TECHNICAL FISHERY REPORT 94-09

Alaska Department of Fish and Game
Commercial Fisheries Management
and Development Division
P.O. Box 25526
Juneau, Alaska 99802-5526

June 1994

Origins of Chinook Salmon in the Yukon River Fisheries, 1991

by

Daniel J. Schneiderhan

State of Alaska Walter J. Hickel, Governor

The Technical Fishery Report Series was established in 1987, replacing the Technical Data Report Series. The scope of this new series has been broadened to include reports that may contain data analysis, although data oriented reports lacking substantial analysis will continue to be included. The new series maintains an emphasis on timely reporting of recently gathered information, and this may sometimes require use of data subject to minor future adjustments. Reports published in this series are generally interim, annual, or iterative rather than final reports summarizing a completed study or project. They are technically oriented and intended for use primarily by fishery professionals and technically oriented fishing industry representatives. Publications in this series have received several editorial reviews and at least one *blind* peer review refereed by the division's editor and have been determined to be consistent with the division's publication policies and standards.

ORIGINS OF CHINOOK SALMON IN THE YUKON RIVER FISHERIES, 1991

By

Daniel J. Schneiderhan

Technical Fishery Report No. 94-09

Alaska Department of Fish and Game
Commercial Fisheries Management
and Development Division
P.O. Box 99802-5526
Juneau, Alaska 99802-5526

June 1994

AUTHOR

Daniel J. Schneiderhan is Yukon River salmon stock identification project leader for the Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, 333 Raspberry Road, Anchorage, AK 99518.

ACKNOWLEDGMENTS

Commercial Fisheries Management and Development Division Yukon Area staff who provided assistance in gathering scale samples were Tracy Lingnau, Mike Erickson, Alden Walker, Jay Wilcox, Shelby Edmund, Gene Sandone, Louis Barton, and Dan Bergstrom. David and Sharon Ball of the U.S. Fish and Wildlife Service (USFWS) aided in the collection of scale samples in the District 1 commercial fishery. In a cooperative relationship, Dick Wilmot of USFWS coordinated his agency's portion of the combined sampling effort to attain tissue samples for USFWS genetic studies, as well as scale samples for this investigation. Alan Burkholder and Matt Evenson from the Division of Sport Fisheries office in Fairbanks supplied scale samples for fish from the Chena and Salcha Rivers. Jim Menard aged and digitized the scales. Dan Bergstrom, Louis Barton, and Gene Sandone provided assistance and support for this project. Jeff Bromaghin provided statistical support during the analysis. Review of the manuscript was provided by Gene Sandone and Larry Buklis. Finally, appreciation is extended to Camille Gosselin of the Canadian Department of Fisheries and Oceans for providing samples needed to model the Upper Yukon Run.

PROJECT SPONSORSHIP

This investigation was partially funded by U.S./Canada salmon research Cooperative Agreement Award No. NA17FP0250-01.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Analysis of scale patterns and age composition of chinook salmon *Oncorhynchus tshawytscha* (Walbaum) from Yukon River escapements in Alaska and salmon tagging study catches in Canada were used to construct run-of-origin classification models for Yukon River Districts 1, 2, 3, and 4 commercial and subsistence harvests. Linear discriminant models were used to estimate stock composition for age-1.3 and -1.4 fish. Observed age composition differences among escapements were used to estimate run of origin for other age groups. Run of origin for all other drainage harvests was estimated based on geographic incidence of catches. The total Yukon River harvest was 174,606 chinook salmon, of which 45% was estimated to be the Upper Yukon Run, 29% the Middle Yukon Run, and 26% the Lower Yukon Run. The total harvest estimated for the Upper Yukon Run was the lowest since 1984. The fraction of the District 1 and 2 commercial catch composed of the Lower Yukon Run generally increased through time, and the fraction composed of the Upper Yukon Run generally declined. The middle run component fluctuated somewhat through the season.

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

INTRODUCTION

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

During the first 20 years after statehood, 1960–1979, the combined Alaskan and Canadian Yukon River chinook salmon commercial and subsistence harvest averaged 122,971 fish annually (JTC 1991). Beginning in 1980, annual harvests increased substantially. During the most recent 5-year period (1986 through 1990), annual commercial and subsistence catches together averaged 175,829 fish. Although chinook salmon are harvested virtually throughout the Yukon River, the majority of the catch has been taken in commercial gillnet fisheries in Districts 1 and 2: 1986-90 average was 54% of total drainage harvest. Subsistence harvests throughout the drainage, including Canadian catches, accounted for another 32% of the total harvest between 1986 and 1990. Most of the subsistence harvest is taken with fish wheels and gillnets in Districts 4, 5, and 6. In 1991, commercial, subsistence, and sport fishermen in Alaska and Canada harvested a total of 174,606 chinook salmon, of which 96,185 (55%) 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 (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 objectives, and management strategies requires information on the stock composition of the harvest. In addition, biological information on these stocks provides the technical basis for treaty negotiations between the U.S. and Canada concerning allocation, management, and conservation of those stocks spawned in Canada.

Harvest estimates of Western Alaskan/Canadian Yukon chinook salmon in the Japanese high seas gillnet fisheries were made using scale pattern analysis (Rogers et al. 1984; Meyers et al. 1984; Meyers and Rogers 1985). Stock composition of Yukon River freshwater fisheries has been studied by the Alaska Department of Fish and Game to provide useful information for management and conservation of the various runs of chinook salmon. Stock composition estimates derived from scale pattern analysis of the catch through time for Yukon River chinook salmon were first available for 1980 and 1981 District 1 harvests (McBride and Marshall 1983). Since then, harvest proportions by geographic stock (Table 1) 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). The objective of the 1991 investigation, similar to preceding years, was to classify Yukon River chinook salmon commercial and subsistence harvest to the 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 Districts 1, 2, 4, 5, 6, and in Yukon Territory, Canada. 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, albeit District 3 harvests delivered to buyers in Marshall could at times have comprised a small fraction of the District 2 catch sample. For purposes of this report, I assumed (1) that subsistence fishing in Districts 1 and 2 occurred immediately prior to the onset of commercial fishing, and (2) that period 1 catch samples in each district were most representative of the subsistence harvest. Experimental or test gillnet samples were also taken in District 1 and from fish wheels in Yukon Territory, Canada.

Sampling of Alaskan fisheries was conducted by the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries; Canadian samples were collected by the Canada Department of Fisheries and Oceans (DFO) in conjunction with a tagging study conducted downstream from Dawson near the U.S.-Canada border.

Escapement Sampling

Scale samples were collected during the period of peak spawner mortality from the Andreafsky, Anvik, Chena, Salcha, Goodpaster, and Barton (Creek) Rivers in Alaska. Samples were primarily collected from carcasses; however, some samples were obtained from live fish captured with spears. Canadian tributaries were not sampled in 1991.

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. These escapements were indexed by aerial surveys or mark/recapture spawning population estimates, but sampled tributaries lacking abundance estimates were not used.

Estimation of Catch Composition

Linear discriminant function analysis (Fisher 1936) of scale patterns, observed differences in age composition between escapements, and geographic relationships of catches were used to estimate run of origin for 1991 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, Salcha, Goodpaster, and Barton (Creek) Rivers. The Upper Yukon Run was represented by samples collected from test fish wheels operated in conjunction with the DFO tagging study at White Rock and Sheep Rock sites, Canada, between 6 and 12 mi (10–20 km) 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 fishing periods with adequate sample sizes. The sampling plan was designed to provide sample sizes of 50 or more for each major age class; however, smaller samples were sometimes included in the analysis to provide more detailed and comparable results for an age class.

Measurements of scale features followed procedures 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 or variables (Appendix A) were calculated from the basic incremental distances and circuli counts. Run-of-origin standards from 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 scale pattern analysis 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 ($\hat{R}_{cia}$) for each run. This was done by dividing the proportion of an unclassified age class in escapements from each run of origin ($\hat{E}_{ci}$) by the proportion of an analogous age class in escapements from the same runs which were classified by scale pattern analysis ($\hat{E}_{ca}$):

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

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 scale pattern analysis, 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; and

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

Proportions of age-1.2 and -2.2 fish in escapement samples collected in previous years tended to decrease as the distance upriver increased. Therefore, proportions for the age class were divided by the proportion of age-1.3 fish that analogously 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 treated similarly as analogs of age-1.4 fish because these ages have historically increased with upriver distance. Further, the age-2.3 fish were analogous to age-1.4 fish because both were from the same brood year.

