Bull Trout Distribution and Abundance on and Bordering the Warm Spring Reservation

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

2003 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 healthy 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 to date from this multi-year study aimed at determining the life history, habitat needs and limiting factors of bull trout in the lower Deschutes subbasin.

Juvenile bull trout and brook trout (*Salvelinus fontinalis*) relative abundance has been assessed in the Warm Springs River and Shitike Creek since 1999. In the Warm Springs River, the relative density of juvenile bull trout was 0.008 fish/m^2 during 2003. This density was the highest recorded in the Warm Springs River since surveys began in 1999. Brook trout relative density during 2003 was 0.002 fish/m^2. In Shitike Creek, there was a significant difference in densities of juvenile bull trout and brook trout. The relative density of juvenile bull trout was 0.0037 fish/m^2 and brook trout density was 0.0093 fish/m^2 during 2003.

The utility of using index reaches to monitor trends in juvenile bull trout and brook trout relative abundance has been assessed in the Warm Springs River since 1999. During 2003 the relative density of juvenile bull trout in the 2.4 km study area was higher than the density observed in each of the four index reaches. The relative density for brook trout in the study area was equal to the density in the index reaches. However, the average densities among the four index reaches is similar to what was observed in the study area for both species.

Habitat use by juvenile bull trout and brook trout was determined in the Warm Springs River and Shitike Creek. Juvenile bull trout and brook trout occupied pools and glides more frequently than riffles and rapids. However, pools and glides only accounted for 13.7% of the available habitat in the study area during 2003 suggesting that preferred habitat is limited in the Warm Springs River.

Multiple-pass spawning ground surveys were conducted during late August through October in the Warm Springs River and Shitike Creek during 2003. One hundred and three (103) redds were enumerated in the Warm Springs River and 203 redds in Shitike Creek. This was the second highest number of redds observed in both streams since surveys began in 1998. Spatial and temporal distribution in spawning within the Warm Springs River and Shitike Creek is discussed.

Juvenile bull trout emigration has been monitored in Shitike Creek since 1996. As in past years' both a spring and fall migration period was observed. A total of 424 juvenile bull trout were estimated to have emigrated during the spring period in 2003. Thirty-three

(33) adults were recorded ascending the Warm Springs National Fish Hatchery weir during 2003. This was the highest number of adults passing the weir to date. A weir equipped with an underwater videocamera near the spawning grounds was operated in the Warm Springs River. One hundred and forty-eight (148) adults were recorded passing through the weir. The weir in Shitike Creek was successfully operated during 2003. A total of 31 adult bull trout were enumerated during 2003.

Thermographs were placed throughout the Warm Springs River and Shitike Creek to monitor water temperatures during bull trout migration, holding and spawning/rearing periods. During 1999-2003 water temperatures ranged from 13.8-19.8º C near the river mouths' during adult migration; 11.4-14.6º C during pre-spawn holding; and 6.5-9.5º C during adult spawning and juvenile rearing.

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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 within 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 populations in the Metolius River from those in the lower Deschutes River since the 1960's.

The project 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 I
Juvenile Bull Trout and Brook Trout Relative Abundance Monitoring

Introduction

Bull trout require complex stream habitat and cold-water temperatures (<15º C) during their juvenile life stage (Dambacher and Jones 1997; Fraley and Shepard 1989; Ratliff 1992; Reiman and McIntyre 1993). Such habitat is limited to the headwaters of many streams within the Pacific Northwest. Juveniles rear in streams from two to three years or longer (Ratliff et al. 1996; Pratt 1992). Historic land management activities, including timber harvest and livestock grazing, have reduced the quality and quantity of naturally limited rearing habitat throughout the range of bull trout (Fraley and Shepard 1989).

The presence of non-native brook trout (*Salvelinus fontinalis*) in juvenile bull trout habitat may pose a serious threat to bull trout 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).

Monitoring the abundance and distribution of juvenile bull trout within a stream is essential to assess the health of a given population. However, due to limited resources and access difficulties, many bull trout populations are monitored by sub-sampling portions of juvenile rearing habitat. It is unknown how representative these "index" reaches are to the whole juvenile population in many streams. In the Warm Springs River, juvenile bull trout distribution is confined to a 3.6 km portion of the stream. Access to juvenile bull trout rearing habitat is confined to a 2.4 km section. These circumstances provide an opportunity to assess the utility of using "index" reaches to

assess trends in juvenile bull trout and sympatric brook trout relative abundance in the majority of juvenile rearing habitat within the Warm Springs River.

Beginning in 1999, the relative densities of juvenile bull trout and sympatric brook trout were assessed in the Warm Springs River and Shitike Creek. Within the Warm Springs River the objectives were to:

1. Determine relative densities of juvenile bull trout and brook trout in the study area.
2. Determine habitat unit use by both species.
3. Collect data to assess the utility of using "index" reaches for monitoring trends in juvenile bull trout and brook trout relative abundance by comparing Warm Springs River night snorkel total counts in a 2.4 km reach to 4 "index" reaches.

The objective in Shitike Creek is to monitor trends in juvenile bull trout and brook trout relative abundance, by sub-sampling a portion of the available juvenile rearing habitat.

Methods

Warm Springs River

Habitat Description

The Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventory Protocol (Moore et al. 1993) was used to classify physical habitat in the study area within the Warm Springs River. Major habitat features including pools, glides, riffles and rapids were identified. The length and average bankful width of each habitat unit was measured prior to fish enumeration. The surface area (m^2) of each habitat unit was calculated by multiplying its length by the average bankful width within each unit. The upper and lower bounds of each unit was sequentially numbered with flagging.

"Index" Reaches

Four "index" reaches were established within the study area during initial juvenile bull trout distribution surveys conducted during 1998 (Brun 1999). The "index" reaches ranged from 94 - 105 m in length. Each reach began and ended at the beginning of a habitat unit. Prior to fish enumeration the surface area (m^2) of each index reach was determined using the methods described above. Flagging was placed at both ends of the reach so divers could easily determine the up and downstream bounds. The "index" reaches, when combined, represent approximately 17% of the total survey area.

Juvenile Bull and Brook Trout Enumeration

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 and cover, such as log jams and substrate interstices (Goetz 1991). Surveys were replicated during the same time period as in previous years (mid-June through early August from 22:00-03:00). Surveys began at the downstream end of the study area (Rkm 56.9) and proceeded upstream to Rkm 59.3. Two or three divers searched each habitat unit for juvenile bull trout and brook trout. The estimated total length of each bull trout and brook trout encountered was recorded. At the end of each habitat unit and "index" 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 >300mm total length). These lengths correspond to juvenile (ages I and II), sub-adult (ages III and IV) and adult (IV+) bull trout life stages determined by scale analysis. Age 0 fish were tallied when observed but were not included in the relative density estimates due to difficulty in enumerating this age class by night snorkeling (Goetz 1991).

Shitike Creek

Eight index reaches have been surveyed each year since 1998 in Shitike Creek (refer to Appendix A) [Brun 1999; Brun and Dodson 2000, 2001, 2002]. The reaches were randomly located at 1 km intervals between Rkm 35.8-48.6. A total of 1.1 km was surveyed (9% of available juvenile rearing habitat). Survey reaches ranged in length from 109-213 meters. Each reach began and ended at the beginning of a habitat unit. Prior to fish enumeration the surface area (m^2) was determined using methods described above. Flagging was placed at both ends of each reach so divers could easily determine the up and downstream reach boundaries. Juvenile bull trout and brook trout were enumerated by night snorkeling according to methods described above.

Results and Discussion

Warm Springs River

Relative Abundance

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 186 juvenile bull trout and 47 brook trout were counted between Rkm 56.9 – 59.3 during 2003. The relative densities for the entire survey reach were 0.008 juvenile bull trout/m^2 and 0.002 brook trout/m^2. Figure I.1 displays the relative densities of juvenile bull trout and brook trout in the 2.4 km survey reach from 1999-2003. Juvenile bull trout relative density during 2003 was the highest density observed since surveys began in 1999. Relative density of brook trout increased slightly from 2002, but was still lower than what was observed from 1999-2001. The estimated densities probably underestimate the true number of fish present in the study area due to the presence of complex habitat features including log jams, deeply undercut banks and numerous small side channels. Some fish present in these habitats may have escaped detection.

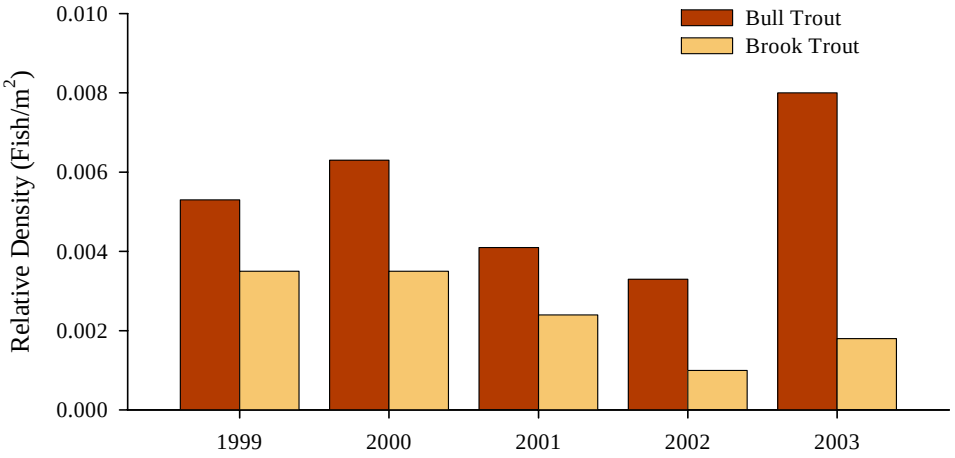

Figure I.1. Relative density of juvenile bull trout and brook trout in the 2.4 km study area in the Warm Springs River, 1999-2003.

Habitat Use

As in previous years, juvenile bull trout and brook trout were most abundant in pool and glide habitats during 2003 (Figure I.2). Approximately 82% of the juvenile bull trout and 75% of brook trout were found in pool and glide habitat. However, pools and glides accounted for only 13.7% of the total habitat area during 2003 surveys. The lowest densities of fish were found in rapids, which account for over 50% of the available habitat within the study area. The preferred habitats for both juvenile bull trout (Figure I.3) and brook trout (Figure 1.4) are pools and glides yet these habitats are very limited within the study area. Therefore there may be competitive interaction between the two species for space within the study area in the Warm Springs R. It should be noted that past snorkel surveys have failed to identify significant numbers of bull trout outside of the study area.

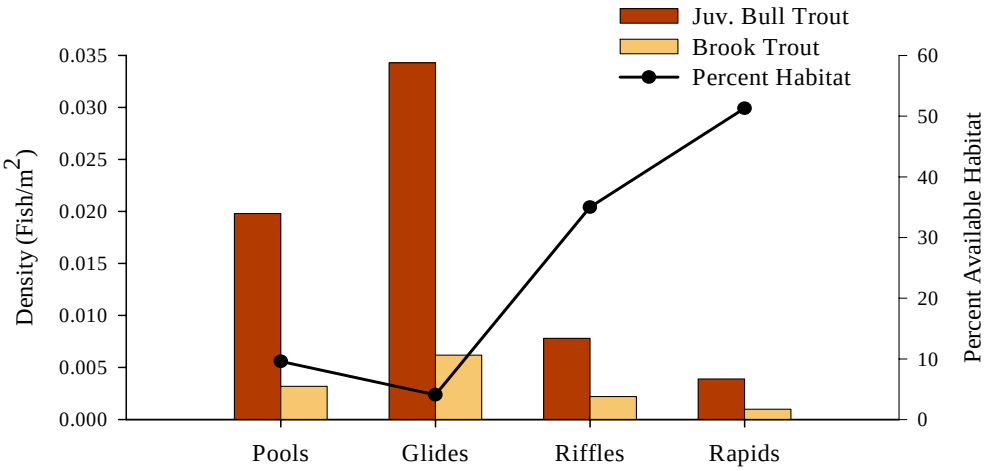

Figure I.2. Juvenile bull trout and brook trout relative densities by habitat type and percentage of each habitat type within the Warm Springs River study area.

