Distribution and Spawning Migrations of Fluvial Bonneville Cutthroat Trout in the Bear River, Idaho

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February 2009

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Introduction

In lotic ecosystems, the ability of fish to move between critical habitats is essential in maintaining viable populations with a diversity of life history strategies (Schmetterling and Adams 2004). Such movements are especially important for highly mobile species, such as cutthroat trout (*Oncorhynchus clarkii*), which can use large spatial scales to complete their life cycle in fluvial habitats (Colyer et al. 2005; Schoby 2006; Roberts and Rahel 2008). The movement of individuals within populations can vary dramatically and may be due to a variety of natural and anthropogenic factors. Understanding and quantifying the movements within cutthroat trout populations creates a basis for research and management practices.

Although Bonneville cutthroat trout (*Oncorhynchus clarkii utah*) were once widely distributed in rivers and stream of the Great Basin (Behnke 1992), one of the last remaining large river populations is known to exist in the Bear River watershed of Idaho, Utah and Wyoming (Colyer et al. 2005). Unfortunately, this population has been fragmented, due to numerous dams throughout the main channel of the Bear River. Dams can alter the migratory behavior and spawning success of fluvial fish (Schemetterling 2003). These dams have potentially restricted migratory behaviors of Bonneville cutthroat trout (BCT) in the Bear River, resulting in sub-populations isolated into river segments. In addition, dams may have influenced the longitudinal distribution of BCT throughout the main-stem Bear River due to alterations in river habitat (e.g. flows, temperature) (Buisson et al. 2008; Stoneman and Jones 2000). Despite the impact of past habitat alterations and the potential impact of future habitat alterations, little information is available on the movement and spawning migrations of this unique fluvial population of BCT in the Bear River. Therefore, PacifiCorp Energy, who operate the dams on the Bear River, and Idaho Fish and Game agreed to fund a radio-telemetry project, which would provide information

on life history characteristics of BCT in the Bear River. This information could then be used by the Environmental Coordination Committee (ECC), who prioritizes habitat restoration projects, which will be paid for by PacifiCorp mitigation funding.

In 2005, Idaho Fish and Game and Idaho State University initiated a Bonneville cutthroat trout study in the Bear River of Idaho. We used radio telemetry methods to monitor the movements and spawning migrations of fluvial BCT. The primary objectives of this study include 1) identify the distribution of fluvial BCT in the Bear River in Idaho 2) use radio telemetry to identify which tributary streams are being used by fluvial BCT for spawning, and 3) use radio telemetry to identify seasonal movement of fluvial BCT in the Bear River of Idaho. The results from this project will be used to evaluate current management strategies of the BCT in the Bear River system and help direct conservation measures to enhance current populations.

Study Area

The Bear River watershed lies within the states of Utah, Idaho and Wyoming, and covers 18,648 km^2 (Figure 1). The Bear River is entirely surrounded by mountains and is the largest river in the western hemisphere to never reach an ocean. The climate within the Bear River watershed consists of cold winters, hot summers and low precipitation. The main channel of the Bear River has a length over 885 river kilometers (rkm) from the headwaters in the Uinta Mountains of Utah to the mouth at Great Salt Lake, also in Utah. Although the river makes almost a 1,000 km journey to its' final destination, the headwaters and mouth are approximately 120 km apart (Denton 2007). Land ownership in the Bear River watershed is 54% private, 47% under public land management and 3% classified as other. The United States Forest Service manages 22% of the public land, followed by the Bureau of Land Management with 15%, and state agencies 6% of the land that is publicly owned (Denton 2007). The Bear River has a history of human-induced alterations, such as irrigation diversions, agricultural production of lands, livestock grazing and logging (USFW 2001). The Bear River water is allocated primarily for irrigation, hydroelectric power, domestic, stock, and industrial purposes.

Three hydroelectric power operations separate the study area into four distinct segments. We refer to these segments as: Riverdale, Thatcher, Nounan and Pegram, in an upstream order from the Utah border (Figure 2). The Riverdale segment begins at the Utah border and continues upstream to the Oneida Narrows Dam (Figure 2). This segment has a total length of 50.2 rkm (Table 1). Mink creek is the only major tributary in this segment. The hydrograph for this segment is regulated by the Oneida Narrows Dam.

The Thatcher segment begins at the head of Oneida reservoir and continues upstream to the former Cove dam site (Figure 2). This segment has a total length of 37.8 rkm

(Table 1). This segment has 14 perennial tributary streams. The largest tributaries are: Cottonwood, Williams, Whiskey, and Trout creeks. The hydrograph for this segment is regulated by the Grace Dam. We did not include the Black Canyon reach from Cove Dam upstream to Alexander Dam. This reach has no significant spawning tributaries and movement of cutthroat trout is limited due to Grace Dam and irrigation diversions.

The Nounan segment begins at the head of Alexander Reservoir, near Soda Springs, Idaho and ends at the outlet of Bear Lake (Figure 2). The Nounan segment has a total length of 93 rkm (Table 1). There are approximately 10 tributaries in this segment, although summer connectivity with the Bear River, due to decreased flows or irrigation diversions, is limited. The hydrograph of this segment is typically lower in the spring and winter and highest in the summer. This altered flow regime is a result of water being released from Bear Lake for irrigation purposes.

The Pegram segment has a total length of 81 rkm (Table 1) and begins at Stewart Dam and continues upriver 2.5 km above the Smith Fork River, in Wyoming (Figure 2). The hydrograph of this segment is similar to most non-regulated western rivers, with peak flows in the spring during snowmelt and base flows in the summer through winter. There are two tributaries in this segment, the Thomas Fork River in Idaho and the Smith Fork River in Wyoming. The entire Bear River at the lowest end of this segment is diverted at Stewart Dam into Rainbow canal that goes to Bear Lake for irrigation storage.

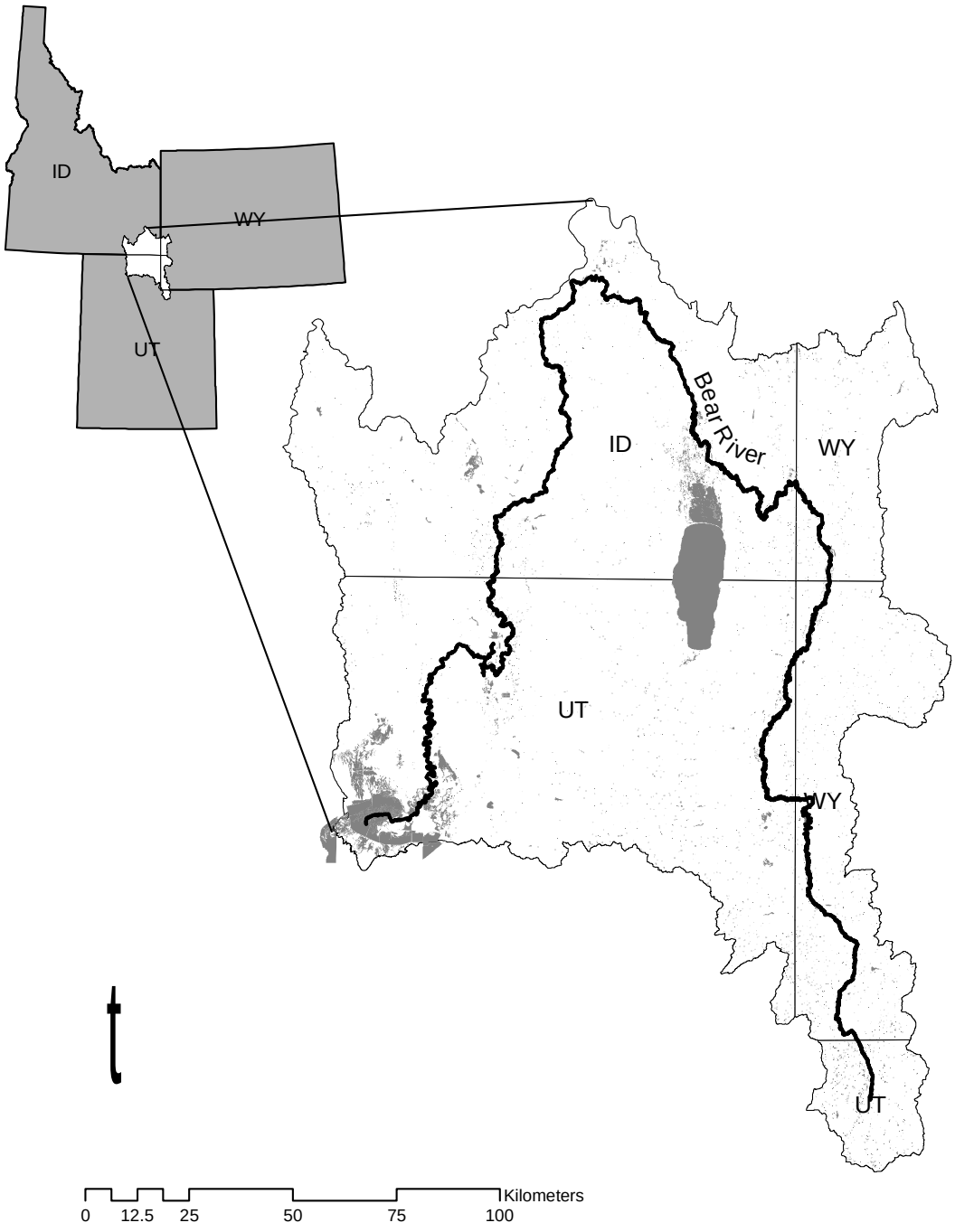

Figure 1. Map of the Bear River watershed of Idaho, Wyoming and Utah.

