DISTRIBUTION AND ABUNDANCE OF RADIO TAGGED CHINOOK SALMON IN THE CANADIAN PORTION OF THE YUKON RIVER WATERSHED AS DETERMINED BY 2004 AERIAL TELEMETRY SURVEYS

RE Project 77-04

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Abstract

2004 was the third year of a Yukon River basin wide adult chinook salmon radio tagging and monitoring program. In 2004, a total of 995 chinook salmon were radio-tagged with standard radio transmitters, including 77 fish tagged with radio-archival tags that record depth and water temperature. The 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 basin wide chinook 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 2004 aerial surveys conducted in Canada.

Aerial tracking surveys were conducted on all major tributaries and streams with documented chinook spawning. The surveys were conducted between July 23 and September 15. Of the 284 radio tagged chinook that migrated upstream of the Alaska – Yukon border, 48 were captured in fisheries or assessment projects, 221 were detected and assigned terminal locations during the aerial surveys, and 15 were not located. A total of 15 archival radio tags passed upstream of the Alaska-Yukon border and 13 were recovered. 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 56 (24%) in the Mainstem Yukon watershed to a low of 12 (4%) in both the south Yukon River and White River drainages. In general the 2004 radio tag distributions were similar to those observed during the 2002 and 2003 study years.

A 2004 above border chinook population estimate of 67,280 with a 95% CI of +/- 22,989 was obtained using telemetry and tag recovery data and in three combined but separate assessment projects. A revised and statistically more robust estimate of 50,121 (CI +/- 11,307) was obtained using selective catch information. Using a radio tag ratio of one radio tag per 176 untagged chinook and a simple linear arithmetic relationship of tagged/untagged ratios it was possible to generate 2004 escapement indices of all surveyed streams that contained radio tagged chinook.

1.0 Introduction

The Yukon River basin drains an area of approximately 855,000. The Yukon River flows more than 3000 km from the headwaters in northern British Columbia to the outlet into the Bering Sea (Fig. 1) and drains an area of approximately 855,000 km^2. Within Canada several major tributaries flow into the Yukon mainstem including the Klondike, Stewart, White, Pelly, Big Salmon, and Teslin rivers. Much of the Yukon River basin is very remote with limited road access.

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. 2004 , Mercer and Eiler, 2004, Milligan et al. 1985, Osborne et al. 2003, Pahlke et al. 2003). 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 (Eiler et al. 2004). The 2004 Yukon River chinook telemetry project was the third year that a large-scale transboundary telemetry study was conducted within the Yukon River system. The objectives of the 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, 2003, and 2004, two private companies, B. Mercer & Associates Ltd. and Haldane Environmental Services, 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 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

[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 2004 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).

River), based on results of the aerial telemetry surveys conducted in 2004. [2] The 2004 and 2003 aerial surveys encompassed the entire upper Yukon watershed, whereas the 2002 aerial surveys were limited to comprehensive surveys of the North Mainstem Yukon, Stewart, Big Salmon, and Teslin systems. The results of the 2002 and 2003 aerial surveys are detailed in previous reports (Osborne et al 2003; Mercer and Eiler, 2004).

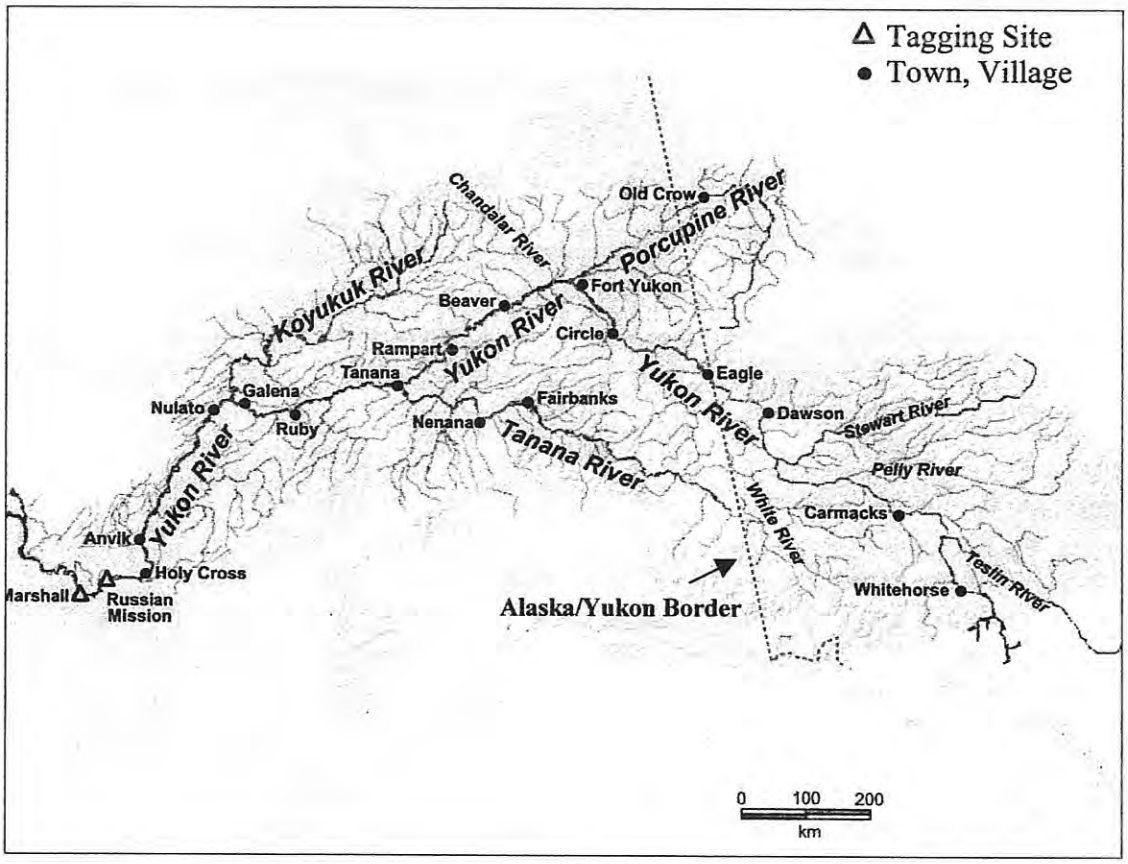

Figure 1. Yukon River Basin.

A companion report (Osborne 2005) describes the distribution and migration rates and timing of the radio tagged chinook in the upper Yukon based on the 2004 RTS tracking information.

[2] The Porcupine River drainage was surveyed in 2004 under a separate R&E program, these results are presented in a separate report prepared by Environmental Dynamics Inc. and the Vuntut Gwitchen First Nation.

1.1 Objectives

The remote tracking stations used in the 2004 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, it is known that chinook salmon move and spawn throughout the watershed. Therefore 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 2004 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 2004 chinook capture and tag application methods are detailed in reports produced by U.S. agencies (Eiler et al., 2004). As occurred in the previous two years, chinook salmon in 2004 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 was re-activated. The tags had a minimum battery life of 90 days.

In addition to 918 standard radio tags applied, 77 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

In order to determine the terminal spawning distribution of all the radio tagged chinook migrating upstream of the Alaska-Yukon border attempts were made to survey all known

and suspected chinook spawning streams. 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 three sites on the mainstem Yukon River (Osborne 2005; Map 9). The RTS's provided records of radio tagged fish migrating into these watersheds. Typically the total number and identity of the radio tagged fish that passed the respective RTS's was known prior to the aerial surveys.

The Stewart, White, Pelly, Big Salmon, and Teslin watersheds 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 (Maps 1 through 9).

The timing of the 2004 surveys for each watershed was dependent on the migration timing obtained from the 2002 and 2003 Yukon River telemetry results, prevailing weather, and the logistical considerations required 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 23 and August 22. Aerial surveys were conducted in the other seven watersheds over the period August 12 through September 14. The dates each watershed was surveyed are listed in Table 1.

Table 1. Aerial survey dates, 2004.

Watershed	**Survey Dates**
North Mainstem/Klondike	July 23,27,30 and Aug. 2,4,5,12,16,19,21,22
Stewart River	Aug. 12 -14
Mainstem Yukon River	Aug. 20 and 29
White River	Aug.19 and 31
Pelly River	Aug. 16-18, and Aug. 25,26,27.
Big Salmon River	Aug. 12 and Aug. 24
Teslin River	Aug. 12,19,21 to 23, and Aug. 29 and Sept. 14
South Yukon River	Aug.19,20 and Aug. 29,31,

The Stewart River watershed was surveyed once during the period August 12 through 14. This was because 20 of the 24 tags at large were located on the first survey and since it is known to be an early spawning stock it was probable that all fish were in terminal areas

during the initial survey period. The mainstem Teslin River was surveyed three times to account for the protracted spawning period observed within this area in previous telemetry studies and to determine, with confidence, if the detected fish were in transit or stationary.

2.2 Aerial tracking equipment

The aerial surveys were conducted using a Maule M-7 fixed wing float equipped aircraft.[3] 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 2). 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

Figure 2. Maule M-7 aircraft and "H" antennae configuration

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.

[3] Surveys in the North Mainstem/Klondike watershed only, were conducted by the Yukon River Commercial Fishery Association using a fixed wing, Piper J-3 aircraft.

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 date, time, signal strength, tag frequency and code, activity status, and the corresponding GPS co-ordinates. The observer also manually recorded the date, time, 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 the operator noted the frequency and manually recorded the aircraft GPS co-ordinates that corresponded to the highest audio signal.

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. Typically, final radio tag locations were determined by using the GPS co-ordinates that matched the median of the 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 were 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. All 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 near the located tag. A chartered Bell 206 helicopter was used to access the archival tag if it was located where conditions prevented floatplane access.

3.0 Results

A total of 163.5 hours was flown in fixed wing aircraft during the 2004 aerial surveys of the upper Yukon River watershed.[4] In addition, approximately 7.5 hours of fixed wing aircraft and 5.6 hours of helicopter time were used for the detection and recovery of the archival tags.

Of the 995 chinook radio tagged at the Alaskan tagging sites, a total of 284 were recorded as passing upstream of the Alaska – Yukon border tracking stations. Forty-eight tagged fish were reported captured in assessment projects, commercial, sport, subsistence, and aboriginal fisheries (Unpublished data, DFO Whitehorse; JTC report, 2005). Of the remaining 236 radio tags potentially at large, 221 (94%), were located and assigned terminal spawning locations during the aerial surveys. The distribution of located radio tags, by watershed, is illustrated in Figure 2. The number of tags recorded by the RTS's,

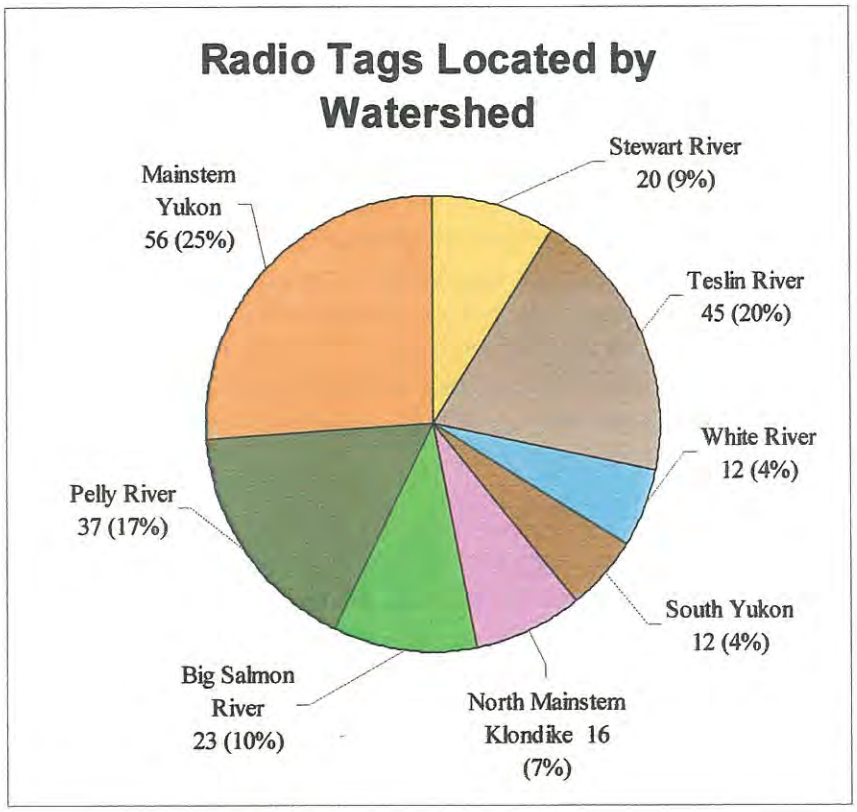

Figure 2. Distribution of radio tags located during the 2004 aerial surveys.

