YUKON AREA
STOCK SEPARATION
REPORT #17

FEASIBILITY OF USING SCALE PATTERNS ANALYSIS TO IDENTIFY THE ORIGINS OF CHUM SALMON IN YUKON RIVER FISHERIES, 1986

by

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October 1987

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ACKNOWLEDGMENTS

The author is grateful to the Division of Commercial Fisheries Yukon Area staff and Canadian Department of Fisheries and Oceans Whitehorse office staff for providing the samples used in this analysis. Particular thanks are due to Louis Barton and Al Bagley who risked bodily harm and mental anguish in the subzero pursuit of escapement counts and sample goals. The author is also grateful to Larry Buklis for providing much of the basic escapement information and for his continuing guidance and advice. Critical review was provided by Bill Arvey, Linda Brannian, and Larry Buklis.

PROJECT SPONSORSHIP

This analysis was partially financed under U.S./Canada Treaty Negotiations Federal Funds, Contract No. 41828.

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ABSTRACT

Analysis of scale patterns was investigated as a method of apportioning Yukon River fall chum salmon (*Oncorhynchus keta*) harvests to stock of origin. Classification accuracies for five-way stock of origin models for the Toklat, Delta, Sheenjek, Fishing Branch, and Canadian mainstem Yukon Rivers were low for both age-0.3 and -0.4 fish (38.7% and 28.0%, respectively). Two-way classifications of summer and fall chum salmon yielded mean classification accuracies of 67.1% and 65.9% for age-0.3 and -0.4 fish, respectively. Classification accuracies were considered unacceptably low and no attempt was made to apportion harvests.

KEY WORDS: Chum salmon, *Oncorhynchus keta*, stock separation, catch and run apportionment, linear discriminant analysis, Yukon River, Alaska.

INTRODUCTION

Yukon River chum salmon (*Oncorhynchus keta* Walbaum) are harvested in a wide range of fisheries in both marine and fresh waters. During their ocean residence, they are harvested in salmon gillnet fisheries in the North Pacific Ocean and Bering Sea, in trawl fisheries in the Bering Sea, and in coastal purse seine and gillnet fisheries of the Alaska Peninsula. They are the most abundant species returning to the Yukon River, averaging more than 1.5 million fish harvested annually (1981-85) by inriver commercial and subsistence fisheries in Alaska and Canada (Figures 1 and 2).

Yukon River Fishery

Chum salmon return to the Yukon River in two distinct runs termed summer and fall chum salmon. Summer chum salmon are the most abundant of the two with an average annual commercial and subsistence harvest of 1,086,353 fish (1981-85). They are characterized by their earlier run timing (early June to mid July), smaller size (average 6-7 lb), and rapid maturation in fresh water. Spawning occurs primarily in run-off tributaries in the lower 500 miles of the drainage and in the Tanana River system. Most summer chum salmon are harvested in a commercial gillnet fishery in Districts 1 and 2 (1981-85 average 591,069 fish) and commercial and subsistence gillnet and fishwheel fisheries in District 4 (1981-85 average 347,482 fish).

Fall chum salmon are distinguished by their later run timing (mid July to early September), larger size (average 7-8 lb), robust body shape, and bright silvery appearance. Fall stocks migrate further upstream and spawn primarily in spring-fed tributaries of the upper drainage which typically remain ice-free during the winter. Fall chum salmon are in great demand due to their appearance, size, and high oil content, and are harvested in commercial and subsistence fisheries in all Yukon River districts. An average of 61.8% (1981-85) of the annual total utilization (commercial and subsistence combined) occurred in the commercial gillnet fishery in Districts 1 and 2 (1981-85 average 209,358 fish) and in a subsistence gillnet and fishwheel fishery in District 5 (1981-85 average 100,812 fish).

Recent fishery trends for fall chum salmon have necessitated a conservative management approach which precludes achievement of optimum sustained yield, the overall objective of the research and management programs of the Alaska Department of Fish and Game (ADF&G). The total utilization of Yukon River fall chum salmon in the Alaska portion of the drainage increased 20% from the 1976-80 average of 399,000 fish to the 1981-85 average of 477,000 fish. Similarly, total utilization in Yukon Territory, Canada, increased from an average of 14,000 fish during 1976-80 to an average of 28,000 fish during 1981-85. This harvest increase was accompanied by a corresponding decline in escapements for most of the major spawning areas, especially in 1982-84. Escapements in the Sheenjek, Fishing Branch, Toklat, and Delta Rivers for the period 1982-84 averaged 42%, 60%, 59%, and 26%, respectively, below the escapement objectives established in 1987 for each of these streams (L. S.

Buklis, Alaska Department of Fish and Game, Anchorage, personal communication).

Stock conservation concerns, especially for the 1986-88 returns, prompted fishery managers to adopt conservative management strategies with reduced fishing time and season closures. The Alaska Board of Fisheries reduced the lower Yukon River (Districts 1-3) commercial guideline harvest range for fall chum salmon from 110,000-220,000 to 0-110,000 fish beginning with the 1986 season. The guideline harvest range in the upper Yukon River (Districts 4-6) for fall chum and coho salmon combined[1] was similarly reduced from 25,500-100,500 to 0-50,250 fish beginning in 1986.

Management of chum salmon harvest in the lower Yukon River is complicated by an overlap in run timing of fall chum and summer chum salmon during July. There is evidence from mark and recapture studies conducted during the 1970's (Buklis 1984) that fall chum salmon destined for spawning tributaries farthest upstream begin entering the lower Yukon River during this transition period. Because stock composition information which details the relative abundance of each run is lacking, current Board of Fisheries management regulations require closure of the fishery in the lower river on July 15 for at least 2 to 3 weeks. This is done to protect the early portion of the fall run which is subject to high exploitation in upstream districts.

Accurate estimates of escapements and information about stock composition of Yukon River fall chum salmon harvests are essential to formulation and adoption of less conservative management strategies which will permit achievement of the Department's stated goal of optimum sustained yield.

Previous Stock Composition Investigations

The ADF&G has investigated scale patterns analysis (SPA) as a possible method for obtaining estimates of fall chum salmon stock contributions to Yukon River harvests in 1974-77 and 1982 (Bethe 1978; P. V. Krasnowski, ADF&G, Anchorage, personal communications; D. N. McBride, ADF&G, Anchorage, personal communications). Initial investigations on the feasibility of using SPA (Appendices A.1-A.5) indicated potential utility for the method, but results were generally inconclusive as not all major spawning groups were sampled.

In a 2-way classification of Toklat and Sheenjek River fish from 1974, Bethe (1978) obtained mean classification accuracies of 67.6% and 70.8% for models based on age-0.2 and age-0.3 fall chum salmon, respectively (Appendix A.1). Small sample sizes, non-freshwater rearing life history of chum salmon, and mis-aging of scales due to excessive resorption of scale

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[1] Fall chum and coho catches are combined in Districts 1-4 as the less abundant coho salmon are only harvested incidentally to the directed fall chum salmon fishery and are seldom differentiated in catches by fishermen and processors.

margins were listed as possible reasons for low classification accuracies. In contrast, the percentage of age-0.2 fish correctly classified in 1976 was 75.6% in a 3-way classification of Toklat, Sheenjek, and Delta River samples.

P. V. Krasnowski (ADF&G, Anchorage, personal communications) estimated the average percentage of age-0.3 samples correctly classified in 1977 for a three-way classification of the Sheenjek, Toklat, and Delta Rivers, and a four-way classification of the Sheenjek, Toklat, Delta and Fishing Branch Rivers to be 60.5% and 56.7%, respectively (Appendix A.4).

Because of the inaccuracies involved in aging fish from resorbed scales, D. N. McBride (ADF&G, Anchorage, personal communications) investigated the use of SPA models using data from ages-0.2 and -0.3 fish pooled for samples collected in 1974, 1975, and 1982. Stock standards were constructed from individual spawning stocks and fisheries pooled for the three major Yukon River sub-drainages which support fall chum salmon spawning: 1) the Tanana River drainage, 2) the Porcupine River drainage, and 3) the mainstem Yukon River drainage in Canada. The 3-way classification of Tanana, Porcupine, and Canadian stock groupings yielded average percentages for samples correctly classified of 44.1% (Appendix A.1), 54.6% (Appendix A.2), and 50.2% (Appendix A.5) for 1974, 1975, and 1982, respectively. Analysis of variance for scale features indicated large differences between age groups.

