1994 Progress Report:

Adult Fluvial Bull Trout Movement in Upper Clark Fork River Drainages

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Abstract

Seasonal movement and habitat use of 12 sub-adult and adult fluvial bull trout (*Salvelinus confluentus*) in the Clark Fork, Blackfoot and Rock Creek drainages were described using radiotelemetry and snorkel surveys from June to December, 1994. Nine fish made migrations (10-130 km), only 4 of which were related to spawning. Three bull trout in the lower Blackfoot River began their migration during a large increase in water temperature and decrease in discharge. Migrations were generally directed and rapid (1.87-5.14 km d^{-1}), with movement occurring nocturnally. Two fish entered Blackfoot tributaries 2 and 3 months before spawning; snorkel surveys indicated that other bull trout were also present at these times. While in spawning tributaries, bull trout used deep pools with high amounts of woody debris disproportional to availability, and were positively associated with whitefish and cutthroat trout. Non-migrating fish in the lower Blackfoot and Clark Fork remained near cold water confluence areas during summer months. Since the cooling of water temperatures in the fall, no fish have been located near confluences. These preliminary results suggest that water temperature may be an important influence on movement and habitat use of adult fluvial bull trout during summer months. Management implications include the importance of maintaining and restoring main river thermal refugia and pre-spawning habitat in tributaries.

Introduction

Conservation status

Bull trout (*Salvelinus confluentus*) is listed as a **species of special concern** in Montana by the Montana Department of Fish, Wildlife, and Parks. The U.S. Fish and Wildlife Service has recently considered listing this species as **threatened** under the Endangered Species Act. Concern for the bull trout is due primarily to its decrease in range and secondarily to the reductions in population sizes (Thomas 1992). Degradation of spawning and rearing habitat (Weaver and Fraley 1991), over-fishing (Bond 1992, Fraley and Shepard 1989), hybridization with brook trout (*S. fontinalis*), Leary et al. 1993), and hydroelectric development (Fraley and Shepard 1989, Goetz 1994) have been identified as causes for these decreases.

The factors identified as causing decline for all bull trout life history forms have had particularly adverse effects on fluvial fish due to the areas they inhabit. Rivers have historically received higher fishing pressure, pollution, habitat degradation from drainage-wide disturbance, and more impoundments than either lakes or streams. In western Montana, the Clark Fork, Kootenai and Bitterroot Rivers historically contained large fluvial bull trout populations. Today no fluvial bull trout exist in the Bitterroot, and few exist in the Clark Fork and Kootenai. The Blackfoot River and Rock Creek drainages contain the only two relatively large fluvial bull trout populations in western Montana (approximately 200 and 100 spawning individuals, respectively; D. Peters, MDFWP, pers. comm.). Both populations are adversely affected by the existence of the Milltown Dam on the Clark Fork River as a migration barrier and are at high risk of extirpation due to their small sizes (Rieman and McIntyre 1993). Although perhaps the life history form most threatened with extinction, fluvial bull trout have not received detailed study due to their existence for much of the year in large rivers where conventional fisheries investigation methods are not effective (McLeod and Clayton 1994).

Project objectives

The patterns of migration on both a seasonal and diel scale and the habitat use during main river and spawning stream residence are not well understood for fluvial bull trout. The objectives of this study are to determine these life history features using radiotelemetry, snorkeling observations, and habitat surveys. A further objective is to document the degree to which Milltown Dam on the Clark Fork River and the Stimson weir on the Blackfoot River interfere with upstream passage. Study of these aspects of adult fluvial bull trout will aid in the re-establishment and management of its populations. Total project duration is expected to be five years. This report presents preliminary information gathered from May to December, 1994 and outlines the objectives for 1995.

Funding

Transmitters, radio receivers, and snorkel equipment for this study were provided by the Montana Department of Fish, Wildlife, and Parks (MDFWP). The funding for this equipment was provided to MDFWP by the Montana Power Company as mitigation fees for the pending relicensing of Milltown Dam. Further equipment funding is provided through a traineeship from the Montana Organization for Research in Energy (*MORE*). *MORE* is additionally providing a graduate research stipend for the 1994/1995 academic year.

Study areas

Migration

Bull trout were implanted with transmitters in the Clark Fork River, immediately below Milltown Dam and in the lower Blackfoot River, from Bonner to Wisherd Bridge. Fish captured below the Milltown Dam were transported above and released in the Blackfoot River below the Stimson weir. Implanted fish moved into Rock Creek, two tributaries to the Upper Blackfoot River, and the Clark Fork River at Missoula (Figure 1).

Use of tributary habitat

A habitat selection study was conducted on Monture Creek, a tributary to the upper Blackfoot River (Figure 1). The 6 km study section on this stream encompasses the major bull trout spawning area in the drainage. In 1994, 49 bull trout redds were observed within this area (MDFWP, unpublished data). Through the study section, Monture Creek flows over predominantly gravel substrate in an unconfined floodplain Average gradient is 0.4%, with a base flow of 64 cfs. Riparian vegetation is dominantly Engelmann spruce and subdominantly willow; some riparian grazing has occurred recently. Pools constitute 46% of the stream surface area, with a very deep average residual depth of 1.1 m. Woody debris is abundant (7.1 pieces/50 m) and serves as a structural feature in approximately 95% of the pools; much of the woody debris is recently input.

Methods

Migration study

Transmitter implants

Bull trout were captured by hook and line or electrofishing during May 9 - September 8. High frequency transmitters (Lotek Eng. Inc., model CFRT, 16.0, 8.1, or 5.1 g) were surgically implanted in the coelomic cavity. Throughout the surgery latex gloves were worn, and all surgical tools and transmitters sterilized in betadine. Fish were anesthetized with an application of MS-222 in a livecar for 2-4 min. Once equilibrium was lost, the fish were removed from the livecar, turned ventral side up, and placed on a V-shaped operating table. While out of water, gills were continually bathed in river water or dilute MS222 to maintain a proper level of unconsciousness. Prior to each surgery, length and weight measurements were made, a scale sample taken, and an incision site (3 cm in length, immediately anterior of the pelvic girdle) cleansed with betadine. After completion of the incision, a second 5 mm incision was made posterior to the pelvic girdle to trail a flexible wire antenna. The transmitters were placed on the pelvic girdle and the antennas slid through the posterior incisions. Four to six non-degradable sutures closed the incisions. Once this procedure, lasting 6-10 minutes, was completed the fish were placed in a livecar containing freshwater. Shortly after recovery of equilibrium, the fish were hand-held in a slow-water portion of the river until able to swim. Transmitter weight did not exceed 2% of fish body weight. Test surgeries using this technique where performed on rainbow trout in May, 1994. Some inflammation of the sutures was reported in the first month (D. Peters, MDFWP personal communication). As of August, 1994 all test rainbow trout were alive and infection free.

Description of movement

Aerial and ground relocations were made using a Lotek model SRX-400 receiver. On the Blackfoot River, weekly flights were conducted 100-200 m above the river at 100 km h^{-1} with a 3-element Yaggi antenna attached to a wing strut. Monthly aerial relocations were conducted over Rock Creek under similar specifications. Ground relocations were made with radial truck-top and 3-element Yaggi antennas.

Fish locations were entered into a GIS to facilitate calculation of movement distances. Distances reported represent the most direct path between locations; accordingly these distances are conservative. Movements are described as migratory or local. Migratory fish moved distances >10 km in a continuos manner and typically returned to river locations near those held before the migration began. Migrations appeared to be related to spawning and feeding, although thermoregulation may also have been a factor. For purposes of clarity, migrations will be referred to as spawning or *other*. Spawning migrations were partitioned into three intervals: upstream migration to the spawning site, holding while in the spawning site, and downstream migration to an over-wintering area. Local movements were typically unidirectional and <3 km.

Description of migration patterns

Diel timing of migrations was described for three fish in the Blackfoot River by comparing fish locations in the morning and afternoon of the same day, and again the next morning. A more rigorous estimate of timing was made on two occasions by continuously monitoring fish over a 24 hour period.

Seasonal timing of migrations for these same fish was correlated with water temperature and discharge. Hourly water temperatures were monitored at 10 locations in the Blackfoot River drainage from August to December. June and July water temperatures were monitored at one station in the lower Blackfoot and Monture Creek. Daily discharge for the study period was estimated from a gauging station at Milltown Dam, located at the confluence of the Blackfoot and Clark Fork Rivers.

Description of fish use of cold water areas

Fish locations in cool-water mixing zones downstream of tributary confluences were noted. Successive relocations in this zone were considered evidence of behavioral thermoregulation. Time spent in tributaries prior to spawning was also noted, and an estimate of energy savings calculated based on a Q_{10} of 2.0.