[4] For the North Mainstem–Klondike watershed aerial surveys only, a Piper J-3 aircraft was flown approximately 40 hours survey time and 10 hours ferry time. A Maule M-7 aircraft was flown a total of 123.5 hours to survey the other seven watersheds and recover archival tags.

caught in fisheries and assessment projects, and located by aerial surveys is presented in Table 2. Fifteen (6%) of the 236 radio tagged fish at large in the upper Yukon River basin were never located during the aerial surveys. The largest number of tags not located were known to be in the mainstem Yukon River between the Selkirk and Teslin RTS's.

Table 2. Number of radio tags past RTS, caught in fisheries, and located by aerial Surveys in the upper Yukon River basin.

Watershed	RTS Records[a]	Reported Caught in Fisheries/Assessment Projects	Located by Aerial Surveys	Not Located by Aerial Surveys
North Mainstem/Klondike	18	25	16	2
Stewart River	26	2	20	4
Mainstem Yukon River	67	7	56	4
White River	12	0	12	0
Pelly River	47	8	37	2
Big Salmon River	25	0	23	2
Teslin River	50	4	45	1
South Yukon River	14	2	12	0
Total	**259**	**48**	**221**	**15**

a) Denotes those radio tags recorded as being within the watershed covered by the RTS.

3.1 North Mainstem/Klondike Watershed

In 2004 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.

Of the 18 radio tags potentially at large within the North Mainstem/Klondike watershed , terminal locations were established for 16 radio tagged fish (Table 3, Map no. 1, Appendix 1-a). Twelve radio tags were located in the Klondike system, two were in the mainstem Yukon between the Alaska – Yukon border and the White River, and one each in the Chandindu and Sixty Mile rivers. In addition, 25 radio tagged fish were caught in the commercial, aboriginal, and test fisheries in the area. It is probable that most of the fish caught in fisheries were in transit to areas upstream of the north mainstem region.

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

Fate	Total
Chandindu River	1
Klondike River	12
North Mainstem Yukon River	2
Sixty Mile River	1
Caught in Fishery	25
Total	41

As occurred in 2002 and 2003 the highest radio tag density in the region was found in the Klondike River. It is assumed the two Mainstem Yukon radio tags detected were in terminal locations but as the last aerial survey in this region was on August 20 it is possible, but unlikely, they were later run fish and still in transit to other North Mainstem-Klondike tributaries.

3.2 Stewart River Watershed

Within the Stewart River watershed the areas surveyed included: The Stewart River mainstem downstream of Fraser Falls, Crooked Creek, McQuesten River (including North and East McQuesten), Moose Creek, Mayo River, Janet Creek, Williamson Creek, Watson Creek, and No Gold Creek. Upstream of Fraser Falls streams surveyed included the mainstem Stewart River , Beaver River, Rackla River, Lansing Creek, portions of the Rogue River, Pleasant Creek, Emerald Creek, and the Hess River to Ollie Lakes. The final radio tag locations are presented in Table 4, Appendix 1-b, and Map 2. The Stewart River aerial surveys located 20 (87%) of the 24 extent radio tagged fish in the system. Three of the unlocated tags were downstream of the Fraser Falls RTS and one was upstream. Two radio tagged fish were captured in the local fisheries and were submitted to the DFO office, in Whitehorse, Yukon.

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

Fate	Total
Caught in Fishery	2
Emerald Creek	1
Mayo River	2
McQuesten River	12
Not located	4
Rackla River	1
Stewart River	3
Watson Creek	1
Total	26

Downstream of Fraser Falls, the 2004 distribution of radio tagged fish in the Stewart system was similar to that observed during the 2002 and 2003 studies, with the McQuesten River drainage again receiving 12 (50%) of the 24 tags at large. As occurred in the previous studies the radio tagged fish in the McQuesten River were located in the lower reaches of the system. The Stewart River mainstem received three tags. Mayo River accounted for two tagged fish and Watson Creek one tag.

During the 2004 study an RTS was operational immediately upstream of Fraser Falls (Osborne 2005). The RTS was situated to determine, with certainty, the number and identity of the radio tagged fish that ascended the falls and entered the upper reaches of the Stewart system. The Fraser Falls RTS recorded three tagged fish passing by the station. Of these fish two were located in headwater tributaries; the Rackla River and

Emerald Creek. The remaining tag upstream of the falls was not located. The presence of the tag in Emerald Creek may be the first documented occurrence of adult chinook salmon in that stream.

Fifteen of the 20 radio tags (75%) located in the Stewart system during the August 13-15 surveys had activated mortality sensors (Appendix 1-b). This is consistent with the findings of the 2002 and 2003 studies. Based on the ratio of activated mortality sensors recorded during the Stewart River surveys, indications are that this stock, along with the north mainstem stocks, are the earliest spawning chinook within the headwater tributaries.

3.3 Pelly River Watershed

The Pelly River system is the largest of the watersheds surveyed. Adult chinook salmon have been documented in most Pelly River tributaries. The streams surveyed in the Pelly drainage in 2004 included the Earn, Glenlyon, Hoole, Kalzas, Macmillan (including North and South Macmillan), Ketza, Lapie, Pelly, Prevost, and Ross rivers. Also surveyed were Anvil, Blind, Big Campbell, Little Kalzas, LaForce, Mica, Needlerock, Rose, and Otter creeks. All the streams were systematically surveyed twice.

The Pelly drainage RTS recorded 47 radio tagged chinook entering the system. The aerial surveys were successful in locating 37 of these fish, eight were reported caught in the aboriginal fisheries, and two 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
Anvil Creek	1	N. Macmillan River	1
Big Campbell Creek	2	Not Located	2
Blind Creek	4	Pelly Lakes outlet	1
Caught in Fishery	8	Pelly River	10
Glenlyon River	2	Prevost Creek	2
Hoole River	2	Ross River	5
Kalzas River	3	S. Macmillan River	4
		Total	47

As occurred in 2003, the radio tags located in 2004 were distributed extensively and disparately throughout the Pelly system. The mainstem Pelly and Ross 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. Anvil Creek and Prevost River each contained radio tagged fish in 2004 whereas none were present in 2003 or 2002.

Fish #336 was located approximately 30 km downstream of Pelly Crossing. This tag was located within an aboriginal fishing area and may have been a tagged fish that was not

reported as caught. The remaining radio tags in the system were all considered to be at terminal locations.

Of the 37 radio tagged fish assigned terminal locations, 31(84%) had activated mortality sensors (Appendix 1-c) by the date of the second survey.

3.4 White River Watershed

The streams surveyed in the White River drainage included portions of the White, Donjek, Generic, Nisling, Kluane, Ladue, Klaza, and Klotassin rivers. The lower reaches of Beaver, as well as all of Onion, Teepee, and Tincup creeks were also surveyed. Teepee and Onion creeks were surveyed once only. All the other streams were surveyed twice, on August 19 and 31.

Twelve radio tagged fish were located in the White River system during the two aerial surveys (Table 6, Map 4, Appendix 1-d). The Nisling River with 6 tags contained the largest number and density of radio tagged fish. The Nisling River radio tags were concentrated in the lower 20 km of the system. Four radio tagged fish were located in the White River, and one in the Donjek River. Tincup Creek received one radio tag.

Table 6. Radio tag distribution in White River watershed.

Fate	Total
Donjek River	1
Nisling River	6
Tincup Creek	1
White River	4
Total	12

Two of the nine fish located during the first survey had activated mortality sensors. On the second survey, seven of the 12 radio tags located were registered as mortalities.

3.5 Mainstem Yukon River

The mainstem Yukon River was designated as that 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, Selwyn, and Magundy rivers. Big, Tatchun, Drury, Rowlison, Incised, Kirkland, and Walsh creeks were also surveyed. Two aerial surveys were conducted on all the streams on August 20 and 29.

Within the mainstem Yukon area terminal locations were assigned to 56 radio tags (Table 7, Map 5, Appendix 1-e). As in 2003, The largest number of tags (46) was located within the Yukon River. These tags were disbursed throughout the area of the Yukon River surveyed; however, concentrations of tags were observed in the reaches between Tatchun

Creek and the mouth of the Pelly, and between Carmacks and the Little Salmon River. The highest radio tag densities were found in the area around the Ingersoll Islands within the mainstem Yukon. The Little Salmon River received four radio tags and Bearfeed Creek one. Two tags were located in the Nordenskiold River and three radio tags were detected in Tatchun Creek between the mouth and Tatchun Lake.

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

Fate	Total
Caught in Fisheries	7
Bearfeed Creek	1
Little Salmon River	4
Yukon River	46
Nordenskiold River	2
Not Located	4
Tatchun Creek	3
Total	67

Based on RTS data, the mainstem Yukon River area contained the largest number (60) of radio tags at large. It also contained one of the largest number of radio tags (4) recorded by the RTS's but not located by the aerial surveys.

During the first survey on August 20 only one of the 50 radio tags detected had an activated mortality sensor. On the second survey 12 (22%) of the 54 located radio tagged fish were identified as mortalities. This is consistent with the 2003 results indicating the mainstem Yukon stocks spawn relatively later than other upper tributary stocks.

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, Souch, Northern, and Scurvy creeks were also surveyed.

A total of 25 tags were recorded passing the Big Salmon RTS. Of these, 23 (92%) were located during the two aerial surveys (Table 8, Map 6, Appendix 1-f). Four tagged fish were observed in the North Big Salmon River and 18 were found in the Big Salmon River. With the exception of Northern Creek (fish no. 440), 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 with the highest concentration located within a 10 km section upstream of Souch Creek. Radio tag densities were comparatively lower in the North Big Salmon River. The radio tags in the North Big Salmon were located downstream from the confluence of Northern Creek.

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

Fate	Total
Big Salmon River	18
North Big Salmon River	4
Northern Creek	1
Not located	2
Total	25

Two radio tags were recorded passing the Big Salmon RTS but were not located. It is possible these fish were caught and the tag not relinquished. The tags may not have been detected during the aerial surveys, however, the overall stream morphology is generally favourable for signal detection and all documented and probable spawning areas were surveyed.

During the first survey on August 12, six of the 23 tags (26%) located had activated mortality sensors. The second survey on August 24 registered 10 (43%) mortalities in the 23 tags located.

3.7 Teslin River System

The Teslin River drainage surveys were conducted on August 12, 19,21 to 23, and 29. A final mainstem Teslin River survey occurred on September 15. Since the Teslin River system is a relatively large watershed, encompassing approximately 26,000 sq. km, not every watercourse in the system was surveyed. However, 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, McNeil, Morley, 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, and Tlingit creeks (Map 7).

Of the 50 radio tagged chinook that were recorded passing the Teslin RTS in 2004, 45 were assigned terminal locations during the aerial surveys, four were caught in various fisheries, and one was not located (Table 9, Map 7, Appendix 1-g). As occurred in the previous two years, the highest number and concentration of radio tags (71% of tags located in the system) were found in the mainstem Teslin River. Within the mainstem Teslin River the greatest tag concentrations were found in the 40 km section downstream of Swift Creek. The Nisutlin River system contained eight radio tagged fish with five in the Nisutlin River and three in 100 Mile Creek. One tag was found in the Morley River and one tag was determined to be in Teslin Lake near the mouth of the Gladys River.

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

Fate	Total	Fate	Total
100 Mile Creek	3	Nisutlin River	5
Caught in Fishery	4	Not Located	1
Jennings River	1	Wolf River	2
Mainstem Teslin	32	Morley River	1
		Teslin Lake	1
		Total	50

During the first Mainstem Teslin survey on August 12, all of the 24 radio tagged fish located were alive. During the August 22 and 24 surveys, six of the 32 (18%) of the tagged fish were found to be dead. During the final Mainstem Teslin River survey on September 15, a total of 13 (41%) of the 32 radio tagged fish were dead.

3.8 South Yukon River watershed

The streams surveyed in the South Yukon watershed included: the Yukon River from the Teslin confluence to Marsh Lake, the Takhini River from the mouth of the Yukon to Kusawa Lake, Mendenhall, and McClintock rivers as well as lower portions of Croucher and Ibex creeks. Each stream was surveyed twice, on August 19 and 31.

The chinook passing through 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.

Thirteen radio tags were recorded passing the Hootalinqua RTS and entering the South Yukon watershed. Two radio tagged fish were detected at the Whitehorse Rapids Fishway and the radio transmitters were recovered. One of these radio tags (Fish no. 3034) was an archival tag that was not recorded by the Hootalinqua RTS. It was subsequently determined that this radio transmitter was inoperative prior to passing the Alaska-Yukon border and had not been recorded by any of the other downstream RTS's. As a result of this recovery the total number of radio tagged chinook entering the system was determined to be 14.

A total of 12 radio tags were located by the aerial surveys. These, when included with the two recoveries at the fishway, accounted for all the radio tagged fish known to be in the system. Five radio tags were detected in the Takhini River, three were located in the Yukon River between Lake Laberge and the Junction of the Teslin River, and four were located within a 10 km reach downstream of the Whitehorse Rapids Dam. (Table 10, Map 8, Appendix 1-h).

One of the 4 tags located near Whitehorse during the first survey (fish no. 614) had an activated mortality sensor. On the second survey an additional two fish in the Takhini River were considered dead.