The low classification accuracies of pooled age models, large differences in scale feature measurements between age groups, and inconclusive results from initial feasibility studies led to the general conclusion that the utility of scale patterns analysis could not be determined for Yukon River fall chum salmon unless 1) more accurate methods of aging could be developed, and 2) scale sampling programs were designed to meet SPA requirements for sample sizes and numbers of stocks sampled.

An alternative method of stock identification is electrophoretic analysis of fish tissue proteins, which has recently been shown to be useful for estimating stock composition of chum salmon catches in British Columbia (Beacham et al. 1985). Beacham (Department of Fisheries and Oceans, Nanaimo, B.C., personal communications) investigated the feasibility of using this technique to estimate fall chum salmon stock contributions in Yukon River District 1 test fishing catches during 1985 and 1986. Baseline samples from individual stocks were collected from the Delta, Toklat, Sheenjek, Chandalar, mainstem Porcupine, Fishing Branch, Kluane, Koidern, and mainstem Yukon Rivers during 1984-86. He estimated the average contribution of Alaskan stocks in 1985 and 1986 to be 39% and 62%, respectively.

The U.S. Fish and Wildlife Service (USFWS) is currently finalizing plans to continue research on the utility of this method during 1987 (R. L. Wilmot, USFWS, Anchorage, personal communications). However, there are several drawbacks to using electrophoresis for stock identification of Yukon River fall chum salmon, including: 1) sample collection and processing are costly and logistically difficult, 2) preliminary results have indicated possibly poor discrimination for some important stocks, particularly the Sheenjek and Kluane Rivers (T. D. Beacham, Department of Fisheries and Oceans, Nanaimo, B.C., personal communications), and 3) interannual variability of allelic frequencies within stocks may be high, necessitating too frequent updating of known origin base line samples (R. L. Wilmot, personal communications, USFWS, Anchorage).

ADF&G has continued to investigate the feasibility of scale patterns analysis as a method of stock assessment since 1) feasibility of electrophoresis has not been completely established, 2) scales are collected annually for age-sex-size analyses, and 3) scale feature measurements may have utility when incorporated with electrophoresis results in maximum likelihood techniques. Techniques for accurately aging fall chum salmon using vertebrae were developed (Clark 1987) which permit the construction of models using only scales from fish of the same brood year. Sampling for scales and vertebrae was expanded to include all identified major spawning populations, with sufficient samples collected from each stock to construct models for both major age groups.

Classification accuracies of linear discriminant models were used to assess the feasibility of using scale feature measurements to estimate stock contributions of fall chum salmon to Yukon River harvests. In addition, classification accuracies were used to assess scale patterns analysis as a method for estimating the proportions of summer and fall chum salmon during the mid-July transition period between the two runs.

METHODS

Yukon River summer and fall chum salmon escapements were sampled for age, sex, and size information using standard scale sampling techniques. Sample goals were established according to statewide standards to meet predetermined levels of accuracy and precision (D. R. Bernard, R. H. Conrad, L. K. Brannian, ADF&G, Anchorage, personal communications). Scales were collected from the left side of the fish approximately two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin (INPFC 1963). Scales were mounted on gum cards and impressions were made in cellulose acetate (Clutter and Whitesel 1956). Vertebrae were collected for age determination from fall chum salmon spawning in Yukon River tributaries in Alaska. Ages were recorded in European notation.

Model Construction

Selection of Standards

Major spawning stocks included in model construction were represented by scales sampled[2] from escapements to the Delta, Toklat, Sheenjek, and

[2] Sampling of Alaskan escapements was conducted by Alaska Department of Fish and Game staff, Division of Commercial Fisheries. Sampling of Canadian escapements and catches was conducted by Canadian Department of Fisheries and Oceans staff.

Fishing Branch Rivers, and fishwheel catches from the mainstem Yukon River upstream of the U.S./Canada border . Sample goals for escapements in Alaska were 450 fish from each stream to obtain an age composition estimate for a population with three major age groups at a 90% chance of being within ±0.05 percentage points of the true proportion. Samples from the Delta and Toklat Rivers were collected during peak spawner die-off. While most samples were collected from carcasses, 150 samples from each river were collected from sacrificed live fish. Scale samples from the Sheenjek River were collected from beach seine catches made during operation of a sidescan sonar escapement enumeration project and from carcasses subsequent to seasonal termination of the project.

Sample goals for chum salmon sampled in Canada were established by Canadian Department of Fisheries and Oceans (DFO) personnel. Scale samples of 940 fish from the Fishing Branch River were collected from up to 40 live fish per day passing through a weir. Samples representing spawning escapements to tributaries of the mainstem Yukon River in Canada were collected from all chum salmon caught with fishwheels during the marking phase of a DFO tagging project to estimate upriver escapement across the U.S./Canada border. These fishwheel samples were considered to be the most representative composite available for escapements to the mainstem Yukon River and its tributaries in Canada, and were located downstream of all major documented spawning concentrations. Radiotelemetry studies (Milligan et. al 1984) have indicated that escapements to the mainstem Yukon River and White River sub-basin (including the Kluane and Koidern Rivers) comprise 60% and 34%, respectively, of this Canadian component. Escapement samples from Canadian rivers could not be pooled to form a reasonable standard due to the lack of samples from significant spawning populations, particularly the mainstem Yukon River.

The analysis was limited to age-0.3 and -0.4 fish as these two age classes comprised over 90% of all sampled catches and escapements of Yukon River fall chum salmon in 1986 (Buklis In press). The sample size goal for stock standards was 200 scales for each spawning stock and age group. This sample size was intended to optimize precision levels obtainable for catch allocations with costs of scale data acquisition (R. H. Conrad, ADF&G, Anchorage, personal communication). However, 200 scales were not available for many stock standards and all samples available were used in such cases.

Five-way classification models were constructed for each age class using samples from individual fall chum salmon spawning escapements and catches. In addition, three-way (Tanana, Porcupine, and Canadian Yukon) models were constructed to test the utility of pooled stock standards for Tanana and Porcupine River drainage systems. Samples from the Delta and Toklat Rivers were used to represent the Tanana River drainage standard, while samples from the Sheenjek and Fishing Branch Rivers represented the Porcupine River standard. Samples from individual stocks were selected in proportion to their estimated escapement abundance (Table 1) as indicated by expanded multiple surveys for the Toklat and Delta Rivers, sonar count for the Sheenjek River, weir count for the Fishing Branch River, and preliminary population estimates from tagging studies for the Canadian mainstem Yukon River.

Two-way classification models for summer chum and fall chum salmon were constructed for both age-0.3 and -0.4 fish. Scale samples representing the fall chum salmon run were selected from the Delta, Toklat, Sheenjek, and Fishing Branch Rivers, and Yukon Territory fishwheel catches. Scales representing the summer chum salmon run were selected from samples of the Anvik, Andreafsky, and Nulato River escapements, and Tanana River commercial and subsistence catches. All samples were selected in proportion to their estimated escapement abundance pooled for each race. Anvik River samples comprised approximately 65% of the summer chum salmon stock standard.

Scale Features Measurement

Measurements of scale features were made using standardized fish scale digitizing techniques. 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 a standard drawing axis about 20^{o} dorsal of the primary axis (a posterior-anterior line approximately perpendicular to the sculptured field). The distance between each circulus along the axis in selected scale growth zones was recorded.

Three growth zones were measured for age-0.3 fall chum salmon (Figure 3) within the first annular zone as follows: (1) scale focus to the outside edge of the freshwater growth zone, (2) the last circulus of freshwater growth to the end of the supplementary check (first ocean growth zone), and (3) the last circulus of the supplementary check to the outer edge of the first annulus (second ocean growth zone). The total distance from the last circulus of the first annulus to the last circulus of the second annulus (the second annular zone) was also measured. Incremental distances and circuli counts were used to calculate seventy scale characters (Appendix B.1) for this age group.

Because of the difficulty in determining the edge of freshwater growth for some stocks, only two growth zones from the first annular zone were measured for age-0.4 fall chum salmon (Figure 3). These two zones were: 1) the focus to the last circulus of the supplementary check (freshwater growth plus first ocean growth zone), and 2) the last circulus of the supplementary check to the outer edge of the first annulus (second ocean growth zone). In addition, incremental distances between circuli from the second annular zone were measured. Eighty-five scale characters (Appendix B.2) were calculated from the basic incremental distances and circuli counts for this age group.

