FISHERY RESEARCH

KOOTENAI RIVER FISHERIES INVESTIGATIONS: SALMONID STUDIES

BULL TROUT STUDIES SUMMARY REPORT
April 1, 1998 — April 30, 2010

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ABSTRACT

Bull trout *Salvelinus confluentus* are listed as a threatened species and native to the Kootenai River, Idaho and Montana USA and British Columbia, Canada. Little is known about their life history and movements downstream of Kootenai Falls, Montana. From 1998 through 2006, we monitored 18 bull trout (of 27 total) with radio and or sonic transmitters during migration, spawning, and post-spawn periods and located them a total of 1,276 times. Temperature of the Kootenai River during spawning migration ranged from 7.1 to 15.0°C and averaged 11.4°C for seven bull trout that made one or more spawning migrations. We found two bull trout life history forms; 16 bull trout were likely fluvial, and two were adfluvial. We found evidence of likely spawning for only about 33% of the bull trout we tracked; of those, 50% were annual spawners and 50% alternate year spawners. Population fragmentation from both anthropogenic (Libby Dam) and natural (Kootenai Falls) sources may limit recruitment of bull trout in the Idaho and Montana reach by isolating entrained fish from natal spawning locations. Results suggested about 67% of the adult bull trout concentrated below Kootenai Falls during the spawning season and likely did not spawn. Two tagged bull trout were located in Kootenay Lake; one fish moved 228 km from Kootenay Lake, British Columbia to Kootenai Falls, Montana. Bull trout also used several tributary streams outside of the spawning season possibly as a thermal refuge. Annual bull trout redd counts from 2000 to 2009 ranged from zero to 32 (primarily in the Callahan Creek drainage because it was the only stream bull trout were found to spawn in). The annual out-migration estimate of juvenile bull trout from Callahan Creek was 68 fish, which ranged from about 100 to 200 mm TL. The age distribution of juvenile bull trout (n = 15) was 13% age 1, 73% age 2, 7%, age 3, and 7% age 4. Transboundary management should consider population fragmentation, life histories, and spawning frequency in a comprehensive management and habitat plan.

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INTRODUCTION

Bull trout *Salvelinus confluentus* are native to the Kootenai River (spelled Kootenay in Canada) in north Idaho and Montana (Simpson and Wallace 1982). The fish were listed as threatened on November 1, 1998 by the US Fish and Wildlife Service (USFWS) under the Endangered Species Act (ESA) (USFWS 2002; 2006) in the Columbia and Klamath drainages of four western states (Washington, Idaho, Oregon, and Montana),

The bull trout has a preference for coldwater lakes and streams and as a consequence has evolved several potamodromous life history patterns including fluvial (reside and spawn in streams or rivers; Goetz 1989), lacustrine-adfluvial (migrate between rivers and lakes and spawn in inlet tributaries; Varley and Gresswell 1988), allacustrine (migrate between lakes and rivers, rear in lakes and spawn in outlet tributaries; DuPont et al. 2007), adfluvial (reside in lakes and may spawn in rivers or streams), and variations thereof. It was not known which of these life history patterns may be present in the Kootenai River of Idaho.

Although much work has been done on bull trout across their listed range, little is known about the life history of bull trout residing the Kootenai River downstream of Kootenai Falls, Montana, Idaho, and BC. The objectives of this investigation were to examine bull trout movement patterns, identify spawning locations of bull trout having some residence time in Idaho, estimate spawning escapement for various tributaries, determine juvenile densities for some streams, and determine the age distribution of out-migrating juvenile bull trout. Acquiring this information will be valuable for preparing future transboundary management plans.

STUDY AREA

The Kootenai River originates in Kootenay National Park, BC. The river flows south into Montana and turns northwest at Jennings, near the site of Libby Dam, at river kilometer (rkm) 352.4 (Figure 1). Kootenai Falls, 42 rkm downstream of Libby Dam at rkm 310, was a presumed migration barrier to upstream fish movement (Chapman and May 1986), though a bull trout has since been documented to have passed upstream through the falls reach (M. Hensler, Montana Fish, Wildlife and Parks, personal communication). From Montana, the Kootenai River passes into Idaho at rkm 275.7. In Idaho, the river has the following three reaches: 1) the Canyon Reach (22 km) from the Montana border to the Moyie River (rkm 257), which is comprised of substantial reaches of cobbles, gravels, some boulders, with pools to 30 m; 2) the Braided Reach (10 km) from the Moyie River to Bonners Ferry, which is shallower and cobbles and gravels; and 3) the Meandering Reach (73 km) from Bonners Ferry to the Canadian border comprised of deep pools to 32 m in depth, and silt and sand substrate (Fredericks and Hendricks 1997; Barton 2004). Upstream from Bonners Ferry, the channel has an average gradient of 0.6 m/km, and the velocities are often higher than 0.8 m/s. Downstream from Bonners Ferry, the river slows to velocities typically less than 0.4 m/s; the average gradient is 0.02 m/km, and the channel deepens as the river meanders north through the Kootenai River Valley. The river returns to BC at rkm 170 and enters the South Arm of Kootenay Lake at rkm 121. The river leaves the lake through the West Arm of Kootenay Lake and flows to its confluence with the Columbia River at Castlegar, BC. Lower Bonnington Falls (now a series of four dams), 16 km downstream from Nelson, BC formed a natural barrier to upstream movement of fish from the lower Kootenay River (Northcote 1973). The Kootenai Basin drains an area of 49,987 km^2 (Bonde and Bush 1975).

Historic pre-dam flows for the Kootenai River during spring ranged from 1,416 to 2,832 m^3/s, but after Libby Dam peak runoff events were generally in the range of 250-450 m^3/s. During winter, flows ranged from about 170 to 230 m^3/s while post-dam winter discharges are now three to four times greater, up to 652 m^3/s, than they were historically when conditions were relatively stable. The temperature regime and nutrient supply of the Kootenai River are also thought to be important factors for burbot spawning and recruitment; they too have changed since construction of Libby Dam (Partridge 1983; Snyder and Minshall 1996). The river temperature also changed, it was about 1°C cooler in the summer and 4°C warmer in winter (Partridge 1983) and the river was less productive (Woods 1982; Snyder and Minshall 1996).

The Canyon Reach of Montana and Idaho have tributaries in which bull trout are occasionally found and some in which they are known to spawn: Lake and O'Brien creeks in Montana and Boulder and North and South Callahan creeks in Idaho as well as the Moyie River (Figure 1). There are no tributaries in the braided reach known to be used by bull trout. However, adult and immature bull trout have been found in Snow, Myrtle, Caribou, Grass (U. S. Forest Service, unpublished report), and Long Canyon creeks (Paragamian 1994; Walters et al. in progress).

METHODS

Adult Bull Trout Collections

Bull trout were collected during spring and autumn night electrofishing in the Idaho reach of the Kootenai River from rkm 244.5 to 275.5 and within weir trap in O'Brien Creek, Montana. Bull trout were also caught coincidentally in winter hoop net sets fished for burbot *Lota lota maculosa* (Paragamian et al. 2008). Captured bull trout were anesthetized, weighed (g) and measured for total length (TL) in mm. Gender was determined if gametes could be expressed with moderate pressure to the ventral region, if a kype (male) was obvious, or gonads visible during surgery.

