group of Origin (%)	
		<u>Kvichak/Naknek</u>	<u>Egeqik</u>
Kvichak/Naknek	295	<u>92.9</u>	7.1
Egeqik	198	9.6	<u>90.4</u>

Mean classification accuracy = 91.6%
 Variables used: 64,54,27,76,42,86,50
 Box's Test of Variance-Covariance Equality
 F-statistic = 2.50
 df = 28, 625141
 P = 0.002

Actual Group Of Origin	Sample Size	Classified Group of Origin (%)	
		<u>Egeqik</u>	<u>Ugashik</u>
Egeqik	200	<u>95.0</u>	5.0
Ugashik	200	1.5	<u>98.5</u>

Mean classification accuracy = 96.7%
 Variables used: 66,16,50,5,8,96,47,55
 Box's Test of Variance-Covariance Equality
 F-statistic = 2.11
 D.F. = 28, 551970
 P = 0.002

^a The equality of the variance-covariance matrices tested with a procedure described by Box (1949).

^b Samples from Kvichak and Naknek Rivers were combined.

Table 13. Run composition estimates and 90% confidence intervals (C.I.) calculated from scale pattern analyses of age-1.3 sockeye salmon by fishery and date for the East Side of Bristol Bay, 1991.

Fishery	Date	Egegik		Other ^a	
		Pt. Est.(%)	90% C.I.	Pt. Est.(%)	90% C.I.
Naknek-Kvichak	6/04-6/30	2.3	(0.0, 7.6)	97.7	(92.4, 100.0)
	7/01-7/03	4.9	(1.0, 8.9)	95.1	(91.1, 99.0)
	7/04-7/06	0.0	Trace ^b	100.0	(96.5, 100.0)
	7/07-7/09	10.2	(3.4, 17.0)	89.8	(83.0, 96.6)
	7/10-7/13	1.4	(0.0, 6.5)	98.6	(93.5, 100.0)
	7/14-7/15	8.0	(1.6, 14.4)	92.0	(85.6, 98.4)
	7/16	1.3	(0.0, 6.4)	98.7	(93.6, 100.0)
	7/17-8/27	5.7	(0.0, 11.7)	94.3	(88.3, 100.0)
Egegik	6/12-6/29	73.7	(65.1, 82.4)	26.3	(17.6, 32.4)
	6/30	77.1	(68.7, 85.5)	22.9	(14.5, 31.3)
	7/01	47.2	(37.4, 57.0)	52.8	(43.0, 62.6)
	7/02	78.2	(69.9, 86.5)	21.8	(13.5, 30.1)
	7/03-7/04	81.6	(73.6, 89.6)	18.4	(10.4, 26.4)
	7/05-7/07	84.7	(77.0, 92.4)	15.3	(7.6, 23.0)
	7/08-7/09	52.5	(43.1, 61.9)	47.5	(38.1, 56.9)
	7/10-7/11	92.7	(86.2, 99.3)	7.3	(0.7, 13.8)
	7/12-7/13	60.1	(50.1, 70.2)	39.9	(29.8, 49.9)
	7/14-8/30	54.4	(44.8, 64.0)	45.6	(36.0, 55.2)
	Ugashik	6/11-6/21	65.8	(50.9, 80.7)	34.2
7/03-7/05		3.4	(0.0, 8.8)	96.6	(91.2, 100.0)
7/06-7/08		8.9	(2.4, 15.5)	91.1	(84.5, 97.6)
7/09-7/10		17.9	(10.1, 25.6)	82.1	(74.4, 89.9)
7/11-7/13		16.8	(9.1, 24.4)	83.2	(75.6, 90.9)
7/14-9/03		9.6	(1.6, 17.7)	90.4	(82.3, 98.4)

^a Represents samples from Kvichak, Naknek, and Ugashik Rivers.

^b Trace was recorded for systems that were originally included in the model used to classify the catch, the point estimates were zero, and the upper bounds of the 90% C.I. was greater than zero.

Table 14. Estimated harvest of age-1.3 sockeye salmon and 90% confidence intervals (C.I.), East Side Bristol Bay, 1991.

District	River	Estimated Percent	Estimated Numbers	Standard Error of Estimate	90% C.I.	
					Lower	Upper
Naknek-Kvichak	Egegik	3.7	207,046	76,658	80,872	333,261
	Other ^a	96.3	5,371,141	112,094	5,186,611	5,555,671
	Total	100.0	5,578,187			
Egegik	Egegik	69.1	1,887,206	60,635	1,787,388	1,987,025
	Other	30.9	884,188	53,921	755,422	932,953
	Total	100.0	2,731,394			
Ugashik	Egegik	13.5	187,735	31,751	135,466	240,003
	Other	86.5	1,198,543	42,113	1,129,217	1,267,870
	Total	100.0	1,386,278			
Total East Side	Egegik	23.4	2,281,987	102,768	2,112,830	2,451,184
	Other	76.6	7,453,872	131,324	7,197,686	7,630,059
	Total	100.0	9,735,859			

^a Kvichak, Naknek, and Ugashik Rivers combined.

Table 15. Run composition estimates and 90% confidence intervals (C.I.) calculated from scale pattern analyses of age-2.2 sockeye salmon by fishery and date for the East Side of Bristol Bay, 1991.

Fishery	Date	Kvichak/Naknek		Egegik		Ugashik	
		Pt. Est. (%)	90% C.I.	Pt. Est. (%)	90% C.I.	Pt. Est. (%)	90% C.I.
Naknek-Kvichak	6/04-6/30	40.4	(24.2, 74.7)	45.5	(26.2, 64.8)	5.0	(0.0, 22.6)
	7/01-7/03	55.3	(45.0, 65.6)	44.7	(34.4, 55.0)	0.0	Trace ^a
	7/04-7/09	77.2	(58.8, 95.6)	20.3	(8.9, 31.6)	2.5	(0.0, 16.5)
	7/10-7/15	62.5	(42.4, 82.6)	23.3	(10.7, 36.0)	14.1	(0.0, 30.4)
	7/16-8/27	73.3	(63.6, 83.0)	26.7	(17.0, 36.4)	0.0	Trace
Egegik	6/12-6/29	4.2	(0.0, 12.0)	95.8	(88.0, 100)	0.0	Trace
	6/30	1.4	(0.0, 13.1)	95.1	(83.5, 100)	3.5	(0.0, 12.4)
	7/01-7/02	7.1	(0.0, 19.9)	87.0	(74.6, 99.3)	5.9	(0.0, 15.7)
	7/03-7/04	8.1	(0.0, 16.4)	91.9	(83.6, 100)	0.0	Trace
	7/05-7/07	0.0	Trace	87.2	(80.1, 94.2)	12.8	(5.8, 19.9)
	7/08-7/09	1.1	(0.0, 13.2)	95.7	(83.7, 100)	3.2	(0.0, 12.4)
	7/10-7/11	0.6	(0.0, 7.9)	99.4	(92.1, 100)	0.0	Trace
	7/12-7/13	15.2	(5.8, 24.5)	84.8	(75.5, 94.2)	0.0	Trace
	7/14-8/30	18.6	(3.8, 33.4)	80.1	(67.0, 93.1)	1.3	(0.0, 10.7)
Ugashik	6/11-6/21	2.9	(0.0, 39.3)	76.6	(36.3, 100)	20.5	(0.0, 59.9)
	7/03-7/05	9.9	(0.0, 25.9)	6.3	(0.1, 2.4)	83.8	(68.2, 99.5)
	7/06-7/08	20.5	(3.4, 37.7)	10.7	(2.6, 18.8)	68.8	(52.1, 85.5)
	7/09-7/10	21.9	(5.3, 38.6)	25.1	(13.9, 36.3)	53.0	(36.5, 69.4)
	7/11-7/13	19.5	(2.9, 36.2)	13.9	(5.1, 22.7)	66.6	(50.1, 83.0)
	7/14-9/03	21.1	(2.7, 39.4)	5.3	(0.0, 11.9)	73.6	(56.1, 91.1)

^a Trace was recorded for systems that were included in the model used to classify the catch, the point estimates were zero, and the upper bounds of the 90% confidence interval was greater than zero.

Table 16. Estimated harvest of age-2.2 sockeye salmon and 90% confidence intervals (C.I.), East Side Bristol Bay, 1991.

District	River	Estimated Percent	Estimated Numbers	Standard Error of Estimate	90% C.I.	
					Lower	Upper
Naknek-Kvichak	Egegik	28.5	391,633	37,535	311,041	472,224
	Ugashik	3.5	48,220	32,323	0	117,621
	Other ^a	68.0	936,566	58,897	810,110	1,063,023
	Total	100.0	1,376,419			
Egegik	Egegik	90.4	2,195,994	61,878	2,063,135	2,328,852
	Ugashik	3.8	93,163	29,056	30,778	155,549
	Other	5.8	141,518	42,464	50,344	232,693
	Total	100.0	2,430,675			
Ugashik	Egegik	13.1	113,233	17,330	76,024	150,443
	Ugashik	67.4	580,455	37,781	499,323	661,587
	Other	19.5	168,887	33,826	96,259	241,515
	Total	100.0	862,575			
Total East Side	Egegik	57.8	2,700,860	74,419	2,541,075	2,860,644
	Ugashik	15.5	721,838	57,593	598,181	845,494
	Other	26.7	1,246,971	80,102	1,074,986	1,418,957
	Total	100.0	4,669,669			

^a Kvichak and Naknek Rivers combined.

Table 17. Run composition estimates of sockeye salmon catch by age group and date, Naknek-Kvichak District, 1991.

Date	System	0.3		1.2		1.3		2.2		1.4		2.3		Other ^a		Total	
		%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number
6/04 ^b	Kvichak	77.5	158	83.3	64,613	12.1	21,601	25.9	9,078	2.9	34	35.9	38,234	0.0	0	33.5	133,719
thru	Naknek	21.4	44	11.8	9,186	80.8	144,247	23.6	8,272	96.7	1,134	57.3	60,972	0.0	0	56.1	223,854
6/30	Egegik	0.3	1	2.2	1,729	2.3	4,106	45.5	15,948	0.4	4	5.5	5,893	0.0	0	6.9	27,681
	Ugashik	0.8	2	2.7	2,071	4.8	8,569	5.0	1,753	0.0	0	1.3	1,386	0.0	0	3.5	13,781
	Total	100.0	204	100.0	77,599	100.0	178,524	100.0	35,050	100.0	1,173	100.0	106,485	0.0	0	100.0	399,035
7/01	Kvichak	80.6	10,292	86.4	346,556	12.3	133,814	28.9	103,223	3.5	63	39.1	196,587	66.7	3644	33.5	794,179
thru	Naknek	18.9	2,405	10.4	41,605	82.8	900,799	26.4	94,294	95.9	1,748	52.6	264,728	0.0	0	55.1	1,305,580
7/03	Egegik	0.5	59	3.2	12,748	4.9	53,308	44.7	159,656	0.6	11	8.3	41,644	33.3	1822	11.4	269,248
	Ugashik	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
	Total	100.0	12,756	100.0	400,909	100.0	1,087,922	100.0	357,173	100.0	1,822	100.0	502,959	100.0	5,466	100.0	2,369,007
7/04	Kvichak	79.8	7,457	87.3	383,670	12.8	169,421	40.4	103,924	3.3	304	40.1	123,642	0.0	0	33.6	788,418
thru	Naknek	19.9	1,865	11.2	49,278	85.6	1,133,002	36.8	94,663	96.6	9,039	57.7	178,128	0.0	0	62.4	1,465,975
7/06	Egegik	0.1	9	0.7	3,001	0.0	0	20.3	52,219	0.1	11	1.8	5,569	0.0	0	2.6	60,809
	Ugashik	0.2	23	0.8	3,692	1.6	21,178	2.5	6,431	0.0	0	0.4	1,346	0.0	0	1.4	32,670
	Total	100.0	9,354	100.0	439,642	100.0	1,323,601	100.0	257,237	100.0	9,354	100.0	308,684	0.0	0	100.0	2,347,872
7/07	Kvichak	83.8	6,859	88.4	332,715	11.5	104,450	40.4	143,799	0.0	0	44.7	201,182	0.0	0	37.6	789,005
thru	Naknek	15.6	1,275	8.4	31,756	76.8	697,544	36.8	130,986	0.0	0	47.9	215,380	0.0	0	51.3	1,076,940
7/09	Egegik	0.4	29	2.4	9,048	10.2	92,643	20.3	72,256	0.0	0	7.0	31,508	0.0	0	9.8	205,484
	Ugashik	0.2	19	0.8	2,876	1.5	13,624	2.5	8,898	0.0	0	0.4	1,967	0.0	0	1.3	27,384
	Total	100.0	8,182	100.0	376,395	100.0	908,260	100.0	355,939	0.0	0	100.0	450,037	0.0	0	100.0	2,098,813
7/10	Kvichak	76.6	1,894	81.4	141,499	11.5	156,544	32.8	62,128	2.9	157	36.1	136,909	0.0	0	23.6	499,131
thru	Naknek	21.5	532	11.7	20,416	76.9	1,046,803	29.8	56,446	96.9	5,243	58.5	221,569	0.0	0	64.0	1,351,009
7/13	Egegik	0.1	3	1.0	1,674	1.4	19,058	23.3	44,134	0.2	9	2.5	9,328	100.0	2473	3.6	76,679
	Ugashik	1.8	44	5.9	10,207	10.2	138,848	14.1	26,708	0.0	0	2.9	11,169	0.0	0	8.8	186,975
	Total	100.0	2,473	100.0	173,796	100.0	1,361,252	100.0	189,415	100.0	5,409	100.0	378,976	100.0	2,473	100.0	2,113,794

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Table 17. (p 2 of 2).

Date	System	0.3		1.2		1.3		2.2		1.4		2.3		Other ^a		Total	
		%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number
7/14	Kvichak	0.0	0	80.7	19,590	10.7	21,854	32.8	10,306	3.0	21	35.6	12,964	0.0	0	21.7	64,736
thru	Naknek	0.0	0	11.2	2,718	71.8	146,646	29.8	9,364	96.6	690	55.4	20,173	0.0	0	60.4	179,590
7/15	Egegik	0.0	0	2.4	590	8.0	16,339	23.3	7,321	0.4	3	6.2	2,249	100.0	714	9.1	27,217
	Ugashik	0.0	0	5.7	1,383	9.5	19,403	14.1	4,431	0.0	0	2.8	1,035	0.0	0	8.8	26,252
	Total	0.0	0	100.0	24,281	100.0	204,243	100.0	31,422	100.0	714	100.0	36,421	100.0	714	100.0	297,795
7/16	Kvichak	79.4	350	87.4	35,853	12.8	22,481	38.3	12,845	3.2	14	39.2	12,798	0.0	0	29.7	84,342
	Naknek	20.4	90	11.5	4,720	85.9	150,869	35.0	11,738	96.6	426	57.9	18,897	87.3	385	65.8	187,125
	Egegik	0.2	1	1.1	467	1.3	2,283	26.7	8,955	0.2	1	2.9	960	12.7	56	4.5	12,722
	Ugashik	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
	Total	100.0	441	100.0	41,040	100.0	175,633	100.0	33,538	100.0	441	100.0	32,655	100.0	441	100.0	284,189
7/17 ^b	Kvichak	0.0	0	88.5	79,183	12.2	41,328	38.3	44,675	0.0	0	43.0	28,142	0.0	0	31.6	193,328
thru	Naknek	0.0	0	9.4	8,398	82.1	278,115	35.0	40,826	0.0	0	51.1	33,478	0.0	0	58.9	360,816
8/27	Egegik	0.0	0	2.1	1,902	5.7	19,309	26.7	31,144	0.0	0	5.9	3,893	100.0	1,598	9.5	57,846
	Ugashik	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
	Total	0.0	0	100.0	89,482	100.0	338,752	100.0	116,645	0.0	0	100.0	65,513	100.0	1,598	100.0	611,990
Total	Kvichak	80.8	27,011	86.5	1,403,679	12.0	671,494	35.6	489,978	3.1	594	39.9	750,458	34.1	3,644	31.8	3,346,858
	Naknek	18.6	6,210	10.4	168,075	80.7	4,498,026	32.4	446,588	96.7	18,280	53.8	1,013,325	3.6	385	58.5	6,150,889
	Egegik	0.3	102	1.9	31,159	3.7	207,046	28.5	391,633	0.2	39	5.4	101,044	62.3	6,663	7.0	737,686
	Ugashik	0.3	87	1.2	20,231	3.6	201,621	3.5	48,220	0.0	0	0.9	16,903	0.0	0	2.7	287,062
	Total	100.0	33,410	100.0	1,623,144	100.0	5,578,187	100.0	1,376,419	100.0	18,913	100.0	1,881,730	100.0	10,692	100.0	10,522,495

^a Other includes ages 0.2, 0.4, 2.4, and 3.3.

