Upper North Saskatchewan River and Abraham Lake Bull Trout Study, 2002 - 2003

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EXECUTIVE SUMMARY

Historically, bull trout (*Salvelinus confluentus*) have been the most abundant and widely distributed char species in Alberta. However, many native populations have declined in range and abundance due to overfishing and habitat loss. To prevent further decline in their populations, a province-wide ban (zero bag limit) on bull trout harvest was introduced in 1994 by Alberta Sustainable Resource Development as part of Alberta's Bull Trout Management and Recovery Plan. The current study is part of a larger study designed to generate data on the status of bull trout populations in the upper North Saskatchewan River region. Here, we evaluate the extent and timing of seasonal migrations and the distribution of spawning and over-wintering habitat using radio-telemetry.

A total of 38 bull trout ranging in fork length (FL) from 446 to 665 mm were implanted with radio-transmitters, 35 implanted in 2002 and three in 2003. Radio-tagged bull trout were located during 20 tracking events between 7 June 2002 and 25 September 2003. Forty-nine percent (17 of 35) and 47% (18 of 38) of tagged bull trout in 2002 and 2003, respectively, underwent fall migrations presumably to access spawning habitats. Ten of the 35 bull trout tracked both years (29%) did not undergo fall-migrations in either year. Of the 25 fall-migrants tracked both years, 17 (68%) underwent fall migrations in one year only and 8 (32%) migrated both years. There was no significant difference in mean length (FL) between fall-migrant and non-migrant bull trout. Over-wintering migrations were observed for 77% of all radio-tagged fish.

Migrations to suspected spawning tributaries were detected as early as 7 July in 2002 and 13 June in 2003. All migrations into tributaries were completed by 18 September in both years. In 2002, all fall-migrant bull trout had departed from tributaries by 6 October, whereas in 2003 four fall-migrants still occupied tributaries during the last tracking event conducted 25 September. Over-wintering migrations began 8 August 2002, and by 6 December, 89% of winter migrants had moved to their winter locations.

The mean (± SD) distance of fall spawning period migrations was 25.2 ± 19.3 km. Maximum likelihood estimates of the average distances traveled during August, September, and October, by fall-migrant bull trout were 9.6, 14.6, and 17.4 km,

respectively. The mean distance traveled for migrations to over-wintering locations was 16.0 ± 12.3 km. Mean winter movement between 6 December 2002 and 27 February 2003 was 1.5 ± 3.3 km, with 50% of fish showing no movement. Maximum likelihood estimates of mean monthly distance traveled by all radio-tagged bull trout, ranged from 2.6 to 5.8 km during the spring and summer months, 6.6 to 11.0 km during the fall months, and 2.8 to 4.6 km during the winter months.

Spawning locations were identified in Owen Creek and Unnamed Creek #22932. In addition, the Howse River, Siffleur River, Murchison Creek, and Whiterabbit Creek were identified through telemetry as fall-use tributaries, presumably for spawning purposes. Over-wintering locations used by 89% of radio-tagged bull trout were distributed throughout much of the main-stem in the upper North Saskatchewan River below the confluence of Owen Creek, and 11% of bull trout over-wintered in Abraham Lake.

ACKNOWLEDGEMENTS

We thank the following individuals, agencies, and corporations for their contributions and assistance in delivering the Upper North Saskatchewan River and Abraham Lake Bull Trout Study, 2002 - 2003. From Trans Alta Utilities Ltd., Paige Mcgrath, Paul Godman, and Roger Drury for their part in securing funding. From Parks Canada, Joanne Williams for her cooperation, fund raising and field support. From the Alberta Conservation Association, Craig Johnson for his scientific advice and for editing this report. Calvin McLeod for envisioning this study, field and editorial support, Donna Rystephanuk for GIS support, David Fairless and Paul Hvenegaard for providing advice and field support, as well as, Mike Blackburn for reviewing an earlier draft. For their tireless work in the field, Susan Armitage, Jim Berdula, Roger Korth, Dean Baayens, Sean Nichols and Wade Stewart. From Alberta Sustainable Resource Development, David Christiansen and Steve Herman for their advice, support and for editing the original study design and an earlier draft of this report. John Day for field support and allowing us to store equipment at his personal residence, Darren Schwieger, Rocklynn Konynenbelt and Vance Wolsky for field support and Lee Hanky for the loan of a boat on several occasions. From the Northern Alberta Institute of Technology (NAIT), Vic Snyder and his students for sample collection. Kelsey Kure for providing tag returns and Trevor Christian for volunteering his time to assist with fieldwork. Finally, we thank Icefield Helicopter Tours and Ahlstrom Air Division for their excellent service and special flight rates.

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1.0 INTRODUCTION

1.1 Background

Historically, bull trout (*Salvelinus confluentus*) have been the most abundant and widely distributed char species in Alberta (Brewin 1997). However, many native populations have declined in range and abundance (Allan 1980; Berry 1994; Fitch 1997; McCart 1997) due to overfishing (Bond 1992; Donald and Stelfox 1997), loss of spawning and rearing habitat (Fraley and Shepard 1989), competition from introduced species (Donald and Alger 1992; Gunckel et al. 2002), hybridization with brook trout (*S. fontinalis*) (Leary et al. 1993), and displacement by lake trout (*S. namaycush)* (Donald and Alger 1992; Fredenberg 2002). Hydroelectric development, resulting in habitat loss and migration barriers, has also been implicated in the decline of bull trout populations (Goetz 1997).

To prevent further decline in their populations, a province-wide ban (zero bag limit) on bull trout harvest was introduced in 1994 by Alberta Sustainable Resource Development (ASRD) as part of Alberta's Bull Trout Management and Recovery Plan (Berry 1994). Studies conducted in the Lower Kananaskis Lake in the central East Slopes five years after implementation of the zero bag limit reported a dramatic decline in annual bull trout mortality (Stelfox 1997) and a steady increase in the number of adult spawners (Mushens et al. 2001). Similar recoveries in bull trout populations have been reported from other parts of the province (Post and Johnston 2002). In response to mounting pressure from recreational fishermen to re-open the bull trout harvest, ASRD is considering Abraham Lake, in the North Saskatchewan River drainage, as a potential candidate on which to allow a limited harvest as a pilot project (D. Christiansen, Head Fisheries Management, ASRD, personal communication). Such management decisions should be based on rigorous quantitative data. The current study is part of a larger study designed to generate data on the status of bull trout populations in the upper North Saskatchewan River region (Gardiner 2001; Gardiner and Rodtka 2004). In this report, we evaluate the extent and timing of seasonal migrations and the distribution of spawning and over-wintering habitat using radio-telemetry. The use of radio-telemetry has been beneficial to other researchers documenting seasonal movements and habitat use by bull trout (Brown and Mackay

1995; Rhude and Rhem 1995; Boag and Hvenegaard 1997; McLeod and Clayton 1997; Swanberg 1997; Burrows *et al.* 2001; Clayton 2001). However, monitoring bull trout movement and habitat use in relation to reservoirs (Fernet and O'Neil 1997) has received little attention.

In addition, protecting this population across provincial and federal management jurisdictions required determining the extent to which bull trout from Abraham Lake use the upper reaches of the North Saskatchewan River within Banff National Park.

1.2 Study rationale

This study was conducted to provide specific information regarding seasonal movements of bull trout in the North Saskatchewan River above the Bighorn Dam using radio-telemetry. Data collected will enable ASRD and Banff National Park fisheries managers, as well as development planners, to ensure that fishing regulations and timing restrictions on instream work are sufficient to adequately protect bull trout in this area.

1.3 Study objectives

i. Describe timing and distance of seasonal migrations of bull trout residing above the Bighorn Dam.

ii. Identify bull trout spawning and over-wintering areas in the upper North Saskatchewan River and Abraham Lake.

2.0 STUDY AREA

2.1 Description

Abraham Lake, located approximately 80 km west of Rocky Mountain House and 25 km east of the Banff National Park boundary along the David Thompson Highway (Highway #11), is an artificial lake created in 1972 as a result of the Bighorn Dam on the upper North Saskatchewan River (Tebby 1974) (Figure 1). This large, 5200-ha reservoir is supplied mainly by the upper North Saskatchewan River and is subject to both daily

and seasonal water fluctuations. Annual reservoir drawdown results in surface water level variations of approximately 39 to 50 m (Tebby 1974). Major tributaries to the upper North Saskatchewan River included in this study were the Howse River, Murchison Creek, Owen Creek, and the Siffleur River (Figure 1). Tributaries to Abraham Lake include Whiterabbit Creek, Tershishner Creek, Whitegoat Creek, Allstones Creek, and the Cline River. The upper North Saskatchewan River, Abraham Lake, and their tributaries combined make up approximately 4243 km of stream and contain a drainage area of approximately 3872 km^2. The study area, bounded by the Universal Transverse Mercator (UTM) coordinates 481115 to 567711 East and 5739849 to 5802016 North, NAD 83 Zone 11U, is a popular recreational destination for kayaking, rafting, off-highway-vehicle use, hunting and fishing. Popular sport fishes in the area include bull trout, cutthroat trout (*Onchorhynchus clarki*), rainbow trout (*O. mykiss*), brook trout, lake trout, and mountain whitefish (*Prosopium williamsoni*). Potential threats to fisheries resources in the area include oil and gas development, gravel extraction, timber harvesting, ranching, and tourism.

