FEASIBILITY OF SCALE PATTERN ANALYSIS TO IDENTIFY THE ORIGINS OF CHINOOK SALMON (*Oncorhynchus tshawytscha* Walbaum) IN THE LOWER YUKON RIVER COMMERCIAL GILLNET FISHERY, 1980-1981

by

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ABSTRACT

During 1980 and 1981, the feasibility of using scale patterns to identify major component stocks of chinook salmon (*Oncorhynchus tshawytscha* Walbaum) in the Yukon River commercial chinook salmon fishery was investigated. For both years, scale samples and sex and size data were collected from both the District 1 commercial catch and major spawning tributaries throughout the Yukon River drainage. Samples of known origin were pooled into three broad geographic regions for analysis; the lower, middle, and upper Yukon runs. Nearest neighbor classification models of scale measurements were used to determine the origin of age 1.3 and 1.4 fish in the District 1 commercial catch. The District 1 harvest was composed mostly of age 1.4 and 1.3 fish during both 1980 (47.5% and 47.4%, respectively) and 1981 (76.3% and 18.1%, respectively). Pooled age composition estimates for the lower, middle, and upper Yukon runs were found to be significantly different during both 1980 and 1981. Nearest neighbor classification accuracies were considered marginally acceptable and varied from .582 to .932. Point estimates for the contribution of age 1.3 fish indicate that upper Yukon fish predominated the catch during both 1980 (57.6%) and 1981 (59.0%). Point estimates for the composition of age 1.4 fish indicate that middle Yukon fish predominated the catch during both 1980 (70.6%) and 1981 (77.7%). For both age classes combined, fish of Alaskan origin (i.e. lower and middle Yukon runs) accounted for 56.6% of the 1980 catch and 70.7% of the 1981 catch.

INTRODUCTION

In 1980, a study was initiated to evaluate the feasibility of identifying major component stocks of chinook salmon (*Oncorhynchus tshawytscha* Walbaum) in the Yukon River commercial chinook salmon fishery. The annual harvest of chinook salmon in the Yukon River is one of the largest in Alaska with successive record catches during 1980 and 1981 of 152,788 and 157,509 fish, respectively[1]. While chinook salmon are commercially harvested throughout virtually the entire length of the Yukon River, most of the catch is taken in the District 1 gillnet fishery which operates in the lower 101 km of the river (Figures 1 and 2). During the period 1971 to 1981, the District 1 fishery sustained an annual average harvest of 71,354 chinook salmon and ranged from 44,585 to 99,219 fish. Most of the harvest of chinook salmon in District 1 is taken in a directed fishery that commences in early June where mostly gillnets of 203 and 229 mm (8 to 9 inch) stretched mesh are operated[2]. This June fishery is commonly referred to as the "early" or "chinook" season. The remaining harvest is taken incidentally to the chum *(O. keta)* and coho *(O. kisutch)* salmon fishery. This fishery, in which gillnets of up to 152 mm (6 inch) stretched mesh are allowed, is commonly referred to as the "chum" or "fall" season and commences in late June to early July.

The lower river fishery harvests mixed stocks of chinook salmon destimed for spawning streams throughout the Yukon River drainage. Data from past tagging studies (Regnart 1964, 1966, 1967; Geiger 1968; Lebida 1969; Trasky 1973) indicate that considerable mixing of stocks occurs throughout the duration of the commercial fishery. Identification of major component stocks of chinook salmon as they enter the lower river and are subjected to the commercial fishery is critical to achievement of optimum escapement and production for each stock.

In this report, we evaluate the feasibility of using scale pattern measurements to identify major component stocks of chinook salmon in the District 1 commercial catch. We chose scale pattern analysis as we believed that measurable differences in growth characteristics, as reflected in scale patterns, would exist between fish whose spawning and rearing sites extend over 3,218 km of drainage. Age composition data is presented for both the District 1 commercial fishery and major Yukon River drainage escapements, and chi-square analysis is used to test for differences in age composition among the various escapements. We used nearest neighbor analysis (Clover and Hart 1967) of scale patterns to estimate the contribution of major component stocks of chinook salmon to the District 1 catch. Finally, recommendations are made regarding further study of this problem.

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[1] Preliminary data. These data are for Alaskan commercial catches only.

[2] 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 inch) stretched mesh are also operated.

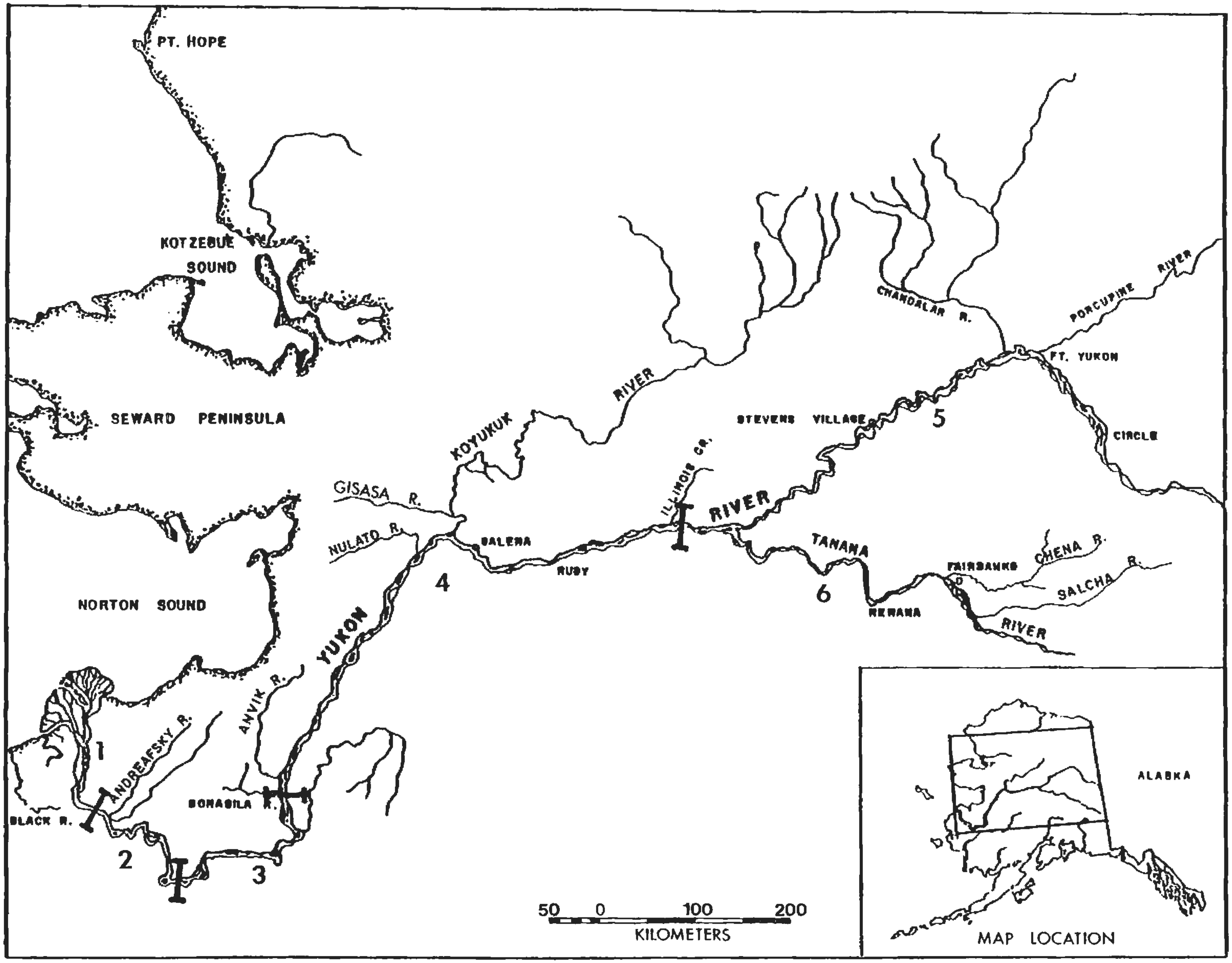

Figure 1. Alaskan portion of the Yukon River showing the Alaska regulatory districts.

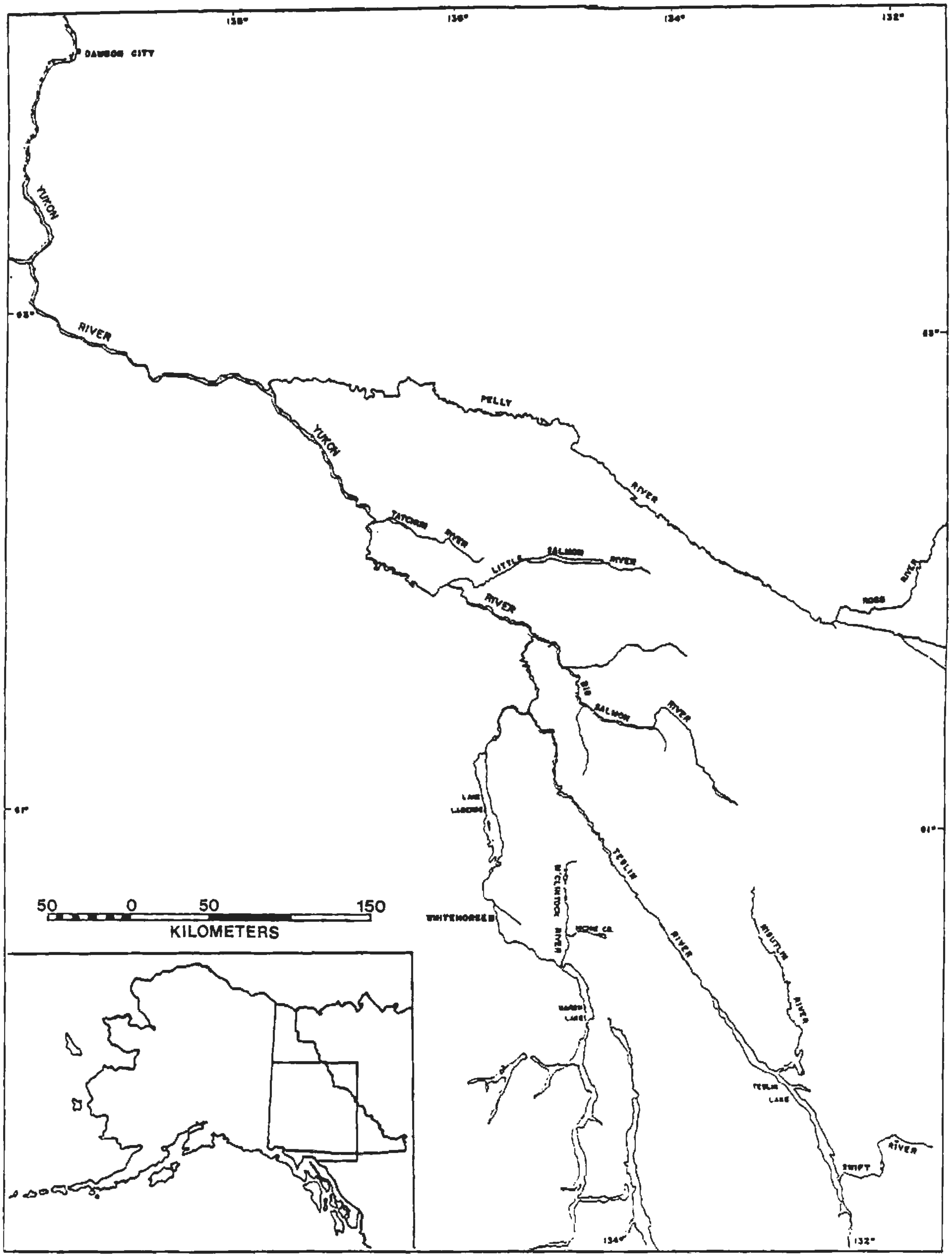

Figure 2. Canadian portion of the Yukon River.

METHODS

Catch statistics reported in this paper were obtained from preliminary tabulations of individual sales records (fish tickets) of chinook salmon in the Yukon River (ADF&G 1980, 1981). Virtually all escapement enumeration data reported in this paper are peak aerial survey counts for selected spawning streams (Barton 1982). The only exception are escapement data at the Whitehorse Dam in the Yukon Territory, Canada where the entire escapement is visually counted through a fishway. It is recognized that aerial survey data from any stream does not represent a complete enumeration of escapement to that stream, that the proportion observed probably varies significantly between rivers, and that not all spawning concentrations of chinook salmon within the Yukon River drainage are surveyed.

Age Composition

Examination of scale samples provided age information of 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 (INPFC 1963). Scales were mounted on gum cards and impressions were made in cellulose acetate (Clutter and Whitesel 1956). Ages were recorded in European[3] notation.

Catch:

Scale samples were collected from the commercial catch for each fishing period during the chinook salmon season and an age composition was computed for each period catch. An attempt was made to collect a minimum of 210 samples for each fishing period. Chinook salmon catches made during the fall season were relatively small and samples were collected incidentally to chum salmon samples. Therefore, samples during the fall season were pooled to obtain a minimum sample size of 200 fish and age compositions were computed for each of these pooled samples. Summaries from which these age computations were obtained (ADF&G 1980, 1981) only represent marine ages as all fish were assumed to have one freshwater annulus.

Escapement:

Scale samples were collected from the larger chinook salmon spawning concentrations (as determined from aerial survey data) throughout the Yukon River drainage and an age composition was computed for each river that was sampled. Virtually all samples were collected from carcasses obtained by sampling streams during the period of peak spawner die-off. During 1980, the timing of these sampling trips was consistently late and relatively few samples were collected. Conversely, the timing of the sampling trips during 1981 coincided

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[3] European formula: Numerals preceding the decimal refer to the number of freshwater annuli, numerals following the decimal are the number of marine annuli. Total age is the sum of these two numbers plus 1.

with peak die-off and adequate samples were collected. Sampling of the Andreafsky River stock during 1981 and the Anvik, Salcha, and Chena River (Figure 1) stocks during 1980 and 1981 was accomplished throughout the duration of the die-off. Fish passing through the Whitehorse fishway (Figure 2) during 1981 were collected by dip-net, anesthetized, and sampled. An attempt was made to sample 20% of each days ecapement.

Samples of known origin were pooled into three broad geographic regions for analysis; the lower, middle, and upper Yukon River. It was necessary to pool the escapement samples because the large number of spawning streams throughout the Yukon River drainage precludes identification or management of each stock. In the remainder of this paper, we refer to these geographical groupings as runs and they are defined as follows:

1) The lower Yukon run is comprised of samples from the Andreafsky, Anvik, and Nulato Rivers (Figure 1).

2) The middle Yukon run is comprised of samples from the Salcha and Chena Rivers (i.e., Tanana River drainage).

3) The upper Yukon run (Figure 2) is comprised of samples from the Big Salmon, Little Salmon, Tachun, Pelly, and Teslin Rivers; and escapement past the Whitehorse Dam (i.e., spawning tributaries in Canada's Yukon Territory).

Samples from individual spawning streams within each run were pooled to form a composite proportional to their contribution to that run as measured by aerial survey data.

Chi-square analysis was used to determine if significant differences in age composition existed within or between the lower, middle, and upper Yukon runs. Differences within each run were measured by chi-square comparisons of age composition data from the major escapements within each run. Differences between runs were measured by chi-square comparisons of pooled age composition data from each run.

Run Identification

Estimates of the contribution of the lower, middle, and upper Yukon runs to the District 1 commercial catch were made using nearest neighbor analysis of scale patterns. Because of the dominance of age 1.3 and 1.4 fish, we limited our analysis to these age classes.

Scale Measurements:

Scale impressions were magnified to 100 power and projected onto a digitizing tablet using equipment similar to that described by Ryan and Christie (1976). Data recording onto computer diskettes from the digitizer tablet was under the control of a FORTRAN program executing on a microcomputer. Measurements were taken along an axis approximately 20 degrees off the primary scale axis, this axis is perpendicular to the sculptured field. The distance was measured between each circulus in each of three scale pattern zones. The zones were as follows: (1) scale focus to the outside edge of the freshwater annulus, (2) outside edge of the freshwater annulus to the last circulus of the plus growth, and (3) the last circulus of the plus growth zone to the outer edge of the first ocean annulus (Figure 3). For samples collected in 1981, the incremental distance of successive scale pattern zones was also measured as follows: (1) the last circulus of the first ocean annulus to the outer edge of the second ocean annulus, and (2) the last circulus of the second ocean annulus to the outer edge of the third ocean annulus (age 1.4 fish only). A set of 11 variables was then computed for each of the first three zones while only one variable was computed for each of the last two zones (Table 1).

Analytical Procedures:

Nearest neighbor analysis (Clover and Hart 1967) of scale pattern data was used to identify the origin of chinook salmon harvested in the District 1 fishery. Nearest neighbor analysis was selected for this classification as the technique is nonparametric (i.e. it requires no underlying assumptions concerning population parameters). We used the computational routines of the FORTRAN program ARTHUR (Duewer et al. 1975) for the nearest neighbor analysis in this study.

Selection of a subset of scale variables for inclusion in the nearest neighbor model was made by offering all variables to the selection procedures available in ARTHUR. These procedures removed correlations, evaluated the usefulness of each variable (by Fisher weighting), and ranked them in order of their utility. The Fisher weights of these ranked variables were then subjectively examined to determine those variables for inclusion in the model in order to obtain the highest possible classification accuracy. Subsequent analysis was then limited the these top selected variables. This procedure was evaluated by calculating the accuracies of a seriesof nearest neighbor models for the 1981 age 1.3 samples using a stepwise procedure for selecting the ranked variables.

