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Assessing the Origin of Bull Trout Spawners in the Misinchinka River and the River's Potential as a Redd Count Index System: 2004 and 2005 Radiotelemetry Results.

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ABSTRACT

The creation of Williston Reservoir affected historic bull trout (*Salvelinus confluentus*) populations that existed in the Peace, Parsnip, and Finlay rivers prior to impoundment in 1968. The present status of bull trout populations in Williston Reservoir is unknown. Redd count surveys of indexed locations in representative rivers are proposed as a methodology to determine trends in Williston Reservoir's bull trout population. This two-year study will (1) determine if the bull trout spawning population in the Misinchinka River (central British Columbia, Canada) is adfluvial or fluvial and (2) indicate the suitability of the Misinchinka River as a long-term, annual redd count index site to detect trends in Williston Reservoir's bull trout population. Bull trout were captured by angling in the Misinchinka River, anaesthetised, and surgically implanted with Lotek MCFT-3A radio tags. A fixed radiotelemetry receiver (base) station was established on the Parsnip River to log post-spawn migration of fish to Williston Reservoir. Telemetry flights to determine bull trout locations were conducted by helicopter, and locations of radio-tagged fish were recorded and logged with a Garmin global positioning system (GPS) unit in conjunction with a Lotek SRX 400 telemetry receiver. Aerial and ground-based surveys combined with telemetry data were used to identify a potentially suitable redd count index site. In 2004 and 2005, reconnaissance surveys were conducted to assess spawning habitat potential and the presence of bull trout redds. Aerial surveys (to locate redds) conducted with a helicopter were followed with ground surveys. Redd locations were geo-referenced, and associated channel characteristics, such as proximity to cover and local morphology, were noted. Shed and malfunctioning tags coupled with predation of tagged bull trout reduced the useable data to 6 of 15 tags in 2005, and 10 of 14 tags in 2006. In 2004, 83% (n=5) of tagged bull trout were adfluvial, while in 2005, 100% (n=10) of tagged bull trout were adfluvial. Based on telemetry data, the majority of fish captured in the Misinchinka River were adfluvial. There is some indication that at least a few fluvial bull trout from Parsnip River spawn in the Misinchinka River. Based on two years of ground and aerial survey results, we recommend that the Misinchinka River is suitable for inclusion in a long-term monitoring program to detect trends in Williston Reservoir's bull trout populations.

INTRODUCTION

Background and Scope

Bull trout are a char endemic to western North America (McPhail and Baxter 1995), and their population numbers are declining throughout their range. Bull trout are identified by the B.C. Conservation Data Centre as "blue listed," meaning the species is of "special concern" and is particularly sensitive to the effects of human activities and natural events that result in habitat fragmentation, degradation, and inter-specific competition with introduced fish species (McPhail and Baxter 1996, BC Species and Ecosystems Explorer 2003).

The status of Williston Reservoir's bull trout populations is uncertain and even crude population estimates do not exist. Gill netting surveys (Barrett and Halsey 1985, Blackman 1992, Pillipow and Langston 2002) and hydroacoustic surveys (Johnson and Yesaki 1989, Sebastian et al. 2003) have either captured bull trout or reported their presence in Williston Reservoir; however, it has not been possible to determine bull trout population size or trends in population size.

The lack of a species-specific population estimate for bull trout is directly attributable to the size and complexity of the reservoir, coupled with bull trout propensity for vast and sometimes varied annual migrations. A method is required to establish trends in Williston Reservoir's bull trout population without the prohibitive cost and potentially impossible logistical task of developing a population estimate for the entire reservoir.

We propose redd count surveys of indexed locations of representative rivers, as described by Bonar et al. (1997) and Rieman and Myers (1997), as a methodology to estimate bull trout populations. These studies suggest that multi-year (10+ yr) redd counts have the ability to accurately reflect population trends. We hypothesized that trend data (based on annual redd count surveys) can then be used to determine if protection or management plans are achieving desirable results, if changes are required, and which enhancement plans may be beneficial. Further, trend data may also be used to evaluate the effects of protection measures and habitat enhancement projects undertaken on Williston Reservoir tributaries.

Study Objectives

The primary objective of this two-year (2004 and 2005) project is to use radiotelemetry methods to determine if the bull trout spawning population in the Misinchinka River is adfluvial (returning to Williston Reservoir post spawn), fluvial (remaining in Misinchinka or Parsnip rivers post spawn), or a combination of both life forms. We anticipate gathering additional information about migration timing and duration, biological parameters, spawning locations, and annual site fidelity of Misinchinka bull trout. The information will indicate the suitability of the Misinchinka River as a long-term, annual redd count index site to detect trends in Williston Reservoir's bull trout population. Recommendations will be presented on the suitability of the Misinchinka River as an index site, methodologies to be used, and locations to examine on an annual or biannual basis.

Description of Study Area

The Misinchinka River (56° 06' N latitude, 122° 56' W longitude), located 30 km southeast of Mackenzie BC, is a fourth-order stream with a drainage area of 595 km^2 (Figure 1). The river drains the western slope of the Rocky Mountain Misinchinka Ranges from an elevation of approximately 5,000 m and flows west for 100 km to join the Parsnip River at an elevation near 2,500 m. The water then flows approximately 40 km northwest to Williston Reservoir.

Access

The lower 50 km of the Misinchinka River is accessible in numerous locations by highway, gravel road, and rail bed. Deactivation of the timber extraction road and removal of the bridge crossing near Bijoux Creek in the late 1980's has reduced access to the upper half of the river to occasional entry by all-terrain vehicles, snowmobiles, horses, and hiking.

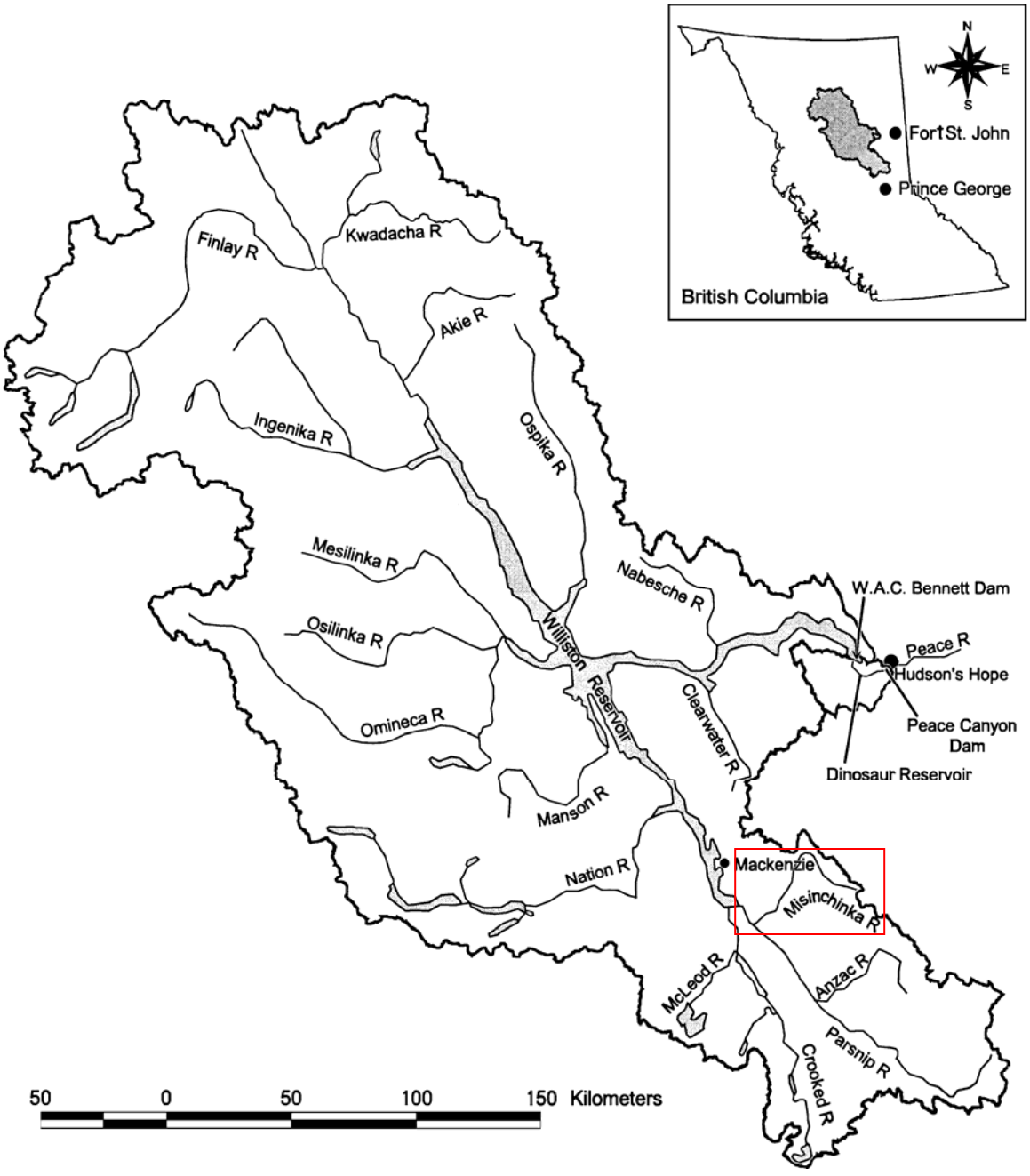

Figure 1. Williston and Dinosaur Reservoir watersheds. Red box indicates study area.

