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Origins of Chinook Salmon in the Yukon River Fisheries, 1987

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Margaret F. Merritt

State of Alaska Steve Cowper, Governor

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ABSTRACT

Analysis of scale patterns and age composition of chinook salmon (*Oncorhynchus tschawytscha* Walbaum) from Yukon River escapements in Alaska and commercial fishery catches in Canada were used to construct run-of-origin classification models for age-1.4 fish. Ages-1.3 and -1.5 fish comprised a small portion of the total harvest, and sample size was deemed insufficient to construct run of origin models for those age classes. Samples from the Nulato and Gisasa Rivers, Alaska, were collected in 1987 and included in models. Yukon River commercial and subsistence catch proportions by stock were estimated by run-of-origin models which yielded the greatest classification accuracy and allocation precision.

Total Yukon River harvest was 202,125 chinook salmon of which 64.9% was estimated to be the Upper Yukon Run, 18.0% the Middle Yukon Run and 17.1% the Lower Yukon Run. Similar to results obtained from 1982 through 1986, the fraction of the Districts 1 and 2 commercial catch composed of the Lower Yukon Run generally increased through time, while the fraction composed of the Upper Yukon run generally declined. The middle run component fluctuated slightly throughout the fishing season, declining to insignificant numbers during the last fishing period in District 1. The contribution of the Middle Yukon Run to the total harvest was slightly greater than the Lower Yukon Run in 1987, which is in contrast to 1986, when the middle run contribution was the lowest ever estimated.

KEY WORDS: chinook salmon, *Oncorhynchus tschawytscha*, stock separation, catch and run composition, linear discriminant analysis, Yukon River

INTRODUCTION

Yukon River chinook salmon *(Oncorhynchus tschawytscha* Walbaum) are harvested in a wide range of fisheries in both marine and fresh waters. During their ocean residence, they are harvested in salmon gill net fisheries in the North Pacific Ocean and Bering Sea and as an incidental catch in trawl fisheries in the Bering Sea (Meyers and Rogers 1985). Within the Yukon River returning adults are harvested in commercial and subsistence fisheries in both Alaska and Canada (Figures 1 and 2).

In the first 20 years after statehood (1960-79), the combined Alaskan and Canadian Yukon River chinook salmon commercial and subsistence harvest averaged 122,971 fish annually (ADF&G 1987). However, commercial and subsistence catches combined during the recent 5 years (1983-87) have increased substantially to a yearly average of 193,177 fish. While chinook salmon are harvested virtually throughout the entire length of the Yukon River, the majority of the catch has been taken in commercial gill net fisheries in Districts 1 and 2 (1983-87 average 63% of total drainage harvest). Subsistence harvests throughout the drainage, including Canadian catches, account for another 27% (1983-87 average) of the total harvest. Most of the subsistence harvest is taken with fish wheels and gill nets in Districts 4, 5, and 6. In 1987, commercial and subsistence fishermen in Alaska and Canada harvested a total of 202,125 chinook salmon, of which 124,101 fish (61.4%) were taken by District 1 and 2 commercial fishermen (ADF&G 1987).

Chinook salmon harvested in the Yukon River fisheries consist of a mixture of stocks destined for spawning areas throughout the Yukon River drainage. Although more than 100 spawning streams have been documented (Barton 1984), aerial surveys of chinook salmon escapements indicate that the largest concentrations of spawners occur in three distinct geographic regions: (1) tributary streams that drain the Andreafsky Hills and Kaltag Mountains between river miles 100 and 500; (2) Tanana River tributaries between river miles 800 and 1,100; and (3) tributary streams that drain the Pelly and Big Salmon Mountains between river miles 1,300 and 1,800. Chinook salmon stocks within these geographic regions were collectively termed runs by McBride and Marshall (1983) and are now referred to as the Lower, Middle, and Upper Yukon Runs.

A major controversy currently facing managers of Yukon River chinook salmon is allocation of the harvest among competing user groups. Two such allocation issues which have recently received considerable public attention are: (1) high seas interceptions of North American chinook salmon (including fish destined for the Yukon River) in the gill net and trawl fisheries in the North Pacific Ocean and Bering Sea; and (2) negotiations between the United States and Canada over inriver harvest of chinook salmon destined for the Canadian portion of the Yukon River drainage.

An increasingly important facet of Yukon River chinook salmon management is identification of the fisheries in which stocks are harvested and the relative harvest proportions. Harvest estimates of Western Alaskan/Canadian Yukon chinook salmon in the Japanese high seas gill net fisheries (Rogers et al. 1984, Meyers et al. 1984, Meyers and Rogers 1985), have become major elements in the regulation of these ocean fisheries. Concurrent with offshore studies, stock composition of inriver fisheries has been studied to provide useful information for resource regulators making inriver allocation decisions and managers seeking to improve management precision through a better understanding of spatial and temporal migratory patterns of Yukon stocks. Stock composition estimates of the catch through time for Yukon River chinook salmon became available in 1980 and 1981 when the use of scale patterns analysis for District 1 was initially investigated (McBride and Marshall 1983). Since then, harvest proportions by geographic region of origin have been estimated annually for the entire drainage (Wilcock and McBride 1983; Wilcock 1984, 1985, 1986; Merritt et al. 1988).

The objective of this report was to classify the 1987 Yukon River chinook salmon commercial and subsistence harvest to the run of origin and compare relative precision of catch composition estimates.

METHODS

Age Composition

Scale samples provided age information for fish in the catch and escapement. Scales were collected from the left side of the fish approximately two rows above the lateral line along a diagonal line downward from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (Clutter and Whitesel 1956). Scales were mounted on gummed cards and impressions made in cellulose acetate.

Catch

Scales were collected from commercial catches in Districts 1, 2, 4, 5, and 6, and in the Yukon Territory, Canada, and from subsistence catches in Districts 4, 5, and 6. District 3 was not sampled because few fish are harvested in that portion of the Yukon River and access is difficult. A small fraction of the District 2 catch can at times include District 3 catches delivered in District 2. Subsistence fishing in Districts 1 and 2 occurred concurrently with commercial effort, and the age compositions for subsistence catches were assumed to be similar to the commercial catch. Samples were also collected from a test gill net fishery in District 1 and from a test fish wheel used to capture fish in a tagging project in Yukon Territory. Sampling of Alaskan fisheries was conducted by the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries, while Canadian fishery and test fish wheel samples were collected by the Canadian Department of Fisheries and Oceans (DFO).

Escapement

Scale samples were collected during peak spawner die off from the Andreafsky, Anvik, Nulato, Gisasa, Koyukuk, Jim, Chena, Salcha and

Chandalar Rivers and Henshaw and Clear Creeks in Alaska, and from the Big Salmon, Little Salmon, Nisutlin, Teslin, Tatchun, Morley, Nordenskjold and mainstem Yukon Rivers in Canada. Reabsorbtion is generally not a major problem for chinook escapement sampling if three scales are collected per fish and scales are visually inspected at the time of sampling. The majority of all samples were collected from carcasses except those live fish obtained with spears or gill nets for a genetic stock identification study. Samples from the Big Salmon River in Canada were taken from live fish at a weir. The age composition of Lower, Middle, and Upper Yukon Runs was estimated by weighting the age composition calculated for the individual spawning tributaries in each area by the escapement to each tributary as indexed by aerial surveys. Those tributaries which were sampled, but for which no abundance estimate was available, were not included.

Catch Composition

Linear discriminant function analysis (Fisher 1936) of scale patterns data and observed differences in age composition between escapements were used to classify 1987 Yukon River chinook salmon catches to their run of origin.

Scale Patterns Analysis

Escapement samples in Alaska and commercial fishery samples in Canada provided scales of known origin that were used to build linear discriminant functions (LDF). Canadian escapement samples could not be pooled to form a reasonable standard due to the lack of samples from several significant spawning populations.

Catch samples provided scales of mixed stock composition which were classified using the discriminant functions. Run proportions of fish aged 1.4 were estimated in District 1 and 2 catches by fishing period. It was assumed that the District 3 catch composition by stock was similiar to that in District 2. District 4, 5 and 6 catches were classified for the entire season.

Measurements of scale features were made as described by McBride and Marshall (1983). Scale images were projected at 100X magnification using equipment similar to that described by Ryan and Christie (1976) and measurements were made and recorded by a microcomputer-controlled digitizing system. Measurements were taken along an axis located at the approximate apex of circuli formations in the freshwater growth zone. The apex of circuli formations tends to gradually shift between the growth zones and consistency of axis placement was deemed most likely to occur if the apex of circuli in the freshwater zone served as the axis indicator. The distance between each circulus in each of three scale growth zones (Figure 3) was recorded. The three zones were: (1) scale focus to the outside edge of the freshwater annulus (first freshwater annular zone), (2) outside edge of the freshwater annulus to the last circulus of freshwater growth (freshwater plus growth zone), and (3) the last circulus of the freshwater plus growth zone to the outer edge of the first ocean annulus (first marine annular zone). In addition, the total width of successive scale patterns zones was also measured for: (1) the last circulus of the first ocean annulus to the last circulus of the second ocean annulus, and (2) the last circulus of the second ocean annulus to the last circulus of the third ocean annulus. Seventy-nine scale characters (Appendix A) were calculated from the basic incremental distances and circuli counts. Run-of-origin standards (pooled rivers) were weighted by aerial abundance estimates. Unlike past years, run-of-origin models were constructed for the 1.4 age class only, because age-1.3 fish were too few in number (8.5% of the total drainage harvest).