Estimates of the proportions of age 1.3 and 1.4 fish originating from the lower, middle, and upper Yukon runs were made by classifying scale pattern data obtained from a sample of the commercial catch during each fishing period. Point estimates were corrected for misclassification error rates 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 fewer runs if the final proportion estimate was less than or equal to zero for the run in question.

1980 Analysis:

A 3-way stock identification model was constructed from age 1.3 scale measurements representing the lower, middle, and upper Yukon runs. Because of the limited sample size (N=73) from the lower Yukon run and the requirement for equal sample sizes, we limited this analysis to 73 scale samples from each run. In addition, the extremely small number of available samples for age 1.4 fish from the lower (N=28) Yukon run precluded a 3-way model for this age class. Therefore, we pooled all available samples from the lower (N=28) and middle (N=81) Yukon runs for a 2-way model of Alaskan and Canadian Yukon runs.

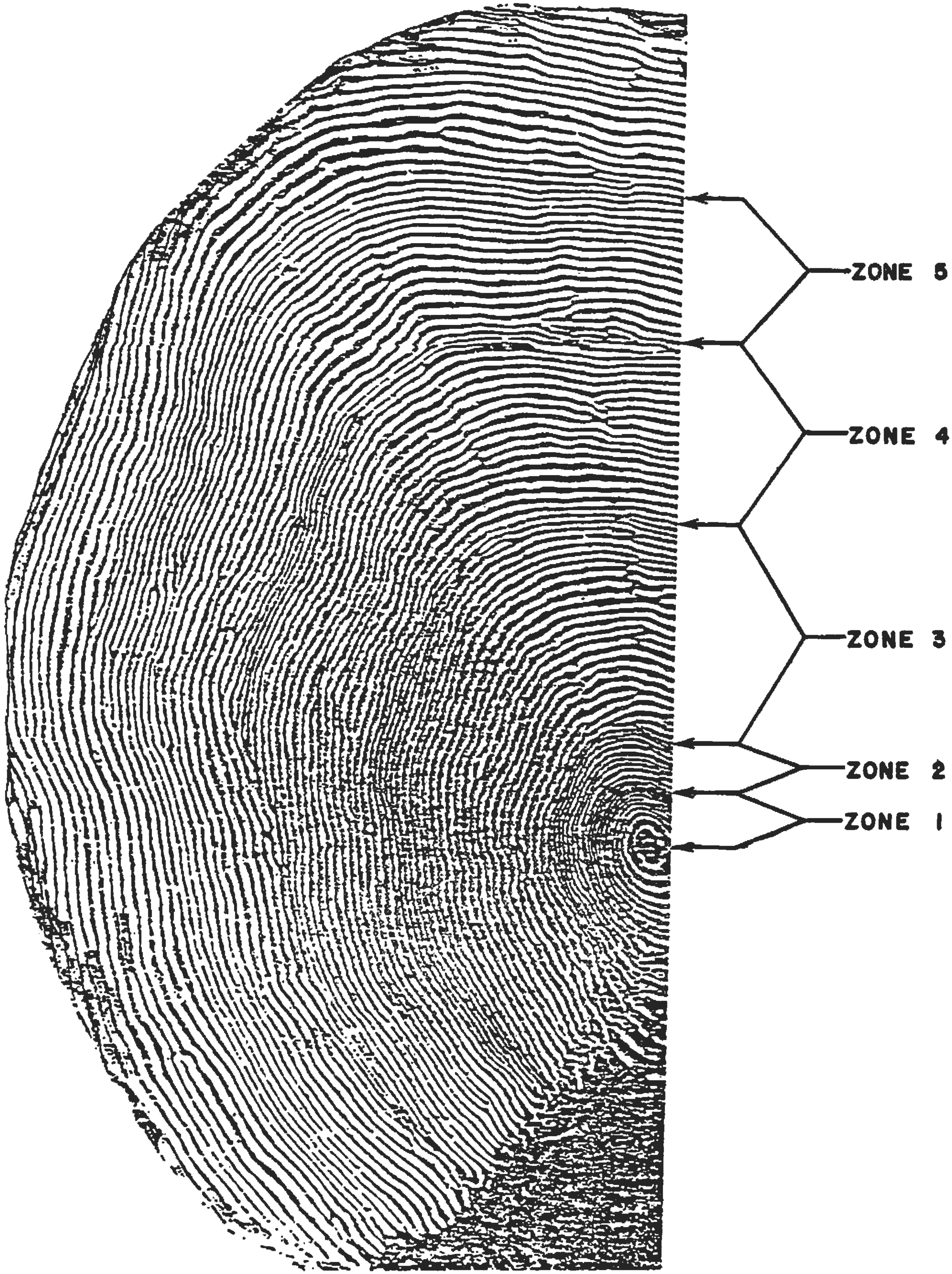

Figure 3. Age 1.4 chinook salmon scale showing the zones measured for nearest neighbor analysis.

Table 1. Variables computed from scale patterns for inclusion in the nearest neighbor analysis.

Variable Name	Description
NC(i)[1]	Number of circuli in zone (i).
ID(i)	Measured size of zone (i).
TWO(i)	Distance from the beginning of zone (i) to the second circulus of zone (i).
FOUR(i)	Distance from the beginning of zone (i) to the fourth circulus of zone (i).
SIX(i)	Distance from the beginning of zone (i) to the sixth circulus of zone (i).
EIGHT(i)	Distance from the beginning of zone (i) to the eighth circulus of zone (i).
MIN(i)	Distance between the two closest circuli in zone (i).
MAX(i)	The maximum distance between two contigious circuli in zone (i).
LMIN(i)	The distance from the beginning of the zone (i) to the first circulus of variable MIN(i) in zone (i).
LMAX(i)	The distance from the beginning of zone (i) to the first circulus of variable MAX(i) in zone (i).
NCH(i)	The number of circuli in the first half of zone (i).

1 Where i = 1, 2, 3.

We classified catch samples from each period and age class during the chinook salmon season (periods 1-5), and pooled samples from periods 6-7 and periods 8-21.

1981 Analysis:

Three-way stock identification models were constructed from both age 1.3 and 1.4 scale measurements representing the lower, middle, and upper Yukon runs. Smaller sample sizes limited the age 1.3 model to 150 samples from each run while the age 1.4 model was composed of 200 samples from each run. Samples from individual spawning streams within each run were included in the model relative to their contribution to that run as measured by aerial survey data. All age 1.4 samples for the upper Yukon run were obtained from the Dawson City commercial catch. This fishery occurs downstream from the major spawning tributaries in the Canadian Yukon Territory and takes place throughout the duration of the run. We felt that these samples would provide better representation of the upper Yukon run than the pooled escapement samples. Because only 30 usable age 1.3 samples were obtained from the Dawson City fishery, we used age 1.3 escapement samples as previously described. Limited sample sizes also required that we pool catch samples from age 1.3 fish for the periods 1-2, 3-5, 6-7, and 8-19. These mixed stock samples also included all available samples from ADF&G test fishing projects[4] at the Yukon River mouth. We classified commercial catch samples from age 1.4 fish for each period during the chinook salmon season (periods 1-5), period 6, and pooled samples from periods 7-19.

RESULTS

Age Composition

We computed the age composition of the 1980 and 1981 District 1 harvest by applying age composition data for each period for both the chinook salmon season and the fall season (Appendix Tables 1-4) to the actual catch for that period (Appendix Tables 5 and 6). Similarly, we computed an age composition for each run by weighting age composition data from selected tributaries for the lower, middle, and upper Yukon River (Appendix Tables 7-12) by aerial survey estimates of abundance (Appendix Table 13).

Catch:

In 1980, the District 1 harvest of 87,871 chinook salmon (Table 2) was composed mostly of age 1.4 (47.5%) and 1.3 fish (47.4%) followed by age 1.2 (3.4%) and age 1.5 fish (1.7%). In 1981, the District 1 harvest of 99,219 chinook salmon (Table 3) was composed mostly of age 1.4 fish (76.3%) followed by age 1.3 (18.1%), age 1.2 (3.4%), and age 1.5 fish (2.2%). During both years, the percentage of

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[4] 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 unknown origin in District 1.

Table 2. Numbers by age class of chinook salmon in the commercial catches by period, District 1, Yukon River, 1980.

Period	Dates	N	1.2		1.3		1.4		1.5		Period Total
			No.	%	No.	%	No.	%	No.	%	
1	6/9 - 6/10	187	361	5.3	3,170	46.5	3,210	47.1	75	1.1	6,816
2	6/12 - 6/14	190	238	1.0	11,267	47.4	12,147	51.1	119	0.5	23,771
3	6/16 - 6/17	182	161	1.1	7,559	51.7	6,507	44.5	395	2.7	14,622
4	6/19 - 6/21	184	131	0.5	12,086	46.2	13,368	51.1	576	2.2	26,161
5	6/23 - 6/24	189	0	0	1,970	43.9	2,328	51.9	189	4.2	4,487
Chinook Salmon Season		932	891	1.2	36,052	47.5	37,560	49.5	1,354	1.8	75,857
6-7 [1]	6/26 - 7/1	219	1,204	18.3	3,092	47.0	2,223	33.8	59	0.9	6,578
8	7/2 - 7/4	165	489	15.1	1,533	47.3	1,122	34.6	97	3.0	3,241
9-21 [2]	7/7 - 8/19	78	395	18.0	1,012	46.1	788	35.9			2,195
Fall Season		462	2,088	17.4	5,637	46.9	4,133	34.4	156	1.3	12,014
Total		1,394	2,979	3.4	41,689	47.4	41,693	47.5	1,510	1.7	87,871

[1] Unweighted samples from periods 6 (N = 33) and 7 (N = 186).
[2] Unweighted samples from periods 9 (N = 72), 14 (N = 5), and 16 (N = 1).

Table 3. Numbers by age class of chinook salmon in the commercial catches by period, District 1, Yukon River, 1981.

Period	Dates	Sample Size	1.2 No.	1.2 %	1.3 No.	1.3 %	1.4 No.	1.4 %	1.5 No.	1.5 %	Period Total
1	6/5 - 6/6	185	56	0.5	2,223	20.0	8,593	77.3	245	2.2	11,117
2	6/8 - 6/9	189	0	0	3,888	24.9	11,571	74.1	156	1.0	15,615
3	6/11 - 6/12	177	87	0.6	3,027	20.9	11,123	76.8	246	1.7	14,483
4	6/15 - 6/16	191	183	1.0	2,215	12.1	15,339	83.8	567	3.1	18,304
5	6/18 - 6/19	190	456	1.6	4,363	15.3	22,958	80.5	742	2.6	28,519
Chinook Salmon Season		932	782	1.0	15,716	17.8	69,584	79.0	1,956	2.2	88,038
6	6/22 - 6/23	182	570	13.7	640	15.4	2,831	68.1	116	2.8	4,157
7-19[1]	6/25 - 8/18	197	2,002	28.5	1,602	22.8	3,315	47.2	105	1.5	7,024
Fall season		379	2,572	23.0	2,242	23.0	6,146	55.0	221	2.0	11,181
Total		1,329	3,354	3.4	17,958	18.1	75,730	76.3	2,177	2.2	99,219

[1] Unweighted samples from periods 7(N = 106), 8 (N = 40), 9 (N = 3), 10 (N = 10), 11 (N = 17), and 12 (N = 21).

age 1.4 fish was less during the fall season than during the chinook salmon season. Conversely, the percentage of age 1.2 fish increased between the same time periods. No temporal changes in age composition were observed within the chinook salmon season or fall season.

Escapement:

The age composition estimates for the runs to the lower, middle, and upper Yukon (Tables 4 and 5) were found to be significantly different (α = .005) in both 1980 (Table 6) and 1981 (Table 7). Significant differences in age composition were also found within the runs to the middle and upper Yukon runs in 1981 but this variability was much less than between the runs. No significant within-run variability in age composition was found in 1980.

Significant differences in the age composition between runs was due primarily to differences in ocean age. During both years, the percentage of age 1.2 and 1.3 fish progressively declined from the lower to upper Yukon runs (Figures 4 and 5). Conversely, the percentage of age 1.4 fish increased from the lower to the upper Yukon runs. The secondary reason for the significant differences in age composition between runs is that 2-freshwater age fish were found in significant numbers in only the upper Yukon.

Run Identification

For both age classes and years, the incremental distance (ID2) and number of circuli (NC2) in the freshwater plus growth zone increased from the lower to upper Yukon runs (Tables 8-11). Conversely, ID and NC in the zone of the first marine year's growth (i.e., Zone 3) declined from the lower to upper Yukon runs. The mean value for most of the other variables from the middle Yukon samples was intermediate between the lower and upper Yukon run samples.

Variable Selection Procedure:

Choosing the optimum subset for variables for inclusion in pattern recognition studies requires that all possible combinations of the available variables be evaluated with the classification rule. The optimum subset is that group which provides the best accuracy. Because there are 8.68 x 10^{36} possible subsets of 33 variables (3 zones with 11 variables computed for each zone), determination of the optimum subset is unrealistic. We, therefore, decided to plot Fisher weights of ranked variables in order to judge the relative contribution of each variable and exclude those which did not appear to add significant discriminatory power. The 1981 age 1.3 data base was arbitrarily chosen to evaluate this procedure.

The plot of the ordered variables (Figure 6) shows a significant decrease in the discriminatory power of variables entered after the first step. A second though much smaller decrease in Fisher weight values was observed between the fourth and fifth variable. Based upon the absolute and relative value of Fisher weights for variables after the fourt [ID(1)], we judged that inclusion of any of the other variables would not significantly increase classification accuracy, and might actually decrease accuracy. By computing classification accuracy of models which included the first two variables selected, the first three and so

Table 4. Age composition of chinook salmon escapements, weighted by aerial survey data, Yukon River, 1980.

Location	N	Escapement Count	Percent Age Composition 1.2	1.3	2.3	1.4	2.4	1.5
Lower								
Andreafsky River	67	2,458	23.9	56.7		16.4		3.0
Anvik River	83	1,330	24.1	50.6		21.7		3.6
Nulato River	21	1,323	19.0	38.1		38.1		4.8
Total	171	5,111	22.7	50.3		23.4		3.6
Middle								
Salcha River	293	6,757	17.8	44.7	0.3	35.5		1.7
Chena River	61	2,541	23.0	49.2	1.6	26.2		
Total	354	9,298	19.2	45.9	0.7	32.9		1.3
Upper								
Tatchum Creek	7	222	14.3	28.6		57.1		
Big Salmon River[1]	128	1,854	3.1	39.8		55.5	0.8	0.8
Teslin River[2]	109	2,272	0.9	41.3	0.9	49.5	3.7	3.7
Total	244	4,348	2.5	40.0	0.5	52.4	2.3	2.3

[1] Includes Little Salmon River.

[2] Includes Nisutlin, Wolf, Morley, Swift, Jennings, and Gladys Rivers.

Table 5. Age composition of chinook salmon escapements, weighted by aerial survey data, Yukon River, 1981.

Location	N	Escapement Estimate	Percent Age Composition									
			1.1	1.2	0.4	1.3	2.2	1.4	2.3	1.5	2.4	2.5
Lower												
Andreafsky River	297	2,377		9.8		34.6		55.3		0.3		
Anvik River	263	807		12.9		36.5	0.4	49.8		0.4		
Nulato River	41	791		4.9		34.1		56.1		4.9		
Total	601	3,975		9.6		34.8	-	54.4		1.2		
Middle												
Salcha River	490	1,237		6.3		28.8		64.5		0.4		
Chena River	105	600	1.0	1.0		22.8		74.2			1.0	
Total	595	1,837	0.3	4.6		26.8		67.7		0.3	0.3	
Upper												
Tatchun Creek	46	133		2.2		30.4	2.2	65.2				
Little Salmon R.	205	670		2.4		15.1		81.5		1.0		
Big Salmon R.	529	2,411		1.7		21.3		74.3	0.4	1.3	0.8	0.2
Nisutlin River	270	2,189		0.4	0.4	13.7		83.3	0.7	0.4	1.1	
Swift River	123	302				26.8		73.2				
Ross River	288	767		0.3		14.6		80.9	0.3	3.9		
Whitehorse Dam	233	595 [1]		2.6		20.2		73.8		2.2	1.2	
Total	1,694	7,067		1.2	0.1	17.9	0.1	78.2	0.4	1.3	0.7	0.1

[1] In order to make the 1,539 fish counted at the Whitehorse Fishway comparable to other aerial survey estimates, an approximation was made of the number of fish that would have been seen by aerial survey using data collected in 1980: (aerial survey estimate of Michie Creek in 1980/Fishway count in 1980) = 535/1,383 = .387, 1981: .387 x 1,539 = 595.

Table 6. Variability of escapement age composition estimates as estimated through chi-square analysis, Yukon River, 1980.

Areas Compared	Sample Size	Calculated Chi-square
Andreafsky River	67	
Anvik River	83	0.9
Chena River	61	
Salcha River	293	5.3
Big Salmon River	126	
Nisutlin River	85	6.1
Lower [1]	171	
Middle [2]	354	
Upper [3]	244	82.1****

**** Significantly different at α = .005

[1] Pooled samples, weighted by aerial survey data, from the Andreafsky, Anvik, and Nulato Rivers.