<u>Use of tributary habitat</u>

Habitat level surveys (Hankin and Reeves 1988) were conducted over the 6 km study segment on Monture Creek from July 7 to 12. Each section was partitioned into pool, riffle, or glide habitat units types. In each unit, volume, percent cover, cover type, substrate type, and woody debris amounts and size classes were then estimated. Dimensions of habitat units were ocularly estimated. Correction coefficients for these dimensions were obtained by accurately measuring a subsample of each habitat unit type.

After the stream had been surveyed, bank and snorkel surveys were conducted to determine habitat use by adult bull trout. Pre-spawning surveys were conducted July 18-22 and August 15-16. A mid-spawning survey was conducted September 25. Habitat use was determined by recording the habitat unit occupied by the observed fish. Upon sighting a fish, activity was observed for a 3 minute period. Activity levels were recorded as motionless, focal point maintenance with little activity, swimming at a focal point, swimming with no focal point maintenance, or spooked by observer. To examine depth selection and association with woody debris, these characteristics in habitats occupied by bull trout were compared to available habitat in the study section using a Mann-Whitney U test. Association with other species was also noted.

Results

Transmitter status

Nineteen bull trout, ranging from 345 to 725 mm TL and from 350 to 4876 g, received transmitter implants (Table 1). Six of these fish were implanted in the Clark Fork River below Milltown Dam, 7 in the lower Blackfoot, 5 in the North Fork of the Blackfoot River, and 1 in Monture Creek (Table 1).

On December 31, 12 of the 19 transmitters were active. Of the 6 no longer functioning, 4 were expelled, 2 possibly moved out of the search area [although transmitter failure occurs; McLeod and Clayton (1994)], and the antenna of one was clipped by an angler. With one exception of one instance, the fates of the bull trout that carried the dropped transmitters are unknown. Anglers could have been responsible for the loss of 2, as these fish were in the frequently fished lower Blackfoot River or Milltown Reservoir prior to transmitter expulsion and the transmitters were found in unnatural positions on the channel bottom. Three instances of anglers catching and releasing fish with transmitters were reported; it is likely that unreported instances occurred. A third transmitter was recovered 2.4 km up Welcome Creek, a tributary to Rock Creek. Due to the small size of this stream (approx. 3 cfs on October 11) abrasion of the sutures, causing the incision to open, or predation are possible explanations for this expulsion. The fourth dropped transmitter was recovered from a carcass in the Kelly Island water diversion canal 30 d after implanting. The death of this fish was likely due to a deeply swallowed barbed hook remaining in the fish from our capture effort. Stress from the implant surgery and high temperatures in the irrigation canal likely contributed to the mortality.

Transmitter effect on fish behavior

On several occasions, direct and indirect observations of implanted fish showed no abnormal behavior. Three implanted fish were caught by anglers, indicating the fish were actively feeding. On three occasions, implanted fish were seen holding with other bull trout. By comparison to the surrounding fish, no noticeable differences in behavior were obvious. One implanted female fish was observed over a partially completed redd with a likely mate nearby, indicating that the social interactions and mechanics of mating were not inhibited. Seemingly illogical behavior, such as movement in and out of tributaries, was observed on four occasions, but it is not possible to attribute this to effects of the transmitters.

Movement

From May 9 to December 31, 12 fish made migrations and four fish local movements. Transmitters were active from 9 to 221 d, during which time fish were relocated an average of 18 times (range: 3-41; Table 1). Distances migrated to spawn or feed ranged from 10 to 130 km, and generally were not prolonged (Table 2). Local movements were not accurately documented, but were generally < 200 m.

Spawning migrations

Four fish (505-665 mm TL) made upstream migrations to known or likely spawning areas in the Blackfoot and Rock Creek drainages. Three of these fish also made downstream migrations.

Upstream migration

During upstream migration, the 2 Blackfoot River fish were relocated more times and had fewer days between relocations than did the two Rock Creek fish (Table 2). Mainstem river distances of migrations ranged from 43 to 130 km and elapsed time ranged from 19 to 78 d (Table 2). Average rates of movement for all fish ranged between 1.69 and 4.91 km d^{-1}, with a maximum of 8.40 km d^{-1} (Table 2). Movement rates for Rock Creek fish were slower than Blackfoot River fish.

Two fish released above the Milltown Dam, 21-04 and 21-08, moved immediately into Rock Creek after receiving transmitters on May 27 and June 7, respectively. On approximately July 26, 21-08 entered Welcome Creek, a tributary to Rock Creek, ascending it 2.4 km. On July 26, 21-04 arrived at the Middle Fork of Rock Creek-Copper Creek confluence area (Figure 1). Two fish released in the lower Blackfoot River, 21-03 and 21-07, began upstream movement on 30-May and 8-June, 7 and 8 d after receiving implants, respectively. Fish 21-03 ascended 17 km of Monture Creek to reach a spawning area on June 23. On June 28, fish 21-07 entered a spawning area on the North Fork of the Blackfoot River 15 km above the Lolo NF boundary (Figure 1).

Holding in the spawning area

Elapsed time in spawning areas for these 4 fish ranged from 47 to 95 d (Table 3). Movement while in the spawning area was not well documented for any fish, but generally appeared minimal. As with the upstream migration, Rock Creek fish were relocated fewer times during this period than the Blackfoot River fish.

The movement of 21-04 near its probable spawning area was monitored for a 4 d period beginning August 1. This fish was located 0.4 km up Copper Creek on Day 1, 0.2 km up the Middle Fork Rock Creek on Day 2 (a movement of 0.7 km), at the same location on Day 3, and finally at the Copper Creek-Middle Fork confluence area on Day 4 (a movement of 0.3 km). The spawning site of this fish was unknown. Twenty one days later it had left the area. While in Welcome Creek, 21-08 was found in the same location 5 times; relocations 1 and 5 were beneath the same log. On the fifth relocation the transmitter was recovered with no evidence of a carcass. Because the fate of this fish is unknown, the location 2.4 km upstream from the confluence with Rock Creek should be considered the minimum distance ascended. No suitable spawning substrate was observed in the immediate area.

During the first 57 d in Monture Creek, 21-03 held in two locations, separated by 0.4 km, for at least 11 and 17 d each. This fish moved a final 0.8 km upstream nearer the eventual redd site on August 19. It was observed spawning on September 25, after at least

38 d in the area of the redd. Fish 21-07 completed spawning sometime before September 20, after 63 d in the area.

Downstream migrations

Fishes 21-03, 21-04, and 21-07 made downstream movements after spawning. Only 21-07 returned to the area it occupied prior to upstream migration. In Monture Creek, 21-03 descended 1.8 km to a location 3.3 m beneath a loose aggregate of woody debris were it has remained to present (84 d). Fishes 21-04 and 21-07 descended distances of 24 and 119 km, respectively (Table 2, Figure 1). Fish 21-07 returned to the lower Blackfoot River to within 3 km of the location of transmitter implanting.

Other migrations

Three fish made migrations which were considered unrelated to spawning. Fish 21-05, passed over the Milltown Dam June 8, descending 10 km to the Rattlesnake Creek confluence. This location was held for 65 d. On August 21, a second wandering migration began which lasted 11 d. During this time, 5 km of the Clark Fork were ascended, descended, and 3 km of Rattlesnake Creek ascended. After <3 d in Rattlesnake Creek, 10 km of the Clark Fork were ascended to the Milltown Dam (Table 2, Figure 2). This fish remained in the vicinity of the dam 38 d before descending again to the Rattlesnake Creek confluence area on October 20.

Such wandering migrations were also observed for fishes 21-06 and 21-09. Fish 21-06 held within 1 km of its release point in the lower Blackfoot River until July 1 (38 d) before moving 13 km to a location near Turah on the Clark Fork River. This location was held for at least 9 d, before a return to the original Blackfoot River location was made. On its return this fish ascended the Stimson weir. River discharge at this time was approximately 756 cfs (modified MPC Milltown Dam discharge data).

Fish 21-09 held within 3 km of its release site in the lower Blackfoot River until June 14 (15 d) before ascending 83 km to a location in the lower North Fork of the Blackfoot River (Figure 1). This location was held for 22 d and was followed by movement into Monture Creek, a distance of 34 km. This location, 10 km below the known spawning area, was held until August 21 (22 d). Descent to within 1 km of the release site on the lower Blackfoot River, a distance of 79 km, occurred within 9 d (8.5 km d^{-1}).

Non-migratory movements

Two fish (345 and 388 mm TL) remained in the lower Blackfoot River near where they received transmitters. Fish 22-14 moved <100 m during the 90 d it was tracked; it seemed to be closely associated with a cold water pocket created by a tributary confluence. Fish 24-20 occupied the same confluence area for 17 d after descending 3 km from its transmitter implant location. The transmitters of both fish became inoperable mid-way through the summer (Table 1). Whether this site fidelity would have persisted into the fall is unknown.