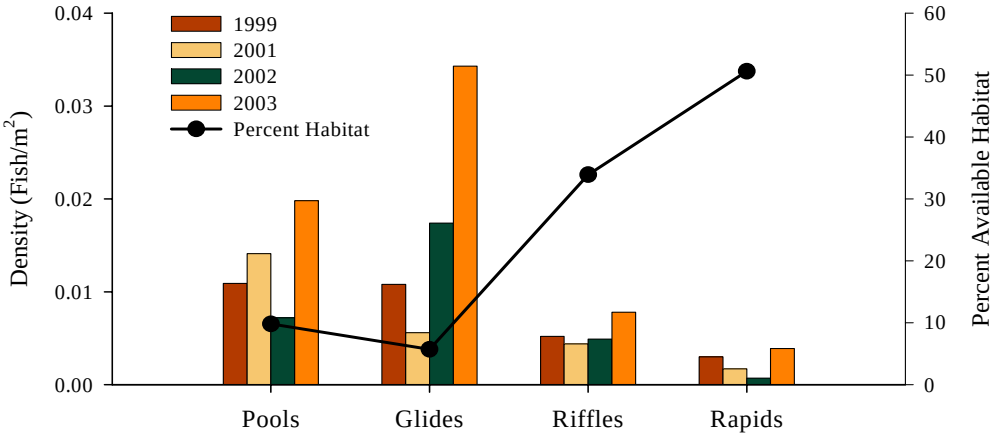

Figure I.3. Comparison of juvenile bull trout relative abundance and the average percent available habitat, 1999 & 2001-2003.

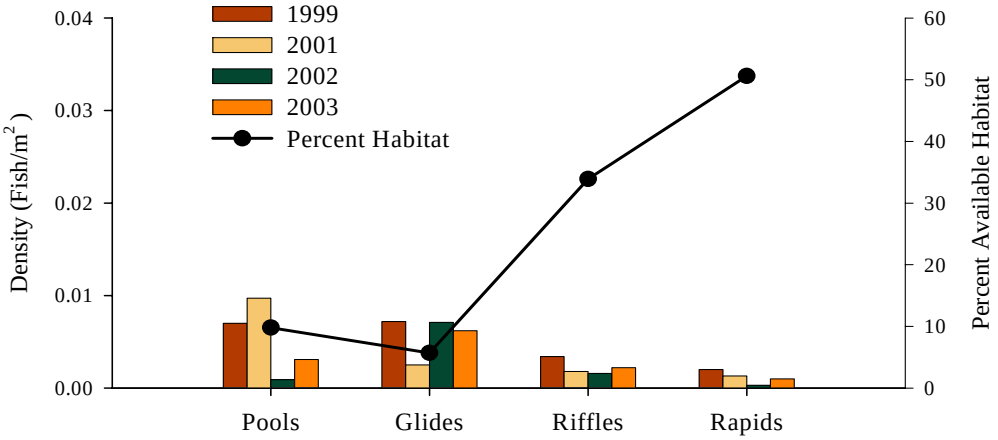

Figure I.4. Comparison of brook trout relative abundance and the average percent available habitat, 1999 & 2001-2003.

Index Reach Comparison

Since 1999, there has been considerable variance in the relative densities of juvenile bull trout and brook trout among the individual index reaches (Table I.1 and I.2). [refer to Appendix B]. The density in reach II was similar to the densities observed in the 2.4 km study area during 3 of the 5 years (1999-2001) [Figure I.5]. However, reaches I and III-IV, either underestimated or overestimated the observed density in the 2.4 km study area.

Table I.1. Summary statistics for juvenile bull trout relative densities observed within individual index reaches in the Warm Springs River, 1999-2003.

	Fish/m^2 in Individual Index Reaches				Fish/m^2 Total Survey Area	Summary Statistics for Index Reaches		
	I	II	III	IV		Mean	Var.	SD.
1999	.006	.005	.003	.012	.005	.006	.000015	.0039
2000	.011	.007	.005	.013	.006	.009	.000013	.0036
2001	.009	.004	.002	.011	.004	.006	.000018	.0042
2002	.005	.001	.002	.002	.003	.0024	.0000026	.0016
2003	.011	.005	.007	.005	.008	.007	.000008	.0028

Table I.2. Summary statistics for brook trout relative densities observed within individual index reaches in the Warm Springs River, 1999-2003.

	Fish/m^2 in Individual Index Reaches				Fish/m^2 Total Survey Area	Summary Statistics for Index Reaches		
	I	II	III	IV		Mean	Var.	SD.
1999	.002	.003	.008	.003	.0035	.004	.000007	.0027
2000	.012	.005	.006	.004	.0035	.007	.000013	.0036
2001	.0015	0	.002	.005	.002	.0017	.000016	.0040
2002	.003	0	0	.002	.001	.0013	.0000023	.0015
2003	.004	.0006	.003	.001	.002	.002	.0000026	.0016

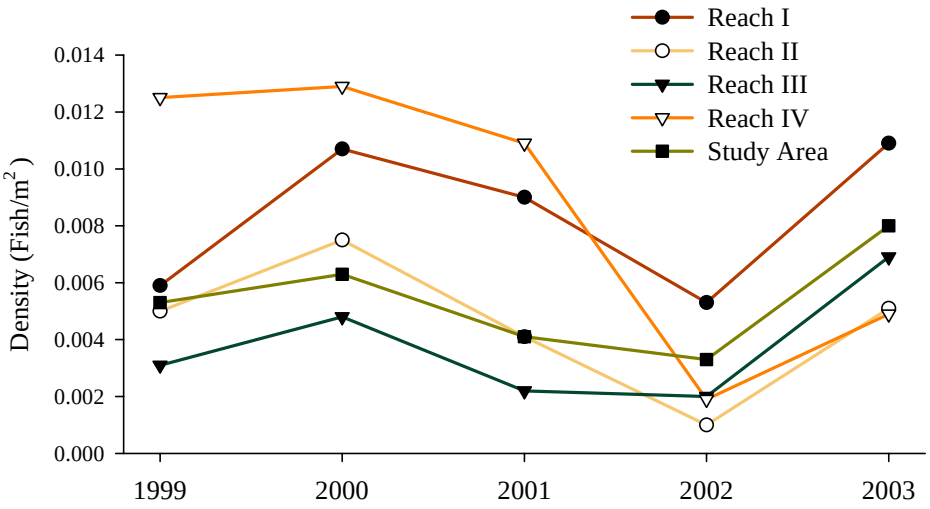

Figure I.5. Relative densities of juvenile bull trout in the individual index reaches and the study area, 1999-2003.

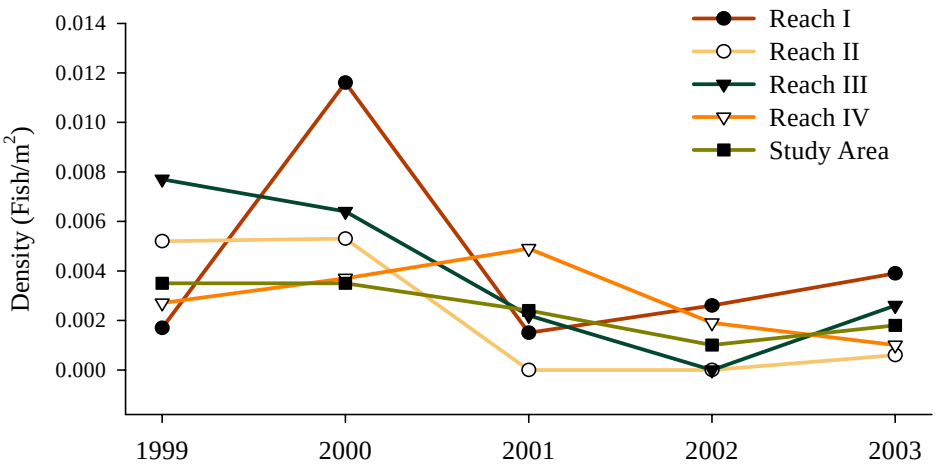

Figure I.6. Relative densities of brook trout in the individual index reaches and the study area, 1999-2003.

Due to the high variance of juvenile bull trout and brook trout densities among the individual index reaches, we averaged the densities observed within the four index reaches to determine if sub-sampling a larger area would provide a more representative density estimate. By combining the four index reaches the survey was increased to 17% of the study area. From 1999-2001, the mean relative densities within the four combined index reaches has been greater than the observed relative densities in the study area. However, during 2002-2003, the density within the study area has been slightly greater than the density in the combined index reaches for juvenile bull trout (Figure I.7).

The annual variation in counts of juvenile bull trout in the four combined index reaches compared to the 2.4 km study area is insignificant due to the low numbers of fish observed ($X^2_{0.05,4df} = 2.95$, $0.75<P<0.5$ [P=0.57]). There appears to be a relatively strong correlation between the two ($R^2=.71$) [Figure I.9]. For brook trout, the relative density in the 2.4 km study area has been equal to the relative density of the combined index reaches during 2002-2003 (Figure I.8). There is a strong correlation between the two surveys from 1999-2003 (Figure I.10). Based upon the 1999-2003 data it appears that surveying the four index reaches and averaging the results is very comparable to what was observed in the 2.4 km survey area for both juvenile bull trout and brook trout.

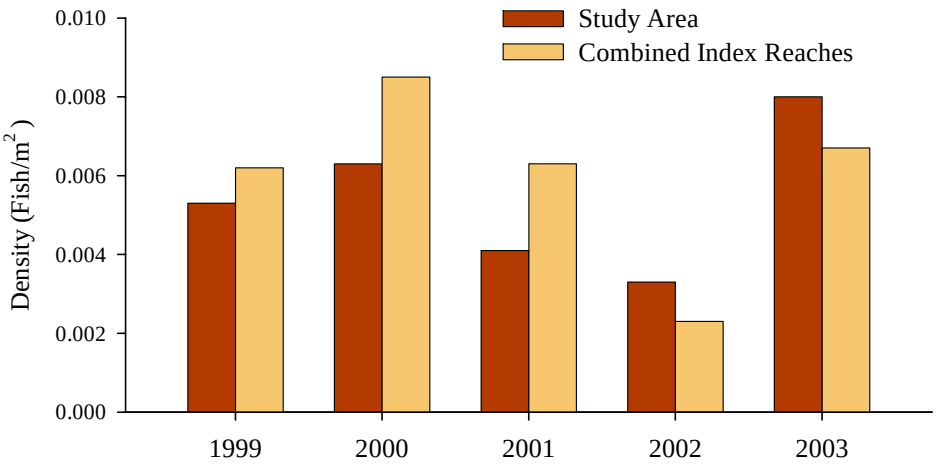

Figure I.7. Relative density of juvenile bull trout within the study area and the combined index reaches in the Warm Springs River, 1999-2003.

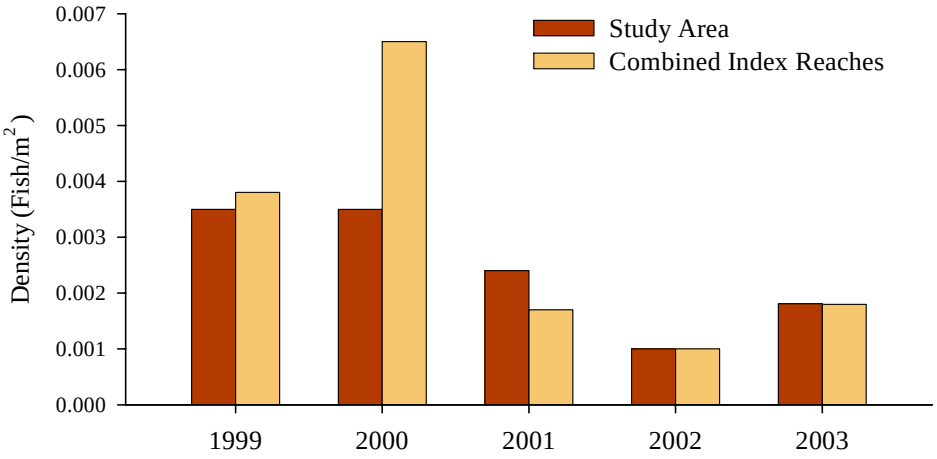

Figure I.8. Relative density of brook trout within the study area and the combined index reaches in the Warm Springs River, 1999-2003.

