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

2001 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 fourth year (2001) of the 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 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 were the lowest observed since surveys began in 1999. Relative densities of juvenile bull trout and brook trout increased in Shitike Cr. Juvenile bull trout vastly out numbered brook trout in Shitike Cr.

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 third year. Mean relative densities of juvenile bull trout within the index reaches was slightly higher than what was observed in the 2.4 km control reach. However, the mean relative density of brook trout in the 2.4 km control reach was slightly higher than what was observed in within the index reaches.

Habitat use by both juvenile bull trout and brook trout was determined in the Warm Springs R. Juvenile bull trout and brook trout occupied pools more frequently than glides, riffles and rapids. However, pools accounted for only a small percentage of the total habitat.

Multiple pass spawning ground surveys were conducted during late August through October in the Warm Springs R. and Shitike Cr. The number of redds enumerated in the Warm Springs R. declined substantially from 1998-2000 observations. Total redds recorded in Shitike Cr. was higher than 2000, but fewer than observed in 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 emigrants was the highest recorded since 1996. 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 second highest recorded since 1995. An adult trap was successfully operated in Shitike Cr. Eighty adult bull trout were enumerated during 2001.

Thermographs were placed throughout Warm Springs R. and Shitike Cr. to monitor water temperatures during bull trout migration, holding and spawning/rearing periods. During 1999-2001 water temperatures ranged from 11.8-15.4^{o}C near the mouths during adult migration; 10.3-13.1 ^{o}C during pre-spawning holding; and 6.2-6.9 ^{o}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 Relative Abundance Monitoring

Introduction

Bull trout require complex stream habitat and cold-water temperatures (<15º C) during the juvenile life stage (Dambacher and Jones 1997; Fraley and Shepard 1989; Ratliff 1992; Reiman and McIntyre 1992). 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 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 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 is good to the majority of juvenile rearing habitat. 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 (age I – III) and brook trout in the study area.
2.) Determine habitat unit use by both species.
3.) Collect data to assess the utility of using linear "index" reaches for monitoring trends in juvenile bull trout and brook trout relative abundance by comparing night snorkel total counts in a 2.4 km. reach of the Warm Springs River to 4 "index" reaches.

In Shitike Creek the objective was 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 meters 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 18.5% 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 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 July 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 >300 mm total length). These lengths correspond to juvenile (ages I & II), sub-adult (ages III & IV) and adult (age 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

In Shitike Creek nine index reaches, established during 1998, were re-surveyed during 1999-2001 (Brun, 1999; Brun and Dodson, 2000). The reaches were randomly located within1 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 the 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 the methods described above.

Results and Discussion

Warm Springs River

Relative Abundance

In the Warm Springs River two-thirds of the known juvenile bull trout summer distribution (2.4 km.) was surveyed (refer to Appendix A). A total of 101 juvenile bull trout and 62 brook trout were counted between Rkm 56.9-59.3 during 2001. The relative densities for the entire survey reach were .0041 juvenile bull trout/m^2 and .0025 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 in the Warm Springs R. from 1999-2001. The lowest juvenile

bull trout density recorded since surveys began in 1999 occurred during 2001 (.0041 fish/m^2). The relative density of brook trout decreased as well to .0025 fish/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 the Warm Springs River relative to other standard techniques (Thurow and Schill 1996).

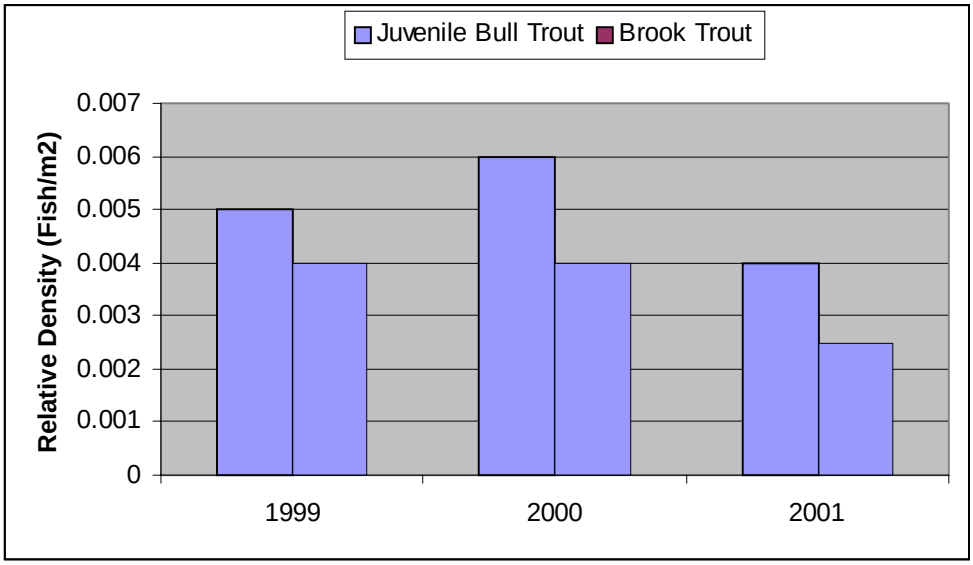

Figure I.1. Relative density of juvenile bull trout and brook trout in the 2.4 km. survey reach in the Warm Springs R., 1999-2001.

Habitat Use

Figure I.2 displays the relative density of juvenile bull trout and brook trout within the various habitat types. Pools were most widely used by juvenile bull trout and brook trout. However, pools accounted for only 9% of the total habitat within the survey area. This suggests that preferred juvenile rearing habitat is limited and there may be competition for space within pools between juvenile bull trout and brook trout in the Warm Springs River.

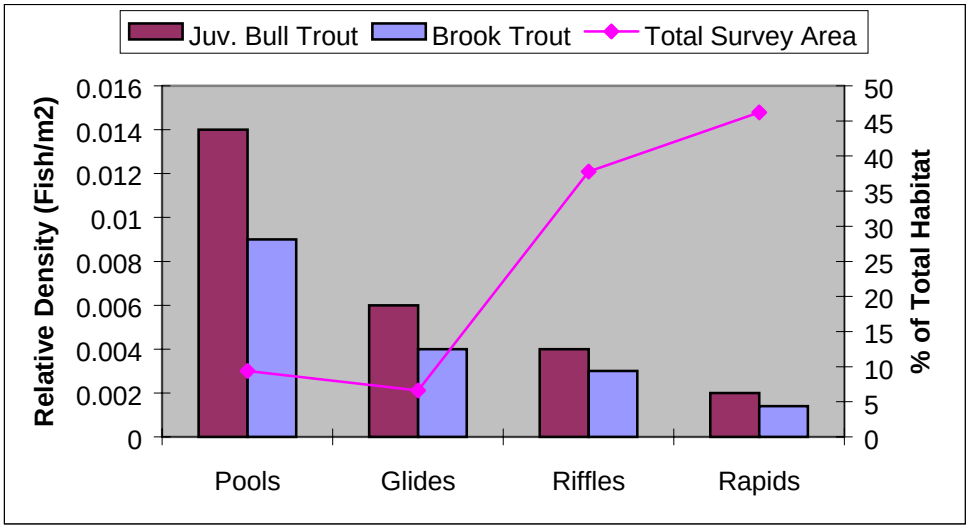

Figure I.2. Juvenile bull trout and brook trout relative densities by habitat type and percentage of each habitat type in the Warm Springs R.

Pool and glide habitat decreased during 2001 compared with 1999 (habitat measurements were not recorded during 2000). This may have been due to abnormally low summer stream flows. During 1999 pools and glides accounted for 19.3% of total habitat within the 2.4 km. reach. This decreased to 16.0% during 2001. Riffles increased by 4% in 2001 and rapids remained the same during 1999 and 2001. With a decrease in pool area, there was an increase in relative abundance of bull trout in this particular habitat, 0.014 fish/m^2 in 2001 compared with .011 fish/m^2 in 1999 (Figure I.3). Brook trout relative abundance decreased from .013 fish/m^2 in 1999 to .009 fish/m^2 during 2001 in the pool habitat. Additionally the relative density for brook trout decreased in each habitat type during 2001.

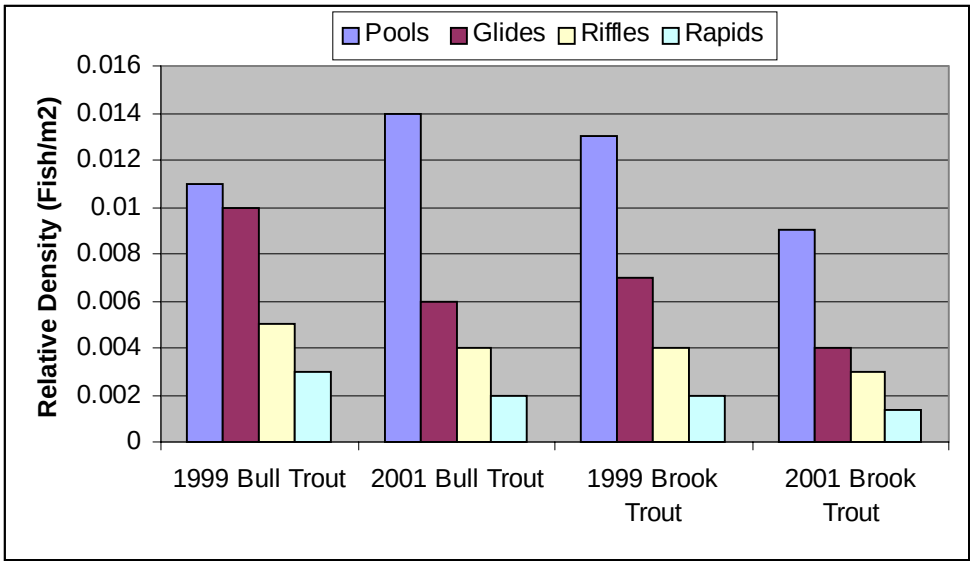

Figure I.3. Comparison of 1999 and 2001 juvenile bull trout and brook trout relative abundance in the four types of habitats in the Warm Springs River.

Index Reach Comparison

As in previous years there was considerable variance in the relative densities of juvenile bull trout among the individual index reaches (Table I.1). However the mean relative density from the combined index reaches has consistently been higher than the relative abundance of juvenile bull trout in the total survey area. The same was true for brook trout relative densities during 1999-2000 (Table I.2). However, the mean relative abundance of brook trout from the combined index reaches was less than recorded in the total survey area during 2001 (Figures I.4 and I.5).

Table I.1. Summary statistics for juvenile bull trout relative densities observed in individual index reaches in the Warm Springs River, 1999-2001.

	Fish/m^2 in Individual Index Reaches				**Fish/m^2 Total Survey Area**	**Summary Statistics for Index Reaches**		
	12	**13**	**14**	**15**		**Mean**	**Var.**	**SD.**
1999	.006	.007	.003	.013	.005	.007	.000018	.0042
2000	.011	.012	.005	.013	.006	.010	.000013	.0036
2001	.009	.005	.002	.011	.004	.007	.000016	.0040

Table I.2. Summary statistics for brook trout relative densities observed in individual index reaches in the Warm Springs River, 1999-2001.