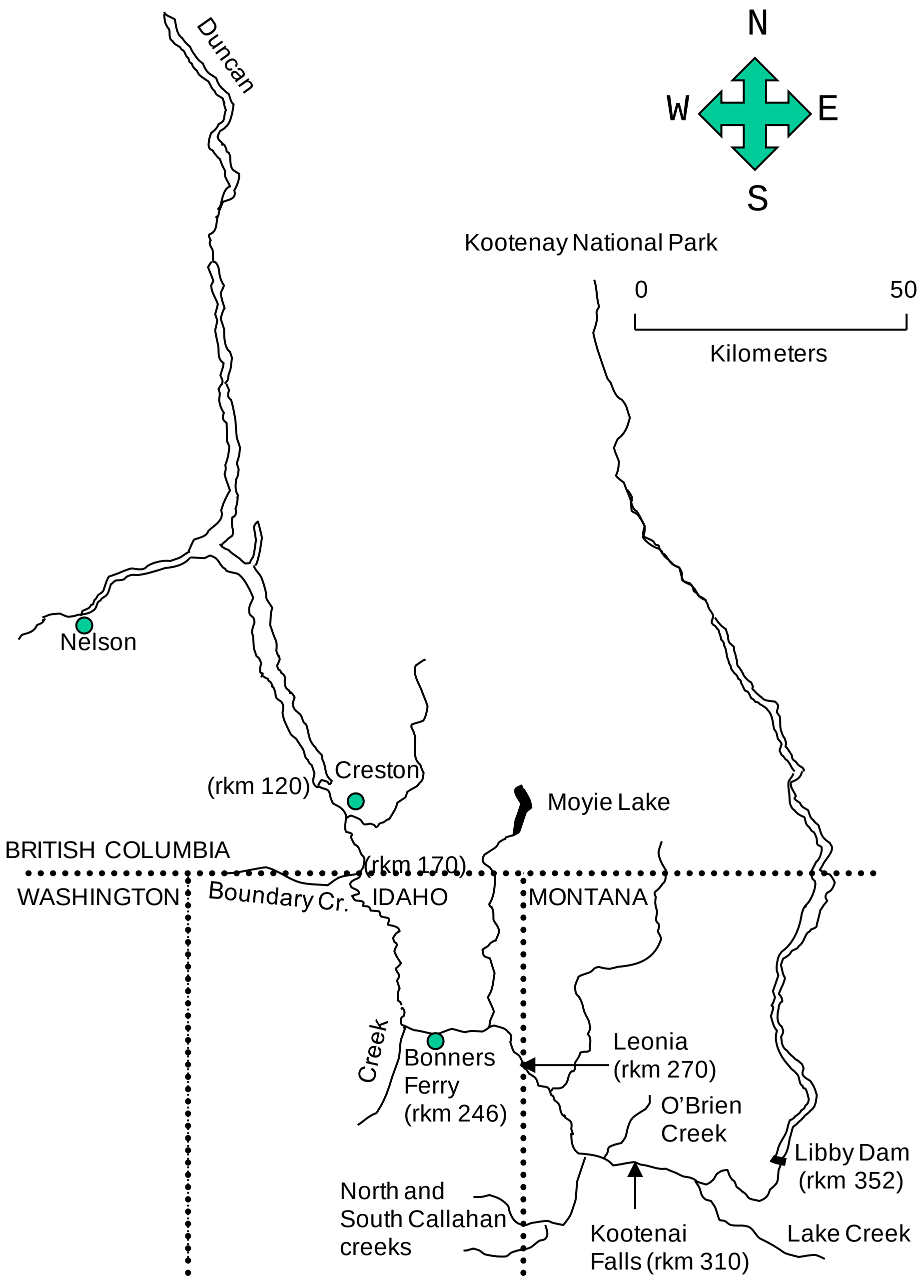

Figure 1. The Kootenai (Kootenay) River drainage showing some major tributaries and landmarks.

Telemetry

Radio and ultrasonic telemetry were used to monitor bull trout movements. Following the recommendation of Winter (1996), fish were not equipped with transmitters that weighed more than 2% of the fish's weight out of water. Bull trout were placed ventral side up in a wooden surgery cradle lined with 6 mm hardware cloth. The cradle was in a plastic container holding an anesthetic bath. The cradle was angled downward, partially submerging the gills, while the abdomen (surgical area) remained above the water line. During surgery, an assistant bathed the gills with anesthetic or fresh water as needed.

An incision into the abdominal cavity was made slightly on either side of the midventral line about halfway between the pectoral and pelvic fins. The body wall was then pierced with a catheter needle just anterior to the pelvic girdle and about 1/3 the distance from the ventral surface to the lateral line to serve as an exit hole for the antenna. A slightly modified shielded needle technique (Ross and Kleiner 1982) was used. To prevent internal damage from the catheter, a small spoon was inserted through the abdominal incision to shield the internal organs while piercing the body wall. The transmitter was then placed into the abdominal cavity with the catheter needle still inserted through the body wall. The antenna was then threaded into the catheter needle and the needle extracted, in turn leaving the antenna exiting the hole through the body wall. The abdominal incisions were then closed with 3/0 polypropylene sutures using a cutting NCP-2 needle. To expedite recovery, the assistant began bathing the gills with fresh water at initiation of wound closure. The trout were typically held in live-cars until fully recovered (typically 20 min) and then released at the capture site, though some fish were released the following morning.

Low-frequency (30–31 MHz) radio tags were used to maximize signal transmission in the deep, oligotrophic waters of the Kootenai River (Winter 1996). Five different transmitter types were used; with life expectancies of 360, 730, and 912 d; models 6, F1840, F1850, 5955, and 10-35; (Advanced Telemetry Systems, Isanti, Minnesota, USA). Most radio transmitters were active for 8 h and off for 16 h each d in order to increase the lifespan of the tag. Radio signals were at the rate of 40 or 50 pulses per minute (ppm). In 2005, a concurrent telemetry study on Kootenai River white sturgeon *Acipenser transmontanus* incorporated the use of ultrasonic telemetry and stationary sonic receivers by tagging five bull trout with both radio and ultrasonic tags. Vemco V13-1L-R04K coded acoustic transmitters were surgically implanted. Each transmitter was 13 mm in diameter and 36 mm long, had an approximate battery life of three years, and weighed 6 grams in water. An array of passive Vemco VR2 sonic single channel fixed telemetry receivers were previously deployed from Kootenay Lake, BC upstream into Idaho near the Montana border (Rust and Wakkinen 2007; Neufeld and Rust 2009).

We attempted to locate radio-tagged bull trout at least once every month and once every week during spawning and migration periods. Radio telemetered bull trout were searched for by fixed-wing aircraft or by boat. The process was to start the telemetry flight at Kootenay Lake and fly upstream to Kootenai Falls. An additional flight over the lake was made if a fish was not located in the river or tributaries. The search area included the South and West Arms of Kootenay Lake, BC upstream to Kootenai Falls, Montana, including Idaho and Montana tributaries up to the first migration barrier (Figure 1). Radio signals from the same location in spawning tributaries lasting beyond the spawning season were assumed to represent mortalities or shed tags. Fish with ultrasonic transmitters were passively monitored via the stationary sonic receivers deployed at 53 locations, beginning in the North and South Arms of Kootenay Lake, BC and continuing upstream in the Kootenai River to the Idaho-Montana border (Rust and Wakkinen 2007; Neufeld and Rust 2009).

