3A96-10

ORIGINS OF CHINOOK SALMON

IN THE YUKON RIVER FISHERIES, 1994

By

Daniel J. Schneiderhan

Regional Information Report[1] No. 3A96-10

Alaska Department of Fish and Game
Commercial Fisheries Management and Development Division, AYK Region
333 Raspberry Road
Anchorage, Alaska 99518-1599

March 1996

[1] The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Commercial Fisheries Management and Development Division.

AUTHOR

Daniel J. Schneiderhan is the 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 Jim Menard, Alden Walker, Richard Chapell, Shelby Edmund, Tyler Ellingboe, Gene Sandone, Louis Barton, and Dan Bergstrom. 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, Chuck Blaney, 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 Sandy Johnston and 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. NA46FP0343.

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 1994 was 191,252 chinook salmon, of which 60% was estimated to be the Upper Yukon Run, 24% the Middle Yukon Run, and 16% 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 exhibited a less pronounced decline 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 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 occur primarily in the Tanana River drainage and in Canada. However, small unreported sport fishing harvests are known to occur elsewhere in the Alaskan portion of the Yukon River drainage.

In the 20 years after statehood (1960-1979), the total chinook salmon harvest in the Yukon River in both Alaska and Canada ranged from 77,250 to 169,607 and averaged 123,033 fish annually (JTC 1994). Beginning in 1980, annual harvests increased substantially. During the most recent 5-year period (1989-1993) total annual catches averaged 177,052 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 1989-93 average commercial harvest in Districts 1 and 2 was 53% of total drainage harvest, and subsistence harvests in the two districts accounted for another 9%. Most of the subsistence harvest is taken with fish wheels and gillnets in Districts 4, 5, and 6. In 1994, commercial, subsistence, Aboriginal, domestic, and sport fishermen in Alaska and Canada harvested a total of 191,252 Yukon River chinook salmon, of which 105,564 fish (55.2%) were taken by District 1 and 2 commercial fishermen.

Chinook salmon harvested in the Yukon River fisheries consist of a mixture of stocks bound 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, 1994a, 1994b, 1994c).

The objective of this study was to classify all Yukon River chinook salmon harvests to run of origin for the 1994 season.

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 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 Sampling

Spawning escapements for the three Yukon River chinook salmon runs were characterized by separate age compositions and indexes of abundance. Scale samples for age composition estimates were collected during the period of peak spawner mortality from the Anvik, Chena, and Salcha Rivers in Alaska. Carcasses were the primary source of samples; however, some samples were obtained from live fish captured with spears or other methods. Live salmon from the Andreafsky River were sampled at a weir project operated by U. S. Fish and Wildlife Service (FWS). Chinook salmon in Canadian tributaries were not sampled in 1994; however, the Canadian border passage of chinook salmon was sampled at DFO fish wheel sites prior to entry of the run into Canadian Yukon River fisheries.

Since comparable escapement estimates for the Lower Yukon Run tributaries, i.e., Andreafsky and Anvik Rivers, were not available as weighting factors, the age composition of the Lower Yukon Run was estimated simply as the age proportions of combined Andreafsky and Anvik River samples. The Chena and Salcha River escapements, which are used to characterize the Middle Yukon Run, had abundance estimates of comparable quality that were used as weighting factors in conjunction with sample age compositions to obtain an estimate of age composition for the run. The age composition obtained from samples collected at the two DFO salmon tagging sites was used to characterize the spawning escapement for the Upper Yukon Run.

Estimation of Catch Composition

Linear discriminant function analysis (Fisher 1936) of scale pattern data, observed differences in age composition between escapements, and geographic occurrence of catches were used to estimate runs of origin for 1994 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 a four-way run of origin classification model based on linear discriminant functions (LDF) of scale variables. Scales representing major age classes, i.e., age classes with large *n*, that were subject to digitizing for the Lower Yukon Run component of the SPA 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 fish captured in test fish wheels which were operated in conjunction with the U.S.-Canada border passage study at White Rock and Sheep Rock sites operated by DFO and located in Canada between 6 and 12 mi (10-20 km) upstream from the U.S.-Canada border.

Only scales with one freshwater annulus (age 1.) were considered for digitizing and subsequent scale pattern analysis. Salmon scales from the dominant age classes, i.e., ages 1.3 and 1.4, that were obtained from the samples taken from the lower river commercial gillnet fishery were classified to run of origin using the discriminant functions. 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 1994.

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.

The run-of-origin standard (pooled rivers) for the Middle Yukon Run was weighted by spawning population estimates from mark and recapture studies on the Chena and Salcha Rivers for the Middle Yukon Run. Escapement indexes of similar quality were not available for the Andreafsky and Anvik Rivers; however, there was little difference (Non-statistical comparison, NSC) in age compositions between the two rivers and an unweighted standard was thought to introduce little bias for the SPA classification model for major ages.

A four-way run classification model consisting of separate standards for Lower Yukon, Chena River, Salcha River, and Upper Yukon stocks was used for the first time in 1994. This was necessary because samples from the two middle run tributaries, the Chena and Salcha Rivers, exhibited marked differences ($F>4$, $\alpha=.05$) in a number of important growth variables and therefore could not be lumped as usual. Run-of-origin models were constructed for age-1.3 and -1.4 fish. The resulting proportions obtained for the Chena and Salcha Rivers were subsequently combined to represent the Middle Yukon Run proportion.

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 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. This assumption may have been violated, but any bias introduced was believed to be minor. Escapement age composition data, either unweighted or weighted by acceptable escapement 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, i.e. Lower, Middle, or Upper Yukon Run;

a = age class in the escapement which was classified to run of origin by SPA, i.e., 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.

In previous years the proportion of age-1.1, -0.3, -1.2 and -0.4 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 also from a recent brood year. Proportions of age-2.2, -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 and are the oldest group of fish in the return. 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, i.e., 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, i.e., 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, i.e., 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 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 catches taken in the first commercial period 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. Even though lower Koyukuk River subsistence harvests are classified as Lower Yukon Run, 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. These fish were removed from the District 4 total catch prior to classification by the SPA and age composition ratio methods. They were then added to the Middle Yukon Run in the same proportions by age class as the other fish that were classified to the run. 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, which totalled 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 slight 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. Also, subsistence catches of salmon numbering about 90 fish taken in the Chandalar River by residents of Venetie were clearly not of Canadian origin. Those fish were assigned 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 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 Yukon Territory.

RESULTS

Escapement Age Composition

Estimated spawning escapement age compositions of Yukon River chinook salmon in 1994 exhibited some differences between lower and middle Yukon River escapements (Table 1). While Table 1 also lists Canadian samples taken at White Rock and Sheep Rock sites, they can not be considered escapement samples, because Canadian fisheries occur above those sampling sites. No spawning escapement sampling was conducted for upper Yukon River stocks. Fish wheels do not provide samples that can be used for valid comparisons to the spawning ground samples which were obtained prior to 1991.

All escapement sample size objectives were achieved. Age-1.3 fish were more abundant than age-1.4 fish in lower Yukon River escapements; however, in middle Yukon River escapements, age-1.4 fish dominated. This type of relative age composition has been noted in other years. As in many past years, age 1.4 was the largest age class of the Middle Yukon Run. The large proportions of age 1.2 from the 1989 brood year that were present in 1993 middle Yukon River escapements were reflected in large proportions of age 1.3 for the same brood year in 1994 escapements. As usual, except for age-2.2 fish, age 2. fish were seldom represented in lower and middle Yukon River escapements.

Classification Accuracies of Run of Origin Models

The mean classification accuracy of the 4-way, run of origin model for age 1.3 was 72.9% and for age 1.4 was 70.6% (Table 2). This was comparable to accuracies normally achieved with 3-way models used in other years. Also, similar to past years, the lower river standard showed the greatest classification accuracy for age 1.3 (83.7%), as well as for age 1.4 (77.4%). Upper river standards reflected slightly better than usual classification accuracies: 69.8% for age 1.3 and 74.5% for age 1.4. Upper river standards most often misclassified to the Middle Yukon Run (21.9% for age 1.3 and 16.7% for age 1.4), and middle river standards most often misclassified to the Upper Yukon Run (27.4% for age 1.3 and 32.6% for age 1.4). Chena River standards were responsible for the majority of misclassification attributed to the Middle Yukon Run, i.e., 26.3% of age 1.3 and 27.6% of age 1.4 misclassify to the Upper Yukon Run. Historically, this magnitude of misclassification of the Middle Yukon Run, as a whole, to the Upper Yukon Run is common and expected. In contrast, the Salcha River stock standards resulted in very little misclassification to either the Lower or Upper Yukon Runs, rather most misclassification was to the other Middle Yukon Run stock, i.e., Chena River stock.

