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Alaska Department of Fish and Game
Commercial Fisheries Management
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P.O. Box 25526
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August 1995

**Component Analysis of Kenai River**

**Sockeye Salmon in the Commercial Fisheries**

**of Upper Cook Inlet in 1990 and 1991**

**Based on Scale Patterns**

**by**

**David L. Waltemyer**

State of Alaska Tony Knowles, Governor

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# COMPONENT ANALYSIS OF KENAI RIVER SOCKEYE SALMON IN THE COMMERCIAL FISHERIES OF UPPER COOK INLET IN 1990 AND 1991 BASED ON SCALE PATTERNS

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## ABSTRACT

Age-specific scale characteristics were used to identify the contributions of Kenai River sockeye salmon *Oncorhynchus nerka* to the 1990 and 1991 commercial harvests of Upper Cook Inlet, Alaska. Several multivariate linear discriminant models were developed to classify age-1.2, -1.3, and -2.3 sockeye salmon. Overall mean classification accuracies for two-way, Kenai-*Other* models ranged from 0.678 (age 1.3) to 0.837 (age 2.3). The approximate 90% confidence intervals for the 1990 and 1991 age-1.3 models were $\pm 0.216$ and $\pm 0.249$, respectively. Within and between stock variability of scale variables was large because of the complexity of the rearing environments and the multi-population composition of the stock groupings. Scale characteristics appear to be of limited use for identifying the mixture of stock groupings in Upper Cook Inlet commercial harvests.



KEY WORDS: Sockeye salmon, *Oncorhynchus nerka*, stock separation, scale pattern analysis, linear discriminant analysis, Upper Cook Inlet, Alaska

## INTRODUCTION

One of the more important and persistent needs for management of sockeye salmon *Oncorhynchus nerka* fisheries in Upper Cook Inlet (UCI), Alaska, is a better understanding of stock contribution in the mixed stock commercial fisheries. To address this concern, the Alaska Department of Fish and Game (ADF&G) initiated a stock identification research project in 1976 (Krasnowski and Bethe 1978). The major emphasis was directed toward scale pattern analysis (SPA) that had been proven useful for determining racial origins of salmon captured on the high seas and along the Pacific coast region (Henry 1961; Mosher 1963; Anas 1964; Wright 1965; Anas and Murai 1969; Lechner 1969; and Major et al. 1973). SPA has been a part of the UCI salmon management program since 1976 (Bethe and Krasnowski 1979; Bethe et al. 1980; Cross et al. 1981, 1982, 1983, 1985, 1986, 1987; Cross and Goshert 1988; and Waltemyer and Tarbox 1988, 1991).

Unfortunately, technical problems have been identified in the UCI sockeye salmon SPA. Recent examination of model classification accuracies, model performance for minor stocks (<20% of the total return), and model assumptions seem to bear out concerns perceived by Waltemyer and Tarbox (1988, 1991). The UCI models have relatively poor classification accuracies, cannot be used reliably during the fishing season because of temporal changes in the scale variables, and tend to overestimate the contributions of minor stocks (B. Bue, ADF&G, Anchorage, personal communication). Variables used in the linear discriminant function (LDF) models did not always meet the assumptions of (1) multivariate normal distributions and (2) equal variances (Lachenbruch 1975).

Most successful attempts to use SPA to determine racial origin have dealt with large stock groupings, such as continent of origin (Henry 1961; Mosher 1963; Anas 1964; Wright 1965; Anas and Murai 1969; Lechner 1969; and Major et al. 1973). Results of previous work in UCI (Waltemyer and Tarbox 1991) have suggested that estimates of only the Kenai River component may provide useful results. A review of SPA as a stock identification technique for UCI has not been completed. However, realizing that the public, other investigators, and the commercial fishing industry are interested in Kenai River stock component results, the division staff decided that only Kenai River stock component estimates would be documented in future reports. This report presents estimates of the contributions of three major sockeye salmon age classes returning to the Kenai River system in 1990 and 1991.

## METHODS

Scale samples were collected from sockeye salmon migrating into the Kasilof, Kenai, Crescent, and Susitna River systems to spawn (Figure 1). Scale samples were collected within the Susitna River drainage from both the Yentna River at river mile 5.0 and the Susitna River mainstem at Sunshine Station (river mile 80.0). Samples were taken from salmon captured in fish wheels operated in the Kasilof, Kenai, and Susitna Rivers and from a modified fish trap used in Crescent River. In addition to samples taken from the four major river systems, seven commercial fishery harvests within UCI were sampled (Figure 2). These commercial fisheries included set gillnet fisheries in the Eastern, General, Upper (Cohoe/Ninilchik Beach, Kalifonsky Beach, and Salamatof Beach), and Western Subdistricts, as well as the drift gillnet fishery in the Central District (Figure 1).

Scales were collected according to the procedures of Koo (1955) and Clutter and Whitesel (1956). Impressions of these scales were made in cellulose acetate as described by Clutter and Whitesel (1956) and were viewed with a microfiche reader. Age was determined using the criteria of Mosher (1969) and were recorded in European notation (Koo 1962).

Sample size goals were 200 scales for each escapement or composite (stock) of known origin in the LDF model and 100 scales for each mixed stock harvest of unknown origin to be classified by an SPA model (R. Conrad, ADF&G, Anchorage, personal communication). The two predominate age classes of sockeye salmon within each year's run were used in the analysis.

Linear measurements for discriminant analysis (Moris 1975) were taken along the anterior-posterior axis of each scale as defined in Clutter and Whitesel (1956). Scale impressions were magnified 100X using equipment similar to that described by Ryan and Christie (1976). Conrad (1985) developed the computer software used to both record data from scales measured on a digitizing tablet and analyze these data. The scale variables consisted of circuli counts and incremental distances within freshwater and marine growth zones of age-1.2, -1.3, and -2.3 sockeye salmon (Figure 3). The number of scale variables produced by the computer program ranged from 79 for an age-1.2 to 109 for an age-2.3 sockeye salmon (Table 1).

A two-way linear discriminant model, constructed based on procedures outlined by Conrad (1985), used samples from the Kenai River and *Other* (a combined weighted sample from the Kasilof and Susitna Rivers that included scales from Yentna River and Sunshine Station) river systems. Although samples were collected from the Crescent River, emphasis was placed on accurately identifying the Kenai River component in the major commercial harvests. Assuming that Crescent River sockeye salmon do not contribute meaningfully to the Northern District, Upper Subdistrict, and drift gillnet commercial harvests, they were excluded from the model construction and analysis. Selection of scale variables for each model was made with a forward stepwise procedure using partial F-statistics ($F = 4.0$; Enslein et al. 1977). Classification accuracy for each model was determined by a leaving-one-out procedure (Lachenbruch 1967). Construction of the LDF model was completed when the Kenai component in the self-classification matrix was maximized. When an LDF model was built, each commercial harvest sample was evaluated using the classification program (Conrad 1985). Initial results ("first-order" estimates) of stock composition were then adjusted for misclassification errors using the procedure of Cook and Lord (1978). These adjusted ("second-order") estimates of mean proportions and 90% confidence bounds for the Kenai and *Other* river components were subsequently tabulated. The variance and confidence interval for the adjusted estimate were calculated using the procedure described by Pella and Robertson (1979). In cases where adjusted proportions were either $<0$ or $>1$, results were reported either as 0 or 1.

## RESULTS

### *1990 Field Season*

A commercial harvest of 3,540,807 sockeye salmon was taken from seven major UCI fisheries in 1990 (Table 2). The commercial drift gillnet harvest accounted for 65.1% (2,305,707 sockeye salmon) of the total harvest. Estimated total escapement into the four major river systems was 1,210,046 sockeye salmon (Table 2). The Kenai River accounted for 54.5% (659,521 sockeye salmon) of the total escapement. The number of sockeye salmon sampled in 1990 were 19,199 from selected commercial gillnet harvests and 8,884 from escapements (Table 2). These sample collections represented between 0.4% and 5.8% of the harvest by fishery and from 0.3% to 1.7% of the escapement by river. A total of 4,856 age-1.3 and 3,152 age-2.3 sockeye salmon scales were digitized in 1990 (Table 2). Age-1.3 sockeye salmon represented 49.5% and age-2.3 24.5% of the total return (Waltemyer 1993).

Mean and standard error estimates for individual scale variables of age-1.3 sockeye salmon showed no significant statistical differences (ANOVA, $P > 0.05$) for the number of circuli in (variable 1) or size of the first freshwater zone (variable 2) between Kenai and *Other* river systems (Table 3). However, significant differences (ANOVA, $P < 0.05$) were found for the number of circuli in (variable 70) and the size of the first marine growth zone (variable 71), as well as the size of the second marine growth zone (variable 109).

In contrast, mean and standard error estimates for scale variables of age-2.3 sockeye salmon showed significant statistical differences (ANOVA, $P < 0.05$) for the number of circuli in (variable 1) and size of the first freshwater zone (variable 2) between Kenai and *Other* river systems (Table 4). Significant differences (ANOVA, $P < 0.05$) were also found for the number of circuli in (variables 31 and 70) and size of the second freshwater and first marine growth zones (variables 32 and 71), as well as the size of the second marine growth zone (variable 109).

Variables 109, 96, 104, 4, 106, 70, and 65 were selected by the forward stepwise procedure to build the two-way discriminate model for age-1.3 sockeye salmon in 1990 (Table 5). The age-1.3 model had a mean classification accuracy of 0.707. The misclassification rate for Kenai River sockeye salmon was 0.259.

The age-2.3 sockeye salmon model developed for 1990 included variables 56 and 67 (Table 5). Mean classification accuracy was 0.837. The misclassification rate of Kenai River sockeye salmon was 0.116.

Stock composition estimates of age-1.3 sockeye salmon showed that the greatest proportion of the Kenai River component occurred in the drift fishery on 23 July (Table 6; Figure 4). Estimates of the Kenai River proportion were greatest on 30 July in the Cohoe/Ninilchik Beach fishery, 27 July in the Kalifonsky Beach fishery, and 23 July in the Salamatof Beach fishery. The 90% confidence intervals around the adjusted proportions (not including stock estimates of 0 or 1) averaged $\pm 0.377$ in the drift fishery, ±0.413 in the Cohoe/Ninilchik Beach fishery, ±0.302 in the Kalifonsky Beach fishery, and ±0.318 in the Salamatof Beach fishery.

The proportion of age-2.3 Kenai River sockeye salmon in the drift fishery harvest after 27 July ranged from 0.996 to 1.000 (Table 7). Kenai River stock proportions were greatest toward the end of July in the Cohoe/Ninilchik, Kalifonsky, and Salamatof Beach fisheries (Table 7; Figure 5). The 90% confidence intervals around the adjusted proportions (not including stock estimates of 0 or 1) varied considerably by period and averaged ±0.449 in the drift fishery, ±0.448 in the Cohoe/Ninilchik Beach fishery, and ±0.188 in the Salamatof Beach fishery.

### *1991 Field Season*

Seven major UCI gillnet fisheries accounted for a commercial harvest of 2,095,062 sockeye salmon in 1991 (Table 8). The commercial drift gillnet fishery accounted for 53.3% (1,117,510 sockeye salmon) of the total harvest. Estimated total escapement into the four major river systems was 1,248,374 sockeye salmon (Table 8). The Kenai River system accounted for 51.9% (647,597 sockeye salmon) of the total escapement. The number of sockeye salmon sampled in 1991 were 12,931 from selected commercial gillnet fisheries and 11,076 from escapements (Table 8). These sample collections represented between 0.3% and 3.0% of the harvest by fishery and from 0.1% to 2.4% of the escapement by river. A total of 3,079 age-1.3 and 1,673 age-1.2 sockeye salmon scales were digitized in 1991 (Table 8). Age-1.3 sockeye salmon represented 43.2% and age-1.2 27.7% of the total return (Waltemyer 1994).

Mean and standard error estimates for individual scale variables of age-1.3 sockeye salmon showed significant statistical differences (ANOVA, $P<0.05$) for the number of circuli in (variable 1) and size of the first freshwater zone (variable 2) between Kenai and *Other* river systems (Table 9). No significant differences were found (ANOVA, $P>0.05$) for the number of circuli in (variable 61) or size of the freshwater plus growth zone (variable 62). Similarly, no significant differences (ANOVA, $P>0.05$) were found for the number of circuli in (variable 70) or size of the first marine growth zone (variable 71). A highly significant difference in size of the second marine growth zone (variable 109) was found between Kenai and *Other* rivers.

Mean and standard error estimates for scale variables of age-1.2 sockeye salmon showed highly significant statistical differences (ANOVA, $P<0.05$) for the number of circuli in (variable 1) and size of the first freshwater zone (variable 2) between Kenai and *Other* river systems (Table 10). There were also significant differences found (ANOVA, $P<0.05$) for the number of circuli in (variable 61) and size of the freshwater plus growth zone (variable 62). A significant difference (ANOVA, $P<0.05$) was found for the number of circuli in (variable 70), but not for size of the first marine growth zone (variable 71; ANOVA, $P>0.05$).

Variables 8, 109, 85, 25, 1, 17, and 66 were selected to build the two-way model for age-1.3 sockeye salmon in 1991 (Table 11). The mean classification accuracy for the two-way model in 1991 was 0.678 with a Kenai River misclassification rate of 0.315.

The age-1.2 model developed in 1991 included variables 65, 15, 98, 25, 76, 24, 105, and 17 (Table 11). The mean classification accuracy was 0.788 and the misclassification rate for the Kenai River was 0.269.

Stock composition estimates of age-1.2 sockeye salmon in the drift fishery showed that the greatest proportion of the Kenai River component occurred on 19 July (Table 12; Figure 6). Estimates of the Kenai River proportion were greatest on 29 July in the Cohoe/Ninilchik Beach fishery, 19 July in the Kalifonsky Beach fishery, and 29 July in the Salamatof Beach fishery. The 90% confidence intervals around the adjusted proportions (not including stock estimates of 0 or 1) averaged ±0.420 in the drift fishery, ±0.778 in the Cohoe/Ninilchik Beach fishery, and ±0.367 in the Salamatof Beach fishery.

Estimates of stock composition of age-1.3 sockeye salmon showed that the greatest proportion of the Kenai River component in the drift fishery occurred on 29 July (Table 13; Figure 7). Kenai River stock proportion estimates were greatest toward the end of July in all other Central District fisheries as well. The 90% confidence intervals around the adjusted proportions (not including stock estimates of 0 or 1) averaged ±0.519 in the drift fishery and ±0.616 in the Cohoe/Ninilchik Beach fishery.

