MOVEMENT AND HABITAT SELECTION OF ARCTIC GRAYLING, BROOK TROUT, AND MOUNTAIN WHITEFISH DURING DROUGHT CONDITIONS IN THE BIG HOLE RIVER, MT

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January 2003

Acknowledgments

We'd like to thank Scott Lula (MFWP) for conducting the field portion of this study. Scott helped capture the fish, surgically implanted transmitters, tracked fish, and recorded the data for this study. Randy Gazda USFWS's Partners for Fish and Wildlife Program assisted with project design, funding efforts and reviewed this report. David Schmetterling (MFWP) provided assistance with telemetry techniques and coordinated a telemetry workshop. Washoe Park State Fish Hatchery personnel provided facilities and fish for telemetry workshop. This project was funded by Montana Fish, Wildlife and Parks, the USFWS's Partners for Fish and Wildlife Program, a USFWS grant from reverted Dingel Johnson funds and Montana Trout Foundation. The Montana Trout Foundation grant was administered through the Big Hole River Foundation and we would like to thank Jennifer Dwyer for her administrative and funding efforts.

Abstract

We used radio telemetry to track the movement patterns of 15 Arctic grayling (*Thymallus arcticus*), 8 brook trout (*Salvelinus fontinalis*), and 7 mountain whitefish (*Prosopium williamsoni*) during the summer drought conditions of 2002 in the Big Hole River, MT. Study fish were captured, transmitters were implanted, and fish were released into the Big Hole River during the last two weeks of April. Fish were tracked and location and habitat preferences were recorded over the period of April 15 to September 9, 2002. Individuals of each species moved long distances (> 15 mi.). These movements were correlated with periods of high stream flow and warm water temperatures. The three species of study fish showed a habitat preference for pools. While grayling and whitefish were most often found using water depth, brook trout showed a preference for undercut banks and large woody debris, as a cover source. A high rate of apparent predation (> 50%) was observed during the study. We believe that this was due to the relative advantage given to potential predators during the low water conditions that occurred during the study period.

Introduction

The Big Hole River in southwestern Montana supports the last fluvial population of Arctic grayling (*Thymallus arcticus*) in the contiguous United States (Byorth and Magee 1998). Low instream flow in the Big Hole River has been identified as a limiting factor of Arctic grayling and other sport fish species (Kaya 1992). The current high level of agricultural demand for water can exacerbate the impacts of low streamflow during drought years by reducing the volume of water available to fish, impeding migration and reducing access and quality of instream thermal refugia (Kaya 1992, Elliott 2000). Conducting a telemetry study that provides additional understanding of the effects of drought conditions on the behavior and survival of Arctic grayling and other species of game fish in the Big Hole River was identified as a short-term priority by the Fluvial Arctic Grayling Recovery Program (Magee 2002). The objectives of the study were: 1) to determine the movement patterns of game fish species in the Big Hole River during drought conditions, and; 2) to determine the habitat and cover type preferences of game fish species in the Big Hole River during drought conditions.

Methods

Fish for the study were captured in April 2002 using a mobile-anode DC system powered by a 4,000 watt generator, coupled with a Coffelt Mark XXII-M rectifying unit mounted on a drift boat (Table 1). Fish captured for the study were held in a live well prior to processing. Prior to surgery, individuals were anesthetized in a Tricaine Methanesulfonate (MS-222) bath, measured for total length (± 0.1 in.) and weight (± 0.01 lb.). Scale samples were taken from each individual for the purpose of aging. A visible-implant (VI) tag was injected into the adipose eyelid to provide an additional method of identifying individuals used in the study in the event of recapture during future population sampling events. We captured 15 Arctic grayling, 8 brook trout (*Salvelinus fontinalis*), and 7 mountain whitefish (*Prosopium williamsoni*) from the Big Hole River for the study (Table 1). Arctic grayling averaged 14.0 in. in length (range 13.2 – 15.2 in.) with an average weight of 0.88 lb. (range 0.72 – 1.09 lb.). Brook trout averaged 15.4 in. in length (range 13.6 – 19.3 in.) with an average weight of 1.27 lb. (range 0.87 – 2.08 lb.). Mountain whitefish averaged 16.0 in. in length (range 14.0 – 18.0 in.) with an average weight of 1.34 lb. (range 0.86 – 1.79 lb.).