^b Scale samples were collected on 17, 19, and 30 June. Stock composition estimates calculated for these dates were applied to 4 through 30 June catches.

^c Scale samples were collected on 17 and 18 July. Stock composition estimates calculated for these dates were applied to 17 July through 27 August catches.

Table 18. Run composition estimates of sockeye salmon setnet catch from selected beaches, Naknek Section, Naknek-Kvichak District, 1991.

Beach	Date	Percent Classification by Stock				Total
		Kvichak	Naknek	Egegik	Ugashik	
Libbyville to Pederson Pt.	7/10	33.0	67.0	0.0	0.0	100.0
Pederson Pt. to Inside Marker	7/10	32.7	66.5	0.9	0.0	100.0
South Naknek Beach	7/11	24.0	29.4	46.6	0.0	100.0

Table 19. Run composition estimates of sockeye salmon catch by age group and date, Egegik District, 1991.

Date	System	1.2		1.3		2.2		1.4		2.3		2.4		3.3		Other ^a		Total	
		%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number
6/12 ^b	Kvichak	42.2	2,824	3.4	358	2.2	233	0.0	0	10.5	301	0.0	0	0.0	0	74.2	556	13.6	4,273
thru	Naknek	5.4	358	22.9	2,415	2.0	212	0.0	0	14.9	429	0.0	0	0.0	0	14.5	109	11.2	3,523
6/29	Egegik	52.4	3,503	73.7	7,771	95.8	10,157	0.0	0	74.6	2,152	0.0	0	100.0	58	11.3	85	75.2	23,725
	Ugashik	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
	Total	100.0	6,685	100.0	10,544	100.0	10,602	0.0	0	100.0	2,882	0.0	0	100.0	58	100.0	750	100.0	31,521
6/30	Kvichak	18.0	5,550	1.2	1,325	0.7	609	0.0	0	4.1	1,274	0.0	0	0.0	0	24.4	238	3.5	8,996
	Naknek	2.8	875	9.1	10,050	0.7	609	0.0	0	7.3	2,251	0.0	0	0.0	0	7.2	71	5.3	13,855
	Egegik	64.1	19,723	77.1	85,148	95.1	82,722	0.0	0	84.7	26,061	0.0	0	100.0	489	62.1	608	82.4	214,751
	Ugashik	15.1	4,637	12.6	13,915	3.5	3,044	0.0	0	3.9	1,201	0.0	0	0.0	0	6.3	61	8.8	22,860
	Total	100.0	30,786	100.0	110,438	100.0	86,984	0.0	0	100.0	30,787	0.0	0	100.0	489	100.0	978	100.0	260,462
7/01	Kvichak	51.2	25,176	4.8	21,453	3.7	5,741	2.5	23	16.5	20,637	0.0	0	0.0	0	48.7	1,357	9.4	74,388
	Naknek	8.0	3,962	32.3	144,361	3.4	5,276	91.4	849	29.0	36,426	17.1	477	0.0	0	13.8	386	24.3	191,736
	Egegik	26.6	13,113	47.2	210,955	87.0	135,001	6.1	56	49.3	61,902	82.9	2,310	100.0	4,646	33.4	932	54.5	428,915
	Ugashik	14.2	6,997	15.7	70,169	5.9	9,155	0.0	0	5.2	6,475	0.0	0	0.0	0	4.0	112	11.8	92,909
	Total	100.0	49,247	100.0	446,938	100.0	155,174	100.0	929	100.0	125,440	100.0	2,787	100.0	4,646	100.0	2,787	100.0	787,948
7/02	Kvichak	36.7	13,866	2.0	6,859	3.7	4,406	2.7	20	9.5	9,188	0.0	0	0.0	0	44.9	960	5.8	35,298
	Naknek	4.6	1,748	13.3	45,612	3.4	4,048	80.1	571	13.5	12,993	6.0	128	0.0	0	10.7	228	10.8	65,328
	Egegik	49.6	18,736	78.2	268,185	87.0	103,589	17.2	123	74.3	71,499	94.0	2,011	100.0	3,565	41.0	877	77.5	468,585
	Ugashik	9.1	3,438	6.5	22,292	5.9	7,025	0.0	0	2.7	2,572	0.0	0	0.0	0	3.4	74	5.9	35,401
	Total	100.0	37,788	100.0	342,947	100.0	119,068	100.0	713	100.0	96,253	100.0	2,139	100.0	3,565	100.0	2,139	100.0	604,612
7/03	Kvichak	47.2	47,153	2.4	8,821	4.2	20,828	4.3	63	12.7	17,176	0.0	0	0.0	0	28.7	1,257	8.6	95,298
thru	Naknek	3.6	3,554	16.0	58,808	3.9	19,340	74.9	1,092	10.8	14,522	4.7	34	0.0	0	3.9	170	8.8	97,521
7/04	Egegik	49.2	49,203	81.6	299,921	91.9	455,734	20.8	304	76.5	103,216	95.3	695	100.0	4,376	67.4	2,947	82.6	916,395
	Ugashik	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
	Total	100.0	99,910	100.0	367,550	100.0	495,902	100.0	1,458	100.0	134,915	100.0	729	100.0	4,376	100.0	4,374	100.0	1,109,214
7/05	Kvichak	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
thru	Naknek	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
7/07	Egegik	72.7	68,561	84.7	293,657	87.2	407,900	100.0	1,376	93.2	118,556	100.0	688	100.0	4,127	84.4	3,485	85.9	898,351
	Ugashik	27.3	25,682	15.3	53,046	12.8	59,875	0.0	0	6.8	8,706	0.0	0	0.0	0	15.6	643	14.1	147,951
	Total	100.0	94,243	100.0	346,703	100.0	467,775	100.0	1,376	100.0	127,262	100.0	688	100.0	4,127	100.0	4,128	100.0	1,046,302

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Table 19. (p 2 of 2).

Date	System	1.2		1.3		2.2		1.4		2.3		2.4		3.3		Other ^a		Total	
		%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number
7/08	Kvichak	26.6	27,167	2.7	10,678	0.6	1,946	0.0	0	7.5	10,329	0.0	0	0.0	0	0.0	0	5.2	50,120
thru	Naknek	4.0	4,091	16.4	64,860	0.5	1,622	0.0	0	12.6	17,447	0.0	0	0.0	0	0.0	0	9.2	88,020
7/09	Egegik	44.8	45,646	52.5	207,631	95.7	310,460	0.0	0	72.1	99,939	0.0	0	0.0	0	0.0	0	69.1	663,676
	Ugashik	24.6	25,158	28.4	112,319	3.2	10,381	0.0	0	7.8	10,798	0.0	0	0.0	0	0.0	0	16.5	158,656
	Total	100.0	102,062	100.0	395,488	100.0	324,410	0.0	0	100.0	138,512	0.0	0	0.0	0	0.0	0	100.0	960,472
7/10	Kvichak	12.7	14,120	0.9	2,811	0.3	1,030	1.5	17	2.4	2,365	0.0	0	0.0	0	0.0	0	2.3	20,344
thru	Naknek	2.0	2,210	6.4	19,988	0.3	1,030	52.8	633	4.2	4,152	1.6	19	0.0	0	0.0	0	3.2	28,031
7/11	Egegik	85.3	94,951	92.7	289,507	99.4	341,355	45.7	547	93.4	91,601	98.4	1,178	0.0	0	0.0	0	94.5	819,138
	Ugashik	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
	Total	100.0	111,281	100.0	312,305	100.0	343,415	100.0	1,197	100.0	98,118	100.0	1,197	0.0	0	0.0	0	100.0	867,513
7/12	Kvichak	64.7	20,110	5.1	6,852	7.9	11,383	4.2	39	21.6	13,556	0.0	0	0.0	0	27.6	346	13.7	52,288
thru	Naknek	5.8	1,806	34.8	46,758	7.3	10,519	86.9	819	21.8	13,658	11.9	149	0.0	0	4.1	52	19.4	73,761
7/13	Egegik	29.5	9,163	60.1	80,751	84.8	122,192	8.9	84	56.6	35,571	88.1	1,107	100.0	4,707	68.3	858	66.9	254,432
	Ugashik	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
	Total	100.0	31,079	100.0	134,361	100.0	144,094	100.0	942	100.0	62,786	100.0	1,256	100.0	4,707	100.0	1,256	100.0	380,481
7/14	Kvichak	68.6	41,861	5.7	15,055	9.7	27,475	4.5	83	24.8	30,645	0.0	0	0.0	0	29.7	732	15.5	115,851
thru	Naknek	5.8	3,557	38.3	101,158	8.9	25,209	88.1	1,631	23.7	29,207	14.0	345	0.0	0	4.1	101	21.6	161,209
8/30	Egegik	24.4	14,933	54.4	143,681	80.1	226,884	7.4	138	51.0	62,955	86.0	2,123	100.0	9,258	65.9	1,627	61.7	461,599
	Ugashik	1.2	742	1.6	4,226	1.3	3,682	0.0	0	0.5	613	0.0	0	0.0	0	0.3	8	1.2	9,270
	Total	100.0	61,093	100.0	264,120	100.0	283,251	100.0	1,851	100.0	123,420	100.0	2,468	100.0	9,258	100.0	2,468	100.0	747,929
Total	Kvichak	31.7	197,827	2.7	74,213	3.0	73,652	2.9	245	11.2	105,472	0.0	0	0.0	0	28.9	5,448	6.7	456,856
	Naknek	3.6	22,161	18.1	494,008	2.8	67,866	66.1	5,594	13.9	131,086	10.2	1,152	0.0	0	5.9	1,116	10.6	722,984
	Egegik	54.0	337,531	69.1	1,887,206	90.4	2,195,994	31.0	2,627	71.7	673,452	89.8	10,112	100.0	31,226	60.5	11,418	75.8	5,149,567
	Ugashik	10.7	66,655	10.1	275,967	3.8	93,163	0.0	0	3.2	30,365	0.0	0	0.0	0	4.8	898	6.9	467,047
	Total	100.0	624,174	100.0	2,731,394	100.0	2,430,675	100.0	8,466	100.0	940,375	100.0	11,264	100.0	31,226	100.0	18,880	100.0	6,796,454

^a Other includes ages 0.2, 0.3, 2.1, and 3.2.

^b Scale samples were collected on 21 June. Stock composition estimates calculated for that date were applied to 12 through 29 June catches.

^c Scale samples were collected on 16 and 18 July. Stock composition estimates calculated for these dates were applied to 14 July through 30 August catches.

Table 20. Run composition estimates of sockeye salmon setnet catch from selected beaches, Egegik District, 1991.

Beach	Date	Percent Classification by Stock				Total
		Kvichak	Naknek	Egegik	Ugashik	
Big Creek to Bishop Creek	7/09	5.5	1.8	92.7	0.0	100.0
Bishop Creek to Coffee Point	7/08	5.3	2.5	85.3	6.9	100.0

Table 21. Run composition estimates of sockeye salmon catch by age group and date, Ugashik District, 1991.

Date	System	0.3		1.2		1.3		2.2		1.4		2.3		Other ^a		Total	
		%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number
6/11 ^b	Kvichak	42.5	262	17.2	234	1.0	67	1.5	30	0.0	0	5.1	89	100.0	246	7.4	927
thru	Naknek	11.4	70	2.4	32	6.5	433	1.4	28	0.0	0	7.9	136	0.0	0	5.6	699
6/21	Egegik	16.6	102	43.2	586	65.8	4,381	76.6	1,511	0.0	0	74.4	1,283	0.0	0	62.5	7,864
	Ugashik	29.5	181	37.2	505	26.7	1,778	20.5	404	0.0	0	12.6	217	0.0	0	24.5	3,086
	Total	100.0	616	100.0	1,357	100.0	6,658	100.0	1,973	0.0	0	100.0	1,726	100.0	246	100.0	12,576
7/03	Kvichak	52.8	308	29.8	10,299	2.4	3,655	5.2	5,015	0.0	0	20.6	4,340	0	0	7.7	23,617
thru	Naknek	9.6	56	2.8	966	15.7	23,907	4.7	4,533	0.0	0	21.7	4,567	0	0	11.2	34,029
7/05	Egegik	0.4	3	1.6	547	3.4	5,177	6.3	6,076	0.0	0	6.3	1,328	0	0	4.3	13,132
	Ugashik	37.2	217	65.8	22,677	78.5	119,534	83.8	80,825	0.0	0	51.4	10,808	0	0	76.8	234,062
	Total	100.0	584	100.0	34,489	100.0	152,273	100.0	96,450	0.0	0	100.0	21,044	0.0	0	100.0	304,840
7/06	Kvichak	0.0	0	49.1	17,233	4.4	7,297	10.7	9,700	0.0	0	29.2	9,033	0.0	0	13.4	43,262
thru	Naknek	0.0	0	4.7	1,666	29.3	48,591	9.8	8,884	0.0	0	31.7	9,798	0.0	0	21.3	68,940
7/08	Egegik	0.0	0	2.9	1,015	8.9	14,760	10.7	9,700	0.0	0	9.9	3,065	100.0	703	9.0	29,243
	Ugashik	0.0	0	43.3	15,221	57.4	95,192	68.8	62,368	0.0	0	29.2	9,023	0.0	0	56.3	181,805
	Total	0.0	0	100.0	35,136	100.0	165,840	100.0	90,651	0.0	0	100.0	30,920	100.0	703	100.0	323,250
7/09	Kvichak	69.5	1,287	52.8	46,956	4.8	24,268	11.5	25,131	0.0	0	27.5	37,122	0	0	14.2	134,764
thru	Naknek	14.4	267	5.6	5,002	31.9	161,283	10.4	22,727	0.0	0	32.8	44,355	0	0	24.6	233,634
7/10	Egegik	1.3	24	6.4	5,657	17.9	90,500	25.1	54,852	0.0	0	19.0	25,753	0	0	18.6	176,786
	Ugashik	14.8	274	35.2	31,279	45.4	229,537	53.0	115,822	0.0	0	20.7	27,964	0	0	42.6	404,878
	Total	100.0	1,852	100.0	88,894	100.0	505,589	100.0	218,533	0.0	0	100.0	135,194	0.0	0	100.0	950,062
7/11	Kvichak	69.0	810	49.2	34,665	3.9	10,588	10.2	20,140	4.8	113	28.9	17,637	0.0	0	13.9	83,953
thru	Naknek	11.2	132	4.1	2,905	26.4	71,675	9.3	18,363	93.0	2,186	27.1	16,577	0.0	0	18.5	111,839
7/13	Egegik	1.0	12	4.8	3,374	16.8	45,612	13.9	27,446	2.2	51	16.2	9,887	100.0	1,175	14.5	87,557
	Ugashik	18.8	221	41.9	29,573	52.9	143,622	66.6	131,503	0.0	0	27.8	17,015	0.0	0	53.1	321,935
	Total	100.0	1,175	100.0	70,518	100.0	271,498	100.0	197,452	100.0	2,350	100.0	61,116	100.0	1,175	100.0	605,284

-Continued-

Table 21. (p 2 of 2).