## DISCUSSION

Post-season SPA to determine the occurrence of Kenai River sockeye salmon in commercial harvests was of limited use in 1990 and 1991. The two-way classification models had only fair self-classification accuracies with wide confidence intervals (>20%) according to criteria established for management purposes. There was as much variability within stocks as between stocks for most scale growth measurements. The first freshwater growth zone of age-1.3 sockeye salmon in 1990 was a good example of this. Variable 109 was the only variable common to age-1.3 classification models for both years.

The Kenai River is composed of several distinct stocks or populations that have different age classes and size compositions in their runs. The same situation occurs in the Susitna River system. Thus, our ability to distinguish among populations from major river systems based on scale characteristics is generally poor, misclassification errors ranging from 11.6% to 31.5%.

There also appears to be temporal differences within the years 1988–1990 in scale variables examined for the Kenai, Kasilof, and Susitna Rivers (Waltemyer et al. 1994). The fact that scale growth patterns differ with time will increase the within-stock variability for individual scale variables used to build yearly stock models and reduce the precision in estimating stock contributions. Thus, the problem of discriminating among fish stocks is compounded.

In the past, SPA results for one to three major age classes were used in conjunction with relative escapement age composition for the four major river systems to classify other age classes of sockeye salmon harvested in the UCI commercial fishery. However, regional and local area staff decided at the annual UCI staff meeting in 1989 (Browning 1989) not to allocate minor stock components and age classes to river of origin using this technique. Therefore, this report was prepared with the goal of presenting the best available SPA data for Kenai River age-1.3 sockeye salmon only. Unfortunately, after preliminary examination of the data, it appears that there is only fair classification accuracy for a two-way model between Kenai River and a composite sample from other systems for both 1990 and 1991. Age-1.3 sockeye salmon historically accounted for most (>70%) of the Kenai River run. However, in 1990 and 1991 age-1.3 sockeye salmon accounted for <40% of the total escapement into the Kenai River.

The history of the UCI stock identification program seems to be one of poor to moderate model performance and gradual loss of precision in estimating stock contributions. In an attempt to improve this program, other biological discriminators must be explored and evaluated if a reliable, long-term stock identification program is to be successful. Such investigations have begun that include the use of parasites (Tarbox et al. 1991; Waltemyer et al. 1993) and the use of parasites in conjunction with genetic discriminators (Tarbox 1993). The usefulness of the parasite *Philonema oncorhynchi* to classify sockeye salmon stocks in UCI appears to be limited, but promising. The combination of both parasite and genetic discriminators is presently being explored.

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Table 1. Scale variables screened for linear discriminant function analysis of age-1.2, -1.3, and -2.3 sockeye salmon, Upper Cook Inlet, Alaska, in 1990 and 1991.

| Variable Number | Variable Name | Zone |
|---|---|---|
| | | ***First Freshwater Annular Zone*** |
| 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 4) to end first freshwater |
| 13 (26) | C(NC - 2)–E1FW | Distance, circulus (number circuli first freshwater minus 2) 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 | C0–C2/S1FW... | Relative widths, (variables 3–13)/S1FW |
| 26 | C(NC-2)–E1FW/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 |
| | | ***Second Freshwater Annular Zone*** |
| 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 | E1FW–C2/S2FW... | Relative widths, (variables 33–43)/S2FW |
| 56 | C(NC-2)–E2FW/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 |
| | | ***Plus Growth Zone*** |
| 61 | NCPG | Number of circuli in plus growth |
| 62 | SPGZ | Size (width) plus growth zone |

– Continued –

Table 1. (Page 2 of 2).

| Variable Number | Variable Name | Zone |
|---|---|---|
| | | ***Freshwater and Plus Growth Zones*** |
| 63 | NC1 + NC2 | 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 freshwaters and plus growth |
| 66 | S1FW + S2FW + SPGZ | Total size (width) first and second freshwaters 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 |
| | | ***First Marine Annular Zone*** |
| 70 | NC1OZ | Number of circuli in first ocean zone |
| 71 | S1OZ | 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)–E1OZ | Distance, circulus (number circuli first ocean minus 6) to end first ocean |
| 86 (104) | C(NC - 3)–E13OZ | Distance, circulus (number circuli first ocean minus 3) to end first ocean |
| 87 | C3–E1OZ | Distance, circulus 3 to end of first ocean |
| 88 | C9–E1OZ | Distance, circulus 9 to end of first ocean |
| 89 | C15–E1OZ | Distance, circulus 15 to end of first ocean |
| 90 thru 104 | EFW–C3/S1OZ... C(NC - 3)–E13OZ/S1OZ | Relative widths, (variables 72-86)/S1OZ |
| 105 | S1OZ/NC1OZ | 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/S1OZ | Relative width, (variable 107)/S1OZ |
| | | ***Second Marine Annular Zone*** |
| 109 | S2OZ | Size (width) of second ocean zone |

Table 2. Number of sockeye salmon in commercial harvests and escapements and number of scale samples taken and digitized, Upper Cook Inlet, Alaska, in 1990.

| Sample Location | Number of Fish | Scale Sample | Percent of Harvest or Escapement | Digitized Scales Age 1.3 | Digitized Scales Age 2.3 |
|---|---|---|---|---|---|
| **Commercial Fisheries**[a]: | | | | | |
| ***Central District*** | | | | | |
| Drift[b] | 2,305,707 | 8,143 | 0.4 | 1,422 | 1,257 |
| Cohoe/Ninilchik Beach | 198,652 | 2,968 | 1.5 | 506 | 492 |
| Kalifonsky Beach | 425,396 | 2,100 | 0.5 | 395 | 390 |
| Salamatof Beach | 492,927 | 2,400 | 0.5 | 403 | 360 |
| Western Subdistrict | 21,727 | 813 | 3.7 | ND[c] | ND |
| ***Northern District*** | | | | | |
| Eastern Subdistrict | 27,012 | 1,575 | 5.8 | 291 | 82 |
| General Subdistrict | 69,386 | 1,200 | 1.7 | ND | ND |
| **Total**[d] | 3,540,807 | 19,199 | 0.5 | 3,017 | 2,581 |
| **Escapements:** | | | | | |
| Kenai River | 659,521 | 2,161 | 0.3 | 631 | 191 |
| Kasilof River | 144,136 | 873 | 0.6 | 141 | 84 |
| Crescent | 52,238 | 785 | 1.5 | ND | 165 |
| Packers | 31,868 | 442 | 1.4 | ND | ND |
| Yentna River | 140,290 | 2,408 | 1.7 | 663 | 26 |
| Sunshine Station | 133,276[e] | 1,333 | — | 404 | 105 |
| Fish Creek | 48,717 | 555 | 1.1 | ND | ND |
| **Total** | 1,210,046 | 8,884 | 0.7 | 1,839 | 571 |

[a] Commercial harvests sampled through 31 July but totals represent final fish ticket numbers.

[b] Harvest does not include Chinitna Bay Subdistrict harvest of 35 fish.

[c] No scale samples digitized.

[d] Total represents 98.2% of the total Upper Cook Inlet commercial harvest.

[e] An estimate based on the relation between Yentna River and Sunshine Station escapements for the years 1981–1985. The estimate of Sunshine Station escapement equals 0.95 of the Yentna escapement estimate.

Table 3. Mean and standard error of scale variables screened for linear discriminant analysis of age-1.3 sockeye salmon sampled in the Kenai and *Other* river systems, Upper Cook Inlet, Alaska, in 1990.

| | | Kenai[a] | | *Other*[b] | | |
|---|---|---|---|---|---|---|
| Number | Variable | Mean | S.E. | Mean | S.E. | F-Stat |
| | ***First Freshwater Annulus*** | | | | | |
| 1 | NC1FW | 8.294 | 0.123 | 8.654 | 0.138 | 3.572 |
| 2 | S1FW | 118.114 | 1.388 | 119.883 | 1.574 | 0.661 |
| 3 | C0–C2 | 49.871 | 0.378 | 48.414 | 0.388 | 6.907 |
| 4 | C0–C4 | 75.612 | 0.496 | 73.015 | 0.487 | 13.483 |
| 5 | C0–C6 | 96.198 | 0.564 | 94.346 | 0.588 | 4.912 |
| 6 | C0–C8 | 116.225 | 0.714 | 113.879 | 0.916 | 3.772 |
| 7 | C2–C4 | 25.741 | 0.262 | 24.602 | 0.267 | 8.873 |
| 8 | C2–C6 | 46.360 | 0.380 | 45.785 | 0.417 | 0.980 |
| 9 | C2–C8 | 66.413 | 0.578 | 66.358 | 0.694 | 0.003 |
| 10 | C4–C6 | 20.665 | 0.253 | 21.046 | 0.237 | 1.185 |
| 11 | C4–C8 | 40.464 | 0.455 | 41.110 | 0.506 | 0.859 |
| 12 | C(NC - 4)–E1FW | 39.876 | 0.483 | 40.173 | 0.415 | 0.219 |
| 13 | C(NC - 2)–E1FW | 18.940 | 0.261 | 19.316 | 0.259 | 1.007 |
| 14 | C2–E1FW | 68.244 | 1.361 | 71.470 | 1.569 | 2.234 |
| 15 | C4–E1FW | 42.715 | 1.289 | 46.868 | 1.469 | 4.188 |
| 16 | C0–C2/S1FW | 0.431 | 0.005 | 0.419 | 0.006 | 2.307 |
| 17 | C0–C4/S1FW | 0.653 | 0.007 | 0.630 | 0.007 | 5.225 |
| 18 | C0–C6/S1FW | 0.824 | 0.007 | 0.802 | 0.008 | 4.021 |
| 19 | C0–C8/S1FW | 0.929 | 0.007 | 0.883 | 0.008 | 16.607 |
| 20 | C2–C4/S1FW | 0.222 | 0.003 | 0.210 | 0.003 | 9.028 |
| 21 | C2–C6/S1FW | 0.396 | 0.004 | 0.386 | 0.004 | 3.156 |
| 22 | C2–C8/S1FW | 0.530 | 0.004 | 0.513 | 0.005 | 6.015 |
| 23 | C4–C6/S1FW | 0.176 | 0.002 | 0.177 | 0.002 | 0.132 |
| 24 | C4–C8/S1FW | 0.322 | 0.003 | 0.317 | 0.003 | 1.181 |
| 25 | VAR 12/S1FW | 0.347 | 0.006 | 0.348 | 0.005 | 0.000 |
| 26 | VAR 13/S1FW | 0.165 | 0.003 | 0.166 | 0.003 | 0.178 |
| 27 | S1FW/NC1FW | 14.421 | 0.108 | 14.094 | 0.108 | 4.430 |
| 28 | NC 1ST 3/4 | 4.746 | 0.090 | 5.071 | 0.104 | 5.204 |
| 29 | MAX DIST | 16.468 | 0.173 | 15.823 | 0.165 | 7.096 |
| 30 | VAR 29/S1FW | 0.142 | 0.002 | 0.136 | 0.002 | 4.986 |
| | ***Plus Growth*** | | | | | |
| 61 | NCPG | 2.552 | 0.129 | 2.816 | 0.116 | 2.275 |
| 62 | SPGZ | 30.358 | 1.674 | 30.222 | 1.272 | 0.004 |
| | ***Freshwater and Plus Growth*** | | | | | |
| 65 | NC1 + NC2 + NCPG | 10.846 | 0.150 | 11.470 | 0.142 | 8.876 |
| 66 | S1F + S2F + SPGZ | 148.473 | 1.799 | 150.105 | 1.542 | 0.477 |
| 67 | S1FW/VAR 66 | 0.808 | 0.009 | 0.803 | 0.008 | 0.166 |
| | ***First Marine Annulus*** | | | | | |
| 70 | NC1OZ | 0.473 | 0.182 | 0.312 | 0.168 | 21.579 |
| 71 | S1OZ | 414.612 | 2.797 | 398.004 | 2.734 | 17.451 |

– Continued –

Table 3. (Page 2 of 2).

| Number | Variable | Kenai[a] Mean | S.E. | *Other*[b] Mean | S.E. | F-Stat |
|---|---|---|---|---|---|---|
| | ***First Marine Annulus*** (continued) | | | | | |
| 72 | EFW–C3 | 44.632 | 0.521 | 45.259 | 0.498 | 0.738 |
| 73 | EFW–C6 | 96.164 | 0.852 | 99.323 | 0.825 | 6.892 |
| 74 | EFW–C9 | 150.159 | 1.126 | 154.759 | 1.070 | 8.550 |
| 75 | EFW–C12 | 204.836 | 1.353 | 209.346 | 1.245 | 5.923 |
| 76 | EFW–C15 | 257.259 | 1.500 | 260.170 | 1.389 | 1.994 |
| 77 | C3–C6 | 51.532 | 0.522 | 54.064 | 0.529 | 11.117 |
| 78 | C3–C9 | 105.527 | 0.834 | 109.500 | 0.819 | 11.157 |
| 79 | C3–C12 | 160.204 | 1.087 | 164.086 | 1.027 | 6.582 |
| 80 | C3–C15 | 212.627 | 1.256 | 214.913 | 1.202 | 1.686 |
| 81 | C6–C9 | 53.995 | 0.512 | 55.436 | 0.492 | 4.004 |
| 82 | C6–C12 | 108.672 | 0.793 | 110.023 | 0.743 | 1.514 |
| 83 | C6–C15 | 161.095 | 1.013 | 160.860 | 0.946 | 0.028 |
| 84 | C9–C15 | 107.1 0 | 0.789 | 105.411 | 0.704 | 2.531 |
| 85 | C(NC - 6)–E1OZ | 82.393 | 0.663 | 83.383 | 0.692 | 1.015 |
| 86 | C(NC - 3)–E1OZ | 37.801 | 0.350 | 38.951 | 0.395 | 4.426 |
| 87 | C3–E1OZ | 369.980 | 2.879 | 352.744 | 2.808 | 17.784 |
| 88 | C9–E1OZ | 264.453 | 2.994 | 243.244 | 2.752 | 26.776 |
| 89 | C15–E1OZ | 157.353 | 2.859 | 138.419 | 2.531 | 24.483 |
| 90 | EFW–C3/S1OZ | 0.109 | 0.002 | 0.115 | 0.002 | 8.647 |
| 91 | EFW–C6/S1OZ | 0.234 | 0.003 | 0.253 | 0.003 | 22.316 |
| 92 | EFW–C9/S1OZ | 0.366 | 0.004 | 0.393 | 0.004 | 27.234 |
| 93 | EFW–C12/S1OZ | 0.498 | 0.004 | 0.531 | 0.004 | 27.447 |
| 94 | EFW–C15/S1OZ | 0.625 | 0.005 | 0.659 | 0.005 | 22.177 |
| 95 | C3–C6/S1OZ | 0.125 | 0.002 | 0.137 | 0.002 | 28.102 |
| 96 | C3–C9/S1OZ | 0.257 | 0.003 | 0.278 | 0.003 | 32.073 |
| 97 | C3–C12/S1OZ | 0.389 | 0.003 | 0.416 | 0.003 | 30.720 |
| 98 | C3–C15/S1OZ | 0.517 | 0.004 | 0.544 | 0.004 | 23.266 |
| 99 | C6–C9/S1OZ | 0.131 | 0.002 | 0.140 | 0.001 | 19.714 |
| 100 | C6–C12/S1OZ | 0.264 | 0.002 | 0.279 | 0.002 | 20.877 |
| 101 | C6–C15/S1OZ | 0.391 | 0.003 | 0.407 | 0.003 | 13.937 |
| 102 | C9–C15/S1OZ | 0.260 | 0.002 | 0.266 | 0.002 | 5.130 |
| 103 | VAR 85/S1OZ | 0.201 | 0.002 | 0.213 | 0.003 | 10.910 |
| 104 | VAR 86/S1OZ | 0.092 | 0.001 | 0.099 | 0.001 | 14.756 |
| 105 | S1OZ/NC1OZ | 16.325 | 0.080 | 16.424 | 0.078 | 0.762 |
| 106 | NC 1ST 1/2 | 11.642 | 0.101 | 10.936 | 0.088 | 27.729 |
| 107 | MAX DIST | 25.035 | 0.223 | 25.162 | 0.202 | 0.176 |
| 108 | VAR 107/S1OZ | 0.061 | 0.000 | 0.064 | 0.000 | 11.709 |
| | ***Second Marine Annulus*** | | | | | |
| 109 | S2OZ | 389.861 | 2.988 | 360.425 | 2.530 | 56.958 |

[a] Kenai River scale sample was 201.