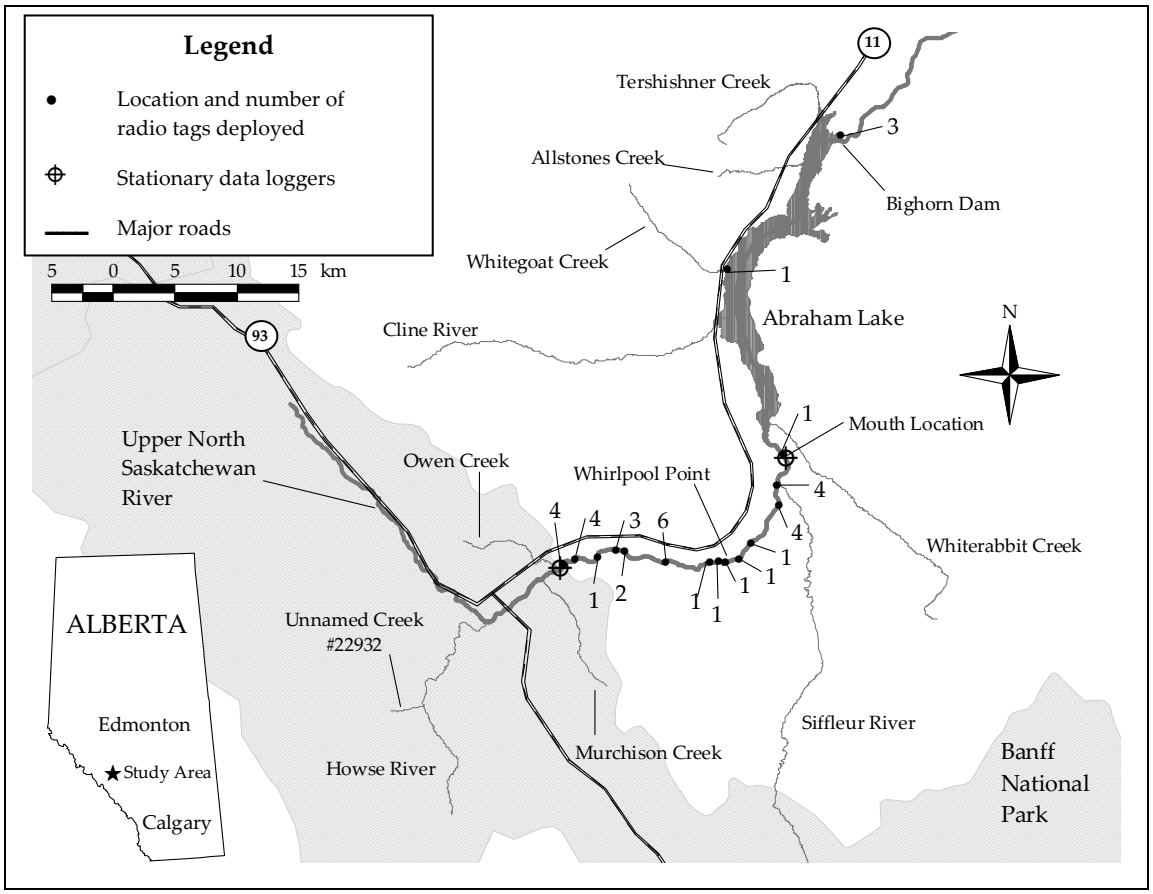

Figure 1. Map of study area showing radio-tagging and stationary data-logger locations. Numbers associated with tagging sites indicate number of tags deployed.

2.2 Ecoregions

The upper North Saskatchewan River and the Abraham Lake study area are located in the Cordilleran Ecoprovince as defined by Strong and Legatt (1992). Abraham Lake, the Cline River, and the majority of the upper North Saskatchewan River are located within the Montane Ecoregion (Archibald et al. 1996). The main-stem portions of many smaller order tributaries in the study area and the headwaters of the upper North Saskatchewan River are located within the Subalpine Ecoregion. The surrounding mountains and glaciers, which feed many of these tributaries, reach into the Alpine Ecoregion (Strong and Legatt 1992; Archibald et al. 1996). The Montane Ecoregion is typified by a complex topography resulting in highly variable ecological conditions (Archibald et al. 1996). Yearly precipitation totals are moderate ranging from 308 to 1279 mm, with precipitation peaking in July (Strong and Leggat 1992). Summer temperatures are relatively cool, averaging 11.9^{o}C, with a July maximum. Typical mean winter temperatures in the Montane are close to -5.5^{o}C and are the warmest of any forested ecoregion due to chinook activity and reduced Arctic air influence (Archibald et al. 1996). The Subalpine Ecoregion's lower boundary abuts the Montane Ecoregion with a topography consisting of strongly rolling ridges underlain with bedrock at varying depths (Archibald et al. 1996). The Alpine Ecoregion is situated above the Subalpine and is marked by the end of contiguous forest with only isolated islands of trees present (Strong and Leggat 1992). Summer months are colder and winter precipitation is greater in the Alpine and Subalpine relative to the Montane Ecoregion (Strong and Legatt 1992). Freezing temperatures can occur during all months in the study area. Colder mean winter temperatures, especially in the Alpine and Subalpine, help to maintain snow pack which contributes to the overall watershed area.

3.0 MATERIALS AND METHODS

3.1 Study design

Radio-tagging a sufficient sample size of bull trout was attempted to adequately represent the seasonal movements and habitat use by adult bull trout residing in the study area. Thirty-five bull trout from the upper North Saskatchewan River and ten

from Abraham Lake were surgically implanted with radio-transmitters in the abdominal region. To ensure the survival of individual fish, transmitters did not exceed 2% of a fish's weight (Winter 1996; S. Strathern, salesman Lotek™, personal communication). A minimum fork length (FL) of 450 mm, corresponding to < 2% fish weight, was determined from a regression of log-transformed FL to weight (W) data ($W = 2.902 * FL - 4.7659$; $R^2 = 0.99$) calculated from Gardiner and Rodtka (2004).

Bull trout abundance has been estimated at 16.6 fish/km for a 10.4-km section immediately downstream of the Banff National Park boundary (Gardiner and Rodtka 2004), with bull trout having FLs > 450 mm comprising approximately 35% of the estimate. We assumed an even distribution of bull trout of this size throughout the main-stem of the upper North Saskatchewan River between Abraham Lake and Banff National Park. Therefore, approximately 20% of all bull trout of this size between Abraham Lake and Banff National Park were radio-tagged for this study. Comparable population estimates and size-frequency distribution data do not exist for Abraham Lake or the upper North Saskatchewan River within Banff National Park. However, it appears a sufficiently large proportion of bull trout were radio-tagged to represent the general movement patterns and habitat use by adult bull trout above the Bighorn Dam.

Bull trout captured during the study were also marked with externally visible Floy ™ spaghetti tags attached behind the dorsal fin of fish to provide supplemental location data from tag returns provided by anglers.

Bull trout for radio-tagging were captured between mid-April and mid-May of 2002 and 2003 (Table 1). Locations for capture and subsequent release of tagged fish were distributed throughout the upper North Saskatchewan River, between the Bighorn Dam and the border of Banff National Park (Figure 1). Capture effort at Abraham Lake was focussed at the mouths of Tershishner Creek, Allstones Creek, Whitegoat Creek, the Cline River, and directly above the Bighorn Dam (Figure 1).

Table 1. Summary information on bull trout captured for radio-tagging in the upper North Saskatchewan River and Abraham Lake in 2002 and 2003.

Location	Radio-tagged Bull Trout			
	n	2002	n	2003
Upper North Saskatchewan River	33	22 April – 19 May	0	N/A
Abraham Lake	2	12 May & 9 July	3	17 April – 15 May

Typical spawning activity was expected between the months of July and October (Nelson and Paetz 1992; Berry 1994; McPhail and Baxter 1996; Joynt and Sullivan 2003). Therefore, this timeframe is hereafter referred to as the fall spawning period. Aerial tracking was conducted at approximately 10-day intervals between August and September when the most fish movement was expected. Because bull trout remain fairly stationary during winter, relative to the fall spawning period (Hvenegaard and Fairless 1998), fish tracking during late fall and winter were conducted monthly and bimonthly, respectively.

Because standard radio-transmitters were only detectable in water depths < 5 m (S. Strathern 2002, Salesman Lotek™, personal communication) aerial-tracking was not always sufficient to determine movement of tagged fish between the main-stem upper North Saskatchewan River channel and Abraham Lake. Therefore, a fixed-position data-logger was installed near the mouth of Abraham Lake (Figure 1) to monitor movement of tagged fish past that location (i.e., into and out of the lake). To determine if bull trout traveled into the Banff National Park region of the study area, a second data-logger station was employed at the Banff National Park boundary (Figure 1). Upon confirmation of fish movement past this logger, aerial tracking was extended to include all portions of the upper North Saskatchewan River within Banff National Park beginning 23 July 2002 and the use of the Banff National Park data-logger was discontinued in 2003.

