Evaluation of the Life History of Native Salmonids in the Malheur River Basin

Cooperative Bull Trout/Redband Trout Research Project

Annual Report
2000 - 2001

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Burns Paiute Tribe

Evaluation of the Life History of Native Salmonids in the Malheur Subbasin

2000 Annual Report

Prepared for

U.S. Department Of Energy
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Evaluation of the Life History of Native Salmonids in the Malheur River Basin (BPA project #9701900 / 9701901)
FY 2000 Annual Report

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Investigations into the Life History of native Salmonids in the Malheur River Basin (BPA project #9701900 / 9701901)
FY 2000 Annual Report

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General Introduction

The Malheur basin lies within southeastern Oregon (Figure 1). The Malheur River is a tributary to the Snake River, entering at about River Kilometer (RK) 595 (Figure 1). The hydrological drainage area of the Malheur River is approximately 12,950 km^2 and is roughly 306 km in length. The headwaters of the Malheur River originate in the Blue Mountains at elevations of 6,500' to 7,500', and drops to an elevation of 2000' at the confluence with the Snake River near Ontario, Oregon. The climate of the Malheur basin is characterized by hot dry summers, occasionally exceeding 38^{o}C and cold winters that may drop below –29^{o}C. Average annual precipitation is 300 centimeters and ranges from 100 centimeters in the upper mountains to less than 25 centimeters in the lower reaches (Gonzalez 1999). Wooded areas consist primarily of mixed fir and pine forest in the higher elevations. Sagebrush and grass communities dominate the flora in the lower elevations.

Efforts to document salmonid life histories, water quality, and habitat conditions have continued in fiscal year 2000. The Burns Paiute Tribe (BPT), United States Forest Service (USFS), and Oregon Department of Fish and Wildlife (ODFW), have been working cooperatively to achieve this common goal. Bull trout *Salvenlinus confluentus* have specific environmental requirements and complex life histories making them especially susceptible to human activities that alter their habitat (Howell and Buchanan 1992). Bull trout are considered to be a cold-water species and are temperature dependent. This presents a challenge for managers, biologists, and private landowners in the Malheur basin. Because of the listing of bull trout under the Endangered Species Act as threatened and the current health of the landscape, a workgroup was formed to develop project objectives related to bull trout. Individuals that participated in the 2000 work group are listed in Table 1.

Table 1. Participants and associated organization present for the 2000 Bull Trout Workgroup meetings.

Organization	Participant
Burn Paiute Tribe	Daniel Gonzalez
	Lawrence Schwabe
	Mark Tiley
	Jason Fenton
US Bureau of Reclamation	Rick Rieber
	Tammi Salow
Oregon Department of Fish and Wildlife	Wayne Bowers
	Ray Perkins
	Tim Unterwegner
US Bureau of Land Management	Cynthia Tate
	Brain Lampman
US Forest Service	Alan Mauer
	Alan Miller
	Herb Roerick
	Sarah Bush

This report will reflect work completed during the Bonneville Power contract period starting 1 April 2000 and ending 31 March 2001.

The study area will include the North Fork Malheur River and the Upper Malheur River from Warm Springs Reservoir upstream to the headwaters (Figure 1.).

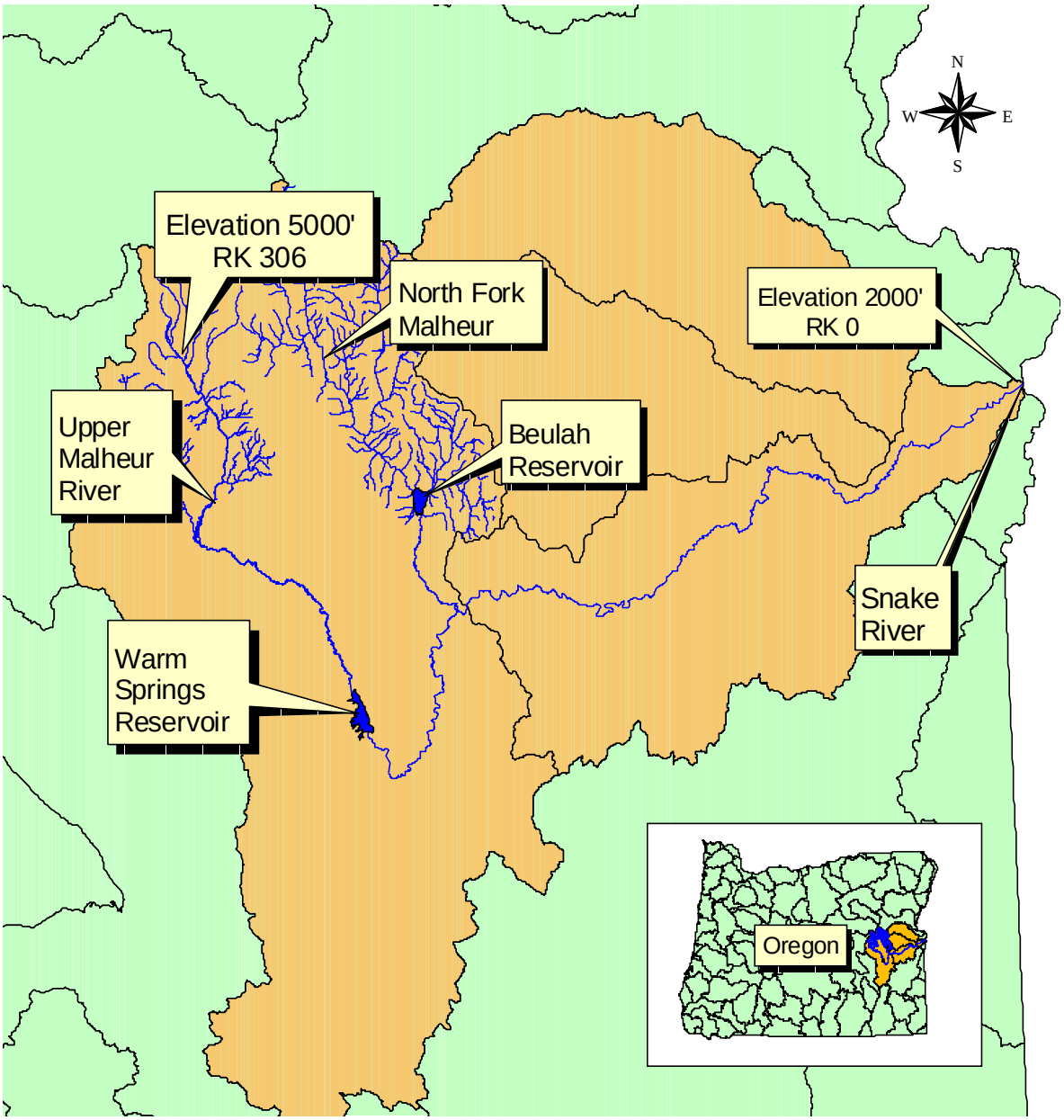

Figure 1. Malheur Basin Location Map

Radio Telemetry to Document Movements of Bull Trout in the North Fork Malheur Basin in Oregon

Author: Lawrence Schwabe, Burns Paiute Tribe Fish and Wildlife Department, Burns, Oregon

Introduction

In 1999, bull trout *Salvelinus confluentus* were collected in the North Fork Malheur basin and implanted with radio tags. Twenty bull trout were released above Agency Dam and five released below (Schwabe 2000). Of the bull trout implanted with radio tags in 1999, ten bull trout still had active radios in 2000. Nine were above Agency Valley Dam and one below. Five radio tagged fish had 11-gram radio transmitters and the remaining five had 17-gram radio transmitters. All radio transmitters have exceeded the manufacture's guaranteed life expectancy. Tracking these bull trout would provide additional migratory data for bull trout in the North Fork Malheur basin. No additional fish were radio tagged in 2000.

2000 Research Objectives:

1) Document the migratory patterns of adult (> 300 mm fork length) bull trout in the North Fork Malheur basin.

2) Determine the seasonal adult bull trout (>300 mm fork length) use of Beulah Reservoir.

The study area includes the North Fork Malheur River from Juntura, Oregon (RK 0) upstream approximately 60 km to the headwaters (map page 3). Radio telemetry was conducted in the North Fork Malheur basin and started in January 2000. Fish tracking continued until radio transmission was undetectable.

Methods

Radio Telemetry

Radio tagged bull trout were tracked once a week until radio transmission could not be detected or battery life expired. Guaranteed battery life for the largest radio is only 208 days. All radios being tracked were past their guaranteed life expectancy. We found radios to be active for over 1 year from activation.

An Advanced Telemetry Systems (ATS) receiver, a Yagi antenna, and a 12-channel hand-held Global Positioning System (GPS) unit were used to document the location of each fish. Foot and vehicle travel were the primary means to track fish movement. Boat tracking was used to locate bull trout within Beulah Reservoir. If telemetry effort resulted in lower than expected radio detection, aerial tracking surveys were conducted. One aerial survey was conducted from a fixed winged aircraft when tagged fish entered roadless or private areas. Once fish were located with the ATS receiver, an effort to visually identify located fish was attempted. The radio frequency

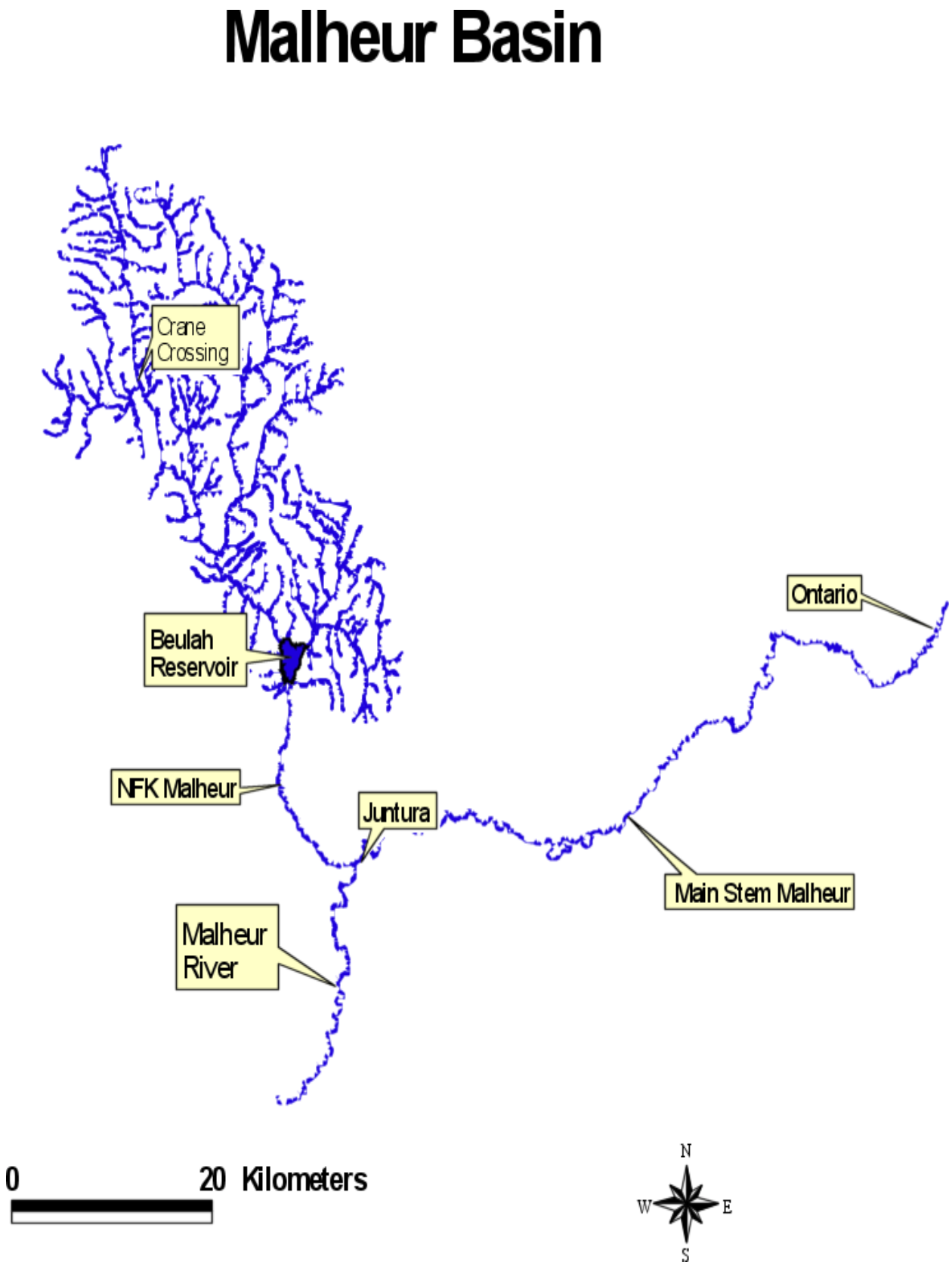

Figure 1. North Fork Malheur River Study Area

of each fish, the time it was located, and the Universal Transverse Mercator (UTM) location were recorded for all identifications. If applicable, additional information was taken on fish locations including stream temperatures, habitat characteristics, redds or pairing fish, and cover present.

Results

Telemetry Results

The telemetry study on the North Fork Malheur River (North Fork) continued in the year 2000. Ten radio tagged bull trout implanted in 1999 were detected in 2000 (Appendix A). Of these fish, forty-two telemetry observations were documented from 29 February 2000 to 19 April 2000 (Tables 1 and 2). No radio transmissions were detected after 19 April 2000. Lack of detection was presumed to be due to battery expiration.

Table 1 – 1999 radio-tagged bull trout that were located in 2000. Fish tracking was conducted on the North Fork Malheur River basin. Detection of radio transmitters started to decrease in March and April.

Fish Number (Frequency)	Tagging and Release Date	Number of times located in 2000	Date of last detection
150.433	4/4/99	4	3/29/00
150.522	4/18/99	7	4/19/00
150.922	4/8/99	6	4/14/00
151.023	4/18/99	8	4/19/00
151.133	4/16/99	1	3/15/00
151.152	4/22/99	2	3/15/00
151.182	6/8/99	4	4/19/00
151.192	4/10/99	7	4/19/00
150.433	4/4/99	1	3/23/00
151.593	4/14/99	2	3/15/00

Six radio-tagged bull trout from 1999 returned to the reservoir in November and December 1999 (Schwabe 2000). Tracking efforts in 2000 found all afore-mentioned bull trout in the reservoir in

February and early March. The last bull trout was found entering the reservoir on 17 March 2000. Shortly after this observation, the first bull trout was documented leaving the reservoir and entering the North Fork on 29 March 2000.

One radio-tagged bull trout was detected below Agency Valley Dam. This fish was originally released below the dam to detect bull trout movements and survivability (Schwabe 2000). Telemetry results in 2000 documented this fish 1.6 kilometers downstream on private land in the main channel of the North Fork.

Table 2 – Telemetry effort in the North Fork Malheur River basin. Number of tracking observations in 2000.

Foot Observations	Vehicle Observations	Plane Observations	Boat Observations	Total Observations
6	18	8	10	42

A radio tagged bull trout was located in the North Fork Malheur River at RK 46 on 15 March 2000. This fish was located on private land on a relatively remote section of the North Fork Malheur River. The flight in 2000 observed this fish in the same general location as in 1999 (Schwabe 2000). This particular fish has been observed in the same location for over one year. The landowners did not permit access to groundtruth. It is assumed this bull trout had died or expelled its tag.

Discussion

Radio Telemetry

Transmission from the 1999 radio implants was not detected after 19 April 2000. Five of the eight bull trout that were tracked in the reservoir from January to early March migrated into the river by late March. It is undetermined when or if the remaining three bull trout in the reservoir migrated into the North Fork due to the loss of radio transmission and/or expired radios.

Previous telemetry efforts in 1998 and 1999 did not document bull trout migration from the reservoir into the North Fork until early April (Gonzalez 1999, Schwabe 2000). In 2000, however, bull trout were observed in the North Fork by late March, two weeks earlier than previous years.

One additional bull trout was found in the reservoir on 17 March 2000. This fish was documented at RK 7 above the reservoir 4 months earlier. The transmission of this fish was not detected for 118 days. Primary tracking efforts in January and February were conducted on foot or by vehicle. The reservoir was iced over for all of January and most of February. This fish also went undetected during the flight on 15 March 2000. It is possible that this particular fish did migrate into the reservoir in January but because of limited access and ice formation on the reservoir the radio transmission was undetectable.

For the two-year study on the North Fork, a general migratory pattern for adult bull trout (>315 mm fork length) is evident (Table 3). Fish were observed leaving Beulah Reservoir from late March to early June, with peak migration occurring in April. All fish were observed at their upper limits in mid August to early September. Fish were observed leaving the headwaters after peak spawning periods in mid-September and returning to the reservoir in late October to early January. Radio tagged bull trout were observed over wintering in the reservoir and were documented to repeat the migratory cycle in the spring.

Table 3 – Typical distribution of migratory adult bull trout (>315 mm fork length) in the North Fork Malheur River basin. Note: This only represented bull trout tagged from Beulah Reservoir and does not include the distribution of fluvial or subadult bull trout.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North Fork Headwaters								X	X			
North Fork				X	X	X	X	X	X	X	X	X
Beulah Reservoir	X	X	X	X	X						X	X

Acknowledgements

A special thanks is extended to: Wayne Bowers (ODFW), Ray Perkins (ODFW), Rick Rieber (BOR), and Allen Mauer (USFS) who donated equipment, knowledge, and time to the project; Sarah Bush (USFS) for her time tracking fish and GIS mapping skills; Mark Tiley (BPT), Newton Skunkcap (BPT), Garrett Sam (BPT), and Jason Fenton (BPT) who spent hours of data collection in the field; and Cynthia Tate (BLM) for her participation in the work group. Bonneville Power Administration provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this study. Bureau of Reclamation provided funds needed for extra tribal personnel.

References

Gonzalez, D. 1999. Evaluate the Life History of Native Salmonids in the Malheur Basin. Fiscal Year 1998 Annual Report. Unpublished Data. Burns Paiute Tribe Fish and Wildlife Department. Burns, Or

Schwabe, L.T. 2000. Evaluate the Life History of Native Salmonids in the Malheur Basin. Use of radio telemetry to document bull trout movements in the Malheur River basin in Oregon. Fiscal Year 1999 Annual Report. Unpublished Data. Burns Paiute Tribe Fish and Wildlife Department. Burns, Oregon.

Appendix A – List of bull trout tracked in the North Fork Malheur River in 2000. Includes last tracked location for 1999 and all tracked locations for 2000.

Date	Fish ID	Frequency	UTM (E)	UTM (N)	Observer	tracked by:
12/21/99	but-99-20	150.433	408624	4865271	Fenton	vehicle
2/9/00	but-99-20	150.433	406648	4862675	Schwabe	foot
3/13/00	but-99-20	150.433	407464	4866382	Fenton	vehicle
3/15/00	but-99-20	150.433	406682	4865074	Bush	plane
3/29/00	but-99-20	150.433			tiley	vehicle
12/13/99	but-99-21	150.522	406596	4864583	Tiley	boat
3/13/00	but-99-21	150.522	408936	4865568	Fenton	vehicle
3/15/00	but-99-21	150.522	408103	4865582	Bush	plane
3/23/00	but-99-21	150.522	406836	4866367	Fenton	boat
3/30/00	but-99-21	150.522	406692	4866420	Fenton	boat
4/4/00	but-99-21	150.522	407274	4866543	Fenton	boat
4/14/00	but-99-21	150.522	403917	4869598	Fenton	vehicle
4/19/00	but-99-21	150.522	404034	4869570	Fenton	vehicle
12/13/99	but-98-18	150.922	406512	4863998	Tiley	boat
3/13/00	but-98-18	150.922	407721	4862930	Schwabe	vehicle
3/15/00	but-98-18	150.922	4007371	4866209	Bush	plane
3/23/00	but-98-18	150.922	406713	4866264	Fenton	boat
3/30/00	but-98-18	150.922	406810	4866316	Fenton	boat
4/4/00	but-98-18	150.922	407274	4866543	Fenton	boat
4/14/00	but-98-18	150.922	401753	4871778	Fenton	vehicle
12/6/99	but-99-27	151.023	407404	4861498	Schwabe	vehicle
2/9/00	but-99-27	151.023	407302	4861556	Schwabe	vehicle
3/13/00	but-99-27	151.023	407459	4861600	Fenton	vehicle
3/15/00	but-99-27	151.023	407352	4862833	Bush	plane
3/17/00	but-99-27	151.023	407459	4861600	Fenton	vehicle
3/29/00	but-99-27	151.023			tiley	vehicle
4/4/00	but-99-27	151.023			Fenton	vehicle
4/14/00	but-99-27	151.023	407207	4861635	Fenton	vehicle
4/19/00	but-99-27	151.023	407207	4861635	Fenton	vehicle
11/18/99	but-98-6	151.133	399881	4872755	Mauer	plane
3/15/00	but-98-6	151.133	399247	4873737	Bush	plane
12/21/99	but-99-28	151.152	407889	4863962	Fenton	foot
2/9/00	but-99-28	151.152	408019	4863855	Schwabe	foot
3/15/00	but-99-28	151.152	408476	4865124	Bush	plane
11/18/99	but-99-30	151.182	400318	4872550	Mauer	plane
3/17/00	but-99-30	151.182	406739	4862791	Fenton	vehicle
3/29/00	but-99-30	151.182			tiley	foot
4/14/00	but-99-30	151.182	402550	4870527	Fenton	vehicle
4/19/00	but-99-30	151.182	400432	4873194	Fenton	vehicle

Appendix A continued.

Date	Fish ID	Frequency	UTM (E)	UTM (N)	Observer	tracked by:
12/13/99	but-98-12	151.192	406897	4865843	Tiley	boat
3/15/00	but-98-12	151.192	406311	4866506	Bush	plane
3/29/00	but-98-12	151.192			tiley	foot
3/30/00	but-98-12	151.192	406311	4866420	Fenton	boat
4/4/00	but-98-12	151.192			Fenton	boat
4/12/00	but-98-12	151.192	405980	4866479	Fenton	boat
4/14/00	but-98-12	151.192	405971	4867368	Fenton	vehicle
4/19/00	but-98-12	151.192	404132	4869512	Fenton	vehicle
12/21/99	but-99-20	150.433	408624	4865271	Fenton	vehicle
3/23/00		150.433	406668	4865931	Fenton	boat
12/13/99	but-99-35	151.593	406952	4865573	Tiley	boat
2/9/00	but-99-35	151.593	407992	4863681	Schwabe	foot
3/15/00	but-99-35	151.593	406181	4866552	Bush	plane

Use of radio telemetry to document movements of bull trout in the Upper Malheur River, Oregon

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In 2000, research was conducted on bull trout *Salvelinus confluentus* in the Malheur River above Warm Springs Reservoir (referred to as the Upper Malheur River). Bull trout in the Upper Malheur River are at a high risk of extinction and are suppressed by habitat degradation, downstream losses, and hybridization and competition with brook trout *Salvelinus fontinalis* (Ratliff and Howell 1992).

Past fish and creel surveys have determined the current distribution of bull trout, however, little is known on the seasonal distribution of bull trout in the Upper Malheur River. Considering both the biological and political sensitivities surrounding the management of bull trout habitat, a clear understanding of their life history pattern is necessary to guide land management decisions and activities.

The Malheur River Bull Trout Workgroup developed the following objectives for bull trout (See Page 1):

1) Document the migratory patterns of adult/subadult bull trout in the Upper Malheur River.

2) Determine the seasonal bull trout use of Warm Springs Reservoir.

3) Determine the location of bull trout spawning in the Upper Malheur River.

The focus of the study area for the 2000 field season was primarily on the Upper Malheur River from Warm Springs Reservoir upstream to the headwaters (see page 3 and Figure 1). This report will reflect the research completed from 1 June 2000 to 31 January 2001.

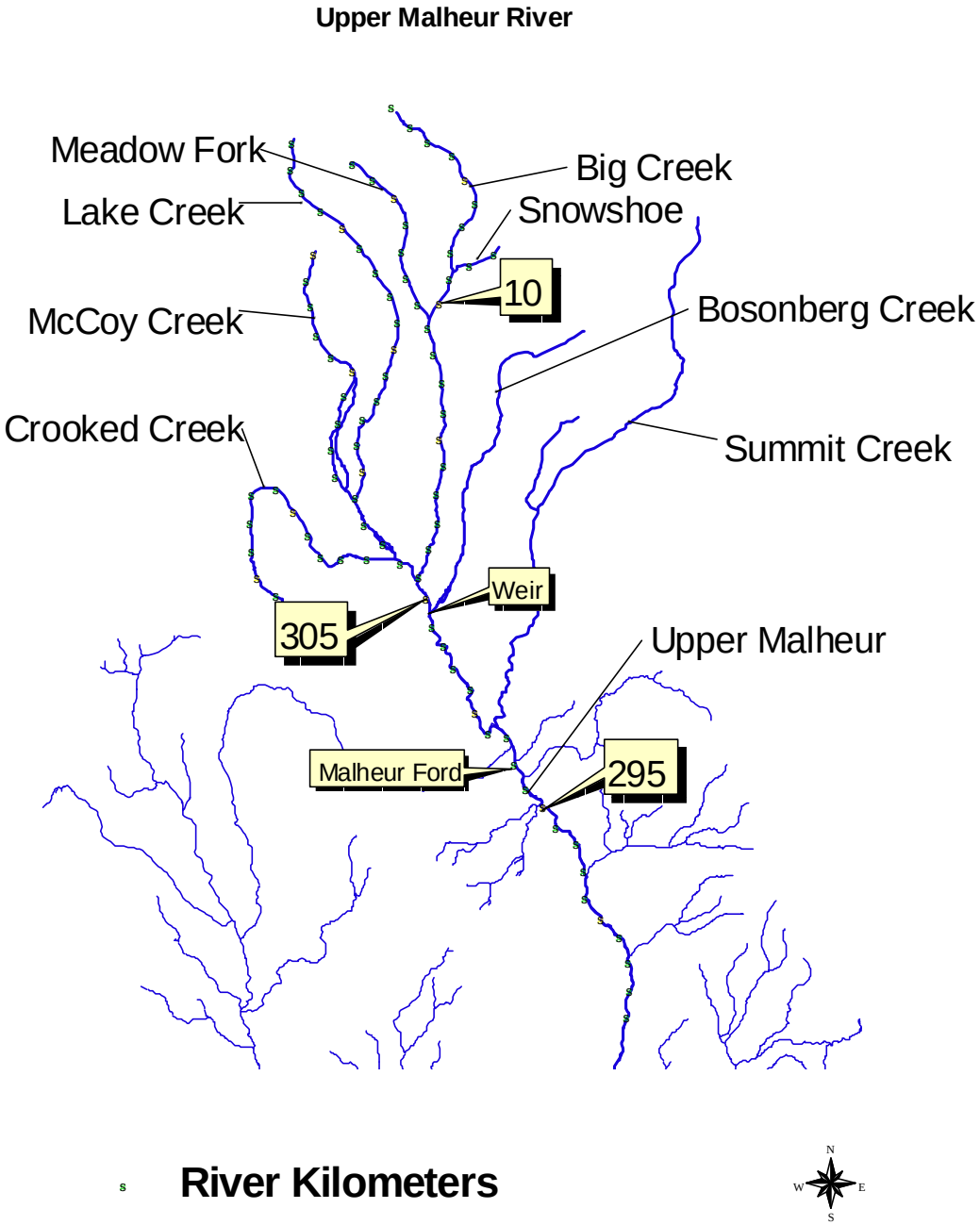


Figure 1. Study area for bull trout migration study in 2000.

Methods

Fish Collection

Bull trout were collected using two methods: angling and trapping via a weir. The weir trap was set on the Upper Malheur River at River Kilometer (RK) 304 approximately 120 meters below the confluence of Bosonberg Creek. The weir trap was designed to span a width slightly larger than the wetted channel. It was installed on a slight angle across the channel. The structure was constructed of 12-foot aluminum panels that had ½ inch diameter holes. Conduit rods were spread ¼ inch apart. The weir was stabilized with fence posts that were anchored into the streambed. Weir panels were attached to the fence post with fencing wire. Upstream and downstream trap boxes were placed near opposite stream banks and interlocked into the weir panels. All fish caught in the upstream trap were released in calm water upstream from the weir site. Those caught in the downstream trap were released below the site. The Malheur River Bull Trout Workgroup were concerned of detaining endangered fish species in traps for extended periods of time. Therefore, the weir trap was checked twice a day in June when bull trout catches were relatively high and once a day from July to October.

Angling was conducted to collect additional bull trout using bait, lures, and flies with barbless hooks. Bull trout were kept in live traps until trained personnel were able to implant a radio transmitter and/or a Passive Intergraded Transponder (PIT tag). PIT tags were 12 mm long and are passive devices, meaning that the transponder carries no battery and remains inactive most of the time. The transponder's tiny electronic circuit is energized by the low-power radio beam sent by a compatible reading device. The transponder sends the ID number as a radio signal in the 134 kHz frequency band back to the scanner, which then decodes the unique number and displays it on a small screen similar to that on an electronic calculator.

Flow data were taken at the weir site. A staff gauge was installed at approximately 100 meters below the weir trap. Personnel recorded the daily staff gauge height and periodic flow measurements using a Marsh-McBirney Flow Mate flow meter. A transect was set along a homogeneous section of stream that consisted of a relatively level streambed with no major channel obstructions (i.e. boulders, logs). Along the transect, a minimum of 30 flow readings were required. All statistical analysis and calculations were performed using Microsoft Excel. Regression and R^2 values were used to test for relationships between staff gauge height and discharge measurements taken below the weir site.

Radio and Passive Intergraded Transponder (PIT) Tag Implantation

Radio transmitters manufactured by Advanced Telemetry Systems Inc. (ATS) had external whip antennas that emitted a unique frequency in either the 150 or 151 MHz band. Radios came in three sizes and are guaranteed by the manufacturer for up to 140 days (3.6 g radios), 90 days (8g radios), and 175 days (11g radios) respectively. Transmitter weight was not to exceed 3% of the bull trout body weight: 11g radio (for bull trout > 366g), 8g radio (for bull trout > 266g), and 3.6g radio (for bull trout > 120g). Bull trout weighing less than 120g were not implanted with radios.

When using PIT tags, ODFW district biologist requested that fish to be no less than 150 millimeters fork length. PIT tag injectors and 1 ¼ inch X 12 gauge injector needles purchased from BioMark Inc. were used to insert PIT tags into the subcutaneous area of the dorsal fin.

The Malheur Bull Trout Working Group set the maximum target of 20 bull trout to be collected and radio tagged in the Upper Malheur River at the weir trap site (RK 304). Radio tagged bull trout were released at the site of capture.

Captured bull trout were anesthetized with MS 222 (tricaine methanesulfonate), measured (fork length in mm), and weighed (g). Radio transmitters were inserted internally through a midline internal incision (Ross and Kleiner 1982). The external whip antennas were threaded through the body cavity and exited behind the pelvic fin, during which time the gills were bathed with diluted MS 222 (60 mg / liter) using a suction apparatus (Turkey Baster). Absorbable surgical sutures and super glue were used to seal the incision. After surgery, fish were held in fresh water until equilibrium was recovered, then released back into the river. Fish tank aerators were used in all holding buckets to provide increased oxygen levels during recovery and when anesthetizing fish.

Radio Telemetry

The tracking of radio tagged bull trout was conducted on an average of four times a week to obtain frequent locations of each fish. An ATS receiver, Yagi antenna, and a 12 channel hand-held GPS unit were used to locate fish. Foot travel and a vehicle were the primary means to track individual fish. Visual identification for the fish was preferred but rarely possible. The frequency of each fish, time located, and Universal Transverse Mercator (UTM) location were recorded for all positive identifications. Aerial surveys were conducted from a fixed winged aircraft when observations of tagged fish were less than expected. Bull trout were also located by angling or by capture in the weir trap. If applicable, additional information was taken on fish locations including stream temperatures, habitat characteristics, redds or pairing fish, and cover present.

Results

Fish Collection

The weir trap was set on 31 May 2000 on the Upper Malheur River at RK 304 located just downstream from the confluence of Bosonberg Creek and the Upper Malheur River (Figure 1). Ice buildup on the weir compromised its effectiveness to capture fish. On 21 October 2000, ice blew out two panels of the weir trap. The trap was then dismantled on 22 October 2000. Between 01 June 2000 and 22 October 2000, the weir trap collected 66 bull trout including recaptures (Table 1). Twenty bull trout that were collected from the trap were implanted with radio tags (Table 2). The target of 20 implanted fish with radios was achieved by 26 June 2000.

Table 1 – Bull trout collection in the upper Malheur River basin during the 2000 field season.

	Weir Trap	Angling	Total
Number of Bull Trout Caught	66	6	72

Table 2 – The table is a list of bull trout that were radio tagged in 2000. All fish were collected at the weir trap (RK 304).

Date of Implant	**Radio Frequency**	**Weight (g)**	**Fork Length (mm)**	**Maximum Distance Traveled above weir trap (km)**
6/3/00	151.552	604	357	9
6/5/00	151.223	713	396	13
6/5/00	150.922	189	275	5
6/5/00	150.983	155	241	14
6/5/00	151.869*	581	378	1
6/5/00	151.881	472	358	14
6/7/00	151.151	276	295	13
6/7/00	151.893	607	387	14
6/19/00	150.584	880	417	14
6/19/00	151.633	303	314	8
6/19/00	151.851	732	408	14
6/21/00	151.134	188	270	0
6/21/00	151.204	290	301	12
6/21/00	151.363	446	310	14
6/21/00	151.703	NA**	370	13
6/21/00	151.869*	NA**	336	12
6/22/00	150.683	NA**	279	7
6/22/00	151.295	NA	297	14
6/26/00	151.171	136	240	0
6/26/00	151.195	309	305	13

** 151.869 was recovered in a dead fish one week after radio implant surgery. The radio transmitter was sterilized and put into a new bull trout on 6/21/00.*
***Weigh scale was not functioning. Weights were not taken on these fish.*

Sixty-three bull trout were caught the first ten weeks of operation (Figure 2). The fork length of bull trout ranged from 117 to 455 mm. Bull trout were primarily caught in the upstream trap from 01 June 2000 to 02 August 2000. During this period, bull trout collected in the upstream trap box represent 78% of the total catch. Four of the ten bull trout collected in the downstream trap box were recaptured in the upstream box.

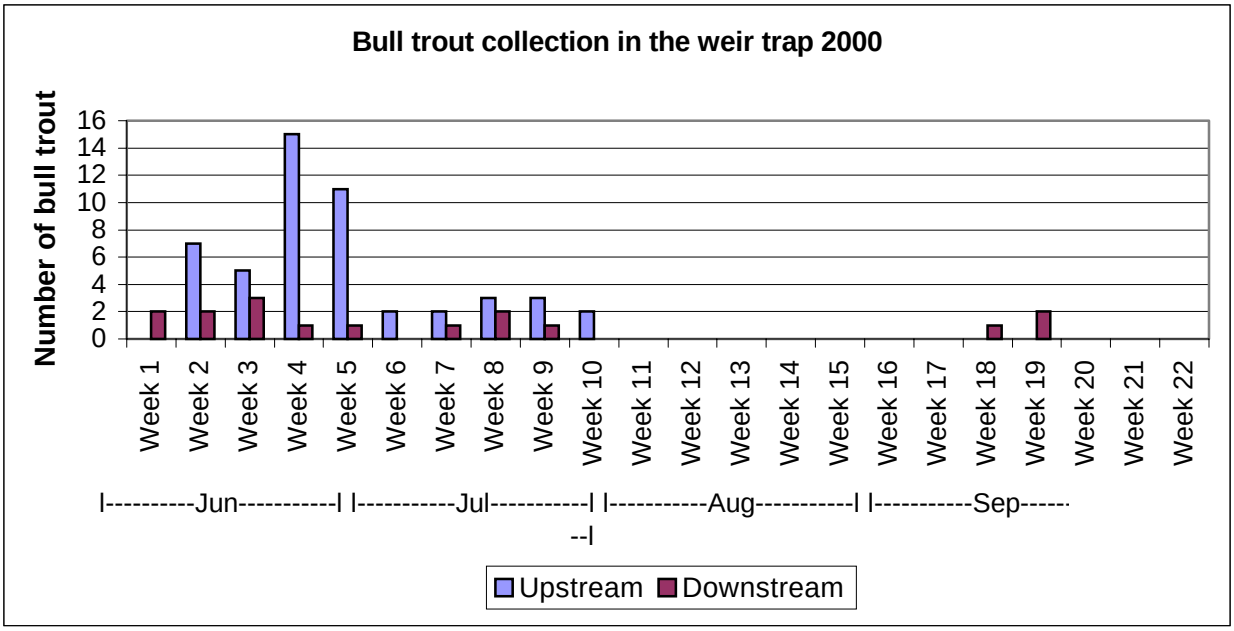


Figure 2 – Summary of bull trout catch for the weir trap in 2000. Weekly counts are figured by weekly upstream trapbox catch, weekly downstream trapbox catch, and total weekly catch.

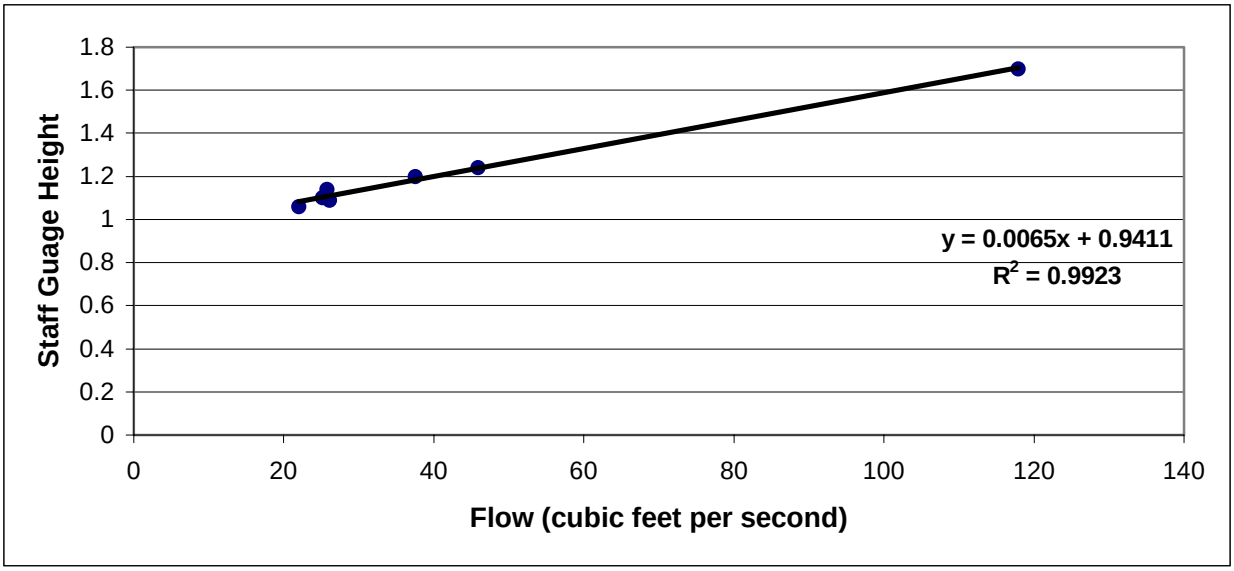


Figure 3 – Staff gauge readings were taken with every flow measurement. A total of seven flow measurements were taken from June 1, 2000 to August 30, 2000. Staff gauge height was plotted against flow. A significant relationship between the staff gauge and flow is evident.

No bull trout were collected for a 7-week period from 03 August 2000 to 23 September 2000. Three bull trout were collected in late September and early October in the downstream trap. No bull trout were caught in the upstream trap during this time period.

Other species caught in the weir trap on the Upper Malheur include: brook trout *Salvelinus fontinalis*, redband trout *Oncorhynchus mykiss*, mountain whitefish *Prosopium williamsoni*, bridgelip suckers *Catostomus columbianus*, speckled dace *Rhinichthys osculus*, longnose dace *Rhinichthys cataractae*, sculpin *Cottus spp*., and redside shiners *Richardsonius balteatus*.

A total of seven discharge readings were taken from 09 June 2000 to 31 August 2000. The staff gauge height was plotted against the associated discharge reading. A significant relationship between the staff gauge and discharge readings is evident ($y=0.0065x + 0.9411$: $R^2 = 0.9923$)(Figure 3). The regression equation was used to convert 142 daily staff gauge heights recorded to estimated daily flow for the Upper Malheur River below the weir trap (Figure 5). Daily staff gauge readings were taken from 02 June 2000 to 21 October 2000.

Telemetry Results

A total of 343 telemetry observations were documented between 01 June 2000 to 10 January 2001 (Table 3). Most of the tracking effort was done by foot and by vehicle. The US Forest Service and the Tribe conducted two aerial tracking flights by fixed wing aircraft for radio tagged bull trout. One flight on was conducted 11 August 2000 and the other following on 04 January 2001. No fish were detected during the flight of 04 January 2001.

Table 3 – Number of tracking observations during 2000.

Foot Observations	**Vehicle Observations**	**Plane Observations**	**Total Observations**
318	11	14	**343**

Radio tagged bull trout that were released below the weir were all located above the trap by 22 July 2000. Fish were observed in the Upper Malheur River, Big Creek, Meadow Fork Big Creek, and Snowshoe Creek. No observations were noted in Lake Creek or its tributaries (Figure 4).

Tracking observations in July 2000 to mid August 2000 documented fish migrating upstream. The uppermost observation for each individual bull trout occurred from July 25th to September 13th. Fish were located up to 15 km above the trap site (Figure 6). Tracking observations in late August 2000 and early September find fish migrating downstream. This migration trend continued throughout the rest of the study period. By the end of November, fish were observed as far as 7 km below the weir trap site near the Malheur Ford Crossing (RK 296). Monthly observations of radio tagged bull trout can be viewed in Appendix A.

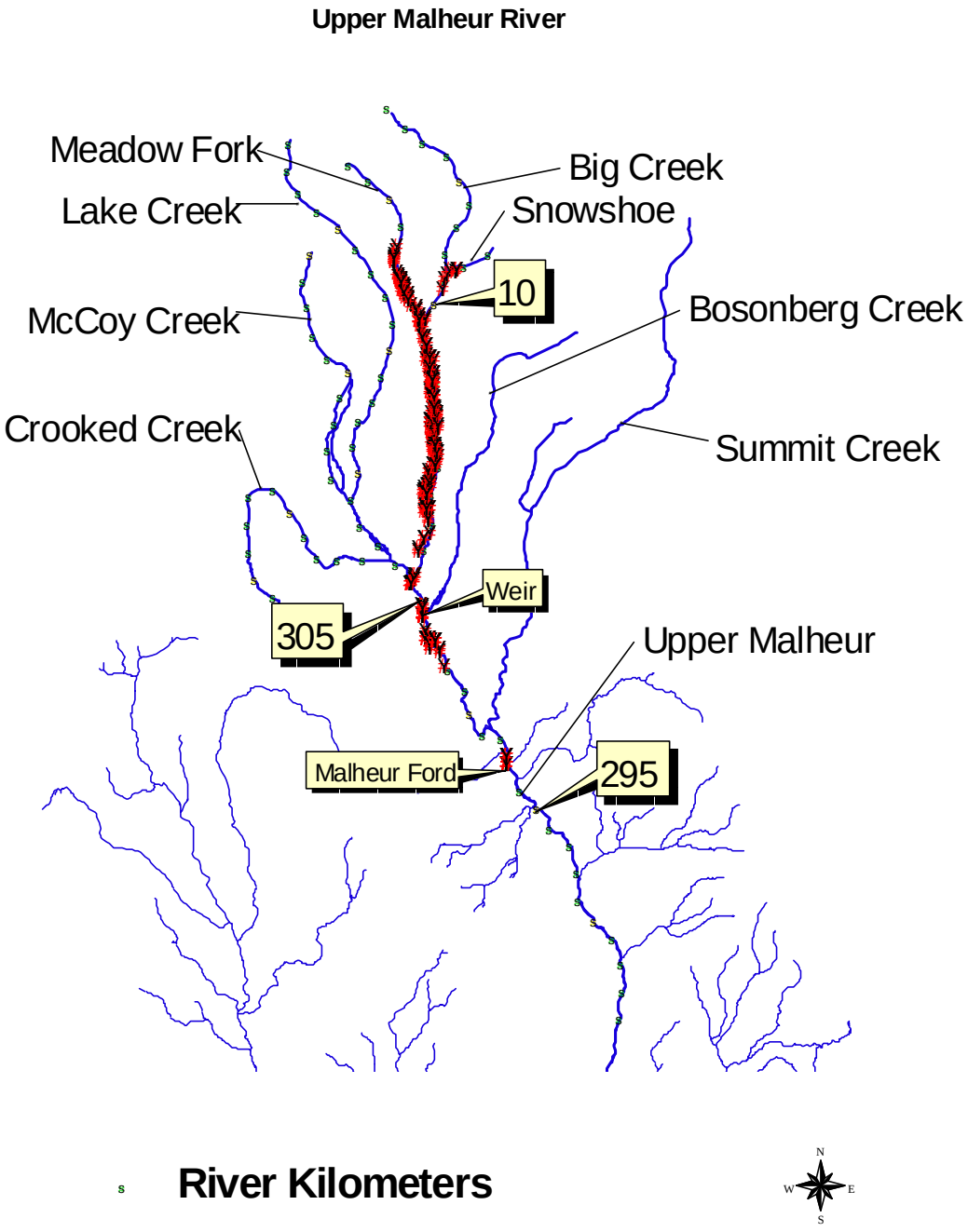


Figure 4. All Radio Tagged Bull Trout Telemetry Observation for 2000.

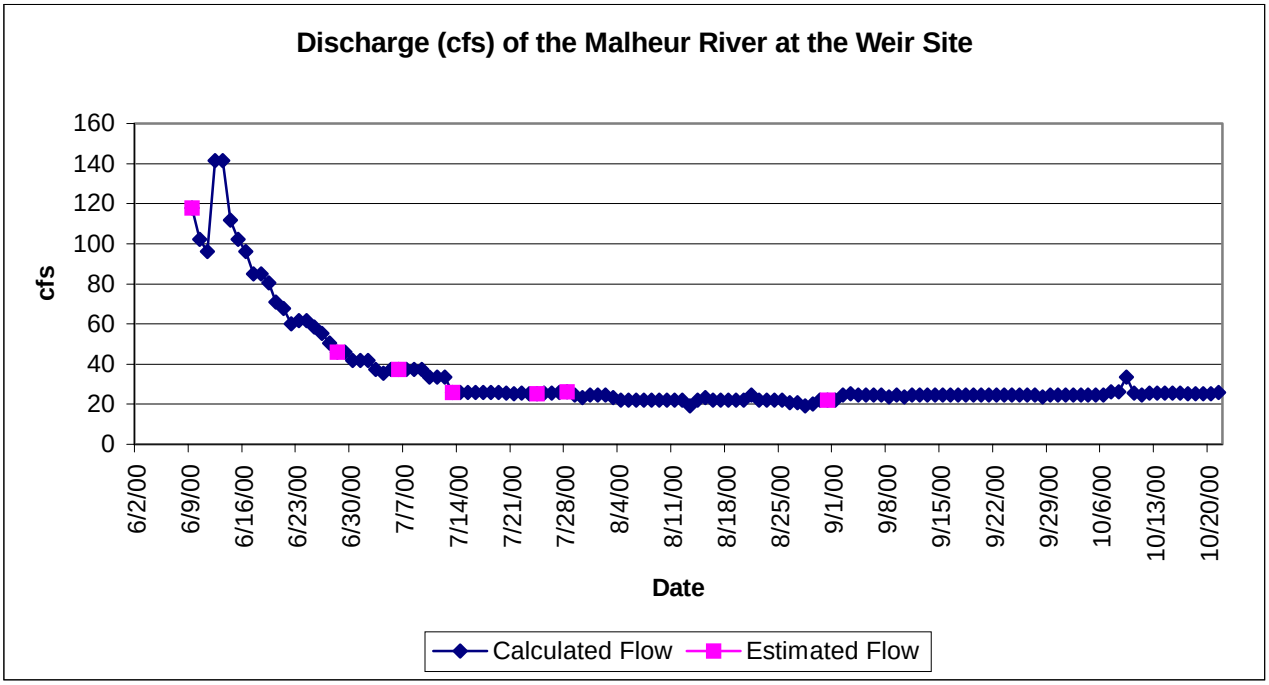


Figure 5 – Using the equation y=0.0065x + 0.9411, a calculated flow of the Upper Malheur River at the weir trap site can be determined. Estimated discharge was taken using a Marsh-McBirney,Inc. flow meter and an estimate flow was determined.

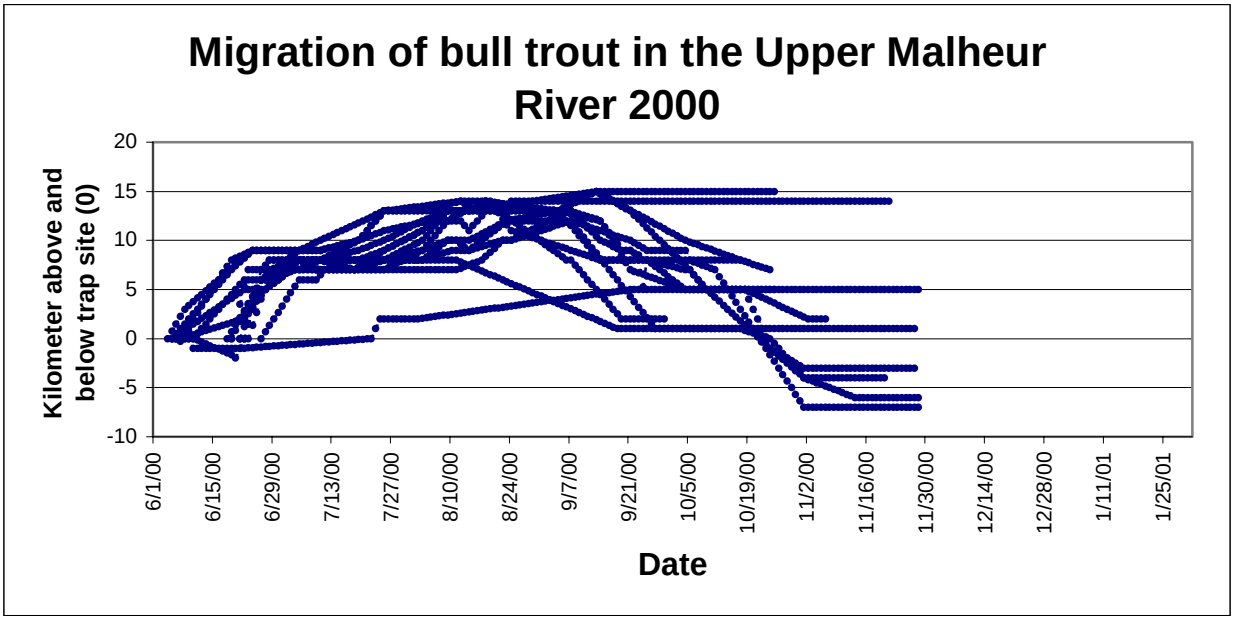


Figure 6 – 2000 bull trout migration. Graph includes all fish tracking observations during the field season of 2000.

Discussion

Fish Collection

Data from the weir trap suggest that bull trout were migrating upstream from the Malheur River below RK 304 in June through early July. Peak collection at the weir site occurred during the fourth week of trap operation. This may not represent peak migration of bull trout at RK 304 because the weir was set in late May and there is no data for migration of bull trout for the month of May.

Six bull trout caught in the downstream trap between 03 June 2000 and 02 August 2000 were not recaptured in the upstream trap box. These fish ranged from 181 to 314 mm in fork length. It is still undetermined if these fish migrated back upstream through a gap in the weir, were lost to predation, or have over summered in the reaches below the weir trap (RK 304).

Appendix B is comprised of data collected from 2000 that includes daily flow cubic feet per second (cfs), as well as daily and total counts of bull trout. The flow regime is dominated by a falling hydrograph during the study period. Though undetermined, temperature may provide a more significant role in bull trout migration. The temperature gauge at the weir site malfunctioned but will be replaced for the 2001 field season.

Telemetry

Preliminary results from our first year of study on the Upper Malheur River suggest bull trout are migrating upstream from below RK 304 in June through early August. Our data suggest that migratory bull trout in this system were limited to the Big Creek drainage although in previous studies bull trout have been documented in the upper reaches of Lake Creek (Bowers et al. 1993). Of the combined total (20); 12 fish continued their migration into the Meadow Fork of Big Creek, 1 fish observed in Snowshoe Creek (a tributary of Big Creek), and 2 remained in the mainstem of Big Creek (RK 4 to 7)(Table 4). The remaining 5 radioed fish are believed to be lost to predation or anglers.

Table 4 – Number of radio tagged bull trout that were found in the following drainages. It is assumed that these fish have spawned in these drainages.

Drainage	**Number of Radio tagged Bull trout**
Meadow Fork	12
Big Creek	2
Snowshoe Creek	1

Spawning destinations for five fish were not determined due to the lack of data. Two fish experienced pre-spawn mortality, two fish were not detected through radio telemetry after

release (3.6 gram radios), and one fish was tracked in Big Creek to Forest Service road 1648 (RK 13) on 10 July 2000 after which the fish was never detected.

Soon after spawning, bull trout were observed migrating downstream in late August and into September. Fish continued to migrate downstream and were observed near the Malheur Ford (RK 297) by the end of November. Due to the smaller radios used for implantation, many radios were undetectable by the end of November.

It is still unknown how far downstream these bull trout migrate. Some of the 3.6 gram tags from ATS Inc. were difficult to track, two of which were not tracked after the fish were released from surgery. Tracking of the remaining fish will continue in 2001 to determine over wintering areas for bull trout in the Upper Malheur River.

Bull trout collected at the weir site in 2000 were much larger than anticipated. The larger bull trout (>315 mm in fork length) collected on the North Fork Malheur River basin in 1998 and 1999 resemble in size and weight of the larger bull trout collected in the Upper Malheur River in 2000. Over 90% of the larger bull trout sampled from the North Fork Malheur River basin were collected in Beulah Reservoir. Local fishery managers suspect that they over winter in a larger body of water. In its current condition, the Upper Malheur River above Warm Springs Reservoir does not have suitable habitat, water quality, and /or prey base to sustain a healthy population of bull trout. It is assumed that bull trout in the Upper Malheur River are able to migrate down to Warm Springs Reservoir. Though migration corridors have been altered by the development of push up dams and diversions, migration down to Warm Springs Reservoir is possible at certain times of the year. With larger radio use in 2001, we anticipate to get a better idea on where and when bull trout of the Upper Malheur River migrate and over winter.

Acknowledgements

A special thanks is extended to: Wayne Bowers (ODFW), Ray Perkins (ODFW), Rick Rieber (BOR), and Allen Mauer (USFS) who donated equipment, knowledge, and time to the project; Sarah Bush (USFS) for her time tracking fish and GIS mapping skills; Mark Tiley (BPT), Newton Skunkcap (BPT), Garrett Sam (BPT), and Jason Fenton (BPT) who spent hours of data collection in the field; and Cynthia Tate (BLM) for her participation in the work group. Bonneville Power Administration provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this study.

