Migratory Patterns, Structure, Abundance, and Status of Bull Trout Populations from Subbasins in the Columbia Plateau and Blue Mountain Provinces

2005 Annual Report

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I. Comparing Methods of Estimating the Abundance of Adult Bull Trout

Introduction

This study began in 2002. Background, methods, and results from prior years are presented in previous annual reports (Sankovich et al. 2003; Sankovich et al. 2004; Starcevich et al. 2005).

Methods

This study was conducted in the upper Mill Creek watershed (Walla Walla subbasin), upstream from a dam and intake structure in Mill Creek that supplies water to the city of Walla Walla, Washington (Figure 1). A ladder on the dam allows passage for upstream migrants. We operated a trap, designed as described in Hemmingsen et al. (2001b), at the head of the dam's ladder from 15 May through 29 October 2005. The trap was usually checked daily when bull trout began to move up the ladder, which occurred on 21 June. As in previous years, bull trout trapped at the ladder were anesthetized, measured, weighed, interrogated for a PIT tag, and, if no PIT tag was present, injected with one. Each fish was also inspected for maturity using ultrasound, and mature females were identified. All bull trout were marked by hole-punching the middle of the caudal fin to distinguish fish marked with an upper caudal punch in 2004. The punch was used to mark fish for the mark-recapture estimate to determine the number of adult-sized (> 299 mm) bull trout residing above the trap that did not pass through the trap. As in previous years, we installed a net across the stream near the base of the dam to eliminate the possibility of fish avoiding the trap by jumping the dam so we could fully enumerate the number of fish that migrated upstream from below the dam.

To account for any fluvial-sized females that might have overwintered upstream from the dam, we snorkeled the study area from 30 August–1 September, 2005. A single diver snorkeled all the pools and a portion of the other habitats capable of holding fluvial adult-sized fish. The diver recorded the number of marked (caudal fin punch) and unmarked bull trout ≥ 300 mm fork length (FL) that were observed. Since 2002, only four adult females < 300 mm have been identified at the trap. All four of those fish were ≥ 289 mm. We estimated the number of unmarked bull trout ≥ 300 mm FL by incorporating the number of marked and unmarked bull trout observed snorkeling and the number of marked bull trout released upstream of the trap at the time of snorkeling into Bailey's (1951) mark-recapture estimator:

$$\hat{N} = \frac{(C+1)M}{R+1}$$

where *N* is the population size, *M* is the number of bull trout marked, *C* is the number of marked and unmarked bull trout observed snorkeling, and *R* is the number of marked bull trout observed snorkeling. The Bailey estimate accounts for the possibility a marked bull trout may be observed multiple times in the snorkel count. Since the percentage of marked fish in the snorkel count exceeded 10% of the total snorkel count, confidence intervals were based on a binomial distribution (Seber 1982).

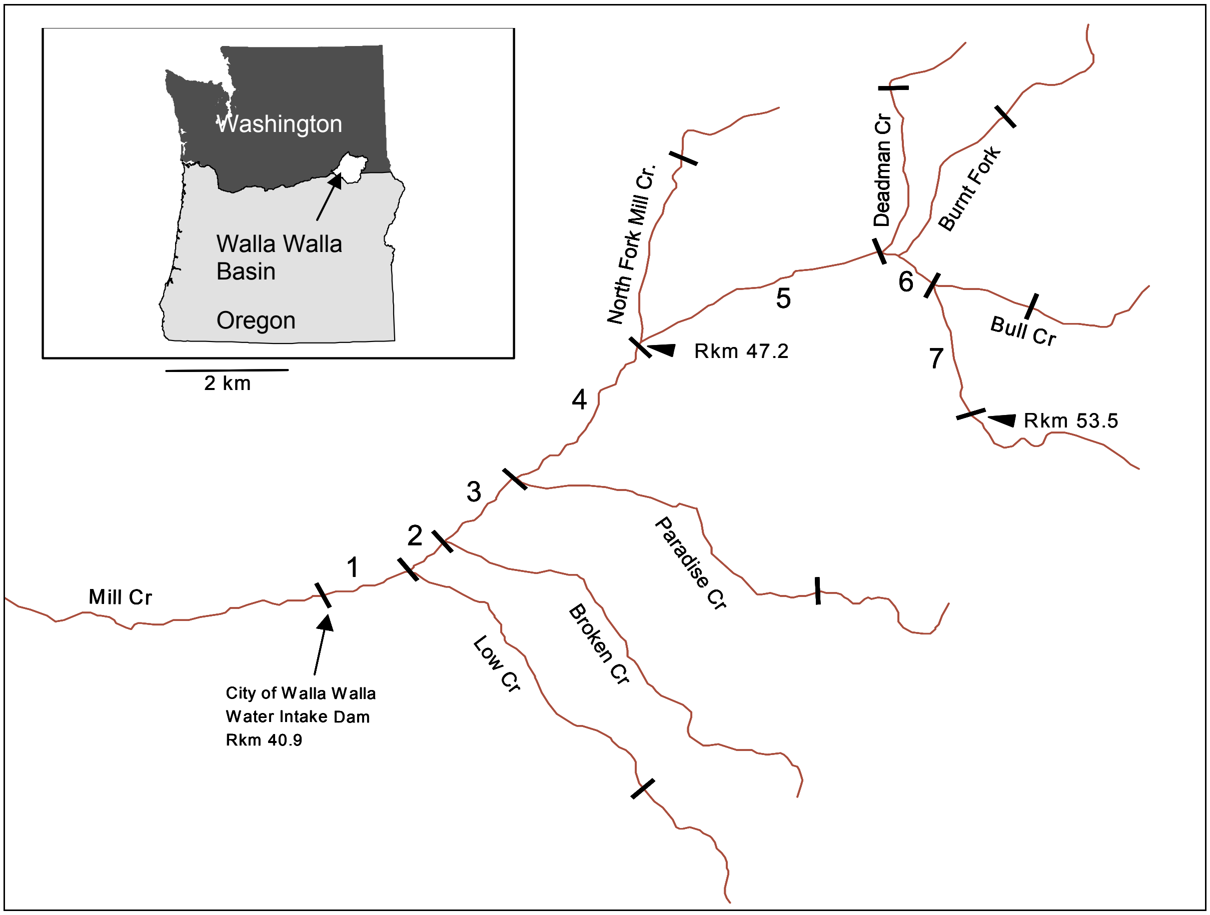


Figure 1. Map of the Mill Creek study area showing landmarks and reach units in which redds were counted during spawning ground surveys.

The number of unmarked fish (N_U), therefore, equals the population estimate (N) minus the number of fish marked at the trap (M), and the number of unmarked mature females equals N_U multiplied by the fraction of mature females $\geq$ 300 mm observed at the trap, assuming the female fraction of the unmarked fish was the same as that of the fish inspected at the trap. The overall estimate for mature fluvial females in the study area, then, was calculated as the sum of the unmarked females above the trap plus the females counted at the trap. The confidence interval assumes all of the error is from the estimate of unmarked females.

We also estimated the number of mature females in Low Creek, similar to 2003 (Sankovich et al. 2003). In early August, we block-netted and electrofished every third pool and riffle to obtain removal estimates of mature resident females. A sample of the fish collected while conducting the removal estimates was inspected using an endoscope to identify mature females. Similar work we conducted previously in Silver Creek (Powder River drainage) indicated resident females began maturing at 140 mm FL (Hemmingsen et al. 2001b). Therefore, to be conservative, we inspected every fish captured that was ≥ 130 mm FL. These fish were first anesthetized in an aerated bath containing MS-222. We then made a small incision slightly anterior and dorsal to the pelvic fin, injected saline solution into the abdominal cavity, and inserted the endoscope to inspect the reproductive organs. The incision was closed with surgical glue, and the fish were allowed to recover fully from anesthesia before being released into the habitat unit from which they came. Densities were determined by combining removal estimates with surface area of the units sampled. These densities were expanded across the available habitat area using methods described by Hankin (1986) to obtain an abundance estimate for mature resident females. Habitat unit areas were measured in 2002-2003, with habitat units being classified as pools or riffles. Because of possible bias in electrofishing removal estimates, we evaluated bias in our estimates following methods of Peterson et al. (2004). In a subsample of eight pools and eight riffles longitudinally spaced throughout the distribution of bull trout in Low Creek, we marked bull trout ≥ 130 mm FL that we collected during the removal passes with a caudal clip and released the marked fish back into the block-netted units. The following day, we completed electrofishing removal passes in these block-netted units and counted marked and unmarked bull trout in the catch.

Redd counts in the study area were conducted three times between mid-September and early November throughout the entire spawning distribution. During each survey, we flagged newly observed redds, identified them with a unique number, measured their length (from the beginning of the pit to the end of the mound) and width (at the widest part of the mound), and noted all fish observed within 1 m of the redd.

Results and Discussion

We captured 165 bull trout in the upstream trap, 83 of which were identified as mature females (Table 1). One of the bull trout was < 300 mm FL and a male. Two fish recycled through the trap a second time.

Table 1. Number, sex, and maturity status of bull trout captured in an upstream migrant trap in Mill Creek in 2005. Female maturity was determined using ultrasound. Counts of other species are also included.

Species	Mature females	Mature males and immature males and females	Total
Bull trout	83	81	164[a]
Sucker			1

a. *Does not include one mortality.*

We marked and released 114 bull trout above the trap before the study area was snorkeled. The diver located 37 marked fish and 22 unmarked bull trout ≥ 300 mm. Thus, we estimated there were a total of 66 unmarked fluvial adults, of which 33 were assumed to be mature females based on the female fraction (0.51) at the trap. Combining these females with the 83 released at the trap yielded an estimate of 116 (95% CL = 102-143) mature fluvial females in the study area.

The population estimate for Low Creek was 97± 28 (95% CI) mature females. The distribution of bull trout in 2005 was similar to that in 2003. We recaptured 56% of the marked bull trout (61% in pools, 46% in riffles) during the second electrofishing removal from the subsample. However, we captured only one unmarked bull trout, which was < 130 mm. Since the removal estimates are similar to the sum of the total fish captured across all passes, our removal estimates generally assume an overall capture probability approaching 1. However, data collected in Low Creek in 2005 showed capture probabilities to be substantially lower. The reasons for this discrepancy are unclear but could be explained by three possible factors: 1) marked fish either escaping from the calibration sections or dying between sampling events, 2) changes in the capture vulnerability of marked fish between the two sampling events, or 3) imprecision in our estimate of capture probability. The absence of any unmarked fish in the size range of mature females (142-198 mm) during the recapture removal and the generally higher electrofishing efficiencies for larger sized fish (Peterson et al. 2004) suggests our removal estimates of mature females were not substantially negatively biased. It also suggests that the most likely reason for the low recapture rate was reduced capture vulnerability of previously sampled fish.

Ninety-five fluvial redds were counted during regular census surveys in mainstem Mill Creek and North Fork Mill Creek (Table 2). Based on the size of the redds (Table 3) and fish observed on redds, fluvial-sized bull trout (> 299 mm) spawned almost exclusively in the mainstem Mill Creek and North Fork Mill Creek. In Low Creek, 43 redds were counted. Prior to and during the last survey, there was a substantial amount of rain, which increased flows and turbidity, and may have reduced visibility of redds on that survey. However, surveys from previous years for the period covered by that survey when flows were stable accounted for only 3-4% of the total redds. Consequently, few redds were likely to have been missed during the last survey as a result of the conditions.

Table 2. Redd counts from regular surveys in Mill Creek in 2005. The locations of survey sections are shown in Figure 1.

Survey section	Number of redds
0 (below dam)	1
1	0
2	0
3	3
4	34
5	33
6	10
7	6
Paradise Cr.	3
N.F. Mill Cr.	9
Deadman Cr.	0
Bull Cr	0
Burnt Fk.	0
Total	142
Low Cr.	43

Table 3. Mean redd size and 95% CI in Mill Creek and tributaries, 1998-2005.

Stream	Redd Area (m^2) Mean	95% CI
Mill Cr.	14.6	1.0
NF Mill Cr.	12.2	2.9
Low Cr.	2.7	0.2
Bull Cr.	5.4	2.4
Paradise Cr.	3.4	0.8

The redd:female ratio for Mill Creek in 2005 was the lowest since 1998 (Table 4). Adjusting the estimated error in the redd count due to bias among surveyors (Starcevich et al. 2005) increased the redd count and corresponding ratio only slightly. The relationship between females and redds has low power (R^2=0.06) and is not statistically significant (Figure 2). The poor relationship is primarily due to variation in redd:female ratios observed in 2001, 2002, and 2005.

Table 4. Redds and mature females in Mill Creek and Low Creek, 1998-2005. Females for 1998-2002 in Mill Creek were calculated by applying mean female ratio at the trap during 2002-2005 (0.50) to the upstream trap count and also applying the mean proportion of unmarked females above the trap during 2003-2005 (0.29).

				Redd count		Redds/female	
Population	Year	Females	95% CI	Raw	Adjusted	Raw	Adjusted
Mill Creek	1998	95		101		1.1	
	1999	127		133		1.0	
	2000	129		127		1.0	
	2001	98		180		1.8	
	2002	117		173		1.5	
	2003	96	88-114	106		1.1	
	2004	89	80-105	97	97	1.1	1.1
	2005	116	102-143	95	107	0.8	0.9
Low Creek	2003	48	27-69	28	51	0.6	1.1
	2005	97	69-125	43	78	0.4	1.2

Our inability to detect a relationship between redds and females may also result from a relatively low between-year variation in female abundance coupled with relatively high within-year variation of this parameter. The precision of annual estimates of mature females in 2003-05 averaged ± 20% and was likely higher for earlier years where only trap counts were available. This level of variation is comparable to the level of variation associated with the range of annual estimates over the study period (35%). Because both of these sources of variation have similar magnitude, our ability to detect a relationship between females and redds has low sensitivity. Consequently, it is inappropriate to conclude from our results that redd counts do not provide some measure of the abundance of fluvial bull trout.

Redd:female ratios in Low Creek in 2005 and 2003 were comparable to those in Mill Creek only when redd counts were adjusted for the large negative bias determined in 2004 (Starcevich et al. 2005).

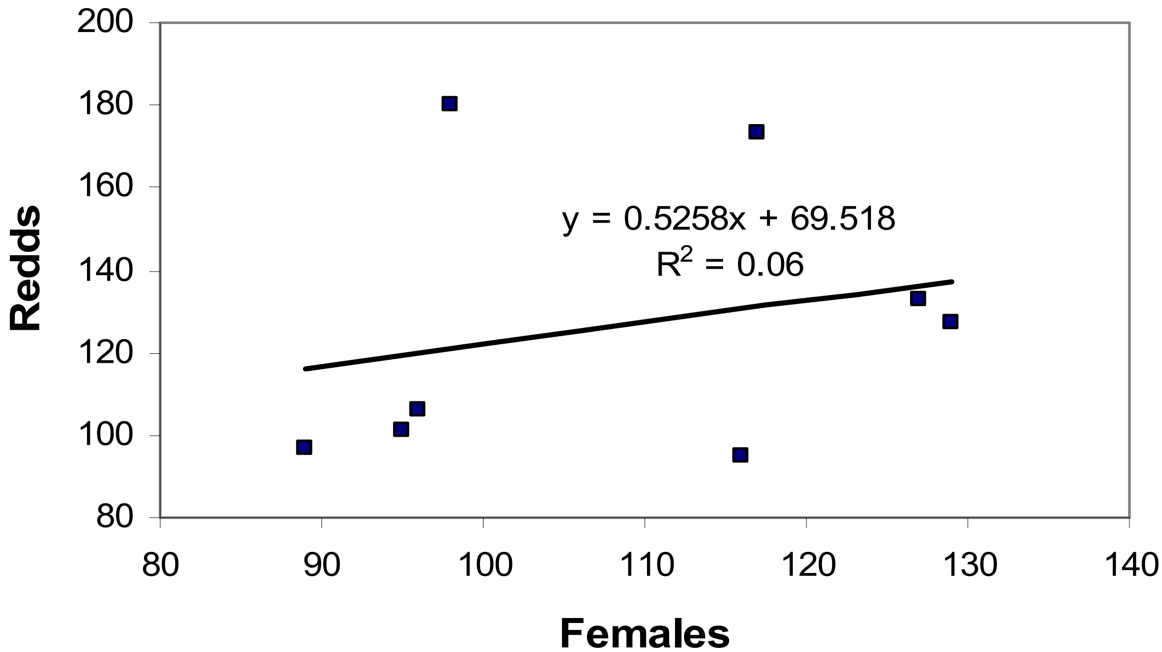


Figure 2. Regression of redds on mature females, Mill Creek, 1998-2005.

