U.S. Fish & Wildlife Service

Distribution and Genetic Origin of Chinook Salmon Rearing in Nonnatal U.S. Tributary Streams of the Yukon River, 2008–2010

Alaska Fisheries Data Series Number 2012-10

Fairbanks Fish and Wildlife Field Office
Fairbanks, Alaska
July 2012

The Alaska Region Fisheries Program of the U.S. Fish and Wildlife Service conducts fisheries monitoring and population assessment studies throughout many areas of Alaska. Dedicated professional staff located in Anchorage, Fairbanks, and Kenai Fish and Wildlife Offices and the Anchorage Conservation Genetics Laboratory serve as the core of the Program's fisheries management study efforts. Administrative and technical support is provided by staff in the Anchorage Regional Office. Our program works closely with the Alaska Department of Fish and Game and other partners to conserve and restore Alaska's fish populations and aquatic habitats. Our fisheries studies occur throughout the 16 National Wildlife Refuges in Alaska as well as off-Refuges to address issues of interjurisdictional fisheries and aquatic habitat conservation. Additional information about the Fisheries Program and work conducted by our field offices can be obtained at:

http://alaska.fws.gov/fisheries/index.htm

The Alaska Region Fisheries Program reports its study findings through the Alaska Fisheries Data Series (AFDS) or in recognized peer-reviewed journals. The AFDS was established to provide timely dissemination of data to fishery managers and other technically oriented professionals, for inclusion in agency databases, and to archive detailed study designs and results for the benefit of future investigations. Publication in the AFDS does not preclude further reporting of study results through recognized peer-reviewed journals.

Cover photo (USFWS): Setting minnow traps in Texas Creek (1,177 rkm); captured juvenile Chinook salmon (insert).

Alaska Fisheries Data Series Number 2012-10
U.S. Fish and Wildlife Service

Distribution and Genetic Origin of Chinook Salmon Rearing in Nonnatal U.S. Tributary Streams of the Yukon River, 2008–2010

David W. Daum and Blair G. Flannery

Abstract

Use of nonnatal rearing areas by juvenile, stream-type Chinook salmon *Oncorhynchus tshawytscha* is well documented in some large river systems in northwestern North America. In the Canadian portion of the upper Yukon River drainage, age-0 Chinook salmon have been found rearing in many small, non-spawning tributary streams of the Yukon River main stem. In downstream U.S. waters, an exploratory study in 2006–2007 revealed, for the first time, rearing of Canadian-origin Chinook salmon in eight U.S. tributary streams. This discovery in turn lead to a comprehensive three-year investigation into the extent of Chinook salmon rearing in nonnatal tributary streams of the Yukon River between the U.S.–Canada border and Tanana, Alaska, a distance of over 850 km. Juvenile Chinook salmon were captured in 45 of the 57 streams sampled. Mixed-stock analysis of genetic samples revealed that Canadian-origin Chinook salmon contributed between 88% and 100% of the yearly mixtures, with Canadian percentages decreasing with increased distance downstream from the U.S.–Canada border. The Carmacks regional group, 470 to 590 km upstream from the border, made up the majority of the stock composition mixtures. Other Canadian groups were under-represented, including the large-river stocks from the Stewart, Pelly, and Teslin rivers. The longest travel distance from natal origin was estimated to be over 1,300 km. The mechanism that causes this disproportionate number of Carmacks area juveniles to leave their natal streams for downstream rearing areas and the cost, if any, of this dispersal strategy are unknown.

Introduction

Yukon River Chinook salmon *Oncorhynchus tshawytscha* exhibit "stream-type" life history characteristics (Gilbert 1922; Healey 1983), typically leaving upstream rearing areas for marine waters during their second year of life (Beacham et al. 1989). Most rearing is assumed to take place in natal streams, though many nonnatal streams in the upper Canadian portion of the Yukon River drainage have been found to provide important feeding, and in some cases, overwintering habitat for Chinook salmon juveniles (Brown et al. 1976; Walker 1976; Beacham et al. 1989; Murray et al. 1990; Moodie et al. 2000; Bradford et al. 2001; Perry et al. 2003; Mossop and Bradford 2004, 2006). In sharp contrast to the numerous Canadian studies, little information was available on the use of nonnatal streams by Chinook salmon juveniles in the U.S. portion of the drainage until an exploratory study was conducted in 2006–2007 by U.S. Fish and Wildlife Service (USFWS; Daum and Flannery 2011). Eight non-spawning streams downstream of the U.S.–Canada border were found to contain rearing age-0 juveniles. The juveniles from these eight streams were genetically analyzed at 13 microsatellite loci that form a

Author: David W. Daum can be contacted at U.S. Fish and Wildlife Service, Fairbanks Fish and Wildlife Field Office, 101 12th Ave., Rm. 110, Fairbanks, AK 99701 or David_Daum@fws.gov. Blair G. Flannery can be contacted at U.S. Fish and Wildlife Service, Conservation Genetics Laboratory, 1011 E. Tudor Rd., Anchorage, AK 99503 or Blair_Flannery@fws.gov.

genetic baseline for Yukon River Chinook salmon (Table 1; Figure 1) and provide accurate and precise estimates of stock composition and individual assignment for region and country (Beacham et al. 2008; Daum and Flannery 2011; Flannery et al. in press). Genetic stock composition analysis indicated that 100% of the samples were of Canadian origin. The Carmacks region of Canada (over 470 km upstream from the border) contributed 91% to the sample mixtures in 2006 and 82% in 2007. The Carmacks genetic stock group includes spawning populations from Tatchun Creek, and Little Salmon, Big Salmon, Nordenskiold, and main-stem Yukon rivers. Canadian stocks nearest the border and from large river systems were underrepresented in the collections. Some age-0 Chinook salmon may have travelled over 1,200 km to reach these downstream rearing areas.

Yukon River Chinook salmon support important subsistence fisheries and are managed under the Pacific Salmon Treaty (PST) between the United States and Canada, which requires conservation and equitable sharing of fishery resources. Identifying and protecting rearing habitat for Canadian-origin Chinook salmon, which comprise approximately half of the spawning migration, is an important step in meeting these PST obligations. Therefore, based on the pilot study results of Daum and Flannery (2011), a comprehensive three-year investigation was conducted to determine the extent of Chinook salmon rearing in nonnatal tributary streams of the Yukon River between the U.S.–Canada border and Tanana, Alaska, a distance of over 850 km. Along with distributional, biological, and aquatic habitat information, genetic samples from juvenile fish were analyzed for stock origin. This paper describes the results from this three-year study.

Study Area

The Yukon River is approximately 3,200 km in length, with roughly two thirds of the drainage in the United States and one third in Canada. The study area included tributary streams of the Yukon River main stem located in the U.S. portion of the basin, between 1,118 and 1,970 km upstream from the Yukon River mouth (Figure 2). The area was divided into two, approximately, 250-km sections: one located between the U.S.–Canada border and Circle, Alaska and the second upstream of the Tanana River confluence. Streams in the upper area originate from the Ogilvie Mountains to the north of the Yukon River and the Yukon-Tanana Uplands to the south, while streams in the lower section originate from the Ray Mountains to the north and the Yukon-Tanana Uplands to the south. Between the two sampling areas, the Yukon River passes through 350 km of the Yukon Flats, an extensive wetland area consisting of a wide, multi-braided floodplain characterized by extensive side channels, slough systems, and low topographic relief. The major contributor to flows in Yukon River tributary streams during early summer is from snowmelt while late summer flows are mostly from rainfall (Brabets et al. 2000). Streams are typically ice-free by early May and freeze-up occurs from late September to mid-October. Summer turbidity in tributary streams is highly variable depending on localized rain events and erosion after forest fires. The Yukon River main stem in this area is highly turbid throughout the summer months with glacier-driven, suspended-sediment concentrations averaging 200 mg/L with peaks of over 2,000 mg/L (Brabets et al. 2000). During winter months, glacial input ceases and the Yukon River main stem becomes clear.

Methods

Stream Selection

Tributary streams of the Yukon River between Tanana, Alaska and the U.S.–Canada border were selected for potential juvenile Chinook salmon sampling between 2008 and 2010 (Figure 2).

Prior to sampling, U.S. Geological Survey 1:250,000 scale topographic maps were used to identify stream locations and site coordinates were entered into a boat-mounted, global positioning system. The primary goal of this investigation was to document new nonnatal rearing areas, so streams with known spawning populations or previously described rearing locations were excluded (Barton 1984; Daum 1994; Eiler 2006a, Eiler 2006b; Johnson and Weiss 2007; Daum and Flannery 2011). An exception was Mission Creek 1 near Eagle (Figure 3, reference #3). This stream was previously documented to contain juvenile Chinook salmon (Daum and Flannery 2011), but was selected because of it's connectivity to American Creek (Figure 3, reference #4). It should be noted that two different streams named "Mission Creek" were selected during this study. To avoid confusion between the two sites, the stream near Eagle is referred to as Mission Creek 1, and the stream near Tanana designated as Mission Creek 2.

After initial selection, candidate streams were investigated in the field to determine fish sampling potential. Only tributary streams with access to the main-stem Yukon River (juvenile immigration pathway), either by direct main-channel connection or through side-channel habitat, were selected for sampling. Streams with no noticeable flow, intermittent connection to the Yukon River main stem, or difficult foot access were not selected. Some small streams, not originally noted from maps, were added on site.

Fish Sampling

Streams were generally sampled in a systematic order, beginning near the U.S.–Canada border and ending near Tanana, Alaska. Sampling schedules were based on timing data from previous downstream migrant studies of age-0 Chinook salmon in the Canadian Yukon River main stem (Brown et al. 1976; Walker 1976; Bradford et al. 2008) and subsequent entry into nonnatal streams (Bradford et al. 2001; Daum and Flannery 2011). Sampling dates were delayed each successive year as distance downstream from the border increased. Stream sampling began above any visible influence from the main-stem Yukon River and continued upstream for 0.5 to 6 km, depending on stream accessibility and sampling gear placement constraints.

Fish were captured using minnow traps and beach seines as described by Daum and Flannery (2011). Catch per unit effort was recorded for minnow trapping as the number of Chinook salmon juveniles captured per trap-day (24-hour) and for seining as juveniles per haul. Caution should be taken when comparing catch data between streams, since many factors affecting catch rates were not evaluated, i.e., gear saturation, standardized effort, uniform catch rates, constant catchability, and standardized sampling within specific habitat types (Hubert 1996; Hubert and Fabrizio 2007).

Collection of biological data from captured juvenile Chinook salmon followed techniques used by Daum and Flannery (2011). Fork length (FL) was measured to the nearest millimeter and weight was measured to the nearest 0.1 g. A maximum of 30 fish per stream were measured. An exception was American Creek (Figure 3, reference #4) where sampling occurred twice in 2008 (July and September). Fulton's condition factor (K) was used to estimate the fitness of age-0 Chinook salmon in each sample stream. Fulton's K was calculated by dividing fish weight by the cube of the length and multiplying by 10^5 (Anderson and Neumann 1996). Juveniles <85 mm FL were classified as age 0 (young-of-year) based on temporally-adjusted length at age data from Duncan and Bradford (2006). Scale samples from fish ≥85 mm FL were collected and aged in the USFWS laboratory in Fairbanks. From past upper Yukon River studies, it was expected that most age-1 fish would have smolted before sampling began (Bradford et al. 2008; Daum and

Flannery 2011). When other fish species were captured, species and life stage (juvenile or adult) were noted.

Genetic Collections and Processing

A sample of genetic tissue (from the anal fin) was collected from each juvenile Chinook salmon measured for length and weight. Tissue was stored in 2-ml vials containing 100% ethanol. The samples were genotyped at 13 standardized microsatellite loci using methods described in Daum and Flannery (2011). Before genetic analysis, all samples were confirmed to species using diagnostic loci with non-overlapping allele size distributions.

Stock Composition and Individual Assignment Analyses of Genetic Samples

The genotypes of captured Chinook salmon were compared to a genetic baseline representing 34 major spawning populations of Yukon River Chinook salmon (Table 1; Figure 1; Daum and Flannery 2011). Distances from upper Yukon River baseline populations to the U.S.–Canada border and to the Yukon River mouth are presented in Table 2. The 34 genetically defined populations were further divided into 10 regional stock groupings based on neighbor-joining results, geography, and management goals (Daum and Flannery 2011). Stock composition and individual assignment of the sampled juveniles were estimated to region and country using the program cBAYES (Neaves et al. 2005). Individuals were assigned to region and country of origin if their posterior source probabilities were ≥95%; otherwise, they were classified as unknown. Samples were analyzed by collection year, with individual assignments also compiled by collection site or area. The probability of unrepresented extra-baseline stocks being present in the 2008–2010 samples was tested using HWLER (Pella and Masuda 2006). Detailed descriptions of the cBAYES and HWLER analyses, the genetic techniques used, and results from baseline testing are presented in Daum and Flannery (2011).