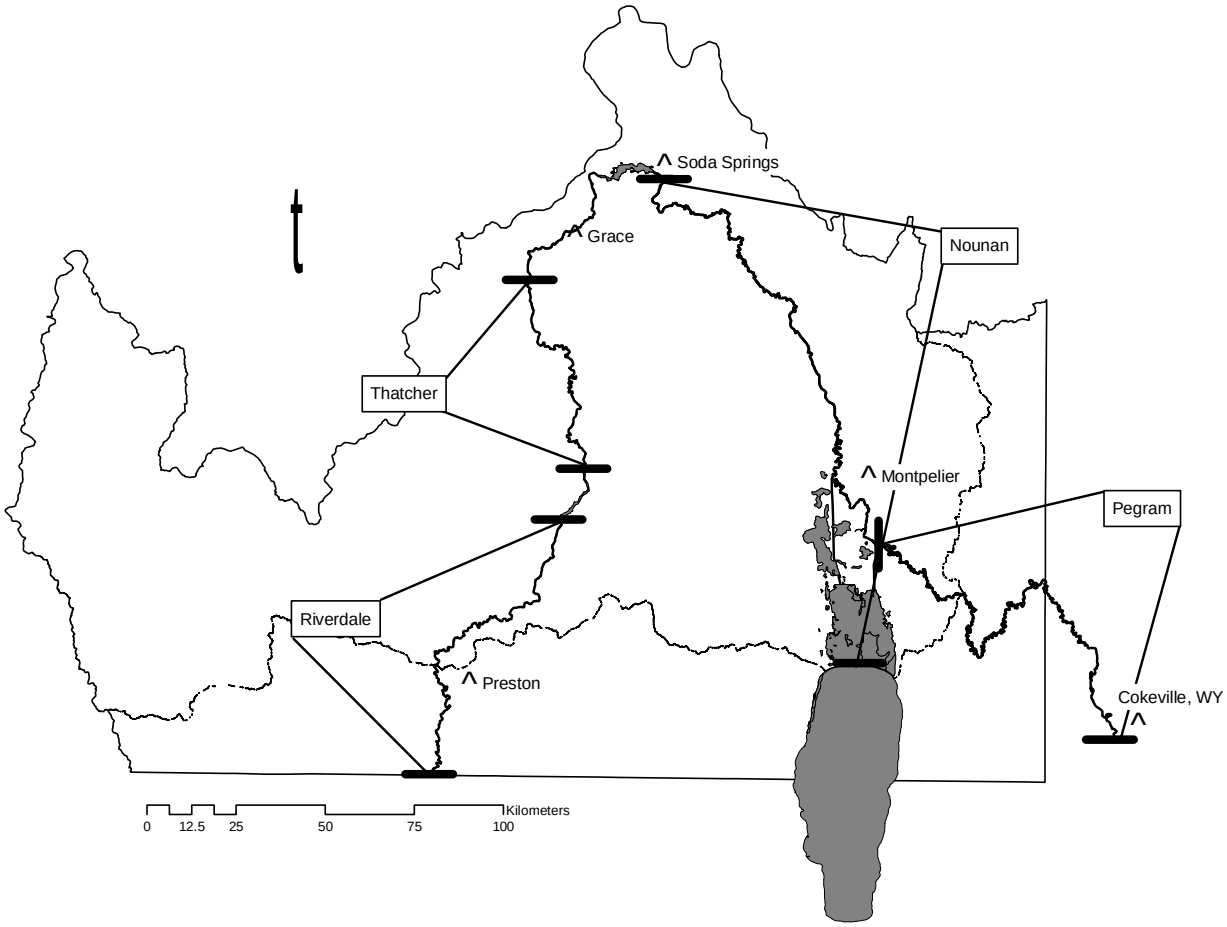

Figure 2. Map of the Bear River study area in Idaho and the boundaries for the four major river segments used in the study.

Table 1. Locations of each reach within the major study segments of the Bear River in Idaho.

			Datum (NAD 83)		
Segment	**Reach**	**Length (km)**	**Zone**	**Easting**	**Northing**
Riverdale	R1	17.9	12	422620	4650238
	R2	7.6	12	424236	4660966
	R3	6.0	12	424485	4665001
	R4	9.2	12	431200	4668531
	R5	9.5	12	435307	4671819
Segment length (km)		50.2			
Thatcher	T1	12.6	12	440963	4686391
	T2	8.3	12	439645	4695346
	T3	12.5	12	439686	4699454
	T4	3.3	12	434919	4705066
	T5	1.1	12	434593	4708043
Segment length (km)		37.8			
Nounan	N1	8.8	12	449392	4722037
	N2	8.8	12	451984	4718365
	N3	9.0	12	457319	4717441
	N4	9.8	12	459411	4712522
	N5	8.5	12	463950	4707341
	N6	10.5	12	466607	4702883
	N7	16.4	12	470778	4694343
	N8	22.7	12	471057	4686305
Segment length (km)		94.5			
Pegram	P1	8.1	12	476253	4677786
	P2	14.9	12	479647	4675269
	P3	4.8	12	485548	4671803
	P4	9.9	12	487674	4669889
	P5	10.3	12	487503	4665065
	P6	5.6	12	490139	4666808
	P7	7.6	12	493344	4671173
Segment length (km)		61.2			
Total length (km)		**243.7**			

Methods

Sampling

We used boat electro-fishing to collect BCT during the spring and fall of 2005 and spring of 2006. A Coffelt model VVP-15 boat mounted electro-fishing unit was used to collect fish, while drifting downriver. Data collection consisted of, recording fish species, lengths, and weights for game species and implanting temperature sensitive radio-telemetry transmitters into the body cavity of BCT with a mass greater than 250 grams. We counted but did not net non-game species, such as Common carp *Cyprinus carpio* and Utah sucker *Catostomus ardens*. Instead, we used a tally meter mounted to the railing of the electro-fishing boat to count these species as they passed by the electro-fishing boat.

Tagging

To monitor movements of BCT, we surgically implanted fish with radio transmitters from Advanced Telemetry Systems (ATS, Isanti, MN), models F1820 and F1830, equipped with a temperature sensor, mortality sensor, and a unique frequency code (148.000-149.999 MHz) for each individual. Since transmitter weight effects fish physiology, we used two sizes of transmitters to increase the size range of potential cutthroat trout that could be tagged. This enabled us to tag BCT with transmitters that weighed approximately 3% less than their body weight (Brown et al. 1999). We implanted a 12 gram transmitter into fish that weighed at least 400 grams. These transmitters had a battery life lasting approximately eight months. In addition, we tagged fish that weighed at least 250 grams with a nine gram transmitter that had a battery life lasting approximately six months.

We replicated surgical procedures for transmitter implantation as described by Ross and Kleiner (1982). We anesthetized all fish with tricaine methanesulfonate (MS-222) in a dosage of

approximately 60 mg/L of water and measured for total length (±1 mm) and wet mass (±1g). We then placed unconscious fish on a V-shaped surgery tray where first a 3.5 cm long incision was made, on the linea alba, immediately anterior to the pelvic girdle. We then inserted a 15 cm long grooved directional tool into the incision and slid the tool posterior behind the pelvic girdle. We then used a 15 cm long catheter needle to puncture the body wall posterior to the pelvic girdle and the groove director guided the needle tip forward until it exited the anterior incision. We slid the antenna of the transmitter through the needle shaft until it exited the opposite end. By slightly pulling on the antenna, we could slide the transmitter into the body cavity, while simultaneously removing the needle from the fish. We closed the 3.5 cm incision with three staples. We immediately put tagged BCT back into the river in a slack pool and monitored swimming ability until reestablished. This surgery process took an average of two minutes.

Tracking

We used ATS model 4500 receivers to track seasonal distributions and spawning locations of tagged BCT. The receivers also recorded fish body temperature (± 0.1°C) associated with the location of the tracked individual. During the course of the study period, we attempted to relocate radio-tagged BCT on a weekly basis using vehicle, fixed-wing aircraft or boat. When ground tracking with a vehicle, we used a truck-mounted five-element Yagi antenna. In areas without roads, we tracked fish using a motorized boat or drift boat with a boat-mounted three-element Yagi antenna. If a tracking location was not obtained on tagged BCT for an extended period of time (e.g. 2+ weeks), we used a fixed-wing aircraft to cover a larger spatial extent. If these individuals were found, we returned with more accurate ground tracking equipment. At

each tracking location, we geo-referenced the site with a handheld Garmin e-trex Global Positioning Unit (GPS) and recorded the temperature used by tagged BCT.

We used two fixed radio-telemetry stations to identify spawning locations of radio-tagged BCT. We positioned these stations within the Thomas Fork and Smith Fork tributaries of the Pegram segment (Figure 4). These data logging stations consisted of an ATS model R4500 receiver connected to two five-element Yagi antennas mounted at each site: one pointing upstream and one pointing downstream. We used this configuration to determine the directional movement of tagged BCT. We powered these stations with two 12V deep cycle batteries, which we exchanged with recharged batteries every two weeks.