[2] Pooled samples, weighted by aerial survey data, from the Salcha and Chena Rivers.

[3] Pooled samples, weighted by aerial survey data, from the Tatchun, Big Salmon, Little Salmon, Nisutlin, and Swift Rivers.

Table 7. Variability of escapement age composition estimates as estimated through chi-square analysis, Yukon River, 1981.

Areas Compared	Sample Size	Calculated Chi-square
Andreafsky	297	
Anvik	263	3.3
Chena	105	
Salcha	490	15.4***
Little Salmon	205	
Big Salmon	529	
Nisutlin	270	
Ross	288	
Whitehorse	233	41.8**
Lower [1]	601	
Middle [2]	595	
Upper [3]	1,694	209.7****

** Significantly different at $\alpha = .05$

*** Significantly different at $\alpha = .01$

**** Significantly different at $\alpha = .005$

[1] Pooled samples, weighted by aerial survey data, from the Andreafsky, Anvik, and Nulato Rivers.

[2] Pooled samples, weighted by aerial survey data, from the Salcha and Chena Rivers.

[3] Pooled samples, weighted by aerial survey data, from the Tatchun, Little Salmon, Big Salmon, Nisutlin, Swift, and Ross Rivers and the Whitehorse fishway.

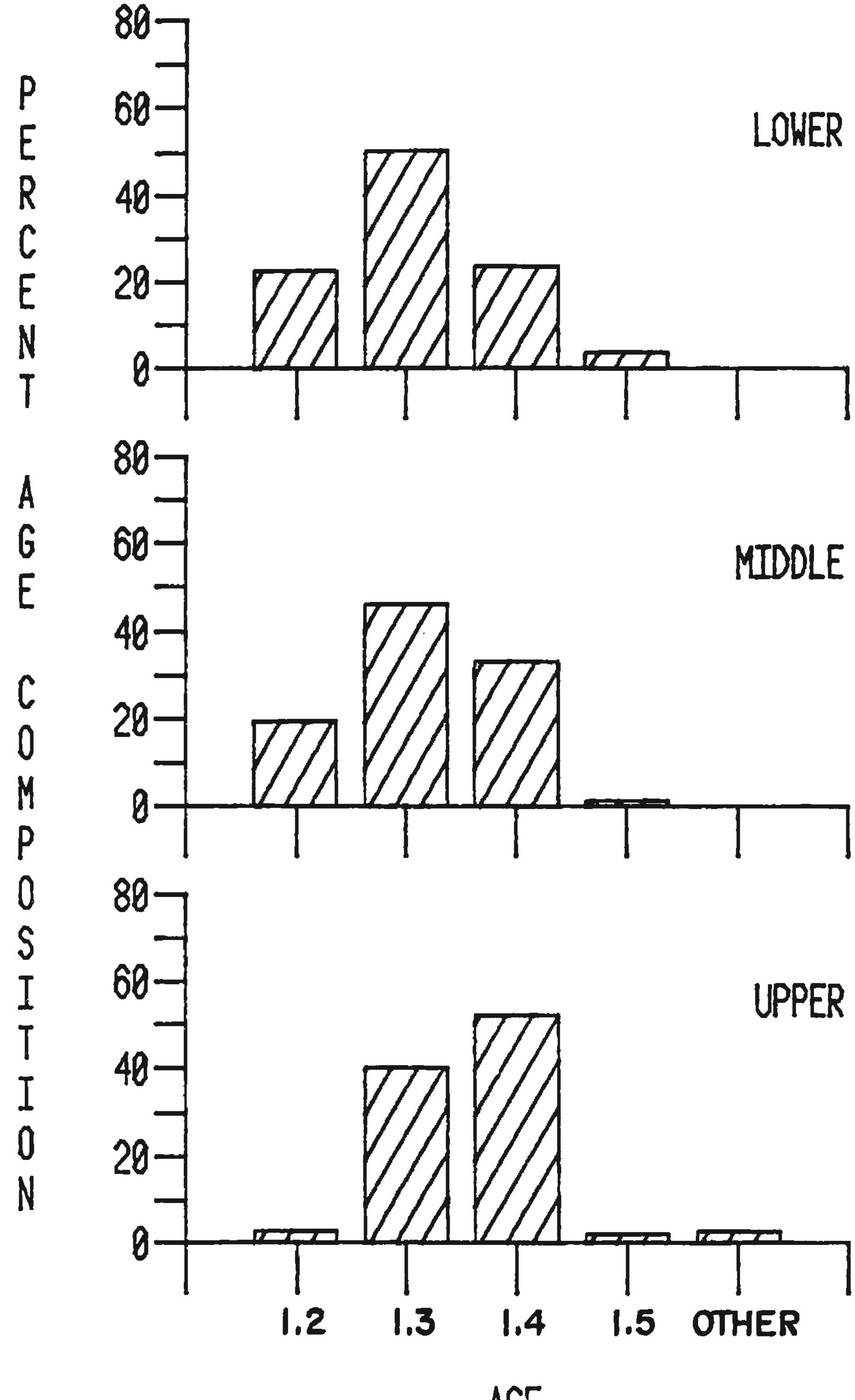

Figure 4. Age composition of the lower, middle, and upper Yukon runs, 1980. The 'other' category includes ages 2.3 and 2.4.

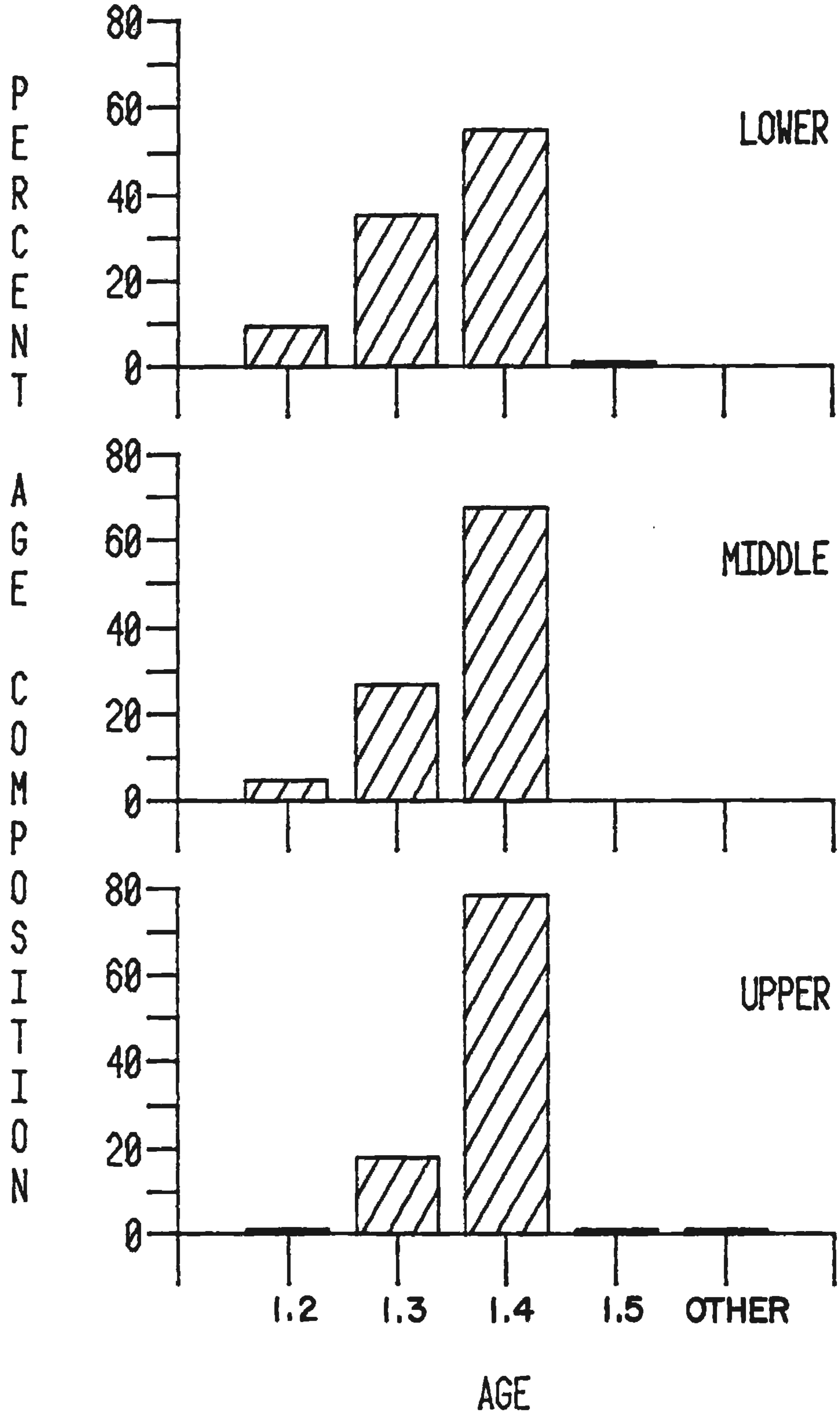

Figure 5. Age composition of the lower, middle, and upper Yukon runs, 1981. The 'Other' category includes ages 1.1, 0.4, 2.2, 2.4, and 2.5.

Table 8. Groups means, standard deviations, one-way analysis of variance F-test, and probability for equality of group means for scale variables measured from age 1.3 chinook salmon sampled at selected lower, middle and upper Yukon River sites, 1980.

Variable	Lower		Middle		Upper		F Value	Probability
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s		
TWO 1	61.4	7.4	56.7	7.9	60.6	7.5	9.1804	0.0001
FOUR 1	79.9	9.5	73.5	10.4	79.1	8.9	11.2712	0.0000
SIX 1	96.1	11.6	87.9	11.7	91.1	17.0	7.2397	0.0009
EIGHT 1	105.2	25.2	92.1	31.2	90.1	40.5	4.7481	0.0095
MAX 1	49.5	6.8	45.2	6.8	47.9	6.2	9.1936	0.0001
MIN 1	4.7	1.3	4.5	1.1	4.7	1.3	0.5845	0.5581
LMAX 1	1.0	0.0	1.0	0.0	1.0	0.0	0.0000	1.0000
LMIN 1	7.1	2.1	6.8	2.1	6.9	2.0	0.2851	0.7522
NC 1	9.8	1.6	9.3	1.3	9.0	1.9	5.2645	0.0058
ID 1	121.5	16.2	109.2	20.0	112.5	20.4	8.7287	0.0002
NCH 1	1.4	0.7	1.4	0.7	1.2	1.0	1.8994	0.1518
TWO 2	13.7	6.9	18.0	6.5	19.5	5.5	18.1672	0.0000
FOUR 2	7.2	13.9	26.8	19.5	41.5	11.0	100.9573	0.0000
SIX 2	2.4	11.6	17.6	28.1	47.4	30.7	66.0815	0.0000
EIGHT 2	0.0	0.0	4.4	18.3	27.9	40.7	27.0958	0.0000
MAX 2	10.4	2.8	12.8	3.1	15.0	3.4	44.0063	0.0000
MIN 2	6.7	2.0	7.2	2.2	6.8	1.9	1.4169	0.2444
LMAX 2	2.1	1.1	3.1	2.1	3.5	1.7	14.0559	0.0000
LMIN 2	1.4	0.7	2.4	1.7	2.9	2.5	12.2554	0.0000
NC 2	2.8	1.2	4.6	2.1	6.6	1.9	90.6256	0.0000
ID 2	23.3	12.0	46.6	23.3	71.0	22.0	112.6641	0.0000
NCH 2	1.1	0.7	1.9	1.2	3.4	5.1	12.0832	0.0000
TWO 3	24.9	5.4	29.4	6.9	29.2	6.9	12.1403	0.0000
FOUR 3	54.4	8.8	60.6	10.3	63.5	10.1	17.9163	0.0000
SIX 3	86.1	12.2	93.9	14.2	99.4	12.9	20.4380	0.0000
EIGHT 3	120.8	14.1	130.2	18.0	137.3	16.0	20.7778	0.0000
MAX 3	29.5	4.8	29.7	4.7	29.8	4.7	0.0474	0.9537
MIN 3	8.9	1.8	10.2	1.8	10.6	1.9	18.2225	0.0000
LMAX 3	19.4	5.6	18.6	6.8	15.3	6.5	9.7425	0.0001
LMIN 3	8.2	9.9	10.6	10.3	9.3	10.5	1.0626	0.3471
NC 3	30.6	2.7	30.1	2.8	27.2	2.6	39.5724	0.0000
ID 3	542.9	54.6	549.3	54.5	510.3	57.3	12.4786	0.0000
NCH 3	15.8	1.5	15.2	1.8	13.6	1.5	40.3283	0.0000
Sample Size	73		90		89			

Table 9. Groups means, standard deviations, one-way analysis of variance F-test, and probability for equality of group means for scale variables measured from age 1.4 chinook salmon sampled at selected lower, middle and upper Yukon River sites, 1980.

	Lower		Middle		Upper		F	
Variable	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	Value	Probability
TWO 1	62.5	8.6	55.1	7.3	49.2	7.9	41.6923	0.0000
FOUR 1	81.7	10.1	72.4	10.1	68.5	9.5	23.2996	0.0000
SIX 1	98.8	13.5	84.9	15.3	83.3	12.6	15.6103	0.0000
EIGHT 1	110.6	26.4	78.4	42.3	91.0	27.3	10.8657	0.0000
MAX 1	49.2	8.0	44.2	6.0	35.7	7.8	63.2656	0.0000
MIN 1	4.6	1.6	4.4	1.0	4.9	1.2	4.1866	0.0162
LMAX 1	1.0	0.0	1.0	0.0	1.0	0.0	0.0000	1.0000
LMIN 1	7.9	2.5	6.7	2.0	7.1	1.8	3.8597	0.0223
NC 1	10.7	1.9	9.1	1.8	9.8	1.7	9.6153	0.0001
ID 1	132.1	21.0	104.9	19.7	110.7	20.5	18.8366	0.0000
NCH 1	1.9	0.8	1.3	0.8	2.2	1.0	22.2938	0.0000
TWO 2	13.2	8.2	17.0	5.0	20.9	4.5	35.3273	0.0000
FOUR 2	8.9	16.5	31.3	14.1	39.5	12.5	64.2888	0.0000
SIX 2	1.6	8.5	30.8	28.7	41.7	30.7	24.2514	0.0000
EIGHT 2	0.0	0.0	12.7	27.1	24.0	37.8	8.0209	0.0004
MAX 2	9.9	3.1	13.1	3.3	14.3	2.6	28.2295	0.0000
MIN 2	7.0	2.2	6.5	2.0	7.1	1.7	2.8809	0.0578
LMAX 2	1.9	1.0	3.8	2.0	3.2	2.1	9.3706	0.0001
LMIN 2	1.4	0.6	2.4	1.5	3.3	2.1	16.2670	0.0000
NC 2	2.6	1.4	5.7	1.7	6.4	2.0	49.7565	0.0000
ID 2	22.5	13.5	53.3	18.0	67.0	22.9	58.0213	0.0000
NCH 2	1.0	0.8	2.5	1.1	2.7	1.2	27.8844	0.0000
TWO 3	25.9	5.1	26.9	6.0	29.3	5.6	7.6128	0.0006
FOUR 3	56.3	9.0	58.2	10.0	62.4	9.5	8.1553	0.0004
SIX 3	89.9	12.5	89.8	13.5	97.3	13.3	10.2199	0.0001
EIGHT 3	125.1	16.2	125.4	17.5	133.8	16.0	8.7718	0.0002
MAX 3	28.5	4.5	29.0	6.3	27.7	5.2	1.5256	0.2194
MIN 3	9.2	2.0	9.4	1.9	10.5	2.0	12.7906	0.0000
LMAX 3	16.4	5.6	14.0	6.1	11.7	4.8	11.9546	0.0000
LMIN 3	8.8	9.2	7.3	8.3	9.6	9.0	1.7300	0.1793
NC 3	26.4	3.1	25.9	2.7	23.0	2.6	42.5133	0.0000
ID 3	464.0	62.2	449.1	56.4	407.7	51.6	23.5283	0.0000
NCH 3	13.2	2.0	12.9	1.8	11.2	1.5	41.6794	0.0000
Sample Size	28		81		163			

Table 10. Groups means, standard deviations, one-way analysis of variance F-test, and probability for equality of group means for scale variables measured from age 1.3 chinook salmon sampled at selected lower, middle and upper Yukon River sites, 1981.

