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ORIGINS OF CHINOOK SALMON

IN THE YUKON RIVER FISHERIES, 1993

By

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Analysis of scale patterns and age composition ratio analysis of chinook salmon *Oncorhynchus tshawytscha* (Walbaum) from Yukon River escapements in Alaska and salmon tagging-study catches in Canada were used to construct classification models for assigning Yukon River District 1 and 2 commercial and subsistence harvests to run of origin. Linear discriminant models were used to estimate stock composition for age-1.3 and -1.4 fish in District 1 and 2 harvests. Observed age composition differences among escapements were used to estimate runs of origin for other age groups. District 3 and 4 commercial and subsistence harvests were assigned to run of origin using the estimated proportions obtained in the analysis of District 2 harvests combined with assignment of Koyukuk River subsistence harvests to the Middle Yukon Run based on geographic occurrence. Runs of origin for all other drainage harvests were estimated based on geographic occurrence. The total Yukon River harvest in 1993 was 175,205 chinook salmon, of which 65% was estimated to be the Upper Yukon Run, 13% the Middle Yukon Run, and 22% the Lower Yukon Run. The fraction of the District 1 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 displayed no consistent trends in District 1. In District 2 catches, fractions of the Upper and Lower Yukon Runs were relatively high in all periods while those of the Middle Yukon Run indicated no particular trend.

KEY WORDS: Chinook salmon, *Oncorhynchus tshawytscha*, stock separation, catch and run composition, linear discriminant function analysis, Yukon River

INTRODUCTION

Yukon River chinook salmon *Oncorhynchus tshawytscha* (Walbaum) have historically been harvested in a wide range of fisheries in both marine and fresh waters. Within the Yukon River returning adults are harvested in subsistence and personal use fisheries in Alaska, Aboriginal and domestic fisheries in Canada, and commercial and sport fisheries in Alaska and Canada (Figures 1, 2). Commercial harvests consist of fish sold in the round, numbers of fish involved in commercial roe production, and fish sold in the round by the Alaska Department of Fish and Game (ADF&G) from test fisheries in Districts 1, 2, and 6. Sport fisheries are confined primarily to the Tanana River drainage and Canada.

In the 20 years after statehood (1960-1979), the total harvest from all fisheries of Yukon River chinook salmon in both Alaska and Canada ranged from 77,250 to 169,607 and averaged 122,999 fish annually (JTC 1993). Beginning in 1980, annual harvests increased substantially. During the most recent 5-year period (1988 - 1992), annual catches from all fisheries averaged 176,658 fish. While chinook salmon are harvested virtually throughout the length of the Yukon River, the majority of the catch has been taken in commercial gillnet fisheries in Districts 1 and 2. The 1988-92 average commercial harvest in Districts 1 and 2 was 55% of total drainage harvest, and subsistence harvests in the two districts accounted for another 7%. Most of the subsistence harvest is taken with fish wheels and gillnets in Districts 4, 5, and 6. In 1993, commercial, subsistence, personal use, Aboriginal, domestic, and sport fishermen in Alaska and Canada harvested a total of 175,205 chinook salmon, of which 88,151 fish (50%) were taken by District 1 and 2 commercial fishermen.

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 in Alaska that drain the Andreafsky Hills and Kaltag Mountains between river miles 100 and 500, (2) Upper Koyukuk River and Tanana River tributaries in Alaska between river miles 800 and 1,100, and (3) tributary streams in Canada 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, respectively.

Evaluating stock productivities, spawning escapement goals, and management strategies requires information on the stock composition of the harvest. In addition, the U.S. and Canada are engaged in treaty negotiations concerning management and conservation of stocks spawned in Canada. Biological information on these stocks provides the technical basis for the negotiations.

Harvest estimates of western Alaskan and Canadian Yukon River chinook salmon in the Japanese high seas gillnet fisheries were made using scale pattern analysis (SPA; Rogers et al. 1984; Meyers et al. 1984; Meyers and Rogers 1985). Stock composition of Yukon River fisheries has been studied by the Alaska Department of Fish and Game to provide useful postseason information for management and conservation of the various runs of chinook salmon. For Yukon River chinook salmon, stock composition estimates derived from scale pattern analysis of the catch through time were first available for 1980 and 1981 District 1 harvests (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, 1990; Merritt et al. 1988; Merritt 1988; Schneiderhan and Wilcock 1992; Schneiderhan 1993, 1994, *In press*).

The objective of this study was to classify all chinook salmon harvests to run of origin.

METHODS

Age Determination

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 in an area transected by a diagonal 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. Ages were reported in European notation.

Catch Sampling

Scales were collected from commercial catches in all fishing districts except District 3. Subsistence catches in Districts 4, 5, and 6 were also sampled. District 3 was not targeted for sampling because relatively few fish were harvested in that portion of the Yukon River and access was difficult. Salmon harvested in District 3 and delivered to buyers in District 2 could at times have comprised a small fraction of the District 2 catch sample. For purposes of this report, I assumed that subsistence fishing in Districts 1 and 2 occurred prior to or near the beginning of commercial fishing and could therefore be described using the Period 1 commercial sample data for each district. In addition samples were collected from salmon harvested by the District 1 ADF&G gillnet test fishing crew and from fish captured in fish wheels by personnel from the Canadian Department of Fisheries and Oceans (DFO) in Yukon, Canada. Some preliminary analyses included the District 1 test fishing samples, but those data were not needed in the final analysis. Escapement samples were collected in Alaska from the Andreafsky, Anvik, Chena, and Salcha Rivers.

Escapement Sampling

Scale samples were collected during the period of peak spawner mortality from the Andreafsky, Anvik, Chena, and Salcha Rivers in Alaska. Carcasses were the primary source of samples; however, some were obtained from live fish captured with spears or other methods. Canadian tributaries were not sampled in 1993.

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 or mark/recapture spawning population estimates.

Estimation of Catch Composition

Linear discriminant function analysis (Fisher 1936) of scale patterns data, observed differences in age composition between escapements, and geographic occurrence of catches were used to estimate runs of origin for 1993 Yukon River chinook salmon catches.

Scale Pattern Analysis

Escapement samples from Alaska and salmon tagging study samples from Canada provided scales of known origin that were used to build linear discriminant functions (LDF). Scales representing the Lower Yukon Run were selected from samples collected on the Andreafsky and Anvik Rivers. The Middle Yukon Run was represented by scales from the Chena and Salcha Rivers. The Upper Yukon Run was represented by samples collected from test fish wheels which were operated in conjunction with the DFO tagging study at White Rock and Sheep Rock sites located in Canada between 6 and 12 mi (10-20 km) upstream from the U.S.-Canada border.

Scales from the lower river commercial gillnet fishery catch samples were classified to run of origin using the discriminant functions. Only scales with one freshwater annulus (age 1.) were considered for digitizing and subsequent analysis. Run proportions of fish aged 1.3 and 1.4 were estimated for District 1 and 2 catches for all fishing periods. The sampling plan was designed to provide sample sizes of 50 or more for each major age class and harvest strata; however, in order to classify harvests to run of origin by period, smaller samples were sometimes used. Samples were successfully obtained from harvests in all commercial periods in Districts 1 and 2 in 1993.

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). Measurements taken along an axis located at the approximate apex of circuli formations in the freshwater growth zone were recorded by a microcomputer-controlled digitizing system.

The apex of circuli formations tends to differ between 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 annulus 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 pattern 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-eight scale characters (variables, Appendix A) were calculated from the basic incremental distances and circuli counts. Run-of-origin standards (pooled rivers) were weighted by aerial abundance estimates for the Lower Yukon Run and by spawning population estimates from mark/recapture studies on the Chena and Salcha Rivers for the Middle Yukon Run. Run-of-origin models were constructed for age-1.3 and -1.4 fish.

Selection of scale characters for linear discriminant functions 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-1.3 and -1.4 fish in the District 1 and 2 catches were estimated for each fishing period using the procedures described above. The resultant estimates were adjusted for misclassification errors using a constrained maximum likelihood procedure similar to that described by Hoenig and Heisey (1987). Variances were approximated using an infinitesimal jackknife procedure described by Millar (1987).

Results of the age-specific scale patterns analysis by fishing period were summed to estimate total contribution by run of origin for age-1.3 and -1.4 chinook salmon to the District 1 and 2 commercial catches.

Age Composition Ratio Analysis

Age classes in the District 1 and 2 commercial catches which were not classified by SPA were apportioned to run of origin based on escapement age composition ratios. An assumption implicit in this calculation is that fisheries did not differentially harvest stocks or age groups. This assumption may have been violated, but any bias introduced was believed to be minor. Escapement age composition data, weighted by aerial survey estimates, were used to compute ratios of proportional abundance (R_{cia}) for each run:

$$\hat{R}_{cia} = \frac{\hat{E}_{ci}}{\hat{E}_{ca}}, \qquad (1)$$

where:

c = run of origin, e.g. Lower, Middle, or Upper Yukon Run;

a = age class in the escapement which was classified to run of origin by SPA, e.g., age 1.3 or 1.4;

i = unclassified (unknown proportion by run) escapement age class which was determined to be an analog of age class a;

$\hat{E}_{ca}$ = estimated proportion of fish of age class a in run c escapement samples;

$\hat{E}_{ci}$ = estimated proportion of fish of age class i in run c escapement samples.

