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Origins of Chinook Salmon in the Yukon River Fisheries, 2003

by

Larry DuBois

August 2005

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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TABLE OF CONTENTS

Page

LIST OF TABLES ii

LIST OF FIGURES ii

ABSTRACT 1

INTRODUCTION 1

METHODS 2

Overview 2
Escapement Sampling 2
Harvest Sampling 3
Scale Processing 4
Analytical Methods 4

RESULTS 6

Age Composition 6
Catch Composition 6
    Scale Pattern Analysis 6
    Estimation Accuracy Simulations 7
    Maximum Likelihood Estimates for Major Age Classes 7
    Differential Age Composition Analysis 8
    Assignment by Geographical Analysis 9
    Total Harvest 10

DISCUSSION 10

ACKNOWLEDGMENTS 11

REFERENCES CITED 12

TABLES AND FIGURES 13

LIST OF TABLES

Table **Page**

1. Yukon River Chinook salmon escapement age composition by tributary and weighted age composition by geographic area, 2003.....14
2. Yukon River Chinook salmon commercial, subsistence, and test fish age composition by location, gear type, and sample size, 2003.....15
3. Set of scale variables and their descriptions selected for Yukon River Chinook salmon stock identification, 2003.....16
4. Set of scale variables and their corresponding values for Lower, Middle, and Upper river stocks selected for Yukon River Chinook salmon stock identification, 2003.....17
5. Accuracy of maximum likelihood estimates for Yukon River Chinook salmon stock composition by age and stock group, 2003.....18
6. Yukon River District 1 commercial harvest estimated stock composition by period and subsistence harvest for age-1.3 and -1.4 Chinook salmon, 2003.....19
7. Yukon River Chinook salmon District 1 commercial harvest by age, stock group, and period, 2003.....20
8. Yukon River District 2 commercial harvest estimated stock composition by period for age-1.3 and -1.4 Chinook salmon, 2003.....21
9. Yukon River Chinook salmon District 2 commercial harvest by age, stock group, and period, 2003.....22
10. Yukon River Chinook salmon harvest by age, stock group, and fishery, 2003.....23
11. Yukon River Chinook salmon harvest proportions by age, stock group, and fishery, 2003.....25
12. Yukon River District 4 commercial and subsistence harvest estimated stock composition for age-1.3 and -1.4 Chinook salmon, 2003.....27
13. Yukon River Chinook salmon Districts 5 and 6 commercial harvest by age, stock group, and period, 2003.....28
14. Yukon River Chinook salmon historical harvest by stock group for the United States and Canada, 1981–2003.....29
15. Yukon River Chinook salmon historical harvest proportions by stock group for the United States and Canada, 1981–2003.....30

LIST OF FIGURES

Figure **Page**

1. Alaska portion of the Yukon River drainage showing salmon district boundaries and major spawning tributaries.....31
2. Canada portion of the Yukon River drainage and major spawning tributaries.....32
3. Chinook salmon scale illustrating the different zones measured for scale growth analysis.....33
4. Comparison of Yukon River Chinook salmon fresh water scale areas from Andreafsky River escapement (Lower stock group), Salcha River escapement (Middle stock group) and Canadian Sheep Rock harvest (Upper stock group).....34
5. Canonical variable plots for Yukon River age-1.3 and -1.4 Chinook salmon, 2003.....35
6. Estimated number of age-1.3 and -1.4 Chinook salmon harvested, by commercial period, subsistence, and stock group, Yukon River District 1, 2003.....36
7. Estimated proportion of age-1.3 and -1.4 Chinook salmon harvested, by commercial period, subsistence, and stock group, Yukon River District 1, 2003.....37
8. Estimated number of age-1.3 and -1.4 Chinook salmon harvested, by commercial period and stock group, Yukon River District 2, 2003.....38
9. Estimated proportion of age-1.3 and -1.4 Chinook salmon harvested, by commercial period and stock group, Yukon River District 2, 2003.....39
10. Estimated number of age-1.3 and age-1.4 Chinook salmon harvested by stock group, Yukon River District 4, 2003.....40
11. Estimated proportion of age-1.3 and -1.4 Chinook salmon harvested by stock group, Yukon River Districts 4, 2003.....41

ABSTRACT

Stock composition of all harvests of Chinook salmon *Oncorhynchus tshawytscha*, within the Yukon River drainage was estimated in 2003. Stock composition proportions were estimated for 3 geographically based stock groups termed Lower, Middle, and Upper. Maximum likelihood models were used to estimate stock composition for the most abundant age classes, age-1.3 and -1.4 Chinook salmon in Districts 1 through 4 harvests. Observed age composition ratios among escapements, in combination with maximum likelihood estimates, were used to estimate the stock composition of the less abundant age classes. Districts 1 and 2 commercial harvests and Districts 1 and 4 subsistence harvests were apportioned to stock groups using estimated proportions from samples collected in each harvest. Districts 2 and 3 subsistence harvests were apportioned using samples from other harvests. Districts 5, 6, and Canadian harvests, were assigned to stock group based on the geographic location of the harvests. The total estimated Yukon River harvest in 2003 was 108,185 Chinook salmon, of those, 6.8% were estimated to be of Lower, 28.9% Middle and 64.3% Upper Yukon River stock group origin.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, Yukon River, stock composition, age composition, commercial harvest, subsistence harvest, maximum likelihood, age 1.3, age 1.4, Canadian harvest, stock groups

INTRODUCTION

The goal of this project is to estimate the proportion of stock groups (i.e., geographic region) for all Yukon River Chinook salmon *Oncorhynchus tshawytscha* harvested in the drainage during the 2003 season utilizing scale pattern data with a maximum likelihood estimator. Results from scale pattern analysis on these stocks provide valuable stock separation information for management and conservation of various runs of Chinook salmon throughout the Yukon River drainage. Alaska Department of Fish and Game (ADF&G) have conducted similar scale pattern analysis studies annually since 1981 (e.g., DuBois 2004).

Yukon River Chinook salmon are harvested annually in various fisheries in both marine and fresh water. Within the Yukon River, returning adult salmon are harvested in subsistence and personal use fisheries in Alaska, Aboriginal and domestic fisheries in Canada, and commercial and sport fisheries in Alaska and Canada (Figures 1 and 2). Commercially sold harvests consist of whole fish (round), fish utilized for commercial roe harvests, and fish harvested by ADF&G test fishing projects. Sport fisheries primarily occur in tributaries of the Tanana River and in Canada; smaller sport fishing harvests occur throughout the Alaska portion of the Yukon River drainage. The total harvest of Chinook salmon within the Yukon River drainage based on a 10-year average from 1991 through 2000 is approximately 60.7% commercial harvest, 37.1% subsistence harvest, 0.1% personal use, 0.9% test fish, and 1.2% sport fish harvest (Vania et al. 2002).

The Yukon River drains roughly 531,100 km^2, originates in northern British Columbia, and flows 3,700 km to the Bering Sea (Vania et al. 2002). Chinook salmon spawn in major tributaries, such as the Andreafsky River approximately 161 river kilometers (rkm) from the mouth of the Yukon River, and 3,200 rkm upriver in the Swift River, British Columbia, near the Yukon Territory border. More than 100 spawning streams have been documented in the Yukon River drainage. Aerial surveys of Chinook salmon escapements indicate the largest concentrations of spawning salmon occur in tributary groupings in 3 distinct geographic regions: 1) Alaskan tributary streams draining the Andreafsky Hills and Kaltag Mountains (rkm 161-805); 2) Alaskan tributary streams in the Upper Koyukuk River and Tanana River basins (rkm 1,290–1,770); and 3) Canadian tributary streams draining the Pelly and Big Salmon Mountains (rkm 2,090–2,900). Initially, McBride and Marshall (1983) termed Chinook salmon stocks within these geographic regions runs but Lingnau and Bromaghin (1999) now refer to these as Lower, Middle and Upper Yukon River stock groups.

Evaluating stock production, spawning escapement goals, and management strategies requires information on stock composition of the various Yukon River mixed stock harvests. ADF&G studies stock composition of Yukon River fishery harvests using scale growth measurements to differentiate Chinook salmon stock groups. Annual harvests within the drainage are apportioned to their geographic stock group (Lower, Middle, or Upper). In addition, the U.S. and Canada have been engaged in the cooperative management and conservation of stocks spawning in Canada.

In the first 20 years after statehood (1960–1979), the total Chinook salmon harvest combined from the Yukon River in Alaska and Canada ranged from an estimated 77,250 to 169,607, and averaged 123,033 fish annually (JTC 2004). Beginning in 1980 total annual harvests increased, and for the period 1980 through 1997, average total annual harvest was approximately 187,194 fish. Total annual harvest of Chinook salmon began to decline in 1998; average harvest for the period 1998 through 2002 was 86,580 fish (JTC 2004). In 2003, the Chinook salmon total combined harvest for Alaska and Canada was 108,185 fish. The Canadian escapement was 48,636 Chinook salmon for an estimated total Canadian run of 58,082 fish. There were 21 directed Chinook salmon commercial fishing periods in the Alaskan portion of the drainage and these composed 41.7% of the total Alaskan harvest (T. L. Lingnau, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). The subsistence harvest accounted for 56.1% of the Alaskan harvest (Busher and Hamazaki *In prep*) and the sport fish harvest was 2.2%. The Aboriginal harvest accounted for 65.4% of the Canadian harvest and the commercial harvest accounted for 27.8%. The remainder of the Canadian harvest was from domestic, sport, and run assessment test fisheries (JTC 2004).

METHODS

OVERVIEW

Stock composition is based on measurements of the distances between scale circuli; therefore, scales for each stock and age class are needed to represent each stock of origin or stock standard. These scale samples need to be collected annually because changes in environmental conditions effect scale growth. Crews sampled the 3 stocks of origin from spawning grounds in areas of the Yukon River drainage where stock separation is assumed. Scales were removed from the preferred area on the left side of the fish, approximately 2 rows above the lateral line, in an area transected by a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin (Clutter and Whitesel 1956). Crews removed 3 scales from each Chinook salmon to increase scale readability and to provide accurate age determination. All scale samples were cleaned and mounted on gummed cards. These scale data are used to estimate the age composition for each sampling location. Scales of the abundant age classes, termed major age classes, were digitized with several growth measurements made on each scale. These data are considered to characterize all salmon from each of the distinct stock groups, and are the main component of the stock identification project.

ESCAPEMENT SAMPLING

During peak spawning mortality (late July through early August), ADF&G personnel collect scale samples from Chinook salmon carcasses from the Anvik and Chena rivers and Bering Sea

Fisherman's Association collects carcass samples from the Salcha River. U. S. Fish and Wildlife Service (USFWS) crews sample live salmon at weir projects on the East Fork Andreafsky, Gisasa, and Tozitna rivers and Henshaw Creek. Canadian Department of Fisheries and Oceans (CDFO) collect samples from fish captured in fish wheels used for a mark–recapture project at White Rock and Sheep Rock in the Yukon Territory, Canada. These scale samples provide data used to estimate age composition of the escapement, and major age classes were digitized from these scales for subsequent analysis.

HARVEST SAMPLING

ADF&G crews sampled Chinook salmon for age, sex, and length data from all 5 commercial periods in District 1, and 2 of 4 commercial periods in District 2. These samples, or a combination thereof, were used for age composition analysis and digitized for scale pattern analysis. District 1 commercial harvest, periods 1 through 3, and District 2 commercial harvest, periods 1 and 2 were apportioned using age and stock composition from each respective sample. District 1, period 4 was apportioned using period 4 age composition, age 1.3 stock composition from period 4, and age 1.4 stock composition from periods 3 and 4. District 1, period 5 was apportioned using period 5 age composition, age 1.3 stock composition from periods 4 and 5, and age 1.4 stock composition from periods 3, 4, and 5. Scale samples were not collected from District 2, periods 3 and 4. Age and stock composition estimates for District 1, periods 4 and 5 were applied to District 2, periods 3 and 4, respectively.

The age and stock composition from District 1 subsistence harvest samples were used to apportion age and stock composition for that respective harvest. Scale samples were not collected from the subsistence harvest in Districts 2 and 3. The District 2 subsistence harvest was apportioned using age composition from District 1 subsistence harvest, and stock composition from District 1 subsistence harvest combined with District 1, period 1 commercial harvest. The District 3 subsistence harvest was apportioned using age composition from the Russian Mission Dogfish tagging project, and stock composition from District 1 subsistence harvest combined with District 2, period 1 commercial harvest.

The City of Kaltag operated a project in District 4 to collect subsistence scale samples from Chinook salmon harvested in large mesh gillnets fished near Kaltag. ADF&G crews collected District 4 subsistence samples from fish wheels near Ruby. The District 4 subsistence harvest was apportioned using age and stock composition from these samples. District 4-C commercial harvest was apportioned using age and stock composition from commercial harvest samples collected by ADF&G crews from fish wheels near Ruby, which represents the entire commercial harvest in that district.

Scale samples collected from Chinook salmon in Districts 5 and 6 commercial harvests were used to estimate age composition from each respective district. Harvests in these districts were apportioned to Middle and Upper river stocks based by geographic location. District 5 harvest was apportioned to the Upper stock group and District 6 harvest to the Middle stock group. Sport fish harvests in Alaska were apportioned to the Middle stock group with age composition based on escapement samples from the Chena and Salcha rivers. Tributaries in the middle Yukon River, specifically the Chena and Salcha rivers, support most of the sport fishery harvest. All harvests occurring in Canada were apportioned to the Upper stock group. The upriver adjusted harvest from fish wheel samples was used to estimate age composition of Canadian commercial, test fish, domestic, sport, and Aboriginal harvests.

SCALE PROCESSING

A heated hydraulic press makes impressions in cellulose acetate from the scales, which were mounted on gummed cards by crews in the field. Staff age scale impressions by viewing with a microfiche reader, interpreting circuli patterns, and reporting ages in European notation. The European method is a 2 number system, the first number refers to the number of years spent in fresh water after hatching and the second number, separated by the first with a period, represents the number of years spent in the ocean. Total age is calculated by summing the 2 numbers and then adding 1; to account for the time eggs spend incubating in gravel.

On a salmon scale, a year's growth is represented by a zone of widely spaced circuli (summer growth) followed by a zone of closely spaced circuli (winter growth). These closely spaced circuli are defined as an annulus. In fresh water, fish growth is slower than in salt water and freshwater circuli are thinner and spaced closer together than those formed in salt water. This distinction makes it possible to define periods fish spend in each environment.

Age-1.3 and -1.4 Chinook salmon were the major age classes in 2003 and accounted for the largest segment of samples in 2003 (these 2 age classes are usually digitized). Scales collected during the 2003 season were analyzed using a computerized digitizing system first used for Yukon River Chinook salmon in 2001. After scales were aged, each scale of adequate quality from the major age classes was electronically scanned from an image magnified 42 times on a microfiche reader and the image was digitally stored. Images were then processed by a software program which uses algorithms to mark each circuli. ADF&G staff edits these marked circuli and mark each annulus and scale growth zone. The new system allows for storage of scale images and overlay with annuli and circuli marks. In the old system, used from 1981 through 2000, the images were not stored, and all circuli measurements were manually marked on a digitizing table. Consequently, units of measurement are not similar between the old and new systems.

Scale growth zones (first freshwater annulus, freshwater plus growth; and first, second, and third ocean) were identified (Figure 3), and distances between circuli measured in microns. Measurements within each zone were identified by a specific cursor key code. The center of scale growth, the area enclosed by the first circulus, is identified as the focus. The focus, where digitizing begins, represents "0", the origin. The first incremental distance measured is from "0" to the first circulus. In a one freshwater annulus fish, typically key 1 identifies the first freshwater zone, key 2 the freshwater plus growth zone, key 3 the first ocean zone, key 4 the second ocean zone, and key 5 the third ocean zone. Distances between consecutive circuli were measured in freshwater zones and in the first ocean zone. With other ocean zones, the entire zone width was measured, the measurements for age-1.3 fish end with the second ocean zone and age 1.4 measurements end with the third ocean zone. These data were recorded in an ASCII file for later statistical analysis. For some scales assigned to different stock groups, differences in freshwater and freshwater plus growth can often be interpreted by viewing the magnified scale image (Figure 4).