[b] *Other* river scale sample of 266 was weighted proportionately to escapement level and represented Kasilof (133 scales), Susitna (66 scales, mile 80 mainstem), and Yentna (67 scales) Rivers.

Table 4. Mean and standard error of scale variables screened for linear discriminant analysis of age-2.3 sockeye salmon sampled in the Kenai and *Other* river systems, Upper Cook Inlet, Alaska, in 1990.

| | | Kenai[a] | | *Other*[b] | | |
|---|---|---|---|---|---|---|
| Number | Variable | Mean | S.E. | Mean | S.E. | F-Stat |
| | ***First Freshwater Annulus*** | | | | | |
| 1 | NC1FW | 5.674 | 0.112 | 7.066 | 0.134 | 64.234 |
| 2 | S1FW | 80.200 | 1.302 | 96.880 | 1.611 | 66.110 |
| 3 | C0–C2 | 44.280 | 0.402 | 45.144 | 0.454 | 2.041 |
| 4 | C0–C4 | 64.924 | 0.546 | 67.725 | 0.611 | 11.746 |
| 5 | C0–C6 | 83.458 | 0.876 | 87.518 | 0.726 | 12.781 |
| 6 | C0–C8 | 105.765 | 3.019 | 108.859 | 1.125 | 1.341 |
| 7 | C2–C4 | 20.738 | 0.287 | 22.581 | 0.335 | 17.615 |
| 8 | C2–C6 | 39.500 | 0.616 | 42.219 | 0.506 | 11.714 |
| 9 | C2–C8 | 61.941 | 2.030 | 62.797 | 0.933 | 0.168 |
| 10 | C4–C6 | 18.042 | 0.364 | 19.036 | 0.291 | 4.631 |
| 11 | C4–C8 | 37.706 | 1.080 | 38.688 | 0.629 | 0.535 |
| 12 | C(NC - 4)–E1FW | 43.342 | 0.855 | 40.862 | 0.676 | 4.989 |
| 13 | C(NC - 2)–E1FW | 18.768 | 0.347 | 18.491 | 0.265 | 0.388 |
| 14 | C2–E1FW | 36.537 | 1.155 | 51.737 | 1.478 | 67.099 |
| 15 | C4–E1FW | 19.465 | 1.019 | 31.212 | 1.270 | 51.993 |
| 16 | C0–C2/S1FW | 0.566 | 0.008 | 0.482 | 0.008 | 59.456 |
| 17 | C0–C4/S1FW | 0.815 | 0.008 | 0.721 | 0.009 | 56.779 |
| 18 | C0–C6/S1FW | 0.935 | 0.009 | 0.868 | 0.008 | 28.810 |
| 19 | C0–C8/S1FW | 0.941 | 0.022 | 0.948 | 0.009 | 0.116 |
| 20 | C2–C4/S1FW | 0.259 | 0.003 | 0.238 | 0.003 | 18.747 |
| 21 | C2–C6/S1FW | 0.440 | 0.005 | 0.418 | 0.005 | 10.505 |
| 22 | C2–C8/S1FW | 0.550 | 0.014 | 0.546 | 0.007 | 0.072 |
| 23 | C4–C6/S1FW | 0.201 | 0.003 | 0.188 | 0.003 | 8.635 |
| 24 | C4–C8/S1FW | 0.336 | 0.010 | 0.336 | 0.005 | 0.000 |
| 25 | VAR 12/S1FW | 0.569 | 0.016 | 0.449 | 0.013 | 33.127 |
| 26 | VAR 13/S1FW | 0.249 | 0.008 | 0.199 | 0.004 | 27.628 |
| 27 | S1FW/NC1FW | 14.456 | 0.174 | 13.897 | 0.131 | 6.319 |
| 28 | NC 1ST 3/4 | 3.063 | 0.080 | 3.988 | 0.101 | 52.273 |
| 29 | MAX DIST | 13.741 | 0.171 | 14.802 | 0.197 | 16.712 |
| 30 | VAR 29/S1FW | 0.175 | 0.003 | 0.157 | 0.002 | 24.155 |
| | ***Second Freshwater Annulus*** | | | | | |
| 31 | NC2FW | 8.579 | 0.110 | 6.144 | 0.154 | 171.530 |
| 32 | S2FW | 92.068 | 1.255 | 65.150 | 1.967 | 139.562 |
| 33 | E1FW–C2 | 22.174 | 0.256 | 21.006 | 0.332 | 7.964 |
| 34 | E1FW–C4 | 46.063 | 0.371 | 42.127 | 0.583 | 34.619 |
| 35 | E1FW–C6 | 67.457 | 0.500 | 63.424 | 0.986 | 16.502 |
| 36 | E1FW–C8 | 87.468 | 0.682 | 89.643 | 2.349 | 1.333 |
| 37 | C2–C4 | 23.889 | 0.272 | 18.599 | 0.856 | 38.455 |
| 38 | C2–C6 | 45.285 | 0.428 | 42.636 | 0.811 | 10.110 |
| 39 | C2–C8 | 65.338 | 0.635 | 67.500 | 2.251 | 1.495 |
| 40 | C4–C6 | 21.2[illegible] | 0.304 | 20.869 | 0.529 | 0.538 |
| 41 | C4–C8 | 41.2[illegible] | 0.537 | 44.821 | 1.869 | 5.775 |

– Continued –

Table 4. (Page 2 of 3).

| Number | Variable | Kenai[a] Mean | S.E. | *Other*[b] Mean | S.E. | F-Stat |
|---|---|---|---|---|---|---|
| | ***Second Freshwater Annulus*** (continued) | | | | | |
| 42 | C(NC - 4)–E2FW | 39.868 | 0.488 | 39.140 | 0.971 | 0.486 |
| 43 | C(NC - 2)–E2FW | 19.079 | 0.289 | 20.557 | 0.347 | 10.883 |
| 44 | C2–E2FW | 69.895 | 1.193 | 44.144 | 1.898 | 138.557 |
| 45 | C4–E2FW | 46.005 | 1.148 | 27.257 | 1.812 | 83.173 |
| 46 | E1FW–C2/S2FW | 0.248 | 0.004 | 0.355 | 0.009 | 126.220 |
| 47 | E1FW–C4/S2FW | 0.514 | 0.006 | 0.673 | 0.013 | 135.194 |
| 48 | E1FW–C6/S2FW | 0.741 | 0.007 | 0.860 | 0.014 | 66.864 |
| 49 | E1FW–C8/S2FW | 0.911 | 0.007 | 0.904 | 0.026 | 0.120 |
| 50 | C2–C4/S2FW | 0.266 | 0.004 | 0.278 | 0.019 | 0.413 |
| 51 | C2–C6/S2FW | 0.497 | 0.005 | 0.577 | 0.011 | 55.150 |
| 52 | C2–C8/S2FW | 0.680 | 0.006 | 0.678 | 0.020 | 0.023 |
| 53 | C4–C6/S2FW | 0.232 | 0.003 | 0.282 | 0.007 | 55.741 |
| 54 | C4–C8/S2FW | 0.428 | 0.005 | 0.449 | 0.016 | 2.458 |
| 55 | VAR 42/S2FW | 0.447 | 0.008 | 0.616 | 0.016 | 99.193 |
| 56 | VAR 43/S2FW | 0.214 | 0.004 | 0.348 | 0.010 | 168.769 |
| 57 | S2FW/NC2FW | 10.760 | 0.079 | 10.566 | 0.129 | 1.745 |
| 58 | NC 1ST 3/4 | 5.653 | 0.078 | 4.096 | 0.112 | 134.745 |
| 59 | MAX DIST | 14.500 | 0.137 | 13.659 | 0.218 | 11.217 |
| 60 | VAR 59/S2FW | 0.162 | 0.002 | 0.228 | 0.005 | 151.605 |
| | ***Plus Growth*** | | | | | |
| 61 | NCPG | 0.516 | 0.044 | 0.323 | 0.054 | 7.790 |
| 62 | SPGZ | 1.484 | 0.390 | 1.904 | 0.530 | 0.421 |
| | ***Freshwater and Plus Growth*** | | | | | |
| 63 | NC1 + NC2 | 14.253 | 0.138 | 13.210 | 0.174 | 22.531 |
| 64 | S1F + S2F | 172.268 | 1.519 | 162.030 | 2.188 | 15.341 |
| 65 | NC1 + NC2 + NCPG | 14.768 | 0.144 | 13.533 | 0.188 | 28.011 |
| 66 | S1F + S2F + SPGZ | 173.753 | 1.560 | 163.934 | 2.286 | 13.096 |
| 67 | S1FW/VAR 66 | 0.461 | 0.006 | 0.597 | 0.008 | 190.264 |
| 68 | SPGZ/VAR 66 | 0.042 | 0.009 | 0.091 | 0.014 | 8.982 |
| 69 | S2FW/VAR 66 | 0.531 | 0.006 | 0.393 | 0.008 | 197.448 |
| | ***First Marine Annulus*** | | | | | |
| 70 | NC1OZ | 24.900 | 0.154 | 24.036 | 0.210 | 11.409 |
| 71 | S1OZ | 414.732 | 2.716 | 398.030 | 3.535 | 14.394 |
| 72 | EFW–C3 | 46.863 | 0.676 | 46.036 | 0.716 | 0.705 |
| 73 | EFW–C6 | 104.453 | 1.021 | 103.198 | 1.058 | 0.726 |
| 74 | EFW–C9 | 162.116 | 1.170 | 160.012 | 1.336 | 1.415 |
| 75 | EFW–C12 | 218.474 | 1.410 | 215.192 | 1.591 | 2.399 |
| 76 | EFW–C15 | 270.253 | 1.569 | 265.341 | 1.723 | 4.459 |

– Continued –

Table 4. (Page 3 of 3).

| Number | Variable | Kenai[a] Mean | Kenai[a] S.E. | *Other*[b] Mean | *Other*[b] S.E. | F-Stat |
|---|---|---|---|---|---|---|
| | ***First Marine Annulus*** (continued) | | | | | |
| 77 | C3–C6 | 57.589 | 0.596 | 57.162 | 0.666 | 0.230 |
| 78 | C3–C9 | 115.253 | 0.797 | 113.976 | 1.007 | 1.010 |
| 79 | C3–C12 | 171.611 | 1.046 | 169.156 | 1.298 | 2.209 |
| 80 | C3–C15 | 223.389 | 1.249 | 219.305 | 1.484 | 4.498 |
| 81 | C6–C9 | 57.663 | 0.497 | 56.814 | 0.591 | 1.225 |
| 82 | C6–C12 | 114.021 | 0.735 | 111.994 | 0.956 | 2.897 |
| 83 | C6–C15 | 165.800 | 0.976 | 162.144 | 1.159 | 5.903 |
| 84 | C9–C15 | 108.137 | 0.735 | 105.329 | 0.875 | 6.118 |
| 85 | C(NC - 6)–E1OZ | 80.037 | 0.668 | 83.401 | 0.820 | 10.301 |
| 86 | C(NC - 3)–E1OZ | 37.663 | 0.385 | 39.557 | 0.474 | 9.790 |
| 87 | C3–E1OZ | 367.868 | 2.718 | 351.994 | 3.608 | 12.699 |
| 88 | C9–E1OZ | 252.616 | 2.566 | 238.018 | 3.487 | 11.721 |
| 89 | C15–E1OZ | 144.479 | 2.440 | 132.689 | 3.215 | 8.768 |
| 90 | EFW–C3/S1OZ | 0.114 | 0.002 | 0.117 | 0.002 | 1.718 |
| 91 | EFW–C6/S1OZ | 0.253 | 0.003 | 0.263 | 0.004 | 4.520 |
| 92 | EFW–C9/S1OZ | 0.393 | 0.003 | 0.406 | 0.005 | 6.021 |
| 93 | EFW–C12/S1OZ | 0.530 | 0.004 | 0.546 | 0.006 | 6.372 |
| 94 | EFW–C15/S1OZ | 0.655 | 0.004 | 0.673 | 0.006 | 6.139 |
| 95 | C3–C6/S1OZ | 0.140 | 0.001 | 0.145 | 0.002 | 5.157 |
| 96 | C3–C9/S1OZ | 0.279 | 0.002 | 0.289 | 0.003 | 6.899 |
| 97 | C3–C12/S1OZ | 0.416 | 0.003 | 0.429 | 0.004 | 7.094 |
| 98 | C3–C15/S1OZ | 0.541 | 0.003 | 0.556 | 0.005 | 6.423 |
| 99 | C6–C9/S1OZ | 0.140 | 0.001 | 0.144 | 0.002 | 4.043 |
| 100 | C6–C12/S1OZ | 0.276 | 0.002 | 0.284 | 0.003 | 4.981 |
| 101 | C6–C15/S1OZ | 0.402 | 0.003 | 0.410 | 0.003 | 4.429 |
| 102 | C9–C15/S1OZ | 0.262 | 0.002 | 0.267 | 0.002 | 2.374 |
| 103 | VAR 85/S1OZ | 0.195 | 0.002 | 0.212 | 0.003 | 25.261 |
| 104 | VAR 86/S1OZ | 0.092 | 0.001 | 0.101 | 0.001 | 24.450 |
| 105 | S1OZ/NC1OZ | 16.686 | 0.083 | 16.607 | 0.100 | 0.376 |
| 106 | NC 1ST 1/2 | 10.968 | 0.084 | 10.629 | 0.106 | 6.446 |
| 107 | MAX DIST | 25.753 | 0.230 | 25.958 | 0.260 | 0.340 |
| 108 | VAR 107/S1OZ | 0.062 | 0.000 | 0.066 | 0.000 | 12.221 |
| | ***Second Marine Annulus*** | | | | | |
| 109 | S2OZ | 371.605 | 3.379 | 344.204 | 3.919 | 28.350 |

[a] Kenai River scale sample was 190.