METHODS

Fish Capture

Bull trout were captured by angling during the period deemed most likely for these fish to be congregating or "staging" (mid-July to early September) before spawning (McPhail and Baxter 1996). Angling gear and effort were biased to increase the probability of selecting for body size that ensures tag mass is no more than 1 – 2% of a fishes body mass as identified by Marty and Summerfelt (1986) and Winter (1996). All capture locations were accessed by helicopter (Figure 2). Typically, sexual dimorphism is exhibited strongly in bull trout, allowing for visual sex determination. In addition, bull trout fork length and mass were recorded, and the leading edge of the pectoral fin was clipped as close to the base as possible and retained for age determination. Otoliths were collected from bull trout mortalities for age determination.

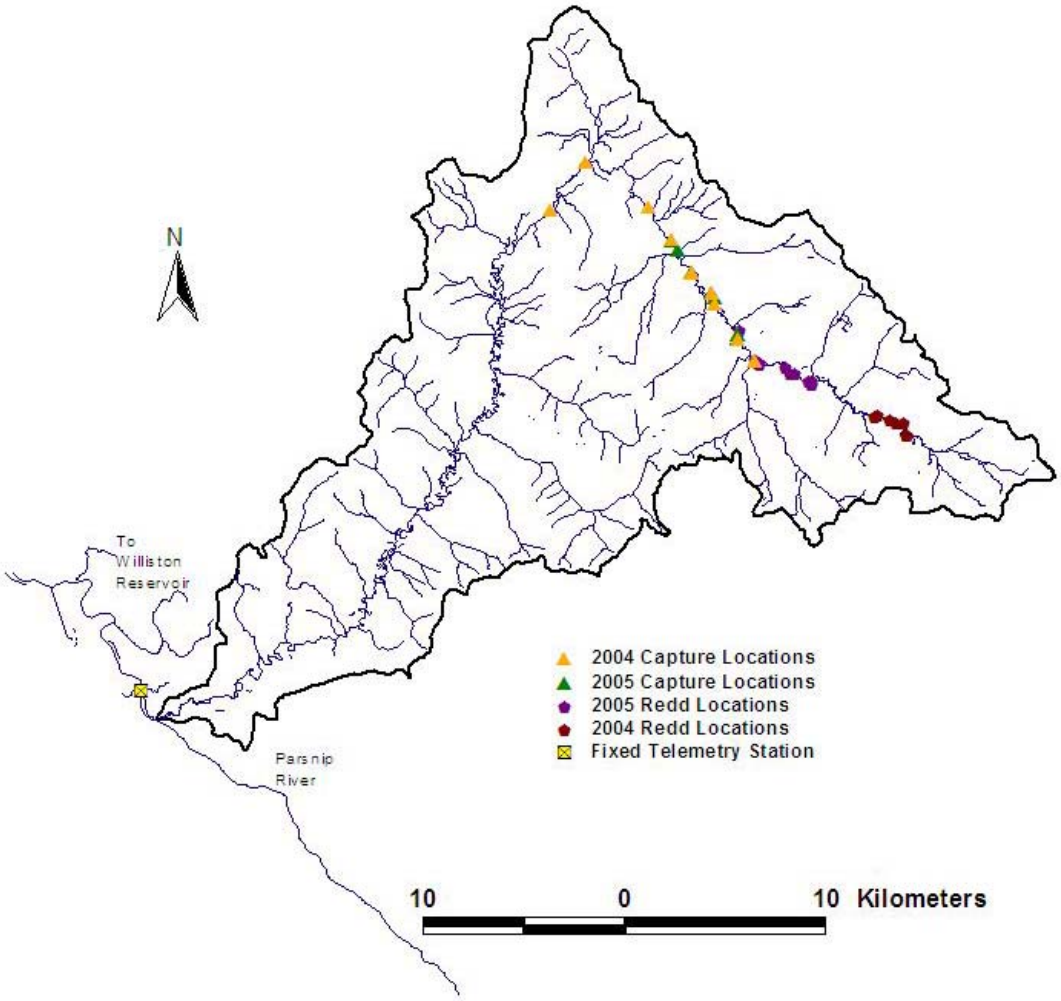

Figure 2. The Misinchinka River bull trout telemetry project area, including capture locations, redd locations, and the fixed telemetry base station location

Prior to surgery to implant the radiotelemetry tags, captured fish were anaesthetized in river water with a 40 ppm clove oil/ethanol solution, as described in Anderson et al. (1997) and Blackman (2002). Surgical implements and equipment were sterilized with a solution of distilled water and Chemisol™. The surgical procedure involved making a 2–3-cm ventral, medial incision anterior to the pelvic girdle and inserting a hollow 14-gauge hypodermic needle through the left abdominal wall

approximately 1–2 cm posterior to the pelvic girdle and slightly dorsal to the mid-ventral line. A sterilized Lotek MCFT-3A digitally coded transmitter (Table 1) was inserted through the ventral incision, leaving the 400-mm antenna to protrude from the fish's side. The incision was closed with three or four interrupted sutures, and surgical wounds were sterilized with Betadine.

Table 1. Lotek digitally coded transmitter specifications.

Model #	Dimensions (mm)	Air weight (g)	Water weight (g)	Pulse (secs)	Battery expectancy (days)
MCFT-3A	16 × 46	16.0	6.7	5	761

In 2004, radio-tagged bull trout also received passive integrated transponder (PIT) tags and a 5-cm-long numbered "t-bar" tag (Floy tag). PIT tags were inserted into the cheek flesh, while Floy tags were attached immediately below the posterior insertion of the dorsal fin to ensure the tag was anchored between subcutaneous fin rays. Fish captured in 2005 did not have PIT tags inserted, but they did receive t-bar Floy tags.

In 2005, larger male bull trout were selected for radio tag insertion whenever possible because of concerns that female fish may expel tags in the process of spawning.

Radiotelemetry

A fixed radiotelemetry receiver (base) station was set up on the left bank of the Parsnip River between the Misinchinka River confluence and Williston Reservoir (Figure 2). The base station was equipped with a Lotek SRX 400 telemetry receiver and a four-element Yagi-Uda antenna positioned vertically (perpendicular to the horizon) and oriented 45 degrees upstream of river flow direction.

The base station receiver was programmed to continually monitor radio tag frequencies at 6-second intervals and log contacts made with tagged fish as they passed by the base station. Contacts were taken to represent post-spawn bull trout emigrating out of the Misinchinka system, presumably to over-winter in Williston Reservoir. The base station was operational July 30 to December 8, 2004, and May 1 to December 2, 2005.

Eight telemetry flights were conducted in 2004 and two in 2005 to obtain data on bull trout movements and preferred habitat use (Table 1 in Appendix A). The first 2004 flight (August 23) and both 2005 flights were conducted in a Bell 206 Jet Ranger. A two-element Yagi-Uda antenna was attached to the fuselage of the Bell 206 passenger cabin. The antenna was oriented vertically to the horizon. All other flights were performed using a Robinson R44 helicopter. The same antenna, in the same vertical orientation, was mounted on the skid assembly of the R44.

All radiotelemetry flights (Appendix A), except one, were flown over the Misinchinka River from the confluence with the Parsnip River in an upstream direction and were terminated near its headwaters. One flight (Sept. 2, 2004) was flown in a downstream direction due to weather concerns. The flights were increased to one every two to three days during the expected bull trout spawning period.

Locations of radio-tagged fish were recorded in Universal Transverse Mercator (UTM) coordinates using a handheld global positioning system (GPS) unit when the strongest reception power level was obtained using a Lotek SRX 400 telemetry receiver. Bull trout location data for each flight were converted into Albers equal-area conic projection, and geographic information systems (GIS)

software was used to lay them onto an ArcGIS coverage of the river channel obtained from the BC Watershed Atlas.