Date	System	0.3		1.2		1.3		2.2		1.4		2.3		Other ^a		Total	
		%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number
7/14 ^b	Kvichak	70.3	1,352	51.2	55,053	4.2	11,946	11.0	28,327	5.3	103	32.9	31,003	0.0	0	17.0	127,782
thru	Naknek	10.4	200	3.9	4,175	28.4	80,775	10.1	26,009	93.7	1,800	28.0	26,370	0.0	0	18.6	139,328
9/03	Egegik	0.5	9	2.1	2,292	9.6	27,304	5.3	13,648	1.0	20	7.9	7,433	100.0	1,922	7.0	52,629
	Ugashik	18.8	362	42.8	46,100	57.8	164,395	73.6	189,532	0.0	0	31.2	29,359	0.0	0	57.4	429,748
	Total	100.0	1,922	100.0	107,619	100.0	284,420	100.0	257,516	100.0	1,922	100.0	94,166	100.0	1,922	100.0	749,487
Total	Kvichak	65.4	4,018	48.6	164,439	4.2	57,820	10.2	88,343	5.0	215	28.8	99,224	6.1	246	14.1	414,305
	Naknek	11.8	725	4.4	14,746	27.9	386,664	9.3	80,544	93.3	3,986	29.6	101,804	0.0	0	20.0	588,469
	Egegik	2.4	150	4.0	13,472	13.5	187,735	13.1	113,233	1.7	71	14.2	48,750	93.9	3,800	12.5	367,211
	Ugashik	20.4	1,256	43.0	145,356	54.4	754,059	67.4	580,455	0.0	0	27.4	94,388	0.0	0	53.4	1,575,514
	Total	100.0	6,149	100.0	338,013	100.0	1,386,278	100.0	862,575	100.0	4,272	100.0	344,166	100.0	4,046	100.0	2,945,499

^a Other includes ages 0.4 and 3.3.

^b Scale samples were collected on 21 June. Stock composition estimates calculated for that date were applied to 11 through 21 June catches.

^c Scale samples were collected on 15 July. Stock composition estimates calculated for that date were applied to 14 July through 3 September catches.

Table 22. Catch of sockeye salmon by run and district for the East Side of Bristol Bay, 1991.

Run		District			Total
		Naknek-Kvichak	Egegik	Ugashik	
Kvichak	Numbers	3,346,858	456,856	414,305	4,218,019
	Percent	79.4	10.8	9.8	100.0
Naknek	Numbers	6,150,889	722,984	588,469	7,462,342
	Percent	82.4	9.7	7.9	100.0
Egegik	Numbers	737,686	5,149,567	367,211	6,254,464
	Percent	11.8	82.3	5.9	100.0
Ugashik	Numbers	287,062	467,047	1,575,514	2,329,623
	Percent	12.3	20.0	67.7	100.0
Total	Numbers	10,522,495	6,786,454	2,945,499	20,264,448
	Percent	52.0	33.5	14.5	100.0

Table 23. Numbers of sockeye salmon by run and age group for the East Side of Bristol Bay, 1991.

		0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total
Kvichak	Escapement	8,338	4,390	38,318	2,583,669	30,307	566	337,769	677,990	1,281	539,115	1,045			4,222,788
	In-District Catch	1,822		27,011	1,403,679		1,822	671,494	489,978	594	750,458				3,346,858
	Other Dist. Catch	116		8,745	362,266	255	246	132,033	161,995	460	204,696	349			871,161
	Total Run	10,276	4,390	74,074	4,349,614	30,562	2,634	1,141,296	1,329,963	2,335	1,494,269	1,394			8,440,807
Naknek	Escapement			5,991	207,414	3,695		2,234,203	617,121	23,784	485,429		871		3,578,508
	In-District Catch			6,210	168,075			4,498,026	446,588	18,280	1,013,325		385		6,150,889
	Other Dist. Catch			1,809	36,907	33		880,672	148,410	9,580	232,890		1,152		1,311,453
	Total Run			14,010	412,396	3,728		7,612,901	1,212,119	51,644	1,731,644		2,408		11,040,850
Egegik	Escapement		1127	532	230,173	58,964		868,132	1,341,991	532	276,584	1,495	1,432	5,918	2,786,880
	In-District Catch			1,512	337,531	4,360		1,887,206	2,195,994	2,627	673,452	5,547	10,112	31226	5,149,567
	Other Dist. Catch			252	44,631			394,781	504,866	110	149,794		56	10,407	1,104,897
	Total Run		1,127	2,296	612,335	63,324		3,150,119	4,042,851	3,269	1,099,830	7,042	11,600	47,551	9,041,344
Ugashik	Escapement	484	1,497	2,171	455,629	10,233		944,598	935,364		107,330				2,457,306
	In-District Catch			1,256	145,356			754,059	580,455		94,388				1,575,514
	Other Dist. Catch			936	86,886	48		477,588	141,383		47,268				754,109
	Total Ru	484	1,497	4,363	687,871	10,281		2,176,245	1,657,202		248,986				4,786,929

Table 24. Percentages of sockeye salmon by run and age group for the East Side of Bristol Bay, 1991.

		0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	1.4	2.3	3.2	2.4	3.3	Total
Kvichak	Escapement	0.1	0.1	0.5	30.6	0.4	0.0 ^a	4.0	8.0	0.0	6.4	0.0			50.0
	In District Catch	0.0		0.3	16.6		0.0	8.0	5.8	0.0	8.9				39.7
	Other Dist. Catch	0.0		0.1	4.3	0.0	0.0	1.6	1.9	0.0	2.4	0.0			10.3
	Total Return	0.1	0.1	0.9	51.5	0.4	0.0	13.5	15.8	0.0	17.7	0.0			100.0
Naknek	Escapement			0.1	1.9	0.0		20.2	5.6	0.2	4.4		0.0		32.4
	In District Catch			0.1	1.5			40.7	4.0	0.2	9.2		0.0		55.7
	Other Dist. Catch			0.0	0.3	0.0		8.0	1.3	0.1	2.1		0.0		11.9
	Total Return			0.1	3.7	0.0		69.0	11.0	0.5	15.7		0.0		100.0
Egegik	Escapement		0.0	0.0	2.5	0.7		9.6	14.8	0.0	3.1	0.0	0.0	0.1	30.8
	In District Catch			0.0	3.7	0.0		20.9	24.3	0.0	7.4	0.1	0.1	0.3	57.0
	Other Dist. Catch			0.0	0.5			4.4	5.6	0.0	1.7		0.0	0.1	12.2
	Total Return		0.0	0.0	6.8	0.7		34.8	44.7	0.0	12.2	0.1	0.1	0.5	100.0
Ugashik	Escapement	0.0	0.0	0.0	9.5	0.2		19.7	19.5		2.2				51.3
	In District Catch			0.0	3.0			15.8	12.1		2.0				32.9
	Other Dist. Catch			0.0	1.8	0.0		10.0	3.0		1.0				15.8
	Total Return	0.0	0.0	0.1	14.4	0.2		45.5	34.6		5.2				100.0

^a Represented < 0.1%

Table 25. Comparison of sockeye salmon run estimates for the East Side of Bristol Bay, 1991.

Stock	Estimated Run		Difference
	Standard Method ^a	Scale Pattern Analysis	
Kvichak	8,205,675	8,440,807	- 235,132
Naknek	10,118,116	11,040,850	- 922,734
Egegik	9,583,334	9,041,344	541,990
Ugashik	5,402,805	4,786,929	615,876
Total	33,309,930	33,309,930	

^a Standard method assumes fish harvested in a district originated within that district and divides Naknek-Kvichak District catch to Naknek and Kvichak Rivers based on escapement age composition. These numbers have been adjusted to include Branch River run.

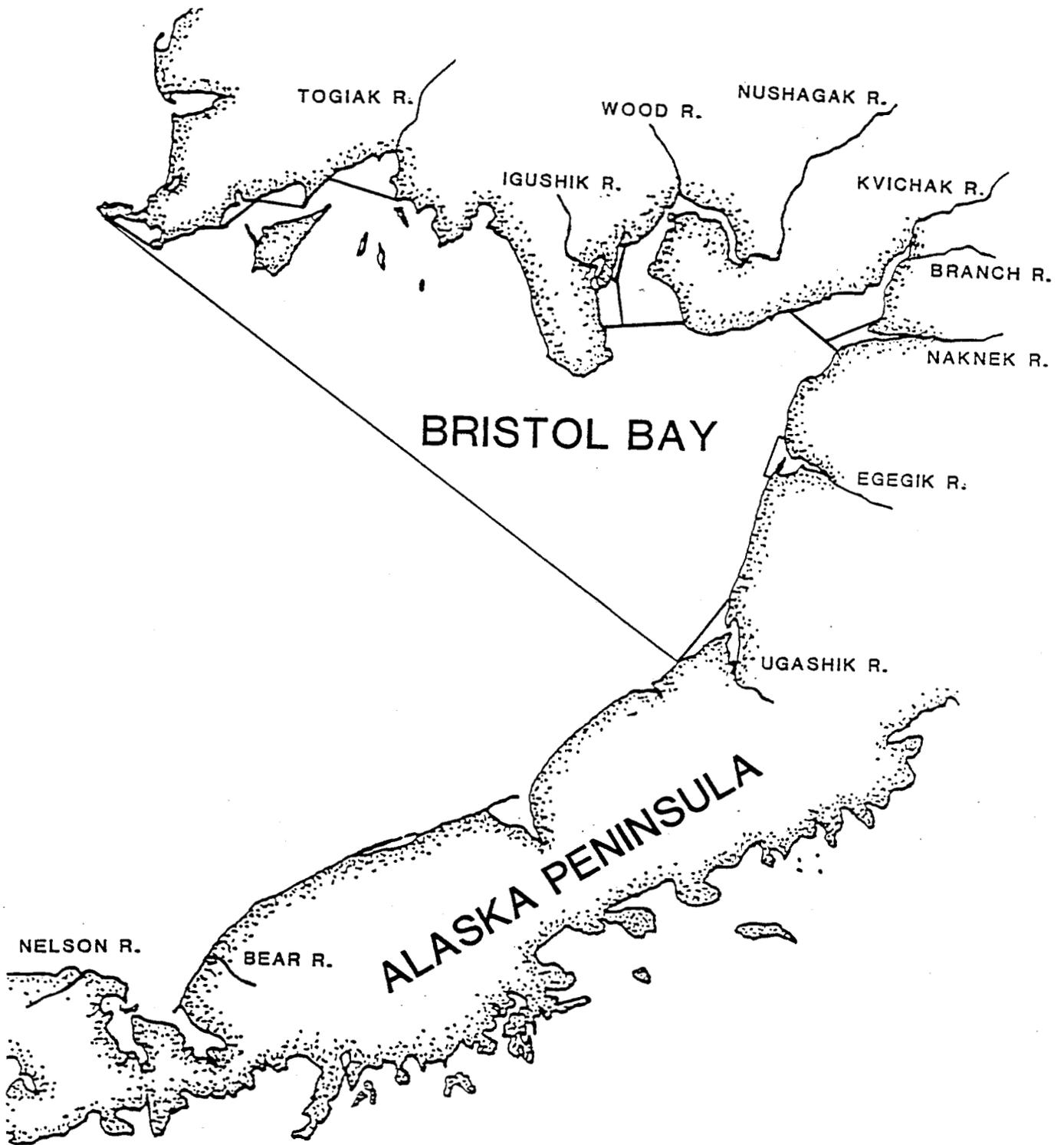


Figure 1. Map of Bristol Bay showing major rivers and fishing districts.

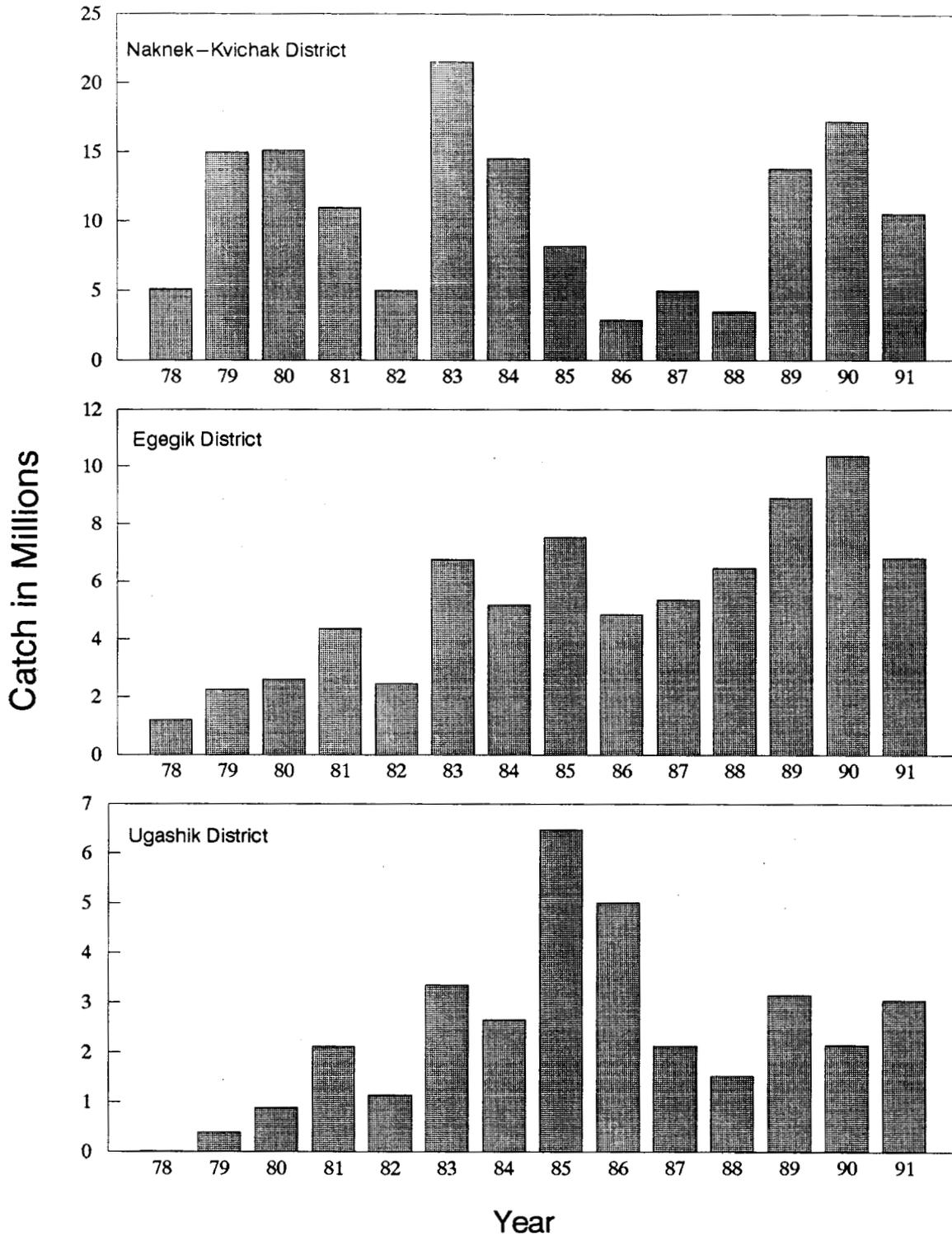


Figure 2. Commercial catch of sockeye salmon in Naknek-Kvichak, Egegik, and Ugashik Districts from 1978 through 1991.