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 61, the number of circuli in the freshwater plus growth zone, (2) variable 18, the relative width of the distance from circulus 0 to circulus 6 in the first freshwater annular zone divided by the width of the first freshwater annular zone, and (3) variable 14, the distance from circulus 2 to the end of the first freshwater annular zone (Appendix B). Variables 98, 105, 83, 94, and 21 (Appendix B) provided somewhat less discrimination to the model.

The primary distinguishing characters for age 1.4 in order of selection were (1) variable 61, described above, (2) variable 25, the relative width of variable 12, i.e., the distance from the fourth circulus before the first freshwater annular zone to the end of the zone, divided by the width of the first freshwater annular zone, and (3) variable 82, the distance from circulus 6 to circulus 12 of the first marine annular zone. Variables 12, 21, 108, 14, and 100 (Appendix B) were also selected. Variables involving freshwater and freshwater plus 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 3. Upper run fish comprised the largest proportion of District 1 harvests of age 1.4 in periods 2 - 5 (Table 3). Somewhat differently, in District 2 Upper Yukon Run fish were the strongest segment of the catch of both age 1.3 and 1.4 in periods 2 and 3 (Table 4).

Usually, Upper Yukon Run fish tend to dominate the harvest during the early commercial fishing periods in District 1 and gradually decrease during the later periods. In 1994 this trend was most apparent for only age-1.3 chinook salmon. The switch in dominance occurred around 22 or 23 June, or between the third and fourth periods (Figure 4). Uncharacteristically, the proportion of age 1.4 in the Upper Run continued to strengthen through time in the commercial fishery in District 1 (Table 3, Figure 4). Similar to previous years, run contribution estimates for age-1.3 salmon through time in District 1 (Figure 4) demonstrated increasing proportions of Lower Yukon fish and initially stable followed by decreasing proportions of Upper Yukon fish; however, age-1.4 salmon showed atypically steady to increasing proportions of Upper Yukon fish (Figure 4). In terms of numbers of fish caught in District 1 commercial periods (Figure 5), generally, Lower Yukon fish were most often caught in commercial periods 2 through 4, while Upper Yukon fish were caught primarily in periods 1 through 4. Few fish were caught in period 5.

The trends in proportions of Lower and Upper Yukon Run fish in District 2 appear to generally conform to those observed in District 1 (Figures 6, 7). District 1 and 2 proportions (Figures 4, 6) and harvests (Figures 5, 7) of Middle Yukon fish demonstrated generally decreasing trends in relative abundance through time in the commercial fishery.

The estimated District 1 commercial catch of age-1.3 and -1.4 fish combined was 12,615 (21.2%) Lower, 16,230 (27.3%) Middle, and 30,623 (51.5%) Upper Yukon Run (Table 5). In District 2 the estimated age-1.3 and -1.4 combined catch was 8,987 (22.8%) Lower, 12,456 (31.6%) Middle, and 17,963 (45.6%) Upper Yukon Run (Table 6).

Classification by SPA Analysis

A total of 98,873 age-1.3 and -1.4 fish (51.7% 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. Additionally, 34,087 (17.8% of the total drainage harvest) age-1.3 and -1.4 fish caught in Districts 1 and 2 subsistence fisheries and Districts 3 and 4 commercial and subsistence fisheries 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 8,528 fish (4.5%) to the total drainage harvest (Table 7). With the exception of 710 fish taken in the Koyukuk River subsistence fishery and 524 fish taken in Chandalar River and Black River subsistence fisheries, 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, i.e., age 1.3 or 1.4, through SPA.

Classification by Geographical Analysis

The Koyukuk River subsistence catch of 710 fish in District 4 is represented in the numbers of fish reported in the above sections on SPA and age composition analysis; however, the Koyukuk fish were classified to the Middle River Run based on geographical segregation as explained above. Additionally, a total of 49,764 fish (26.0% of total drainage harvest) in Districts 5, 6, and Yukon Territory was classified to run of origin based on geographical segregation. With the exception of Chandalar River subsistence catches, District 5 and Yukon Territory commercial, subsistence, Aboriginal, domestic, and sport harvests were assumed to be Upper Yukon fish. The Chandalar River subsistence catch totalling 90 fish in District 5 were classified to the Middle River Run based on geographical segregation from stocks of the Upper River Run, i.e., Canadian origin. Commercial, subsistence, and sport harvests in District 6 (Table 7) were classified entirely to the Middle Yukon Run based on geographic location of the fisheries.

Total Harvest

The commercial and subsistence harvest from the entire Yukon River drainage of 191,252 chinook salmon was classified to run of origin (Table 7) based on: (1) findings of the scale pattern analyses of age-1.3 and -1.4 fish in District 1 and 2 commercial catches, (2) age composition analyses 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 113,467 fish or 59.3% of the total drainage harvest. The Middle Yukon Run was next in abundance at 47,040 fish (24.6%), followed by the Lower Yukon Run at 30,745 fish (16.1%).

DISCUSSION

Attainment of sample size objectives presented in the annual sampling plan has been considered to be a fair measure of operational success. For all escapements which would have contributed to the standard three-way LDF classification model, sample sizes were good to excellent both quantitatively and qualitatively. Escapement sample sizes were fair to excellent in support of the four-way model that was necessary to appropriately classify 1994 catches. Acceptable sample quality depends on environmental, biological, and methodological factors. When the expected rejection rate is exceeded for scale specimens, the quantity of acceptable specimens becomes problematic. The rejection rate attributed 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.

A four-way classification model was used for the first time in 1994 to allocate the major age classes to run of origin. This was necessary because scale variables showed that substantial differences, as indicated by very large F values, existed in many comparisons of paired variables from the two components of the Middle Yukon Run, i.e., samples from the Chena and Salcha Rivers. However, some of the variables with large F values which strongly suggested a difference in growth patterns between the Chena and Salcha stocks were not selected for use in the final four-way model while other variables showing similar growth patterns or weakly different patterns between the stocks were selected for the ability to discriminate among the four stocks in the analysis. In other words, variables which were important for discriminating between the Chena and Salcha stocks were not the best choices for discriminating among Lower Yukon Run, Chena, Salcha, and Upper Yukon Run stocks. Conversely, variables with the most discriminating power in the four-way analysis were not useful to discriminate between Chena and Salcha stocks. The result of this was that the model allocated few or no fish to the Salcha River stock. After re-examining the process, I concluded that because the model misclassified most Salcha River fish to the Chena River (Table 2), the results acheived by later combining fish separately classified to the Chena and Salcha stocks in order to form the traditional Middle Yukon Run were valid and historically comparable. A three-way classification model using the traditional treatment of the Chena and Salcha stocks, combined as a single Middle Yukon Run component, resulted in slightly lower classification accuracies, further verifying the chosen methodology.

Proportions of total drainage harvest that were attributed to each run in 1994 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 56.9% since 1982. The proportion of Upper Yukon Run fish in 1994 was slightly higher than the long term average.

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 since 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 designed 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 that 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, scheduling of more unrestricted mesh-size commercial periods increases the harvest of female salmon. Increased harvests of the female component of the run can 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 and when chinook salmon returns may be problematic, 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.

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 and escapement samples were inadequate or unavailable, as in 1994.

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 available source. 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 catches, i.e., primarily from gill net gear, as well as total Upper Yukon Run escapements. The well known bias of fish wheel catches toward smaller chinook salmon renders that assumption invalid relative to gill net catches which are size-selected by gear dimensions and flexible fishing techniques.

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 DFO test fish wheel scale samples as the sole 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 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 efforts have since been eliminated because of tightening budgets. Additionally, DFO stopped sampling the commercial salmon catch in Canada for age and sex information in 1990. The lack of catch and escapement sampling in the Canadian portion of the drainage results in a serious void of basic biological information for modelling the population dynamics and stock composition of Yukon River chinook salmon.

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. Annual 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). 1994. Yukon River salmon season review for 1994 and technical committee report (December 1994). 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 No. 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.