Catch by 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, i.e. 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:

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

where

$\hat{F}_{ci}$ = estimated proportion of fish of run c in 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 (3).

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

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

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 scale pattern analysis and differential age composition analysis were used to classify District 1 and 2 commercial catches by period. Classification of Districts 1 and 2 subsistence catches was based on estimates of run composition from scale pattern analysis and differential age composition analysis of Period 1 commercial harvests in both districts. The proportions by age class and run which were obtained through analysis of 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

Commercial and subsistence harvests in District 5, District 6, and Yukon Territory were classified to run of origin based on geographical segregation. The entire District 5 harvest was assumed to be from the Upper Yukon Run. This assumption was made because most of the District 5 catch occurred above the confluence of the Tanana River, and aerial survey counts of chinook salmon spawning in the Porcupine and Chandalar River drainages, totaling < 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 is known to be violated, because a small but unknown proportion of the District 5 subsistence harvest is taken on the south bank below the Tanana confluence. Violation of the assumption affects the results of this study by providing a slight positive bias to the Upper Yukon Run and a corresponding negative bias to 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 are present in the Tanana River. The Yukon Territory harvest was assigned to the upper run because neither lower nor middle runs are present in Yukon Territory.

RESULTS

Escapement Age Composition

Yukon River chinook salmon escapement age compositions in 1991 exhibited a variety of trends and contrasts (Table 2). Age 1.3 was atypically more abundant than age 1.4 in escapements throughout the drainage. The trend for the proportion of older fish to increase progressively upriver continued to be noticeable, though not as pronounced as usual. Proportions of ages 1.4 and 1.5 were smaller in the Andreafsky and Anvik Rivers than in tributaries farther upriver. The high proportion of age-1.4 fish in the middle river tributaries was typical. Samples of Upper Yukon Run fish from the White Rock and Sheep Rock sites exhibited the usual high proportion of age 1.4. As in most other years, the proportion of age-2. fish was greatest in the Upper Yukon Run, whereas, relatively few age-2. fish comprised the Lower or Middle Yukon Runs.

Classification Accuracies of Run of Origin Models

Mean classification accuracies of 3-way, run-of-origin models were 70.8% for ages 1.3 and 74.3% for age 1.4 (Table 3), typical of past experience. Also, similar to past years, the lower river standard showed the greatest classification accuracies (84.6% for age 1.3 and 81.3% for age 1.4). Upper river standards yielded fairly typical classification accuracies: 66.4% and 71.3% for age 1.3 and 1.4 with the greatest likelihood of misclassifying as Middle Yukon Run. The accuracy of classification of the middle run standards was less than usual: 61.3% for age 1.3 and 70.3% 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 103, the width of the last six circuli of the second ocean zone divided by the width of the second ocean zone, and (3) variable 62, the width of the freshwater plus zone (Appendix B). Secondarily selected variables were derived primarily from measurements within the total marine zone and the first freshwater annular zone. The primary distinguishing characters for age 1.4 were (1) variable 67, the freshwater annular zone divided by the total width of freshwater growth zones, and (2) variable 14, the distance from the second circuli to the end of the first freshwater annular zone (Appendix B). Secondarily selected variables were derived from measurements within the freshwater plus and the first marine annular zones. As in 1990, measurements of marine growth atypically provided noticeable discrimination in all models. Group means and their standard errors for the number of circuli and width of the first freshwater annular, plus growth, and marine annular zones are listed in Appendix C.

Proportion of Catch

The majority of the commercial chinook salmon catch was taken in the first five fishing periods in Districts 1 and 2. Upper Yukon Run fish comprised the largest proportion of the District 1 commercial harvest of age-1.3 and -1.4 chinook salmon in Period 1 (Table 4). Likewise, age-1.4 Upper Yukon Run fish comprised the largest proportion in the first period in District 2 (Table 5). However, age-1.3 Upper-Yukon-Run fish were a small proportion (0.058) in Period 1 in District 2 (Table 5). The generally high proportion of Upper Yukon Run fish showed a decrease in Period 2 and continued at relatively lower levels throughout the season (Figure 4). Run contribution estimates through time in Districts 1 and 2 (Tables 4, 5; Figures 4, 5) generally demonstrated increasing proportions of Lower Yukon fish and decreasing proportions of Upper Yukon fish. The apparent increase in age-1.4 Upper Yukon Run fish during the last period in District 1 (Figure 4) may be an artifact of small sample size. District 1 and 2 proportions and harvests of middle Yukon fish demonstrated no clear overall trend in relative abundance (Figures 4-7).

The estimated District 1 commercial catch of age-1.3 and -1.4 fish combined was 20,199 (40.2%) for Lower, 12,268 (24.4%) for the Middle, and 17,813 (35.4%) for the Upper Yukon Run (Table 6). In District 2 the estimated age-1.3 and -1.4 combined catch was 12,985 (36.1%) for the Lower, 15,912 (44.3%) for the Middle, and 7,053 (19.6%) for the Upper Yukon Run (Table 7). The percentage of Upper Yukon Run fish harvested in Districts 1 and 2 was smaller than generally seen in the past.

Classification by SPA Analysis

Based on results of scale pattern analysis (SPA), 49.4% or 86,228 age-1.3 and -1.4 fish were directly classified to run of origin from District 1 and 2 commercial catches. In addition, 17.5% or 30,580 age-1.3 and -1.4 fish in Districts 1 and 2 subsistence harvests and Districts 3 and 4 commercial and subsistence harvests were classified using run-of-origin ratios based on SPA of District 1 and 2 commercial catches of those age classes.

Classification by Differential Age Composition Analysis

The remaining 1.2, 2.3, 1.5, 2.4, 1.6, and 2.5 age classes from Districts 1, 2, 3, and 4 commercial and subsistence catches contributed 12,551 fish (7.2%) to the total drainage harvest (Table 8). They were classified to run of origin using differences in escapement age composition in each run.

Classification by Geographical Analysis

A total of 45,248 fish (25.9% of total drainage harvest) in Districts 5, 6, and Yukon Territory were classified to run of origin based on geographical segregation. District 5 and Yukon Territory commercial, subsistence, and sport catches were assumed to be upper Yukon fish. Commercial, subsistence, and sport catches in District 6 (Table 8) were classified entirely to the Middle Yukon Run.

Total Harvest

The commercial and subsistence harvests of chinook salmon from the entire Yukon River drainage were classified to run of origin (Table 8) 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 run component and contributed 78,468 fish or 44.9% of the total drainage harvest. The Middle Yukon Run was next in abundance at 50,621 fish (29.0%), followed by the Lower Yukon Run at 45,518 fish (26.1%).

DISCUSSION

The percentage (44.9) of Upper Yukon Run fish in the 1991 total harvest was the second lowest estimate since this study was initiated (Table 1). Estimates of the Upper Yukon Run component have ranged from 35.4% in 1984 to 67.9% in 1986, with an unweighted average of 56.8% since 1982. A steady decline in the percentage of the total drainage harvest of the Upper Yukon Run has been noted since 1986. This may be a result of recent management actions that were initiated to increase the proportion of chinook salmon harvested in commercial gillnet openings in Districts 1, 2, and 3 that restrict mesh sizes. Decreasing Alaskan exploitation rates of Canadian stocks over a similar period supports this view (G. Sandone, Alaska Department of Fish and Game, Anchorage, personal communication).

Sample sizes were fair to excellent for all escapements which contribute to the standard three-way LDF classification model. Catch sample sizes in Districts 1 and 2 were excellent overall, although weak for some periods when logistics or small catches prevented sampling objectives from being obtained.

Sampling upper Yukon tributaries remains problematic. The Upper Yukon Run is sampled in Canada near the U.S.-Canada border at the DFO tagging project site. 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 1991. Samples from the DFO mainstem Yukon River test fish wheels are used to build run-of-origin models. Although we assume that those samples are representative of the overall Canadian chinook salmon run, the 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, would be a more desirable basis for the construction of the Upper Yukon Run stock composition model. Unfortunately, escapement sampling effort has failed to provide data that can be confidently used for the Upper Yukon Run stock standard and scales collected from tagging fish wheel catches are the best compromise available.