ANALYTICAL METHODS

In 1998, ADF&G staff wrote a program, SPAYK, combining the multiple steps required for analysis into a single comprehensive program, taking advantage of new commercial software and the increased capacity and speed of modern desktop computers. This program automated several processing tasks and implemented improvements in analytical methods. A single program execution estimates stock composition of all age classes, in all harvests. Schneiderhan (1997) provides a summary of analysis methods historically used in the stock identification project. Lingnau (2000) reprocessed historical data for years 1981 through 1996 using the new methodology.

Analytical improvements in the SPAYK program primarily occurred in 2 areas, the first improvement involved the method of estimating stock composition of major age classes. Bromaghin and Bruden (1998) developed a maximum likelihood estimation mixture model, which replaced the linear discriminant model used previously. The second improvement incorporated robust estimators of sample means and variance-covariance matrices, which reduced the influence of extreme observations on estimates (Campbell 1980). These changes substantially decreased requisite data processing and increased statistical quality of stock composition estimates. Bromaghin and Bruden (1999) detail methods implemented in the SPAYK program.

One assumption necessary was scale measurement data from escapement samples of each stock group were assumed to represent characteristics of the entire stock group. The SPAYK program computes as many as 113 variables from the measurement data for each major age. A stepwise variable selection algorithm based on Wilks' ratio (Seber 1984) selects variables that best differentiate the stock groups for inclusion in the model. The harvest samples were modeled as a weighted mixture of the estimated probability distributions of each stock group, with the weights being the stock composition proportions (Bromaghin and Bruden 1999). Stock composition proportions of each harvest, by major age class, were estimated using maximum likelihood techniques when digitized harvest samples were available.

The SPAYK program performs bootstrap sampling (Efron 1982) to determine the estimation accuracy of the maximum likelihood estimator for fish of each major age class and stock group. For each stock group within each major age class, artificial mixture or bootstrap samples of fish from that stock group were selected at random with replacement from observed escapement data. The bootstrap sample size is equal to the sample size of the stock standard. A maximum likelihood estimate of the stock composition of each bootstrap sample is obtained, and the average estimate over at least 500 simulations is computed. The results from these simulations provide an indication of the estimator performance using the stock standard data (Bromaghin and Bruden 1999).

Harvest of minor age classes, with associated digitized data were apportioned to stock group based on escapement age composition ratios (Schneiderhan 1997). Staff collected age composition data used in analysis for the Lower stock group from the Andreafsky, Anvik, Gisasa, and Tozitna rivers. Middle stock group age composition data were collected from the Chena and Salcha rivers, Henshaw Creek, and District 6 commercial harvests. CDFO provided age composition data from fish wheels located just up river from the U.S./Canada border used for the Upper stock group. Age composition estimates from multiple projects within each stock group were weighted by abundance information, when available. Raw fish wheel age composition data from Canada were collected, however, no corresponding abundance information was available to pair with them, and these data were pooled into a single sample. The estimated age composition of the Upper stock group observed in fish wheel catches was not used directly. Fish wheels preferentially harvest younger fish; therefore, the age composition of fish wheel catches does not represent the true age of the Canadian border passage. In 1996, a comparative analysis of historical Canadian age information from fish wheels, commercial gillnets and spawning ground escapements was conducted (J. Bromaghin, former Commercial Fisheries Biometrician, ADF&G, Anchorage;

unpublished memorandum). Selectivity coefficients from this analysis were applied to the observed fish wheel catch age composition, and the resulting age composition (termed “upriver adjusted”) is a more accurate estimate for the Canadian border passage age composition.

RESULTS

AGE COMPOSITION

The Lower river weighted age composition was 0.554 for age-1.3 and 0.284 for age-1.4 fish. Weighted age composition from the Middle river was 0.443 for age-1.3 and 0.418 for age-1.4 fish (Table 1). Weighted age composition from the Lower river is typically younger than the Middle river. Escapement sampling size objectives were achieved at the East Fork Andreafsky, Anvik, Gisasa, and Chena rivers and Henshaw Creek. Objectives were not achieved at the Salcha River because of high water, which prevented sampling crews from locating carcasses.

The combined Sheep Rock and White Rock fish wheel sample size from the Canadian tagging project at the border was 1,096 Chinook salmon. The adjusted Canada border passage escapement age composition was 0.268 for age-1.3 fish and 0.623 for age-1.4 fish (Table 1). These proportions were within normally observed ranges for age-1.3 and -1.4 Chinook salmon.

Yukon River Chinook salmon commercial, subsistence, and test fish age compositions are reported in Table 2. Overall, age-1.4 Chinook salmon was the most abundant age class followed by age-1.3 fish. Older-aged fish were more abundant in the lower river samples because of selectivity of 8-inch and larger mesh nets used in that area. For example, age 1.4 proportions from locations using large-mesh gear were 0.654 from the District 1 commercial harvest, 0.671 from the Big Eddy and Middle Mouth test fisheries, 0.592 from the District 2 commercial harvest, and 0.693 from the Russian Mission/Dogfish tagging project (Table 2). District 1 subsistence harvest samples, collected from nets with mesh sizes ranging from 5.5 to 8.5 inch, showed a lower proportion of age-1.4 fish (0.518) (Table 2). Small mesh (5.5 inch), large mesh (8.5 inch) and unknown mesh sized gear accounted for 27%, 47%, and 26%, respectively of District 1 subsistence samples (DuBois *Unpublished*). Frequent use of small mesh gear in this fishery explains the decreased proportion of age-1.4 fish. Lower proportions of age-1.4 fish were also observed further upriver in Districts 4 through 6 (range 0.155 to 0.583) (Table 2). The upriver samples in Alaska included samples collected from fish wheels that tend to harvest younger fish.

CATCH COMPOSITION

Scale Pattern Analysis

The SPAYK program selected 12 scale measurement characters, or variables, in distinguishing the 3 stock groups for age-1.3 fish. These variables were, in order of importance, 66, 27, 89, 1, 79, 105, 14, 7, 108, 109, 82, and 74 (Table 3). The number of variables selected for age-1.3 fish reflects the difficulty in distinguishing that age class among stock groups. The 6 variables selected for age-1.4 fish, in order of importance, were 75, 68, 111, 25, 65, and 103. In 2003, most of the variables selected were related to freshwater growth (variables 1 through 69) and first ocean growth (variables 70 through 108). There were 5 variables selected for age-1.3 fish were related to freshwater growth, 6 were related to first ocean growth, and 1 was related to second ocean growth. There were 3 variables selected for age-1.4 fish were related to freshwater growth, 2 were related to first ocean growth, and 1 was related to total ocean growth. Minimum, maximum, average, and standard deviation, by variable and age group, are presented in Table 4. The variables listed first best separate the stocks and were placed into the model accordingly. Variables involving freshwater growth usually account for most of the discriminatory power in the models. For example, variable 66, total distance of all freshwater zones was selected first for age-1.3 fish. Average measurements for this variable were 416, 459, and 541 microns for Lower, Middle and Upper stocks, respectively (Table 4). A similar increase in total freshwater growth from Lower to Upper stocks is shown in Figure 4.

Estimation Accuracy Simulations

Bootstrap sampling simulations conducted by the SPAYK program estimated accuracies for each stock group. Estimation accuracies for age-1.3 fish were 0.939 for Lower, 0.920 for Middle, and 0.958 for the Upper river standards (Table 5). Estimation accuracies for age-1.4 fish were 0.949 for Lower, 0.936 for Middle, and 0.961 for the Upper river standards. The Middle river usually has the lowest estimation accuracy. The average estimation accuracies were 0.939 for age-1.3 fish and 0.949 for age-1.4 fish. A record high number of digitized scales (n = 2,179) were used for Lower, Middle, and Upper stock standards in 2003, more than twice the average number used from 1981–2002 (Table 5). The high number of usable samples contributed to a robust stock separation model. The greatest estimation biases occurred between the Middle and Upper stock groups, historically, estimation bias is common between these groups.

Canonical variable plots provide a visual indication of separation among stock groups, given the variables selected for each major age class. Canonical variables are uncorrelated linear combinations of variables that maximize the F-statistic value in an analysis of variance hypothesis test of equal means (Johnson 1998). A scatter plot of the first 2 canonical variables for each age class provides a two-dimensional summary of the separation among the stocks (Figure 5). The first 2 canonical variables were plotted for each fish from each stock group used in the analysis. The average for each stock clearly shows the distinct separation among stocks.

Maximum Likelihood Estimates for Major Age Classes

In 2003, commercial fishing occurred in Districts 1, 2, 4, 5, and 6 of the Alaskan portion of the Yukon River drainage. Technicians collected mixed stock scale samples from commercial harvests in Districts 1, 2, and 4, and from subsistence harvests in Districts 1 and 4 (Table 2). Maximum likelihood estimates for harvests in Districts 1 through 4 were based on scale pattern analysis and age composition from these samples. Maximum likelihood estimates were not used in Districts 5 and 6 because these are not considered mixed stock fisheries.

Maximum likelihood stock composition estimates for all 5 commercial harvest periods in District 1 are presented in Table 6. The Middle stock dominated all District 1 commercial harvests for age-1.3 Chinook salmon. The Upper stock dominated the first 2 commercial harvests for age-1.4 fish and the proportion markedly decreases by period 3 (Table 6; Figures 6 and 7). In District 1, the Upper stock typically dominates the early commercial harvests and the percentage gradually decreases thereafter. The total District 1 commercial harvest stock group composition for age-1.3 fish was 1,666 Lower, 2,931 Middle, and 1,497 Upper stock group (Table 7). Age 1.4 stock composition was 1,800 Lower, 1,816 Middle, and 11,632 Upper stock group. Of the 23,327 fish harvested in the District 1 commercial fishery, 21,342 (91.5%) were age-1.3 and -1.4 Chinook salmon. Of these age-1.3 and -1.4 fish, an estimated 3,466 (16.2%) were Lower, 4,747 (22.2%) were Middle and 13,129 (61.5%) were Upper stock group (Table 7).

Maximum likelihood stock composition estimates for 2 of 4 commercial harvest periods in District 2 are presented in Table 8. Periods 3 and 4 were estimated from similar dates in District 1. The Upper stock group dominated age-1.3 Chinook salmon in both periods and age-1.4 fish in period 2 (Table 8; Figures 8 and 9). The District 2 commercial harvest stock group composition for age-1.3 fish was 352 Lower, 1,594 Middle, and 2,482 Upper stock group (Table 9). Age-1.4 fish composition was 1,529 Lower, 3,451 Middle, and 3,668 Upper stock group. Of the 14,281 fish harvested in the District 2 commercial fishery, 13,074 (91.5%) were age-1.3 and -1.4 Chinook salmon. Of these age-1.3 and -1.4 fish, an estimated 1,881 (14.4%) were Lower, 5,045 (38.6%) were Middle, and 6,150 (47.0%) were Upper stock group (Table 9).

ADF&G technicians collected mixed stock scale samples from gillnets in the District 1 subsistence harvest. Maximum likelihood analysis estimated the Middle stock group dominated stock composition of this harvest for age-1.3 and -1.4 Chinook salmon (Table 6). Figures 6 and 7 show the number and proportion of these fish. Of the 6,332 Chinook salmon harvested in the District 1 subsistence fishery (Busher and Hamazaki *In prep*), 2,438 were age-1.3 and 3,281 were age-1.4 fish (Table 10). Of these age-1.3 and -1.4 fish, an estimated 212 (3.7%) were Lower, 3,286 (57.5%) were Middle, and 2,221 (38.8%) were Upper stock group (Tables 10 and 11).

Samples were not collected from Districts 2 or 3 subsistence harvests and were indirectly classified based on scale growth analysis from other samples (Tables 10 and 11). Age composition for District 2 was based on samples collected from the District 1 subsistence harvest and District 3 age composition was based on the Russian Mission tagging project (Table 2).

Mixed stock scale samples were collected from gillnets and fish wheels in the District 4 commercial and subsistence harvests. Table 12 presents maximum likelihood stock composition estimates for these harvests. Figures 10 and 11 show the number and proportion of these fish. The Middle stock group dominated the commercial harvest. The commercial harvest samples were from fish wheels in District 4-C (south bank) where Tanana River fish, a Middle river stock, are assumed to be south-bank oriented. Of the age-1.3 and -1.4 Chinook salmon commercial harvest, an estimated 32 fish (8.1%) were Lower, 280 (70.7%) were Middle and 84 (21.2%) were Upper stock group (Tables 10 and 11; Figures 10 and 11).

The subsistence harvest in District 4 was dominated by the Upper stock group for age-1.4 Chinook salmon (Table 12; Figures 10 and 11). Of the 10,142 age-1.3 and -1.4 fish, an estimated 96 fish (0.9%) were Lower, 2,378 (23.4%) were Middle, and 7,668 (75.6%) were Upper stock group (Tables 10 and 11; Figures 10 and 11).

A total of 63,968 age-1.3 and -1.4 Chinook salmon were harvested in mixed stock fisheries in Districts 1 through 4 (Table 10). Of these, 49,220 (76.9%) were directly classified to a stock group based on results of scale growth analysis. Directly classified age-1.3 and -1.4 fish include commercial and subsistence harvests from Districts 1 and 4, and District 2 commercial harvest from periods 1 and 2.

Differential Age Composition Analysis

The minor age classes (ages-1.1, -1.2, -2.3, -1.5, -2.4, and -1.6) from Districts 1 through 4 commercial and subsistence harvests contributed 7,075 fish (10.0%) to the total drainage harvest (Table 10). These minor age classes were classified to stock groups by applying escapement age composition ratios in each stock group to maximum likelihood abundance estimates from the analogous major age class, for example, age-1.3 or -1.4 fish (Schneiderhan 1997). The most abundant minor age classes in these districts were age-1.5 fish (5,533, 7.8%) and age-1.2 fish (1,395, 2.0%) (Table 10).

Assignment by Geographical Analysis

Harvests in Districts 5 and 6 and the Canadian portion of the Yukon River drainage are assigned to a stock group based on geographic location. Age composition estimates for these harvests were based on samples collected from Districts 5 and 6 commercial harvests in Alaska and from mark–recapture fish wheels in Canada (Tables 1 and 2).

Age composition estimates for 1,134 Chinook salmon, commercially harvested in District 5, by period, are presented in Table 13. Age-1.4 fish were the most abundant age class harvested. These commercially harvested fish and a subsistence harvest of 19,016 fish (Busher and Hamazaki *In prep*) were assigned to the Upper stock group. District 5 harvest was comprised of 10,054 age-1.4 fish (49.9%), 7,376 age-1.3 fish (36.6%), 1,195 age-1.2 fish (5.9%), and 1,414 age-1.5 fish (7.0%) (Tables 10 and 11). The District 5 harvest composes 18.6% of the total Yukon River drainage harvest.

Genetic stock identification studies indicate Upper Koyukuk River fish are more similar to Middle stocks than to Lower or Upper stocks (Wilmot et al. 1992). Therefore, the Upper Koyukuk River subsistence harvest of 900 Chinook salmon (Busher and Hamazaki *In prep*) was assigned to the Middle stock group and was included with the District 6 harvest (Table 10). Chandalar and Black rivers subsistence harvest of 175 Chinook salmon were also assigned to the Middle stock group and were included with the District 6 harvest. Although Chandalar and Black rivers harvest occurred in District 5, which is classified as an Upper stock group (Canadian origin), they occur in Alaskan tributaries and therefore are not assigned to the Upper stock group. A subsistence harvest of 3,424 Chinook salmon in District 6 (includes harvests from Upper Koyukuk, Chandalar and Black rivers) were assigned to the Middle stock group based on the geographic location of the fisheries (Table 10).

