ORIGINS OF CHINOOK SALMON *(Oncorhynchus tschawytscha* Walbaum*)* IN THE YUKON RIVER FISHERIES, 1984

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ABSTRACT

Analysis of scale patterns and age composition of chinook salmon (*Oncorhynchus tschawytscha* Walbaum) from Yukon River catches and escapements was used to apportion the lower Yukon River District 1, 2, and 3 commercial harvests to geographic region (run) of origin. A similar apportionment of subsistence harvests was made. Other Yukon River chinook salmon harvests were apportioned primarily by geographical area of occurrence. Geographic contribution to total Yukon River utilization was estimated at 63,781 (35.7%) middle Yukon, 63,037 (35.2%) upper Yukon, and 51,970 (29.1%) lower Yukon fish. The fraction of the Districts 1 and 2 commercial catch apportioned to the lower Yukon generally increased during the period of the analysis while the fraction apportioned to the middle Yukon generally declined.

KEY WORDS: chinook salmon, *Oncorhynchus tschawytscha*, stock separation, catch and run apportionment, linear discriminant analysis.

INTRODUCTION

Yukon River chinook salmon (*Oncorhynchus tschawytscha* Walbaum) are harvested in a wide range of fisheries in both marine and fresh waters. During their ocean residence, they are harvested in salmon gillnet fisheries in the North Pacific Ocean and Bering Sea and in trawl fisheries in the Bering Sea. Upon returning to the Yukon River as adults, they are harvested in a variety of commercial and subsistence fisheries in both the United States and Canada (Figures 1 and 2).

One of the major issues facing management of the Yukon River chinook salmon resource is allocation of the harvest among the various user groups. Foremost among these allocation issues are: (1) high seas interceptions of North American chinook salmon (including fish destined for the Yukon River) in the gillnet 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.

Identification of stock groupings and estimation of their contribution rates is becoming an increasingly important facet of management of the Yukon River chinook salmon resource. The contribution of Western Alaska/Canadian Yukon Territory chinook salmon has recently been estimated for the Japanese high seas gillnet fisheries (Rogers et al. 1984, Meyers et al. 1984, and Meyers and Rogers 1985). These stock contribution estimates have become major elements in the regulation of these ocean fisheries. Concurrent with these offshore studies, stock composition of inriver fisheries has been studied in order to build a data base with which to address the inriver allocation issues, as well as to improve management precision through a better understanding of stock-specific production units and their spatial/temporal migratory patterns. Stock composition estimates through time for Yukon River chinook salmon have only recently become available as the feasibility of annually apportioning catches using scale pattern analysis for District 1 catches was initially investigated in 1980 and 1981 (McBride and Marshall 1983). The entire drainage harvest was apportioned to geographic region of origin in 1982 (Wilcock and McBride 1983) and 1983 (Wilcock 1984).

The Yukon River combined commercial and subsistence chinook salmon fishery is one of the largest in Alaska, accounting for an annual average (1979-1983) of 16% of statewide chinook salmon harvest. In the first 19 years after statehood (1960-1978), combined Alaskan and Canadian annual harvest averaged 120,663 fish. However, catches in recent years have increased substantially (1979-1983 average 195,491 fish). While chinook salmon are harvested virtually throughout the entire length of the Yukon River, the majority of the catch is taken in commercial gillnet fisheries in Districts 1 and 2 (1979-1983 average 67% of total drainage harvest). Subsistence harvests, including Canadian catches, account for another 22% (1979-1983 average) of the total harvest. Most of the subsistence harvest is taken with fishwheels and gill nets in Districts 3, 4, and 5. In 1984, commercial and subsistence fishermen in Alaska and Canada harvested a total of 178,338 chinook salmon, of which 111,368 fish (62%) were taken by District 1 and District 2 commercial fishermen.

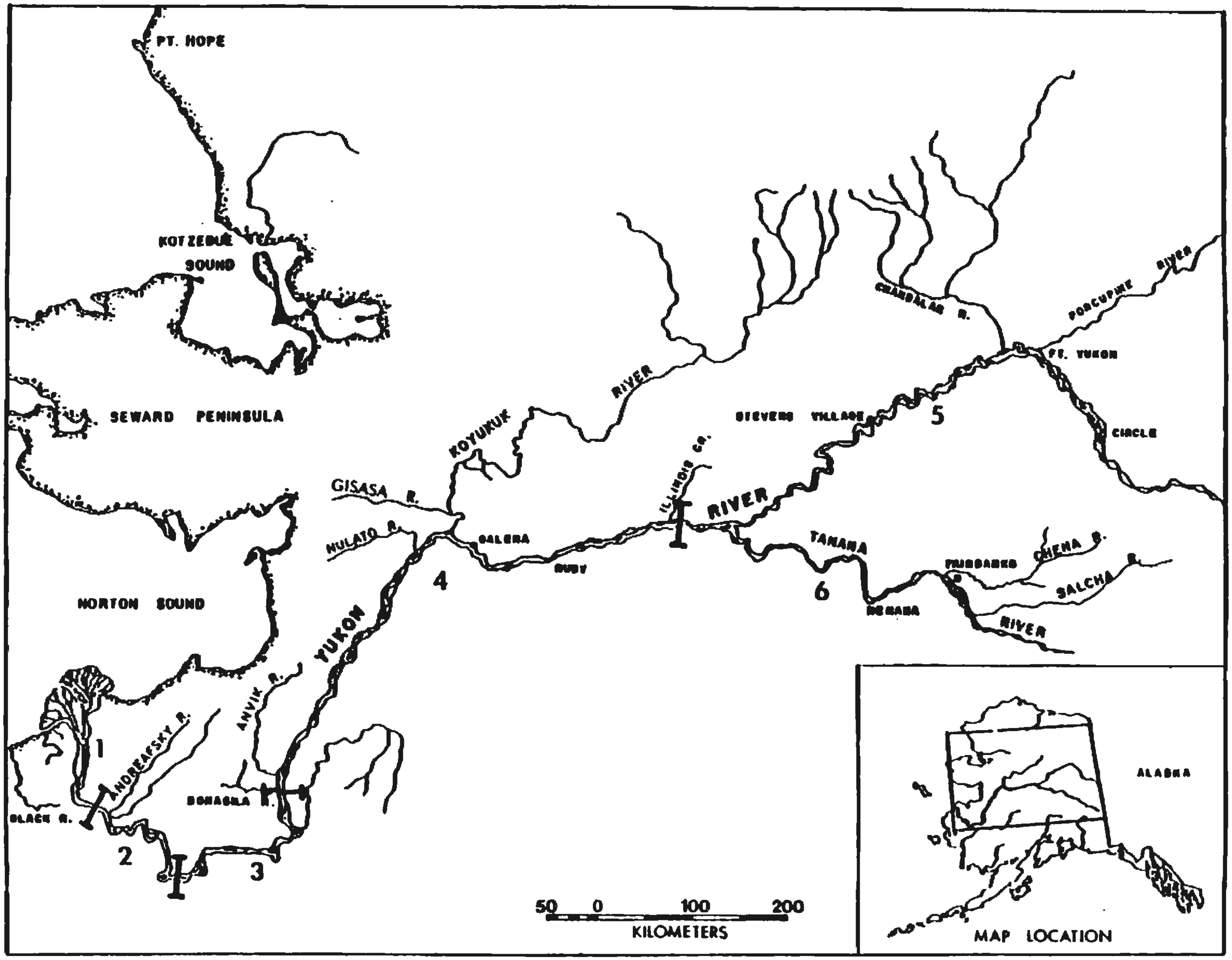

Figure 1. Alaskan portion of the Yukon River showing the six regulatory districts.