3.2 Fish capture

Four capture methods, including angling, float electrofishing, gill netting, and fence-trapping were used to capture bull trout in 2002. Only angling was used in 2003 because it was the most effective method of capturing bull trout in 2002. In addition, one bull trout captured in a gill net during a field trip by students from the Northern Alberta Institute of Technology (NAIT) was included in this study.

Due to a permit restriction, non-baited angling was conducted from 22 April to 13 May 2002 throughout the study area. The restriction was removed on 14 May 2002 and baited angling was used on 15 and 16 May in the upper North Saskatchewan River and for all subsequent sampling in Abraham Lake; bait consisted of small slices of steak, beef liver, or chicken attached to a single hook. Large, silver spoons (lures) were most commonly used when angling the upper North Saskatchewan River. When targeting bull trout at greater depths, such as in Abraham Lake and at Whirlpool Point (Figure 1), a three-way swivel, bell weight, and a J-hook were used. A more detailed explanation of all fish capture methods can be found in Gardiner (2004).

All fish captured were identified to species using Scott and Crossman (1973) and Nelson and Paetz (1992). Fork lengths were measured to the nearest 1 mm for all fish caught. Sex and stage of maturity were recorded, when discernible, by testing for the expression of milt or eggs. All bull trout, rainbow trout, and lake trout > 300 mm FL were tagged with individually labelled Floy™-anchor/spaghetti tags and released.

3.3 Radio telemetry

Bull trout > 450 mm FL were surgically implanted with radio transmitters using a procedure similar to that described in Rhude and Rhem (1995). Tags were implanted in 2-3 cm incisions on the ventral surface, anterior to the pelvic girdle. All fish were anesthetized with Tricaine Methansulfonate (MS–222) for about 5 minutes prior to the surgery. Implanted fish were held in a flow-through pen until they regained equilibrium before being released as close to the capture location as possible.

Lotek Wireless™ model MBFT-3A radio-transmitters, weighing 16 g and measuring 16 x 46 mm, were used in 2002 and model MBFT-6 transmitters, weighing 10 g and measuring 11 x 59 mm were used in 2003. The transmitters were 3V Micro Beepers that functioned at 40 beeps/min (BPM) with frequencies ranging from 148.32 to 150.80 MHz. The transmitters implanted in 2002 had a life span of 542 d, whereas those implanted in 2003 had a life span of 324 d.

Fish were located during 20 tracking events starting 7 June 2002 and ending 25 September 2003. A Jet Ranger helicopter fitted with two, forward facing, Yagi-style four-element antennas connected to two Lotek™ SRX_400 programmable receivers and standard portable stereo headphones were used for aerial tracking. A telemetry flight involved a two-person crew scanning for fish, each with half the list of deployed frequencies. The location of each fish, i.e. where the audible tone (signal strength) was the strongest, was marked with a Garmin™ 12XL Global Positioning System (GPS) unit.

In addition to aerial tracking, a rafting trip (float-tracking) was conducted to locate radio-tagged fish. Float-tracking involved launching a raft at the Banff National Park boundary and scanning for frequencies as the survey team drifted downstream. Tracking ceased near the convergence of the upper North Saskatchewan River and Abraham Lake. Scanning and recording procedures were similar to aerial tracking events. A minimum two-person crew performed float surveys. One member maneuvered the raft while the other scanned for radio-tagged fish.

Tributaries to the upper North Saskatchewan River and Abraham Lake were visually inspected for spawning activity, when possible. Visual inspections involved searching for bull trout redds or paired adults in sections of tributaries where concentrations of radio-tagged bull trout were detected during the fall spawning period.

Lotek™ SRX_400 stationary data-loggers fitted with a programmable receiver with an Event_Log function were installed at the mouth of Abraham Lake, to assess fish movement between the river and the lake, and at the Banff National Park boundary, to assess fish movement in and out of the park (Table 2). The loggers were powered by two 12-volt, deep-cycle batteries connected in series and operated 24 h/d. Two directional, Yagi-style, four-element antennas, one facing upstream and one

downstream, were used at both stations in 2002. In 2003, a single downstream facing antenna was used. The scan time for each transmitter frequency was 3 sec/antennae. Data recorded included the transmitter frequency, signal strength, and date. Data were downloaded from loggers to a laptop computer approximately every two weeks, at which time the batteries were also replaced. Data-logger stations were tested to ensure detection of radio transmitters prior to operation by having a technician walk 200 m upstream to 200 m downstream of the receiver, while carrying an active radio-transmitter.

Table 2. Stationary data-logger locations and dates of deployment in the upper North Saskatchewan River and Abraham Lake study area in 2002 and 2003.

Location	Date installed	Date removed	Non-operational[1]
Confluence of upper North Saskatchewan River and Abraham Lake	11 May 2002	5 December 2002	13 June & 7 July 2002
	26 April 2003	9 September 2003	2 – 29 May 2003
Banff National Park boundary	15 May 2002	15 October 2002	-

[1]Equipment breakdown

3.4 Data management

Activity dates and UTM coordinates recorded on portable GPS units and stationary data-loggers were downloaded to Microsoft Excel™ spreadsheets. UTM locations were then corrected to intersect the provincial government Base Features – Single Line Network (SLNET) hydro-layer using MapInfo™ software.

Biological data collected from all fish species, angler tag return data, and telemetry data were entered into the Alberta Fisheries Management Information System (FMIS) provincial database as Project ID 1189.

3.5 Data analysis

All spatial analysis and mapping of seasonal habitat use was completed using ArcView GIS 3.3™ software. Distances, upstream of the Bighorn Dam, for all contact locations were assigned to the nearest 0.5-km stretch using 0.25-km intervals. Due to water fluctuations associated with the hydroelectric operations of the Bighorn Dam, the location of the mouth of the upper North Saskatchewan River to the Abraham Lake varied considerably. For consistency, we fixed the location of the mouth at full supply level which was approximately 32 km upstream from Bighorn Dam (Figure 1).

The magnitude of seasonal migrations was defined as the proportion of radio-tagged bull trout that underwent seasonal migrations. Bull trout were categorized as fall-migrants if located in tributaries to the upper North Saskatchewan River or Abraham Lake during the fall spawning period. Fall spawning period migrations were characterized as the time when bull trout began moving towards lower order tributaries to the upper North Saskatchewan River and Abraham Lake to when they ceased movement within those tributaries, as determined through tracking observations. Migrations for over-wintering purposes were established if radio-tagged bull trout were found in different locations during winter tracking events conducted on 6 December 2002 and 27 February 2003 from those occupied the previous fall. All migration distances were calculated using the absolute cumulative distance traveled, upstream and downstream, between tracking events. A two-sample *t*-test was used to determine if differences in sizes existed between fall migrant and non-migrant fish.

Probability density functions (PDF) were used to calculate estimates and illustrate variation of mean monthly movement of radio-tagged bull trout. The bootstrapping technique described by Haddon (2001) and Walker and Sullivan (2003) was used to generate PDFs. All location contacts for every tracking event in each calendar month, including both 2002 and 2003 data, were pooled together to perform the frequency analysis of bootstrapped means. PDFs of distances traveled during the fall spawning period were produced using data from fall-migrant bull trout only; PDFs of distances traveled during each calendar month for an entire year were produced using data from all radio-tagged bull trout.

Fall tributary use was illustrated graphically by highlighting sections of tributaries to the most upstream location occupied by radio-tagged bull trout during the fall spawning periods of 2002 and 2003. Over-wintering areas were illustrated by showing percentage occurrence of location contacts for concentrations of radio-tagged bull trout by pooling all location data, from tracking events conducted on 6 December 2002 and 27 February 2003, from all radio-tagged bull trout implanted prior to December 2002.

4.0 RESULTS

Of the 38 bull trout radio-tagged, 27 (71%) were captured by angling, 10 (26%) by float electrofishing and one (3%) by gillnetting; no bull trout were captured in migration traps. A summary of bull trout capture data and radio-tag deployment is provided in Appendix 1.

A mean ($\pm$ SD) of 15 $\pm$ 5 contacts were made for each fish during 20 tracking events between 7 June 2002 and 25 September 2003 (Appendix 2). The efficiency of locating radio-tagged fish during each tracking event ranged from 97% on 27 February 2003 to 47% on 25 September 2003, with a mean of 77 $\pm$ 12% (Appendix 3). Mean percentage efficiency was 81 $\pm$ 8% (n = 9) in 2002 and 73 $\pm$ 14% (n = 11) in 2003. Approximately one month before the last tracking event, Lotek Wireless™ confirmed that at least 25 transmitter batteries prematurely ceased functioning and may have contributed to the lower tracking success in 2003 compared to 2002.

No mortality of radio-tagged fish was observed during the study. This was confirmed by upstream movement of all fish during subsequent tracking events. During the last tracking event on 25 September 2003, 29 (76%) radio-tagged fish were active and showed location changes. Nine (24%) were inactive and at the same locations as the previous year; these fish demonstrated similar movement patterns the previous year and were therefore assumed to be alive and behaving normally. Although 20 tagged fish were not located during the last tracking event on 25 September 2003, stationary logger data showed six of these fish entered Abraham Lake between 10 July and 18 September 2003 where the transmitter signal was not detectable by aerial tracking. Although it is possible that radio-tagged bull trout could have been removed from the

study area, it was believed that the remaining 14 missing bull trout were carrying those transmitters whose batteries prematurely ceased functioning.