The Chena, Salcha, and Chatanika rivers, tributaries of the Tanana River, support the largest Chinook salmon sport fish harvest in the Alaska portion of the Yukon River drainage. All other sport harvests occurring in the Alaska portion of the drainage are considered minor. The Tanana River is assigned to the Middle stock group; therefore, all sport fish harvested Chinook salmon in Alaska are assigned to this stock group. The sport fish harvest of 2,136 Chinook salmon (M. Doxey, Sport Fish Biologist, ADF&G, Fairbanks; personal communication) is recorded in Table 10.

Age composition estimates for 1,813 Chinook salmon, commercially harvested in District 6, by period, are presented in Table 13. The 7,373 Chinook salmon harvested from District 6 commercial, subsistence, and sport fisheries were 6.8% of the total Yukon River drainage harvest. The District 6 harvest was comprised of 3,152 age-1.3 fish (42.7%), 2,920 age-1.4 fish (39.6%), 750 age-1.2 fish (10.2%), 459 age-1.5 fish (6.2%), 63 age-1.1 fish (0.9%), 13 age-2.3 fish (0.2%), and 16 age-2.4 fish (0.2%) (Tables 10 and 11).

The total harvest from Canadian fisheries, 9,619 Chinook salmon (JTC 2004), was assigned to the Upper stock group. This harvest composed 8.9% of the total drainage harvest. The Canadian harvest was comprised of 2,672 commercial, 6,294 Aboriginal (includes Porcupine River harvest near Old Crow), 263 test, 115 domestic, and 275 sport harvested fish (Table 10; JTC 2004). The age composition was comprised of 5,998 age-1.4 fish (62.4%), 2,582 age-1.3 fish (26.8%), 937 age-1.5 fish (9.7%), 42 age-1.2 fish (0.4%), 13 age-2.3 fish (0.1%), and 47 age-2.4 fish (0.5%) (Tables 10 and 11).

Total Harvest

Alaskan and Canadian fishers harvested 108,185 Chinook salmon from the Yukon River drainage in 2003 (Tables 10 and 14). In numbers of fish, the years 2000 through 2002 had the lowest total harvests since 1981, and consequently, the 2003 harvest is about 25% more than the 5-year average (1998–2002) and 20% less than the 10-year average (1993–2002) harvest (Table 14).

The Upper stock group was the largest estimated component of the total harvest, contributing 69,559 fish, or 64.3% of the total (Tables 10 and 11). Upper stock group harvest by country was 59,940 fish in the U.S. and 9,619 fish in Canada (Table 14). The 2003 Upper stock group harvest, in numbers of fish, was approximately 50% more than the 5-year average (1998–2002) and 10% less than the 10-year average (1993–2002) harvest (Table 14). The proportion of the Upper stock group harvest in the U.S. was 0.554, above all the average proportions (Table 15).

The Middle stock group was second in harvest abundance with an estimated 31,232 fish (28.9%) (Tables 10, 11, and 14). The 2003 harvest estimate from the Middle stock group, in numbers of fish, is above the 5-year average (1998–2002) and 10-year average (1993–2002) harvests (Table 14). The 2003 Middle stock harvest proportion was well above average (Table 15).

The Lower stock group was the least abundant stock group in the 2003 harvest contributing an estimated 7,394 fish (6.8%) (Tables 10, 11 and 14). This harvest was the lowest on record for the Lower stock group (Table 14).

DISCUSSION

In 2003, the relatively high proportion of Upper river stocks in the total Yukon River Chinook salmon harvest is corroborated by record high escapement and border passage numbers into Canada (JTC 2004). The border passage estimate was 58,082 fish, the highest estimate on record since 1982. The higher than average proportion of Middle river stocks in the total Chinook salmon harvest is supported by near record returns to the Chena and Salcha rivers (JTC 2004). Estimated escapement to these rivers was 12,500 fish to the Chena River and 14,600 fish to the Salcha River. The below average proportion of Lower river stocks is not attributable to lower returns. Escapements of Lower river stocks were assessed to be average or better based on weir counts and limited aerial surveys (T. L. Lingnau, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). The high abundance of Upper and Middle river stocks accounts for the decreased proportions of Lower river stocks.

Attainment of sample size objectives presented in the annual sampling plan is a reasonable measure of operational success. In 2003, sample sizes were judged above average from most escapement sampling locations. Sample sizes from commercial and subsistence harvests were also above average. These larger sample sizes contributed to increased accuracies in stock separation models. Sample size objectives are designed to ensure an adequate number of scales from age-1.3 and -1.4 Chinook salmon are digitized for scale pattern analysis to describe the age composition of the harvests and escapements. Larger sample size objectives from escapement sampling locations are required because these samples are from carcasses and live fish with longer migrations than the mixed stock samples. Acceptable sample quality depends on environmental and biological factors, which are difficult to control, and sampling techniques, which can be controlled. For the data set size used in the analysis to remain acceptable, sampling techniques must be optimized. Less than adequate sample sizes can become problematic when developing a stock group model. Collection of good quality samples forms the foundation upon which this stock identification program rests.

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TABLES AND FIGURES

Table 1.–Yukon River Chinook salmon escapement age composition by tributary and weighted age composition by geographic area, 2003.

	Age Group									
Tributary	**1.1**	**1.2**	**1.3**	**1.4**	**2.3**	**1.5**	**2.4**	**1.6**	**2.5**	**Total**
East Fork Andreafsky River	0.005	0.160	0.520	0.307	0.000	0.008	0.000	0.000	0.000	1.000
Anvik River	0.002	0.089	0.547	0.332	0.000	0.030	0.000	0.000	0.000	1.000
Gisasa River	0.004	0.055	0.678	0.254	0.000	0.010	0.000	0.000	0.000	1.000
Tozitna River	0.004	0.269	0.518	0.205	0.000	0.004	0.000	0.000	0.000	1.000
Lower River Weighted	0.004	0.146	0.554	0.284	0.000	0.012	0.000	0.000	0.000	1.000
Chena River	0.000	0.051	0.465	0.416	0.000	0.068	0.000	0.000	0.000	1.000
Salcha River	0.007	0.073	0.424	0.424	0.000	0.073	0.000	0.000	0.000	1.000
Henshaw Creek	0.014	0.195	0.457	0.318	0.000	0.017	0.000	0.000	0.000	1.000
Middle River Weighted	0.004	0.066	0.443	0.418	0.000	0.069	0.000	0.000	0.000	1.000
Upper River Combined (unadjusted)	0.000	0.112	0.481	0.368	0.001	0.036	0.002	0.000	0.000	1.000
Upper River Combined (adjusted)[a]	0.000	0.005	0.268	0.623	0.002	0.097	0.005	0.000	0.000	1.000

[a] Adjusted age composition after gear-selectivity coefficients were applied to the combined Sheep Rock and White Rock fish wheel age composition to obtain a more accurate estimate of the border passage escapement age composition.

Table 2.–Yukon River Chinook salmon commercial, subsistence, and test fish age composition by location, gear type, and sample size, 2003.

		Sample	Age Group									
Location	Gear [a]	Size	1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	2.5	Total
District 1 Commercial	≥ 8.0" GN	1,405	0.000	0.005	0.261	0.654	0.000	0.079	0.000	0.001	0.000	1.000
District 1 Subsistence	SGN/DGN	330	0.000	0.039	0.385	0.518	0.000	0.058	0.000	0.000	0.000	1.000
Big Eddy/ Middle Test Fish	8.25" DGN 8.5" SGN	1,706	0.000	0.006	0.250	0.671	0.000	0.072	0.001	0.000	0.001	1.000
District 2 Commercial	≥ 8.0" GN	779	0.000	0.010	0.325	0.592	0.000	0.073	0.000	0.000	0.000	1.000
Russian Mission Dogfish Tagging	8.5" DGN	997	0.000	0.004	0.221	0.693	0.000	0.081	0.000	0.001	0.000	1.000
District 4 Commercial	FW	191	0.027	0.236	0.549	0.155	0.000	0.034	0.000	0.000	0.000	1.000
District 4 Subsistence	SGN/FW	254	0.000	0.031	0.272	0.583	0.000	0.106	0.008	0.000	0.000	1.000
District 5 Commercial	SGN/FW	368	0.000	0.049	0.347	0.525	0.003	0.068	0.008	0.000	0.000	1.000
District 6 Commercial	SGN/FW	464	0.010	0.115	0.413	0.398	0.002	0.060	0.003	0.000	0.000	1.000
Canada Test Fish	FW	1,036	0.000	0.107	0.380	0.380	0.005	0.122	0.005	0.000	0.000	1.000

[a] SGN is set gillnet, DGN is drift gillnet, GN is gillnet, and FW is fish wheel.

Table 3.–Set of scale variables and their descriptions selected for Yukon River Chinook salmon stock identification, 2003.

Age Group	Scale Variable	Description of the Scale Characteristics
1.3	66	Total distance of all the freshwater zones (1st freshwater, 2nd freshwater, and freshwater plus).
	27	Total distance of the 1st freshwater zone divided by number of circuli within the 1st freshwater zone.
	89	Total distance within the 1st ocean zone minus the distance from the beginning of the 1st ocean zone to circulus 15.
	1	The number of circuli within the 1st freshwater zone.
	79	The distance from circulus 3 to circulus 12 within the 1st ocean zone.
	105	Total distance of the 1st ocean zone divided by the number of circuli within the 1st ocean zone.
	14	Total distance of the 1st freshwater zone minus the distance between the scale focus to the 2nd circulus in the 1st freshwater zone.
	7	The distance from circulus 2 to circulus 4 within the 1st freshwater zone.
	108	The maximum distance between consecutive circuli within the 1st ocean zone divided by the total distance within the 1st ocean zone.
	109	Total distance within the 2nd ocean zone.
	82	The distance from circulus 6 to circulus 12 within the 1st ocean zone.
	74	The distance from the beginning of the 1st ocean zone to circulus 9 within the 1st ocean zone.
1.4	75	The distance from the beginning of the 1st ocean zone to circulus 12 within the 1st ocean zone.
	68	The total distance of the freshwater plus growth zone divided by the total freshwater distance.
	111	Total distance of all the ocean zones (1st ocean, 2nd ocean, and 3rd ocean).
	25	The distance from the 4th circulus preceding the end of the 1st freshwater zone to the end of the 1st freshwater zone divided by the total distance within the 1st FW zone.
	65	Total number of circuli in all the freshwater zones (1st freshwater, 2nd freshwater, and freshwater plus).
	103	The distance from the 6th circulus preceding the end of the 1st ocean zone to the end of the 1st ocean zone divided by the total distance within the 1st ocean zone.

Table 4.–Set of scale variables and their corresponding values for Lower, Middle, and Upper river stocks selected for Yukon River Chinook salmon stock identification, 2003.

Age Group	Variable	Unit [a]	Minimum			Maximum			Average			Standard Deviation		
			Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Age 1.3	66	*m* [b]	256	306	320	684	659	692	416	459	541	72	62	61
	27	*m* / circuli	21.2	22.0	22.2	49.2	48.0	47.7	34.6	32.0	32.8	4.9	4.4	4.2
	89	*m*	175	95	0	1,428	1,154	1,029	739	624	518	183	162	161
	1	circuli	4	5	6	12	13	14	7.5	8.4	9.6	1.7	1.4	1.4
	79	*m*	274	304	279	636	663	677	449	75	519	58	56	54
	105	*m* / circuli	34.8	35.8	41.2	63.4	62.0	64.8	50.8	50.7	53.1	4.5	4.2	4.1
	14	*m*	47	67	112	388	264	339	141	152	196	47	35	38
	7	*m*	23	31	32	113	91	107	62	60	68	13	12	12
	108	*m* / *m*	0.03	0.04	0.04	0.08	0.10	0.09	.05	0.06	0.06	0.01	0.01	0.01
	109	*m*	542	511	630	1,909	1,664	1,734	1,218	1,178	1,191	207	187	181
	82	*m*	202	210	112	433	501	339	316	333	196	41	43	38
	74	*m*	210	300	297	557	589	623	395	427	475	59	51	52
Age 1.4	75	*m*	378	392	493	787	810	815	574	579	649	65	68	61
	68	*m* / *m*	0.24	0.26	0.32	0.55	0.60	0.58	0.39	0.44	0.44	0.06	0.06	0.05
	111	*m*	2,352	2,133	2,467	4,572	4,417	4,559	3,523	3,381	3,442	331	387	318
	25	*m* / *m*	0.18	0.19	0.20	1.00	1.00	0.58	0.38	.36	0.30	0.12	0.10	0.06
	65	circuli	10	10	13	20	20	24	5.0	15.0	17.0	2.0	1.9	1.9
	103	*m* / *m*	0.13	0.11	0.12	0.47	0.40	0.40	0.22	0.21	0.22	0.04	0.04	0.04

[a] Units used in measurement and calculation of variable. Table 3 lists scale characteristics used for each variable.

[b] All measurements of distance were recorded in microns.

Table 5.–Accuracy of maximum likelihood estimates for Yukon River Chinook salmon stock composition by age and stock group, 2003.

Age Group	Stock Group	Sample Size	Stock Composition Proportion [a] Lower	Middle	Upper	Total
Age 1.3	Lower	535	0.939	0.035	0.027	1.000
	Middle	399	0.028	0.920	0.053	1.000
	Upper	345	0.025	0.017	0.958	1.000
	Total	1,279			Average Accuracy	0.939
			Lower	Middle	Upper	Total
Age 1.4	Lower	296	0.949	0.040	0.011	1.000
	Middle	341	0.017	0.936	0.047	1.000
	Upper	263	0.014	0.025	0.961	1.000
		900			Average Accuracy	0.949

Note: boxes represent proportions used to estimate average accuracy.

[a] Stock composition proportions were based on 500 bootstrap simulations for each age and stock group.

Table 6.–Yukon River District 1 commercial harvest estimated stock composition by period and subsistence harvest for age-1.3 and -1.4 Chinook salmon, 2003.

	Estimated stock composition for age 1.3				Estimated stock composition for age 1.4			
Strata [a]	**Sample Size**	**Stock Group**	**Estimate**	**Standard Error**	**Sample Size**	**Stock Group**	**Estimate**	**Standard Error**
Commercial	81	Lower	0.320	0.080	195	Lower	0.010	0.048
Period 1		Middle	0.527	0.105		Middle	0.068	0.081
16-Jun		Upper	0.153	0.065		Upper	0.921	0.084
Commercial	75	Lower	0.176	0.067	167	Lower	0.091	0.046
Period 2		Middle	0.464	0.122		Middle	0.013	0.135
21-Jun		Upper	0.360	0.102		Upper	0.897	0.090
Commercial	85	Lower	0.343	0.083	158	Lower	0.356	0.072
Period 3		Middle	0.348	0.112		Middle	0.313	0.115
26-Jun		Upper	0.309	0.085		Upper	0.331	0.077
Commercial	26	Lower	0.312	0.156	157 [b]	Lower	0.453	0.075
Period 4		Middle	0.453	0.249		Middle	0.465	0.098
2-Jul		Upper	0.235	0.130		Upper	0.082	0.049
Commercial	39 [c]	Lower	0.235	0.113	154 [d]	Lower	0.418	0.074
Period 5		Middle	0.519	0.208		Middle	0.570	0.088
7-Jul		Upper	0.246	0.111		Upper	0.012	0.030
Subsistence	161	Lower	0.087	0.041	162	Lower	0.000	0.077
3-13 June		Middle	0.599	0.089		Middle	0.557	0.126
		Upper	0.315	0.065		Upper	0.443	0.097

[a] Mesh size was restricted to 8 inch or larger for all District 1 commercial periods.
[b] Samples from periods 3 and 4 were used to estimate stock composition of age-1.4 fish harvested in period 4.
[c] Samples from periods 4 and 5 were used to estimate stock composition of age-1.3 fish harvested in period 5.
[d] Samples from periods 3, 4, and 5 were used to estimate stock composition of age-1.4 fish harvested in period 5.

Table 7.–Yukon River Chinook salmon District 1 commercial harvest by age, stock group, and period, 2003.

