3A95-21

Completion Report for U.S. Department of Commerce

Federal FY 1994 Grant to ADF&G for Yukon River Salmon

U.S./Canada Negotiation Studies

Prepared By

Alaska Department of Fish and Game

Regional Information Report[1] No. 3A95-21

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August 1995

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PROJECT SPONSORSHIP

This work was partially funded by Yukon River Salmon U.S./Canada Negotiation Studies grant Award No. NA46FP0343 from the U.S. Department of Commerce.

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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 1994 funds were passed through to ADF&G to provide some support for negotiation meeting costs and field data collection for the period 1 July 1994 through 30 June 1995 through grant Award No. NA46FP0343.

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 seven field data collection projects or activities funded with this grant for the period 1 July 1994 through 30 June 1995, which was essentially the 1994 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, 1994
2) Chum Salmon Stock Identification Using GSI, 1994
3) Salmon Catch and Escapement Age-Sex-Length Sampling, 1994
4) Subsistence Harvest Surveys, 1994

5) Spawning Escapement Surveys, 1994
6) Lower Yukon River Sonar at Pilot Station, 1994
7) Yukon River Border Sonar at Eagle, 1994

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, 1994

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, respectively. 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 patterns analysis (SPA) methodology. A more comprehensive source of information on the background of this project, the methods used, the results and discussion for 1994, 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 1994 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 Districts 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. Additionally, samples were collected from salmon captured in fish wheels by personnel from the Canadian Department of Fisheries and Oceans (DFO) in Yukon Territory, Canada. 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 Andreafsky River at a weir project operated by U. S. Fish and Wildlife Service. Canadian tributaries were not sampled in 1994. 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 function (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 1994 Yukon River chinook salmon catches.

Yukon River chinook salmon escapement age compositions in 1994 exhibited variations of trends and characteristics seen in other years, but it appears that some shifts in usual age compositions have taken place since 1991. As normally expected, age-1.4 fish were relatively less abundant than age 1.3 in Lower Yukon River escapements. However, age 1.4 was atypically much more abundant than age 1.3 in Middle Yukon River escapements, and much less abundant than age 1.3 in upper river escapements. Generally, the expected trend for the observed proportion of older, e.g., age 6 and older, fish to increase progressively upriver was not upheld in 1994. The expected trend was last noted in 1991, though less pronounced than in prior years. More specifically, in 1994 the proportion of age 1.4 was larger in the Chena and Salcha Rivers than in tributaries either lower or higher in the Yukon River drainage.

A 4-way run classification model consisting of separate standards for Lower Yukon, Chena River, Salcha River, and Upper Yukon stocks was used for the first time in 1994. This was necessary because samples from the two middle run tributaries, the Chena and Salcha Rivers, exhibited marked differences in growth patterns and therefore could not be lumped as usual. The mean classification accuracy of the 4-way, run of origin model for age 1.3 was 72.9% and for age 1.4 was 70.6%. This was comparable to accuracies normally achieved with 3-way models used in other years. Also, similar to past years, the lower river standard showed the greatest classification accuracy for age 1.3 (83.7%), as well as for age 1.4 (77.4%). Upper river standards reflected slightly better than usual classification accuracies: 69.8% for age 1.3 and 75.4% for age 1.4. Upper river standards most often misclassified to the Middle Yukon Run (21.9% for age 1.3 and 16.7% for age 1.4), and middle river standards most often misclassified to the Upper Yukon Run (27.4% for age 1.3 and 32.6% for age 1.4). Chena River standards were responsible for the majority of misclassification attributed to the Middle Yukon Run.

The commercial and subsistence harvest from the entire Yukon River drainage of 190,241 chinook salmon was classified to run of origin based on (1) findings of the scale patterns 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 113,181 fish or 59.5% of the total drainage harvest. The Middle Yukon Run was next in abundance at 46,366 fish (24.4%), followed by the Lower Yukon Run at 30,694 (16.1%).

The estimated commercial harvest of ages 1.3 and 1.4 in Districts 1 and 2 combined was 98,873 chinook salmon or 51.9% of the total Yukon River drainage catch. The estimated District 1 commercial catch of age-1.3 and -1.4 fish combined was 12,614 (21.2%) Lower, 16,230 (27.3%) Middle, and 30,623 (51.5%) Upper Yukon Run. In District 2 the estimated age-1.3 and -1.4 combined catch was 8,988 (22.8%) Lower, 12,456 (31.6%) Middle, and 17,963 (45.6%) Upper Yukon Run. The majority of the commercial chinook salmon catch in Districts 1 and 2 was taken in the first three 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, and 3. Upper run fish comprised the largest proportion of the District 1 commercial harvest of age-1.4 chinook salmon in periods 2, 3, 4, and 5. Somewhat differently, in District 2 Upper Yukon Run fish were the strongest segment of the catch of both age 1.3 and 1.4 in periods 2 and 3. 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. However, the Middle Yukon Run was relatively very strong in period 1 of both districts.

Proportions of total drainage harvest that were attributed to each run were typical of most other years. Estimates of the Upper Yukon Run component have ranged from 35.4% in 1984 to 67.9% in 1986, with an overall average of 56.9% since 1982. The proportion of Upper Yukon Run fish in 1994 was 59.5% or slightly above the long-term average.

Chinook salmon return and harvest dynamics appear to have been relatively stable in the Yukon River since the early 1980's. Current guideline harvest ranges were implemented in 1981 and can be partially credited with providing stable harvests during that time. Commercial chinook salmon harvests in the lower Yukon Area during that time included a component of age 1.3 and younger salmon which were primarily harvested during restricted mesh-size periods. Those periods were allowed 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 recent poor summer chum salmon runs, there has been a reduction in the number of restricted mesh-size openings which have been allowed. Season harvests from predominately 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 restricted mesh-size openings are curtailed because of chum salmon conservation concerns, managers should consider reducing the overall chinook salmon harvest so 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 good to excellent both quantitatively and qualitatively. Escapement sample sizes were fair to excellent in support of the four-way model used to classify 1994 catches. Acceptable sample quality depends on environment, biological, and sampling technique 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 escapement samples were inadequate or unavailable, as in 1994. 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. Curtailment of harvest and escapement sampling effort 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 catch and escapement sampling in the Canadian portion of the drainage in recent years results in a serious void of basic biological information for modelling the population dynamics and stock composition of Yukon River salmon.