The spawning migration period was defined as the time bull trout began upstream movements towards spawning tributaries until the time they returned to a post-spawn home range location (an area where movement was <0.5 km between telemetry locations). The bull trout spawning migration period in our study was May 1-October 20 each year. The actual spawning season, September 1–October 20, was defined as the time bull trout were in tributaries to build redds and spawn, based on water temperatures and observations of fish by Downs (2000), Walters (2004), and unpublished IDFG data. Temperature of the Kootenai River was recorded at a station at Leonia, Montana (LEOI) at the Idaho-Montana border below Libby Dam (rkm 270). Estimated average daily temperature values were calculated from a station located at Bonners Ferry, Idaho (rkm 246).

Spawning Escapement Surveys

Bull trout redds are easy to count (Pratt 1984) and are useful in estimating the adult spawning escapement. Bull trout redd surveys were conducted for standardized index reaches in North Callahan, South Callahan, and Boulder creeks from 2000 through 2009 (usually during October 11-13). Each index reach was counted once during midday. Disturbed and cleaned gravel or cobble areas showing a pit and tailspill were identified as bull trout redds (Shepard and Graham 1983; Dunham et al. 2001). To estimate the number of adults in the spawning escapement we used an average of 3.2 adult bull trout for each redd counted in the annual surveys (Downs and Jakubowski 2005; Fraley and Shepard 1989).

We used a rotary screw trap in 2003 to validate bull trout spawning and escapement of recruitments from the Callahan Creek drainage of Idaho and Montana (Thedinga et al. 1994; Kennen et al. 1994). A mark-recapture technique was employed to estimate trap efficiency (TE) for juvenile bull trout (Seelbach et al. 1985; Kennen et al. 1994; Thedinga et al. 1994; Roper 1995) at the beginning of each week (typically Sunday).

The proportion of marked fish recaptured provides an estimate of TE. TE was estimated as (Thedinga et al. 1994):

$$TE = R/M \quad (1)$$

where:

R = number of marked fish recaptured
M = number of marked fish

Upper and lower 95% confidence limits for the TE were estimated using a normal approximation to the binomial distribution for large samples, when TE is small (<0.3) (Fleiss 1981):

$$\text{Lower 95\% CL} = P_L = \frac{(2np + c^2_{\alpha/2} - 1) - c_{\alpha/2}\sqrt{c^2_{\alpha/2} - (2 + 1/n) + 4p(nq + 1)}}{2(n + c^2_{\alpha/2})} \quad (2)$$

$$\text{Upper 95\% CL} = P_U = \frac{(2np + c^2_{\alpha/2} + 1) + c_{\alpha/2}\sqrt{c^2_{\alpha/2} + (2 - 1/n) + 4p(nq - 1)}}{2(n + c^2_{\alpha/2})} \quad (3)$$

where:

p = proportion in question (TE)
$q = 1-p$
n = sample size (number of marks released)
$c_{\alpha/2} = c_{.025} = 1.96$ (for df = ∞)

Our sample sizes were appropriate for the large sample approximation as defined by Fleiss (1981):

$$np \geq 5 \text{ and } nq \geq 5 \quad (4)$$

TE was used to estimate the total number of out-migrants from the unmarked catch for a given time period as (Thedinga et al. 1994):

$$N_t = U_t/\mathrm{TE}_t \quad (5)$$

where:

N_t = out-migrant estimate for time period t
U_t = unmarked catch for time period t
TE_t = trap efficiency for time period t

Successful estimates of TE were defined as recovering a minimum of ≥3 recaptures to minimized bias (Ricker 1975) and operation of the screw trap for four consecutive days post-release of marked fish.

The 95% confidence intervals for the outmigration estimate were derived by substituting the upper and lower boundary of the confidence interval for trap efficiency into the formula used to calculate out-migration (Equation 5). Point estimates and confidence limits for daily out-migration were summed to arrive at approximate seasonal estimates of out-migration (Seelbach et al. 1985, Roper 1995).

Age at out-migration was estimated by analyzing scales collected from juvenile bull trout during March and April. Scales were collected from the area immediately dorsal to the lateral line and slightly anterior to the insertion of the adipose fin. Scales were impressed onto acetate slides and aged using a microfiche reader at 42X. An age-length key (Westerheim and Ricker 1978) was developed from the scale sample and applied to a random subsample of fish lengths collected during March and April to provide an unbiased estimate of the age composition of out-migrants in March and April.

In August of 2003, backpack electrofishing was used to determine juvenile bull trout densities in North and South Callahan creeks. Two 150 m reaches in each stream were sampled; each reach had an upper and lower block net placed to prevent fish from entering or leaving the reach. Two passes were made in each using two backpack electrofishers. Captured fish were held in a bucket, enumerated, measured for total length, weighed, and held in a net pen until the final pass. Two-pass removal density estimates and 95% CI were calculated by using computer software MicroFish 2.2 (Van Deventer and Platts 1983). The area of each reach was calculated with the length and average width from measures at 5 m intervals.

Temperature and Discharge of the Kootenai River

Daily temperature and discharge values for the Kootenai River at Leonia, Montana were obtained from the USACE and the U.S. Geological Survey (USGS) water resources website.

RESULTS

Adult Bull Trout Collection and Tagging

From 1998 through 2006, 27 bull trout were tagged with radio transmitters of which five were dual tagged with sonic transmitters (Table 1). Eight bull trout were caught in a weir trap in O'Brien Creek, Montana in October 1999 as part of a cooperative radio-tagging effort with the U.S. Forest Service; Montana Fish, Wildlife, and Parks; and the Idaho Department of Fish and Game. The remaining bull trout were captured in the Kootenai River with nighttime electrofishing (Table 1). Lengths of bull trout ranged from 459 to 800 mm TL (mean = 648 mm TL), and weights of 20 fish ranged from 1,000 to 3,206 g (Table 1) Sex of bull trout could only be determined for seven fish, precluding any analysis regarding gender.

Telemetry

Of the 27 tagged bull trout, nine fish provided little to no information (transmitter failure and one known mortality) and are not included in the data set. The 18 active bull trout were located a total of 1,276 times. Number of locations for individual fish ranged from ten (eight bull trout) to 164 records (five bull trout) and a mean of 70.9 locations/fish.

Examples of movements for five of the 18 bull trout are shown in Figures 2 through 6 because they were representative of the various activity patterns we noted; Figures 2 and 3 were examples of fluvial fish with distinct home pools, Figure 2 two annual years of spawning, and Figure 3 four annual years of spawning. Figure 4 is a fluvial fish that likely did not spawn; Figure 5 is an example of a fluvial fish that was likely an alternate year spawner, and Figure 6 an adfluvial fish that entered Kootenay Lake yet had a home pool in the Kootenai River. Because our telemetry study was an assemblage of movements of many individuals, we have chosen to describe general movements of bull trout.

Spawning Migration and Spawning Locations—Eighteen bull trout were monitored during the spawning migration period (May 1—October 20) (Table 1). Temperature of the Kootenai River at Leona (RKM 270) for this period ranged from 7.1 to 15.0°C and averaged 11.4°C for seven bull trout that made 19 spawning migrations to a known spawning tributary from 1999 through 2006. Bull trout migrated from home pools as early as May 27 and as late as August 8.

Fifteen of the 18 bull trout showed upstream movements during their spawning migration (examples of four fluvial fish are shown in Figures 2, 3, 4, and 5) but only six were thought to have spawned (September 1—October 20) (Table 2). O'Brien Creek, Montana and the Moyie River, Idaho were the only tributaries where bull trout were located during the spawning season (Table 2). Two of the five bull trout recorded in O'Brien Creek were tagged in O'Brien Creek. Bull trout 7 was also tagged in O'Brien Creek in October 1999 but was not relocated there in following years. Bull trout 13 was known to have been entrained through Libby Dam because it was originally passive integrated transponder (PIT) tagged in the Wigwam River, BC in 1998, then recaptured in a weir trap in O'Brien Creek on October 8, 1999.