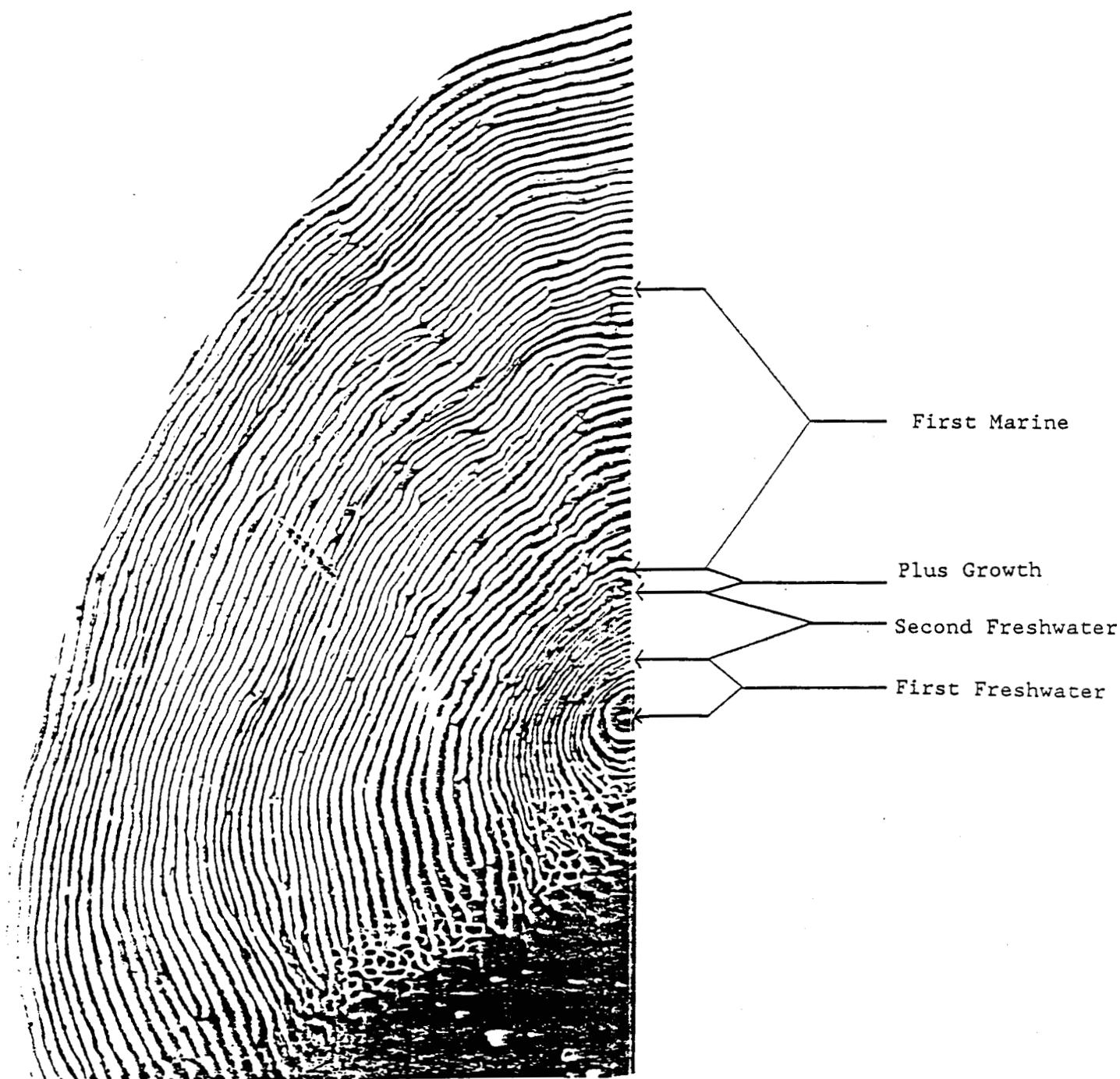


Figure 3. Age-2.2 sockeye salmon scale showing the growth zones measured to generate variables to build linear discriminant functions.

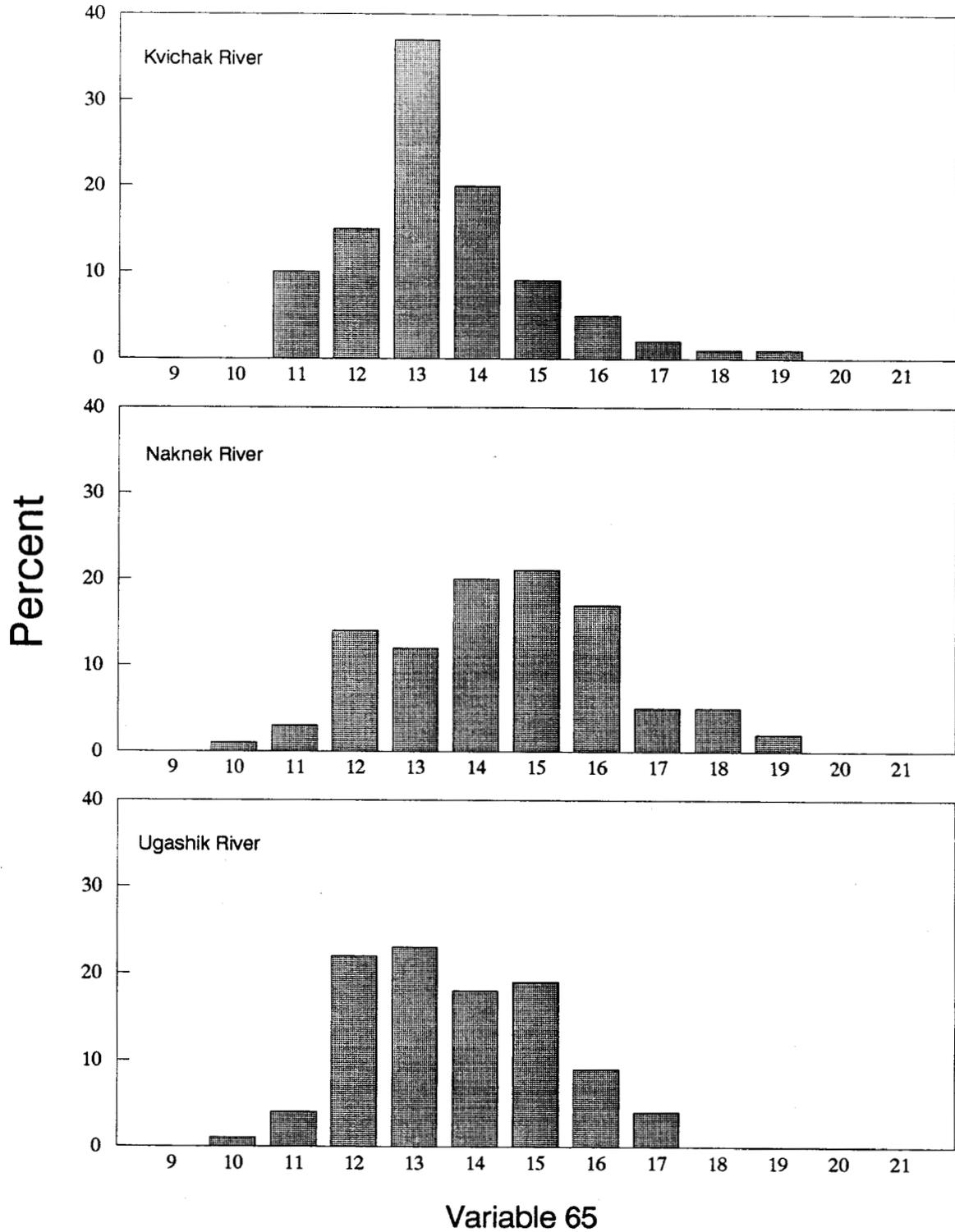


Figure 4. Total number of circuli counted in all freshwater growth zones (NC1FW+ NCPG) on age-1.3 sockeye salmon escapement scales, Kvichak, Naknek, Egegik, Ugashik Rivers, 1991.

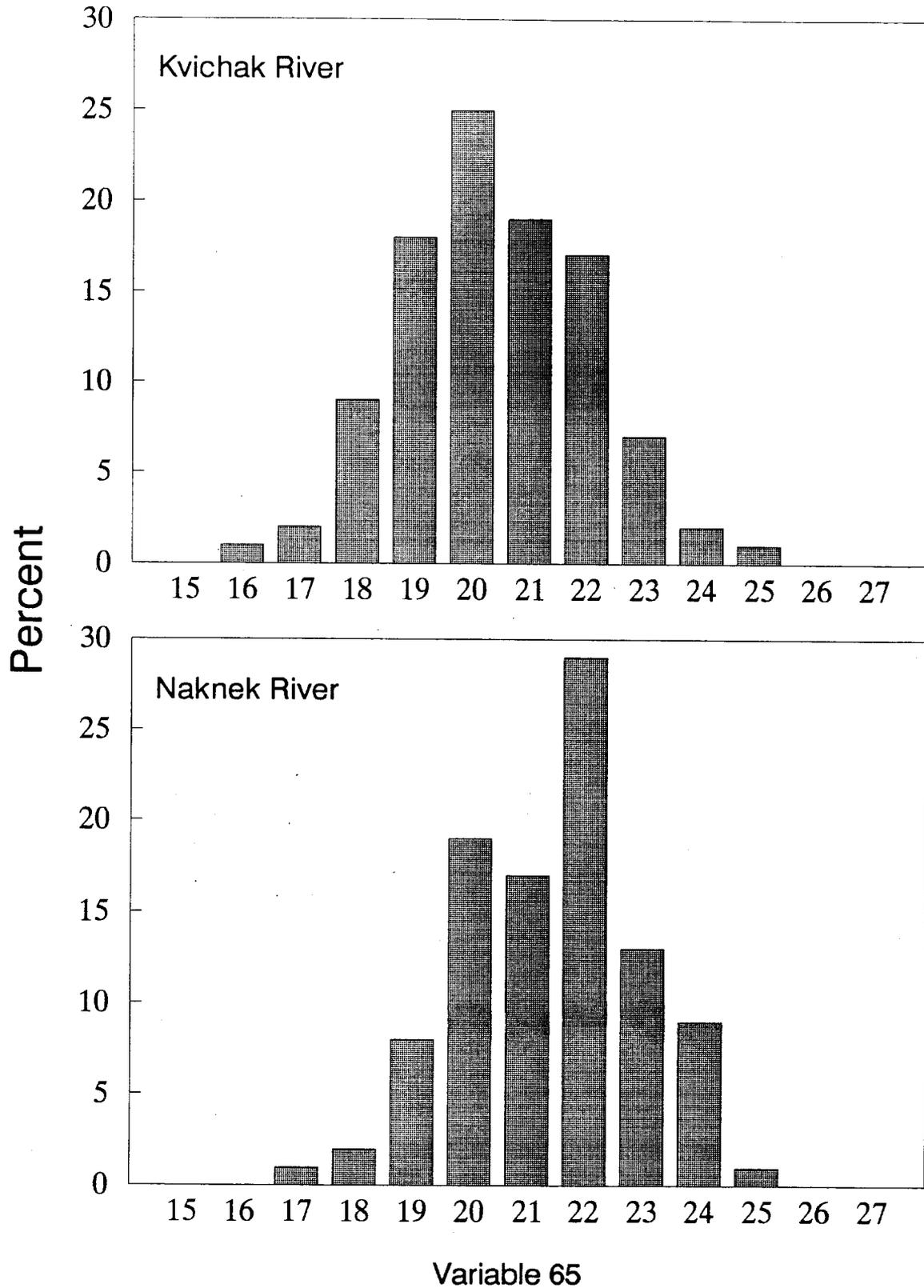


Figure 5. Total number of circuli counted in all freshwater growth zones (NC1FW+NC2FW+NCPG) on age-2.2 sockeye salmon escapement scales, Kvichak and Naknek Rivers, 1991.

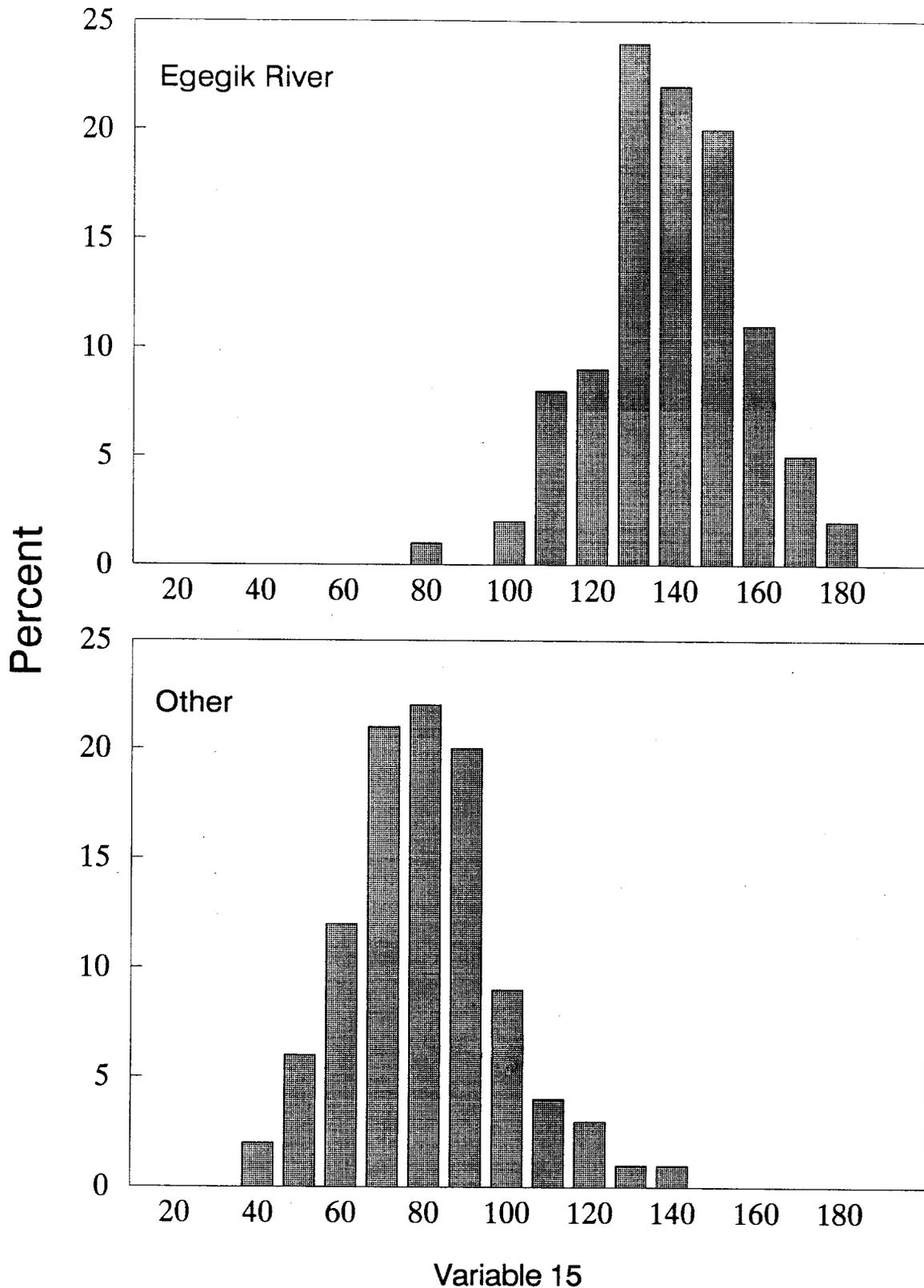


Figure 6. Distance from fourth circuli to end of first freshwater annulus (C4-E1FW) on age-1.3 sockeye salmon escapement scales, Egegik and Kvichak/Naknek/Ugashik (Other) Rivers combined, 1991.