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. This remains the only 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 in order to document the age and sex composition of chinook salmon in the Upper River escapement. Tightening budgets have resulted in elimination of those sampling efforts. Additionally, DFO stopped sampling the commercial salmon catch in Canada for age and sex information. Lack of catch and escapement sampling in the Canadian portion of the drainage has weakened basic biological information on the age and sex composition of the run and made the scale pattern analysis study dependent on DFO tagging study fish wheel samples for characterizing the stock standard.

LITERATURE CITED

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

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

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

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

Hoenig, J.M., and D.M. Heisey. 1987. Use of a log-linear model with the EM algorithm to correct estimates of stock composition and to convert length to age. Transactions of the American Fisheries Society 116:232–243.

JTC (Joint United States/Canada Yukon River Technical Committee). 1991. Yukon River salmon season review for 1991 and technical committee report. Whitehorse, Yukon Territory.

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

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

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

Merritt, M.F. 1988. Origins of chinook salmon in the Yukon River fisheries, 1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fishery Report 88-14, Juneau.

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

Meyers, K.W., and D.E. Rogers. 1985. Determination of stock origins of chinook salmon incidentally caught in foreign trawls in the Alaskan FCZ. Draft Report, University of Washington, Fisheries Research Institute, Contract 84-3 FRI-UW-8502, Seattle.

Millar, R.B. 1987. Maximum likelihood estimation of mixed stock fishery composition. Canadian Journal of Fisheries and Aquatic Science 44:583–590.

LITERATURE CITED (Continued)

Rogers, D.E., and five coauthors. 1984. Origins of chinook salmon in the area of the Japanese mothership salmon fishery. University of Washington, Fisheries Research Institute, Final Report, July 1983–September 1984, Contract 84-0152, Seattle.

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

Schneiderhan, D.J., and J.A. Wilcock. 1992. Origins of chinook salmon in the Yukon River, 1989. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fishery Report 92-02, Juneau.

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

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

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

Wilcock, J.A. 1990. Origins of chinook salmon in the Yukon River fisheries, 1988. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fishery Report 90-02, Juneau.

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

Table 1. Run of origin percentages for the total Yukon River harvest of chinook salmon, 1982–91.

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
1982–90 Avg	22.3	20.9	56.8
1986–90 Avg	23.0	14.5	62.5

Table 2. Age proportions of Yukon River chinook salmon escapement samples, 1991.

Location	Escapement Index Abundance Estimate	Sample Size[a]	Brood Year and Age Group									
			1988	1987	1986		1985		1984		1983	
			1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5
Lower Yukon												
Andreafsky River[b]	4,482	424	0.0000	0.0802	0.5967	0.0000	0.3019	0.0000	0.0212	0.0000	0.0000	0.0000
Anvik River	875	379	0.0000	0.1029	0.5488	0.0000	0.3193	0.0000	0.0290	0.0000	0.0000	0.0000
Average Proportion[c]			0.0000	0.0909	0.5741	0.0000	0.3101	0.0000	0.0249	0.0000	0.0000	0.0000
Middle Yukon												
Chena River[d]	3,025	340	0.0000	0.0846	0.5594	0.0000	0.2823	0.0000	0.0737	0.0000	0.0000	0.0000
Salcha River[d]	5,608	526	0.0019	0.0798	0.4392	0.0000	0.4163	0.0019	0.0589	0.0000	0.0019	0.0000
Average Proportion			0.0012	0.0815	0.4813	0.0000	0.3694	0.0012	0.0641	0.0000	0.0012	0.0000
Upper Yukon (Canada)												
White Rock & Sheep Rock[d]	40,993	1415	0.0000	0.0707	0.5011	0.0014	0.3618	0.0064	0.0565	0.0014	0.0000	0.0007

[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 1,938 and 2,544.

[c] Calculated based on sample size rather than escapement estimates because the Anvik estimate was derived under poor survey conditions.

[d] Mark and recapture population estimate.

Table 3. Classification accuracies of linear discriminant run–of–origin models for age–1.3 and –1.4 Yukon River chinook salmon, 1991.

Age 1.3

Region of Origin	Sample Size	Classified Region of Origin: Lower	Middle	Upper
Lower	247	0.846	0.138	0.016
Middle	243	0.119	0.613	0.267
Upper	235	0.030	0.306	0.664

Mean Classification Accuracy: 0.708
Variables in Analysis: 67, 103, 62, 111, 79, 2, 25, 23, 1

Age 1.4

Region of Origin	Sample Size	Classified Region of Origin: Lower	Middle	Upper
Lower	155	0.813	0.097	0.090
Middle	155	0.084	0.703	0.213
Upper	171	0.023	0.263	0.713

Mean Classification Accuracy: 0.743
Variables in Analysis: 67, 14, 61, 70, 81

Table 4. Run composition estimates for age-1.3 and -1.4 chinook salmon commercial catches in Yukon River District 1, 1991.

			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	6/13-14	Lower	113	0.293	0.055	0.175 < P < 0.411	112	0.343	0.057	0.222 < P < 0.463
		Middle		0.057	0.122	0.000 < P < 0.315		0.161	0.087	0.000 < P < 0.346
		Upper		0.650	0.111	0.414 < P < 0.886		0.497	0.088	0.310 < P < 0.683
2	6/17-18	Lower	106	0.326	0.063	0.193 < P < 0.460	106	0.521	0.064	0.383 < P < 0.658
		Middle		0.380	0.131	0.102 < P < 0.658		0.306	0.087	0.120 < P < 0.492
		Upper		0.294	0.109	0.062 < P < 0.526		0.173	0.077	0.009 < P < 0.337
3	6/20-21	Lower	35	0.411	0.108	0.182 < P < 0.641	33	0.242	0.100	0.030 < P < 0.455
		Middle		0.066	0.209	0.000 < P < 0.510		0.458	0.176	0.084 < P < 0.832
		Upper		0.523	0.189	0.122 < P < 0.924		0.300	0.159	0.000 < P < 0.638
4	6/24-25	Lower	74	0.472	0.082	0.298 < P < 0.646	115	0.403	0.059	0.278 < P < 0.528
		Middle		0.494	0.149	0.177 < P < 0.811		0.246	0.086	0.062 < P < 0.430
		Upper		0.034	0.107	0.000 < P < 0.262		0.351	0.083	0.174 < P < 0.527
5	7/01-02	Lower	50	0.681	0.095	0.479 < P < 0.884	129	0.538	0.058	0.414 < P < 0.663
		Middle		0.158	0.159	0.000 < P < 0.496		0.275	0.078	0.109 < P < 0.441
		Upper		0.161	0.120	0.000 < P < 0.417		0.187	0.070	0.038 < P < 0.336
6	7/04-05	Lower	2	1.000	0.000		6	0.387	0.240	0.000 < P < 0.897
		Middle		0.000	0.000			0.000	0.000	
		Upper		0.000	0.000			0.613	0.240	0.103 < P < 1.000

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

Table 5. Run composition estimates for age–1.3 and –1.4 chinook salmon commercial catches in Yukon River District 2, 1991.

Commercial Fishing Period	Dates	Run–of–Origin	Age 1.3 N	Age 1.3 P	Age 1.3 S.E.	Age 1.3 Simultaneous 90% CI[a]	Age 1.4 N	Age 1.4 P	Age 1.4 S.E.	Age 1.4 Simultaneous 90% CI[a]
1	6/16–17	Lower	55	0.143	0.079	0.000 < P < 0.312	58	0.324	0.079	0.157 < P < 0.491
		Middle		0.799	0.190	0.395 < P < 1.000		0.230	0.125	0.000 < P < 0.495
		Upper		0.058	0.153	0.000 < P < 0.383		0.446	0.122	0.187 < P < 0.705
2	6/19–20	Lower	144	0.325	0.056	0.206 < P < 0.443	88	0.315	0.067	0.173 < P < 0.456
		Middle		0.583	0.113	0.344 < P < 0.823		0.580	0.105	0.357 < P < 0.803
		Upper		0.092	0.087	0.000 < P < 0.277		0.106	0.087	0.000 < P < 0.290
3	6/23–24	Lower	91	0.564	0.071	0.413 < P < 0.715	109	0.461	0.062	0.329 < P < 0.594
		Middle		0.171	0.125	0.000 < P < 0.437		0.264	0.087	0.079 < P < 0.450
		Upper		0.265	0.102	0.048 < P < 0.482		0.274	0.082	0.101 < P < 0.448
4	6/26	Lower	77	0.534	0.079	0.366 < P < 0.702	130	0.327	0.053	0.213 < P < 0.440
		Middle		0.311	0.141	0.011 < P < 0.611		0.312	0.085	0.132 < P < 0.492
		Upper		0.155	0.108	0.000 < P < 0.385		0.362	0.080	0.192 < P < 0.531
5	6/30–7/01	Lower	44	0.581	0.103	0.362 < P < 0.800	29	0.509	0.124	0.245 < P < 0.773
		Middle		0.210	0.180	0.000 < P < 0.592		0.378	0.170	0.016 < P < 0.740
		Upper		0.209	0.142	0.000 < P < 0.512		0.113	0.142	0.000 < P < 0.414
6	7/03–04	Lower	69	0.580	0.083	0.404 < P < 0.756	115	0.388	0.060	0.261 < P < 0.516
		Middle		0.420	0.083	0.244 < P < 0.596		0.438	0.090	0.247 < P < 0.629
		Upper		0.000	0.000	0.000 < P < 0.000		0.174	0.077	0.009 < P < 0.338
7[b]	7/07									

