MONTANA FISH, WILDLIFE AND PARKS

FISHERIES DIVISION
JOB PROGRESS REPORT

STATE: MONTANA PROJECT TITLE: STATE-WIDE FISHERIES **INVESTIGATIONS**

PROJECT NO.: F-78-R-1 STUDY TITLE: SURVEY AND INVENTORY OF COLDWATER **LAKES**

JOB NO.: _____ JOB TITLE: NORTHWEST MONTANA COLWATER LAKES INVESTIGATIONS

PROJECT PERIOD: JULY 1, 1995 THROUGH JUNE 30, 2000

ABSTRACT

We monitored the Flower-Pipe section of the Kootenai River after imposing the slot limit regulation and spawning closure from Libby Dam to Fisher River in 1994. Based on population estimates, it appears that the special regulations are working to increase both age III+ and older trout and the number of trout greater than 12 inches. Additionally, Redd counts from larger trout between Libby Dam and Fisher River increased substantially since 1992. What is important to note is that we were able to approach our goal of larger trout in an ever increasing angler use by discriminating against those who kept trout rather than discriminating against those who used different angling techniques. An important objective for the future will be to educated the angling public more about catch-and-release techniques using all methods of capture.

With the help of BPA funded special projects and Idaho Fish and Game Department, we implanted radio tags in 34 bull trout at Libby dam, nine outmigrant bull trout from Quartz Creek and eight outmigrant bull trout from O'Brien Creek (below Kootenai Falls). We located 15 bull trout implanted with transmitters that have remained above Kootenai Falls. Except for two of the fish, they have remained within 4 miles of Libby Dam. The other two moved 22 miles downstream and have remained for several months.
The other 17 bull trout crossed over Kootenai Falls and remained in the Kootenai River above Kootenay Lake. None of the 17 bull trout that crossed over Kootenai Falls have returned. We will continue to monitor these bull trout and try to determine why some stay above Kootenai Falls and some travel over the falls.

We evaluated movement, distribution and habitat selection by redband trout during spring and summer 1998. We determined to quantify redband trout spawning production and characterize habitat selection in Basin Creek, Montana, determine the role of temperature in spawning, egg incubation and emergence for redband trout, and describe the movement, distribution and habitat use by post-spawned adult redband trout in Basin Creek, Montana. Out survey revealed that redband trout selected spawning sites in low-gradient reaches. Stream gradient ranged from 0.5 to 1.5%. Spawning behavior (e.g. pairing and redd construction) coincided with a sharp decline in spring runoff and gradual increase in water temperature. Fish began to pair on June 2 when average daily water temperature was 42^{o} F (high = 44.1^{o} F, low = 41.6^{o} F) and stream discharge was approximately 130 ft^3/s. We observed redband trout building redds from June 13 through June 24. Our telemetry-based results suggest that redband trout in Basin Creek and East Fork Yaak River (above the barrier falls) may represent a metapopulation of redband trout that includes both resident and fluvial life history forms. Management considerations are discussed.

Background

The Kootenai River is on of Northwest Montana's popular rainbow trout angling streams. Regulation of flows and temperatures through a selective withdrawal system out of Libby Dam (constructed in 1972) made it fishable during most times of the year.

In the past 20 years, several events have changed the fishery and angling on the Kootenai River dramatically:

1) Kokanee salmon (*Oncorhynchus nerka*) were inadvertently released into Lake Koocanusa by British Columbia Ministry of Environment personnel from the Wardner Fish Hatchery between 1975 and 1979. Kokanee became well established in Lake Koocanusa and by 1997 sustained a 48,000 angler-day/year fishery. In addition, more than 1million kokanee (age 0+ to 2+) may be entrained through Libby dam each year. Most of these kokanee (79 percent) survive (Skaar et al. 1996). Kokanee are the main food source for a trophy rainbow trout fishery (up to 33 pounds) and important bull trout fishery as far as four miles downstream.

2) In 1993, the public perception was that angling success for trout on the Kootenai River was not as good as it could be and that the very large trout they had been catching within 4 miles of Libby Dam had declined. Anglers from all fishing groups agreed in principle with a management goal to increase the number of larger trout in the Kootenai River. There was general consensus that a restrictive slot limit could help to attain the goal. Favro et al. (1980) noted that it is important that the proposed slot limit be large enough that the fish targeted for protection don't grow beyond the protection too quickly.

   Part of the reason for imposing a slot limit for the Kootenai River rainbow population was to protect a portion of the "first time spawners" to improve recruitment to the river. We found that rainbow trout in the Kootenai River spawn for the first time at age III+ or IV+. Based on 13 years of electrofishing data we knew that the mean length of age III+ trout was 12.3 inches. Additionally we accomplished a creel survey on a section of the Kootenai River below Libby dam in 1989 and found that the percent of trout in the creel greater than 13 inches was much greater than the percent in the population (Figure A). We chose 13 inches as the lower limit of the slot. We also knew that there was an opportunity to catch larger trout (up to 30 pounds) in the Kootenai River. From trout age-growth information collected on the Kootenai River we found that if the upper limit of the slot was 18 inches we would protect and individual trout from 1 to 3 years depending on growth rates and migration class of the individual.

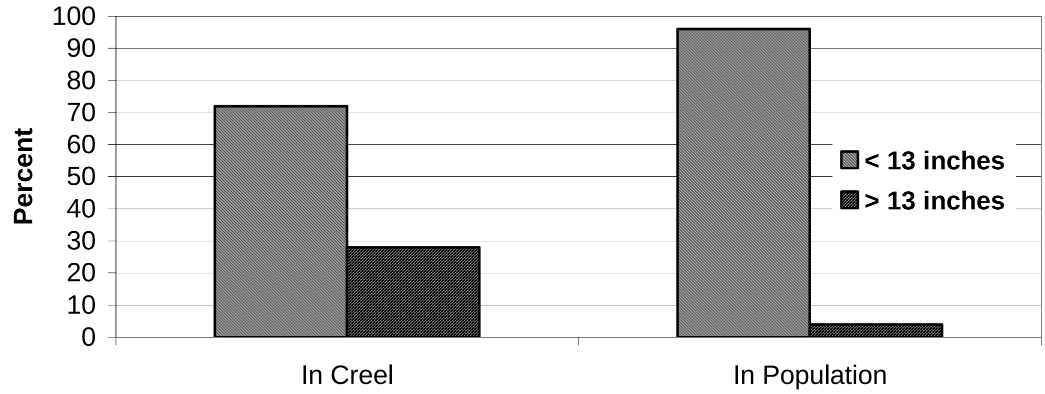

Figure A. Percent of rainbow trout estimated from creel and in the population from a survey conducted on the Kootenai River, Montana 1989.

The greatest point of contention with the regulation was whether or not bait fishing should be allowed. There are numerous studies and publications on comparisons of terminal gear types and bait caught versus artificial lure caught fish. Wydoski (1977) compiled previous studies accomplished for several trout species and found that bait fishing caused an average mortality of 25 percent (range 3.3 to 61.5 percent), artificial flies caused an average mortality of four percent (range 0 to 11.3 percent).

We knew that the most important problem with bait fishing was that at times it leads to deep hooking. Mortalities from deeply hooked (esophagus and gill area) have been shown to range from 35 percent to 89 percent (Hunsaker et al. 1970; Mason and Hunt 1967; Shetter and Allison 1955; Stringer 1967; Warner and Johnson 1978; and Warner1979). It is important to note that not all "bait caught" trout swallow the hook deeply. Several studies showed that between 45 and 68 percent of the fish caught are caught superficially, i.e. the roof of the mouth, tongue, and jaw (Stringer 1967; Warner and Johnson 1978; Hulbert and Engstrom-Heg 1980).

We felt that superficially caught trout are susceptible to similar or less probability to mortality than fly caught trout because in the Kootenai River, bait anglers tended to use stiffed rods and heavier line than fly anglers, hence, landed trout more quickly. Moreover, it was shown that mortality of deeply hooked fish can be decrease by almost 40 percent by cutting the leader near the hook rather than pulling the hook out (Schill 1991). Taylor and White (1992) also suggested that using barbless hooks could keep average mortality below 10 percent for "bait caught" trout. Hunt (1964) found that bait fishermen caught and released 40 percent of the stocks in Lawrence Creek without increasing total mortality of the population.

