DISTRIBUTION AND ABUNDANCE OF RADIO TAGGED CHINOOK SALMON IN THE CANADIAN PORTION OF THE YUKON RIVER WATERSHED AS DETERMINED BY 2003 AERIAL TELEMETRY SURVEYS

RE Project 77-03

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Abstract

In 2003, the second year of a Yukon River basin wide adult chinook salmon tagging and monitoring program, 1,097 radio tags were applied to migrating chinook salmon captured at Marshall and Russian Mission on the lower Yukon River in Alaska. As a complement to the larger basin wide monitoring project, aerial surveys were conducted in the Canadian portion of the Yukon River to determine the distribution and relative abundance of the radio tagged fish. This report details the results of the 2003 aerial surveys in Canada.

Aerial tracking surveys were conducted on all major tributaries and streams with documented chinook spawning streams. The surveys were conducted between July 31 and September 14. Of the 419 radio tagged chinook that migrated upstream of the Alaska – Yukon border, 42 were captured in fisheries, 348 were detected and assigned terminal locations during the aerial surveys, and 29 were not located. Radio tagged fish were distributed throughout the survey area with higher concentrations in the Klondike, McQuesten, Big Salmon, Little Salmon, the mainstem Yukon, and the mainstem Teslin rivers. Proportional distribution of located radio tags ranged from a high of 70 (19%) in the Pelly drainage to a low of 10 (3%) in the south Yukon River. In general, the 2003 radio tag distribution was similar to that observed in the streams surveyed during the 2002 study.

Based on telemetry data and the recovery of tags in three assessment projects a 2003 above border chinook population estimate of 93,975 with a 95% CI of +/- 12,035 was obtained. Using the telemetry data radio tag ratio of 0.00446 (1 radio tag per 224 untagged chinook) and a simple linear arithmetic relationship of tagged/untagged ratios it was possible to generate 2003 escapement indices of all surveyed streams that contained radio tagged chinook.

1.0 Introduction

Aerial telemetry surveys have been used extensively to monitor the movements, distribution, run timing, and estimate proportional abundance of radio tagged adult salmon in northern Canada and Alaska (Boyce 1999, Eiler et al. 2000 & 2002, Milligan et al. 1985, Osborne et al. 2003, Pahlke et al. 1996). Aerial surveys often provide the only efficient and cost effective means of tracking the movements and distribution of radio tagged fish in large remote watersheds.

The Yukon River chinook salmon, (*Onchorhynchus tshawytscha*), radio telemetry program was inaugurated in 2000 to assist with the management of Yukon River chinook by providing additional information on distribution, run timing, and abundance. In 2000 and 2001, the United States National Marine Fisheries Service (NMFS) and the Alaska Department of Fish and Game (ADF&G) directed two pilot chinook radio tagging studies on the Yukon River preparatory to a basin-wide program initiated in 2002 (Spencer et al. 2003). The 2003 Yukon River chinook telemetry project was the second year that a large-scale transboundary telemetry study was conducted in the Yukon River system. The objectives of the 2002 and 2003 studies were to release up to 1,100 radio tagged chinook salmon in the lower Yukon River at Marshal and Russian Mission in Alaska. The movements of the tagged fish would be tracked throughout the Yukon River drainage using remote tracking stations (RTS's) and aerial surveys.

Although largely directed by ADF&G and NMFS, the Yukon River chinook telemetry program is a transboundary program involving government agencies, non-government entities, and consultants in both Canada and the U.S. In 2002 and 2003, two private companies, B. Mercer & Associates Ltd. (BMA) and Haldane Environmental Services (HES), were contracted through the Yukon River Panel[1] to track the radio tagged chinook that entered the Canadian portion of the upper Yukon River watershed. ADF&G and NMFS assisted the contractors in providing technical advice and help as well as in-season data. This report details the distribution and abundance of radio tagged chinook in Canadian portions of the upper Yukon River watershed, (hereafter referred to as the upper Yukon River watershed), based on results of the aerial telemetry surveys conducted in 2003. A companion report (Osborne, 2004) describes the distribution and migration rates and timing of the radio tagged chinook in the upper Yukon based on RTS tracking information. The 2003 aerial surveys encompassed the entire upper Yukon watershed, whereas the 2002 aerial surveys were limited to comprehensive surveys of the North mainstem, Stewart, Big Salmon, and Teslin systems. The results of the 2002 aerial surveys are detailed in a previous report (Osborne et al. 2003).

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[1] The Yukon River Panel administers the Yukon River Restoration and Enhancement (R&E) fund. This fund, established through the Yukon River Salmon Agreement of the Pacific Salmon Treaty, is used to fund specific projects addressing salmon habitat restoration, enhancement, and management issues. In 2003 the R&E fund also funded aerial tracking projects on the Porcupine River drainage (presented in a separate R&E report), and the north mainstem Yukon/Klondike (incorporated in this report).

1.1 Objectives

It is known that chinook salmon move and spawn throughout the 885,000 km^2 Canadian portion of the Yukon River basin. The remote tracking stations used in the basin wide study were situated to provide information on the proportional distribution of radio tagged fish to the main tributaries of the Yukon River. However, the stations do not yield information on the movements and spawning distribution of radio tagged fish within the tributaries.

The specific objectives of the upper Yukon River aerial survey portion of the 2003 Yukon River chinook telemetry study were to:

1. Conduct aerial surveys to determine the spawning distribution of radio tagged chinook throughout the Canadian portion of the upper Yukon River basin.
2. Determine the location of archival/radio tagged fish and recover the archival radio transmitters.
3. Validate the passage of radio tagged fish recorded by the stationary receivers.
4. Provide a population estimate and relative abundance indices for the tributaries surveyed using the radio telemetry information.

2.0 Methods

The 2003 fish capture and tag application methods and procedures will be detailed in a report similar to the 2002 study report produced by U.S. agencies (Eiler et al., 2004; in preparation). As occurred in 2002, the fish in 2003 were captured and tagged at Marshall and Russian Mission, located approximately 250 km upstream from the Bering sea on the lower Yukon River in Alaska. The fish were tagged with individually identifiable pulse-coded transmitters manufactured by Advanced Telemetry Systems (Isanti, Minnesota). The tags were fitted with a motion sensor and activity monitor that emitted a distinct signal and code if the motion sensor was not triggered for 24 hours. The signal would revert to the original pattern if the motion sensor were re-activated. The tags had a minimum battery life of 90 days.

In addition to the 1,054 standard radio tags applied, 43 fish were fitted with radio-archival tags that recorded water depth and temperature every three minutes as well as emitting the standard radio signal.

All radio tagged fish were marked with external spaghetti tags; yellow for standard radio tags and pink for archival tags. Information on sex, length, age, and a tissue sample for genetic stock identification was also collected for each tagged fish.

2.1 Aerial Survey Area and Timing

The primary objective of the 2003 upper Yukon River aerial telemetry survey project was to determine the terminal spawning distribution of all radio tagged fish migrating upstream of the Canada/U.S. border. To accomplish this, all known and suspected chinook spawning streams were to be surveyed. To facilitate the survey and data collection the Canadian portion of the upper Yukon River basin was classified into eight separate regions based on watershed configurations (Map 9) and the location of tributary RTS's. Tracking stations were located at the mouths of the Stewart, Pelly, Big Salmon, Teslin, and South Yukon watersheds as well as at 3 sites on the mainstem Yukon River (Osborne 2004). The RTS's provided records of radio tagged fish migrating into these watersheds. The number of radio tagged fish that had passed the respective RTS's was made available prior to the aerial surveys.

The Stewart, White, Pelly, Big Salmon, and Teslin regions were delineated by their respective drainage boundaries. The North Mainstem/Klondike area included the portion of the Yukon River and associated tributaries extending from the Stewart River confluence downstream to the Canada/U.S. boundary. The Mainstem Yukon (and associated tributaries) was designated as that portion of the Yukon River extending from the mouth of the Stewart River upstream to the Teslin RTS. The South Yukon area comprised the Yukon River and associated tributaries upstream of the Hootalinqua RTS.

The timing of the surveys for each watershed reflected the migration timing obtained from the 2002 Yukon River telemetry results as well as logistical considerations to minimise flying between watersheds. The dates each watershed was surveyed are listed in Table 1. In order to obtain a high probability the radio tagged fish would be detected in their terminal spawning area, at least two surveys were conducted in each tributary approximately 7-14 days apart. Within the North mainstem/Klondike watershed the aerial surveys were performed between July 31 and August 13. Aerial surveys were conducted in the other seven watersheds over the period August 14 through September 14.

Table 1. Aerial survey dates, 2003.

Watershed	**Survey Dates**		
North Mainstem/Klondike	July 31 - Aug. 3	Aug. 10 - 13	
Stewart River	Aug. 15 -17	Aug. 26	
Mainstem Yukon River	Aug. 19,21	Sept. 3	
White River	Aug.14-15	Aug. 31	
Pelly River	Aug. 17 -19	Aug. 25 -28	
Big Salmon River	Aug. 20	Sept. 1	
Teslin River	Aug. 21-23	Sept. 1,4	Sept. 14
South Yukon River	Aug.20,	Aug. 31	Sept. 1

The Stewart River watershed was surveyed once during the period August 15 through 17. Only one survey was conducted because at the time it was thought (erroneously) that 29 of the 30 tags that had passed the Stewart River RTS were located. The mainstem Teslin River was surveyed three times to account for the protracted spawning period observed within this area during the 2002 study and to determine, with confidence, if the detected fish were in transit or stationary. The Takhini River in the South Yukon drainage was surveyed once only.

2.2 Aerial tracking equipment

The aerial surveys were conducted using a Piper PA-18 fixed wing float equipped aircraft.[2] The surveys were flown at an average of 300 m above ground level at an airspeed of approximately 110 km per hour. A two-element "H" type stainless steel receiving antenna (150.00 – 152.00 MHz. Range) was mounted on the wing struts on each side of the aircraft (Figure 1). The antennae were arrayed so that maximum directional gain was achieved at a 25 degree angle of bank and approximately 70 degrees aft of the forward flight path. Both antennae were connected to a single, model R 4500 receiver using RG58/U coaxial cable and coaxial splitter. The receiver, as well as the radio tags deployed, were manufactured and distributed by Advanced Telemetry Systems. The receiver was connected to an aircraft supplied 12 volt power supply. This receiver has a frequency range of 4 MHz., with 4 memory banks, channel spacing of 1 KHz., and an enhanced Digital Signal Processor. The R4500 receiver has a geographic positioning system (GPS) that provides co-ordinates each time a radio tag signal is recorded. A total of 12 frequencies were sequentially scanned at 2 seconds per frequency.

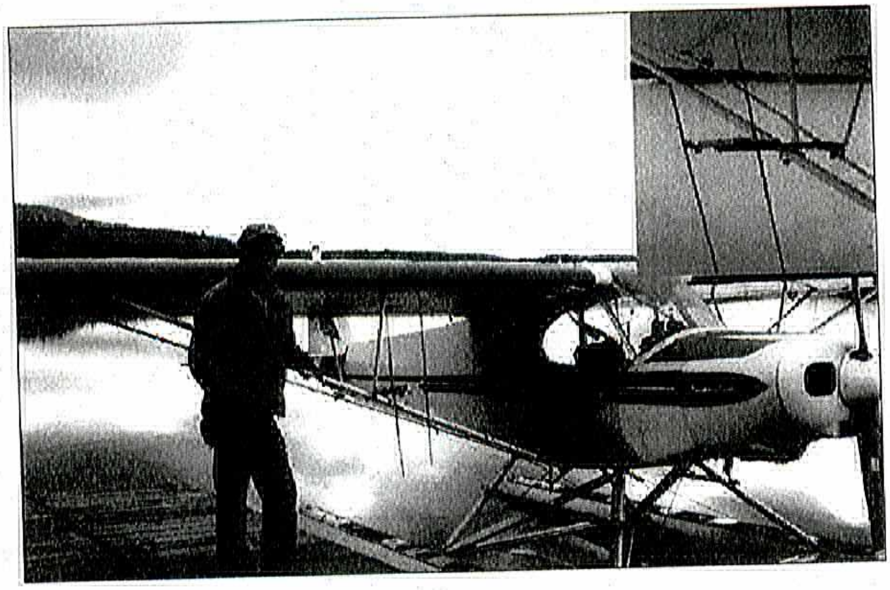

Figure 1. PA-18 aircraft and "H" antennae configuration.

One observer operated the receiving equipment. Headsets and an intercom connection allowed the pilot to monitor the audio output of the receiver as well as to communicate with the observer. When a radio tag signal was heard at sufficient strength to achieve signal processing, the operator would exit scan mode and select the frequency to determine the pulse code(s). If required, the aircraft would make more than one pass to obtain the highest audio output (signal strength). The receiver automatically recorded the

[2] Surveys in the North Mainstem/Klondike watershed were conducted using a float equipped Bellanca Citabria fixed wing aircraft.

date, time, signal strength, tag frequency and code, activity status, and the corresponding GPS co-ordinates. The observer also manually recorded the tag frequency, code, activity status, and tributary name. The equipment was checked before the beginning of each survey and one spare receiving unit was taken on each flight.

If a strong signal was heard but the pulse code and corresponding GPS co-ordinate were not obtained by the receiver (6 occurrences in 2003), the operator noted the frequency and manually recorded the aircraft GPS co-ordinates that corresponded to the highest audio signal.

A total of 161 hours was flown in fixed wing aircraft during the 2003 aerial surveys of the Canadian portion of the upper Yukon River watershed.[3] In addition, approximately 14 hours of fixed wing aircraft and 3.5 hours of helicopter time were used for the detection and recovery of the archival tags.

2.3 Data Analysis

The logged data was downloaded onto a laptop computer after completion of each aerial survey. Backup files of the aerial records were also copied onto a floppy disc at this time. Typically, final radio tag locations were determined by using the GPS co-ordinates that matched the median maximum signal strength in the record for each tagged fish located. When radio tagged fish moved between surveys, the furthest upstream point recorded for that fish was used to establish the terminal location, regardless of signal strength. If a tagged fish died between surveys the furthest upstream point recorded on the initial survey was used as the terminal location. The frequency and code of each tag was cross referenced with the respective RTS records to validate the identity of each located radio tag. The final GPS co-ordinates for each radio tag was plotted on topographic maps using geographic information system (Arcview) software.

The radio tag locations presented in this report are limited to those considered to be at large and in probable terminal spawning locations. Several radio tags were located near towns and a few near rural residences. Most of these tags had been recovered by fishers and were subsequently forwarded either to Fisheries and Oceans Canada (DFO), ADF&G, or NMFS. The radio tags that were captured in fisheries and subsequently relinquished were categorised as "caught in fisheries" and were not assigned a terminal location.

