RADIO TELEMETRY TRACKING OF CHINOOK SALMON IN THE CANADIAN PORTION OF THE YUKON RIVER WATERSHED – 2002

PROJECT RE – 78 - 02

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ABSTRACT

In 2002, a project was initiated to track radio-tagged chinook salmon in the Canadian portion of the upper Yukon River watershed. The purpose of the project was to complement a larger concurrent Yukon River chinook radio-tagging program initiated by U.S. agencies in Alaska. Six remote tracking stations (*RTS's*), in addition to 6 existing *RTS's,* were established at three locations on the mainstem Yukon River and on three primary tributaries. The passage of the radio-tagged chinook recorded by the *RTS's* was used to determine proportional distribution, migration rates and timing, and to make inferences on relative abundance of primary tributary stocks. Aerial tracking surveys were also conducted on the Stewart, Big Salmon and Teslin rivers to obtain more detailed information on chinook spawning distribution in these systems. Other areas of the upper Yukon River basin were surveyed to locate and recover archival radio tags.

Two hundred and fifteen radio-tagged fish, representing 28% of the 768 radio tags applied in 2002 on the lower Yukon River, migrated upstream of the Alaska / Yukon border. A total of 115 radio-tagged fish (60%) entered primary tributaries monitored by *RTS's* with the remaining (40%), either staying in the Yukon River mainstem, or ascending un-monitored tributaries. Proportional distributions of radio-tagged fish ranged from a high of 19% in the Teslin River to a low of 4% in the south Yukon River. Stock specific mean migration rates from the Alaska-Yukon border to the tributary *RTS's* were significantly different and ranged from a high of 50.9 km/day for the Stewart River fish to a low of 43.5 km/day for the south Yukon River fish. There were no significant differences in mean migration rates between gender. There was no distinct separation in run timing among the primary tributary stocks at the Alaska-Yukon border. Run timing at the respective tributary *RTS's* showed the earliest arriving stock was the Stewart River fish and the latest arrivals were associated with the Teslin River system. Indices of abundance for selected tributary stocks were calculated using the DFO 2002 chinook border escapement estimate.

A total of 105 radio tags was detected during the aerial-tracking surveys. These surveys were successful in locating 96% of the radio-tagged fish that were recorded by the RTS located near the mouths of the Stewart, Big Salmon and Teslin rivers. Twenty-one radio-tagged fish were located in the Stewart River, 16 in the Big Salmon River, and 36 in the Teslin River drainages. The remaining tags were located in the Yukon River mainstem, the Pelly system, and other smaller tributaries. Within the Stewart River system, the largest proportion of radio-tagged fish (33) was found in the McQuesten River. In the Big Salmon River drainage the highest concentration of radio tags (30%) were located within 6 km. of the outlet of Big Salmon Lake. In the Teslin River system the largest concentration of fish (73%) was located in the mainstem Teslin River between Hootalinqua and Teslin Lake.

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1.0 INTRODUCTION

In 2000 and 2001 the United States National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADF&G) conducted pilot / feasibility radio telemetry studies on Yukon River chinook salmon (*Onchorhynchus tschawytscha*) (Spencer et al in prep). Based on information from the pilot studies, these agencies initiated a large-scale telemetry project in 2002. The intent of the 2002 project was to radio tag and release up to 1000 returning adult chinook salmon captured throughout the run in the lower Yukon River near the Alaskan towns of Marshall and Russian Mission (Figure 1). Twenty-three archival (recording temperature and depth data) radio tags were applied at the same location and were to be retrieved during the aerial tracking surveys. The radio-tagged fish were to be tracked throughout Alaska and Canada using remote tracking stations (*RTS*'s) (Eiler 1995) and aerial tracking methods.

In 2002, ADF&G, B. Mercer & Associates Ltd (BMA), Haldane Environmental Services (HES), and NMFS applied for and received funding from the Yukon River Restoration and Enhancement (R&E) Fund[1] and Fisheries and Oceans Canada (DFO) to undertake a project to track radio-tagged fish in the Canadian portions of the Yukon River watershed. The purpose of this project was to complement the U.S. program by adding to the six existing *RTS's* in the Yukon Territory and to conduct aerial radio tracking surveys on three of the primary Yukon River tributaries in Canada. This report presents information on the distribution and movements of radio-tagged fish within the upper Yukon River watershed.[2] The Porcupine River, with headwaters in the northern Yukon Territory and portions of the watershed in Alaska, was not

[1] The R&E Fund was established pursuant to the Canada / U.S. Yukon River Salmon Agreement of the Pacific Salmon Treaty. The agreement was proclaimed in Dec. 2002; however the R&E fund has operated since 1996.

[2] A separate comprehensive report detailing the results of tracking radio tagged fish in both Canadian and U.S. portions of the Yukon River basin is to be prepared by NMFS and ADF&G.

included in this study.

Two methods were used in this project to track radio-tagged chinook: *RTS's* and aerial-tracking surveys. The *RTS's* were situated at or near the mouths of principle tributaries and at four locations on the mainstem Yukon River. The *RTS's* were situated to provide information on the proportional distribution of radio-tagged fish to the primary tributaries as well as specific sections of the mainstem Yukon River. Aerial tracking surveys, used to locate the radio-tagged fish within selected tributaries, were judged to be the only efficient and cost effective means of tracking fish in these areas. Sufficient funding was not available to conduct comprehensive aerial surveys of all the primary upper Yukon River tributaries. After consultation with the Restoration and Enhancement Fund (R&E) technical advisor and other Department of Fisheries and Oceans (DFO) staff, it was decided to concentrate aerial survey efforts on the Stewart, Big Salmon, and Teslin River systems. These three tributaries were chosen for comprehensive aerial surveys because: a) there was a paucity of information on chinook spawning distribution within the Stewart River system, particularly in the headwater systems above Fraser Falls; and b) portions of the Big Salmon and Teslin drainages are used by DFO as chinook escapement indices and there was an interest in verifying these indices.

1.1 Objectives

The principal objectives of this project were to:

1. Obtain precise information on the numbers of radio-tagged fish entering large first order tributaries of the upper Yukon River to determine proportional distribution, migration rates and migration timing.

2. Document spawning distributions within the Stewart, Big Salmon and Teslin Rivers through a minimum of 2 comprehensive aerial tracking surveys during the peak spawning period.

3. Validate, by aerial tracking, the passage of radio-tagged fish recorded by the stationary receivers.

4. Determine the location of archival radio tagged fish detected by the RTS, and retrieve the transmitters containing water temperature and depth data.

5. Provide relative abundance indices using the border escapement estimate generated by DFO to enable comparisons with index counts and other population assessment programs conducted by DFO.

Funding for this project came principally from the R&E fund. DFO purchased the RTS towers and electronic components except the radio receivers and data-loggers. Radio transmitters where purchased and applied by NMFS and ADF&G as part of their basin-wide study.

1.2 Study Area

The study area covered by this project is the upper Yukon River[3] and it's principal tributaries. The entire Yukon River drainage is the 5th largest in North America in terms of land area drained and mean annual flows. Approximately 59% of the drainage lies in Alaska; the remaining 41% is situated in the Yukon Territory and northern British Columbia (Todd 1970). The upper Yukon River drains an area of 245,200 km^2. The Stewart, Big Salmon and Teslin Rivers have drainage areas of 51,000, 6,850, and 35,500 square kilometres respectively.

1.3 Chinook Salmon Resource

Adult chinook salmon enter the mouth of the Yukon River in late May / early June after an ocean residency of 2 to 6 years. The Yukon River chinook migration occurs through to early September and represents the longest salmon migration in North America, in terms of distance traveled in fresh water (DFO 2002, Morrow 1980).

The 1995 – 2001 estimates of the lower Yukon River chinook salmon run determined by the ADF&G Pilot Station Sonar Project range from 70,112 to 254,142 (Yukon River Joint Technical Committee 2001). Estimates of the mainstem Alaska/Yukon border escapement for the period 1982 – 2001, determined by a Canadian mark-recapture program, have ranged from 16,995 to 56,679 (Yukon River Joint Technical Committee 2001). The harvest of chinook salmon from the Yukon River in Alaska from all fisheries averaged 154,958 pieces (90% of the total catch of chinook salmon in the Yukon River) during the twenty-year period 1981 – 2000 (Yukon River Joint Technical Committee 2001). On average, approximately one half of the Alaskan Yukon River chinook catch consists of Canadian origin fish. The harvest of chinook salmon from the Canadian portion of the Yukon River from all fisheries over the same time period averaged 17,185 pieces (10% of the total catch of chinook salmon in the Yukon River) (Yukon River Joint Technical Committee 2001).

[3] The upper Yukon River in this report refers to the Canadian portion of the Yukon River watershed, excluding the Porcupine drainage.

1.4 Previous Upper Yukon River Telemetry Studies

Four previous telemetry studies have been conducted on the upper Yukon River salmon in Canada: 3 involving chinook salmon; and one chum study (Milligan et al, 1986). In a 1983 study, 130 radio transmitters were affixed to chinook salmon captured at 4 fish wheel locations between Dawson City and the Alaska - Yukon border (Milligan et al. 1985). In this study, individual fish were tracked daily in the mainstem Yukon, Stewart, White, Pelly and Teslin Rivers from the tagging site until they entered a secondary tributary. Cleugh and Russell (1980) applied radio transmitters to chinook salmon at the Whitehorse Rapids hydroelectric dam site to determine if the dam and the fish-way caused a significant delay in their upstream migration. Matthews (1999) radio-tagged chinook salmon to investigate their distribution upstream of the Whitehorse Rapids Dam fish-way.

The NMFS began large scale radio telemetry studies in 1998 with the installation of 12 *RTS's* throughout the Yukon River drainage in Alaska and 6 *RTS's* in the Yukon Territory in order to track chum salmon. In 1998, 530 chum salmon and 50 chinook salmon, captured in fish wheels at Rampart Rapids in Alaska (up-river from the Yukon-Tanana River confluence), were fitted with radio transmitters and tracked throughout the drainage upstream of the tagging site. The chinook salmon were fitted with radio transmitters primarily to assess their survival and behaviour after handling in preparation for future large scale tracking projects. An automated database and GIS mapping program was developed to plot salmon locations and provide in-season summaries (Eiler and Masters 2000). In 1999, 1050 chum salmon were fitted with radio transmitters at Rampart Rapids and tracked by the 18 *RTS's* in Alaska and Yukon and by aerial tracking surveys (Boyce 1999, Boyce and Eiler 2000).

ADF&G and NMFS began a chinook radio telemetry program in the lower Yukon River drainage in 2000. Ninety-one fish were radio-tagged after being captured with drift gill nets near the Alaskan towns of Marshall and Russian Mission. Fish were tracked by *RTS's* in the lower mainstem Yukon only. The primary objective for the 2000 study was to develop effective capture and release techniques and to refine tracking methods for the mainstem Yukon River. In 2001, 117 chinook salmon and 17 fall chum salmon were radio-tagged at the Marshall and Russian Mission tagging sites. Thirty-one *RTS's* were established in Alaska in preparation for an expanded chinook salmon radio-tagging program in 2002 (Yukon River Joint Technical Committee, 2001). In summary, preparatory work for large scale chinook salmon radio telemetry tracking in 2002 involved: a) the application of 50 transmitters plus the establishment of the RTS network in 1998; b) the application of 91 transmitters in 2000; and c) the application of 117 transmitters and the expansion of the RTS network in 2001.

2.0 MATERIALS AND METHODS

2.1 Remote Tracking Stations

2.1.1 Description of Remote Tracking Station Equipment

The RTS tower structures were fabricated by a manufacturer in Whitehorse, Yukon. The remaining tower components were purchased from Canadian and U.S. vendors. The radio receivers and data collection computers (DCC) for each station were rented for the season from Advanced Telemetry Systems (ATS) of Isanti, Minnesota. ATS equipment was used to maintain uniformity with the transmitters and RTS

equipment used in the ADF&G and NMFS study. All 6 *RTS's* were set up and tested prior to deployment to ensure that all electronic components were functioning correctly.

Eiler (1995) describes the RTS structure and equipment in detail. Some of the electronic components have changed slightly since 1995 and therefore, a description of the station components is given here. A portable aluminium-tubing tower, 10 meters in height, served as the basic framework to which antennas, solar panels and an electronic equipment housing were attached (Figures 2 & 3). Two, four-element Yagi antennas were attached to the top of the mast with approximately 1-meter vertical separation. An antenna, for transmitting data to a geo-stationary operational environmental satellite (GOES), was attached near the midpoint of the mast and oriented at a 10° upward angle from horizontal toward the satellite. All electronic components (receiver, data collection computer, switch box, GOES) were located within a weatherproof housing attached to the mast and one of the tower's three extendable legs. All coaxial cables and wiring connecting antennas and power supply to the electronic equipment were shielded within flexible metal conduit to protect against external damage by animals and weather. Electrical power was supplied by 6 six-volt gelled lead-acid batteries connected in series-parallel to provide 12 volts DC output. The batteries were charged by 2 solar panels attached to the tower above the housing. An insulated fibreglass container, located on the ground between the tower legs, housed the battery bank.

2.1.2 Remote Tracking Station Site Selection

Helicopter flights were undertaken in mid-May to select station sites on the Stewart, White, Pelly, Big Salmon, Teslin and south Yukon

rivers[4]. Representatives of the Little Salmon / Carmacks and the Tr'ondëk Hwëch'in First Nations participated in site selection. Several topographic criteria as summarized below, needed to be satisfied for an optimal site:

1. An elevated site above the river channel of greater than 30 meters to maximize reception range.
2. A site located along a section of river that had a straight channel free of islands and sandbars over a distance of 0.5 – 1.0 km., both upstream and downstream.
3. A site close enough to the channel to provide for adequate 'foreshore' coverage. A signal emanating from close to the near bank should have a clear line of transmission to the tower antennas.
4. A site with a clear line of transmission to avoid signal blockage or deflection by trees, islands, ridges and to provide the satellite transmission antenna with a 10° angle above the horizon, facing due south.
5. A site with difficult access from the river was desirable to provide some security for the equipment.
6. A site with level terrain in close proximity to the tower placement to provide for a helicopter landing zone.

Due to the braided nature of the White River, a suitable site for a single station could not be located and an alternate site on the Yukon River mainstem approximately 4 km. upstream of the White River was selected. A site with adequate elevation and security protection could not be located on the Teslin River so an alternate site was selected approximately 7 kilometers downstream of the confluence of the Teslin and Yukon rivers. RTS names and locations are illustrated in Figure 1.

[4] In this report, south Yukon River refers to that portion of the Yukon River south of its confluence with the Teslin River, to maintain consistency with DFO maps and databases.