A Lotek MCFT–3CM radio transmitter was surgically inserted into the body cavity of each fish with the antennae extending approximately 18" through the body wall on the ventral side behind the pelvic girdle (Picture 1). Transmitters were 1.75" long and weighed approximately 2.4 oz in water. Transmitters were inserted into individuals that provided for a transmitter to body weight ratio equal to or less than 0.02 (Hop et al 1986). After surgery was completed, fish were allowed to recover, and released near the point of capture.

Picture 1. Surgically implanting a radio transmitter into a mountain whitefish.

Table 1. Summary of capture information for fish used in the 2002 Big Hole River telemetry study.

SECTION	SPECIES	LENGTH (In.)	WEIGHT(lb.)	VI#	FREQ	DATE OF SURGERY
MCDOWELL	BROOK TROUT	13.6	0.87	YN9	560.01	04/29/2002
MCDOWELL	BROOK TROUT	15.5	1.36	YP3	560.06	04/29/2002
MCDOWELL	BROOK TROUT	16.9	1.49	YN8	560.09	04/29/2002
MCDOWELL	BROOK TROUT	14.9	1.27	YN7	580.07	04/29/2002
MCDOWELL	BROOK TROUT	19.3	2.08	YN3	600.05	04/29/2002
MCDOWELL	BROOK TROUT	14.0	0.90	YN5	600.09	04/29/2002
WISDOM-WEST	BROOK TROUT	15.1	1.20	NP4	600.06	04/24/2002
WISDOM-WEST	BROOK TROUT	13.9	0.95	NP0	600.10	04/24/2002
	MEAN	15.4	1.27			
LNF	GRAYLING	13.4	0.78	NS9	580.04	04/26/2002
LNF	GRAYLING	14.0	1.00	YN1	580.10	04/26/2002
MCDOWELL	GRAYLING	14.4	0.86	BK4	560.10	04/29/2002
MCDOWELL	GRAYLING	14.0	0.76	YN4	580.03	04/29/2002
UNF	GRAYLING	13.2	0.82	C94	560.05	04/25/2002
UNF	GRAYLING	14.8	0.94	NR5	560.08	04/25/2002
UNF	GRAYLING	13.9	0.78	NS3	580.02	04/25/2002
UNF	GRAYLING	15.2	1.09	NR3	580.05	04/25/2002
UNF	GRAYLING	13.4	0.86	NR2	580.06	04/25/2002
UNF	GRAYLING	13.2	0.72	NR8	600.01	04/25/2002
UNF	GRAYLING	14.5	1.04	NS2	600.02	04/25/2002
UNF	GRAYLING	14.3	0.94	NR9	600.07	04/25/2002
WISDOM-WEST	GRAYLING	13.6	0.92	NP9	580.01	04/24/2002
WISDOM-WEST	GRAYLING	13.8	0.92	NP2	580.08	04/24/2002
WISDOM-WEST	GRAYLING	13.7	0.84	EP0	580.09	04/24/2002
	MEAN	14.0	0.88			
LNF	WHITEFISH	17.1	1.68	YN2	600.04	04/29/2002
MCDOWELL	WHITEFISH	14.0	0.86	YP1	600.08	04/29/2002
PINTLAR-SQUAW	WHITEFISH	18.0	1.79	YM4	560.02	04/15/2002
UNF	WHITEFISH	17.1	1.56	NS1	560.04	04/25/2002
UNF	WHITEFISH	16.5	1.47	NS0	560.07	04/25/2002
WISDOM-WEST	WHITEFISH	14.4	0.98	NN9	560.03	04/24/2002
WISDOM-WEST	WHITEFISH	14.6	1.04	NP3	600.03	04/24/2002
	MEAN	16.0	1.34			

Fish were tracked and located using a Lotek SRX 400 radio telemetry receiver during daylight hours on 34 days over the 148-day period, April 15 to September 9, 2002. When fish were located the UTM coordinates and habitat variables at that site were recorded. Habitat information collected at each location included: water temperature, stream habitat unit and cover types. Locations and habitat selection data were plotted using Arcview 3.2 GIS software. Data was analyzed using Arcview 3.2 GIS and Microsoft Excel software.