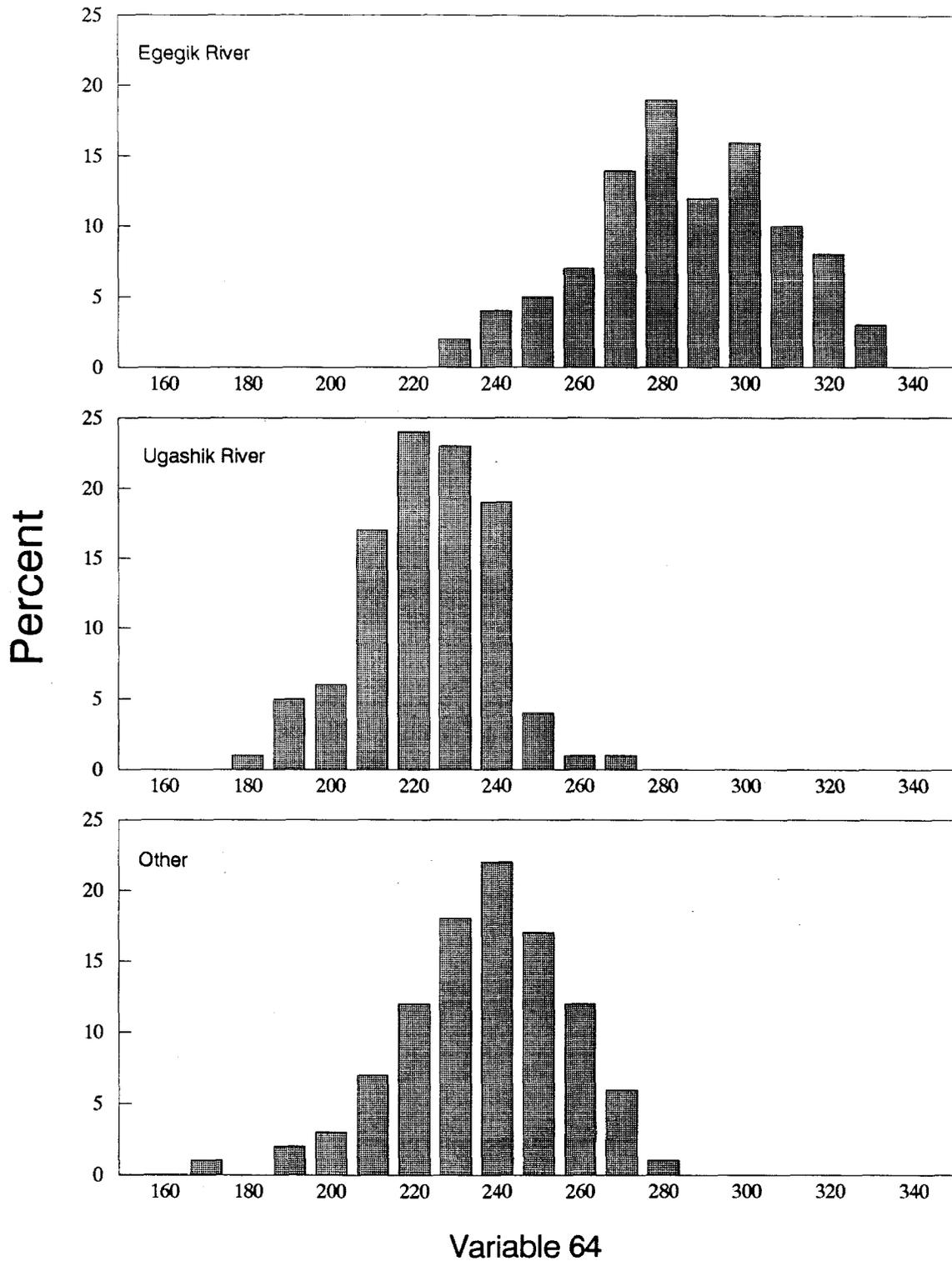


Figure 7. Size of freshwater annular zones (S1FW+S2FW) on age-2.2 sockeye salmon escapement scales, Egegik, Ugashik, and Kvichak/Naknek (Other) Rivers combined, 1991.

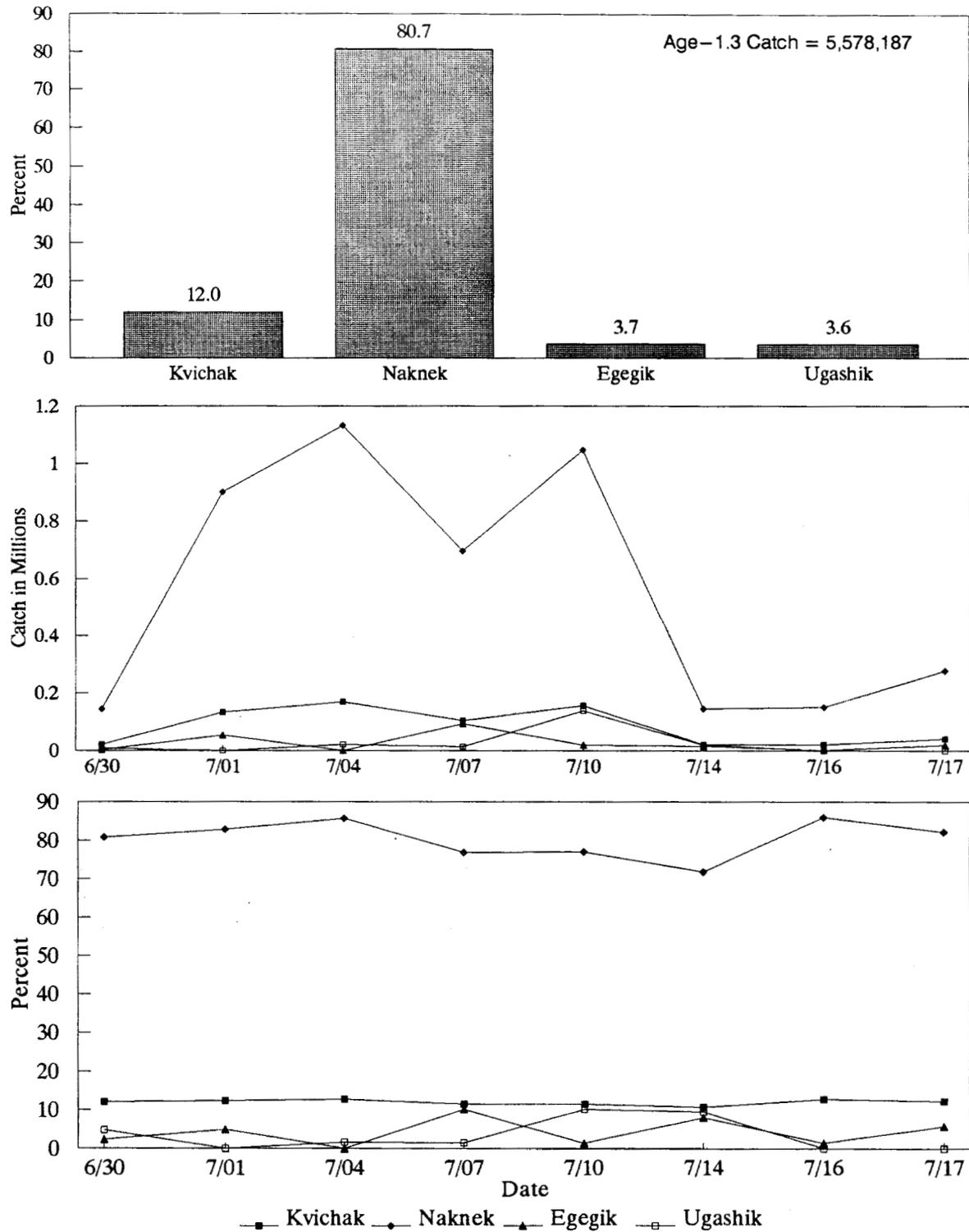


Figure 8. Stock composition estimates for 1991 Naknek-Kvichak District age-1.3 sockeye salmon catch in percent and numbers through time.

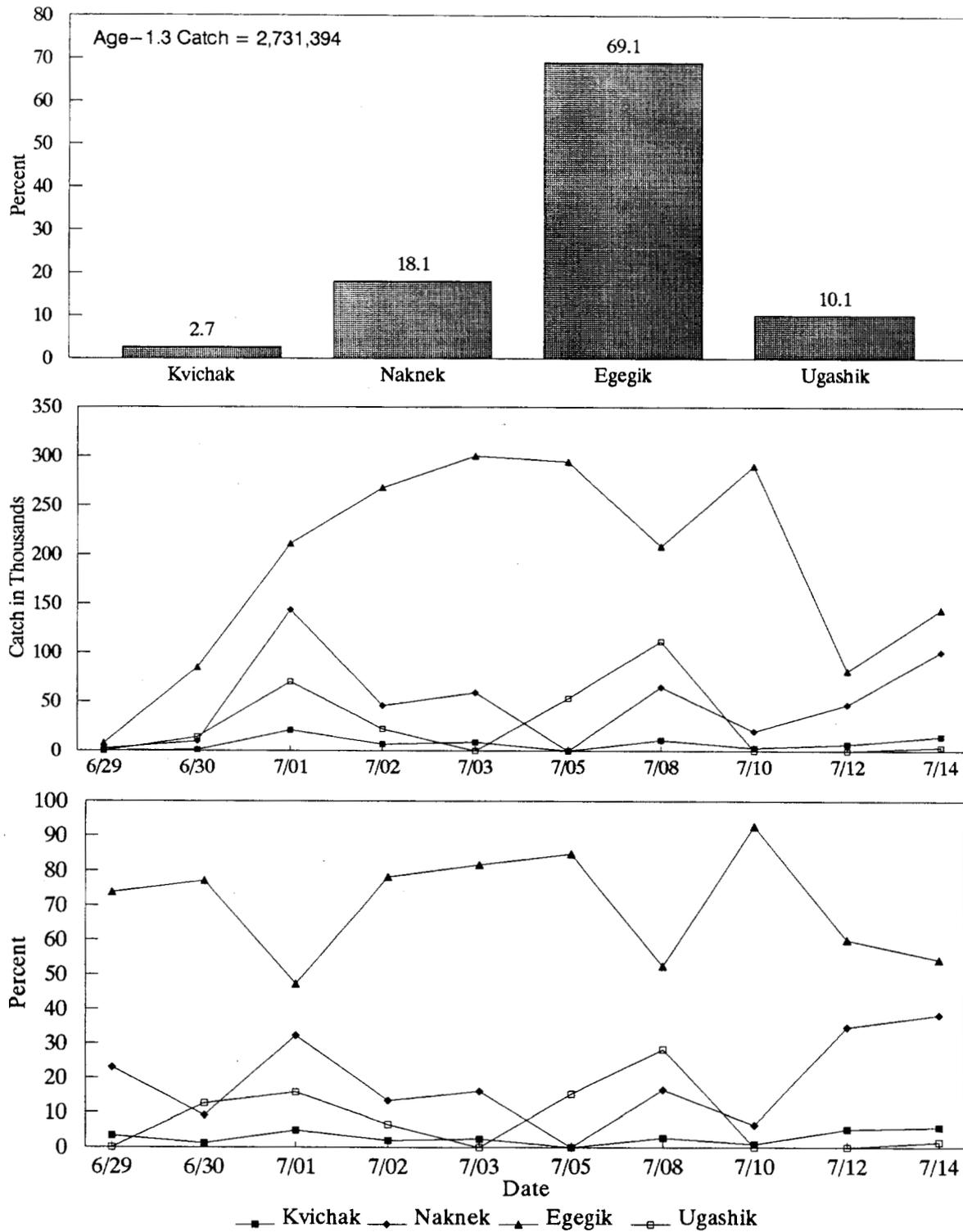


Figure 9. Stock composition estimates for 1991 Egegik District age-1.3 sockeye salmon catch in percent and numbers through time.

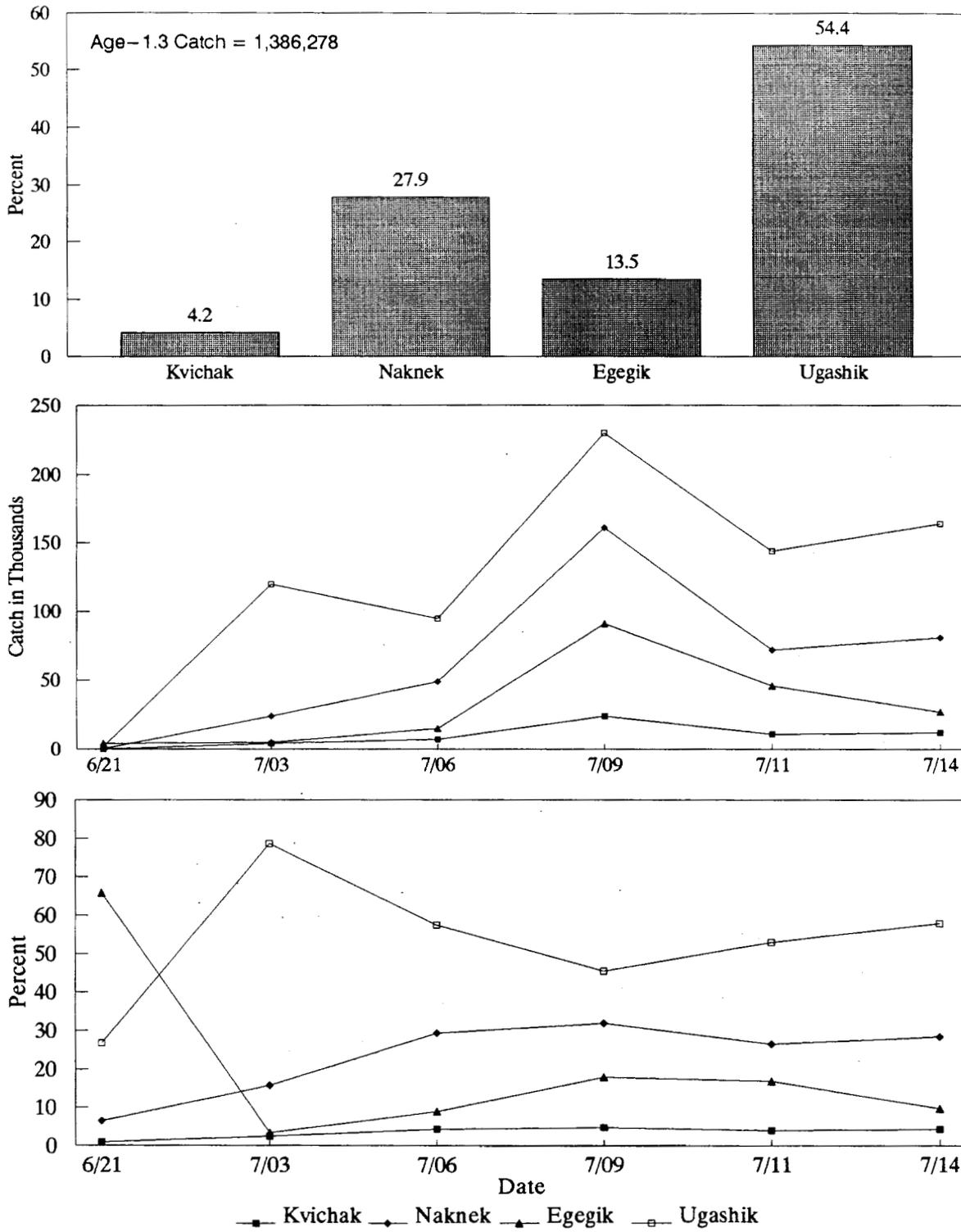


Figure 10. Stock composition estimates for 1991 Ugashik District age-1.3 sockeye salmon catch in percent and numbers through time.