Selection of scale characters for linear discriminant functions (LDF) was by a forward stepping procedure using partial F statistics as the criteria for entry and deletion of variables (Enslein et al. 1977). A nearly unbiased estimate of classification accuracy for each LDF was determined using a leaving-one-out procedure (Lachenbruch 1967).

Contribution rates for age-1.4 fish in the District 1 and 2 catches were estimated for each fishing period. Contribution rates for the combined commercial and subsistence harvests in District 4 were estimated from samples collected from both fisheries (including both gill net and fish wheel gear types) during most of the season. Point estimates were adjusted for misclassification errors using the procedure of Cook and Lord (1978). The variance and 90% confidence intervals for these estimates were computed using the procedures of Pella and Robertson (1979).

When classified catch samples indicated an adjusted proportional estimate equal to or less than zero, the run indicating the most negative contribution was deleted from the model. Data were then resubmitted to the variable selection routines, and a new subset of variables was chosen for the LDF. Catch was then reclassified. This process was continued until all adjusted proportional estimates in the catch were positive.

Results of the scale patterns analysis were summed to estimate total contribution by run of origin for age-1.4 chinook salmon to the District 1, 2, and 3 commercial and District 4 combined commercial and subsistence catches. For each district, the variance (V) around N_{ijt} (the catch of age class i and run j during period t) was computed for each period (t) as follows:

$$V[N_{ijt}] = N_t^2\{S_{ijt}^2 \cdot V[P_{it}] + P_{it}^2 \cdot V[S_{ijt}] - V[P_{it}] \cdot V[S_{ijt}]\} \qquad (1)$$

where:

$$V[P_{it}] = \frac{P_{it}(1-P_{it})}{n_t-1} \qquad (2)$$

In equations (1) and (2) P is the proportion of age class i; S is the proportion of run j of age class i harvested during period t; and the variance, $V[S_{ijt}]$, is as derived by Pella and Robertson (1979).

Variance around the district catch of age 1.4 by run, N_j, was computed by summing variances across periods:

$$V[N_j] = \sum_{t}^{T} V[N_{ijt}] \quad (3)$$

where:

T is the total number of fishing periods sampled in each district and n_t is the sample size for the estimate of age composition in period t.

Variance around the estimate of total harvest of age-1.4 fish by run of origin from Districts 1, 2, 3, and 4 (estimated from scale patterns analysis) was calculated as the sum of the seasonal variances across all districts. Total harvest estimates and associated variances by country of origin were calculated by assuming the sum of the Alaskan Lower and Middle Yukon runs to be equal to the Alaskan contribution and the Upper Yukon equal to the Canadian contribution. Variance around the estimate of Alaskan contribution, $N_{i(L+M)t}$, was computed by summing variances across runs:

$$V[N_{i(L+M)t}] = N_t^2\{(S_{iLt}+S_{iMt})^2 \cdot V[P_{it}] + P_{it}^2 \cdot V[S_{iLt}+S_{iMt}] - V[P_{it}] \cdot V[S_{iLt}+S_{iMt}]\} \quad (4)$$

where:

S_{iLt} = estimated proportion of Lower Yukon Run present for age i at period t

S_{iMt} = estimated proportion of Middle Yukon Run present for age i at period t; and

$$V[S_{iLt}+S_{iMt}] = V[S_{iLt}] + V[S_{iMt}] - 2Cov[S_{iLt}S_{iMt}] \quad (5)$$

Differential Age Composition Analysis

Classification of the remaining age classes in the District 1, 2, and 3 commercial catches and District 4 combined commercial and subsistence catches was based on differences in escapement age composition in each run of origin. An assumption implicit in this calculation is that harvest rates by stock and age did not differ. This assumption may have been violated, but any bias introduced was believed to be minor. Escapement age composition data, weighted by aerial survey estimates, was directly compared by computing ratios for each river or run whereby the proportion in the escapement of the age class in question was divided by the escapement proportion of an age class where the catch composition estimated by scale patterns analysis (age-1.4) was known:

$$R_{ci} = E_{ci}/E_{ca} \tag{6}$$

where:

E_{ci} = Proportion of fish of age class i in run c escapement samples where i was an age class of unknown river or run composition in the catch

E_{ca} = Proportion of fish of age class a in run c where a was an age class of known river or run composition in the catch (age-1.4)

In past years, the relative contribution of age-1.2 fish in escapement samples was compared to age-1.3 fish. Since scale patterns analysis was conducted on only age-1.4 fish in 1987, all age classes were compared to age-1.4 fish. These ratios of proportional abundance were then multiplied by the catch stock proportions of age-1.4 fish. These computations were summed over all runs to calculate age-specific contribution rates. Multiplication by total catch by age class yielded age-specific run contribution estimates:

$$F_{ci} = \frac{R_{ci} \cdot N_{ca}}{\sum_{j=1}^{n} R_{ji} \cdot N_{ja}} \quad \text{(where j was run number and n was 3 for run)} \tag{7}$$

where:

N_i = Total catch of age group i

N_{ca} = Catch of age group a (where a was age-1.4 in run c)

F_{ci} = Proportion of fish of run c in N_i

The total harvest of run c for age group i was then:

$$N_{ci} = F_{ci} \cdot N_i \tag{8}$$

Catch Composition by Fishery

Estimates of run composition from scale pattern analysis and differential age composition analysis of District 1, 2, and 3 commercial catches were used to classify the catches of subsistence fisheries in these districts. District 4 catches were divided into two components for purposes of estimating catch proportions by stock: mainstem catches and Koyukuk River subsistence catches. Mainstem catches were classified to the lower, middle, or upper runs based on estimates of run composition from scale patterns analysis and differential age composition analysis of pooled samples from commercial and subsistence gill net and fish wheel catches. Subsistence catches from the Koyukuk River were taken primarily in the upper portions of the drainage beyond river mile 700 and were assumed to more closely resemble the Middle Yukon Run. No attempt was made to classify the Koyukuk River catch by age class.

Catch Composition Based on Geography

Catches in Districts 5, 6, and the Yukon Territory were classified to run based on geography. The entire District 5 harvest was determined to be the Upper Yukon Run as most of the District 5 catch occurred above the confluence of the Tanana River, and there are few documented chinook salmon spawning concentrations between the Tanana River confluence and the Yukon Territory fishery centered in Dawson. The entire District 6 harvest was considered to be from the Middle Yukon Run, since neither lower nor upper runs are present in the Tanana River. The Yukon Territory harvest was assigned to the upper run since neither lower nor middle runs are present in the Yukon Territory.

RESULTS AND DISCUSSION

Age Composition

Age-1.4 fish comprised a large proportion of samples from all Alaskan rivers and in most Canadian rivers in 1987 (Table 1). The relatively weak age-1.3 contribution to escapements indicates relatively poor productivity and/or survival from the 1982 brood year. Increasing proportions of older-age fish in escapements progressing upriver were similiar to trends observed in prior years. Age-1.5 fish generally increased in relative abundance from 2.1% and 3.8% in the Andreafsky and Anvik Rivers, respectively, to an average of 17.0% for the sampled Canadian rivers combined. The proportion of age-1.3 fish was similiar in abundance between the Alaska rivers (an average of 10.0%) and Canadian rivers (an average of 9.0%).

The greatest proportion of age-2. fish was found in the Nisutlin River sample, comprising 41.7%, although this was only a sample of 24 fish. Age-2. fish are primarily found in the Canadian portion of the drainage. Samples from the Jim and Koyukuk Rivers in 1986 showed a relatively high proportion (9.0%) age-2. fish (Merritt et al. 1988). However, sample size from the Jim and Koyukuk Rivers in 1987 was inadequate to compare to other escapements.

Classification Accuracies of Run of Origin Models

A 3-way run of origin model was constructed which differed from previous years in that it included samples from the Gisasa River in the lower river standard. The Gisasa River was included into the lower river standard because univariate analysis of variance F-tests of scale feature measurements indicated no significant difference (α = 0.05, df = 1,421) in the majority (53.2%) of mean freshwater annular, freshwater plus growth and combined marine annular zone scale variables among the Gisasa River and pooled lower river standard (consisting of the Andreafsky, Anvik and Nulato Rivers). These four rivers are located in the same Lower Yukon geographic area.

The pooled-river standards were: (1) lower: Andreafsky, Anvik, Nulato and Gisasa Rivers; (2) middle: Chena and Salcha Rivers; and (3) upper: Canada mainstem commercial fishery. Mean classification accuracy of the model was 78.1% (Table 2A), 2.3 times greater than random chance. Model classification accuracy of age-1.4 fish in 1987 was 8.5% greater than in 1986. Similiar to past years the lower river standard showed the greatest classification accuracy (92.5%). Middle and upper river standards showed the least classification accuracy (73.5% and 68.3%, respectively), misclassifying primarily to each other. High misclassification between middle and upper river standards has been observed every year since initiation of the Yukon River chinook salmon stock identification study in 1980.