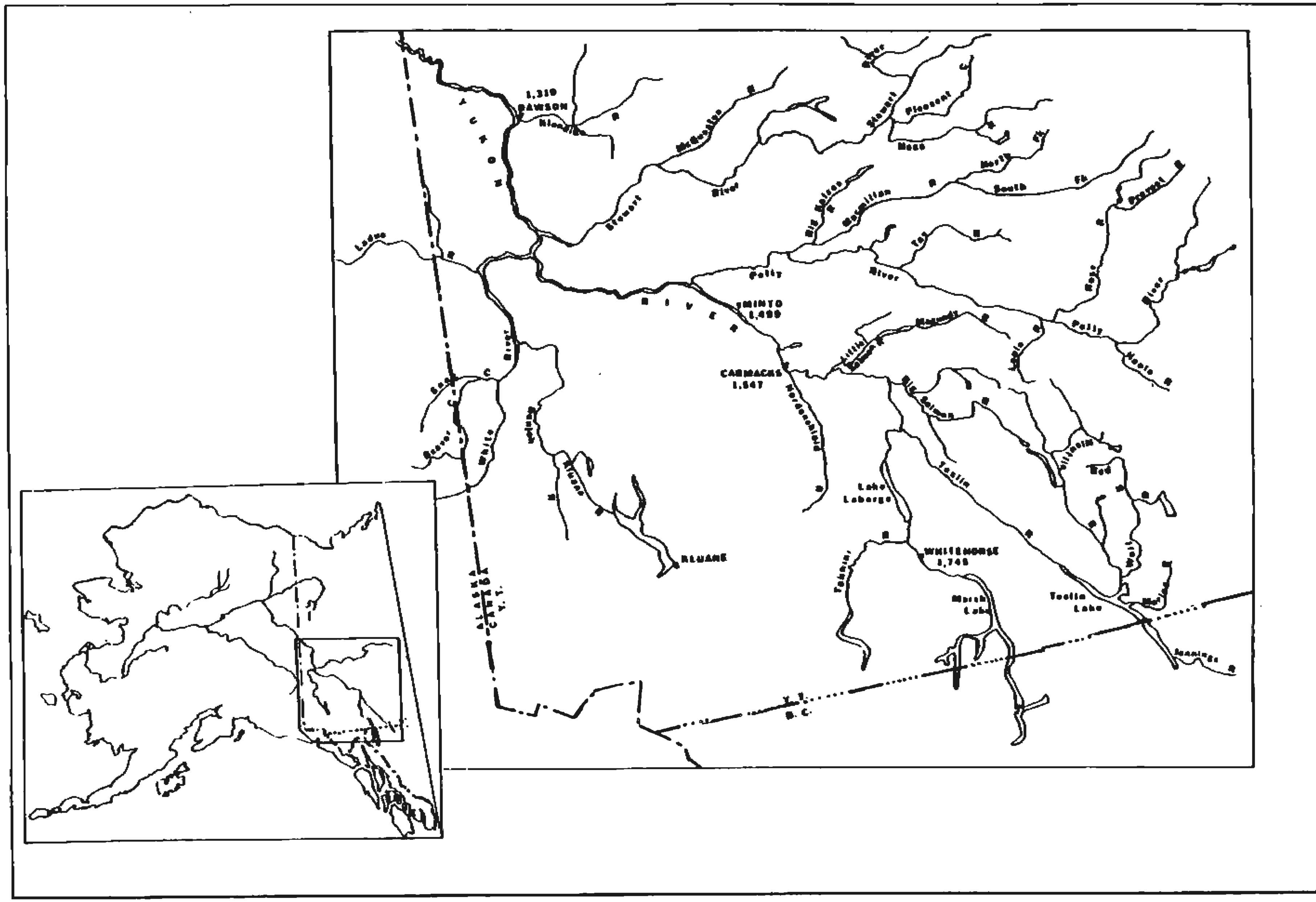

Figure 2. Canadian portion of the Yukon River.

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 approximately between river miles 100 and 500; (2) Tanana River tributaries approximately between river miles 800 and 1,100; and (3) tributary streams that drain the Pelly and Big Salmon Mountains approximately between river miles 1,300 and 1,800. Chinook salmon stocks within these geographic regions have been termed runs (McBride and Marshall 1983) and defined as the lower, middle, and upper Yukon runs, respectively.

This report builds upon the catch, escapement, and age composition data base compiled by Buklis and Wilcock (in press) for the 1984 returns of salmon to the Yukon River. Its objective is to apportion the 1984 Yukon River commercial and subsistence harvest of chinook salmon by run of origin. Procedures and analyses used to apportion individual fisheries are illustrated in Figure 3. Commercial catches from Districts 1, 2, and 3 were allocated to run of origin by analyses of scale patterns of age 6_2 and 5_2 fish[1], and catch and escapement age composition data. Estimates of the contribution by run in commercial catches were applied to subsistence catches from these districts. Commercial and subsistence catches from Districts 5 and 6, and the Yukon Territory, were allocated based on geography. Pooled commercial and subsistence catches from District 4 were allocated based on geography, scale pattern analysis of age 6_2 and 5_2 fish, and catch and escapement age composition data.

METHODS

Age Composition

Scale samples provided age information for fish in the catch and escapement. Samples were collected on the left side of the fish approximately two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin (Clutter and Whitesel 1956). Scales were mounted on gummed cards and impressions made in cellulose acetate.

Catch:

Scales were collected[2] from the commercial catches from Districts 1, 2, and 3, and the Yukon Territory and an age composition was estimated for each

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[1] Gilbert-Rich formula: the first numeral refers to the total age of the fish. The second numeral, usually subscripted, refers to the number of years of freshwater residence. Marine age is the arithmetic difference between these two numbers.

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

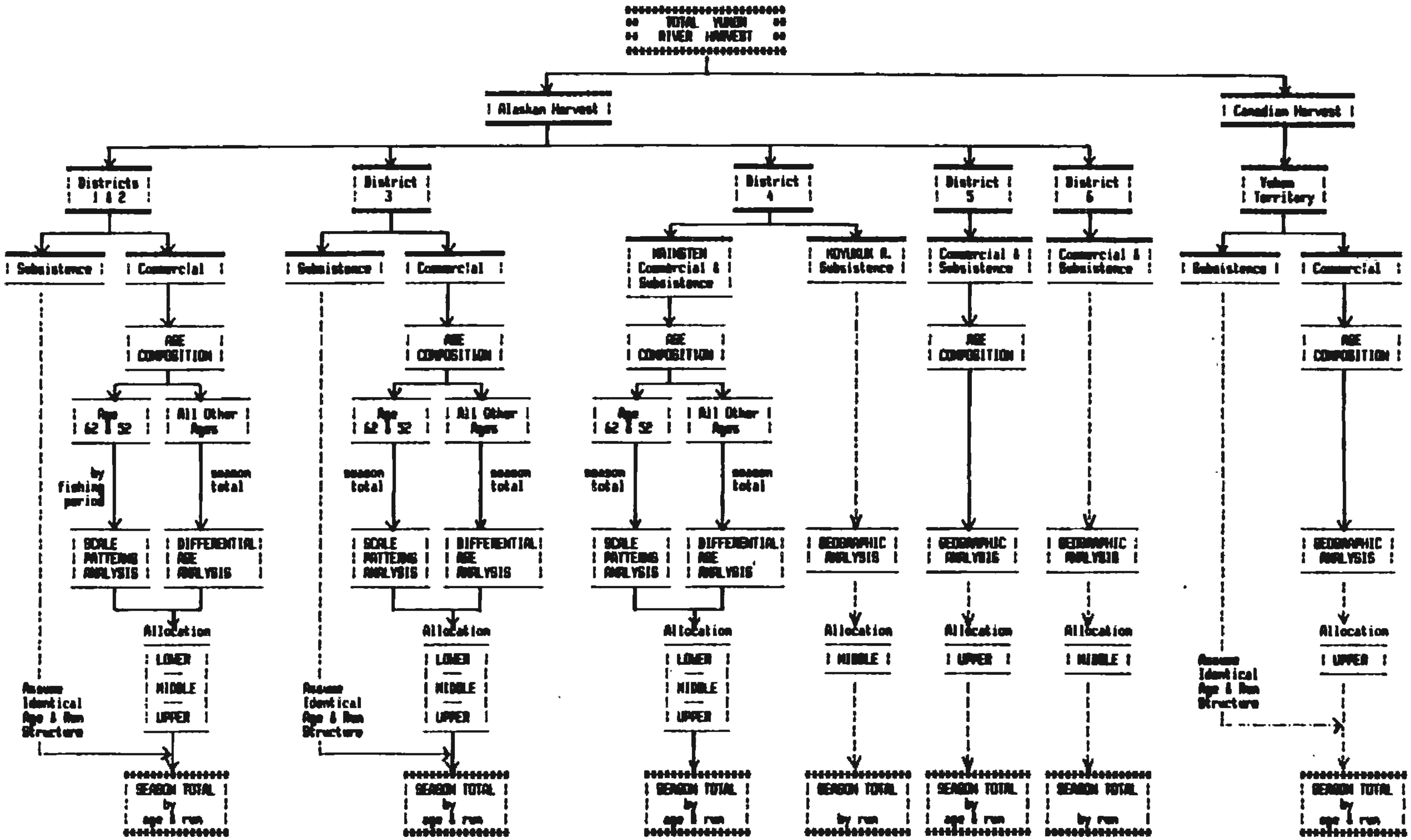

Figure 3. Schematic representation of analyses used to allocate Yukon River chinook salmon by age class and run of origin, 1984.