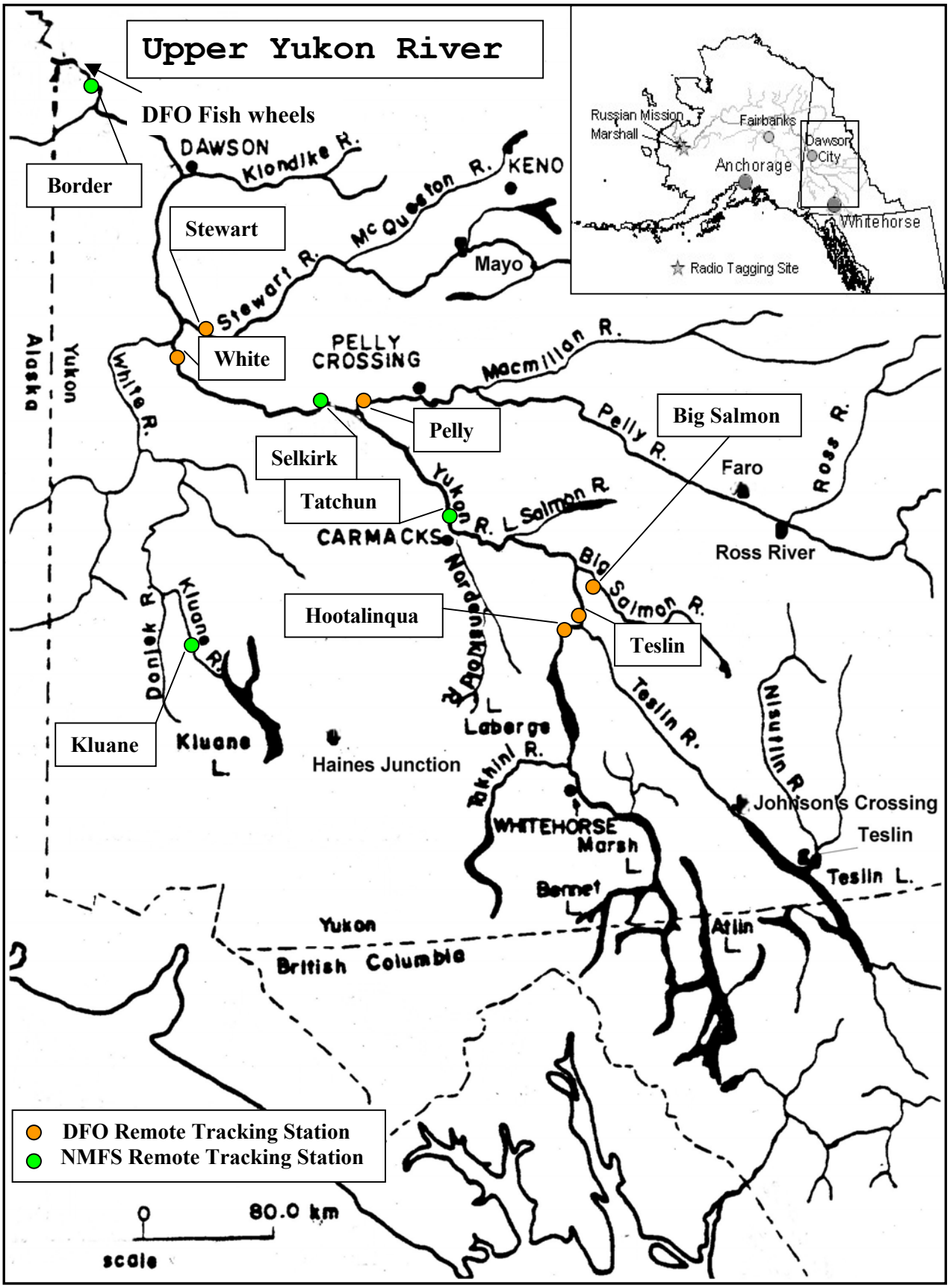

Figure 1. Location of remote tracking stations in the upper Yukon River drainage, 2002.

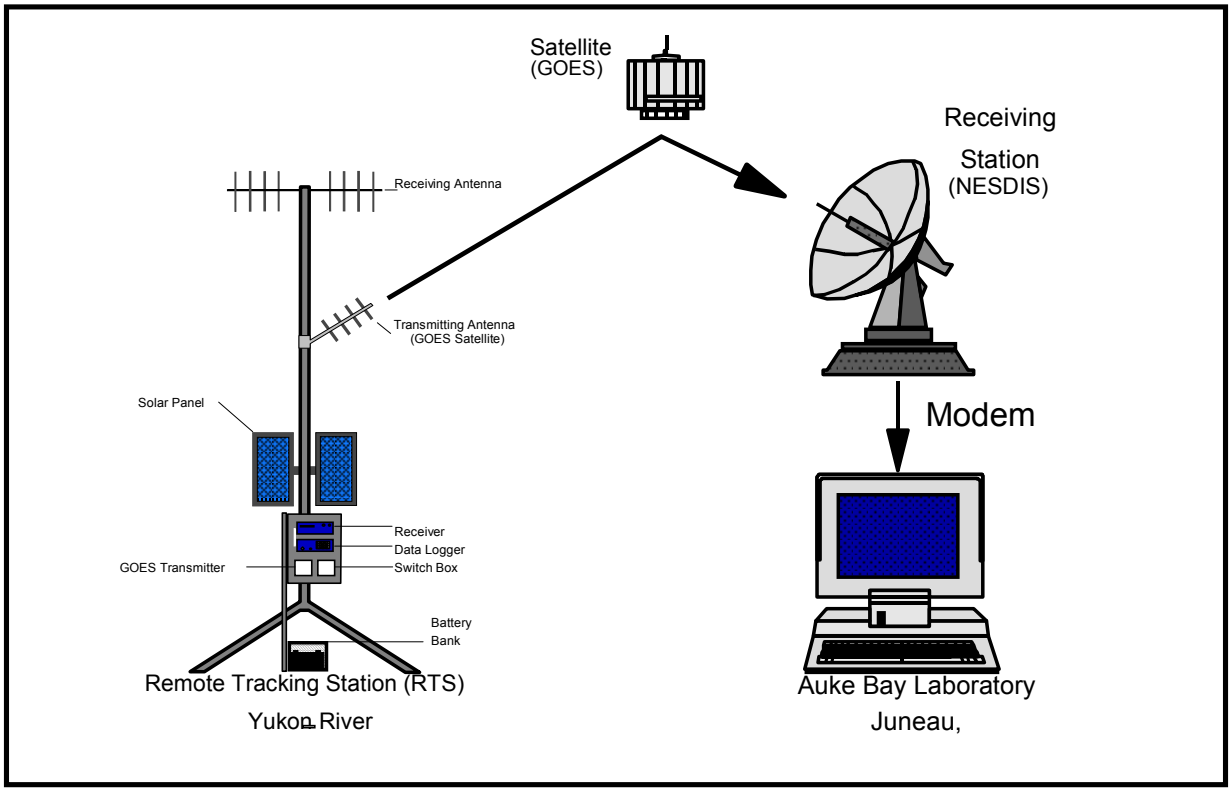

Figure 2. Schematic of radio telemetry data acquisition path (adapted from Eiler and Masters 2000).

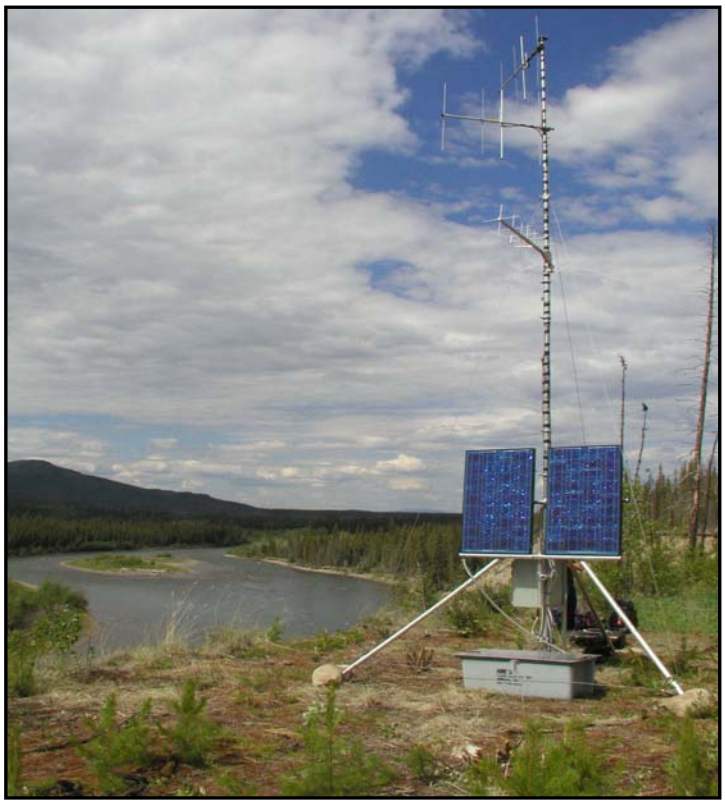

Figure 3. RTS on Big Salmon River approximately 12 km. upstream of its mouth, 2002.

An ATS R4000 radio receiver and a data collection computer (DCC) (Phillips Processor 80-C552) (Figure 5) received, identified, and stored data from transmitters attached to fish as they passed through the station coverage area. The receiver had a frequency range of 4 MHz, 4 memory banks, channel spacing of 1 kHz and a tone detection range of +/-2 kHz. Thirteen frequencies, ranging from 150.684 MHz to 151.183 MHz, were programmed into the DCC and were scanned at 2-second intervals throughout the migration period. One frequency was assigned to reference transmitters (Figure 4) placed near each RTS to provide a continuous signal source to monitor station performance. Signals received were scanned for 10 seconds to allow the DCC to obtain the frequency code and store relevant data including date, time, antenna, frequency, code and activity. Transmitters contained activity monitors and motion sensors. If motion was not detected within a 24-hour period, the activity monitor altered the signal so that it would be decoded as inactive. A line of data was recorded every 10 minutes while a transmitter was within the station reception area.

Once hourly, data was automatically downloaded to a satellite up-link (SAT HDR GOES transmitter – Campbell Scientific, Edmonton, Alberta), also mounted within the instrument housing. The up-link had a built in global positioning system (GPS) that provided accurate time and position data. The data collected by the HDR up-link was transmitted hourly to the GOES satellite at a designated transmission time and forwarded to a receiving station in Camp Springs, Maryland, U.S.A. (Eiler, 1995). NMFS personnel at the laboratory at Auke Bay, Juneau, Alaska downloaded the data files from Maryland daily by telephone modem.

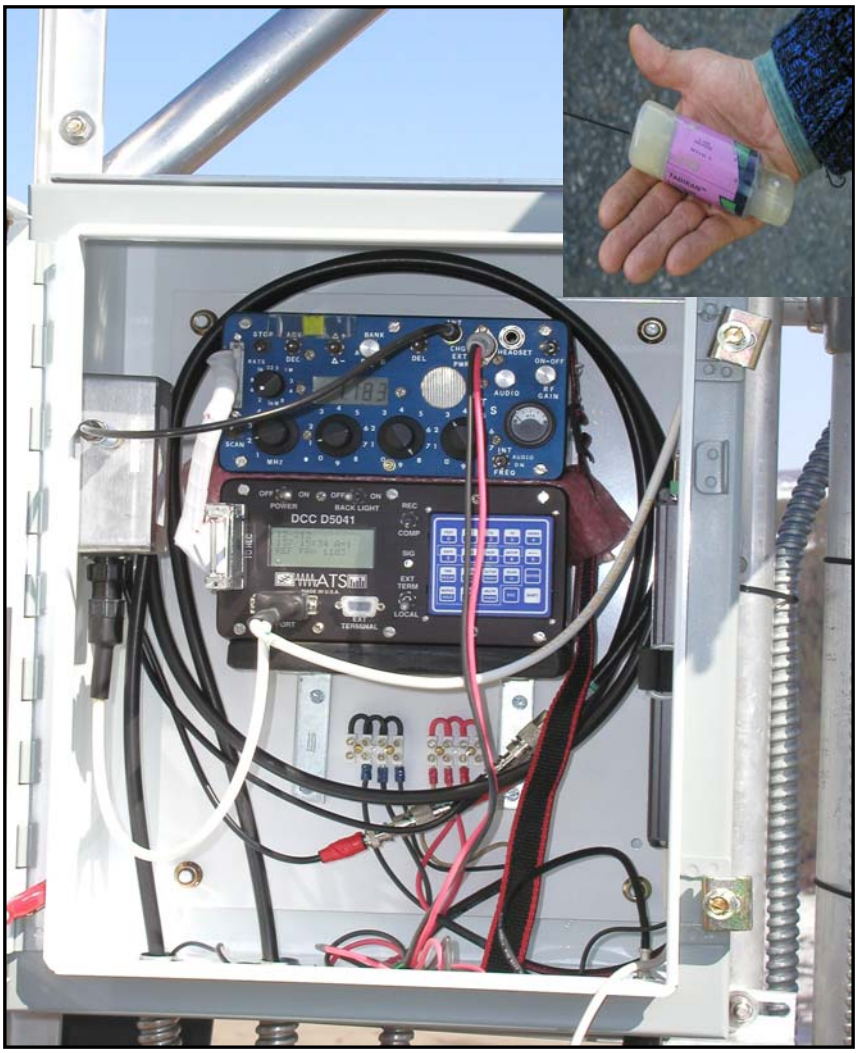

Figure 4. RTS electronic equipment: from left, switch box (upper left wall, R4000 receiver (centre top), DCC (centre bottom), reference transmitter, (upper right) HDR SAT GOES transmitter, (lower right wall).

2.1.3 Tower Installation and Inspection

Site land use permits were not required by the federal Department of Indian and Northern Affairs (DIAND) because of the portable and temporary nature of the towers' structures. DIAND Forestry was notified in late May that a small amount of timber had to be cut down to clear the tower location and helicopter landing pad. Consultations with First Nations' Renewable Resource officers were made with regard to the site locations and possible environmental impacts. The site

selected for the Pelly River station was located on Category 'A' Settlement Lands and authorization to install the station was granted by the Selkirk First Nation council.

The station towers and components were transported close to the sites by boat throughout the month of June. A Bell 206 Jet Ranger helicopter was used to sling the boxed towers and components to the cleared RTS sites. The towers were erected and the stations were activated the same day. A final inspection visit was conducted at all of the new sites in mid July to ensure that site location criteria were satisfied and that the stations were operating properly.

2.1.4 Data Analysis

Radio tagged fish were considered to have passed a given RTS when the recorded data indicated the following sequence of events: a) increasing signal strength recorded by the downstream antenna; b) maximum signal strength received by both antennae; and c) diminishing signal strengths of the upstream directed antenna as the tagged fish proceeded upstream out of signal range. Tagged fish moving downstream past an RTS would result in a similar but opposite pattern in the data.

Migration rates for individual radio-tagged fish were calculated using the time-taken / distance-travelled data from the border RTS to the *RTS's* on primary tributaries. The frequency/code combinations as registered by the tributary *RTS's* were matched with those recorded at the border RTS to generate data on stock specific migration timing near the Alaska – Yukon border.

Proportional distribution of radio-tagged fish was used to generate tributary weighted escapement indices[5]. Population estimates using standard mark recapture methods based on the proportional radio tag distribution could not be obtained because there were no representative recapture projects in tributaries in 2002. Without the determination of radio tagged/untagged ratios, variances for population estimates could not generated. These indices were produced using:

1. The DFO above-border mark-recapture population estimate of 30,247 (95% C.I. 24,791 – 36,891) (Yukon River Joint Technical Committee, 2002).
2. The proportions of the border DFO fish wheel catches by calendar period to determine relative run strength (Appendix 4).
3. The number of observed radio tags passing the border RTS by calendar period (Appendix 4).

Escapement indices were calculated for the primary tributaries as well as for the McQuesten and mainstem Teslin rivers. It should be noted that although the escapement indices may have relational and comparative value, they may not be numerically accurate as their generation is based on assumptions that may not be valid (see section 2.3.2).

[5] For the purposes of this paper, a tributary escapement index refers to a tributary population point estimate without confidence limits.