Seasonal timing of movements

All 6 radio-tagged fish in the lower Blackfoot River made migratory or local movement within a 20 d period beginning June 2 (Figure 3). Ambient daily water temperatures in the lower Blackfoot River increased from 10 to 17.5°C during this time, while discharge decreased by 40%. Three of 4 fish which moved to the upper portion of the Blackfoot River began their migrations during a 3 d pulse in the descending limb of the hydrograph.

Diel timing of movements

An approximate diel timing of migratory movement was determined on 6 occasions. On all occasions but one, afternoon locations of fish were in the same spot as that morning. In one instance, a fish had moved upstream 0.3 km between the morning and afternoon locations. Movement in excess of 2.8 km between afternoon and *next* morning relocations was documented on three of these occasions, indicating that movement had occurred nocturnally.

Stronger evidence of nocturnal migratory movement was obtained by continual tracking on two occasions. On both occasions movement was observed to begin and end precisely with sunset and sunrise (Figure 4). Additionally, in one instance movement appeared to be continuos, averaging 7.7 m min^{-1} (range: 5.6-9.2 m min^{-1}, or 0.13-0.23 body lengths s^{-1}).

Fish use of cold water areas

From June to August ambient temperature in the Blackfoot River was greater than 16°C. During this time 3 of 7 tagged fish moved into cold water tributaries and four made constant or occasional use of a cold water confluence area in the lower Blackfoot River.

During the month of August, the North Fork of the Blackfoot River, to which 2 fish moved, and Monture Creek, which also held two fish, were approximately 8-15°C cooler than main river temperatures; main river and tributary temperature differences where likely even greater during July. From June to August tracked fish spent 48 to 94 d in tributaries (Table 3). Additionally, movement to and from tributaries was rapid.

During the month of August, Johnson Creek (estimated Q 5 cfs) maintained temperatures 6°C cooler than the lower Blackfoot River (Figure 5). An obvious cold water pocket (approx. 12 m^2) existed in the Blackfoot River at its confluence. This pocket appeared to be maintained by an eddy which reduced mixing with river water. During the summer months two radio tagged fish made constant use of this area, one fish receiving its transmitter at this location on May 24 and the other descending 3 km to arrive June 27. Unfortunately, the transmitters of both these fish were inoperable by August 15 and July 15 (after 90 and 26 d in the pocket), respectively. On August 10, a school of 9 bull trout (estimated 300-500 mm TL) was observed in this area.

Two other fish occasionally used the Johnson Creek confluence during the summer months. Fish 21-06 spent 2 d there before descending to the Clark Fork July 1. On returning to the Blackfoot River on August 17, this fish again remained in the area of the pocket for 13 d before ascending another 3 km September 7. Ambient temperatures in the lower Blackfoot River August 17 and September 7 were 17 and 13°C, respectively. Johnson Creek temperature during this period remained near 10°C. After descending from Monture Creek August 30, fish 21-09 also spent a short time (<7 d) in the vicinity of Johnson Creek confluence before ascending 3 km to its present location.

Tributary habitat use

Activity

Thirty six fish were observed for 15-300 sec (mean 110 sec) during the three snorkel surveys conducted in Monture Creek. Activity levels ranged from motionless to swimming without a focal point, but were predominantly motionless (Chi-square = 21.4, n=3 (use df), $P<0.001$; Figure 6). No difference in activity levels was observed between the pre-spawning and mid-spawning surveys (Chi-square = 5.13, n = 3, $P > 0.10$).

Species associations

Whitefish (*Prosopium williamsoni*), westslope cutthroat trout (*Oncorhynchus clarki lewisi*), and brook trout (*Salvelinus fontinalis*), were observed in habitat units with bull trout. During the two pre-spawning surveys, mountain whitefish were present in 70% of the habitat units where bull trout were observed (Chi-square = 5.37, n=1, $P<0.025$; Figure 7a). An opposite pattern was observed during the mid-spawning survey, whitefish being in only 14% of habitat units containing bull trout (Chi-square = 7.14, n=1, $P<0.01$; Figure 7a).

A similar pattern was observed with cutthroat-bull trout associations. During the two pre-spawning surveys, cutthroat were more frequently present in habitat units where bull trout were observed than absent (Chi-square = 3.85, n=1, $P<0.05$; Figure 7b). During the mid-spawning survey, cutthroat were more often absent from habitat units where bull trout were observed, although this difference was not significant (Chi-square = 2.57, n=1, $P>0.10$; Figure 7b).

Habitat use

Habitat use was determined for 38 adult bull trout during the three surveys. Fish preferentially occupied pools over glides and riffles ($N = 34$; Chi-square = 19.8, df= 1, $P<0.001$); the remainder of fish occurred in glides (N=4).

Within pool habitat, bull trout used deep pools in greater proportion to availability (Mann-Whitney U, $P<0.001$; Figure 8a). Bull trout also used pools with high amounts of woody debris in greater proportion to availability (Mann-Whitney U, $P<0.001$; Figure 8b). The significance of this relationship is due to the presence of 6 bull trout on a pools with 36 pieces of wood. If this pool is not included in the analysis, bull trout appear to select wood amounts in pools at random.

Discussion

Preliminary results have been presented. Because of the small sample size (N= 12 fish), these results are inconclusive, and are best used to direct objectives for the 1995 field season.

Movements

Migrations

The observed migrations of bull trout in the Blackfoot River and Rock Creek were generally continuos, direct, and rapid. Lengths of observed migrations (range: 43-130 km) were consistent with the literature (Bjornn 1971, McLeod and Clayton 1994, Schill et al. 1993). Migrations observed in the Blackfoot River likely represent the total distance moved, because fish were captured in the lower river near their probable over-wintering sites. Migration distances observed for Rock Creek fish are conservative because these fish were captured below Milltown Dam; distances migrated below the dam before capture may have been substantial.

Daily migration rates for Blackfoot and Rock Creek fish (range: 1.69 - 4.91 km d^{-1}) were consistent with other fluvial populations receiving study. McLeod and Clayton (1993) documented average rates of 2.0 km d^{-1}, Schill et al. (1993) 1 km d^{-1}, and R.L. and L. Environmental Services Ltd. (1991) 7.1 km d^{-1}. The pattern of nocturnal migration observed in the Blackfoot River has not been reported elsewhere. In contrast, Thurow (personal communication) observed no diel migration pattern in the Rapid River, ID.

Use of coldwater areas

A large change in temperature (from 12 to 18°C) and discharge in lower Blackfoot River was coincident with the beginning of upstream migration for 3 bull trout. Thurow (personal communication) similarly noted 13°C as coinciding with upstream movement for bull trout in the Rapid River, ID.

The early arrival of the 2 Blackfoot River fish to spawning areas (2-3 months before spawning) is not consistent with the literature.(Fraley and Shepard 1989, Thurow 1993). Although the 2 Blackfoot River fish ultimately entered tributaries to spawn, their early arrival indicates that a more proximal cause existed. The cool temperatures in Monture Creek and the North Fork of the Blackfoot River likely allowed a significant reduction in metabolic rate from that possible in the Blackfoot River. Berman and Quinn (1991) calculated that pre-spawning chinook salmon (*Oncorhynchus tshawytscha*) inhabiting cool-water refugia near spawning areas in the Yakima River, WA reduced their metabolic rate by 12 to 20% from that possible in ambient river temperatures 2.5°C warmer. From late June to late August, 1994 water temperatures in Monture Creek averaged 8°C. Over this same time period, temperatures in the Blackfoot River averaged 5°C warmer; North Fork of the Blackfoot temperature differences were similar (unpublished data). A substantial reduction in metabolic expenditure must have occurred for bull trout in these tributaries. Consequently, thermoregulation may be a proximal cause for early arrival. In support of this assertion, a third fish migrated into the North Fork but did not spawn. Similar behavior for non-spawning fish has been observed in the Rapid River, ID (Russ Thurow, personal communication). Although it is likely that thermoregulation is <u>the</u> proximal cause for early arrival to spawning areas, during this study it will not be possible to show beyond the existence of temperature differences and fish locations that it occurs, as alternative hypothesis exist which cannot be disproved.

Bull trout which did not migrate, or which were unable to migrate because of Milltown Dam, also possibly thermoregulated. Use of cold water confluences by these fish appeared continual over the duration they were tracked (i.e., the use of the Johnson Creek and Rattlesnake Creek confluences by 4 fish). Seasonal use by bull trout of cold water confluences in the main river environment has been long known (Bradner 1950), and may even be reflected in the specific epithet. However, the use of these areas is traditionally regarded as staging prior to ascent of the tributary to spawn. Preliminary results from this study suggest that use of confluences cannot be termed staging, as fish occupying these areas were likely sub-adults (personal observation) or non-spawning adults.

