ORIGINS OF CHINOOK SALMON

IN THE YUKON RIVER FISHERIES, 2002

By

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ABSTRACT

Stock composition of all harvests of chinook salmon *Oncorhynchus tshawytscha,* within the Yukon River drainage was estimated in 2002. Stock composition proportions were estimated for three 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 fish 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 samples were apportioned using a combination of District 1 maximum likelihood estimates, and age composition from the Marshall and Russian Mission radio telemetry tagging project, respectively. Districts 5 and 6, and Canadian harvests, were assigned to stock group based on the geographic location of the harvests. The total estimated Yukon River harvest in 2002 was 76,677 chinook salmon, of those, 19.4% were estimated to be of Lower, 29.2% Middle and 51.4% 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 study 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 2002 season utilizing scale pattern data with a maximum likelihood estimator. Results from scale pattern analyses on these stocks provide valuable stock separation information for management and conservation of the various runs of chinook salmon throughout the Yukon River drainage. Similar scale pattern analyses studies have been conducted annually since 1981 (Moore 2002).

Yukon River chinook salmon are harvested annually in various fisheries in both marine and fresh waters. 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 fish sold in the round, fish utilized for commercial roe harvests, and fish harvested by the Alaska Department of Fish and Game (ADF&G) in 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 1991-2000 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 square kilometers and originates in northern British Columbia, and flows 3,700 kilometers 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 three distinct geographic regions: 1) Alaskan tributary streams draining Andreafsky Hills and Kaltag Mountains (rkm 161-805); 2) Alaskan tributary streams in Upper Koyukuk River and Tanana River (rkm 1,290-1,770); and 3) Canadian tributary streams that drain the Pelly and Big Salmon Mountains (rkm 2,090-2,900). Initially, chinook salmon stocks within these geographic regions were collectively termed runs (McBride and Marshall 1983) but are now referred to as the Lower, Middle and Upper Yukon River stock groups (Lingnau and Bromaghin 1999).

Evaluating stock production, spawning escapement goals, and management strategies requires information on the stock composition of the various Yukon River mixed stock harvests. Stock composition of Yukon River fishery harvests is studied by ADF&G 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 in the Yukon River in Alaska and Canada combined, ranged from an estimated 77,250 to 169,607 and averaged 123,033 fish annually (JTC 2002). Beginning in 1980, total annual harvests increased, and for the period of 1980-1999 the average total annual harvest was approximately 180,579 fish. Total annual harvest of chinook salmon began to decline in 1998; the average harvest for the period of 1997-2001 was 109,462 fish (JTC 2002). In 2002, the chinook salmon total combined harvest for Alaska and Canada was 76,677 fish. The Canadian border passage was 43,359 for an estimated total Canadian run of 64,088 chinook salmon. There were 13 commercial fishing periods in the Alaskan portion of the drainage and these comprised 38.5% of the total Alaskan harvest. The subsistence harvest accounted for 63.5% of the Alaskan harvest (Brase and Hamner 2003) and the sport fish harvest was less than 1%. The Aboriginal harvest accounted for 78.5% of the Canadian harvest and commercial harvest accounted for 7.6%. The remainder of the Canadian harvest was from test fish, domestic, and sport fisheries (JTC 2002).

METHODS

Overview

The three stocks of origin were sampled from spawning grounds in areas of the Yukon River drainage where the stocks are assumed to be separated. Scales were collected from the preferred area on the left side of the fish approximately two 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). Three scales were collected from each chinook salmon to increase the scale readability and to provide accurate age determination. All of the scale samples were mounted on gummed cards. These scale data were used to estimate the age composition for each sampling location. The scales of the abundant age classes, termed major age classes, were digitized (several growth measurements were 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), scale samples were collected from chinook salmon carcasses by ADF&G personnel from the Anvik and Chena Rivers and by Bering Sea Fisherman's Association from the Salcha River. Live salmon were sampled at weir projects operated by the U. S. Fish and Wildlife Service (USFWS) on the East Fork Andreafsky, Gisasa and Henshaw Rivers. Scale samples were also collected from fish captured in fish wheels used for a mark-recapture project at White Rock and Sheep Rock in the Yukon Territory, Canada by the Canadian Department of Fisheries and Oceans (CDFO). These scale samples provided data used to estimate the age composition of the escapement, and major age classes were digitized from these scales for subsequent analysis.

Harvest Sampling

Chinook salmon were sampled for age, sex, and length data from all commercial periods in Districts 1 and 2 and from the District 1 subsistence fishery. These samples were used for age composition analysis and digitized for scale pattern analysis. The commercial harvests, by period, and the District 1 subsistence harvest were apportioned using the age and stock composition from each respective sample.

Scale samples were not collected from the subsistence fishery in Districts 2 and 3. These subsistence harvests were apportioned using stock composition data from the District 1 subsistence fishery samples. Age composition data from the Marshall tagging project were used to describe the District 2 harvest and age composition data collected from the Russian Mission tagging project were used for the District 3 harvest.

Most District 4 subsistence scale samples were collected from chinook salmon harvested in large mesh gillnets fished near Kaltag, and the remainder of the samples were from fish wheels near Ruby. The District 4 subsistence harvest was apportioned using the age and stock composition from these samples.

Scale samples collected from chinook salmon commercially harvested in Districts 5 and 6 and subsistence harvested in District 5 were used to estimate the age composition of harvests 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 the age composition based on escapement samples. 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. Age composition of Canadian commercial, test fish, domestic and Aboriginal harvests were estimated using commercial gillnet and test fishing samples collected in Canada. Age composition of the Canadian sport fish harvest was estimated using the upriver adjusted harvest from the fish wheel samples.

Scale Processing

All scales samples were mounted on gummed cards and impressions were made in cellulose acetate. Scale impressions were aged using a microfiche reader with a 40x lens and ages were reported in European notation. The European method is a two 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. The total age is calculated by summing the two numbers and then adding 1; to account for the time the eggs spend incubating in the gravel.

Age-1.3 and -1.4 chinook salmon were the major age classes in 2002 and accounted for the largest segment of samples in 2002 (these two age classes are usually digitized). The scales collected during the 2002 season were analyzed using the computerized digitizing system first used for Yukon River chinook salmon in 2001. After the scales were aged, each scale of adequate quality from the major age classes was electronically scanned from an image magnified 42x on a microfiche reader and the image was digitally stored. The images were then brought into a program that uses an algorithm to mark the circuli. The circuli marks must be edited and the annuli marked. The new system allows for the storage of the scale images and the overlay with the annuli and circuli marks. The old system was used from 1981-2000, 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.

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

Scale growth zones (first freshwater annulus, freshwater plus growth zone; and first, second and third ocean zones) were identified (Figure 3), and distances between circuli were measured in microns. Measurements within each zone were identified by a specific cursor key code. 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 only in the freshwater zones and in the first ocean zone. With other ocean zones, only the entire width of the zone was measured, the measurements for age-1.3 fish ended with the second ocean zone and age-1.4 fish measurements ended 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 interrupted by viewing the magnified scale image (Figure 4).

Analytical Methods

In 1998, a program (SPAYK.EXE) was written by ADF&G staff to combine the multiple steps required for the analysis into a single comprehensive program, taking advantage of new commercial software and the increased capacity and speed of modern desktop computers. Several processing tasks were automated, and improved analytical methods were implemented. The stock composition of all age classes, in all harvests, was estimated in a single execution of the program. Schneiderhan (1997) provides a summary of the analysis methods historically used in the stock identification program. The historical data for years 1981 through 1996 were reprocessed using the new methodology (Lingnau 2000).

Analytical improvements in the new program primarily occurred in two areas, the first improvement involved the method of estimating the stock composition of the major age classes. The linear discriminant model used previously was replaced with a maximum likelihood estimation mixture model (Bromaghin and Bruden 1998). 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 the requisite data processing and increased the statistical quality of stock composition estimates, Bromaghin and Bruden (1999) detail the methods implemented in the new program.

Several assumptions were necessary, for example, scale measurement data from the escapement samples of each stock group were assumed to represent characteristics of the entire stock group. In addition, these data for each major age class and stock group were assumed to have a multivariate normal probability distribution (Johnson and Kotz 1972), although robust estimators of the mean vector and the covariance matrix (Campbell 1980) were used to minimize the influence of outliers. For each major age, a stepwise variable selection algorithm based on Wilks' ratio (Seber 1984) was used to select variables for inclusion in the model. The harvest samples were modeled as a weighted mixture of the estimated probability distributions of each of the stock groups, with the weights being the stock composition proportions (Bromaghin and Bruden 1999). The stock composition proportions for each major age class were estimated using maximum likelihood techniques.

A simulation was conducted to investigate 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 samples consisting of fish from that stock group were constructed by selecting fish at random with replacement from the observed data, this process is termed bootstrap sampling (Efron 1982). Artificial mixture samples were treated as harvest samples, and the stock composition of the mixture was estimated and compared with the correct answer, which was 100% in each case. Sample sizes for the bootstrap samples were equal to the observed sample size, a total of 500 artificial mixture samples were drawn from each major age class and stock group, and the average estimate was computed. This simulation study was conducted using robust estimators of the mean vector, and the variance-covariance matrix.

Harvest of minor age classes, with associated digitized data were apportioned to stock group based on escapement age composition ratios (Schneiderhan 1997). Age composition data used in the analysis for the Lower stock group were collected from the Andreafsky, Anvik and Gisasa Rivers. Middle stock group age composition data were collected from the Chena and Salcha Rivers and Henshaw Creek. Upper stock group age composition data from fish wheels located just up river from the U.S./Canada border and from Canadian commercial and test fishing was provided by CDFO. 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 (Jeff Bromaghin, ADF&G, Commercial Fisheries Division, 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 0.4548 for age-1.3 and 0.2395 for age-1.4 chinook salmon (Table 1). Weighted age composition for the Middle River was 0.2147 (age-1.3 fish) and 0.3829 (age-1.4 fish). 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. The Salcha River samples were adequate to determine age composition, however, many of the scales could not be digitized because they were improperly cleaned.

The combined Sheep Rock and White Rock fish wheel sample size from the Canadian tagging project at the border was 888 fish. The adjusted Canada border passage escapement age composition was 0.3195 for age-1.3 fish and 0.5779 for age-1.4 fish (Table 1). These proportions were within normally observed ranges for age-1.3 and age-1.4 chinook salmon.

The 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 0.634 from the District 1 commercial harvest, 0.647 from the Big Eddy and Middle Mouth test fisheries, 0.587 from the District 2 commercial harvest, 0.621 from the Marshall tagging project and 0.632 from the Russian Mission 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 (0.356, Table 2). Small mesh (5.5-inch), large mesh (8.5-inch) and unknown mesh sized gear accounted for 72%, 16% and 12%, respectively, of District 1 subsistence samples (Richard Price, ADF&G, Commercial Fisheries Division, Anchorage, personal communication). 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 and Canada (range 0.367 to 0.547, Table 2). The upriver samples in Alaska included samples collected from fish wheels that tend to harvest younger fish.

Scale Pattern Analysis

Eleven scale measurement characters, or variables, were selected in distinguishing the three stock groups for age-1.3 fish. These variables were, in order of importance, 68, 102, 103, 105, 76, 8, 109, 14, 16, 29, and 62 (Table 3). The number of variables selected for age-1.3 chinook salmon reflects the difficulty in distinguishing that age class among stock groups. Seven variables were selected for age-1.4 fish, in order of importance, 62, 70, 89, 13, 16, 75, and 110. Variables involving freshwater and freshwater plus growth usually account for most of the discriminatory power in the models and these were the first variables selected for each age class. For example, variable 68 (age-1.3 first selection) was calculated from freshwater plus and freshwater zone measurements and variable 62 (age-1.4 first selection) was a freshwater plus zone measurement. In 2002, most of the variables selected were related to freshwater growth (variables 1 through 69) and first ocean growth (variables 70 through 108). Six of the variables selected for age-1.3 fish were related to freshwater, four were related to the first ocean and one was related to the second ocean. Three of the variables selected for age-1.4 fish were related to freshwater, three were related to the first ocean and one was related to the third ocean. 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. Average measurements for variable 62 (total distance within the freshwater plus growth zone) were 130.30, 155.96 and 202.38 microns for Lower, Middle and Upper stocks, respectively (Table 4). A similar increase in freshwater plus growth from Lower to Upper stocks is shown in Figure 4.