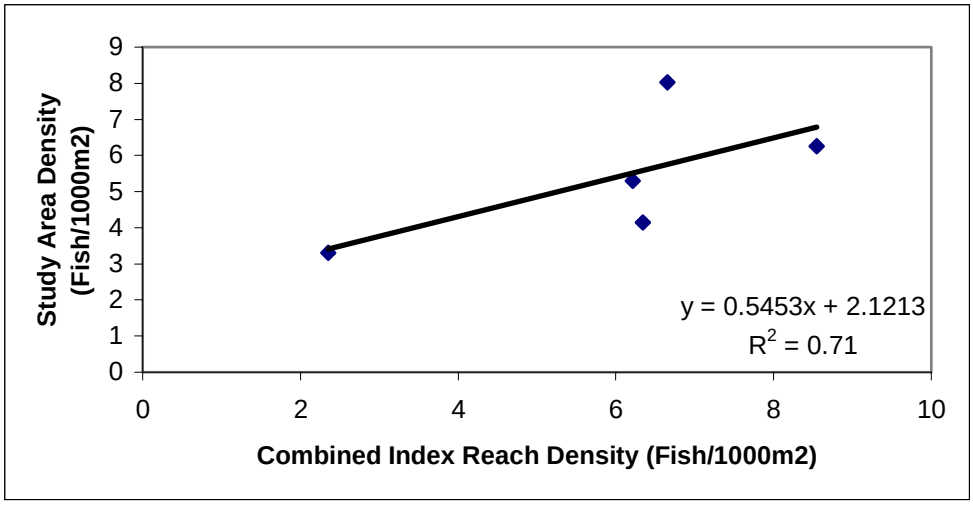

Figure I.9. Relationship between density for combined index reach and density of study area for juvenile bull trout.

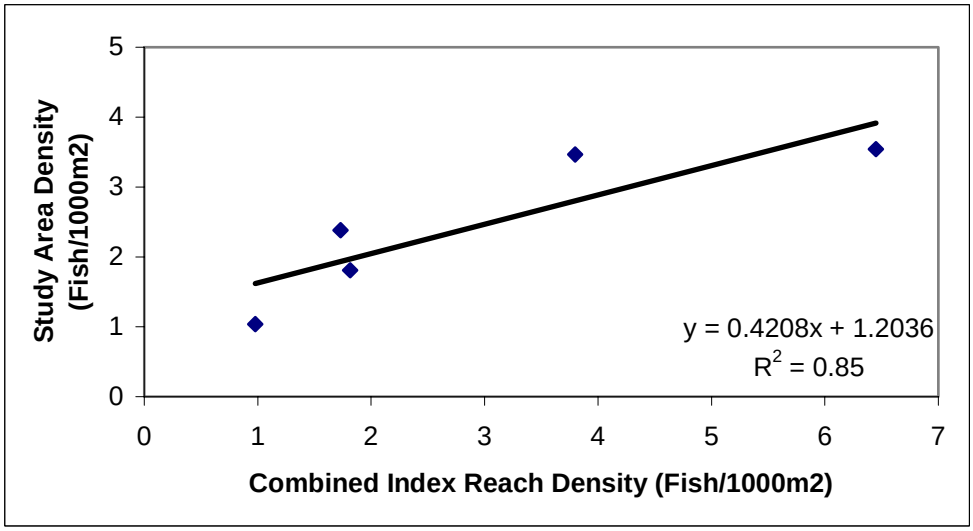

Figure I.10. Relationship between density for combined index reach and density of study area for brook trout.

Shitike Creek

The mean relative densities in the 9 combined index reaches for juvenile bull trout and brook trout were 0.037 fish/m^2 and 0.0093 fish/m^2 during 2003 (Figure I.11).

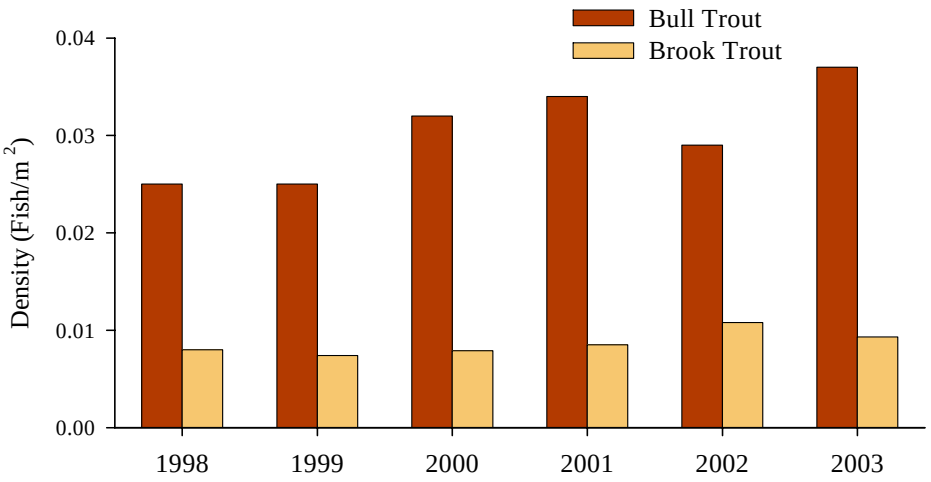

Figure I.11. Mean relative densities of combined index reaches surveyed during 1998-2003 in Shitike Creek.

Juvenile bull trout density during 2003 was the highest observed since surveys began in 1998. The relative density of brook trout declined for the first time since 1999. Brook trout densities have remained fairly constant during the period of study (Range of 0.008 fish/m^2 in 1999 to 0.01 fish/m^2 in 2002).

Nine index reaches were surveyed during 2003. Reach 13 was not surveyed during 1999 and 2002 due to low stream flow. Among the individual index reaches there has been significant annual fluctuations in relative densities of juvenile bull trout and brook trout in Shitike Creek. Of the 9 index reaches surveyed during 2003, seven reaches had increases from 2002 observations in the relative density of juvenile bull trout (Figure I.12). Reaches 9, 10 and 12 had significant increases in juvenile bull trout density.

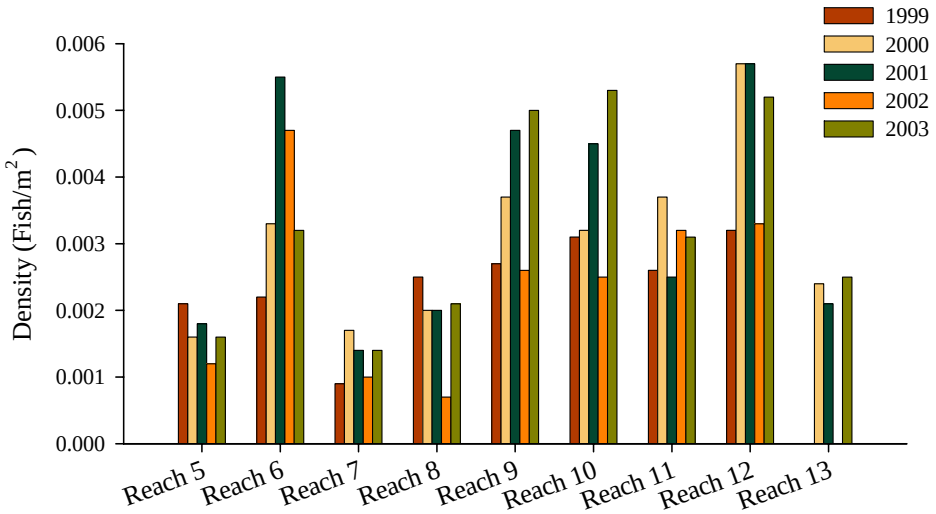

Figure I.12. Relative densities of juvenile bull trout within each index reach in Shitike Creek surveyed during 1999-2003.

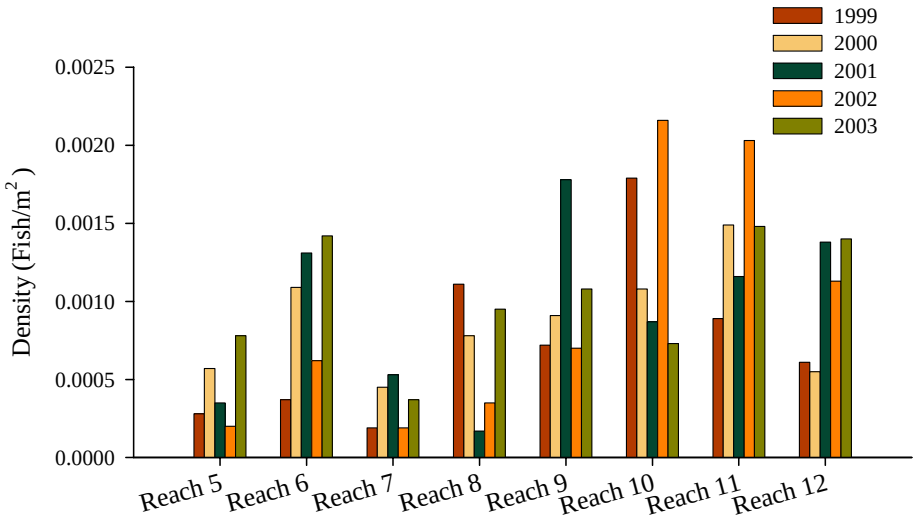

Figure I.13. Relative densities of brook trout within each index reach surveyed in Shitike Creek during 1999-2003.

Of the 8 reaches where brook trout were observed, brook trout densities increased in reaches 5, 6, 7, 8, 9 and 12 but decreased in reaches 10 and 11 from 2002 observations (Figure I.13). The density of brook trout in reach 12 has significantly increased in the last 3 years from the 1999-2000 observations. Though brook trout densities remain low in Shitike Cr. their upstream distribution appears to be expanding.

Section II
Bull Trout Spawning Surveys

Introduction

Bull trout require cold water, complex instream habitat and clean gravel for successful spawning. They spawn during the fall when the availability of cool water is limited in most streams. As a result, there is only a small amount of suitable spawning habitat available in most streams (Fraley and Shepard 1989). Identification and protection of spawning areas is crucial for preservation of this species.

Annual redd counts within index reaches are widely used to monitor trends in bull trout abundance throughout their range (Sanborn et al. 1998). Prior to establishing index reaches, basin-wide spawning surveys should be conducted to locate bull trout spawning areas. The surveys, repeated throughout the spawning period, are necessary to determine the specific locations, timing and duration of spawning. Information obtained from basin-wide 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 within a particular stream.

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). Although Whitewater River is located within the Metolius basin, it is the only tributary of the Metolius River located entirely on the Warm Springs Reservation that supports bull trout spawning and juvenile rearing. We conduct redds surveys in this stream to assist with Metolius basin bull trout monitoring.

The objectives of the bull trout redd surveys were to:

1. Enumerate redds in the Warm Springs River, Shitike Creek and Whitewater River to establish baseline trend data.
2. Determine if there are annual changes in spawning distribution within the Warm Springs River and Shitike Creek.
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 the Warm Springs R. and Shitike Cr. from August through October 2003. Stream reaches that contained suitable spawning habitat were surveyed. Suitable spawning habitat was present in portions of streams containing cold water temperatures during the fall (<12º C), low stream gradient (<3%), gravel/cobble substrate and abundant cover including large woody debris, log jams, pools and undercut banks (Buchanan and Gregory 1997; Fraley and Shepard 1989; Reiser and Bjornn 1979). The entire known spawning habitat was surveyed in the Warm Springs R. and Shitike Cr. The location of the survey reaches was based primarily on access considerations. The locations of the survey reaches are displayed in Appendix C**.**

Redd surveys were conducted on alternate weeks, with 3-5 passes, from late-August through October in Warm Springs R. and Shitike Cr. during the 1998-2003 spawning seasons. The specific timing of each survey varied within the two-week periods among years due to scheduling difficulties. One or two surveyors began at the upstream end of each survey reach and walked downstream in or along side the river channel recording redds. Water temperatures were recorded at the beginning and end of each survey reach. Flagging was placed next to each bull trout redd to avoid double counting during later passes. The presence of live adults and their approximate total lengths (cm) were recorded. Redds were tallied during each survey. After the final pass, redds were summed for each reach within the Warm Springs R. and Shitike Cr. to obtain the total count.

