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State of Alaska Walter J. Hickel, Governor

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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 lower Yukon River Districts 1, 2, and 3 commercial and subsistence harvests. Linear discriminant models were used to estimate stock composition for age-1.3 and -1.4 fish. Discriminant models and observed age composition differences among escapements were used to estimate run origins for other age groups. Run origins for all other fisheries was estimated primarily from geographic occurrence. Total Yukon River harvest was 171,504 chinook salmon, of which 58.4% was estimated to be the Upper Yukon Run, 15.9% the Middle Yukon Run, and 25.7% the Lower Yukon Run. The fraction of the District 1 and 2 commercial catch composed of the Lower Yukon Run generally increased through time, while the fraction composed of the Upper Yukon Run generally declined. The middle run component fluctuated 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 salmon gill net fisheries in the North Pacific Ocean and Bering Sea and as an incidental catch in trawl fisheries in the Bering Sea (Meyers and Rogers 1985). Within the Yukon River returning adults are harvested in commercial and subsistence fisheries in both Alaska and Canada (Figures 1 and 2).

In the first 20 years after statehood (1960-1979), the combined Alaskan and Canadian Yukon River chinook salmon commercial and subsistence harvest averaged 122,971 fish annually (ADF&G 1988). Beginning in 1980, annual harvests increased substantially. During the most recent 5-year period (1984-88) yearly commercial and subsistence catches together averaged 184,983 fish. While chinook salmon are harvested virtually throughout the entire length of the Yukon River, the majority of the catch has been taken in commercial gill net fisheries in Districts 1 and 2 (1984-88 average was 60% of total drainage harvest). Subsistence harvests throughout the drainage, including Canadian catches, account for another 29% (1984-88 average) of the total chinook harvest. Most of the subsistence harvest is taken with fish wheels and gill nets in Districts 4, 5, and 6. In 1989 commercial and subsistence fishermen in Alaska and Canada harvested a total of 171,504 chinook salmon, of which 92,378 (53.9%) 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 that drain the Andreafsky Hills and Kaltag Mountains between river miles 100 and 500, (2) Tanana River tributaries between river miles 800 and 1,100, and (3) tributary streams that drain the Pelly and Big Salmon Mountains between river miles 1,300 and 1,800. Chinook salmon stocks within these geographic regions were collectively termed runs by McBride and Marshall (1983) and are now referred to as the Lower, Middle, and Upper Yukon Runs, respectively. Pending future study of spawner distribution, the boundary between Lower and Middle Runs has not been precisely resolved.

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

Harvest estimates of Western Alaskan/Canadian Yukon chinook salmon in the Japanese high seas gill net fisheries (Rogers et al. 1984; Meyers et al. 1984;

Meyers and Rogers 1985) have become major elements in the regulation of these ocean fisheries. Similarly, stock composition of inriver fisheries has been studied to provide useful information for inriver allocation decisions and to improve management precision through a better understanding of spatial and temporal migratory patterns of Yukon stocks. Stock composition estimates of the catch through time for Yukon River chinook salmon became available in 1980 and 1981 with the initial investigation of scale patterns analysis in District 1 (McBride and Marshall 1983). Since then, harvest proportions by geographic region of origin have been estimated annually for the entire drainage (Wilcock and McBride 1983; Wilcock 1984, 1985, 1986; Merritt et al. 1988; Merritt 1988).

The objective of this study was to classify the 1989 Yukon River chinook salmon commercial and subsistence harvests to run of origin.

METHODS

Age Determination

Scale samples provided age information for fish in commercial catches and escapements. Age compositions of subsistence catches were assumed to be the same as those of related commercial catches. 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, and 6, and in Yukon Territory, Canada. Subsistence catches in Ditricts 4, 5, and 6 were also sampled. District 3 was not sampled because few fish were harvested in that portion of the Yukon River and access was difficult. A small fraction of the District 2 catch could at times include District 3 catches delivered in District 2. Subsistence fishing in Districts 1 and 2 occurred concurrently with commercial fishing, and similar or identical mesh size gear was used. The age composition of the subsistence catch was assumed to be similar to that of the related commercial catch. Samples were also collected from a gill net test fishery in District 1 and from test fish wheels used to capture fish for a mark and recapture project in the Yukon Territory. Sampling of fisheries in Alaska was conducted by the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries, while Canadian commercial fishery and test fish wheel samples were collected by the Canada Department of Fisheries and Oceans (DFO).

Escapement Sampling

Scale samples were collected during peak spawner mortality from the Andreafsky, Anvik, Chena, and Salcha Rivers in Alaska, and from the Big Salmon, Little Salmon, Nisutlin, Tatchun, Ross, Wolf, Morley, Swift, and mainstem Yukon Rivers in Canada. Samples were primarily collected from carcasses. However, some samples were obtained from live fish captured with spears, gill nets, or snagging gear for a separate genetic stock identification study conducted by the U.S. Fish and Wildlife Service (USFWS).

The age composition of Lower, Middle, and Upper Yukon Runs was estimated by weighting the age composition calculated for the individual spawning tributaries in each area by the escapement to each tributary as indexed by aerial surveys or mark/recapture spawning population estimates. Those tributaries which were sampled but for which no abundance estimate was available were not included.

Estimation of Catch Composition

Linear discriminant function analysis (Fisher 1936) of age-1.3 and -1.4 scale patterns data and observed differences in age composition among escapements were used to estimate 1989 Yukon River chinook salmon catches by their run of origin. The technique was also used to examine age-1.3 and -1.4 fish entering the Yukon River through three main channels (mouths) for possible preferred routes by run of origin into the main river.

Scale Pattern Analysis

Escapement samples from Alaska and salmon tagging study samples from Canada provided scales of known origin that were used to build linear discriminant functions (LDF). Scales representing the Lower Yukon Run were selected from samples collected on the Andreafsky and Anvik Rivers. The Middle Yukon Run was represented by scales from the Chena and Salcha Rivers. Canadian escapement samples could not be pooled to form a reasonable standard because of the lack of samples from several substantial spawning populations. Therefore, the Upper Yukon Run was represented with samples from the DFO tagging study near Dawson, Y.T.

Scale samples from the lower river commercial gill net fishery were classified to run of origin using the discriminant functions. Only scales with one freshwater annulus (age-1.) were examined. Run proportions of fish aged 1.3 and 1.4 were estimated for District 1 and 2 catches by fishing period for periods with adequate samples sizes. Sample sizes of 50 or more were preferred, though smaller samples were often used.

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 annulus 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-nine scale characters (variables, Appendix A) were calculated from the basic incremental distances and circuli counts. Run-of-origin standards (pooled rivers) were weighted by aerial abundance estimates for the Lower Yukon Run and by spawning population estimates from mark/recapture studies on the Chena and Salcha Rivers for the Middle Yukon Run. As in all previous years, except 1987, run-of-origin models were constructed for age-1.3 and -1.4 fish. As in most previous years, age-1.5 models were not constructed due to very small sample size.

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. Point estimates were adjusted for misclassification errors using a constrained maximum likelihood procedure described by Hoenig and Heisey (1987) which does not require construction of models with fewer standards when one or more standards are not present in mixed stock samples. Variance and 90% confidence intervals were approximated using an infinitesimal jackknife procedure described by Millar (1987). This method of estimating variance accounts for variation in the mixed stock sample but does not account for the variation of the classification matrix. It has been demonstrated that the two sources of error are additive, and future methods for estimating variance may include both sources. Although confidence intervals are probably underestimated by the present method, it was used over previous methods to take advantage of the considerable analytical efficiencies of the constrained maximum likelihood classification procedure.

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

Classification of the remaining age classes in the District 1 and 2 commercial catches by run of origin was 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, was used to compute ratios for each run by dividing the proportion in the escapement of the age class in question by the proportion in the escapement of an age class where the catch composition (R_{cia}) was estimated by scale pattern analysis (age 1.3 or 1.4):

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

where:

C = Lower, Middle, or Upper Yukon Run;

$\hat{E}_{ci}$ = estimated proportion of fish of age i in run c escapement samples where i was an age class of **unknown** run composition in the commercial catch; and

$\hat{E}_{ca}$ = estimated proportion of fish of age class a in run c where a was an age class of **known** run composition in the commercial catch (age 1.3 or 1.4).