	Lower		Middle		Upper		F	
Variable	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	Value	Probability
TWO 1	47.3	5.2	48.0	5.8	46.8	6.3	1.82	0.1634
FOUR 1	68.2	7.5	70.1	8.4	67.1	9.2	4.94	0.0075
SIX 1	83.7	9.3	86.1	10.1	82.0	11.2	6.12	0.0024
EIGHT 1	97.0	10.5	99.0	11.6	94.3	12.4	6.60	0.0015
MAX 1	33.2	4.3	32.8	4.7	32.2	5.0	1.83	0.1620
MIN 1	4.2	1.1	4.4	1.3	4.1	1.2	2.20	0.1115
LMAX 1	1.0	0.0	1.0	0.0	1.0	0.0	0.00	1.0000
LMIN 1	8.2	2.1	7.9	1.8	7.7	1.8	2.29	0.1019
NC 1	11.2	1.4	10.2	1.0	10.4	1.5	22.37	0.0000
ID 1	117.2	16.3	113.6	16.0	109.9	18.6	7.13	0.0009
NCH 1	2.5	0.7	2.3	0.7	2.3	0.9	5.23	0.0057
TWO 2	17.5	4.6	19.4	4.4	21.0	5.2	20.42	0.0000
FOUR 2	28.6	17.8	38.2	11.3	41.4	11.2	36.70	0.0000
SIX 2	9.7	22.7	34.0	31.1	49.1	29.3	78.07	0.0000
EIGHT 2	2.2	13.5	7.7	24.3	24.5	39.6	26.64	0.0000
MAX 2	12.6	3.1	13.5	2.7	14.6	3.2	17.11	0.0000
MIN 2	6.7	2.2	7.0	1.8	7.0	2.0	1.13	0.3231
LMAX 2	3.0	1.4	3.5	1.8	3.6	2.4	4.42	0.0125
LMIN 2	2.0	1.4	2.6	1.6	3.3	2.3	19.55	0.0000
NC 2	4.3	1.4	5.7	1.3	6.7	2.6	71.27	0.0000
ID 2	41.8	17.4	59.9	16.7	72.0	40.1	47.45	0.0000
NCH 2	2.2	4.0	2.5	0.8	2.9	1.3	3.04	0.0488
TWO 3	27.6	5.0	27.7	5.2	28.1	6.3	0.27	0.7657
FOUR 3	56.4	7.6	58.4	8.4	58.2	10.7	2.27	0.1040
SIX 3	87.9	10.6	90.1	11.1	91.9	14.4	4.06	0.0178
EIGHT 3	120.0	13.3	125.0	14.4	126.5	18.3	7.45	0.0007
MAX 3	27.8	4.3	28.1	4.0	29.7	34.2	0.40	0.6715
MIN 3	8.9	1.9	9.0	2.2	12.2	35.4	1.24	0.2903
LMAX 3	17.4	5.1	16.3	5.1	14.1	5.0	17.46	0.0000
LMIN 3	11.1	10.3	10.9	10.5	9.9	8.8	0.70	0.4955
NC 3	27.4	2.8	26.4	2.3	24.9	3.3	30.18	0.0000
ID 3	468.7	57.2	466.2	51.0	435.5	55.9	17.93	0.0000
NCH 3	14.1	1.7	13.3	1.4	12.3	1.9	42.80	0.0000
ID 4	416.6	75.4	428.8	66.7	416.3	78.3	1.43	0.2403
Sample Size	150		150		150			

Table 11. Groups means, standard deviations, one-way analysis of variance F-test, and probability for equality of group means for scale variables measured from age 1.4 chinook salmon sampled at selected lower, middle and upper Yukon River sites, 1981.

Variable	Lower		Middle		Upper		F	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	Value	Probability
TWO 1	50.3	6.5	47.4	6.9	48.1	6.6	10.02	0.0001
FOUR 1	70.2	8.2	66.9	9.5	66.8	9.4	9.05	0.0001
SIX 1	86.2	10.4	82.1	11.0	80.2	11.4	15.71	0.0000
EIGHT 1	98.7	15.1	95.8	12.5	81.4	33.1	34.70	0.0000
MAX 1	36.2	5.2	33.7	5.5	33.6	5.2	15.74	0.0000
MIN 1	4.2	1.3	4.5	1.2	4.2	1.1	4.91	0.0077
LMAX 1	1.0	0.0	1.0	0.0	1.0	0.0	0.00	1.0000
LMIN 1	7.9	2.0	7.6	2.1	6.8	1.7	17.27	0.0000
NC 1	10.4	1.5	10.7	1.2	9.1	1.4	76.63	0.0000
ID 1	115.0	17.2	113.9	17.0	99.8	17.4	49.02	0.0000
NCH 1	2.2	0.7	2.5	0.7	1.7	0.8	51.13	0.0000
TWO 2	16.9	6.2	20.3	4.5	19.6	4.9	23.94	0.0000
FOUR 2	12.8	19.1	37.3	13.9	38.7	10.7	189.03	0.0000
SIX 2	1.5	9.5	18.3	29.0	33.9	31.3	82.42	0.0000
EIGHT 2	0.0	0.0	1.3	10.6	9.6	26.2	20.33	0.0000
MAX 2	11.6	2.9	13.9	2.5	14.1	2.6	52.30	0.0000
MIN 2	7.5	2.2	7.7	1.9	6.9	1.8	9.87	0.0001
LMAX 2	2.4	1.2	3.2	1.7	3.7	1.8	33.65	0.0000
LMIN 2	1.6	0.9	2.4	1.4	2.7	1.9	30.84	0.0000
NC 2	3.1	1.2	4.9	1.2	5.8	1.4	250.78	0.0000
ID 2	29.2	13.5	52.0	14.6	59.9	16.4	228.20	0.0000
NCH 2	1.2	0.7	2.1	0.7	2.5	0.9	153.89	0.0000
TWO 3	26.2	5.5	28.8	5.3	28.6	4.9	14.77	0.0000
FOUR 3	55.3	8.9	60.1	8.3	60.2	8.2	21.56	0.0000
SIX 3	86.3	11.9	94.5	11.2	92.6	11.1	28.18	0.0000
EIGHT 3	116.9	14.6	128.9	13.6	125.1	13.4	38.62	0.0000
MAX 3	26.6	4.0	27.3	3.3	25.9	3.6	7.84	0.0004
MIN 3	8.8	1.9	9.7	2.0	9.3	2.0	9.19	0.0001
LMAX 3	19.2	5.9	17.6	6.2	16.4	5.4	11.77	0.0000
LMIN 3	9.4	9.9	10.5	10.1	11.7	9.8	2.73	0.0662
NC 3	29.9	2.6	29.2	2.4	26.7	2.5	90.15	0.0000
ID 3	502.0	55.4	515.4	50.6	451.1	59.8	75.04	0.0000
NCH 3	15.5	1.6	14.7	1.5	13.4	1.5	100.19	0.0000
ID 4	395.6	60.4	412.7	56.7	382.5	61.3	12.99	0.0000
ID 5	384.5	59.5	398.4	55.8	357.1	56.4	27.01	0.0000
Sample Size	200		200		200			

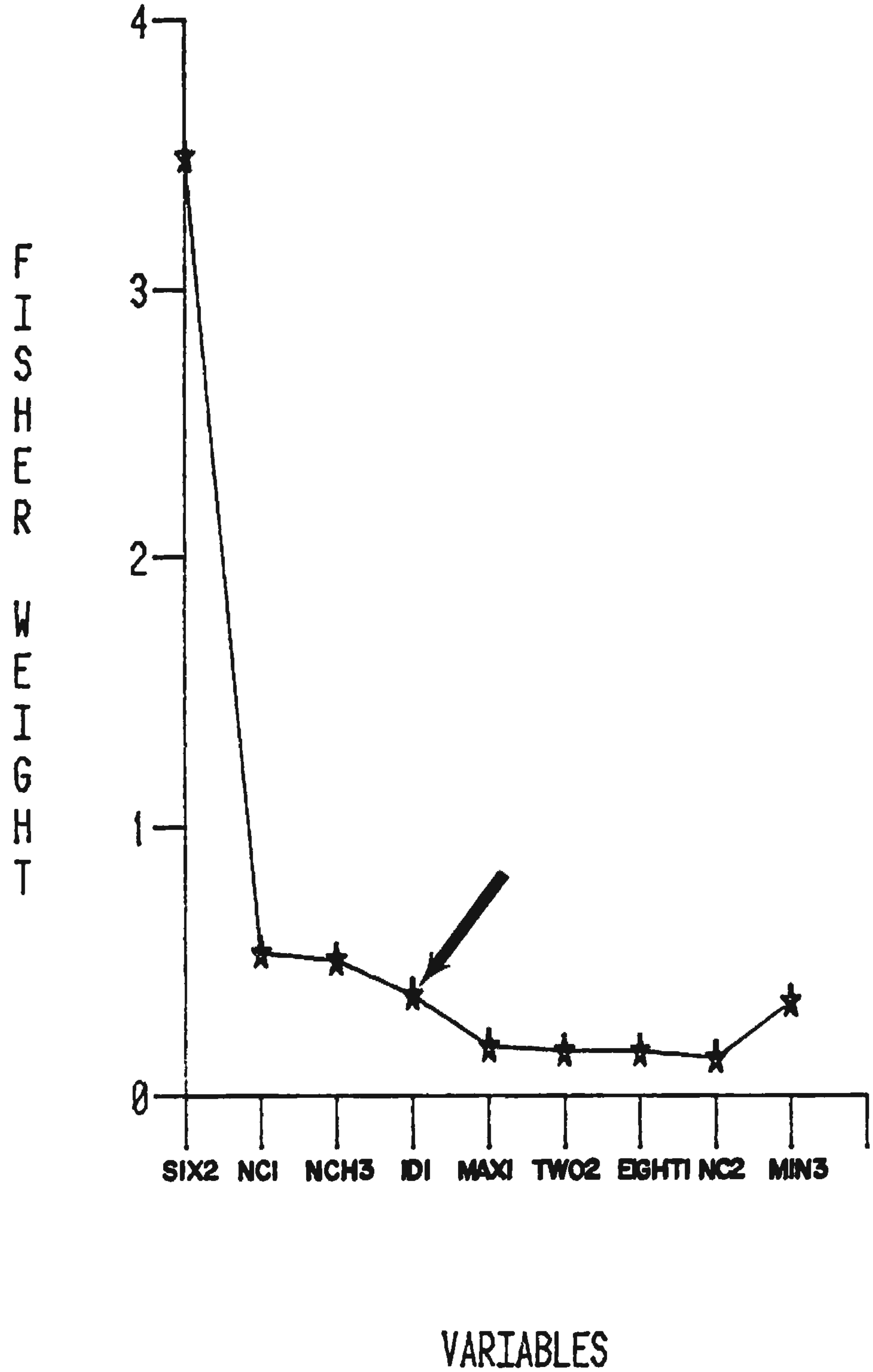

Figure 6. Fisher weights of the top ranked variables, and those variables included in the final classification model (arrow), as determined from nearest neighbor analysis of age 1.3 lower, middle, upper Yukon fish, 1981. Fisher weights are expressed in scientific notation (x 10^{-3}).

forth up to six (Table 12), we concluded that this procedure yielded an acceptable subset of variables. Similar plots for each model used in this study (Appendix Figures 1-7) resulted in inclusion of from two to five variables.

1980 Analysis:

Classification accuracy for the 3-way model of age 1.3 fish was 71.7% (Table 13). Middle Yukon fish showed the poorest classification accuracy (53.4%) and were equally misclassified to the lower and upper Yukon runs (23.3%). Lower Yukon fish were seldom confused with upper Yukon fish (1.4%) and similarly, upper Yukon fish were seldom confused with lower Yukon fish (4.1%). The classification accuracy of 93.2% for the 2-way model between the lower and upper Yukon runs was extremely high while the classification accuracy of 71.9% for the 2-way model between the middle and upper Yukon runs was only marginally acceptable. Classification accuracy for the 2-way model between age 1.4 Alaskan (i.e., fish of lower and middle Yukon River origin) and Canadian (upper) Yukon runs was 81.6% (Table 14).

Point estimates and corresponding confidence intervals for the contribution of age 1.3 fish to the commercial harvest in District 1 indicate that upper Yukon fish predominated the catch in all but the one period of 19-21 June (Table 15). Corresponding data for age 1.4 fish (Table 16) indicate that Alaskan fish were most abundant in all but the one period of 19-21 June. Neither of these data sets indicate a sequential pattern of time-of-entry of the component runs. Expansion of these point estimates to numbers of fish for age class 1.3 (Table 17) indicate that upper Yukon fish accounted for about 57.6% of the age 1.3 harvest, middle Yukon fish accounted for approximately 24.9%, and lower Yukon fish comprised about 17.5%. Expansion for age class 1.4 indicate a dominance of Alaskan Yukon fish (70.6%), while we estimated that upper Yukon fish accounted for 29.4%. For both age classes combined, we estimated that 56.6% were of Alaskan (i.e., lower and middle) Yukon origin while 43.6% were of upper Yukon origin. Contribution rates were not directly estimated for age 1.2 and 1.5 fish. However, it is possible to infer from age composition data collected from spawning sites (see Figure 4) that most of the age 1.2 fish were probably of lower and middle Yukon origin.

1981 Analysis:

The classification accuracy of 58.2% for the 3-way model (Table 18) for age 1.3 fish was quite low and substantially less than that observed in 1980 (71.7%, Table 13). As with the 1980 model, the tendency for lower Yukon fish to be confused with upper Yukon fish (9.4%) and vice-versa (16.7%) was low. There was a tendency for middle Yukon fish to resemble lower Yukon fish (27.3%) more than upper Yukon fish (18.7%) in this model. Lower Yukon fish were the most distinct (66.6% accuracy) while middle and upper Yukon fish exhibited the same (54.0%) low accuracy. Overall classification accuracy for the 2-way model of lower vs upper Yukon fish was fairly high at 80.7% with lower Yukon fish again exhibiting the highest accuracy (84.0%). The 3-way model for age 1.4 (Table 19) fish exhibited an overall classification accuracy of 69.5%. Classification trends were similar to the age 1.3 model in that: (1) lower Yukon fish showed the highest classification accuracy (72.0%), (2) lower Yukon

Table 12. Test classification matrices for nearest neighbor analysis of age 1.3 lower, middle, and upper Yukon River chinook salmon, 1981.

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = SIX2, NC1)		
		Lower	Middle	Upper
Lower	150	.840	.060	.100
Middle	150	.447	.333	.220
Upper	150	.267	.220	.513

Average Correctly Classified = .562

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = SIX2, NCI, NCH3)		
		Lower	Middle	Upper
Lower	150	.753	.147	.100
Middle	150	.320	.473	.207
Upper	150	.180	.300	.513

Average Correctly Classified = .582

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = SIX2, NC1, NCH3, ID1)		
		Lower	Middle	Upper
Lower	150	.693	.213	.094
Middle	150	.247	.573	.180
Upper	150	.167	.340	.493

Average Correctly Classified = .591

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = SIX2, NC1, NCH3, ID1, MAX1)		
		Lower	Middle	Upper
Lower	150	.680	.193	.127
Middle	150	.247	.540	.213
Upper	150	.160	.360	.480

Average Correctly Classified = .571

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = SIX2, NC1, NCH3, ID1, MAX1, TWO2)		
		Lower	Middle	Upper
Lower	150	.700	.207	.093
Middle	150	.273	.473	.254
Upper	150	.133	.380	.487

Average Correctly Classified = .553

Table 13. Test classification matrices for nearest neighbor analysis of age 1.3, Yukon River chinook salmon, 1980.

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID2, NC3, FOUR1, EIGHT2, TWO3)		
		Lower	Middle	Upper
Lower	73	.781	.205	.014
Middle	73	.233	.534	.233
Upper	73	.041	.123	.836

Average Correctly Classified = .717

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = ID2, FOUR2, NC3)	
		Lower	Upper
Lower	73	.932	.068
Upper	73	.068	.932

Average Correctly Classified = .932

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = NC3, FOUR2, TWO3)	
		Middle	Upper
Middle	73	.712	.288
Upper	73	.274	.726

Average Correctly Classified = .719

Table 14. Test classification matrix for nearest neighbor analysis of age 1.4, Yukon River chinook salmon, 1980.

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = MAX1, NCH3, TWO2)	
		Alaskan [1]	Upper
Alaskan [1]	109	.816	.184
Upper	109	.184	.816
		Average Correctly Classified = .816	

[1] Due to insufficient sample sizes, samples were pooled from the lower (N=28) and middle (N=81) Yukon runs (i.e. fish of Alaskan origin).

Table 15. Sample sizes of unknown fish, age class specific run composition estimates and 90% confidence intervals calculated from scale pattern analysis of age 1.3 chinook salmon, District 1, Yukon River, 1980.

Period	Dates	N	Lower	Middle	Upper
1	6/9 - 6/10	52	.278± .236	.173± .379	.549± .273
2	6/12 - 6/14	65	.223± .199	.112± .353	.665± .260
3	6/16 - 6/17	61	.244± .118	[1]	.756± .118
4	6/19 - 6/21	48	[2]	.607± .306	.393± .306
5	6/23 - 6/24	62	.127± .196	.216± .376	.657± .271
6 - 7 [3]	6/26 - 7/1	57	.204± .222	.245± .379	.551± .269
8 - 21 [4]	7/2 - 8/19	66	.469± .244	.020± .321	.511± .213

[1] Original 3-way classification model yielded a negative value for the middle Yukon corrected run composition estimate (-.067± .359).

[2] Original 3-way classification model yielded a negative value for the lower Yukon corrected run composition estimate (-.033± .252).

[3] Samples from Period 7 only.

[4] Samples from Periods 8 (N=47), 9 (N=17), and 14 (N=2) only.

Table 16. Sample sizes of unknown fish, age class specific run composition estimates, and 90% confidence intervals calculated from scale patterns analysis of age 1.4 chinook salmon, District 1, Yukon River, 1980.