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

Fate	Total
South Yukon River	7
Takhini River	5
Whitehorse Fishway	2
Total	14

3.9 Archival Tag Location and Retrieval

A total of 15 archival radio tags were recorded passing the border RTS into the Canadian portion of the upper Yukon River drainage and 13 of these were subsequently recovered. Thirteen archival tags were located during the aerial surveys. Three of the archival tags were found in the Klondike system, one in the White, four in the Pelly, two in the Big Salmon, two in the Teslin, and one was recovered at the Whitehorse fishway. One archival tag (Fish no. 3005), was caught in the commercial fishery downstream of Dawson City (Table 11). The terminal spawning locations of the archival tags are illustrated in the individual watershed maps as well as in Map 9.

Table 11. Archival tag recoveries.

Fish Number	Location	Retrieval Date	Retrieval Method	Remarks
3034	Klondike River	August 13	Boat	In carcass, sex unknown
3055	North Klondike River	August 13	Boat	Loose tag
3046	Klondike River	unknown	Helicopter	Loose tag
3001	White River	August 31	Helicopter	Loose tag, mouth of Creek
3008	Pelly system, South Macmillan River	August 26	Helicopter	Decomposed carcass
3019	Mainstem Pelly River	August 26	Helicopter	Loose Tag
3010	Mainstem Pelly River	August 26	Helicopter	Loose Tag
3058	Mainstem Pelly River		Not recovered	Not relocated on survey
3041	Big Salmon River	August 23	Helicopter	Loose tag on river bank
3013	North Big Salmon River	August 23	Helicopter	Loose tag on river bank
3039	Mainstem Teslin R.	September 16	Fixed Wing a/c	Loose Tag
3037	Teslin system, Wolf River	September 16	Fixed Wing a/c	Loose Tag
3034	South Yukon R.	August 10		Whitehorse Fishway
3005	North Mainstem	July 26	Gill net	Caught in commercial fishery, Dawson City
3004	Mainstem Yukon R.			Not Located

The three archival tags in the North Mainstem system were located in the Klondike (2) and North Klondike Rivers (1). One of these (fish no. 3034) was removed from a decomposed carcass, and the other two tags were found loose on the shore.

The archival tag retrieved from the White River system was located in the mouth of Mickey Creek a clearwater stream entering the eastern side of the White River approximately 30 km upstream from the confluence with the Yukon River.

The Pelly system received four archival tags, of which three were recovered. Two tags were found loose on the mainstem Pelly River and one was found in a carcass in the South Macmillan River. The carcass was too decomposed to determine sex or if it had spawned. The tag from fish no. 3058 was not recovered. While this tag was located on the first survey, it was not found on the second survey on august 26 when the other Pelly system archival tags were retrieved. All the Pelly system tags were recovered using a 206 helicopter chartered from the town of Ross River.

Two archival tags were detected in and retrieved from the Big Salmon system on August 23. One tag was located in the North Big Salmon and one in the Big Salmon approximately 30 km upstream from the confluence with the Yukon River. Both tags were loose and not associated with a carcass. The Big Salmon tags were retrieved using a Bell 206 helicopter chartered from Whitehorse.

The two archival tags located in the Teslin River system were located in the mainstem Teslin 5 km upstream from Boswell Creek and in the Wolf River 20 km downstream from the outlet of Wolf Lake. Both tags were loose and were retrieved on September 15 using the fixed wing survey aircraft.

One archival tag was not located during the aerial surveys (Fish no. 3004). However it was determined that it was caught in the aboriginal fishery in the vicinity of Carmacks since the corresponding spaghetti tag was subsequently submitted to DFO Whitehorse. Since this tag was recorded by the Tatchun RTS but never detected in aerial surveys, it is assumed it was rendered inoperative after the fish was captured or the tag was transported out of the survey area.

3.10 Telemetry Derived 2004 Chinook Escapement Indices

A population estimate of the 2004 chinook escapement entering the Canadian portion of the upper Yukon River basin was obtained using the 2004 radio telemetry data. The 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

The total number of chinook (n) captured in fisheries and observed in assessment projects was determined to be 11,601 (Table 12). This figure was obtained using: 1) the combined commercial, and test gill net and fish wheel catches; 2) aboriginal fisheries catches; and 3) the Blind Creek weir counts (Yukon River JTC report, 2004). The total number of radio tagged chinook captured in the fisheries and observed in assessment projects was 50. The number of radio tags crossing the border (D) was 284.

Using the above data a 2004 above border chinook population estimate of 65,894 with a 95% CI of +/- 7,995 was obtained ($\alpha = 0.05$, s.d. =5,769, n = 3). Using the telemetry data radio tag ratio of 0.00431 (1 radio tag per 232 untagged chinook) and a simple linear arithmetic relationship of tagged/untagged ratios it is possible to generate 2004 escapement indices of all surveyed streams that contained radio tagged chinook. A table of radio tag counts and resultant population indices is presented in Appendix 2. As discussed in section 4.10 below a revised population estimate of 50,121 is used to produce the table of escapement indices.

Table 12. Radio tags recorded in 2004 upper Yukon River fisheries and assessment projects.

Category	# of Fish	# of Tags	Proportion tagged	Population estimate	95% C.I.
Commercial, recreational, test, and domestic fisheries	4,313	25	0.00579	48,996	
Aboriginal fisheries	6,483	21	0.00323	87,675	
Blind Creek weir	805	4	0.00496	57,155	
Combined	11,601	50	0.00430	65,894	7,995

It should be noted that although the escapement indices presented do have relational and comparative value, the indices especially for streams with lower tag numbers, are population point estimates based on simple tagged/untagged ratios without quantifiable confidence limits. It would be naïve to assume that escapements to spawning areas are uniformly equal to the observed distribution of radio tagged fish. 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.

4.0 Discussion

The success of the 2004 Yukon River telemetry project was again due to a number of factors. Large scale basin wide telemetry studies, while technically feasible, are nevertheless challenging and are dependent on the successful outcome of all facets of the

project. To yield relevant information salmon telemetry studies rely on the realization of a number of assumptions. The most critical of these are:

1. Tagging does not induce behavioural changes in the fish.
2. The tagged fish can be successfully tracked to their final destination.

A primary assumption of telemetry studies is that capture, handling and tagging methods do not adversely affect the fish (i.e. tagged fish behave similar to untagged fish). It appears the chinook salmon radio tagged during the four years of the program have responded well to the procedures used. In the four years of the program more than 97% of the tagged fish resumed migration activity after tagging. The relatively fast and sustained movement rates and the scarcity of fish in non-terminal areas of the upper river basin suggest that adverse effects from tagging were minimal (Eiler et al. 2004, Mercer and Eiler 2004, Osborne et. al, 2003).

With the exception of one defective tag, all the radio tagged fish crossing the Alaska – Yukon border were monitored by the RTS's located along the mainstem Yukon River and the larger associated tributaries. The 2004 upper Yukon River aerial telemetry surveys were successful in locating and assigning terminal locations to 94% of the radio tagged fish at large. The fate of the 15 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 was 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. In 2004 the highest incidence of unlocated radio tags occurred in the mainstem Yukon River between the Selkirk and Hootalinqua RTS's, in an area with aboriginal, commercial, domestic, and sport fisheries. This, in conjunction with the absence of any local un-surveyed tributaries that may have contained the tags suggests the missing tags may have been removed from the area or destroyed. Aerial surveys conducted in 2002 over villages along the Tanana and Yukon rivers in Alaska, documented that 49 of the 270 (18.2%), tagged fish caught in fisheries were not reported (Eiler et al., 2004.)

In 2002 and 2003, 94% and 95% respectively, of the RTS recorded radio tags were subsequently located during the aerial surveys (Osborne et. al, 2003; Mercer & Eiler 2004)). The aerial survey area in the Canadian portion of the upper Yukon basin encompasses approximately 240,000 sq. km. Notwithstanding the large area as well as the time, weather, and budget constraints associated with the aerial surveys, the proportion of tags located was large enough to determine the chinook spawning distribution with a relatively high degree of accuracy.

As occurred in 2002 and 2003, the combined mainstem Yukon and Teslin rivers received the largest number of radio tags (78 tags, 33%), 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 the 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 interfered with their migratory capability and/or caused pre-spawn mortality. However, as in previous years there is no evidence from the 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 would 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.

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-Yukon River confluence if the radio tagged mainstem fish were located in non-terminal areas. In both 2003 and 2004 no radio tags were observed in the 100 km reach of the Yukon mainstem from the mouth of the White River to the Klondike River. This pattern may be a function of the high sediment inputs from the White River system. These high sediment loads may limit available spawning habitat within this section of the mainstem Yukon River.

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. Therefore, the mortality sensor information obtained from the aerial surveys should be interpreted cautiously. 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. It is probable that some of the radio signals indicating fish were alive were erroneous. 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

Within the north mainstem Yukon/Klondike area a total of 16 radio tags was located during the aerial surveys. This represents 7% of the radio tags potentially at large within the upper Yukon River system. As occurred in 2002 and 2003, the Klondike River drainage contained the largest number (12) as well as the highest concentration of radio tags in the area. The radio tag located in the Sixty Mile was the first radio tagged fish located in the system over the three years of the telemetry program.

It is assumed that most of the 25 radio tags caught in gill net fisheries in the North mainstem area would have been enroute to other systems upstream.

4.2 Stewart River Watershed

The Stewart River system was surveyed once over the period August 14-16. Twenty of the 24 tags at large were located. Given the large number of dead fish detected at this

time it was decided to limit the Stewart system to a single survey. It was probable that all fish detected had reached their respective spawning locations.

Four radio tags recorded by the Stewart River RTS were not located during the aerial surveys. Three of these radio tags were known to be downstream of the Fraser Falls RTS. Although these fish may have been in a lower tributary not surveyed there is a higher probability they were caught in a fishery and not reported. One tag that migrated upstream of the Fraser Falls RTS was not located. The upper Stewart watershed comprises over 60% of the total system and encompasses a vast area with numerous smaller tributaries. Although the upper Stewart system was extensively surveyed it is probable that this fish was in one of the many smaller tributaries that were not examined.

The 2004 radio tag distribution in the Stewart system was similar to that observed in 2002 and 2003 in that the McQuesten River received the largest proportion of tags (33% in 2002, 50% in 2003, and 50% in 2004 (Osborne et. al, 2003; Mercer & Eiler 2004). In all years relatively low numbers of tags were located in Janet and Watson creeks and in the mainstem Stewart and Mayo rivers. In addition, all three years saw a relatively low number of radio tags migrate upstream of Fraser Falls. In all three study years the number of tags located above Fraser Falls ranged from 12% in 2004 to 25% (2002)[5]. Anecdotal reports suggest that prevailing water levels during the chinook migration period may influence fish passage over the falls. The radio tag distribution in all three years suggests that although the upper Stewart system encompasses approximately 60% of the drainage, it receives a disproportionately low number of returning chinook.

Although the run timing past the border and Stewart RTS's is similar that of the other upper Yukon River stocks, the aerial telemetry surveys indicate that the Stewart River origin chinook spawn earlier than most of the other upper tributary stocks. This is evidenced in all three years by the relatively large proportion of dead fish detected during the mid-August survey

4.3 Pelly River Watershed

The radio tags located in the Pelly system exhibited a widespread distribution throughout most of the drainage. Of the 39 radio tags at large, 37 were located by the aerial surveys with the mainstem Pelly receiving the largest number. The highest radio tag densities were found in Blind Creek and a single section of the Ross River. The overall distribution pattern of the radio tagged fish was similar to that found in the 2003 study. However in 2004, radio tags were found in Anvil Creek and the Prevost River, two tributaries where radio tags were absent the previous year. In 2003, tags were detected in the Earn River and in Little Kalzas, Laforce, and Otter creeks but were absent in these waterways in 2004. The absence of tags in these tributaries is likely a function of the comparatively lower number of tags entering the system in 2004.

[5] The upper Stewart River watershed was not surveyed in 2003 and the Fraser Falls RTS was not operational. However the maximum undetected tags at large that could have migrated upstream of the falls in 2003 was 5/30 or 16%.

Two 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 they were in streams that were not surveyed or they had been caught and not reported.

4.4 White River Watershed

All 12 of the radio tagged fish recorded entering the White River system were located during the aerial surveys. As in 2003, The Nisling River again received the largest number of radio tags but unlike the 2003 distribution all the tags were concentrated in the lower 20 km of the system. Tincup Creek, a well documented chinook spawning stream (Wilson 2000), received only one radio tag in 2004 whereas it received four in 2003.

Four radio tags were detected in the mainstem White River and one tag was located in the Donjek River. The fish were assigned to these terminal locations as they were detected in approximately the same locations on both surveys. One of the radio tags located in the White was an archival tag (Fish # 3001) that was subsequently recovered. The tag was located upstream of the mouth of a small tributary (Mickey Creek) flowing into a side channel of the White River. It is not known if this fish spawned in the White River or further upstream in Mickey Creek. It is probable that the muddy substrate within the lower reaches of Mickey Creek would have prevented successful spawning at this location.