Results

Sampling Effort

We sampled a total of 181 km (62%) of the 290 km available in Bear River of Idaho, excluding the Black Canyon reach (Figure 3). To maximize the number of tagged BCT and the probability of collecting BCT in all four river segments, we sampled some reaches within each river segment multiple occasions during each season and sampled both fall and spring (Table 2).

Species Composition

We collected BCT in two of the four river segments. We attempted to collect BCT in the Riverdale and Thatcher segments multiple times during each season (Table 2). Unfortunately, we sampled zero fluvial BCT in these two segments (Table 3). In the Nounan and Pegram segments, we sampled limited numbers of fluvial BCT. BCT distributions were patchy and corresponded to certain reaches within each segment. In Nounan, we sampled more BCT in the lower reaches (Table 3), while in Pegram; we sampled BCT in the upper reaches (Table 3). In both segments, BCT accounted for a small percentage of the overall species composition. Although, the proportions of the three most common species varied among river reaches in each segment, suckers (three species of *Catostomus* sp.), common carp (*Cyprinus carpio*) and mountain whitefish (*Prosopium williamsoni*) were the most prominent species, respectively (Table 3). Overall, we sampled 14 different species throughout the four river segments, of these 14 species; six are native to the Bear River watershed (Table 3).

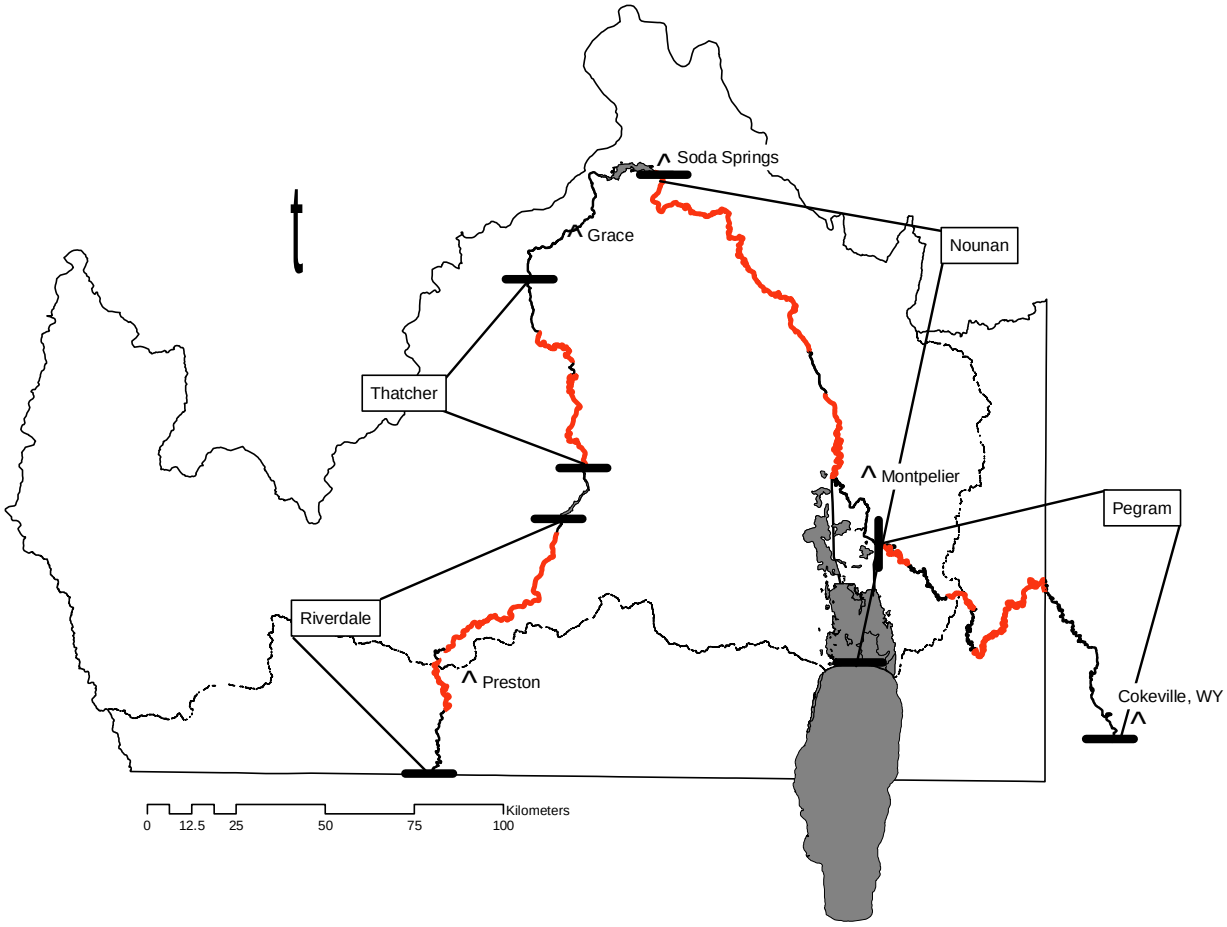

Figure 3. Map of the Bear River study area in Idaho. The red lines represent areas of the Bear River sampled for Bonneville cutthroat trout.

Table 2. Sampling dates for each reach within each of the four major Bear River segments.

Total Effort (Days Sampled)									
	Reach	Spring 2005			Fall 2005		Spring 2006		
Riverdale	R1						31-Mar		
	R2						31-Mar		
	R3	7-Apr							
	R4	12-Apr			18-Sep	26-Nov			
	R5	12-Apr			18-Sep				
Thatcher	T1	5-Apr			21-Nov				
	T2				29-Nov				
	T3						2-Apr		
	T4								
	T5								
Nounan	N1	7-Apr	10-Apr	21-Apr	17-Nov				
	N2	11-Apr	21-Apr		28-Oct		13-Apr	19-May	
	N3	13-Apr			1-Nov	22-Nov	29-Apr	18-May	7-Jun
	N4	15-Apr		22-Apr	22-Nov		17-May		
	N5	15-Apr							
	N6	11-May					1-May		
	N7								
	N8	3-May							
Pegram	P1								
	P2				20-Sep				
	P3	27-Apr	4-May		4-Oct				
	P4								
	P5	24-Apr	28-Apr		14-Oct	15-Oct	11-Mar	26-May	
	P6	25-Apr			5-Oct	25-Oct	15-Apr	28-Apr	
	P7	26-Apr	4-May		11-Oct	13-Oct	14-Apr	15-Apr	25-May

Table 3. The percentage of each fish species captured within four sections of the Bear River, during electrofishing sampling periods of spring and fall of 2005 and spring of 2006.

			Species Composition (%)												
Segment	Section	Total Catch	Bonneville Cutthroat Trout	Rainbow Trout *	Rainbow Trout (Hatchery) *	Brown Trout *	Brook Trout *	Walleye *	Largemouth Bass *	Smallmouth Bass *	Yellow Perch *	Mountain Whitefish	Common Carp *	Sucker	Utah Chub
Riverdale	R1	41										22.0	14.6	63.4	
	R2	72										8.3	51.4	40.3	
	R3	479			0.6	0.4						5.0	31.3	62.6	
	R4	486			6.8	2.9		0.2	0.2			11.9	28.0	50.0	
	R5	384			9.9	0.8				0.3		20.1	6.5	62.5	
Total		1462			5.1	1.3		0.1	0.1	0.1		11.9	24.2	57.3	
Thatcher	T1	408			0.2		0.2	1.5					98.0		
	T2	162			1.9			0.6					90.7	6.8	
	T3	272		1.8									96.7	1.5	
	T4														
	T5														
Total		842		0.6	0.5		0.1	0.8					96.2	1.8	
Nounan	N1	301	1.0	0.0	9.3	0.3						1.3	54.2	33.9	
	N2	717	1.5	0.7	2.4	0.7						2.0	60.4	32.4	
	N3	1488	1.8	0.5	0.1	0.9	0.5					1.3	63.5	31.4	
	N4	1462	0.3	0.1	0.3	1.2	0.1					0.5	67.1	30.4	
	N5	331	0.9			0.9						0.3	43.8	54.1	
	N6	703	0.1	0.3	0.3	3.0						3.0	47.7	45.7	
	N7														
	N8	330	0.6			0.3							41.5	57.3	0.3
Total		5332	1.0	0.3	1.0	1.2	0.2					1.3	60.3	37.2	
Pegram	P1	126									2.4	10.3	39.7	47.6	
	P2	126									2.4	10.3	39.7	47.6	
	P3	240	2.9			1.7					0.8	18.8	32.1	42.9	0.8
	P4														
	P5	1098	2.4			0.9						53.2	17.7	25.5	0.4
	P6	389	4.1			0.8						40.9	22.9	30.6	0.8
	P7	527	7.0			0.4						21.8	34.5	35.9	0.4
Total		2506	3.4			0.8					0.3	37.1	25.6	32.4	0.4

* - Indicates non-native fish species.

Tagging

During the course of the study, we were successful in tagging a total of 115 BCT (Appendix 1). We were unable to tag any BCT in the Riverdale or Thatcher segments. Although BCT are known to inhabit nearby tributary streams, such as Cottonwood Creek and Mink Creek, we did not sample them in adjacent mainstem habitat perhaps because of water diversions that seasonally disconnect streams. In the Nounan and Pegram segments we tagged 42 and 68 BCT, respectively (Figure 4). In addition, we tagged five BCT in the Cub River below a diversion. In the Cub River, we found three of the five implanted tags in the summer without any sign of the fish carcass. One fish was never tracked after tagging, possibly due to tag failure. The other fish remained within one km of its tagging location.