II. Migration and Temperature Patterns of Adult Bull Trout in the Lostine River

Introduction

In 2001 we began studies in the Lostine and Wallowa rivers to examine migration and temperature use patterns of adult bull trout that spawn in the Lostine River. The background, study design, and preliminary results are described in the 2004 annual report (Starcevich et al. 2005). In 2005 we completed field data collection, including tracking of radio-tagged fish, recapture of fish tagged with archival temperature tags, and ambient stream temperature data from the fall of 2004 through the summer of 2005. This report describes those activities and initial analysis of the data.

Data Collection

We tracked the locations of 24 radio- and temperature-tagged adults from the time of tagging in 2004 through August, 2005. Tracking frequency varied from weekly during periods of increased movement (late spring, summer and fall) to monthly during winter and early spring. Most tracking was done from vehicles with occasional tracking from a plane, particularly in winter when some fish were in locations where transmitter reception was more limited from vehicles.

Three fish with archival tags were recaptured at the Nez Perce trap in the Lostine River during the spring and summer of 2005. One of these fish was recaptured a second time at the trap in late August.

Thermographs were retrieved from locations in the Lostine, Wallowa, and Grande Ronde rivers that recorded ambient water temperatures during 2004-2005.

Results and Discussion

Potential mink predation of tagged fish was high. Five tags were found at a mink den near the Nez Perce trap and five additional post-surgical mortalities occurred in the vicinity of the den (Table 5). Although vulnerability to predation could increase following tag surgery, personnel operating the trap observed mink chasing untagged bull trout at the upstream edge of the weir. In addition to these 10 post-tagging mortalities, 4 additional fish died soon after tagging from unknown reasons. Eight to 10 tagged fish survived until after spawning. Of these fish, eight were tracked through the spawning period and appeared to spawn based on movement patterns. The remaining two fish were tracked to the upper portion of the river where spawning occurs but either shed the tag or died prior to spawning. Temperature tags were recovered from the three fish that survived through the spring following spawning. Two of these fish overwintered in the Wallowa River just downstream of the mouth of the Lostine River; the third overwintered in the Wallowa River approximately 3.5 km downstream of the mouth of the Lostine River.

Table 5. Fate of 24 bull trout tagged with radio and archival temperature tags in the Lostine River, 2004.

Fate of tagged adult bull trout	Number
Post-surgery mortality	4
Post-surgery mortality/mink predation	5
Post-surgery mortality/possible mink predation	5
Pre-post spawning mortality/shed tag	2
Post-spawning/mink predation	1
Post-spawning mortality/other	1
Post-spawning or winter mortality	3
Alive spring-summer 2005	3

Spawning locations and timing of tagged fished were estimated based on uppermost upstream distribution during late August through October and subsequent downstream migration (Table 6). Spawning of tagged fish was focused in two areas: Pole Bridge (Rkm 65) and Shady Campground (Rkm 81) near the upper end of spawning distribution in the Lostine River below a falls that prevents further upstream movement. Most of the fish likely spawned from late August through mid-September.

Table 6. Spawning locations and timing of tagged bull trout, 2004. River kilometer is measured from the mouth of the Wallowa River.

Fish tag no.	Location		Period
	River Km	Area	
1	81.0	Shady CG	early-mid Sept.
4[T]	81.0	Shady CG	mid Sept.
18[T]	81.0	Shady CG	mid Sept.
9	65.2	upper Pole Br. gorge	early Sept.
10	> 65	below Pole Br.	late Aug.-early Sept.
13[T]	64.7	below Pole Br.	late Sept.
14	64.7	below Pole Br.	early Sept.
19	62.2	Green Br.-Lostine Ranch	late Aug.

T *indicates fish with recovered temperature tags.*

Three fish with archival temperature tags were recaptured at the Nez Perce trap (Lostine Rkm 1.3) on 22 May (Fish #18), 31 May (Fish #4), and 17 June (Fish #13). Fish 13 and 18 had previously been recaptured in August 2004. Consequently, we have complete archival temperature data for these two fish from initial tagging (23 June 2004 and 17 May 2004, respectively) through recapture in the late spring 2005. Fish 4 was initially tagged on 20 August 2004, recaptured 31 May 2005, passed downstream of the trap a few days subsequently, and recaptured a second time at the trap on 29 August 2005. Archival temperature data was retrieved at the first recapture; however, the temperature tag failed after it was relaunched. As a result, no archival temperature data for that fish is available between the first and second captures in 2005.

Prior to upstream movement fish 13 and 18 experienced 7-day average daily maximum temperatures (7DADM) in April and May of 2005 of 11.4°C and 12.4°C, 3.6-4.6°C below the maximum state water temperature criteria for bull trout in migratory habitat (Table 7). The archival tag of fish 4 began to fail in the winter of 2004-5 based on comparisons with thermograph data so no data on spring temperatures experienced by that fish are available.

Table 7. Seven day daily average maximum temperatures and corresponding ODEQ water temperature criteria for bull trout with archival temperature tags, 2004-2005.

	Month, DEQ Temperature Criteria														
	July '04 16°C			August '04 12°C			Sept. '04 9°C			April '05 16°C			May '05 16°C		
Fish tag no.	Temp.	Date	Rkm	Temp.	Date	Rkm	Temp.	Date	Rkm	Temp.	Date	Rkm	Temp.	Date	Rkm
4	-	-	-	-	-	-	7.1	9/20	81	-	-	-	-	-	-
18	-	-	-	-	-	-	7.1	9/20	81	12.4	4/24	39-43	11.4	5/3	39-43
13	15.6	7/14-15	49-54	15.3	8/12-18	65.2	10.6	9/28	64.7	12.4	4/24	41.5	12.4	5/27	41.5

Summer 7DADM for fish 13 were 15.6°C and 15.3°C during July and August of 2004, respectively. These were 0.4°C lower and 3.3°C higher, respectively than state water temperature criteria. In July, the fish was in the lower Lostine River, where the temperature criterion (16°C) for migratory habitat applies, whereas in August the fish was near Pole Bridge, where the temperature criterion (12°C) for rearing habitat applies.

Thermograph data collected indicate ambient water temperatures where other migratory bull trout may occur in the Wallowa and Lostine rivers. Summer 7DADM over the course of the study are summarized in Table 8. Those data indicate that 7DADM during the study have consistently exceeded DEQ temperature criteria

Summer 7DADM temperatures in the Wallowa River and Lostine River below the Nez Perce trap were approximately 19-25°C, 3-9°C higher than the DEQ standard. Although data from the trap and this telemetry study indicate that most bull trout have moved upstream when those temperatures occur, some bull trout encounter those temperatures. For example, in 2005 a radio-tagged bull trout remained below the trap until 29 August. This was not a single anomaly since ODFW snorkeling crews observed 12 bull trout >300mm in the Lostine River below the trap during August 2005 (Ian Wilson, ODFW, pers. comm.).

At the time of spawning, archival-tagged fish were experiencing 7DADM temperatures of 7-10°C in 2004 (Figure 3). This was substantially cooler than for tagged fish in 2001 and more consistent with the water quality criteria of 9°C. However, ambient 7DADM temperatures during early-mid September were 12-16°C in 2004 and 2005, when most of the radio-tagged fish appeared to spawn (Figure 3). Temperatures in most of the spawning area (upstream of the Lostine Ranch) are unaffected by flow diversions.

Table 8. Summer maximum 7DADM temperature (°C) from thermographs within the range of radio-tagged bull trout in the Wallowa and Lostine rivers, 2002-2005.

Thermograph	DEQ criteria	7DADM	Date
Wallowa 3	16	22.7	7/29/02
(Deer Cr., RK 18.5)	16	25.1	7/31-8/6/05
Wallowa 4	16	21.5	7/29/02
(Rock Cr., RK 31.0)	16	23.2	8/6-7/05
Wallowa 5	16	19.6	7/28/02
(below Lostine mouth, RK 41.4)	16	20.9	8/6-7/05
Lostine 1	16	20.6	7/29/02
(NP trap, RK 43.5)	16	19.3	7/29/04
	16	20.8	7/29/05
Lostine 2	16	17.6	8/15/02
(Trout Farm, RK 54.0)	16	18.2	8/12/04
	16	18.4	8/7-8/05
Lostine 3	12	16.9	8/17/02
(Lostine Ranch, RK 58.9)	12	17.6	8/12/04
	12	17.9	8/7-8/05
Lostine 4	12	15.1	7/24/02
(Pole Br., RK 65.5)	12	15.4	7/27-28/04
	12	16.2	8/7/05
Lostine 5	12	15.7	8/15/02
(Lostine GS, RK 73.1)	12	16.2	8/10/04
	12	17.5	8/7-8/05
Lostine 6	12	13.7	8/13/04
(Shady CG, RK 81.8)	12	14.5	8/8/05

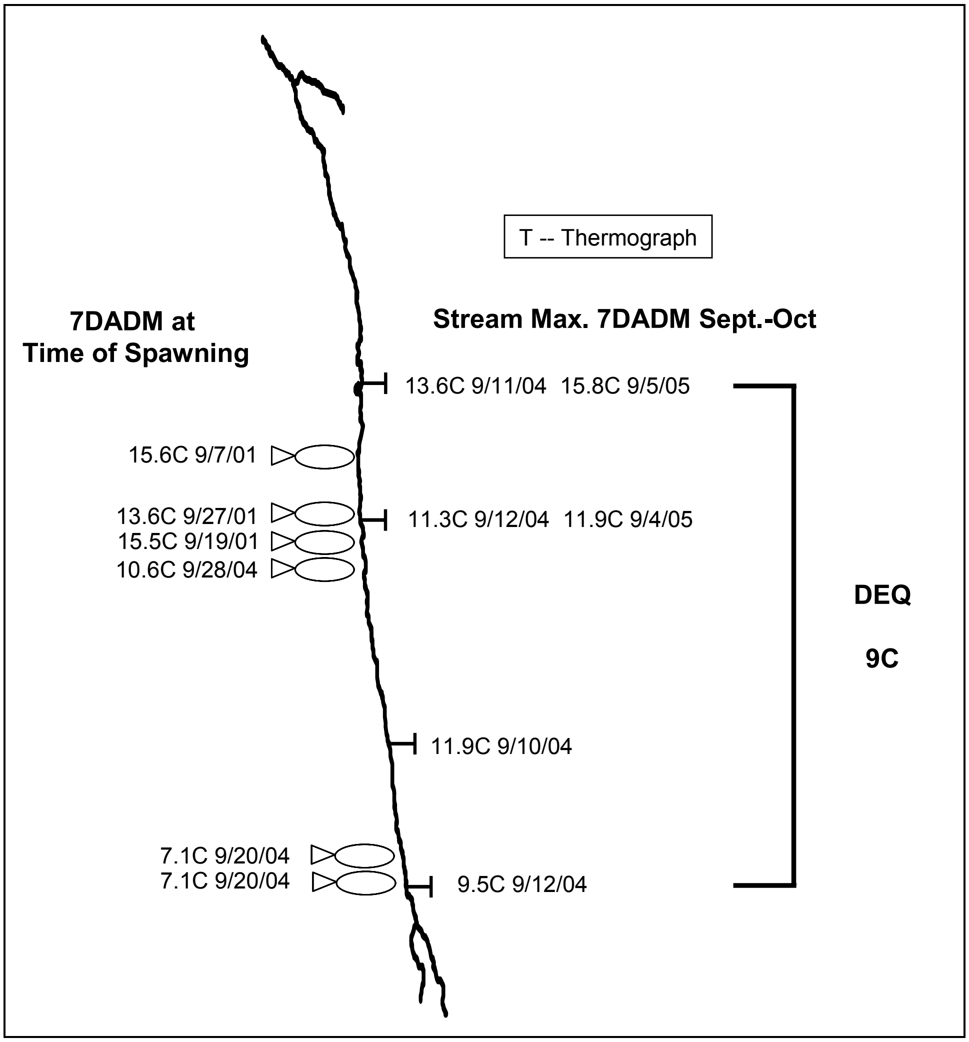


Figure 3. 7DADM temperatures (°C) at the estimated time of spawning of archival-tagged bull trout and maximum 7DADM temperatures during September-October, 2001, 2002, 2004.

III. Seasonal Movements of Subadult Fluvial Bull Trout in Mill Creek

Introduction

Bull trout (*Salvelinus confluentus*) exhibit many life history strategies. Stream-resident bull trout complete their life cycles in or near natal tributaries. Migratory bull trout typically spend 1-4 years rearing in natal streams and then migrate downstream to more productive feeding areas. Migratory "subadult" bull trout may spend several years foraging in the lower reaches of their natal streams, a larger river, or a lake before returning to natal streams to spawn (Rieman and McIntyre 1993). Resident and migratory forms may occur together and either form can produce resident or migratory offspring (Rieman and McIntyre 1993). Migratory forms may be particularly important to the persistence of bull trout populations (Rieman and McIntyre 1993). Therefore, understanding the movement patterns and associated habitat requirements of fluvial bull trout is critical to developing appropriate habitat protection measures for this species. For example, subadults may inhabit the lower reaches of a stream for long periods of time. In many watersheds, the lower reaches have been extensively altered and degraded by anthropogenic activities. However, studies of fluvial bull trout to date have focused almost exclusively on adults.

Our objective for 2005 was to investigate the seasonal movements of subadult fluvial bull trout in Mill Creek, a tributary to the Walla Walla River. To accomplish this, we installed a rotary screw trap in Upper Mill Creek to capture bull trout for PIT tagging. PIT tag detector arrays were installed at a road crossing approximately 7 Rkm downstream of the tagging site and at Bennington Dam.

Methods

On 10 April 2005, we installed a 1.5-meter rotary screw trap in Mill Creek at Rkm 42. According to screw trap data collected at this location from 1998 through 2002, most subadult bull trout in Mill Creek migrate downstream between April and June (Hemmingsen et al. 2001d). Therefore, we attempted to maximize our catch by operating the screw trap five days per week from 12 April through 28 July. Because the main purpose of the screw trap was to capture subadult bull trout for PIT tagging, we did not attempt to sample the entire period of downstream migration or to obtain a population estimate.

All captured bull trout were anesthetized with a diluted mixture of tricaine methanesulfonate (MS-222) and measured to the nearest millimeter (mm) fork length (FL). Other species were counted and tallied according to an estimated size category. All bull trout were interrogated for the presence of PIT tags. Untagged bull trout ≥130 and ≤ 299 mm (FL) were surgically implanted with full-duplex, 23 mm PIT tags. Tags were inserted into the body cavity through a small incision on the left side, just above and anterior to the pelvic fins. The incision area was then swabbed with isopropyl alcohol, dried with sterile absorbent gauze and a small drop of veterinary grade tissue adhesive was applied to the wound. Untagged bull trout ≥112 and ≤ 129 mm (FL) were implanted with full-duplex, 11.5 mm SGL PIT tags in the abdominal cavity using a syringe and hypodermic needle. After processing, all fish were allowed to recover in buckets filled with fresh, cold stream water. Recovered fish were released into a quiet backwater pool downstream of the screw trap.