[a] Confidence intervals are calculated as $p \pm ((z_{(alpha/2k)})(S.E. \text{ of } p))$, where k=3 and alpha/2k=2.128.
[b] Not sampled.

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 1, 1991.

Commercial Fishing Period	Dates	Region of Origin	Age Group 1.3	1.4	Total
1	6/13–14	Lower	2,240	3,030	5,270
		Middle	435	1,419	1,854
		Alaska	2,675	4,449	7,124
		Upper	4,963	4,394	9,357
		Total	7,637	8,843	16,480
2	6/17–18	Lower	2,411	3,772	6,183
		Middle	2,808	2,219	5,028
		Alaska	5,219	5,992	11,211
		Upper	2,170	1,256	3,426
		Total	7,389	7,248	14,637
3	6/20–21	Lower	860	550	1,410
		Middle	137	1,038	1,176
		Alaska	997	1,588	2,585
		Upper	1,093	681	1,774
		Total	2,091	2,269	4,359
4	6/24–25	Lower	1,604	2,072	3,676
		Middle	1,679	1,265	2,944
		Alaska	3,283	3,337	6,620
		Upper	114	1,804	1,918
		Total	3,397	5,141	8,537
5	7/01–02	Lower	870	2,086	2,955
		Middle	202	1,065	1,267
		Alaska	1,072	3,151	4,223
		Upper	205	723	928
		Total	1,277	3,874	5,151
6	7/04–05	Lower	429	249	678
		Middle	0	0	0
		Alaska	429	249	678
		Upper	0	394	394
		Total	429	643	1,072
Post–Season[a]		Lower	18	10	28
		Middle	0	0	0
		Alaska	18	10	28
		Upper	0	16	16
		Total	18	26	44
District 1 Season Total		Lower	8,430	11,769	20,199
		Middle	5,261	7,007	12,268
		Alaska	13,692	18,776	32,468
		Upper	8,545	9,268	17,813
		Total	22,237	28,044	50,281

[a] Fall season (16 July and later) commercial catch.

Table 7. 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, 1991.

Commercial Fishing Period	Dates	Region of Origin	Age Group 1.3	1.4	Total
1	6/16–17	Lower	821	1,718	2,538
		Middle	4,578	1,218	5,796
		Alaska	5,399	2,935	8,334
		Upper	333	2,365	2,698
		Total	5,732	5,300	11,032
2	6/19–20	Lower	1,632	1,260	2,892
		Middle	2,931	2,321	5,253
		Alaska	4,563	3,581	8,144
		Upper	461	423	884
		Total	5,024	4,004	9,028
3	6/23–24	Lower	1,739	1,464	3,203
		Middle	528	839	1,367
		Alaska	2,267	2,303	4,570
		Upper	817	870	1,687
		Total	3,085	3,173	6,257
4	6/26	Lower	677	755	1,433
		Middle	394	722	1,116
		Alaska	1,072	1,477	2,549
		Upper	197	836	1,033
		Total	1,268	2,313	3,582
5	6/30–7/01	Lower	519	294	813
		Middle	187	219	406
		Alaska	706	513	1,219
		Upper	187	65	252
		Total	893	578	1,471
6	7/03–04	Lower	880	990	1,870
		Middle	637	1,116	1,753
		Alaska	1,517	2,106	3,623
		Upper	0	442	442
		Total	1,517	2,548	4,065
7[a]	7/07	Lower	106	119	225
		Middle	77	134	211
		Alaska	182	253	435
		Upper	0	53	53
		Total	182	306	488
Post–Season[b]		Lower	5	6	11
		Middle	4	7	11
		Alaska	9	13	22
		Upper	0	3	3
		Total	9	16	25
District 2 Season Total		Lower	6,380	6,605	12,985
		Middle	9,337	6,575	15,912
		Alaska	15,716	13,180	28,897
		Upper	1,995	5,058	7,053
		Total	17,711	18,238	35,949

[a] No sample data available. Allocated with Period 6 proportions.

[b] Fall season (16 July and later) commercial catches.

Table 8. Total catch by age class and run of chinook salmon from Yukon River Districts 1–6 and Canada commercial and subsistence catches, 1991.

22–Sep–93 EARLIER OR UNDATED MATERIAL IS SUPERCEDED

			Brood Year and Age Group										
			1988	1987	1986		1985		1984		1983		
District	Fishery	Run of Origin	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	Total
1	Commercial Gill Net	Lower	0	279	8,430	0	11,769	0	1,164	0	17	0	21,659
		Middle	0	186	5,261	0	7,007	50	1,497	0	22	0	14,023
		Alaska	0	465	13,692	0	18,776	50	2,661	0	39	0	35,682
		Upper	0	252	8,545	0	9,268	345	1,783	832	26	85	21,136
		Total [a]	0	716	22,236	0	28,043	394	4,444	832	66	85	56,817
	Subsistence Gill Net [b]	Lower	0	11	726	0	982	0	88	0	0	0	1,808
		Middle	0	2	141	0	460	2	89	0	0	0	695
		Alaska	0	13	867	0	1,443	2	178	0	0	0	2,503
		Upper	0	22	1,609	0	1,425	33	249	65	0	18	3,422
		Total	0	36	2,477	0	2,868	36	427	65	0	18	5,925
2	Commercial Gill Net	Lower	0	401	6,380	0	6,605	0	416	0	8	0	13,810
		Middle	0	627	9,337	0	6,575	36	896	0	16	0	17,486
		Alaska	0	1,028	15,716	0	13,180	36	1,312	0	24	0	31,296
		Upper	0	112	1,995	14	5,058	144	620	122	11	0	8,076
		Total [c]	0	1,139	17,711	14	18,238	179	1,933	122	35	0	39,373
	Subsistence Gill Net [d]	Lower	0	0	537	0	1,123	0	69	0	0	0	1,728
		Middle	0	0	2,993	0	796	4	105	0	0	0	3,899
		Alaska	0	0	3,530	0	1,919	4	174	0	0	0	5,627
		Upper	0	0	218	0	1,546	42	184	0	0	0	1,990
		Total	0	0	3,748	0	3,465	46	358	0	0	0	7,617
3	Commercial Gill Net [d]	Lower	0	24	380	0	393	0	25	0	0	0	822
		Middle	0	37	556	0	391	2	53	0	1	0	1,041
		Alaska	0	61	936	0	785	2	78	0	1	0	1,863
		Upper	0	7	119	1	301	9	37	7	1	0	481
		Total	0	68	1,054	1	1,086	11	115	7	2	0	2,344
	Subsistence Gill Net [d]	Lower	0	0	211	0	442	0	27	0	0	0	680
		Middle	0	0	1,178	0	313	2	41	0	0	0	1,535
		Alaska	0	0	1,389	0	755	2	68	0	0	0	2,215
		Upper	0	0	86	0	609	16	72	0	0	0	783
		Total	0	0	1,475	0	1,364	18	141	0	0	0	2,998
4	Commercial & Subsistence GN & FW [e]	Lower	0	145	2,315	0	2,397	0	151	0	3	0	5,010
		Middle	0	227	3,388	0	2,386	13	325	0	6	0	6,344
		Alaska	0	373	5,702	0	4,782	13	476	0	9	0	11,355
		Upper	0	40	724	5	1,835	52	225	44	4	0	2,930
		Total	0	413	6,426	5	6,617	65	701	44	13	0	14,285