Mean lengths varied between the Nounan and Pegram segments. The mean total length (TL) of tagged BCT from Nounan was 366 ± 64 mm (mean ± SD). In the Pegram segment, the average length was 394 ± 39 mm TL (Appendix 1). Despite considerable overlap in the distribution of lengths, we caught larger BCT from the Pegram segment (366 mm versus 394 mm; t-test $t_{1, 56}$ 1.67, P <0.024). A total of eight cutthroat trout, (5 in Nounan, 3 in Pegram) were tagged that did not meet the 3% transmitter to body mass guideline suggested by Brown et al. (1999). The smallest fish had a transmitter to body mass ratio of 3.75%.

In the spring of 2005, we tagged 10 BCT in Nounan and 16 in Pegram. (Appendix 1). The mean TL in Nounan was 371 ± 53 mm. In Pegram, the mean TL was 372 ± 18 mm. The size difference between the two segments during this period was not significantly different (371 mm versus 372 mm; t-test $t_{1, 24} = 1.71$, $P < 0.46$).

We tagged 13 BCT in Nounan and 32 in Pegram during the fall of 2005 (Appendix 1). The mean TL in Nounan and Pegram was 427 ± 51 mm and 407 ± 39 mm, respectively. The size difference between the two segments during this period was not significantly different (427 mm versus 407 mm; t-test $t_{1, 18} = 1.83$, $P < 0.11$).

During the spring of 2006, we tagged 19 BCT in Nounan (mean TL: 325 ± 31 mm) and 20 BCT in Pegram (mean TL: 374 ± 64 mm; Appendix 1). During this period, the BCT we caught in Nounan were significantly smaller than in Pegram (325 mm versus 374 mm; t-test $t_{1, 28} = 1.70$, $P = 0.003$). We tagged an additional three fish during the summer of 2006, (2 in Nounan, 1 in Pegram), to increase the sample size.

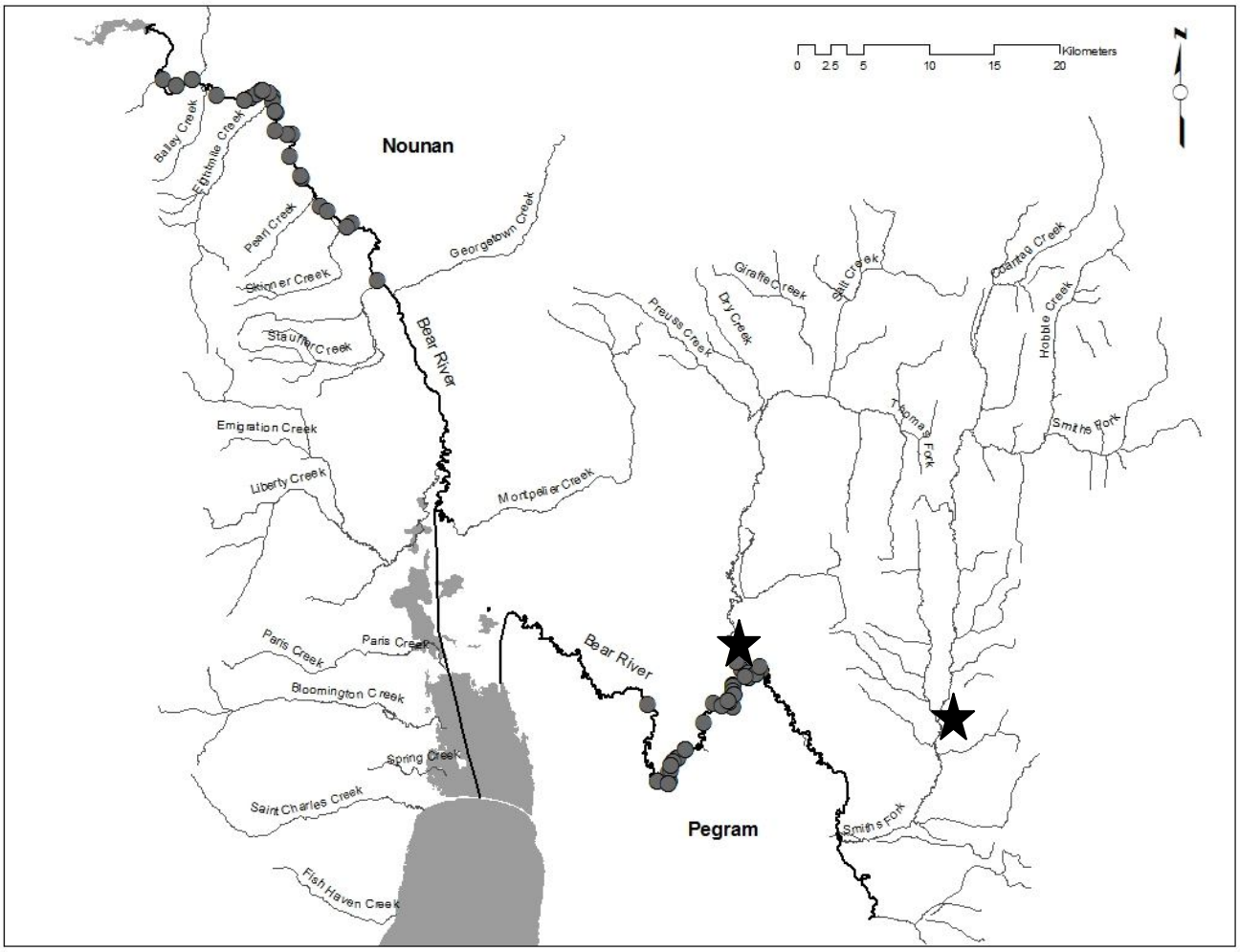

Figure 4. Tagging locations for 110 Bonneville cutthroat trout in the Nounan and Pegram segments of the Bear River. Black stars represent the locations of fixed, radio telemetry receiver sites.

Spawning locations

A total of 52 tagged BCT (47%) exhibited migrations indicative of spawning behavior (Figure 5). In the spring of 2005, 26 BCT were tagged during the spawning period and eight of those fish (31%) migrated into potential spawning tributaries. In Nounan, five BCT spawned in two tributaries. There were 80% that spawned in Eightmile Creek and 20% that spawned in Georgetown Creek (Figure 5). In Pegram, the three BCT that spawned used the Smith Fork in Wyoming (Figure 5). In the spring of 2006, about 50% of tagged BCT migrated into spawning tributaries. In Nounan, 14 BCT spawned in two tributaries, 79% spawned in Eightmile Creek and 21% spawned in Stauffer Creek (Figure 5). In Pegram, 30 BCT spawned in two tributaries, 93% spawned in the Smith Fork and two 7% in the Thomas Fork (Figure 5). During 2005 and 2006, one fish spawned above the forest service boundary in Eightmile Creek, while the remaining fish spawned in habitat lower in the tributary.