A 2-way model was constructed which differed from the above 3-way model in that the middle river standard was excluded (Table 2B). This model was necessary to identify runs of origin in age-1.4 samples from commercial fishing periods in which middle river stocks did not contribute to the harvest. Mean classification accuracy of this model was 94.9%.

Catch Apportionment

Scale Patterns Analysis

Scale character measurements which were most powerful in distinguishing between the three runs of origin for age-1.4 fish were: (1) distance between the fourth and eighth circulus divided by the total width of the freshwater annular zone, (2) distance between the fourth from last circulus in the freshwater annular zone and the last circulus in the zone, divided by the total width of the freshwater annular zone, (3) number of circuli in the freshwater plus growth zone, (4) width of the freshwater annular zone divided by the sum of the widths of the freshwater annular and freshwater plus growth zones, (5) distance between the sixth from the last circulus of the first marine annular zone and the last circulus of the zone, and (6) distance between the ninth and fifteenth circulus divided by the total width of the first marine annular zone (variables 24, 25, 61, 67, 84 and 102, respectively, in Appendix B).

Group means and their standard errors for the number of circuli and width of the first freshwater annular, plus growth, and marine annular zones are shown in Appendix C.

Proportion of Catch

Lower and Upper Yukon Runs comprised the greatest proportion of the catch in District 1, while in District 2 the Middle and Upper Runs comprised the greatest proportion of the catch for age-1.4 fish (Table 3). This compares with results for years prior to 1986, in which middle run stocks contributed significantly to the commercial catch (Wilcock and McBride 1983; Wilcock 1984, 1985, 1986).

Similiar to previous years, proportions of lower and upper runs varied in Districts 1 and 2 catches through time (Figures 4 and 5). In District 1 the contribution of lower run age-1.4 fish sharply increased and the upper run sharply decreased in fishing period 6. In District 2 the greatest contribution of lower run age-1.4 fish occurred in fishing period 5, while the upper run contribution sharply declined in fishing period 5. Run of origin contribution rates by fishing period demonstrated irregular linear trends which were likely due to differential run timing of the contributing stocks and differential harvest pressures.

The estimated District 1 age-1.4 catch was 18,603 (31.4%) Lower, 10,457 (17.6%) Middle, and 30,239 (51.0%) Upper Yukon Run (Table 4). In District 2, the estimated age-1.4 catch was 6,564 (19.2%) Lower, 7,869 (23.1%) Middle, and 19,684 (57.7%) Upper Yukon Run (Table 5).

Scale patterns analysis was applied to the age-1.4 commercial catches from Districts 1 (sampled fishing periods 1-7) and 2 (sampled fishing periods 1-5 only) and commercial and subsistence catches from District 4 to classify 69.8% (98,372 fish) of the total Yukon River age-1.4 harvest (140,978 fish) to their run of origin. Of those fish classified, 46,185 (46.9%) were estimated to be of Alaskan origin (Table 6). Precision of this estimate was relatively high (coefficient of variation 7.0%). Harvest of Canadian origin fish was estimated at 52,187 (53.1%).

An additional 16,074 fish (8.0% of total harvest) from estimated age-1.4 subsistence catches in Districts 1, 2, and 3 were classified to their run of origin by applying proportions estimated from scale patterns analysis of commercial catches in these same districts.

Because the present sampling scheme assumes no variation in stock entry patterns for a given time period, a preliminary study was conducted in District 1 during fishing period 5 to test the assumption that catch samples from different areas of the Yukon River delta (Figure 6) do not vary in run composition. Classification to run of origin for age-1.4 fish delivered from the north mouth (Statistical Area 334-16) was compared to that for age-1.4 fish mixed deliveries from the south and middle mouths (Statistical Areas 334-13, 334-14, 334-15) and the mainstem (334-17). Precision of these two samples was insufficient to detect significant differences ($P<0.10$) in run composition (Table 7), although further study of this assumption is suggested.

Differential Age Composition Analysis

The remaining (not age 1.4) nine age classes (from Districts 1, 2, 3, and mainstem 4) contributed 39,793 fish (19.7%) to the total drainage harvest. They were classified to run of origin using differences in escapement age composition in each run (Table 8). The majority of age-1.5 harvests (79.5%) in Districts 1-4 were Upper Yukon Run, as were the majority of age-1.3 harvests (63.4%). Virtually all age-2. fish were classified to the Upper Yukon Run.

The Middle Yukon Run comprised a greater percentage of the commercial and subsistence catches in District 4 (42.2%) than in District 1 (16.2%). The Lower Yukon Run was most abundant in District 1 (27.4%) and 2 (16.4%) commercial and subsistence catches and least abundant in District 4 (11.1%). The Upper Yukon Run was also more abundant in District 1 (56.4%) and 2 (62.7%) than in District 4 (46.7%) commercial and subsistence catches.

Geographic Analysis

A total of 45,363 fish (22.4% of total drainage harvest) was classified to run of origin based on geography. District 5 and Yukon Territory commercial and subsistence catches (19.5% of total drainage harvest) were assumed to be Upper Yukon River origin, except for 13 fish taken in the Chandalar/Black Rivers, which were classified to the Middle Yukon run. Commercial and subsistence catches in District 6 and subsistence catches from the Koyukuk River in District 4 were classified entirely to the Middle Yukon run and totaled 5,966 fish (3.0% of total drainage harvest).

Total Harvest

The commercial and subsistence harvest of chinook salmon from the entire Yukon River drainage was classified to run of origin (Table 8) based on: (1) findings of the scale patterns analysis of age-1.4 fish, (2) age composition analysis of the remaining age classes, (3) assumptions concerning unsampled fisheries, and (4) stock origins based on geography. The Upper Yukon Run comprised the largest run component and contributed 131,233 fish or 64.9% of the total drainage harvest. The Middle Yukon Run was next in abundance at 36,353 fish (18.0%), followed by the Lower Yukon Run at 34,539 fish (17.1%).

LITERATURE CITED

ADF&G (Alaska Department of Fish and Game). 1987. Yukon Area salmon report to the Board of Fisheries, November 1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Anchorage.

Barton, L. H. 1984. A catalog of Yukon River salmon spawning escapement surveys. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 121, Juneau.

Clutter, R.I., and L.E. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. Bulletin of the International Pacific Salmon Fisheries Commission 9, Vancouver, British Columbia.

Cook R., and G. Lord. 1978. Identification of stocks of Bristol Bay sockeye by evaluating scale patterns with a polynomial discriminant method. U.S. Fish and Wildlife Service Fisheries Bulletin 76 (2):415-423.

Enslein, K., A. Ralston, and H.S. Wilf, Editors. 1977. Statistical methods for digital computers. John Wiley & Sons, Inc., New York.

Fisher, R.A. 1936. The use of multiple measurements in taxonomic problems. Annual Eugenics 7:179-188.

Lachenbruch, P.A. 1967. An almost unbiased method of obtaining confidence intervals for the probability of misclassification in discriminant analysis. Biometrics 23(4):639-645.

McBride, D.N., and S. L. Marshall. 1983. Feasibility of scale pattern analysis to identify the origins of chinook salmon (*Oncorhynchus tschawytscha* Walbaum) in the lower Yukon River commercial gillnet fishery, 1980-1981. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 208, Juneau.

Merritt, M., J. Wilcock, and L. Brannian. 1988. Origins of chinook salmon in the Yukon River fisheries, 1986. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 223, Juneau.

Meyers, K. W., and five coauthors. 1984. Origins of chinook salmon in the area of the Japanese mothership and landbased driftnet salmon fisheries in 1975-1981. (Report to annual meeting of the International North Pacific Fisheries Commission, Vancouver, November 1984). Fisheries Research Institute, University of Washington. Seattle.

Meyers, K.W., and D.E. Rogers. 1985. Determination of stock origins of chinook salmon incidentally caught in foreign trawls in the Alaskan FCZ. Draft Report, Contract No. 84-3 Fisheries Research Institute, FRI-UW-8502, University of Washington, Seattle.

Pella, J., and T. Robertson. 1979. Assessment of composition of stock mixtures. Fishery Bulletin 77 (2): 387-398.

Rogers, D.E., and five coauthors. 1984. Origins of chinook salmon in the area of the Japanese mothership salmon fishery. Final Report, July 1983-Sept. 1984. Contract No. 84-0152. Fisheries Research Institute, University of Washington, Seattle.

Ryan, P., and M. Christie. 1976. Scale reading equipment. Fisheries and Marine Service, Canada. Technical Report PAC/T-75-8, Vancouver.

Wilcock, J.A., and D.N. McBride. 1983. Origins of chinook salmon (*Oncorhynchus tschawytscha* Walbaum) in the Yukon River fisheries, 1982. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 226, Juneau.

Wilcock, J.A. 1984. Origins of chinook salmon (*Oncorhynchus tschawytscha* Walbaum) in the Yukon River fisheries, 1983. Alaska Department of Fish and Game, Division of Commercial Fisheries, Informational Leaflet 243, Juneau.

Wilcock, J.A. 1985. Origins of chinook salmon (*Oncorhynchus tschawytscha* Walbaum) in the Yukon River fisheries, 1984. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 157, Juneau.

