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U.S./Canada Negotiation Studies

Prepared By

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I. INTRODUCTION

The United States and Canada began negotiations on Yukon River salmon in March 1985. Since then, negotiations have been held about twice per year. The negotiations have relied heavily on information supplied by the Alaska Department of Fish and Game (ADF&G) about the salmon fisheries and stocks in the Yukon River drainage. Some of that information has been gained because of specific appropriations from Congress passed through the Department of Commerce to ADF&G. Federal FY 1995 funds were passed through to ADF&G to provide some support for negotiation meeting costs and field data collection for the period 1 July 1995 through 30 June 1996 through grant Award No. NA46FP0343-1.

The purpose of the program supported by Federal funds for Yukon River salmon negotiation studies is to help provide the technical support necessary to effectively manage the complex Yukon River salmon fisheries in the context of the U.S./Canada negotiation process, as well as to help provide support for the treaty negotiation process.

The Yukon River (Figures 1 and 2) is the largest river in Alaska, and one of the largest in North America. It drains an area of approximately 330,000 square miles, nearly two-thirds of which is in Alaska. For perspective, the Yukon River drainage exceeds the combined areas of the U.S. Pacific coast states of Washington, Oregon, and California combined. The area is mostly remote, undeveloped, and in its natural pristine condition. The Yukon River supports one of the largest runs of chinook and chum salmon in the world.

The existing Yukon River salmon research and management program is inadequate to meet the technical requirements currently demanded of it, or anticipated in the near future. Allocation of the allowable harvest of salmon among users in both the United States and Canada, and concerns for conserving specific stocks in a fully developed fishery harvesting from a mixture of a great number of stocks, makes the Yukon River one of the most challenging salmon fisheries to manage for optimum sustainable yields. The Yukon River Joint Technical Committee (JTC) has determined that the technical program, for both countries, is inadequate to meet the requirements anticipated with a treaty management regime.

This report serves as a completion report in summary form for six field data collection projects or activities funded with this grant for the period 1 July 1995 through 30 June 1996, which was essentially the 1995 field season for these projects. The salmon catch and escapement sampling activity is ancillary to the stock identification project. Specifically, the projects or activities described in this report are as follows:

1) Chinook Salmon Stock Identification Using SPA, 1995
2) Chum Salmon Stock Identification Using GSI, 1995
3) Salmon Catch and Escapement Age-Sex-Length Sampling, 1995
4) Subsistence Harvest Estimation, 1995

5) Spawning Escapement Surveys, 1995
6) Lower Yukon River Sonar at Pilot Station, 1995

Results from each of these projects or activities will be summarized in the subsequent individual sections of this completion report. Reference will be provided to specific reports in preparation or already completed which provide a more comprehensive source of information on the background for these projects or activities, the methods used, the results and discussion, and literature references.

CHINOOK SALMON STOCK IDENTIFICATION USING SPA, 1995

Yukon River chinook 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. Chinook salmon harvested in the Yukon River fisheries consist of a mixture of stocks destined for spawning areas throughout the Yukon River drainage. Although more than 100 spawning streams have been documented, aerial surveys of chinook salmon escapements indicate that the largest concentrations of spawners occur in three distinct geographic regions: (1) tributary streams in Alaska that drain the Andreafsky Hills and Kaltag Mountains between river miles 100 and 500, (2) Upper Koyukuk River and Tanana River tributaries in Alaska between river miles 800 and 1,100, and (3) tributary streams in Canada that drain the Pelly and Big Salmon Mountains between river miles 1,300 and 1,800. Chinook salmon stocks within these geographic regions are collectively termed the Lower, Middle, and Upper Yukon Runs. For management purposes the Alaska portion of the drainage is divided into six districts.

Evaluating stock productivities, spawning escapement goals, and management strategies requires information on the stock composition of the harvest. The U.S. and Canada are engaged in treaty negotiations concerning management and conservation of stocks spawned in Canada. Biological information on these stocks provides the technical basis for the negotiations. The objective of this project is to classify all chinook salmon harvests in the Yukon River drainage to run of origin primarily using scale pattern analysis (SPA). A more comprehensive source of information on the background of this project, the methods used, the results and discussion for 1995, and literature references can be found in Schneiderhan (In Prep).

Chinook salmon scale samples provided age information for fish in the catch and escapement. Scales were collected from commercial catches in all fishing districts in 1995 except District 3. Subsistence catches in Districts 4 and 6 were also sampled. District 3 was not targeted for sampling because relatively few fish were harvested in that portion of the Yukon River and access was difficult. Salmon harvested in District 3 and delivered to buyers in District 2 could at times have comprised a small fraction of the District 2 catch sample. For purposes of this report, it was assumed that subsistence fishing in District 1 and 2 occurred prior to or near the beginning of commercial fishing and could therefore be described using the Period 1 commercial sample data for each district. Spawning escapement scale samples were collected during the period of peak spawner mortality from the Anvik, Chena, and Salcha Rivers in Alaska. Carcasses were the primary source of these samples; however, some were obtained from live, spawned-out fish captured with spears or other methods. Live salmon were sampled on the East Fork of the Andreafsky River at a weir project operated by U.S. Fish and Wildlife Service. Canadian tributaries were not sampled in 1995. However, samples for use as stock standards were collected from chinook salmon captured in fish wheels by personnel from the Canadian Department of Fisheries and Oceans (DFO) in Yukon Territory, Canada. The age composition of Lower, Middle, and Upper Yukon Runs was estimated by weighting the age composition calculated for the individual spawning tributaries in each area by the escapement to each tributary as indexed by aerial surveys or mark/recapture spawning population estimates.

Linear discriminant functions (LDF) analysis of scale patterns data were used to classify the two major age classes, e.g., ages 1.3 and 1.4, to run of origin. Minor age classes were estimated using the major age class results in conjunction with observed differences in age composition between escapements and geographic occurrence for the 1995 Yukon River chinook salmon catches.

Yukon River chinook salmon escapement age compositions in 1995 exhibited variations of trends and characteristics seen in other years. Further discussion of age information is provided in the section of this report on salmon catch and escapement age-sex-length sampling.

A 3-way run classification model consisting of separate standards for Lower, Middle, and Upper Yukon stocks was used in 1995. Preliminary results will be reported here, but are subject to further research and analysis. The mean classification accuracy of the run of origin model was 72.0% for age 1.3 and 66.0% for age 1.4. This was similar to most other years. Also similar to past years, the lower river standard showed the greatest classification accuracy for age 1.4 (71.2%); however, contrary to past results, the upper river standard provided the greatest classification accuracy for age 1.3 (81.3%). Upper river standards most often misclassified to the Middle Yukon Run (18.8% for age 1.3 and 26.0% for age 1.4), and middle river standards most often misclassified to the Lower Yukon Run (16.7% for age 1.3 and 22.4% for age 1.4).

The commercial and subsistence harvest from the entire Yukon River drainage of 198,418 chinook salmon was classified to run of origin based on (1) findings of the scale pattern analysis for age-1.3 and -1.4 fish in District 1 and 2 commercial catches, (2) age composition analysis of the remaining age classes, (3) assumptions concerning unsampled fisheries, and (4) stock origins based on geographical segregation. The Upper Yukon Run was the largest estimated run component and contributed 148,513 fish or 74.8% of the total drainage harvest. The Middle Yukon Run was next in abundance at 26,021 fish (13.1%), followed by the Lower Yukon Run at 23,885 fish (12.0%).