–Continued–

Table 8. (Page 2 of 2)

District	Fishery	Run of Origin	Brood Year and Age Group: 1988	1987	1986		1985		1984		1983		Total
			1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	1.6	2.5	
5	Commercial & Subsistence GN & FW[f]	Upper	0	1,340	9,503	27	6,862	121	1,072	27	0	13	18,965
6	Commercial & Subsistence GN & FW[g]	Middle	7	456	2,694	0	2,068	7	359	0	7	0	5,598
Canada	Commercial GN & FW[h]	Upper	0	771	5,465	15	3,946	69	617	15	0	8	10,906
	Non-Commercial[i]	Upper	0	691	4,900	14	3,538	62	553	14	0	7	9,779
TOTAL HARVEST		Lower	0	860	18,979	0	23,712	0	1,940	0	28	0	**45,518**
		Middle	7	1,536	25,548	0	19,996	115	3,366	0	52	0	**50,621**
		Alaska	7	2,396	44,527	0	43,708	115	5,307	0	80	0	**96,139**
		Upper	0	3,234	33,162	76	34,389	893	5,412	1,128	42	131	**78,468**
		Total	7	5,630	77,689	76	78,097	1,008	10,719	1,128	123	131	**174,606**

[a] Includes 485 fish from ADF&G test fisheries, 607 fish from fish tickets witheld by Department of Health and Social Services (DHSS), and 2,711 fish from illegal sales discovered during investigations by the Alaska Division of Fish and Wildlife Protection (FWP).

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

[c] Includes 113 fish harvested in the ADF&G Pilot Station test fishery, 30 fish from fish tickets witheld by DHSS, and 284 fish from illegal sales investigated by FWP.

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

[e] Age composition in total row is based on District 4 combined commercial and subsistence fish wheel and gill net samples. Stock composition of age class is proportioned using District 2 stock composition by age class. Commercial catch = 2,996 fish. Subsistence catch =11,289 fish.

[f] Gill net & fish wheel catches combined. Commercial catch = 3,826. Subsistence catch = 15,073. Subsistence catch unassigned to district = 66 fish (Bromaghin 1992).

[g] Gill net and fish wheel catches combined. Includes commercial (1,072), subsistence (3,805), and ADF&G test fish (91) catches. Also includes sport catch of 630.

[h] Run and age composition based on Canada DFO tagging study fish wheel samples.

[i] Run and age composition based on Canada DFO tagging study fish wheel samples. Harvest components include Yukon River Indian food (9,011), Porcupine River Indian Food (163), domestic (305), and sport (300) fisheries.

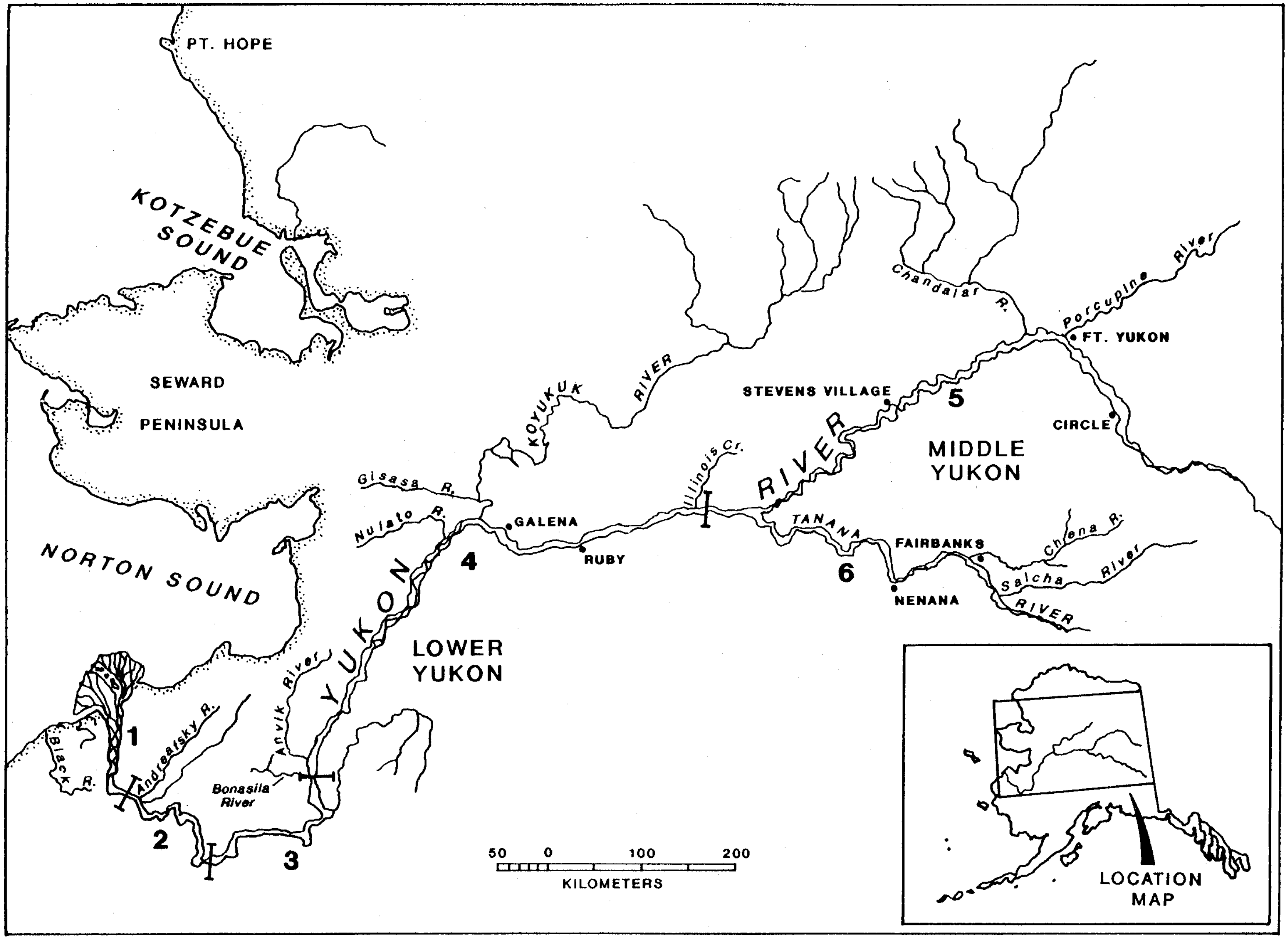

Figure 1. Alaskan portion of the Yukon River showing fishing district boundaries.