4.1 Magnitude, timing and distance of seasonal migrations

4.1.1 Magnitude

Seventeen (49%) of 35 radio-tagged bull trout tracked in 2002 and 18 (47%) of 38 bull trout tracked in 2003 underwent fall migrations to tributaries of the upper North Saskatchewan River and Abraham Lake (Appendix 4). Of the 35 bull trout tracked both years, 10 (29%) did not undergo fall migrations in either year. Of the 25 fall-migrants tracked both years, 17 (68%) underwent fall migrations in one year only, and 8 (32%) migrated both years. There was no significance difference in mean FL between fall-migrant (534 $\pm$ 60 mm) and non-migrant (505 $\pm$ 39 mm) bull trout (t = 2.048; df = 28; P = 0.097; Figure 2).

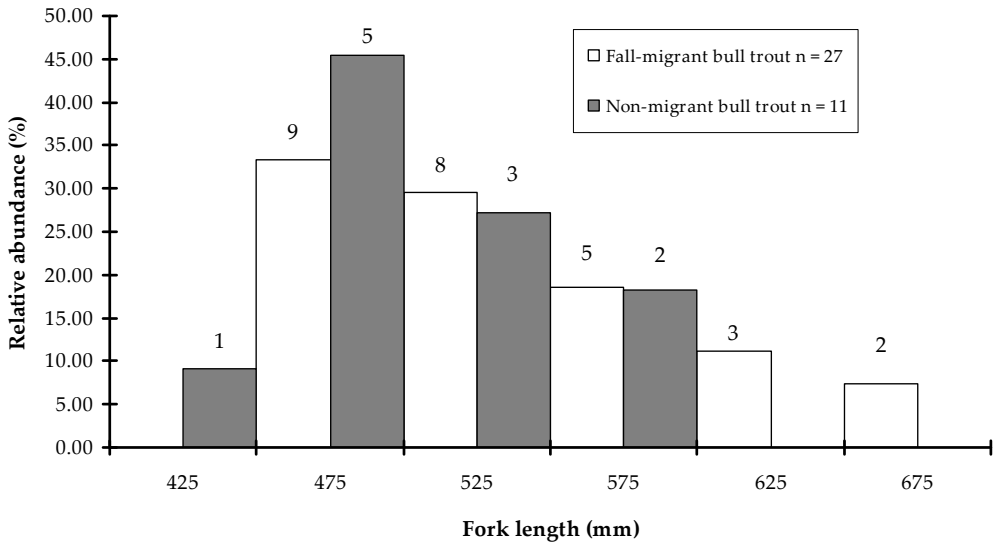

Figure 2. Length-frequency distribution of fall-migrant and non-migrant bull trout in the upper North Saskatchewan River and Abraham Lake during the 2002-2003 survey. Numbers above bars represent the number of fish in each category.

Twenty-seven (77%) of 35 bull trout radio-tagged before the winter of 2002/2003 migrated to over-wintering locations. All 17 2002 fall-migrant bull trout left tributaries to find suitable over-wintering areas in the mainstem upper North Saskatchewan River or Abraham Lake. Ten (56%) of the 18 non-fall-migrant bull trout migrated for over-wintering purposes.

4.1.2 Timing

The earliest migrations to tributaries were observed on 7 July in 2002 and 13 June in 2003, whereas the latest were observed on 3 September in 2002 and 11 September in 2003. In 2002, 82% of fall-migrant bull trout started migrations to tributaries by 21 August and remained in tributaries until 6 October. In 2003, 89% of the fall-migrants started migrations to tributaries by 26 August and 26% (n = 4) still occupied tributaries during the last tracking event on 25 September.

Migrations toward over-wintering locations were observed as early as 8 August 2002. Fifty-nine percent of the 27 radio-tagged bull trout that migrated towards over-wintering areas did so between 3 September and 6 October 2002. Another 30% had migrated to over-wintering locations by 6 December 2002. The remaining 11% migrated to over-wintering locations before 27 February 2003.

4.1.3 Distances

Migration distances for fall-migrant bull trout ranged from 1.0 to 57.5 km with a mean of 23.0 $\pm$ 16.8 km in 2002 and from 1.0 to 63.5 km with a mean of 27.3 $\pm$ 21.6 km in 2003. The mean distance traveled by fall-migrant bull trout for both years was 25.2 $\pm$ 19.3 km. The maximum likelihood estimates of mean distances traveled during August, September, and October were 9.6, 14.6, and 17.4 km, respectively (Figure 3). The greatest variation in distances traveled occurred in October and the least variation occurred in August. The PDFs of mean distances traveled by all radio-tagged bull trout during each calendar month are shown in Figure 4. The maximum likelihood estimates of distance traveled ranged from 2.6 to 5.8 km during the spring and summer months, 6.6 to 11.0 km during the fall months and 2.8 to 4.6 km during the winter months (Table 3).

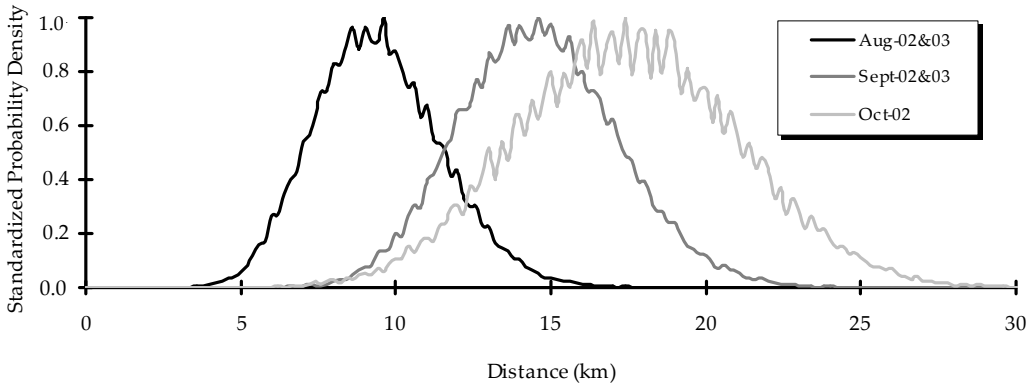

Figure 3. Probability density functions of mean distance traveled per month by fall-migrant bull trout in the upper North Saskatchewan River and Abraham Lake during the fall spawning period. Data from 2002 and 2003 have been pooled.

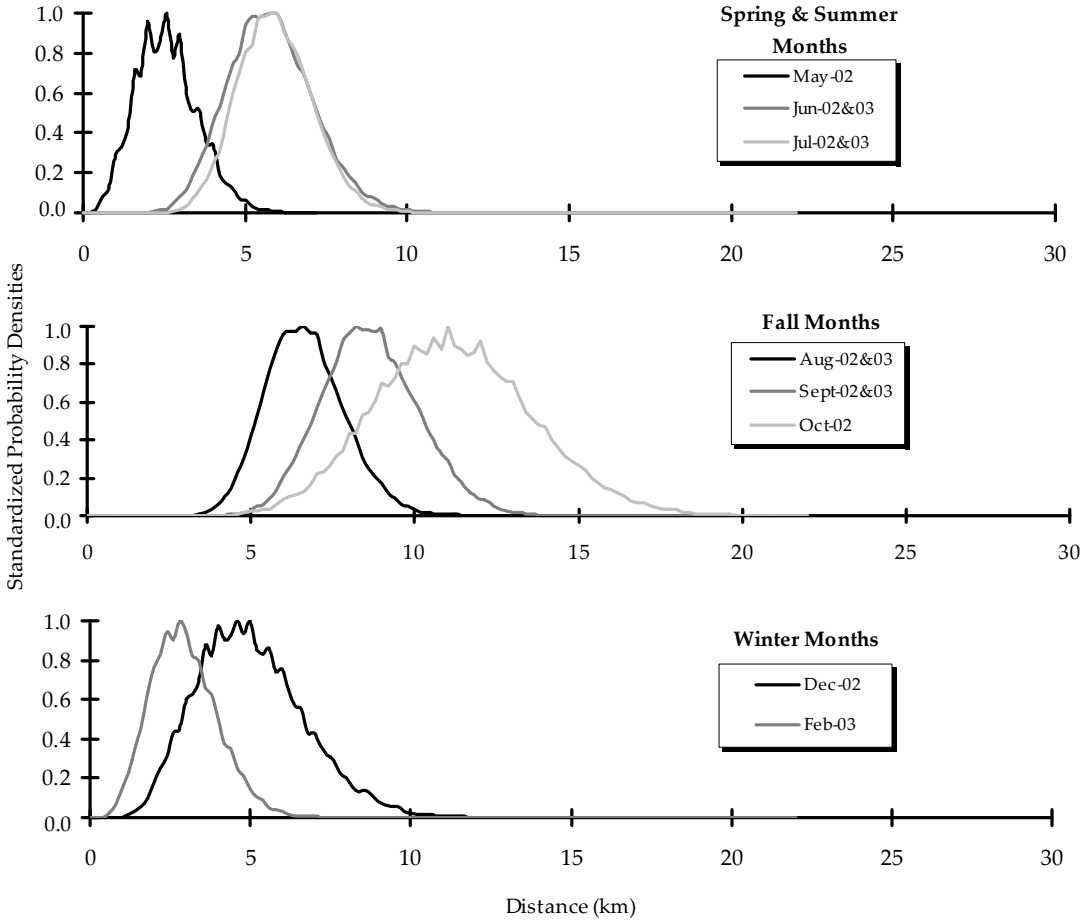

Figure 4. Probability density functions of mean distance traveled per month by all radio-tagged bull trout in the upper North Saskatchewan River and Abraham Lake. Data for 2002 and 2003 have been pooled.

