BULL TROUT DISTRIBUTION AND ABUNDANCE IN THE WATERS ON AND BORDERING THE WARM SPRINGS RESERVATION

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BULL TROUT DISTRIBUTION AND ABUNDANCE IN THE WATERS ON AND BORDERING THE WARM SPRINGS RESERVATION

2000 ANNUAL REPORT

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Abstract

The range of bull trout (*Salvelinus confluentus*) in the Deschutes River basin has decreased from historic levels due to many factors including dam construction, habitat degradation, brook trout introduction and eradication efforts. While the bull trout population appears to be stable in the Metolius River-Lake Billy Chinook system they have been largely extirpated from the upper Deschutes River (Buchanan et al. 1997). Little was known about bull trout in the lower Deschutes basin until BPA funded project #9405400 began during 1998. In this progress report we describe the findings from the third year (2000) of the multi-year study aimed at determining the life history, genetics, habitat needs and limiting factors of bull trout in the lower Deschutes subbasin.

Juvenile bull trout and brook trout (*Salvelinus fontinalis*) relative abundance was assessed in the Warm Springs River and Shitike Creek by night snorkeling. In the Warm Springs R. juvenile bull trout were slightly more numerous than brook trout, however, both were found in low densities. Relative densities of both species declined from 1999 observations. Juvenile bull trout vastly out numbered brook trout in Shitike Cr. Relative densities of juvenile bull trout increased while brook trout abundance was similar to 1999 observations in eight index reaches.

The utility of using index reaches to monitor trends in juvenile bull trout and brook trout relative abundance was assessed in the Warm Springs R. for the second year. Mean relative densities of both species, within the index reaches was slightly higher than what was observed in a 2.4 km control reach.

Mill Creek was surveyed for the presence of juvenile bull trout. The American Fisheries Society "Interim protocol for determining bull trout presence" methodology was field tested. No bull trout were found in the 2 km survey area.

Twelve adult bull trout were fitted with radio transmitters to monitor movements associated with spawning in the lower Deschutes R., Warm Springs R. and Shitike Cr. during spring, summer and fall. Bull trout moved little in the Deschutes River during the spring. During early summer they migrated to Shitike Cr. By September they had reached the spawning grounds. After spawning they returned to their original holding locations in the Deschutes R. Data was not collected from three out of the four fish tagged in the Warm Springs R. due to tag failures and mortalities. One fish held in the lower river throughout the study period. In Shitike Cr. only one fish was successfully tracked. Movement patterns were similar to the bull trout tagged in the Deschutes R. Radio tag failure and mortality prevented data collection on the remaining four tagged bull trout.

Multiple pass spawning ground surveys were conducted during late August through October in the Warm Springs R. and Shitike Cr. Total redds recorded in Warm Springs R. was higher than 1999 but similar to 1998 counts. The number of redds enumerated in

Shitike Cr. declined substantially from 1998-1999. Spatial and temporal distribution in spawning within Warm Springs R. and Shitike Cr. is discussed.

Juvenile emigration was monitored in Shitike Cr. The number of migrants was lower than 1999 but higher than 1998. As in past years both a spring and fall migration period was observed. Adult escapement was monitored in the Warm Spring R. and Shitike Cr. The number of adults recorded passing the Warm Springs National Fish Hatchery weir was the highest ever recorded. An adult trap was successfully operated in Shitike Cr. Fifty-six adult bull trout were enumerated.

In the Warm Spring R. and Shitike Cr. fin clips from bull trout within the zone of sympatry with brook trout were genetically tested for evidence of hybridization. No hybridization was documented.

Length at age was assessed for bull trout in the lower Deschutes R., Warm Springs R. and Shitike Cr. by scale analysis. Length at age data is provided.

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Project Area

The Warm Springs Reservation covers 240,000 hectares. It is located on the eastern slopes of the Cascade Mountains in central Oregon. The Reservation boundaries run from the crest of the Cascades to the north and west, the Deschutes River to the east and the Metolius River to the south. The Warm Springs River and Shitike Creek, major tributaries to the lower Deschutes River, are located on the Reservation. The lower Deschutes River flows below an impassable hydroelectric complex at river kilometer (Rkm) 161. The Pelton – Round Butte complex has isolated bull trout (*Salvelinus confluentus*) populations in the Metolius River from those in the lower Deschutes River since the 1960's**.**

Research was conducted in two Reservation watersheds: Warm Springs and Shitike. The Warm Springs River is the largest river system within the Reservation. The river flows for 85 kilometers and drains 54,394 hectares. Major tributaries include Beaver Creek and Mill Creek. It is the largest tributary to the lower Deschutes River. It enters the Deschutes at Rkm 135. Shitike Creek is the third largest tributary to the lower Deschutes River. It flows for 48 km and drains 36,000 hectares. Shitike Creek enters the Deschutes River at Rkm 151.

Section 1
Juvenile Bull Trout Relative Abundance Monitoring

Introduction

Bull trout require complex stream habitat and cold water temperatures ($<15^{o}$ C) during the juvenile life stage (Dambacher and Jones 1997; Fraley and Shepard 1989; Ratliff 1992; Reiman and McIntyre 1993). Juveniles rear in streams from two to three years or longer (Ratliff et al. 1996; Pratt 1992). They are dependent on high quality stream habitat for a major portion of their lives. Historic land management activities, including timber harvest and livestock grazing, has reduced the quality and quantity of rearing habitat throughout the range of the bull trout (Fraley and Shepard 1989).

The presence of non-native brook trout (*Salvelinus fontinalis*) in juvenile bull trout habitat may pose a serious problem from hybridization and competition (Ratliff and Howell 1992). Brook trout are present throughout all of the known juvenile bull trout rearing habitat in the Warm Springs River and a portion of Shitike Creek (Brun 1999).

The relative densities of sympatric juvenile bull trout and brook trout was assessed in the Warm Springs River and Shitike Creek. The objectives were to:

1.) Determine relative densities of juvenile bull trout (age I – III) and brook trout in the Warm Springs River during the summer by night snorkeling.
2.) Collect data to assess the utility of using linear "index" reaches for monitoring trends in juvenile bull trout and brook trout relative abundance.

Methods

Snorkeling

Fish enumeration was conducted by night snorkeling using techniques described by Thurow (1994). Juvenile bull trout are nocturnal and readily observable at night. In darkness they emerge from concealment cover such as logjams and substrate interstices (Goetz 1991). Surveys were conducted in mid-June through July from 22:00 – 03:00. Two or three divers began surveying each flagged reach at the downstream end. In unison, the divers proceeded upstream. Each diver was responsible for covering a certain portion of the stream to prevent duplication in counts. The estimated total length of each bull trout and brook trout encountered was recorded. At the end of each reach the fish counts from each diver were consolidated and recorded.

Bull and brook trout were grouped into one of three length categories (50-200 mm., 200-300 mm. and >300 mm.). These lengths correspond to juvenile, sub-adult and adult bull trout life stages determined by scale analysis.

Results and Discussion

Warm Springs River

In the Warm Springs River two-thirds of the known juvenile bull trout distribution (2.4 km) was surveyed (refer to Appendix A). A total of 168 juvenile bull trout and 102 brook trout were counted between Rkm 56.9 – 59.3. The relative densities for the entire survey reach was .0063 juvenile bull trout per m^2 and .0038 brook trout per m^2. The estimated densities probably under-represent the true number of fish present in the study area. This may be due to the presence of complex habitat, such as log jams and deeply undercut banks and numerous small un-surveyed side channels, that may have allowed some fish to escape detection. Additionally the sampling efficiency of night snorkeling has yet to be determined in these streams relative to other standard techniques (Thurow and Schill 1996).

Four index reaches within the survey area, established during 1998, were re-surveyed using the methods described above. The goal of this project is to determine if index reaches will provide a reliable representation of juvenile bull and brook trout relative abundance. The index reaches, when combined, represented approximately 17% of the total survey area. The relative densities of juvenile bull trout and brook trout were .0063 and .0038 fish/m^2 respectively in the 2.4 km survey area. The mean relative densities of juvenile bull trout and brook trout within the four combined index reaches was .009 and .0056 fish/m^2 respectively (Figure 1.1).

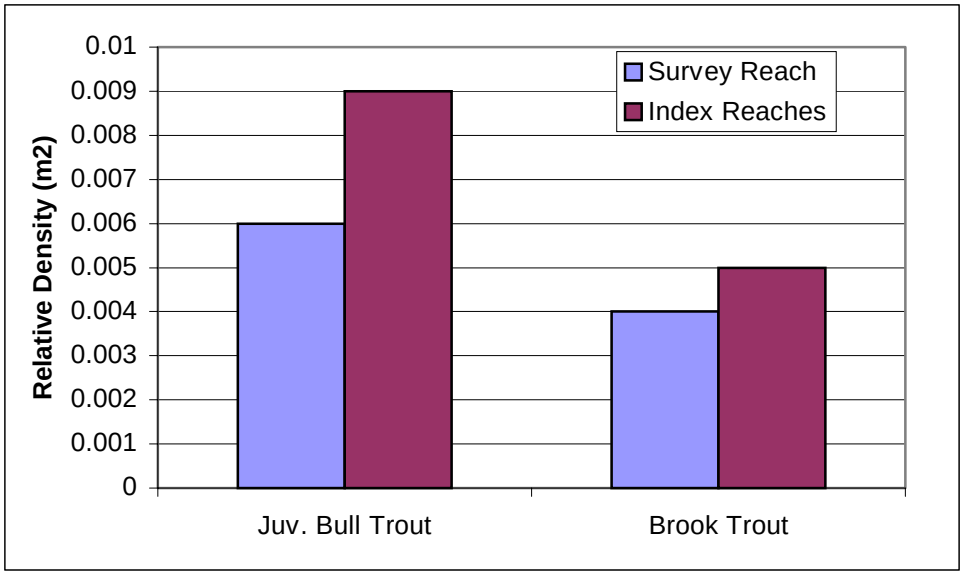

Figure 1.1. Relative densities of juvenile bull trout and brook trout in the 2.4 km survey reach in Warm Springs R. compared to the mean of the combined index reaches during 2000.

Initial analysis of replicate surveys conducted during 1999 and 2000 indicate that the mean relative densities of juvenile bull trout and brook trout within the four combined index reaches is greater than the relative densities observed within the 2.4 km survey area (Figure 1.2). The survey will be repeated during 2001. The results of the 1999-2001 survey will be analyzed by goodness of fit test and bivariate analysis. The results will be presented in the 2001 final report.