Tag Recovery

A number of radio tags were not contacted by the base station in October and November 2004 and 2005, well past the expected timing of spawning activities for the region, as identified in McPhail and Baxter (1996). Therefore, a final telemetry flight was conducted on November 30, 2004, and November 21, 2005, to determine the fate and, if possible, the movement of live bull trout to locations other than Williston Reservoir and Misinchinka River. When radio tags were contacted in the Misinchinka system while airborne, a field crew equipped with a ground-based telemetry receiver, snorkel gear, and dry suit attempted to locate the tags in the channel. Conclusions about the fate of radio-tagged bull trout were made from the available evidence.

Index Site Selection and Redd Counts

Aerial and ground-based surveys combined with telemetry data were used to identify a potentially suitable index site. Criteria for the index site required it to have four characteristics: high value as bull trout spawning habitat, reasonable access, good visibility, and high potential for conducting an accurate and repeatable annual census.

In 2004, an initial reconnaissance survey was conducted to assess spawning habitat potential and the presence of bull trout redds. An aerial survey (to locate redds) conducted with a helicopter was followed with two ground surveys. Approximately 4 km of river was ground surveyed. The 2005 (year 2) activities assessed a second potential redd count index location and included an intensive redd survey over 5 km of river length. Redd locations were geo-referenced in UTMs with a GPS unit, and associated channel characteristics such as proximity to cover and local morphology were noted.

RESULTS

Fish Capture

Forty-one adult bull trout were captured in 2004 and 2005 (Table 2 in Appendix A), and 37 of them were analyzed for a length–weight relationship (Table 2). Twenty-nine bull trout with fork lengths greater than 500 mm were implanted with digitally coded radio tags. Four female bull trout, too small for radio tagging, were captured during initial project reconnaissance in 2004 and died from the stress of capture. Two bull trout, one male and one female, captured on August 4, 2004, and one bull trout of undetermined sex captured on August 9, 2005, also died. Otoliths were removed from five of the six angling mortality fish in 2004. No otoliths were collected from bull trout captured in 2005.

Table 2. Mean fork length, mass, and data range for bull trout captured in the Misinchinka River

Category	N	Fork length (mm)			Mass (g)		
		Mean	Min–Max	SD	Mean	Min–Max	SD
Sample population	37*	632	388–834	110	2960	400–6600	1582
Implanted with radio tags	29	661	510–834	88	3309	1600–6600	1434

* four fish excluded due to incomplete data collection.

A fork length (FL) to mass (M) relationship was calculated using the capture data (n=37) for the Misinchinka River. Log transformed regression analysis describes this relationship with the equation: $\log(M) = 3.35[\log(FL)] - 5.95$ ($r^2=0.97$). This equation can be used for comparison with other bull trout populations within the Williston Reservoir watershed and in other regions in BC, as reported in

Baxter (1996), O'Brien (1999), O'Brien and Zimmerman (2001), and Pillipow and Williamson (2003). Figure 3 illustrates the fork length to mass relationship of all bull trout sampled in 2004 and 2005.

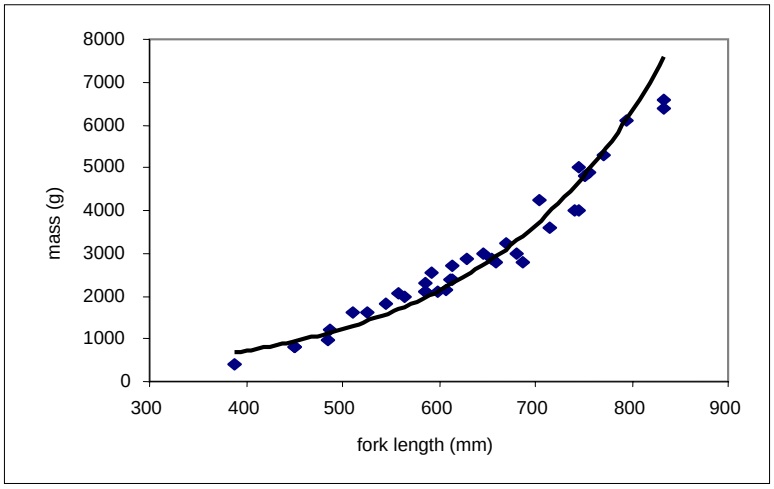

Figure 3. The fork length (FL) to mass (M) relationship of all bull trout sampled (n=37) from the Misinchinka River in 2004 and 2005. Log transformed linear regression produces the equation: log(M) = 3.35[log(FL)] – 5.95 (r^2=0.97).

Fin rays were used to assign ages to 34 of the bull trout captured in 2004 and 2005 (Table 2 in Appendix A). The mean age was 10 years, the minimum age was 7, and the oldest fish was 15 (Figure 4).

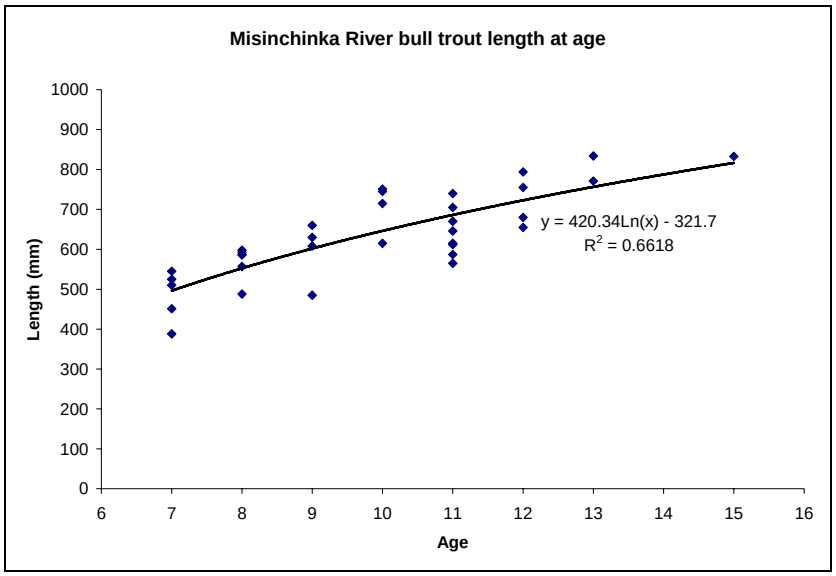

Figure 4. The fork length (mm) at age relationship of Misinchinka River bull trout.

Telemetry

The fixed telemetry base station operated continuously for 132 days in 2004 (July 30–December 8) and 216 days in 2005 (May 1–December 2). The base station recorded contacts from five radio-tagged bull trout between September 1 and 24, 2004, and ten radio-tagged bull trout between September 9 and October 13, 2005 (Table 3 in Appendix A). The contacts were from post-spawn bull trout migrating out of the Misinchinka River, presumably back to Williston Reservoir. The majority of contacts occurred during low light conditions of late evening or early morning.

After surgical implantation in 2004, each radio-tagged bull trout was contacted an average of 6.3 times (range of 0–8 contacts) during all telemetry flights, including the tag recovery flight. Graphical movement patterns of each radio-tagged fish over the course of the project can be found in Appendix B.

Tag Recovery / Outcomes

2004

Fifteen bull trout were implanted with radio transmitters in 2004 (Table 4 in Appendix A). Five of these bull trout spawned and migrated downstream to Williston Reservoir. One bull trout spawned and migrated to the Parsnip River. The remaining nine tagged bull trout provided no information related to post-spawn behaviour: six tags were "shed" and the other three tags either malfunctioned or moved outside the study area.

The 2004 tag recovery flight line was over the Misinchinka River from the mouth to the headwaters. When some radio tags were still not contacted, the flight continued over the Parsnip River upstream to its confluence with Reynolds Creek. The flight concluded by flying over the Parsnip River from the base station downstream to Williston Reservoir and over the southern portion of the reservoir while making the approach to the Mackenzie airport.

Of the nine tags unaccounted for, seven emitted signals from locations in the Misinchinka River in late November 2004. Two of the seven tags were recovered during the November 30, 2004, recovery flight. No external damage was noted on the recovered tags. The locations were determined for the other five tags, but they could not be seen, because they were under ice, snow, or mud. No signals were received in 2004 from the remaining two radio-tagged bull trout (codes 3 and 9).

On August 14, 2005, the fixed telemetry base station logged a weak contact from the 2004 code 9 radio tag. On July 22, a contact was made with 2004 code 6 radio tag.