In 2003, one radio tag was also located in each of the Donjek and White rivers. Although the high sediment loads of the White and Donjek rivers would seem to preclude the existence of chinook spawning habitat, chum salmon spawning has been documented in up-welling areas on the White River (Milligan et. al 1985). It may be relevant that the location of the radio tag located in the White River in 2003 is the same as one of the fish (# 125) located in 2004. The presence of radio tagged chinook in the mainstem White River in both years of the study suggest that the turbidity of the system may not preclude spawning in the mainstem if clear ground water up-welling areas are present.

4.5 Mainstem Yukon River Watershed

As occurred in 2003, the mainstem Yukon River in 2004 received the largest number of radio tags (67). Fifty-six of these tags were located in aerial surveys, accounting for 24% of the total radio tags at large in the upper Yukon River. Within this area the mainstem Yukon River received the largest proportion (46) of radio tags. Four radio tags were observed in the Little Salmon River which is considerably less than the 19 observed in 2003. The DFO aerial index count conducted August 15 on the Little Salmon River was 1,140. This count produces a tag ratio 0.35% that is not inconsistent with the total combined telemetry based tag ratio of 0.42%.

The Yukon mainstem area and the Stewart system also had the largest number (4) 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.[6] As well, significant fishing effort occurs in the Yukon mainstem area and it is probable that not all the captured radio tags were reported.

4.6 Big Salmon River Watershed

A total of 25 radio tagged chinook entered the Big Salmon system; accounting for 10% of the radio tags at large in the upper Yukon River basin. This was lower than the 2003 proportion (15%) but comparable to the 2002 proportion (9%). All radio tags except one were located in the Big Salmon and North Big Salmon rivers. As occurred in 2002 and 2003 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 eight radio tags in the DFO aerial escapement survey area. The DFO aerial index survey conducted on August 18 between Souch Creek and Big Salmon Lake produced a count of 762 chinook (JTC 2004).

The North Big Salmon received five radio tagged fish which was similar to the numbers located in this system in 2002 (6) and 2003 (7). In 2004, one tag was located in Northern Creek, a stream that had not received radio tagged fish in either 2002 or 2003.

4.7 Teslin River Watershed

In 2004, the Teslin River drainage contained approximately the same proportion (19%) of radio tagged fish as it received in 2002 and 2003. Once again the mainstem Teslin River received the highest proportion of radio tags within the system (70% in 2002, 68% in 2003, and 70% in 2004). Due to the protracted run into the mainstem Teslin, this section was surveyed three times on August 12, 21 and September 14. This was done to be certain the detected tags were in terminal locations rather than still in transit. The RTS and aerial survey data from all three years suggest the mainstem Teslin origin chinook run later and have a more protracted spawning period than other upper Yukon River stocks (Osborne et. al. 2003; Mercer & Eiler 2004).

The Nisutlin River system received five radio tagged fish. A 2004 DFO aerial index survey conducted on the Nisutlin River between 100 Mile Creek and Rose River counted 330 fish. No radio tags were observed in the aerial index area although a tagged fish was recorded immediately above and below the index area.

Within the Jennings River, fish no. 388 was located in the same location as the radio tags found in the system in 2002 and 2003. This would appear to indicate that chinook spawning in the Jennings River may be localised in a few areas. The large substrate size observed in much of the Jennings River may be one factor limiting chinook spawning distribution within the system.

[6] 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.

One tag was observed in the Morley River whereas none were observed there in previous years. In all three study years no radio tags were observed in the Swift or Smart rivers, although these streams have well documented spawning utilisation (DFO Whitehorse, unpublished data base). Approximately 12 spawning chinook were observed from the survey aircraft in the Swift and Morley systems during the 2004 telemetry surveys[7]. The absence of radio tags suggests escapements in these streams were relatively low during the survey years.

Of all the radio tagged fish detected in the upper Yukon River system, fish no. 24 located in the upper Nisutlin migrated the furthest from the tagging site, a distance of approximately 2,620 km.

4.8 South Yukon Watershed

Fourteen radio tags were recorded passing into the South Yukon system in 2004. This amounted to 6% of the total radio tags at large in the upper Yukon basin. All the tags were accounted for with 12 located in the aerial surveys and two retrieved at the Whitehorse Fishway. As in 2003, the Takhini River system received a relatively large proportion (36% in 2004) of the radio tags within the watershed.

Four radio tags were located in the south Yukon mainstem within a 5 km reach downstream of the Whitehorse rapids fishway. Chinook salmon have been documented spawning in this area, which is within the city of Whitehorse. It is possible these fish had been caught and the tags were in a private residence. However, since all the fish had been recorded passing the Hootalinqua RTS and maximum signal strength was observed over the river, it is assumed these fish were in a terminal spawning area.

4.9 Archival Tag Recovery

Only two of the 13 archival tags recovered were collected from carcasses; the remaining 11 were found free of the carcass, presumably after the carcass had been scavenged and consumed. This was not unexpected since archival rag recovery was not initiated until after the mortality sensor had been activated. However it does emphasize how quickly spawned out carcasses are consumed by scavengers.

Two of the 15 archival tags that were recorded passing the border RTS were not recovered. Archival tag # 3004 was never located although a member of the Little Salmon/Carmacks First Nation submitted the corresponding spaghetti tag. No information about catch location or time was provided. Since this tag was not detected during the aerial surveys it is assumed it was removed from the area or was rendered inoperative. Archival tag # 3058 was located in the Pelly River on the first survey but was not subsequently detected during later surveys. The fate of this archival tag remains unknown.

[7] Visual observation of spawning chinook was not attempted during most surveys. However spawning chinook were occasionally counted when readily apparent on definable redds.

The distribution of the archival tags was not consistent with the general radio tag dispersion. The tributaries with the largest number of radio tags did not also receive the largest number of archival tags. The upper Pelly River and the Klondike River both received more archival tags than would be expected from random dispersal. Examination of the tagging dates and dates these fish passed the border RTS do not suggest a cause for the non-random distribution other than as a result of the relatively small number or archival tags present in the Upper Yukon system. There is no reason to infer the distribution of the archival tags was the result of non-random factors other than coincidence.

4.10 Telemetry Based Population Estimate and Indices

The 2004 above border chinook population estimate derived from the telemetry data is dependent on several standard mark-recapture model assumptions. These assumptions are: 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 recoveries are representative of the population.

It is probable that assumption one is correct since the border RTS's combined with the aerial surveys were successful in recording all but one of the radio tags that crossed the border.

With regard to assumption two, there was no data from the project indicating that the distribution of radio tagged fish was not representative of the non-tagged chinook distribution. If radio tagged fish died in transit at a higher rate than untagged fish due to *Icthyophonus* or other diseases and/or stress induced from the handling and marking process, the population estimates would be biased high. However as noted above, there was no evidence of pre-spawn morbidity of the radio tagged fish or the presence of radio tagged fish in non-terminal areas. Further information from comparative DNA analysis of the tagged fish and stock specific baseline DNA would help corroborate this assumption.

Assumption three 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, as in 2003, the 2004 radio tag application matched well with the catch per unit effort (CPUE) data from Russian Mission near the tagging sites (JTC report, 2004). Therefore, although the radio tagged fish were not representative of the size and age class of the population, the tags were applied proportional to relative run strength.

Assumption four is difficult to verify and has the potential to bias the population estimate. Meaningful mark-recapture estimates require similar tag ratios among the sets

of recovery data used[8]. Data from three different assessment and recovery projects was used to obtain a combined tag proportion of 0.0042 (Table 12). The Blind Creek weir count provided the only tag proportion (0.0049) based on a whole population sample, however the total sample size (805) was relatively small. The commercial and test fishery count of 4,313 yielded a tagged proportion of 0.0057. The largest sample size (6,830) was from the aboriginal gill net fisheries. The tagged proportion from this sample (0.0032), was significantly lower than the other two (p=.0001, t=18.9, df = 48).

The above border chinook population estimate, based on the combined 2004 telemetry data is 65,894 (95% C.I. +/- 7,995). This is considerably higher than the 2004 preliminary population estimate of 47,000 (95% CI +/- 9,000) obtained from the spaghetti tagging mark-recapture program conducted by DFO (JTC 2004). The telemetry based population estimate may be biased high due to the tag recoveries and total catch reported in the aboriginal fisheries. Based on the higher number of unlocated tags within the mainstem Yukon River it is probable that the number of radio tags caught was under-reported. In addition some of the aboriginal fisheries catch figures lack rigor as they rely to an extent on anecdotal reporting. If the aboriginal catch figures are removed from the assessment data the telemetry based chinook salmon border escapement estimate is lowered to 50,121 (95% CI +/- 11,307). The radio tag based population indices listed in Appendix 2 were obtained using this population estimate (tagged:untagged ratio = 176) rather than the larger estimate (65,894) obtained from the combined catch data.

The DFO aerial index surveys on the Little Salmon, Big Salmon, and Nisutlin rivers yielded counts that were consistent with the population indices generated from the 2004 telemetry data. Using the surveys with maximum counts, the pooled aerial counts from the three systems totalled 2,232 (JTC 2004). Fourteen radio tags were located in the aerial survey areas yielding a ratio of one radio tag per 160 chinook based on the aerial survey counts. Under good viewing conditions, helicopter aerial surveys typically count approximately 50% of a spawning chinook population (Pahlke, 2003). However aerial survey counts may vary greatly depending on viewing conditions, observer, and fish densities. Using the telemetry based tagged/untagged ratio of 1/176 the 14 radio tags in the DFO surveyed index areas would yield a population index of 2,464. The pooled aerial count of 2,232 was 90% of the telemetry based population index of 2,464.

As occurred in the previous two years, the 2004 Yukon River telemetry study was successful in obtaining unique information on the distribution, run timing, and movements of Yukon River chinook salmon. Since Canadian origin 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. Sufficient numbers of fish were tagged and subsequently tracked to properly identify and make comparative assumptions of the primary components of the overall upper Yukon River escapements. Although actual tagged chinook numbers varied, the proportional distribution of radio tags throughout the upper

[8] Data from the Whitehorse Fishway was not used because this population is known to be non-representative due to the large number of small males (jacks) present in the returning hatchery produced fish (Pat Milligan DFO Whitehorse, Per. Comm.).

Yukon River system was relatively consistent over the three years the basin wide program operated. The information collected will continue to be useful for the management and conservation of basin-wide as well as specific chinook stocks. It will also contribute to the identification of future research requirements.

This report was prepared to provide a summary of the results of the 2004 aerial telemetry surveys; the last year of operation for the Yukon River basin wide chinook telemetry program. It is anticipated that a final peer reviewed report will be published that will consolidate and present all the results from all the 2002, 2003, and 2004 upper Yukon River chinook telemetry studies.

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Acknowledgements

The aerial telemetry survey project in the Canadian portion of the upper Yukon River watershed was just one component of the larger basin wide chinook telemetry program. The program was only made possible by the contribution of many individuals and government and non-government agencies in the U.S. and Canada. Funding for the program has come from several sources, including for this project, the Yukon River Restoration and Enhancement Fund. Of course it is not agencies that initiate, conduct, and report on programs such as these but the individuals that work within those agencies. Special acknowledgement is due to John Eiler of the National Marine Fisheries Service and Ted Spencer from the Alaska Department of Fish and Game for their roles in making this program possible. John Eiler has been particularly helpful to the Canadian aerial telemetry survey portion of the program by sharing his wealth of experience and providing in-season technical advice and data.

Several people contributed to the operational success of the 2004 upper Yukon River aerial telemetry survey project. Clive Osborne and Jane Wilson acted as observers and operated the telemetry receiving equipment during the aerial surveys. They, along with Ross Mercer also assisted with the retrieval of archival tags. Jake Duncan supervised the north mainstem Yukon River/Klondike aerial surveys and archival tag recovery and provided the data from that area for incorporation into this report. Pat Milligan of DFO Whitehorse helped collect the Big Salmon River archival tags and supplied editorial comment on the report. Tung Ho of DFO Whitehorse provided valuable assistance with the preparation of the maps.