2.2 Aerial Tracking

2.2.1 Description of Aerial Tracking Equipment

A Piper PA-18 fixed wing float equipped aircraft was used for the aerial tracking. A two element, "H" type, stainless steel, receiving antenna (150.00 – 152.00 MHz. Range) manufactured by Lotek Engineering (Newmarket, Ontario), was mounted on the wing struts on each side of the aircraft. The antennae were arrayed so that maximum directional gain was achieved at a 25° angle of bank and approximately 70° aft of the forward flight path (Figure 5). Both antennae were connected to a single receiver using RG58/U coaxial cable and coaxial splitter. The surveys were flown on average 300 meters above ground level at an air speed of approximately 110 km/h. One observer operated the receiving equipment. An intercom connection allowed the pilot to monitor the audio output of the receiver as well as to communicate with the observer. The equipment was checked before the beginning of each survey and two spare receiving units were taken on each flight.

A prototype R4500 receiver manufactured by ATS, capable of receiving, decoding and storing signal frequencies and codes was used for all the aerial surveys. The receiver had a frequency range of 4 MHz, with 4 memory banks, channel spacing of 1 kHz, a tone detection range of +/-2 kHz, and an enhanced Digital Signal Processor (DSP). The R4500 receiver has a built-in geographic positioning system (GPS) that provided co-ordinates each time a radio-tagged fish was recorded. A total of 12 frequencies was scanned sequentially at 2 seconds per frequency. Typically, when a signal was heard through the headset at sufficient signal strength to achieve quick signal processing, the

Figure 5. Piper PA-18 with H antennas mounted on each wing strut, 2002.

operator would exit the scan mode to lock on the frequency in order to determine the pulse code(s). A few passes were made to obtain the highest audio output and, if conditions allowed, to obtain a visual observation. The receiver automatically recorded the date, time, signal strength, tag frequency and code, and the GPS co-ordinates. As a contingency measure, the observer also manually recorded the tag frequency, code, and location.

2.2.2 Survey Period

Aerial surveys were conducted in the selected tributaries from August 11 through September 10. Two surveys were conducted in each tributary, approximately 7 – 10 days apart to attain a high probability of detecting the radio-tagged fish on, or near, the spawning areas. Due to the relatively large number of tags located in the mainstem portion of the Teslin River, and the uncertainty of

their status, three surveys were conducted in this area over a period of 25 days. This was done to determine, with confidence, if the tagged fish detected were actively migrating, holding while in transit, or stationary.

A total of 110 hours was flown during the aerial tracking portion of the study. Ninety-six hours were relegated to tributary aerial surveys and 14 to archival tag detection.

2.2.3 Data Analysis

The logged data was downloaded to a computer upon completion of each survey. Radio tag locations were determined by using the recorded GPS co-ordinates that matched the median maximum signal strength. Logged frequency/code combinations were crossed checked with data from *RTS's*, to verify that locations were real. When a radio-tagged fish was observed to move between surveys, the furthest point upstream was used to establish the final fish location. The GPS co-ordinates were plotted on topographic maps with GPS mapping software which, in turn, were used to generate large scale maps using a geographic information system (GIS) software program.

2.2 Archival Radio Tag Recovery

The original proposed project did not include provision for the recovery of archival transmitters. The contractors were requested by NMFS to search out and retrieve archival transmitters in late August. Data from the *RTS's* indicated in which drainages the archival transmitters were located and a search and recovery plan was developed.

Archival tag surveys were conducted on selected streams on August 24 and 31 and on September 14 and 18. The primary goals of these surveys were to: 1) determine the location of archival tags recorded by tributary and mainstem *RTS's* but not detected during the tributary surveys; and 2) to recover these tags where possible. During these surveys, the standard radio tags were also detected. Tatchun Creek, Nordenskiold River, and the mainstem Yukon River from the Big Salmon River to Tatchun Creek were surveyed twice comprehensively during the period of peak spawning. The Little Salmon River and portions of the Pelly system were surveyed only once (September 14-18) following the peak spawning period.

3.0 RESULTS

3.1 Remote Tracking Station Results

Of the 768 chinook salmon tagged with radio transmitters at the Alaskan tagging sites near Russian Mission and Marshall, a total of 215 (28%) migrated upstream of the Alaska – Yukon border. The remaining tagged fish were captured in U.S. fisheries, migrated to terminal areas in Alaska and the Canadian portion of the Porcupine River, or dropped below the tagging site. The 2002 proportion of radio-tagged fish passing the Alaska – Yukon border is similar to the ratios observed in 2000 (25%) and 2001 (27%)(Spencer et al, in prep.)

3.1.1 Recovered Radio-tagged Chinook Salmon

Of the 215 radio-tagged chinook that crossed the Alaska – Yukon border, just upstream of Eagle, Alaska, 36 radio-tagged fish were captured in Canadian commercial, First Nation, and test fisheries (Table 1). Twenty-four tagged fish were caught in the mainstem Yukon River downstream of its confluence with the Teslin River and the remaining 12 were caught in associated tributaries. Of the 24 tags recovered from the mainstem Yukon River 15 were turned in from the commercial / test fisheries and agency programs near Dawson City, 8 came from a First Nation fishery near Carmacks and 1 came from a recreational fishery in Tatchun Creek. Of the 12 tags recovered from tributaries, one radio tag was recovered from a egg-take fishery in the Takhini River, one archival radio tag was recovered from the McQuesten River and one radio tag was recovered from the Whitehorse Rapids Fishway. The remaining tags were recovered from First Nations fisheries (Appendix 5).

The 24 radio-tagged fish recovered from the mainstem Yukon River in the various fisheries were deducted from the number of radio-tagged chinook entering the Yukon Territory (215) leaving 191 tags to apply to distribution analysis.

Table 1. Radio-tagged chinook salmon recovered from fisheries in the upper Yukon River drainage upstream of the Alaska – Yukon border, 2002.

Nearest Village to Capture site	**Number of Radio Transmitters Recovered**	**Inclusion in Distribution Analysis**
Dawson City	15	No
Mayo	3	Yes
Pelly Crossing	7	Yes
Carmacks	9	No
Whitehorse	2	Yes
Total	**36**	

Radio-tagged chinook that passed the tributary *RTS's* but were subsequently harvested, were included in the distribution.

3.1.2 Distribution

Of the 191 radio-tagged fish not caught in mainstem Yukon River fisheries, 115 (60%) returned to tributaries monitored by *RTS's* (Figure 6). The Teslin and Pelly drainages received the largest portion of tagged fish with 19% and 17% of the total respectively. The Stewart and Big Salmon rivers accounted for 12% and 9% of the tags respectively, while 4% of the tagged fish returned to the south Yukon River (upstream of the Hootalinqua site).

Seventy-six (40%) radio-tagged fish remained in the mainstem Yukon River or were located in other tributaries during aerial surveys. Some of these fish are accounted for by tags detected during archival tag aerial searches (section 3.2.4), and other related studies (J. Duncan in prep, J. Wilson in prep.) Movements between terminal tributaries were observed for three tagged fish. These fish were recorded migrating upstream past the first tributary RTS, were later recorded passing the RTS downstream and finally recorded further upstream in the mainstem Yukon River (Table 2.). The second relocation was designated as the final destination for the fish.

3.1.3 Migration Rates

The Pelly River fish had the highest mean migration rate (50.88 km/day) and the south Yukon River fish had the slowest mean migration rate (43.50 km/day) (Table 3), (Appendix 1).

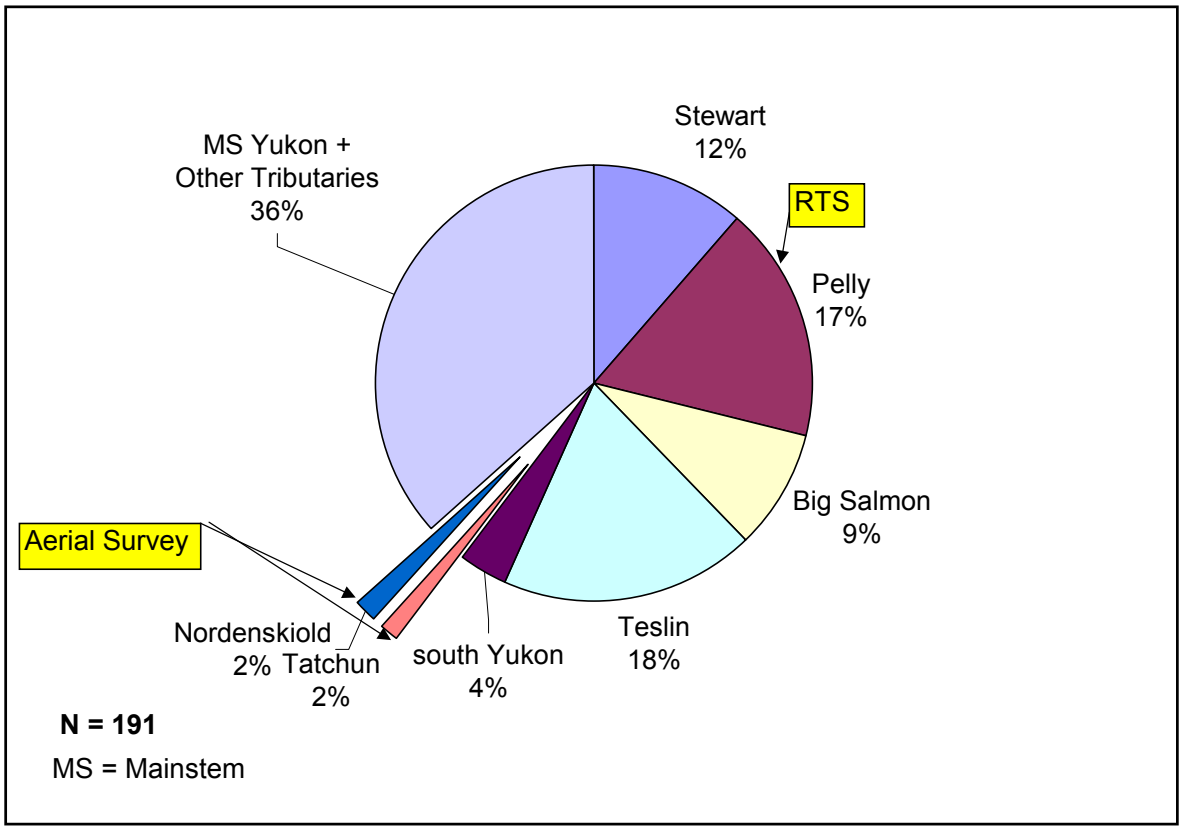

Figure 6. Proportional distribution of chinook salmon the upper Yukon River drainage, 2002.

Table 2. Radio-tagged fish relocated in more than one primary tributary to the Yukon River, 2002.

Fish Number	First Location	Second Location
1012	Pelly RTS	Teslin RTS
1039	Stewart RTS	Pelly RTS
3008	Stewart RTS	White RTS

Mean migration rates between the tributary stocks were significantly different (Single factor ANOVA, tested for homogeneity of variance: $F=3.11$, $df=4, 117$, $\alpha=0.05$, $p=0.018$). There appeared to be an inverse relationship between distance travelled and mean migration rates ($r^2=0.75$, $df=4$, $\alpha=0.05$) indicating that the longer migrating fish travelled at slower average rates. There was no difference in mean

migration rates between females and males, from the pooled tributary stocks population, travelling from the border to the tributary *RTS's* (Z=0.10 (2-tailed), α=0.05).

Table 3. Mean migration rates of radio-tagged salmon in the upper Yukon River drainage, 2002.

Mean Migration Rate (km/day)				
Tributary Stock	**Upper Border *RTS* to Tributary *RTS***	**N**	**Standard Deviation**	**Distance from Border RTS (Km.)**
Stewart River	52.66	23	6.32	198
Pelly River	50.88	33	7.36	362
Big Salmon River	46.11	17	7.44	618
Teslin River	47.18	42	6.96	632
south Yukon River	43.50	7	5.36	652
Total	47.63	122	6.81	
Total Mean Female*	47.25	56	7.29	
Total Mean Male*	49.58	43	6.90	

* The sex ratio presented in Table 3 may not be representative of the run crossing the border. When transmitters were applied, gender could not be determined for 19% of the radio-tagged fish that later passed the border RTS.

3.1.4 Migration Timing

The timing of tributary stocks passing the border RTS is presented in Figure 7. In general, the Big Salmon and Stewart River fish passed the border earlier than the Pelly, Teslin and south Yukon River fish. However, there is overlap in the run timing of these stocks, with no distinct temporal separation. With the exception of the south Yukon River stock, the tagged fish that entered the monitored tributaries began arriving at the border station between July 9 and July 11. The date when 90% of the stocks passed the border station ranged from July 30 for Big Salmon River fish to August 9 for the south Yukon River stocks (Figure 7). The timing of the arrivals of the stocks at their spawning primary tributaries to the Yukon River reflected the distance

travelled. Ninety percent of the Stewart River stock had passed the Stewart RTS by the beginning of August; 90% of the Pelly and Big Salmon stocks had passed their respective *RTS's* by mid-August; 90% of the Teslin and south Yukon stocks had passed their respective *RTS's* by late August (Figure 8). It should be noted that the relatively small sample sizes of radio tagged fish may influence the run timing of the separate stocks. Assuming a normal distribution, a higher number of tags would likely result in a greater range in run timing.

To examine how representative the general timing of the radio-tagged fish population was to the true population, the timing of chinook captures at the DFO border fish wheels was compared to the timing of the radio-tagged fish passing by the border RTS. The relative proportion of radio-tagged fish passing the border RTS exhibited a bell-shaped distribution and was typically greater than the proportion of fish being caught in the border fish wheels during the same periods (Figure 9). This was due largely to a pulse in the fish wheel catches during the fourth calendar period (July 28 – August 3) which was not reflected in the number of radio tagged fish passing the border RTS.

3.1.5 Tributary Escapement Indices

Both weighted and un-weighted tributary escapement indices are listed in Table 4. The Teslin River had the highest weighted escapement index of 5,978 chinook, with the mainstem portion having an index of 4,275 chinook (72% of the fish in the Teslin River system). The Pelly River weighted index was 4,007 chinook. The Stewart River weighted index was 3,184 chinook, with the McQuesten River having a weighted index of 1,245 chinook (33% of the fish in the Stewart River system).