2005

Fourteen bull trout were implanted with radio transmitters in 2005 (Table 4 in Appendix A). Ten of these fish spawned and migrated downstream to Williston Reservoir. The remaining four tagged bull trout provided no information related to post-spawn behaviour: three tags were "shed" and the fourth tag could not be located. Not enough telemetry flights were conducted in 2005 to generate the migration maps (Appendix B) that were created to depict 2004 fish migrations.

Index Site Selection and Redd Counts

The site selected for the 2004 redd count survey yielded nine bull trout redds within the uppermost 3 km of channel length surveyed by intensive ground scrutiny. A 1-km-long site slightly downstream yielded no redds. In 2005, a site downstream of the 2004 survey locations was selected. Using the same methodology as in 2004, the 2005 survey identified 13 redds over a channel length of approximately 5 km. The locations of redds identified in 2004 and 2005 and, by association, the approximate location of the survey sites are presented in Figure 2.

Four of the nine (44%) radio-tagged females were located during telemetry flights (and were presumed to have spawned) in the upper 3 km of the redd count survey site examined in 2004. These females were large (>612 mm) and were expected to secure optimal redd sites because of their size.

DISCUSSION

Radiotelemetry provided valuable insight to the spawning habitat preferred by bull trout in the Misinchinka system. O'Brien (2001) observed that bull trout in the Duncan River tended to migrate to the upstream extent of available habitat. Location data from the 2004 telemetry showed that individual bull trout moved throughout the potential spawning habitat. This high degree of movement suggests that spawning bull trout, especially females, actively seek out optimal redd sites within the much greater area of "useable" spawning habitat.

The bull trout implanted with radio tags in 2005 emigrated, after spawning, past the Parsnip River telemetry base station in the early September to late October spawning period window identified in McPhail and Baxter (1996). However, immigration into spawning tributaries from Williston Reservoir may occur earlier than in other systems in BC. Cooler weather and a shorter growing season may allow water temperature thresholds to occur earlier in summer than they do farther south in BC.

The base station that recorded post-spawn migration out of the Misinchinka River logged the majority of contacts at night, which is consistent with the observations of Bonneau and Scarnecchia (1998) and Hilderbrand and Kershner (2000) that bull trout movements increase at night. This nocturnal activity suggests that the degree of movement, particularly large-scale movement, by bull trout that temporarily reside in small to mid-sized tributaries is influenced by the relative availability of overhead cover from predators.

Increased stream flow caused by intense precipitation events in early September 2004 tended to correlate with increased bull trout movement within the Misinchinka system. Increased fish movement could be associated with stream temperature change or increased turbidity providing protection from predators.

None of the five adfluvial bull trout that spawned in Misinchinka River in 2004 returned to spawn in 2005, possibly supporting the alternate-year spawning life history. However, two interesting re-contacts with 2004 tag contacts occurred in 2005:

1. A tagged bull trout (code 6, a 3.6-kg male) presumably spawned successfully and over-wintered in Williston Reservoir in 2004. On July 22, 2005, one contact with the Parsnip River base station suggested the fish was migrating up the Parsnip River from Williston Reservoir. The fish did not enter the Misinchinka River and no further contact with the base station occurred. This could represent an adfluvial annual spawner that entered a different stream to spawn in 2005, a summer feeding foray, or a fluvial resident bull trout residing in the lower Parsnip River.

2. A tagged bull trout (code 9, a 4.0-kg female) presumably spawned in the Misinchinka River in 2004. The fish was last detected in the upper Misinchinka River on a September 17, 2004, telemetry flight and was not detected at the Parsnip River base station to indicate a migration to Williston Reservoir. On August 14, 2005, the Parsnip River base station logged a weak contact from the code 9 radio tag. The tag was not detected in the 2005 telemetry flights, suggesting that the fish did not enter the Misinchinka River. The weak signal could be interpreted as a shed tag or a fish fatality in the area of the base station or as the one-time presence of the fish upstream or downstream of the Parsnip River base station. The fish did not pass by the base station, however.

The initial study plan did not include a second year of radio tag application; however, tag loss was common in 2004, requiring a methodology revision and project extension. For the purposes of this

discussion, we define "tag loss" to mean that the tag is no longer in the fish. This could occur due to the fish actively expelling the tag and swimming away or by the death of the fish from any cause (e.g., post surgical stress, predation). The loss of as many as 6 of 15 radio tags in 2004 coupled with lack of data from three other tags reduced the ability to confidently determine if the spawning bull trout in Misinchinka River were adfluvial or fluvial. Additionally, the opportunity was lost to ascertain if alternate year or annual spawning was occurring. The decision to preferentially tag larger male bull trout in 2005 was appropriate as only 3 of 14 tags were lost, and only one tag failed to provide definitive fish location data.

Bull trout mortality rates from capture and surgery reported in similar studies range from 68% over two years of tagging (Salow and Hostettler 2003) to 11% (O'Brien and Zimmerman 2001) during one season of tagging. If the tag losses experienced in 2004 were attributable to fatalities from the capture and surgical procedure, then a significant effort would be required to select bull trout of adequate size for surgery and to improve surgical methods.

The higher proportion of female bull trout implanted with radio tags in 2004 suggests that radio tags were expelled during spawning or redd building activities, as hypothesized in a similar study by Salow and Hostettler (2003). Tag loss most commonly occurs in one of two ways:

1. Release of sutures. Redd building is undertaken predominately by the female (McPhail and Baxter 1996) and may compromise surgical sutures due to the vigorous nature of this activity. An opening into the peritoneal cavity large enough to insert a radio tag provides a clear path for aquatic pathogens to colonize the host fish. Death of bull trout expelling tags in this manner likely occurs shortly after spawning.

2. Expulsion of tag through ovipositor. Tag expulsion can occur in conjunction with the female's vigorous egg evacuation from the body cavity. A tag expelled in this manner may impart no harm to the fish.

Tags were lost by males (four in total; two in each of 2004 and 2005) either through suture release or by some form of post-capture fatality, such as infection from the surgical procedure, predation, or death from old age. Underwater visual observations during the peak redd construction period in 2005 indicated that sutures were sound, and no cases of infection were noted. The most probable reason for the high rate of tag loss in 2004 is tag release through female ovipositors. The remaining incidents listed as tag loss are attributable to fatalities.

Only two radio tags were recovered during the November 2004 recovery flight due to weather conditions. Daylight was limited, and snow and sheet ice partially covered the channel and limited landing sites. As well, frazil ice hindered our ability to locate tags in the stream bottom substrate. No evidence of damage from a predator chewing on tags was noted. Tag 10 (2.1-kg male) was recovered some distance downstream from the presumed spawning location, which suggests a fatality with the carcass floating downstream to the tag's final resting location (Appendix B). Tag 11 (6.4-kg female) was located at the uppermost location the fish migrated to and was located in an area of spawning habitat. It is possible that this tag was expelled by the female during egg deposition. Lack of external damage on radio tags 10 and 11 suggests that the fish were not captured by predators, which usually drag the carcass and tag away and leave telltale scratch or chew marks on the tags (A. Langston, pers. obs.).

Excluding data from tags that were expelled, malfunctioned, or provided unusable data, the 2004 results indicate that five of six bull trout (83%) were adfluvial, while the 2005 results indicate that ten of ten bull trout (100%) were adfluvial. It is possible that the one bull trout located in the Parsnip River in November 2004 migrated to Williston Reservoir after the base station was removed in early December. If so, the tagged (and tracked) bull trout in 2004 would also have been 100% adfluvial. However, the Parsnip River fish could represent a fluvial bull trout. An additional scenario is that a fish not located after spawning in 2005 migrated down the Misinchinka River and up the Parsnip River; however, it is also possible that this fish was simply removed from the study area by a predator and likely would have migrated to the Williston Reservoir had it survived.

The telemetry data show that the majority of fish captured in the Misinchinka River were adfluvial. There also appears to be at least a few Parsnip River fluvial bull trout that spawn in the Misinchinka River, as evidenced by some of the previously noted activity by tagged fish. These fish could simply represent a different life stage or they could be a separate and distinct Parsnip River fluvial population.

The site selected for the 2004 redd count survey yielded nine bull trout redds in the 3-km upstream stretch and no redds in the 1-km stretch slightly downstream. The majority of redds were located in the upper portion of the 3-km stretch that was surveyed. The 2005 survey site started slightly downstream of the 2004 survey location and extended 5 km downstream. Thirteen redds were observed, but the site was determined to be unsuitable for future redd count surveys due to attributes like depth, wetted width, and difficulty seeing redds (sight-ability).