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. 1993. Origins of chinook salmon in the Yukon River, 1990. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Fishery Report 93-11, Juneau.

Schneiderhan, D.J. 1994a. Origins of chinook salmon in the Yukon River Fisheries, 1991. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Technical Fishery Report No. 94-09, Juneau.

Schneiderhan, D.J. 1994b. Origins of chinook salmon in the Yukon River Fisheries, 1992. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Technical Fishery Report No. 94-18, Juneau.

Schneiderhan, D.J. 1994c. Origins of chinook salmon in the Yukon River Fisheries, 1993. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report No. 3A94-14, Anchorage.

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.

TABLES

Table 1. Age proportions of Yukon River chinook salmon escapement samples, 1994.

			Brood Year and Age Group												
			1991		1990		1989			1988		1987		1986	
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]		440	0.0000	0.0000	0.0000	0.0800	0.0000	0.5280	0.0020	0.3450	0.0000	0.0430	0.0000	0.0020	0.0000
Anvik River [b]		405	0.0000	0.0000	0.0000	0.0300	0.0000	0.5190	0.0000	0.3980	0.0000	0.0530	0.0000	0.0000	0.0000
Average Proportion			0.0000	0.0000	0.0000	0.0550	0.0000	0.5235	0.0010	0.3715	0.0000	0.0480	0.0000	0.0010	0.0000
Middle Yukon															
Chena River [b]	12,006	512	0.0000	0.0000	0.0000	0.0290	0.0000	0.4360	0.0000	0.5080	0.0040	0.0230	0.0000	0.0000	0.0000
Salcha River [b]	18,376	524	0.0000	0.0060	0.0000	0.0270	0.0040	0.3910	0.0000	0.5220	0.0020	0.0480	0.0000	0.0000	0.0000
Average Proportion			0.0000	0.0036	0.0000	0.0278	0.0024	0.4088	0.0000	0.5165	0.0028	0.0381	0.0000	0.0000	0.0000
Upper Yukon (Canada)															
White Rock & Sheep Rock [b]	25,890	933	0.0000	0.0300	0.0011	0.1093	0.0021	0.5702	0.0011	0.2476	0.0032	0.0289	0.0054	0.0000	0.0011

[a] Samples from the Anvik, Chena, and Salcha Rivers were collected from carcasses and live spawnouts captured with fish spears. Andreafsky River samples were from live fish captured in a weir trap, and White Rock and Sheep Rock samples were obtained from fish captured in fish wheels.

[b] Escapement index abundance estimates are from mark and recapture studies at the Chena, Salcha, and Canadian sites. Andreafsky and Anvik River age compositions were not weighted due to the non-comparability of escapement estimation results and the close similarity of age compositions between the two rivers.

Table 2. Classification accuracies of linear discriminant run–of–origin models for age–1.3 and –1.4 Yukon River chinook salmon, 1994.

		Classified Run of Origin			
Region of Origin	Sample Size	Lower	Chena	Salcha	Upper
Age 1.3					
Lower	264	0.837	0.080	0.008	0.076
Chena	95	0.084	0.568	0.084	0.263
Salcha	91	0.000	0.176	0.813	0.011
Upper	182	0.082	0.203	0.016	0.698
	Mean Classification Accuracy:			**0.729**	
	Variables in Analysis:		61, 18, 14, 98, 106, 83, 94, 21		
Age 1.4					
Lower	159	0.774	0.119	0.019	0.088
Chena	98	0.071	0.531	0.122	0.276
Salcha	101	0.010	0.168	0.772	0.050
Upper	102	0.088	0.167	0.000	0.745
	Mean Classification Accuracy:			**0.706**	
	Variables in Analysis:		61, 25, 82, 12, 21, 108, 14, 100		

Table 3. Run composition estimates for age-1.3 and -1.4 chinook salmon commercial catches in Yukon River District 1, 1994.

			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	91	0.095	0.050	0.000 < P < 0.207	93	0.090	0.052	0.000 < P < 0.207
		Chena		0.289	0.112	0.038 < P < 0.541		0.514	0.110	0.267 < P < 0.761
		Salcha		0.000	0.000	0.000 < P < 0.000		0.000	0.000	0.000 < P < 0.000
		Upper		0.616	0.115	0.360 < P < 0.873		0.397	0.109	0.152 < P < 0.641
2	6/17-18	Lower	97	0.247	0.060	0.113 < P < 0.381	101	0.141	0.055	0.018 < P < 0.265
		Chena		0.136	0.099	0.000 < P < 0.359		0.386	0.096	0.171 < P < 0.601
		Salcha		0.000	0.000	0.000 < P < 0.000		0.000	0.000	0.000 < P < 0.000
		Upper		0.617	0.107	0.378 < P < 0.856		0.473	0.097	0.256 < P < 0.689
3	6/21	Lower	68	0.338	0.074	0.171 < P < 0.504	111	0.183	0.056	0.058 < P < 0.308
		Chena		0.000	0.000	0.000 < P < 0.000		0.319	0.092	0.113 < P < 0.524
		Salcha		0.037	0.030	0.000 < P < 0.104		0.000	0.000	0.000 < P < 0.000
		Upper		0.626	0.078	0.452 < P < 0.800		0.498	0.093	0.289 < P < 0.708
4	6/24	Lower	72	0.500	0.078	0.325 < P < 0.675	105	0.243	0.061	0.106 < P < 0.379
		Chena		0.138	0.105	0.000 < P < 0.374		0.325	0.094	0.114 < P < 0.536
		Salcha		0.000	0.000	0.000 < P < 0.000		0.000	0.000	0.000 < P < 0.000
		Upper		0.362	0.111	0.112 < P < 0.611		0.433	0.094	0.221 < P < 0.644
5	6/28	Lower	27	0.581	0.127	0.296 < P < 0.866	32	0.378	0.120	0.109 < P < 0.646
		Chena		0.048	0.171	0.000 < P < 0.430		0.000	0.001	0.000 < P < 0.001
		Salcha		0.028	0.049	0.000 < P < 0.139		0.000	0.000	0.000 < P < 0.000
		Upper		0.343	0.172	0.000 < P < 0.729		0.623	0.120	0.354 < P < 0.891

[a] Simultaneous confidence intervals are calculated as $p \pm ((z_{(alpha/2k)})(\text{S.E. of } p))$, where $k=4$ and $z_{(alpha/2k)}=2.241$.

Table 4. Run composition estimates for age−1.3 and −1.4 chinook salmon commercial catches in Yukon River District 2, 1994.

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	87	0.123	0.054	0.003 < P < 0.244	71	0.156	0.066	0.009 < P < 0.304
		Chena		0.685	0.136	0.379 < P < 0.991		0.701	0.121	0.430 < P < 0.971
		Salcha		0.052	0.046	0.000 < P < 0.155		0.000	0.000	0.000 < P < 0.000
		Upper		0.139	0.110	0.000 < P < 0.385		0.143	0.111	0.000 < P < 0.392
2	6/20−21	Lower	92	0.309	0.064	0.165 < P < 0.453	90	0.156	0.060	0.022 < P < 0.291
		Chena		0.175	0.100	0.000 < P < 0.399		0.306	0.103	0.075 < P < 0.538
		Salcha		0.000	0.000	0.000 < P < 0.000		0.000	0.000	0.000 < P < 0.000
		Upper		0.516	0.106	0.278 < P < 0.753		0.537	0.106	0.300 < P < 0.775
3	6/25	Lower	97	0.274	0.061	0.137 < P < 0.411	123	0.142	0.050	0.030 < P < 0.254
		Chena		0.017	0.100	0.000 < P < 0.242		0.253	0.106	0.015 < P < 0.491
		Salcha		0.007	0.021	0.000 < P < 0.053		0.030	0.034	0.000 < P < 0.106
		Upper		0.703	0.104	0.470 < P < 0.935		0.575	0.092	0.370 < P < 0.780
4	6/27	Lower	70	0.632	0.079	0.454 < P < 0.809	106	0.428	0.068	0.275 < P < 0.580
		Chena		0.197	0.104	0.000 < P < 0.431		0.220	0.108	0.000 < P < 0.463
		Salcha		0.000	0.000	0.000 < P < 0.000		0.004	0.031	0.000 < P < 0.073
		Upper		0.171	0.099	0.000 < P < 0.394		0.349	0.090	0.147 < P < 0.551

[a] Simultaneous confidence intervals are calculated as $p \pm ((z_{(alpha/2k)})(S.E.\ of\ p))$, where $k=4$ and $z_{(alpha/2k)}=2.241$.