Estimation Accuracy Simulations

Estimation accuracies for age-1.3 fish were 0.937 for Lower, 0.956 for Middle and 0.985 for the Upper river standard (Table 5). Estimation accuracies for age-1.4 fish were 0.951 for Lower, 0.964 for Middle and 0.975 for the Upper river standard. The Upper river standards showed higher estimation accuracies and the Lower river standards showed lower estimation accuracies for both age classes. The average estimation accuracies were 0.959 for age-1.3 fish and 0.963 for age-1.4 fish. The greatest estimation biases occurred between the Lower and Middle stock groups (age-1.3, 0.043; age-1.4, 0.037). Historically, estimation bias is most common between the Middle and Upper stock groups, and the Lower and Upper river stocks have been the easiest to separate.

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

Maximum Likelihood Estimates For Major Age Classes

In 2002, commercial fishing occurred in Districts 1, 2, 5 and 6 of the Alaskan portion of the Yukon River drainage. Mixed stock scale samples were collected from commercial harvests in Districts 1 and 2 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 mixed stock fisheries.

Maximum likelihood stock composition estimates for each commercial harvest period in District 1 are presented in Table 6. In District 1, the Upper stock typically dominates the early commercial harvests and the percentage gradually decreases thereafter. However, in the 2002 District 1 commercial fishery, Lower stocks for both age-1.3 and -1.4 fish were the dominant stock group in each period, except for one age class in the last period (Table 6, Figures 6 and 7). Upper stocks were the second most abundant stock group. The District 1 commercial harvest stock group composition for age-1.3 fish was 1,457 Lower, 211 Middle and 568 Upper stock group (Table 7). For age-1.4 fish the composition was 3,502 Lower, 1,069 Middle and 2,407 Upper stock group. Of the 11,081 chinook salmon harvested in the District 1 commercial fishery, 9,214 (83.2%) were age-1.3 and -1.4 fish. Of these age-1.3 and -1.4 fish, an estimated 4,959 (53.8%) were Lower, 1,280 (13.9%) were Middle and 2,975 (32.3%) were Upper stock group (Table 7).

Maximum likelihood stock composition estimates for each commercial harvest period in District 2 are presented in Table 8. There were not any consistent trends in stock group dominance among the three commercial periods (Table 8, Figures 8 and 9). In the first period, age-1.3 fish were dominated by the Upper stock group and age-1.4 fish by the Middle stock group. The Lower stock group dominated both age groups in the second period and the Middle stock group dominated both age groups in the third period. District 2 commercial harvest stock group composition for age-1.3 fish was 758 Lower, 954 Middle and 1,153 Upper stock group (Table 9). For age-1.4 fish the composition was 2,292 Lower, 2,897 Middle and 1,469 Upper stock group. Of the 11,434 chinook salmon harvested in the District 2 commercial fishery, 9,523 (83.3%) were age-1.3 and -1.4 fish. Of these age-1.3 and -1.4 fish, an estimated 3,050 (32.0%) were Lower, 3,851 (40.4%) were Middle and 2,622 (27.5%) were Upper stock group (Table 9).

Mixed stock scale samples were collected from gillnets in the District 1 subsistence harvest. Maximum likelihood analysis estimated the stock composition of this harvest was dominated by the Upper stock group for age-1.3 fish and the Middle stock group for age-1.4 fish (Table 10, Figures 10 and 11). Of the 5,603 chinook salmon harvested in the District 1 subsistence fishery (Brase and Hamner 2003), 2,072 were age-1.3 and 1,996 were age-1.4 fish (Table 11). Of these age-1.3 and -1.4 fish, an estimated 995 (24.5%) were Lower, 1,407 (34.6%) were Middle and 1,666 (41.0%) were Upper stock group (Table 11).

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

Mixed stock scale samples were collected from gillnets and fish wheels in the District 4 subsistence harvest. Maximum likelihood stock composition estimates for this harvest are presented in Table 10. Similar to the District 1 subsistence harvest, age-1.3 fish were dominated by the Upper stock group and age-1.4 fish were dominated by the Middle stock group (Figures 10 and 11). Of the 8,964 chinook salmon harvested in the District 4 subsistence fishery (Brase and Hamner 2003), 6,519 were age-1.3 and -1.4 fish (Table 11). Of these age-1.3 and -1.4 fish, an estimated 1,326 (20.3%) were Lower, 2,650 (40.7%) were Middle and 2,543 (39.0%) were Upper stock group (Table 11).

A total of 50,175 age-1.3 and -1.4 chinook salmon were harvested in mixed stock fisheries in Districts 1 through 4. Of these, 29,324 (58.4%) were directly classified, and 10,749 (21.4%) were indirectly classified to stock group based on results of scale growth analysis (Table 11). Directly classified age-1.3 and –1.4 fish include harvests from District 1 subsistence and commercial, District 2 commercial and District 4 subsistence fisheries. Indirectly classified age-1.3 and –1.4 fish include the Districts 2 and 3 subsistence harvests. Of the total drainage harvest of 76,677 chinook salmon, 38.2% of these fish, which were harvested in mixed stock fisheries, were directly classified, and 14.0% were indirectly classified based on scale growth analysis (Table 11).

Differential Age Composition Analysis

The minor age classes (age-1.1, -1.2, -2.3, -1.5, and -2.4 fish) from Districts 1 through 4 commercial and subsistence harvests contributed 10,102 fish (20.1%) to the total drainage harvest (Table 11). These minor age classes were classified to stock group 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 (6,199, 12.4%) and age-1.2 fish (3,891, 7.8%, Table 11).

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 are based on samples collected from Districts 5 and 6 commercial harvests in Alaska and from mark-recapture fish wheels, test and commercial catches in Canada (Tables 1 and 2).

Age composition estimates for 771 chinook salmon, commercially harvested in District 5, by period, are presented in Table 12. Age-1.4 fish were the most abundant age class harvested. These commercially harvested chinook salmon and a subsistence harvest of 13,298 chinook salmon (Brase and Hamner 2003) were assigned to the Upper stock group (Tables 11 and 12). District 5 harvest was comprised of 7,242 age-1.4 fish (51.5%), 4,661 age-1.3 fish (33.1%), 1,178 age-1.2 fish (8.4%) and 988 age-1.5 fish (7.0%, Tables 11 and 13). District 5 harvest comprises 18.3% 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 492 chinook salmon (Brase and Hamner 2003) was assigned to the Middle stock group and was included with the District 6 harvest (Table 11). Chandalar and Black River subsistence harvests of 103 chinook salmon were also assigned to the Middle stock group and were included with the District 6 harvest. Although Chandalar and Black River harvests 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 1,788 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 11).

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 in Alaska are assigned to this stock group. The sport fish harvest of 480 chinook salmon (Mike Doxey, ADF&G, Sport Fish Division, Fairbanks, personal communication) is recorded in Table 11.

Age composition estimates for 836 chinook salmon, commercially harvested in District 6, by period, are presented in Table 12. Age-1.3 fish were the most abundant age class harvested. The 3,104 chinook salmon harvested from District 6 commercial, subsistence, and sport fisheries were 4.0% of the total Yukon River drainage harvest (Table11). The District 6 harvest was comprised of 1,352 age-1.3 fish (43.6%), 1,134 age-1.4 fish (36.5%), 444 age-1.2 fish (14.3%), 160 age-1.5 fish (5.2%) and 14 age-1.6 fish (0.5%, Tables 11 and 13).

Total harvest from Canadian fisheries was 9,329 chinook salmon (JTC 2002 and Pat Milligan, CDFO, Whitehorse, personal communication) or 12.2% of the total Yukon River drainage harvest (Table 11). The Canadian harvest was assigned to the Upper stock group. The Canadian chinook salmon harvest was comprised of 708 fish from the commercial fishery, 7,326 fish from the Aboriginal fisheries (includes Porcupine River harvest near Old Crow), 1,036 fish from a test fishery to recover tag-marked fish, 59 fish from the domestic fishery, and 200 fish from the sport fishery (Table 11). The age composition was comprised of 3,585 age-1.4 fish (38.4%), 3,534 age-1.3 fish (37.9%), 1,123 age-1.5 fish (12.0%), 984 age-1.2 fish (10.5%), 51 age-2.3 fish (0.5%), and 51 age-2.4 fish (0.5%, Tables 11 and 13).

Total Harvest

A total of 76,677 chinook salmon were harvested from the Yukon River drainage in 2002 (Table 11). Upper stock group was the largest estimated component, contributing 39,387 fish, or 51.4% of the total (Tables 11, 13 and 14). Upper stock group harvest by country was 30,058 fish by the U.S. (76.3%) and 9,329 fish by Canada (23.7%). The 2002 Upper stock group harvest, in numbers of fish, is below the 5-year average (1997-2001), 10-year average (1985-2001), and 1981-2001 average harvests (Table 14). The decrease in fish harvested from the Upper stock group can be attributed to decreased harvest levels beginning in 1998 by U.S. and Canada. The U.S. 5-year average harvest was 69.8% of the 10-year average, and 64.9% of the 1981-2001 average harvests. The Canada 5-year average harvest was 68.4% of the 10-year average, and 59.4% of the 1981-2001 average harvests (Table 14).

Middle stock group was second in harvest abundance with an estimated 22,395 fish (29.2%, Tables 11, 13, and 14). The 2002 harvest estimated from the Middle stock group, in numbers of fish, is above the 5-year average and below both the 10-year average and 1981-2001 average harvests (Table 14). The 2002 Middle stock harvest proportion is the highest since 1984 and well above all average proportions (Table 15).

Lower stock group was the least abundant stock group in the 2002 total harvest contributing an estimated 14,895 fish (19.4% Tables 11, 13 and 14). This harvest is the second lowest on record for the Lower stock group (Table 14). The 5-year average, 10-year average, and 1981-2001 average harvests of this stock group are consistently about 35,000 fish. The 2002 Lower stock group harvest, in number of fish and proportion, are not similar to recent years. Unlike the Middle and Upper stock groups, the average proportional harvest for the Lower stock group is trending up since 1981. For example, the 1981-2001 average, 10-year average, and 5-year average proportions for this stock group were 0.212, 0.239, and 0.323, respectively (Table 15).

DISCUSSION

District 1 subsistence harvest samples can be compared to commercial harvest samples. Comparing age compositions, fewer older-aged fish and more younger-aged fish were present in the subsistence samples. As stated earlier, gear selectivity provides justification for this discrepancy in age compositions.

Comparing District 1 stock group allocations, more Upper and Middle river fish were estimated in the subsistence fishery and more Lower river fish were estimated in the commercial fishery (Tables 6 and 10). This discrepancy may be partly related to sampling bias, however, timing differences between the two fisheries may be influencing stock group composition. In District 1, Upper River stocks peak early in the season and gradually decrease thereafter (Tracy Lingnau, ADF&G, Summer Season Area Manager, Anchorage, personal communication). Conversely, the Lower river stock component gradually increases throughout the season. Middle river stocks are believed to peak near the midpoint of the run. In 2002, the subsistence fishery sample dates were June 6 through 18, whereas the commercial fishery dates were later, June 20, 24 and 27. Earlier dates of subsistence harvest sampling occurred when the Upper and Middle river stocks were historically in greater abundance and the later dates of the commercial harvest correspond to increased abundance of the Lower River stock.

In recent years, fishery managers have delayed the start of commercial fishing until near the midpoint of the run. For example, average start dates for the lower river commercial fishery were June 15, 16, and 18, for the years 1981-2000, 1992-2000, and 1997-2000, respectively (Vania et al. 2002). The later start date allows Upper river stocks to migrate through the lower river and to be harvested by the subsistence fishery only. Near the midpoint of the run, when commercial fishing begins, the proportion of Lower river stocks present in the lower river fishing districts is increasing.

In recent years, later timing of the commercial fishery should account for increased Lower river stock proportions in the total harvest (Table 15).

In 2002, the relatively high proportion of Middle river stock and low proportion of Lower river stock in the total harvest is an anomaly difficult to interpret (Table 15). Digitized mixed stock samples with higher than average estimated proportions of the Middle river stock were the District 2 commercial samples (age-1.3 and -1.4 fish, Table 8) and Districts 1 and 4 subsistence samples (age-1.4 fish, Table 10). Several different combinations of digitized escapement samples were used in the SPAYK.EXE program to estimate mixed stock harvests, and all of these combinations resulted in high proportions for the Middle river stock group.

Attainment of sample size objectives presented in the annual sampling plan is a reasonable measure of operational success. In 2002, sample sizes were judged adequate from most escapement and harvest sampling locations. Sample size objectives are designed to ensure adequate numbers of scales from age-1.3 and –1.4 fish are digitized for scale pattern analysis, and enough aged scales to describe 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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Table 1. Yukon River chinook salmon escapement age composition by tributary and weighted age composition by geographic area, 2002.