We recommend the Misinchinka River for addition to the initiative to create bull trout population trend index for Williston Reservoir. Based on two years of ground and aerial survey results, the most suitable index location will start 3 km upstream of the 2004 redd survey site and extend downstream for 5 km to include the first 2 km of the site surveyed in 2004.

Results from comparisons of aerial-based and ground-based redd surveys conducted on the Davis and Misinchinka rivers suggest that aerial-based surveys are not reliable. For this reason, we recommend ground-based visual surveys as the methodology for counting redds in the Misinchinka River.

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APPENDIX A

Table 1. Telemetry flight dates in 2004 and 2005.

Flight #	Date of telemetry/recovery flight	Flight duration* (hrs)	Type of helicopter
1	August 23, 2004	2.7	Bell 206 Jet Ranger
2	August 28, 2004	3.2	Robinson R44
3	September 2, 2004	3.9	Robinson R44
4	September 10, 2004	3.8	Robinson R44
5	September 13, 2004	3.8	Robinson R44
6	September 17, 2004	3.6	Robinson R44
7	September 21, 2004	3.5	Robinson R44
Recovery	November 30, 2004	2.0	Bell 206 Jet Ranger
1	September 7, 2005	4.3	Bell 206 Jet Ranger
2	November 21, 2005	2.5	Bell 206 Jet Ranger

*Total time invoiced, including ferry time.

Table 2. Summary of individual fish and tag data, 2004 and 2005. Dashes indicate no data collected.

Tagging Date	Fork Length (mm)	Mass (g)	Sex	Floy Tag	PIT Tag	Radio Frequency (MHz)	Code	Ageing Sample Taken	Age	Notes
29-Jul-04	388	400	F	-	-	-	-	otolith	7	Fatality
30-Jul-04	451	800	F	-	-	-	-	-	-	Fatality
30-Jul-04	451	810	F	-	-	-	-	otolith	7	Fatality
30-Jul-04	485	960	F	-	-	-	-	otolith	9	Fatality
04-Aug-04	612	2400	F	2100	452A493101	149.520	23	fin ray	11	Released
04-Aug-04	598	2100	M	2099	-	149.480	4	fin ray	8	Released
04-Aug-04	615	2400	M	2098	423A08166E	149.480	3	fin ray	10	Released
04-Aug-04	510	1600	F	2097	452A25754F	149.480	8	fin ray	7	Released
04-Aug-04	715	3600	M	2096	4527621E48	149.480	6	fin ray	10	Released
04-Aug-04	751	4800	M	2095	423A194506	149.480	5	fin ray	10	Released
04-Aug-04	660	2800	F	2094	452A163B56	149.480	7	fin ray	9	Released
04-Aug-04	834	6400	F	2093	423A0F0041	149.480	11	fin ray	13	Released
04-Aug-04	745	4000	F	2091	45297C2602	149.480	9	fin ray	10	Released
04-Aug-04	587	2100	M	2090	4239791F16	149.480	10	fin ray	8	Released
04-Aug-04	608	2150	F	2089	45271C6418	149.480	12	fin ray	9	Released
04-Aug-04	525	1600	F	-	-	-	-	otolith	7	Fatality
04-Aug-04	488	1200	M	-	-	-	-	otolith	8	Fatality
05-Aug-04	545	1800	F	2088	4525317053	149.520	22	fin ray	7	Released
05-Aug-04	670	3250	F	2087	4238180106	149.520	26	fin ray	11	Released
05-Aug-04	705	4250	M	2086	4529185F19	149.520	25	fin ray	11	Released
05-Aug-04	655	2850	F	2085	423972115A	149.520	24	fin ray	12	Released
09-Aug-05	833	6600	M	5048	-	149.480	15	fin ray	15	Released
09-Aug-05	646	3000	M	5047	-	149.480	14	fin ray	11	Released
09-Aug-05	587	2100	F	5046; 5045	-	149.520	28	fin ray	11	Released
09-Aug-05	740	4000	M	5044	-	149.480	13	fin ray	11	Released
09-Aug-05	615	2700	M	5043	-	149.520	20	fin ray	11	Released
09-Aug-05	565	2000	F	5042	-	149.480	17	fin ray	11	Released
09-Aug-05	586	2300	F	5041	-	149.520	21	fin ray	8	Released
09-Aug-05	557	2050	F	5040	-	149.520	34	fin ray	8	Released
09-Aug-05	794	6100	M	5039	-	149.520	30	fin ray	12	Released
09-Aug-05	630	2850	F	5038	-	149.520	29	fin ray	9	Released
09-Aug-05	592	2550	F	5036	-	149.520	33	fin ray	8	Released
09-Aug-05	755	4900	M	5033; 5034	-	149.480	16	fin ray	12	Released
09-Aug-05	472	-	-	5049	-	-	-	fin ray	-	Released
09-Aug-05	525	-	-	5037	-	-	-	fin ray	-	Released
09-Aug-05	468	-	-	-	-	-	-	fin ray	-	Released
10-Aug-05	680	3000	M	5031	-	149.520	31	fin ray	12	Released
10-Aug-05	771	5300	F	5029; 5028	-	149.520	32	fin ray	13	Released
10-Aug-05	745	5000	F	5027	-	-	-	fin ray	-	Released
10-Aug-05	688	2800	F	*5026	-	-	-	fin ray	-	Released
10-Aug-05	632	-	F	*5026	-	-	-	-	-	Released

* Floy Tag number uncertain. Tag 5026 was recorded as attached to two different fish. Tag 5025 may be attached to one of the fish.

Table 3. Dates of base station contacts with radio-tagged bull trout.

Date	Time of contact (24 hr clock)	Code	Sex
September 1, 2004	01:25	26	Female
September 15, 2004	22:33	6	Male
September 20, 2004	00:02	24	Female
September 22, 2004	22:41	25	Male
September 24, 2004	02:19	4	Male
September 9, 2005	02:34	13	Male
September 11, 2005	00:26	30	Male
September 11, 2005	01:47	28	Female
September 11, 2005	03:52	14	Male
September 11, 2005	21:12	20	Male
September 12, 2005	03:10	15	Male
September 13, 2005	21:06	17	Female
September 23, 2005	21:41	16	Male
October 9, 2005	20:00	32	Female
October 13, 2005	19:38	21	Female

Table 4. Outcomes based on radiotelemetry of bull trout with radio transmitters in 2004 and 2005.

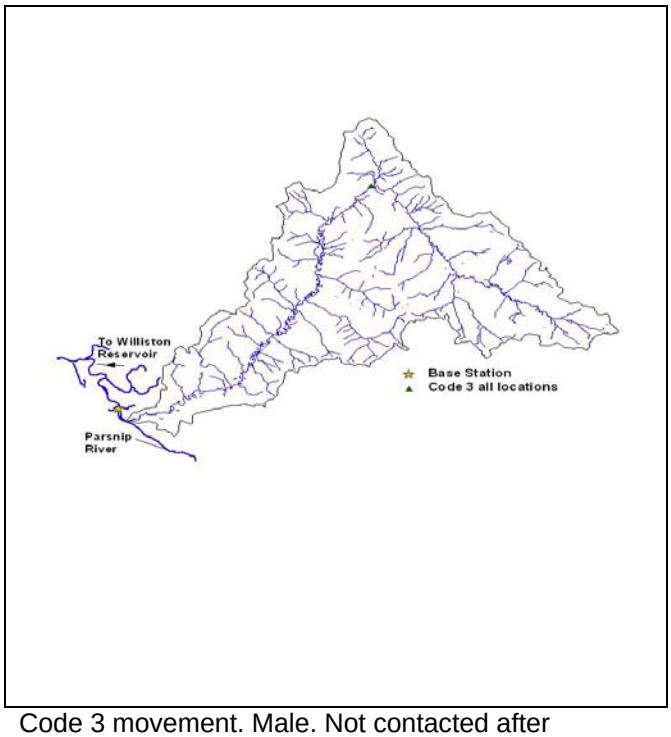
Code	Sex	Number of Contacts[b]	Fate / Outcome
2004			
3	Male	0	Final location and fate unknown. Possible radio tag malfunction.
4	Male	4	Presumed to have successfully spawned. Returned to Williston Reservoir.
5	Male	8	Fatality shortly after surgery. Did not spawn.
6	Male	6	Presumed to have successfully spawned. Returned to Williston Reservoir.
7	Female	6	Tag shed.
8	Female	8	Tag shed. Cut during capture.
9	Female	6	Final location and fate unknown. May have successfully spawned.
10[a]	Male	8	Tag shed, probable fatality.
11[a]	Female	8	Tag shed.
12	Female	8	Presumed to have spawned in Misinchinka R., located in Parsnip R. above Colbourne Cr.
22	Female	7	Tag shed.
23	Female	8	Tag shed.
24	Female	6	Presumed to have successfully spawned. Returned to Williston Reservoir.
25	Male	5	Presumed to have successfully spawned. Returned to Williston Reservoir.
26	Female	4	Presumed to have successfully spawned. Returned to Williston Reservoir.
2005			
13	Male	2	Presumed to have successfully spawned. Returned to Williston Reservoir
14	Male	2	Presumed to have successfully spawned. Returned to Williston Reservoir
15	Male	2	Presumed to have successfully spawned. Returned to Williston Reservoir
16	Male	2	Presumed to have successfully spawned. Returned to Williston Reservoir
17	Female	2	Presumed to have successfully spawned. Returned to Williston Reservoir
20	Male	2	Presumed to have successfully spawned. Returned to Williston Reservoir
21	Female	3	Presumed to have successfully spawned. Returned to Williston Reservoir
28	Female	2	Presumed to have successfully spawned. Returned to Williston Reservoir
29	Female	2	Tag shed.
30	Male	2	Presumed to have successfully spawned. Returned to Williston Reservoir
31	Male	2	Tag shed, probable fatality.
32	Female	2	Presumed to have successfully spawned. Returned to Williston Reservoir
33	Male	2	Tag shed, probable fatality.
34	Female	1	Final location and fate unknown. May have successfully spawned.