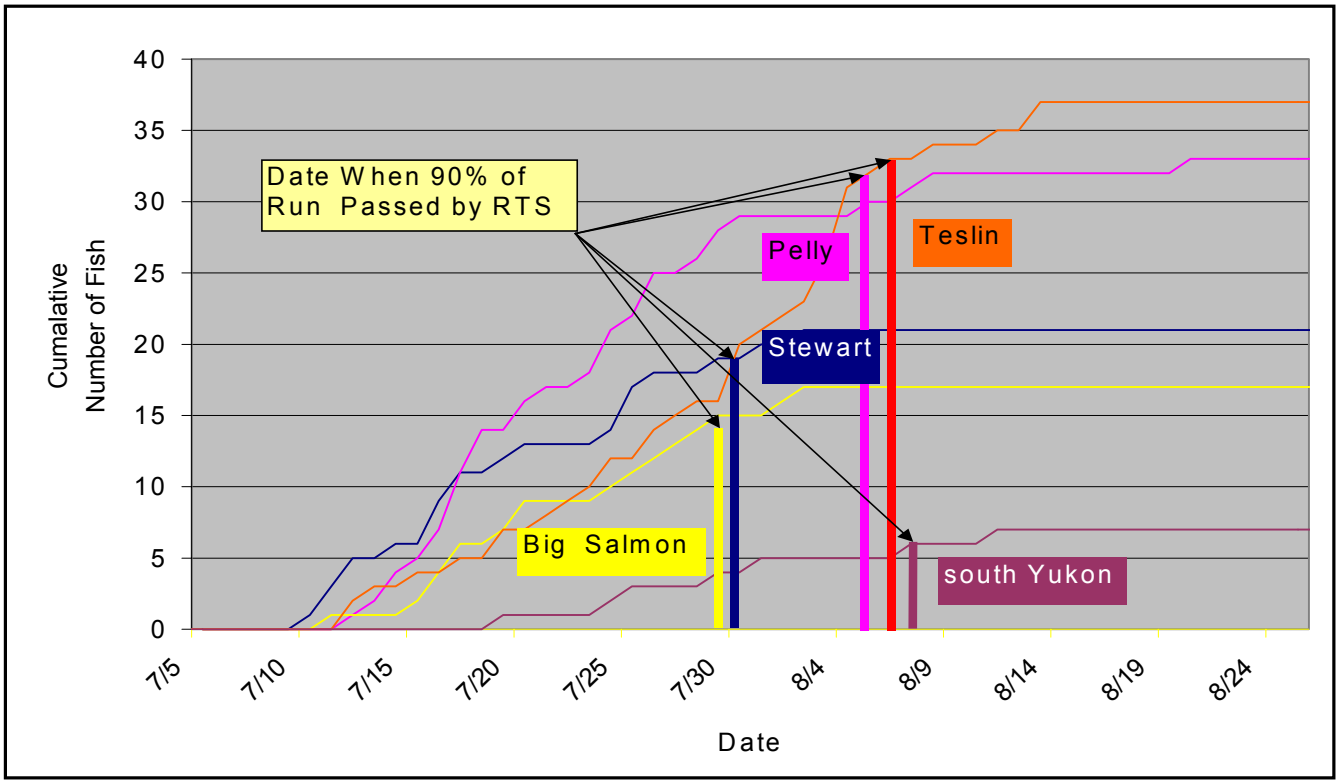

Figure 7. Arrival of radio-tagged chinook salmon at the border RTS on the upper Yukon River, 2002.

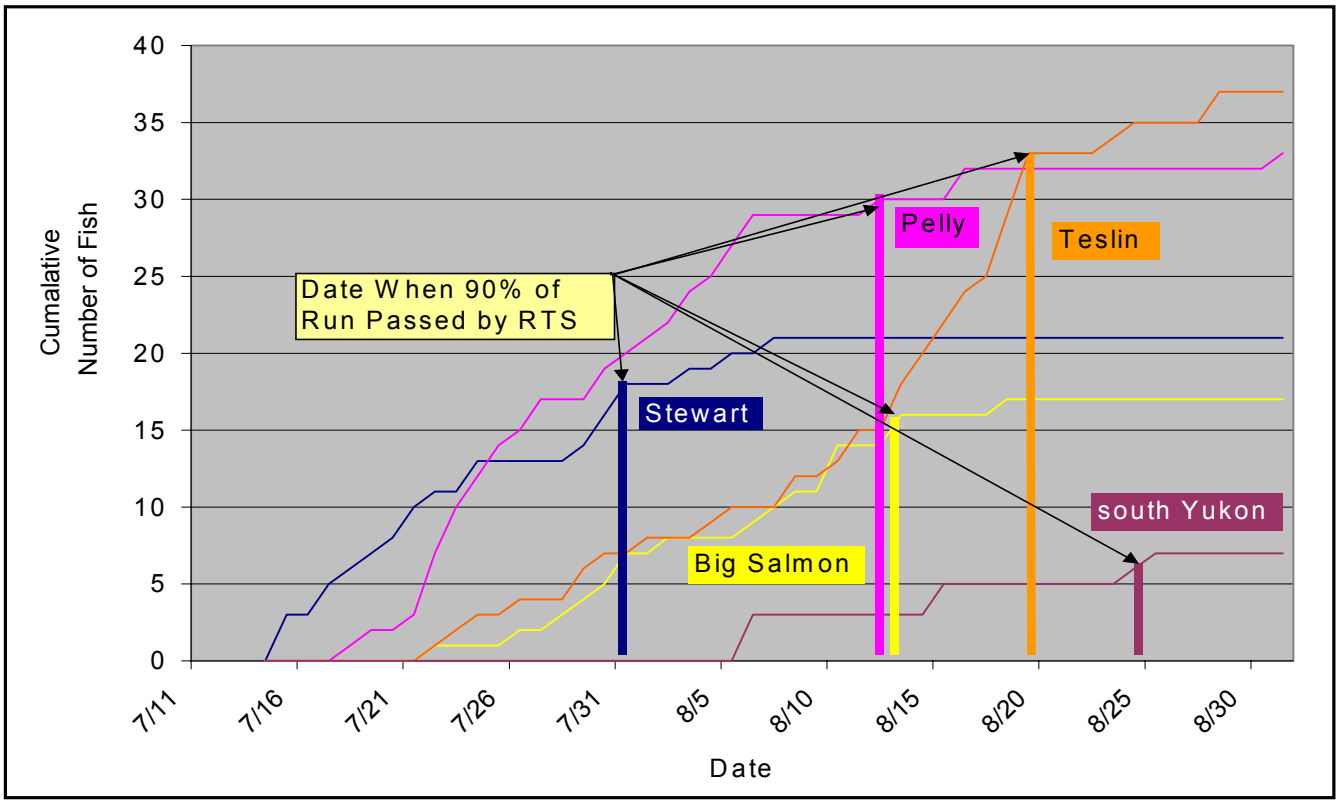

Figure 8. Arrival of radio-tagged chinook salmon at their respective tributary *RTS's*, 2002.

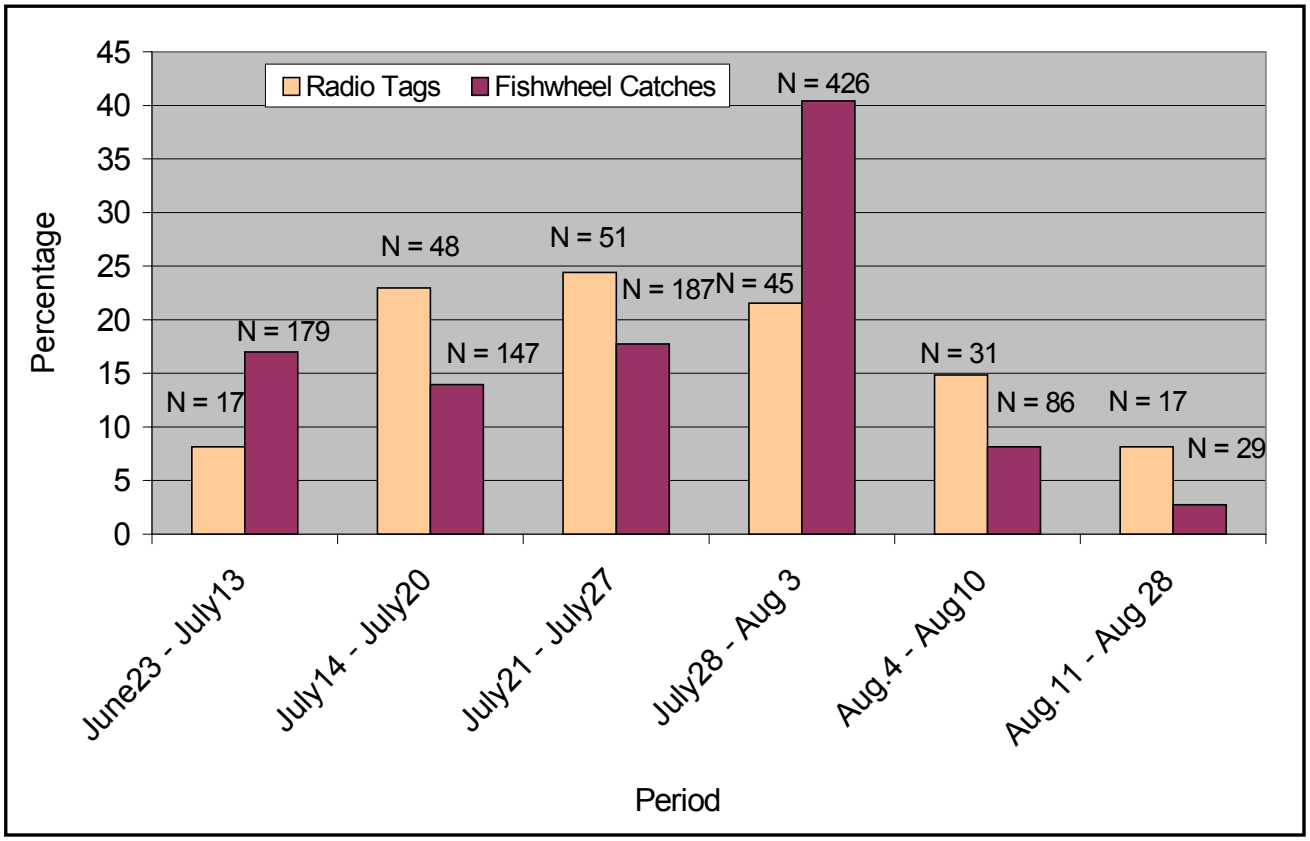

Figure 9. Percentage of radio-tagged fish passing the border RTS compared with the percentage of fish caught in the border fish wheels, 2002.

The south Yukon River had the lowest weighted index at 729 chinook. The weighted and un-weighted escapement indices are similar for all tributaries. The greatest percentage difference between weighted and unweighted indices was observed for the McQuesten and Big Salmon rivers (Table 4).

3.2 Aerial Tracking Results

3.2.1 General Distribution

Of the radio-tagged fish that moved into terminal areas (179) upstream of Alaska-Yukon border (215) and not caught in fisheries (36), a total of 104 (58%) radio tags were subsequently detected during the tributary and archival tag aerial surveys.

Table 4. Abundance indices for chinook salmon entering primary tributaries to the upper Yukon River, 2002.

Primary Tributary	**Weighted Escapement Index**	**Un-Weighted Escapement Index**	**Percentage Difference**
Stewart River (includes McQuesten R.)	3,184	3,184	0
McQuesten River	1,245	1,015	23
Pelly River	4,007	4,775	19
Big Salmon River	2,040	2,465	21
Teslin River (includes mainstem)	5,978	5,220	15
mainstem Teslin River (outlet of Teslin Lake to mouth of river)	4,275	3,915	9
south Yukon River	729	870	19
Total to Primary Tributaries	15,940	16,515	4
Total Harvest	2,707	2,755	2
Escapement to mainstem Yukon and other tributaries	11,602	10,977	6

The tags located during the tributary surveys represented 96% of the cumulative tags recorded by the respective RTS (Table 5). Of the 73 radio-tagged fish located in the tributaries, 21 were located in the Stewart River, 16 in the Big Salmon River, and 36 in the Teslin River system. The remaining 31 radio tags were located in the Yukon River mainstem, the upper Pelly system, and other smaller tributaries while searching for archival tags.

Table 5. Distribution of radio-tagged chinook salmon located in tributaries by aerial surveys and *RTS's*, 2002.

Tributary	**Aerial Survey Count**	**RTS Count**	**Percentage (Aerial / RTS)**
Stewart River	21	22	95
Big Salmon River	16	17	94
Teslin River	36	37	97
Total	73	76	96

3.2.1 Stewart River System

The primary areas surveyed within the Stewart River watershed included the Stewart River mainstem, McQuesten River (North and East McQuesten), Mayo River, Hess River, Ollie River, Rogue River, Beaver River, and Rackla River (including East Rackla); smaller tributaries included Black Hills, Rosebud, Lake, Crooked, Moose, Talbot, Janet, Watson, No Gold, Pleasant, and Lansing Creeks. The final tag locations and areas surveyed are summarized in Table 6 and illustrated in (Appendix 7; Map 1). Twenty-one of the 22 tags that passed the Stewart River RTS were located during the course of the aerial surveys. The first survey, conducted August 11-13, located 18 tags and the second survey, on August 21- 24, located 17 tags. One tag was captured at an unknown location in the local fishery and was subsequently passed on to DFO Whitehorse before the surveys began. A second tag (fish no. 967) was located during the aerial surveys at a residence approximately 10 km west of Mayo and was relinquished to DFO Whitehorse after the aerial surveys were completed. The Stewart River aerial surveys located 100% of the available radio-tagged fish in the system.

Within the Stewart River watershed, the McQuesten River drainage received the largest number of radio-tagged fish (7, 33% of total). All McQuesten River fish were located in the lower reaches of the river. Using the tags observed in the McQuesten River and the weighted proportional population indices generated in section 2.2.5 above, the 2002 escapement index for the McQuesten River was 1,245 chinook (39% of the Stewart River index total of 3,184 chinook).

Table 6. Stewart River radio tag locations, 2002.

Fish No.	Final Aerial Survey Location		Fate	* Status (D) Dead
	(Lat.)	(Long.)		
7	63.5725	-137.3505	McQuesten R.	D
17	63.5179	-134.1603	mainstem Stewart R.	
28	63.5371	-135.1432	McQuesten R.	D
32	63.6114	-137.2497	McQuesten R.	
47	63.6197	-135.9022	Mayo R.	D
57	63.6387	-137.1150	McQuesten R.	D
129	63.5370	-135.1446	Watson Ck.	
146	63.3927	-138.1924	mainstem Stewart R.	
180	63.5371	-135.1432	Watson Ck.	
183	63.5623	-137.3841	McQuesten R.	
918	63.2773	-131.2232	Ollie Ck.	
967	63.5960	-135.9098	Mayo R	
971	63.5935	-137.7331	mainstem Stewart R.	
974	63.5217	-136.1823	mainstem Stewart R.	
977	63.4771	-134.3175	mainstem Stewart R.	
1019	63.6395	-135.4530	Janet Ck.	D
1021	63.6366	-137.0047	McQuesten R.	D
1118	63.6325	-135.9271	Mayo R	
1132	64.1369	-134.3147	Rackla R.	
1203	63.6325	-135.9271	Janet Ck.	
3013	63.6671	-136.7787	McQuesten R.	D

* Based on sustained inactive signal (>24 hours) from transmitter

The second highest tag concentration was in the Mayo River, which received 3 tags. The remaining tributaries where radio-tagged fish were present contained 2 tags or less. Although approximately 60% of the Stewart River drainage area is upstream of Fraser Falls, only 5 tags (25%) were located in that area.

During the second Stewart River survey, 5 tags were observed that had the mortality sensor activated indicating that the fish had been inactive for more than 24 hours and were presumed dead.

3.2.2 Big Salmon River System

The streams surveyed in the Big Salmon River drainage included the Big Salmon River, North Big Salmon River, South Big Salmon River, Pleasant Creek, Souch Creek, Northern Creek, and Scurvey Creek (Appendix 7; Map 2). Two separate aerial surveys were conducted on August 14 – 15 and on August 25 – 26. Of the 17 tags recorded passing the Big Salmon RTS, 16 (94%) were located during the aerial surveys (Table 7). Five tagged fish were observed in the North Big Salmon River and 11 were found in the Big Salmon River upstream of its confluence with the North Big Salmon River. The highest density of radio-tagged fish was observed within 4 km. of the outlet of Big Salmon Lake. One tagged fish (number 962) was observed in Scurvey Creek during the first survey (approximately 4 km. from the confluence with the Big Salmon River, (designated 962-A on Map 2) but was relocated in the Big Salmon River during the second survey (962-B). Although the Scurvey Creek location was the furthest upstream detection in the drainage, the stream velocity, gradient, and substrate size suggested it was not ideal spawning habitat.