The estimated commercial harvests of ages 1.3 and 1.4 in Districts 1 and 2 combined was 110,625 chinook salmon or 55.8% of the total Yukon River drainage catch. The estimated District 1 commercial catch of age-1.3 and -1.4 fish combined was 14,895 (20.7%) Lower, 9,863 (13.7%) Middle, and 47,250 (65.6%) Upper Yukon Run. In District 2 the estimated age-1.3 and -1.4 combined catch was 3,800 (9.8%) Lower, 2,978 (7.7%) Middle, and 31,839 (82.5%) Upper

Yukon Run. The majority of the commercial chinook salmon catch in Districts 1 and 2 was taken in the first five fishing periods. Upper Yukon Run fish comprised the largest proportion of the District 1 commercial harvest of age-1.3 chinook salmon in periods 1, 2, 4, and 5. Upper run fish comprised the largest proportion of the District 1 commercial harvest of age-1.4 chinook salmon in periods 1 through 4. Similarly, in District 2 Upper Yukon Run fish were the strongest segment of the catch of both ages 1.3 and 1.4 in each of the first five periods. As noted in prior years, run contributions through time in District 1 generally demonstrated increasing proportions of Lower Yukon fish and decreasing proportions of Upper Yukon fish. The Middle Yukon Run was relatively most abundant in period 3.

The proportion of total drainage harvest that was attributed to the Upper Yukon Run was the highest of record at 74.8%. Estimates of the Upper Yukon Run component have ranged from 35.4% in 1984 to the previous high of 67.9% in 1986 with an overall average of 58.2% since 1982. Conversely, the proportion of Lower Yukon Run was the lowest on record (12.0%) while the Middle Yukon Run was third lowest since 1982 at 13.1%.

Commercial chinook salmon harvests in the lower Yukon Area during the years since the implementation of current guideline harvest ranges included a component of age 1.3 and younger salmon which were primarily harvested during restricted mesh-size periods. Those periods were designed to specifically target chum salmon; however, the smaller mesh size also resulted in an increased proportion of age-1.3 and younger chinook salmon in the district commercial harvest. Because of poor summer chum salmon runs and/or weakening market conditions for summer chum salmon, there are now typically fewer restricted mesh size openings in Districts 1 and 2 in recent years. In District 1 in 1995, the first five commercial openings were with unrestricted mesh size. This was followed by six restricted mesh-size openings which resulted in much smaller catches of chinook salmon, especially since the return of age-1.3 fish appeared to be weak. In District 2 in 1995, there were only five openings, all with unrestricted mesh size. Season harvests from predominantly unrestricted mesh-size openings are comprised of proportionally more larger, older chinook salmon, a majority of which tend to be female. Therefore, in years when the number of commercial unrestricted mesh-size openings in the fishing season produce large catches of large fish, managers should continue to take this into account when setting harvest targets such that numbers of female salmon in the escapement and the consequent productivity of the stocks can be sustained.

Attainment of sample size objectives presented in the annual sampling plan is a fair measure of operational success. For all escapements which contribute to the standard three-way LDF classification model, sample sizes were of good to excellent quality; however, the weak return of age-1.3 fish provided marginal sample sizes for analysis of the age class. Acceptable sample quality depends on biological and sampling factors. When the expected rejection rate is exceeded for scale specimens, the quantity of acceptable specimens becomes problematic. The rejection rate due to sampling technique is a key factor in determining sample sizes. In order to optimize sampling effort, sampling technique must also be optimized; therefore, the production of good quality samples will continue to be emphasized in sampling plans.

Sampling upper Yukon tributaries in Canada is of continuing concern. The Upper Yukon Run is sampled in Canada near the U.S.-Canada border at the DFO tagging project sites. Total abundance estimates for the Upper Yukon Run have been obtained from that study, and scales taken from chinook salmon have provided the Upper Yukon Run scale pattern standard when commercial harvest samples and/or escapement samples were inadequate or unavailable, as in 1995. For assignment of harvests to run of origin, the approach of using samples from the DFO mainstem Yukon River test fish wheels to build run-of-origin models assumes that those samples are representative of the run of Canadian-spawned chinook salmon. Test fish wheels may not catch all sizes of chinook salmon and all component stocks in proportion to their abundance. Therefore, appropriately weighted escapement samples, such as those used for the Lower and Middle Yukon Runs, could improve the construction of the Upper Yukon Run stock composition model. Unfortunately, escapement sampling is not conducted for the Upper Yukon Run stock standard. At this time the scales collected from tagging fish wheel catches are accepted as the best available source. The dominant age classes which are modeled for the SPA analysis are adequately represented in catches from the tagging study fish wheels and the sample is assumed to represent age and stock compositions in Canadian harvests, as well as total Upper Yukon Run escapements.

Failure to obtain appropriate sample sizes from DFO to adequately represent the Upper Yukon Run would seriously weaken or invalidate the SPA analysis. Lack of escapement sampling in Canada highlights the importance of DFO test fish wheel scale samples as the sole source for the Upper Yukon Run chinook SPA stock standard and for sex and age composition of salmon in Canada. The lack of escapement sampling in the Canadian portion of the drainage in recent years results in a serious void of basic biological information for modeling the population dynamics and stock composition of Yukon River salmon.

CHUM SALMON STOCK IDENTIFICATION USING GSI, 1995

A preliminary baseline for Yukon River chum salmon (Wilmot et al. 1992) was established in 1992, using allele frequency data from 22 chum salmon populations collected between 1987 and 1990. Genetic stock identification efforts in recent years have focused on augmenting the 1992 baseline by adding new populations to the baseline, resampling populations of special concern, and identifying additional genetic markers. To date, 16 populations have been resampled and 14 new populations have been sampled for genetic data.

Samples were collected in 1995 for genetic analysis from Clear Creek, Henshaw Creek, and the South Fork Koyukuk River (late) in the Koyukuk River drainage; and from Big Creek in the Canadian Yukon River mainstem. Clear Creek was more closely related to lower Koyukuk River populations than to the Upper Koyukuk. Henshaw Creek, South Fork Koyukuk River (late), and Big Creek showed temporal stability of allele frequencies when compared to data from these locations in previous years.

A baseline was constructed from populations with complete data using 22 loci collected from

1987 to 1994. Reporting regions for the new baseline were delineated to reflect genetic lineages and to incorporate management interests, and differed slightly from those used in Wilmot et al. (1992). Reporting regions under study include 1) Lower Yukon Summer Run: Andreafsky River, Chulinak River, Anvik River, Innoko River, Rodo River, Nulato River, Kaltag Creek, Gisasa River, Huslia River, Dakli River, Clear Creek, and Melozitna River; 2) Middle Yukon Summer Run: Jim River, Henshaw Creek, South Fork Koyukuk River (early and late), Tozitna River, Chena River, and Salcha River; 3) Toklat River; 4) Upper Tanana Fall Run: Delta River, Bluff Cabin Slough, and Tanana River mainstem; 5) Chandalar/Sheenjek: Chandalar River and Sheenjek River; 6) Fishing Branch/Canadian Mainstem (Canada): Fishing Branch River (Porcupine River drainage), Tatchun Creek, Minto, and Big Creek (mainstem Yukon River drainage); 7) Teslin River (Canada); and 8) Kluane/Donjek (Canada): Kluane River and Donjek River.