	Fish/m^2 in Individual Index Reaches				**Fish/m^2 Total Survey Area**	**Summary Statistics for Index Reaches**		
	12	**13**	**14**	**15**		**Mean**	**Var.**	**SD.**
1999	.003	.003	.008	.005	.004	.0045	.000007	.0026
2000	.012	0	.007	.004	.004	.0058	.000026	.0051
2001	.0015	0	.002	.005	.0025	.0068	.000016	.0040

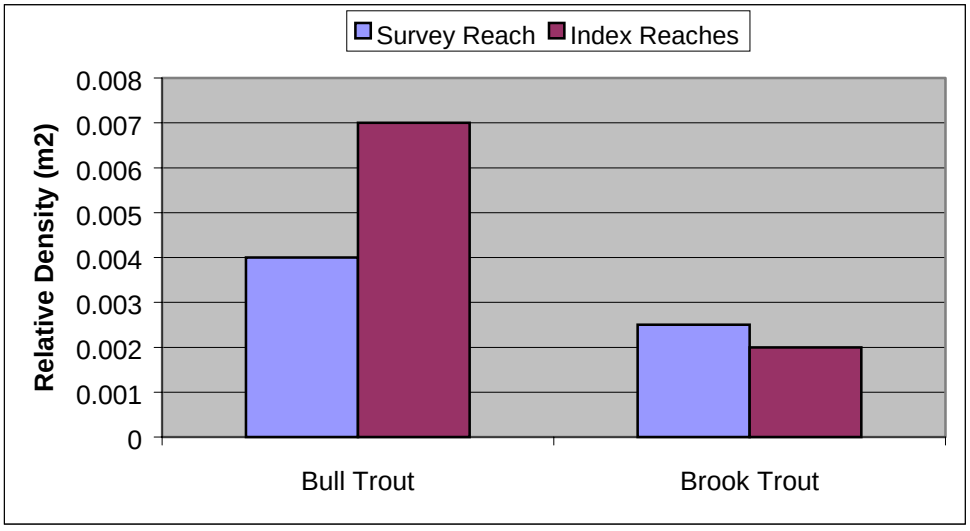

Figure I.4 Relative densities of juvenile bull trout and brook trout in the 2.4 km survey reach in the Warm Springs R. compared to the mean of the combined index reaches during 2001.

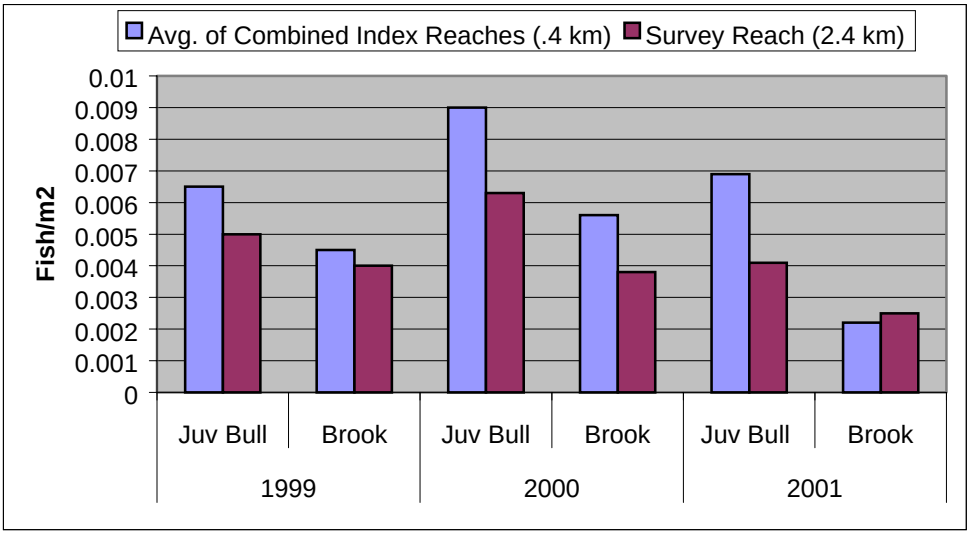

Figure I.5. Relative densities of juvenile bull trout and brook trout within the study area and index reaches in the Warm Springs R. 1999-2001.

From 1999-2001 the mean relative densities within the four combined index reaches has been greater than the relative densities observed within the 2.4 km survey area (Figure I.5). The use of index reaches to monitor trends in relative abundance appears to be slightly overestimating the number of juvenile bull trout present within the Warm Springs R. study area by an average of .002 fish/m^2. This is the difference in the mean relative densities of the combined index reaches and the total survey area for the 1999-2001 survey years combined. The relative brook trout abundance in the combined index reaches has been remarkably similar between the index reaches and the total survey area. The average overestimate of brook trout within the combined index reaches to the total survey area was .0001 fish/m^2 for the 1999-2001 survey years.

Figure I.6 displays the percentage of habitat types within the four index reaches in the Warm Springs River during 2001. Thirty-one juvenile bull trout and 10 brook trout were observed in these index reaches. Seventy-seven percent (N=24) of the juvenile bull trout were observed in the pool habitats. The remaining 23% (N=7) were observed in the riffle habitat. All brook trout (N=10) were observed in pool habitat. No juvenile bull trout or brook trout were observed within rapids in any of the index reaches. Additionally no juvenile bull trout were observed in glide habitat although this habitat type was under represented within the index reaches.

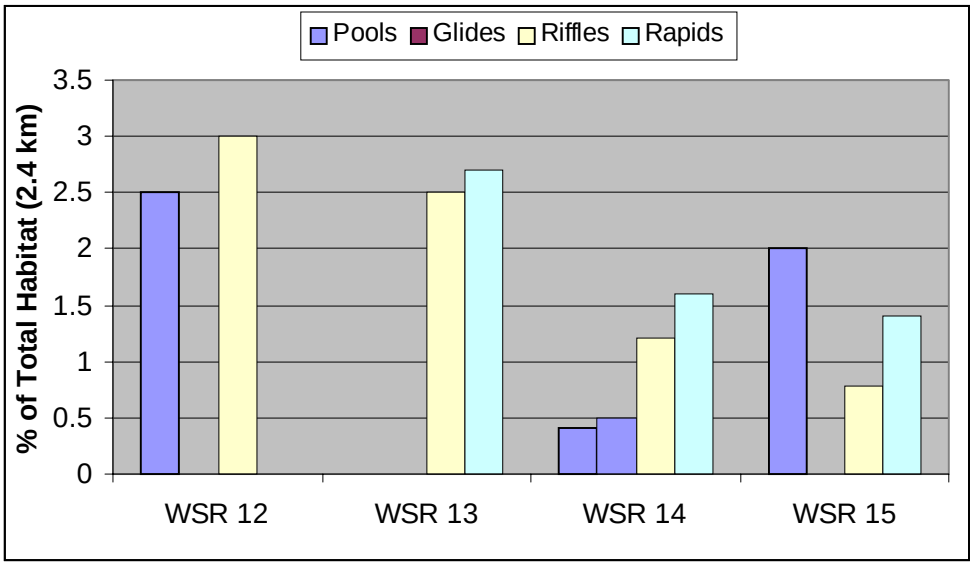

Figure I.6. Percentage of habitat types within the four index reaches in the Warm Springs R., compared to total habitat (2.4 km).

Shitike Creek

The mean relative densities in the combined reaches for juvenile bull trout and brook trout were .034 and .0094 fish/m^2 respectively (Figure I.7).

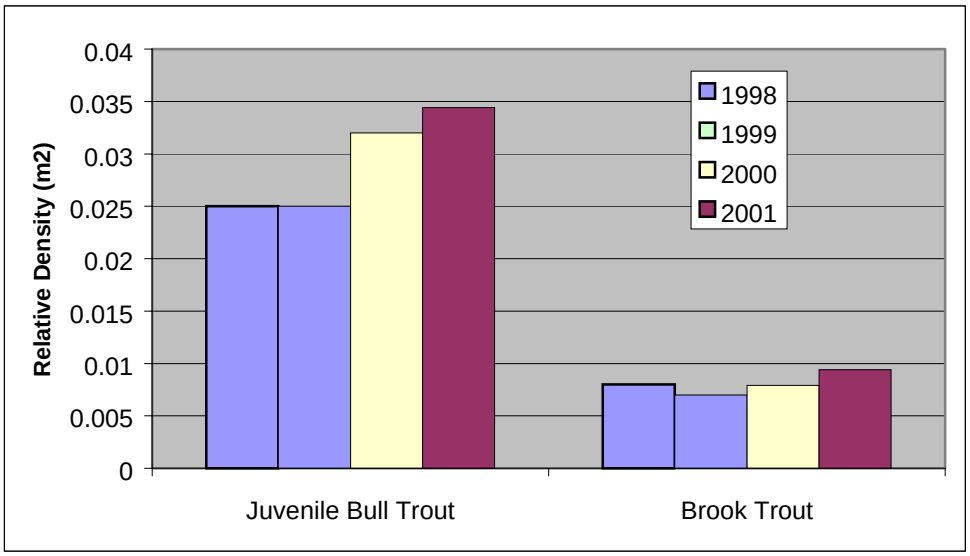

Figure I.7. Mean relative densities of combined index reaches surveyed during 1998-2001 in Shitike Cr.

Juvenile bull trout and brook trout numbers increased slightly from 2000 observations. Juvenile bull trout densities have continued an upward trend since surveys began during 1998. Brook trout relative densities have increased slightly as well. It should be noted that there has been significant annual fluctuations in relative densities of juvenile bull and brook trout among index reaches in Shitike Cr. Reach 6 had a significant increase in

relative density of juvenile bull trout from 2000 observations (Figure I.8). Reaches 6, 9 and 10 have shown upward trends since 1999. Other reaches have shown slight increases or decreases from 2000 observations. Despite the annual fluctuations within reaches in Shitike Cr., juvenile bull trout numbers continue increasing in the area as a whole.

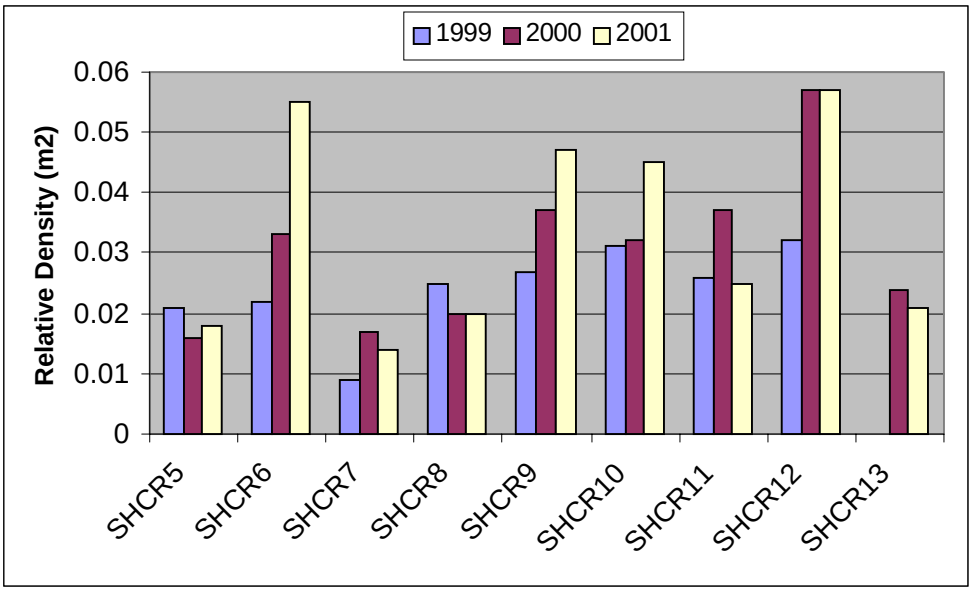

Figure I.8. Relative densities of juvenile bull trout within each index reach surveyed during 1999-2001.