fishery. Although subsistence catches in these districts were not sampled, subsistence fishing occurred concurrently with commercial effort and the age composition for subsistence catches in each district was assumed to be similar to the commercial catch.

Samples were also collected from commercial and subsistence catches in Districts 4 and 5. For each of these districts, pooled age compositions were estimated for the combined commercial and subsistence catches from both fishwheels and gill nets. Catches in District 6 were not aequately sampled to estimate age composition.

Escapement:

Scale samples were collected during peak spawner die-off from the major spawning tributaries (as determined by aerial surveys). Virtually all samples were collected from carcasses. The age composition of middle and upper Yukon areas was estimated by weighting the age composition estimated for the individual spawning tributaries in each area by the escapement to each tributary as estimated by aerial surveys. There were no aerial survey data for the East Fork Andreafsky River in 1984, and only data from an incomplete survey of the Anvik River were available. Therefore, a pooled sample was selected for the lower Yukon run weighted for abundance of individual stocks using sonar data from the East Fork Andreafsky River, aerial survey data from the West Fork Andreafsky River, and the limited aerial survey data for the Anvik River.

Catch Apportionment

Linear discriminant function analysis (Fisher 1936) of scale pattern data and observed differences in age composition between escapements were used to allocate 1984 Yukon River chinook salmon catches to run of origin.

Scale Pattern Analysis:

Escapement samples and Yukon Territory commercial catch samples provided scales of known origin that were used to build linear discriminant functions (LDF). Commercial catch and test fishing[1] samples provided scales of mixed stock composition which were classified using the discriminant functions to estimate proportions of lower, middle, and upper Yukon ages 6_2 and 5_2 fish in the District 1, 2, 3, and 4 catches. Subsistence catch samples were included in mixed stock composition samples for District 4.

Model Construction. Measurements of scale features were made as described by McBride and Marshall (1983). Scale images were projected at 100X magni-

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[1] ADF&G conducts test fishing projects in the Yukon River delta to index the timing and magnitude of the salmon migration entering the Yukon River. Test fishing is conducted concurrently with the commercial fishery and samples collected from these projects also represent fish of mixed stock composition in District 1.

fication using equipment similar to that described by Ryan and Christie (1976) and measurements were made and recorded by a microcomputer-controlled digitizing system. Measurements were taken along an axis approximately perpendicular to the sculptured field and the distance between each circulus in each of three scale growth zones (Figure 4) was recorded. The three zones were: (1) scale focus to the outside edge of the freshwater annulus (first freshwater annular zone), (2) outside edge of the frewhwater 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 (ages 6_2 and 5_2), and (2) the last circulus of the second ocean annulus to the last circulus of the third ocean annulus (age 6_2 only). Seventy-nine scale characters (Appendix Table 1) were calculated from the basic incremental distances and circuli counts.

Scale samples (standards) representing the three Yukon chinook salmon runs were constructed for the 6_2 and 5_2 age classes. Because of limited sample sizes, all available age 6_2 samples representing the lower Yukon (the Andreafsky and Anvik Rivers) were used. Age 6_2 and age 5_2 scales representing the middle Yukon run (the Chena and Salcha Rivers), and age 5_2 scales representing the lower run were selected in proportion to their abundance as indicated by aerial surveys or sonar counts.

Scales representing the upper Yukon run included all available Yukon Territory commercial catch samples. These samples were considered to be the most representative composite available for upper Yukon escapements. Because of small samples sizes, samples from individual escapements were also included in proportion to their abundance as indexed by aerial surveys.

Classification. Linear discriminant functions (LDF) were calculated for each age class. Selection of scale characters for each analysis was by a forward stepping procedure using partial F statistics as the criteria for entry/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 ages 6_2 and 5_2 fish in the District 1 and 2 catches were estimated for each fishing period during the chinook salmon season and a pooled sample for the chum salmon *(O. keta)* season[1]. A total season contribution

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[1] Most of the chinook salmon harvested in these two districts are taken by a directed fishery that commences in early June when mostly gillnets of 203 to 229 mm (8 to 9 in) stretched mesh are operated. This June fishery is commonly referred to as the "early" or "chinook" season. During this fishery, there are no gillnet mesh size restrictions and most fishermen operate large mesh nets for chinook salmon. However, some nets of 140 to 152 mm (5-1/2 - 6 in) stretched mesh are also operated. The remaining harvest is taken incidentally to the chum and coho *(O. kisutch)* salmon fishery. This fishery, in which gillnets of up to 152 mm (6 in) stretched mesh are allowed, commences in late June or early July.