Table 3. Maximum likelihood estimates of distances traveled, per month, by all radio-tagged bull trout in the upper North Saskatchewan River and Abraham Lake in 2002 and 2003.

Season	Month	Maximum likelihood estimate of distance traveled by all fish (km)
Spring/Summer	May[1]	2.6
	June[2]	5.8
	July[2]	5.8
Fall	August[2]	6.6
	September[2]	8.2
	October[1]	11.0
Winter	December[1]	4.6
	February[1]	2.8

[1]Data from 2002 only

[2]Data pooled for 2002 and 2003.

Migrations to over-wintering locations ranged from 1.0 to 42.5 km with a mean of 16.0 $\pm$ 12.3 km. Downstream movements (mean distance = 17.7 km) made up 57% of over-wintering migrations and the remaining 43% were upstream migrations (mean distance = 6.5 km). Movement within over-wintering areas ranged from 0 to 15 km (mean = 1.5 $\pm$ 3.3 km) between 6 December 2002 and 27 February 2003. Fifty percent of fish showed no movement and another 22% moved 0.5 km between the two winter tracking events.

4.2 Spawning and over-wintering areas

4.2.1 Spawning areas

In the fall of 2002 and 2003, radio-tagged bull trout migrated into four tributaries to the upper North Saskatchewan River and one tributary to Abraham Lake. These included the Howse River, Siffleur River, Owen Creek, Murchison Creek and Whiterabbit Creek (Figure 5, Table 4). In both years three radio-tagged fish that migrated into the Howse River continued to migrate upstream into Unnamed Creek #22932 (FMIS Waterbody Identification Number); a tributary to the Howse River that was observed to receive groundwater inputs. Two spawning sites, confirmed by presence of bull trout redds,

were identified during the study. The first was identified on 16 September 2002, 200 m upstream in Unnamed Creek #22932, and the second on 25 September 2003, 1.3 km upstream in Owen Creek (Figure 5). Geographic coordinates (UTM) of confirmed spawning locations are provided in Appendix 5. Geographic coordinates of locations for radio-tagged fish during the fall spawning period are provided in Appendix 6.

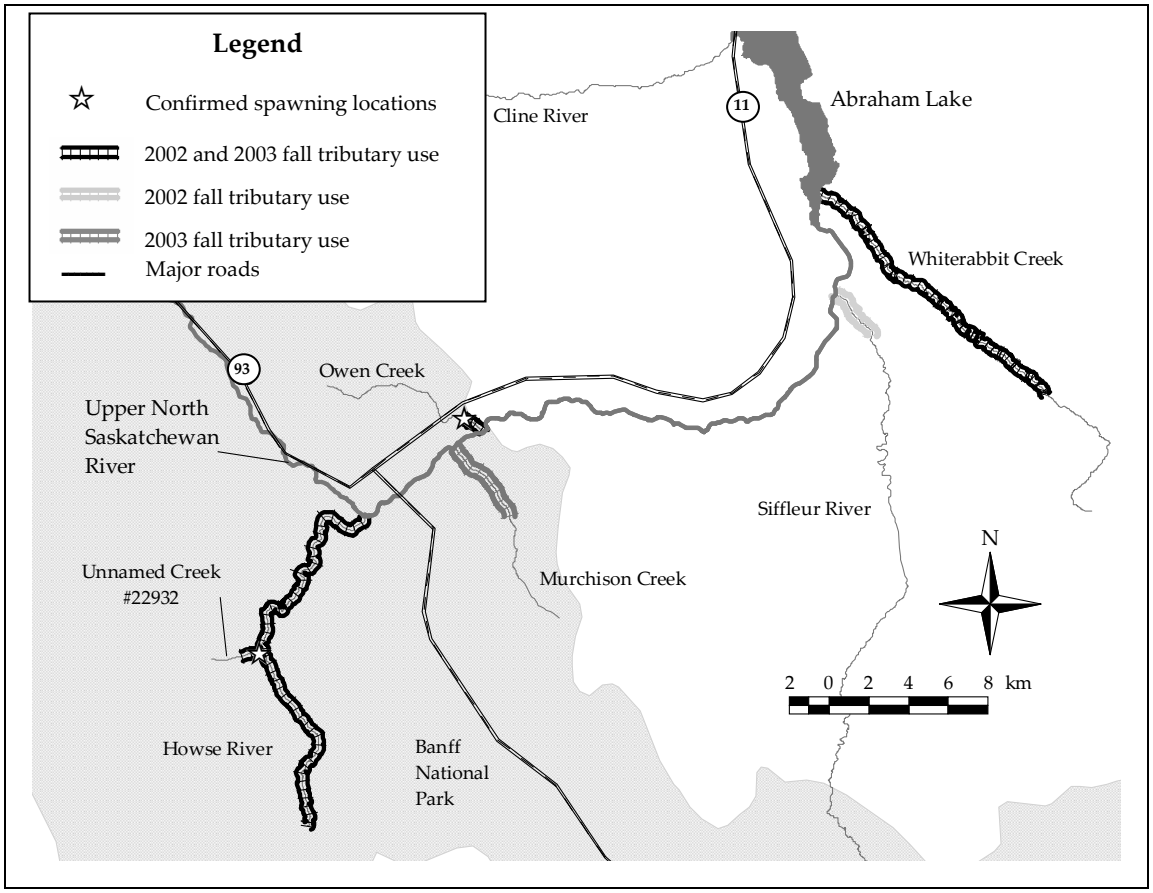

Figure 5. Spawning sites and tributaries used by radio-tagged bull trout during fall migrations in the upper North Saskatchewan River and Abraham Lake in 2002 and 2003.

Table 4. Number of fall-migrant bull trout located in tributaries of the upper North Saskatchewan River and Abraham Lake in 2002 and 2003.

Tributary name	2002		2003	
	Number of fish	Date	Number of fish	Date
Howse River	6	3 – 16 Sept	8	28 Jul – 25 Sept
Unnamed Creek #22932	3[a]	3 – 16 Sept	3[a]	4 – 25 Sept
Siffleur River	2	23 Jul – 16 Sept	0	N/A
Owen Creek	7	8 Aug – 16 Sept	5	22 Aug – 11 Sept
Murchison Creek	0	N/A	1	12 – 22 Aug and 4 – 25 Sept
Whiterabbit Creek	2	23 Jul – 16 Sept	4	12 Aug – 18 Sept

[a] Three of six bull trout in 2002 and three of eight bull trout in 2003 identified as migrating into the Howse River continued to migrate upstream into Unnamed Creek # 22932.

4.2.2 Over-wintering areas

The percentage occurrence of all contact locations for winter tracking events illustrate over-wintering areas used by 35 radio-tagged bull trout (Figure 6). Four radio-tagged bull trout (11%) over-wintered in Abraham Lake and 31 (89%) over-wintered in the Upper North Saskatchewan River up to the confluence of Owen Creek. Main-stem over-wintering locations were distributed over an area 2.5 to 28.0 km upstream of Abraham Lake. The greatest percentage occurrence (34%) was observed at Whirlpool Point, 11.0 km upstream of Abraham Lake (Figure 6). A summary of winter-tracking data is provided in Appendix 7.