2.4 Archival Tag Location and Recovery

It was assumed archival radio tags would be detected during the course of the aerial surveys. Recovery of an archival tag was only attempted after the mortality sensors were activated. Additional surveys were required to locate the archival tags after the fish died. Access to the archival tag was via floatplane if the stream conditions allowed for landing

[3] For the North Mainstem–Klondike watershed aerial surveys only, a float equipped Bellanca-Citabria aircraft was flown a total of 32.5 hours. A Piper PA-18 aircraft was flown a total of 143 hours to survey the other seven watersheds and recover archival tags.

near the located tag. A chartered Bell 206 helicopter was used to access the archival tag if the location conditions prevented floatplane access.

3.0 Results

Of the 1,097 chinook radio tagged at the Alaskan tagging sites, a total of 413 were recorded as passing upstream of the Alaska – Yukon border tracking stations. Forty-two tagged fish were reported captured in commercial, sport, subsistence, and aboriginal fisheries (JTC report, 2003). Of the remaining 377 radio tags potentially at large, 349 (93%), were assigned terminal spawning locations during the aerial surveys. The distribution of located radio tags, by watershed, is illustrated in Figure 2.

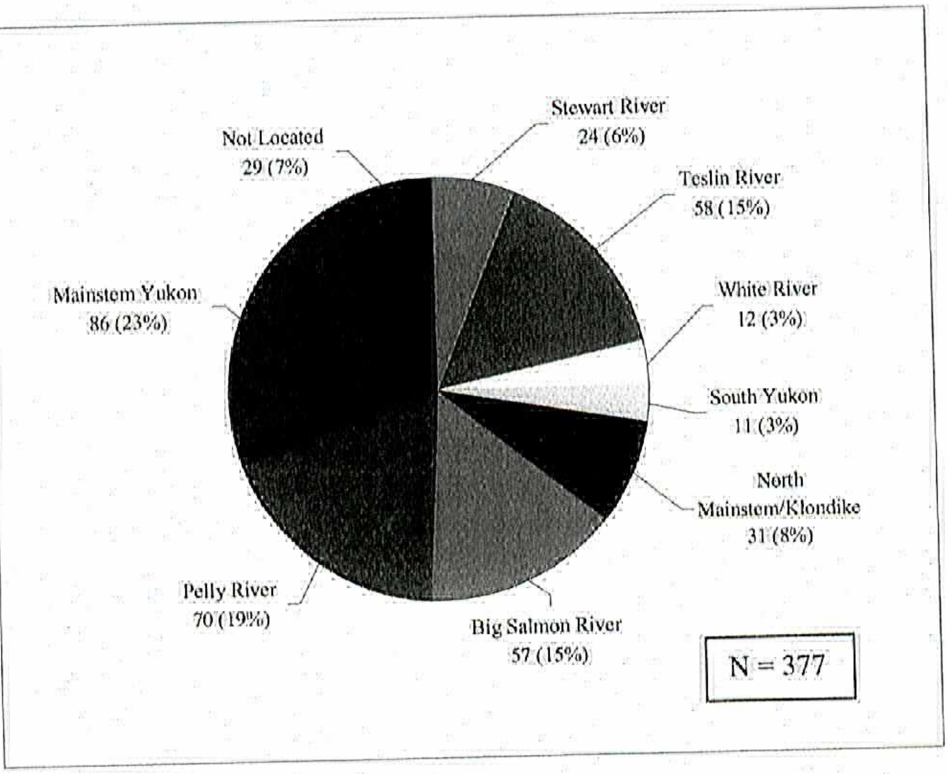

Figure 2. Distribution of radio tags located during the 2003 aerial surveys.

During the 2003 aerial surveys, six (two in Stewart system and four in the Pelly watershed) radio tag signals were detected that were not decoded. Without the identifier code the fish number could not be positively determined. All six radio tag signals were detected on more than one survey at a consistent location and frequency. The radio signals were clear and unambiguous and it was the opinion of the observer and pilot they were radio tagged fish. All were located in documented spawning areas, and for those within the Pelly River system, in proximity to other radio tags. None of the frequencies of these particular radio transmitters matched any of the frequencies of tags not located by aerial surveys that had been recorded as passing the tributary RTS. It is assumed the pulse coding in these transmitters was faulty and consequently they would not have been detected by the RTS's. These 6 unidentified fish were added to the recorded total that passed the border and the respective tributary RTS's. For the purposes of this report the total number of tagged fish entering the Canadian portion of the upper Yukon Basin is 419, with 33 and 83 entering the Stewart and Pelly systems respectively. The number of radio tags recorded passing the border and tributary RTS's, reported caught in fisheries, and located by aerial surveys is presented in Table 2.

3.1 North Mainstem/Klondike Watershed

The streams surveyed in the North Mainstem/Klondike region included the Mainstem Yukon River from the Alaska – Yukon border to the mouth of the Stewart River, and portions of the Forty Mile, Fifteen Mile, Chandindu, Klondike, Indian, and Sixty Mile rivers. Sections of Coal, Swede, Rock, and Flat creeks were also surveyed. The Forty Mile River was surveyed once on August 13.

Table 2. Number of radio tags past RTS, caught in fisheries, and located by aerial surveys.

Watershed	RTS Record	Reported Caught in Fisheries	Located by Aerial Surveys	Not Located by Aerial Surveys
North Mainstem/Klondike	44[a]	14	30	0
Stewart River	33[b]	4	24	5
Mainstem Yukon River	104[a]	9	86	9
White River	13[a]	0	12	1
Pelly River	83[c]	8	70	5
Big Salmon River	59	0	57	2
Teslin River	70	7	58	5
South Yukon River	13	0	11	2
Total	**419**	**42**	**348**	**29**

[a]Inferred RTS count by subtraction.
[b]Addition of 2 radio tags not decoded
[c]Addition of 4 radio tags not decoded

Within the North Mainstem/Klondike watershed, terminal locations were established for 30 radio tags (Table 3, Map no. 1, Appendix 1-a). Nineteen radio tags were located in the Klondike system, 7 were in the Mainstem Yukon between the Alaska – Yukon border and Dawson City, and 4 were located in the Chandindu River. In addition, 14 radio tagged fish were caught in the commercial and test fisheries in the area.

The highest radio tag density in this region was found in the Klondike River. One radio tag (Fish no. 231) was recovered at the Chandindu River chinook weir, the designated terminal location. It is assumed the 7 Mainstem Yukon radio tags detected were in terminal locations but as the last aerial survey in this region was on August 13 it is possible they were later run fish and still in transit to other North Mainstem-Klondike tributaries. Five of the 7 North Mainstem fish were recorded on more than one survey but fish nos. 909 and 890 (Map 1) were observed once only during the August 13 survey.

Table 3. Radio tag distribution in the North Mainstem/Klondike Watershed.

Fate	Total
Chandindu River	4
Klondike River	19
North Mainstem Yukon River	7
Caught in Fishery	14
Total	44

3.2 Stewart River Watershed

Within the Stewart River watershed the areas surveyed included: The Stewart River mainstem downstream of Fraser Falls, Lake Creek, Crooked Creek, McQuesten River (North and East McQuesten), Moose Creek, Mayo River, Janet Creek, Williamson Creek, Watson Creek, and No Gold Creek. The final radio tag locations are presented in Table 4, Appendix 1-b, and Map 2. The Stewart River aerial surveys located 24 (83%) of the 29 potentially available radio tagged fish in the system. Four tagged fish were captured in the local fisheries before the surveys began and were subsequently passed on to DFO – Whitehorse, Yukon.

Table 4. Radio tag distribution in the Stewart River watershed.

Fate	Total
Caught in Fishery	4
Janet Creek	1
Mayo River	2
McQuesten River	16
Not located	5
Stewart River	4
Watson Creek	1
Total	33

The 2003 distribution of radio tagged fish in the Stewart system was similar to that of 2002 (Osborne et al, 2003), with the McQuesten River drainage again receiving the largest number of radio tagged fish (16, 48%). As occurred in 2002, radio tagged fish in the McQuesten River were located in the lower reaches of the system. The Stewart River mainstem received 4 tags. The remaining tributaries where radio tagged fish were present contained 2 tags or less.

Of the 24 radio tags located in the Stewart system during the August 15 –17 surveys, 19 had activated mortality sensors (Appendix 1-b). All 4 of the tagged fish located in the Stewart mainstem were dead.

3.3 Pelly River Watershed

The Pelly River system is a relatively large watershed that includes many tributaries with documented chinook utilisation. The streams surveyed in the Pelly drainage included the Earn, Glenlyon, Hoole, Kalzas, Macmillan, Pelly, Tay, and Ross rivers. Also surveyed were Blind, Big Campbell, Little Kalzas, LaForce, Mica, Needlerock, and Otter creeks. Excepting the Tay and Hoole rivers and Big Campbell Creek, which were surveyed once, all the streams were systematically surveyed twice.

Of the upper Yukon River tributaries, the Pelly River system received the largest number radio tags. As noted in section 3.0 above, an additional 4 unidentified radio tagged fish were added to the RTS count to bring the total number of radio tagged fish in the system to 83. A total of 79 radio tagged fish was recorded passing the Pelly River RTS. Eight radio tags were reported caught in the Pelly River aboriginal fishery, 70 tagged fish were assigned terminal locations based on the aerial surveys, and 5 radio tags were not located. The final radio tag locations are presented in Table 5, Map 3, and Appendix 1-c.

Table 5. Radio tag distribution in the Pelly River watershed.

Fate	Total	Fate	Total
Big Campbell Creek	2	Macmillan River	1
Blind Creek	1	Mica Creek	2
Caught in Fishery	8	N. Macmillan River	2
Earn River	2	Needlerock Creek	1
Glenlyon River	2	Not Located	5
Hoole River	4	Otter Creek	4
Kalzas River	2	Pelly Lakes outlet	2
Laforce Creek	1	Pelly River	13
Little Kalzas Creek	3	Ross River	11
		S. Macmillan River	12
		Grand Total	83

The radio tags located were distributed extensively and disparately throughout the Pelly system. The mainstem Pelly, Ross, and Macmillan rivers received the largest number of radio tags while the highest tag densities were found in Blind Creek and between km 60 and km 80 on the Ross River. Three radio tagged fish were also found in close proximity within Little Kalzas Creek.

Only three radio tags were located in the lower 160 km of the mainstem Pelly River. Fish no. 272 located near the Pelly River mouth was detected during the August 25 aerial survey, 2 and 6 days after passing the Selkirk and White RTS's respectively. It is probable this was a late run fish still in transit to a location further upstream. Mainstem fish no. 239 and 316 were at the same location on both surveys so were regarded as stationary. The remaining radio tags in the system were all considered to be at terminal locations.

Of the 70 radio tagged fish assigned terminal locations, 31(44%) had activated mortality sensors (Appendix 1-c). On the first survey 19/65 (29%) of the radio tags located were considered dead, and on the second survey 24/67 (36%) of the tagged fish had expired.

3.4 White River Watershed

The streams surveyed in the White River drainage included portions of the White, Donjek, Nisling, Kluane, Ladue, Klaza, and Klotassin rivers. The lower reaches of Beaver, as well as all of Onion and Tincup creeks were also surveyed. The Donjek and White rivers downstream from the confluence of the Klotassin River were flown once only during the first survey. The other streams were surveyed twice, on August 14 and 31.

Table 6. Radio tag distribution in White River watershed.

Fate	Total
Donjek River	1
Klotassin River	1
Nisling River	4
Not Located	1
Tincup Creek	5
White River	1
Grand Total	13

Twelve radio tagged fish were located in the White River system during the two aerial surveys (Table 6, Map 4, Appendix 1-d)[4]. The Nisling River and Tincup Creek had the largest number of radio tagged fish with 4 and 5 tags respectively. The highest tag density was found in Tincup Creek, with all the tags observed within 10 km of the outlet of Tincup Lake. Within the Nisling River, the radio tag terminal locations were evenly distributed over 45 km of the stream length from the mouth to the confluence with the Klaza River. Fish 762 in the mainstem White River and fish no. 178 in the mainstem Donjek River were detected only during the first survey. Although the mainstem Donjek and White rivers were surveyed only once these fish were not observed during the second survey upstream of their initial locations. Due to the high sediment loads of the White and Donjek Rivers it would seem unlikely chinook would be spawning in these areas.

[4] In 2003 a second RTS was established on the mainstem Yukon River near the mouth of the White River to determine the number of radio tags entering the system. However the RTS was not established until late July when most of the fish would have passed into the drainage (Osborne 2004). Therefore it is not known how many radio tagged fish were available for detection within the drainage. Through a process of elimination using the White River and Selkirk RTS records it was surmised that 13 radio tags entered the system.

However, with the absence of contrary evidence the locations of these fish were considered terminal.

Three of 11 fish located during the first survey had activated mortality sensors. On the second survey, 4 of the 10 radio tags located were considered mortalities. It should be noted that 3 of the 4 radio tagged fish located on the Nisling River during the August 14 survey were designated as mortalities; whereas all five tags located in Tincup Creek during the August 31 survey were classified as still alive. Fish no. 557 observed in Tincup Creek was not located during the first survey indicating it had entered the system after mid-August.

3.5 Mainstem Yukon River

For the purposes of this study, the mainstem Yukon River was designated as the portion of the Yukon River, and associated tributaries, extending from the mouth of the Stewart River upstream to the junction of the Yukon and Teslin Rivers. The streams surveyed in this area included all the mainstem Yukon, and portions of the Nordenskiold, Little Salmon, and Magundy rivers. Big, Tatchun, Drury, Rowlison, and Walsh creeks were also surveyed. Two aerial surveys were conducted on all the streams on August19, 21 and September 3.

Table 7. Radio tag distribution in mainstem Yukon River watershed.

Fate	Total
Big Creek	1
Caught in Fishery	9
Little Salmon River	19
Mainstem Yukon River	56
Nordenskiold River	6
Not Located	9
Tatchun Creek	4
Grand Total	104

Within the mainstem Yukon area terminal locations were assigned to 86 radio tags (Table 7, Map 5, Appendix 1-e). The largest number of tags (56) were located within the Yukon River. These tags were disbursed throughout the length of the Yukon River in the area surveyed; however, higher densities were observed in the vicinity of Carmacks and between the mouth of Big Creek and the Pelly River. The highest radio tag densities were found in the Little Salmon River with 19 tags located within the 25 km reach between Little Salmon Lake and the Yukon River confluence. Six tags were located in the Nordenskiold River with 5 of these in a 10 km section downstream of Kirkland Creek. Four radio tags were detected in Tatchun Creek between the creek mouth and Tatchun Lake.

Of all the watersheds surveyed, the mainstem Yukon River area contained the largest number (104) of radio tags at large, based on RTS data. It also contained the largest number of radio tags (9) reported in the system but not located by the aerial surveys.