We used a simulation study to determine how accurately the baseline could identify each reporting region in mixtures and compared the results to a simulation study of the Wilmot et al. (1992) baseline. In each simulation, baseline genotypes and mixture genotypes are generated from the baseline using Hardy-Weinberg expectations. Average mixture estimates are derived from 100 simulations for each reporting region, where each region comprises 100% of the mixture. Overall, the new baseline verified the results of Wilmot et al. (1992) and showed slightly improved accuracy and precision in estimating regional components. In particular, the mean allocation for the Lower Yukon Summer Run component increased from 0.84 to 0.95. Separating Teslin River from Kluane River and separating Toklat River from Upper Tanana Fall Run was possible. The accuracy of estimating the Middle Yukon Summer Run, Chandalar/Sheenjek, and Fishing Branch/Canadian Mainstem improved, with smaller standard deviations. The two baselines also performed similarly in estimating summer versus fall components, though the new baseline had increased accuracy and precision.

Because of the difficulty in correctly allocating chum salmon to the Sheenjek River, Fishing Branch River, and the Canadian Mainstem, geneticists from the NBS, ADF&G, and USF&WS began an evaluation of additional molecular genetic markers for fall chum salmon and for their implementation in mixed-stock fisheries analysis. The objectives of this study were to 1) assay levels of genetic variability and inter-population differentiation for U.S. and Canadian stocks of fall chum using four classes of genetic markers, and 2) conduct simulations to ascertain the accuracy and precision of each marker class in assigning country of origin for mixed stock fall chum salmon fisheries. Analyses using allozymes, mitochondrial (mt)DNA, microsatellites, and gene introns focused on eight fall chum salmon stocks (Delta River, Chandalar River, Sheenjek River, Fishing Branch River, Big Creek, Minto Slough, Tatchun Creek, and Kluane River).

The majority of loci assayed (13 of 25 loci across all marker types) showed significant heterogeneity in gene frequency among the eight populations; 10 of 25 loci surveyed showed significant variation between stocks in the United States and Canada. Genetic relationships among populations were generally concordant among all marker types and were in agreement with earlier allozyme work by Wilmot et al. (1992) and with the allozyme results described above.

Simulation studies were conducted to determine the accuracy and precision of estimates of fall chum salmon allocation based on country-of-origin. Artificial mixtures were evaluated at 20% incremental increases in Canadian contributions (i.e., 0% Canadian, 20% Canadian, 40% Canadian, etc.). Simulations were conducted assuming that total U.S. and Canadian proportions of the simulated mixture comprised equal contributions of stocks from the respective countries. Bias in the estimates occurred at the extreme in the simulations, i.e. 0% Canadian or 100% Canadian, partially due to the properties of the algorithm itself to overestimate stocks with low contributions. Accuracy graphs revealed that Canadian stocks were consistently over represented up to contributions of less than approximately 50% and under represented at higher contributions. This bias was consistent regardless of the marker type used in the analysis. Greater precision was realized when using all four classes of genetic markers as compared to simulations conducted using each marker type separately. These results were consistent in terms of accuracy and precision with those of earlier studies using similar reporting groups.

The allozyme database for chum salmon from the Yukon River provides extensive geographic and temporal coverage. The stability of allele frequencies within stock groupings and across years has been verified by independent sampling and analysis by two laboratories representing separate agencies. Further, the results from the DNA study were concordant with allozyme results revealing similar patterns and levels of divergence. The comprehensive nature and observed stability of the database provide a strong foundation for estimating the components of complex mixtures from fishery or other stock aggregate samples using a maximum likelihood model.

The ability of the model to identify components of the mixture with a particular level of accuracy and precision is a function of the amount of genetic divergence among the components, and of desired groupings of baseline stocks into reporting groups (i.e. country of origin versus other biologically meaningful aggregations). More divergent components can be estimated with a high level of accuracy and precision. Conversely, separating less divergent components, such as fall stocks within the Porcupine River drainage, is more difficult, and estimates will have a lower level of accuracy and precision.

During the next year, we plan to continue to evaluate the model and develop potential applications with an acceptable level of accuracy and precision necessary for fisheries management and to complete a report of allozyme studies to date.

SALMON CATCH AND ESCAPEMENT AGE-SEX-LENGTH SAMPLING, 1995

Samples for age, sex, and length (ASL) composition of salmon were obtained in conjunction with sampling of salmon for stock identification purposes. Additionally, salmon were sampled at selected locations in the Alaska portion of the Yukon River drainage from both catches and escapements for ASL data. This information will be published in an annual Yukon River salmon catch and escapement report for the 1995 season. Some of the ASL data presented here was collected from projects that were not funded with this U.S. Department of Commerce grant, but the information is presented here in order to provide a more complete overview of the ASL information.

Sampling objectives for each species were established which were designed to provide acceptable levels of precision and accuracy ($\delta = 0.05$, $\alpha = 0.01$) of composition analyses. The sample size required for a three age category analysis of chum salmon, assuming a ten percent rate of unusable samples, was 160 fish. A four age category analysis for chinook salmon, assuming a 10 percent or smaller rate of unusable samples, required samples from 180 fish. In order to attain a 10 percent or smaller rate of unusable samples for chinook, three scales, rather than one, were taken from each fish. The sample size required for a two age category analysis of coho salmon, assuming a 10 percent or smaller rate of unusable samples, required samples from 120 fish.

Commercial and subsistence catch samples were obtained in district catches from gillnets and fish wheels. Test fishing samples were also obtained. Useable samples in 1995 were taken from a total of 6,340 chinook, 10,911 summer chum, 3,374 fall chum, and 1,516 coho salmon. Commercial catch samples totaled 3,918 chinook, 5,399 summer chum, 1,731 fall chum, and 664 coho salmon. Test fishing efforts resulted in samples from 1,318 chinook, 2,204 summer chum, 1,643 fall chum, and 496 coho salmon. Escapement sampling was conducted on the Andreafsky, Anvik, Kaltag, Nulato, Gisasa, Chena, Salcha, Clear Creek, Toklat, Delta, and Sheenjek Rivers in Alaska. Escapement samples totaled 1,097 chinook, 3,308 summer chum, and 356 coho salmon. DFO sampled over 785 chinook salmon from the White Rock and Sheep Rock tagging project fish wheels just upriver from the U.S.-Canada border.

Ages 1.3 and 1.4 are the two principal age classes of chinook salmon taken in commercial gear. Samples obtained from chinook salmon taken in commercial gillnets were composed of 50% to 80% age 1.4 in most District 1 and 2 catches. It should be noted that large-mesh gillnets tend to select for larger, older chinook. Chinook salmon escapement samples from lower Yukon River tributaries were composed of significant proportions of age-1.4 fish; e.g., 31% for the Andreafsky, 63% for the Anvik, and 52% for the Gisasa Rivers. Samples from the middle Yukon River tributaries were similar to District 1 and 2 catches, e.g., the Chena and Salcha River samples were 71% and 63% age 1.4, respectively. Chinook salmon samples from the Canadian tagging project fish wheels were composed of 46% age 1.4. It should be noted that fish wheels tend to select for smaller chinook, more of which are typically younger males.