Table 1. Bull trout tagged with radio and ultrasonic tags in the Kootenai River drainage, 1998—2005. Some bull trout were not weighed because a scale was inoperative.

Fish ID	Radio frequency	Total Length (mm)	Weight (g)	Sex	Tag date	Tag contact location (rkm)	Last date	Monitored contact during spawning?	Expected tag life days
1[a,b]	30.031	705	—	M	10/8/1999	301.2	7/5/2001	Y	730
2[b]	30.08	514	1000	U	12/14/2001	237	4/15/2002	N	730
3	30.14	495	1022	U	9/21/2000	270.5	6/17/2002	Y	730
4	30.15	524	1418	U	10/10/2000	252.5	11/5/2001	Y	730
5	30.16	478	1077	U	4/23/2002	264.8	12/14/2006	Y	730
6[b]	30.17	562	1400	U	12/13/2000	151	12/13/2000	N	730
7[a]	30.191	800	—	M	10/8/1999	301.2	7/31/2003	Y	730
8	30.231	595	1701	U	3/6/2001	244.5	9/18/2002	Y	730
9	30.241	459	1077	U	9/15/1999	262.5	4/15/2002	Y	730
10[a,b]	30.251	737	—	M	10/8/1999	301.2	8/22/2001	Y	730
11[b]	30.323	728	3206	U	3/23/2001	240	3/28/2001	N	730
12[a]	30.333	762	—	F	10/8/1999	301.2	6/10/2002	Y	912
13[a]	30.394	775	—	M	10/8/1999	301.2	7/31/2003	Y	912
14[a]	30.452	458	1021	U	9/10/1998	262.5	10/10/2000	Y	360
15	30.474	690	—	U	10/1/1999	301.2	12/3/2002	Y	912
16	30.623	580	2438	U	9/24/1998	256	11/29/1999	Y	360
17[a,b]	30.654	711	—	F	10/1/1999	301.2	2/13/2002	Y	912
18	30.711	750	5500	U	10/1/1998	275.5	11/1/2000	Y	360
19	31.033	581	2084	U	3/14/2001	221.5	10/12/2004	Y	912
20[b]	31.041	547	1315	U	12/14/2001	240.3	12/21/2001	N	912
21[a,,c]	31.423	838	—	M	10/8/1999	301.2	2/13/2002	Y	912
22[d]	31.761	725	—	U	4/28/2005	275.6	6/16/2005	Y	730
23[d]	31.812	723	2600	U	4/7/2005	262	12/14/2006	Y	360
24[b, d]	31.821	736	4050	U	10/20/2005	260.5	8/23/2006	N	730
25[d]	31.831	691	3630	U	4/5/2005	244	10/10/2006	Y	730
26[d]	31.843	685	—	U	4/19/2005	262.5	8/1/2006	Y	730
27	31.882	673	2450	U	5/6/2003	261.9	11/9/2005	Y	730

[a] Tagged in O'Brien Creek, Montana.
[b] Fish died, expulsed transmitter, or transmitter failed prematurely.
[c] Fish was tagged in O'Brien Creek in October 1999 as a post spawner and in Kootenay Lake, British Columbia the following year.
[d] Also tagged with an ultrasonic tag.

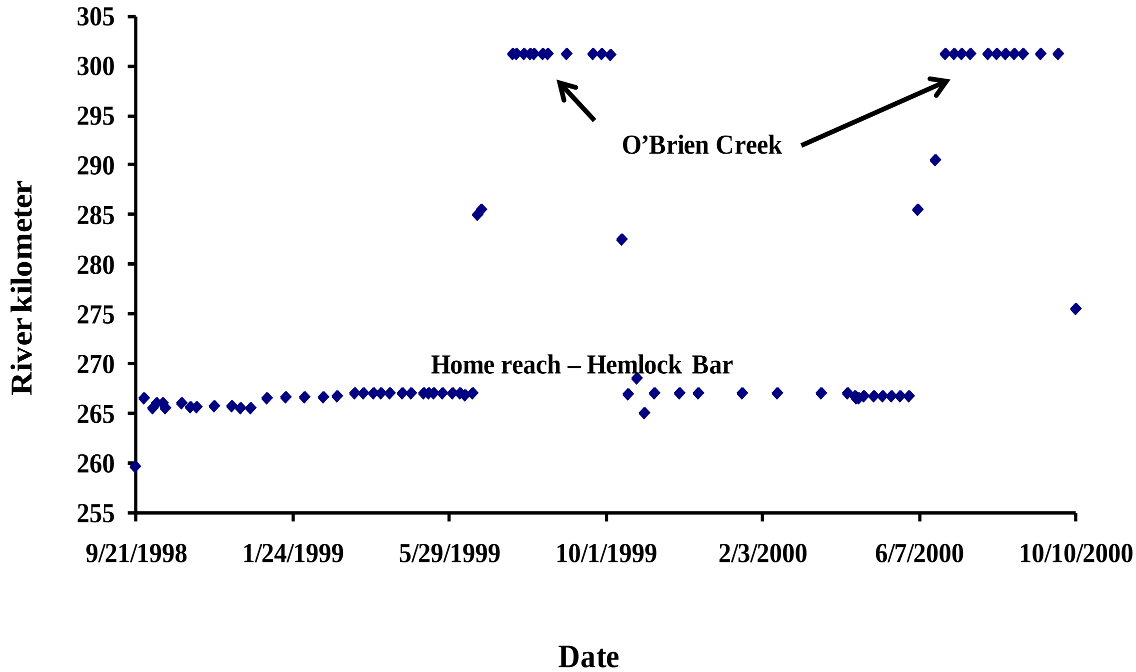

Figure 2. River kilometer telemetry locations for bull trout 14 in the Kootenai River, September 21, 1998 through October 10, 2000, an example of a fluvial fish and annual spawner two consecutive years of study.