The fate of fish number 132, which passed the Big Salmon River RTS but was not located in the aerial surveys, is unknown. The overall stream morphology was favourable for signal detection and all known and probable spawning habitats were surveyed. The Big Salmon River RTS records for this fish suggest it may have moved back downstream after initially moving upstream past the station. It is also possible the tag was destroyed by a predator or caught by an angler and not relinquished; the Big Salmon River is quite popular with canoeists and kayakers.

Table 7. Big Salmon River radio tag locations, 2002.

Fish No.	Final Aerial Survey Location		Fate	* Status (D) Dead
	(Lat.)	(Long.)		
3	61.7901	-134.2553	N. Big Salmon R.	
56	61.7533	-134.6021	N. Big Salmon R.	D
10	61.8620	-134.0953	N. Big Salmon R.	
73	61.3304	-133.3439	Big Salmon R.	D
206	61.7388	-134.5928	Big Salmon R.	
409	61.7673	-134.3689	N. Big Salmon R.	
437	61.6961	-134.5342	Big Salmon R.	
945	61.7856	-134.2661	N. Big Salmon R.	D
962	61.3487	-133.3692	Big Salmon R.	D
980	61.3197	-133.3343	Big Salmon R.	D
1006	61.6086	-133.7198	Big Salmon R.	
1031	61.3254	-133.3369	Big Salmon R.	D
1055	61.3368	-133.3570	Big Salmon R.	
1060	61.5715	-134.3264	Big Salmon R.	
1108	61.6642	-134.5168	Big Salmon R.	
1156	61.5631	-133.6270	Big Salmon R.	

* Based on sustained inactive signal (>24 hours) from transmitter

All fish located during the first survey were active, whereas 8 tags observed during the second survey had activated mortality sensors and were presumed dead.

The 17 radio tags recorded by the Big Salmon River RTS produced a 2002 chinook weighted escapement index of 2,040 chinook (Table 9). Seven radio tags were located within the DFO aerial index area located between Souch Creek and Big Salmon Lake. Using the radio-tag based population expansion factor, described in section 2.2.5 above, the escapement index for this area would be 650 fish. The 2002 DFO aerial count in this same area was 1,149 chinook (Appendix 6).

3.2.3 Teslin River System

The Teslin River system is a relatively large watershed located within the southern Yukon Territory and northern B.C. Although not every watercourse in the system was surveyed, the surveys were comprehensive with every documented and potential spawning area surveyed at least once. The streams surveyed included the mainstem Teslin River (Hootalinqua to Teslin Lake), the upper Teslin River from Teslin Lake to Chesmania Lake and the Nisutlin, Rose, Wolf, Red, McConnell, Morley, Swift, Smart, Gladys, Jennings, and Glundeberry Rivers. Smaller tributaries included Boswell, Thirty-Mile, Swift, Hundred Mile, Sidney, Evelyn, Tlingit, and Hayes Creeks (Appendix 7 - Map 3).

Two comprehensive aerial surveys of the Teslin system were conducted on August 15-16, and September 1-2. These surveys detected 36 (97%) of the 37 available tags that were recorded passing the Teslin RTS (Table 8)[6]. A total of 25 (70%) of the Teslin River radio tags were located in the mainstem portion of the river, from the mouth to Teslin Lake, representing the highest concentration found within the watershed. One radio tagged fish (fish number 419) was located dead in the Yukon River between the mouth of the Teslin River and the Teslin RTS. The remaining radio tagged fish were disparately distributed throughout the upper reaches of the drainage (Appendix 7 – Map 3).

DFO maintains two chinook escapement aerial index survey areas located within the Teslin system: 1) on the Nisutlin River in the area between Hundred Mile Creek and Sydney Creek; and 2) on the Wolf River between

[6] The number of Teslin River destined tags was determined by subtracting the south Yukon River tags from the total recorded at the Teslin RTS.

Wolf Lake and the Fish Lake outlet stream. Within the Nisutlin index area the aerial count for 2002 was 280 chinook, however no radio tags were located within this area. One radio was located in the Wolf River index area where the aerial count for 2002 was 84 chinook (Appendix 6).

In addition to the two earlier comprehensive aerial surveys, a third mainstem Teslin River aerial survey was conducted on September 10. Ten of the 25 tags detected during this survey had activated mortality sensors (Table 8). The prevalence of mortality signals indicated the tagged fish in the mainstem portion of the Teslin River had spawned or were spawning in the area rather than still being in transit.

3.3 Archival Radio Tag Recovery Results

3.3.1 Location of Archival Radio Tags

Nine of the 23 (39%) archival radio tags deployed at the Alaskan tagging sites were recorded passing the Alaska – Yukon border to the upper Yukon River. Four archival tags were recovered in the commercial and First Nation fisheries, 2 tags were recovered from agency programs, 2 tags were located but not recovered (located in areas with deep, turbid and fast-flowing water) and 1 tag (fish no. 3009) was not relocated after passing the Pelly RTS. Information on swimming depth and water temperature obtained from the archival tag results will be detailed in a separate report (Eiler and Spencer, in prep.).

Table 8. Teslin River radio tag locations, 2002.

Fish No.	Final Aerial Survey Location		Fate	* Status (D)= Dead
	(Lat.)	(Long.)		
8	60.9671	-132.9250	Nisutlin R.	D
37	59.1968	-131.8466	upper Teslin R.	D
64	60.9925	-132.7721	100 Mile Ck.	D
86	60.9162	-134.0129	mainstem Teslin R.	
91	60.9010	-133.9796	mainstem Teslin R.	D
136	61.5182	-134.8329	mainstem Teslin R.	
185	61.2623	-134.5950	mainstem Teslin R.	D
187	61.2702	-134.5925	mainstem Teslin R.	D
191	61.1457	-134.3529	mainstem Teslin R.	
194	60.5114	-133.3544	mainstem Teslin R.	
213	Not Located			
233	60.9335	-134.0644	mainstem Teslin R.	D
242	61.3470	-134.6638	mainstem Teslin R.	D
260	60.8295	-133.8805	mainstem Teslin R.	
274	60.9326	-134.0368	mainstem Teslin R.	D
282	61.2679	-134.5851	mainstem Teslin R.	
286	60.5400	-133.4141	mainstem Teslin R.	D
414	61.2386	-134.5661	mainstem Teslin R.	D
419	61.6109	-134.8699	mainstem Yukon R.	D
420	61.0412	-134.2219	mainstem Teslin R.	D
443	61.4101	-134.6555	mainstem Teslin R.	D
456	60.7312	-133.6974	mainstem Teslin R.	D
466	61.2652	-134.6069	mainstem Teslin R.	D
508	61.1737	-134.3921	mainstem Teslin R.	
522	60.6425	-132.7826	Nisutlin R.	
550	61.1970	-134.4420	Swift R. mouth	
901	59.5960	-131.8698	Jennings R	
981	60.7375	-133.6948	mainstem Teslin R.	D
988	60.9876	-132.7699	100 Mile Ck.	
997	59.2371	-131.9285	upper Teslin R.	D
1012	60.6641	-132.1132	Wolf River	
1030	59.7341	-132.1970	Jennings R.	D
1040	60.7381	-133.7007	mainstem Teslin R.	D
1049	61.2674	-134.6338	mainstem Teslin R.	
1089	60.5157	-133.3622	mainstem Teslin R.	
1114	61.0351	-134.2084	mainstem Teslin R.	D
1175	61.1420	-134.3545	mainstem Teslin R.	D

* Based on sustained inactive signal (>24 hours) from transmitter

3.3.2 Aerial Archival Radio Tag Tracking Surveys

A total of 33 radio tags, including 2 archival tags, was located during the archival tag surveys (Table 9; Appendix 7 - Map 4). Of note were the high tag densities in Tatchun Creek (3 tags) and portions of the mainstem Yukon River near Carmacks (6 tags). Two radio tagged chinook were located in the portion of the Little Salmon River drainage that was surveyed for archival radio tags. This portion of the drainage corresponds with a DFO maintained aerial index survey area from it's confluence with the Yukon River to the outlet of Little Salmon Lake where the aerial count for 2002 was 526 chinook (Appendix 6). Ground based searches for the archival tags indicated the actual tag locations were within 200 meters of the location determined from the aerial surveys. The two archival tags detected were not recovered due to the water velocity, depth and/or turbidity where they were located.

4.0 DISCUSSION

4.1 Remote Tracking

4.1.1 Migration Rates and Timing

The mean migration rates of the radio-tagged chinook tracked upstream of the Alaska - Yukon border in 2002 are considerably higher than rates recorded in a previous chinook telemetry study (Milligan et al. 1985; Appendix 2).

Table 9. Archival surveys radio tag locations, 2002.

Fish No.	Final Aerial Survey Location		Fate	* Status (D) = Dead
	(Lat.)	(Long.)		
458	62.0569	-135.3956	L. Salmon R.	D
1172	62.0629	-135.4426	L. Salmon R.	D
81	62.1165	-136.2604	mainstem Yukon R.	
131	62.2132	-136.3448	mainstem Yukon R.	
207	62.0587	-135.6618	mainstem Yukon R.	
266	62.3397	-136.4378	mainstem Yukon R.	
403	62.0476	-135.9313	mainstem Yukon R.	
476	62.1454	-136.3592	mainstem Yukon R.	
485	62.0649	-136.0240	mainstem Yukon R.	
1088	61.9345	-135.1035	mainstem Yukon R.	
1154	62.0693	-136.0430	mainstem Yukon R.	
1166	61.7782	-134.978	mainstem Yukon R.	
3003	62.3582	-136.4673	mainstem Yukon R.	
459	61.5106	-135.1290	south Yukon R.	D
26	62.0993	-136.3054	Nordenskiold R.	
61	61.7687	-136.0328	Nordenskiold R.	
124	61.7798	-136.0417	Nordenskiold R.	D
97	62.4872	-134.1666	Pelly R.	
189	61.7460	-131.2507	Pelly R.	D
246	61.7768	-131.1338	Pelly R.	D
461	61.9883	-132.4822	Pelly R.	
976	62.3261	-130.9904	Pelly R.	
1039	62.0339	-132.2684	Pelly R.	D
1084	62.7270	-134.5629	Pelly R.	D
1130	61.8612	-131.0962	Pelly R.	
1170	61.7618	-131.1732	Pelly R.	
1197	62.1370	-131.7131	Pelly R.	D
3001	62.2652	-132.9523	Pelly R.	D
209	62.2838	-136.2624	Tatchun Ck.	D
216	62.2803	-136.2919	Tatchun Ck.	
1102	62.2847	-136.3137	Tatchun Ck.	

- Based on sustained inactive signal (>24 hours) from transmitter

The slower rates observed in the 1983 study may be due to the inclusion of a recovery interval[7], immediately after tagging, with the

[7] In this study (2002), radio tagged fish were processed immediately upon capture to minimize handling time before being released. Migration rates were calculated after the fish reached the first upstream RTS, while in the 1983 study, the recovery period was included in the migration rate.

migration period. Several chinook radio-tagging studies have observed a period of interrupted migration (3 – 10 days) immediately following the application of radio tags (Burger et al 1985, Pahlke et al 1999, Evenson and Wuttig 2000). Other environmental factors such as flow rates may also affect migration rates within specific time periods. The stock specific migration patterns of the radio-tagged chinook indicate there was considerable temporal overlap both at the border RTS and when the fish reached their spawning tributaries. A general pattern is presented that indicates the Pelly, Teslin, and south Yukon stocks passed the border later than the Stewart and Big Salmon stocks (Figure 6). However, considerable temporal mixing of the tributary stocks likely occurs in the mainstem fisheries operating between the Alaska – Yukon border and Dawson City.

4.1.2 Distribution and Escapement Indices

All radio transmitters located by aerial tracking within the drainages of the Stewart and Big Salmon rivers, were also recorded by their respective *RTS's*. The general distribution of radio-tagged fish into the primary tributaries in this study is similar to the distribution observed in an earlier chinook telemetry study (Milligan et al 1985) (Appendix 3). The proportions of radio-tagged fish in all the RTS monitored tributaries were considerably higher in 2002 compared to 1983. The differences in the proportions observed in the two studies may be due to several factors including inter-annual run strength variations among the stocks, the different tagging and tracking methodologies used and the application of fewer radio transmitters in 1983. As in mark-recapture population estimates, the validity of the

escapement indices generated from the radio-tagged fish assumes that: 1) the fates of all the radio-tagged fish are known; 2) tagging does not affect the spawning destination of the fish; and 3) tagged fish are proportionately representative of the run and are not stock selective. The validity of assumption 1 (with respect to tributary stocks) was verified during the study. Assumption 2 is a basic tenet of most salmon tagging programs. Assumption 3 is difficult to verify, however, weighting of the proportional contribution of each radio-tagged fish by calendar period would counter bias due to temporal stock selectivity during the tagging process. The proportional weighting used in this study was based on standardised fish wheel catches. It is unknown how well the fish wheel catches reflect relative run strength; fish wheel capture efficiency may be influenced by several independent factors (e.g. water flows, gear size selectivity). These factors have not been quantified yet (R.E. Johnston, pers. comm.).

4.1.3 Future Study

It may be possible to generate population estimates based on the radio-tagged fish if a larger number of radio-tagged fish were deployed and/or had been captured in monitored fisheries. Due to the relatively low chinook returns in 2002 the Canadian commercial / test fisheries catches were low and catches in the First Nations fisheries were below average (U.S./Canada Yukon River Joint Technical Committee Report. 2002). As well, there were no operational chinook weirs in place to determine tagged/untagged ratios, other than the Whitehorse Rapids fish-way. If this type of study is repeated in the future, the deployment of additional radio tags in the Yukon Territory and the

capture of higher numbers of radio tagged fish in monitored fisheries (augmented by weir data) may facilitate the generation of accurate tributary population estimates.

There is a need to further refine the distribution of chinook salmon in the upper Yukon River drainage, particularly with respect to the White River, and also to investigate annual variation in distribution, migration rates and run timing. Should the chinook salmon radio-tagging project in Alaska continue at the same level as 2002, we recommend that an RTS be established on the White River near its mouth.

4.2 Aerial Tracking

4.2.1 Survey Period

The aerial survey methods and equipment used were successful at detecting, identifying, tracking and determining the location of the tagged fish with precision. All the transmitters detected during the first survey in each tributary indicated the tagged fish were alive, whereas during the second surveys (third on mainstem Teslin River), 48% of the tags had activated mortality sensors, indicating the timing of the aerial tracking surveys appeared to coincide relatively well with peak spawning. The proportions of radio-tagged fish that had activated mortality sensors in the Stewart, Big Salmon, and Teslin drainages were 33%, 38%, and 61% respectively. Although it was not possible to verify that spawning in the radio tagged fish had occurred, the majority of the tags located in terminal areas were either in previously documented spawning streams or were in areas with

gradient and substrate conditions suggestive of potential spawning habitat. Chinook spawning distribution in the larger mainstem rivers is less certain since tagged fish could be in transit or delayed and/or stopped due to tag induced behavior/impairment. Of those fish that were located in the mainstems of the Stewart, Big Salmon and Teslin rivers, the proportion that had activated mortality sensors were 0%, 45% and 63% respectively. Increasing the survey frequency and duration of the survey period in mainstem areas would reduce this uncertainty about whether fish detected were in close proximity to their respective spawning areas.