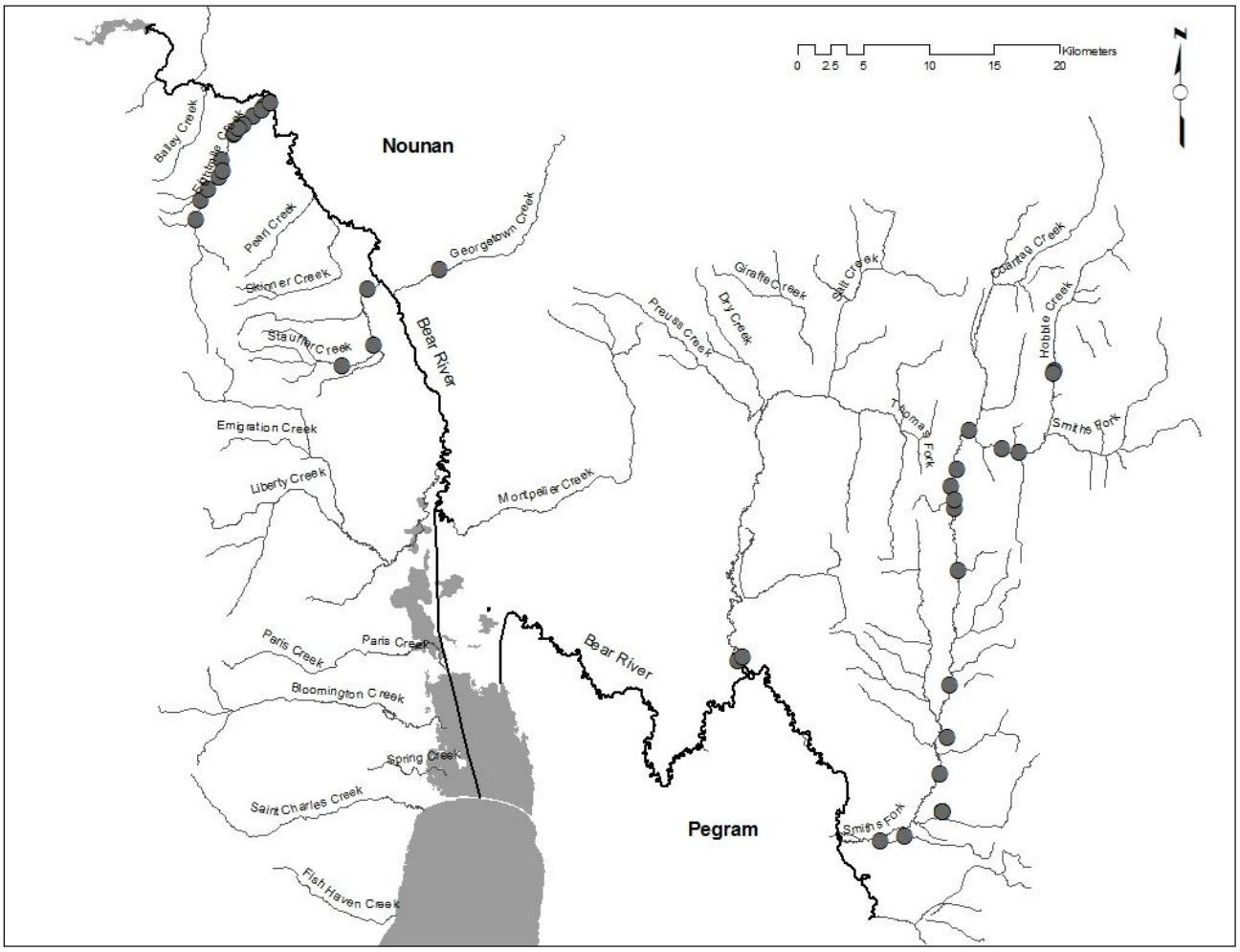

Figure 5. Spawning locations for 55 (Nounan; n=22 and Pegram; n=33) tagged Bonneville cutthroat trout during 2005 and 2006.

Seasonal Distribution

In Nounan and Pegram, BCT utilized about 50% of the available habitat in each Bear River segment and a few key tributaries (Figures 4 and 6). In Nounan, tagged BCT utilized habitat in the Bear River and tributaries below Georgetown Creek. In contrast, tagged BCT utilized habitat in the upper half of the Pegram segment. In Nounan, during the spring (May - June) of 2005 and 2006, tracking locations for 35 BCT consisted of 66% in the Bear River and 34% in tributaries (Table 4; Figure 6a). In Pegram, we recorded 103 tracking locations on 40 tagged BCT. The Bear River consisted of 83% and tributaries 17% of these locations. In the summer (July – August) of 2005 and 2006, tagged BCT increased tributary use in Pegram, while BCT locations remained similar to spring locations in Nounan (Figure 6b). In Nounan, we recorded 231 individual locations on 37 tagged BCT during this period. The majority (65%) of locations occurred in the Bear River (Table 4). In Pegram, we tracked 68 tagged BCT a total of 201 different locations. BCT locations included the Bear River 73%, tributaries 26%, and 1% in irrigation canals. In the fall (September – November) of 2005 and 2006, tagged BCT distributions remained similar to other seasons in Nounan (Figure 6c). We recorded 61 tracking locations on 25 tagged BCT. In Pegram, tributary use decreased and canal entrainment increased (Figure 6c). We recorded 55 tracking locations on 45 tagged BCT and the Bear River consisted of 75% of these locations, 15% in tributaries and 10% in canal systems (Table 4).

The distribution of tagged BCT within the Bear River varied between segments (Figure 6). In Nounan, tagged BCT congregated near the mouth of tributaries, namely Eightmile Creek and Bailey Creek. Most of the tagged BCT that spawned in Eightmile Creek emigrated out and remained near the mouth. A few of these fish immigrated back into the creek during the summer and fall periods. In addition, some tagged BCT that did not spawn replicated this movement

pattern between the Bear River and Eightmile Creek. In contrast, tagged BCT in Pegram did not congregate near the mouth of tributaries. These fish utilized most of the upper portion of the river segment. A few of the fish that spawned in the Smith Fork emigrated out of the tributary soon after spawning. Others remained in the Smith Fork through the summer (Figure 6b) and then began to emigrate to the lower reaches of the tributary in the fall (Figure 6c).

Mortalities/Tag Retention

Throughout the study period, 51 transmitters omitted a mortality signal. Unfortunately, we located only 8% with a fish carcass, so determining the causes of mortality signals were very limited (Table 3). The mean number of days between transmitter implantation and a mortality signal was 143 days (± 100 S.D.) with a range of 11 - 317 days for all tagged BCT. In the Nounan segment, approximately 50% of tagged BCT omitted a mortality signal. We located 15 (75%) transmitters in the Bear River and five (25%) in tributaries. Approximately 45% of the tagged BCT in the Pegram segment omitted mortality signals. We located 20 (65%) of these transmitters in the Bear River and 11 (35%) in tributaries. In both segments, the month of July accounted for 24 (47%) of the total mortalities signals followed by August with 12 (23%), June with nine (18%), September with four (8%) and both May and October with one (2%) (Figure 7).

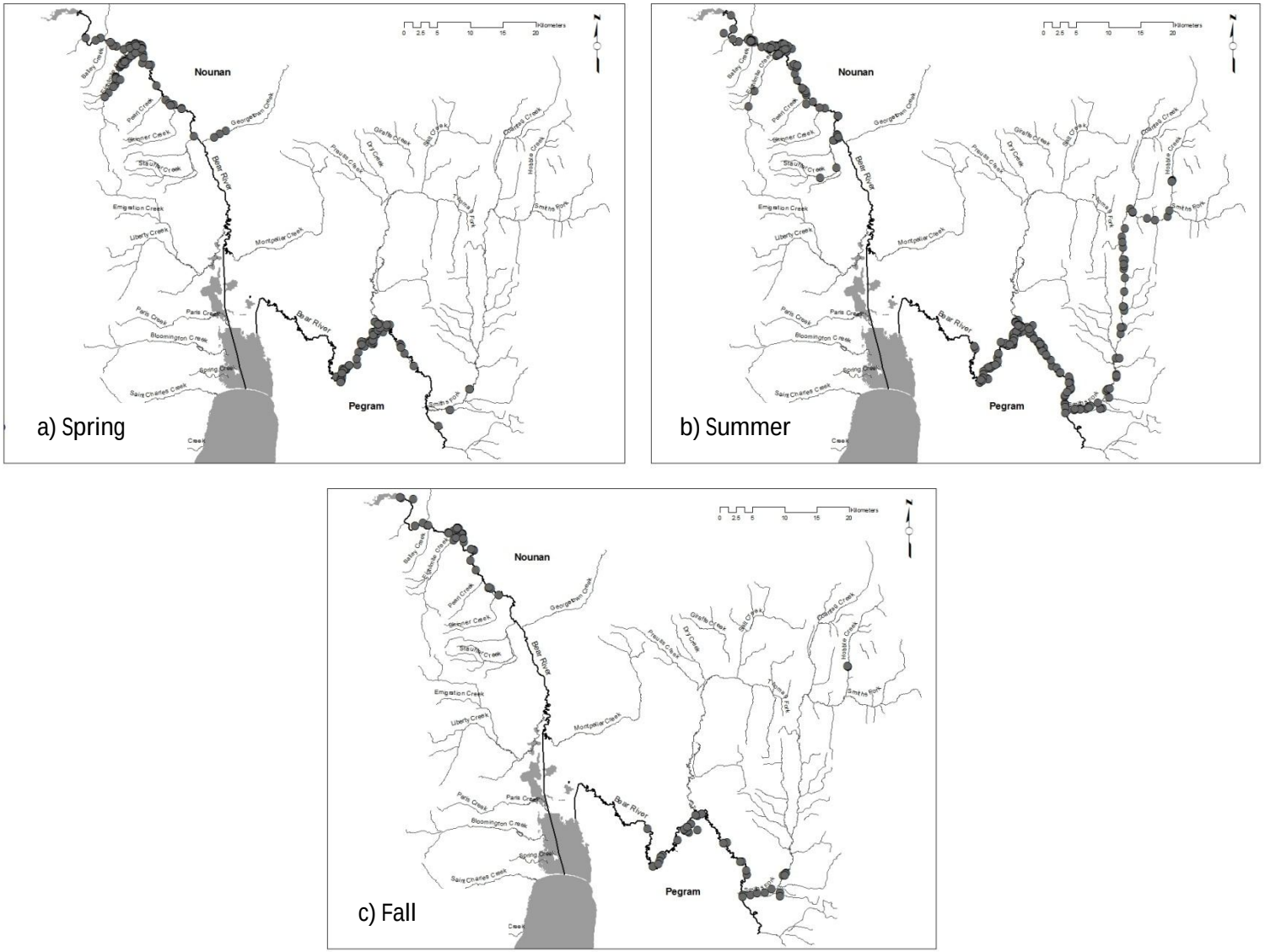

Figure 6. a) Distribution of 75 tagged Bonneville cutthroat trout (BCT) in the Nounan (n=35) and Pegram (n=40) segments during the spring (May – June) of 2005 and 2006. (b) Distribution of 105 tagged BCT in the Nounan (n=37) and Pegram (n=68) segments during the summer (July - August) of 2005 and 2006. (c) distribution of 70 tagged BCT in the Nounan (n=25) and Pegram (n=45) segments during the fall (September - November) of 2005 and 2006.

Table 4. Number of Bonneville cutthroat trout (BCT) tagged, total tracking locations, and tracking locations (river, tributary or irrigation canal) in the Pegram and Nounan segments of the Bear River.