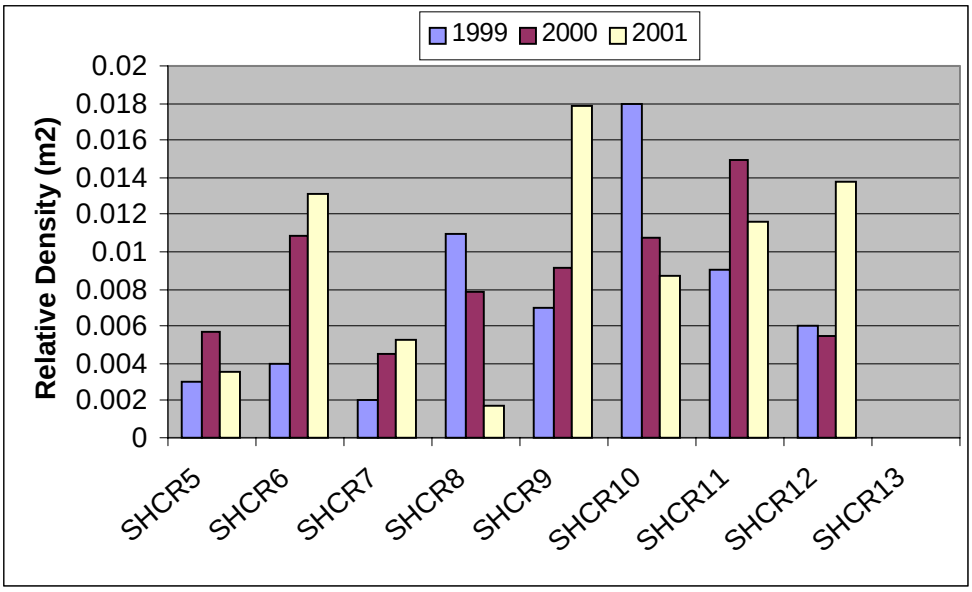

Figure I.9. Relative densities of brook trout within each index reach surveyed during 1999-2001.

Brook trout relative densities within the combined index reaches increased during 2001 observations. Densities among the index reaches varied during 1999-2001 (Figure I.9). Index reaches 6, 7, 9 and 12 all had increases in brook trout relative densities whereas

reaches 5, 8 and 10 had decreases in the relative densities of brook trout. Brook trout have been absent from reach 13 in all survey years.

Section II
Juvenile and Adult Migrant Monitoring

Introduction

The majority of bull trout in the lower Deschutes basin exhibit a fluvial life history pattern. Adults spawn and 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. Adult immigration monitoring began in Shitike Creek during 2000 with the installation of a fish weir near its mouth.

Methods

Juvenile Migration

Juvenile emigration from Shitike Cr. was monitored using a rotary screw trap near the mouth (Rkm 0.7). The trap was operated from April through early July, and mid-September through November, 24 hrs/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 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 bull trout released was 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 ($n^{\wedge}=X*T/C$). River flows and water / air temperatures were recorded on a daily basis. A humphrey trap situated near the mouth of the Warm Springs River (Rkm 0.5) was not operated during 2001 due to low river flows.

Adult Migration

A vertical picket fence weir was installed across Shitike Creek near the mouth (Rkm 0.75) during late January 2001. 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, during the morning and late afternoon. All immigrating bull trout captured in the weir were tagged with an individually numbered floy tag. The fork length was measured and scale samples were collected. River flows were monitored daily and water temperatures were continuously recorded with a thermograph. During the adult bull trout spring immigration period (mid-May through early July) the weir was operated 24 hrs/day, 7 days per week. From mid-July through September, the weir operation ceased due to low flows and high water temperatures.

When water temperatures lowered below 15° C in late-September weir operation resumed. Weir operation was 24 hrs/day, 5 days a week during the fall.

Adult immigration into the Warm Springs River at the WSNFH was monitored by U.S. Fish and Wildlife Service personnel from April – August 2001. Adults were enumerated, inspected for tags and fork lengths estimated using video equipment as they ascended a fish ladder around a concrete weir.

Winter Distribution Surveys

Winter distribution surveys were conducted in the Warm Springs R. and Shitike Cr. during the months of January – March. The surveys were conducted by night snorkeling using the methods described in Section I. In the Warm Springs R., these surveys were conducted to determine if sub-adult (200-300 mm.) and adult (>300 mm.) bull trout over wintered. In both the Warm Springs R. and Shitike Cr. surveys were conducted to determine if juvenile bull trout move downstream during the winter. Four survey reaches were established in Warm Springs R. (Rkm 41.8-61.9) and three in Shitike Cr. (Rkm 7.1-23.9). The reaches were located downstream of the summer juvenile abundance monitoring reaches in areas where juveniles have not been found during summer surveys. The reaches were established using the same protocol describes in Section I. Index reach 12 (WSR 12) in Warm Springs R. and index reach 6 (SHCR 6) in Shitike Cr. were used as controls. These reaches are surveyed during juvenile bull trout abundance monitoring in the summer and are located at the downstream end of the summer range of distribution.

Results and Discussion

Juvenile Migration

A total of 123 juvenile bull trout were captured as they emigrated from Shitike Cr. during 2001. The mean fork length was 162.4 mm (Sd. = 36.8, 95% CI = ±7.0 mm). Sixty percent (N=74) left Shitike Cr. during the spring period (April - May). The remaining 40% (N=49) were captured during the fall (mid-October – N ovember). The mean fork length of fish captured in the spring was 150.3 mm (Sd. = 19.5, 95% CI = ±4.7 mm). The mean fork length of fall migrants was 183.9 (Sd. = 49.0, 95% CI = ±15.6 mm) (Figure II.1).

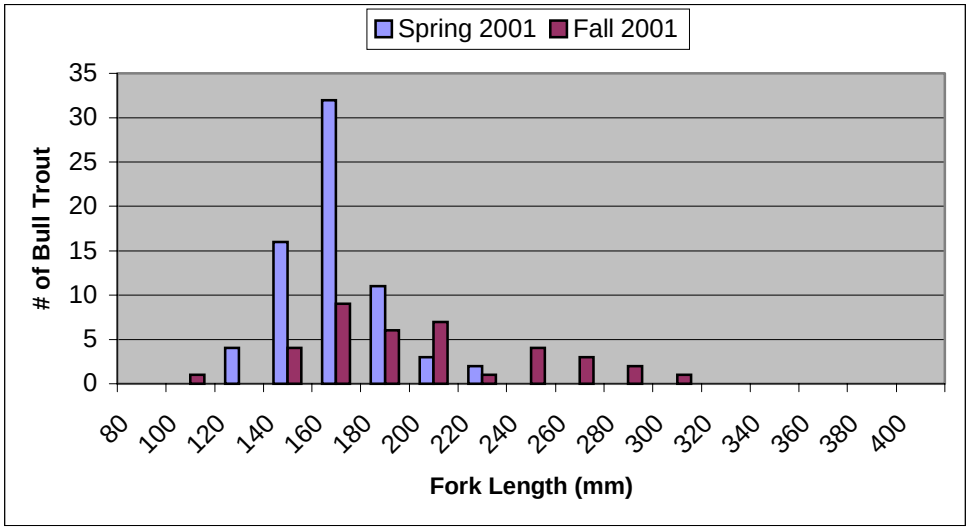

Figure II.1. Length frequency of juvenile bull trout captured during 2001 at rotary screw trap on Shitike Cr.

Age II fish (121-166 mm) accounted for 65% of the combined spring and fall emigration. Age III fish (167-296 mm) represented 27% of the catch. The remainder were age IV (297-431 mm)[0.8%] and V (432-461 mm)[7%]. Age II fish dominated the spring catch while age III fish were more abundant in the fall catch. The mean length of juvenile bull trout captured during their out migration into the Deschutes River during 2001 was similar to past years observations.

Approximately 62% of the spring emigrating juvenile bull trout left during the first two weeks after trap operation began, April 3, 2001 (Figure II.2). The operation of the rotary screw trap may have began after the onset of juvenile bull trout emigration.

The majority of juvenile bull trout left Shitike Cr. when temperatures were below 7° C. However a few juveniles emigrated when water temperatures exceeded 15° C. The fall migration period (mid-October – November) commenced when the water temperature fell below 10° C. The majority (56.7%) of the fall emigration occurred when water temperatures decreased to 4.3° C in early November (Figure II.2).

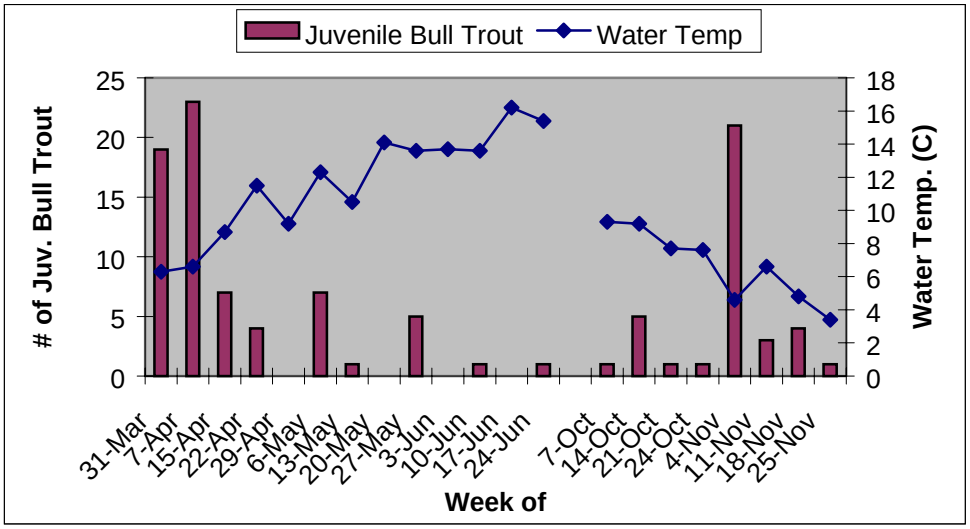

Figure II.2. Weekly number of emigrating juvenile bull trout and the associated 7-day average water temperatures during spring and fall migration, 2001.

Determining the onset and completion of juvenile emigration and estimating the numbers of emigrants has been difficult due to the inconsistent periods of trap operation in Shitike Cr. High river flows or mechanical problems have hampered efforts to install the trap during the late-winter months in recent years. Fall freshets have limited the period of trap operation during late fall. However it is know that the spring juvenile emigration commences by early March and continues through mid-June. The fall migrations occur from September through November. It very well may continue throughout the winter months. The timing of peak emigration varies by year between mid-March to mid-May (Figure II.3).