Stream Habitat Measurements

Physical stream characteristics were described for each sampled stream in the study. Stream order was assigned based on Strahler (1957). Watershed area (km^2) for each stream was calculated by first importing the 1:24,000 scale Yukon Basin National Hydrography Dataset (NHD) Flowline data layer (USGS 2006) into ESRI ArcMap (ver. 9.02) and then measuring watershed area with ArcMap digital measuring tool. Stream type was described using the Rosgen (1996) classification system. Stream gradient (%) of the lower stream reach was determined from U.S. Geological Survey 1:63,360 scale topographic maps (McMahon et al. 1996). The dominant stream bottom substrate for each lower stream reach was assigned using substrate classification according to Platts et al. (1983). Seasonal accessibility to the tributary stream from either the main-stem Yukon River or through side-channel habitat (smaller braids) was estimated using direct observations. Digital photographs were taken of each sample stream and outlet area. Any streams or parts of drainages found to contain juvenile Chinook salmon not previously reported in the Alaska Anadromous Waters Catalog (Johnson and Weiss 2007) were nominated for inclusion. A handheld global positioning system (geographic coordinate datum NAD 83) was used to record the upper extent of juvenile Chinook salmon distribution for each stream. Physical stream measurements are presented as a generalized description of each sampled stream or reach and should not be used to infer microhabitat preferences for rearing Chinook salmon.

Water quality measurements were collected near each stream's mouth (upstream of any Yukon River influence) and included water temperature, river stage, water color, conductivity, and pH. All measurements were taken once per stream (during juvenile fish sampling). Water

temperature was taken using a handheld, pocket case thermometer, standardized with a National Institute of Standards and Technology traceable thermometer. River stage and water color were described qualitatively. Conductivity and pH were measured with a Hach multi-meter, Model HQ40D. The multi-meter was calibrated and periodically checked with appropriate standards during field measurements.

Results

Stream Selection

Ninety-seven Yukon River tributary streams were selected as possible candidates: 26 streams in 2008; 45 streams in 2009; and 26 streams in 2010 (Table 3; Figures 2–6). The upper sample area (between the U.S.–Canada border and Circle, Alaska) contained 40 streams and the lower sample area (upstream of Tanana, Alaska) contained 57 streams. Upon field investigation, 40 of the 97 streams initially identified as possible candidates were not sampled due to unsuitable rearing habitat or site accessibility issues (Table 4). Most unsampled streams were from 2009, when a prolonged drought caused many streams to run completely dry. These streams were not re-visited in 2010.

Fish Sampling

The remaining 57 streams were sampled for the presence of Chinook salmon juveniles: 21 streams in 2008, 16 streams in 2009, and 20 streams in 2010 (Table 3; Figures 2–6). Streams were visited once, between mid-July and August, depending on distance downstream from the U.S.–Canada border (farthest downstream sites generally sampled later in the year than upstream sites). Two exceptions to the sampling schedule occurred in 2008; American Creek (Figure 3, reference #4) was sampled twice (July and September) and Mission Creek 1 (Figure 3, reference #3) was sampled only in September (previously sampled in 2006 and 2007; Daum and Flannery 2011). Juvenile Chinook salmon were captured in 45 of the 57 streams sampled. Distances from these rearing streams to the U.S.–Canada border and to the Yukon River mouth are presented in Table 5.

Over the 3-year study, minnow trapping (324 trap-days) and seining (8 hauls) yielded 946 juvenile Chinook salmon (Table 6). All captured Chinook salmon were classified as age 0 based on measured length and scale age verification for fish ≥85 mm FL. The highest catch rate in the upper sample area was from the September sample in American Creek (23 fish per trap-day; Figure 3, reference #4). For the lower sample area, the highest catch rates came from the Big Salt River (10 fish per trap-day; Figure 5, reference #50) and Spicer Creek (24 fish per trap-day; Figure 6, reference #94). Eleven fish species were captured from the 57 sampled streams (Table 6). These species included Chinook salmon, Arctic grayling *Thymallus arcticus*, burbot *Lota lota*, chum salmon *O. keta*, coho salmon *O. kisutch*, Dolly Varden *Salvelinus malma*, humpback whitefish *Coregonus pidschian*, lake chub *Couesius plumbeus*, longnose sucker *Catostomus catostomus*, round whitefish *Prosopium cylindraceum*, and slimy sculpin *Cottus cognatus.* Most fish captured were juveniles. Chinook salmon, Arctic grayling, longnose sucker, and slimy sculpin were the most common species captured. Species diversity was similar to previous studies on larger rivers and small streams in the region using similar gear types (Daum 1994; Johnson and Weiss 2007; Daum and Flannery 2011). Coho salmon juveniles were only found in the lower sample area, near Tanana, Alaska (Schieffelin and Jackson creeks; Figure 6, reference #91 and #96, respectively). Arctic grayling, burbot, chum and coho salmon, Dolly Varden, humpback whitefish, and round whitefish were only captured when juvenile Chinook salmon were also present. Fork lengths of juvenile Chinook salmon ranged from 46 to 95 mm and

weights ranged from 0.7 to 9.1 g, with early captured fish (July) being the smallest and late captured fish (September) being the largest (Table 7). Condition (*K*) varied from 0.68 to 1.68, with no apparent trend in condition with sample site location or sample date. American Creek (Figure 3, reference #4)) was sampled twice in 2008, July 17 and September 9. The average length of captured fish in the July sample was 63.8 mm and in September was 75.6 mm (an increase of 18%), while average weight increased from 2.5 to 4.3 g (an increase of 72%). Condition (*K*) remained fairly constant between the two American Creek samples, with July captures averaging 0.94 and September averaging 0.96.

Genetic Collections and Processing

Of the 45 streams found to contain age-0 Chinook salmon, 616 genetic samples were collected (Table 8). A total of 611 (99%) were successfully genotyped at a minimum of 10 of the 13 loci. All genotyped samples field identified as Chinook or coho salmon were genetically confirmed.

Stock Composition and Individual Assignment Analyses of Genetic Samples

The HWLER analysis indicated with a probability of 90–96% that no significant stocks were missing from the baseline for the 2008–2010 collections. Stock composition analysis of the 2008–2010 juvenile samples indicated that Canadian-origin Chinook salmon contributed between 88% and 100% to the yearly mixtures, with Canadian percentages decreasing with increased distance from the U.S.–Canada border (Table 9). Fish from the Carmacks region in Canada contributed 82% to the mixtures in 2008, 86% in 2009, and 71% in 2010. Individual assignment results were similar to the stock composition analysis with 100% of the assigned samples being of Canadian origin in 2008, 98% in 2009, and 91% in 2010 (Tables 10–12). Four of the 10 Yukon River stock regions were represented in the individual assignment analysis, with no regions downstream from the sampled streams represented in the individually assigned samples. The Carmacks regional group made up 96% of the individuals assigned in 2008, 97% in 2009, and 85% in 2010. A few fish from the Pelly ($n = 5$) and Stewart ($n = 1$) river stock groups of Canada were present, though no fish were identified from the Lower Canada, White, Upper Canada, and Teslin groups. Little Salt Creek (Figure 5, reference #51), downstream from the Dalton Highway Bridge, was the first stream containing a U.S.-origin stock (Table 11), 672 km downstream from the U.S.–Canada border (Table 5). The farthest downriver stream (Mission Creek 2 near Tanana, 847 km downstream from the U.S.–Canada border) had a fish from the Carmacks regional group, an estimated travel distance of over 1,300 km. Overall, individual assignment with the ≥95% probability criterion resulted in 54% of the 611 individuals being assigned to specific regions and 96% to country.

Habitat Measurements

Physical characteristics varied substantially among the 57 sampled streams (Table 13). Streams containing juvenile Chinook salmon were generally similar to streams where Chinook salmon were not captured. Stream order varied from first to fourth order in streams with and without Chinook salmon juveniles. Watershed area ranged from 5 to 682 km^2, with the four largest drainages (Eagle Creek, Mission Creek 1 near Eagle, Washington Creek, and Big Salt River) containing juveniles. Gradient also varied considerably among sampled streams, from 0.3 to 9.9%, with the four highest gradient streams (Unnamed creeks #7, #55, #67 and #79) being absent of juveniles. These streams were all small, ranging in stream order from 1 to 2 and watersheds <13 km^2. The dominant substrate varied from silt to boulder for streams with and without juvenile Chinook salmon and the Rosgen stream type varied from B4 to E5. Thirty-three streams containing juveniles had direct access from the main-stem Yukon River and twelve

streams were accessed through side-channel habitat. All study streams with two or more juvenile Chinook salmon captured (Table 6) were nominated and accepted for inclusion into the Alaska Anadromous Waters Catalog.

Water quality measurements were highly variable among sampled streams (Table 14). Water temperature varied between 2 and 20ºC, with streams ≥14ºC not yielding any juvenile Chinook salmon. River stage was rated low for all sampled streams in 2009 and 2010. Many streams that were investigated in 2009 were dry. In 2010, an active wildfire was burning in the headwaters of Canyon Creek (Figure 6, reference #81), causing extremely muddy conditions during sampling (no fish captured). Water color varied from clear to muddy, with juveniles present in all water color types. Conductivity ranged from 108 to 824 µS/cm and pH varied from 6.6 to 8.5, with juvenile Chinook salmon found in a wide range of water chemistry values.

Discussion

This study substantially expanded on the initial 2006–2007 investigation of eight tributary streams in the upper U.S. portion of the Yukon River (Daum and Flannery 2011). Fifty-seven streams were sampled for juvenile Chinook salmon presence and selected habitat characteristics from 2008 through 2010, with juveniles captured in 45 of the sampled streams. Forty additional sites were identified but low water conditions precluded sampling many of these streams in 2009. Re-visiting these sites during more favorable water conditions should document additional rearing streams in this portion of the Yukon River drainage.

Juvenile Chinook salmon originating from upstream spawning grounds were found in tributary streams throughout the study area, from Boundary Creek near the U.S.–Canada border downstream to Mission Creek 2 by Tanana, a distance of approximately 850 km. Juveniles were found in a wide variety of stream and habitat types, with stream access directly from the Yukon River main stem or through side-channel braids. Large and small streams contained rearing Chinook salmon, from 1st to 4th order streams and watersheds areas from 9 to 682 km^2. Juveniles were not captured in small shallow streams with high gradients and few pools. Mossop and Bradford (2006) found that steeper gradient streams in the Canadian portion of the upper Yukon River had lower densities of rearing Chinook salmon than lower gradient streams. Habitat features influencing juvenile abundance included quantity and depth of residual pools, channel morphology, and amount of large wood debris. In our study, lower reaches of large streams with low gradient, slow flow, high relative water temperature, and lack of cover were absent of juvenile Chinook salmon. It is not known if these areas are avoided by juveniles in response to predation risk and food availability as suggested by Metcalfe et al. (1999), or used as short-term, temporal migratory corridors to reach preferred habitat farther upstream.

Similar to the 2006–2007 findings (Daum and Flannery 2011), age-0 Chinook salmon from the Carmacks region of Canada represented the vast majority of individually-assigned, downstream captures (93%). The largest Canadian river systems (Stewart, Pelly, and Teslin rivers) were underrepresented in the stream collections, representing <2% of samples. Unlike the 2006–2007 study, no Upper Canada, White, or Lower Canada regional groups were found. The Upper U.S. group was identified in 10 downstream sites beginning approximately 670 km downstream from the U.S.–Canada border. These streams were substantially downstream from the three spawning populations represented in the baseline (Beaver Creek, Chandalar and Sheenjek rivers), but without an exhaustive population-specific baseline, specific spawning origins of these captured fish can not be determined.

Study results suggest that the full extent of rearing areas by Canadian-origin Chinook salmon in U.S. streams have yet been described. Future sampling of Yukon River tributary streams below the Tanana River confluence should yield farther downstream dispersal distances. These long-range movements by almost exclusively one regional stock, the Carmacks group, beg the question as to why these fish have a greater propensity to disperse to distant rearing streams than other stock groups in the upper Yukon River drainage and what, if any, cost is associated with this long-distance dispersal strategy.

Acknowledgements

Special appreciation is extended to those who contributed to this project: P. Sanders and staff of Yukon-Charley Rivers National Park and Preserve in Eagle; T. Beacham and A. von Finster of Department of Fisheries and Oceans, Canada; J. Johnson of Alaska Department of Fish and Game; M. Bradford of Simon Fraser University; Stan Zuray of Rapids Research Center; students of the Eagle Community School and Maudry J. Sommer School of Tanana; and J. Adams, R. Brown, B. Carter, L. Daum, and C. Lewis of USFWS. Funding for this project was provided by the USFWS Fairbanks Fish and Wildlife Field Office and Conservation Genetics Laboratory, the Alaska Sustainable Salmon Fund, and the Restoration and Enhancement Fund of the Yukon River Panel.

References

Anderson, R.O., and R.M. Neumann. 1996. Length, weight, and associated structural indices. Pages 447–482 *in* B.R. Murphy and D.W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Barton, L.H. 1984. A catalog of Yukon River salmon spawning escapement surveys. Alaska Department of Fish and Game, Division of Commercial Fisheries, Technical Data Report 121, Juneau, Alaska.

Beacham, T.D., C.B. Murray, and R.E. Withler. 1989. Age, morphology, and biochemical genetic variation of Yukon River Chinook salmon. Transactions of the American Fisheries Society 118:46–63.