The U.S. Geological Survey (USGS) Wisdom gauging station monitored water temperature and discharge data. Hourly measurements from the gauging station for temperature and discharge were entered into Microsoft Excel software for analysis.

Results

Stream flow and temperature conditions

Flows at the Wisdom gauging station in the Big Hole River peaked on June 3 at 1330 cubic feet per second (cfs) (Table 2, Figure 1). Minimum flows of 13 cfs occurred on August 19 and 20 (Table 2). Monthly mean flows peaked in June at 409 cfs and bottomed out in August at 27 cfs (Table 2).

Table 2. Monthly summary of stream flow conditions at the Wisdom gauging station in the Big Hole River.

Month	Mean (cfs)	Max (cfs)	Min (cfs)
May	199	435	69
June	409	1330	100
July	62	88	36
August	27	51	13
September	39	52	20

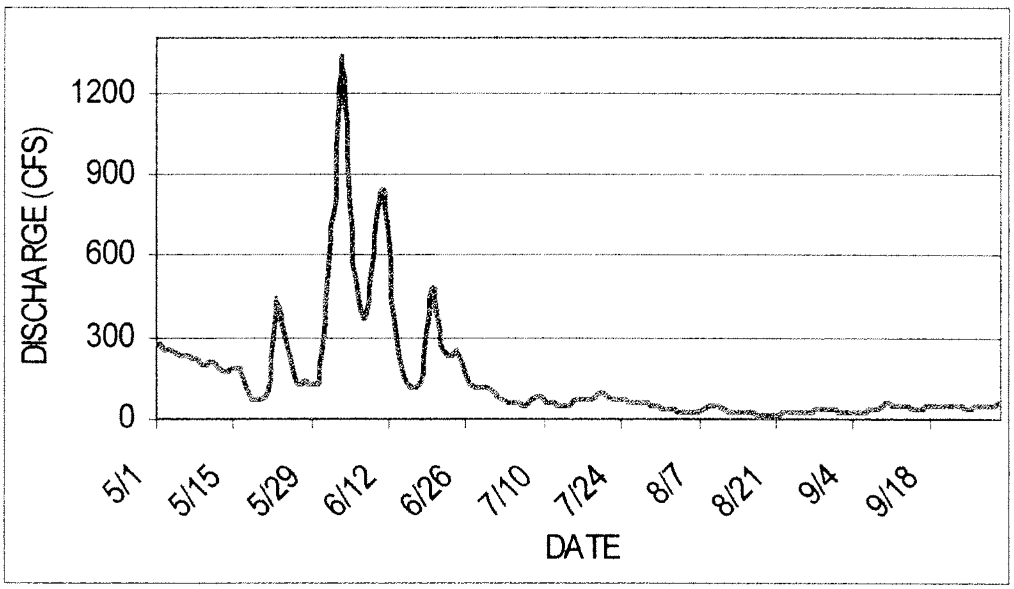

Figure 1. Hydrograph data from the Wisdom gauging station in the Big Hole River.

Stream water temperatures at the Wisdom gauging station in the Big Hole River peaked on July 12 at 80° F (Table 3, Figure 2). Monthly mean water temperatures were highest in July (66° F) and lowest in May (49° F) (Table 3). The month of July had the greatest number (26) of days that the maximum water temperature for the day was above

70° F (Table 3). Daily maximum temperatures did not exceed 70° F during the months of May and September (Table 3).

Table 3. Monthly summary of stream temperatures at the Wisdom gauging station in the Big Hole River.