Because the proportions of age-1.1, -1.2, and -2.2 fish in escapement samples collected in previous years have tended to decrease as the distance upriver increased, proportions for these age classes were divided by the proportion of age-1.3 fish. Proportions of age-2.3, -1.5, -2.4, and -2.5 fish were divided by the proportion of age-1.4 fish, because these ages have historically increased with distance upriver. Further, the age-2.3 fish were divided by the proportion of age-1.4 fish because both ages were of the same brood year and both increased in upriver escapements. These ratios of proportional abundance were then multiplied by the estimated catch by run of age-1.3 or -1.4 fish to approximate the catch of an age class of the unknown run composition. Estimates of age- and run-specific contribution rates were calculated by dividing the approximate catch of an age class of unknown run composition by the total approximated catch of the same age class. Multiplying the age-specific contribution rates by the catch of he age class yielded age-specific run contribution estimates, or

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

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 = 3 (number of runs).

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

$$N_{ci} = F_{ci} N_i \quad , \tag{3}$$

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 of District 1 and 2 commercial catches were used to classify the catches of subsistence fisheries in Districts 1 and 2 as well as commercial and subsistence fisheries in District 3.

District 4 catches were divided into two components for purposes of estimating catch proportions by stock: (1) commercial and subsistence catches from the mainstem Yukon River, and (2) subsistence catches from the Koyukuk River. Estimation of catch composition for District 4 was complicated by a number of conditions relating to the availability of catch samples and the number of stocks potentially present in District 4 catches. District 4 is over 350 mi long, and only a portion of the Lower Yukon Run tributaries (Anvik, Nulato, and Gisasa Rivers) contribute to District 4 harvests. Of these tributaries Anvik River fish contribute only to catches within a few miles of the downstream end of District 4, while Nulato and Gisasa River fish contribute only to catches in the lower half of District 4. Scale samples from District 4 mainstem catches in 1989 were collected both upstream and downstream of the Koyukuk, while in past years most samples were collected upstream of the Koyukuk confluence. The Koyukuk River was assumed to be the upstream boundary of Lower Yukon Run stocks in the mainstem

Yukon River. Confidence in the placement of the boundary between Lower and Middle Yukon Runs is pending further examination of spawning distribution. However, chinook salmon spawning in the Melozitna and Tozitna Rivers, averaging from 100 to 300 aerial survey counts for both streams combined, are the only documented spawning concentrations between the uppermost Lower Yukon Run streams sampled (Nulato and Gisasa Rivers) and Middle Yukon Run escapements in the Tanana River drainage (Chena and Salcha Rivers). The small sample sizes and limited scope of sampling were felt to inadequately represent contributions by stock in District 4 mainstem commercial and subsistence harvests. Contribution rates were estimated by applying the 1984-87 average contributions by age class to the season total harvest from both fisheries (including both gill net and fish wheel gear type). Previous contribution estimates (1984-87) were based on scale pattern analysis of age-1.3 and -1.4 fish and differential age composition analysis of remaining age groups (Wilcock 1985, 1986; Merritt et al. 1988; Merritt 1988).

Subsistence catches from the Koyukuk River were taken primarily in the upper portions of the drainage beyond river mile 700. Scales collected from the upper Koyukuk River drainage during 1986 resembled scales from the Middle and Upper Yukon Runs (Merritt et al. 1988). Because the Koyukuk River drainage lies entirely within Alaska, Koyukuk River subsistence catches were assumed to be entirely Middle Yukon Run. The age composition of the Koyukuk River subsistence catch was assumed to be similar to the age composition of District 4 mainstem catches.

Catch Composition Based on Geographical Segregation

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

RESULTS

Escapement Age Composition

Yukon River chinook salmon escapement age compositions in 1989 exhibited a variety of trends and contrasts (Table 1). Similar to all other years sampled, increasing proportions of older fish were noted in escapements progressing upriver. Age 1.4, the generally predominant age class of Yukon River chinook returns, was similar to other years, except for the low proportions in the Andreafsky River. The relatively low proportion of age-1.4 fish in the Andreafsky was not expected because of the relatively strong return of age-1.3 fish in 1988 from the same brood year (1983). However, the strong contribution of age-1.3 fish to the Andreafsky run in 1989 may have accounted for this apparent discrepancy. As in all previous years, the greatest proportions of age-2.3, -2.4 and -2.5 fish were found in Upper Yukon Run samples.

Classification Accuracies of Run of Origin Models

Mean classification accuracies of 3-way, run-of-origin models for both age-1.3 and -1.4 fish (79.3% and 86.2%, Table 2) were considerably higher than the average of 69.9% for age-1.3 and -1.4 models from 1980 to 1988. Similar to past years, the lower river standard showed the greatest classification accuracies (92.9% and 95.9% for age-1.3 and -1.4, respectively). Upper river standards yielded unusually high classification accuracies (73.6% and 82.1% for age-1.3 and -1.4, respectively) with the greatest likelihood of misclassifying found in the Middle Yukon Run. Classification accuracy of the middle river standards was relatively high (71.4% and 80.5% for age-1.3 and 1.4, respectively). Relatively high misclassification between middle and upper river standards has been observed every year since initiation of the Yukon River chinook salmon stock identification study in 1980.

Catch Composition

Scale Pattern Analysis

The scale measurement characters which were most powerful in distinguishing between the three runs of origin were (1) the freshwater annular zone divided by the total width of freshwater growth zones, and (2) the width of the freshwater annular zone (Appendix B). Secondarily selected variables were derived primarily from measurements within the first annular zone or were variables combining features of the freshwater annular and plus growth zones. As in prior analyses, measurements of marine growth provided relatively little 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

Combined Lower and Middle Yukon fish comprised the largest proportions of District 1 and 2 commercial harvest of age-1.3 chinook salmon, while Upper Yukon fish comprised the largest proportions of the harvest of age-1.4 fish over the period of greatest harvest magnitude (periods 1 - 4) in 1989 (Tables 3 and 4). Run contribution estimates through time in District 1 demonstrated increasing proportions of Lower Yukon fish and decreasing proportions of Upper Yukon age-1.3 and -1.4 fish as the spawning season progressed (Figures 4 and 5). District 1 harvests of Middle Yukon age-1.3 and -1.4 fish demonstrated no discernible temporal trend in relative abundance.

The estimated District 1 catch of age-1.3 and -1.4 fish combined was 19,036 (38.0%) Lower; 9,742 (19.4%) Middle; and 21,326 (42.6%) Upper Yukon Run (Table 5). In District 2 the estimated age-1.3 and -1.4 combined catch was 11,860 (43.2%) Lower; 3,793 (13.8%) Middle; and 11,776 (42.9%) Upper Yukon Run (Table 6).

A total of 77,532 age-1.3 and -1.4 fish (45.2% of total drainage utilization) from District 1 and 2 commercial catches were directly classified to run of origin based on results of scale pattern analysis (SPA). An additional 15,362 fish (9.0% of total drainage utilization) from District 1, 2, and 3 subsistence and District 3 commercial harvests were also classified to run of origin by applying season total SPA results to individual district season totals by age class (Table 7).

Differential Age Composition Analysis

The remaining age classes (not age 1.3 or 1.4) from Districts 1 and 2 commercial catches contributed 16,841 fish (9.8%) to the total drainage harvest. The majority of age-1.2 fish harvested (3,936 or 75.4%) in District 1 and 2 commercial catches were Lower or Middle Yukon Run. Virtually all age-2. fish were classified to the Upper Yukon Run.

Geographical Analysis

A total of 49,600 fish (28.9% of total drainage harvest) were classified to run of origin based on geographical segregation. Except for 88 fish caught in the Chandalar River which were classified to the Middle Yukon Run, District 5 and Yukon Territory commercial and subsistence catches (25.4% of total drainage harvest) were assumed to be Upper Yukon fish. Commercial and subsistence catches in District 6 and subsistence catches from the Koyukuk River (796) in District 4 (Table 7) were classified entirely to the Middle Yukon Run and totaled 6,023 fish (3.5% of total drainage harvest).

Total Harvest

The commercial and subsistence harvest of chinook salmon from the entire Yukon River drainage was classified to run of origin (Table 7) based on (1) findings of the scale patterns analysis of age-1.3 and -1.4 fish in District 1 and 2 commercial catches, (2) age composition analysis of the remaining age classes, (3) assumptions concerning unsampled fisheries, and (4) stock origins based on geographical segregation. The Upper Yukon Run comprised the largest run component and contributed 100,121 fish or 58.4% of the total drainage harvest. The Lower Yukon Run was next in abundance at 44,113 fish (25.7%), followed by the Middle Yukon Run at 27,271 fish (15.9%).

