AYK Chinook Stock Separation
Report #13

ORIGINS OF CHINOOK SALMON (*Oncorhynchus tschawytscha* Walbaum) IN THE YUKON RIVER FISHERIES, 1986

by

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ABSTRACT

Analysis of scale patterns and age composition of chinook salmon (Oncorhynchus tschawytscha Walbaum) from Yukon River escapements in Alaska and fishwheel catches in Canada were used to construct run and river of origin classification models for age-1.4 and 1.3 fish. Samples from the Nulato, Jim and south fork Koyukuk Rivers, Alaska, were collected in 1986 and included in various models. Yukon River commercial and subsistence catches were apportioned to run of origin with the model which yielded the greatest classification accuracy and allocation precision.

Total Yukon River utilization was 165,317 chinook salmon and was estimated to be 67.9% upper Yukon, 26.6% lower Yukon and 5.5% middle Yukon run of origin. Similar to previous years, the fraction of the Districts 1 and 2 commercial catch apportioned to the lower Yukon run generally increased through time while the fraction apportioned to the upper Yukon generally declined. The middle Yukon run of origin contribution to total harvest was the lowest since entire drainage harvest has been apportioned beginning in 1982.

Effects of digitizer on stock allocation was investigated with multivariate statistics. A significant difference in mean size of scale variable zones was detected between digitizers but the difference in size among runs of origin was not significant ($p=0.32$). Overall, the two digitizers apportioned catch similarly. The small fraction of the 1986 Yukon River chinook salmon harvest apportioned to middle Yukon run can not be directly attributed to a change in digitizer.

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

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 gill net 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 Alaska and Canada (Figures 1 and 2).

A major controversy currently facing managers of Yukon River chinook salmon is apportionment of the harvest among the various user groups. Two such apportionment issues which have recently received considerable public 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.

Identification of stock groupings and estimation of their contribution rates is becoming an increasingly important facet of Yukon River chinook salmon management. Contribution estimates of Western Alaskan/Canadian Yukon chinook salmon, recently estimated for the Japanese high seas gill net fisheries (Rogers

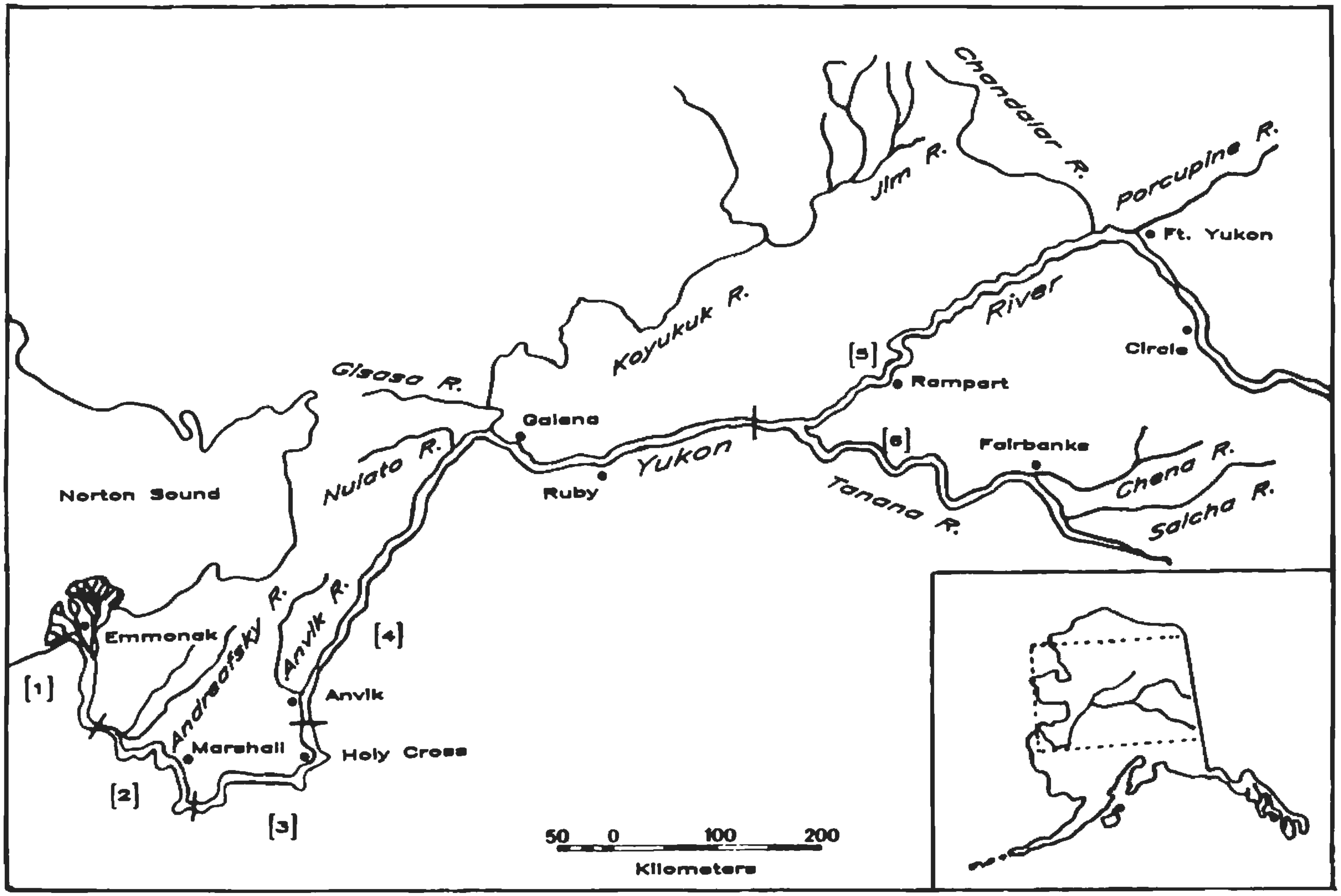

Figure 1. Alaskan portion of the Yukon River showing the six regulatory districts.

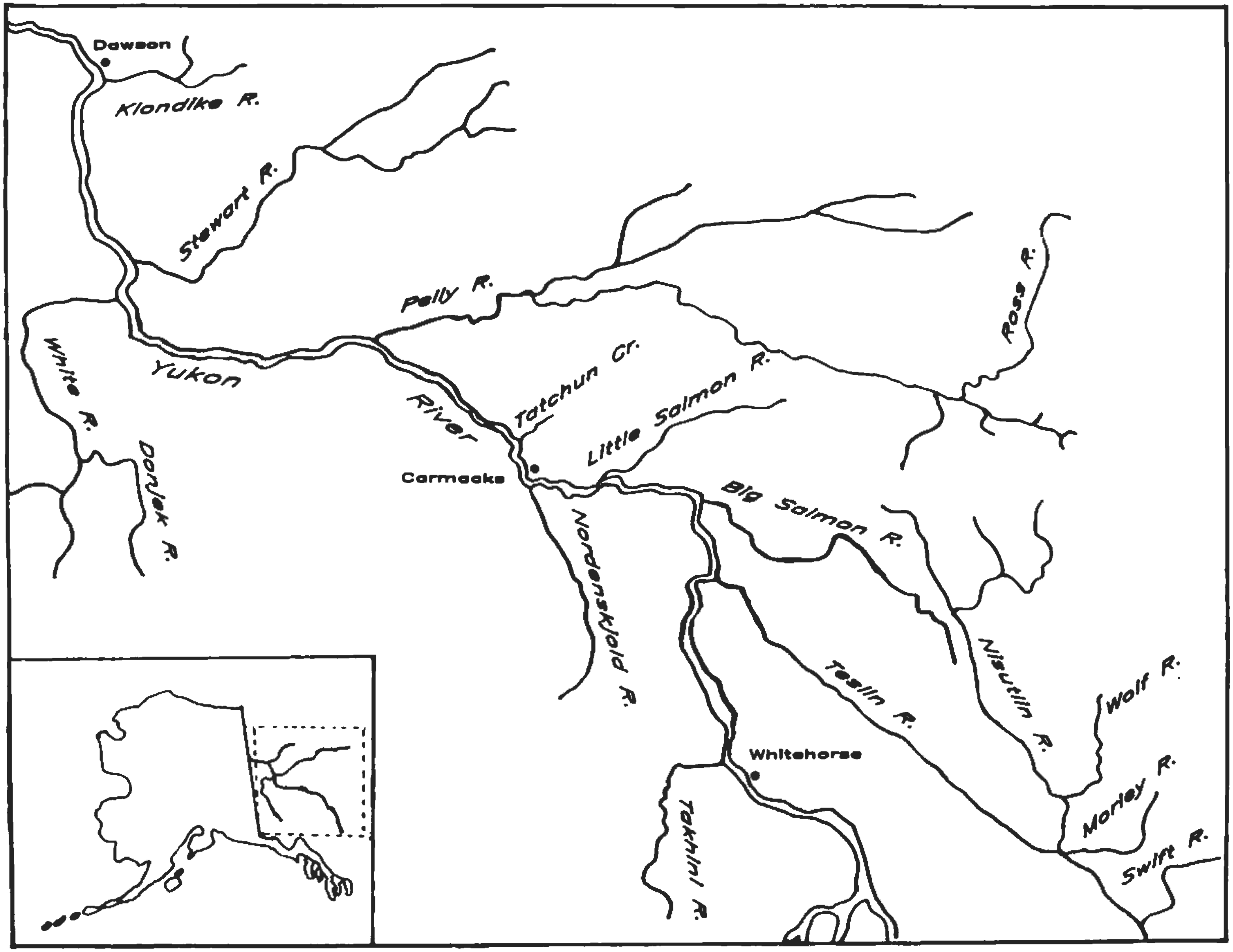

Figure 2. Canadian portion of the Yukon River.

et al. 1984, Meyers et al. 1984, Meyers and Rogers 1985), have become major elements in the regulation of these ocean fisheries. Concurrent with offshore studies, stock composition of inriver fisheries has been studied to provide useful information for resource administrators making inriver apportionment decisions and managers seeking 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 became available in 1980 and 1981 when the feasibility of apportioning catches using scale patterns analysis for District 1 catches was initially investigated (McBride and Marshall 1983). Since then, the entire drainage harvest has been apportioned annually to geographic region of origin (Wilcock and McBride 1983, Wilcock 1984, Wilcock 1985, Wilcock 1986).

The Yukon River combined commercial and subsistence chinook salmon fishery is one of the largest in Alaska, averaging 17% of statewide chinook salmon harvest annually (1980-1984). In the first 20 years after statehood (1960-1979), combined Alaskan and Canadian Yukon River chinook salmon harvest averaged 122,971 fish annually. However, catches during the recent five years (1982-1986) have increased substantially to a yearly average of 183,481 fish. While chinook salmon are harvested virtually throughout the entire length of the Yukon River, the majority of the catch is taken in commercial gill net fisheries in Districts 1 and 2 (1982-1986 average 65% of total drainage harvest).

Subsistence harvests, including Canadian catches, account for another 25% (1982-1986 average) of the total harvest. Most of the subsistence harvest is taken with fish wheels and gill nets in Districts 4, 5, and 6. In 1986, commercial and subsistence fishermen in Alaska and Canada harvested a total of 165,316 chinook salmon, of which 94,884 fish (57%) 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 are termed runs (McBride and Marshall 1983) and have previously been defined as lower, middle, and upper Yukon runs, respectively.

The U.S./Canada Joint Technical Committee (JTC) on Yukon River salmon recommended in April 1987 that chinook salmon be apportioned to river of origin, where possible, and that these stock apportionments could then be summed to yield run of origin apportion estimates (Yukon River JTC, 1987). It was suggested that this approach may yield greater precision and similiar accuracy as the method used previously in this study. In past years, scales from different tributaries were pooled, weighted by aerial survey indices of abundance, to form run of origin standards. Both because of this recommendation by the JTC, and because escapement samples were collected from the Jim and and South Fork Koyukuk Rivers in Alaska in 1986 for the first time, and the Nulato River, which had not been sampled since 1981, this new apportionment method was tested. Several different apportionment models were constructed for the 1986 data base, and that method which yielded the best classification accuracy and apportionment precision was selected for the final estimates of catch by river or run of origin.

This report builds upon the catch, escapement, and age composition database compiled by Buklis (In Press) for the 1986 return of salmon to the Yukon River. The objective is to apportion the 1986 Yukon River chinook salmon commercial and subsistence harvest to river of origin or run of origin, whichever provides the greatest precision. Commercial catches from Districts 1, 2, and 3 were apportioned to river or run of origin by analysis of scale patterns of age-1.4 and 1.3 fish, and catch and escapement age composition data. Estimates of the contribution by river or run of origin in commercial catches were then applied to subsistence catches from these districts. Commercial and subsistence catches from Districts 5 and 6, and the Yukon Territory were apportioned based on geography. Pooled commercial and subsistence catches from

District 4 were apportioned based on geography, scale pattern analysis of age-1.4 and 1.3 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 from commercial catches in Districts 1, 2, 4, 5, 6, and the Yukon Territory, Canada, and from subsistence catches in Districts 4, 5, and 6. District 3 was not sampled because few fish are harvested in that portion of the Yukon River and access is difficult. A small fraction of the District 2 catch can at times include District 3 catches delivered in District 2. Although subsistence catches were not sampled in Districts 1 and 2, subsistence fishing occurred concurrently with commercial effort and the age compositions for subsistence catches were assumed to be similiar to the commercial catch. Samples were also collected from a test gill net fishery in District 1 and from a test fish wheel used to capture fish in a tagging project in the Yukon Territory. Sampling of Alaskan fisheries was conducted by the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries, while Canadian fishery and test fish wheel samples were collected by the Canadian Department of Fisheries and Oceans (DFO).

Escapement:

Scale samples were collected during peak spawner die off from the Andreafsky, Anvik, Nulato, Jim, Chena, and Salcha Rivers in Alaska, and from the Big Salmon, Little Salmon, Nisutlin, Teslin, Tatchun, and mainstem Yukon Rivers in Canada. Virtually all samples were collected from carcasses. The age composition of lower, middle, and upper Yukon areas 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.

<u>Catch Apportionment</u>

Linear discriminant function analysis (Fisher 1936) of scale patterns data and observed differences in age composition between escapements (Wilcock 1986) were used to apportion 1986 Yukon River chinook salmon catches to river or run of origin.

Scale Patterns Analysis:

Escapement samples in Alaska and DFO test fish wheel samples provided scales of known origin that were used to build linear discriminant functions (LDF). The Canadian standard was based on DFO fish wheel samples in 1986 because the Canadian commercial fishery was terminated early due to marketing problems. It was felt that some spawning stocks might not be adequately represented in the commercial fishery sample for 1986. Canadian escapement samples could not be pooled to form a reasonable standard due to the lack of samples from several significant spawning populations.

Catch and test gill net samples provided scales of mixed stock composition which were classified using the discriminant functions. Proportions of river or run of origin fish aged 1.4 and 1.3 were estimated in District 1 and 2 catches by fishing period. It was assumed that District 3 catch apportionments were similiar to those in District 2. District 4, 5 and 6 catches were apportioned for the entire season.