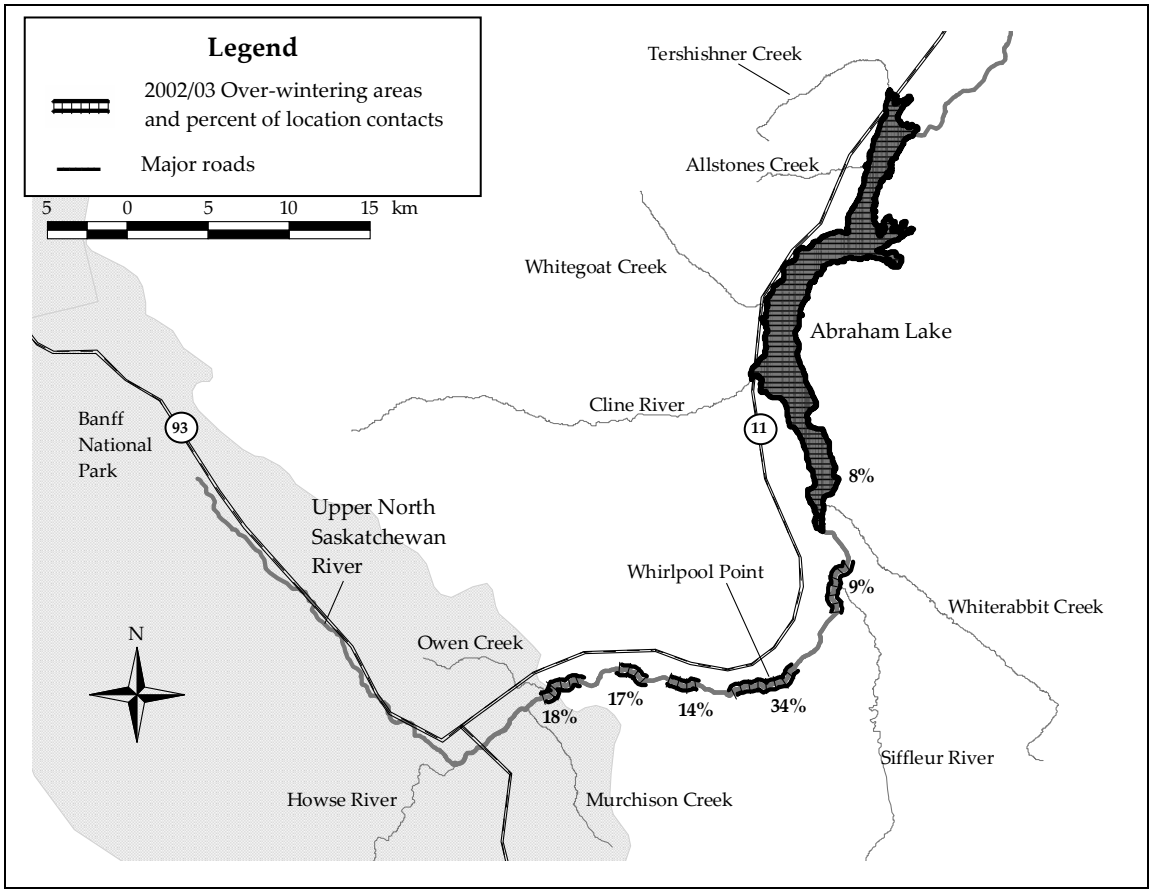

Figure 6. Over-wintering areas within the upper North Saskatchewan River and Abraham Lake showing percentage of all location contacts from pooled data collected 6 December 2002 and 27 February 2003 (65 location contacts total).

5.0 DISCUSSION

Our study provides fundamental information on the magnitude and timing of spawning and over-wintering migrations by bull trout that will be useful to fisheries managers in formulating management strategies for this species in the upper North Saskatchewan region. A description of spatial and temporal concentrations of bull trout in the upper North Saskatchewan River and Abraham Lake should help manage populations and protect spawning and over-wintering habitat above the Bighorn Dam.

Although we were unable to detect direct spawning activity by radio-tagged fish, spawning sites, confirmed by the presence of bull trout redds, were identified at observed fish locations (e.g., Unnamed Creek #22932 and Owen Creek) during the fall. Therefore, we assumed that fish location during the fall migration were associated with spawning activity. However, it was impossible to differentiate between spawning and non-spawning fall-migrant bull trout, as described by Swanberg (1997).

5.1 Magnitude, timing and distance of seasonal migrations

5.1.1 Magnitude

The magnitude of fall spawning migrations was similar in both years, being 49% and 47% of radio-tagged bull trout in 2002 and 2003, respectively. Only 32% of the fall-migrants tracked both years migrated in consecutive years (both 2002 and 2003) suggesting that bull trout in the upper North Saskatchewan River area may undergo alternate-year spawning similar to fluvial populations in the Clearwater River (Allan 1980), Flathead River (Fraley and Shepard 1989), upper Peace River (Baxter 1997), Kakwa River drainage (Hvenegaard and Fairless 1998; Hvenegaard and Thera 2001), and the Belly River (Clayton 2001).

Additional work examining the size-at-maturity and spawning periodicity would be necessary to make predictions regarding the true numbers of bull trout conducting fall spawning migrations in the study area.

The number of individuals migrating to over-wintering areas is heavily influenced by the availability of suitable over-wintering habitat and its proximity to fall-use areas (McLeod and Clayton 1997; Hvenegaard and Fairless 1998; Burrows et al. 2001). The magnitude of the over-wintering migration consisted of 77% of radio-tagged bull trout in the study area. Characteristic of fluvial populations, all fall-migrant bull trout in the upper North Saskatchewan River and Abraham Lake did not over-winter in the tributaries presumably used for spawning. This pattern of habitat use necessitated 63% of the over-wintering migrations observed as fall-migrant bull trout moved out of smaller order tributaries. Approximately half (56%) of the non-fall-migrant bull trout also contributed to the number of individuals that underwent over-wintering migrations. The remaining non-migrant bull trout found suitable over-wintering conditions overlapping with fall-use areas in the mainstem upper North Saskatchewan River. The pattern of spawning periodicity could have direct implications on the yearly variation in the number of individuals carrying out over-wintering migrations in the study area as fluvial bull trout are prone to move from smaller order fall-use tributaries to mainstem locations to over-winter.

5.1.2 Timing

Our telemetry data showed that fall spawning migrations were initiated as early as the beginning of July in 2002 and mid-June in 2003. Consistent with what has been documented in other bull trout movement studies (Rhude and Rhem 1995; McLeod and Clayton 1997; Swanberg 1997; Fraley and Sheppard 1989; Hvenegaard and Fairless 1998), the majority of radio-tagged bull trout (82% in 2002 and 89% in 2003) entered spawning tributaries prior to the end of August. The early summer movement pattern (July 2002 and June 2003) of the upper North Saskatchewan River area bull trout is similar to the early summer migrations toward spawning tributaries observed in the Peace River (RL&L 1992), the upper Athabasca River (McLeod and Clayton 1997), and the Blackfoot River (Swanberg 1997), but is earlier than those described for bull trout in the Clearwater River (Rhude and Rhem 1995) and the Kakwa River (Hvenegaard and Fairless 1998) drainages. Decreasing stream temperatures and shortening day lengths have been suggested as the primary cues that trigger the onset of spawning migrations in fishes (Swanberg 1997).

Tributaries were occupied until 16 September in 2002 and on the last sampling date, 25 September, in 2003. Return migration (individuals traveling away from spawning areas) peaked in October suggesting that fall-use tributaries may have been occupied up to October in the upper North Saskatchewan River area.

Over-wintering migrations have also been suggested to be initiated by cues related to declining stream temperatures (Jakober et al. 1998), as well as low stream flows (Swanberg 1997). Similar to the observations of Fernet and O'Neil (1997) and Burrows et al. (2001), the majority of migrations to over-wintering areas in the upper North Saskatchewan River and Abraham Lake study area took place from September to the end of October and all were completed by early December when stream flows are declining. The onset of over-wintering migrations for fall-migrant bull trout in the study area also coincides with the end of spawning activity. Consistent with McLeod and Clayton (1997), Hvenegaard and Fairless (1998) and Chandler et al. (2001), bull trout movement over the winter period was minimal.

5.1.3 Distances

Spawning and over-wintering migration distances seem to vary widely between different drainages, as well as among individual bull trout within a single system. Factors influencing the distance travelled by migrating bull trout include the overall size of the system (Swanberg 1997) and the location of seasonal habitat used, such as the proximity of smaller order tributaries used for spawning relative to summer and over-wintering habitat (Fraley and Shepard 1989). Migration distances in the upper North Saskatchewan River are influenced by the relatively close proximity of fall-use tributaries to summer-use areas and the presence of natural barriers to migrations (i.e., waterfalls on Owen Creek and the Siffleur River). The average distance of 25 km for spawning period migrations observed in our study suggest relatively short fall movements compared to those reported for other bull trout populations (Fraley and Shepard 1989; Swanberg 1997; Burrows et al. 2001). For example, migrations of an adfluvial population in the Flathead River, Montana was observed to reach distances of up to 275 km (Fraley and Shepard 1989).

5.2 Spawning and over-wintering areas

5.2.1 Spawning areas

Specific bull trout spawning locations were identified in Unnamed Creek #22932, a tributary to the Howse River, and Owen Creek, both of which are located within Banff National Park. Groundwater influence, described as an important characteristic of bull trout spawning-site selection (Allan 1980; Fairless et al. 1994; Boag and Hvenegaard 1997; Hvenegaard and Fairless 1998), was observed at both locations. Additional fall-use tributaries in the study area, presumably containing spawning habitat, included the Howse River, Siffleur River, Murchison Creek, and Whiterabbit Creek. Although 38 bull trout were radio-tagged the locations of these fish during two fall spawning periods may not have shown all potential fall-use tributaries in the study area. Captures of bull trout < 100 mm FL have been reported from Loudon Creek, Spreading Creek, Tershishner Creek, Whitegoat Creek and three unnamed tributaries in the summer and fall of 1994, 2000, and 2002 (McGillivary 1994; Gardiner et al. 2001; Rodtka 2002), respectively, suggesting spawning habitat may also be present in other tributaries to the upper North Saskatchewan River and Abraham Lake not occupied by radio-tagged bull trout.