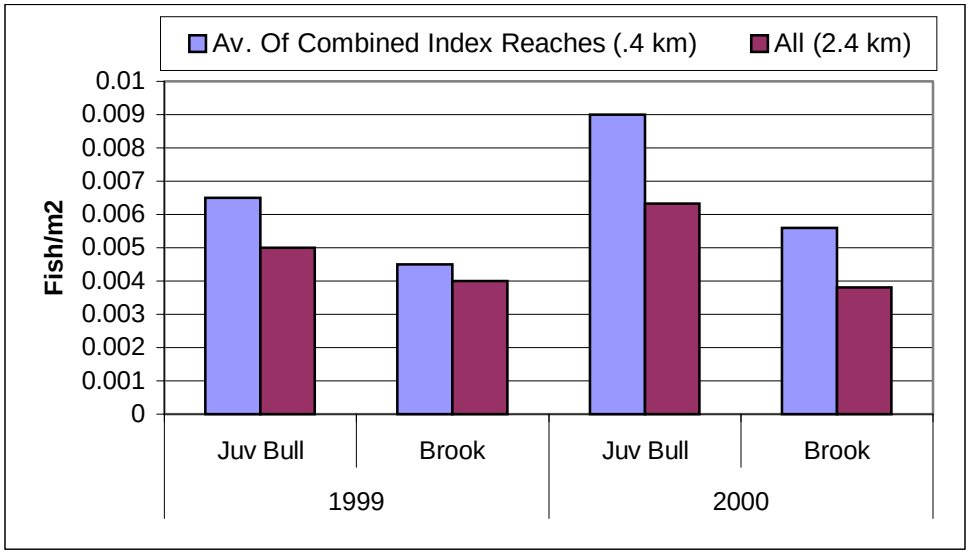

Figure 1.2. Relative densities of juvenile bull trout and brook trout within the study area and index reaches in Warm Springs R. 1999-2000.

Shitike Creek

In Shitike Creek nine index reaches, established during 1998, were re-surveyed during 1999 and 2000 (Brun, 1999 and 2000). The reaches were randomly located at approximately 1 km intervals between Rkm 35.8 - 48.6. A total of 1.1 km was surveyed. Juvenile bull trout and brook trout relative densities were .032 and .008 fish/m^2 (Figure 1.3).

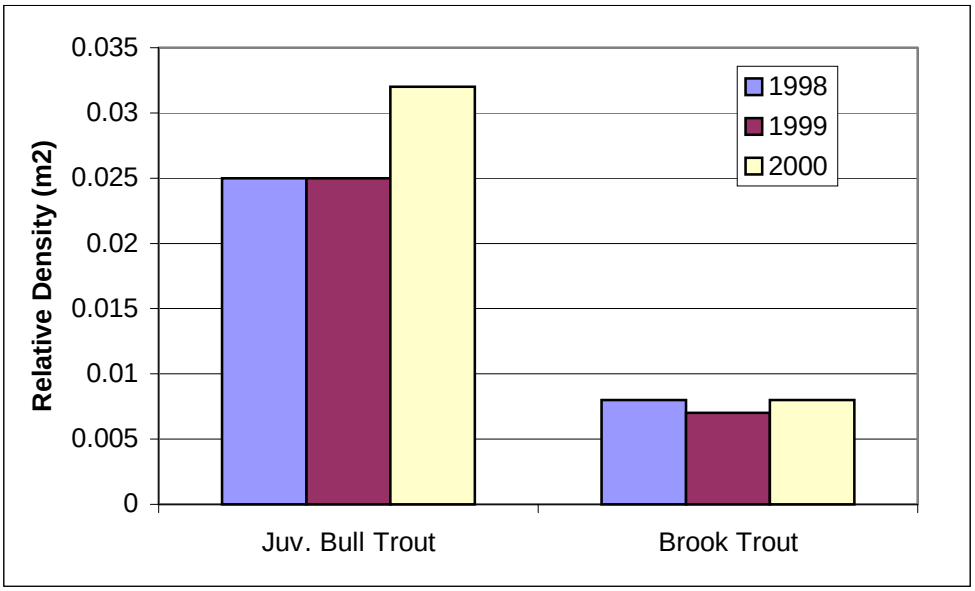

Figure 1.3. Mean relative densities of combined index reaches surveyed during 1998-2000 in Shitike Cr.

The numbers of juvenile bull trout increased during 2000 from 1998-1999 observations. Brook trout densities remained similar between 1998-2000.

Section 2
Bull Trout Presence/Absence Surveys

Introduction

During 1999 a bull trout, radio tagged at the WSNFH, entered Mill Creek. It was last located near its headwaters (Rkm 29.6) [Brun 2000]. Mill Cr. was surveyed for bull trout presence during 1998 using the methods of Bonar et al. (1997) modified from Hillman and Platts (1993). The minimum detectable density with an 80% level of confidence was assumed to be .0015 fish/m^2. The methodology assumed equal distribution of bull trout within the surveyed area with 25% sampling efficiency. No bull trout were detected in Mill Cr. using the methodology.

Investigators from the USFS Rocky Mountain Research Station have re-evaluated presence-absence bull trout survey assumptions and developed an interim presence/absence protocol for determining bull trout presence (Peterson et al. 2000). Results of recent research conducted by Peterson and Wollrab (1999) indicate that bull

trout are not uniformly distributed within available habitat. Additionally Thurow (2000) found that sampling efficiency for day snorkeling is lower than 25%. The presence/absence protocol builds on previous approaches (Hillman and Platts 1993; Bonar et al. 1997), except it uses the variation in observed bull trout densities instead of a minimum threshold density and adjusts for measured differences in sampling efficiency due to gear types and habitat characteristics. The protocol is under evaluation in several sub-basins in the Pacific Northwest (R. Thurow, USFS Rocky Mountain Research Station, Boise, Idaho, pers. comm.). The interim protocol methodology was utilized to detect bull trout presence in Mill Cr. during June 2000.

Methods

Suitable juvenile bull trout habitat was selected by identifying the portion of Mill Cr. that did not exceed 15^{o} C (average 7-day maximum temperature)[Brun 1999]. Using the Peterson et al. (2000) methodology habitat specific mean sampling efficiencies for night snorkeling and sample probabilities of detection were calculated to select the number of sample reaches required to detect juvenile bull trout with 80% and 95% probabilities of detection in 100 m sampling units. Due to difficult access a 200 m. reach was randomly selected each Rkm. Data was recorded at 100 m intervals within the 200 m reach. This allowed for two samples per Rkm. Habitat parameters recorded at each sampling reach included: water temperatures < or > 9^{o} C; stream gradient (< or > 3.5%) and large woody debris density (< or > 0.065 pieces per m^2). Night snorkeling was conducted by two divers using the methods described in Section 1.

Results and Discussion

A total of 18 sites were sampled in Mill Cr. between Rkm 22-32 and 2 sites in a small tributary (Rkm 0.0-1.0). The combined probability of detection for all the sample sites in Mill Cr. was 86% (Table 2.1). No bull trout were detected. Brook trout were found in high densities (.025 fish/m^2).

Table 2.1. Habitat criteria ranking, probability of detection and sampling power by sample reach in Mill Cr.

Sample Unit #	Visibility	Gradient	LWD Density	Water Temp (C)	Reach Length (m)	Average Width (m)	Single Sample Prob. Of Detection	Sampling Power
1a	HIGH	low	low	10	100	9.3	0.096	0.904
1b	HIGH	low	low	10	100	10.3	0.096	0.904
2a	HIGH	low	low	10	100	10.2	0.096	0.904
2b	HIGH	low	HIGH	10	100	10.2	0.092	0.908
3a	HIGH	low	HIGH	11	100	7.1	0.092	0.908
3b	HIGH	low	HIGH	11	100	7.1	0.092	0.908
4a	HIGH	low	low	11	100	10.5	0.096	0.904
4b	HIGH	low	low	11	100	10.5	0.096	0.904
5a	HIGH	low	low	12	100	10.5	0.096	0.904
5b	HIGH	HIGH	low	12	100	10.5	0.106	0.894
6a	HIGH	low	HIGH	12	100	5	0.092	0.908
6b	HIGH	low	HIGH	12	100	5	0.092	0.908
7a	HIGH	low	HIGH	12.5	100	14.1	0.092	0.908
7b	HIGH	low	HIGH	12.5	100	14.1	0.092	0.908
8a	HIGH	low	low	12.5	88	9.6	0.096	0.904
8b	HIGH	low	low	12.5	88	9.6	0.096	0.904
9a	HIGH	HIGH	low	13	100	8.5	0.106	0.894
9b	HIGH	HIGH	low	13	100	8.5	0.106	0.894
10a*	HIGH	low	HIGH	6	100	3.8	0.083	0.917
10b*	HIGH	low	HIGH	6	100	3.8	0.083	0.917

While it is impossible to be 100% certain that juvenile bull trout are absent from the surveyed portion of Mill Cr. we are 86% certain that bull trout occur in densities less than .0002 fish/m^2. The results of this study will be pooled with data from presence-absence surveys conducted in other portions of the PNW by researchers at the USFS Rocky Mountain Research Station (Boise). Further refinements of the interim presence/absence protocol may result as data from various geographic regions is incorporated in the model (J. Dunham, USFS Rocky Mountain Research Station, Boise, Idaho, pers. comm.).

Section 3
Adult Migration

Introduction

Bull trout are present in the lower Deschutes River from the Pelton hydroelectric projects downstream to at least Sherar's Falls (Rkm 71). There is much uncertainty about timing, duration and habitat use by lower Deschutes River bull trout during spawning migrations. Obtaining this information will allow managers to protect habitats used by bull trout. In order to better understand lower Deschutes R. bull trout migration movements a radio telemetry study was undertaken during 1999 and continued during 2000. During 2000 twelve fish were radio tagged and tracked from February 2000 through early January 2001.

The objectives of this study are to:
1.) Determine migration timing and duration of tributary use by adult fluvial bull trout from the lower Deschutes River.
2.) Describe the thermal experience of bull trout during the migration.
3.) Locate previously unidentified areas of bull trout use.