Yukon River chum salmon taken in commercial and subsistence gear are composed principally of age-0.3 and -0.4 fish. Samples taken from commercial catches of summer chum salmon ranged from 67% age 0.4 in Districts 1 and 2 to between 20% and 50% in District 4. Age-0.4 composed 52% for the Andreafsky River, 34% for the Anvik River, 44% for the Nulato River, 25% for the Gisasa River, and 34% for Clear Creek summer chum salmon escapements.

Fall chum salmon were sampled only from commercial and test fishing gear in 1995. Samples were 32% to 43% age 0.4 in District 1 and 2 commercial catches. District 1 test fishing samples were composed of 23% to 37% age 0.4.

Coho salmon were sampled from the District 1 commercial catch, District 1 test fishing catch, and Andreafsky River escapement. District 1 commercial and test fishing catches were composed of 53% to 68% age 2.1, while the Andreafsky River escapement was 64% age 2.1. Most of the remainder of the coho salmon samples were age 1.1, with a very small number of age 3.1.

SUBSISTENCE HARVEST ESTIMATION, 1995

Successful management of the Yukon River fishery resources depends upon accurate estimates of subsistence harvests. Estimates of subsistence salmon harvests presented in this report may not be strictly comparable to some historical estimates for a number of reasons: 1) commercially harvested fish retained for subsistence purposes have been included in the estimates of subsistence harvests for some years and not included for other years; 2) village survey dates early in the fall in some years would result in harvest estimates less than the actual harvest levels due to the amount of harvest which occurred after the interviews were conducted; and 3) sampling design and questions have changed periodically throughout the history of the program. Although comparing historical harvest estimates of subsistence salmon to more recent estimates is difficult due to the varied methodologies, it is felt that the estimates do reflect harvest trends. A more comprehensive source of information on the background of this project, the methods used, the results and discussion for 1995, and literature references can be found in Borba and Hamner (1996).

The number of salmon harvested in the subsistence and personal use fisheries in the Yukon River drainage in Alaska in 1995 was estimated from survey and fishing permit programs. Additionally, the number of fish given to the public for subsistence use from various test fishing projects throughout the drainage were also documented.

The majority of villages within the Yukon River drainage in Alaska have no regulatory requirements to report their subsistence salmon harvest. To estimate the salmon harvest from these villages, the ADF&G has implemented a voluntary survey program. The 1995 survey program utilized subsistence catch calendars, postseason household interviews, and postseason household telephone interviews and postcards. Stratified random sampling techniques were used to select households to be interviewed in the Yukon River drainage in Alaska during the 1995 postseason survey. Based on information collected from 1,011 households that were contacted by surveyors in 1995, an estimated total of 41,304 chinook (*Oncorhynchus tshawytscha*), 115,025 summer and 53,344 fall chum (*O. keta*), and 8,042 coho salmon (*O. kisutch*) were harvested by subsistence fishermen in the survey portion of the Yukon River drainage in Alaska.

A portion of the Yukon River management area requires subsistence or personal use fishermen to obtain an annual household permit prior to fishing. In these areas, fishermen are required to document their harvest on the household permit. Permits are to be returned to the ADF&G with household harvest information. A total of 519 subsistence and personal use permits were issued in 1995. A total of 508 subsistence and personal use permits had been returned to the ADF&G as of 29 February 1996. A total of 298 permit holders indicated that they fished in 1995. The reported permit harvest was 7,830 chinook, 13,474 summer chum, 71,068 fall chum, and 19,245 coho salmon. This does not include Stevens Village household permit harvest information. In Stevens Village the permit information was used to supplement the postseason survey.

From the test fishery projects throughout the Alaska portion of the Yukon River drainage, a total of 1,885 chinook, 8,364 summer chum, 7,311 fall chum, and 1,507 coho salmon were given away to households for subsistence use. Residents of the villages of Emmonak, Kotlik, Pilot Station, Mountain Village, Galena, Tanana, Fort Yukon, Manley, and Nenana were the primary recipients of the fish given away from the test fisheries.

Combining survey, permit, and test fishery information, an estimated total of 51,019 chinook, 136,863 summer chum, 131,723 fall chum, and 28,794 coho salmon were harvested for use in the communities in the Alaska portion of the Yukon River drainage in 1995 from subsistence, personal use, and test fisheries. There were an estimated 1,428 subsistence and personal use fishing households in the Alaska portion of the Yukon River drainage in 1995.

The 1995 subsistence harvest of chinook and summer chum salmon was average when compared to the recent five year (1990-1994) average. However, the summer chum salmon harvest was well below the 1985-1989 five year average. This is primarily due to the artifact that the surveys prior to 1988 included commercial-related harvests. Summer chum salmon roe sold in Districts 4, 5, and 6 produced female carcasses which were retained from the commercial harvest and were available for subsistence use.

Fall chum salmon subsistence harvest was average in 1995 when compared to the recent five year (1990-1994) average. However, the 1995 harvest was well below the 1985-1989 five year average. The more recent period includes the low harvest in 1992 which resulted from an early freeze-up, and the 1993 and 1994 harvests, in which regulations restricting the fall season fishery resulted in reduced fishing opportunities. The 1995 coho salmon harvest was substantially below the recent five year (1990-1994) average. The 1995 Yukon River coho salmon return appeared to be weak. In 1993, coho salmon harvests were affected by the same fishing restrictions that affected fall chum salmon harvests, but a similar reduction was not apparent in 1994. A large coho salmon return was observed in 1994, and this, along with the lifting of the subsistence fishing restrictions prior to the end of the later run timing of the coho salmon, probably contributed to an average harvest in 1994.

SPAWNING ESCAPEMENT SURVEYS, 1995

An essential requirement for management of the Yukon River salmon fisheries is the documentation of annual salmon spawning escapements. Such documentation provides for determination of appropriate escapement levels or goals for selected spawning areas or management units; evaluation of escapement trends; evaluation of the effectiveness of the management program, which in turn forms the basis for proposing regulatory changes and management strategies; and evaluation of stock status for use in projecting subsequent returns.

The Yukon River drainage is too extensive for comprehensive escapement coverage of all individual salmon spawning streams during any given season. Consequently, low-level aerial surveys from single-engine fixed-wing aircraft or helicopters form an integral component of the escapement assessment program. Nevertheless, comprehensive assessment projects employing such techniques as intensified ground surveys, mark-and-recovery methods, counting towers, weirs, and hydroacoustics are also conducted. Regardless of the method utilized, the overall objective of escapement assessment in the Yukon River drainage is to estimate abundance (or often indices of relative abundance), timing, and distribution of spawning salmon populations.