CHUM SALMON STOCK IDENTIFICATION USING GSI, 1994

ADF&G, USFWS, and DFO have been working cooperatively to establish a genetic baseline for chum salmon in the Yukon River since 1987. The goal of this project is to investigate the utility of genetic stock identification to identify country of origin of chum salmon in the Yukon River. Genetic stock identification (GSI) research on Yukon River salmon was initiated with a small scale feasibility study on chum salmon in the mid-1980's by DFO. In 1987 this research was taken up by the USFWS and expanded to include chinook salmon, with ADF&G providing support for field sampling. In recent years this research has been conducted by both the USFWS and ADF&G. A progress report by the USFWS (Wilmot, et al 1992) presented information for the 1987-1990 chinook and chum salmon spawning stock baseline and District 1 commercial and test fishery sampling. A report including the 1991 data is in preparation by the USFWS.

Beginning in 1992, GSI sampling of chinook salmon and chum salmon in the District 1 commercial and test fisheries was suspended in order to focus efforts on chum salmon baseline sampling and analysis. This should provide for improved accuracy of fishery sample analyses in the future. Lab analyses of baseline samples collected by ADF&G and the USFWS in 1992 have been concluded. In addition to baseline sampling, the USFWS sampled chum salmon in 1992 from the subsistence fishery near Tanana Village on the Yukon River. Preliminary analysis for a subset (about one-quarter) of the Tanana Village fishery samples has been concluded by USFWS, and a report will be completed after baseline samples collected by ADF&G are incorporated.

In 1994, chum salmon populations were sampled in the Nulato River, Gisasa River, Melozitna River, Chena River, Salcha River, Delta River, Fishing Branch River, and Donjek River, and allele frequency estimates were obtained. These data were compiled into a comprehensive baseline along with allele frequencies reported in Wilmot et al. (1992) and Crane et al. (1994). This baseline, comprised of 35 populations and 16 loci, was analyzed to determine genetic stock groupings of chum salmon in the Yukon River in the manner that will be described briefly here. A more comprehensive source of information on the background of this project, the methods used, the results and discussion for 1994, and literature references can be found in Crane et al (In Prep).

All populations analyzed were incorporated into the baseline except mainstem Anvik River from 1987 and 1988. In 1992 and 1993, five separate spawning populations in the Anvik River drainage were sampled; genetic data from these populations were used to represent the Anvik River instead of the older samples. Multiple year collections in the baseline were compared using G-statistics (Weir et al. 1990) and pooled. The Toklat River was the only case where heterogeneity among samples was detected (P<0.01). Differences may occur because of chance; the presence of multiple spawning stocks; or factors such as drift, migration, or selection causing allele frequencies to change over time. Toklat River allele frequencies were pooled because we do not have adequate data to determine the cause of the observed heterogeneity.

A multidimensional scaling analysis was used to group closely related populations. Cavalli-Sforza and Edwards genetic distances (Cavalli-Sforza and Edwards 1967) were calculated from the pooled frequencies, and distances plotted such that observed distances closely match plotted distances in multidimensional space. Eight genetic groups representing eight possible reporting regions for mixture analysis were identified from the multidimensional scaling (Figure 3): 1) Lower Summer Run: Andreafsky River, Chulinak River; Anvik River; Innoko River; Rodo River; Nulato River; Kaltag River; Gisasa River; Huslia River; Dakli River; and Melozitna River,

2) Middle Summer Run: Jim River; Henshaw River; S. Fork Koyukuk-Early; S. Fork -Late; Tozitna River; Chena River; and Salcha River, 3)Toklat River, 4)Upper Tanana Fall: Delta River; Bluff Cabin Slough; and Tanana River Mainstem, 5)Chandalar/Sheenjek/Fishing Branch: Chandalar River; Sheenjek River; and Fishing Branch, 6)Mainstem Canada: Minto River; Big Creek; and Tatchun River, 7)Teslin, 8)Kluane/Donjek: Kluane River and Donjek River.

These reporting regions are similar to those used in Wilmot et al. (1992). However, Wilmot et al. (1992) included all Koyukuk populations in their Mid-river Summer Run group though lower Koyukuk River populations appear more similar to Lower Summer Run group. Additionally, this analysis separates Toklat River from other fall run Tanana populations; combines Fishing Branch with Chandalar/Sheenjek instead of with Canadian Mainstem; and separates Kluane and Teslin.

The ability of the baseline to correctly allocate individuals in a mixture to the correct region was evaluated using 100% simulations. In a simulation, baseline genotypes and mixture genotypes are generated from the baseline using Hardy-Weinberg expectations. Average mixture estimates were derived from 100 simulations for each region, where each region comprised 100% of the mixture (N=300). These simulations illustrate the identifiability of each reporting region and also show where misallocations occur. Simulation results showed the Lower Summer Run, Teslin, and Kluane/Donjek were highly identifiable, with mean estimates > 94%. Middle Summer Run, Toklat, and Upper Tanana Fall Run mean estimates ranged from 83% to 89%. Chandalar/Sheenjek/Fishing Branch and Canadian Mainstem performed the worst, with estimates ranging from 76% to 80%. For these two reporting regions, most of the misallocation was to the other group.

ADF&G and USFWS are working towards updating the current baseline with allele frequencies for additional loci. After incorporation of new loci, a second series of simulations will be performed to finalize identifiable genetic groups of chum salmon using the allozyme data set. It is anticipated simulations results will improve with added markers.

SALMON CATCH AND ESCAPEMENT AGE-SEX-LENGTH SAMPLING, 1994

Samples for age, sex, and length (ASL) composition of salmon were obtained in conjunction with sampling of salmon for stock identification purposes. 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 1994 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 ($d = 0.05$, $a = 0.01$) 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.

Commercial and subsistence catch samples were obtained in district catches from gillnets and fish wheels. Test fishing samples were also obtained. Efforts in 1994 resulted in a total of 9,692 chinook, 10,937 summer chum, 2,225 fall chum, and 1,362 coho salmon samples. Commercial catch samples totaled 4,270 chinook and 2,530 summer chum salmon. Subsistence samples totaled 1,162 chinook, 83 summer chum, and 174 fall chum salmon. Test fishing efforts resulted in samples from 1,618 chinook, 6,243 summer chum, and 1,398 fall chum salmon. Escapement sampling was conducted on the Andreafsky, Anvik, Nulato, Chena, Salcha, Toklat, Delta, and Sheenjek Rivers in Alaska; and by DFO at the White Rock and Sheep Rock fish wheel sites operated by DFO in Canada. Escapement samples totaled 3,688 chinook, 2,081 summer chum, and 683 fall chum. Efforts during the fall season also resulted in samples from 1,362 coho salmon from test fishing and escapement projects.