Entry Pattern by Mouth

Age-1.3 and -1.4 fish entering the South Mouth displayed a pattern similar to the run composition of District 1 catches. The Upper Yukon Run was strongest in the earlier portion of the season, and the Lower Yukon Run dominated later in the season. The Middle Yukon Run remained at intermediate to low levels throughout. Age-1.3 fish entering the Middle Mouth displayed a noticeably stronger presence of the Middle Yukon Run except in period 3. Age-1.4 entry to the Middle Mouth was similar to the South Mouth entry pattern exhibited by both ages 1.3 and 1.4. A single adequate sample from the North Mouth in period three indicated that age 1.3 was dominated by Middle Yukon Run, and age 1.4 was dominated by Upper Yukon Run (Tables 8 and 9).

DISCUSSION AND RECOMMENDATIONS

District 4 sampling effort should be increased to better allocate chinook salmon in the district to run of origin. The juxtaposition of District 4 commercial fishing boundaries with the boundary chosen to differentiate between Lower Yukon and Middle Yukon Runs, e.g., just upstream of the Koyukuk River, allows a high likelihood that the various district fisheries and fishing locations result in a differential harvest within the district by run of origin. Of primary concern are the presumed different catch compositions expected in District 4 harvests below and above the Koyukuk River confluence. To adequately address this problem would require increasing sampling sizes from catches obtained in the area between the Anvik River and 10 mi downstream (the District 4 lower boundary), as well as the area immediately upstream of the Koyukuk River.

The entire Upper Yukon Run is sampled by the DFO tagging project located in Canada near the U.S.-Canada border. 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 to meet that need. For allocation of harvests to run-of-origin, the approach of using either samples from the commercial harvest or samples from the DFO test fish wheel assumes that Canadian stocks are present in the sample proportional to their abundance in the population of Upper Yukon spawners and that fish from all Canadian tributaries have a similar mix of scale growth characters. Those assumptions are probably violated.

Ideally the stock standard for Upper Yukon Run fish would be provided by adequate sample sizes from the several major Yukon tributaries in Canada weighted by reliable estimates of abundance from each tributary. This has not been done to the extent required. Many of the assumptions made in the current methodology have not been tested. In the absence of such testing, the optimum sampling plan should incorporate tributary sampling and abundance estimation.

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Table 1. Age composition of Yukon River chinook salmon escapement samples, 1989.

River	Escapement Index Abundance Estimate	Sample Size	Brood Year and Age Group[a]								
			1986	1985	1984		1983		1982		1981
			1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	2.5
Lower Yukon											
East F. Andreafsky	1,399	83	0.0	2.4	74.7	0.0	21.7	0.0	1.2	0.0	0.0
West F. Andreafsky	1,089	145	0.0	6.9	70.3	0.0	20.7	0.0	2.1	0.0	0.0
Anvik[b]	442	381	0.3	4.2	49.1	0.0	43.5	0.0	2.9	0.0	0.0
Middle Yukon											
Chena[c]	2,730	288	0.3	4.2	29.5	0.7	54.5	0.3	10.4	0.0	0.0
Salcha[c]	3,572	222	0.5	4.1	28.9	0.0	57.8	0.0	8.8	0.0	0.0
Upper Yukon											
Tatchun	100	31	0.0	6.5	32.3	0.0	61.3	0.0	0.0	0.0	0.0
Ross	433	58	0.0	0.0	20.0	0.0	59.3	3.4	12.1	3.4	1.7
Little Salmon	862	50	0.0	6.0	14.0	0.0	68.0	0.0	12.0	0.0	0.0
Big Salmon	1,999	176	0.0	1.1	15.9	0.0	50.6	2.3	25.6	2.3	2.3
Nisutlin	1,328	129	0.0	0.0	7.8	0.0	45.7	7.8	2.3	32.6	3.9
Wolf	324	49	0.0	2.0	8.2	0.0	61.2	12.2	8.2	6.1	2.0
Morley[d]		65	0.0	1.5	24.6	0.0	67.7	0.0	1.5	4.6	0.0
Swift[d]		16	0.0	0.0	6.3	0.0	56.3	18.8	0.0	18.8	0.0

[a] All samples were collected from carcasses or from speared or snagged live spawnouts except as noted.
[b] Salmon were not proportioned by aerial escapement index due to under estimation caused by poor survey conditions.
[c] Population estimate from mark and recapture program.
[d] Population estimate not available.

Table 2. Classification accuracies of linear discriminant run–of–origin models for age–1.3 and –1.4 Yukon River chinook salmon, 1989.

Region of Origin	Sample Size	Classified Region of Origin: Lower	Middle	Upper
Age 1.3				
Lower	198	**0.929**	0.025	0.045
Middle	91	0.044	**0.714**	0.242
Upper	144	0.076	0.188	**0.736**
	Mean Classification Accuracy:			**0.793**
	Variables in analysis:		67, 106, 16, 108, 14, 109.	
Age 1.4				
Lower	146	**0.959**	0.014	0.027
Middle	123	0.041	**0.805**	0.154
Upper	151	0.046	0.132	**0.821**
	Mean Classification Accuracy:			**0.862**
	Variables in analysis:		67, 62, 74, 25, 30, 21, 18, 14.	

Table 3. Yukon River chinook salmon run composition estimates for age–1.3 and –1.4 in District 1 commercial catches, 1989.

			Age 1.3				Age 1.4			
					90% Conf. Int.				90% Conf. Int.	
Commercial Fishing Period[a]	Dates	Region of Origin	Sample Size	Prop. of Catch	Lower Bound	Upper Bound	Sample Size	Prop. of Catch	Lower Bound	Upper Bound
Prior to Season[b]	6/06–13	Lower	12	0.316	0.000	0.653	58	0.366	0.214	0.517
		Middle		0.374	0.000	0.897		0.124	0.000	0.282
		Upper		0.311	0.000	0.848		0.511	0.313	0.709
1[c]	6/13–14	Lower	38	0.171	0.003	0.338	47	0.091	0.000	0.209
		Middle		0.346	0.030	0.662		0.326	0.101	0.550
		Upper		0.484	0.148	0.819		0.584	0.348	0.819
2[d]	6/15–16	Lower	70	0.291	0.150	0.432	141	0.230	0.140	0.320
		Middle		0.303	0.078	0.528		0.150	0.030	0.269
		Upper		0.407	0.166	0.647		0.621	0.481	0.761
3[d]	6/19–20	Lower	53	0.370	0.203	0.536	130	0.337	0.235	0.440
		Middle		0.439	0.178	0.699		0.057	0.000	0.163
		Upper		0.192	0.000	0.445		0.606	0.465	0.747
4[d]	6/22	Lower	37	0.557	0.353	0.761	113	0.367	0.257	0.477
		Middle		0.329	0.057	0.601		0.144	0.024	0.265
		Upper		0.115	0.000	0.369		0.489	0.343	0.635
5[c]	6/24–25	Lower	60	0.603	0.442	0.763	45	0.631	0.459	0.803
		Middle		0.209	0.014	0.404		0.047	0.000	0.177
		Upper		0.189	0.000	0.393		0.322	0.127	0.518
6[c]	6/26–27	Lower	67	0.520	0.367	0.673	41	0.565	0.381	0.748
		Middle		0.371	0.155	0.587		0.120	0.000	0.288
		Upper		0.110	0.000	0.310		0.315	0.107	0.524
7[c]	6/29–30	Lower	50	0.596	0.419	0.772	34	0.723	0.538	0.909
		Middle		0.131	0.000	0.329		0.105	0.000	0.268
		Upper		0.274	0.042	0.505		0.171	0.000	0.361
8[c]	7/03–04	Lower	37	0.499	0.295	0.702	35	0.607	0.411	0.804
		Middle		0.465	0.169	0.760		0.123	0.000	0.300
		Upper		0.037	0.000	0.291		0.270	0.055	0.486
9[c]	7/06–07	Lower	21	0.641	0.375	0.907	22	0.548	0.298	0.798
		Middle		0.113	0.000	0.397		0.170	0.000	0.415
		Upper		0.247	0.000	0.585		0.282	0.004	0.561
10[c]	7/10–11	Lower	8	0.507	0.070	0.945	3	0.679	0.038	1.320
		Middle		0.275	0.000	0.842		0.000	n.a.	n.a.
		Upper		0.218	0.000	0.797		0.398	0.000	1.153

[a] Sample sizes for Period 11 were insufficient for analysis.
[b] Samples were from District 1 test fishery collected prior to the commercial fishing season.
[c] Restricted (6 in maximum mesh size) gear.
[d] Unrestricted mesh gear.