Methods

Fish Capture and Surgery

Three bull trout were radio tagged in the lower Deschutes R. during February, 2000. The fish were captured by electrofishing during rainbow trout population surveys (Newton and Nelson 2000). Two adult bull were captured at Devil's Canyon (Rkm 91) and one was captured at Harpham Flats boat launch (Rkm 89). All three bull trout were released at Harpham Flats (Table 3.1).

Four adult bull trout were collected from a weir at the Warm Springs National Fish Hatchery (WSNFH) in the Warm Springs River (Rkm 16) between late-May and early-June, 2000. The fish were tagged and released into a raceway that allowed for volitional passage to the Warm Springs River above the hatchery (Table 3.1). Five adult bull trout were captured at a weir on Shitike Creek (Rkm 1.4) during the month of May, 2000. The fish were tagged and released upstream of the weir (Table 3.1).

After capture the bull trout were placed in a covered 50 gallon aerated trash can filled with river water for at least 30 minutes. They were transferred to a container filled with a 60 mg/l solution of MS-222 anesthetic. Once the fish had been anesthetized the radio-tags were implanted in the abdominal cavity through a 20-30 mm incision using the surgical procedure outlined by Bellerude (1998). The surgical procedure took approximately five minutes to complete. After the surgery the bull trout were returned to the trash can filled with fresh river water. Bull trout were released when they had visibly recovered from the effects of the anesthetic, approximately 30 minutes following surgery. Surgical implantation of radio transmitters occurred only when water temperatures were less than 15^{o} C. Temperatures during recovery were monitored and the status of the bull trout was closely observed.

Two sizes of radio transmitters were used in this study. The largest tag weighed 15 grams. The smallest tag weighed 10 grams. The weight of the tag in each fish are displayed in Table 3.1. The percentage of tag weight to body weight, as measured in air, ranged from 0.4% to 1.5%. A common rule of thumb in fisheries telemetry studies is that the weight of the radio tag should not greatly exceed 2% of the body weight of a fish in air. Tags exceeding 2-3% of the fish's body weight are believed to affect swimming performance (Winter 1983). However, recent studies indicate that tags exceeding 3% of body weight may be used for effective telemetry studies in salmonids (Brown et al. 1999).

Table 3.1. Data from radio tagged bull trout during 2000.

Release Point	Date	Fork Length (mm)	Weight (g)	Tag Frequency	Tag Weight (g)
Deschutes R.	2/18/00	540	1090	150.604	15
Deschutes R	2/18/00	435	1060	150.543	15
Deschutes R	2/23/00	519	1080	150.524	15
Shitike Cr.	5/16/00	446	1100	150.534	15
Shitike Cr.	5/17/00	425	1000	150.613	15
Shitike Cr.	5/19/00	665	3300	150.594	15
Shitike Cr.	5/23/00	495	1500	150.563	15
Shitike Cr.	5/24/00	565	2200	150.680 (04)	10
Warm Springs R.	5/22/00	568	2500	150.584	15
Warm Springs R.	5/31/00	515	1750	150.544	15
Warm Springs R.	6/5/00	615	2600	150.574	15
Warm Springs R.	6/7/00	540	200	150.680 (03)	10

Monitoring

Both 10-gram and 15-gram radio tags were on a duty cycle to extend battery life. The 10-gram tags transmitted 10 hrs/day with an estimated battery life of 700 days. They were coded tags which used a single frequency but retained the ability to identify individual fish. The radio tags were manufactured by Lotek (model #MCFT-3FM). The tags were implanted into two bull trout, one in the Warm Springs R., the other in Shitike Cr.

The 15-gram tags transmitted a signal for 12 hrs/day with an estimated life expectancy of 400 days. The radio tags were manufactured by Advanced Telemetry Systems (ATS). Ten bull trout were implanted with these tags, three in the lower Deschutes R., three in the Warm Springs R. and four in Shitike Cr.

Tracking was conducted from a vehicle during February through mid-July and from an airplane beginning in mid-July through November. Locations were determined weekly from February – early July, bi-weekly from mid-July through mid-September and monthly from mid-September through December 2000.

Fish were tracked with a Lotek scanning receiver (model SX-400) equipped with a directional antenna. Locations were recorded with a GPS unit when movement occurred. Habitat use was also recorded.

Thermographs (Onset Computer Corporation, Stow Away™ and HoboTemps™) were placed in Shitike Cr. and Warm Springs R. to record stream temperatures throughout the migration and spawning period. A total of nineteen thermographs were deployed within the two rivers from the mouth to the headwaters during May (Appendix C). They were retrieved during October and November. The data was summarized using Eel River

Water Temperature Analysis Program V. 97.8[c]. Water temperatures were recorded using a hand held thermometer in the Deschutes R.

Results

Movement

Deschutes River:

All fish moved downstream immediately after tagging. During the months of February-April, two fish made short up and downstream movements of less than 1 km. These two fish were located in deep pools or eddys during this period. One adult remained at Rkm 80 throughout the study period.

The spawning migration began in mid-May. One fish (tag 150.524) migrated 73 km upstream into lower Shitike Cr. during May and June. It held in a deep pool near Rkm 15 in Shitike Cr. from July through early September before continuing its spawning migration. This fish was located on the spawning grounds by 18-Sept. at Rkm 41. By 16-Nov. it had returned to Harpham Flats in the Deschutes R. where it was originally radio tagged (Appendix D). Tag 150.604 entered Shitike Cr. in mid-July. By early August this fish had reached a holding area near Rkm 15. The tag signal failed in early August.

Shitike Creek:

Five adult bull trout were tagged at a weir (Rkm 1.4) on Shitike Cr. during May. Four fish initially moved upstream after radio tag implantation, but were recaptured at the weir and passed downstream. One fish remained approximately 100 m below the weir, where it was presumed to be a mortality. Three fish were not relocated after 08-June. It is likely the radio tags failed in these fish.

Tag 150.563 moved downstream into the Deschutes R. near the mouth of Shitike Cr. after tagging. It remained stationary for one month. On 16-June the fish was recaptured at the weir. By 18-Sept. this fish had reached the spawning grounds in Shitike Cr. at Rkm 48.5. By early October it had reached the mouth of Trout Creek in the Deschutes R. (Rkm 140). In November it was located at Rkm 103 in the Deschutes R.

Warm Springs River:

Four adult bull trout (> 40 cm) were tagged at WSNFH during mid-May through mid-June. Two adults were unable to be located after tagging. Their tags are presumed to have failed.

One fish (tag 150.680.03) immediately moved downstream to the mouth of the Warm Springs R. where it remained throughout the study period. It is presumed to be a mortality. Tag 150.574 moved upstream 8 km from the WSNFH where it continued to make short up and downstream movements throughout the study period.

Water Temperature

Deschutes River:

Water temperatures ranged from 6 - 13.5^{o} C (mean 8.6 ^{o} C) in the lower Deschutes R. from mid-February through mid-April (Figure 3.1). The spawning migration commenced when the mean water temperatures increased to 11-14 ^{o} C during May and June.

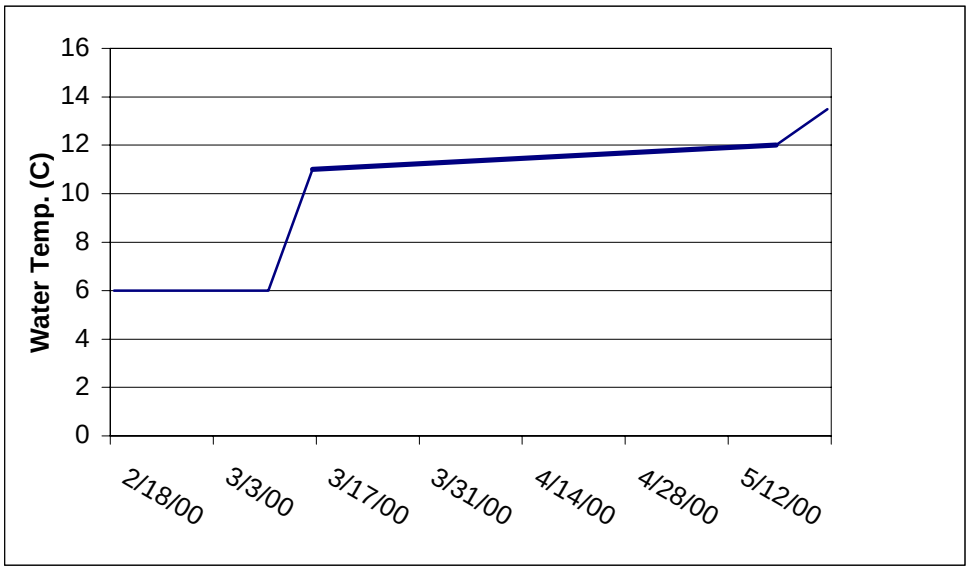

Figure 3.1. Mean water temperatures near the radio tagged bull trout in the lower Deschutes R. (18 Feb – 25 May).

Shitike Creek:

Figure 3.2 displays the water temperatures in Shitike Cr. from the time bull trout entered Shitike Cr. through spawning. Bull trout from the Deschutes R. entered Shitike beginning 16-May through 4-August. The mean water temperatures recorded at Rkm 7.0 during this period was 13.5^{o} C. Throughout the migration to the spawning grounds the mean temperature was 11.1^{o} C between Rkm 1.4 and 30. Between Rkm 30-45 the water temperatures averaged 6.7 ^{o} C during the September – October spawning period. These temperatures are based on mean 7 day averages from thermographs placed near the mouth to the headwaters of Shitike Cr. (Appendix C).

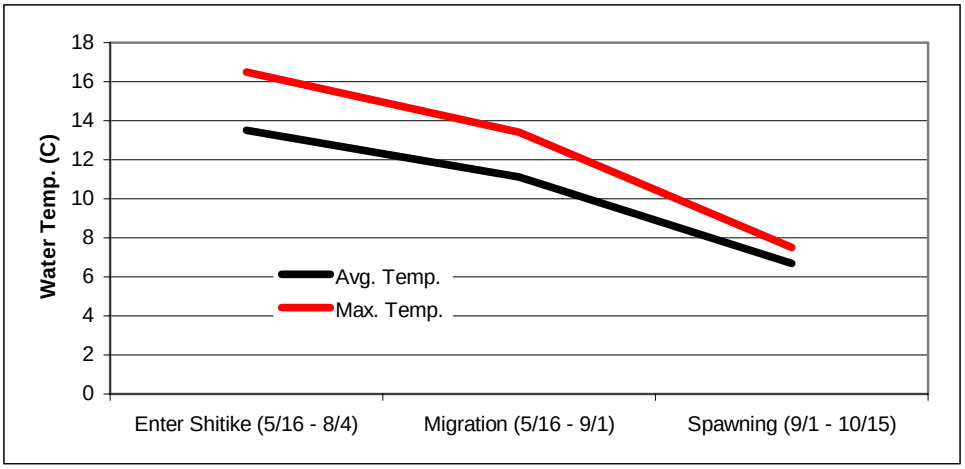

Figure 3.2. Mean 7 day average and maximum temperatures in Shitike Cr. when bull trout entered the stream through spawning.