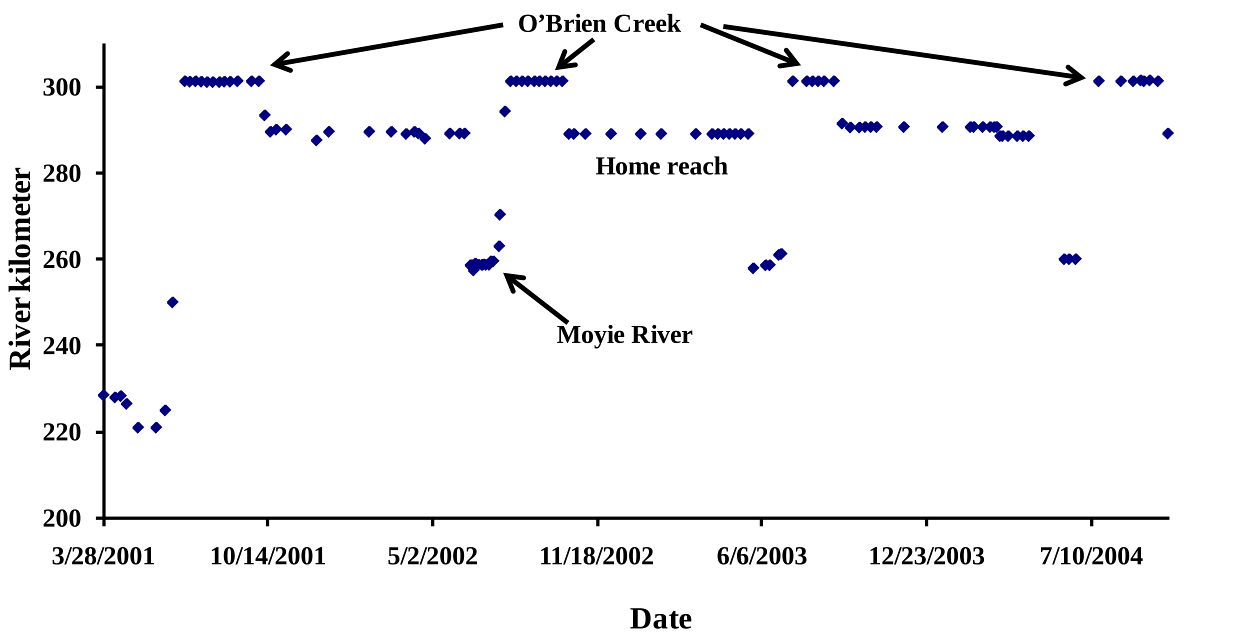

Figure 3. River kilometer telemetry locations for bull trout 19 in the Kootenai River, March 22, 2001 through November 17, 2004, Kootenai River, Idaho, an example of a fluvial fish and annual spawner four consecutive years of study.

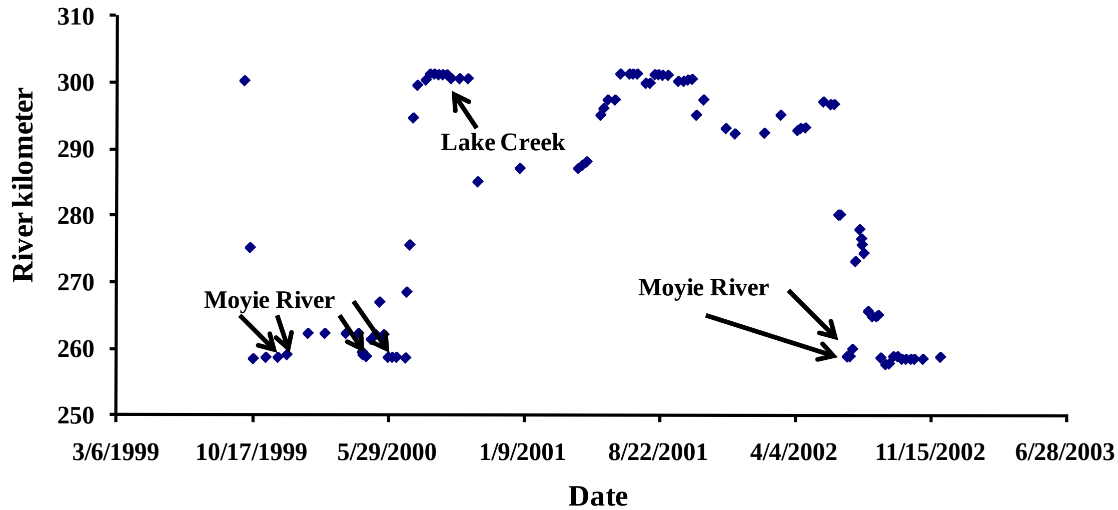

Figure 4. River kilometer telemetry locations for bull trout 15 in the Kootenai River, October 5, 1999 through December 3, 2002, an example of a fluvial fish that likely did not spawn.

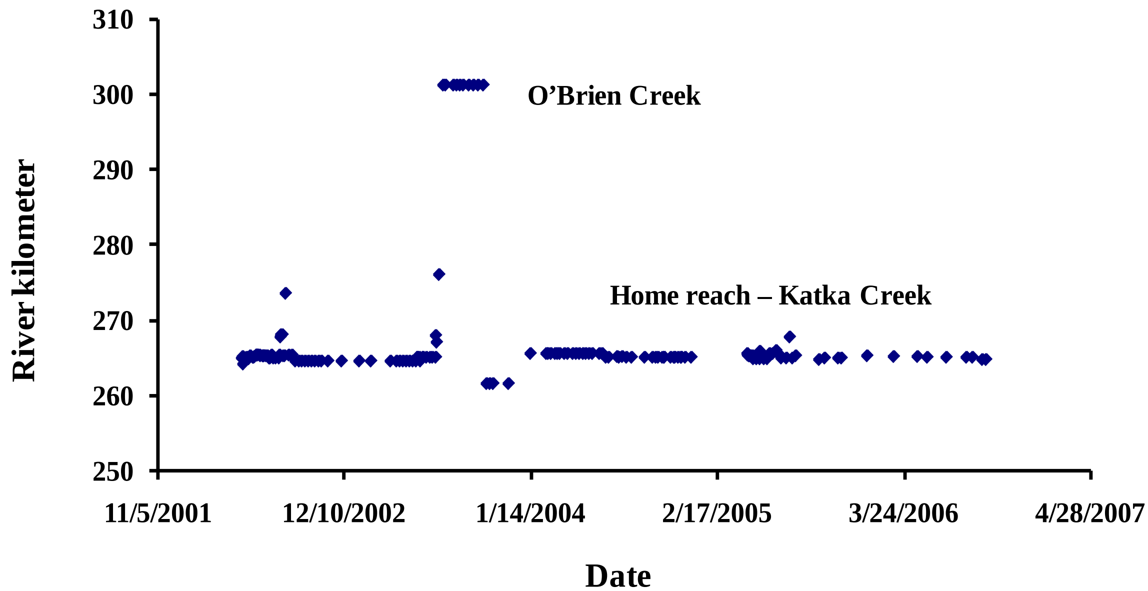

Figure 5. River kilometer telemetry locations for bull trout 5 in the Kootenai River from April 23, 2002 through September 15, 2006, an example of a fluvial fish that was likely an alternate year spawner.

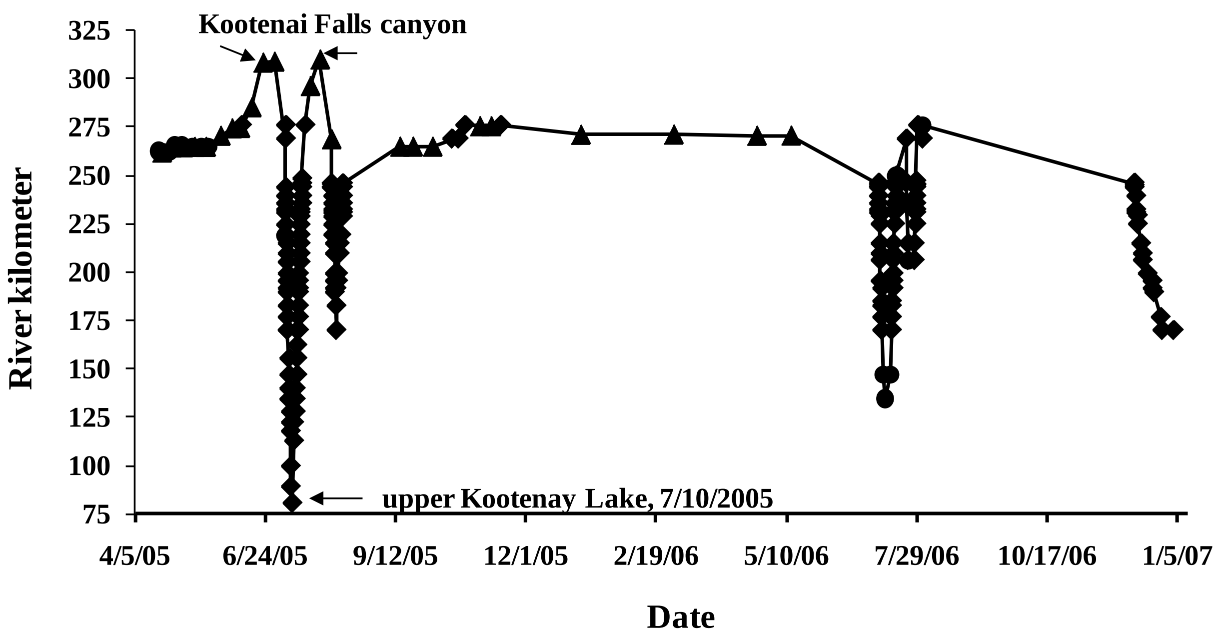

Figure 6. River kilometer telemetry locations for bull trout 26 in the Kootenai River from April 21, 2005 through August 1, 2006, including locations in Kootenay Lake, British Columbia (rkms <120), an example a adfluvial fish with a home pool, including movements to Kootenai Falls spawning migration.