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% or greater age 1.4 in most District 1, 2, and 4 catches. The age composition of samples obtained from District 5 commercial gillnet catches was nearly 64% age 1.4. 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 smaller proportions of age 1.4, e.g., 34% for the Andreafsky River and 40% for the Anvik River. Samples from middle Yukon River tributaries were similar to District 1 and 2 catches, e.g., the Chena and Salcha River samples were 51% and 52% age 1.4, respectively. Samples from the Canadian Yukon River stock were taken from fish wheel catches near the U.S.-Canada border and were composed of 25% age 1.4. It should be noted that fish wheels tend to select for smaller, younger chinook.

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 31% and 46% age 0.4 in District 4 and 34% age 0.4 in District 6. Escapements of summer chum salmon were composed of 30% age 0.4 for the Andreafsky River, 62% age 0.4 for the Anvik River, and 64% age 0.4 for the Nulato River.

Fall chum salmon were sampled only from test fishing and subsistence gear in 1994. Samples were 35% to 45% age 0.4 from the lower Yukon River test fishing sites. The subsistence catch sample in Subdistrict 5B was composed of 30% age 0.4. Escapements of fall chum salmon ranged from 26% age 0.4 for the Toklat River to 60% age 0.4 for the Delta River.

Test fishing catches of coho salmon sampled from the lower Yukon River test fishery were composed of about 83% age 2.1 and 17% age 1.1, while the escapement sample from the Delta Clearwater River was about 67% age 2.1 and 33% age 1.1.

SUBSISTENCE HARVEST SURVEYS, 1994

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 may or may not have been included in the estimates of subsistence harvests prior to 1988; 2) village survey dates early in the fall in some prior 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 1994, and literature references can be found in Holder and Hamner (In Prep).

The total number of salmon harvested in the subsistence fishery in the Alaskan portion of the Yukon River drainage in 1994 was estimated from the survey program, subsistence fishing permit information, department test fish given to the public, and information on fish retained from commercial catches for subsistence use. The estimated harvests and number of households obtained from the individual programs are not additive because of overlapping harvest reporting from Stevens Village. The 1994 subsistence salmon harvest estimates from all sources for the Alaskan portion of the Yukon River drainage (excluding Hooper Bay and Scammon Bay) by 1,324 fishing households were estimated at 54,563 chinook; 132,510 summer chum; 123,218 fall chum; and 44,594 coho salmon. Fish retained from commercial catches for subsistence use (excluding commercial related salmon) were included in the subsistence salmon harvest estimates. Commercial related salmon were female salmon harvested to produce roe sold in Districts 4, 5, and 6. The commercial-related harvest of summer chum salmon in District 4 also includes male salmon. The chinook salmon harvest was 7% above the average (1989-1993) of 50,780 fish; the summer chum harvest (excluding commercial related harvest) was 4% above the average of 127,560 fish; the fall chum salmon harvest was 14% below the average of 144,000 fish; and the coho salmon harvest was 14% above the average of 39,260 fish. The coastal harvests near the villages of Hooper Bay and Scammon Bay were estimated to be 825 chinook, 14,903 summer chum, 347 fall chum, and 81 coho salmon. A portion of these harvests were probably from local non-Yukon River drainage streams, as well as from salmon stocks migrating beyond the Yukon River.

The majority of households in the Yukon River drainage, outside of the Fairbanks area, are located in villages in which there are no regulatory requirements concerning reporting of their subsistence salmon harvest. The department has implemented a survey program to estimate the salmon harvest from areas not requiring a permit. The survey program utilizes subsistence catch calendars, postseason household interviews, and postseason household telephone interviews to improve the sampling frame and to estimate the harvest. The 1994 survey database contained 2,453 households in 31 villages and included the villages of Hooper Bay and Scammon Bay. Not included were 77 households in the three villages of Hughes, Allakaket, and Alatna, which were not surveyed in 1994 because of disastrous Koyukuk River flooding in September 1994. Stratified random sampling techniques were used to identify 1,083 households which were to be interviewed during the 1994 survey. The stratification of the households was based on prior year harvest information. Based on the 934 households surveyed, an estimated (95 percent confidence intervals are in parentheses), 1,109 (±87) fishing households harvested a total of 43,369 (±3,637) chinook; 100,559 (±10,528) summer chum; 68,444 (±6,651) fall chum; and 12,146 (±2,942) coho salmon.

Subsistence salmon fishing permits were required by regulation for households which desired to fish in the Tanana River, the Yukon River between Hess Creek and the Dall River, or the Yukon River between Twenty-Two Mile Slough and the U.S./Canada border. Households which fished in areas requiring a permit were required to obtain a permit, document their catch, and return the permit upon expiration. A total of 473 salmon subsistence permits were issued which includes 2 households that were issued permits to fish for salmon in two different permit areas (separate times) and 37 Minto, 2 Fairbanks, and 1 Manley households that were issued Tolovana River subsistence pike permits and salmon permits. Also included are 4 permits to collect fall chum salmon carcasses from the Delta River floodplain. The reported subsistence permit catches by 457 permittees who had returned their permits as of 20 March 1995 was 8,536 chinook salmon, 7,555 summer chum salmon, 49,602 fall chum salmon (including 250 Delta River carcasses), and 26,544 coho salmon.

Additionally, 1,486 chinook, 22,606 summer chum, and 2,900 coho salmon were reported to have been retained from commercial catches for subsistence use. Commercial fishermen were required to document the number of fish retained for subsistence use from their commercial catch on fish tickets but compliance was poor. Therefore, the estimate of salmon retained from commercial catches was a combination of survey responses and fish ticket records and is considered a minimal estimate. ADF&G test fisheries gave away a total of 2,319 chinook salmon, 10,058 summer chum salmon, 5,817 fall chum salmon, and 3,085 coho salmon to households in the villages of Emmonak, Kotlik, Pilot Station, Tanana, and Nenana for subsistence use.

SPAWNING ESCAPEMENT SURVEYS, 1994

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 unsurveyable 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 1994, 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 (>500) and South Fork (>800) 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.

Chinook salmon escapements in the lower Yukon River drainage were characterized by counts obtained for the Andreafsky and Anvik rivers. Reliable aerial surveys of the East Fork and West Fork Andreafsky River were not possible due to inclement weather. However, a total of 7,801 chinook salmon were counted through the weir operated by the USFWS on the East Fork, suggesting that the escapement goals in this river were met. In the Anvik River a total of 913 chinook salmon were observed under poor survey conditions in the mainstem index area from Yellow River to McDonald Creek.

