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STOCK SEPARATION STUDIES OF COOK INLET SOCKEYE SALMON BASED ON SCALE PATTERN ANALYSIS, 1977

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Division of Commercial Fisheries
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ABSTRACT

The Statewide Salmon Stock Separation Project was initiated in July 1976 to research and apply new techniques of stock identification to mixed-stock salmon fisheries. During 1977 scales were collected from the sockeye escapements into the major systems of Upper Cook Inlet. Commercial catches were sampled at strategic locations. A projection microscope at 100x magnification was used to examine scales and measure numbers of circuli and widths of annual growth zones. Stock identification and classification of mixed-stock catch samples was based on pattern recognition procedures using discriminant function analyisis of scale measurement data. The spatial and temporal distributions of the major sockeye stocks within the commercial fishery were partially identified. Application of stock identification techniques based upon scale pattern recognition to the mixed-stock upper Cook Inlet commercial salmon fishery is logistically and statistically feasible.

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INTRODUCTION

The Statewide Salmon Stock Separation Project of the Alaska Department of Fish and Game, Division of Commercial Fisheries, was first funded for the fiscal year 1977, beginning July 1, 1976. Its objectives are the research, development, and application of stock identification techniques to Alaskan salmon fisheries. Although other stock identification techniques have been examined, the major efforts of the Division's stock separation project have been directed towards the development and application of scale characteristic analysis for identification of salmon stocks.

Commonly commercial harvests of Alaskan salmon occur in areas containing multiple species of salmon and within each species stocks from two or more river systems are often present. The resultant overlap in the timing and distribution of the various species and stocks often creates situations wherein management strategies can consider only the most abundant species and/or stocks.

The development of a management strategy capable of allowing the harvest of the surplus of the healthy stocks while protecting those stocks that fall below escapement requirements can be approached through the application of stock identification techniques. The determination of spawning requirements, based upon spawner-recruit models, demands an accurate determination of the stock composition of the commercial harvest in order to determine the total return to each component river system. Application of stock separation techniques can also be used to develop sampling programs designed to describe the movements of each stock through time within the fishing districts. A management strategy can then be implemented to optimize the harvest based on stock composition.

The Upper Cook Inlet area encompasses the marine waters and drainages north of the latitude of Anchor Point (Figure 1). The area currently consists of two fishing districts, the Northern and Central districts. The Central District, where the majority of the salmon are harvested, is further subdivided into six subdistricts.

Types of fishing gear have varied during the history of the fishery. Prior to statehood in 1959, regulations permitted the use of drift gill nets, set gill nets, pile traps, and hand traps. Following statehood the use of traps was prohibited. Current regulations permit the use of set gill nets in the Northern and Central districts. Drift gill nets are permitted only in the Central District.

Within Cook Inlet the major sockeye salmon (Oncorhynchus nerka) stocks originate in the Kenai, Kasilof, and Susitna River systems. Numerous other systems are known to produce smaller runs of sockeye salmon. There is substantial overlap in the timing of these stocks within the fishery. As a result, the harvest is composed of varying proportions of fish from each system. In the past, methods have not been available by which individual stocks of sockeye salmon within the commercial harvest could be identified. This has precluded catch apportionment, run forecasting, and the determination of spawning requirements through spawner-recruit models. Consequently, it has not been possible to detect and protect less abundant stocks and simultaneously harvest the excess of the healthy stocks.

Commercial catches of sockeye salmon within the Upper Cook Inlet area have declined significantly in recent decades. The average catch during the period of 1923 through 1952 was approximately 1.6 million fish, whereas the harvest since that date has averaged only 1.0 million fish (Figure 2). This decline in catches is believed to be due primarily to the overharvest of various stocks. For example, during the first 5 years (1936-1940) of escapement enumeration on Fish Creek (the outlet stream of Big Lake), the average escapement was approximately 172,000 fish. During the past 5 years, the escapement has averaged approximately 500 fish. Other systems such as Nancy Lake and Cottonwood-Wasilla Lake have exhibited similar declines (Namtvedt et. al. 1978).

Because of the mixed-stock nature of the Upper Cook Inlet commercial salmon fishery and recent declines in catches, the Statewide Salmon Stock Separation Project initiated investigations into the application of

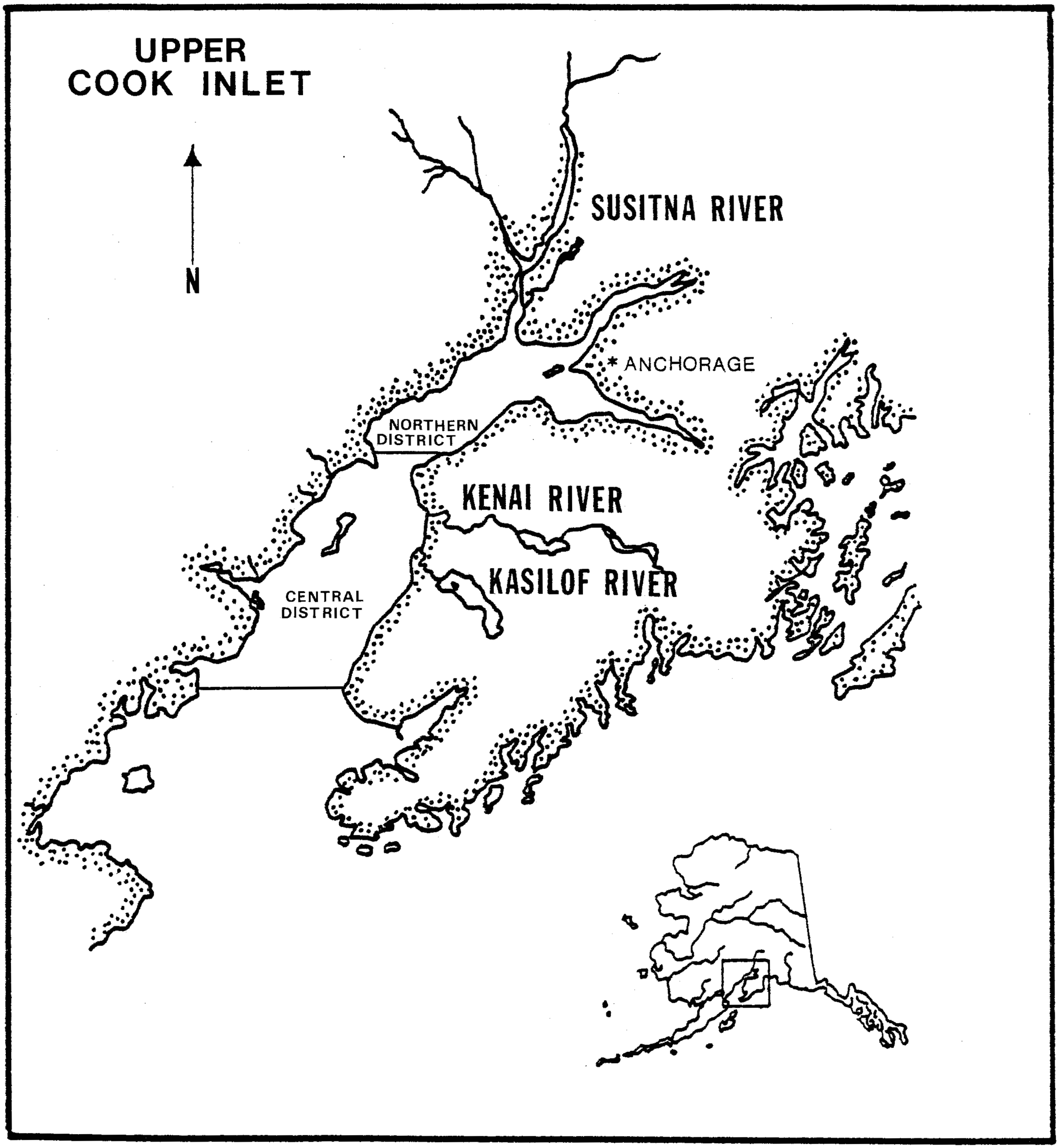

Figure 1. The upper Cook Inlet area showing the locations of the Northern and Central Districts and the major sockeye salmon producing drainages.