This use of thermal refugia by non-spawning bull trout in the main river environment has important management implications. Firstly, because thermal refugia allow fish to conserve energy or avoid adverse temperatures, identification and conservation of these areas will provide critical habitat. Secondly, because streams creating thermal refugia may not contain bull trout, their importance as providers of critical main river habitat may be overlooked by land managers. Although warming of water temperatures in a first or second order tributary may not have a great overall affect on ambient temperatures in the main river, the loss of a thermal refugia will have negative consequences for bull trout.

Tributary habitat use

Adult fluvial bull trout were observed in Monture Creek 2 to 3 months before spawning, indicating that some spend a large portion of the summer months in tributaries. Use of deep pools in this environment appeared to be selected over shallow pools, while wood amounts appeared not to influence use. Possible mechanisms responsible for this observed pattern of use are thermoregulation (deep pools may be cooler than shallow pools) and prey availability (most pools with bull trout also were with whitefish).

Spring and summer, 1995 research plans

Field work for 1995 will continue data collection begun in 1994. Additional work to be conducted will:

1) accurately document use of thermal refugia (temperature sensitive transmitters and ambient temperature loggers will be used to document thermoregulation)

2) accurately document the diel timing of migrations

3) Determine reason for selecting deep, woody pools in spawning streams

4) collect activity level data on fish during August to compare with winter, 1994/1995 activity levels.

5) determine accuracy of transmitter relocations

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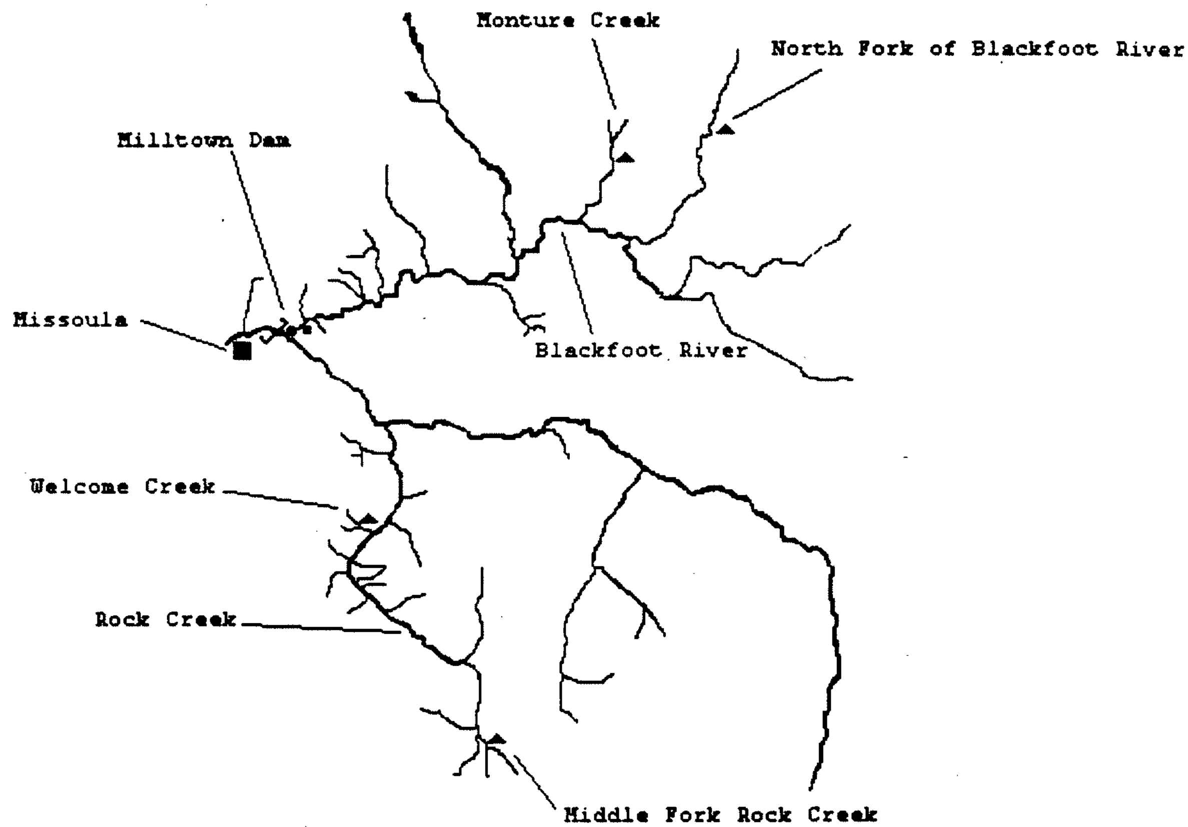
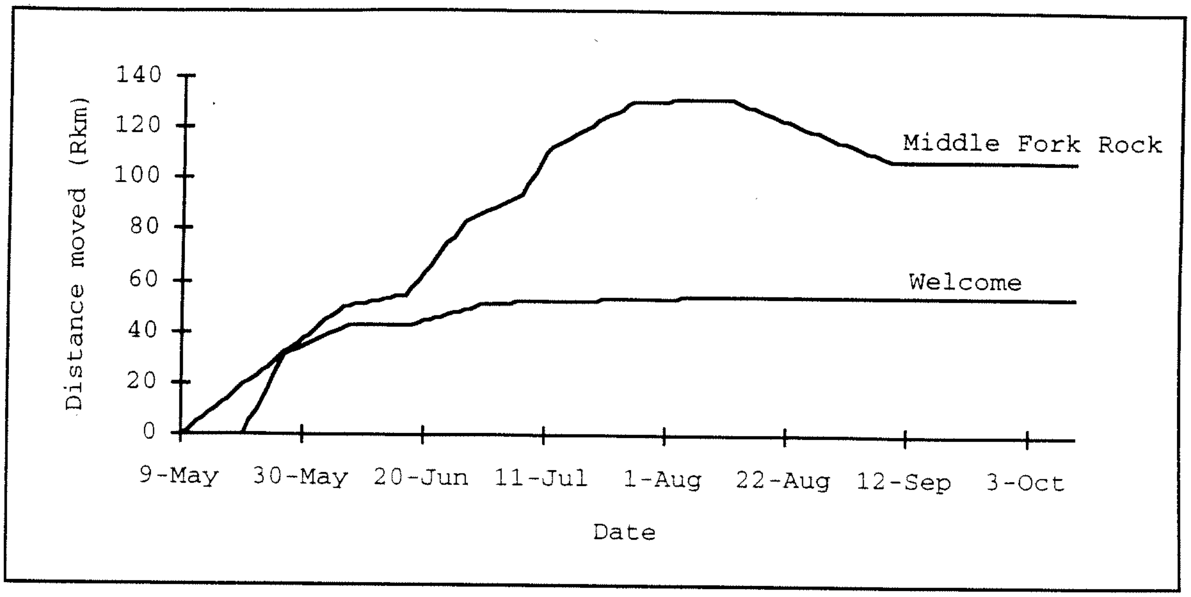


Figure 1. Upper Clark Fork drainages. During 1994, 2 bull trout released above Milltown Dam (•) moved to Rock Creek and 2 bull trout released in the lower Blackfoot River (▪) moved to Monture Creek and the North Fork of the Blackfoot River. Upstream-most locations for fish are ▲.