Period	Dates	N	Alaskan [1]	Upper
1	6/9 - 6/10	48	.827 ± .189	.173 ± .189
2	6/12 - 6/14	63	.786 ± .171	.214 ± .171
3	6/16 - 6/17	61	.822 ± .172	.178 ± .172
4	6/19 - 6/21	57	.486 ± .185	.514 ± .185
5	6/23 - 6/24	63	.786 ± .171	.214 ± .171
6 - 7 [2]	6/26 - 7/1	45	1.000 ± .177	.000 ± .177
8 - 21 [3]	7/2 - 8/19	46	.705 ± .199	.295 ± .199

[1] Due to insufficient sample sizes, samples for standards were pooled from the lower (N=28) and middle (N=81) Yukon runs (i.e. fish of Alaskan origin).
[2] Samples from Period 7 only.
[3] Samples from Periods 8 (34), 9 (9), and 14 (3) only.

Table 17. Run composition estimates of age 1.3 and 1.4 chinook salmon catches, District 1, Yukon River, 1980.

Period	Dates	Run	1.3 %	1.3 No.	1.4 %	1.4 No.	Total %	Total No.
1	6/9 - 6/10	Lower	27.8	881				
		Middle	17.3	549				
		Alaskan Subtotal	45.1	1,430	82.7	2,655	64.0	4,085
		Upper	54.9	1,740	17.3	555	36.0	2,295
		Total	100.0	3,170	100.0	3,210	100.0	6,380
2	6/12 - 6/14	Lower	22.3	2,512				
		Middle	11.2	1,262				
		Alaskan Subtotal	33.5	3,774	78.6	9,548	56.9	13,322
		Upper	66.5	7,493	21.4	2,599	43.1	10,092
		Total	100.0	11,267	100.0	12,147	100.0	23,414
3	6/16 - 6/17	Lower	24.4	1,844				
		Middle	0.0	tr				tr
		Alaskan Subtotal	24.4	1,844	82.2	5,349	51.1	7,193
		Upper	75.6	5,715	17.8	1,158	48.9	6,873
		Total	100.0	7,559	100.0	6,507	100.0	14,066
4	6/19 - 6/21	Lower	0.0	tr				
		Middle	60.7	7,336				tr
		Alaskan Subtotal	60.7	7,336	48.6	6,497	54.4	13,833
		Upper	39.3	4,750	51.4	6,871	45.6	11,621
		Total	100.0	12,086	100.0	13,368	100.0	25,454
5	6/23 - 6/24	Lower	12.7	250				
		Middle	21.6	426				
		Alaskan Subtotal	34.3	676	78.6	1,830	58.3	2,506
		Upper	65.7	1,294	21.4	498	41.7	1,792
		Total	100.0	1,970	100.0	2,328	100.0	4,298
1 - 5	Chinook Salmon Season Subtotal	Lower	15.2	5,487				
		Middle	26.6	9,573				
		Alaskan Subtotal	41.8	15,060	68.1	25,879	55.6	40,939
		Upper	58.2	20,992	31.1	11,681	44.4	32,673
		Total	100.0	36,052	100.0	37,560	100.0	73,612

Continued

Table 17. Run composition estimates of age 1.3 and 1.4 chinook salmon catches, District 1, Yukon River, 1980 (cont.).

Period	Dates	Run	1.3 %	1.3 No.	1.4 %	1.4 No.	Total %	Total No.
6 - 7	6/26 - 7/1	Lower	20.4	631				
		Middle	24.5	757				
		Alaskan Subtotal	44.9	1,388	100.0	2,223	67.9	3,611
		Upper	55.1	1,704	0.0	tr	32.1	1,704
		Total	100.0	3,092	100.0	2,223	100.0	5,315
8 - 21	7/2 - 8/19	Lower	46.9	1,194				
		Middle	2.0	51				
		Alaskan Subtotal	48.9	1,245	70.5	1,347	58.2	2,592
		Upper	51.1	1,300	29.5	563	41.8	1,863
		Total	100.0	2,545	100.0	1,910	100.0	4,455
6 - 21	Fall Season Sub Total	Lower	32.4	1,825				
		Middle	14.3	808				
		Alaskan Subtotal	46.7	2,633	86.4	3,570	63.5	6,203
		Upper	53.3	3,004	13.6	563	36.5	3,567
		Total	100.0	5,637	100.0	4,133	100.0	9,770
	Total	Lower	17.5	7,312				
		Middle	24.9	10,381				
		Alaskan Subtotal	42.4	17,693	70.6	29,449	56.5	47,142
		Upper	57.6	23,996	29.4	12,244	43.6	36,240
		Total	100.0	41,689	100.0	41,693	100.0	83,382

tr = trace

Table 18. Test classification matrices for nearest neighbor analysis of age 1.3 Yukon River chinook salmon, 1981.

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = SIX2, NC1, NCH3, ID1)		
		Lower	Middle	Upper
Lower	150	.666	.240	.094
Middle	150	.273	.540	.187
Upper	150	.167	.293	.540

Average Correctly Classified = .582

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = SIX2, NCH3)	
		Lower	Upper
Lower	150	.840	.160
Upper	150	.227	.773

Average Correctly Classified = .807

Table 19. Test classification matrices for nearest neighbor analysis of age 1.4 Yukon River chinook salmon, 1981.

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = NC2, NC1, EIGHT2, ID3)		
		Lower	Middle	Upper
Lower	200	.720	.200	.080
Middle	200	.135	.705	.160
Upper	200	.110	.230	.660

Average Correctly Classified = .695

Actual Group of Origin	Sample Size	Classified Group of Origin (Variables = NC1, ID3, TWO1)	
		Middle	Upper
Middle	200	.805	.195
Upper	200	.225	.775

Average Correctly Classified = .790

fish were seldom classified as upper Yukon fish (8.0%) and vice-versa (11.0%), and (3) middle and upper Yukon fish showed lower classification accuracies (70.5 and 66.0%, respectively). The 2-way model for age 1.4 middle vs upper Yukon runs was 79.0% with approximately equal tendencies for misclassification (19.5 and 22.5%, respectively).

Temporal differences in the point estimates of the age 1.3 run composition were evident (Table 20) as the percentage of lower Yukon fish increased over time (2.0 to 55.4%) while the percentage of upper Yukon fish declined (76.4 to 44.6%). Confidence intervals based on the analysis were large however, ranging from .201 to .595. All point estimates computed for age 1.4 lower Yukon run composition using the 3-way model were negative and ranged from -.020 to -.139 (Table 21). However, confidence intervals around these estimates exhibited a range from .115 to .147 indicating that this run may have been present in the District 1 catch in low abundance. As a result of these negative estimates, the catch allocation for age 1.4 fish was accomplished with a 2-way model between the middle and upper Yukon runs. This analysis suggests that middle Yukon fish were consistently most abundant (range 71.2 - 88.4%) and that no temporal patterns in time-of-entry were evident.

Expansion of the point estimates to numbers of fish (Table 22) indicates that among age class 1.3, the upper Yukon run predominated (59.0%) followed by the lower Yukon run (32.3%) and the middle Yukon run (8.7%). For age class 1.4, middle Yukon fish were most abundant (77.7%) followed by the upper Yukon (22.3%). We allocated no age 1.4 fish to the lower Yukon run but believe that they were present in low numbers based upon the fact that confidence intervals for the 3-way model exceeded zero. When abundance estimates for the two age classes were combined, we estimated that about 64.5% were destined for middle Yukon spawning sites, 29.3% to upper Yukon sites and 6.2% to lower Yukon sites.

As with the 1980 data, insufficient samples were available to make point estimates for the contribution of age classes 1.2 or 1.5. We believe, however, that the extremely low incidence of age 1.2 fish in the upper Yukon spawning ground samples suggest that most of these fish were bound for lower and middle Yukon spawning sites.

DISCUSSION

Age Composition

The relatively small difference in age composition observed within each run lends support to our geographical grouping of stocks. The significant differences in age composition observed between the lower, middle, and upper Yukon runs provides a potentially powerful stock identification tool for the lower river fishery. However, it is not possible to use age composition data to allocate catches until the magnitude of the escapements to each area are better defined and the selective effects of the fishery are better understood.

Table 20. Sample sizes of unknown fish, age class specific run composition estimates, and 90% confidence intervals calculated from scale pattern analysis of age 1.3 chinook salmon, District 1, Yukon River, 1981.

Period	Dates	N	Lower	Middle	Upper
1 - 2 [1]	6/5 - 6/9	57	.020± .267	.216± .574	.764± .497
3 - 5 [2]	6/11 - 6/19	49	.496± .201	[3]	.504± .201
6 - 7 [4]	6/22 - 6/26	41	.305± .351	.180± .595	.515± .506
8 - 19 [5]	6/29 - 8/18	30	.554± .250	[6]	.446± .250

[1] Samples from Big Eddy test fish project, 6/1-6/4 (N=7); Period 1 (N=15); and Period 2 (N=29).

[2] Samples from Periods 3 (N=23), 4 (N=10), and 5 (N=16).

[3] Original 3-way classification model yielded a negative value for the middle river corrected stock composition estimate (-.015± .512).

[4] Samples from Periods 6 (N=17); and 7 (N=15); and Big Eddy test fish project; 6/21-6/26 (N=9).

[5] Samples from periods 8 (N=5); 9 (N=1); 10 (N=3); 11 (N=3); and 12 (N=4); and Big Eddy test fish project, 6/28-7/14 (N=14).

[6] Original 3-way calssification model yielded a negative value for the middle river corrected run composition estimate (-.151± .636).

Table 21. Sample sizes of unknown fish, age class specific run composition estimates, and 90% confidence intervals calculated from scale patterns analysis of age 1.4 chinook salmon, District 1, Yukon River, 1981.

Period	Dates	N	Lower	Middle	Upper
1	6/5 - 6/6	83	[1]	.712± .162	.288± .162
2	6/8 - 6/9	88	[1]	.884± .151	.116± .151
3	6/11 - 6/12	80	[1]	.689± .165	.311± .165
4	6/15 - 6/16	88	[1]	.747± .157	.253± .157
5	6/18 - 6/19	86	[1]	.794± .156	.206± .156
6	6/22 - 6/23	68	[1]	.828± .171	.172± .171
7 - 19[2]	6/25 - 8/18	57	[1]	.851± .182	.149± .182

[1] Original 3-way classification model yielded a negative value for the lower river corrected run composition estimate.

Period 1	-.135± .119
Period 2	-.139± .115
Period 3	-.050± .145
Period 4	-.057± .130
Period 5	-.020± .145
Period 6	-.121± .136
Period 7	-.099± .147

[2] Samples from Periods 7 (N=31), 8 (N=13), 10 (N=4), 11 (N=2), and 12 (N=7).

Table 22. Run composition estimates of age 1.3 and 1.4 chinook salmon catches, District 1, Yukon River, 1981.

Period	Dates	Run	1.3 %	1.3 No.	1.4 %	1.4 No.	Total %	Total No.
1	6/5 - 6/6	Lower	2.0[1]	44	0.0		0.4	44
		Middle	21.6[1]	481	71.2	6,118	61.0	6,599
		Alaskan Subtotal	23.6	525	71.2	6,118	61.4	6,643
		Upper	76.4	1,698	28.8	2,475	38.6	4,173
		Total	100.0	2,223	100.0	8,593	100.0	10,816
2	6/8 - 6/9	Lower	2.0[1]	78	0.0		0.5	78
		Middle	21.6[1]	840	88.4	10,229	71.6	11,069
		Alaskan Subtotal	23.6[1]	981	88.4	10,229	72.1	11,147
		Upper	76.4[1]	2,970	11.6	1,342	27.9	4,312
		Total	100.0	3,888	100.0	11,571	100.0	15,459
3	6/11 - 6/12	Lower	49.6[2]	1,501	0.0	tr	10.6	1,501
		Middle	0.0[2]	tr	68.9	7,664	54.2	7,664
		Alaskan Subtotal	49.6[2]	1,501	68.9	7,664	64.8	9,165
		Upper	50.4[2]	1,526	31.1	3,459	35.2	4,985
		Total	100.0	3,027	100.0	11,123	100.0	14,150
4	6/15 - 6/16	Lower	49.6[2]	1,099	0.0	tr	6.3	1,099
		Middle	0.0[2]	tr	74.7	11,458	65.2	11,458
		Alaskan Subtotal	49.6[2]	1,099	74.7	11,458	71.5	12,557
		Upper	50.4[2]	1,116	25.3	3,881	28.5	4,997
		Total	100.0[2]	2,215	100.0	15,339	100.0	17,554
5	6/18 - 6/19	Lower	49.6	2,164	0.0	tr	7.9	2,164
		Middle	0.0	tr	79.4	18,229	66.7	18,229
		Alaskan Subtotal	49.6	2,164	79.4	18,229	74.6	20,393
		Upper	50.4	2,199	20.6	4,729	25.4	6,928
		Total	100.0	4,363	100.0	22,958	100.0	27,321
1 - 5	Chinook Salmon Season Subtotal	Lower	31.1	4,886	0.0	tr	5.7	4,886
		Middle	8.4	1,321	77.2	53,698	64.5	55,019
		Alaskan Subtotal	39.5	6,207	77.2	53,698	70.2	59,905
		Upper	60.5	9,509	22.8	15,886	29.8	25,395
		Total	100.0	15,716	100.0	69,584	100.0	85,300

-Continued-

Table 22. Run composition estimates of age 1.3 and 1.4 chinook salmon catches, District 1, Yukon River, 1981 (continued).

Period	Dates	Run	1.3 %	1.3 No.	1.4 %	1.4 No.	Total %	Total No.
6	6/22 - 6/23	Lower	30.5[3]	195	0.0	tr	5.7	195
		Middle	18.0[3]	115	82.8	2,344	70.8	2.459
		Alaskan Subtotal	48.5[3]	310	82.8	2,344	76.5	2,654
		Upper	51.5[3]	330	17.2	487	23.5	817
		Total	100.0	540	100.0	2,831	100.0	3,471
7	6/25 - 6/26	Lower	30.5	202	0.0[5]	tr	10.0	202
		Middle	18.0	119	85.1[5]	1,165	63.2	1,284
		Alaskan Subtotal	48.5	321	85.1[5]	1,165	73.2	1,486
		Upper	51.5	340	14.9[5]	204	26.8	544
		Total	100.0	661[4]	100.0	1,369[4]	100.0	2,030
8 - 19	6/29 - 8/18	Lower	55.4[6]	521	0.0[5]	tr	18.0	521
		Middle	0.0[6]	tr	85.1[5]	1,656	57.4	1,656
		Alaskan Subtotal	55.4[6]	521	85.1[5]	1,656	75.4	2,177
		Upper	44.6[6]	420	14.9[5]	290	24.6	710
		Total	100.0	941[4]	100.0	1,946[4]	100.0	2,887[4]
6 - 19	Fall Season Subtotal	Lower	41.0	918	0.0	tr	10.9	918
		Middle	10.4	234	84.0	5,165	64.4	5,399
		Alaskan Subtotal	51.4	1,152	84.0	5,165	75.3	6,317
		Upper	48.6	1,090	16.0	981	24.7	2,071
		Total	100.0	2,242	100.0	6,146	100.0	8,388
	Total	Lower	32.3	5,804	0.0	tr	6.2	5,804
		Middle	8.7	1,555	77.7	58,863	64.5	60,418
		Alaskan Subtotal	41.0	7,359	77.7	58,863	70.7	66,222
		Upper	59.0	10,599	22.3	16,867	29.3	27,466
		Total	100.0	17,958	100.0	75,730	100.0	93,688

[1] Pooled samples from Periods 1 and 2.
[2] Pooled samples from Periods 3 - 5.
[3] Pooled samples from Periods 6 and 7.
[4] Pooled samples from Periods 7 - 19.
[5] Pooled samples from Periods 7 - 19.
[6] Pooled samples from Periods 8 - 19.

Scale Analysis

The original 3-way analysis of 1981 age 1.4 fish resulted in negative values for each point estimate of lower Yukon run composition. However, in 90% confidence intervals associated with these estimates show that the contribution of age 1.4 lower Yukon fish could have been as high as 12.5% during some periods (see Table 21). We believe that it is unlikely that the lower Yukon run did not contribute to the commercial harvest of age 1.4 fish in 1981. Instead we interpret this result as a demonstration of the difficulty in estimating contribution rates for stocks present in low abundance using scale pattern analysis when classification accuracy is low.

During 1981 we estimated in Table 22 that the single largest component of the combined age 1.3 and 1.4 harvest to have originated from the middle Yukon run (64.5%). Although we were not able to fully evaluate the middle Yukon contribution during 1980, most of the samples used to construct the Alaskan portion of the age 1.4 model were of middle Yukon origin (70.6% of the age 1.4 harvest). While both the Salcha and Chena Rivers are known to be major producers of Yukon River chinook salmon, we feel that it is unlikely that the majority of the District 1 catch was destined for these rivers. Instead we hypothesize that it is more likely that the Salcha and Chena River scale patterns are similar to patterns from other tributaries in the middle Yukon area, particularly the Koyukuk, Melozitna, Tozitna, and Chandalar Rivers, and other Tanana River tributaries.

During 1981 we estimated that the lower Yukon run contributed relatively little production to the District 1 commercial fishery (we were not able to fully evaluate the contribution of lower Yukon fish during 1980). Since aerial survey data of escapements (see Appendix Table 7) indicated that the lower Yukon escapement is roughly equal to that of the middle and upper Yukon runs, we conclude that either: (1) peak aerial survey escapement estimates did not provide sufficiently accurate comparisons of individual escapements; or (2) the exploitation rate of lower Yukon fish is much less than that of the middle and upper Yukon runs. It is not possible at this time to determine which of these alternatives is most plausible.