We installed a 5-antenna PIT tag detector array at Rkm 34.7 (identified as KCB (Kiwanis Camp Bridge) in the PTAGIS database (http://www.ptagis.org/ptagis/) on 28 April 2005. However, we moved the location slightly upstream (Rkm 34.9) on 10 June 2005 because of radio frequency noise problems that we could not resolve at the initial location. The U.S. Fish and Wildlife Service (USFWS) installed two detector arrays at Bennington Dam (Rkm 18.5) (identified as MCD in the PTAGIS database): one in the downstream low flow outlet and another in the upstream ladder. Locations of the screw trap and PIT tag detection arrays are shown in Figure 4.

To relate stream temperatures to subadult movements and habitat, we installed thermographs at the rotary screw trap, the Kiwanis and Bennington PIT tag detector arrays, and near the mouth of Blue Cr. (Rkm 27.4).

Results and Discussion

Screw trap

From 12 April through 28 July 2005, we captured 566 bull trout, ranging in size from 112 to 480 mm (FL) (Table 9). Ninety-eight percent (n = 559) of the bull trout captured were < 300 mm FL (subadults). Subadult bull trout ranged from 112 to 287 mm (FL); with a mean FL of 144 mm (SD 19). Only 7 bull trout > 299 mm (adults) were captured. Adult bull trout ranged from 320 to 480 mm, with a mean FL of 410 mm (SD 52).

Table 9. Length data for bull trout captured in the Mill Creek screw trap, 2005.

		Fork Length (mm)			
Month	**Number captured**	**Min**	**Max**	**Mean**	**Standard Deviation (SD)**
		Subadults (< 300 mm FL)			
April	98	117	166	137	11
May	259	112	287	143	17
June	120	112	283	145	21
July	76	116	268	156	25
		Adults (> 300 mm FL)			
May	3	390	480	420	--
June	2	320	465	465	--
July	1	407	407	407	--

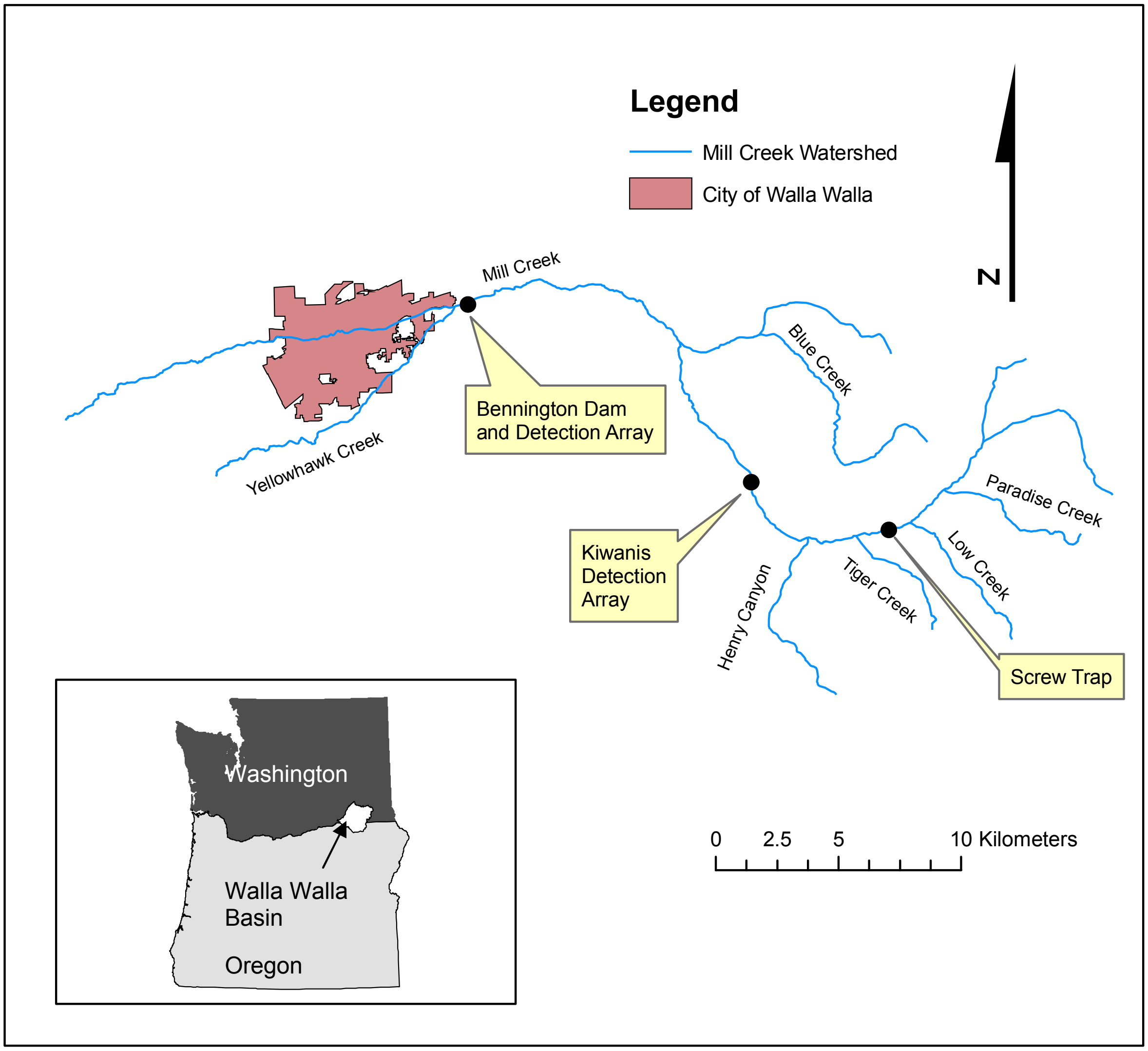


Figure 4. Map of Mill Creek showing location of screw trap used to capture subadult bull trout for PIT tagging and the locations of PIT tag detection arrays. Mill Creek is located in the eastern portion of the Walla Walla Basin near the Oregon-Washington border.

Peak migration of bull trout occurred in May. The migration timing and average size of bull trout captured by the screw trap from mid-April through July, 2005 were consistent with previous year's period (Table 9, Figure 5). In addition to bull trout, we captured five sculpin (*Cottus* spp.); one rainbow trout (Oncorhychus mykiss) < 50 mm FL, nine rainbow trout between 50-200 mm FL, and five rainbow trout > 200 mm; and three lamprey (*Lampetra* spp.).

Of the 560 bull trout captured in the screw trap, 538 were implanted with PIT tags (91 with 11 mm tags and 447 with 23 mm tags). Of the 22 we did not tag, 2 were already PIT tagged, 1 died during the tagging process and 19 were judged too small or otherwise unfit for tagging. PIT-tagged bull trout ranged in size from 112 to 410 mm FL, with an average length of 145 mm (SD 22). Length-frequency data for PIT tagged bull trout < 300 mm are displayed in Figure 6. Only three bull trout > 300 mm FL were PIT tagged at the screw trap.

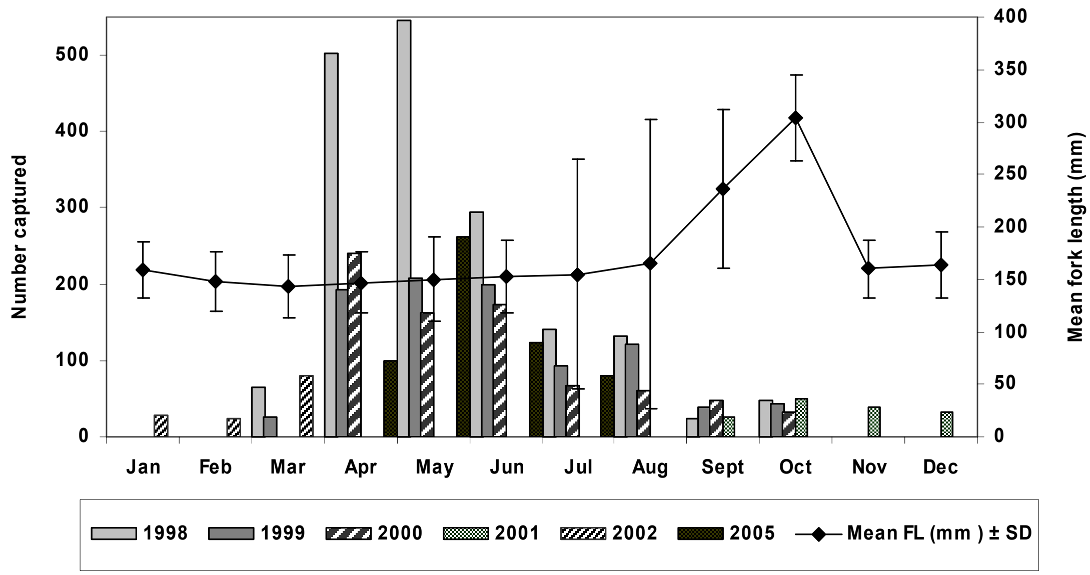


Figure 5. Timing (bars) and average size (line, with SD error bars) of bull trout captured in the Mill Creek screw trap, 1998-2005.

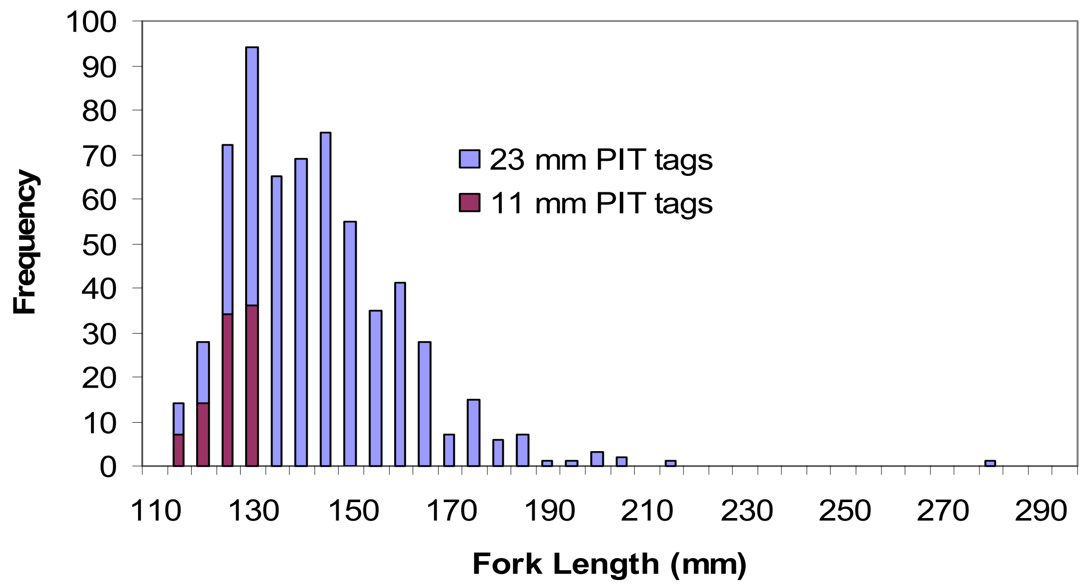


Figure 6. Length frequency distribution for subadult bull trout PIT tagged at the Mill Creek screw trap during 2005.

<u>Movement of PIT tagged subadults</u>

From 16 April 2005 through 2 January 2006, 139 (25%) of the subadult bull trout PIT-tagged at the screw trap during 2005 were detected by the "Kiwanis" antenna array (Table 10). Detection rates at the Kiwanis array did not vary appreciably between the two tag sizes. We detected 27% of the 23 mm tags versus 22% of the 11 mm tags. This was surprising given that we intentionally used the larger PIT tags because of their larger field of detection by instream antennas. The similarity in detection rates between the two tag sizes suggests that subadult bull trout stay close to the stream bottom and consequently close to the antenna while migrating.

Of the 139 fish detected at the Kiwanis array, 6 were also subsequently detected at the Bennington array and 2 moved back upstream to be detected at the Kiwanis array months later (Table 10). Additionally, there were four detections at the Bennington array that were not detected at the Kiwanis array. With unknown detection efficiency at the instream arrays, it is difficult to draw conclusions regarding the downstream distribution of subadult bull trout; however, the large discrepancy in the number of detections at the two arrays suggests that the vast majority of these fish rear in Mill Creek upstream from Bennington Dam. Our results also suggest that about 25% of subadult bull trout migrate downstream past the Kiwanis Camp for rearing. However, this is likely an underestimate because of problems we had with our initial installation of the antenna array. By the time the array was relocated and functioning properly in early June, screw trap catches indicated that peak migration had already occurred.

Our results further suggest that fish migrating downstream from the Kiwanis Camp remain downstream of this location at least throughout mid winter. The evidence for this behavior was demonstrated by the pattern of detections at the Kiwanis array. Most detections occurred relatively soon after tagging and only two fish were detected at this array more than once. This finding suggests that the portion of the Mill Creek watershed downstream of the natal area may provide better foraging and/or overwintering habitat for subadult bull trout.

Table 10. Travel time (days) between tagging site and locations first and last detected for subadult bull trout PIT tagged at the Mill Creek screw trap during 2005. Values in parenthesis are standard deviations.

Location, First/last detected	Number detected	Travel Time 1[b]			Travel Time 2[c]		
		Min	Max	Mean	Min	Max	Mean
Kiwanis	139	1	182	11 (25)	-	-	-
Kiwanis/Kiwanis[a]	2	3	47	-	39	98	-
Kiwanis/Bennington	6	2	10	5 (3)	2	31	16 (11)
Bennington only	4	7	29	18 (10)	-	-	-

a *Excludes one fish detected on two consecutive days.*
b *Travel time (days) from tagging location to location first detected.*
c *Travel time (days) from location first detected to location last detected.*

Fish size did not appear to influence distance traveled. The average size-at-tagging for bull trout detected at Bennington Dam (distance traveled 23.5 Rkm) was 139 mm (SD 14). The average size-at-tagging for bull trout detected only at the Kiwanis site (distance traveled 7 Rkm) was 145 mm (SD 14.1). Furthermore, there was no apparent relationship between size-at-tagging and travel duration for detections at either array (Figure 7).

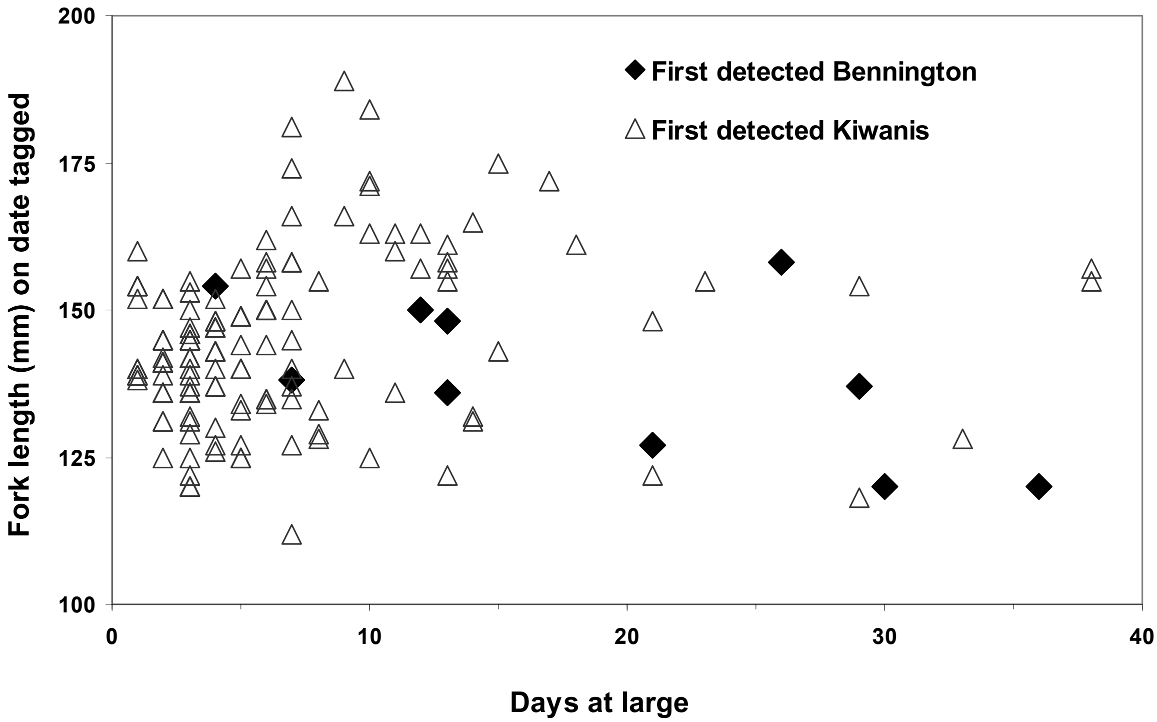


Figure 7. Fish length vs. travel time to detection at downstream arrays for subadult bull trout PIT tagged in 2005. Fish having travel times > 100 days are not included.