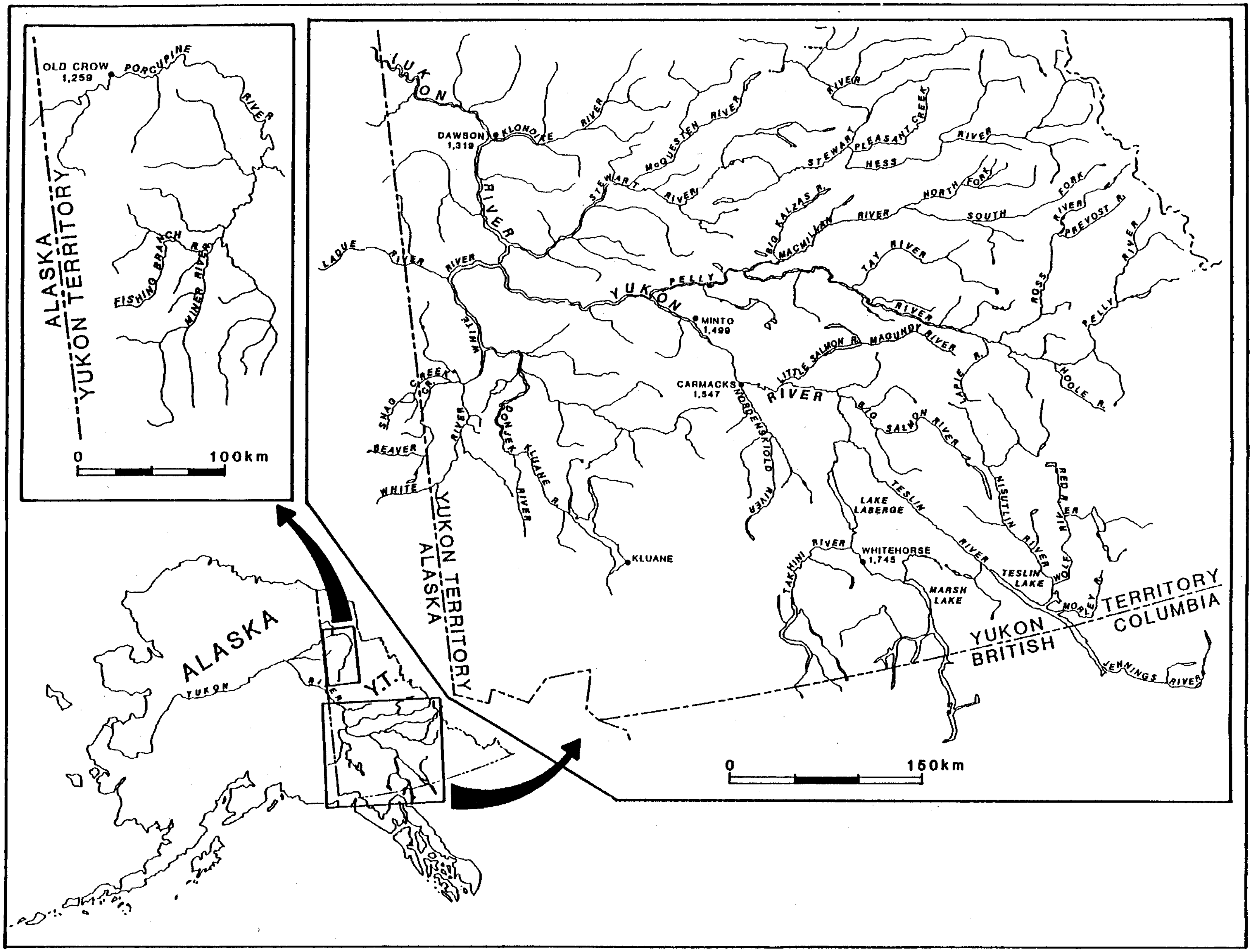

Figure 2. Canadian portion of the Yukon River drainage.

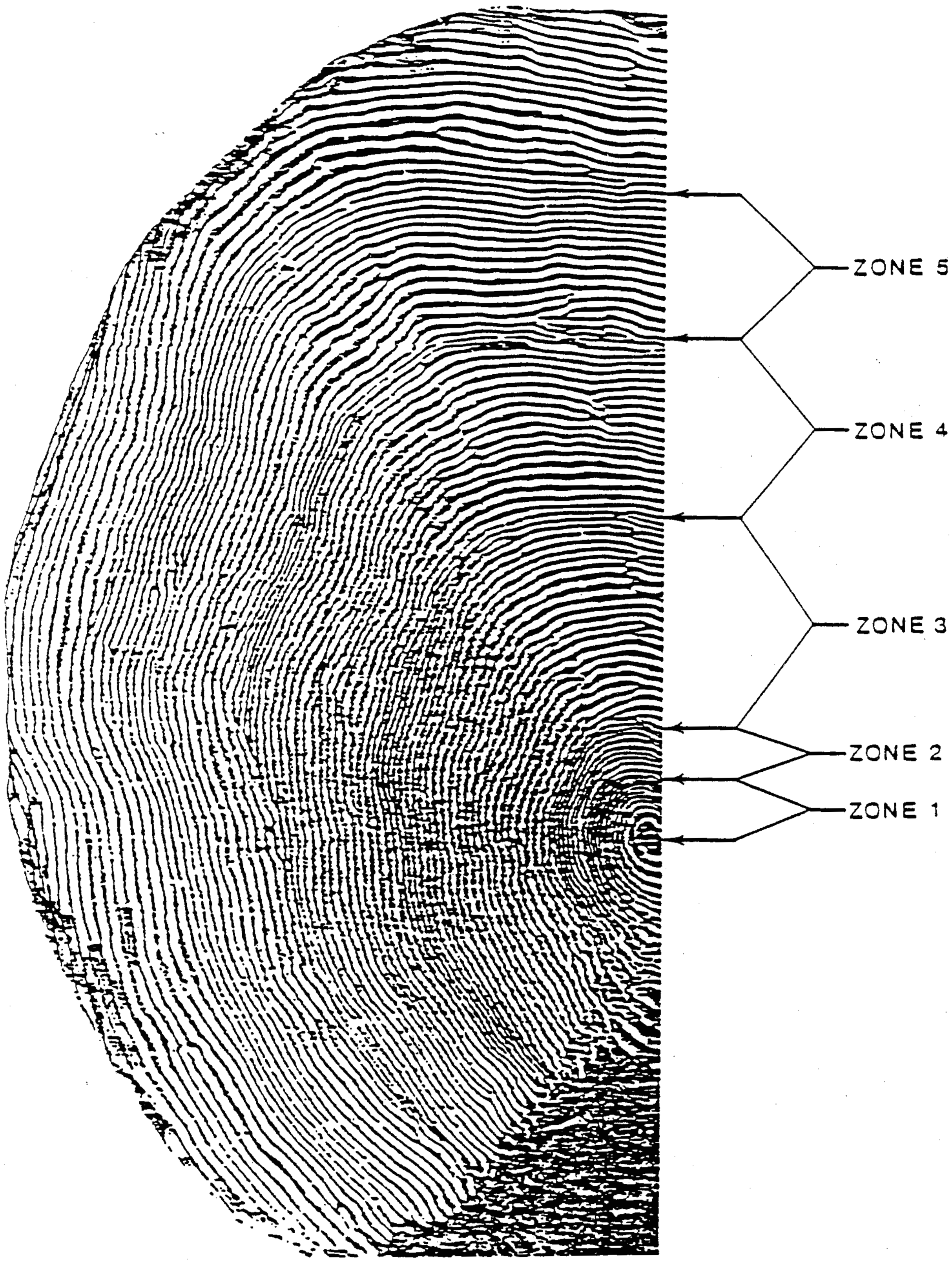

Figure 3. Age-1.4 chinook salmon scale showing zones measured for linear discriminant analysis.