Month	Mean (F)	Max (F)	Min (F)	Days Max > 70
May	49	68	35	0
June	58	74	42	7
July	66	80	55	26
August	60	72	49	6
September	54	69	42	0

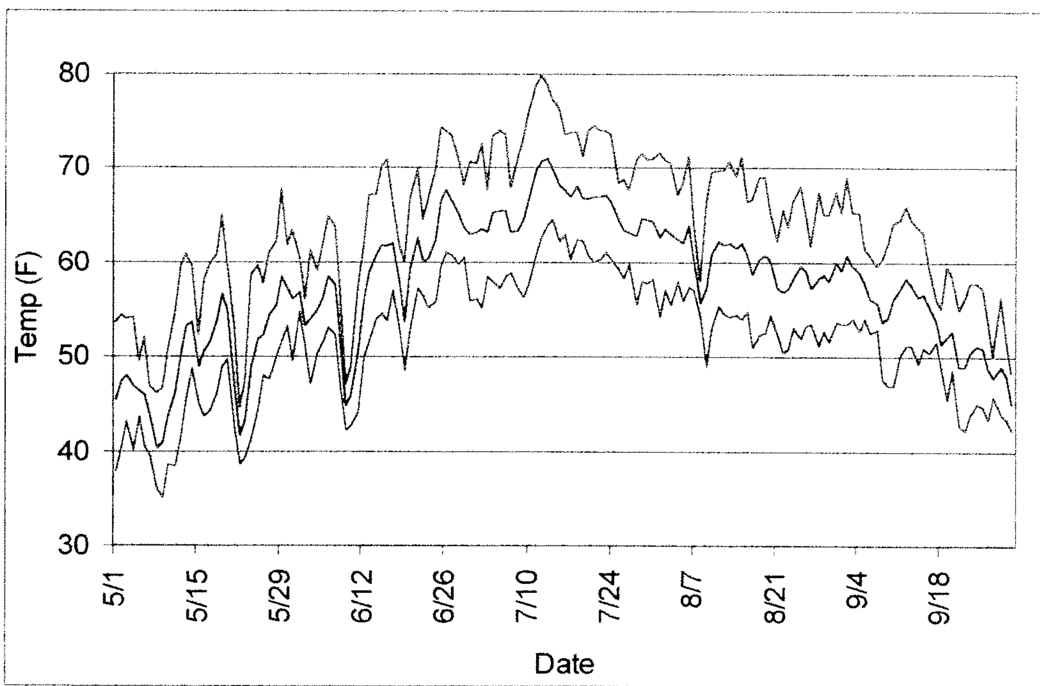

Figure 2. Stream thermograph data from Wisdom gauging station in the Big Hole River.

Fish Movement Patterns

We located fish on 144 occasions over the period April 24 to September 9 2002 (Figures 3-5). Of the three species tracked during the study, brook trout moved the least (mi.) and at the slowest rate (mi. / wk.) (Table 4). Movement parameters for Arctic grayling and mountain whitefish were not statistically different (Table 4).

Table 4. Summary of location and movement results for the Big Hole River telemetry study 2002. Variations are shown as standard error.

species	# of fish	# of loc.	period of locations	mean dist. moved (mi)	rate of movement (mi/wk)
grayling	15	62	Apr 24 – Aug 13	5.1 ± 1.4	1.7 ± 0.4
brook trout	8	48	Apr 24 – Sept 9	1.5 ± 0.5	0.6 ± 0.2
whitefish	7	34	Apr 15 – July 22	4.4 ± 1.7	1.6 ± 0.4

Movement patterns for the 3 species of fish used in the study are best described as having long periods of little movement, followed by short periods in which individuals moved long distances, either upstream or downstream. Peak movement for Arctic grayling occurred between May 24 and June 12 (Figure 6). The timing of these movements seems to be correlated with the high flows that occurred during this period of time (Figure 1). Grayling may be using these high flow events to assist in moving from spawning areas to more productive feeding areas downstream.