Classification accuracies for three measurement schemes were compared to evaluate the utility of measuring multiple growth zones within the first annular zone. Incremental distances and circuli counts for zones 1, 2, and 3 as defined for age-0.3 fish from the Delta River and Canadian fishwheel catches were combined to calculate scale characters for two zones (as described for age-0.4 fish) and for one zone (from the focus to the last circulus of the first marine annulus). Classification accuracies were similar for all three measurement schemes, and discriminant models for summer chum vs. fall chum salmon were constructed using scale characters calculated for a single growth zone (focus to the last circulus of the first annulus) within the first annular zone. Eighty-six scale characters (Appendix B.3) were calculated and used to classify age-0.4 summer and fall chum salmon. Due to resorption of some scales, age-0.3 summer and fall chum salmon were classified using only the forty scale characters calculated for the first annular zone.

Selection of Variables

Mean, variance, and one-way analysis of variance F-statistic were calculated for each scale character generated to evaluate their discriminatory utility. Selection of scale characters for the analysis was by a forward stepping procedure using partial F-statistics as the criteria for entry/deletion of variables (Enslein et al. 1977). Selected variables were entered into or removed from a linear discriminant function (Fisher 1936) in a step-wise manner. At each step, a classification matrix of actual vs. classified groups of origin, and a mean classification accuracy were calculated using the leaving-one-out procedure of Lachenbruch (1967). Frequency distributions were plotted for each selected scale variable and subjectively examined for violations of assumed normality. Statistical tests for normality were not applied as the method has been shown to be robust to violations of normality. Subjective examination was primarily to detect bimodality, extreme skewness or kurtosis, and data outliers due to recording and measurement errors.

Evaluation of Discriminant Models

Discriminant models which produced the highest classification accuracies and included only variables with acceptable frequency distributions were selected and evaluated. In general, researchers using SPA techniques seek classification accuracies at least 20-30% greater than random chance. If classification accuracies are acceptable, stock composition estimates with 90% confidence intervals which are within $\pm$25-30% of the estimate are sought.

Multiple Axis Measurements

Two geographically distant stocks which had previously poor SPA separability and had also been subjected to vertebra aging were chosen for testing scale feature measurements made using more than one axis. Eight axes (Figure 4) originating at the focus were defined as follows: 1) a line dorsally perpendicular to the standard anterior-posterior drawing axis, 2) a line bisecting the angle between axis number one and a line 17-1/2^{o} dorsal of the standard drawing axis, 3) a line 17-1/2^{o} dorsal to the standard drawing axis, 4) the standard drawing axis, 5) a line 17-1/2^{o} ventral to the standard axis, 6) a line bisecting the angle between the fifth axis and the ventral perpendicular of the standard axis, 7) the ventral perpendicular of the standard axis and 8) the posterior extension of the second axis.

An arbitrary sample size of fifty fish each from the Delta and Sheenjek River escapements, which were previously measured using standard single axis measurements, were also measured for multiple axis scale features. This sample size was chosen according to the time available for digitizing. In the course of the analysis several samples were found to be unusable and the analysis was completed with 42 fish for each stock. The total incremental distance from the focus to the intersection of axis number 1 with the last circulus of the first annulus was measured and recorded. The seven distances between succeeding adjacent axes along the circumference of the first annulus (i.e. chord lengths) were measured and recorded. The sum of these distances around the circumference of the first annulus (sum of the chord lengths), and the sum of all distances measured were calculated.

RESULTS AND DISCUSSION

Classification Accuracy

Mean classification accuracies (Table 2) were low for the age-0.3 five-way model for individual spawning stocks (38.7%) and three-way model using individual spawning stocks pooled for major drainages of origin (49.0%). Sheenjek River samples showed the highest classification accuracy (55.6%) and were most frequently misclassified as Fishing Branch River fish (20.9%). More Canadian mainstem Yukon River drainage samples were misclassified as Delta River fish (28.4%) than were classified correctly (21.8%) in the five-way model. Correct classification of Canadian Yukon River drainage fish in the three-way major drainage model increased to 50.8%, and was probably due to the relatively small number of Delta River samples (62) included in the Tanana River drainage standard. Major variables selected for construction of these models were the number of circuli of freshwater growth, the distance from the end of freshwater growth to the supplementary check, and the proportion of the first annular zone represented by freshwater growth.

Five-way classification of age-0.4 individual stocks (Table 3) was less accurate (28.0%) than for age-0.3 fish. Unlike the age-0.3 model, age-0.4 samples from the Canadian mainstem Yukon River drainage showed the highest accuracy at 42.0% correctly classified. Only 11.1% and 10.5% of the Delta and Fishing Branch River samples, respectively, were correctly classified. This is considerably below the 20% correctly classified that would be expected from random chance alone. Mean classification accuracy for the age-0.4, three-way, drainage-of-origin model (46.6%) was similar to mean accuracy for the age-0.3 model (49.0%). Primary variables selected for age-0.4 models were the number of circuli in the first annular zone, the width of the supplementary check, and the total size of the first and second annular zones summed. Comparisons of group means, standard errors, and one-way analysis of variance F-test for annular growth zones of age-0.3 and -0.4 fish are presented in Appendix C.1.

Previous stock identification studies of Yukon River fall chum salmon (Appendices A.1-A.5) which used models for three or four individual tributary stocks resulted in mean classification accuracies ranging from 1.8 to 2.3 times what would be expected from random chance alone. However, classification accuracies for some models were probably positively biased as accuracies were generated using a self-classification procedure. This procedure employs the same samples used for construction of the model to estimate accuracy, and previous investigators estimated bias to be 4-8% (Krasnowski 1978). Considering this positive bias, classification accuracies for five-way models for 1986 were somewhat similar to previous results in that mean classification accuracies were approximately 1.3 to 1.9 times greater than would be expected from random chance alone. The low mean classification accuracies for three-way models of Tanana, Porcupine, and Canadian Yukon River stock groupings in 1986 were very similar for both ages 0.3 and 0.4 (49.0% and 46.6%, respectively) to 1974, 1975, and 1982 models (44.1%, 54.6%, and 50.2%, respectively) constructed from pooled age-0.2 and -0.3 samples.

Two-way models classifying 1986 summer chum and fall chum salmon to run of origin yielded classification accuracies for age-0.3 and -0.4 samples of 67.1% and 65.9%, respectively (Table 4). Bethe (1978) obtained similar mean classification accuracies of 59.1% and 62.9% for age-0.2 and -0.3 fish, respectively, in three-way classifications of Toklat, Sheenjek, and Anvik River samples. Variables selected for construction of the age-0.3 model were the distance from the focus to the sixth circulus, focus to the twelfth circulus, and third to fifteenth circulus of the first annular zone. Major variables selected for the age-0.4 model were derived primarily from the second annular zone.

Multiple Axis Measurements

Methods for improving the performance of standardized scale patterns analysis for Yukon River fall chum salmon were investigated. Adding measurements of the intervals between eight pre-set axes along the length of the first ocean annulus to the standard scale feature measurement model for fall chum salmon from the Toklat and Sheenjek Rivers in 1986 improved mean classification accuracy from 72.6% to 76.2% (Table 5). Bethe (1978) found that using computed characteristics of fish length divided by the interval distance of each portion of the scale, fish length alone, and the computed characteristic of fish length divided by the number of circuli in the supplementary check improved mean classification accuracy from 62.9% to 66.7% for a three-way classification of 1974 Sheenjek, Toklat, and Anvik River fish sampled in 1974.

Stock identification methods using measurements of scale features and morphometric characteristics are based on the premise that differing environmental influences upon geographically separate groups of fish result in growth history differences that may be used to identify the individual groups. These growth history differences between stocks must be great enough to be identified through measurements of scale features or morphometric characteristics. While technique refinements to standard measurements may offer some help in improving discrimination somewhat for stocks that are basically different, it appears unlikely that these fine adjustments can greatly improve classification accuracy for stocks with similar growth histories.

CONCLUSIONS

Acceptable levels of classification accuracies and confidence intervals for stock composition estimates must be obtainable to provide usable information to fishery managers. Results from SPA investigations of Yukon River fall chum salmon from 1976 were very encouraging for a three-way classification of the Sheenjek, Toklat, and Delta River stocks (75.6% mean classification accuracy). However, classification accuracies for discriminant models from all other previous studies were generally low, and recommendations were made for continuation of feasibility studies only with improvements to sampling design and aging techniques. Fall chum salmon SPA studies in 1986 incorporated recommended changes for larger sample sizes, greater numbers of spawning stocks sampled, and the use of vertebrae for aging. However, mean classification accuracies obtained in 1986 were also low, ranging from a high of 38.7% for a five-way classification of age-0.3 fish (18.7% better than expected for random chance) to a low of 28.0% for a five-way classification of age-0.4 fish (8.0% better than chance). Yukon River fall chum salmon harvests were not apportioned to stock of origin as classification accuracies were considered to be too low to justify the digitizing of mixed stock composition catch samples.