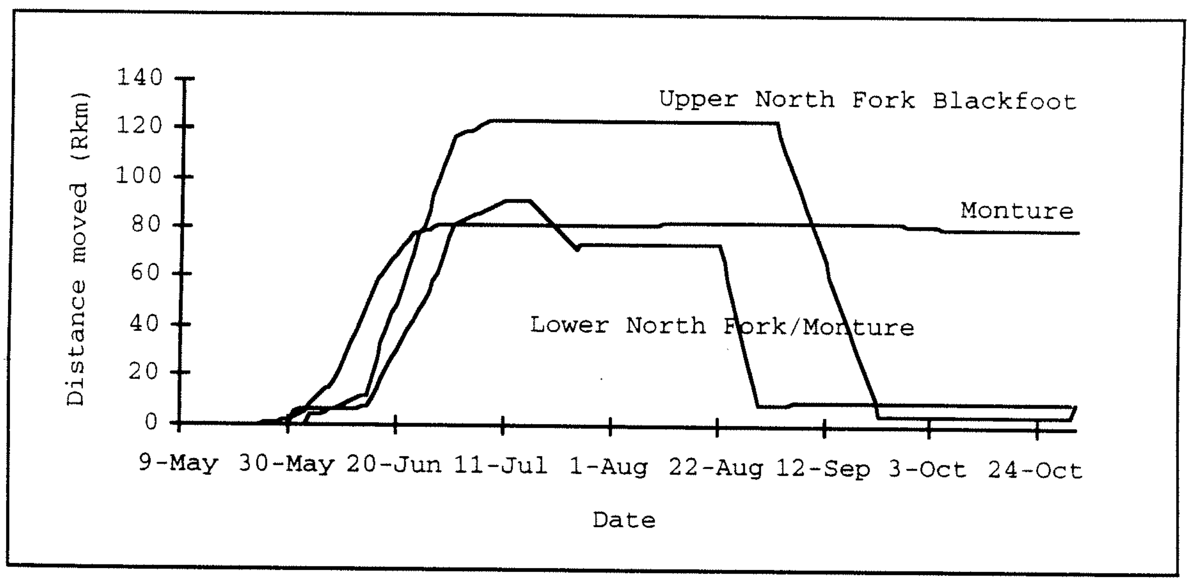
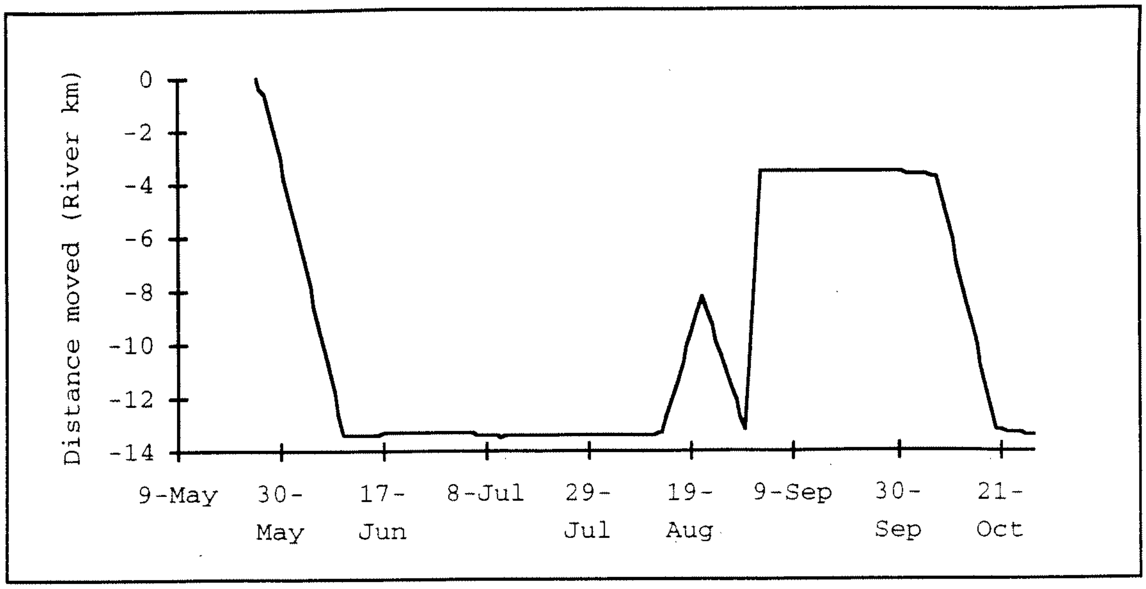


Figure 1. Seasonal movement of radio tagged bull trout in the Rock Creek (upper) and Blackfoot River (lower) drainages from May to October, 1994. River km 0 is approximately at the Clark Fork-Blackfoot confluence. Lines represent the daily average movement distance. All fish spawned, with the exception of the lower North Fork/Monture fish.



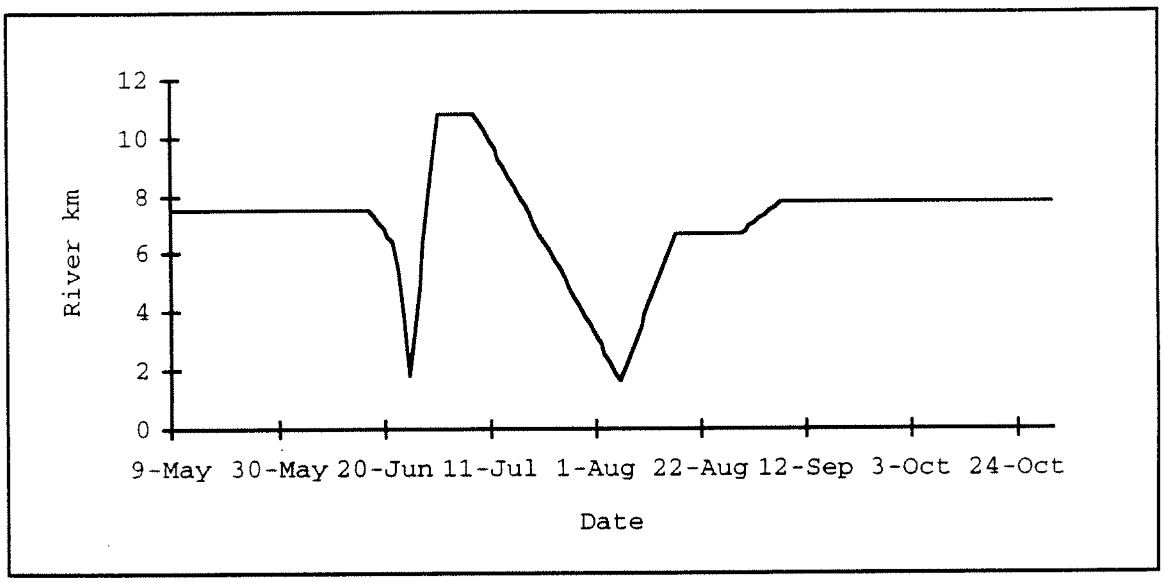
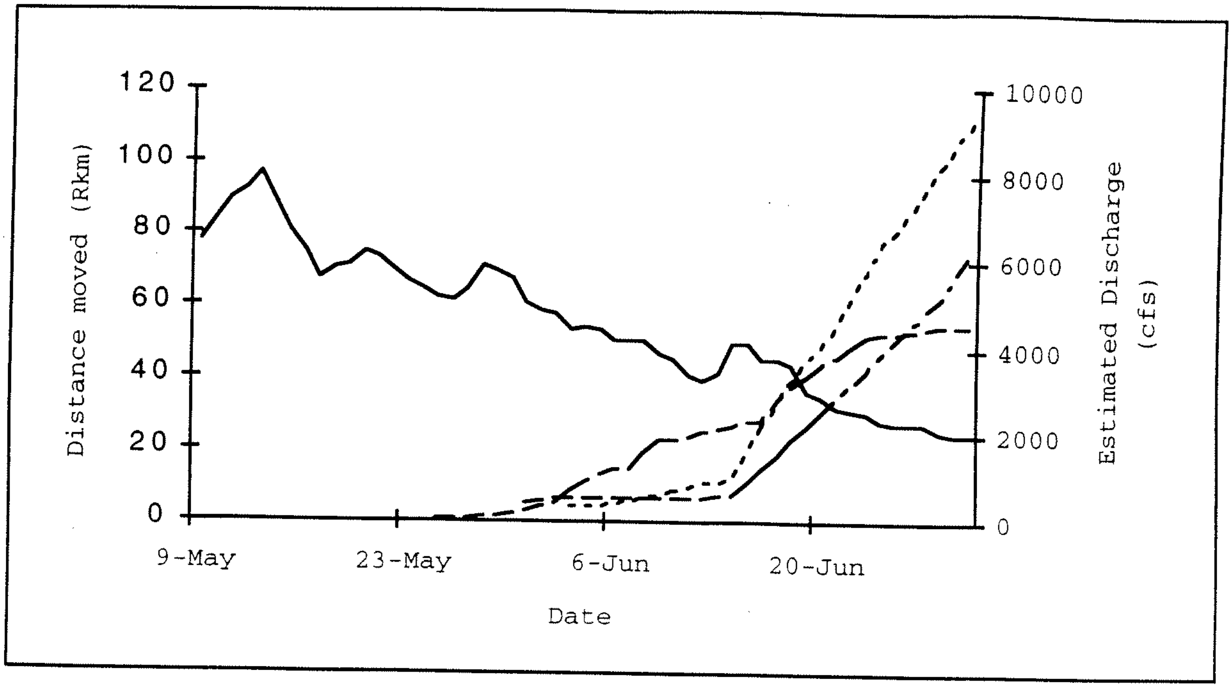


Figure 2. Seasonal movement of radio tagged bull trout in the Clark Fork River at Missoula (top) and the lower Blackfoot and upper Clark Fork Rivers (bottom). River km 0 is approximately at the Clark Fork-Blackfoot confluence. Lines represent the daily average movement distance. Neither of these fish spawned.