References

Bowers, W., P. Dupee, M. Hanson, and R. Perkins. 1993. Bull trout population summary Malheur River Basin. Unpublished Data. Oregon Department of Fish and Wildlife. Hines, OR.

Buchanan, D.V., M.L. Hanson, and R.M. Hooton. 1997. Status of Oregon's bull trout. Oregon Department of Fish and Wildlife, Portland.

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout population in Oregon. In: Howell P.J.; Buchanan, D.V. eds. Proceedings of the Gearhart Mountain bull trout worshop. Corvallis, R: Oregon Chapter of the American Fisheries Society; 37-44.

Ross, M.J. and C.F.Kleiner. 1982. Sheilded – neddle techniques for surgically implanting radio – frequency transmitters in fish. Progressive Fish – Culturist 44(1): 41 – 43.

Appendix A.

Daily staff gauge heights and assosiated flow readings, bull trout counts in both trapboxes and total year counts in respective trapboxes.

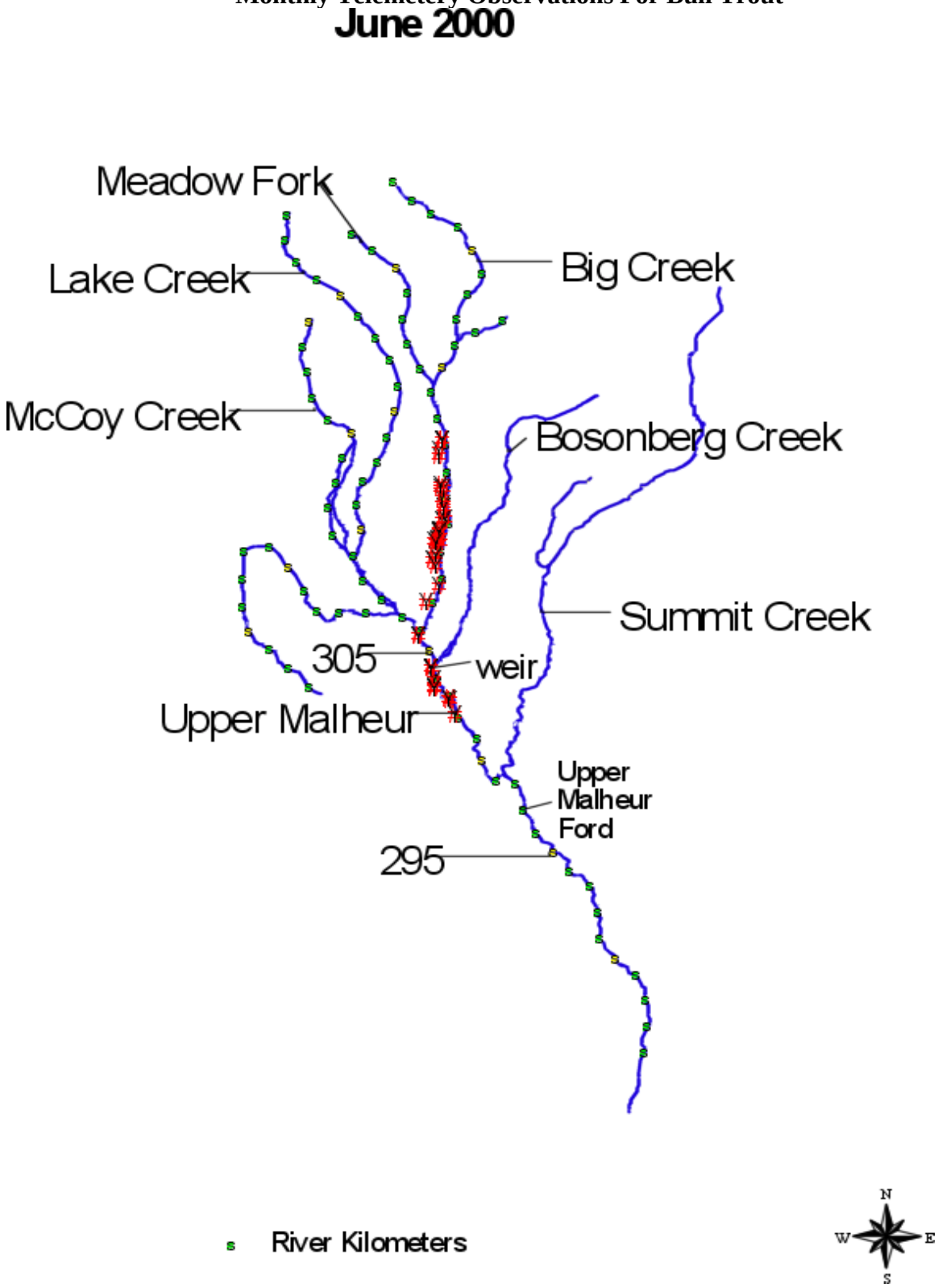
Date	Flow CFS	Staff Gauge	Upstream Count		Downstream Count	
			Daily Count	Total Count	Daily Count	Total Count
6/1/00	**NA**	**NA**	**0**	**0**	**0**	**0**
6/2/00	**NA**	**NA**	**0**	**0**	**1**	**1**
6/3/00	**NA**	**NA**	**0**	**0**	**1**	**2**
6/4/00	**NA**	**NA**	**0**	**0**	**1**	**3**
6/5/00	**NA**	**NA**	**5**	**5**	**0**	**3**
6/6/00	**NA**	**NA**	**2**	**7**	**0**	**3**
6/7/00	**NA**	**NA**	**0**	**7**	**0**	**3**
6/8/00	**NA**	**NA**	**0**	**7**	**0**	**3**
6/9/00	117.9	1.70	0	7	0	3
6/10/00	102.2	1.60	0	7	1	4
6/11/00	96.0	1.56	0	7	1	5
6/12/00	141.4	1.85	0	7	0	5
6/13/00	141.4	1.85	0	7	1	6
6/14/00	111.6	1.66	0	7	0	6
6/15/00	102.2	1.60	2	9	0	6
6/16/00	96.0	1.56	1	10	0	6
6/17/00	85.0	1.49	2	12	1	7
6/18/00	85.0	1.49	1	13	0	7
6/19/00	80.3	1.46	1	14	0	7
6/20/00	70.9	1.40	2	16	0	7
6/21/00	67.8	1.38	4	20	0	7
6/22/00	60.0	1.33	3	23	1	8
6/23/00	61.6	1.34	2	25	0	8
6/24/00	61.6	1.34	2	27	0	8
6/25/00	58.4	1.32	1	28	1	9
6/26/00	55.3	1.30	0	28	0	9
6/27/00	50.6	1.27	2	30	0	9
6/28/00	45.9	1.24	2	32	0	9
6/29/00	45.9	1.24	2	34	0	9
6/30/00	41.7	1.22	2	36	0	9
7/1/00	41.7	1.22	2	38	0	9
7/2/00	41.7	1.22	2	40	0	9
7/3/00	37.5	1.20	1	41	0	9
7/4/00	35.4	1.19	0	41	0	9
7/5/00	37.5	1.20	0	41	0	9
7/6/00	37.5	1.20	0	41	0	9
7/7/00	37.5	1.20	0	41	0	9
7/8/00	37.5	1.20	0	41	0	9
7/9/00	37.5	1.20	0	41	0	9
7/10/00	33.6	1.18	1	42	0	9
7/11/00	33.6	1.18	0	42	0	9
7/12/00	33.6	1.18	0	42	1	10
7/13/00	25.8	1.14	0	42	0	10

7/14/00	25.8	1.14	0	42	0	10
7/15/00	25.8	1.14	1	43	0	10
7/16/00	25.8	1.14	0	43	0	10
7/17/00	25.8	1.14	2	45	0	10
7/18/00	25.8	1.14	0	45	2	12
7/19/00	25.8	1.14	0	45	0	12
7/20/00	25.5	1.12	0	45	0	12
7/21/00	25.3	1.10	0	45	0	12
7/22/00	25.5	1.12	1	46	0	12
7/23/00	25.2	1.09	1	47	0	12
7/24/00	25.2	1.09	0	47	0	12
7/25/00	25.4	1.09	0	47	0	12
7/26/00	25.7	1.09	1	48	0	12
7/27/00	25.9	1.09	1	49	0	12
7/28/00	26.1	1.09	0	49	0	12
7/29/00	24.7	1.08	0	49	0	12
7/30/00	23.4	1.07	0	49	0	12
7/31/00	24.7	1.08	1	50	0	12
8/1/00	24.7	1.08	0	50	0	12
8/2/00	24.7	1.08	1	51	0	12
8/3/00	23.4	1.07	0	51	0	12
8/4/00	22.0	1.06	0	51	0	12
8/5/00	22.0	1.06	0	51	0	12
8/6/00	22.0	1.06	0	51	0	12
8/7/00	22.0	1.06	0	51	0	12
8/8/00	22.0	1.06	0	51	0	12
8/9/00	22.0	1.06	0	51	0	12
8/10/00	22.0	1.06	0	51	0	12
8/11/00	22.0	1.06	0	51	0	12
8/12/00	22.0	1.06	0	51	0	12
8/13/00	19.3	1.04	0	51	0	12
8/14/00	22.0	1.06	0	51	0	12
8/15/00	23.4	1.07	0	51	0	12
8/16/00	22.0	1.06	0	51	0	12
8/17/00	22.0	1.06	0	51	0	12
8/18/00	22.0	1.06	0	51	0	12
8/19/00	22.0	1.06	0	51	0	12
8/20/00	22.0	1.06	0	51	0	12
8/21/00	24.7	1.08	0	51	0	12
8/22/00	22.0	1.06	0	51	0	12
8/23/00	22.0	1.06	0	51	0	12
8/24/00	22.0	1.06	0	51	0	12
8/25/00	22.0	1.06	0	51	0	12
8/26/00	20.6	1.05	0	51	0	12
8/27/00	20.6	1.05	0	51	0	12
8/28/00	19.3	1.04	0	51	0	12
8/29/00	20.0	0.00	0	51	0	12
8/30/00	22.0	1.06	0	51	0	12

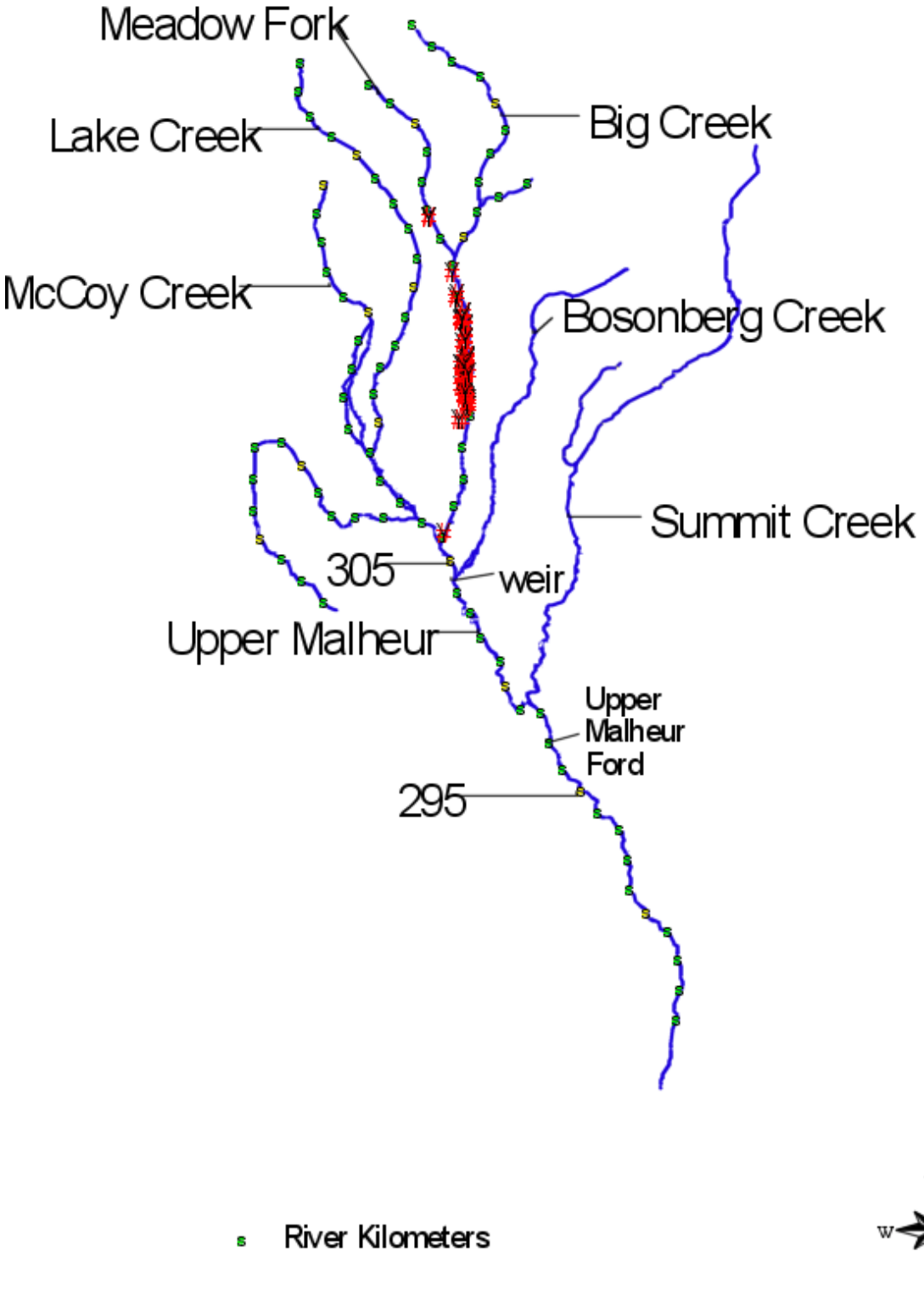
8/31/00	22.0	1.06	0	51	0	12
9/1/00	22.0	1.06	0	51	0	12
9/2/00	24.7	1.08	0	51	0	12
9/3/00	25.3	1.10	0	51	0	12
9/4/00	24.7	1.08	0	51	0	12
9/5/00	24.7	1.08	0	51	0	12
9/6/00	24.7	1.08	0	51	0	12
9/7/00	24.7	1.08	0	51	0	12
9/8/00	23.7	1.07	0	51	0	12
9/9/00	24.7	1.08	0	51	0	12
9/10/00	23.7	1.07	0	51	0	12
9/11/00	24.7	1.08	0	51	0	12
9/12/00	24.7	1.08	0	51	0	12
9/13/00	24.7	1.08	0	51	0	12
9/14/00	24.7	1.08	0	51	0	12
9/15/00	24.7	1.08	0	51	0	12
9/16/00	24.7	1.08	0	51	0	12
9/17/00	24.7	1.08	0	51	0	12
9/18/00	24.7	0.00	0	51	0	12
9/19/00	24.7	1.08	0	51	0	12
9/20/00	24.7	1.08	0	51	0	12
9/21/00	24.7	1.08	0	51	0	12
9/22/00	24.7	1.08	0	51	0	12
9/23/00	24.7	1.08	0	51	0	12
9/24/00	24.7	1.09	0	51	0	12
9/25/00	24.7	1.08	0	51	1	13
9/26/00	24.7	1.08	0	51	0	13
9/27/00	24.7	1.08	0	51	0	13
9/28/00	23.7	1.07	0	51	0	13
9/29/00	24.7	1.08	0	51	0	13
9/30/00	24.7	1.08	0	51	0	13
10/1/00	24.7	1.08	0	51	0	13
10/2/00	24.7	1.08	0	51	0	13
10/3/00	24.7	1.08	0	51	0	13
10/4/00	24.7	1.08	0	51	0	13
10/5/00	24.7	1.08	0	51	0	13
10/6/00	24.7	1.08	0	51	0	13
10/7/00	26.1	1.09	0	51	2	15
10/8/00	26.1	1.09	0	51	0	15
10/9/00	33.5	1.17	0	51	0	15
10/10/00	25.5	1.12	0	51	0	15
10/11/00	24.7	1.09	0	51	0	15
10/12/00	25.5	1.12	0	51	0	15
10/13/00	25.5	1.12	0	51	0	15
10/14/00	25.5	1.12	0	51	0	15
10/15/00	25.5	1.12	0	51	0	15
10/16/00	25.5	1.12	0	51	0	15
10/17/00	25.3	1.10	0	51	0	15

10/18/00	25.3	1.10	0	51	0	15
10/19/00	25.3	1.10	0	51	0	15
10/20/00	25.3	1.10	0	51	0	15
10/21/00	25.8	1.14	0	51	0	15

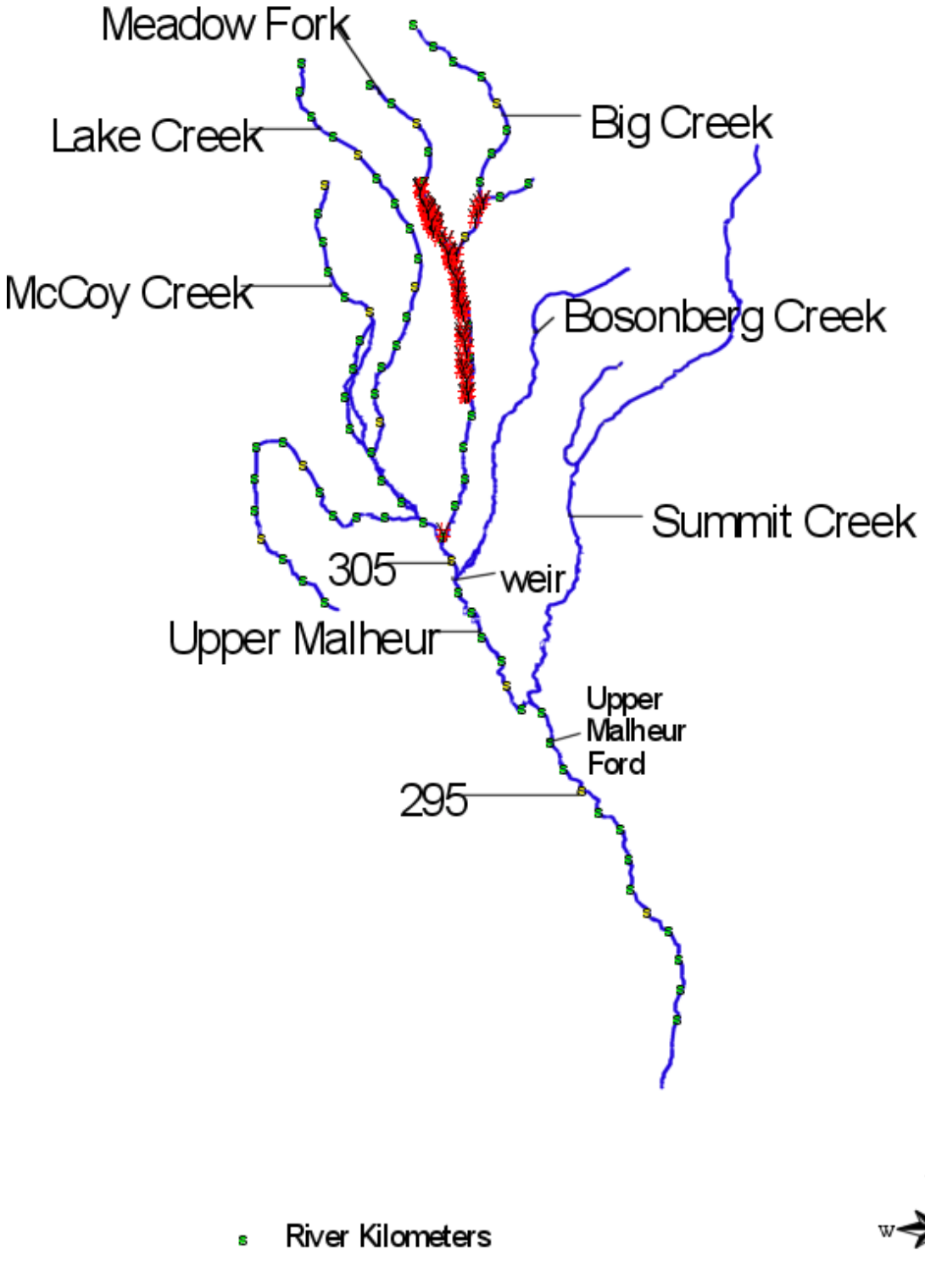
Appendix B.
Monthly Telemetery Observations For Bull Trout



July 2000


Meadow Fork
Lake Creek
Big Creek
McCoy Creek
Bosonberg Creek
Summit Creek
305
weir
Upper Malheur
Upper Malheur Ford
295
River Kilometers
N
W
E
S

August 2000


Meadow Fork
Lake Creek
Big Creek
McCoy Creek
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Summit Creek
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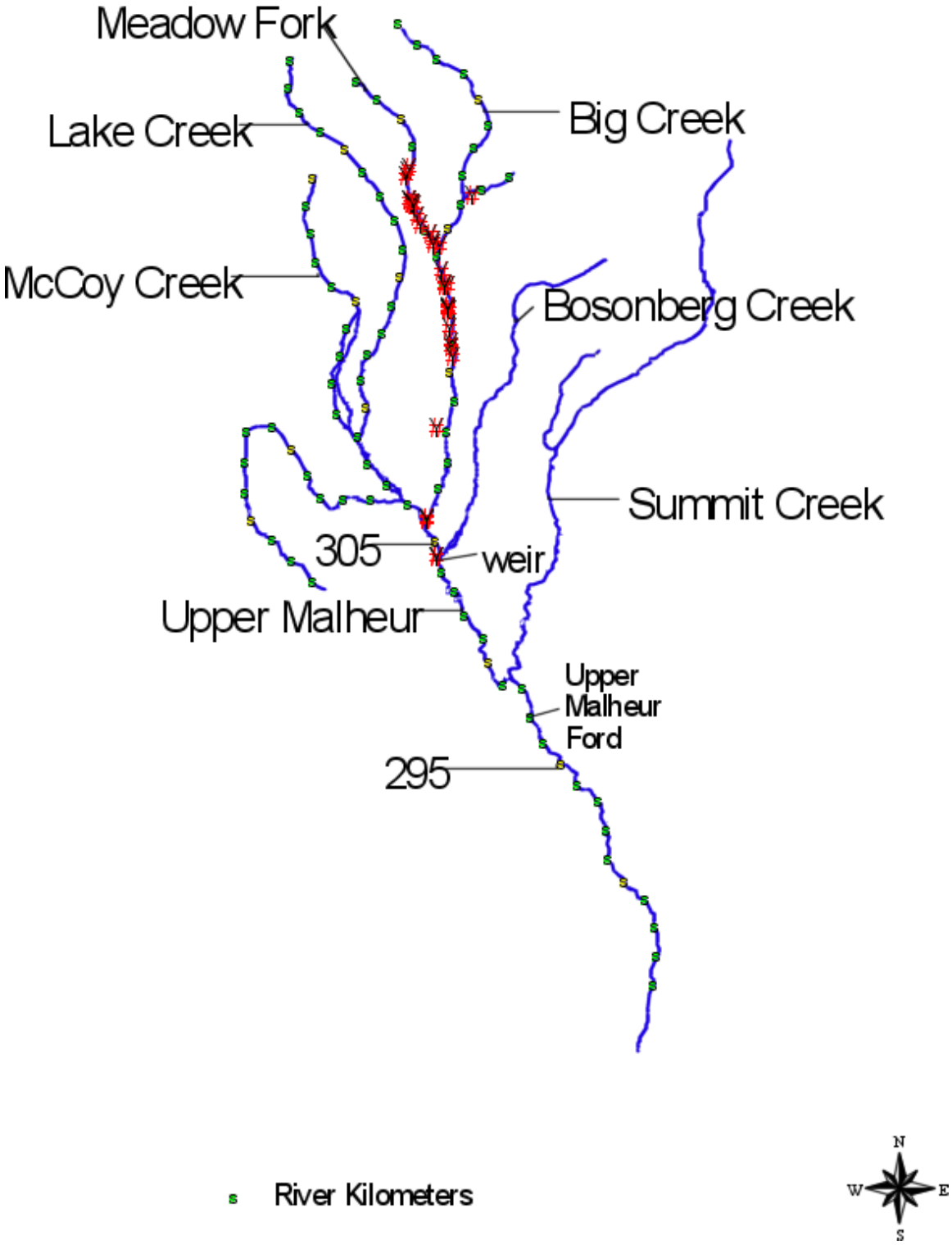
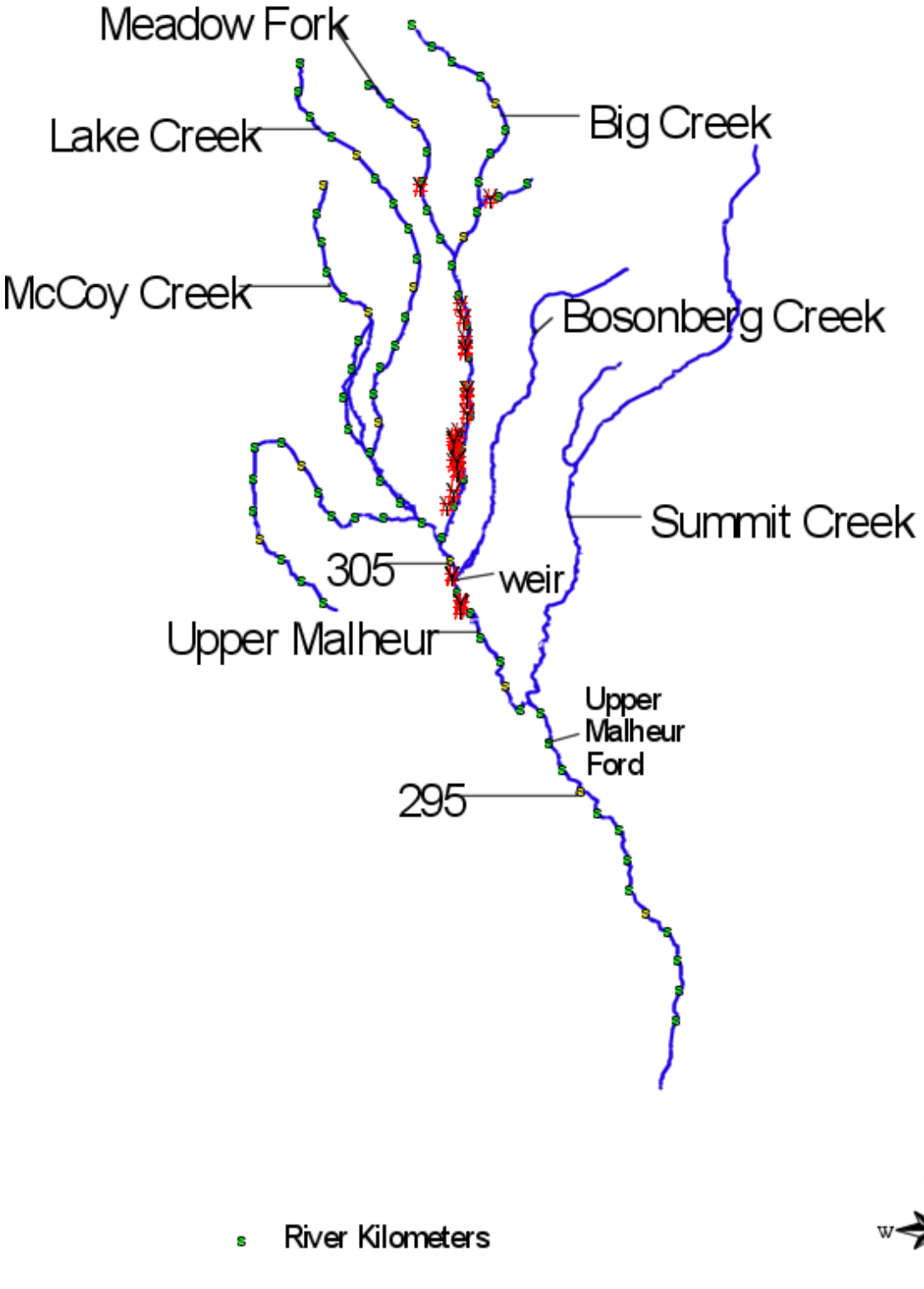
weir
Upper Malheur
Upper Malheur Ford
295
River Kilometers
N
W
E
S

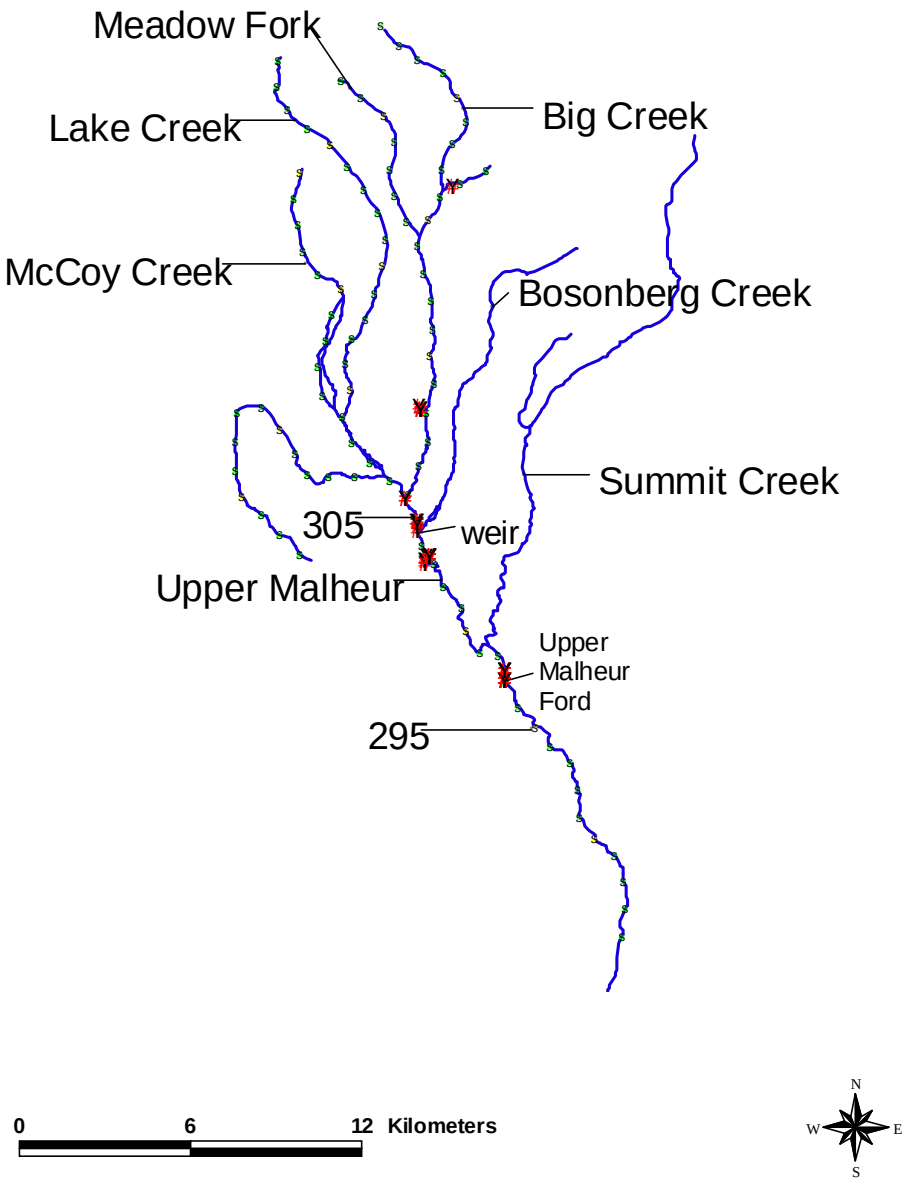
September 2000



October 2000



November 2000



Bull Trout Spawning Survey Report, 2000
Malheur Fish District

Bill Tinniswood and Ray Perkins

April 24, 2001

INTRODUCTION

Bull trout (*Salvelinus confluentus*) spawning surveys by ODFW began in 1992. There are four main objectives for this study. The first three objectives apply to both watersheds. Objectives one, two, and three were to determine timing, location, and numbers of spawning bull trout. Objective four applies specifically to the upper Malheur River watershed. It was to try and determine timing and location of brook trout spawning.

METHODS

Spawning surveys were completed on streams in the Upper Malheur and North Fork Malheur watershed streams known or suspected to support bull trout populations. Streams were surveyed from 29-31 August, 12-14 September, and 26-28 September. A fourth spawning survey was completed on streams in the Upper Malheur River watershed on 11-12 October.

Two or more people surveyed stream sections in an upstream direction. There was at least one experienced surveyor per team. Usually one member of each team walked on each side of the stream. Each crew used a GPS unit to record coordinates at the start and end of each stream section, redds, brook trout, and positively identified bull trout. Each GPS unit was set to record coordinates in decimal degrees or decimal minutes and the datum to NAD 1983. All redds, except for the last survey, were flagged for future reference and marked on a 7.5' quadrangle map. The estimated size (inches) of each bull trout positively identified was recorded. All GPS coordinates were entered into Arcview 3.1 and mapped.

RESULTS

North Fork Malheur River Watershed

North Fork Malheur River

The upper North Fork Malheur was surveyed three times in 2000. The survey began at the mouth of Deadhorse Creek and ended 3.5 miles upstream at the headwater spring (Appendix Figure A-1). Six redds and two bull trout were observed on 29 August, ten redds and no bull trout were observed on 12 September, and no redds and four bull trout were observed on 26 September (Table 1).

Table 1. Bull trout redds observed in the mainstem of the North Fork Malheur River.

YEAR	REDDS	MILES	REDDS/MILE
1992[a]	1	5.9	0.2
1993	1	15.5	0.1
1994	0	7.3	0.0
1995	0	6.0	0.0
1996	6	3.9	1.5
1997	10	2.3	4.4
1998	3	3.8	0.8
1999	9	3.5	2.6
2000	16	3.5	4.3

[a]- Does not include 14 questionable redds observed by volunteers included in earlier reports.

Horseshoe Creek

Horseshoe Creek was surveyed three times in 2000. The survey began at its confluence of North Fork Malheur River and ended about 0.8 miles upstream (Appendix Figure A-1). Four redds and five bull trout were observed on 29 August, three redds and no bull trout were observed on 12 September, and no redds or bull trout were observed on 26 September (Table 2).

Table 2. Bull trout redds observed in Horseshoe Creek, tributary to North Fork Malheur River.

YEAR	REDDS	MILES	REDDS/MILE
1998	4	0.4	10.0
1999	4	0.8	5.0
2000	7	0.8	6.3

Deadhorse Creek

Deadhorse Creek was surveyed twice in 2000. The survey began at its confluence of North Fork Malheur River and ended about 0.8 miles upstream (Appendix Figure A-1). No redds or bull trout were observed on 12 and 24 September (Table 3). No redds or bull trout were observed in 1999.

Table 3. Bull trout redds observed in Deadhorse Creek, tributary to North Fork Malheur River.

YEAR	REDDS	MILES	REDDS/MILE
1999	0	0.8	0.0
2000	0	0.8	0.0

Flat Creek

Flat Creek was not surveyed this year.

Swamp Creek

Upper Swamp Creek was surveyed three times in 2000 (Appendix Figure A-2). Eight redds and 16 bull trout were observed on 29 August, twenty-one redds and 39 bull trout were observed on 12 September, and six redds and 12 bull trout were observed on 26 September (Table 4). Lower Swamp was surveyed three times in 2000 (Appendix Figure A-2). Five redds and one bull trout were observed on 29 August. No redds and four bull trout were observed on 12 September, and no redds or bull trout or were observed on 26 September (Table 4).

Table 4. Bull trout redds observed in Swamp Creek, tributary to North Fork Malheur River.

YEAR	REDDS	MILES	REDDS/MILE
1992	0	1.2	0.0
1993	3	2.2	1.4
1994	9	3.9	2.3
1995	0	3.9	0.0
1996	8	3.8	2.1
1997	21	4.1	5.1
1998	24	4.2	5.7
1999	35	4.1	8.5
2000	40	4.1	9.8

Sheep Creek

The Sheep Creek survey was divided into two sections. The lower survey began at the mouth and ended about two miles upstream. The upper section began at the two-mile mark and ended near the 4-mile mark. Upper Sheep Creek was surveyed three times in 2000 (Appendix Figure A-2). One redd and three bull trout were observed on 29 August, five bull trout and no redds were observed on 12 September, and one redd and no bull trout were observed on the 26 September (Table 5). Lower Sheep Creek was surveyed three times in 2000 (Appendix Figure A-2). Nine redds and 12 bull trout were recorded on 29 August, nine redds and 14 bull trout were observed on 12 September, and five redds and seven bull trout were observed on 27 September (Table 5).

Table 5. Bull trout redds observed in Sheep Creek, tributary to North Fork Malheur River.

YEAR	REDDS	MILES	REDDS/MILE
1992	0	1.1	0.0
1993	0	2.2	0.0
1994	0	2.2	0.0
1995	2	2.9	0.7
1996	13	3.4	3.8
1997	8	2.9	2.8
1998	17	3.5	4.9
1999	22	3.0	7.3
2000	25	4.0	6.3

Elk Creek

Elk Creek was surveyed three times in 2000 (Appendix Figure A-3). The lower section started at the confluence with North Fork Malheur River and ended at North Fork and South Fork confluence. Three redds and five bull trout were observed on 30 August, no redds and six bull trout were observed on 13 September, and no redds or bull trout were observed on 28 September (Table 6). North Fork Elk Creek was surveyed three times in 2000. This section began at the confluence of the North and South Forks and ended upstream about 1 mile. No redds or bull trout were observed on 30 August, two redds and eleven bull trout were observed on 13 September, and no redds or bull trout were observed on 28 September (Table 6). South Fork Elk Creek was surveyed three times in 2000. This section began at the confluence of the North and South forks and ended upstream about ¼ mile. No redds or bull trout were observed on 30 August, no redds and two bull trout were observed on 13 September, and no bull trout or redds were observed on 28 September (Table 6).

Table 6. Bull trout redds observed in mainstem Elk Creek and North and South Forks, tributary to North Fork Malheur River.

YEAR	REDDS	MILES	REDDS/MILE
1992	1	1.0	1.0
1993	1	2.3	0.4
1994	0	2.0	0.0
1995	1	4.0	0.3
1996	3	4.1	0.7
1997	9	4.1	2.2
1998	6	3.5	1.7
1999	12	3.0	4.0
2000	5	3.0	1.7

Crane Creek

Crane Creek was not surveyed this year.

Little Crane Creek

Upper Little Crane Creek was surveyed five times in 2000 (Appendix Figure A-4). This section starts at the 16 road and ends about two miles upstream at the 1665-0498 road. This stream section was surveyed each day during the first week of surveys. This is done to try and determine how much time it takes to build a redd, how many redds a spawning pair would dig, and movement and pairing differences between days. Thirteen redds and forty-four bull trout were observed on 29 August, seven additional

redds were observed on the 30 August, another nine redds were observed on 31 August. Twenty new redds and 37 bull trout were observed on 12 September. Ten redds and nine bull trout were observed on 26 September (Table 7). Cattle use was observed on Little Crane Creek during the survey. Lower Little Crane Creek was surveyed three times in 2000 (Appendix Figure A-5). The section begins at the confluence of Little Crane and Crane creeks and ends at Forest Road 16. No redds and five bull trout were observed on 30 August, no redds and four bull trout were observed on 13 September, and one redd and no bull trout were observed on 26 September (Table 7).

Table 7. Bull trout redds observed in Little Crane Creek, tributary to North Fork Malheur.

YEAR	**REDDS**	**MILES**	**REDDS/MILE**
1992			
1993	3	5.6	0.5
1994	4	7.5	0.5
1995	6	6.0	1.0
1996	8	6.0	1.3
1997	16	4.2	3.8
1998	20	6.0	3.3
1999	33	6.1	5.4
2000	60	6.1	9.8

Cow Creek

Cow Creek was surveyed twice in 2000 (Appendix Figure A-2). This section began at the confluence of Cow Creek and the North Fork Malheur River and ended about one mile upstream. No redds and four bull trout were observed on 29 August and no redds and one bull trout was observed on 13 September.

Little Cow Creek

Little Cow Creek was surveyed twice in 2000 (Appendix Figure A-2). This section began at its confluence with Cow Creek and ended about ½ mile upstream. No redds or bull trout were observed on the 29 August or 13 September.

Bull Trout Observations

Beginning in 1999 frequency, size and location of bull trout was documented (Appendix Figure C-2). The number of bull trout observed during the surveys increased this year (Table 8). As in 1999, larger bull trout were observed on the 29-31 August survey. In the North Fork Malheur and upper Malheur watersheds 41 bull trout greater than 305mm length were observed in 2000.

Table 8. Average lengths (inches) and frequency of bull trout observed during spawning surveys on the North Fork Malheur River Watershed 29 August – 28 September.

STREAM	YEAR	1ST PASS		2ND PASS		3RD PASS		TOTAL
		N	FL	N	FL	N	FL	
Swamp Cr.	1999	25	11”	23	10”	0		48
	2000	14	12”	43	9”	12	9’	66
L. Crane Cr.	1999	37	10”	39	8”	19	8”	95
	2000	75	10”	41	9”	9	NA	94
Sheep Cr.	1999	24	8”	11	9”	8	10”	43
	2000	15	10”	19	10”	7	8”	41
Elk Cr.	1999	10	10”	5	10”	3	10”	18
	2000	5	11”	18	8”	0		24
Upper North Fork	1999	11	13”	3	8”	0		14
	2000	7	12”	0		4	9”	11
Cow Cr.	2000	4	5”	1	5”	0		5
Total	**1999**	**107**		**81**		**30**		**218**
Total	**2000**	**120**		**122**		**32**		**274**

Bull Trout Observed On Redds

A total of 44 or 29%(44/151) of redds were observed with bull trout. Redds were observed with up to five bull trout. Fifteen, twenty-two, four, two, and one redds were observed with one, two, three, four and five bull trout, respectively. Which converts into about 2.4 bull trout per redd.

Upper Malheur River Watershed

Summit Creek

Upper Summit Creek was surveyed four times in 2000 (Appendix Figure B-1). This section began at private property boundary and ended upstream about 2.3 miles. Two redds and no bull trout were observed on 30 August, eight redds and no bull trout were observed on 14 September, and thirty-three redds and no bull trout were observed on 27 September (Table 9). Forty-three redds and one bull trout were observed on 11 October. Middle Summit Creek was surveyed twice in 2000. The section began at the 1651 road and ended about 2.5 miles upstream at the forest boundary downstream of the prairie. No bull trout or redds were observed on 30 August and 28 September.

Table 9. Redds observed in Summit Creek, tributary to Upper Malheur River.

YEAR	REDDS	MILES	REDDS/MILE
1999	18	2.3	7.8
2000	43	4.8	9.0

Snowshoe Creek

Snowshoe Creek was surveyed three times in 2000 (Appendix Figure B-2). The section began at the confluence of Snowshoe and Big creeks and ended about 1.7 miles upstream. No redds or bull trout were observed on 31 August, three redds and no bull trout were observed on 13 September, and no redds and one bull trout were observed on 28 September (Table 10).

Table 10. Redds observed in Snowshoe Creek, tributary to Big Creek.

YEAR	REDDS	MILES	REDDS/MILE
1998	10	1.7	5.9
1999	25	1.7	14.7
2000	3	1.7	1.8

Big Creek

Lower Big Creek was surveyed four times in 2000 (Appendix Figure B-3). The section began at the 16 road and ended at the 1648 road. No redds or bull trout were observed on 30 August, four redds and one bull trout were observed on 14 September, and eighteen redds and one bull trout were observed on 28 September (Table 11). Nineteen redds and no bull trout were observed on 12 October. Upper Big Creek was

surveyed three times in 2000 (Appendix Figure B-3). The section began at the 1648 road and ended at the confluence with Snowshoe Creek. No redds or bull trout were observed on 30 August or 28 September, while no redds and one bull trout was observed on 13 September (Table 11).

Table 11. Redds observed in Big Creek, tributary to Upper Malheur River.

YEAR	REDDS	MILES	REDDS/MILE
1998	0	2.3	0.0
1999	8	4.6	1.7
2000	22	4.6	4.8

Meadow Fork Big Creek

Lower Meadow Fork was surveyed four times in 2000 (Appendix Figure B-4). The section began at the confluence with Big Creek and ended upstream at the trailhead. One redd and four bull trout were observed on 31 August, five redds and three bull trout on 14 September, and thirteen redds and no bull trout were observed on 27 September (Table 12). Three redds and no bull trout were observed on 12 October. Upper Meadow Fork was surveyed four times in 2000 (Appendix Figure B-4). The section began at the trailhead and ended upstream about 2 miles at the waterfall. Ten redds and seven bull trout were observed on 31 August, thirteen redds and eleven bull trout were observed on 13 September, and nine redds and six bull trout were observed on the 27 September (Table 12). Five redds and eleven bull trout were observed on 12 October.

Table 12. Redds observed in Meadow Fork Big Creek, tributary to Big Creek, from late August-late September.

YEAR	REDDS	MILES	REDDS/MILE
1998	39	3.3	11.8
1999	25	3.3	7.6
2000	51	3.3	14.8

Lake Creek

Lower Lake Creek was surveyed three times in 2000 (Appendix Figure B-5). The section started at the 1648 road and ended at the trailhead. No redds or bull trout were observed on 29 August, one redd and two bull trout were observed on 14 September, and three redds were observed on 27 September (Table 12). Upper Lake Creek was surveyed four times in 2000 (Appendix Figure B-5). The section started at the trailhead

and ended at an approximately 30-foot waterfall. Three redds and two bull trout were observed on 31 August, three redds and no bull trout were observed on 14 September, twelve redds and three bull trout were observed on 27 September (Table 13). Two redds and no bull trout were observed on 12 October (Table 13).

Table 13. Redds observed in Lake Creek, tributary to Upper Malheur River, from late August-late September, 1998-2000 Grant County, OR.

YEAR	REDDS	MILES	REDDS/MILE
1998	34	2.1	16.2
1999	21	4.3	4.9
2000	22	4.3	5.1

Bosonberg Creek

Bosonberg Creek was not surveyed this year. In 1999 Bosonberg Creek was surveyed twice and no redds or bull trout were observed.

Fish Observed On Redds

A total of 38 or 27% (38/141) redds were observed with fish. Redds were observed with up to six brook trout and three bull trout. Fourteen and eighteen redds were observed with bull trout and brook trout, respectively (Appendix Figure C-1). Two redds were observed with one brook trout and a possible bull trout but a positive identification could not be made. Fish were seen on redds but could not be identified (Table 14). In this watershed there were 2.2 bull trout per redd, which is similar to the North Fork Malheur River number.

Table 14. Frequency of bull trout and brook trout observed on redds in the Upper Malheur River watershed from late August –early October 2000, Grant County, OR.

	One Fish	Two Fish	Three Fish	Four Fish	Five fish	Six Fish	Unk. # Fish
Bull Trout	9	4	1				
Brook Trout	7	7	0	1	0	1	2
Brook Trout and unknown fish	0	2					
Unknown fish	3	1					

DISCUSSION

North Fork Malheur redd counts for the years 1992-95 were influenced by inconsistent survey techniques between years. During those years project personnel were struggling with uncertainties related to spawning timing, and location. Consequently, there was variation in timing of surveys and areas surveyed. Livestock were also abundant in spawning areas during those years making identification of redds difficult. Since 1996, survey areas and timing have been standardized. Expertise of surveyors has also increased and all are familiar with each stream. A change in livestock management has reduced stream disturbance and made redds more easily identifiable.

Generally, most streams in the North Fork Malheur showed increases in redd counts. The mainstem North Fork Malheur, Swamp Creek, Sheep Creek, and Little Crane Creek had the highest redd counts since surveys started in 1992. Little Crane showed the highest increase in redd counts at almost two-fold. However, in 1997 North Fork Malheur had a higher redd per mile count than in 2000. Elk Creek showed a large decline in redds. More redds were observed in 1997-1999 than 2000 in Elk Creek. Cattle were present during all surveys on Elk Creek.

A total of 153 redds were observed in the North Fork Malheur basin in 2000 compared to 115 redds in 1999. Sixty redds were observed on Little Crane Creek this year compared to thirty-three in 1999. Little Crane Creek was also surveyed three days in succession to determine the length of time it requires bull trout to construct redds. New

redds were observed on the second and third day suggesting bull trout construct redds in one day. It was not possible to identify individual bull trout on succeeding days to assist in determining movements or if a bull trout makes more than one redd.

Lower Sheep, Upper Swamp and Upper Little Crane Creek continue to be prime spawning areas for bull trout. Good spawning habitat seems to be concentrated in small areas of these three sites (Appendix Figure A-2). It is unknown if these areas are the only suitable spawning sites. Further research needs to be completed to get a better understanding of why bull trout spawn in these areas.

One bull trout (381mm) mortality was found on 28 September on Sheep Creek. Bull trout up to 635mm were observed on Swamp Creek. Most large bull trout were observed during the first spawning survey on the 29 August.

Cow and Little Cow Creek were surveyed for the first time this year. Only a few bull trout were observed.

Redd counts in the Upper Malheur River Watershed also increased. A total of 141 redds were observed in the first three surveys in 2000 compared to 97 redds in 1999. Upper Summit, Big Creek, and Meadow Fork Big Creek had the highest redd counts since the surveys started in 1998. Upper Summit and Meadow Fork Big Creek showed a two-fold increase. Big Creek showed close to a three-fold increase in observed redds. Snowshoe showed a large decline in observed redds. Alder is becoming increasingly thick along Snowshoe Creek which is making observing redds more difficult than in past years. The change in streamside canopy is the result of ecological change from fire disturbance.

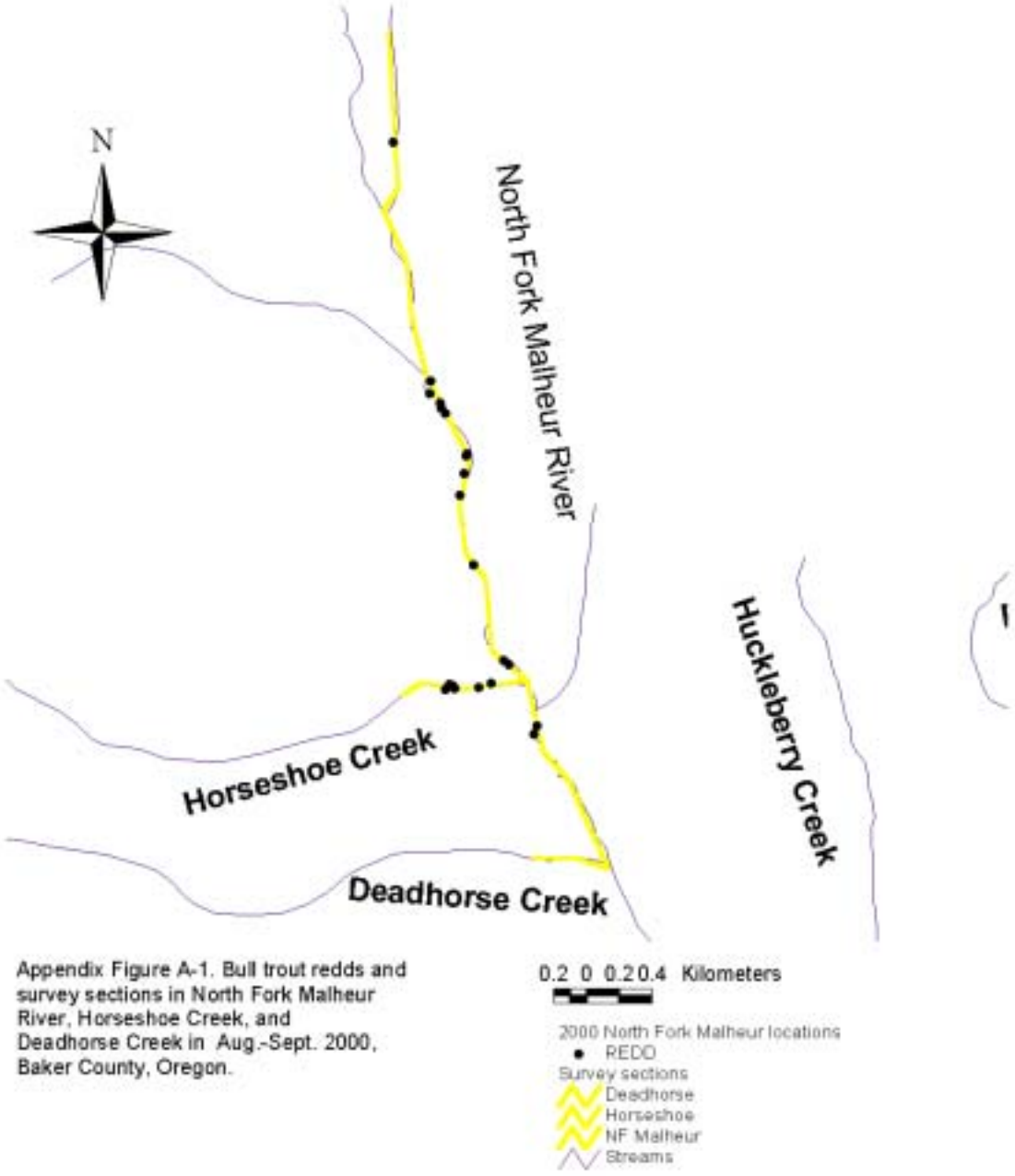
A total of 72 redds were observed on the fourth spawning survey in Upper Summit, Lower Big Creek, Upper and Lower Meadow Fork, and Upper Lake Creek. Number of redds on the fourth pass comprised almost 50% of the total observed in Lower Big Creek and Summit Creek. Very few bull trout were observed in either of these streams. The bull trout identified this year in Summit Creek is the first during spawning time and the first this high in the stream. If one assumes most of the redds on the fourth pass were made by brook trout, this suggests that peak spawning of brook trout in the Upper Malheur River Watershed occurs later than bull trout spawning. Upper Meadow Fork Creek is the only stream in the upper Malheur watershed where bull trout dominated the observations. New redds observed on Upper Meadow Fork Big Creek and the lack of brook trout observed infers low overlap between brook and bull trout spawning. Surprisingly, only two stream sections, Lower Big Creek and Upper Summit, had high brook trout redd counts while Upper Lake, Snowshoe, Lower Meadow Fork, and Upper Big Creek had very low redd counts. This might be beneficial in suppressing or eliminating brook trout in the Upper Malheur River Watershed.