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. Although an aerial survey estimate of salmon abundance could not be obtained for the Nulato River due to poor weather conditions, a total of 1,633 chinook salmon were counted past the tower site located below the forks. Given that project start-up was delayed by high water and counting conditions hampered by turbid water, the tower count is considered conservative and it is likely that the minimum escapement goal for each fork of the Nulato River was achieved in 1994. For the Gisasa River, in the Koyukuk River drainage, an aerial survey count of 2,775 chinook salmon was made under fair survey conditions. This was the highest chinook salmon count on record for this stream and well above the aerial survey escapement goal minimum of 600 chinook salmon. The new weir project on this river provided a total count of 2,888 chinook salmon for the period 11 July through 10 August. Although no chinook salmon escapement goals have been established for other streams in the Koyukuk River drainage, results of aerial surveys made on a few other tributaries in 1994 indicated escapements were at least average in magnitude. Counts were 526 chinook salmon for Henshaw Creek and 468 collectively, for the South Fork Koyukuk and Jim Rivers.

It should be noted that many of the chinook salmon which spawn in the upper portion of the Koyukuk River utilize mainstem sections of the North, Middle, and South Fork rivers, in addition to several tributary streams. While it is not known what effect the severe August flooding which occurred throughout the river basin in 1994 will have on future production from channel scouring, the potential deleterious impact could be great.

In the Tanana River drainage, aerial surveys of the Chena and Salcha Rivers indicated that excellent chinook salmon escapements were achieved. Most notable was the Salcha River index area count of 11,189 chinook salmon, the highest on record. Inseason assessment of chinook salmon escapement to the Tanana River drainage was improved in 1994 (and 1993) compared to prior years by operation of counting towers on the Chena and Salcha Rivers. The 1994 tower estimates of escapement were 12,006 chinook for the Chena River and 18,376 chinook salmon for the Salcha River. These estimates exceeded the average total population escapement estimates obtained by mark and recapture methods in prior years. Although no chinook salmon escapement goals have been established for other Tanana River streams, an aerial survey count of 1,392 chinook salmon was obtained for the Goodpaster River in 1994, the highest on record.

The preliminary DFO mark-and-recovery population estimate of chinook salmon entering the Canadian portion of the mainstem Yukon River in 1994 was 45,711 (95% C.I. = 40,743 to 51,283), within 1% of the 1988-1993 average of 45,543. 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 25,027 chinook salmon. This was well above the stabilization objective of 18,000, although it was below the long-term escapement goal range of 33,000 to 43,000 chinook salmon.

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 summer chum run was expected in 1994, the return materialized stronger than projected, due at least in part to a stronger than average return of age 5 fish. Escapements throughout the drainage were judged to be good. Although no aerial survey estimate was made for the Andreafsky River due to poor weather conditions, it is considered that the minimum escapement objectives for the East and West Fork of the river were met. This is based upon a weir passage of 201,000 summer chums in the East Fork after a delayed startup due to high water conditions. The Anvik River sonar project estimated 1,129,000 summer chum salmon through 23 July, more than double the escapement goal minimum and represented approximately 56% of the total passage estimate of summer chum salmon at the Pilot Station sonar project on the mainstem Yukon River.

Upstream of Anvik, summer chum salmon escapements were judged adequate based upon observations made in Kaltag Creek and the Nulato, Gisasa, and Dakli Rivers. A preliminary expanded estimate of 47,600 summer chums passed the Kaltag Creek tower site between 21 June and 28 July, while a preliminary expanded estimate of approximately 144,600 summer chums were estimated passing the Nulato River tower site. In the lower Koyukuk River drainage a total of 51,100 summer chum salmon were counted past the Gisasa River weir while in the upper Koyukuk River an aerial survey flown of Dakli River and Wheeler Creek resulted in an estimate of approximately 25,400 summer chum salmon, the highest aerial survey count made in that area.

Summer chum salmon escapements were also considered adequate in the Tanana River drainage as evidenced by observations made in the Chena and Salcha Rivers. Although less than 2,000 summer chum salmon were counted during an aerial survey of the Chena River on 4 August, the counting tower estimate was 10,108 fish for the period 1 July through 12 August. This was a conservative count due to turbid water conditions for a period of the counting operation. In the Salcha River an aerial survey count of the index area resulted in 4,575 summer chum salmon. This was above the minimum goal of 3,500. Furthermore, an abundance estimate of 39,343 chum salmon was made from the counting tower on the Salcha River during the period 1 July through 12 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 Toklat, Delta, 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.

The preseason projected return of fall chum salmon to the Yukon River in 1994 was 605,000 fish. That projection included an anticipated drainage-wide shortfall of 112,000 age-5 fish from the 1989 brood year based upon performance of returning age-4 fish observed in 1993. Beyond the age-5 shortfall, it was anticipated that the age-4 component of returning fall chum salmon might also exhibit some weakness based upon the extremely low number of age-3 fish observed returning in 1993. The public was cautioned that if this was the case, then the 1994 projected return could change to one of critically low abundance. The 1994 projected return without the age-5 shortfall would have been 717,000 fall chum salmon. In brief, fall chum salmon run strength was assessed inseason to be much weaker than it in fact was due to poor performance of the Pilot Station sonar project during the fall season. This resulted in closures or restrictions to various fall season fisheries throughout the drainage, on a run size much larger than originally believed. The low exploitation on Yukon River fall chum salmon resulted in excellent escapements throughout the drainage.

Evaluation of escapement for 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 1994 was approximately 153,000 fish for the 52-day period of 8 August through 28 September, some 139% above the escapement goal minimum of 64,000. The interim minimum escapement goal for the Fishing Branch River was achieved for the first time since 1985 and the second time since 1981. A weir passage of approximately 65,200 fall chums was approximately 30% above the minimum goal of 50,000 fish, but still well below the upper level of 120,000.

Tanana River fall chum salmon escapement was 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. In 1994, in addition to this technique, a more comprehensive assessment of escapement to the Toklat River was also attempted using hydroacoustic techniques. The expanded total population estimate of escapement based upon ground surveys made of the spawning grounds in mid-October was approximately 73,900 fall chums. Comparatively, preliminary field data indicates that approximately 71,000 salmon were estimated by sonar in the mainstem river during the period mid-August through early October. While species apportionment was not made at the sonar site, inferences from the ground survey indicate that less than one percent of the sonar estimate was coho salmon. This preliminary finding would indicate that past estimates of total fall chum salmon escapement to the Toklat River are reasonable. Further, these data reveal the fall chum salmon escapement to the Toklat River in 1994 to have been more than 120% above the minimum goal of 33,000.

The estimated total abundance of fall chum spawners in the Delta River was 23,777 based upon replicate ground surveys and salmon stream-life data; approximately 116% 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, escapement counts during peak spawning were approximately 2,300 and 900 fish, respectively, in Bluff Cabin and Clearwater Lake Outlet Sloughs (Big Delta region). These numbers approximate 50% or less of the recent ten-year averages of chum salmon observed in these areas.