Whitewater R. was not surveyed during 2003 due to poor water visibility resulting from glacial turbidity throughout the spawning season.

Results and Discussion

Redd Enumeration and Distribution

A total of one hundred and three (103) redds were counted in the Warm Springs R. Two hundred and three (203) redds were counted in the three reaches of Shitike Cr. (Table II.1). Due to hazardous conditions resulting from a large forest fire (B&B Complex) in adjacent drainages, the first redd survey pass in reaches II and III in Shitike Cr. did not commence until the second week of September.

Table II.1. Bull trout redd survey reaches and numbers of redds recorded in Warm Springs R. and Shitike Cr. during 2003.

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
Warm Springs R.	I	57.5-52.0	5.5	77	1	41	19	16
Warm Springs R.	II	59.3-57.5	1.8	26	0	3	11	12
Shitike Cr.	I	35.8-31.6	4.2	40	0	1	22	17
Shitike Cr.	II	41.9-38.6	3.3	70	-	12	48	10
Shitike Cr.	III	43.8-41.9	1.9	93	-	24	58	11

Redds enumerated in the Warm Springs R. during 2003 (N=103) were similar to the number of redds observed during 1998 (N=101) and 2000 (N=102) [Figure II.1.]. Redd density (redds/km) in the two reaches of the Warm Springs R. during 2003 was 14.2 redds/km, which was greater than the 1998-2003 average density of 13.1 redds/km (Table II.2). The redd density in reach I decreased from 2002 observations (16.2 redd/km) to 14.0 redds/km in 2003. Redds/km during 2003 in reach I was greater than the 6-year average of 12.8 redds/km. Redd density in reach II increased from 13.3 redds/km during 2002 to 14.4 redds/km in 2003 (Figure II.2).

Table II.2. Bull trout redd densities (redds/km) in the Warm Springs R., 1998-2003.

Survey Reach	1998	1999	2000	2001	2002	2003	Mean
Reach I (Rkm 52.0-57.5)	12.7	12.2	13.6	8.2	16.2	14.0	12.8
Reach II (Rkm 57.5-59.3)	17.2	12.2	15	8.3	13.3	14.4	13.4
Mean	14.95	12.2	14.3	8.25	14.75	14.2	13.1

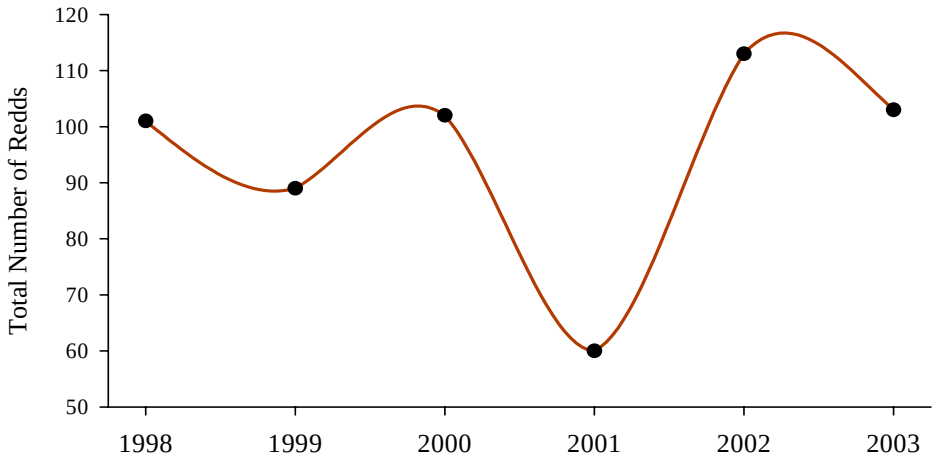

Figure II.1. Total number of redds in the Warm Springs R., 1998-2003.

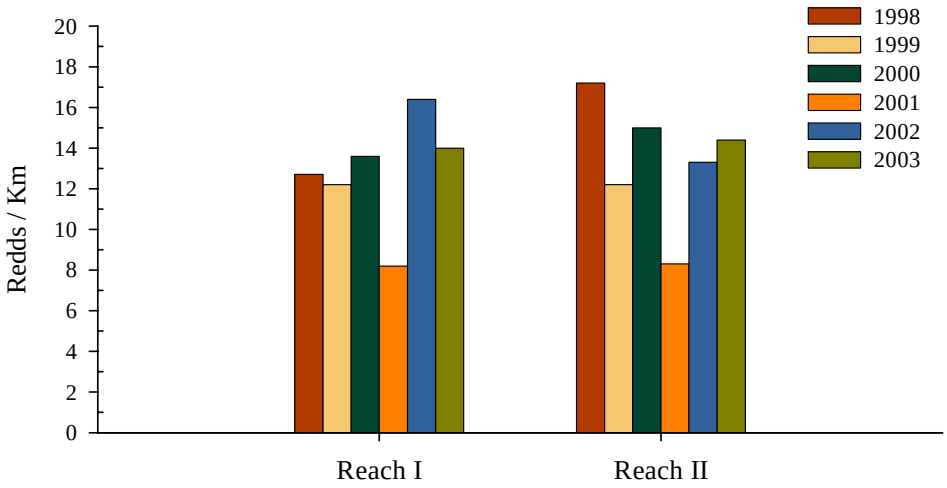

Figure II.2. Redds per kilometer by survey reach (Rkm) in the Warm Springs R., 1998-2003.

A total of two hundred and three (203) redds were enumerated in Shitike Cr. during 2003 (Figure II.3). This was only one redd less than what was counted during 2002. The density increased significantly in reach I (Rkm 31.6-35.8) during 2003 (Figure II.4). The redd density in reach I was 9.5 redds/km during 2003, compared to the 6-year average of 4.85 redds/km. Redd densities in reach II (Rkm 38.6-41.9) and reach III (Rkm 41.9-43.8) were greater than the 1998-2003 average (Table II.3).

Table II.3. Bull trout redd densities (redds/km) in Shitike Cr., 1998-2003.

Survey Reach	1998	1999	2000	2001	2002	2003	Mean
Reach I (Rkm 31.6-35.8)	6.7	4.3	1.2	2.6	4.8	9.5	4.85
Reach II (Rkm 38.6-41.9)	17.6	17.6	15.8	16.7	28.2	21.2	19.5
Reach III (Rkm 41.9-43.8)	12.6	20	14.7	16.3	47.9	48.9	26.7
Mean	12.3	14.0	10.6	11.9	27.0	26.5	17.05

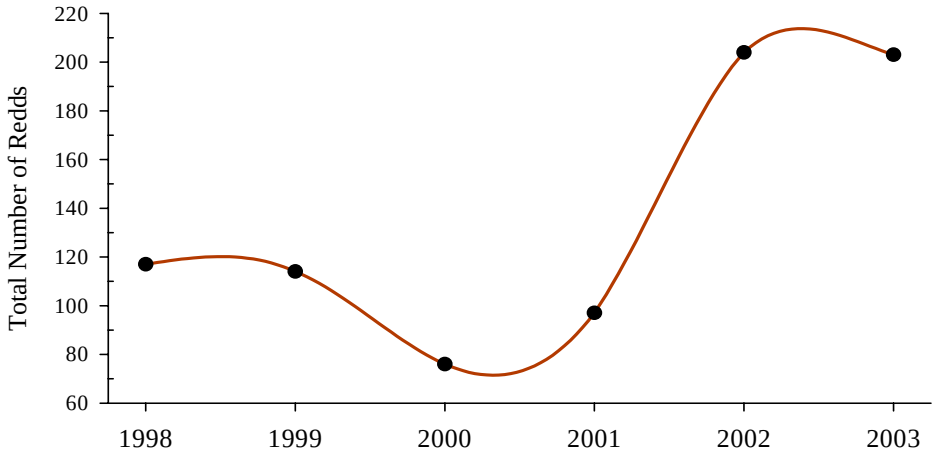

Figure II.3. Total number of redds in Shitike Cr., 1998-2003.

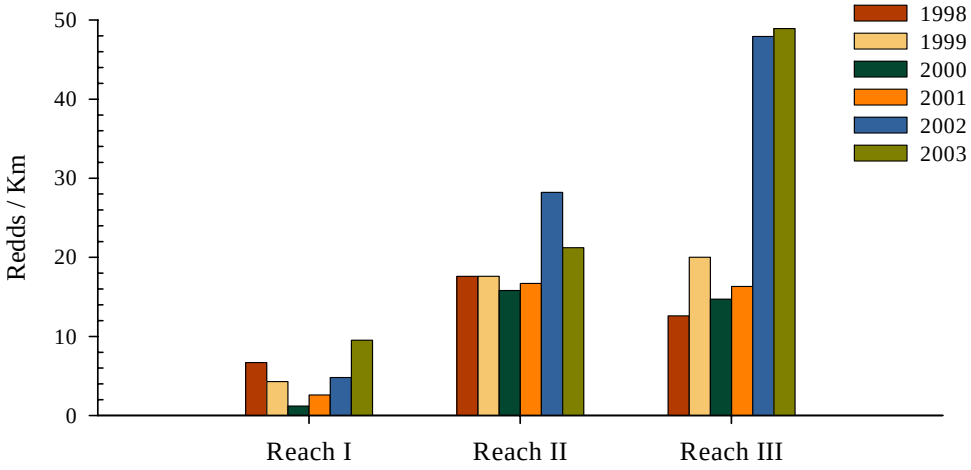

Figure II.4. Redds per kilometer by survey reach (Rkm) in Shitike Cr., 1998-2003.

Spawn Timing and Associated Water Temperatures

The first bull trout redd in the Warm Springs R. was observed in early September when the water temperature averaged 8.9º C. Peak spawning occurred in mid-September when the average water temperature dropped to 8.0º C (Figure II.5). Average water temperatures during peak spawning in 2003 increased from 7º C in 2002. Water temperatures ranged from 6.5-8.9º C during the September and October spawning period

during 2003. These temperatures are higher than what has been observed in previous years.

Spawning in the Warm Springs R. occurred during the same time period as in 2001-2002. However, compared to the spawn timing that occurred in 1999-2000, spawning occurred later during 2001-2003. During 1999-2000, spawning began in late-August in the two reaches of the Warm Springs R. Spawning commenced in early to mid-September during 2001-2003.

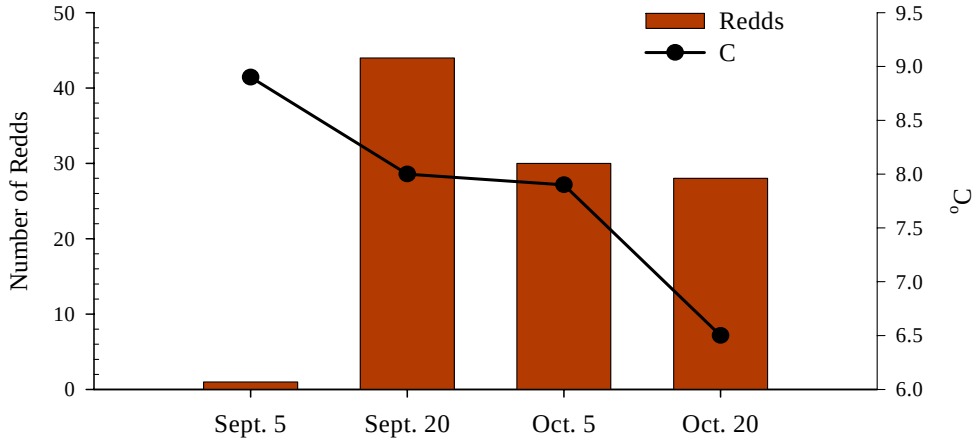

Figure II.5. 2003 Warm Springs R. redd counts and associated average water temperatures.