Excellent water years and the prohibited take of bull trout might be some reasons why redd counts have continued to increase since 1992. Increases in water levels have increased possible habitat in Beulah Reservoir and North Fork Malheur River. Recent aggressive riparian and cattle management has also contributed improved habitat for

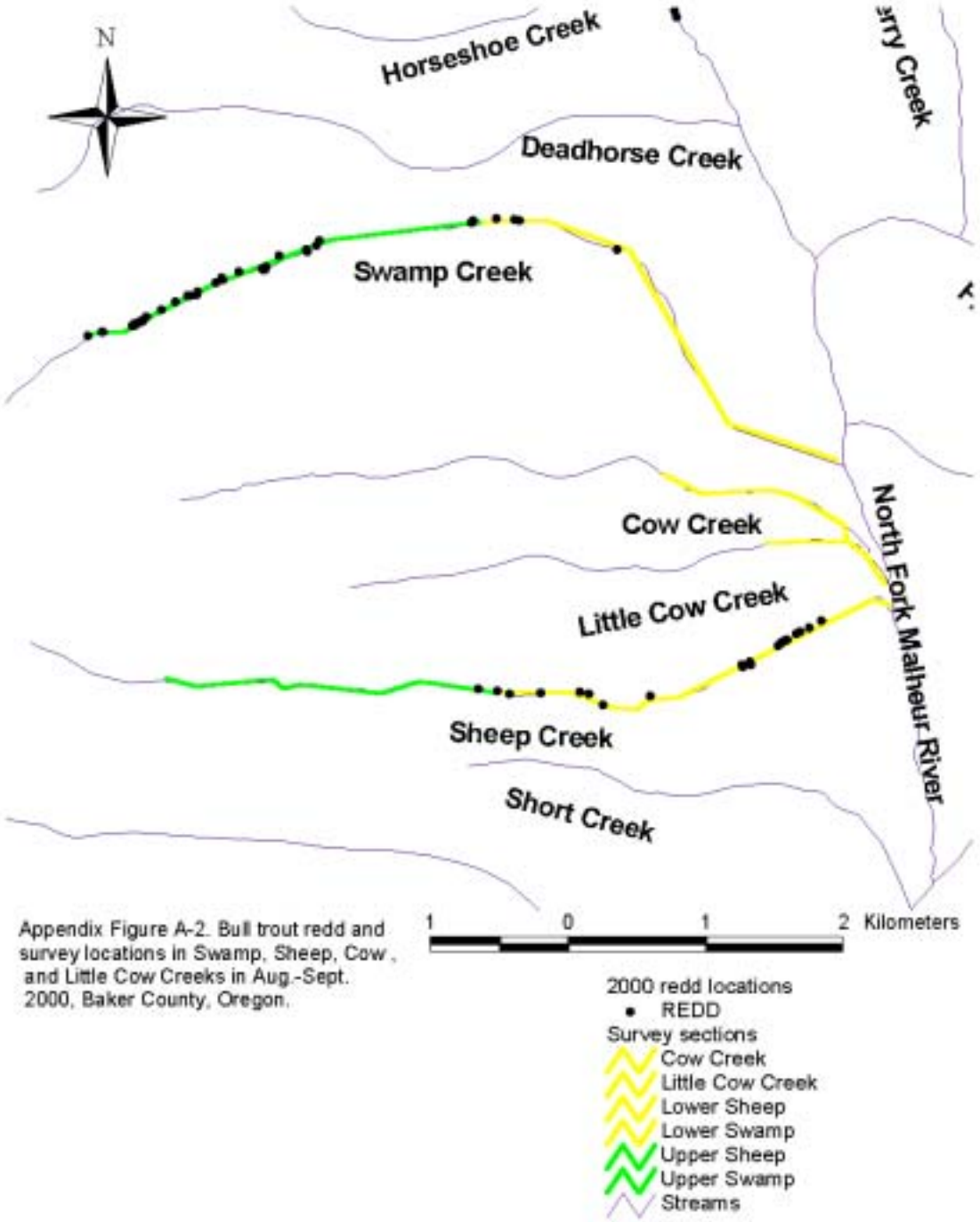
bull trout. The increase in redds on Big Creek and Upper Summit Creek, both noted for having lots of brook trout, might suggest excellent water years are more responsible for an increase in the bull trout population than prohibited take.

APPENDIX A

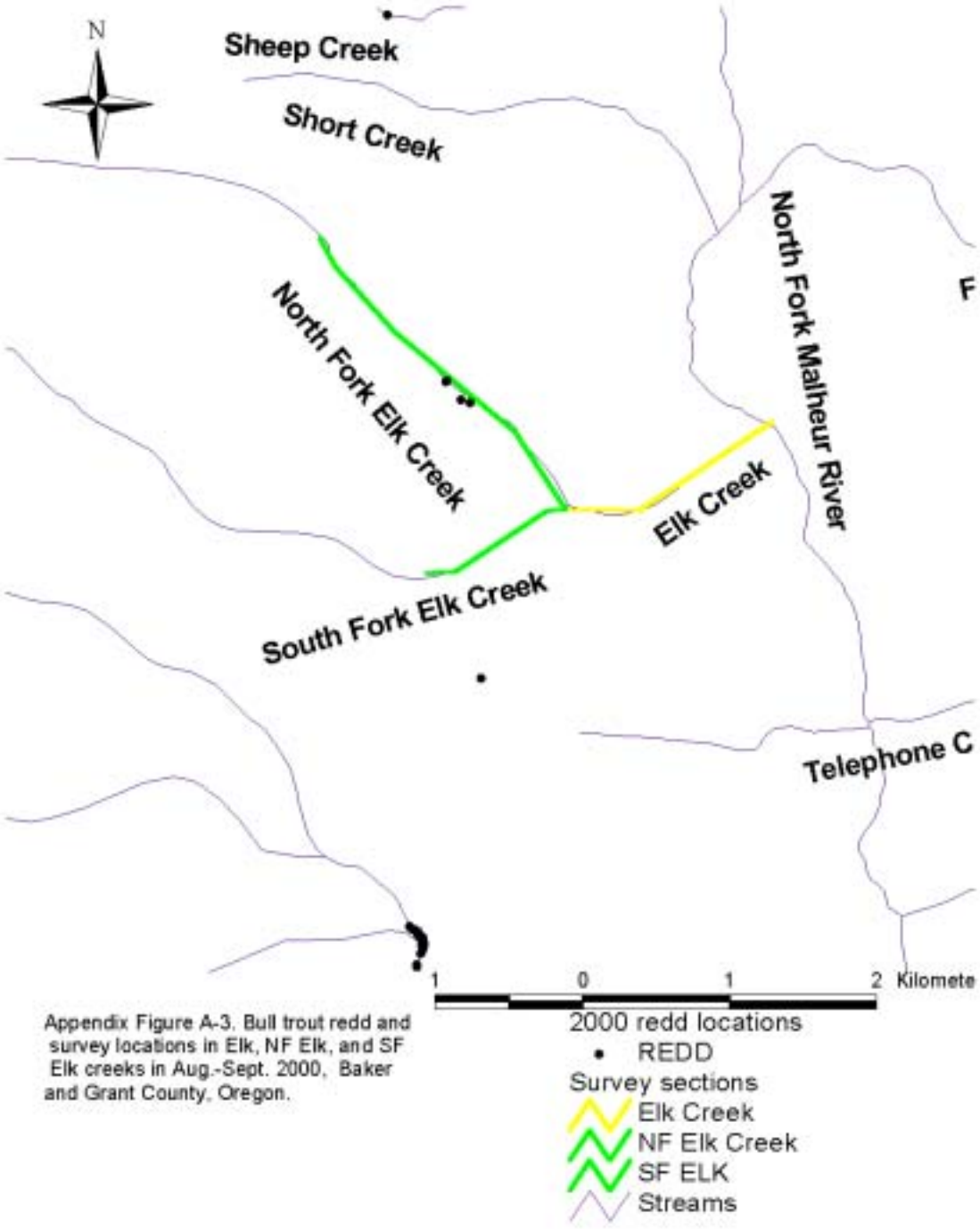
Locations of Bull Trout Redds Observed During Spawning Surveys in the North Fork Malheur Watershed in 2000, Baker and Grant Counties, Oregon



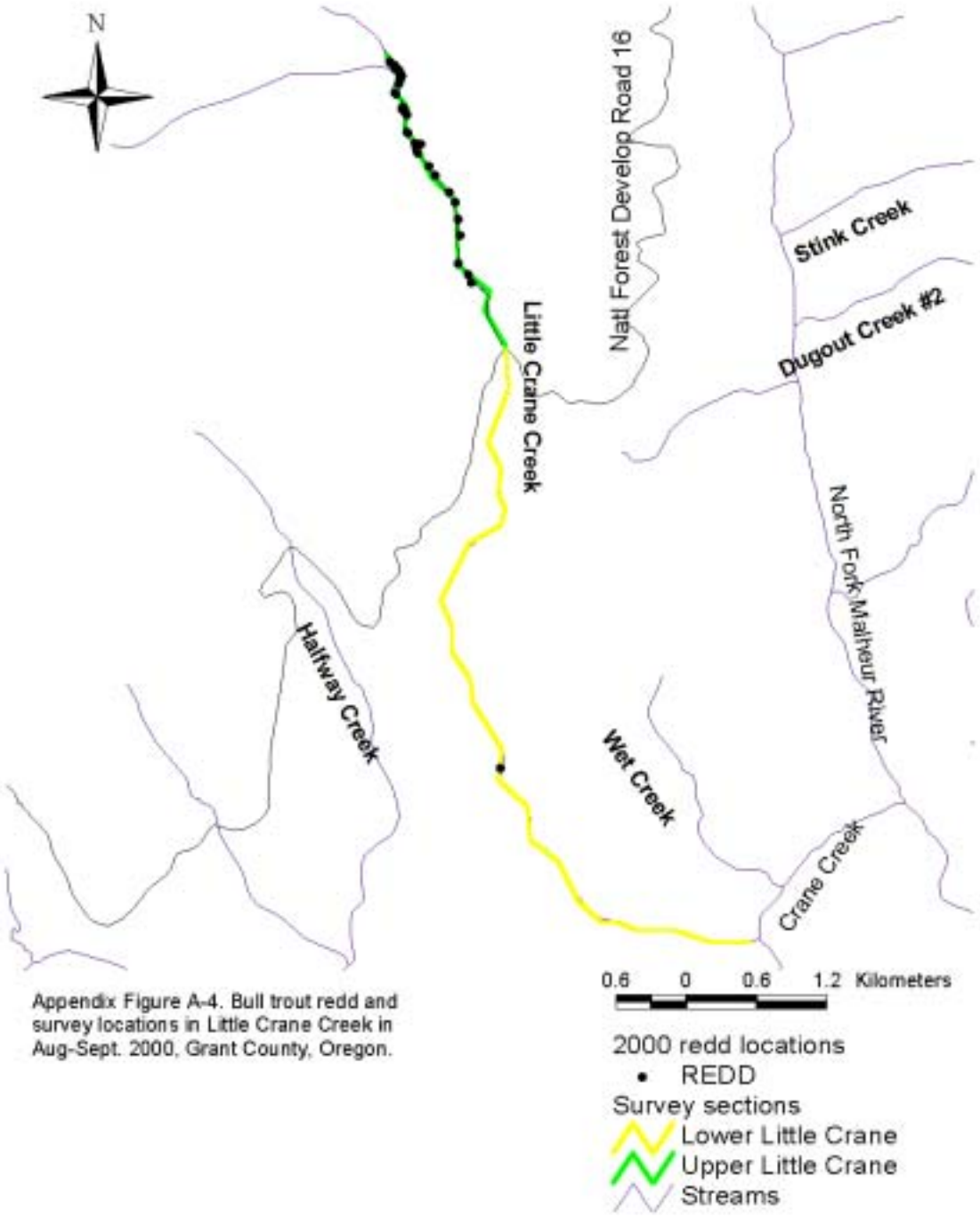
Appendix Figure A-1. Bull trout redds and survey sections in North Fork Malheur River, Horseshoe Creek, and Deadhorse Creek in Aug.-Sept. 2000, Baker County, Oregon.



Appendix Figure A-2. Bull trout redd and survey locations in Swamp, Sheep, Cow, and Little Cow Creeks in Aug.-Sept. 2000, Baker County, Oregon.



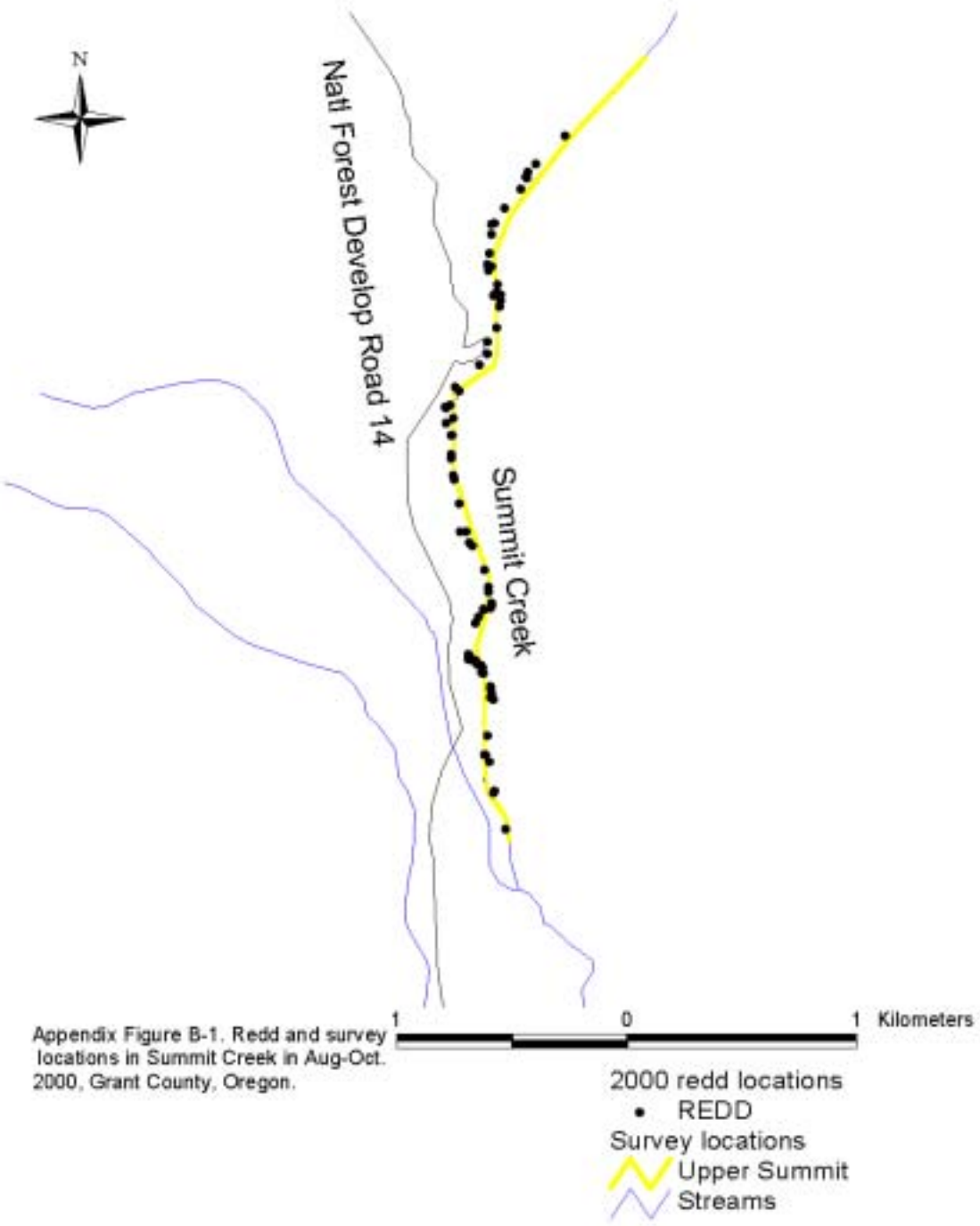
Appendix Figure A-3. Bull trout redd and survey locations in Elk, NF Elk, and SF Elk creeks in Aug.-Sept. 2000, Baker and Grant County, Oregon.



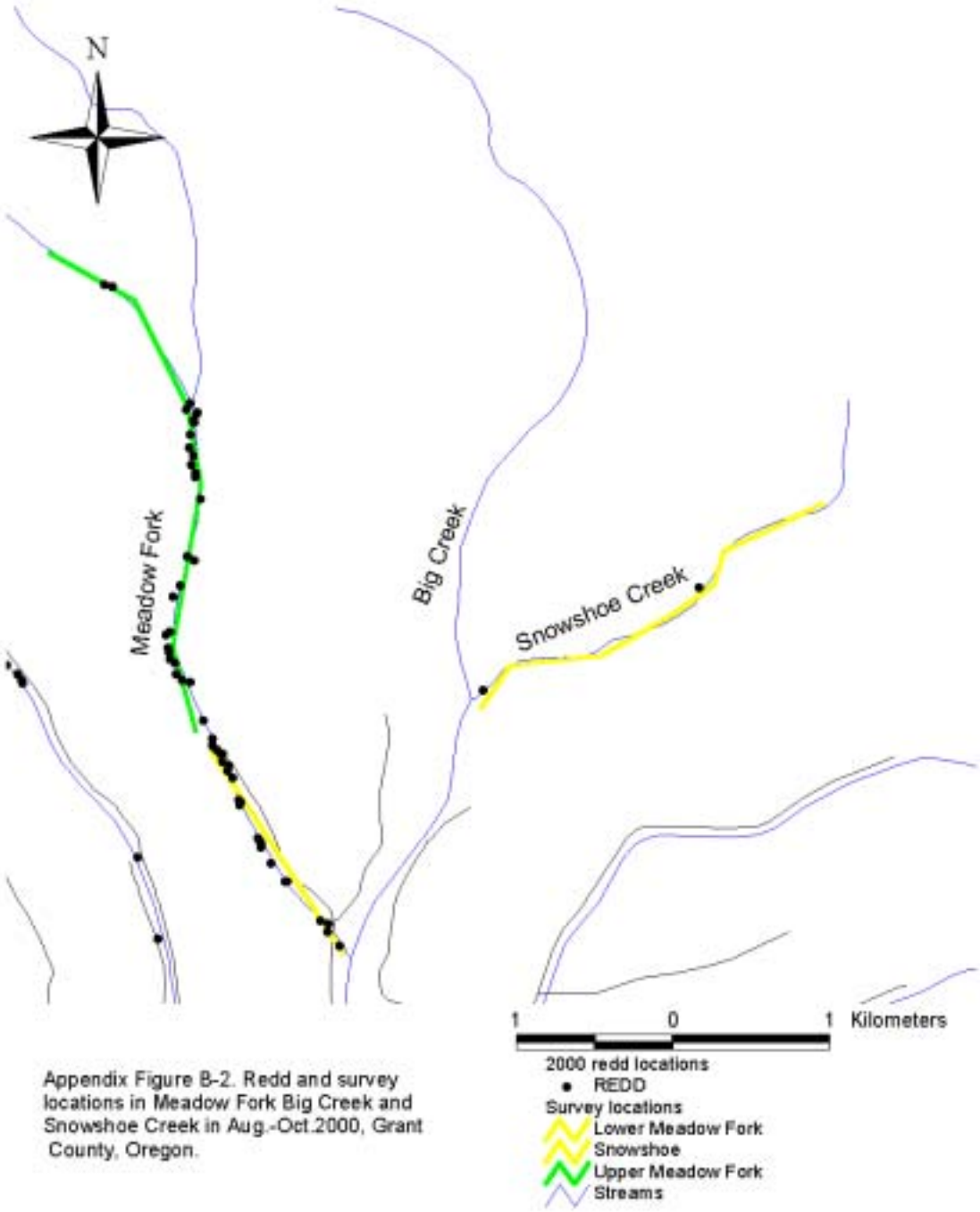
Appendix Figure A-4. Bull trout redd and survey locations in Little Crane Creek in Aug-Sept. 2000, Grant County, Oregon.

APPENDIX B

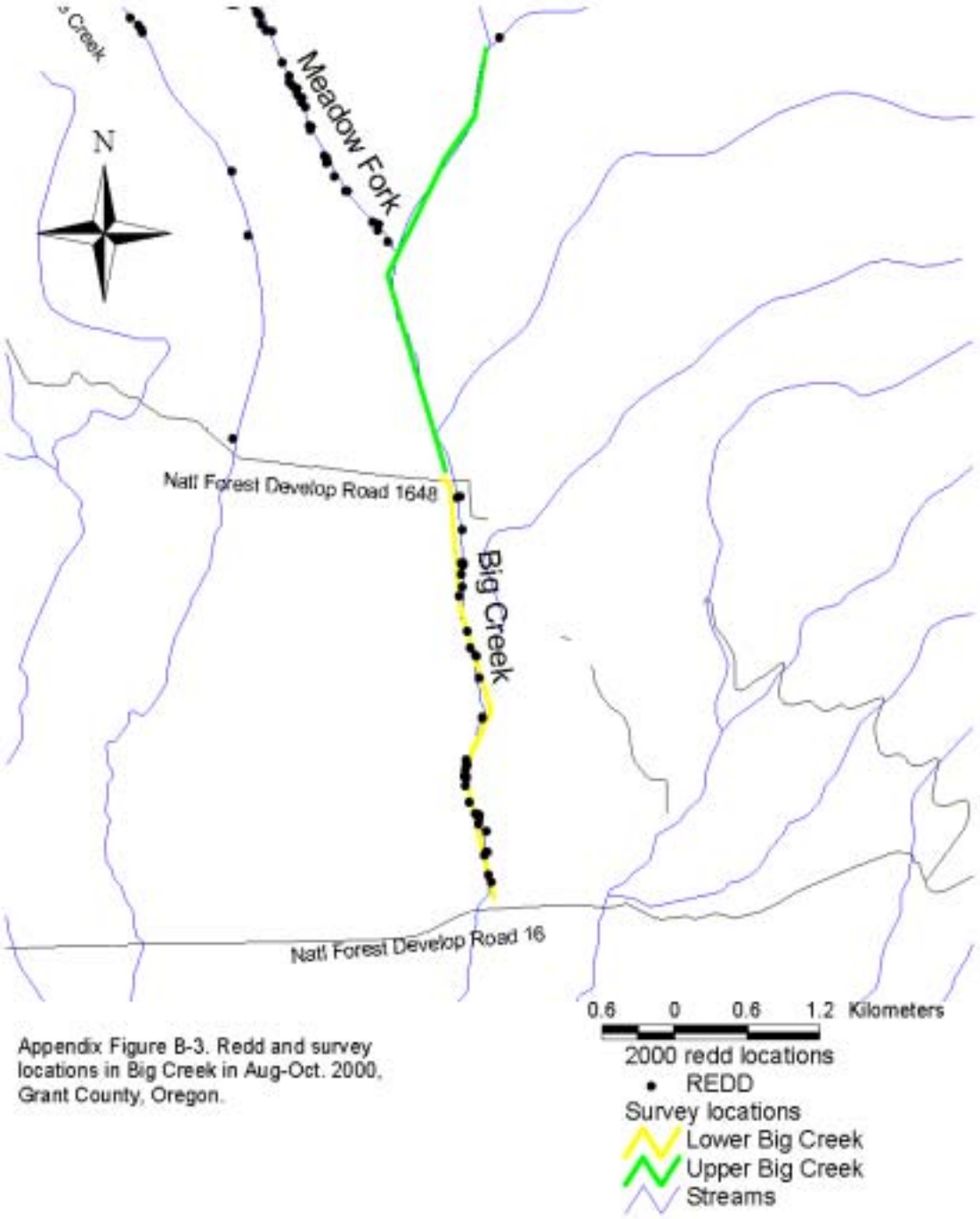
Locations of Redds in the Upper Malheur River Watershed in Aug-Oct. 2000, Baker County, Oregon.



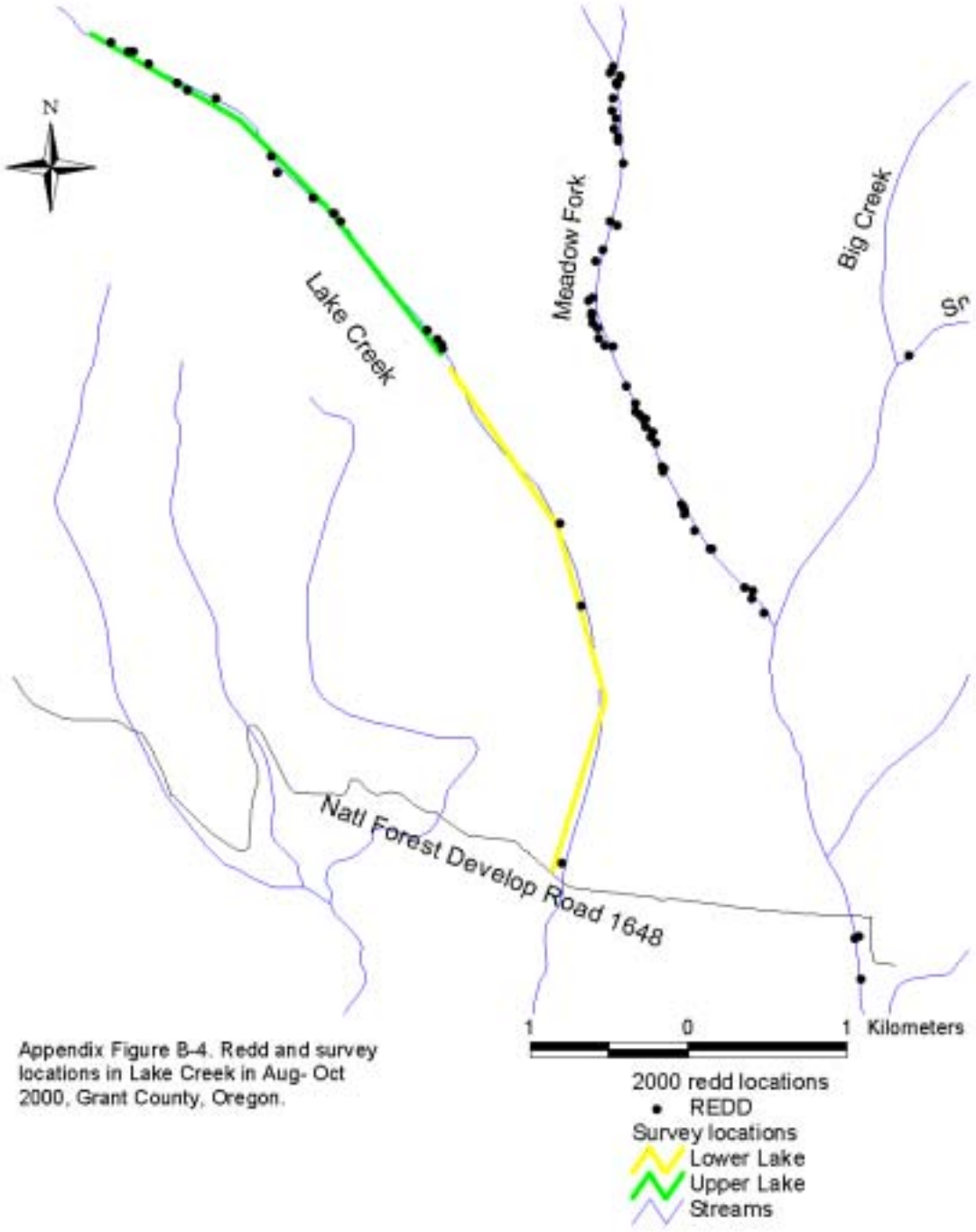
Appendix Figure B-1. Redd and survey locations in Summit Creek in Aug-Oct. 2000, Grant County, Oregon.



Appendix Figure B-2. Redd and survey locations in Meadow Fork Big Creek and Snowshoe Creek in Aug.-Oct.2000, Grant County, Oregon.



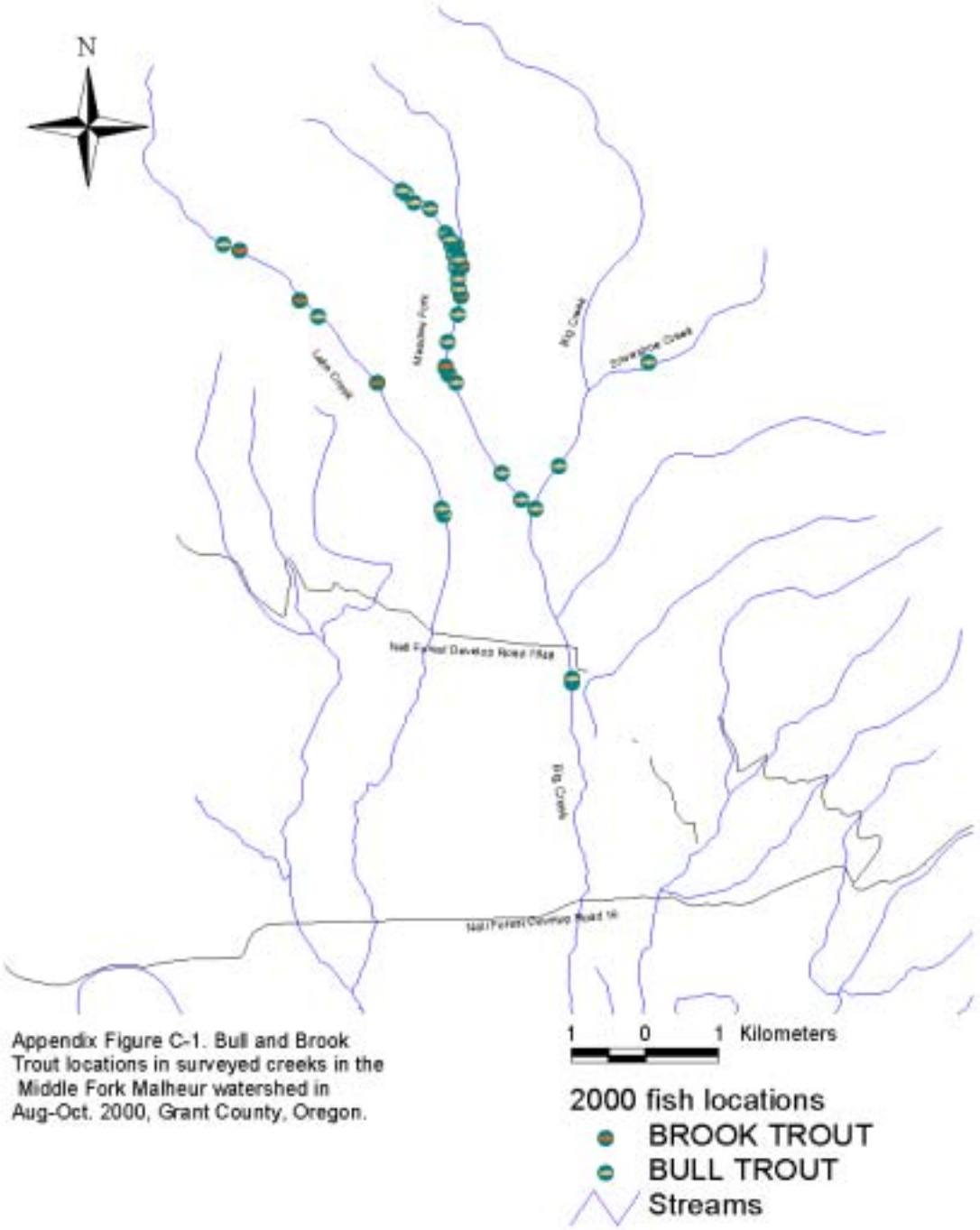
Appendix Figure B-3. Redd and survey locations in Big Creek in Aug-Oct. 2000, Grant County, Oregon.



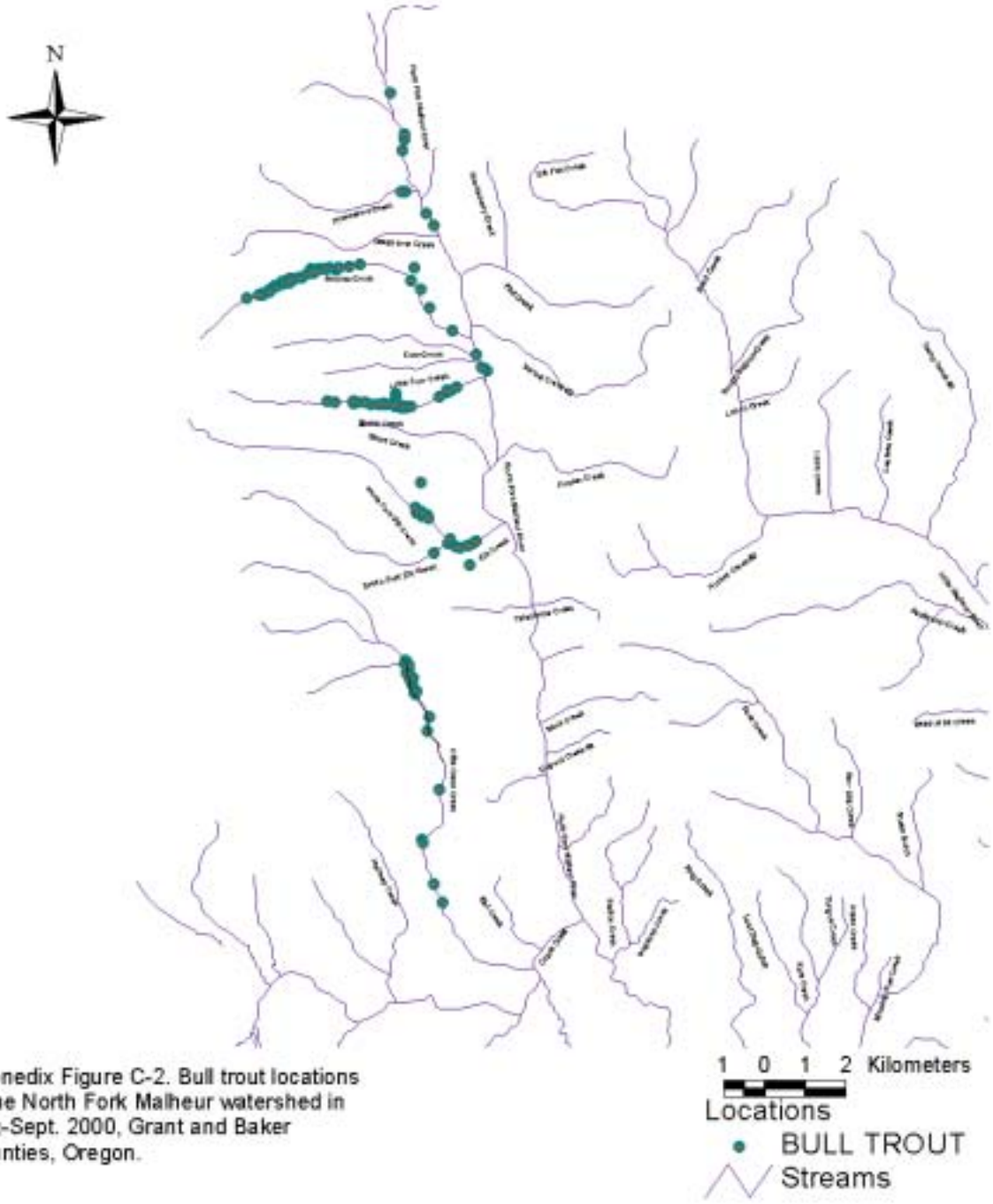
Appendix Figure B-4. Redd and survey locations in Lake Creek in Aug- Oct 2000, Grant County, Oregon.

APPENDIX C

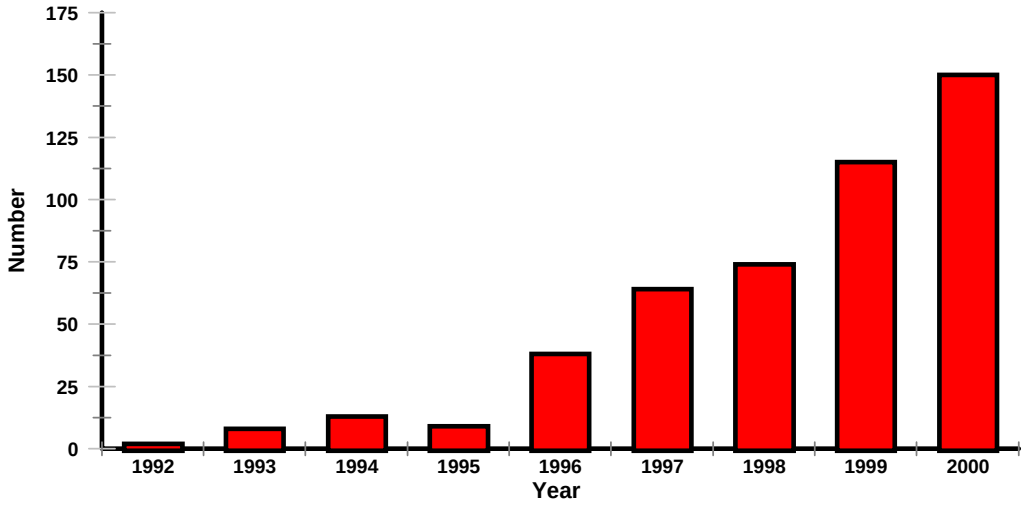
Locations of Bull trout and Brook trout Observed on Spawning Surveys in the Upper Malheur River Malheur and North Fork Malheur Watersheds in Aug-Oct. 2000, Baker and Grant Counties, Oregon.



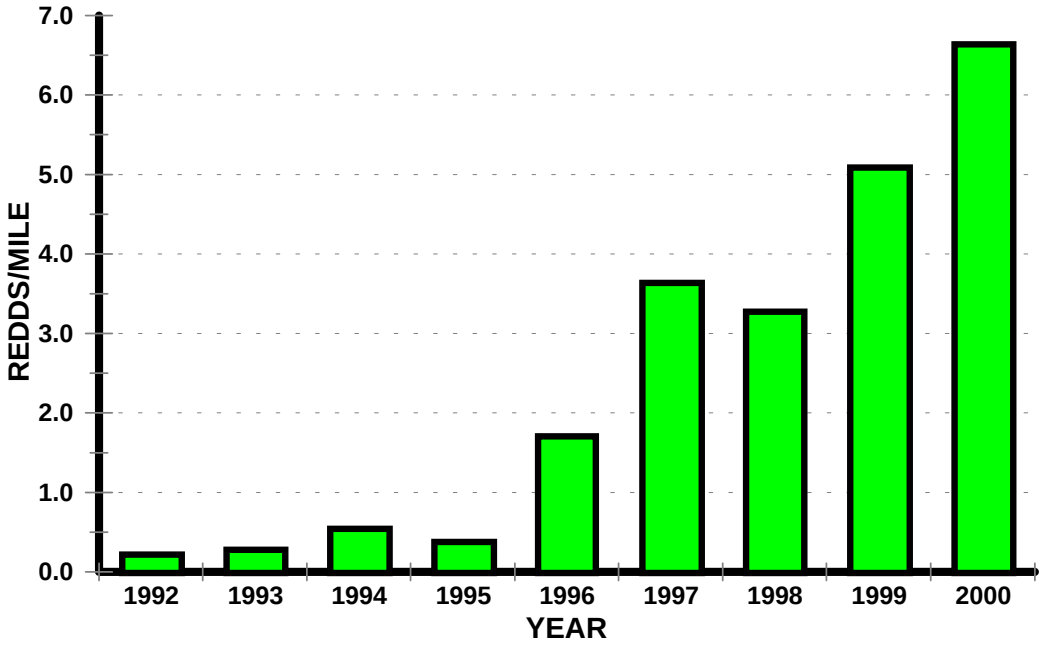
Appendix Figure C-1. Bull and Brook Trout locations in surveyed creeks in the Middle Fork Malheur watershed in Aug-Oct. 2000, Grant County, Oregon.



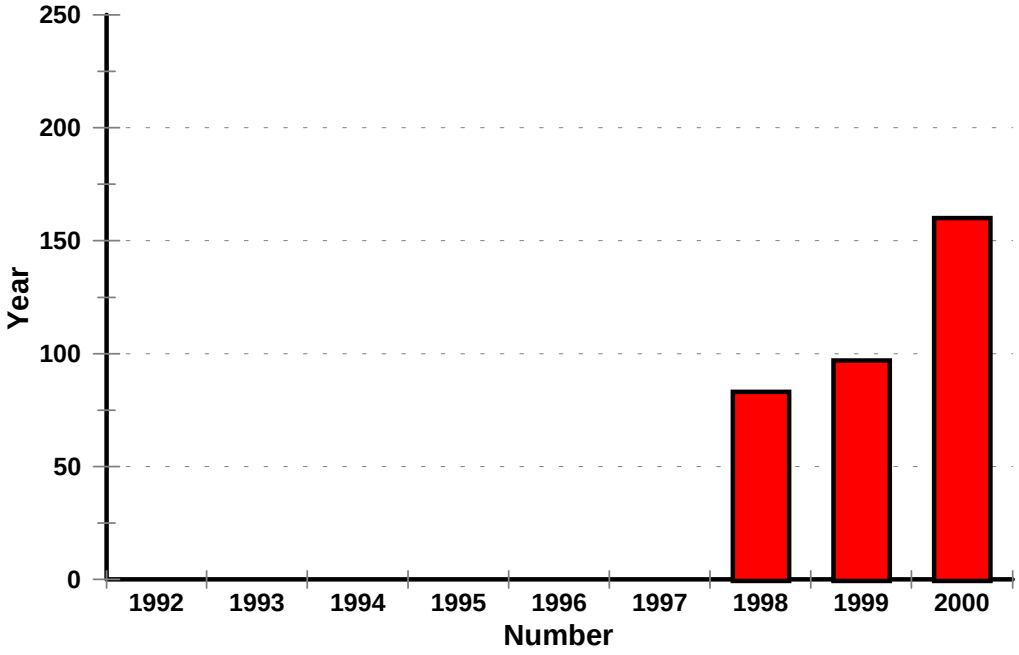
Appnedix Figure C-2. Bull trout locations in the North Fork Malheur watershed in Aug-Sept. 2000, Grant and Baker Counties, Oregon.



Appendix Figure C-3. The number bull trout redds observed in the North Fork Malheur River watershed from 1992-2000.



Appendix Figure C-4. The number bull trout redds per mile of stream observed in the North Fork Malheur River watershed from 1992-2000.



Appendix Figure C-5. The number of brook trout and bull trout redds observed in the upper Malheur River watershed from 1998-2000.

Entrainment of Bull Trout at Agency Valley Dam

Author: Jason Fenton, Burns Paiute Tribe Fish and Wildlife Department, Burns, Oregon

Introduction

The United States Bureau of Reclamation (USBR), Oregon Department of Fish and Wildlife, and the Burns Paiute Tribe have determined that bull trout *Salvenlinus confluentus* entrainment occurs over the Agency Valley Dam through its spillway (Schwabe 2000). Bull trout are listed as a threatened species due to past land management activities, which include the construction of dams and fish eradication projects by poisoning (Bowers et al. 1993).

In 1998 and 1999, a migrational study on bull trout was conducted. In both years, radio tagged bull trout were observed in Beulah Reservoir on their way to the headwaters by mid April to late May (Schwabe 2000). The Vale Irrigation District, in accordance to irrigation demands, started to release water from the reservoir in mid-March. During the periods of water release, there was a risk of bull trout entrainment through the Agency Valley Dam. Bull trout were still being observed in the reservoir from mid-March through June. In previous research, (Schwabe 2000) bull trout have been documented leaving the reservoir during these periods of irrigation withdrawals and returning from post spawning/migrational activities prior to cessation of water releases.

Currently, there are no fish passage facilities at Agency Valley Dam for upstream migrating or entrained fish. During the 1998 and 1999 irrigation storage release periods, water was released over the spillway. This resulted in the entrainment of radio tagged bull trout from the reservoir. Changes in the 2000 irrigation season resulted in the release of water through the flow valves rather than over the spillway to try to reduce the number of entrained bull trout. The Burns Paiute Tribe and partners developed the following objectives for this study:

1) Identify bull trout entrainment in response to water management activities.

2) Determine if the release of water from the tubes will reduce the rate of entrainment of radio tagged fish in comparison to traditional water management practices.

Methods

Creel surveys were conducted for six hours a day, three times a week from mid-March to mid-June in 1999 and 2000. All anglers within ¼ mile below the dam were creeled. The surveys consisted of recording catch per effort (number of fish per hour) for the total hours fished per angler. Bull trout that were angled were collected in a bucket with an aerator and transported above the dam to be released in the reservoir. Fall creel surveys started at the beginning of August and ended in early November, after the tubes closed on October 15th 2000.

Results

Between mid-March and mid-June 1999, 20 bull trout, at a rate of 0.05 fish per hour, were angled in the tailrace and released above the dam (Table 1). During this same time period in 2000, five bull trout were angled at a rate of .01 fish per hour. In 2000 there was a reduction in the catch rate for bull trout of 80 percent.

Creel data on rainbow trout *Oncorhynchus mykiss* was also collected between mid-March and mid-June 1999 and 2000. In 1999, 150 rainbow trout were angled at a rate of .34 fish per hour. In 2000, only 107 rainbow trout with a catch rate of .21 fish per hour were angled. In 2000 there was a reduction in the catch rate for rainbow trout of 61 percent.

Between August and November of 2000, no bull trout and 4 rainbow trout were angled. There were no fish creels in the fall of 1999. These results were from the days that were creeled. There may have been more bull trout and rainbow trout angled on the days that were not creeled.

Table 1. Catch rate (#/hour) for 1999 and 2000

	# Fish Caught in Spring		# Fish Caught in Fall	
	Bull Trout	Rainbow	Bull Trout	Rainbow
1999	20	150	Na*	Na*
2000	5	107	0	4
	Catch Rate (#/hour) for Spring		Catch Rate (#/hour) for Fall	
	Bull Trout	Rainbow	Bull Trout	Rainbow
1999	0.05	0.34	Na*	Na*
2000	0.01	0.21	0.00	0.02

* No creel in fall of 1999.

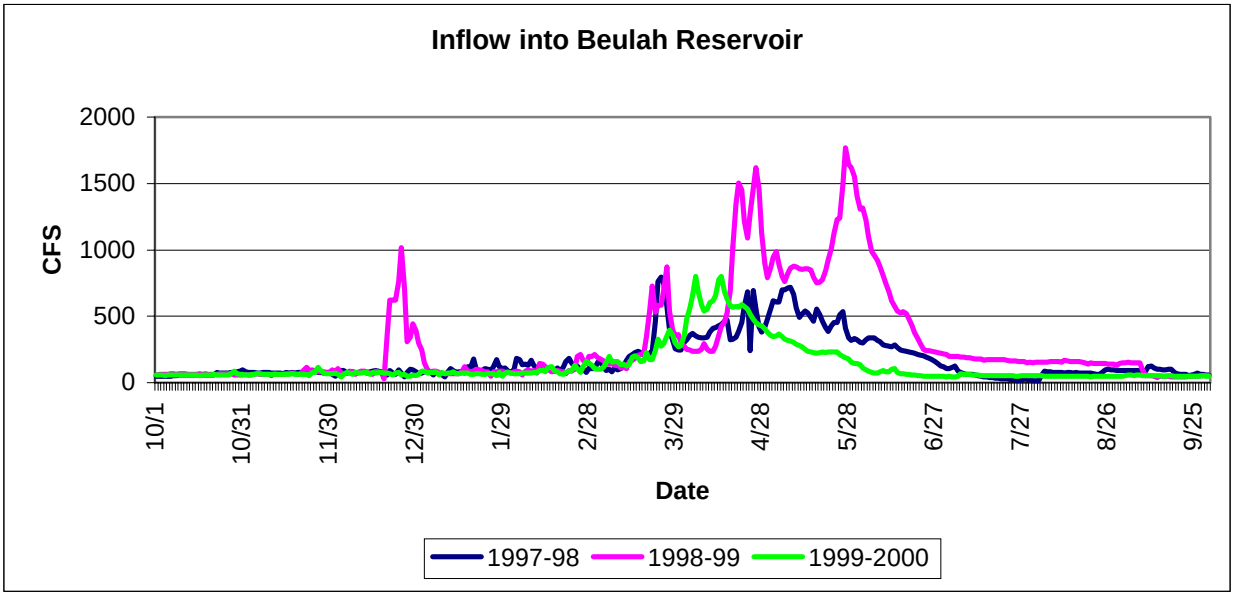
Discussion

It is presumed that bull trout caught below the spillway in 2000 were entrained.
During the period of 1998-1999, it was documented that four fish were entrained over the spillway (Schwabe 2000). Currently there are no known active water quality parameters enforced or in practice below the reservoir. Therefore, the survivability of entrained salmonids, which require a higher standard of water quality (lower temperatures), is minimal to non-existent during late spring to early fall. Furthermore, it is assumed that bull trout caught below the spillway are coming from the reservoir and not from downstream habitats.

The catch rate for bull trout angled during the creel survey below the spillway when water is released from the tubes is less than when water is released over the spillway (Table 1). The data collected suggests that releasing water from the flow valves rather than the spillway would help reduce but not eliminate bull trout entrainment. Future creel surveys will help to verify entrainment rates.

The flow valves can output a maximum of 650 cubic feet per second (cfs). If outflow exceeds more than 650 cfs, the Vale Irrigation District has to release water over the spillway (Reiber, personal communication 2000). Between 1998 and 2000, the inflow to Beulah reservoir has exceeded 650 cfs (Table 2) during the months of April through June. Depending on reservoir levels, there is a risk that water released over the spillway may occur during years with above-average precipitation and snow pack. The 1999 tracking data indicates that if the spillway is only used from mid-June to early October, entrainment of bull trout may be reduced since the bull trout tend to be upstream during this time (Schwabe 2000). There is no data showing whether juvenile bull trout (<315mm) are entrained. However, there have been observations through creel surveys that indicate the presence of juvenile and sub-adult bull trout in the tailrace of the spillway. It is assumed that these juvenile fish were entrained. Creel surveys for 2001 will be conducted in the spring and fall to continue monitoring fish populations below Agency Valley Dam.

Table 2. North Fork Malheur Inflow from 1997 through 2000. Raw Data Provided by USBR



References

Bowers, W.L., P.A. Dupee, M.L. Hanson, and R.R. Perkins. 1993 Bull Trout Populations Summary Malheur River Basin. Oregon Department of Fish and Wildlife, Hines, Oregon. Unpublished report.

Reiber, Rick. Personal communication, Employee of United States Bureau of Reclamation 2000.

Schwabe, L.T. 2000 Malheur River Basin Cooperative Bull Trout/Redband Trout Research Project. Use of Radio Telemetry to Document Movements of Bull Trout in the Malheur Basin in Oregon. Fiscal Year 1999 Annual Report. Unplublished Data. Burns Paiute Tribe Fish and Wildlife Department. Burns, Oregon.

Use of stream surveys and temperature data to assess habitat conditions on the Malheur River, Oregon.

Author: Lawrence Schwabe, Burns Paiute Tribe Fish and Wildlife Department, Burns, Oregon

Habitat degradation, migration barriers from irrigation projects, and introduced salmonid have been linked to the decline of bull trout *Salvelinus confluentus* populations (Ratliff and Howell 1992, Rieman and McIntyre 1993, Goetz 1994). The patchy distribution of bull trout in relation to other species suggest that these fish have specific habitat requirements and may be prone to habitat disruption and fragmentation (Fraley and Shepard 1989). Rieman et al. (1993) noted five habitat characteristics that appear to be particularly important for bull trout and include: (1) stream channel stability, (2) habitat complexity, (3) substrate composition, (4) temperature, and (5) migratory corridors. Changes in the forest canopy, riparian shading, and in hydrologic patterns have altered stream temperatures (Anderson 1973; Rishel et al. 1982; Barton et al. 1985; Beschta et al. 1987; McGurk 1989). Although there is no direct evidence that alteration of temperature patterns has influenced the persistence or distribution of bull trout, a strong association between temperature and distribution make such a response likely (Rieman and McIntyre 1993).

The Burns Paiute Tribe (BPT), Oregon Department of Fish and Wildlife (ODFW), Bureau of Reclamation (USBR) and the US Forest Service (USFS) set the following objectives for the Upper Malheur River:

1). Identify the temperature profile of the upper Malheur River using stream temperature probes and Forward Looking Infrared (FLIR) Videography.

2). Identify habitat conditions of the upper Malheur River from data collected during habitat surveys. Format consistency with other reports

Isolated reports of bull trout have been documented in the Upper Malheur River (Figure 1). In the spring of 1993, an angler caught and released a bull trout in the Upper Malheur at river kilometer (RK) 286 (Buchanan et al. 1997). The BPT documented radio tagged bull trout at RK 296 in June 2000 (pp. 9-29). The bull trout population in the Upper Malheur River is considered at “high risk” of extinction (Ratliff and Howell 1992).

Methods

The study area includes the Upper Malheur River from Warm Springs Reservoir to Logan Valley where Lake and Big Creek converge (RK 306)(see page 3). Habitat and temperature surveys were conducted on USFS and Tribal lands (Figure 1). In addition, Forward Looking Infrared (FLIR) Videography surveys were conducted from Warms Springs Reservoir (RK 211) upstream to the headwaters.

Stream Surveys

Stream surveys were conducted on the Upper Malheur River from River Kilometer (RK) 286 to 304 using ODFW Salmon Trout Enhancement Project (STEP) stream inventory protocol (ODFW 1999). This inventory does not include data on undercut banks, which are critical habitats for juvenile bull trout (Dambacher et al. 1997). Therefore, lengths of undercut banks were visual estimated in meters and recorded during these surveys on the Upper Malheur River. Stream survey data was entered into the ODFW d-base program. Data analysis and reports were generated from this program.

The Upper Malheur River habitat survey began at the USFS boundary at RK 286 and continued for 19,094 meters. The Upper Malheur River was broken into four reaches. The reaches were designated based on changes in channel morphology/form and land use. Reach 1: (T18S R34E Sec 9 SE/SE) Surveyed length 10,788 meters. Reach 1 begins at the USFS boundary and ends at the Malheur Ford (RK 296). Reach 2: (T17S R34E Sec 18 SE/SW) Surveyed length 1642 meters. Reach 2 begins at the Malheur Ford and ends at the confluence with Summit Creek (RK 298). Reach 3: (T17S R33 ½ E Sec 13 SE/NE) Surveyed length 5,898 meters. Reach 3 begins at the confluence of Summit Creek (RK 298) and ends at RK 303.5 (about 1 km downstream of the Burnt River Bridge Crossing). Reach 4: (T17S R33 ½ E Sec 2 NE/NW) Surveyed length 766 meters. Reach 4 begins at RK 303.5 and end at the USFS boundary (RK 304).

Forward Looking Infrared (FLIR) Videography

Thermal infrared images collected on the Upper Malheur River survey are used to develop broad scale temperature patterns in the basin. The images were collected using a helicopter mounted Thermal Infrared Radiometer (TIR also know as FLIR). The radiometer was co-located with a day TV video camera in a gyro-stabilized gimbal mount and images were collected by flying longitudinally over the center of the stream channel. The TIR images were tagged with position information from a global positioning system (GPS) and recorded directly to an on-board computer. The imagery from the Day TV camera was also tagged with GPS positions and recorded to a videocassette recorder on the helicopter. The survey was conducted between 2:27 pm and 3:00 pm on 7-8 August 1998.

The radiometer measures the thermal infrared energy emitted from the water's surface as well as other objects in the scene. The measured energy is converted to temperature by knowing the conditions under which the images were collected and the emissivity of water. As a result, each pixel in the image represents the radiant temperature at that location.

Stream Temperature Probes

Six stream temperature thermographs were deployed in the Malheur River in 2000. Thermographs were deployed under the guidelines outlined in the Oregon Department of Environmental Quality (1998). Temperature probes were program to take at least one temperature reading every 90 minutes. Thermographs are calibrated before and after field season use to be consistent with the Oregon Department of Environmental Quality's protocol. Onset Hobo XT and Stowaway thermographs were used to monitor stream temperatures. The Burns Paiute Tribe deployed 4 stream temperature thermographs in the Upper Malheur River and the Forest Service deployed 2.

