FLUVIAL WESTSLOPE CUTTHROAT TROUT MOVEMENTS AND RESTORATION RELATIONSHIPS IN THE UPPER BLACKFOOT BASIN, MONTANA

Ronald W. Pierce, Montana Fish, Wildlife and Parks, Missoula, Montana 59804
Ryen B. Aasheim, Montana Fish, Wildlife and Parks, Missoula, Montana 59804
Craig S. Podner, Montana Fish, Wildlife and Parks, Missoula, Montana 59804

ABSTRACT

We telemetered fluvial westslope cutthroat trout (*Oncorhynchus clarki lewisi,* WSCT*)* to relate migratory life history traits to restoration opportunities in the upper Blackfoot Basin (upstream of the North Fork confluence) of Montana. Telemetry confirmed life-history similarities to fish of the lower basin but also identified higher fidelity to spawning areas and mainstem pools as well as movements through intermittent channels to headwater spawning areas. Anthropogenic influences limit fluvial WSCT abundance and their ability to reproduce and thus, place sensitive areas of the Blackfoot River environment at increased risk. Road crossings, riparian grazing, and irrigation practices, primarily in tributaries of the Garnet Mountains, adversely influence fluvial WSCT from the tributary to sub-basin scales. Localized life history characteristics demonstrated in the upper Blackfoot River environment confirm the value of fisheries investigations at reach and regional fisheries scales. Understanding local life history strategies is vital when planning fluvial native fish recovery in watersheds of geo-spatial and anthropogenic variability. Telemetry results indicated that WSCT conservation and recovery in the upper Blackfoot basin will rely on restoration of tributaries, protection of intermittent channels, changes in grazing and timber harvest practices on alluvial stream channels, and careful management of private ponds (to avoid hybridization). These assessments identified a fundamental need to work with private landowners for fluvial WSCT recovery at a metapopulation scale to be effective.

Key words: fluvial westslope cutthroat trout, movement, *Oncorhynchus clarki lewisi*, private land, tributary restoration, telemetry, upper Blackfoot River

---

INTRODUCTION

Concern over declines in both abundance and distribution of westslope cutthroat trout (*Oncorhynchus clarki lewisi*) (WSCT*)* throughout the subspecies range have prompted fisheries managers to attempt to identify mechanisms responsible for declines and develop effective conservation and recovery programs (Behnke 1992, Shepard et al. 1997, 2003, Pierce et al. 2005). Historical accounts suggest WSCT were once abundant in river systems of western Montana (Lewis 1805, Behnke 1992, Shepard et al. 2005), where populations expressed a range of migratory (fluvial and adfluvial) and stream-resident life history traits (Behnke 2002, Shepard et al. 2003). Fluvial WSCT often occupy large home ranges, spawn in tributaries where the young rear for ≤ 3 years, migrate to a large river to mature, and then return as adults to their natal tributaries to spawn (Schmetterling 2001, Behnke 2002). Fluvial WSCT have become increasingly rare as a result of habitat loss and degradation, competition with non-native fishes, genetic introgression, and fish passage barriers (McIntyre and Reiman 1995, Shepard 2003) of which all are common in the Blackfoot watershed (Pierce et al. 2005).

Radio telemetry has recently been used to elucidate migratory life history traits of native trout species in the lower Blackfoot basin, i.e. from the North Fork downstream (Swanberg 1997, Schmetterling 2001), such as extensive spawning migrations (>80 km) to natal tributaries by WSCT (Schmetterling

2001, 2003). Telemetered native trout have also helped identify specific population recovery and protection actions at critical sites; validate restoration assumptions; and monitor fluvial use of completed restoration projects (Swanberg 1997, Schmetterling 2001, Pierce et al. 2004). Two examples of these applications include Dunham Creek and Chamberlain Creek, both recently restored tributaries to the lower Blackfoot River. Dunham Creek involved a bull trout (*Salvelinus confluentus*) tagged in the lower Blackfoot River, tracked to an unknown and severely altered (channelized) spawning site, and then entrained in an irrigation ditch during the out-migration (Swanberg 1997). This information, generated during the formative years of bull trout recovery planning, led to restoration of the channelized site and screening of the Dunham ditch (Pierce et al 2002), and contributed to designation of Dunham Creek as *proposed critical habitat* for bull trout under the Endangered Species Act (USDI Fish and Wildlife Service 2002). The second example is Chamberlain Creek, a tributary to the lower Blackfoot river where, after chronic issues such as dewatering, entrainment, grazing and channel alterations were remediated (Pierce et al 1997), telemetered WSCT indicated that fluvial adults began to use the tributary for spawning in greater numbers (Schmetterling 2001). And higher numbers (densities) of WSCT continue to persist in this stream, years after the restoration efforts (Pierce et al. 2006). Results from these and other telemetry-based investigations have been integrated into monitoring and restoration planning that allows these activities to be targeted more efficiently. However, these applications have focused primarily on the lower Blackfoot basin, and other sub-basins within the Blackfoot watershed (Clearwater River basin and upper Blackfoot River basin) have not been emphasized.

Because of the successful interface between understanding life history traits through applied research and restoration planning and implementation in the lower Blackfoot basin, we investigated fluvial adult WSCT movements and related our findings to anthropogenic impairments in the upper Blackfoot basin where WSCT occur (Pierce et al. 2004). We hypothesize the physical and human environment of the upper Blackfoot basin would locally influence WSCT movement patterns, and areas with low densities of fluvial WSCT therein would reflect human disturbance of aquatic habitat. Study objectives were to 1) describe movement patterns of fluvial WSCT in the upper Blackfoot basin following Schmetterling (2001), and 2) discuss restoration implications by comparing known upper basin impairments (Pierce et al 2004) with movement of adult WSCT as well as spawning, summering, and wintering needs in the upper Blackfoot basin. The purpose of this study is to characterize seasonal movements over a sub-basin scale so that specific recovery actions can be directed at important, but anthropogenically impaired habitat and movement corridors with the goal of conserving and restoring the fluvial WSCT life history in the upper Blackfoot basin.