Beacham, T.D., M. Wetklo, C. Wallace, J.B. Olsen, B.G. Flannery, J.K. Wenburg, W.D. Templin, A. Antonovich, and L.W. Seeb. 2008. The application of microsatellites for stock identification of Yukon River Chinook salmon. North American Journal of Fisheries Management 28:283–295.

Brabets, T.P., B. Wang, and R.H. Meade. 2000. Environmental and hydrologic overview of the Yukon River Basin, Alaska and Canada. U.S. Geological Survey, Water-Resources Investigations Report 99-4204, Anchorage, Alaska.

Bradford, M.J., J. Duncan, and J.W. Jang. 2008. Downstream migrations of juvenile salmon and other fishes in the upper Yukon River. Arctic 61:255–264.

Bradford, M.J., J.A. Grout, and S. Moodie. 2001. Ecology of juvenile Chinook salmon in a small non-natal stream of the Yukon River drainage and the role of ice conditions on their distribution and survival. Canadian Journal of Zoology 79:2043–2054.

Brown, R.F., M.S. Elson, and L.W. Steigenberger. 1976. Catalogue of aquatic resources of the Upper Yukon River drainage (Whitehorse Area). Environment Canada, Fisheries and Marine Service Technical Report PAC/T-76-4.

Daum, D.W. 1994. Fisheries investigations on the Kandik, Charley, Nation, and Tatonduk rivers, Yukon-Charley Rivers National Preserve, 1987 and 1988. U.S. Fish and Wildlife Service, Fairbanks Fishery Resource Office, Alaska Fisheries Technical Report 23, Fairbanks, Alaska.

Daum, D.W., and B.G. Flannery. 2011. Canadian-origin Chinook salmon rearing in nonnatal U.S. tributary streams of the Yukon River, Alaska. Transactions of the American Fisheries Society 140:207–220.

Duncan, J., and M. Bradford. 2006. Yukon River juvenile Chinook and chum salmon out-migration timing and sampling characteristics as determined using a rotary screw trap, 2004. Report to Yukon River Panel, Project Number CRE-01-04.

Eiler, J.H., T.R. Spencer, J.J. Pella, and M.M. Masuda. 2006a. Stock composition, run timing, and movement patterns of Chinook salmon returning to the Yukon River basin in 2003. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-163.

Eiler, J.H., T.R. Spencer, J.J. Pella, and M.M. Masuda. 2006b. Stock composition, run timing, and movement patterns of Chinook salmon returning to the Yukon River basin in 2004. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-165.

Flannery, B.G., P.A. Crane, J.H. Eiler, T.D. Beacham, N.A. Decovich, W.D. Templin, O.L. Schlei, and J.K. Wenburg. in press. Comparison of radio telemetry and microsatellites for determining the origin of Yukon River Chinook salmon. North American Journal of Fisheries Management.

Gilbert, C.H. 1922. The salmon of the Yukon River. U.S. Bureau of Fisheries Bulletin 38:317–332.

Healey, M.C. 1983. Coastwide distribution and ocean migration patterns of stream- and ocean-type Chinook salmon, *Oncorhynchus tshawytscha*. Canadian Field-Naturalist 97:427–433.

Hubert, W.A. 1996. Passive capture techniques. Pages 157–181 *in* B.R. Murphy and D.W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Hubert, W.A., and M.C. Fabrizio. 2007. Relative abundance and catch per unit effort. Pages 279–325 *in* C.S. Guy and M.L. Brown, editors. Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda, Maryland.

Johnson, J., and E. Weiss. 2007. Catalog of waters important for spawning, rearing, or migration of anadromous fishes - Interior Region, effective June 1, 2007. Alaska Department of Fish and Game, Habitat Division, Special Publication 07-04, Anchorage, Alaska.

McMahon, T.E., A.V. Zale, and D.J. Orth. 1996. Aquatic habitat measurements. Pages 83–120 *in* B.R. Murphy and D.W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Metcalfe, N.B., N.H.C. Fraser, and M.D. Burns. 1999. Food availability and the nocturnal vs. diurnal foraging trade-off in juvenile salmon. Journal of Animal Ecology 68:371-381.

Moodie, S., J.A. Grout, and A. von Finster. 2000. Juvenile Chinook salmon (*Oncorhynchus tshawytscha*) utilization of Croucher Creek, a small non-natal tributary of the upper Yukon River during 1993. Department of Fisheries and Oceans, Canadian Manuscript Report of Fisheries and Aquatic Sciences 2531.

Mossop, B., and M.J. Bradford. 2004. Importance of large woody debris for juvenile Chinook salmon habitat in small boreal forest streams in the upper Yukon River basin, Canada. Canadian Journal of Forest Resources 34:1955–1966.

Mossop, B., and M.J. Bradford. 2006. Using thalweg profiling to assess and monitor juvenile salmon (*Oncorhynchus* spp.) habitat in small streams. Canadian Journal of Fisheries and Aquatic Sciences 63:1515–1525.

Murray, C.B., M.A. Henderson, and T.D. Beacham. 1990. Size and scale characteristics of upper Yukon River juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Department of Fisheries and Oceans, Canadian Technical Report of Fisheries and Aquatic Sciences 1767.

Neaves, P.I., C.G. Wallace, J.R. Candy, and T.D. Beacham. 2005. CBayes: computer program for mixed stock analysis of allelic data, version v4.02. Free program distributed by the authors over the internet from http://www.pac.dfo-mpo.gc.ca/sci/mgl/Cbayes_e.htm.

Pella, J., and M. Masuda. 2006. The Gibbs and split-merge sampler for population mixture analysis from genetic data with incomplete baselines. Canadian Journal of Fisheries and Aquatic Sciences 63:576–596.

Perry, R.W., M.J. Bradford, and J.A. Grout. 2003. Effects of disturbance on contribution of energy sources to growth of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in boreal streams. Canadian Journal of Fisheries and Aquatic Sciences 60:390–400.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-138.

Rosgen, D. 1996. Applied river morphology, 2nd edition. Wildland Hydrology, Pagosa Springs, Colorado.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. Transactions of the American Geophysical Union 38:913–920.

USGS (U.S. Geological Survey). 2006. Yukon Basin NHD Flowline data layer. U.S. Geological Survey, National Hydrography Dataset, Reston, Virginia.

Walker, C.E. 1976. Studies on the freshwater and anadromous fishes of the Yukon River within Canada. Fisheries and Marine Service, Canadian Technical Report PAC/T-76-7.

Table 1. Genetic baseline collections by sampled population, region, collection year, and number of fish sampled (*n*) from 34 Yukon River Chinook salmon populations. See map in Figure 1 for stream locations.

Population	Region	Sample year	*n*
Andreafsky	Lower USA	2003	208
Anvik	Lower USA	2002	94
Gisasa	Lower USA	2001	188
Henshaw	Upper USA	2001	147
South Fork Koyukuk	Upper USA	2003	56
Tozitna	Lower USA	2003	190
Kantishna	Tanana	2005	187
Chena	Tanana	2001	189
Salcha	Tanana	2003, 2004	133
Beaver	Upper USA	1997	100
Chandalar	Upper USA	2002, 2003	113
Sheenjek	Upper USA	2002, 2004, 2006	51
Chandindu	Lower Canada	1998, 2000, 2001, 2003, 2004	566
Klondike	Lower Canada	1995, 1999, 2001, 2002, 2003	102
Stewart	Stewart	1996, 1997	110
Mayo	Stewart	1992, 1997, 2003	195
Tincup	White	2003	32
Pelly	Pelly	1996, 1997	125
Big Kalzas	Pelly	2003	22
Little Kalzas	Pelly	2003, 2004	40
Earn	Pelly	2003, 2004	54
Glenlyon	Pelly	2003	23
Blind	Pelly	1997, 2003, 2004	161
Tatchun	Carmacks	1987, 1996, 1997, 2002, 2003	366
Yukon main stem	Carmacks	1987, 2002	27
Little Salmon	Carmacks	1987, 1997	100
Big Salmon	Carmacks	1987, 1997	116
Nordenskiold	Carmacks	2003	99
Takhini	Upper Canada	1997, 2002, 2003	167
Whitehorse	Upper Canada	1985, 1987, 1997	241
Wolf	Upper Canada	1995, 2003	59
Michie	Upper Canada	1994	47
Nisutlin	Teslin	1987, 1997	56
Morley	Teslin	1997, 2002, 2003	28

Table 2. Distances from the confluence of each tributary to Yukon River mouth and U.S.–Canada border for genetic baseline populations in the upper Yukon River drainage.

Regional groups and populations	Distance from (km)	
	Yukon River mouth	U.S.–Canada border
Upper USA		
Beaver Creek	1,436	534
Chandalar River	1,580	390
Sheenjek River	1,696	441
U.S.–Canada Border	*1,970*	*0*
Lower Canada		
Chandindu River	2,068	98
Klondike River	2,100	130
Stewart		
Stewart River	2,196	226
Mayo River	2,426	456
White		
Tincup Creek	2,489	519
Pelly		
Pelly River	2,356	386
Big Kalzas River	2,481	511
Little Kalzas River	2,486	516
Earn River	2,526	556
Glenlyon River	2,581	611
Blind Creek	2,641	671
Carmacks		
Tatchun Creek	2,439	469
Yukon main stem (above Tatchun Creek)	2,439	469
Little Salmon River	2,510	540
Big Salmon River	2,558	588
Nordenskiold River	2,467	497
Upper Canada		
Takhini River	2,701	731
Whitehorse	2,719	749
Wolf Creek	2,732	762
Michie Creek	2,774	804
Teslin		
Nisutlin River	2,830	860
Morley River	2,832	862

Table 3. Candidate stream, location, survey date, and juvenile Chinook salmon present for 97 tributary streams of the Yukon River, 2008–2010. If Chinook salmon were present, coordinates (datum NAD 83) are from the uppermost capture site; otherwise, locations are from tributary confluence with main-stem Yukon River. Map reference refers to numbering of stream locations on Figures 3–6. Streams are geographically ordered by stream location, upstream to downstream.

Stream	Map reference	Coordinates Lat (N)	Long (W)	Survey date	Survey type	Chinook salmon captured
Boundary Creek	1	64.68027	141.00546	7/17/2008	fish sampling	Yes
Eagle Creek	2	64.77488	141.03609	7/17/2008	fish sampling	Yes
Mission Creek 1	3	64.79539	141.20703	9/9/2008	fish sampling	Yes
American Creek (trib to Mission Creek)	4	64.79128	141.23784	7/17/2008 9/9/2008	fish sampling	Yes Yes
Unnamed Creek #A	5	65.04560	141.32893	7/24/2008	observation	N/A
Unnamed Creek #3	6	65.09008	141.37588	7/18/2008	observation	N/A
Unnamed Creek #4	7	65.10148	141.39755	7/18/2008	observation	N/A
Montauk Creek	8	65.09987	141.51237	7/18/2008	observation	N/A
Unnamed Creek #6	9	65.14222	141.66050	7/25/2008	fish sampling	Yes
Unnamed Creek #7	10	65.15988	141.69058	8/6/2008	fish sampling	No
Unnamed Creek #8	11	65.17975	141.67471	7/20/2008	fish sampling	No
Unnamed Creek #38	12	65.18435	141.67945	7/20/2008	fish sampling	No
Michigan Creek	13	65.19445	141.80950	8/9/2008	fish sampling	Yes
Fourth of July Creek	14	65.19514	141.82910	8/9/2008	fish sampling	Yes
Bull Creek	15	65.19728	141.85392	7/21/2008	observation	N/A
Unnamed Creek #39	16	65.21141	141.81915	7/21/2008	fish sampling	No
Schley Creek	17	65.21528	141.88545	7/23/2008	fish sampling	Yes
Unnamed Creek #13	18	65.24973	141.88942	8/7/2008	fish sampling	Yes
Butte Creek	19	65.25477	141.95822	7/23/2008	fish sampling	Yes
Rock Creek	20	65.27908	141.93770	8/11/2008	fish sampling	Yes
Logan Creek	21	65.27045	141.99664	7/23/2008	fish sampling	Yes
Glenn Creek	22	65.29718	142.09320	8/11/2008	fish sampling	Yes
Washington Creek	23	65.31777	142.31344	8/13/2008	fish sampling	Yes
Unnamed Creek #19	24	65.33649	142.39714	8/13/2008	fish sampling	Yes
Weshrinarin Creek	25	65.33152	142.46496	8/12/2008	fish sampling	Yes
Unnamed Creek #21	26	65.40006	142.64161	8/14/2008	fish sampling	Yes
Andrew Creek	27	65.36621	143.03994	7/29/2009	fish sampling	No
Edwards Creek	28	65.36398	143.20793	7/29/2009	fish sampling	No
Woodchopper Creek	29	65.35153	143.32633	7/31/2009	fish sampling	Yes
Unnamed Creek #25	30	65.35512	143.39650	7/30/2009	fish sampling	Yes
Webber Creek	31	65.40512	143.54997	7/31/2009	fish sampling	Yes
Eureka Creek	32	65.44012	143.57140	8/1/2009	fish sampling	Yes
Takoma Creek	33	65.45906	143.68441	8/1/2009	observation	N/A
Unnamed Creek #34	34	65.56690	143.89718	8/2/2009	observation	N/A
Unnamed Creek #35	35	65.57023	143.91937	8/2/2009	observation	N/A
Unnamed Creek #36	36	65.58203	143.98402	8/2/2009	observation	N/A
Unnamed Creek #29	37	65.68329	144.06976	8/2/2009	observation	N/A
Fourteenmile Creek	38	65.71062	144.05337	8/2/2009	observation	N/A
Unnamed Creek #32	39	65.79603	143.95872	8/3/2009	observation	N/A
Jefferson Creek	40	65.85060	143.96300	8/2/2009	observation	N/A
Hamlin Creek	41	65.89305	149.22742	8/20/2009	observation	N/A
Waldron Creek	42	65.86230	149.31563	8/20/2009	observation	N/A

Table 3. continued.