	Age Group								
	1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
E.F. Andreafsky R.	0.0000	0.3050	0.4817	0.1995	0.0000	0.0138	0.0000	0.0000	1.0000
Anvik River	0.0000	0.1949	0.4313	0.3419	0.0000	0.0319	0.0000	0.0000	1.0000
Gisasa River	0.0000	0.3194	0.4183	0.2338	0.0000	0.0285	0.0000	0.0000	1.0000
Lower River Weighted	0.0000	0.2843	0.4548	0.2395	0.0000	0.0214	0.0000	0.0000	1.0000
Chena River	0.0011	0.2895	0.2981	0.3846	0.0000	0.0267	0.0000	0.0000	1.0000
Salcha River	0.0000	0.3617	0.1383	0.3865	0.0000	0.1135	0.0000	0.0000	1.0000
Henshaw Creek	0.0000	0.3026	0.3602	0.3141	0.0000	0.0231	0.0000	0.0000	1.0000
Middle River Weighted	0.0005	0.3288	0.2147	0.3829	0.0000	0.0732	0.0000	0.0000	1.0000
Sheep Rock	0.0129	0.3650	0.3496	0.2442	0.0000	0.0283	0.0000	0.0000	1.0000
White Rock	0.0160	0.4349	0.3567	0.1844	0.0000	0.0080	0.0000	0.0000	1.0000
Upper River Combined (unadjusted)	0.0146	0.4043	0.3536	0.2106	0.0000	0.0169	0.0000	0.0000	1.0000
Upper River Combined (adjusted)[a]	0.0032	0.0265	0.3195	0.5779	0.0000	0.0728	0.0000	0.0000	1.0000

[a] Adjusted age composition after gear-selectivity coefficients were applied to the combined Sheep Rock and White Rock fishwheel 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, 2002.

			Age Group								
Location	Gear [a]	Sample Size	1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
District 1 Commercial	≥ 8.0" SGN	1,133	0.000	0.034	0.194	0.634	0.000	0.139	0.000	0.000	1.000
District 1 Subsistence	SGN/DGN	511	0.000	0.198	0.370	0.356	0.000	0.076	0.000	0.000	1.000
Big Eddy/ Middle Mouth Test Fish	8.25" DGN 8.5" SGN	1,323	0.000	0.029	0.207	0.647	0.000	0.117	0.000	0.000	1.000
District 2 Commercial	≥ 8.0" SGN	1,124	0.000	0.033	0.242	0.587	0.000	0.138	0.000	0.000	1.000
Marshal Tagging	8.5" DGN	253	0.000	0.036	0.182	0.621	0.000	0.162	0.000	0.000	1.000
Russian Mission Tagging	8.5" DGN	454	0.000	0.044	0.229	0.632	0.000	0.095	0.000	0.000	1.000
District 4 Subsistence	SGN/FW	231	0.000	0.165	0.268	0.459	0.000	0.108	0.000	0.000	1.000
District 5 Commercial	SGN/FW	338	0.000	0.077	0.305	0.547	0.000	0.071	0.000	0.000	1.000
District 5 Subsistence	FW	33	0.000	0.084	0.332	0.515	0.000	0.070	0.000	0.000	1.000
District 6 Commercial	FW	210	0.000	0.105	0.471	0.367	0.000	0.052	0.000	0.005	1.000
Canada Test Fish and Commercial	GN	205	0.000	0.107	0.380	0.380	0.005	0.122	0.005	0.000	1.000

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

Table 3. Set of scale variables and their descriptions selected for Yukon River chinook salmon stock identification, 2002.

Age Group	Scale Variable	Description of the Scale Characteristics
1.3	68	The total distance of the freshwater plus growth zone divided by the total freshwater distance.
	102	The difference between the distances from the beginning of the 1st ocean zone to circulus 15 and the beginning of the 1st ocean zone to circulus 9 divided by the total distance within the 1st ocean zone.
	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.
	105	Total distance of the 1st ocean zone divided by the number of circuli within the 1st ocean zone.
	76	The distance from the beginning of the 1st ocean zone to circulus 15 within the 1st ocean zone.
	8	Difference between the distance from the scale focus to circulus 6 and the distance from the scale focus to circulus 2 within the 1st freshwater zone.
	109	Total distance within the 2nd ocean zone.
	14	Total distance of the 1st. freshwater zone minus the distance between the scale focus to the 2nd ciculi in the 1st freshwater zone.
	16	The distance from the scale focus to circulus 2 in the 1st freshwater zone divided by the total distance within the 1st freshwater zone.
	29	The maximum distance between consecutive circuli within the 1st freshwater zone.
	62	Total distance within the freshwater plus growth zone.
1.4	62	Total distance within the freshwater plus growth zone.
	70	The number of circuli within the 1st ocean zone.
	89	Total distance within the 1st ocean zone minus the distance from the beginning of the 1st ocean zone to circulus 15.
	13	The distance from the 2nd circulus preceding the end of the 1st freshwater zone to the end of the 1st freshwater zone.
	16	The distance from the scale focus to circulus 2 in the 1st freshwater zone divided by the total distnce within the 1st freshwater zone.
	75	The distance from the beginning of the 1st ocean zone to circulus 12 within the 1st ocean zone.
	110	Total distance within the 3rd 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, 2002.

Age Group	Variable	Minimum			Maximum			Average			Standard Deviation		
		Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper	Lower	Middle	Upper
Age 1.3	68	0.14	0.07	0.31	0.53	0.55	0.57	0.33	0.39	0.42	0.08	0.07	0.06
	102	0.14	0.16	0.22	0.44	0.47	0.44	0.26	0.29	0.32	0.05	0.06	0.04
	103	0.14	0.09	0.17	0.46	0.47	0.40	0.24	0.23	0.25	0.06	0.06	0.05
	105	34.22	37.05	41.87	78.72	62.68	64.45	50.12	48.98	53.73	4.67	5.20	4.43
	76	461.00	513.00	622.00	1014.00	939.00	977.00	714.47	740.61	824.08	74.22	91.18	74.96
	8	58.00	61.00	64.00	183.00	177.00	165.00	117.88	100.77	113.12	20.37	18.35	20.71
	109	321.00	538.00	734.00	1873.00	1712.00	1697.00	1219.67	1133.03	1156.86	217.04	223.46	195.80
	14	75.00	78.00	90.00	298.00	286.00	231.00	162.45	140.45	161.47	41.07	38.91	36.32
	16	0.19	0.25	0.28	0.59	0.62	0.56	0.42	0.45	0.42	0.07	0.07	0.06
	29	21.00	23.00	27.00	100.00	67.00	66.00	44.62	41.98	43.52	9.23	8.10	8.77
	62	43.00	24.00	135.00	294.00	304.00	267.00	137.24	164.11	200.14	38.03	48.20	34.94
Age 1.4	62	37.00	67.00	113.00	364.00	278.00	352.00	130.30	155.96	202.38	46.44	39.19	51.90
	72	18.00	17.00	15.00	39.00	41.00	38.00	26.87	26.09	22.84	3.95	3.80	3.80
	89	134.00	57.00	0.00	1162.00	1101.00	1200.00	626.53	531.68	392.96	191.56	174.48	199.15
	13	23.00	23.00	25.00	79.00	73.00	70.00	43.30	41.82	46.17	10.64	9.58	9.32
	16	0.25	0.27	0.22	0.72	0.72	0.61	0.45	0.47	0.42	0.08	0.09	0.08
	75	382.00	384.00	752.00	708.00	720.00	1404.00	519.04	543.33	1061.10	64.92	73.81	141.64
	110	482.00	716.00	752.00	1821.00	1451.00	1404.00	1133.14	1050.61	1061.10	215.88	169.17	141.64

Table 5. Accuracy of maximum likelihood estimates for Yukon River chinook salmon stock composition by age and stock group, 2002. [a]

Age Group	Stock Group	Sample Size	Stock Composition Proportion: Lower	Middle	Upper	Total
Age 1.3	Lower	287	0.937	0.043	0.020	1.000
	Middle	181	0.026	0.956	0.018	1.000
	Upper	132	0.014	0.001	0.985	1.000
					Average Accuracy	0.959
			Lower	Middle	Upper	Total
Age 1.4	Lower	168	0.951	0.037	0.012	1.000
	Middle	174	0.019	0.964	0.017	1.000
	Upper	96	0.019	0.006	0.975	1.000
					Average Accuracy	0.963

[a] Stock composition is based on over 500 simulations for each age and stock group.

Table 6. Yukon River chinook salmon District 1 commercial harvest estimated stock composition by period for ages-1.3 and -1.4 fish, 2002. [a]

	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	48	Lower	0.6389	0.1302	120	Lower	0.5049	0.0854
20-Jun		Middle	0.0896	0.0956		Middle	0.2028	0.0805
		Upper	0.2716	0.0916		Upper	0.2922	0.0766
Period 2	59	Lower	0.7596	0.1227	91	Lower	0.5270	0.0992
24-Jun		Middle	0.0566	0.0657		Middle	0.0746	0.0714
		Upper	0.1838	0.0679		Upper	0.3984	0.0896
Period 3	44	Lower	0.2988	0.1109	100	Lower	0.4255	0.0866
27-Jun		Middle	0.2499	0.1288		Middle	0.2134	0.0855
		Upper	0.4513	0.1264		Upper	0.3611	0.0873

[a] Mesh size was restricted to 8 inch or larger for all District 1 commercial periods.

Table 7. Yukon River chinook salmon District 1 commercial harvest by age, stock group, and period, 2002.[a]

Strata [b]	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	110	618	1,589	0	231	0	0	2,548
20-Jun	Middle	0	38	87	638	0	199	0	0	962
	Alaska	0	148	705	2,227	0	430	0	0	3,510
	Upper	0	6	263	919	0	189	0	0	1,377
	Total	0	154	968	3,146	0	619	0	0	4,887
Period 2	Lower	0	190	758	1,468	0	231	0	0	2,647
24-Jun	Middle	0	35	57	208	0	70	0	0	370
	Alaska	0	225	815	1,676	0	301	0	0	3,017
	Upper	0	6	183	1,110	0	246	0	0	1,545
	Total	0	231	998	2,786	0	547	0	0	4,562
Period 3	Lower	0	9	81	445	0	84	4	0	623
27-Jun	Middle	0	19	67	223	0	90	4	0	403
	Alaska	0	28	148	668	0	174	8	0	1,026
	Upper	0	2	122	378	0	100	4	0	606
	Total	0	30	270	1,046	0	274	12	0	1,632
All Periods	Lower	0	309	1,457	3,502	0	546	4	0	5,818
Combined	Middle	0	92	211	1,069	0	359	4	0	1,735
	Alaska	0	401	1,668	4,571	0	905	8	0	7,553
	Upper	0	14	568	2,407	0	535	4	0	3,528
	Total	0	415	2,236	6,978	0	1,440	12	0	11,081

[a] Includes 416 fish from test fish sales.

[b] Mesh size restricted to 8 inch or larger.

Table 8. Yukon River chinook salmon District 2 commercial harvest estimated stock composition by period for ages-1.3 and -1.4 fish, 2002.

	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	60	Lower	0.0827	0.3193	141	Lower	0.2715	0.0804
20-Jun		Middle	0.2982	1.3602		Middle	0.4178	0.0930
		Upper	0.6191	0.1209		Upper	0.3107	0.0699
Period 2	69	Lower	0.5021	0.1005	153	Lower	0.4503	0.0800
26-Jun		Middle	0.3032	0.1083		Middle	0.4251	0.0870
		Upper	0.1947	0.0768		Upper	0.1246	0.0463
Period 3	42	Lower	0.2107	0.1033	162	Lower	0.3319	0.0979
30-Jun		Middle	0.5256	1.6538		Middle	0.4953	0.1028
		Upper	0.2637	0.1112		Upper	0.1728	0.0683

[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, 2002.[a]

Strata [b]	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	12	110	844	0	115	0	0	1,081
20-Jun	Middle	0	104	398	1,298	0	379	0	0	2,179
	Alaska	0	116	508	2,142	0	494	0	0	3,260
	Upper	0	12	826	965	0	186	0	0	1,989
	Total	0	128	1,334	3,107	0	680	0	0	5,249
Period 2	Lower	0	87	560	1,025	0	149	0	0	1,821
26-Jun	Middle	0	129	338	968	0	301	0	0	1,736
	Alaska	0	216	898	1,993	0	450	0	0	3,557
	Upper	0	5	217	284	0	58	0	0	564
	Total	0	221	1,115	2,277	0	508	0	0	4,121
Period 3	Lower	0	6	88	423	0	67	0	0	584
30-Jun	Middle	0	37	218	631	0	214	0	0	1,100
	Alaska	0	43	306	1,054	0	281	0	0	1,684
	Upper	0	1	110	220	0	49	0	0	380
	Total	0	44	416	1,274	0	330	0	0	2,064
All Periods	Lower	0	105	758	2,292	0	331	0	0	3,486
Combined	Middle	0	270	954	2,897	0	894	0	0	5,015
	Alaska	0	375	1,712	5,189	0	1,225	0	0	8,501
	Upper	0	18	1,153	1,469	0	293	0	0	2,933
	Total	0	393	2,865	6,658	0	1,518	0	0	11,434

[a] Includes 34 fish from test fish sales.