Biological Interpretation of Scale and Age Data

In both 1980 and 1981, we observed an increase in the average ocean age and hence size[5] of chinook salmon sampled at spawning sites moving progressively further upriver. We hypothesize that this may be explained by differential prolonged swimming performance between age classes in relation to distance from the river mouth to natal spawning grounds. This hypothesis is based upon data which suggests that prolonged swimming endurance is dependent upon length (Beamish 1978) in that sustained swimming performance seems to be limited by the rate at which muscle tissue can be supplied with raw materials for contraction and relieved of metabolic waste materials. Beamish (1978) concluded that larger fish, therefore, had a relatively higher scope for metabolic activity than smaller fish. This relationship has been shown to exist for Atlantic herring *(Clupea harengus harengus)* and for the sea lamprey *(Petromyzon marinus)*.

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[5] Ocean age is indicative of size at return so that for instance among males sampled in the District 1 fishery during the chinook salmon season, average length (mid-eye to fork of tail was; age 1.2, 596 mm; age 1.3, 766 mm; age 1.4, 912 mm; age 1.5, 1,058 mm.

Secondly, age at maturity in chinook salmon has been shown to be heritable (Ricker 1972). When we consider these facts in light of the progressively increasing distance from the mouth of the Yukon River to principal spawning sites (Andreafsky River mouth, 167 km from Yukon River mouth; Salcha River mouth, 1,595 km; Teslin River mouth, 2,661 km), it seems reasonable that larger, hence older, fish may have a selective advantage that would be reflected in an older average age of fish returning to spawning sites progressing further upriver.

Significant and persistent differences in the size of the three growth zones measured on the scales of lower, middle, and upper Yukon runs provides insight into differences in their life history which permit scale pattern analysis as a method for determining origins in the lower river fishery. The size of the first freshwater year zone ([ID (1)] was consistently largest among lower Yukon fish. The upper Yukon fish exhibited the smallest first year's growth zone in three of four comparisons. The first year's growth zone of the middle Yukon fish was likewise intermediate in size in three of four comparisons (see Tables 8-11). These data suggest that growing conditions for juvenile chinook salmon in their first year improve in rearing areas moving down the drainage from the headwaters in Canada towards the river mouth. We can only speculate on the factors which produce this differential growth at this time.

The size of the freshwater plus growth zone [ID (2)] increased dramatically in samples collected from the lower to upper Yukon runs (see Table 8-11). Because this zone represents the freshwater growth achieved in the spring of smolting and the distance each of these runs must migrate to reach the Bering Sea is also substantially longer moving upstream, we hypothesize that this growth reflects the differential migration time and growth achieved during that time for the three runs.

The size of the first marine zone [ID (3)] decreased in samples collected from the runs moving upstream (see Tables 8-11). These data suggest that the growth realized by Yukon chinook salmon in their first year at sea decreases among stocks whose spawning site are located progressively further from the Yukon River mouth. We believe that this result is consistent with the concurrent increase in the size of the plus growth zone. Because of the longer time it would take for smolts to migrate from upriver rearing areas to the Bering Sea than it would take for smolts of downriver areas, the amount of time fish of the three runs would be at sea and growing in their first year would decrease moving upstream from the river mouth.

In summary, we believe that these significant and persistent differences in scale patterns of Yukon River chinook salmon may be interpreted in terms of differential life histories between stocks of fish spawning along the length of the river. Because these patterns persist, it appears worthwhile to pursue the concept of pooling data collected during several years to construct models to identify the origin of fish harvested in the lower river on an in-season basis. The success of this aspect of our work will depend upon differences within stocks between years relative to the differences between stocks within years.

RECOMMENDATIONS

Based on the results of this study, we recommend that the current sampling and allocation program be continued with the following modifications made:

1) Increase the sampling level for the District 1 fishery. Sampling should be increased to obtain approximately 100 samples each from the age 1.3 and 1.4 catch for each period during the chinook salmon season and those periods during the fall season when significant chinook salmon catches are made. It is recommended that sampling be increased to 300 fish per period.

2) Sampling should be expanded to the other Yukon River fishing districts. Substantial catches are sustained in other fishing districts, notably District 2 (1980 and 1981 harvest of 50,824 and 45,302 fish, respectively). Allocation of these catches is necessary to determine the total commercial utilization by run.

3) Obtain sufficient samples (test fish and subsistence catch samples) for allocation during the initial portion of the migration before the first commercial opening. Allocation of these samples will assist determination of the run composition of that portion of the migration that escapes the fishery early in the run. It will also assist in determining if differential time-of-entry patterns exist between runs.

4) Expand the escapement sampling and aerial enumeration program to other spawning tributaries. This is particularly important because of the large number of commercially caught fish that were allocated to the middle Yukon run.

5) Investigate the possibility of development of a historical model for in-season use. If the variability in scale patterns within a run between years is less than the variability between runs within a year, it may be possible to develop a model based on previous years escapement data to determine trends in the migration on an in-season basis.

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APPENDICES

Appendix Table 1. Sex and age composition of chinook salmon commercial catches taken during the chinook salmon season, District 1, Yukon River, 1980.

Period	Dates	Sex	1.2		1.3		1.4		1.5		Period Total	
			No.	%	No.	%	No.	%	No.	%	No.	%
1	6/9 - 6/10	Male	10	5.3	70	37.4	28	15.0			108	57.7
		Female			17	9.1	60	32.1	2	1.1	79	42.3
		Subtotal	10	5.3	87	46.5	88	47.1	2	1.1	187	100.0
2	6/12 - 6/14	Male	2	1.0	79	41.6	32	16.8	1	0.5	114	60.0
		Female			11	5.8	65	34.2			76	40.0
		Subtotal	2	1.0	90	47.4	97	51.1	1	0.5	190	100.0
3	6/16 - 6/17	Male	2	1.1	72	39.6	22	12.1	1	0.5	97	53.3
		Female			22	12.1	59	32.4	4	2.2	85	46.7
		Subtotal	2	1.1	94	51.7	81	44.5	5	2.7	182	100.0
4	6/19 - 6/21	Male	1	0.5	66	35.9	23	12.5	3	1.6	93	50.5
		Female			19	10.3	71	38.6	1	0.5	91	49.5
		Subtotal	1	0.5	85	46.2	94	51.1	4	2.2	184	100.0
5	6/23 - 6/24	Male			58	30.7	28	14.8	4	2.1	90	47.6
		Female			25	13.2	70	37.1	4	2.1	99	52.4
		Subtotal			83	43.9	98	51.9	8	4.2	189	100.0

Appendix Table 2. Sex and age composition of chinook salmon commercial catches taken during the fall season, District 1, Yukon River, 1980.

Period	Dates	Sex	1.2		1.3		1.4		1.5		Period Total	
			No.	%	No.	%	No.	%	No.	%	No.	%
6	6/26 - 6/27	Male	13	39.4	14	42.4	2	6.1	1	3.0	30	90.9
		Female			2	6.1	1	3.0			3	9.1
		Subtotal	13	39.4	16	48.5	3	9.1	1	3.0	33	100.0
7	6/30 - 7/1	Male	27	14.5	66	35.5	25	13.4	1	0.5	119	64.0
		Female			21	11.3	46	24.7			67	36.0
		Subtotal	27	14.5	87	46.8	71	38.2	1	0.5	186	100.0
8	7/2 - 7/4	Male	25	15.1	65	39.4	24	14.6	2	1.2	116	70.3
		Female			13	7.9	33	20.0	3	1.8	49	29.7
		Subtotal	25	15.1	78	47.3	57	34.6	5	3.0	165	100.0
9	7/7 - 7/8	Male	13	18.1	21	29.2	1	2.8			36	50.0
		Female			13	18.1	23	31.9			36	50.0
		Subtotal	13	18.1	34	47.2	25	34.7			72	100.0
14	7/24 - 7/25	Male			2	40.0	1	20.0			3	60.0
		Female					2	40.0			2	40.0
		Subtotal			2	40.0	3	60.0			5	100.0
16	7/31	Male	1	100.0							1	100.0
		Female										
		Subtotal	1	100.0							1	100.0

Appendix Table 3. Sex and age composition of chinook salmon commercial catches taken during the chinook salmon season, District 1, Yukon River, 1981.

Period	Dates	Sex	1.2		1.3		1.4		1.5		Period Total	
			No.	%	No.	%	No.	%	No.	%	No.	%
1	6/5 - 6/6	Male	1	0.5	30	16.2	66	35.7	2	1.1	99	53.5
		Female			7	3.8	77	41.6	2	1.1	86	46.5
		Total	1	0.5	37	20.0	143	77.3	4	2.2	185	100.0
2	6/8 - 6/9	Male			43	22.8	52	27.5	2	1.0	97	51.3
		Female			4	2.1	88	46.6			92	48.7
		Total			47	24.9	140	74.1	2	1.0	189	100.0
3	6/11 - 6/12	Male	1	0.6	31	17.5	41	23.2			73	41.2
		Female			6	3.4	95	53.7	3	1.7	104	58.8
		Total	1	0.6	37	20.9	136	76.8	3	1.7	177	100.0
4	6/15 - 6/16	Male	2	1.0	19	10.0	46	24.1	1	0.5	68	35.6
		Female			4	2.1	114	59.7	5	2.6	123	64.4
		Total	2	1.0	23	12.1	160	83.8	6	3.1	191	100.0
5	6/18 - 6/19	Male	3	1.6	23	12.1	49	25.8	2	1.0	77	40.5
		Female			6	3.2	104	54.7	3	1.6	113	59.5
		Total	3	1.6	29	15.3	153	80.5	5	2.6	190	100.0

Appendix Table 4. Sex and age composition of chinook salmon commercial catches taken during the fall season, District 1, Yukon River, 1981.

Period	Dates	Sex	1.2 No.	1.2 %	1.3 No.	1.3 %	1.4 No.	1.4 %	1.5 No.	1.5 %	Period Total No.	Period Total %
6	6/22 - 6/23	Male	24	13.2	23	12.6	54	29.7	3	1.7	104	57.1
		Female	1	0.6	5	2.8	70	38.5	2	1.1	78	42.9
		Total	25	13.7	28	15.4	124	68.1	5	2.8	182	100.0
7	6/25 - 6/26	Male	30	28.3	16	15.1	17	16.0			63	59.4
		Female			7	6.6	34	32.1	2	1.9	43	40.6
		Total	30	28.3	23	21.7	51	48.1	2	1.9	106	100.0
8	6/29 - 6/30	Male	12	30.0	6	15.0	6	15.0	1	2.5	25	62.5
		Female			3	7.5	12	30.0			15	37.5
		Total	12	30.0	9	22.5	18	45.0	1	2.5	40	100.0
9	7/6 - 7/3	Male	1	33.3			1	33.3			2	66.7
		Female			1	33.3					1	33.3
		Total	1	33.3	1	33.3	1	33.3			3	100.0
10	7/6 - 7/7	Male			3	30.0	3	30.0			6	60.0
		Female			1	10.0	3	30.0			4	40.0
		Total			4	40.0	6	60.0			10	100.0
11	7/9 - 7/10	Male	6	35.3	2	11.8	5	29.4			13	76.5
		Female			1	5.9	3	17.7			4	23.5
		Total	6	35.3	3	17.7	8	47.1			17	100.0
12	7/13 - 7/14	Male	7	33.3	5	23.8	2	9.5			14	66.7
		Female					7	33.3			7	33.3
		Total	7	33.3	5	23.8	9	42.9			21	100.0

Appendix Table 5. Commercial catches of chinook salmon from District 1, Yukon River, 1980[1] [2].

Period	Dates	Period Total	Cumulative Total
1[3]	6/09 - 6/10	6,816	6,816
2	6/12 - 6/14	23,771	30,587
3	6/16 - 6/17	14,622	45,209
4	6/19 - 6/21	26,161	71,370
5	6/23 - 6/24	4,487	75,857
6[4]	6/26 - 6/27	3,000	78,857
7	6/30 - 7/01	3,578	82,435
8	7/02 - 7/04	3,241	85,676
9	7/07 - 7/08	838	86,514
10	7/10 - 7/12	694	87,208
11	7/14 - 7/15	389	87,597
12	7/17 - 7/18	131	87,728
13	7/21 - 7/22	45	87,773
14	7/24 - 7/25	40	87,813
15	7/28 - 7/29	20	87,833
16	7/31	8	87,841
17	8/04	5	87,846
18	8/07	14	87,860
19	8/11	2	87,862
20	8/14	3	87,865
21	8/18 - 8/19	6	87,871

[1] Preliminary.

[2] Includes drift and set gillnet catches.

[3] Chinook salmon season through 6/24.

[4] Fall season through 8/19.

Appendix Table 6. Commercial catches of chinook salmon from District 1, Yukon River, 1981[1] [2].

Period	Dates	Period Total	Cumulative Total
1[3]	6/05 - 6/06	11,117	11,117
2	6/08 - 6/09	15,615	26,732
3	6/11 - 6/12	14,483	41,215
4	6/15 - 6/16	18,304	59,519
5	6/18 - 6/19	28,519	88,038
6[4]	6/22 - 6/23	4,157	92,195
7	6/25 - 6/26	2,901	95,096
8	6/29 - 6/30	1,550	96,646
9	7/02 - 7/03	1,178	97,824
10	7/06 - 7/07	661	98,485
11	7/09 - 7/10	342	98,827
12	7/13 - 7/14	186	99,013
13	7/16 - 7/17	97	99,110
14	7/20 - 7/21	42	99,152
15	7/23 - 7/24	14	99,166
16	7/27 - 7/28	29	99,195
17	7/30 - 7/31	18	99,213
18	8/13 - 8/14	4	99,217
19	8/12 - 8/18	2	99,219

[1] Preliminary.

[2] Includes set and drift gillnet catches.

[3] Chinook salmon season through 6/19.

[4] Fall season through 8/18.

Appendix Table 7. Sex and age composition of chinook salmon escapements from lower Yukon tributaries, Yukon River, 1980[1].

Location	Dates	Sex	1.2		1.3		1.4		1.5		Period Total	
			No.	%	No.	%	No.	%	No.	%	No.	%
Andreafsky River	8/8 - 8/23	Male	16	23.9	27	40.3	4	6.0			47	70.2
		Female			11	16.4	7	10.4	2	3.0	20	29.8
		Total	16	23.9	38	56.7	11	16.4	2	3.0	67	100.0
Anvik River	8/7 - 8/15	Male	20	24.1	21	25.3	1	1.2			42	50.6
		Female			21	25.3	17	20.5	3	3.6	41	49.4
		Total	20	24.1	42	50.6	18	21.7	3	3.6	83	100.0
Nulato River	8/5 - 8/6	Male	4	19.0	4	19.0	5	23.8			13	61.9
		Female			4	19.0	3	14.3	1	4.8	8	38.1
		Total	4	19.0	8	38.1	8	38.1	1	4.8	21	100.0

[1] Carcass samples unless otherwise noted.

Appendix Table 8. Sex and age composition of chinook salmon escapements from middle Yukon tributaries, Yukon River, 1980[1].

Location	Dates	Sex	1.2		1.3		2.3		1.4		1.5		Period Total	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Chena River	8/11 - 8/20	Male	14	23.0	15	24.6							29	47.5
		Female			15	24.6	1	1.6	16	26.2			32	52.5
		Total	14	23.0	30	49.2	1	1.6	16	26.2			61	100.0
Salcha River	8/6 - 8/15	Male	52	17.8	87	29.7	1	0.3	17	5.8	2	0.7	159	54.3
		Female			44	15.0			87	29.7	3	1.0	134	45.7
		Total	52	17.8	131	44.7	1	0.3	104	35.5	5	1.7	293	100.0

[1] Carcass samples unless otherwise noted.

Appendix Table 9. Sex and age composition of chinook salmon escapements from upper Yukon tributaries, Yukon River, 1980[1].

Location	Dates	Sex	1.2 No.	1.2 %	1.3 No.	1.3 %	2.3 No.	2.3 %	1.4 No.	1.4 %	2.4 No.	2.4 %	1.5 No.	1.5 %	Total No.	Total %
Tatchun Cr.	9/7	Male	1	14.3	2	28.6									3	42.9
		Female							4	57.1					4	57.1
		Total	1	14.3	2	28.6			4	57.1					7	100.0
Little Salmon River	9/2	Male	1	50.0											1	50.0
		Female			1	50.0									1	50.0
		Total	1	50.0	1	50.0									2	100.0
Big Salmon River	8/29 - 8/31	Male	3	2.4	23	18.3			16	12.7					42	33.3
		Female			27	21.4			55	43.6	1	0.8	1	0.8	84	66.7
		Total	3	2.4	50	39.7			71	56.3	1	0.8	1	0.8	126	100.0
Teslin River[2]	9/1	Male			1	7.1							2	14.3	3	21.4
		Female			1	7.1			8	57.1			2	14.3	11	78.6
		Total			2	14.3			8	57.1			4	28.6	14	100.0
Nisutlin River	9/2 - 9/4	Male	1	1.2	14	16.5	1	1.2	8	9.4	4	4.7			28	32.9
		Female			21	24.7			36	42.3					57	67.1
		Total	1	1.2	35	41.2	1	1.2	44	51.7	4	4.7			85	100.0
Michie Cr.	9/10 - 9/11	Male	2	50.0	1	25.0									3	75.0
		Female							1	25.0					1	25.0
		Total	2	50.0	1	25.0			1	25.0					4	100.0
Swift River	9/5	Male			3	30.0									3	30.0
		Female			5	50.0			2	20.0					7	70.0
		Total			8	80.0			2	20.0					10	100.0

[1] Carcass samples unless otherwise noted.