Site #1. - River kilometer 287.5 – BPT temp site
Site #2. - River kilometer 295.5 – BPT temp site
Site #3. - River kilometer 296 – USFS temp site (the Malheur Ford)
Site #4. - River kilometer 300.5 – USFS temp site
Site #5. - River kilometer 304 – BPT temp site (Weir Trap)
Site #6. - River kilometer 306 – BPT temp site

The rate of temperature increases was figured between temperature sites. The rate of temperature change is expressed as: change in temperature (^{o}C) / distance between temperature sites (kilometers). Change in temperature (^{o}C) is figured by: the difference between the maximum daily high stream temperature ($X^1 - X^2$), X^1 and X^2 representing stream temperature sites. Statistical analysis was done in Excel 97. Temperature change per kilometer was figured between sites. Student t-tests were conducted to determine the if their was significant difference in the rate of temperature change between sites.

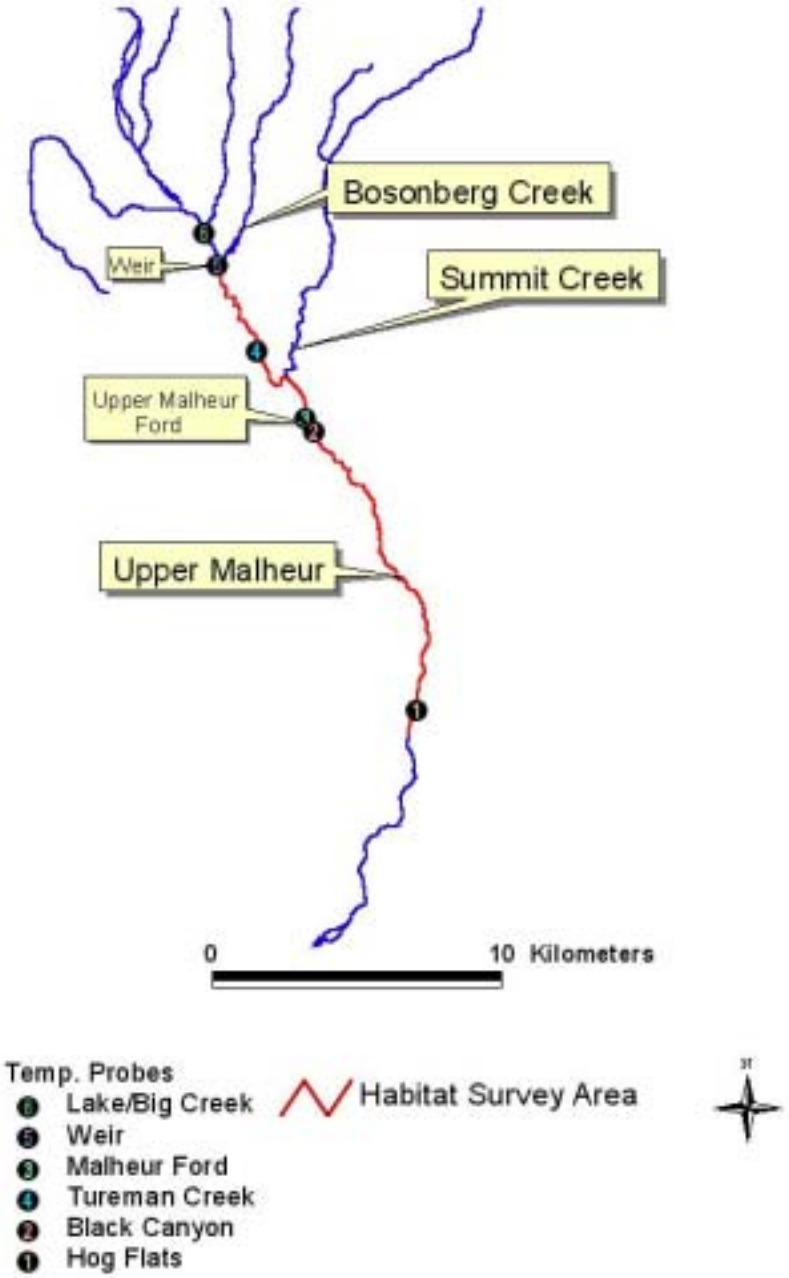


Figure 1. Location of stream temperature probes and habitat survey study area in 2000 on the Upper Malheur River.

Results

Stream Habitat Surveys

Total pieces of Large Woody Debris (LWD) ranged from 0 pieces per 100 meters in Reach 4 to 11 pieces of LWD/100 meters in Reach 3 (Figure 2). Percent active erosion per reach was highest in Reach 4 at 30% while Reach 1 had no observed active erosion (Figure 3). Reach 1 and 3 had higher boulder counts and a higher percentage of fast water habitats (riffles and rapids)(Figure 4 and 5).

Reach 1: Access to this reach is primarily by foot trail with all road access limited to the ridge tops adjacent to the river. Channel gradient for this reach is 1.7%. Stream habitat is comprised of riffle (85%) and rapid habitat (10%). Stream substrate is dominated by cobble (46%), boulder (27%), and gravel (19%). Total LWD pieces per 100 meters of stream is 3.1. Percent shade in this reach is higher than the other reaches surveyed (61%)(Figure 6) with no observed active erosion. The trees most frequently found in the riparian zone (zone 1) are hardwood species.

Reach 2: Access to this reach is limited to the road crossing at the Malheur Ford. Channel gradient for this reach is 0.9%. Stream habitat is comprised of riffle (48%) and glide habitat (42%). Stream substrate is dominated by cobble (45%), gravel (34%), and boulder (11%). Total LWD pieces per 100 meters of stream is 5.1. Percent shade for this reach is 52% with 6% active erosion. The trees most frequently found in the riparian zone (zone 1) are conifer species.

Reach 3: Best access to this reach is using both closed and open forest service roads on the west bank and hiking down the hillslope. Channel gradient for this reach is 1.2%. Stream habitat is comprised of riffle (69%) and glide habitat (23%). Stream substrate is dominated by cobble (37%), gravel (31%), and boulder (18%). Highest levels of LWD were observed within this reach. Total LWD pieces per 100 meters of stream are 11.6. Percent shade for this reach is 48% with 10 percent active erosion. The trees most frequently found in the riparian zone (zone 1) are conifer species.

Reach 4: Best access to this reach is using forest service roads that cross the Malheur River at Burnt Bridge Crossing (RK 304). Channel gradient for this reach is 0.9%. Stream habitat is comprised of glide (45%), pool (28%), and riffle habitat (27%). Stream substrate is dominated by gravel (43%), cobble (33%), and boulder (16%). Total LWD pieces per 100 meters of stream is 0. Percent shade for this reach is 0% with 30% active erosion. The trees most frequently found in the riparian zone (zone 1) are conifer species. Stream survey data analysis generated from ODFW d-base program and riparian survey data can be viewed in Appendix A.

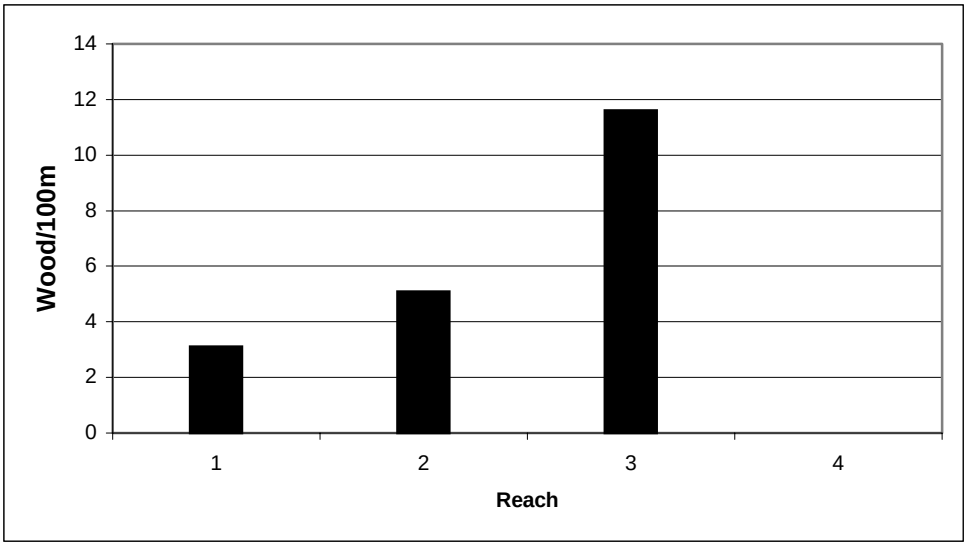


Figure 2. Stream survey conducted on the Upper Malheur River included counts of Large Woody Debris (LWD). Graph illustrates by reach the density of LWD per 100 meters of stream.

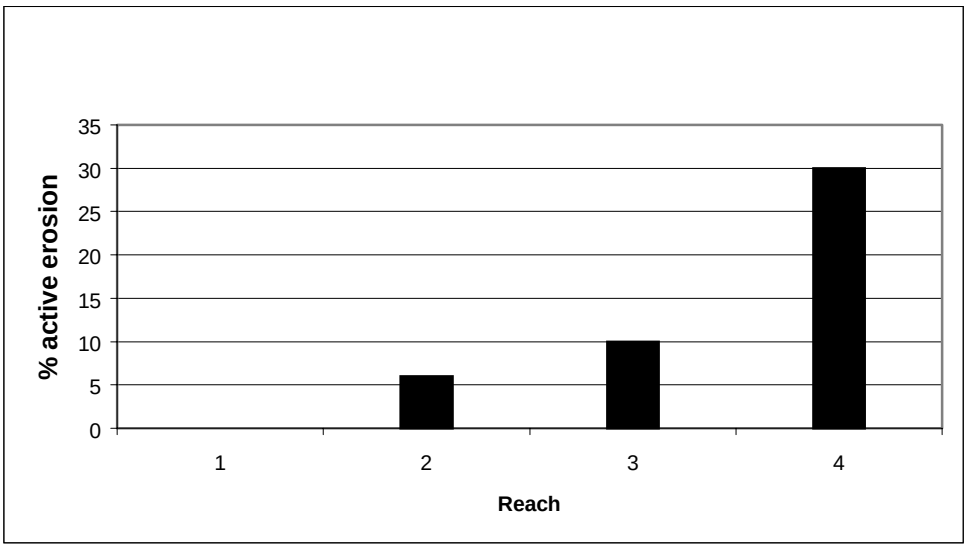


Figure 3. Stream survey conducted on the Upper Malheur River in 2000 included estimated length of active eroding banks. Graph illustrates by reach the percent of active erosion. Percent of active eroding bank per reach is figured by length of active eroding bank / Length of reach X 2.

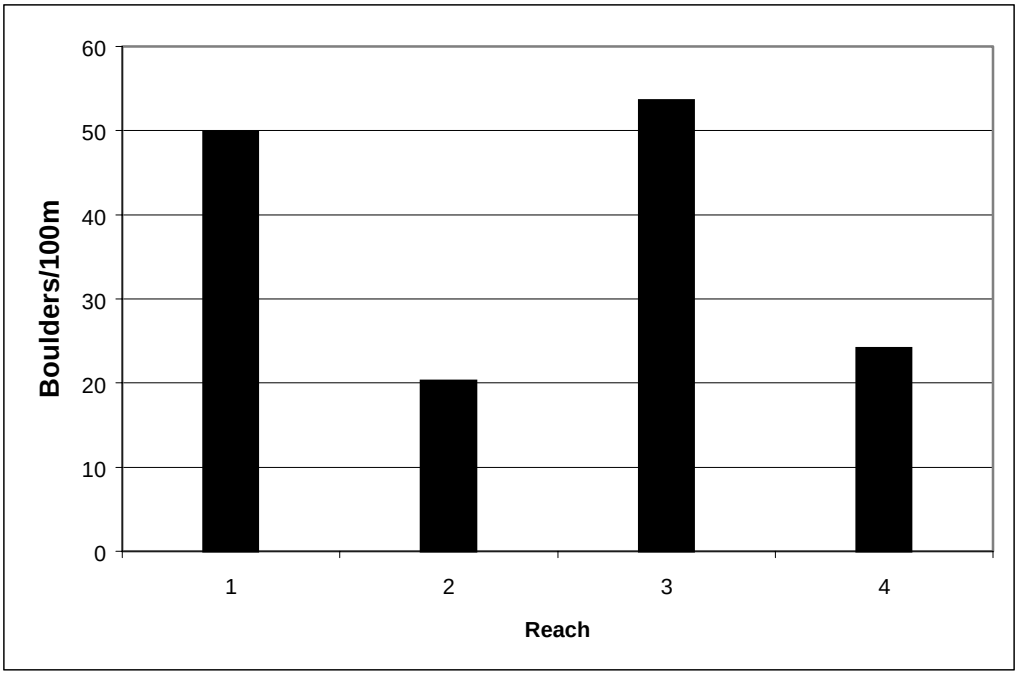


Figure 4. Stream survey conducted on the Upper Malheur River in 2000 included boulder counts. Graph illustrates by reach the number of boulders per 100 meters of stream channel.

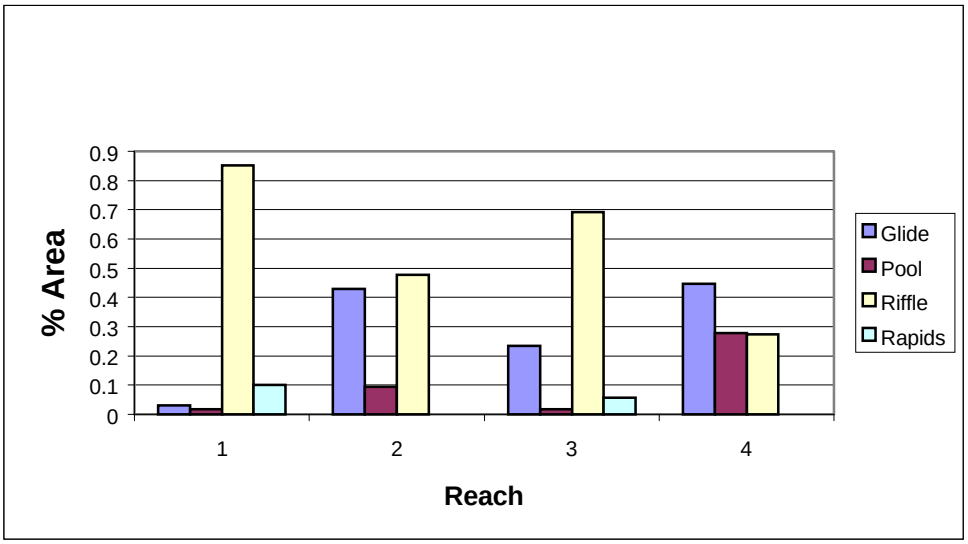


Figure 5. The stream survey in 2000 estimated area of different habitat types on the Upper Malheur River. The above graph illustrates percent habitat area per reach of being one on the following dominant habitat types: pool, glide, riffle or rapid. Riffle with pocket units were lumped into riffle habitat. Dam pools, lateral scour pools, backwater pools and straight scour pool units were lumped into pool habitat. Glides and rapids represent themselves.

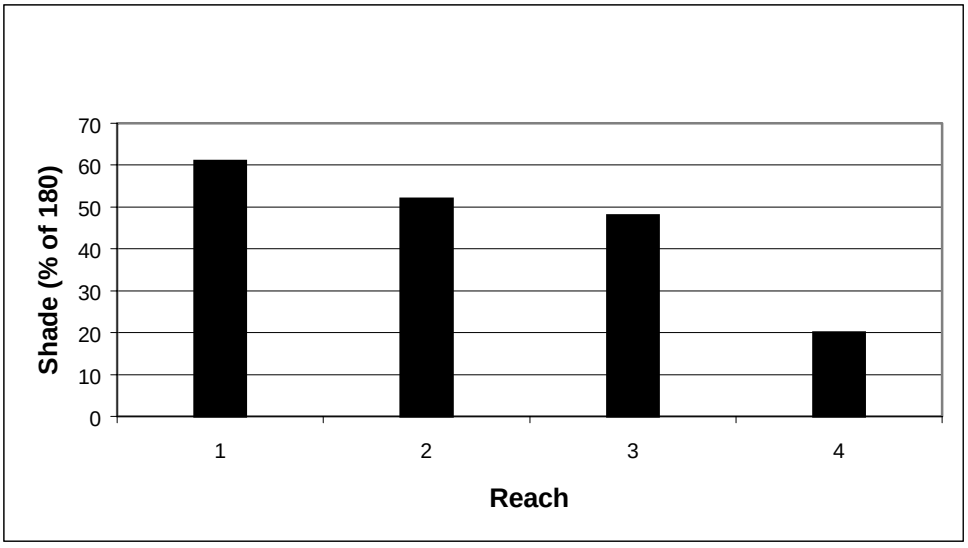


Figure 6. Stream survey conducted on the Upper Malheur River in 2000 included estimating shade every habitat unit. Graph illustrates the average percent of shade recorded by reach.

Forward Looking Infrared (FLIR) Videography

Data collected from the FLIR flights were entered into the Geographic Information System (GIS). A GIS map printout of the data illustrates stream temperature characteristics and variations in the Upper Malheur River (Figure 7). The data collected during the 1998 survey suggested a cold-water source located below the Malheur Ford at RK 294 and 1.5 km below Bosenburg Creek (UTM 0370966E 4886749N).

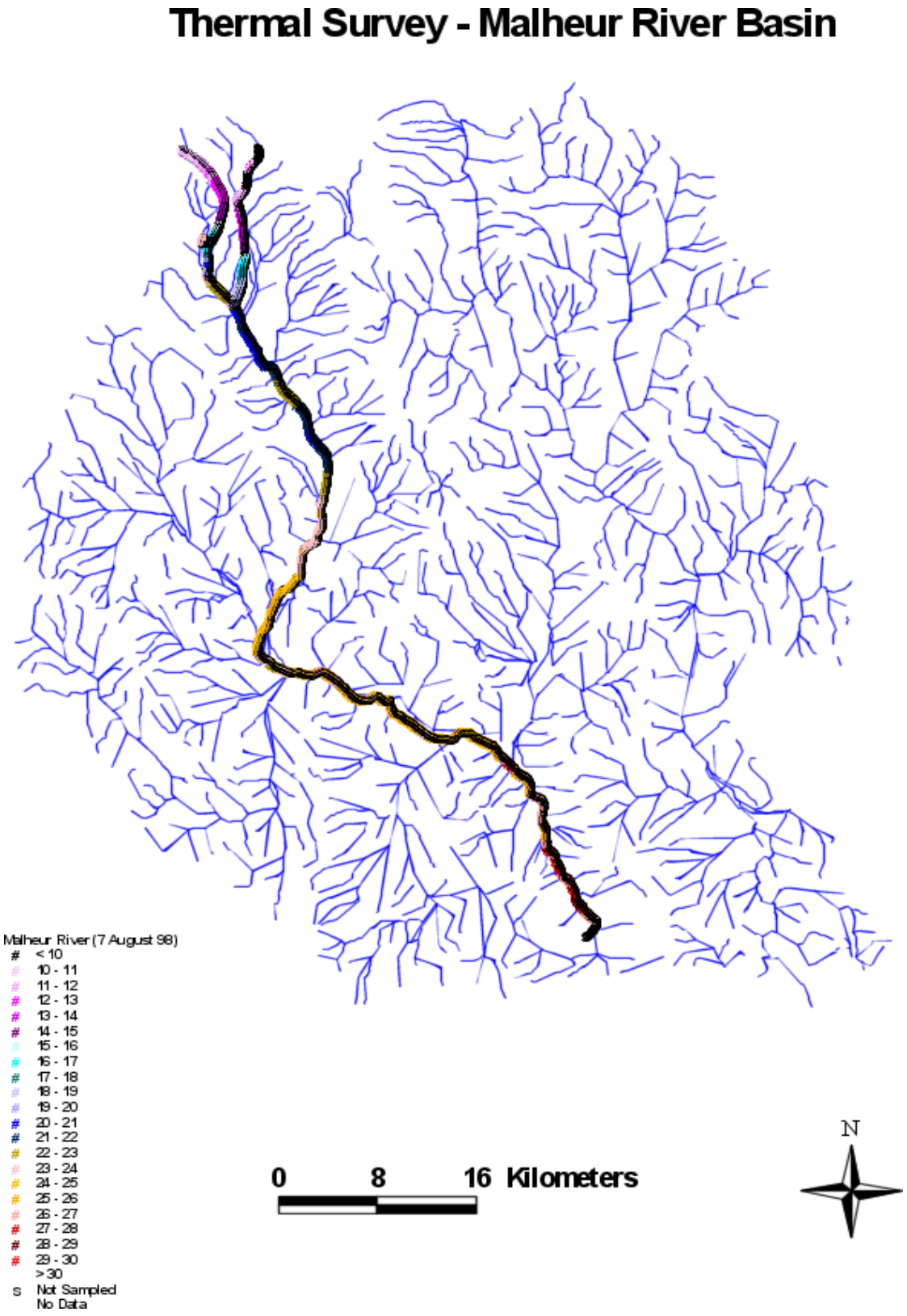


Figure 7. FLIR flight data for the Upper Middle Fork from Warm Springs Reservoir to the headwaters

Stream Temperature Data

Of the six stream temperature hydrographs deployed in the Upper Malheur River, five temperature gauges provided satisfactory results and met the requirements in the Oregon DEQ protocol. All stream temperature probes were deployed by 22 June 2000 and removed by 2 November 2000 (Table 1). The data collected at site 5 will not be incorporated into this report. Site 5, located below Bosonberg Creek, was the only temperature hydrograph that did not function properly due to manufacture defect. Stream temperature data from the five temperature probes on the Upper Malheur River exceeded Oregon State water quality standards for bull trout during the summer of 2000 (pp. 86-108). Figure 8 is a record of daily maximum stream temperatures for the Upper Malheur River.

Site 6 (RK 306), the uppermost site, recorded the coolest temperatures. Four of the five temperature probes recorded maximum high temperatures on 29 July 2000. Plotting temperature vs. River Kilometer for 29 July 2000, stream temperatures generally increase downstream (Figure 9). The exception is from site 3 to site 2 where stream temperature decreased 1.1^{o}C on 29 July 2000.

Table 1. Dates for deployment and retrieval of stream temperature probes on the Malheur River.

Stream Temperature Site	Date Deployed	Date Retrieved
Site #1	5/31/00	11/2/00
Site #2	6/2/00	10/17/00
Site #3	6/7/00	10/21/00
Site #4	6/8/00	10/17/00
Site #5	6/2/00	10/22/00
Site #6	6/22/00	9/18/00

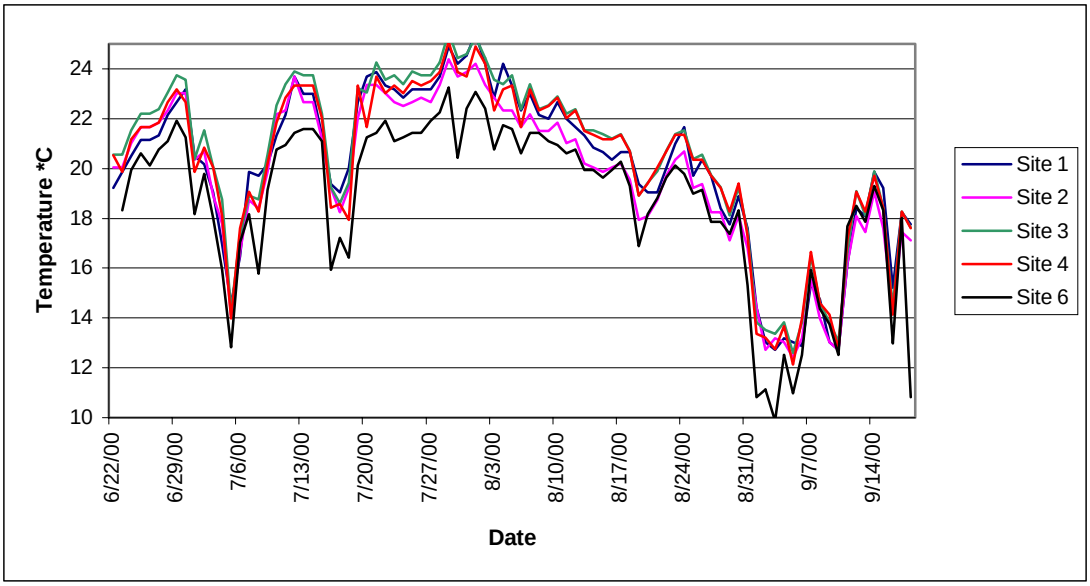


Figure 8. Daily maximum temperatures on the five temperature data loggers deployed in the upper Malheur River.

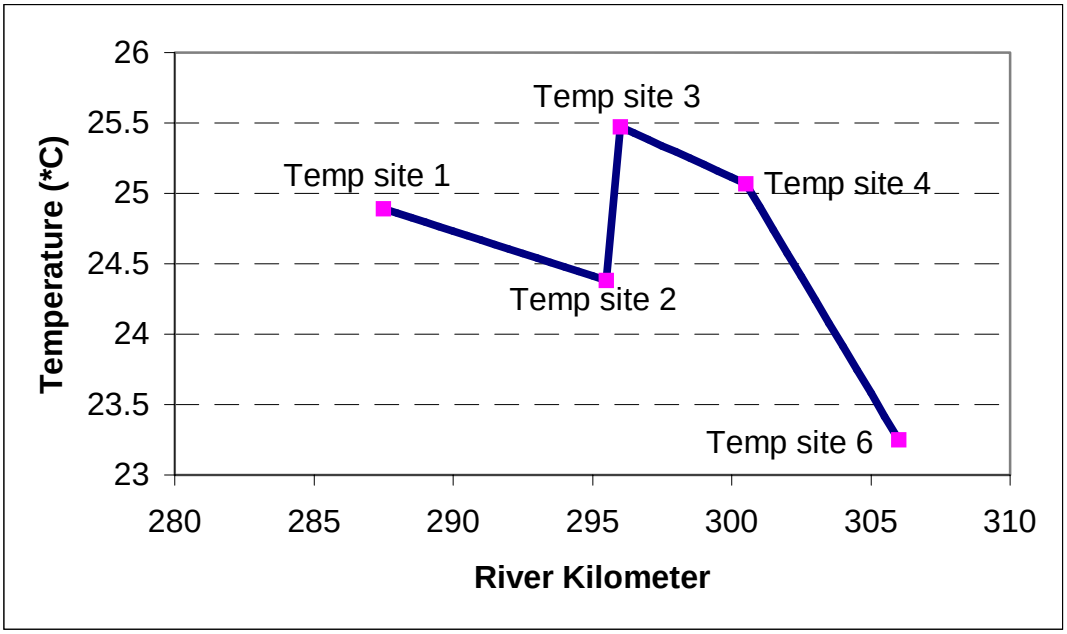


Figure 9. Maximum temperature (^{O}C) on 29 July 2000. Temperature sites 2-6 recorded maximum temperatures on this date. Temperature site 1 did not record peak temperature on this date. Peak temperature for Site 1 occurred on 1 Aug 2000. The second warmest temperature for site 1 occurred on 29 Jul 2000.

Discussion

An increase risk of extinction may occur with the cumulative loss or otherwise persistent change of critical habitat within the species environment (Gilpin and Soule 1986). Due to the high risk of extinction, bull trout in the Upper Malheur River are threatened. Therefore, it is critical to understand the effects land managers have on fish populations. Land managers may have to apply conservative land management practices in order to effectively restore and benefit bull trout and other resident fish in the Upper Malheur River.

Wild and Scenic management restrictions coupled with poor access may explain the light impacts observed on the lower three reaches of the Upper Malheur River (RK 286 to 303.5). Channel characteristics for these three reaches resemble a Rosgen B channel type (Rosgen 1996). Though hardwood counts in the riparian are low, the stream survey conducted on reaches 1 through 3 detect no direct management impacts to the stream channel and encourage land managers to continue maintain current management activities.

Reach 4 (RK 303.5 to 304) had high levels of active erosion, low shade, and low riparian hardwood counts. Width to depth ratio for this reach is relatively high. Surveys noted high cattle impacts to the channel and riparian vegetation (ie. overgrazed willow, post holing, trampled banks, presence of cattle). The data and information collected from reach 4 suggest that cattle grazing may be having a negative effect on the channel and riparian conditions. Bull trout have been documented in this area from June through October (pp. 9-29). Management recommendations to land managers include riparian fencing, riparian planting, off site stock water development or change in allotment management.

Water temperatures in the Upper Malheur River exceed DEQ maximums (pp. 86-108). In the months of July and August 2000, the rate of stream temperature change per kilometer of stream was determined to identify areas of accelerated warming and cooling (Table 2). Two sample t-tests were used to determine significant changes in stream temperature (Appendix B). Significant warming of stream temperatures occurred from RK 300.5 to RK 306 (p-value = 0.000). From RK 287.5 to 300.5, stream temperatures increased at a fairly constant rate with no significant difference (p-value= 0.936) except for a significant change in temperature on a 0.5 km section of stream (p-value= 0.000). From the Malheur Ford (RK 296) downstream to temp site #2 (295.5), the average daily max stream temperatures decreased 0.9^{o}C in July and August.

Table 2. List of active temperature sites and the change in temperature per site. The change in temperature can be expressed in the rate of change per kilometer.

Stream Temp Site #	Distance between Temperature Probes (km)	Average Change Temp (^{o}C)	Average Change in Temp per Kilometer
Site 1 and 2	**8.0**	**0.546935**	**0.068367**
Site 2 and 3	**0.5**	**0.901520**	**1.80305**
Site 3 and 4	**4.5**	**0.302975**	**0.067327**
Site 4 and 6	**5.5**	**1.56**	**0.284633**

In addition, data generated by the FLIR survey conducted in 1998 has determined an area of cold-water refugia located 2 km below the Malheur Ford (RK 296) (Figure 10). Data from FLIR suggest a cool water source located at RK 294 while stream temperature probes record a cold-water source entering the Upper Malheur River at RK 295.5. Reasons for inconsistencies in the data may be due to the level of temperature measurement. FLIR measures temperature in full degrees (^{O}C) while stream temperature probes measure to the nearest tenth of a degree (^{O}C). Continued monitoring of the stream temperature sites will help determine if discrepancies in the data is a product from the temperature data loggers.

A significant increase in temperature occurred from RK 306 to 300.5. This would include all of reach 4 and half of the upper 3 km of reach 3. This area was noted to have management resource impacts to the channel and riparian areas. Also, a significant decrease in temperature occurred below the Malheur River Ford (RK 296) suggesting a cool-source of water affecting the mainstem is present. Research needs to be conducted to determine: (1) the source and temperature of the cold water, (2) bull trout and other salmonid use cold water refugia areas during the peak summer stream temperatures. By identifying cold-water sources and salmonid use of these areas in the Upper Malheur River Basin, land managers can protect these areas from land management activities that may have significant impacts to these micro-habitats. Furthermore, improving habitat conditions in the tributaries that flow into the Upper Malheur River can enhance water quality conditions in the Upper Malheur River.

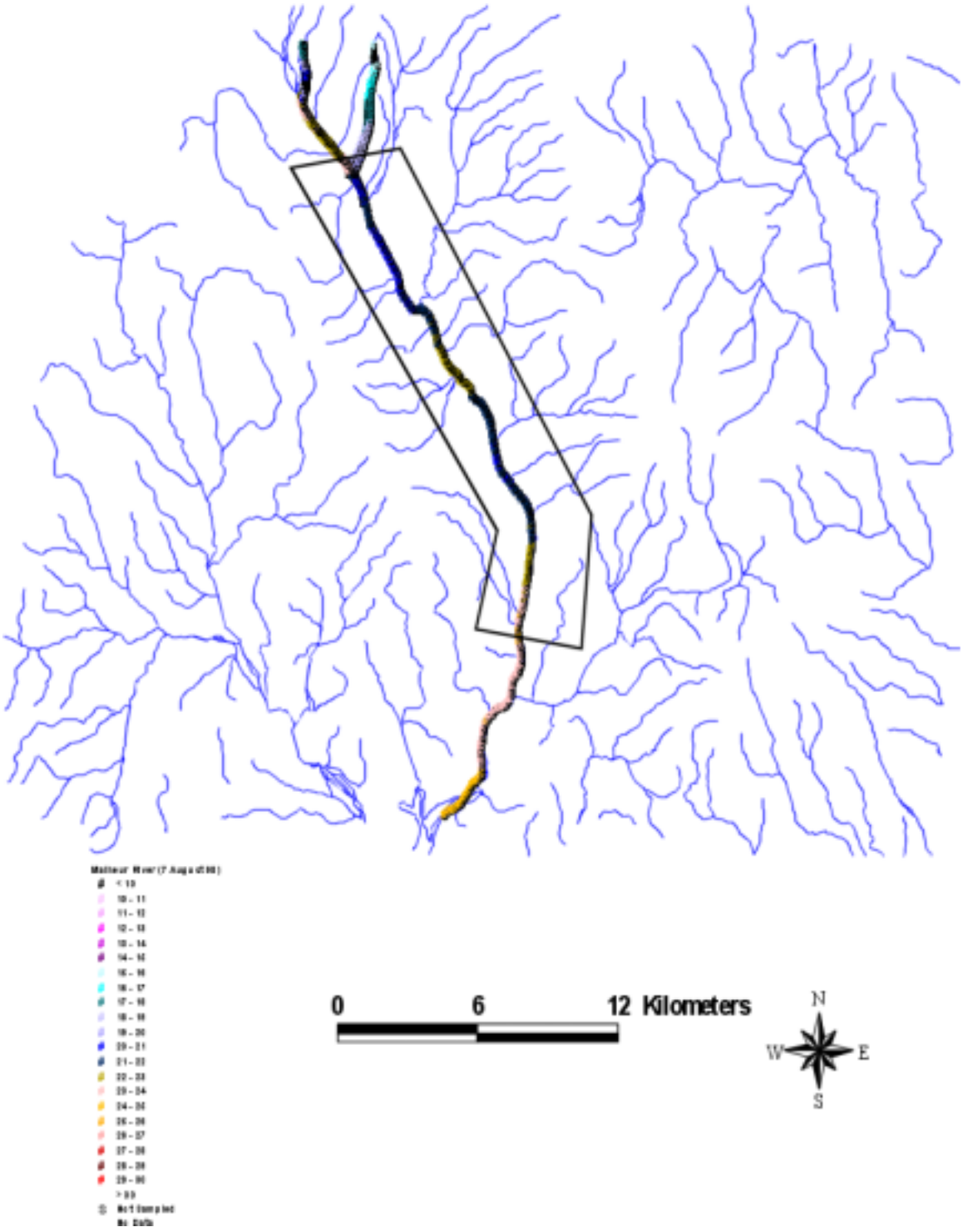


Figure 10. FLIR flight data from US forest Service Boundary to the confluence of Lake and Big Creek.

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References

Anderson, H.W. 1973. The effects of clear cutting on stream temperature, a literature review. Rep. No. 29. Olympia, WA: Washington Department of Natural Resources.

Barton, D.R., W.D.Taylor and R.M. Biette. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. North American Journal of Fisheries Management. 5: 364 – 378.

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. In: Salo, E.O. Cundy, T.W. eds. Streamside management: forestry and fishery interaction. Seattle, WA: University of Washington: 191-232.

Buchanan, D.V., M.L. Hanson, and R.M. Hooton. 1997. Status of Oregon's Bull Trout. Oregon Department of Fish and Wildlife, Portland.

Fraley, J.J. and B.B. Shepard. 1989. Life history, ecology and population status of migratoy bull trout (Salvelinus confuentus) in the Flathead Lake River System, Montana. Northwest Science. 63(4); 133-143

Gilpin, M.E., M.E. Soule. 1986. Minimum viable populations: processes of species extinction: 13-34. In; Soule, M.E. ed. Conservation biology: the science of scarcity and diversity. Sunderland MA: Sinaur Associates. 584 p.

Goetz, F. A. 1994. Distribution and juvenile ecology of bull trout (*Salvelinus confluentus*) in the Cascade mountains. M.S. Thesis. Oregon State University, Corvallis, Oregon.

McGurk , G.J. 1989. Predicting stream temperature after riparian vegetation removal. Gen. Tech. Rep. PSW-110. Berkeley, CA: US Department of Agriculture, Forest Service.

Oregon Department of Fish and Wildlife. 1999. Aquatic Habitat Inventory Intermediate Level Stream Survey. Portland, OR

Oregon Department of Environmental Quality. 1998. Water Quality Monitoring Handbook. Chapter 6 Stream Temperature Protocol. pp 12 – 29.

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout population in Oregon. In: Howell P.J.; Buchanan, D.V. eds. Proceedings of the Gearhart Mountain bull trout worshop. Corvallis, R: Oregon Chapter of the American Fisheries Society; 37-44.

Schwabe, L.T. 2001. Evaluate the Life History of Native Salmonids in the Malheur Basin. Use of radio telemetry to document bull trout movements in the Malheur River basin, Oregon. Fiscal Year 2000 Annual Report. Unpublished Data. Burns Paiute Tribe Fish and Wildlife Department. Burns, Oregon.

Rieman, B.E. and J.D. McIntyre. 1993. Habitat and Demographic Requirements of Bull Trout. USDA Forest Service, intermountain Research Station.

Rishel, G.B., J.A. Corbett and E.S.Corbett. 1982. Seasonal stream temperature changes following forest harvesting. Journal of Environmental Quality. 11(1): 112-116.

Rosgen, D. 1996. Applied river morphology. Pub. Highland Hydrology. Pagosa Springs, CO.

Appendix A.

Data analysis for habitat survey conducted on the Upper Malheur River.

OREGON DEPT. FISH AND WILDLIFE MF MALHEUR
HABITAT INVENTORY Report Date: 03/12/01 Survey Date: 07/06/00

HABITAT UNIT SUMMARY

REACH 1 REACH 1

HABITAT DETAIL

Habitat Type	Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m2)	Large Boulders (#>0.5m)	Substrate Percent Wetted Area S/O	Snd	Grvl	Cbbl	Bldr	Bdrk
GLIDE	7	346	16.4	0.00	5,832	153	1	8	27	44	21	0
POOL-ALCOVE	1	10	2.0	0.00	20	0	36	18	27	18	0	0
POOL-BACKWATER	2	13	6.0	1.00	81	8	28	30	10	19	15	0
POOL-LATERAL SCOUR	7	106	11.4	1.00	1,254	73	2	8	22	40	29	0
POOL-PLUNGE	1	5	26.0	1.00	130	5	2	5	22	38	33	0
POOL-STRAIGHT SCOUR	8	137	10.3	1.00	1,635	56	4	8	24	34	31	0
RAPID/BOULDERS	14	1,321	14.3	0.00	19,064	1420	0	4	12	40	44	0
RIFFLE	43	5,284	17.2	0.00	100,845	2076	1	4	19	52	24	0
RIFFLE W/ POCKETS	30	3,510	16.3	0.00	59,184	1580	1	4	20	48	27	0
STEP/BOULDERS	1	3	0.0	0.00	0	0	0	0	0	0	0	0
STEP/COBBLE	3	53	13.0	1.00	683	12	0	7	16	62	15	0
Total:	117	10,788	15.2	0.18	188,728	5383	Avg: 2	5	19	46	27	0

HABITAT SUMMARY

Habitat Group	No. Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Wetted Area (m2)	Wetted Area Percent	Large Boulders Number	Large Boulders #/100m2
Dammed & BW Pools	3	23	4.7	0.67	101	0.05	8	7.92
Scour Pools	16	248	11.8	1.00	3019	1.60	134	4.44
Glides	7	346	16.4	0.00	5832	3.09	153	2.62
Riffles	73	8,794	16.8	0.00	160029	84.79	3656	2.28
Rapids	14	1,321	14.3	0.00	19064	10.10	1420	7.45
Cascades	0	0	.	.	0	0.00	0	0.00
Step/Falls	4	56	9.8	0.75	683	0.36	12	1.76
Dry	0	0	.	.	0	0.00	0	0.00

POOL SUMMARY

	Total	#/km
All Pools	19	1.8
Pools >1m deep:	17	1.6
Complex pools (wood pieces>3):	5	0.5
Pool frequency (channel widths/pool):	24.7	

LARGE WOOD DEBRIS

	Pieces	Pieces/100m
Small (>15cm dbh, 3m length)	157	1.5
Medium (>30cm dbh, 6m length)	139	1.3
Large (>60cm dbh, 10m length)	39	0.4
Total - all LWD classes	335	3.1

OREGON DEPT. FISH AND WILDLIFE MF MALHEUR
HABITAT INVENTORY Report Date: 03/12/01 Survey Date: 07/26/00

HABITAT UNIT SUMMARY

REACH 2 REACH 2

HABITAT DETAIL

Habitat Type	Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m2)	Large Boulders (#>0.5m)	Substrate Percent Wetted Area S/O	Snd	Grvl	Cbbl	Bldr	Bdrk
	1	89	12.0	0.00	1,068	30	0	10	40	40	10	0
GLIDE	8	661	16.6	0.00	11,039	129	3	9	35	43	10	0
POOL-LATERAL SCOUR	6	153	15.7	1.00	2,436	62	6	10	31	42	12	0
RIFFLE	10	739	16.9	0.00	12,294	112	0	6	34	48	12	0
Total:	25	1,642	16.3	0.24	26,837	333	Avg: 3	8	34	45	11	0

HABITAT SUMMARY

Habitat Group	No. Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Wetted Area (m2)	Wetted Area Percent	Large Boulders Number	Large Boulders #/100m2
Dammed & BW Pools	0	0	.	.	0	0.00	0	0.00
Scour Pools	6	153	15.7	1.00	2436	9.08	62	2.55
Glides	8	661	16.6	0.00	11039	41.13	129	1.17
Riffles	10	739	16.9	0.00	12294	45.81	112	0.91
Rapids	0	0	.	.	0	0.00	0	0.00
Cascades	0	0	.	.	0	0.00	0	0.00
Step/Falls	0	0	.	.	0	0.00	0	0.00
Dry	0	0	.	.	0	0.00	0	0.00

POOL SUMMARY

	Total	#/km
All Pools	6	3.7
Pools >1m deep:	6	3.7
Complex pools (wood pieces>3):	5	3.0
Pool frequency (channel widths/pool):	14.4	

LARGE WOOD DEBRIS

	Pieces	Pieces/100m
Small (>15cm dbh, 3m length)	40	2.4
Medium (>30cm dbh, 6m length)	30	1.8
Large (>60cm dbh, 10m length)	14	0.9
Total - all LWD classes	84	5.1

OREGON DEPT. FISH AND WILDLIFE MF MALHEUR
HABITAT INVENTORY Report Date: 03/12/01 Survey Date: 07/26/00

HABITAT UNIT SUMMARY

REACH 3 REACH 3

HABITAT DETAIL

Habitat Type	Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m2)	Large Boulders (#>0.5m)	Substrate Percent Wetted Area S/O	Snd	Grvl	Cbbl	Bldr	Bdrk
GLIDE	27	1,501	13.0	0.04	22,006	356	6	8	36	36	15	1
POOL-BACKWATER	5	66	4.0	0.20	287	3	28	21	41	8	3	0
POOL-ISOLATED	3	35	1.3	0.33	58	0	21	38	38	2	2	0
POOL-LATERAL SCOUR	5	74	7.8	0.80	781	29	7	13	54	20	6	0
POOL-STRAIGHT SCOUR	2	39	12.0	1.00	450	9	4	7	29	43	19	0
RAPID/BOULDERS	2	300	17.5	0.00	5,250	497	0	3	12	29	47	11
RIFFLE	37	3,199	15.4	0.00	53,621	1749	1	5	26	46	22	0
RIFFLE W/ POCKETS	10	684	14.8	0.00	11,116	520	1	5	26	42	26	1
Total:	91	5,898	13.1	0.10	93,569	3163	Avg: 5	8	31	37	18	0

HABITAT SUMMARY

Habitat Group	No. Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Wetted Area (m2)	Wetted Area Percent	Large Boulders Number	Large Boulders #/100m2
Dammed & BW Pools	8	101	3.0	0.25	345	0.37	3	0.87
Scour Pools	7	113	9.0	0.86	1231	1.32	38	3.09
Glides	27	1,501	13.0	0.04	22006	23.52	356	1.62
Riffles	47	3,883	15.2	0.00	64737	69.19	2269	3.50
Rapids	2	300	17.5	0.00	5250	5.61	497	9.47
Cascades	0	0	.	.	0	0.00	0	0.00
Step/Falls	0	0	.	.	0	0.00	0	0.00
Dry	0	0	.	.	0	0.00	0	0.00

POOL SUMMARY

	Total	#/km
All Pools	15	2.5
Pools >1m deep:	8	1.4
Complex pools (wood pieces>3):	5	0.8
Pool frequency (channel widths/pool):	24.6	

LARGE WOOD DEBRIS

	Pieces	Pieces/100m
Small (>15cm dbh, 3m length)	220	3.7
Medium (>30cm dbh, 6m length)	391	6.6
Large (>60cm dbh, 10m length)	74	1.3
Total - all LWD classes	685	11.6

OREGON DEPT. FISH AND WILDLIFE MF MALHEUR
HABITAT INVENTORY Report Date: 03/12/01 Survey Date: 07/27/00

HABITAT UNIT SUMMARY

REACH 4 REACH 4

HABITAT DETAIL

Habitat Type	Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m2)	Large Boulders (#>0.5m)	Substrate Percent Wetted Area S/O	Snd	Grvl	Cbbl	Bldr	Bdrk
GLIDE	5	433	14.8	0.00	6,423	68	5	5	45	30	15	0
POOL-BACKWATER	1	9	1.0	0.00	9	5	9	14	59	9	9	0
POOL-LATERAL SCOUR	1	40	10.0	1.00	400	11	0	5	32	42	21	0
RIFFLE	5	284	14.2	0.00	3,943	101	1	2	40	39	18	0
Total:	12	766	13.0	0.08	10,775	185	Avg: 3	5	43	33	16	0

HABITAT SUMMARY

Habitat Group	No. Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Wetted Area (m2)	Wetted Area Percent	Large Boulders Number	Large Boulders #/100m2
Dammed & BW Pools	1	9	1.0	0.00	9	0.08	5	55.56
Scour Pools	1	40	10.0	1.00	400	3.71	11	2.75
Glides	5	433	14.8	0.00	6423	59.61	68	1.06
Riffles	5	284	14.2	0.00	3943	36.59	101	2.56
Rapids	0	0	.	.	0	0.00	0	0.00
Cascades	0	0	.	.	0	0.00	0	0.00
Step/Falls	0	0	.	.	0	0.00	0	0.00
Dry	0	0	.	.	0	0.00	0	0.00

POOL SUMMARY

	Total	#/km
All Pools	2	2.6
Pools >1m deep:	1	1.3
Complex pools (wood pieces>3):	0	0.0
Pool frequency (channel widths/pool):	547.1	

LARGE WOOD DEBRIS

	Pieces	Pieces/100m
Small (>15cm dbh, 3m length)	0	0.0
Medium (>30cm dbh, 6m length)	0	0.0
Large (>60cm dbh, 10m length)	0	0.0
Total - all LWD classes	0	0.0

STREAM SUMMARY MF MALHEUR

Number Units	Total Length (m)	Avg Width (m)	Avg Depth (m)	Total Area (m2)	Substrate Percent Wetted Area S/O	Sand	Grvl	Cbbl	Bldr	Bdrk	Total Large Boulder
245	19,094	14.4	0.15	319,909	3	7	26	42	22	0	9,064

Wetted Area

Habitat Group	(m2)	Percent
Scour Pool	7,086	2.2
Backwater Pools	455	0.1
Glide	45,300	14.2
Riffle	241,003	75.3
Rapid	24,314	7.6
Cascade	0	0.0
Step	683	0.2
Dry	0	0.0

OREGON DEPT. FISH AND WILDLIFE - STEP MF MALHEUR
HABITAT INVENTORY Report Date: 02/01/01 Survey Date: 07/06/00

REACH SUMMARY

REACH 1 T18SR34ESEC9SE
REACH 1

UTM Zone: 11
Start: Easting 0377484 End: Easting
Northing 4874264 Northing

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

Narrow Valley Floor		Broad Valley Floor	
Steep V-shape	0	Constraining Terraces	0
Moderate V-shape	100	Multiple Terraces	0
Open V-shape	0	Wide Floodplain	0

Valley Width Index: 1

Channel Morphology (Percent Reach Length)

Constrained		Unconstrained	
Hillslope	100	Single Channel	0
Bedrock	0	Multiple Channel	0
Terrace	0	Braided Channel	0
Alt. Terrace/Hill	0		
Landuse	0		

Channel Characteristics

Type	Length(m)	Area (m2)	Dry Units
Primary	10,788	188,728	0
Secondary	52	189	0

Channel Dimensions(m)

Wetted		Active		Floodprone	
Width	15.2	Width	23.0		29.0
Depth	0.18	Height	0.7		1.4
		W:D ratio	32.9	Entrenchment	1.3

Stream Flow Type: MF Water Temp: 8C/0900
Avg. Unit Gradient: 1.7% Habitat Units/100m: 0.6

Riparian and Bank Summary

	Primary	Secondary
Land Use:		
Riparian Vegetation:	C	P

Bank Condition and Shade

Bank Status	% Reach Length	Shade (% of 180)
Actively Eroding	0%	Reach avg: 61%
		Range: 0- 81%

Reach notes: USFS BOUNDARY

OREGON DEPT. FISH AND WILDLIFE - STEP MF MALHEUR
HABITAT INVENTORY Report Date: 02/01/01 Survey Date: 07/26/00

REACH SUMMARY

REACH 2
REACH 2

UTM Zone: 11
Start: Easting End: Easting
Northing Northing

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

Narrow Valley Floor		Broad Valley Floor	
Steep V-shape	0	Constraining Terraces	0
Moderate V-shape	100	Multiple Terraces	0
Open V-shape	0	Wide Floodplain	0

Valley Width Index: 1-2.5

Channel Morphology (Percent Reach Length)

Constrained		Unconstrained	
Hillslope	100	Single Channel	0
Bedrock	0	Multiple Channel	0
Terrace	0	Braided Channel	0
Alt. Terrace/Hill	0		
Landuse	0		

Channel Characteristics

Type	Length(m)	Area (m2)	Dry Units
Primary	1,572	26,137	0
Secondary	70	700	0

Channel Dimensions(m)

Wetted		Active		Floodprone	
Width	16.3	Width	19.0		25.0
Depth	0.24	Height	0.8		1.6
		W:D ratio	23.8	Entrenchment	1.3

Stream Flow Type: LF Water Temp:
Avg. Unit Gradient: 0.9% Habitat Units/100m: 1.5

Riparian and Bank Summary

	Primary	Secondary
Land Use:	LG	
Riparian Vegetation:	C	P

Bank Condition and Shade

Bank Status	% Reach Length	Shade (% of 180)
Actively Eroding	6%	Reach avg: 52%
		Range: 39- 69%

OREGON DEPT. FISH AND WILDLIFE - STEP MF MALHEUR
HABITAT INVENTORY Report Date: 02/01/01 Survey Date: 07/26/00

REACH SUMMARY

REACH 3
REACH 3

UTM Zone: 11
Start: Easting End: Easting
Northing Northing

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

Narrow Valley Floor		Broad Valley Floor	
Steep V-shape	0	Constraining Terraces	0
Moderate V-shape	100	Multiple Terraces	0
Open V-shape	0	Wide Floodplain	0

Valley Width Index: 1-2.5

Channel Morphology (Percent Reach Length)

Constrained		Unconstrained	
Hillslope	100	Single Channel	0
Bedrock	0	Multiple Channel	0
Terrace	0	Braided Channel	0
Alt. Terrace/Hill	0		
Landuse	0		

Channel Characteristics

Type	Length(m)	Area (m2)	Dry Units
Primary	5,143	89,210	0
Secondary	755	4,359	0

Channel Dimensions(m)

Wetted		Active		Floodprone	
Width	13.1	Width	16.0		23.0
Depth	0.10	Height	0.6		1.3
		W:D ratio	26.7	Entrenchment	1.4

Stream Flow Type: LF Water Temp: 62F/1220
Avg. Unit Gradient: 1.2% Habitat Units/100m: 1.5

Riparian and Bank Summary

	Primary	Secondary
Land Use:	LG	
Riparian Vegetation:	C	P

Bank Condition and Shade

Bank Status	% Reach Length	Shade (% of 180)
Actively Eroding	10%	Reach avg: 48%
		Range: 27- 77%

Reach notes:

OREGON DEPT. FISH AND WILDLIFE - STEP MF MALHEUR
HABITAT INVENTORY Report Date: 02/01/01 Survey Date: 07/27/00

REACH SUMMARY

REACH 4
REACH 4

UTM Zone: 11
Start: Easting End: Easting
Northing Northing

Valley and Channel Summary

Valley Characteristics (Percent Reach Length)

Narrow Valley Floor		Broad Valley Floor	
Steep V-shape	0	Constraining Terraces	0
Moderate V-shape	0	Multiple Terraces	0
Open V-shape	100	Wide Floodplain	0

Valley Width Index: 1-2.5

Channel Morphology (Percent Reach Length)

Constrained		Unconstrained	
Hillslope	100	Single Channel	0
Bedrock	0	Multiple Channel	0
Terrace	0	Braided Channel	0
Alt. Terrace/Hill	0		
Landuse	0		

Channel Characteristics

Type	Length(m)	Area (m2)	Dry Units
Primary	757	10,766	0
Secondary	9	9	0

Channel Dimensions(m)

Wetted		Active		Floodprone	
Width	13.0	Width	26.7		56.0
Depth	0.08	Height	0.7		1.4
		W:D ratio	37.14	Entrenchment	2.1

Stream Flow Type: LF Water Temp: 20C/1723
Avg. Unit Gradient: 0.9% Habitat Units/100m: 1.6

Riparian and Bank Summary

	Primary	Secondary
Land Use:	HG	
Riparian Vegetation:	B	P

Bank Condition and Shade

Bank Status	% Reach Length	Shade (% of 180)
Actively Eroding	30%	Reach avg: 20%
		Range: 13- 43%

Reach notes:

Riparian transects.