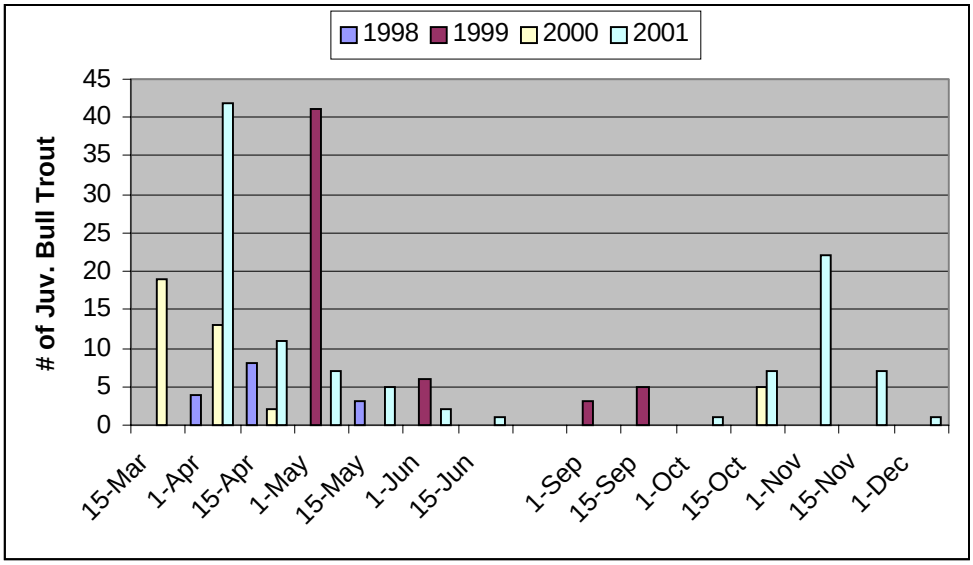

Figure II.3. Number of emigrating juvenile bull trout during spring and fall migrations, 1998-2001.

During 2001 spring and fall juvenile bull trout trap efficiency and rough population estimates were generated. The spring trap efficiency was 17%. The population estimate for the spring emigration was 751 fish (Sd. = 1021, 95% CI = +3987, -2504). For fall emigration the trap efficiency was determined to be 22%. The population estimate for the fall was 495 fish (Sd. = 475, 95%CI = +1721, -722).

Adult Immigration

Warm Springs River

Twenty-five bull trout were counted as they passed the WSNFH weir during 2001. There has been an increase in the number of adult bull trout passing the WSNFH weir since 1995 (Figure II.4). Immigration occurred from early May through mid-June with the peak migration observed during the last full week of May (Figure II.5). Run timing has been similar among years. The mean estimated fork length was 53 cm (Sd.=10.1, 95% CI=±4.17 cm). Repeat spawning was again documented by a previously tagged bull trout observed passing through the weir.

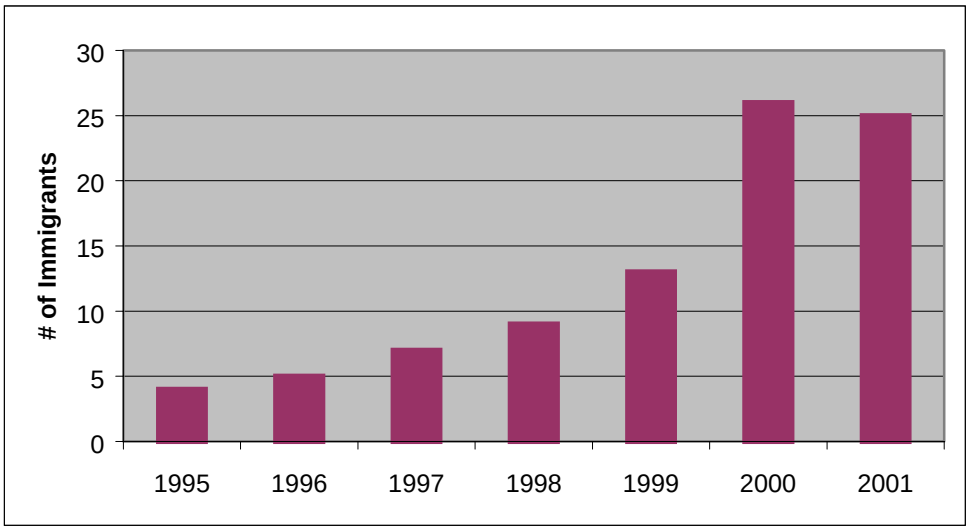

Figure II.4. Number of immigrating bull trout counted at the Warm Springs National Fish hatchery (1995-2001).

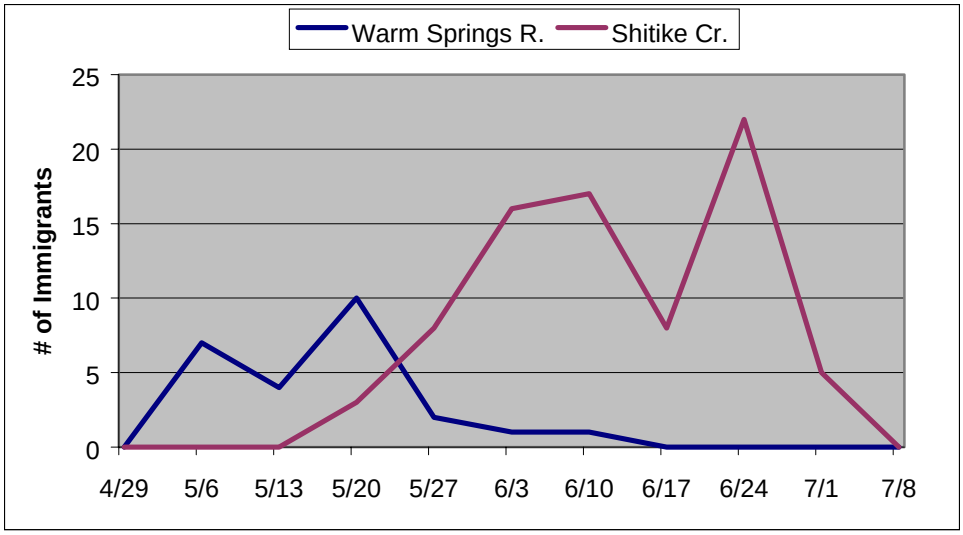

Figure II.5. Emigration timing of bull trout into Warm Springs R. and Shitike Cr. during 2001.

Seven day average water temperatures in the Warm Springs R., recorded at the WSNFH, ranged from 10-16.2° C throughout the immigration period. The water temperature averaged 15.9° C during the peak of the migration (Figure II.6). Water temperatures during peak spawning were approximately 3° C higher than recorded during the same time period in 2000.

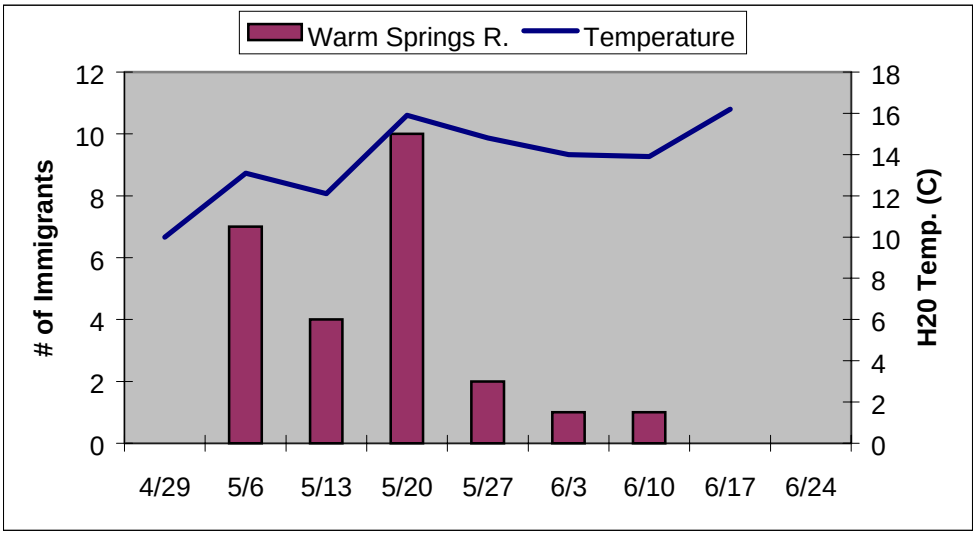

Figure II.6. Water temperatures in the Warm Springs R. at WSNFH during adult bull trout immigration.

Shitike Creek

Eighty adult bull trout were captured in the Shitike Cr. weir during 2001. All fish were released upstream of the weir in good condition after tagging and measurement. The sizes of the adult immigrants ranged from 39-79 cm (age IV – VII). The mean length

was 53.7 cm (age VI). Of the 80 adults captured, 50 were males, 15 were females and the sex was undetermined for 15.

In early July, the weir operation ceased due to increasing water temperatures and low flows. This occurred near the end of the adult bull trout immigration period. Peak migration occurred in late-June when water temperatures were 15.4° C (Figure II.7). Water temperatures ranged from 10.5-18.4° C from the beginning of the immigration to the cease of weir operation in early-July.

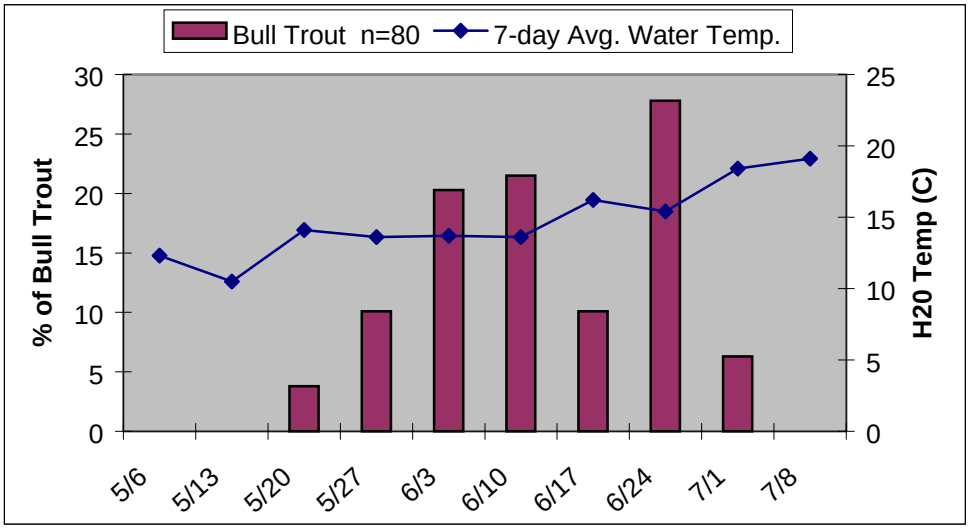

Figure II.7. Percentage of adult bull trout captured in the Shitike Cr. weir and 7-day average water temperatures during 2001.