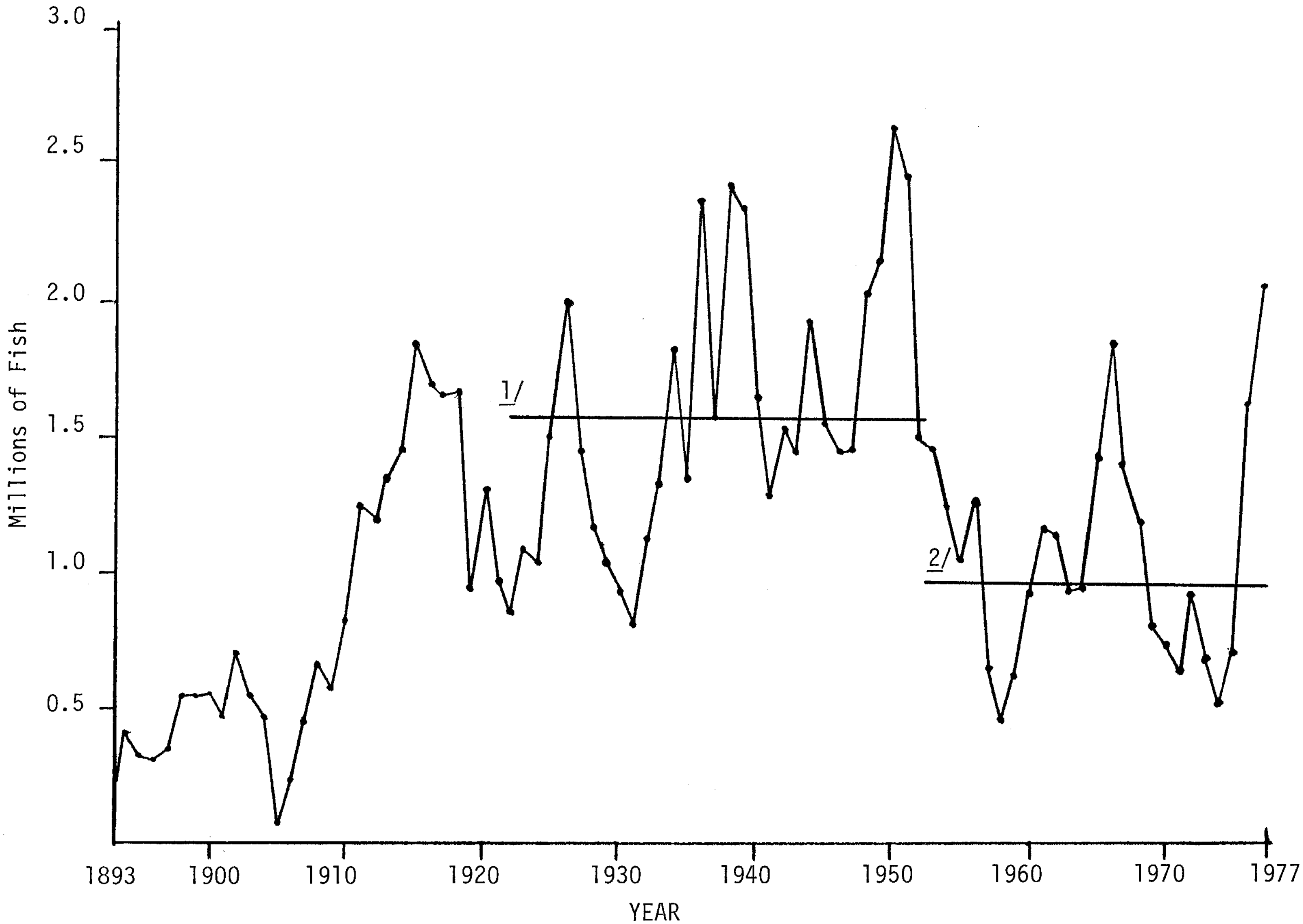

Figure 2. Annual commercial harvest of sockeye salmon, all districts, Cook Inlet area, 1893-1977

1/ Average harvest 1923 through 1952.

2/ Average harvest 1953 through 1977.

scale pattern analysis as a method of stock identification to this fishery during 1977. This report presents results of these studies.

MATERIALS AND METHODS

Sample Collection and Data Processing

In order to examine the distribution and timing of stocks within the commercial fishery, normal catch sampling efforts at the local area canneries were intensified and a program of scale collection from set net sites along the east-side beaches of the Central District was initiated.

The escapements were sampled by fishwheels located at the sonar counting sites on the Kenai and Kasilof Rivers and at Susitna Station on the Susitna River. In addition, a gill net test fishing program was conducted in the lower portion of the Kenai River. At each location, the fish caught were measured for length and a scale sample obtained, (Namtvedt et. al. 1978).

Commercially caught fish, taken in the set gill net fishery along Salamatof, Kalifonsky, Coho, and Ninilchik beaches of the Central District (Figure 3) and the east and west side beaches of the Northern District, were sampled at the canneries prior to processing. In addition, samples were obtained from fish harvested in the drift gill net fishery of the Central District. For each fish sampled at the canneries, mid-eye to fork of tail length was measured, sex was determined, and a scale was collected.

In order to augment catch samples taken at the cannery and to provide a closer look at the distribution of stocks along the east-side Central District beaches, samples were collected from specific areas on Salamatof, Kalifonsky, Coho, and Ninilchik beaches. Sampling efforts were directed toward comparisons of stock compositions on the northern and southern sections of each beach. Commercial set gill net fishermen on Kalgin Island voluntarily collected scales and forwarded them to the Soldotna ADF&G office.

During 1977, an offshore test fishing program was conducted between Point Adams on the lower Kenai Peninsula, and Cape Douglas on the Alaska Peninsula, to develop a short range forecast of the magnitude of the Cook Inlet return (Figure 4). Samples were collected for age-weight-length analysis and scale characteristics were measured to estimate the stock composition of the test fish catches.

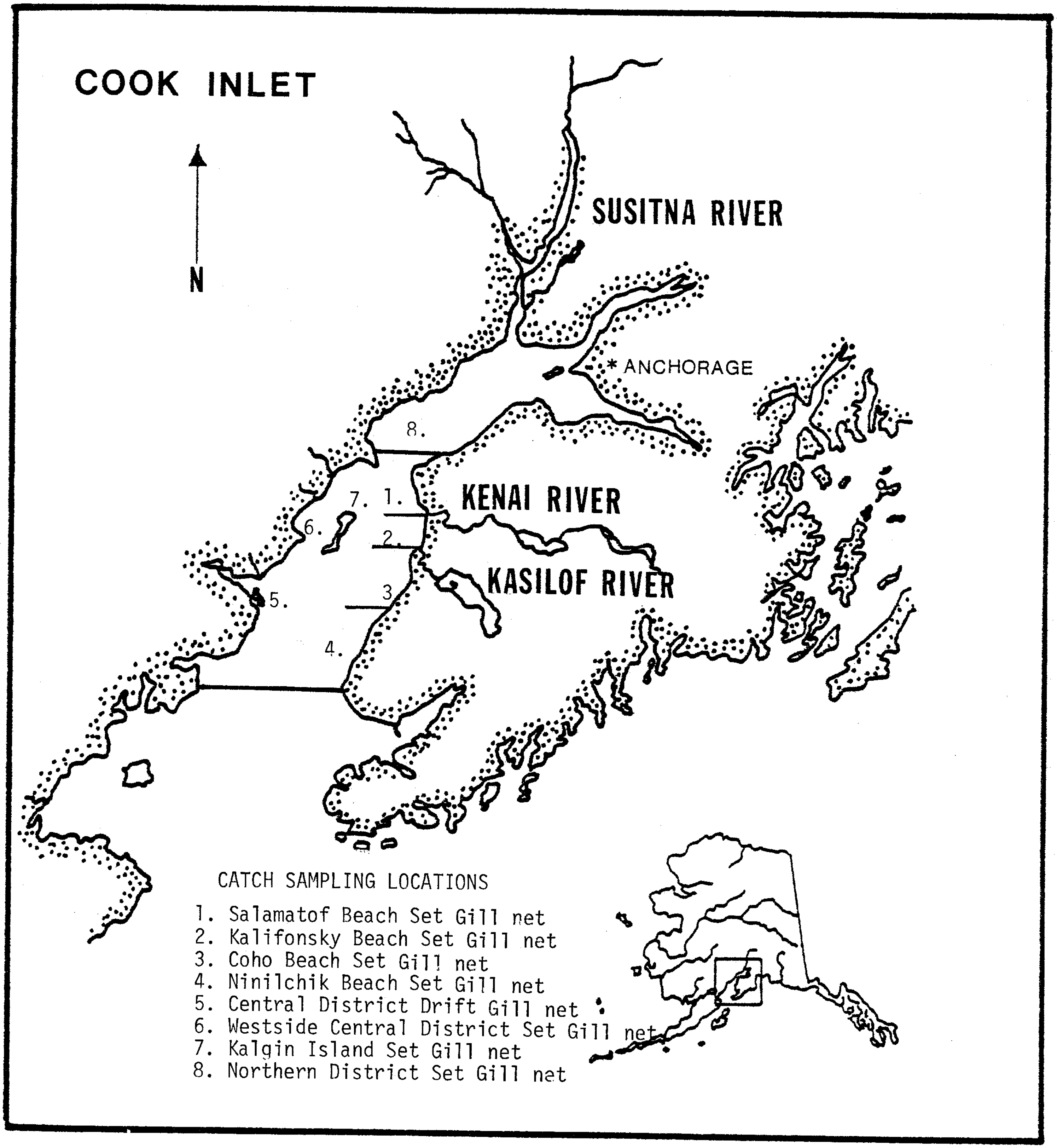

Figure 3. Commercial fishery catch sampling locations, Upper Cook Inlet area, 1977.