Reach 1					Cover (percent)				Diameter class (cm)					
UNIT	SIDE	ZONE	SURFACE	SLOPE	CANOPY	SHRUB	GRASS		3-15	15-30	30-50	50-90	>90	Notes
1	LF	1	HS	39.0	40	10	70	CONIFER						
								HARDWOOD	9					
1	LF	2	HS	52.0	40	0	60	CONIFER				1		
								HARDWOOD						
1	LF	3	HS	60.0	50	5	50	CONIFER			2			
								HARDWOOD						
1	RT	1	LT	14.0	80	90	5	CONIFER						
								HARDWOOD		4				
1	RT	2	HS	21.0	95	80	15	CONIFER	1			1		
								HARDWOOD						
1	RT	3	HS	50.0	85	10	75	CONIFER						
								HARDWOOD						
30	LF	1	HS	37.0	15	35	60	CONIFER						
								HARDWOOD	5					
30	LF	2	HS	15.0	70	15	75	CONIFER	2				1	
								HARDWOOD						
30	LF	3	HS	10.0	40	15	65	CONIFER	1	1				
								HARDWOOD						
30	RT	1	HS	34.0	40	30	40	CONIFER	1					
								HARDWOOD	4					
30	RT	2	HS	35.0	90	15	50	CONIFER			2			
								HARDWOOD						
30	RT	3	HS	39.0	50	20	25	CONIFER				1		
								HARDWOOD						
60	LF	1	HT	1.0	60	80	20	CONIFER						
								HARDWOOD	2					
60	LF	2	HT	0.0	5	60	30	CONIFER						
								HARDWOOD	1					
60	LF	3	HT	1.0	10	69	20	CONIFER	2					
								HARDWOOD	3					
60	RT	1	HS	72.0	5	15	20	CONIFER						
								HARDWOOD	2					
60	RT	2	HS	70.0	30	40	35	CONIFER	2					
								HARDWOOD						
60	RT	3	HS	58.0	55	20	60	CONIFER						
								HARDWOOD						
90	LF	1	FP	0.0	20	20	70	CONIFER						
								HARDWOOD						
90	LF	2	HS	9.0	40	5	55	CONIFER	4	1	1			
								HARDWOOD						
90	LF	3	HS	17.0	30	10	60	CONIFER	9					
								HARDWOOD						
90	RT	1	HS	55.0	0	0	0	CONIFER						
								HARDWOOD						ROCKSLIDE
90	RT	2	HS	55.0	0	0	0	CONIFER						
								HARDWOOD						ROCKSLIDE
90	RT	3	HS	55.0				CONIFER						
								HARDWOOD						ROCKSLIDE

Riparian transects.

Reach 2					Cover (percent)				Diameter class (cm)					
UNIT	SIDE	ZONE	SURFACE	SLOPE	CANOPY	SHRUB	GRASS		3-15	15-30	30-50	50-90	>90	Notes
120	LF	1	HS	40.0	80	25	65	CONIFER	3	4				
								HARDWOOD						
120	LF	2	HS	62.0	50	20	50	CONIFER	2				1	
								HARDWOOD						
120	LF	3	HS	70.0	20	10	55	CONIFER		1				
								HARDWOOD						
120	RT	1	HS	45.0	15	15	60	CONIFER			1	0		
								HARDWOOD						
120	RT	2	HS	41.0	55	5	50	CONIFER	2	4				
								HARDWOOD						
120	RT	3	HS	45.0	70	5	35	CONIFER	1	1	1			
								HARDWOOD						

Reach 3					Cover (percent)				Diameter class (cm)					
UNIT	SIDE	ZONE	SURFACE	SLOPE	CANOPY	SHRUB	GRASS		3-15	15-30	30-50	50-90	>90	Notes
150	LF	1	HS	30.0	0	5	10	CONIFER						
								HARDWOOD						
150	LF	2	HS	62.0	0	5	0	CONIFER						
								HARDWOOD						
150	LF	3	HS	120.0	0	15	5	CONIFER						
								HARDWOOD						
150	RT	1	HS	44.0		25	10	CONIFER	1					
								HARDWOOD						
150	RT	2	HS	80.0	0	10	5	CONIFER						
								HARDWOOD						
150	RT	3	HS	51.0	0	10	5	CONIFER						
								HARDWOOD						
180	LF	1	HS	35.0	10	5	35	CONIFER	6					
								HARDWOOD						
180	LF	2	HS	46.0	20	5	55	CONIFER		1				
								HARDWOOD						
180	LF	3	HS	60.0	15	5	60	CONIFER		1	1			
								HARDWOOD						
180	RT	1	HS	22.0	15	5	35	CONIFER						
								HARDWOOD						
180	RT	2	HS	52.0	5	5	35	CONIFER						
								HARDWOOD						
180	RT	3	HS	55.0	20	5	20	CONIFER		1	1			
								HARDWOOD						
210	LF	1	HS	28.0	0	20	20	CONIFER						
								HARDWOOD						
210	LF	2	HS	16.0	0	30	5	CONIFER						
								HARDWOOD						
210	LF	3	HS	20.0	15	15	2	CONIFER			2			
								HARDWOOD						
210	RT	1	HS	30.0	40	15	55	CONIFER						
								HARDWOOD						
210	RT	2	HS	52.0	40	2	40	CONIFER	1					

Riparian transects.

								HARDWOOD						
210	RT	3	HS	62.0	0	5	5	CONIFER						
								HARDWOOD						

Reach 4					Cover (percent)				Diameter class (cm)					
UNIT	SIDE	ZONE	SURFACE	SLOPE	CANOPY	SHRUB	GRASS		3-15	15-30	30-50	50-90	>90	Notes
240	LF	1	FP	4.0	0	5	90	CONIFER						
								HARDWOOD						
240	LF	2	HS	19.0	65	0	50	CONIFER		3	1			
								HARDWOOD						
240	LF	3	HS	47.0	90	0	50	CONIFER	2	4				
								HARDWOOD						
240	RT	1	FP	4.0	0	5	90	CONIFER						
								HARDWOOD						
240	RT	2	HS	19.0	0	30	55	CONIFER						
								HARDWOOD						
240	RT	3	HS	45.0	0	25	25	CONIFER						
								HARDWOOD						
250	LF	1	HT	8.0	0	25	50	CONIFER						
								HARDWOOD						
250	LF	2	HT	3.0	0	20	50	CONIFER						
								HARDWOOD						
250	LF	3	HS	4.0	0	80	5	CONIFER						
								HARDWOOD						
250	RT	1	FP	1.0	0	0	90	CONIFER						
								HARDWOOD						
250	RT	2	HS	7.0	0	10	85	CONIFER						
								HARDWOOD						
250	RT	3	HS	29.0	0	55	5	CONIFER						
								HARDWOOD						

Codes:
Sides:
LF – Left side
RT – Right side
Surface:
HS – Hillslope
LT – Low Terrace
HT – High Terrace
FP – Floodplain

Appendix B.

Statistical tables produced from Microsoft Excel. Tables test for significant changes of temperature between temperature probe sites. Rates of temperature change per kilometer from July 1 to September 2, 2000 were statistically compared between sites to determine if temperature sites recorded a significant rate of stream temperature change.

Site 4 versus 3

Parameters

Analysis	2 Sample t	Ho: Mean Diff. = 0	0
Input Column 1	Variable 1	Ha: Not equal to 0	0
Input Column 2	Variable 1	Confidence	0.95
		Pooled Variance	TRUE

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Variable 1	62	0.28463343	0.099202443	0.012598723
Variable 1	62	0.08656426	0.102806273	0.013056410

t-Test Analysis

Mean Diff.	Std. Err.	t	df	p-value	lower 95%	upper 95%
0.19806917	0.018143805	10.917	122.00	8.9816E-20	0.16215167	0.23398668

Site 3 versus 1

Parameters

Analysis	2 Sample t	Ho: Mean Diff. = 0	
Input Column 1	Variable 1	Ha: Not equal to 0	
Input Column 2	Variable 1	Confidence	0.95
		Pooled Variance	TRUE

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Variable 1	62	0.08656426	0.102806273	0.013056410
Variable 1	62	0.0683669	0.06164896	0.00782943

t-Test Analysis

Mean Diff.	Std. Err.	t	df	p-value	lower 95%	upper 95%
0.01819732	0.015223985	1.195	122.00	0.234	-0.01194010	0.04833475

Site 4 versus 1

Parameters

Analysis	2 Sample t	Ho: Mean Diff. = 0	0
Input Column 1	Variable 1	Ha: Not equal to 0	0
Input Column 2	Variable 1	Confidence	0.95
		Pooled Variance	TRUE

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Variable 1	62	0.28463343	0.099202443	0.012598723
Variable 1	62	0.0683669	0.06164896	0.00782943

t-Test Analysis

Mean Diff.	Std. Err.	t	df	p-value	lower 95%	upper 95%
0.21626650	0.014833331	14.580	122.00	1.693E-28	0.18690241	0.24563058

Site 4 versus 2

Parameters

Analysis	2 Sample t	Ho: Mean Diff. = 0	0
Input Column 1	Variable 1	Ha: Not equal to 0	0
Input Column 2	Variable 1	Confidence	0.95
		Pooled Variance	TRUE

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Variable 1	62	0.28463343	0.099202443	0.012598723
Variable 1	62	1.80304659	0.785238970	0.099725449

t-Test Analysis

Mean Diff.	Std. Err.	t	df	p-value	lower 95%	upper 95%
-1.51841316	0.100518123	-15.106	122.00	1.0343E-29	-1.71739900	-1.31942733

Site 3 versus 2

Parameters

Analysis	2 Sample t	Ho: Mean Diff. = 0	0
Input Column 1	Variable 1	Ha: Not equal to 0	0
Input Column 2	Variable 1	Confidence	0.95
		Pooled Variance	TRUE

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Variable 1	62	0.08656426	0.102806273	0.013056410
Variable 1	62	1.80304659	0.785238970	0.099725449

t-Test Analysis

Mean Diff.	Std. Err.	t	df	p-value	lower 95%	upper 95%
-1.71648233	0.100576513	-17.066	122.00	4.0786E-34	-1.91558376	-1.51738091

Site 2 versus 1

Parameters

Analysis	2 Sample t	Ho: Mean Diff. = 0	0
Input Column 1	Variable 1	Ha: Not equal to 0	0
Input Column 2	Variable 1	Confidence	0.95
		Pooled Variance	TRUE

Descriptive Statistics

	N	Mean	Std. Dev.	Std. Err.
Variable 1	62	0.0683669	0.06164896	0.00782943
Variable 1	62	1.80304659	0.785238970	0.099725449

t-Test Analysis

Mean Diff.	Std. Err.	t	df	p-value	lower 95%	upper 95%
-1.7346797	0.10003232	-17.341	122.00	1.0217E-34	-1.9327038	-1.5366555

Upper Malheur River Water Quality and Bull Trout

Author: Steve Namitz, Burns Paiute Fish and Wildlife Department, Burns, Oregon

Introduction

The Burns Paiute Tribe (BPT), United States Forest Service (USFS), and Oregon Department of Fish and Wildlife (ODFW), participated in documenting temperature trends in the Upper Malheur River. Bull trout *Salvenlinus confluentus* have specific environmental requirements and complex life histories making them especially susceptible to human activities that alter their habitat (Howell and Buchanan 1992). Bull trout are considered to be a cold-water species and are temperature dependent. This presents a challenge for managers, biologists, and private landowners in the Malheur River basin. The results of this paper are based on data temperature data collected in the year 2000 field season. Efforts to document water quality conditions will continue in fiscal year 2001.

Project #: 199701900

Objective 3. Monitor water quality within the Malheur Subbasin.

Task 3.a - Continue using thermographs to gather data on established sites.

Methods

The Burns Paiute Tribe strategically placed 9 temperature logger units within the Upper Malheur River. One of the probes received some damage and the data was not retrievable (the probe that was placed at the BPT fish weir at the Burnt Bridge Crossing). The Tribe focused most of their efforts on the Upper Malheur River above Warm Springs Reservoir. Recently purchased lands by the Tribe in the Logan Valley are actively managed for riparian and wetland restoration. The Tribe has rested these lands from cattle grazing since April, 2000. Stream temperature data was also gathered from the ODFW, and the USFS to comprise an effort of 22 functioning temperature logger units in the Upper Malheur River.

The most commonly used technique for gathering water temperature is the use of continuous data recorders. The Tribe uses a combination of Hobo XT's and Stow Away data loggers. Loggers were calibrated for accuracy using methods recommended by Oregon's "Water Quality Monitoring Guide Book" version 2.0 (http://www.oweb.state.or.us/publications/mon_guide99.shtml). Recorders were then placed in a stable housing with the purpose of withstanding high flows and certain degrees of bed load movement. Probes are placed into streams in late spring or as access permits. There is little to no maintenance required for either of the apparatuses, as long as they

stay watertight. The probes are collected at the end of the season and the data is downloaded on to a computer database to be analyzed.

Temperature data will be analyzed based on daily maximum temperatures averaged over seven day spans. Once water temperature data is analyzed the results will be correlated with salmonids life history and the Department of Environmental Quality's (Oregon DEQ) current standards for water quality within the Upper Malheur River.

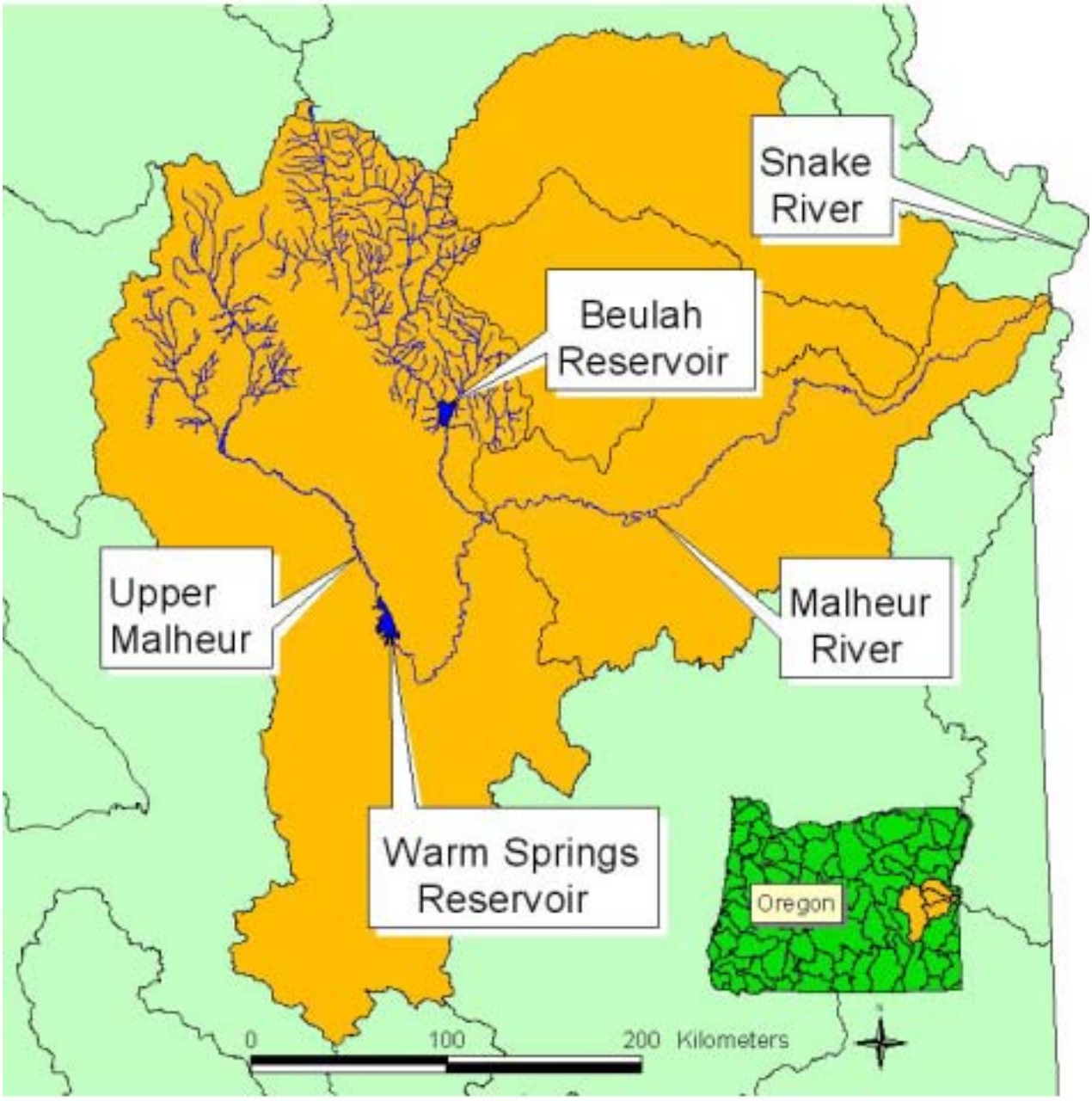

Figure 1. Malheur Subbasin 2000

Results

The Upper Malheur River above Warm Springs Reservoir and most tributaries are on Oregon's Final 1998 303(d) list (Figures 2&3)(Appendix A). Waters in the Malheur are considered to be water quality limited. The Upper Malheur River is characterized as being a priority one area, with temperature being the major limiting factor for native salmonid production and distribution (DEQ 1998).

The BPT and other cooperating agencies had a total of 22 continuous data loggers in the Upper Malheur River (Table 1). The focus area was broken up into six areas or reaches to make it easier to analyze the data.

Table 1. Data Recorder Locations 2000

Continuous Data Recorder			Location (UTM Zone 11)	
Probe	River Kilometer	DEQ Parameter	East	North
Malheur River #1 (BPT)	306	1	370083	4888999
Malheur River #2 (BPT)	301	1	371907	4884876
Malheur River #3 (USFS)	297	1	373610	4882537
Malheur River #4 (BPT)	296	1	373903	4882112
Malheur River #5 (BPT)	285	1	377421	4872433
Big Creek #1 (USFS)	12	1	371376	4899712
Big Creek #2 (USFS)	11	1	371377	4899783
Big Creek #3 (ODFW)	7	1	370935	4896360
Big Creek #4 (ODFW)	4	1	370999	4892975
Big Creek #5 (BPT)	4	1	370930	4892673
Big Creek #6 (BPT)	2	1	370842	4891072
Meadow Fork Creek #1 (ODFW)	2	1	369753	4899548
Meadow Fork Creek #2 (ODFW)	0	1	370475	4898306
Lake Creek #1 (USFS)	12	1	369192	4898931
Lake Creek #2 (ODFW)	9.5	1	369123	4896665
Lake Creek #3 (ODFW)	5	1	368027	4892765
Lake Creek #4 (ODFW)	5	1	368204	4892755
Lake Creek #5 (BPT)	4	1	367885	4891695
Lake Creek #6 (BPT)	1	1	369389	4889745
McCoy Creek #1 (ODFW)	6.5	2	366675	4897254
McCoy Creek #2 (ODFW)	1	2	367147	4892777
Crooked Creek (USFS)	2	2	367614	4889901

DEQ parameters (DEQ 1998):

1. 10° C or less for bull trout.
2. 17.8° C or less for native salmonids spawning, egg incubation, and fry emergence

Temperature data was compiled and sorted to show seven-day average maximum temperatures for the summer and early fall of 2000. Data will also be correlated to the historical life history of bull trout in the Upper Malheur River.

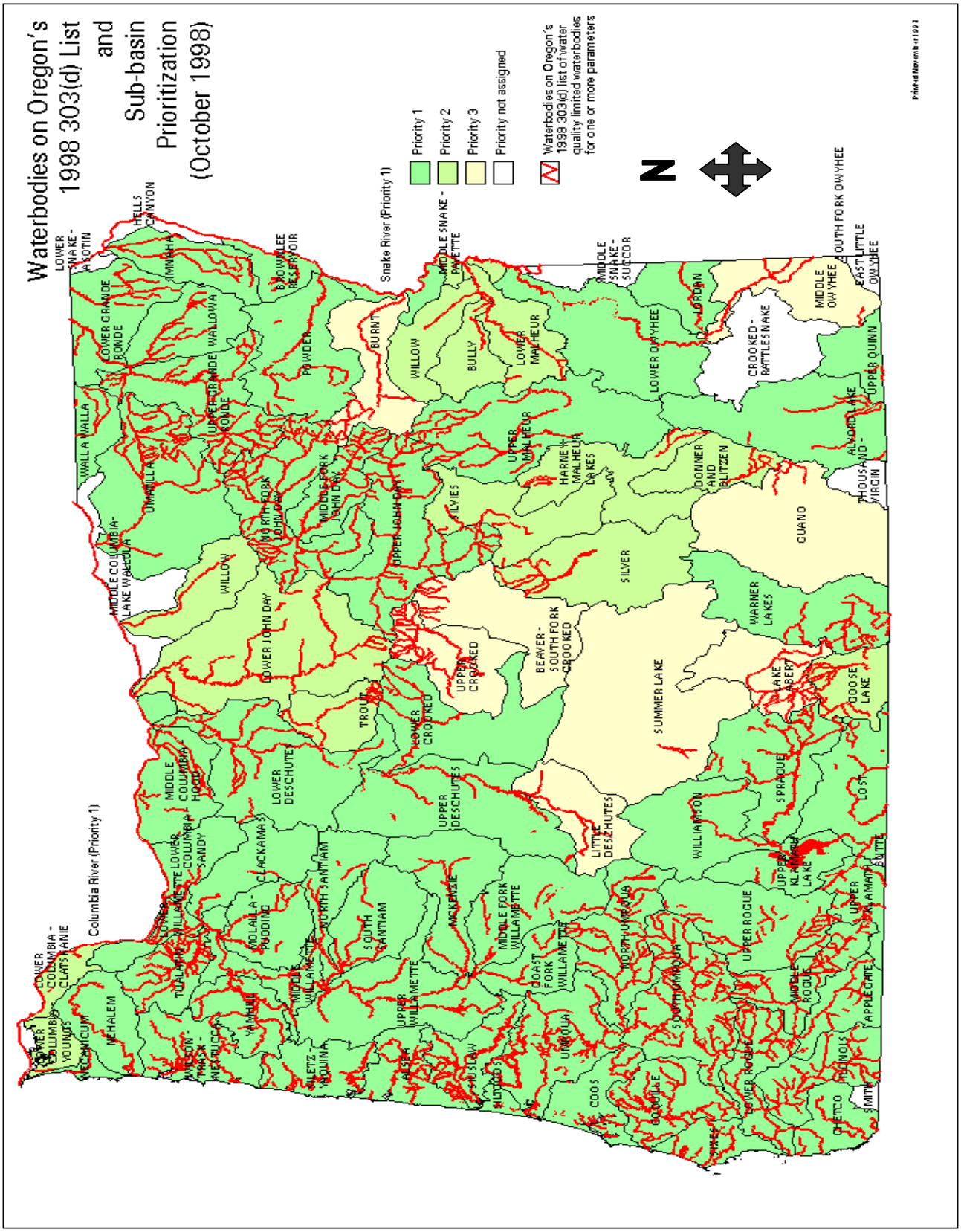

Figure 2. 1998 303(d) Water bodies Map (DEQ 1998) for Oregon.

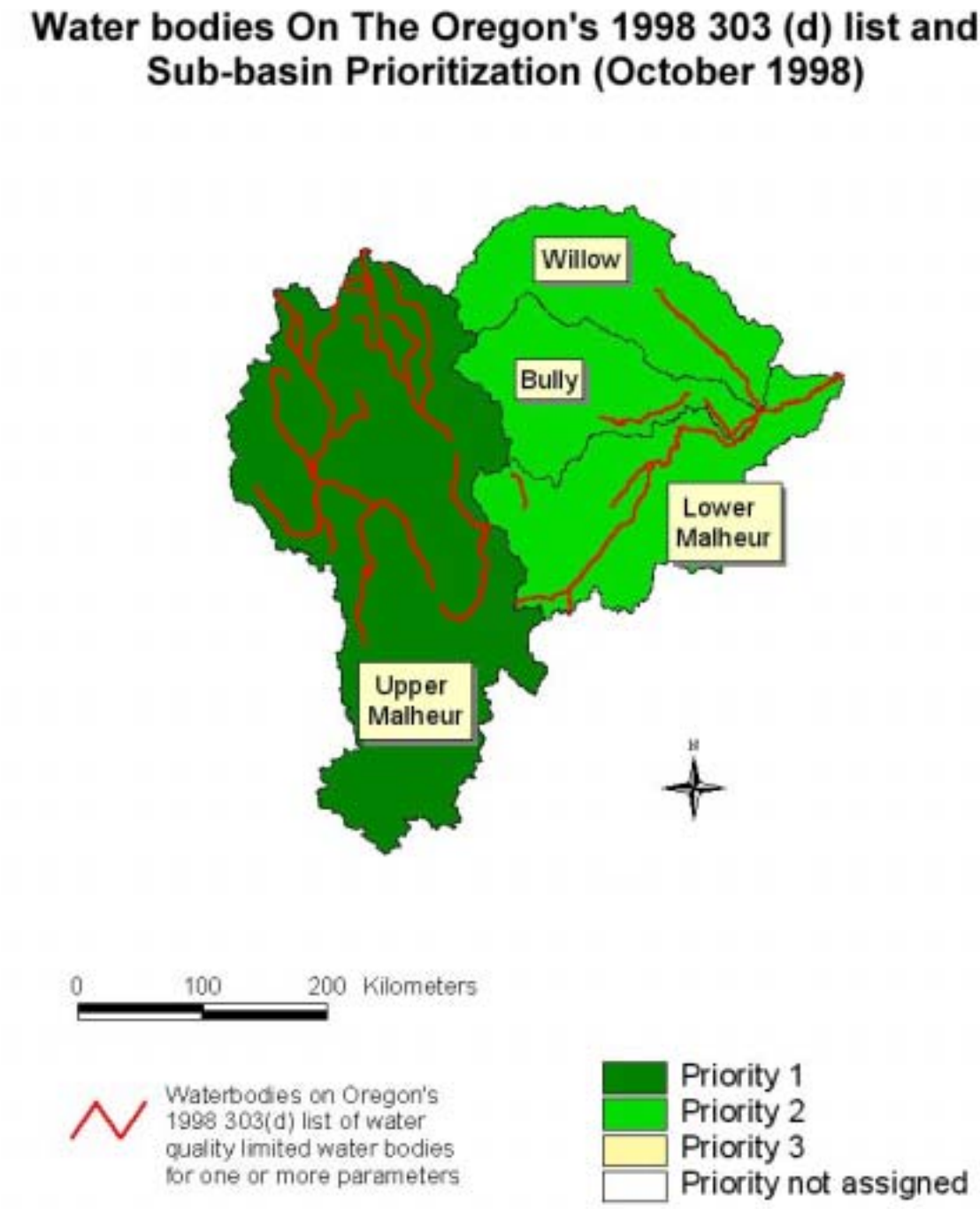

Figure 3. Malheur Basin 303(d) Map (DEQ 1998)

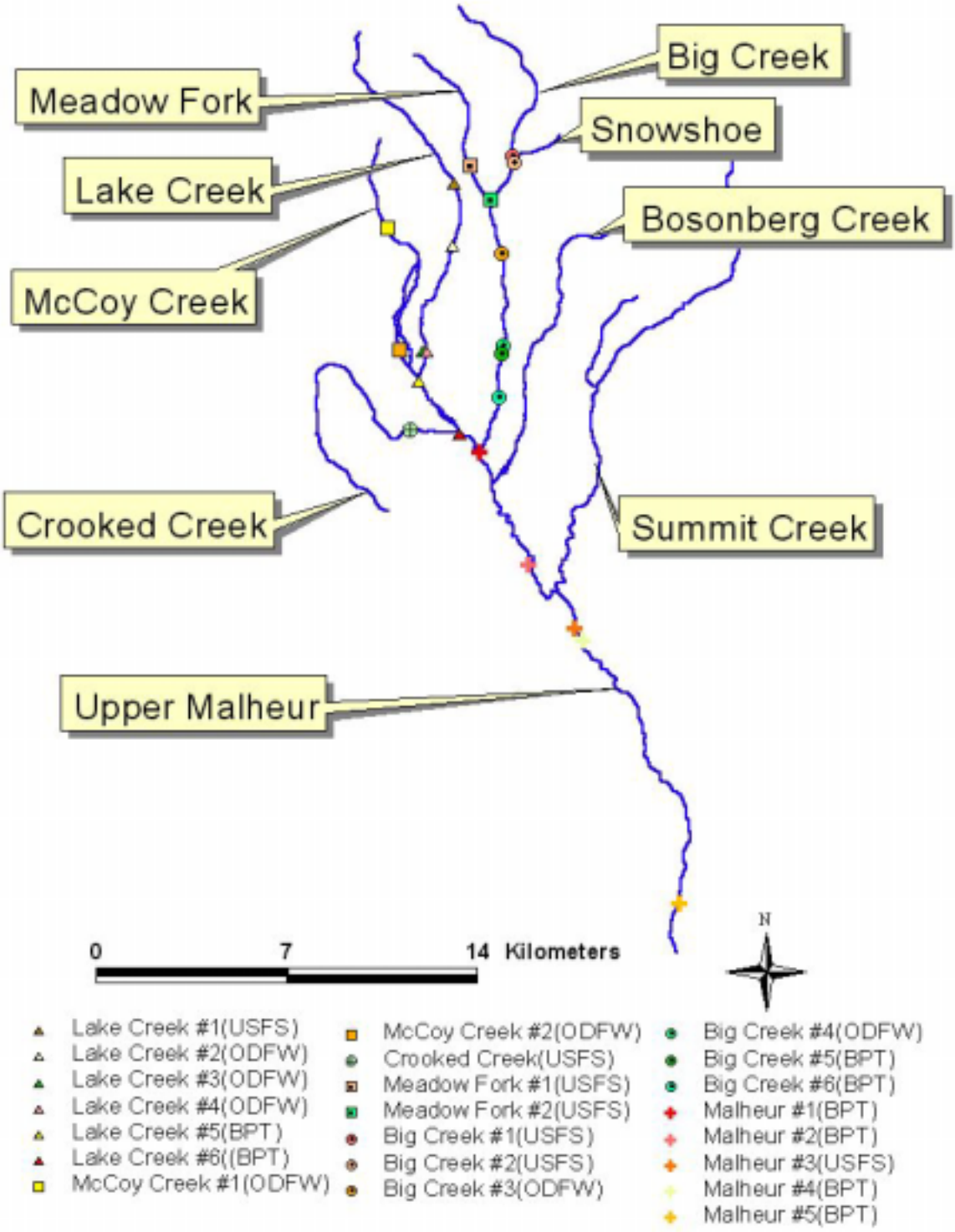

Figure 4. Upper Malheur River Temperature Probe Location Map 2000.

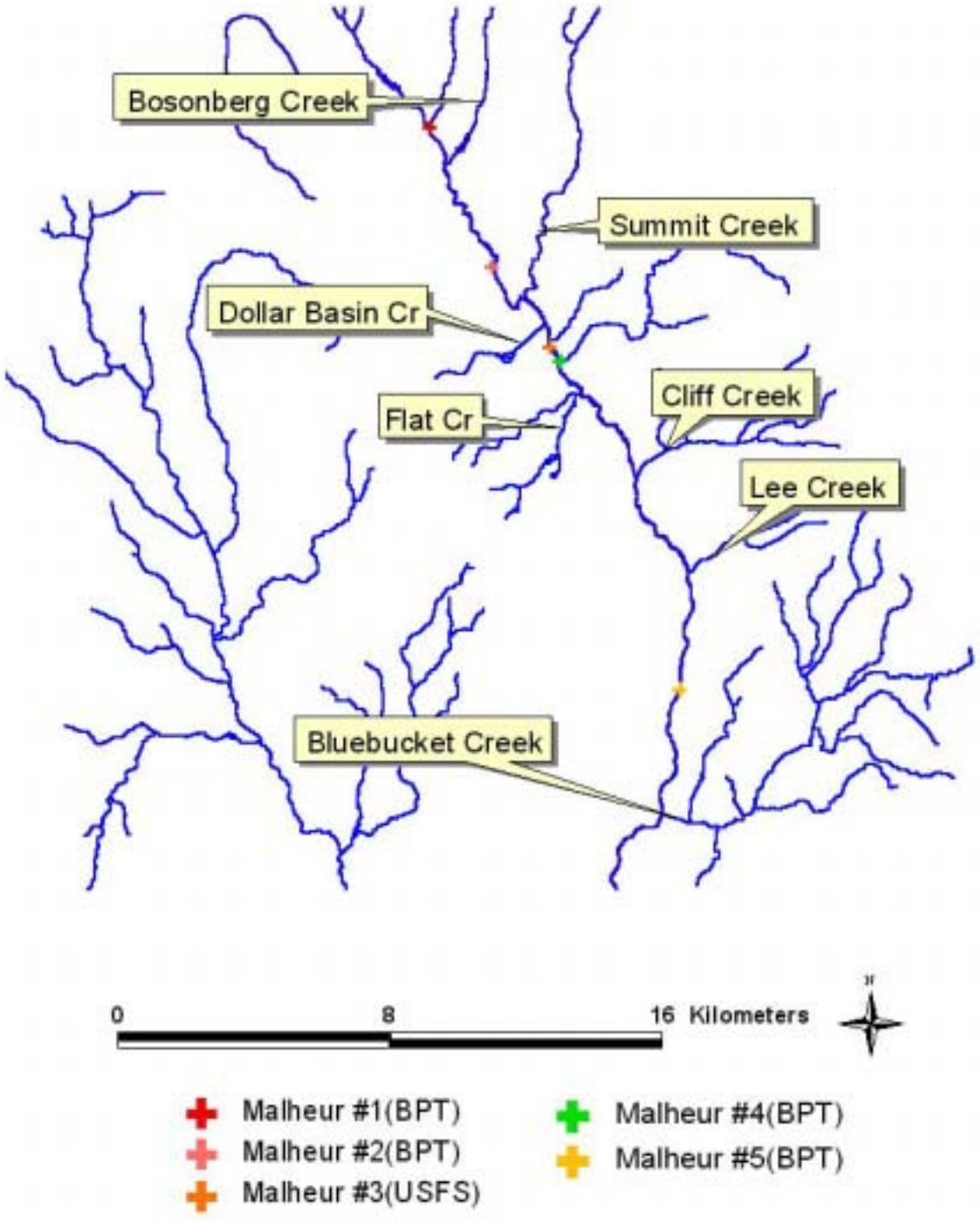

Figure 5. Temperature Probe Location Map for Upper Malheur River 2000

Upper Malheur River:

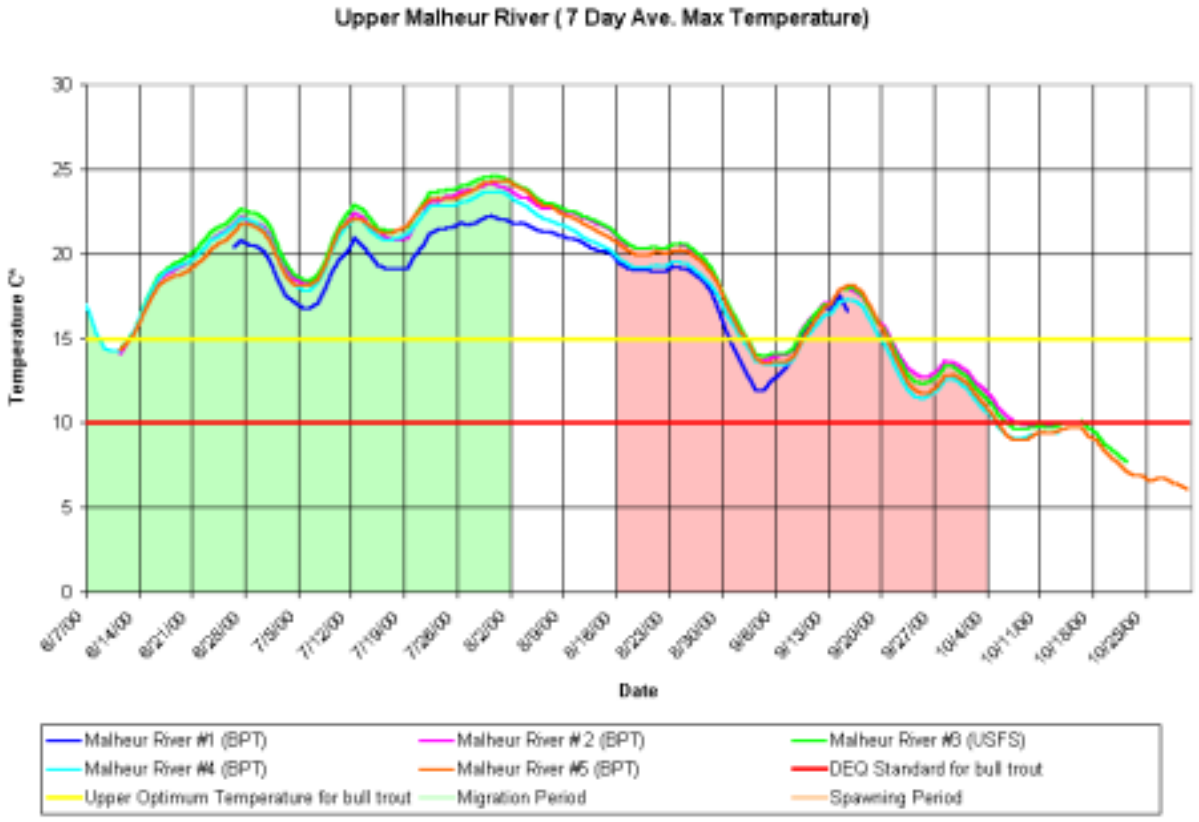

Figure 6. Comparison of the 7-day average maximum temperatures for the Upper Malheur River with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur River 2000.

The Upper Malheur River flows into Warm Springs Reservoir at RK 208 (Oregon Water Resources Department 1983). There were five probes placed in the Upper Malheur River in the late spring of 2000 between RK 283-306 (Figure 5). Figure 5 is based on daily maximum temperatures averaged over seven day spans. According to the standards established by DEQ in 1998 temperatures at all locations peaked above the acceptable limits for bull trout. Temperatures also exceeded the upper optimum levels for adult bull trout (15° C), and optimum juvenile growth at 4 to 10° C (McPhail and Murray 1979, Shepard et al 1984, Buckman et al 1992, Ratliff 1992, Buchanan and Gregory 1997). Acceptable water temperatures for spawning bull trout are to be less than 10° C (McPhail and Murray 1979, Shepard et al 1984, Buckman et al 1992, Ratliff 1992, Buchanan and Gregory 1997). Although bull trout were present throughout the Upper Malheur River no assumptions were made as to their health or survival from the temperature trends observed. Temperatures in the Upper Malheur River exceeded the thresholds established for bull trout until roughly October 2000 after peak spawning had occurred (page 30).

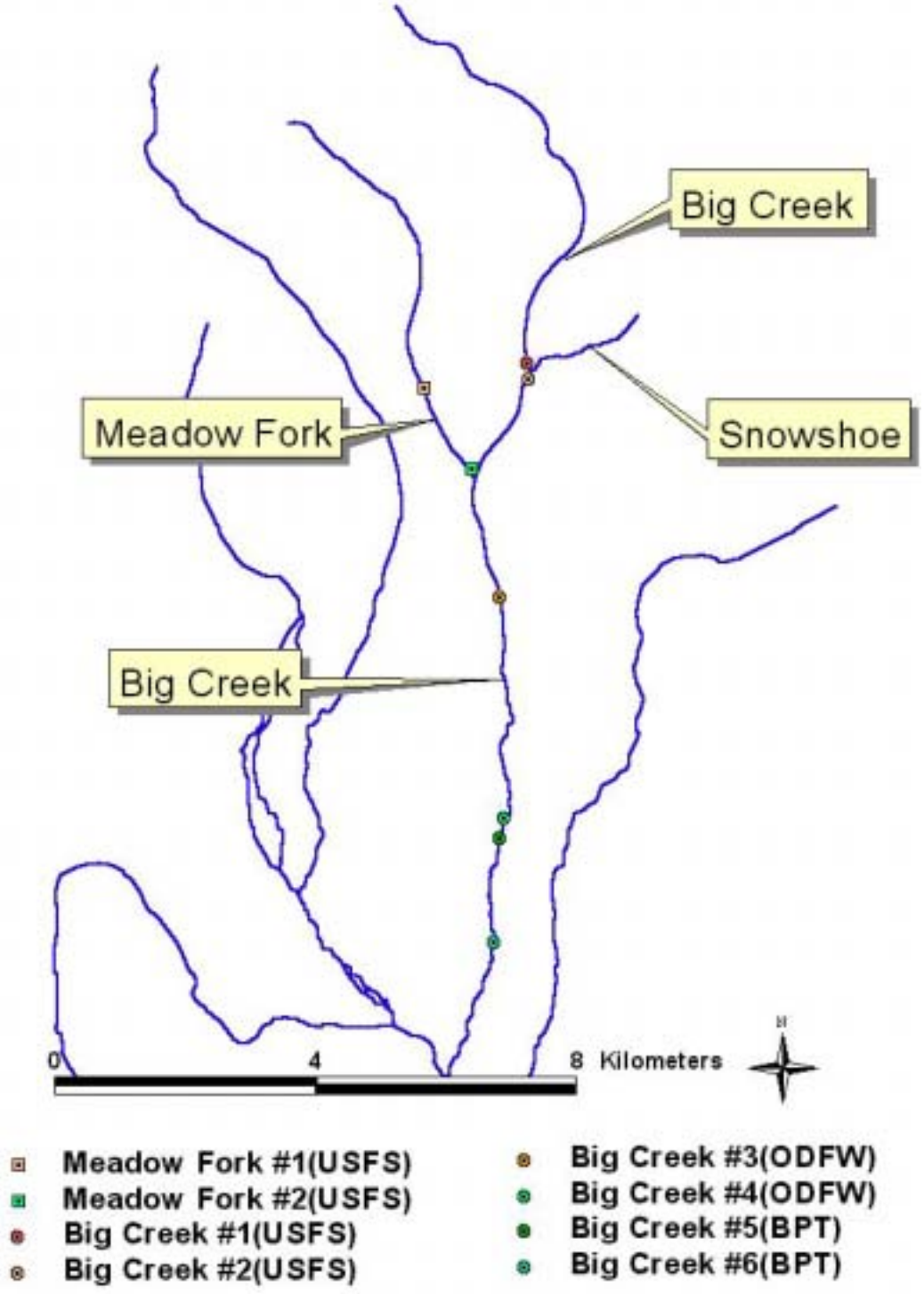

Figure 7. Temperature Probe Location Map for Big and Meadow Fork Creeks 2000.

Big Creek:

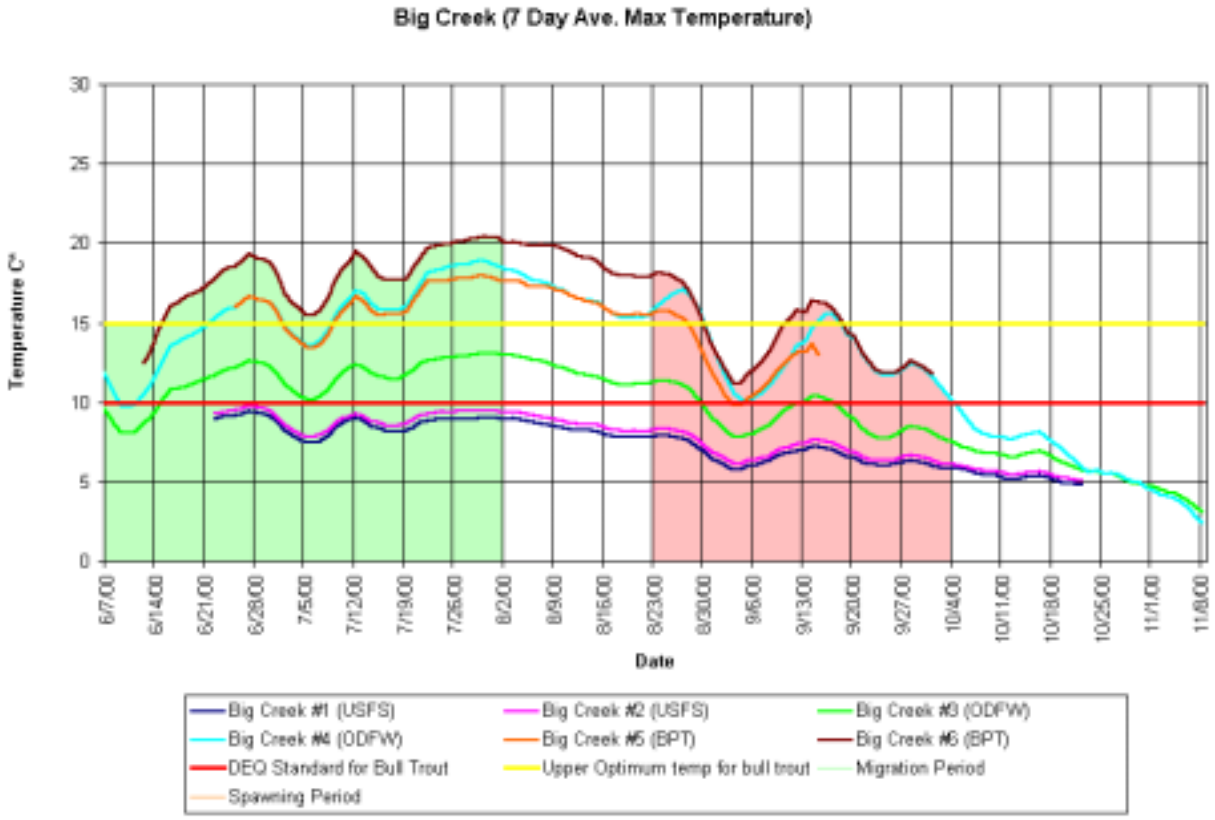

Figure 8. Comparison of the 7-day average maximum temperatures for Big Creek with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur River 2000.

Big Creek is a tributary of the Upper Malheur River entering in at RK 306 or RK 0 (Oregon Water Resources Department 1983). Six probes were placed in Big Creek between RK 0 and 16 (Figure 7). Figure 8 is based on daily maximum temperatures averaged over seven day spans. The graph depicts what would be expected in a normal system, as waters are usually coolest in the headwaters and increase in temperature as the stream drops in elevation. Temperatures exceeded DEQ standards for bull trout in most reaches. Bull trout were present throughout Big Creek in late spring, and fish were observed in all reaches of Big Creek throughout the summer season (page 9). Although bull trout were present throughout Big Creek no assumptions were made as to their health or survival from the temperature trends observed.

Meadow Fork Creek:

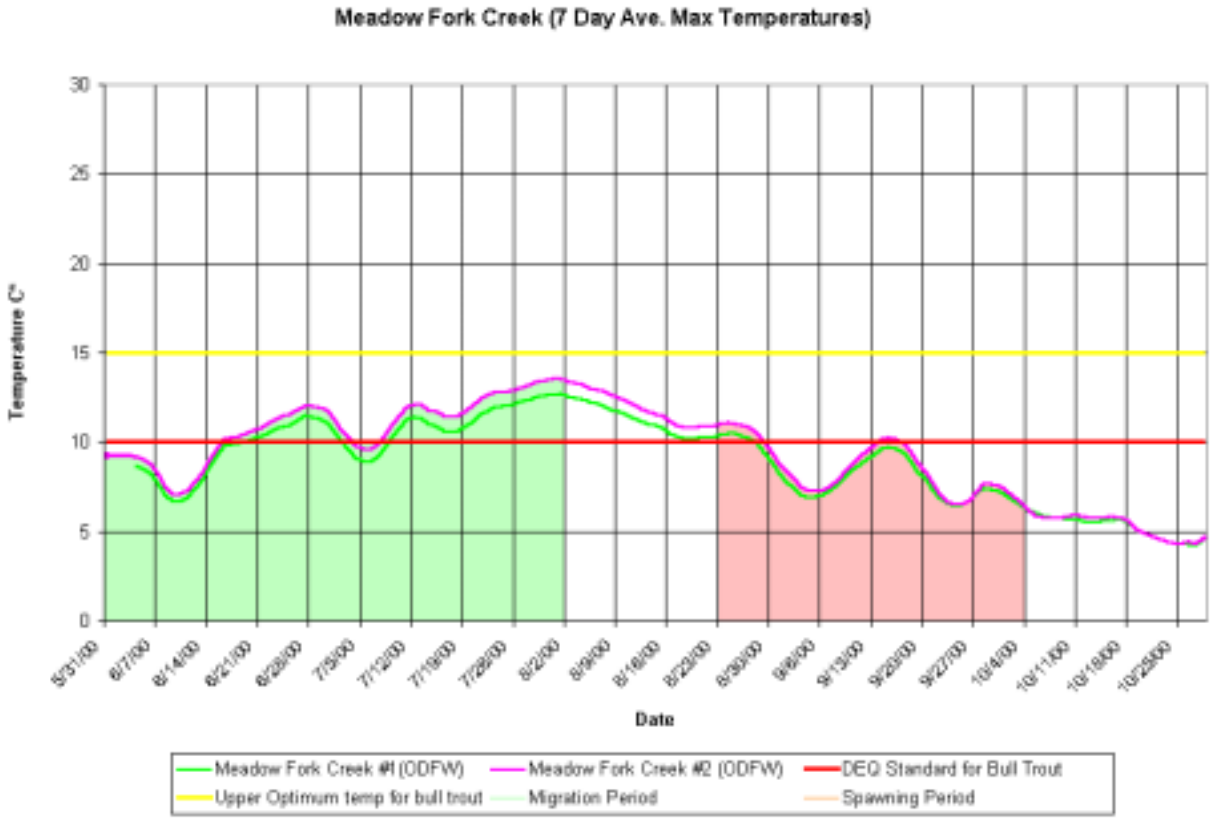

Figure 9. Comparison of the 7-day average maximum temperatures for Meadow Fork Creek with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur basin 2000.

Meadow Fork Creek is a tributary of Big Creek flowing in at RK 16 (Figure 7). Meadow Fork Creek is considered a headwater stream and lies within the ownership of the USFS, Prairie City Ranger District. Average temperatures for 2000 in Meadow Fork were below the upper optimum temperature for bull trout but exceeded the DEQ standards (10^{o} C). For periods when temperatures were above the DEQ standards they were still below the upper optimum temperatures for adult bull trout. Temperatures were generally below the standards established for bull trout spawning (10^{o} C) with two peaks not exceeding 11^{o} C. The BPT established that the Majority of bull trout spawning within the Upper Malheur River is occurring in Meadow Fork Creek. This was determined with the use of radio telemetery and spawning surveys conducted by the Tribe and ODFW over the past several years (Page 9 & 30).

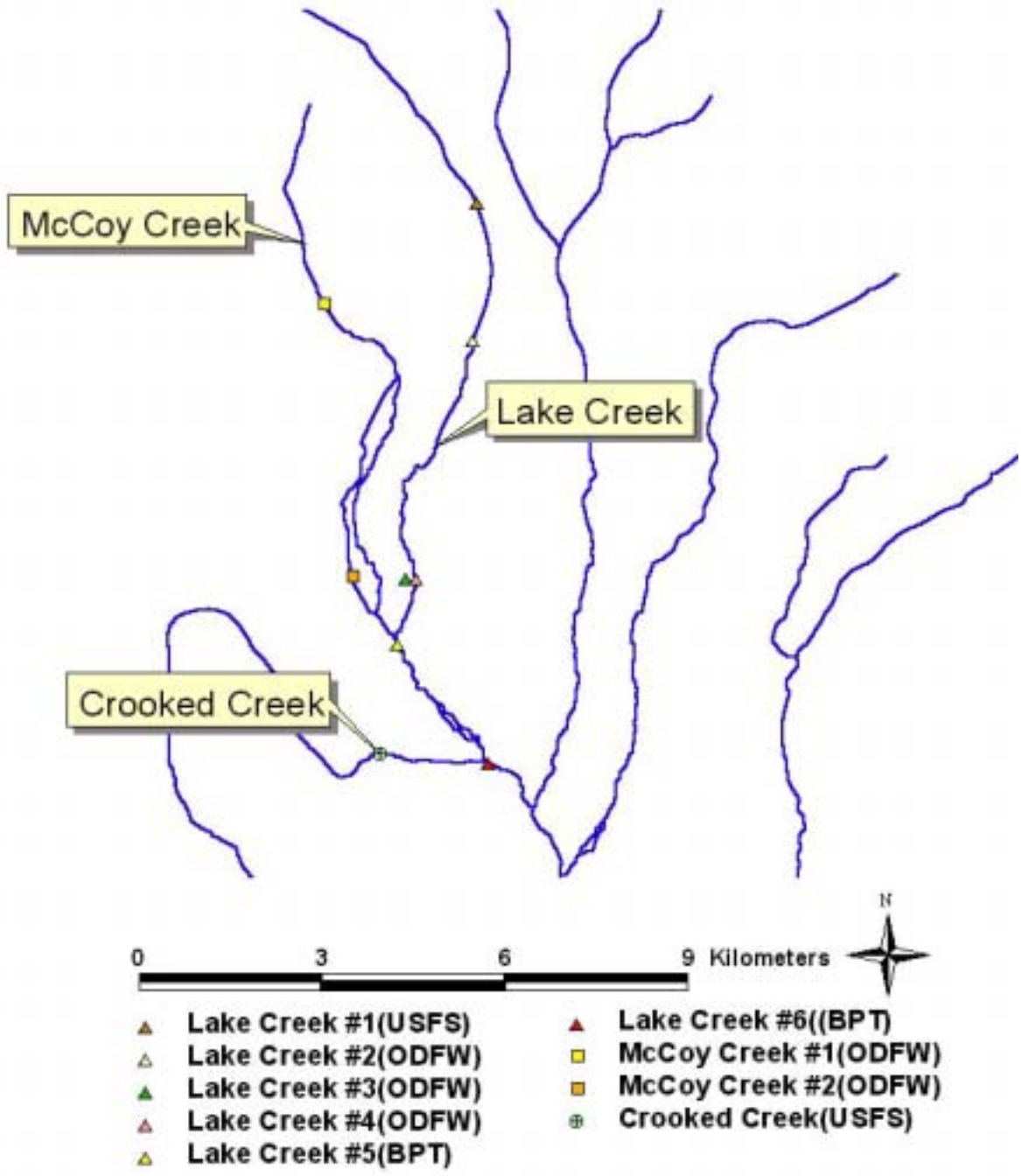

Figure 10. Temperature Probe Location Map for Lake, Crooked and McCoy Creeks 2000.

Lake Creek:

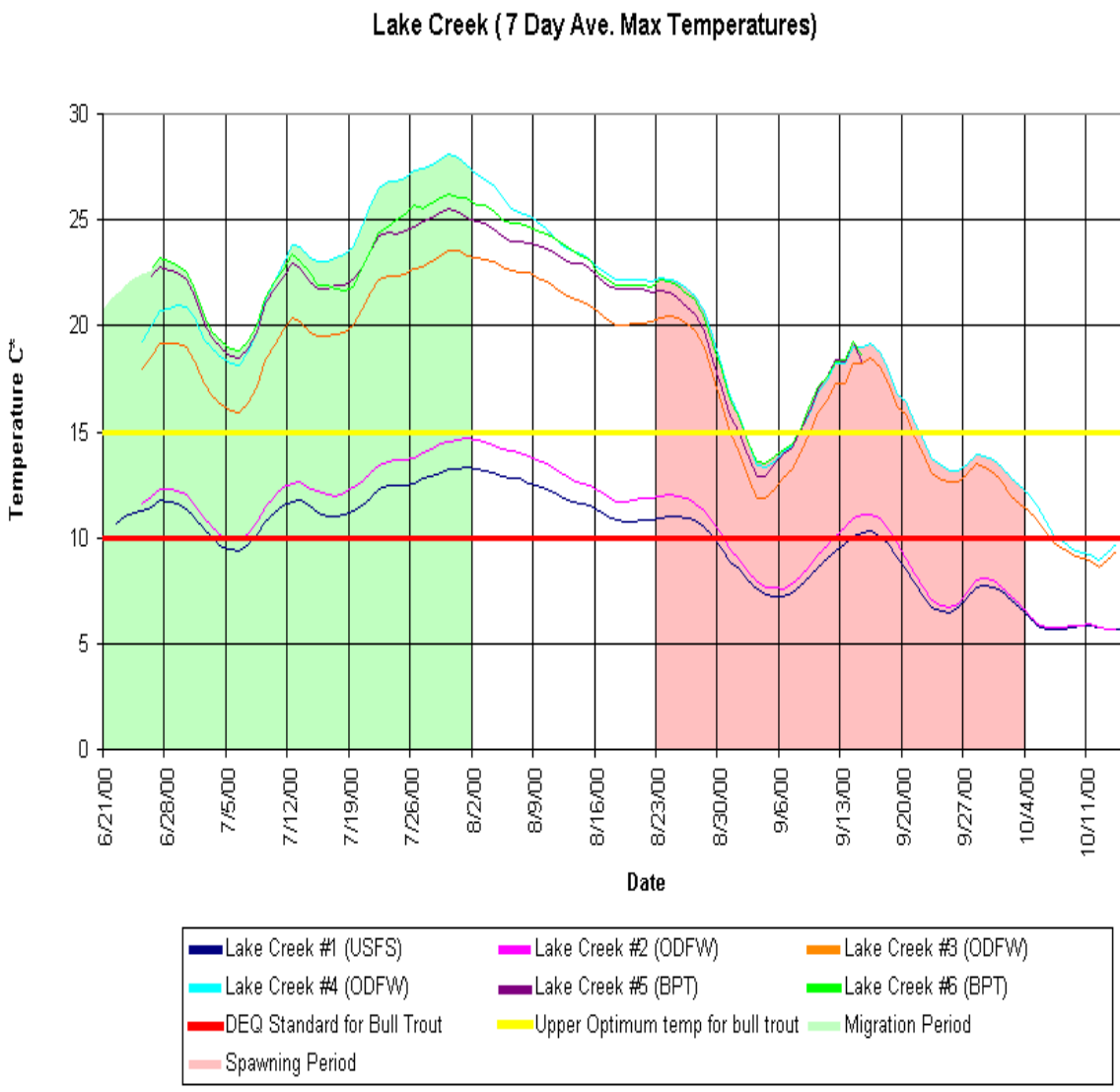

Figure 11. Comparison of the 7-day average maximum temperatures for Lake Creek with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur basin.