Perhaps the greatest advantage of aerial surveys is the cost-effectiveness of obtaining escapement information throughout an extremely vast area, most of which is remote. Another advantage to aerial surveillance is that real or potential habitat-related problems arising from natural or man-induced causes can be readily identified. Among the disadvantages are that results may be highly variable if non-standardized procedures are used. Variability in aerial survey accuracy is dependent upon a number of factors such as weather and water conditions (turbidity), timing of surveys with respect to peak spawning, aircraft type, survey altitude, experience of both pilot and observer, and species of salmon being estimated. It is generally recognized that aerial estimates are lower than actual stream abundance due to these factors. Further, peak spawning abundance measured by aerial survey methods is significantly lower than total season abundance due to the die-off of early spawners and arrival of later fish. Also, aerial estimates in a given stream may demonstrate a wide range in the proportion of fish being estimated from year to year. Peak aerial counts, however, can serve either as indices of relative abundance for examination of annual trends in escapement or as a basis from which to estimate total escapement using base year data and established expansion factors.

Aerial escapement estimates are obtained from as many spawning streams as possible within the confines of fiscal, personnel, and weather constraints. However, selected spawning streams have been identified and receive highest priority. Index areas have been designated due to their importance as spawning areas and/or by their geographic location with respect to other unsurveyeable salmon spawning streams in the general area. A more comprehensive source of information is presented by L.H. Barton (in Bergstrom et al, In Prep) on the background of the escapement survey project, the methods used, the results and discussion for 1995, and literature references. Some of the spawning escapement information presented here was collected from field projects that were not funded with this U.S. Department of Commerce grant, but the information is presented here along with the escapement survey data funded by the grant in order to provide a more complete overview of the escapement information.

Biological escapement goals (BEG's) have been established for several Yukon River salmon spawning streams or areas. These goals represent the approximate minimum number of spawners considered necessary to maintain the historical yield from the stocks and are based upon historical performance, i.e., they are predicated upon some measure of historic averages. Establishment of escapement goals for specific spawning stocks based upon a rigorous analysis of maximum sustained yield (MSY) is not feasible at this time due to the nature of the Yukon River mixed stock fisheries, lack of stock identification data, and the inability to reconstruct inriver stock-specific returns.

Chinook Salmon

Chinook salmon escapement goals established by ADF&G for eight Alaskan streams, or index areas, are: East (>1,500) and West Fork (>1,400) Andreafsky, Anvik (>1,300 entire drainage or >500 Yellow River to McDonald Creek), North (>800) and South Fork (>500) Nulato, Gisasa (>600), Chena (>1,700), and Salcha (>2,500) Rivers. These escapement goals are based upon aerial survey index counts which do not represent total escapement.

The overall Yukon River chinook salmon run was considered above average in 1995 with chinook salmon escapement goals achieved throughout most of the Yukon River drainage. The sonar passage estimate of 242,000 chinook salmon at Pilot Station was the largest on record since the project was initiated in 1986. However, passage estimates for 1995 are not comparable to those years prior to 1993 because of the change to lower frequency equipment in 1993. In addition, aiming criteria were changed in 1995 to maximize the ability to detect passing fish. As a consequence, all detected fish were classified as upstream oriented.

Chinook salmon escapements in the lower Yukon River drainage were characterized by counts obtained for the Andreafsky and Anvik rivers. Chinook salmon escapement to the Andreafsky River was at or near the escapement goal level as evidenced by aerial survey results on 26 July. While the aerial estimate for the West Fork (1,108) was approximately 21% below the minimum goal of 1,400 chinook salmon, an aerial estimate of 1,635 chinook salmon in the East Fork indicated the minimum escapement goal of 1,500 fish was reached for that stream. The 1995 East Fork Andreafsky weir count was 5,841 chinook salmon, which was approximately 75% of the 1994 chinook salmon weir count. The chinook salmon escapement goal for the Anvik River was achieved in 1995 based upon an aerial count of 1,147 fish observed on 21 July in the mainstem index area between Yellow River and McDonald Creek. This was more than double the aerial survey escapement goal of 500 chinook salmon.

Chinook salmon escapements in the middle Yukon River drainage were characterized by escapements observed in the Nulato River, tributaries of the Koyukuk River, and tributaries of the Tanana River. The aerial survey estimate of chinook salmon in the Nulato River on 21 July was 1,649 fish, of which 681 were observed in the South Fork Nulato River and 968 were counted in the North Fork, including that section of the mainstem river below the confluence of the South Fork. The tower count for the Nulato River was only 1,412 chinook salmon. However, it was observed that chinook salmon tended to migrate in the deeper, mid-river areas at the counting site, an area of the river in which visibility is somewhat limited. Therefore, it is considered that the chinook salmon passage estimate based upon tower observations is a minimal estimate. For the Gisasa River (Koyukuk River drainage) an aerial survey count of only 410 chinook salmon was made on 21 July under fair survey conditions. This count was approximately 32% below the minimum escapement goal of 600 chinook salmon. However, the second-year weir project on this river provided a passage estimate of 4,023 chinook salmon for the period 21

June through 3 August, which was up from the 1994 weir count. Although no chinook salmon escapement goals have been established for other streams in the Koyukuk River, results of aerial surveys made on a few other tributaries in 1995 indicated escapements were near average in magnitude. Counts were 271 chinook salmon in Henshaw Creek, and 358 collectively in the South Fork Koyukuk and Jim Rivers.

In the Tanana River drainage, aerial surveys of the Chena and Salcha Rivers indicated that chinook salmon escapement goals were achieved in both rivers in 1995. Aerial counts of the Chena (3,039) and Salcha River (3,734) index areas were 79% and 49% above the respective minimum escapement goals. Assessment of chinook salmon escapement to both the Chena and Salcha Rivers has improved since 1993 by operation of counting towers on both rivers. Although high and turbid water limited tower operations on the Chena River in 1995, a post-season population estimate of 9,680 chinook salmon was made, based upon mark-recapture techniques. The 1995 tower estimate of escapement in the Salcha River was 13,537 chinook salmon. Although no chinook salmon escapement goals have been established for other Tanana River streams, an aerial count of 621 chinook salmon in the Goodpaster River and a boat count of 444 in the Chatanika River, suggested good escapements were realized in other tributaries.

The preliminary DFO mark-and-recovery population estimate of chinook salmon entering the Canadian portion of the mainstem Yukon River in 1995 was 52,088 (95% C.I. = 47,306 to 57,353). Subtracting the estimated Canadian commercial and non-commercial harvest (excluding Old Crow) from this population estimate results in a total spawning escapement estimate to Yukon Territory (excluding the Porcupine River drainage) of approximately 32,168 chinook salmon. This was well above the stabilization objective of 18,000, and essentially equal to the low end of the long-term escapement goal range of 33,000 to 43,000 chinook salmon. Yukon Territory chinook salmon spawning streams surveyed by DFO in 1995 included a ground survey of Tatchun Creek, and aerial surveys of Tincup Creek (Kluane River drainage), the Little Salmon, Ross (Pelly River drainage), Big Salmon, Nisutlin and Wolf Rivers (Teslin River drainage). Results from these surveys revealed escapements ranged from between approximately 6% to 44% above the 1989-1994 average escapements for these streams.

Summer Chum Salmon

Summer chum salmon escapement goals established by ADF&G for seven spawning streams are: East (>109,000) and West Fork (>116,000) Andreafsky, Anvik (>500,000), North Fork Nulato (>53,000), Clear Creek (>8,000) and Caribou Creek (>9,000) in the Hogatza River drainage, and the Salcha River (3,500) in the Tanana River drainage. With the exception of the Anvik River goal, which is based upon sonar counts, all other goals are based upon aerial survey observations during periods of peak spawning.