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, 1994.

Commercial Fishing Period	Dates and Mesh Size	Region of Origin	Age Group 1.3	Age Group 1.4	Total
1	6/14−15	Lower	639	586	1,225
		Middle[a]	1,955	3,353	5,308
	Unrestricted	Alaska	2,595	3,939	6,533
		Upper	4,169	2,589	6,758
		Total	6,764	6,528	13,292
2	6/17−18	Lower	2,989	1,432	4,421
		Middle[a]	1,645	3,913	5,558
	Unrestricted	Alaska	4,634	5,346	9,980
		Upper	7,462	4,790	12,252
		Total	12,097	10,136	22,232
3	6/21	Lower	1,746	1,409	3,155
		Middle[a]	189	2,451	2,640
	Unrestricted	Alaska	1,935	3,860	5,795
		Upper	3,236	3,834	7,070
		Total	5,172	7,694	12,865
4	6/24	Lower	1,955	1,617	3,572
		Middle[a]	539	2,166	2,704
	Restricted	Alaska	2,494	3,782	6,276
		Upper	1,414	2,885	4,299
		Total	3,908	6,667	10,576
5	6/28	Lower	146	95	241
		Middle[a]	19	0	19
	Unrestricted	Alaska	165	95	260
		Upper	86	157	243
		Total	251	252	503
District 1 Season Total		Lower	7,476	5,139	12,614
		Middle[a]	4,347	11,883	16,230
		Alaska	11,823	17,022	28,845
		Upper	16,369	14,254	30,623
		Total	28,191	31,276	59,467

[a] Middle Yukon Run was estimated by applying the combined classification proportions for the Chena and Salcha Rivers.

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, 1994.

Commercial Fishing Period	Dates and Mesh Size	Region of Origin	Age Group 1.3	Age Group 1.4	Total
1	6/16−17	Lower	444	650	1,095
		Middle[a]	2,657	2,919	5,576
	Unrestricted	Alaska	3,101	3,569	6,670
		Upper	501	598	1,099
		Total	3,602	4,167	7,769
2	6/20−21	Lower	2,453	1,472	3,926
		Middle[a]	1,391	2,885	4,276
	Unrestricted	Alaska	3,844	4,357	8,201
		Upper	4,095	5,061	9,157
		Total	7,940	9,418	17,358
3	6/25	Lower	1,244	859	2,103
		Middle[a]	106	1,712	1,818
	Unrestricted	Alaska	1,351	2,571	3,921
		Upper	3,191	3,481	6,672
		Total	4,541	6,051	10,593
4	6/27	Lower	893	971	1,865
		Middle[a]	279	507	786
	Unrestricted	Alaska	1,173	1,478	2,651
		Upper	242	793	1,035
		Total	1,415	2,271	3,686
District 2 Season Total		Lower	5,035	3,952	8,988
		Middle	4,433	8,023	12,456
		Alaska	9,469	11,975	21,444
		Upper	8,030	9,933	17,963
		Total	17,498	21,908	39,406

[a] Middle Yukon Run was estimated by applying the combined classification proportions for the Chena and Salcha Rivers.

Table 7. Total commercial and subsistence catch of chinook salmon by age class and run in Yukon River Districts 1–6 and Canada, 1994.

			Brood Year and Age Group													
			1991		1990		1989			1988		1987		1986		
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	1.6	2.5	Total
1	Commercial Gillnet	Lower	0	0	0	207	0	7,476	0	5,139	0	588	0	0	0	13,410
		Middle	0	0	0	78	0	4,347	0	11,883	22	777	0	0	0	17,106
		Alaska	0	0	0	285	0	11,823	0	17,022	22	1,365	0	0	0	30,516
		Upper	0	0	34	828	0	16,369	0	14,254	62	1,473	265	0	0	33,286
		Total [a]	0	0	34	1,114	0	28,191	0	31,276	83	2,838	265	0	0	63,802
	Subsistence Gillnet [b]	Lower	0	0	0	28	0	859	0	514	0	15	0	0	0	1,417
		Middle	0	0	0	11	0	500	0	1,188	10	20	0	0	0	1,729
		Alaska	0	0	0	39	0	1,359	0	1,702	10	35	0	0	0	3,146
		Upper	0	0	0	114	0	1,881	0	1,425	30	38	20	0	0	3,508
		Total	0	0	0	153	0	3,240	0	3,127	40	73	20	0	0	6,654
2	Commercial Gillnet	Lower	0	0	0	60	0	5,035	0	3,952	0	393	0	0	0	9,441
		Middle	0	3	0	34	22	4,433	0	8,023	14	455	0	0	0	12,984
		Alaska	0	3	0	95	22	9,469	0	11,975	14	848	0	0	0	22,425
		Upper	0	31	110	175	24	8,030	0	9,933	41	891	102	0	0	19,337
		Total [c]	0	34	110	270	46	17,498	0	21,908	55	1,739	102	0	0	41,762
	Subsistence Gillnet [d]	Lower	0	0	0	28	0	1,144	0	830	0	53	0	0	0	2,055
		Middle	0	0	0	16	0	1,007	0	1,684	0	61	0	0	0	2,769
		Alaska	0	0	0	44	0	2,151	0	2,513	0	115	0	0	0	4,823
		Upper	0	0	0	82	0	1,824	0	2,085	0	120	99	0	0	4,211
		Total	0	0	0	126	0	3,975	0	4,598	0	235	99	0	0	9,034
3	Commercial Gillnet [d]	Lower	0	0	0	2	0	134	0	105	0	10	0	0	0	252
		Middle	0	0	0	1	1	118	0	214	0	12	0	0	0	346
		Alaska	0	0	0	3	1	253	0	319	0	23	0	0	0	598
		Upper	0	1	3	5	1	214	0	265	1	24	3	0	0	516
		Total	0	1	3	7	1	467	0	584	1	46	3	0	0	1,114
	Subsistence Gillnet [d]	Lower	0	0	0	18	0	742	0	538	0	34	0	0	0	1,332
		Middle	0	0	0	10	0	653	0	1092	0	40	0	0	0	1,795
		Alaska	0	0	0	29	0	1395	0	1630	0	74	0	0	0	3,128
		Upper	0	0	0	53	0	1183	0	1352	0	78	64	0	0	2,730
		Total	0	0	0	82	0	2578	0	2982	0	152	64	0	0	5,858
4	Commercial & Subsistence GN & FW [e]	Lower	0	0	0	18	0	1514	0	1188	0	118	0	0	0	2,838
		Middle	0	1	0	14	6	1591	0	2844	4	153	0	0	0	4,613
		Alaska	0	1	0	33	6	3105	0	4032	4	271	0	0	0	7,451
		Upper	0	9	33	53	7	2414	0	2986	12	268	31	0	0	5,813
		Total	0	10	33	85	14	5518	0	7018	16	539	31	0	0	13,264

–Continued–

Table 7. (Page 2 of 2)

			Brood Year and Age Group													
			1991		1990		1989			1988		1987		1986		
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	1.6	2.5	Total
5	Commercial & Subsistence GN & FW[f]	Middle	0	0	0	9	0	50	0	27	0	4	0	0	0	90
		Alaska	0	0	0	9	0	50	0	27	0	4	0	0	0	90
		Upper	0	81	0	2,353	0	12,898	0	6,895	0	1,055	0	0	0	23,282
		Total	0	81	0	2,362	0	12,948	0	6,922	0	1,059	0	0	0	23,372
6	Commercial & Subsistence GN & FW[g]	Middle	0	287	0	747	0	2,213	0	1,811	0	115	0	0	0	5,174
Canada	Commercial GN & FW	Upper	0	361	13	1,315	26	6,858	13	2,978	39	348	64	0	13	12,028
	Non-Commercial[h]	Upper	0	276	10	1,005	20	5,240	10	2,275	30	266	49	0	10	9,190
TOTAL HARVEST		Lower	0	0	0	362	0	16,904	0	12,266	0	1,212	0	0	0	**30,744**
		Middle	0	292	0	921	29	14,913	0	28,765	50	1,637	0	0	0	**46,606**
		Alaska	0	292	0	1,284	29	31,817	0	41,031	50	2,849	0	0	0	**77,351**
		Upper	0	759	203	5,982	78	56,912	23	44,449	214	4,562	699	0	23	**113,901**
		Total	0	1,050	203	7,266	107	88,728	23	85,480	264	7,410	699	0	23	**191,252**

[a] Includes 1,561 fish from ADF&G test fisheries.