Table 4. Yukon River chinook salmon run composition estimates for age−1.3 and −1.4 in District 2 commercial catches, 1989.

Commercial Fishing Period	Dates	Region of Origin	Age 1.3 Sample Size	Age 1.3 Prop. of Catch	Age 1.3 90% Conf. Int. Lower Bound	Age 1.3 90% Conf. Int. Upper Bound	Age 1.4 Sample Size	Age 1.4 Prop. of Catch	Age 1.4 90% Conf. Int. Lower Bound	Age 1.4 90% Conf. Int. Upper Bound
1[a]	6/15	Lower	58	0.277	0.100	0.453	24	0.224	0.014	0.434
		Middle		0.303	0.021	0.585		0.091	−0.153	0.335
		Upper		0.421	0.119	0.723		0.686	0.381	0.992
2[b]	6/18−19	Lower	43	0.229	0.083	0.375	133	0.378	0.275	0.481
		Middle		0.402	0.142	0.662		0.060	−0.042	0.162
		Upper		0.369	0.100	0.639		0.562	0.425	0.700
3[b]	6/21−22	Lower	60	0.286	0.132	0.441	125	0.397	0.291	0.503
		Middle		0.111	−0.107	0.330		0.147	0.033	0.261
		Upper		0.603	0.343	0.862		0.456	0.319	0.594
4[b]	6/25	Lower	37	0.836	0.665	1.006	32	0.600	0.394	0.806
		Middle		0.135	−0.042	0.358		0.002	−0.134	0.137
		Upper		0.007	−0.165	0.180		0.399	0.158	0.640
5[a]	6/27	Lower	41	0.460	0.264	0.656	27	0.640	0.420	0.860
		Middle		0.156	−0.086	0.398		0.081	−0.100	0.262
		Upper		0.385	0.103	0.666		0.280	0.036	0.523

[a] Restricted (6 in maximum mesh size) gear.
[b] Unrestricted mesh gear.

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, 1989.

Commercial Fishing Period	Dates	Region of Origin	Age Group 1.3	Age Group 1.4	Total
1 [a]	6/13−14	Lower	534	266	800
		Middle	866	951	1,817
		Alaska	1,400	1,217	2,617
		Upper	1,132	1,701	2,833
		Total	2,532	2,918	5,450
2 [b]	6/15−16	Lower	1,693	2,364	4,158
		Middle	1,762	1,542	3,249
		Alaska	3,455	3,906	7,407
		Upper	2,227	6,372	8,607
		Total	5,682	10,278	16,014
3 [b]	6/19−20	Lower	940	2,398	3,356
		Middle	1,113	406	1,318
		Alaska	2,053	2,804	4,674
		Upper	488	4,312	4,983
		Total	2,541	7,116	9,657
4 [b]	6/22	Lower	246	585	831
		Middle	123	230	353
		Alaska	369	815	1,184
		Upper	86	780	866
		Total	455	1,595	2,050
5 [a]	6/24−25	Lower	2,145	2,115	4,191
		Middle	745	158	870
		Alaska	2,890	2,271	5,061
		Upper	673	1,079	1,852
		Total	3,563	3,350	6,913
6 [a]	6/26−27	Lower	1,364	1,553	2,917
		Middle	804	330	1,134
		Alaska	2,168	1,883	4,051
		Upper	522	866	1,388
		Total	2,690	2,749	5,439
7 [a]	6/29−30	Lower	675	802	1,476
		Middle	186	117	302
		Alaska	861	919	1,778
		Upper	302	189	491
		Total	1,163	1,108	2,269

−Continued−

Table 5. (Page 2 of 2)

Commercial Fishing Period	Dates	Region of Origin	Age Group 1.3	1.4	Total
8[a]	7/03–04	Lower	199	228	426
		Middle	144	46	190
		Alaska	343	274	616
		Upper	66	101	167
		Total	409	375	783
9[a]	7/06–07	Lower	243	277	519
		Middle	56	86	142
		Alaska	299	363	661
		Upper	93	142	235
		Total	392	505	896
10–19[a]	7/10–11	Lower	154	255	408
		Middle	77	0	77
		Alaska	154	255	408
		Upper	77	118	195
		Total	231	373	603
District 1 Unrestricted Mesh Size Total		Lower	2,879	5,347	8,226
		Middle	2,998	2,178	5,176
		Alaska	5,877	7,525	13,402
		Upper	2,801	11,464	14,265
		Total	8,678	18,989	27,667
District 1 Restricted Mesh Size Total		Lower	5,314	5,496	10,810
		Middle	2,878	1,688	4,566
		Alaska	8,192	7,184	15,376
		Upper	2,865	4,196	7,061
		Total	11,057	11,380	22,437
District 1 Season Total		Lower	8,193	10,843	19,036
		Middle	5,876	3,866	9,742
		Alaska	14,069	14,709	28,778
		Upper	5,666	15,660	21,326
		Total	19,735	30,369	50,104

[a] Restricted (6 in maximum mesh size) summer chum salmon commercial period.
[b] Unrestricted mesh gear.

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, 1989.

Commercial Fishing Period	Dates	Region of Origin	Age Group 1.3	Age Group 1.4	Total
1[a]	6/13-14	Lower	347	169	516
		Middle	379	69	448
		Alaska	726	238	964
		Upper	527	518	1,045
		Total	1,253	756	2,009
2[b]	6/15-16	Lower	708	2,420	3,117
		Middle	971	384	1,352
		Alaska	1,679	2,804	4,469
		Upper	889	3,597	4,469
		Total	2,568	6,401	8,938
3[b]	6/19-20	Lower	504	1,879	2,383
		Middle	196	695	892
		Alaska	700	2,575	3,275
		Upper	1,062	2,159	3,221
		Total	1,762	4,734	6,496
4[b]	6/22	Lower	1,030	784	1,814
		Middle	195	3	198
		Alaska	1,225	787	2,012
		Upper	9	520	529
		Total	1,234	1,307	2,541
5-19[a,c]	6/24-8/27	Lower	1,835	2,183	4,017
		Middle	624	277	901
		Alaska	2,189	2,460	4,876
		Upper	1,539	956	2,495
		Total	3,557	3,416	7,289
District 2 Unrestricted Mesh Total		Lower	2,243	5,083	7,326
		Middle	1,362	1,082	2,444
		Alaska	3,605	6,165	9,770
		Upper	1,960	6,276	8,236
		Total	5,565	12,441	18,006
District 2 Restricted Mesh Mesh Total		Lower	2,182	2,352	4,534
		Middle	1,003	346	1,349
		Alaska	3,185	2,698	5,883
		Upper	2,066	1,474	3,540
		Total	5,251	4,172	9,423
District 2 Season Total		Lower	4,425	7,435	11,860
		Middle	2,365	1,428	3,793
		Alaska	6,790	8,863	15,653
		Upper	4,026	7,750	11,776
		Total	10,816	16,613	27,429

[a] Restricted (6 in maximum mesh size) gear.
[b] Unrestricted mesh gear.
[c] Periods 6-19 run-of-origin compositions were estimated from and pooled with samples collected from District 2, Period 5.

Table 7. Total catch by age class and run of chinook salmon from Yukon River Districts 1 – 6 and Yukon Territory, Canada commercial and subsistence catches, 1989.