<u>Model Construction</u>. 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) 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 3) 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 freshwater annulus to the last circulus of freshwater growth (freshwater plus growth zone), and (3) the last circulus of the freshwater plus growth zone to the outer edge of the first ocean annulus (first marine annular zone). In addition, the total width of successive scale patterns zones was also measured for: (1) the last circulus of the first ocean annulus to the last circulus of the second ocean annulus (ages 1.4 and 1.3), and (2) the last circulus of the second ocean annulus to the last circulus of the third ocean annulus (age-1.4 only). Seventy-nine scale characters (Apppendix Table 1) were calculated from the basic incremental distances and circuli counts. All available scale samples (standards) from six rivers in Alaska (Andreafsky, Anvik, Nulato, Jim and South Fork Koyukuk, Chena, Salcha) were used and 200 systematically-pooled samples from three DFO fish wheel sites comprised the primary river of origin model. Run of origin standards (pooled rivers) were weighted by aerial abundance estimates. River and run of origin models were constructed for the 1.4 and 1.3 age classes.

<u>Classification</u> 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

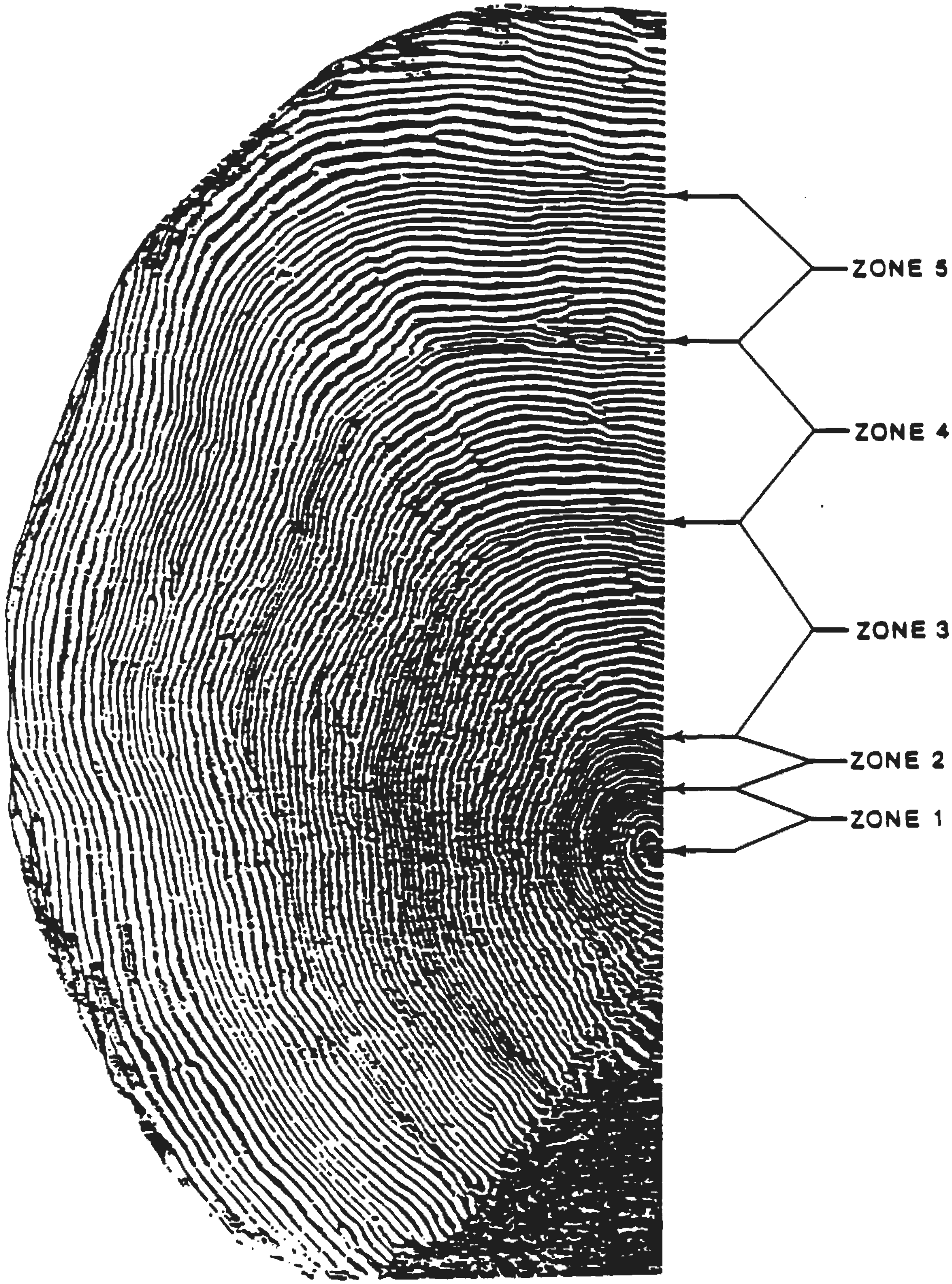

Figure 3. Age-1.4 chinook salmon scale showing zones measured for linear discriminant analysis.

leaving-one-out procedure (Lachenbruch 1967).

Contribution rates for age-1.4 and 1.3 fish in the District 1 and 2 catches were estimated for each fishing period. Contribution rates for the combined commercial and subsistence harvests in District 4 were estimated from samples collected from both fisheries (including both gill net and fish wheel gear types) during most of the season. Point estimates were adjusted for misclassification 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).

When classified catch samples indicated an adjusted proportional estimate equal to or less than zero, the river or run indicating the most negative contribution was deleted from the model. Data were then resubmitted to the variable selection routines and a new subset of variables chosen for the LDF. Catch was then reclassified. This process was continued until all adjusted proportional estimates in the catch were positive.

Results of the age-specific scale patterns analysis were summed to estimate total contribution by river or run of origin for age-1.4 and 1.3 chinook salmon to 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:

$$(1)\quad V[N_{ijt}] = N_t^2\{S_{ijt}^2 \cdot V[P_{it}] + P_{it}^2 \cdot V[S_{ijt}] - V[P_{it}] \cdot V[S_{ijt}]\}$$

where:

$$(2)\quad V[P_{it}] = \frac{P_{it}(1-P_{it})}{n_t - 1}$$

P was the proportion of age class i; S was the proportion of run j of age class i harvested during period t; and the variance, $V[S_{ijt}]$, was as derived by Pella and Robertson (1979). Variance around the district catch of ages 1.4 and 1.3 by run, N_j, was computed by summing variances across age classes and periods:

$$(3)\quad V[N_j] = \sum_{t}^{T} \sum_{i}^{2} V[N_{ijt}] + 2 \sum_{t}^{T} \sum_{i>k}^{2} \sum^{2} N_t^2 \cdot Cov[P_{it}P_{kt}] \cdot S_{ijt} \cdot S_{kjt}$$

where:

$$(4)\quad Cov[P_{it}P_{kt}] = -\frac{P_{it}P_{kt}}{n_t - 2}$$

T was the total number of fishing periods sampled in each district and n_t was the sample size for the estimate of age composition in period t. Variance around the estimate of total harvest of age-1.4 and 1.3 fish by river or run of origin from Districts 1, 2, 3, and 4 estimated from scale patterns 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 Alaskan rivers or the lower and middle Yukon runs to be equal to the Canadian 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

$$(5) \quad V[N_{i(L+M)t}] = N_t^2\{(S_{iLt}+S_{iMt})^2 \cdot V[P_{it}] + P_{it}^2 \cdot V[S_{iLt}+S_{iMt}] - V[P_{it}] \cdot V[S_{iLt}+S_{iMt}]\}$$

where:

$$(6) \quad V[S_{iLt}+S_{iMt}] = V[S_{iLt}] + V[S_{iMt}] - 2Cov[S_{iLt}S_{iMt}]$$

Differential Age Composition Analysis:

Apportionment 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 run of origin. Escapement age composition data, weighted by aerial survey estimates, was directly compared by computing ratios for each river or 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 patterns analysis (either age-1.4 or 1.3):

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

E_{ca} = Proportion of fish of age class a in river or run c where a was an age class of known river or run composition in the catch (either age-1.4 or 1.3)

$$(7) \quad R_{ci} = E_{ci}/E_{ca}$$

Because the relative contribution of age-1.2 fish in escapement samples collected in previous years has tended to decrease moving progressively upriver, this age class was compared to age-1.3 fish. All other age classes (2.3, 1.5, 2.4,and 2.5) were compared to age-1.4 fish since the relative contributions of each of these age classes have historically tended to increase in escapement samples moving progressively upriver. These ratios of proportional abundance were then multiplied by the apportioned catch of either age-1.4 or 1.3 fish. These computations were summed over all runs to calculate age-specific contribution rates. Multiplication by total catch by age class yielded age-specific run contribution estimates:

N_i = Total catch of age group i

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

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

(8) $$F_{ci} = \frac{R_{ci} \cdot N_{ca}}{\sum_{j=1}^{n} R_{ji} \cdot N_{ja}}$$ (where j was run number and n was 7 for river and 3 for run)

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

(9) $$N_{ci} = F_{ci} \cdot N_i$$

Catch Apportionment 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 apportion the catches of subsistence fisheries in these districts. District 4 catches were divided into two components for purposes of catch apportionment: mainstem catches and Koyukuk River subsistence catches. Mainstem catches were apportioned to the lower, middle, or upper run based on estimates of run composition from scale patterns analysis and differential age composition analysis of pooled samples from commercial and subsistence gill net and fish wheel 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.

Catch Apportionment Based on Geography:

Catches in Districts 5, 6, and the Yukon Territory were apportioned to run based on geography. The entire District 5 harvest was apportioned to the upper Yukon run as most of the District 5 catch occured above the confluence of the Tanana River, and there are few documented chinook salmon spawning concentrations between the Tanana River confluence and the Yukon Territory fishery centered in Dawson. The entire District 6 harvest was apportioned to the middle Yukon run, since neither lower nor upper runs are present in the Tanana River. The Yukon Territory harvest was apportioned to the upper run since neither lower nor middle runs are present in the Yukon Territory.

RESULTS AND DISCUSSION

Age Composition

Age-1.3 and 1.5 fish comprised a greater proportion of samples from all Alaskan rivers and in most Canadian rivers than found in previous years for each of these rivers (Table 1). The weaker age-1.4 contribution to escapements as compared with samples from earlier years indicates relatively poor productivity and/or survival from the 1980 brood year. Increasing proportions of older-age fish in escapements progressing upriver were similiar to trends observed in prior years. Age-1.5 fish generally increased in relative abundance from 5.8% and 10.6% in the Andreafsky and Anvik Rivers, respectively, to an average of 20.0% for Canadian rivers combined. Conversely, the proportion of age-1.3 fish declined from 69.8% and 50.0% in the Andreafsky and Anvik Rivers, respectively, to an average of 13.9% for Canadian rivers combined.

The greatest proportion of 2-freshwater age fish was found in

Table 1. Age composition summary of Yukon River chinook salmon escapements, 1986.

			Brood Year and Age Group								
	Aerial	Sample	1983	1982	1981		1980		1979		1978
River	Survey Est.	Size	1.1	1.2	1.3	2.2	1.4	2.3	1.5	2.4	2.5
Andreafsky	5,112	275[1]	0.0	2.2	69.8	0.0	21.5	0.4	5.8	0.4	0.0
Anvik	1,118	142[2]	0.0	0.7	50.0	0.0	38.0	0.0	10.6	0.7	0.0
Nulato	2,974	189	0.0	1.6	50.3	0.5	31.2	0.0	15.3	1.1	0.0
Jim	238	166	0.0	3.0	48.2	1.2	25.3	4.8	12.0	3.0	2.4
Chena	2,288[3]	729	0.1	9.3	51.2	0.0	28.5	1.4	9.2	0.1	0.1
Salcha	3,368	586	0.2	11.8	43.7	0.0	28.5	1.0	14.8	0.0	0.0
Big Salmon	745[4]	233	0.0	1.7	21.9	0.9	41.2	5.6	19.7	6.0	3.0
Little Salmon	54[5]	58	0.0	0.0	20.7	0.0	39.7	10.3	20.7	5.2	3.4
Nisutlin	703	177	0.0	0.0	2.8	0.0	40.7	2.8	11.9	31.1	10.7
Tatchun	155[6]	2	0.0	50.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0
Teslin	-	34	0.0	5.9	8.8	0.0	41.2	0.0	38.2	2.9	2.9
Mainstem Yukon	-	30	0.0	0.0	10.0	0.0	30.0	0.0	46.7	0.0	13.3

1 Includes 17 East Fork beach seine samples, 81 East Fork carcass samples, and 177 West Fork carcass samples.
2 Includes 3 beach seine samples.
3 Includes carcasses removed by tag recovery crew before date of aerial survey.
4 ADF&G aerial survey above Souch Cr.
5 Incomplete or poor survey conditions resulting in a minimal count.
6 Foot survey, DFO, Canada.

the Nisutlin River sample, comprising 33.9%. In past years, 2-freshwater age fish were primarily found in upper river samples. However, samples from the Jim River in 1986 showed a relatively high proportion of age-2.2, 2.3 and 2.4 fish (9.0% combined) compared to other samples collected in interior Alaska.

<u>Classification Accuracies of Run and River of Origin Models</u>

Age-1.4:

A 3-way run of origin model using the same pooled-river standards as in previous years (lower: Andreafsky and Anvik Rivers; middle: Chena and Salcha Rivers; upper: Canada mainstem commercial fishery) gave a mean classification accuracy of 69.6% (Table 2A), 2.1 times greater than random chance. Model classification accuracy of age-1.4 fish in 1986 was slightly less than in 1985 (71.1%). The only difference in the model presented in Table 2A from models used in previous years was the use of DFO fish wheel samples as the standard and not Canadian commercial fishery samples. Similiar to past years, the lower river standard showed the greatest classification accuracy (86.4%). Middle and upper river standards showed the least classification accuracy (62.6% and 59.8%, respectively), misclassifying primarily to each other. 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.

Table 2. Classification accuracies of linear discriminant run of origin models for age-1.4 Yukon River chinook salmon, 1986.