Most bull trout showed no evidence of spawning; for example (based on habitat occupied during spawning season, see below), some fish moved during the migration period, but we found no evidence of migration to a suitable tributary for spawning (e.g., fish 3, 7, 12, 15, 16, 18, 23, 26, and 27). Bull trout 15 repeatedly entered the Moyie River, a river that is thought to be unsuitable for bull trout spawning and rearing (Table 2 and Figure 4). Bull trout 15 entered Lake Creek in 2000 very briefly, bull trout 16 entered Myrtle Creek and the Moyie River for one d each, while bull trout 22 entered the Moyie River for one d. Six of the bull trout that moved upstream during the migration period were relocated in the downstream vicinity of Kootenai Falls, Montana and did not enter a tributary (Figure 1).

Spawning Frequency

Three bull trout were tracked for one spawning season, eight for two seasons, two for three seasons, and two for four spawning seasons. As previously mentioned, only six fish were believed to have spawned during the study. Three bull trout were apparently alternate year spawners (5, 12, and 25), while three were likely annual spawners (9, 14, and 19). Bull trout 12 was tagged in O'Brien Creek in 1999, as a post-spawner, was tracked two years, and was thought to have also been an alternate year spawner because it did not return the following year. Based on habitat selection during the spawning season we did not believe we had sufficient evidence to suggest the remaining fish spawned.

One-way travel distance to tributaries for migratory bull trout ranged from 34.2 km to 83.2 km. Migratory bull trout travel time ranged from 15 d to 30 d, and travel time ranged up to 32 d while travel rate ranged from 1.1 km/d to 5.9 km/d.

Post-spawning Period

Home Pools

Eleven of the 18 bull trout tracked for at least a full year remained in a general reach of river ranging from about 0.1 to 7.7 km with a mean of about 2.3 km. Examples of a home pool are shown in Figures 2, 3, and 6. Bull trout using a home reach remained in each respective reach through the winter. Depths of home pools ranged from 2.2 to 16.4 m, mean of 10.8 m, but only one fish occupied a home pool shallower than 4.5 m. These pools were often located in an outside bend. Seven other bull trout did not appear to maintain a home pool or specific reach during the winter and spring.

Tributary Use Post Spawn

Five bull trout were located in tributaries outside of the spawning season during late fall, winter, spring, and summer (Table 2). Tributaries used by bull trout outside of the spawning season included Lake, Myrtle, and O'Brien creeks and the Moyie River.

Table 2. Maximum upstream river kilometer (rkm) for Kootenai River locations of 15 radio-tagged bull trout that moved upstream during the spawning migration period (May 1—October 20), and dates and locations of those fish that were located in tributaries.

Fish ID	Year	First date located in tributary	Last date located in tributary	Name of tributary	Date when first located back in Kootenai R.	Maximum upstream location in Kootenai R. (rkm)	Estimated number of spawning migrations
3	2001	—	—	—	—	293.3	0
5	2002	—	—	—	—	273.5	
5	2003	8/7	10/3	O'Brien Cr.	10/10	301.2	1
7[a]	2000	—	—	—	—	309.5	0
7[a]	2001	—	—	—	—	309.7	
7[a]	2002	—	—	—	—	307.3	
9	2000	—	—	—	—	301.2	1
9	2001	7/5	4/15	O'Brien Cr.	—	301.2	
12[a]	2000	—	—	—	—	309.8	0
14[a]	1999	7/19	9/28	O'Brien Cr.	10/5	301.2	2
14[a]	2000	6/28	9/26	O'Brien Cr.	10/10	301.2	
15	1999	11/9	11/29	Moyie R.	12/14	301.2	1
15	2000	6/6	6/13	Moyie R.	6/28	301.2	
15	2000	8/1	8/1	Lake Cr.	8/8	301.2	
15	2001	—	—	—	—	301.1	
15	2002	7/2	7/2	Moyie R.	7/6	297.0	
15	2002	9/16	9/16	Moyie R.	9/23	297.0	
16	1998	12/14	12/14	Myrtle Cr.	12/22	256	0
16	1999	6/21	6/21	Moyie R.	6/24	299.5	
18	1999	—	—	—	—	308.2	0
18	2000	—	—	—	—	295.2	
19	2001	7/5	7/5	O'Brien Cr.	7/11	301.2	4
19	2001	7/18	7/18	O'Brien Cr.	7/25	301.2	
19	2001	9/7	10/3	O'Brien Cr.	10/10	301.2	
19	2002	6/17	6/19	Moyie R.	6/20	301.2	
19	2002	8/26	10/7	O'Brien Cr.	10/15	301.2	
19	2003	7/31	8/21	O'Brien Cr.	9/2	301.2	
19	2004	7/20	9/30	O'Brien Cr.	10/12	301.2	
22	2005	5/11	5/11	Moyie R.	5/11	243.5	0
23	2005	—	—	—	—	309.8	0
23	2006	—	—	—	—	307	
25	2005	7/3	7/27	O'Brien Cr.	8/3	301.3	1
25	2006	—	—	—	—	307	
26	2005	—	—	—	—	309.6	0
26	2006	—	—	—	—	275.5	
27	2003	—	—	—	—	309.5	0
27	2004	—	—	—	—	284.5	
27	2005	—	—	—	—	275.3	

[a] Tagged in O'Brien Creek, Montana October 1999.
[b] This late date was likely due to a shed tag or mortality in O'Brien Creek.

Adfluvial Movements

Two bull trout tagged in the Kootenai River were eventually relocated in Kootenay Lake, BC, and showed adfluvial behavior. Bull trout 21 was tagged in O'Brien Creek on October 8, 1999 as a post spawner and was relocated in Kootenay Lake at rkm 120 on November 29, 1999; by the next relocation on January 18, 2000, it was in the Kootenai River at rkm 207.7. No subsequent movements were documented for this fish because the transmitter battery likely failed.

Bull trout 26 had one of the most extensive movements of all the bull trout we monitored (Figure 6). Bull trout 26 was located with radio telemetry at rkm 308.5 on June 29, 2005 below Kootenai Falls, Montana, and was then detected by ultrasonic receivers from July 6 through July 18, 2005 when it moved downstream to rkm 81 in Kootenay Lake (a one-way distance of 228 km). Bull trout 26 was next relocated by radio telemetry on July 21 at rkm 269 and on July 27 at rkm 309.6 below Kootenai Falls, Montana. Bull trout 26 was detected back upstream at Kootenai Falls on July 11, 2005, then was located several days later at rkm 170, the Idaho/BC border (Figure 6). Later that year and 2006 it had a home range, for nearly a full year, at around rkm 270.6. To our knowledge, this fish never entered a tributary and it is not known if it spawned.