[b] Mesh size restricted to 8 inch or larger.

Table 10. Yukon River chinook salmon Districts 1 and 4 subsistence harvests estimated stock composition for ages-1.3 and -1.4 fish, 2002.

	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 1 Subsistence	73	Lower	0.3767	0.0953	44	Lower	0.1073	0.1598
		Middle	0.1715	0.0971		Middle	0.5271	0.1913
		Upper	0.4519	0.0931		Upper	0.3656	0.1299
District 4 Subsistence	37	Lower	0.3591	4.3617	62	Lower	0.1122	0.3489
		Middle	0.2529	0.2321		Middle	0.4965	0.1551
		Upper	0.3880	0.1275		Upper	0.3913	0.1175

Table 11. Yukon River chinook salmon harvest by age, stock group, and fishery, 2002.

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	309	1,457	3,502	0	546	4	0	5,818
		Middle	0	92	211	1,069	0	359	4	0	1,735
		Alaska	0	401	1,668	4,571	0	905	8	0	7,553
		Upper	0	14	568	2,407	0	535	4	0	3,528
		Total	0	415	2,236	6,978	0	1,440	12	0	11,081
	Subsistence	Lower	0	487	781	214	0	26	0	0	1,508
		Middle	0	543	355	1,052	0	275	0	0	2,225
		Alaska	0	1,030	1,136	1,266	0	301	0	0	3,733
		Upper	0	78	936	730	0	126	0	0	1,870
		Total	0	1,108	2,072	1,996	0	427	0	0	5,603
2	Commercial [b]	Lower	0	105	758	2,292	0	331	0	0	3,486
		Middle	0	270	954	2,897	0	894	0	0	5,015
		Alaska	0	375	1,712	5,189	0	1,225	0	0	8,501
		Upper	0	18	1,153	1,469	0	293	0	0	2,933
		Total	0	393	2,865	6,658	0	1,518	0	0	11,434
	Subsistence [c]	Lower	0	140	614	596	0	88	0	0	1,438
		Middle	0	156	279	2,929	0	935	0	0	4,299
		Alaska	0	296	893	3,525	0	1,023	0	0	5,737
		Upper	0	22	735	2,032	0	428	0	0	3,217
		Total	0	318	1,628	5,557	0	1,451	0	0	8,954
3	Subsistence [d]	Lower	0	80	357	281	0	24	0	0	742
		Middle	0	89	162	1,379	0	253	0	0	1,883
		Alaska	0	169	519	1,660	0	277	0	0	2,625
		Upper	0	13	428	957	0	116	0	0	1,514
		Total	0	182	947	2,617	0	393	0	0	4,139
4	Subsistence [e]	Lower	0	514	864	462	0	63	0	0	1,903
		Middle	0	887	608	2,042	0	597	0	0	4,134
		Alaska	0	1,401	1,472	2,504	0	660	0	0	6,037
		Upper	0	74	934	1,609	0	310	0	0	2,927
		Total	0	1,475	2,406	4,113	0	970	0	0	8,964
5	Commercial	Upper	0	67	252	396	0	56	0	0	771
	Subsistence [f]	Upper	0	1,111	4,409	6,846	0	932	0	0	13,298
		Total	0	1,178	4,661	7,242	0	988	0	0	14,069
6	Commercial	Middle	0	94	389	305	0	43	0	5	836
	Subsistence [g]	Middle	0	203	838	644	0	94	0	9	1,788
	Sport Fish	Middle	0	147	125	185	0	23	0	0	480
		Total	0	444	1,352	1,134	0	160	0	14	3,104
Canada [h]	Commercial	Upper	0	76	269	269	4	86	4	0	708
	Aboriginal	Upper	0	786	2,784	2,784	41	890	41	0	7,326
	Test Fish	Upper	0	111	394	393	6	126	6	0	1,036
	Domestic	Upper	0	6	23	23	0	7	0	0	59
	Sport Fish	Upper	1	5	64	116	0	14	0	0	200
		Total	1	984	3,534	3,585	51	1,123	51	0	9,329
Total Harvest		Lower	0	1,635	4,831	7,347	0	1,078	4	0	14,895
		Middle	0	2,481	3,921	12,502	0	3,473	4	14	22,395
		Alaska	0	4,116	8,752	19,849	0	4,551	8	14	37,290
		Upper	1	2,381	12,949	20,031	51	3,919	55	0	39,387
		Total	1	6,497	21,701	39,880	51	8,470	63	14	76,677

Table 11. (page 2 of 2).

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[a] District 1 commercial harvest includes 416 chinook salmon caught by test fishing projects.

[b] District 2 commercial harvest includes 34 chinook salmon caught by test fishing projects.

[c] Stock group estimates are based on District 1 subsistence samples. Age composition estimates are based on Russian Mission tagging samples.

[d] Stock group estimates are based on District 1 subsistence samples. Age composition estimates are based on Marshall tagging samples.

[e] Stock group and age composition estimates are based on samples from gillnet and fishwheel harvests in District 4. Upper 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, and domestic age compositions are based on samples from Canadian commercial and test fish harvests. Sport fish age composition is based on the upriver adjusted harvest from fishwheels. The Porcupine River harvest near Old Crow is included under the Aboriginal harvest.

Table 12. Yukon River chinook salmon Districts 5 and 6 commercial harvest by age, stock group, and period, 2002.

Subdistrict/ District	Period	Stock Group	Age Group 1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
5BC	1	Upper	0	9	53	145	0	16	0	0	223
5BC	2	Upper	0	40	131	145	0	25	0	0	341
5D	1	Upper	0	18	68	106	0	15	0	0	207
5BCD	All	Total	0	67	252	396	0	56	0	0	771
6	1	Middle	0	14	176	141	0	17	0	0	348
6	2	Middle	0	75	179	96	0	26	0	0	376
6	3	Middle	0	4	29	58	0	0	0	4	95
6	4	Middle	0	1	5	10	0	0	0	1	17
	All	Total	0	94	389	305	0	43	0	5	836

Table 13. Yukon River chinook salmon harvest proportions by age, stock group, and fishery, 2002.

			Age Group								
District	Fishery	Stock Group	1.1	1.2	1.3	1.4	2.3	1.5	2.4	1.6	Total
1	Commercial	Lower	0.000	0.028	0.131	0.316	0.000	0.049	0.000	0.000	0.525
		Middle	0.000	0.008	0.019	0.096	0.000	0.032	0.000	0.000	0.157
		Alaska	0.000	0.036	0.151	0.413	0.000	0.082	0.001	0.000	0.682
		Upper	0.000	0.001	0.051	0.217	0.000	0.048	0.000	0.000	0.318
		Total	0.000	0.037	0.202	0.630	0.000	0.130	0.001	0.000	1.000
	Subsistence	Lower	0.000	0.087	0.139	0.038	0.000	0.005	0.000	0.000	0.269
		Middle	0.000	0.097	0.063	0.188	0.000	0.049	0.000	0.000	0.397
		Alaska	0.000	0.184	0.203	0.226	0.000	0.054	0.000	0.000	0.666
		Upper	0.000	0.014	0.167	0.130	0.000	0.022	0.000	0.000	0.334
		Total	0.000	0.198	0.370	0.356	0.000	0.076	0.000	0.000	1.000
2	Commercial	Lower	0.000	0.009	0.066	0.200	0.000	0.029	0.000	0.000	0.305
		Middle	0.000	0.024	0.083	0.253	0.000	0.078	0.000	0.000	0.439
		Alaska	0.000	0.033	0.150	0.454	0.000	0.107	0.000	0.000	0.743
		Upper	0.000	0.002	0.101	0.128	0.000	0.026	0.000	0.000	0.257
		Total	0.000	0.034	0.251	0.582	0.000	0.133	0.000	0.000	1.000
	Subsistence	Lower	0.000	0.016	0.069	0.067	0.000	0.010	0.000	0.000	0.161
		Middle	0.000	0.017	0.031	0.327	0.000	0.104	0.000	0.000	0.480
		Alaska	0.000	0.033	0.100	0.394	0.000	0.114	0.000	0.000	0.641
		Upper	0.000	0.002	0.082	0.227	0.000	0.048	0.000	0.000	0.359
		Total	0.000	0.036	0.182	0.621	0.000	0.162	0.000	0.000	1.000
3	Subsistence	Lower	0.000	0.019	0.086	0.068	0.000	0.006	0.000	0.000	0.179
		Middle	0.000	0.022	0.039	0.333	0.000	0.061	0.000	0.000	0.455
		Alaska	0.000	0.041	0.125	0.401	0.000	0.067	0.000	0.000	0.634
		Upper	0.000	0.003	0.103	0.231	0.000	0.028	0.000	0.000	0.366
		Total	0.000	0.044	0.229	0.632	0.000	0.095	0.000	0.000	1.000
4	Subsistence	Lower	0.000	0.057	0.096	0.052	0.000	0.007	0.000	0.000	0.212
		Middle	0.000	0.099	0.068	0.228	0.000	0.067	0.000	0.000	0.461
		Alaska	0.000	0.156	0.164	0.279	0.000	0.074	0.000	0.000	0.673
		Upper	0.000	0.008	0.104	0.179	0.000	0.035	0.000	0.000	0.327
		Total	0.000	0.165	0.268	0.459	0.000	0.108	0.000	0.000	1.000
5	Commercial	Upper	0.000	0.005	0.018	0.028	0.000	0.004	0.000	0.000	0.055
	Subsistence	Upper	0.000	0.079	0.313	0.487	0.000	0.066	0.000	0.000	0.945
		Total	0.000	0.084	0.331	0.515	0.000	0.070	0.000	0.000	1.000
6	Commercial	Middle	0.000	0.030	0.125	0.098	0.000	0.014	0.000	0.002	0.269
	Subsistence	Middle	0.000	0.065	0.270	0.207	0.000	0.030	0.000	0.003	0.576
	Sport Fish	Middle	0.000	0.047	0.040	0.060	0.000	0.007	0.000	0.000	0.155
		Total	0.000	0.143	0.436	0.365	0.000	0.052	0.000	0.005	1.000
Canada	Commercial	Upper	0.000	0.008	0.029	0.029	0.000	0.009	0.000	0.000	0.076
	Aboriginal	Upper	0.000	0.084	0.298	0.298	0.004	0.095	0.004	0.000	0.785
	Domestic	Upper	0.000	0.012	0.042	0.042	0.001	0.014	0.001	0.000	0.111
	Test Fish	Upper	0.000	0.001	0.002	0.002	0.000	0.001	0.000	0.000	0.006
	Sport Fish	Upper	0.000	0.001	0.007	0.012	0.000	0.002	0.000	0.000	0.021
		Total	0.000	0.105	0.379	0.384	0.005	0.120	0.005	0.000	1.000
Total Harvest		Lower	0.000	0.021	0.063	0.096	0.000	0.014	0.000	0.000	0.194
		Middle	0.000	0.032	0.051	0.163	0.000	0.045	0.000	0.000	0.292
		Alaska	0.000	0.054	0.114	0.259	0.000	0.059	0.000	0.000	0.486
		Upper	0.000	0.031	0.169	0.261	0.001	0.051	0.001	0.000	0.514
		Total	0.000	0.085	0.283	0.520	0.001	0.110	0.001	0.000	1.000

Table 14. Yukon River chinook salmon historical harvest by stock group for the United States and Canada, 1981-2002.