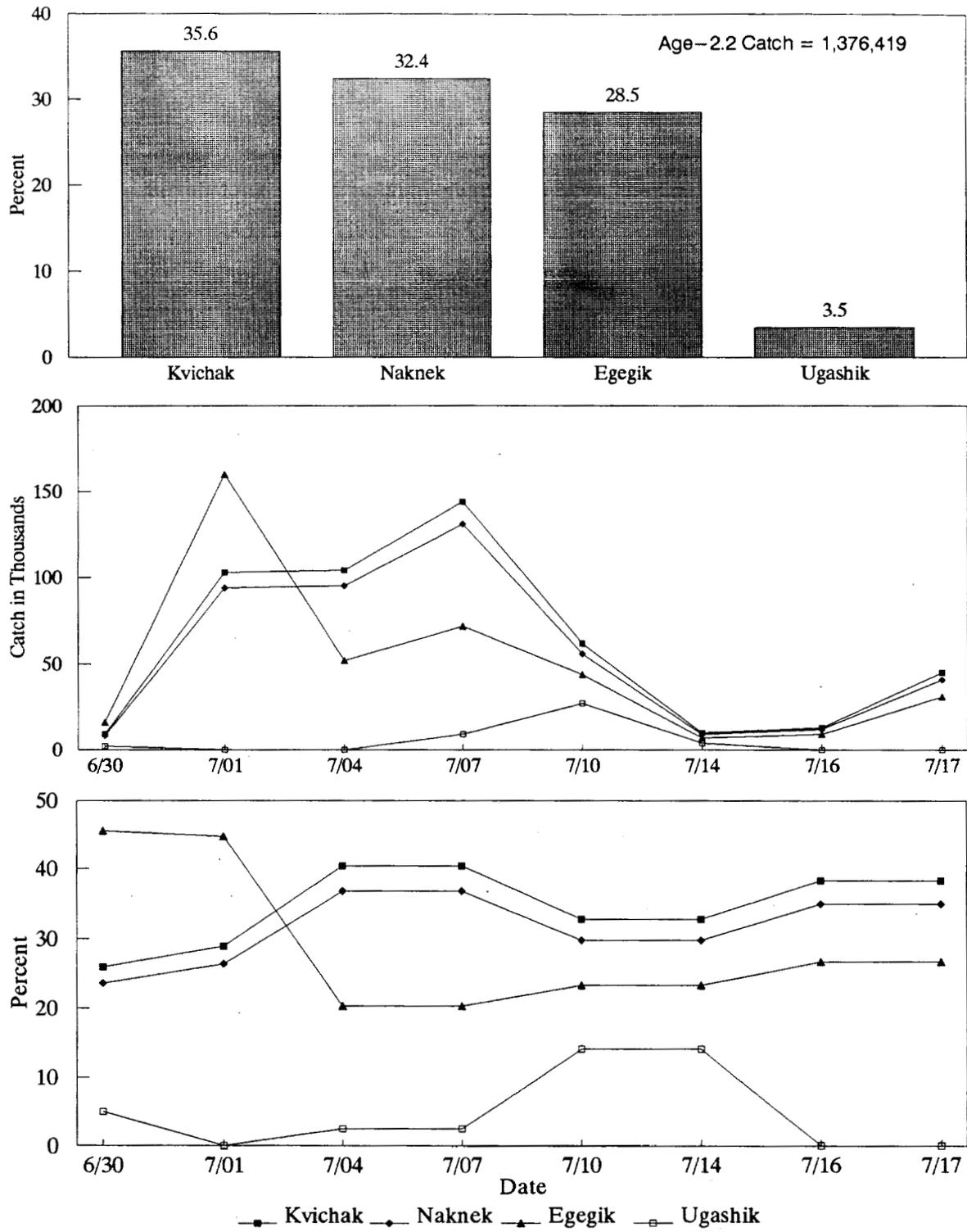


Figure 11. Stock composition estimates for 1991 Naknek-Kvichak District age-2.2 sockeye salmon catch in percent and numbers through time.

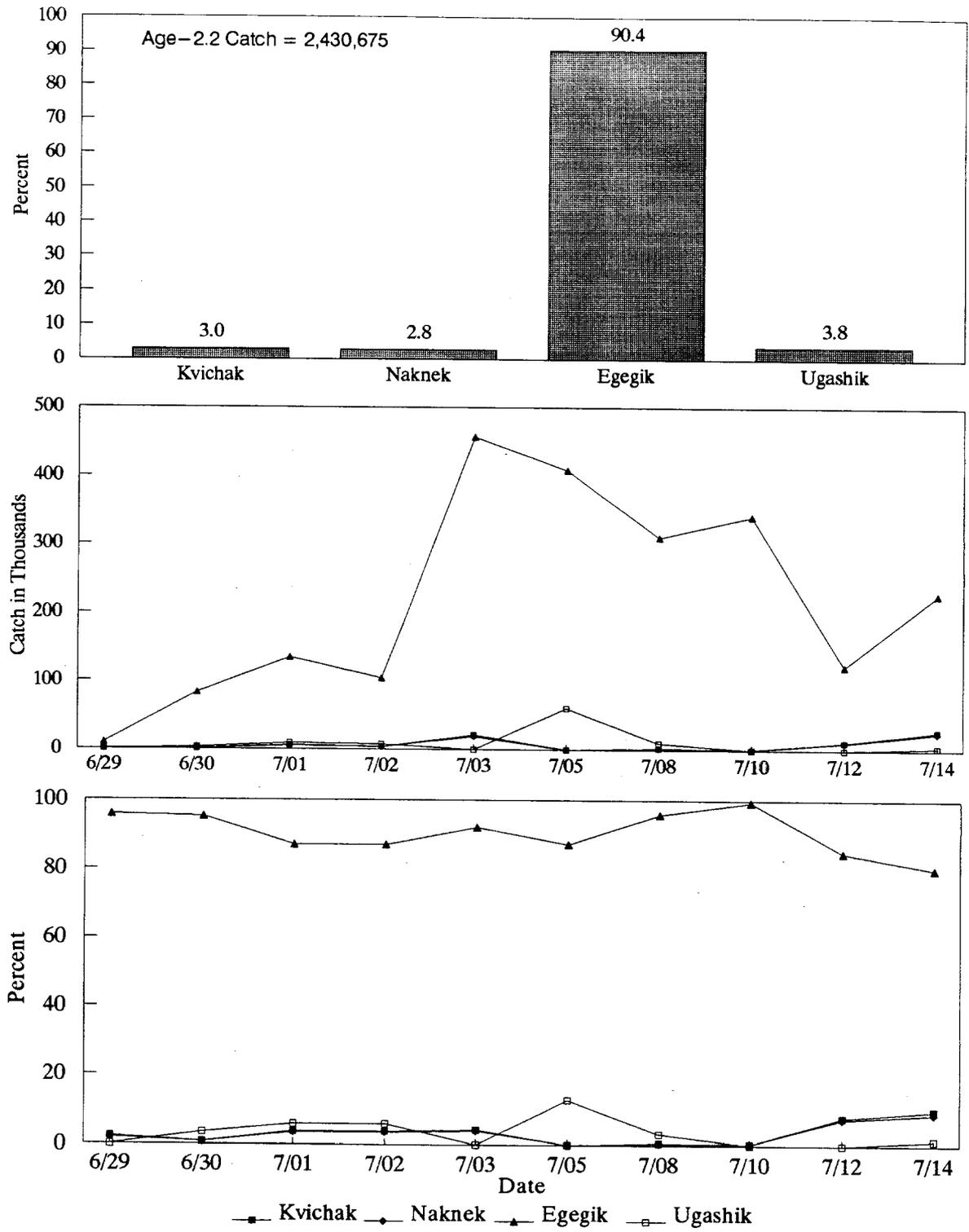


Figure 12. Stock composition estimates for 1991 Egegik District age-2.2 sockeye salmon catch in percent and numbers through time.

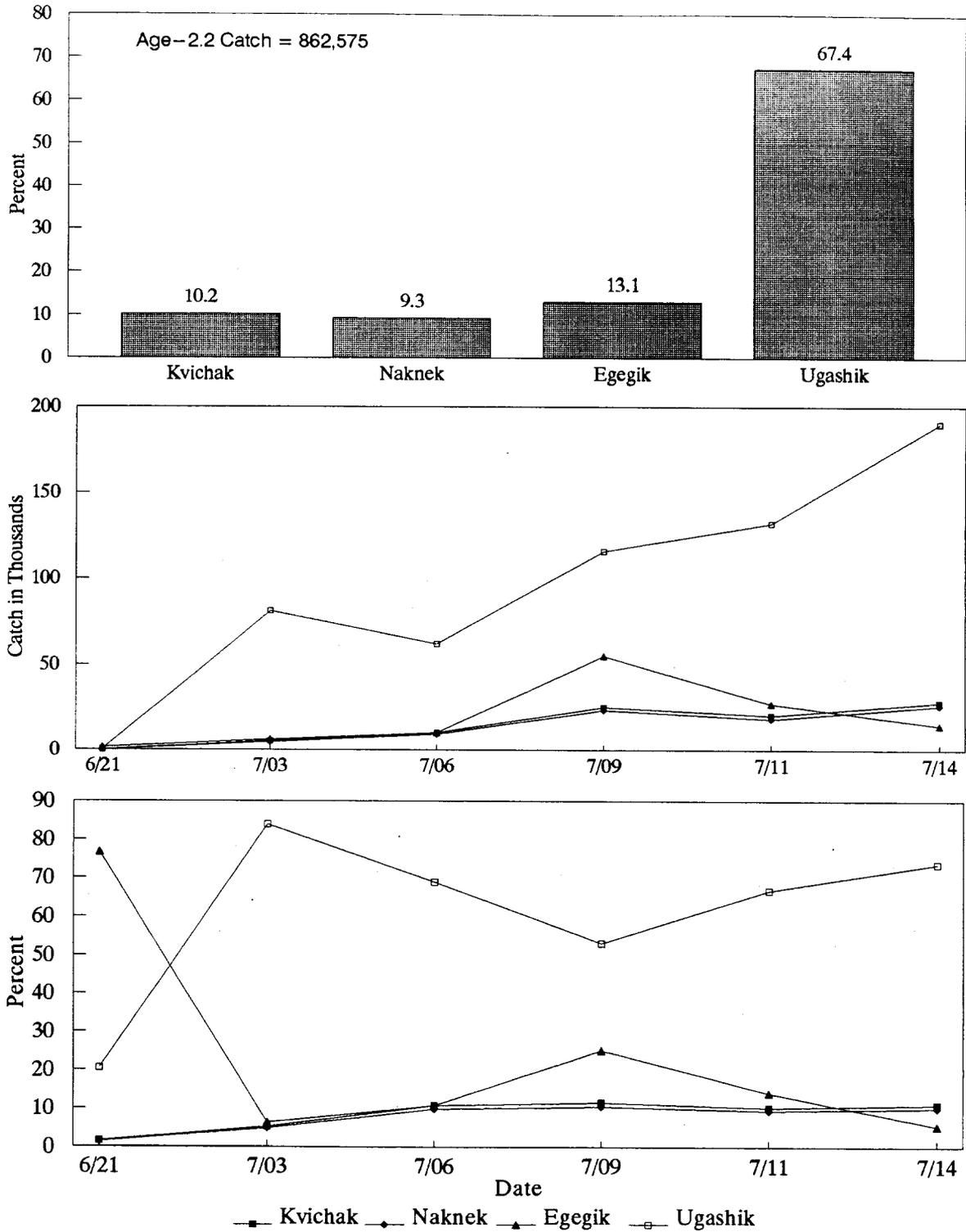


Figure 13. Stock composition estimates for 1991 Ugashik District age-2.2 sockeye salmon catch in percent and numbers through time.

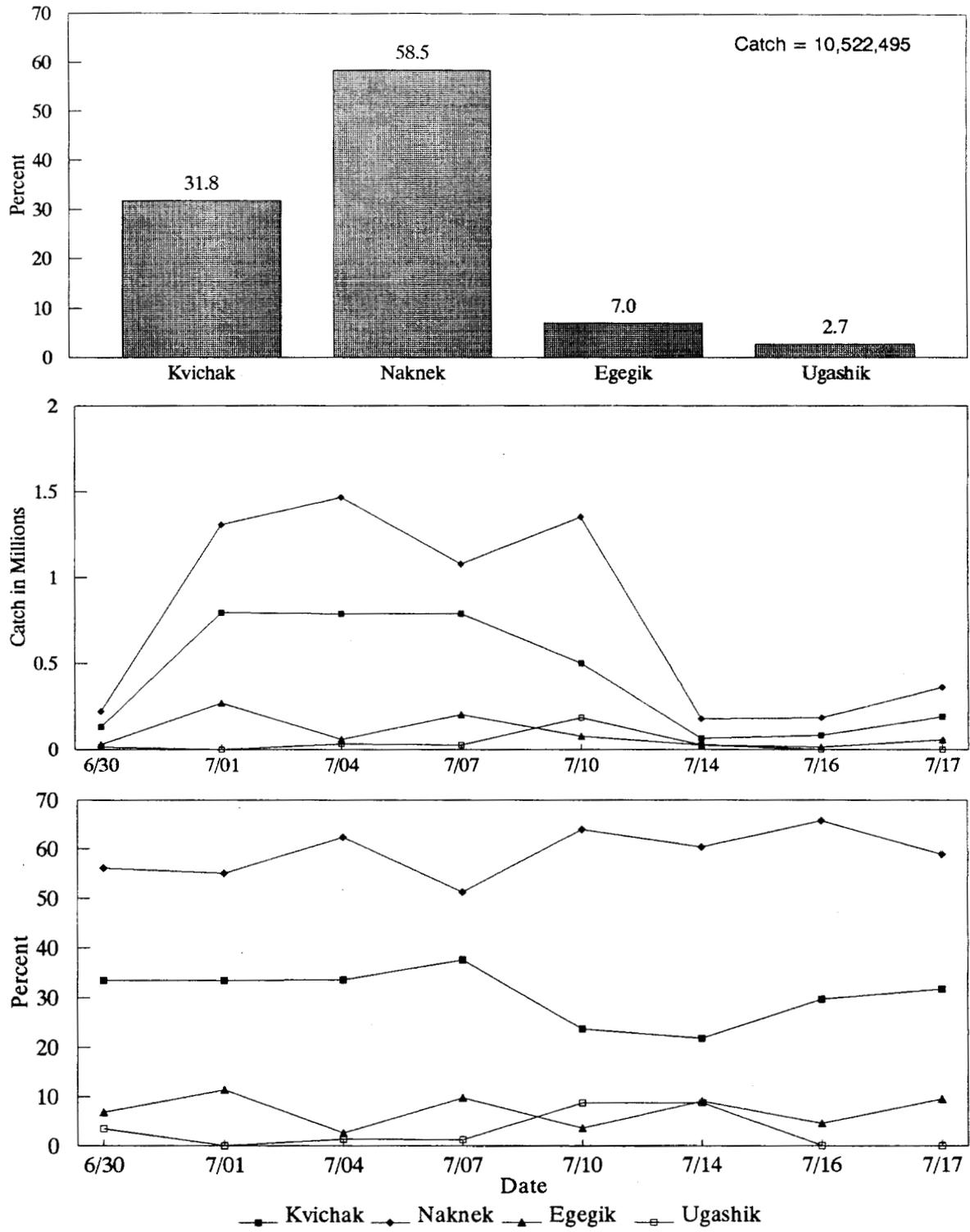


Figure 14. Stock composition estimates for 1991 Naknek-Kvichak District total sockeye salmon catch in percent and numbers through time.