STUDY AREA

The Blackfoot River, a 5th order tributary (Strahler 1957) of the upper Columbia River, lies in west-central Montana and flows west 211 km from the Continental Divide to its confluence with the Clark Fork River at Bonner, Montana (Fig. 1). The Blackfoot River drains a 3728-km^2 watershed through 3040 km of perennial streams and discharges a mean annual flow of 45.2 m^3/sec (United States Geological Survey 2004). High-elevation, glaciated mountains to the north and a low-relief, nonglaciated landscape to the south define the physical geography of the Blackfoot watershed. Northern tributary streams begin in high cirque basins and flow through alluviated glacial valleys where sections of stream are often seasonally intermittent. The Garnet Mountains to the south of the Blackfoot River produce small streams that are naturally perennial to the Blackfoot River although most are anthropogenically

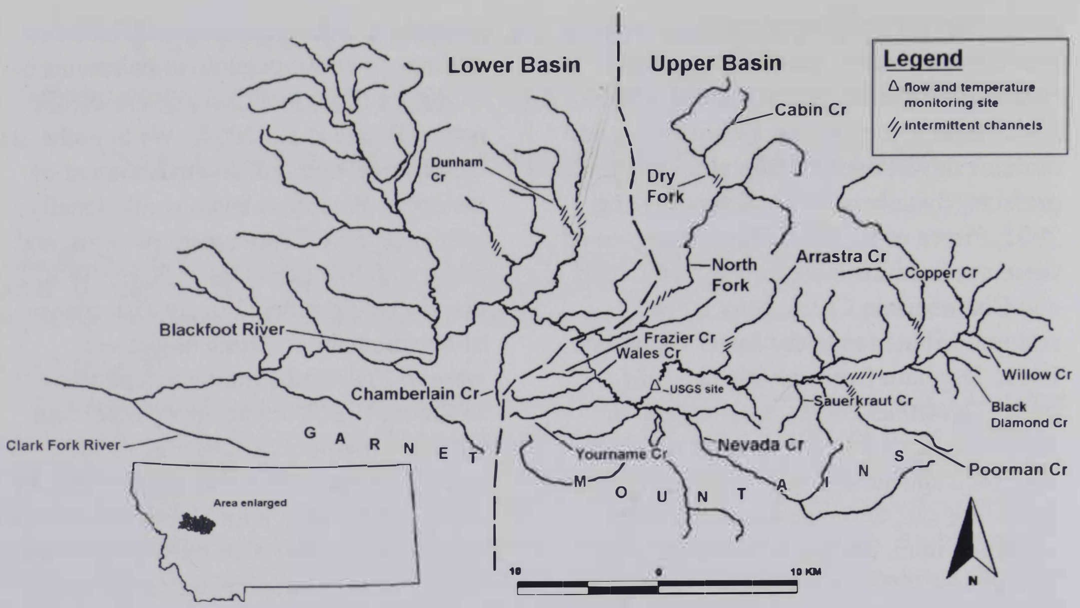

Figure 1. Study area: upper Blackfoot River basin with water temperature and flow monitoring station and intermittent stream channels

degraded or dewatered during the irrigation season. Lands in the upper Blackfoot Basin are mostly public (65%) headwater areas, with private lands consisting primarily of timbered foothills and agricultural bottomland.

The regional (natural and human-induced) variability of the basin is further expressed within the valley of the Blackfoot River. The upper Blackfoot River occupies a low-gradient, alluvial channel with long segments without tributary input, and tributaries that are present are often seasonally intermittent or degraded in lower reaches often as a result of agricultural activities. The upper river supports low instream (secondary) productivity and water quality impairment from non-point agricultural sources increases between Nevada Creek and the North Fork Blackfoot River (Ingman et al. 1990). At the junction of the North Fork, the divide between the upper and lower basins, the lower Blackfoot River receives a large influx of cold water, which reduces summer water temperature, improves water quality and approximately doubles the base flow of the lower Blackfoot River (Ingman et al. 1990, Pierce et al 2006, United States Geological Survey 2006). Contained by glacial boulders and bedrock, the lower river channel is steeper, geomorphically stable and bedrock controlled. The lower Blackfoot River has high secondary productivity (Ingman et al. 1990) and much higher densities of WSCT than the upper Blackfoot River (Pierce et al. 2004). The density of adult WSCT in the upper mainstem Blackfoot River near Nevada Creek are as low as 4/km compared to 58/km in the lower Blackfoot River near Chamberlain Creek and few, if any, fluvial WSCT from the lower Blackfoot River migrate to the upper Blackfoot basin upstream of the North Fork confluence (Schmetterling 2001, 2003, Pierce et al. 2006).

Unlike the lower Blackfoot basin and despite no isolating mechanism, the upper Blackfoot Basin is absent of fluvial rainbow trout (*O. mykiss*) reproduction with the exception of Wales Creek (Shepard et al. 2003, Pierce et al. 2005). Here, WSCT occupy about 90 percent of headwater tributaries although population abundances usually decrease in the downstream direction due to tributary alterations (Pierce et al. 2004). The loss of spawning areas has been identified as a major reason for the decline and low abundance of WSCT within the upper Blackfoot River. Correcting anthropogenic impairments in the upper Blackfoot basin is increasingly a restoration focus (Blackfoot Challenge 2005), but prior to this study no attempt was made to identify problems specifically affecting fluvial WSCT.