There did however appear to be a relationship between date and rate of travel to the Kiwanis array. On average, it took fish twice as long to reach the Kiwanis array during the summer than it did during the spring (Figure 8). Omitting fish that took longer than 100 days to reach the site, fish tagged in April and May took an average of six days to reach the Kiwanis array, whereas fish tagged in June and July took an average of 12 days. This difference was statistically significant ($p<0.01$, t-test assuming unequal variances). Stream discharge was a likely factor contributing to this difference in the rate of downstream movement (Figure 9). Discharge during April and May averaged about three-times higher than flow during June and July.

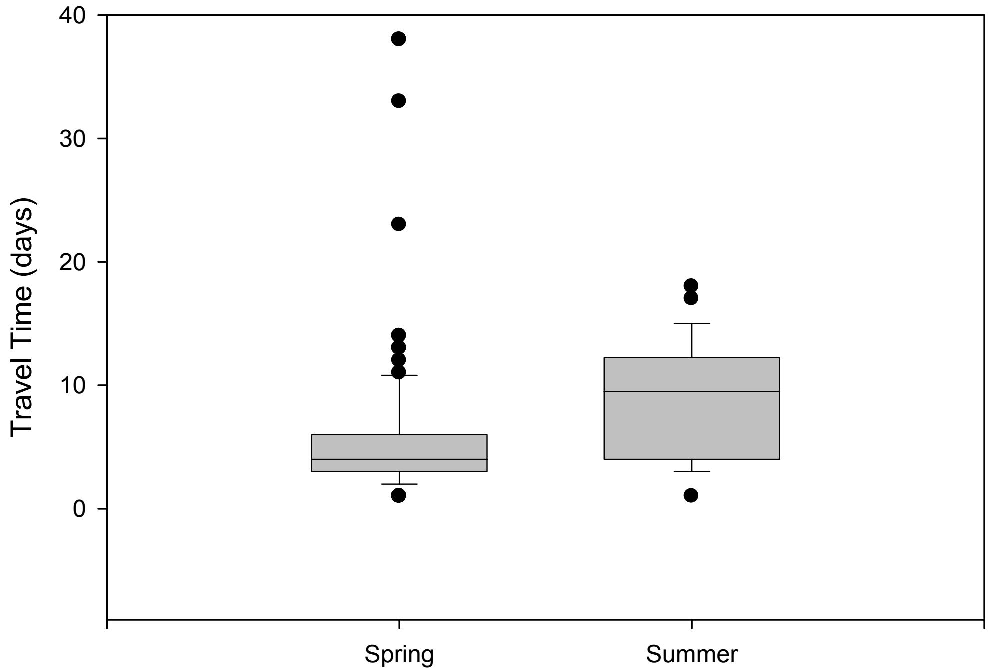


Figure 8. Box plots of travel time between the screw trap and Kiwanis array for subadult bull trout PIT-tagged during the spring and summer of 2005 in Mill Creek. Spring includes fish tagged in April and May. Summer includes fish tagged in June and July. Fish having travel times > 100 days are not included. Box boundaries represent upper and lower quartiles with horizontal line corresponding to median. Vertical lines represent range except for outliers (points).

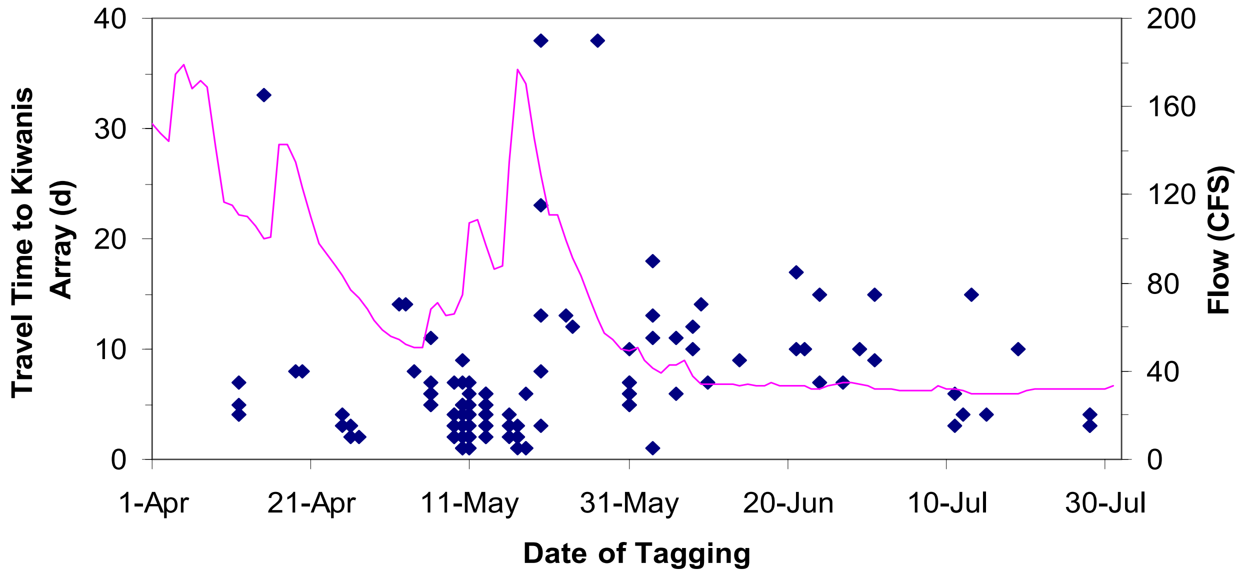


Figure 9. Relationship between date of tagging, stream flow and travel time between the screw trap and Kiwanis array for subadult bull trout PIT-tagged in 2005 in Mill Creek. Fish having travel times > 100 days are not included. Flow data derived from the USGS gauge number 14013000 near Walla Walla (http://waterdata.usgs.gov/wa/nwis/current/?type=flow).

Daily maximum water temperatures downstream of the Kiwanis array routinely exceeded 16° C during June through August (Figure 10). The 7-day average daily maximum temperature for subadult foraging and migration recommended by EPA is 16° C (EPA 2003). Peak summer daily maxima downstream from the Kiwanis array were 20-24° C during mid-July through mid-August. These data, along with our findings on subadult summer distribution, indicate that at least a portion of subadult bull trout in Mill Creek encounter summer temperatures well above recommended criteria.

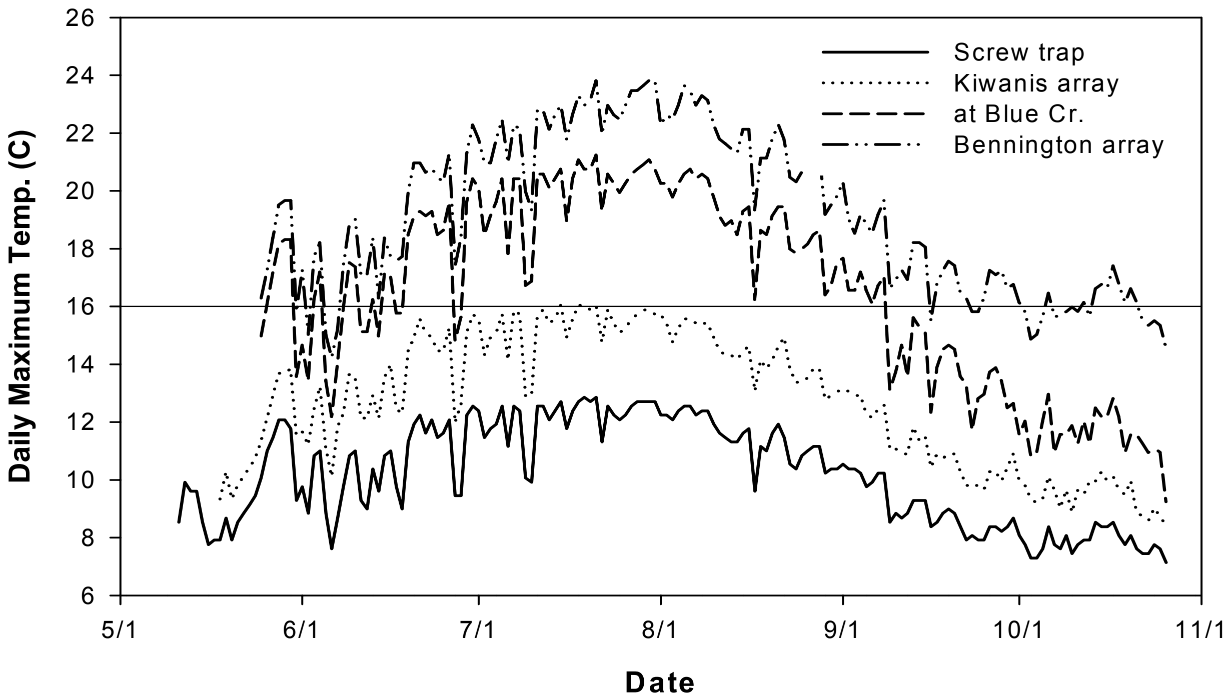


Figure 10. Daily maximum temperatures (°C) at four sites on Mill Creek, 2005. Horizontal line shows the 7-day average daily maximum temperature for subadult foraging and migration recommended by EPA.

IV. Spatial Distribution of Bull Trout Redds in the John Day Basin and Evaluation of Various Statistical Sampling Designs

Introduction

The ability to accurately assess bull trout population status, trend, and distribution is central to conservation efforts for the species. A coordinated approach to conducting such assessments is needed to support restoration efforts. Currently, most monitoring activities are not part of an overall framework for coordinating effort and synthesizing and interpreting results. The Environmental Protection Agency (EPA) has developed the Environmental Monitoring and Assessment Program (EMAP) to evaluate the status of natural resources at regional and national scales. The goal of EMAP is to provide a scientific basis for monitoring programs that measure current and changing resource status.

EMAP employs a probabilistic sampling design that allows resource assessment over large areas based on data from representative sample locations. The design involves a spatially balanced random sampling strategy that distributes sample locations evenly throughout the area of assessment. Trends in status are best assessed by visiting randomly selected sampling sites on annual and multi-year cycles. The EMAP sampling design allows evaluation of status, trend, and distribution at multiple scales with statistical rigor.

From 2002 to 2004, we used the EMAP protocol to monitor the abundance of adult bull trout in the Oregon and part of the Southeast Washington portion of the Columbia Plateau Province; specifically, the Deschutes, John Day, Umatilla, and Walla Walla River subbasins (Starcevich et al. 2005). We used redd counts to assess adult abundance. Counting redds is the easiest and often the least costly way to monitor adult abundance. Although there can be substantial error associated with the enumeration of redds (Bonneau and LaBar 1997; Dunham et al. 2001; Hemmingsen et al. 2001b), some research has shown that redd counts are strongly correlated with estimates of adult escapement (Dunham et al. 2001).

Questions concerning the design of monitoring approaches used for bull trout led to our pilot study to test the applicability of EMAP as a sampling framework. In the case of bull trout redds, EMAP can be used to select survey sites that should provide a representative sample for the population in question. Conceptually, this approach has advantages over the traditional practice of subjectively using index areas to monitor redd abundance. Obvious advantages of the EMAP design over the index area approach include lack of bias due to spatial and temporal variation in spawner distribution, ability to draw inference across the entire extent of the spawning population, and ability to detect changes in spawner distribution. We employed a pilot study to use EMAP sampling designs in each of the last three spawning seasons (2002, 2003 and 2004). Evaluations were undertaken in each of three subbasins within the Columbia Plateau Province: the Deschutes, John Day, and Umatilla/ Walla Walla (Hemmingsen et al. 2002). Our approach used the EMAP methodology to draw a random sample of 50 spatially-balanced sample points for each subbasin for each of the three years. A 1.6 km stream reach that encompassed each point was then surveyed to obtain cumulative redd counts. From these data, estimates of total redd abundance with associated 95% confidence intervals were calculated for each subbasin in each year. Additionally, in the Umatilla/Walla Walla subbasin we conducted a census of redds in the entire sample frame to determine the level of bias associated with the EMAP methodology.

Initial results from the pilot study showed that the EMAP methodology provides reasonably precise estimates (< ±30%) and in the Umatilla/ Walla Walla subbasin the estimates were generally unbiased. In the case of the John Day subbasin, however, very few redds were observed and the estimates of total redd abundance indicated a very small spawner population. The pilot study also showed the John Day subbasin to have the largest sampling frame and a redd distribution that was more fragmented than that occurring in the other two subbasins. These attributes add complexity to developing an optimal sampling design for the John Day subbasin. One approach that is commonly used to sample fragmented resource distributions is stratified random sampling (Cochran 1977). To perform stratified random sampling, one first needs to have a good understanding of the underlying distribution pattern. Having this, the sampling frame can then be partitioned into strata and a sampling design can be applied individually to each stratum.

In order to evaluate a stratified random sampling design in the John Day subbasin we must first determine the redd distribution. To accomplish this we conducted a census of known spawning streams in 2005 and geo-referenced the locations of all bull trout redds. These data were then used to develop GIS coverage of redd distribution. This coverage will then be used to simulate various sampling strategies, including stratified random sampling, to determine which strategies perform the best in terms of providing accuracy and precision.

Methods

The John Day subbasin sample frame consists of all potential and current bull trout natal streams in the North Fork, Middle Fork, and upper mainstem John Day River (Figure 11). The identification of this sample frame was based on ODFW maps of current distribution (derived from the EPA's 1:100k river reach data set) and input from ODFW district biologists and other fishery managers via Streamnet's (http://www.streamnet.org) 1:24K mapping effort. Because of limited crew size and unique problems on the North Fork (such as extensive sympatry with fall spawning brook trout and fine granitic substrate), we limited our 2005 census to tributaries of the Middle Fork and upper John Day River. This sample frame constituted 273 km; however we were unable to survey the lower 6 km of the mainstem John Day River and the lower 1 km of Rail Creek because the landowner denied our access. Excluding these 7 km from the sampling frame probably had little effect on redd counts because no bull trout redds were observed on EMAP surveys conducted in this area in 2002-04 (Figure 11).

To survey the study area, the sample frame was divided into 34 distinct and contiguous stream reaches that divided each tributary into logistically practical survey units. Survey end-points were marked with flagging, and plastic identification signs were fixed to a nearby tree on the stream bank.