We also found that many of the larger rainbow trout (18 inches to >25 pounds) spawned at only two or three sites between Libby Dam and Fisher River (4 miles). Between 1982 and 1993, the number of rainbow trout redds counted in this area declined dramatically (Table A). From Warden observations, we found that anglers were concentrating on the areas where trout were spawning and surmised that there was some amount of poaching taking place.

Table A. Summary of rainbow trout spawning site inventories for the Kootenai River 1990 - 1999.

Year*	Number of Redds
1982	37
1987	61
1989	51
1990	11
1992	7
1993	15
1994	18
1995	32
1998	54
1999	94

* High flows obscured redds in 1996 and 1997.

By using this information and consensus building within the community, we determined that we would implement a limit of 3 trout less than 13 inches and one trout greater than 18 inches daily and in possession. Additionally, we closed a four-mile length of the Kootenai River between Libby dam and Fisher River to protect staging and spawning adult rainbow trout.

3) The Kootenai River population of white sturgeon (*Acipenser transmontanus*) was listed as endangered on September 6, 1994. The Recovery Plan for the Kootenai River White Sturgeon Population (USFWS 1999) includes provisions to “restore Kootenai River white sturgeon using flow augmentation”. The strategy changed flow regimes considerably since dam construction more closely resembled historic flow regimes (Figure B).

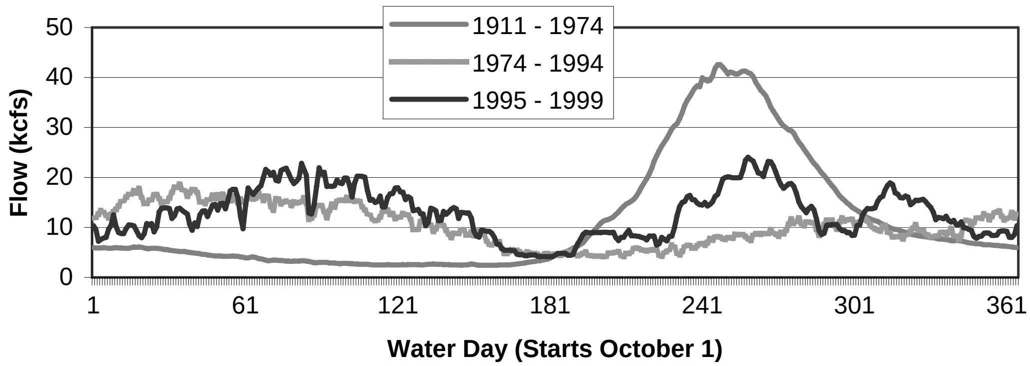

Figure B. Flows measured on Kootenai River, Montana 1911 – 1999.

Additionally, the strategy may include:

1) Producing variously formed peak flows created by dam operation during May through July when river temperatures at Bonners Ferry, Idaho are between 10 degrees Celsius and 14 degrees Celsius.

2) Adjusting the selective withdrawal system to “shape” water temperatures in the Kootenai River during spawning.

3) Considering the use of the spillway to “augment” flows at Bonners Ferry, Idaho. Water from the spillway falls 100 feet into a stilling basin approximately 60 feet deep. May (1973) noted that the dissolved gas saturation levels increased to over 140 percent and created lethal conditions from immediately below the dam to the Fisher River 3.5 miles down stream.

4) The listing of several Columbia River salmon species during the 1990’s. This led to the demand for flows from Libby Dam and others to augment spring salmon flows in the Columbia River. These flows peak to full powerhouse capacity in early August and end in early October (Figure B.)

5) The bull trout population of the Columbia River system was listed as threatened throughout its range. MFWP had already closed fishing for bull trout in 1994. The recovery plan for bull trout was not published at the time this report was written, although, if the recovery plan for Kootenai River white sturgeon is an example, it is safe to assume that additional demands on the Kootenai River and Libby Dam may occur.

6) In response to these concerns by Montana Fish, Wildlife and Parks (MFWP) and Kootenai National Forest (KNF), state and federal agencies classified redband trout as a sensitive species or a species of special concern. In 1994, the Kootenai River redband trout population in Montana was petitioned for listing as a threatened species under the Endangered Species Act. The petition was dismissed due to lack of information to classify them as a unique or separate species, although MFWP continued to classify the distribution of redband trout.

Kootenai River Special Regulation

Findings

Survey sampling for game fish began in 1971 on the Kootenai River and has continued in some form to the present. Four survey sections were established but the only section used for continuous population estimates was the Flower-Pipe section, a section between Flower Creek and Pipe Creek below the town of Libby, Montana.

We continued to monitor the Flower-Pipe section after imposing the slot limit regulation and spawning closure from Libby Dam to Fisher River in 1994. Based on population estimates, it appears that the special regulations are working to increase both age III+ and older trout and the number of trout greater than 12 inches (Tables B and C).

Table B. Population estimates per 1,000 feet for rainbow trout captured in the Kootenai River, Montana 1989 – 1999.

		Age					
Month	**Year**	**I+**	**II+**	**III+**	**IV+ and Older**	**Total**	**Greater than 12 inches**
September	1989	293	68	10	3	374	16
September	1990	279	80	13	0	372	13
August	1991	394	130	12	0	536	11
July	1993	250	171	13	3	437	18
August	1994	162	100	22	2	285	21
September	1995	303	256	43	5	607	36
October	1997	262	161	42	5	470	34
July	1999	226	183	54	7	470	31

Table C. Mean lengths by age class of rainbow trout captured in the Kootenai River, Montana 1989 – 1999.

Year	Average Length by Age Class (in inches)			
	I+	II+	III+	IV+
1989	3.0	8.5	11.4	14.0
1990	3.1	7.9	11.0	*
1991	2.9	7.3	12.1	*
1993	3.1	7.1	11.3	13.5
1995	3.1	7.1	11.3	12.9
1997	4.1	7.7	11.6	13.4
1999	4.1	8.2	11.8	14.7

* No trout greater than age III+ were caught in 1990 and 1991.

Additionally, Redd counts from larger trout between Libby Dam and Fisher River have increased substantially (Table A). What is important to note is that we were able to approach our goal of larger trout in an ever increasing use (Table D) by discriminating against those who kept trout rather than discriminating against those who used different angling techniques. An important objective for the future will be to educated the angling public more about catch-and-release techniques using all methods of capture. A more aggressive catch-and-release campaign may help to increase the density of larger trout further.

Table D. Angler use for Kootenai River, Montana 1991 – 1998.

Year	Total angler-days	Angler-days/mile
March 1991 – February 1992	26135	913.8
March 1993 – February 1994	30869	1079.3
March 1995 – February 1996*	19927	696.7
March 1997 – February 1998	42040	1470.0

* First year of Sturgeon flows and very high run-off year

Bull Trout Radio Telemetry Monitoring

Procedures

To monitor movements of bull trout in the Kootenai River and Koocanusa system, we surgically implanted radio tags into the fish. The tags and reception equipment we used were manufactured by Lotek Engineering Inc., New Market, Ontario. We chose transmitters at frequency 49 to 50 mega-hertz (Mhz) because the lower frequency penetrates deeper water than the higher frequency transmitters. Radio tags weighed 26.5 grams, length was 70 mm and antenna length was 350 mm. When practicable, we implanted radio tags in bull trout greater than 500 mm TL to ensure the weight of the radio tag did not exceed two percent of the weight of the bull trout.

We selected bull trout near the Libby Dam afterbay for surgery. We anesthetized each bull trout with tricane methane sulfonate (MS222) and placed it on its back in a v-shaped trough so that the gills remained irrigated but the incision site was dry. We made an incision in the abdominal cavity just long enough to receive the transmitter (approximately 2.5 cm), just anterior to the pelvic girdle and approximately 2 cm off the mid-ventral line.