Juvenile chum salmon migrate seaward soon after emergence and are not subject to the extensive differential environmental influences that are typical for freshwater rearing species such as chinook and sockeye salmon. There do not appear to be substantial growth history differences which are identifiable using scale patterns analysis techniques between component stocks of Yukon River fall chum salmon. T. D. Beacham (personal communication, DFO, Nanaimo, B.C.) has recently shown electrophoretic analysis of tissue proteins to have some utility in identifying fall chum salmon component stocks based on genetic differences between spawning populations. However, he observed poor discrimination for several major contributing stocks, particularly between fish from Sheenjek River and fish from the Kluane and Koidern Rivers. Although stock discrimination from most SPA studies was generally poor, Sheenjek River samples (which showed poor separability using electrophoresis) produced the highest classification accuracies observed in scale patterns models from 1976 and 1986. In addition, mean body length measurements of fall chum salmon sampled from the Sheenjek River have consistently been larger than measurements for fish sampled from other Yukon River escapements (McBride et al. 1983; Buklis and Wilcock 1984, 1985, 1986; Buklis In press). It is very possible that results from electrophoresis, scale patterns analysis, and morphometric measurements combined in maximum likelihood estimation can provide stock composition estimates more accurate and precise than are obtainable with any single stock identification method.

Although scale patterns analysis alone has not proven to be a feasible method of estimating stock composition in mixed stock harvests of Yukon

River fall chum salmon, it is recommended that paired samples of tissues, scales, and standardized length measurements be collected in 1987. Maximum likelihood techniques should be used to assess the feasibility of combining SPA, morphometric, and electrophoretic results.

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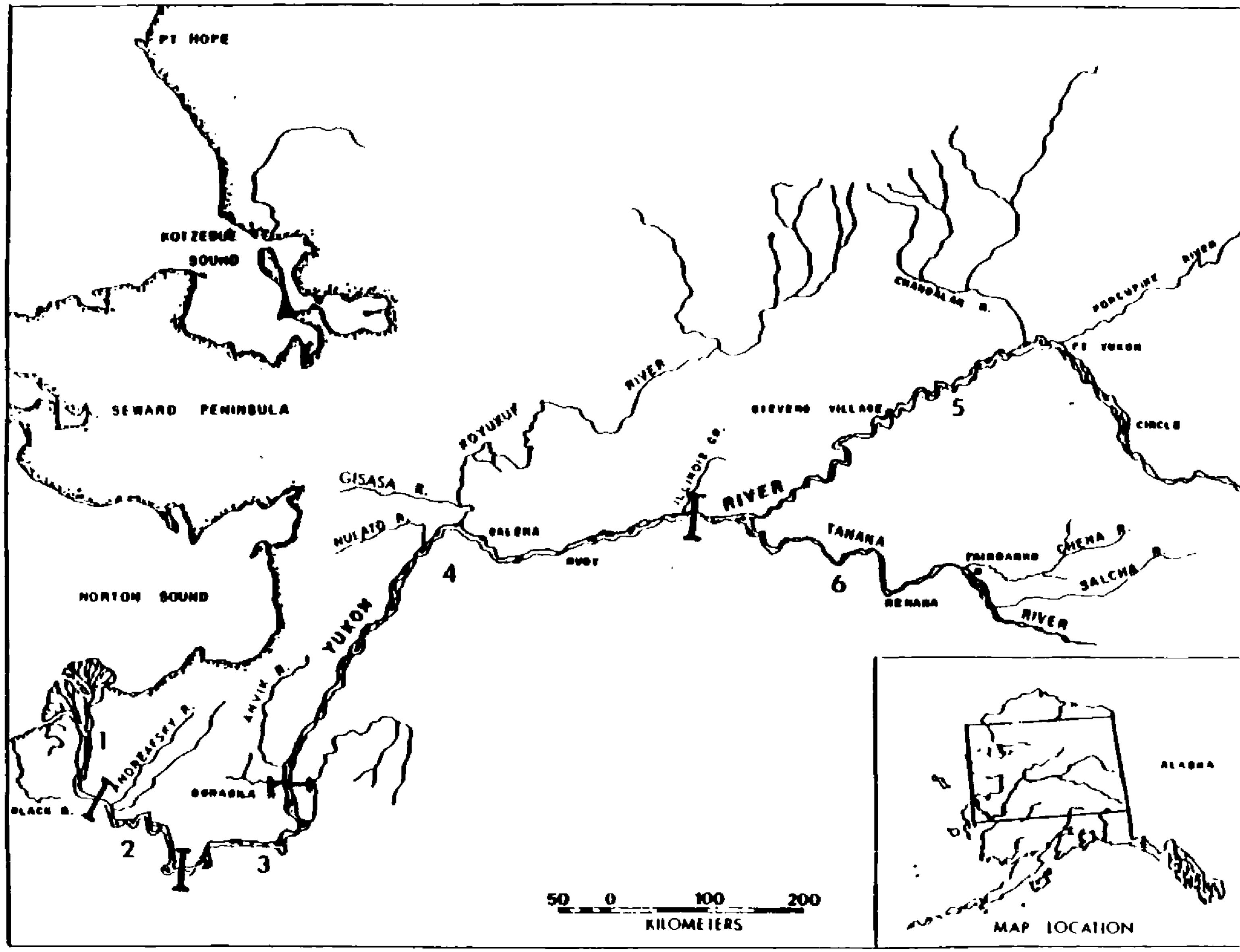

Figure 1. Alaskan portion of the Yukon River showing the six regulatory districts.

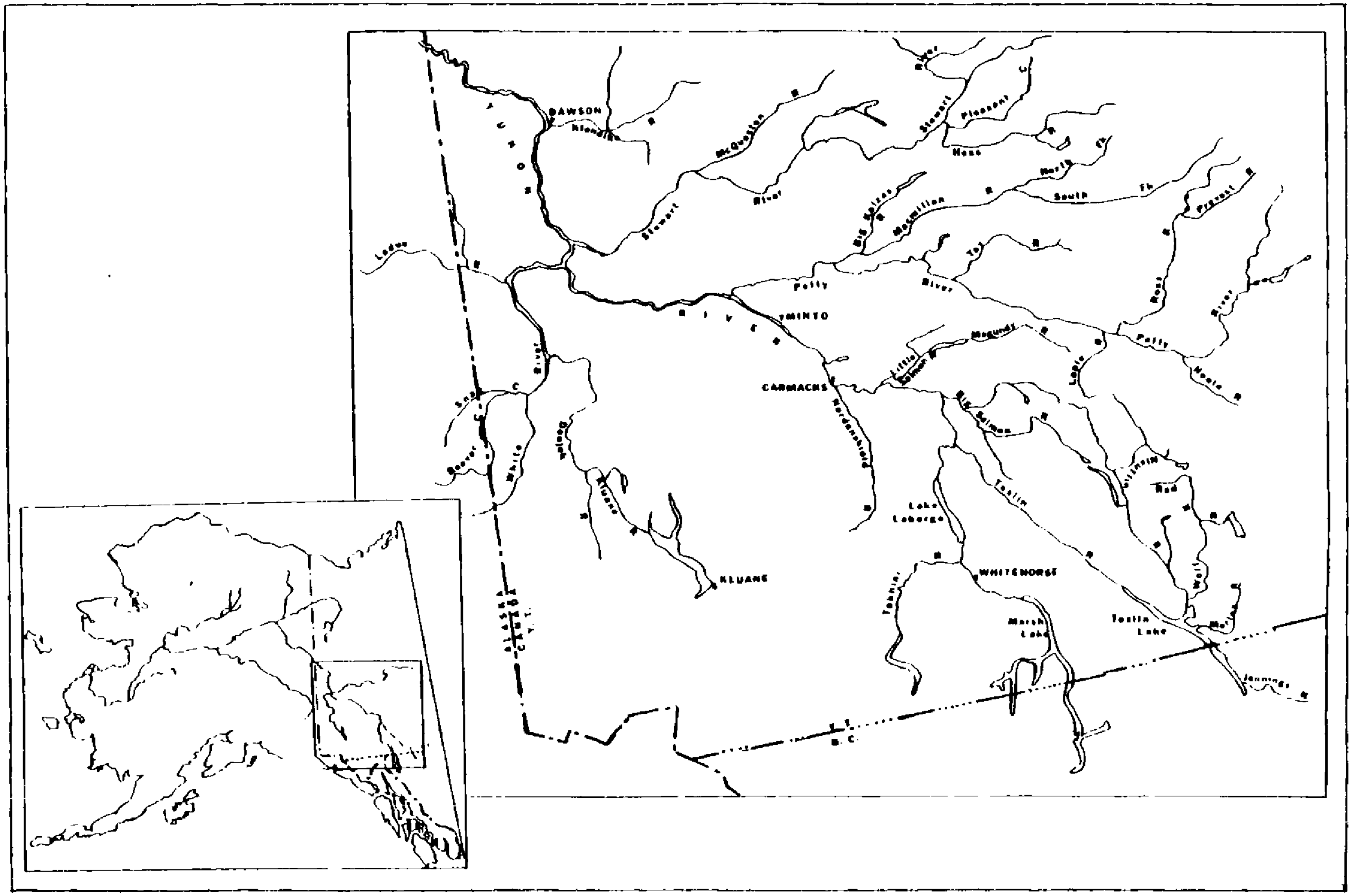

Figure 3. Canadian portion of the Yukon River.