During the first survey on August 19 and 21, 12 (14%) of the 86 radio tags detected had activated mortality sensors. On the second survey 26 (31%) of the 84 located radio tagged fish were identified as dead. Within the Little Salmon River the number of tags with activated mortality sensors remained consistent between surveys at 25%. Compared to the other mainstem radio tagged fish, the Nordenskiold River had higher ratios of expired fish during each survey (33% and 67% respectively).

3.6 Big Salmon River System

The streams surveyed in the Big Salmon River drainage included the Big Salmon, North Big Salmon, and South Big Salmon rivers. Pleasant Creek, Souch Creek, Northern Creek, and Scurvy Creek were also surveyed.

Of the 59 tags recorded passing the Big Salmon RTS, 57 (97%) were located during the two aerial surveys (Table 8, Map 6, Appendix 1-f). Six tagged fish were observed in the North Big Salmon River and 51 were found in the Big Salmon River. No radio tags were located in any of the smaller tributaries. Within the Big Salmon River, radio tags were disbursed between the RTS and the outlet of Big Salmon Lake. The majority of the radio tags were located in the upper reaches of the Big Salmon with the highest densities (28 tags) in the 40 km reach between the outlet of Big Salmon Lake, and the mouth of Souch Creek. Radio tag densities were comparatively lower in the North Big Salmon River. The radio tags in the North Big Salmon were distributed between the river mouth and the confluence with Northern Creek.

Table 8. Radio Tag distribution in the Big Salmon River watershed.

Fate	Total
Big Salmon River	51
North Big Salmon River	6
Not located	2
Grand Total	59

Two radio tags, one of which was an archival tag, were recorded passing the Big Salmon RTS but were not located. It is possible the fish was caught and the tag not relinquished (although relatively remote, the Big Salmon is a very popular river for canoeists and kayakers). The tags simply may not have been detected during the aerial surveys, although the overall stream morphology is generally favourable for signal detection and all documented and probable spawning habitat was surveyed.

During the first survey on August 20, 16 of the 54 tags (30%) located had activated mortality sensors, whereas 20 of the 54 tags (37%) observed on September 1 were considered dead. All 6 of the North Big Salmon radio tagged chinook located during the second survey were classified as dead.

3.7 Teslin River System

The Teslin River system is a relatively large watershed encompassing approximately 26,000 sq. km within the southern Yukon 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 twice. The streams surveyed included the mainstem Teslin River (RTS site to Teslin Lake) and the upper Teslin River from Teslin Lake to Chesmania Lake. The Nisutlin, Rose, Wolf, Red, McConnell, Morely, Swift, Smart, Gladys, Jennings, and Glundeberry rivers were also surveyed. Smaller tributaries surveyed included Boswell (lower portion), Thirty Mile, Swift, Hundred Mile, Dave, Fat, Sidney, Evelyn, Tlingit, and Hayes creeks (Map 7). The Teslin River drainage surveys were conducted on August 21-23, September 1 and 4, and a final mainstem Teslin River survey occurred on September 14.

A total of 70 radio tagged chinook were recorded passing the Teslin RTS in 2003. Of these, 58 were assigned terminal locations during the aerial surveys, 7 were caught in various fisheries, and 5 were not located (Table 9, Map 7, Appendix 1-g). The highest number and concentration of radio tags (68% of tags located in the system) were found in the mainstem Teslin River. Within the mainstem Teslin the highest densities were found in a 10 km section downstream of the Teslin Lake outlet and a 15 km reach between Boswell and Swift creeks. The Nisutlin River system contained 14 radio tagged fish with 10 in the Nisutlin River proper, 3 in 100 Mile Creek, and 1 in the McNeil River.

Table 9. Radio tag distribution in the Teslin River watershed.

Fate	Total	Fate	Total
100 Mile Creek	3	Nisutlin River	10
Caught in Fishery	7	Not Located	5
Jennings River	1	Red River	1
Mainstem Teslin	39	Swift Creek	1
McNeil River	1	Wolf River	2
		Grand Total	70

During the first Teslin watershed survey on August 22- 23 only 3 (6%) of the 47 radio tags located had activated mortality sensors. On the September 1,4 survey 17 (35%) of the 48 tagged fish were found dead. During the final Mainstem Teslin River survey on September 14, a total of 17 (53%) of the 32 tagged fish were moribund.

3.8 South Yukon River watershed

Within the South Yukon watershed the streams surveyed included: the Yukon River from the Teslin confluence to Marsh Lake, portions of the Takhini, Mendenhall, and

McClintock rivers as well as lower portions of Croucher and Ibex creeks and the whole of Mitchie Creek. The Yukon River section was surveyed twice, on August 20 and September 1. The Takhini, Mendenhall, and Ibex rivers were surveyed once only on August 31. The McClintock /Mitichie Creek system was surveyed once only on September 14.

All chinook passing the Whitehorse rapids fishway were examined for spaghetti/radio tags. Detected radio tags were removed; therefore it was assumed no radio tags would have been at large upstream of the Whitehorse fishway. The survey conducted on the system above the fishway on September 14 was performed enroute to the final mainstem Teslin survey and was done to validate this assumption. No tagged fish upstream of the fishway were observed.

Thirteen radio tags were recorded passing the Hootalinqua RTS and entering the South Yukon watershed. Ten radio tags were located in the aerial surveys, 1 was recovered at the Whitehorse rapids fishway, and 2 were not located (Table 10, Map 8, Appendix 1-h). Six of the 10 radio tags located were found in the Takhini system: 5 in the Takhini River proper and 1 in Ibex Creek 3 km upstream from the mouth. Four radio tags were observed in the Yukon River: 3 downstream of Lake Laberge and 1 approximately 5 km downstream from the Whitehorse rapids fishway. It should be noted that observations of the Takhini River fish and the radio tag located near Whitehorse were from one late season survey and may not be representative of actual terminal spawning locations. Nevertheless, all but one of the 6 Takhini River chinook was recorded as being still alive on the September 1 survey.

Table 10. Distribution of radio tags in the South Yukon River watershed.

Fate	Total
Ibex Creek	1
Not Located	2
South Yukon River	4
Takhini River	5
Whitehorse Fishway	1
Grand Total	13

Two of the 10 tags located during the south Yukon surveys had activated mortality sensors. These tags were observed on only a single survey, one of which was performed on September 14.

3.9 Archival Tag Location and Retrieval

Eleven archival radio tags were recorded passing the border RTS into the Canadian portion of the upper Yukon River drainage. Of the 11 tags that passed the Alaska/Yukon border, 9 were located during the aerial surveys and were subsequently recovered. Two were not located in the aerial surveys and remained at large. Three of the archival tags were found in the Pelly system, 3 in the mainstem Teslin River, and one each in the

The RTS records indicated the 2 archival tags not located by the aerial surveys were last recorded in the mainstem Yukon River upstream of the Tatchun RTS (fish no. 3105) and in the Big Salmon River (fish no. 3127).

3.10 Telemetry Derived 2003 Chinook Escapement Indices

Using the 2003 telemetry data it is possible to obtain a population estimate of the 2003 chinook escapement entering the Canadian portion of the upper Yukon River basin. This estimate is based on the number of radio tags recorded by the border RTS's and the ratio of radio tagged/untagged chinook recovered in upstream fisheries and assessment projects. The following population estimate was derived using a simple Petersen estimator (Seber 1982):

$$N = D*(n/c)$$

Where: N = total population of chinook crossing the Alaska/Yukon border
n = total number of chinook captured in fisheries and counted in assessment projects
D = number of radio tagged chinook crossing the border
c = number of radio tagged chinook captured in fisheries and observed in assessment projects

For the purposes of this report, the total number of chinook (n)captured in fisheries and observed in assessment projects was determined to be 11,887 (Table 11). This figure was obtained using: 1) the combined commercial, test and aboriginal gill net fishery catches; 2) DFO fish wheel catches; and 3) the Blind Creek weir counts (Yukon River JTC report, 2003). The total number of radio tagged chinook captured in the fisheries and observed in assessment projects © was 53. The number of radio tags crossing the border (D) was determined to be 419 (413 recorded by the RTS's plus the 6 non-coded tags identified in the aerial surveys).

Table 11. Radio tags recorded in 2003 fisheries and assessment projects.

Category	# of Fish	# of Tags	Proportion tagged	Population estimate
Gill net fisheries*	1,446	42	0.00444	94,235
Fish wheels*	1,248	5	0.00400	104,582
Blind Creek weir[5]	1,193	6	0.00502	83,311
Combined	11,887	53	0.00445	93,975
				Standard deviation = 10,637

*Data source: Yukon River JTC report, 2003.

Based on the above data a 2003 above border chinook population estimate of 93,975 with a 95% CI of +/- 12,035 was obtained ($\alpha = 0.05$, s.d. = 10,637, n = 3). Using the telemetry data radio tag ratio of 0.00446 (1 radio tag per 224 untagged chinook) and a simple linear arithmetic relationship of tagged/untagged ratios it is possible to generate 2003 escapement indices of all surveyed streams that contained radio tagged chinook. For example, the Hoole and Ross rivers each received 4 and 11 radio tags resulting in

[5] The Blind Creek chinook number is the sum of the weir count of 1,155 plus 38 counted spawning downstream of the weir (J. Wilson per. com.).

population indices of 896 and 2,464 respectively. A table of radio tag counts and resultant population indices is presented in Appendix 2.

The telemetry based population estimate is based on a number of standard mark-recapture assumptions. The validity of these assumptions is discussed below in section 4.10. It must be stressed that although the escapement indices presented do have relational and comparative value, their numerical accuracy, especially for streams with lower tag numbers, is questionable. These indices are population point estimates based on simple tagged/untagged ratios without quantifiable confidence limits.

4.0 Discussion

The 2003 upper Yukon River telemetry surveys were successful in locating and assigning terminal locations to 93% of the radio tagged fish at large. The fate of the 29 tags not located will remain unknown but it is likely they either: a) migrated to streams not surveyed; b) were captured and not reported; c) were not detected because the transmitter was damaged or at a water depth from which the signal could not propagate; or d) the signal was simply missed during the surveys. It is probable that a proportion of the tags not located had been captured in fisheries but were not reported. Aerial surveys flown in 2002 over villages along the Tanana and Yukon rivers in Alaska documented that 49 of the 270 tagged fish (18.2%) caught in fisheries were not reported (Eiler et al., 2004, in prep.)

In 2002, 96% of the RTS recorded radio tags in selected tributaries were subsequently located during the aerial surveys (Osborne et. al, 2003). The aerial survey area in the Canadian portion of the upper Yukon basin encompasses approximately 240,000 sq. km. Given the large area as well as the time, weather, and budget constraints associated with the aerial surveys, it would be impractical to attempt to increase the proportion of located tags beyond those achieved in 2002 and 2003.

Sixteen of the 1,097 fish radio tagged were subsequently categorised as "lost"; meaning a signal from these fish with an accompanying code identifier was not recorded by RTS's above the tagging site[6]. The 6 radio tags that were located but not decoded during aerial surveys on the Stewart and Pelly systems may have had faulty code pulse identifiers and been among those tags designated as lost. If this occurs in future telemetry projects efforts should be made to retrieve the radio tag to determine the nature of the fault.

The mainstem Yukon and Teslin rivers received a large portion (95 tags, 23%) of the radio tags found in the upper Yukon drainage. It has been postulated that the radio tag abundance in these areas may not be representative of spawning distribution. This is based on a premise that higher than expected ratios of tagged fish would be found in the mainstem Yukon and Teslin rivers if the radio tagged fish suffered from tag induced behavioural and/or physiological responses that either interfered with their migratory capability or caused pre-spawn mortality. However, there is no evidence from the

[6] Source: preliminary data from 2003 basin wide Yukon River chinook telemetry study; J. Eiler per. comm.

telemetry data to suggest that the proportion of radio tags observed in the mainstem Yukon River was not representative of existent spawning distribution. If higher ratios of tagged fish were present in mainstem areas because of pre-spawn mortality it should be apparent in elevated numbers of mortalities observed in the earlier stages of the spawning period. This did not occur as the data indicate the ratios of dead:live fish observed in the first and second mainstem aerial surveys were actually lower than the ratios found in adjacent tributaries. Additionally, if there were elevated numbers of radio tagged fish found in mainstem areas because their migratory capability was impaired it should be reflected in a slower migration rate. The migration rates of radio tagged mainstem stocks were indeed significantly slower than most of the tributary stocks (Osborne 2004). However this could be attributed to natural run timing rather than the presence of radio tagged fish with impaired migration capacities. The non-random dispersal of radio tagged chinook in the mainstem Yukon and Teslin rivers also suggests the distribution of tags is a result of homing to natal areas. For instance it is unlikely there would be an absence of radio tags for 100 km downstream of the White River confluence if the mainstem distribution was a result of or was influenced by pre-spawn mortality.

The mortality sensor information obtained from the aerial surveys should be interpreted cautiously. While it is unlikely that a tag would have an activated mortality sensor if the fish was still alive, it is very possible that a fish that was designated as alive could indeed be dead. The action of current or the intermittent disturbance of a carcass by scavengers could create enough movement to prevent activation of or stop the mortality signal output. It is certain that 2 of the archival tagged fish retrieved on the Macmillan and Teslin rivers had been dead for several days but were recorded as being alive on surveys conducted one day prior to recovery. Consequently the actual number of tagged fish designated as dead was probably higher than was indicated by the activated mortality sensors.

4.1 North mainstem Yukon/Klondike Watershed

The north mainstem Yukon/Klondike area received a total of 31 radio tags resulting in a 2003 chinook escapement index for the area of 6,944; approximately 8% of the above border escapement. As occurred in 2002, the Klondike River drainage contained the largest number (19) and highest concentration of radio tags in the area, resulting in a telemetry based population index of 4,526.

Within the mainstem Yukon River no radio tags were observed for approximately 100 km downstream from the mouth of the White River. The high sediment inputs from the White River system may limit available spawning habitat in this section of the mainstem Yukon River. Five of the 7 radio tags located in the north mainstem Yukon were observed on two surveys at the same position. The other 2 fish (909 and 890), were observed once only during the last survey on August 13. As the surveys occurred when many fish were still in transit these fish may not have been at terminal locations; although it is known they did not pass the White River RTS, 100 km upstream.

It is likely most of the 14 radio tags caught in gill net fisheries in the area were destined for other systems upstream.

4.2 Stewart River Watershed

The Stewart system was surveyed once on August 15 –17 when 24 of the 33 tags in the system were located. At the time of the first Stewart River survey the number of fish reported past the RTS was 29 and it was erroneously thought that combined with the 4 tags caught in fisheries, all but one of the radio tags had been accounted for. For this reason, as well as the high number of dead fish detected, it was decided to limit the surveys to one. The area upstream of Fraser Falls encompasses approximately 60% of the drainage, requiring a further 10-12 flying hours to survey. It was not considered practical to search for a small number of radio tags, the fate of which were unknown.