Within the upper Blackfoot basin, the first 88 km of upper mainstem Blackfoot River above the confluence of the North Fork Blackfoot River is naturally stratified into three (hereafter upper, middle and lower) reaches, among which anthropogenic impairments are spatially variable (Pierce et al 2004). The upper reach extends 33.4 river kilometers (rkm) from Poorman Creek (rkm 174.2) to Arrastra Creek (rkm 140.8) and is a densely wooded C4 alluvial channel-type (Rosgen 1996). This reach begins at the downstream end of an intermittent section of the mainstem where groundwater and spring creek inflows re-enter the mainstem Blackfoot River. The middle reach, also a C4 channel-type, extends 32.5 km from Arrastra Creek downstream to Nevada Creek (rkm 108.3). The channel in this less-wooded reach loses slope, becomes highly sinuous, prone to bank erosion, and deposition of fine sediment. Riparian livestock grazing is more common in downstream areas (Marler 1997, Confluence Consulting 2003), and the lower section of this reach is increasingly dewatered during the irrigation season (Pierce et al 2005). Other than at reach boundaries no tributaries enter the middle reach. The lower reach extends 22.3 km from Nevada Creek, a water quality (nitrate, phosphate, total suspended solids and temperature) impaired tributary, to the mouth of the North Fork (rkm 86) (Ingman et al. 1990, Pierce et al. 2006). Below Nevada Creek, the Blackfoot River transitions from a low gradient alluvial (C4) channel to a more confined, higher gradient geologically controlled (B3 and F3) channel (Rosgen 1996). Several small but degraded and dewatered tributaries enter this reach from the Garnet Mountains (Pierce et al. 2005).

METHODS

Radio Telemetry

WSCT were captured in the upper Blackfoot River, phenotypically identified, implanted with continuous radio Lotek™ transmitters between 13 March–18 April 2002 and 18 March– 3 April 2003 and tracked fish through one full spawning migration cycle. Visual identification was later verified through genetic analysis of fin clips using 17 fragments of nuclear DNA at the University of Montana, Trout and Wild Salmon Genetics Laboratory (Boecklen and Howard 1997). We evenly distributed transmitters (10-11/reach) within each of the three study reaches. Fish were captured prior to spring run off, presumably prior to spawning migrations by angling or electro-fishing in suspected wintering pools. Individually coded transmitters, which did not exceed 2 percent of fish weight, weighed 7.7 g, had an estimated life of 450 days, (Winters 1997) and were implanted following standard surgical methods (Swanberg 1997, Schmetterling 2001).

We located fish from the ground using either an omni-directional whip antenna mounted on a truck or a hand held three-element Yagi antenna when walking. When ground tracking failed to locate a fish, we relied on fixed-wing aircraft equipped with a three-element Yagi antenna attached to the wing strut flying ~ 100-200 m above the river. Similar to Schmetterling (2001), we located fish at least three times/ week immediately prior to and during spring migrations and spawning, once/ week while holding in tributaries or the Blackfoot River following spawning, and once/month thereafter. For each ground-based relocation within a habitat unit, we triangulated the fish's location to within an estimated 5 m and recorded its location using GPS.

Within tributaries and the Blackfoot River, we expressed locations as distances upstream from the mouth in river kilometers (rkm). Following Schmetterling (2001), we assumed fish to have spawned if they ascended a stream (or river reach) with suitable spawning habitats during a spring spawning period, and the upper-most location was the assumed spawning site. Because of high flows and poor instream visibility, we were unable to visually validate spawning at most assumed spawning areas. We therefore relied on the presence of juvenile (age-0 and I) WSCT within < 2 km of all identified spawning areas (FWP unpublished data) to support spawning site assumptions. The mean date between two contacts surrounding an event, such as a migration start or spawning date was used to estimate the date of an event (Schmetterling 2001). We considered relocations from November through April to represent winter habitat use, whereas a spring spawning-migration period was delineated from May through 14 July and summer habitat use from 15 July through October.

Blackfoot River daily discharge data were obtained from U.S. Geological Survey (USGS) gauging station (No. 12335100) located in the middle reach at rkm 115.5 to examine potential relationships between discharge and fish movement. We also placed thermographs (Onset™) at the USGS gauge to evaluate effect of maximum daily water temperature on onset of migration and spawning. We used the FWP "dewatered stream list" to identify naturally intermittent reaches (Pierce et al. 2005) and compared basin area above intermittent channels between lower and upper Blackfoot subbasins.

Because of small sample size, we grouped all first-year WSCT spawners from 2002 and 2003 by reach. We then tested between-reach differences by dates that migrations began and dates WSCT entered tributaries using a Kruskal-Wallis one way analysis of variance (ANOVA) on ranks. To explore between-year (2002 and 2003) differences influencing onset of movement and spawning, we compared daily water temperatures for the May through 14 July spawning migration period using a paired *t*-test. Mann-Whitney rank sum tests were then used to test between-year differences in the dates migrations began and the date first year WSCT spawners entered tributaries. Potential associations between date migrations began and total pre-spawning distance moved, and spawning tributary size (drainage area) and number of days WSCT spent in each of these tributaries was assessed with linear regressions. Second-year (repeat) spawners were tracked in 2003 but not included in our analyses because of limited transmitter life during the second migration/spawning period. All results were tested at the $\alpha = 0.05$ level of significance.

RESULTS

Over the course of this study we tagged and tracked 31 WSCT to spawning sites, and those fish with active transmitters were then tracked to summering and wintering areas. These 31 fish were located each an average of 39 times (range = 17-88) between March 2002 and December 2004. We tracked four spawners tagged in 2002 as repeat spawners in 2003 and used these fish to identify spawning site fidelity. Twenty-nine (94%) of 31 fish tested genetically pure WSCT. Two fish (6%) contained all WSCT genetic markers plus two of seven rainbow trout genetic markers and were classified as post-F1 generation hybrids (Martin 2004). Because of their visual WSCT features the low level of hybridization, we included these fish in our analyses. Overall, 28 (90%) fish migrated to tributaries, whereas three migrated to spawning sites in the upper main stem Blackfoot River during the 2-year study (Fig. 2, Table 1).