Spring (May-June)

	Tagged BCT	Tracking Locations	Bear River (%)	Tributaries (%)	Canal (%)
Nounan	35	92	66	34	0
Pegram	40	103	83	17	0

Summer (July-August)

	Tagged BCT	Tracking Locations	Bear River (%)	Tributaries (%)	Canal (%)
Nounan	37	231	65	35	0
Pegram	68	201	73	26	1

Fall (September-November)

	Tagged BCT	Tracking Locations	Bear River (%)	Tributaries (%)	Canal (%)
Nounan	25	61	66	34	0
Pegram	45	59	75	15	10

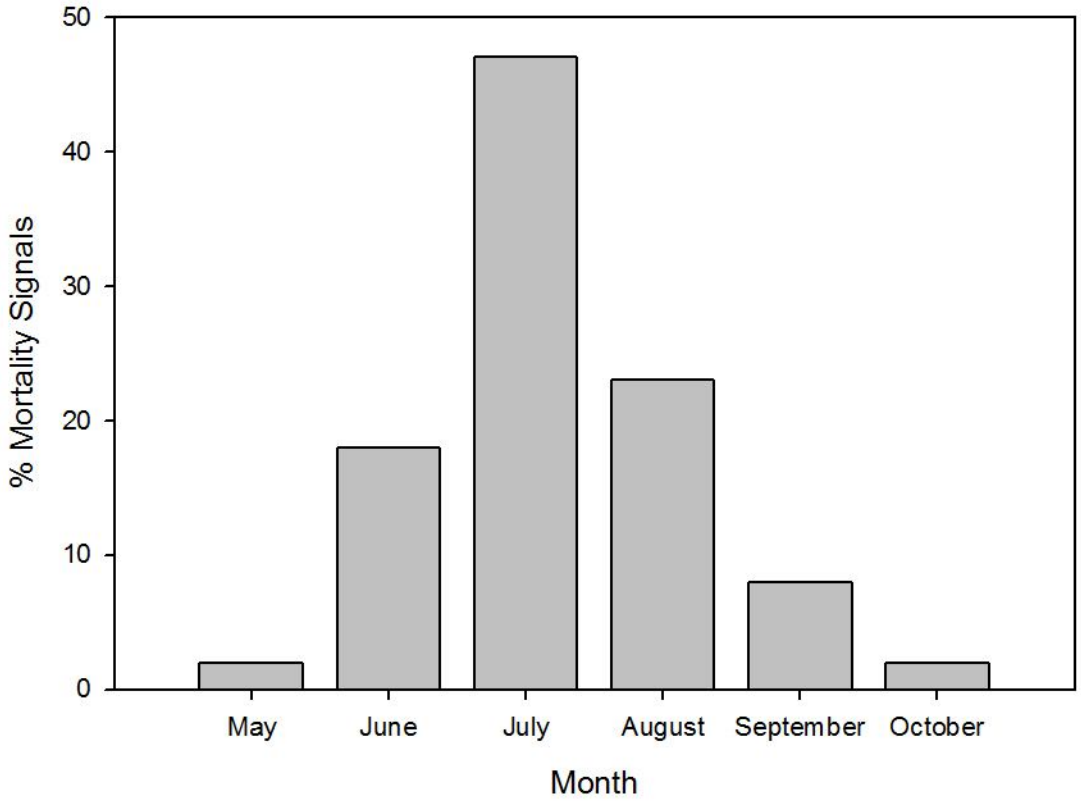

Figure 7. The percent of all mortality signals detected by radio telemetry during each month in both Nounan and Pegram segments of the Bear River.

Discussion and Conclusions

Overall catch of BCT in the Bear River was less than 1 fish per river km sampled. In the Pegram segment, the highest catch rates occurred in the upper portion near the Idaho-Wyoming border. In the Nounan segment, BCT were distributed between Alexander Reservoir and Georgetown Creek, but concentrated near the confluence of Eightmile Creek. Surprisingly, no BCT were caught in the Thatcher or Riverdale segments. Despite the lack of BCT in our electro-fishing samples from these two segments, anglers continue to report catching the occasional BCT. In a 2002 creel survey, one angler interviewed reported catching a cutthroat trout below Oneida Dam in the Riverdale segment. Furthermore, many of the tributaries that enter the Bear River in the Thatcher and Riverdale segments support BCT. Those tributary populations likely have seasonal connection to the Bear River and may supply fish to the main-stem river. Maintaining flows in some tributary streams of these segments of the Bear River may increase the abundance of BCT in adjacent mainstem habitat.

Eightmile Creek and the Smiths Fork River appear to be the two most important spawning tributaries for BCT caught in the Nounan and Pegram segments, respectively. In Eightmile Creek, BCT appeared to spawn primarily in the lower few rkm of the stream, which is privately owned. Only one BCT was tracked above the forest service boundary. These results emphasize the importance of working with private land owners to achieve cutthroat trout conservation goals. In addition, understanding why BCT spawning migrations are limited above the forest service boundary, such as migration barriers, could be beneficial to increase spawning habitat. The nearly exclusive selection of Eightmile Creek by BCT for spawning in the Nounan segment is disconcerting. The type of diversion dams used in Eightmile Creek are primarily non-hardened structures, which are less likely to obstruct migrating fish. These structures may

be an important factor influencing spawning success of fluvial BCT in the Nounan segment. There are a number of other tributaries that should provide spawning habitat in the Nounan segment (i.e., Bailey, Skinner, Stauffer, Pearl, Ovid, Georgetown, and Co-op creeks). The lack of spawning in those tributaries may be due to the types of diversion dams and subsequent altered flows. Identifying limiting factors in the Nounan segment tributaries, where a significant fluvial population persists, should be useful in directing enhancement efforts downriver where fluvial BCT populations appear to be much lower, such as the Thatcher and Riverdale segments.

The Smith Fork River in Wyoming is the primary spawning tributary in the Pegram segment. The majority of the BCT tagged in Idaho migrated into this tributary to spawn. Maintaining a connection between the Idaho portion of the Bear River and this tributary is critical for spawning success of fluvial BCT in this segment. The lack of spawning in the Thomas Fork River in Idaho may be correlated to the long term operation of diversion dams in this river. In 2006, we captured two fluvial BCT with hook and line in a pool below the lowest diversion dam on the Thomas Fork River. These fish may have been obstructed to upstream migration due to this diversion. Since 2006, a fish ladder has been installed on this diversion, which may facilitate future spawning migrations of fluvial BCT in the Thomas Fork River.

The seasonal distribution of fluvial BCT varied between the two segments. In Nounan, tagged BCT utilized the mouth of tributaries. The importance of tributaries in the Nounan segment may be due to the lack of suitable summer habitat in the majority of the Bear River. Maximum water temperatures at the Bear Lake outlet can exceed 25° C during the summer, which can be lethal to BCT (Johnstone and Rahel 2003) although, these high water temperatures begin to decline downstream. These high summer water temperatures could play a factor in limiting the distribution of fluvial BCT above Georgetown Creek. The use of cool-water inputs

from tributaries could be critical for the survival of fluvial BCT in the summer. For example, Eightmile and Bailey Creek exhibited cooler temperatures than the Bear River and most of the summer locations of tagged BCT were near the mouths of these two tributaries.

In the Pegram segment, tagged BCT utilized habitats in the upper portion of the segment and within the Smith Fork River in Wyoming. The majority of tagged BCT that spawned in the Smith Fork River remained until the fall period. The tagged BCT that emigrated from the river, after spawning, utilized habitats throughout the upper portion of the segment. In the fall, most of the tagged BCT moved back into the Bear River below the Thomas Fork River. The large migrations observed in this study and another from the Smiths Fork (Roberts and Rahel 2008), likely increase entrainment in irrigation canals.

During the fall period, approximately 10% of tracking locations of tagged BCT were in canal systems. In Pegram, flow rates are low in the summer and fall and diversion structures divert the majority of the flow at these locations. This attractive flow into diversion canals can increase the potential of fish entrainment. The main diversion structures are located on the Bear River in Wyoming, but the canal systems are used to irrigate land in Idaho. Therefore, screening these diversion structures would require cooperation between multiple states and landowners, but the results could increase survival of fluvial BCT in the Pegram segment.

Fish mortality rates were high during the study period. About 50% of all the fish tagged in this study died. The average time between surgery and mortality signals was 143 days. This suggests the majority of mortality rates were not associated to surgery procedures or fish expelling transmitters. In addition, most of the mortality signals were during July and not in the spring and fall when tagging occurred. The high mortality rates in July could be the result of post-spawning mortalities from fish moving back into the Bear River. Over 65% of the mortality

signals were located in the Bear River in both segments. The combination of high water temperatures in the Bear River and post-spawning stress could be the cause of these mortalities.

This telemetry project has increased our knowledge of the current distributions and migratory behaviors of fluvial BCT in the Bear River. There is limited data on historic population trends for BCT in the four river segments. Therefore, the knowledge gained from this project should become a basis for future population monitoring. The establishment of future long-term monitoring sites in the four river segments will enable management agencies to identify population trends and evaluate the efficacy of habitat enhancement projects that are being implemented in the Bear River.