The preliminary DFO mark-and-recovery population estimate of fall chum salmon entering the Canadian portion of the upper Yukon River in 1994 was 137,701 fish. Subtracting the preliminary 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 drainage) of approximately 104,676 spawners. An escapement level of this magnitude is the highest on record since inception of the DFO mark and recapture program in 1982. Further, this escapement estimate, as part of the twelve year rebuilding plan for the 1990 brood year, was approximately 59% above the minimum 1994 targeted level of 65,900 fall chum spawners.

Preliminary fall chum salmon inriver estimated commercial and subsistence harvest added to an estimated total spawning escapement (based upon a doubling of a standardized escapement index) resulted in a total run estimate for 1994 of 796,000 fish, the largest even-year return on record. This measure of total return was most similar to the 717,000 projection which excluded any age-5 shortfall. Strength of the 1994 return appeared, in fact, to lie in the age-5 component.

Coho Salmon

Coho salmon spawning escapement assessment is very limited in the Yukon River drainage due to funding limitations and survey conditions at that time of year. Most of the information that has been collected is from the Tanana River drainage. The only escapement goal established for coho salmon thus far is for the Delta Clearwater River, which is >9,000 fish. The Sport Fisheries Division conducted a boat survey of the Delta Clearwater River index area on 24 October and counted 62,675 coho salmon. That is the highest coho salmon escapement on record for this stream. An additional 17,565 coho salmon were observed in tributaries of the Delta Clearwater River on 27 October. It also appears that coho salmon spawning escapements in other portions of the Tanana River drainage were average to above average, although not nearly to the extent as in the Delta Clearwater River.

For example, 3,425 coho salmon were observed in the outlet to Clearwater Lake on 24 October; 57% greater than the 1989-1993 average of 2,176 coho salmon. Coho salmon aerial survey counts in the Nenana River drainage were 944 in Lost Slough (79% above the 1990-1993 average), 2,909 in Seventeen Mile Slough (second highest on record), and 1,647 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, double the most recent 5-year (1989-1993) average. Approximately, 2,000 coho salmon passed a weir site on Barton Creek (Toklat River drainage) during the period 11 September through 5 October.

LOWER YUKON RIVER SONAR AT PILOT STATION, 1994

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 1994 were to provide daily and seasonal passage estimates for chinook, chum, and coho salmon, and to estimate the precision of those estimates.

The sonar project was operated from 4 June through 8 September in 1994. Salmon passage estimates, most notably during the fall season, were low relative to post-season reconstructions of run size. The poor performance of the sonar project during the fall season had a significant negative impact on management of the fall chum salmon fisheries.

The salmon passage estimates at Pilot Station are based upon a sampling design in which sonar equipment is typically operated for 7.5 hours each day. The sonar equipment was operated 24 hours per day on five occasions in 1994 to collect information with which to evaluate the sampling design.

Estimates of annual fish passage, rounded to the nearest one thousand fish for each species category, for the period 1986-1991, using the 420 kHz sonar equipment, were as follows:

Yr	Chinook	S. Chum	F. Chum	Coho	Other Fish[a]
86	169,000	1,933,000	583,000	210,000	1,414,000
87	116,000	826,000	596,000	228,000	104,000
88	121,000	1,773,000	424,000	263,000	817,000
89	92,000	1,604,000	606,000	169,000	324,000
90	156,000	931,000	546,000[b]	241,000[b]	327,000[b,c]
91	76,000	1,233,000	597,000[d]	71,000[d]	351,000[d,c]

[a] "Other Fish" may include pink salmon (which are substantially more abundant in even-numbered years), whitefish, sheefish, northern pike, and other species.

[b] Includes an estimate of fish passage offshore beyond the range of side-looking shore based sonar beams based upon down-looking sonar transects conducted across the width of the river and onshore gill net test fishing data.

[c] Does not include fish passing near shore on the left (south) bank.

[d] Includes an estimate of fish passage offshore beyond the range of side-looking shore based sonar beams based upon down-looking sonar transects conducted across the width of the river and offshore gill net test fishing data.

Estimates of annual fish passage, rounded to the nearest one thousand fish for each species category, for the period 1993-1994, using the 120 kHz sonar equipment, were as follows:

Yr	Chinook	S. Chum	F. Chum	Coho	Other Fish[a]
93	135,000	947,000	292,000	42,000	351,000[b]
94	141,000	1,997,000	407,000	191,000	271,000[b]

[a] "Other Fish" may include pink salmon (which are substantially more abundant in even-numbered years), whitefish, sheefish, northern pike, and other species.

[b] Does not include fish passing near shore on the left (south) bank.

The acoustic and test fishing sampling schedules in 1994 were unchanged from prior years, except that the left bank offshore transducer was not included in passage estimation until early August, at which time an additional 0.5 hour of sampling time was added to each of the three daily 2.5-hour sonar sampling periods. As in prior years, cross-river transects were conducted every few days to monitor the river bottom and assess whether any fish were passing beyond the range of the shore based units. During the course of test fishing at the sonar site for species apportionment in 1994, more than 8,600 fish were captured, of which more than 8,100 were salmon.

Performance of the Yukon River sonar project at Pilot Station was verified on a number of occasions in 1994 by personnel outside of the immediate project staff. Bottom topography was examined on 8-9 June and 1-2 August using imaging side-scanning sonar equipment. Acoustic system performance was verified both in terms of target detection at range and in terms of standard target estimates. Tests of target detection on 9 June at 60 meters, and on 1 August at 20 meters and 124 meters found that the vertical water column was covered such that a standard target (a 38.1 mm diameter tungsten-carbide sphere) could be acoustically detected on the bottom and at the surface of the river at 20 meters and 60 meters range, and 30 cm off bottom and 60 cm below surface at 124 meters range. Target strength estimates were close to the theoretical value. Performance of the radio telemetry equipment was verified on 8-9 June, 1-2 August, and on 21 August. This equipment is used to control sonar equipment for both banks all from one bank. ADF&G headquarters and regional staff visited the site on four occasions in 1994, on 8-9 June, 23-24 June, 1-2 August, and 19-23 August. There was a site visit on 30 July-2 August by a contractor from the firm that manufactured and marketed the sonar equipment used at Pilot Station.