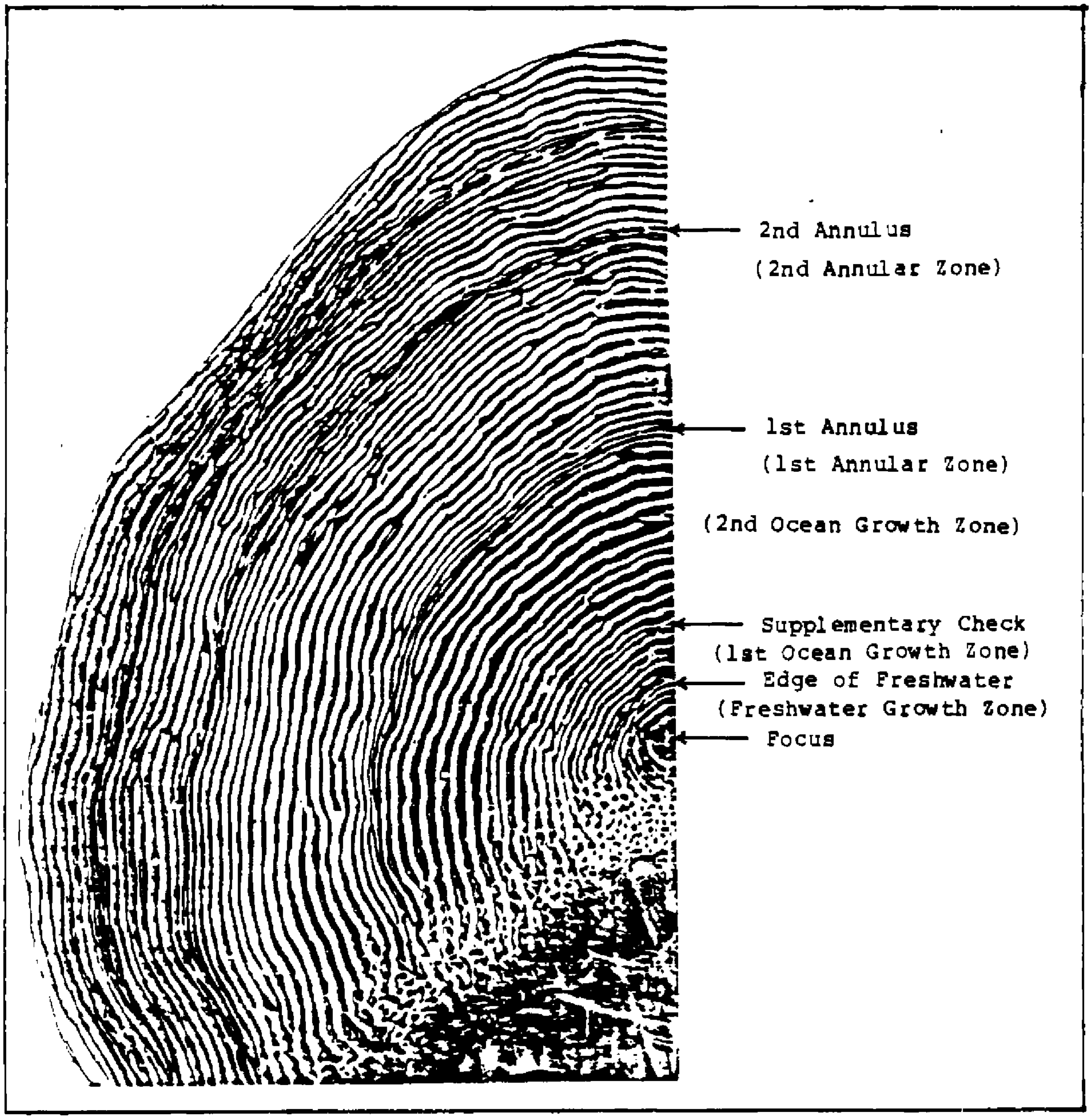

Figure 3. Age 0.3 chum salmon scale showing growth zones measured for linear discriminant ananlysis of age 0.3 and 0.4 Yukon River chum salmon, 1986.

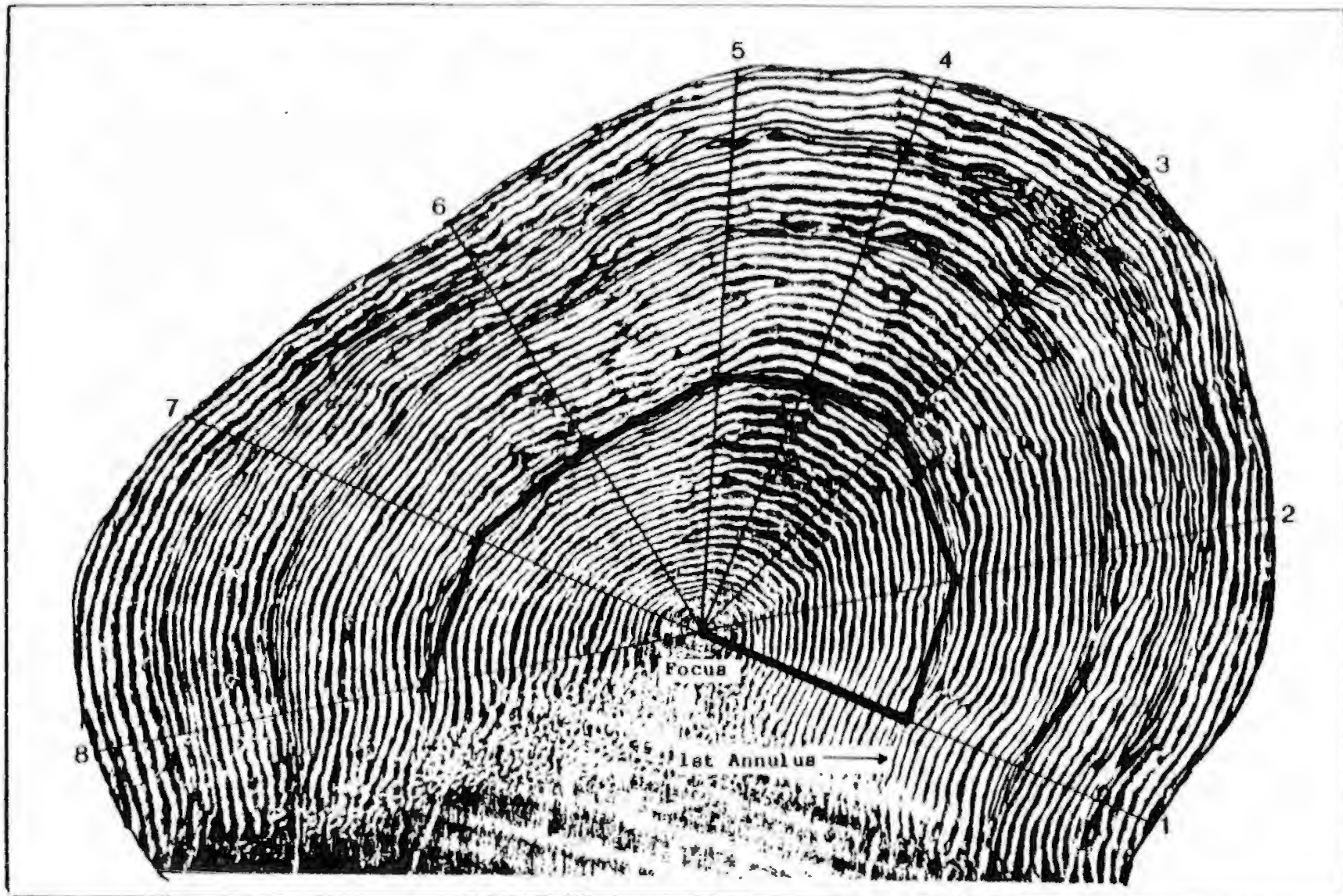

Figure 4. Chum salmon scale showing location of multiple axes and chords measured for linear discriminant analysis of Delta and Sheenjek River fall chum salmon, 1986.