[b] *Other* river scale sample of 167 was weighted proportionately to escapement level and represented Kasilof (84 scales), Susitna (31 scales, mile 80 mainstem), and Yentna (52 scales) Rivers.

Table 5. Final classification matrices derived from discriminant analyses of selected scale variables of age-1.3 and -2.3 sockeye salmon scale samples from the Kenai and *Other* rivers that maximized classification of the Kenai River component, Upper Cook Inlet, Alaska, in 1990.

| Age Group | Actual Group of Origin | Sample Size | Classification Matrix Kenai | *Other* | |
|---|---|---|---|---|---|
| 1.3[a] | Kenai | 201 | 0.741 | 0.259 | |
| | *Other*[b] | 266 | 0.327 | 0.673 | |
| | | | *mean classification accuracy* | | 0.707 |
| 2.3[c] | Kenai | 190 | 0.884 | 0.116 | |
| | *Other*[d] | 167 | 0.210 | 0.790 | |
| | | | *mean classification accuracy* | | 0.837 |

[a] Two-way model included the primary variables 109, 96, 104, and 4 with associated negatively correlated variables 106, 70, and 65.

[b] *Other* included Kasilof, Susitna (river mile 80), and Yentna Rivers with sample sizes of 133, 66, and 67 scales, respectively.

[c] Two-way model included the primary variables 56 and 67.

[d] *Other* included Kasilof, Susitna (river mile 80), and Yentna Rivers with sample sizes of 84, 31, and 52 scales, respectively.

Table 6. Estimates of stock composition and statistical precision (90% interval) of commercial harvests using linear discriminant analysis of age-1.3 sockeye salmon, Upper Cook Inlet, Alaska, in 1990.

| | | Kenai | | | *Other*[a] | | |
|---|---|---|---|---|---|---|---|
| | | Adjusted[d] | 90% Interval[b] | | Adjusted | 90% Interval | |
| Fishery | Date[c] | Proportion | Lower | Upper | Proportion | Lower | Upper |
| **Central District**: | | | | | | | |
| *Drift* | 6/25 | 0.000 | 0.000 | 0.185 | 1.000 | 0.815 | 1.000 |
| | 6/29 | 0.047 | 0.000 | 0.265 | 0.953 | 0.735 | 1.000 |
| | 7/02 | 0.442 | 0.226 | 0.658 | 0.558 | 0.342 | 0.774 |
| | 7/06 | 0.276 | 0.061 | 0.491 | 0.724 | 0.509 | 0.939 |
| | 7/09 | 0.669 | 0.456 | 0.882 | 0.331 | 0.118 | 0.544 |
| | 7/16[e] | 0.908 | 0.696 | 1.000 | 0.092 | 0.000 | 0.304 |
| | 7/18[f] | 0.539 | 0.324 | 0.754 | 0.461 | 0.246 | 0.676 |
| | 7/20[g] | 0.780 | 0.566 | 0.994 | 0.220 | 0.006 | 0.434 |
| | 7/23[h] | 0.932 | 0.720 | 1.000 | 0.068 | 0.000 | 0.280 |
| | 7/26[i] | 0.903 | 0.695 | 1.000 | 0.097 | 0.000 | 0.305 |
| | 7/27[j] | 0.749 | 0.537 | 0.962 | 0.251 | 0.038 | 0.463 |
| | 7/29[k] | 0.702 | 0.490 | 0.915 | 0.298 | 0.085 | 0.510 |
| | 7/30[l] | 0.678 | 0.466 | 0.891 | 0.322 | 0.109 | 0.534 |
| | 7/31[m] | 0.717 | 0.504 | 0.930 | 0.283 | 0.070 | 0.496 |
| *Cohoe/Ninilchik Beach* | 7/02 | 0.358 | 0.143 | 0.573 | 0.642 | 0.427 | 0.857 |
| | 7/09 | 0.645 | 0.431 | 0.859 | 0.355 | 0.141 | 0.569 |
| | 7/20 | 0.820 | 0.608 | 1.000 | 0.180 | 0.000 | 0.392 |
| | 7/23 | 0.669 | 0.456 | 0.882 | 0.331 | 0.118 | 0.544 |
| | 7/30[n] | 0.908 | 0.696 | 1.000 | 0.092 | 0.000 | 0.304 |
| *Kalifonsky Beach* | 7/02 | 0.110 | 0.000 | 0.333 | 0.890 | 0.667 | 1.000 |
| | 7/06 | 0.708 | 0.494 | 0.922 | 0.292 | 0.078 | 0.506 |
| | 7/16[o] | 0.702 | 0.490 | 0.915 | 0.298 | 0.085 | 0.510 |
| | 7/27[p] | 0.978 | 0.763 | 1.000 | 0.022 | 0.000 | 0.237 |
| *Salamatof Beach* | 7/09 | 0.749 | 0.537 | 0.962 | 0.251 | 0.038 | 0.463 |
| | 7/16 | 0.812 | 0.600 | 1.000 | 0.188 | 0.000 | 0.400 |
| | 7/23 | 1.000 | 0.906 | 1.000 | 0.000 | 0.000 | 0.094 |
| | 7/30[q] | 0.611 | 0.396 | 0.826 | 0.389 | 0.174 | 0.604 |

– Continued –

Table 6. (Page 2 of 2).

| Fishery | Date[c] | Kenai Adjusted[d] Proportion | Kenai 90% Interval[b] Lower | Kenai 90% Interval[b] Upper | *Other*[a] Adjusted Proportion | *Other*[a] 90% Interval Lower | *Other*[a] 90% Interval Upper |
|---|---|---|---|---|---|---|---|
| **Northern District**: | | | | | | | |
| *Eastern Subdistrict* | 7/13 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 | 1.000 |
| | 7/20 | 0.000 | 0.000 | 0.106 | 1.000 | 0.894 | 1.000 |
| | 7/27 | 0.000 | 0.000 | 0.100 | 1.000 | 0.900 | 1.000 |

[a] *Other* represents Yentna and Kasilof River samples combined.
[b] Estimates that were <0 or >1 as a result of the Cook and Lord (1978) procedure are noted as 0 or 1, respectively.
[c] Standard 12-h fishing period (0700-1900 hours) if not otherwise noted.
[d] Adjusted Proportion represents an adjusted estimate derived from the Cook and Lord (1978) procedure.
[e] All except within 5 mi of beach south of mid-Kalifonsky Beach.
[f] 0900–1200 hours; Colliers Dock to mid-Kalifonsky Beach within 3 mi of beach.
1200–2200 hours; Colliers to Ninilchik Beach within 3 mi.
[g] 0700–1900 hours; all open.
1900–2200 hours; Colliers to Ninilchik Beach within 3 mi.
[h] 0500–0700 hours; Colliers to Ninilchik Beach within 3 mi.
0700–1900 hours; south of Kalgin Island, south of Colliers within 3 mi.
[i] 0500–2200 hours; Colliers to mid-Kalifonsky Beach within 3 mi.
[j] 0500–0700 hours; Colliers to mid-Kalifonsky Beach within 3 mi.
0700–1900 hours; all open.
1900–2200 hours; Colliers to Ninilchik Beach within 3 mi.
[k] 0600–2200 hours; Colliers to mid-Kalifonsky Beach within 6 mi.
[l] 0600–2200 hours; Colliers to mid-Kalifonsky Beach within 6 mi.
0700–1900 hours; all open.
1900–2200 hours; Colliers to Ninilchik Beach within 6 mi.
[m] 0500–2200 hours; Colliers to Ninilchik Beach within 6 mi.
[n] 0700–2400 hours; open.
[o] All except Western, Upper south of mid-Kalifonsky Beach.
[p] 0000–0700 hours; Upper north of mid-Kalifonsky Beach, Knik Arm.
0700–1900 hours; all plus Knik Arm.
1900–2200 hours; Upper, Knik Arm.
[q] 0000–0700 hours; Upper north of mid-Kalifonsky Beach.
0700–2400 hours; open.

Table 7. Estimates of stock composition and statistical precision (90% interval) of commercial harvests using linear discriminant analysis of age-2.3 sockeye salmon, Upper Cook Inlet, Alaska, in 1990.

| | | Kenai | | | *Other*[a] | | |
|---|---|---|---|---|---|---|---|
| | | Adjusted[d] | 90% Interval[b] | | Adjusted | 90% Interval | |
| Fishery | Date[c] | Proportion | Lower | Upper | Proportion | Lower | Upper |
| **Central District**: | | | | | | | |
| *Drift* | 6/25 | 0.344 | 0.151 | 0.537 | 0.656 | 0.463 | 0.849 |
| | 6/29 | 0.172 | 0.037 | 0.308 | 0.828 | 0.692 | 0.963 |
| | 7/02 | 0.171 | 0.032 | 0.311 | 0.829 | 0.689 | 0.968 |
| | 7/06 | 0.678 | 0.534 | 0.821 | 0.322 | 0.179 | 0.466 |
| | 7/09 | 0.707 | 0.575 | 0.840 | 0.293 | 0.160 | 0.425 |
| | 7/16[e] | 0.893 | 0.777 | 1.000 | 0.107 | 0.000 | 0.223 |
| | 7/18[f] | 0.909 | 0.801 | 1.000 | 0.091 | 0.000 | 0.199 |
| | 7/20[g] | 0.947 | 0.844 | 1.000 | 0.053 | 0.000 | 0.156 |
| | 7/23[h] | 0.908 | 0.801 | 1.000 | 0.092 | 0.000 | 0.199 |
| | 7/26[i] | 0.867 | 0.757 | 0.976 | 0.133 | 0.024 | 0.243 |
| | 7/27[j] | 1.000 | 0.972 | 1.000 | 0.000 | 0.000 | 0.028 |
| | 7/29[k] | 0.996 | 0.899 | 1.000 | 0.004 | 0.000 | 0.101 |
| | 7/30[l] | 1.000 | 1.000 | 1.000 | 0.000 | 0.000 | 0.000 |
| | 7/31[m] | 1.000 | 1.000 | 1.000 | 0.000 | 0.000 | 0.000 |
| *Cohoe/Ninilchik Beach* | 7/02 | 0.159 | 0.028 | 0.289 | 0.841 | 0.711 | 0.972 |
| | 7/09 | 0.217 | 0.078 | 0.357 | 0.783 | 0.643 | 0.922 |
| | 7/20 | 0.717 | 0.596 | 0.838 | 0.283 | 0.162 | 0.404 |
| | 7/23 | 0.736 | 0.616 | 0.855 | 0.264 | 0.145 | 0.384 |
| | 7/30[n] | 1.000 | 0.916 | 1.000 | 0.000 | 0.000 | 0.084 |
| *Kalifonsky Beach* | 7/02 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 | 1.000 |
| | 7/06 | 0.000 | 0.000 | 0.122 | 1.000 | 0.878 | 1.000 |
| | 7/16[o] | 0.801 | 0.683 | 0.919 | 0.199 | 0.081 | 0.317 |
| | 7/27[p] | 0.996 | 0.899 | 1.000 | 0.004 | 0.000 | 0.101 |
| *Salamatof Beach* | 7/09 | 0.601 | 0.459 | 0.744 | 0.399 | 0.256 | 0.541 |
| | 7/16 | 0.875 | 0.755 | 0.996 | 0.125 | 0.004 | 0.245 |
| | 7/23 | 1.000 | 0.916 | 1.000 | 0.000 | 0.000 | 0.084 |
| | 7/30[q] | 0.996 | 0.899 | 1.000 | 0.004 | 0.000 | 0.101 |

– Continued –

Table 7. (Page 2 of 2).

| | | Kenai | | | *Other* [a] | | |
|---|---|---|---|---|---|---|---|
| | | Adjusted[d] | 90% Interval[b] | | Adjusted | 90% Interval | |
| Fishery | Date[c] | Proportion | Lower | Upper | Proportion | Lower | Upper |
| **Northern District:** | | | | | | | |
| *Eastern Subdistrict* | 7/20 | 0.304 | 0.159 | 0.448 | 0.696 | 0.552 | 0.841 |

[a] *Other* represents Yentna and Kasilof River samples combined.

[b] Estimates that were <0 or >1 as a result of the Cook and Lord (1978) procedure are noted as 0 or 1, respectively.

[c] Standard 12-h fishing period (0700–1900 hours) if not otherwise noted.

[d] Adjusted Proportion represents an adjusted estimate derived from the Cook and Lord (1978) procedure.

[e] All except within 5 mi of beach south of mid-Kalifonsky Beach.

[f] 0900–1200 hours; Colliers Dock to mid-Kalifonsky Beach within 3 mi of beach.
1200–2200 hours; Colliers to Ninilchik Beach within 3 mi.

[g] 0700–1900 hours; all open.
1900–2200 hours; Colliers to Ninilchik Beach within 3 mi.

[h] 0500–0700 hours; Colliers to Ninilchik Beach within 3 mi.
0700–1900 hours; south of Kalgin Island, south of Colliers within 3 mi.

[i] 0500–2200 hours; Colliers to mid-Kalifonsky Beach within 3 mi.

[j] 0500–0700 hours; Colliers to mid-Kalifonsky Beach within 3 mi.
0700–1900 hours; all open.
1900–2200 hours; Colliers to Ninilchik Beach within 3 mi.

[k] 0600–2200 hours; Colliers to mid-Kalifonsky Beach within 6 mi.

[l] 0600–2200 hours; Colliers to mid-Kalifonsky Beach within 6 mi.
0700–1900 hours; all open.
1900–2200 hours; Colliers to Ninilchik Beach within 6 mi.

[m] 0500–2200 hours; Colliers to Ninilchik Beach within 6 mi.

[n] 0700–2400 hours; open.

[o] All except Western, Upper south of mid-Kalifonsky Beach.

[p] 0000–0700 hours; Upper north of mid-Kalifonsky Beach, Knik Arm.
0700–1900 hours; all plus Knik Arm.
1900–2200 hours; Upper, Knik Arm.

[q] 0000–0700 hours; Upper north of mid-Kalifonsky Beach.
0700–2400 hours; open.