During migration and spawning periods, river temperatures were similar between 2002 and 2003 ($P = 0.29$), and WSCT migrations began on the rising limb of the hydrograph as temperatures approached 4 °C (Fig. 3). Twenty-two WSCT migrated upstream, nine moved downstream and one repeat spawner (fish No. 8) moved upstream in 2002 and downstream in 2003 before ascending spawning streams. The period of migration in the Blackfoot River averaged 16 days and fish moved an average of 21 km in the Blackfoot River before reaching spawning tributaries or main stem spawning sites (Table 1). Tributary spawners

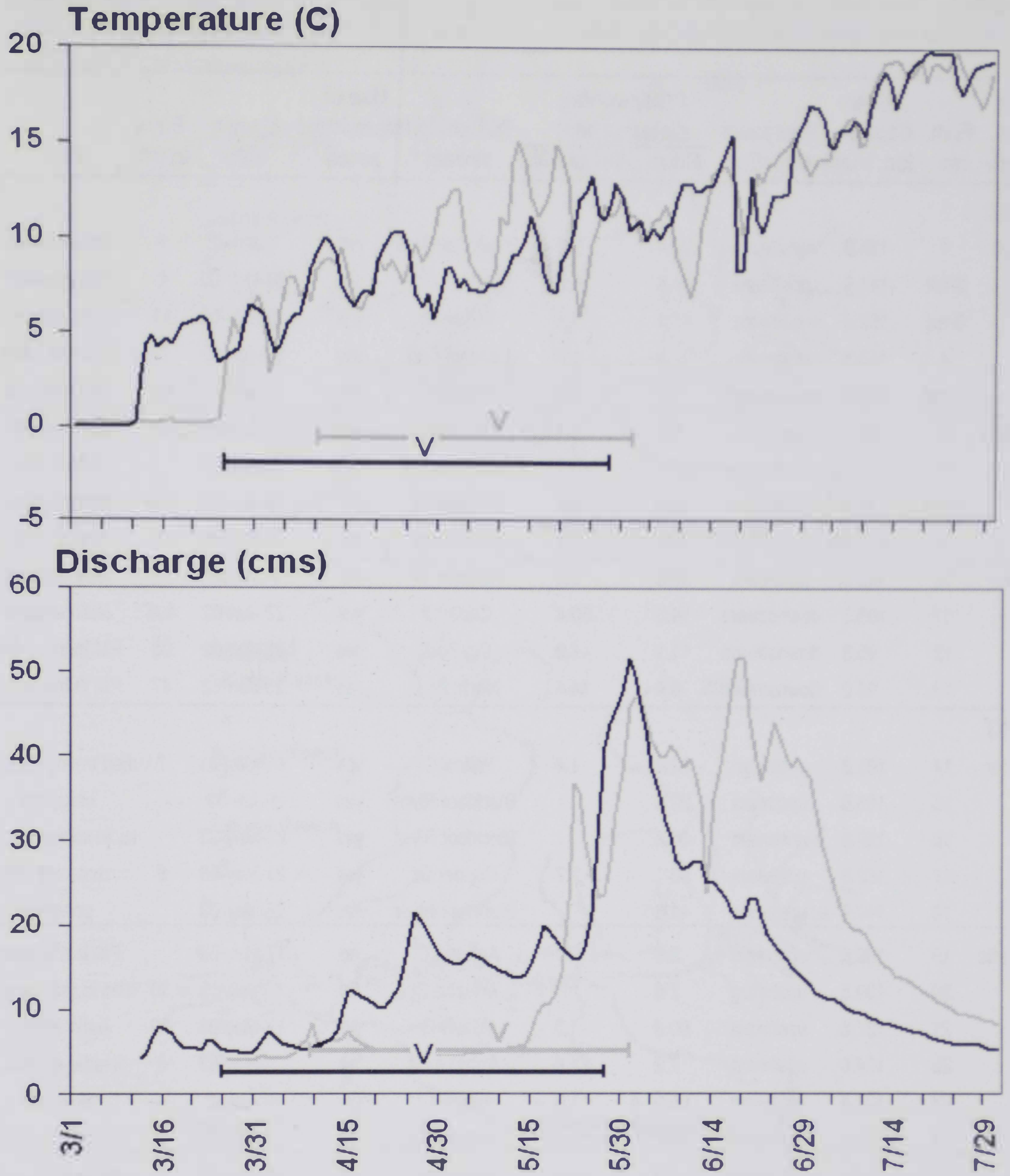

Figure 2. Relationships of water temperature (top) and discharge (bottom) to dates WSCT began migrations (range and median) in 2002 (gray) and 2003 (black). The range is shown by the horizontal bar and median migration start date by vertical arrows.

entered spawning streams at mean water temperatures of 6-7 °C and migrated another 8 km to spawning sites.

Among the three reaches, the start of spawning migrations incrementally increased in the upstream direction from 29 April in the lower reach, to 1 May in the middle reach, to 4 May in the upper reach; however, differences were not significant (ANOVA, $P = 0.89$). Between years, WSCT began their spawning migrations 17 days later (13 Apr vs. 26 Mar) in 2002 (range = 54 days) than in 2003 (range = 61 days). Although slight annual variation was detected ($P = 0.085$) differences were not significant. Likewise, the starting dates of WSCT migrations were not associated with the distance moved ($R^2 = 0.08$, $P = 0.24$).

Overall, WSCT spawning occurred in nine tributaries varying from 1st to 4th

Table 1. Summary of capture locations, spawning movements sites and dates, time spent in tributaries and fate of postspawning WSCT, 2002 and 2003; PM = post spawning mortality.