Although a below average to average summer chum run was anticipated in 1995, the run materialized well above average. Total run size was approximately 4.0 million salmon based on the passage estimate at Pilot Station (3,700,000) and harvest and escapement estimates below the sonar site. Escapement goals appear to have been met throughout the Yukon River drainage for the second consecutive year.

Although no aerial survey estimates of chum salmon were made for the East and West Fork Andreafsky Rivers in 1995, a total of 172,148 summer chum salmon were counted through the weir on the East Fork. It is difficult to determine from the weir count, alone, if the summer chum escapement goals were achieved in 1995 since there are few data which describe the relationship between the aerial survey counts and the weir counts. By comparison however, the Anvik River escapement was estimated to be approximately 1,339,000 summer chum salmon based on sonar, more than double the escapement goal, and representing approximately 36% of the total passage estimate of summer chum salmon at Pilot Station.

Summer chum salmon escapements upstream of Anvik were judged good based upon observations made in Kaltag Creek and in the Nulato, Gisasa, Hogatza and Dakli Rivers. The estimated summer chum salmon escapement into Kaltag Creek based upon tower counts was 75,240 fish for the period 21 June through 25 July, exceeding the 1994 estimated escapement by more than 55% for the same period of time. No escapement goal exists for this stream. The estimated summer chum salmon escapement into the Nulato River (both forks combined) was 236,890, based upon expanded tower counts. An aerial survey of the North Fork Nulato River, including the mainstem below the confluence of the two forks, resulted in an aerial survey index count of only 29,949 summer chum salmon, an unusually low aerial survey proportion relative to a population assessment, considering that the survey conditions were rated "fair".

In the lower Koyukuk River drainage, a total of 136,886 summer chum salmon were counted past the Gisasa River weir. The estimated escapement into Clear Creek (Hogatza River drainage) from tower observations, 116,735 chum salmon, indicates that the minimum escapement goal of 9,000 chum salmon, based upon aerial surveys, was achieved. In the upper Koyukuk River, an aerial survey flown of Dakli River and Wheeler Creek resulted in an estimate of approximately 42,000 summer chum salmon, the highest aerial estimate on record for that area.

In the Tanana River drainage, frequent interruptions from high and turbid water conditions precluded an accurate estimate of the total summer chum salmon escapement by tower count in the Chena River. Only 3,473 summer chum salmon were estimated passing the tower site for the period 10-30 July. Unfortunately, survey conditions during the period of spawning was not conducive for obtaining an aerial index of summer chum salmon abundance in the Chena River in 1995. By comparison, although a single aerial survey of the Salcha River, flown under poor survey conditions, resulted in a count of less than 1,000 summer chum salmon, the escapement goal was likely achieved based upon a counting tower passage estimate of 31,329 fish for the period 5 July through 14 August.

Fall Chum Salmon

The most complete database on Yukon River fall chum salmon escapements dates back to the early 1970's and exists for four streams: the Delta, Toklat, Sheenjek, and Fishing Branch Rivers. Escapement goals for these streams are >11,000, >33,000, >64,000, and 50,000-120,000 fall chum salmon, respectively. These goals are of total abundance. In addition to estimates of total escapement to these four streams, annual estimates of border passage and subsequent spawning escapement are available since 1982 for the fall chum stock in the mainstem Yukon River in Canada. The escapement goal for this stock is >80,000 fall chum salmon spawners.

Although the preseason projected return of fall chum salmon to the Yukon River in 1995 was 803,000 fish, total run size was estimated to approximate 1.4 million fish, with all escapement goals being achieved for the second consecutive year.

Evaluation of escapement to the Porcupine River drainage was assessed by observations made in the Sheenjek and Fishing Branch Rivers. The sonar-estimated escapement in the Sheenjek River in 1995 was approximately 235,000 fish for the 47-day period of 10 August through 25 September, the largest on record and more than 3.5 times the escapement goal minimum of 64,000. The minimum escapement goal for the Fishing Branch River was achieved for the second consecutive year and third time since 1981. Approximately 52,000 chum salmon were enumerated through the weir, but this count excludes fish which passed the weir site during a 9-day, high water period in early September when the weir was inoperable.

Tanana River fall chum salmon escapement was primarily evaluated by observations made in the Toklat and Delta Rivers. Population estimates of fall chum salmon escapement to the Toklat River have in the past been made from expanded aerial or ground survey counts of the spawning area and using stream residence data collected from the Delta River. Beginning in 1994, a new sonar project is being conducted on the Toklat River. The Toklat River expanded ground survey count for 1995 of 54,500 fall chum salmon is a minimum estimate of the total due to late timing of surveys as a result of high and turbid water conditions which delayed observations during the early part of October. Even so, it is 65% above the minimum escapement goal of 33,000 fish and marks the second consecutive year the goal has been achieved. Estimated total abundance of fall chum spawners in the Delta River was 20,587, approximately 87% above the minimum escapement goal of 11,000 chum salmon. While no escapement goals exist for other fall chum salmon spawning areas in the upper Tanana River, an escapement survey during peak spawning provided an index count of 19,460 fall chum salmon in Bluff Cabin Slough (Big Delta region), the largest estimate on record for that spawning area and more than triple the most recent ten-year average of approximately 6,200 fish. Data from the first-year Tanana River mark-recapture program (above the Kantishna River confluence) are still being finalized, but preliminary results indicate that total abundance of fall chum salmon in the upper Tanana River (upstream of the Kantishna River) exceeded 250,000 fish.

The population estimate of fall chum salmon entering the Canadian portion of the upper Yukon River made by DFO in 1995 was 198,203 fish. Subtracting estimated Canadian commercial and non-commercial harvest (excluding Old Crow) from this population estimate results in a total escapement estimate to Yukon Territory (excluding the Porcupine River) of 158,240 spawners. An escapement level of this magnitude is the highest on record since inception of the DFO mark and recapture program in 1982. This escapement estimate is nearly double the targeted rebuilding spawning escapement level of 80,000 fall chum salmon for 1995.

In summary, preliminary estimates of fall chum salmon inriver commercial and subsistence harvest, when added to estimated total spawning escapement based upon a doubling of a standardized escapement index, resulted in a total 1995 run size estimate of approximately 1,200,000 fish. This measure of run size was the third largest on record and 50% above the preseason projected return of 803,000 fall chum salmon. Further, it compares to an estimated fall chum salmon run size of approximately 1,400,000 when summing the Pilot Station sonar passage estimate ($\approx$1,200,000) to the estimated harvest below Pilot Station.

Coho Salmon

The sonar project at Pilot Station estimated a total passage of 154,000 coho salmon through 3 September in 1995. However, coho salmon passage estimates at Pilot Station are not complete run assessments due to termination of the project each year prior to conclusion of the coho salmon migration.

Coho salmon spawning escapement assessment is very limited in the Yukon River drainage due to funding limitations and often marginal survey conditions which prevail during the periods of peak spawning. While most escapement information on coho salmon is from the Tanana River drainage, cooperative efforts of USFWS and BSFA in 1995 allowed the East Fork Andreafsky summer season weir operation to be extended into September. This provided the first comprehensive escapement information concerning timing and abundance of coho salmon to a tributary in the lower Yukon River. A total of 10,901 coho salmon passed the weir during the period 3 August through 16 September.