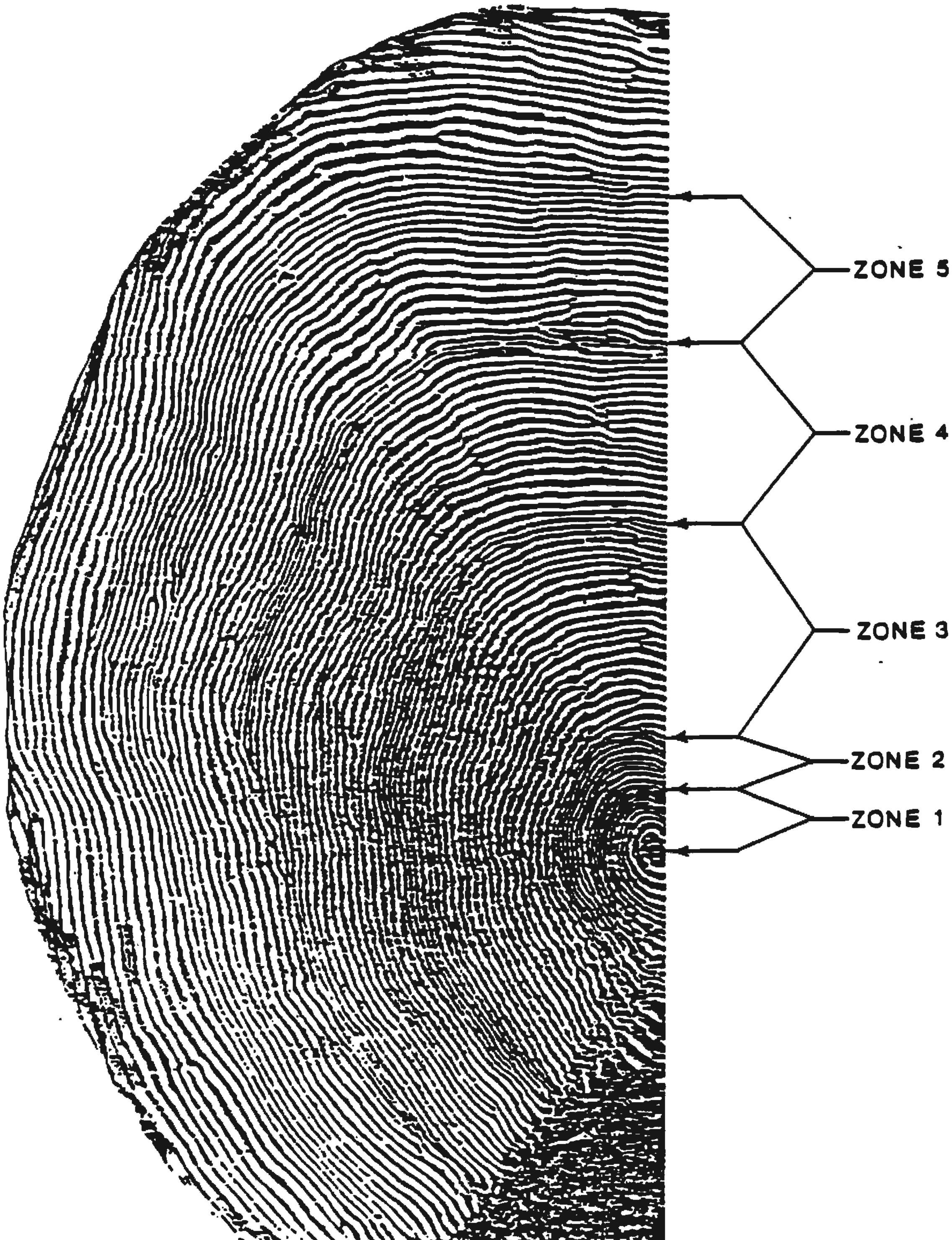

Figure 4. Age 6_2 chinook salmon scale showing the zones measured for the linear discriminant analysis.

rate for the District 3 catch was estimated from a sample collected during the first fishing period. Contribution rates for the combined commercial and subsistence harvests in District 4 were estimated from samples collected from both fisheries (including both gillnet and fishwheel gear types) during most of the season. Point estimates were adjusted for miscellaneous errors using the procedure of Cook and Lord (1978). The variance and 90% confidence intervals for these estimates were computed using the procedures of Pella and Robertson (1979).

A catch sample was reclassified with a model representing only two runs if the final proportional estimate was less than or equal to zero for any run. A two-way model was constructed using only standards from the two runs with positive classification estimates. Data were resubmitted to the variable selection routines and a new subset of variables was chosen for inclusion in the two-way model.

Results of the age-specific scale pattern analysis were summed to estimate total contribution by run of origin for ages 6_2 and 5_2 chinook salmon from the District 1, 2, and 3 commercial and District 4 combined commercial and subsistence catches. For each district, the variance (V) around N_{ijt} (the catch of age class i and run j during period t) was computed for each period t as follows:

$$V[N_{ijt}] = N_t^2(S_{ijt}^2 \cdot V[P_{it}] + P_{it}^2 \cdot V[S_{ijt}] - V[P_{it}] \cdot V[S_{ijt}]\}$$

where:

$$V[P_{it}] = \frac{P_{it}(1-P_{it})}{n_{t-1}}$$

P is the proportion of age class i, and S is the proportion of run j of age class i harvested during period t. Variance around the district catch of ages 6_2 and 5_2 by run, N_j, was computed by summing variances across age classes and periods:

$$V[N_j] = \sum_t^T \sum_i^2 V(N_{ijt}] + 2 \sum_t^T \sum_{i>k}^2 \sum^2 N_t^2 \cdot Cov[P_{it}P_{kt}] \cdot S_{ijt} \cdot S_{kjt}$$

where:

$$Cov[P_{it}P_{kt}] = \frac{-P_{it}P_{kt}}{n_t-2}$$

T is the total number of fishing periods sampled in each district and n_t is the sample size for the estimate of age composition in period t. Variance around the estimate of total harvest of ages 6_2 and 5_2 fish by run from Districts 1, 2, 3, and 4 estimated from scale pattern analysis was calculated as the sum of the seasonal variances for combined ages across all districts. Total harvest estimates and associated variances by country of origin were calculated by assuming the sum of the lower and middle Yukon to be equal to the Alaskan contribution and the upper Yukon equal to the Canadian contribution. Variance around the estimate of Alaskan contribution, $N_{i(L+M)t}$, was computed by summing variances across runs:

S_{iLt} = estimated proportion of lower Yukon run present for age i at period t

S_{iMt} = estimated proportion of middle Yukon run present for age i at period t

$$V[N_{i(L+M)t}] = N_t^2(S_{iLt}+S_{iMt})^2 \cdot V[P_{it}] = P_{it}^2 \cdot V[S_{iLt}+S_{iMt}] - V[P_{it}] \cdot V[S_{iLt}+S_{iMt}]\}$$

where:

$$V[S_{iLt}+S_{iMt}] = V[S_{iLt}] + V[S_{iMt}] - 2Cov[S_{iLt}S_{iMt}]$$

Differential Age Composition Analysis:

Allocation of the remaining age classes in the District 1, 2, and 3 commercial catches and District 4 combined commercial and subsistence catches was based on differences in escapement age composition in each of the three runs. Escapement age composition data were directly compared by computing ratios for each run whereby the proportion in the escapement of the age class in question was divided by the proportion in the escapement of an age class of known catch composition estimated by scale pattern analysis (either age 6_2 or 5_2):

E_{ci} = Proportion of fish of age class i in run c escapement samples where i is an age class of unknown run composition in the catch

E_{ca} = Proportion of fish of age class a in run c where a is an age class of known run composition in the catch (either age 6_2 or 5_2)

$R_{ci} = E_{ci}/E_{ca}$

Because the relative contribution of age 4_2 fish decreased in escapement samples moving progressively upriver, this age class was compared to age 5_2 fish. All other age classes (6_3, 7_2, 7_3, and 8_3) were compared to age 6_2 fish since the relative contributions of each of these age classes increased in escapement samples moving progressively upriver. These ratios of proportional abundance were then multiplied by the allocated catch of either age 5_2 or 6_2 fish. These computations were summed over all runs to calculate age-specific contribution rates. Multiplication by total catch by age class yields age-specific run contribution estimates:

N_i = Total catch of age group i

N_{ca} = Catch of age group a (where a is either age 6_2 or 5_2) in run c

F_{ci} = Proportion of fish of run c in N_i

$$F_{ci} = \frac{R_{ci} \cdot N_{ca}}{\sum_{j=1}^{3} R_{ji} \cdot N_{ja}}$$ (where j is run number; either 1, 2, or 3 for lower, middle, or upper run)

The total harvest of run c for age group is is then:

$$N_{ci} = F_{ci} \cdot N_i$$

Catch Allocation by Fishery:

Estimates of run composition from scale pattern analysis and differential age composition analysis of District 1, 2, and 3 commercial catches were used to allocate the catches of subsistence fisheries in these districts (Figure 4). District 4 catches were divided into two components for purposes of catch allocation: mainstem catches and Koyukuk River subsistence catches. Mainstem catches were allocated to the lower, middle, or upper run based on estimates of run composition from scale pattern analysis and differential age composition analysis of pooled samples from commercial and subsistence gillnet and fishwheel catches. Subsistence catches from the Koyukuk River were taken primarily in the upper portions of the drainage beyond river mile 700 and were assumed to more closely resemble fish of middle Yukon origin. No attempt was made to apportion the Koyukuk River catches by age class.

Catches in Districts 5, 6, and the Yukon Territory were allocated to run based on geography. The entire District 5 harvest was allocated to the upper Yukon run as most of the District 5 catch occurred above the confluence of the Tanana River and there are few documented spawning concentrations between the Tanana River confluence and the Yukon Territory fishery centered in Dawson. The entire District 6 harvest was allocated to the middle Yukon run although no attempt was made to apportion catches by age class.

RESULTS AND DISCUSSION

Age Composition

Trends in age composition for the lower, middle, and upper Yukon River escapements (Table 1) were consistent with previous years' results (McBride and Marshall 1983, Wilcock and McBride 1983, Wilcock 1984). The proportion of

Table 1. Age composition summary of chinook salmon escapements, Yukon River, 1984.