From late August through early November, all reaches were surveyed three to six times. Two 2-person crews were trained in the identification of bull trout redds, and spawning surveys were conducted according to ODFW protocols (Bellerud 1997). To minimize variation in the consistency of redd identification, crew members rotated among survey reaches during successive visits. During the surveys, each newly observed redd was recorded and flagged. Additionally, a GPS receiver was used to record the UTM coordinates of each newly observed redd.

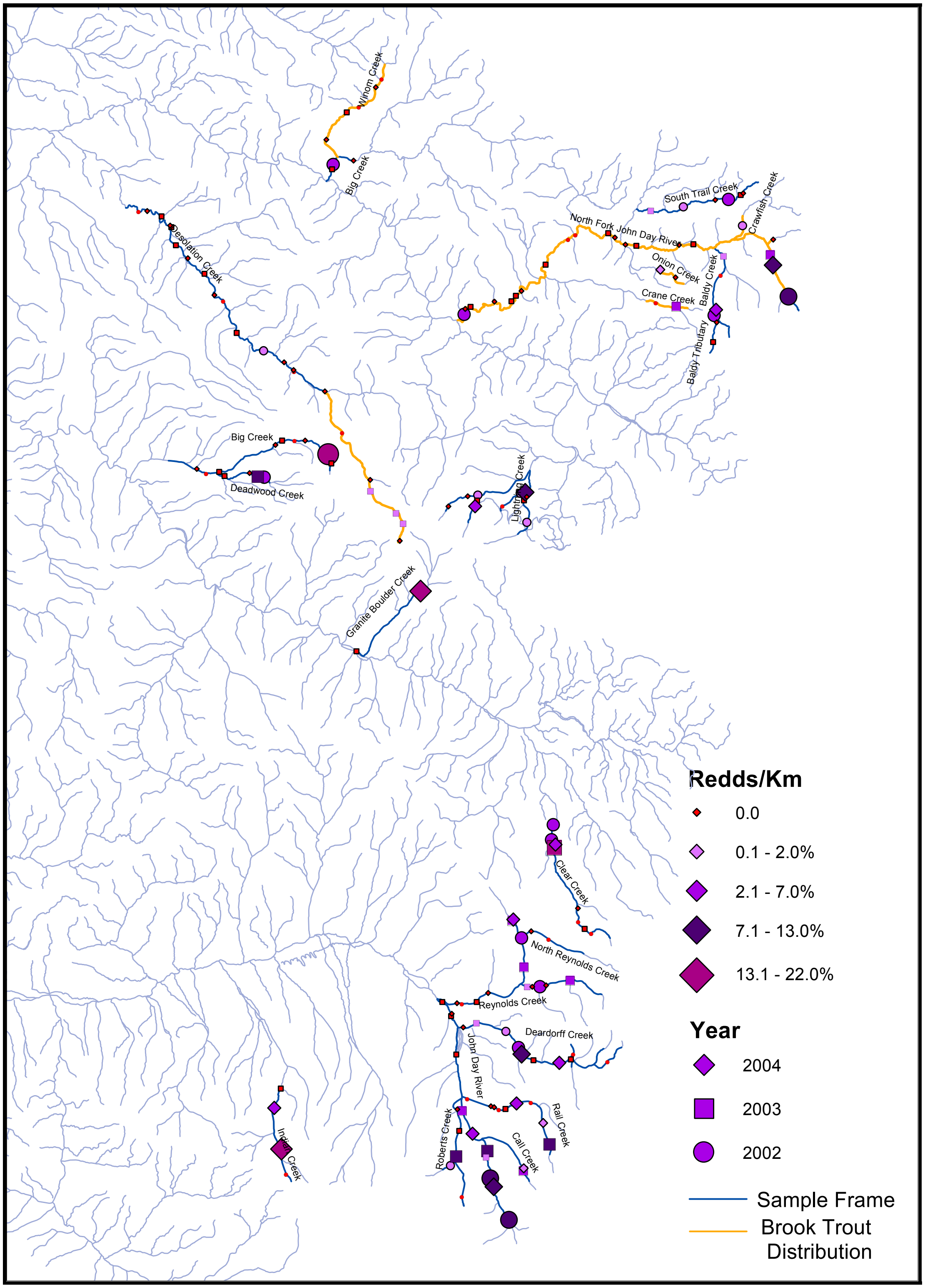


Figure 11. Bull trout sample frame, distribution of brook trout within the sampling frame and relative redd densities observed on EMAP surveys in the John Day Basin, 2002-04. Relative redd densities were calculated as the proportion of the total annual density observed in each respective sample location.

To create a GIS coverage, we associated the coordinates of each observed redd with the nearest point on a stream in the sample frame. This process was conducted using ArcGIS software that snapped the redd point coverage to the line coverage representing the sample frame. The resulting coverage allowed the location of each redd to be precisely located relative to the sample frame.

Results and Discussion

In all, we observed 154 redds in the 2005 census (Table 11). Surveys began on 25 August and extended through 3 November. All reaches were surveyed at least four times, with the exception of Rail Creek, which was only surveyed three times because of difficulties with access. Redds were observed during each week of the 10-week survey season and peak numbers of redds were observed during the week of 16 October (Figure 12). This temporal pattern was partly due to the protracted nature of bull trout spawn timing as well as the relatively long interval between survey visits.

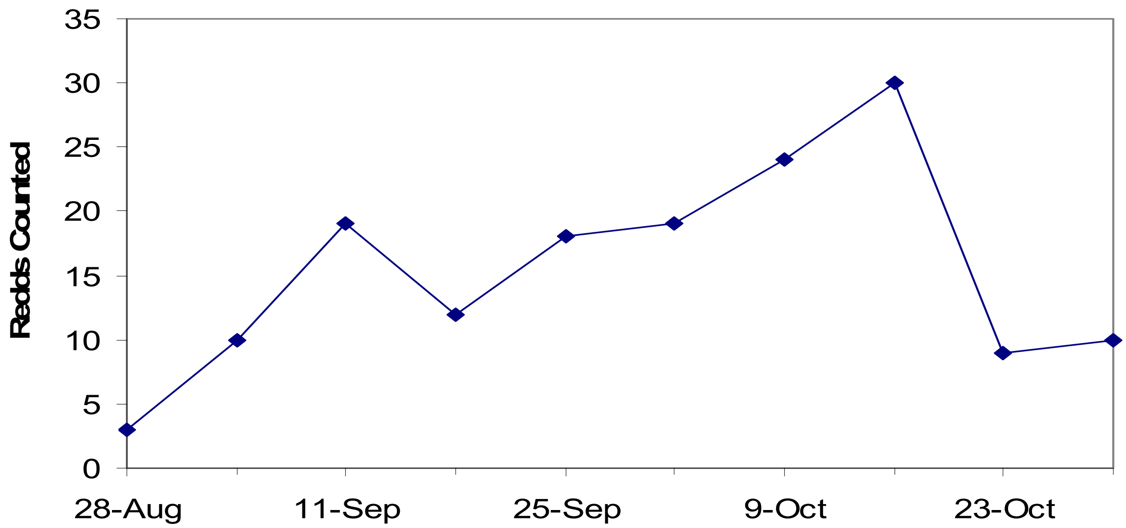


Figure 12. Temporal distribution of bull trout redds observed in the John Day Basin, 2005. Points displayed represent total numbers of redds observed for consecutive 7-day periods.

Redds were unevenly distributed within the sampling frame (Figure 13). In general, most of the sampling frame was void of redds, with a few locations supporting most of the redds. With the exception of Clear Creek, only two redds were observed in Middle Fork John Day tributaries. Further, within Clear Creek, most of the observed redds occurred within approximately 1 km of each other. In the mainstem John Day tributaries, the highest densities of redds were found in upper Deardorff and Rail creeks and the upper John Day River.

We are currently in the process of modeling the performance of statistical sampling designs using the redd distribution coverage we obtained in 2005. We are conducting this work in conjunction with staff from the Department of Statistics at Oregon State University. Sampling designs that are being modeled include a stratified version of EMAP and an Adaptive Sampling Design that varies survey reach length when redds are encountered to maximize the probability of observing redds in the sample. Results of this modeling will be reported in 2007.

Table 11. Stream reaches surveyed to census bull trout redds in the John Day Basin in 2005.

Subbasin	Stream	Reach	Times Surveyed	Date of First Survey	Date of Last Survey	Redd Count
Middle Fork John Day	Clear Creek	1	5	9/6/2005	10/25/2005	1
		2	5	9/6/2005	10/25/2005	0
		3	5	9/6/2005	11/2/2005	5
		4	5	9/6/2005	11/1/2005	17
	Granite Boulder Creek	1	5	9/12/2005	10/31/2005	0
		2	5	9/12/2005	10/31/2005	1
	Deadwood Creek	1	4	8/30/2005	10/25/2005	0
		2	4	8/30/2005	10/25/2005	0
	Big Creek	1	4	8/30/2005	10/24/2005	0
		2	4	8/30/2005	10/24/2005	0
		3	4	8/30/2005	10/24/2005	1
		4	4	8/30/2005	10/24/2005	0
Upper John Day	Mossy Gulch	1	5	8/31/2005	11/1/2005	1
	North Reynolds Creek	1	5	8/21/2005	11/1/2005	0
		2	5	8/31/2005	10/27/2005	3
	Call Creek	1	5	9/1/2005	11/2/2005	2
		2	4	9/1/2005	10/20/2005	2
	Rail Creek	2	3	9/8/2005	10/8/2005	3
		3	3	9/8/2005	10/26/2005	11
		4	3	9/8/2005	11/1/2005	6
	Roberts Creek	1	5	9/6/2005	11/3/2005	19
	Deardorff Creek	1	5	8/25/2005	11/3/2005	1
		2	5	8/25/2005	11/2/2005	1
		3	5	8/25/2005	11/2/2005	9
		4	4	9/1/2005	10/17/2005	17
	Reynolds Creek	1	5	9/7/2005	11/1/2005	1
		2	4	9/12/2005	10/9/2005	2
		3	4	9/12/2005	10/19/2005	0
	Indian Creek	1	4	8/31/2005	10/25/2005	5
		2	4	8/31/2005	10/25/2005	5
	John Day River	1	5	9/7/2005	10/25/2005	0
		2	5	9/7/2005	11/2/2005	16
		3	5	9/7/2005	11/2/2005	10
		4	6	9/7/2005	11/2/2005	15

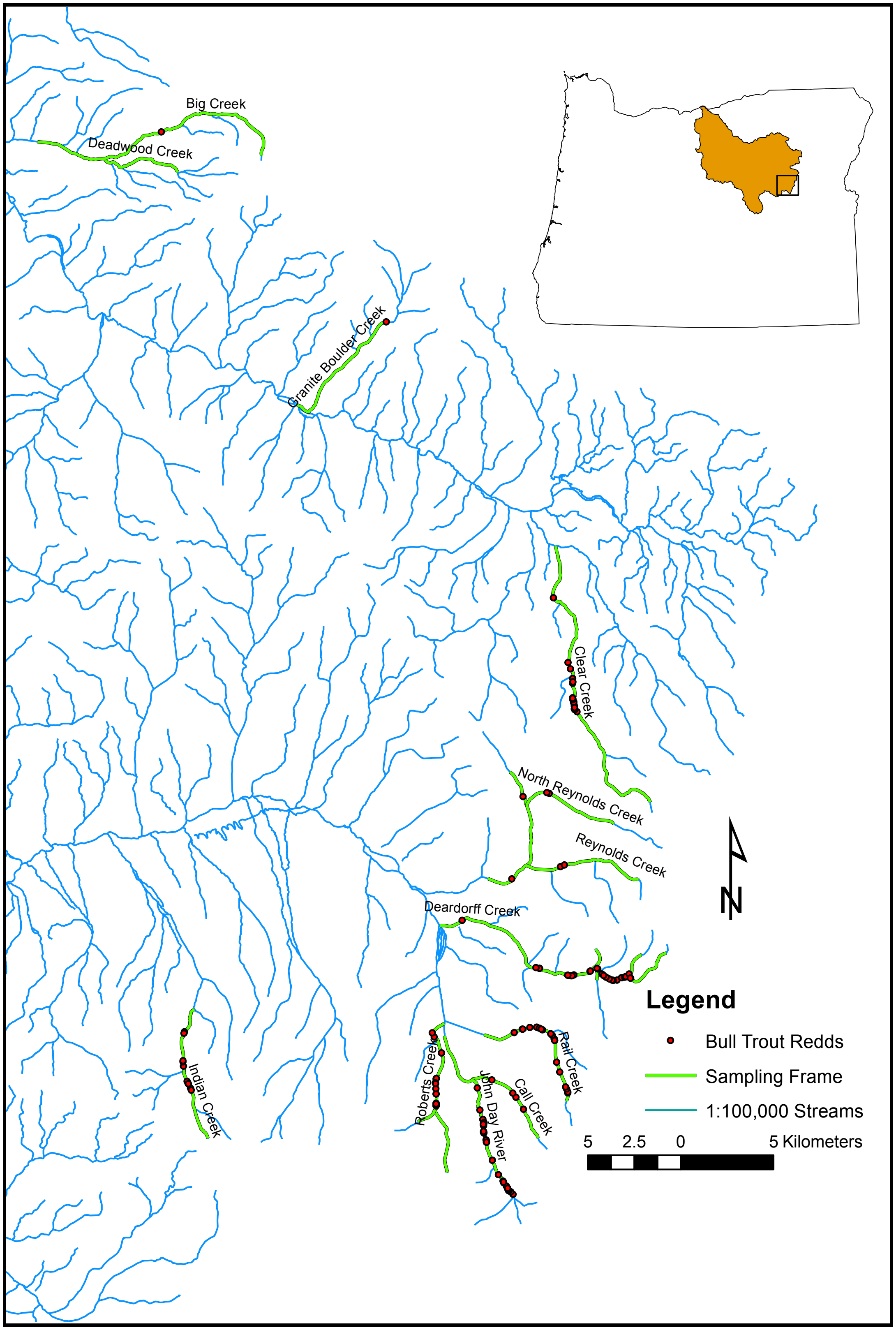


Figure 13. Locations of bull trout redds observed during the 2005 census in the Upper John Day Watershed.

V. Analysis and Synthesis of Project Results

Introduction

The intent of this objective is to progress towards scientific publications or summary reports from results of past work of this project. During FY 2005 project staff have worked principally on the following data sets:

- Analysis of migration patterns of fluvial bull trout from NE Oregon using radio telemetry
- Life history of Mill Creek fluvial bull trout using PIT tags and cohort analysis-development of database and initial analysis
- Temperature selection of adult bull trout in the Lostine River
- Application of the EMAP sampling design to monitor bull trout through redd counts.

A description of accomplishments for specific data sets is provided below.

Analysis of Migration Patterns of Fluvial Bull trout Using Radio Telemetry

We developed a relational database that compiles all radio telemetry data obtained to date. This database contains migration histories of 214 bull trout from nine different watersheds (Table 12). Data records are currently being screened to identify tracking histories that accurately represent migrating fish. To date, the screening is complete for the Upper John Day, Umatilla and Lostine rivers and Mill Creek. Additionally, migration patterns have been characterized for the Lostine and Upper John Day populations. Elements of this analysis for the upper John Day population are presented here.

Table 12. Watersheds where adult bull trout were tracked using radio telemetry.