Spawning in Shitike Cr. was first observed during mid-September when the average water temperatures declined to 7.4º C. Peak spawning also occurred at this same water temperature during early October (Figure II.6). This was similar to previous years' observations. Water temperatures ranged from 6.2-8.4º C during the September and October spawning period.

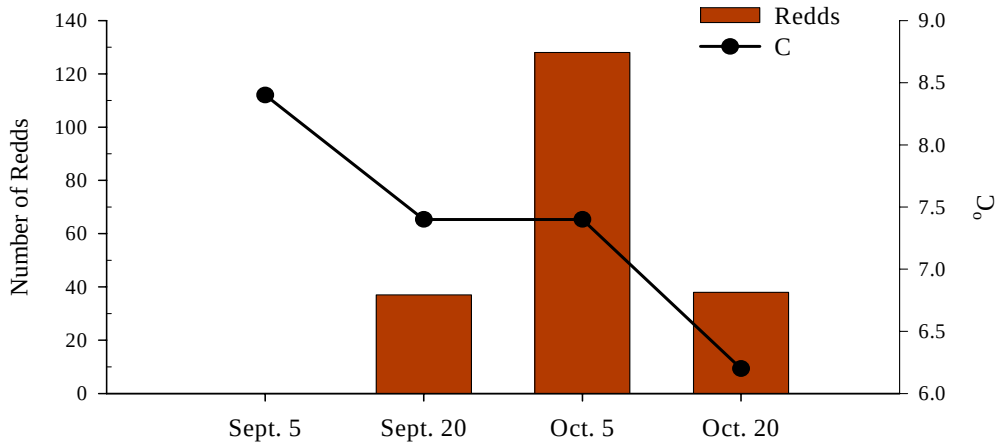

Figure II.6. 2003 Shitike Cr. redd counts and average water temperatures.

Spawning Duration

From 1998-2002, we have observed annual shifts in the timing of peak spawning within the Warm Springs R. It had alternated annually from mid-September to early October. However the timing of peak spawning during 2003 did not shift from 2002 observations (Figure II.7). Peak spawning occurred during mid-September in 2002 and 2003.

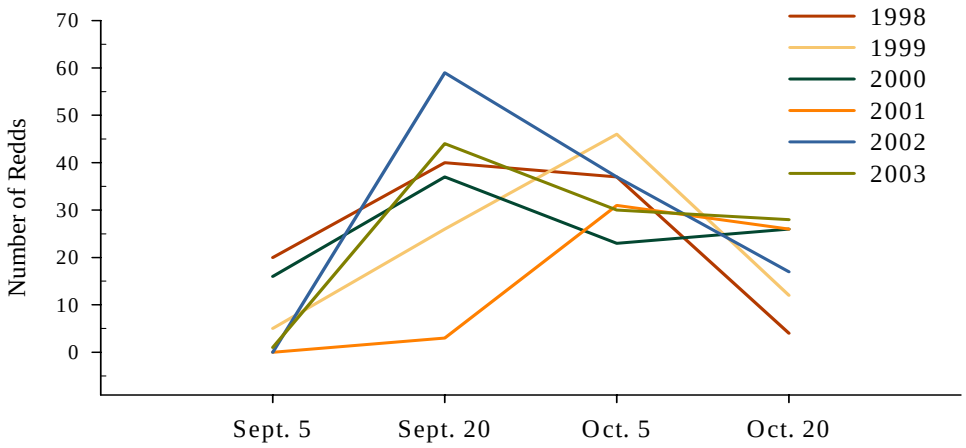

Figure II.7. Peak spawning of bull trout in the Warm Springs River, 1998-2003.

Timing of peak spawning in Shitike Cr. has generally occurred during early October (Figure II.8). The one exception was in 2001 when peak spawning occurred in mid-September. The cause of the 2001 anomaly is unclear. The low stream flows and warm water temperatures recorded during 2001 would lead one to believe spawning would occur later in the fall rather than earlier (Brun and Dodson 2002).

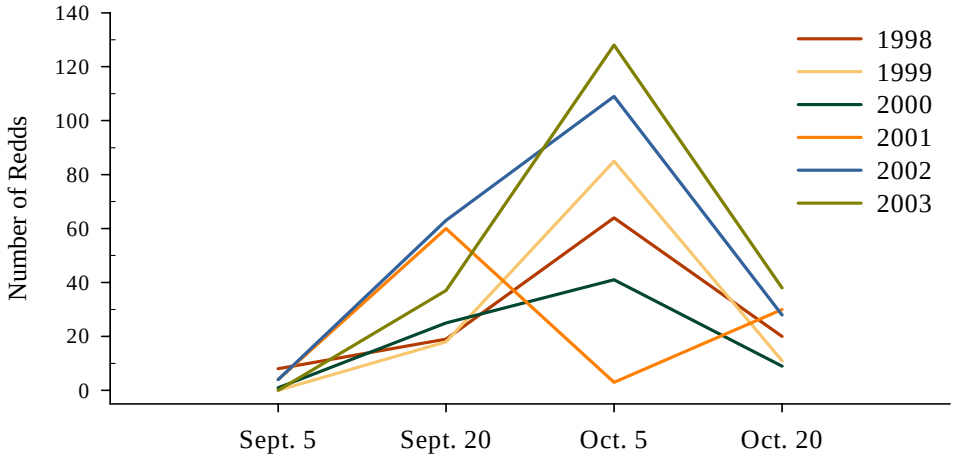

Figure II.8. Peak spawning of bull trout in Shitike Cr., 1998-2003.

Section III
Juvenile and Adult Bull Trout Migrant Monitoring

Introduction

The majority of bull trout in the lower Deschutes basin exhibit a fluvial life history pattern. Adults spawn and juveniles rear near the headwaters of the Warm Springs River and Shitike Creek. Juveniles rear for two to three years in these streams before migrating to the Deschutes River. Adults return to their natal streams to spawn beginning at age IV (Brun and Dodson 2000). The migration timing of juvenile and adult bull trout in the lower Deschutes basin has been monitored since 1995 to determine juvenile emigration and adult immigration timing and escapement. 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 Springs River (Rkm 16) at a weir located at the Warm Springs National Fish Hatchery (WSNFH) since 1995. A weir equipped with an underwater video camera was placed downstream of the bull trout spawning grounds in the Warm Springs River (Rkm 52.0) during 2002. Adult immigration monitoring began in Shitike Creek during 2000 with the installation of a fish weir near the creek's mouth (Rkm 1.4).

Methods

Juvenile Migration

Warm Springs River

During 2002, the humphrey trap was replaced with an eight-foot rotary screw trap and placed upstream (Rkm 1.75) from the original site. The trap was operated from mid-March through mid-June and September through early December, 24 hours/day, Monday through Friday.

Shitike Creek

Juvenile emigration from Shitike Cr. was monitored using a rotary screw trap near the mouth (Rkm 1.4). The trap was operated from mid-March through August and mid-October through mid-December, 24 hours/day, Monday through Friday. All captured bull trout were placed in a solution of 60 mg/l MS-222 and fork lengths recorded. Juvenile bull trout were clipped either on top or bottom caudal fin and released approximately one mile upstream of the trap. Trap efficiency and population estimates for both spring and fall bull trout emigration were estimated. To determine weekly trap efficiency, the number of marked and unmarked bull trout released were divided by the number of marked bull trout recaptured. The weekly estimates were summed and divided by the number of releases to determine the population estimate. In determining a population estimate, the fraction of days sampled (T) was multiplied by trap efficiency (X). This number was then divided by the total number of bull trout captured (C) to

derive a population estimate (n^=X*T/C). River flows and water/air temperatures were recorded on a daily basis.

Adult Migration

Warm Springs River

Adult immigration into the Warm Springs R. at the WSNFH was monitored by U.S. Fish and Wildlife Service personnel from April through September 2003. Adults were enumerated, inspected for tags and fork lengths estimated using video equipment as they ascended a fish ladder around a concrete weir.

The number of redds observed in the spawning grounds and the number of adult bull trout recorded at the WSNFH weir appear to have no correlation (Brun and Dodson 2001). In order to better estimate the number of spawning bull a vertical picket fence weir was located immediately downstream of the spawning grounds (Rkm 52.0) in the Warm Springs R. during early June. Enumeration of adults destined for the spawning ground was conducted with an underwater video camera, attached to a time-lapse VCR. Due to the remoteness of the location, all equipment was solar powered. Every 72 hours, the videotape was replaced, batteries and electronic equipment checked and the weir cleaned of debris. Videotapes were reviewed in the office to collect bull trout data. Adult fish were identified, direction of movement noted and date/time recorded. Water temperatures were continuously recorded with a thermograph. The weir and camera operated from mid-June through early October.

Shitike Creek

A vertical picket fence weir was installed across Shitike Cr. near the mouth (Rkm 1.4) during early March 2003. Two fish boxes with fyke entrances were attached to the weir to capture upstream and downstream migrating adults. The weir was checked twice per day, morning and afternoon. The sex and fork length was recorded from all captured bull trout. River flows were monitored daily and water temperatures were continuously recorded with a thermograph. Weir operation ceased during early July due to low stream flows and warm water temperatures.

Results and Discussion

Juvenile Migration

Warm Springs River

One juvenile bull trout was captured at the rotary screw trap site on the Warm Springs R. during 2003. This was the first bull trout ever captured in a juvenile migrant trap since trapping operations began in 1990. It is unclear why juveniles have not been captured in the juvenile trap in the Warm Springs R. The location of the trap may preclude effective capture. However it may be that juveniles rear to adulthood upstream of the traps. This

may partially explain the discrepancy between the number of adults observed passing the WSNFH and numbers of redds observed in the spawning grounds.

Shitike Creek

A total of 110 juvenile bull trout were captured as they emigrated from Shitike Cr. during 2003 (January-May, October-December). The mean fork length was 140.1 mm (Sd.= 20.3, 95% CI= ±3.91). Sixty-six percent (N=72) left Shitike Cr. during the March and April. During the fall migration (October – December), eighteen percent (N=20) were captured. The mean fork length of bull trout during the spring migration was 137.8 mm (Sd.= 18.9, 95% CI =±4.02). The mean fork length of fall outmigrants was 151.3 mm (Sd.= 23.2, 95% CI=±11.54) [Figure III.1].

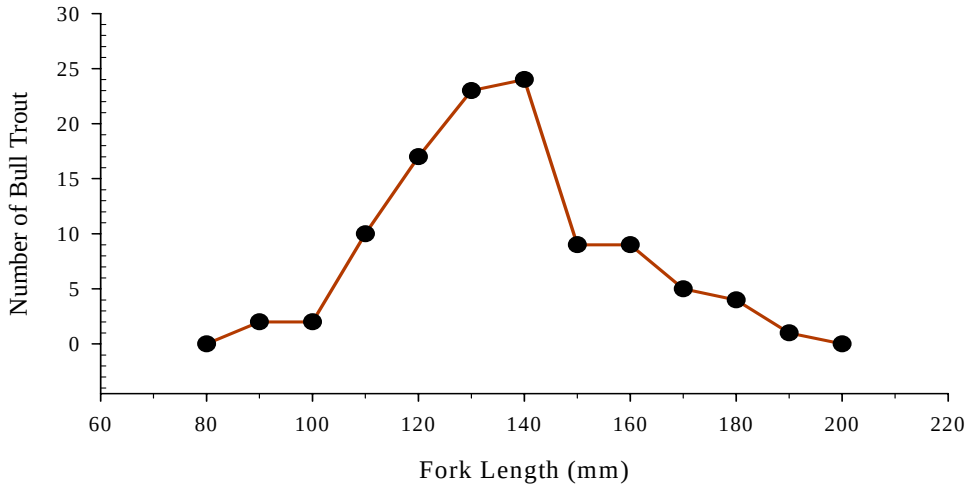

Figure III.1. Length frequency of juvenile bull trout captured at rotary screw trap on Shitike Cr. during 2003.

Age II fish (121-166 mm) accounted for 72% of the combined spring and fall emigration. Age I fish (50-120 mm) and age III (167-296 mm) represented 13% and 11% respectively. Four fish (4%) were tallied and no lengths recorded.