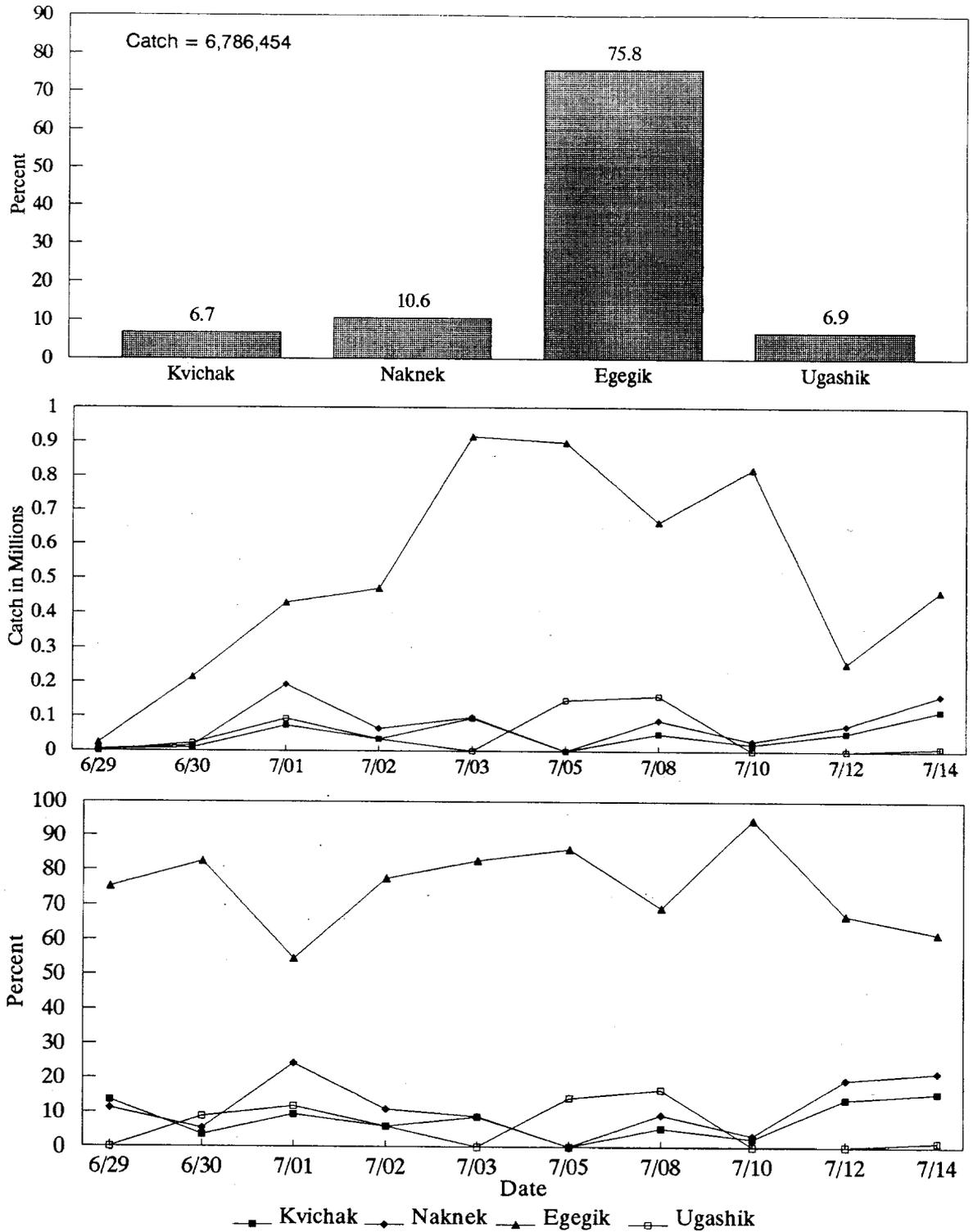


Figure 15. Stock composition estimates for 1991 Egegik District total sockeye salmon catch in percent and numbers through time.

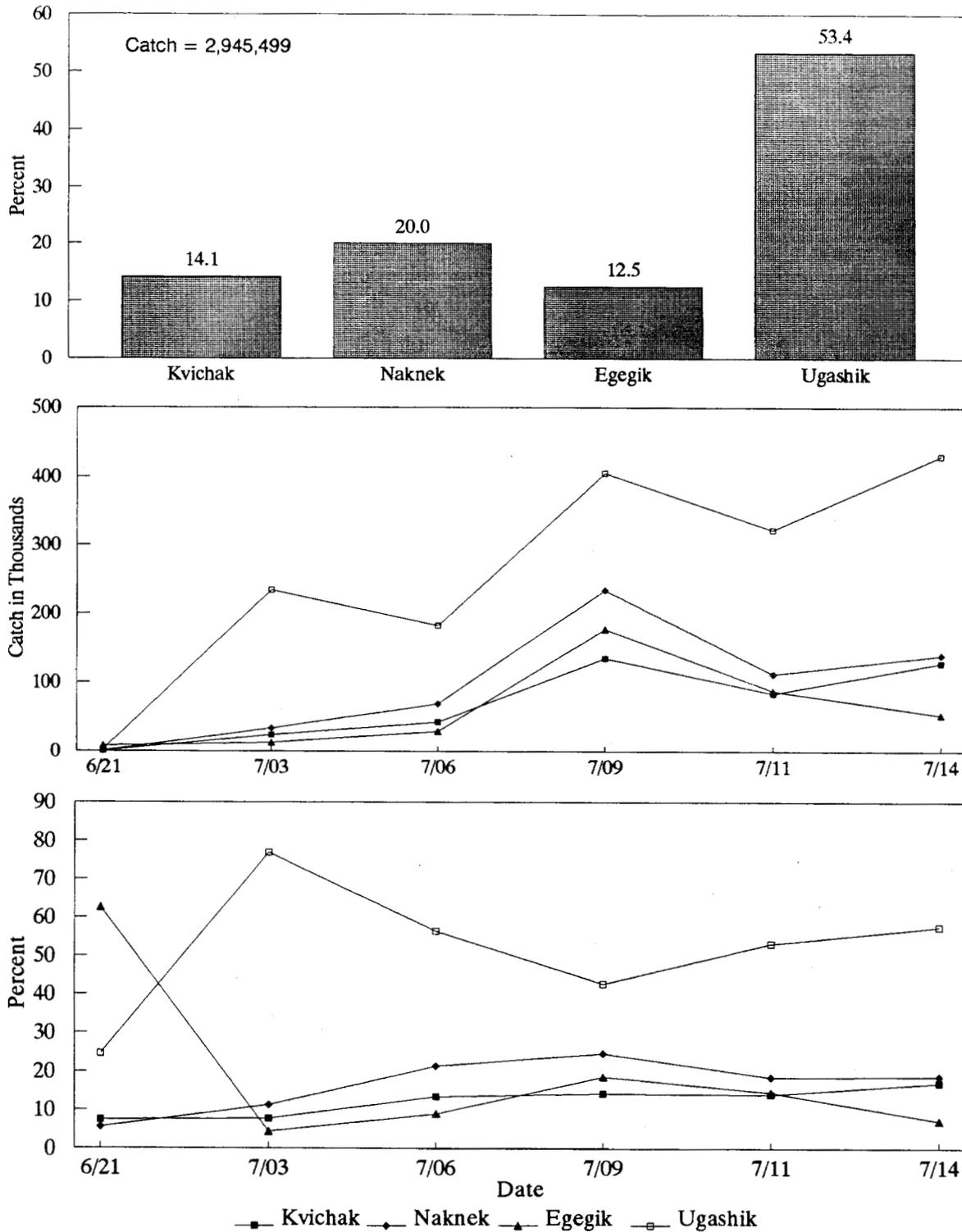


Figure 16. Stock composition estimates for 1991 Ugashik District total sockeye salmon catch in percent and numbers through time.

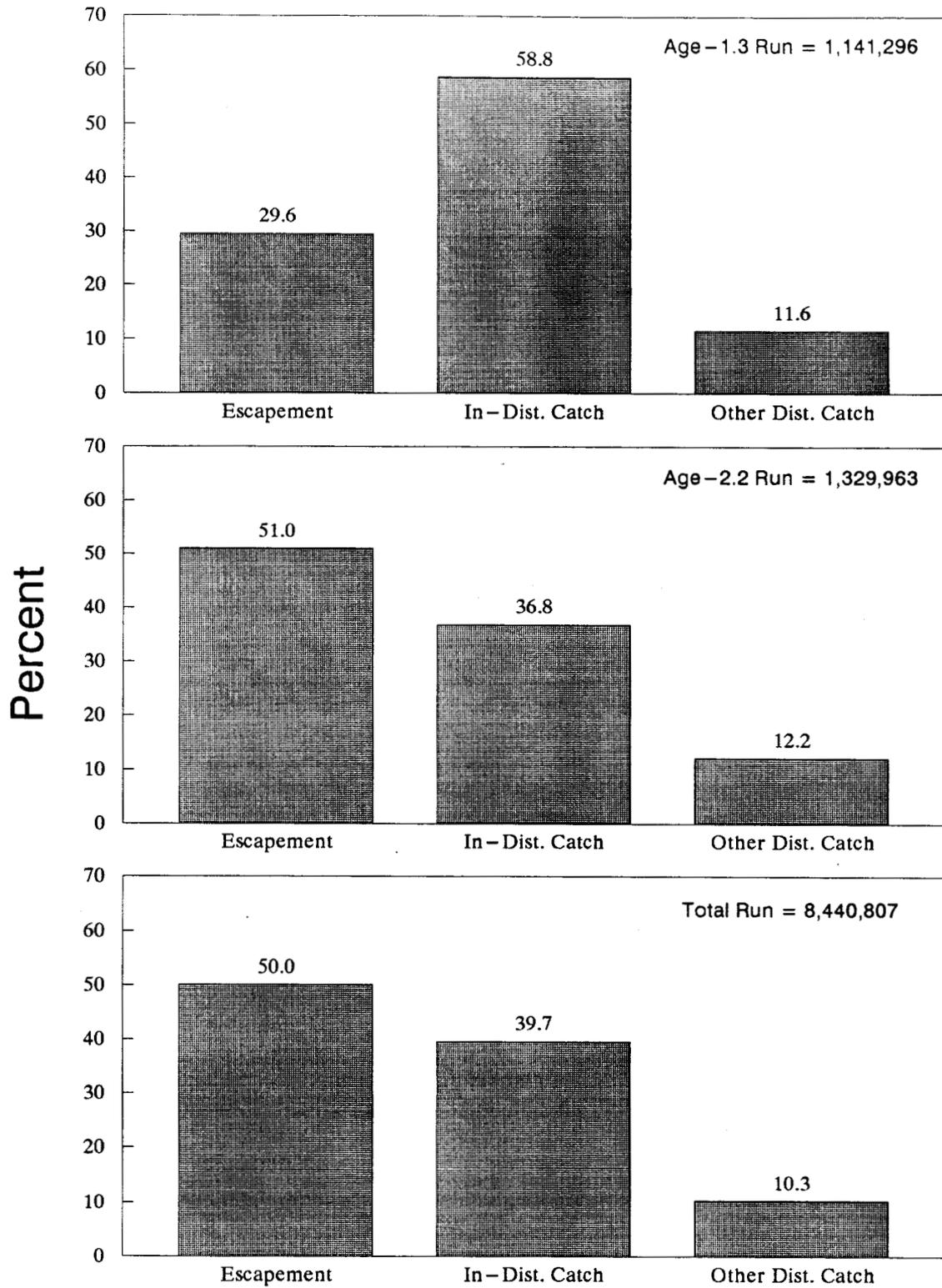


Figure 17. Estimated 1991 Kvichak River sockeye salmon run, escapement, in-district catch, and other district catch for ages 2.2 and 1.3, and all ages combined.

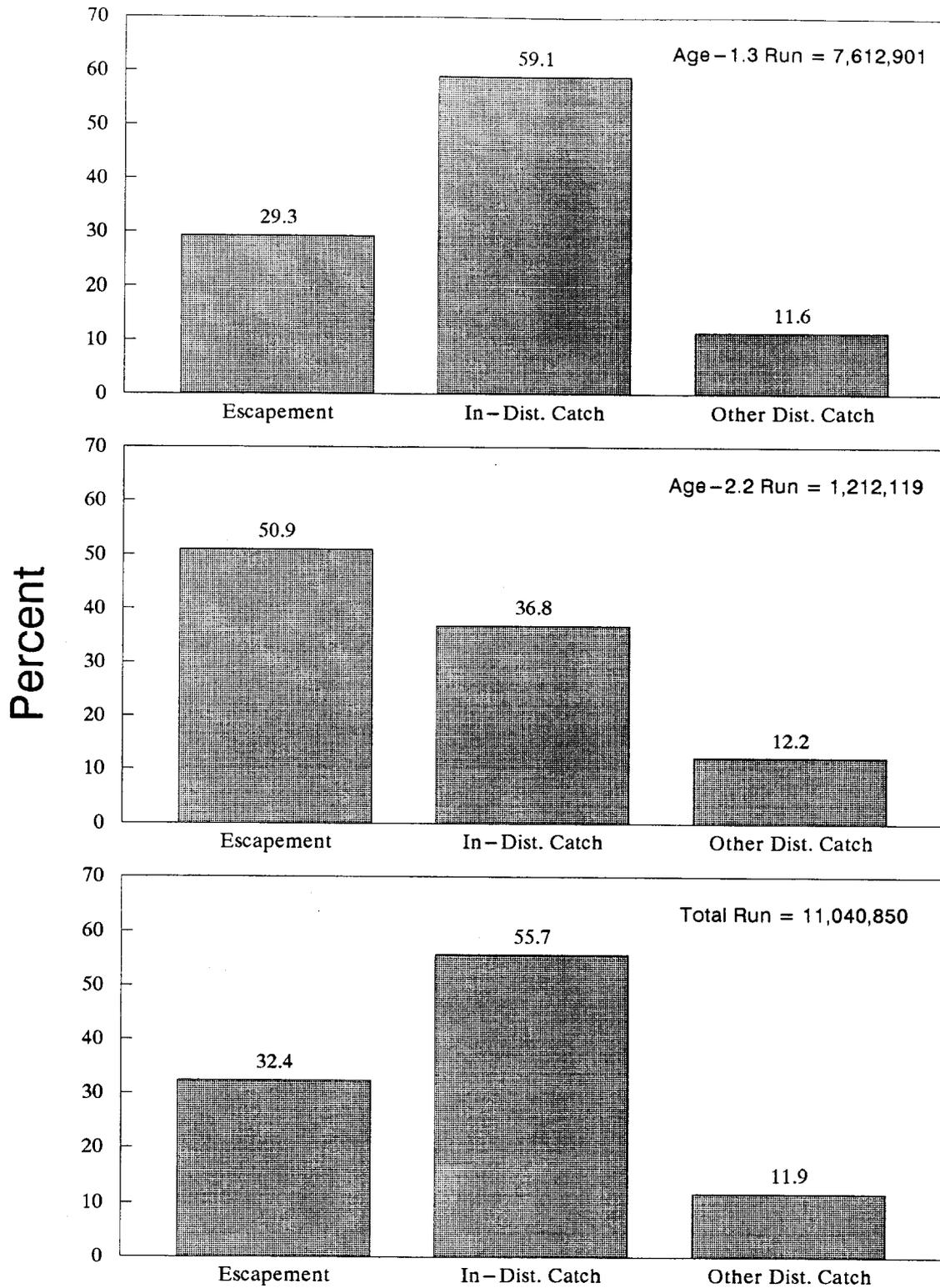


Figure 18. Estimated 1991 Naknek River sockeye salmon run, escapement, in-district catch, and other district catch for ages 2.2 and 1.3, and all ages combined.