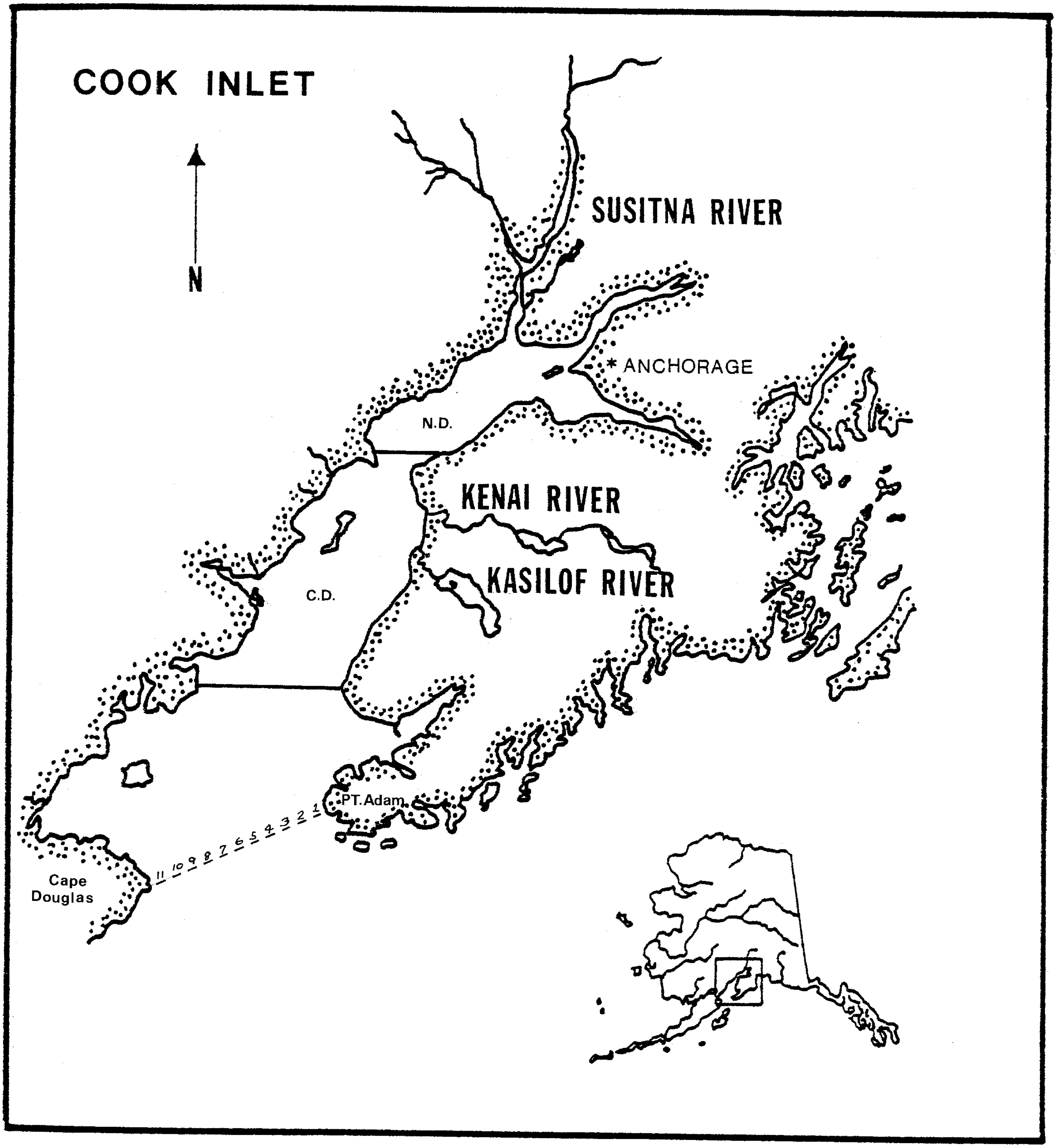

Figure 4. The Cook Inlet area showing offshore test fishing transects and stations.

An attempt was made to have all scales collected from the left side of the body, below the insertion of the dorsal fin and two or three rows above the lateral line (INPFC 1961). Scales were mounted on gum cards and impressions of the scale surface made using methods similar to those described by Clutter and Whitesel (1956). Initial scale examination was accomplished using a portable microfiche reader and the ages described using Gilbert-Rich notation.

Scale images were projected onto a table surface utilizing equipment similar to that initially described by Bilton (1970) and later modified by the Canadian Fisheries and Marine Service (Ryan and Christie 1975). Standard scale characteristics (Figure 5) were measured from these 100x images and prepared for computer analysis as described by Krasnowski and Bethe (1978). Age 5_2 fish, i.e., those five year old fish that emigrated from freshwater during their second spring, were predominant. Only scales from this age class were examined.

Statistical Techniques

Linear discriminant function analysis was used to classify individuals within mixed-stock fishery samples. The linear discriminant function was introduced by R.A. Fisher (1936) as a method by which individuals from a mixed sample could be classified into their group of origin. This analysis can be separated into two phases: the analysis phase and the classification phase.

The analysis requires data (learning samples) taken from members of known group origin, in our case, samples from the escapement into each river system. From these, a selected set of counts or measurements (circuli counts and growth zone width measurements) were taken. The variability between river systems for each of these counts and measurements was examined and used to compute a set of classification functions. These equations use the set of counts or measurements from an individual to compute a single value which serves as the basis by which an individual in an unknown (mixed-stock) sample can be classified as to river of origin. The efficacy of the classification functions was then tested by the trial classification of the learning samples used in the analysis. This resulted in estimates of classification accuracy and error for each of the systems in the analysis. Krasnowski and Bethe (1978) present a description of this type of analysis and the initial classification routines used.

Estimates of classification accuracy obtained by the classification of learning samples, i.e., classification of those samples used to derive the classification functions, have been shown to exhibit some degree of