Table 1. Age and sex composition of Yukon River fall chum salmon sampled from the District 1 commercial harvest and escapements to major spawning areas, 1986[a].

Location and Harvest or Estimation Method	Abundance Estimate	Sample Size	Sex		Brood Year and Age Group 1983 0.2	1982 0.3	1981 0.4	1980 0.5	Total
District 1 Commercial Gillnet Harvest	59,352	1,366	Female	Percent	3.7	44.5	11.6	0.4	60.2
				Number	2,198	26,429	6,898	224	35,749
			Male	Percent	2.8	28.1	8.8	0.1	39.8
				Number	1,670	16,656	5,239	38	23,603
			Combined	Percent	6.5	72.6	20.4	0.4	100.0
				Number	3,868	43,085	12,137	262	59,352
				SE	397	717	648	106	
Toklat River Expanded Multiple Surveys	18,903	445	Female	Percent	2.0	37.8	7.2	0.2	47.2
				Number	382	7,136	1,359	42	8,921
			Male	Percent	0.9	42.0	9.2	0.7	52.8
				Number	170	7,944	1,742	127	9,983
			Combined	Percent	2.9	79.8	16.4	0.9	100.0
				Number	552	15,080	3,101	170	18,903
				SE	151	360	332	85	
Delta River Expanded Multiple Surveys	6,703	442	Female	Percent	5.0	39.4	7.7	0.2	52.3
				Number	334	2,638	516	15	3,503
			Male	Percent	2.7	37.8	7.2	0.0	47.7
				Number	182	2,533	485	0	3,200
			Combined	Percent	7.7	77.1	14.9	0.2	100.0
				Number	516	5,171	1,001	15	6,703
				SE	85	134	114	14	
Sheenjek River Sonar Count	83,197	442	Female	Percent	5.0	22.2	27.6	0.5	55.2
				Number	4,141	18,447	22,964	376	45,928
			Male	Percent	3.2	19.0	22.4	0.2	44.8
				Number	2,635	15,811	18,635	188	37,269
			Combined	Percent	8.1	41.2	50.0	0.7	100.0
				Number	6,776	34,258	41,599	564	83,197
				SE	1,081	1,950	1,981	330	
Fishing Branch River Weir Count	31,173	629	Female	Percent	2.7	26.9	24.5	0.2	54.2
				Number	843	8,376	7,632	50	16,901
			Male	Percent	1.3	21.3	22.3	1.0	45.8
				Number	396	6,641	6,938	297	14,272
			Combined	Percent	4.0	48.2	46.7	1.1	100.0
				Number	1,239	15,017	14,570	347	31,173
				SE	79	622	621	130	
Mainstem Yukon River[b] Minto Area Peak Aerial Survey Index of Abundance	825	41	Female	Percent	4.9	46.3	19.5	0.0	70.7
			Male	Percent	0.0	17.1	12.2	0.0	29.3
			Combined	Percent	4.9	63.4	31.7	0.0	100.0
				SE	3.4	7.6	7.4	0.0	
Kluane River[b] Peak Aerial Survey Index of Abundance	16,686	181	Female	Percent	0.6	47.0	6.6	0.0	54.1
			Male	Percent	0.0	34.3	11.1	0.6	45.9
			Combined	Percent	0.6	81.2	17.7	0.6	100.0
				SE	0.6	2.9	2.8	0.6	

[a] All samples collected by carcass survey, except for Sheenjek River (beach seine) and Fishing Branch River (live sampled at weir). Those spawning areas with total season population estimates are apportioned by age and sex, while only the sample composition is presented for those areas with only indices of abundance.

[b] Preliminary results from a mark and recapture study conducted by DFO indicated a total of 87,990 fish crossed the U.S./Canada border in the mainstem Yukon River.

Table 2. Classification accuracies of linear discriminant models for age-0.3 Yukon River fall chum salmon, 1986.

Actual River of Origin	Sample Size	Classified River of Origin: Toklat	Delta	Sheenjek	Fishing Branch	Canadian Yukon
Toklat	201	0.308	0.234	0.194	0.129	0.134
Delta	189	0.169	0.434	0.074	0.153	0.169
Sheenjek	153	0.085	0.085	0.556	0.209	0.065
Fishing Branch	201	0.129	0.104	0.219	0.418	0.129
Canadian Yukon	197	0.152	0.284	0.152	0.193	0.218
		Mean Classification Accuracy =				0.387

Variables in the analysis: 1, 34, 68, 54, 15, 62.
(Refer to Appendix B.1)

Actual River of Origin	Sample Size	Classified River of Origin: Tanana	Porcupine	Canadian Yukon
Tanana	262	0.355	0.271	0.374
Porcupine	224	0.201	0.607	0.192
Canadian Yukon	197	0.294	0.198	0.508
		Mean Classification Accuracy =		0.490

Variables in the analysis: 1, 63, 34, 5, 14.
(Refer to Appendix B.1)

Table 3. Classification accuracies of linear discriminant models for age-0.4 Yukon River fall chum salmon, 1986.

Actual River of Origin	Sample Size	Classified River of Origin: Toklat	Delta	Sheenjek	Fishing Branch	Canadian Yukon
Toklat	64	0.406	0.078	0.266	0.078	0.172
Delta	63	0.238	0.111	0.254	0.095	0.302
Sheenjek	181	0.182	0.122	0.359	0.122	0.215
Fishing Branch	200	0.255	0.110	0.295	0.105	0.235
Canadian Yukon	200	0.175	0.125	0.225	0.055	0.420
		Mean Classification Accuracy =				0.280

Variables in the analysis: 81, 14, 74.
(Refer to Appendix B.2)

Actual River of Origin	Sample Size	Classified River of Origin: Tanana	Porcupine	Canadian Yukon
Tanana	84	0.452	0.262	0.286
Porcupine	265	0.242	0.494	0.264
Canadian Yukon	200	0.260	0.290	0.450
		Mean Classification Accuracy =		0.466

Variables in the analysis: 81, 85, 14, 74, 34.
(Refer to Appendix B.2)

Table 4. Classification accuracies of linear discriminant models for age-0.3 and-0.4 Yukon River summer chum and fall chum salmon, 1986.

Age-0.3		Classified Run of Origin	
Actual Run of Origin	Sample Size	Summer Chum Salmon	Fall Chum Salmon
Summer Chum Salmon	262	0.632	0.368
Fall Chum Salmon	197	0.290	0.710
		Mean Classification Accuracy =	0.671

Variables in the analysis: 4, 6, 10.
(Refer to Appendix B.3)

Age-0.4		Classified Run of Origin	
Actual Run of Origin	Sample Size	Summer Chum Salmon	Fall Chum Salmon
Summer Chum Salmon	189	0.688	0.312
Fall Chum Salmon	200	0.370	0.630
		Mean Classification Accuracy =	0.659

Variables in the analysis: 70, 39, 73, 24, 59,74.
(Refer to Appendix B.3)

Table 5. Classification accuracies of linear discriminant models using single axis measurements and multiple axis measurements for age-0.3 Toklat and Sheenjek River fall chum salmon, 1986.

<u>Single Axis</u> Actual River of Origin	Sample Size	Classified River of Origin: Toklat	Classified River of Origin: Sheenjek
Toklat	42	<u>0.714</u>	0.286
Sheenjek	42	0.262	<u>0.738</u>
		Mean Classification Accuracy =	0.726

Variables in the analysis: 61.
(Refer to Appendix B.1)

<u>Multiple Axes</u> Actual River of Origin	Sample Size	Classified River of Origin: Toklat	Classified River of Origin: Sheenjek
Toklat	42	<u>0.690</u>	0.310
Sheenjek	42	0.310	<u>0.690</u>
		Mean Classification Accuracy =	0.690

Variables in the analysis: Sum of chord distances.