Table 8. Number of sockeye salmon in commercial harvests and escapements and number of scale samples taken and digitized, Upper Cook Inlet, Alaska, in 1991.

| Sample Location | Number of Fish | Scale Sample | Percent of Harvest or Escapement | Digitized Scales Age 1.3 | Digitized Scales Age 1.2 |
|---|---|---|---|---|---|
| **Commercial Fisheries**[a]: | | | | | |
| ***Central District*** | | | | | |
| Drift[b] | 1,117,510 | 3,020 | 0.3 | 466 | 224 |
| Cohoe/Ninilchik Beach | 400,483 | 3,000 | 0.7 | 444 | 276 |
| Kalifonsky Beach | 242,048 | 2,200 | 0.9 | 390 | 174 |
| Salamatof Beach | 201,625 | 1,700 | 0.8 | 278 | 172 |
| Western Subdistrict | 17,195 | 300 | 1.7 | ND[c] | ND |
| ***Northern District*** | | | | | |
| Eastern Subdistrict | 34,292 | 1,044 | 3.0 | 82 | 100 |
| General Subdistrict | 81,909 | 1,667 | 2.0 | 276 | 36 |
| **Total**[d] | 2,095,062 | 12,931 | 0.6 | 1,936 | 982 |
| **Escapements:** | | | | | |
| Kenai River | 647,597 | 2,827 | 0.4 | 320 | 273 |
| Kasilof River | 238,269 | 2,383 | 0.1 | 316 | 200 |
| Crescent | 44,578 | 438 | 1.0 | ND | ND |
| Packers | 44,879 | 1,064 | 2.4 | ND | ND |
| Yentna River | 109,632 | 1,815 | 1.7 | 232 | 108 |
| Sunshine Station | 104,150e | 2,029 | — | 275 | 110 |
| Fish Creek | 59,269 | 520 | 0.9 | ND | ND |
| **Total** | 1,248,374 | 11,076 | 0.9 | 1,143 | 691 |

[a] Commercial harvests sampled through 31 July but totals represent final fish ticket numbers.

[b] Harvest does not include Chinitna Bay Subdistrict harvest of 4 fish.

[c] No scale samples digitized.

[d] Total represents 96.2% of the total Upper Cook Inlet (UCI) commercial harvest.

[e] An estimate based on the relation between Yentna River and Sunshine Station escapements for the years 1981–1985. The estimate of Sunshine Station escapement equals 0.95 of the Yentna escapement estimate.

Table 9. Mean and standard error of scale variables screened for linear discriminant analysis of age-1.3 sockeye salmon sampled in the Kenai and *Other* river systems, Upper Cook Inlet, Alaska, in 1991.

| | | Kenai[a] | | *Other*[b] | | |
|---|---|---|---|---|---|---|
| Number | Variable | Mean | S.E. | Mean | S.E. | F-Stat |
| | ***First Freshwater Annulus*** | | | | | |
| 1 | NC1FW | 9.470 | 0.120 | 8.995 | 0.120 | 6.234 |
| 2 | S1FW | 130.245 | 1.269 | 121.308 | 1.401 | 16.881 |
| 3 | C0–C2 | 50.080 | 0.383 | 48.548 | 0.285 | 9.944 |
| 4 | C0–C4 | 76.100 | 0.492 | 72.582 | 0.381 | 30.109 |
| 5 | C0–C6 | 97.895 | 0.544 | 93.488 | 0.450 | 35.569 |
| 6 | C0–C8 | 117.178 | 0.596 | 113.076 | 0.599 | 21.128 |
| 7 | C2–C4 | 26.020 | 0.257 | 24.035 | 0.206 | 33.453 |
| 8 | C2–C6 | 47.815 | 0.350 | 44.787 | 0.302 | 38.088 |
| 9 | C2–C8 | 67.256 | 0.444 | 64.346 | 0.436 | 19.743 |
| 10 | C4–C6 | 21.795 | 0.232 | 20.604 | 0.170 | 16.918 |
| 11 | C4–C8 | 41.128 | 0.356 | 39.737 | 0.300 | 8.650 |
| 12 | C(NC - 4)–E1FW | 38.175 | 0.356 | 38.452 | 0.285 | 0.342 |
| 13 | C(NC - 2)–E1FW | 18.240 | 0.220 | 18.385 | 0.169 | 0.258 |
| 14 | C2–E1FW | 80.165 | 1.273 | 72.760 | 1.338 | 12.491 |
| 15 | C4–E1FW | 54.145 | 1.228 | 49.093 | 1.250 | 6.606 |
| 16 | C0–C2/S1FW | 0.391 | 0.004 | 0.417 | 0.004 | 14.526 |
| 17 | C0–C4/S1FW | 0.593 | 0.006 | 0.621 | 0.006 | 9.915 |
| 18 | C0–C6/S1FW | 0.762 | 0.006 | 0.786 | 0.006 | 5.687 |
| 19 | C0–C8/S1FW | 0.889 | 0.006 | 0.877 | 0.007 | 1.544 |
| 20 | C2–C4/S1FW | 0.202 | 0.002 | 0.204 | 0.002 | 0.461 |
| 21 | C2–C6/S1FW | 0.371 | 0.003 | 0.375 | 0.003 | 0.569 |
| 22 | C2–C8/S1FW | 0.510 | 0.003 | 0.498 | 0.004 | 3.909 |
| 23 | C4–C6/S1FW | 0.169 | 0.002 | 0.172 | 0.002 | 1.566 |
| 24 | C4–C8/S1FW | 0.311 | 0.003 | 0.308 | 0.003 | 0.903 |
| 25 | VAR 12/S1FW | 0.299 | 0.004 | 0.334 | 0.005 | 20.573 |
| 26 | VAR 13/S1FW | 0.143 | 0.002 | 0.159 | 0.002 | 20.509 |
| 27 | S1FW/NC1FW | 13.892 | 0.089 | 13.677 | 0.071 | 3.325 |
| 28 | NC 1ST 3/4 | 5.475 | 0.086 | 5.220 | 0.088 | 3.370 |
| 29 | MAX DIST | 15.695 | 0.132 | 15.035 | 0.110 | 13.227 |
| 30 | VAR 29/S1FW | 0.122 | 0.001 | 0.128 | 0.001 | 8.195 |
| | ***Plus Growth*** | | | | | |
| 61 | NCPG | 1.965 | 0.077 | 2.065 | 0.063 | 0.924 |
| 62 | SPGZ | 21.645 | 0.888 | 22.073 | 0.729 | 0.125 |
| | ***Freshwater and Plus Growth*** | | | | | |
| 65 | NC1 + NC2 + NCPG | 11.435 | 0.131 | 11.060 | 0.112 | 4.166 |
| 66 | S1F + S2F + SPGZ | 151.890 | 1.418 | 143.380 | 1.300 | 16.501 |
| 67 | S1FW/VAR 66 | 0.860 | 0.005 | 0.844 | 0.005 | 3.776 |
| | ***First Marine Annulus*** | | | | | |
| 70 | NC1OZ | 26.950 | 0.178 | 26.987 | 0.145 | 0.024 |
| 71 | S1OZ | 446.375 | 2.835 | 450.723 | 2.308 | 1.288 |
| 72 | EFW–C3 | 42.935 | 0.498 | 41.938 | 0.398 | 2.261 |

– Continued –

Table 9. (Page 2 of 2).

| Number | Variable | Kenai[a] Mean | Kenai[a] S.E. | *Other*[b] Mean | *Other*[b] S.E. | F-Stat |
|---|---|---|---|---|---|---|
| | ***First Marine Annulus*** (continued) | | | | | |
| 73 | EFW–C6 | 96.245 | 0.851 | 95.015 | 0.648 | 1.259 |
| 74 | EFW–C9 | 150.895 | 1.060 | 149.798 | 0.824 | 0.627 |
| 75 | EFW–C12 | 207.635 | 1.224 | 206.333 | 0.939 | 0.675 |
| 76 | EFW–C15 | 263.890 | 1.371 | 262.902 | 1.052 | 0.309 |
| 77 | C3–C6 | 53.310 | 0.554 | 53.077 | 0.414 | 0.109 |
| 78 | C3–C9 | 107.960 | 0.820 | 107.860 | 0.637 | 0.009 |
| 79 | C3–C12 | 164.700 | 1.012 | 164.395 | 0.773 | 0.055 |
| 80 | C3–C15 | 220.955 | 1.173 | 220.965 | 0.901 | 0.000 |
| 81 | C6–C9 | 54.650 | 0.477 | 54.783 | 0.383 | 0.043 |
| 82 | C6–C12 | 111.390 | 0.712 | 111.317 | 0.537 | 0.006 |
| 83 | C6–C15 | 167.645 | 0.922 | 167.887 | 0.689 | 0.043 |
| 84 | C9–C15 | 112.995 | 0.695 | 113.105 | 0.518 | 0.016 |
| 85 | C(NC - 6)–E1OZ | 82.480 | 0.677 | 85.122 | 0.520 | 9.074 |
| 86 | C(NC - 3)–E1OZ | 39.625 | 0.400 | 41.135 | 0.305 | 8.569 |
| 87 | C3–E1OZ | 403.440 | 2.878 | 408.785 | 2.359 | 1.870 |
| 88 | C9–E1OZ | 295.480 | 2.970 | 300.925 | 2.408 | 1.852 |
| 89 | C15–E1OZ | 182.485 | 2.946 | 187.820 | 2.365 | 1.833 |
| 90 | EFW–C3/S1OZ | 0.097 | 0.001 | 0.094 | 0.001 | 2.830 |
| 91 | EFW–C6/S1OZ | 0.217 | 0.002 | 0.213 | 0.002 | 2.258 |
| 92 | EFW–C9/S1OZ | 0.341 | 0.003 | 0.336 | 0.002 | 1.549 |
| 93 | EFW–C12/S1OZ | 0.469 | 0.004 | 0.462 | 0.003 | 1.674 |
| 94 | EFW–C15/S1OZ | 0.595 | 0.004 | 0.588 | 0.003 | 1.454 |
| 95 | C3–C6/S1OZ | 0.120 | 0.001 | 0.119 | 0.001 | 0.813 |
| 96 | C3–C9/S1OZ | 0.244 | 0.002 | 0.241 | 0.002 | 0.540 |
| 97 | C3–C12/S1OZ | 0.372 | 0.003 | 0.368 | 0.002 | 0.821 |
| 98 | C3–C15/S1OZ | 0.498 | 0.004 | 0.494 | 0.003 | 0.734 |
| 99 | C6–C9/S1OZ | 0.123 | 0.001 | 0.123 | 0.001 | 0.117 |
| 100 | C6–C12/S1OZ | 0.251 | 0.002 | 0.249 | 0.002 | 0.517 |
| 101 | C6–C15/S1OZ | 0.378 | 0.003 | 0.376 | 0.002 | 0.466 |
| 102 | C9–C15/S1OZ | 0.255 | 0.002 | 0.253 | 0.001 | 0.569 |
| 103 | VAR 85/S1OZ | 0.186 | 0.002 | 0.191 | 0.002 | 3.240 |
| 104 | VAR 86/S1OZ | 0.089 | 0.001 | 0.092 | 0.000 | 4.272 |
| 105 | S1OZ/NC1OZ | 16.598 | 0.070 | 16.747 | 0.055 | 2.643 |
| 106 | NC 1ST 1/2 | 12.375 | 0.098 | 12.570 | 0.076 | 2.309 |
| 107 | MAX DIST | 25.320 | 0.178 | 25.392 | 0.141 | 0.094 |
| 108 | VAR 107/S1OZ | 0.057 | 0.000 | 0.057 | 0.000 | 0.120 |
| | ***Second Marine Annulus*** | | | | | |
| 109 | S2OZ | 333.495 | 3.204 | 312.788 | 2.198 | 28.986 |

[a] Kenai River scale sample was 200.

[b] *Other* river scale sample of 400 was weighted proportionately to escapement level and represented Kasilof (200 scales), Susitna (100 scales, mile 80 mainstem), and Yentna (100 scales) Rivers.

Table 10. Mean and standard error of scale variables screened for linear discriminant analysis of age-1.2 sockeye salmon sampled in the Kenai and *Other* river systems, Upper Cook Inlet, Alaska, in 1991.

| | | Kenai[a] | | *Other*[b] | | |
|---|---|---|---|---|---|---|
| Number | Variable | Mean | S.E. | Mean | S.E. | F-Stat |
| | ***First Freshwater Annulus*** | | | | | |
| 1 | NC1FW | 12.260 | 0.262 | 10.012 | 0.130 | 74.289 |
| 2 | S1FW | 151.670 | 2.922 | 131.970 | 1.533 | 43.292 |
| 3 | C0–C2 | 48.095 | 0.382 | 48.897 | 0.265 | 3.017 |
| 4 | C0–C4 | 73.655 | 0.520 | 73.670 | 0.401 | 0.000 |
| 5 | C0–C6 | 94.760 | 0.657 | 94.763 | 0.482 | 0.000 |
| 6 | C0–C8 | 114.387 | 0.844 | 114.320 | 0.555 | 0.005 |
| 7 | C2–C4 | 25.560 | 0.305 | 24.772 | 0.225 | 4.186 |
| 8 | C2–C6 | 46.665 | 0.487 | 45.791 | 0.324 | 2.339 |
| 9 | C2–C8 | 66.140 | 0.685 | 65.115 | 0.418 | 1.818 |
| 10 | C4–C6 | 21.105 | 0.285 | 20.896 | 0.180 | 0.418 |
| 11 | C4–C8 | 40.403 | 0.495 | 39.974 | 0.299 | 0.618 |
| 12 | C(NC - 4)–E1FW | 34.750 | 0.326 | 36.882 | 0.296 | 19.893 |
| 13 | C(NC - 2)–E1FW | 17.050 | 0.212 | 17.785 | 0.174 | 6.531 |
| 14 | C2–E1FW | 103.575 | 2.823 | 83.073 | 1.474 | 50.502 |
| 15 | C4–E1FW | 78.015 | 2.681 | 58.300 | 1.408 | 51.452 |
| 16 | C0–C2/S1FW | 0.339 | 0.006 | 0.387 | 0.004 | 42.640 |
| 17 | C0–C4/S1FW | 0.517 | 0.009 | 0.580 | 0.005 | 41.004 |
| 18 | C0–C6/S1FW | 0.662 | 0.010 | 0.737 | 0.006 | 43.372 |
| 19 | C0–C8/S1FW | 0.769 | 0.011 | 0.851 | 0.007 | 46.982 |
| 20 | C2–C4/S1FW | 0.178 | 0.003 | 0.194 | 0.002 | 20.328 |
| 21 | C2–C6/S1FW | 0.323 | 0.005 | 0.354 | 0.003 | 34.873 |
| 22 | C2–C8/S1FW | 0.441 | 0.006 | 0.483 | 0.004 | 42.987 |
| 23 | C4–C6/S1FW | 0.145 | 0.002 | 0.162 | 0.002 | 37.965 |
| 24 | C4–C8/S1FW | 0.268 | 0.003 | 0.296 | 0.002 | 47.363 |
| 25 | VAR 12/S1FW | 0.248 | 0.005 | 0.293 | 0.004 | 43.355 |
| 26 | VAR 13/S1FW | 0.121 | 0.003 | 0.141 | 0.002 | 32.357 |
| 27 | S1FW/NC1FW | 12.524 | 0.075 | 13.336 | 0.070 | 52.596 |
| 28 | NC 1ST 3/4 | 7.370 | 0.184 | 5.872 | 0.097 | 63.201 |
| 29 | MAX DIST | 15.775 | 0.171 | 15.648 | 0.125 | 0.355 |
| 30 | VAR 29/S1FW | 0.111 | 0.002 | 0.123 | 0.001 | 27.084 |
| | ***Plus Growth*** | | | | | |
| 61 | NCPG | 4.110 | 0.121 | 2.632 | 0.070 | 126.261 |
| 62 | SPGZ | 45.990 | 1.455 | 29.075 | 0.859 | 112.893 |
| | ***Freshwater and Plus Growth*** | | | | | |
| 65 | NC1 + NC2 + NCPG | 16.370 | 0.294 | 12.645 | 0.122 | 190.088 |
| 66 | S1F + S2F + SPGZ | 197.660 | 3.484 | 161.045 | 1.379 | 135.923 |
| 67 | S1FW/VAR 66 | 0.767 | 0.006 | 0.817 | 0.005 | 32.998 |
| | ***First Marine Annulus*** | | | | | |
| 70 | NC1OZ | 26.915 | 0.192 | 26.155 | 0.124 | 11.785 |
| 71 | S1OZ | 444.775 | 3.034 | 440.212 | 2.055 | 1.595 |
| 72 | EFW–C3 | 44.165 | 0.626 | 42.673 | 0.388 | 4.487 |