Stream	Map reference	Coordinates Lat (N)	Long (W)	Sampling date	Survey type	Chinook salmon captured
Unnamed Creek #43	43	65.87017	149.41000	8/20/2009	observation	N/A
Unnamed Creek #44	44	65.87540	149.44672	8/20/2009	observation	N/A
Unnamed Creek #45	45	65.88358	149.45115	8/20/2009	observation	N/A
Unnamed Creek #46	46	65.88320	149.51005	8/20/2009	observation	N/A
Unnamed Creek #47	47	65.88005	149.57805	8/20/2009	observation	N/A
Unnamed Creek #49	48	65.85817	149.77468	8/20/2009	observation	N/A
Unnamed Creek #50	49	65.85150	149.84738	8/20/2009	observation	N/A
Big Salt River	50	65.85433	149.90849	8/22/2009	fish sampling	Yes
Little Salt Creek	51	65.80754	150.07631	8/22/2009	fish sampling	Yes
Unnamed Creek #53	52	65.79322	150.11218	8/23/2009	fish sampling	Yes
Unnamed Creek #54	53	65.77838	150.12187	8/23/2009	observation	N/A
Unnamed Creek #55	54	65.76307	150.09255	8/24/2009	fish sampling	No
Unnamed Creek #56	55	65.76880	149.92032	8/23/2009	observation	N/A
Unnamed Creek #57	56	65.76208	149.92631	8/24/2009	fish sampling	No
Unnamed Creek #58	57	65.76155	149.89543	8/23/2009	observation	N/A
Unnamed Creek #59	58	65.76618	149.87892	8/23/2009	observation	N/A
Isom Creek	59	65.75027	149.78691	8/25/2009	fish sampling	Yes
Clinton Creek	60	65.71637	149.81485	8/25/2009	observation	N/A
McDermott Creek	61	65.64507	149.81255	8/25/2009	observation	N/A
Alder Creek	62	65.62308	149.87843	8/25/2009	observation	N/A
Unnamed Creek #65	63	65.62358	149.88723	8/25/2009	observation	N/A
Twentymile Creek	64	65.64054	149.92165	8/26/2009	fish sampling	Yes
Unnamed Creek #67	65	65.63912	150.16273	8/28/2009	fish sampling	No
Unnamed Creek #68	66	65.61652	150.17640	8/27/2009	observation	N/A
Sarah Creek	67	65.60250	150.18545	8/28/2009	fish sampling	Yes
Susie Creek	68	65.58228	150.17119	8/29/2009	fish sampling	Yes
Unnamed Creek #71	69	65.57598	150.14370	8/28/2009	observation	N/A
Hannah Creek	70	65.57155	150.15370	8/28/2009	observation	N/A
Chicago Creek	71	65.55873	150.12222	8/28/2009	observation	N/A
Russian Creek	72	65.47957	150.27302	8/4/2010	fish sampling	Yes
Sixmile Creek	73	65.48582	150.37627	8/4/2010	fish sampling	Yes
Marshall Creek	74	65.48789	150.51585	8/4/2010	observation	N/A
Roadhouse Creek	75	65.50059	150.55666	8/5/2010	fish sampling	Yes
Unnamed Creek #79	76	65.49440	150.57482	8/6/2010	fish sampling	No
Unnamed Creek #80	77	65.49318	150.62387	8/5/2010	observation	N/A
Moose Creek	78	65.46625	150.68737	8/6/2010	fish sampling	Yes
Fish Creek	79	65.42117	150.75360	8/7/2010	observation	N/A
Unnamed Creek #83	80	65.43464	150.75744	8/7/2010	fish sampling	Yes
Canyon Creek	81	65.42893	150.80168	8/8/2010	fish sampling	No
Unnamed Creek #97	82	65.41210	150.89910	8/9/2010	fish sampling	Yes
Stevens Creek	83	65.39293	150.88530	8/9/2010	fish sampling	No
Bear Creek	84	65.36561	151.00031	8/10/2010	fish sampling	Yes
Texas Creek	85	65.34478	150.99454	8/11/2010	fish sampling	Yes
Jordan Creek	86	65.29466	151.12137	8/19/2010	fish sampling	Yes
Cheyenne Creek	87	65.24680	151.23330	8/19/2010	fish sampling	Yes

Table 3. continued.

Stream	Map reference	Coordinates Lat (N)	Coordinates Long (W)	Sampling date	Survey type	Chinook salmon captured
Windy Creek	88	65.26143	151.24143	8/19/2010	observation	N/A
Quartz Creek	89	65.26223	151.36369	8/20/2010	fish sampling	Yes
Unnamed Creek #98	90	65.22996	151.43403	8/20/2010	observation	N/A
Schieffelin Creek	91	65.22890	151.44560	8/21/2010	fish sampling	Yes
Unnamed Creek #99	92	65.18211	151.46074	8/22/2010	fish sampling	Yes
Unnamed Creek #92	93	65.18407	151.62038	8/21/2010	observation	N/A
Spicer Creek	94	65.20162	151.71960	8/24/2010	fish sampling	Yes
Coal Creek	95	65.20742	151.77553	8/24/2010	fish sampling	Yes
Jackson Creek	96	65.20872	151.82990	8/25/2010	fish sampling	Yes
Mission Creek 2	97	65.19512	151.96862	8/26/2010	fish sampling	Yes

Table 4. Tributary streams of the Yukon River investigated, but not sampled for juvenile Chinook salmon, and comments on observed stream characteristics, 2008–2010. For stream locations refer to Table 3 and Figures 3–6.

Stream	Comments
Unnamed Creek #A	flowing mud, no riffles, old burn area above, unlikely Chinook habitat
Unnamed Creek #3	> 6 m drop to Yukon, inaccessible to fish, fast current
Unnamed Creek #4	2 m steep drop to Yukon, limited access to fish, fast current
Montauk Creek	hard to access by foot above mouth, mud bottom, thick alder/willow banks
Bull Creek	hard to access by foot above mouth, lots of beaver activity, draining large flats
Takoma Creek	creek dry
Unnamed Creek #34	creek dry
Unnamed Creek #35	very small, no flow, mud and gravel bottom, no riffles
Unnamed Creek #36	no flow, mud banks and bottom, no riffles, Yukon backed up > 1 km into creek
Unnamed Creek #29	creek dry
Fourteenmile Creek	creek dry
Unnamed Creek #32	creek dry, intermittent pools, pool/riffle stream type
Jefferson Creek	no flow, log jam in mouth, muddy incised banks, Yukon backed up into creek
Hamlin Creek	creek dry
Waldron Creek	creek dry
Unnamed Creek #43	creek dry
Unnamed Creek #44	creek dry
Unnamed Creek #45	creek dry
Unnamed Creek #46	creek dry
Unnamed Creek #47	creek dry
Unnamed Creek #49	creek dry
Unnamed Creek #50	creek dry
Unnamed Creek #54	creek dry
Unnamed Creek #56	creek dry
Unnamed Creek #58	creek dry
Unnamed Creek #59	creek dry
Clinton Creek	creek dry
McDermott Creek	no flow, mud banks and bottom, no riffles
Alder Creek	little flow, tannic stain, very shallow, silt banks and bottom, Yukon backed up 40 m
Unnamed Creek #65	creek dry
Unnamed Creek #68	creek dry
Unnamed Creek #71	creek dry
Hannah Creek	creek dry
Chicago Creek	creek dry
Marshall Creek	creek dry
Unnamed Creek #80	creek dry
Fish Creek	fire in 2009, muddy water, difficult foot access, stream incised, muddy banks
Windy Creek	2 m waterfall at mouth, no access to fish, small creek
Unnamed Creek #98	very little flow, mud bottom and banks
Unnamed Creek #92	creek dry

Table 5. Distances from the confluence of each tributary to Yukon River mouth and U.S.–Canada border for streams with captured juvenile Chinook salmon, 2008–2010. Place names in italics.

	Distance from (km)	
Sampled stream	Yukon River mouth	U.S.-Canada border
U.S.–Canada Border	*1,970*	*0*
Boundary Creek	1,969	1
Eagle Creek	1,959	11
Eagle	*1,952*	*18*
Mission Creek 1	1,951	19
American Creek (trib to Mission Creek)	1,953	20
Unnamed Creek #6	1,881	89
Michigan Creek	1,870	100
Fourth of July Creek	1,869	101
Schley Creek	1,867	103
Unnamed Creek #13	1,863	107
Butte Creek	1,860	110
Rock Creek	1,859	111
Logan Creek	1,858	112
Glenn Creek	1,853	117
Washington Creek	1,838	132
Unnamed Creek #19	1,834	136
Weshrinarin Creek	1,830	140
Unnamed Creek #21	1,819	151
Woodchopper Creek	1,786	184
Unknown Stream #25	1,783	187
Webber Creek	1,774	196
Eureka Creek	1,771	199
Circle	*1,708*	*262*
Yukon River Bridge (Haul Road)	*1,320*	*650*
Big Salt River	1,308	662
Little Salt Creek	1,298	672
Unnamed Creek #53	1,296	674
Isom Creek	1,279	691
Twentymile Creek	1,261	709
Sarah Creek	1,242	728
Susie Creek	1,239	731
Rampart	*1,228*	*742*
Russian Creek	1,222	748
Sixmile Creek	1,217	753
Roadhouse Creek	1,208	762
Moose Creek	1,200	770
Unnamed Creek #83	1,194	776
Unnamed Creek #97	1,187	783
Bear Creek	1,179	791
Texas Creek	1,177	793
Jordan Creek	1,170	800
Cheyenne Creek	1,162	808
Quartz Creek	1,157	813
Schieffelin Creek	1,152	818
Unnamed Creek # 99	1,147	823
Spicer Creek	1,134	836
Coal Creek	1,132	838
Jackson Creek	1,130	840
Mission Creek	1,123	847
Tanana	*1,118*	*852*

Table 6. Fish sampling effort, number sampled (*n*), and catch-per-unit-effort (CPUE) of age-0 Chinook salmon, and other fish species captured or observed for 57 tributary streams of the Yukon River, 2008–2010. CPUE for minnow traps are expressed as fish per trap-day and for seining as fish per haul. Life stage for other fish species indicated by letter "j" for juvenile and "a" for adult.

		Chinook salmon		
Stream	Effort	*n*	CPUE	Other fish species captured [1]
		2008		
Boundary Creek	5.9 d	42	7.2 /d	AGj, LNSj, SSja
Eagle Creek	5.8 d	29	5.0 /d	LNSj, SSja
Mission Creek 1(late)	4.3 d	23	5.4 /d	- -
American (early)	5.9 d	135	23.0 /d	SSja
Creek (late)	4.1 d	18	4.4 /d	SSja
Unnamed Creek #6	6.9 d	12	1.8 /d	- -
Unnamed Creek #7	5.9 d	0	0.0 /d	LNSj, SSja
Unnamed Creek #8	2.2 d	0	0.0 /d	- -
Unnamed Creek #38	2.3 d	0	0.0 /d	SSja
Michigan Creek	6.6 d	21	3.2 /d	LNSj, SSja
Fourth of July Creek	4.5 d	5	1.1 /d	- -
Unnamed Creek #39	1.7 d	0	0.0 /d	LCHa, LNSj
Schley Creek	5.6 d	5	0.9 /d	- -
Unnamed Creek #13	5.8 d	32	5.6 /d	BBj, LNSj
Butte Creek	4.6 d	1	0.2 /d	AGj, SSja
	8 hauls	13	1.6 /haul	AGj, HWFj, LNSj, RWFj,
Rock Creek	5.5 d	6	1.1 /d	AGj, SSja
Logan Creek	5.8 d	11	1.9 /d	SSja
Glenn Creek	5.8 d	16	2.8 /d	SSja
Washington Creek	5.5 d	1	0.2 /d	- -
Unnamed Creek #19	5.4 d	3	0.6 /d	AGj
Weshrinarin Creek	6.3 d	4	0.6 /d	AGj, LNSj, SSja
Unnamed Creek #21	4.5 d	6	1.3 /d	SSja
		2009		
Andrew Creek	6.4 d	0	0.0 /d	- -
Edwards Creek	6.3 d	0	0.0 /d	LNSa
Woodchopper Creek	4.4 d	2	0.5 /d	LNSj, RWFj
Unnamed Creek #25	5.2 d	3	0.6/ d	AGj, LNSj, SSja
Webber Creek	5.5 d	11	2.0 /d	BBj
Eureka Creek	6.1 d	15	2.5 /d	AGj, SSja
Big Salt River	6.5 d	65	10.0 /d	CSa, LNSj, SSja
Little Salt Creek	6.5 d	55	8.5 /d	AGj, LNSj, SSja
Unnamed Creek #53	6.0 d	8	1.3 /d	AGj, SSja
Unnamed Creek #55	5.5 d	0	0.0 /d	SSja

Table 6. continued.