<u>Combined</u> Actual River of Origin	Sample Size	Classified River of Origin: Toklat	Classified River of Origin: Sheenjek
Toklat	42	<u>0.810</u>	0.190
Sheenjek	42	0.286	<u>0.714</u>
		Mean Classification Accuracy =	0.762

Variables in the analysis: 61, Sum of chord distances.
(Refer to Appendix B.1)

APPENDIX A: PREVIOUS INVESTIGATIONS

Appendix A.1. Classification accuracies of linear discriminant models for age-0.2 and -0.3 Yukon River fall chum salmon, 1974.

Age-0.2[a,b] Actual River of Origin	Sample Size	Classified River of Origin: Sheenjek	Toklat
Sheenjek	58	0.621	0.379
Toklat	81	0.284	0.716
		Mean Classification Accuracy =	0.676

Age-0.3[a,b] Actual River of Origin	Sample Size	Classified River of Origin: Sheenjek	Toklat
Sheenjek	34	0.618	0.382
Toklat	55	0.236	0.764
		Mean Classification Accuracy =	0.708

Age-0.3[b,c] Actual River of Origin	Sample Size	Classified River of Origin: Fishing Branch	Canadian Yukon
Fishing Branch	38	0.789	0.211
Canadian Yukon	43	0.279	0.721
		Mean Classification Accuracy =	0.753

Pooled Ages[d,e] Actual River of Origin	Sample Size	Classified River of Origin: Tanana	Porcupine	Canadian Yukon
Tanana	189	0.439	0.280	0.333
Porcupine	145	0.359	0.455	0.186
Canadian Yukon	96	0.198	0.333	0.469
			Mean Classification Accuracy =	0.441

[a] From Bethe (1978).
[b] Self classification accuracy.
[c] From P.V. Krasnowski (personal communications, ADF&G, Anchorage).
[d] From D.N. McBride (peronal communications, ADF&G, Anchorage).
[e] Leaving-one-out classification accuracy.

Appendix A.2. Classification accuracies of linear discriminant models for Yukon River fall chum salmon, 1975[a,b].

Pooled Ages Actual River of Origin	Sample Size	Classified River of Origin Tanana	 Porcupine	 Canadian Yukon
Tanana	100	0.530	0.260	0.210
Porcupine	100	0.090	0.680	0.230
Canadian Yukon	51	0.431	0.255	0.314
	Mean Classification Accuracy =			0.546

[a] From D.N. McBride (personal communications, ADF&G, Anchorage).

[b] Leaving-one-out classification accuracy.

Appendix A.3. Classification accuracies of linear discriminant models for age-0.3 Yukon River fall chum salmon, 1976[a,b].

Age 0.3 Actual River of Origin	Sample Size	Classified River of Origin Sheenjek	Toklat	Delta
Sheenjek	44	0.886	0.045	0.068
Toklat	51	0.098	0.667	0.235
Delta	36	0.167	0.111	0.722
		Mean Classification Accuracy =		0.756

a From Bethe (1978).
b Self classification accuracies.

Appendix A.4. Classification accuracies of linear discriminant models for age-0.3 Yukon River fall chum salmon, 1977[a].

Age-0.3[b] Actual River of Origin	Sample Size	Classified River of Origin: Sheenjek	Toklat	Delta
Sheenjek	35	0.543	0.314	0.143
Toklat	34	0.294	0.529	0.177
Delta	60	0.117	0.200	0.683
		Mean Classification Accuracy =		0.605

Age-0.3[c] Actual River of Origin	Sample Size	Classified River of Origin: Sheenjek	Toklat	Delta	Fishing Branch
Sheenjek	40	0.425	0.175	0.150	0.250
Toklat	40	0.200	0.550	0.050	0.200
Delta	40	0.100	0.100	0.750	0.050
Fishing Branch	37	0.135	0.243	0.081	.541
		Mean Classification Accuracy =			0.567

[a] From Krasnowski (personal communications, ADF&G, Anchorage).
[b] Test sample set classification accuracy.
[c] Self classification accuracy.

Appendix A.5. Classification accuracies of linear discriminant models for Yukon River fall chum salmon, 1982[a,b].

Pooled Ages Actual River of Origin	Sample Size	Classified River of Origin: Tanana	Porcupine	Canadian Yukon
Tanana	153	0.471	0.255	0.274
Porcupine	114	0.237	0.535	0.228
Canadian Yukon	201	0.279	0.214	0.508
		Mean Classification Accuracy =		0.502

[a] From McBride (personal communications, ADF&G, Anchorage).

[c] Leaving-one-out classification accuracy.

APPENDIX B: SCALE VARIABLES SCREENED

Appendix B.1. Scale variables screened for linear discriminant function analysis of age-0.3 Yukon River fall chum salmon, 1986.

Variable	Freshwater Growth Zone
1	Number of circuli (NCFW)[a]
2	Width of zone (SFW)[b]
Variable	**1st Marine Growth Zone**
3	Number of circuli (NC1OGZ)[c]
4	Width of zone (S1OGZ)[d]
5 (18)	Distance, end freshwater (C0) to circulus 2 (C2)
6	Distance, C0-C4
7 (20)	Distance, C0-C6
8	Distance, C0-C8
9 (22)	Distance, C2-C4
10	Distance, C2-C6
11 (24)	Distance, C2-C8
12	Distance, C4-C6
13 (26)	Distance, C4-C8
14	Distance, C(NC1OGZ -4) to end of zone
15 (28)	Distance, C(NC1OGZ -2) to end of zone
16	Distance, C2 to end of zone
17	Distance, C4 to end of zone
18-28	Relative widths, (variables 5-15)/S1OGZ
29	Average interval between circuli, S1OGZ/NC1OGZ
30	Number of circuli in first 3/4 of zone
31	Maximum distance between 2 consecutive circuli
32	Relative width, (variable 31)/S1OGZ
Variable	**2nd Marine Growth Zone**
33	Number of circuli (NC2OGZ)[e]
34	Width of zone (S2OGZ)[f]
35 (48)	Distance, end 1st marine zone (C0) to circulus 2 (C2)
36	Distance, C0-C4
37 (50)	Distance, C0-C6
38	Distance, C0-C8
39 (52)	Distance, C2-C4
40	Distance, C2-C6
41 (54)	Distance, C2-C8
42	Distance, C4-C6
43 (56)	Distance, C4-C8
44	Distance, C(NC2OGZ -4) to end of zone
45 (58)	Distance, C(NC2OGZ -2) to end of zone
46	Distance, C2 to end of zone
47	Distance, C4 to end of zone
48-58	Relative widths, (variables 35-45)/S2OGZ
59	Average interval between circuli, S2OGZ/NC2OGZ
60	Number of circuli in first 3/4 of zone
61	Maximum distance between 2 consecutive circuli
62	Relative width, (variable 61)/S2OGZ

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Appendix B.1. (page 2 of 2).

Variable	1st Annual Zone
63	Total number circuli to supplementary check (NCFW+ NC1OGZ)
64	Total width to supplementary check (SFW+S1OGZ)
65	Total number circuli 1st annular zone (NCFW+NC1OGZ+ NC2OGZ)
66	Total width 1st annular zone (SFW+S1OGZ+S2OGZ)
67	Relative width, SFW/Var 66
68	Relative width, S1OGZ/Var 66
69	Relative width, S2OGZ/Var 66
Variable	**2nd Annular Zone**
70	Width of zone (S2AZ)[g]

[a] Number of circuli, freshwater zone.
[b] Size (width) freshwater zone.
[c] Number of circuli, 1st ocean growth zone.
[d] Size (width) 1st ocean growth zone.
[e] Number of circuli, 2nd ocean growth zone.
[f] Size (width) 2nd ocean growth zone.
[g] Size (width) 2nd annular zone.

Appendix B.2. Scale variables screened for linear discriminant function analysis of age-0.4 Yukon River fall chum salmon, 1986.