– Continued –

Table 10. (Page 2 of 2).

| Number | Variable | Kenai[a] Mean | Kenai[a] S.E. | *Other*[b] Mean | *Other*[b] S.E. | F-Stat |
|---|---|---|---|---|---|---|
| | ***First Marine Annulus*** (continued) | | | | | |
| 73 | EFW–C6 | 96.255 | 1.029 | 96.185 | 0.703 | 0.003 |
| 74 | EFW–C9 | 152.945 | 1.271 | 154.557 | 0.873 | 1.114 |
| 75 | EFW–C12 | 209.420 | 1.330 | 212.970 | 0.963 | 4.602 |
| 76 | EFW–C15 | 266.030 | 1.388 | 271.035 | 1.095 | 7.456 |
| 77 | C3–C6 | 52.090 | 0.649 | 53.513 | 0.466 | 3.140 |
| 78 | C3–C9 | 108.780 | 0.920 | 111.885 | 0.660 | 7.442 |
| 79 | C3–C12 | 165.255 | 1.046 | 170.298 | 0.783 | 14.342 |
| 80 | C3–C15 | 221.865 | 1.149 | 228.363 | 0.930 | 17.652 |
| 81 | C6–C9 | 56.690 | 0.511 | 58.373 | 0.388 | 6.557 |
| 82 | C6–C12 | 113.165 | 0.707 | 116.785 | 0.541 | 15.696 |
| 83 | C6–C15 | 169.775 | 0.900 | 174.850 | 0.724 | 17.732 |
| 84 | C9–C15 | 113.085 | 0.746 | 116.478 | 0.526 | 13.852 |
| 85 | C(NC - 6)–E1OZ | 78.740 | 0.711 | 79.865 | 0.471 | 1.818 |
| 86 | C(NC - 3)–E1OZ | 38.825 | 0.460 | 39.708 | 0.285 | 2.900 |
| 87 | C3–E1OZ | 400.610 | 3.207 | 397.540 | 2.103 | 0.674 |
| 88 | C9–E1OZ | 291.830 | 3.478 | 285.655 | 2.180 | 2.452 |
| 89 | C15–E1OZ | 178.745 | 3.230 | 169.178 | 2.104 | 6.505 |
| 90 | EFW–C3/S1OZ | 0.101 | 0.002 | 0.098 | 0.001 | 2.074 |
| 91 | EFW–C6/S1OZ | 0.219 | 0.003 | 0.221 | 0.002 | 0.111 |
| 92 | EFW–C9/S1OZ | 0.348 | 0.004 | 0.354 | 0.003 | 1.654 |
| 93 | EFW–C12/S1OZ | 0.476 | 0.005 | 0.487 | 0.003 | 4.684 |
| 94 | EFW–C15/S1OZ | 0.604 | 0.005 | 0.620 | 0.003 | 7.278 |
| 95 | C3–C6/S1OZ | 0.119 | 0.002 | 0.123 | 0.001 | 3.318 |
| 96 | C3–C9/S1OZ | 0.247 | 0.003 | 0.256 | 0.002 | 6.963 |
| 97 | C3–C12/S1OZ | 0.375 | 0.004 | 0.390 | 0.002 | 12.230 |
| 98 | C3–C15/S1OZ | 0.503 | 0.004 | 0.522 | 0.003 | 15.494 |
| 99 | C6–C9/S1OZ | 0.129 | 0.001 | 0.133 | 0.000 | 7.606 |
| 100 | C6–C12/S1OZ | 0.256 | 0.002 | 0.267 | 0.001 | 16.055 |
| 101 | C6–C15/S1OZ | 0.384 | 0.003 | 0.400 | 0.002 | 19.361 |
| 102 | C9–C15/S1OZ | 0.256 | 0.002 | 0.266 | 0.001 | 19.157 |
| 103 | VAR 85/S1OZ | 0.179 | 0.002 | 0.183 | 0.001 | 3.315 |
| 104 | VAR 86/S1OZ | 0.088 | 0.001 | 0.091 | 0.000 | 5.164 |
| 105 | S1OZ/NC1OZ | 16.565 | 0.072 | 16.867 | 0.054 | 10.935 |
| 106 | NC 1ST 1/2 | 12.200 | 0.113 | 11.915 | 0.070 | 5.047 |
| 107 | MAX DIST | 25.765 | 0.189 | 25.938 | 0.152 | 0.463 |
| 108 | VAR 107/S1OZ | 0.058 | 0.000 | 0.059 | 0.000 | 2.117 |

[a] Kenai River scale sample was 200.

[b] *Other* river scale sample of 400 was weighted proportionately to escapement level and represented Kasilof (200 scales), Susitna (100 scales, mile 80 mainstem), and Yentna (100 scales) Rivers.

Table 11. Final classification matrices derived from discriminant analyses of selected scale variables of age-1.3 and -1.2 sockeye salmon scale samples from the Kenai and *Other* rivers that maximized classification of the Kenai River component, Upper Cook Inlet, Alaska, in 1991.

| Age Group | Actual Group of Origin | Sample Size | Classification Matrix Kenai | Classification Matrix *Other* | |
|---|---|---|---|---|---|
| 1.3[a] | Kenai | 200 | 0.685 | 0.315 | |
| | *Other*[b] | 400 | 0.329 | 0.671 | |
| | | | *mean classification accuracy* | | 0.678 |
| 1.2[c] | Kenai | 200 | 0.731 | 0.269 | |
| | *Other*[d] | 400 | 0.156 | 0.844 | |
| | | | *mean classification accuracy* | | 0.788 |

[a] Two-way model included the primary variables 80, 109, 85, 25, 1, 17, and 66.

[b] *Other* included Kasilof, Susitna (river mile 80), and Yentna Rivers with sample sizes of 200, 100, and 100 scales, respectively.

[c] Two-way model included the primary variables 65, 15, 98, 25, 76, 24, and 105 and the negatively correlated variable 17.

[d] *Other* included Kasilof, Susitna (river mile 80), and Yentna Rivers with sample sizes of 200, 100, and 100 scales, respectively.

Table 12. Estimates of stock composition and statistical precision (90% interval) of commercial harvests using linear discriminant analysis of age-1.2 sockeye salmon, Upper Cook Inlet, Alaska, in 1991.

| | | Kenai | | | *Other*[a] | | |
|---|---|---|---|---|---|---|---|
| | | Adjusted[d] | 90% Interval[b] | | Adjusted | 90% Interval | |
| Fishery | Date[c] | Proportion | Lower | Upper | Proportion | Lower | Upper |
| **Central District:** | | | | | | | |
| *Drift* | 7/08 | 0.308 | 0.000 | 0.630 | 0.692 | 0.370 | 1.000 |
| | 7/12[e] | 0.490 | 0.233 | 0.746 | 0.510 | 0.254 | 0.767 |
| | 7/15 | 0.511 | 0.280 | 0.743 | 0.489 | 0.257 | 0.720 |
| | 7/15[f] | 0.598 | 0.142 | 1.000 | 0.402 | 0.000 | 0.858 |
| | 7/19[g] | 0.685 | 0.451 | 0.920 | 0.315 | 0.080 | 0.549 |
| | 7/29[h] | 0.527 | 0.336 | 0.718 | 0.473 | 0.282 | 0.664 |
| *Cohoe/Ninilchik Beach* | 7/01 | 0.256 | 0.022 | 0.490 | 0.744 | 0.510 | 0.978 |
| | 7/05[i] | 0.029 | 0.000 | 0.236 | 0.971 | 0.764 | 1.000 |
| | 7/08 | 0.247 | 0.050 | 0.443 | 0.753 | 0.557 | 0.950 |
| | 7/15 | 0.000 | 0.000 | 0.128 | 1.000 | 0.872 | 1.000 |
| | 7/29 | 0.298 | 0.111 | 0.485 | 0.702 | 0.515 | 0.889 |
| *Kalifonsky Beach* | 7/01 | 0.045 | 0.000 | 0.382 | 0.955 | 0.618 | 1.000 |
| | 7/05[i] | 0.039 | 0.000 | 0.253 | 0.961 | 0.747 | 1.000 |
| | 7/12 | 0.132 | 0.000 | 0.286 | 0.868 | 0.714 | 1.000 |
| | 7/19[j] | 0.381 | 0.175 | 0.587 | 0.619 | 0.413 | 0.825 |
| *Salamatof Beach* | 7/08 | 0.430 | 0.238 | 0.623 | 0.570 | 0.377 | 0.762 |
| | 7/15 | 0.709 | 0.506 | 0.912 | 0.291 | 0.088 | 0.494 |
| | 7/29 | 0.832 | 0.603 | 1.000 | 0.168 | 0.000 | 0.397 |
| **Northern District:** | | | | | | | |
| *General Subdistrict* | 7/15–22 | 0.350 | 0.086 | 0.613 | 0.650 | 0.387 | 0.914 |
| *Eastern Subdistrict* | 7/19–22 | 0.607 | 0.449 | 0.766 | 0.393 | 0.234 | 0.551 |

[a] *Other* represented a weighted sample of Kasilof, Yentna, and Susitna mainstem combined.

[b] Estimates that were <0 or >1 as a result of the Cook and Lord (1978) procedure are noted as 0 or 1, respectively.

[c] Standard 12-h fishing period (0700–1900 hours) if not otherwise noted.

[d] Adjusted Proportion represents an adjusted estimate derived from the Cook and Lord (1978) procedure.

[e] South of Colliers dock within 3 mi of beach.

[f] A special test sample taken to look for the nematode *Philonema oncorhynchi*.

[g] All except Chinitna Bay.

[h] All except Western and Chinitna Bay Subdistricts.

[i] Additional fishing time for Upper Subdistrict south of Blanchard Line, 1900–2400 hours.

[j] Additional fishing time for Upper Subdistrict south of Blanchard Line within 1/2 mi, 0000–0700 hours and 1900–2400 hours.

Table 13. Estimates of stock composition and statistical precision (90% interval) of commercial harvests using linear discriminant analysis of age-1.3 sockeye salmon, Upper Cook Inlet, Alaska, in 1991.

| | | | Kenai | | | *Other* [a] | | |
|---|---|---|---|---|---|---|---|---|
| | | Sample | Adjusted[d] | 90% Interval[b] | | Adjusted | 90% Interval | |
| Fishery | Date[c] | Size | Proportion | Lower | Upper | Proportion | Lower | Upper |
| **Central District**: | | | | | | | | |
| *Drift* | 7/08 | 98 | 0.337 | 0.088 | 0.586 | 0.663 | 0.414 | 0.912 |
| | 7/12[e] | 66 | 0.651 | 0.349 | 0.952 | 0.349 | 0.048 | 0.651 |
| | 7/15 | 95 | 0.495 | 0.240 | 0.750 | 0.505 | 0.250 | 0.760 |
| | 7/15[f] | 55 | 0.863 | 0.536 | 1.000 | 0.137 | 0.000 | 0.464 |
| | 7/19[g] | 98 | 0.710 | 0.453 | 0.966 | 0.290 | 0.034 | 0.547 |
| | 7/29[h] | 99 | 0.949 | 0.686 | 1.000 | 0.051 | 0.000 | 0.314 |
| *Cohoe/Ninilchik Beach* | 7/01 | 100 | 0.059 | 0.000 | 0.303 | 0.941 | 0.697 | 1.000 |
| | 7/05[i] | 100 | 0.284 | 0.038 | 0.529 | 0.716 | 0.471 | 0.962 |
| | 7/08 | 100 | 0.537 | 0.286 | 0.787 | 0.463 | 0.213 | 0.714 |
| | 7/15 | 70 | 0.561 | 0.268 | 0.853 | 0.439 | 0.147 | 0.732 |
| | 7/29 | 73 | 0.769 | 0.479 | 1.000 | 0.231 | 0.000 | 0.521 |
| *Kalifonsky Beach* | 7/01 | 100 | 0.000 | 0.000 | 0.106 | 1.000 | 0.894 | 1.000 |
| | 7/05[i] | 99 | 0.000 | 0.000 | 0.228 | 1.000 | 0.772 | 1.000 |
| | 7/12 | 100 | 0.874 | 0.615 | 1.000 | 0.126 | 0.000 | 0.385 |
| | 7/19[j] | 90 | 1.000 | 0.920 | 1.000 | 0.000 | 0.000 | 0.080 |
| *Salamatof Beach* | 7/08 | 77 | 0.389 | 0.112 | 0.667 | 0.611 | 0.333 | 0.888 |
| | 7/15 | 100 | 0.874 | 0.615 | 1.000 | 0.126 | 0.000 | 0.385 |
| | 7/29 | 99 | 1.000 | 0.769 | 1.000 | 0.000 | 0.000 | 0.231 |
| **Northern District**: | | | | | | | | |
| *General Subdistrict* | 7/15 | 81 | 0.186 | 0.000 | 0.454 | 0.814 | 0.546 | 1.000 |
| | 7/19 | 95 | 0.170 | 0.000 | 0.420 | 0.830 | 0.580 | 1.000 |
| | 7/22 | 75 | 0.050 | 0.000 | 0.324 | 0.950 | 0.676 | 1.000 |
| *Eastern Subdistrict* | 7/19–22 | 77 | 0.061 | 0.000 | 0.333 | 0.939 | 0.667 | 1.000 |

[a] *Other* represented a weighted sample of Kasilof, Yentna, and Susitna mainstem combined.
[b] Estimates that were <0 or >1 as a result of the Cook and Lord (1978) procedure are noted as 0 or 1, respectively.
[c] Standard 12-h fishing period (0700–1900 hours) if not otherwise noted.
[d] Adjusted Proportion represents an adjusted estimate derived from the Cook and Lord (1978) procedure.
[e] South of Colliers dock within 3 mi of beach.
[f] A special test sample taken to look for the nematode *Philonema oncorhynchi*.
[g] All except Chinitna Bay.
[h] All except Western and Chinitna Bay Subdistricts.
[i] Additional fishing time for Upper Subdistrict south of Blanchard Line, 1900–2400 hours.
[j] Additional fishing time for Upper Subdistrict south of Blanchard Line within 1/2 mi, 0000–0700 hours and 1900–2400 hours.