Stream	Effort	Chinook salmon *n*	Chinook salmon CPUE	Other fish species captured [1]
Unnamed Creek #57	5.5 d	0	0.0 /d	SSja
Isom Creek	5.9 d	3	0.5 /d	AGj
Twentymile Creek	6.5 d	45	6.9 /d	AGj, LNSj, SSja
Unnamed Creek #67	5.9 d	0	0.0 /d	SSja
Sarah Creek	6.1 d	4	0.7/ d	AGj, SSja
Susie Creek	4.8 d	1	0.2 /d	AGj, BBj, SSja
		2010		
Russian Creek	6.0 d	18	3.0 /d	AGj, LNSj
Sixmile Creek	6.0 d	1	0.2 /d	CSa, LNSj, SSja
Roadhouse Creek	4.8 d	2	0.4 /d	BBj, SSja
Unnamed Creek #79	3.1 d	0	0.0 /d	SSja
Moose Creek	5.9 d	2	0.3 /d	BBj, CSa, LNSj, SSja
Unnamed Creek #83	7.3 d	2	0.3 /d	AGj, BBj, DVj, SSja
Canyon Creek	6.5 d	0	0.0 /d	- -
Unnamed Creek #97	7.1 d	2	0.3 /d	SSja
Stevens Creek	6.3 d	0	0.0 /d	LNSj, SSja
Bear Creek	6.1 d	29	4.7 /d	BBj, CSa, LNSj
Texas Creek	5.5 d	25	4.6 /d	BBj, LNSj, SSja
Jordan Creek	5.8 d	1	0.2 /d	AGja, CSa, DVj, LNSj, SSja
Cheyenne Creek	5.7 d	2	0.4 /d	LNSj, SSja
Quartz Creek	5.9 d	28	4.8 /d	AGj, BBj, DVj, SSja
Schieffelin Creek	6.8 d	49	7.3 /d	CSa, COj
Unnamed Creek #99	6.4 d	24	3.8 /d	- -
Spicer Creek	6.0 d	144	24.0 /d	AGja, BBj, CSa, SSja
Coal Creek	6.4 d	12	1.9 /d	AGj, LNSj, SSja
Jackson Creek	6.1 d	6	1.0 /d	CSa, COj, SSja
Mission Creek 2	5.9 d	4	0.7 /d	DVj, LNSj, SSja

[1] AG=Arctic grayling, BB=Burbot, CS=chum salmon, CO=coho salmon, DV=Dolly Varden, HWF=humpback whitefish, KS=Chinook salmon, LCH=lake chub, LNS=longnose sucker, RWF=round whitefish, SS=slimy sculpin

Table 7. Sample statistics for length and weight analyses of age-0 Chinook salmon from 45 tributary streams of the Yukon River, 2008–2010. Streams are arranged by collection date (not geographically ordered).

Stream	Date	*n*	Fork length (mm) mean (SE)	Weight (g) mean (SE)	Fulton *K* mean (SE)
			2008		
Boundary Creek	07/17	30	58.7 (0.7)	1.9 (0.1)	0.95 (0.01)
Eagle Creek	07/17	29	57.4 (0.8)	1.8 (0.1)	0.93 (0.01)
American Creek (early)	07/17	30	63.8 (0.9)	2.5 (0.1)	0.94 (0.01)
Schley Creek	07/23	5	60.6 (2.5)	2.0 (0.3)	0.85 (0.04)
Butte Creek	07/23	14	64.6 (1.5)	2.8 (0.2)	1.04 (0.05)
Logan Creek	07/23	11	61.2 (1.6)	2.4 (0.2)	1.02 (0.02)
Unnamed Creek #6	07/25	12	64.4 (0.8)	2.6 (0.1)	0.98 (0.01)
Unnamed Creek #13	08/07	30	67.2 (0.9)	3.0 (0.1)	0.98 (0.01)
Michigan Creek	08/09	21	70.8 (1.9)	3.7 (0.3)	0.99 (0.01)
Fourth of July Creek	08/09	4	63.8 (2.5)	2.6 (0.3)	0.98 (0.02)
Rock Creek	08/11	6	67.8 (2.6)	3.3 (0.4)	1.04 (0.02)
Glenn Creek	08/11	16	66.7 (1.0)	3.1 (0.2)	1.02 (0.01)
Weshrinarin Creek	08/12	4	66.8 (2.0)	3.1 (0.3)	1.03 (0.01)
Washington Creek	08/13	1	71.0	3.6	1.01
Unnamed Creek #19	08/13	3	69.7 (2.6)	3.4 (0.2)	1.00 (0.08)
Unnamed Creek #21	08/14	6	65.5 (2.6)	2.9 (0.4)	1.03 (0.02)
Mission Creek 1 (late)	09/09	23	76.4 (1.7)	4.7 (0.4)	1.01 (0.01)
American Creek (late)	09/09	18	75.6 (1.5)	4.3 (0.3)	0.96 (0.01)
			2009		
Unnamed Creek #25	07/30	3	71.7 (4.2)	3.7 (0.5)	1.00 (0.05)
Woodchopper Creek	07/31	2	62.0 (3.0)	2.4 (0.4)	0.98 (0.00)
Webber Creek	07/31	11	65.2 (0.9)	2.8 (0.1)	1.00 (0.01)
Eureka Creek	08/01	15	64.4 (1.5)	2.7 (0.2)	0.99 (0.01)
Big Salt River	08/22	30	71.2 (1.2)	3.6 (0.2)	0.96 (0.01)
Little Salt Creek	08/22	30	73.1 (1.2)	4.0 (0.2)	0.99 (0.01)
Unnamed Creek #53	08/23	8	72.4 (2.5)	3.8 (0.3)	0.97 (0.02)
Isom Creek	08/25	3	65.7 (2.7)	3.1 (0.4)	1.07 (0.04)
Twentymile Creek	08/26	30	69.8 (1.0)	3.3 (0.2)	0.96 (0.01)
Sarah Creek	08/28	4	74.0 (3.3)	4.0 (0.7)	0.94 (0.05)
Susie Creek	08/29	1	73.0	3.7	0.95

Table 7. continued.

Stream	Date	*n*	Fork length (mm) mean (SE)	Weight (g) mean (SE)	Fulton *K* mean (SE)
			2010		
Russian Creek	08/04	18	73.6 (0.9)	4.1 (0.2)	1.01 (0.01)
Sixmile Creek	08/04	1	59.0	2.1	1.02
Roadhouse Creek	08/05	2	65.0 (2.0)	2.7 (0.1)	0.99 (0.05)
Moose Creek	08/06	2	73.0 (1.0)	3.9 (0.2)	1.00 (0.01)
Unnamed Creek #83	08/07	2	80.5 (0.5)	5.3 (0.4)	1.01 (0.06)
Unnamed Creek #97	08/09	2	77.0 (3.0)	4.9 (0.3)	1.08 (0.06)
Bear Creek	08/10	28	72.8 (1.2)	3.9 (0.2)	0.99 (0.01)
Texas Creek	08/11	25	73.4 (0.8)	4.1 (0.1)	1.03 (0.01)
Jordan Creek	08/19	1	80.0	4.8	0.94
Cheyenne Creek	08/19	2	74.5 (5.5)	4.1 (0.8)	0.98 (0.02)
Quartz Creek	08/20	28	72.9 (1.1)	3.9 (0.2)	0.98 (0.01)
Schieffelin Creek	08/21	30	72.3 (1.1)	3.7 (0.2)	0.96 (0.01)
Unnamed Creek #99	08/22	24	74.5 (1.0)	4.5 (0.2)	1.06 (1.01)
Spicer Creek	08/24	30	72.1 (0.7)	3.5 (0.1)	0.94 (0.01)
Coal Creek	08/24	12	75.8 (1.7)	4.5 (0.3)	1.00 (0.02)
Jackson Creek	08/25	6	78.0 (3.0)	5.0 (0.6)	1.01 (0.03)
Mission Creek 2	08/26	4	73.3 (1.8)	4.2 (0.3)	1.07 (0.02)

Table 8. Genetic field collection data and number genotyped for age-0 Chinook salmon sampled from 45 tributary streams of the Yukon River, 2008–2010.

Stream	Field collected (*n*)	Genotyped (*n*)
	2008	
Boundary Creek	30	30
Eagle Creek	29	27
Mission Creek 1 (late)	23	23
American (early)	30	30
Creek (late)	17	17
Unnamed Creek #6	12	11
Michigan Creek	21	21
Fourth of July Creek	4	4
Schley Creek	5	5
Unnamed Creek #13	30	29
Butte Creek	14	14
Rock Creek	6	6
Logan Creek	11	11
Glenn Creek	16	16
Washington Creek	1	1
Unnamed Creek #19	3	3
Weshrinarin Creek	4	4
Unnamed Creek #21	6	6
Total	262	258
	2009	
Woodchopper Creek	2	2
Unnamed Creek #25	3	3
Webber Creek	11	11
Eureka Creek	15	15
Big Salt River	30	30
Little Salt Creek	30	30
Unnamed Creek #53	8	8
Isom Creek	3	3
Twentymile Creek	30	30
Sarah Creek	4	4
Susie Creek	1	1
Total	137	137

Table 8. continued.

Stream	Field collected (*n*)	Genotyped (*n*)
	2010	
Russian Creek	18	18
Sixmile Creek	1	1
Roadhouse Creek	2	2
Moose Creek	2	2
Unnamed Creek #83	2	2
Unnamed Creek #97	2	2
Bear Creek	28	28
Texas Creek	25	25
Jordan Creek	1	1
Cheyenne Creek	2	2
Quartz Creek	28	28
Schieffelin Creek	30	30
Unnamed Creek #99	24	24
Spicer Creek	30	29
Coal Creek	12	12
Jackson Creek	6	6
Mission Creek 2	4	4
Total	217	216
Total (all years)	616	611

Table 9. Age-0 Chinook salmon stock composition estimates from genetic collections (2008, *n* = 258; 2009, *n* = 137; 2010, *n* = 216) with associated standard deviations (SD) and 95% confidence intervals (CI). Mean stock compositions, standard deviation, and 95% confidence intervals were estimated using cBAYES (Neaves et al. 2005).

	Stock composition			
Regional and country groups	Estimate	SD	95% CI	
2008				
Lower USA	0.001	0.002	0.000	0.007
Tanana	0.001	0.001	0.000	0.004
Upper USA	0.002	0.004	0.000	0.016
Lower Canada	0.007	0.007	0.000	0.024
Stewart	0.103	0.033	0.044	0.174
White	0.000	0.002	0.000	0.005
Pelly	0.058	0.019	0.025	0.101
Carmacks	0.815	0.039	0.735	0.885
Upper Canada	0.012	0.013	0.000	0.045
Teslin	0.001	0.002	0.000	0.007
USA	0.004	0.005	0.000	0.018
Canada	0.996	0.005	0.982	1.000
2009				
Lower USA	0.004	0.009	0.000	0.031
Tanana	0.001	0.002	0.000	0.007
Upper USA	0.031	0.018	0.006	0.072
Lower Canada	0.001	0.002	0.000	0.006
Stewart	0.009	0.021	0.000	0.076
White	0.000	0.001	0.000	0.002
Pelly	0.032	0.022	0.002	0.085
Carmacks	0.855	0.046	0.752	0.932
Upper Canada	0.066	0.032	0.010	0.137
Teslin	0.002	0.007	0.000	0.020
USA	0.036	0.020	0.007	0.082
Canada	0.964	0.020	0.918	0.993
2010				
Lower USA	0.001	0.003	0.000	0.011
Tanana	0.006	0.008	0.000	0.028
Upper USA	0.113	0.024	0.069	0.165
Lower Canada	0.012	0.011	0.000	0.037
Stewart	0.111	0.040	0.040	0.198
White	0.000	0.001	0.000	0.002
Pelly	0.037	0.026	0.000	0.097
Carmacks	0.709	0.048	0.612	0.798
Upper Canada	0.008	0.010	0.000	0.035
Teslin	0.001	0.005	0.000	0.017
USA	0.120	0.024	0.076	0.172
Canada	0.880	0.024	0.828	0.924

Table 10. Individual assignments of age-0 Chinook salmon stream samples from 2008 to region and country using cBAYES (Neaves et al. 2005). Individuals were assigned if their source probabilities were at least 95%. Differences in total individuals assigned between region and country result from cases where individuals could not be assigned to region but could be assigned to country. Streams are sequentially ordered, beginning with stream farthest upstream.