Adult bull trout migrate primarily during the night. Of the 80 adult bull trout captured at the weir, 93.7% (N=75) of the adults were in the trap box during the morning check. Other species captured with adult bull trout were spring chinook salmon (*Oncorhynchus tshawytscha*), rainbow trout (*O. mykiss*), bridgelip sucker (*Catostomus columbianus*) and largescale suckers (*C. macrocheilus*) [Figure II.8].

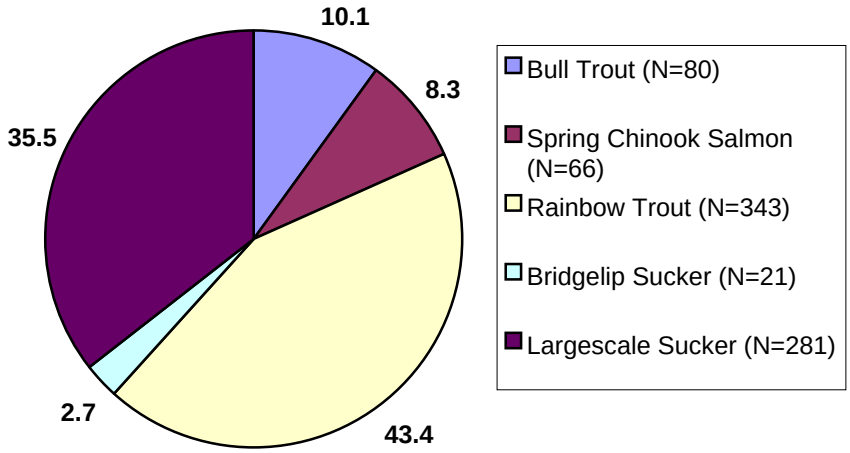

Figure II.8. Percent species composition captured at the Shitike Cr. weir during adult bull trout immigration, May 23 – June 9, 2001.

No bull trout were captured during the fall months. They may have avoided being captured by remaining in a pool upstream of the weir and moving downstream when the weir pickets were removed on weekends. The only species captured during the fall were mountain whitefish (*Prosopuim williamsoni*).

Winter Distribution Surveys

Warm Springs R.

Two surveys were conducted within the 5 reaches on the Warm Springs R. A total of 34 juvenile bull trout were observed. The majority of juvenile bull trout were in the control reach (91.2%, N=31). A total of 3 juvenile bull trout were observed in the two reaches downstream of the control reach. These results indicate that juvenile distribution extends downstream to Rkm 56.3 during the winter months, but the number of juveniles moving downstream during the winter are not large.

Eight sub-adult and 2 adult bull trout were observed during the winter surveys. Five of these fish were located within the control reach. This indicates that some adult bull trout over winter in the Warm Springs R. It may partially explain the discrepancy between relatively low numbers of immigrating bull trout through the WSNFH weir and the high redd counts observed in the spawning areas.

Shitike Cr.

Due to poor winter access conditions only one pass was completed on Shitike Cr. A total of 52 juvenile bull trout were observed within the four reaches. Ninety percent (N=46) of the juvenile bull trout were observed in the control reach. The remaining 10% were observed in the reach located at Rkm 23.9. Only two sub-adult bull trout were observed and no adult bull trout observed in the four reaches. The winter range of juvenile

distribution extends downstream to Rkm 23.9. Based upon the results of these limited surveys adults may not over winter in Shitike Cr., however, additional winter surveys are needed to verify this assumption.

Section III
Bull Trout Spawning Surveys

Introduction

Bull trout require cold water, complex instream habitat and clean gravels for successful spawning. They spawn during the fall when the availability of cool water is limited in most streams. As a result, bull trout spawn only in 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 throughout their range (Sanborn et al. 1998). Prior to establishing index reaches basin-wide surveys are needed to identify spawning habitat. The surveys, repeated throughout the spawning period, are necessary to determine the specific locations, and 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 R. located entirely on the Warm Springs Reservation that supports significant bull trout spawning and juvenile rearing. We conducted redd 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 Warm Springs R., Shitike Cr. and Whitewater R. to establish baseline trend data.
2.) Determine if there are annual changes in spawning distribution within Warm Springs R. and Shitike Cr.
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 2001. Stream reaches that contained suitable bull trout

spawning habitat were surveyed. The entire known spawning habitat was surveyed in Warm Spring R. and 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 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). Two reaches were delineated in Warm Springs R. and three in Shitike Cr. The location of the survey reaches was based primarily upon access considerations.

Redd surveys were conducted on alternate weeks from late-August through October in Warm Springs R. and Shitike Cr. during the 1998-2001 spawning seasons. The specific timing of each survey varied within the two-week periods among years due to scheduling difficulties. Suitable spawning habitat in each stream was surveyed 3-5 times from late August through October. 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 on each survey and summed for each reach within the Warm Springs R. and Shitike Cr. after the final pass for each year to obtain the total count.

Whitewater River was surveyed in late-October 2001. Poor water visibility resulting from glacial turbidity throughout most of the spawning period allowed for only one pass.

Results and Discussion

Redd Enumeration and Distribution

A total of sixty redds were counted in the two survey reaches in Warm Springs R. Ninety-seven redds were found in the three reaches in Shitike Cr. (Table III.1). Due to the deteriorating weather conditions a fourth pass was not conducted in Shitike Cr. reaches II and III. Only one redd was found in Whitewater R.

Table III.1. Bull trout redd survey reaches and numbers of redds recorded in Warm Springs R., Shitike Cr. and Whitewater R. during 2001.

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	45	0	3	21	21
"	II	59.3-57.5	1.8	15	0	0	10	5
Shitike Cr.	I	35.8-31.6	4.2	11	0	6	3	2
"	II	41.9-38.6	3.3	55	3	32	20	-
"	III	43.8-41.9	1.9	31	1	22	8	-
Whitewater R.	I	20.6-15.8	4.8	0	0	-	-	-
Spring Cr. (Whitewater R.)	II	0.0-0.7	0.7	1	1	-	-	-

The number of redds recorded in the Warm Springs R. during 2001 was the lowest count since surveys began in 1998. Redd densities decreased significantly in both reaches during 2001. There were approximately 5 fewer redds/km in reach I (Rkm 57.5-52.0) and approximately 6 fewer redds/km in reach 2 (Rkm 59.3-57.5) during 2001 than in 2000 (Figure III.5). There was a 41% decline in the number of redds found in Warm Springs R. from the peak count recorded in 2000. The reasons for the dramatic decline in redd numbers are unclear. Water temperatures within the Warm Springs R. from the WSNFH to the upper spawning limits were not significantly warmer than observed during previous years (Figure III.2).

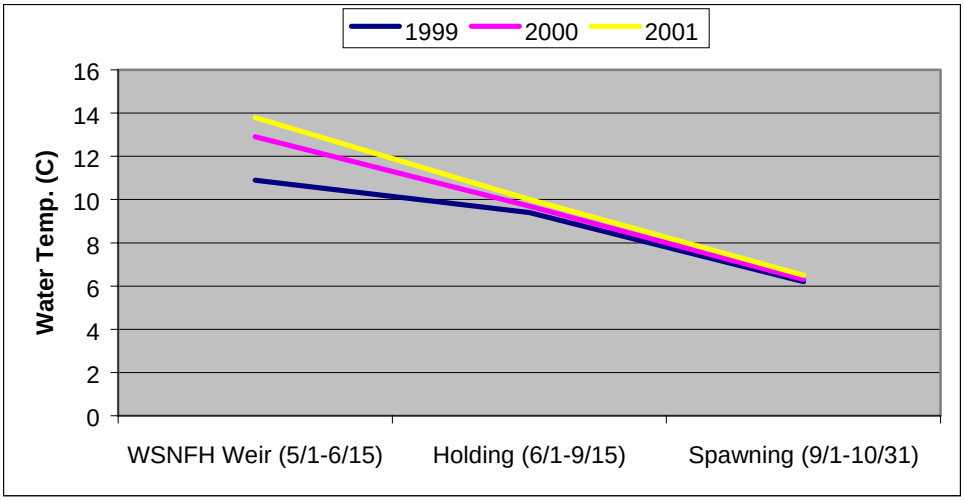

Figure III.2. Mean 7-day average water temperatures in the Warm Springs R. from the weir at WSNFH to the spawning area, 1999-2001.

The following theories may explain the apparent decline in redds during 2001 in the Warm Springs R.:

1. Bull trout spawning in the Warm Springs R. began in late-September. This is much later than previous years. New redds were observed during the final survey in reach I (Rkm 57.5-52.0) [Table III.1]. Spawning in this reach may have continued into November resulting in an undercount of the true number of redds within this reach. Poor weather conditions prevented further passes in the Warm Springs R.

2. Observer error may account for the yearly discrepancies. In previous years (1998-2000) the beginning of bull trout spawning overlapped with spring chinook spawning. In reach I (Rkm 57.5-52.0), both bull trout and spring chinook salmon utilize the same spawning habitat. It is possible that the observers experienced difficulty in differentiating bull trout redds from spring chinook salmon redds and test digs. During 2001, bull trout spawning began after spring chinook salmon spawning was completed. Spring chinook redds were flagged prior to the first bull trout redd observations. This may have led to a more accurate enumeration of bull trout redds than during previous years.

3. In reach II (Rkm 59.3-57.5) there was a decline in the amount of available spawning habitat due to low water levels. The reduced amount of suitable spawning habitat may have resulted in a decreased amount of spawning within this reach.

There appears to be no relationship between the number of adult immigrants recorded at the WSNFH weir during the spring and the number of bull trout redds observed during the fall (Figure III.3). Bull trout may over-winter in the canyons of the Warm Springs R. for up to a year before migrating to the spawning grounds. Radio telemetry data collected during 1999 confirms this observation (Brun and Dodson 2000). There is a large juvenile spring chinook salmon forage base in the Warm Springs River which may induce over wintering behavior.

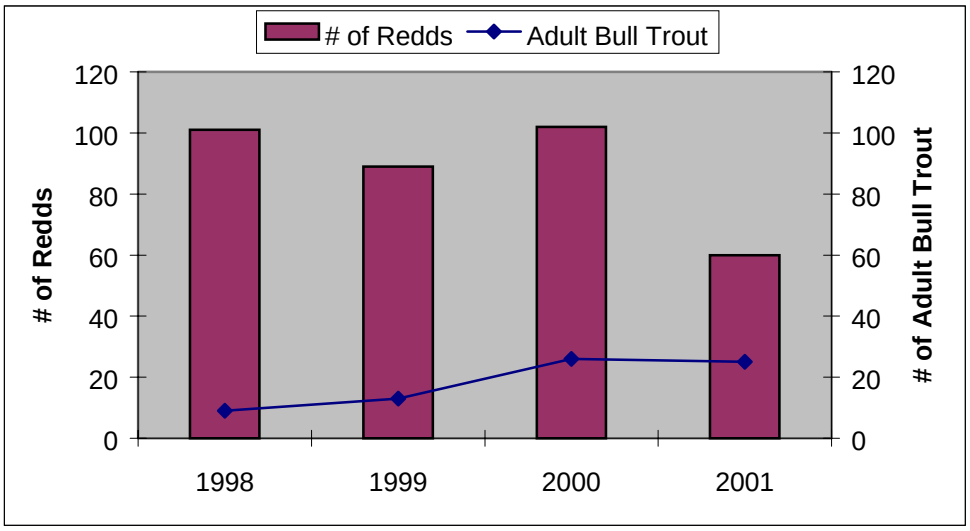

Figure III.3. Total number of redds in the Warm Springs R. and the number of adult bull trout over the WSNFH weir, 1998-2001.