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	12,569	73,477	136,884
2000	16,989	6,176	22,143	4,879	27,022	50,187
2001	20,115	10,190	23,325	10,096	33,421	63,726
2002	14,895	22,395	30,058	9,329	39,387	76,677
1981-2001 Average	35,433	38,484	76,277	16,847	93,124	167,041
1992-2001 10-Year Average	34,995	26,409	70,393	14,624	85,017	146,420
1997-2001 5-Year Average	35,414	15,107	49,097	10,002	59,099	109,620

Table 15. Yukon River chinook salmon historical harvest proportions by stock group for the United States and Canada, 1981-2002.

Year	Lower	Middle	Upper U.S.	Upper Canada	Upper 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	0.400	0.063	0.445	0.092	0.537	1.000
2000	0.339	0.123	0.441	0.097	0.538	1.000
2001	0.316	0.160	0.366	0.158	0.524	1.000
2002	0.194	0.292	0.392	0.122	0.514	1.000
1981-2001 Average	0.212	0.230	0.457	0.101	0.557	1.000
1992-2001 10-Year Average	0.239	0.180	0.481	0.100	0.581	1.000
1997-2001 5-Year Average	0.323	0.138	0.448	0.091	0.539	1.000

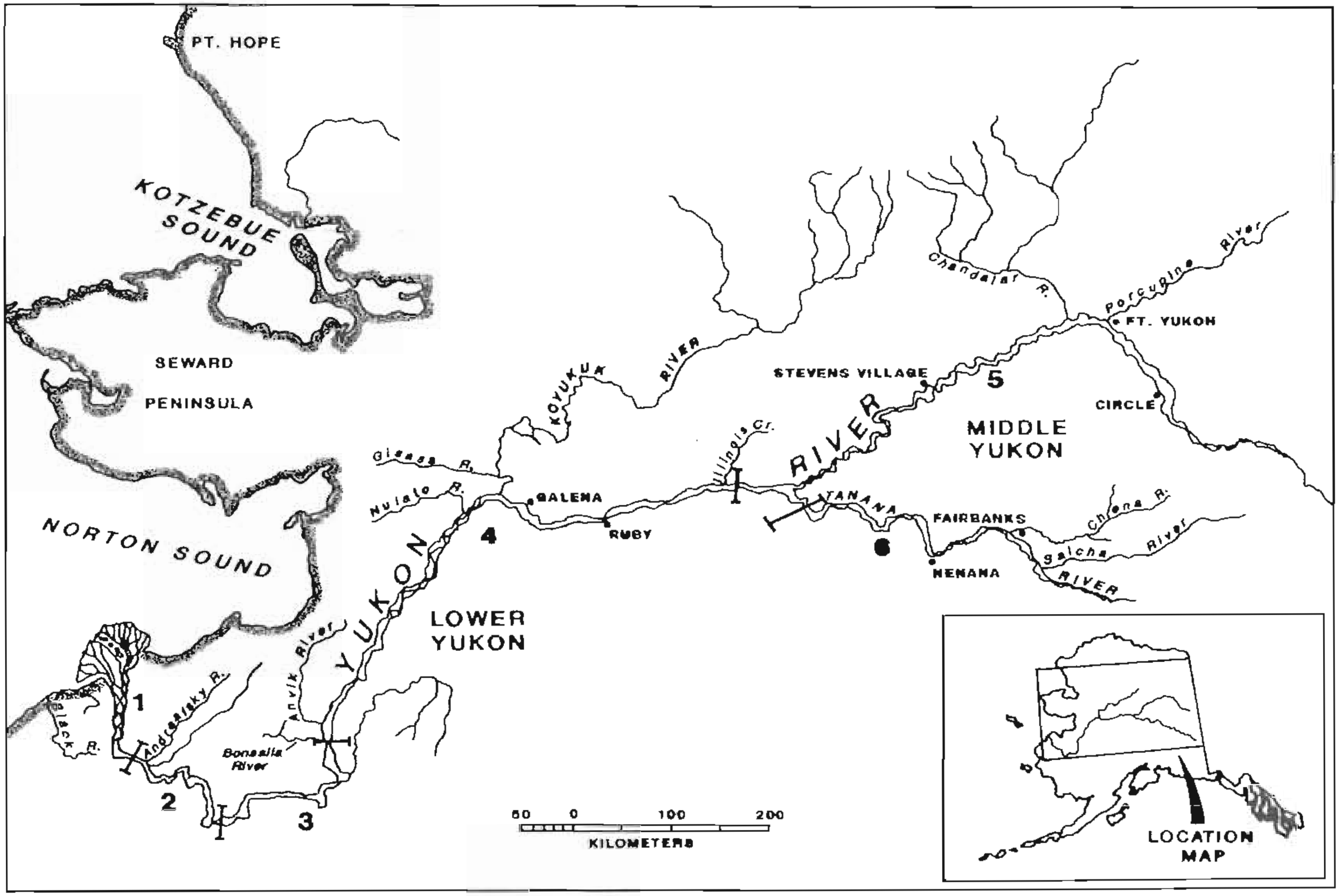


Figure 1. Alaska portion of the Yukon River drainage with district boundaries and major spawning tributaries.

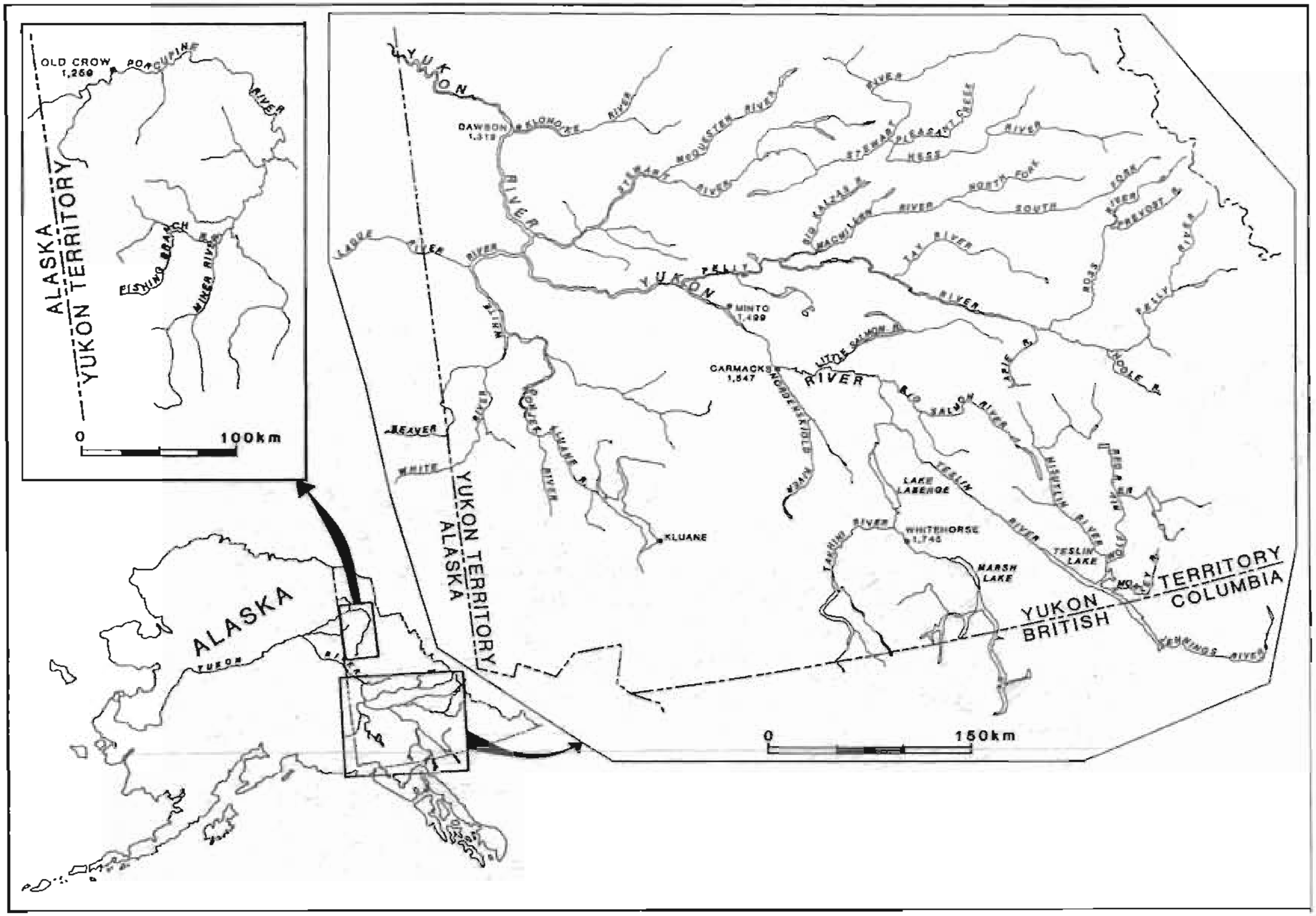


Figure 2. Canada portion of the Yukon River drainage and major spawning tributaries.

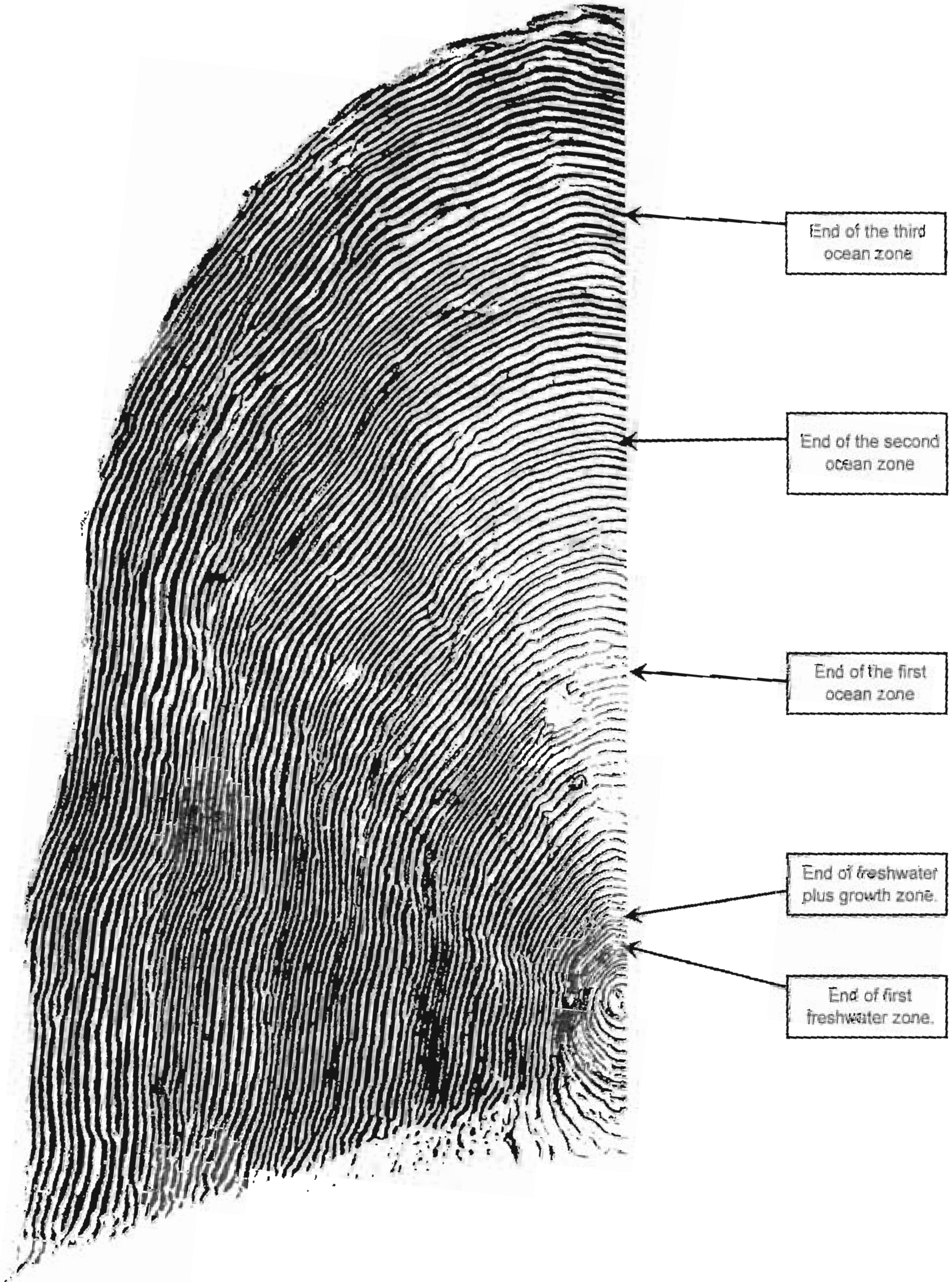
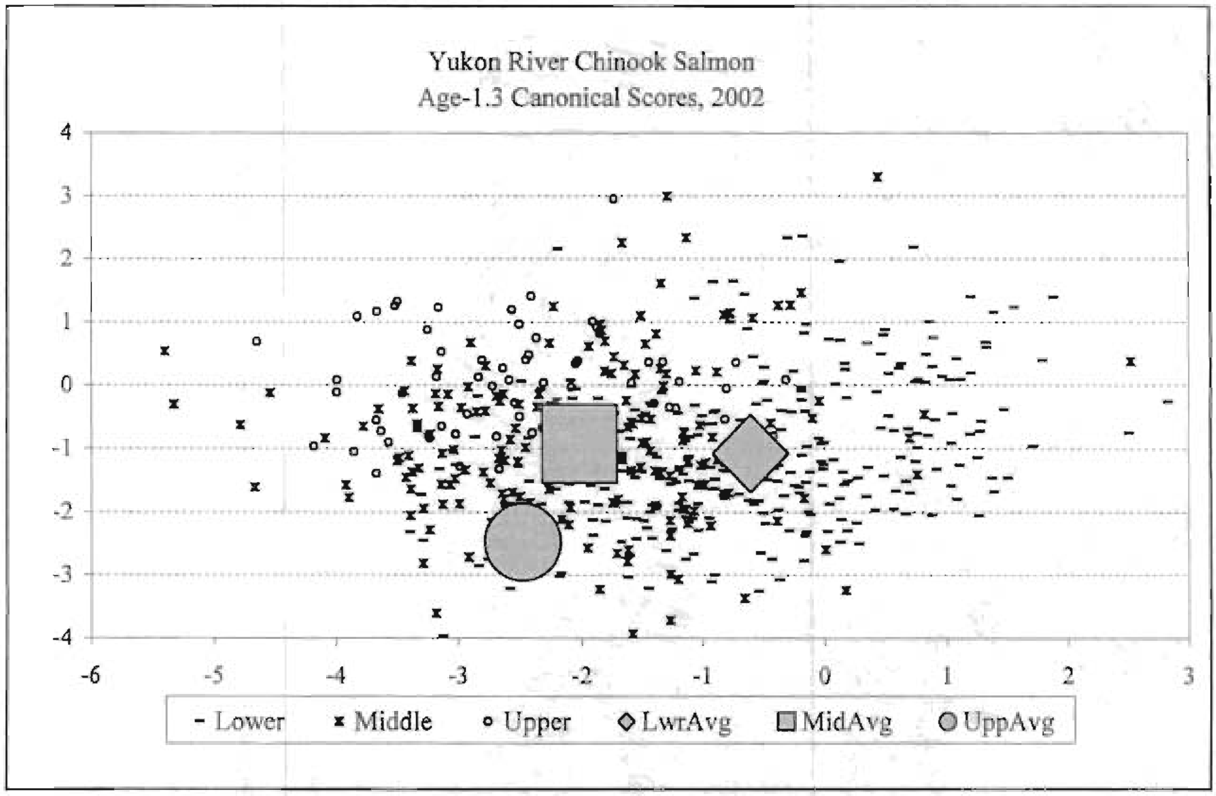