[b] Run composition is based on District 1, period 1 commercial catch samples.

[c] Includes 70 fish from ADF&G test fisheries.

[d] Run composition based on District 2, period 1 commercial catch samples.

[e] Gillnet and fish wheel catches combined. Commercial catch = 2,204 fish, commercial related catch = 46, and subsistence catch = 9,820. The Koyukuk River subsistence catch (710) was assigned to the Middle River Run (see METHODS).

[f] Gillnet and fish wheel catches combined. Commercial catch = 3,739 and subsistence catch = 19,633.

[g] Gillnet and fish wheel catches combined. Preliminary data includes 2,135 commercial, 472 commercial related, 696 subsistence, and 1,871 sport harvest.

[h] Run and age composition are based on Canada DFO tagging study fish wheel samples. Harvest components include commercial (12,028), Canadian Aboriginal fishery (8,517), domestic (373), and sport (300) harvests.

Table 8. Harvest percentages by run of the total Yukon River harvest of chinook salmon, 1982–94.

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
1994	16.1	24.4	59.6
1982–94 Avg	21.8	21.4	56.8
1989–93 Avg	22.2	20.7	57.1

FIGURES

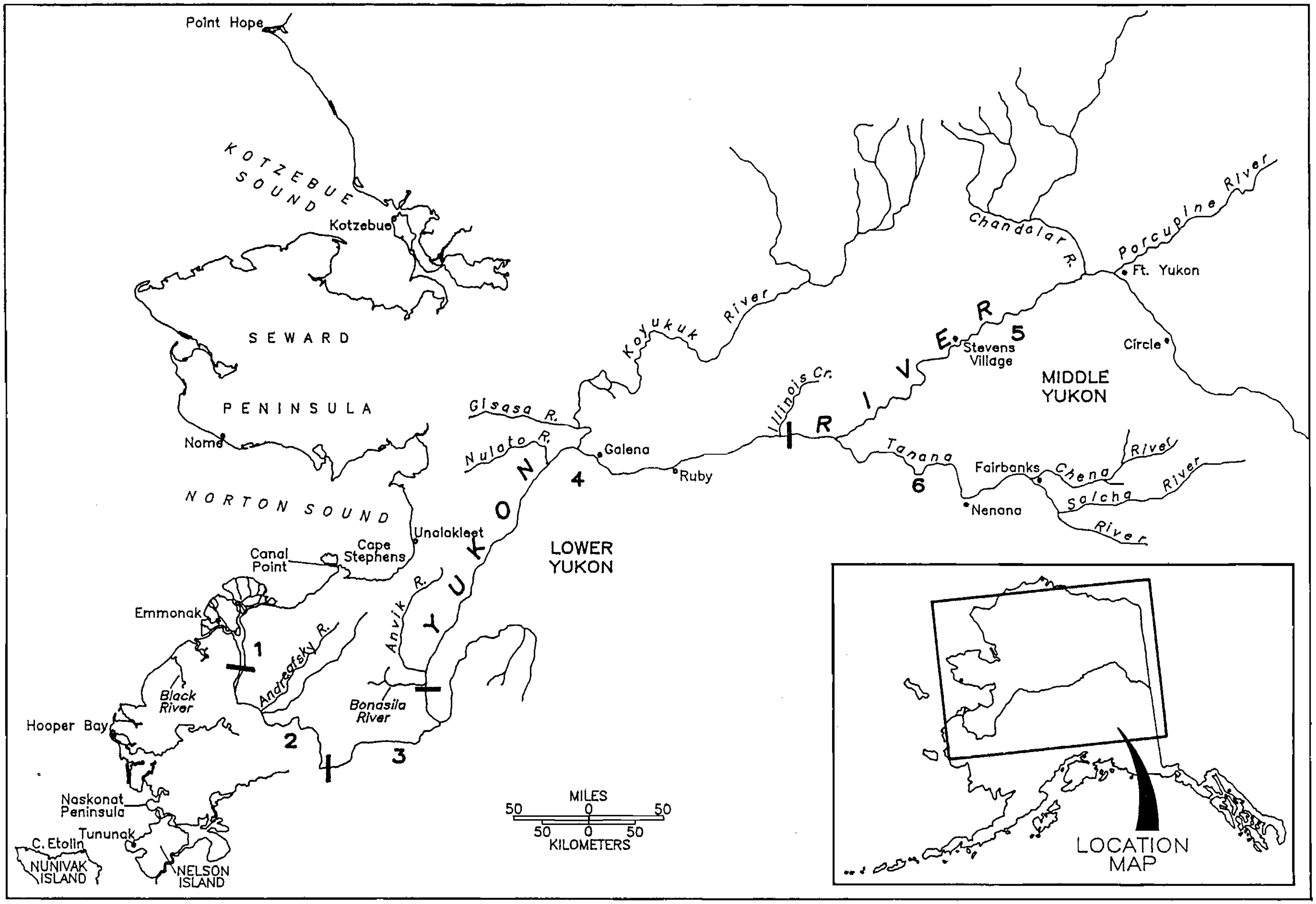

Figure 1. Alaskan portion of the Yukon River with fishing district boundaries.

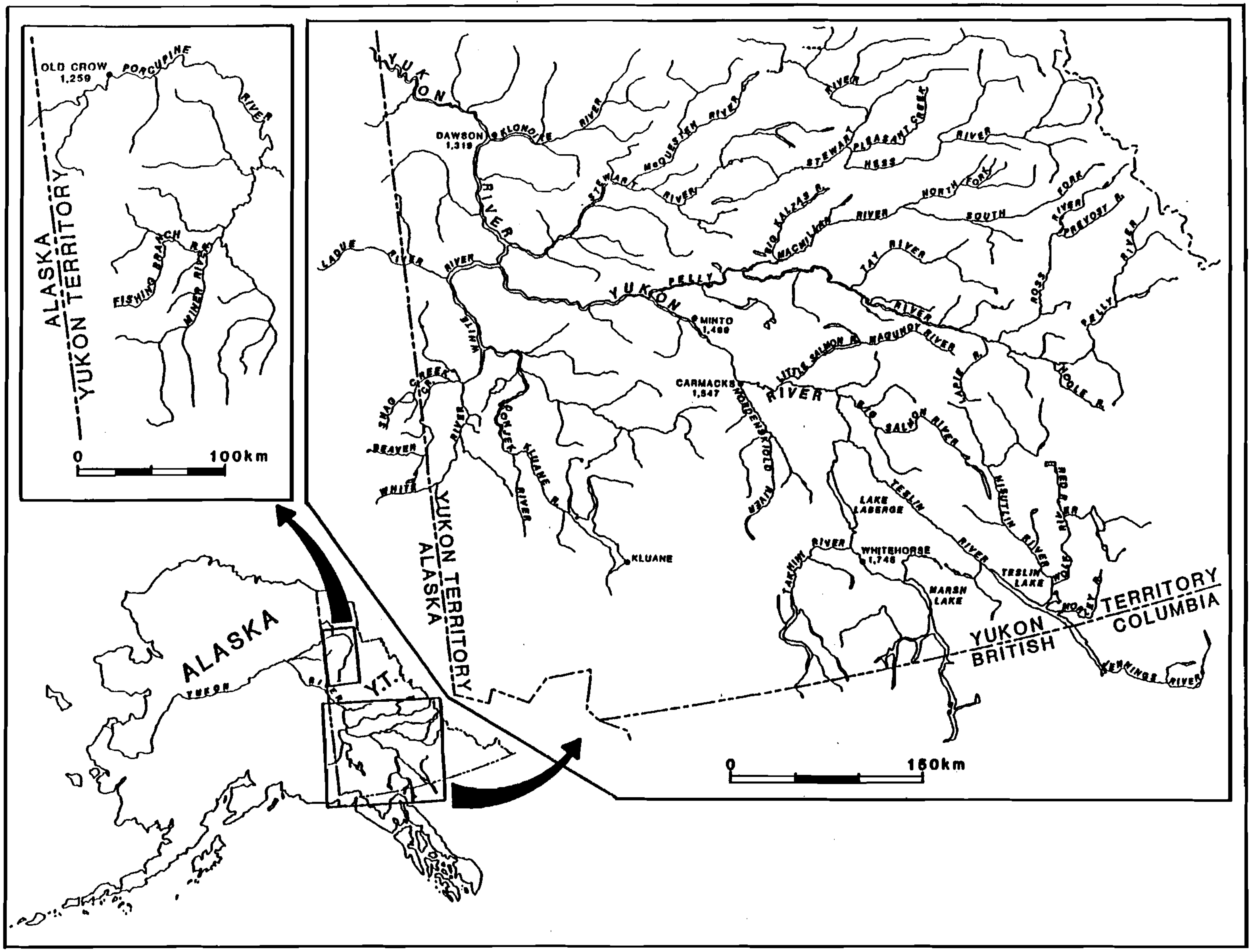

Figure 2. Canadian portion of the Yukon River drainage.