Wilcock, J.A. 1986. Origins of chinook salmon (*Oncorhynchus tschawytscha* Walbaum) in the Yukon River fisheries, 1985. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 178, Juneau.

Table 1. Age composition summary of Yukon River chinook salmon escapements, 1987.

River	Peak Aerial Survey Count	Sample Size	1984 1.1	1983 1.2	1982 1.3	1982 2.2	1981 1.4	1981 2.3	1980 1.5	1980 2.4	1979 1.6	1979 2.5
Alaska												
Andreafsky	4,889	383[a]	0.3	4.7	8.9	0.0	83.8	0.0	2.1	0.3	0.0	0.0
Anvik	1,179	238	0.0	8.8	12.2	0.0	75.2	0.0	3.8	0.0	0.0	0.0
Nulato[b]	1,638	155	0.6	8.4	6.5	0.0	75.5	0.0	8.4	0.0	0.6	0.0
Gisasa[c]	731	96	0.0	4.2	13.5	0.0	76.0	0.0	4.2	1.0	1.0	0.0
Henshaw Cr.[d]	-	7	0.0	0.0	0.0	0.0	71.4	0.0	28.6	0.0	0.0	0.0
Jim[e]	100	14	0.0	7.1	28.6	0.0	64.3	0.0	0.0	0.0	0.0	0.0
Koyukuk[f]	136	1	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Chena	1,312	560	0.0	2.9	13.0	0.0	75.4	0.4	8.0	0.4	0.0	0.0
Salcha	1,898	551	0.2	6.0	12.5	0.0	73.5	0.0	7.8	0.0	0.0	0.0
Chandalar	-	2	0.0	0.0	0.0	0.0	50.0	0.0	50.0	0.0	0.0	0.0
Clear Cr.	165[g]	110	0.0	10.0	8.2	0.0	66.4	0.9	13.6	0.9	0.0	0.0
Canada												
Big Salmon[h]	1,121	259	0.0	2.3	15.1	0.4	53.3	3.1	15.4	7.3	0.0	3.1
Little Salmon[i]	456	180	0.0	7.2	10.0	0.0	71.1	0.0	10.0	1.7	0.0	0.0
Nisutlin[i]	275	24	0.0	0.0	0.0	0.0	45.8	4.2	12.5	33.3	0.0	4.2
Tatchun[i]	159[j]	57	0.0	10.5	19.3	0.0	50.9	0.0	17.5	1.8	0.0	0.0
Teslin[i,l]	-	17	0.0	11.8	11.8	0.0	35.3	0.0	23.5	11.8	0.0	5.9
Morley[i]	83	28	0.0	3.6	10.7	0.0	42.9	7.1	17.9	14.3	0.0	3.6
Nordenskjold[i]	-	30	0.0	0.0	6.7	0.0	86.7	0.0	6.7	0.0	0.0	0.0
Mainstem Yukon[i,k]	-	23	0.0	0.0	0.0	0.0	60.9	0.0	34.8	4.3	0.0	0.0

[a]Includes 15 East Fork beach seine samples, 199 East Fork carcass samples, and 169 West Fork carcass samples.

[b]Includes 10 gill net samples.

[c]Includes 22 gill net samples.

[d]Includes 7 hook and line samples.

[e]Includes 13 hook and line samples.

[f]South Fork Koyukuk aerial survey estimate was 136 chinook salmon. Includes 1 hook and line sample.

[g]Weir count from 7/13-8/2 was 142 chinook salmon. Estimated total escapement was 165.

[h]Live sample from weir.

[i]Includes a portion of live spawned out fish obtained by spearing.

[j]Foot survey conducted by DFO.

[k]Includes a potion of live fish obtained by gill netting.

Table 2. Classification accuracies of linear discriminant run-of-origin models for age-1.4 Yukon River chinook salmon, 1987.

A.
(1) Lower: Andreafsky, Anvik, Nulato, Gisasa (2) Middle: Chena, Salcha (3) Upper: Canadian commercial fishery [a]

Region of Origin	Sample Size	Classified Region of Origin Lower	Middle	Upper
Lower	334	0.925	0.033	0.042
Middle	223	0.049	0.735	0.215
Upper	101	0.040	0.277	0.683

Mean Classification Accuracy: 0.781

[a]Variables in the Analysis: 24, 25, 61, 67, 84, 102

B.
(1) Lower: Andreafsky, Anvik, Nulato, Gisasa (2) Upper: Canadian commercial fishery [a]

Region of Origin	Sample Size	Classified Region of Origin Lower	Upper
Lower	334	0.937	0.063
Upper	101	0.040	0.960

Mean Classification Accuracy: 0.949

[a]Variables in the Analysis: 24, 25, 61, 67, 84, 102

Table 3. Run composition estimates for age-1.4 chinook salmon from sampled commercial catches in Yukon River Districts 1, 2, and 4 in 1987.

District	Commercial Fishing Period	Dates	Sample Size	Region of Origin	Prop. of Catch	90% Confidence Int. Lower	90% Confidence Int. Upper
1	1[a]	6/15-6/16	128	Lower	0.315	0.211	0.419
				Middle	0.177	-0.024	0.378
				Upper	0.508	0.297	0.720
	2[a]	6/18-6/19	137	Lower	0.242	0.146	0.338
				Middle	0.114	-0.099	0.327
				Upper	0.644	0.419	0.869
	3[a]	6/22-6/23	133	Lower	0.249	0.153	0.346
				Middle	0.283	0.078	0.488
				Upper	0.468	0.259	0.677
	4[a]	6/25-6/26	132	Lower	0.329	0.226	0.433
				Middle	0.199	0.004	0.394
				Upper	0.472	0.268	0.676
	5[b]	6/29-6/30	141	Lower	0.338	0.237	0.439
				Middle	0.148	-0.043	0.339
				Upper	0.514	0.311	0.717
	6[b]	7/02-7/03	58	Lower	0.713	0.560	0.865
				Middle	0.189	-0.009	0.387
				Upper	0.099	-0.089	0.286
	7[b]	7/09-7/10	29	Lower	0.686	0.523	0.849
				Upper	0.314	0.151	0.477
2	1[a]	6/17-6/18	134	Lower	0.145	0.061	0.229
				Middle	0.368	0.151	0.585
				Upper	0.487	0.269	0.705
	2[a]	6/21-6/22	133	Lower	0.250	0.153	0.347
				Middle	0.185	-0.024	0.394
				Upper	0.565	0.346	0.783
	3[a]	6/24-6/25	136	Lower	0.118	0.038	0.198
				Middle	0.293	0.068	0.517
				Upper	0.590	0.362	0.817
	4[a]	6/29	137	Lower	0.160	0.072	0.249
				Middle	0.070	-0.162	0.302
				Upper	0.770	0.527	1.013
	5[b]	7/01-7/02	53	Lower	0.401	0.236	0.566
				Middle	0.144	-0.121	0.410
				Upper	0.455	0.167	0.743
4	1-16[c]	7/06-7/27	116	Lower	0.136	0.048	0.224
				Middle	0.408	0.180	0.637
				Upper	0.456	0.228	0.684

[a] Unrestricted mesh size

[b] Six in (15.2 cm) maximum mesh size.

[c] Fish taken by set gill net and fish wheel.

Table 4. Classification of age-1.4 chinook salmon catches by run and fishing period for the commercial fishery in Yukon River District 1 in 1987.

Region of Origin	Commercial Fishing Period	Dates	Catch	Region of Origin	Commercial Fishing Period	Dates	Catch
Lower	1[a]	6/15-6/16	3,078	Lower	5[d]	6/29-6/30	1,875
Middle			1,730	Middle			821
Alaska[b]			4,808	Alaska			2,696
Upper[c]			4,964	Upper			2,852
Total			9,772	Total			5,548
Lower	2[a]	6/18-6/19	4,298	Lower	6[d]	7/02-7/03	2,097
Middle			2,025	Middle			556
Alaska			6,323	Alaska			2,653
Upper			11,437	Upper			288
Total			17,760	Total			2,941
Lower	3[a]	6/22-6/23	2,956	Lower	7[d]	7/09-7/10	1,048
Middle			3,359	Middle			0
Alaska			6,315	Alaska			1,048
Upper			5,555	Upper			480
Total			11,870	Total			1,528
Lower	4[a]	6/25-6/26	3,251				
Middle			1,966				
Alaska			5,217				
Upper			4,663				
Total			9,880				
TOTAL				Lower	1-7	6/15-7/10	18,603
				Middle			10,457
				Alaska			29,060
				Upper			30,239
				Total			59,299

[a]Unrestricted mesh size

[b]Lower and middle runs comprise the Alaskan contribution.

[c]Upper runs comprise the Canadian contribution.

[d]Chum salmon season, 6 in (15.2 cm) maximum mesh size.

Table 5. Classification of age-1.4 chinook salmon catches by run and fishing period for the commercial fishery in Yukon River District 2 in 1987.