Watershed	Number of Tagged Fish[a]	Date Tagging Began	Date Tracking Completed	Average FL of Tagged Fish (mm)	Average Number of Observations Per Fish	Average Duration of Tracking (months)
Grand Ronde River	2	4/9/97	11/25/97	264	13	2.1
Catherine Creek	9	4/30/97	6/17/99	198	7	6.3
Upper John Day River	24	6/17/98	6/11/01	401	38	21.8
Lookingglass Creek	7	10/9/97	7/31/01	457	15	21.4
Wenaha River	53	7/16/97	7/31/01	462	21	22.1
Mill Creek	58	6/10/97	11/16/01	402	58	14.8
Imnaha River	21	7/23/01	9/19/02	465	15	6.1
Lostine River	25	4/22/97	1/8/03	413	14	7.4
Umatilla River	15	6/12/02	10/31/03	410	11	10.2

a *Only includes fish that were tracked for a minimum of one month following the date of tagging.*

In the upper John Day River subbasin, bull trout were captured and surgically implanted with radio transmitters between mid-July 1998 and November 1999. Fish that were tagged were captured either as downstream or upstream migrants. Upstream migrants were captured at weir traps in Call Creek at Rkm 0.7, Deardorff Creek at Rkm 5.3, Roberts Creek at Rkm 1.3, and the upper John Day River at Rkm 449.2 (Figure 14). Downstream migrants were captured in traps placed a few meters upstream of traps that captured upstream migrants at each location and in a screw trap located on the John Day River at Rkm 436.8. Radio tagged fish were tracked about twice a month usually by vehicle or foot (to pinpoint locations), or occasionally by plane.

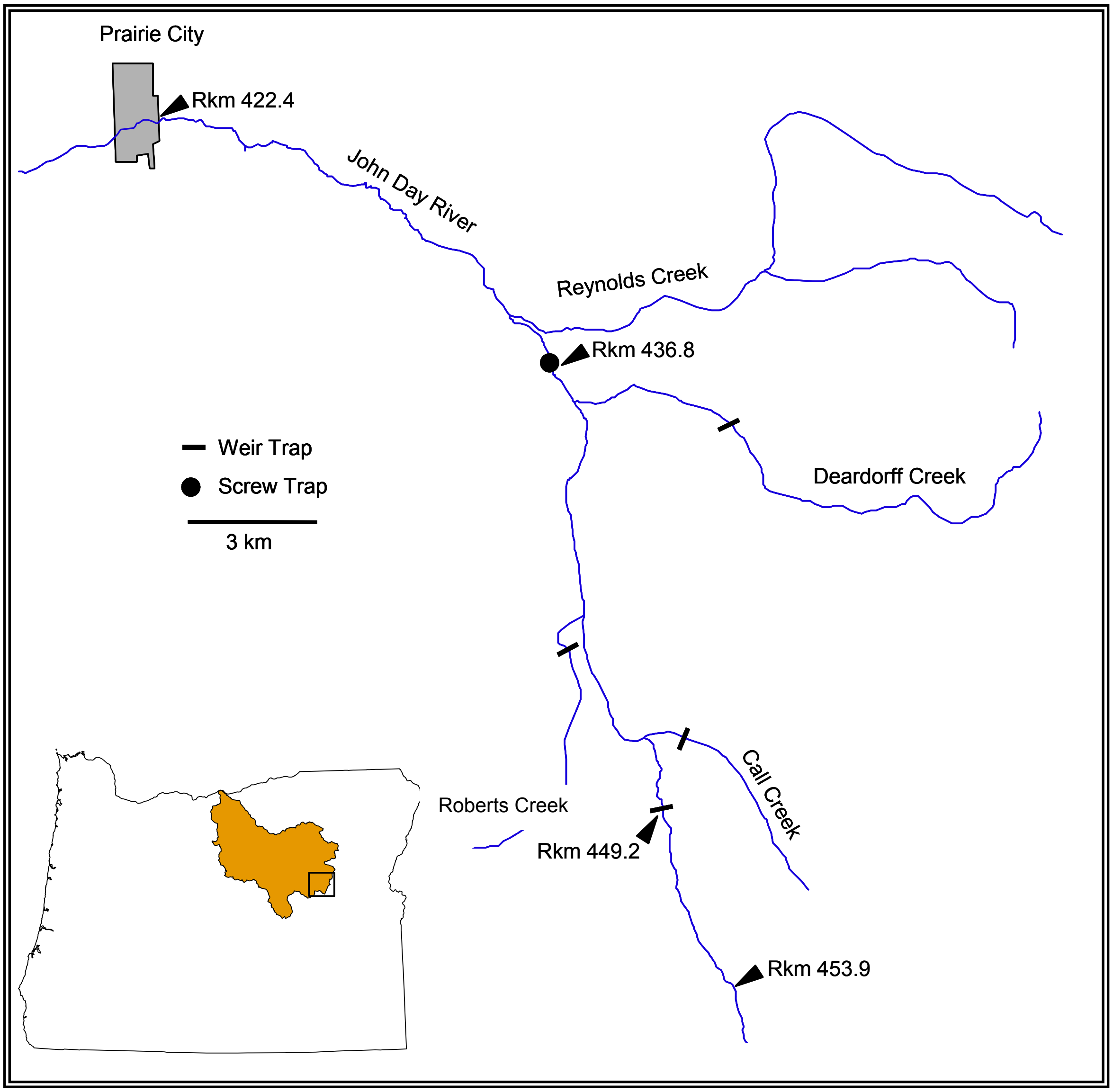


Figure 14. Map of the Upper John Day River showing location where bull trout were captured, radio tagged, and tracked.

Movement of Upper John Day Basin bull trout was generally limited. Of the 24 radio tagged fish that were tracked for a minimum of four months, home range averaged 16.6 km and ranged from 3.2 to 45.9 km (Table 13). Although any conclusions must be tempered by the relatively low sample size, these findings suggest that bull trout inhabiting the upper John Day do not make extensive migrations in the mainstem river for foraging or overwintering.

Table 13. Bull trout radio tagged and successfully tracked in the Upper John Day Basin, 1998-2001.

Tag Frequency	Tagging Date	Fork Length (mm)	Capture Method[a]	Transmitter Battery life (months)	Number of Observations	Last Date of Detection	Duration of Tag Detection (months)	Duration of Fish Movement[b] (months)	Home Range (km)[c]
				Call Creek					
150.433	8/18/1998	510	D	24	30	7/20/2000	23.4	15.5	31.7
150.472	7/13/1998	465	U	24	47	6/4/2001	35.2	21.6	21.6
150.493	7/21/1998	530	U	24	72	6/11/2001	35.2	19.9	5.3
150.554	9/10/1998	520	D	24	58	3/23/2001	30.8	18.2	39.9
150.982	10/5/1998	465	D	18	32	1/13/2000	15.5	15.5	27.2
151.302	10/23/1999	285	D	18	47	6/11/2001	19.9	13.1	3.2
151.562	7/13/1999	318	D	18	32	7/20/2000	12.4	12.4	5.6
				Deardorff Creek					
150.453	6/17/1998	482	D	24	68	6/11/2001	36.3	35.5	13.4
150.534	7/28/1998	459	U	24	26	1/13/2000	17.8	17.8	26.5
150.604	8/1/1998	502	U	24	56	3/23/2001	32.2	20.9	8.0
151.081	7/8/1998	261	D	5	16	7/26/2000	25.0	22.7	14.1
151.703	6/8/1999	247	D	9	31	8/25/2000	14.8	11.3	10.9
				John Day River					
150.354	8/1/1998	501	U	24	65	6/4/2001	34.6	22.9	26.9
150.952	9/23/1998	320	D	18	25	7/6/2000	21.7	17.7	16.8
151.222	9/1/1999	305	D	18	22	6/14/2000	9.6	2.6	3.3
151.301	11/9/1999	360	D	--	42	5/25/2001	18.8	11.0	4.3
151.313	6/25/1999	319	D	18	21	7/6/2000	12.6	4.2	12.4
151.541	10/13/1999	400	D	36	8	2/22/2000	4.4	3.3	15.7
160.601	7/9/1999	285	D	9	24	7/6/2000	12.1	2.0	16.3
170.582	11/9/1999	495	D	18	47	6/11/2001	19.3	14.7	5.1
				Roberts Creek					
150.623	9/8/1998	560	U	36	35	12/20/2000	27.8	14.8	45.9
150.932	9/16/1998	240	D	9	24	4/21/2000	19.4	18.3	24.5
150.992	9/17/1998	420	D	18	42	8/18/2000	23.4	23.0	5.4
151.343	7/23/1999	362	U	18	32	4/30/2001	21.6	20.8	14.4

a *D=downstream Trap, U=Upstream Trap.*
b *Duration between date of tagging and date when last movement occurred.*
c *Maximum distance traveled.*

Movement histories of fish associated with capture locations in individual tributaries are displayed in Figures 15-18. Most movement appeared to be associated with spawning or post-spawning. We determined fish were spawning if they were observed in tributaries or the mainstem John Day River upstream of Rkm 448 during the period from mid-September through October. All but five of the radio-tagged fish exhibited moved to known spawning areas during the spawning periodevidence of spawning. Also, fish that appeared to spawn in a tributary generally left the tributary soon after spawning and either rapidly moved downstream, or more gradually moved upstream.

Of the seven fish that were tracked after apparently spawning in Call Creek, three (tags 150.554, 472, and 433) rapidly moved downstream after spawning while the remaining four fish remained within a short distance from the mouth of Call Creek. (Figure 15). Of the five fish associated with Deardorff Creek (Figure 16), all five left the creek shortly after apparently spawning and resided in the mainstem, either upstream (tags 150.604 and 150.534) or downstream (tags 150.453, 151.081 and 151.703) of Call Creek confluence.

Only three of the eight fish radio tagged in the mainstem apparently spawned (Tags 150.354, 151.301 and 170.582; Figure 17). One of these fish moved about 15 km downstream after spawning while the other two remained within a few km of their spawning locations. Post-spawning migration patterns for fish in Roberts Creek were similar to the range of patterns observed elsewhere, with two of the four fish moving downstream after spawning and the remaining two holding near the spawning area (Figure 18).

The movement patterns we detected suggest that following spawning, bull trout in the upper John Day watershed do not have a propensity for extensive migration but are more opportunistic in perhaps seeking nearby locations offering foraging or over-wintering habitat. Additionally, it appears that some of these fish repeat spawn in consecutive seasons. Of the 17 tracked fish with movement histories that spawned two spawning seasons, eight showed evidence of spawning in both seasons. The best example is exhibited by tag 150.453 in Deardorff Creek.

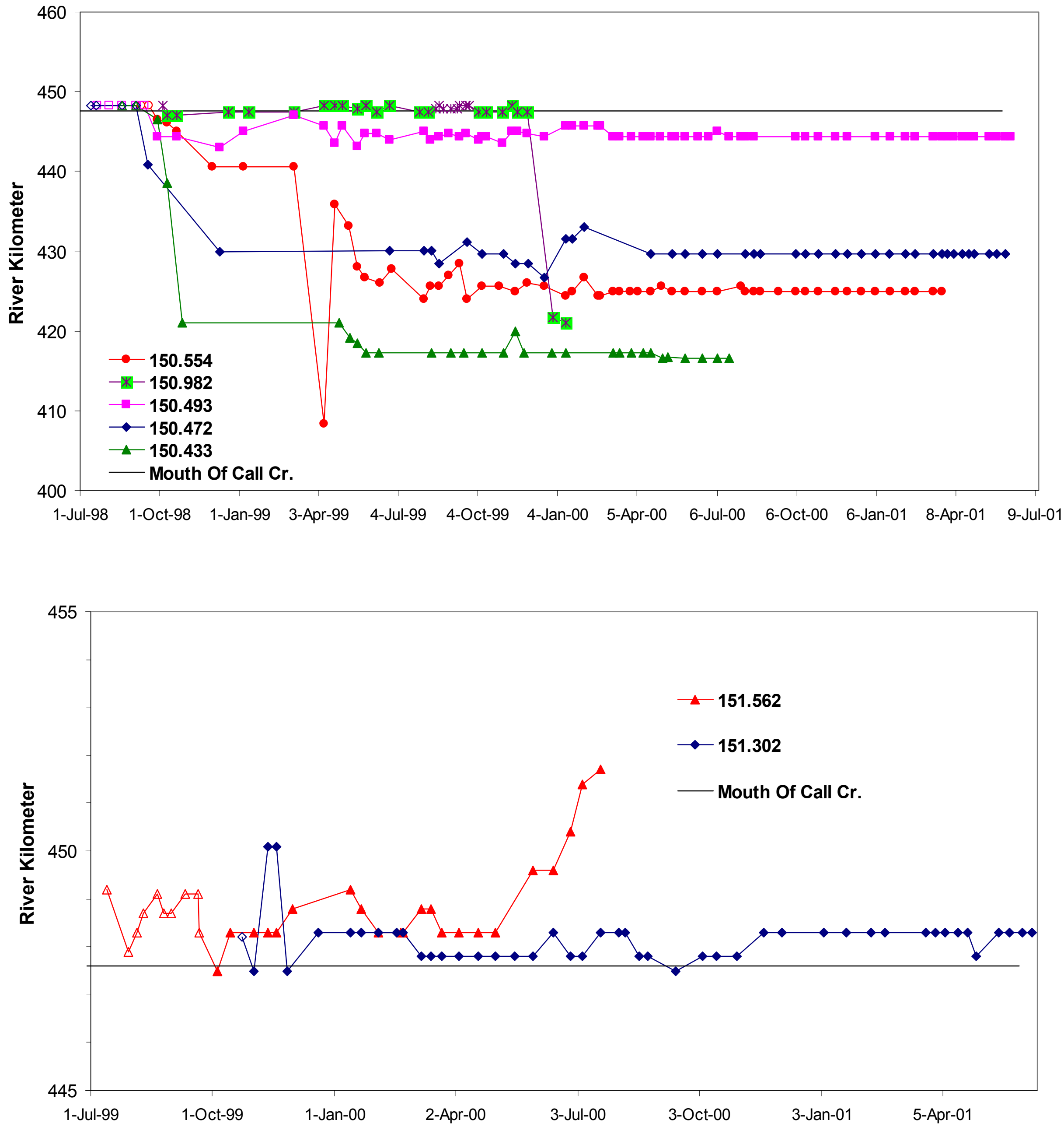


Figure 15. Movement history of radio tagged bull trout either captured or associated with Call Creek, John Day River. Open symbols represent locations in Call Creek and solid symbols represent locations in the mainstem John Day River. Horizontal line represents location of the confluence of Call Creek and John Day River. Upper panel includes fish that migrated downstream from confluence and lower panel includes fish that migrated upstream from confluence.