Warm Springs River:

Water temperatures in the Warm Springs R. during the tagging period at WSNFH (Rkm 16) and during the period tag #150.574 held in the canyon are displayed in Figure 3.3. The mean water temperature at WSNFH during tagging was 13.1 ^{o}C. The average temperature in the canyon (Rkm 24) when the fish was holding was 15.2 ^{o}C. These temperatures are based on mean 7 day averages from thermographs deployed at WSNFH and in the canyon (Appendix C).

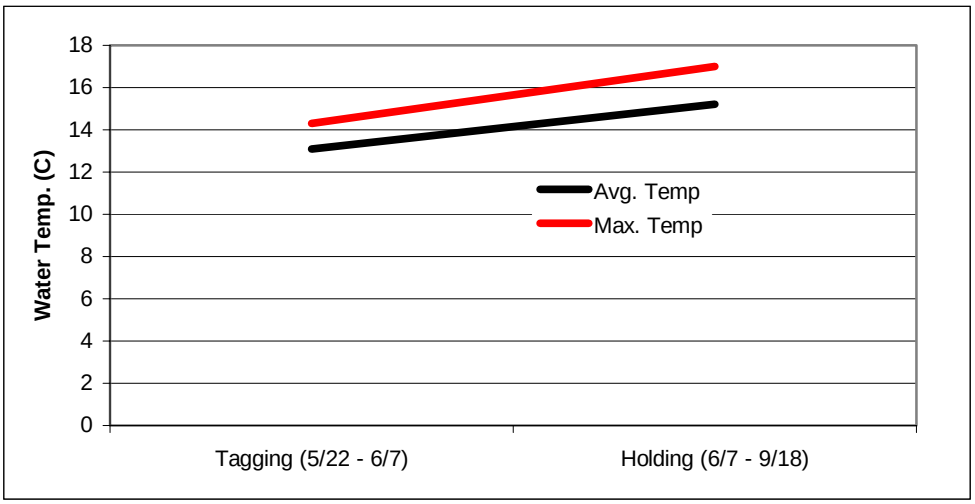

Figure 3.3. Mean 7 day average and maximum water temperatures in the Warm Springs R. from radio-tagging at WSNFH to the holding area for tag # 150.574.

Discussion

Lower Deschutes River and Shitike Creek:

Two bull trout were tracked during their migration from the lower Deschutes R. to Shitike Cr. Despite the large number of tag failures the results from this study combined with the 1999 telemetry data (Brun 1999) confirms that Shitike Cr. is a major spawning tributary for bull trout residing in the lower Deschutes R. (Buchanan et al, 1997).

Movement patterns were similar to those observed during the 1999 telemetry study. Bull trout moved little during the winter and early spring. During May and June they made a rapid migration to Shitike Cr. They held in the mid-reaches of Shitike Cr. until September. During September they migrated to the spawning grounds, spawned and rapidly emigrated back to the Deschutes R. One bull trout returned to its point of capture in the Deschutes R. This indicates that adult bull trout may occupy the same territory in the Deschutes R. on an annual basis. One fish, tag 150.524, traveled approximately 210 km during its spawning and post-spawning migration.

Migration timing of lower Deschutes bull trout are similar to the adjacent Lake Billy Chinook / Metolius population (Thiesfeld et al. 1996). In the Metolius River migration to the spawning grounds occurs during July through August. Spawning occurs during September followed by a rapid downstream migration. Rapid post-spawning downstream migration has been noted in other fluvial bull trout populations (McLeod and Clayton 1994; Oliver 1979; and Shepard et al. 1984).

Bull trout commenced their spawning migration in the Deschutes R. when water temperatures ranged from 8-12 ^{o}C. They entered the Warm Springs R. and Shitike Cr. when the average water temperatures did not exceed 15 ^{o}C but were greater than 12 ^{o}C . The bull trout that held throughout the study period in the Warm Springs R. canyon experienced an average water temperature of 16.4 ^{o}C. For fish that held in Shitike Cr. prior to spawning the average water temperatures did not exceed 15 ^{o}C. Spawning commenced in Shitike Cr. when average temperatures fell below 8 ^{o}C.

Fluvial Deschutes R. bull trout demonstrated an affinity for deep pools and glides. They occupied deep pools and glides in the Deschutes R. during the fall, winter and early spring. They briefly used shallow riffles during this period. During migration and holding in Shitike Cr. they were primarily located in pools.

Several bull trout entered the Warm Springs R. and Shitike Cr. but returned to the Deschutes R. shortly after tagging. One bull trout did not complete a spawning migration in the Warm Springs R. It held in the lower reaches of the Warm Springs R. throughout the study period. It appears that not all adults entering these streams are destined for the spawning grounds. The reasons for this behavior are unclear.

Section 4
Bull Trout Spawning Surveys

Introduction

Bull trout spawn in streams during the fall. They have specific habitat requirements for spawning. Throughout their range bull trout spawn in only a small percentage of available habitat (Fraley and Shepard 1989). Identification and protection of spawning areas is crucial for preservation of this species. Annual redd counts within index reaches is widely used to monitor trends in bull trout abundance (Sanborn et al. 1998). Conducting basin-wide surveys of know spawning habitat, repeated throughout the spawning period, reveals the timing and duration of spawning. Information obtained from these surveys may be used to determine if a sub-sample of the known spawning habitat i.e. index reaches may be used to reliably monitor spawning abundance.

Annual redd surveys began in the Warm Springs River and Shitike Creek during 1998 (Brun 1999). Redd surveys began in Whitewater River in 1995 after a radio tagged bull trout was tracked into the river from Lake Billy Chinook (Thiesfeld et al.1996). However Whitewater River was not surveyed in 2000 due to near zero visibility from glacial turbidity that was present throughout the spawning period.

The objectives of the ongoing bull trout redd surveys were to:

1.) Enumerate the number of redds in Warm Springs R., Shitike Cr. and Whitewater R. to establish baseline trend data.
2.) Determine if there are annual changes in spawning distribution.
3.) Detect changes in timing and duration of spawning.
4.) Record water temperatures associated with spawning.

Methods

Multiple-pass spawning ground surveys were conducted in Warm Springs R. and Shitike Cr. from August through October, 2000. Stream reaches that contained juvenile bull trout and suitable spawning habitat were surveyed. The entire known spawning habitat was surveyed in Warm Springs R. while 70% of the available habitat was surveyed in Shitike Cr. The locations of the surveys are displayed in Appendix B. Suitable spawning habitat was present in portions of streams containing cold water temperatures ($\leq 12^0$ C), low stream gradient (<3%), gravel/cobble substrate and abundant cover including large woody debris, log jams, pools and undercut banks (Buchanon and Gregory 1997; Fraley and Shepard 1989; Reiser and Bjornn 1979).

Redd surveys were conducted every other week in Warm Springs R. and Shitike Cr. during 1998-2000 spawning seasons. The specific timing of each survey varied within the two week periods among years due to scheduling difficulties. Each reach was surveyed 3-5 times from late-August through October. One or two surveyors began at the upstream end of the reach and walked downstream in or along-side the river channel

sighting and recording redds. Water temperatures were recorded during each survey. Flagging was placed next to each bull trout redd to avoid double counting during later passes. Redds were tallied and the presence of live adults and their approximate total lengths (cm) were recorded.

Results and Discussion

One hundred and two redds were counted in the two survey reaches in Warm Springs R. Seventy-six redds were found in three reaches within Shitike Cr. (Table 4.1). Due to inclement weather a fourth pass on reaches 2 and 3 in Shitike Cr. was not conducted.

Table 4.1. Bull trout redd survey reaches and numbers of redds recorded in Warm Springs R. and Shitike Cr. during 2000.

Stream	Reach #	Reach (River km)	Reach Length (km)	Total # of Redds	# of Redds Pass 1	# of Redds Pass 2	# of Redds Pass 3	# of Redds Pass 4	# of Redds Pass 5
Warm Springs River	1	57.5-52.0	5.5	75	11	27	8	5	24
"	2	59.3-57.5	1.8	27	5	10	10	2	-
Shitike Creek	1	35.8-31.6	4.2	5	1	3	1	0	-
"	2	41.9-38.6	3.3	43	16	19	8	-	-
"	3	43.8-41.9	1.9	28	6	21	1	-	-

During 1998 one hundred and one redds were observed in the Warm Springs R. The following year, 1999, eighty-nine redds were found. In Shitike Cr. the number of redds found were similar during 1998 (N=117) and 1999 (N=114). In 2000, there was a 33% decline in the number of redds found in Shitike Cr. (Figure 4.1). There was a significant decline in the number of redds enumerated in the downstream reach (Rkm 35.8-31.6) in Shitike Cr. from 1998 and 1999 observations (Figure 4.2).

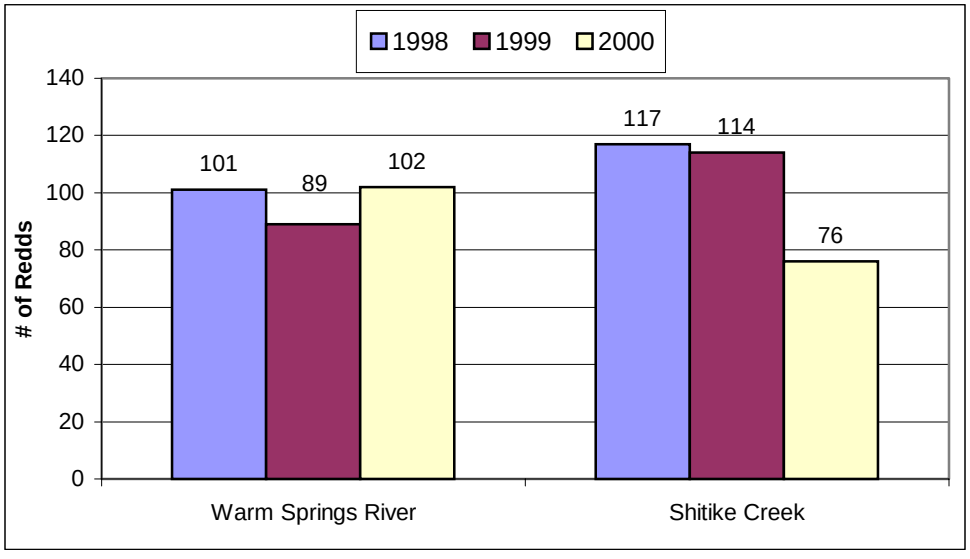

Figure 4.1. Total number of redds in Warm Springs River and Shitike Creek, 1998-2000.