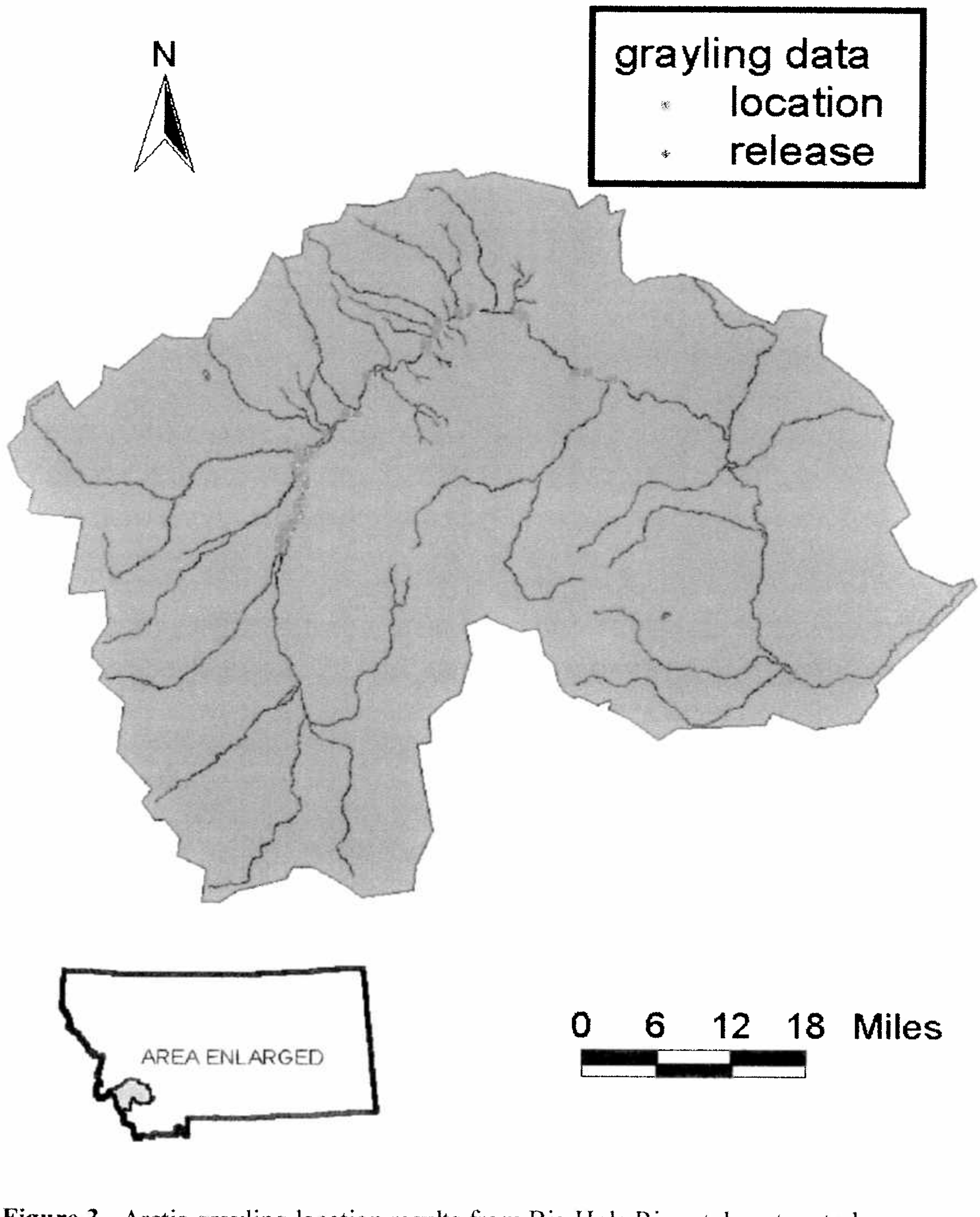

Figure 3. Arctic grayling location results from Big Hole River telemetry study.