We inserted a stainless steel spinal tap needle through the body cavity posterior to the incision near the pelvic girdle. We then threaded the antennae through the incision and needle, removed the needle and close the incision with three or four interrupted sutures. After surgery we kept the bull trout in a live car until the effects of the anesthesia sufficiently wore off (generally overnight) and released them in a backwater eddy near the capture site.

We used a radio telemetry receiver manufactured by Lotek Engineering inc., to record movement patterns of radio-tagged bull trout. We used fixed wing aircraft with antennae attached to both struts and mobile antennae in vehicles and boats. When a bull trout was located we entered the locations by 0.1 river mile.

Findings

With the help of BPA funded special projects and Idaho Fish and Game Department, we implanted radio tags in 34 bull trout at Libby dam, nine outmigrant bull trout from Quartz Creek and eight outmigrant bull trout from O'Brien Creek (below Kootenai Falls). These studies are on-going, therefore, we will present basic preliminary information for this report.

Of the 43 radio transmitters implanted in bull trout above Kootenai Falls at Libby Dam or as outmigrants from Quartz Creek, 11 were not located during the last attempt. These transmitters have not been located for various lengths of time (Table X.). We believe there are five possible reasons why we haven't located the eleven bull trout: 1) The battery for the transmitter died; 2) The transmitter malfunctioned; 3) The transmittered bull trout are in water too deep to receive a signal (approximately 40 feet); 4) The transmittered bull trout have crossed below Kootenai Falls to Kootenay Lake B.C. and cannot be located due to depth; 5) The transmittered bull trout were captured and the transmitter was destroyed.

We located 15 bull trout implanted with transmitters that have remained above Kootenai Falls. Except for two of the fish, they have remained within 4 miles of Libby Dam. The other two moved 22 miles downstream and have remained for several months.
The other 17 bull trout crossed over Kootenai Falls and remained in the Kootenai River above Kootenay Lake (Table X.). None of the 17 bull trout that crossed over Kootenai Falls have returned. Prior to damming of the Kootenai River, the mean peak flow was 45,000 cubic feet per second (Figure B), many years flow were greater (as high as 105,000 cfs). These flows occurred during June – July when bull trout in the Kootenai drainage stage near the mouths of spawning tributaries. It is possible that at higher flows, Kootenai Falls was not a barrier. Additionally, there was historic angling for and poaching of bull trout immediately below Kootenai Falls. The maximum flows currently out of Libby dam are 28,000 cfs.

We will continue to monitor these bull trout and try to determine why some stay above Kootenai Falls and some travel over the falls. We are currently monitoring flows out of Libby dam and water temperatures. In Summer 2000, USFWS proposes to increase flows at Bonners Ferry, Idaho by spilling out of the Libby dam spillway. We will, with the help of BPA funded special projects, implant 8 more transmitters in bull trout below the dam and monitor there reactions to increased flow and possibly elevated gas saturation levels caused by spilling.

Table X. Radio-tracking information for bull trout captured in Kootenai River drainage, Montana 1998 – 2000.

Tag Frequency	Species	Length	Weight	Date Tagged	Date of Last Location	Above or below Falls	Greatest distance moved since capture (miles)
49.055	DV	770	4270	05/07/1999	4/11/00	A	3.5
49.104	DV	761	6980	03/24/1999	1/12/00	A	0.5
49.114	DV	760		10/07/1999	3/15/00	A	22.3
49.124	DV	449	1078	03/24/1999	4/11/00	A	12.8
49.164	DV	823	6158	03/24/1999	4/11/00	A	4.3
49.184	DV	480	1362	03/24/1999	4/23/99	A	1.0
49.210	DV	615		09/28/1999	4/13/00	A	1.9
49.251	DV	620		09/28/1999	9/28/99	A	-
49.260	DV	698		09/28/1999	4/13/00	A	1.9
49.311	DV	529	1670	05/17/1999	5/17/99	A	-
49.350	DV	435	1164	03/24/1999	4/13/00	A	84.3
49.390	DV	431	1334	03/24/1999	4/11/00	A	0.75
49.520	DV	488	1390	02/22/1998	4/11/00	A	4.5
49.541	DV	493	1588	02/22/1998	4/11/00	A	0.5
49.551	DV	580	1688	02/22/1998	4/11/00	A	3.5
49.571	DV	492	1486	02/22/1998	4/11/00	A	1.3
49.600	DV	571	1936	01/28/1998	4/11/00	A	0.5
49.621	DV	645	2950	02/22/1998	8/25/99	A	30.6
49.641	DV	482	1340	01/28/1998	4/11/00	A	3.5
49.694	DV	782	6101	03/24/1999	4/11/00	A	1.6
49.710	DV	746	5079	03/12/1998	4/13/00	A	34.7
49.754	DV	818	6186	03/12/1998	7/23/99	A	2.4
49.034	DV	635		10/07/1999	4/13/00	B	82.2
49.084	DV	484	1362	03/24/1999	4/13/00	B	67.6
49.144	DV	430	1164	03/24/1999	4/13/00	B	28.3
49.174	DV	720		10/07/1999	4/13/00	B	62.9
49.221	DV	650		10/07/1999	4/13/00	B	9.2
49.231	DV	730	5130	02/22/1998	1/10/00	B	28.6
49.241	DV	815	7500	09/29/1999	4/13/00	B	62.7
49.270	DV	650	2280	10/09/1998	10/9/99	B	-
49.271	DV	740		10/07/1999	4/13/00	B	63.9
49.330	DV	700	2950	05/18/1999	4/13/00	B	52.8
49.338	DV	595	4058	03/24/1999	4/13/00	B	39.9
49.581	DV	587	2682	02/22/1998	1/10/00	B	34.9
49.590	DV	649	2469	03/12/1998	4/13/00	B	15.7
49.650	DV	603	2506	01/28/1998	3/27/00	B	34.1
49.660	DV	622	3161	02/22/1998	4/13/00	B	28.6
49.681	DV	552	1988	02/22/1998	5/6/99	B	15.6
49.740	DV	446	1088	02/22/1998	4/13/00	B	30.3
49.770	DV	694	4341	03/12/1998	4/13/00	B	29.7

Introduction

The redband trout of the Columbia River basin (*Oncorhynchus mykiss gairdneri)* are a subspecies of the rainbow trout evolutionary line (*Oncorhynchus mykiss*) and is native to the Fraser and Columbia River drainages east of the Cascade Mountains to barrier falls on the Pend Oreille, Spokane, Snake and Kootenai rivers (Allendorf et al. 1980; Behnke 1992). A complex combination of anthropogenic influences (logging, mining, agriculture, grazing, dams), hybridization, and competition with non-native fishes have contributed to the decline of redband trout abundance, distribution and genetic diversity in the Columbia River basin (Williams et al. 1989; Behnke 1992). Consequently, many redband trout populations are restricted to headwater streams.

Redband trout in the Kootenai River drainage represent the furthest inland penetration of native rainbow trout in the Columbia River drainage. Based on genetic analysis, we have identified populations of redband trout in Callahan Creek, East Fork Yaak River and its tributaries, Yaak River (below Yaak Falls), North Fork Yaak River and tributaries to Libby Creek and Fisher River, all in the Kootenai River drainage (Allendorf et al. 1980; Leary et al. 1991; Huston 1995; Hensler et al. 1996). Results from genetic surveys indicate that redband trout may have been native to low-gradient valley-bottom streams throughout the Kootenai River drainage; currently they appear to be restricted to headwater areas. Allendorf et al. (1980) concluded that redband trout are native rainbow trout in the Kootenai River, Montana, and that "…planting of hatchery rainbow trout has created a situation of tremendous genetic divergence (hybridization) among local populations".

Montana Fish, Wildlife and Parks (MFWP) and Kootenai National Forest (KNF) raised concerns that the Kootenai River Basin redband trout population was at risk of extinction due to habitat fragmentation, stream habitat degradation, competition with non-native species, and hybridization with non-native rainbow trout (Perkinson 1993; Hensler et al. 1996). In response to these concerns, state and federal agencies classified redband trout as a sensitive species or a species of special concern. In 1994, the Kootenai River redband trout population in Montana was petitioned for listing as a threatened species under the Endangered Species Act. The petition was dismissed due to lack of information to classify them as a unique or separate species.