Ninety percent (N=82) of the juvenile bull trout left Shitike Cr. when the temperatures were below 10º C (Figure III.2). The highest water temperature during the spring migration was 13.4º C. Water temperatures were not recorded during the fall emigration period due to technical difficulties.

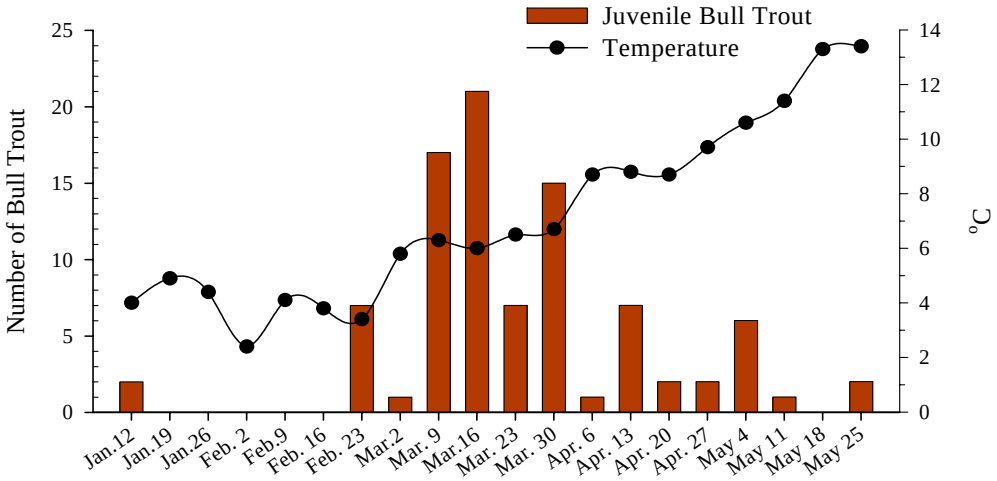

Figure III.2. Weekly number of emigrating juvenile bull trout and the associated 7-day average water temperatures during spring migration, 2003.

A trap efficiency and population estimate was generated for juvenile bull trout during the spring emigration during 2003. The trap efficiency was 32%. The population estimate for spring emigration was 424 fish (Sd. = 1146.35, 95% CI = 1146, -2948). Trap efficiency and population estimate for fall emigration was not determined due to the small sample size.

Adult Immigration

Warm Springs River

Thirty-three adult bull trout were counted as they passed the WSNFH weir during 2003. There has been an increase in the number of adult bull trout passing over the WSNFH weir since 1995 (Figure III.3). The number of adults returning during 2003 was the highest number recorded to date. Immigration occurred from mid-May through early June. Eighty-five percent (N=28) migrated during the month of May. Since 2001, peak immigration has occurred during May (Figure III.4). The mean estimated fork length was 47.2 cm (range 25-71 cm, Sd.= 12.8, 95% CI = $\pm$4.54).

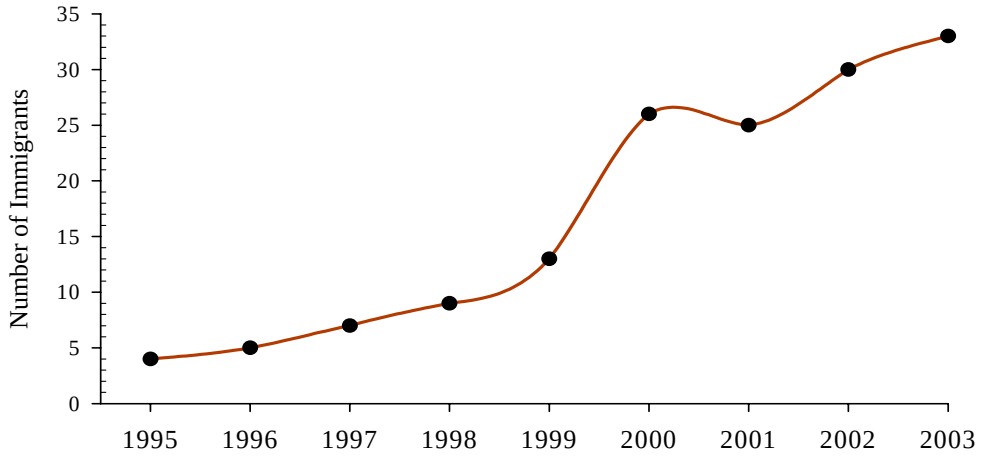

Figure III.3. Number of immigrating adult bull trout counted at the Warm Springs National Fish Hatchery, 1995-2003.

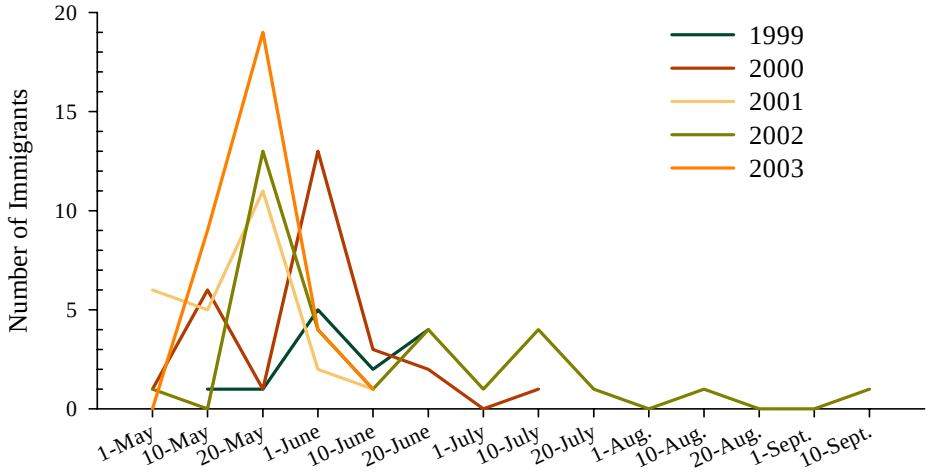

Figure III.4. Immigration timing of adult bull trout at the WSNFH, 1999-2003.

Seven-day average water temperatures recorded in the Warm Springs R. at the WSNFH ranged from 10.7-16.9º C throughout the migration period. Water temperature during peak immigration was 15.3º C (Figure III.5). Water temperatures during the first week of June reached 16.9º C. but declined to 15.0º C by mid-June. Bull trout immigration into the Warm Springs R. was completed by mid-June.

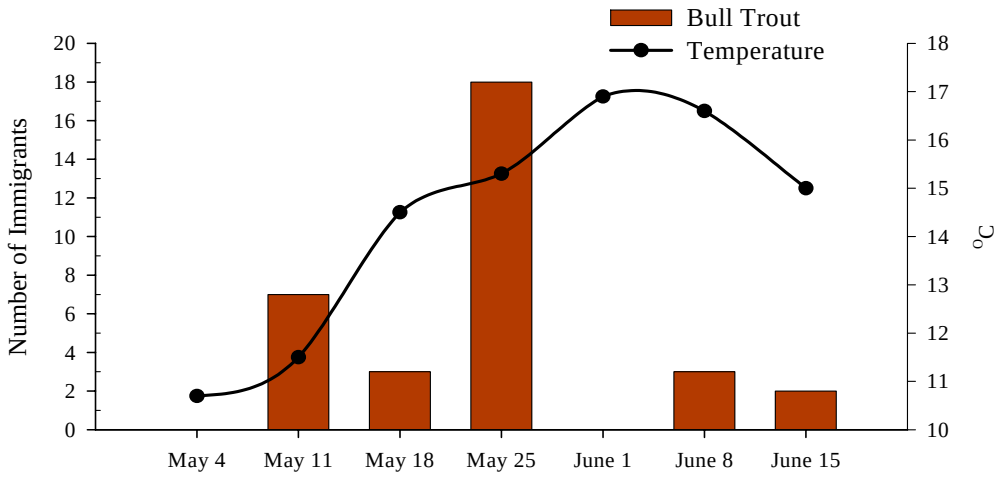

Figure III.5. Water temperatures in the Warm Springs R. at WSNFH during adult bull trout immigration.

A total of 167 adult bull trout were counted passing through the video weir located near the lower bounds of the bull trout spawning grounds in the Warm Springs R. during 2003. Considerable up and downstream movement was observed prior to spawning. A total of 148 adults are believed to have remained upstream of the weir and presumably spawned. Based upon the difference in counts from the two weirs approximately 80% of the adults enumerated in the Warm Springs R. during 2003 did not immigrate from the Deschutes R.

The number of adults recorded entering the spawning grounds was likely underestimated due to mechanical problems that prevented video weir operations from September 6 through September 15. A lightning storm occurred during early September that caused a power surge, which destroyed the photovoltaic controller, causing the system to shut down. The video system resumed operation during mid-September after a new controller was installed.

During 2002 only 34 adults pass through the weir. However lighting difficulties prevented night time movement monitoring. The infrared LED illuminators on the camera did not produce enough light to illuminate the fish box at night during 2002. In 2003 a halogen headlamp was placed inside the fish box. This allowed for sufficient illumination that resulted in a more accurate count of adult bull trout passing through the weir during 2003. Minor modifications will be made to the video system during 2004. A second halogen headlamp will be placed opposite of the first light and both headlamps will use a red lens to reduce reflection of white light. Measurement lines, 10 cm apart, will be marked inside the box to estimate fish length. The black and white video camera will be replaced with a color camera to further aid in identification of fish species.

Shitike Creek

Thirty-one adult bull trout were captured in the Shitike Cr. weir during 2003. All fish were released upstream in good condition after measurement. The sizes of the adults ranged from 31-61 cm (age IV – VII). The mean length was 40.3 cm (age V) [Sd.= 66.8, 95% CI= ±24.5]. Of the 31 adults captured, 7 were female, 23 males and one unknown.

Peak migration occurred in late-June when water temperatures were 16.7º C (Figure III.6). Water temperatures during adult bull trout immigration ranged from 13.2-19.2º C. Temperatures during peak migration during 2003 were 1.3-5.7º C warmer than water temperatures observed during 2000-2001. On July 10, 2003 weir operation ceased due to increasing water temperatures and low stream flow.

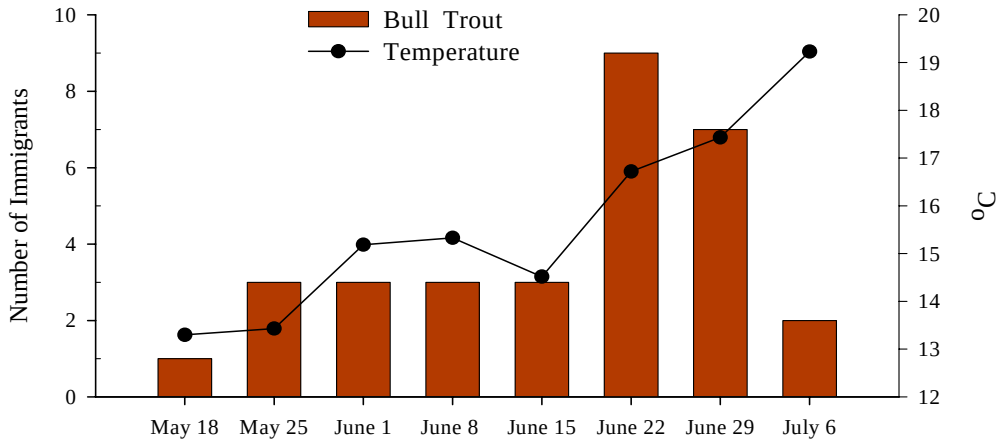

Figure III.6. Weekly number of immigrating adult bull trout captured in the Shitike Cr. weir and associated 7-day average water temperatures during 2003.

During 2000 and 2001 peak immigration by adult bull trout occurred in mid-June (Figure III.7). The weir was not operated successfully during 2002. A spring high water event significantly damaged the weir and altered the stream channel morphology at the trapping site. The weir was re-located downstream approximate 0.5 km downstream from its previous location in 2003. During 2003 peak immigration occurred during early July.