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

Fishno	Lat	Long	Fate	Status
20	63.96795000	-138.46821000	Klondike River	
64	64.02577500	-138.56576333	North Klondike River	
85	64.29216167	-139.32027000	Klondike River	
109	64.13323500	-138.50779500	North Klondike River	
114	63.97644000	-138.40047000	Klondike River	
137	64.02001833	-138.09147833	Klondike River	
187	64.03173833	-138.56916000	North Klondike River	
210	63.96308167	-138.70069830	Klondike River	
220	63.54434667	-139.84195167	Sixty Mile River	
362	64.02053667	-137.78954000	Klondike River	
467	64.03063833	-137.93159833	Klondike River	
504	64.32142333	-140.13902670	North Mainstem Yukon	D
679	64.22495167	-139.58097667	North Mainstem Yukon	
554	63.91635833	-139.71142500	North Mainstem Yukon	
881			Not Located	
1034			Not Located	
3034	64.03770167	-139.19538500	Klondike River	
3055	63.96163833	-138.65973000	Klondike River	
3046	64.00598500	-138.16316830	Klondike River	D

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

Fishno	Lat	Long	Fate	Status
33	63.59371667	-137.28464667	McQuesten River	D
45	63.53631667	-135.17501167	Watson Creek	D
61	63.64379667	-136.96513000	McQuesten River	D
90	63.59667667	-137.27935500	McQuesten River	
95	63.57462000	-137.32299333	McQuesten River	
100	63.73855000	-136.59741667	McQuesten River	D
121	63.77442500	-136.54031500	McQuesten River	D
127	64.10817500	-134.36174833	Rackla River	D
182	63.45396667	-131.35616333	Emerald Creek	D
205	63.67443000	-136.70044333	McQuesten River	D
214			Not Located	
242	63.77738667	-136.53102000	McQuesten River	D
277			Not Located	
286	63.57307167	-137.33598167	McQuesten River	D
345	63.55596667	-137.39241000	McQuesten River	
366	63.60736167	-137.66263500	Stewart Mainstem	
379	63.60069667	-137.69788833	Stewart Mainstem	D
433			Not Located	
512	63.59207833	-135.90105167	Mayo River	D
536			Not Located	
621	63.63097333	-137.11348167	McQuesten River	
624	63.57285833	-137.36200000	McQuesten River	
806	63.55344667	-137.45319667	Stewart Mainstem	D
813	63.62170167	-135.92583667	Mayo River	D

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

Fishno	Lat	Long	Fate	Status
4			Caught	
5			Not Located	
9	62.77509833	-131.77142170	South Macmillan River	D
13	61.52569333	-130.83515500	Big Campbell Creek	D
48	62.27525833	-132.89718500	Blind Creek	D
52	63.04933000	-133.17332830	North Macmillan River	D
57			Not Located	
78			Caught	
80			Caught	
97	62.28993333	-132.79069170	Blind Creek	
103	62.57112667	-130.64482330	Prevost Creek	
120	62.25981333	-131.58480670	Ross River	
147	61.62625333	-131.70217830	Hoole River	
156			Caught	
174	62.84827167	-132.42108330	South Macmillan	
194	61.79208833	-131.81974170	Pelly River	
213	63.10393833	-135.20964830	Kalzas River	D
265			Caught	
228	62.41352333	-131.36773000	Ross River	
276	61.78001333	-131.13757500	Pelly River	D
288	61.78696167	-131.80065000	Pelly River	D
317	62.87665167	-132.63444500	South Macmillan River	
327	61.69738833	-131.10747670	Big Campbell Creek	D
333	61.81916833	-131.09082000	Pelly River	
336	62.83594833	-137.09268330	Pelly River	
347	62.82843667	-136.57632000	Pelly River	D
350	62.61164167	-134.46173330	Pelly River	D
357	63.12356667	-135.15827500	Kalzas River	
363			Caught	
380	62.81955500	-136.60164500	Pelly River	
389	62.60543167	-131.21289170	Ross River	
404	61.47832667	-131.50746330	Hoole River	
415	61.84955500	-132.06112000	Pelly River	D
480	62.92632000	-135.44423500	Kalzas River	D
487	62.26006667	-131.57582830	Ross River	
495	62.20109667	-133.15335000	Blind Creek	
516	62.28993667	-131.57759330	Ross River	
637	62.04829333	-132.70152170	Pelly River	D
655	62.04540833	-130.47944170	Outlet of Pelly Lakes	
658	62.17640833	-133.22433330	Pelly River	D
668	62.55709167	-131.03607330	Prevost Creek	
829	62.19693900	-133.17480500	Caught	D
1024	62.45728500	-133.94750170	Anvil Creek	D
3008	62.79302167	-131.86485000	South Macmillan River	D
3010	62.07978500	-132.80722670	Pelly River	D
3019	62.15541167	-133.09879170	Pelly River	D
3058	61.80979500	-132.00826830	Pelly River	D

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

Fish No.	Lat.	Long.	Fate	Status
117	62.39709500	-139.30877000	Nisling River	
125	62.66286333	-140.04588330	White River	
128	62.41210000	-139.34211500	Nisling River	
183	63.04785333	-140.33065500	White River	D
232	62.25897000	-139.12388500	Nisling River	D
292	61.92336667	-139.85727330	Donjek river	
300	62.41956833	-139.36084330	Nisling River	D
307	62.35303667	-139.18622670	Nisling River	
405	62.45479167	-139.46608170	Nisling River	
408	62.71742500	-140.04684833	White River	D
506	61.87463000	-139.34269330	Tincup Creek	D
3001	62.99248833	-140.26257833	White River	

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

Fish no.	Lat.	Long.	Fate	Status
22			Not Located	
34	61.76000333	-136.03377000	Nordenskiold River	
36			Caught in Fishery	D
172	62.23492333	-135.10631000	Little Salmon river	
219	60.75567000	-135.06502170	Mainstem Yukon River	
181			Caught in Fishery	
192			Not Located	
252	62.37519333	-136.51486833	Mainstem Yukon River	
258	62.06826167	-135.35675000	Little Salmon river	D
264	61.92835833	-135.08022500	Mainstem Yukon River	
318			Not Located	
364	61.75608833	-136.04050500	Nordenskiold River	
384	62.04522167	-135.93481500	Mainstem Yukon River	D
399	62.55987667	-136.82851670	Mainstem Yukon River	
400	62.05333667	-135.43982330	Little Salmon river	D
432	62.40555833	-136.61742000	Mainstem Yukon River	
438	62.57178333	-136.85904000	Mainstem Yukon River	
439			Not Located	
441	62.70859333	-137.24090000	Mainstem Yukon River	
449	61.99507667	-135.45567167	Mainstem Yukon River	
465	62.61248000	-136.98922500	Mainstem Yukon River	
472	62.47262833	-136.70721170	Mainstem Yukon River	D
475	62.08394000	-136.04414670	Mainstem Yukon River	
484	62.44899667	-136.67591000	Mainstem Yukon River	
513	62.28247000	-136.25289833	Tatchun Creek	
515			Caught in Fishery	
528	61.91179833	-134.94056830	Mainstem Yukon River	
552	62.18971000	-136.34915833	Mainstem Yukon River	
554	62.98092000	-139.36988500	Mainstem Yukon River	
560	62.35567667	-136.47769500	Mainstem Yukon River	
564	62.07443833	-135.45143833	Little Salmon river	
565	62.46499833	-136.70328833	Mainstem Yukon River	
603	61.89634000	-134.92806830	Mainstem Yukon River	
604	62.27992833	-136.28205167	Tatchun Creek	
615	62.80333667	-138.24663170	Mainstem Yukon River	
634	62.67011167	-137.12927330	Mainstem Yukon River	
639	62.90279667	-139.04504000	Mainstem Yukon River	
649	61.90818500	-134.93550000	Mainstem Yukon River	
654	61.78440000	-134.97992670	Mainstem Yukon River	
659			Caught in fishery	
662	63.14351167	-139.55505830	Mainstem Yukon River	
673	62.50798667	-136.76609333	Mainstem Yukon River	
676			Caught in Fishery	D
678	61.88553833	-134.92615330	Mainstem Yukon River	D
680	62.80014000	-137.43817330	Mainstem Yukon River	D
683	62.10286000	-135.25674330	Little Salmon river	

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

Fish no.	Lat.	Long.	Fate	Status
816	62.80894000	-138.12963670	Mainstem Yukon River	
854	61.93961000	-135.16488170	Mainstem Yukon River	
855	62.81811167	-137.71910000	Mainstem Yukon River	D
860	62.28215500	-136.26265670	Tatchun Creek	
899	62.97763333	-139.34719000	Mainstem Yukon River	D
911	62.92580000	-139.19129333	Mainstem Yukon River	
920	62.80898833	-137.78150167	Mainstem Yukon River	
922			Caught in Fishery	
928	61.62546500	-134.85183830	Mainstem Yukon River	D
935	62.98565333	-139.39904830	Mainstem Yukon River	D
949	62.80630500	-138.13032667	Mainstem Yukon River	
958	62.35198500	-136.45629167	Mainstem Yukon River	
966	62.91611000	-139.14011330	Mainstem Yukon River	
1007	61.55520833	-134.87007333	Mainstem Yukon River	
3004			Not Located	

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

Fish No.	Lat.	Long.	Fate	Status
30	61.33306500	-133.34083667	Big Salmon River	D
87			Not Located	
93	61.55637167	-133.60066000	Big Salmon River	
129	61.61402167	-133.73011000	Big Salmon River	D
239	61.58436667	-134.34181667	Big Salmon River	
244	61.85727333	-134.03563667	North Big Salmon River	
245	61.49484667	-133.51914167	Big Salmon River	
298	61.72181333	-134.55878833	Big Salmon River	D
305	61.56801500	-133.58932333	Big Salmon River	
312	61.85386833	-134.12826667	North Big Salmon River	
352	61.59239000	-133.68387167	Big Salmon River	
359	61.33645833	-133.34451500	Big Salmon River	
371	61.53355667	-133.96744667	Big Salmon River	
401	61.69097000	-134.51808833	Big Salmon River	D
431	61.66980000	-134.51403833	Big Salmon River	D
440	61.80889500	-133.90216167	North Big Salmon River	D
473	61.57291500	-133.63145500	Big Salmon River	D
496	61.68452167	-134.51290333	Big Salmon River	
617	61.54743833	-134.17611500	Big Salmon River	
638	61.80225000	-134.23253833	North Big Salmon River	
640	61.61934000	-133.77137500	Big Salmon River	
652	61.55701500	-133.59932333	Big Salmon River	D
684			Not Located	
3013	61.86068000	-134.07564900	North Big Salmon River	
3041	61.59666667	-134.35181667	Big Salmon River	

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

Fish No.	Lat.	Long.	Fate	Status
24	61.19181500	-132.94353667	Nisutlin River	D
29	61.02556000	-132.84911833	100 Mile Creek	
42	60.99822167	-132.79340333	100 Mile Creek	
75			Caught in Fishery	
168	61.02282333	-132.82050333	100 Mile Creek	D
233	60.91470333	-134.02141333	Mainstem Teslin River	
246	60.89399667	-132.97805500	Mainstem Teslin River	D
254	59.80857500	-132.27957667	Teslin Lake	
263	60.87086167	-133.95180667	Mainstem Teslin River	
337	60.73473667	-133.70296167	Mainstem Teslin River	
339	60.72862167	-133.69541333	Mainstem Teslin River	
340	60.84302833	-133.90273333	Mainstem Teslin River	
381	60.83226833	-133.88579833	Mainstem Teslin River	
388	59.47801667	-131.60731830	Jennings Lake	
407			Not Located	
417			Caught in Fishery	
428	60.80720500	-133.84953000	Mainstem Teslin River	D
457	60.75324667	-132.95830500	Nisutlin River	D
491	61.25468167	-134.60790333	Mainstem Teslin River	
493	60.57856000	-133.48118833	Mainstem Teslin River	D
499	60.64245333	-132.78191000	Nisutlin River	D
507	60.81166833	-133.84902167	Mainstem Teslin River	
544	61.16014000	-134.38634000	Mainstem Teslin River	
622			Caught in Fishery	
631	60.72441333	-133.68883000	Mainstem Teslin River	
632	60.89449167	-133.98771833	Mainstem Teslin River	D
633	60.97928167	-132.93080500	Nisutlin River	D
635	60.97845833	-134.11190500	Mainstem Teslin River	
656	60.03926500	-132.31985500	Morley River	D
661	61.01372667	-134.16128500	Mainstem Teslin River	D
663	60.98038167	-134.12256333	Mainstem Teslin River	
670	60.86102000	-133.93625000	Mainstem Teslin River	
675	60.60335333	-133.51617500	Mainstem Teslin River	D
682	60.81489167	-133.85518000	Mainstem Teslin River	
690	60.77842333	-133.78162333	Mainstem Teslin River	D
693			Caught in Fishery	
810	61.24931667	-134.60664833	Mainstem Teslin River	D
826	60.48680333	-132.28443500	Wolf River	D
827	61.12678000	-134.33382167	Mainstem Teslin River	D
853	60.77602167	-133.77667000	Mainstem Teslin River	
857	60.77178833	-133.76645000	Mainstem Teslin River	
866	61.14980333	-134.36644000	Mainstem Teslin River	D
893	60.85892833	-133.93077500	Mainstem Teslin River	
933	60.46961667	-133.26967833	Mainstem Teslin River	
941	61.11639833	-134.30707500	Mainstem Teslin River	
977	60.89715500	-133.98450833	Mainstem Teslin River	
1013	61.13692667	-134.35499667	Mainstem Teslin River	D
3037	60.74244167	-132.09960000	Wolf River	
3039	60.99324000	-134.15043333	Mainstem Teslin River	