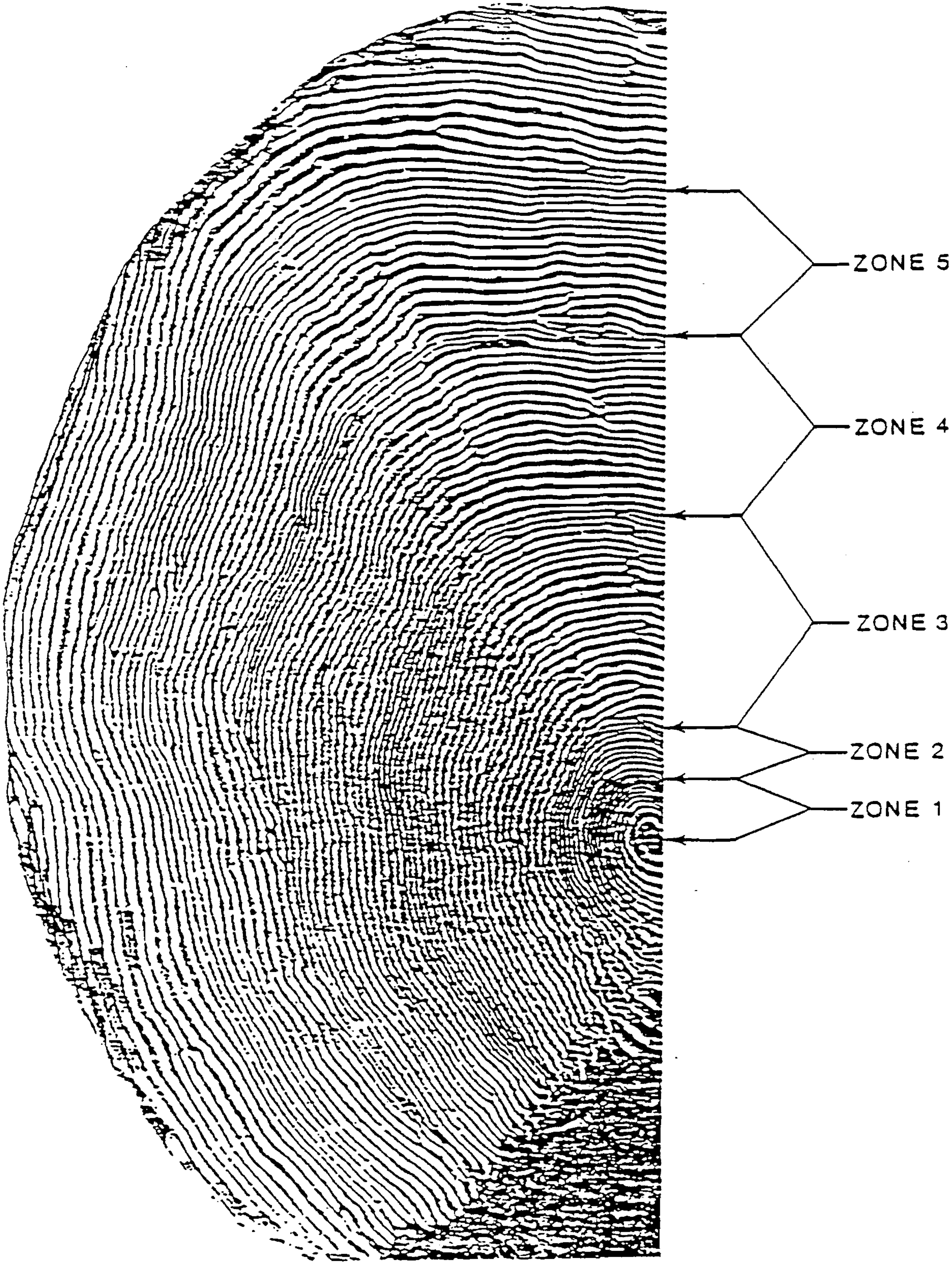

Figure 3. Age-1.4 chinook salmon scale showing zones measured for linear discriminant analysis.

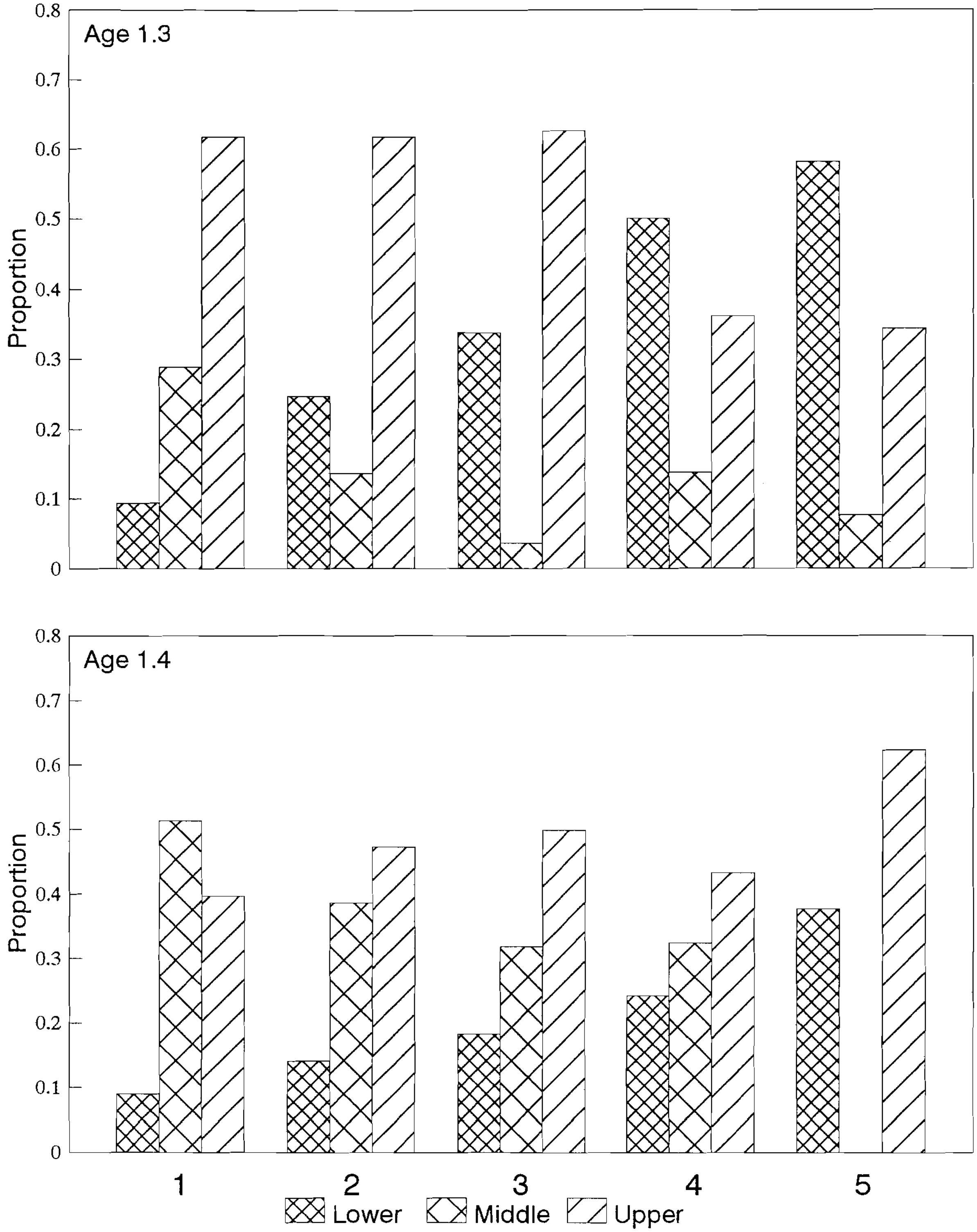

Figure 4. Estimated proportion of catch by period (all periods unrestricted mesh size) and run from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 1, 1994.