Variable	Freshwater + 1st Ocean Growth Zone
1	Number of circuli (NCFW+NC1OGZ)[a]
2	Width of zone (SFW+S1OGZ)[b]
3	Distance, focus (C0) to circulus 3 (C3)
4 (20)	Distance, C0-C6
5	Distance, C0-C9
6 (22)	Distance, C0-C12
7	Distance, C0-C15
8 (24)	Distance, C3-C9
9	Distance, C3-C12
10 (26)	Distance, C3-C15
11	Distance, C6-C12
12 (28)	Distance, C6-C15
13	Distance, C9-C15
14 (30)	Distance, C(NCFW+NC1OGZ -6) to end of zone
15	Distance, C(NCFW+NC1OGZ -3) to end of zone
16	Distance, C3 to end of zone
17	Distance, C9 to end of zone
18	Distance, C15 to end of zone
19-31	Relative widths, (variables 3-15)/(SFW+S1OGZ)
32	Average interval circuli, (SFW+S1OGZ)/(NCFW+NC1OGZ)
33	Number of circuli in first 1/2 of zone
34	Minimum distance between 2 consecutive circuli
35	Maximum distance between 2 consecutive circuli
36	Relative width, (variable 34)/(SFW+S1OGZ)
37	Relative width, (variable 35)/(SFW+S1OGZ)
38	Number incremental distances less than 10
39	Number incremental distances between 10 and 20
40	Number incremental distances greater than 20
Variable	**2nd Ocean Growth Zone**
41	Number of circuli (NC2OGZ)[c]
42	Width of zone (S2OGZ)[d]
43	Distance, supplementary check (C0) to C3
44 (60)	Distance, C0-C6
45	Distance, C0-C9
46 (62)	Distance, C0-C12
47	Distance, C0-C15
48 (64)	Distance, C3-C9
49	Distance, C3-C12
50 (66)	Distance, C3-C15
51	Distance, C6-C12
52 (68)	Distance, C6-C15
53	Distance, C9-C15

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Variable	2nd Ocean Growth Zone
54 (70)	Distance, C(NC2OGZ -6) to end of zone
55	Distance, C(NC2OGZ -3) to end of zone
56	Distance, C3 to end of zone
57	Distance, C9 to end of zone
58	Distance, C15 to end of zone
59-71	Relative widths, (variables 43-55)/S2OGZ
72	Average interval between circuli, S2OGZ/NC2OGZ
73	Number of circuli in first 1/2 of zone
74	Minimum distance between 2 consecutive circuli
75	Maximum distance between 2 consecutive circuli
76	Relative width, (variable 74)/S2OGZ
77	Relative width, (variable 75)/S2OGZ
78	Number incremental distances less than 10
79	Number incremental distances between 10 and 20
80	Number incremental distances greater than 20
Variable	**Growth Zones Combined**
81	Number circuli 1st annular zone (NCFW+NC1OGZ+NC2OGZ)
82	Width of 1st annular zone, (SFW+S1OGZ+S2OGZ)
83	Average circulus width (variable 82/variable 81)
84	Relative width, SFW+S1OGZ/(SFW+S1OGZ+S2OGZ)
85	Width 1st+2nd annular zones (SFW+S1OGZ+S2OGZ+S2AZ[e])

[a] Number of circuli, freshwater + 1st ocean growth zone.
[b] Size (width) freshwater + 1st ocean growth zone.
[c] Number of circuli, 2nd ocean growth zone.
[d] Size (width) 2nd ocean growth zone.
[e] Size (width) 2nd annular zone.

Appendix B.3. Scale variables screened for linear discriminant function analysis of age-0.3 and -0.4 Yukon River summer chum vs. fall chum salmon, 1986.

Variable	1st Annular Zone
1	Number of circuli (NC1AZ)[a]
2	Width of zone (S1AZ)[b]
3	Distance, focus (C0) to circulus 3 (C3)
4 (20)	Distance, C0-C6
5	Distance, C0-C9
6 (22)	Distance, C0-C12
7	Distance, C0-C15
8 (24)	Distance, C3-C9
9	Distance, C3-C12
10 (26)	Distance, C3-C15
11	Distance, C6-C12
12 (28)	Distance, C6-C15
13	Distance, C9-C15
14 (30)	Distance, C(NC1AZ -6) to end of zone
15	Distance, C(NC1AZ -3) to end of zone
16	Distance, C3 to end of zone
17	Distance, C9 to end of zone
18	Distance, C15 to end of zone
19-31	Relative widths, (variables 3-15)/S1AZ
32	Average interval between circuli, S1AZ/NC1AZ
33	Number of circuli in first 1/2 of zone
34	Minimum distance between 2 consecutive circuli
35	Maximum distance between 2 consecutive circuli
36	Relative width, (variable 34)/S1AZ
37	Relative width, (variable 35)/S1AZ
38	Number incremental distances less than 10
39	Number incremental distances between 10 and 20
40	Number incremental distances greater than 20

Variable	2nd Annular Zone
41	Number of circuli (NC2AZ)[c]
42	Width of zone (S2AZ)[d]
43	Distance, beginning of zone (C0) to C3
44 (60)	Distance, C0-C6
45	Distance, C0-C9
46 (62)	Distance, C0-C12
47	Distance, C0-C15
48 (64)	Distance, C3-C9
49	Distance, C3-C12
50 (66)	Distance, C3-C15
51	Distance, C6-C12
52 (68)	Distance, C6-C15
53	Distance, C9-C15

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Appendix B.3. (page 2 of 2).

Variable	2nd Annular Zone
54 (70)	Distance, C(NC2AZ -6) to end of zone
55	Distance, C(NC2AZ -3) to end of zone
56	Distance, C3 to end of zone
57	Distance, C9 to end of zone
58	Distance, C15 to end of zone
59-71	Relative widths, (variables 43-55)/S2AZ
72	Average interval between circuli, S2AZ/NC2AZ
73	Number of circuli in first 1/2 of zone
74	Minimum distance between 2 consecutive circuli
75	Maximum distance between 2 consecutive circuli
76	Relative width, (variable 74)/S2AZ
77	Relative width, (variable 75)/S2AZ
78	Number incremental distances less than 10
79	Number incremental distances between 10 and 20
80	Number incremental distances greater than 20
Variable	**Annular Zones Combined**
81	Number circuli 1st + 2nd annular zones (NC1AZ+NC2AZ)
82	Width of 1st + 2nd annular zones, (S1AZ+S2AZ)
83	Average circulus width (variable 82/variable 81)
84	Relative width, S1AZ/(S1AZ+S2AZ)
85	Width 3rd annular zone (S3AZ)[e]
86	Total width 1st-3rd annular zones (S1AZ+S2AZ+S3AZ)

[a] Number of circuli, 1st annular zone.
[b] Size (width) 1st annular zone.
[c] Number of circuli, 2nd annular zone.
[d] Size (width) 2nd annular zone.
[e] Size (width) 3rd annular zone.

APPENDIX C: SCALE GROWTH MEASUREMENTS

Appendix C.1. Group means, standard errors, and one-way analysis of variance F-test for the number of circuli and incremental distance of salmon scale annular growth zone measurements from age-0.3 and -0.4 Yukon River chum salmon, 1986.

		1st Annular Zone						2nd Annular Zone		
		Number of Circuli			Incremental Distance			Incremental Distance		
Age	Stock Grouping	Mean	S.E.	F-Value	Mean	S.E.	F-Value	Mean	S.E.	F-Value
0.3	Toklat	27.68	0.12	27.470	490.56	3.20	13.778	292.76	2.44	5.278
	Delta	28.30	0.14		508.03	3.02		306.58	2.74	
	Sheenjek	26.73	0.13		484.26	2.79		303.22	2.73	
	Fishing Branch	26.99	0.11		489.06	2.55		307.29	2.80	
	Canadian Yukon	27.95	0.11		508.08	3.21		350.79	2.70	
	Tanana	27.83	0.11	32.841	494.40	2.73	16.086	296.25	2.28	4.862
	Porcupine	26.80	0.11		485.08	2.33		304.62	2.34	
	Canadian Yukon	27.95	0.11		508.08	3.21		305.79	2.70	
	Summer Chum Salmon	27.26	0.14	1.730	506.42	2.81	3.993			
	Fall Chum Salmon	27.51	0.12		498.41	2.82				
0.4	Toklat	26.17	0.24	13.066	477.92	4.99	4.452	283.60	3.743	3.326
	Delta	26.60	0.26		485.89	4.32		290.88	4.679	
	Sheenjek	26.20	0.12		471.55	2.42		300.87	2.583	
	Fishing Branch	26.08	0.12		477.18	2.42		294.39	2.638	
	Canadian Yukon	27.23	0.13		486.22	2.99		294.04	2.229	
	Tanana	26.41	0.22	19.874	482.95	4.12	5.837	284.51	3.25	5.968
	Porcupine	26.19	0.11		474.46	2.07		298.94	2.23	
	Canadian Yukon	27.23	0.13		486.22	2.99		294.05	2.23	
	Summer Chum Salmon	26.15	0.12	2.45	479.40	2.55	0.11	301.30	2.43	8.27
	Fall Chum Salmon	26.44	0.14		478.24	2.50		291.67	2.31	