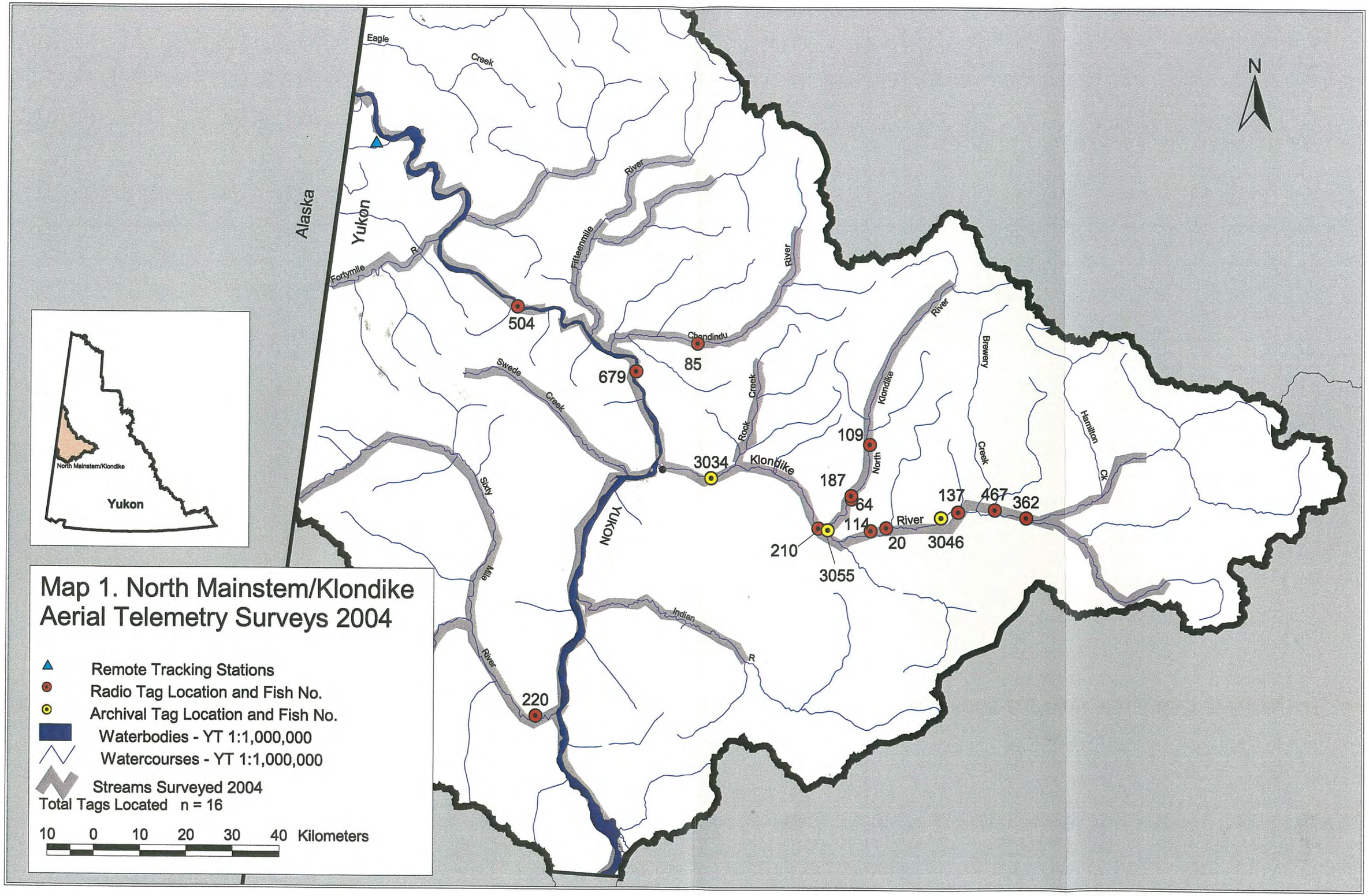
Appendix 1-h. Terminal location and fate of radio tags in the south Yukon River watershed.

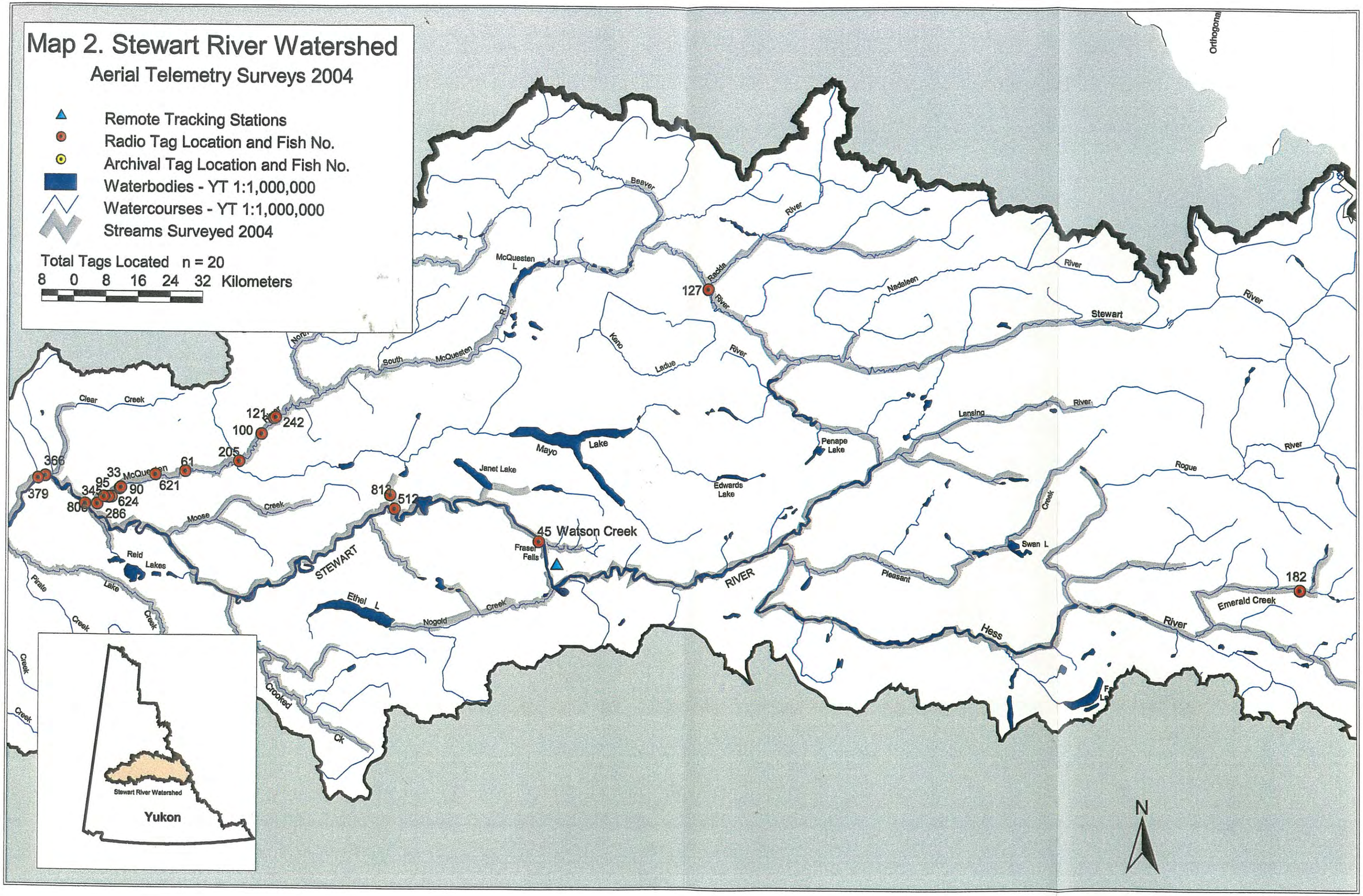
Fish No.	Lat.	Long.	Fate	Status
219	60.75567000	-135.06502170	South Yukon River	
355	60.72074833	-136.03206830	Takhini River	
435	60.79725333	-135.92466500	Takhini River	
456	60.75452500	-135.07812330	South Yukon River	
614	60.72941833	-135.04308670	South Yukon River	D
646	61.56069167	-134.97449670	South Yukon River	
665			Whitehorse Fishway	
672	61.39800833	-135.21475000	South Yukon River	
805	60.74204667	-135.05499670	South Yukon River	
834	60.64851333	-136.10077000	Takhini River	D
869	60.84054667	-135.74222000	Takhini River	D
871	61.51265667	-135.13193500	South Yukon River	
873	60.69311833	-136.06151167	Takhini River	
3034			Whitehorse Fishway	

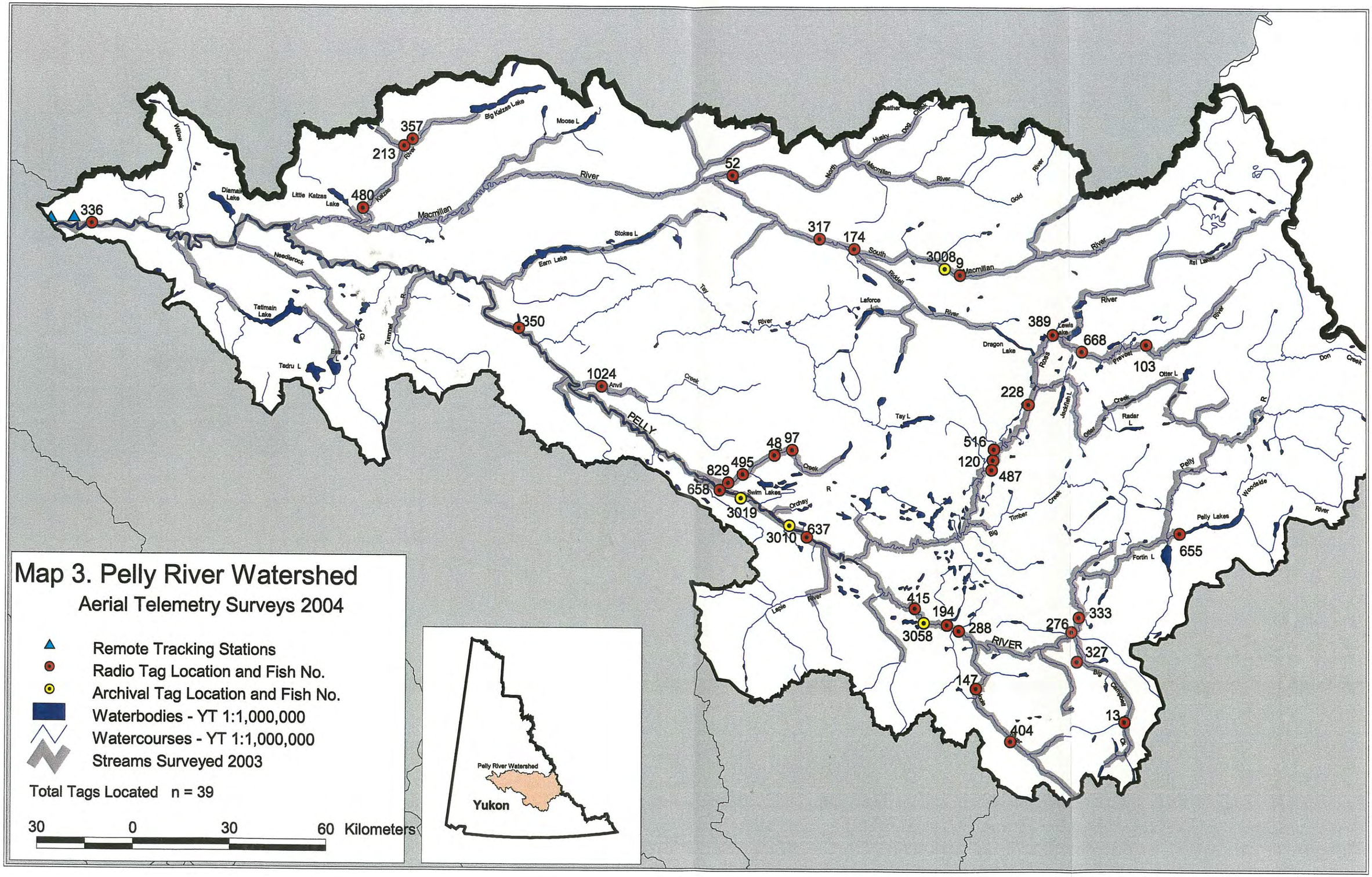
Appendix 2. Radio tag count and corresponding 2004 chinook population indices.