A. Three-way with pooled standards equivalent to historical data (1) lower: Andreafsky, Anvik (2) middle: Chena, Salcha (3) upper: DFO fish wheel[1]

Run of Origin	Sample Size	Classified Region of Origin Lower	Middle	Upper
Lower	44	0.864	0.023	0.114
Middle	187	0.102	0.626	0.273
Upper	199	0.181	0.221	0.598

Mean Classification Accuracy: 0.696

1 Variables in the Analysis: 67, 62, 102, 26, 85, 61

B. Three-way[1]
(1) lower: Andreafsky, Anvik, Nulato (2) middle: Chena, Salcha (3) upper: DFO fish wheel

Run of Origin	Sample Size	Classified Region of Origin Lower	Middle	Upper
Lower	65	0.785	0.077	0.138
Middle	184	0.082	0.658	0.261
Upper	200	0.192	0.250	0.560

Mean Classification Accuracy: 0.667

1 Variables in the Analysis: 67, 100, 26, 61, 70, 89, 8, 2

C. Two-way[1]
(1) lower: Andreafsky, Anvik, Nulato (2) upper: DFO fish wheel

Run of Origin	Sample Size	Classified Region of Origin Lower	Upper
Lower	61	0.787	0.213
Upper	185	0.205	0.795

Mean Classification Accuracy: 0.791

1 Variables in the Analysis: 101, 62, 70

D. Four-way[1]
(1) lower: Andreafsky, Anvik, Nulato (2) Koyukuk: Jim, South Fork (3) middle: Chena, Salcha (4) upper: DFO fish wheel

Run of Origin	Sample Size	Classified Region of Origin Lower	Koyukuk	Middle	Upper
Lower	61	0.574	0.262	0.049	0.115
Koyukuk	23	0.261	0.391	0.217	0.130
Middle	136	0.037	0.184	0.574	0.206
Upper	186	0.194	0.124	0.210	0.473

Mean Classification Accuracy: 0.503

1 Variables in the Analysis: 67, 26, 61, 100, 85

A second 3-way model was constructed which differed in that it included samples from the Nulato River in the lower river standard (Table 2B). The Nulato River was included into the lower river standard because univariate analysis of variance F-tests of scale feature measurements indicated no significant difference ($P<0.05$, $df=2,102$) in the majority (59.5%) of mean freshwater annular, freshwater plus growth and combined marine annular zone scale variables among the Nulato, Andreafsky and Anvik Rivers. These three rivers are located in the same lower Yukon geographic area. Mean classification accuracy of this model was 66.7%, 2.0 times greater than random chance. Again, the lower river standard had the greatest classification accuracy (78.5%) and the upper river standard had the least (56.0%). Misclassification trends were similiar to those of the model in Table 2A.

A 2-way model was constructed which differed from the above 3-way model in that the middle river standard was excluded (Table 2C). This model was necessary to the identification of runs of origin in age-1.4 samples from commercial fishing periods which did not include middle river stocks. Mean classification accuracy of this model was 79.1% , 1.6 times greater than random chance.

A 4-way model was constructed with the Nulato River included in the lower river standard and the Jim and South Fork Koyukuk River escapements) as a fourth standard (Table 2D). Middle and upper river standards were the same as in the preceeding 3-way models.

Jim and South Fork Koyukuk Rivers were chosen as a fourth standard because in analysis of variance tests using run of origin data for age-1.4 fish, scale variables in samples from the Jim and South Fork Koyukuk Rivers suggested distinction from other Alaskan escapement samples. Geographically, the confluence of the Koyukuk River with the Yukon River is located between the lower and middle river regions. However, chinook salmon spawning populations in the upper Koyukuk River drainage are about as far from the mouth of the Yukon River as is the Canadian border, and were the northern most samples collected in this study. Mean classification accuracy for this 4-way model was 50.3%, 2.0 times greater than random chance. The lower and middle river standards showed the greatest classification accuracy (57.4% each), while the Jim and South Fork Koyukuk Rivers showed the least (39.1%). Jim and South Fork Koyukuk River samples misclassified primarily to lower and middle river fish in this age-1.4 model.

Mean classification accuracy of a 7-way river of origin model (six Alaskan escapements and pooled DFO fish wheel sample) was 38.4%, or 2.7 times greater than random chance (Table 3). The Chena River showed the greatest classification accuracy (54.6%) while the Anvik River showed the least (19.2%). Andreafsky, Anvik and Nulato Rivers misclassify primarily among themselves as a group (75.7%, 57.6% and 82.5%, respectively) supporting pooling of these rivers into a lower river standard. Samples from the Jim and South Fork Koyukuk Rivers misclassified in equal proportions (30.4%) to escapements downriver and upriver from

Table 3. Classification accuracy of a seven-way linear discriminant river of origin model for age-1.4 Yukon River chinook salmon, 1986.[1]

River of Origin	Sample Size	Classified River of Origin						
		Andreafsky	Anvik	Nulato	Jim	Chena	Salcha	DFO f. w.
Andreafsky	33	0.424	0.030	0.303	0.152	0.000	0.030	0.061
Anvik	26	0.192	0.192	0.192	0.154	0.077	0.038	0.154
Nulato	40	0.225	0.150	0.450	0.075	0.075	0.000	0.025
Jim	23	0.174	0.087	0.043	0.391	0.000	0.174	0.130
Chena	97	0.010	0.062	0.052	0.062	0.546	0.186	0.082
Salcha	82	0.024	0.012	0.024	0.183	0.232	0.378	0.146
DFO f. w.	185	0.092	0.168	0.065	0.065	0.200	0.103	0.308

Mean Classification Accuracy: 0.384

1 Variables in the Analysis: 67, 8, 102, 61, 30, 85, 26, 70, 106

the confluence of the Koyukuk with the Yukon River. These results indicate that sampling of the Koyukuk River drainage should be expanded, and scale patterns more fully examined. Chena and Salcha Rivers misclassify primarily to each other as a group (73.2% and 61.0%, respectively) which supports pooling of these rivers into a middle river standard. Misclassification of age-1.4 DFO fish wheel samples to Alaskan rivers was 69.2%. The average age-1.4 Alaskan escapement sample misclassified 10.0% to Canada.

Age-1.3:

A 3-way run of origin model using the same pooled-river standards as in previous years gave a mean classification accuracy of 83.4% (Table 4A), which is 2.5 times greater than random chance. Model classification accuracy of age-1.3 fish in 1986 is the highest on record. Similiar to past years, the lower river standard showed the greatest classification accuracy (96.5%). Middle and upper river standards showed the least accuracy (75.8% and 77.9%, respectively), misclassifying primarily to each other.

A second 3-way model was constructed which differed in that it included samples from the Nulato River in the lower river standard (Table 4B). The Nulato River was included in the lower river standard because, similiar to age-1.4 fish, analysis of variance F-tests indicated no significant difference ($P<0.05$, $df=2,234$) in the majority (66.7%) of mean freshwater annular, freshwater plus growth, and combined marine annular zone scale

Table 4. Classification accuracies of linear discriminant run of origin models for age-1.3 Yukon River chinook salmon, 1986.

A. Three-way with pooled standards equivalent to historical data (1) lower: Andreafsky, Anvik (2) middle: Chena, Salcha (3) upper: DFO fish wheel[1]

Run of Origin	Sample Size	Classified Region of Origin		
		Lower	Middle	Upper
Lower	143	0.965	0.000	0.035
Middle	132	0.023	0.758	0.220
Upper	199	0.030	0.191	0.779

Mean Classification Accuracy: 0.834

1 Variables in the Analysis: 67, 1, 83, 61, 26, 103, 72, 21, 71, 18

B. Three-way[1]
(1) lower: Andreafsky, Anvik, Nulato (2) middle: Chena, Salcha (3) upper: DFO fish wheel

Run of Origin	Sample Size	Classified Region of Origin		
		Lower	Middle	Upper
Lower	211	0.953	0.014	0.033
Middle	132	0.053	0.705	0.242
Upper	199	0.025	0.211	0.764

Mean Classification Accuracy: 0.807

1 Variables in the Analysis: 67, 62, 27, 61, 83, 14, 106, 8, 1, 16

C. Two-way[1]
(1) lower: Andreafsky, Anvik, Nulato (2) DFO fish wheel

Run of Origin	Sample Size	Classified Region of Origin	
		Lower	Upper
Lower	211	0.962	0.038
Upper	199	0.030	0.970

Mean Classification Accuracy: 0.966

1 Variables in the Analysis: 67, 83, 61, 62, 2, 14

D. Four-way[1]
(1) lower: Andreafsky, Anvik, Nulato (2) Koyukuk: Jim, South Fork (3) middle: Chena, Salcha (4) upper: DFO fish wheel

Run of Origin	Sample Size	Classified Region of Origin			
		Lower	Koyukuk	Middle	Upper
Lower	211	0.943	0.033	0.009	0.014
Koyukuk	55	0.109	0.509	0.145	0.236
Middle	132	0.061	0.076	0.674	0.189
Upper	199	0.015	0.286	0.216	0.482

Mean Classification Accuracy: 0.652

1 Variables in the Analysis: 67, 62, 27, 61, 83, 72

variables among the Nulato, Andreafsky and Anvik Rivers. Mean classification accuracy was 80.7%, 2.4 times greater than random chance. Again, the lower river standard had the greatest classification accuracy (95.3%) and the middle river standard had the least (70.5%). Misclassification trends were similiar to those in the model in Table 4A.

A 2-way model was constructed which differed from the above 3-way model in that the middle river standard was excluded (Table 4C). This model was necessary to the identification of runs of origin in age 1.3 samples from commercial fishing periods which did not include middle river stocks. Mean classification accuracy of this model was 96.6%, 1.9 times greater than random chance.

A 4-way model was constructed which included the Nulato River in the lower river standard and the Jim and South Fork Koyukuk River escapements as a fourth standard (Table 4D). Middle and upper river standards were the same as in the preceeding 3-way models. In analysis of variance tests using run of origin scale variable data from age-1.3 fish, Jim and South Fork Koyukuk River scale variables were significantly different from lower river standards, although not as distinctive from middle river standards. Mean classification accuracy for this 4-way model was 65.2%, 2.6 times greater than random chance. Similiar to age-1.4 fish, the lower and middle river standards showed the greatest classification accuracy (94.3% and 67.4%, respectively). However, in contrast to the age 1.4 model, Canada showed the poorest classification accuracy (48.2%), and age-1.3 Jim and

South Fork Koyukuk River samples misclassified primarily to Canada.

Mean classification accuracy of a 7-way river of origin model was 43.5%, or 3.0 times greater than random chance (Table 5). The Salcha River showed the greatest classification accuracy (68.8%), while the Anvik River showed the least (19.6%). Andreafsky, Anvik, and Nulato Rivers classified primarily among themselves as a group (94.8%, 89.2% and 93.3%, respectively) supporting pooling of these rivers into a lower river standard. Samples from the Jim and South Fork Koyukuk Rivers misclassified primarily to Canada. Chena and Salcha Rivers classify primarily to each other as a group (67.8% and 84.4%, respectively) supporting pooling of these rivers into a middle river standard. The misclassification rate of age-1.3 DFO fish wheel samples to Alaskan rivers was 55.8%. The average age-1.3 Alaskan escapement sample misclassified 9.2% to Canada.

Catch Apportionment

Model Selection:

The greatest levels of precision in apportioning catches for both age-1.4 and 1.3 fish were obtained using 3-way run of origin models which included samples from the Nulato River in the lower river standards. These models were chosen to apportion the 1986 Yukon River chinook salmon harvest to geographic region of origin. Hereafter, any references to a run of origin model will

Table 5. Classification accuracy of a seven-way linear discriminant river of origin model for age-1.3 Yukon River chinook salmon, 1986.[1]

River of Origin	Sample Size	Classified River of Origin Andreafsky	Anvik	Nulato	Jim	Chena	Salcha	DFO f. w.
Andreafsky	117	<u>0.427</u>	0.256	0.265	0.026	0.017	0.000	0.009
Anvik	46	0.326	<u>0.196</u>	0.370	0.087	0.000	0.000	0.022
Nulato	74	0.311	0.176	<u>0.446</u>	0.041	0.027	0.000	0.000
Jim	55	0.036	0.073	0.000	<u>0.436</u>	0.109	0.073	0.273
Chena	118	0.000	0.000	0.042	0.102	<u>0.407</u>	0.271	0.178
Salcha	77	0.013	0.000	0.026	0.026	0.156	<u>0.688</u>	0.091
DFO f. w.	199	0.005	0.010	0.000	0.261	0.141	0.141	<u>0.442</u>

Mean Classification Accuracy: <u>0.435</u>

1 Variables in the Analysis: 67, 62, 1, 65, 80, 106

be the 3-way which included samples from the Nulato River.

Catch apportionment for age-1.4 and 1.3 fish using 7-way river fourth standard apportioned only small percentages of the total harvest to middle run stocks. Primary problems with the 4-way models were misclassification of Jim and South Fork Koyukuk River stocks with lower and upper run of origin stocks, and low precision of adjusted mean estimates.

Catch apportionment for age-1.4 and 1.3 fish using 7-way river of origin models produced wide 90% confidence intervals around adjusted mean estimates. Increased precision in discerning river of origin stocks is required before these models can supplant geographic region of origin models.

Scale Patterns Analysis:

Scale character measurements which were most powerful in distinguishing between the three runs of origin for age-1.4 fish were width of freshwater annular zone relative to size of total freshwater growth zone, distance between the sixth and twelfth circulus relative to the total width of the first marine annular zone, distance between the last two circuli of the freshwater annular zone relative to the width of the zone, and the number of circuli in the freshwater plus growth zone (variables 67, 100, 26, and 61, respectively, in Appendix Table 2). For age-1.3 fish, the most distinguishing scale measurements were width of freshwater annular zone relative to size of total freshwater growth zone, width of the freshwater plus growth zone, average distance between circuli in the freshwater zone, and number of circuli in freshwater plus growth (variables 67, 62, 27, and 61, respectively) Secondarily selected variables were derived from the first marine and first freshwater annular zones.

Group means and their standard errors for the number of circuli and width of the first freshwater, plus growth, and marine annular zones are shown in Appendix Table 3. The number of circuli and width of zones by year for lower, middle and upper runs of origin are shown in Appendix Figures 1-3. Digitized scales of age-1.4 and 1.3 middle run fish in 1986 demonstrated the least freshwater growth of the last five years (1982-1986). For age-1.3 fish, lower run stocks were characterized with the least plus growth and upper run stocks with the greatest first marine zone growth of the last five years.

Proportion of Catch:

Lower and upper runs of origin comprised the greatest proportion of the catch in Districts 1 and 2 for age-1.4 and 1.3 fish (Tables 6 and 7) in 1986. This contrasts with results for previous years, in which middle run of origin stocks contributed significantly to the commercial catch. Possibilities for the apparent low harvest of middle run fish were investigated, including bias in digitizing (Appendix A). Results from multivariate tests between different digitizers did not indicate

Table 6. Run composition estimates for age-1.4 chinook salmon from sampled commercial catches in Yukon River Districts 1, 2, and 4, 1986.