No information exists concerning the spawning requirements of isolated populations of redband trout in the upper Columbia River Basin in Montana. Identification of the temporal and spatial distribution of redband trout during spawning will help provide watershed managers with appropriate information to develop biologically sound and effective conservation strategies. These strategies might be used to improve and protect critical habitat.

In this study, we evaluated movement, distribution and habitat selection by redband trout during spring and summer 1998. Additionally, a portion of this project is part of a larger statewide study to "…Determine the spawning life history of this strain of rainbow trout [redband trout] with emphasis on spatial and thermal requirement. Determine if this strain has either some life history attributes or WD (whirling disease) resistance which may be utilized in solutions to whirling disease in other Montana streams where rainbow trout are present" (MFWP, unpublished 1999). The objectives of this study were to (1) quantify redband trout spawning production and characterize habitat selection in Basin Creek, Montana; (2) determine the role of temperature in spawning, egg incubation and emergence for redband trout; (3) describe the movement, distribution and habitat use by post-spawned adult redband trout in Basin Creek, Montana.

Study Area

Basin Creek originates in the north slopes of the Purcell Mountains and flows south to north approximately 29.5 km to the confluence with East Fork of the Yaak River, approximately 45 km east of Yaak, Montana. This drainage includes East Fork Yaak River, Basin Creek, West Fork Basin Creek, mainstem Basin Creek and Porcupine Creek (Figure 1). The drainage mostly flows through national forest (Kootenai National Forest) and a privately owned parcel along mainstem Basin Creek. Annual precipitation ranges from 63.5 cm to 142 cm (U.S. Forest Service, Three Rivers Ranger District, Troy, MT; unpublished data). Elevation ranges from 976 m at the confluence of East Fork Yaak River to 2,095 m at the Purcell Divide.

The underlying bedrock is mostly from the Precambrian sediments of the Belt Supergroup (U.S. Forest Service, Three Rivers Ranger District, Troy, MT; unpublished data). The soil material is derived from alpine and continental glaciation, glacio-fluvial deposits, and residual material (U.S. Forest Service, Three Rivers Ranger District, Troy, MT; unpublished data). Most of this drainage supports mixed conifer stands dominated by western larch, Douglas fir, lodgepole pine and ponderosa pine. The drainage has been intensively managed for timber production.

Redband trout are the only trout species found in the Basin Creek drainage (Muhlfeld, 1999). We identified a barrier falls approximately 3.6 km upstream from the confluence with the North Fork Yaak River. We suspect this barrier is an isolating mechanism that prevents genetic exchange with other trout in the Yaak River system.

Methods

Spawning and Incubation Surveys

We conducted spawning surveys in mainstem Basin Creek to quantify redband trout spawning production and characterize redd site habitat selection during May and June 1998 (Figure 1). One or two observers walked along the streambank, mapping fish locations and redd sites one to three times per week. To quantify the

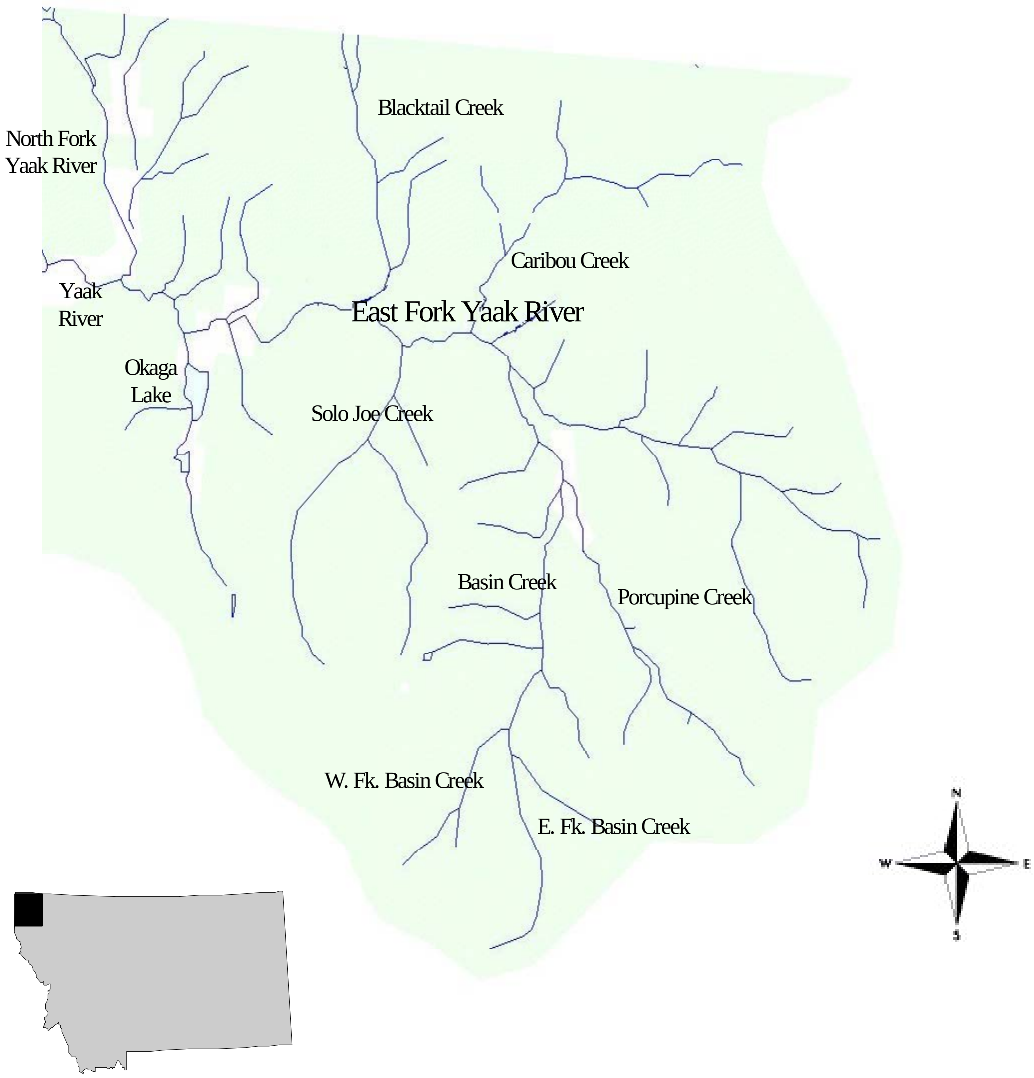

Figure 1. Study area of East Fork Yaak River drainage, Montana.

physical characteristics at each redd site we recorded the length (m), width (m), total depth (m), mean water column velocity (m/s), and substrate composition. We measured physical characteristics (length, width and depth) with a meter stick (to the nearest 0.01 m) and measured velocity with a Swoffer model 2100 electronic flowmeter attached to a wading rod. We used a modified Wentworth scale to determine a weighted substrate score for each redd (Table 1).

Table 1. Rankings for substrate types used for scoring redd material.

Rank	Substrate Diameter	Description
1	Less than 0.2 cm	Sand-silt
2	0.2 cm – 0.6 cm	Small gravel
3	0.6 cm – 7.5 cm	Large gravel
4	7.5 cm – 30.0 cm	Cobble
5	30.0 cm – 60.0 cm	Small boulder
6	Greater than 60.0 cm	Large boulder
7		Bed rock

Habitat units that spanned the entire channel width were classified either as pool, riffle, run or channel braid (Bisson et al. 1982). We recorded hourly temperatures with Orion Hobo and Tidbit temperature data loggers in mainstem Basin Creek, Porcupine Creek and East Fork Yaak River during the study period. We measured stream discharge at the USGS station on mainstem Basin Creek.

To quantify habitat availability throughout the spawning reach, we used a systematic transect survey. We defined the spawning reach as the furthest redd site found upstream of the confluence of East Fork Yaak River and Basin Creek to the mouth of Porcupine Creek. We established transects perpendicular to the stream at 50 m intervals throughout the section of stream beginning with a random start point and measured physical characteristics (depth, mean velocity and dominant substrate type) at 10 equally spaced locations across each transect.