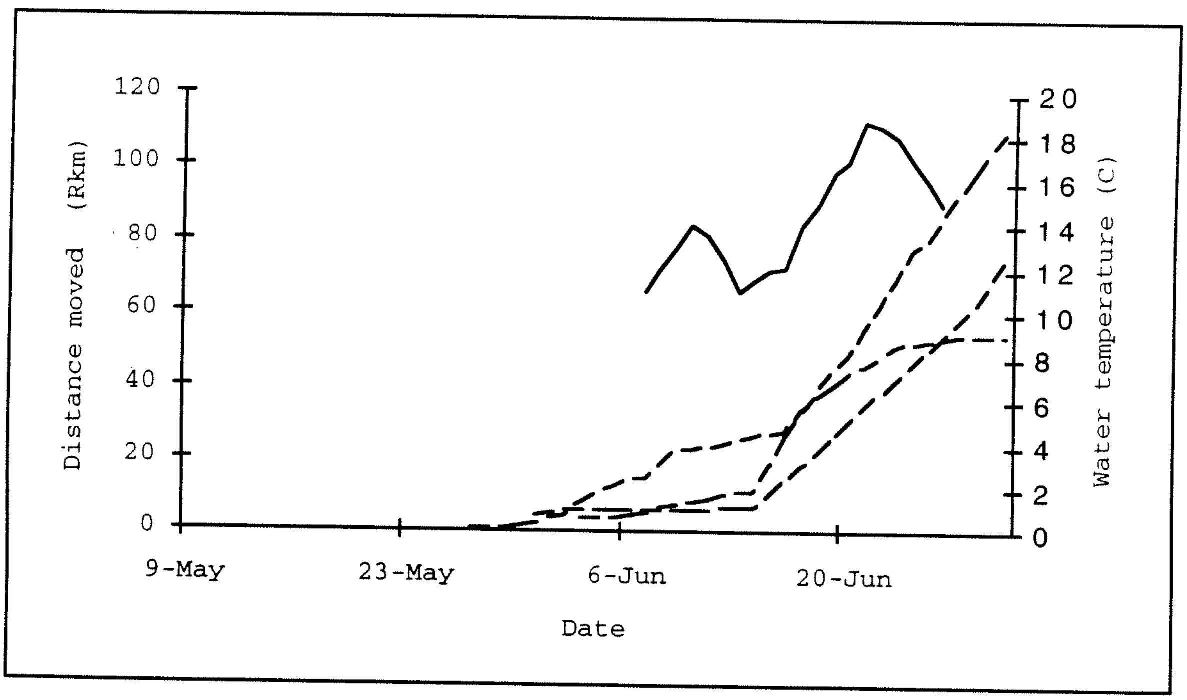


Figure 3. Correspondence of the initiation of seasonal movements with decreasing discharge (top) and increasing temperature (bottom) for radio tagged bull trout in the lower Blackfoot River. Solid line represents discharge and temperature, dashed lines represent fish movements.

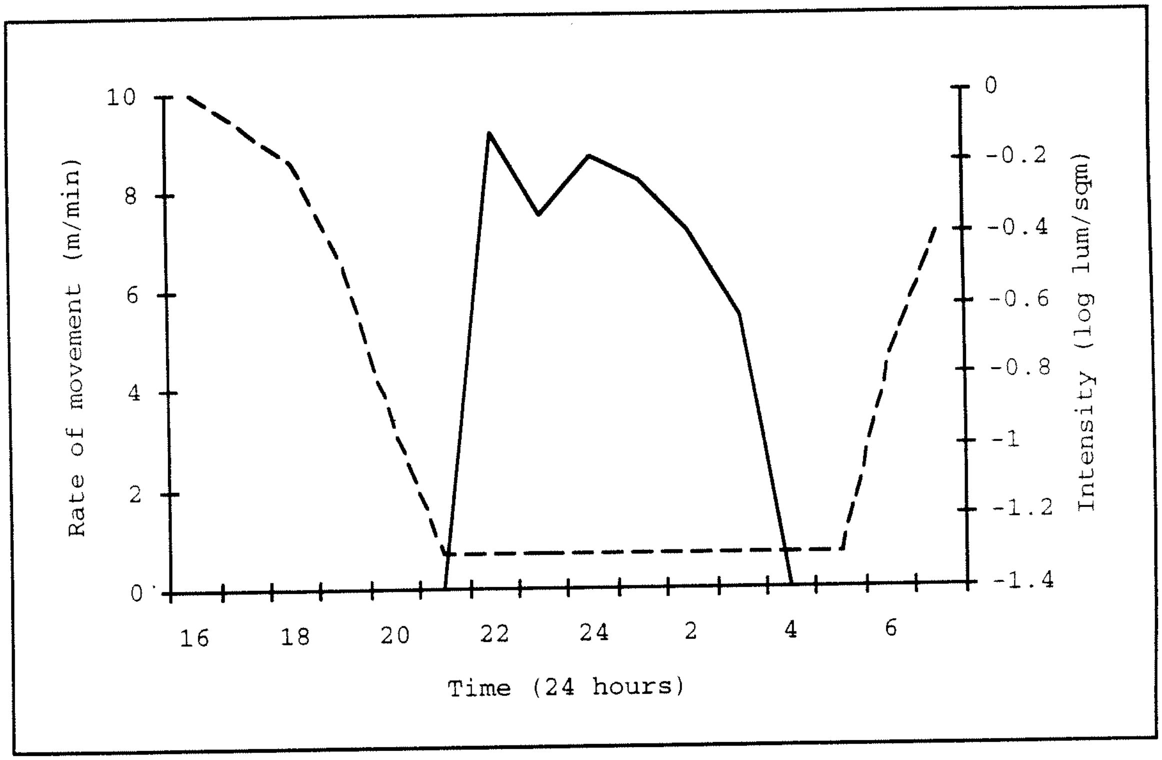


Figure 4. The relationship between light intensity and upstream movement during one night of a 14 d migration. Light intensity (dashed line) and rate of movement (solid line) are hourly averages.

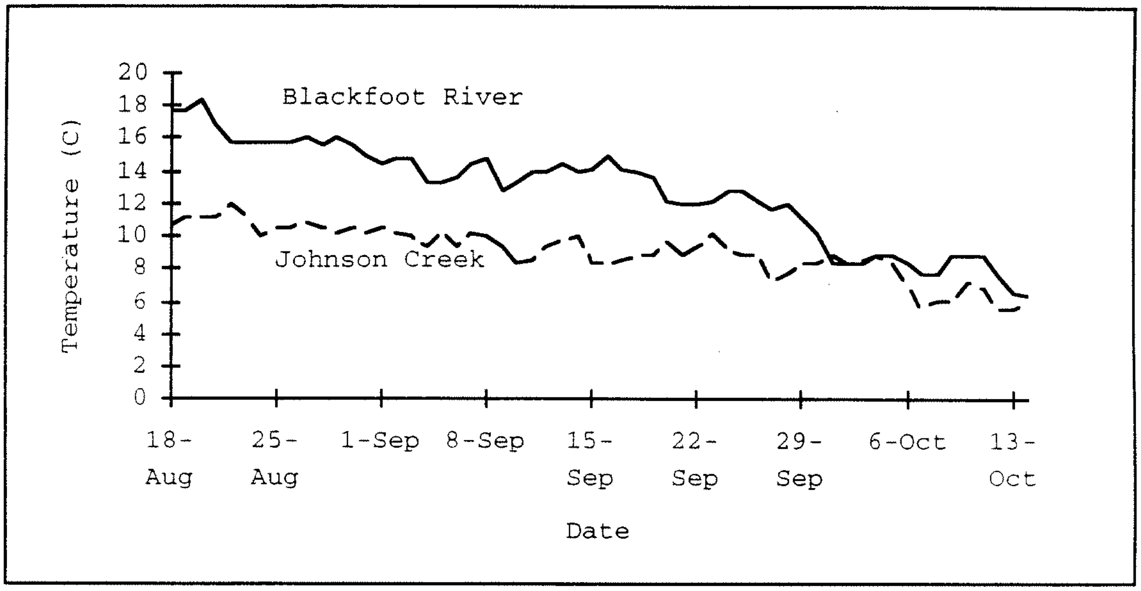


Figure 5. Daily average temperatures of Johnson Creek, a 5 cfs tributary to the Blackfoot River, and the Blackfoot 3 km above its confluence from August to October.