5.2.2 Over-wintering areas

Telemetry data indicates suitable over-wintering habitat is present throughout much of the main-stem in the upper North Saskatchewan River up to the confluence of Owen Creek. Most of these sites were characterized by groundwater input and deep pools typical of bull trout over-wintering habitats (Brown and Mackay 1995; McCart 1997; Hvenegaard and Fairless 1998). Consistent with other fluvial populations (McCart 1997), fall-use tributaries were not used for over-wintering. It was initially suspected that Abraham Lake would provide preferred over-wintering conditions. However 89% of radio-tagged bull trout selected over-wintering sites in the upper North Saskatchewan River main-stem and seemed to avoid the reservoir.

5.3 Conclusion

Spatial and temporal patterns of bull trout distributions described in the upper North Saskatchewan River above the Bighorn Dam should aid in the conservation of the species. In addition, spawning and over-wintering areas have been identified to assist resource managers and development planners to protect habitat from potentially negative disturbances and alterations associated with various industrial practices.

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7.0 APPENDICES

Appendix 1. Summary of bull trout capture and radio-tag deployment in the upper North Saskatchewan River and Abraham Lake study area, 2002 - 2003.

Tag deployment	Bull Trout ID (radio frequency)	Fork length (mm)	Capture method
22-Apr-02	148.56	527	Angling
22-Apr-02	148.66	582	Angling
22-Apr-02	148.68	656	Angling
22-Apr-02	148.70	600	Angling
23-Apr-02	148.72	510	Angling
27-Apr-02	148.58	558	Angling
27-Apr-02	148.64	484	Angling
5-May-02	148.42	522	Angling
5-May-02	148.50	515	Angling
6-May-02	148.52	483	Angling
6-May-02	148.54	535	Angling
11-May-02	148.76	450	Angling
12-May-02	148.34	554	Electrofishing
12-May-02	148.48	573	Electrofishing
12-May-02	149.38	483	Angling
12-May-02	149.40	535	Electrofishing
12-May-02	150.80	521	Electrofishing
13-May-02	149.50	475	Electrofishing
13-May-02	149.54	481	Electrofishing
13-May-02	150.38	489	Electrofishing
13-May-02	150.4	460	Electrofishing
13-May-02	150.62	504	Electrofishing
13-May-02	150.70	506	Electrofishing
15-May-02	148.78	651	Angling
15-May-02	150.36	471	Angling
15-May-02	150.74	583	Angling
19-May-02	148.32	576	Angling
19-May-02	148.40	472	Angling
19-May-02	148.46	485	Angling
19-May-02	149.32	511	Angling
19-May-02	150.42	475	Angling
19-May-02	150.46	498	Angling
19-May-02	150.48	480	Angling
19-May-02	150.66	517	Angling
9-July-02	150.76	446	Angling
14-Apr-03	149.44	649	Angling
1-May-03	148.60	551	Gillnetting[1]
15-May-03	150.44	607	Angling

[1]Gillnetting performed by NAIT.

Appendix 2. Summary table showing the number of contacts for each radio-tagged bull trout tracked in the upper North Saskatchewan River and Abraham Lake in 2002 and 2003.

Bull trout ID (radio frequency)	Number of contacts made on tracking events
148.32	17
148.34	10
148.40	18
148.42	16
148.46	17
148.48	20
148.50	18
148.52	22
148.54	6
148.56	20
148.58	20
148.60	4
148.64	12
148.66	9
148.68	13
148.70	15
148.72	18
148.76	20
148.78	16
149.32	17
149.38	17
149.40	19
149.44	6
149.50	14
149.54	14
150.36	18
150.38	20
150.40	15
150.42	19
150.44	8
150.46	19
150.48	18
150.62	18
150.66	17
150.70	15
150.74	15
150.76	6
150.80	9

Appendix 3. Percentage efficiency of tracking radio-tagged bull trout in the upper North Saskatchewan River and Abraham Lake in 2002 and 2003. Percentage efficiency equals the number radio tags located divided by the total number of radio tags deployed to date multiplied by 100.

Date	Event Notes	# Located	Total # Deployed	Percentage Efficiency
7-Jun-02	Float tracking	23	34	68
3-Jul-02	Aerial tracking	25	34	74
23-Jul-02	Aerial tracking	30	35	86
8-Aug-02	Aerial tracking	28	35	80
21-Aug-02	Aerial tracking	26	35	74
3-Sep-02	Aerial tracking	33	35	94
16-Sep-02	Aerial tracking	30	35	86
6-Oct-02	Aerial tracking	28	35	80
6-Dec-02	Aerial tracking	31	35	89
27-Feb-03	Aerial tracking	34	35	97
13-Jun-03	Aerial tracking	31	38	82
10-Jul-03	Aerial tracking	30	38	79
28-Jul-03	Aerial tracking	31	38	82
12-Aug-03	Aerial tracking	32	38	84
22-Aug-03	Aerial tracking	30	38	79
26-Aug-03	Aerial tracking	30	38	79
4-Sep-03	Aerial tracking	24	38	63
11-Sep-03	Aerial tracking	23	38	61
18-Sep-03	Aerial tracking	22	38	58
25-Sep-03	Aerial tracking	18	38	47

Appendix 4. Fall-migrant bull trout identified in the upper North Saskatchewan River and Abraham Lake study area in 2002 and 2003.

Bull trout ID (radio frequency)	2002 fall-migrants	2003 fall-migrants
148.32	✓	
148.34	✓	✓
148.42	✓	
148.48	✓	
148.50		✓
148.52	✓	✓
148.56		✓
148.58		✓
148.66	✓	
148.68	✓	✓
148.70		✓
148.72	✓	✓
148.76	✓	
148.78	✓	
149.32	✓	
149.38	✓	✓
149.40		✓
149.44[a]		✓
149.50		✓
150.36	✓	✓
150.38	✓	
150.40		✓
150.42	✓	✓
150.44[a]		✓
150.48	✓	
150.66	✓	✓
150.70		✓

[a]Bull trout deployed in 2003.

Appendix 5. Coordinates (UTM, NAD 83 Zone 11U) of confirmed bull trout spawning locations in the upper North Saskatchewan River and Abraham Lake study area in 2003.

Waterbody name	Visual observation	Date	UTM coordinates	
			Easting	Northing
Owen Creek	Bull trout redds	16-Sep-02	522141	5761394
Unnamed Creek[1]	Bull trout redds	25-Sep-03	511873	5749605

[1]Unnamed Creek # 22932 (FMIS) is a tributary to the Howse River.

Appendix 6. Tributary use by radio-tagged bull trout in the upper North Saskatchewan River and Abraham Lake study area in 2002 and 2003. UTM locations are projected in NAD83 zone 11U.

Bull trout ID (radio frequency)	Date	Waterbody name	UTM coordinates	
			Easting	Northing
148.34	03-Sep-02	Unnamed Creek[1]	511942.00	5749650.00
148.34	16-Sep-02	Howse River	512135.00	5750544.00
148.34	12-Aug-03	Howse River	514392.00	5745707.51
148.34	22-Aug-03	Howse River	513732.69	5746642.78
148.34	26-Aug-03	Howse River	512882.00	5747916.00
148.42	03-Sep-02	Howse River	514302.00	5740890.00
148.42	16-Sep-02	Howse River	514310.00	5741618.00
148.50	12-Aug-03	Howse River	514594.00	5754036.00
148.50	22-Aug-03	Howse River	514692.00	5754283.00
148.50	26-Aug-03	Howse River	513606.00	5752776.00
148.50	04-Sep-03	Unnamed Creek[1]	511942.00	5749650.00
148.50	11-Sep-03	Unnamed Creek[1]	511942.00	5749650.00
148.50	18-Sep-03	Unnamed Creek[1]	511873.00	5749605.01
148.58	12-Aug-03	Howse River	514522.00	5754247.00
148.58	22-Aug-03	Unnamed Creek[1]	511942.00	5749650.00
148.58	26-Aug-03	Unnamed Creek[1]	512294.00	5751408.00
148.58	04-Sep-03	Unnamed Creek[1]	511884.89	5750582.52
148.58	18-Sep-03	Unnamed Creek[1]	511562.00	5749576.00
148.58	25-Sep-03	Unnamed Creek[1]	511698.00	5749592.00
148.66	03-Sep-02	Unnamed Creek[1]	511942.00	5749650.00
148.66	16-Sep-02	Howse River	512953.00	5747682.00
148.68	03-Sep-02	Howse River	514117.00	5743150.00
148.68	16-Sep-02	Howse River	512392.00	5751630.00
148.68	12-Aug-03	Howse River	513949.00	5753339.00
148.68	22-Aug-03	Unnamed Creek[1]	511942.00	5749650.00
148.68	04-Sep-03	Howse River	514048.00	5743287.00
148.68	11-Sep-03	Howse River	514509.00	5740735.00
148.68	18-Sep-03	Howse River	514048.00	5743134.00
148.70	12-Aug-03	Howse River	514871.00	5744998.00
148.70	22-Aug-03	Howse River	514871.00	5744998.00
148.70	26-Aug-03	Howse River	514871.00	5744998.00
148.70	04-Sep-03	Howse River	514620.00	5744416.00
148.72	03-Sep-02	Howse River	514041.00	5743220.00
148.72	16-Sep-02	Howse River	514462.00	5744240.00
148.72	12-Aug-03	Howse River	514781.00	5754413.00
148.72	22-Aug-03	Howse River	513163.00	5751990.00
148.72	26-Aug-03	Howse River	512494.00	5749219.00