In previous years the proportion of age-1.2 and -2.2 fish in escapement samples have tended to decrease as the distance upriver increased; therefore, proportions for the age class were divided by the proportion of age-1.3 fish, which analogously have displayed a similar tendency and were from the same brood year. Proportions of age-2.3, -1.5, -2.4, -1.6, and -2.5 fish were similarly treated as analogs of age-1.4 fish because these ages have historically increased with distance upriver. Further, age-2.3 fish were treated as analogs of age-1.4 fish because both were from the same brood year. Age-0. fish were treated the same as age-1. fish from the same brood year.

The catch of each age class for each run was approximated by multiplying the run- and age-specific rate of proportional abundance for each unclassified age class by the estimated catch, by run, of the analogous age class (e.g., age 1.3 or 1.4).

Run- and age-specific contribution rates were then estimated by dividing the approximated catch-by-run of an unclassified age class by the total approximated catch of the same age class. Multiplying the run- and age-specific contribution rates by the catch of the age class (from sample age compositions and reported commercial harvests) yielded age-specific run contribution estimates, or

$$\hat{F}_{ci} = \frac{\hat{R}_{cia} N_{ca}}{\sum_{c=1}^{n} \hat{R}_{cia} N_{ca}}, \qquad (2)$$

where:

$\hat{F}_{ci}$ = estimated proportion of fish of run c in the total catch of age class i, (e.g., N_i),

N_{ca} = catch of age group a (where a was either age 1.3 or 1.4 in run c), and

n = number of runs or 3.

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

$$\hat{N}_{ci} = \hat{F}_{ci} \cdot N_i, \qquad (3)$$

where:

$\hat{N}_{ci}$ = catch of age class i in run c and

N_i = total catch of age class i.

Estimation of Catch Composition by Fishery

Estimates of run composition from SPA and differential age composition analysis were used to classify District 1 and 2 commercial catches by period. Classifications of Districts 1 and 2 subsistence catches were based on estimates of run composition from SPA and differential age composition analysis of commercial harvests in each district. The proportions by age class and run obtained through analysis of total

District 2 commercial and subsistence catches were then used to classify commercial and subsistence catches in Districts 3 and 4.

Catch Composition Based on Geographical Segregation

Subsistence harvests in the upper Koyukuk River in District 4 and Commercial and subsistence harvests in District 5, District 6, and Yukon Territory were classified to run of origin based on geographical segregation. The subsistence harvests in the upper Koyukuk River were assumed to be from the Middle Yukon Run because scale patterns of upper Koyukuk fish were most like those of middle river fish in years when samples were available for testing. The entire District 5 harvest was assumed to be from the Upper Yukon Run because (1) most of the District 5 catch occurred above the confluence of the Tanana River, and (2) aerial survey counts of chinook salmon spawning in the Porcupine and Chandalar River drainages, totaling less than 100 fish for each year since 1980, are the only documented chinook salmon spawning concentrations between the Tanana River confluence and the Yukon Territory fishery centered in Dawson. This assumption was known to be violated because a small but unknown proportion of the District 5 subsistence harvest was taken on the south bank below the Tanana River confluence. Those fish were believed to be mostly of Tanana River (District 6) origin; however, the relatively small numbers of fish in the harvest created only a negligible bias. The bias which was introduced in that manner affected the results of this study by providing a small overestimate of the Upper Yukon Run and a corresponding underestimate of the Middle Yukon Run.

The entire District 6 harvest was considered to be from the Middle Yukon Run because neither Lower nor Upper Yukon Runs were considered to be present in the Tanana River. The Yukon Territory harvest was assigned to the upper run because neither lower nor middle runs were considered to be present in the Yukon Territory.

RESULTS

Escapement Age Composition

Yukon River chinook salmon escapement age compositions in 1993 exhibited a variety of trends and contrasts (Table 1). In contrast to 1992, the sample size objective for the Andreafsky River was achieved and sex and size biases were not considered problematic. Age-1.3 fish were typically less abundant than age 1.4 fish in Lower and Upper Yukon River escapements. In middle river escapements the opposite was true. The large proportion of age 1.3 relative to age 1.4 in the Middle Yukon Run is reverse of the expected age class ratio. Unusually large proportions of age 1.2 were present in Lower, Middle, and Upper Yukon River escapements. Generally, the expected trend for the proportion of older fish to increase progressively upriver was reversed; this was similar to 1992 and dissimilar to 1991 when the expected trend was last noted, though less pronounced than usual. More specifically, proportions of ages 1.4 and 1.5 were larger in the Andreafsky and Anvik Rivers than in tributaries farther up in the Yukon River drainage. The proportion of age-1.4 fish in the middle river tributaries was somewhat lower than usual for the second year in a row. Samples of Upper Yukon Run fish from the White Rock and Sheep Rock sites exhibited an unusually small proportion of age-1.4 fish, also for the second year in a row. As in most other years, the largest proportion of age-2. (three winters in freshwater) fish was attributed to the Upper Yukon Run, whereas relatively few age-2. fish were attributed to Lower or Middle Yukon Runs.

Classification Accuracies of Run of Origin Models

Typical of past years, mean classification accuracy of the 3-way, run-of-origin model for age 1.3 was 73.4% and for age 1.4 was 75.2% (Table 2). Also similar to past years, the lower river standard showed the greatest classification accuracy for age 1.3 (80.9%), as well as for age 1.4 (84.3%). The accuracy of classification of the middle run standards was similar to or somewhat better than usual: 77.3% for age 1.3 and 71.4% for age 1.4. Upper river standards reflected relatively low classification accuracies similar to most past years: 62.1% for age 1.3 and 69.9% for age 1.4. Upper river standards most often misclassified to the Middle Yukon Run (23.7% for age 1.3 and 21.2% for age 1.4), and middle river standards most often misclassified to the Upper Yukon Run (15.2% for age 1.3 and about 21.4% for age 1.4).

Catch Composition

Scale Pattern Analysis

The scale measurement characters (Appendix A) that were most powerful in distinguishing between the three runs of origin for age 1.3 were (1) variable 67, the freshwater annular zone divided by the total width of freshwater growth zones, (2) variable 8, the distance from circuli 2 to the circuli 6 in the first freshwater annular zone, and (3) variable 78, the distance from circuli 3 to circuli 9 in the first marine annular zone (Appendix B). Variables 61, 14, and 75 (Appendix B) provided somewhat less discrimination to the model.

The primary distinguishing characters for age 1.4 in order of selection were (1) variable 67, described above, (2) variable 7, the distance from circuli 2 to circuli 4 in the first freshwater annular, and (3) variable 61, the number of circuli in the freshwater plus growth zone. Variables 97 and 103 (Appendix B) were also selected. Measurements of freshwater growth typically accounted for most of the discriminatory power in both models. Group means and standard errors for the number of circuli and width of the first freshwater annular, plus growth, and marine annular zones are listed in Appendix C.

Proportion of Catch

The majority of the commercial chinook salmon catch in Districts 1 and 2 was taken in the first three fishing periods. Upper Yukon Run fish comprised the largest proportion of the District 1 commercial harvest of age-1.3 chinook salmon in periods 1, 2, and 5. Upper run fish comprised the largest proportion of District 1 harvests of age 1.4 in periods 1 and 2 (Table 3). Somewhat differently, in District 2 Upper Yukon Run fish were the strongest segment of the catch of age 1.3 in periods 1 - 4 and closely approached the Middle Yukon Run as the strongest segment in period 5, while age-1.4 Upper Yukon Run fish only slightly dominated in periods 1, 3, and 5 (Table 4). In District 1 where the expected trend for Upper Yukon Run fish to dominate early periods and gradually decrease in later periods was most apparent, the switch in dominance occurred for both ages in the third period on 21 June (Table 3). Run contribution estimates through time in District 1 (Figures 4, 5) generally demonstrated increasing proportions of Lower Yukon fish and decreasing proportions of Upper Yukon fish also seen in past years. Unlike prior years, however, the proportion of Lower Yukon Run fish in District 2 appears to vary considerably in successive periods for age 1.3 while it appears to decrease for age 1.4 (Figure 6). District 1 and 2 proportions (Figures 4, 6) and harvests (Figures 5, 7) of Middle Yukon fish demonstrated no clear overall trend in relative abundance.

The estimated District 1 commercial catch of age-1.3 and -1.4 fish combined was 14,136 (32.9%) Lower, 6,685 (15.6%) Middle, and 22,148 (51.5%) Upper Yukon Run (Table 5). In District 2 the estimated age-1.3 and -1.4 combined catch was 13,154 (40.1%) Lower, 6,872 (20.9%) Middle, and 12,789 (39.0%) Upper Yukon Run (Table 6).

Classification by SPA Analysis

A total of 75,785 age-1.3 and -1.4 fish (43.2% of the total drainage harvest) from District 1 and 2 commercial catches were directly classified to run of origin based on results of scale pattern analysis. There were 38,703 (22.1% of the total drainage harvest) age-1.3 and -1.4 fish in Districts 1 and 2 subsistence harvests and Districts

3 and 4 commercial and subsistence harvests that were indirectly classified based on the scale pattern analysis.

Classification by Differential Age Composition Analysis

The remaining age classes (0.2, 1.1, 0.3, 1.2, 0.4, 2.2, 2.3, 1.5, 2.4, and 2.5) from Districts 1, 2, 3, and 4 commercial and subsistence catches contributed 16,242 fish (9.3%) to the total drainage harvest (Table 7). With the exception of 460 fish taken in the Koyukuk River subsistence fishery, they were classified to run of origin by applying differences in escapement age composition in each run to classifications derived from the analogous major age class through scale pattern analysis, e.g., age 1.3 or 1.4.