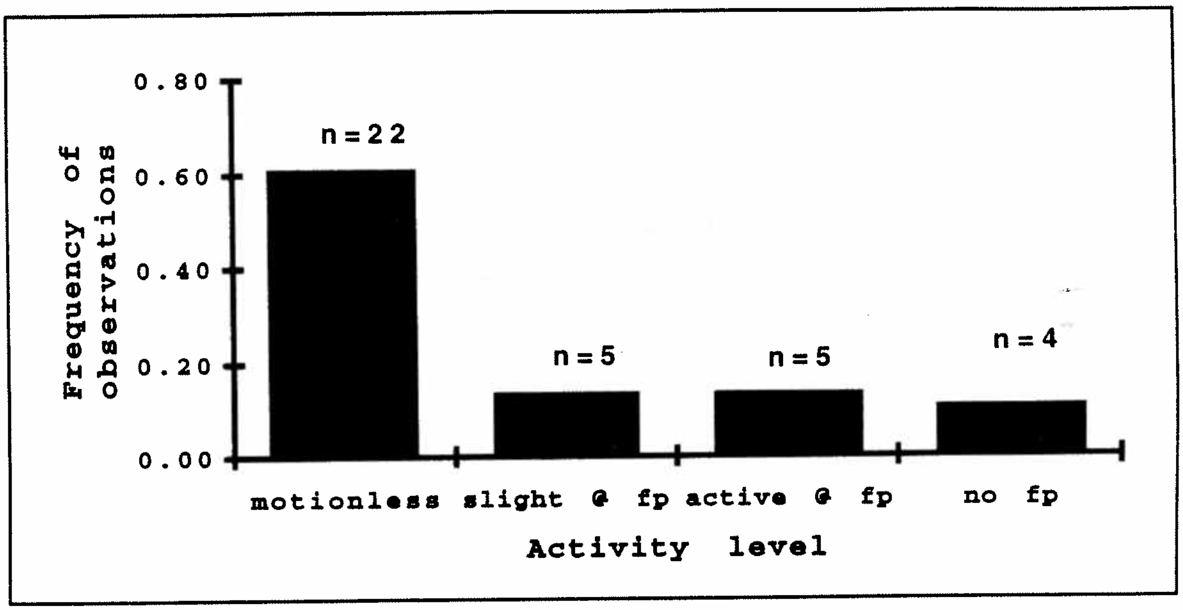


Figure 6. Observed activity levels of adult bull trout during summer and fall surveys in Monture Creek.

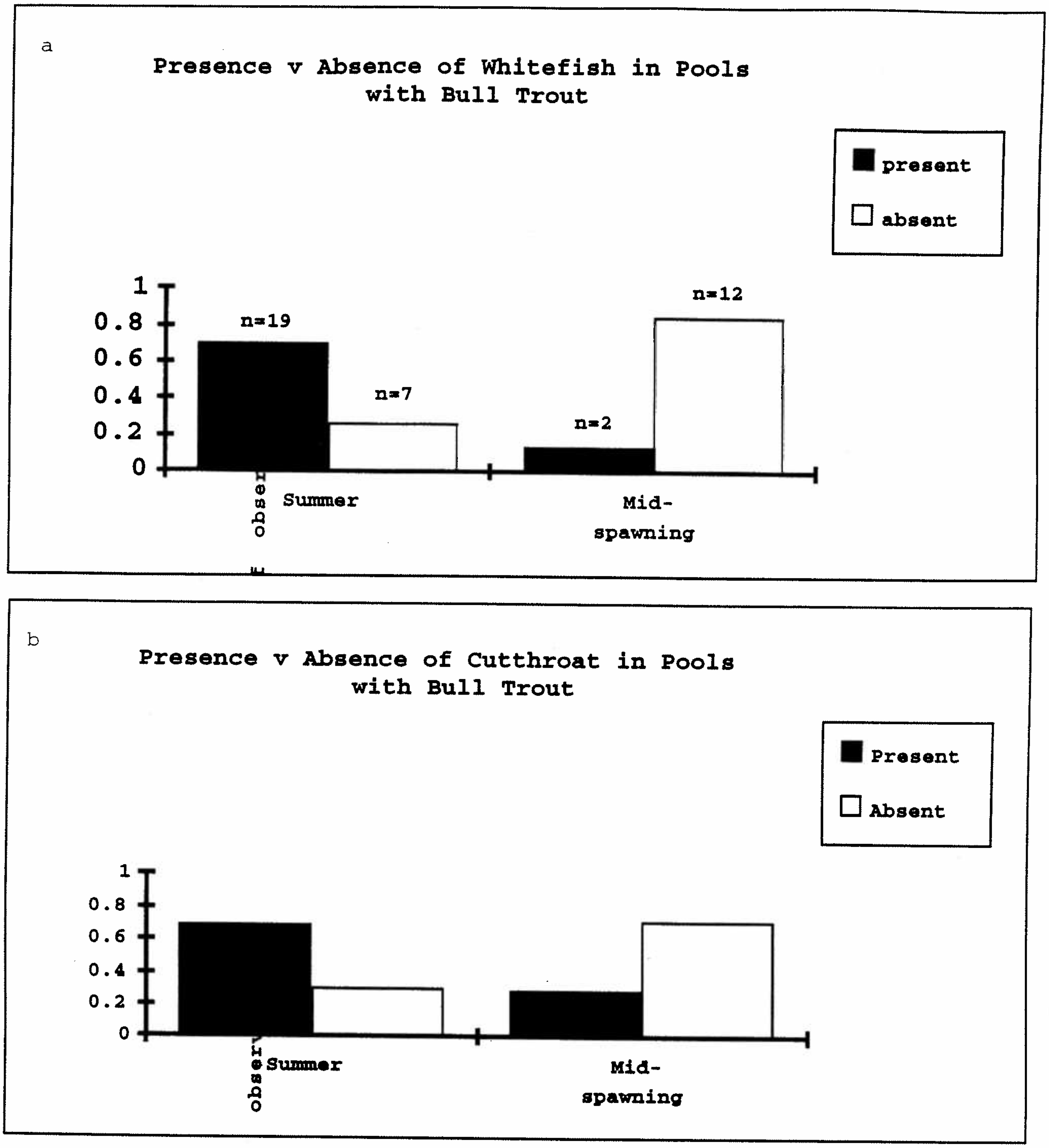
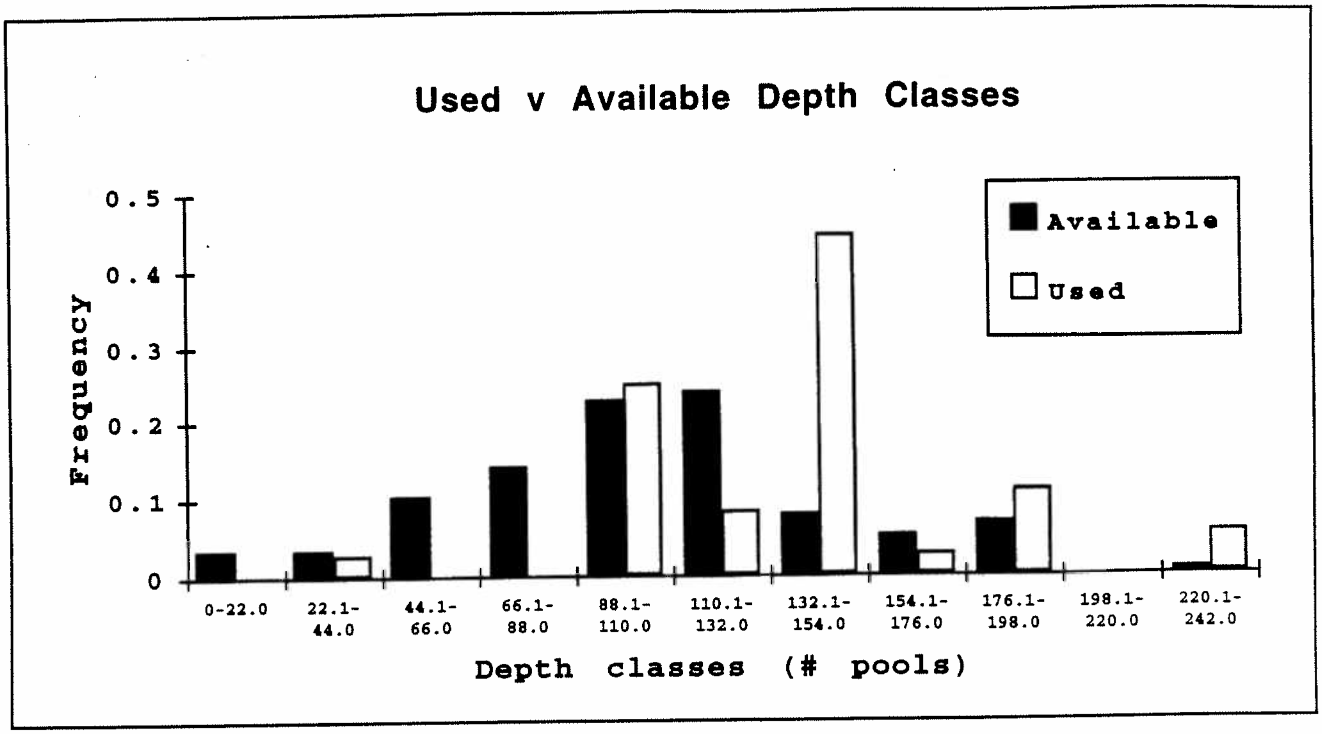


Figure 7. The association of bull trout with whitefish (7a) and cutthroat (7b) during summer and mid-spawning surveys.