District	Commercial Fishing Period	Dates	Sample Size	Run of Origin	Prop. of Catch	90 Percent Confidence Interval Lower Bound	90 Percent Confidence Interval Upper Bound
1	Preseason	6/06-6/13	104	Lower	0.082	-0.069	0.233
				Upper	0.918	0.767	1.069
	1[1]	6/14-6/14	71	Lower	0.062	-0.111	0.236
				Upper	0.938	0.764	1.111
	2[2]	6/19-6/20	98	Lower	0.309	0.146	0.471
				Upper	0.691	0.529	0.854
	3[2]	6/23-6/24	120	Lower	0.244	0.065	0.423
				Middle	0.252	-0.035	0.539
				Upper	0.504	0.157	0.850
	4[1]	6/25-6/26	64	Lower	0.360	0.165	0.555
				Upper	0.640	0.445	0.835
	5[2]	6/29-6/30	132	Lower	0.416	0.268	0.565
				Upper	0.584	0.435	0.732
	6[1]	7/02-7/02	25	Lower	0.364	0.068	0.661
				Upper	0.636	0.339	0.932
	7[2]	7/03-7/04	105	Lower	0.711	0.539	0.884
				Upper	0.289	0.116	0.461
	8[1]	7/07-7/08	25	Lower	0.434	0.135	0.733
				Upper	0.566	0.267	0.865
2	1[1]	6/15-6/15	34	Lower	0.160	-0.084	0.404
				Upper	0.840	0.596	1.084
	2[1]	6/21-6/21	29	Upper	1.000	0.853	1.279
	3[2]	6/22-6/23	125	Lower	0.112	-0.031	0.255
				Upper	0.888	0.745	1.031
	5[2]	6/26-6/27	119	Lower	0.580	0.419	0.740
				Upper	0.420	0.260	0.581
	6[2]	7/01-7/02	125	Lower	0.799	0.630	0.967
				Upper	0.201	0.033	0.370
	8[2]	7/06-7/07	123	Lower	0.379	0.184	0.573
				Middle	0.084	-0.184	0.352
				Upper	0.537	0.196	0.878
4	1-16[3]	6/22-8/29	268	Lower	0.268	0.154	0.382
				Middle	0.208	0.049	0.367
				Upper	0.524	0.319	0.729

1 Six in (15.2 cm) maximum mesh size.
2 Unrestricted mesh size.
3 Fish taken by set gill net and fish wheel.

Table 7. Run composition estimates for age-1.3 chinook salmon from sampled commercial catches in Yukon River Districts 1, 2, and 4, 1986.

District	Commercial Fishing Period	Dates	Sample Size	Run of Origin	Prop. of Catch	90 Percent Confidence Interval Lower Bound	Upper Bound
1	Preseason	6/06-6/13	133	Lower	0.279	0.186	0.372
				Middle	0.050	-0.111	0.210
				Upper	0.671	0.493	0.849
	1[1]	6/14-6/14	106	Lower	0.288	0.183	0.392
				Middle	0.012	-0.158	0.183
				Upper	0.700	0.506	0.894
	2[2]	6/19-6/20	82	Lower	0.452	0.354	0.550
				Upper	0.548	0.450	0.646
	3[2]	6/23-6/24	84	Lower	0.249	0.162	0.335
				Upper	0.751	0.665	0.838
	4[1]	6/25-6/26	104	Lower	0.432	0.345	0.519
				Upper	0.568	0.481	0.655
	5[2]	6/29-6/30	82	Lower	0.648	0.553	0.744
				Upper	0.352	0.256	0.447
	6[1]	7/02-7/02	52	Lower	0.463	0.340	0.586
				Upper	0.537	0.414	0.660
	7[2]	7/03-7/04	55	Lower	0.592	0.474	0.711
				Upper	0.408	0.289	0.526
	8[1]	7/07-7/08	35	Lower	0.642	0.497	0.787
				Upper	0.358	0.213	0.503
2	1[1]	6/15-6/15	60	Lower	0.129	0.045	0.212
				Upper	0.871	0.788	0.955
	2[1]	6/21-6/21	84	Lower	0.121	0.051	0.191
				Upper	0.879	0.809	0.949
	3[2]	6/22-6/23	83	Lower	0.304	0.213	0.395
				Upper	0.696	0.605	0.787
	5[2]	6/26-6/27	103	Lower	0.453	0.338	0.569
				Middle	0.029	-0.122	0.180
				Upper	0.518	0.336	0.699
	6[2]	7/01-7/02	83	Lower	0.524	0.426	0.622
				Upper	0.476	0.378	0.574
	8[2]	7/06-7/07	44	Lower	0.358	0.229	0.487
				Upper	0.642	0.513	0.771
4	1-16[3]	6/22-8/29	268	Lower	0.428	0.353	0.503
				Middle	0.016	-0.079	0.111
				Upper	0.555	0.439	0.671

1 Six in (15.2 cm) maximum mesh size.
2 Unrestricted mesh size.
3 Fish taken by set gill net and fish wheel.

that bias in digitizing caused middle run fish to drop out of catch allocations. Lack of significant middle run contribution to the 1986 Yukon River chinook salmon harvest may be attributed to either a less than average return of middle run fish and/or the timing of the lower river fishery relative to the entry timing of middle run stocks. In either case, the escapement objectives were achieved for the Chena and Salcha Rivers.

Similiar to previous years, proportions of lower and upper run fish varied in Districts 1 and 2 catches through time (Figures 4-7). In District 1, the contribution of the lower run increased and the upper run decreased as the fishing season progressed. Run of origin contribution rates by fishing period demonstrated an irregular linear trend in District 1 and a sigmoidal trend in District 2 for both age-1.4 and 1.3 lower and upper run fish. Differences in run of origin contribution rates by fishing period are likely due to differential run timing of stocks comprising run of origin models, and differential harvest pressure on stocks.

The total District 1 age-1.4 catch was composed of 7,999 (35.1%) lower, 1,109 (4.9%) middle, and 13,696 (60.0%) upper Yukon run of origin fish (Table 8). In District 2, the age-1.4 catch was composed of 7,116 (40.2%) lower, 104 (0.6%) middle, and 10,466 (59.2%) upper Yukon run of origin fish, (Table 9).

The age-1.3 catch in District 1 was composed of 7,278 (44.1%) lower, 15 (0.1%) middle, and 9,202 (55.8%) upper run of origin

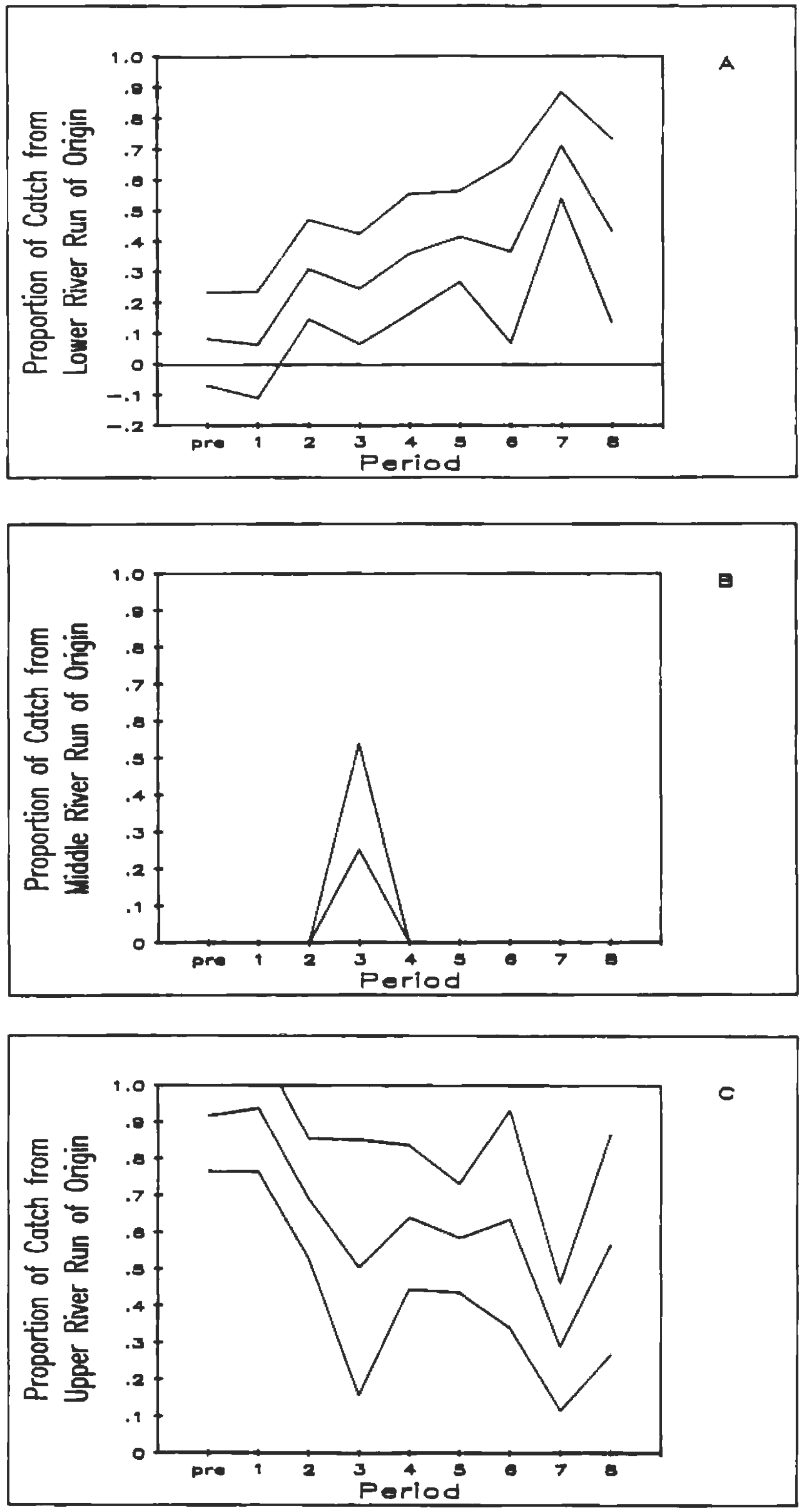

Figure 4. Run composition estimates and 90% confidence intervals from scale patterns analysis of age-1.4 chinook salmon, Yukon River District 1, 1986.

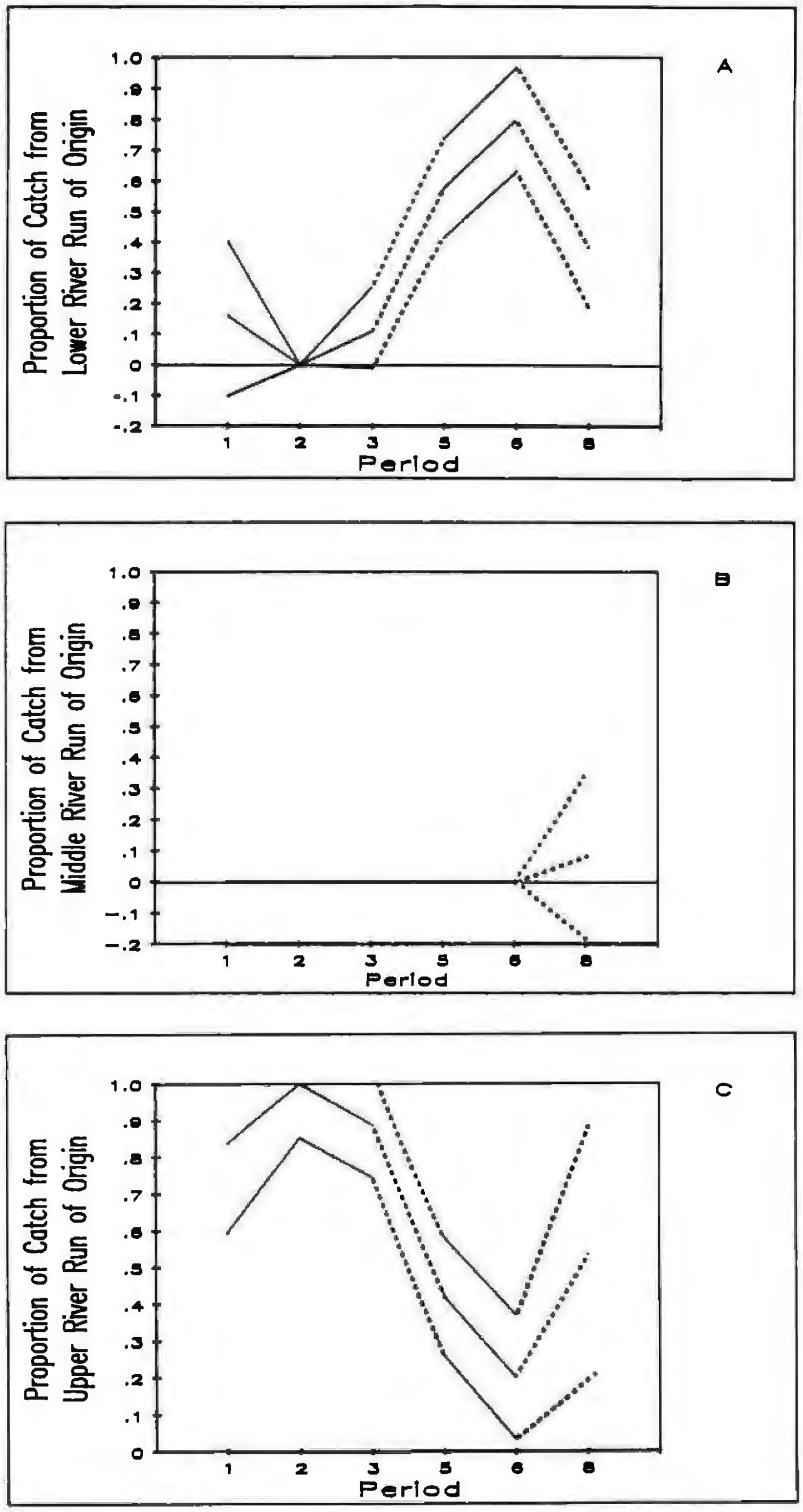

Figure 5. Run composition estimates and 90% confidence intervals from scale patterns analysis of age-1.4 chinook salmon, Yukon River District 2, 1986.

