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Ron Pierce
Montana Fish, Wildlife and Parks
3201 Spurgin Road
Missoula, MT 59804
406-542-5532

**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 A. 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) in order 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 of reproduce and 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 indicate 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: upper Blackfoot River, telemetry, movement, fluvial WSCT, tributary restoration, private land,

INTRODUCTION

Concern over the declines in both abundance and distribution of westslope cutthroat trout (WSCT) throughout the subspecies range have prompted fisheries managers to attempt to identify the 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 up to three 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), all of which 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 to 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 the designation of Dunham Creek as *proposed critical habitat* for bull trout under the Endangered Species Act (USFWS 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 indicate that fluvial adults were beginning 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). The results from these and other telemetry-based investigations have been integrated into monitoring and restoration planning allowing 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.

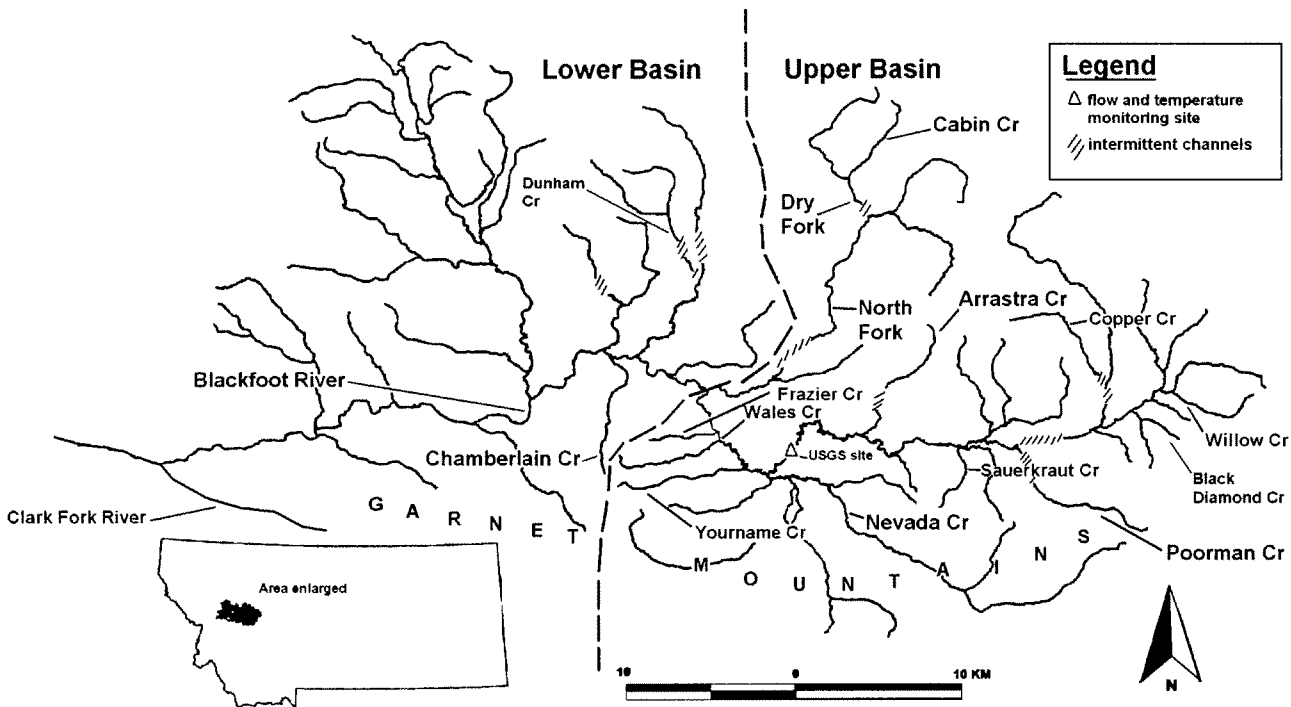
Because of the successful interface between understanding life history traits through applied research and restoration planning and implementation in the lower