Classification by Geographical Analysis

The Koyukuk River subsistence harvest of 460 fish in District 4 is represented in the numbers of fish reported in the above section on age composition analysis; however, the Koyukuk fish were classified to the Middle River Run based on geographical segregation. Additionally, a total of 44,549 fish (25.4% of total drainage harvest) in Districts 5, 6, and Yukon Territory was classified to run of origin based on geographical segregation. District 5 and Yukon Territory commercial, subsistence, personal use, Aboriginal, domestic, and sport harvests were assumed to be Upper Yukon fish. Commercial, subsistence, personal use, and sport harvests in District 6 (Table 7) were classified entirely to the Middle Yukon Run.

Total Harvest

The commercial and subsistence harvest from the entire Yukon River drainage of 175,205 chinook salmon was classified to run of origin (Table 7) based on (1) findings of the scale patterns analysis of age-1.3 and -1.4 fish in District 1 and 2 commercial catches, (2) age composition analysis of the remaining age classes, (3) assumptions concerning unsampled fisheries, and (4) stock origins based on geographical segregation. The Upper Yukon Run was the largest estimated run component and contributed 113,230 fish or 64.6% of the total drainage harvest. The Lower Yukon Run was next in abundance at 39,023 fish (22.3%), followed by the Middle Yukon Run at 22,952 fish (13.2%).

DISCUSSION

Proportions of total drainage harvest that were attributed to each run were typical of most other years (Table 8). Estimates of the Upper Yukon Run component have ranged from 35.4% in 1984 to 67.9% in 1986, with an unweighted average of 55.9% since 1982. The proportion of Upper Yukon Run fish in 1993 was the third highest on record.

The large catch proportions of age-1.4 chinook in Districts 1 (64%) and 2 (63%) in 1993 were probably due in part to the high ratio of unrestricted to restricted mesh-size periods, e.g., 10:1 for both districts combined. Age 1.4 in the total harvest is usually composed of relatively more Upper Yukon Run fish than of other major age classes. Therefore, it is likely that the catches of age 1.4 in Districts 1 and 2 accounted for much of the increased proportion of Upper Yukon Run fish in the total drainage harvest. A similar situation occurred in 1992.

Chinook salmon return and harvest dynamics appear to have been relatively stable in the Yukon River since the early 1980's. Current guideline harvest ranges were implemented in 1981 and can be partially credited with providing stable harvests during that time. Commercial chinook salmon harvests in the lower Yukon Area during that time included a component of age 1.3 and younger salmon which were primarily harvested during restricted mesh-size periods. Those periods were allowed to specifically target chum salmon; however, the smaller mesh size also resulted in an increased proportion of age-1.3 and younger chinook salmon in the district commercial harvest. Because of recent poor summer chum salmon runs, there has been a reduction in the number of restricted mesh-size openings which have been allowed. Season harvests from predominately unrestricted mesh-size openings are comprised of proportionally more larger, older chinook salmon. Because a majority of these large, older-age chinook are female, a sustained harvest policy will increase the harvest of female salmon. Assuming that optimum production is not being exceeded, increased harvests of the female component of the run will negatively affect the quality of the escapement and, ultimately, the productivity of Yukon chinook salmon stocks. Therefore, in years when the number of commercial restricted mesh-size openings are curtailed because of chum salmon conservation concerns, managers should consider reducing the overall chinook salmon harvest so numbers of female salmon in the escapement and the consequent productivity of the stocks can be sustained.

Attainment of sample size objectives presented in the annual sampling plan is a fair measure of operational success. For all escapements which contribute to the standard three-way LDF classification model, sample sizes were fair to excellent both quantitatively and qualitatively. Acceptable quality depends on environmental, biological, and sampling technique factors. When the expected rejection rate is exceeded for scale specimens, the quantity of acceptable specimens becomes problematic. The rejection rate due to sampling technique is a key factor in determining sample sizes. In order to optimize sampling effort, sampling technique must also be optimized; therefore, the production of good quality samples will continue to be emphasized in sampling plans.

In 1992 District 2 catches were sampled only during unrestricted mesh-size periods. Because the schedule of District 2 mesh-size restrictions is often quite different from that of District 1, there was no logical data on which to base age compositions for those periods. The 1993 sampling plan was changed to include sampling for all District 2 fishing periods (coincidentally, there were no District 2 restricted mesh periods) so the resulting analysis would not require the same weak assumptions. Because the combined District 1 and 2 harvest is the largest single proportion of the total drainage harvest, it continues to be important to acquire adequate samples from all periods in both districts. Future sampling plans should include sampling at least 200 chinook salmon from District 2 harvests taken with restricted mesh-size gear.

Sampling upper Yukon tributaries in Canada is of continuing concern. The Upper Yukon Run is sampled in Canada near the U.S.-Canada border at the DFO tagging project sites. Total abundance estimates for the Upper Yukon Run have been obtained from that study, and scales taken from chinook salmon have provided the Upper Yukon Run scale pattern standard when commercial harvest samples were inadequate or unavailable, as in 1993. For assignment of harvests to run of origin, the approach of using samples from the DFO mainstem Yukon River test fish wheels to build run-of-origin models assumes that those samples are representative of the run of Canadian-spawned chinook salmon. Test fish wheels may not catch all sizes of chinook salmon and all component stocks in proportion to their abundance. Therefore, appropriately weighted escapement samples, such as those used for the Lower and Middle Yukon Runs, could improve the construction of the Upper Yukon Run stock composition model. Unfortunately, escapement sampling is not conducted for the Upper Yukon Run stock standard. At this time the scales collected from tagging fish wheel catches are accepted as the best compromise available. The dominant age classes which are modeled for the SPA analysis are adequately represented in catches from the tagging study fish wheels and the sample is assumed to represent age and stock compositions in Canadian harvests, as well as total Upper Yukon Run escapements.

Failure to obtain appropriate sample sizes from DFO to adequately represent the Upper Yukon Run would seriously weaken or invalidate the SPA analysis. Curtailment of harvest and escapement sampling effort in Canada by DFO and ADF&G highlights the importance of the DFO test fish wheel scale samples as the only remaining source for the Upper Yukon Run chinook SPA stock standard and for sex and age composition of salmon in Canada. Prior to 1991, ADF&G mounted an extensive effort in cooperation with the U.S. Fish and Wildlife Service and DFO to sample Yukon River tributaries in Canada. Aimed at documenting the age and sex composition of chinook salmon in the Upper River escapement, those sampling efforts have since been eliminated by tightening budgets. Additionally, DFO stopped sampling the commercial salmon catch in Canada for age and sex information in 1990. Lack of catch and escapement sampling in the Canadian portion of the drainage results in a lack of basic biological information on the age and sex composition of the run and makes the scale pattern analyses characterizing the stock standard critically dependent on DFO tagging study fish wheel samples.

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TABLES

Table 1. Age proportions of Yukon River chinook salmon escapement samples, 1993.

			Brood Year and Age Group												
			1990		1989		1988			1987		1986		1985	
Location	Escapement Index Abundance Estimate	Sample Size[a]	0.2	1.1	0.3	1.2	0.4	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5
Lower Yukon															
Andreafsky River[b]	8,620	406	0.0000	0.0025	0.0000	0.1576	0.0000	0.3399	0.0000	0.4778	0.0000	0.0222	0.0000	0.0000	0.0000
Anvik River	1,720	340	0.0000	0.0000	0.0000	0.1382	0.0000	0.3853	0.0000	0.4559	0.0000	0.0206	0.0000	0.0000	0.0000
Average Proportion			0.0000	0.0021	0.0000	0.1544	0.0000	0.3475	0.0000	0.4742	0.0000	0.0219	0.0000	0.0000	0.0000
Middle Yukon															
Chena River[c]	12,241	187	0.0000	0.0053	0.0000	0.2941	0.0000	0.4118	0.0000	0.2781	0.0000	0.0107	0.0000	0.0000	0.0000
Salcha River[c]	10,007	453	0.0000	0.0088	0.0000	0.2804	0.0000	0.3907	0.0000	0.3091	0.0022	0.0088	0.0000	0.0000	0.0000
Average Proportion			0.0000	0.0069	0.0000	0.2879	0.0000	0.4023	0.0000	0.2920	0.0010	0.0098	0.0000	0.0000	0.0000
Upper Yukon (Canada)															
White Rock & Sheep Rock[c]	28,578	966	0.0041	0.0041	0.0010	0.3168	0.0093	0.3458	0.0010	0.2764	0.0010	0.0383	0.0021	0.0000	0.0000

[a] All samples were collected from carcasses and live spawnouts captured with fish spears, unless otherwise noted. Escapement index abundance estimates are peak aerial survey counts except as noted.

[b] Includes respective East and West Fork aerial survey counts of 5,855 and 2,765.

[c] Mark and recapture population estimate.

Table 2. Classification accuracies of linear discriminant run–of–origin models for age–1.3 and –1.4 Yukon River chinook salmon, 1993.