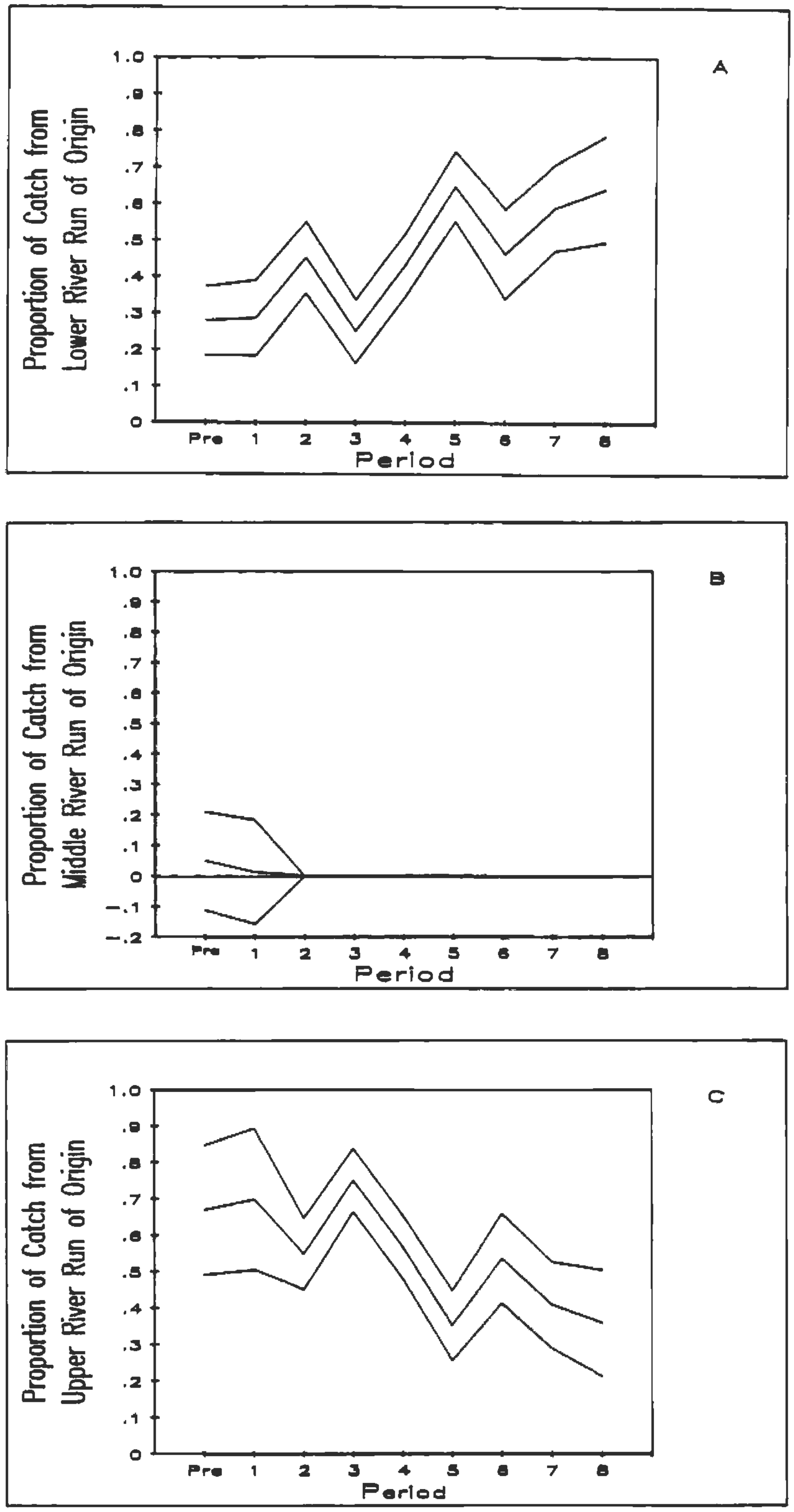

Figure 6. Run composition estimates and 90% confidence intervals from scale patterns analysis of age-1.3 chinook salmon, Yukon River District 1, 1986.

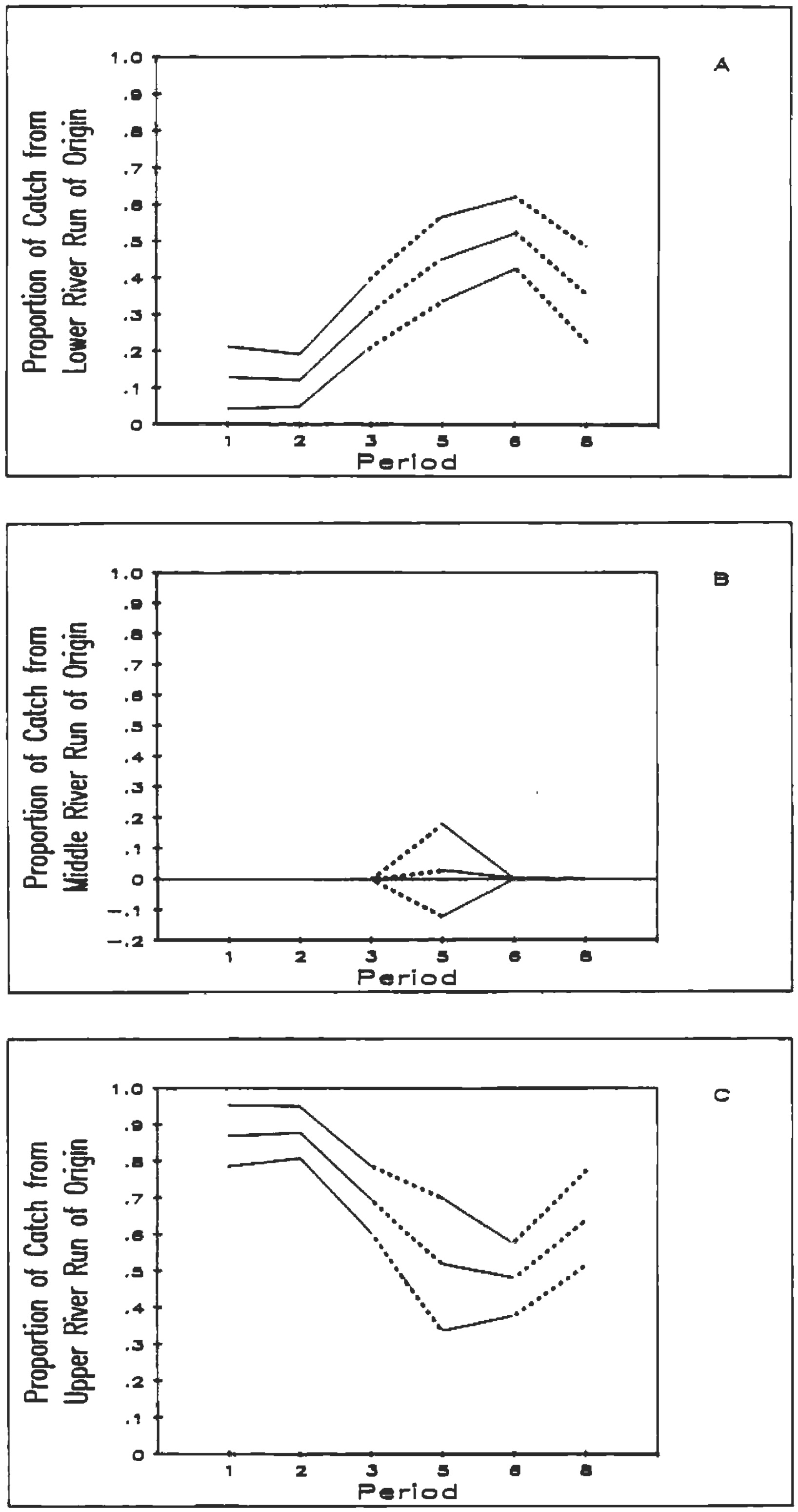

Figure 7. Run composition estimates and 90% confidence intervals from scale patterns analysis of age-1.3 chinook salmon, Yukon River District 2, 1986.

Table 8. Apportionment of age-1.4 and 1.3 chinook salmon catches by run and fishing period for the commercial fishery in Yukon River District 1, 1986.

Run of Origin	Commercial Fishing Period	Dates	Age Group 1.3	Age Group 1.4
Lower	1[1]	6/14-6/14	362	61
Middle			15	0
Alaska			377	61
Upper			880	922
Total			1,257	983
Lower	2	6/19-6/20	2,448	3,040
Middle			0	0
Alaska			2,448	3,040
Upper			2,969	6,798
Total			5,417	9,838
Lower	3	6/23-6/24	750	1,074
Middle			0	1,109
Alaska			750	2,183
Upper			2,264	2,219
Total			3,014	4,402
Lower	4[1]	6/25-6/26	909	483
Middle			0	0
Alaska			909	483
Upper			1,196	858
Total			2,105	1,341
Lower	5	6/29-6/30	1,039	1,103
Middle			0	0
Alaska			1,039	1,103
Upper			565	1,548
Total			1,604	2,651
Lower	6[1]	7/02-7/02	386	182
Middle			0	0
Alaska			386	182
Upper			448	319
Total			834	501
Lower	7	7/03-7/04	823	1,837
Middle			0	0
Alaska			823	1,837
Upper			567	747
Total			1,390	2,584
Lower	8-16[1]	7/07-8/22	561	219
Middle			0	0
Alaska			561	219
Upper			313	285
Total			874	504
TOTAL				
Lower	1-16	6/14-8/22	7,278	7,999
Middle			15	1,109
Alaska			7,293	9,108
Upper			9,202	13,696
Total[2]			16,495	22,804

1 Chum salmon season, 6 in (15.2 cm) maximum mesh size.

2 Restricted mesh periods 9-16 were not sampled, but catch composition was assumed to be the same as in period 8.

Table 9. Apportionment of age-1.4 and 1.3 chinook salmon catches by run and fishing period for the commercial fishery in Yukon River District 2, 1986.

Run of Origin	Commercial Fishing Period	Dates	Age Group 1.3	Age Group 1.4	Run of Origin	Commercial Fishing Period	Dates	Age Group 1.3	Age Group 1.4
Lower	1[1]	6/15-6/15	51	33	Lower	5	6/26-6/27	1,875	3,181
Middle			0	0	Middle			120	0
Alaska			51	33	Alaska			1,995	3,181
Upper			345	174	Upper			2,143	2,304
Total			396	207	Total			4,138	5,485
Lower	2[1]	6/21-6/21	108	0	Lower	6	7/01-7/02	1,056	2,538
Middle			0	0	Middle			0	0
Alaska			108	0	Alaska			1,056	2,538
Upper			783	465	Upper			960	638
Total			891	465	Total			2,016	3,176
Lower	3	6/22-6/24	1,291	716	Lower	7[1]	7/03-7/04	53	34
Middle			0	0	Middle			0	0
Alaska			1,291	716	Alaska			53	34
Upper			2,955	5,675	Upper			360	182
Total			4,246	6,391	Total			413	216
Lower	4[1]	6/24-6/24	68	44	Lower	8	7/07-7/15	149	469
Middle			0	0	Middle			0	104
Alaska			68	44	Alaska			149	573
Upper			460	231	Upper			266	665
Total			528	275	Total			415	1,238
					Lower	9-16[1]	7/09-8/24	259	101
					Middle			0	0
					Alaska			259	101
					Upper			145	132
					Total			404	233
TOTAL					Lower	1-16	6/15-8/24	4,910	7,116
					Middle			120	104
					Alaska			5,030	7,220
					Upper			8,417	10,466
					Total[2]			13,447	17,686

1 Chum salmon season, 6 in (15.2 cm) maximum mesh size.
2 Restricted mesh periods 4, 7, and 9-16 were not sampled. Catch composition of periods 4 and 7 was estimated from period 1. Catch composition of periods 9-16 was estimated to be the same as in periods 8-16, District 1.

fish (Table 8). In District 2, the age-1.3 catch was composed of 4,910 (36.5%) lower, 120 (0.6%) middle, and 8,417 (59.5%) upper run of origin fish (Table 9).

Scale patterns analysis was applied to the age-1.4 and 1.3 commercial catches from Districts 1 and 2 and commercial and subsistence catches from District 4 to apportion 64.8% (72,942 fish) of the total Yukon River age-1.4 and 1.3 harvest (112,626 fish) to run of origin. Of those fish apportioned, a total of 31,263 (42.9%) were estimated to be of Alaskan origin (Table 10). Precision of this estimate was high (coefficient of variation 5.9%). Harvest of Canadian origin fish was estimated at 41,679 (57.1%).

An additional 11,891 fish (7.2% of total harvest) from estimated age-1.4 and 1.3 subsistence catches in Districts 1, 2, and 3 were apportioned to run of origin by applying proportions estimated from scale patterns analysis of commercial catches in these same districts.

Differential Age Composition Analysis:

The remaining six age classes contributed 52,691 fish (31.5%) to the total drainage harvest and were apportioned to run of origin using differential age composition analysis (Table 11). The majority of age-1.5 harvests (54%-63%) in Districts 1-4 were apportioned to the upper run of origin, as were the majority of age-1.2 harvests (75%-79%). Virtually all fish with two years

Table 10. Total harvest of age-1.4 and 1.3 chinook salmon by nation of origin estimated from scale patterns analysis for Yukon River Districts 1, 2 and 4, 1986.

Region of Origin	Number of Fish	(%)	90 Percent Confidence Interval Lower Bound	90 Percent Confidence Interval Upper Bound	Coefficient of Variation[1]
Alaska	31,263	(42.9)	26,198	36,328	5.9%
Canada	41,679	(57.1)	36,471	46,887	4.5%
Total[2]	72,942	(100.0)			

1 Coefficient expressed as a percentage.

2 Includes District 1 commercial catch in periods 1-8, District 2 commercial catch in periods 1-3, 5, 6, and 8, and District 4 commercial and subsistence season total catch minus 941 from the Koyukuk River.

Table 11. Run apportionment by age class and region of origin of chinook salmon from Yukon River Districts 1, 2, 3, 4, 5, 6 and Yukon Territory commercial and subsistence catches, 1986.

District	Fishery	Commercial Fishing Dates	Run of Origin	1983 1.1	1982 1.2	1981 1.3	1981 2.2	1980 1.4	1980 2.3	1979 1.5	1979 2.4	1978 2.5	Total
1	Commercial Gillnet	6/14-8/22	Lower	0	159	7,278	0	7,999	21	3,813	26	0	19,296
			Middle	0	3	15	0	1,109	8	672	0	0	1,807
			Alaska	0	162	7,293	0	9,108	29	4,485	26	0	21,103
			Upper	0	538	9,202	0	13,696	241	7,666	496	92	31,931
			Total	0	700	16,495	0	22,804	270	12,151	522	92	53,034
	Subsistence Gillnet[1]		Lower	0	16	723	0	795	2	379	3	0	1,918
			Middle	0	0	2	0	111	1	67	0	0	181
			Alaska	0	16	725	0	906	3	446	3	0	2,099
			Upper	0	54	915	0	1,362	24	763	49	9	3,176
			Total	0	70	1,640	0	2,268	27	1,209	52	9	5,275
2	Commercial Gillnet	6/15-8/24	Lower	0	93	4,908	0	7,057	32	3,385	20	0	15,495
			Middle	0	19	120	0	104	1	63	0	0	307
			Alaska	0	112	5,028	0	7,161	33	3,448	20	0	15,802
			Upper	0	429	8,424	7	10,508	323	5,916	331	110	26,048
			Total	0	541	13,452	7	17,669	356	9,364	351	110	41,850
	Subsistence Gillnet[2]		Lower	0	14	760	0	1,093	5	524	3	0	2,399
			Middle	0	3	19	0	16	0	10	0	0	48
			Alaska	0	17	779	0	1,109	5	534	3	0	2,447
			Upper	0	67	1,305	1	1,628	50	917	51	17	4,036
			Total	0	84	2,084	1	2,737	55	1,451	54	17	6,483
3	Commercial Gillnet	6/26-8/24	Lower	0	2	119	0	178	1	86	1	0	387
			Middle	0	0	2	0	8	0	5	0	0	15
			Alaska	0	2	121	0	186	1	91	1	0	402
			Upper	0	9	169	0	194	7	110	7	2	498
			Total	0	12	290	0	380	8	201	8	2	901
	Subsistence Gillnet[3]		Lower	0	11	559	0	840	4	407	3	0	1,824
			Middle	0	2	11	0	40	1	25	0	0	79
			Alaska	0	13	570	0	880	5	432	3	0	1,903
			Upper	0	42	797	1	915	31	520	33	11	2,350
			Total	0	55	1,367	1	1,795	36	951	36	11	4,252
4	[4]	6/22-8/29	Lower	0	98	1,213	0	860	29	398	11	0	2,609
			Middle	0	5	45	0	668	61	393	0	0	1,172
			Alaska	0	103	1,258	0	1,528	90	791	11	0	3,781
			Upper	0	340	1,573	0	1,682	388	915	227	239	5,364
			Total	0	443	2,831	0	3,210	478	1,706	238	239	10,086[5,6]
5	[4]	6/27-8/31	Upper	562	4,301	1,287	0	6,410	933	3,851	962	415	18,721[7]
6	[4]	7/04-9/13	Middle	0	206	2,135	0	1,645	95	570	0	0	4,651
Yukon Territory	Commercial Gill net	7/02-10/9	Upper	0	0	1,661	0	4,865	119	4,034	59	59	10,797
	Subsistence Gill net[8]		Upper	0	0	1,426	0	4,175	102	3,462	51	51	9,267
Total Harvest			Lower	0	393	15,560	0	18,822	94	8,992	67	0	43,928[5]
			Middle	0	238	2,349	0	3,701	167	1,805	0	0	9,201[5]
			Alaska	0	631	17,909	0	22,523	261	10,797	67	0	53,129[5]
			Upper	562	5,780	26,759	9	45,435	2,218	28,154	2,266	1,005	112,188[5]
			Total	562	6,411	44,668	9	67,958	2,479	38,951	2,333	1,005	165,317[5]

1 apportionment based on season total District 1 commercial catch samples
2 apportionment based on season total District 2 commercial catch samples
3 apportionment based on District 3 commercial catch samples
4 combined commercial and subsistence, fish wheel and gill net
5 includes Koyukuk River subsistence catch (941 fish) not apportioned by age class
6 commercial catch = 502; subsistence catch = 9,583
7 commercial catch = 2,733; subsistence catch = 15,988
8 age apportionment based on Yukon Territory commercial catch samples

of freshwater growth (age-2.3, 2.4 and 2.5) were apportioned to the upper run of origin.