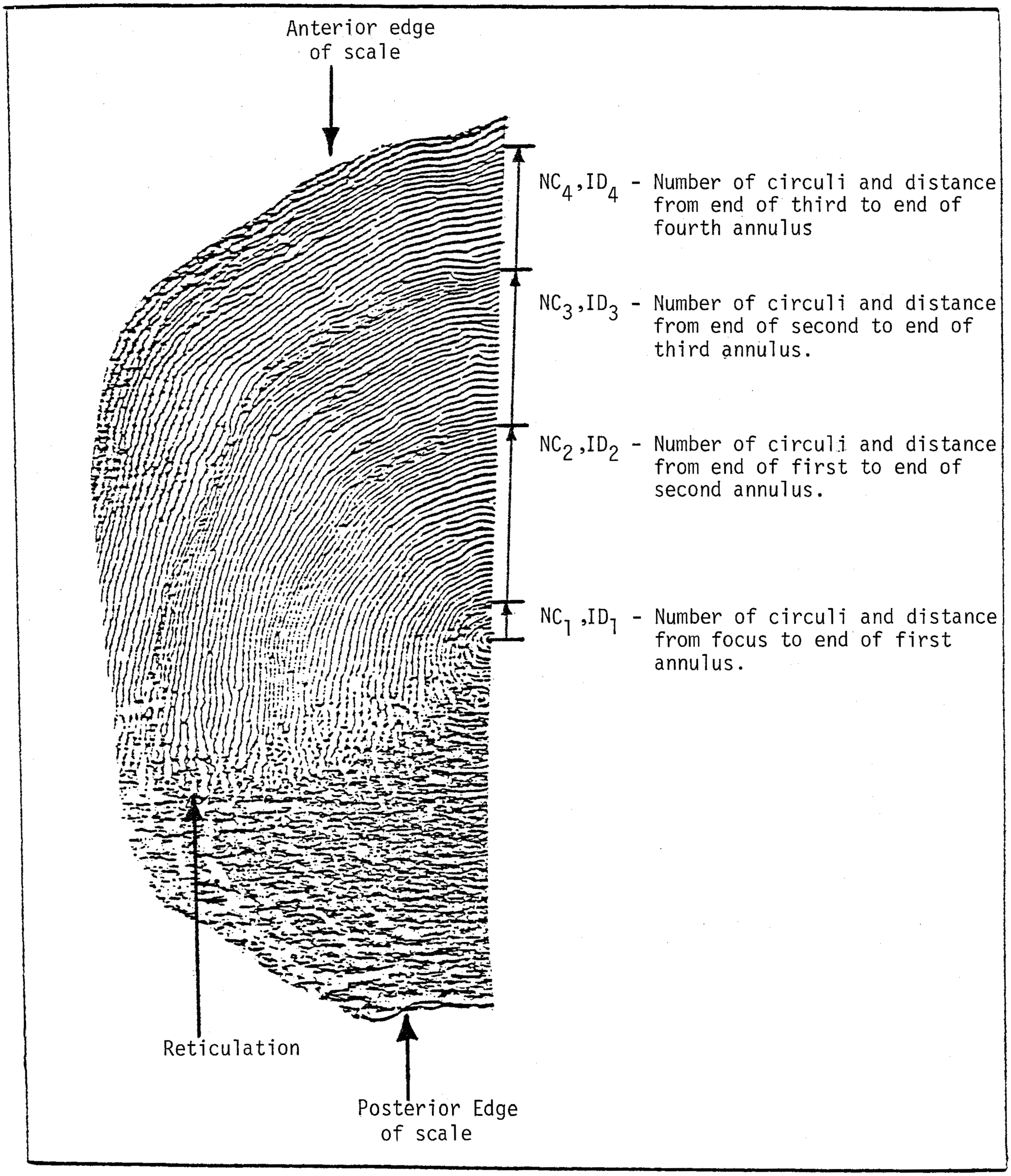

Figure 5. Age 5_2 sockeye salmon scale showing standard scale characteristics used in discriminant analysis.

positive bias. In order to avoid this bias, independent test samples from each of the escapements were classified to obtain unbiased estimates of classification accuracy. The proportion of stocks in mixed-stock fishery samples were corrected for estimated error (see Krasknowki and Bethe 1978) and 90% confidence intervals calculated using methods described by Pella and Robertson (in press).

Learning and test samples from the Kenai, Kasilof, and Susitna Rivers were of equal size (n=45). Whenever possible, classification of mixed-stock samples were based on samples from at least 100 fish.

Catch Apportionment

Preliminary catch figures were used to obtain total sockeye catch estimates by gear type for the time periods examined. The proportion of age 5_2 fish in each catch sample was determined and applied to the catch estimates to provide estimates of the age 5_2 harvest by period. Stock composition estimates were then applied to yield estimates of the numbers of age 5_2 fish from each stock in the catch.

In-season Run Analysis

Scales from the early escapements into the Kenai, Kasilof, and Susitna Rivers were collected and analyzed in order to determine the feasibility of application of scale analysis as a method of stock identification on a real-time basis. As catch samples were received, they were classified on the basis of classification functions derived from these early escapement samples. The comparison of these in-season classification results with those obtained from the final post-season analysis are intended to provide information to evaluate the value of this technique as an in-season management tool.

RESULTS

Catch and Escapement Samples

During 1977, the Upper Cook Inlet commercial salmon fishery produced one of the largest odd-year harvests (more than 4 million fish) experienced in the area. The sockeye salmon run produced a catch of over 2 million, the highest harvest since 1951. Escapements into the major sockeye producing river systems were excellent. Kenai River received in excess of 800,000 sockeye, the largest escapement recorded since enumeration by means of sonar counters began in 1968. Kasilof River received an escapement of over 150,000 sockeye. Although the escapement into the Susitna River is not enumerated, there were indications of an excellent escapement.

The Kenai and Susitna escapements were composed predominantly of age 5_2 fish (Figures 6 and 7). The Kasilof escapement, however, exhibited a shift from an early predominance of age 4_2 and 5_2 fish (Figure 8). The Kenai escapement showed a strong peak on July 15 with lesser peaks occurring on July 20 and 24. Although the entrance of the Kasilof River escapement exhibited a much flatter curve than Kenai or Susitna, a discernable peak occurred between July 11 and 15. Fishwheel catch information from the Susitna River indicates that the escapement built sharply up to a peak on July 14.

During 1977, more than 12,000 sockeye salmon scales were collected from the commercial fishery. Cannery samplers collected 7,288 scales; samplers on the east-side beaches collected 5,083 scales. Table 1 presents numbers of fish sampled from each area.

Discriminant Analysis

During the fall of 1977, discriminant function analysis was used to examine the separability of Kenai, Kasilof, and Susitna age 5_2 stocks. Analyses were conducted utilizing all standard circuli counts and measurements with and without the inclusion of fish length as a variable. Resulting classification matrices from test sample classifications are presented in Table 2. Distribution statistics for the variables included in analyses from the Kenai, Kasilof, and Susitna learning samples are presented in Table 3.

The analysis including only standard scale counts and measurements yielded an overall classification accuracy of approximately 55%. Results showed that both Kenai and Kasilof could be correctly identified in a mixed sample of the three stocks 58% of the time, whereas Susitna fish can be correctly identified 49% of the time. Kasilof fish were primarily misclassified as Kenai with few (9%) being mistaken as Susitna. Kenai fish were primarily misclassified as Susitna (27%), whereas Susitna fish were more frequently misclassified as Kasilof (31%).

The analysis which included fish length as a variable yielded a slightly higher overall classification accuracy of 60%. The addition of fish length as a variable in this analysis resulted in a substantial increase in the classification accuracy of Kenai fish (from 58% to 76%), mostly due to a decrease in misclassification as Kasilof. Misclassification of Susitna fish as Kasilof decreased from 31% to 27%, whereas misclassification of

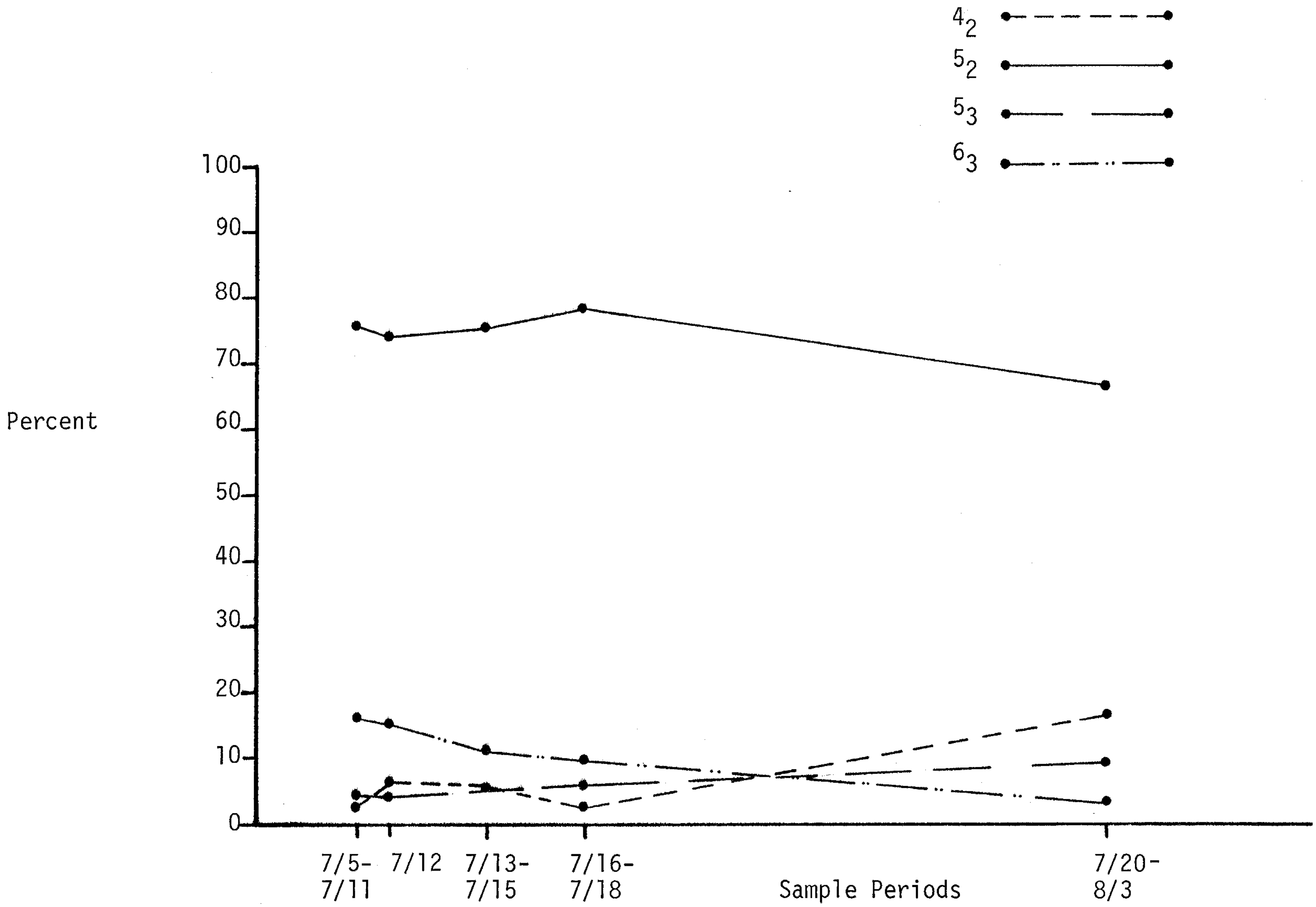

Figure 6. Percent age composition of Kenai escapement by sample period. Sample periods represent minimum sample size of 286.