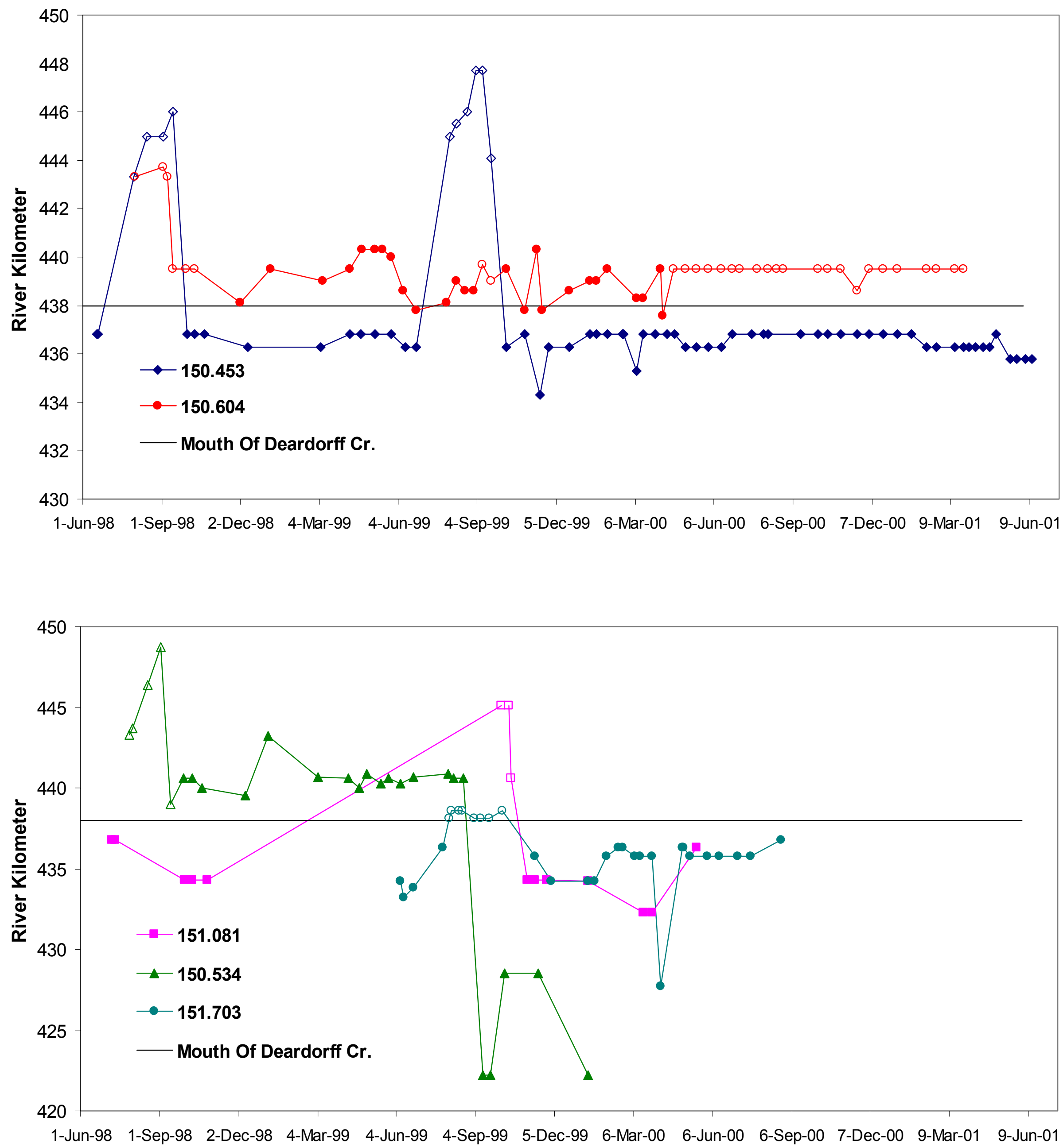
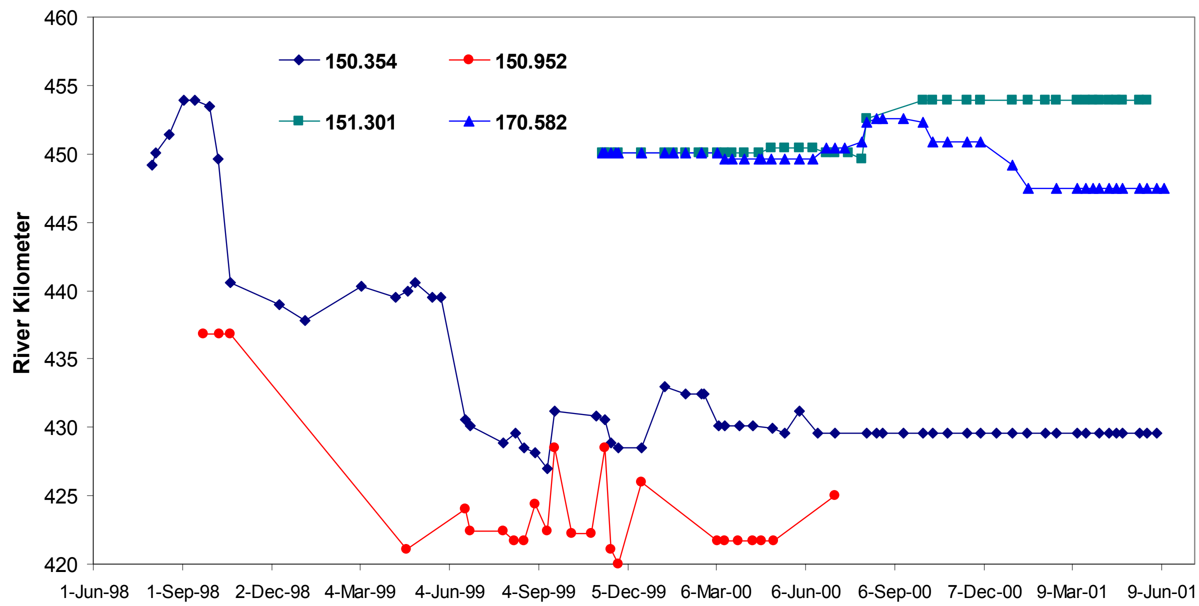


Figure 16. Movement history of radio tagged bull trout either captured or associated with Deardorff Creek, John Day River. Open symbols represent locations in Deardorff Creek and solid symbols represent locations in the mainstem John Day River. Horizontal line represents location of the confluence of Deardorff Creek and John Day River.



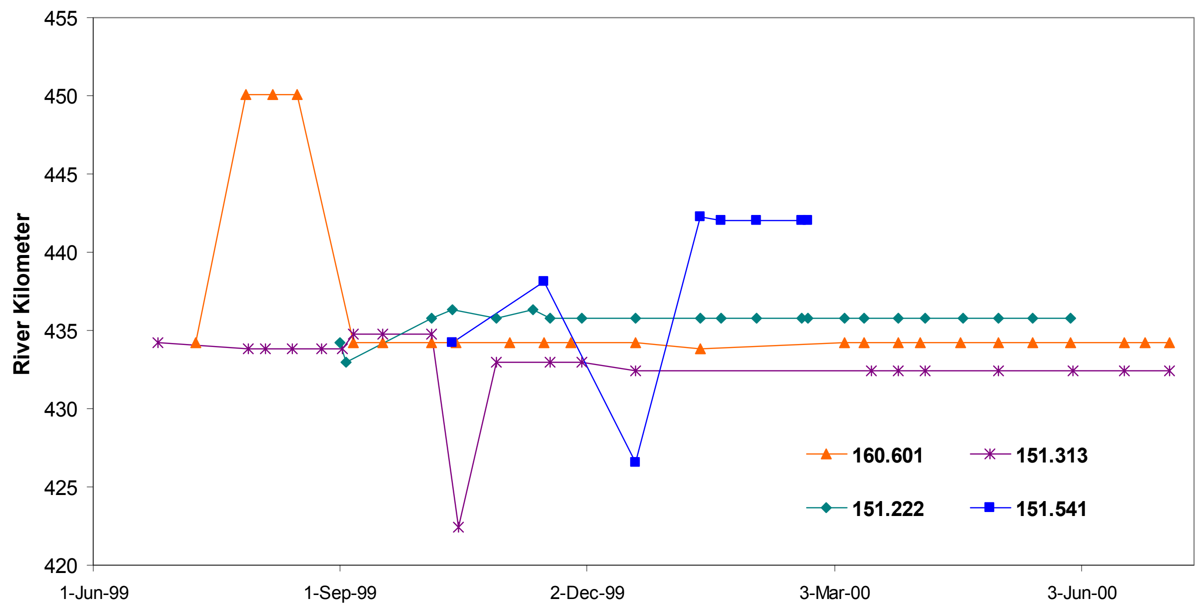


Figure 17. Movement history of radio tagged bull trout captured in the upper John Day River.

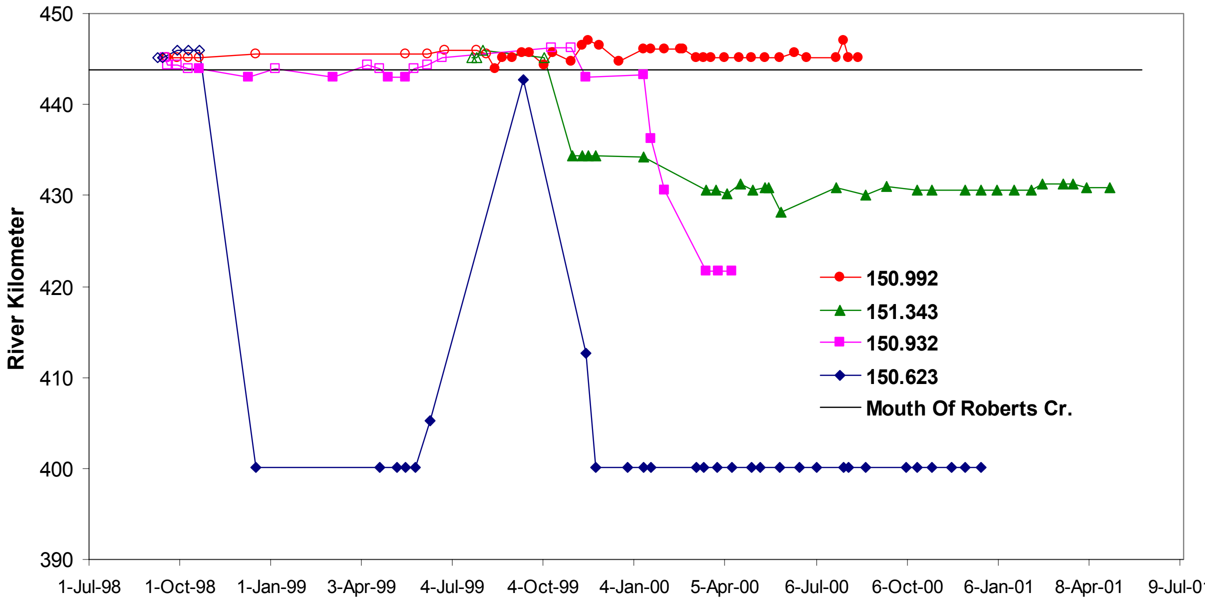


Figure 18. Movement history of radio tagged bull trout either captured or associated with Roberts Creek, John Day River. Open symbols represent locations in Roberts Creek and solid symbols represent locations in the mainstem John Day River. Horizontal line represents location of the confluence of Roberts Creek and John Day River.

Life History of Mill Creek Fluvial Bull Trout Using PIT Tags and Cohort Analysis

This project has been investigating the life history characteristics and seasonal migration patterns of Mill Creek bull trout since 1998. Our goal is to summarize past data and communicate our findings in a peer reviewed publication or summary report. In 2005, we devoted time to analyzing data, and have made significant progress. For example, we developed an MS Access database that consolidates biological data collected at the upstream and downstream migrant traps and PIT tag detection data collected both at the traps and PIT tag interrogation sites located downstream. This database greatly improves our ability to manipulate large, complex datasets. Selected examples of our findings are presented in this section.

<u>Downstream migration</u>

We operated a 1.5 meter (m) rotary screw trap in upper Mill Creek (Rkm 42) from March to October 1998-2000, and from September 2001 through March 2002. Our main goals were to investigate the timing and biological characteristics of subadult bull trout emigrating from natal areas in the headwaters of Mill Creek, and to capture bull trout for tagging purposes.

During periods of operation from 1998-2005, the screw trap captured 4,113 bull trout; which ranged in size from 34 to 652 mm (FL). Ninety-six percent (n=3,959) were < 300 mm (subadults). Subadult bull trout ranged from 34 to 297 mm (mean 151, SD 27). Peak migration of subadults occurred in April or May (Figures 19 and 20). Although the number captured varied widely throughout the year, the mean lengths of all subadults captured in the screw trap were similar (Figure 1). These data provide evidence that in Mill Creek most bull trout emigrate from natal headwater areas after reaching a size threshold generally exceeding 100 mm.

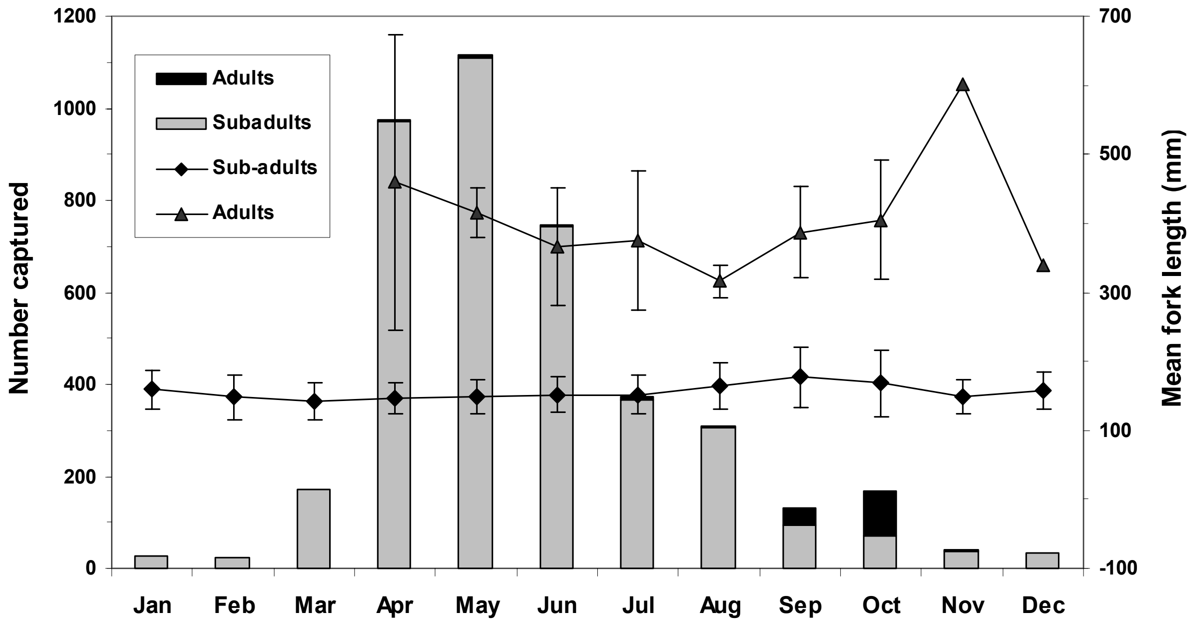


Figure 19. Number and average size (mean FL ± SD) of bull trout captured in the Mill Creek screw trap, 1998-2005.

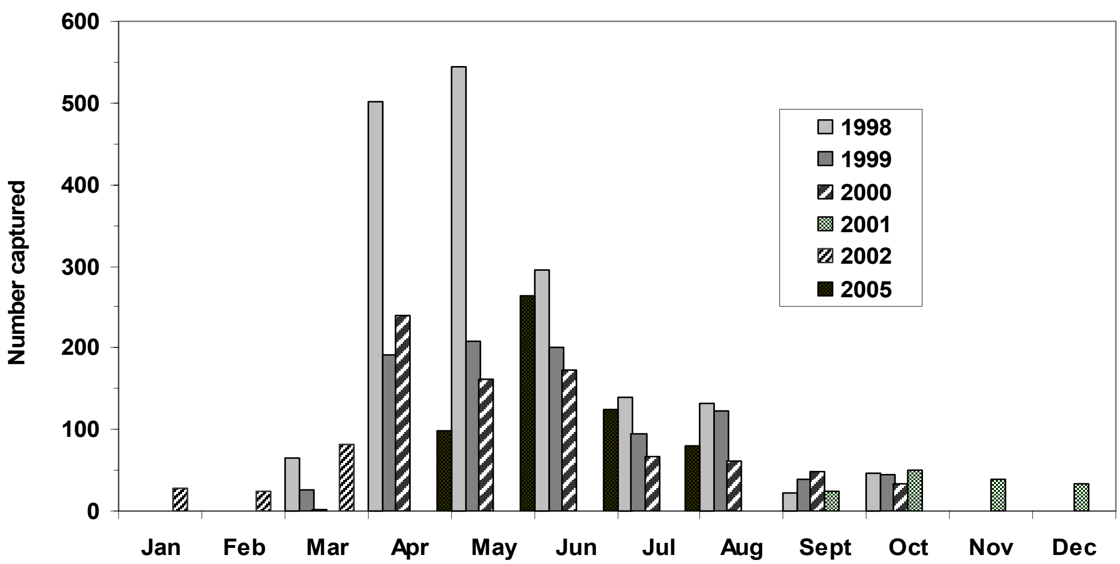


Figure 20. Number of bull trout captured each month in the Mill Creek screw trap, 1998-2005.