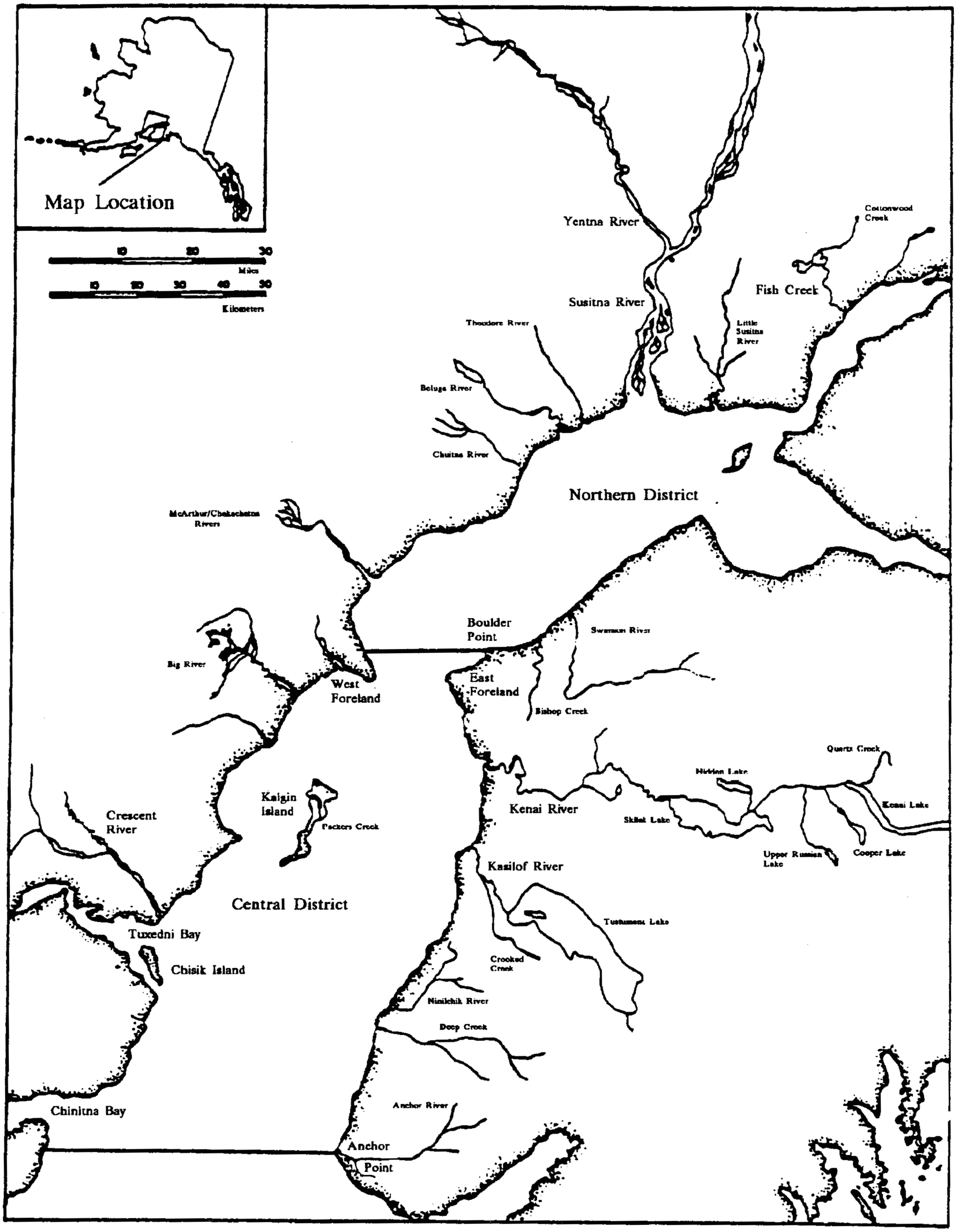


Figure 1. Map of Upper Cook Inlet showing locations of the Northern and Central Districts and the primary salmon spawning drainages.

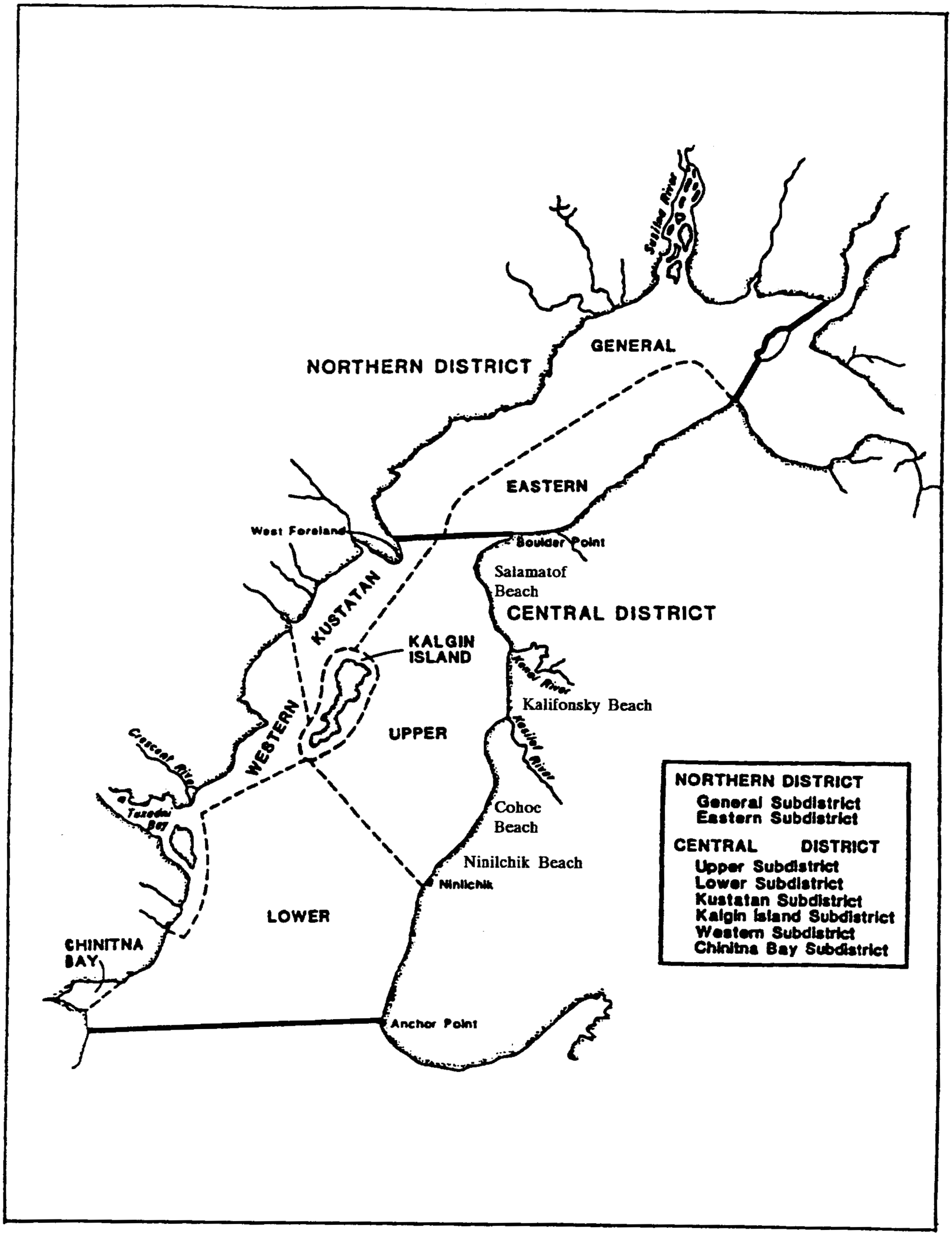


Figure 2. Map of Upper Cook Inlet showing the commercial fishing districts, subdistricts, and Upper Subdistrict beach fisheries.

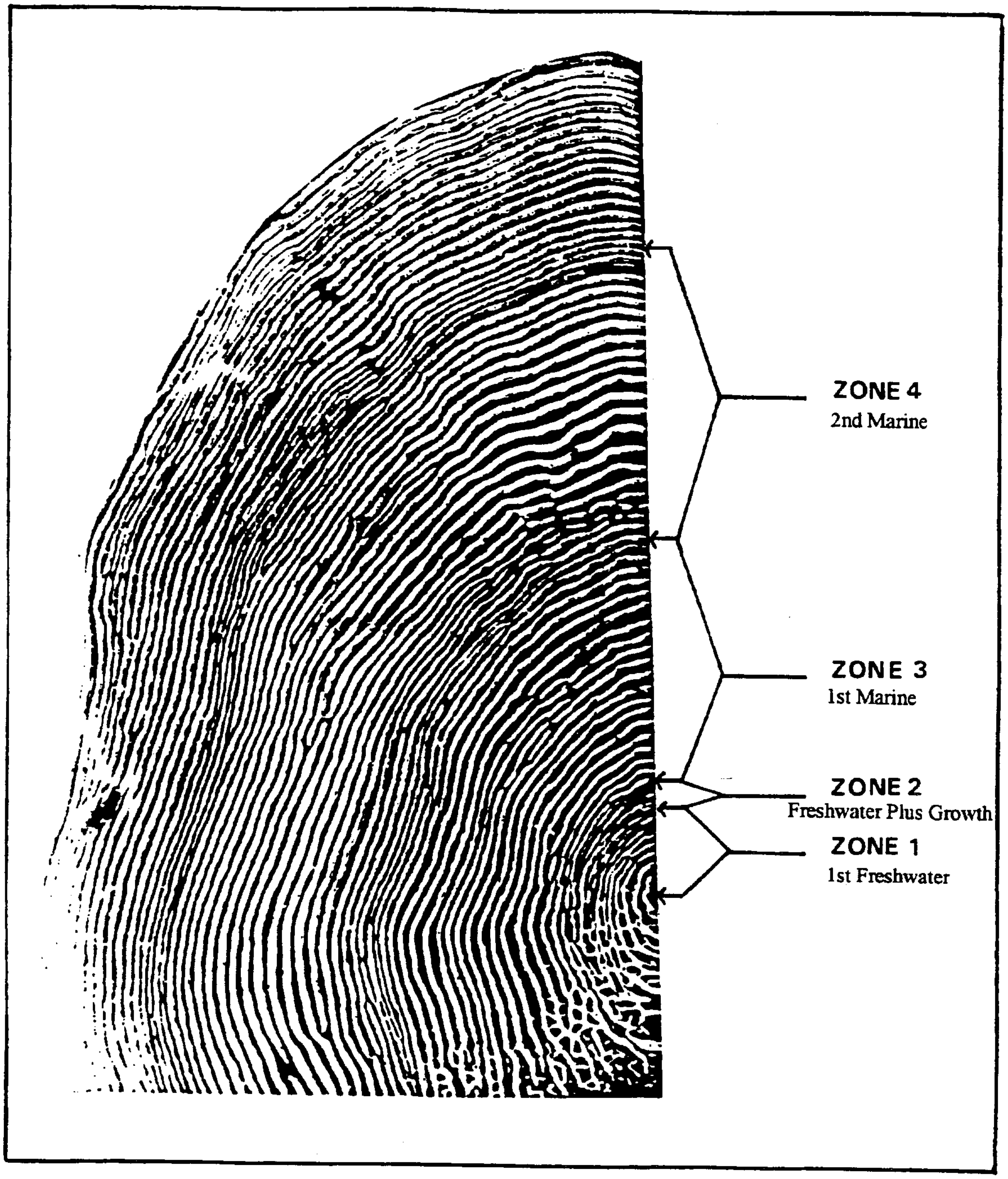


Figure 3. Diagram of an age-1.3 sockeye salmon scale showing the two freshwater and two marine growth zones that are measured to generate variables used to build linear discriminant functions.