Location	Sample Size	Escapement Estimate[1]	Age Group 3_2	4_2	5_2	6_2	6_3	7_2	7_3	8_2	8_3
Lower											
Andreafsky R.	420[2]	4,466[3]	0.2	12.6	49.8	35.7	0.0	1.7	0.0	0.0	0.0
Anvik R.	276[4]	641[5]	0.0	12.0	50.0	35.9	0.0	2.2	0.0	0.0	0.0
Total	696	5,107	0.2	12.5	49.8	35.7	0.0	1.8	0.0	0.0	0.0
Middle											
Chena R.	499	501[5]	0.0	11.6	47.7	30.5	0.4	9.4	0.4	0.0	0.0
Salcha R.	515	1,031[5]	0.0	8.9	38.6	40.8	0.0	11.1	0.4	0.2	0.0
Total	1,014	1,532	0.0	9.8	41.6	37.4	0.1	10.5	0.4	0.1	0.0
Upper											
Big Salmon R.	154	1,044	0.0	0.0	21.4	57.8	0.6	17.5	2.6	0.0	0.0
Little Salmon R.	105	434	0.0	6.7	37.1	35.2	1.9	19.0	0.0	0.0	0.0
Nisutlin R.	216	1,178	0.0	0.0	16.6	57.9	0.9	6.5	17.6	0.0	0.5
Tatchun Cr.	23	161[6]	0.0	0.0	17.4	65.2	0.0	17.4	0.0	0.0	0.0
Total	498	2,817	0.0	1.0	21.6	54.8	0.9	13.1	8.3	0.0	0.2

[1] Aerial surveys, except as noted.
[2] Carcass samples: East Fork = 237, West Fork = 118. Beach seine samples = 65.
[3] Sonar estimate for East Fork = 2,473. Aerial survey for West Fork = 1,993.
[4] Carcass samples = 275. Beach seine samples = 1.
[5] Incomplete or poor survey conditions resulting in a very minimal count.
[6] Foot survey, Department of Fisheries and Oceans, Canada.

older fish increased in spawning populations moving progressively upriver. Age 6_2 fish increased in relative abundance from the lower, and middle, to the upper Yukon (35.7%, and 37.4%, to 54.8%, respectively). Conversely, the proportion of younger fish (ages 4_2 and 5_2 combined) declined in escapements moving upriver (62.3% lower, 51.4% middle, and 22.6% upper river fish). Nearly all 2-freshwater age fish were observed in the upper Yukon escapement (conbined ages 6_3, 7_3, and 8_3 total of 9.4%).

Catch Apportionment

Yukon River fisheries that consisted of mixed stocks of lower, middle, or upper run fish were allocated to run of origin based on scale pattern analysis and differential age composition analysis.

Scale Pattern Analysis:

Scale characters from the zone of freshwater plus growth were the most powerful in distinguishing the three runs. Secondarily selected variables were generally derived from measurements of the initial portion of the first marine annular zone and the initial portion of the first freshwater annual zone. The number of circuli and the width of the freshwater plus growth zone increased markedly from the lower to upper Yukon runs (Appendix Table 2). Conversely, number of circuli and width of the first freshwater and first marine annual zones generally decreased from the lower to upper runs.

Mean classification accuracies of the three-way models for age 6_2 and 5_2 fish (Tables 2 and 3) were similar (66.2% and 71.2%, respectively). Lower Yukon fish had the highest classification accuracies in both models (75.1% and 84.3%, respectively). Misclassification rates between middle and upper Yukon fish were the highest (range of 10.0% to 29.8%).

Contribution rates for the three runs were variable (Tables 4 and 5). Contrary to results from previous studies, in which middle and upper Yukon fish predominated age 6_2 catches, lower and middle Yukon fish were generally predominant in both age 6_2 and 5_2 catches during 1984. Differences over time by run were evident for age 6_2 and age 5_2 fish from the lower and middle Yukon (Figures 5 and 6). The contribution of lower Yukon fish generally increased from the first chinook salmon season period to the pooled chum salmon season periods in both Districts 1 and 2, while point estimates for middle Yukon fish tended to decline. Upper Yukon contributions by fishing period were variable (range of 0% to 44.4%), and did not exhibit clear trends through time.

The age 6_2 catch in District 1 (Table 6) was comprised of nearly equal numbers of fish of lower and middle Yukon origin (17,712 fish or 40.7%, and 17,755 fish or 40.8%, respectively). Catches of upper Yukon fish were smaller (8,091 fish or 18.6%). The age 6_2 catch in District 2 was predominated by fish of middle Yukon origin (9,866 fish or 50.1%).

Age 5_2 catches were comprised primarily of lower Yukon fish. The District 1 harvest of age 5_2 fish was comprised of 61.2% (10,956 fish) lower Yukon, 31.7% (5,680 fish) middle Yukon, and 7.0% (1,254 fish) upper Yukon fish. Lower Yukon fish also dominated the catch of age 5_2 fish in District 2 (6,489 fish or 55.0%). Middle Yukon fish comprised 31.1% (3,667 fish) of the catch while 13.9% (1,643 fish) were allocated to the upper Yukon run.

Table 2. Classification accuracies of the linear discriminant models for age 6_2 Yukon River chinook salmon, 1984.

Actual Region of Origin	Sample Size	Classified Region of Origin: Lower	Middle	Upper
Lower	185	0.751	0.157	0.092
Middle	200	0.140	0.660	0.200
Upper	191	0.126	0.298	0.576
			Mean Classification Accuracy =	0.662

Variables in the analysis: 67, 96, 5, 71, 61, 62, 2.

Actual Region of Origin	Sample Size	Classified Region of Origin: Middle	Upper
Middle	200	0.745	0.255
Upper	191	0.298	0.702
		Mean Classification Accuracy =	0.723

Variables in the analysis: 89, 62, 61, 2, 67.

Table 3. Classification accuracies of the linear discriminant models for age 5_2 Yukon River chinook salmon, 1984.

Actual Region of Origin	Sample Size	Classified Region of Origin: Lower	Middle	Upper
Lower	198	0.843	0.141	0.015
Middle	198	0.182	0.611	0.207
Upper	110	0.100	0.218	0.682
			Mean Classification Accuracy =	0.712

Variables in the analysis: 67, 88, 98, 8.

Actual Region of Origin	Sample Size	Classified Region of Origin: Lower	Middle
Lower	197	0.832	0.168
Middle	192	0.182	0.818
		Mean Classification Accuracy =	0.825

Variables in the analysis: 67, 96, 9.

Actual Region of Origin	Sample Size	Classified Region of Origin: Lower	Upper
Lower	199	0.955	0.045
Upper	110	0.118	0.882
		Mean Classification Accuracy =	0.918

Variables in the analysis: 67, 89.

Table 4. Run composition estimates for age 6_2 chinook salmon from the commercial catches in Yukon River Districts 1, 2, 3, and 4, 1984.

District	Commercial Fishing Period	Dates	Sample Size	Region of Origin	Proportion of Catch	90 Percent Confidence Interval Lower Bound	Upper Bound
1	Preseason[1]	6/08-6/18	155	Lower	0.355	0.208	0.502
				Middle	0.491	0.262	0.721
				Upper	0.153	-0.048	0.355
	1	6/18-6/19	122	Lower	0.180	0.034	0.327
				Middle	0.515	0.248	0.782
				Upper	0.305	0.057	0.553
	2	6/21-6/22	149	Lower	0.366	0.215	0.517
				Middle	0.543	0.308	0.778
				Upper	0.091	-0.110	0.291
	3	6/25-6/26	133	Lower	0.395	0.238	0.551
				Middle	0.244	0.009	0.479
				Upper	0.361	0.133	0.589
	4	6/28-6/29	141	Lower	0.572	0.409	0.737
				Middle	0.380	0.155	0.604
				Upper	0.048	-0.136	0.232
	5-14[2]	7/02-8/17	150	Lower	0.605	0.446	0.763
				Middle	0.204	-0.005	0.413
				Upper	0.191	0.001	0.382
2	1	6/20-6/21	144	Lower	0.397	0.242	0.553
				Middle	0.541	0.303	0.777
				Upper	0.062	-0.136	0.261
	2	6/24-6/25	79	Lower	0.169	-0.010	0.347
				Middle	0.641	0.318	0.965
				Upper	0.190	-0.101	0.481
	3	6/27-6/28	137	Lower	0.291	0.142	0.439
				Middle	0.439	0.196	0.683
				Upper	0.270	0.045	0.495
	4[2]	7/01-7/02	50	Lower	0.723	0.467	0.980
				Middle	0.122	-0.196	0.440
				Upper	0.155	-0.138	0.447
3	1	6/28-6/29	100	Lower	0.219	0.055	0.383
				Middle	0.505	0.219	0.791
				Upper	0.276	0.012	0.540
4[3]	8-17	7/09-8/10	80[4]	Lower	0.272	0.086	0.458
				Middle	0.284	-0.023	0.591
				Upper	0.444	0.143	0.745

[1] Prior to commercial season. All samples obtained from test fish catches.