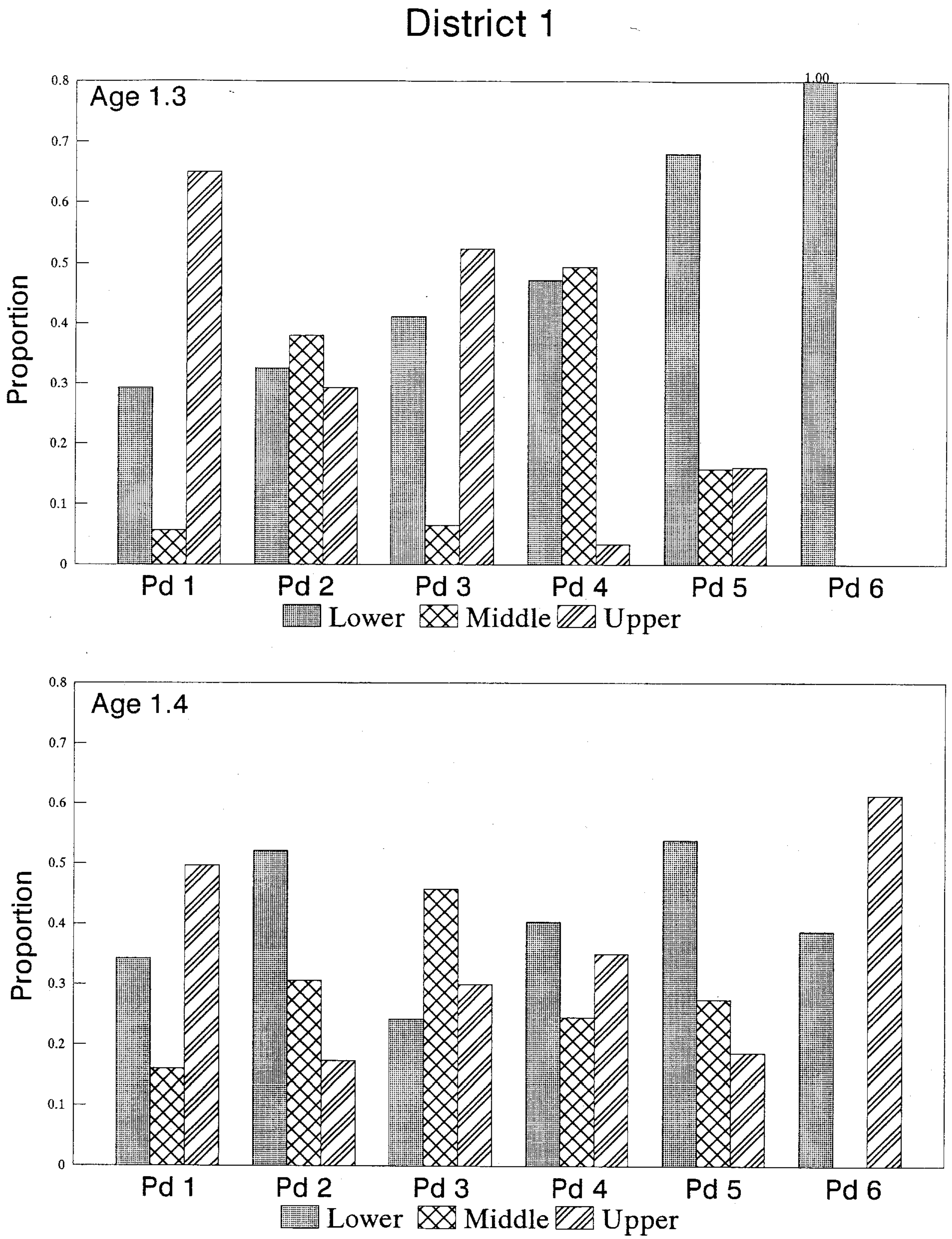

Figure 4. Proportion of catch by run estimated from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 1, 1991.

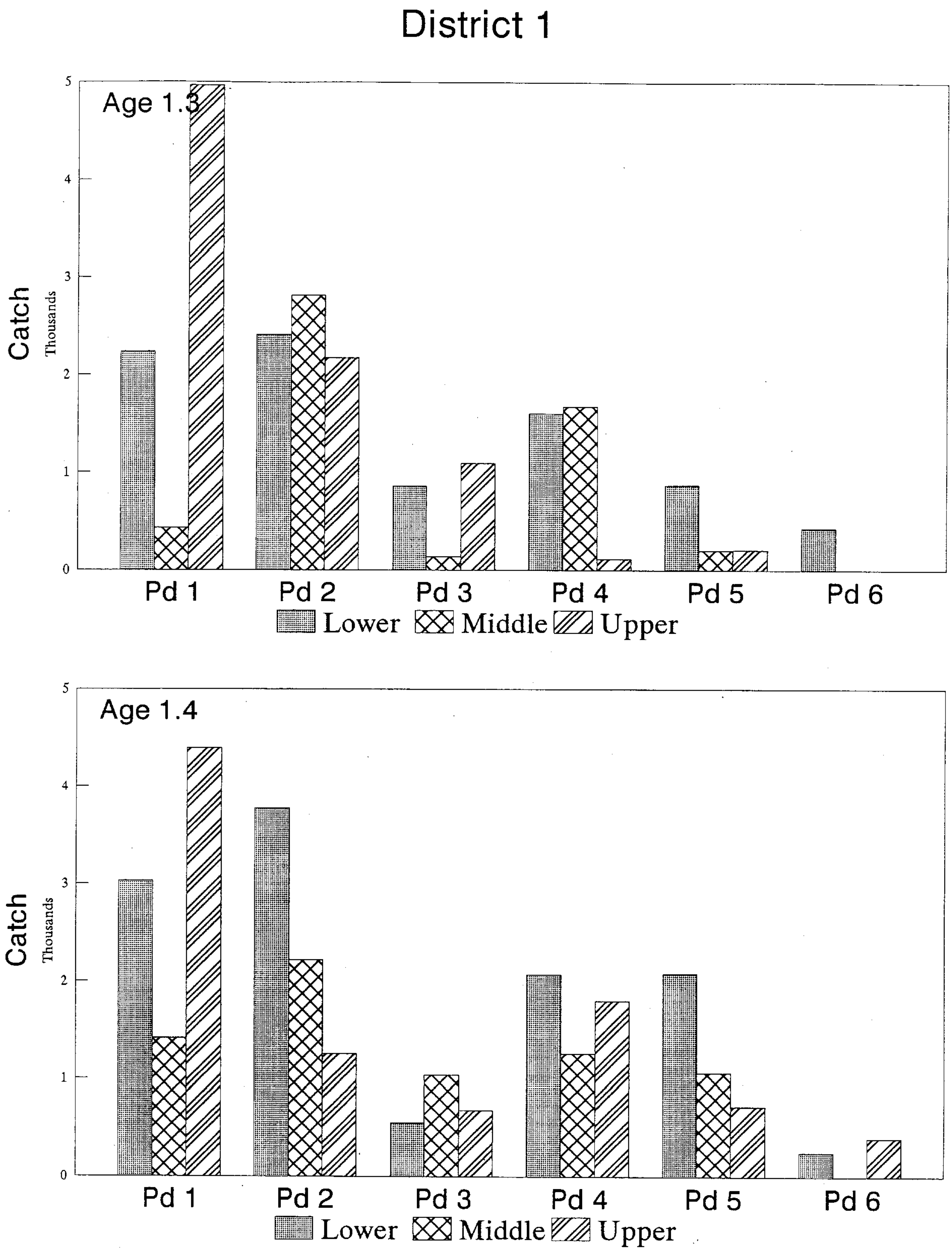

Figure 5. Catch by run in numbers of fish estimated from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 1, 1991.

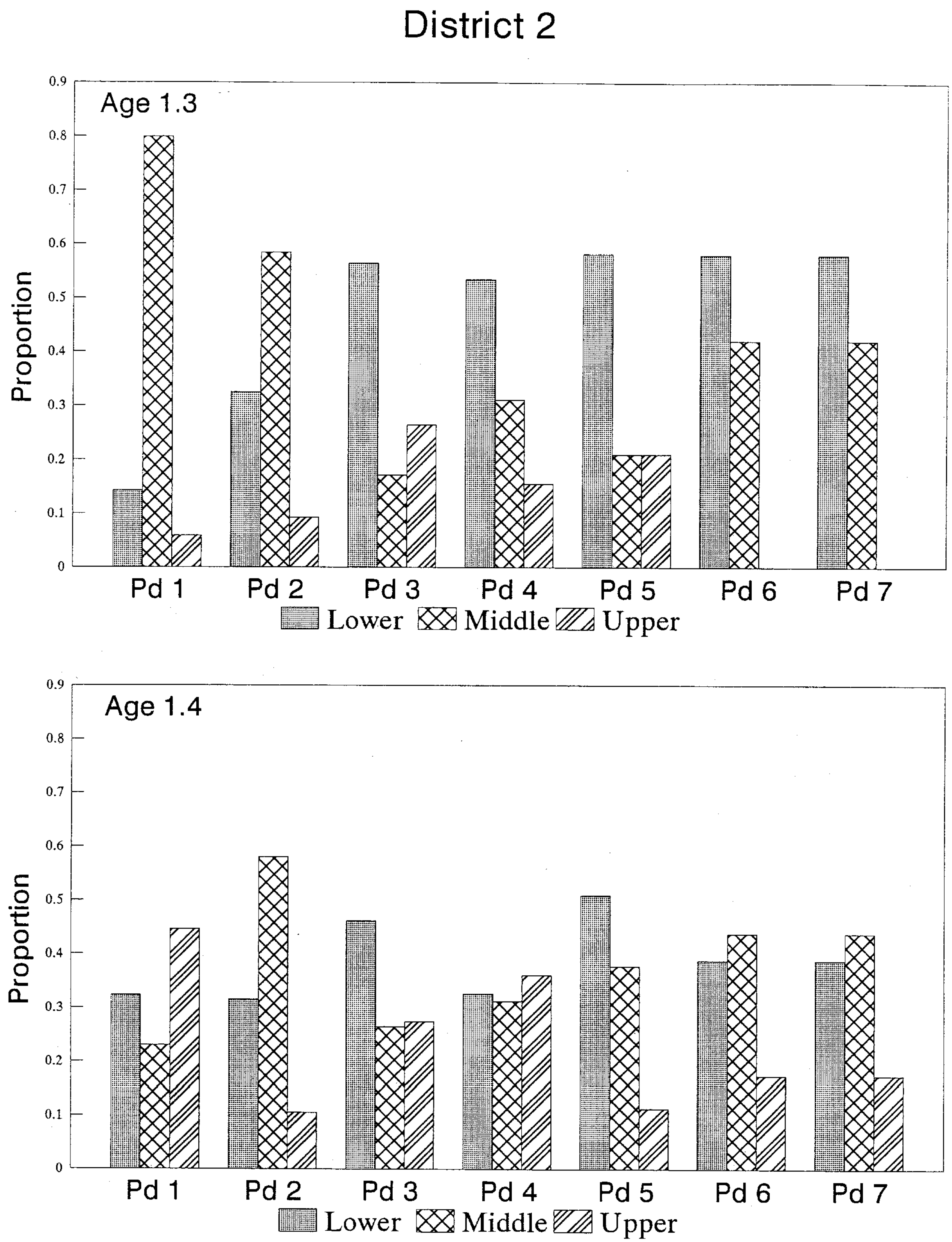

Figure 6. Proportion of catch by run estimated from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 2, 1991.