We used Mann-Whitney U tests to determine if physical characteristics of depth and velocity used by redband trout for redd sites were significantly different than random availability (Zar 1996). To assess if trout used substrate in proportion to its availability we used a chi-square goodness of fit test (Neu et al. 1971) and considered significance at the $P<0.05$ level for all statistical analyses.

As part of the spawning survey we noted fry emergence times in Basin Creek. We captured and manually spawned redband trout (four females, five males) from Porcupine Creek (Figure 1). From the crosses we fertilized approximately 400 eggs. We transported the eggs to the MFWP whirling disease facility in Pony, Montana. We used incubation, hatching and yolk sac absorption times in daily temperature units (equal to one degree Fahrenheit {^{o}F} above 32 ^{o}F for a 24-hour period [Piper et al. 1982]) to estimate incubation and hatching times for trout in Basin Creek.

Telemetry Project

We used radio telemetry to monitor movement and habitat use by post-spawned redband trout in Basin Creek. We captured seven post-spawn adult fish by hook and line; 4 (mean total length = 224 mm, range 228-285 mm) on 17 June and 3 (mean total length = 253, range: 245-299 mm) between 19 June 19 and 26 June (Table 4). For the original study, we monitored redband trout movement from 22 June to 24 September, 1998 and additional movement in winter and spring 1999.

We anesthetized each fish with a 400mg/L solution of MS-222 then placed it in a padded V-shaped trough and irrigated its gills with a 200 mg/l solution of MS-222 during surgery. We made an incision immediately anterior of the pelvic girdle and to the side (3 mm) of the mid-ventral line (Young, 1995), inserted a sterilized transmitter into the body cavity and extended the whip antenna through the side of the body wall. Finally, we closed each incision with two to three sutures.

To ensure proper recovery, prior to their release we placed post-surgery fish in live traps along the stream margin for approximately 12 hours (Winter 1983). Transmitters weighed 7.0 g in air and had a predicted life expectancy of 1 year (Advanced Telemetry Systems [ATI], Isante, Minn., model 10-28). Each tag emitted a unique frequency (56 pulses/minute) in the range of 48.131- 48.260 MHZ for 112 hours (7 days on/16 hours on/8 hours off and 7 days off) to maximize the longevity of the tag.

Large redband trout ($\geq$200g) were difficult to capture during June, 1998. Consequently, some transmitters exceeded the recommended 2% transmitter to body weight ratio as suggested by Winter (1983). However, we felt that it was unlikely that swimming performance was substantially altered. Brown et al. (in-press) demonstrated that swimming performance of interperitonealy implanted juvenile rainbow trout was not significantly altered by the presence of the tag or the effects of the operation even though the transmitter comprised 6-12% of the fish's weight. The authors suggested that the 'two percent rule' could be replaced by an index that incorporates the weight of the transmitter in water and volume of the tag.

We tracked fish during the daytime with a Lotek (model SRX 400) scanning receiver equipped with an ATS loop antenna. We started at vehicle access points along the stream. Once we detected a signal we walked along the stream bank and replaced the loop antenna with a stripped coaxial cable antenna to obtain more accurate locations. We found that our accuracy was within 1 m of the transmitter. Therefore, we assumed the habitat used was within a 1 m^2 area of the identified location. Additionally, we used fixed wing aerial telemetry to survey remote and inaccessible areas throughout the East Fork Yaak River drainage.

We obtained primary habitat data (i.e. habitat units which spanned the entire channel) at each fish location and classified habitat as a pool, riffle, run, or channel braid (Bisson et al. 1982). To quantify individual fish movements we measured the distance from the previous location to the new location along the stream bank with a measuring tape or from stream survey information collected during July 1998 (Muhlfeld 1999). We determined that individual movement was the linear distance moved between locations and total movement was the sum of all movements for the duration of the study.

Results and Discussion

Spawning Surveys

Our survey in mainstem Basin Creek during May and June 1998 revealed that redband trout selected spawning sites in low-gradient reaches downstream from the mouth of Porcupine Creek to approximately 1,875 m upstream of the confluence of Basin Creek and East Fork Yaak River (Figure 1). Total length of the spawning section was approximately 1,475 m. Stream gradient ranged from 0.5 to 1.5%. Mean daily stream temperatures ranged from 37^{o} - 46.5^{o} F during May and June (Figure 2). Stream discharge declined from 132 ft^3/s on May 2 to 48 ft^3/s on June 27 (Figure 3). We did not collect discharge measurements from May 7 - June 1, although a flood event that exceeded bank full width occurred from May 10-12; discharge was approximately 310 ft^3/s.

Spawning behavior (e.g. pairing and redd construction) coincided with a sharp decline in spring runoff and gradual increase in water temperature (Figure 3). Fish began to pair on June 2 when average daily water temperature was 42^{o} F (high = 44.1^{o} F, low = 41.6^{o} F) and stream discharge was approximately 130 ft^3/s (Figure 2). We observed redband trout building redds from June 13 through June 24 (Figure 2). During the redd construction period stream discharge generally declined and ranged between 70- 58 ft^3/s and mean water temperatures ranged from 44^{o} F- 46^{o} F (hi = 48.0, low = 41.6).

We identified 30 redds in Basin Creek during June 1998 (Table 2). For each of three variables (depth, velocity, substrate) we obtained 230 random habitat availability measurements (Table 2). Mean total depth (m) of redds was 0.28 (range: 0.20-0.46), mean water column velocity (m/s) at redds was 0.50 (range: 0.23-0.69) and mean substrate score was 2.1 (range: 1.95-2.25; Table 2).

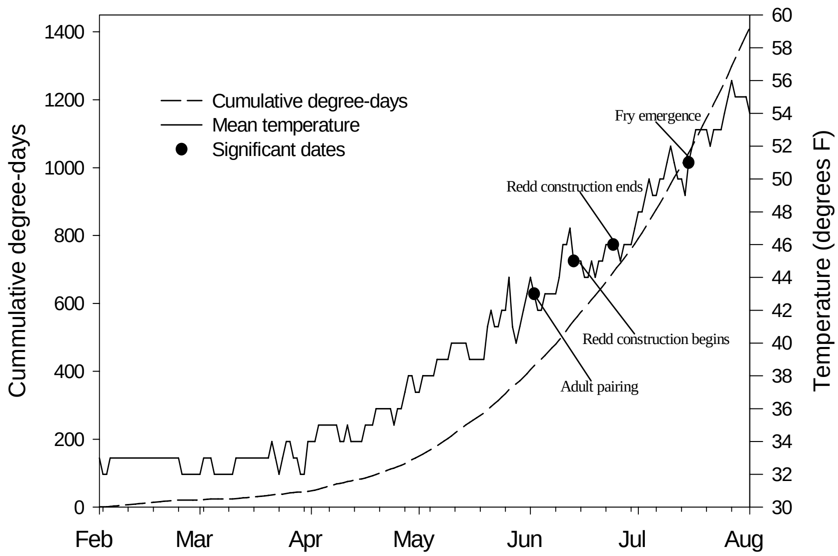

Figure 2. Cumulative degree-days and mean temperature associated with major spawning events

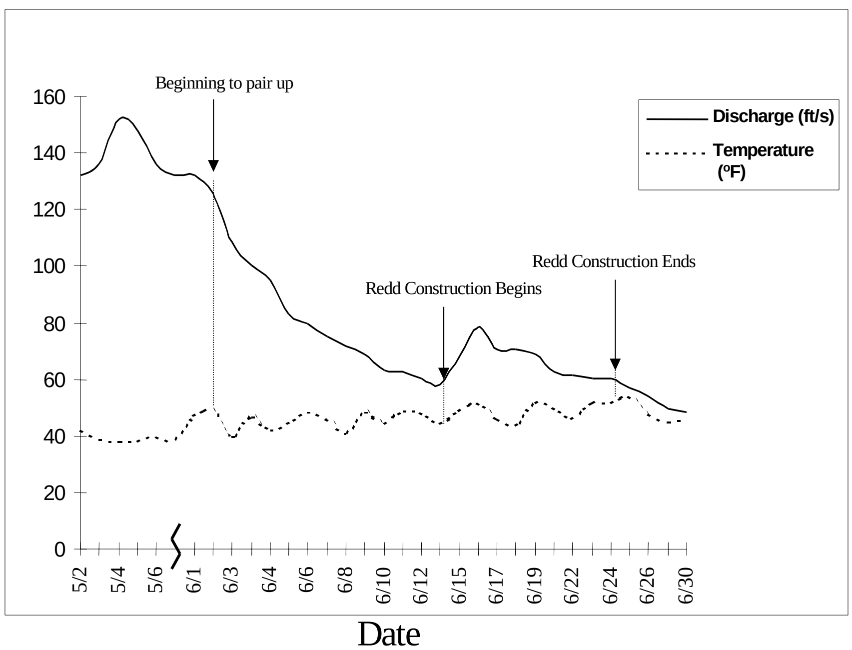

Figure 3. Temperature (ºF) and stream discharge (ft^3/s) as related to the timing of spawning by redband trout during spring (May-June) in Basin Creek, Montana 1998.