Five radio tags recorded by the Stewart River RTS were not located during the aerial surveys. Although these fish may have been in a lower tributary not surveyed it is more likely they were caught in a fishery and not reported and/or migrated upstream of Fraser Falls. The RTS at Fraser Falls was not operable until August 5 when most of the chinook returning to the upper Stewart would have already migrated past the station. If at the time of the first survey it was known 5 tags were not accounted for, a second survey would have been conducted, including portions of the drainage above Fraser Falls.

The 2003 radio tag distribution in the Stewart system was similar to that observed in 2002 in that the McQuesten River received the largest proportion of tags (33% in 2002 and 50% in 2003; Osborne et. al, 2003). In both years, relatively low numbers of tags were located in Janet and Watson creeks and the mainstem Stewart and Mayo rivers. If all 5 tags not located in 2003 had migrated past Fraser Falls, this proportion (15%) would still be lower than the proportion (25%) observed above the falls in 2002. Local anecdotal reports suggest the relatively lower 2003 water levels experienced in July and August may have hindered the passage of migrating chinook at Fraser Falls. Conversely, the above average water levels experienced in 2002 (Osborne et. al 2003) may account for the higher radio tag proportion above the falls in that year. The distribution results from both years suggest that although the upper Stewart system encompasses approximately 60% of the drainage, it received a disproportionately low number of returning chinook.

The high number (79%) of activated mortality sensors suggests the 2003 Stewart River origin chinook spawned considerably earlier than in 2002, when only 25% had died at the time of the second aerial survey on August 21-24 (Osborne et. al 2003). However, the run timing of the 2003 Stewart origin chinook past the border and tributary RTS's was not significantly different from the 2002 timing (Osborne 2004). The 2002 and 2003 telemetry data suggests that in general the Stewart River origin chinook spawn earlier than most other upper tributary stocks.

4.3 Pelly River Watershed

Of the upper Yukon River tributaries surveyed, the Pelly system contained the largest number of radio tags (83). The radio tags exhibited a widespread distribution throughout most of the drainage. The mainstem Pelly received the largest number of radio tags although densities in the lower reaches were low. The highest radio tag densities were found in Blind Creek and a single section of the Ross River. A chinook weir has been operated on Blind Creek intermittently in the past (Yukon River JTC report 2003). The telemetry results from 2003 and 2002, coupled with other factors, indicate it is likely the most suitable stream in the system for an index weir.

Five radio tags were not located during the Pelly watershed surveys. Every documented and suspected spawning tributary was surveyed, however, given the widespread and disparate tag distribution it is probable at least some of the tags not located were in smaller, less obvious streams that were not flown.

Single radio tags were observed in LaForce Creek and the upper Ross River (fish no. 111 and 152), areas where chinook spawning has not been previously documented (unpublished data base, DFO Whitehorse). The Tay River, a relatively large tributary of the Pelly River, with numerous headwater lakes (Map 3), was surveyed once with no radio tags detected. Cursory observation suggests the system contains extensive spawning habitat but a falls/velocity barrier near the mouth prevents passage of chinook into the drainage. Big Timber Creek, a tributary of the Ross River, also contains extensive spawning habitat in the upper reaches but access is prevented by impassable falls approximately 8 km upstream from the mouth. One radio tag (fish no. 180) was observed downstream of this barrier.

4.4 White River Watershed

The White River watershed contained relatively few radio tags (13), compared to the other systems surveyed. The highest number and concentration of radio tags was in Tincup Creek; a well documented chinook spawning stream (Wilson, 2000). Four radio tags were detected within the Nisling River and although densities were low, the distribution was extensive, covering approximately 100 km of the stream length.

All 5 radio tagged fish detected in Tincup Creek on the August 31 survey were recorded as alive, whereas 3 of the 4 Nisling River and the one Klotassin River tagged fish were dead. One of the Tincup Creek origin tags did not enter the White system until after mid August. Although the data set is small it appears Tincup Creek chinook may typically spawn later than the other sub-stocks in the system; a characteristic perhaps related to the temperature moderating influence of Tincup Lake.

The two radio tags observed in the White and Donjek rivers (fish no. 762 and 178) on the first mid-August survey were not detected in the upper tributaries of the system on the second survey. The White and lower Donjek rivers were not flown on the second survey due to time/weather constraints. Terminal locations were assigned to these fish based on the first survey. Although the high sediment loads of the White and Donjek rivers would seem to preclude the existence of prime chinook spawning habitat, chum salmon spawning has been documented in up-welling areas on the White River (Milligan et. al, 1986). The presence of radio tagged chinook in the mainstem White River warrants further investigation if the chinook telemetry program continues.

4.5 Mainstem Yukon River Watershed

The mainstem Yukon River received the largest number of radio tags (104). It also had the highest number (9) of radio tags not located. All documented and probable streams in the area were surveyed and the fate of these radio tags is unknown. However, due to the relatively large size of the mainstem Yukon some of the radio tagged fish not located may have been at depths exceeding the radio signal transmission capability.[7] As well, the mainstem origin chinook are exposed to significant fishing effort and not all the captured radio tags may have been reported.

Nineteen radio tags were observed in the Little Salmon River resulting in an escapement index of 4,256 chinook based on telemetry data. The DFO aerial index count conducted August 15 on the Little Salmon River was 1,658 chinook; 162 % higher than the recent 10 year average of 633 (JTC report 2003).

4.6 Big Salmon River Watershed

Fifty-nine radio tags entered the Big Salmon watershed, accounting for 15% of the radio tags at large in the upper Yukon River basin in 2003. This was larger than the 2002 proportion (9%). All radio tags located in aerial telemetry surveys were found in the Big Salmon and North Big Salmon rivers. The proportion (10%) of radio tags found in the North Big Salmon in 2003 was considerably smaller than was found in 2002 (30%).

As occurred in 2002, the highest tag densities were situated between the outlet of Big Salmon Lake and Souch Creek; a section of the Big Salmon River that DFO has established for an annual aerial escapement survey. The telemetry surveys detected a total of 28 radio tags in the DFO aerial escapement survey area. The DFO aerial index survey conducted on August 17 produced a count of 3,075 chinook (JTC report, 2003); approximately 49% of the telemetry based escapement index of 6,272 for the same area.

4.7 Teslin River Watershed

In 2003, the Teslin River drainage contained the same proportion (18%) of radio tagged fish as in 2002. As in 2002, the mainstem Teslin River received the highest ratio of radio tags (70% in 2002, and 68% in 2003). The mainstem Teslin section was surveyed 3 times between August 21 and September 14 in order to be certain the detected tags were in terminal locations rather than still in transit. The RTS and aerial survey data suggests

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[7] The radio signals emitted by the ATS radio tags are able to propagate, depending on conductivity of the water, through a maximum depth of approximately 9 meters.

the mainstem Teslin origin chinook run later and have a more protracted spawning period than other upper Yukon River stocks (Osborne 2004).

In 2003 the Nisutlin River system received a significantly higher proportion of radio tagged fish (20%) than occurred in 2002 (11%). A DFO aerial index survey conducted on the Nisutlin River between 100 Mile Creek and Rose River counted 687 fish. Two radio tags were observed in the aerial index area yielding a telemetry based escapement index of 448 chinook. It should be noted however, an additional 3 radio tags were located immediately upstream of the index survey area.

Fish number 128, observed on the Jennings River was located in exactly the same location as the two radio tags found in this area in 2002. The large substrate size observed in much of the Jennings River, along with other possible factors, may limit chinook spawning distribution in the system to specific areas.

In both 2002 and 2003, no radio tags were observed in the Morley, Swift, and Smart rivers. These streams have well documented spawning utilisation (DFO Whitehorse, unpublished data base; Wilson 2001). Although a few spawning chinook were observed in the Swift and Morley systems during the aerial surveys, the absence of radio tags suggests escapements in these streams were relatively low in 2002 and 2003.

Of the radio tagged Yukon River chinook located in Alaska and Canada in 2003, the McNeil River tag (fish no. 309 in the upper Nisutlin drainage, Map 7) possessed the distinction of having migrated the greatest distance from the tagging site, approximately 2,680 km.

4.8 South Yukon Watershed

Only 13 radio tags, amounting to 3% of the total, were recorded passing into the South Yukon system in 2003. Six of the 10 radio tags located by aerial surveys were found in the Takhini system indicating it likely receives the largest escapements within the watershed. The Takhini was only surveyed once but due to its relative importance two surveys would have been advantageous. Because of time and weather constraints not all the Takhini was surveyed. It is possible one or both of the 2 tags not located could have been in the upper Takhini River and/or other streams draining into Kusawa Lake.

Fish number 745 was located at the north end of Lake Laberge at the outlet. This fish was observed at this location on both surveys. Although the signal indicated the fish was not dead, wave action in the lake during the second survey could have prevented activation of the mortality sensor.

Fish number 540, located near Whitehorse, was observed once on September 14 (dead) suggesting it possibly drifted downstream from a spawning location between the terminal location and the Whitehorse hydro dam. This tag emitted a strong signal that was detected 8 km away indicating it was probably out of the water. The tag may have been in a Whitehorse residence; however, since it was recorded passing the Hootalinqua RTS and maximum signal strength was detected over the river it was assigned a terminal location.

4.9 Archival Tag Recovery

Five of the 9 archival tags were recovered from carcasses and 4 were found loose, presumably after the carcass had been scavenged and consumed. One of the 5 carcasses was an unspawned female (fish 3132) located in the Macmillan River. This fish, found in an advanced state of decomposition, likely died en-route to a spawning destination further up the Macmillan system. The archival recovery sample size is too small to draw inferences about pre-spawn mortality rates of the radio tagged fish. While this fish could have died from radio tag induced effects, it may also have died from other pathogenic and/or /physiological causes. "Natural" prespawn mortality is not uncommon in many salmon species, and in chinook can reach as high as 10% or more, dependent on environmental and stock specific parameters (Shepherd 1975; cited in Groot and Margolis, 1991).

The distribution of the archival tags was consistent with the general radio tag distribution in that the tributaries with the largest number of radio tags also received the highest number of archival tags. There is no reason to conclude the close proximity of the three archival tags in the mainstem Teslin River was due to any factor other than coincidence.

4.10 Telemetry Based Population Estimate and Indices

The validity of the 2003 above border chinook population estimate derived from the telemetry data rests on several standard mark-recapture model assumptions. These include: 1) the fate of all the radio tagged fish are known; 2) radio tagging does not affect the spawning destination of the tagged fish; 3) tagged fish are proportionately representative of the run; and 4) the tagged/untagged ratios obtained from upstream assessments/recoveries are representative of the population.

Assumption 1 is likely correct since the border RTS's combined with the aerial surveys were successful in recording all the radio tags that crossed the border (Osborne 2004). Regarding assumption 2, there was no data from the project indicating that the distribution of radio tagged fish was not representative of the actual distribution. Further information from comparative DNA analysis of the tagged fish and stock specific baseline DNA may help corroborate this assumption. Assumption 3 is not completely valid since the radio tagged gill net caught chinook were not representative of the whole population due to size and age class bias inherent with a fixed gill net mesh size. However, preliminary evidence indicates the 2003 radio tag application matched well with CPUE data from Russian Mission near the tagging sites (JTC report, 2003). Therefore although the radio tagged fish were not representative of the size and age class of the population, it appeared that tags were applied proportional to relative run strength. Assumption 4 is difficult to verify and has the potential to bias the population estimate. Meaningful mark-recapture estimates require similar tag ratios among the recovery data used[8]. Data from 3 different assessment/recovery projects was used to obtain a combined tag proportion of 0.44% (Table 11). The Blind Creek weir count provided the only tag proportion based on a whole population sample, however the total sample size (1,193) was relatively small. The fish wheel catch was also small (1,248) and may not be representative as the wheels only capture fish migrating along relatively shallow shoreline areas (Pat Milligan, DFO Whitehorse, per. com.). The largest sample size (9,446) was from the various non-standardised gill net fisheries. The resultant tagged:untagged ratio from all the fisheries was similar to the overall combined ratio. Nevertheless, the tag ratios from the 3 recovery projects were not significantly different (single factor ANOVA: f= 0.746, p=0.55). The combined Canadian radio tag proportion of 0.44% was comparable to the tag ratio of 0.42%[9] observed in the Koyukuk Drainage in Alaska (JTC report 2003).

The 2003 telemetry based above border chinook population estimate of 93,975 (95% C.I. +/- 12,035) is 35,883 (62%) higher than the population point estimate of 58,092 (95% C.I. +/- 12,021) obtained from the spaghetti tagging mark-recapture program conducted by DFO. The 2003 telemetry based population estimate is 2.3 times higher than the previous 10 year average of 40,931 that was derived from spaghetti tag mark-recapture methods (JTC report, 2003).

There is evidence from other assessment projects that corroborate the higher telemetry derived population estimate. The Pilot Station sonar project on the lower Yukon River in Alaska obtained a 2003 chinook passage estimate of 257,636, approximately 110,000 higher than the previous high count of 148,000 in 1997, and 2.5 times greater than the previous 7 year average of 102,000 (JTC report, 2003). In addition, the 2003 DFO aerial chinook index surveys yielded record high counts on the Big and Little Salmon rivers, and counts on all the index streams 100% to 300% higher than the previous 10 year average. Under good viewing conditions, helicopter aerial surveys typically count in the range of 25% - 50% of a spawning chinook population (Pahlke, 2003). The Big Salmon and Little Salmon aerial index counts of 3,075 and 1,658 were 49% and 39% respectively, of the corresponding telemetry based population indices of 6,272 and 4,526 for those areas (Appendix 2).

The 2003 Yukon River telemetry study was successful in gathering unique information on the distribution, run timing, and movements of Yukon River chinook salmon. Since Canadian Yukon River stocks typically comprise over 50% of the Yukon River return, the aerial telemetry surveys conducted in the Canadian portions of the upper Yukon River watershed were an integral part of the basin wide study. The information collected will be useful for the management and conservation of basin-wide as well as specific chinook stocks, and will contribute to the identification of future research requirements.

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[8] Data from 2 other assessment projects was not used because either the sampling was demonstrated to be unrepresentative (Whitehorse fishway), or the population assessment methods were not validated (Klondike River, Area Under the Curve population estimate). The tag proportions from these two recovery sites were significantly different from the proportions that were used.

[9] A total tag proportion of 0.36% was calculated for the Alaskan portion of the Yukon basin, but this may be biased low due to high water affects on the Tanana River recovery projects (JTC report 2003).

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Appendix 1-a. Terminal location and fate of radio tags in the north Yukon River mainstem/Klondike area.