Region of Origin	Commercial Fishing Period	Dates	Catch	Region of Origin	Commercial Fishing Period	Dates	Catch
Lower	1[a]	6/17-6/18	1,135	Lower	4[a]	6/29	906
Middle			2,881	Middle			396
Alaska[b]			4,016	Alaska			1,302
Upper[c]			3,813	Upper			4,359
Total			7,829	Total			5,661
Lower	2[a]	6/21-6/22	2,287	Lower	5-7[d]	7/01-7/09	1,248
Middle			1,692	Middle			448
Alaska			3,979	Alaska			1,696
Upper			5,167	Upper			1,415
Total			9,146	Total			3,111
Lower	3[a]	6/24-6/25	988				
Middle			2,452				
Alaska			3,440				
Upper			4,930				
Total			8,370				
TOTAL				Lower	1-7	6/17-7/09	6,564
				Middle			7,869
				Alaska			14,433
				Upper			19,684
				Total			34,117

[a]Unrestricted mesh size

[b]Lower and middle runs comprise the Alaskan contribution.

[c]Upper runs comprise the Canadian contribution.

[d]Chum salmon season, 6 in (15.2 cm) maximum mesh size.

Table 6. Total harvest of age-1.4 chinook salmon by nation of origin estimated from scale patterns analysis for Yukon River Districts 1, 2 and 4 in 1987.[a]

Nation of Origin	Number of Fish	(%)	Approximate 90 Percent Confidence Interval Lower Bound	Upper Bound	SE	Coefficient of Variation[b]
Alaska	46,185	(46.9)	40,890	51,480	3,219	7.0%
Canada	52,187	(53.1)	46,874	57,500	3,230	6.2%
Total[c]	98,372	(100.0)				

[a]For illustration purposes the estimated number of fish is assumed to follow a normal distribution.
[b]Coefficient expressed as a percentage.
[c]Includes District 1 commercial catch in periods 1-7, District 2 commercial catch in periods 1-5, and District 4 commercial and subsistence season total catch minus 668 from the Koyukuk River.

Table 7. Run composition estimates for age-1.4 chinook salmon from sampled commercial catches located at different areas in Yukon River District 1, fishing period 5 in 1987.

Yukon River Delta Area	Sample Size	Run of Origin	Prop. of Catch	90 Percent Confidence Interval	
				Lower Bound	Upper Bound
North Mouth	42	Lower	0.412	0.226	0.598
		Middle	0.030	-0.253	0.314
		Upper	0.558	0.230	0.886
South & Middle Mouths, Mainstem	99	Lower	0.307	0.190	0.423
		Middle	0.198	-0.024	0.420
		Upper	0.496	0.263	0.728

Table 8. Run composition by age class and region of origin of chinook salmon from Yukon River Alaskan Districts 1, 2, 3, 4, 5, 6 and Yukon Territory commercial and subsistence catches, 1987.

				Brood Year and Age Group										
				1984	1983	1982		1981		1980		1979		
District	Fishery	Commercial Fishing Dates	Region of Origin	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Total
1	Commercial Gill net	6/15-7/10	Lower	0	667	1,028	0	18,603	0	625	34	50	0	21,007
			Middle	0	323	854	0	10,457	8	789	14	0	0	12,445
			Alaska	0	990	1,882	0	29,060	8	1,414	48	50	0	33,452
			Upper	0	1,008	3,144	32	30,239	415	5,446	2,554	0	353	43,191
			Total	0	1,998	5,026	32	59,299	423	6,860	2,602	50	353	76,643
	Subsistence Gill net[a]		Lower	0	63	97	0	1,767	0	60	3	5	0	1,995
			Middle	0	31	81	0	993	1	75	1	0	0	1,182
			Alaska	0	94	178	0	2,760	1	135	4	5	0	3,177
			Upper	0	96	299	3	2,871	39	516	243	0	34	4,101
			Total	0	190	477	3	5,631	40	651	247	5	34	7,278
2	Commercial Gill net	6/17-7/09	Lower	0	457	459	0	6,564	0	286	9	0	0	7,775
			Middle	0	472	812	0	7,869	6	771	8	0	0	9,938
			Alaska	0	929	1,271	0	14,433	6	1,057	17	0	0	17,713
			Upper	0	1,275	2,587	35	19,684	247	4,604	1,252	0	61	29,745
			Total	0	2,204	3,858	35	34,117	253	5,661	1,269	0	61	47,458
	Subsistence Gill net[b]		Lower	0	95	95	0	1,364	0	59	2	0	0	1,615
			Middle	0	98	169	0	1,636	1	160	2	0	0	2,066
			Alaska	0	193	264	0	3,000	1	219	4	0	0	3,681
			Upper	0	265	538	7	4,092	52	958	260	0	13	6,185
			Total	0	458	803	7	7,092	53	1,177	264	0	13	9,866
3	Commercial Gill net[c]	6/21-7/02	Lower	0	20	20	0	282	0	12	0	0	0	334
			Middle	0	20	35	0	338	0	33	0	0	0	426
			Alaska	0	40	55	0	620	0	45	0	0	0	760
			Upper	0	55	111	2	846	11	198	53	0	3	1,279
			Total	0	95	166	2	1,466	11	243	53	0	3	2,039
	Subsistence Gill net[c]		Lower	0	45	45	0	645	0	28	1	0	0	764
			Middle	0	46	80	0	772	1	76	1	0	0	976
			Alaska	0	91	125	0	1,417	1	104	2	0	0	1,740
			Upper	0	126	254	3	1,934	24	452	123	0	6	2,921
			Total	0	216	379	3	3,351	25	556	125	0	6	4,661
4[d,g]		6/22-10/30	Lower	12	92	77	0	829	0	38	1	0	0	1,049
			Middle	16	370	441	0	2,862	0	312	8	0	0	4,009[e]
			Alaska	28	462	518	0	3,691	0	350	9	0	0	5,058[e]
			Upper	0	287	488	0	2,778	0	684	190	0	0	4,427
			Total	28	749	1,006	0	6,469	0	1,034	199	0	0	9,485[e]
5[h]	Fish wheel	6/27-11/11	Upper	51	979	1,414	13	3,549	51	314	26	0	0	6,397
	Gill net		Middle	0	0	0	0	7	0	6	0	0	0	13[f]
			Alaska	0	0	0	0	7	0	6	0	0	0	13[f]
			Upper	0	639	1,278	0	11,459	32	2,389	160	0	0	15,957
			Total	0	639	1,278	0	11,466	32	2,395	160	0	0	15,970
6		7/04-11/06	Middle											5,298
Yukon Territory	Commercial Gill net	7/21-8/06	Upper	0	523	1,349	0	6,132	218	1,654	740	0	88	10,704
	Subsistence Gill net[i]		Upper	0	310	797	0	3,624	127	981	436	0	51	6,326[j]
Total Harvest			Lower	12	1,439	1,821	0	30,054	0	1,108	50	55	0	34,539
			Middle	16	1,360	2,472	0	24,934	17	2,222	34	0	0	36,353[e]
			Alaska	28	2,799	4,293	0	54,988	17	3,330	84	55	0	70,892[e]
			Upper	51	5,562	12,259	95	87,208	1,216	18,196	6,037	0	609	131,233
			Total	79	8,361	16,552	95	142,196	1,233	21,526	6,121	55	609	202,125[e,f]

[a] Apportionment based on season total District 1 commercial catch samples.
[b] Apportionment based on season total District 2 commercial catch samples.
[c] Apportionment based on District 2 commercial catch samples.
[d] Combined commercial and subsistence, fish wheel and gill net.
[e] Includes Koyukuk River subsistence catch (668 fish) allocated to middle region of origin.
[f] Includes Chandalar/Black River catch (13 fish) allocated to middle region of origin.
[g] Commercial catch = 1,524; subsistence catch = 7,961.
[h] Combined commercial and subsistence catch; commercial catch = 3,105; subsistence catch = 19,262.
[i] Age apportionment based on Yukon Territory commercial catch samples.
[j] Catch from Old Crow is not included.