In districts of mixed runs (Districts 1-4) middle run fish of all ages combined were least abundant in Districts 1 (1,988 fish or 3.4%) and 2 (355 fish or 0.7%) and most abundant in District 4 (1,172 or 21.8%) commercial and subsistence catches. Lower Yukon fish comprised a greater percentage of District 1 (21,214 fish or 36.4%) and 2 (17,894 fish or 37.0%) commercial and subsistence catches than in District 4 (2,609 fish or 25.9%) catches. Upper Yukon fish were also more abundant in District 1 (35,107 fish or 60.2%) and 2 (30,084 fish or 62.2%) commercial and subsistence catches than in District 4 (5,364 fish or 53.2%) catches.

Geographic Analysis:

A total of 44,377 fish (26.8% of total drainage harvest) was apportioned to run of origin based on geography. District 5 and Yukon Territory commercial and subsistence catches (38,785 fish or 23.5% of total drainage harvest) were assumed to be of upper Yukon River origin. Commercial and subsistence catches in District 6 and subsistence catches from the Koyukuk River in District 4, were apportioned entirely to the middle Yukon run, and totaled 5,592 fish (3.4% of total drainage harvest).

Total Harvest:

Based on the findings of the scale patterns analysis of age-1.4

and 1.3 fish, the differential age composition apportionment of the remaining age classes, the assumptions concerning unsampled fisheries, and stock origins based on geography, the commercial and subsistence harvest of chinook salmon from the entire Yukon River drainage was apportioned to run of origin (Table 11). Upper Yukon River fish comprised the largest run component and contributed 112,188 fish or 67.9% of the total drainage harvest. Lower Yukon fish were next in abundance at 43,928 fish (26.6%). The contribution of 9,201 fish from the middle Yukon run comprised only 5.6% of the total harvest.

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Appendix Table 1. Scale variables screened for linear discriminant function analysis of age-1.4 and 1.3 Yukon River chinook salmon.

Variable	1st Freshwater Annular Zone
1	Number of circuli (NC1FW)[1]
2	Width of zone (S1FW)[2]
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)[3]
62	Width of zone (SPGZ)[4]

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 age 1.4 and 1.3 Yukon River chinook salmon (continued).

Variable	1st Marine Annular Zone
70	Number of circuli (NC1OZ)[5]
71	Width of zone (S1OZ)[6]
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 3nd 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)

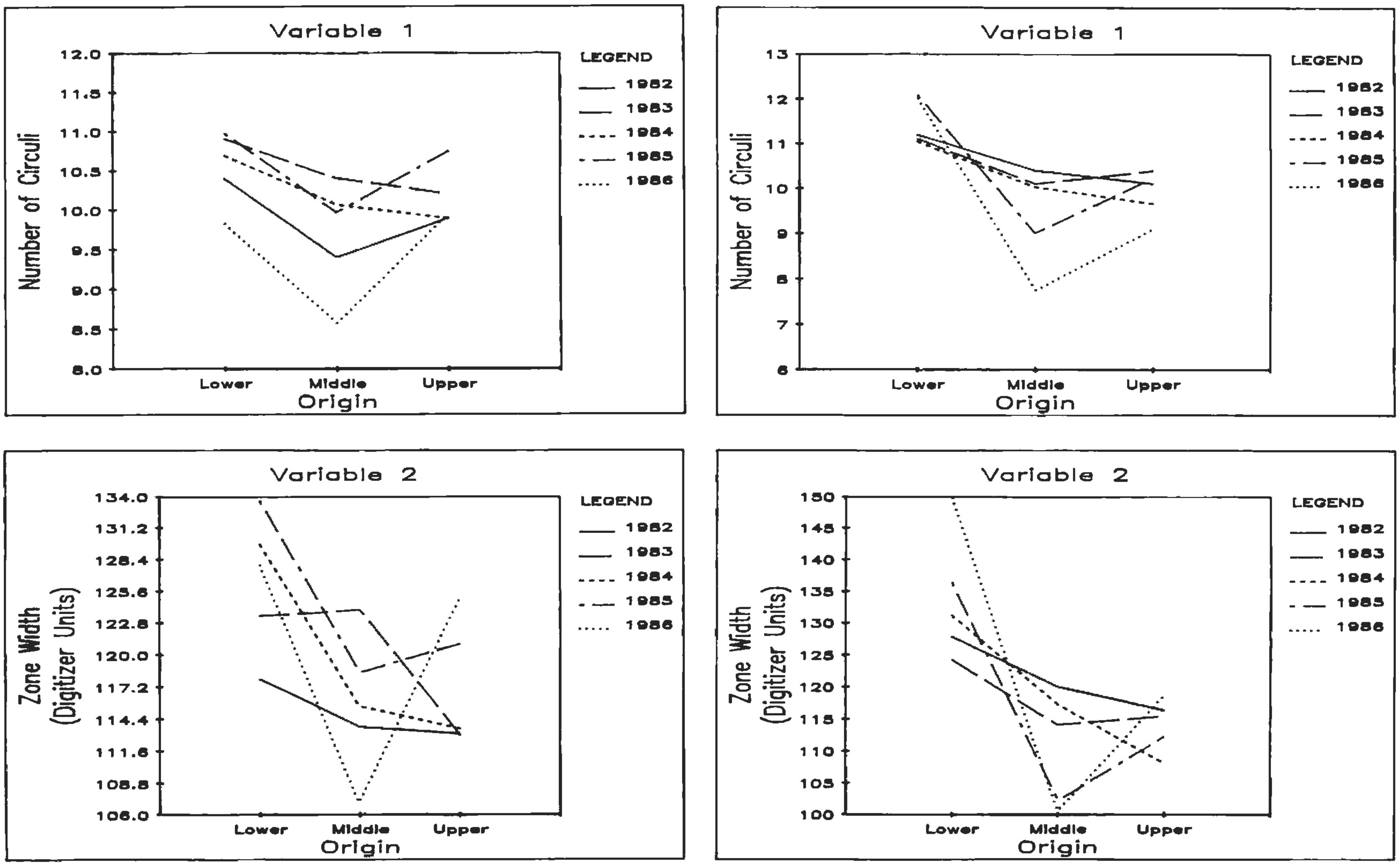
1 Number of circuli, 1st freshwater zone.
2 Size (width) 1st freshwater zone.
3 Number of circuli, plus growth zone.
4 Size (width) plus growth zone.
5 Number of circuli, 1st ocean zone.
6 Size (width) 1st ocean zone.

Appendix Table 2. Group means, standard errors and one-way analysis of variance F-test for scale variables selected for use in linear discriminant models of age-1.4 and 1.3 Yukon River chinook salmon runs, 1986.

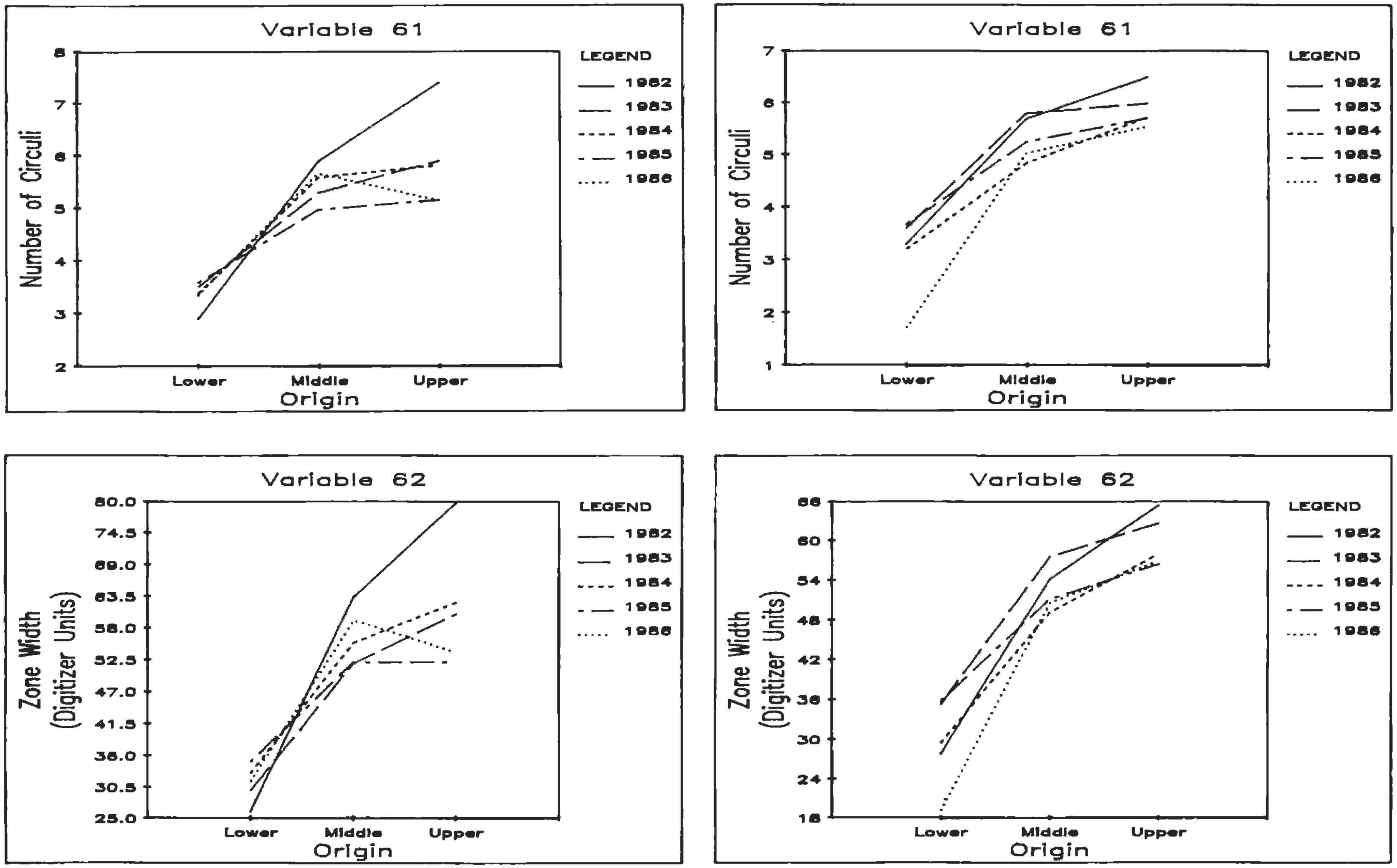
Age	Growth Zone	Variable	Lower Mean	Lower SE	Middle Mean	Middle SE	Upper Mean	Upper SE	F-value
1.4	1st FW Annular	2	127.92	1.99	107.14	1.29	125.09	1.43	55.61
		8	45.19	0.88	36.59	0.50	42.03	0.48	50.01
		26	0.12	0.01	0.15	0.01	0.12	0.01	43.33
	FW Plus Growth	61	3.34	0.19	5.65	0.13	5.13	0.17	32.06
	Total FW Growth	67	0.81	0.01	0.65	0.01	0.71	0.01	63.02
	1st Ocean Ann.	70	26.00	0.34	25.14	0.22	24.09	0.23	11.36
		89	219.45	7.21	182.79	4.37	165.17	4.36	20.14
		100	0.23	0.01	0.26	0.01	0.28	0.01	26.77
1.3	1st FW Annular	1	12.02	0.12	7.74	0.11	9.11	0.11	330.62
		8	45.44	0.46	35.57	0.58	41.10	0.51	84.18
		14	95.14	1.26	48.39	1.23	63.93	1.00	395.60
		16	0.37	0.01	0.53	0.01	0.47	0.01	293.78
		27	12.57	0.09	13.08	0.14	13.26	0.14	10.17
	FW Plus Growth	61	1.71	0.06	5.04	0.12	5.54	0.10	558.36
		62	19.18	0.67	50.70	1.24	56.93	1.10	467.76
	Total FW Growth	67	0.89	0.01	0.67	0.01	0.68	0.01	684.73
	1st Ocean Ann.	83	168.74	1.35	171.26	1.84	186.18	1.42	42.50
		106	13.74	0.10	13.85	0.14	12.62	0.11	37.09

Appendix Table 3. 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-1.4 and 1.3 Yukon River chinook salmon runs, 1986.