Fish No.	Lat.	Long.	Fate	Status
1			Caught in Fishery	
3	63.98613667	-138.27508830	Klondike	
11			Caught in Fishery	
25			Caught in Fishery	
44	63.98232500	-138.37425833	Klondike	
47			Caught in Fishery	
61	64.05854667	-138.91944167	Klondike	D
79	64.04737333	-138.85874000	Klondike	
80			Caught in Fishery	
100	64.02410500	-137.97996500	Klondike	D
135			Caught in Fishery	
147	64.02021667	-138.09446330	Klondike	
164	63.97065000	-138.43275170	Klondike	
176	63.97418000	-138.40988170	Klondike	
190	63.95393833	-138.66429330	Klondike	
209	64.03760667	-139.18887000	Klondike	
231	64.29839500	-139.20672170	Chandindu	D
237	63.97752667	-138.39893667	Klondike	
242	64.02278000	-137.82171500	Klondike	
248			Caught in Fishery	
258	63.96968500	-138.44125000	Klondike	D
273	64.11877333	-138.52063000	Klondike	
274	64.29254167	-139.46271500	Chandindu	
288			Caught in Fishery	
299	64.06380000	-138.95589333	Klondike	
318	63.98369833	-138.30797830	Klondike	D
338			Caught in Fishery	
405	63.96185500	-138.69244330	Klondike	
408	64.30267333	-139.18532670	Chandindu	
426			Caught in Fishery	
512	64.26750333	-139.78053667	North Mainstem Yukon	
645	63.98559667	-138.74455667	Klondike	
651	64.06420500	-138.99731500	Klondike	
656	64.21829333	-139.59406500	North Mainstem Yukon	D
683	64.29140167	-139.53615500	Chandindu	
699			Caught in Fishery	
837	64.26571333	-139.77805833	North Mainstem Yukon	D
838	64.67604167	-140.94275167	North Mainstem Yukon	
890	64.56160667	-140.60687167	North Mainstem Yukon	
907			Caught in Fishery	
909	64.54614333	-140.66625500	North Mainstem Yukon	D
970			Caught in Fishery	
990			Caught in Fishery	
1033	64.47105000	-140.45197167	North Mainstem Yukon	

Appendix 1-b. Terminal location and fate of radio tags in the Stewart River watershed.

Fish No.	Lat.	Long.	Fate	Status
38	63.30239500	-138.38680167	Stewart River	D
48	63.67742833	-136.72488000	McQuesten River	D
50	63.65173000	-136.93101670	McQuesten River	
84	63.64859167	-136.85806330	McQuesten River	D
88	63.64786667	-136.96942500	McQuesten River	D
92	63.26378333	-138.66998500	Stewart River	D
112			Caught in Fishery	
No Code	63.61835167	-135.91529167	Mayo River	
159	63.73136667	-136.61419170	McQuesten River	D
172	63.65360500	-136.79566670	McQuesten River	D
193	63.60516333	-137.28598830	McQuesten River	D
218	63.53790000	-135.15090000	Janet Creek	
261	63.61186333	-137.23467000	McQuesten River	D
275	63.49494167	-137.84261833	Stewart River	D
296	63.55948333	-137.44947830	Stewart River	D
342			Not located	
354	63.62660000	-135.92499830	Mayo River	D
360	63.69137000	-136.65868500	McQuesten River	D
362	63.63458667	-137.09181330	McQuesten River	D
373	63.61613667	-137.25035330	McQuesten River	D
399	63.55878500	-137.39195830	McQuesten River	D
425	63.61428500	-137.24003330	McQuesten River	D
562	63.59700000	-137.29445000	McQuesten River	
571	63.64234000	-137.00217830	McQuesten River	D
No Code	63.63440000	-135.46350000	Watson Creek	
617			Not located	
672			Caught in Fishery	
682			Caught in Fishery	
832	63.57567500	-137.33603830	McQuesten River	D
847			Not located	
927			Caught in Fishery	
963			Not located	
964			Not located	

Appendix 1-c. Terminal location and fate of radio tags in the Pelly River watershed.

Fish No.	Lat.	Long.	Fate	Status
2			Not Located	
5			Not Located	
18	62.25628167	-131.58943500	Ross River	
31	62.87976333	-132.67087830	S. MacMillan River	D
53	62.80686500	-131.91500000	S. MacMillan River	D
62	63.06172000	-132.85140500	N. MacMillan River	D
69	61.46733000	-131.46233330	Hoole River	D
87	61.44724667	-131.41300170	Hoole River	
95	62.81751167	-131.96470167	S. MacMillan River	D
104	61.45672000	-130.80754000	Big Campbell Creek	
111	62.69224167	-132.07163330	Laforce Creek	
126	62.79157167	-136.04403667	Needlerock Creek	
144	61.68242167	-131.03679000	Big Campbell Creek	D
148			Not Located	
149	62.19376000	-133.18156167	Blind Creek	D
152	62.82018833	-130.57705500	Ross River	
154	62.05103167	-130.49594500	Pelly Lakes outlet	
163	62.86084333	-132.48118000	S. MacMillan River	D
177	62.46562667	-131.10128833	Otter Creek	
180	62.08475833	-131.68868830	Ross River	
196			Not Located	
227			Caught in Fishery	
230	62.91747833	-135.52017500	Little Kalzas Creek	
239	62.82672167	-136.67031667	Pelly River	D
243	62.91884500	-132.88389170	S. MacMillan River	D
250	62.31609500	-131.02486500	Otter Creek	
256			Not Located	
260	62.82731833	-136.67458167	Caught in Fishery	
272	62.8295	-137.205	Pelly River	D
279	62.98576000	-133.11749333	S. MacMillan River	
281			Caught in Fishery	
290	62.60563000	-131.16461833	Ross River	
293	62.43682000	-134.19143833	Glenlyon River	
297	61.85370167	-132.06632167	Pelly River	D
314	62.98588167	-133.11690670	S. MacMillan River	D
316	62.74374667	-134.77683000	Pelly River	D
317	62.89114667	-132.74654000	S. MacMillan River	D
320	62.256498	-132.980387	Blind Creek	
321	61.99010833	-132.48709833	Pelly River	D
322	62.07957667	-131.76533500	Ross River	D
326	62.39580667	-133.93068500	Pelly River	
341			Caught in Fishery	
372	62.27667500	-131.57267667	Ross River	
396	62.30098667	-131.53702167	Ross River	
400	62.28824167	-132.78904333	Blind Creek	D
403			Caught in Fishery	
404			Caught in Fishery	
409	63.05055333	-133.13274000	N. MacMillan River	D
419	62.287449	-132.84463	S. MacMillan River	D
435	62.232218	-133.044772	Blind Creek	
456	62.32872333	-131.49678833	Ross River	
468	62.81934833	-131.99442670	S. MacMillan River	D
473	62.32918167	-131.47759833	Ross River	
488			Caught in Fishery	
494	62.48973500	-134.17598000	Glenlyon River	
502	61.55777333	-131.63662670	Hoole River	
607	62.256498	-132.980387	Blind Creek	D
626			Caught in Fishery	
648	62.93518833	-132.91480500	S. MacMillan River	

Appendix 1-c (continued).

Fish No.	Lat.	Long.	Fate	Status
664	62.37081500	-131.08900667	Otter Creek	D
813	62.92923000	-135.43817000	Kalzas River	
817	63.15956667	-135.06232667	Kalzas River	
823	62.27487667	-132.92417330	Blind Creek	D
824	62.18828667	-133.22737500	Pelly River	
836	62.76175500	-134.51015500	Earn River	
861	61.89052167	-132.24583000	Pelly River	
869	62.23884167	-133.44838833	Pelly River	D
896	62.04509667	-130.46999000	Pelly Lakes outlet	
900	62.77264833	-136.52684500	Mica Creek	D
901	62.26276500	-131.56822000	Ross River	
926	62.75548500	-134.47383500	Earn River	D
951	62.21144833	-133.33615500	Pelly River	
976	62.91647333	-135.51220667	Little Kalzas Creek	
986	62.02203500	-132.57607330	Pelly River	
989	62.15459667	-133.04802833	Pelly River	
1055	63.03819000	-134.42505000	S. MacMillan River	D
3106	61.51126167	-131.55158830	Hoole River	D
3111	62.28922667	-131.57169833	Ross River	D
3132	63.01595500	-134.62806333	McMillan River	D
No Code	61.75780000	-131.18100000	Pelly River	
No Code	62.91420000	-135.50297000	Little Kalzas Creek	
No Code	62.74192000	-136.47890000	Mica Creek	
No Code	62.35430000	-130.93600000	Otter Creek	

Appendix 1-d. Terminal location and fate of radio tags in the White River watershed.

Fish No.	Lat.	Long.	Fate	Status
557	61.85416833	-139.31203333	Tincup Creek	
65	62.07564833	-138.47649000	Nisling River	
51	62.24595500	-139.12187333	Nisling River	D
762	62.65334500	-140.04128667	White River	
759	61.84495333	-139.28845667	Tincup Creek	
178	62.58415667	-139.82720500	Donjek River	
184	61.88005000	-139.35503500	Tincup Creek	D
359	61.84861500	-139.29793500	Tincup Creek	
481	62.41634167	-139.37234333	Nisling River	
516	62.53910167	-139.35633500	Klotassin River	D
420	62.34530667	-139.18835333	Nisling River	D
991	61.905515	-139.4462867	Tincup Creek	

Appendix 1-e. Terminal location and fate of radio tags in the mainstem Yukon River watershed.

Fish No.	Lat.	Long.	Fate	Status
26			Caught in Fishery	D
36	62.20610667	-136.34313500	Mainstem Yukon River	
74			Caught in Fishery	D
77	62.03658333	-136.28524167	Nordenskiold River	D
107			Caught in Fishery	
130			Caught in Fishery	
132			Not Located	
138	62.08450000	-135.49715167	Little Salmon River	
166			Caught in Fishery	
170	62.13019500	-135.17843333	Little Salmon River	
182	62.06565667	-135.64752167	Little Salmon River	
188	62.87307000	-138.72913667	Mainstem Yukon River	D
202	62.77275833	-137.35881833	Mainstem Yukon River	
207	62.12964000	-136.32064670	Mainstem Yukon River	D
229	61.82958167	-136.11228500	Nordenskiold River	D
255			Not Located	
286	62.46231167	-137.05897670	Big Creek	D
291			Caught in Fishery	
300	61.77246833	-136.03440833	Nordenskiold River	D
302	62.10803500	-135.25161500	Little Salmon River	
304	62.15468667	-135.12265333	Little Salmon River	D
315	62.71139333	-137.25648833	Mainstem Yukon River	
319	61.75811833	-136.03265167	Nordenskiold River	
358	62.76758667	-137.34382167	Mainstem Yukon River	D
363	62.68751167	-137.18232000	Mainstem Yukon River	D
364	62.38814167	-136.57173833	Mainstem Yukon River	D
366	62.80858000	-138.04637833	Mainstem Yukon River	D
383	62.82362167	-137.73104170	Mainstem Yukon River	
392	62.12543333	-135.18253167	Little Salmon River	
436	61.78338000	-136.05337500	Nordenskiold River	D
459	62.08190000	-135.49400000	Little Salmon River	
476	62.06744000	-135.64283833	Little Salmon River	D
505	62.16062000	-135.10446000	Little Salmon River	
537	62.12103667	-135.20094833	Little Salmon River	
549	62.80781833	-138.09837170	Mainstem Yukon River	
551	62.63107167	-137.01374167	Mainstem Yukon River	
555	62.10264167	-136.26213830	Mainstem Yukon River	
561			Not Located	
563	62.80329167	-138.23733500	Mainstem Yukon River	
567	62.37873000	-136.53745170	Mainstem Yukon River	
570	62.08504333	-136.13198170	Mainstem Yukon River	
572	63.28980000	-139.43617500	Not Located	
580	62.61371333	-136.95594500	Mainstem Yukon River	D
582	62.28586667	-136.29571333	Tatchun Creek	
588	62.91246333	-139.06440667	Mainstem Yukon River	
603	62.08357333	-135.53194000	Little Salmon River	D
623	62.04779000	-135.95705500	Mainstem Yukon River	D
633			Not Located	
652	62.07242167	-135.62702500	Little Salmon River	D
658	62.28546333	-136.30205000	Tatchun Creek	D
670	62.63732333	-137.02234330	Mainstem Yukon River	D
680			Not Located	
687	62.51104500	-136.77154000	Mainstem Yukon River	D
688	62.10726500	-135.25925000	Little Salmon River	D

Appendix 1-e. continued

Fish No.	Lat.	Long.	Fate	Status
692	62.18763667	-136.35598330	Mainstem Yukon River	
695	63.10205833	-139.51301667	Mainstem Yukon River	D
702	61.77879167	-134.97053333	Mainstem Yukon River	D
723	62.81642000	-137.53717000	Mainstem Yukon River	
728	62.81920000	-138.46108167	Mainstem Yukon River	D
730	61.63174667	-134.84708000	Mainstem Yukon River	
768	62.58173167	-136.87542670	Mainstem Yukon River	D
779	62.04437667	-135.95021500	Mainstem Yukon River	D
781	62.81557333	-137.74735833	Mainstem Yukon River	
785	62.35202833	-136.46315830	Mainstem Yukon River	
787	62.67825833	-137.14456670	Mainstem Yukon River	
788	62.75304000	-137.31448670	Mainstem Yukon River	
795	62.83482167	-138.54672500	Mainstem Yukon River	
796			Not Located	
803			Caught in Fishery	
804	62.04049167	-135.95081833	Mainstem Yukon River	
806	61.91400167	-134.96285170	Mainstem Yukon River	D
807	61.93018500	-135.08873500	Mainstem Yukon River	
820	62.07297833	-135.36124167	Little Salmon River	
826	62.60998667	-136.94789170	Mainstem Yukon River	D
842	62.28096500	-136.26606000	Tatchun Creek	D
856	62.12634000	-135.17909667	Little Salmon River	
868	61.73997000	-134.93088000	Mainstem Yukon River	D
871	62.05138000	-135.64411333	Mainstem Yukon River	
893	62.11119333	-135.25293333	Little Salmon River	
908	62.97438500	-139.32346833	Mainstem Yukon River	D
912	62.09459833	-136.28225333	Mainstem Yukon River	D
913	62.45530000	-136.68969170	Mainstem Yukon River	
929	62.86516000	-138.65737167	Mainstem Yukon River	
932			Not Located	
942	62.43297500	-136.65275500	Mainstem Yukon River	D
945			Caught in Fishery	
966	62.10942000	-136.25702500	Mainstem Yukon River	
980	62.08714000	-136.11406333	Mainstem Yukon River	
994	62.06717833	-135.65587000	Little Salmon River	
996			Caught in Fishery	
1002	62.68543167	-137.17856170	Mainstem Yukon River	D
1003	62.60559667	-136.93690170	Mainstem Yukon River	D
1004	61.98381833	-135.30586833	Mainstem Yukon River	
1009	62.91541833	-139.13197670	Mainstem Yukon River	D
1028	62.28326833	-136.29482333	Tatchun Creek	
1029	62.07650667	-135.60917167	Little Salmon River	
1032	62.03815167	-135.90798670	Mainstem Yukon River	D
1035	62.11441167	-135.24511167	Little Salmon River	
1036	62.47537000	-136.72539170	Mainstem Yukon River	
1046	62.12982167	-136.29966670	Mainstem Yukon River	D
1052	62.15610333	-136.35747830	Mainstem Yukon River	
3104	61.81189167	-136.10622000	Nordenskiold River	
3105			Not Located	
3107	62.07680667	-136.04463330	Mainstem Yukon River	

Appendix 1-f. Terminal location and fate of radio tags in the Big Salmon River watershed.