			Brood Year and Age Group[a]										
		Region of	1986	1985	1984		1983		1982		1981		
District	Fishery	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 (GN)	Lower	5	702	8,193	122	10,843	11	85	9	116	0	20,086
		Middle	7	1,076	5,876	87	3,866	0	343	1	0	1	11,257
		Alaska	**12**	**1,778**	**14,069**	**209**	**14,709**	**11**	**428**	**10**	**116**	**1**	**31,343**
		Upper	7	984	5,666	0	15,660	207	3,837	1,049	0	400	27,810
		Total	**19**	**2,762**	**19,735**	**209**	**30,369**	**218**	**4,265**	**1,059**	**116**	**401**	**59,153**
1	Subsistence[b] Gill Net	Lower	0	58	677	10	896	1	7	1	10	0	1,660
		Middle	1	89	486	7	319	0	28	0	0	0	930
		Alaska	**1**	**147**	**1,163**	**17**	**1,215**	**1**	**35**	**1**	**10**	**0**	**2,590**
		Upper	1	81	468	0	1,294	17	317	87	0	33	2,298
		Total	**2**	**228**	**1,631**	**17**	**2,509**	**18**	**352**	**88**	**10**	**33**	**4,888**
2	Commercial Gill Net	Lower	6	984	4,425	60	7,435	23	72	9	6	0	13,020
		Middle	4	671	2,365	32	1,427	0	158	0	3	1	4,661
		Alaska	**10**	**1,655**	**6,789**	**92**	**8,863**	**23**	**230**	**9**	**9**	**1**	**17,681**
		Upper	2	179	4,026	0	7,750	308	2,369	696	22	192	15,544
		Total	**12**	**1,834**	**10,816**	**92**	**16,612**	**331**	**2,599**	**705**	**31**	**193**	**33,225**
2	Subsistence[c] Gill Net	Lower	1	212	952	13	1,599	5	15	2	1	0	2,801
		Middle	1	144	509	7	307	0	34	0	1	0	1,003
		Alaska	**2**	**356**	**1,461**	**20**	**1,906**	**5**	**49**	**2**	**2**	**0**	**3,803**
		Upper	0	39	866	0	1,667	66	510	150	5	41	3,344
		Total	**3**	**395**	**2,327**	**20**	**3,573**	**71**	**559**	**152**	**7**	**42**	**7,147**
3	Commercial[c] Gill Net	Lower	0	32	224	1	411	1	4	0	0	0	673
		Middle	0	22	105	1	77	0	9	0	0	0	214
		Alaska	**0**	**53**	**329**	**2**	**488**	**1**	**13**	**0**	**1**	**0**	**887**
		Upper	0	6	146	0	407	13	137	39	1	9	758
		Total	**0**	**59**	**475**	**2**	**895**	**14**	**150**	**39**	**2**	**9**	**1,645**
3	Subsistence[c] Gill Net	Lower	0	91	646	4	1,186	3	12	0	1	0	1,943
		Middle	0	62	303	2	222	0	26	0	1	0	616
		Alaska	**0**	**154**	**949**	**6**	**1,408**	**3**	**38**	**0**	**2**	**0**	**2,559**
		Upper	0	17	421	0	1,174	38	394	113	4	26	2,187
		Total	**0**	**170**	**1,370**	**6**	**2,582**	**40**	**433**	**113**	**6**	**26**	**4,746**
4	Combined Commercial & Subsistence	Lower	2	297	1,336	18	2,244	7	22	3	2	0	3,930
		Middle[d]	3	471	1,661	22	1,003	0	111	0	2	1	3,274
		Alaska	**5**	**768**	**2,997**	**41**	**3,247**	**7**	**133**	**3**	**4**	**1**	**7,204**
		Upper	1	54	1,215	0	2,339	93	715	210	7	58	4,692
		Total	**5**	**822**	**4,212**	**41**	**5,586**	**100**	**848**	**213**	**11**	**59**	**11,896**
5	Commercial & Subsistence GN&FW[f]	Middle[e]	0	6	20	0	40	1	17	2	0	1	88
		Upper	29	1,881	5,758	54	11,729	435	4,813	623	17	206	25545
6[g]	Commercial GN&FW	Middle	8	78	558	0	1,226	47	248	15	0	0	2,181
	Subsistence GN&FW	Middle	29	614	1,194	0	964	16	225	0	3	0	3,046
Yukon Territory	Commercial GN	Upper	0	96	1,000	0	6,480	0	2,017	98	49	49	9,789
	Subsistence GN[h]	Upper	0	80	834	0	5,399	0	1,680	81	41	41	8,155
Total Chinook Harvest		Lower	14	2,376	16,453	228	24,614	51	217	23	136	0	44,113
		Middle	53	3,234	13,077	158	9,451	65	1,200	18	10	4	27,271
		Alaska	**67**	**5,218**	**28,201**	**372**	**32,887**	**109**	**1,296**	**39**	**142**	**3**	**71,383**
		Upper	39	3,416	20,401	54	53,899	1,177	16,788	3,145	146	1,055	100,121
		Total	**107**	**8,635**	**48,602**	**426**	**86,786**	**1,286**	**18,084**	**3,185**	**288**	**1,058**	**171,504**

[a] Due to hidden decimals (a characteristic of the computation and formatting process), rounding error may cause subtotals to appear incorrect by one fish; however, totals by fishery are correct.

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

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

[d] Includes 796 fish captured by residents of the upper Koyukok River.

[e] Fish captured by residents of Venetie on the Chandalar River.

[f] FW = fishwheel.

[g] Gill net samples composition based on District 6 Fishwheel. Includes 440 fish sold from ADF&G test fish project.

[h] Includes 525 fish captured by residents of Old Crow on the Porcupine River.

Table 8. Yukon River chinook salmon run composition estimates for age–1.4, comparing South, Middle, and North Mouth, 1989.

			South Mouth				Middle Mouth				North Mouth			
					90% Conf. Int.				90% Conf. Int.				90% Conf. Int.	
Commercial Fishing Period	Dates	Region of Origin	Sample Size	Prop. of Catch	Lower Bound	Upper Bound	Sample Size	Prop. of Catch	Lower Bound	Upper Bound	Sample Size	Prop. of Catch	Lower Bound	Upper Bound
1 [a]	6/13–14	Lower	14	0.109	−0.112	0.329	15							
		Middle		0.459	0.045	0.875		0.265	−0.105	0.686				
		Upper		0.432	0.015	0.849		0.735	0.360	1.158				
2 [b]	6/15–16	Lower	50	0.279	0.125	0.433	71	0.182	0.064	0.299				
		Middle		0.180	−0.007	0.366		0.129	−0.031	0.288				
		Upper		0.541	0.324	0.759		0.689	0.503	0.878				
3 [b]	6/19–20	Lower	57	0.469	0.311	0.626	46	0.283	0.122	0.445	27	0.150	−0.027	0.331
		Middle		0.068	−0.070	0.207		0.080	0.094	0.253				
		Upper		0.463	0.270	0.656		0.637	0.413	0.862		0.850	0.581	1.125
5 [a]	6/24–25	Lower	29	0.781	0.592	0.970	16	0.361	0.075	0.646				
		Middle		0.043	−0.097	0.183		0.053	−0.207	0.312				
		Upper		0.176	−0.025	0.377		0.586	0.221	0.954				
6 [a]	6/26–27	Lower	27	0.477	0.251	0.705	14	0.732	0.447	1.017				
		Middle		0.163	−0.064	0.389		0.038	−0.167	0.243				
		Upper		0.360	0.092	0.627		0.230	−0.082	0.541				
7 [a]	6/29–30	Lower	15	0.607	0.309	0.905	4	0.731	0.260	1.281				
		Middle		0.108	−0.153	0.370								
		Upper		0.284	−0.045	0.614		0.269	−0.310	0.891				

[a] Restricted (6 in maximum mesh size) gear.
[b] Unrestricted mesh gear.

Table 9. Yukon River chinook salmon run composition estimates for age–1.3, comparing South, Middle, and North Mouth, 1989.