[a] radio tag found during Nov. 30, 2004, recovery flight.

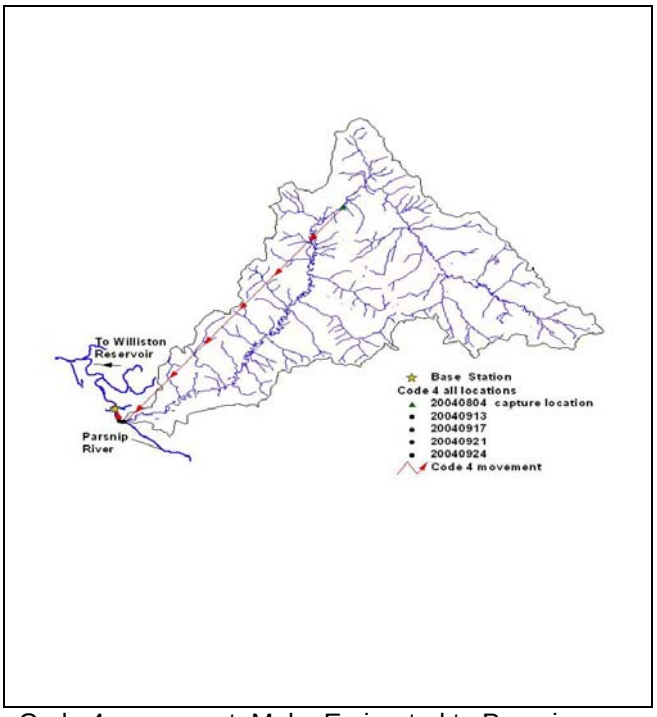
[b] after capture/surgical implantation.

Appendix B. Individual movements of bull trout radio tagged in 2004.

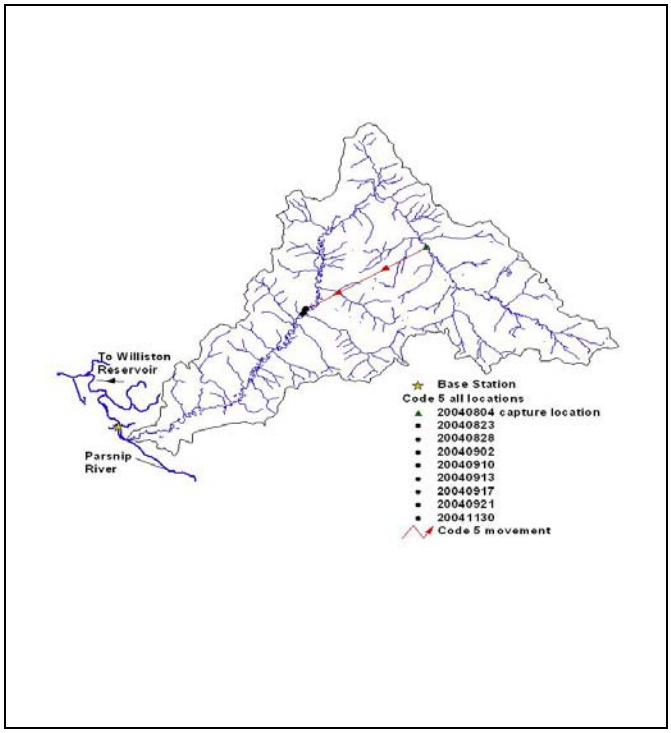
Note- black dots indicating fish location will superimpose showing only one dot if no movement has occurred between contacts.



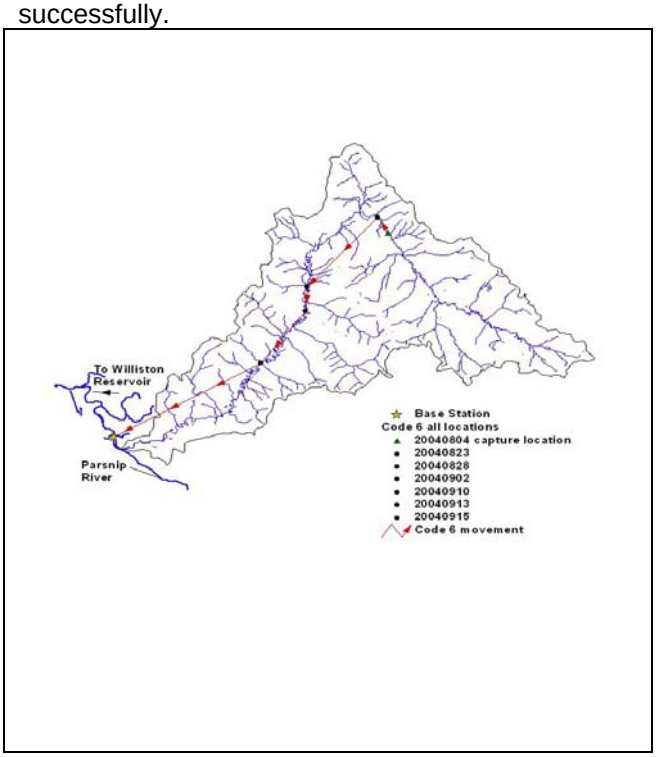
Code 3 movement. Male. Not contacted after capture. Location and fate unknown. Possible tag malfunction.



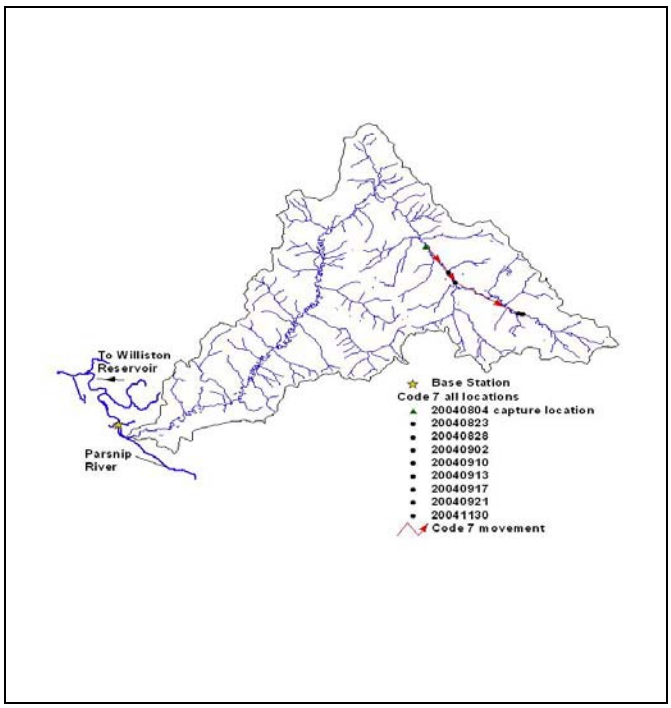
Code 4 movement. Male. Emigrated to Parsnip River then to reservoir. Presumed to have spawned successfully.