Age	Growth Zone	Variable	Lower Mean	Lower SE	Middle Mean	Middle SE	Upper Mean	Upper SE	F-Value
1.4	1st FW Annular	No. Circ.	9.82	0.19	8.57	0.12	9.96	0.13	32.85
		Incr. Dist.	127.92	1.99	107.14	1.29	125.09	1.43	55.61
	FW Plus Growth	No. Circ.	3.34	0.20	5.65	0.13	5.13	0.17	32.06
		Incr. Dist.	31.51	1.86	59.40	1.36	53.77	1.79	41.10
	1st Ocean Annular	No. Circ.	26.00	0.34	25.14	0.21	24.09	0.23	11.36
		Incr. Dist.	477.51	7.02	447.20	4.22	441.77	4.00	9.80
	2nd Ocean Annular	Incr. Dist.	402.57	9.31	383.63	5.56	385.52	5.24	1.62
	3rd Ocean Annular	Incr. Dist.	411.57	7.62	403.36	4.29	407.58	3.78	0.57
1.3	1st FW Annular	No. Circ.	12.02	0.12	7.74	0.11	9.11	0.11	330.62
		Incr. Dist.	149.83	1.31	100.71	1.54	118.81	1.43	343.03
	FW Plus Growth	No. Circ.	1.71	0.62	5.04	0.12	5.54	0.10	558.36
		Incr. Dist.	19.18	0.67	50.70	1.24	56.93	1.10	467.76
	1st Ocean Annular	No. Circ.	26.33	0.17	26.70	0.22	25.11	0.18	19.79
		Incr. Dist.	492.54	3.68	485.90	4.66	475.08	3.68	5.61
	2nd Ocean Annular	Incr. Dist.	472.95	4.98	439.27	6.10	427.21	4.96	22.57



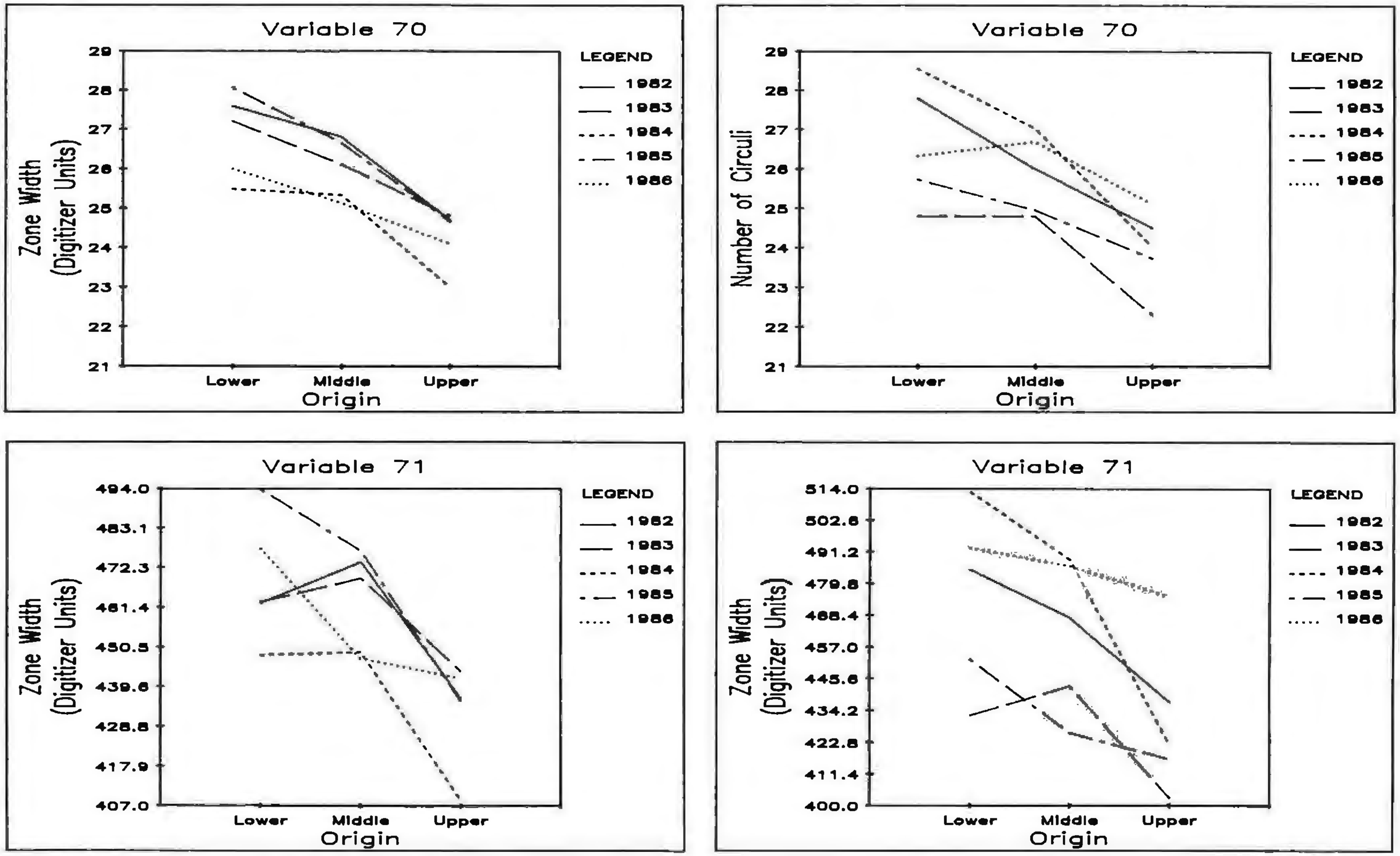
Appendix Figure 1. Number of circuli (variable 1) and width (variable 2) of the freshwater annular zone in digitized scales by year for lower, middle, and upper Yukon runs of origin. Age-1.4 (left) and 1.3 (right) chinook salmon are shown.



Appendix Figure 2. Number of circuli (variable 61) and width (variable 62) of the freshwater plus growth zone in digitized scales by year for lower, middle, and upper Yukon runs of origin. Age-1.4 (left) and 1.3 (right) chinook salmon are shown.

Appendix A Table 1. Mean size and standard deviation for the size of scale zones used in the linear discrimination of Yukon River chinook salmon runs, 1986. Each standard deviation was calculated from 25 observations. Only the treatment cells of the first marine zone had significantly different variances (α =.05 with F_{max}-test, Sokal and Rohlf 1969).

Run of Origin	Mean (top) and STD (bottom) for Size of Scale Zone					
	Freshwater		Freshwater Plus Growth		First Marine	
	Wilcock	Merritt	Wilcock	Merritt	Wilcock	Merritt
Lower	129.4	122.8	29.0	30.8	413.6	458.5
	15.9	15.6	14.1	14.6	62.5	67.1
Middle	111.3	105.1	56.8	59.7	435.2	465.1
	18.4	20.7	13.2	13.5	50.6	42.0
Upper	119.6	121.7	64.7	45.1	426.6	452.5
	18.5	19.3	22.4	19.8	86.0	51.6



Appendix Figure 3. Number of circuli (variable 70) and width (variable 71) of the first marine annular zone in digitized scales by year for lower, middle, and upper Yukon runs of origin. Age-1.4 (left) and 1.3 (right) chinook salmon are shown.

Appendix A. Change in Scale Digitizer and the Effect on Scale Measurements and Catch Apportionments

INTRODUCTION

The senior author became project leader for the Yukon River chinook salmon stock biology project in November 1986, and was responsible for aging scales, measuring scale features (digitizing), constructing run of origin models and apportioning catches. The second author had digitized Yukon River chinook salmon scales collected from 1982 through 1985 and had been responsible for model construction and catch apportionment (Wilcock and McBride 1983; Wilcock 1984; 1985; 1986). Merritt was trained by Wilcock to read and digitize scales using standard techniques discussed previously in the methods section. An attempt was made to calibrate the new digitizer with Wilcock to minimize differences that could arise due to the subjective nature of interpreting scale features.

METHODS

It was hypothesized that the change in project leaders would not adversely affect the comparability of current stock composition estimates with historical data. Two approaches were taken to investigate the effect a change in digitizer might have on scale measurements, model construction, and catch apportionment. First, to test for a significant effect on scale measurements due to digitizer, a two-way multivariate analysis of variance (MANOVA) was conducted. A full factorial two-way MANOVA design (Morrison 1976) was used and of interest was the resulting source of variation due to the interaction of digitizer and stock. A significant interaction effect would indicate that the main effect or difference in scale measurements between stocks would be confounded with a digitizer effect. A second approach was to compare the accuracy of linear discriminant functions and the resulting catch apportionments based on models built with scale measurements made by Wilcock and Merritt from the same group of scales. Even if there was a significant effect due to digitize,r or interaction between digitizer and stock, of ultimate interest was the effect on model accuracy and catch apportionment.

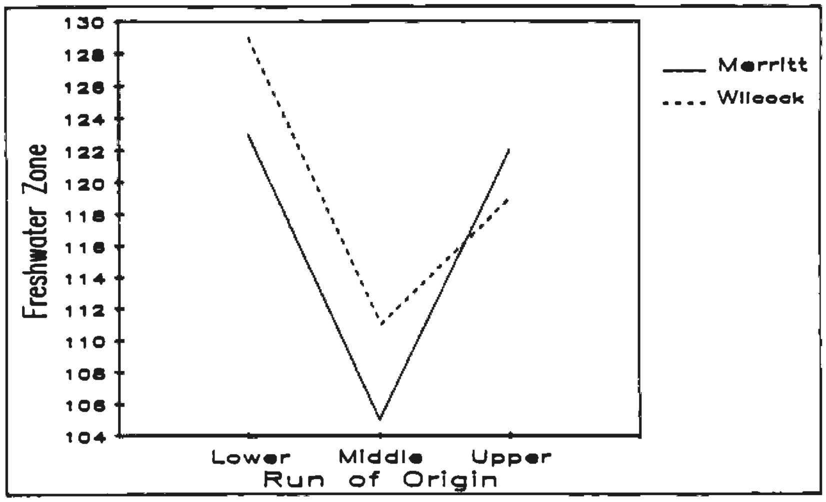
Variability due to experimental error was controlled directly by randomly selecting 25 Yukon River chinook salmon age-1.4 scales from each of the three runs of origin. Scales were digitized by the two readers using standard procedures and the same hardware and software. A fixed effect model was assumed and the Pilai trace was used as a test statistic. It is the most robust statistic against violation of the assumptions of multivariate normality and homogeneity of covariance matrices of those statistics commonly reported by computer based statistical packages (Harris 1985). All variables currently screened for LDF analysis (Appendix Table 1) are functions of the number of circuli or size of each of five scale growth zones, resulting in 10 key measurements. The size and count variables are highly correlated for each scale zone. Only variables which were a function of the size of the first three zones entered the LDF model in 1986. Accordingly, only the size of the first three scale zones (freshwater annular, freshwater plus growth, and first marine annular) were included as dependent variables. Run of origin (upper, lower, and middle) and digitizer (Merritt and Wilcock) were the independent variables.

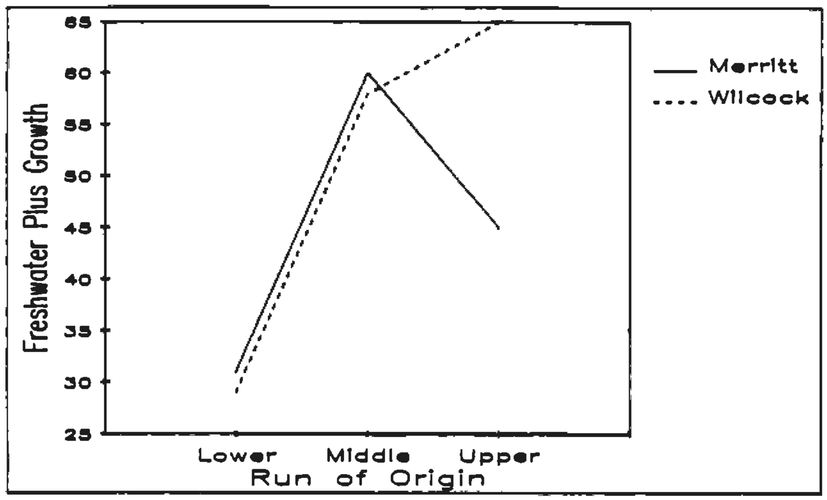
Each scale reader digitized all age-1.4 scale samples from the lower run, a subsample of 100 scales each from the middle and upper Yukon runs, and all available catch samples from the four largest periods in the 1986 lower Yukon River commercial fishery. Stock standards were composed of samples in proportion to abundance as indexed by aerial surveys from the Andreafsky, Anvik and Nulato Rivers for the lower Yukon run, and the Chena and Salcha Rivers for the middle run. The upper run was represented by scales sampled from fish wheel catches of a mark and recapture study conducted by DFO in the mainstem Yukon River just upstream from the US/Canada border. Linear discriminant functions were calculated for each reader using standard procedures. Classification results were used to estimate the stock composition of catches from fishing periods 2 and 3 in District 1, and fishing periods 3 and 5 in District 2. Run composition estimates were intended only for comparison between readers, therefore no attempt was made to apportion catches, and constrained models with fewer than three stocks were not generated when estimated proportions were less than zero.

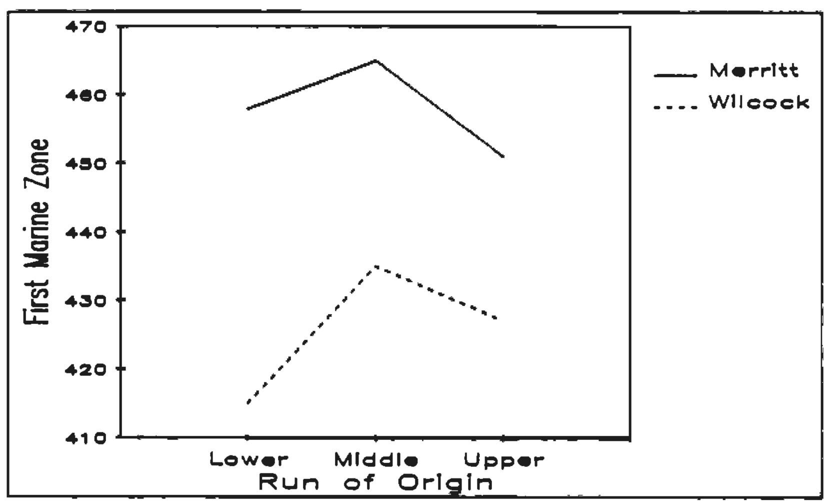
RESULTS

There were differences in the mean size of the first three scale growth zones as measured by Merritt and Wilcock (Appendix A Table 1). In addition there appears to be a departure from parallelism (Appendix A Figure 1) in all cases, though it is most striking in the freshwater plus growth zone. This departure indicates a possible interaction between the effect due to the run of origin and the change in digitizer. Results from a series of Analysis of Variance (ANOVA) support the conclusions drawn from inspection of the data. Tests for homogeneity of variance showed no significant difference among treatment cell variances for the freshwater annular and freshwater plus growth zones only. Attempts to fulfill the assumption of homogeneity of variances by transformations of the raw data for the size of the first marine annular zone were unsuccessful, and a non-parametric test was used. Residuals from the ANOVAs are presented in Appendix A Figure 2 and are thought not to deviate too greatly from a normal distribution to invalidate this rather robust technique.