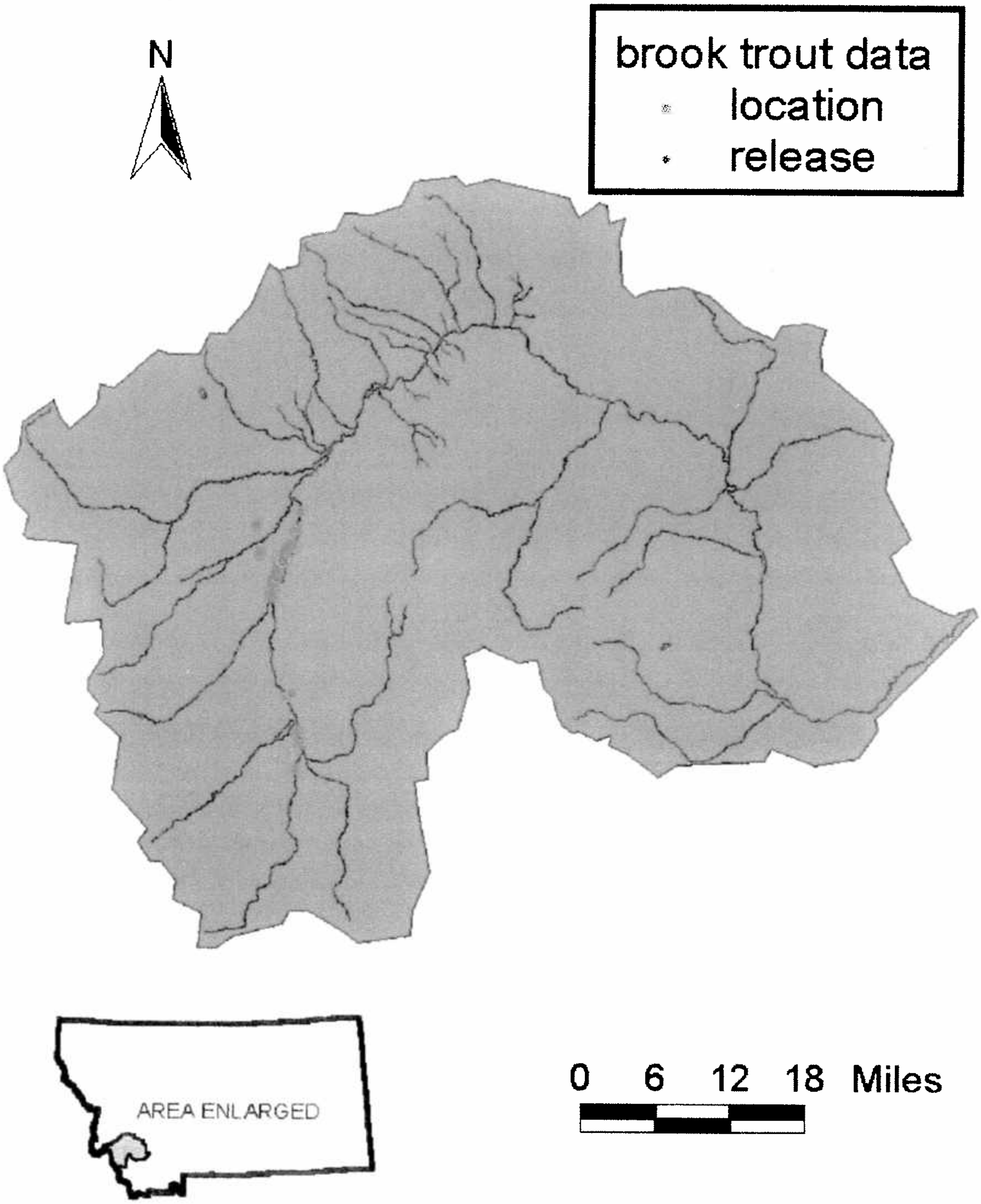

Figure 4. Brook trout location results from Big Hole River telemetry study.