Presently, the only escapement goal which has been established for coho salmon is for the Delta Clearwater River in the Tanana River drainage. The minimum goal is 9,000 coho salmon based upon a boat survey during peak spawning. In 1995, the Sport Fisheries Division conducted a boat survey of the Delta Clearwater River index area on 23-24 October and estimated 20,100 coho salmon, more than double the goal. An additional 6,283 coho salmon were observed in tributaries of the Delta Clearwater River by helicopter on 2 November.

Coho salmon spawning escapements to other portions of the Tanana River drainage appeared to be above average in 1995. For example, 3,625 coho salmon were observed in the outlet to Clearwater Lake, the highest on record and 42% greater than the most recent five-year average (1990-1994) of 2,540 coho salmon. Coho salmon aerial survey counts in the Nenana River drainage were 4,169 in Lost Slough (highest on record), 2,972 in Seventeen Mile Slough (second highest on record), and 2,218 in the mainstem Nenana River upstream of the Teklanika River (highest on record). A total of 410 coho salmon were counted by ground survey in Geiger Creek in the Toklat River drainage; nearly double the most recent 1990-1994, 5-year average of 252 fish. Although only 192 coho salmon actually passed through Barton Creek weir (Toklat River drainage) during the latter half of September, approximately 1,000 more were observed immediately downstream of the weir when it was removed on 2 October.

LOWER YUKON RIVER SONAR AT PILOT STATION, 1995

Salmon are harvested for commercial and subsistence purposes over more than 1,600 km of the Yukon River in Alaska and Canada. These salmon fisheries are critical to the people and economy of dozens of communities along the river, in many instances providing the largest single source of food and/or income to local residents. Management of the fisheries is complex and difficult for many reasons, including the broad geographic distribution of the many individual salmon spawning stocks that support these fisheries.

Sonar estimates of fish passage from the lower Yukon River sonar project at Pilot Station are available in a more timely and comprehensive manner than can be obtained from other sources. The project uses fish passage estimates from shore-based single-beam sonar, and species composition estimates from drift gillnet test fishing with a suite of mesh size gillnets, to estimate daily upstream passage of fish by species. The sonar is deployed at river km 197 near Pilot Station, which is far enough upriver to avoid the wide multiple channels of the Yukon River delta, but far enough downriver to provide timely information for inseason management of the Yukon River fisheries.

This project has been estimating daily upstream fish passage annually since 1986, except for 1992, when the project was operated for experimental purposes only. Project sonar equipment was reconfigured prior to the 1993 season to operate at a frequency of 120 kHz as compared to the former 420 kHz, which has significantly extended the effective range of the sonar and avoids attenuation encountered at the 420 kHz operating frequency. Project objectives in 1995 were to provide daily and cumulative passage estimates for chinook, chum, and coho salmon during the project operational period, and to estimate the precision of those estimates. Passage estimates for 1995 are not comparable to those years prior to 1993 because of the change to lower frequency equipment in 1993. In addition, aiming criteria were changed in 1995 to maximize the ability to detect passing fish. As a consequence, all detected fish were classified as upstream oriented. A more comprehensive source of information on the background of this project, the methods used, the results and discussion for 1995, and literature references can be found in Maxwell, Huttunen, and Skvorc (In Prep).

The salmon passage estimates at Pilot Station for 1995 were based upon a sampling design in which sonar equipment was typically operated for 9.0 hours each day. The sonar equipment was operated 24 hours per day on four occasions in 1995 to collect information with which to evaluate the sampling design.

The sonar project was operational from 7 June through 3 September in 1995. Passage estimates were available to fishery managers in the Emmonak field office by 8:00 AM daily. An estimated 5,949,964 $\pm$ 57,440 (s.e.) fish passed upstream through the sonar beams in 1995, 19.2% along the right bank and 80.8% along the left bank. Included were an estimated 204,822 ± 28,426 large chinook salmon (>700 mm long), 36,938 ± 4,976 small chinook salmon (<700 mm long), 3,700,189 ± 58,761 summer chum salmon, 1,247,541 ± 28,859 fall chum salmon, and 154,464 ± 14,897 coho salmon. It is not the intent of this project to document the complete coho salmon run. Pink salmon were grouped with the non-salmon fish species because of their small numbers during the 1995 season and the fact that they are not a target species for fishery management.

Bottom profiles conducted along the left and right banks at the transducer locations revealed smoothly sloping areas suitable for sonar deployment. No changes were noted in the steeply sloping, rocky bottom along the right bank during the field season. The sandy, gently sloping left-bank bottom changed from a smooth slope during the summer season to an undulating pattern of low sand dunes later in the season, running perpendicular to the shoreline. Due to the perpendicular aspect of the dunes, fish detection was not compromised. Bank-to-bank transects revealed a total of only 32 fish tracings outside the sampling area of the shore-based units over the course of 84 transects. No offshore passage estimates were made using these transect data.

The right (north) bank sonar site has a stable, rocky bottom that drops off steeply to the thalweg. The right bank transducer was initially deployed approximately 3.5 meters from shore, then later moved out to 10 meters from the original shoreline as the water level dropped. The right bank transducer was aimed along the bottom, sampling a single stratum to a range of 90-100 m. The left bank river bottom drops off gradually, with a slightly steeper slope nearshore than offshore. This bottom profile required the deployment of two transducers to ensonify the entire fish migration corridor. One transducer was deployed within 10 m of shore to sample both a nearshore stratum (0-40 m) with a low aim and a midshore stratum (40-250 m) with a higher aim. Changing water levels required the occasional relocation of this transducer during the field season. A second transducer was deployed near the break in the bottom slope 60-70 m out from the first transducer, creating a third stratum and extending the range on the left bank to 315 m. This transducer was pulled and repositioned every other day to avoid burying it in the silty river bottom. After 1 August, the nearshore transducer was used for sampling all three left bank strata. The range was extended to 300 m by increasing the gain. Left and right bank transducers were nearly directly across the river from each other, at a point where the river was approximately 1,030 m wide. However, river width is extremely variable, depending on water level. River width was measured with a laser range finder on 30 June.

Twenty-four hour counts compared favorably with daily passage estimates. The small differences between the two measures were most likely caused by a combination of sampling error and environmental variables.

A total of 6,669 fish were captured during 2,119 gillnet drifts totalling 12,405 minutes, for the purpose of estimating species composition of acoustic fish counts. The catch included 5,167 chum salmon, 330 chinook salmon, 435 coho salmon, 43 pink salmon, 367 whitefish, 231 cisco, and 96 other fish.