[2] Chum season.

[3] Combined commercial and subsistence catches.

[4] Galena commercial and subsistence: fishwheel samples = 3, gillnet samples = 77.

Table 5. Run composition estimates for age 5_2 chinook salmon from the commercial catches in Yukon River Districts 1, 2, 3, and 4, 1984.

District	Commercial Fishing Period	Dates	Sample Size	Region of Origin	Proportion of Catch	90 Percent Confidence Interval Lower Bound	90 Percent Confidence Interval Upper Bound
1	Preseason[1]	6/08-6/18	92	Lower	0.335	0.155	0.516
				Middle	0.645	0.361	0.929
				Upper	0.020	-0.169	0.209
	1	6/18-6/19	44	Lower	0.221	0.031	0.410
				Middle	0.779	0.590	0.969
	2	6/21-6/22	43	Lower	0.365	0.110	0.619
				Middle	0.581	0.192	0.971
				Upper	0.054	-0.207	0.315
	3	6/25-6/26	54	Lower	0.691	0.470	0.913
				Middle	0.193	-0.107	0.493
				Upper	0.116	-0.078	0.311
	4	6/28-6/29	39	Lower	0.870	0.753	0.987
				Upper	0.130	0.013	0.247
	5-14[2]	7/02-8/17	152	Lower	0.814	0.675	0.995
				Middle	0.140	-0.049	0.330
				Upper	0.046	-0.054	0.145
2	1	6/20-6/21	54	Lower	0.407	0.178	0.635
				Middle	0.514	0.169	0.859
				Upper	0.079	-0.153	0.312
	2	6/24-6/25	36	Lower	0.231	-0.018	0.481
				Middle	0.410	-0.013	0.832
				Upper	0.359	0.011	0.708
	3	6/27-6/28	57	Lower	0.552	0.328	0.778
				Middle	0.402	0.080	0.723
				Upper	0.046	-0.152	0.244
	4[2]	7/01-7/02	126	Lower	0.892	0.779	1.006
				Middle	0.108	-0.006	0.221
3	1	6/28-6/29	50	Lower	0.348	0.163	0.533
				Middle	0.652	0.467	0.837
4[3]	8-17	7/09-8/10	53[4]	Lower	0.316	0.094	0.539
				Middle	0.515	0.162	0.868
				Upper	0.169	-0.092	0.429

[1] Prior to commercial season. All samples obtained from test fish catches.

[2] Chum season.

[3] Pooled commercial and subsistence.

[4] Galena commercial and subsistence: fishwheel samples = 7, gillnet samples = 31. Stink Creek test fish fishwheel samples = 15.

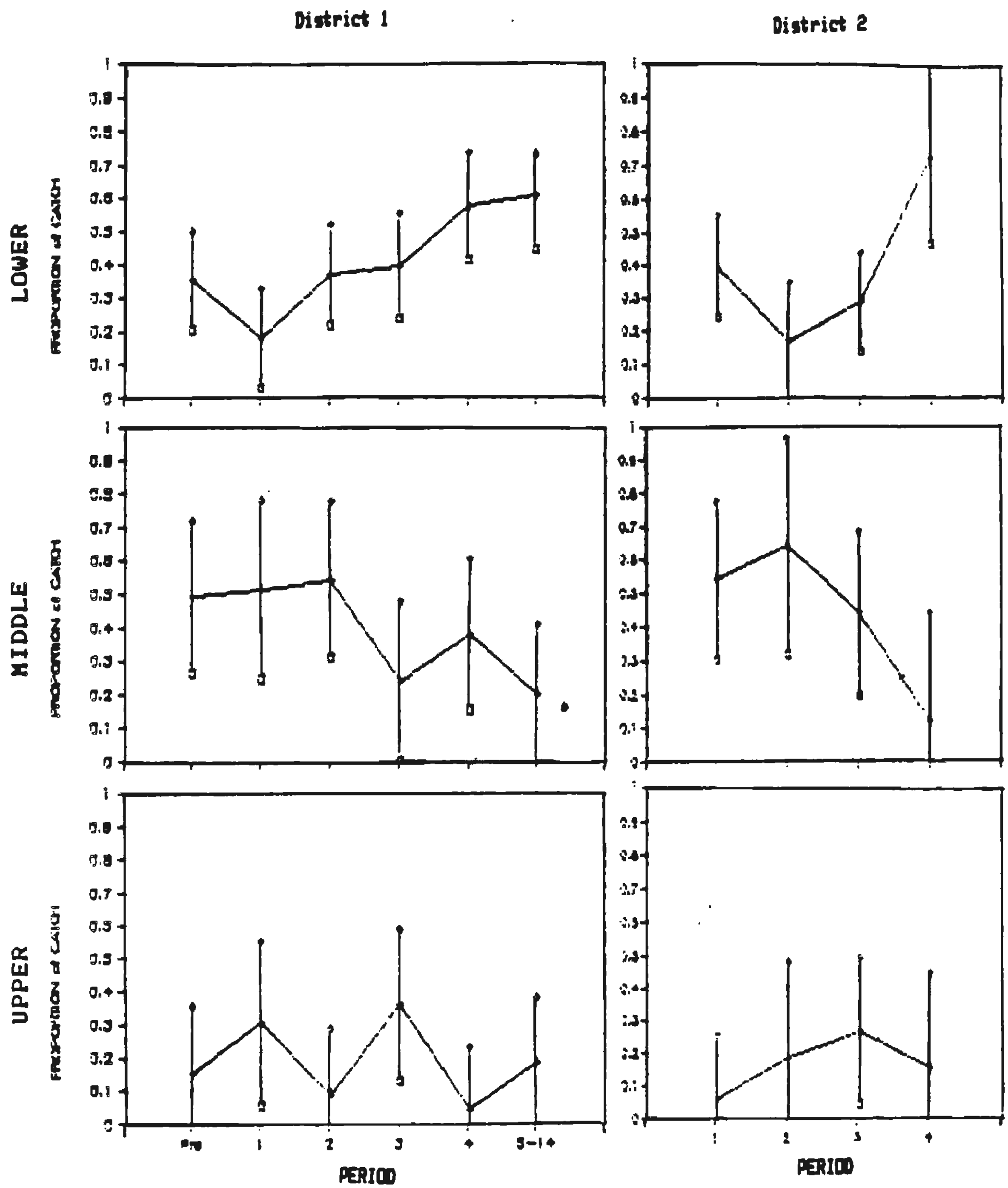

Figure 5. Run composition estimates and 90% confidence intervals from the scale pattern analysis of age 6_2 chinook salmon, Districts 1 and 2, Yukon River, 1984.