4.2.2 Spawning Distribution

Assuming the 2002 aerial survey results were characteristic, some general inferences can be made about chinook spawning distribution within the tributaries surveyed.

These are:

- Within the Stewart system, the findings in 2002 indicate the McQuesten River supports the largest component of the chinook returns. It also appears that although the Stewart River watershed upstream of Fraser Falls constitutes approximately 60% of the system, the spawning contribution of the upper portion of the system was disproportionately low (19% in 2002). Local anecdotal reports contend, that under certain water conditions, returning chinook are unable to ascend Fraser Falls. This suggests that, in some years, chinook would congregate below the falls or perhaps stray into nearby tributaries. Although no pooling below the falls was observed in 2002, two radio tagged fish were found in Watson Creek, close to the falls; a relatively high number given the size of the creek and apparent limited spawning habitat. It is possible the chinook production from the

upper Stewart system is variable and dependent on late summer water conditions during particular brood years.

- The Big Salmon radio tag distribution in 2002 supports the assumption that the DFO chinook index area encompasses a significant portion of the total Big Salmon escapement. The five tagged fish (29% of total) located in the North Big Salmon River suggests this tributary is also an important contributor.
- The Teslin River survey results indicated the mainstem Teslin sub-stock comprised a major part of the total tributary return in 2002. The mainstem Teslin exhibited the highest radio tag densities among the tributaries surveyed, and in terms of production, may rival or exceed the other large Yukon tributaries. In the upper Teslin system, there was a noted scarcity/absence of radio tags in some of the well-documented chinook spawning streams such as the Nisutlin, Wolf, Morley and Swift rivers.

There was a discrepancy between the DFO aerial counts and the radio tag based weighted escapement index within the Big Salmon River (weighted index = 650 chinook; aerial counts = 1149 chinook). This discrepancy is likely greater than indicated since aerial counts are always lower than actual escapements. The un-weighted escapement index of 1,015 chinook is closer to the DFO aerial count. This suggests that: a.) weighting radio tag proportions using fish wheel catches is not valid (at least for the Big Salmon destined radio tags); and/or b.) the above border escapement estimate of 30,247 (95% C.I. 24,791 – 36,891) is low.

4.2.3 Future Study

An extensive network of remote tracking stations is presently in place in both the Canadian and U.S. portions of the Yukon River basin. Should additional chinook telemetry studies (including aerial surveys) be initiated in future years, it is suggested that aerial surveys be conducted on all the relevant portions of the primary tributaries and on the mainstem Yukon River between the White River and the Teslin River. Known salmon spawning streams in this section of the upper Yukon River include Big Creek, Tatchun Creek, Nordenskiold River and Little Salmon River. The efficiency of future aerial surveys could be improved with faster reporting of transmitters that are recovered in fisheries so they are not sought following their removal from the system. Finally, the relatively high concentration of fish encountered in the lower Teslin River warrants a ground survey to verify that this section is an important spawning area.

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Appendix 1. Biological characteristics and migration rates of radio-tagged chinook salmon tracked in the upper Yukon River drainage.

Fish No.	Trans. Freq.	Trans. Code	Gender	Mid-Eye Fk. Lgth. (mm.)	Tagging Date	Date Passing Upper Border RTS	Migration Rate Border to Trib. (Km./Day)	Fate (H)=Harvest
3	722	49	F	820	9-Jun-02	17-Jul-02	44.9	B. Salmon R.
7	881	49	M	730	10-Jun-02	12-Jul-02	49.4	Stewart R.
8	902	49	U	810	10-Jun-02	13-Jul-02	57.9	Teslin R.
10	942	49	F	840	10-Jun-02	17-Jul-02	42.0	B. Salmon R.
13	702	28	U	715	11-Jun-02	12-Jul-02		White R.
14	722	28	U	795	11-Jun-02	16-Jul-02	51.4	Pelly R.
17	842	28	F	890	11-Jun-02	11-Jul-02	60.4	Stewart R.
21	942	28	F	920	12-Jun-02	14-Jul-02	50.4	Pelly R. (H)
26	742	30	U	760	12-Jun-02	12-Jul-02		Nordenskiold R.
27	783	30	M	805	12-Jun-02	13-Jul-02	65.6	Pelly R. (H)
28	842	30	M	795	12-Jun-02	12-Jul-02	43.4	Stewart R.
32	942	30	F	915	12-Jun-02	17-Jul-02	39.7	Stewart R.
35	702	32	F	880	13-Jun-02	21-Jul-02		mainstem Yukon R.(H)
36	722	32	M	1030	13-Jun-02	21-Jul-02		Klondike R.
37	742	32	U	850	13-Jun-02	12-Jul-02	60.2	Teslin R.
47	722	34	F	870	13-Jun-02	19-Jul-02	49.9	Stewart R.
50	842	34	F	900	14-Jun-02	25-Jul-02		Unknown
56	684	36	F	880	15-Jun-02	16-Jul-02	28.4	B. Salmon
57	702	36	M	860	15-Jun-02	16-Jul-02	44.9	Stewart R.
60	783	36	F	680	15-Jun-02	17-Jul-02		White R.
61	842	36	U	740	15-Jun-02	19-Jul-02		Nordenskiold R.
64	922	36	M	850	15-Jun-02	12-Jul-02	58.3	Teslin R.
65	942	36	F	810	15-Jun-02	19-Jul-02		Klondike R.
73	881	38	F	860	16-Jun-02	19-Jul-02	53.3	B. Salmon R.
79	702	40	F	850	16-Jun-02	19-Jul-02	37.6	South Yukon R.
81	742	40	M	850	16-Jun-02	23-Jul-02		mainstem Yukon R.
82	783	40	U	910	16-Jun-02	17-Jul-02	53.4	Pelly R. (H)
86	922	40	F	830	16-Jun-02	22-Jul-02		Teslin R.
91	722	42	F	860	17-Jun-02	23-Jul-02	46.1	Teslin R.
92	742	42	U	680	17-Jun-02	19-Jul-02		mainstem Yukon R.(H)
94	842	42	M	830	17-Jun-02	26-Jul-02	46.4	Pelly R.
97	922	42	F	760	17-Jun-02	23-Jul-02	55.3	Pelly R.
98	942	42	F	790	17-Jun-02	26-Jul-02		mainstem Yukon R.(H)
100	684	44	F	800	17-Jun-02	20-Jul-02	57.2	Pelly R.
106	881	44	F	715	17-Jun-02	20-Jul-02		Chandindu R.
109	942	44	U	890	17-Jun-02	23-Jul-02		Unknown
113	722	46	M	785	18-Jun-02	23-Jul-02		White R.
119	922	46	M	800	19-Jun-02	28-Jul-02		mainstem Yukon R.(H)
124	722	48	M	750	19-Jun-02	23-Jul-02		Nordenskiold R.
129	902	48	F	870	20-Jun-02	25-Jul-02	44.5	Stewart R.
131	942	48	F	900	20-Jun-02	28-Jul-02		mainstem Yukon R.

Fish No.	Trans. Freq.	Trans. Code	Gender	Mid-Eye Fk. Lgth. (mm.)	Tagging Date	Date Passing Upper Border RTS	Migration Rate Border to Trib. (Km./Day)	Fate (H)=Harvest
132	982	48	F	890	20-Jun-02	27-Jul-02	42.9	B. Salmon R.
134	702	76	F	695	21-Jun-02	25-Jul-02	47.8	Pelly R.
136	742	76	M	780	21-Jun-02	30-Jul-02	40.2	Teslin R.
146	722	78	M	575	22-Jun-02	25-Jul-02	48.3	Stewart R.
149	842	78	F	910	22-Jun-02	27-Jul-02		Unknown
155	684	80	U	810	22-Jun-02	28-Jul-02		Unknown
156	702	80	M	725	22-Jun-02	27-Jul-02		mainstem Yukon R.(H)
158	742	80	F	790	22-Jun-02	24-Jul-02		Unknown
166	702	82	M	820	23-Jun-02	30-Jul-02		mainstem Yukon R.(H)
172	902	82	M	790	23-Jun-02	24-Jul-02	49.0	Pelly R.
173	922	82	U	610	23-Jun-02	28-Jul-02		Klondike R.
174	942	82	U	715	23-Jun-02	29-Jul-02	37.4	South Yukon R.
179	783	84	U	930	24-Jun-02	27-Jul-02		mainstem Yukon R.(H)
180	842	84	U	790	24-Jun-02	24-Jul-02	58.7	Stewart R.
183	922	84	U	810	24-Jun-02	31-Jul-02	44.0	Stewart R.
184	942	84	1	780	24-Jun-02	27-Jul-02		Unknown
185	684	86	F	720	24-Jun-02	26-Jul-02	40.9	Teslin R.
186	702	86	M	710	24-Jun-02	31-Jul-02		Unknown
187	722	86	F	920	24-Jun-02	1-Aug-02	41.8	Teslin R.
189	783	86	U	835	24-Jun-02	24-Jul-02	56.4	Pelly R.
191	881	86	M	730	24-Jun-02	31-Jul-02	44.1	Teslin R.
194	942	86	U	930	25-Jun-02	30-Jul-02	42.2	Teslin R.
206	702	90	U	760	25-Jun-02	1-Aug-02	50.0	B. Salmon R.
207	722	90	F	790	25-Jun-02	28-Jul-02		L. Salmon R.
209	783	90	F	720	25-Jun-02	29-Jul-02		Tatchun Ck.
213	922	90	M	780	26-Jun-02	3-Aug-02	38.5	Teslin R.
216	702	92	F	840	27-Jun-02	3-Aug-02		Tatchun Ck.
224	942	92	U	930	27-Jun-02	7-Aug-02		Unknown
225	684	94	F	850	27-Jun-02	9-Aug-02		Unknown
228	742	94	M	750	27-Jun-02	3-Aug-02		Unknown
233	922	94	F	710	28-Jun-02	30-Jul-02	46.3	Teslin R.
242	902	96	F	950	30-Jun-02	4-Aug-02	44.8	Teslin R.
246	702	0	F	835	30-Jun-02	5-Aug-02	47.0	Pelly R.
260	783	2	U	800	3-Jul-02	5-Aug-02	47.7	Teslin R.
263	902	2	F	920	3-Jul-02	13-Aug-02		Unknown
264	922	2	U	780	3-Jul-02	13-Aug-02		Unknown
266	982	2	U	840	5-Jul-02	8-Aug-02		mainstem Yukon R.
267	684	4	U	880	5-Jul-02	13-Aug-02		Unknown
274	902	4	M	890	6-Jul-02	6-Aug-02	48.6	Teslin R.
275	922	4	M	780	6-Jul-02	15-Aug-02		Unknown
278	684	6	M	790	7-Jul-02	11-Aug-02		Unknown
282	783	6	U	800	9-Jul-02	13-Aug-02	42.5	Teslin R.
286	922	6	U	870	11-Jul-02	13-Aug-02	40.7	Teslin R.
287	942	6	F	890	12-Jul-02	17-Aug-02		Unknown
402	742	54	F	905	28-Jun-02	1-Aug-02		mainstem Yukon R.(H)
403	783	54	F	875	28-Jun-02	6-Aug-02		mainstem Yukon R.

Fish No.	Trans. Freq.	Trans. Code	Gender	Mid-Eye Fk. Lgth. (mm.)	Tagging Date	Date Passing Upper Border RTS	Migration Rate Border to Trib. (Km./Day)	Fate (H)=Harvest
409	982	54	M	880	29-Jun-02	29-Jul-02	53.0	B. Salmon R.
414	783	56	F	895	29-Jun-02	3-Aug-02	38.8	Teslin R.
416	881	56	M	870	29-Jun-02	5-Aug-02		mainstem Yukon R.(H)
419	942	56	M	880	29-Jun-02	2-Aug-02	45.5	Teslin R.
420	982	56	M	615	29-Jun-02	4-Aug-02	41.0	Teslin R.
421	684	58	F	875	30-Jun-02	3-Aug-02		Unknown
437	842	60	F	810	1-Jul-02	2-Aug-02	39.6	B. Salmon R.
439	902	60	F	820	1-Jul-02	4-Aug-02		Unknown
440	922	60	F	880	1-Jul-02	9-Aug-02		Unknown
443	684	62	U	850	1-Jul-02	4-Aug-02	45.9	Teslin R.
447	783	62	F	830	1-Jul-02	8-Aug-02		Unknown
448	842	62	M	685	1-Jul-02	1-Aug-02		mainstem Yukon R.(H)
450	902	62	F	895	1-Jul-02	7-Aug-02	41.4	Pelly R.
456	722	64	F	900	2-Jul-02	4-Aug-02	44.2	Teslin R.
458	783	64	M	785	2-Jul-02			L. Salmon R.
459	842	64	F	805	2-Jul-02	7-Aug-02	40.3	South Yukon R.
461	902	64	F	840	3-Jul-02	20-Aug-02	33.5	Pelly R.
466	702	66	M	685	4-Jul-02	3-Aug-02	48.9	Teslin R.
473	922	66	F	815	5-Jul-02	4-Aug-02		White R.
476	684	68	M	780	5-Jul-02	9-Aug-02		mainstem Yukon R.
478	722	68	M	610	5-Jul-02	9-Aug-02		Unknown
484	922	68	M	900	6-Jul-02	17-Aug-02		Unknown
485	942	68	F	870	6-Jul-02	9-Aug-02		mainstem Yukon R.
487	684	70	U	990	6-Jul-02	16-Aug-02		Unknown
491	783	70	M	845	6-Jul-02	7-Aug-02		Unknown
508	982	72	F	930	7-Jul-02	8-Aug-02	41.5	Teslin R.
513	783	74	F	910	7-Jul-02	10-Aug-02		Unknown
516	902	74	F	860	8-Jul-02	13-Aug-02		Unknown
517	922	74	M	740	8-Jul-02	13-Aug-02		Unknown
522	722	15	F	830	8-Jul-02	4-Aug-02	65.2	Teslin R.
531	684	53	F	780	9-Jul-02	7-Aug-02		Unknown
539	922	53	F	760	10-Jul-02	6-Aug-02		Unknown
545	742	55	M	880	10-Jul-02	11-Aug-02	46.1	South Yukon R.
550	922	55	F	910	11-Jul-02	11-Aug-02	47.8	Swift R.
610	722	67	F	875	11-Jul-02	12-Aug-02		Unknown
612	783	67	U	790	13-Jul-02	8-Aug-02		mainstem Yukon R.(H)
901	684	7	F	825	9-Jun-02	15-Jul-02	53.6	Teslin R.
903	722	7	F	760	9-Jun-02	7-Jul-02		White R.
915	742	25	M	720	10-Jun-02	8-Jul-02		mainstem Yukon R.(H)
918	881	25	F	840	10-Jun-02	10-Jul-02	59.9	Stewart R.
936	722	29	F	855	11-Jun-02	14-Jul-02	46.4	Pelly R.
939	842	29	F	825	12-Jun-02	9-Jul-02		Klondike R.
942	922	29	F	835	12-Jun-02	13-Jul-02		White R.
945	684	31	F	910	12-Jun-02	11-Jul-02	55.1	B. Salmon R.
950	842	31	F	895	13-Jun-02	15-Jul-02		Klondike R.
959	742	33	F	720	13-Jun-02	10-Jul-02		Klondike R.