Strata [a]	Stock Group	Age Group 1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
Period 1	Lower	0	0	914	72	0	3	0	9	998
16-Jun	Middle	0	0	1,502	473	0	67	0	9	2,051
	Alaska	0	0	2,416	545	0	70	0	18	3,049
	Upper	0	0	436	6,378	0	845	0	9	7,668
	Total	0	0	2,852	6,923	0	915	0	27	10,717
Period 2	Lower	0	21	348	433	0	14	0	0	816
21-Jun	Middle	0	32	916	60	0	7	0	0	1,015
	Alaska	0	53	1,264	493	0	21	0	0	1,831
	Upper	0	3	710	4,275	0	482	0	0	5,470
	Total	0	56	1,974	4,768	0	503	0	0	7,301
Period 3	Lower	3	29	233	625	0	18	0	0	908
26-Jun	Middle	4	16	237	550	0	61	0	0	868
	Alaska	7	45	470	1,175	0	79	0	0	1,776
	Upper	0	2	210	580	0	61	0	0	853
	Total	7	47	680	1,755	0	140	0	0	2,629
Period 4	Lower	0	0	112	481	0	36	0	0	629
2-Jul	Middle	0	0	164	493	0	143	0	0	800
	Alaska	0	0	276	974	0	179	0	0	1,429
	Upper	0	0	85	86	0	24	0	0	195
	Total	0	0	361	1,060	0	203	0	0	1,624
Period 5	Lower	0	0	15	141	0	5	0	0	161
7-Jul	Middle	0	0	34	192	0	29	0	0	255
	Alaska	0	0	49	333	0	34	0	0	416
	Upper	0	0	16	4	0	1	0	0	21
	Total	0	0	65	337	0	35	0	0	437
All Periods	Lower	3	51	1,666	1,800	0	78	0	9	3,608
Combined [b]	Middle	4	49	2,931	1,816	0	315	0	9	5,125
	Alaska	7	101	4,597	3,616	0	393	0	18	8,733
	Upper	0	5	1,497	11,632	0	1,452	0	9	14,594
	Total	7	106	6,094	15,248	0	1,845	0	28	23,327

[a] Mesh size was restricted to 8 inch or larger for all District 1 commercial periods.
[b] Includes 619 fish from test fish sales.

Table 8.–Yukon River District 2 commercial harvest estimated stock composition by period for age-1.3 and -1.4 Chinook salmon, 2003.

	Estimated Stock Composition for Age 1.3				Estimated Stock Composition for Age 1.4			
Strata [a]	Sample Size	Stock Group	Estimate	Standard Error	Sample Size	Stock Group	Estimate	Standard Error
Period 1	103	Lower	0.069	0.038	158	Lower	0.182	0.052
18-Jun		Middle	0.371	0.096		Middle	0.458	0.108
		Upper	0.561	0.101		Upper	0.361	0.086
Period 2	114	Lower	0.061	0.037	161	Lower	0.076	0.047
25-Jun		Middle	0.325	0.102		Middle	0.268	0.090
		Upper	0.614	0.102		Upper	0.656	0.088
Period 3	Stock composition estimates were based on District 1, period 4.							
2-Jul								
Period 4	Stock composition estimates were based on District 1, period 5.							
7-Jul								

[a] Mesh size was restricted to 8 inch or larger for all District 2 commercial periods.

Table 9.–Yukon River Chinook salmon District 2 commercial harvest by age, stock group, and period, 2003.

Strata [a]	Stock Group	Age Group 1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
Period 1	Lower	0	13	166	809	0	32	0	0	1,020
18-Jun	Middle	0	38	897	2,039	0	312	0	0	3,286
	Alaska	0	51	1,063	2,848	0	344	0	0	4,306
	Upper	0	7	1,358	1,609	0	232	0	0	3,206
	Total	0	58	2,421	4,457	0	576	0	0	7,512
Period 2	Lower	0	14	104	231	0	8	0	0	357
25-Jun	Middle	0	43	552	816	0	102	0	0	1,513
	Alaska	0	57	656	1,047	0	110	0	0	1,870
	Upper	0	9	1,045	1,996	0	235	0	0	3,285
	Total	0	66	1,701	3,043	0	345	0	0	5,155
Period 3	Lower	0	0	52	222	0	16	0	0	290
2-Jul	Middle	0	0	76	227	0	66	0	0	369
	Alaska	0	0	128	449	0	82	0	0	659
	Upper	0	0	39	40	0	11	0	0	90
	Total	0	0	167	489	0	93	0	0	749
Period 4	Lower	0	0	28	260	0	9	0	0	297
7-Jul	Middle	0	0	62	354	0	53	0	0	469
	Alaska	0	0	90	614	0	62	0	0	766
	Upper	0	0	29	7	0	2	0	0	38
	Total	0	0	119	621	0	64	0	0	804
All Periods	Lower	0	27	352	1,529	0	65	0	0	1,972
Combined [b]	Middle	0	81	1,594	3,451	0	535	0	0	5,661
	Alaska	0	108	1,945	4,979	0	601	0	0	7,634
	Upper	0	16	2,482	3,668	0	482	0	0	6,647
	Total	0	124	4,427	8,647	0	1,083	0	0	14,281

[a] Mesh size was restricted to 8 inch or larger for all District 2 commercial periods.

[b] Includes 61 fish from test fish sales.

Table 10.–Yukon River Chinook salmon harvest by age, stock group, and fishery, 2003.

District	Fishery	Stock Group	Age Group 1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
1	Commercial [a]	Lower	3	51	1,666	1,800	0	78	0	9	3,608
		Middle	4	49	2,931	1,816	0	315	0	9	5,125
		Alaska	7	101	4,597	3,616	0	393	0	18	8,733
		Upper	0	5	1,497	11,632	0	1,452	0	9	14,594
		Total	7	106	6,094	15,248	0	1,845	0	28	23,327
	Subsistence	Lower	0	49	212	0	0	0	0	0	261
		Middle	0	189	1,459	1,827	0	208	0	0	3,683
		Alaska	0	238	1,671	1,827	0	208	0	0	3,944
		Upper	0	11	767	1,454	0	156	0	0	2,388
		Total	0	249	2,438	3,281	0	364	0	0	6,332
2	Commercial [b]	Lower	0	27	352	1,529	0	65	0	0	1,972
		Middle	0	81	1,594	3,451	0	535	0	0	5,661
		Alaska	0	108	1,945	4,979	0	601	0	0	7,634
		Upper	0	16	2,482	3,668	0	482	0	0	6,647
		Total	0	124	4,427	8,647	0	1,083	0	0	14,281
	Subsistence [c]	Lower	0	75	792	35	0	1	0	0	903
		Middle	0	289	2,083	1,129	0	120	0	0	3,621
		Alaska	0	364	2,875	1,164	0	121	0	0	4,524
		Upper	0	17	846	3,845	0	436	0	0	5,144
		Total	0	381	3,721	5,009	0	557	0	0	9,668
3	Subsistence [d]	Lower	0	6	84	364	0	14	0	2	470
		Middle	0	21	526	1,739	0	223	0	2	2,511
		Alaska	0	27	610	2,103	0	237	0	4	2,981
		Upper	0	2	474	1,378	0	166	0	1	2,021
		Total	0	29	1,084	3,481	0	403	0	5	5,002
4	Commercial	Lower	2	27	32	0	0	0	0	0	61
		Middle	13	102	216	64	0	14	0	0	409
		Alaska	15	129	248	64	0	14	0	0	470
		Upper	0	3	61	23	0	5	0	0	92
		Total	15	132	309	87	0	19	0	0	562
	Subsistence [e]	Lower	0	21	57	39	0	2	0	0	119
		Middle	0	317	1,579	799	0	154	0	0	2,849
		Alaska	0	338	1,636	838	0	156	0	0	2,968
		Upper	0	36	1,589	6,079	0	1,106	93	0	8,903
		Total	0	374	3,225	6,917	0	1,262	93	0	11,871
5	Commercial	Upper	0	56	394	595	3	77	9	0	1,134
	Subsistence [f]	Upper	0	1,139	6,982	9,459	0	1,337	99	0	19,016
		Total	0	1,195	7,376	10,054	3	1,414	108	0	20,150
6	Commercial	Middle	18	208	748	722	4	108	5	0	1,813
	Subsistence [g]	Middle	41	419	1,437	1,304	9	203	11	0	3,424
	Sport Fish	Middle	4	123	967	894	0	148	0	0	2,136
		Total	63	750	3,152	2,920	13	459	16	0	7,373
Canada [h]	Commercial	Upper	0	12	717	1,666	4	260	13	0	2,672
	Aboriginal	Upper	0	28	1,689	3,924	9	613	31	0	6,294
	Test Fish	Upper	0	1	71	164	0	26	1	0	263
	Domestic	Upper	0	0	31	72	0	11	1	0	115
	Sport Fish	Upper	0	1	74	172	0	27	1	0	275
		Total	0	42	2,582	5,998	13	937	47	0	9,619

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Table 10.–Page 2 of 2.

District	Fishery	Stock Group	Age Group 1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
Total Harvest		Lower	5	256	3,195	3,766	0	160	0	11	7,394
		Middle	80	1,799	13,540	13,745	13	2,029	16	11	31,232
		Alaska	85	2,055	16,734	17,511	13	2,189	16	22	38,626
		Upper	0	1,327	17,673	44,130	16	6,154	248	10	69,559
		Total	85	3,382	34,408	61,642	29	8,343	264	33	108,185

[a] District 1 commercial harvest includes 619 Chinook salmon caught by test fishing projects.

[b] District 2 commercial harvest includes 61 Chinook salmon caught by test fishing projects.

[c] Stock group estimates are based on District 1 subsistence and District 1, period 1 commercial samples. Age composition estimates are based on District 1 subsistence samples.

[d] Stock group estimates are based on District 1 subsistence samples and District 2, period 1 commercial samples. Age composition estimates are based on Russian Mission and Dogfish tagging samples.

[e] Stock group and age composition estimates are based on subsistence samples from gillnet and fish wheel harvests in District 4. Upper Koyukuk River subsistence harvest is not included.

[f] Chandalar and Black rivers subsistence harvest are not included.

[g] Upper Koyukuk River subsistence harvest is included because these salmon are more closely related to the Middle stock group than the Upper or Lower stock groups. Chandalar and Black River subsistence harvests are included because these fish are bound for spawning grounds within the Alaska portion of the Yukon River.

[h] Commercial, Aboriginal, test fish, domestic, and sport fish age compositions are based on the upriver adjusted harvest from fish wheels. The Porcupine River harvest near Old Crow is included under the Aboriginal harvest.

Table 11.–Yukon River Chinook salmon harvest proportions by age, stock group, and fishery, 2003.

District	Fishery	Stock Group	Age Group 1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
1	Commercial [a]	Lower	0.000	0.002	0.071	0.077	0.000	0.003	0.000	0.000	0.155
		Middle	0.000	0.002	0.126	0.078	0.000	0.014	0.000	0.000	0.220
		Alaska	0.000	0.004	0.197	0.155	0.000	0.017	0.000	0.001	0.374
		Upper	0.000	0.000	0.064	0.499	0.000	0.062	0.000	0.000	0.626
		Total	0.000	0.005	0.261	0.654	0.000	0.079	0.000	0.001	1.000
	Subsistence	Lower	0.000	0.008	0.033	0.000	0.000	0.000	0.000	0.000	0.041
		Middle	0.000	0.030	0.230	0.289	0.000	0.033	0.000	0.000	0.582
		Alaska	0.000	0.038	0.264	0.289	0.000	0.033	0.000	0.000	0.623
		Upper	0.000	0.002	0.121	0.230	0.000	0.025	0.000	0.000	0.377
		Total	0.000	0.039	0.385	0.518	0.000	0.057	0.000	0.000	1.000
2	Commercial [b]	Lower	0.000	0.002	0.025	0.107	0.000	0.005	0.000	0.000	0.138
		Middle	0.000	0.006	0.112	0.242	0.000	0.037	0.000	0.000	0.396
		Alaska	0.000	0.008	0.136	0.349	0.000	0.042	0.000	0.000	0.535
		Upper	0.000	0.001	0.174	0.257	0.000	0.034	0.000	0.000	0.465
		Total	0.000	0.009	0.310	0.605	0.000	0.076	0.000	0.000	1.000
	Subsistence [c]	Lower	0.000	0.008	0.082	0.004	0.000	0.000	0.000	0.000	0.093
		Middle	0.000	0.030	0.215	0.117	0.000	0.012	0.000	0.000	0.375
		Alaska	0.000	0.038	0.297	0.120	0.000	0.013	0.000	0.000	0.468
		Upper	0.000	0.002	0.088	0.398	0.000	0.045	0.000	0.000	0.532
		Total	0.000	0.039	0.385	0.518	0.000	0.058	0.000	0.000	1.000
3	Subsistence [d]	Lower	0.000	0.001	0.017	0.073	0.000	0.003	0.000	0.000	0.094
		Middle	0.000	0.004	0.105	0.348	0.000	0.045	0.000	0.000	0.502
		Alaska	0.000	0.005	0.122	0.420	0.000	0.047	0.000	0.001	0.596
		Upper	0.000	0.000	0.095	0.275	0.000	0.033	0.000	0.000	0.404
		Total	0.000	0.006	0.217	0.696	0.000	0.081	0.000	0.001	1.000
4	Commercial	Lower	0.004	0.048	0.057	0.000	0.000	0.000	0.000	0.000	0.109
		Middle	0.023	0.181	0.384	0.114	0.000	0.025	0.000	0.000	0.728
		Alaska	0.027	0.230	0.441	0.114	0.000	0.025	0.000	0.000	0.836
		Upper	0.000	0.005	0.109	0.041	0.000	0.009	0.000	0.000	0.164
		Total	0.027	0.235	0.550	0.155	0.000	0.034	0.000	0.000	1.000
4	Subsistence [e]	Lower	0.000	0.002	0.005	0.003	0.000	0.000	0.000	0.000	0.010
		Middle	0.000	0.027	0.133	0.067	0.000	0.013	0.000	0.000	0.240
		Alaska	0.000	0.028	0.138	0.071	0.000	0.013	0.000	0.000	0.250
		Upper	0.000	0.003	0.134	0.512	0.000	0.093	0.008	0.000	0.750
		Total	0.000	0.032	0.272	0.583	0.000	0.106	0.008	0.000	1.000
5	Commercial	Upper	0.000	0.003	0.020	0.030	0.000	0.004	0.000	0.000	0.056
	Subsistence [f]	Upper	0.000	0.057	0.347	0.469	0.000	0.066	0.005	0.000	0.944
		Total	0.000	0.059	0.366	0.499	0.000	0.070	0.005	0.000	1.000
6	Commercial	Middle	0.002	0.028	0.101	0.098	0.001	0.015	0.001	0.000	0.246
	Subsistence [g]	Middle	0.006	0.057	0.195	0.177	0.001	0.028	0.001	0.000	0.464
	Sport Fish	Middle	0.001	0.017	0.131	0.121	0.000	0.020	0.000	0.000	0.290
		Total	0.009	0.102	0.428	0.396	0.002	0.062	0.002	0.000	1.000

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Table 11.–Page 2 of 2.

District	Fishery	Stock Group	Age Group 1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
Canada [h]	Commercial	Upper	0.000	0.001	0.075	0.173	0.000	0.027	0.001	0.000	0.278
	Aboriginal	Upper	0.000	0.003	0.176	0.408	0.001	0.064	0.003	0.000	0.654
	Domestic	Upper	0.000	0.000	0.007	0.017	0.000	0.003	0.000	0.000	0.027
	Test Fish	Upper	0.000	0.000	0.003	0.007	0.000	0.001	0.000	0.000	0.012
	Sport Fish	Upper	0.000	0.000	0.008	0.018	0.000	0.003	0.000	0.000	0.029
		Total	0.000	0.004	0.268	0.624	0.001	0.097	0.005	0.000	1.000
Total Harvest		Lower	0.000	0.002	0.030	0.035	0.000	0.001	0.000	0.000	0.068
		Middle	0.001	0.017	0.125	0.127	0.000	0.019	0.000	0.000	0.289
		Alaska	0.001	0.019	0.155	0.162	0.000	0.020	0.000	0.000	0.357
		Upper	0.000	0.012	0.163	0.408	0.000	0.057	0.002	0.000	0.643
		Total	0.001	0.031	0.318	0.570	0.000	0.077	0.002	0.000	1.000

[a] District 1 commercial harvest includes 619 Chinook salmon caught by test fishing projects.