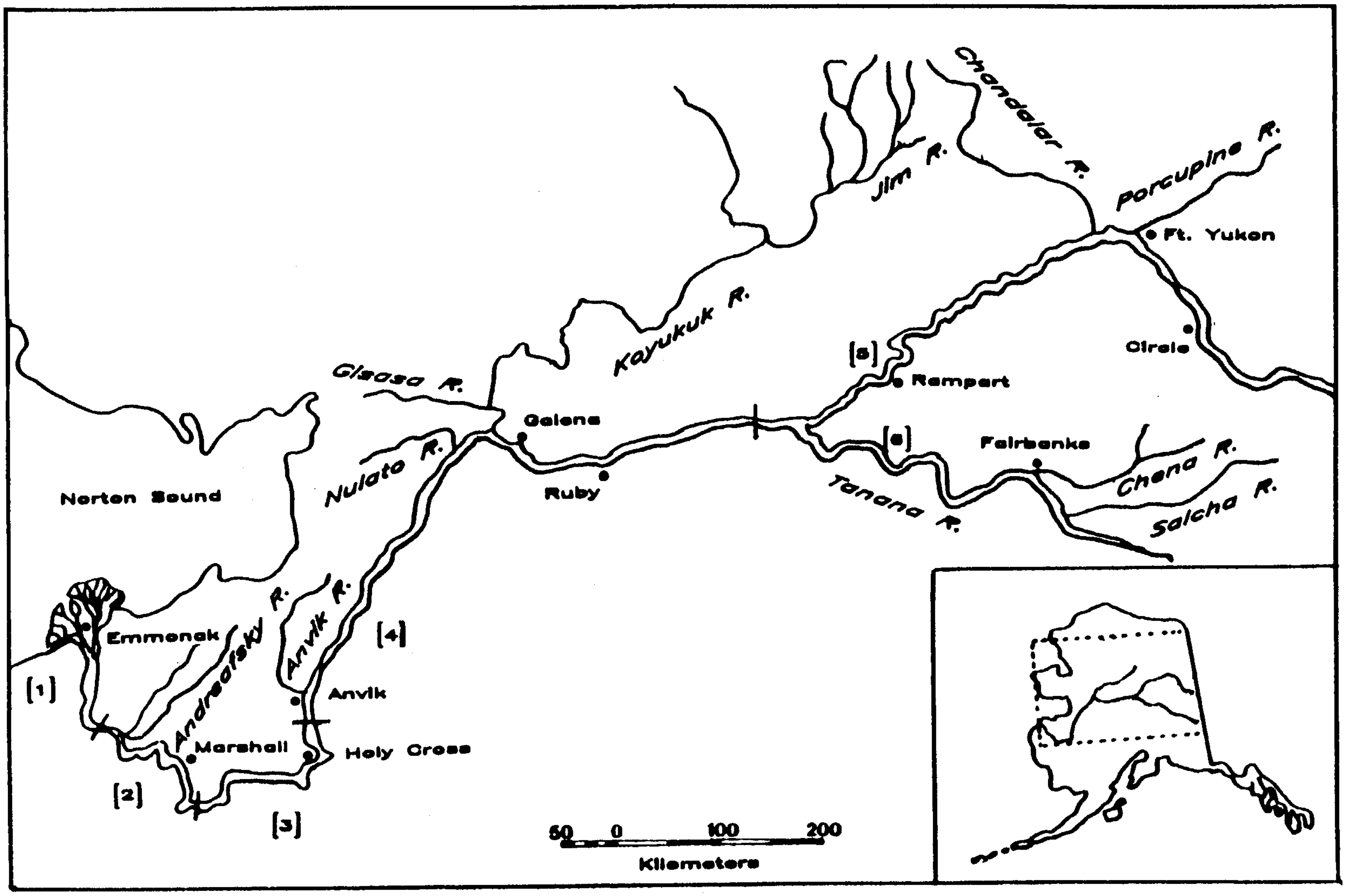

Figure 1. Alaskan portion of the Yukon River showing the six regulatory districts.

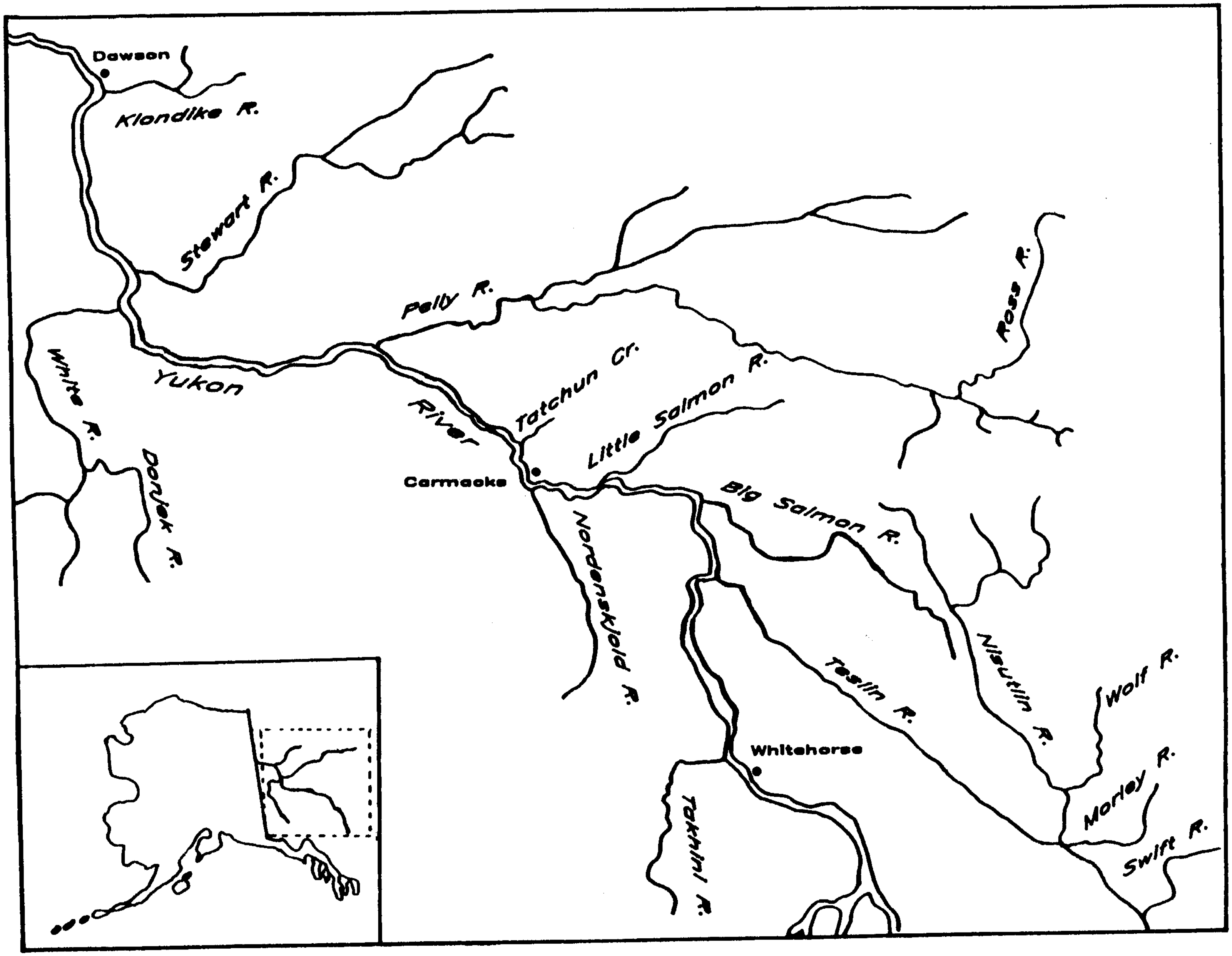

Figure 2. Canadian portion of the Yukon River.

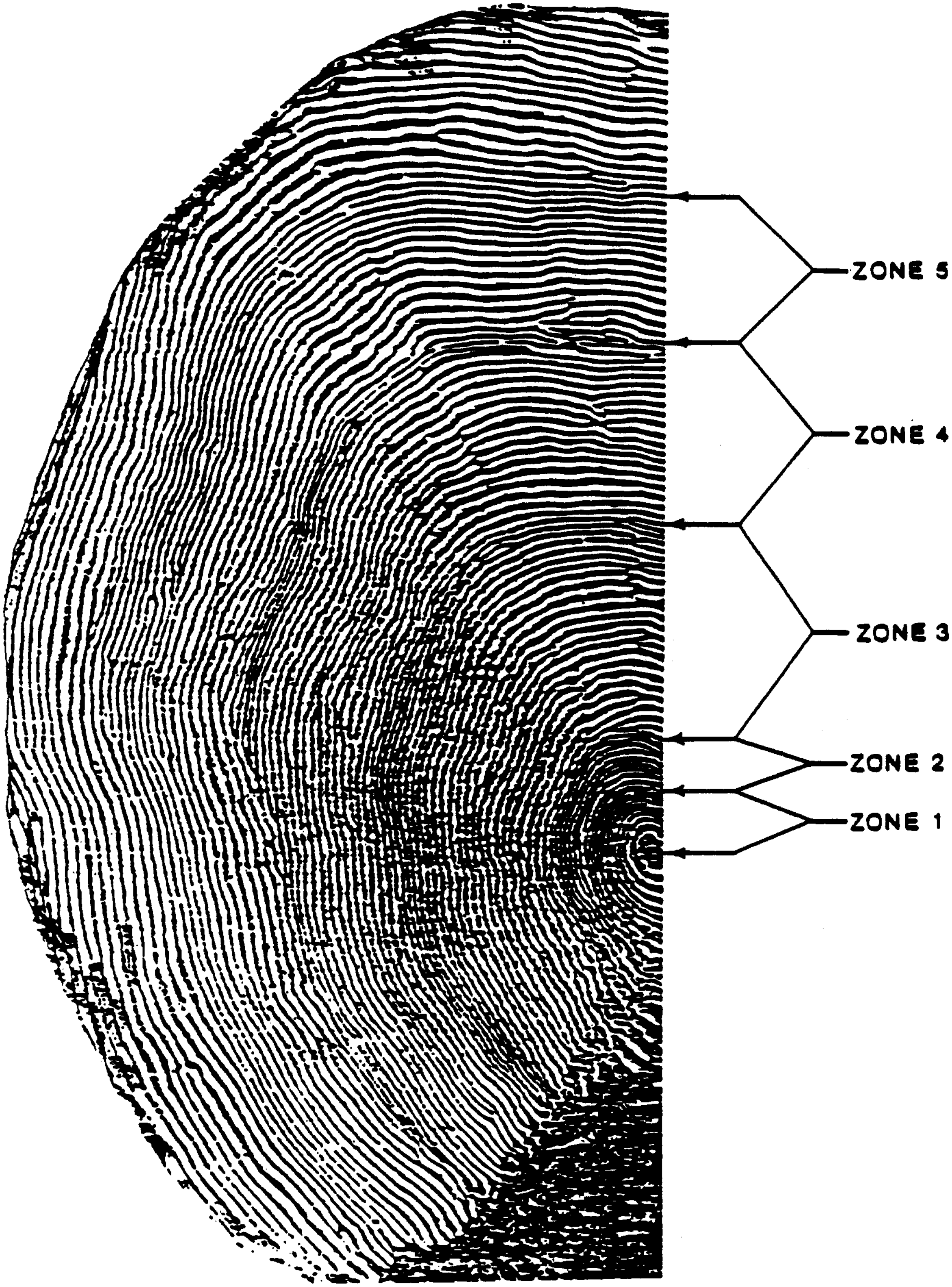

Figure 3. Age-1.4 chinook salmon scale showing zones measured for linear discriminant analysis.