In the Warm Springs R. during 1999-2000, redds/km were similar across the two survey reaches. In Shitike Cr. redd densities were lowest in reach I (Rkm 35.8-31.6) during 1998-2000. Redds/km have steadily declined in reach I since 1998. During 2000 redd densities in reach II and reach III were similar. There were approximately 5 fewer redds/km in reach III (Rkm 43.8-41.9) during 2000 than in 1999 (Figure 4.2).

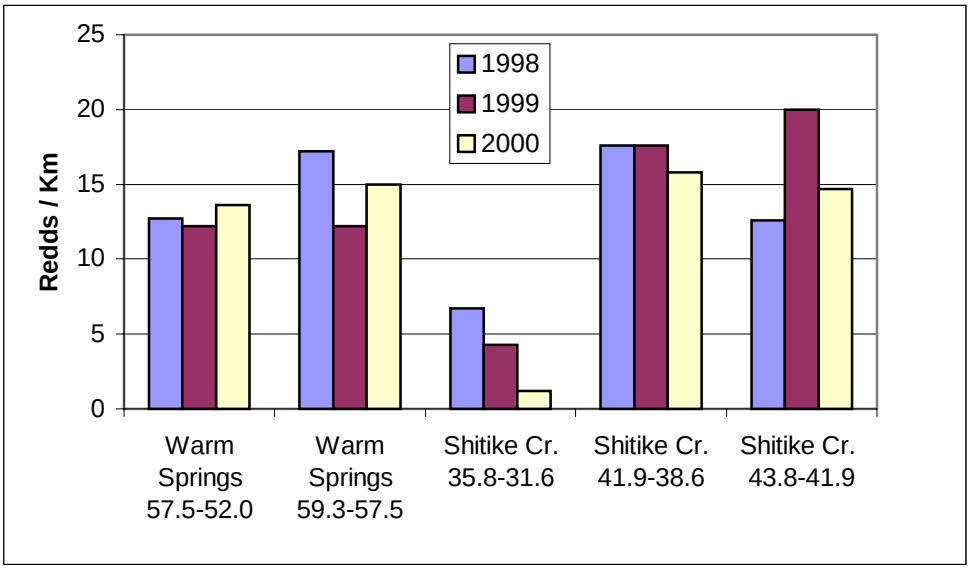

Figure 4.2. Redds per kilometer by survey reach (Rkm) in the Warm Springs R. and Shitike Cr. from 1998-2000.

Bull trout began spawning during the same time period in Warm Springs R. and Shitike Cr. as in 1998-1999. The first redds were observed during late August in Warm Springs R. and early September in Shitike Cr. when water temperatures lowered to 6.3 and 7.7^{o} C respectively. Water temperatures in Warm Springs R. ranged from 6-6.5^{o} C during the months of September and October. In Shitike Cr. the water temperatures during the survey period ranged from 8-5.5^{o} C. Spawning was first observed when temperatures declined to 6.3^{o} C water in Warm Springs R. and 7.7^{o} C in Shitike Cr. Peak spawning occurred when water temperatures were 6.4^{o} C in Warm Springs R. (Figure 4.3) and 5.6^{o} C in Shitike Cr. during late September and early August (Figure 4.4).

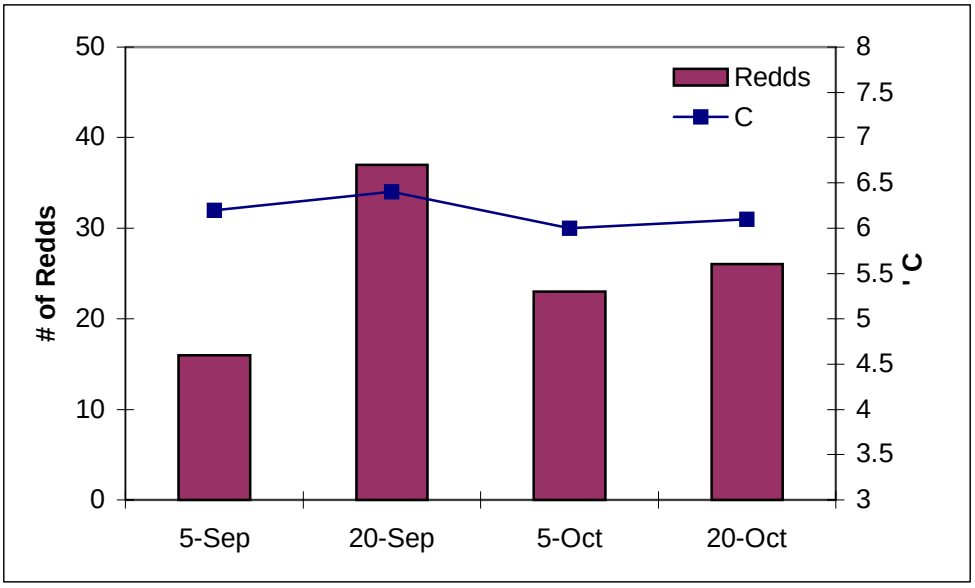

Figure 4.3. 2000 Warm Springs R. redd counts and average water temperature.

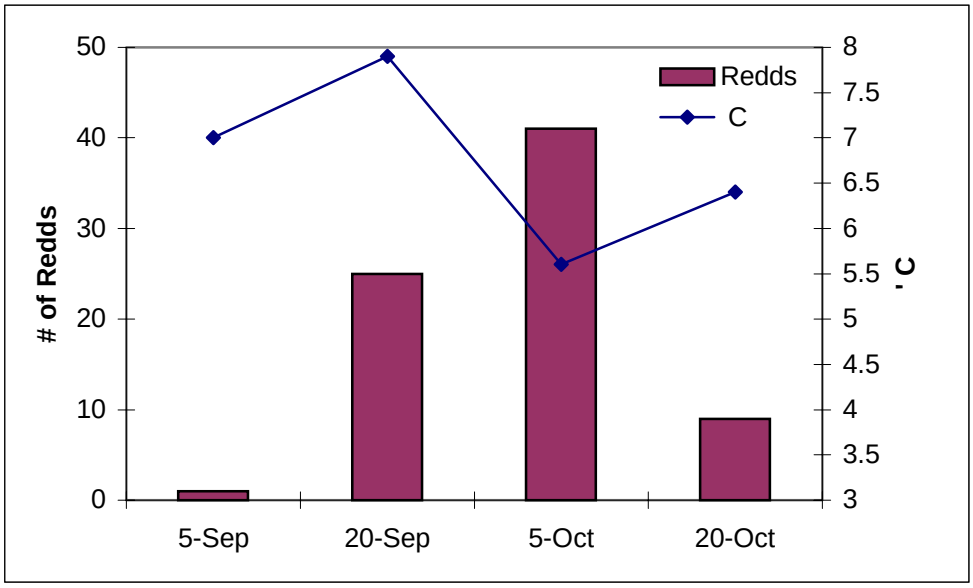

Figure 4.4. 2000 Shitike Cr. redd counts and average water temperature.

Bull trout spawned in Warm Springs R. and Shitike Cr. from late August through October during 2000. The timing of peak spawning changed in Warm Springs R. from 1999 but was similar to 1998 observations (Figure 4.5). Peak spawning occurred in Warm Springs R. during mid-September in 1998 and 2000. However, during 1999 peak spawning was observed during early October.

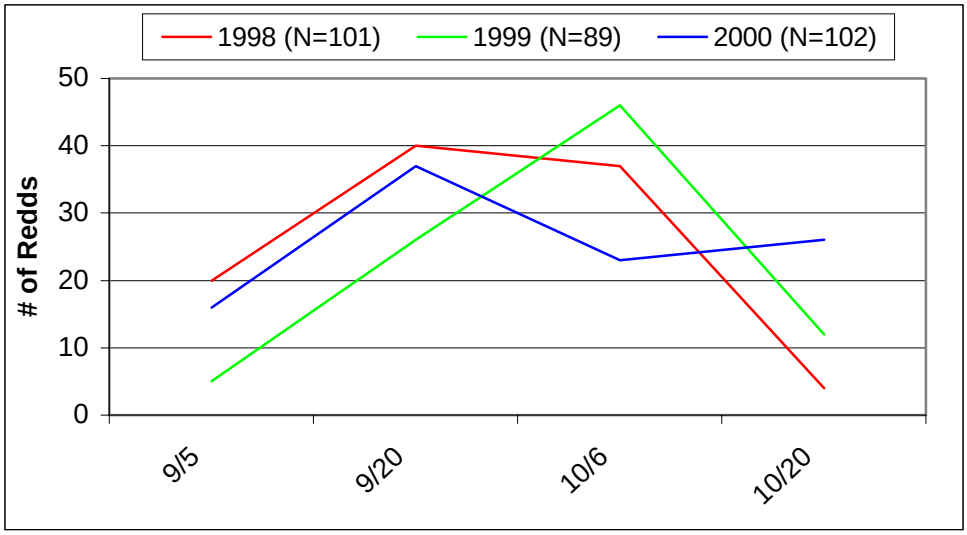

Figure 4.5. Peak spawning of bull trout in Warm Springs River, 1998-2000.