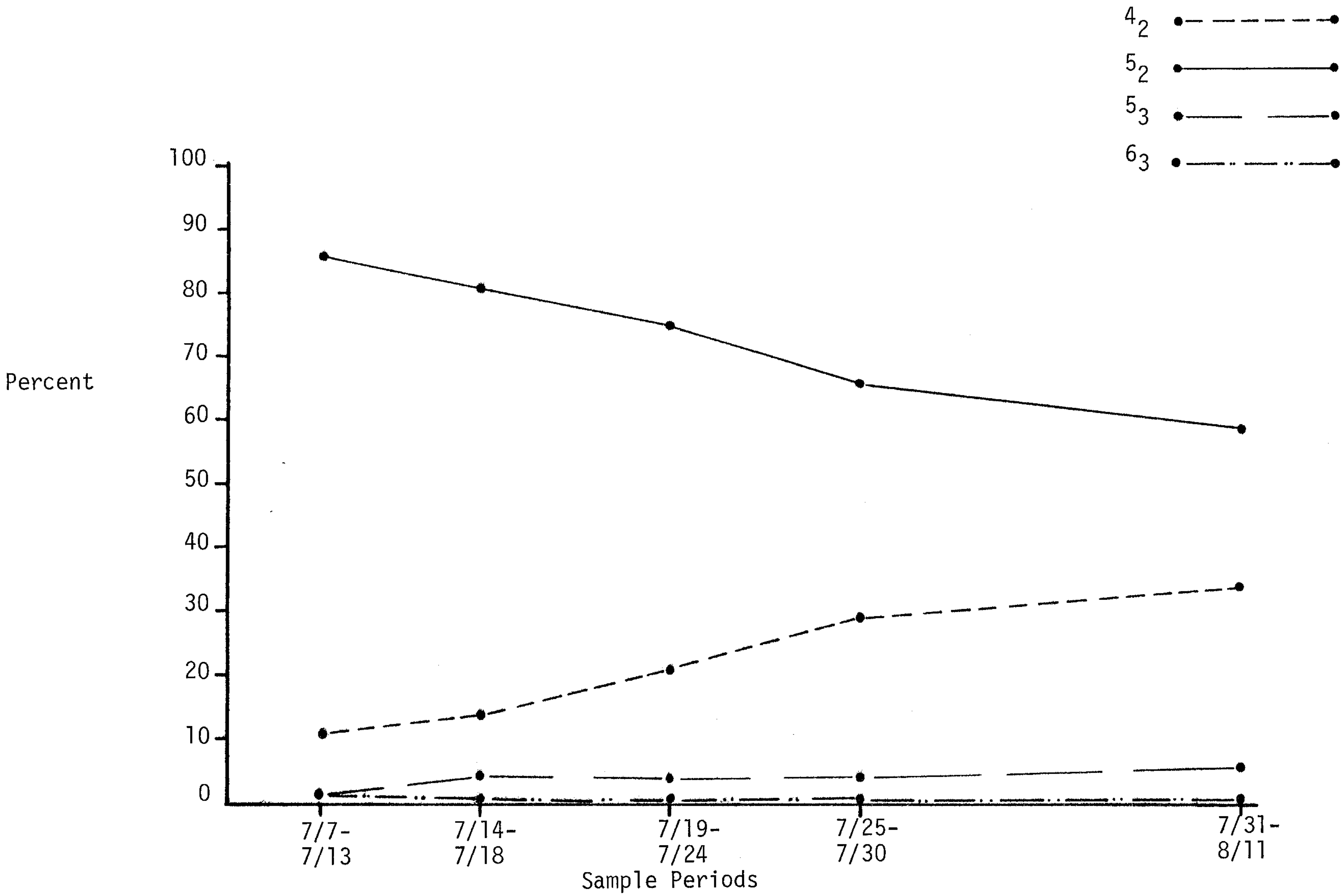

Figure 7. Percent age composition of Susitna escapement by sample period. Sample periods determined by minimum sample size of 286.

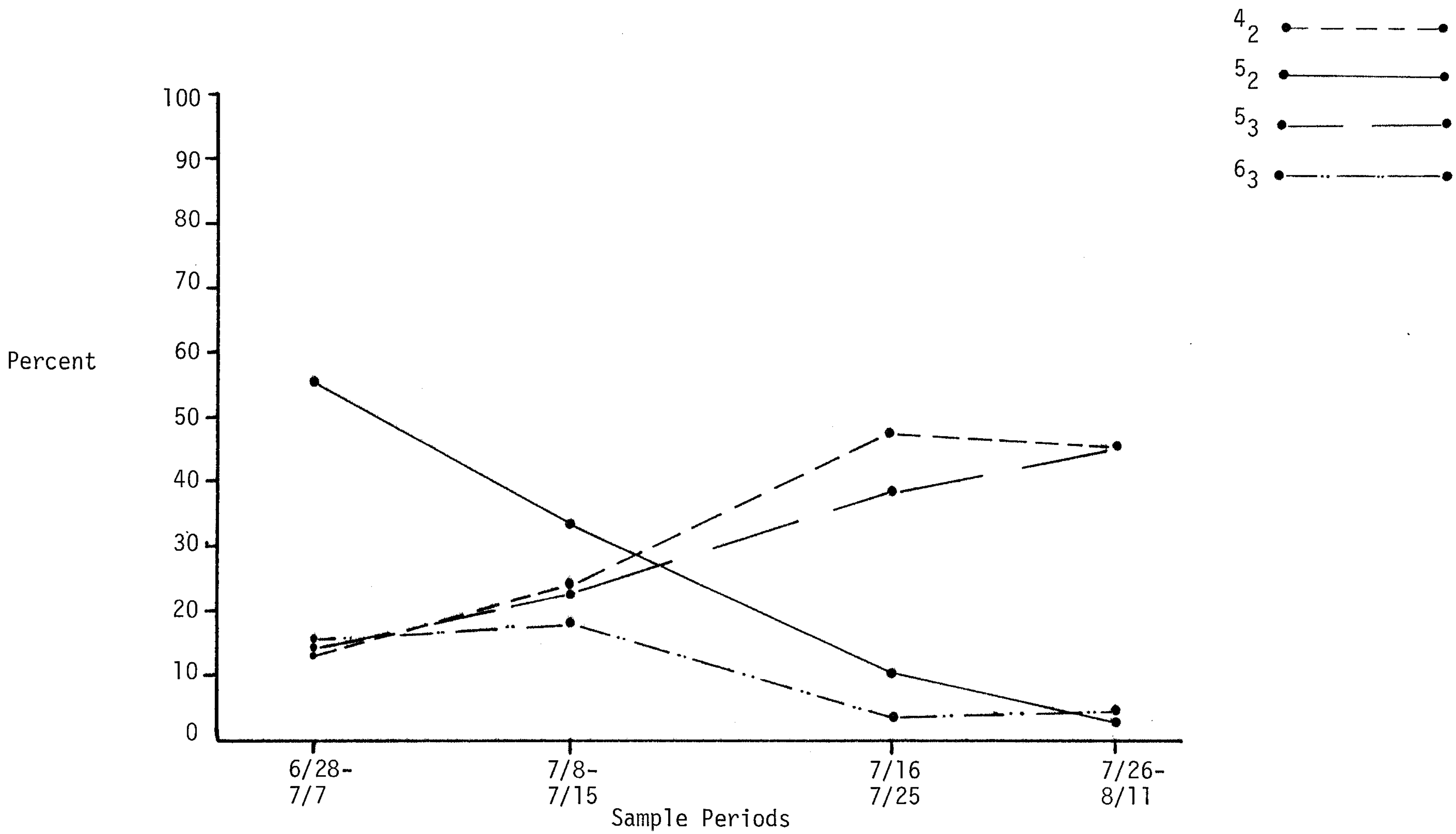

Figure 8. Percent age composition of Kasilof escapement by sample period. Sample periods determined by minimum sample size of 286.