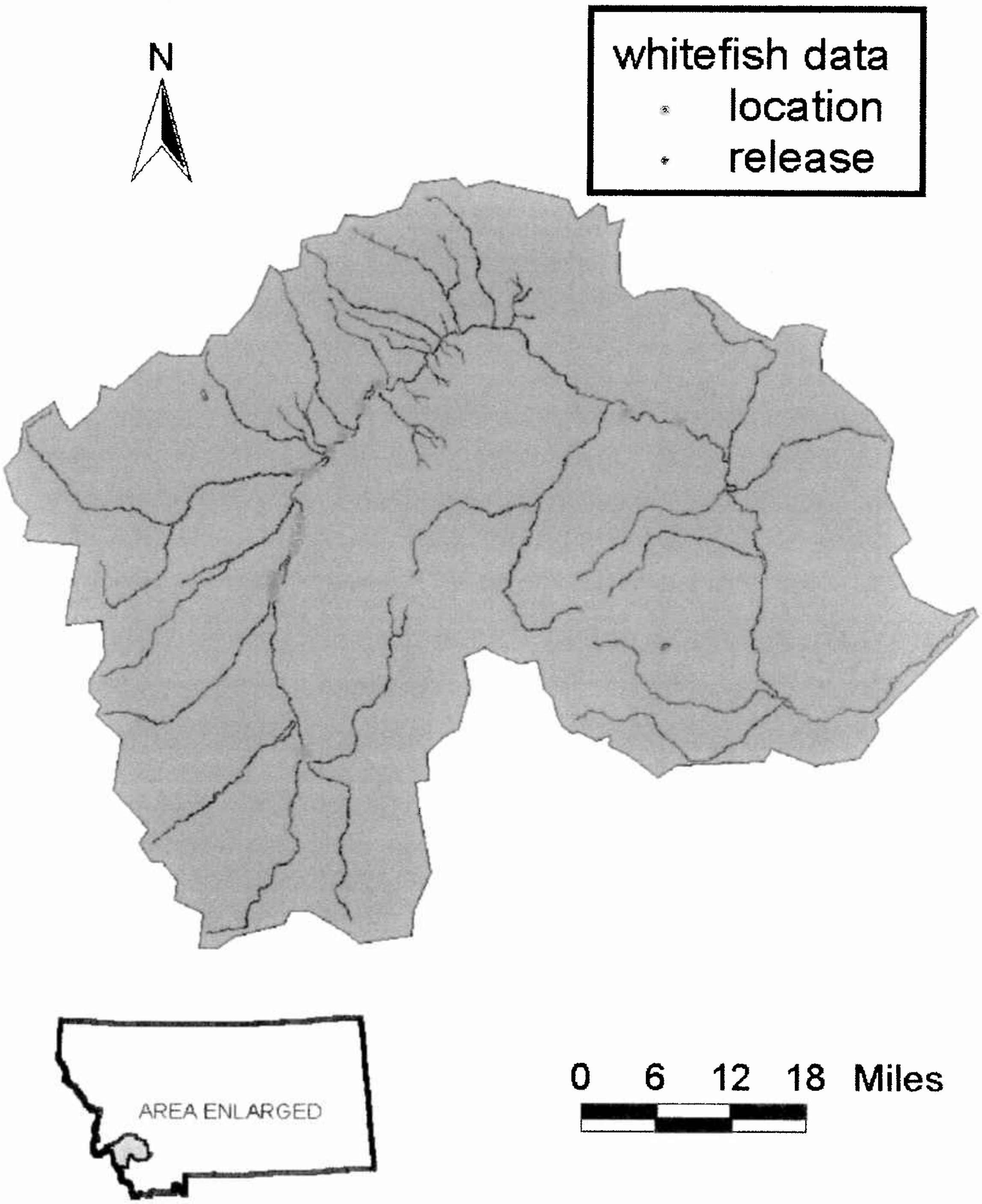

Figure 5. Mountain whitefish location results from Big Hole River telemetry study.

Brook trout movements were greatest during the period of July 8 to July 16 (Figure 7). The brook trout movement pattern seems to be influenced primarily by the warm water temperatures that occurred during their period of peak movement (Figure 2). Movements may have been induced by a need to find thermal refugia during this time, possibly in the form of ground water upwellings or springs.

The period of peak movement for mountain whitefish occurred between June 12 and June 17 (Figure 8). Also, a downstream movement of nearly 40 miles occurred on July 10 by an individual whitefish (Figure 8). These movement periods correlate strongly with the high flows of mid-June (Figure 1) and the warm water temperatures of mid- July (Figure 2).