Redband trout used significantly shallower water for redd sites than the mean depths available (Z= 2.89, P = 0.004). This indicated that redband trout selected spawning locations in lateral areas of the channel and pool tail-outs. We found 24 redds in pools (all in the tail-out section), four in runs (usually on a gravel bar or on the inside bend), one in a small channel braid, and one in a riffle. Redband trout used significantly different substrate than the mean available substrate (P < 0.05) and

Table 2. Descriptive statistics for spawning habitat characteristics available to and used by redband trout in Basin Creek, Montana during spring 1998.

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max	Z or X^2	P-value
Depth	*Use*	30	.2763	7.125E-02	1.301E-02	.2497	.3029	.20	.46		
	Available	230	.3788	.1968	1.297E-02	.3533	.4044	.05	1.07		
	Total	260	.3670	.1894	1.175E-02	.3439	.3901	.05	1.07	2.89	.004
Velocity	*Use*	28	.5018	.1140	2.155E-02	.4576	.5460	.23	.69		
	Available	230	.5187	.3401	2.243E-02	.4745	.5629	.00	1.65		
	Total	258	.5169	.3232	2.012E-02	.4772	.5565	.00	1.65	0.23	.819
Substrate	*Use*	30	2.0667	7.581E-02	1.384E-02	2.0384	2.0950	1.95	2.25	9.5	<0.05
	Available	230	2.6609	1.0397	6.856E-02	2.5258	2.7960	1.00	5.00		
	Total	260	2.5923	.9963	6.179E-02	2.4706	2.7140	1.00	5.00		

selected redd sites dominated by gravel substrate (Table 2; Figure 4). There was no significant difference between use of mean water column velocities and random velocities (Z = 0.23, P = 0.82). This indicates that redband trout built redds in areas where water velocity was close to the mean velocity, probably to maintain optimal positions in moderate to shallow water (0.2-0.45 m) dominated by gravel substrate.

Redd site selection in Basin Creek appears to depend on a combination of abiotic and biotic factors. Redband trout generally selected redd sites in shallow pool tail-out areas with moderate water velocities dominated by gravel substrates. Water temperature, dissolved oxygen, water velocity and gravel permeability are critical factors necessary for successful incubation of rainbow trout embryos (Raleigh et al. 1984). Redband trout selected shallow pool tail-out areas for spawning that were likely areas of upwelling. These areas of upwelling aid in embryo development by removing waste products and providing adequate dissolved oxygen.

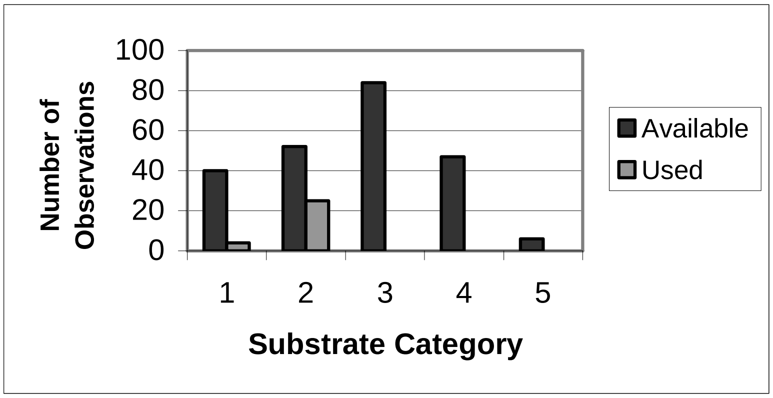

Figure 4. Number of observations in each substrate category used for redd sites and available to redband trout in the mainstem Basin Creek during June 1998.

Redband trout likely selected gravel spawning substrate that was proportional to body size. Redband trout that spawned in mainstem Basin Creek were 15-30 cm in total length and strongly selected gravel dominated substrate. Raleigh et al. (1984) reported that rainbow trout <50 cm select substrate from 1.5 to 6.0 cm in diameter.

Suitable spawning habitat in mainstem Basin Creek appears to be associated with low-gradient (<1.5%) stream reaches that contain abundant pools dominated by gravel substrate. Other studies have shown a positive correlation between density of trout and abundance of spawning gravel in low-gradient streams (Lanka et al. 1987; Bozek and Rahel 1991). Muhlfeld (1999) found the highest densities of redband trout in Basin Creek and Callahan Creek, Montana were in low-gradient stream reaches with abundant pools. Low-gradient reaches with abundant pools may provide areas of extensive cover, low-velocities and complex water depths, and may also provide optimal spawning habitat for redband trout production and distribution.

We sent 400 redband trout eggs to the whirling disease testing facility in Pony, Montana to analyze egg development stages. We compared those developmental stages to egg development from strains of rainbow trout used in the MFWP hatchery system and found in the wild (Dick Vincent and Grant Grisak MFWP, unpublished 1999). The developmental stages for redband trout were considerably more advanced than the rainbow strains (Table 3). This could be important for resistance to whirling disease. Development of redband fry to at least partial ossification of cartilaginous structures might occur before *Myxobolus cerebralis* becomes infectious (Dick Vincent, personal communication). If this occurs, redband trout may be more resistant to *Myxobolus cerebralis* than rainbow trout currently in the MFWP hatchery system or wild progeny of the coastal rainbow trout heritage.

Table 3. Developmental degree-day data for several trout species/strains.

Species/Strain	Time to Eye Stage	Eye stage to hatching	Hatching to Yolk Sac Absorption [3]	Total Degree-Days
DeSmet Rainbow Trout	360	280	120	760
Eagle Lake Rainbow Trout	360	280	120	760
Little Prickly Pear Creek trout	320	325	120	765
Gallatin River II Rainbow Trout	304	323	120	747
Firehole River Rainbow Trout	383	256	120	759
Hell Roaring Creek Rainbow Trout	361	249	120	730
Gallatin River III Rainbow Trout	361	249	120	730
Boulder River Rainbow Trout	323	286	120	729
Gallatin River I Rainbow Trout	302	306	120	728
Freeland Creek Rainbow Trout	305	287	120	712
Kootenai Creek Rainbow Trout	339	230	120	689
Redband trout (Lab)	306	198	120	624
Westslope Cutthroat Trout[1]		310	110-150	420-460
Redband trout (Basin Creek)[2]				351-507

[1] From Smith et.al., 1983.
[2] We assumed yolk sac absorption and emergence occurred simultaneously.
[3] Yolk sac absorption was estimated.

We first observed fry in the spawning reach on 15 July. It took 351 to 507 degree-days for fertilized eggs to develop to fry and fry to emerge from the gravel. Number of degree-days to yolk sac absorption (what we considered emergence) for redband trout eggs sent to the whirling disease station in Pony, Montana was approximately 624 degree-days. This was a considerable discrepancy but not unexpected; bull trout egg development compared between hatchery and wild conditions yielded similar results (Tom Weaver MFWP, personal communication).