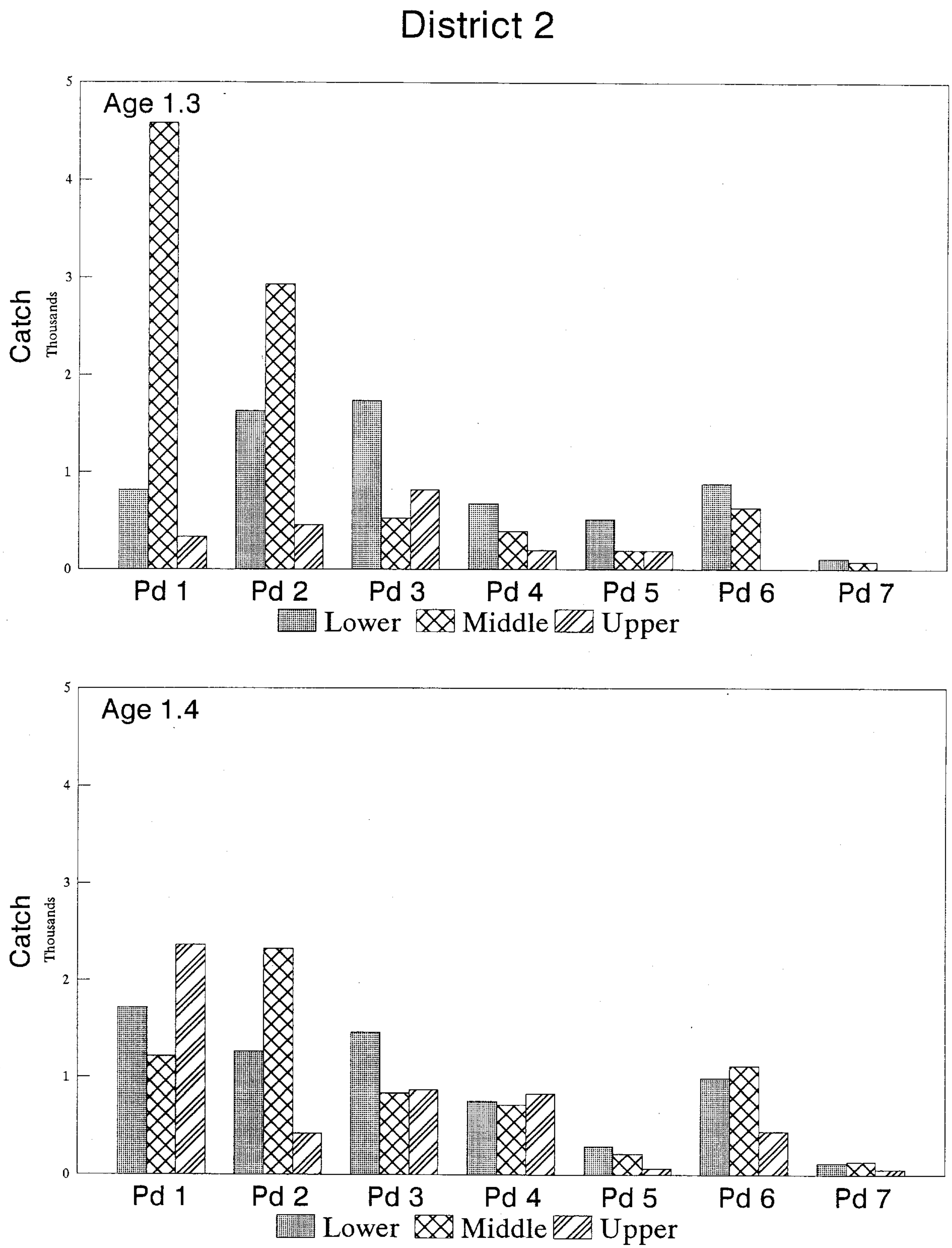

Figure 7. Catch by run in numbers of fish estimated from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon river District 2, 1991.

APPENDIX

Appendix A. Scale variables screened for linear discriminant function analysis of age-1.3 and -1.4 Yukon River chinook salmon, 1991.

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 interaval 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 interaval 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 freshwaterzone.
[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, 1991.

		Lower		Middle		Upper		
Growth Zone	Variable	Mean	SE	Mean	SE	Mean	SE	F-Value
<u>Age-1.3</u>								
1st FW Annular	1	9.49	0.09	8.40	0.10	8.77	0.09	36.69
	2	125.45	1.12	111.67	1.14	115.48	1.05	41.82
	23	0.16	<0.01	0.16	<0.01	0.16	<0.01	2.34
	25	0.27	<0.01	0.31	<0.01	0.29	<0.01	28.03
FW Plus Growth	62	35.15	0.95	61.40	0.91	72.03	0.99	400.76
Total FW Growth	67	0.79	0.01	0.65	<0.01	0.62	<0.01	420.05
1st Marine Ann.	79	160.52	1.16	167.92	1.237	179.26	1.33	57.12
	103	0.22	<0.01	0.22	<0.01	0.22	<0.01	3.58
	111	1005.63	5.76	932.78	7.00	914.84	5.85	59.69
<u>Age-1.4</u>								
1st FW Annular	14	80.36	1.44	53.48	1.14	62.61	1.12	118.23
FW Plus Growth	61	3.51	0.11	5.37	0.10	6.44	0.09	220.44
Total FW Growth	67	0.78	0.01	0.64	0.01	0.61	<0.01	263.55
1st Marine Ann.	70	25.69	0.26	26.76	0.25	25.10	0.21	12.84
	81	54.07	0.65	53.41	0.57	57.95	0.52	18.52
	106	13.03	0.15	13.32	0.14	12.16	0.12	20.19

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, 1991.

			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.	9.49	0.09	8.40	0.10	8.77	0.09	36.69
	2	Distance	125.45	1.12	111.67	1.14	115.48	1.05	41.82
Total FW Growth	61	No. Circ.	3.42	0.09	5.40	0.07	6.44	0.08	353.73
	62	Distance	35.15	0.95	61.40	0.91	72.03	0.99	400.76
1st Ocean Ann.	70	No. Circ.	27.13	0.18	25.56	0.17	24.17	0.15	76.08
	71	Distance	505.94	3.43	470.31	3.93	456.07	3.18	52.89
2nd Ocean Ann.	109	Distance	499.69	3.77	462.46	4.15	458.77	4.02	32.52
<u>Age-1.4</u>									
1st FW Annular	1	No. Circ.	10.23	0.14	7.94	0.11	8.88	0.11	91.24
	2	Distance	132.28	1.59	103.34	1.40	113.29	1.20	107.50
Total FW Growth	61	No. Circ.	3.51	0.11	5.37	0.10	6.44	0.09	220.44
	62	Distance	39.14	1.37	59.04	1.11	59.04	1.11	193.59
1st Ocean Ann.	70	No. Circ.	25.69	0.26	26.76	0.25	25.10	0.21	12.84
	71	Distance	473.47	5.50	480.57	5.13	462.26	4.19	3.59
2nd Ocean Ann.	109	Distance	362.61	5.60	359.83	4.99	356.27	4.67	0.40
3rd Ocean Ann.	110	Distance	427.86	6.54	403.32	4.98	386.85	4.65	14.70