Fish No.	Lat.	Long.	Fate	Status
22	61.42297667	-133.4828433	Big Salmon River	
40	61.76854833	-134.4426317	North Big Salmon River	D
83	61.32651167	-133.333845	Big Salmon River	D
96	61.551275	-134.1630433	Big Salmon River	
103	61.78497833	-134.26284	North Big Salmon River	D
110	61.863505	-134.0676433	North Big Salmon River	D
122	61.41957	-133.4788433	Big Salmon River	D
124	61.54873	-133.58445	Big Salmon River	
139	61.78544333	-134.2765133	North Big Salmon River	D
141	61.86344	-134.0769667	North Big Salmon River	D
156	61.59836667	-133.8223717	Big Salmon River	D
157	61.4191	-133.4884717	Big Salmon River	D
173	61.322055	-133.3345667	Big Salmon River	D
189	61.50966833	-133.530555	Big Salmon River	D
197	61.55517833	-133.6116883	Big Salmon River	D
199	61.61945167	-133.7656067	Big Salmon River	
213	61.60496333	-133.7151483	Big Salmon River	
217	61.56361167	-134.3055633	Big Salmon River	D
247	61.85969833	-134.134315	North Big Salmon River	D
257	61.56501833	-133.6241283	Big Salmon River	D
265	61.58609167	-133.8432667	Big Salmon River	D
284			Not located	
289	61.32844167	-133.3336917	Big Salmon River	
308	61.53411333	-134.0477683	Big Salmon River	D
327	61.33103667	-133.3593867	Big Salmon River	
351	61.406355	-133.4759967	Big Salmon River	
361	61.58216167	-133.841265	Big Salmon River	D
380	61.32990167	-133.3401117	Big Salmon River	D
394	61.538355	-133.57009	Big Salmon River	
418	61.336365	-133.35316	Big Salmon River	
422	61.35180333	-133.3982517	Big Salmon River	D
434	61.33445	-133.3510917	Big Salmon River	
466	61.54954333	-133.5857567	Big Salmon River	D
470	61.53239667	-133.9205983	Big Salmon River	D
471	61.53545	-133.5534833	Big Salmon River	
500	61.672445	-134.50314	Big Salmon River	D
503	61.60517667	-133.7155817	Big Salmon River	D
506	61.66501833	-134.5140167	Big Salmon River	
523	61.60364833	-133.81387	Big Salmon River	
531	61.554385	-133.59751	Big Salmon River	
560	61.43530333	-133.4936967	Big Salmon River	D
566	61.68434667	-134.5157317	Big Salmon River	D
609	61.616085	-133.7865167	Big Salmon River	D
624	61.65037667	-134.50235	Big Salmon River	D
681	61.86100333	-134.0423033	Big Salmon River	
710	61.69343833	-134.5327167	Big Salmon River	
816	61.54959	-134.2245067	Big Salmon River	
827	61.41545667	-133.4840867	Big Salmon River	
829	61.37605167	-133.41555	Big Salmon River	D
853	61.34859833	-133.3625283	Big Salmon River	D
873	61.619685	-133.7730833	Big Salmon River	D
883	61.72378333	-134.5696183	Big Salmon River	D
884	61.534095	-134.044025	Big Salmon River	D
975	61.59770667	-133.708065	Big Salmon River	
979	61.62633333	-134.4807433	Big Salmon River	
983	61.53112333	-133.99938	Big Salmon River	D
1005	61.55197333	-133.6044567	Big Salmon River	D
3103	61.779305	-134.6833917	Big Salmon River	D
3127			Not located	

Appendix 1-g. Terminal location and fate of radio tags in the Teslin River watershed.

Fish No.	Lat.	Long.	Fate	Status
33	61.16191333	-132.86756000	Nisutlin River	D
39	61.04856167	-132.91014500	100 Mile Creek	D
71	60.97695000	-132.73046833	Nisutlin River	D
128	59.59676167	-131.87102500	Jennings River	
153	61.19755500	-134.43234167	Mainstem Teslin	D
155	60.45782500	-132.23303167	Wolf River	
185	61.19386500	-132.34509833	Nisutlin River	
194	60.88768167	-133.97002000	Mainstem Teslin	
201	61.11542500	-132.18835000	Nisutlin River	D
212			Not Located	
221	60.49990833	-133.36335833	Mainstem Teslin	D
234			Not Located	
262			Caught in Fishery	
267	61.04437500	-132.92754833	100 Mile Creek	D
269	61.04360833	-132.93652667	Nisutlin River	
287	61.18577333	-132.32855000	Nisutlin River	
309	61.30966833	-132.02383667	McNeil River	
328	60.99019167	-134.13787833	Mainstem Teslin	
332	60.81112667	-133.83125167	Swift Creek	D
369	61.32022000	-134.66010167	Mainstem Teslin	D
377	61.14341667	-132.24793333	Nisutlin River	
454	61.03045333	-132.88161000	100 Mile Creek	D
463	61.49856500	-134.78968500	Mainstem Teslin	D
464			Not Located	
469	60.72404833	-133.68188833	Mainstem Teslin	D
484	61.18991667	-132.93007500	Nisutlin River	D
513	60.86684833	-133.92960833	Mainstem Teslin	D
514	60.72129500	-133.66581667	Mainstem Teslin	D
518	60.77371500	-132.95669333	Nisutlin River	D
524			Caught in Fishery	
545	60.51420167	-133.36976833	Mainstem Teslin	
559	61.07477000	-134.24365333	Mainstem Teslin	
575	60.72437333	-133.66988667	Mainstem Teslin	D
578	61.33070000	-134.65959000	Mainstem Teslin	D
615	60.58411833	-133.47963000	Caught in Fishery	
616	60.49075833	-132.27267167	Wolf River	D
618	60.77368500	-132.11445667	Red River	D
621	61.02881667	-134.17527167	Mainstem Teslin	
632	60.50942500	-133.36444000	Mainstem Teslin	
635	60.52290500	-133.37512000	Caught in Fishery	
679	61.18798167	-132.94358167	Nisutlin River	D
696			Caught in Fishery	
703			Not Located	
741	60.98643000	-134.13565833	Mainstem Teslin	D
763	60.49323667	-133.32798500	Mainstem Teslin	
764	60.55976333	-133.44016500	Mainstem Teslin	D
767	61.00365833	-134.14330667	Mainstem Teslin	D
771	60.90543500	-133.99877333	Mainstem Teslin	D
776	60.99830333	-134.13564500	Mainstem Teslin	D
794	60.53490833	-133.39154333	Mainstem Teslin	D
797	61.37132833	-134.65838833	Mainstem Teslin	D
799	61.03321333	-134.18626667	Mainstem Teslin	D
802			Caught in Fishery	

Appendix 1-f. continued.

Fish No.	Lat.	Long.	Fate	Status
815	60.89975833	-133.98609167	Mainstem Teslin	D
845	60.53125500	-133.38594000	Mainstem Teslin	D
872	60.20978333	-132.58744333	Caught in Fishery	
897	60.49803167	-133.34496833	Mainstem Teslin	
906	60.83045500	-133.89395833	Mainstem Teslin	
937	61.25476500	-134.59769500	Mainstem Teslin	
940	61.08328000	-134.26401500	Mainstem Teslin	D
946	60.93976167	-134.07051167	Mainstem Teslin	D
988	60.87219333	-133.94074000	Mainstem Teslin	
998	60.93048833	-134.04673000	Mainstem Teslin	
1012	61.25335833	-134.57800167	Mainstem Teslin	
1014	60.50108333	-133.36528667	Mainstem Teslin	
1017	60.90590833	-133.99826000	Mainstem Teslin	D
1054			Not Located	
3108	60.50353333	-133.36045500	Mainstem Teslin	
3128	60.49721667	-133.35427333	Mainstem Teslin	D
3130	60.49805167	-133.35767500	Mainstem Teslin	D

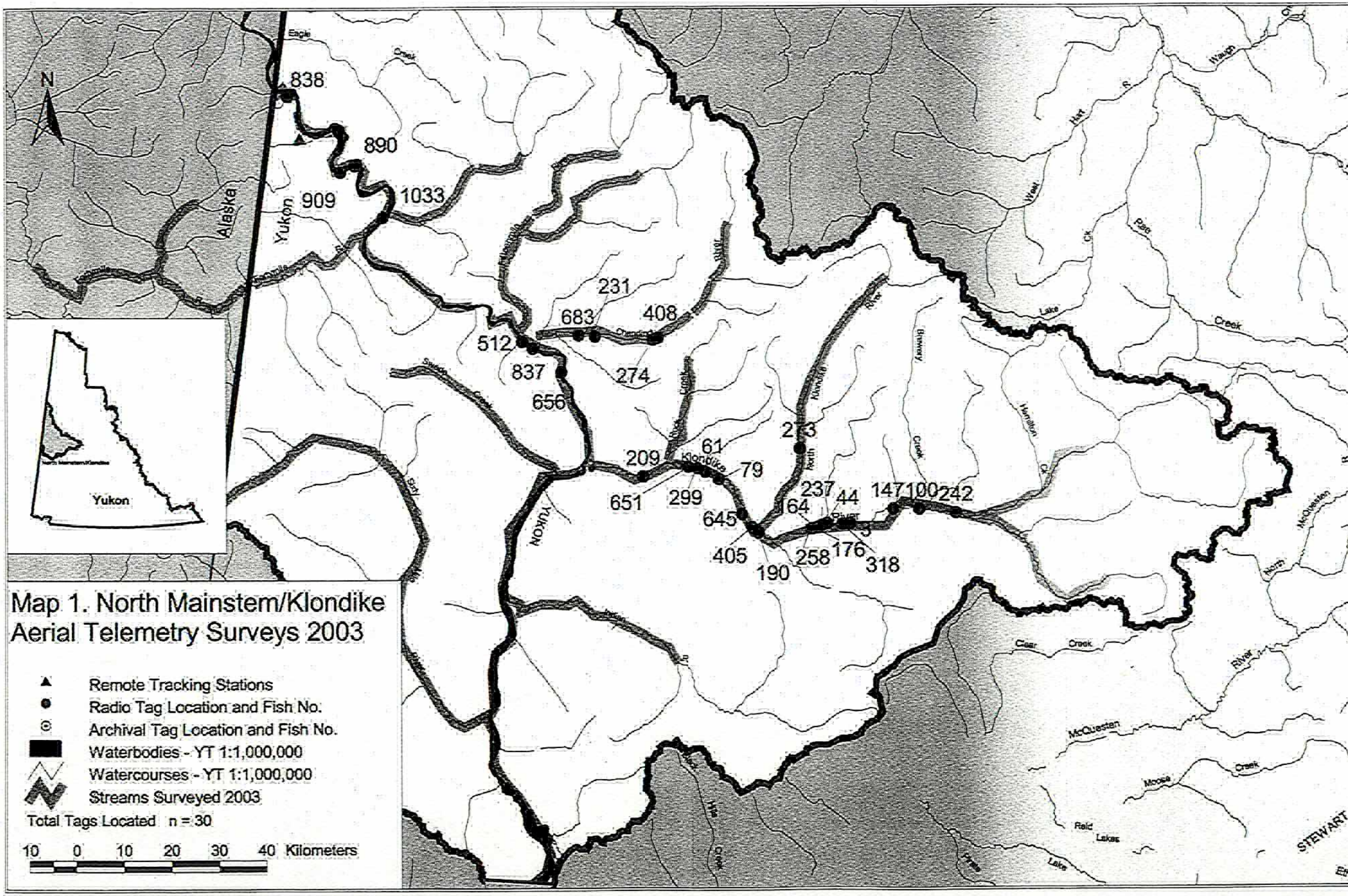
Appendix 1-h. Terminal location and fate of radio tags in the south Yukon River watershed.