The current management strategies for fluvial BCT in the Bear River, has been focused on reducing angling pressure. In 2006, Idaho Fish and Game (IDFG) modified fishing regulations for the Bear River and its tributaries as they relate to BCT. The mainstem Bear River remained open year round, but became a catch and release fishery for BCT. In the tributaries, anglers are restricted to the harvest of two BCT between the dates of July 1 and November 30. These regulations have decreased harvest of BCT in the mainstem Bear River and restricted angling pressure on spawning fluvial BCT in tributaries, when angler vulnerability can be high. Future fishing regulations should consider restricting angling near the mouth of tributaries, since fluvial BCT congregate in these areas, especially in the Nounan segment. This could reduce catch and release mortalities.

Future management and research strategies should focus on the current distribution of fluvial BCT populations. For example, during the summer of 2007, IDFG conducted a survey on fish entrainment in irrigation diversions. This project was funded by PacifiCorp in an effort to improve BCT populations within the Bear River watershed. This survey will help to identify the

effects of fish entrainment on BCT populations in these tributaries. In addition, a tributary monitoring program was established for 10 Bear River tributaries. This monitoring program will provide valuable population trend information, and should be expanded to the mainstem Bear River.

Management Recommendations

1) Establish long-term monitoring sites in each of the four river segments.

2) Prioritize management projects in tributaries and the Bear River in correlation to current distributions of fluvial BCT.

3) Implement research projects that may identify the limitations of current fluvial BCT populations from distributing throughout the four river segments.

Acknowledgements

This work was supported by funding from PacifiCorp and Idaho Department of Fish and Game. We would like to thank Karl Vanderwood, Matt Green, Kelsey Flandro and Megan Tews from Idaho Fish and Game, and Sarra Moller, Steve Seiler, Meredith Seiler and Sam Matsaw from Idaho State University for all their help in the field. We would especially like to thank David Teuscher with Idaho Fish and Game for assisting with the study design, field work, data analysis, and comments on an earlier version of this report. He was an integral part for the success of this study. We would also like to thank the Department of Biological Sciences at Idaho State University for logistical support. This work was conducted under Animal Care Protocol number: S10-19-05, approved by the Animal Welfare Committee of Idaho State University.

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Appendices

Appendix 1. Identification of Bonneville cutthroat trout tagged in the spring of 2005. Comments on spawning movements and outcome of each individual fish.

Frequency (Mhz)	Date Tagged	Segment	Reach	Length (mm)	Mass (g)	Tag Size (g)	No. Tracking Locations	Tracking Period (days)	Comments
Spring 2005									
148.165	10-Apr-05	Nounan	N1	335	405	9	17	194	Spawned in 8-mile Ck. Tag expired during winter.
148.025	11-Apr-05	Nounan	N2	355	505	9	0	0	Possible tag failure or harvested.
148.145	11-Apr-05	Nounan	N2	375	530	9	15	162	No spawning tributary. Tag expired during winter.
148.104	12-Apr-05	Nounan	N2	347	510	9	14	161	No spawning tributary. Tag expired during winter.
148.056	13-Apr-05	Nounan	N3	333	380	9	14	160	Spawned in 8-mile Ck. Tag expired during winter.
148.125	13-Apr-05	Nounan	N3	345	420	9	4	61	Possible tag failure or harvested.
148.327	13-Apr-05	Nounan	N3	425	940	12	13	115	Spawned in 8-mile Ck. Mortality tag not recovered.
148.155	15-Apr-05	Nounan	N4	344	510	9	10	87	No spawning tributary. Mortality tag not recovered.
148.207	22-Apr-05	Nounan	N4	352	500	9	5	31	Spawned in 8-mile Ck. Mortality tag found on bank of 8-mile Ck..
148.295	22-Apr-05	Nounan	N4	500	1200	12	10	106	Spawned in Georgetown Ck. Mortality tag not recovered.
148.246	24-Apr-05	Pegram	P5	365	520	12	0	0	Possible tag failure or harvested.
149.106	24-Apr-05	Pegram	P5	380	460	9	12	180	No spawning tributary. Tag expired during winter.
149.166	24-Apr-05	Pegram	P5	375	560	12	9	180	No spawning tributary. Mortality tag not recovered.
149.235	25-Apr-05	Pegram	P5	384	550	12	3	77	Spawned in Hobble Ck. Possible tag failure or harvested.
149.016	26-Apr-05	Pegram	P7	340	360	9	10	121	No spawning tributary. Tag expired during winter.
149.126	26-Apr-05	Pegram	P6	365	450	9	8	121	No spawning tributary. Tag expired during winter.
149.186	26-Apr-05	Pegram	P6	410	655	12	4	41	Spawned in Smith Fk. Mortality tag not recovered.
149.004	28-Apr-05	Pegram	P5	360	380	9	4	39	No spawning tributary. Possible tag failure or harvested.
148.095	4-May-05	Pegram	P6	353	390	9	10	170	No spawning tributary. Tag expired during winter.
149.055	4-May-05	Pegram	P7	350	370	9	8	113	No spawning tributary. Mortality tag not recovered.
149.086	4-May-05	Pegram	P7	357	380	9	6	51	No spawning tributary. Mortality tag not recovered.
149.136	4-May-05	Pegram	P7	372	460	9	9	170	Spawned in Smith Fk. Mortality tag not recovered.
149.195	4-May-05	Pegram	P6	391	620	12	9	170	No spawning tributary. Tag expired during winter.
149.224	4-May-05	Pegram	P7	378	520	12	3	68	No spawning tributary. Possible tag failure or harvested.
149.256	4-May-05	Pegram	P7	389	525	12	8	51	No spawning tributary. Mortality tag not recovered.
149.285	4-May-05	Pegram	P6	390	560	12	9	170	Spawned in Smith Fk. Tag expired during winter.
148.274	10-May-05	Riverdale	Cub	343	510	12	6	90	No spawning tributary. Tag expired during winter.
148.306	10-May-05	Riverdale	Cub	400	590	12	4	69	No spawning tributary. Mortality tag recovered in Cub R. without carcass.
148.375	10-May-05	Riverdale	Cub	366	550	12	6	90	No spawning tributary. Tag expired during winter.
149.066	10-May-05	Riverdale	Cub	330	400	9	5	69	No spawning tributary. Mortality tag recovered in Cub R. without carcass.
149.114	10-May-05	Riverdale	Cub	350	390	9	0	0	Possible tag failure or harvested.
	Mean (±1 S.D.)			370 (33)	519 (170)		8 (4)	101 (59)	~ 1 location every 13 days

Appendix 2. Identification of BCT tagged in the fall of 2005. Comments on spawning movements and outcome of each individual fish.