Year and reach	Fish no.	River Capture loc. (rkm)	Prespawn direction	Prespawning distance (km) River	Prespawning distance (km) Tributaries	Spawning stream	Use of intermittent reach	Spawn date	Days in trib.	Fate
2002										
upper	1	165.3	upstream	25.4	2.1	Black Diamond	yes	1-Jun-02	7	radio expired
	2-rpt	163.5	upstream	34.4	0.6	Willow Cr	yes	24-May-02	6	radio expired
	3-rpt	152.8	upstream	45.1	1.1	Willow Cr	yes	30-May-02	11	radio expired
	4	148.3	upstream	37.5	1.3	Landers Fork	yes	23-Jun-02	12	summer mort
	5-rpt	142.4	downstream	0.3	3.4	Arrastra Cr	no	9-Jun-02	60	radio expired
middle	6	139	upstream	3.5	1.1	Arrastra Cr	no	7-Jun-03	47	radio expired
	7	132.3	upstream	31	3.7	Sauerkraut Cr	no	3-Jun-02		PM in trib
	8-rpt	131.4	upstream	10.8	4.2	Arrastra Cr	no	29-Jun-02	153	radio expired
	9	113.8	downstream	27.5	4.5	North Fork	no	11-Jul-02	142	died in river
lower	10	103.5	upstream	38.6	5.4	Arrastra Cr	no	7-Jun-02	12	radio expired
	11	103.5	downstream	14.3	50.4	Cabin Cr	yes	27-Jun-02	406	radio expired
	12	95.8	downstream	11.1	41.9	Dry Fork	yes	23-Jun-02	93	PM in trib-avian
	13	94.2	downstream	6.4	14.4	North Fork	yes	25-Jun-02	47	PM in trib-avian
2003										
upper	14	165.8	upstream	32.2	1.4	Willow Cr	yes	14-May-03	7	died in original pool
	15	165.6	upstream	22.6		Blackfoot River	yes	1-Jun-03		unknown
	16	152.8	upstream	36.2		Blackfoot River	yes	21-May-03		radio expired in trib
	17	152.8	upstream	33	7.7	Copper Cr	yes	21-May-03	5	radio expired
	18	147.7	upstream	41.8		Blackfoot River	yes	25-May-03		poached
middle	19	139.5	upstream	2.6	2.7	Arrastra Cr	no	17-May-03		PM in trib-avian
	20	139.5	upstream	2.6	1.1	Arrastra Cr	no	10-Jun-03	30	died in original pool
	21	137.6	upstream	60.3	1.3	Willow Cr	yes	17-May-03	29	radio expired
	22	134.6	upstream	7.2	1.6	Arrastra Cr	no	25-May-03	6	radio expired
	23	131.4	upstream	66.9	1.3	Willow Cr	yes	4-Jun-03	4	poached
	24	115.4	upstream	26.7	1	Arrastra Cr	no	19-May-03		PM in trib-avian
lower	25	101.4	downstream	13.8	0.3	Wales Cr	no	19-May-03		PM in trib-avian
	26	96.2	upstream	45.9	1	Arrastra Cr	no	29-May-03		PM in trib
	27-hyb	96	upstream	2.9	0.6	Wales Cr	no	21-Apr-03	13	PM in river
	28	96	downstream	10.9	43.2	Dry Fork	yes	19-Jun-03		PM in trib
	29	95.7	downstream	9.8	12.2	North Fork	yes	10-Jun-03	80	PM in trib-avian
	30	95.2	downstream	9.3	28.5	North Fork	yes	19-Jun-03		radio expired in trib
	31-hyb	94.2	upstream	2	1.1	Wales Cr	no	19-Jun-03		PM in trib

rpt=repeat spawner
hyb=hybrid

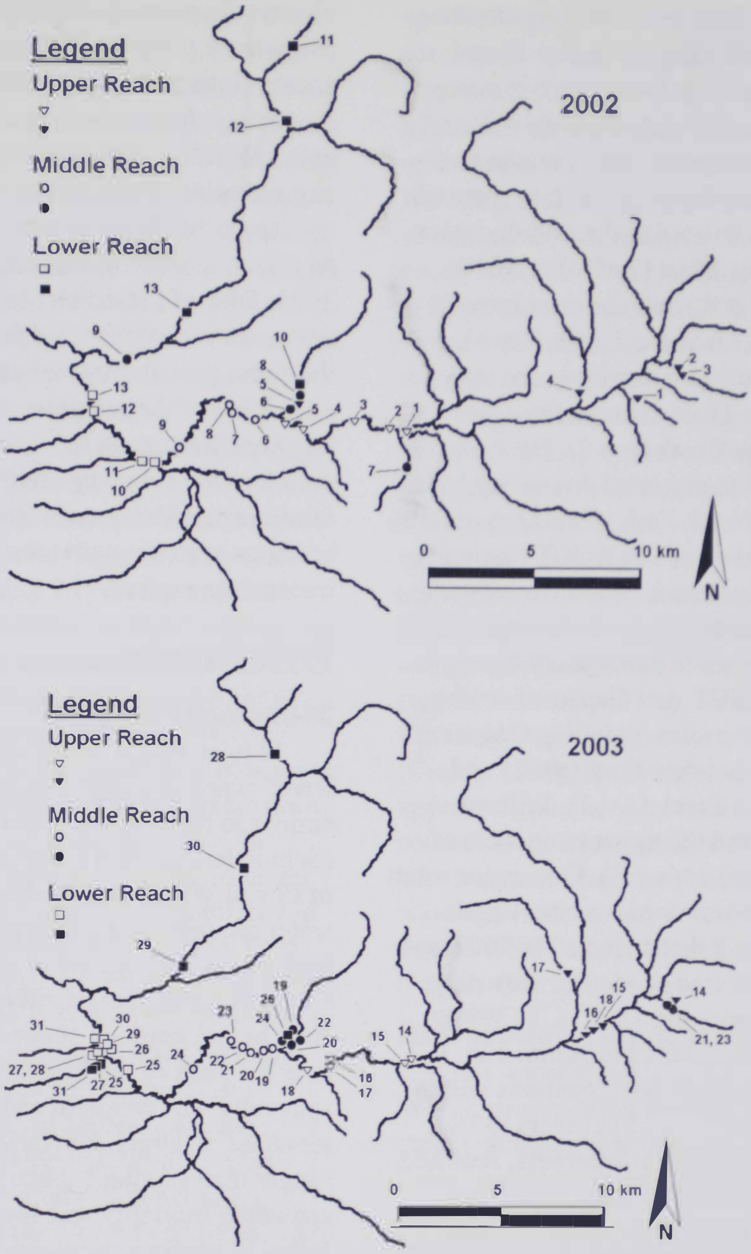

Figure 3. Capture locations (open symbols) and assumed spawning sites (closed symbols) of telemetered WSCT for 2002 (left) and 2003 (right). Numbers refer to individuals in Table 1.

order (see Table 1 and Fig. 2 for locations). Arrastra Creek and Willow Creek supported the highest proportion of telemetered spawners (9 or 29%, and 5 or 16%), respectfully, and each of these tributaries also had at least one 2002 repeat spawner return in 2003. WSCT entered tributaries from mid-April through mid-June (mean date = 16 May). We detected no significant differences in the date WSCT entered spawning tributaries either among reaches (ANOVA, $P = 0.42$) or between years ($P = 0.17$). WSCT spent an average 51 days in tributaries (range = 4-402) and spent significantly different amounts of time in the seven different spawning tributaries ($R^2 = 0.36$, $P = 0.002$), staying the longest in the largest tributary, the North Fork.