Problems arose in 1994, not so much of a technical or equipment nature, but rather with communication and implementation of the operational plan. These problems resulted in low passage estimates and delayed response during the fall season. There was a lack of cooperation in the field with the team approach needed to make use of technical resources, and there was intervention outside of the operational plan. Further analysis of the data collected at Pilot Station in 1994 has not proceeded beyond preparation of a working draft report of basic project information in the fall of 1994 (Mesiar and Fleischman, In Prep.). A directive by the former Director of the Commercial Fisheries Management and Development Division of ADF&G in the fall of 1994 prohibited further analysis pending review by a sonar review team that was announced in September 1994, but which never materialized.

Discussion of capabilities and plans for the 1995 season were taken up by the Yukon River JTC at their March 1995 meeting. The JTC discussed the importance of this project for in-season salmon run assessment and fishery management. It was acknowledged that the events of 1994 would require an even greater effort in 1995 in order to overcome concerns by the public in the use of the data from this project. Whether the project would be operational in 1995 for fishery management remained uncertain as of the date of the JTC meeting because there was uncertainty as to the level of technical support that would be available to the ADF&G large-river sonar program in the Arctic-Yukon-Kuskokwim (AYK) Region, including the project at Pilot Station. The short time frame remaining prior to the 1995 field season was evident and a concern. It was felt that if sufficient resolution was reached within ADF&G to conduct a large-river sonar program in the AYK Region in 1995, the available resources would need to be focused on those projects needed for management, including the Yukon River sonar project at Pilot Station.

YUKON RIVER BORDER SONAR AT EAGLE, 1994

Operational planning for the Yukon River border sonar project was initiated in 1991. The project was designed to investigate the feasibility of using high frequency split beam sonar equipment to assess the passage of chinook and chum salmon into Canada on the mainstem Yukon River. In order to accomplish that objective, the JTC established a sonar subcommittee comprised of representatives of ADF&G, USFWS, and DFO. Split beam sonar was the technology of choice because, while new for riverine applications, it promised the ability to provide real-time three axis target position in the beam and, therefore, the ability to determine direction of travel. As this was the first attempted deployment of spilt beam sonar in a riverine environment, it was agreed that a four field season development schedule would be needed. Equipment was purchased and site surveys were conducted in 1991. Field deployment of prototype split beam sonar equipment was initiated in 1992 and baseline acoustic and gill net test fishing data were collected during late July and September. A full field season of acoustic data were collected in 1993 during which calibration and data handling protocol were established. Additional acoustic data were collected on free-swimming fish and calibration spheres in 1994. In addition, both transducers were deployed on the right bank in 1994 to investigate the possibility of ensonifying more of the complex bottom profile there. Information on the background of this project, the methods used, the results and discussion for 1994, and literature references can be found in Huttunen and Skvorc (In Prep).

Specific tasks outlined as objectives in the 1994 project operational plan which were achieved during the 1994 field season included: 1) collecting acoustic data on fish migrating on the right bank at the existing site 24 hours per day from 28 August through 25 September; 2) archiving all raw electronic and chart recording data following established data management protocol; 3) optimizing sonar beam coverage of the right bank at the existing site given a two transducer deployment and the complex bottom profile noted during the two previous seasons; 4) successfully conducting *in situ* split beam sonar system calibrations following procedures established at Eagle during 1992 and 1993 and those established at Fraser River in 1993; and 5) collecting additional data to measure background noise levels on the right bank, including Digital Audio Tape (DAT) recording data and by direct measurement on a digital storage oscilloscope.

Staff were present on site from 25 August through 23 September in 1994, and acoustic data were acquired from 31 August - 22 September. Tent frame construction and sonar equipment hardware and software malfunctions preempted acoustic data collection until 3 September. Loss of one Digital Echo Processor (DEP) which was damaged in shipment forced a change in sampling strategy at the onset of the project. All acoustic sampling was conducted with the remaining DEP using built-in multiplexing capability to alternately sample using each transducer. The nearshore and offshore strata were sampled in alternating half hour blocks for the duration of the project.

Immediately after arriving on site the bottom profile was documented by conducting a series of cross-river transects using a recording fathometer. This verified that the river bottom had remained substantially unchanged at the site since the first field season, although the 40 m nearshore shelf on the right bank was completely exposed due to low water. The bottom profile, best described as complex sloped, has been examined and the potential for complete coverage based solely on side-looking sonar has been assessed. The nearshore transducer was deployed roughly 5 m from shore at the shelf break. The offshore transducer was deployed 45 m from shore at a depth of 5 m at the bottom of the right bank slope. While we have demonstrated an ability to deploy an offshore transducer at the site, it is unlikely that complete cross-sectional coverage can be obtained by side-looking transducers alone because of the convex bottom profile from 80 m to 180 m from the right bank.

Surface flow rates were measured over the inshore and offshore transducers by timing a float through a measured 50 m range. Flow rates were consistent over the course of data collection at 0.3 m/s over the inshore transducer and 1.3 m/s at both 20 m and 40 offshore.

In all, 314 hours of split beam acoustic data were collected on fish passing through the sonar beams in 1994, including 172 hours of nearshore and 142 hours of offshore data. In addition, 15 hours of standard target electronic data and 22 hours of Digital Audio Tape (DAT) data were collected for later analysis. Complete copies of all electronic data were maintained by both participating agencies, and DAT data from similar and sometimes identical time periods were also maintained by both agencies. Most original chart recordings were catalogued and maintained by ADF&G, with full access by all parties during and after the field season. Of the total, 14 hours of the highest quality DAT data were reprocessed by ADF&G post season to investigate variability in phase-determined target position in the beam. DFO reprocessed and evaluated four days of paired chart recording and electronic fish detection data to investigate variability in automatic fish detection.

In addition to the tasks already discussed, we conducted experiments to document the probability of detection of various spherical targets of known acoustic size at known locations in the beam. These experiments were patterned after similar experiments conducted earlier on the Fraser River where targets were suspended on a rigid frame placed in the river. Note was made of the finding that the frame could be made to disappear acoustically by tilting it at least 10° toward the transducer.

Some potential research tasks identified in the 1994 operational plan were not addressed during 1994 operations. These included collecting acoustic and non-acoustic data to describe: 1) the complete cross-sectional spatial distribution used by migrating chum salmon, and 2) the target strength and mean length of chum salmon migrating past the sonar site. Additionally, we were unable to ensonify a complete cross-section of the right bank of the river with two transducers, and based on the bottom profile of measured depth at range, we came to the conclusion that it is likely that some other form of assessment will be required to address this task at this site.