Regional and country groups	Absolute number	Relative number
Boundary Creek		
Pelly	1	0.059
Carmacks	16	0.941
Canada	29	1.000
Eagle Creek		
Pelly	1	0.091
Carmacks	10	0.909
Canada	27	1.000
Mission Creek 1		
Carmacks	11	1.000
Canada	23	1.000
American Creek		
Pelly	2	0.077
Carmacks	24	0.923
Canada	47	1.000
Unnamed Creek #6		
Carmacks	7	1.000
Canada	11	1.000
Michigan Creek		
Carmacks	10	1.000
Canada	21	1.000
Fourth of July Creek		
Carmacks	1	1.000
Canada	4	1.000
Schley Creek		
Carmacks	3	1.000
Canada	5	1.000
Unnamed Creek #13		
Carmacks	15	1.000
Canada	29	1.000
Butte Creek		
Carmacks	7	1.000
Canada	13	1.000
Rock Creek		
Carmacks	3	1.000
Canada	6	1.000
Logan Creek		
Carmacks	8	1.000
Canada	11	1.000
Glenn Creek		
Stewart	1	0.077
Carmacks	12	0.923
Canada	16	1.000
Washington Creek		
Carmacks	1	1.000
Canada	1	1.000
Unnamed Creek #19		
Carmacks	1	1.000
Canada	3	1.000
Weshrinarin Creek		
Carmacks	1	1.000
Canada	4	1.000
Unnamed Creek #21		
Carmacks	4	1.000
Canada	6	1.000

Table 11. Individual assignments of age-0 Chinook salmon stream samples from 2009 to region and country using cBAYES (Neaves et al. 2005). Individuals were assigned if their source probabilities were at least 95%. Differences in total individuals assigned between region and country result from cases where individuals could not be assigned to region but could be assigned to country. Streams are sequentially ordered, beginning with stream farthest upstream.

Regional and country groups	Absolute number	Relative number
Woodchopper Creek		
Canada	2	1.000
Unnamed Creek #25		
Carmacks	2	1.000
Canada	3	1.000
Webber Creek		
Carmacks	7	1.000
Canada	11	1.000
Eureka Creek		
Carmacks	12	1.000
Canada	14	1.000
Big Salt River		
Carmacks	23	1.000
Canada	28	1.000
Little Salt Creek		
Upper USA	1	0.050
Carmacks	19	0.950
USA	1	0.037
Canada	26	0.963
Unnamed Creek #53		
Pelly	1	0.167
Carmacks	5	0.833
Canada	8	1.000
Isom Creek		
Carmacks	2	1.000
Canada	3	1.000
Twentymile Creek		
Upper USA	1	0.056
Carmacks	17	0.944
USA	1	0.033
Canada	29	0.967
Sarah Creek		
Carmacks	2	1.000
Canada	3	1.000
Susie Creek		
Carmacks	1	1.000
Canada	1	1.000

Table 12. Individual assignments of age-0 Chinook salmon stream samples from 2010 to region and country using cBAYES (Neaves et al. 2005). Individuals were assigned if their source probabilities were at least 95%. Differences in total individuals assigned between region and country result from cases where individuals could not be assigned to region but could be assigned to country. Streams are sequentially ordered, beginning with stream farthest upstream.

Regional and country groups	Absolute number	Relative number
Russian Creek		
Carmacks	10	1.000
Canada	16	1.000
Sixmile Creek		
Upper USA	1	1.000
USA	1	1.000
Roadhouse Creek		
Canada	1	1.000
Moose Creek		
Upper USA	1	1.000
USA	1	0.500
Canada	1	0.500
Unnamed Creek #83		
Canada	2	1.000
Unnamed Creek #97		
Carmacks	1	1.000
Canada	2	1.000
Bear Creek		
Upper USA	2	0.200
Carmacks	8	0.800
USA	2	0.080
Canada	23	0.920
Texas Creek		
Carmacks	13	1.000
Canada	24	1.000
Jordan Creek		
Canada	1	1.000
Cheyenne Creek		
Canada	2	1.000
Quartz Creek		
Carmacks	13	1.000
Canada	25	1.000
Schieffelin Creek		
Upper USA	5	0.357
Carmacks	9	0.643
USA	5	0.192
Canada	21	0.808
Unnamed Creek #99		
Upper USA	1	0.077
Carmacks	12	0.923
USA	1	0.042
Canada	23	0.958
Spicer Creek		
Upper USA	3	0.214
Carmacks	11	0.786
USA	3	0.111
Canada	24	0.889
Coal Creek		
Carmacks	5	1.000
USA	1	0.091
Canada	10	0.909
Jackson Creek		
Upper USA	1	0.500
Carmacks	1	0.500
USA	1	0.200
Canada	4	0.800
Mission Creek 2		
Upper USA	1	0.500
Carmacks	1	0.500
USA	2	0.500
Canada	2	0.500

Table 13. Selected physical characteristics for 57 tributary streams of the Yukon River sampled for juvenile Chinook salmon, 2008–2010. Gradient, substrate, and Rosgen stream type determined from lower stream reach. Yukon access describes location of tributary stream confluence in relation to Yukon River main stem. Table row italicized when juvenile Chinook salmon absent.

Stream	Stream order	Watershed (km^2)	Gradient (%)	Dominant substrate	Rosgen stream type	Yukon access
			2008			
Boundary Creek	3	93	4.3	Small cobble	C3	Main channel
Eagle Creek	4	531	1.2	Small cobble	C4	Main channel
Mission Creek 1	4	602	0.5	Small cobble	C4	Main channel
American Creek (trib to Mission Creek 1)	4	65	1.0	Small cobble	C3	Main channel via Mission Ck
Unnamed Creek #6	2	18	1.6	Silt	E5	Main channel
Unnamed Creek 7	*1*	*8*	*5.8*	*Gravel*	*B4*	*Main channel*
Unnamed Creek #8	*3*	*20*	*1.4*	*Undetermined*	*E5*	*Side channel*
Unnamed Creek #38	*2*	*11*	*3.1*	*Undetermined*	*E5*	*Side channel*
Michigan Creek	3	103	1.0	Gravel	C4	Side channel
Fourth of July Creek	3	124	1.0	Silt	C4	Side channel
Unnamed Creek #39	*1*	*5*	*3.1*	*Undetermined*	*E5*	*Main channel*
Schley Creek	2	23	2.5	Small cobble	B4	Main channel
Unnamed Creek #13	1	9	2.9	Silt	E5	Side channel
Butte Creek	2	37	2.0	Large cobble	B4	Side channel
Rock Creek	3	92	1.4	Large cobble	B4	Side channel
Logan Creek	3	72	1.2	Small cobble	B4	Side channel
Glenn Creek	2	48	1.7	Large cobble	B4	Side channel
Washington Creek	4	490	0.3	Gravel	C4	Side channel
Unnamed Creek #19	2	25	2.1	Silt	E5	Side channel
Weshrinarin Creek	3	54	1.0	Gravel	B4	Side channel
Unnamed Creek #21	3	31	3.5	Small cobble	B4	Main channel
			2009			
Andrew Creek	*4*	*210*	*0.4*	*Silt*	*C3*	*Side channel*
Edwards Creek	*3*	*99*	*0.5*	*Silt*	*C3*	*Side channel*
Woodchopper Creek	4	196	1.0	Gravel	C3	Main channel
Unnamed Creek #25	2	12	3.3	Large cobble	B4	Main channel
Webber Creek	4	207	0.7	Gravel	C3	Side channel
Eureka Creek	3	143	0.6	Gravel	C3	Side channel
Big Salt River	4	682	0.3	Small cobble	C4	Main channel
Little Salt Creek	3	104	0.9	Small cobble	C3	Main channel
Unnamed Creek #53	3	40	2.6	Small cobble	B4	Main channel
Unnamed Creek #55	*1*	*9*	*9.9*	*Boulder*	*B4*	*Main channel*
Unnamed Creek #57	*3*	*54*	*1.2*	*Gravel*	*E5*	*Main channel*
Isom Creek	4	110	1.2	Gravel	C3	Main channel
Twentymile Creek	4	154	0.8	Gravel	C3	Main channel
Unnamed Creek #67	*2*	*11*	*6.8*	*Gravel*	*E5*	*Main channel*
Sarah Creek	2	37	1.9	Gravel	E5	Main channel
Susie Creek	2	37	1.6	Gravel	E5	Main channel

Table 13. continued.

Stream	Stream order	Watershed (km^2)	Gradient (%)	Dominant substrate	Rosgen stream type	Yukon access
			2010			
Russian Creek	2	51	1.7	Small cobble	E5	Main channel
Sixmile Creek	3	57	1.5	Gravel	E5	Main channel
Roadhouse Creek	3	21	3.4	Sand/silt	B4	Main channel
Unnamed Creek #79	*2*	*12*	*4.8*	*Sand*	*B4*	*Main channel*
Moose Creek	3	94	1.6	Sand	C3	Main channel
Unnamed Creek #83	1	30	1.9	Gravel	B4	Main channel
Canyon Creek	*3*	*212*	*0.7*	*Boulder*	*C3*	*Main channel*
Unnamed Creek #97	2	24	2.1	Sand	E5	Main channel
Stevens Creek	*3*	*267*	*0.3*	*Silt*	*C3*	*Main channel*
Bear Creek	4	215	0.7	Small cobble	C3	Main channel
Texas Creek	2	68	0.8	Gravel/silt	E5	Main channel
Jordan Creek	3	69	0.9	Boulder	E5	Main channel
Cheyenne Creek	3	44	1.0	Small cobble	E5	Main channel
Quartz Creek	2	11	3.7	Sand/gravel	B4	Main channel
Schieffelin Creek	2	86	1.3	Sand/silt	C3	Main channel
Unnamed Creek #99	2	12	3.9	Small cobble	B4	Main channel
Spicer Creek	3	72	0.9	Sand/silt	E5	Main channel
Coal Creek	1	11	2.9	Large cobble	B4	Main channel
Jackson Creek	3	94	1.0	Large cobble	E5	Main channel
Mission Creek 2	2	36	1.7	Small cobble	E5	Main channel

Table 14. Water quality measurements for 57 tributary streams of the Yukon River sampled for juvenile Chinook salmon, 2008–2010. Variables not measured represented by "NM". Table row italicized when juvenile Chinook salmon absent.

Stream	Water temperature (ºC)	River stage	Water color	Conductivity (µS/cm)	pH
		2008			
Boundary Creek	8.0	Medium	Clear	404	6.80
Eagle Creek	11.0	Medium	Tannic	462	8.09
Mission Creek 1 (late)	5.0	Medium	Clear	NM	NM
American Creek (early)	8.0	Medium	Tannic	346	6.60
American Creek (late)	6.0	Medium	Clear	NM	NM
Unnamed Creek #6	7.0	Medium	Tannic	141	7.02
Unnamed Creek #7	*2.0*	*Medium*	*Muddy*	*563*	*7.85*
Unnamed Creek #8	*4.0*	*High*	*Muddy*	*248*	*7.30*
Unnamed Creek #38	*4.0*	*High*	*Muddy*	*319*	*7.69*
Michigan Creek	5.0	High	Muddy	218	6.97
Fourth of July Creek	5.0	Medium	Muddy	301	7.09
Unnamed Creek #39	*NM*	*High*	*Muddy*	*NM*	*NM*
Schley Creek	4.0	High	Tannic	281	7.13
Unnamed Creek #13	6.0	Medium	Muddy	295	6.68
Butte Creek	5.0	High	Tannic	267	6.98
Rock Creek	5.0	Medium	Muddy	519	7.60
Logan Creek	5.0	High	Tannic	108	6.68
Glenn Creek	3.0	Medium	Muddy	176	7.33
Washington Creek	6.0	Medium	Muddy	137	6.63
Unnamed Creek #19	6.0	Medium	Clear	344	7.20
Weshrinarin Creek	5.0	Medium	Tannic	188	7.35
Unnamed Creek #21	4.0	Medium	Tannic	639	8.15
		2009			
Andrew Creek	*16.5*	*Low*	*Tannic*	*529*	*7.34*
Edwards Creek	*20.0*	*Low*	*Tannic*	*824*	*7.46*
Woodchopper Creek	10.5	Low	Clear	636	7.22
Unnamed Creek #25	10.5	Low	Tannic	360	7.86
Webber Creek	8.0	Low	Clear	256	6.92
Eureka Creek	8.0	Low	Ferric	725	7.23
Big Salt River	11.0	Low	Clear	149	7.35
Little Salt Creek	7.0	Low	Clear	354	7.62
Unnamed Creek #53	5.0	Low	Clear	325	7.53
Unnamed Creek #55	*5.0*	*Low*	*Clear*	*416*	*8.09*
Unnamed Creek #57	*6.0*	*Low*	*Clear*	*481*	*8.12*
Isom Creek	7.0	Low	Clear	530	7.23
Twentymile Creek	7.0	Low	Clear	234	7.58
Unnamed Creek #67	*4.0*	*Low*	*Clear*	*559*	*8.49*
Sarah Creek	4.0	Low	Clear	442	8.52
Susie Creek	4.0	Low	Clear	369	8.05

Table 14. continued.