The majority of WSCT tagged in the lower river reach (6 of 11 or 55%) migrated downriver to the lower reach boundary before ascending the North Fork for spawning ($n = 3$) or two tributaries to the upper North Fork (Dry Fork ($n = 2$) and Cabin Creek ($n = 1$). Three other lower-reach fish entered Wales Creek ($n = 3$), a tributary adjacent to the lower reach; two ascended the middle river reach to spawn in Arrastra Creek located at the middle-upper reach boundary. Most (9 of 10 or 90%) WSCT tagged in the middle river moved upriver to either Arrastra Creek ($n = 6$), Sauerkraut Creek (a tributary to the upper river reach, $n = 1$), or through the upper reach to Willow Creek ($n = 2$). Only one middle-reach fish migrated downriver before ascending the North Fork. Similar to middle-reach fish, most (9 of 10) WSCT originally in the upper river reach migrated upriver; however, unlike the concentrated spawning of most middle reach fish, spawning of upper-reach WSCT was dispersed among several spawning sites including Copper Creek ($n = 1$), Landers Fork ($n = 1$) and Black Diamond Creek ($n = 1$), Willow Creek ($n = 3$) and the upper main stem of the Blackfoot River ($n = 3$). One upper reach fish moved downriver to Arrastra Creek.

Of 31 WSCT that spawned in 2002 and 2003, 13 (42%) died soon after spawning. Seven of the surviving 18 WSCT (39%) returned from tributaries to summer in their original capture pool locations within 1-55 days (mean = 22). Six others (33%), including two mainstem spawners, returned to summer within an average of 4.3 km (1.1-11.4 km) of their mainstem capture locations. Five (28%) remained in their spawning tributaries during the summer.

Of 18 tagged WSCT that survived into summer, we monitored 11 at wintering locations (1 Nov-30 Apr). Most (6) WSCT that summered at original captures remained there into winter, and two additional fish that summered upstream moved downstream to (or within < 1.0 km) of their original pool capture site; two (18%) over-wintered 11.2 and 25.1 km from their original capture sites. One WSCT, originally captured in a pool in the Blackfoot River near rkm 103.5 in 2002, over-wintered in the North Fork (rkm 31.8) the following year, a distance of 51 rkm between wintering sites. We observed a majority of wintering WSCT using large pools with complex wood associations and fish exhibited very little movement during the winter. The remaining seven WSCT either died or their transmitters expired prior to winter.

Ten WSCT (40%) captured in 2002 remained alive with working transmitters in 2003. Four of these fish (40%) were repeat spawners with three returning to spawn in the same stream they had used in 2002, and all ≤ 1 km of the previous year's spawning location. The fourth fish returned to the mouth of the tributary (Willow Creek) it had used the previous year, within 1.1 km of the previous spawning site, at which point the transmitter expired.

DISCUSSION

Movement patterns

Fluvial WSCT of the upper Blackfoot River expressed migratory characteristics similar to those in the lower Blackfoot River (Schmetterling 2001). Spawning movements of fluvial WSCT began with increasing water temperatures just prior to the rising limb of the hydrograph at which point adult spawners moved either up or down river before entering spawning tributaries near the peak of the hydrograph. Repeat spawning was common and spawners remained in larger tributaries significantly longer than smaller tributaries and post-spawning mortality was high. Telemetry failed to confirm mainstem spawning within the three study reaches; however, we observed spawning migrations to potential spawning sites in the upper-most Blackfoot River. Unlike other studies that showed more discrete use of lower-order tributary streams (Magee et al. 1996), our results identified spawning across 1st through 4th order tributary streams similar to the lower Blackfoot River study.

Despite many similarities to WSCT of the lower basin, we detected differences in certain spawning site and mainstem habitat use compared to Schmetterling (2001), i.e., higher adult WSCT fidelity to both spawning and main stem sites in our study. Spawning site fidelity for WSCT has previously been documented (Magee et al. 1996), but was not apparent in the lower Blackfoot basin where two repeat spawning migrants did not return to their previous year's spawning location (Schmetterling 2001). However, the small sample size of repeat spawners in the lower Blackfoot basin limits the strength of this comparison. Nonetheless, all repeat spawners returned to or within 1.1 km of previous spawning sites. This suggests that spawning sites were more limiting in the upper Blackfoot basin, thus prompting higher fidelity, a premise supported by lower WSCT densities in the upper Blackfoot River. We also found higher fidelity to wintering sites with 73 percent of post-spawning fish returning to their original pool capture locations compared with 11 percent in the lower basin study. These differences suggested a lower number of preferred wintering pools in the upper river compared with the lower Blackfoot River where pools were larger and geologically stable. In our study, we observed wintering in larger pools, a pattern of habitat use confirmed in similar studies (Brown and Mackay 1995, Schmetterling 2001, Dare and Hubert 2002).

A majority of WSCT (55%) from the upper Blackfoot River ascended naturally intermittent reaches, i.e. channels dry during base flows, to access upstream spawning sites, compared with 4 percent in the lower river study (Schmetterling 2001). Including the North Fork basin, 48 percent of the upper basin lies upstream of naturally intermittent channels, compared to 10 percent of the lower basin. This use of natural intermittent channels likely reflected both a higher number of intermittent channels in the upper Blackfoot Basin and more suitable spawning sites found in smaller streams upstream of intermittent reaches. Interestingly, all telemetered WSCT migrating through naturally intermittent reaches from spawning sites returned prior to no flow periods without related mortality.