Redd Surveys

The highest bull trout redd counts were observed in North Callahan Creek even though no redds were observed in many of the years it was counted (Appendix A). Redds were also observed in South Callahan Creek with a high of ten in 2003 while redds were only occasionally found in Boulder Creek. The highest estimate of spawning adults (based on redd counts) for North Callahan was 102 fish for 2003 while for South Callahan Creek it was 32 in 2003. In Boulder Creek, a single redd was counted in 2005 and in all other years none were observed.

Screw Trap

The screw trap was deployed on April 7, 2003 and fished until July 15, 2003 when the flow became too low to turn the trap cone. During this period, there were six days the trap could not be operated due to high water and needed repairs. We captured 17 juvenile bull trout during this time frame and released 16 upstream to estimate trap efficiency. Four of these fish were recaptured and all were caught the day after they were marked. We calculated a trap efficiency of 25% with an upper and lower bound of 3 and 47%. Our juvenile out-migration estimate was 68 bull trout with an upper and lower bound of 36 and 508, respectively. Juvenile bull trout ranged from 100 to 200 mm TL with a mean of about 158 mm TL. Of the 17 young bull trout captured in the screw trap 15 were aged; 13% were age 1, 73% age 2, 7%, age 3, and 7% age 4.

Juvenile Bull Trout Densities in North and South Callahan Creeks

Age 1 bull trout densities in the Callahan Creeks in August 2003 ranged from 1.6 fish / 100 m^2 for transect 2 at North Callahan Creek to 7.7 fish /100 m^2 for South Callahan transect 2 (Table 3). Age 0 bull trout were also caught with a total catch of 24 at North Callahan and 23 at South Callahan, for both transects at each stream. No estimates were made for age 0 bull trout because their capture numbers were so low.

Table 3. Population estimates for age 1 and older bull trout for two reaches for North and South Callahan creeks, and catch of age 0 fish in each reach for August 2003, Idaho.

Stream	Transect	Pass 1	Pass 2	Total ≥age 1 caught	Pop. Est. ≥age 1	Lower 95% CI	Upper 95% CI	Density (n/100 m²)	Number age 0 caught
North	1	6	3	12	9	9	12	2.43	7
Callahan	2	6	0	6	6[a]	—[a]	—[a]	1.64[a]	17
South	1	28	10	38	42	38	51	3.54	13
Callahan	2	21	16	37	69	37	152	7.65	10

[a] A two-pass estimate was made, but confidence intervals could not be made because no fish were caught on the second pass.

DISCUSSION

Bull trout are known to have numerous life history patterns (Goetz 1989; Varley and Gresswell 1988; DuPont et al. 2007) and we found fluvial and adfluvial bull trout using the same tributary during the spawning season (O'Brien Creek, Montana). Westover and Heidt (2004) had similar findings for bull trout in the upper Kootenay River, BC. Because we found fluvial and adfluvial bull trout spawning in the same tributary, we believe it suggests some life history patterns like migratory behavior may not be genetically inherited. Spawning fidelity may be an outcome of differences in reproductive isolation within sympatric populations or a result of phenotypic but volitional behavior. For example, Zimmerman and Reeves (2000) suggested adult resident rainbow trout *Oncorhynchus mykiss* and steelhead in the Deschutes River, Oregon, although they may occupy the same habitat, were reproductively isolated. Using rearing studies, Nordberg (1983), found that resident and migratory Arctic char *S. alpinus* were from the same gene pool.

Population fragmentation by barriers may, in most circumstances, naturally limit the recruitment of bull trout in the Idaho reach of the Kootenai River by isolating entrained bull trout from spawning tributaries. For example, barriers like the Moyie River and Libby dams and Kootenai Falls (a natural barrier), have had bull trout migrate downstream through them. Our results suggested about 67% of the adult bull trout that we tagged in the Kootenai River below Kootenai Falls, concentrated below the falls during the spawning season and likely did not spawn because the substrates in this reach are exceptionally large or small: comprised primarily of boulders or sand. It is possible these fish originated upstream and were unable to return to natal tributaries, thus did not contribute recruits to the population. Migrations back to natal spawning areas have been well studied and it is known that olfactory imprinting of chemical cues from natal water is important (Groves et al. 1968; Hasler and Scholz 1983). The best evidence to support this hypothesis is bull trout telemetry data collected below Libby Dam (M. Hensler, Montana Fish Wildlife and Parks, personal communication). These fish were believed to have been entrained through Libby Dam from the river and Lake Koocanusa upstream. During the spawning season, it was thought these fish would redistribute to known spawning tributaries but remained at the face of the dam. The exception was bull trout 13; it was entrained through Libby Dam and likely originated in the Wigwam River, BC. Furthermore, Ardren et al. (2007) in a genetics investigation of Kootenai basin bull trout found evidence of gene transfer from tributaries in BC downstream to below Libby Dam and that there was little genetic transfer from below Kootenai Falls to fish upstream.

The second example of possible fragmentation was that of bull trout tagged in the Kootenai River that during the spawning season were relocated in the Moyie River. These fish likely did not spawn in the Moyie River below the dam (several rkm upstream with the confluence with the Kootenai River) as the large substrates provide limited spawning habitat, and warm summer water temperatures make it unsuitable for juvenile rearing (Partridge 1983; IDFG unpublished data). Migrations into the Moyie River may have been due to bull trout seeking to return to their natal spawning area above the dam since they are known to have strong fidelity for their natal stream (Spruell et al. 1999). Historically there was a waterfall in the present location of the Moyie River Dam, and it may or may not have been a natural barrier. Bull trout are native to the Moyie drainage including Moyie Lake, BC. Regardless, because of the dam it is not possible for bull trout to migrate further upstream.

Surprisingly, none of the bull trout we tracked moved into the Callahan Creek drainage of Idaho and Montana, which is a known spawning tributary (Walters 2005). But, bull trout studied by Westover and Heidt (2004) in the upper Kootenay River, BC were not subject to fragmentation by such substantial barriers such as dams and they reported a much lower level of fidelity for spawning tributaries.

Bull trout also entered several tributary streams outside of the spawning season. The role these streams play in the life history of adult bull trout remains unknown other than the possible use as a thermal refuge (Partridge 1983). Westover and Heidt (2004) reported nonspawning bull trout in the upper Kootenay River, BC also moved into tributary streams and were thought to have done so for food.

Bull trout 26 had an adfluvial pattern; it moved from O'Brien Creek (a tributary) to the main stem Kootenai River to Kootenay Lake and then back to the Kootenai River. Although bull trout 26 was tracked from O'Brien Creek to Kootenay Lake, our timing of sampling was biased against collecting adfluvial bull trout. Our electrofishing occurred in spring before most adfluvial trout would have entered the river from the lake, and in the fall when adfluvial fish would have been in spawning tributaries. Redd counts concurrent to telemetry identified fluvial or adfluvial bull trout spawning in the Callahan Creek drainage. If the Callahan Creek spawning population is comprised of an adfluvial stock from Kootenay Lake, our electrofishing-induced timing bias could explain why none of our radio-tagged bull trout were located there.