Blackfoot basin, we investigated fluvial adult WSCT movements and related our findings to anthropogenic impairments in upper Blackfoot basin where WSCT are present (Pierce et al. 2004). We hypothesized 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 (Figure 1). The Blackfoot River drains a 3,728 km² watershed through 3,040 km of perennial streams, and discharges a mean annual flow of 45.2 m³/s (United States Geological Survey 2004). Higher elevation, glaciated mountains to the north and a lower 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 degraded or dewatered during the irrigation season. Lands in the upper Blackfoot Basin are mostly public (65%) headwater areas, with the 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 lower gradient, alluvial channel with long segments without tributary input, and those 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 colder 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 higher 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 has been 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 reenter 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). This reach is less wooded and the channel 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 – 13 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). Transmitters were evenly distributed (10-11 per 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 weighed 7.7 g, had an estimated life of 450 days, did not exceed 2 percent of fish weight (Winters 1997) were implanted following standard surgical methods (Swanberg 1997, Schmetterling 2001).

Fish were located 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 flying approximately 100-200 meters above the river, equipped with a three-element Yagi antenna attached to the wing strut. Similar to Schmetterling (2001), fish were located at least three times per week immediately prior to and during spring migrations and spawning, once-per week while holding in tributaries or the Blackfoot River following spawning, and once per 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 with the location using GPS.

Within tributaries and the Blackfoot River, locations were expressed as the distance upstream from the mouth in river kilometers. Following Schmetterling (2001), fish were assumed 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, while 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 the effect of maximum daily water temperature on the onset of migration and spawning. We used the FWP “dewatered stream list” to identify naturally intermittent reaches (Pierce et al. 2005) and we compared basin area above intermittent channels between the lower and upper Blackfoot subbasins.

Because of small sample size, all first-year WSCT spawners from 2002 and 2003 were grouped by reach and reach differences were then tested by the dates 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 the onset of movement and spawning, we compared daily water temperatures for the May through 14 July spawning migration period using 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 the limited transmitter life during the second migration/spawning period. All results were tested at the alpha 0.05 level of significance.