Embryonic development of trout is affected by water temperature, concentrations of dissolved oxygen and type of streambed material. Fluctuating water temperatures in the wild setting may cause considerably different (apparently earlier) incubation times and emergence times than the constant temperatures typically found in labs or hatcheries. Nevertheless, the timing of egg development for redband trout was much more similar to westslope cutthroat trout than the rainbow trout strains derived from coastal stocks. Management implications include using redband trout to refound populations affected by ***Myxobolus cerebralis*** and whirling disease. Because of the dramatic differences in incubation timing between hatchery and wild trout, it is imperative that we design further research around timing of wild trout spawning and development of eggs in streams.

Telemetry Study

We tracked five of the seven radio tagged redband trout through 6 May, 1999 (Table 4). Of the seven implanted trout, we lost two to mortality by September. An angler harvested fish #161 in early September and we found fish #171 dead on the stream bank two weeks after release. We removed both fish from the analysis.

All six redband trout were quite mobile during the spring to fall study period (Table 4, Figures 5-6). Five redband trout displayed distinct downstream migrations to other habitat units (mean total movement per fish = 4199 m, range = 1502- 6330 m) and one fish displayed small upstream and downstream migrations from its release location (mean movement = 301 m, range: 5-1031 m).

Table 4. Summary of radio-tagged redband trout monitored in Basin Creek during spring 1998.

Transmitter Frequency	Length (mm)	Weight (g)	Release Date	Date of last location	Total Distance Moved (m)	Number of Relocations	Number of Movements	Final Location
48.131	285	198	6/17/98	5/6/99	1507	8	4	Basin Creek
48.161	230	100	6/17/98	7/21/98	2029	4	4	Harvested. 9/1
48.171	234	100	6/17/98	7/1/98	18	3	1	Found dead 7/21
48.181	228	90	6/17/98	5/6/99	1502	7	3	Basin Creek
48.260	245	112	6/19/98	5/6/99	5110	7	3	East Fork Yaak
48.151	255	124	6/21/98	5/6/99	6025	7	6	East Fork Yaak
48.111	299	180	6/26/98	5/6/99	6330	4	3	East Fork Yaak

Results from the radio-tracking portion of the study indicate that there is a migratory component to the population of redband trout in the upper East Fork Yaak River and Basin Creek drainages (Figure 5). Three of the five downstream migrants displayed long migrations (mean total movement per fish = 5,822 m, range = 5110- 6330 m) from Basin Creek to East Fork Yaak River (above the barrier falls) in early July after spawning was completed and remained through May 5, 1999 (Figure 5). Two fish did not leave Basin Creek, but migrated downstream to lower Basin Creek near the confluence of Basin Creek and East Fork Yaak River (Figure 6).

Our telemetry-based results suggest that redband trout in Basin Creek and East Fork Yaak River (above the barrier falls) may represent a metapopulation of redband trout that includes both resident and fluvial life history forms. Fluvial stocks are known to occupy larger rivers (i.e. East Fork Yaak R.) and spawn in smaller tributaries (i.e. Basin Creek). However, differentiation of redband trout life history forms (anadromous, adfluvial, fluvial, and resident) is difficult using meristic characteristics, coloration patterns, and genetic markers (Behnke 1992).

Prior to this project we could not use morphologic or genetic characteristics to identify life history forms of Columbia River redband trout. We had to delineate distribution of redband trout only to streams that were free of introgressing species. For example, genetic surveys indicate that the Basin Creek contains no contaminating species whereas East Fork Yaak River has minor genetic introgression and may not considered an redband trout population (Leary et al. 1991). Radio tracking appears to be the only sampling strategy to identify critical adult life history components within this metapopulation framework.

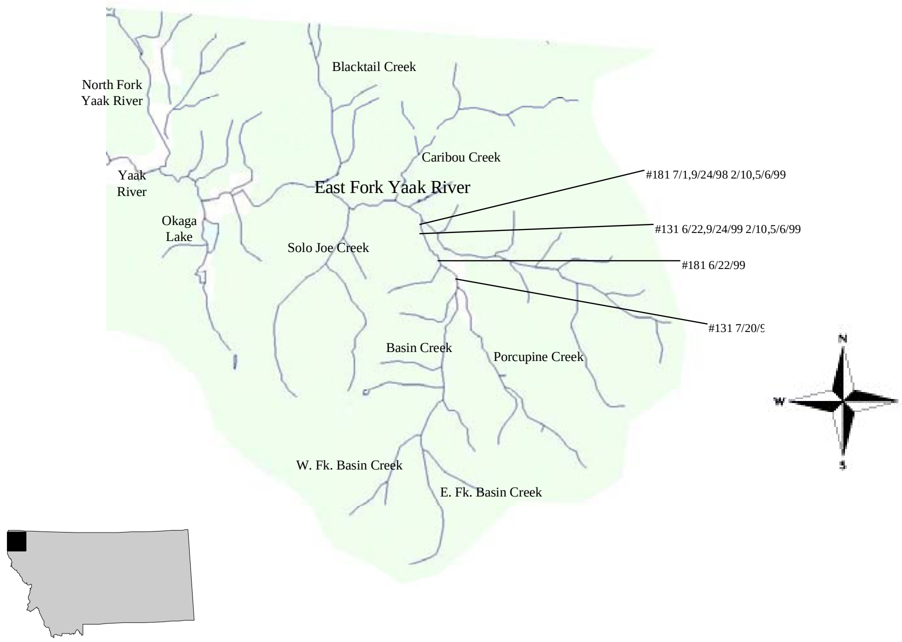

Figure 6. Locations and relocation dates for 2 radio tagged inland rainbow trout in Basin Creek, Montana, 1998-1999.

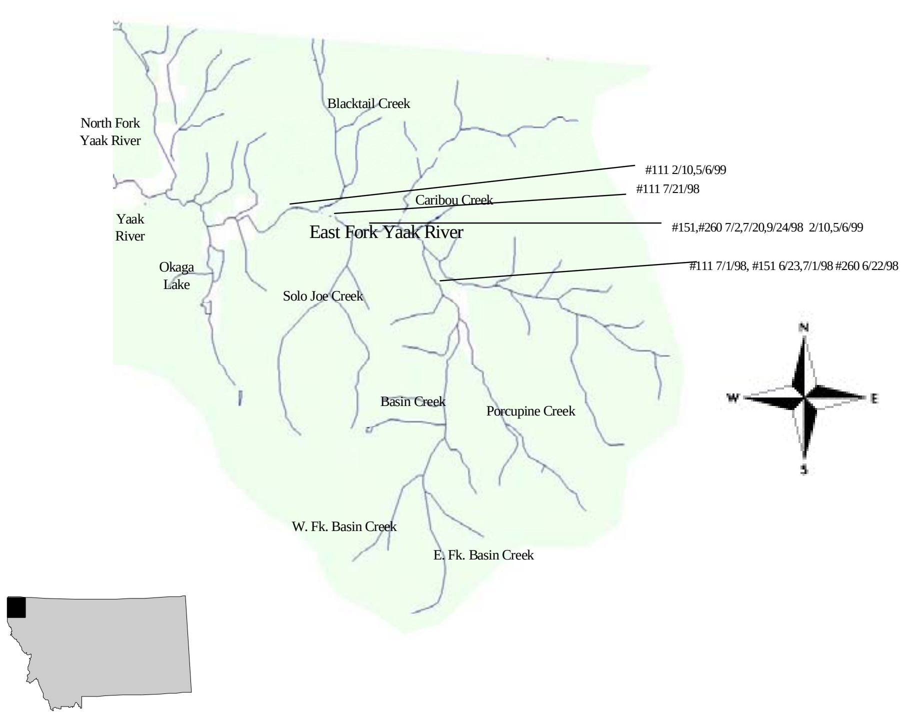

Figure 5. Locations and relocation dates for 3 radio tagged inland rainbow trout in Basin Creek, Montana, 1998-1999.

Our telemetry work also suggested that redband trout used pools more than other habitat types. A total of 21 (81%) of relocations were in pools, 3 (12%) in runs, and 2 (8%) in riffles. In addition, all fish that migrated downstream to East Fork Yaak River after spawning in Basin Creek were consistently relocated (e.g. sedentary) in the same large-deep pools through September and into May, 1999. Trout are known to select pool habitats because they are relatively deep, have low water velocities and contain quality cover.