Spatial/temporal migration patterns of WSCT were inconsistent among reaches and seemingly reflected both natural and anthropogenic influences. As an example, upriver migrations for a majority of middle reach spawners to Arrastra Creek suggested a pattern influenced by lack of natural tributaries downstream. Conversely, lack of spawning at several tributaries in the area of Nevada Creek suggested that anthropogenic loss of natal connections influencing lower-reach WSCT. Although not significantly different, lower-reach WSCT began migrations earlier, and these migrations were on average longer in both distance (4.3 km) and duration (8 days) compared to the combined upper reaches despite the near proximity to several tributaries. Unlike the upper two reaches, lower-reach fish exhibited a downriver movement pattern, and spawners sustained a surprisingly high level of post-spawning mortality (73%) compared with middle and upper reaches (combined total = 27%). Similar to an evaluation with Yellowstone cutthroat trout (Clancy 1988), lower reach difference appeared influenced by loss of recruitment sources from adjacent Garnet Mountains tributaries and coincided with impaired water quality and very low densities of fluvial WSCT in the Blackfoot River near Nevada Creek (Pierce et al. 2004).

Restoration Implications

The upper Blackfoot River fluvial WSCT conservation strategy calls for metapopulation function and enhancing "core" populations of genetically "pure" WSCT (Shepard et al 2003). This strategy relies on access between mainstem habitats in the upper Blackfoot River and suitable spawning tributaries over a large area. The majority of perturbations to WSCT habitat in the Blackfoot Basin, including altered habitat and passage issues, occurred in the lower reaches of most tributaries, primarily on private land (Pierce et al. 2004; 2005). These impairments included over-grazing in riparian areas (32 streams), road crossings (28 streams), irrigation structures (fish passage and entrainment) and irrigation-related flow problems (23 streams), and historical placer mining (12 streams) (Pierce et al. 2004, 2006). Although private lands in the upper Blackfoot basin comprise only 35 percent of the land base, they contained the majority of WSCT spawning sites (64%), migration corridors (69%) and wintering areas (80%) documented in this study. Thus, successful application of the conservation strategy includes correcting human-caused impairments affecting WSCT on private land.

Compared to the lower Blackfoot Basin, fidelity of fluvial upper River WSCT to pools and observations of cover associations suggest heightened preference to pool with instream wood as identified in other studies (Brown and Mackay 1995). Using a census of large instream wood as an index to these habitat requirements, Pierce et al. (2004) measured a significant (89%) decrease in amount of large instream wood between the upper and lower reaches. These findings identify a need to manage for the recruitment of large wood to the Blackfoot River channel between Arrastra Creek and the North Fork.

In a region where land use is dominated by traditional agriculture, tributary fish population inventories indicated a pattern of fewer WSCT in the lower reaches of 32 of 46 tributaries in the upper Blackfoot basin (Pierce et al. 2005). Our telemetered fluvial WSCT entered only one tributary (Wales Creek) between the North Fork and Arrastra Creek, a distance of 55.5 rkm. Consistent with recent population trends that show very little WSCT use in lower reaches of other tributaries to the lower river reach (Pierce et al. 2004), we found no fluvial use of Nevada Creek or its tributaries, Yourname Creek, and Frazier Creek, a large contiguous area comprising 43 percent of the upper Blackfoot Basin upstream of the North Fork, despite stream-resident WSCT widely distributed throughout headwaters of these streams. Between the mainstem Blackfoot River and resident WSCT populations in the upper tributaries, dewatering, habitat degradation, e.g. overgrazing, and low water quality have been identified as fisheries impairments (Ingman et al. 1990, Pierce et al. 2001, Blackfoot Challenge 2005) but correctable with alternative agricultural practices.

Between the North Fork and Arrastra Creek, only lower Wales Creek received limited spawning use by three WSCT, and this was downstream of an on-channel irrigation reservoir. Of these fish, two did not survive spawning potentially due to irrigation-induced low flows. Furthermore, Wales Creek, the lower-most spawning site identified in this study, occurred within the upper range of rainbow trout in the watershed and contained private fishponds with rainbow trout. Both of the WSCT that showed rainbow trout hybridization in our study entered Wales Creek. With exception of the North Fork, all other individual WSCT in our study spawned in tributaries supporting genetically unaltered WSCT stocks (Pierce et al. 2005). These findings confirm the risks of introducing hybridizing species into ponds and lakes within the range of WSCT in the upper Blackfoot basin.

Arrastra Creek, the next identified upstream spawning stream, 45.4 km upstream of Wales Creek, received the highest spawning use of all streams that included WSCT from all reaches as well as the majority of WSCT tagged in the middle reach. However, these fish all spawned downstream from a set of impassable culverts. Compared to concentrated spawning in Arrastra Creek, the majority of upper reach WSCT spawning was dispersed among headwater tributaries and the mainstem Blackfoot River upstream of an intermittent segment. As important migration corridors, intermittent reaches such as this should be managed within the context of migration and downriver recruitment. However, critical fisheries are not often associated with seasonally dry channels, and Montana's stream protection laws do not offer intermittent streams the same legal protection as perennial streams without consent of local conservation districts.

CONCLUSIONS

Variability within the physical and cultural landscape of the Blackfoot watershed influenced expression of fluvial life histories and habitat use at various spatial scales. Understanding this variability within a context of anthropogenic limiting factors is vital towards developing concise restoration actions for fluvial WSCT. We believe that links between human impairments and spawning limitations in the upper Blackfoot River were supported by 1) reach-related low densities of WSCT in the River where adjacent spawning tributaries are no longer functional or accessible, 2) concentrated use of the few available nearby tributary spawning sites between the North Fork and Arrastra Creek, and 3) movement differences and high mortality of lower reach WSCT spawners. These links elucidated the value of the few existing spawning sites and a need to restore habitat and access at sites with high-quality spawning and recruitment potential, particularly those near the lower and middle reaches. This study identified a clear need to engage private landowners, county road departments, and conservation districts in restoration work. Based on the proven ability of the stakeholders within the Blackfoot watershed to find solutions to identified fisheries problems, we expect this information will facilitate development of specific fluvial WSCT restoration actions.

ACKNOWLEDGEMENTS

We thank Northwestern Energy, the Big Blackfoot Chapter of Trout Unlimited, Helena National Forest and USDI Fish and Wildlife Service-Partners for Fish and Wildlife for project funding and other support. Fisheries technician responsible for data collections included Winston Morton and Sibley Ligas-Malee. Key volunteers included Jeff Everett and Don Peters. The H2-O Ranch and manager Kevin Ertle provided a field bunkhouse. We thank all landowners that allowed access to streams. Finally, the comments of David Schmetterling, Brad Shepard, Pat Byorth and Carter Kruse and two anonymous reviewers improved the quality of this report.