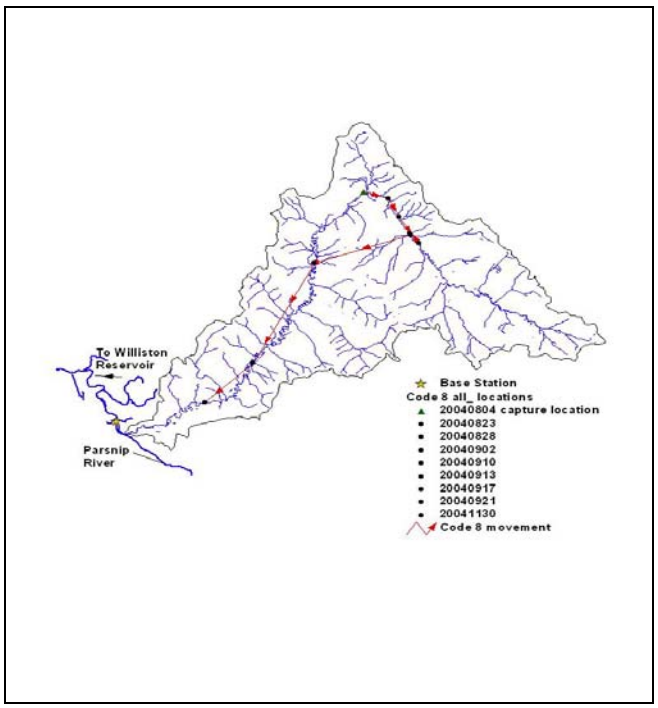
Code 5 movement. Male. No upstream movement after surgery. Contacted radio tag in Misinchinka River Nov. 30/04. Presumed fatality.



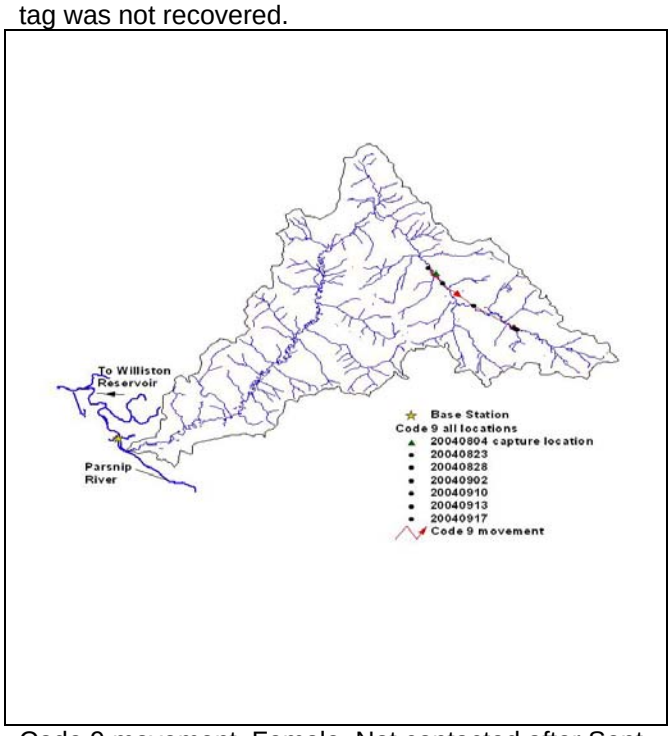
Code 6 movement. Male. Contacted at base station. Presumed to have successfully spawned and returned to reservoir.



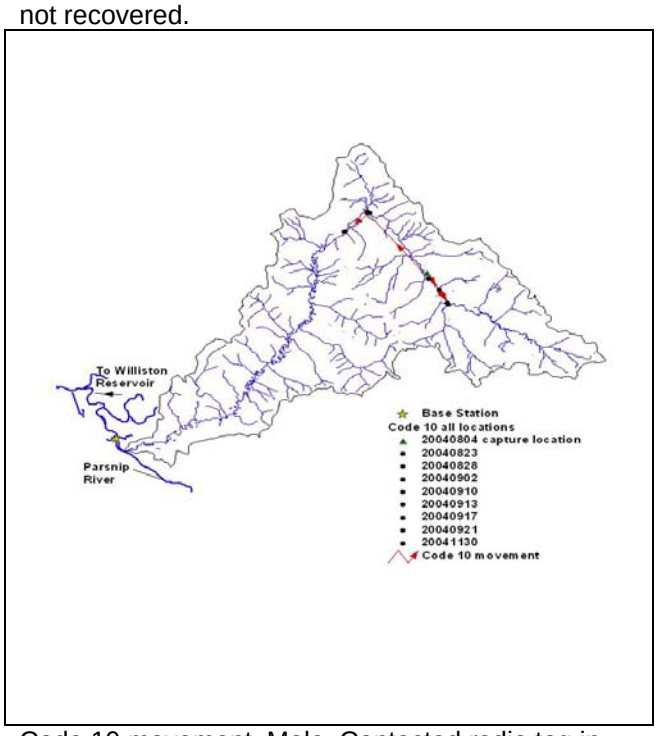
Code 7 movement. Female. Contacted radio tag in Misinchinka River Nov. 30/04. Possible tag expulsion, tag was not recovered.



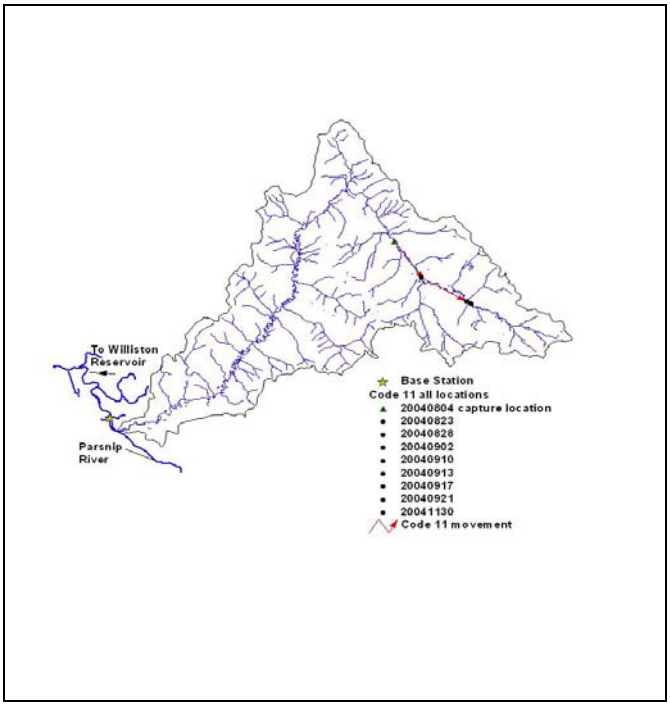
Code 8 movement. Female. Contacted radio tag in Misinchinka River Nov. 30/04. Tag shed, tag was not recovered.



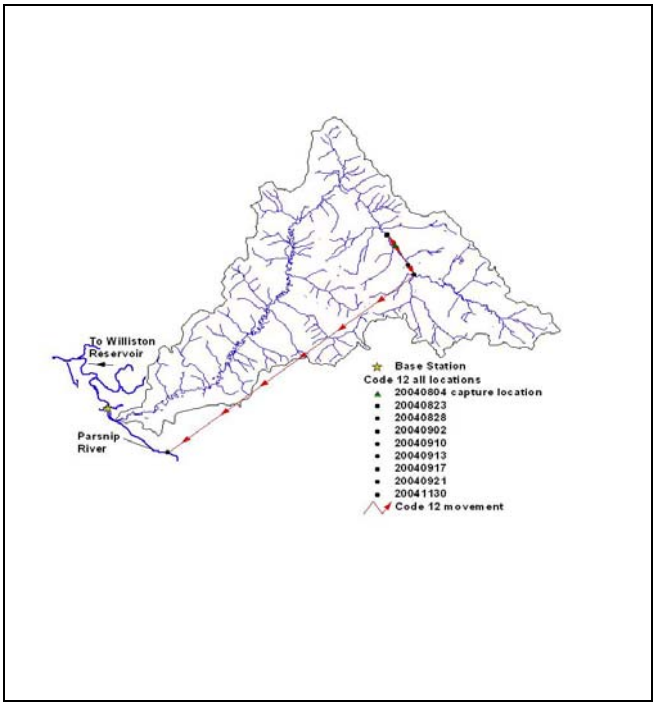
Code 9 movement. Female. Not contacted after Sept. 17/04. Location and fate unknown.