[2] Subsistence and sport catch samples.

Appendix Table 10. Sex and age composition of chinook salmon escapements from lower Yukon River tributaries, 1981[1].

Location	Dates	Sex	1.2		1.3		2.2		1.4		7.5		Total	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Andreafsky R.	7/28 - 8/11	Male	29	9.8	80	26.9			45	15.2			154	51.9
		Female			23	7.7			119	40.1	1	0.3	143	48.1
		Total	29	9.8	103	34.6			164	55.3	1	0.3	297	100.0
Anvik R.	7/24 - 8/12	Male	33	12.5	60	22.8	1	0.4	15	5.7			108	
		Female	1	0.4	36	13.7			116	44.1	1	0.4	155	
		Total	34	12.9	96	36.5	1	0.4	131	49.8	1	0.4	263	
Nulato R.	7/28 - 8/5	Male	2	4.9	13	31.7			3	7.3			18	43.9
		Female			1	2.4			20	48.8	2	4.9	23	56.1
		Total	2	4.9	14	34.1			23	56.1	2	4.9	41	100.0

[1] Carcass samples unless otherwise noted.

Appendix Table 11. Sex and age composition of chinook salmon escapements from middle Yukon River tributaries, 1981[1].

Location	Dates	Sex	1.1		1.2		1.3		1.4		1.5		2.4		Total	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Chena R.	8/11 - 8/12	Male	1	1.0	1	1.0	22	20.9	29	27.6			1	1.0	54	51.4
		Female					2	1.9	49	46.6					51	48.6
		Total	1	1.0	1	1.0	24	22.8	78	74.2			1	1.0	105	100.0
Salcha R.	7/28 -8/6	Male			31	6.3	123	25.1	119	24.3					273	55.7
		Female					18	3.7	197	40.2	2	0.4			217	44.3
		Total			31	6.3	141	28.8	316	64.5	2	0.4			490	100.0

[1] Carcass samples unless otherwise noted.

Appendix Table 12. Sex and age composition of chinook salmon escapements from upper Yukon River tributaries, 1981[1].

Location	Date	Sex	1.2		0.4		1.3		2.2		1.4		2.3		1.5		2.4		2.5		Total	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Tatchun Creek	8/31	Male	1	2.2			8	17.4	1	2.2	9	19.6									19	41.3
		Female					6	13.0			21	45.6									27	58.7
		Total	1	2.2			14	30.4	1	2.2	30	65.2									46	100.0
Little Salmon River	8/29-8/30	Male	5	2.4			22	10.7			33	16.1			2	1.0					62	30.2
		Female					9	4.4			134	65.4									143	69.8
		Total	5	2.4			31	15.1			167	81.5			2	1.0					205	100.0
Big Salmon River	8/22-8/24	Male	7	1.3			69	13.0			75	14.2	2	0.4	1	0.2			1	0.2	155	29.3
		Female	2	0.4			44	8.3			318	60.1			6	1.1	4	0.8			374	70.7
		Total	9	1.7			113	21.3			393	74.3	2	0.4	7	1.3	4	0.8	1	0.2	529	100.0
Teslin[2] River	8/8	Male					2	28.6			4	57.1									6	85.7
		Female					1	14.3													1	14.3
		Total					3	42.9			4	57.1									7	100.0
Nisutlin River	8/20-8/24	Male	1	0.4			27	10.0			42	15.5	1	0.4							71	26.3
		Female			1	0.4	10	3.7			183	67.8	1	0.4	1	0.4	3	1.1			199	73.7
		Total	1	0.4	1	0.4	37	13.7			225	83.3	2	0.7	1	0.4	3	1.1			270	100.0
Swift River	8/26-8/27	Male					22	17.9			7	5.7									29	23.6
		Female					11	8.9			83	67.5									94	76.4
		Total					33	26.8			90	73.2									123	100.0
Ross River	8/25-8/28	Male	1	0.3			28	9.7			66	22.9	1	0.3	1	0.3					97	33.7
		Female					14	4.9			167	58.0			10	3.5					191	66.3
		Total	1	0.3			42	14.6			233	80.9	1	0.3	11	3.9					288	100.0
Whitehorse[3] Dam	7/22-8/18	Male	6	2.6			34	14.6			30	12.9			2	0.9	1	0.4			73	31.3
		Female					13	5.6			142	60.9			3	1.3	2	0.8			160	68.7
		Total	6	2.6			47	20.2			172	73.8			5	2.2	3	1.2			233	100.0

[1] Carcass samples unless otherwise noted.

[2] Sport catch samples.

[3] Fishway samples.

Appendix Table 13. Escapement estimates of chinook salmon from selected spawning tributaries[1], Yukon River, 1980-1981[2].

Year	Andreafsky River[3]	Anvik River	Nulato River[4]	Chena River	Salcha River	Tatchun Creek[5]	Teslin River Drainage: Nisutlin River	Teslin River Drainage: Swift River	Big Salmon River	Little Salmon River	Ross River[6]	Whitehorse Dam[7]
1980	2,458	1,330	1,323	2,541	6,757	222	1,852	420	1,568	286	[8]	1,383
1981	2,377[10]	807[9] [11]	791[9]	600[9]	1,237[9]	133	2,189	302	2,411	670	767	1,539

1 Spawning tributaries where chinook salmon were sampled for age, sex, and size data during 1980 and 1981.

2 Data obtained from aerial surveys unless otherwise indicated. Only peak estimates are listed.

3 East and West Fork.

4 North and South Fork.

5 Foot survey.

6 Pelly River drainage.

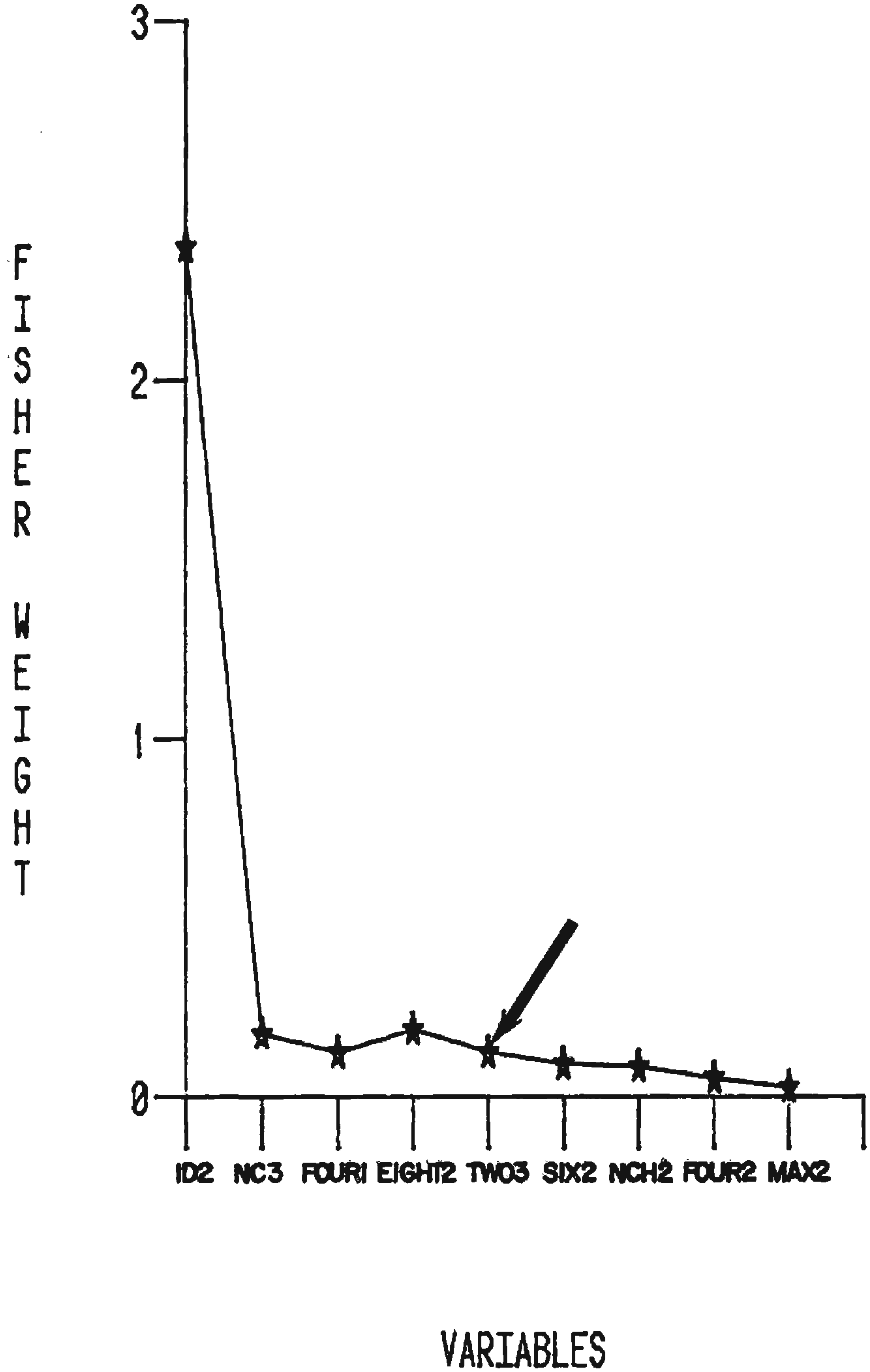
7 Fishway counts. Aerial survey of McClintock River (Michie Creek), the major spawning tributary above the Whitehorse Fishway resulted in a count of 535 chinook salmon.

8 No count.

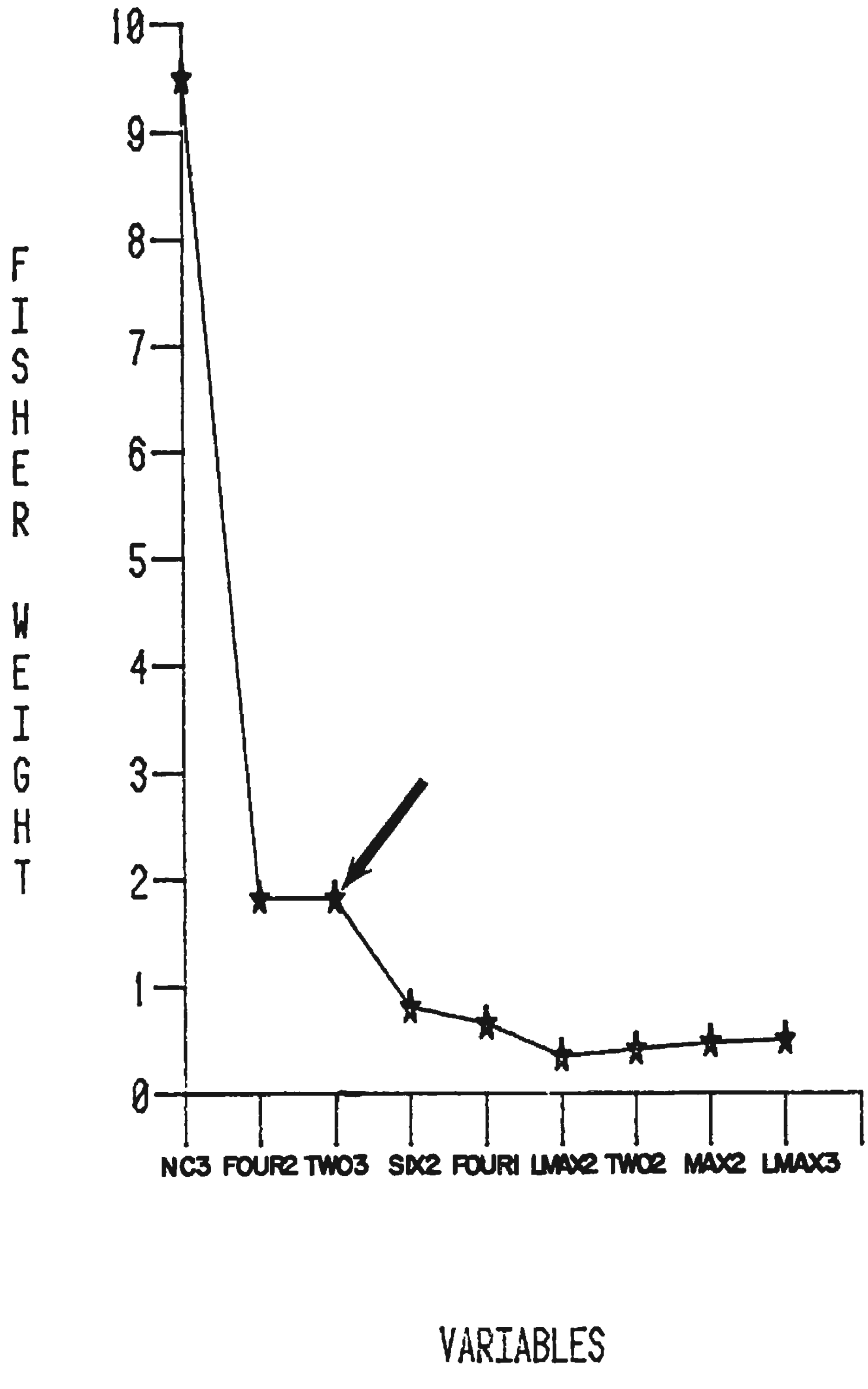
9 Minimal counts due to extremely poor survey conditions.

10 Side scan sonar estimate 5,574 fish in East Fork. Poor survey conditions. West Fork surveyed after peak of spawning.

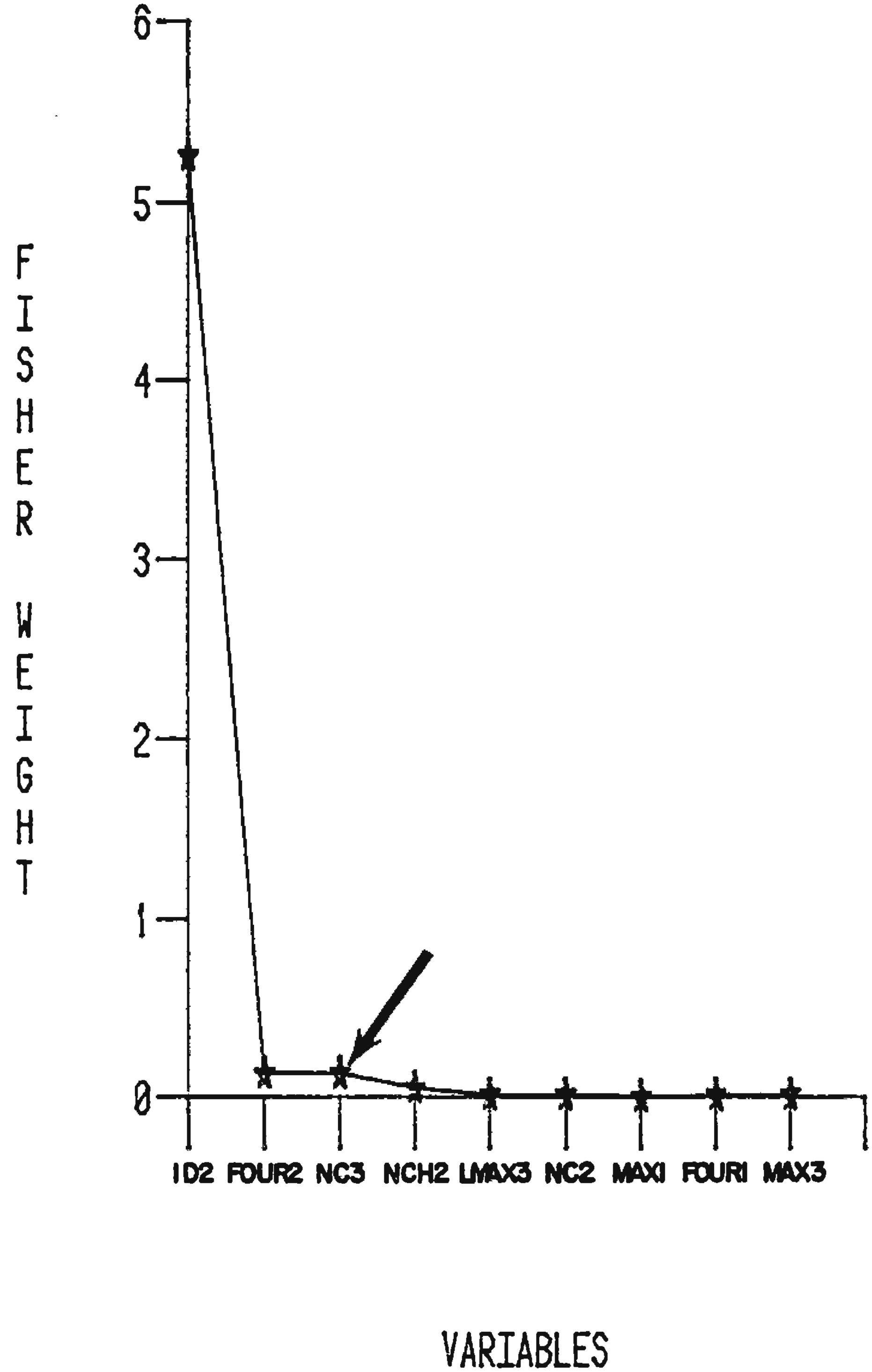
11 Side scan sonar estimate 2,306 fish.