Adult bull trout captured in the screw trap ranged from 300 to 652 mm (mean 400, SD 84). The majority of adults were captured in September and October, most likely as they vacated spawning areas (Figure 19). Of the bull trout captured in the screw trap, 1,446 were implanted with PIT tags. PIT-tagged bull trout ranged in size from 93 to 540 mm (mean 168, SD 44). Ninety-seven percent (n=1,401) of bull trout PIT tagged at the screw trap were subadults. Only 45 adult bull trout were PIT tagged at the screw trap.

Upstream migration

We captured upstream migrants as they exited the fish ladder at the water intake dam for the city of Walla Walla (Rkm 40.9). We operated the upstream migrant trap from June through October 1998, 2000, 2001, 2002 and 2005; March through October 1999; June through September 2003; and May through October 2004. Our main goals were to investigate the timing, biological characteristics, and population size of adult bull trout returning to natal headwater areas to spawn, and to recapture PIT-tagged bull trout.

During periods of operation from 1998-2005, the upstream migrant trap captured 1,419 bull trout, which ranged in size in size from 137 to 830 mm (FL). Ninety-six percent (n=1,362) were > 299 mm (adults). Adult bull trout ranged from 300 to 830 mm (mean 433, SD 90). Peak migration occurred in July, and larger fish migrated first (Figure 21). Most subadults were captured in August or September.

We used ultra-sound to determine the sex of 490 upstream migrants. We identified 238 mature females (49%), the remaining 252 fish were either males or immature females. Seven-hundred twenty-one upstream migrants were surgically implanted with PIT tags, and 655 had been PIT tagged during previous years (either at the screw trap or upstream migrant trap). Newly PIT-tagged bull trout ranged in size from 93 to 540 mm (mean 168, SD 44). Ninety-two percent (n= 663) were adults, ranging in size from 300 to 724 mm (mean 391, SD 67). PIT-tagged subadults ranged from 142 to 297 mm (n=57, mean=225, SD= 51).

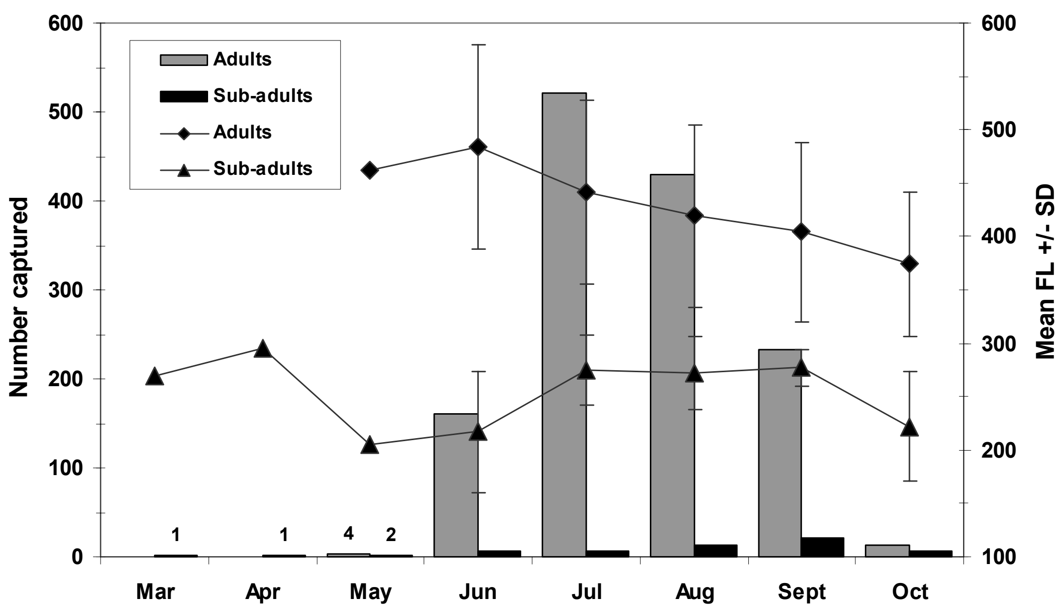


Figure 21. Number and average size (mean FL ± SD) of all bull trout captured at the upstream migrant trap, 1998-2005.

Capturing PIT tagged bull trout at the upstream migrant trap allowed us to determine key life history characteristics. For example, by recapturing and collecting biological data from bull trout that had been PIT tagged as subadults, we were able to establish: 1) the timing of first upstream migration (Figure 22); 2) the average size at first upstream migration (Figures 22 and 23); 3) the average time interval between emigration from natal area and the first upstream migration (Figure 24); and 4) how much fish grew during the subadult rearing phase (Figure 25).

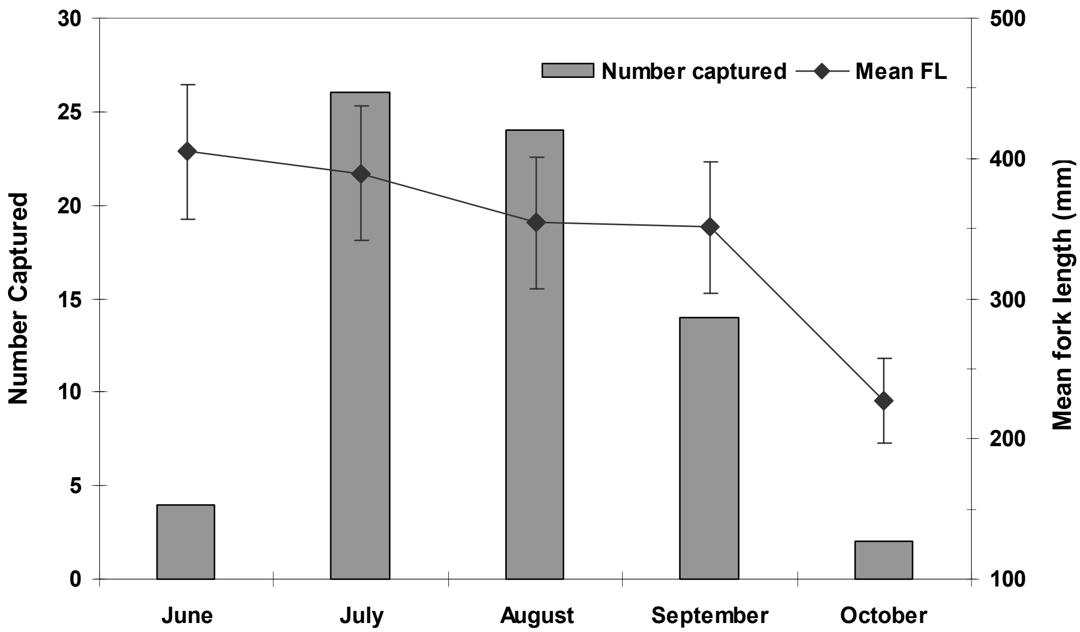


Figure 22. Timing and average size of PIT-tagged bull trout captured at the Mill Creek weir during first upstream migration, 1998-2005.

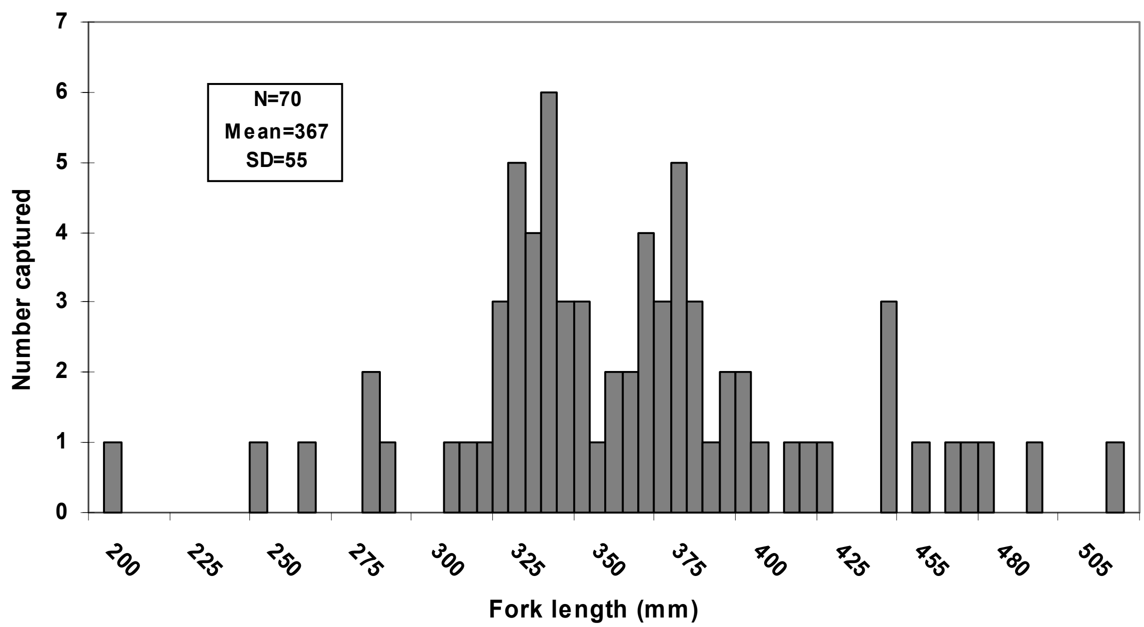


Figure 23. Length frequency histogram for PIT-tagged bull trout captured at the Mill Creek weir during first upstream migration, 1998-2005.

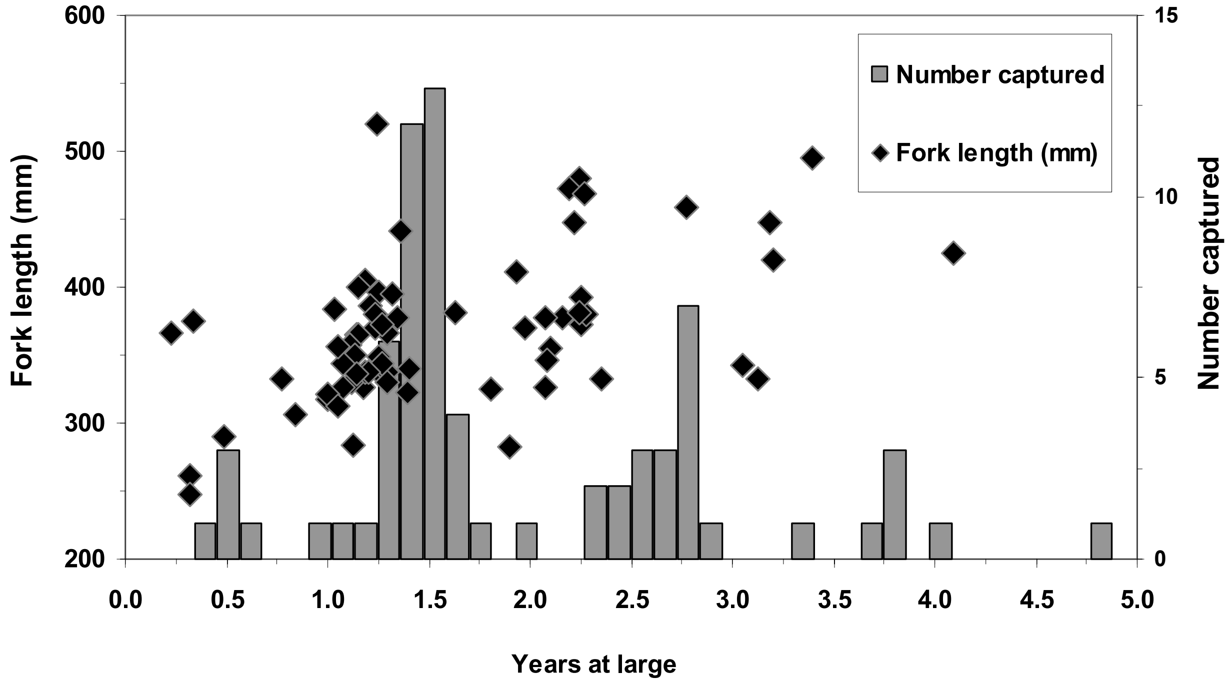


Figure 24. Size of subadult bull trout in Mill Creek at first upstream migration versus the time interval between emigration from natal area and first upstream migration, 1998-2005.

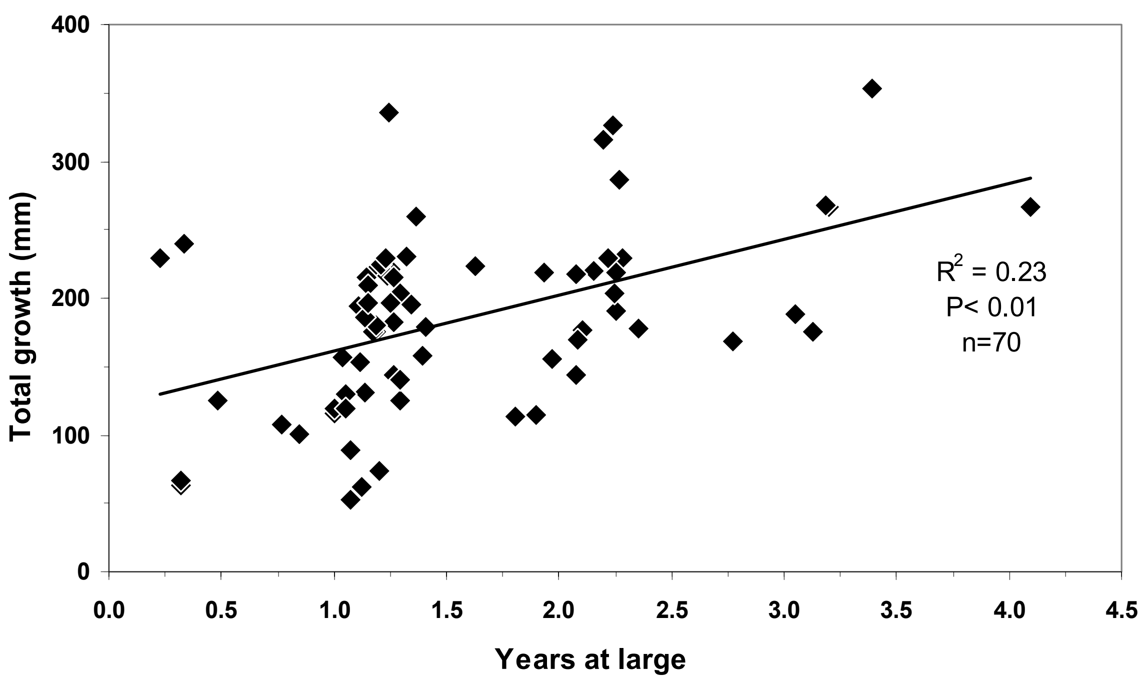


Figure 25. Total growth (mm) of subadult bull trout in Mill Creek during time interval between emigration from headwaters and first upstream migration, 1998-2005.

Our preliminary analysis indicates that migratory bull trout in Mill Creek emigrate from natal headwater areas when they reach a critical size range of approximately 150 mm FL (n=3,959, mean=151, SD=27). Most emigrate in April or May. Before returning to natal headwater areas to spawn, they spend an average of 1.5 years rearing downstream. During the subadult rearing phase, they grow up to 30 mm per month. When they reach an average size of about 365 mm, they return to natal areas to spawn. Most return in July or August. Analysis of data pertaining to adult life history has not yet been completed. However, preliminary results indicate that adults can return to spawn up to seven times, and that repeat spawning occurs on a yearly basis, rather than on alternate years. We are currently preparing a manuscript describing these findings.

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