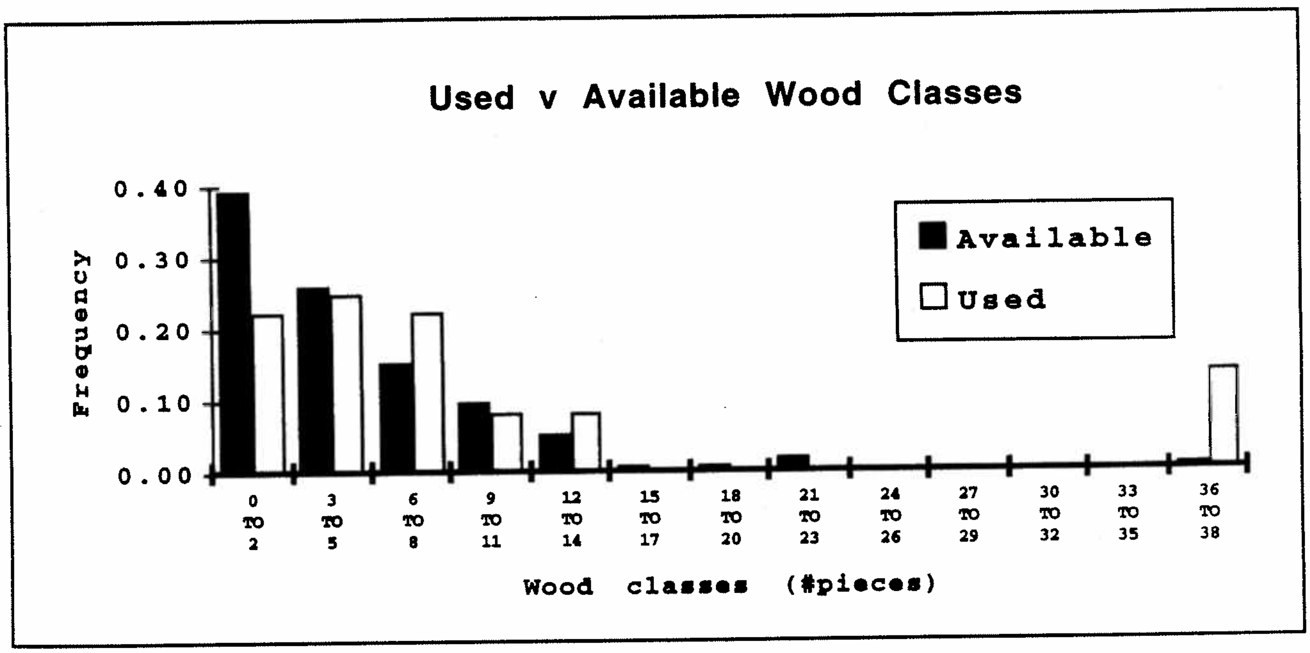


Figure 8. Frequencies of used and available pools for depth and total wood amounts.

Table 1. Information summary of bull trout receiving transmitters during 1994. Fish are grouped according to the area implanting occurred.

Fish code	Total length (mm)	Weight (g)	Estim. Age (y)	Capture date	Capture method	Number days tracked	Number of relocations	Last location	Movement > 10 Rkm	Transmitter status
					Below Milltown Dam					
24-20	378	500	5	16-May	HL	30	8	Clark Fk.- Msla	N	**Dropped 16-Jun**
21-08	505	1240	6	18-May	HL	146	11	Lower Rock Cr.	Y	**Dropped 18-Oct**
21-04	508	1080	6	9-May	HL	236	15	Upper Rock Cr.	Y	Active
21-05	642	3015	8	25-May	ES	220	30	Clark Fk.- Msla	Y	Active
21-01	725	4876	9	25-May	ES	9	3	Milltown Res.	-	**Lost 3-Jun**
					Lower Blackfoot R.					
22-14	345	350	5	24-May	ES	90	12	Lower Blackft R.	N	**No func. 15-Aug**
24-22	388	465	5	31-May	ES	45	13	Lower Blackft R.	N	**Dropped 15-Jul**
21-06	485	1130	6	24-May	ES	221	35	Lower Blackft R.	Y	Active
21-02	565	1850	7	24-May	ES	52	12	Lower Blackft R.	N	**Dropped 15-Jul**
21-09	590	2034	7	31-May	ES	220	36	Lower Blackft R.	Y	Active
21-07	625	3402	8	31-May	ES	220	41	Lower Blackft R.	Y	Active
21-03	665	3515	8	24-May	ES	221	40	Monture Cr.	Y	Active
							N Fork Blackfoot R.			
24-11	395	460	5	23-Aug	ES	130	10	Mid Blackft R.	Y	Active
24-19	491	980	6	23-Aug	ES	130	10	Mid Blackft R.	Y	Active
24-22	495	1040	6	23-Aug	ES	130	10	Mid Blackft R.	Y	Active
21-02	504	1215	6	23-Aug	ES	130	10	Mid Blackft R.	Y	Active
21-10	508	1109	6	23-Aug	ES	130	10	Mid Blackft R.	Y	Active
							Monture Cr.			
24-15	492	990	6	8-Sep	HL	114	8	Mid Blackft R.	N	Active

Table 2. Summary of the movements of bull trout with radio telemetry implants, May 9 to December 31. Movements >10 km were considered migrations. Perceived unidirectional movements were considered dispersals.

Fish code	First movement detected	Length (Rkm)	Elapsed time (d)	Average daily rate (Rkm/d)	Number of relocations during movement	Mean elapsed time between relocations (d)	Start point	End point
				Spawning migrations				
Upstream								
21-08	20-May	43	23	1.87 (0.16-4.43)	4	7.67	Milltown	Welcome Cr
21-04	9-May	130	78	1.69 (0.43-4.25)	7	13	Milltown	U Rock Cr
21-03	30-May	56	19	2.55 (1.07-5.33)	23	1.92	L BFR	Monture Cr
21-07	8-Jun	113	22	5.144 (0.27-8.40)	11	2.4	L BRF	U NFK BFR
Downstream								
21-04	2-Sep	24	21	0.84	1	21	U Rock Cr	U Rock Cr
21-07	20-Sep	119	31	5.67	1	31	N Fk	L BFR
				Other migrations (upstream and downstream)				
21-05	9-Jun	10	16	0.82	1	16	Milltown Res.	Clark Fk.- Msla
21-05	30-Aug	10	17	0.59 (0.56-0.63)	2	8.5	Clark Fk.- E Msla	Rattlesnake Cr.
21-05	2-Sep	10	3	3.24	1	3	Clark Fk.- Msla	Milltown Dam
21-05	20-Oct	10	12	0.79	1	12	Milltown Dam	Clark Fk.- Msla
24-20	8-Jun	10	21	2.1	1	21	Abv Milltwon	Missoula
21-06	1-Jul	13	7	1.95	1	7	L BFR	U Clark Fk
21-06	17-Aug	13	39	-	1	39	U Clark Fk	L BFR
21-09	28-Jun	78	31	2.52 (1.81-6.79)	10	3.44	L BFR	NFK
21-09	30-Jul	30	18	1.90 (0.95-2.17)	2	9	NFK BFR	Monture
21-09	30-Aug	79	9	8.51	1	9	Monture Cr.	L BFR

Table 3. Summary of data from holding period in tributaries. All dates are approximate.

Fish code	Tributary	Date of arrival	Date of departure	Elasped time in tributary (d)	Spawning likely?	Number of relocations during period	Average elapsed time between relocations (d)
			Rock Creek				
21-04	Middle Fork	26-Jul	12-Aug	47	Y	6	2.8 (1-8)
21-08	Welcome Cr.	1-Jul	-	unknown	?	5	17.0 (8-27)
			Blackfoot River				
21-03	Monture Cr.	23-Jun	1-Oct	94	Y	12	8 (1-21)
21-07	North Fork	28-Jun	20-Sep	63	Y	8	10.5 (1-27)
21-09	North Fork	1-Jul	30-Jul	<30	N	2	7.5
21-09	Monture Cr.	30-Jul	30-Aug	>30	N	4	11 (2-16)