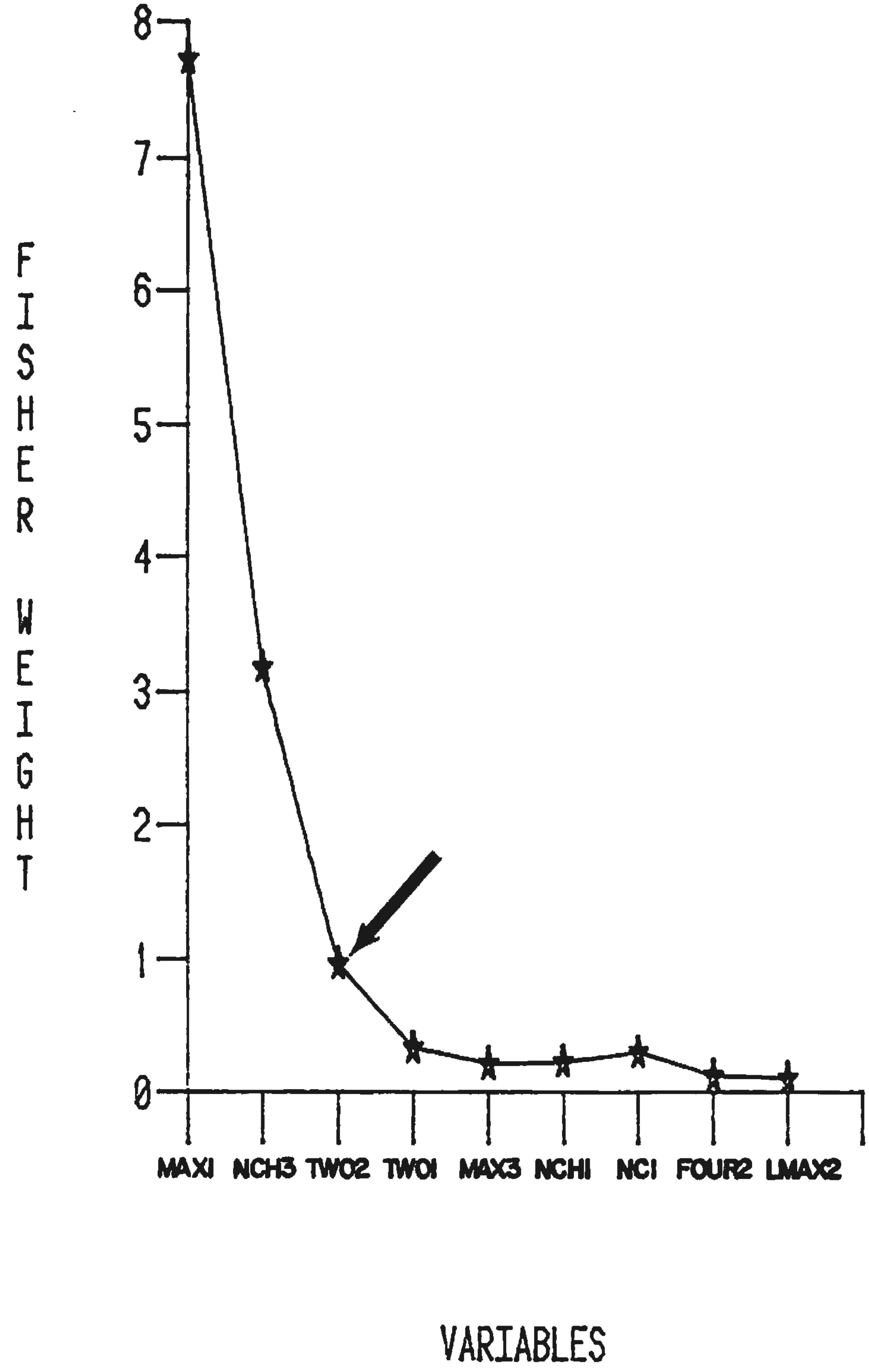
Appendix Figure 1. Fisher weights of the top ranked variables, and those variables included in the final classification model (arrow), as determined from nearest analysis of age 1.3 lower, middle, and upper Yukon fish, 1980. Fisher weights are expressed in scientific notation (x 10^{-2}).



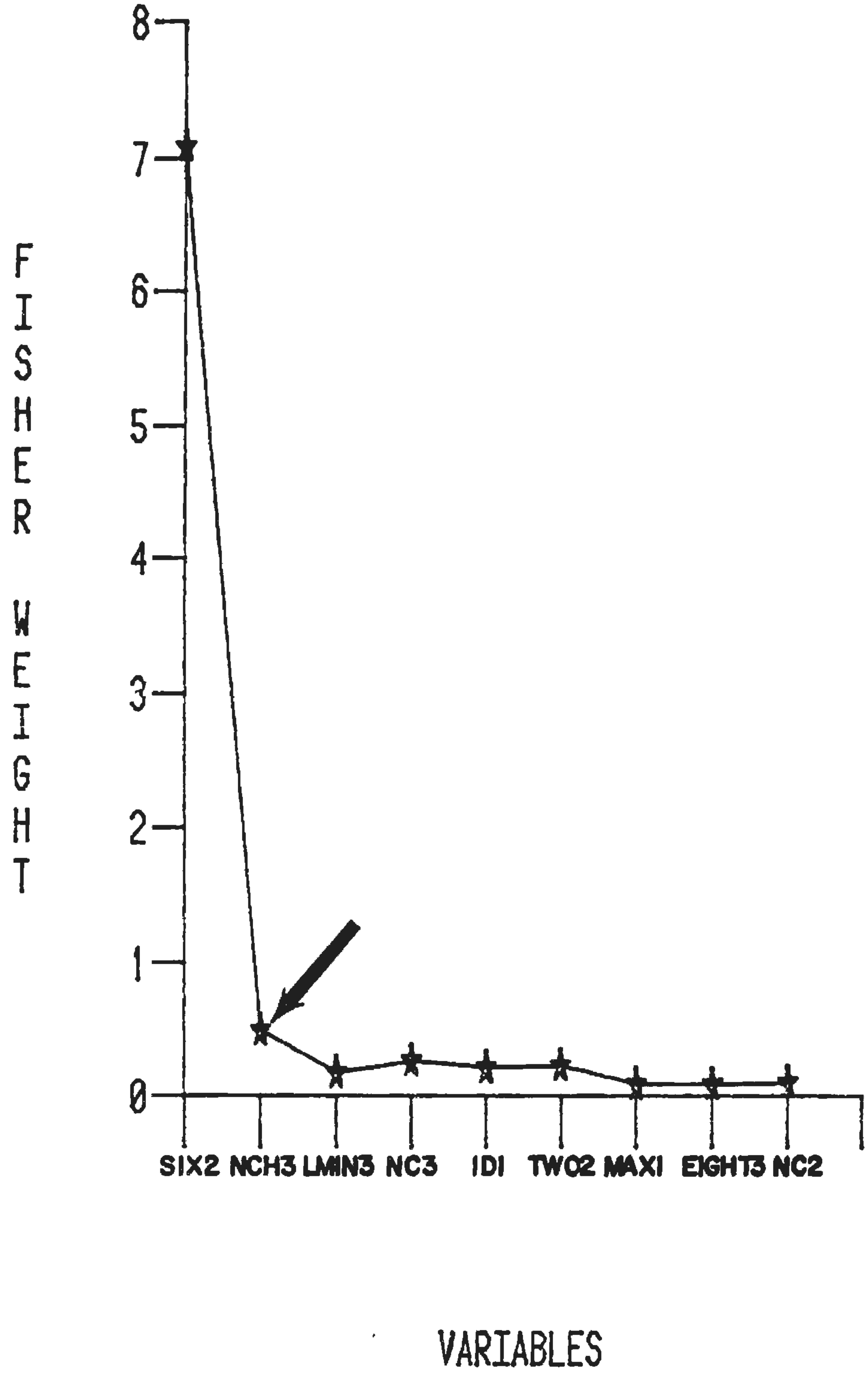
Appendix Figure 2. Fisher weights of the top ranked variables, and those variables included in the final classification model (arrow), as determined from nearest neighbor analysis of age 1.3 middle and upper Yukon fish, 1980. Fisher weights are expressed in scientific notation (x 10^{-3}).



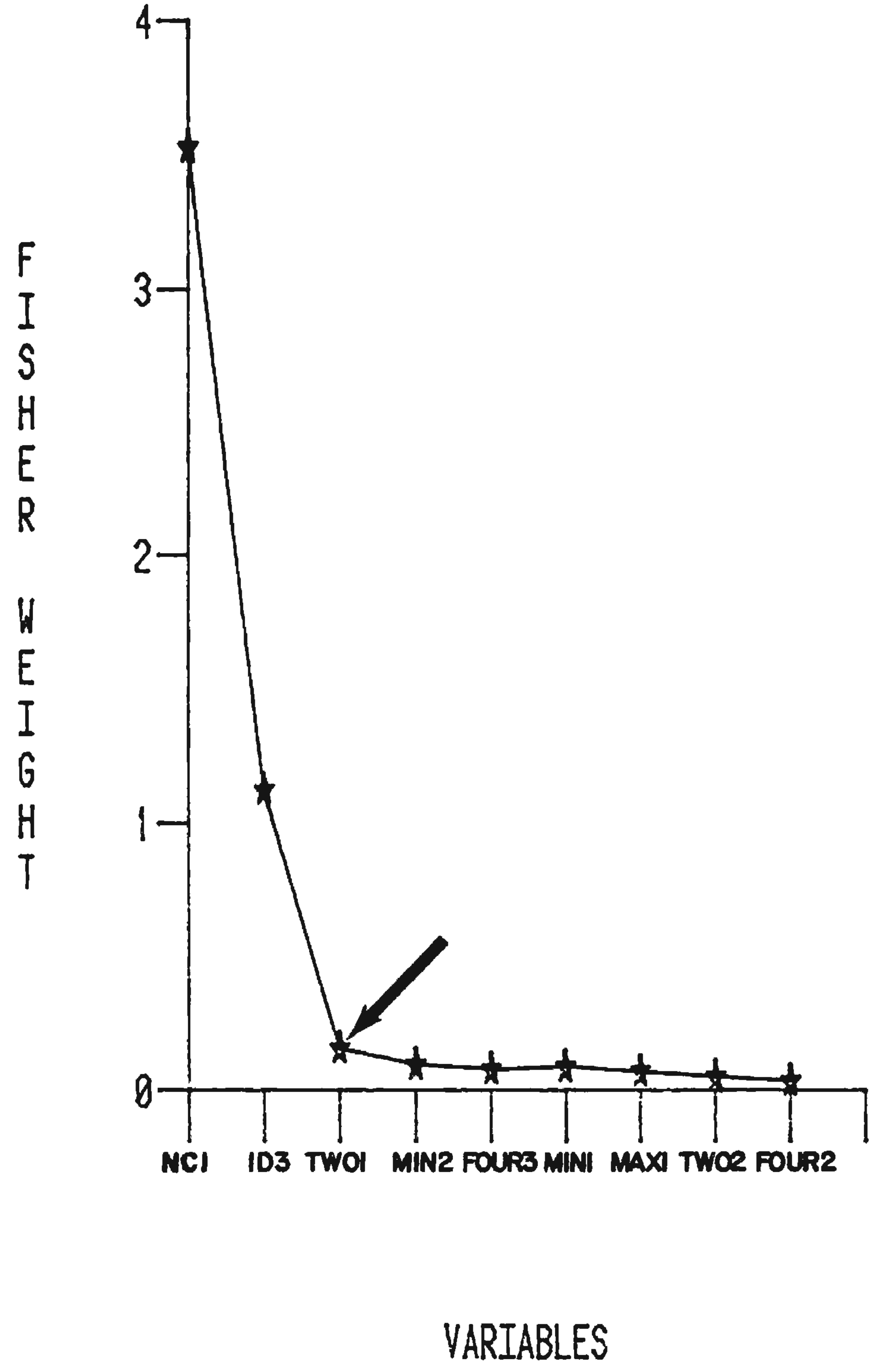
Appendix Figure 3. Fisher weights of the top ranked variables, and those variables included in the final classification model (arrow), as determined from nearest neighbor analysis of age 1.3 lower and upper Yukon fish, 1980. Fisher weights are expressed in scientific notation (x 10^{-2}).



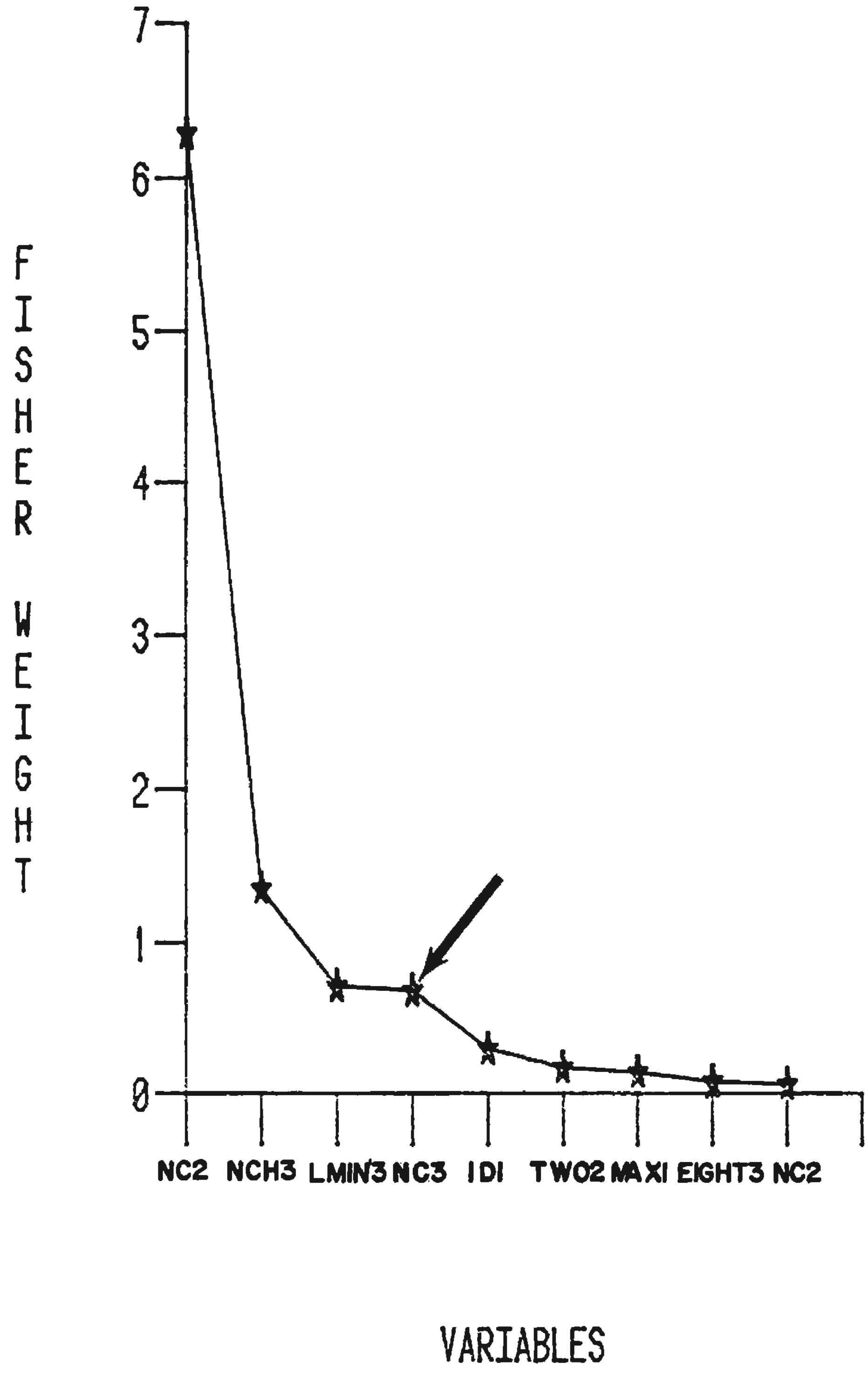
Appendix Figure 4. Fisher weights of the top ranked variables, and those variables included in the final classification model (arrow), as determined from nearest neighbor analysis of age 1.4 Alaskan and upper Yukon fish, 1980. Fisher weights are expressed in scientific notation (x 10^{-3}).



Appendix Figure 5. Fisher weights of the top ranked variables, and those variables included in the final classification model (arrow), as determined from nearest neighbor analysis of age 1.3 lower and upper Yukon fish, 1981. Fisher weights are expressed in scientific notation (x 10^{-3}).



Appendix Figure 6. Fisher weights of the top ranked variables, and those variables included in the final classification model (arrow), as determined from nearest neighbor analysis of age 1.4 middle and upper Yukon fish, 1981. Fisher weights are expressed in scientific notation (x 10^{-3}).



Appendix Figure 7. Fisher weights of the top ranked variables, and those variables included in the final classification model (arrow), as determined from nearest neighbor analysis of age 1.4 lower, middle, and upper Yukon fish, 1981. Fisher weights are expressed in scientific notation (x 10^{-3}).