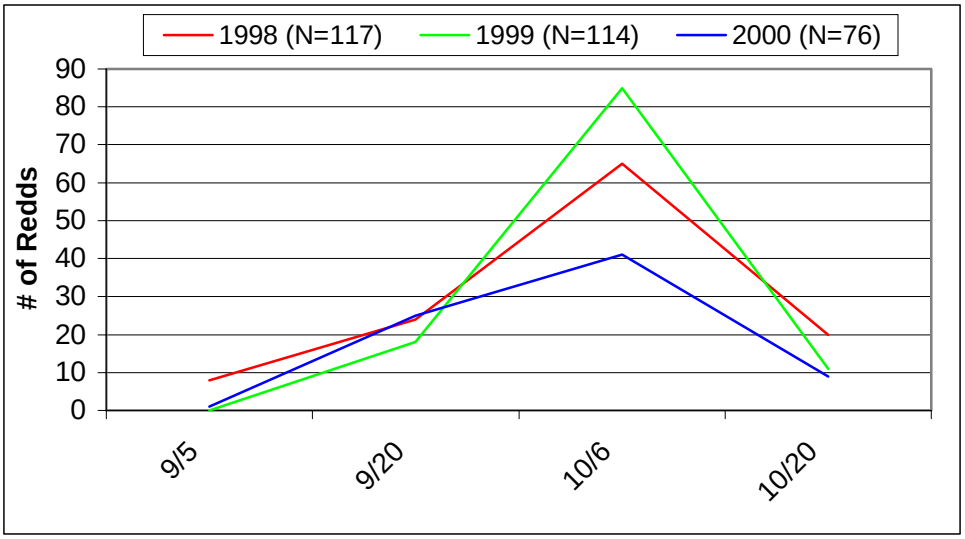

Figure 4.6. Peak spawning of bull trout in Shitike Creek, 1998-2000.

In Shitike Cr. peak spawning has occurred during early October in 1998-2000 (Figure 4.6).

Multiple pass redd surveys will be continued in Warm Springs R., Shitike Cr. and Whitewater R. during 2001.

Section 5
Juvenile and Adult Migrant Monitoring

Introduction

Fluvial bull trout spawn and rear in tributary streams up to 3 years before migrating to larger rivers to forage and mature. Adults return to their natal streams to spawn beginning at age IV (Pratt, 1992, Shepard et al, 1984). The migration timing of juvenile and adult bull trout in the lower Deschutes basin is not well understood. Juvenile emigrant traps have been operated in Shitike Creek and Warm Springs River since 1995. Adult bull trout immigration has been monitored in the Warm Spring R. at a weir located at the Warm Springs National Fish Hatchery (WSNFH) since 1995. Adult immigrant monitoring began in Shitike Cr. during 2000 with the installation of a fish weir.

Methods

Juvenile Migration

Juvenile emigration from Shitike Cr. and Warm Springs R. was monitored using juvenile migrant traps. A rotary screw trap near the mouth of Shitike Cr. (Rkm 0.7) was operated March through November 2000. A Humphrey trap was operated near the mouth of the Warm Springs R. (Rkm 0.5) from March through December. Fork lengths were recorded for all captured bull trout. Both traps were operated 24 hrs/day, Monday though Friday.

Adult Migration

A vertical picket fence weir was installed across Shitike Cr. near the mouth (Rkm 0.75) during April 2000. A fish box with a fyke entrance was attached to the weir to capture adult immigrants. The weir was operated 24 hrs/day, Sunday - Friday through October. All captured bull trout were tagged with individually numbered floy tags, weighed and fork length measured. Scale samples were also collected. Water temperatures and stream flow was recorded.

Adult immigration into the Warm Springs R. at the WSNFH was monitored by U.S. Fish and Wildlife Service personnel from April –August 2000. Adults were enumerated and fork lengths estimated using video equipment as they ascended a fish ladder around a concrete weir. Fork lengths were estimated from video recordings. The video monitoring system was operated from April to mid-May and from late-June through August.

From mid-May through late-June adults were diverted into holding ponds during the adult spring chinook salmon immigration. For bull trout captured during this period fork lengths were recorded. Scale samples were collected. Five bull trout were fitted withradio transmitters. The adult immigration was monitored 7 days/wk throughout the sampling period.

Results and Discussion

Juvenile Migration

A total of 36 juvenile bull trout were captured as they emigrated from Shitike Cr. The mean fork length was 140.5 mm (Sd. = 19.3, 95% CI = ±6.5 mm). No juveniles were captured in the Humphrey trap in the Warm Springs R. (Rkm 1.5). It is likely that the location of the Humphrey trap prevents effective capture of juveniles in the Warm Springs R.

As in previous years the majority of juveniles emigrated during the spring. However a small portion of the emigrants left Shitike Cr. during the fall. Ninety-two percent (N=33) of the fish were trapped during April and May (spring period). The remaining 8% (N=3) were captured during a late-October (fall period). The mean fork length of fish captured during the spring was 139.7 mm (Sd. = 18.3, 95% CI = ±6.4mm). The mean fork length of fall migrants was 170 mm (N = 2).

Age III fish (135-220 mm) accounted for 97% (N=35) and 66% (N=3) of the spring and fall catch respectively. The mean length of bull trout captured during their out migration into the Deschutes River during 2000 is similar to past years observations (Figure 5.1). One age IV (399 mm) fish was captured during the fall.

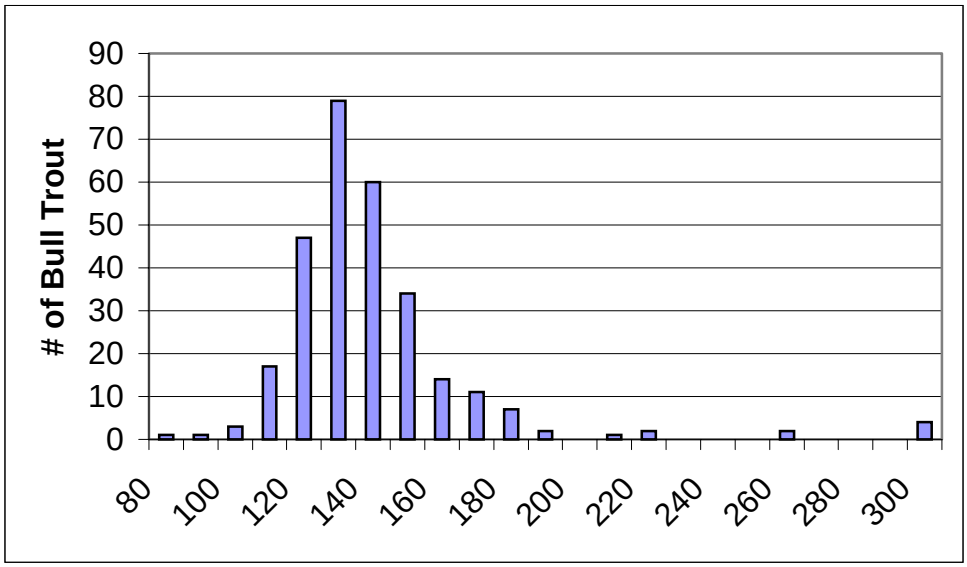

Figure 5.1. Mean fork length of juvenile bull trout emigrants in Shitike Cr. (1995-2000).

Adult Immigration

Warm Springs River:

Twenty-six adults were counted at WSNFH. The number of adults returning to the Warm Springs R. was the highest number recorded to date (Figure 5.2). Immigration occurred from early May through mid-July with the peak migration observed during the first week in June (Figure 5.3). The mean estimated fork length was 56 cm (range 35-70 cm). Based upon length at age analysis (Section 7) age V fish comprised the majority of migrants. One adult that was radio tagged during 1999 was observed passing through the ladder. This indicates that bull trout may spawn annually in the Warm Springs R.

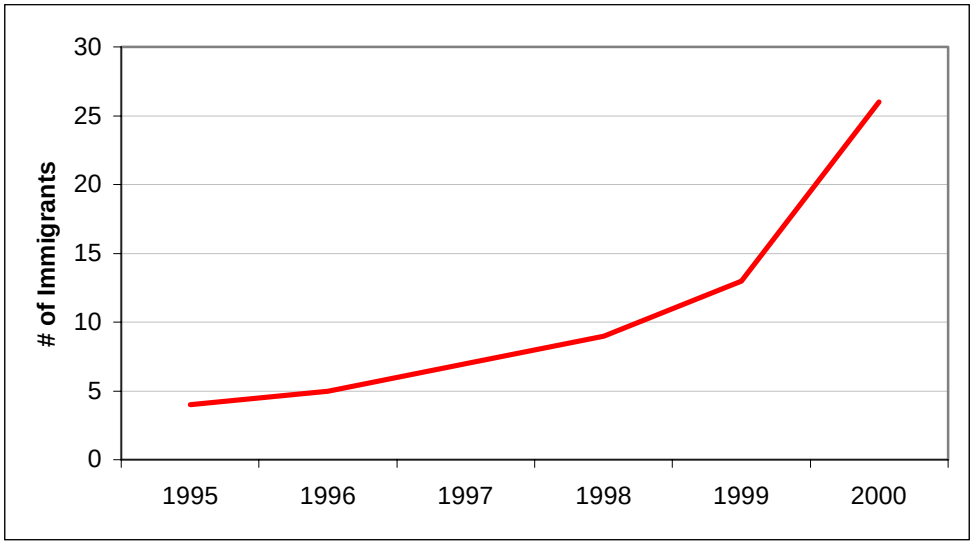

Figure 5.2. Number of bull trout counted at the Warm Springs National Fish Hatchery (1995-2000).

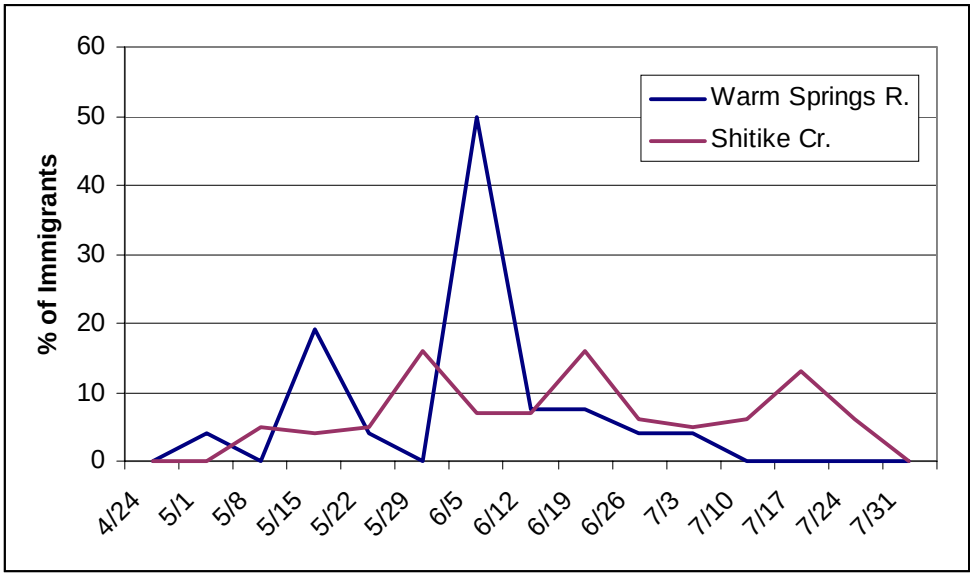

Figure 5.3. Immigration timing of bull trout into Warm Springs R. and Shitike Cr. during 2000.