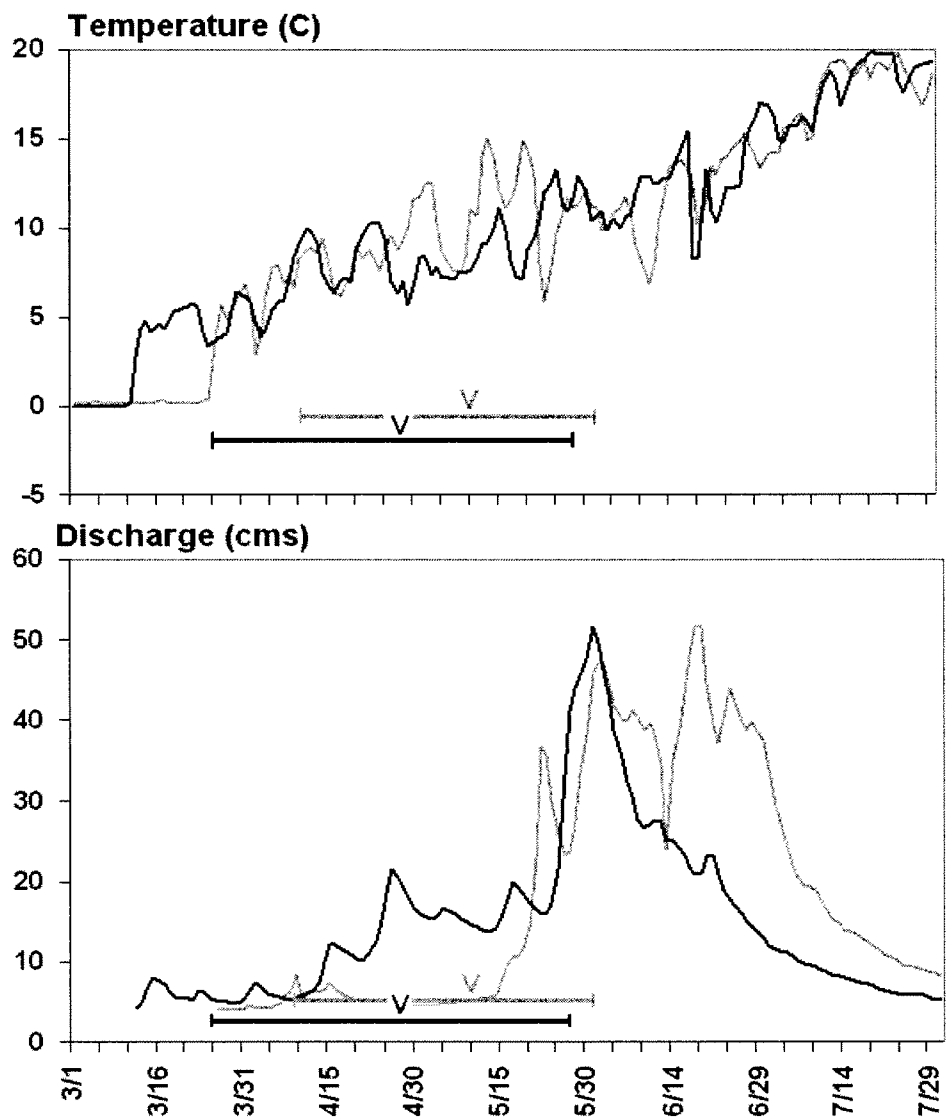
RESULTS

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 the March 2002 and December 2004 study period. Four spawners tagged in 2002 were tracked as repeat spawners in 2003 and these fish were used to identify spawning site fidelity. Twenty-nine (94%) of the 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, twenty-eight (90%) fish migrated to tributaries, while three migrated

to spawning sites in the upper main stem Blackfoot River during the two-year study (Figure 2, Table 1).

During the 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 (Figure 3). Twenty-two WSCT migrated upstream, nine moved downstream and one repeat spawner (fish # 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 entered spawning streams at mean water temperatures of $6\text{-}7^{\circ}\text{C}$ 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 (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 April versus 26 March) 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 order (see Table 1 and Figure 2 for locations). Arrastra Creek and Willow Creek supported the highest proportion of telemetered spawners (9 or 29% and 5 or 16%) respectively, 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: May 16). There were 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.

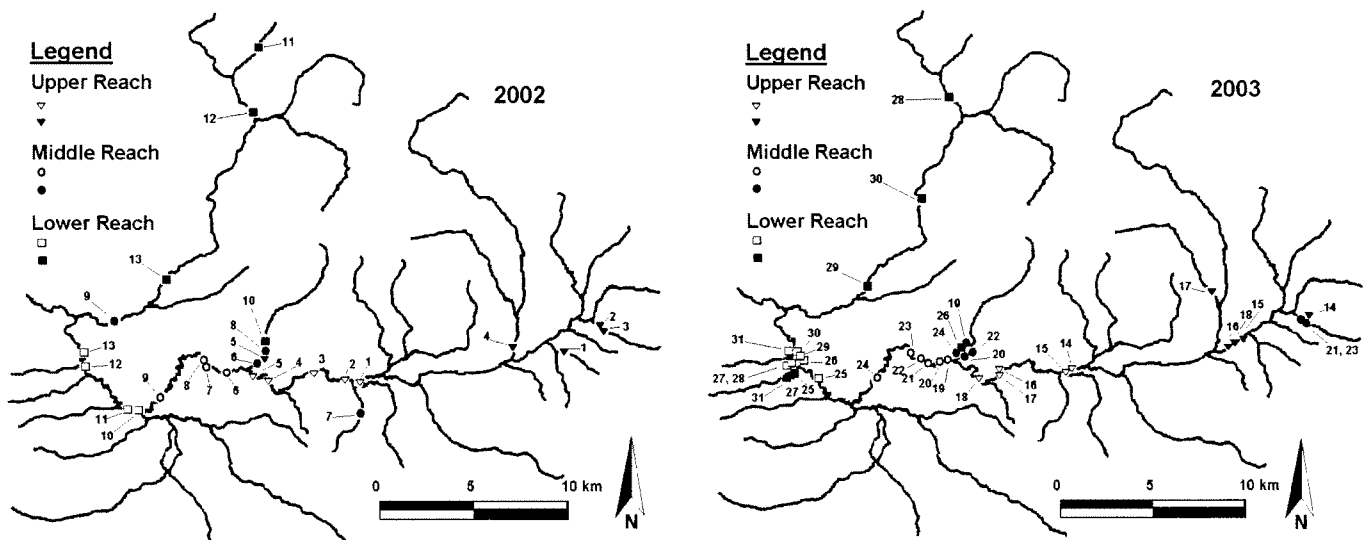


Figure 2. Capture locations (open symbols) and assumed spawning sites (closed symbols) of telemetered WSCT for 2002 (left) and 2003 (right). Numbers refer to individuals in Table 1.