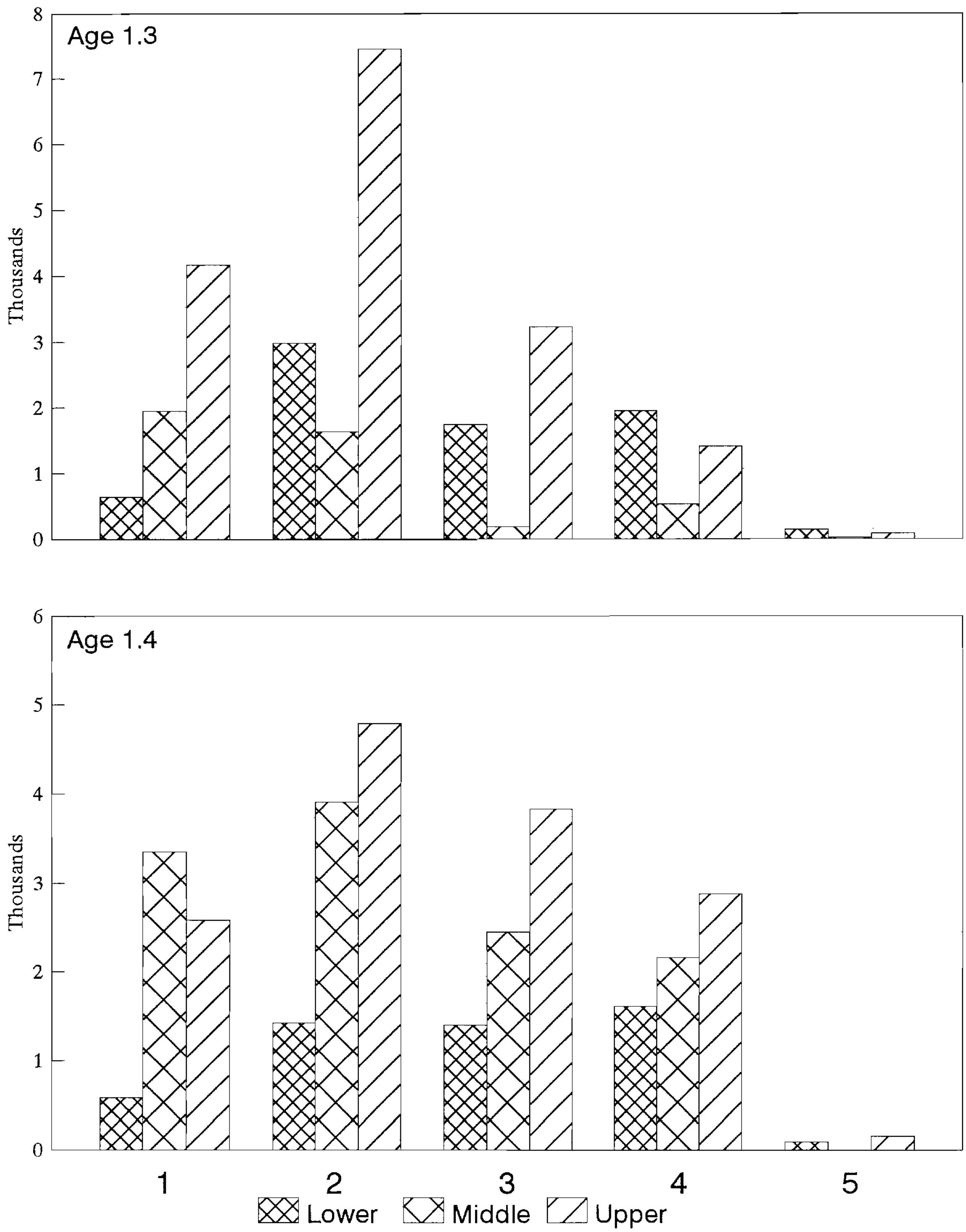

Figure 5. Estimated catch by period (all periods unrestricted mesh size) and run in numbers of fish from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 1, 1994.

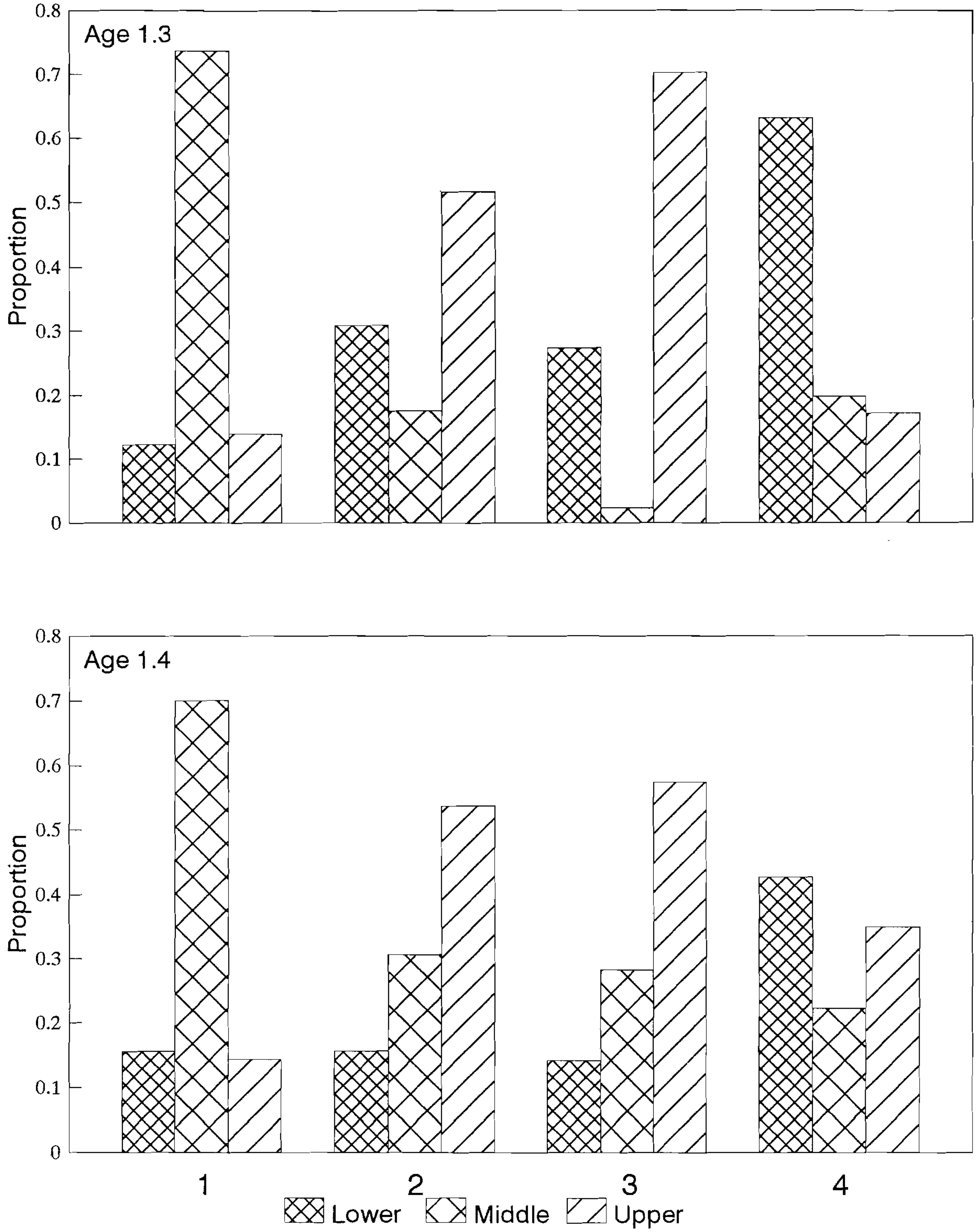

Figure 6. Estimated proportion of catch by period (all periods unrestricted mesh size) and run from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 2, 1994.