Region of Origin	Sample Size	Classified Region of Origin: Lower	Middle	Upper
Age 1.3				
Lower	152	0.809	0.092	0.099
Middle	132	0.076	0.773	0.152
Upper	177	0.141	0.237	0.621
	Mean Classification Accuracy:		**0.734**	
	Variables in Analysis:		67, 8, 78, 61, 14, 75	
Age 1.4				
Lower	185	0.843	0.081	0.076
Middle	126	0.071	0.714	0.214
Upper	113	0.088	0.212	0.699
	Mean Classification Accuracy:		**0.752**	
	Variables in Analysis:		67, 7, 61, 97, 103	

Table 3. Run composition estimates for age−1.3 and −1.4 chinook salmon commercial catches in Yukon River District 1, 1993.

			Age 1.3				Age 1.4			
Commercial Fishing Period	Dates	Run−of−Origin	N	P	S.E.	Simultaneous 90% CI [a]	N	P	S.E.	Simultaneous 90% CI [a]
1	6/14−15	Lower	54	0.107	0.081	$0.000 < P < 0.280$	100	0.255	0.059	$0.129 < P < 0.381$
		Middle		0.139	0.114	$0.000 < P < 0.381$		0.062	0.078	$0.000 < P < 0.228$
		Upper		0.754	0.139	$0.457 < P < 1.000$		0.683	0.093	$0.485 < P < 0.880$
2	6/17−18	Lower	49	0.180	0.090	$0.000 < P < 0.371$	153	0.336	0.051	$0.228 < P < 0.443$
		Middle		0.254	0.122	$0.000 < P < 0.513$		0.121	0.064	$0.000 < P < 0.257$
		Upper		0.566	0.144	$0.261 < P < 0.872$		0.544	0.074	$0.386 < P < 0.701$
3	6/21	Lower	25	0.028	0.094	$0.000 < P < 0.227$	133	0.522	0.057	$0.401 < P < 0.644$
		Middle		0.610	0.181	$0.225 < P < 0.995$		0.088	0.062	$0.000 < P < 0.221$
		Upper		0.362	0.194	$0.000 < P < 0.775$		0.390	0.074	$0.233 < P < 0.547$
4	6/24	Lower	36	0.544	0.123	$0.283 < P < 0.804$	46	0.465	0.096	$0.261 < P < 0.669$
		Middle		0.067	0.114	$0.000 < P < 0.309$		0.262	0.121	$0.004 < P < 0.519$
		Upper		0.389	0.154			0.274	0.123	$0.011 < P < 0.536$
5	6/28	Lower	34	0.291	0.118	$0.041 < P < 0.541$	140	0.418	0.054	$0.303 < P < 0.534$
		Middle		0.185	0.138	$0.000 < P < 0.479$		0.241	0.070	$0.093 < P < 0.390$
		Upper		0.524	0.169	$0.164 < P < 0.884$		0.341	0.073	$0.184 < P < 0.497$
6	7/01	Lower	62	0.571	0.093	$0.374 < P < 0.769$	106	0.538	0.064	$0.403 < P < 0.673$
		Middle		0.103	0.088	$0.000 < P < 0.291$		0.225	0.076	$0.062 < P < 0.388$
		Upper		0.325	0.114	$0.084 < P < 0.567$		0.237	0.078	$0.071 < P < 0.403$

[a] Confidence intervals are calculated as $p \pm ((z_{(alpha/2k)})(S.E.\ of\ p))$, where k=3 and $z_{(alpha/2k)}=2.128$.

Table 4. Run composition estimates for age–1.3 and –1.4 chinook salmon commercial catches in Yukon River District 2, 1993.

			Age 1.3				Age 1.4			
Commercial Fishing Period	Dates	Run–of–Origin	N	P	S.E.	Simultaneous 90% CI[a]	N	P	S.E.	Simultaneous 90% CI[a]
1	6/16–17	Lower	46	0.301	0.101	0.087 < P < 0.515	71	0.443	0.077	0.278 < P < 0.607
		Middle		0.248	0.121	0.000 < P < 0.506		0.001	0.081	0.000 < P < 0.173
		Upper		0.452	0.143	0.147 < P < 0.756		0.556	0.105	0.332 < P < 0.780
2	6/20–21	Lower	48	0.274	0.098	0.065 < P < 0.483	77	0.294	0.059	0.169 < P < 0.419
		Middle		0.176	0.117	0.000 < P < 0.424		0.119	0.078	0.000 < P < 0.284
		Upper		0.551	0.143	0.246 < P < 0.856		0.587	0.090	0.396 < P < 0.777
3	6/25	Lower	33	0.151	0.111	0.000 < P < 0.388	91	0.367	0.066	0.226 < P < 0.508
		Middle		0.000	0.000	0.000 < P < 0.000		0.177	0.085	0.000 < P < 0.358
		Upper		0.849	0.111	0.612 < P < 1.000		0.456	0.095	0.255 < P < 0.658
4	6/27	Lower	22	0.471	0.157	0.137 < P < 0.806	58	0.459	0.085	0.278 < P < 0.641
		Middle		0.024	0.144	0.000 < P < 0.331		0.247	0.107	0.019 < P < 0.475
		Upper		0.504	0.205	0.068 < P < 0.941		0.294	0.111	0.058 < P < 0.530
5	6/30	Lower	17	0.098	0.134	0.000 < P < 0.383	52	0.298	0.084	0.120 < P < 0.477
		Middle		0.462	0.218	0.000 < P < 0.927		0.345	0.123	0.083 < P < 0.606
		Upper		0.440	0.240	0.000 < P < 0.950		0.357	0.126	0.090 < P < 0.624

[a] Confidence intervals are calculated as $p \pm ((z_{(alpha/2k)})(S.E.\ of\ p))$, where k=3 and $z_{(alpha/2k)}=2.128$.

Table 5. Classification of age−1.3 and −1.4 chinook salmon catches by run and fishing period for the commercial fishery in Yukon River District 1, 1993.

Commercial Fishing Period	Dates and Mesh Size	Region of Origin	Age Group 1.3	Age Group 1.4	Total
1	6/14−15	Lower	275	1,358	1,632
		Middle	357	330	687
	Unrestricted	Alaska	632	1,688	2,319
		Upper	1,931	3,635	5,565
		Total	2,563	5,322	7,885
2	6/17−18	Lower	886	5,200	6,086
		Middle	1,249	1,866	3,115
	Unrestricted	Alaska	2,135	7,066	9,201
		Upper	2,789	8,419	11,209
		Total	4,925	15,485	20,410
3	6/21	Lower	51	3,932	3,983
		Middle	1,119	662	1,782
	Unrestricted	Alaska	1,171	4,594	5,765
		Upper	663	2,934	3,597
		Total	1,834	7,528	9,362
4	6/24	Lower	309	438	747
		Middle	38	246	285
	Restricted	Alaska	347	684	1,032
		Upper	221	258	479
		Total	568	942	1,511
5	6/28	Lower	151	846	998
		Middle	96	488	585
	Unrestricted	Alaska	248	1,334	1,582
		Upper	272	689	961
		Total	520	2,023	2,544
6	7/01	Lower	237	453	690
		Middle	43	189	232
	Unrestricted	Alaska	280	642	922
		Upper	135	200	335
		Total	415	842	1,257
District 1 Season Total		Lower	1,910	12,226	14,137
		Middle	2,903	3,782	6,685
		Alaska	4,813	16,009	20,822
		Upper	6,012	16,134	22,146
		Total	10,825	32,143	42,968

Table 6. Classification of age−1.3 and −1.4 chinook salmon catches by run and fishing period for the commercial fishery in Yukon River District 2, 1993.

Commercial Fishing Period	Dates and Mesh Size	Region of Origin	Age Group 1.3	1.4	Total
1	6/16−17	Lower	1,026	2,288	3,314
		Middle	843	7	850
	Unrestricted	Alaska	1,869	2,295	4,164
		Upper	1,539	2,875	4,414
		Total	3,408	5,170	8,578
2	6/20−21	Lower	783	2,925	3,708
		Middle	503	1,186	1,689
	Unrestricted	Alaska	1,286	4,111	5,397
		Upper	1,576	5,834	7,410
		Total	2,862	9,945	12,807
3	6/25	Lower	195	1,659	1,855
		Middle	0	798	798
	Unrestricted	Alaska	195	2,457	2,652
		Upper	1,096	2,062	3,158
		Total	1,291	4,519	5,810
4	6/27	Lower	253	980	1,233
		Middle	13	526	539
	Unrestricted	Alaska	266	1,506	1,772
		Upper	271	627	898
		Total	537	2,134	2,670
5	7/03	Lower	47	468	516
		Middle	224	541	765
	Unrestricted	Alaska	271	1,009	1,281
		Upper	213	561	774
		Total	484	1,570	2,054
District 2 Season Total		Lower	2,304	8,321	10,625
		Middle	1,583	3,058	4,641
		Alaska	3,887	11,379	15,267
		Upper	4,694	11,959	16,653
		Total	8,581	23,338	31,920

Table 7. Total commercial and subsistence catch of chinook salmon by age class and run in Yukon River Districts 1–6 and Canada, 1993.