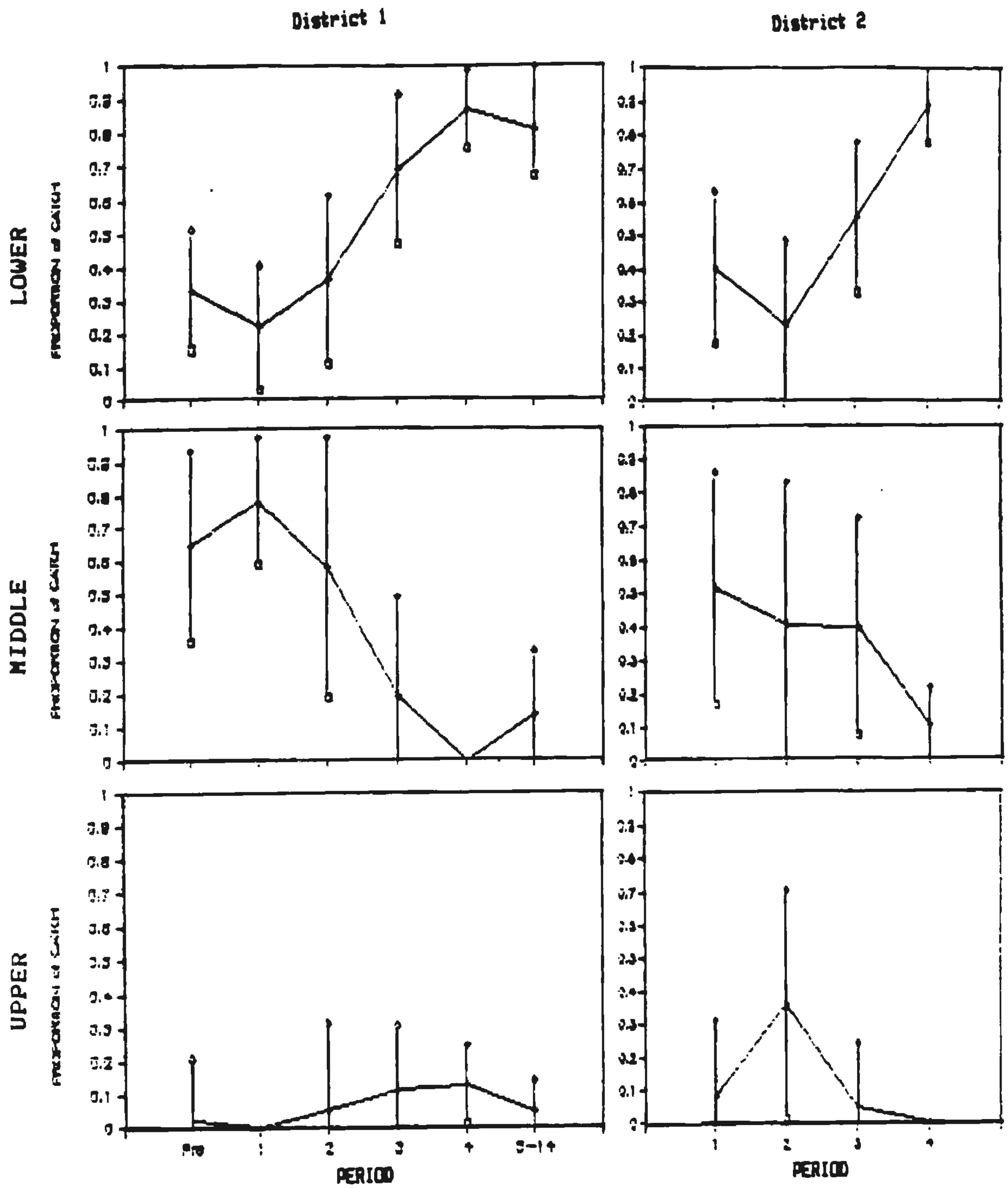

Figure 6. Run composition estimates and 90% confidence intervals from the scale pattern analysis of age 5_2 chinook salmon, Districts 1 and 2, Yukon River, 1984.

Table 6. Allocation of ages 5_2 and 6_2 chinook salmon by run and fishing period for the commercial fishery in Yukon River Districts 1 and 2, 1984.

Commercial Fishing Period	Region of Origin	District 1 Dates	District 1 Age Group 5_2	District 1 Age Group 6_2	District 2 Dates	District 2 Age Group 5_2	District 2 Age Group 6_2	Total Catch
1	Lower	6/18-6/19	665	1,407	6/20-6/21	543	1,330	3,945
	Middle		2,342	4,027		686	1,811	8,866
	Alaska Total		3,007	5,434		1,229	3,141	12,811
	Upper		0	2,384		105	208	2,697
	Total		3,007	7,818		1,334	3,349	15,508
2	Lower	6/21-6/22	1,210	4,569	6/24-6/25	925	1,392	8,096
	Middle		1,926	6,778		1,642	5,279	15,625
	Alaska Total		3,136	11,347		2,567	6,671	23,721
	Upper		179	1,136		1,438	1,565	4,318
	Total		3,315	12,483		4,005	8,236	28,039
3	Lower	6/25-6/26	2,843	3,745	6/27-6/28	1,205	1,683	9,476
	Middle		794	2,314		877	2,538	6,523
	Alaska Total		3,637	6,059		2,082	4,221	15,999
	Upper		477	3,423		100	1,561	5,561
	Total		4,114	9,482		2,182	5,782	21,560
4	Lower	6/28-6/29	2,644	5,933	7/01-8/19[1]	3,816	1,407	13,800
	Middle		0	3,942		462	238	4,642
	Alaska Total		2,644	9,875		4,278	1,645	18,442
	Upper		395	498		0	302	1,195
	Total		3,039	10,373		4,278	1,947	19,637
5-14	Lower	7/02-8/17[2]	3,594	2,058				5,652
	Middle		618	694				1,312
	Alaska Total		4,212	2,752				6,964
	Upper		203	650				853
	Total		4,415	3,402				7,817
Season Total	Lower	6/18-8/17	10,956	17,712	6/20-8/19	6,489	5,812	40,969
	Middle		5,680	17,755		3,667	9,866	36,968
	Alaska Total		16,636	35,467		10,156	15,678	77,937
	Upper		1,254	8,091		1,643	3,636	14,624
	Total		17,890	43,558		11,799	19,314	92,561

[1] Periods 4-15. Allocation based on period 4 sample only.

[2] Chum season.

Scale pattern analysis was applied to the age 6_2 and 5_2 commercial catches from Districts 1, 2, and 3, and commercial and subsistence catches from District 4 to allocate 57.5% (101,373 fish) of the total drainage harvest to run of origin. Of these fish, a total of 84,052 (82.9%) was estimated to be of Alaskan origin (Table 7). Precision of this estimate was high (coefficient of variation 3.3%). Harvest of fish of Canadian origin was estimated at 17,321 fish (17.1%).

Differential Age Composition Analysis:

Large variations were observed in the contribution rates of the remaining age classes (Table 8). The majority of the age 4_2 harvests in Districts 1 and 2 were allocated to the lower Yukon run (1,249 fish or 58.9%, and 517 fish or 50.0%, respectively). Most age 7_2 fish from District 1 and 2 catches were allocated to the middle Yukon run (5,228 fish or 63.8%, and 2,627 fish or 70.4%, respectively). Upper Yukon fish comprised virtually all of the age 6_3, 7_3, and 8_3 catches.

Commercial catches were composed of similar numbers of lower and middle Yukon fish in both District 1 (30,854 fish or 41.3%, and 29,676 fish or 39.7%, respectively) and District 2 (13,097 fish or 35.7% and 16,569 fish or 45.1%, respectively). Upper Yukon fish were least abundant in both District 1 and 2 (14,140 fish or 18.9%, and 7,032 fish or 19.2%, respectively).

Total Harvest:

Based on the findings of the scale pattern analysis of ages 6_2 and 5_2 fish, the differential age composition allocation of the remaining age classes, and the assumptions concerning unsampled fisheries, the commercial and subsistence fishery catches of chinook salmon from the entire Yukon River drainage were allocated to run of origin (Table 8). The total drainage harvest was composed of nearly equal numbers of middle and upper Yukon River fish (73,781 fish or 35.7%, and 63,037 fish or 35.3%, respectively). Lower Yukon fish were only slightly less abundant (51,970 fish or 29.1%). Total harvest numbers include catches documented in Canada.

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Table 7. Total commercial harvests of ages 6_2 and 5_2 chinook salmon by nation of origin estimated from scale pattern analysis for Yukon River Districts 1, 2, 3, and 4, 1984.

Region of Origin	Number of Fish	90 Percent Confidence Interval Lower Bound	90 Percent Confidence Interval Upper Bound	Coefficient of Variation[1]
Alaska	84,052	76,726	91,398	3.3%
Canada	17,321	10,239	24,411	15.5%
Total	101,373			

[1] Coefficient expressed as a percentage.