Fish No.	Trans. Freq.	Trans. Code	Gender	Mid-Eye Fk. Lgth. (mm.)	Tagging Date	Date Passing Upper Border RTS	Migration Rate Border to Trib. (Km./Day)	Fate (H)=Harvest
961	842	33	F	735	14-Jun-02	17-Jul-02		Unknown
962	881	33	F	755	14-Jun-02	16-Jul-02	51.6	B. Salmon R.
966	982	33	F	810	14-Jun-02	15-Jul-02		White R.
967	684	35	F	790	14-Jun-02	14-Jul-02	55.7	Stewart R. (H)
968	702	35	M	745	14-Jun-02	12-Jul-02	57.5	Pelly R. (H)
971	783	35	M	780	14-Jun-02	11-Jul-02	63.7	Stewart R.
974	902	35	M	820	14-Jun-02	14-Jul-02	57.5	Stewart R.
976	942	35	F	980	14-Jun-02	15-Jul-02	50.8	Pelly R.
977	982	35	M	970	15-Jun-02	16-Jul-02	52.2	Stewart R.
979	702	37	F	815	15-Jun-02	17-Jul-02	46.0	Pelly R.
980	722	37	F	740	15-Jun-02	15-Jul-02	52.8	B. Salmon R.
981	742	37	F	895	15-Jun-02	24-Jul-02	39.9	Teslin R.
988	982	37	F	795	16-Jun-02	21-Jul-02	57.2	Teslin R.
990	702	39	F	775	16-Jun-02	18-Jul-02	41.1	Pelly R. (H)
994	842	39	M	735	16-Jun-02	19-Jul-02		Klondike R. (H)
997	922	39	M	680	17-Jun-02	19-Jul-02	57.4	Teslin R.
999	982	39	F	805	18-Jun-02	16-Jul-02	52.0	Pelly R.
1006	881	41	F	740	18-Jun-02	20-Jul-02	47.6	B. Salmon R.
1011	684	43	M	770	19-Jun-02	23-Jul-02		Unknown
1012	702	43	F	760	19-Jun-02	17-Jul-02	52.2	Teslin R.
1019	922	43	1	860	20-Jun-02	20-Jul-02	57.4	Stewart R.
1020	942	43	F	795	20-Jun-02	18-Jul-02		mainstem Yukon R.(H)
1021	982	43	U	890	20-Jun-02	25-Jul-02	50.6	Stewart R.
1024	722	45	U	765	20-Jun-02	20-Jul-02	64.0	Pelly R.
1030	922	45	M	765	20-Jun-02	19-Jul-02	63.7	Teslin R.
1031	942	45	U	760	20-Jun-02	20-Jul-02	55.2	B. Salmon R.
1032	982	45	M	875	20-Jun-02	22-Jul-02		mainstem Yukon R.(H)
1039	881	47	F	865	20-Jun-02	26-Jul-02	33.0	Pelly R.
1040	902	47	F	870	21-Jun-02	24-Jul-02	41.7	Teslin R.
1049	842	10	M	905	21-Jun-02	27-Jul-02	39.1	Teslin R.
1053	942	10	M	725	21-Jun-02	18-Jul-02	62.2	Pelly R.
1055	684	77	M	725	21-Jun-02	25-Jul-02	49.3	B. Salmon R.
1056	702	77	M	720	21-Jun-02	29-Jul-02		Unknown
1057	722	77	M	865	21-Jun-02	26-Jul-02	47.5	Pelly R. (H)
1060	842	77	F	925	21-Jun-02	28-Jul-02	38.3	B. Salmon R.
1073	902	79	U	870	22-Jun-02	23-Jul-02		Klondike R.
1084	902	17	M	670	22-Jun-02	28-Jul-02	47.1	Pelly R.
1088	684	19	F	810	22-Jun-02	26-Jul-02		mainstem Yukon R.
1089	702	19	M	1030	22-Jun-02	26-Jul-02	40.5	Teslin R.
1090	722	19	M	720	22-Jun-02	21-Jul-02	57.4	Pelly R. (H)
1096	922	19	F	775	23-Jun-02	29-Jul-02		Unknown
1099	684	21	M	785	23-Jun-02	19-Jul-02		Unknown
1102	742	21	M	615	23-Jun-02	1-Aug-02		Tatchun Ck.
1108	942	21	M	750	23-Jun-02	24-Jul-02	40.9	B. Salmon R.
1109	982	21	M	640	23-Jun-02	29-Jul-02	53.2	Pelly R.
1113	742	23	M	705	23-Jun-02	24-Jul-02	49.5	South Yukon R. (H)

Fish No.	Trans. Freq.	Trans. Code	Gender	Mid-Eye Fk. Lgth. (mm.)	Tagging Date	Date Passing Upper Border RTS	Migration Rate Border to Trib. (Km./Day)	Fate (H)=Harvest
1114	783	23	M	910	23-Jun-02	28-Jul-02	48.3	Teslin R.
1118	922	23	M	855	23-Jun-02	26-Jul-02	43.0	Stewart R.
1122	702	89	F	885	24-Jun-02	28-Jul-02		Unknown
1123	722	89	M	720	24-Jun-02	26-Jul-02		Unknown
1125	783	89	M	775	24-Jun-02	26-Jul-02		Unknown
1127	881	89	M	710	24-Jun-02	25-Jul-02		mainstem Yukon R.(H)
1130	942	89	M	840	24-Jun-02	24-Jul-02	55.8	Pelly R.
1132	702	91	M	840	24-Jun-02	29-Jul-02	48.5	Stewart R.
1139	922	91	M	850	24-Jun-02	5-Aug-02		Unknown
1141	684	93	F	750	25-Jun-02	30-Jul-02	50.9	Pelly R.
1143	722	93	M	890	25-Jun-02	2-Aug-02		Unknown
1149	922	93	M	740	25-Jun-02	25-Jul-02	50.4	South Yukon R. (H)
1150	942	93	M	840	25-Jun-02	31-Jul-02	43.3	South Yukon R.
1154	742	13	M	1050	25-Jun-02	27-Jul-02		mainstem Yukon R.
1156	842	13	F	810	26-Jun-02	26-Jul-02	39.2	B. Salmon R.
1166	783	1	M	895	26-Jun-02	3-Aug-02		mainstem Yukon R.
1170	922	1	F	830	26-Jun-02	29-Jul-02	49.8	Pelly R.
1172	982	1	M	675	26-Jun-02	28-Jul-02		L. Salmon R.
1175	722	3	F	845	27-Jun-02	30-Jul-02	46.1	Teslin R.
1197	722	12	F	890	28-Jun-02	8-Aug-02	45.4	Pelly R.
1203	922	12	F	835	28-Jun-02	2-Aug-02	50.8	Stewart R.
3001	1033	8	F	870	16-Jun-02	17-Jul-02	53.9	Pelly R.
3003	1033	14	F	885	3-Jul-02	4-Aug-02		mainstem Yukon R.
3008	1033	73	M	725	17-Jun-02	23-Jul-02	52.5	mainstem Yukon R.(H)
3009	1033	75	F	865	17-Jun-02	18-Jul-02	54.8	Pelly R.
3010	1033	96	M	830	17-Jun-02	15-Jul-02		mainstem Yukon R.(H)
3011	1033	9	M	710	17-Jun-02	16-Jul-02		mainstem Yukon R.(H)
3012	1033	11	F	890	17-Jun-02	22-Jul-02		mainstem Yukon R.(H)
3013	1033	12	F	750	17-Jun-02	16-Jul-02	47.8	Stewart R.
3019	1033	35	F	695	18-Jun-02	20-Jul-02		mainstem Yukon R.(H)

Appendix 2. Comparison of migration rates of radio-tagged chinook salmon in the upper Yukon River in 2002 with Milligan et al (1985).

Migration Rates (Km./Day)		
Stock	**2002**	**1983**
Stewart R.	50.5	41.3
White R.	-	28.6
Pelly R.	50.9	39.8
Big Salmon R.	46.1	37.0
Teslin R.	47.2	45.6
south Yukon R.	43.5	32.2

Appendix 3. Comparison of the distributions of radio-tagged chinook salmon in the upper Yukon River in 2002 with Milligan et al (1985).

Area	**Distribution**			
	2002		**1983**	
	N	**Percentage**	**N**	**Percentage**
Stewart R.	22	12	8	6
Pelly R.	33	17	5	4
Teslin R.	17	19	7	6
Big Salmon R.	36	9	3	2
south Yukon R.	7	4	2	2
Mainstem & Other Tributaries	76	39	102	80
Total	191	100	127	100

Appendix 4. Tributary escapement indices based on radio tags and fish wheel catches weighted by calendar period.

Date	Total No. Radio Tags	Weekly Proportion of Total Radio Tags	Fishwheel Catches in Period	Weekly Proportion of Total Fishwheel Catches	Weekly No. Fish past Fish wheels (weekly prop. X 30,247)	Radio tagged - untagged Ratio	Stewart River Weekly Tags And Index	Pelly River Weekly Tags And Index	Big Salmon River Weekly Tags And Index	South Yukon River Weekly Tags And Index	Teslin River Weekly Tags And Index	mainstem Teslin River Weekly Tags And Index	McQuesten River Weekly Tags And Index
June 23 - July 13							3	2	1	0	3	0	2
Wk 1	17	0.081	179	0.170	5137	0.0033	906	604	302		906		604
July 14 - July20							8	13	7	1	2	0	3
Wk 2	48	0.230	147	0.139	4219	0.0114	703	1143	615	88	176		264
July 21 - July 27							6	11	4	2	6	6	1
Wk 3	51	0.244	187	0.177	5366	0.0095	631	1157	421	210	631	631	105
July 28 - Aug. 3							3	3	2	1	12	11	1
Wk 4	45	0.215	426	0.404	12225	0.0037	815	815	543	272	3260	2988	272
Aug. 4 - Aug 10							1	3	2	2	12	7	0
Wk 5	31	0.148	86	0.082	2468	0.0126	80	239	159	159	955	557	
Aug. 11 - Aug 28							1	1	0	0	1	2	0
Wk 6	17	0.081	29	0.028	832	0.0204	49	49			49	98	
Total	**209**		**1054**		**30247**								
Total Index Weighted							**3184**	**4007**	**2041**	**729**	**5978**	**4275**	**1245**
Total Index Un-weighted							**3184**	**4775**	**2465**	**870**	**5220**	**3770**	**1015**

Appendix 5 Recovered Radio Tags from Fisheries and Agency Projects Conducted in the Upper Yukon River Watershed - 2002

Spaghetti Tag Number		Radio Frequency	Radio Code	Date of Recovery	Defined Location Near Point of Recovery
First Nation and Commercial Fisheries					
02-	00092	742	42	28-Jul-02	Carmacks
A02-	03019	1033	35	28-Jul-02	Carmacks
A02-	03012	1033	11	1-Aug-02	Carmacks
02-	00156	702	80	7-Aug-02	Carmacks
02-	00448	842	62	7-Aug-02	Carmacks
02-	00098	942	42	7-Aug-02	Carmacks
02-	01020	942	43	8-Aug-02	Carmacks
02-	00612	783	67	16-Aug-02	Carmacks
A02-	03010	1033	96	17-Jul-02	Dawson City
02-	00402	742	54	3-Aug-02	Dawson City
02-	01044	684	10	4-Aug-02	Dawson City
02-	01128	902	89	4-Aug-02	Dawson City
02-	00462	922	64	4-Aug-02	Dawson City
02-	00204	942	88	4-Aug-02	Dawson City
02-	00166	702	82		Dawson City
02-	00035	702	32		Dawson City
02-	00179	783	84		Dawson City
02-	00994	842	39		Dawson City
02-	00416	881	56		Dawson City
02-	00967	684	35	24-Jul-02	Mayo
02-	01032	982	45	29-Jul-02	Mayo
02-	00072	842	38	19-Jul-02	Old Crow
02-	00968	702	35	18-Jul-02	Pelly Crossing
02-	00990	702	39	20-Jul-02	Pelly Crossing
02-	00021	942	28	20-Jul-02	Pelly Crossing
02-	00082	783	40	22-Jul-02	Pelly Crossing
02-	00027	783	30	27-Jul-02	Pelly Crossing
02-	01090	722	19	28-Jul-02	Pelly Crossing
02-	01057	722	77	3-Aug-02	Pelly Crossing
A02-	03008	1033	73	3-Aug-02	Tatchun Creek (mouth)

Appendix 5 continued

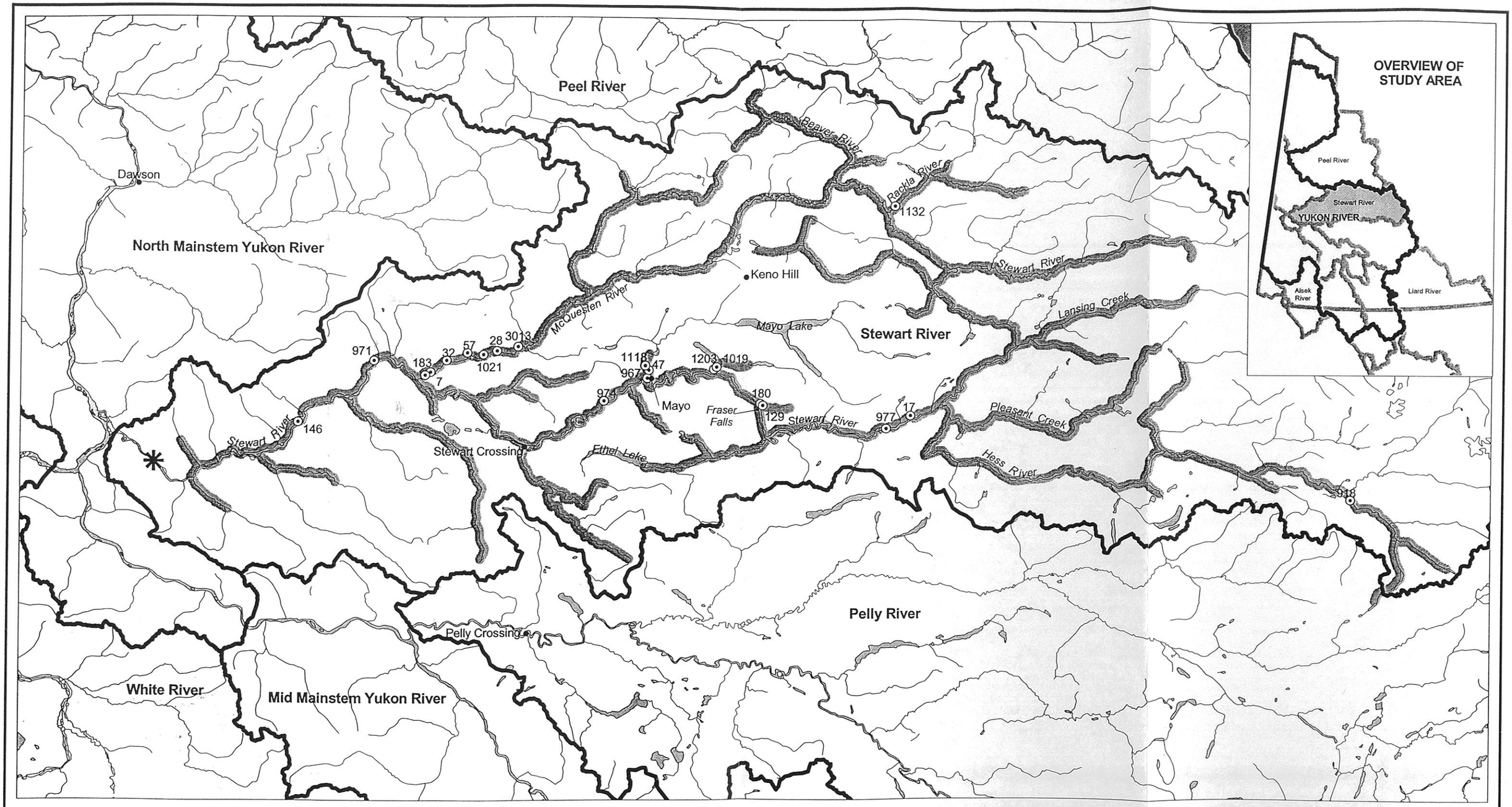
Spaghetti Tag Number		Radio Frequency	Radio Code	Date of Recovery	Defined Location Near Point of Recovery
Agency Projects and Test Fisheries					
02-	00915	742	25	7-Jul-02	Dawson City
02-	01127	881	89	25-Jul-02	Dawson City
02-	00119	922	46	26-Jul-02	Fortymile River (mouth)
A02-	03013	1033	12	21-Aug-02	McQuesten River
02-	01149	922	93	17-Aug-02	Takhini River (mouth)
A02-	03011	1033	9		U.S./Canada Border Tagging (DFO) White Rock
02-	01113	742	23	10-Aug-02	Whitehorse Rapids Fishway
* Data summarized from DFO data file 'US Tags in Canada Nov. 02 – from US'					