[b] District 2 commercial harvest includes 61 Chinook salmon caught by test fishing projects.

[c] Stock group estimates are based on District 1 subsistence and District 1, period 1 commercial samples. Age composition estimates are based on District 1 subsistence samples.

[d] Stock group estimates are based on District 1 subsistence samples and District 2, period 1 commercial samples. Age composition estimates are based on Russian Mission and Dogfish tagging samples.

[e] Stock group and age composition estimates are based on subsistence samples from gillnet and fish wheel harvests in District 4. Upper Koyukuk River subsistence harvest is not included.

[f] Chandalar and Black rivers subsistence harvest are not included.

[g] Upper Koyukuk River subsistence harvest is included because these salmon are more closely related to the Middle stock group than the Upper or Lower stock groups. Chandalar and Black River subsistence harvests are included because these fish are bound for spawning grounds within the Alaska portion of the Yukon River.

[h] Commercial, Aboriginal, test fish, domestic, and sport fish age compositions are based on the upriver adjusted harvest from fish wheels. The Porcupine River harvest near Old Crow is included under the Aboriginal harvest.

Table 12.–Yukon River District 4 commercial and subsistence harvest estimated stock composition for age-1.3 and -1.4 Chinook salmon, 2003.

	Estimated Stock Composition for Age 1.3				Estimated Stock Composition for Age 1.4			
Strata	Sample Size	Stock Group	Estimate	Standard Error	Sample Size	Stock Group	Estimate	Standard Error
District 4-C Commercial	86	Lower	0.104	0.057	22	Lower	0.000	0.219
		Middle	0.699	0.111		Middle	0.733	0.372
		Upper	0.197	0.066		Upper	0.267	0.303
District 4 Subsistence	55	Lower	0.018	0.034	102	Lower	0.006	0.019
		Middle	0.490	0.161		Middle	0.116	0.075
		Upper	0.493	0.136		Upper	0.879	0.111

Table 13.–Yukon River Chinook salmon Districts 5 and 6 commercial harvest by age, stock group, and period, 2003.

Subdistrict/ District	Period	Stock Group	Age Group 1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
5-B, 5-C	1	Upper	0	6	100	158	0	21	0	0	285
5-B, 5-C	2	Upper	0	40	182	224	0	33	4	0	483
5-B, 5-C, 5-D	3, 4	Upper	0	10	112	213	3	23	5	0	366
	All	Total	0	56	394	595	3	77	9	0	1,134
6	1	Middle	0	17	266	167	0	17	0	0	467
6	2	Middle	9	103	282	241	4	45	0	0	684
6	3	Middle	9	66	89	170	0	28	5	0	367
6	4, 5	Middle	0	22	111	144	0	18	0	0	295
	All	Total	18	208	748	722	4	108	5	0	1,813

Table 14.–Yukon River Chinook salmon historical harvest by stock group for the United States and Canada, 1981–2003.

Year	Lower	Middle	Upper U.S.	Upper Canada	Upper Total	Total
1981	11,164	112,669	64,644	18,109	82,753	206,586
1982	23,601	41,967	87,241	17,208	104,449	170,017
1983	28,081	73,361	96,994	18,952	115,946	217,388
1984	45,210	71,656	44,735	16,795	61,530	178,396
1985	57,770	46,753	85,773	19,301	105,074	209,597
1986	32,517	15,894	97,593	20,364	117,957	166,368
1987	32,847	40,281	115,258	17,614	132,872	206,000
1988	36,967	26,805	84,649	21,427	106,076	169,848
1989	42,872	27,936	86,798	17,944	104,742	175,550
1990	34,007	42,430	72,996	19,227	92,223	168,660
1991	49,113	44,328	61,210	20,607	81,817	175,258
1992	30,330	40,600	97,261	17,903	115,164	186,094
1993	38,592	45,671	78,815	16,611	95,426	179,689
1994	35,161	41,488	95,666	21,218	116,884	193,533
1995	35,518	44,404	97,741	20,887	118,628	198,550
1996	33,278	16,386	88,958	19,612	108,570	158,234
1997	50,420	32,043	92,162	16,528	108,690	191,153
1998	34,759	18,509	46,947	5,937	52,884	106,152
1999	54,788	8,619	60,908	12,468	73,376	136,783
2000	16,989	6,176	22,143	4,879	27,022	50,187
2001	20,115	10,190	23,325	10,139	33,421	63,726
2002	14,895	22,395	30,058	9,257	39,387	76,677
2003	7,394	31,232	59,940	9,619	69,559	108,185
1981–2002 Average	34,500	37,753	74,176	16,499	90,677	162,929
1993–2002 10-Year Average	33,452	24,588	63,672	13,754	77,429	135,468
1998–2002 5-Year Average	28,309	13,178	36,676	8,536	45,218	86,705

Table 15.–Yukon River Chinook salmon historical harvest proportions by stock group for the United States and Canada, 1981–2003.

			Upper			
Year	**Lower**	**Middle**	**U.S.**	**Canada**	**Total**	**Total**
1981	0.054	0.545	0.313	0.088	0.401	1.000
1982	0.139	0.247	0.513	0.101	0.614	1.000
1983	0.129	0.337	0.446	0.087	0.533	1.000
1984	0.253	0.402	0.251	0.094	0.345	1.000
1985	0.276	0.223	0.409	0.092	0.501	1.000
1986	0.195	0.096	0.587	0.122	0.709	1.000
1987	0.159	0.196	0.560	0.086	0.645	1.000
1988	0.218	0.158	0.498	0.126	0.625	1.000
1989	0.244	0.159	0.494	0.102	0.597	1.000
1990	0.202	0.252	0.433	0.114	0.547	1.000
1991	0.280	0.253	0.349	0.118	0.467	1.000
1992	0.163	0.218	0.523	0.096	0.619	1.000
1993	0.215	0.254	0.439	0.092	0.531	1.000
1994	0.182	0.214	0.494	0.110	0.604	1.000
1995	0.179	0.224	0.492	0.105	0.597	1.000
1996	0.210	0.104	0.562	0.124	0.686	1.000
1997	0.264	0.168	0.482	0.086	0.569	1.000
1998	0.327	0.174	0.442	0.056	0.498	1.000
1999	0.401	0.063	0.445	0.091	0.536	1.000
2000	0.339	0.123	0.441	0.097	0.538	1.000
2001	0.316	0.160	0.365	0.159	0.524	1.000
2002	0.194	0.292	0.393	0.121	0.514	1.000
2003	0.068	0.289	0.554	0.089	0.643	1.000
1981–2002 Average	0.212	0.232	0.455	0.101	0.557	1.000
1993–2002 10-Year Average	0.247	0.182	0.470	0.102	0.572	1.000
1998–2002 5-Year Average	0.327	0.152	0.423	0.098	0.522	1.000

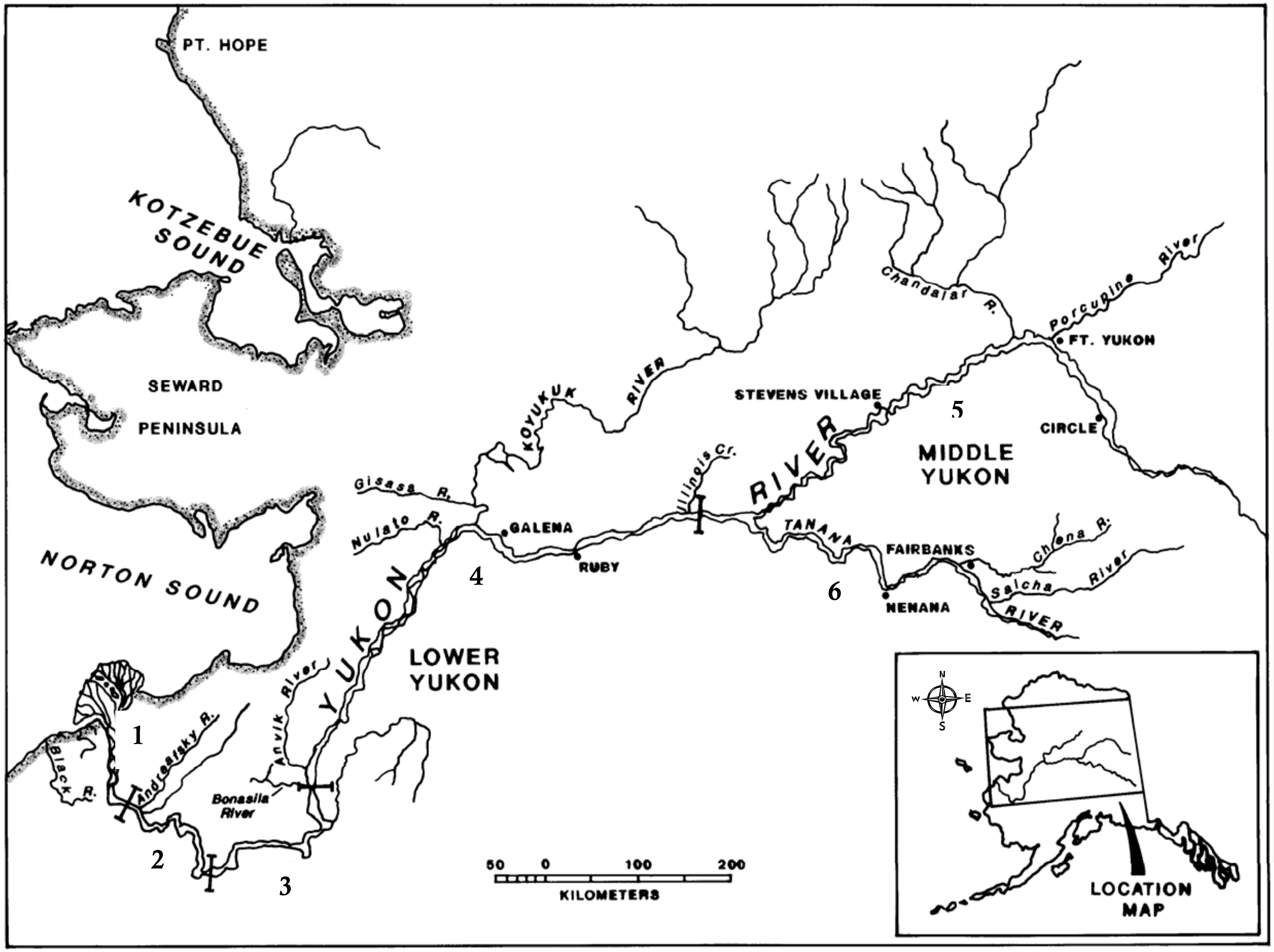


Figure 1.–Alaska portion of the Yukon River drainage showing salmon district boundaries and major spawning tributaries.

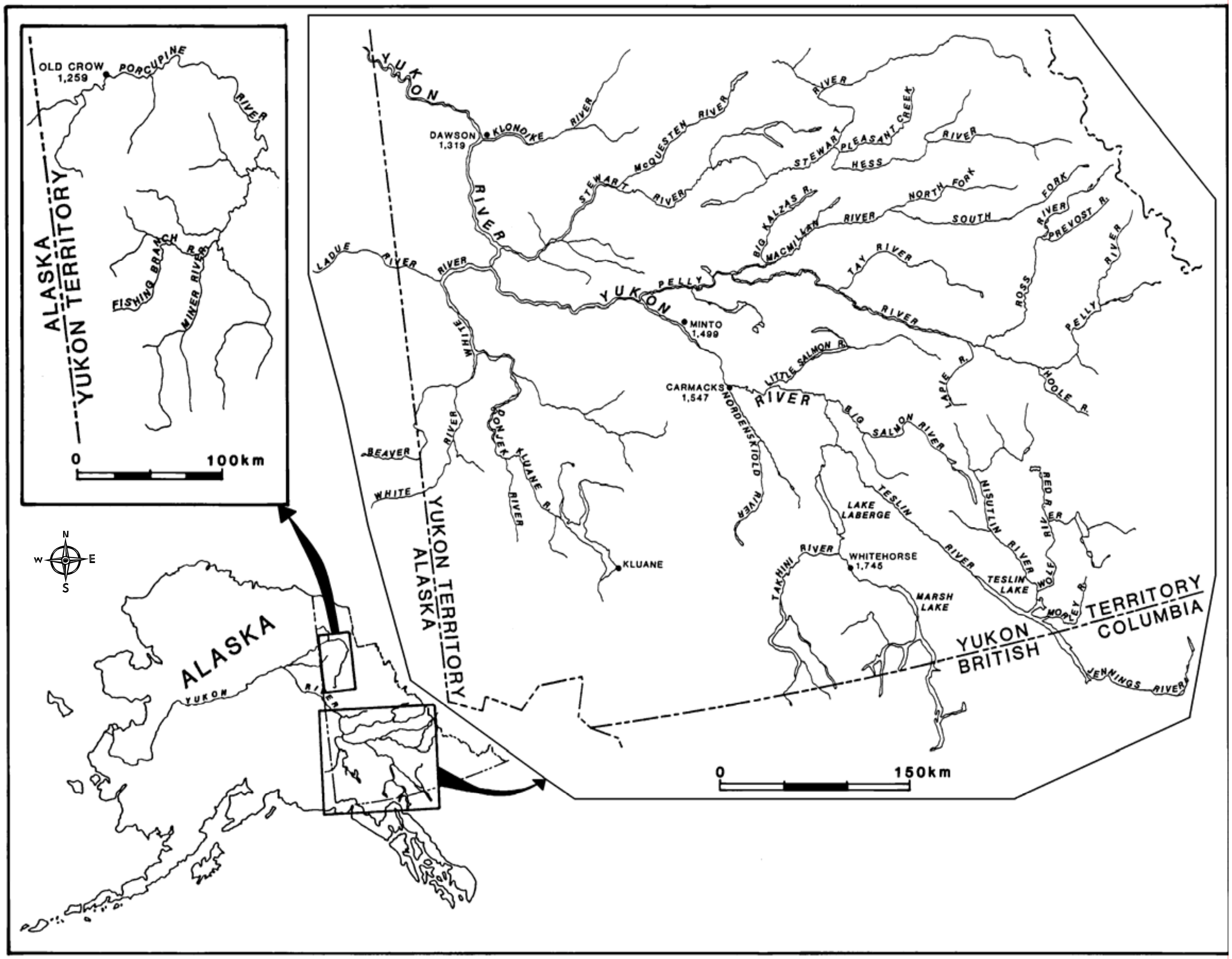


Figure 2.–Canada portion of the Yukon River drainage and major spawning tributaries.