Seven day average water temperatures in the Warm Springs R., recorded at WSNFH, ranged from 7-16.5^0 C throughout the immigration period. The water temperature averaged 13^0 C during the peak of the migration (Figure 5.4).

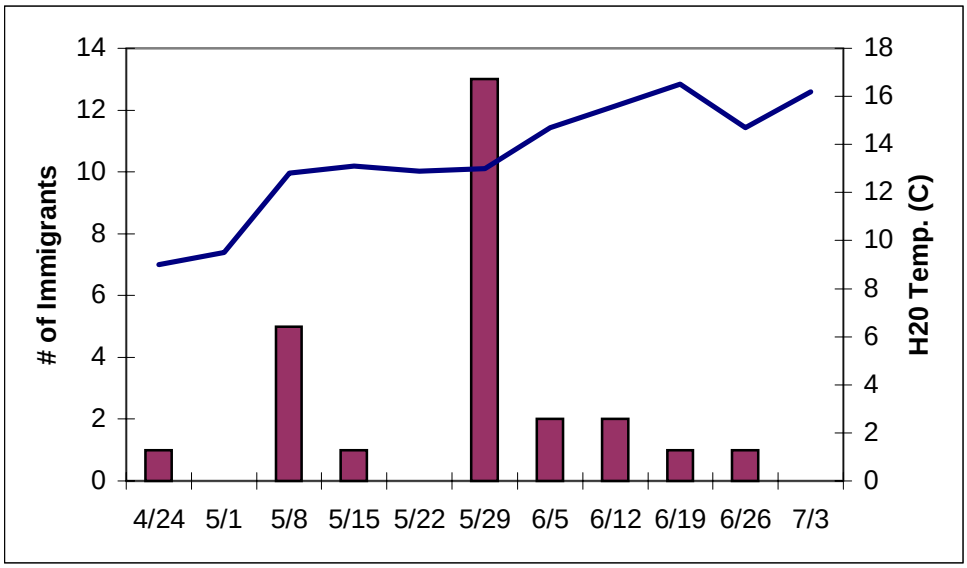

Figure 5.4. Water temperatures in the Warm Springs R. at WSNFH during adult bull trout immigration.

Shitike Creek:

Fifty-six adult bull trout were captured in the Shitike Cr. weir. All fish were released in good condition. The sizes of the adult immigrants ranged from 38-66.5 cm. The mean length was 49.1 cm. Of the 56 adults captured 32 were males, 10 were females and the sex was undetermined for 14. The capture rate (fish/hr) from the days the trap was fished was applied to the days the trap was not fished i.e. weekends. Using this expansion an estimated 93 adult bull trout migrated through the weir during 2000. Five bull trout were fitted with radio transmitters (refer to Section 3).

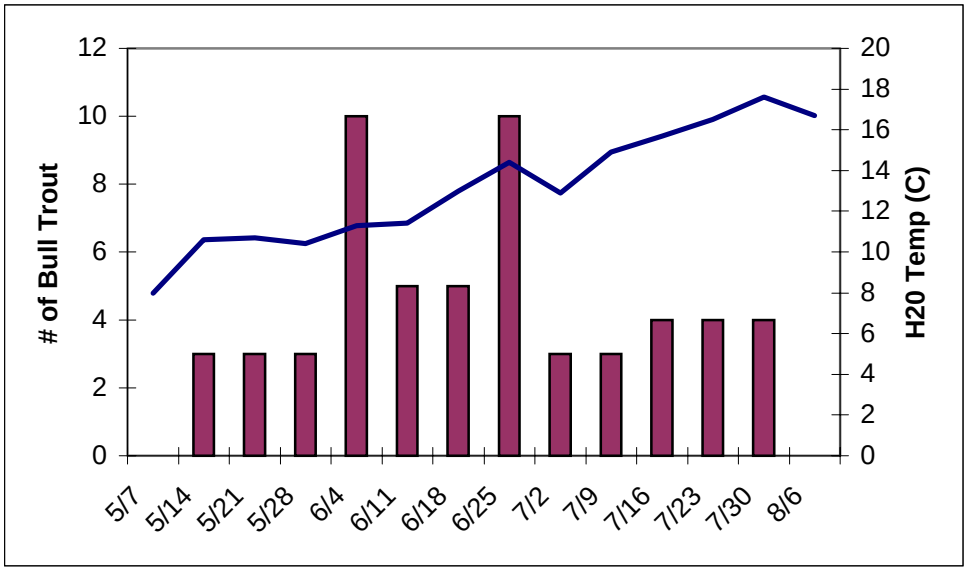

Figure 5.5. Numbers of adult bull trout captured in the Shitike Cr. weir and water temperatures during 2000.

Immigration occurred from May through early August. The peak migration was in June when water temperatures ranged between 11-14^{o} C. Water temperatures (7-day average) ranged from 8-17.6^{o} C throughout the immigration period (Figure 5.5).

Section 6
Bull Trout X Brook Trout Hybridization

Introduction

Non-native brook trout (*Salmo fontinalis*) may displace bull trout where they coexist through hybridization and/or competition for available resources (Kitano et al. 1994; Leary et al. 1991; Markle 1992; Ratliff and Howell 1992; Rieman and McIntyre 1993). Bull trout and brook trout coexist in the Warm Springs River and portions of Shitike Creek.

Methods

During 1999 fin clips from forty-five bull trout were randomly collected within the zone of sympatry with brook trout in the Warm Springs R. (Rkm 57-59) and Shitike Cr. (Rkm 35-40). The non-lethal clips were collected by netting the fish at night during snorkel surveys. The fin clips were preserved and stored in individually labeled vials containing ethanol.

The samples were sent to the Wild Trout and Salmon Genetics Laboratory, University of Montana, for electrophoretic analysis. The Paired Interspersed Nuclear DNA Element-PCR (PINE-PCR) method was used to determine genetic characteristics at 7 diagnostic markers (Spruell et al. 2000). This method produces DNA fragments that can be used to distinguish bull trout from brook trout.

Results

The results from the PINE-PCR tests strongly suggest the Warm Springs R. and Shitike Cr. samples are 100% genetically pure bull trout with 0% evidence of hybridization. Due to the relatively small sample size hybridization cannot be ruled out. However it does not appear to be wide-spread in either stream.

Section 7
Bull Trout Age at Length

Introduction

The age at length of bull trout in the lower Deschutes River has not been determined. Interpretation of fish scales can provide information on age structure, life history patterns and growth rates (Pratt 1992). Assumptions have been made that length at age is similar to bull trout in the Metolius R. (Brun 1999). However this assumption requires validation since bull trout in the Lake Billy Chinook (LBC)-Metolius system are adfluvial and have an abundant forage base which may positively effect growth rates (Ratliff et al. 1996). Bull trout in the lower Deschutes R. have a fluvial life-history pattern (Brun 1999).

Methods

Scales were opportunistically collected from forty juvenile and adult bull trout from the lower Deschutes R., Warm Springs R. and Shitike Cr. during 1998-1999. Four to five scales were collected from each fish and mounted on acetate film. The scales were magnified for measurement using a microfiche reader. Scales were analyzed by Pratt (2000) and Borgerson (2000).

Results

The mean length (mm) at age and the range is displayed in Table 7.1. Due to the small sample size of ages II, VI and VII bull trout no length range is available and length at age determination is inconclusive.

Table 7.1. Length (mm) at age with size range data obtained from lower Deschutes River bull trout.

Age I	Age II	Age III	Age IV	Age V	Age VI	Age VII
120 (117-123)	129	166 (135-220)	296 (162-380)	431 (354-480)	461	629

Age I and II bull trout in the Lake Billy Chinook-Metolius River system appear to be smaller than those in the lower Deschutes R. The smaller size of age I and II fish may be due to the cooler water temperatures and high juvenile bull trout abundance in the Metolius R. and tributaries. As bull trout emigrate from the Metolius River into LBC at age II+ to forage their growth rates increase dramatically (Table 7.2) [Madden and Lewis 2001]. Kokanee form a large part of the bull trout diet and may explain the rapid growth at age IV+ (Beauchamp and Tassell 1999).

Table 7.2. Comparison of the mean lengths at age from Lower Deschutes River and LBC-Metolius River bull trout (Pratt 1991).