			Brood Year and Age Group												
			1990		1989		1988			1987		1986		1985	
District	Fishery	Run of Origin	0.2	1.1	0.3	1.2	0.4	1.3	2.2	1.4	2.3	1.5	2.4	2.5	Total
1	Commercial Gillnet	Lower	0	0	0	281	0	1,910	0	12,226	0	810	0	0	15,228
		Middle	0	0	0	689	0	2,903	0	3,782	36	183	0	0	7,593
		Alaska	0	0	0	970	0	4,813	0	16,009	36	993	0	0	22,821
		Upper	0	0	0	1,827	0	6,012	0	16,134	167	3,203	522	9	27,873
		Total[a]	0	0	0	2,797	0	10,825	0	32,143	202	4,195	522	9	50,694
	Subsistence Gillnet[b]	Lower	0	0	0	68	0	501	0	2,245	0	171	0	0	2,985
		Middle	0	0	0	167	0	762	0	694	6	39	0	0	1,667
		Alaska	0	0	0	235	0	1,263	0	2,939	6	209	0	0	4,652
		Upper	0	0	0	442	0	1,578	0	2,962	26	675	73	0	5,756
		Total	0	0	0	677	0	2,841	0	5,901	31	885	73	0	10,408
2	Commercial Gillnet	Lower	0	3	0	312	0	2,304	0	8,321	0	543	0	0	11,483
		Middle	0	6	0	345	0	1,583	0	3,058	30	145	0	0	5,168
		Alaska	0	9	0	657	0	3,887	0	11,379	30	688	0	0	16,651
		Upper	0	12	0	1,310	0	4,694	0	11,959	128	2,337	353	13	20,806
		Total[c]	0	21	0	1,967	0	8,581	0	23,338	158	3,025	353	13	37,457
	Subsistence Gillnet[d]	Lower	0	0	0	122	0	992	0	1,999	0	198	0	0	3,312
		Middle	0	0	0	135	0	682	0	735	11	53	0	0	1,616
		Alaska	0	0	0	258	0	1,674	0	2,734	11	251	0	0	4,928
		Upper	0	0	0	514	0	2,022	0	2,873	47	854	276	0	6,585
		Total	0	0	0	771	0	3,696	0	5,607	58	1,105	276	0	11,513
3	Commercial Gillnet[d]	Lower	0	0	0	12	0	92	0	333	0	22	0	0	460
		Middle	0	0	0	14	0	63	0	123	1	6	0	0	207
		Alaska	0	0	0	26	0	156	0	456	1	28	0	0	667
		Upper	0	0	0	52	0	188	0	479	5	94	14	1	834
		Total	0	1	0	79	0	344	0	935	6	121	14	1	1,501
	Subsistence Gillnet[d]	Lower	0	0	0	69	0	557	0	1122	0	111	0	0	1,860
		Middle	0	0	0	76	0	383	0	412	6	30	0	0	907
		Alaska	0	0	0	145	0	940	0	1535	6	141	0	0	2,767
		Upper	0	0	0	288	0	1135	0	1613	26	479	155	0	3,697
		Total	0	0	0	433	0	2075	0	3148	32	621	155	0	6,464
4	Commercial & Subsistence GN & FW[e]	Lower	0	1	0	100	0	741	0	2678	0	175	0	0	3,695
		Middle	0	2	0	160	0	757	0	1251	14	66	0	0	2,251
		Alaska	0	3	0	261	0	1499	0	3929	14	241	0	0	5,946
		Upper	0	4	0	421	0	1510	0	3848	41	752	114	4	6,695
		Total	0	7	0	682	0	3009	0	7777	55	993	114	4	12,641

–Continued–

Table 7. (Page 2 of 2)

			Brood Year and Age Group												
			1990		1989		1988			1987		1986		1985	
District	Fishery	Run of Origin	0.2	1.1	0.3	1.2	0.4	1.3	2.2	1.4	2.3	1.5	2.4	2.5	Total
5	Commercial & Subsistence GN & FW[f]	Upper	100	100	25	7,721	227	8,429	25	6,737	25	933	51	0	24,373
6	Commercial & Subsistence GN & FW[g]	Middle	0	24	0	1,020	0	1,425	0	1,035	4	35	0	0	3,543
Canada	Commercial GN & FW	Upper	42	42	10	3,279	96	3,580	11	2,861	11	396	22	0	10,350
	Non–Commercial[h]	Upper	26	26	6	1,983	58	2,165	6	1,731	6	240	13	0	6,261
TOTAL HARVEST		Lower	0	4	0	965	0	7,099	0	28,925	0	2,030	0	0	**39,023**
		Middle	0	32	0	2,606	0	8,558	0	11,091	107	556	0	0	**22,952**
		Alaska	0	36	0	3,572	0	15,657	0	40,016	107	2,586	0	0	**61,975**
		Upper	168	184	41	17,838	381	31,314	42	51,197	482	9,964	1,593	27	**113,230**
		Total	168	220	41	21,409	381	46,971	42	91,213	588	12,550	1,593	27	**175,205**

[a] Includes 1,408 fish from ADF&G test fisheries.

[b] Run composition is based on season total District 1 commercial catch samples.

[c] Includes 164 fish from ADF&G test fisheries.

[d] Run composition based on season total District 2 commercial catch samples.

[e] Gillnet and fish wheel catches combined. Commercial catch = 1,349 fish, commercial related catch = 228, and subsistence catch = 11,116. The Koyukuk River subsistence harvest was assigned to the Middle River Run (see METHODS).

[f] Gillnet and fish wheel catches combined. Commercial catch = 3,008 and subsistence catch = 21,365.

[g] Gillnet and fish wheel catches combined. Preliminary data includes 1,113 commercial, 332 commercial related, 1,672 subsistence, and 426 personal use. Sport harvest data was not available in time for inclusion in this table.

[h] Run and age composition are based on Canada DFO tagging study fish wheel samples. Preliminary harvest components include Canadian Aboriginal fishery (5,690), domestic (243), and sport (300) harvests.

Table 8. Harvest percentages by run of the total Yukon River harvest of chinook salmon, 1982–93.

Year	Lower Run	Middle Run	Upper Run
1982	13.5	23.7	62.8
1983	12.4	36.8	50.8
1984	29.0	35.6	35.4
1985	30.9	19.5	49.6
1986	26.5	5.6	67.9
1987	16.5	17.3	66.2
1988	27.2	11.3	61.4
1989	25.7	15.9	58.4
1990	19.3	22.2	58.5
1991	26.1	29.0	44.9
1992	17.5	23.2	59.3
1993	22.3	13.2	64.6
1982–92 Avg	22.2	21.8	55.9
1988–92 Avg	23.2	20.3	56.5

FIGURES

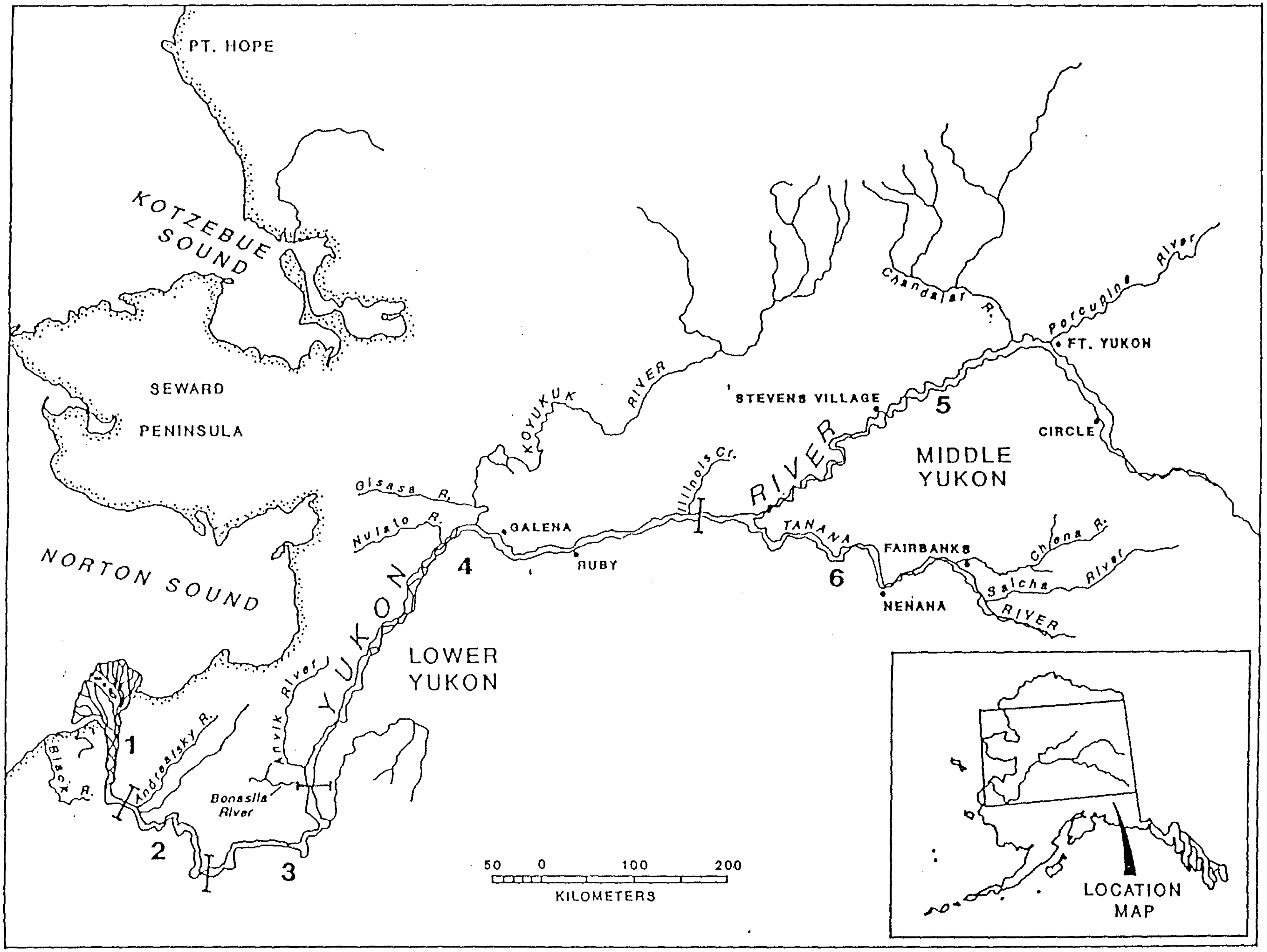

Figure 1. Alaskan portion of the Yukon River showing fishing district boundaries.