Results from the telemetry-based study should be viewed with some caution because of our small sample size (Winter 1983). Future researchers should consider increasing the number of individuals concurrently tagged to obtain a more representative sample of the population. Additionally, the life history and migration patterns of juvenile redband trout in this system needs further study. Nonetheless, our study demonstrated that there likely is a fluvial component to the East Fork Yaak River/Basin Creek population of redband trout.

Management considerations

The probability that a local population will persist over time is a function of both habitat quality and proximity to other populations of the same species (Rieman and McIntyre 1995). Maintaining stream connectivity and habitat quality in East Fork Yaak River will likely decrease the probability of a localized extirpation due to catastrophic events, stream habitat degradation, or the threat of genetic introgression. Results from this study suggest that mainstem Basin Creek is an important spawning area for redband trout from East Fork Yaak River and Basin Creek. Verification of a fluvial life-history form of redband trout has never been documented within this geographic area. A fluvial form may be the key component to the persistence of this isolated metapopulation. By determining resident times of juvenile redband trout in Basin Creek, we can more fully verify the existence of the fluvial life history.

Supplementation efforts for westslope cutthroat trout within the historic range of redband trout are being considered by MFWP. However introductions of species to any aquatic habitat requires many considerations because species interactions are complex and difficult to predict (Li and Moyle 1981). Stocking of exotic salmonids (including westslope cutthroat trout) in adjacent drainages may pose a threat to the genetic purity and population persistence of this subspecies (Allendorf et al. 1980). We need more information to determine the historic range of this species in Montana and a quality source for potential re-founding of redband trout.

Redband trout in East Fork Yaak River are isolated from downstream hybridized and non-native populations. The natural barrier near Okaga Lake has kept this population free from introgression. Consequently, the East Fork Yaak population is the most likely source for refounding the historic distribution of redband trout in the Yaak River system in Montana. Conservation and management strategies that target the recovery of redband trout should consider the importance of this unique population to the persistence of this native subspecies throughout the Kootenai River drainage, Montana and potentially use it for supplementation efforts throughout the Kootenai River drainage. Additionally, the unique spawning and incubation characteristics of these redband trout may provide opportunities for more creative management in other areas of Montana where coastal rainbow trout are unsuccessful or in peril.

Genetic and disease sampling

Survey sampling for westslope cutthroat trout and Columbia River redband trout began in 1978 in the Kootenai River drainage and has continued in some form to the present. We collected fish samples from 29 streams between 1995 and 2000 (Table L). Most of the genetic information is still pending. Additionally, we sampled Basin Creek and Spring Creek at the Libby Field Station for disease. As part of the redband recovery program we will use Basin Creek as a genetic source for redband trout and the Libby Field Station will be used as an isolation facility. The data for general surveys for the Kootenai River drainage are presented in table L.

Table L. Summary of miscellaneous streams surveyed in the Kootenai River drainage 1995 - 1999.

Stream	Year	Survey Type	Species	Results
Kootenai River	1995	Genetics	Bull trout	Partial introgression with brook trout
Fawn Creek	1997	Genetics	trout	Pending
Cow Creek	1997	Genetics	Westslope cutthroat trout	Pending
Brush Creek	1997	Genetics	Westslope cutthroat trout	Pending
East Fisher River	1997	Genetics	Westslope cutthroat trout	Pending
Himes Creek	1997	Genetics	Westslope cutthroat trout	Pending
Midas Creek	1997	Genetics	Westslope cutthroat trout	Pending
Miller Creek	1997	Genetics	Westslope cutthroat trout	Pending
Young Creek	1997	Genetics	Westslope cutthroat trout	Pending
North Fork Callahan Creek	1998	Genetics	Redband trout	Pending
Porcupine Creek	1998	Genetics	Redband trout	Pending
Hatchery Spring Creek	1998	Genetics	Trout	Pending/no diseases
Hatchery Spring Creek	1998	Genetics	Trout	Pending/no diseases
Dutch Creek	1998	Genetics	Westslope cutthroat trout	Pending
Hartman Creek	1998	Genetics	Westslope cutthroat trout	Pending
Smoot Creek	1998	Genetics	Westslope cutthroat trout	Pending
Zulu Creek	1998	Genetics	Westslope cutthroat trout	Pending
Can Creek	1998	Genetics	Westslope cutthroat trout	Pending
East Fork Yaak River	1998	Genetics/disease	Redband Trout	Pending/no diseases
Bear Creek	1998	Genetics	Bull trout	Pending
Grave Creek	1999	Genetics	Bull trout	Pending
Keeler Creek	1999	Genetics	Bull trout	Pending
Kootenai River	1999	Genetics	Bull trout	Pending
Kootenai River	1999	Genetics	Bull trout	Pending
Koocanusa Reservoir	1999	Genetics	Bull trout	Pending
Libby Creek above Falls	1999	Genetics	Bull trout	Pending
Pipe Creek	1999	Genetics	Bull trout	Pending
O’Brien Creek	1999	Genetics	Bull trout	Pending
Quartz Creek	1999	Genetics	Bull trout	Pending

Table A. Summary of Kootenai Drainage bull trout spawning site inventories from 1991-1999 in the stream sections monitored annually.

Stream	1991	1992	1993	1994	1995	1996	1997	1998	1999
Grave Creek [a]	27		36	71	15	35	49	66	134
Wigwam River (British Columbia) [b]				104	247	512	598	679	868
Wigwam River (U.S.)									
Quartz Creek [c]	77	17	89	64	66	47	69	105	102
Pipe Creek	5	11	6	7	5	17	26	34	36
Bear Creek					6	10	13	22	36
O'Brien Creek	25	24	6	7	22	12	36	47	37
Keeler Creek [d]						74	59	92	99

[a] Includes mainstem Grave Creek, Clarence Creek, Blue Sky Creek
[b] Includes mainstem Wigwam River, Ram Creek, Lodgepole Creek, Desolation Creek.
[c] Includes mainstem Quartz Creek and West Fork Quartz Creek
[d] Includes mainstem Keeler Creek, North Fork Keeler Creek, South Fork Keeler Creek.

Table G. Median percentage of streambed material smaller than 6.35 mm in McNeil core samples collected from bull trout spawning areas in xxxx Lake tributary streams from 1994-2000.

Stream	1994	1995	1996	1997	1998	1999	2000
West Fork Quartz Creek	27.0	30.7			27.5		25.3
North Fork Keeler Creek					29.0		18.7
Keeler Creek					26.5		12.8
O'Brien Creek					36.5		
Pipe Creek					38.5	31.5	31.4
Grave Creek					22.0		25.3
Wigwam River B.C.					25.0	29.0	*
Wigwam River U.S.					26.5	21.0	24.9

Table I. Summary of Age 1 and older bull trout densities calculated from electrofishing 150 m section of streams in the Kootenai River system 1997 - 1999.

Stream	**Date**	**N**	**95 % C.I.**	p	**Density (#100m^2)**
West Fork Quartz Creek	8/21/97	69	+/- 1	0.95	5.2
	8/19/98	82	+/- 8	0.74	6.6
O'Brien Creek	8/21/98	26	+/- 1	0.96	3.8
	8/11/99	20	+/- 1	0.91	2.9
Pipe Creek	8/19/99	21	+/- 3	0.68	1.6
Keeler Creek	8/18/98*	70	+/- 26		3.4
	9/1/99	24	+/- 15	0.53	1.2
Grave Creek	8/12/97	143	+/- 9	0.73	8.8
	8/20/898	131	+/- 12	0.72	8.1
	8/10/99	125	+/- 21	0.61	7.7
Bear Creek	8/27/99	98	+/- 9	0.74	8.2

* Three pass depletion estimate

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Recommendations

Recommendations for work items in fiscal year 2001 are listed below

1) Continue to monitor Kootenai River special regulations.
2) Complete distribution survey of Columbia Basin redband trout and westslope cutthroat trout in the Kootenai River drainage.
3) When distribution information is compiled, develop Columbia Basin redband trout management plan.
4) Continue to survey small stream populations as the need and opportunity arises.