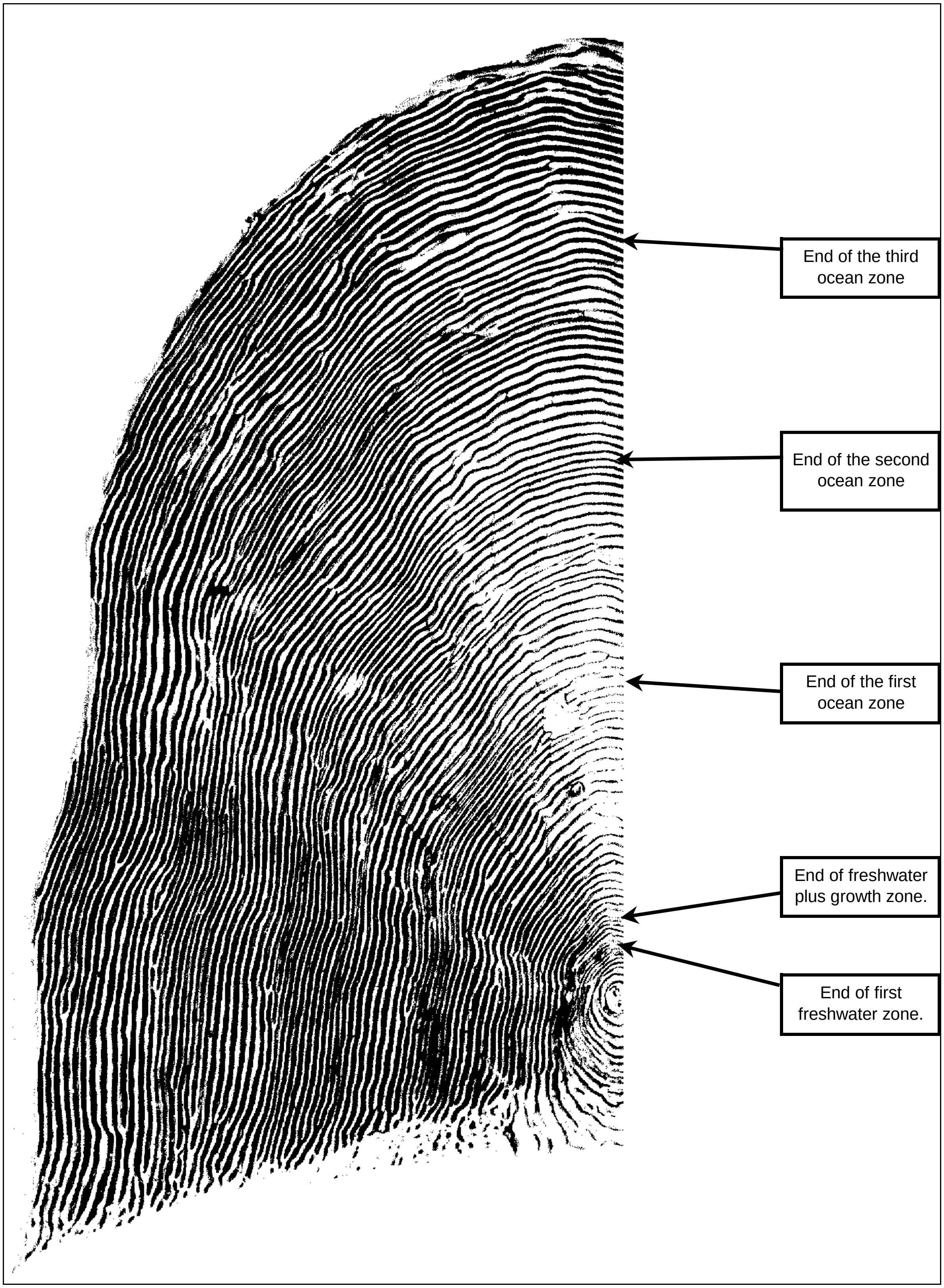
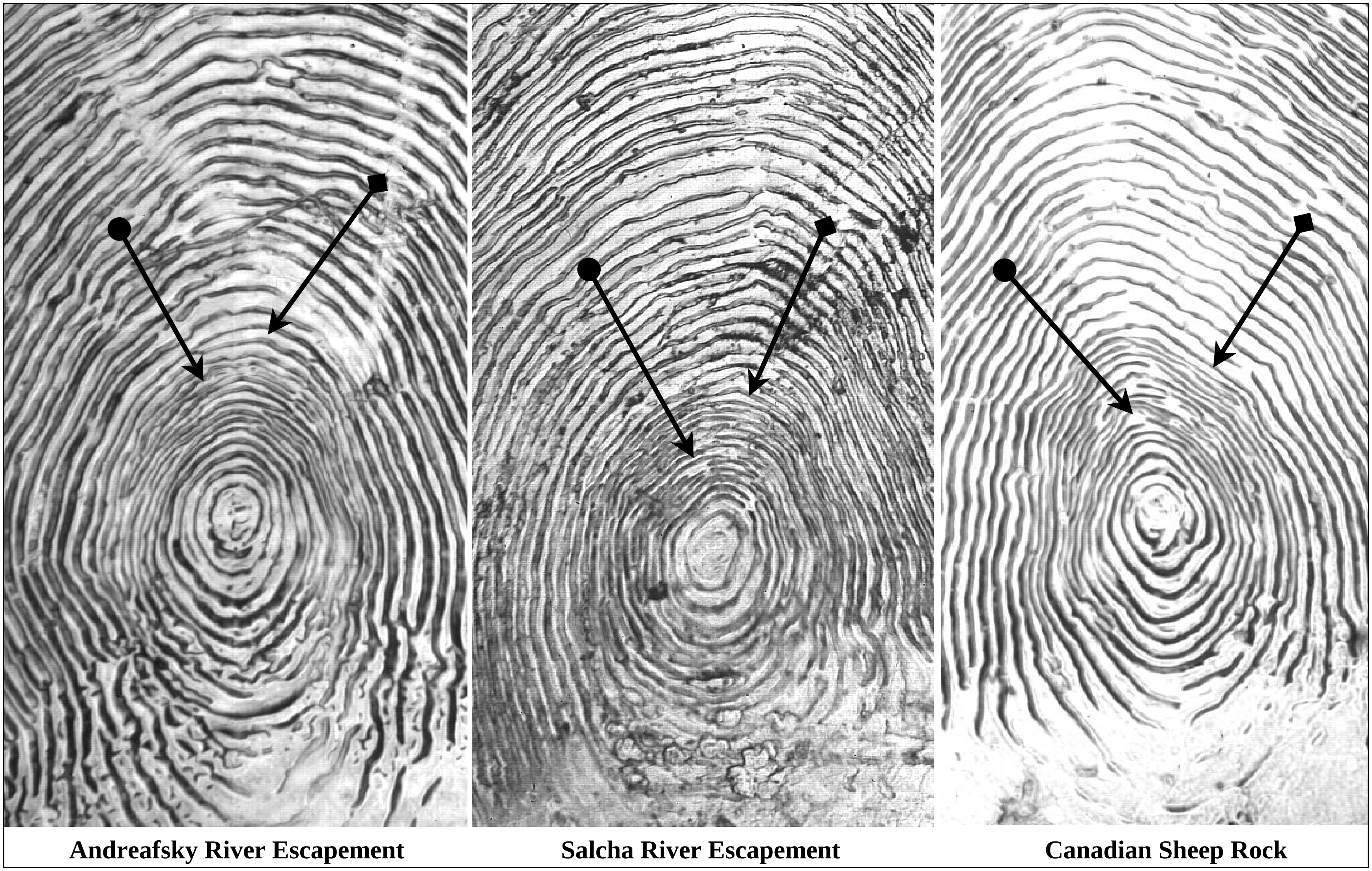
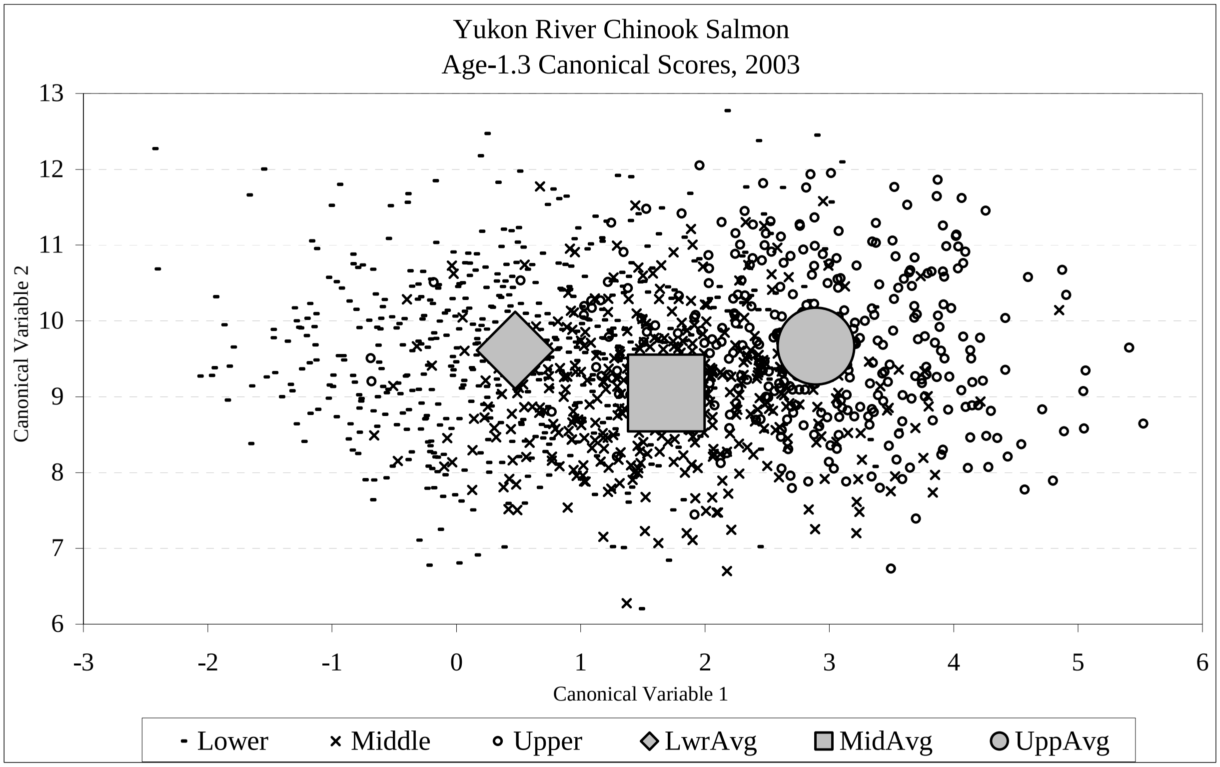


Figure 3.–Chinook salmon scale illustrating the different zones measured for scale growth analysis.



Note: Arrows with "dot" indicate the first freshwater annulus; arrows with "diamond" indicate the end of the freshwater zone.

Figure 4.–Comparison of Yukon River Chinook salmon fresh water scale areas from Andreafsky River escapement (Lower stock group), Salcha River escapement (Middle stock group) and Canadian Sheep Rock harvest (Upper stock group).



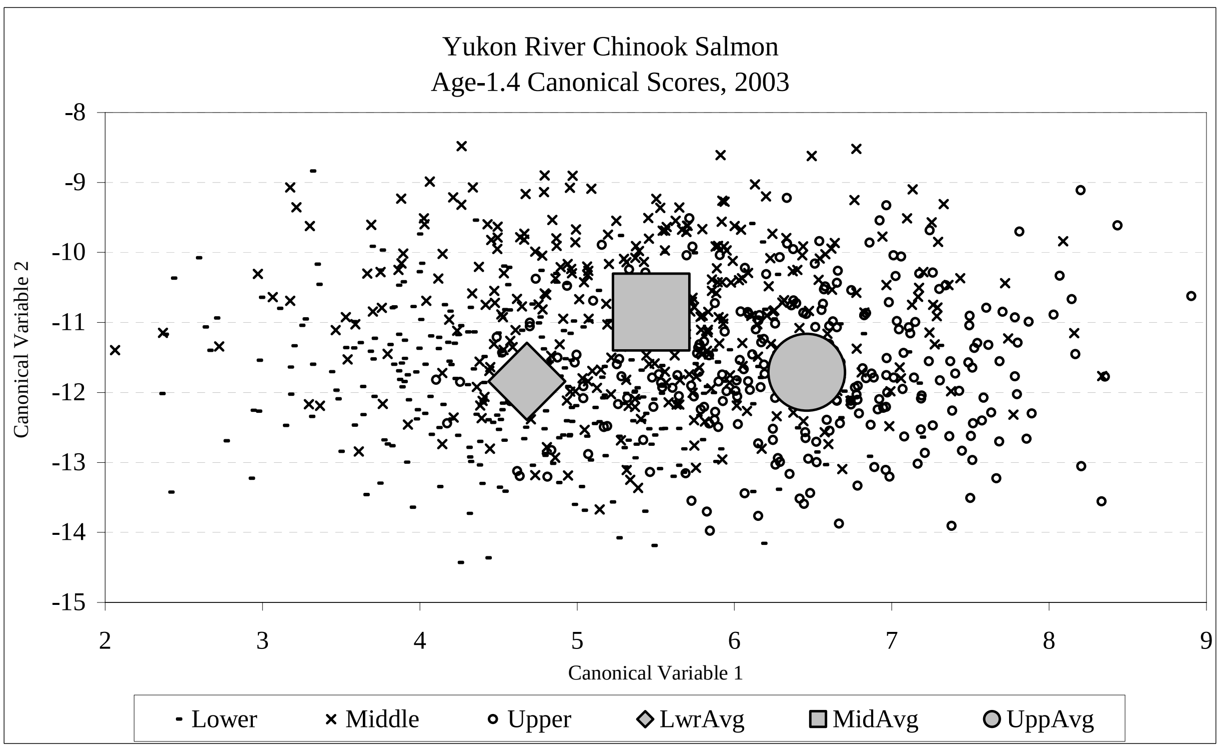
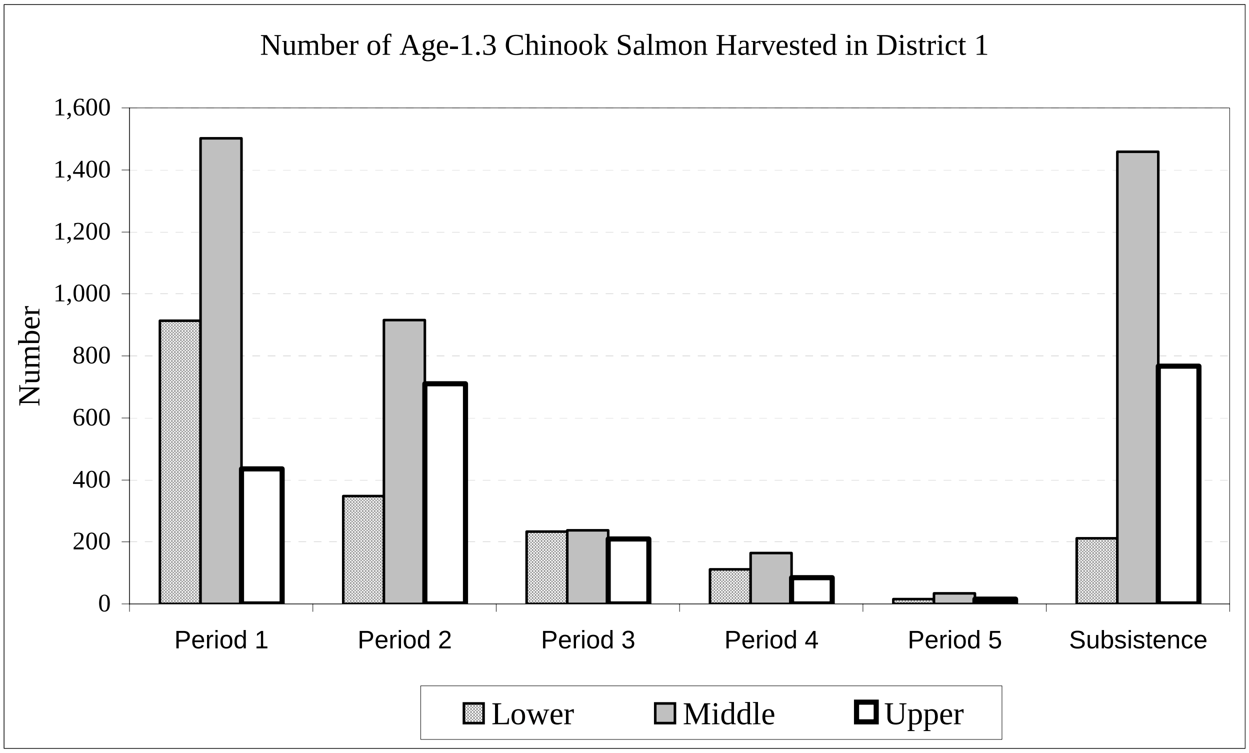


Figure 5.–Canonical variable plots for Yukon River age-1.3 and -1.4 Chinook salmon, 2003.