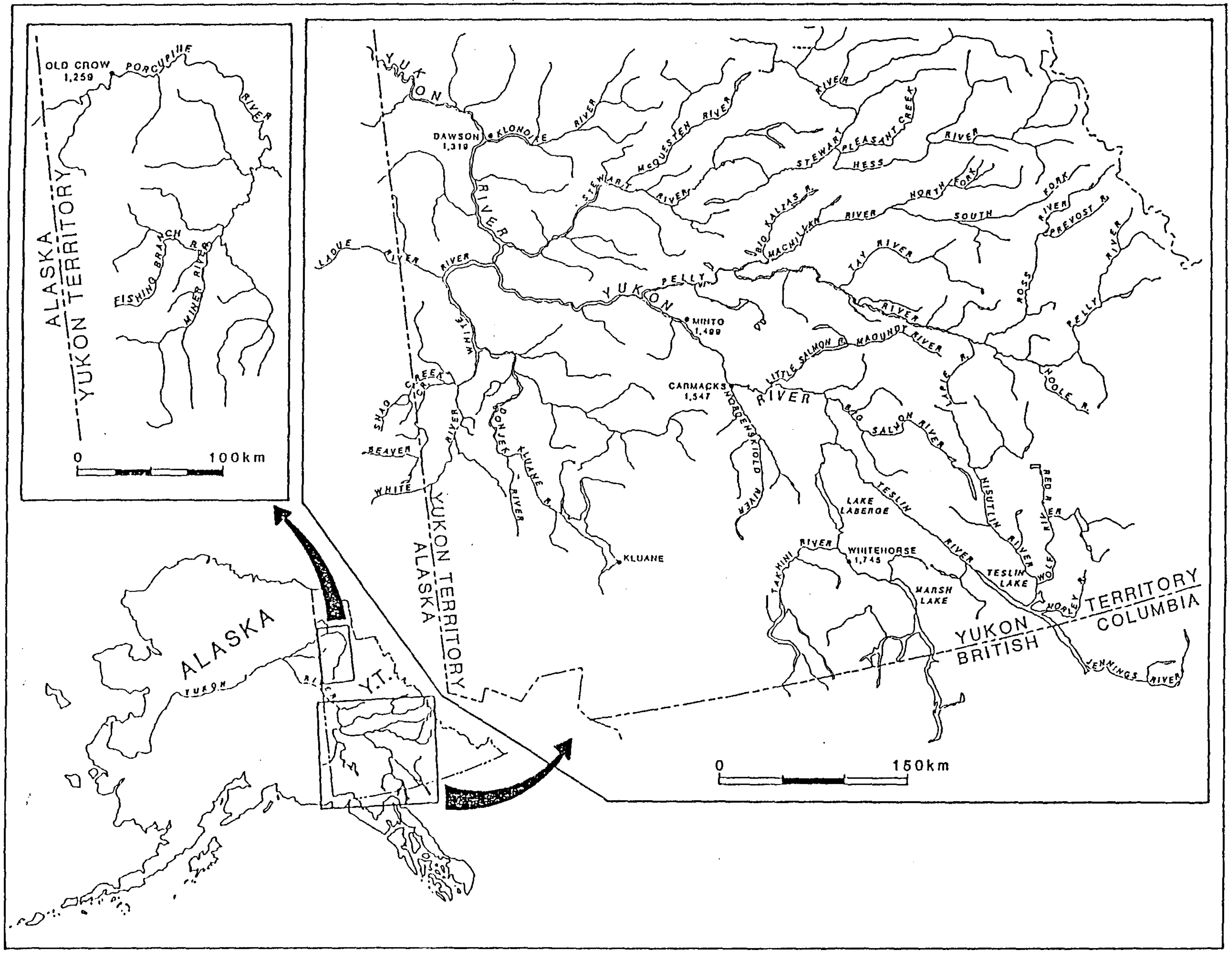

Figure 2. Canadian portion of the Yukon River drainage.

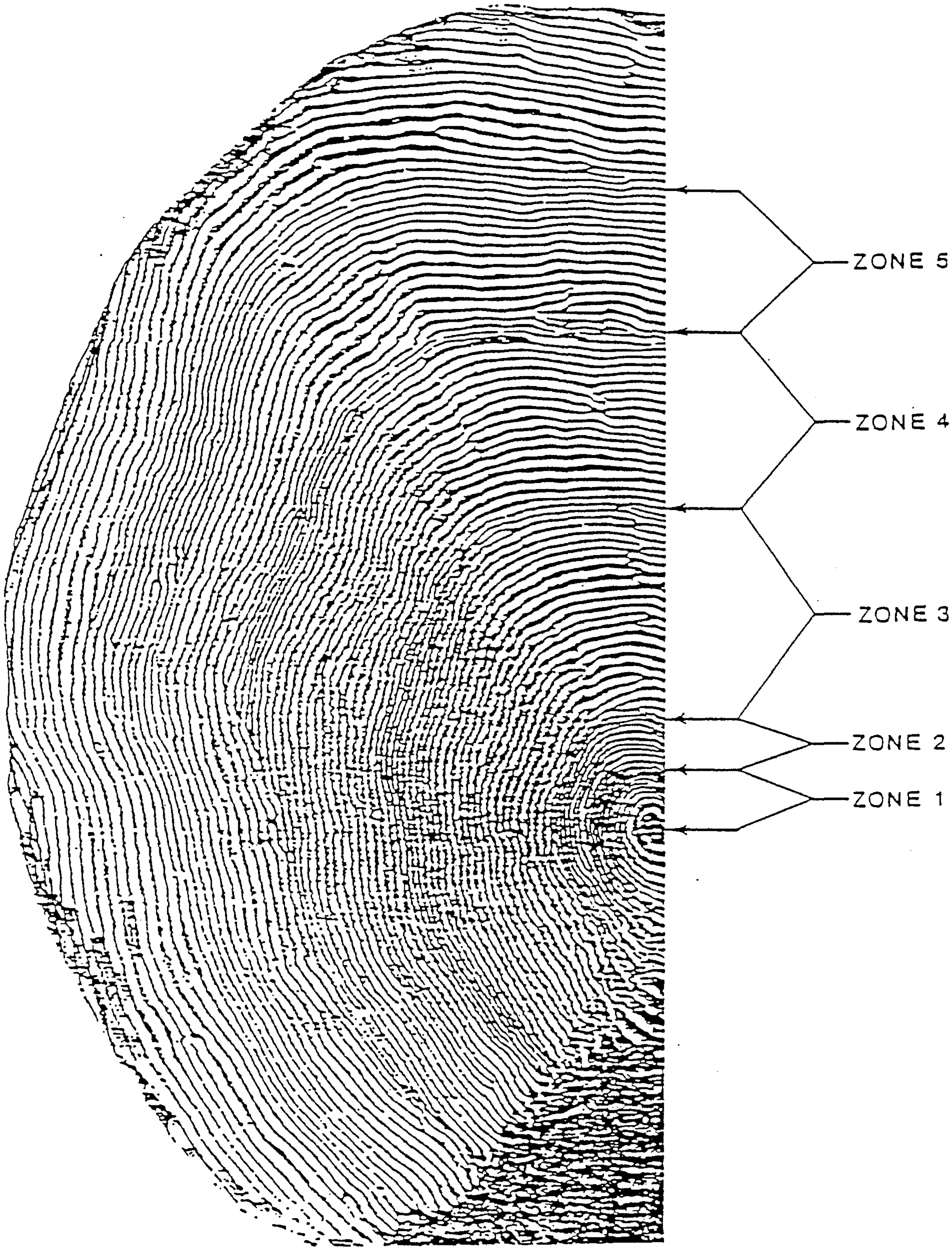

Figure 3. Age-1.4 chinook salmon scale showing zones measured for linear discriminant analysis.