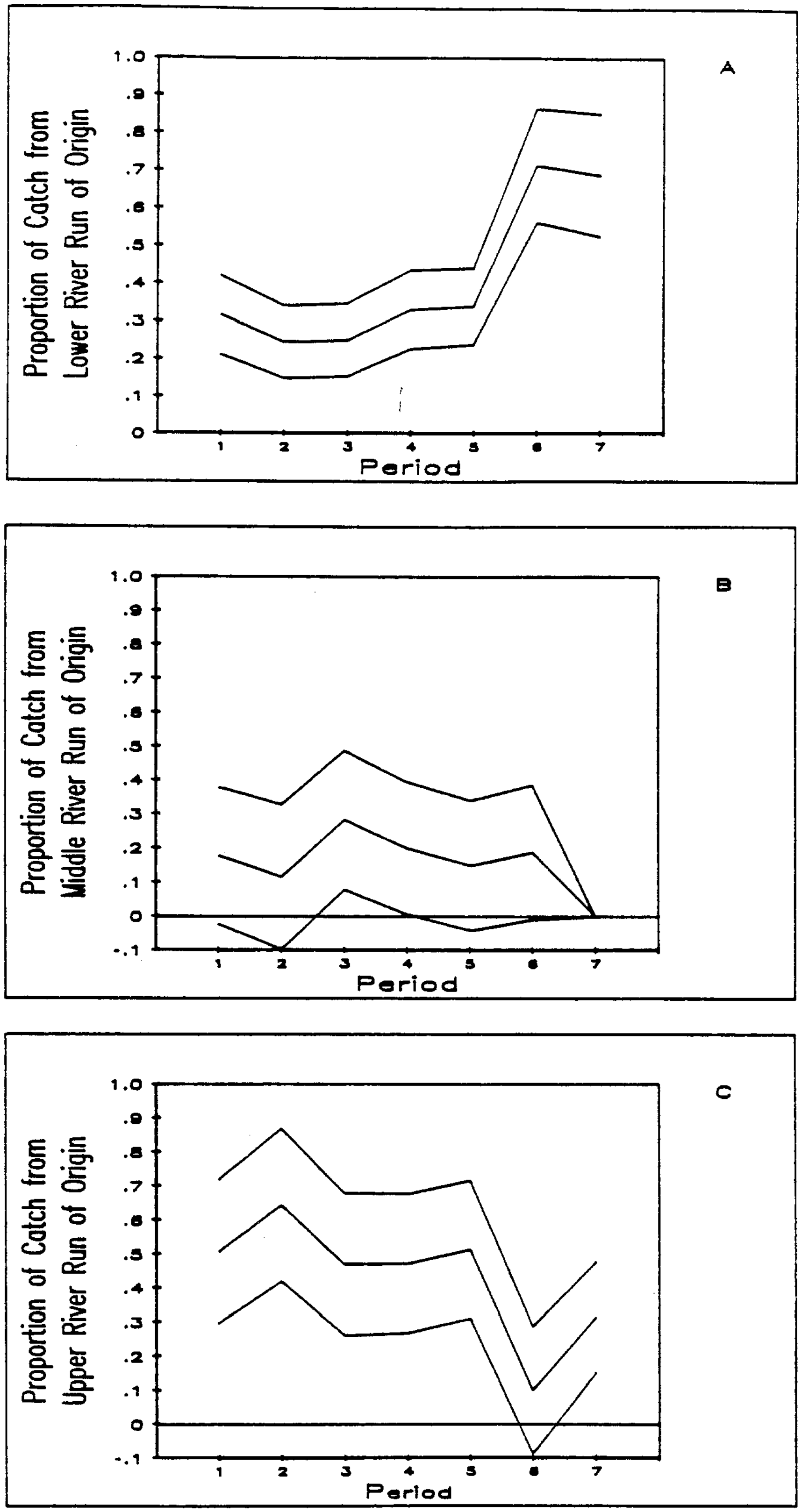

Figure 4. Run composition estimates and 90% confidence intervals from scale patterns analysis of age-1.4 chinook salmon, Yukon River District 1, 1987.

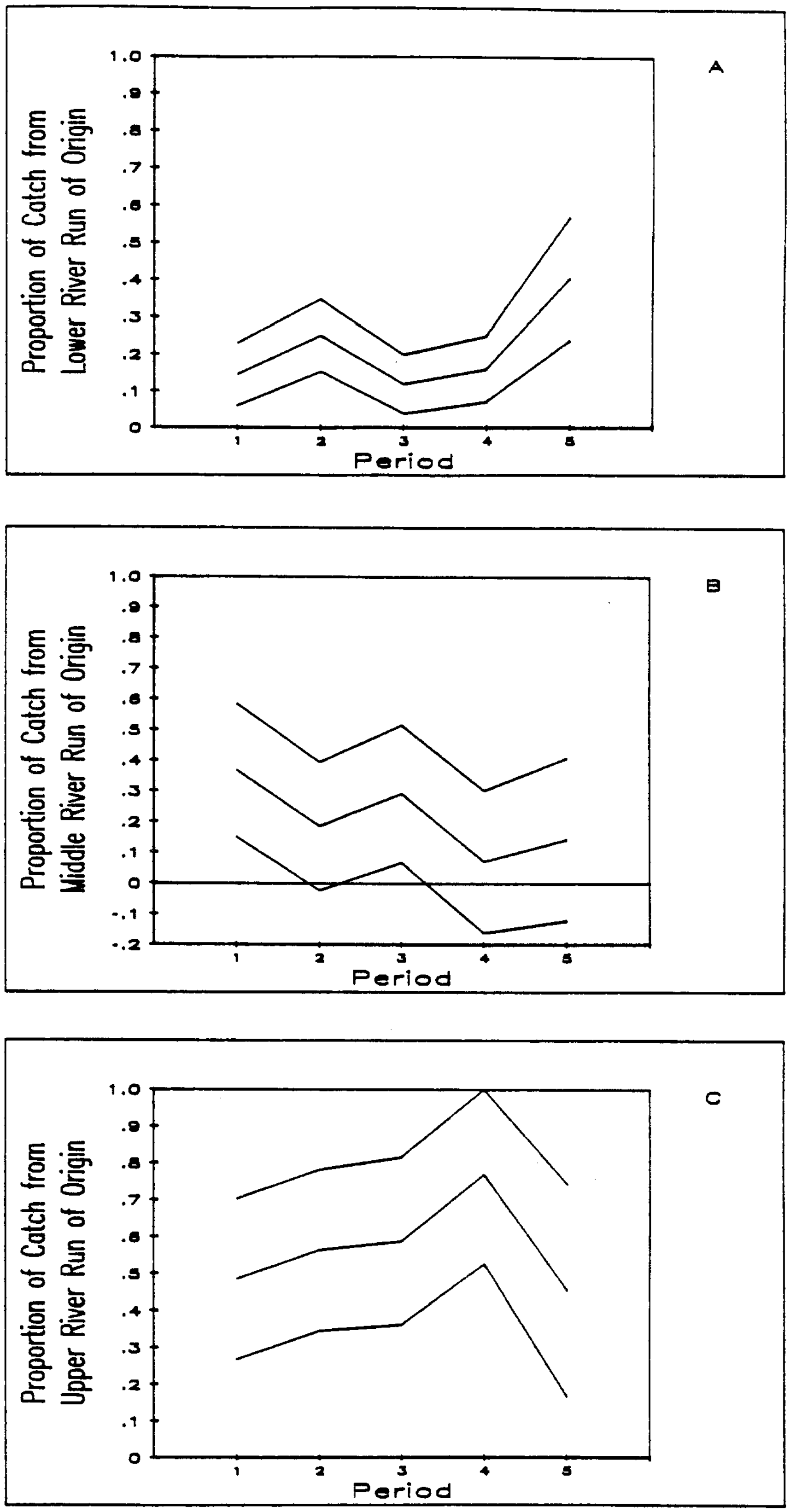

Figure 5. Run composition estimates and 90% confidence intervals from scale patterns analysis of age-1.4 chinook salmon, Yukon River District 2, 1987.