Lake Creek is a tributary to the Upper Malheur River entering in at RK 0 (Oregon Water Resources Department 1983). Six probes were placed in Lake Creek between RK 0 and 19 (Figure 10). Figure 11 is based on daily maximum temperatures averaged over seven day spans. The above graph dictates temperature trends in Lake Creek for 2000. Water temperatures were coolest in the headwaters and increase as the stream drops in elevation with the exception of probe #3, which was put in East Fork Lake Creek. Bull trout have been documented in Lake Creek by ODFW (Bowers 1993, Perkins 1998) but it is feared by local managers that the bull trout within Lake Creek are being out competed for resources by brook trout.

Crooked Creek:

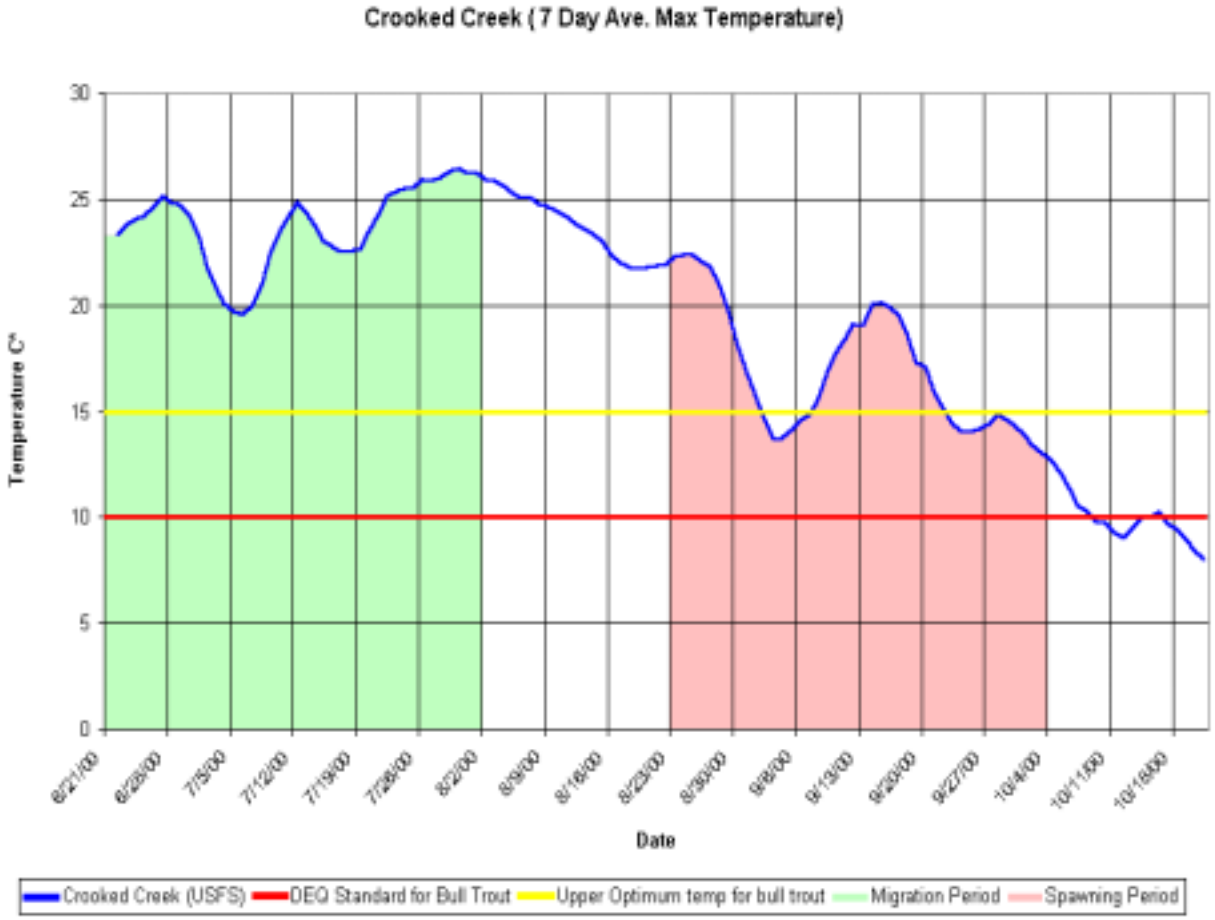

Figure 12. Comparison of the 7-day average maximum temperatures for Crooked Creek with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur basin.

Crooked Creek is a tributary of Lake Creek entering at RK 1. There was only one probe placed in Crooked Creek (Figure 10). There are documented sightings of bull trout in Crooked Creek (Buchanan 1997). The Burns Paiute Tribe documented bull trout in Crooked Creek in 1998, but did not find them during population and habitat surveys of 2000. Crooked Creek is characterized as a low gradient stream with low flow and sections of dry channel in the upper reaches. Temperatures exceed standards established by DEQ for bull trout in late spring and summer as well as the upper optimum threshold for adult bull trout (McPhail and Murray 1979, Shepard et al. 1984, Buckman et al. 1992, Ratliff 1992, Buchanan and Gregory 1997). Acceptable water temperatures for spawning bull trout have been documented to be less than 10° C (McPhail and Murray 1979, Shepard et al. 1984, Buckman et al. 1992, Ratliff 1992, Buchanan and Gregory 1997). Temperatures in Crooked Creek exceeded those thresholds for the duration in which spawning would have been expected to occur.

McCoy Creek:

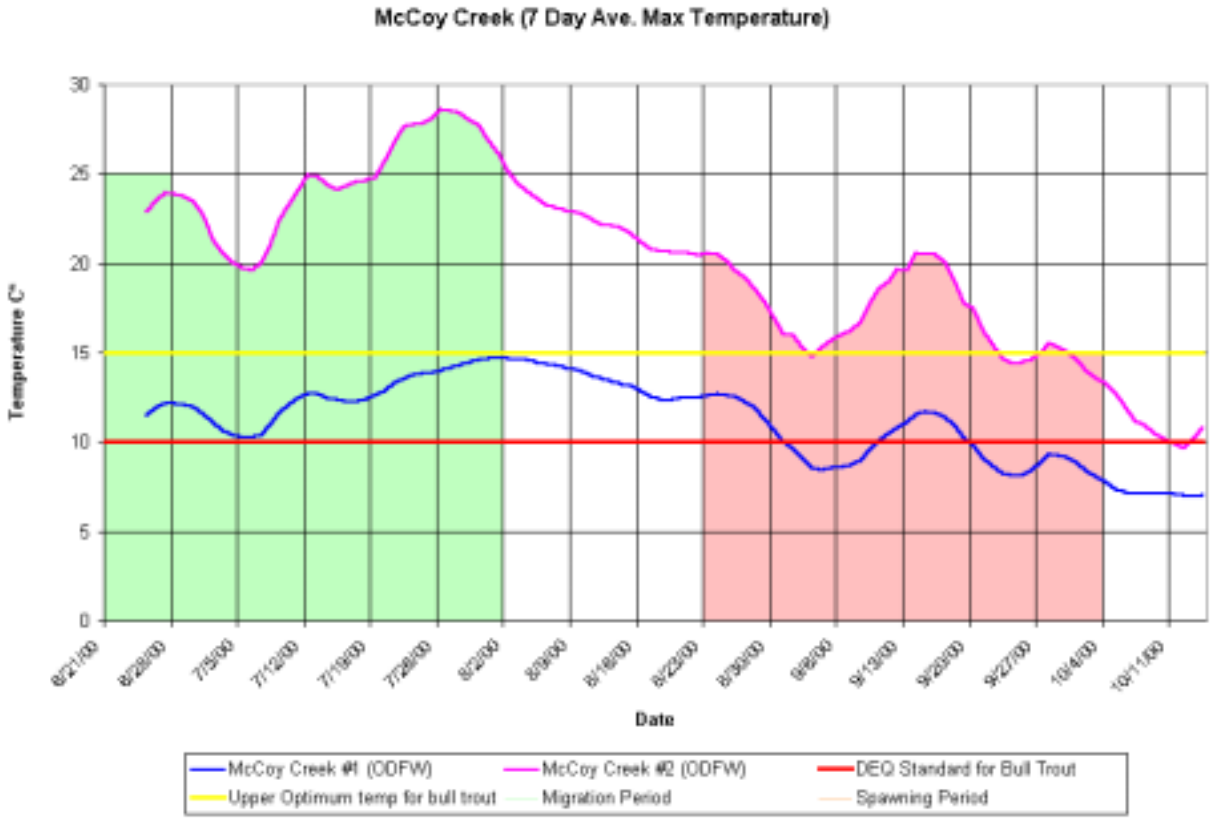

Figure 13. Comparison of the 7-day average maximum temperatures for McCoy Creek with DEQ standards and migration/spawning periods for bull trout in the Upper Malheur basin.

McCoy Creek is a tributary of Lake Creek entering at RK 3 (Figure 10). This creek is considered data limited by local agencies. Information has not been documented in reference to habitat, fish abundance, and distribution. There were efforts in 1993 by ODFW to document bull trout populations within the Malheur basin (Bowers 1993). Brook trout *Salvelinus fontinalis* were the only char documented utilizing McCoy Creek.

Probe # 2 temperatures exceed standards established by DEQ for bull trout in late spring and summer as well as the upper optimum threshold for adult bull trout (McPhail and Murray 1979, Shepard et al 1984, Buckman et al. 1992, Ratliff 1992, Buchanan and Gregory 1997). Probe #1 exhibited trends that were more bull trout friendly. Temperatures generally exceeded standards established by DEQ but remained lower than the upper optimum temperatures for adult bull trout. Acceptable water temperatures for spawning bull trout are to be less than 10^{o} C. Temperatures in McCoy Creek exceeded those thresholds but could be considered cyclic ranging from 8^{o} C to 12^{o} C in the upper reaches allowing for spawning to occur if bull trout were present.

Discussion

Bull trout in the Upper Malheur River are considered to be at "High Risk" of extinction (Ratliff & Howell 1992). In 1998 bull trout became listed under the Federal Endangered Species Act as "threatened" in June 1998. Preliminary genetic work has been completed on bull trout in the Upper and North Fork of the Malheur River (Spruell & Allendorf, 1997), but the data analyses within the Malheur was limited by small sample sizes and may need to be further studied. The conclusion of the preliminary study was that the two populations were genetically similar but due to the construction of the two irrigation dams (Agency Valley Dam 1935 and Warm Springs Dam 1919) these populations have been isolated from each other for roughly 67 years. Given the current health of the landscape, major changes will need to be made in land and water use practices to ensure the persistence of bull trout in the Malheur system.

Temperatures in the Upper Malheur River appear to be a limiting factor for bull trout. Historic information of their distribution in the Basin is limited. The first documentation of this species in the Upper Malheur was in 1955, when bull trout were observed as far down stream as Wolf Creek during an ODFW chemical poisoning project (Hanson et al. 1990). Although there is no recent documentation to prove their presence, it is assumed that bull trout accessed the Snake and Columbia Rivers before dams blocked fish passage.

The continued efforts of cooperating agencies working with the Tribe is commendatory in the documentation of past and current trends, but the data of 2000 doesn't present any new information. The Malheur River and tributaries are consistently too warm during migratory and spawning periods to sustain healthy reproducing population of bull trout with out future restoration.

The below table depicts the number of days temperature exceeds the standards. Graphed images of each probe can be viewed in the results section of this report.

Table 2. Days exceeding DEQ standards

Temperatures are based on daily maximum temperatures.					
Data Logger	Total Temperature days recorded	**Day's over 10° C** (DEQ standards for bull trout)	**Day's over 12.8° C** (DEQ standards for migrating and spawning Salmonids)	**Day's over 15° C** (Upper Optimum temperature for bull trout)	**Day's over 17.8° C** (DEQ standards for salmonid fish rearing)
Malheur River #1 (BPT)	82	82	78	73	59
Malheur River #2 (BPT)	125	119	112	93	78
Malheur River #3 (USFS)	135	122	109	93	78
Malheur River #4 (BPT)	130	121	109	94	73
Malheur River #5 (BPT)	142	116	105	92	78
Big Creek #1 (USFS)	123	0	0	0	0
Big Creek #2 (USFS)	123	0	0	0	0
Big Creek #3 (ODFW)	159	83	11	0	0

Big Creek #4 (ODFW)	159	120	90	66	15
Big Creek #5 (BPT)	83	81	70	57	4
Big Creek #6 (BPT)	112	112	95	84	55
Meadow Fork Creek #1 (ODFW)	147	64	0	0	0
Meadow Fork Creek #2 (ODFW)	147	74	15	0	0
Lake Creek #1 (USFS)	123	68	10	0	0
Lake Creek #2 (ODFW)	112	72	23	0	0
Lake Creek #3 (ODFW)	112	104	92	78	62
Lake Creek #4 (ODFW)	112	105	100	83	74
Lake Creek #5 (BPT)	82	82	82	76	70
Lake Creek #6 (BPT)	82	82	82	76	70
McCoy Creek #1 (ODFW)	112	78	28	0	0
McCoy Creek #2 (ODFW)	112	110	102	91	75
Crooked Creek (USFS)	122	110	104	87	78

The Burns Paiute Tribe administered a radio telemetry study on bull trout in the Upper Malheur in 2000 (BPT 2000). There were 20 bull trout (> 240 mm fork length) tagged and released at RK 304 between Malheur probe #1 and Malheur probe #2. Tagged bull trout ventured up the Malheur and into Big Creek. From there 12 migrated to Meadow Fork Creek, 1 migrated to Snowshoe Creek, and two stayed in Big Creek. Of the twenty radioed bull trout, five were unaccounted for (lost to predators or angling).

Based on the results of the temperature data and the telemetry data in the Upper Malheur River, Meadow Fork Creek was favored for spawning by bull trout in 2000.

Recommendations / Future Projects

The 2000 temperature and telemetry data has raised some interesting questions such as why there is not a greater distribution of bull trout in some of these headwater tributaries. Some of these tributaries do exhibit potential for restoration. Future projects should include: Improving riparian vegetation, changes in land use practices to favor bull trout, eradication of exotic species (Brook trout), flow modification (Putting water back in stream), and aquatic habitat improvement. There needs to be an outreach to the private landowner to practice “Best

Management Techniques" for future land management if the fish species within the Malheur Basin are to persist.

Acknowledgements

A special thanks is extended to: Jason Fenton, Burns Paiute Fish and Wildlife Department for his work putting together the GIS maps for the project and this paper, ODFW, and the USFS who worked with the Tribe to coordinate this effort. Thanks to Bonneville Power Administration who provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this research.

References

Bowers, W.L., P.A. Dupee, M.L. Hanson, and R.R. Perkins. 1993 bull trout population summary Malheur River basin. Oregon Department of Fish and Wildlife, Hines, Oregon. Unpublished report.

Buchanan, M. W. and S. V. Gregory, 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 119 – 126 in McKay, W.C., M.K. Brewin, and M. Monita, ediors. Friends of the bull trout conference proceeding. Bull trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Buckman, R.C., W.E. Hosford, and P.A. Dupee. 1992. Malheur River bull trout investigations. Pages 45-57 *in* P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Dambacher, J.M. and K.K. Jones. 1997. Stream Habitat of Juvenile Bull Trout Populations in Oregon and Benchmarks for Habitat Quality. Pages 353 – 360 in McKay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference proceeding. Bull trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Hanson,L. M., R. C. Buckman and W. E. Hosford. 1990. Malheur River Basin Fish Management Plan. Oregon Department of Fish and Wildlife, Portland.

Howell, P.J. and D.V. Buchanan, editors. 1992. Proceedings of the Gearhart Mountain bull Trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Mc Phail, J.D. and C.B. Murray. 1979. The early life-history and ecology of Dolly Varden (Salvelinus malma) in the upper Arrow Lakes. University of British Columbia, Department of Zoology and Institute of Animal Resources, Vancouver, Canada.

Oregon Department of Fish and Wildlife. 1998. Aquatic Inventory Project: Methods for Stream

Habitat Survyes, version 8.1. Natural Production Program. Corvallis, OR.
Oregon Department of Enviornmental Quality. Final 1998. 303 (d) listings and map. Portland. Oregon.

Oregon Water Resources Department. 1983. Malheur River Basin. Salem, OR.

Perkins, R. 1998. Malheur River Bull Trout Population Status. Oregon Department of Fish & Wildlife. Special Report: Southeast Fisheries District. Ontario, OR.

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 in P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the AFS. Corvallis, OR.

Shepard, B., K.L. Pratt, and P. Graham. 1984. Life history of westslope cutthroat and bull trout in the upper Flathead River Basin, Montana. Montana Dept. of Fish, Wildlife, and Parks.

Spruell, P. and F.W. Allendorf. 1997. Nuclear DNA Analysis of Oregon Bull Trout. Report 97/5. University of Montana, Division of Biological Sciences, Missoula, MT 59812

Appendices A.
Oregon's Final 1998 Water Quality Limited Streams - 303(d) List
Malheur River Basin Data

Sub Basin	Name & Description	Parameter	Criteria	Season	Supporting Data or Information	Changes From 1994/96
Lower Malheur	**Malheur River** Mouth to Hog Creek (Namorf)	Bacteria	Water Contact Recreation (fecal coliform-96 Std)	Summer	USBR Data (4 Sites: MAL006, MAL102, MAL103, MAL104; RM 0.5, 20, 49, 67.2): 56% (22/39); 69% (27/39); 15% (6/39); 6% (2/31) Summer values respectively exceeded fecal coliform standard (400) with a maximum of 9000 between WY 1986 - 1995.	No Change
Lower Malheur	**Malheur River** Mouth to Hog Creek (Namorf)	Bacteria	Water Contact Recreation (fecal coliform-96 Std)	Fall-Winter-Spring	USBR Data (4 Sites: MAL006, MAL102, MAL103, MAL104; RM 0.5, 20, 49, 67.2): 12% (6/52); 19% (10/52); 5% (3/58); 0% (0/40) FWS values respectively exceeded fecal coliform standard (400) with a maximum of 10,800 between WY 1986 - 1995. MOWC 7 sites for spring/summer of 1997 showed no exceedence of fecal coliform or e. coli bacteria standard. Need several more years of data to consider removing from 303d list.	No Change
Lower Malheur	**Malheur River** Mouth to Hog Creek (Namorf)	Chlorophyll a		Summer	USBR Data (4 Sites: MAL006, MAL102, MAL103, MAL104; RM 0.5, 20, 49, 67.2): 87% (27/31); 65% (20/31); 19% (6/31); 6% (2/31) Summer values respectively exceeded chlorophyll a standard (15 ug/l) with 3 month ave exceeding each year in lower R from WY 86-95.	No Change
Lower Malheur	**Malheur River** Mouth to Hog Creek (Namorf)	Toxics	Water - Pesticides (DDT)		USGS Data (Site at Malheur River near Ontario): 3 water samples with a range of 0.001 - 0.004 ug/l and an average of 0.003 ug/l exceeded DDT standard (fresh chronic criteria - 0.001 ug/l, water and fish ingestion - 0.024 ng/l) in 1990.	No Change
Lower Malheur	**Malheur River** Mouth to Hog Creek (Namorf)	Toxics	Water - Pesticides (Dieldrin)		USGS Data (Site at Malheur River near Ontario): 3 water samples with a range of 0.003 - 0.010 ug/l and an average of 0.007 ug/l exceeded Dieldrin standard (fresh chronic criteria - 0.0019 ug/l, water and fish ingestion - 0.071 ng/l) in 1990.	No Change
Middle Snake / Payette	**Shepard Gulch** Mouth to Headwaters	Bacteria	Water Contact Recreation (fecal coliform-96 Std)	Spring/Summer	Malheur Co Data (Site 40, 07Z008, at Mosquite Road): 88% (7 of 8) Summer values exceeded fecal coliform standard (400) with a maximum of 44,000 in 1978 - 1980.	No Change

Sub Basin	Name & Description	Parameter	Criteria	Season	Supporting Data or Information	Changes From 1994/96
Upper Malheur	**Bear Creek** Mouth to Headwaters	Temperature	Rearing 64 F (17.8 C)	Summer	USFS Data (Site at 16S,36E,33): 7 day average of daily maximums of 80 with 71 days exceeding temperature standard (64) in 1993.	No Change
Upper Malheur	**Big Creek** Mouth to Meadow Fork	Temperature	Oregon Bull Trout 50 F (10 C)	Summer	ODFW Data (Site at FSR 16, 16S,33.5E,14): 7 day average of daily maximums of 59 and 61 exceeded Bull Trout temperature standard (50) in 1993 and 1994 respectively.	No Change
Upper Malheur	**Bluebucket Creek** Mouth to Headwaters	Temperature	Rearing 64 F (17.8 C)	Summer	BLM Data (Site North of Moffit Table, 18S,34E,34sene): 7 day average of daily maximums of 79.5 with 44 days exceeding temperature standard (64) in 1995. In 1997 was 21.2 °C.	No Change
Upper Malheur	**Lake Creek** Mouth to Headwaters	Temperature	Oregon Bull Trout 50 F (10 C)	Summer	ODFW Data (Site at FSR 16, 16S,33.5E,14): 7 day average of daily maximums of 65 and 74 exceeded Bull Trout temperature standard (50) in 1993 and 1994 respectively.	No Change
Upper Malheur	**Little Malheur River** Mouth to Headwaters	Temperature	Rearing 64 F (17.8 C)	Summer	USFS Data (Site at FSR 1672, 15S,36E,25): 7 day average of daily maximums of 70 and 80 exceeded temperature standard (64) in 1993 and 1994 respectively; BLM data also available.	No Change
Upper Malheur	**Malheur River** North Fork Malheur R to Warm Springs Res	Bacteria	Water Contact Recreation (fecal coliform-96 Std)	Summer	Malheur Co Data (Site 5, 07F010, near Juntura): 75% (6 of 8) Summer values exceeded fecal coliform standard (400) with a maximum of 3800 in 1978 - 1980. MOWC data in 1997 shows no exceedence of Fecal Coliform or E. Coli bacteria standard, need several more years of data to consider removing from 303d list.	No Change
Upper Malheur	**Malheur River** Warm Springs Reservoir to Wolf Creek	Flow Modification			Redband Trout are a state sensitive species, water withdrawal has been identified as a concern (ODFW, 1990); IWR (68359) is often not met at USGS gage (13214000).	No Change
Upper Malheur	**Malheur River** Warm Springs Reservoir to Wolf Creek	Temperature	Rearing 64 F (17.8 C)	Summer	BLM Data (3 Sites: Upton Cabin, 22S,36E2nwsw; Carey Spring, 21S,36E,21swsw; Below Hwy 20, 21S,36E,5nese): 7 day average of daily maximums of 80.1; 71.5; 77.7 with 41; 14; 36 days respectively exceeding temperature standard (64) in 1995.	No Change

Sub Basin	Name & Description	Parameter	Criteria	Season	Supporting Data or Information	Changes From 1994/96
Upper Malheur	**Malheur River** Wolf Creek to Headwaters	Temperature	Rearing 64 F (17.8 C)	Summer	USFS Data (Site at FSR 1651 (RM 183), 17S-34E-18): 7 day average of daily maximums of 77/76/71/79 with 54/82/57/78 days exceeding temperature standard (64) in 1991/92/93/94 respectively. Two BLM sites in 1997 were 24.1 and 24.6 °C.	No Change
Upper Malheur	**Malheur River, North Fork** Mouth to Beulah Reservoir	Bacteria	Water Contact Recreation (fecal coliform-96 Std)	Spring/Summer	Malheur Co Data (Site 6, 07F003, near mouth): 66% (8 of 12) Summer values exceeded fecal coliform standard (400) with a maximum of 8000 in 1978 - 1980. MOWC data in 1997 shows no exceedence of Fecal Coliform or E. Coli bacteria standard, need several more years of data to consider removing from 303d list.	No Change
Upper Malheur	**Pine Creek** Mouth to Alkali Creek	Temperature	Rearing 64 F (17.8 C)		USFS Data (Site at FSR 120): 7 day average of daily maximums of 75 and 77 with 88 and 100 days exceeding temperature standard (64) in 1993 and 1994 respectively.	No Change
Upper Malheur	**Summit Creek** Mouth to Headwaters	Temperature	Rearing 64 F (17.8 C)	Summer	USFS Data (Site at FSR 1651; RM 2.75): 7 day average of daily maximums of 80, 76, and 79 with 77, 84, and 80 days exceeding temperature standard (64) in 1992, 1993, and 1994 respectively.	No Change
Upper Malheur	**Wolf Creek** Mouth to Headwaters	Temperature	Rearing 64 F (17.8 C)	Summer	USFS Data (Site at FSR 15, 18S-33E-18): 7 day average of daily maximums of 75 with 69 days exceeding temperature standard (64) in 1994.	No Change
Upper Malheur	**East Fork** Mouth to Headwaters	Temperature	Rearing 64 F (17.8 C)	Summer	USFS Data (Site at mouth, 18S-33E-12): 7 day average of daily maximums of 69 and 78 with 34 and 82 days exceeding temperature standard (64) in 1992 and 1994 respectively.	No Change

MICROSATELLITE ANALYSIS OF REDBAND RAINBOW FROM THE UPPER MALHEUR BASIN

Author: Paul Spruell and Aaron Maxwell, Wild Trout and Salmon Genetics Laboratory, Division of Biological Sciences, University of Montana Missoula, MT

Summary

We used six microsatellite loci to estimate the level of genetic differentiation among 14 populations of rainbow trout (*Oncorhynchus mykiss*) from sites throughout the Northwest United States. The expected heterozygosity in the Malheur region ranged from 0.649 to 0.705, with the observed heterozygosity ranging from 0.571 to 0.694. These values are within the range of heterozygosities observed in steelhead populations from the Hood River, though slightly higher than those observed in Kootenai redband populations from Montana. The level of differentiation among the five Malheur sample sites was quite low (F_{st}= 0.004). F_{st} is a measure of population differentiation in which a F_{st} of 0 indicates no differentiation, F_{st} of 1 indicates maximal differentiation. We also compared these samples to rainbow trout populations from 9 other locations in the Northwest. The differentiation level across these 14 sample sites was F_{st}=0.165.

Methods

Samples were collected by Burns Paiute personnel (Figure 2) and were delivered to the Wild Trout and Salmon Genetics Lab in 95% ethanol. DNA was extracted using the Puregene kit (Gentra) following the manufacturer's instructions. We amplified six microsatellite loci using previously described methods (Knudsen and Spruell 1999). The resulting data were analyzed as described in Neraas and Spruell (In Press).

Results

Upper Malhuer Basin

All loci analyzed were polymorphic in the samples from the Upper Malheur Basin. The number of alleles, expected heterozygosities and observed heterozygosities are provided in Table 1. After correcting for multiple tests (Rice 1989), we observed no significant deviations (P>0.05) from Hardy-Weinberg expectations at any of the loci in any population.

The levels of heterozygosity observed *within* Malheur Basin samples are consistent with heterozygosity estimates for steelhead from the Hood River in Oregon (Table 1). Interestingly, these values are substantially higher than the heterozygosity estimates for other interior "redband" populations from northwest Montana (Table 1).

There was relatively little genetic differentiation among the five sample sites from the Upper Malhuer Basin (F_{st}=0.0039). This lack of divergence is also reflected in few loci exhibiting significant differences in allele frequencies. Bear Creek and Crane Creek/Little Crane Creek were the only two populations in which genotypic frequencies were significantly different at three of six loci. The remaining nine comparisons differed at two or fewer loci. Highly differentiated populations are often different at most loci analyzed.

Comparison with other Samples

Samples from the Upper Malhuer Basin were compared to rainbow trout from other Northwest sites (Fig. 1). These samples were analyzed as part of other ongoing research at the University of Montana. Samples included steelhead from the Hood River in Oregon and interior rainbow trout from the upper Kootenai Basin, Montana (upper Yaak, Northfork Yaak). There are substantial differences between samples from the Kootenai Basin and all other samples. Although the samples from the Malheur Basin do form a discrete cluster on the dendrogram, there was surprisingly little differentiation between Malheur Basin samples and steelhead from the Hood River (Fig. 1).

Discussion

There was very little differentiation among the rainbow populations sampled from Upper Malheur Basin (F_{st}=0.004). This value is low when compared to microsatellite-based studies of most other inland salmonids. For example, Knudsen has estimated F_{st} to be 0.427 for six populations of native redband trout (*Oncorhynchus mykiss*) from the upper Kootenai Basin (unpublished data). Similarly**,** Neraas and Spruell (*In Press*) report an F_{st} of 0.137 for bull trout (*Salvelinus confluentus*) from the lower Clark Fork River and Lake Pend Oreille. Samples from the upper Malheur and upper Kootenai regions span similar geographic distances. However, the genetic similarity among samples from the Malheur is far less than that observed in the upper Kootenai.

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References

Knudsen, K. L. and P. Spruell (1999) Genetic analysis of westslope cutthroat trout in tributaries of Couer d'Alene Lake. Wild Trout and Salmon Genetics Lab Report WTSGL99-106 to the Coeur d'Alene Tribe.

Neraas, L. P. and P. Spruell (In Press) Fragmentation of riverine systems: the genetic effects of dams on bull trout (*Salvelinus confluentus*) in the Clark Fork River system. Mol. Ecol.

Rice, W. R. (1989) Analyzing tables of statistical tests. Evolution 43: 223-225.

Table 1. Sample sizes, average number of alleles per locus, expected heterozygosities (H_e) and observed heterozygosities (H_o) estimated using six microsatellite loci.

Sample	Sample size	Average number of alleles per locus	H_e	H_o
Hood/Summer 93	30	6.20	0.684	0.660
Hood/Summer 94	29	7.60	0.680	0.630
Hood/Winter 93	30	8.00	0.700	0.683
Hood/ Winter 94	30	7.40	0.685	0.698
Hatchery Stock 24	30	6.20	0.644	0.680
Hatchery Stock 53	30	4.00	0.497	0.565
Little Malheur	34	7.60	0.675	0.630
Upper North Fork	33	8.00	0.649	0.580
Beulah	35	8.60	0.705	0.694
Bear Cr.	34	7.60	0.673	0.660
Crane/Little Crane	30	7.60	0.649	0.571
Upper Yaak	30	2.80	0.366	0.391
North Fork Yaak above	31	1.60	0.219	0.234
North Fork Yaak below	28	3.80	0.463	0.436

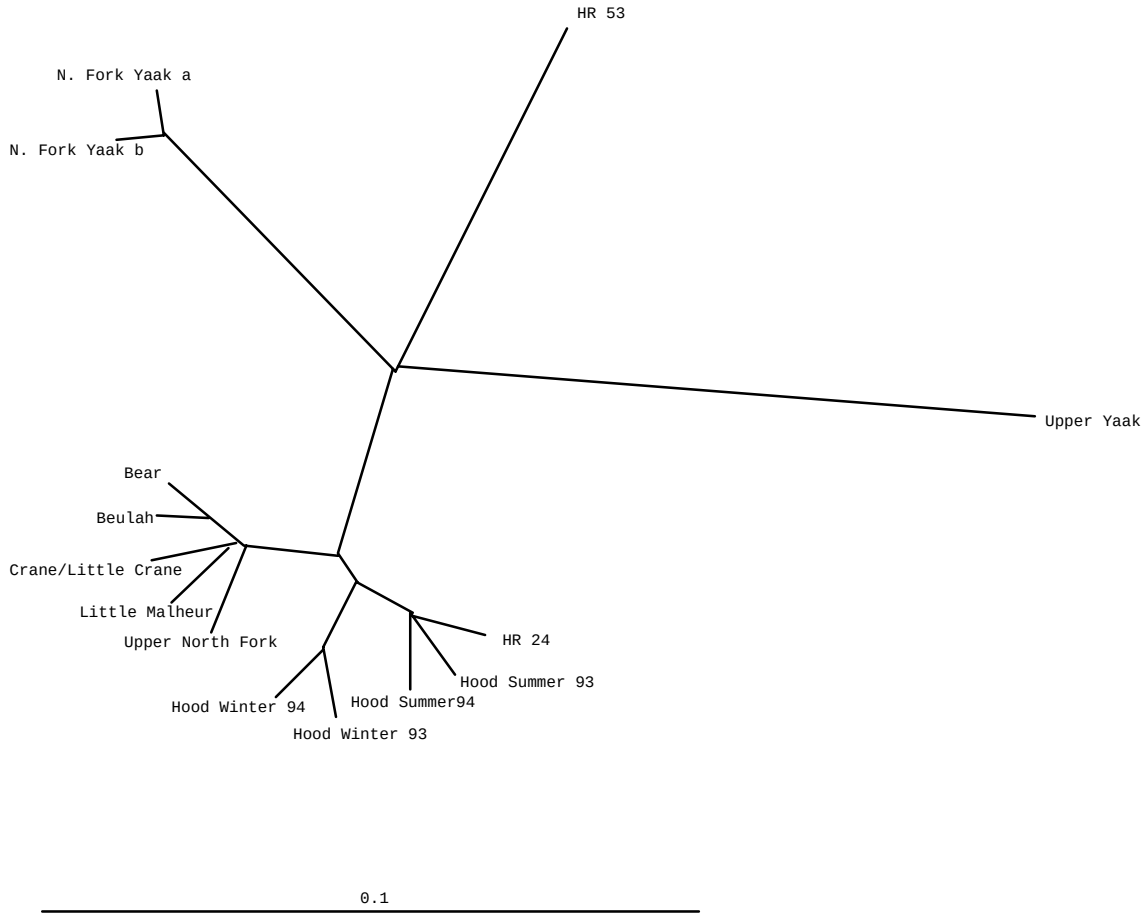

Figure 1: UPMGA dendrogram of sample locations based on Cavalli-Sforza and Edwards Chord Distance. The linear distance between populations corresponds to genetic similarity.

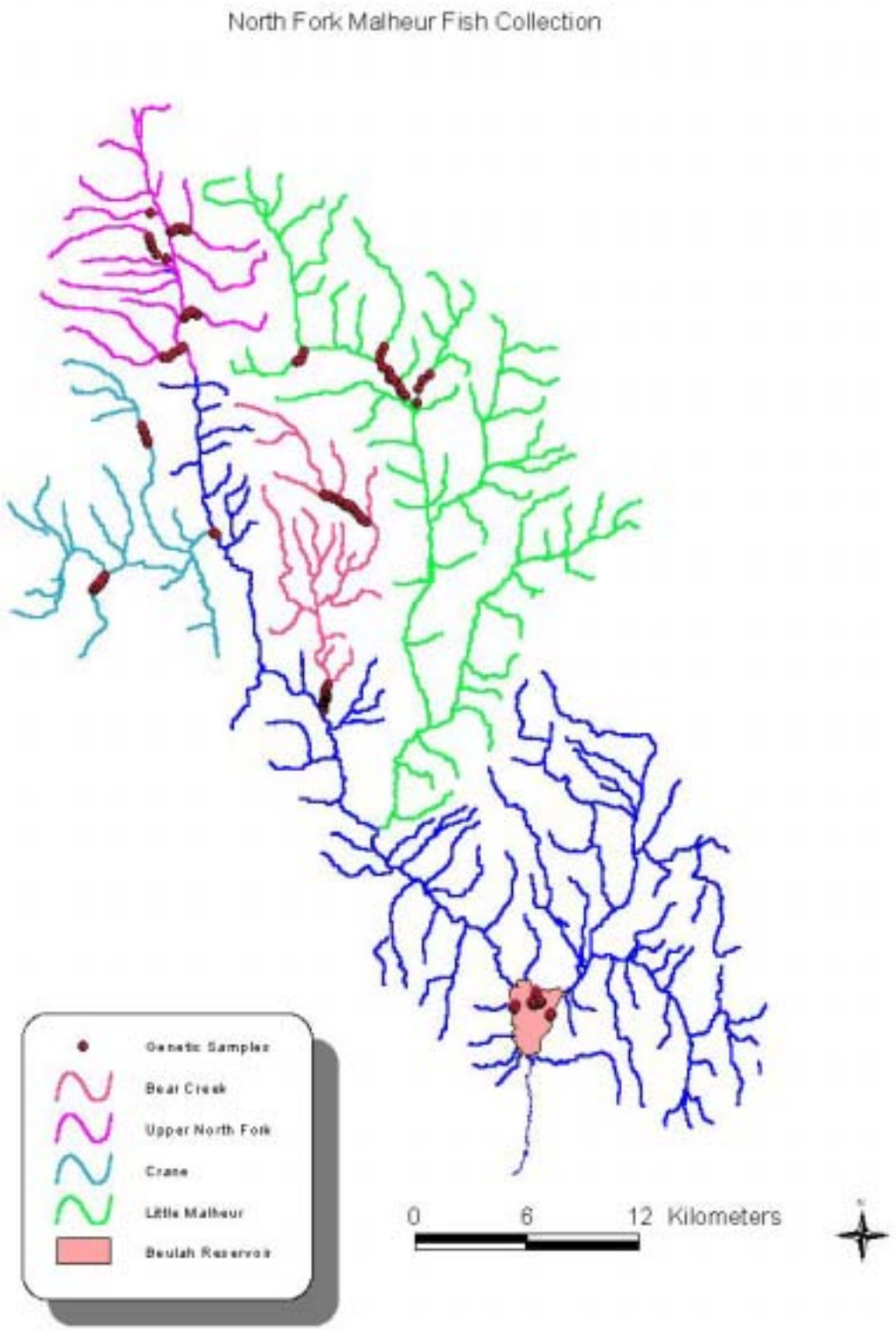

Figure 2. Redband genetic collection map of the North Fork Malheur, map produced by BPT.

Salmonid Population Estimate for the Upper Bosonberg Creek

Author: Steve Namitz, Burns Paiute Fish and Wildlife Department, Burns, Oregon

Introduction

Bosonberg Creek is a tributary of the Upper Malheur River entering in at River Kilometer (RK) 304. Bosonberg Creek is approximately 13 kilometers long and has a hydrologic drainage area of roughly 36.6 square kilometers. Bosonberg Creek was identified by Oregon Department of Fish and Wildlife (ODFW) as a data gap for fish species in the Upper Malheur River system.

Project #: 199701900

Objective 2. Continue monitoring population trends (index) and age class structure in native salmonids within the Malheur basin.

Methods

2000 Electrofishing Protocol

The Burns Paiute Tribe Fish & Wildlife Department (BPT) administered an electrofishing effort in Bosonberg Creek from 01August 2000 to 6 September 2000 using ODFW protocol (Dambacher, 1997). The electrofishing effort was administered to determine fish population estimates within Bosonberg Creek. Efforts were made from the United States Forest Service (USFS) boundary to what is considered to be the upper limits for fish (Personal contact, District ODFW Biologist). Random shocking was conducted above the end of the survey but no fish were found.

The BPT conducted a 2/4 pass 50% reduction population survey on Bosonberg Creek (Figure 1). Sites were 50 meters in length (164 feet). Block nets were anchored into the substrate with tent pegs and rocks at the upper and lower boundary to prevent fish escapement. Survey unit #1 began at the USFS boundary (Figure 2). Sites were separated by 265-foot unshocked section of stream. One pass consisted of shocking from the lower block net up to the upper block net and back down. The second pass must have a 50% reduction in the collection of age 1+ (fork length$\geq$70 mm) *Oncorhynchus mykiss* (redband trout) and *Salvelinus fontinalis* (brook trout) for the site to be complete. If this was not met, 2 more passes were required using the same methodology. The last site of the population survey was determined when no salmonids were collected on the first pass.

The upper limits of brook and redband trout were determined by continuing upstream, shocking 100% of the wetted channel until the stream became dry or intermittent.

Fish collection

Fish collection was accomplished with the use of a Smith & Root electrofisher. The protocol for shocking was to start at the down stream end of the block nets and shock moving upstream then back again. Shocking was accomplished in groups of three, one person operating the shocker, and two netters following behind. The electrofisher was tested for effectiveness in a sample area not included in the population survey. If fish were not observed reacting to the set electrical current, instruments on the shocker were adjusted to increase the impact. After the shocker was adjusted to the appropriate settings then the survey was initiated.

Once the first pass was complete, fish were counted and sorted by species. Fish lengths and weights were measured and recorded. This procedure was repeated for all passes. The percentage of fish captured on the second pass was calculated and compared to fish captured on the first pass to determine if the process needed to be repeated again to reach the 50% reduction for salmonids. If bull trout were observed the sample site was concluded and surveyors proceeded to the next site.

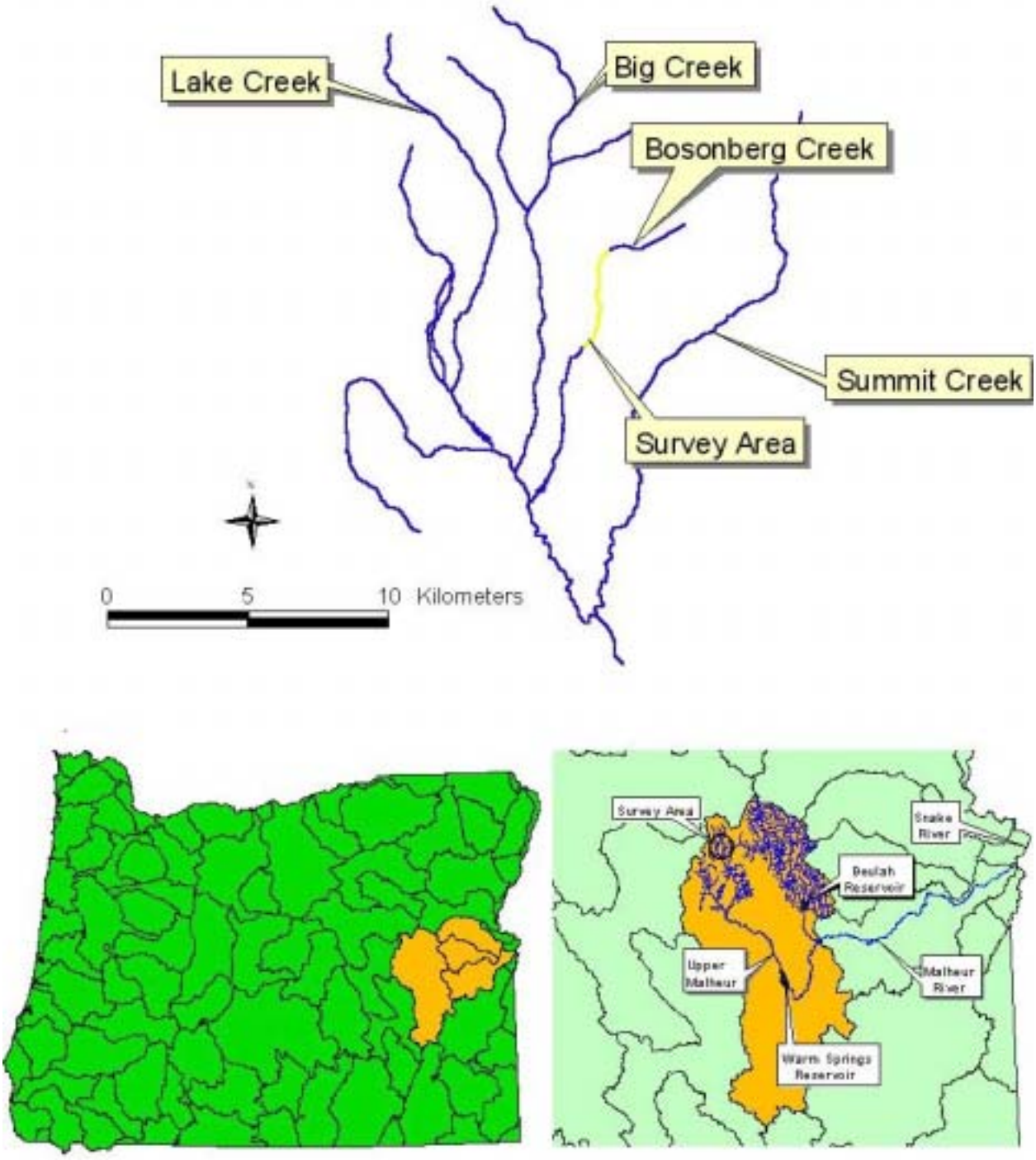

Figure 1. Bosonberg Creek Location Map

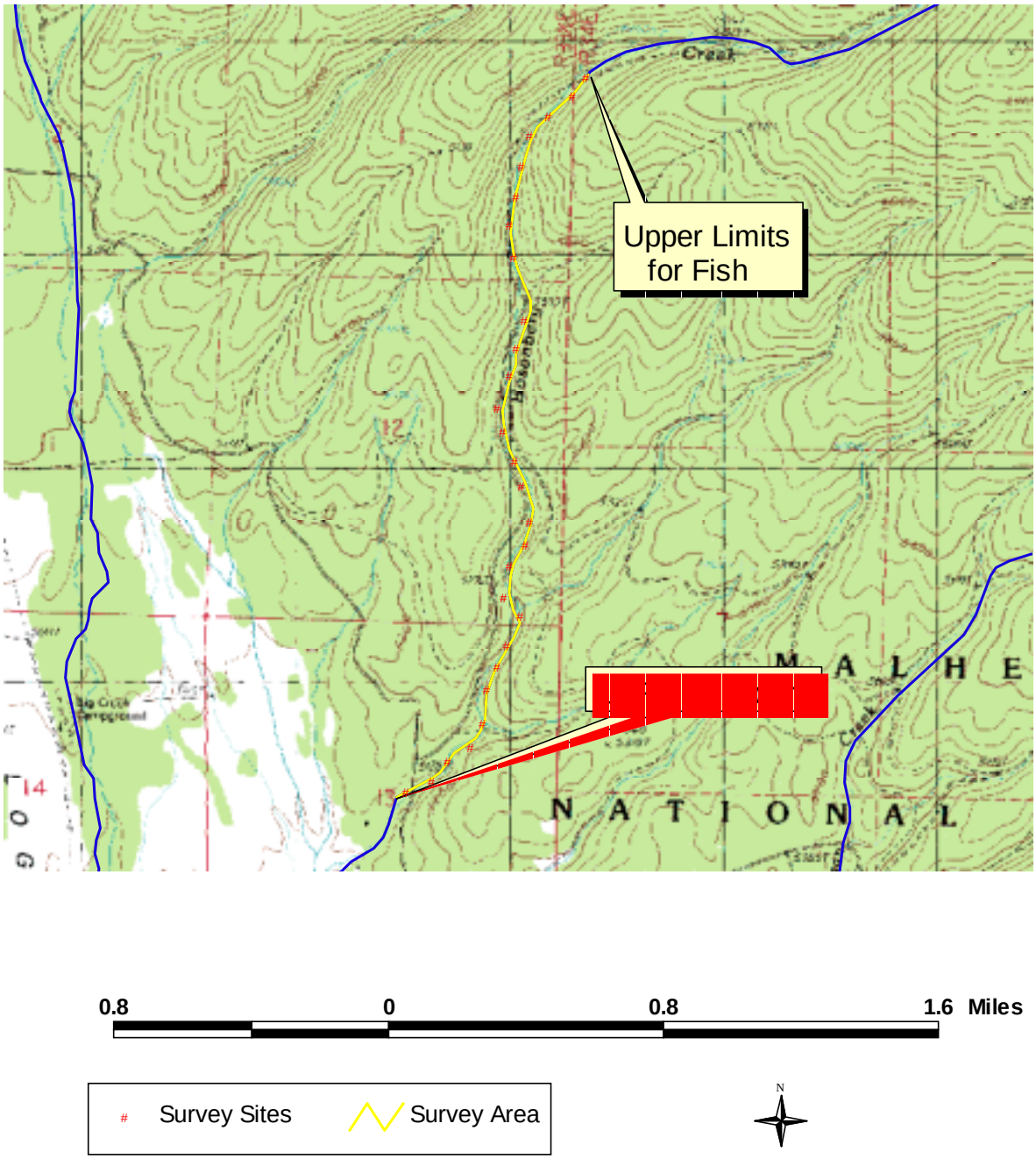

Figure 2. Salmonid Population Estimation and distribution survey for Bosonberg Creek (Malheur River, Oregon) in 2000

Results

Redband trout (*Oncorhynchus mykiss*)

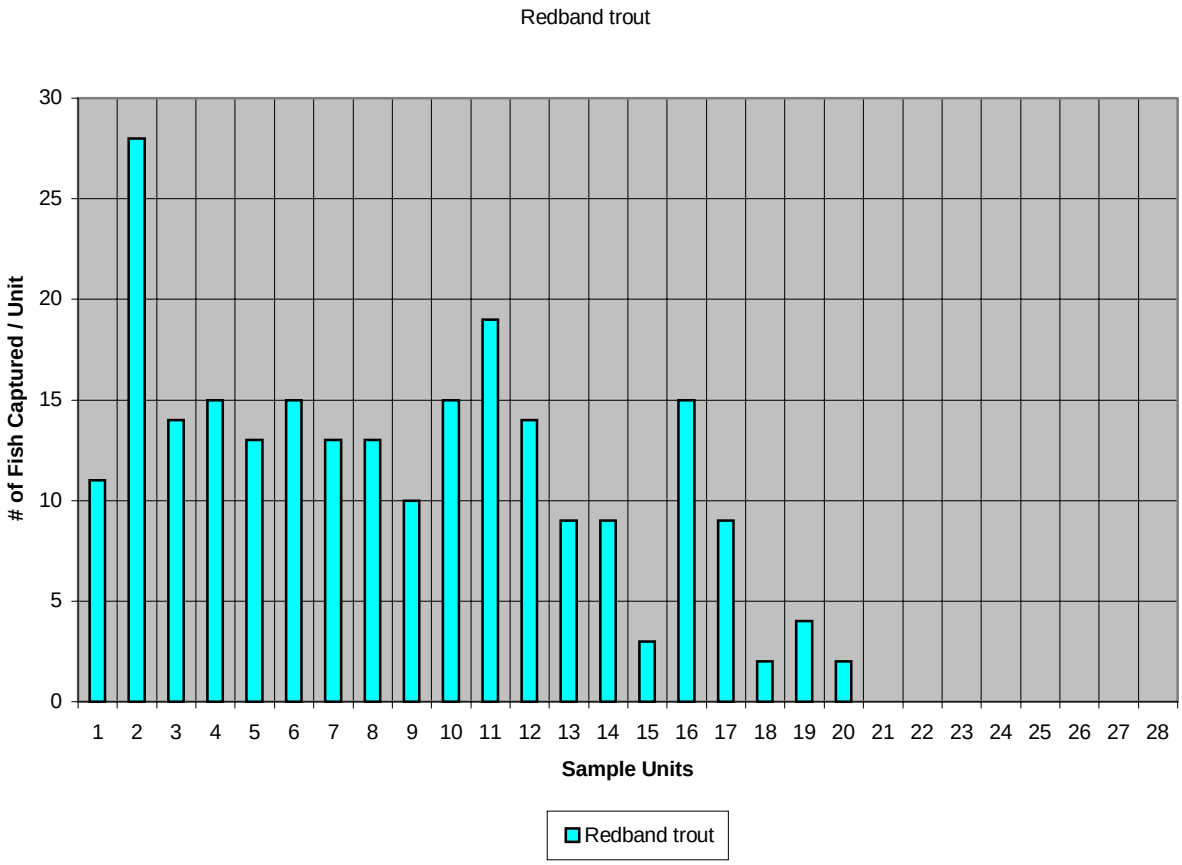

Figure 3. Number of redband trout captured per sample unit 2000, Bosonberg Creek.

Of the 28 units sampled, redband trout were only observed in the first 20. A 50% reduction was achieved at every sample unit. There were 233 redband trout sampled with the average probability of capture being 88% and a probability of non-capture of 12%. Of the total surveyed area, 39.5% was sampled. Average sample units were roughly 90 m^2. The estimated population of redband trout for the upper 3,572 meters of Bosonberg Creek was 614 fish +/- 117 fish with a 95% confidence level (Table 1). Redband statistics tables can be viewed in Appendix A.