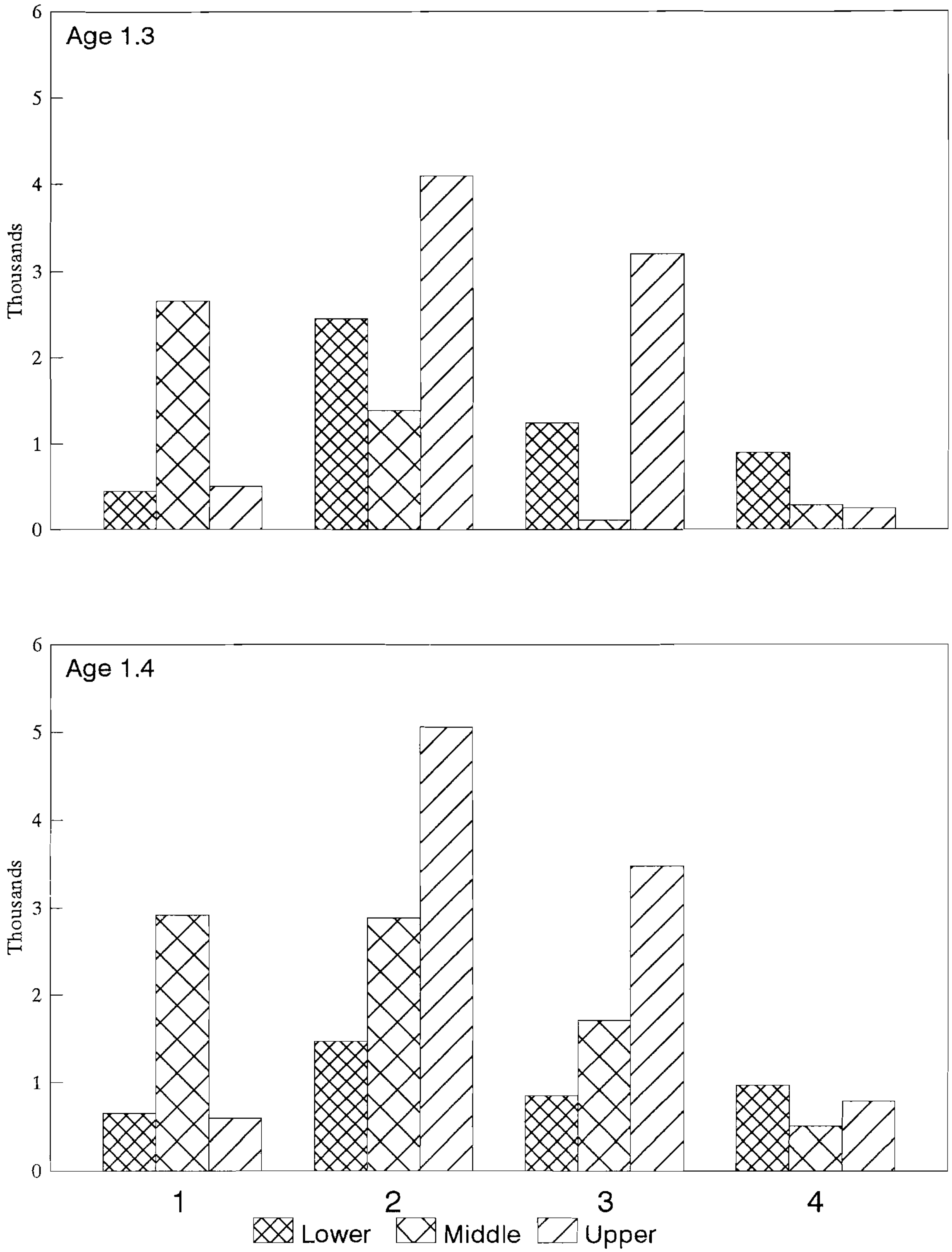

Figure 7. Estimated catch by period (all periods unrestricted mesh size) and run in numbers of fish from scale pattern analysis of age−1.3 and −1.4 chinook salmon, Yukon River District 2, 1994.

APPENDIX

Appendix A. Scale variables screened for linear discriminant function analysis of age-1.3 and -1.4 Yukon River chinook salmon, 1994.

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)	

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	

-Continued-

Variable		1st Marine Annular Zone (Cont.)
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, 1994.

		Lower		Chena		Salcha		Upper		
Growth Zone	Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE	F-Value
Age-1.3										
1st FW Annular	14	95.38	1.10	68.17	1.50	48.03	1.35	75.74	1.11	230.30
	18	0.66	<0.01	0.78	<0.01	0.85	0.01	0.76	<0.01	185.34
	21	0.29	<0.01	0.34	<0.01	0.36	<0.01	0.34	<0.01	91.62
FW Plus Growth	61	2.92	0.08	4.88	0.15	4.83	0.11	5.68	0.09	185.25
1st Marine Ann.	83	172.96	1.26	174.87	2.00	155.95	2.00	184.30	1.43	42.62
	94	0.52	<0.01	0.55	<0.01	0.63	0.01	0.56	<0.01	54.72
	98	0.43	<0.01	0.46	<0.01	0.52	<0.01	0.48	<0.01	59.21
	105	19.03	0.09	18.14	0.14	16.44	0.16	19.12	0.10	93.46
Age-1.4										
1st FW Annular	12	36.96	0.44	34.64	0.50	34.42	0.51	32.02	0.56	17.93
	14	94.39	1.59	66.48	1.52	53.04	1.48	72.89	1.40	138.88
	21	0.32	<0.01	0.33	<0.01	0.37	<0.01	0.34	<0.01	18.08
	25	0.26	<0.01	0.30	<0.01	0.37	<0.01	0.26	<0.01	72.31
FW Plus Growth	61	3.08	0.12	4.85	0.11	4.72	0.11	5.52	0.13	88.68
1st Marine Ann.	82	105.74	0.97	107.54	1.30	100.27	1.37	117.49	1.49	29.70
	100	0.22	<0.01	0.24	<0.01	0.28	<0.01	0.26	<0.01	47.41
	108	0.06	<0.01	0.06	<0.01	0.07	<0.01	0.06	<0.01	15.87

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, 1994.

Growth Zone	Variable	Description	Lower		Chena		Salcha		Upper		
			Mean	SE	Mean	SE	Mean	SE	Mean	SE	F-Value
Age-1.3											
1st FW Annular	1	No. Circ.	11.85	0.11	9.30	0.16	7.76	0.15	9.85	0.10	190.40
	2	Distance	149.34	1.19	122.10	1.61	94.95	1.56	129.52	1.29	233.58
Total FW Growth	61	No. Circ.	2.92	0.08	4.88	0.15	4.83	0.11	5.68	0.09	185.25
	62	Distance	33.31	1.08	54.75	1.65	49.46	1.21	63.53	1.01	145.50
1st Ocean Ann.	70	No. Circ.	28.03	0.17	27.01	0.28	23.79	0.32	26.37	0.19	57.70
	71	Distance	531.61	3.02	488.66	5.08	391.57	6.68	503.51	4.12	160.38
2nd Ocean Ann.	109	Distance	416.57	3.88	390.15	6.94	320.74	5.90	407.42	4.38	54.84
Age-1.4											
1st FW Annular	1	No. Circ.	11.23	0.16	9.30	0.16	8.17	0.17	9.93	0.16	64.38
	2	Distance	147.62	1.78	118.56	1.73	95.95	1.69	126.10	1.56	161.67
Total FW Growth	61	No. Circ.	3.08	0.12	4.85	0.11	4.72	0.11	5.52	0.13	88.68
	62	Distance	34.88	1.43	53.38	1.22	49.73	1.09	61.28	1.58	71.14
1st Ocean Ann.	70	No. Circ.	26.43	0.22	25.49	0.24	22.39	0.32	24.76	0.23	47.16
	71	Distance	476.63	4.44	444.45	5.42	362.70	6.75	455.61	4.61	88.72
2nd Ocean Ann.	109	Distance	403.77	4.21	390.71	5.59	328.03	5.64	404.87	5.02	49.54
3rd Ocean Ann.	110	Distance	401.28	4.29	394.46	4.77	342.75	6.17	407.68	5.11	31.96