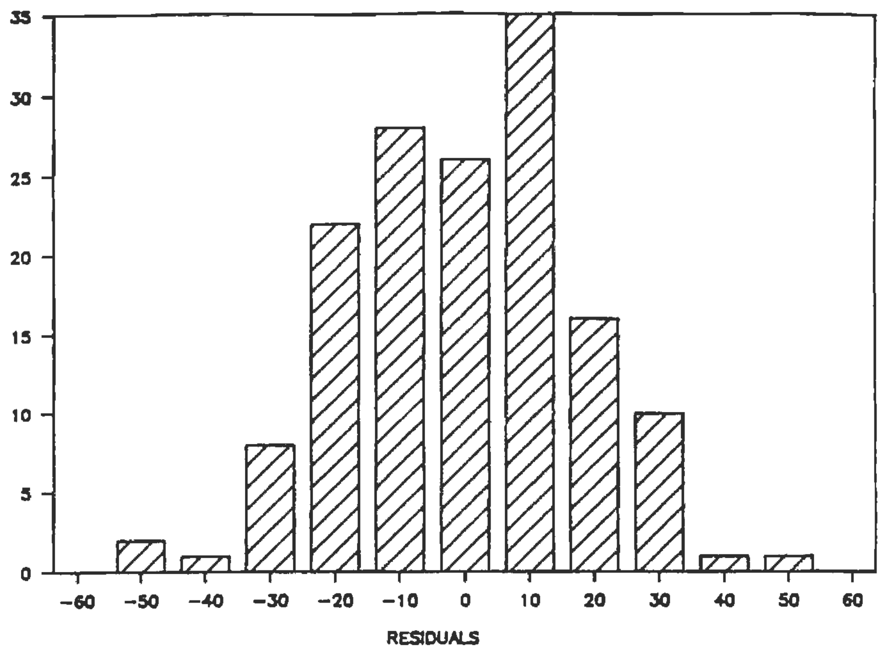
An additive model could be assumed (non-significant interaction term) for freshwater annular growth (Appendix A Table 2). The difference between readers was not significant and the difference

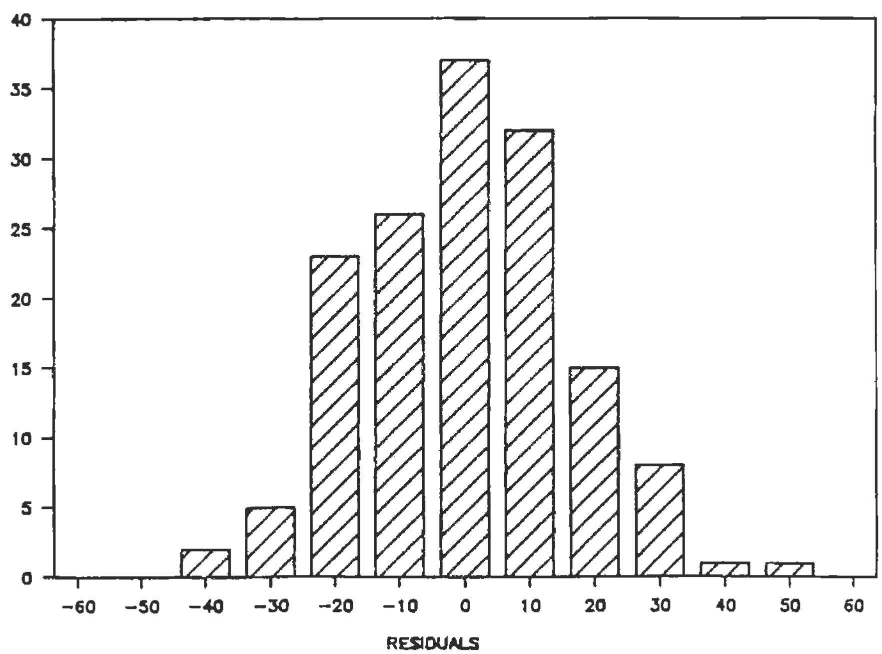






Appendix A Figure 1. Mean size of the freshwater annular zone (top), freshwater plus growth zone (middle) and first marine growth zone of Yukon River chinook salmon by digitizer and run of origin, 1986.





Appendix A Figure 2. Residuals from 2-way ANOVAs with size of freshwater growth (top) and freshwater plus growth (bottom) of 1986 Yukon River chinook salmon scales as dependent variables and digitizer and run of origin independent variables.

Appendix A Table 2. ANOVA and non-parametric test statistics for the univariate analysis of differences in size of scale zone due to dizitizer or run of origin for Yukon River chinook salmon, 1986.

				Size of Zone					
		Sum of Squares		Freshwater		Freshwater Plus		First Marine	
Source	df	Freshwater	Freshwater Plus	F	P-value	F	P-value	T.S. [2]	P-value
Digitizer (D)	1	482	938	1.46	0.23	3.38	0.07 [1]	18,533	0.001
Run (R)	2	8,447	23,953	12.81	0.00	43.22	0.00	2.27	0.32
D x R	2	603	4,027	0.91	0.40	7.27	0.001		
Error	144	4,782	39,905						

[1] Due to the significance of the interaction term the main effect due to digitizer and run of origin are confounded.

[2] Non-parametric test statistic (T.S.) for one-way layout testing for effect of digitizer was the Mann-Whitney U, and for the effect of run of origin the Kruskal-Wallis statistic. (Hollander and Wolfe 1973). Because a two-way design was not used interaction effect could not be tested.

due to run of origin was significant ($p<.05$). A significant interaction between digitizer and run of origin in the size of the freshwater plus growth zone confounded any discussion of the main effect or differences due to digitizer or run of origin. Two non-parametric tests using size of first marine annular zone as the independent variable were conducted. A significant difference due to digitizer was detected but the difference in size among runs of origin was not significant (p-value of 0.32). A run of origin effect could exist but was not detected above the within variation, which in this case contains the significant effect due to digitizer. A non-parametric test designed to test interaction was not found.

Results of the MANOVA (Appendix A Table 3) indicate a significant interaction effect. Again this confounds any discussion of the main effects of run of origin or digitizer.

Linear discriminant models were developed for age-1.4 chinook salmon from measurements made by Merritt and Wilcock using the same scale samples (Appendix A Table 4). Scale character Variable 67, the size of the first freshwater annular zone relative to the size of the total freshwater growth zone, was selected first for discriminant models for both scale readers (Appendix A Table 4). The second variable selected differed between readers (Variable 66 for Wilcock and Variable 62 for Merritt), but were related as both were a function of the size of the freshwater plus growth zone. The third variable selected for each reader was based on incremental distances between circuli in the first marine annular

Appendix A Table 3. MANOVA statistics for the multivariate analysis of differences in size of scale zone due to digitizer or run of origin for Yukon River chinook salmon, 1986. Due to the significance ($p<.05$) of the interaction term the effect of digitizer and run are confounded.

Source	df	Pillai Trace	F-Statistic	P-value
Digitizer (D)	3, 142	0.127	6.874	0.00
Run (R)	2, 286	0.455	14.043	0.00
D x R	6, 286	0.096	2.440	0.03

Appendix A Table 4. Classification accuracies of linear discriminant models for age-1.4 Yukon River chinook salmon digitized by two scale readers, 1986.

Wilcock

Actual Run of Origin	Sample Size	Classified Run of Origin: Lower	Middle	Upper
Lower	65	0.831	0.077	0.092
Middle	100	0.120	0.670	0.210
Upper	100	0.190	0.210	0.600
		Mean Classification Accuracy =		0.700

Variables in the analysis: 67, 66, 100.

Merritt

Actual Run of Origin	Sample Size	Classified Run of Origin: Lower	Middle	Upper
Lower	65	0.692	0.077	0.231
Middle	100	0.101	0.717	0.182
Upper	100	0.210	0.220	0.570
		Mean Classification Accuracy =		0.660

Variables in the analysis: 67, 62, 102, 26, 70.

zone relative to the total size of the zone.

Mean classification accuracies for both scale readers were similar (70% for Wilcock and 66% for Merritt). The greatest difference observed between readers was in the percentage of lower Yukon scales correctly classified (83.1% for Wilcock and 69.2% for Merritt). Lower Yukon scales digitized by Merritt were more frequently misclassified as upper Yukon (23.1%) than scales digitized by Wilcock (9.3%). The difference between readers for all other correct classifications and misclassifications was less than 5%.

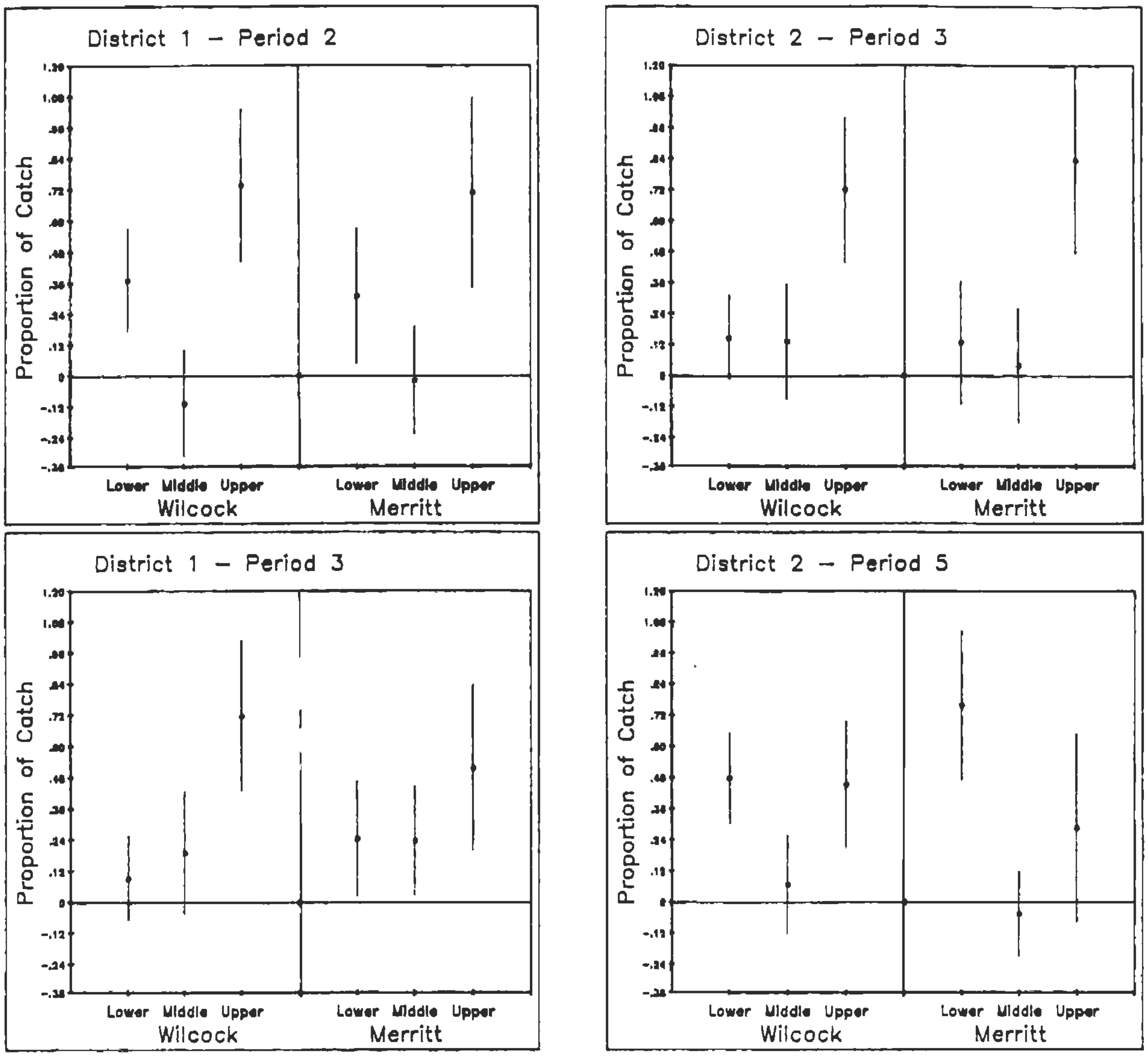
Run composition estimates of catch from four commercial fishing periods compared well between models built by both scale digitizers (Appendix A Table 5, Appendix A Figure 3). Differences in run composition estimates between readers were largest for lower Yukon fish from period 5 of District 2 (28.1% difference) and period 5 of District 1 (19.9% difference). The average difference between run proportion estimates for the two readers was less than 12% and confidence intervals for all estimates overlapped considerably.

DISCUSSION

An evaluation of the difference between readers in their interpretation of scale features was prompted by the 1986 catch

Appendix A Table 5. Run composition estimates for age-1.4 chinook salmon from commercial catches in Yukon River Districts 1 and 2 using linear discriminant function analysis of samples digitized by two scale readers.

				Wilcock			Merritt		
					90% C.I.			90% C.I.	
District	Commercial Fishing Period	Sample Size	Run of Origin	Prop. of Catch	Lower Bound	Upper Bound	Prop. of Catch	Lower Bound	Upper Bound
1	2	108	Lower	0.371	0.175	0.567	0.309	0.048	0.571
			Middle	-0.108	-0.312	0.097	-0.018	-0.226	0.190
			Upper	0.737	0.443	1.031	0.709	0.341	1.077
	3	119	Lower	0.092	-0.070	0.253	0.245	0.025	0.466
			Middle	0.191	-0.046	0.428	0.237	0.028	0.446
			Upper	0.717	0.427	1.008	0.518	0.199	0.837
2	3	131	Lower	0.147	-0.015	0.309	0.128	-0.109	0.365
			Middle	0.134	-0.089	0.357	0.039	-0.182	0.261
			Upper	0.720	0.440	0.999	0.833	0.475	1.191
	5	124	Lower	0.478	0.303	0.653	0.759	0.471	1.046
			Middle	0.067	-0.118	0.253	-0.046	-0.208	0.116
			Upper	0.454	0.212	0.696	0.287	-0.075	0.650



Appendix A Figure 3. Run composition estimates and 90% confidence intervals for age-1.4 chinook salmon from commercial catches in Yukon River Districts 1 and 2 using linear discriminant function analysis of samples digitized by two scale readers.

apportionment results. In no year since catch apportionments were initiated in 1982 has the middle run contributed so few fish to total catch. This could have been due to a very weak return of middle run fish in 1986, differential exploitation of runs due to the timing and execution of the fishery, or an underallocation due to the change in digitizer. Escapement data refuted the assertion of a very weak return of middle run chinook salmon (Barton 1987, ADF&G 1987). The evaluation of the difference between readers did not indicate any bias limited to middle run scales. No significant difference was found between digitizers in either their interpretation of the size of the freshwater annular growth zone (Appendix Table 2) or in the simple effect of digitizer for middle run chinook salmon freshwater plus growth zone measurements (a post hoc comparison of a 2-way ANOVA using a Bonferroni critical value for setwise error of α =.05). There was a significant difference between digitizers for the first marine annular zone and overall a significant interaction effect from the MANOVA. Appendix A Figure 1 best illustrates the difference in mean size of the three scale growth zones by run of origin and digitizer. The relationship between digitizers is fairly constant for the lower and middle run. Additional calibration of the new digitizer for the upper run freshwater plus growth zone, and the first marine growth zone for all runs, could increase comparability with historical data. The middle run proportions are all within 5% between the two digitizers (Appendix A Table 4), and it is the classification of lower run fish that shows the greatest difference, with misclassification to the upper run. Yet overall the two digitizers apportion catch quite similarly (Appendix A Figure 3) and trend well together.

In conclusion, the small apportionment of the 1986 catch to middle run chinook salmon can not directly be attributed to a change in digitizer. Results are compatible with previous years, although additional calibration is recommended for upper run freshwater plus growth zone measurements and the first marine growth zone for all three runs.