			South Mouth				Middle Mouth				North Mouth			
					90% Conf. Int.				90% Conf. Int.				90% Conf. Int.	
Commercial Fishing Period	Dates	Region of Origin	Sample Size	Prop. of Catch	Lower Bound	Upper Bound	Sample Size	Prop. of Catch	Lower Bound	Upper Bound	Sample Size	Prop. of Catch	Lower Bound	Upper Bound
1[a]	6/13–14	Lower	9	0.044	−0.224	0.312	7	0.097	−0.233	0.426				
		Middle		0.079	−0.496	0.653		0.487	−0.262	1.237				
		Upper		0.877	0.235	1.520		0.416	−0.358	1.190				
2[b]	6/15–16	Lower	19	0.345	0.065	0.673	34	0.336	0.131	0.541				
		Middle		0.049	−0.288	0.387		0.306	−0.001	0.613				
		Upper		0.606	0.176	1.037		0.358	0.033	0.684				
3[b]	6/19–20	Lower	28	0.391	0.162	0.619	13	0.460	0.116	0.805	12	0.223	−0.087	0.533
		Middle		0.510	0.158	0.863		0.224	−0.218	0.666		0.503	−0.052	1.060
		Upper		0.099	−0.222	0.421		0.316	−0.167	0.799		0.274	−0.281	0.829
5[a]	6/24–25	Lower	42	0.587	0.396	0.780	18	0.637	0.353	0.921				
		Middle		0.187	−0.041	0.415		0.262	−0.093	0.617				
		Upper		0.226	−0.022	0.474		0.101	−0.232	0.435				
6[a]	6/26–27	Lower	35	0.393	0.187	0.600	32	0.636	0.447	0.869				
		Middle		0.362	0.059	0.665		0.364	0.094	0.668				
		Upper		0.245	−0.060	0.550								
7[a]	6/29–30	Lower	11	0.765	0.428	1.102	10	0.385	−0.003	0.773				
		Middle		0.052	−0.267	0.371		0.142	−0.348	0.632				
		Upper		0.183	−0.228	0.594		0.473	−0.108	1.054				

[a] Restricted (6 in maximum mesh size) gear.
[b] Unrestricted mesh gear.

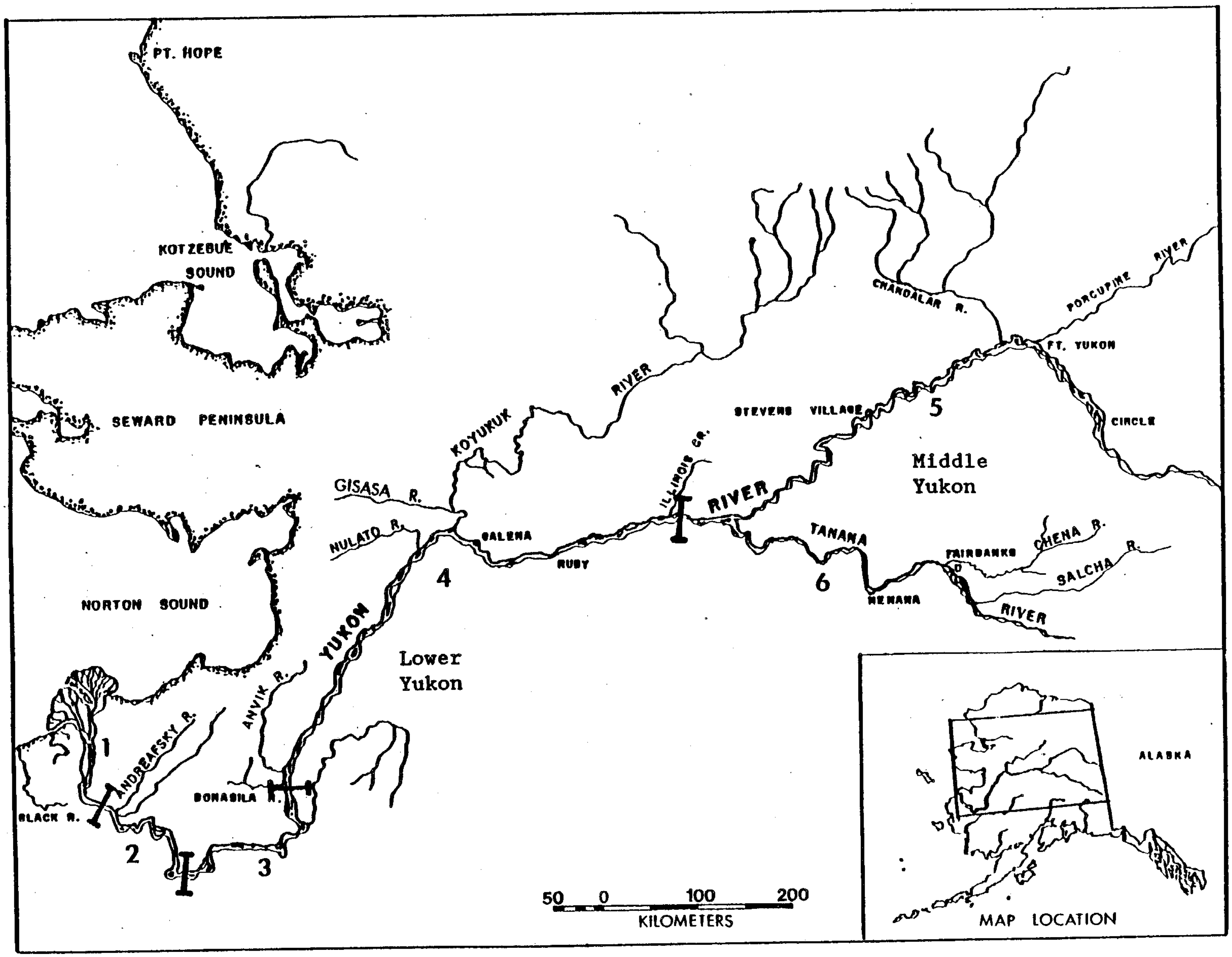

Figure 1. Alaskan portion of the Yukon River, showing fishing district boundaries.

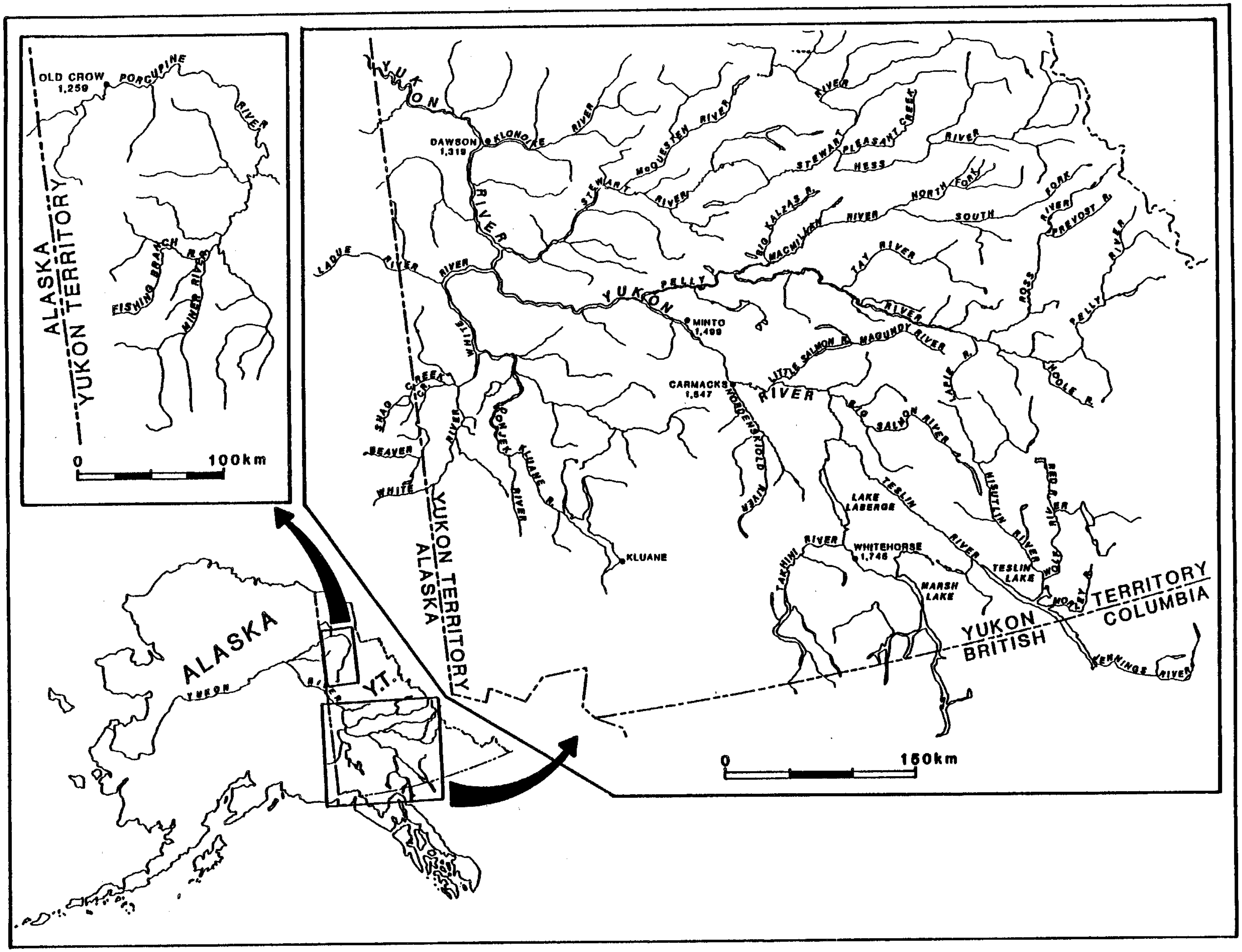

Figure 2. Canadian portion of the Yukon River.