Stream	Water temperature (ºC)	River stage	Water color	Conductivity (µS/cm)	pH
		2010			
Russian Creek	7.5	Low	Clear	450	7.36
Sixmile Creek	7.0	Low	Clear	259	7.27
Roadhouse Creek	4.5	Low	Clear	421	7.74
Unnamed Creek #79	*4.0*	*Low*	*Clear*	*631*	*7.79*
Moose Creek	10.5	Low	Clear	789	8.03
Unnamed Creek #83	9.5	Low	Ferric	788	8.09
Canyon Creek [1]	*12.0*	*Low*	*Muddy*	*423*	*8.16*
Unnamed Creek #97	6.5	Low	Clear	529	7.94
Stevens Creek	*14.0*	*Low*	*Muddy*	*244*	*7.85*
Bear Creek	10.0	Low	Clear	402	7.85
Texas Creek	12.0	Low	Muddy	451	8.24
Jordan Creek	11.0	Low	Clear	444	8.39
Cheyenne Creek	9.5	Low	Clear	439	8.25
Quartz Creek	6.0	Low	Clear	551	8.27
Schieffelin Creek	7.5	Low	Clear	317	8.15
Unnamed Creek #99	6.0	Low	Clear	428	8.15
Spicer Creek	7.0	Low	Clear	342	7.76
Coal Creek	5.0	Low	Clear	353	8.21
Jackson Creek	7.5	Low	Clear	324	7.87
Mission Creek 2	6.5	Low	Clear	204	8.01

[1] Active wildfire burning in upper Canyon Creek caused extremely muddy water while sampling.

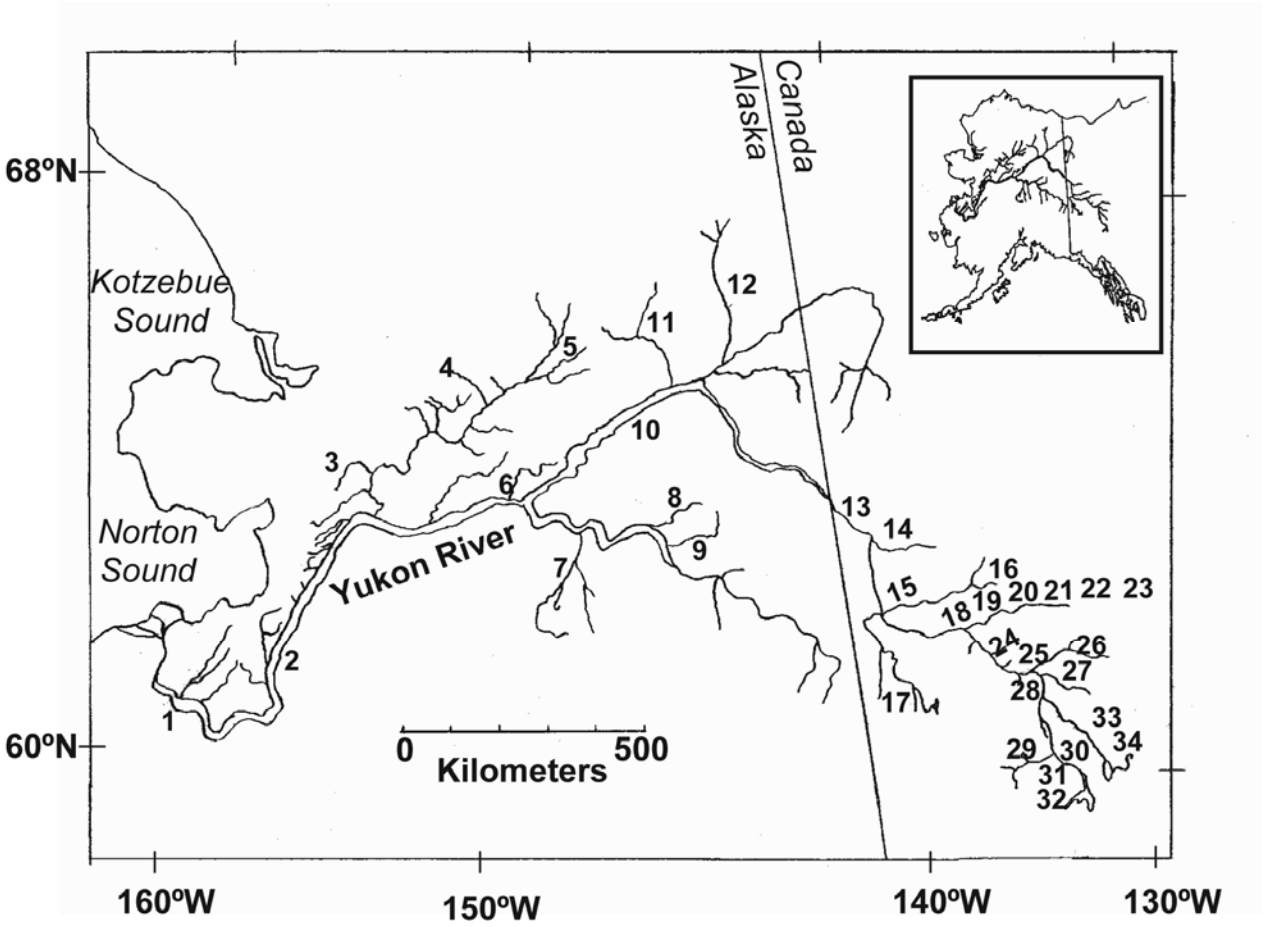

Figure 1. Locations of genetic baseline collections (described in Table 1) for 34 Yukon River Chinook salmon populations: 1=Andreafsky, 2=Anvik, 3=Gisasa, 4=Henshaw, 5=South Fork Koyukuk, 6=Tozitna, 7=Kantishna, 8=Chena, 9=Salcha, 10=Beaver, 11=Chandalar, 12=Sheenjek, 13=Chandindu, 14=Klondike, 15=Stewart, 16=Mayo, 17=Tincup, 18=Pelly, 19=Big Kalzas, 20=Little Kalzas, 21=Earn, 22=Glenlyon, 23=Blind, 24=Tatchun, 25=Yukon main stem, 26=Little Salmon, 27=Big Salmon, 28=Nordenskiold, 29=Takhini, 30=Whitehorse, 31=Wolf, 32=Michie, 33=Nisutlin, and 34=Morley.

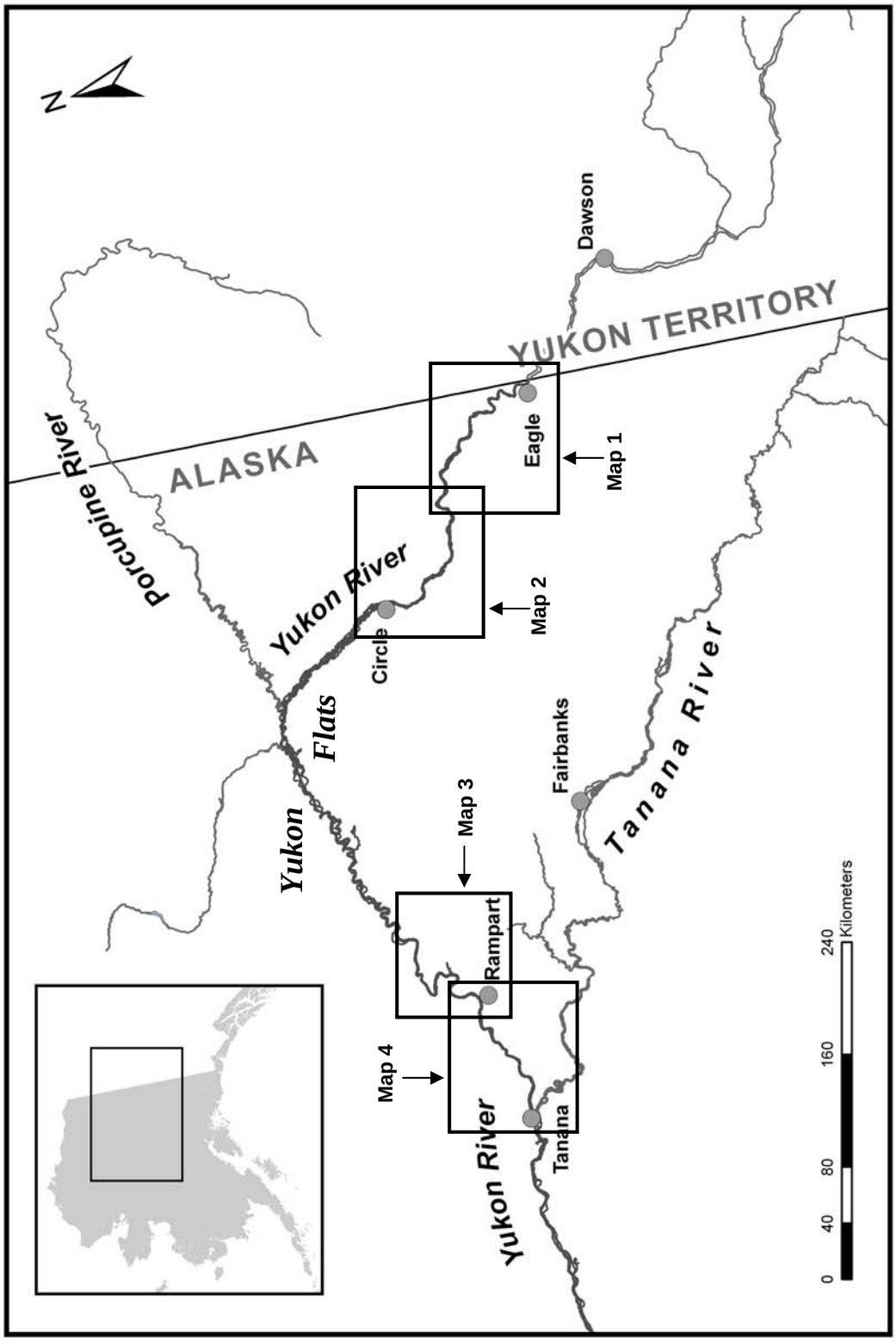

Figure 2. Generalized map of the central Yukon River region with study areas represented by enclosed rectangles (Maps 1–4 presented in Figures 3-6).

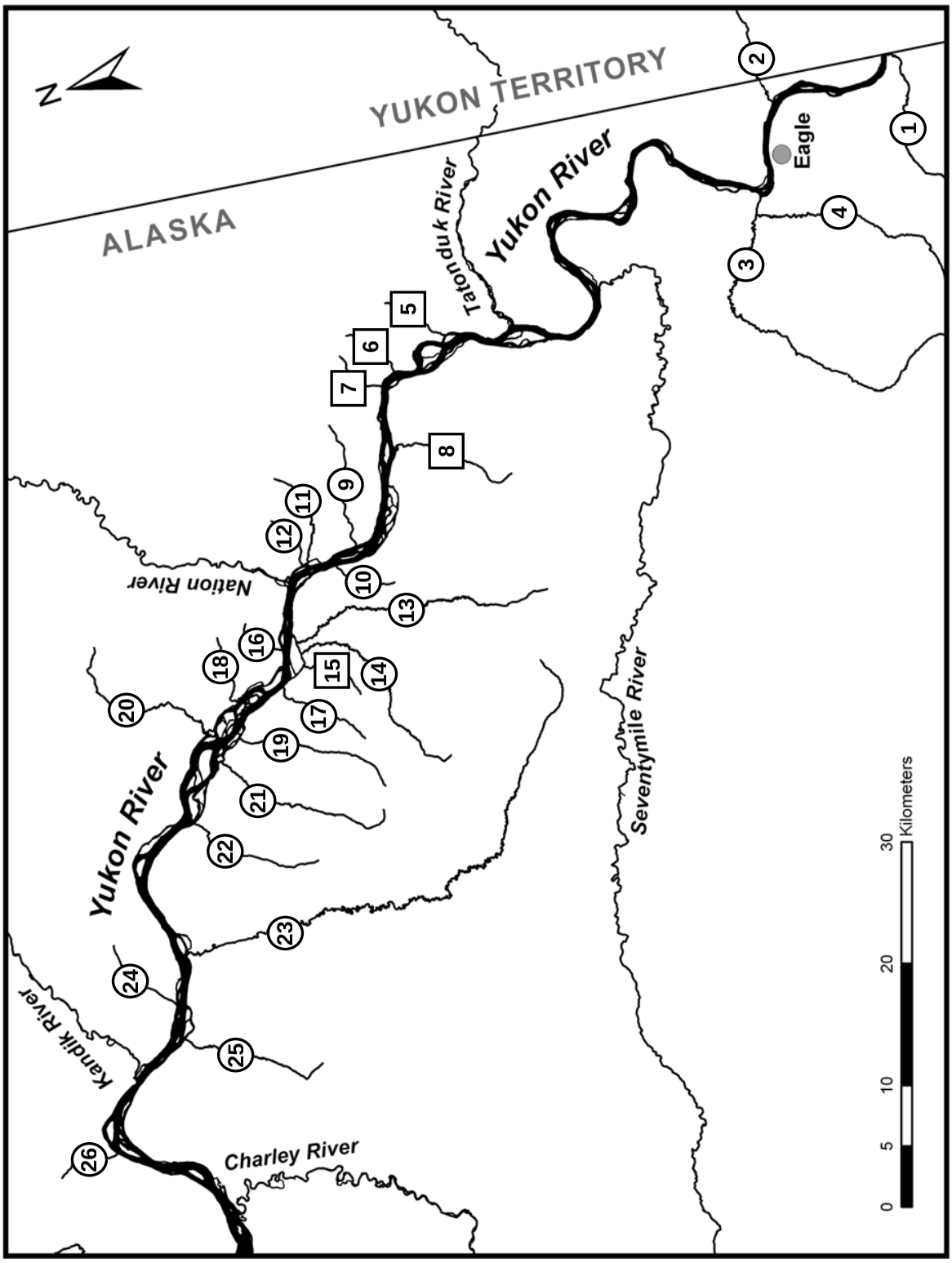

Figure 3. Tributary streams of the Yukon River surveyed in 2008, refer to Figure 2, Map 1. Stream sampled for fish indicated by symbol ○ and observation only (not sampled) represented by □. Table 3 cross-references stream name with map numbering.