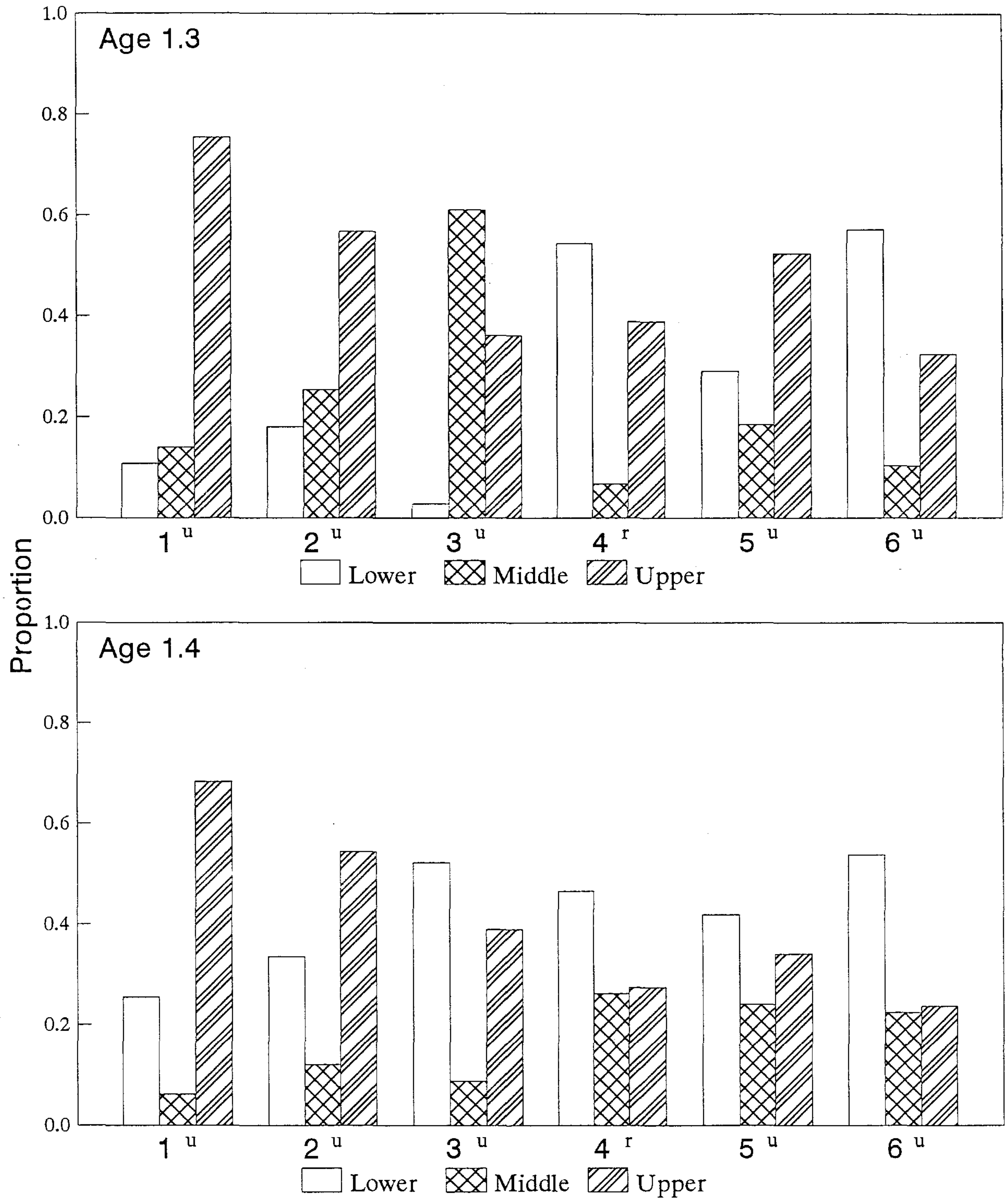

Figure 4. Estimated proportion of catch by period (u = unrestricted, r = restricted mesh size) and run from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 1, 1993.

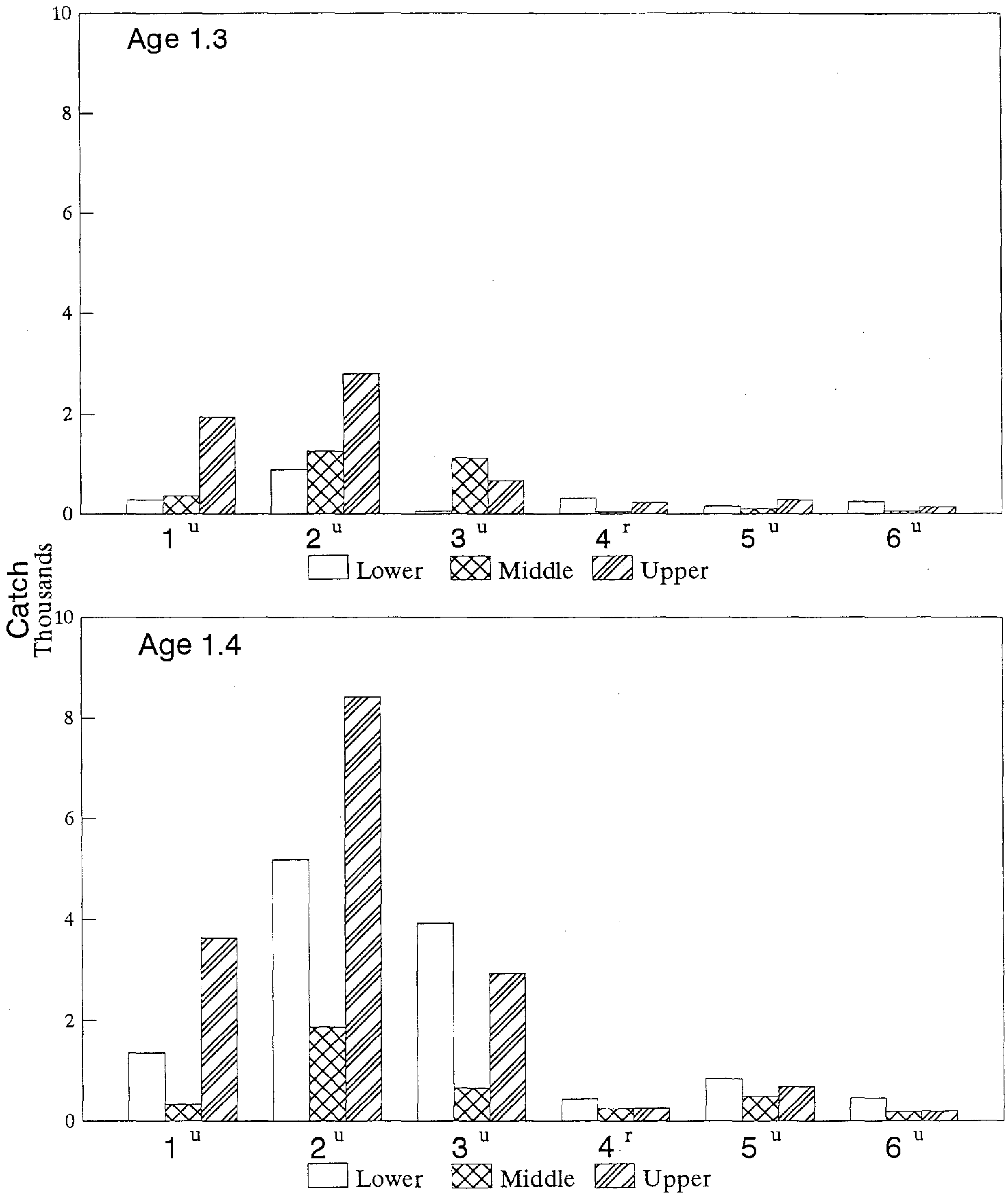

Figure 5. Estimated catch by period (u = unrestricted, r = restricted mesh size) and run in numbers of fish from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 1, 1993.