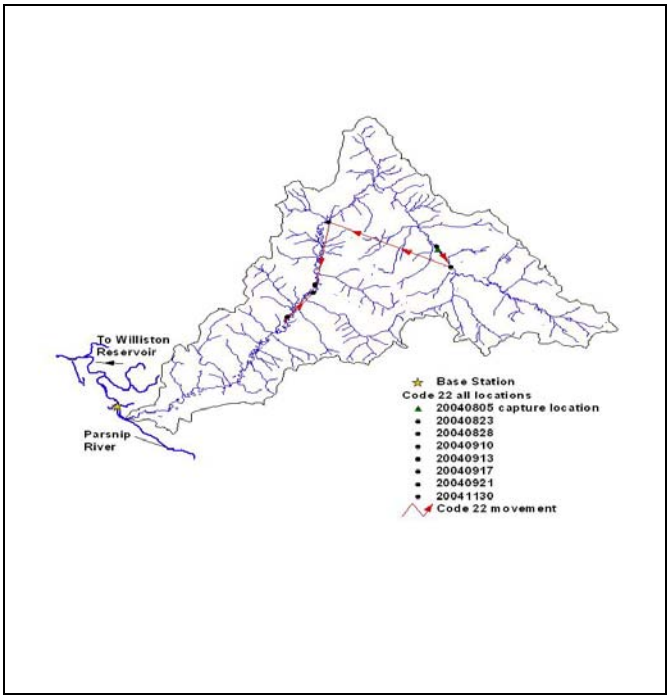
Code 10 movement. Male. Contacted radio tag in Misinchinka River Nov. 30/04. Tag shed, presumed fatality, tag recovered.



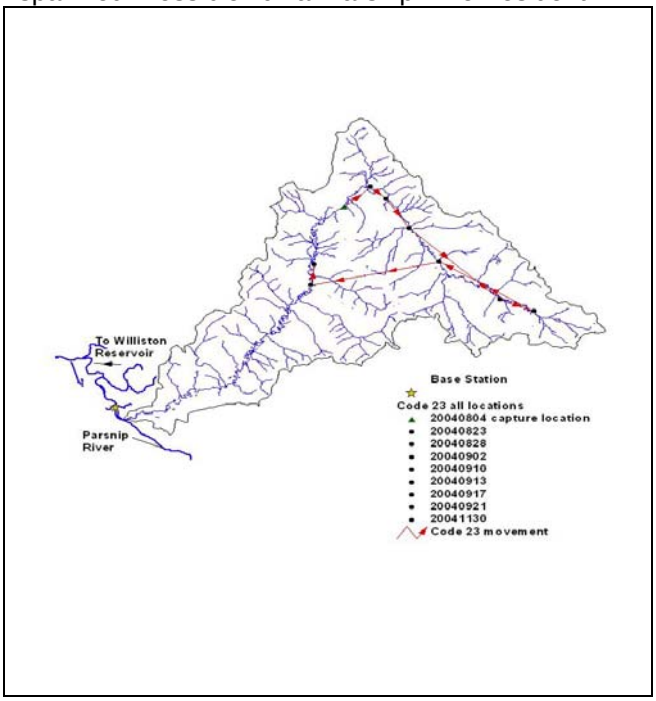
Code 11 movement. Female. Contacted radio tag in Misinchinka River Nov. 30/04. Tag shed, tag recovered in spawning habitat location.



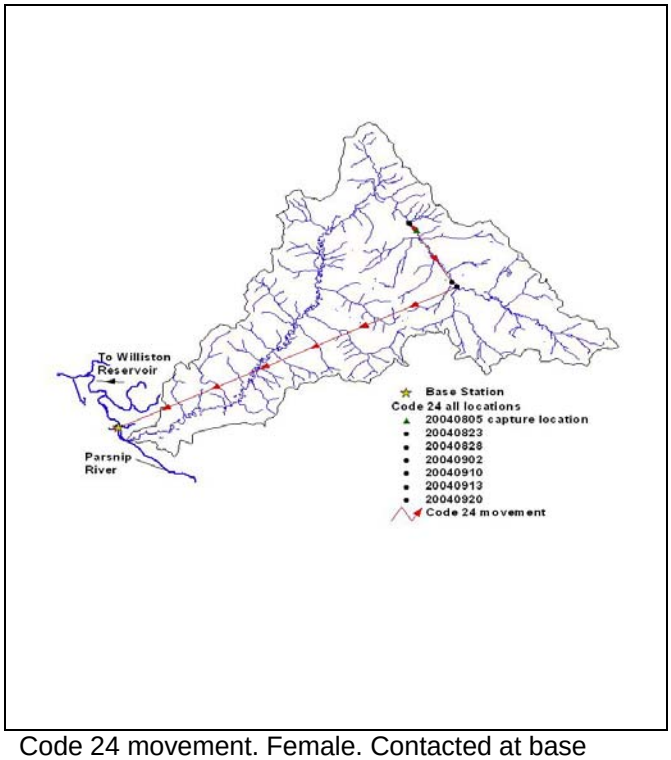
Code 12 movement. Female. Contacted radio tag in Parsnip River Nov.30/04. Presumed to have spawned. Possible fluvial Parsnip River resident.



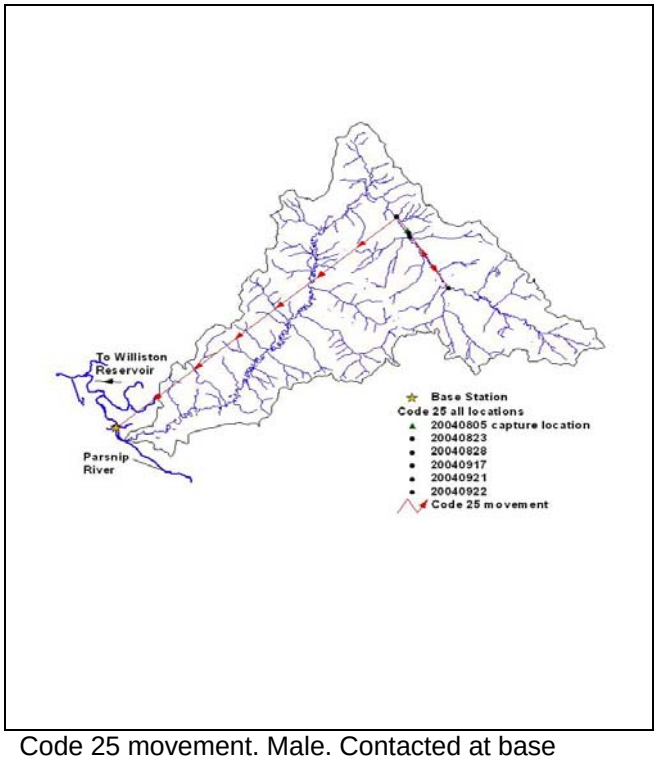
Code 22 movement. Female. Contacted radio tag in Misinchinka River Nov. 30/04. Tag shed, tag was not recovered.



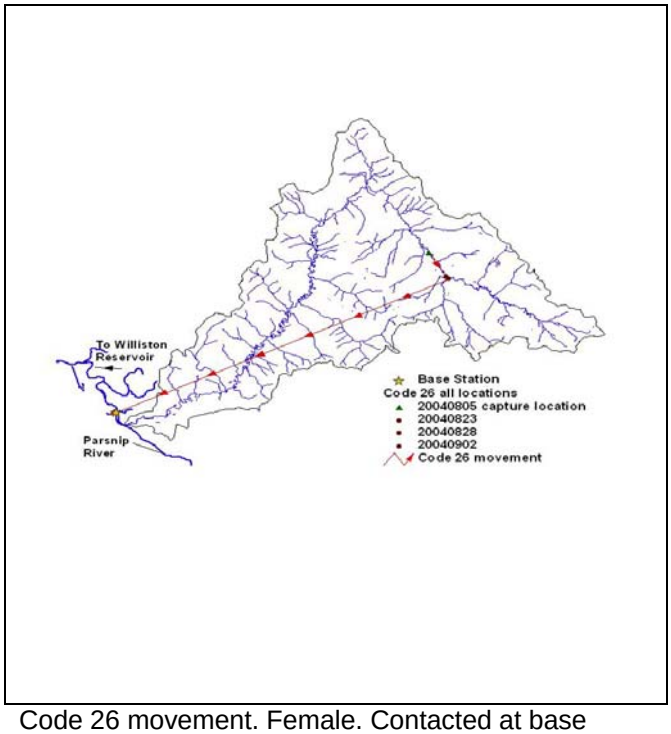
Code 23 movement. Female. Contacted radio tag in Misinchinka River Nov. 30/04. Tag shed, tag was not recovered.



Code 24 movement. Female. Contacted at base station. Presumed to have successfully spawned and returned to reservoir.



Code 25 movement. Male. Contacted at base station. Presumed to have successfully spawned and returned to reservoir.



Code 26 movement. Female. Contacted at base station. Presumed to have successfully spawned and returned to reservoir.