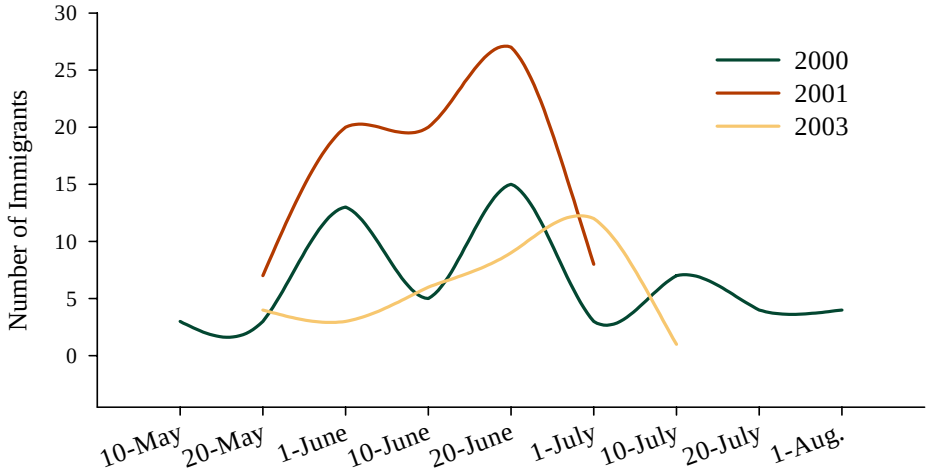

Figure III.7. Immigration timing of adult bull trout at the Shitike Cr. weir, 2000-2001 and 2003.

Modifications to the Shitike Cr. weir will be made during the 2004 field season to improve passage for bull trout. During 2003 and past years, high water temperatures have prevented trapping throughout the entire emigration period. This has resulted in an incomplete census of spawning escapement. The USFWS, through separate project funding, will install an underwater video camera at the weir during spring, 2004. This will allow for enumeration of adults when live trapping is not feasible.

Section IV
Stream Temperature Monitoring in Bull Trout Habitat in the Warm Springs River and Shitike Creek

Introduction

Bull trout require cold water for a significant portion of their lives. Water temperatures have limited bull trout distribution within some drainages (Reiman and McIntyre 1993; Fraley and Shepard 1989; Howell and Buchanan 1992). They require cold water for spawning and juvenile rearing. Juveniles are largely absent in streams with water temperatures exceeding 15º C. Adults commence spawning when water temperatures decline below 10º C. However little is known about adult temperature tolerances during migration and pre-spawning holding periods (Buchanan and Gregory 1997; Shepard et al. 1984; Goetz 1989). Tribal, federal and state agencies have promulgated rules designed to protect water temperatures in streams containing bull trout and other salmonids. However these temperature standards have not been evaluated as to their effectiveness for protecting bull trout in the lower Deschutes River. Our objective is to conduct long term water temperature monitoring in Shitike Creek and Warm Springs River to determine the annual range of water temperatures associated with tributary entry; migration and holding; and spawning. Temperature monitoring began during 1999 and is ongoing. The results will be used to evaluate the effectiveness of using water temperature standards to

protect bull trout habitat and to further refine bull trout temperature requirements by life-history stages.

Methods

A total of 16 calibrated, continuously recording thermographs (Onset Computer Corporation, StowAway™ and HoboTemps™) were located throughout Shitike Cr. and Warm Springs R. to record stream temperatures from spring through late fall. Thermographs were placed near the river mouths' to record hourly temperatures associated with immigration into each stream; within the migratory/holding corridors; and in the spawning grounds (Table IV.1 and IV.2) [Brun 1999, Brun and Dodson 2000]. Thermographs were deployed during April, prior to bull trout immigration and retrieved during late September through early November 2003, after the cessation of spawning. The data was summarized using Eel River Water Temperature Analysis Program V.97.8^{C}.

For analysis, the data from individual thermographs were grouped by life history use i.e. migration, pre-spawn holding and spawning/rearing areas within each stream. The data was averaged to obtain a single daily maximum and 7-day average maximum temperature (ºC) for each stratum during the time period that adult bull trout occupied each area. The dates from which water temperature data was used in the analysis for each stream reach are displayed in Table IV.3.

Table IV.1. Location of data loggers and duration of water temperature monitoring in Warm Springs R. during 2003.

	Location	Rkm	Deployment Date	Recovery Date
Immigration	Mouth	0.4	17-April	7-Oct.
	Hatchery	14.0	16-April	7-Oct.
Holding	Powerline	41.8	22-April	7-Oct.
	Hehe-Schoolie	55.5	16-April	7-Oct.
Spawning/Rearing	Meadows	62.8	27-May	7-Oct.
	W240 Bridge	68.1	16-April	17-Aug.*

*- Thermograph was recovered in early-October, but a malfunction caused the thermograph to cease recording on August 17, 2003.

Table IV.2. Location and duration of temperature data loggers in Shitike Cr. during 2003

	Location	Rkm	Deployment Date	Recovery Date
Immigration	Weir	1.4	16-April	9-Oct.
Holding	Bennets	14.0	27-May	6-Oct.
	Powerline	23.0	22-April	30-Sept.
Spawning/Rearing	Peters Pasture	38.1	17-April	30-Sept.
	Upper	43.5	18-April	5-Nov.

Table IV.3. The time periods used for water temperature data analysis for immigration, holding and spawning/rearing in Shitike Cr. and Warm Springs R. during 2003.

	Shitike Creek	Warm Springs River
Immigration	May 1 to July 15	May 1 to September 1
Holding	May 1 to September 1	May 1 to September 1
Spawning/Rearing	September 1 to October 31	September 1 to October 31

Results

Warm Springs River

Water temperatures near the mouth (Rkm 0.4) and WSNFH (Rkm 16.0) averaged 19.8º C (range 10.7-24.6º C) during adult bull trout immigration (May 1 – September 1) [Figure IV.1). The average water temperatures in the Warm Springs River canyon (Rkm 16.0 – 52.0) during the May to September holding period was 13.4º C (range 9.0-15.7º C). During the spawning period the average water temperature was 9.5º C (range 8.7-10.2º C) between Rkm 52.0 – 63.0.

Water temperatures in the Warm Springs R. have remained relatively consistent during holding and spawning, 1999-2003. The 7-day average of the daily maximum (7 DADM) mean water temperatures during immigration has had the highest variation since 1999 (Table IV.4). There was an increase of 2.2º C in 7 DADM during 2003 in the spawning grounds (Figure IV.2). Although the Warm Springs R. is a spring-fed system, there was an obvious decrease in water level in the spawning grounds. The lower stream flows observed during 2003 likely were the result of an extremely dry preceding winter. Temperatures in the holding corridor (Warm Springs R. canyon) have remained similar as one would expect in a spring-fed system. The Warm Springs R. canyon is below the meadow area, where a large number of springs feed into the system helping to maintain the water temperature.

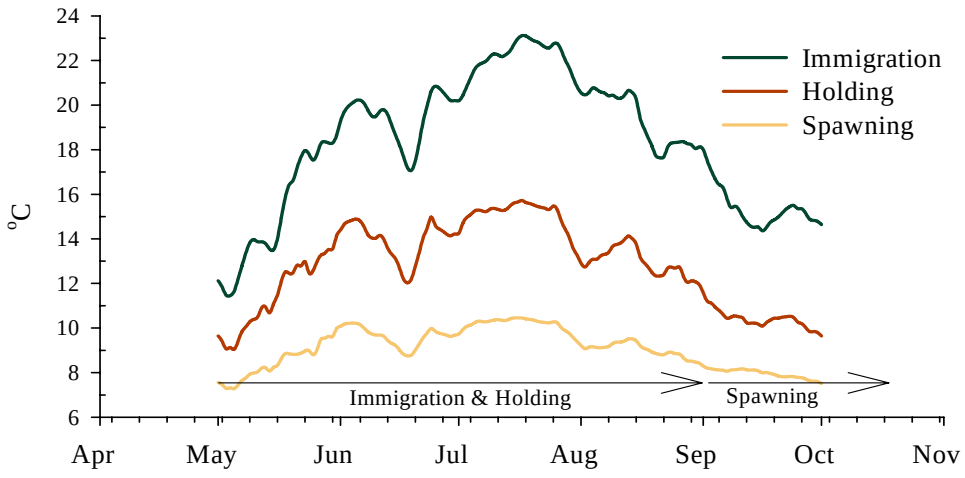

Figure IV.1. 7 DADM (7-day Average of Daily Maximum) water temperatures during 2003 in Warm Springs R. The arrows represent the time period adult bull trout were immigrating, holding and spawning.

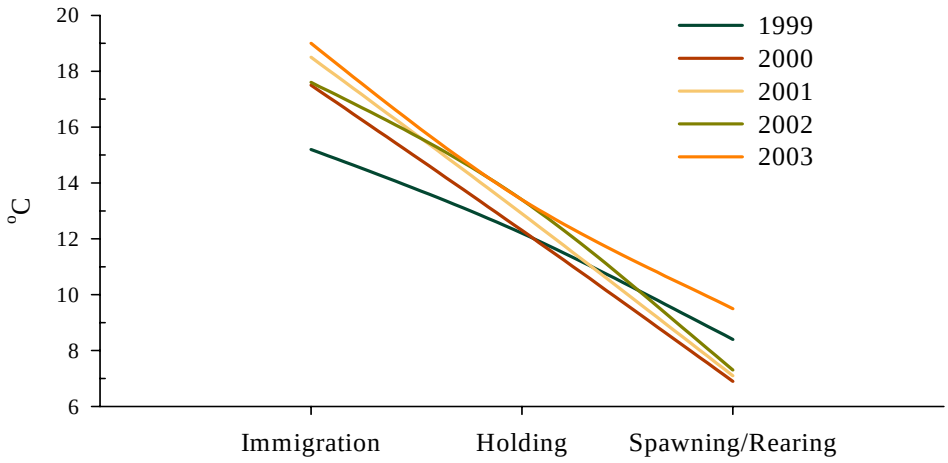

Figure IV.2. 7 DADM mean water temperatures in Warm Springs R., when adult bull trout entered the stream through spawning, 1999-2003.

The 7 DADM water temperature fluctuations during immigration, holding and spawning/rearing time periods within the Warm Springs R. during 1999-2003 are displayed in Table IV.4.

Table IV.4. 7 DADM water temperatures in the Warm Springs R. during seasonal immigration, holding and spawning/rearing (May – November), 1999-2003.

		Immigration	Holding	Spawning
1999	Mean	15.2	12.2	8.4
	Min.	9.2	8.4	6.7
	Max.	19.4	15.0	9.4
	Std. Dev.	2.91	1.86	0.82
	Variance	8.44	3.46	0.67
2000	Mean	17.5	12.3	6.9
	Min.	11.0	8.3	6.1
	Max.	20.9	14.2	7.5
	Std. Dev.	2.32	1.61	0.41
	Variance	5.39	2.59	0.17
2001	Mean	18.5	12.9	7.1
	Min.	12.4	10.6	6.1
	Max.	21.8	14.9	8.3
	Std. Dev.	2.16	1.07	0.78
	Variance	4.66	1.14	0.61
2002	Mean	17.6	13.4	7.3
	Min.	10.5	8.6	6.4
	Max.	22.0	16.4	8.0
	Std. Dev.	3.14	2.06	0.46
	Variance	9.84	4.22	0.21
2003	Mean	19.0	13.4	9.5
	Min.	10.7	9.0	8.7
	Max.	24.6	15.7	10.2
	Std. Dev.	3.19	1.66	0.34
	Variance	10.21	2.77	0.12

Shitike Creek

Figure IV.3 displays the water temperatures recorded in Shitike Cr. during adult bull trout immigration through spawning during 2003. The mean water temperature recorded during bull trout immigration into Shitike Cr. was 19.8º C (range 12.2-25.9º C). Within the mid-portion of Shitike Cr. (Rkm 14.0-17.7), used by adults for holding during June through August, the mean water temperature was 14.6º C (range 7.9-20.4º C). The mean water temperature recorded in the spawning grounds (Rkm 30.0-45.0) was 7.9º C (range 3.7-10.1º C) during the September through October spawning period.