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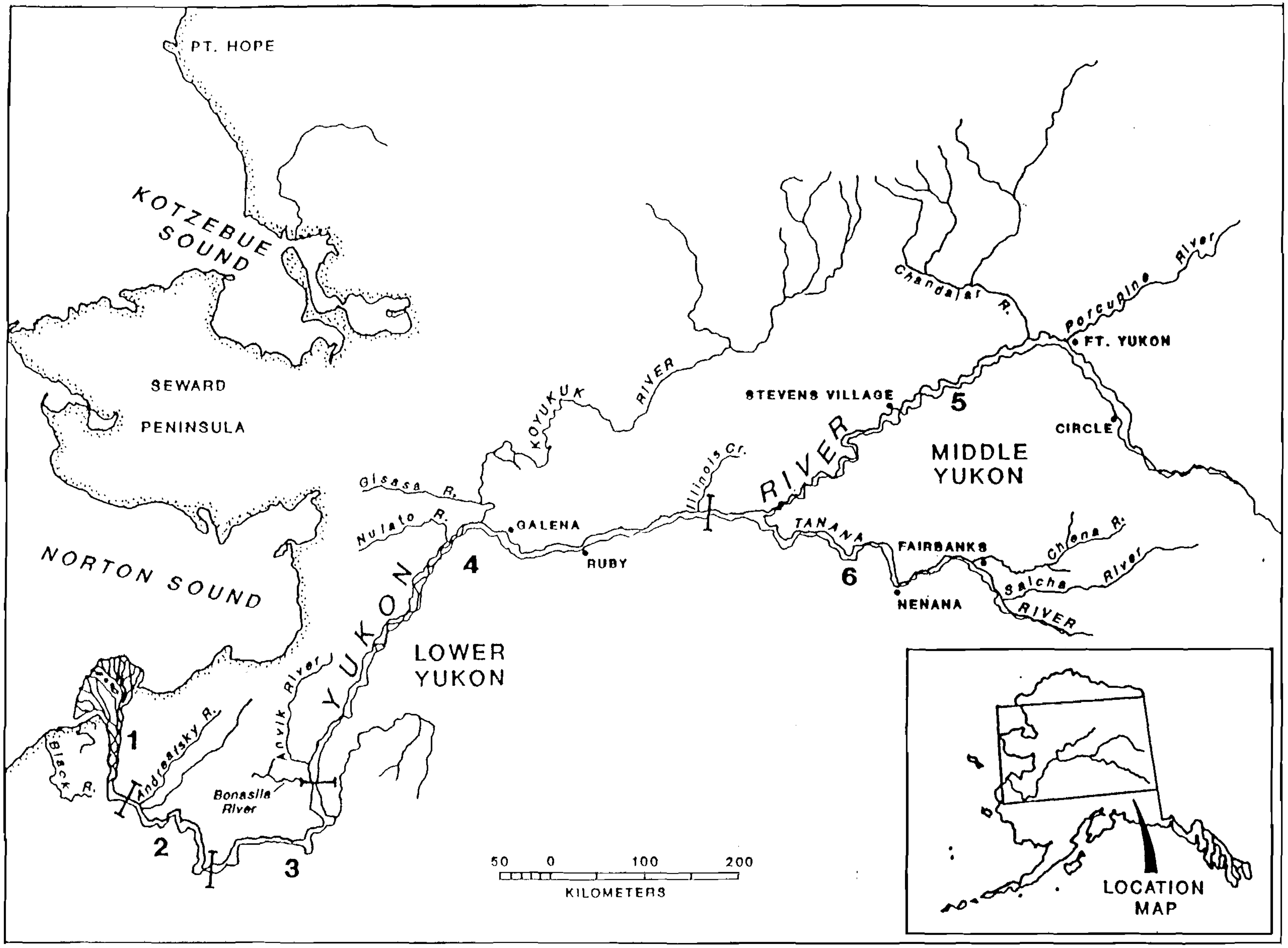

Figure 1. Alaska portion of the Yukon River drainage, showing fishing district boundaries.

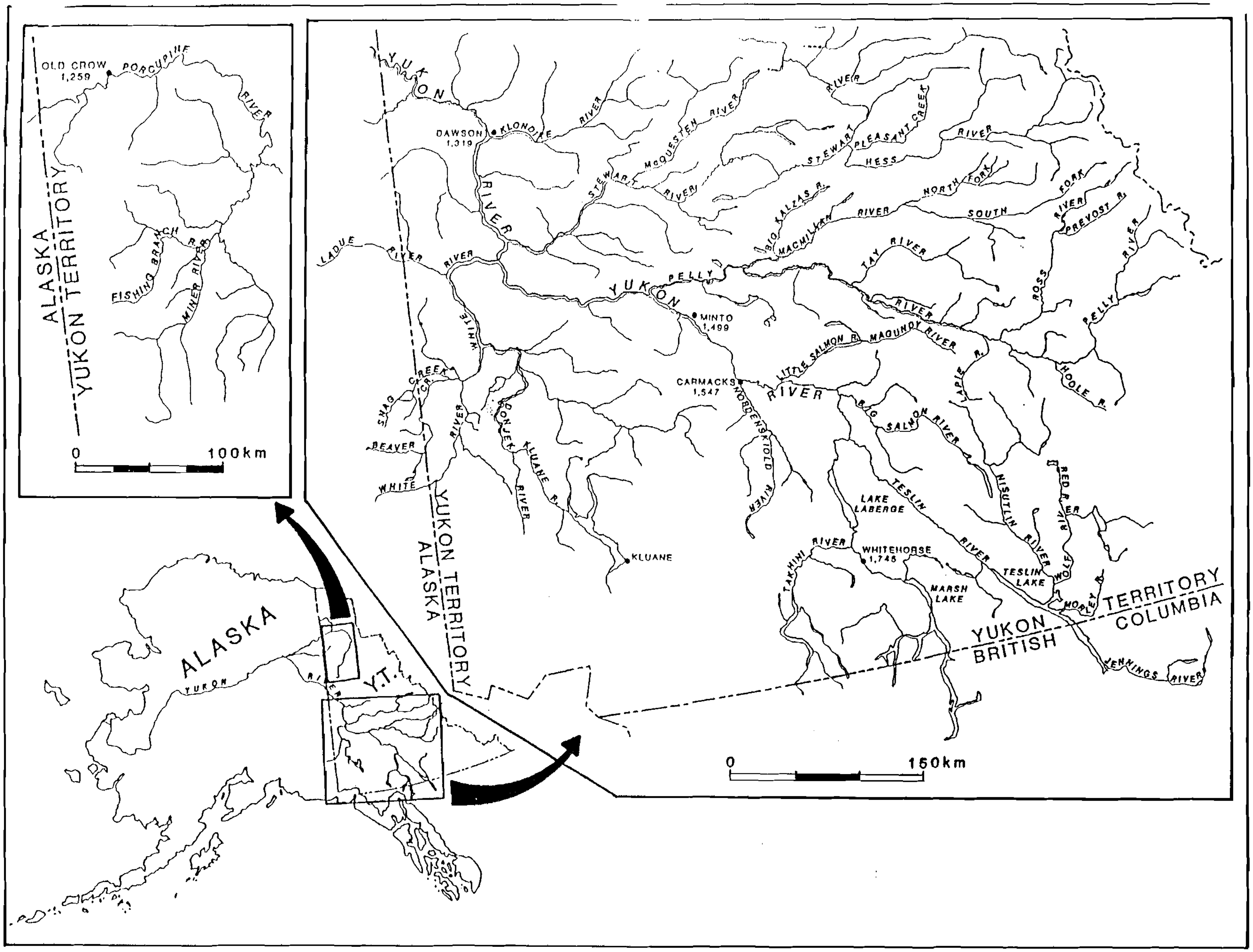

Figure 2. Canadian portion of the Yukon River drainage.