We found evidence of likely spawning for only about 33% of the bull trout we tracked in the Kootenai River below Kootenai Falls (as noted earlier), of which 50% were alternate year and 50% annual spawners (albeit a small sample of six fish). Contrary to our findings, Baxter and Westover (1999) found alternate year spawners were outnumbered by annual spawners by 2:1 above Libby Dam in the Wigwam River of BC, while Elle (1995) reported similar results in Rapid River, Idaho, a tributary to the Salmon River, while Downs et al. (2006) found a major portion of bull trout were annual spawners. Annual and alternate year spawners occur in other systems as well (Fraley and Shepard 1989; Pratt 1984). As expressed earlier in this report, this low proportion of spawners in the Kootenai River could also have been due to sampling bias or failure to reach natal tributaries and can only be resolved with a larger sample size and greater detail to monitoring fish during the spawning season.

North and South Callahan creeks were found to be the most important Kootenai River tributaries in the Idaho reach for bull trout recruitment. The total of 42 redds found in North and

South Callahan creeks in 2003 was higher than the 17 redds found in 2002. However, some redds found in 2003 were in a reach of North Callahan Creek that was not surveyed in 2002 (Jill Creek to 100 m downstream of Smith Creek).

Although the Callahan drainage is a source of juvenile bull trout recruitment to the Kootenai River it is not known whether these fish continue to rear in the river or Kootenay Lake. Juvenile bull trout densities (1.6 to 7.7 fish age 1/100 m^2) in North and South Callahan creeks are in the lower range of densities reported for other bull trout streams, but are the highest of any Kootenai River tributaries in Idaho (Fraley and Shepard 1989; Paragamian 1995; Saffel and Scarnecchia 1995). In North Callahan Creek just upstream of the confluence with South Callahan Creek in Montana, juvenile bull trout densities of 0.7/100 m^2 and 3.2/100 m^2 were documented in 2003 and 2004, respectively (J. Dunnigan, Montana Fish, Wildlife and Parks, personal communication).

Results from these studies suggest that a combination of natural and anthropogenic factors may limit the Kootenai River bull trout population. The river corridor has been fragmented by the natural barrier at Kootenai Falls and the artificial barriers, Moyie and Libby dams and fish entrained through them may not successfully spawn as often as other stocks. Further, bull trout migrating from the Idaho reach of the Kootenai River result in a transboundary population with either Montana or BC where management measures are different. In BC there is a harvest fishery for bull trout while it is closed in Idaho and Montana. There are also other elements outside of the scope of this study that impact bull trout including nutrient and productivity losses due to Lake Koocanusa, (Hardy 2006) and how changes in water temperature and discharge post Libby Dam may have affected bull trout migrations. On the other hand there may not have ever been a robust bull trout population in the Idaho reach of the Kootenai River.

RECOMMENDATIONS

1. A spawning and rearing habitat inventory should take place in Idaho tributaries because it is not known if it is a limiting factor to improving recruitment of bull trout in Idaho.

2. A transboundary forum of managers should be convened to determine future direction for bull trout research in the Kootenai River.

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APPENDICES

Appendix A. Bull trout index redd counts for the Idaho portion of the Kootenai drainage for 2000 through 2009. Boulder Creek was first surveyed in 2000; N. and S. Callahan creeks were first surveyed in 2002. The reach surveyed the first year (2002) on North Callahan was shorter than in subsequent years, so this count may not be comparable.

Stream	Year	Transect start point description	Start Point UTM coordinates		Transect end point description	End point UTM coordinates		Number of bull trout redds
			Eastings	Northings		Eastings	Northings	
Boulder Cr.	2000	mouth	569849	5386164	waterfalls 1.9 km upstr.	568641	5385028	0
Boulder Cr.	2001	mouth	569849	5386164	waterfalls 1.9 km upstr.	568641	5385028	2
Boulder Cr.	2002	mouth	569849	5386164	waterfalls 1.9 km upstr.	568641	5385028	2
Boulder Cr.	2003	mouth	569849	5386164	waterfalls 1.9 km upstr.	568641	5385028	0
Boulder Cr.	2004	mouth	569849	5386164	waterfalls 1.9 km upstr.	568641	5385028	0
Boulder Cr.	2005	mouth	569849	5386164	waterfalls 1.9 km upstr.	568641	5385028	1
Boulder Cr.	2006	mouth	569849	5386164	waterfalls 1.9 km upstr.	568641	5385028	0
Boulder Cr.	2007	mouth	569849	5386164	waterfalls 1.9 km upstr.	568641	5385028	0
Boulder Cr.	2008	mouth	569849	5386164	waterfalls 1.9 km upstr.	568641	5385028	0
Boulder Cr.	2009	mouth	569849	5386164	waterfalls 1.9 km upstr.	568641	5385028	0
N. Callahan Cr.	2002	100 m downstr. of Smith Cr.	569501	5365990	Waterfalls barrier	568218	5366538	13
N. Callahan Cr.	2003	Jill Cr., Montana[a]	570786[b]	5365340[b]	Waterfalls barrier	568218	5366538	32
N. Callahan Cr.	2004	Jill Cr., Montana	570786[b]	5365340[b]	Waterfalls barrier	568218	5366538	17
N. Callahan Cr.	2005	Jill Cr., Montana	570786[b]	5365340[b]	Waterfalls barrier	568218	5366538	10
N. Callahan Cr.	2006	Jill Cr., Montana	570786[b]	5365340[b]	Waterfalls barrier	568218	5366538	29
N. Callahan Cr.	2007	Jill Cr., Montana	570786[b]	5365340[b]	Waterfalls barrier	568218	5366538	3[f]
N. Callahan Cr.	2008	Jill Cr., Montana	570786[b]	5365340[b]	Waterfalls barrier	568218	5366538	17
N. Callahan Cr.	2009	Jill Cr., Montana	570786[b]	5365340[b]	Waterfalls barrier	568218	5366538	10
S. Callahan Cr.	2002	bridge on forest rd. 4554	570596	5362719	Forest Rd. 414 bridge (trailhead #154)	566519	5361191	3[d]
S. Callahan Cr.	2003	bridge on forest rd. 4554	570596	5362719	Forest Rd. 414 bridge (trailhead #154)	567347	5360822	10
S. Callahan Cr.	2004	bridge on forest rd. 4554	570596	5362719	Forest Rd. 414 bridge (trailhead #154)[c]	567347	5360822	8
S. Callahan Cr.	2005	bridge on forest rd. 4554	570596	5362719	Forest Rd. 414 bridge (trailhead #154)	567347	5360822	5
S. Callahan Cr.	2006	bridge on forest rd. 4554	570596	5362719	Forest Rd. 414 bridge (trailhead #154)	567347	5360822	4
S. Callahan Cr.	2007	bridge on forest rd. 4554	570596	5362719	Forest Rd. 414 bridge (trailhead #154)	567347	5360822	0[f]
S. Callahan Cr.	2008	bridge on forest rd. 4554	570596	5362719	Forest Rd. 414 bridge (trailhead #154)	567347	5360822	0
S. Callahan Cr.	2009	bridge on forest rd. 4554	570596	5362719	Forest Rd. 414 bridge (trailhead #154)	567347	5360822	0

[a] On 9/24/2003 the section from approx. 500 m downstream of Jill Creek upstream to Jill Creek was also surveyed but no redds were seen.
[b] Estimated from electronic version of topographical map.
[c] On 10/4/04, S. Callahan was also surveyed from the Forest Rd. 414 bridge upstream for approx. 500 m but no redds were seen (mainly high gradient with large substrates).
[d] One additional redd was found within 0.9 km upstream of Forest Rd. 414 bridge, but this is outside the index reach.
[e] High flows made counts more difficult.

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