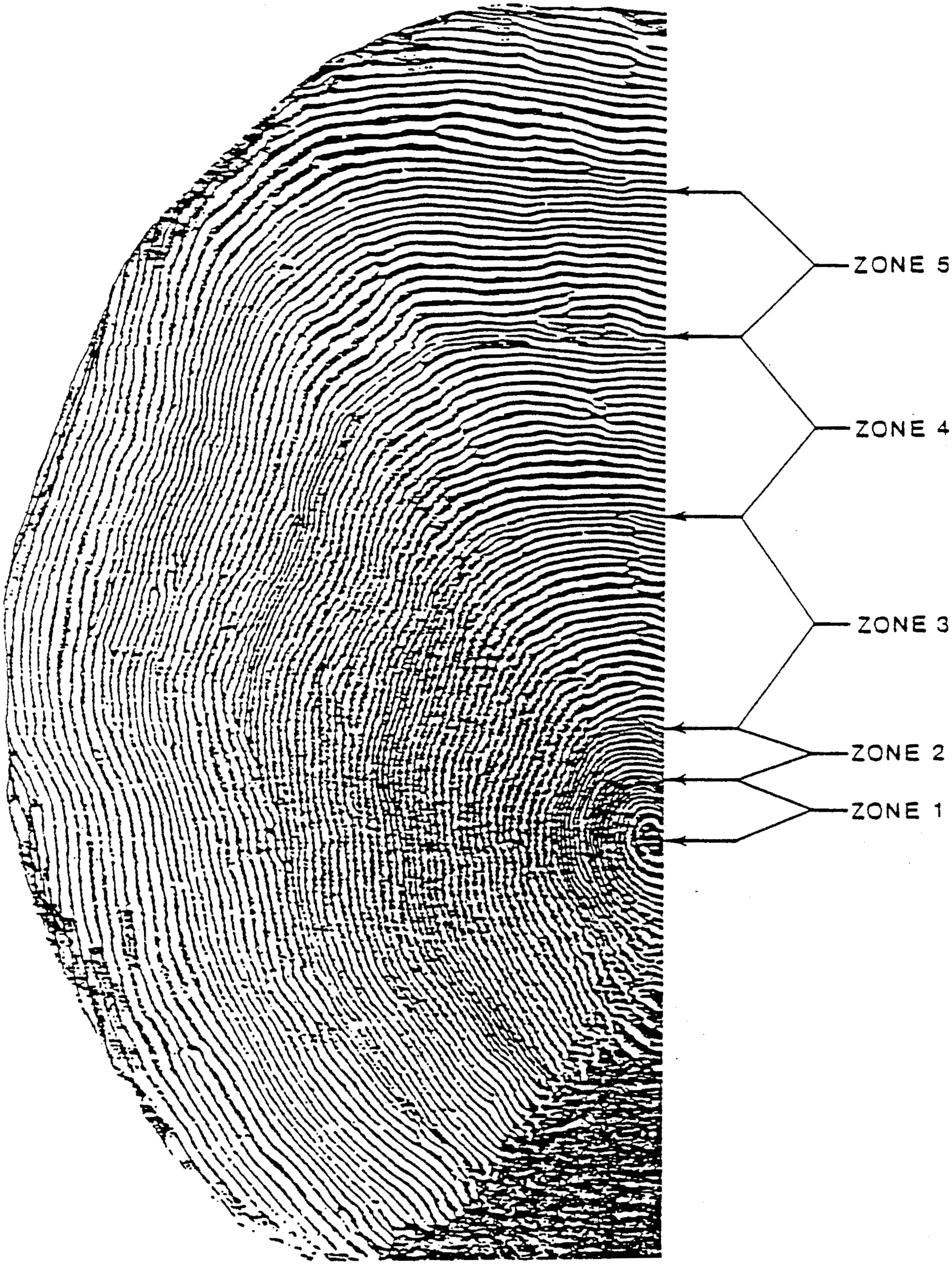

Figure 3. Age-1.4 chinook salmon scale showing zones measured for linear discriminant analysis.

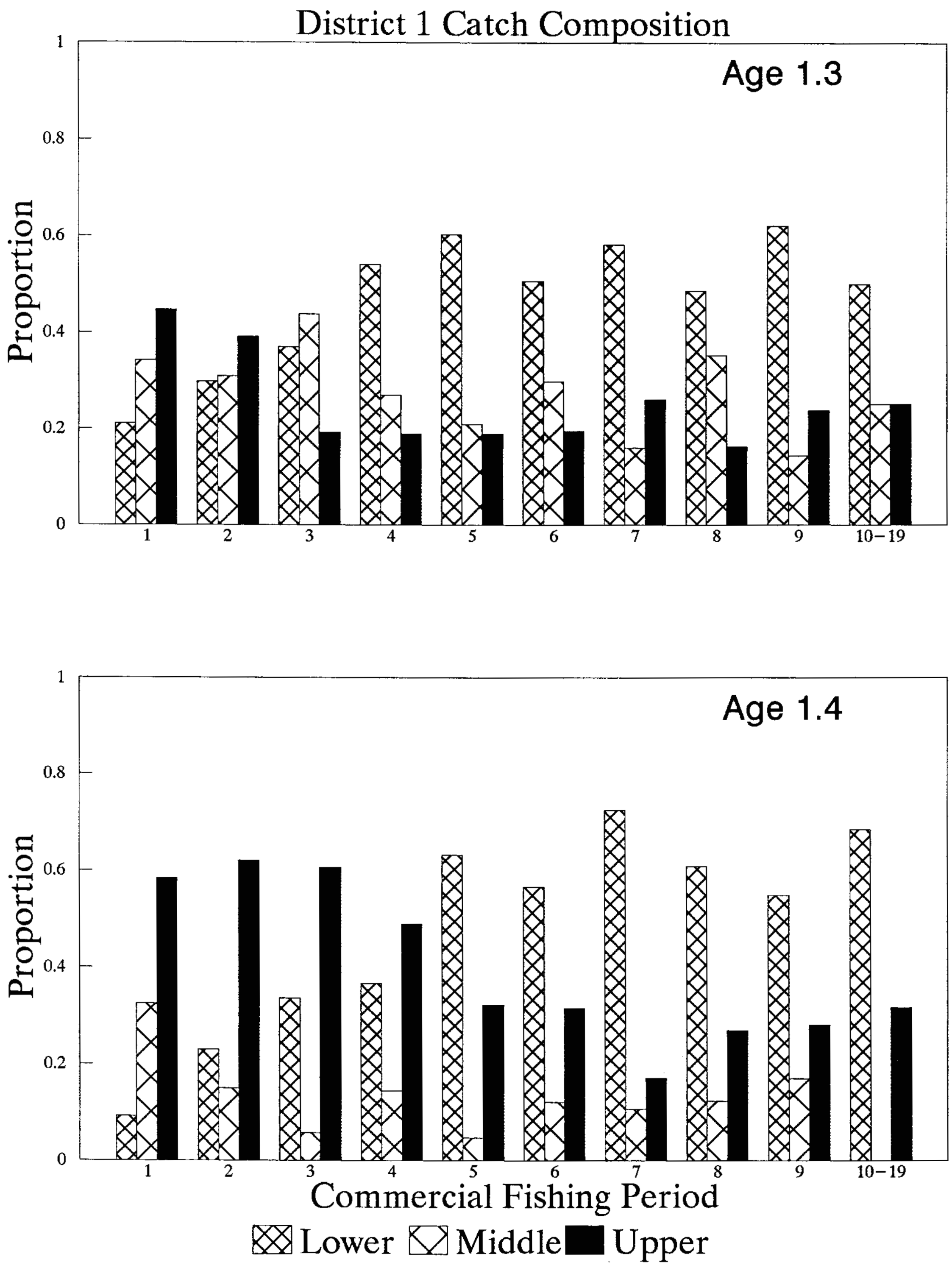

Figure 4. Proportion of catch by run estimated from scale pattern analysis of age-1.3 and -1.4 chinook salmon, Yukon River District 1, 1989.