LITERATURE CITED

Behnke, R. 1992. Native trout of western North America. American Fisheries Society monograph 6. American Fisheries Society. Bethesda, MD.

Behnke, R. 2002. Trout and salmon of North America. Chanticleer Press, New York.

Blackfoot Challenge. 2005. A basin-wide restoration action plan for the Blackfoot Watershed.

Boecklen, W. J., and D. J. Howard. 1997. Genetic analysis of hybrid swarms: numbers of markers and power of resolution. Ecology 78:2611-2616.

Brown, R. S., and W. C. Mackay. 1995. Spawning ecology of cutthroat trout (*Oncorhynchus clarki*) in the Ram River, Alberta. Canadian Journal of Fisheries and Aquatic Sciences 52: 983-992.

Chapman, D. W., and E. Knutsen. 1980. Channelization and livestock impacts on salmonid habitat and biomass in western Washington. Transactions of the American Fisheries Society 109:357-363.

Clancy, C. G. 1988. Effects of dewatering on spawning by Yellowstone cutthroat trout in tributaries to the Yellowstone River, Montana. Pp 37-41 *in* R. R Gresswell, editor. Status and management of interior stocks of cutthroat trout. American Fisheries Society, Symposium 4, Bethesda, MD.

Confluence Consulting, 2003. Blackfoot headwaters planning area water quality and habitat restoration plan and TMDL for sediment. A draft report to the Blackfoot Challenge and Montana DEQ.

Dare, M. R., and W. A Hubert. 2002. Changes in habitat availability and habitat use and movements by two trout species in response to declining discharge in a regulated river during winter. North American Journal of Fisheries Management. 22:917-928.

Ingman, G. L., M. A. Kerr, and D. L. McGuire. 1990. Water quality investigations in the Blackfoot River drainage, Montana. Department of

Health and Environmental Services, Helena.

Jakober, M. J., T. E. McMahon, R. F. Thurow, and C. Clancy. 1998. Role of stream ice and fall and winter movement and habitat use by bull trout and cutthroat trout in Montana headwater streams. Transactions of the American Fisheries Society. 127:223-235.

Kanda, N., R. F. Leary, P. Spruell, and F. W. Allendorf. 2002. Molecular genetic markers identifying hybridization between Colorado River-greenback cutthroat trout complex and Yellowstone cutthroat trout or rainbow trout. Transactions of the American Fisheries Society 131:312-319.

Lewis, M. 1805. Lewis and Clark Expedition journal entry 13 June.

Magee, J. P., T. E. McMahon, and R. F. Thurow. 1996. Spatial variation in spawning habitat of cutthroat trout in a sediment-rich stream basin. Transactions of the American Fisheries Society 125:768-779.

Marler, M. 1997. Riparian health and inventory of the Blackfoot River between Nevada Creek and the North Fork Confluence: A GIS mapping project. Report to Montana Fish, Wildlife and Parks, Missoula.

Martin, A. E. 2004. WSCT genetics lab report. Wild Trout and Salmon Genetics Laboratory, Division of Biological Sciences, University of Montana, Missoula.

Meehan, W. R., editor. 1991. Influence of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19.

McIntyre, J. D., and B. E. Reiman. 1995. Westslope WSCT. Pp 1-15 *in* M. K. Young, editor. Conservation assessment for inland WSCT. USDA Forest Service, General Technical Report. RM-256.

Peters, D. 1990. Inventory of fishery resources in the Blackfoot River and major tributaries to the Blackfoot River. Montana Department of Fish, Wildlife and Parks, Missoula.

Pierce, R., D. Peters, and T. Swanberg. 1997. Blackfoot River restoration progress report. Montana Fish Wildlife and Parks, Missoula.

Pierce, R., C. Podner and J. McFee. 2002. The Blackfoot River Fisheries Inventory, Restoration and Monitoring Progress Report for 2001. Montana Fish Wildlife and Parks, Missoula.

Pierce, R., R. Anderson, and C. Podner. 2004. The Big Blackfoot River Restoration Progress Report for 2002 and 2003. Montana Fish Wildlife and Parks, Missoula.

Pierce, R., R. Aasheim, and C. Podner. 2005. An integrated stream restoration and native fish conservation strategy for the Big Blackfoot River basin. Montana Fish Wildlife and Parks, Missoula.

Pierce, R., and C. Podner. 2006. The Big Blackfoot River Restoration Progress Report for 2004 and 2005. Montana Fish Wildlife and Parks, Missoula.

Rosgen, D. 1996. Applied Fluvial Geomorphology. Wildland Hydrology, Pagosa Springs, CO.

Schmetterling, D. A. 2001. Seasonal movements of fluvial westslope cutthroat trout in the Blackfoot River drainage, Montana. North American Journal of Fisheries Management 21:507-520.

Schmetterling, D. A. 2003. Reconnecting a fragmented river: movements of westslope cutthroat trout and bull trout after transport upstream of Milltown dam, Montana. North American Journal of Fisheries Management. 23:721-731.

Shepard, B. B., B. E. May, and W. Urie. 2003. Status of westslope cutthroat trout (*Oncorhynchus clarki lewisi*) in the United States: 2002. A report to the Westslope Cutthroat Interagency Conservation Team.

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. Transactions, American Geophysical Union 38:913-920.

Swanberg, T. R. 1997. Movements of and habitat use by fluvial bull trout in Blackfoot River. Transactions of the American Fisheries Society 126:735-746.

USDI Fish and Wildlife Service. 2002. Draft recovery plan for the bull trout and proposed critical habitat. Portland, OR.

U.S. Geological Survey 2004, 2006. Gauging stations 12335100 and 12340000 provisional unpublished data.

Winters, J. D. 1996. Advances in underwater biotelemetry. Pp. 555-590 *in* B. R. Murphy and D. W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

Received 24 March 2006
Accepted 31 July 2007