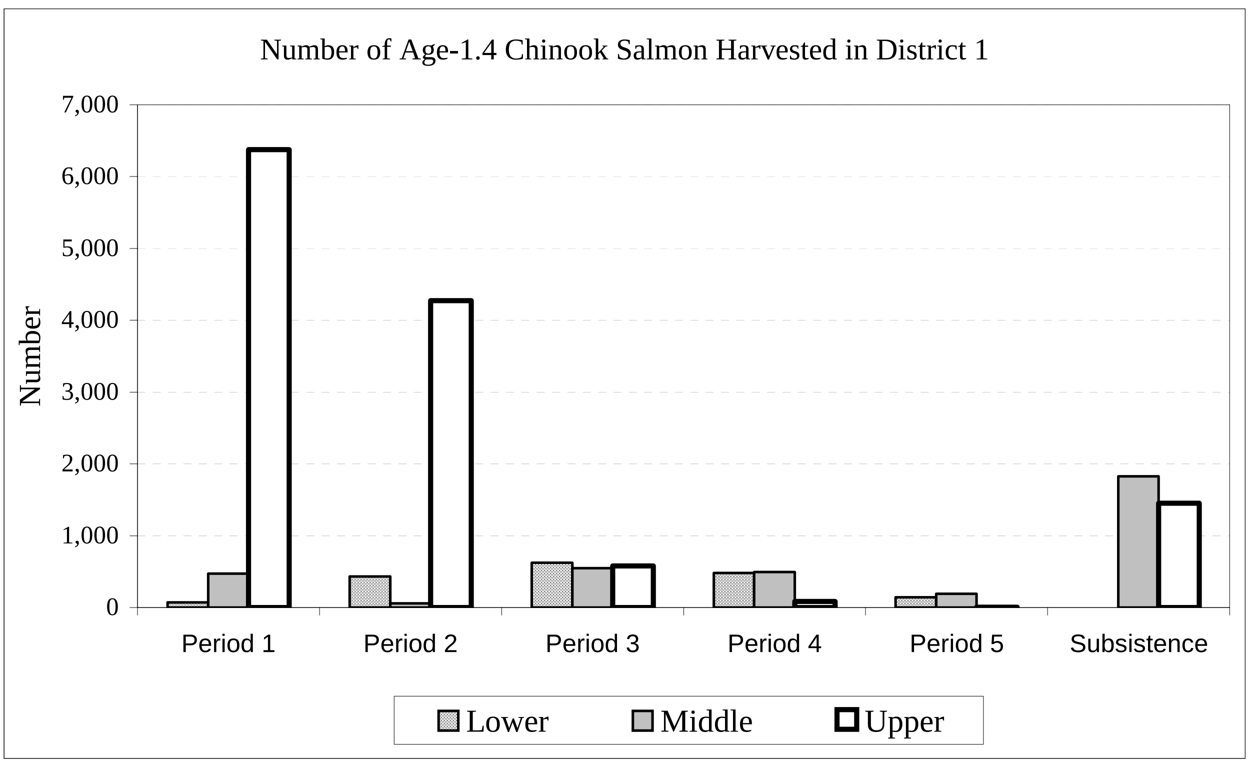
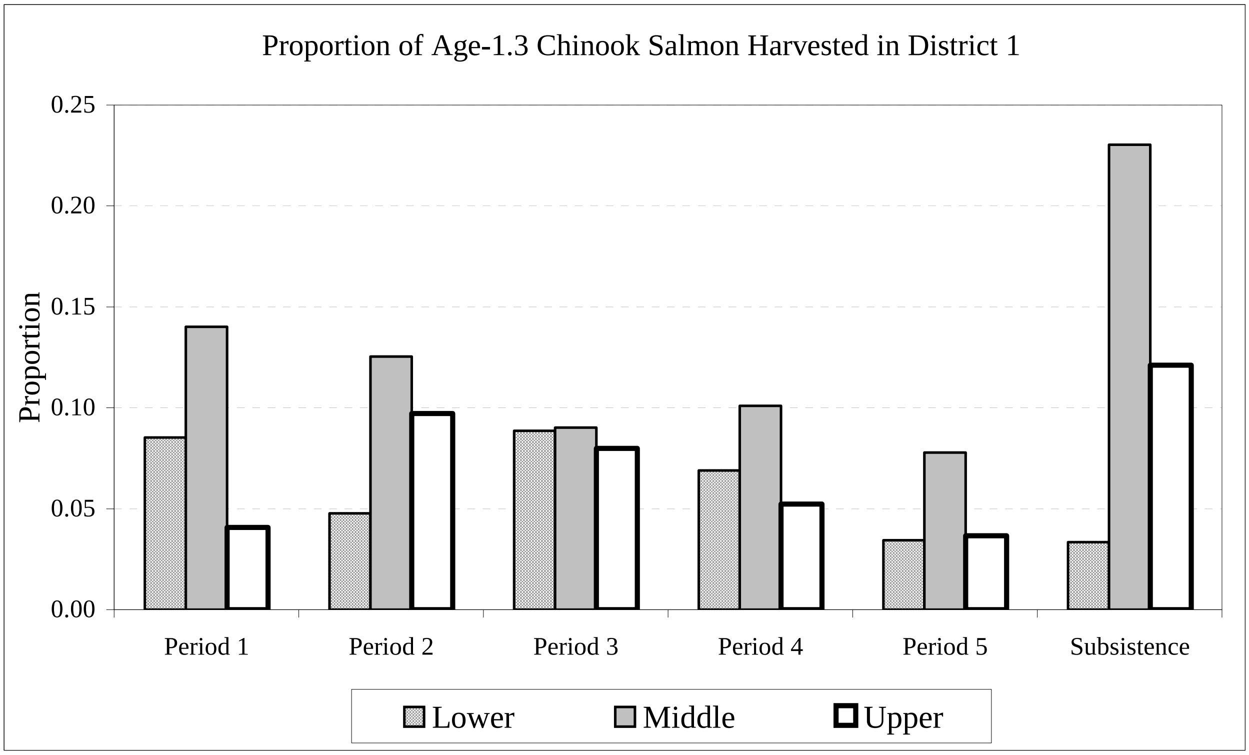


Figure 6.–Estimated number of age-1.3 and -1.4 Chinook salmon harvested, by commercial period, subsistence, and stock group, Yukon River District 1, 2003.



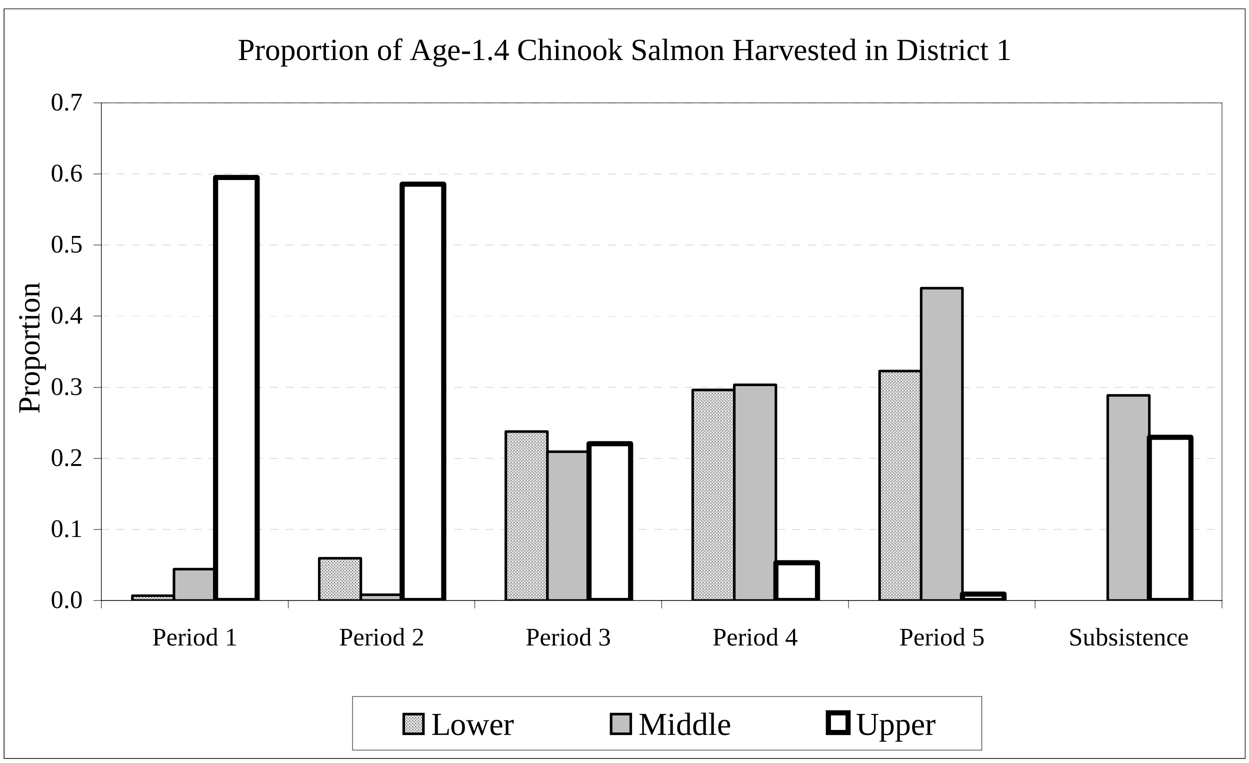


Figure 7.–Estimated proportion of age-1.3 and -1.4 Chinook salmon harvested, by commercial period, subsistence, and stock group, Yukon River District 1, 2003.

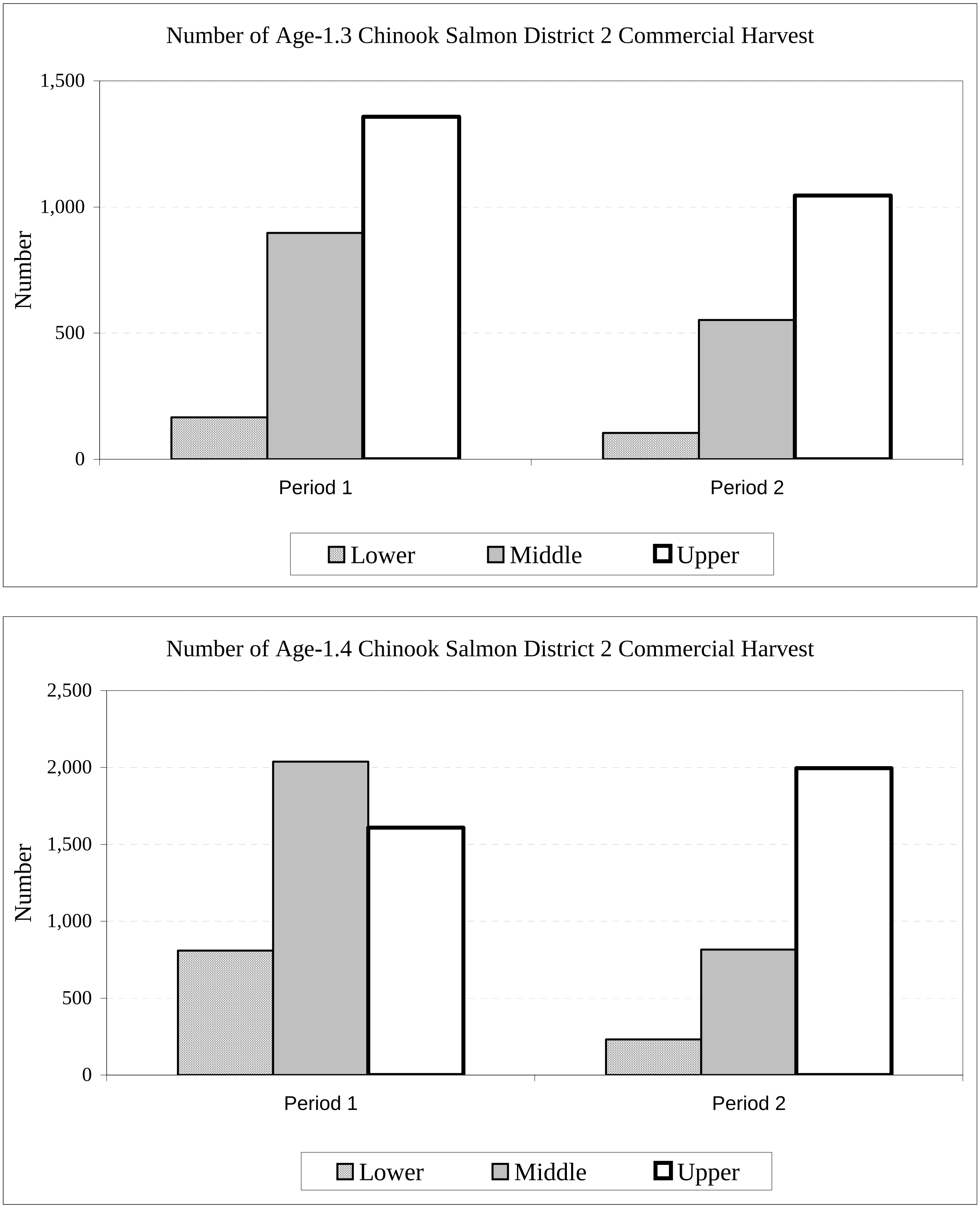
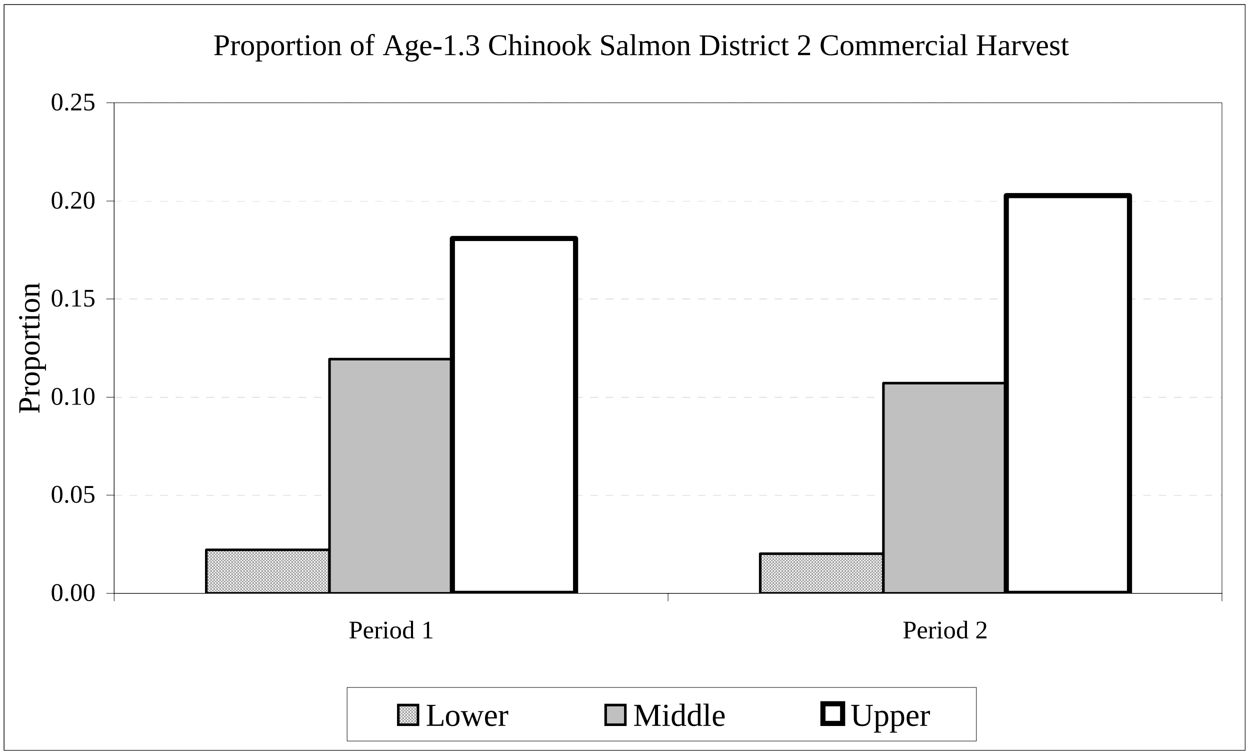


Figure 8.–Estimated number of age-1.3 and -1.4 Chinook salmon harvested, by commercial period and stock group, Yukon River District 2, 2003.