Appendix 6. Continued

Bull trout ID (radio frequency)	Date	Waterbody name	UTM coordinates	
			Easting	Northing
148.72	04-Sep-03	Howse River	514154.00	5743747.00
148.72	11-Sep-03	Howse River	514048.00	5743134.00
148.72	18-Sep-03	Howse River	514048.00	5743134.00
148.76	03-Sep-02	Unnamed Creek[1]	511942.00	5749650.00
148.76	16-Sep-02	Unnamed Creek[1]	511933.00	5749610.00
150.42	22-Aug-03	Howse River	516952.00	5756108.32
150.42	26-Aug-03	Howse River	515916.00	5756048.00
150.42	04-Sep-03	Howse River	514964.00	5755997.00
150.42	11-Sep-03	Howse River	514964.00	5755997.00
150.70	12-Aug-03	Howse River	513163.00	5751990.00
150.70	22-Aug-03	Howse River	513350.00	5752537.00
150.70	26-Aug-03	Howse River	515012.00	5755757.00
149.38	08-Aug-02	Siffleur River	542602.13	5765770.24
149.38	21-Aug-02	Siffleur River	542602.13	5765770.24
149.38	03-Sep-02	Siffleur River	542602.13	5765770.24
149.38	16-Sep-02	Siffleur River	542602.13	5765770.24
150.36	16-Sep-02	Siffleur River	541005.15	5767515.62
149.50	22-Aug-03	Owen Cr	522699.56	5761042.12
149.50	26-Aug-03	Owen Cr	522141.57	5761394.10
150.38	29-Aug-02	Owen Cr	522913.59	5760877.54
150.38	03-Sep-02	Owen Cr	522561.31	5761178.03
150.38	16-Sep-02	Owen Cr	522870.24	5760920.62
150.40	27-Aug-03	Owen Cr	522880.44	5760910.49
150.42	03-Sep-02	Owen Cr	522141.57	5761394.10
150.48	08-Aug-02	Owen Cr	522141.57	5761394.11
150.66	03-Sep-02	Owen Cr	522561.31	5761178.03
150.66	26-Aug-03	Owen Cr	522699.56	5761042.12
150.66	27-Aug-03	Owen Cr	522561.31	5761178.03
150.66	04-Sep-03	Owen Cr	522415.26	5761183.18
149.38	12-Aug-03	Murchison Cr	523098.20	5758555.58
149.38	22-Aug-03	Murchison Cr	523287.96	5758389.73
149.38	04-Sep-03	Murchison Cr	523287.96	5758389.73
149.38	11-Sep-03	Murchison Cr	523287.96	5758389.73
149.38	25-Sep-03	Murchison Cr	524411.19	5756641.96
148.48	08-Aug-02	Whiterabbit Cr	550651.72	5763462.56
148.48	21-Aug-02	Whiterabbit Cr	550696.08	5763311.14
148.48	03-Sep-02	Whiterabbit Cr	551303.84	5762758.28
148.48	16-Sep-02	Whiterabbit Cr	551303.84	5762758.27
148.78	08-Aug-02	Whiterabbit Cr	540840.84	5772226.00
148.78	21-Aug-02	Whiterabbit Cr	546193.15	5767177.21

Appendix 6. Continued

Bull trout ID (radio frequency)	Date	Waterbody name	UTM coordinates	
			Easting	Northing
148.78	03-Sep-02	Whiterabbit Cr	551303.84	5762758.28
148.78	16-Sep-02	Whiterabbit Cr	550580.32	5763496.97
149.40	18-Sep-03	Whiterabbit Cr	540307.52	5772458.95
149.40	25-Sep-03	Whiterabbit Cr	540307.52	5772458.95
149.44	12-Aug-03	Whiterabbit Cr	549991.66	5763803.94
149.44	26-Aug-03	Whiterabbit Cr	549991.66	5763803.94
149.44	04-Sep-03	Whiterabbit Cr	550358.23	5763563.88
149.44	11-Sep-03	Whiterabbit Cr	548366.87	5765129.35
150.36	18-Sep-03	Whiterabbit Cr	540851.97	5772210.24
150.44	11-Sep-03	Whiterabbit Cr	541923.59	5771268.45
150.44	18-Sep-03	Whiterabbit Cr	544060.84	5768440.65
150.44	25-Sep-03	Whiterabbit Cr	550580.32	5763496.97

[1]Unnamed Creek # 22932 (FMIS) is a tributary to the Howse River.

Appendix 7. Bull trout locations (UTM NAD83 Zone 11U) during winter tracking events conducted in the upper North Saskatchewan River and Abraham Lake study area in 2002 and 2003.

Tracking date	Bull trout ID (radio frequency)	Waterbody name	UTM coordinates	
			Easting	Northing
6-Dec-02	148.32	N.Sask.R	522685.32	5760598.40
	148.34	N.Sask.R	535958.78	5761371.10
	148.40	N.Sask.R	534432.11	5760903.95
	148.42	N.Sask.R	532252.57	5761366.30
	148.48	N.Sask.R	537890.45	5761891.94
	148.50	N.Sask.R	536091.81	5761394.44
	148.52	N.Sask.R	523352.36	5761014.91
	148.56	N.Sask.R	531600.08	5761287.25
	148.58	N.Sask.R	528076.39	5762203.38
	148.64	N.Sask.R	536420.89	5761220.56
	148.66	N.Sask.R	524314.45	5761508.22
	148.68	N.Sask.R	525089.24	5761550.29
	148.70	N.Sask.R	528563.15	5761881.15
	148.72	N.Sask.R	536420.89	5761220.56
	148.76	N.Sask.R	535631.26	5761223.67
	149.32	N.Sask.R	528354.48	5762138.57
	149.38	N.Sask.R	536420.89	5761220.56
	149.40	N.Sask.R	541577.20	5768954.25
	149.50	N.Sask.R	523292.72	5760932.74
	149.54	N.Sask.R	528354.48	5762138.57
	150.36	N.Sask.R	540815.34	5767644.36
	150.38	N.Sask.R	528076.39	5762203.38
	150.40	N.Sask.R	528076.39	5762203.38
	150.42	N.Sask.R	540852.14	5765873.53
	150.46	N.Sask.R	532252.57	5761366.30
	150.48	N.Sask.R	524314.45	5761508.22
	150.62	N.Sask.R	529115.31	5761622.40
	150.66	Abraham Lake	539753.00	5772913.21
	150.70	N.Sask.R	530481.14	5761662.17
	150.74	N.Sask.R	536420.89	5761220.56
	150.76	N.Sask.R	536420.89	5761220.56

Appendix 7. Continued

Tracking date	Bull trout ID (radio frequency)	Waterbody name	UTM coordinates	
			Easting	Northing
27-Feb-03	148.32	N.Sask.R	522942.39	5760502.37
	148.34	N.Sask.R	535317.74	5761260.24
	148.40	N.Sask.R	535768.18	5761276.19
	148.42	N.Sask.R	534633.27	5761108.16
	148.48	N.Sask.R	538277.09	5762445.46
	148.50	Abraham Lake	539713.27	5772090.66
	148.52	N.Sask.R	523352.36	5761014.91
	148.54	Abraham Lake	537876.40	5786537.12
	148.56	N.Sask.R	531600.08	5761287.25
	148.58	N.Sask.R	527389.79	5762343.03
	148.64	N.Sask.R	536420.89	5761220.56
	148.66	N.Sask.R	524314.45	5761508.22
	148.68	N.Sask.R	525089.24	5761550.29
	148.70	N.Sask.R	535317.74	5761260.24
	148.72	N.Sask.R	536306.53	5761267.24
	148.76	N.Sask.R	535317.74	5761260.24
	148.78	Abraham Lake	540079.49	5774175.77
	149.32	N.Sask.R	528354.48	5762138.57
	149.38	N.Sask.R	536420.89	5761220.56
	149.40	N.Sask.R	540852.14	5765873.53
	149.50	N.Sask.R	523352.36	5761014.91
	149.54	N.Sask.R	530481.14	5761662.17
	150.36	N.Sask.R	540712.11	5767486.24
	150.38	N.Sask.R	528354.48	5762138.57
	150.40	N.Sask.R	527939.16	5762281.23
	150.42	N.Sask.R	540852.14	5765873.53
	150.46	N.Sask.R	532041.50	5761427.30
	150.48	N.Sask.R	524314.45	5761508.22
	150.62	N.Sask.R	531600.08	5761287.25
	150.66	Abraham Lake	539728.46	5773868.31
	150.70	N.Sask.R	530786.97	5761527.21
	150.74	N.Sask.R	536420.89	5761220.56
	150.76	N.Sask.R	536306.53	5761267.24
	150.80	N.Sask.R	536306.53	5761267.24

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