Table 8. Allocation by age class and region of origin of chinook salmon from Districts 1, 2, 3, 4, 5, 6, and Yukon Territory commercial and subsistence catches, Yukon River, 1984.

District	Fishery	Dates	Region of Origin	Number of Fish by Age Class								Total
				4_2	5_2	5_3	6_2	6_3	7_2	7_3	8_3	
1	Commercial Gillnet	6/18-8/17	Lower	1,249	10,956	0	17,712	0	937	0	0	30,854
			Middle	608	5,680	0	17,755	67	5,228	338	0	29,676
			Alaska Total	1,857	16,636	0	35,467	67	6,165	338	0	60,530
			Upper	264	1,254	67	8,091	188	2,029	2,181	66	14,140
			Total	2,121	17,890	67	43,558	255	8,194	2,519	66	74,670
	Subsistence Gillnet[1]		Lower	77	679	0	1,097	0	58	0	0	1,910
			Middle	38	352	0	1,099	4	323	21	0	1,837
			Alaska Total	115	1,030	0	2,196	4	381	21	0	3,748
			Upper	16	78	4	501	12	126	135	4	875
			Total	131	1,108	4	2,697	16	507	156	4	4,624
2	Commercial Gillnet	6/20-8/19	Lower	517	6,490	0	5,812	0	278	0	0	13,097
			Middle	275	3,667	0	9,866	23	2,627	111	0	16,569
			Alaska Total	792	10,157	0	15,678	23	2,905	111	0	29,666
			Upper	242	1,643	0	3,636	53	825	579	54	7,032
			Total	1,034	11,800	0	19,314	76	3,730	690	54	36,698
	Subsistence Gillnet[2]		Lower	101	1,268	0	1,136	0	54	0	0	2,560
			Middle	54	717	0	1,928	5	513	22	0	3,238
			Alaska Total	155	1,985	0	3,064	5	568	22	0	5,798
			Upper	47	321	0	711	10	161	113	11	1,375
			Total	202	2,306	0	3,775	15	729	135	11	7,172
3	Commercial Gillnet	6/28-8/14	Lower	13	262	0	403	0	16	0	0	694
			Middle	24	492	0	930	0	208	8	0	1,662
			Alaska Total	37	754	0	1,333	0	224	8	0	2,356
			Upper	0	0	0	508	0	97	66	12	683
			Total	37	754	0	1,841	0	321	74	12	3,039
	Subsistence Gillnet[3]		Lower	19	375	0	577	0	23	0	0	994
			Middle	34	705	0	1,333	0	298	11	0	2,381
			Alaska Total	53	1,080	0	1,910	0	321	11	0	3,376
			Upper	0	0	0	728	0	139	95	18	979
			Total	53	1,080	0	2,638	0	460	106	18	4,355
4	[4]	6/24-8/10	Lower	39	656	0	1,126	0	40	0	0	1,861
			Middle	60	1,070	0	1,176	0	233	12	0	3,951[5]
			Alaska Total	99	1,726	0	2,302	0	273	12	0	5,812
			Upper	38	351	0	1,837	0	311	262	0	2,799
			Total	137	2,077	0	4,139	0	584	274	0	8,611
5	[4]	6/29-8/07	Upper	1,185	5,528	0	9,872	197	1,777	99	0	18,658
6	[4,6]	7/06-8/08	Middle	-	-	-	-	-	-	-	-	4,466
Yukon Territory	Commercial Gillnet	7/08-9/09	Upper	963	2,439	32	4,943	96	1,348	64	0	9,885
	Subsistenc[7] Gillnet		Upper	644	1,631	21	3,305	64	901	43	0	6,610
TOTAL HARVEST			Lower	2,015	20,686	0	27,863	0	1,406	0	0	51,970
			Middle	1,093	12,682	0	34,087	99	9,431	523	0	63,781[8]
			Alaska Total	3,107	33,368	0	61,950	99	10,837	523	0	115,751
			Upper	3,400	13,245	124	34,132	620	7,714	3,637	165	63,037
			Total	6,507	46,613	124	96,082	719	18,551	4,160	165	178,788

1 Allocation based on season total District 1 commercial catch samples.
2 Allocation based on season total District 2 commercial catch samples.
3 Allocation based on District 3 commercial catch samples.
4 Combined fishwheel and gillnet.
5 Includes Koyukuk River subsistence catches not apportioned by age class.
6 Not apportioned by age class due to insufficient samples.
7 Age apportionment based on Yukon Territory commercial catch samples.
8 Includes Districts 4 and 6 catches allocated to middle Yukon run but not apportioned by age class.

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APPENDICES

Appendix Table 1. Scale variables screened for linear discriminant function analysis of ages 6_2 and 5_2 Yukon River chinook salmon.

Variable	1st Freshwater Annular Zone
1	Number of circuli (NC1FW)
2	Width of zone (S1FW)
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)
62	Width of zone (SPGZ)

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 Table 1. Scale variables screened for linear discriminant function analysis of ages 6_2 and 5_2 Yukon River chinook salmon (continued).

Variable	1st Marine Annular Zone
70	Number of circuli (NC1OZ)
71	Width of zone (S1OZ)
72 (90)	Distance, end of freshwater growth (EFW) to C3
73	Distance, EFW-C6
74 (92)	Distance, EFW-C9
75	Distance, EFW-C12
76 (94)	Distance, EFW-C15
77	Distance, C3-C6
78 (96)	Distance, C3-C9
79	Distance, C3-C12
80 (98)	Distance, C3-C15
81	Distance, C6-C9
82 (100)	Distance, C6-C12
83	Distance, C6-C15
84 (102)	Distance, C(NC1OZ -6) to end of zone
85	Distance, C(NC1OZ -3) to end of zone
86 (104)	Distance, C3 to end of zone
87	Distance, C9 to end of zone
88	Distance, C15 to end of zone
90-104	Relative widths, (variables 73-86)/S1OZ
105	Average interval between circuli, S1OZ/NC1OZ
106	Number of circuli in first 1/2 of zone
107	Maximum distance between 2 consecutive circuli
108	Relative width, (variable 107)/S1OZ

Variable	All Marine Zones
109	Width of 2nd marine zone, (S2OZ)
110	Width of 2nd 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)

Appendix Table 2. 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 6_2 and 5_2 chinook salmon, Yukon River, 1984.

			Lower		Middle		Upper		
Age	Growth Zone	Variable	Mean	Std. Err.	Mean	Std. Err.	Mean	Std. Err.	F-Value
6_2	1st FW Annular	No. Circ.	10.69	0.12	10.06	0.11	9.89	0.12	13.182
		Incr. Dist.	129.76	1.38	115.47	1.29	113.55	1.26	44.721
	FW Plus Growth	No. Circ.	3.37	0.11	5.59	0.10	5.82	0.14	129.763
		Incr. Dist.	32.91	1.19	55.48	1.10	62.52	1.67	130.239
	1st Ocean Annular	No. Circ.	25.48	0.20	25.33	0.18	22.98	0.22	47.416
		Incr. Dist.	448.18	3.93	449.12	3.41	408.63	3.83	38.648
	2nd Ocean Annular	Incr. Dist.	427.91	4.21	424.64	4.40	421.40	4.12	0.574
	3rd Ocean Annular	Incr. Dist.	413.62	4.82	412.39	5.11	397.74	4.16	3.479
5_2	1st FW Annular	No. Circ.	11.04	0.11	10.03	0.10	9.66	0.16	36.450
		Incr. Dist.	131.18	1.26	117.19	1.18	108.12	1.74	68.422
	FW Plus Growth	No. Circ.	3.20	0.09	4.85	0.08	5.73	0.18	138.595
		Incr. Dist.	29.49	0.88	49.17	0.96	58.12	2.14	143.198
	1st Ocean Annular	No. Circ.	28.55	0.18	27.03	0.17	24.03	0.30	106.602
		Incr. Dist.	512.79	3.57	488.24	4.00	422.19	5.97	95.472
	2nd Ocean Annular	Incr. Dist.	381.47	5.14	390.66	5.07	365.89	6.89	4.186