A video weir system will be placed immediately downstream of the bull trout spawning ground in 2002 pending funding. This system will allow for a better estimate of adult bull trout escapement to the spawning grounds

In Shitike Cr. the number of redds counted increased from 2000 observations. However the 2001 count was 17% less than the peak count recorded during 1998 (Figure III.4).

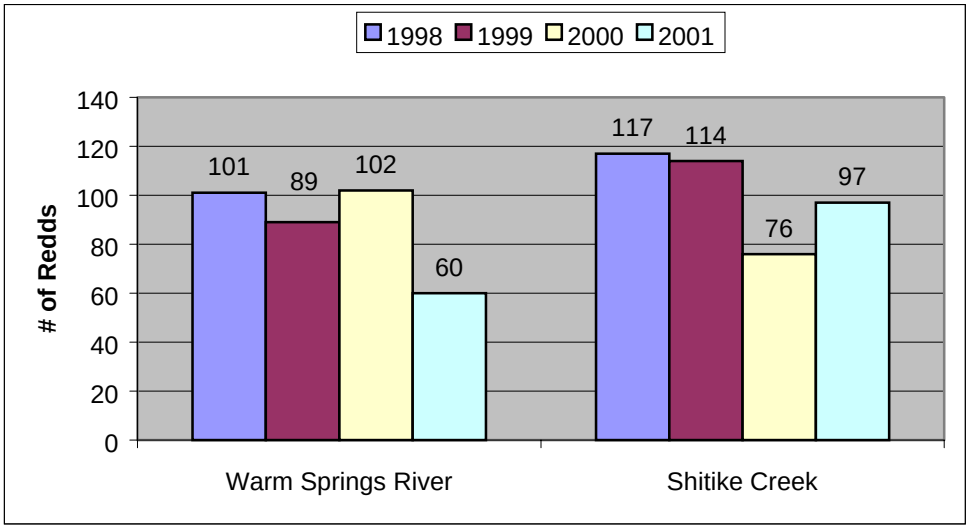

Figure III.4. Total number of redds in Warm Springs R. and Shitike Cr., 1998-2001.

Redd densities in Shitike Cr. increased during 2001 from 2000 observations. However there has been a shift in the redd densities observed within the survey reaches among years. There has been an overall downward trend in the redd densities in reach I, but an increase in reach III since surveys began during 1998 (Figure III.5).

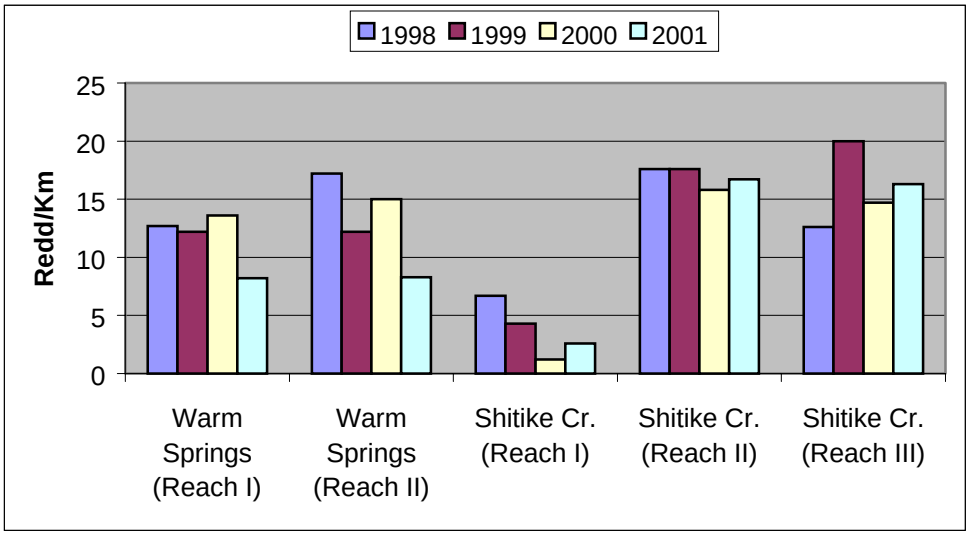

Figure III.5. Redds per kilometer by survey reach (Rkm) in the Warm Springs R. and Shitike Cr. from 1998-2001.

Spawning Timing and Associated Water Temperatures

Spawning in the Warm Springs R. occurred later in the fall during 2001 than in previous years. The first redds were observed in mid-September. Water temperatures ranged from 6-7° C during the months of September and October. Spawning was first observed when water temperatures declined to 7° C. Peak spawning occurred when temperatures

declined to 6.4° C in Warm Springs R. (Figure III.6). Temperatures in the Warm Springs R. during 1999-2000 were similar to 2001 spawning temperatures.

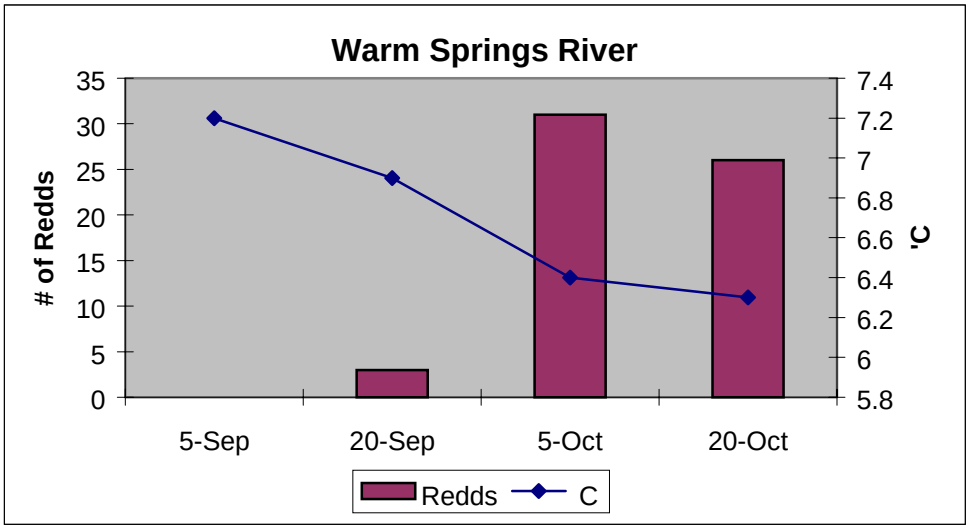

Figure III.6. 2001 Warm Springs R. redd counts and average water temperatures.

Bull trout redds were first observed in Shitike Cr. during the same time period as in 1998-2000. Water temperatures in Shitike Cr. ranged from 5-8° C during September through October spawning period. Spawning in Shitike Cr. was first observed when water temperatures declined to 8.5° C. Peak spawning occurred when temperatures declined to 8.0° C in Shitike Cr. (Figure III.7).

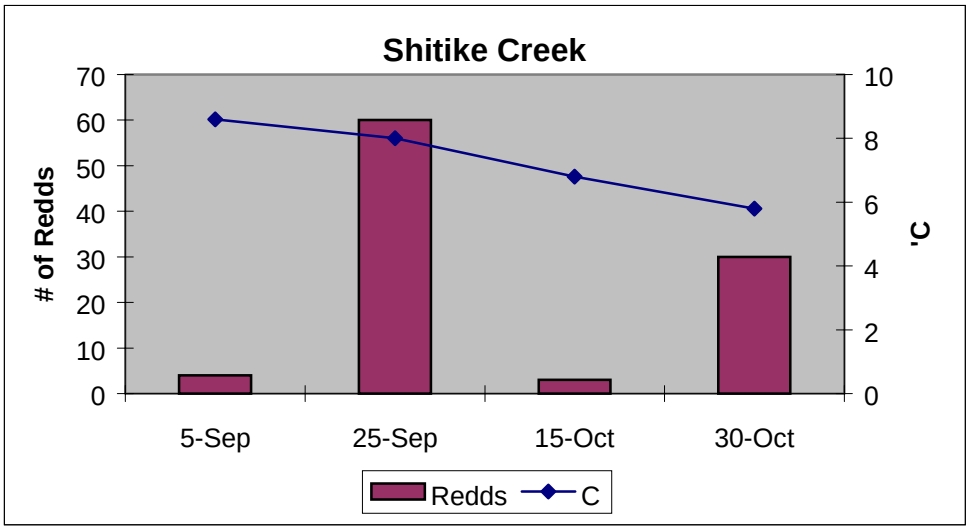

Figure III.7. 2001 Shitike Cr. redd counts and average water temperature.

Spawning Duration

Bull trout spawned in Warm Springs R. from early September through October. The timing of peak spawning was later than during 1998 and 2000, but was similar to 1999

observations (Figure III.8). Peak spawning occurred in mid-September in 1998 and 2000. However, during 1999 and 2001 peak spawning was observed during early October. There appears to be annual variation in the timing of peak spawning within the Warm Springs R.

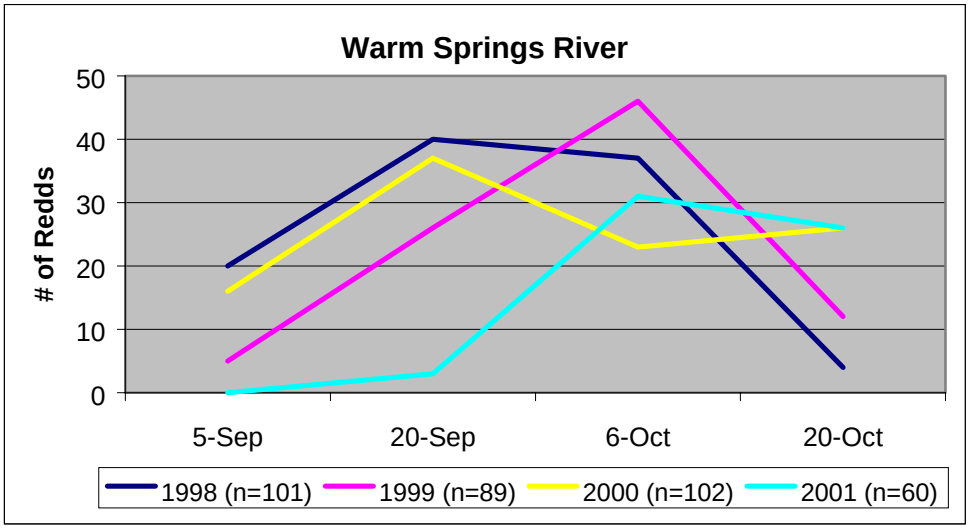

Figure III.8. Peak spawning of bull trout in Warm Springs R., 1998-2001.