Table 1. Numbers of sockeye salmon sampled from the upper Cook Inlet commercial salmon fishery for stock separation studies during 1977.

	Cannery Samples	Beach Site Samples
Ninilchik Beach Set Net	581	900
Coho Beach Set Net	620	1,091
Salamatof Beach Set Net	1,210	1,126
Kalifonsky Beach Set Net	1,227	1,966
Kalgin Island Set Net	718	-
Northern District Set Net	530	-
Central District Drift	2,402	-
	7,288	5,083

Table 2. Test sample classification matrices resulting from discriminant analyses with and without fish length used as a variable.

A. With fish length

ACTUAL GROUP MEMBERSHIP	CLASSIFIED GROUP MEMBERSHIP		
	Kenai	Kasilof	Susitna
Kenai (n=45)	34 76%	1 2%	10 22%
Kasilof (n=45)	11 24%	27 60%	7 16%
Susitna (n=45)	13 29%	12 27%	20 44%

Overall Classification Accuracy = 60%

B. Without fish length

ACTUAL GROUP MEMBERSHIP	CLASSIFIED GROUP MEMBERSHIP		
	Kenai	Kasilof	Susitna
Kenai (n=45)	26 58%	7 15%	12 27%
Kasilof (n=45)	15 33%	26 58%	4 9%
Susitna (n=45)	9 20%	14 31%	22 49%

Overall Classification Accuracy = 55%

Table 3. Escapement sample distribution statistics for characteristics used in discriminant analysis.

VARIABLE	STATISTIC	RIVER SYSTEM		
		Kenai	Kasilof	Susitna
Length	Mean	594.3	564.4	583.3
	Std. Dev.	25.5	16.7	36.0
	Range	146.0	71.0	171.0
NC_1	Mean	9.7	12.2	11.6
	Std. Dev.	2.0	2.2	2.7
	Range	8.0	9.0	11.0
ID_1	Mean	72.7	86.9	81.1
	Std. Dev.	12.6	14.4	18.9
	Range	57.0	60.0	62.0
NC_2	Mean	31.6	28.6	29.4
	Std. Dev.	2.5	2.4	3.4
	Range	11.0	11.0	16.0
ID_2	Mean	293.2	282.3	274.4
	Std. Dev.	25.5	22.2	27.9
	Range	124.0	115.0	136.0
NC_3	Mean	22.6	21.4	22.1
	Std. Dev.	2.5	2.6	4.1
	Range	13.0	10.0	19.0
ID_3	Mean	202.5	198.1	205.8
	Std. Dev.	23.6	25.3	35.3
	Range	107.0	119.0	180.0
NC_4	Mean	17.8	15.1	16.2
	Std. Dev.	2.0	2.5	2.5
	Range	9.0	12.0	11.0
ID_4	Mean	166.2	143.2	161.7
	Std. Dev.	19.6	22.7	19.0
	Range	86.0	121.0	82.0

Susitna fish as Kenai increased from 20% to 29%. The correct identification of Kasilof fish increased slightly (58% to 60%) due to reduced misclassification as Kenai (33% to 24%).

The scale characteristics which provided the best discrimination were the third and first marine years growth characters followed by fish length, for those analyses in which it was included. Most of the other characteristics were included but provided less discriminatory power.

The classification accuracy of the functions derived from these analyses are sufficient to examine catch samples for trend information with respect to spatial and temporal distributions of stocks within the commercial fishery. In three group discriminant analyses, classification accuracy estimates in this range produced wide confidence intervals in estimating stock composition proportions of mixed samples. However, the relative power of these classification functions is demonstrated by the fact that in a three-way analysis, given chance alone, one could expect to correctly identify only 33.3% of the fish.

Classification of Mixed-Stock Samples

The availability of commercial fishery catch samples for a given time period and location determined the size of each mixed-stock sample. In the classification phase of discriminant analysis, the mixed-stock sample size affects the variability of the stock composition estimates. Therefore, in order to improve the statistical accuracy, it was often necessary to combine samples of set net caught fish collected at canneries with those collected at specific set net sites on the beaches. Classification of these pooled samples was accomplished using the classification functions that did not include fish length as a variable since that measurement was not taken for samples collected at beach sites.

Table 4 presents the results of classification of mixed-stock samples collected from the east-side Central District set net beaches, pooled samples. Sample periods were designated to allow comparison with samples collected from the Central District drift gillnet fishery.

Classification results indicate several trends. Generally, the proportion of Kasilof and Susitna stocks decreased with time, whereas the proportion of Kenai fish tended to increase. During the first sample period (June 27 through July 11), Kenai stocks were at their weakest and Kasilof-Susitna stocks were present in strong proportions. On the beaches, Kasilof stocks were present in the strongest proportions on Coho and Ninilchik Beach. The proportion of Kasilof fish found in the set net catches tended to decrease with increased distance from the Kasilof River entrance. Susitna stocks were very strong on all beaches parti-

Table 4. Results of classification of mixed-stock catch samples collected from east-side Central District set net areas and Central District drift gill net fishery, upper Cook Inlet, 1977.

SAMPLE LOCATION		CLASSIFICATION RESULTS BY SAMPLE PERIOD 1/		
		6/27 - 7/11	7/13 - 7/15 2/	7/21- 7/24 3/
Salamatof Beach Set Net	Kenai	23 (0,51)	95 (62,100)	92 (60,100)
	Kasilof	18 (0,44)	0 (0,26)	8 (0,34)
	Susitna	59 (28,90)	5 (0,40)	0 (0,29)
Kalifonsky Beach Set Net	Kenai	38 (16,60)	64 (41,87)	87 (56,100)
	Kasilof	31 (12,50)	20 (0,40)	13 (0,38)
	Susitna	31 (0,43)	16 (0,39)	0 (0,29)
Cohoe Beach Set Net	Kenai	0 (0,29)	85 (50,100)	94 (62,100)
	Kasilof	52 (20,84)	6 (0,30)	6 (0,32)
	Susitna	48 (17,79)	9 (0,39)	0 (0,32)
Ninilchik Beach Set Net	Kenai	15 (0,45)	74 (46,100)	82 (43,100)
	Kasilof	47 (18,76)	12 (0,35)	0 (0,31)
	Susitna	38 (8,68)	14 (0,42)	18 (0,60)
Central District Drift Gill Net	Kenai	41 (15,67)	86 (56,100)	95 (65,100)
	Kasilof	29 (6,52)	13 (0,37)	5 (0,29)
	Susitna	30 (4,56)	1 (0,29)	0 (0,30)

1/ Classification results expressed in percentages with 90% confidence interval.
2/ Normal 12 hour Central District openings.
3/ Drift fleet fished east of a line between Nikiski docks and Cape Ninilchik.

cularly Salamatof. Kenai fish showed strongly on Kalifonsky Beach with few present on Coho Beach during this early time period. In the drift gill-net fishery, Kenai stocks predominated, closely followed by nearly equal proportions of Kasilof and Susitna.

During the latter two sample periods (July 13, 15, and July 21 through 24) Kenai stocks were dominant throughout the fishery. In most cases, Kasilof and Susitna stocks appeared to decrease with time. Kasilof fish were strongest on Kalifonsky Beach, whereas Susitna fish appeared strongest on Ninilchik Beach. Similarly, in the drift fishery, the proportions of Kenai stocks increased through time and during the last period (July 21 through 24), comprised better than 90% of the harvest.

Table 5 shows similar data for set net catches only from June 27 through July 29. Sample periods have been altered to allow for optimal sample sizes in each period. Results presented in Table 5 show similar trends, i.e., at most locations there was a general decrease in the proportion of Kasilof-Susitna stocks present through time. After July 16, Susitna stocks appeared to be present in very low proportions. In most samples, Kasilof fish were present in larger proportions than were Susitna stocks.

Sufficient samples collect at set net sites on Kalifonsky Beach are available to allow a more detailed examination of the distribution of the stocks in this area. Comparison of samples collected from north and south Kalifonsky Beach (Figure 9) during the first sample period (July 4, 8) indicated substantial differences in the distribution of Kenai and Kasilof fish (Table 6). Samples taken from the southern half of Kalifonsky Beach were primarily Kasilof River fish (66%) with a low proportion of Kenai River fish (4%). During this same time period, samples from the northern half of the beach were classified as 50% Kenai and 4% Kasilof. Samples taken on Kalifonsky Beach on July 13 show a uniform distribution of stocks with a slight preponderance of Kenai fish. After July 15 both north and south Kalifonsky Beach samples were almost entirely Kenai River with a few Kasilof and essentially no Susitna stocks present.