Figure 3. Scale of a chinook salmon illustrating the different zones measured for scale growth analysis.

Andreafsky River Escapement | **Salcha River Escapement** | **Canadian Sheep Rock**

Figure 4. Yukon River chinook salmon fresh water scale areas, comparing scales from Andreafsky River escapement (Lower stock group), Salcha River escapement (Middle stock group) and Canadian fishwheel catch (Upper stock group). (Arrows with "dot" indicate the first freshwater annulus; arrows with "diamond" indicate the end of the freshwater zone.



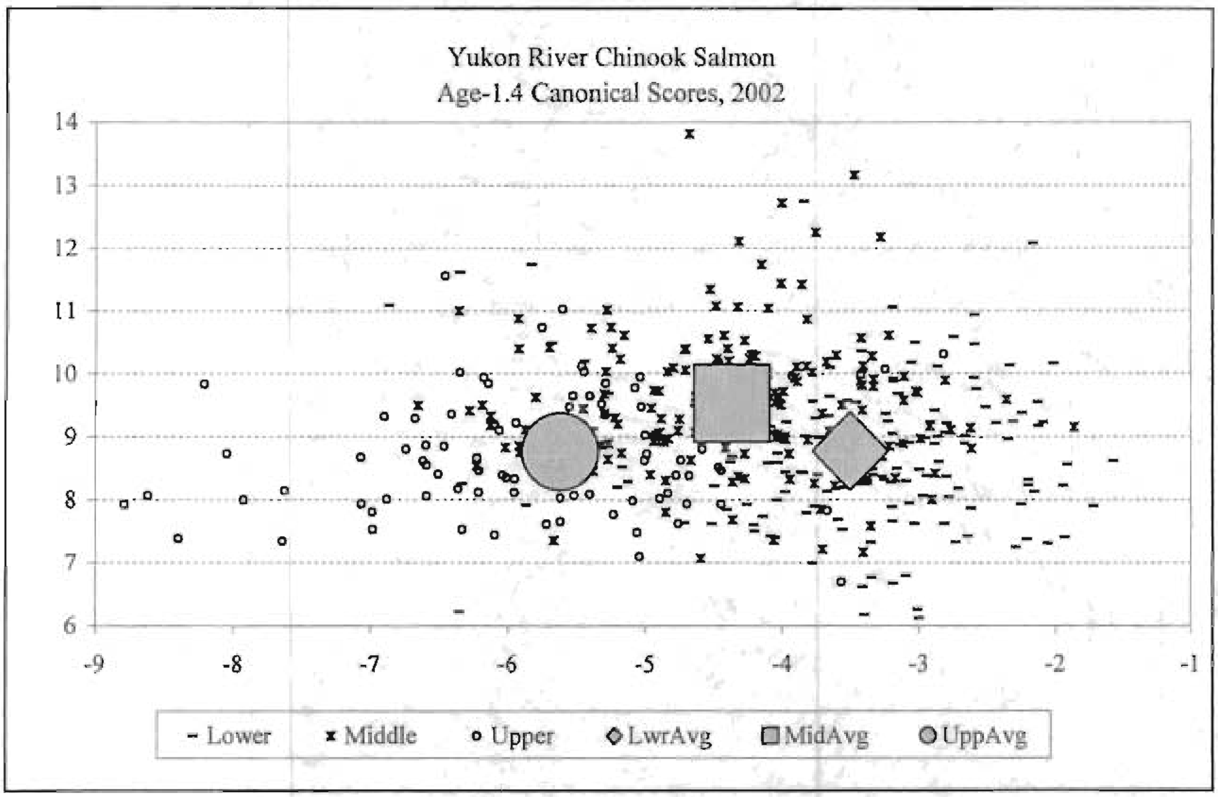


Figure 5. Canonical variable plots for Yukon River age-1.3 and -1.4 chinook salmon, 2002.

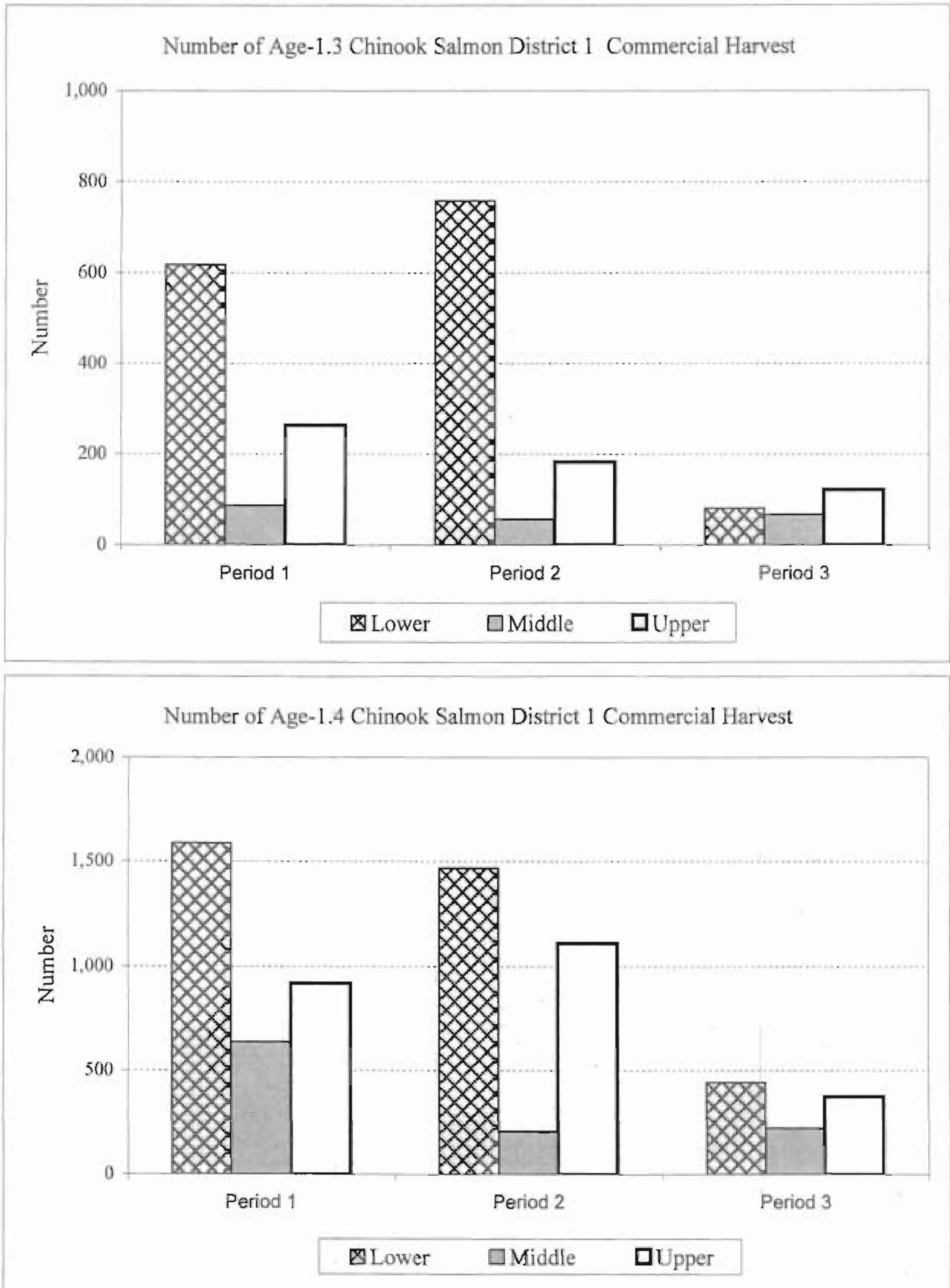
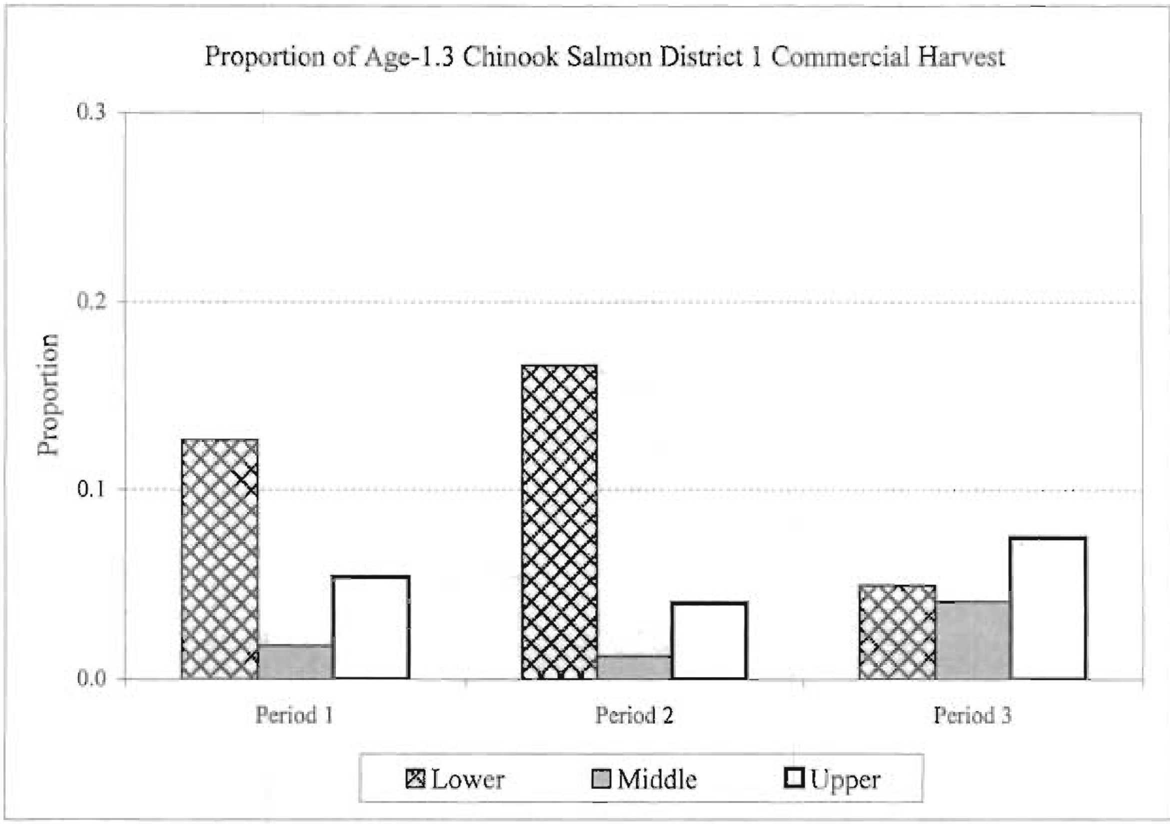


Figure 6. Estimated number of age-1.3 and -1.4 chinook salmon harvested, by commercial period and stock group, Yukon River District 1, 2002.