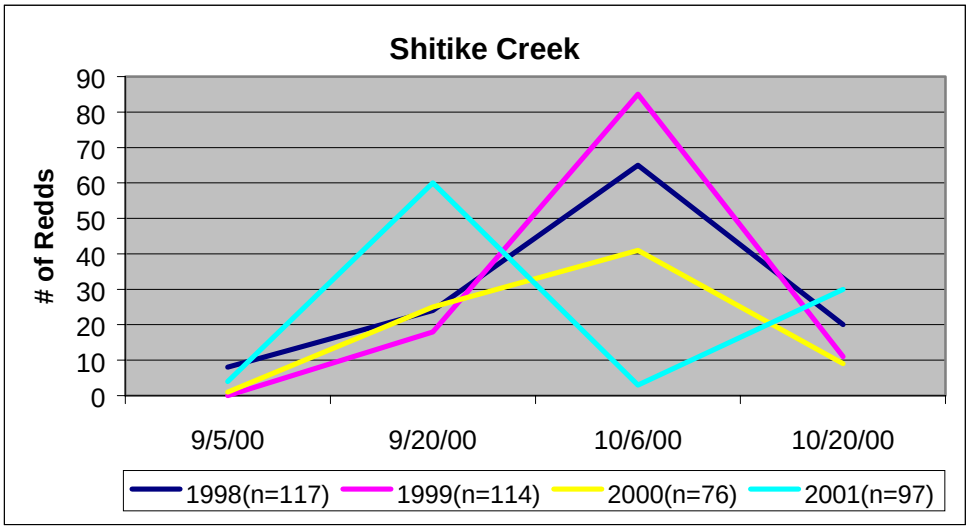

Figure III.9. Peak spawning of bull trout in Shitike Cr., 1998-2001.

Timing of peak spawning was one month earlier in Shitike Cr. than 1998-2000 observations. Peak spawning occurred in mid-September, whereas peak spawning occurred in early October during 1998-2000 (Figure III.9). The explanations for the shift in timing of peak spawning in Shitike Cr. are unclear.

Section IV
Water Temperatures Monitoring in Bull Trout Habitat in 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 15° C. Adults commence spawning when water temperatures decline below 10° 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 temperatures 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 14 calibrated, continuously recording thermographs (Onset Computer Corporation, Stow Away^{TM} and HoboTemps^{TM}) were located throughout Shitike Cr. and Warm Springs R. to record stream temperatures from spring through the 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 within the spawning grounds (Appendix C and Table IV.1) [Brun 1999, Brun and Dodson 2000]. Thermographs were deployed during March, prior to bull trout immigration and retrieved during late-October and November 2001, 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 was grouped by life history use ie. migration, pre-spawning holding, spawning/rearing areas within each stream. The data was averaged to obtain a single daily maximum and 7-day average temperature (° C) 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 stratum is displayed in Table IV. 2.

Table IV.1. Numbers and locations of thermographs deployed in Shitike Cr. and Warm Springs R. during 2001.

		# of Thermographs	Locations (Rkm)
Shitike Cr.	Immigration	1	1.4
	Holding	2	14.0, 17.7
	Spawning/Rearing	2	38.1, 43.5
Warm Springs R.	Immigration	1	16.0
	Holding	2	29.5, 41.8
	Spawning/Rearing	2	62.8, 68.1

Table IV.2. The time periods used for water temperature data analysis for immigration, holding and spawning/rearing in Shitike Cr. and Warm Springs R. during 2001.

	Shitike Cr.	**Warm Springs R.**
Immigration	23 May to 15 July	7 May to 11 June
Holding	23 May to 1 September	11 June to 1 September
Spawning/Rearing	1 September to 15 November	1 September to 15 November

Results

Shitike Cr.

Figure IV.1 displays the water temperatures recorded in Shitike Cr. during adult immigration through spawning during 2001. The mean water temperature recorded during bull trout immigration into Shitike Cr. was 15.4° C (range 13.2-19.1° C). Within the mid-portion of the Shitike Cr. (Rkm 14.0-17.7), used by adults for holding during June through August, the mean water temperature was 13.1° C (range 9.0-17.1° C). The mean water temperatures recorded in the spawning grounds (Rkm 30-45) was 7.4° C (range 4.9-9.3° C) during the September through October spawning period.

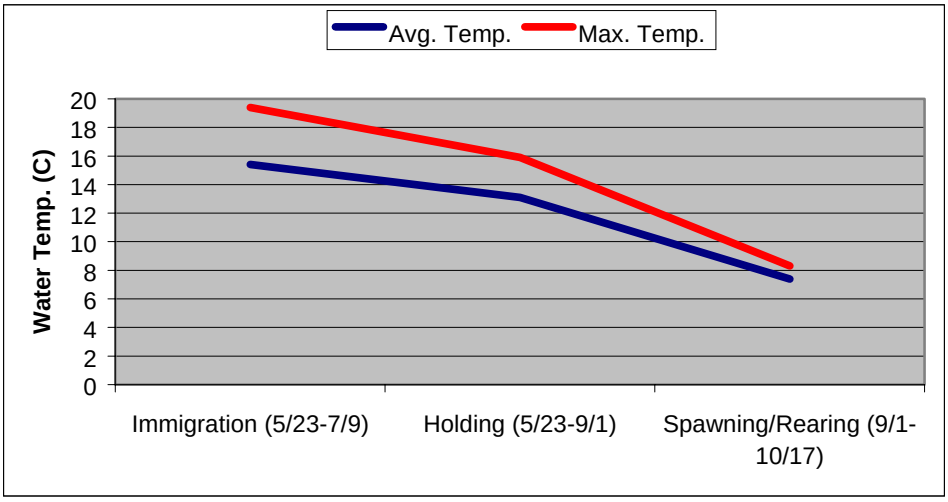

Figure IV.1. Mean 7-day average and maximum water temperatures in Shitike Cr. when bull trout entered the stream through spawning.

Water temperatures in Shitike during 2001 were warmer than in previous years, 1999-2000 (Figure IV.2). The average water temperatures recorded near the mouth of Shitike

Cr. during immigration and within the holding areas during the adult staging period were 1.5-2.0° C higher than recorded during 1999-2000. With the low water flow, higher temperatures were expected in Shitike Cr. during 2001. However, water temperatures in the spawning grounds remained relatively similar to previous years' observations. The 7-day average temperature fluctuations during the immigration, holding and spawning/rearing time periods within the Warm Springs R. during 1999-2001 are displayed in Table IV.3.

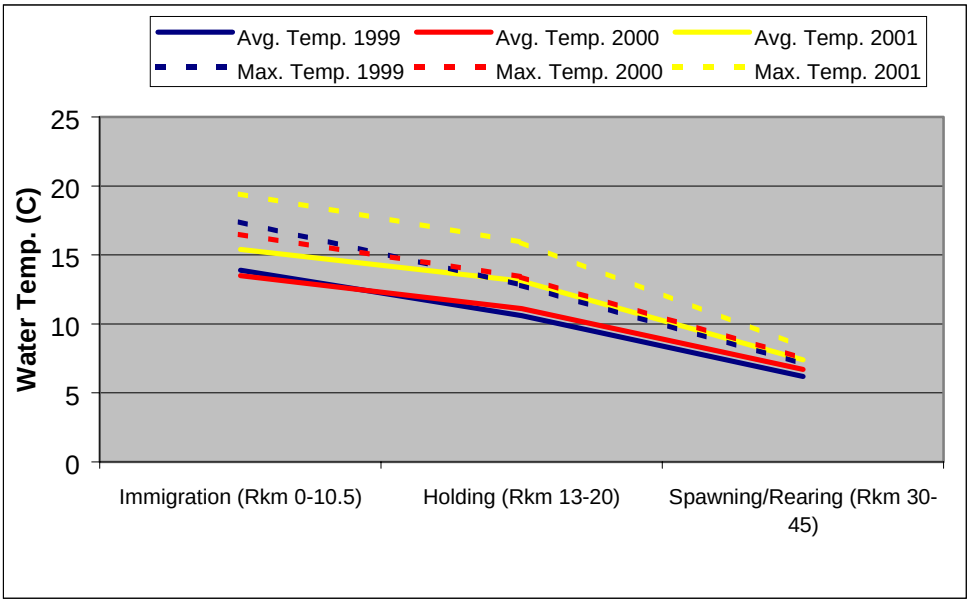

Figure IV.2. Mean 7-day average and maximum water temperatures in Shitike Cr. when bull trout entered the stream through spawning, 1999-2001.

Table IV.3. Average water temperatures in Shitike Cr. during seasonal immigration, holding and spawning/rearing (May – November), 1999-2001.

		Migration	Holding	Spawning
1999	Mean	13.9	11.3	6.20
	Max.	15.6	13.1	7.20
	Min.	11.5	9.20	4.90
	Std. Dev.	1.22	1.05	0.62
	Variance	1.49	1.10	0.38
2000	Mean	12.7	11.3	6.70
	Max.	15.6	15.4	8.80
	Min.	10.8	7.40	5.40
	Std. Dev.	1.42	2.05	0.92
	Variance	2.01	4.20	0.84
2001	Mean	15.4	13.1	6.90
	Max.	19.1	17.1	9.30
	Min.	13.2	9.0	4.90
	Std. Dev.	1.95	2.01	1.27
	Variance	3.81	4.06	1.62

Warm Springs R.

Water temperatures near the mouth of the Warm Springs R. at WSNFH (Rkm 16) averaged 14.1° C (range 10.2-16.3° C) during adult bull trout immigration (May 5 – June 11) [Figure IV.3]. The average water temperature in the Warm Springs canyon (Rkm 16-52) during the June – August holding period was 10.3° C (range 8.3-12.6° C). During spawning the average temperature was 6.5° C (range 5.7-8.1° C) between Rkm 52-59.

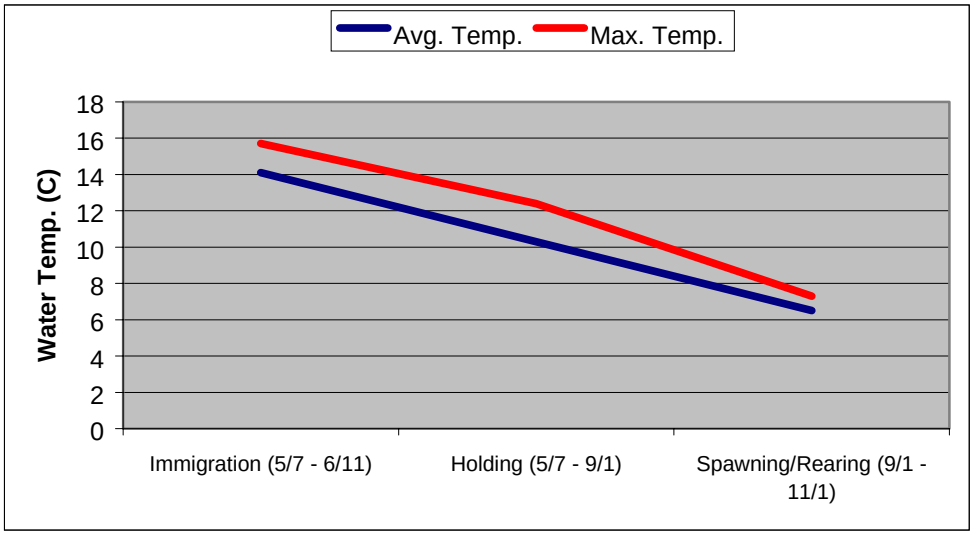

Figure IV.3. Mean 7-day average and maximum water temperatures in the Warm Springs R. when bull trout passed through the hatchery to the spawning grounds.