	I	II	III	IV	V	VI	VII
Lower Deschutes River	120 mm	129 mm	166 mm	296 mm	431 mm	461 mm	629 mm
LBC-Metolius River	54 mm	111 mm	191 mm	299 mm	459 mm	652 mm	820 mm

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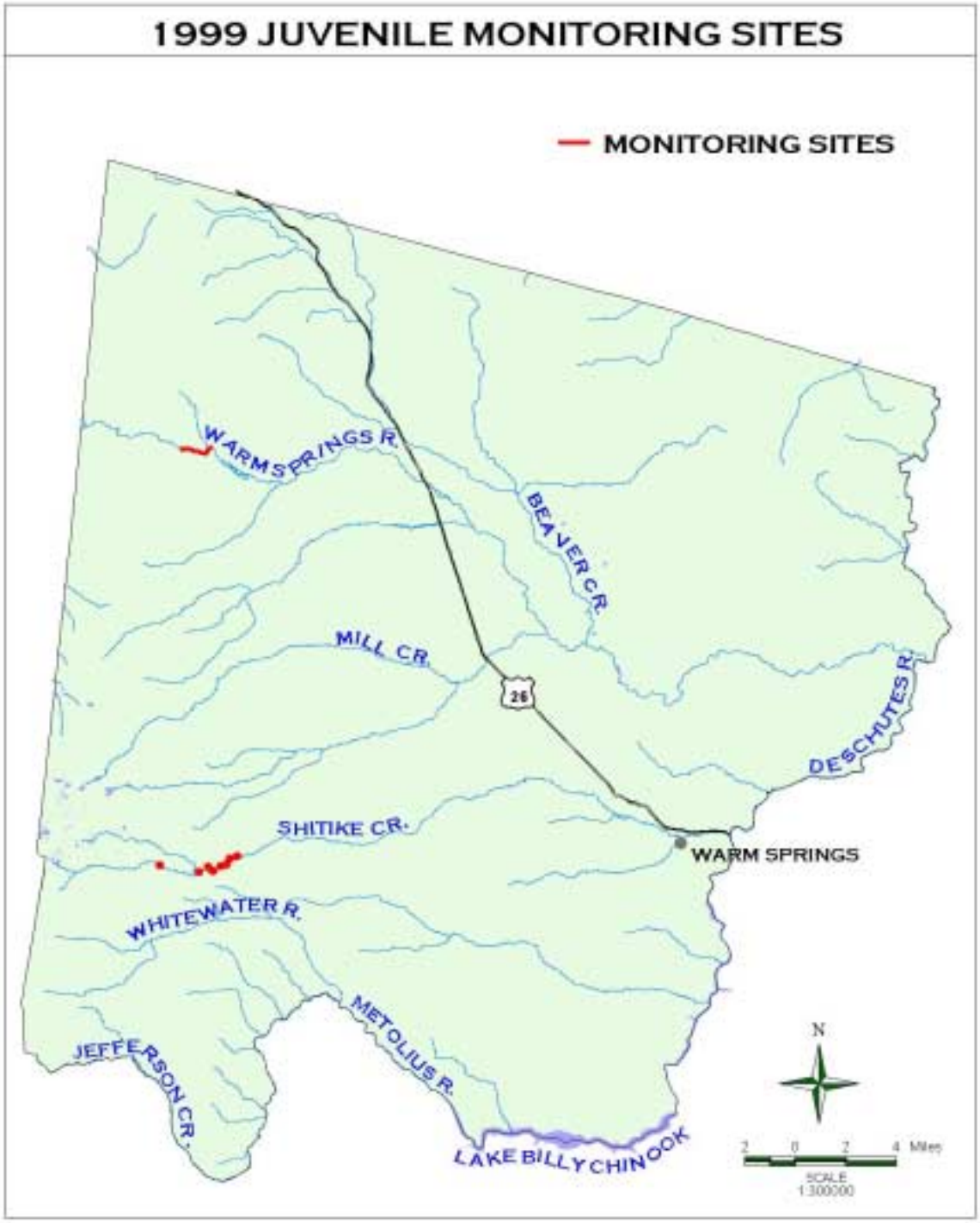
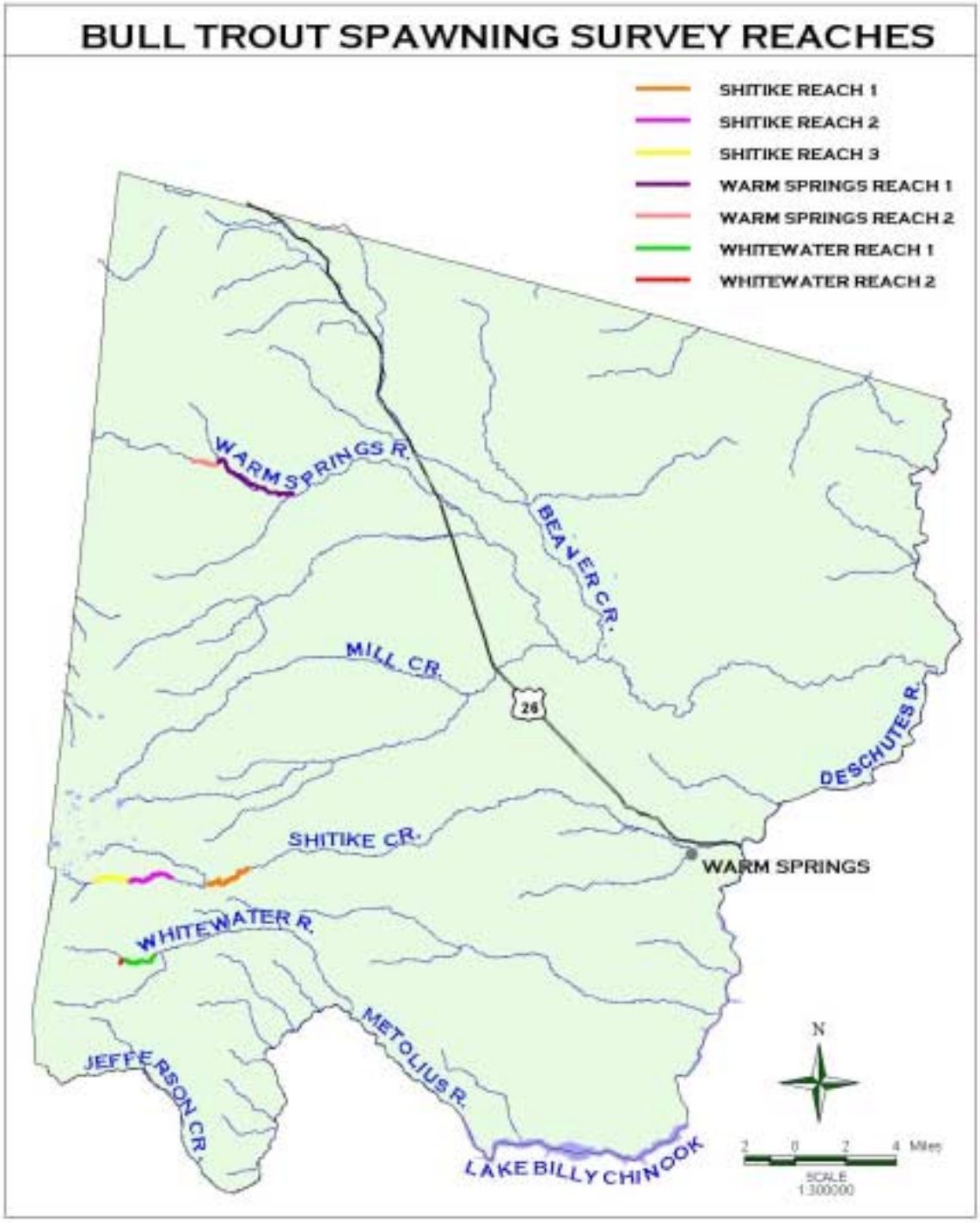
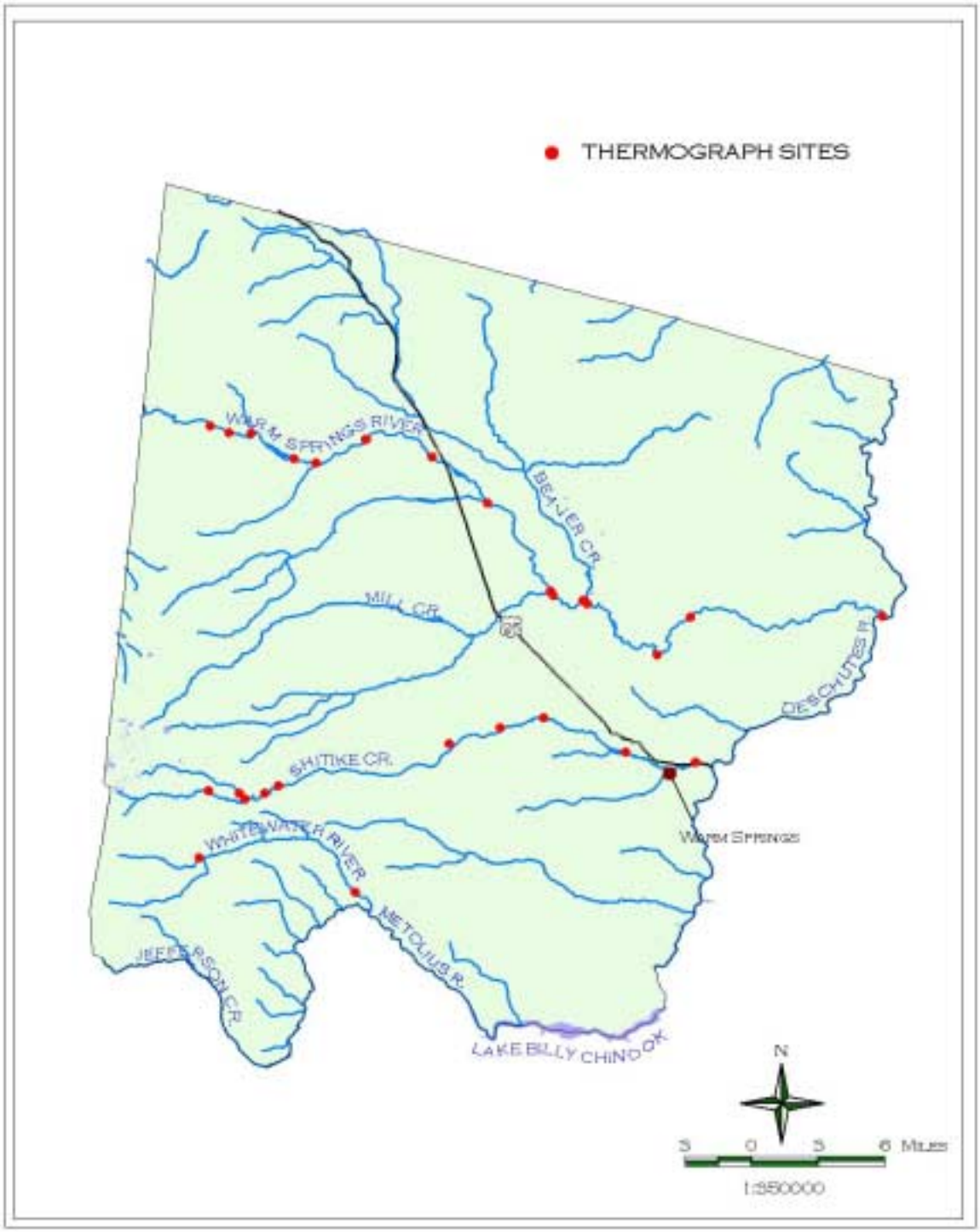
Appendix A. Juvenile bull trout survey locations.



Appendix B. Bull trout spawning survey index reaches.



Appendix C. Stream temperature monitoring stations.



Appendix D. Movements of radio tagged bull trout.