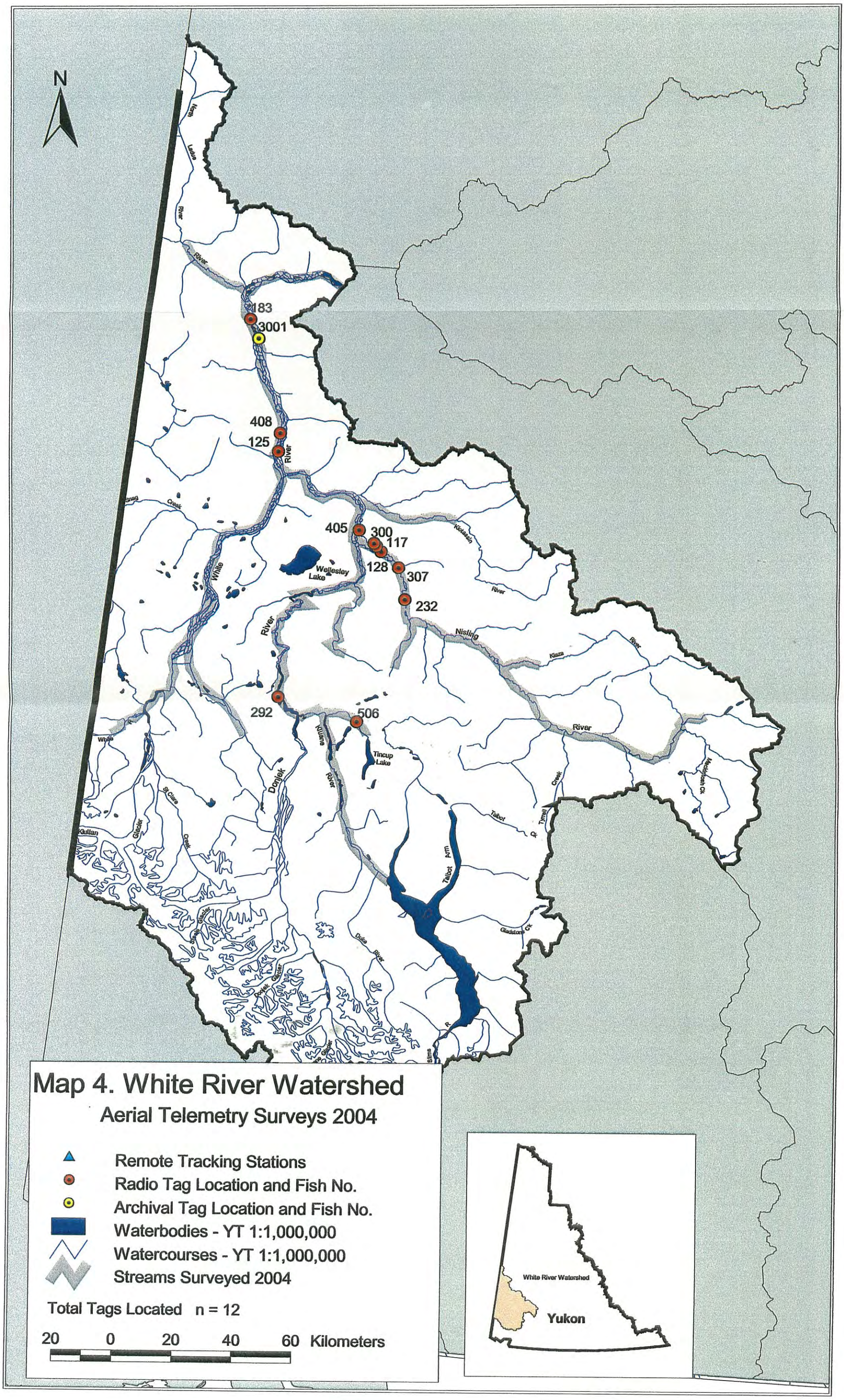
Number of Radio Tags	Population Index	Number of Radio Tags	Population Index	Number of Radio Tags	Population Index	Number of Radio Tags	Population Index
1	176	25	4576	49	8,976	75	13,376
2	352	26	4752	51	9,152	76	13,552
3	528	27	4928	52	9,328	77	13,728
4	704	28	5104	53	9,504	78	13,904
5	880	29	5280	54	9,680	79	14,080
6	1056	30	5456	55	9,856	80	14,256
7	1232	31	5632	56	10,032	81	14,432
8	1408	32	5808	57	10,208	82	14,608
9	1584	33	5984	58	10,384	83	14,784
10	1760	34	6160	59	10,560	84	14,960
11	1936	35	6336	60	10,736	85	15,136
12	2112	36	6512	61	10,912	86	15,312
13	2288	37	6688	62	11,088	87	15,488
14	2464	38	6864	63	11,264	88	15,664
15	2640	39	7040	64	11,440	89	15,840
16	2816	40	7216	65	11,616	90	16,016
17	2992	41	7392	66	11,792	91	16,192
18	3168	42	7568	67	11,968	92	16,368
19	3344	43	7744	68	12,144	93	16,544
20	3520	44	7920	69	12,320	94	16,720
21	3696	45	8096	70	12,496	95	16,896
22	3872	46	8272	71	12,672	96	17,072
23	4048	47	8448	72	12,848	97	17,248
24	4224	48	8624	73	13,024	98	17,424
25	4400	49	8800	74	13,200	99	17,662

MAPS

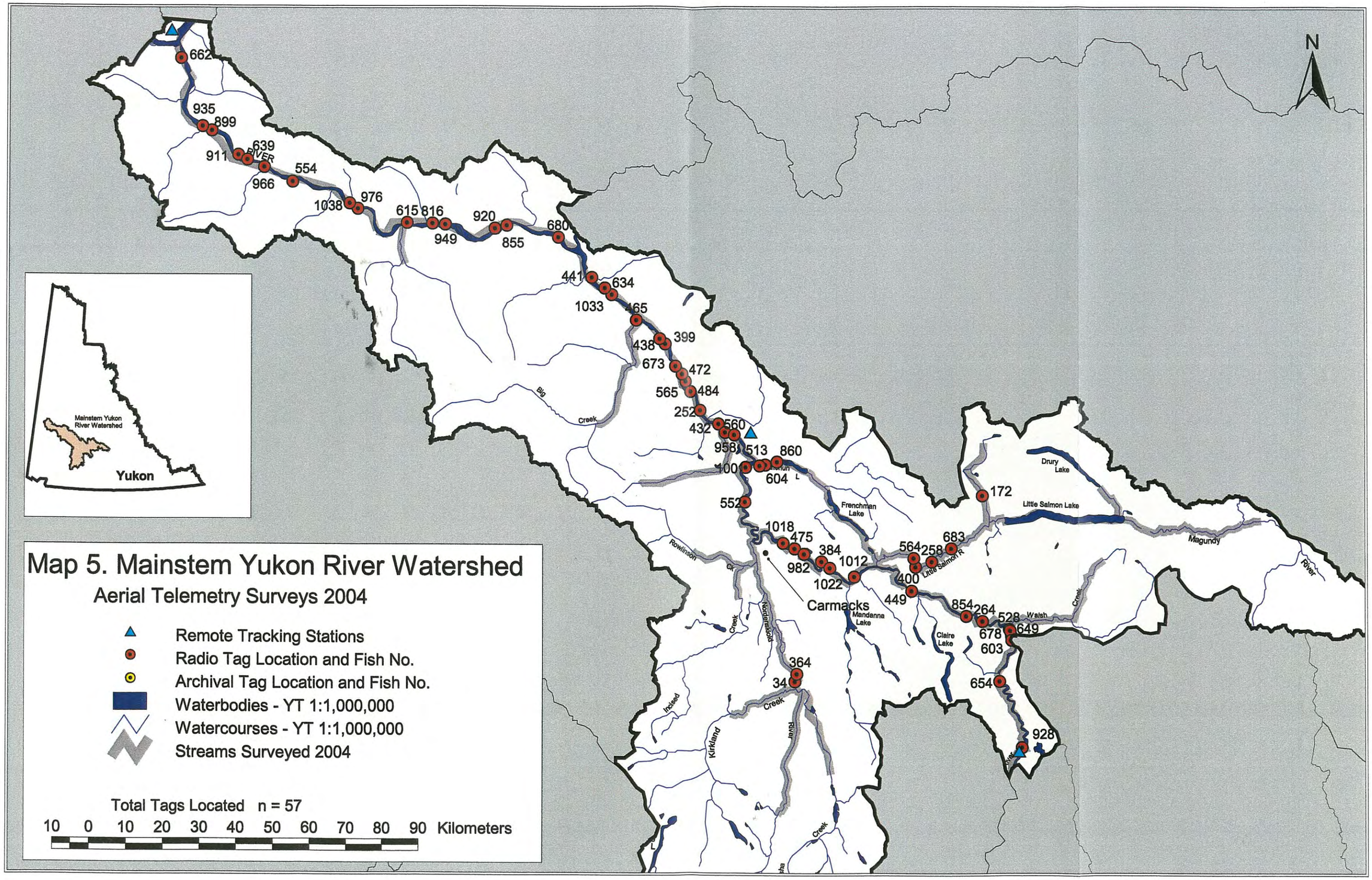

Map 1. North Mainstem/Klondike
Aerial Telemetry Surveys 2004
Remote Tracking Stations
Radio Tag Location and Fish No.
Archival Tag Location and Fish No.
Waterbodies - YT 1:1,000,000
Watercourses - YT 1:1,000,000
Streams Surveyed 2004
Total Tags Located n = 16
10 0 10 20 30 40 Kilometers
N
Alaska
Yukon
North Mainstem/Klondike
Yukon
Eagle
Creek
Fortymile
R
Fifteenmile
River
Chandindu
Swede
Creek
Sixty
Mile
River
Rock
Creek
Klondike
River
Brewery
Creek
Hamilton
Ck
North
Klondike
River
YUKON
Indian
R
504
679
85
3034
109
187
64
114
20
210
3055
137
3046
467
362
220


Map 2. Stewart River Watershed
Aerial Telemetry Surveys 2004
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 2004
Total Tags Located n = 20
8 0 8 16 24 32 Kilometers
Orthogonal
Beaver
River
McQuesten L
Rackla
River
127
Nadaleen
River
Stewart
River
Keno
Ladue
River
South
McQuesten
Clear
Creek
121
242
100
205
61
621
366
379
33
95
345
90
624
806
286
McQuesten
Moose
Creek
Reid
Lakes
Pirate
Lake
Creek
Creek
Creek
Creek
Mayo
Lake
Janet Lake
Edwards Lake
Penape Lake
Lansing
River
Rogue
River
Creek
Swan L
Pleasant
Hess
River
Emerald Creek
182
45 Watson Creek
Fraser Falls
STEWART
RIVER
Ethel L
Nogold
Creek
Crooked
Ck
Stewart River Watershed
Yukon
N