Classification of samples collected by the Cook Inlet offshore test fishing program showed Susitna to be the most frequently intercepted stock at both inshore and offshore stations (Table 7). Point estimates of stock proportions indicate that few, if any, Kasilof fish were intercepted. Nearly equal proportions of Kenai fish were caught at inshore and offshore locations.

Classification of samples collected from the Kenai River inside test fishing project (Table 7) showed that little mixing of stocks occurred at that location. Although point estimates indicate that low proportions of Kasilof fish were present, a stock composition estimate of zero would fall within the 90% confidence range.

Table 5. Results of classification of mixed-stock catch samples collected from east-side Central District set net areas, upper Cook Inlet, 1977.

SAMPLE LOCATION		CLASSIFICATION RESULTS 1/ BY SAMPLE PERIOD				
		6/27-7/11	7/13, 7/15	7/16, 7/18	7/20-7/23	7/24-7/29
Salamatof Beach Set Net	Kenai	23 (0,51)	95 (62,100)	82 (52,100)	97 (68,100)	91 (58,100)
	Kasilof	18 (0,44)	0 (0,26)	18 (0,42)	3 (0,27)	9 (0,35)
	Susitna	59 (28,90)	5 (0,40)	0 (0,27)	0 (0,28)	0 (0,31)
Kalifonsky Beach Set Net	Kenai	38 (16,60)	64 (41,87)	98 (61,100)	93 (58,100)	88 (52,100)
	Kasilof	31 (12,50)	20 (0,40)	2 (0,31)	7 (0,34)	12 (0,41)
	Susitna	31 (0,53)	16 (0,39)	0 (0,38)	0 (0,35)	0 (0,33)
Cohoe Beach Set Net	Kenai	0 (0,29)	85 (50,100)	85 (49,100)	80 (48,100)	96 (51,100)
	Kasilof	52 (0,34)	6 (0,30)	15 (0,43)	19 (0,44)	3 (0,37)
	Susitna	48 (17,79)	9 (0,39)	0 (0,35)	1 (0,31)	1 (0,48)
Ninilchik Beach Set Net	Kenai	14 (0,44)	74 (46,100)		88 (52,100)	77 (44,100)
	Kasilof	48 (19,77)	12 (0,35)		12 (0,40)	17 (0,43)
	Susitna	38 (8,68)	14 (0,42)		0 (0,36)	6 (0,38)

1/ Classification results expressed in percentages with 90% confidence interval.

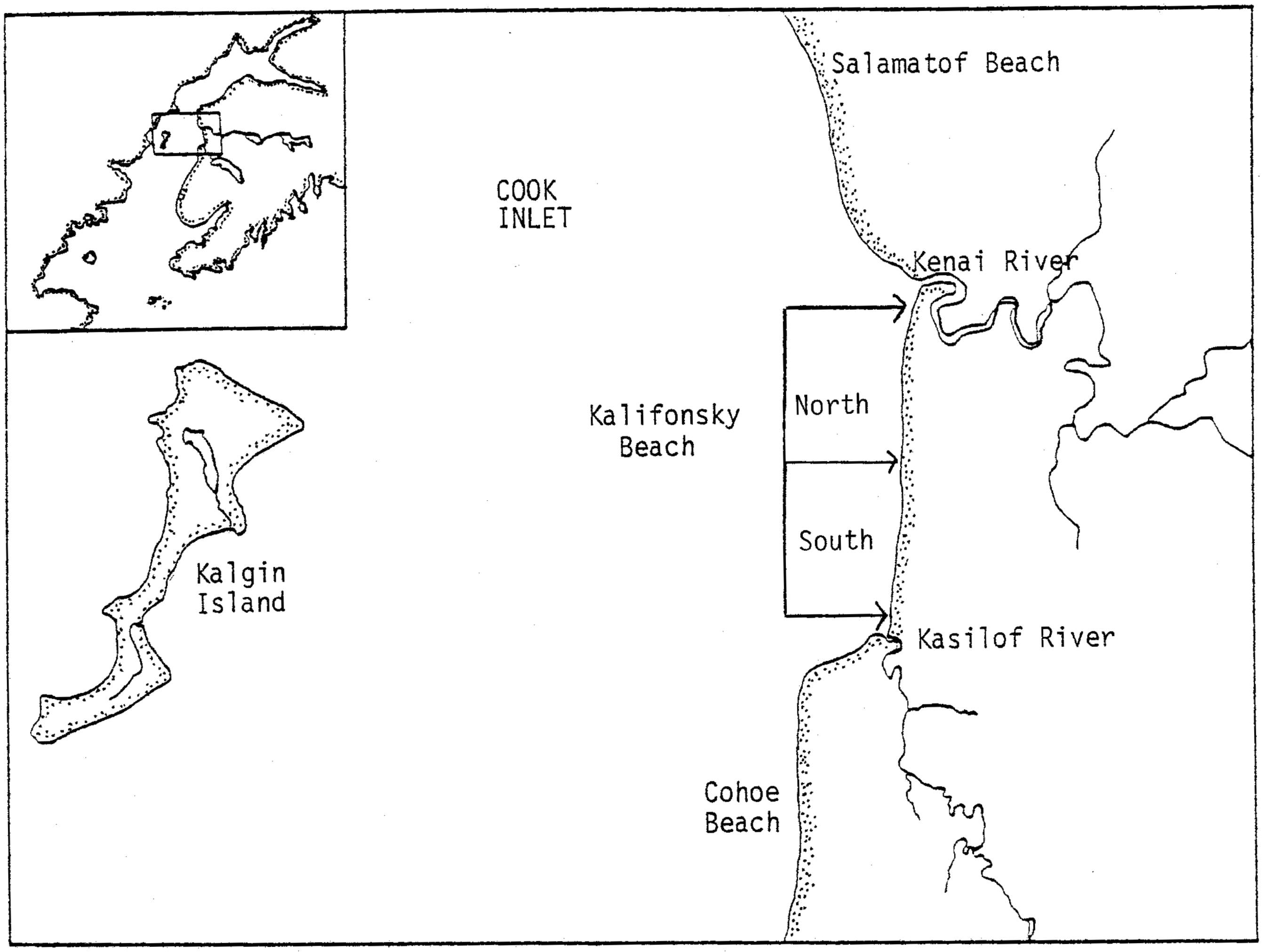

Figure 9. Sampling locations of catch samples collected from Kalifonsky Beach, upper Cook Inlet, 1977.

Table 6. Classification results of mixed-stock catch samples collected from the Kalifonsky Beach set net area, Central district, upper Cook Inlet, 1977.

Sample Location		CLASSIFICATION RESULTS 1/ BY SAMPLE PERIOD			
		7/4,7/8	7/13	7/15-7/21	7/23-7/29
North Kalifonsky Beach Set Net	Kenai	50 (19,81)	45 (11,79)	93 (63,100)	87 (52,100)
	Kasilof	4 (0,31)	28 (0,57)	7 (0,31)	13 (0,40)
	Susitna	46 (11,80)	27 (0,61)	0 (0,29)	0 (0,40)
South Kalifonsky Beach Set Net	Kenai	4 (0,44)	42 (4,80)		99 (61,100)
	Kasilof	66 (29,100)	36 (4,68)		1 (0,31)
	Susitna	30 (0,66)	22 (0,58)		0 (0,40)

1/ Classification results expressed in percentages with 90% confidence interval.

Table 7. Classification of Cook Inlet offshore test fishing and Kenai River inside test fishing samples, 1977.

SAMPLE LOCATION	CLASSIFICATION RESULTS 1/ KENAI	KASILOF	SUSITNA
Kenai River Inside Test (7/6-7/18)	90 (72,100)	10 (0,29)	0 (0,36)
Kenai River Inside Test (7/19-8/31)	86 (68,100)	14 (0,32)	0 (0,33)
Cook Inlet Offshore 2/ Test (Inshore Stations)	29 (4,54)	0 (0,27)	71 (23,100)
Cook Inlet Offshore 3/ Test (Offshore Stations)	33 (7,59)	0 (0,27)	67 (18,100)

1/ Classification results expressed in percentages with 90% confidence interval. Estimates derived from classification functions utilizing fish length as a variable.

2/ East-side stations 1-6.

3/ West-side stations 7-11.