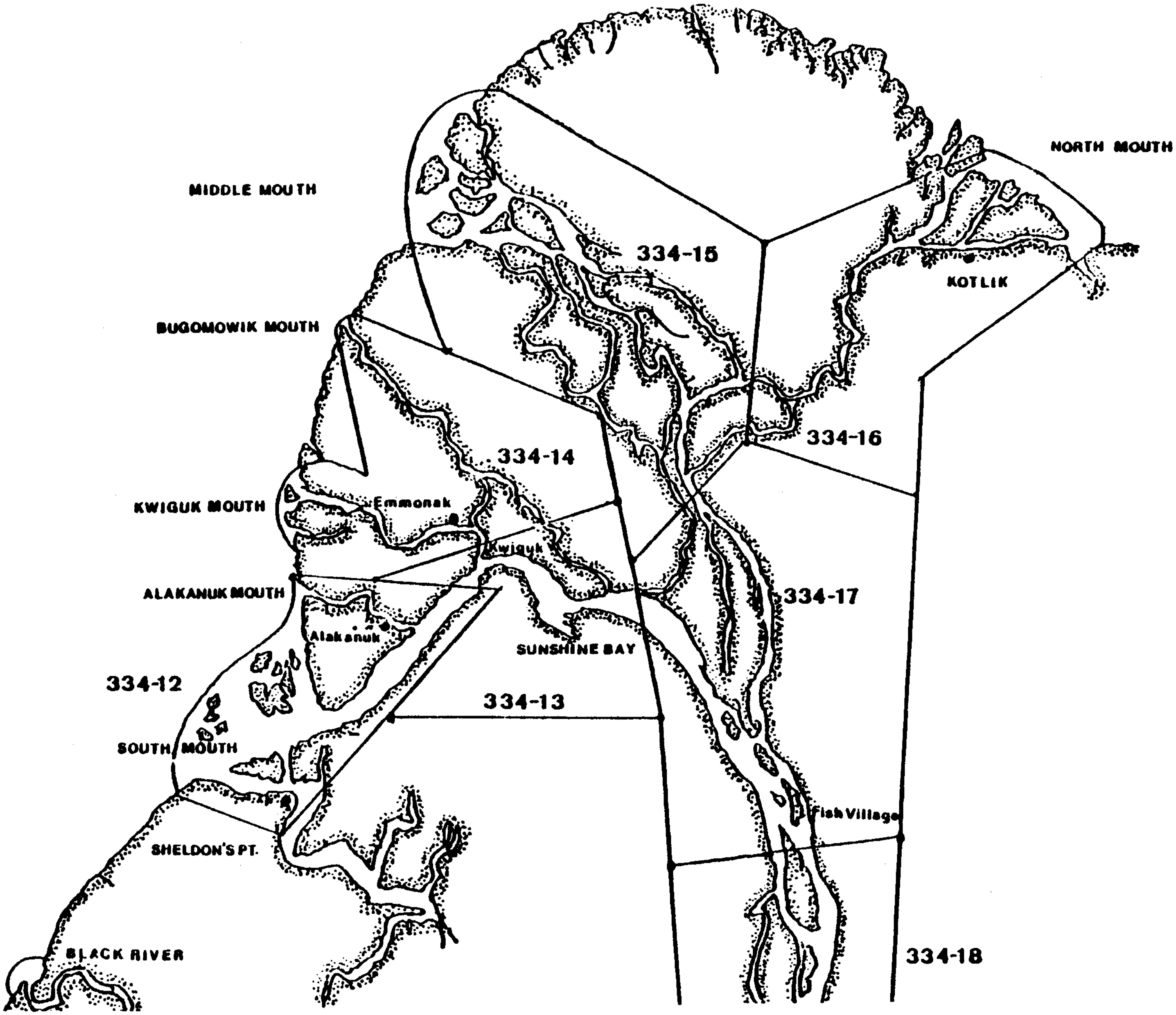

Figure 6. Statistical areas of Yukon River District 1.

APPENDICES

Appendix A. Scale variables screened for linear discriminant function analysis of age-1.4 Yukon River chinook salmon.

Variable	1st Freshwater Annular Zone
1	Number of circuli (NC1FW)[a]
2	Width of zone (S1FW)[b]
3 (16)	Distance, scale focus (C0) to circulus 2 (C2)
4	Distance, C0-C4
5 (18)	Distance, C0-C6
6	Distance, C0-C8
7 (20)	Distance, C2-C4
8	Distance, C2-C6
9 (22)	Distance, C2-C8
10	Distance, C4-C6
11 (24)	Distance, C4-C8
12	Distance, C(NC1FW -4) to end of zone
13 (26)	Distance, C(NC1FW -2) to end of zone
14	Distance, C2 to end of zone
15	Distance, C4 to end of zone
16-26	Relative widths, (variables 3-13)/S1FW
27	Average interval between circuli, S1FW/NC1FW
28	Number of circuli in first 3/4 of zone
29	Maximum distance between 2 consecutive circuli
30	Relative width, (variable 29)/S1FW

Variable	Freshwater Plus Growth
61	Number of circuli (NCPG)[c]
62	Width of zone (SPGZ)[d]

Variable	All Freshwater Zones
65	Total number of freshwater circuli (NC1FW+NCPG)
66	Total width of freshwater zone (S1FW+SPGZ)
67	Relative width, S1FW/(S1FW+SPGZ)

- Continued -

Appendix A. Scale variables screened for linear discriminant function analysis of age-1.4 Yukon River chinook salmon (continued).

Variable	1st Marine Annular Zone
70	Number of circuli (NC1OZ)[e]
71	Width of zone (S1OZ)[f]
72 (90)	Distance, end of freshwater growth (EFW) to C3
73	Distance, EFW-C6
74 (92)	Distance, EFW-C9
75	Distance, EFW-C12
76 (94)	Distance, EFW-C15
77	Distance, C3-C6
78 (96)	Distance, C3-C9
79	Distance, C3-C12
80 (98)	Distance, C3-C15
81	Distance, C6-C9
82 (100)	Distance, C6-C12
83	Distance, C6-C15
84 (102)	Distance, C(NC1OZ -6) to end of zone
85	Distance, C(NC1OZ -3) to end of zone
86 (104)	Distance, C3 to end of zone
87	Distance, C9 to end of zone
88	Distance, C15 to end of zone
90-104	Relative widths, (variables 73-86)/S1OZ
105	Average interval between circuli, S1OZ/NC1OZ
106	Number of circuli in first 1/2 of zone
107	Maximum distance between 2 consecutive circuli
108	Relative width, (variable 107)/S1OZ

Variable	All Marine Zones
109	Width of 2nd marine zone, (S2OZ)
110	Width of 3nd marine zone, (S3OZ)
111	Total width of marine zones (S1OZ+S2OZ+S3OZ)
112	Relative width, S1OZ/(S1OZ+S2OZ+S3OZ)
113	Relative width, S2OZ/(S1OZ+S2OZ+S3OZ)

[a] Number of circuli, 1st freshwater zone.
[b] Size (width) 1st freshwater zone.
[c] Number of circuli, plus growth zone.
[d] Size (width) plus growth zone.
[e] Number of circuli, 1st ocean zone.
[f] Size (width) 1st ocean zone.

Appendix B. Group means, standard errors and one-way analysis of variance F-test for scale variables selected for use in linear discriminant models of age-1.4 Yukon River chinook salmon runs, 1987.

		Lower		Middle		Upper		
Growth Zone	Variable	Mean	SE	Mean	SE	Mean	SE	F-value
1st FW Annular	24	0.27	<0.01	0.29	<0.01	0.26	<0.01	27.38
	25	0.24	<0.01	0.31	<0.01	0.25	<0.01	136.60
FW Plus Growth	61	3.09	0.07	6.03	0.08	6.08	0.12	514.71
Total FW Growth	67	0.82	<0.01	0.63	<0.01	0.66	<0.01	839.95
1st Ocean Ann.	84	112.79	0.84	122.10	1.00	131.15	1.47	61.50
	102	0.23	<0.01	0.25	<0.01	0.27	<0.01	52.75

Appendix C. Group means, standard errors, and one-way analysis of variance F-test for the number of circuli and incremental distance of salmon scale growth zone measurements from age-1.4 Yukon River chinook salmon runs, 1987.

		Lower		Middle		Upper		
Growth Zone	Variable	Mean	SE	Mean	SE	Mean	SE	F-Value
1st FW Annular	No. Circ.	10.21	0.09	8.15	0.07	9.45	0.16	147.62
	Incr. Dist.	138.04	1.00	104.37	0.89	121.71	1.60	312.59
FW Plus Growth	No. Circ.	3.09	0.07	6.03	0.08	6.08	0.12	514.71
	Incr. Dist.	29.87	0.60	62.93	0.84	63.54	1.17	625.93
1st Ocean Annular	No. Circ.	26.81	0.13	26.53	0.14	25.55	0.24	11.65
	Incr. Dist.	487.90	2.48	491.69	2.79	483.26	5.10	1.36
2nd Ocean Annular	Incr. Dist.	414.68	3.37	401.52	3.75	394.32	6.03	5.78
3rd Ocean Annular	Incr. Dist.	392.02	3.15	407.05	3.51	382.33	5.03	9.26