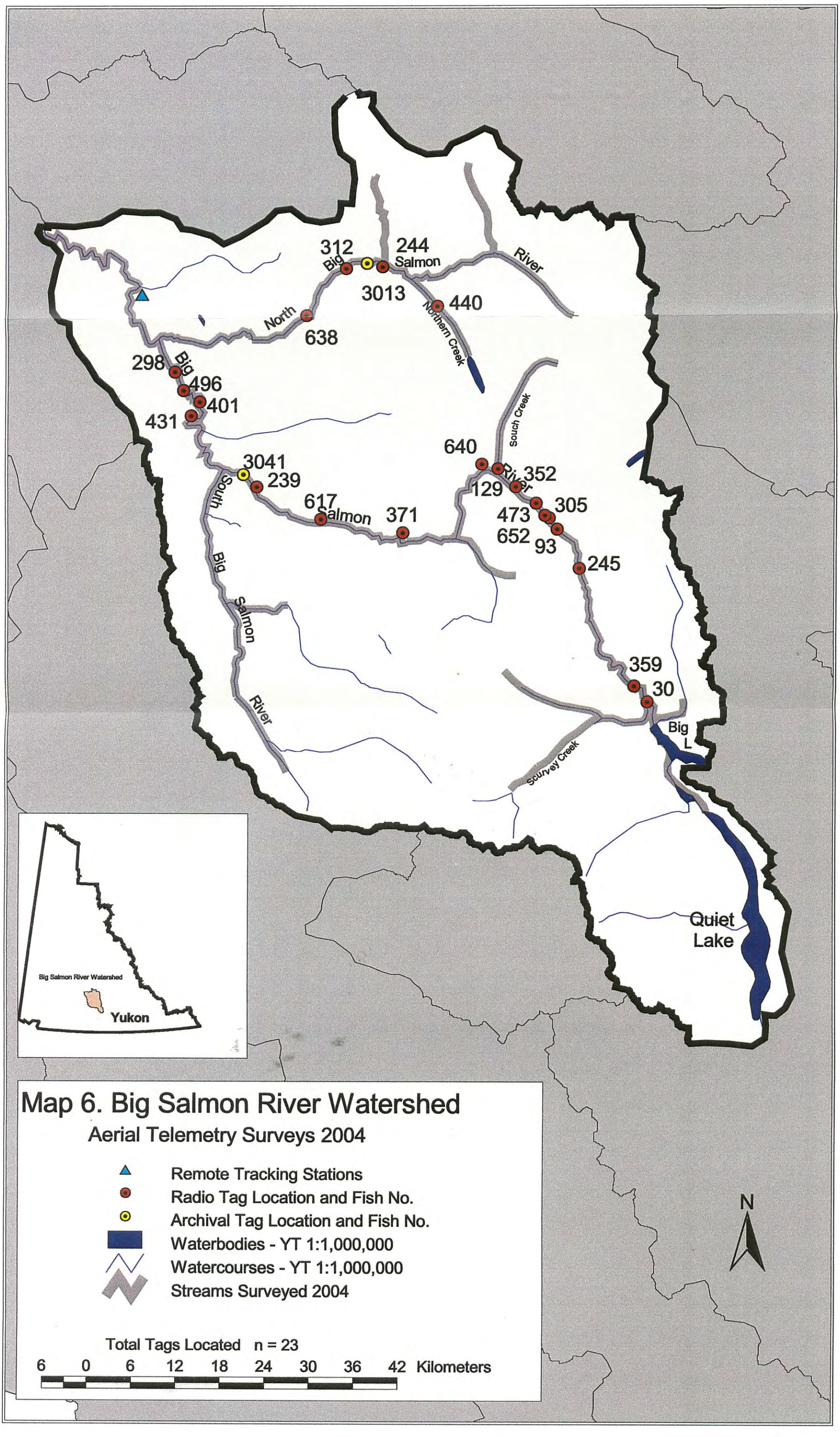

Map 3. Pelly River Watershed
Aerial Telemetry Surveys 2004
Remote Tracking Stations
Radio Tag Location and Fish No.
Archival Tag Location and Fish No.
Waterbodies - YT 1:1,000,000
Watercourses - YT 1:1,000,000
Streams Surveyed 2003
Total Tags Located n = 39
30 0 30 60 Kilometers
Pelly River Watershed
Yukon
336
357
213
480
52
317
174
3008
9
350
1024
389
668
103
228
516
120
487
48
97
829
495
658
3019
3010
637
655
415
194
3058
288
276
333
327
147
404
13
Big Kalzas Lake
Moose L
Diamond Lake
Little Kalzas Lake
Macmillan
River
Stokes L
Earn Lake
Needlerock
Tatlmain Lake
Tadru L
Laforce L
Dragon Lake
Lewis Lake
Tay L
Otter L
Radar L
Swim Lakes
Pelly Lakes
Fortin L
PELLY
RIVER



Map 4. White River Watershed
Aerial Telemetry Surveys 2004

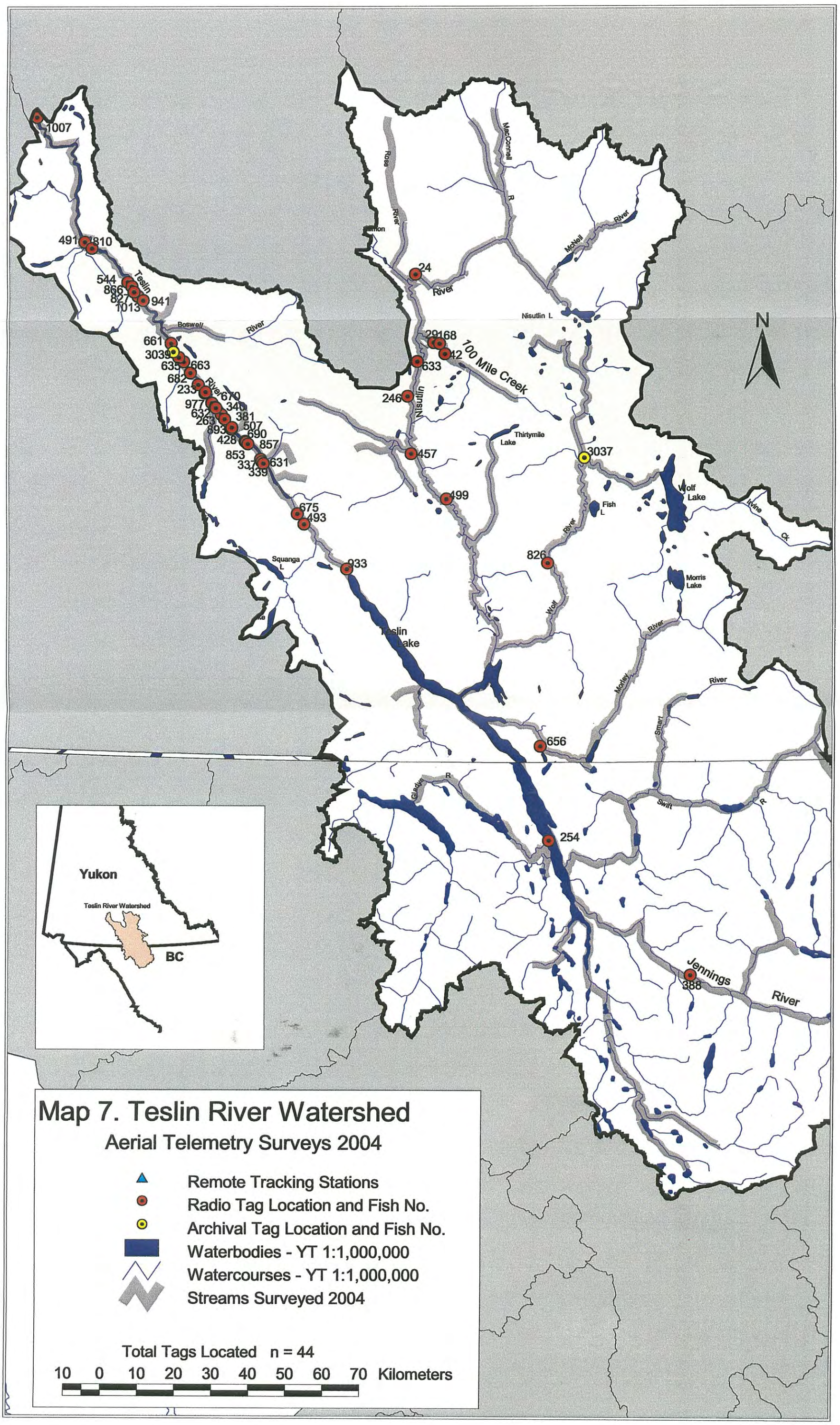


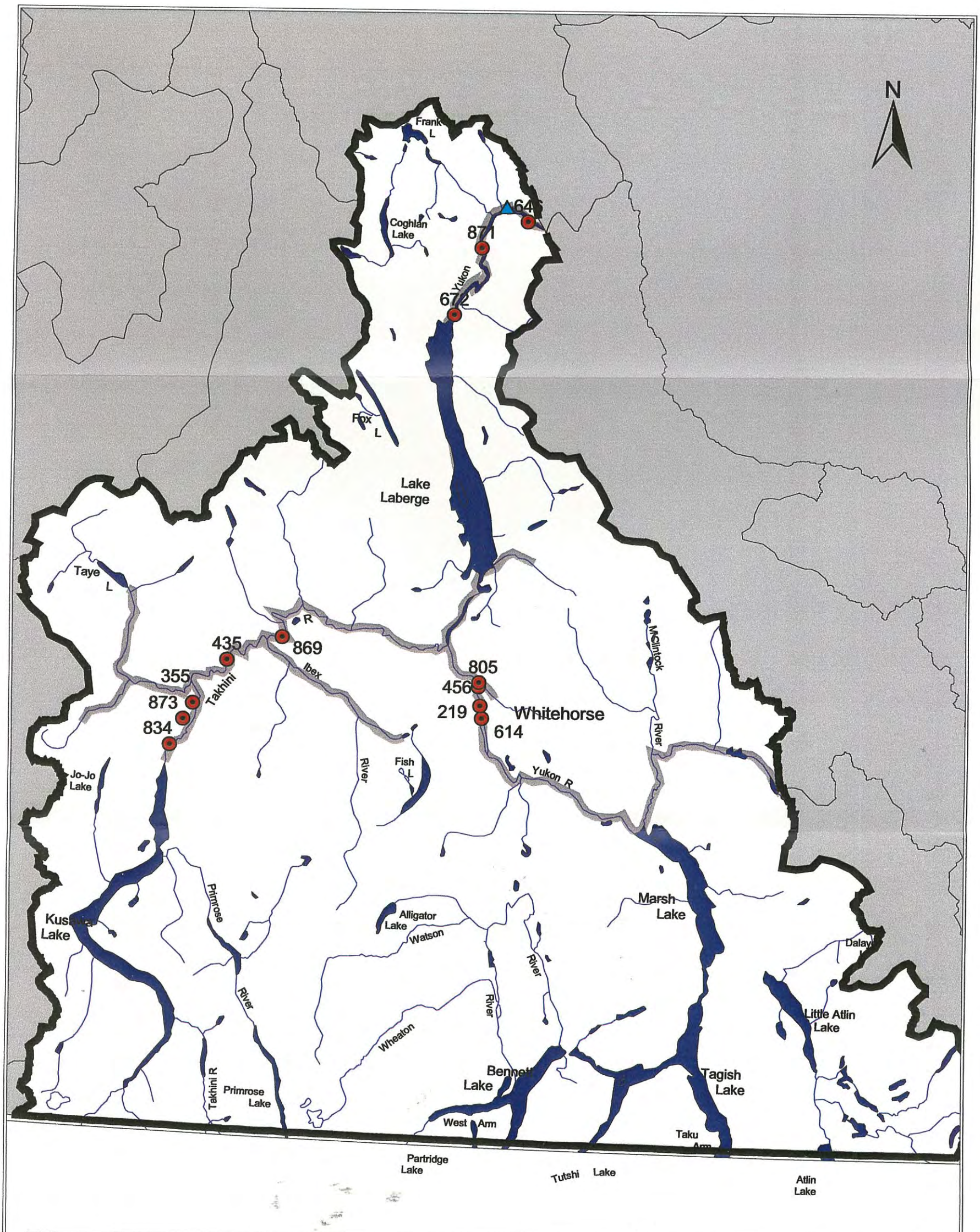
Map 5. Mainstem Yukon River Watershed
Aerial Telemetry Surveys 2004
Remote Tracking Stations
Radio Tag Location and Fish No.
Archival Tag Location and Fish No.
Waterbodies - YT 1:1,000,000
Watercourses - YT 1:1,000,000
Streams Surveyed 2004
Total Tags Located n = 57
10 0 10 20 30 40 50 60 70 80 90 Kilometers
Mainstem Yukon River Watershed
Yukon
N
Carmacks
Big Creek
Frenchman Lake
Drury Lake
Little Salmon Lake
Little Salmon R
Mandanna Lake
Claire Lake
Rowlinson Ck
Nordenskiold
Kirkland Creek
Incised Creek
Walsh Creek
Magundy River
662
935
899
639
911
966
554
1038
976
615
816
949
920
855
680
441
634
1033
465
438
399
673
472
565
484
252
432
560
958
513
860
100
604
552
1018
475
384
982
1012
1022
564
258
683
400
449
854
264
528
649
678
603
654
928
172
364
34



Map 6. Big Salmon River Watershed

Aerial Telemetry Surveys 2004

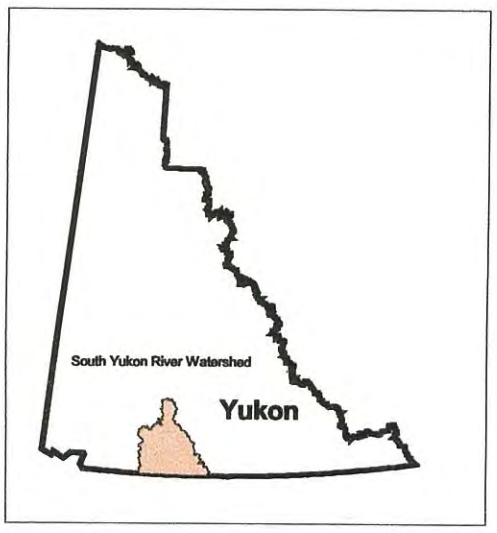

Map 7. Teslin River Watershed
Aerial Telemetry Surveys 2004
Remote Tracking Stations
Radio Tag Location and Fish No.
Archival Tag Location and Fish No.
Waterbodies - YT 1:1,000,000
Watercourses - YT 1:1,000,000
Streams Surveyed 2004
Total Tags Located n = 44
10 0 10 20 30 40 50 60 70 Kilometers
Yukon
Teslin River Watershed
BC
N
Teslin River
Boswell River
Nisutlin River
100 Mile Creek
Thirtymile Lake
Wolf Lake
Fish L
Morris Lake
Squanga L
Teslin Lake
Nisutlin L
Jennings River
Swift R
Smart River
Morley River
Wolf River
McNeil River
MacConnell R
Ross River
Gladys R
Ivine Ck
1007
491
810
544
866
827
1013
941
661
3039
635
663
682
235
670
977
340
632
381
263
507
893
690
428
857
853
337
631
339
675
493
933
24
29
168
42
633
246
457
499
826
656
254
388
3037



Map 8. South Yukon River Watershed

Aerial Telemetry Surveys 2004

- 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 2004

Total Tags Located n = 12

10 0 10 20 30 40 50 60 70 Kilometers