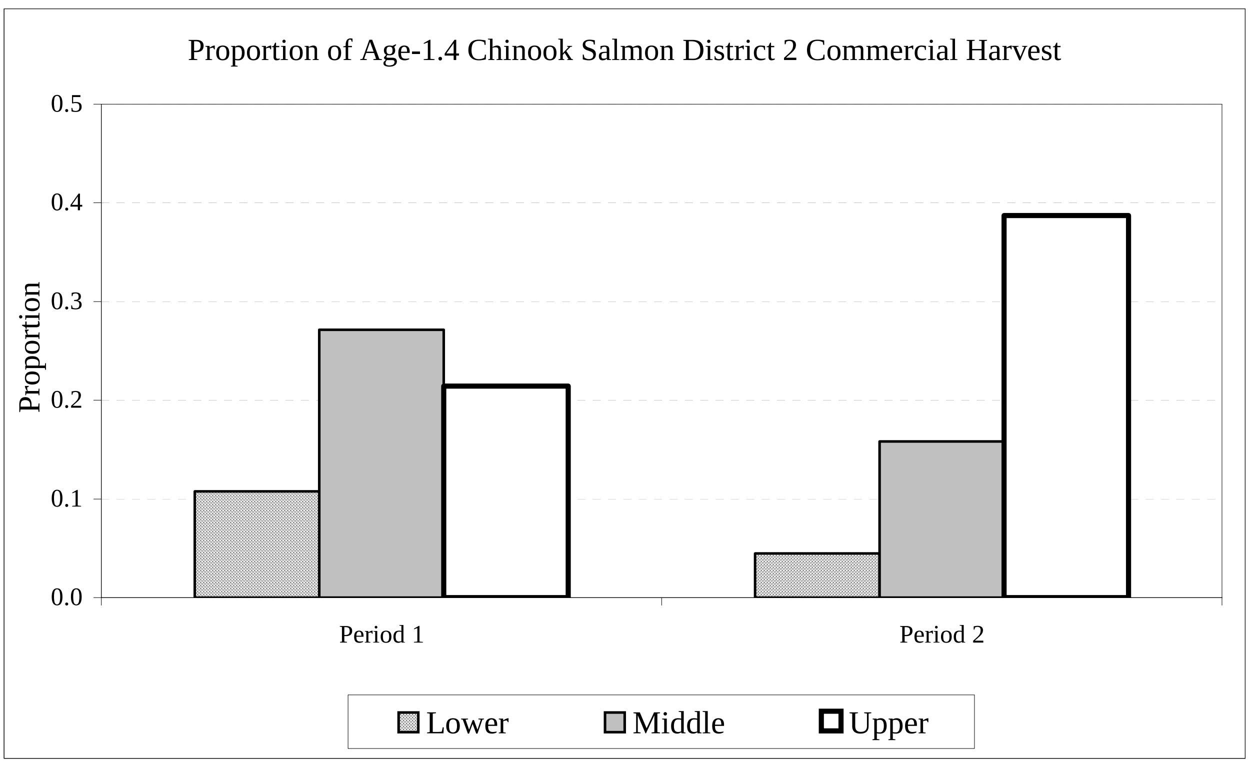
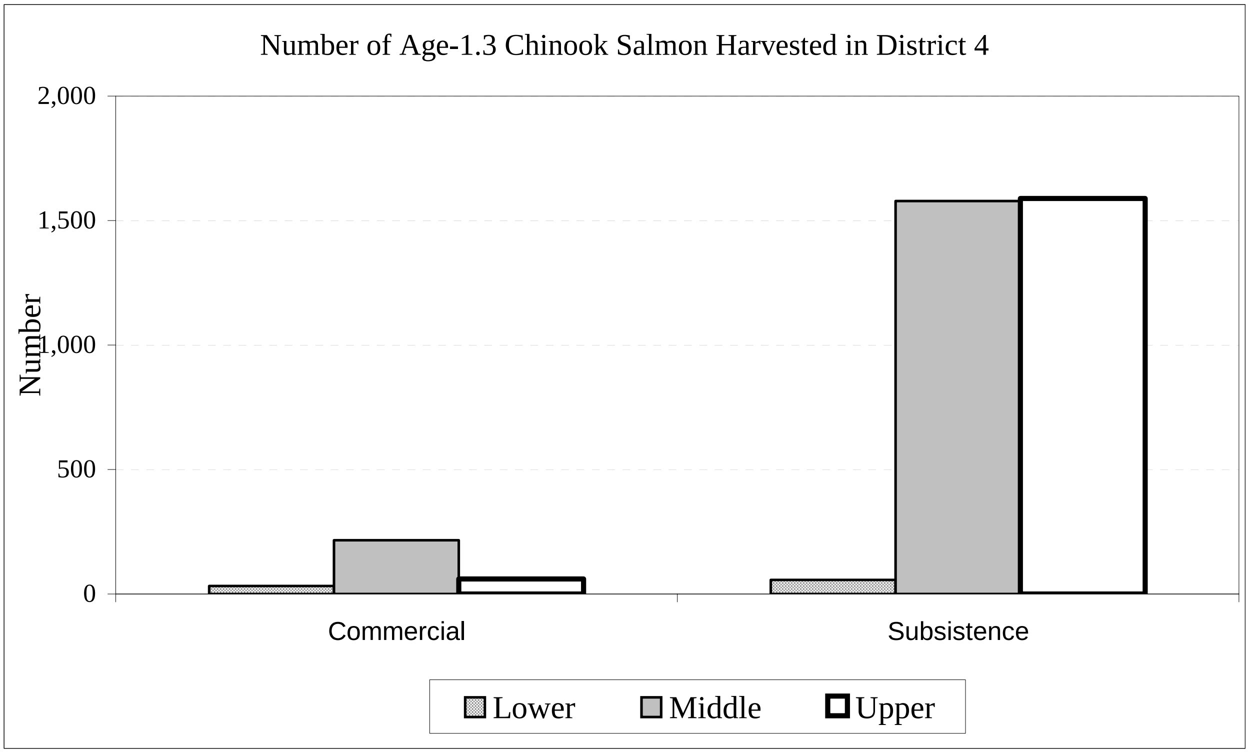


Figure 9.–Estimated proportion of age-1.3 and -1.4 Chinook salmon harvested, by commercial period and stock group, Yukon River District 2, 2003.



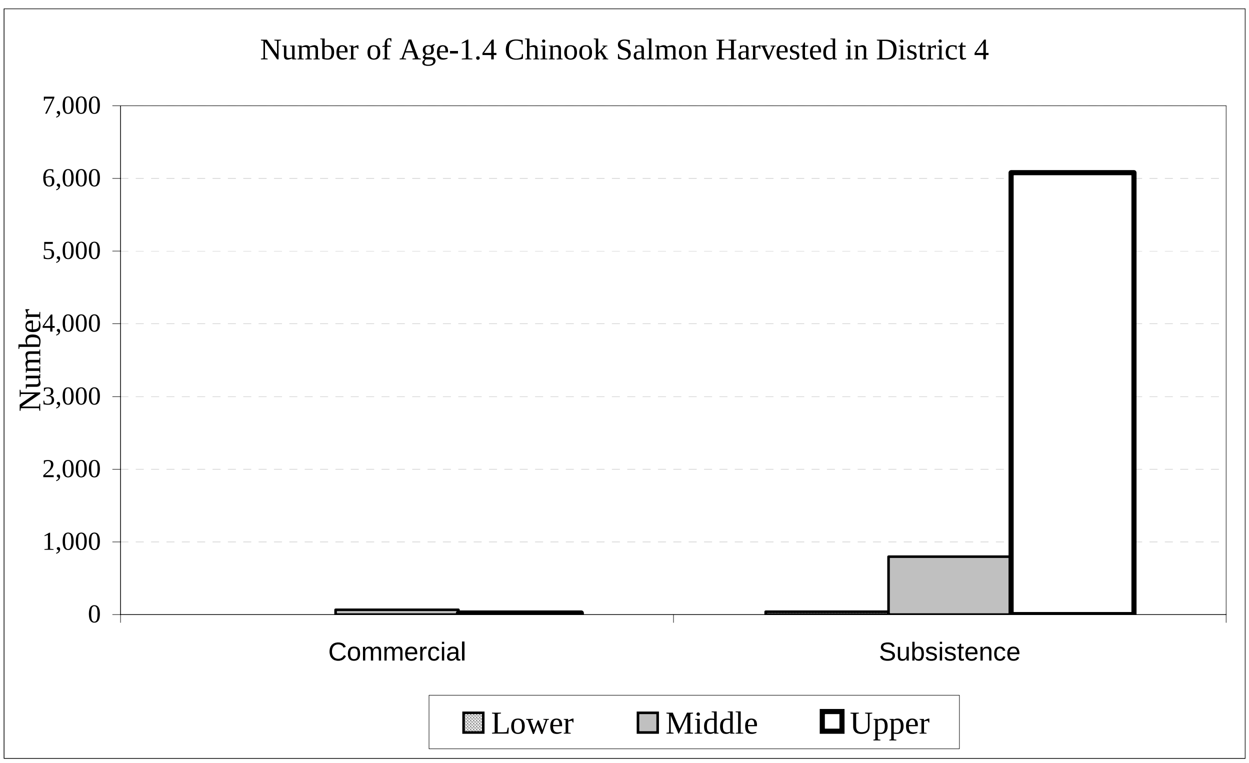
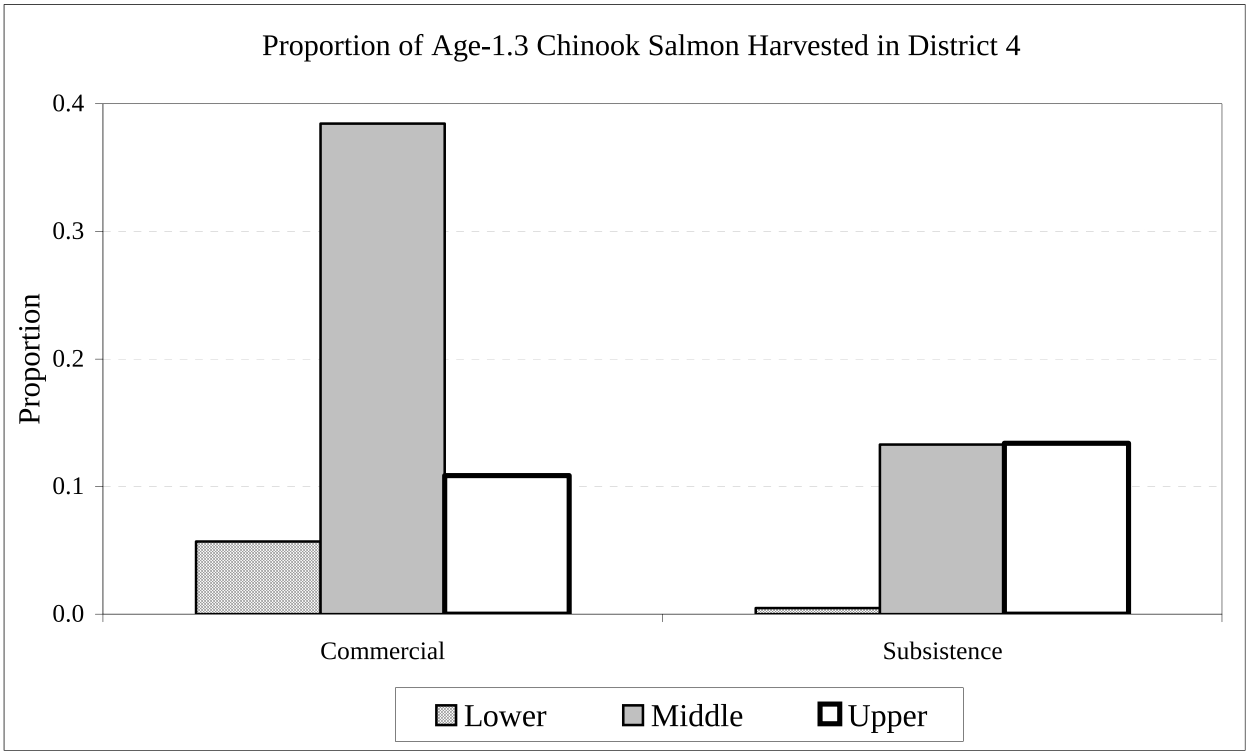


Figure 10.–Estimated number of age-1.3 and age-1.4 Chinook salmon harvested by stock group, Yukon River District 4, 2003.



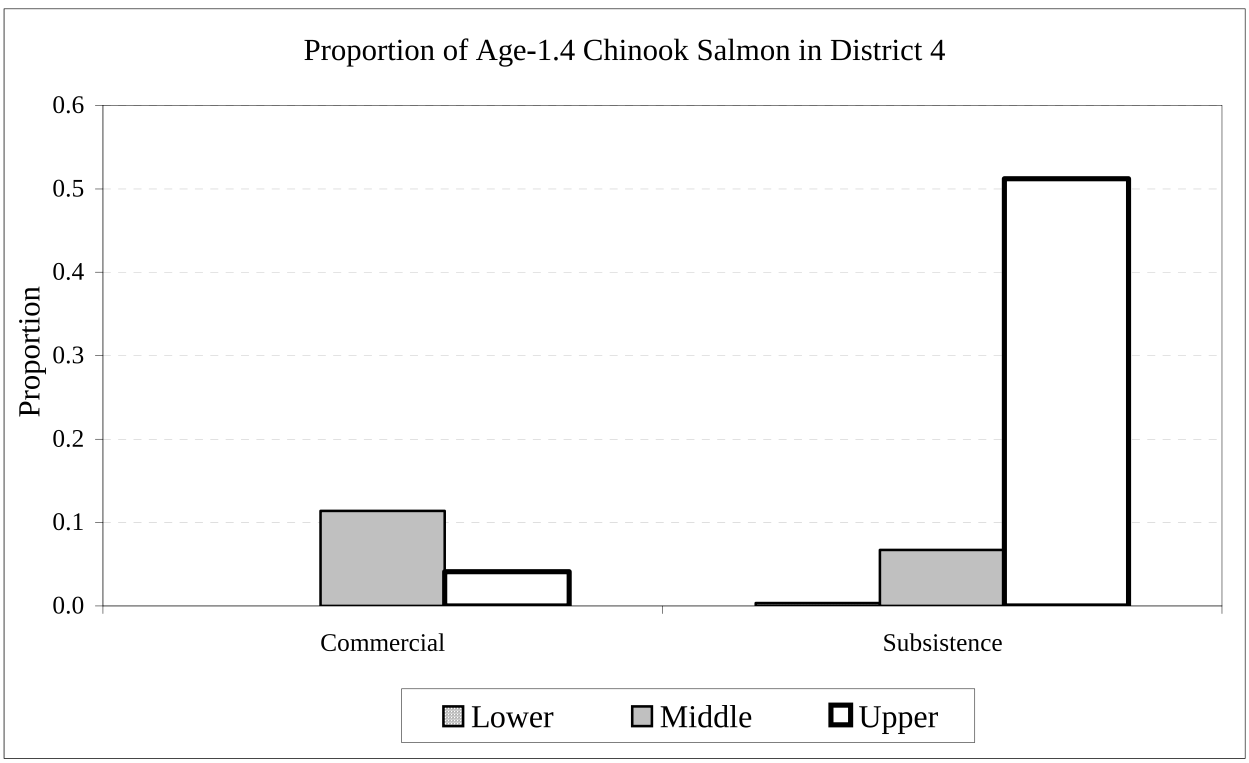


Figure 11.–Estimated proportion of age-1.3 and -1.4 Chinook salmon harvested by stock group, Yukon River Districts 4, 2003.