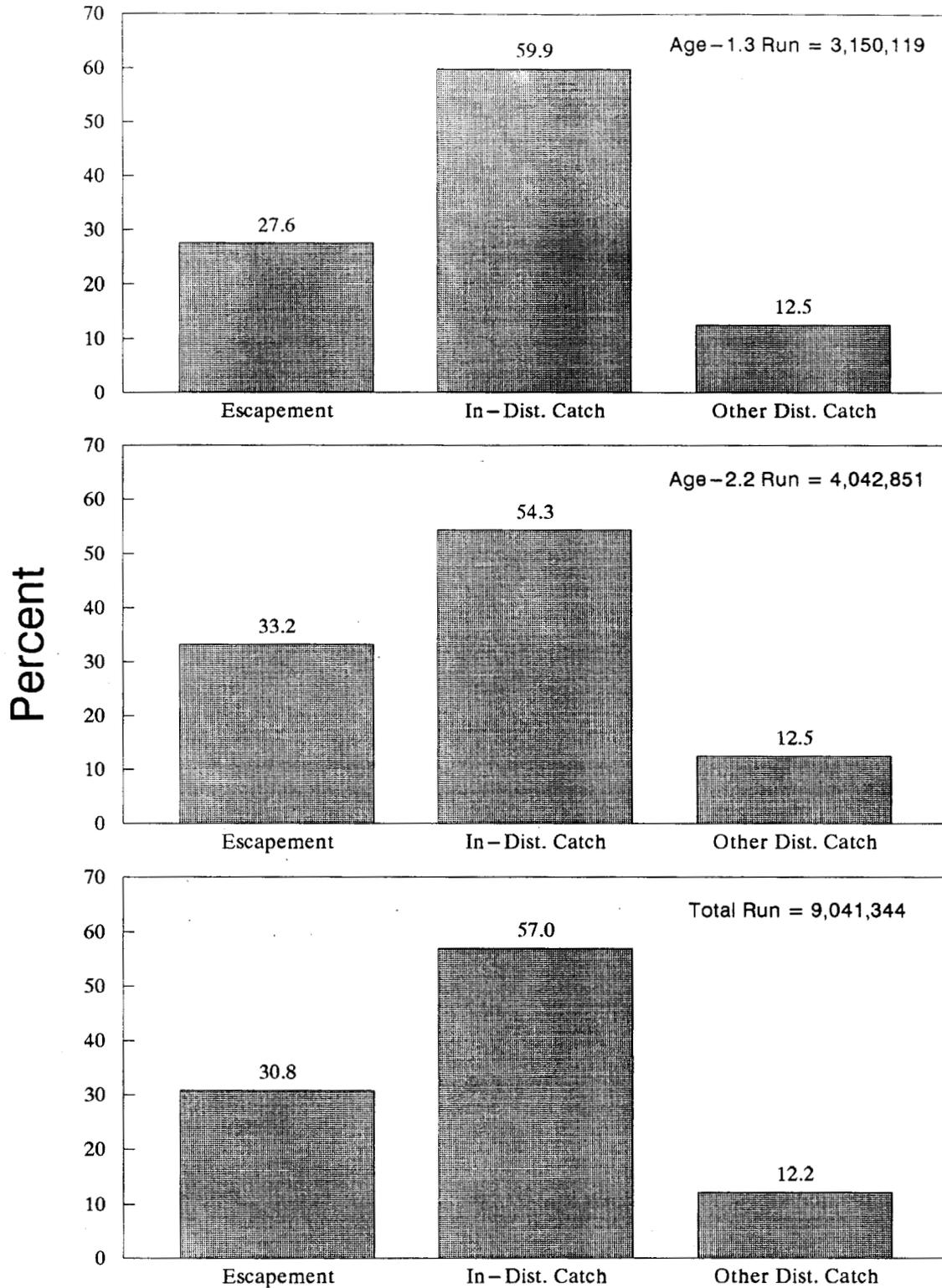


Figure 19. Estimated 1991 Egegik River sockeye salmon run, escapement, in-district catch, and other district catch for ages 2.2 and 1.3, and all ages combined.

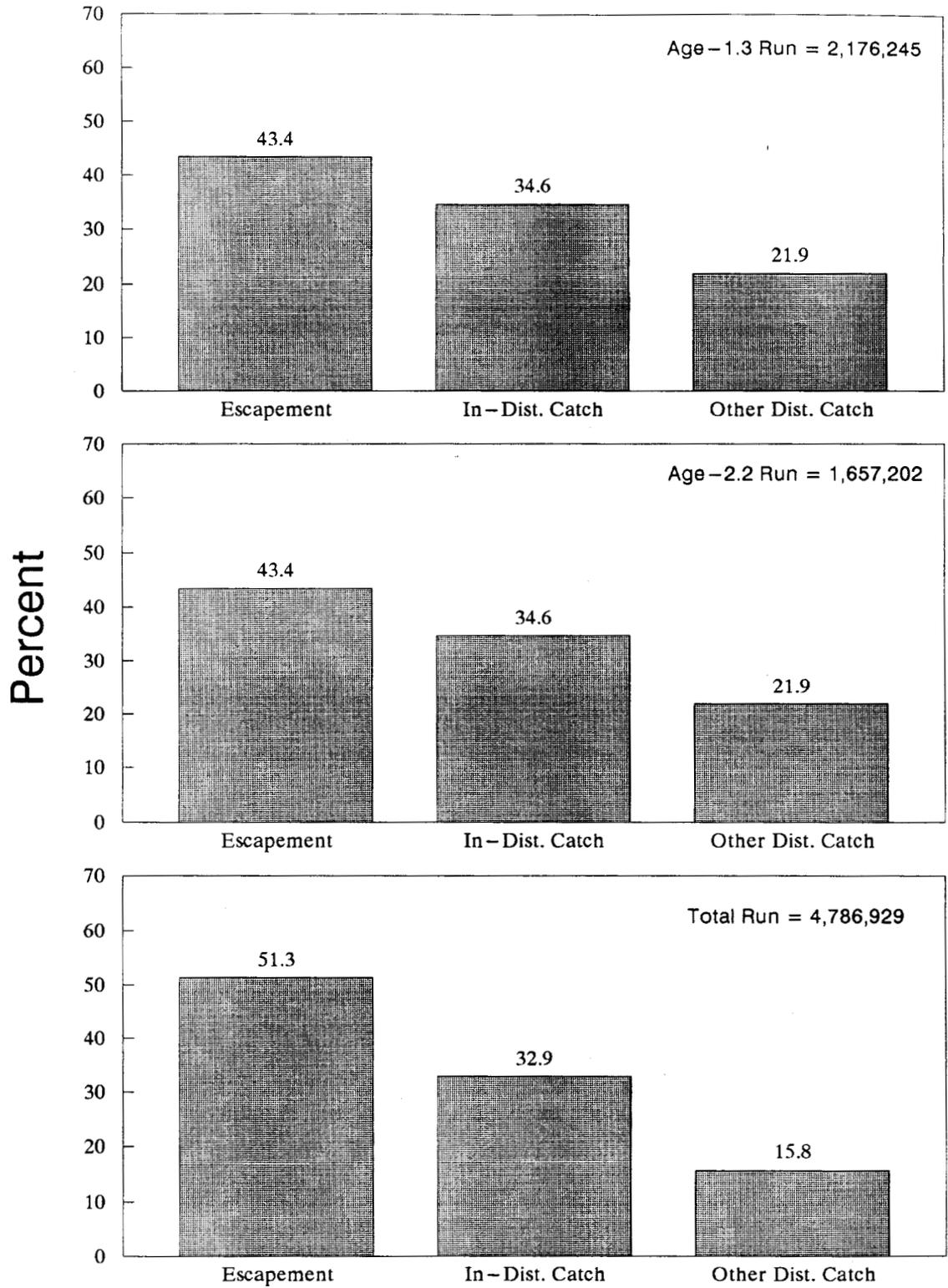


Figure 20. Estimated 1991 Ugashik River sockeye salmon run, escapement, in-district catch, and other district catch for ages 2.2 and 1.3, and all ages combined.

APPENDIX

Appendix A.1. Scale variables screened for linear discriminant function analysis of age-1.3, and -2.2 sockeye salmon for the East Side of Bristol Bay, 1991.

Variable Number	Variable Name	Zone
<u>First Freshwater Annular Zone</u>		
1	NC1FW	Number of circuli first freshwater
2	S1FW	Size (width) of first freshwater
3 (16)	C0-C2	Distance, scale focus (C0) to circulus 2 (C2)
4 (17)	C0-C4	Distance, scale focus to circulus 4
5 (18)	C0-C6	Distance, scale focus to circulus 6
6 (19)	C0-C8	Distance, scale focus to circulus 8
7 (20)	C2-C4	Distance, circulus 2 to circulus 4
8 (21)	C2-C6	Distance, circulus 2 to circulus 6
9 (22)	C2-C8	Distance, circulus 2 to circulus 8
10 (23)	C4-C6	Distance, circulus 4 to circulus 6
11 (24)	C4-C8	Distance, circulus 4 to circulus 8
12 (25)	C(NC-4)-E1FW	Distance, circulus (number circuli first freshwater minus 2) to end first freshwater
13 (26)	C(NC-2)-E1FW	Distance, circulus (number circuli first freshwater minus 4) to end first freshwater
14	C2-E1FW	Distance, circulus 2 to end first freshwater
15	C4-E1FW	Distance, circulus 4 to end first freshwater
16 thru 26	C0-C2/S1FW ... C(NC-2)-E1FW/S1FW	Relative widths, (variables 3-13)/S1FW
27	S1FW/NC1FW	Average interval between circuli in first freshwater
28	NC 1ST 3/4	Number of circuli in first 3/4 of first freshwater
29	MAX DIST	Maximum distance between 2 consecutive circuli in first freshwater
30	MAX DIST/S1FW	Relative width, (variable 29)/S1FW
<u>Second Freshwater Annular Zone</u>		
31	NC2FW	Number of circuli second freshwater
32	S2FW	Size (width) of second freshwater
33 (46)	E1FW-C2	Distance, end of first freshwater to circulus 2 (C2) in second freshwater
34 (47)	E1FW-C4	Distance, end of first freshwater to circulus 4
35 (48)	E1FW-C6	Distance, end of first freshwater to circulus 6
36 (49)	E1FW-C8	Distance, end of first freshwater to circulus 8
37 (50)	C2-C4	Distance, circulus 2 to circulus 4
38 (51)	C2-C6	Distance, circulus 2 to circulus 6
39 (52)	C2-C8	Distance, circulus 2 to circulus 8
40 (53)	C4-C6	Distance, circulus 4 to circulus 6
41 (54)	C4-C8	Distance, circulus 4 to circulus 8
42 (55)	C(NC-4)-E2FW	Distance, circulus (number circuli second freshwater minus 4) to end second freshwater
43 (56)	C(NC-2)-E2FW	Distance, circulus (number circuli second freshwater minus 2) to end second freshwater
44	C2-E2FW	Distance, circulus 2 to end second freshwater
45	C4-E2FW	Distance, circulus 4 to end second freshwater
46 thru 56	E1FW-C2/S2FW ... C(NC-2)-E2FW/S2FW	Relative widths, (variables 33-43)/S2FW
57	S2FW/NC2FW	Average interval between circuli in second freshwater
58	NC 1ST 3/4	Number of circuli in first 3/4 of second freshwater
59	MAX DIST	Maximum distance between 2 consecutive circuli in second freshwater
60	MAX DIST/S2FW	Relative width, (variable 59)/S2FW

-Continued-

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Variable Number	Variable Name	Zone
<u>Plus Growth Zone</u>		
61	NCPG	Number of circuli in plus growth
62	SPGZ	Size (width) plus growth zone
<u>Freshwater and Plus Growth Zones</u>		
63	NC1FW + NC2FW	Total number of circuli first and second freshwater
64	S1FW + S2FW	Total size (width) of first and second freshwater
65	NC1FW+NC2FW+NCPG	Total number of circuli first and second freshwater and plus growth
66	S1FW+S2FW+SPGZ	Total size (width) first and second freshwater and plus growth
67	S1FW/S1FW+S2FW+SPGZ	Relative width, (variable 2)/S1FW+S2FW+SPGZ
68	SPGZ/S1FW+S2FW+SPGZ	Relative width, (variable 62)/S1FW+S2FW+SPGZ
69	S2FW/S1FW+S2FW+SPGZ	Relative width, (variable 32)/S1FW+S2FW+SPGZ
<u>First Marine Annular Zone</u>		
70	NC10Z	Number of circuli in first ocean zone
71	S10Z	Size (width) first ocean zone
72 (90)	EFW-C3	Distance, end of freshwater growth to circulus 3
73 (91)	EFW-C6	Distance, end of freshwater growth to circulus 6
74 (92)	EFW-C9	Distance, end of freshwater growth to circulus 9
75 (93)	EFW-C12	Distance, end of freshwater growth to circulus 12
76 (94)	EFW-C15	Distance, end of freshwater growth to circulus 15
77 (95)	C3-C6	Distance, circulus 3 to circulus 6
78 (96)	C3-C9	Distance, circulus 3 to circulus 9
79 (97)	C3-C12	Distance, circulus 3 to circulus 12
80 (98)	C3-C15	Distance, circulus 3 to circulus 15
81 (99)	C6-C9	Distance, circulus 6 to circulus 9
82 (100)	C6-C12	Distance, circulus 6 to circulus 12
83 (101)	C6-C15	Distance, circulus 6 to circulus 15
84 (102)	C9-C15	Distance, circulus 9 to circulus 15
85 (103)	C(NC-6)-E10Z	Distance, circulus (number circuli first ocean minus 6) to end first ocean
86 (104)	C(NC-3)-E130Z	Distance, circulus (number circuli first ocean minus 3) to end first ocean
87	C3-E10Z	Distance, circulus 3 to end of first ocean
88	C9-E10Z	Distance, circulus 9 to end of first ocean
89	C15-E10Z	Distance, circulus 15 to end of first ocean
90 thru	EFW-C3/S10Z ...	Relative widths, (variables 72-86)/S10Z
104	C(NC-3)-E130Z/S10Z	
105	S10Z/NC10Z	Average interval between circuli in first ocean
106	NC 1ST 1/2	Number of circuli in first 1/2 of first ocean
107	MAX DIST	Maximum distance between 2 consecutive circuli in first ocean
108	MAX DIST/S10Z	Relative width, (variable 107)/S10Z
<u>Second Marine Annular Zone</u>		
109	S20Z	Size (width) of second ocean zone

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