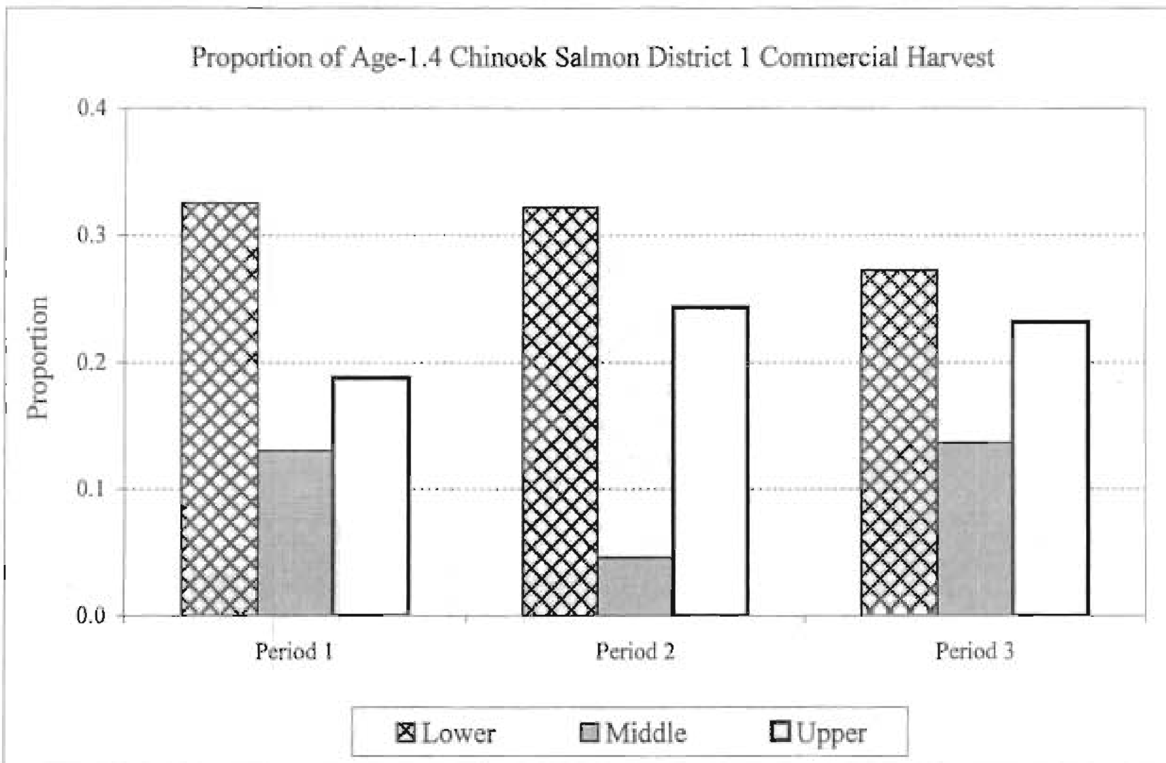


Figure 7. Estimated proportion of age-1.3 and -1.4 chinook salmon harvested, by commercial period and stock group, Yukon River District 1, 2002.

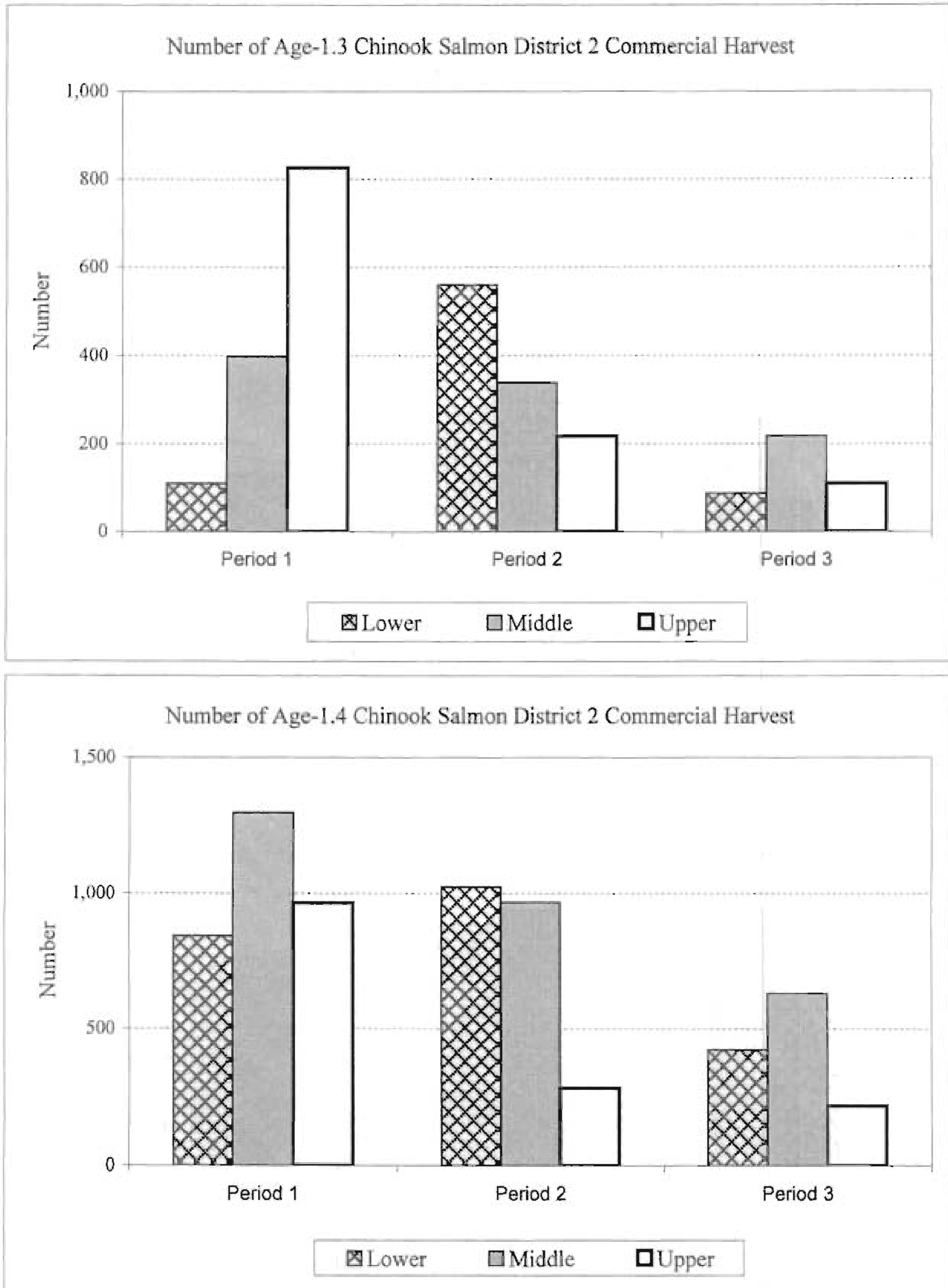
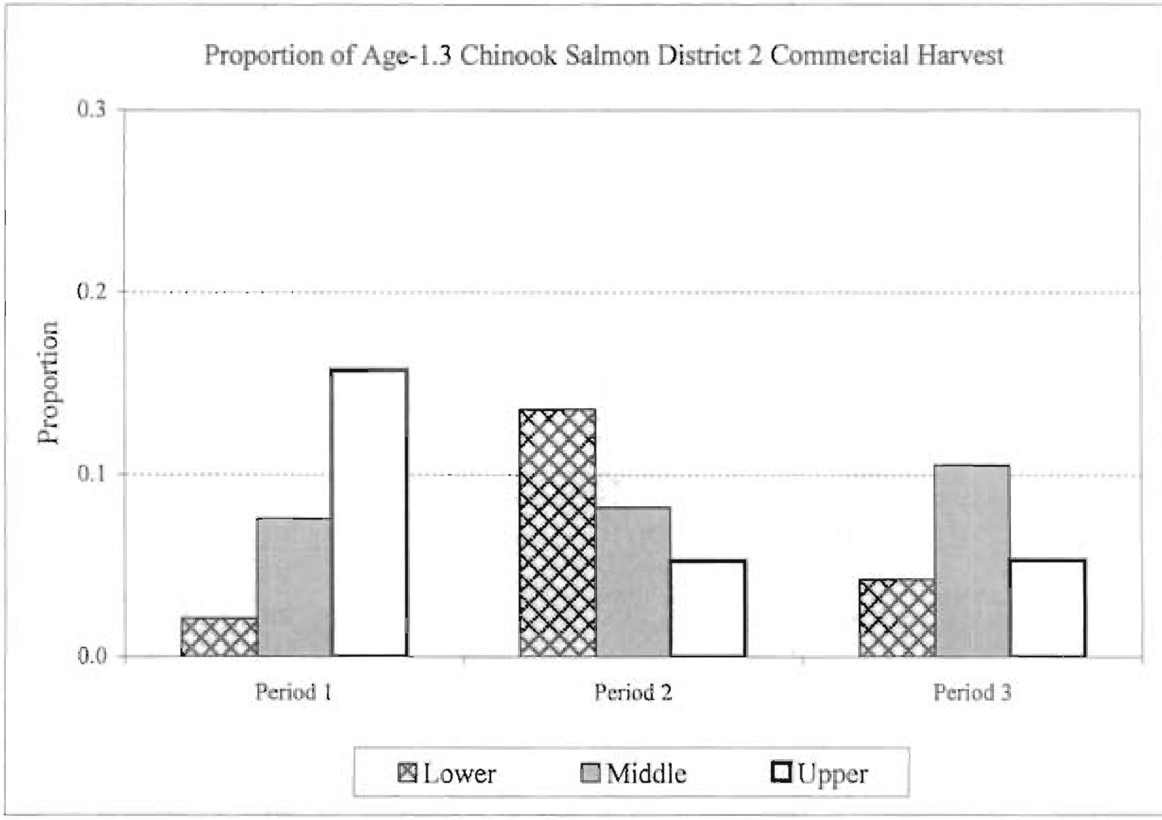


Figure 8. Estimated number of age-1.3 and -1.4 chinook salmon harvested, by commercial period and stock group, Yukon River District 2, 2002.