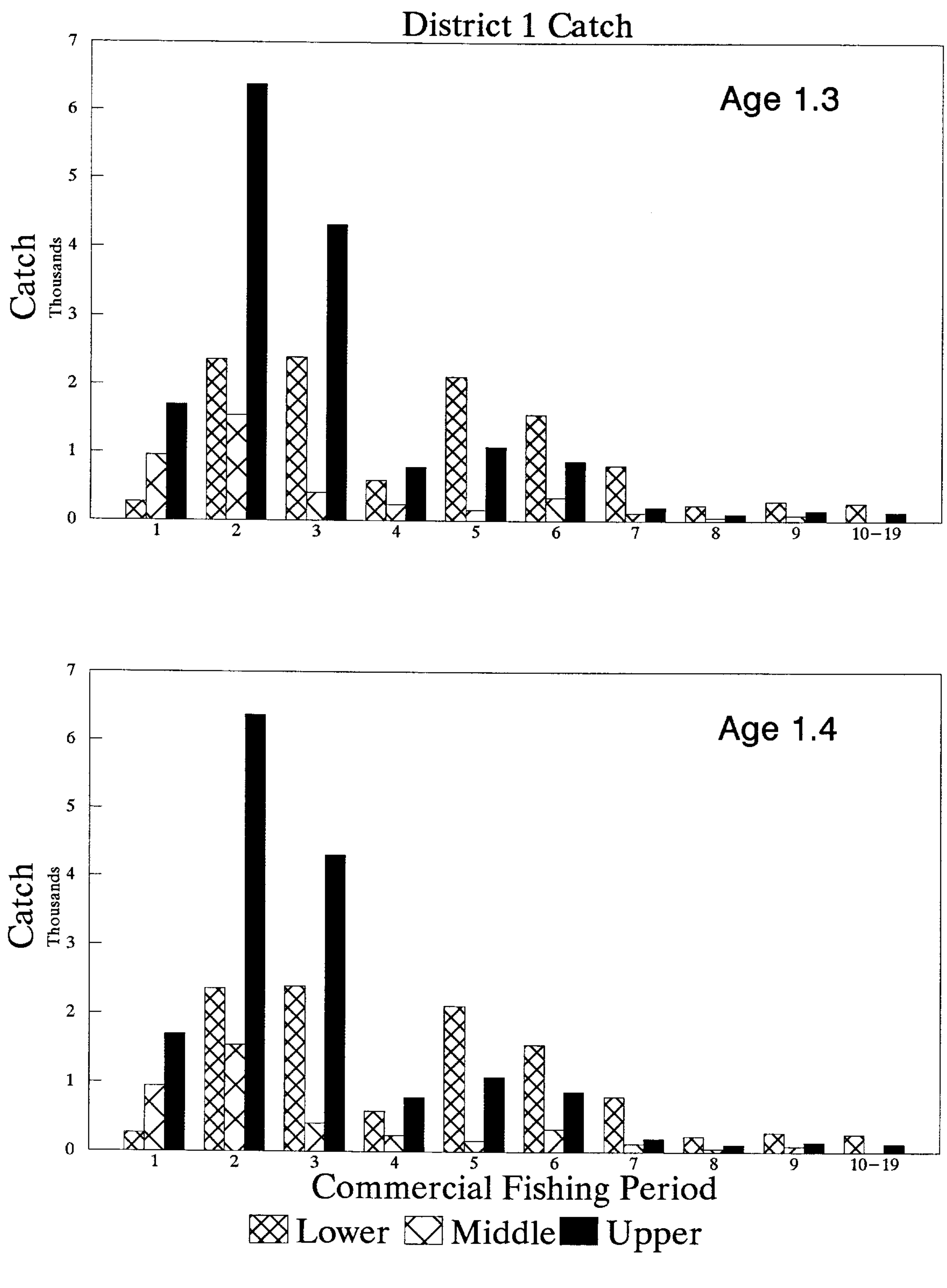

Figure 5. Catch by run in numbers of fish estimated from scale pattern analysis of age-1.3 and -1.4 chinook salmon, Yukon River District 1, 1989.

APPENDICES

Appendix A. Scale variables screened for linear discriminant function analysis of age–1.3 and –1.4 Yukon River chinook salmon, 1989.

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–

Appendix A. (Page 2 of 2)

Variable		1st Marine Annular Zone	
70		Number of circuli	(NC1OZ)[e]
71		Width of zone	(S1OZ)[f]
72	(90)	Distance, end of frshwater 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 (width) 1st freshwater zone.
[c] Number of circuli, plus growth zone.
[d] Size (width) plus growth zone.
[e] Number of circuli, 1st ocean zone.
[f] Size (width) 1st ocean zone.

Appendix B. Group means, standard errors, and one-way analysis of variance F-test for scale variables selected for use in linear discriminant models of age-1.3 and -1.4 Yukon River chinook salmon runs, 1989.

Growth Zone	Variable	Lower		Middle		Upper		F-Value
		Mean	SE	Mean	SE	Mean	SE	
Age-1.3								
1st FW Annular	14	72.72	1.75	46.74	1.57	63.49	1.33	81.91
	16	0.43	<.01	0.53	0.01	0.44	0.01	70.80
Total FW Growth	67	0.87	<.01	0.66	0.01	0.68	0.01	421.64
1st Ocean Annular	106	14.07	0.09	12.85	0.15	11.82	0.13	109.53
	108	0.06	0.00	0.06	0.00	0.06	0.00	20.62
Marine Zones Comb.	109	466.91	4.65	449.07	8.10	423.91	5.13	17.35
Age-1.4								
1st FW Annular	14	74.95	1.30	43.47	1.07	61.95	1.14	171.18
	18	0.75	0.01	0.90	0.01	0.82	0.01	117.71
	21	0.33	<.01	0.38	0.01	0.37	<.01	44.45
	25	0.24	0.01	0.34	0.01	0.27	0.01	105.99
	30	0.13	<.01	0.17	<.01	0.15	<.01	82.74
FW Plus Growth	62	24.06	0.91	55.25	1.27	66.45	1.96	227.58
Total FW Growth	67	0.84	0.01	0.63	0.01	0.63	0.01	338.85
1st Ocean Annular	74	130.56	1.15	134.61	1.24	157.79	1.26	150.99

Appendix C. Group means, standard errors, and one-way analysis of variance F-test for the number of circuli and incremental distance of salmon scale growth zone measurements from age-1.3 and -1.4 Yukon River chinook salmon runs, 1989.

			Lower		Middle		Upper		
Growth Zone	Variable	Description	Mean	SE	Mean	SE	Mean	SE	F-Value
Age-1.3									
1st FW Annular	1	No. Circ.	9.72	0.11	7.43	0.15	9.24	0.13	70.54
	2	Distance	125.49	1.28	97.00	1.73	111.56	1.47	85.61
Total FW Growth	61	No. Circ.	2.28	0.07	5.10	0.12	5.15	0.13	285.85
	62	Distance	19.57	0.69	49.86	1.33	53.49	1.42	331.61
1st Ocean Annular	70	No. Circ.	27.12	0.15	25.81	0.31	24.18	0.23	55.28
	71	Distance	506.56	3.27	457.13	6.78	453.26	4.45	51.80
2nd Ocean Annular	109	Distance	466.19	4.65	449.06	8.01	423.91	5.13	17.35
Age-1.4									
1st FW Annular	1	No. Circ.	10.36	0.14	7.36	0.12	8.97	0.11	144.85
	2	Distance	127.90	1.35	91.67	1.29	111.40	1.34	177.48
Total FW Growth	61	No. Circ.	2.74	0.10	5.64	0.10	5.91	0.15	209.53
	62	Distance	24.06	0.91	55.25	1.27	66.45	1.96	227.58
1st Ocean Annular	70	No. Circ.	26.91	0.21	25.71	0.26	24.20	0.24	34.70
	71	Distance	477.45	3.77	443.64	5.31	453.62	4.53	14.47
2nd Ocean Annular	109	Distance	410.48	5.99	413.16	7.48	390.19	5.45	4.12
3rd Ocean Annular	110	Distance	398.84	4.07	382.38	5.64	370.86	4.01	10.00