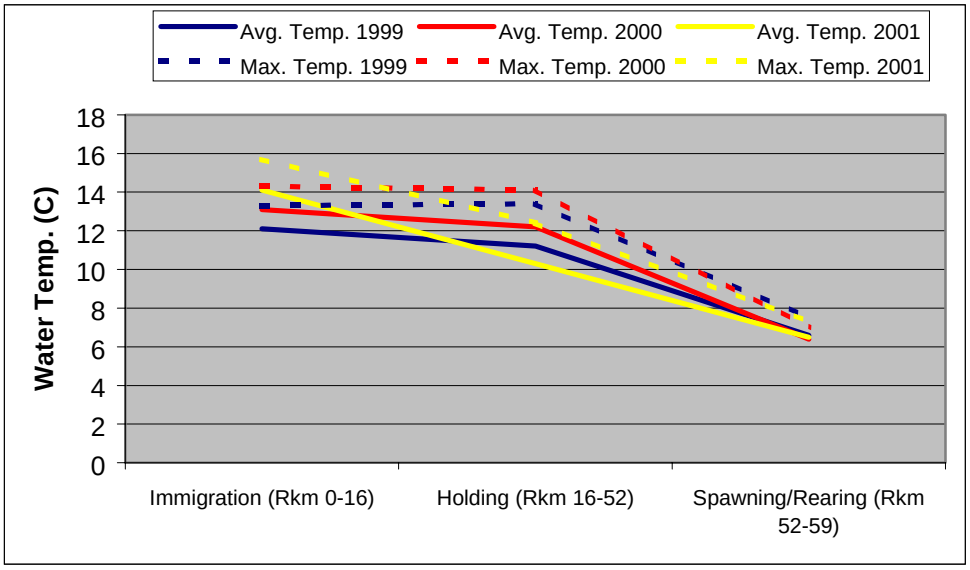

Figure IV.4. Mean 7-day average and maximum water temperatures in the Warm Springs R. when bull trout pass the WSNFH to the spawning grounds, 1999-2001.

The 7-day average temperature fluctuations during the immigration, holding and spawning/rearing time periods within the Warm Springs R. during 1999-2001 are displayed in Table IV.4.

Table IV.4. Average water temperatures in the Warm Springs R. during season immigration, holding and spawning/rearing (May – November), 1999-2001.

		Migration	Holding	Spawning
1999	Mean	11.8	11.0	6.3
	Max.	15.0	15.2	7.4
	Min.	10.2	7.3	3.8
	Std. Dev.	1.49	2.17	0.85
	Variance	2.23	4.73	0.73
2000	Mean	13.4	11.4	6.2
	Max.	15.2	15.6	6.6
	Min.	12.3	7.9	5.9
	Std. Dev.	0.79	2.11	0.16
	Variance	0.62	4.47	0.02
2001	Mean	13.8	10.3	6.5
	Max.	16.3	12.6	8.1
	Min.	10.2	8.3	5.7
	Std. Dev.	1.39	1.06	0.68
	Variance	1.92	1.13	0.47

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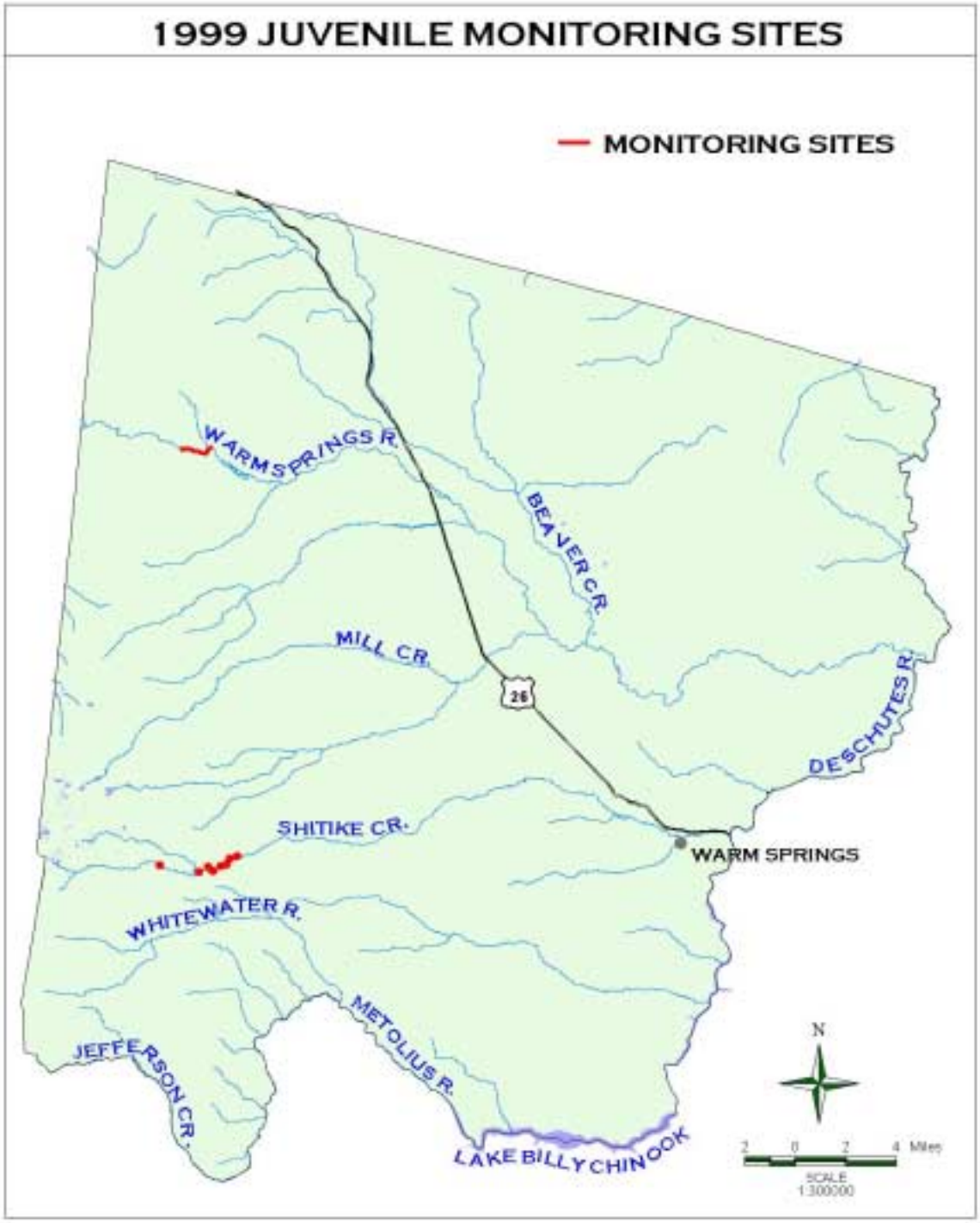
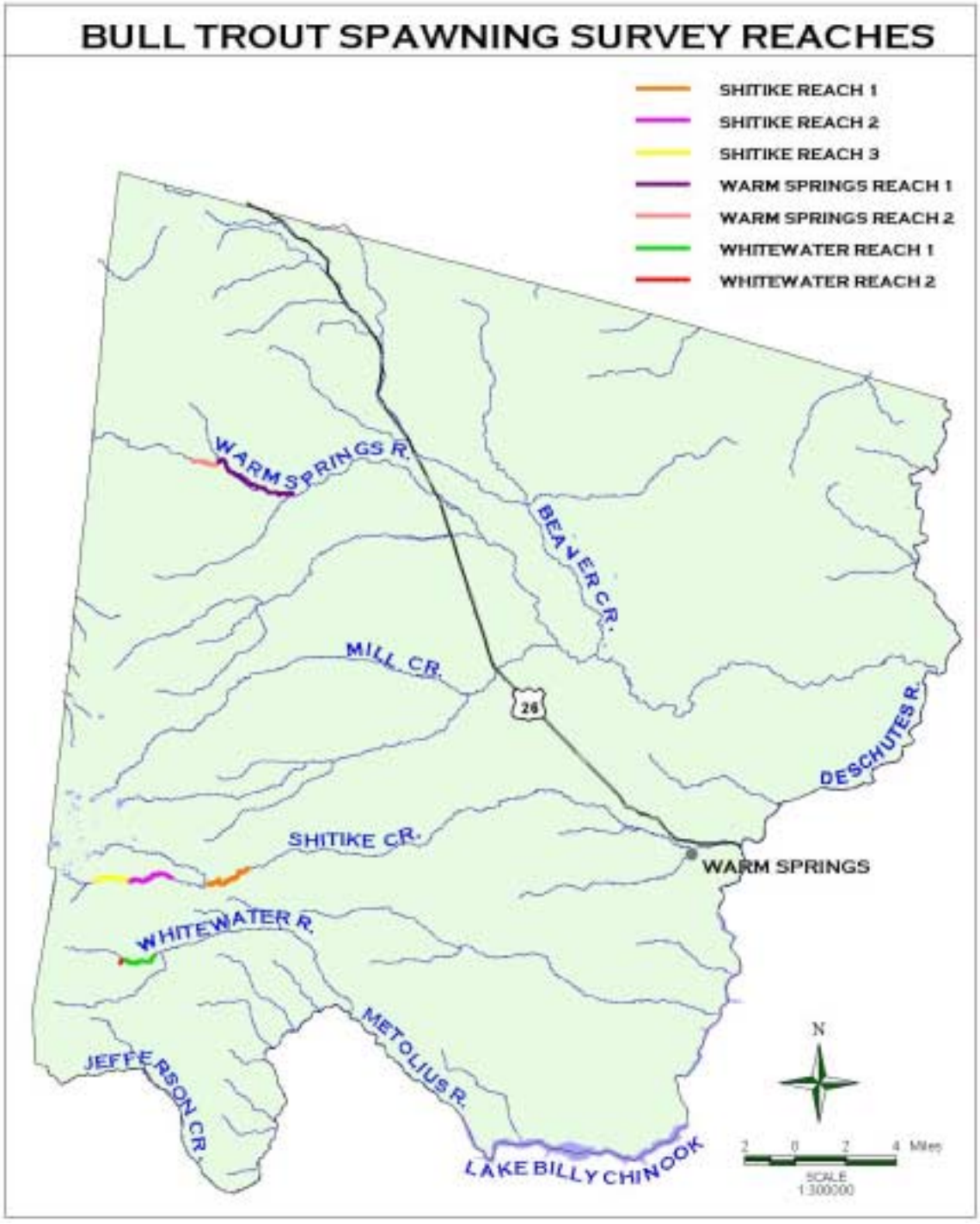
Appendix A. Juvenile bull trout survey locations.



Appendix B. Bull trout spawning survey index reaches.



Appendix C. Stream temperature monitoring stations.