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; while 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 the 31 WSCT that spawned in 2002 and 2003, 13 (42%) died soon after spawning. Seven of the surviving eighteen 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 the 18-tagged WSCT that survived into summer, we monitored eleven at wintering locations (1 November – 30 April). Most (six) 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, while two (18%) over-wintered 11.2 and 25.1km 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 were still alive with working transmitters in

| Year and reach | Fish no. | River capture location (rkm) | Prespawning direction | Prespawning distance (km) | | Spawning stream | Use of intermittent reach | Spawning date | Days in trib. | Fate |
|----------------|----------|------------------------------|-----------------------|---------------------------|-------------|-----------------|---------------------------|---------------|---------------|-----------------------|
| | | | | River | Tributaries | | | | | |
| 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 |
| 2002 middle | 6 | 139 | upstream | 3.5 | 1.1 | Arrastra Cr | no | 7-Jun-02 | 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 |
| 2002 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 |
| 2003 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 |
| | 25 | 101.4 | downstream | 13.8 | 0.3 | Wales Cr | no | 19-May-03 | | PM in trib-avian |
| 2003 lower | 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

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 within one 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 and contact was lost.

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 spawning migrations to potential spawning sites in the upper-most Blackfoot River were observed. Unlike other studies that showed more discrete use of lower-order tributary streams (Magee et al. 1996), our results were similar to the lower Blackfoot River study as we identified spawning across 1st through 4th order tributary streams.

Despite many similarities to WSCT of the lower basin, we detected certain spawning site and mainstem habitat use differences compared to Schmetterling (2001). Adult WSCT fidelity to both spawning and main stem sites was higher 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, suggesting spawning sites may be more limiting in the upper Blackfoot basin, 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% of post-spawning fish returning to their original pool capture locations compared with 11% in the lower basin study. These differences suggest a lower number of preferred wintering pools in the upper river compared with the lower Blackfoot River where pools are 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, forty-eight 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 reflects 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 with no related mortality.

WSCT spatial/temporal migration patterns were inconsistent among reaches and seem to reflect both natural and anthropogenic influences. As an example, upriver migrations for a majority of middle reach spawners to Arrastra Creek suggests a pattern influenced by the lack of natural tributaries downstream of there. Conversely, the lack of spawning at several tributaries in the area of Nevada Creek suggests the 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 surprising 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 seem to be influenced by the loss of recruitment sources from adjacent Garnet Mountains tributaries and coincide 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, occur in the lower reaches of most tributaries, primarily on private land (Pierce et al. 2004; 2005). These impairments include 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, the fidelity of fluvial upper River WSCT to pools and observations of cover associations suggests 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 indicate 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% of the upper Blackfoot Basin upstream of the North Fork, despite stream-resident WSCT widely distributed throughout the 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 are identified 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, is within the upper range of the rainbow trout in the watershed and contains private fishponds with rainbow trout. Both of the WSCT that showed rainbow trout hybridization in our study entered Wales Creek. With the 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, including 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 the 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 of the Blackfoot River. 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 the consent of local conservation districts.

CONCLUSIONS

Variability within the physical and cultural landscape of the Blackfoot watershed influences the expression of fluvial life histories and habitat use at various spatial scales. Understanding this variability within a context of anthropogenic limiting factors is a vital step towards developing concise restoration actions for fluvial WSCT. We believe the links between human impairments and spawning limitations in the upper Blackfoot River

are supported by: 1) reach-related low densities of WSCT in the River where adjacent spawning tributaries are no longer functional or accessible, 2) the 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 the lower reach WSCT spawners. These links elucidate 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 identifies 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 the development of specific fluvial WSCT restoration actions.

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