Appendix 6 Radio Tagged Fish Recovered in Monitored Fisheries or Located in Index Survey Areas – 2002

Fishery / Index Survey	**Number of Radio Tags in River (RTS monitored or AT Survey Area)**	**Number of Radio Tags Recovered or Located in Index Area**	**Number of Fish Caught in Fishery or Counted in Index Area ***
Stewart River First Nation Fishery	21	2	800
Pelly River First Nation Fishery	33	7	1857
Big Salmon River (Index Survey)	17	7	1149
Teslin River (Wolf River Index Survey)	37	1	84
Little Salmon River Index Area only (Index Survey)	2	2	526
south Yukon River (Whitehorse Rapids Fishway)	7	1	605

AT – Aerial Tracking
* U.S./Canada Yukon River Joint Technical Committee Report. 2002.

Appendix 7. (Maps 1-4)



LEGEND

- Fish Number
- Radio Tag Location
- RTS Location
- Surveyed Stream
- DFO Aerial Index
- Waterbody
- Watercourses
- Watershed Boundaries

Yukon River Chinook Aerial Telemetry Surveys 2002

Map 1. Stewart River

Scale 1:1,250,000

25 0 25 50 75 100 125 Kilometers

Yukon Albers Equal Area Conic projection

Digital Data Sources and Disclaimers:

Yukon River Chinook Aerial Survey data sources compiled from R&E project 78-02 based on 2002 field observations. Fish locations based on GPS coordinates from the aerial telemetry surveys and surveyed streams compiled based on 1:500,000 basemaps.

National Topographic Database (NTDB) compiled at 1:250,000 by Natural Resources Canada.

Shaded Relief based on 90 meter Digital Elevation Model compiled by YTG Environment GIS Department.

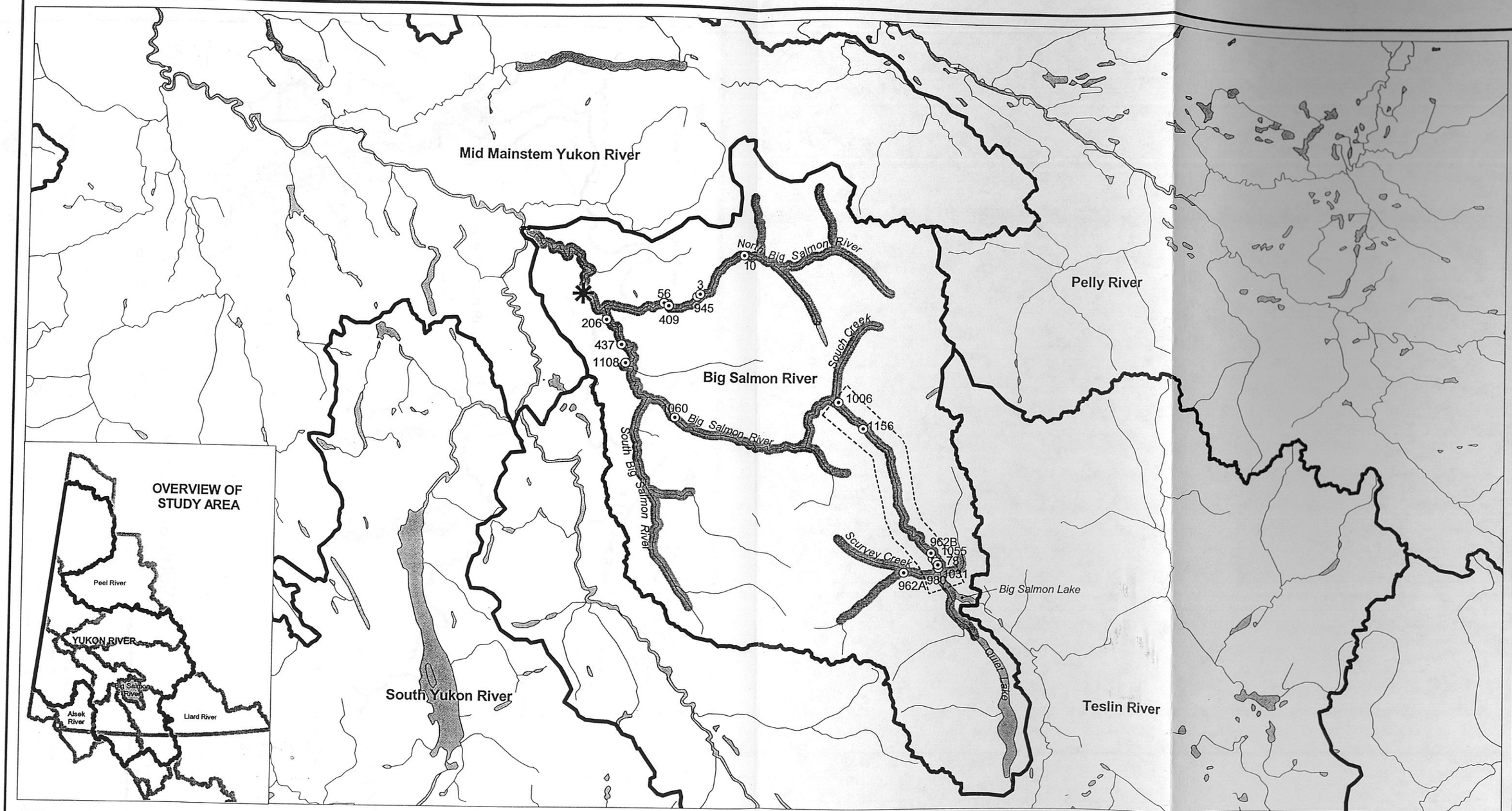
Watershed Boundaries compiled by Fisheries and Oceans Canada at 1:250,000. Boundaries are approximate and are for presentation purposes only.

Map Compiled by:
Fisheries and Oceans Canada
Yukon / Transboundary Rivers Area

Date:
02 June 2003

Fisheries and Oceans Canada

Pêches et Océans Canada



LEGEND

- Fish Number — Radio Tag Location
- RTS Location
- Surveyed Stream
- DFO Aerial Index
- Waterbody
- Watercourses
- Watershed Boundaries

Yukon River Chinook Aerial Telemetry Surveys 2002

Map 2. Big Salmon River

Scale 1:750,000

25 0 25 50 75 Kilometers

Yukon Albers Equal Area Conic projection

Digital Data Sources and Disclaimers:

Yukon River Chinook Aerial Survey data sources compiled from R&E project 78-02 based on 2002 field observations. Fish locations based on GPS coordinates from the aerial telemetry surveys and surveyed streams compiled based on 1:500,000 basemaps.

National Topographic Database (NTDB) compiled at 1:250,000 by Natural Resources Canada.

Shaded Relief based on 90 meter Digital Elevation Model compiled by YTG Environment GIS Department.

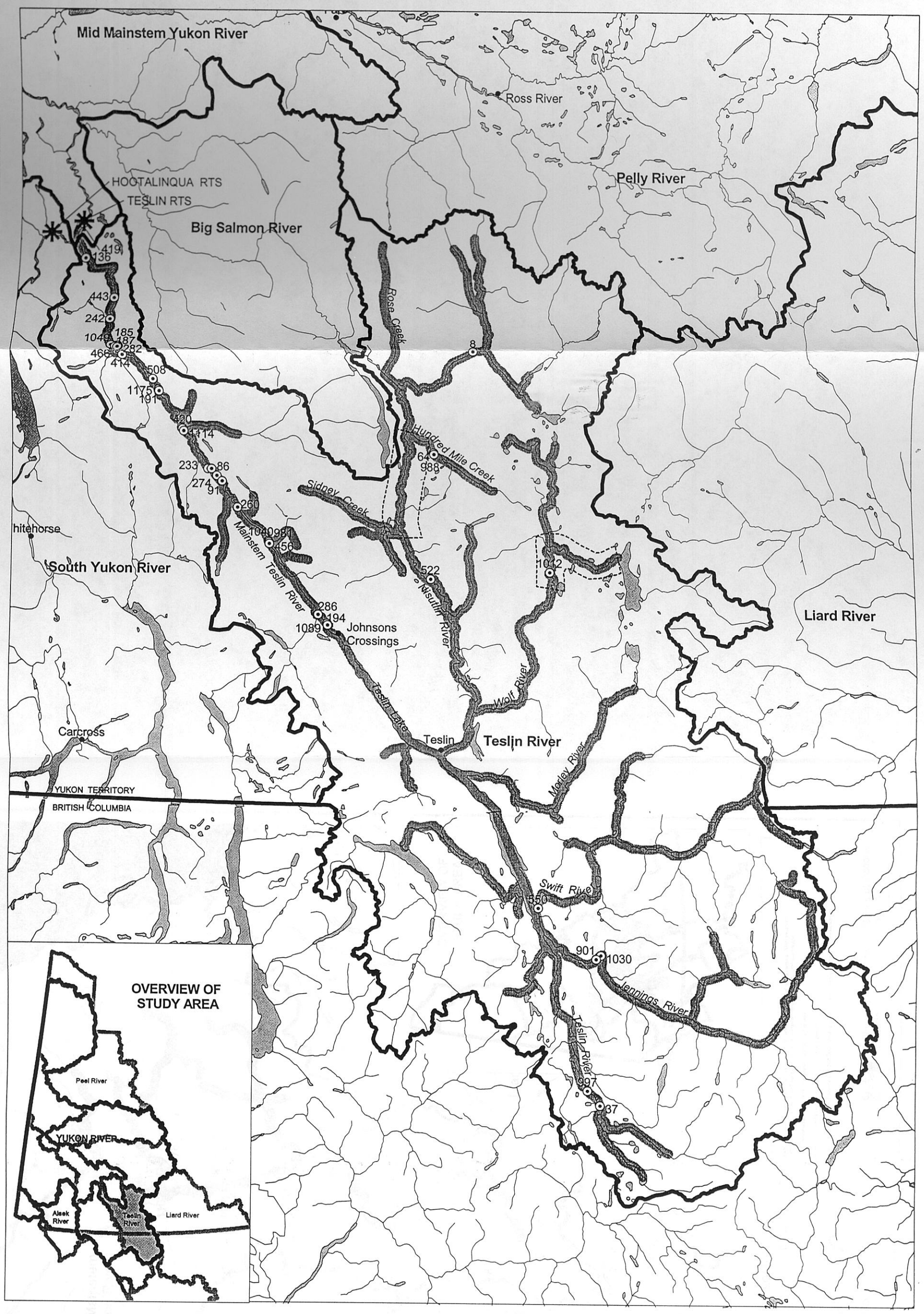
Watershed Boundaries compiled by Fisheries and Oceans Canada at 1:250,000. Boundaries are approximate and are for presentation purposes only.

Map Compiled by:
Fisheries and Oceans Canada
Yukon / Transboundary Rivers Area

Date:
02 June 2003

Fisheries and Oceans Canada

Pêches et Océans Canada



Yukon River Chinook Aerial Telemetry Surveys 2002

Map 3. Teslin River

Scale 1:1,150,000

25 0 25 50 75 Kilometers

Yukon Albers Equal Area Conic projection

LEGEND

- Fish Number
- Radio Tag Location
- RTS Location
- Surveyed Stream
- DFO Aerial Index
- Waterbody
- Watercourses
- Watershed Boundaries

Digital Data Sources and Disclaimers:

Yukon River Chinook Aerial Survey data sources compiled from R&E project 78-02 based on 2002 field observations. Fish locations based on GPS coordinates from the aerial telemetry surveys and surveyed streams compiled based on 1:500,000 basemaps.

National Topographic Database (NTDB) compiled at 1:250,000 by Natural Resources Canada.

Shaded Relief based on 90 meter Digital Elevation Model compiled by YTG Environment GIS Department.

Watershed Boundaries compiled by Fisheries and Oceans Canada at 1:250,000. Boundaries are approximate and are for presentation purposes only.

Map Compiled by:
Fisheries and Oceans Canada
Yukon / Transboundary Rivers Area

Date:
02 June 2003

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Pelly Crossing

Mid Mainstem Yukon River

3003
266
216
1102
209
419
131
476
81
Carmacks
26
403
485
1154
297
1172
458
Little Salmon River
Tatchun Creek
1084
97
Pelly River
Pelly River
Faro
3001
Ross River
976
1197
1039
461
Ross River
Pelly River
1130
246
189
1170
1088
124
61
1166
459
Nordenskiold River
Big Salmon River
Lake Laberge
Liar
Teslin River
Alsek River
South Yukon River
Haines Junction
Whitehorse

OVERVIEW OF STUDY AREA

Peel River
YUKON RIVER
Archival Survey Area
Alsek River
Liard River

LEGEND

Fish Number
Radio Tag Location
RTS Location
Surveyed Stream
DFO Aerial Index
Waterbody
Watercourses
Watershed Boundaries

Yukon River Chinook Aerial Telemetry Surveys 2002

Map 4. Archival Tag Survey

Scale 1:1,250,000

25 0 25 50 75 100 125 Kilometers

Yukon Albers Equal Area Conic projection

Digital Data Sources and Disclaimers:

Yukon River Chinook Aerial Survey data sources compiled from R&E project 78-02 based on 2002 field observations. Fish locations based on GPS coordinates from the aerial telemetry surveys and surveyed streams compiled based on 1:500,000 basemaps.

National Topographic Database (NTDB) compiled at 1:250,000 by Natural Resources Canada.

Shaded Relief based on 90 meter Digital Elevation Model compiled by YTG Environment GIS Department.

Watershed Boundaries compiled by Fisheries and Oceans Canada at 1:250,000. Boundaries are approximate and are for presentation purposes only.

Map Compiled by:
Fisheries and Oceans Canada
Yukon / Transboundary Rivers Area

Date:
02 June 2003

Fisheries and Oceans Canada

Pêches et Océans Canada