Seven-day average of the daily maximum (7 DADM) mean water temperatures in Shitike Cr. during 2003 were similar to those temperatures observed in 2001 (Figure IV.4). Mean water temperatures near the mouth of Shitike Cr. were 1.7-6.0º C warmer than recorded during 1999-2002. In the holding areas during adult staging period were 0.0-3.2º C warmer than 1999-2002. In the spawning grounds, the average water temperature during 2003 increased by 1.2º C from observed temperatures during 2002, but was

similar to temperatures recorded during 2001. The 7 DADM water temperature fluctuations during immigration, holding and spawning/rearing within Shitike Cr. are displayed in Table IV.5 during 1999-2003.

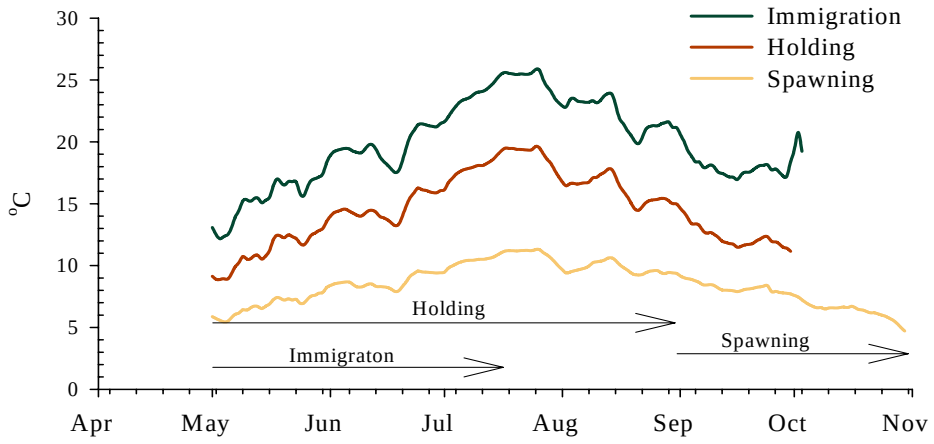

Figure IV.3. 7 DADM (7-day Average of Daily Maximum) water temperatures during Shitike Cr. The arrows represent the time period adult bull trout were immigrating, holding and spawning.

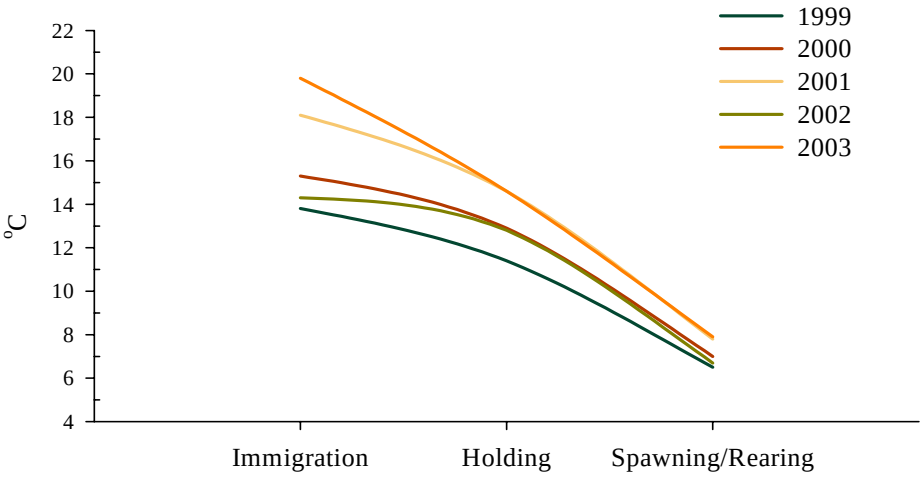

Figure IV.4. 7 DADM mean water temperatures in Shitike Cr. when adult bull trout entered the stream through spawning period, 1999-2003.

Table IV.5. 7 DADM water temperatures in Shitike Cr. during seasonal immigration, holding and spawning/rearing (May-November), 1999-2003.

		Immigration	Holding	Spawning
1999	Mean	13.8	11.4	6.5
	Min.	10.5	7.8	4.6
	Max.	17.4	18.5	7.8
	Std. Dev.	1.93	2.55	1.06
	Variance	3.74	6.51	1.13
2000	Mean	15.3	12.9	7.0
	Min.	11.9	7.8	5.3
	Max.	19.4	16.9	9.2
	Std. Dev.	2.10	2.52	1.21
	Variance	4.43	6.33	1.47
2001	Mean	18.1	14.6	7.8
	Min.	13.1	9.1	5.5
	Max.	23.7	18.5	9.8
	Std. Dev.	2.81	2.55	1.33
	Variance	7.92	6.51	1.78
2002	Mean	14.3	12.8	6.7
	Min.	10.9	8.3	2.1
	Max.	18.2	16.3	9.0
	Std. Dev.	1.91	2.25	7.75
	Variance	3.67	5.07	3.06
2003	Mean	19.8	14.6	7.9
	Min.	12.2	7.9	3.7
	Max.	25.9	20.4	10.1
	Std. Dev.	3.92	3.01	1.28
	Variance	15.4	9.06	1.63

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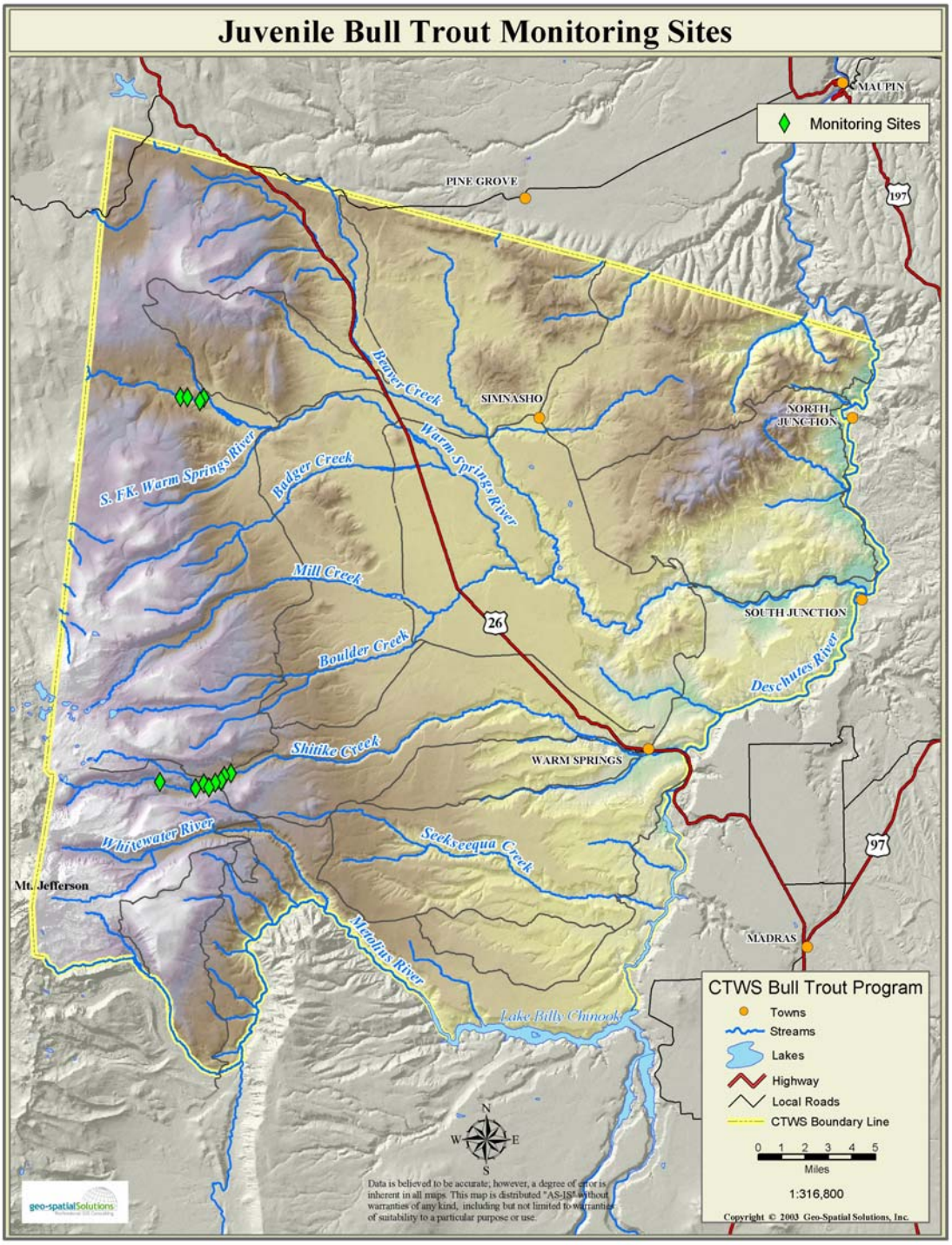
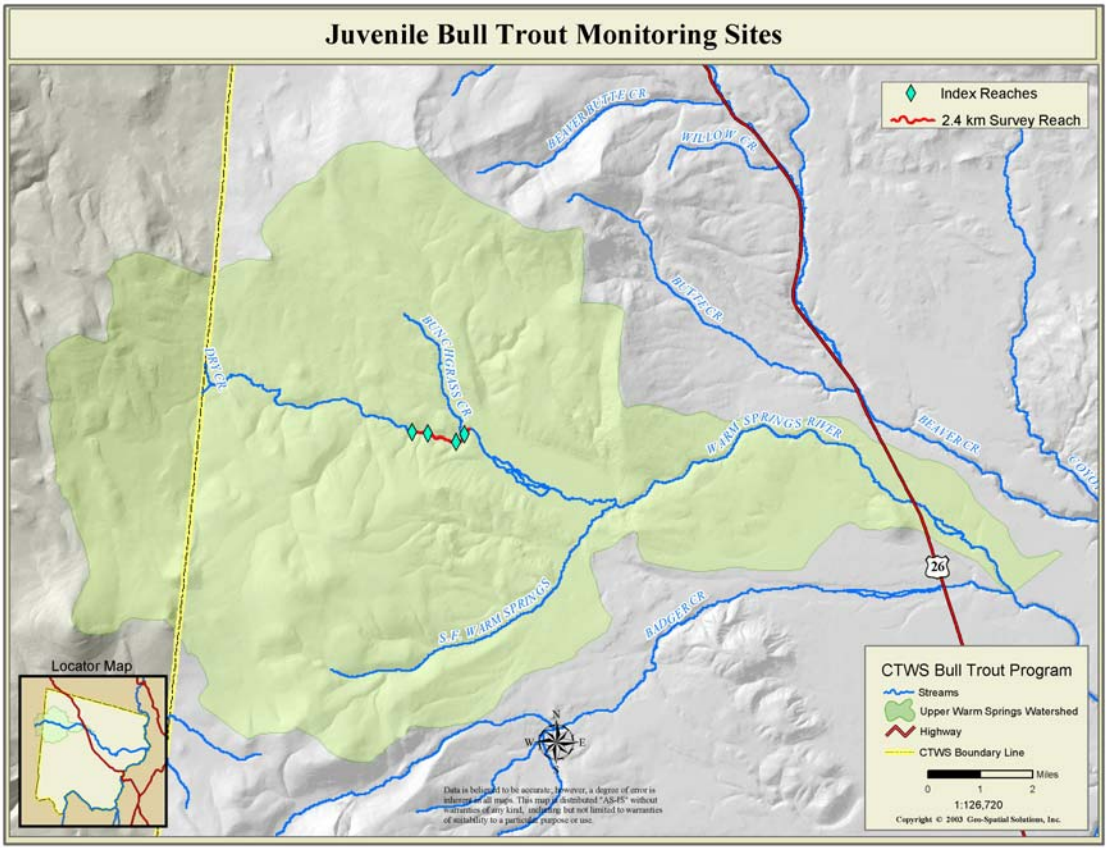
Appendix A. Juvenile bull trout survey locations in the Warm Springs R. and Shitike Cr.



Appendix B. Four index reach and 2.4 km study area location in the Warm Springs R.



Appendix C. Bull trout spawning survey index reaches.