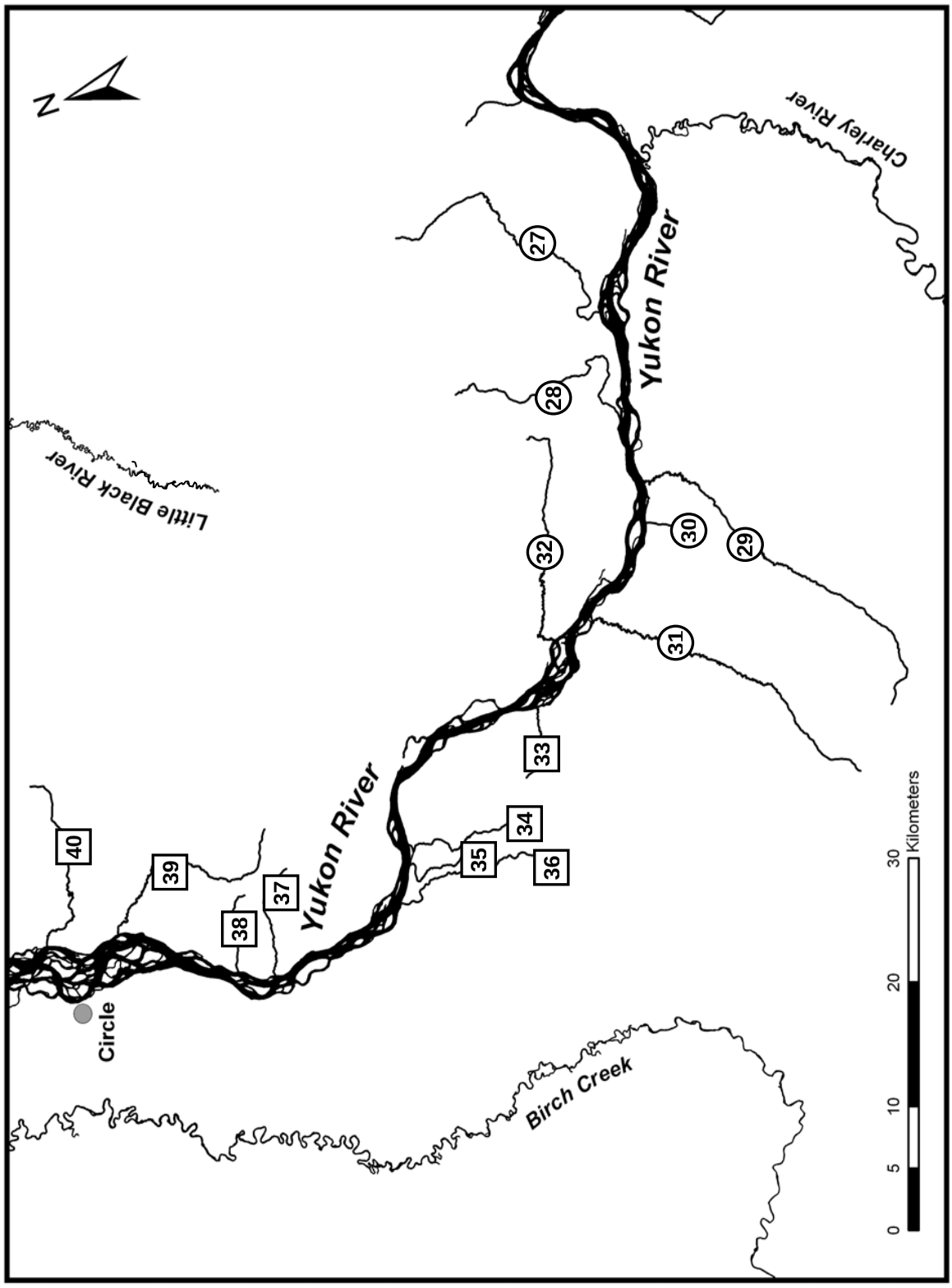

Figure 4. Tributary streams of the Yukon River surveyed during early period, 2009; refer to Figure 2, Map 2. Stream sampled for fish indicated by symbol ○ and observation only (stream not sampled) represented by □. Table 3 cross-references stream name with map numbering.

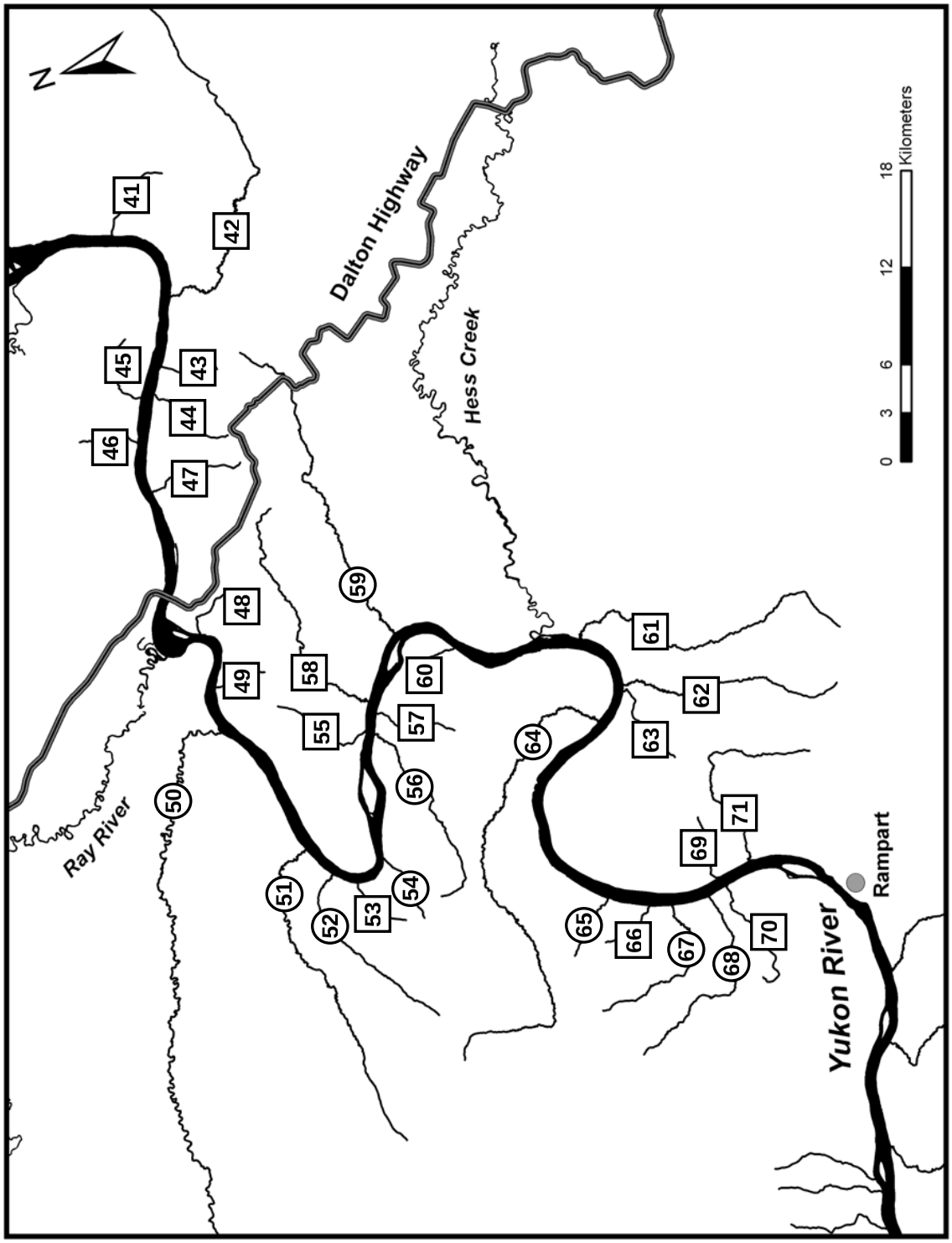

Figure 5. Tributary streams of the Yukon River surveyed in late period, 2009; refer to Figure 2, Map 3. Stream sampled for fish indicated by symbol ○ and observation only (stream not sampled) represented by □. Table 3 cross-references stream name with map numbering.

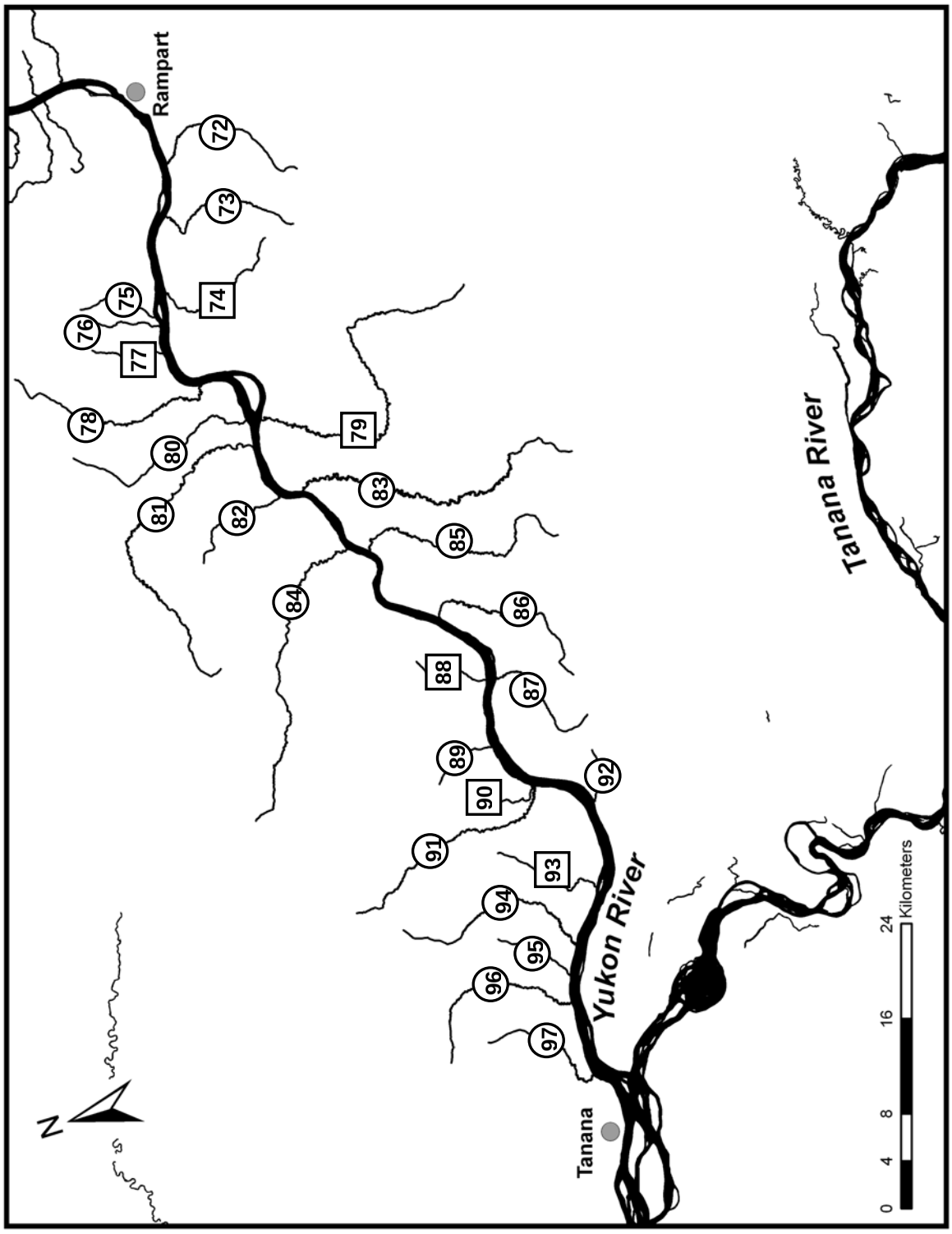

Figure 6. Tributary streams of the Yukon River surveyed in 2010; refer to Figure 2, Map 4. Stream sampled for fish indicated by symbol ○ and observation only (stream not sampled) represented by □. Table 3 cross-references stream name with map numbering.