Analyses conducted by DFO have been aimed at describing the differential probability of detection of a salmon sized target in the beam at ranges typically used by migrating salmon. The goal of these investigations is to develop a model to estimate abundance based on observed detections at known locations in the beam. These detections would be adjusted by an empirically derived model of probability of detection as a function of target location in the beam. Analysis of these data by ADF&G were very limited during the post season due to the state of the Department's sonar program during the past year. Initial analyses were directed toward identifying components of the variability noticed in detection which were contributed by uncertainty in phase-calculated (up/down and right/left) target position, and by systematic ping-to-ping uncertainty in amplitude. Understanding the uncertainty in these components is a step toward developing procedures to allow determination of direction of travel and accurate estimation of target strength.

Once an abundance estimation procedure has been developed for the Yukon River border sonar project based on differential probability of detection in the beam, the remaining fundamental issue to be resolved before implementation can occur involves describing the cross-sectional distribution of migrating salmon at the site. It has been suggested that a systematic program of cross river transects might be a likely place to begin addressing this question.

It has been agreed that while split beam sonar is not yet ready for full scale implementation in a riverine application, based on interim results to date there is the expectation that with future development split beam sonar can be used to estimate salmon passage on the Yukon River at Eagle. However, given the lack of technical leadership that would likely be available for the project at Eagle in 1995 both on the part of ADF&G and DFO, there was consensus by the JTC that planned project development year number four be postponed for one year. It was clearly stated that this action was not meant to imply any reduced confidence in the eventual success of the feasibility study. Rather, that the project has reached a critical juncture requiring close technical oversight at this stage in development for success.

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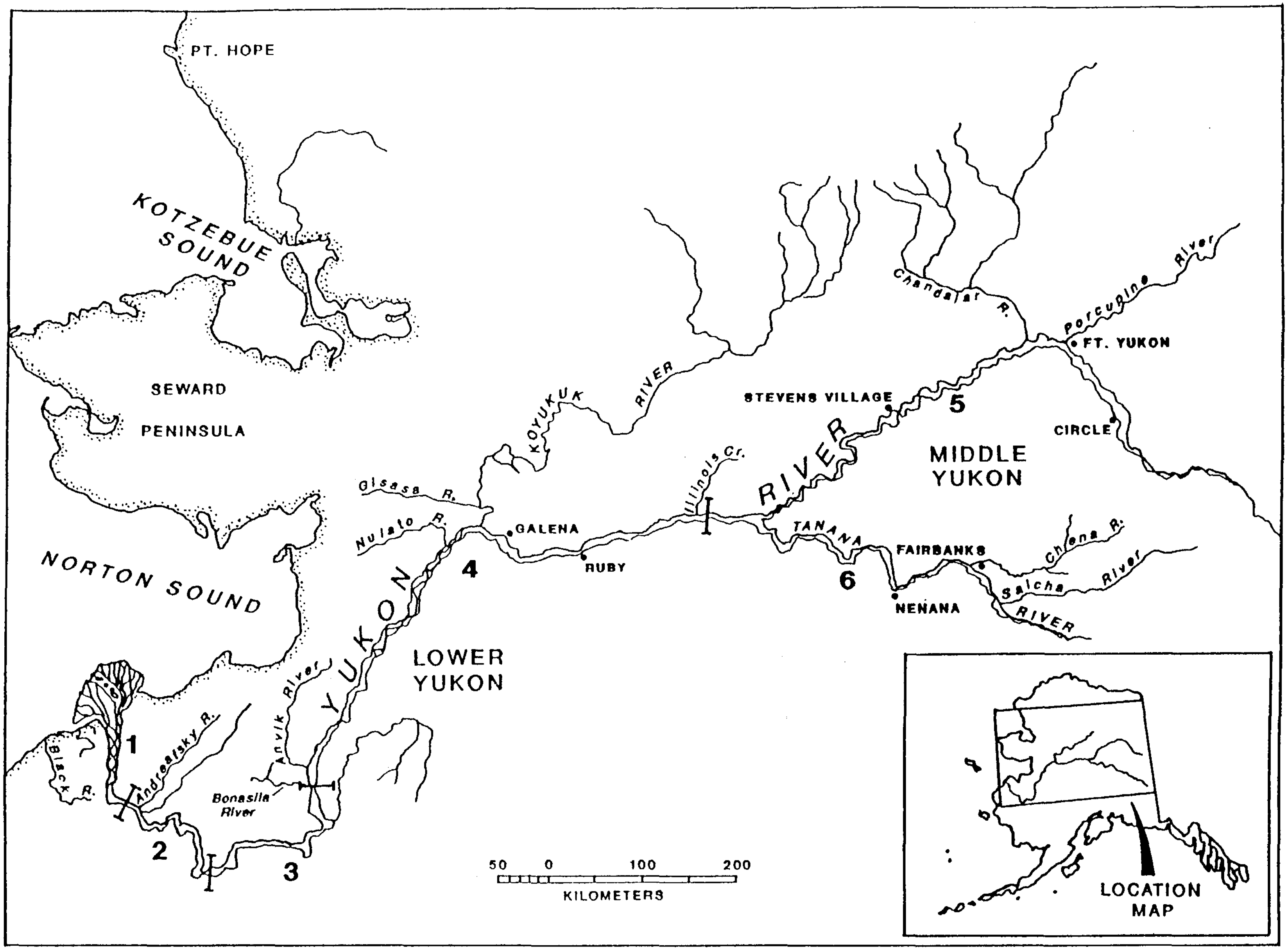

Figure 1. Alaska portion of the Yukon River drainage, showing fishing district boundaries.