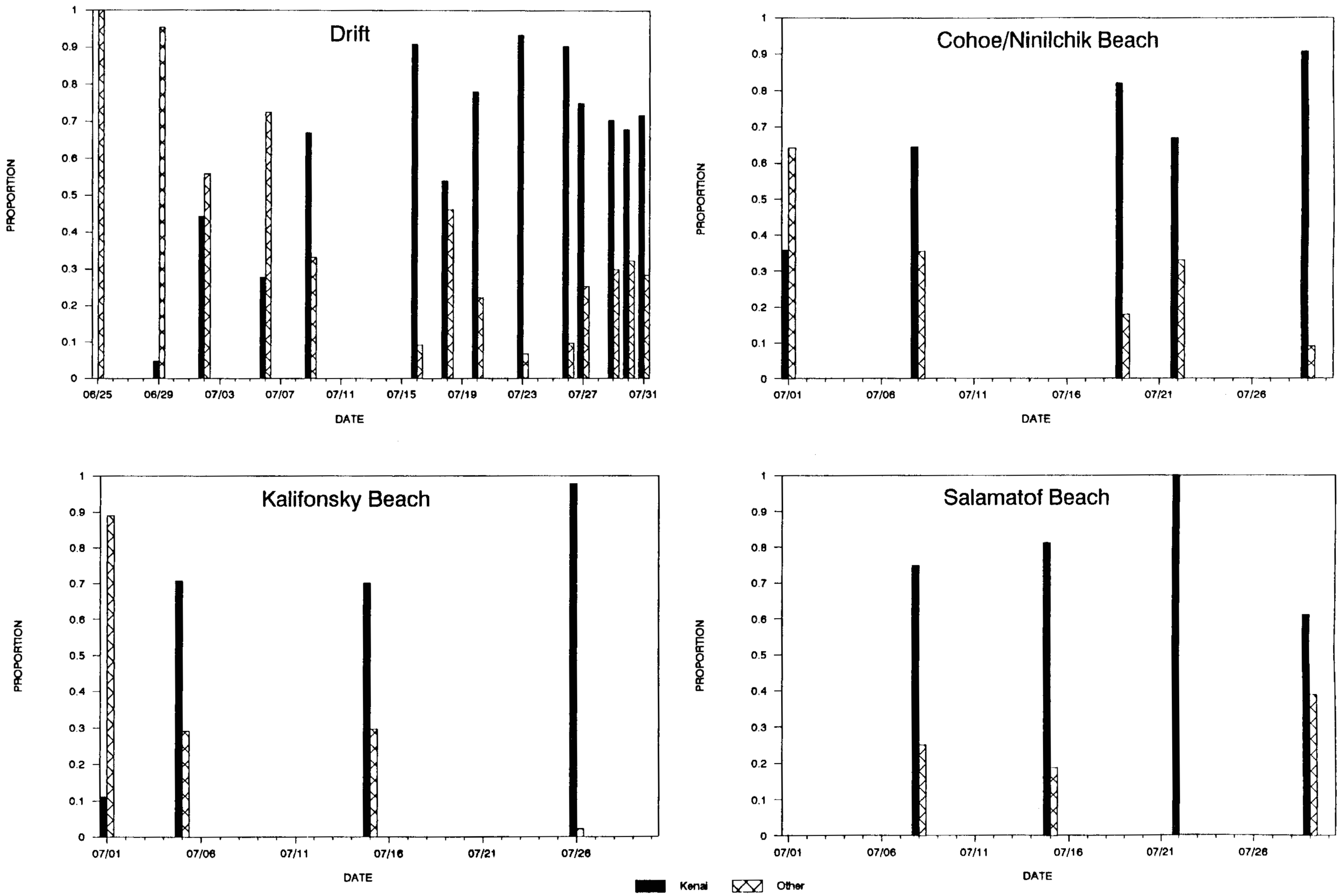


Figure 4. Age-1.3 sockeye salmon stock composition estimates for the Kenai and *Other* river systems in the commercial drift gillnet and Cohoe/ Ninilchik Beach, Kalifonsky Beach, and Salamatof Beach set gillnet fisheries, Upper Cook Inlet, Alaska, in 1990.

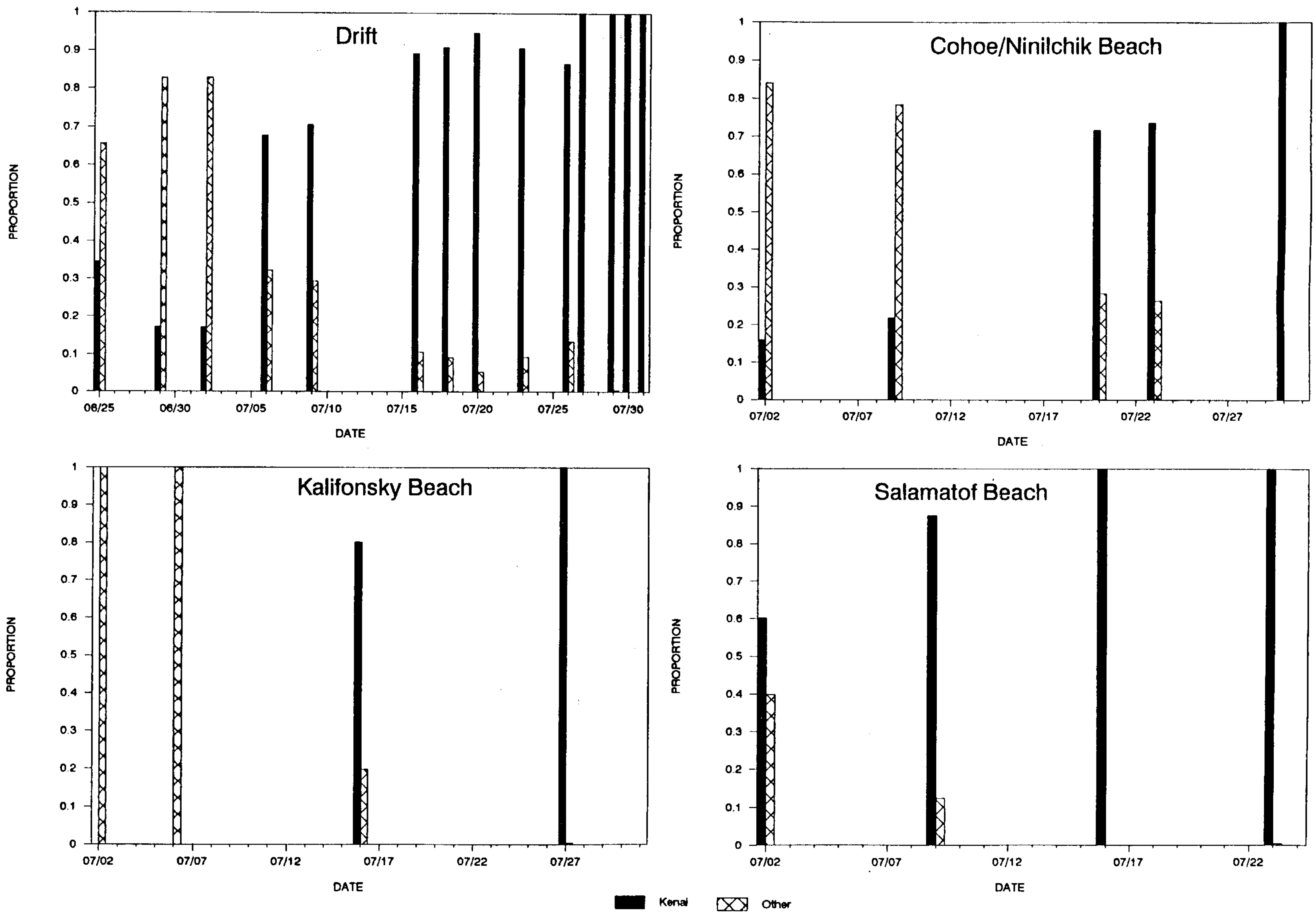


Figure 5. Age-2.3 sockeye salmon stock composition estimates for the Kenai and *Other* river systems in the commercial drift gillnet and Cohoe/ Ninilchik Beach, Kalifonsky Beach, and Salamatof Beach set gillnet fisheries, Upper Cook Inlet, Alaska, in 1990.

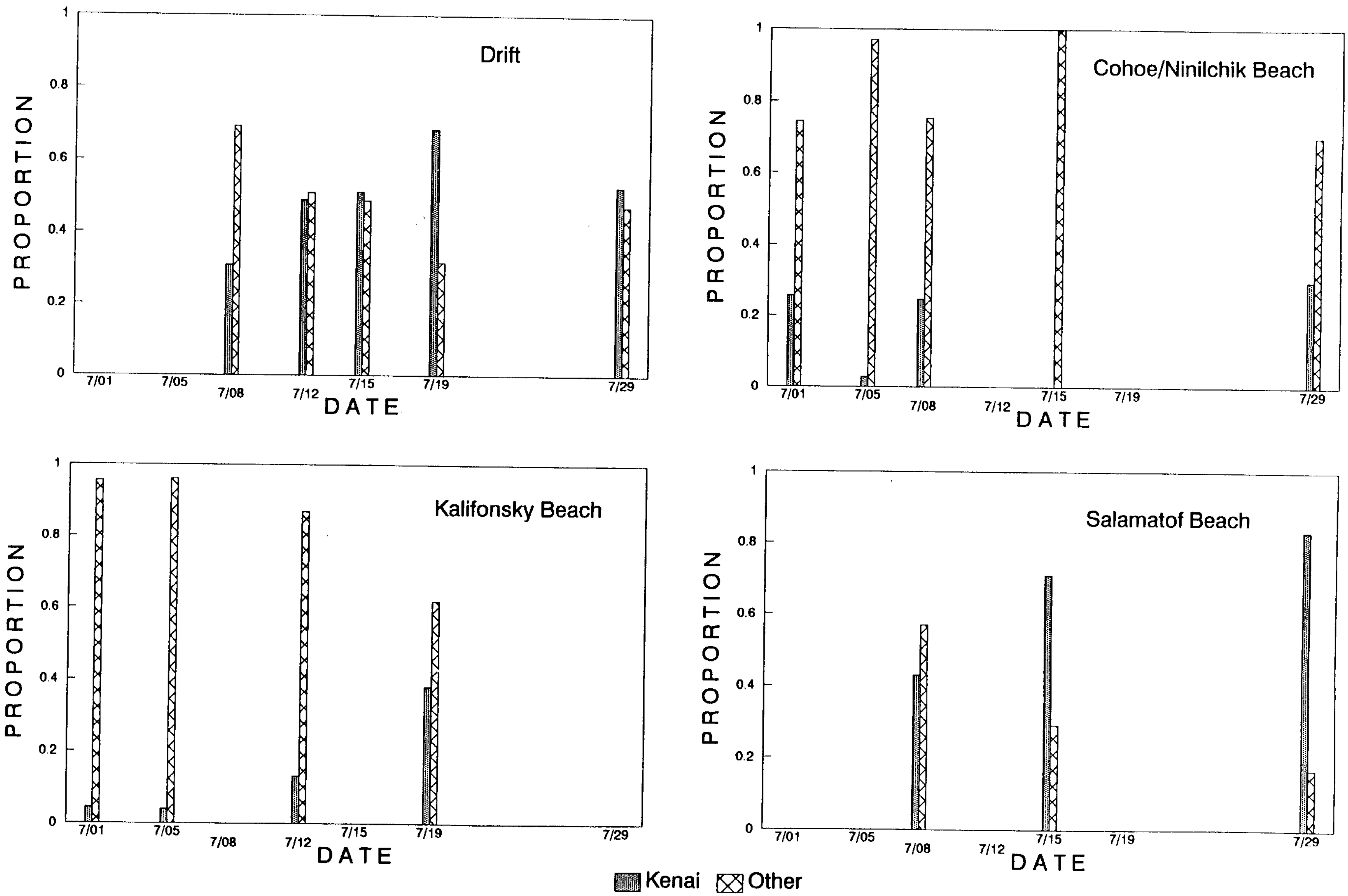


Figure 6. Age-1.2 sockeye salmon stock composition estimates for the Kenai and *Other* river systems in the commercial drift gillnet and Cohoe/ Ninilchik Beach, Kalifonsky Beach, and Salamatof Beach set gillnet fisheries, Upper Cook Inlet, Alaska, in 1991.

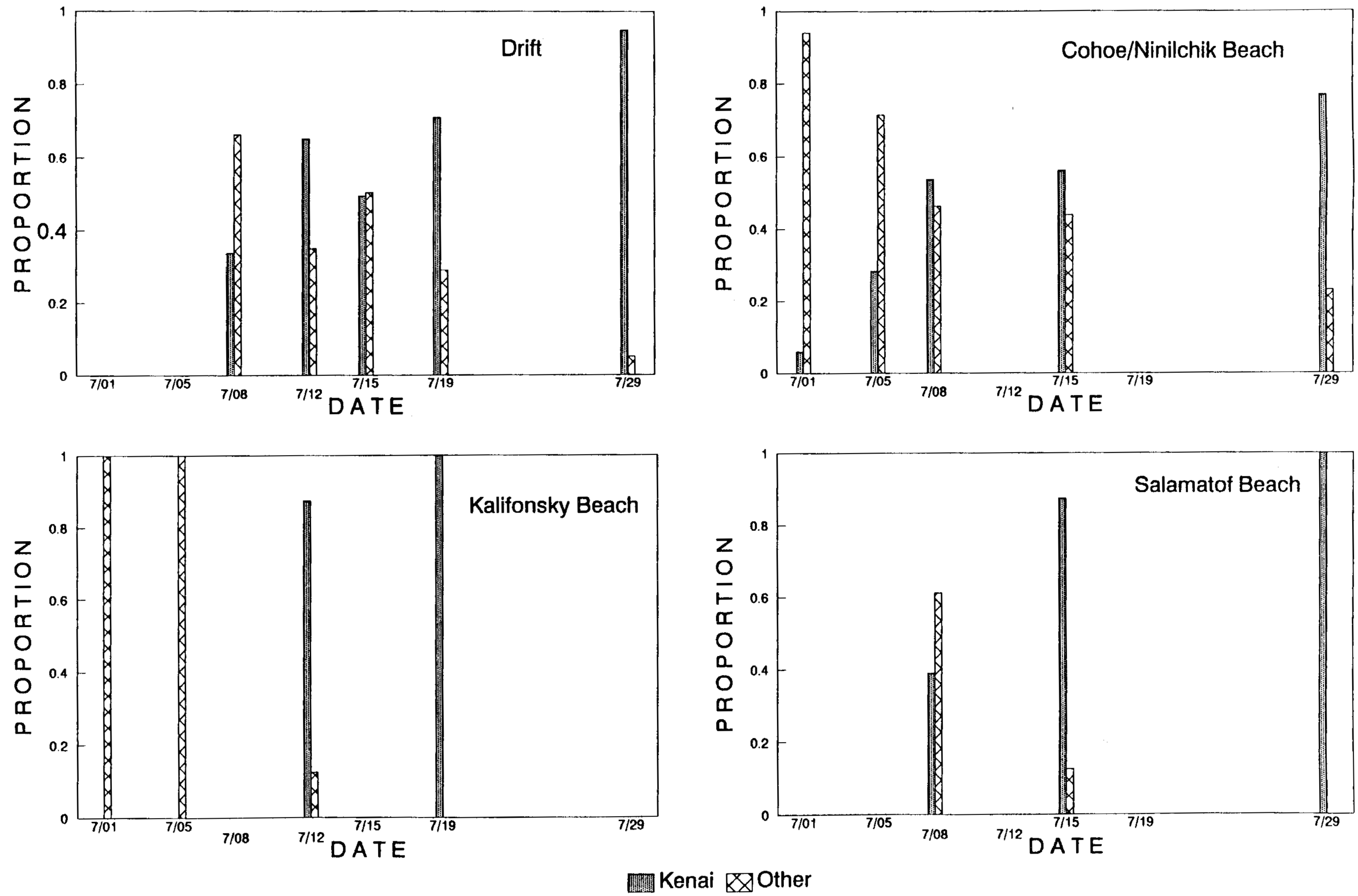


Figure 7. Age-1.3 sockeye salmon stock composition estimates for the Kenai and *Other* river systems in the commerical drift gillnet and Cohoe/ Ninilchik Beach, Kalifonsky Beach, and Salamatof Beach set gillnet fisheries, Upper Cook Inlet, Alaska, in 1991.