Fish No.	Lat.	Long.	Fate	Status
774	61.48133833	-135.12511000	S. Yukon River	D
745	61.39587833	-135.23820000	S. Yukon River	D
535	61.46579500	-135.11652000	S. Yukon River	
540	60.73120000	-135.05370333	S. Yukon River	D
118			Whitehorse Fishway	
579	60.65529833	-136.10849500	Takhini River	D
666	60.83924833	-135.76881333	Takhini River	
675			Not Located	
758	60.75597833	-136.03077500	Takhini River	D
894			Not Located	
955	60.82211333	-135.80880167	Takhini River	D
995	60.81572333	-135.77104000	Ibex Creek	
1031	60.63767833	-136.11741500	Takhini River	

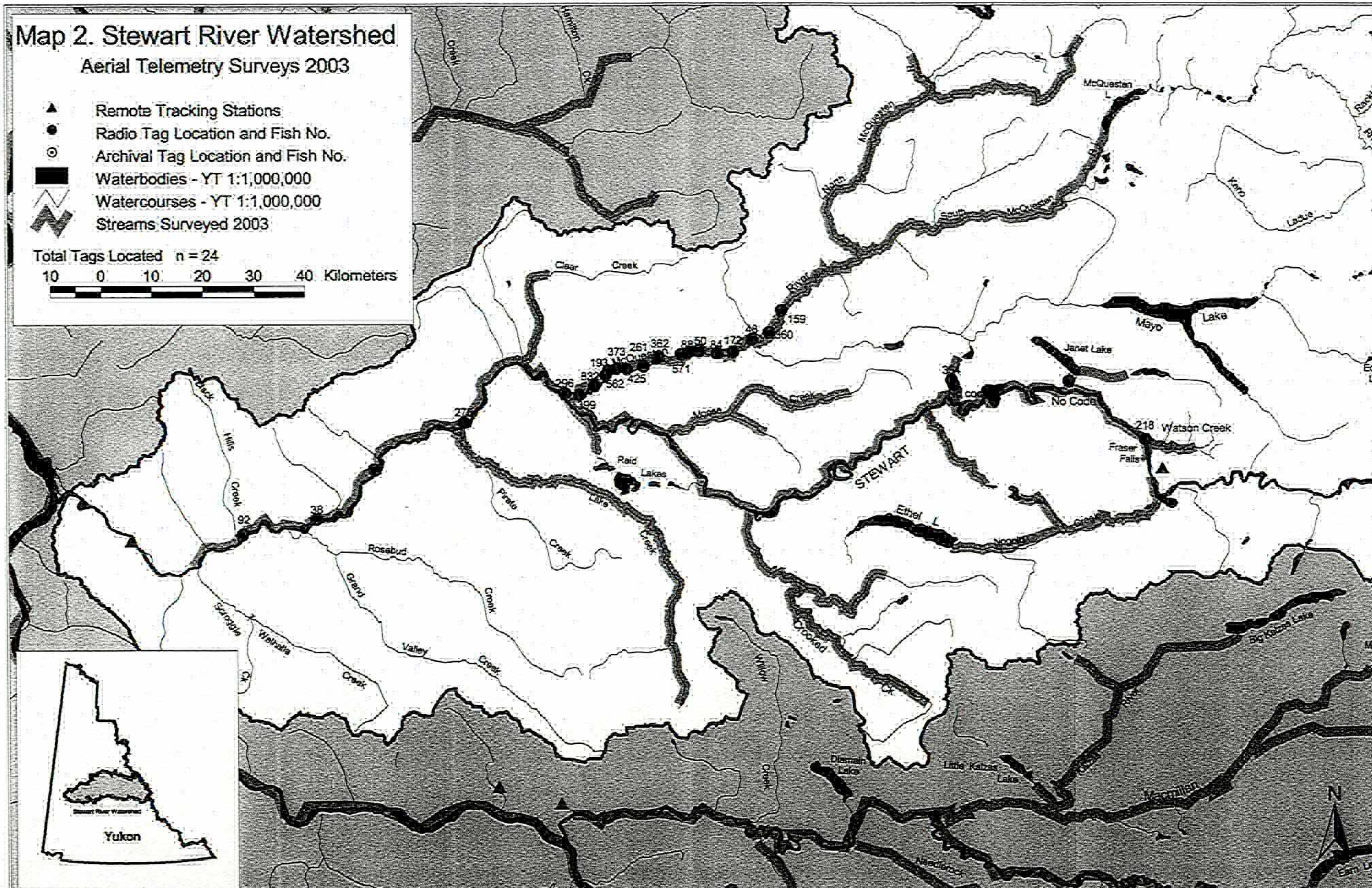
Appendix 2. Radio tag count and corresponding 2003 chinook population indices.

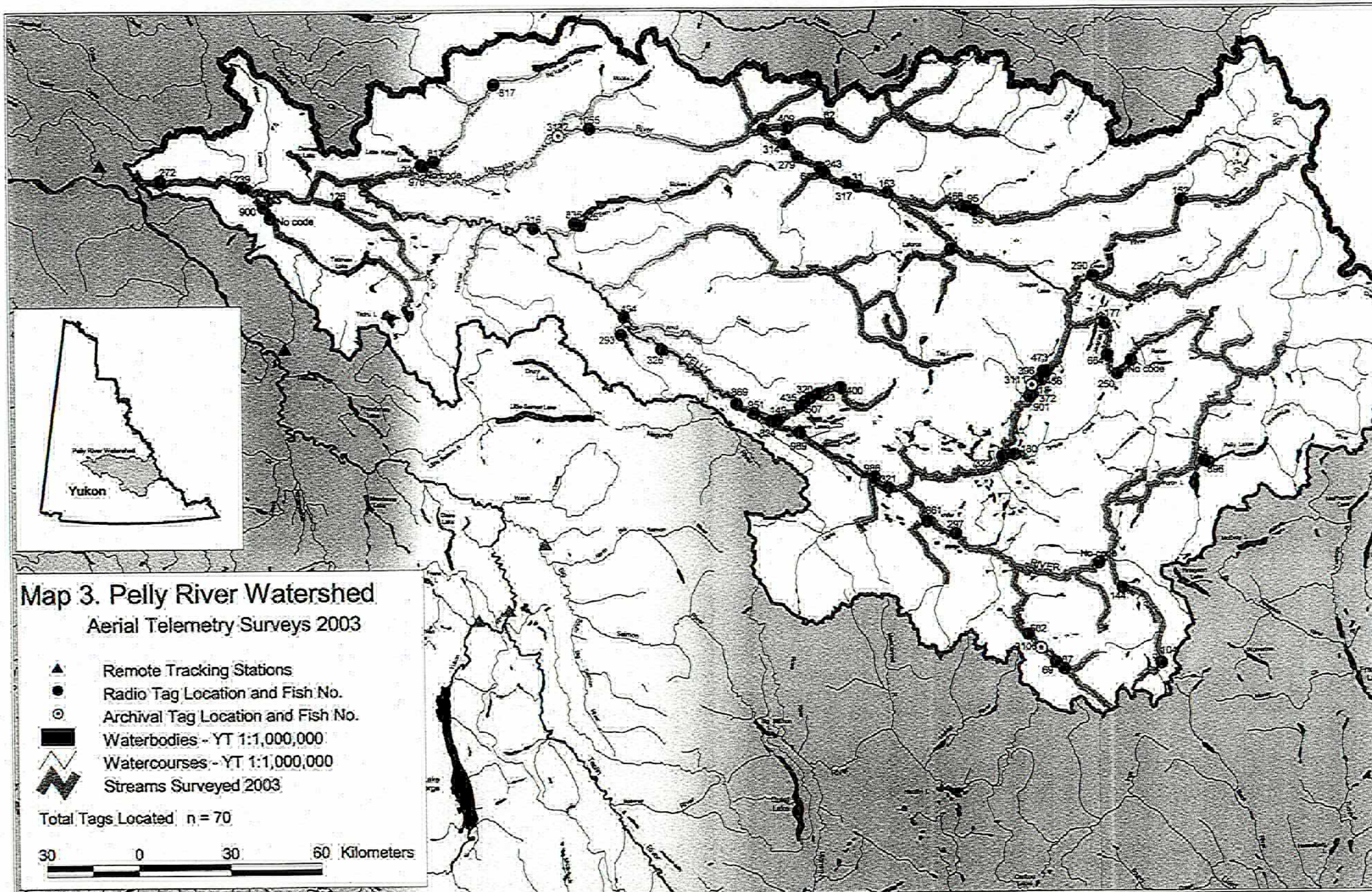
Number of Radio Tags	Population Index	Number of Radio Tags	Population Index	Number of Radio Tags	Population Index	Number of Radio Tags	Population Index
1	224	25	5,600	50	11,200	75	16,800
2	448	26	5,824	51	11,424	76	17,024
3	672	27	6,048	52	11,648	77	17,248
4	896	28	6,272	53	11,872	78	17,472
5	1,120	29	6,496	54	12,096	79	17,696
6	1,344	30	6,720	55	12,320	80	17,920
7	1,568	31	6,944	56	12,544	81	18,144
8	1,792	32	7,168	57	12,768	82	18,368
9	2,016	33	7,392	58	12,992	83	18,592
10	2,240	34	7,616	59	13,216	84	18,816
11	2,464	35	7,840	60	13,440	85	19,040
12	2,688	36	8,064	61	13,664	86	19,264
13	2,912	37	8,288	62	13,888	87	19,488
14	3,136	38	8,512	63	14,112	88	19,712
15	3,360	39	8,736	64	14,336	89	19,936
16	3,584	40	8,960	65	14,560	90	20,160
17	3,808	41	9,184	66	14,784	91	20,384
18	4,032	42	9,408	67	15,008	92	20,608
19	4,256	43	9,632	68	15,232	93	20,832
20	4,480	44	9,856	69	15,456	94	21,056
21	4,704	45	10,080	70	15,680	95	21,280
22	4,928	46	10,304	71	15,904	96	21,504
23	5,152	47	10,528	72	16,128	97	21,728
24	5,376	48	10,752	73	16,352	98	21,952
25	5,600	49	10,976	74	16,576	99	22,176

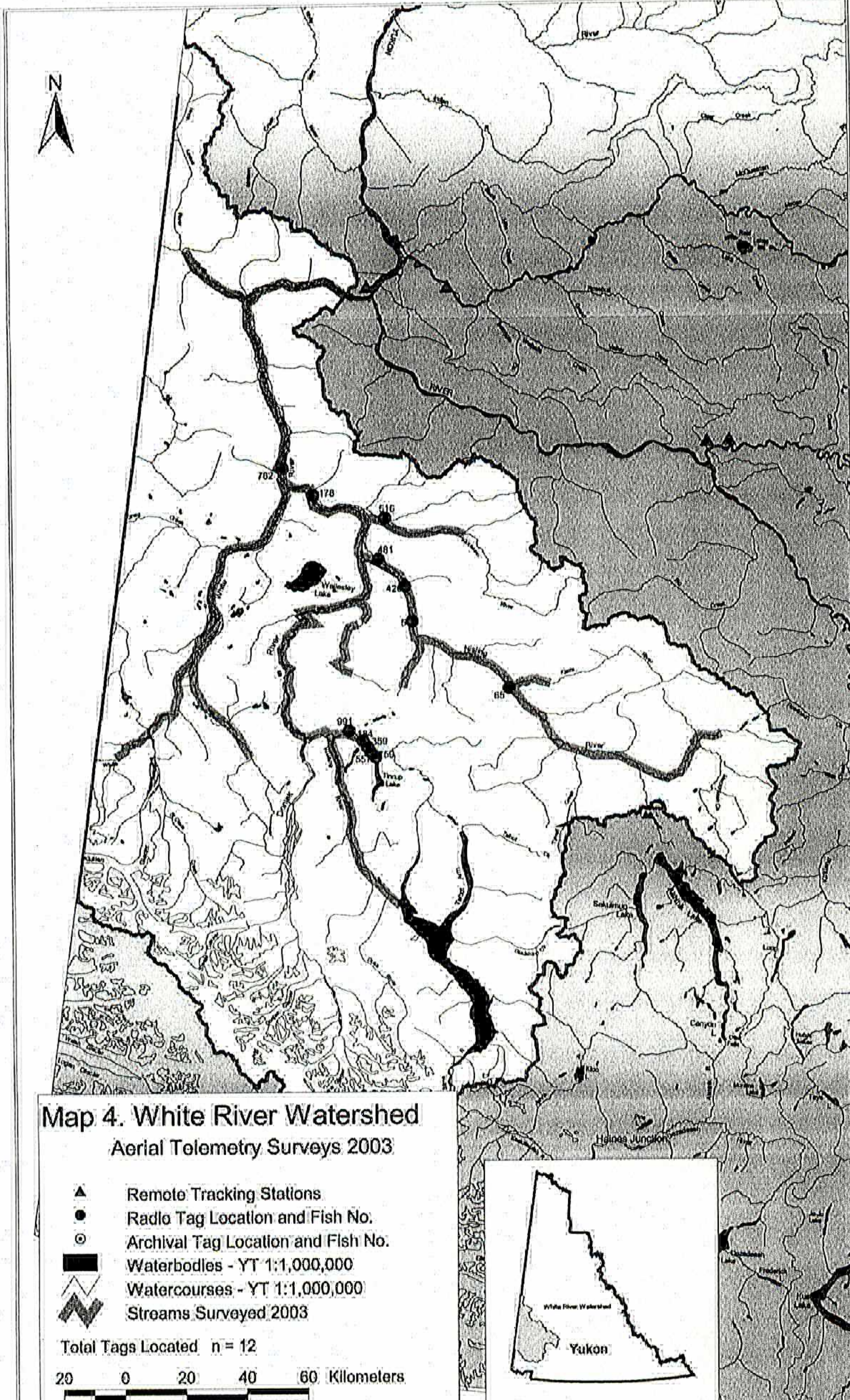
MAPS



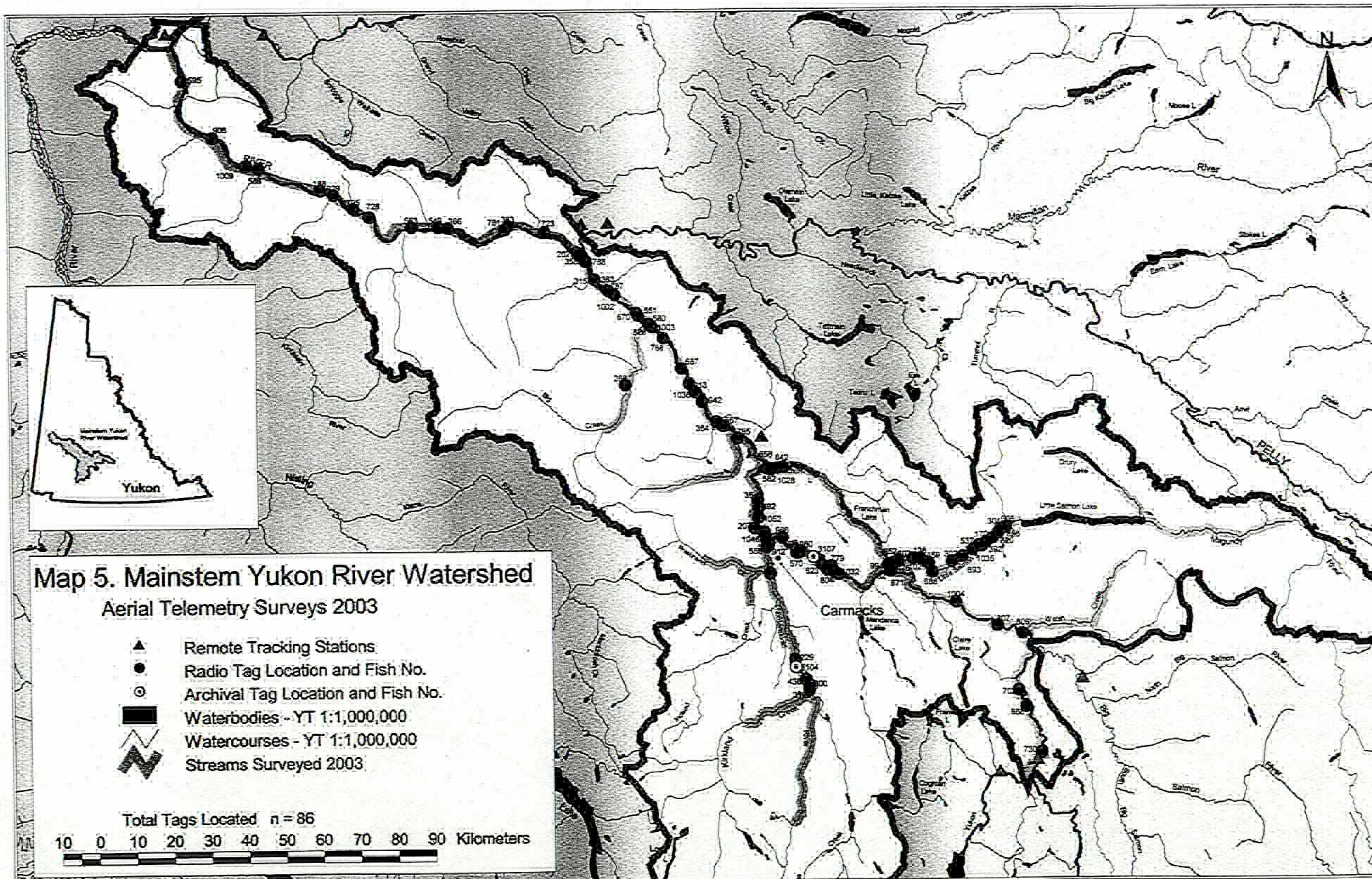
Map 1. North Mainstem/Klondike Aerial Telemetry Surveys 2003