Table 1. Population estimate results table for redband trout

Results Table								
	Species							
Bosonberg Creek	Redband 1+							
				Fish per square meter		Fish per lineal meter		
	Habitat	Population	+/-	CL % of	Habitat	Reach	Habitat	Reach
	Type	Estimate	95% c.l.	Estimate	Type	Average	Type	Average
All reaches	Mixed	614	117	19%	0.0946	na	0.172	na
	Total	614	117	19%	0.0946	na	0.172	na

Brook Trout (*Salvelinus fontinalis*)

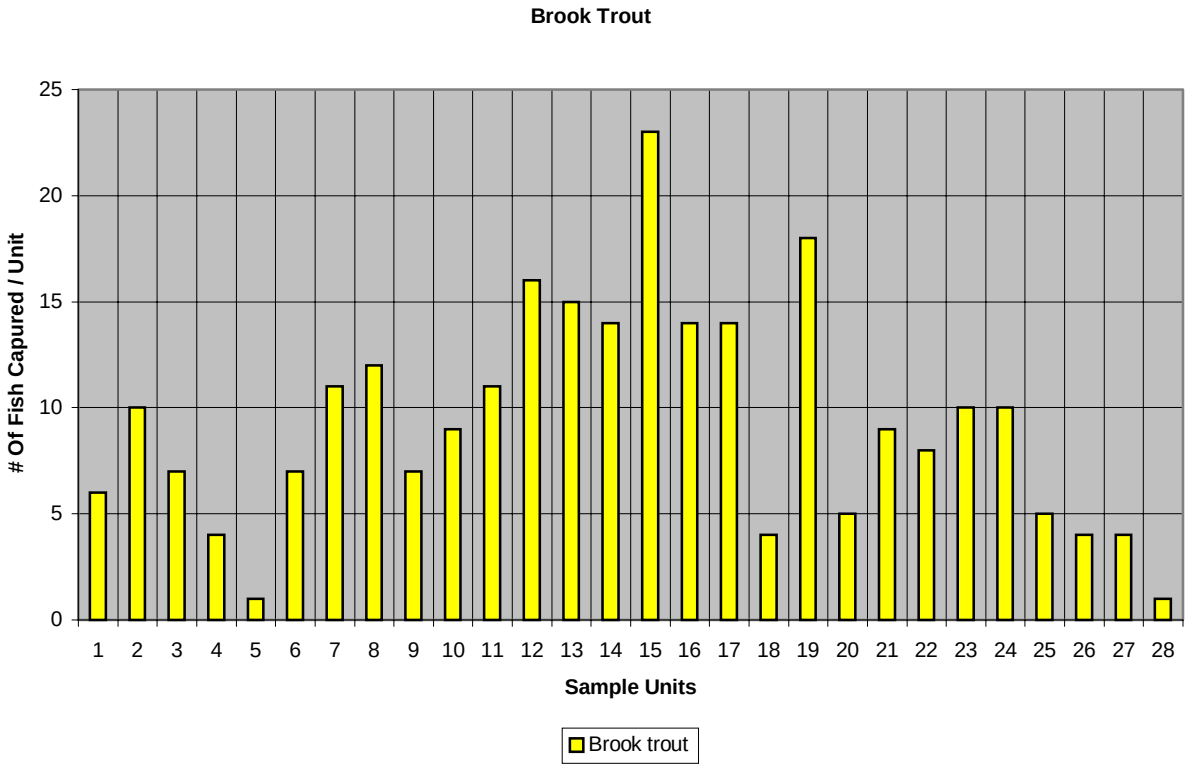

Figure 4. Number of brook trout captured per sample unit 2000, Bosonberg Creek.

Brook trout were observed in all 28 of the sampled units. A 50% reduction was achieved at all surveyed areas. There were 259 brook trout sampled with the average probability of capture being 78% and a probability of non-capture of 22 %. Of the total surveyed area 39.5% was sampled. Average sample units were roughly 90 m^2. The estimated population of brook trout for the upper 3,572 meters of Bosonberg Creek was 588 fish +/- 173 fish with a 95% confidence level (Table 2). Brook trout statistics tables can be viewed in Appendix B.

Table2. Population estimate results table for brook trout

Results Table									
Bosonberg Creek		Brook 1+							
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of	Habitat	Reach		Habitat	Reach
	Type	Estimate	95% c.l.	Estimate	Type	Average		Type	Average
All Reaches	Mixed	588	173	29%	0.0905	na		0.165	na
	Total	588	173	29%	0.0905	na		0.165	na

Sculpin (*Cottus ssp.)*

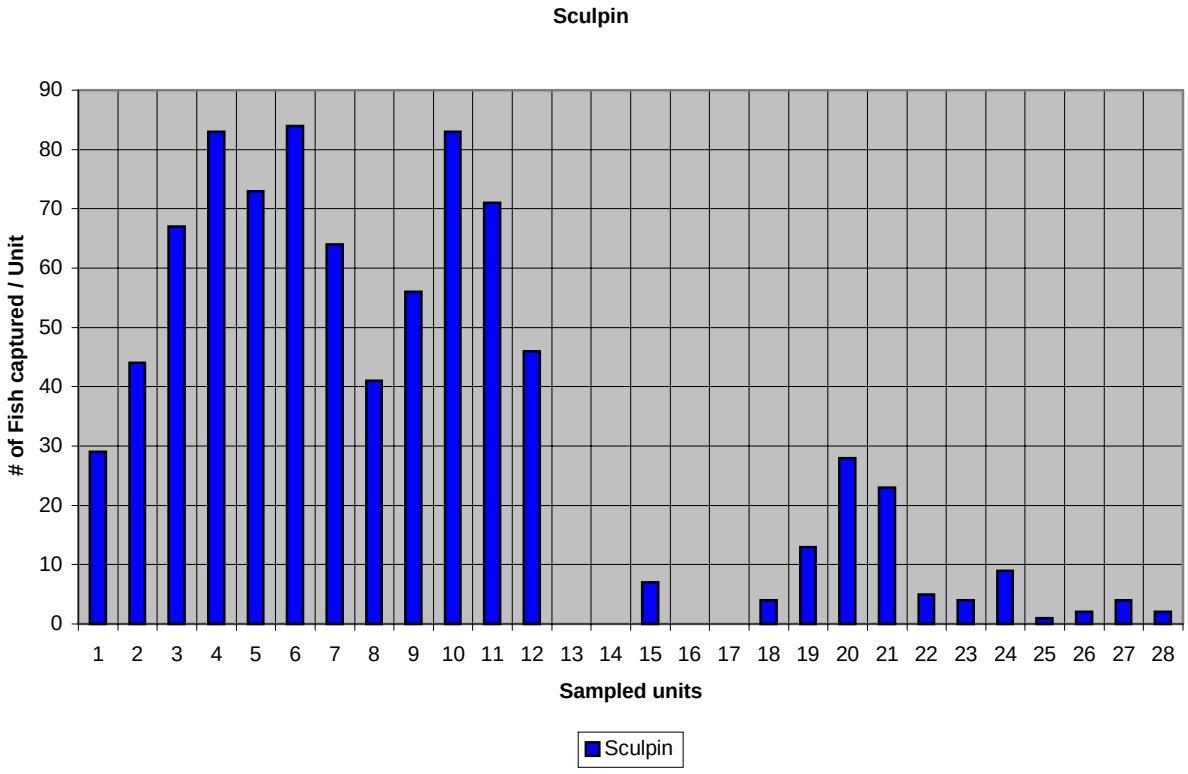

Figure 5. Number of sculpin captured per sample unit 2000, Bosonberg Creek.

Sculpin were observed in all but four of the sampled units. Conducting sculpin population estimates using electrofishing methods is controversial due to how sculpin react when being sampled. Sculpin are bottom dwellers and tend to avoid a taxis response to electrofishing. Sculpin data was collected but should be viewed as presence/absence estimates. Sculpin statistics tables can be viewed in Appendix C.

Bull trout (*Salvenlinus confluentus)*

No bull trout were observed within the 28 sampled units of Bosonberg Creek in 2000. However in 1993 Bowers documented bull trout in Bosonberg Creek as part of that years creel survey (Bowers 1993).

Upper limits of fish species

The upper limits of fish documented during the 2000 survey can be viewed in figure 2.

Discussion

Salmonids were the focus of this population estimate effort. Redband and brook trout were the salmonids sampled in the upper Bosonberg Creek (Figure 3). There were a total of 28 sample

locations in a 3,572 meter (11,907 feet) section. The mean habitat width for the upper portion of Bosonberg Creek was 1.8 meters (6 feet) making the sampled area roughly 6,494 m^2 (69,940 ft^2).

This is not a population estimate for all of Bosonberg Creek; rather it includes the upper portion of the watershed from the USFS boundary to the headwaters (See Figure 2 for survey area). The reason for this is the lower portion of the watershed is privately owned and access was not obtainable.

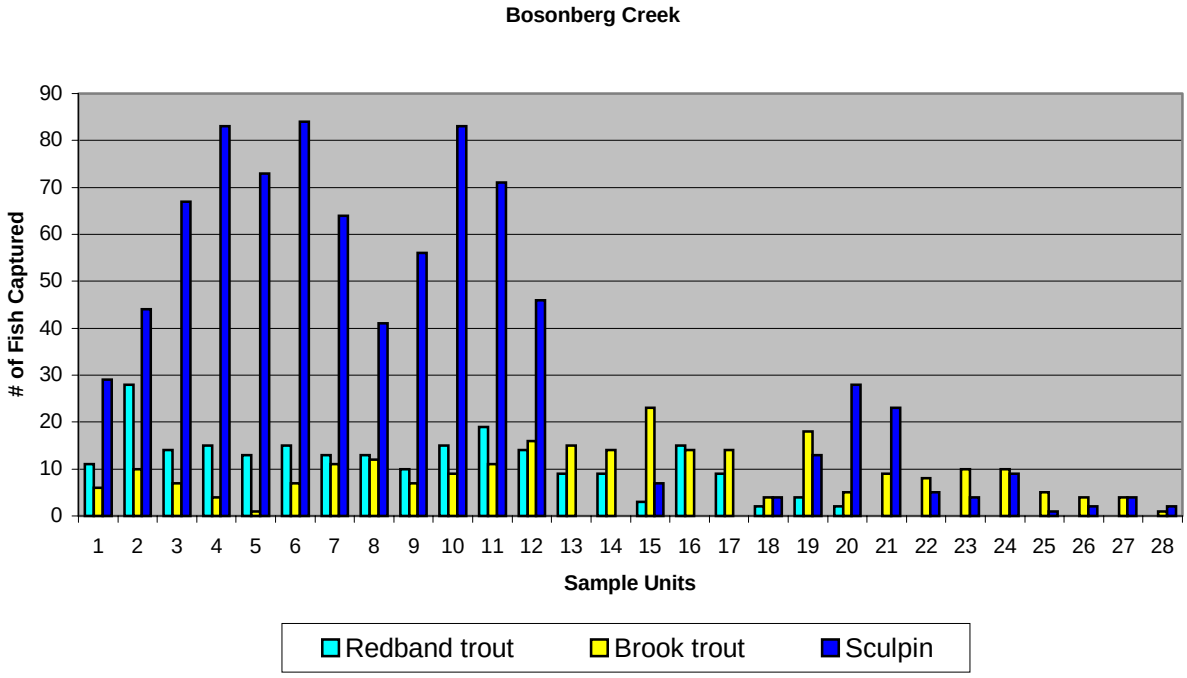

Figure 6. Number of fish captured per sample unit 2000, Bosonberg Creek.

From the population estimate we can conclude that redband trout and brook trout are coinciding in most of the same habitat with brook trout dominating the headwaters. The estimated populations for both species are statistically similar to each other for total number of fish present in the upper reaches of Bosonberg Creek (redband trout 614 fish +/- 117 with a 95%CL compared to brook trout 588 fish +/- 173 fish also with a 95% CL).

Recommendations / Future Projects

The 2000 population estimates for Bosonberg Creek have raised some interesting questions such as why there are no bull trout currently present when they were found historically in the drainage (Bowers, 1993). Bull trout are also currently found in neighboring tributaries and in the main stem of the Upper Malheur River. Bosonberg Creek exhibits potential for future restoration. Potential future projects for Bosonberg Creek may include; Habitat restoration projects, exotic species eradication projects, changes in land use practices by federal agencies to favor bull trout needs. There needs to be an outreach to the private landowners to practice "Best Management

Techniques" for future land management if the salmonid species within Bosonberg Creek and the Upper Malheur Basin are to persist.

Acknowledgements

A special thanks is extended to: Jason Fenton, Burns Paiute Fish and Wildlife Department, for his in GIS, ODFW who worked with the Tribe to coordinate this effort. Thanks to Bonneville Power Administration who provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this research.

References

Bowers, W.L., P.A. Dupee, M.L. Hanson, and R.R. Perkins. 1993 bull trout population summary Malheur River basin. Oregon Department of Fish and Wildlife, Hines, Oregon. Unpublished report.

Bowers, W. Personal communication with employee of Oregon Department of Fish and Wildlife, Burns, Oregon.

Buchanan, M. W. and S. V. Gregory, 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 119 – 126 in McKay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference procedding. Bull trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Buckman, R.C., W.E. Hosford, and P.A. Dupee. 1992. Malheur River bull trout investigations. Pages 45-57 *in* P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corallis.

Dambacher, J.M. 1997. Electrofishing Population Estimation Spreadsheet. Version 2.0

Dambacher, J.M. and K.K. Jones. 1997. Stream Habitat of Juvenile Bull Trout Populations in Oregon and Benchmarks for Habitat Quality. Pages 353 – 360 in McKay, W.C., M.K. Brewin, and M. Monita, ediors. Friends of the bull trout conference proceding. Bull trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Hanson,L. M., R. C. Buckman and W. E. Hosford. 1990. Malheur River Basin Fish Management Plan. Oregon Department of Fishand Wildlife, Portland.

Howell, P.J. and D.V. Buchanan, editors. 1992. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon

Oregon Department of Fish and Wildlife. 1998. Aquatic Inventory Project: Methods for Stream Habitat Survyes, version 8.1. Natural Production Program. Corvallis, OR.

Perkins, R. 1998. Malheur River Bull Trout Population Status. Oregon Department of Fish and Wildlife. Special Report: Southeast Fisheries District. Ontario, Oregon

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 in P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society. Corvallis, OR.

Appendices A.
Redband Trout Statistical Tables

Table 1. Reach and Total Habitat Data Input Table

Reach and Total Habitat Data Input Table						
				Total habitat		
		Sample strata		Number	Area	Length
		Reach	Habitat	Of units	m^2	m
Stream:	Bosonberg	All reaches	Mixed	70.8	6493.8	3572
Species/age:	Redband 1+					
Sample dates (“mm/dd/yy):						
Starting	80100					
Ending						

Table 2. Electro fishing Data Tables

Electrofishing Data Tables												
			Bosonberg Creek				Redband 1+					
		(m^2)	(m)								$(yi-rxi)^2$	
Unit No.	Unit Type	Area	Length	Pass 1	Pass 2	yi	p	q	V(yi)	$(yi-y)^2$	m^2	m
1	Mixed	107	50.0	11	0	11.0	1.00	0.00	0.0	5	1	6
2	Mixed	113	52.0	26	2	28.2	0.92	0.08	0.2	380	307	370
3	Mixed		50.0	11	3	15.1	0.73	0.27	3.7	42	22	43
4	Mixed	158	50.0	13	2	15.4	0.85	0.15	0.7	45	0	46
5	Mixed	148	50.0	10	3	14.3	0.70	0.30	4.9	32	0	32
6	Mixed	105	50.0	14	1	15.1	0.93	0.07	0.1	41	27	42
7		122	50.0	11	2	13.4	0.82	0.18	1.0	23	4	24
8	Mixed	105	55.0	13	0	13.0	1.00	0.00	0.0	19	10	13
9	Mixed	133	50.0	7	3	12.3	0.57	0.43	17.2	13	0	13
10	Mixed	94	55.0	13	2	15.4	0.85	0.15	0.7	45	43	35
11	Mixed	115	50.0	17	2	19.3	0.88	0.12	0.4	112	71	114
12	Mixed	110	50.0	14	0	14.0	1.00	0.00	0.0	28	13	29
13	Mixed	110	50.0	6		12.0	0.50	0.50	36.0	11	3	12
14		90		9	0	9.0	1.00	0.00	0.0	0	0	0
15	Mixed	88	50.0		0	3.0	1.00	0.00	0.0	32	28	31
16	Mixed	105	50.0	14	1	15.1	0.93	0.07	0.1	41	27	42
17	Mixed	88	50.0	8	1	9.1	0.88	0.13	0.2	0	1	0
18	Mixed	60	50.0	2	0	2.0	1.00	0.00	0.0	44	13	43
19	Mixed	100	50.0	4	0	4.0	1.00	0.00	0.0	22	30	21
20	Mixed	51	50.0	2	0	2.0	1.00	0.00	0.0	44	8	43
21	Mixed	52	50	0	0	0	1	0.00	0.0	75	24	74
22	Mixed	60	50		0	0	1	0.00	0.0	75	32	74
23	Mixed	45	50	0	0	0	1	0.00	0.0	75	18	74
24	Mixed	55	50	0	0	0	1	0.00	0.0	75	27	74

25	Mixed	65	50	0	0	0	1	0.00	0.0	75	38	74
26	Mixed	55		0	0	0	1	0.00	0.0	75	27	74
27	Mixed	50	50	0	0	0	1	0.00	0.0	75	22	74
28	Mixed	75	50	0	0	0	1	0.00	0.0	75	50	74

Table 3. Capture Statistics Table

Capture Statistics Table												
Bosonberg Creek		Redband 1+										
									Regular capture statistics of p			
Reach	Habitat	Pooled Capture Statistics									+/-95%	CL %
Strata	Strata	p'	q'	V(p')	Ti'	xi'	V(xi')	n	avg	std dev	CL	of p
All reaches	Mixed	0.88	0.12	0.000648	233	236	12	28	0.91	0.13	0.05	6%
	Total				233	236						
p: Probability of capture.								Ti': Total number of fish captured.				
q: Probability of noncapture.								xi': Total number of fish estimated in sampled units.				
V: Variance.								n: number of sample units				

Table 4. Sample Size Tables

Sample Size Tables												
Bosonberg Creek			Redband 1+									
	Habitat		Total habitat			Sampled habitat				Sample percent of total		
Reach	Type	N	Area	Length		n	Area	Length		Number	Area	Length
All reaches	Mixed	71	6,494	3,572		28	2,567	1,412		39.5%	39.5%	39.5%
	Total	71	6,494	3,572		28	2,567	1,412		39.5%	39.5%	39.5%
N: Total number of habitat units.										Area in square meters		
n: Number of sampled units.										Length in meters		
										Width in meters.		
	Habitat	Mean habitat unit area				Mean habitat unit length				Mean habitat unit width		
Reach	Type	Total	Sample	% diff.		Total	Sample	% diff.		Total	Sample	% diff.
All reaches	Mixed	92	92	0.0%		50	50	0.0%		1.8	1.81798867	0.0%
	Total	92	92	0.0%		50	50	0.0%		2	1.8	0.0%

Table 5. Selected Estimate and Method Table

Selected Estimate and Method Table				
Bosonberg		Redband 1+		
	Habitat		Selected	
	Type	Estimate	Variance	Method
All reaches	Mixed	614	3,553	r #/m2
	Total	614	3,553	
p: Pooled capture method.				
r: Regular capture method.				
#/unit: Fish per habitat unit expansion method.				
#/m2: Fish per square meter expansion method.				
#/m: Fish per lineal meter expansion method.				

Table 6. Estimate Selection Tables

Estimate Selection Tables							
		Bosonberg			Redband 1+		
	all reaches	mixed					
	Choice of Method for Fish Population Estimation						
	1). Use Regular Capture Method						
	2). Select #/unit, #/m2, or #/m, with lowest 1st stage variance.						
	3). Place cursor on selected Pop. Est. shaded below and key "Ctrl P".						
		Pooled Capture Method			Regular Capture Method		
	Variance	#/unit	#/m^2	#/m	#/unit	#/m^2	#/m
Selected	1st Stage	6,338	3,388	6,214	6,338	3,388	6,214
Values	2nd Stage	30	30	30	165	165	165
3,553	Total	6,368	3,418	6,244	6,503	3,553	6,379
r #/m2							
614	Pop. Est.	597	597	597	613	614	614
	+/-95% CL	156	115	155	158	117	157
	% CL/Est.	26%	19%	26%	26%	19%	26%

Table 7. Results Table

Results Table									
Bosonberg Creek		Redband 1+							
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of		Habitat	Reach	Habitat	Reach
	Type	Estimate	95% c.l.	Estimate		Type	Average	Type	Average
All reaches	Mixed	614	117	19%		0.0946		0.172	
		614	117	19%		0.0946		0.172	

Appendices B.
Brook Trout Statistical Tables

Table 8. Reach and Total Habitat Data Input Table

Reach and Total Habitat Data Input Table						
					Total habitat	
		Sample strata		Number	Area	Length
		Reach	Habitat	of units	m^2	m
Stream:	Bosonberg Creek	All Reaches	Mixed	70.8	6493.8	3572
Species/age:	Brook 1+					
Sample dates ("mm/dd/yy):						
Starting	80100					
Ending						

Table 9. Electro fishing Data Tables

Electrofishing Data Tables												
			Bosonberg Creek				Brook 1+					
		(m2)	(m)								$(yi-rxi)^2$	
Unit	Unit Type	Area	Length	Pass 1	Pass 2	yi	p	q	V(yi)	$(yi-y)^2$	m2	m
1	Mixed	107	50.0		2	8.0	0.50	0.50	24.0	0	3	0
2	Mixed	113	52.0	9	1	10.1	0.89	0.11	0.2	3	0	2
3	Mixed	110	50.0	7	0	7.0	1.00	0.00	0.0	2	9	2
4	Mixed	158	50.0	4	0	4.0	1.00	0.00	0.0	18	107	18
5	Mixed	148	50.0		0	1.0	1.00	0.00	0.0	53	152	52
6	Mixed	105	50.0	7	0	7.0	1.00	0.00	0.0	2	6	2
7	Mixed	122	50.0	8	3	12.8	0.63	0.38	10.1	20	3	21
8	Mixed		55.0	7	5	24.5	0.29	0.71	918.8	263	226	239
9	Mixed	133	50.0		1	7.2	0.83	0.17	0.4	1	24	1
10	Mixed	94	55.0	8	1	9.1	0.88	0.13	0.2	1	0	0
11	Mixed	115	50.0	9	2	11.6	0.78	0.22	1.5	11	1	11
12	Mixed		50.0	15	1	16.1	0.93	0.07	0.1	60	37	62
13	Mixed	110	50.0	13	2	15.4	0.85	0.15	0.7	50	29	51
14	Mixed	90	50.0	12	2	14.4	0.83	0.17	0.8	37	39	38
15	Mixed	88	50.0	18	5	24.9	0.72	0.28	6.5	276	288	279
16	Mixed		50.0	12	2	14.4	0.83	0.17	0.8	37	24	38
17	Mixed	88	50.0		4	16.7	0.60	0.40	17.3	70	76	71
18	Mixed	60	50.0	3	1	4.5	0.67	0.33	2.3	14	1	14
19	Mixed	100	50.0	16	2	18.3	0.88	0.13	0.5	100	85	101
20	Mixed	51	50.0	4	1	5.3	0.75	0.25	1.0	9	1	8
21	Mixed	52	50		3	0.0	1.00	0.00	0.0	69	22	68
22	Mixed	60	50	7	1	0.0	1.00	0.00	0.0	69	29	68
23	Mixed	45	50	8	2	0.0	1.00	0.00	0.0	69	17	68
24	Mixed	55	50	7	3	0.0	1.00	0.00	0.0	69	25	68
25	Mixed	65	50	4	1	0.0	1.00	0.00	0.0	69	35	68

26	Mixed	55	50	3	1	0.0	1.00	0.00	0.0	69	25	68
27	Mixed	50	50	3	1	0.0	1.00	0.00	0.0	69	20	68
28	Mixed	75	50	1	0	0.0	1.00	0.00	0.0	69	46	68

Table 10. Capture Statistics Table

Capture Statistics Table													
Bosonberg Creek						Brook Trout							
										Regular capture statistics of p			
Reach	Habitat	Pooled Capture Statistics										+/-95%	CL%
Strata	Strata	p'	q'	V(p')	Ti'	xi'	V(xi')	n		avg	std dev	CL	of p
All Reaches	Mixed	0.78	0.22	0.001279	259	272	183	28		0.85	0.18	0.07	8%
	Total				259	272							
p: Probability of capture.										Ti': Total number of fish captured.			
q: Probability of noncapture.										xi': Total number of fish estimated in sampled units.			
V: Variance.										n: number of sample units			

Table 11. Sample Size Tables

Sample Size Tables												
Bosonberg Creek			Brook 1+									
	Habitat		Total habitat			Sampled habitat				Sample percent of total		
Reach	Type	N	Area	Length		n	area	Length		Number	Area	Length
All Reaches	Mixed	71	6,494	3,572		28	2,567	1,412		39.5%	39.5%	39.5%
	Total	71	6,494	3,572		28	2,567	1,412		39.5%	39.5%	39.5%
N: Total number of habitat units.				Area in square meters								
n: Number of sampled units.				Length in meters.								
				Width in meters.								
	Habitat	Mean habitat unit area				Mean habitat unit length				Mean habitat unit width		
Reach	Type	Total	Sample	% diff.		Total	Sample	% diff.		Total	Sample	% diff.
All Reaches	Mixed	92	92	0.0%		50	50	0.0%		1.8	1.81798	0.0%
	Total	92	92	0.0%		50	50	0.0%		2	1.8	0.0%

Table 12. Selected Estimate and Method Table

Selected Estimate and Method Table				
Bosonberg		Brook 1+		80100
	Habitat		Selected	
	Type	Estimate	Variance	Method
All Reaches	Mixed	588	7,824	R #/m^2
	Total	588	7,824	
P: Pooled capture method.				
R: Regular captures method.				
#/unit: Fish per habitat unit expansion method.				
#/m2: Fish per square meter expansion method.				
#/m: Fish per lineal meter expansion method.				

Table 13. Estimate Selection Tables

Estimate Selection Tables							
					Brook 1+		
	All Reaches	Mixed					
	Choice of Method for Fish Population Estimation						
	1).... Use regular Capture Method.						
	2). Select #/unit, #/m2, or #/m, with lowest 1st stage variance.						
	3). Place cursor on selected Pop. Est. shaded below and key "Ctrl P".						
		Pooled Capture Method			Regular Capture Method		
	Variance	#/unit	#/m2	#/m	#/unit	#/m^2	#/m
Selected	1st Stage	6,329	5,333	6,217	6,329	5,333	6,217
Values	2nd Stage	463	463	463	2,491	2,491	2,491
7,824	Total	6,792	5,796	6,680	8,820	7,824	8,708
R #/m2							
588	Pop. Est.	688	688	688	587	588	588
	+/-95% CL	162	149	160	184	173	183
	% CL/Est.	24%	22%	23%	31%	29%	31%

Table 14. Results Table

Results Table									
Bosonberg Creek		Brook 1+		80100	-	100600			
						Fish per square meter		Fish per lineal meter	
	Habitat	Population	+/-	CL % of		Habitat	Reach	Habitat	Reach
	Type	Estimate	95% c.l.	Estimate		Type	Average	Type	Average
All Reaches	Mixed	588	173	29%		0.0905		0.165	
	Total	588	173	29%		0.0905		0.165	

Appendices C.
Sculpin Statistical Tables

Table 15. Reach and Total Habitat Data Input Table

Reach and Total Habitat Data Input Table						
				Total habitat		
		Sample strata		Number	Area	Length
		Reach	Habitat	Of units	m^2	M
Stream:	Bosonberg	All Reaches	Mixed	70.8	6493.8	3572
Species/age:	Sculpin					
Sample dates ("mm/dd/yy):						
Starting	80100					
Ending	100600					

Table 16. Electro fishing Data Tables

Electrofishing Data Tables												
Sculpin												
		(m2)	(m)								$(yi-rxi)^2$	
Unit No.	Unit Type	Area	Length	Pass 1	Pass 2	yi	p	q	V(yi)	$(yi-y)^2$	m2	M
1	Mixed	107	50.0	21	8	33.9	0.62	0.38	28.7	2	50	1
2	Mixed	113	52.0	40	4	44.4	0.90	0.10	0.7	85	1	66
3	Mixed	110	50.0	50	17	75.8	0.66	0.34	40.8	1642	1121	1666
4	Mixed	158	50.0	55	28	112.0	0.49	0.51	370.4	5899	2621	5945
5	Mixed		50.0	52	21	87.2	0.60	0.40	94.3	2703	932	2734
6	Mixed	105	50.0	69	15	88.2	0.78	0.22	10.6	2802	2286	2834
7	Mixed	122	50.0	42	20	80.2	0.52	0.48	186.7	2020	1119	2047
8	Mixed	105	55.0	31	10	45.8	0.68	0.32	20.3	111	31	54
9	Mixed		50.0		5	56.5	0.90	0.10	0.8	454	28	467
10	Mixed	94	55.0	61	22	95.4	0.64	0.36	64.6	3621	3537	3247
11	Mixed	115	50.0	49	22	88.9	0.55	0.45	155.3	2883	2000	2915
12	Mixed	110	50.0	32	14	56.9	0.56	0.44	87.9	469	213	482
13	Mixed	110	50.0	0		0.0	1.00	0.00	0.0	1241	1787	1220
14	Mixed	90	50.0	0	0	0.0	1.00	0.00	0.0	1241	1197	1220
15	Mixed	88	50.0	5	2	8.3	0.60	0.40	8.6	724	650	708
16	Mixed	105	50.0	0	0	0.0	1.00	0.00	0.0	1241	1629	1220
17	Mixed	88	50.0	0	0	0.0	1.00	0.00	0.0	1241	1144	1220
18	Mixed	60	50.0	4	0	4.0	1.00	0.00	0.0	976	363	957
19	Mixed	100	50.0		1	13.1	0.92	0.08	0.1	490	642	477
20	Mixed	51		19	9	36.1	0.53	0.47	81.9	1	272	1
21	Mixed	52	50	16		28.4	0.56	0.44	44.0	46	72	42
22	Mixed	60	50	4	1	5.3	0.75	0.25	1.0	894	314	876
23	Mixed	45		3		4.5	0.67	0.33	2.3	945	164	926
24	Mixed		50	6	3	12.0	0.50	0.50	36.0	540	84	526
25	Mixed	65	50	1	0	1.0	1.00	0.00	0.0	1172	575	1152
26		55	50	2	0	2.0	1.00	0.00	0.0	1105	366	1085

27	Mixed	50	50		1	4.5	0.67	0.33	2.3	945	217	926
28	Mixed	75	50	2	0	2.0	1.00	0.00	0.0	1105	720	1085

Table 17. Capture Statistics Table

Capture Statistics Table												
Bosonberg		Sculpin							Regular capture statistics of p			
Reach	Habitat	Pooled Capture Statistics									+/-95%	CL%
Strata	Strata	p'	q'	V(p')	Ti'	xi'	V(xi')	n	avg	std dev	CL	of p
All Reaches	Mixed	0.67	0.33	0.000710	841	947	11392	28	0.75	0.19	0.08	10%
	Total				841	947						

p: Probability of capture.	Ti': Total number of fish captured.
q: Probability of noncapture.	xi': Total number of fish estimated in sampled units.
V: Variance.	n: number of sample units

Table 18. Sample Size Tables

Sample Size Tables											
Bosonberg			Sculpin								
	Habitat		Total habitat			Sampled habitat			Sample percent of total		
Reach	Type	N	Area	Length		n	Area	Length	Number	Area	Length
All Reaches	Mixed	71	6,494	3,572		28	2,567	1,412	39.5%	39.5%	39.5%
	Total	71	6,494	3,572		28	2,567	1,412	39.5%	39.5%	39.5%

N: Total number of habitat units.	Area in square meters
n: Number of sampled units.	Length in meters.
	Width in meters.

	Habitat	Mean habitat unit area			Mean habitat unit length			Mean habitat unit width		
Reach	Type	Total	Sample	% diff.	Total	Sample	% diff.	Total	Sample	% diff.
All Reaches	Mixed	92	92	0.0%	50	50	0.0%	1.8	1.81798	0.0%
	Total	92	92	0.0%	50	50	0.0%	2	1.8	0.0%

Table 19. Selected Estimate and Method Table

Selected Estimate and Method Table				
Bosonberg		Sculpin		80100
	Habitat		Selected	
	Type	Estimate	Variance	Method
All Reaches	Mixed	2,496	99,868	r #/m^2
	Total	2,496	99,868	
p: Pooled capture method.				
r: Regular capture method.				
#/unit: Fish per habitat unit expansion method.				
#/m2: Fish per square meter expansion method.				
#/m: Fish per lineal meter expansion method.				

Table 20. Estimate Selection Tables

Estimate Selection Tables							
Sculpin							
	All Reaches	Mixed					
	Choice of Method for Fish Population Estimation						
	1)..... Use Regular Capture Method						
	2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance.						
	3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P".						
		Pooled Capture Method			Regular Capture Method		
	Variance	#/unit	#/m2	#/m	#/unit	#/m^2	#/m
Selected	1st Stage	146,689	96,740	144,701	146,689	96,740	144,701
Values	2nd Stage	28,806	28,806	28,806	3,128	3,128	3,128
99,868	Total	175,495	125,546	173,507	149,817	99,868	147,829
r #/m2							
2,496	Pop. Est.	2,395	2,396	2,396	2,495	2,496	2,496
	+/-95% CL	821	694	816	759	619	754
	% CL/Est.	34%	29%	34%	30%	25%	30%

Table 21. Results Table

Results Table									
Bosonberg		Sculpin		80100 - 100600					
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of		Reach		Habitat	Reach
	Type	Estimate	95% c.l.	Estimate	Type	Average		Type	Average
All Reaches	Mixed	2,496	619	25%	0.3844			0.699	
	Total	2,496	619	25%	0.3844			0.699	

Salmonid Population Estimate for Crooked Creek

Author: Steve Namitz, Burns Paiute Fish and Wildlife Department, Burns, Oregon

Introduction

Crooked Creek is a tributary of Upper Malheur River entering in at River Kilometer (RK) 8 (Figure 1). Crooked Creek is approximately 15.3 Kilometers long (9.45 miles) and has a hydrologic drainage area of roughly 79.5 Square Kilometers (31 square miles). Crooked Creek was identified by Oregon Department of Fish & Wildlife (ODFW) as a data gap for fish species in the Upper Malheur River system.

Project #: 199701900

Objective 2. Continue monitoring population trends (index) and age class structure in native salmonids within the Malheur basin.

Methods

The Burns Paiute Tribe Fish & Wildlife Department (BPT) administered an electrofishing effort in Crooked Creek from 13 August 1999 to 9 September 1999 using ODFW protocol (Dambacher 1997). The electrofishing effort was administered to determine fish population estimates within Crooked Creek, specifically salmonids. Survey efforts were made from the confluence of Crooked Creek and the Upper Malheur River to the upper limits of fish (Figure 1 & 2).

1999 Electro fishing Protocol

The BPT conducted a 2/4 pass 50% reduction population survey on Crooked Creek (Figure 2). Sampled units were 50 meters in length (164 feet). Block nets were anchored into the substrate with tent pegs and rocks at the upper and lower boundary to prevent fish escapement. Survey unit #1 begins at the confluence of the Upper Malheur River and Crooked Creek (Figure 2). Surveyed units were separated by approximately 300 m (1000 ft). A total of 19 sections were sampled. Sampling was stopped when Crooked Creek became dry at River Kilometer 13.75. The first pass consists of shocking from the lower block net upstream to the upper net and back. The second pass must have a 50% reduction in the collection of age 1+ (fork length$\geq$70 mm) salmonids for the site to be complete. If more than one salmonid species is present then a 50% reduction is required for each salmonid species. If this is not met, 2 more passes were required using the same methodology. The last site for the population survey was determined when no salmonids were collected on the first pass. From this site, upper limits of *Oncorhynchus mykiss* (redband trout) and *Salvelinus fontinalis* (brook trout) were determined by shocking 100% of the wetted channel upstream until the channel became dry or intermittent. The survey was terminated due to lack of flow (dry channel).

Fish collection

Fish collection was accomplished with the use of a Smith & Root electrofisher. The protocol for shocking was to start at the down stream end of the block nets and shock moving upstream then back again. By the protocol this is considered to be one pass. Shocking was accomplished in groups of three, one person operating the shocker, and two netters following behind. The electrofisher was tested for effectiveness in a sample area not included in the population survey. If fish were not observed reacting to the set electrical current, instruments on the shocker were adjusted to increase the impact. After the shocker was adjusted to the appropriate settings then the survey was initiated.

Once the first pass was complete, fish were counted and sorted by species. Fish lengths and weights were measured and recorded. This procedure was repeated for all passes. The percentage of fish captured on the second pass was calculated and compared to fish captured on the first pass to determine if the process needed to be repeated again to reach the 50% reduction for salmonids. If bull trout were observed the sample site was concluded and surveyors proceeded to the next site.

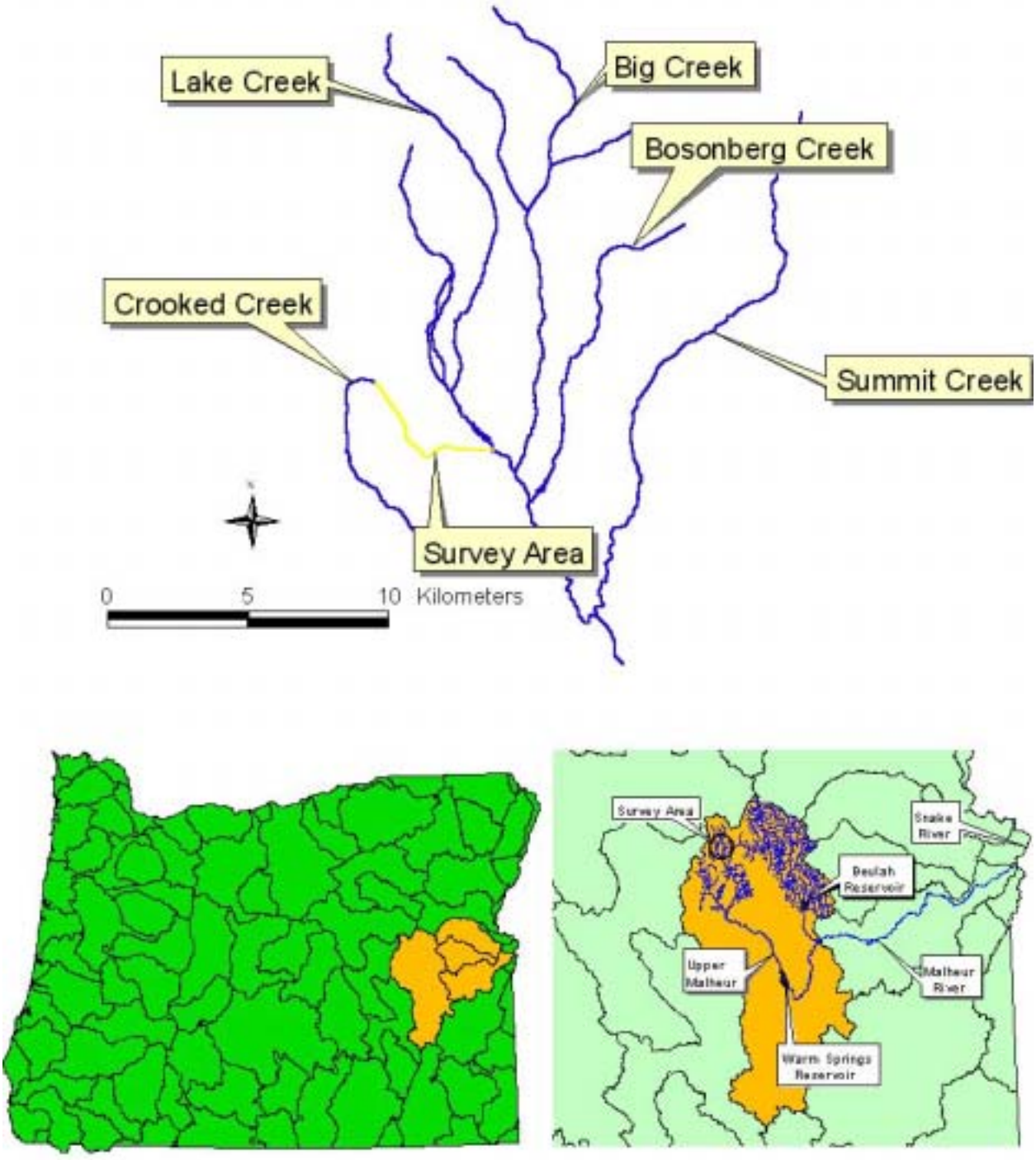

Figure 1. Crooked Creek Location Map

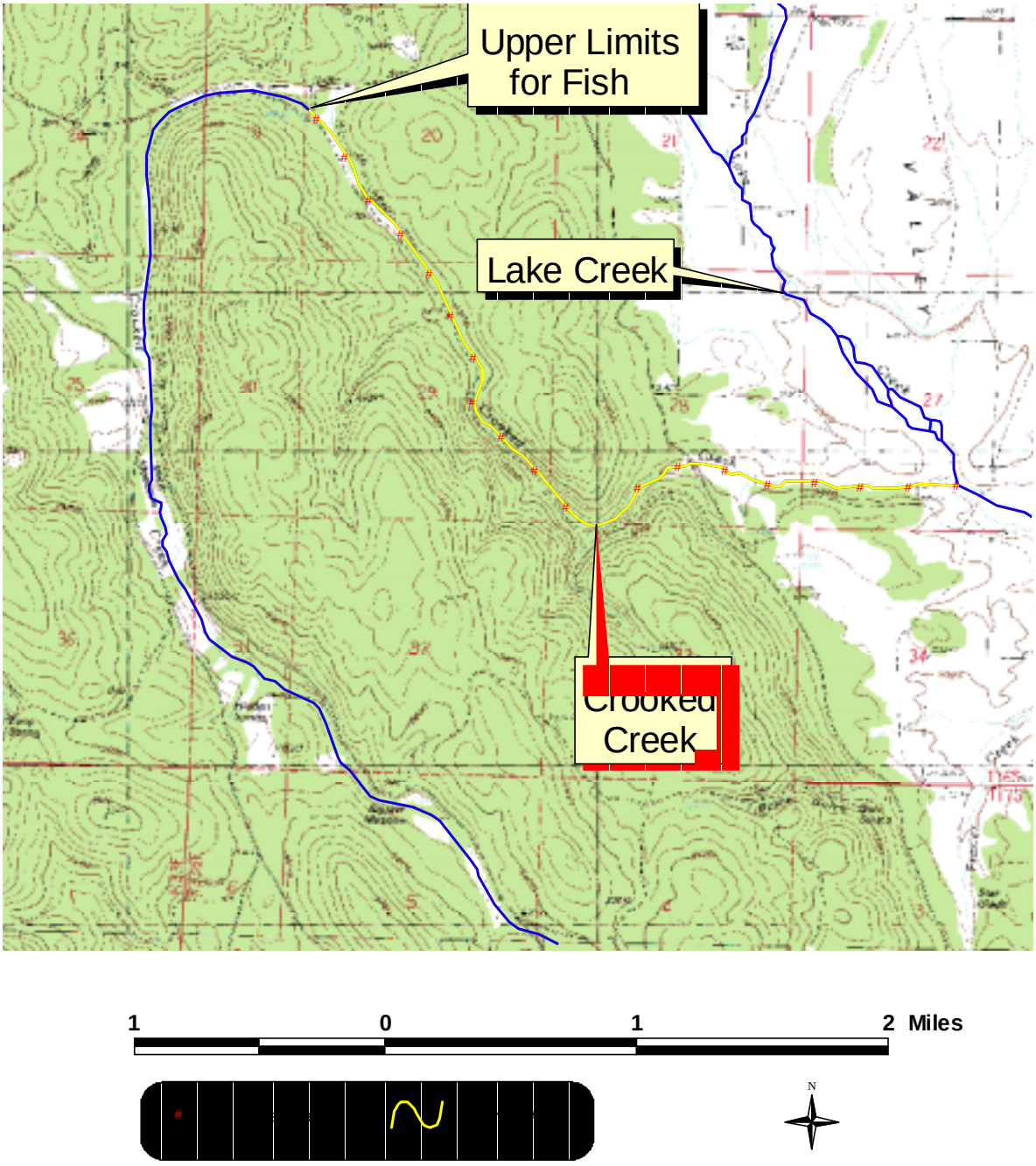

Figure 2. Salmonid Population Estimation and distribution survey for Crooked Creek (Malheur River, Oregon) in 2000

Results

Redband trout (*Oncorhynchus mykiss*)

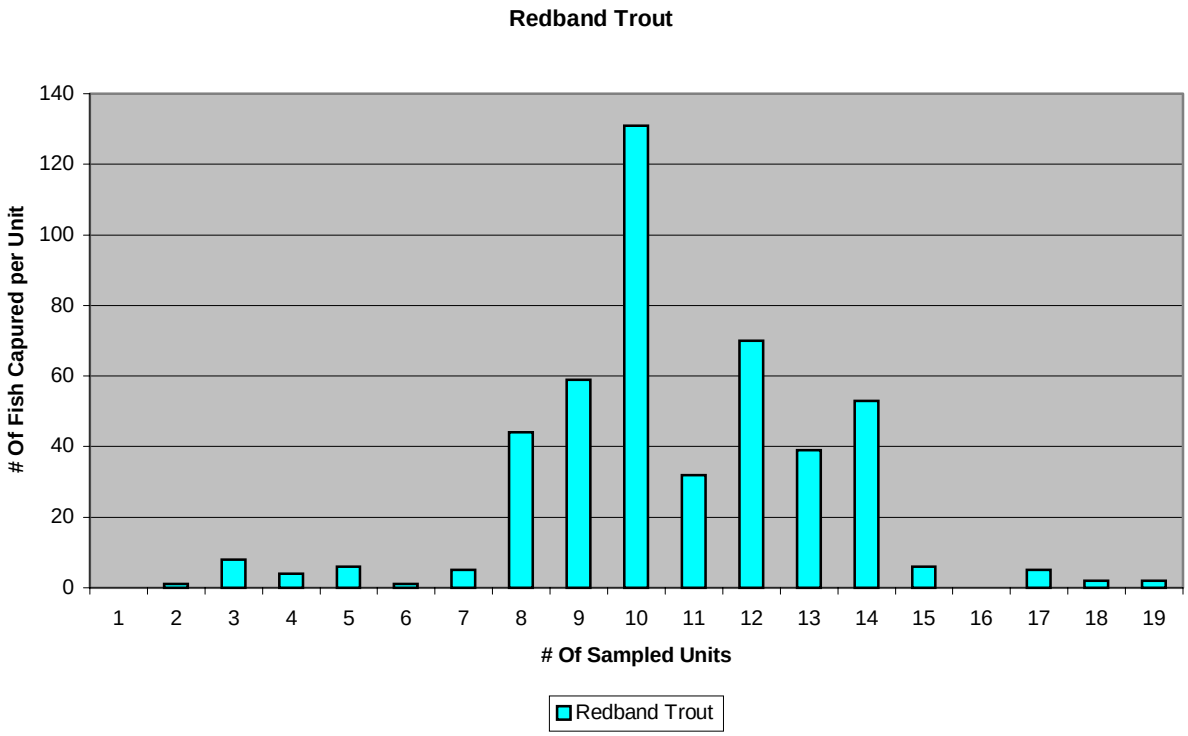

Figure 3. Number of redband trout captured per sample unit (1999, Crooked Creek).

There were a total of 19 sampled units with redband trout being observed in 17 of those units. A 50% reduction was achieved at every sample unit. There were 468 redband trout sampled with the average probability of capture being 81% and a probability of non-capture of 19%. Of the total surveyed area 14% was sampled. Average sample units were roughly 70 m^2. The estimated population of redband trout for Crooked Creek was 3,544 fish +/- 2,137 fish with a 95% confidence level (Table 1). Redband statistics tables can be viewed in Appendix A.

Table 1. Redband Trout Statically Results Table

Results Table									
Crooked Creek		Redband Trout							
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of	Habitat	Reach		Habitat	Reach
	Type	Estimate	95% c.l.	Estimate	Type	Average		Type	Average
All reaches	Mixed	3,544	2,137	60%	0.3632		Na	0.508	Na
	Total	3,544	2,137	60%	0.3632		Na	0.508	Na

Brook Trout (*Salvelinus fontinalis*)

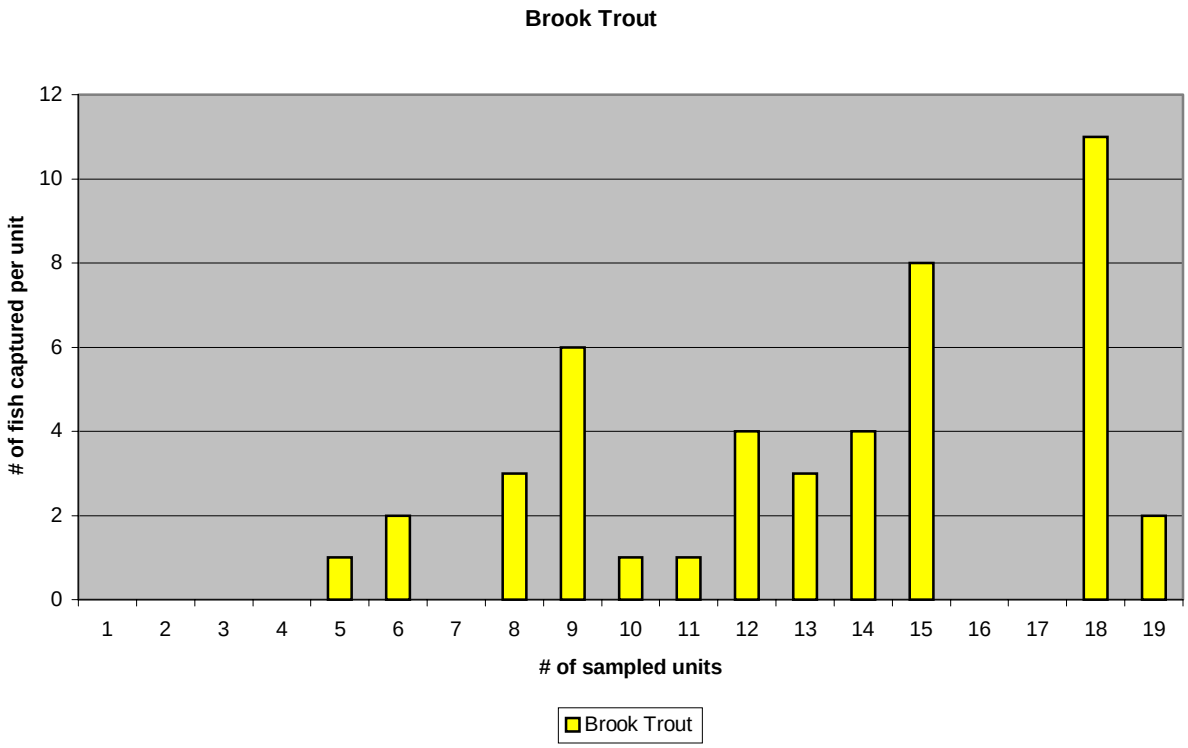

Figure 4. Number of brook trout captured per sample unit (1999, Crooked Creek).

Brook trout were observed periodically throughout the 19 sampled units. A 50% reduction was achieved at all sampled units where brook trout were present. There were 46 brook trout sampled with the average probability of capture being 90% and a probability of non-capture of 10%. Of the total surveyed area 14% was sampled. Average sample units were roughly 70 m^2. The estimated population of brook trout in Crooked Creek was 340 fish +/- 180 fish with a 95% confidence level (Table 2). Brook trout statistic tables can be viewed in Appendix B.

Table 2. Brook Trout Statistical Results Table

Results Table								
Crooked Creek	Brook Trout							
					Fish per square meter		Fish per lineal meter	
	Habitat Type	Population Estimate	+/- 95% c.l.	CL % of Estimate	Habitat Type	Reach Average	Habitat Type	Reach Average
All reaches	Mixed	340	180	53%	0.0348	Na	0.049	Na
	Total	340	180	53%	0.0348	Na	0.049	Na

Dace (*Rhinichthys spp*)

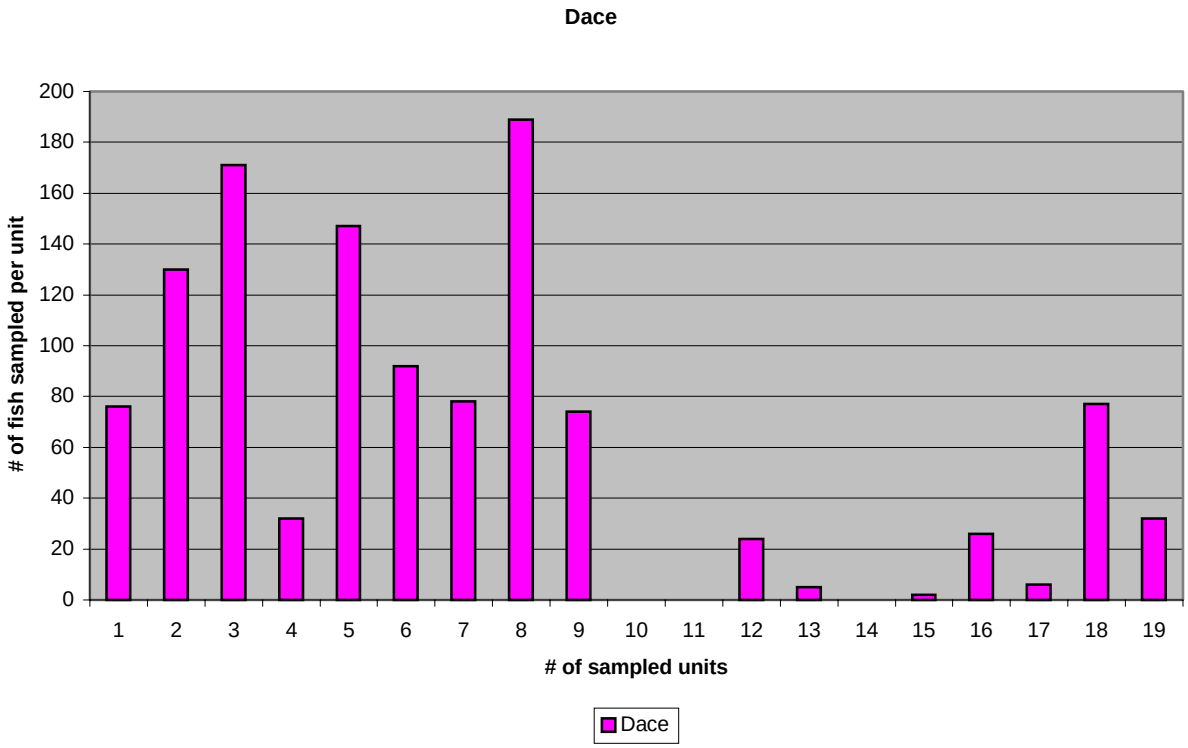

Figure 5. Number of dace captured per sample unit (1999, Crooked Creek).

Dace species were observed throughout Crooked Creek but were most abundant in the lower portions of the creek (Figure 5). A 50% reduction was not achieved at all sampled units because it was not a requirement of the protocol. However when making assumptions about population estimates only the sample units that achieved a 50% reduction should be used. Sample units 13 and 17 were removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 1,150 dace sampled with the average probability of capture being 76% and a probability of non-capture of 24%. Of the total surveyed area 12% was sampled for dace. Average sample units were roughly 70 m^2. The estimated population of dace in Crooked Creek was 10,449 fish +/- 3,579 fish with a 95% confidence level (Table 3). Dace statistics tables can be viewed in Appendix C.