Frequency (Mhz)	Date Tagged	Segment	Reach	Length (mm)	Mass (g)	Tag Size (g)	No. Tracking Locations	Tracking Period (days)	Comments
Fall 2005									
149.326	4-Oct-05	Pegram	P3	407	620	12	2	261	Spawned in Smith Fk. Tag expired or harvested.
149.065	11-Oct-05	Pegram	P7	440	730	12	0	0	Possible tag failure or harvested.
149.174	11-Oct-05	Pegram	P7	379	490	12	6	286	Spawned in Thomas Fk. Mortality tag not recovered.
149.346	11-Oct-05	Pegram	P7	423	610	12	6	286	No spawning tributary. Mortality tag recovered in Bear R. without carcass.
149.385	11-Oct-05	Pegram	P7	404	590	12	4	257	Spawned in Smith Fk. Tag expired or harvested.
149.466	11-Oct-05	Pegram	P7	390	530	12	2	288	Spawned in Smith Fk. Mortality tag not recovered.
149.476	11-Oct-05	Pegram	P7	415	620	12	43	288	Spawned in Smith Fk. Mortality tag not recovered.
149.584	11-Oct-05	Pegram	P7	435	770	12	12	328	Spawned in Smith Fk. Mortality tag recovered in Smith Fk. without carcass.
149.786	11-Oct-05	Pegram	P7	385	480	12	7	303	No spawning tributary. Tag expired or harvested.
149.824	11-Oct-05	Pegram	P7	442	780	12	7	212	Spawned in Smith Fk. Tag expired or harvested.
149.155	13-Oct-05	Pegram	P6	407	660	12	123	231	Spawned in Thomas Fk. Mortality tag not recovered.
149.206	13-Oct-05	Pegram	P6	387	520	12	7	301	No spawning tributary. Tag expired or harvested.
149.346	13-Oct-05	Pegram	P6	420	710	12	6	286	No spawning tributary. Mortality tag recovered in Bear R. without carcass.
149.366	13-Oct-05	Pegram	P7	352	440	12	0	0	Possible tag failure or harvested.
149.435	13-Oct-05	Pegram	P7	421	760	12	9	295	Spawned in Smith Fk. Mortality tag recovered on bank of Bear R. with partial carcass.
149.496	13-Oct-05	Pegram	P6	438	890	12	10	315	Spawned in Smith Fk. Tag expired or harvested.
149.525	13-Oct-05	Pegram	P6	343	400	12	9	315	No spawning tributary. Tag expired or harvested.
149.674	13-Oct-05	Pegram	P6	395	560	12	42	269	Spawned in Smith Fk. Tag expired or harvested.
149.215	14-Oct-05	Pegram	P5	413	770	12	37	277	Spawned in Smith Fk. Tag expired or harvested.
149.444	14-Oct-05	Pegram	P5	420	820	12	16	283	Spawned in Smith Fk. Mortality tag not recovered.
149.516	14-Oct-05	Pegram	P5	410	610	12	17	283	Spawned in Smith Fk. Mortality tag not recovered.
149.546	15-Oct-05	Pegram	P5	376	450	12	2	254	No spawning tributary. Tag expired or harvested.
149.597	15-Oct-05	Pegram	P5	401	660	12	3	279	No spawning tributary. Mortality tag recovered in Bear R. without carcass.
149.775	15-Oct-05	Pegram	P5	445	890	12	1	206	Spawned in Smith Fk. Tag expired or harvested.
149.294	25-Oct-05	Pegram	P6	335	380	9	3	274	Spawned in Smith Fk. Tag expired or harvested.
149.356	25-Oct-05	Pegram	P6	545	1800	12	4	272	Spawned in Smith Fk. Mortality tag caught in log jam in Bear R.
149.376	25-Oct-05	Pegram	P6	351	445	12	1	226	Spawned in Hobble Ck. Tag expired or harvested.
149.567	25-Oct-05	Pegram	P6	360	485	12	38	263	Spawned in Smith Fk. Tag expired or harvested.
149.616	25-Oct-05	Pegram	P6	398	575	12	10	303	Spawned in Smith Fk. Tag expired or harvested.
149.695	25-Oct-05	Pegram	P6	405	680	12	1	219	No spawning tributary. Tag expired or harvested.
149.815	25-Oct-05	Pegram	P6	435	850	12	2	272	Spawned in Hobble Ck. Mortality tag not recovered.
149.836	25-Oct-05	Pegram	P6	437	930	12	36	272	Spawned in Smith Fk. Mortality tag recovered on bank of Bear R. with partial carcass.
148.267	28-Oct-05	Nounan	N2	450	950	12	0	0	Possible tag failure or harvested.
148.313	28-Oct-05	Nounan	N2	466	970	12	4	263	Spawned in 8-mile Ck. Mortality tag not recovered.
148.508	28-Oct-05	Nounan	N2	465	1025	12	15	308	No spawning tributary. Tag expired or harvested.
148.926	28-Oct-05	Nounan	N2	431	850	12	7	263	Spawned in 8-mile Ck. Mortality tag not recovered.
148.076	1-Nov-05	Nounan	N3	315	350	9	0	0	Possible tag failure or harvested.
148.406	1-Nov-05	Nounan	N3	463	1060	12	17	314	Spawned in 8-mile Ck. Tag expired or harvested.
148.834	1-Nov-05	Nounan	N3	447	1010	12	7	263	Spawned in 8-mile Ck. Tag expired or harvested.
148.286	17-Nov-05	Nounan	N1	447	940	12	11	272	No spawning tributary. Mortality tag recovered in Bailey Ck. with carcass.
148.564	17-Nov-05	Nounan	N1	461	1040	12	3	222	Spawned in 8-mile Ck. Tag expired or harvested.
148.425	22-Nov-05	Nounan	N4	397	680	12	1	211	Spawned in Stauffer Ck. Mortality tag not recovered.
148.685	22-Nov-05	Nounan	N4	397	710	12	1	211	Spawned in Stauffer Ck. Mortality tag not recovered.
148.746	22-Nov-05	Nounan	N4	474	1140	12	14	283	No spawning tributary. Tag expired or harvested.
148.809	22-Nov-05	Nounan	N4	338	430	12	0	0	Possible tag failure or harvested.
	Mean (± 1 S.D.)			413 (43)	726 (265)		12 (21)	240 (91)	1 location every 20 days

Appendix 3. Identification of Bonneville cutthroat trout tagged in the fall of 2005. Comments on spawning movements and outcome of each individual fish.

Frequency (Mhz)	Date Tagged	Segment	Reach	Length (mm)	Mass (g)	Tag Size (g)	No. Tracking Locations	Tracking Period (days)	Comments
Spring 2006									
148.034	11-Apr-06	Pegram	P5	347	400	9	4	115	No spawning tributary. Mortality tag recovered in Bear R. without carcass.
148.042	11-Apr-06	Pegram	P5	395	660	9	3	98	Spawned in Hobble Ck. Mortality tag recovered in Bear R. without carcass.
148.136	11-Apr-06	Pegram	P5	325	340	9	4	104	No spawning tributary. Tag expired or harvested.
148.185	11-Apr-06	Pegram	P5	326	380	9	6	171	Spawned in Smith Fk. Entrained in Covey canal. Tag expired or harvested.
148.225	11-Apr-06	Pegram	P5	378	600	12	2	106	Spawned in Smith Fk. Mortality tag not recovered.
148.335	11-Apr-06	Pegram	P5	374	530	12	5	171	Spawned in Hobble Ck. Tag expired or harvested.
148.365	11-Apr-06	Pegram	P5	380	560	12	2	157	No spawning tributary. Tag expired or harvested.
148.446	11-Apr-06	Pegram	P5	389	520	12	2	104	Spawned in Smith Fk. Mortality tag not recovered.
148.527	11-Apr-06	Pegram	P5	356	480	12	12	177	No spawning tributary. Entrained in Cook canal. Tag expired or harvested.
148.986	11-Apr-06	Pegram	P5	423	810	12	3	146	Spawned in Smith Fk. Tag expired or harvested.
148.867	14-Apr-06	Pegram	P7	440	790	12	1	85	Spawned in Smith Fk. Tag expired or harvested.
148.086	15-Apr-06	Pegram	P7	302	300	9	3	83	No spawning tributary. Mortality tag not recovered.
148.957	15-Apr-06	Pegram	P7	425	730	12	4	131	Spawned in Hobble Ck. Mortality tag not recovered.
148.587	28-Apr-06	Pegram	P6	387	540	12	7	154	Spawned in Hobble Ck. Tag expired or harvested.
148.113	29-Apr-06	Nounan	N3	305	310	9	18	180	No spawning tributary. Tag expired or harvested.
148.775	29-Apr-06	Nounan	N3	438	860	12	4	93	No spawning tributary. Tag expired or harvested.
149.024	1-May-06	Nounan	N5	327	310	9	0	0	Possible tag failure or harvested.
148.357	18-May-06	Nounan	N3	325	320	12	2	37	No spawning tributary. Mortality tag recovered in Bear R. without carcass.
149.077	18-May-06	Nounan	N3	320	340	9	13	121	Spawned in 8-mile Ck. Mortality tag found in willow on bank of 8-mile Ck.
149.094	18-May-06	Nounan	N3	304	280	9	4	37	Spawned in 8-mile Ck. Mortality tag not recovered.
149.304	18-May-06	Nounan	N3	302	240	9	16	141	No spawning tributary. Tag expired or harvested.
149.313	18-May-06	Nounan	N3	310	270	9	17	141	Spawned in 8-mile Ck. Mortality tag recovered in Bear R. without carcass.
149.003	23-May-06	Nounan	N3	320	350	9	11	100	No spawning tributary. Mortality tag recovered in Bear R. without carcass.
149.023	23-May-06	Nounan	N2	332	380	9	3	31	No spawning tributary. Mortality tag recovered in Bear R. without carcass.
149.033	23-May-06	Nounan	N2	314	295	9	7	129	No spawning tributary. Mortality tag in Alexander Res. without carcass.
149.053	23-May-06	Nounan	N3	294	280	9	21	136	Spawned in 8-mile Ck. Tag expired or harvested.
149.062	23-May-06	Nounan	N3	320	350	9	5	49	No spawning tributary. Mortality tag not recovered.
149.073	23-May-06	Nounan	N2	329	370	9	5	49	No spawning tributary. Mortality tag recovered in 8-mile Ck. without carcass.
149.085	23-May-06	Nounan	N2	313	320	9	16	136	Spawned in 8-mile Ck. Tag expired or harvested.
149.415	23-May-06	Nounan	N2	333	395	12	7	63	No spawning tributary. Tag expired or harvested.
149.427	23-May-06	Nounan	N2	343	440	12	3	37	No spawning tributary. Mortality tag not recovered.
148.234	25-May-06	Pegram	P7	341	320	9	410	77	No spawning tributary. Mortality tag recovered below bald eagle nest without carcass.
148.236	25-May-06	Pegram	P7	300	280	9	4	60	No spawning tributary. Mortality tag recovered in Bear R. without carcass.
148.558	25-May-06	Pegram	P7	354	450	12	3	54	No spawning tributary. Mortality tag recovered below bald eagle nest without carcass.
148.176	26-May-06	Pegram	P5	309	260	9	5	60	No spawning tributary. Mortality tag not recovered.
148.475	26-May-06	Pegram	P5	341	360	12	3	90	No spawning tributary. Mortality tag not recovered.
148.715	12-Jul-06	Thomas	TF	585	1680	12	1	12	No spawning tributary. Mortality tag recovered 100 meters from bank of Bear R.
148.092	14-Jul-06	Nounan	N3	301	290	9	1	11	No spawning tributary. Mortality tag recovered in Bear R. without carcass.
148.123	14-Jul-06	Nounan	N3	354	460	9	3	25	No spawning tributary. Mortality tag recovered in Bear R. without carcass.
	Mean (±1 S.D.)			350 (56)	458 (258)		16 (65)	94 (51)	~ 1 location every 6 days
	Overall Mean (± 1 S.D.)			380 (53)	579 (267)		12 (40)	153 (100)	~ 1 location every 13 days * Without the 410 outlier the result would be ~ 1 location every 17 days.