Map 2. Stewart River Watershed
Aerial Telemetry Surveys 2003
Remote Tracking Stations
Radio Tag Location and Fish No.
Archival Tag Location and Fish No.
Waterbodies - YT 1:1,000,000
Watercourses - YT 1:1,000,000
Streams Surveyed 2003
Total Tags Located n = 24
10 0 10 20 30 40 Kilometers
Mayo Lake
Janet Lake
No Code
Watson Creek
Fraser Falls
STEWART
Ethel L
McQuestan
Clear Creek
Hills Creek
Rosebud
Grand
Valley Creek
Crooked Ck
Raid Lakes
Little Kalzas Lake
Big Kalzas Lake
Macmillan
Yukon
N

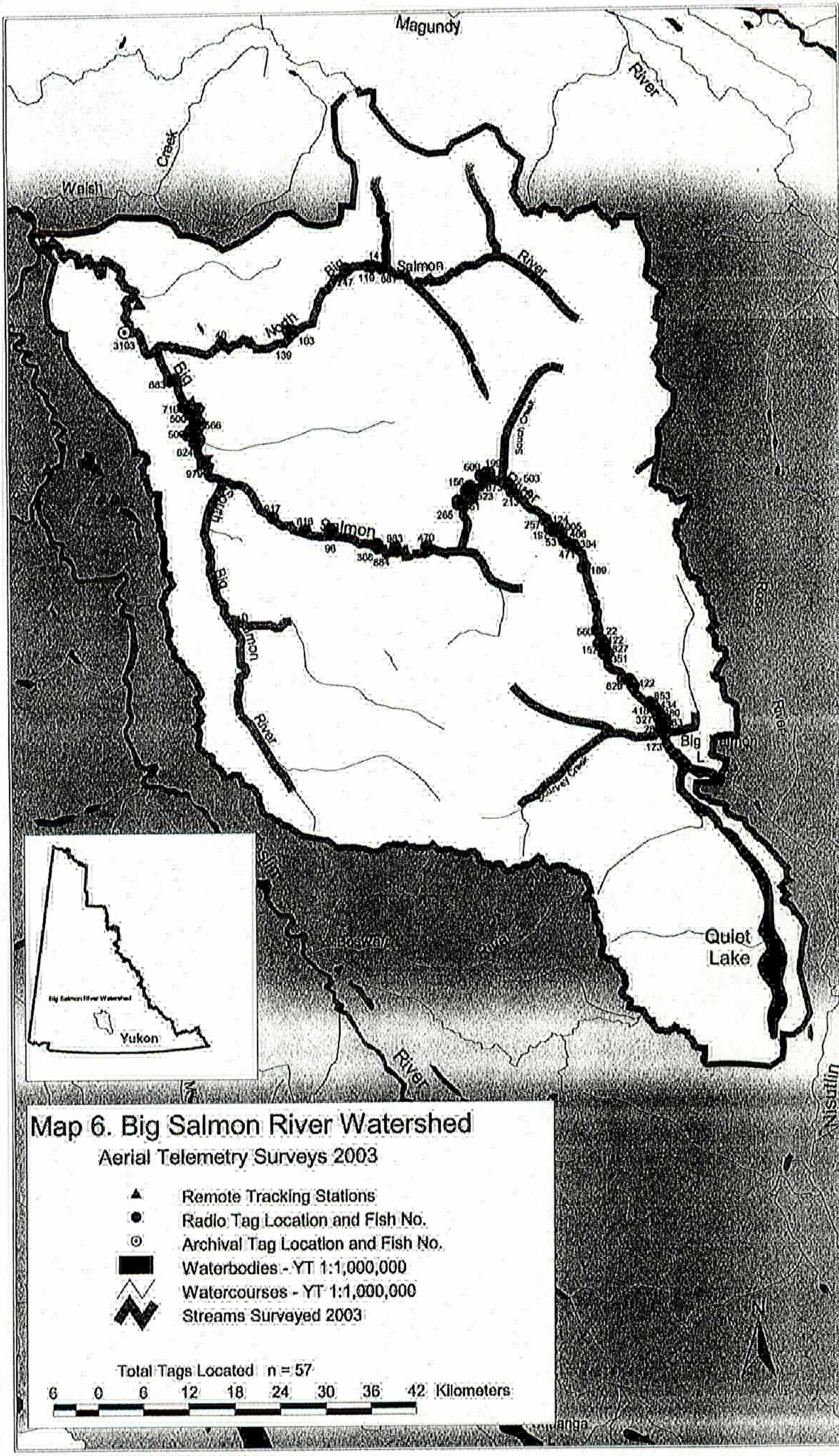

Map 3. Pelly River Watershed
Aerial Telemetry Surveys 2003
Remote Tracking Stations
Radio Tag Location and Fish No.
Archival Tag Location and Fish No.
Waterbodies - YT 1:1,000,000
Watercourses - YT 1:1,000,000
Streams Surveyed 2003
Total Tags Located n = 70
30 0 30 60 Kilometers
Yukon
Pelly River Watershed
River
PELLY
RIVER
No code



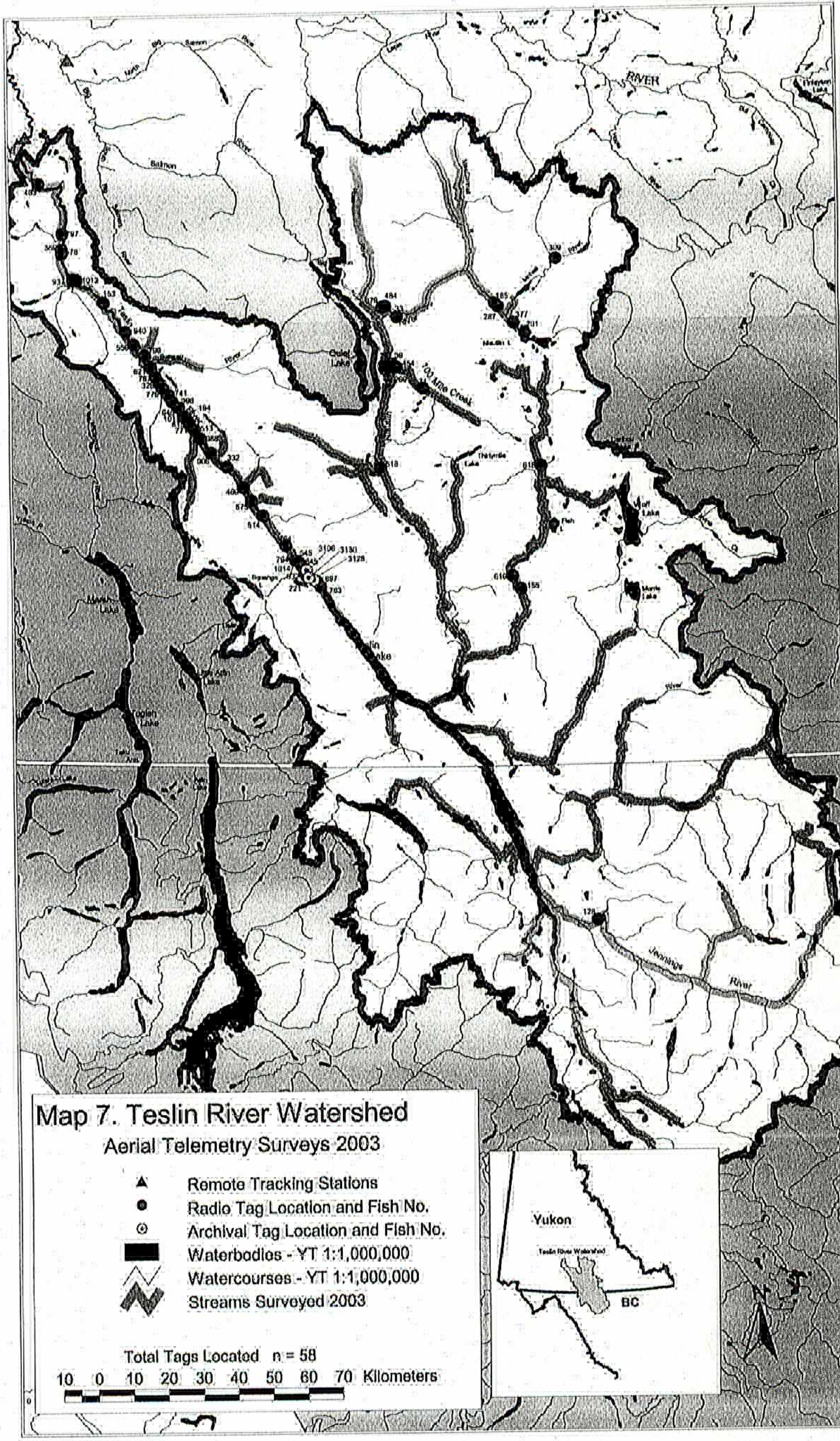
Map 4. White River Watershed
Aerial Telemetry Surveys 2003



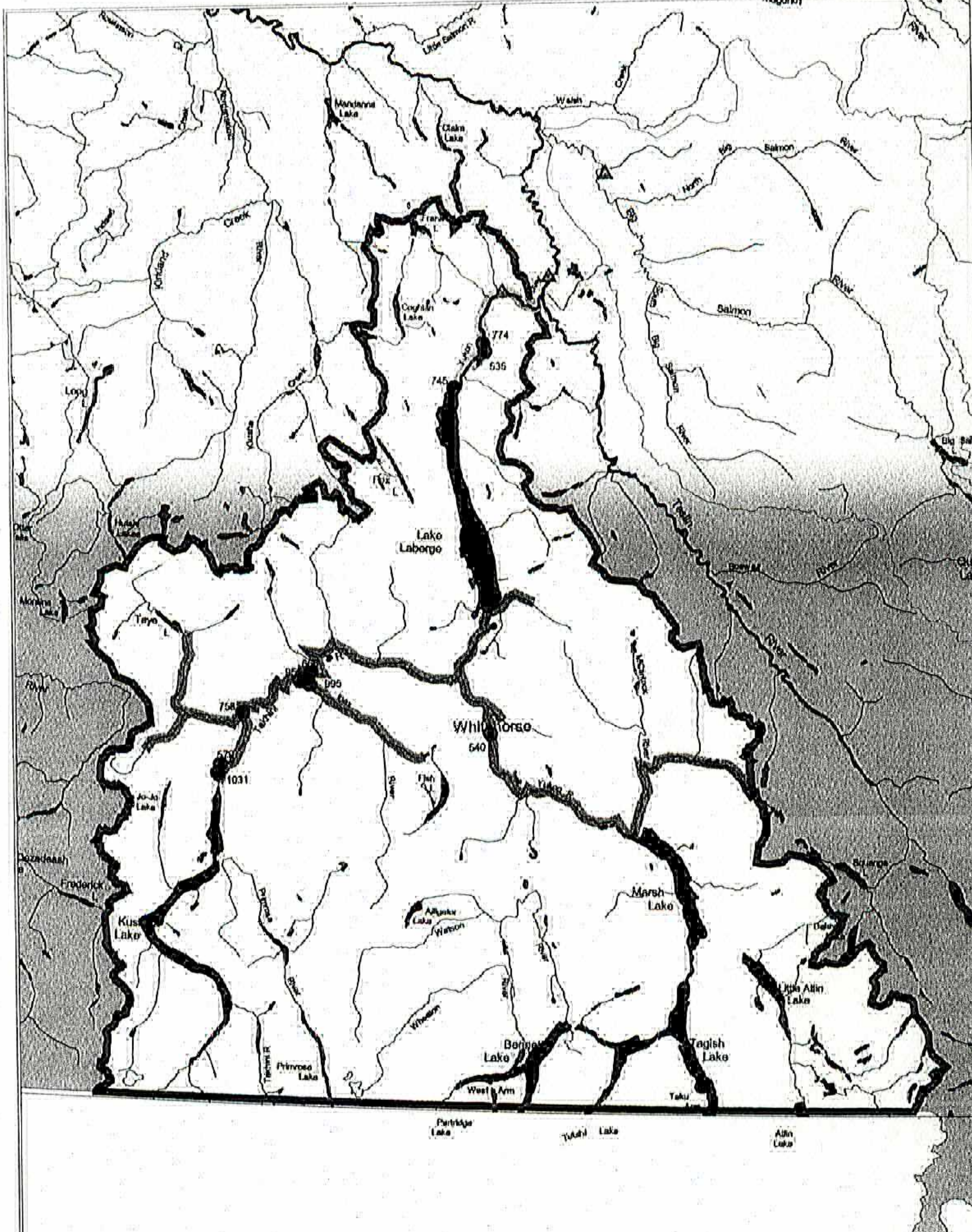
Map 5. Mainstem Yukon River Watershed
Aerial Telemetry Surveys 2003
Remote Tracking Stations
Radio Tag Location and Fish No.
Archival Tag Location and Fish No.
Waterbodies - YT 1:1,000,000
Watercourses - YT 1:1,000,000
Streams Surveyed 2003
Total Tags Located n = 86
10 0 10 20 30 40 50 60 70 80 90 Kilometers
Yukon
Carmacks
PELLY
River
N



Map 6. Big Salmon River Watershed
Aerial Telemetry Surveys 2003



Map 7. Teslin River Watershed
Aerial Telemetry Surveys 2003



Map 8. South Yukon River Watershed

Aerial Telemetry Surveys 2003

▲ Remote Tracking Stations
● Radio Tag Location and Fish No.
⊙ Archival Tag Location and Fish No.
Waterbodies - YT 1:1,000,000
Watercourses - YT 1:1,000,000
Streams Surveyed 2003

Total Tags Located n = 10

10 0 10 20 30 40 50 60 70 80 Kilometers