Table 3. Dace Statistical Results Table

Results Table									
Crooked Creek		Dace							
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of	Habitat	Reach		Habitat	Reach
	Type	Estimate	95% c.l.	Estimate	Type	Average		Type	Average
All reaches	Mixed	10,449	3,579	34%	1.0707		Na	1.499	Na
	Total	10,449	3,579	34%	1.0707		Na	1.499	Na

Redside Shiner *(Richardsonius balteatus)*

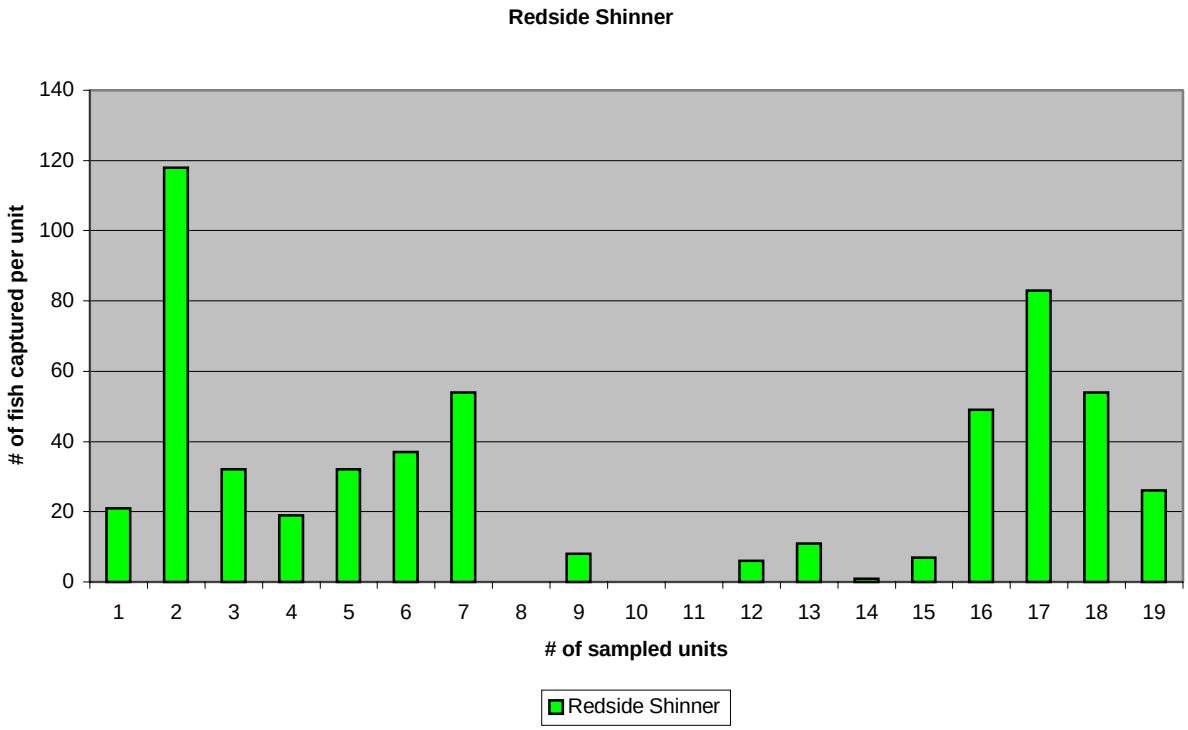

Figure 6. Number of redside shiners captured per sample unit (1999, Crooked Creek).

Redside shiners were observed throughout Crooked Creek but were most abundant in the lower and upper portions of the creek (Figure 6). A 50% reduction was not achieved at all sampled units because it was not a requirement of the protocol. However when making assumptions about population estimates only the sample units that achieved a 50% reduction should be used. Sample units 1, 3 and 12 were removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 499 redside shiners sampled with the average probability of capture being 82% and a probability of non-capture of 18%. Of the total surveyed area 10% was sampled. Average sample units were roughly 70 m^2. The estimated population of redside shiners in Crooked Creek was 5,057 fish +/- 2,211 fish with a 95% confidence level (Table 4). Redside shiners statistic tables can be viewed in Appendix D.

Table 4. Redside Shiner Statistical Results Table

Results Table									
Crooked Creek		Redside Shiner							
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of	Habitat	Reach		Habitat	Reach
	Type	Estimate	95% c.l.	Estimate	Type	Average		Type	Average
All reaches	Mixed	5,057	2,211	44%	0.5182		Na	0.725	Na
	Total	5,057	2,211	44%	0.5182		Na	0.725	Na

Sucker *(Catostomus spp)*

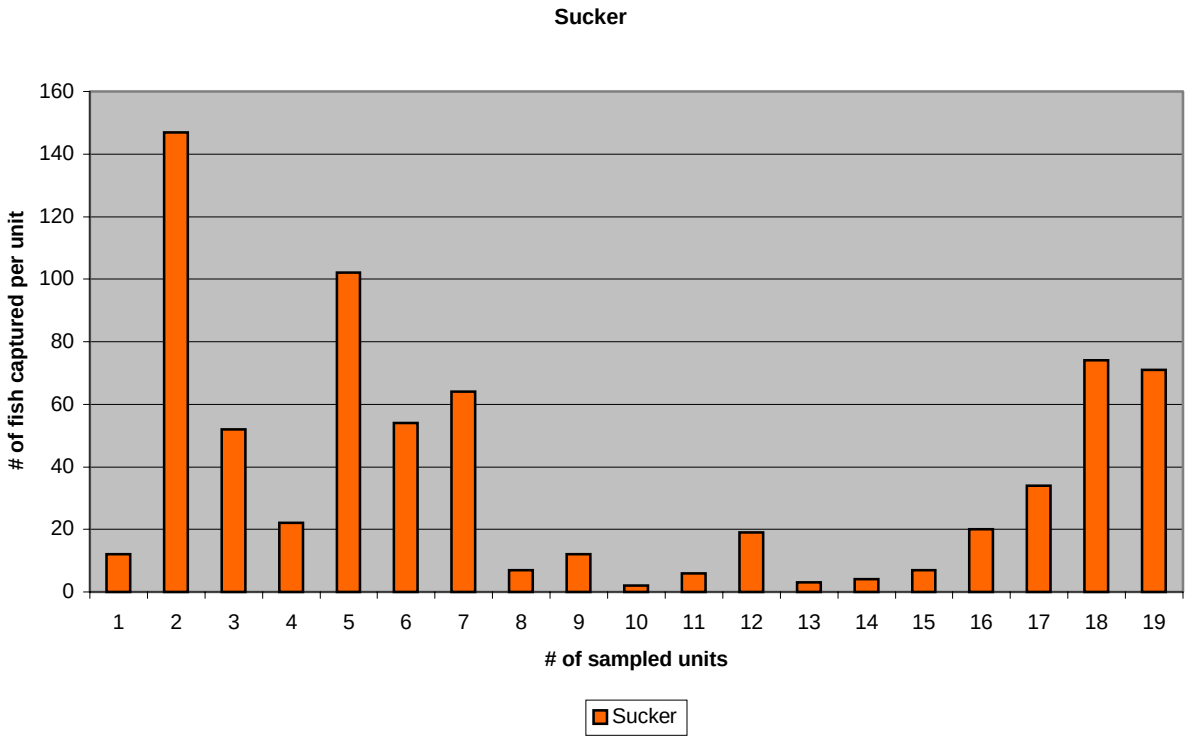

Figure 7. Number of suckers captured per sample unit (1999, Crooked Creek).

Suckers were observed throughout Crooked Creek but were also most abundant in the lower and upper portions of the creek (Figure 7). A 50% reduction was not achieved at all sampled units. Sample units 1 and 3 were removed from the data set to be consistent with the established protocol (Dambacher 1997). There were 648 suckers sampled with the average probability of capture being 85% and a probability of non-capture of 15%. Of the total surveyed area 12% was sampled. Average sample units were roughly 70 m^2. The estimated population of suckers in Crooked Creek was 6,199 fish +/- 2,684 fish with a 95% confidence level (Table 3). Suckers statistics tables can be viewed in Appendix E.

Table 5. Sucker Statistical Results Table

Results Table								
Crooked Creek	Sucker							
					Fish per square meter		Fish per lineal meter	
	Habitat Type	Population Estimate	+/- 95% c.l.	CL % of Estimate	Habitat Type	Reach Average	Habitat Type	Reach Average
All reaches	Mixed	6,199	2,684	43%	0.6352	Na	0.889	Na
	Total	6,199	2,684	43%	0.6352	Na	0.889	Na

Sculpin *(Cottus spp)*

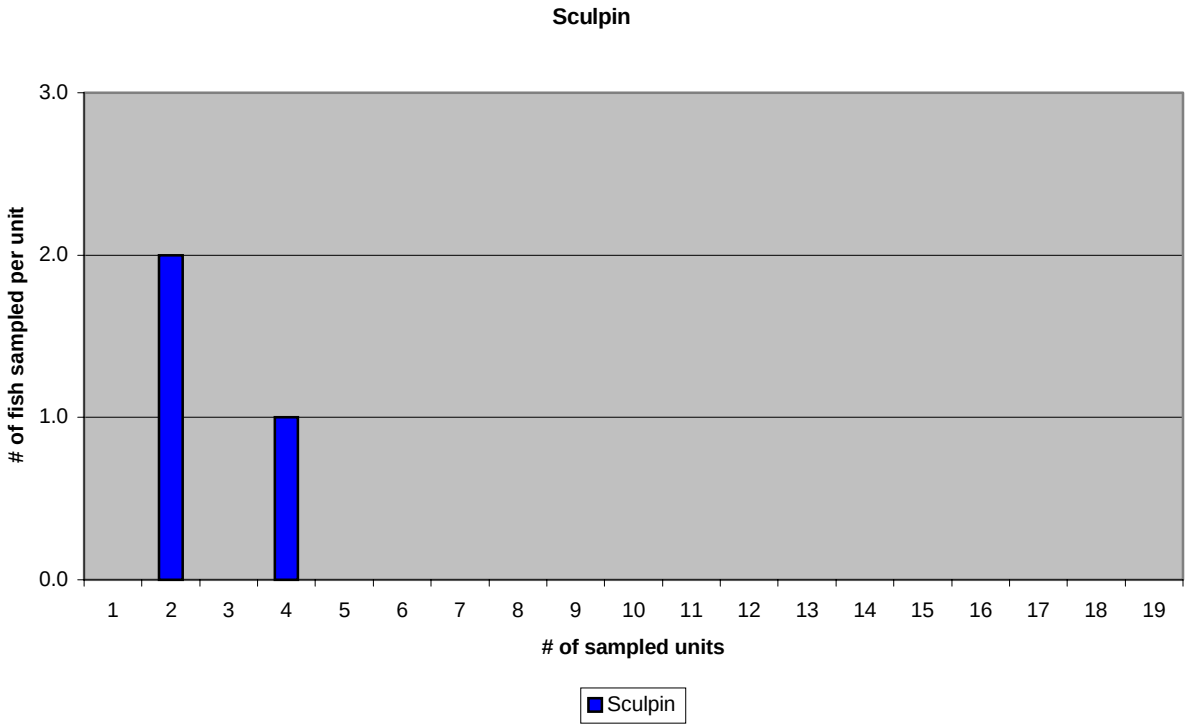

Figure 8. Number of sculpin captured per sample unit (1999, Crooked Creek).

Three sculpins were observed in Crooked Creek (Figure 8.). Conducting sculpin population estimates using an electrofishing method is controversial in the scientific world due to how sculpin react when being sampled. Sculpin are bottom dwellers and tend to avoid a taxis response to electrofishing. Sculpin data was collected but should be viewed as presence/absence data.

Bull trout *(Salvenlinus confluentus)*

No bull trout were observed within the 19 sampled units of Bosonberg Creek in 2000. How ever in 1998 the Burns Paiute Tribe Fish and Wildlife Department documented bull trout in Crooked Creek as part of a fish presence absence survey.

Upper limits of fish species

The upper limits of fish documented during the 1999 survey were almost exactly the same point where ODFW had established the upper limits of fish for Crooked Creek in previous studies (Personal contact, District ODFW Biologist, see figure 2).

Discussion

Salmonids were the focus of this population estimate effort. Redband and brook trout were the salmonids sampled throughout Crooked Creek (Figure 9).

There were a total of 19 sample locations in a 6,971-meter (22,872 feet) section. The mean habitat width for the upper portion of Crooked Creek was 1.4 meters (4.6 feet), making the sampled area roughly 9,759 m^2 (108,433 ft^2).

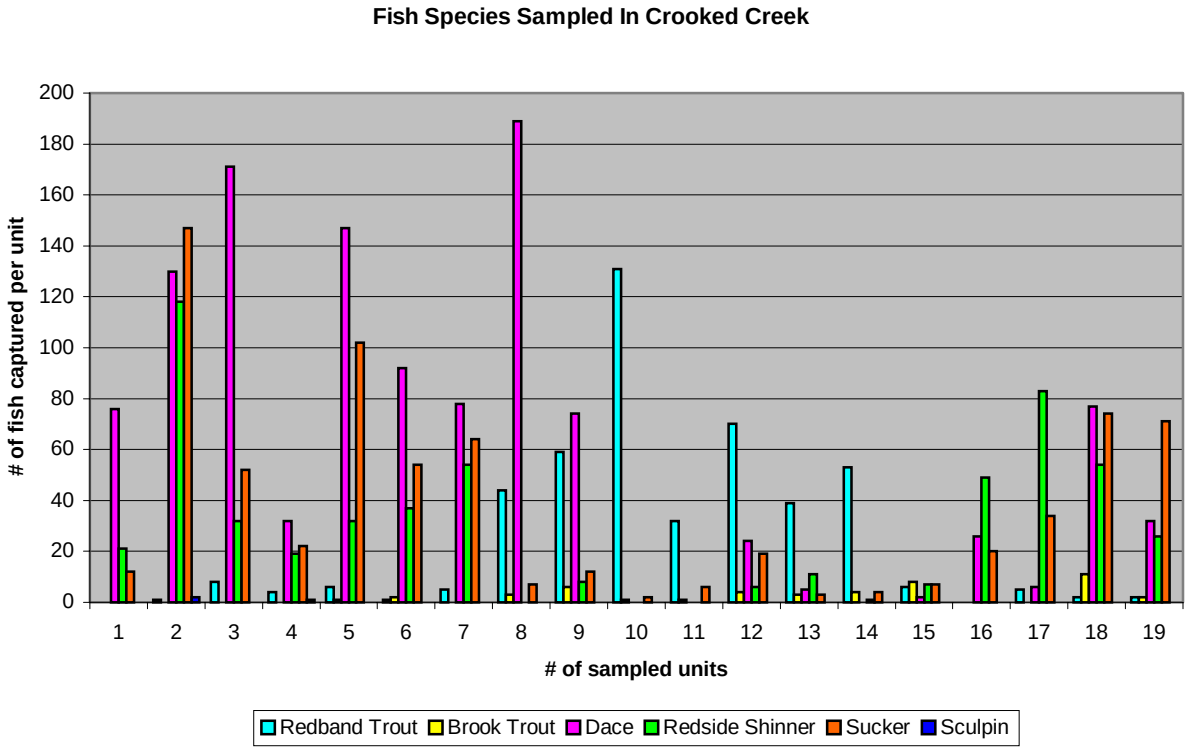

Figure 9. Number of fish captured per sample unit (1999, Crooked Creek).

There were no bull trout observed in Crooked Creek during the 1999 population survey, although there are historical and recent sightings of bull trout in Crooked Creek (Gonzalez et al. 1998). Current summer temperatures in Crooked Creek make it unlikely that bull trout are utilizing this area for spawning habitat although it is believed by local fish biologists that bull trout did reside in the entire drainage. Bull trout in the creek today are most likely using it as rearing or possibly winter habitat for juvenals.

Redband trout and brook trout are coinciding in the same habitat with the former being in greater abundance in 1999 (Figure 10).

There are some interesting trends that can be observed in figures 9 & 10 in regard to population interface between redband trout and non-salmonids (i.e., dace, suckers and redside shiners). The non-salmonids species populations are higher in the lower creek and in the headwaters but are reduced between sample units 9-16 (Figure 9). In contrast redband trout increase in abundance

from sample units 7-15. This factor implies some sort of a transitional zone, which could be contributed to habitat change or possibly a change in water quality. This transition also occurs in the area around site 15. Causes of such a transition could include habitat, temperature (spring influence), dissolved oxygen, gradient, substrate, or a geomorphology change.

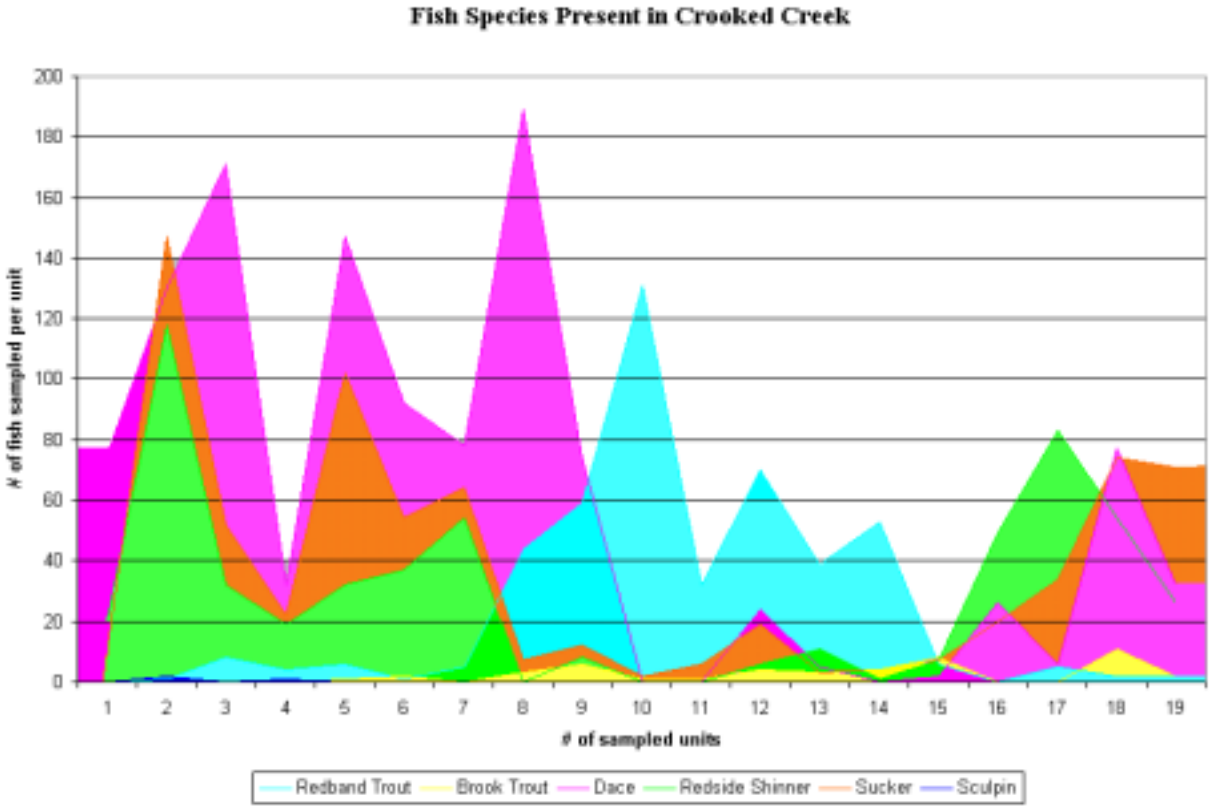

Figure 10. Number of fish captured per sample unit (1999, Crooked Creek).

The Crooked creek population estimate survey has provided some good base line information on what species are present in the system as well as where they reside spatially. This information will be beneficial for managers and landowners when making decisions that will possibly affect the landscape. This information also spawns more questions that will lead to future studies and restoration actions.

Recommendations / Future Projects

The 2000 population estimates for Crooked Creek have raised some interesting questions such as why there are no bull trout currently present when they were found historically in the drainage (Bowers, 1993). Bull trout are also currently found in neighboring tributaries and in the main stem of the Upper Malheur River. Crooked Creek exhibits potential for future restoration. Potential future projects for Bosonberg Creek may include; Habitat restoration projects, exotic species eradication projects, changes in land use practices by federal agencies to favor bull trout needs. There needs to be an outreach to the private landowners to practice “Best Management

Techniques" for future land management if the salmonid species within Bosonberg Creek and the Upper Malheur Basin are to persist.

Acknowledgements

A special thanks is extended to ODFW, who worked with the Tribe to coordinate this effort. Thanks to Bonneville Power Administration who provided the funds to the Burns Paiute Tribe Fish and Wildlife Department to take the lead in this research.

References

Bowers, W.L., P.A. Dupee, M.L. Hanson, and R.R. Perkins. 1993. bull trout population summary Malheur River basin. Oregon Department of Fish and Wildlife, Hines, Oregon. Unpublished report.

Bowers, W. 2001. Personal contact with employee of Oregon Department of Fish and Wildlife, Burns, Oregon.

Buchanan, M. W. and S. V. Gregory, 1997. Development of water temperature standards to protect and restore habitat for bull trout and other cold water species in Oregon. Pages 119 – 126 in McKay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference procedding. Bull Trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Buckman, R.C., W.E. Hosford, and P.A. Dupee. 1992. Malheur River bull trout investigations. Pages 45-57 *in* P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis.

Dambacher, J.M. 1997. Electrofishing Population Estimation Spreadsheet. Version 2.0

Dambacher, J.M. and K.K. Jones. 1997. Stream Habitat of Juvenile Bull Trout Populations in Oregon and Benchmarks for Habitat Quality. Pages 353 – 360 in McKay, W.C., M.K. Brewin, and M. Monita, editors. Friends of the bull trout conference proceeding. Bull trout Task Force (Alberta), c/o Trout Unlimited Canada, Calgary.

Gonzalez, D., Schwabe, L. and M. Tiley. 1999. Evaluate the Life History of Native Salmonids in The Malheur Basin. 1998 Annual Report. Unpublished data.

Hanson,L. M., R. C. Buckman and W. E. Hosford. 1990. Malheur River Basin Fish Management Plan. Oregon Department of Fishand Wildlife, Portland.

Howell, P.J. and D.V. Buchanan, editors. 1992. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon

Oregon Department of Fish and Wildlife. 1998. Aquatic Inventory Project: Methods for Stream Habitat Survyes, version 8.1. Natural Production Program. Corvallis, OR.

Perkins, R. 1998. Malheur River Bull Trout Population Status. Oregon Department of Fish & Wildlife. Special Report: Southeast Fisheries District. Ontario, Oregon

Ratliff, D.E. and P.J. Howell. 1992. The status of bull trout populations in Oregon. Pages 10-17 in P.J. Howell and D.V. Buchanan, editors. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society. Corvallis, OR.

Appendices A.
Redband Trout Statistical Tables

Table 1. Reach and Total Habitat Data Input Table

Reach and Total Habitat Data Input Table								
						Total habitat		
				Sample strata		number	area	length
				reach	habitat	of units	m2	m
Stream:	Crooked Creek			all reaches	mixed	136.6863	9759	6971
Species/age:	Redband Trout							
Sample dates ("mm/dd/yy):								
Starting	8/13/99							
Ending	9/9/99							

Table 2. Electrofishing Data Tables

Electrofishing Data Tables												
all reaches	mixed		Crooked Creek				Redband Trout					
		(m2)	(m)								(yi-rxi)^2	
Unit No.	Unit Type	Area	Length	Pass 1	Pass 2	yi	p	q	V(yi)	(yi-y)^2	m2	m
1	mixed	96	50	0	0	0.0	1.00	0.00	0.0	672	1385	637
2	mixed	105	50	1	0	1.0	1.00	0.00	0.0	621	1576	588
3	mixed	122	49	8	0	8.0	1.00	0.00	0.0	321	1528	274
4	mixed	156	52	3	1	4.5	0.67	0.33	2.3	459	3132	473
5	mixed	68	52	6	0	6.0	1.00	0.00	0.0	397	408	410
6	mixed	54	49	1	0	1.0	1.00	0.00	0.0	621	396	564
7	mixed	26	51	4	1	5.3	0.75	0.25	1.0	424	21	417
8	mixed	46	51	38	6	45.1	0.84	0.16	2.2	369	747	375
9	mixed	123	49	47	12	63.1	0.74	0.26	12.5	1383	244	1473
10	mixed	47	52	100	31	144.9	0.69	0.31	55.5	14161	16075	14083
11	mixed	48	53	29	3	32.3	0.90	0.10	0.5	41	192	31
12	mixed	48	53	60	10	72.0	0.83	0.17	4.0	2123	2864	2047
13	mixed	31	51	35	4	39.5	0.89	0.11	0.8	185	756	189
14	mixed	47	52	45	8	54.7	0.82	0.18	3.7	830	1339	811
15	mixed	48	53	6	0	6.0	1.00	0.00	0.0	397	156	431
16	mixed	47	52	0	0	0.0	1.00	0.00	0.0	672	329	689
17	mixed	57	52	5	0	5.0	1.00	0.00	0.0	438	295	452
18	mixed	59	54	2	0	2.0	1.00	0.00	0.0	572	442	638
19	mixed	46	51	2	0	2.0	1.00	0.00	0.0	572	249	564

Table 3. Capture Statistics Table

Capture Statistics Table												
Crooked Creek		Redband Trout										
									Regular capture statistics of p			
Reach	Habitat	Pooled Capture Statistics									+/-95%	CL%
strata	strata	p'	q'	V(p')	Ti'	xi'	V(xi')	n	avg	std dev	CL	of p
all reaches	mixed	0.81	0.19	0.000591	468	486	338	19	0.90	0.12	0.06	6%
	Total				468	486						
p: Probability of capture.			Ti': Total number of fish captured.									
q: Probability of noncapture.			xi': Total number of fish estimated in sampled units.									
V: Variance.			n: number of sample units									

Table 4. Sample Size Tables

Sample Size Tables											
Crooked Creek			Redband Trout								
	Habitat		Total habitat			Sampled habitat			Sample percent of total		
Reach	type	N	area	length		n	area	length	number	area	length
all reaches	mixed	137	9,759	6,971		19	1,271	976	13.9%	13.0%	14.0%
	Total	137	9,759	6,971		19	1,271	976	13.9%	13.0%	14.0%
N: Total number of habitat units.				Area in square meters							
n: Number of sampled units.				Length in meters.							
				Width in meters.							
	Habitat	Mean habitat unit area				Mean habitat unit length			Mean habitat unit width		
Reach	type	total	sample	% diff.		total	sample	% diff.	total	sample	% diff.
all reaches	mixed	71	67	5.6%		51	51	0.0%	1.4	1.3022541	7.0%
	Total	71	67	5.6%		51	51	0.0%	1	1.3	7.1%

Table 5. Selected Estimate and Method Table

Selected Estimate and Method Table				
Crooked Creek		Redband Trout		
	Habitat		Selected	
	type	estimate	variance	method
all reaches	mixed	3,544	1,188,689	r #/unit
	Total	3,544	1,188,689	
p: Pooled capture method.				
r: Regular capture method.				
#/unit: Fish per habitat unit expansion method.				
#/m2: Fish per square meter expansion method.				
#/m: Fish per lineal meter expansion method.				

Table 6. Estimate Selection Tables

Estimate Selection Tables							
			Crooked Creek		Redband Trout		
	all reaches	mixed					
	Choice of Method for Fish Population Estimation						
	1).....If	**6%**	< or =10%, then use Pooled Capture Method.				
	2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance.						
	3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P".						
		Pooled Capture Method			Regular Capture Method		
	Variance	#/unit	#/m2	#/m	#/unit	#/m2	#/m
Selected	1st Stage	1,188,095	1,511,424	1,182,771	1,188,095	1,511,424	1,182,771
Values	2nd Stage	2,431	2,431	2,431	594	594	594
1,188,689	Total	1,190,526	1,513,855	1,185,202	1,188,689	1,512,017	1,183,365
r #/unit							
3,544	Pop. Est.	3,496	3,732	3,473	3,544	3,783	3,520
	+/-95% CL	2,139	2,412	2,134	2,137	2,410	2,132
	% CL/Est.	61%	65%	61%	60%	64%	61%

Table 7. Results Table

Results Table									
Crooked Creek		Redband Trout							
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of	Habitat	Reach		Habitat	Reach
	type	estimate	95% c.l.	estimate	type	average		type	average
all reaches	mixed	3,544	2,137	60%	0.3632			0.508	
	Total	3,544	2,137	60%	0.3632			0.508	

Appendix B.
Brook Trout Statistical Tables

Table 8. Reach and Total Habitat Data Input Table

Reach and Total Habitat Data Input Table						
				Total habitat		
		Sample strata		number	area	length
		reach	habitat	of units	m2	m
Stream:	Crooked Creek	all reaches		136.6863		6971
Species/age:	Brook Trout					
Sample dates ("mm/dd/yy):						
Starting	8/13/99					
Ending	9/9/99					

Table 9. Electrofishing Data Tables

Electrofishing Data Tables												
all reaches	mixed		Crooked Creek		36385		Brook Trout					
		(m2)	(m)								(yi-rxi)^2	
Unit No.	Unit Type	Area	Length	Pass 1	Pass 2	yi	p	q	V(yi)	(yi-y)^2	m2	m
1	mixed	96	50	0	0	0.0	1.00	0.00	0.0	6	13	6
2	mixed	105	50	0	0	0.0	1.00	0.00	0.0	6	15	6
3	mixed	122	49	0	0	0.0	1.00	0.00	0.0	6	20	6
4	mixed	156	52	0	0	0.0	1.00	0.00	0.0	6	34	6
5	mixed	68	52	1	0	1.0	1.00	0.00	0.0	2	2	2
6	mixed	54	49	2	0	2.0	1.00	0.00	0.0	0	0	0
7	mixed	26	51	0	0	0.0	1.00	0.00	0.0	6	1	6
8		46	51	3	0	3.0	1.00	0.00	0.0	0	2	0
9	mixed	123	49	6	0	6.0	1.00	0.00	0.0	12	2	13
10	mixed	47	52	1	0	1.0	1.00	0.00	0.0	2	1	2
11	mixed	48	53	1	0	1.0	1.00	0.00	0.0	2	1	2
12	mixed	48	53	3	1	4.5	0.67	0.33	2.3	4	7	4
13	mixed	31	51	3	0	3.0	1.00	0.00	0.0	0	3	0
14	mixed	47	52	3	1	4.5	0.67	0.33	2.3	4	8	4
15	mixed	48	53	7	1	8.2	0.86	0.14	0.3	32	41	31
16	mixed	47	52	0	0	0.0	1.00	0.00	0.0	6	3	6
17	mixed	57	52	0	0	0.0	1.00	0.00	0.0	6	5	6
18	mixed	59	54	10	1	11.1	0.90	0.10	0.2	74	79	72
19	mixed	46	51	2	0	2.0	1.00	0.00	0.0	0	0	0

Table 10. Capture Statistics Table

Capture Statistics Table												
Crooked Creek		Brook Trout										
									Regular capture statistics of p			
Reach	Habitat	Pooled Capture Statistics									+/-95%	CL%
strata	strata	p'	q'	V(p')	Ti'	xi'	V(xi')	n	avg	std dev	CL	of p
all reaches	mixed	0.90	0.10	0.002506	46	46	0	19	0.95	0.10	0.05	5%
	Total				46	46						
p: Probability of capture.			Ti': Total number of fish captured.									
q: Probability of noncapture.			xi': Total number of fish estimated in sampled units.									
V: Variance.			n: number of sample units									

Table 11. Sample Size Tables

Sample Size Tables											
Crooked Creek			Brook Trout			36385					
	Habitat		Total habitat			Sampled habitat			Sample percent of total		
Reach	type	N	area	length		n	area	length	number	area	length
all reaches	mixed	137	9,759	6,971		19	1,271	976	13.9%	13.0%	14.0%
	Total	137	9,759	6,971		19	1,271	976	13.9%	13.0%	14.0%
N: Total number of habitat units.				Area in square meters							
n: Number of sampled units.				Length in meters.							
				Width in meters.							
	Habitat	Mean habitat unit area				Mean habitat unit length			Mean habitat unit width		
Reach	type	total	sample	% diff.		total	sample	% diff.	total	sample	% diff.
all reaches	mixed	71	67	5.6%		51	51	0.0%	1.4	1.3022541	7.0%
	Total	71	67	5.6%		51	51	0.0%	1	1.3	7.1%

Table 12. Selected Estimate and Method Table

Selected Estimate and Method Table				
Crooked Creek		Brook Trout		
	Habitat		Selected	
	type	estimate	variance	method
all reaches	mixed	340	8,409	r #/unit
	Total	340	8,409	
p: Pooled capture method.				
r: Regular capture method.				
#/unit: Fish per habitat unit expansion method.				
#/m2: Fish per square meter expansion method.				
#/m: Fish per lineal meter expansion method.				

Table 13. Estimate Selection Tables

Estimate Selection Tables							
			Crooked Creek		Brook Trout		
	all reaches	mixed					
	Choice of Method for Fish Population Estimation						
	1).....If	**5%**	< or =10%, then use Pooled Capture Method.				
	2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance.						
	3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P".						
		Pooled Capture Method			Regular Capture Method		
	Variance	#/unit	#/m2	#/m	#/unit	#/m2	#/m
Selected	1st Stage	8,373	11,119	8,219	8,373	11,119	8,219
Values	2nd Stage	1	1	1	36	36	36
8,409	Total	8,374	11,121	8,220	8,409	11,155	8,255
r #/unit							
340	Pop. Est.	331	353	329	340	363	338
	+/-95% CL	179	207	178	180	207	178
	% CL/Est.	54%	59%	54%	53%	57%	53%

Table 14. Results Table

Results Table								
Crooked Creek		Brook Trout						
					Fish per square meter		Fish per lineal meter	
	Habitat	Population	+/-	CL % of	Habitat	Reach	Habitat	Reach
	type	estimate	95% c.l.	estimate	type	average	type	average
all reaches	mixed	340	180	53%	0.0348		0.049	
	Total	340	180	53%	0.0348		0.049	

Appendix C.
Dace Statistical Tables

Table 15. Reach and Total Habitat Data Input Table

Reach and Total Habitat Data Input Table						
					Total habitat	
		Sample strata		number	area	length
		reach	habitat	of units	m2	m
Stream:	Crooked Creek	all reaches	mixed	136.6863	9759	
Species/age:	Dace					
Sample dates ("mm/dd/yy):						
Starting	8/13/99					
Ending	9/9/99					

Table 16. Electrofishing Data Tables

Electrofishing Data Tables												
all reaches	mixed		Crooked Creek		36385		Dace					
		(m2)	(m)								(yi-rxi)^2	
Unit No.	Unit Type	Area	Length	Pass 1	Pass 2	yi	p	q	V(yi)	(yi-y)^2	m2	m
1	mixed	96	50	50	26	104.2	0.48	0.52	387.1	881	2	999
2	mixed	105	50	92	38	156.7	0.59	0.41	186.9	6766	1964	7087
3	mixed	122	49	128	43	192.8	0.66	0.34	99.2	13987	3927	14939
4	mixed	156	52	26	6	33.8	0.77	0.23	4.9	1655	17748	1736
5	mixed	68	52	130	17	149.6	0.87	0.13	4.4	5636	5957	5490
6	mixed	54	49	72	20	99.7	0.72	0.28	26.1	635	1763	817
7	mixed	26	51	78	0	78.0	1.00	0.00	0.0	12	2570	16
8	mixed	46	51	153	36	200.1	0.76	0.24	30.6	15773	22781	15893
9	mixed	123	49	58	16	80.1	0.72	0.28	20.5	31	2607	81
10	mixed	47	52	0	0	0.0	1.00	0.00	0.0	5548	2511	5694
11	mixed	48	53	0	0	0.0	1.00	0.00	0.0	5548	2608	5915
12	mixed	48	53	17	7	28.9	0.59	0.41	34.0	2078	492	2305
14	mixed	47	52	0	0	0.0	1.00	0.00	0.0	5548	2511	5694
15	mixed	48	53	2	0	2.0	1.00	0.00	0.0	5254	2408	5612
16	mixed	47	52	19	7	30.1	0.63	0.37	22.2	1972	401	2059
18	mixed	59	54	68	9	78.4	0.87	0.13	2.4	15	218	0
19	mixed	46	51	31	1	32.0	0.97	0.03	0.0	1802	293	1762

Table 17. Capture Statistics Table

Capture Statistics Table												
Crooked Creek		Dace										
36385												
									Regular capture statistics of p			
Reach	Habitat	Pooled Capture Statistics									+/-95%	CL%
strata	strata	p'	q'	V(p')	Ti'	xi'	V(xi')	n	avg	std dev	CL	of p
all reaches	mixed	0.76	0.24	0.000329	1150	1223	5384	19	0.80	0.17	0.08	10%
	Total				1150	1223						
p: Probability of capture.			Ti': Total number of fish captured.									
q: Probability of noncapture.			xi': Total number of fish estimated in sampled units.									
V: Variance.			n: number of sample units									

Table 18. Sample Size Tables

Sample Size Tables											
Crooked Creek			Dace								
	Habitat		Total habitat			Sampled habitat			Sample percent of total		
Reach	type	N	area	length		n	area	length	number	area	length
all reaches	mixed	137	9,759	6,971		19	1,183	873	13.9%	12.1%	12.5%
	Total	137	9,759	6,971		19	1,183	873	13.9%	12.1%	12.5%
N: Total number of habitat units.				Area in square meters							
n: Number of sampled units.				Length in meters.							
				Width in meters.							
	Habitat	Mean habitat unit area				Mean habitat unit length			Mean habitat unit width		
Reach	type	total	sample	% diff.		total	sample	% diff.	total	sample	% diff.
all reaches	mixed	71	70	1.4%		51	51	0.0%	1.4	1.35509737	3.2%
	Total	71	62	12.7%		51	46	9.8%	1	1.4	0.0%

Table 19. Selected Estimate and Method Table

Selected Estimate and Method Table				
Crooked Creek		Dace		
	Habitat		Selected	
	type	estimate	variance	method
all reaches	mixed	10,449	3,334,156	r #/m2
	Total	10,449	3,334,156	
p: Pooled capture method.				
r: Regular capture method.				
#/unit: Fish per habitat unit expansion method.				
#/m2: Fish per square meter expansion method.				
#/m: Fish per lineal meter expansion method.				

Table 20. Estimate Selection Tables

Estimate Selection Tables							
			Crooked Creek		Dace		
	all reaches	mixed					
	Choice of Method for Fish Population Estimation						
	1).....If	**10%**	< or =10%, then use Pooled Capture Method.				
	2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance.						
	3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P".						
		Pooled Capture Method			Regular Capture Method		
	Variance	#/unit	#/m2	#/m	#/unit	#/m2	#/m
Selected	1st Stage	3,440,305	3,328,269	3,579,384	3,440,305	3,328,269	3,579,384
Values	2nd Stage	38,731	38,731	38,731	5,886	5,886	5,886
3,334,156	Total	3,479,035	3,367,000	3,618,115	3,446,191	3,334,156	3,585,270
r #/m2							
10,449	Pop. Est.	8,798	10,092	9,770	9,110	10,449	10,116
	+/-95% CL	3,656	3,596	3,728	3,639	3,579	3,711
	% CL/Est.	42%	36%	38%	40%	34%	37%

Table 21. Results Table

Results Table									
Crooked Creek		Dace							
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of	Habitat	Reach		Habitat	Reach
	type	estimate	95% c.l.	estimate	type	average		type	average
all reaches	mixed	10,449	3,579	34%	1.0707			1.499	
	Total	10,449	3,579	34%	1.0707			1.499	

Appendix D.
Redside Shinner Statistical Tables

Table 22. Reach and Total Habitat Data Input Table

Reach and Total Habitat Data Input Table						
				Total habitat		
		Sample strata		number	area	length
		reach	habitat	of units	m2	m
Stream:	Crooked Creek	all reaches	mixed	136.6863	9759	6971
Species/age:	Redside Shinner					
Sample dates ("mm/dd/yy):						
Starting	8/13/99					
Ending	9/9/99					

Table 23. Electrofishing Data Tables

Electrofishing Data Tables												
all reaches	mixed		Crooked Creek				Redside Shinner					
		(m2)	(m)								(yi-rxi)^2	
Unit No.	Unit Type	Area	Length	Pass 1	Pass 2	yi	p	q	V(yi)	(yi-y)^2	m2	m
2		105	50	91	27	129.4	0.70	0.30	42.5	9373	5621	9558
4		156	52	16	3	19.7	0.81	0.19	1.5	166	3740	174
5	mixed	68	52	28	4	32.7	0.86	0.14	1.2	0	6	0
6	mixed	54	49	33	4	37.6	0.88	0.12	0.9	25	93	43
7	mixed	26	51	48	6	54.9	0.88	0.13	1.4	497	1734	511
8	mixed	46	51	0	0	0.0	1.00	0.00	0.0	1061	566	1041
9	mixed	123	49	6	2	9.0	0.67	0.33	4.5	556	2968	484
10	mixed	47	52	0	0	0.0	1.00	0.00	0.0	1061	588	1082
11	mixed	48	53	0	0	0.0	1.00	0.00	0.0	1061	611	1124
13	mixed	31	51	8	3	12.8	0.63	0.38	10.1	391	11	379
14	mixed	47	52	1	0	1.0	1.00	0.00	0.0	997	541	1017
15	mixed	48	53	7	0	7.0	1.00	0.00	0.0	654	314	703
16	mixed	47	52	41	8	50.9	0.80	0.20	4.4	337	712	326
17	mixed	57	52	72	11	85.0	0.85	0.15	3.8	2747	3063	2714
18		59	54	48	6	54.9	0.88	0.13	1.4	497	580	429
19	mixed	46	51	23	3	26.5	0.87	0.13	0.8	38	7	34

Table 24. Capture Statistics Table

Capture Statistics Table												
Crooked Creek		Redside Shinner										
									Regular capture statistics of p			
Reach	Habitat	Pooled Capture Statistics									+/-95%	CL%
strata	strata	p'	q'	V(p')	Ti'	xi'	V(xi')	n	avg	std dev	CL	of p
all reaches	mixed	0.82	0.18	0.000511	499	516	299	17	0.86	0.12	0.06	7%
	Total				499	516						
p: Probability of capture.			Ti': Total number of fish captured.									
q: Probability of noncapture.			xi': Total number of fish estimated in sampled units.									

Table 25. Sample Size Tables

Sample Size Tables											
Crooked Creek			Redside Shinner								
	Habitat		Total habitat			Sampled habitat			Sample percent of total		
Reach	type	N	area	length		n	area	length	number	area	length
all reaches	mixed	137	9,759	6,971		17	1,006	824	12.4%	10.3%	11.8%
	Total	137	9,759	6,971		17	1,006	824	12.4%	10.3%	11.8%
N: Total number of habitat units.				Area in square meters							
n: Number of sampled units.				Length in meters.							
				Width in meters.							
	Habitat	Mean habitat unit area				Mean habitat unit length			Mean habitat unit width		
Reach	type	total	sample	% diff.		total	sample	% diff.	total	sample	% diff.
all reaches	mixed	71	63	11.3%		51	52	-2.0%	1.4	1.22087379	12.8%
	Total	71	59	16.9%		51	48	5.9%	1	1.2	14.3%

Table 26. Selected Estimate and Method Table

Selected Estimate and Method Table				
Crooked Creek		Redside Shinner		36385
	Habitat		Selected	
	type	estimate	variance	method
all reaches	mixed	5,057	1,272,865	r #/m2
	Total	5,057	1,272,865	
p: Pooled capture method.				
r: Regular capture method.				
#/unit: Fish per habitat unit expansion method.				
#/m2: Fish per square meter expansion method.				
#/m: Fish per lineal meter expansion method.				

Table 27. Estimate Selection Tables

Estimate Selection Tables							
			Crooked Creek		Redside Shinner		
	all reaches	mixed					
	Choice of Method for Fish Population Estimation						
	1).....If	**7%**	< or =10%, then use Pooled Capture Method.				
	2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance.						
	3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P".						
		Pooled Capture Method			Regular Capture Method		
	Variance	#/unit	#/m2	#/m	#/unit	#/m2	#/m
Selected	1st Stage	1,170,406	1,272,282	1,179,848	1,170,406	1,272,282	1,179,848
Values	2nd Stage	2,401	2,401	2,401	584	584	584
1,272,865	Total	1,172,807	1,274,682	1,182,248	1,170,990	1,272,865	1,180,431
r #/m2							
5,057	Pop. Est.	4,149	5,007	4,365	4,191	5,057	4,409
	+/-95% CL	2,123	2,213	2,131	2,121	2,211	2,129
	% CL/Est.	51%	44%	49%	51%	44%	48%

Table 28. Results Table

Results Table									
Crooked Creek		Redside Shinner							
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of	Habitat	Reach		Habitat	Reach
	type	estimate	95% c.l.	estimate	type	average		type	average
all reaches	mixed	5,057	2,211	44%	0.5182			0.725	
	Total	5,057	2,211	44%	0.5182			0.725	

Appendix E.
Sucker Statistical Tables

Table 29. Reach and Total Habitat Data Input Table

Reach and Total Habitat Data Input Table						
				Total habitat		
		Sample strata		number	area	length
		reach	habitat	of units	m2	m
Stream:	Crooked Creek	all reaches	mixed	136.6863	9759	6971
Species/age:	Sucker					
Sample dates ("mm/dd/yy):						
Starting	8/13/99					
Ending	9/9/99					

Table 30. Electrofishing Data Tables

Electrofishing Data Tables												
all reaches	mixed		Crooked Creek		36385		Sucker					
		(m2)	(m)								(yi-rxi)^2	
Unit No.	Unit Type	Area	Length	Pass 1	Pass 2	yi	p	q	V(yi)	(yi-y)^2	m2	m
2	mixed	105	50	118	29	156.4	0.75	0.25	27.4	13710	8055	13995
4	mixed	156	52	17	5	24.1	0.71	0.29	7.7	233	5627	243
5	mixed	68	52	92	10	103.2	0.89	0.11	1.9	4078	3633	4038
6	mixed	54	49	46	8	55.7	0.83	0.17	3.5	266	460	335
7	mixed	26	51	57	7	65.0	0.88	0.12	1.6	656	2380	680
8	mixed	46	51	7	0	7.0	1.00	0.00	0.0	1047	491	1018
9	mixed	123	49	12	0	12.0	1.00	0.00	0.0	749	4332	644
10	mixed	47	52	2	0	2.0	1.00	0.00	0.0	1396	769	1419
11	mixed	48	53	5	1	6.3	0.80	0.20	0.6	1096	578	1169
12	mixed	48	53	16	3	19.7	0.81	0.19	1.5	387	113	430
13	mixed	31	51	2	1	4.0	0.50	0.50	12.0	1250	246	1219
		47	52	4	0	4.0	1.00	0.00	0.0	1250	662	1273
15	mixed	48	53	6	1	7.2	0.83	0.17	0.4	1034	534	1105
16		47	52	18	2	20.3	0.89	0.11	0.4	365	90	377
17	mixed	57	52	28	6	35.6	0.79	0.21	4.1	14	0	16
18	mixed	59	54	65	9	75.4	0.86	0.14	2.6	1302	1422	1173
19	mixed	46	51	67	4	71.3	0.94	0.06	0.3	1017	1772	1046

Table 31. Capture Statistics Table

Capture Statistics Table												
Crooked Creek		Sucker										
									Regular capture statistics of p			
Reach	Habitat	Pooled Capture Statistics									+/-95%	CL%
strata	strata	p'	q'	V(p')	Ti'	xi'	V(xi')	n	avg	std dev	CL	of p
all reaches	mixed	0.85	0.15	0.000314	648	664	244	17	0.85	0.12	0.06	7%
	Total				648	664						
p: Probability of capture.		Ti': Total number of fish captured.										
q: Probability of noncapture.		xi': Total number of fish estimated in sampled units										
V: Variance.												

Table 32. Sample Size Tables

Sample Size Tables											
Crooked Creek			Sucker				36385				
	Habitat		Total habitat			Sampled habitat			Sample percent of total		
Reach	type	N	area	length		n	area	length	number	area	length
all reaches	mixed	137	9,759	6,971		17	1,053	877	12.4%	10.8%	12.6%
	Total	137	9,759	6,971		17	1,053	877	12.4%	10.8%	12.6%
N: Total number of habitat units.				Area in square meters							
n: Number of sampled units.				Length in meters.							
				Width in meters.							
	Habitat	Mean habitat unit area				Mean habitat unit length			Mean habitat unit width		
Reach	type	total	sample	% diff.		total	sample	% diff.	total	sample	% diff.
all reaches	mixed	71	62	12.7%		51	52	-2.0%	1.4	1.20068415	14.2%
	Total	71	62	12.7%		51	52	-2.0%	1	1.2	14.3%

Table 33. Selected Estimate and Method Table

Selected Estimate and Method Table				
Crooked Creek		Sucker		
	Habitat		Selected	
	type	estimate	variance	method
all reaches	mixed	6,199	1,874,880	r #/m2
	Total	6,199	1,874,880	
p: Pooled capture method.				
r: Regular capture method.				
#/unit: Fish per habitat unit expansion method.				
#/m2: Fish per square meter expansion method.				
#/m: Fish per lineal meter expansion method.				

Table 34. Estimate Selection Tables

Estimate Selection Tables							
			Crooked Creek		Sucker		
	all reaches	mixed					
	Choice of Method for Fish Population Estimation						
	1).....If	**7%**	< or =10%, then use Pooled Capture Method.				
	2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance.						
	3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P".						
		Pooled Capture Method			Regular Capture Method		
	Variance	#/unit	#/m2	#/m	#/unit	#/m2	#/m
Selected	1st Stage	1,795,467	1,874,365	1,815,210	1,795,467	1,874,365	1,815,210
Values	2nd Stage	1,960	1,960	1,960	515	515	515
1,874,880	Total	1,797,427	1,876,325	1,817,170	1,795,982	1,874,880	1,815,725
r #/m2							
6,199	Pop. Est.	5,339	6,151	5,278	5,380	6,199	5,319
	+/-95% CL	2,628	2,685	2,642	2,627	2,684	2,641
	% CL/Est.	49%	44%	50%	49%	43%	50%

Table 35. Results Table

Results Table									
Crooked Creek		Sucker		36385-36412					
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of	Habitat	Reach		Habitat	Reach
	type	estimate	95% c.l.	estimate	type	average		type	average
all reaches	mixed	6,199	2,684	43%	0.6352			0.889	
	Total	6,199	2,684	43%	0.6352			0.889	

Appendix F.
Sculpin Statistical Tables

Table 36. Reach and Total Habitat Data Input Table

Reach and Total Habitat Data Input Table						
					Total habitat	
		Sample strata		number	area	length
		reach	habitat	of units	m2	m
Stream:	Crooked Creek	all reaches	mixed	136.6863	9759	6971
Species/age:	Sculpin					
Sample dates ("mm/dd/yy):						
Starting	8/13/99					
Ending	9/9/99					

Table 37. Electrofishing Data Tables

Electrofishing Data Tables												
all reaches	mixed		Crooked Creek				Sculpin					
		(m2)	(m)								(yi-rxi)^2	
Unit No.	Unit Type	Area	Length	Pass 1	Pass 2	yi	p	q	V(yi)	(yi-y)^2	m2	m
1	mixed	96	50	0	0	0.0	1.00	0.00	0.0	0	0	0
2	mixed	105	50	0	2	0.0	1.00	0.00	0.0	0	0	0
3	mixed	122	49	0	0	0.0	1.00	0.00	0.0	0	0	0
4	mixed	156	52	1	0	1.0	1.00	0.00	0.0	1	1	1
5	mixed	68	52	0	0	0.0	1.00	0.00	0.0	0	0	0
6	mixed	54	49	0	0	0.0	1.00	0.00	0.0	0	0	0
7	mixed	26	51	0	0	0.0	1.00	0.00	0.0	0	0	0
8	mixed	46	51	0	0	0.0	1.00	0.00	0.0	0	0	0
9	mixed	123	49	0	0	0.0	1.00	0.00	0.0	0	0	0
10	mixed	47	52	0	0	0.0	1.00	0.00	0.0	0	0	0
11	mixed	48	53	0	0	0.0	1.00	0.00	0.0	0	0	0
12	mixed	48	53	0	0	0.0	1.00	0.00	0.0	0	0	0
13	mixed	31	51	0	0	0.0	1.00	0.00	0.0	0	0	0
14	mixed	47	52	0	0	0.0	1.00	0.00	0.0	0	0	0
15	mixed	48	53	0	0	0.0	1.00	0.00	0.0	0	0	0
16	mixed	47	52	0	0	0.0	1.00	0.00	0.0	0	0	0
17	mixed	57	52	0	0	0.0	1.00	0.00	0.0	0	0	0
18	mixed	59	54	0	0	0.0	1.00	0.00	0.0	0	0	0
19	mixed	46	51	0	0	0.0	1.00	0.00	0.0	0	0	0

Table 38. Capture Statistics Table

Capture Statistics Table												
Crooked Creek		Sculpin										
									Regular capture statistics of p			
Reach	Habitat	Pooled Capture Statistics									+/-95%	CL%
strata	strata	p'	q'	V(p')	Ti'	xi'	V(xi')	n	avg	std dev	CL	of p
all reaches	mixed	-1.00	2.00	6.000000	3	-1	16	19	1.00	0.00	0.00	0%
	Total				3	-1						
p: Probability of capture.												
q: Probability of noncapture.			xi': Total number of fish estimated in sampled units.									
V: Variance.			n: number of sample units									

Table 39. Sample Size Tables

Sample Size Tables											
Crooked Creek			Sculpin								
	Habitat		Total habitat			Sampled habitat			Sample percent of total		
Reach	type	N	area	length		n	area	length	number	area	length
all reaches	mixed	137	9,759	6,971		19	1,271	976	13.9%	13.0%	14.0%
	Total	137	9,759	6,971		19	1,271	976	13.9%	13.0%	14.0%
N: Total number of habitat units.				Area in square meters							
n: Number of sampled units.				Length in meters.							
				Width in meters.							
	Habitat	Mean habitat unit area				Mean habitat unit length			Mean habitat unit width		
Reach	type	total	sample	% diff.		total	sample	% diff.	total	sample	% diff.
all reaches	mixed	71	67	5.6%		51	51	0.0%	1.4	1.3022541	7.0%
	Total	71	67	5.6%		51	51	0.0%	1	1.3	7.1%

Table 40. Selected Estimate and Method Table

Selected Estimate and Method Table				
Crooked Creek		Sculpin		
	Habitat		Selected	
	type	estimate	variance	method
all reaches	mixed	0	0	0
	Total	0	0	
p: Pooled capture method.				
r: Regular capture method.				
#/unit: Fish per habitat unit expansion method.				
#/m2: Fish per square meter expansion method.				
#/m: Fish per lineal meter expansion method.				

Table 41. Estimate Selection Tables

Estimate Selection Tables							
			Crooked Creek		Sculpin		
all reaches		mixed			36385		
Choice of Method for Fish Population Estimation							
1).....If		**0%**	< or =10%, then use Pooled Capture Method.				
2)..Select #/unit, #/m2, or #/m, with lowest 1st stage variance.							
3)..Place cursor on selected Pop. Est. shaded below and key "Ctrl P".							
		Pooled Capture Method			Regular Capture Method		
Variance		#/unit	#/m2	#/m	#/unit	#/m2	#/m
1st Stage		45	39	44	45	39	44
2nd Stage		115	115	115	0	0	0
Total		160	154	160	45	39	44
Pop. Est.		(7)	(8)	(7)	7	8	7
+/-95% CL		25	24	25	13	12	13
% CL/Est.		-357%	-300%	-357%	186%	150%	186%

Table 42. Results Table

Results Table									
Crooked Creek		Sculpin							
					Fish per square meter			Fish per lineal meter	
	Habitat	Population	+/-	CL % of	Habitat	Reach		Habitat	Reach
	type	estimate	95% c.l.	estimate	type	average		type	average
all reaches	mixed	0	0	#DIV/0!	0.0000			0.000	
	Total	0	0	#DIV/0!	0.0000			0.000	