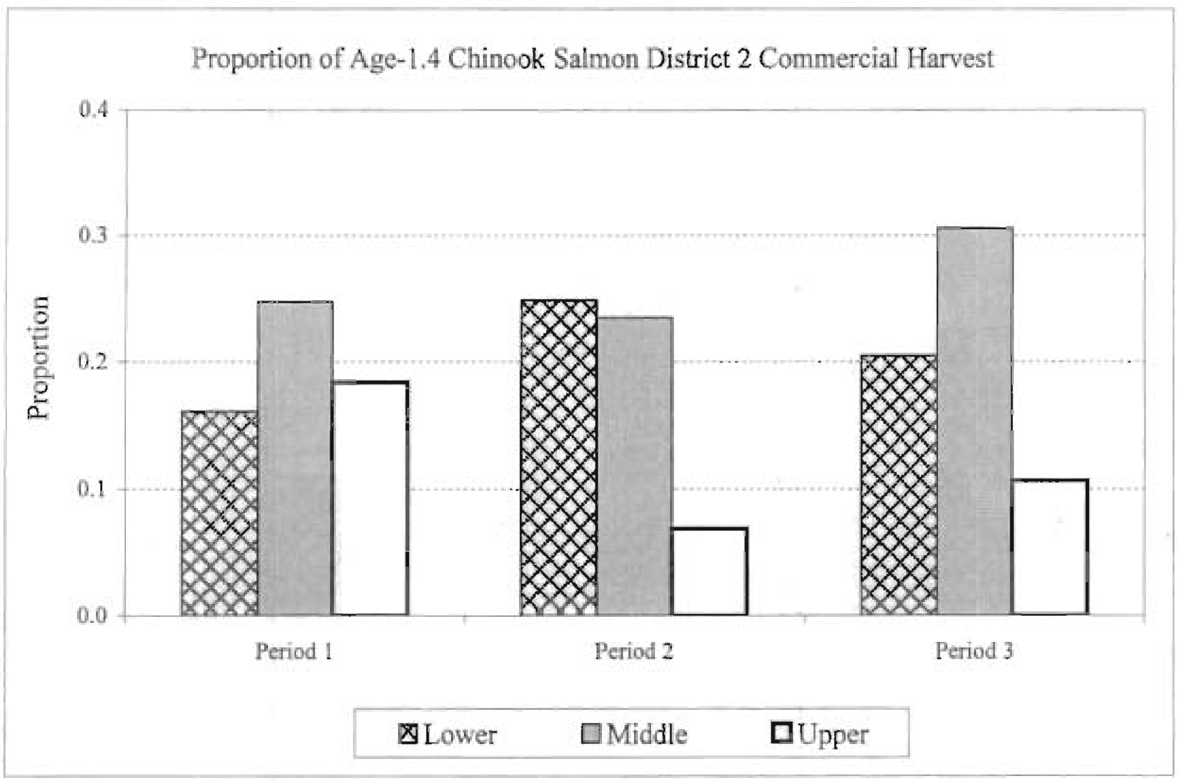
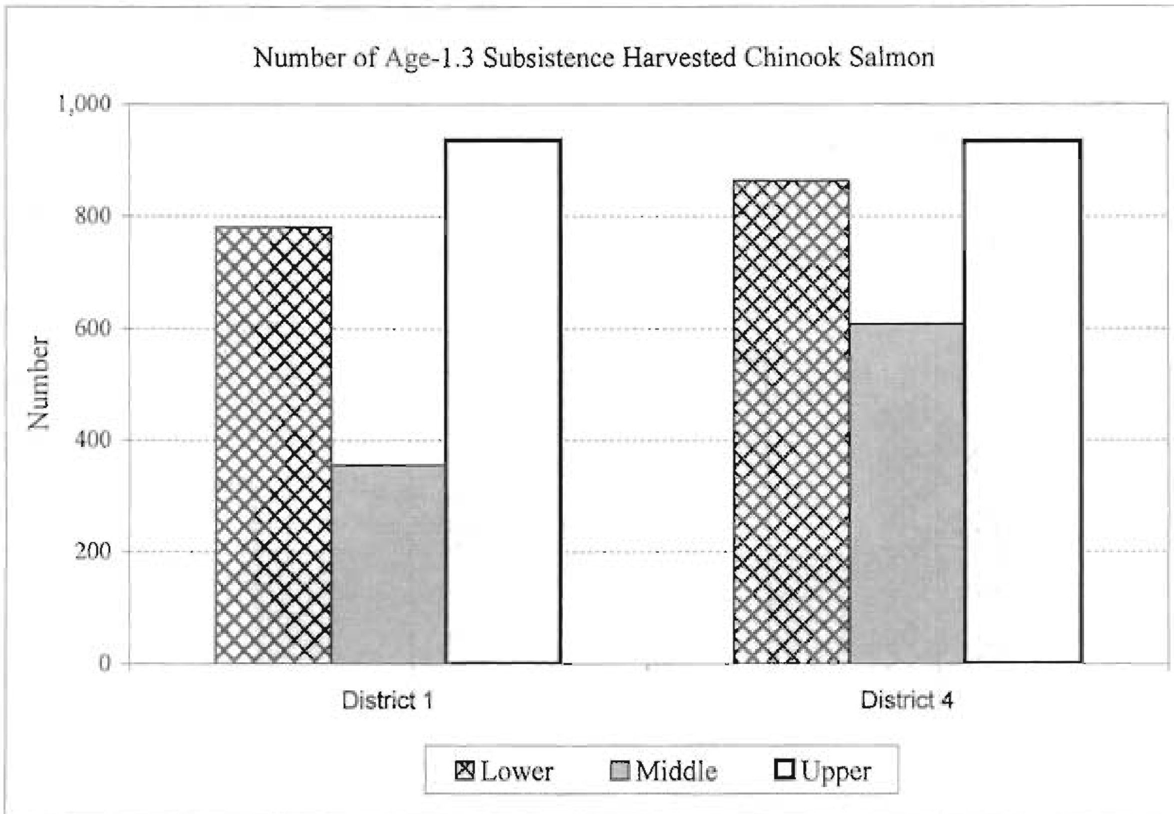


Figure 9. Estimated proportion of age-1.3 and -1.4 chinook salmon harvested, by commercial period and stock group, Yukon River District 2, 2002.



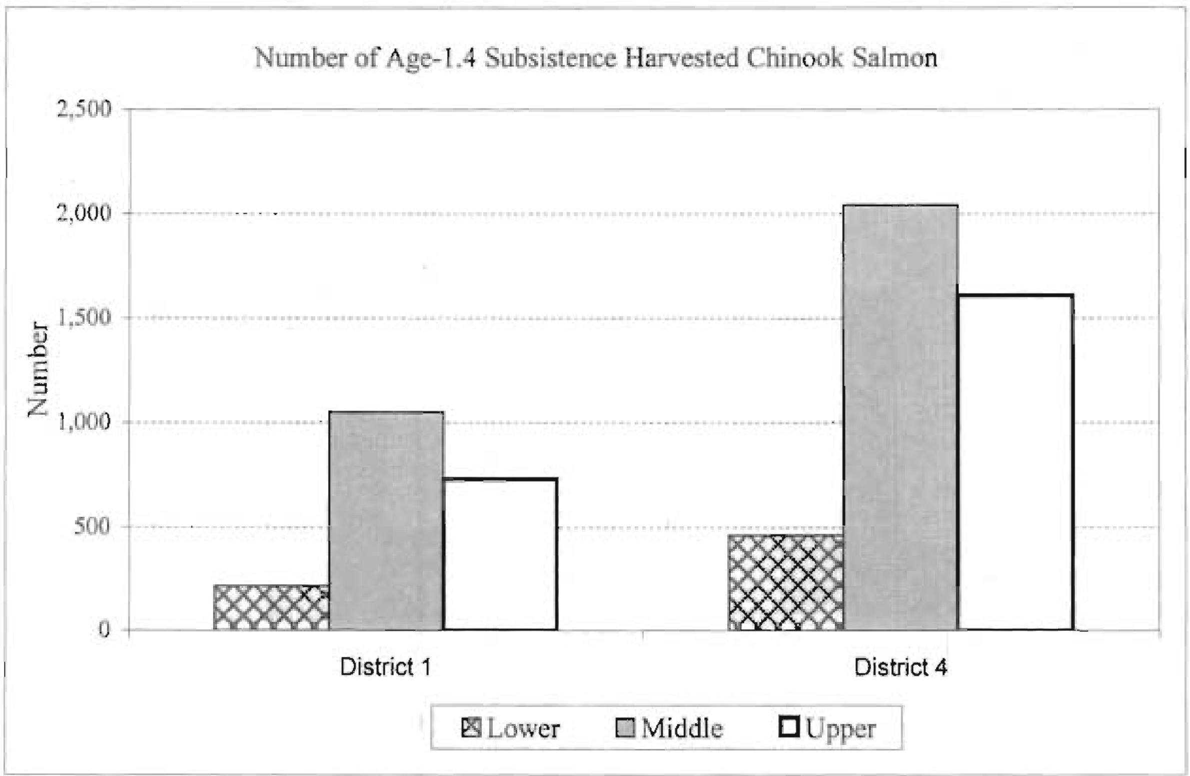


Figure 10. Estimated number of age-1.3 and -1.4 chinook salmon harvested by stock group, Yukon River subsistence fisheries Districts 1 and 4, 2002.

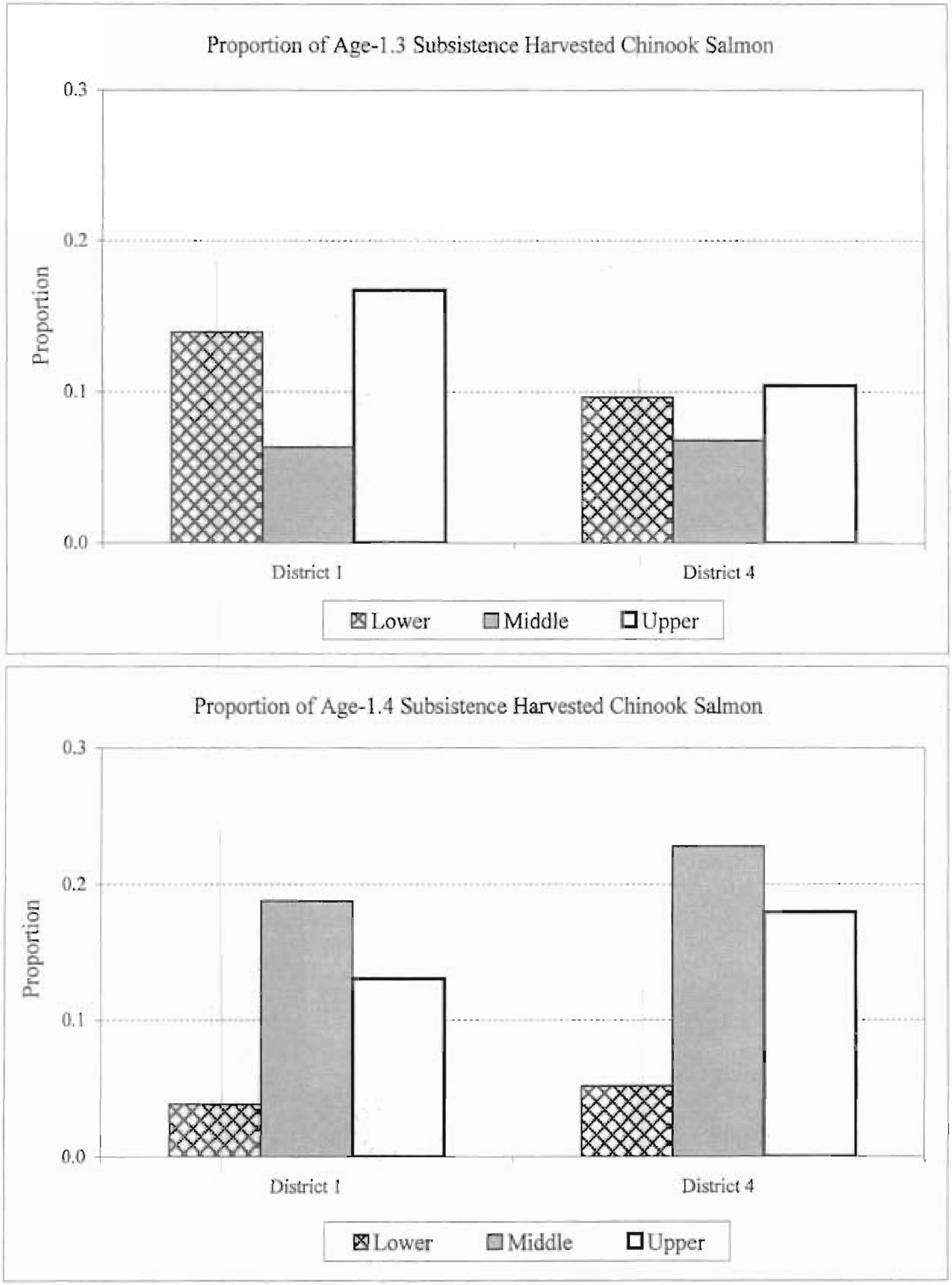


Figure 11. Estimated proportion of age-1.3 and -1.4 chinook salmon harvested by stock group, Yukon River subsistence fisheries Districts 1 and 4, 2002.