Comparison of In-season and Post-season Classification Results

Table 8 shows the classification matrix from the learning samples used during the 1977 sockeye run in Upper Cook Inlet. The in-season analysis, based upon early escapement samples, produced an overall classification accuracy of 69%. Kasilof and Susitna stocks were correctly classified 74% of the time. Kenai fish were correctly identified 61% of the time. Kasilof and Susitna fish were more often misclassified as Kenai, whereas Kenai fish were most frequently misclassified as Kasilof.

Post-season analyses were accomplished using larger escapement samples which were more evenly distributed through time. The classification matrix for the post-season analysis (Table 2) has already been described. Comparison of these two classification matrices shows that the in-season estimates of classification accuracies were slightly higher for each stock. Distribution of classification errors were also slightly different in the two analyses.

Comparisons of the classification of catch samples by in-season and post-season functions are presented in Table 9. Stock composition estimates for each sample have been corrected for estimated error and 90% confidence intervals determined. In-season classification functions tended to estimate lower proportions of Kenai and Kasilof stocks and higher proportions of Susitna stocks than did post-season functions. In-season and post-season classification of samples collected from Kalifonsky Beach (7/4-7/8) and Salamatof Beach (6/29-7/13) are quite similar. Comparison of estimates from samples collected later in the fishery tended to show less agreement.

Catch Apportionment

Preliminary catch information obtained from fish processors served as the basis for estimating the sockeye harvest by stock and gear type. Since these preliminary catch figures did not show harvest by specific statistical area, samples collected from the east-side Central District beaches were pooled for stock allocation purposes. As a result, harvest estimates by stock do not reflect as fine a delineation of the spatial and temporal distributions of the major stocks as would be possible if more precise catch data were available (i.e., catch figures by statistical sub-area). Allocation of the numbers of age 5_2 sockeye, by sample period and gear type for the 1977 Cook Inlet fishery is summarized in Table 9.

Table 8. Classification matrix resulting from self classification of learning samples, in-season analysis, 1977.1/

	CLASSIFIED GROUP MEMBERSHIP		
	Kenai	Kasilof	Susitna
Kenai (n=49)	30 61%	12 25%	7 14%
Kasilof (n=49)	7 14%	36 74%	6 12%
Susitna (n=49)	8 16%	5 10%	36 74%

Overall Classification Accuracy = 69%

1/ Fish length not included as a variable in the analysis.

Table 9. Results of classification of commercial fishery catch samples by in-season and post-season classification functions, 1977.

Catch Sample	"In-season" Classification 1/			"Post-season" Classification 2/		
	Kenai	Kasilof	Suitna	Kenai	Kasilof	Susitna
Kalifonsky Beach 7/4-7/8	28 (7,49)	45 (26,64)	27 (11,43)	36 (6,66)	40 (14,66)	24 (0,53)
Kalifonsky Beach 7/18-7/20	76 (48,100)	6 (0,27)	18 (0,37)	98 (56,100)	2 (0,34)	0 (0,41)
Salamatof Beach 6/29-7/13	36 (11,60)	23 (2,44)	41 (21,61)	28 (0,62)	28 (0,59)	44 (0,80)
Salamatof Beach 7/18	80 (51,100)	2 (0,23)	18 (0,37)	77 (39,100)	23 (0,53)	0 (0,36)
Salamatof Beach 7/20	64 (34,94)	0 (0,18)	36 (14,58)	99 (60,100)	1 (0,31)	0 (0,40)
Coho Beach 7/13-7/15	80 (50,100)	0 (0,19)	20 (0,40)	94 (55,100)	6 (0,36)	0 (0,39)
Ninilchik Beach 7/13-7/18)	63 (32,94)	16 (0,40)	21 (0,42)	72 (28,100)	28 (0,61)	0 (0,38)
Northern District Set 7/8-7/13	94 (63,100)	0 (0,23)	6 (0,25)	93 (54,100)	7 (0,37)	0 (0,40)
North Kalgin Island 7/8-7/18	51 (19,83)	0 (0,17)	49 (25,73)	73 (34,100)	0 (0,32)	27 (0,71)

1/ Results based upon classification functions derived by use of early escapement samples. Results expressed in percentages with 90% confidence interval applied.

2/ Results based upon classification functions derived by use of escapement samples collected throughout the season. Results expressed in percentages with 90% confidence intervals applied.

DISCUSSION

The interpretation of classification results must be made in view of factors affecting the catch as well as the statistical success of the identification technique used. Although classification accuracies achieved during 1977 are inferior to those obtained in the preliminary analyses of 1975 and 1976 data, they are sufficient to observe general trends within the commercial fishery. However, these trends may be "colored" by several missing or incomplete pieces of information. With only a limited amount of escapement information from the Susitna River system, the determination of the relative information from the Susitna River system, the determination of the relative proportion of age 5_2 fish available for harvest from that system becomes difficult. Preliminary catch figures do not yield sufficient detail to allocate catches from each east-side beach. The resulting necessity of pooling samples from these beaches in order to allocate that portion of the catch may have introduced some bias by weighing the harvest from a particular beach. In addition, the ability to correctly estimate the proportion of Kasilof and Susitna stocks later in the fishery was affected by the influx of large numbers of Kenai fish resulting in actual low proportions and a decreased statistical resolution of the other stocks.

Apportionment results (Table 10) indicate that the main body of the Kenai run did not enter the commercial fishery until shortly after July 11. Prior to this date relatively equal numbers of Kenai, Kasilof, and Susitna fish were taken in the commercial fishery. During this time period nearly five Kenai fish were harvested in the drift fishery to each Kenai fish harvested on the beach, indicating that, at this point, Kenai stocks were predominantly located offshore. Kasilof and Susitna stocks, on the other hand, showed considerable strength on the beaches with only slightly larger harvests of each stock occurring in the drift fishery. Over 66% of the combined harvest to this point was composed of Kasilof and Susitna stocks with the Susitna harvest representing the largest harvest in the commercial fishery (146,000 sockeye).

After July 11 the main body of the Kenai run had entered the commercial fishery with significant numbers on the beaches. The catch of Kasilof and Susitna stocks exhibited a dramatic decrease during the periods of July 13 and 15. This may have been due to a "swamping" of the Kasilof and Susitna fish by the influx of large numbers of Kenai fish or may, in fact, indicate an actual decrease in the absolute numbers of Kasilof and Susitna fish available for harvest at these locations.

Table 10. Allocation of age 5_2 sockeye salmon harvest by gear type, upper Cook Inlet, 1977.

		Estimated Harvest Point Estimate (90% confidence interval)		
Gear	Date(s)	Kenai	Kasilof	Susitna
Drift Gill Net	6/27-7/11	116,000 (42,000-190,000)	82,000 (17,000-147,000)	85,000 (11,000-159,000)
	7/13-7/15	120,000 (75,000-165,000)	18,000 (0-51,000)	1,000 (0-40,000)
	7/16-8/5	165,000 (115,000-215,000)	15,000 (0-57,000)	29,000 (0-79,000)
Set Gill Net	6/27-7/11	25,000 (3,000-47,000)	53,000 (31,000-75,000)	61,000 (36,000-86,000)
	7/13-7/15	104,000 (77,000-131,000	15,000 (0-38,000)	16,000 (0-42,000)
	7/16-7/18	40,000 (28,000-52,000)	7,000 (0-17,000)	-0- (0-11,000)
	7/23	46,000 (34,000-58,000)	3,000 (0-13,000)	-0- (0-11,000)
	7/24-7/29	27,000 (19,000-35,000)	3,000 (0-10,000)	-0- (0-8,000)

After July 16 the harvest was composed primarily of Kenai fish (83%). Approximately 59% of the combined Kenai harvest during this period (278,000 sockeye) was taken in the drift fishery. The harvest of Kasilof stocks continued to decrease in both the east-side set net, and drift fisheries. Susitna stocks, on the other hand, seemed to exhibit a shift away from beaches, where the point harvest estimates approached zero.

In summary, the early fishery (through July 11) appeared to be operating primarily on the main body of the Susitna and Kasilof runs. Only a relatively small, early portion of the Kenai run was present and was located primarily in offshore areas. As the peak of the fishery approached, a large body of Kenai fish entered the fishery with substantial numbers moving along the beaches. Susitna stocks moving up the inlet later in the fishery (after July 16) seemed to migrate offshore, away from the east-side beaches.

The comparison of classification results from in-season and post-season analyses shows that the scale analysis technique can be successfully utilized as a management tool during the Upper Cook Inlet sockeye fishery. Classification functions derived from early escapement samples should be periodically updated with additional samples throughout the course of the run. This will assure that the learning samples represent all the sub-stocks present in each river's escapement and should provide increased accuracy in the classification of catch samples.

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