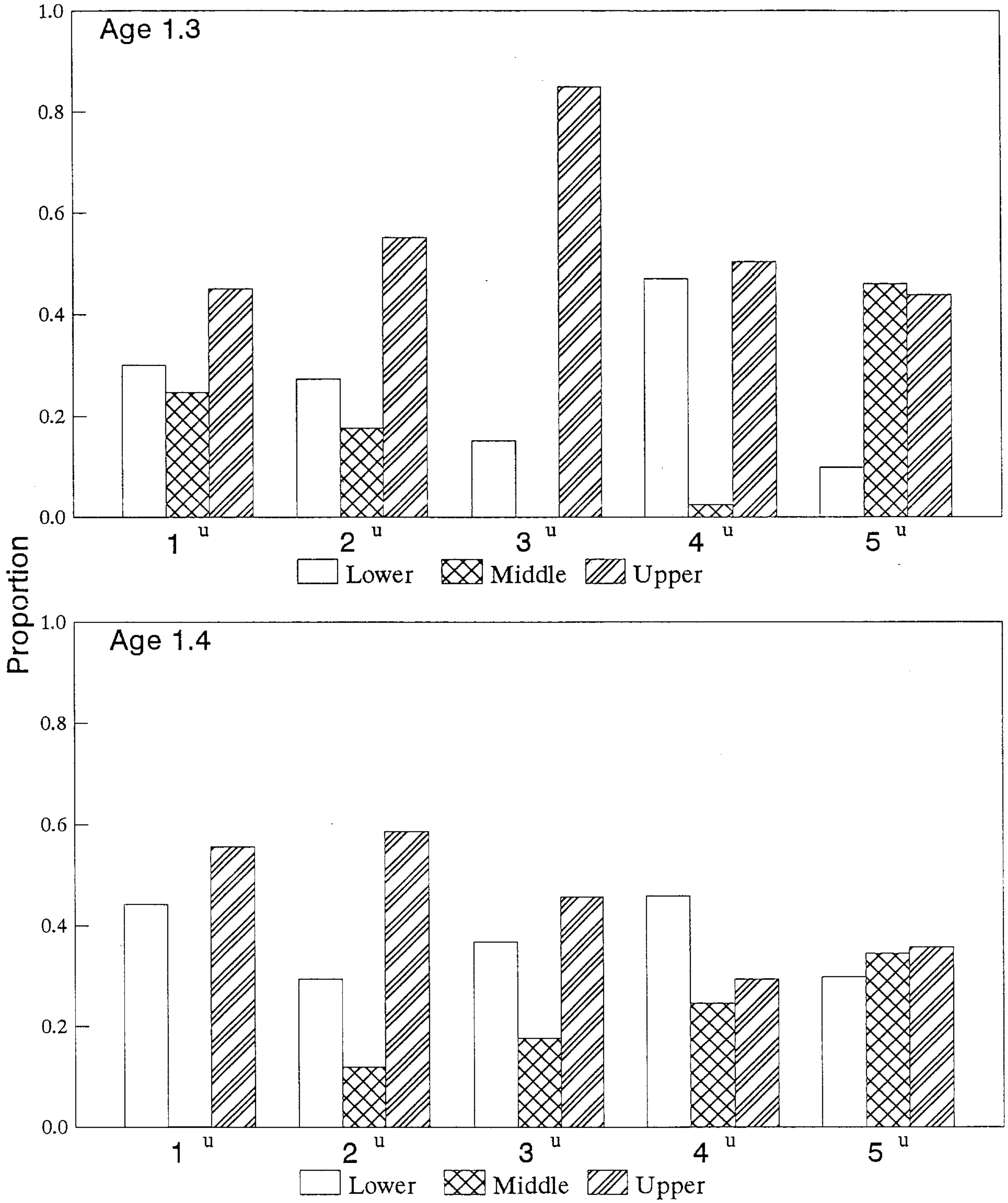

Figure 6. Estimated proportion of catch by period (u = unrestricted, r = restricted mesh size) and run from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 2, 1993.

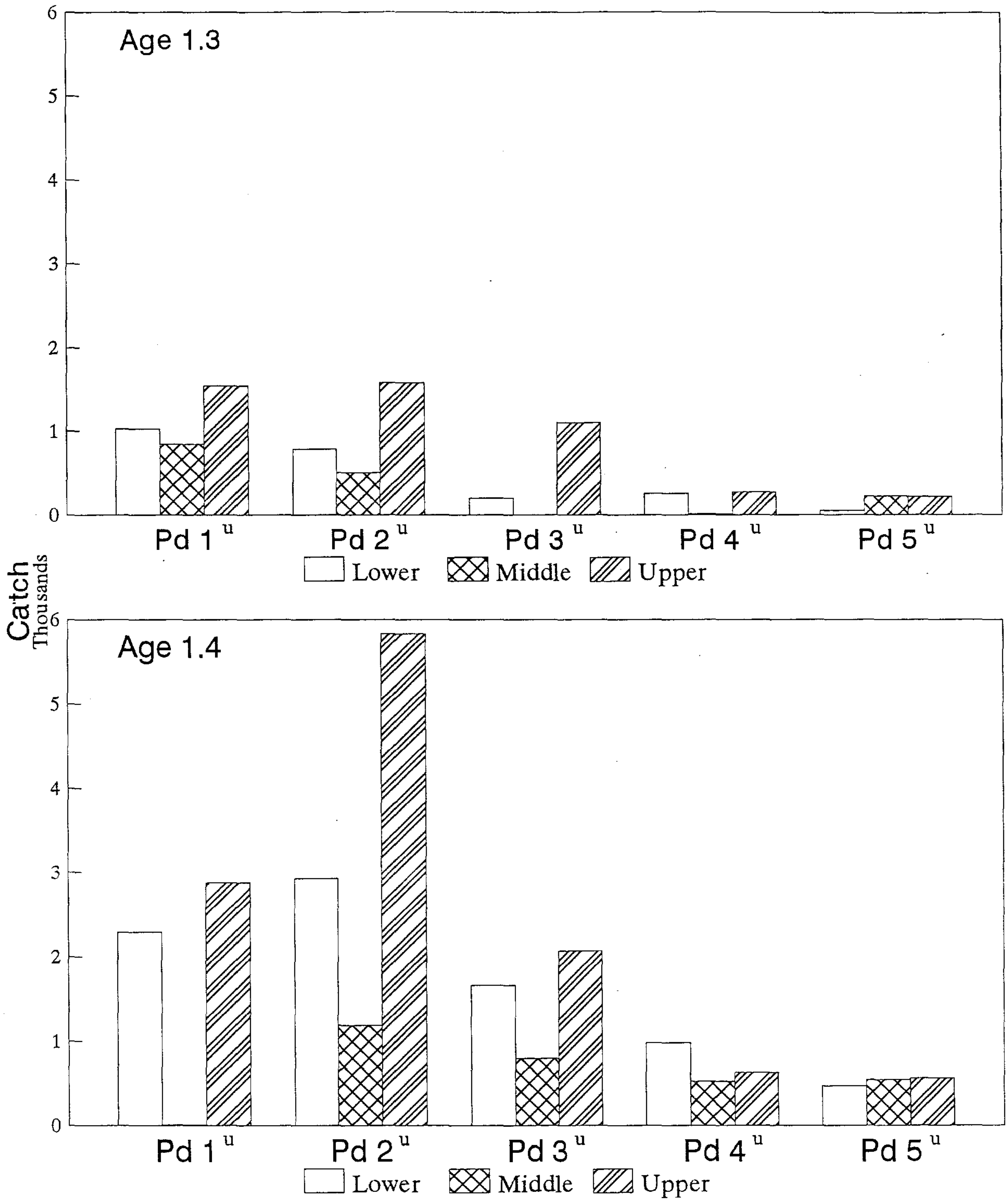

Figure 7. Estimated catch by period (u = unrestricted, r = restricted mesh size) and run in numbers of fish from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 2, 1993.

APPENDIX

Appendix A. Scale variables screened for linear discriminant function analysis of age-1.3 and -1.4 Yukon River chinook salmon, 1993.

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

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 3rd 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 (axial length) 1st freshwater zone.
[c] Number of circuli, plus growth zone.
[d] Size (axial length) plus growth zone.
[e] Number of circuli, 1st ocean zone.
[f] Size (axial length) 1st ocean zone.

Appendix B. Group means, standard errors, and one-way analysis of variance F-statistic for scale variables selected for use in linear discriminant models of age-1.3 and -1.4 Yukon River chinook salmon runs, 1993.

		Lower		Middle		Upper		
Growth Zone	Variable	Mean	SE	Mean	SE	Mean	SE	F-Value
<u>Age-1.3</u>								
1st FW Annular	8	45.79	0.48	35.77	0.54	43.00	0.45	102.08
	14	92.87	1.48	61.93	1.42	77.76	1.45	102.51
FW Plus Growth	61	3.95	0.13	5.78	0.12	6.24	0.12	98.55
Total FW Growth	67	0.76	<0.01	0.63	<0.01	0.65	<0.01	132.61
1st Marine Ann.	75	205.02	1.60	209.24	1.98	230.58	1.73	64.59
	78	101.35	0.91	104.59	1.10	116.92	1.01	71.51
<u>Age-1.4</u>								
1st FW Annular	7	24.23	0.31	20.32	0.39	25.20	0.38	47.15
FW Plus Growth	61	4.14	0.09	6.37	0.14	7.22	0.14	195.54
Total FW Growth	67	0.75	<0.01	0.61	<0.01	0.60	<0.01	241.39
1st Marine Ann.	97	0.38	<0.01	0.41	<0.01	0.43	<0.01	39.12
	103	0.24	<0.01	0.26	<0.01	0.25	<0.01	7.41

Appendix C. Group means, standard errors, and one-way analysis of variance F-statistic for the number of circuli and incremental distance of salmon scale growth zone measurements from age-1.3 and -1.4 Yukon River chinook salmon runs, 1993.

			Lower		Middle		Upper		
Growth Zone	Variable	Description	Mean	SE	Mean	SE	Mean	SE	F-Value
<u>Age-1.3</u>									
1st FW Annular	1	No. Circ.	11.45	0.15	9.17	0.14	10.02	0.14	58.57
	2	Distance	147.41	1.58	111.18	1.63	132.38	1.60	116.27
Total FW Growth	61	No. Circ.	3.95	0.13	5.78	0.12	6.24	0.12	98.55
	62	Distance	47.07	1.65	64.90	1.51	73.15	1.51	75.57
1st Ocean Ann.	70	No. Circ.	25.74	0.26	24.80	0.24	23.25	0.24	27.36
	71	Distance	467.55	4.39	446.28	5.30	443.42	3.99	8.70
2nd Ocean Ann.	109	Distance	449.31	4.89	421.18	5.70	445.58	4.57	8.51
<u>Age-1.4</u>									
1st FW Annular	1	No. Circ.	11.56	0.13	8.95	0.14	9.76	0.15	101.56
	2	Distance	150.54	1.29	115.90	1.65	132.85	1.91	131.45
Total FW Growth	61	No. Circ.	4.14	0.09	6.37	0.14	7.22	0.14	195.54
	62	Distance	50.94	1.19	76.57	1.82	87.81	1.68	166.13
1st Ocean Ann.	70	No. Circ.	24.17	0.18	22.71	0.24	22.56	0.24	18.90
	71	Distance	452.84	3.74	412.54	5.65	427.20	4.64	21.71
2nd Ocean Ann.	109	Distance	393.98	4.37	370.09	5.43	384.08	5.24	6.17
3rd Ocean Ann.	110	Distance	415.89	4.30	391.18	5.70	397.43	4.94	7.51