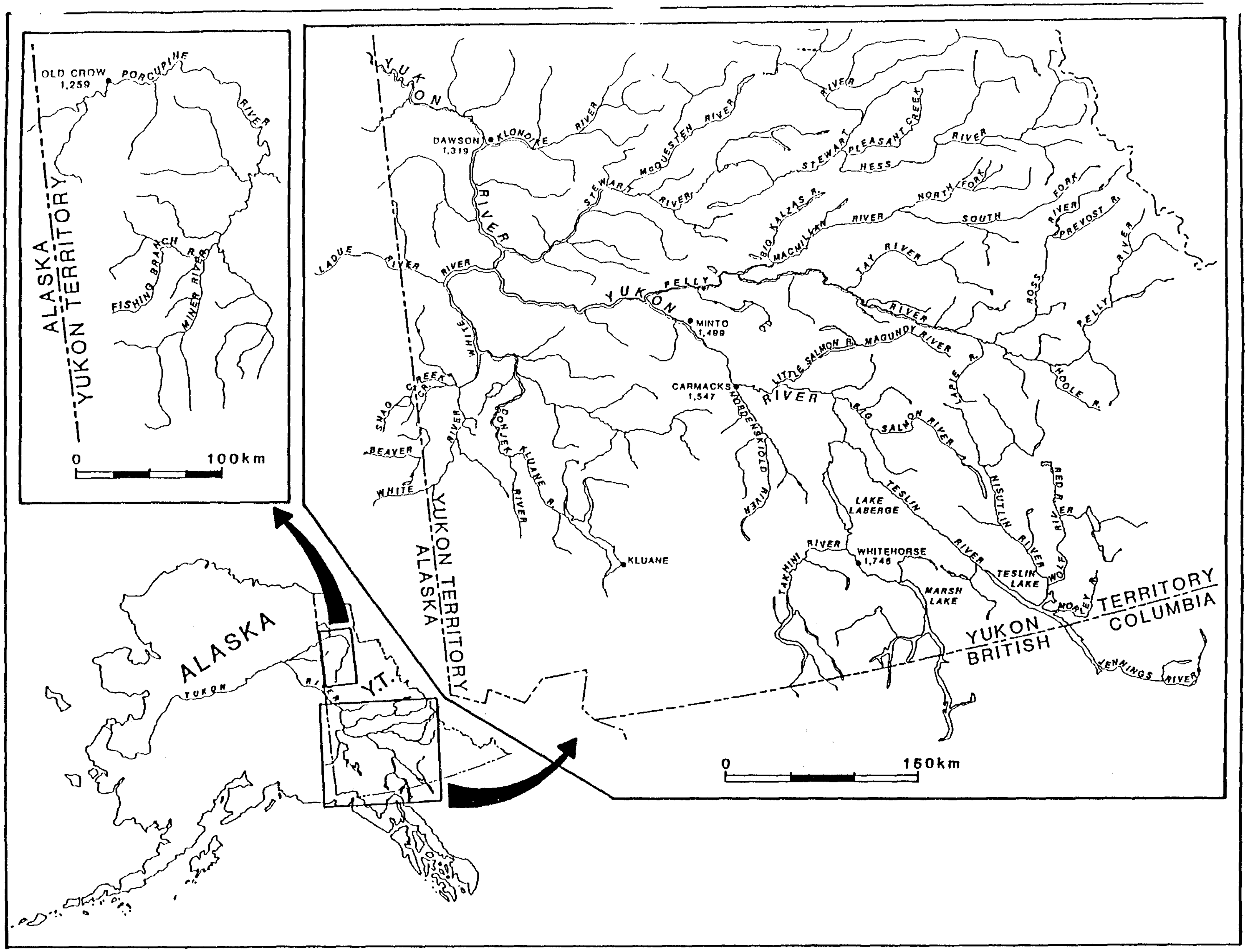

Figure 2. Canadian portion of the Yukon River drainage.

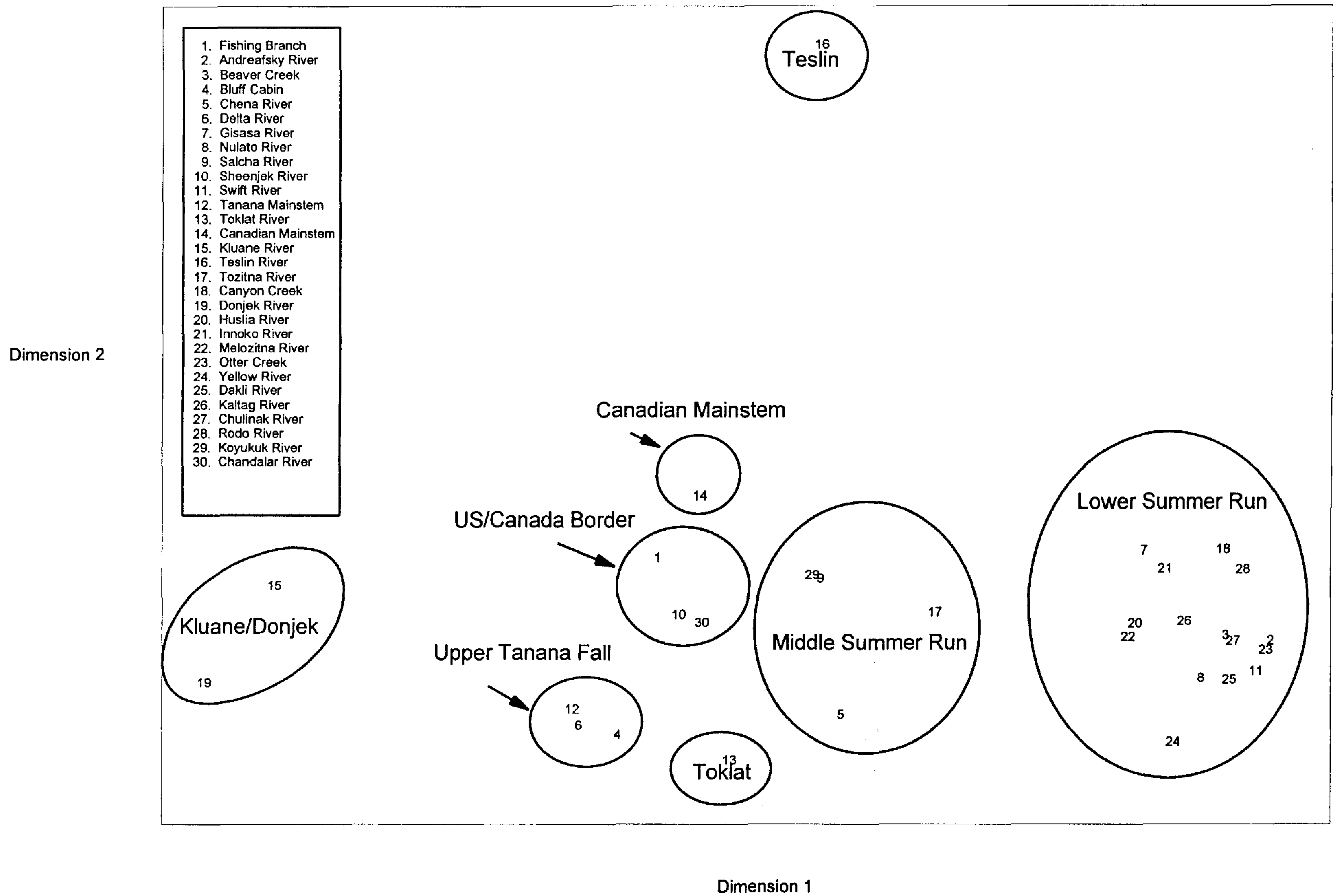

Figure 3. Multidimensional scaling plot of potential chum salmon stock groupings for the Yukon River. Cavalli-Sforza and Edwards chord distances were calculated from allele frequencies for 16 loci.