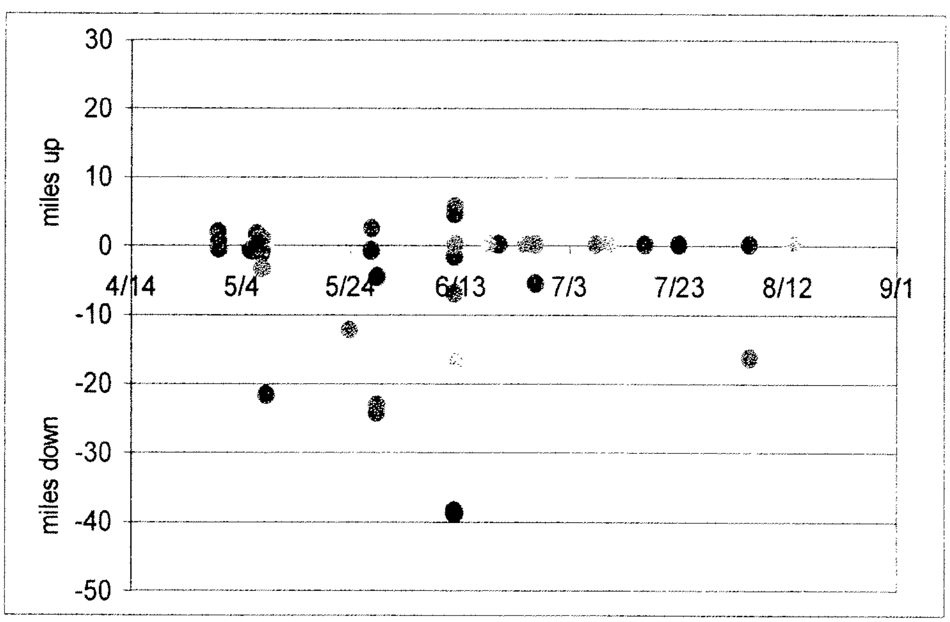

Figure 6. Arctic grayling movement patterns. Colors represent individual fish.

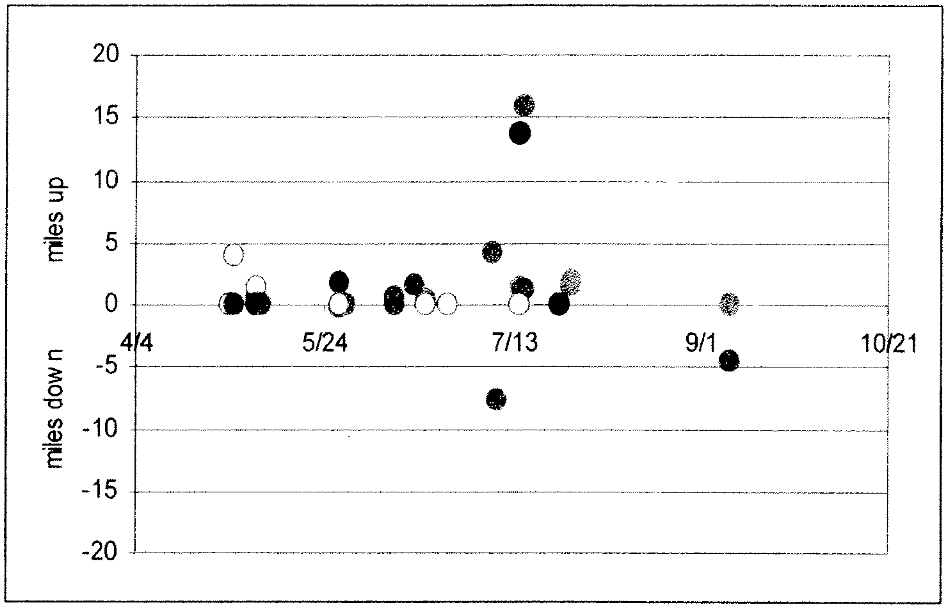

Figure 7. Brook trout movement patterns. Colors represent individual fish.

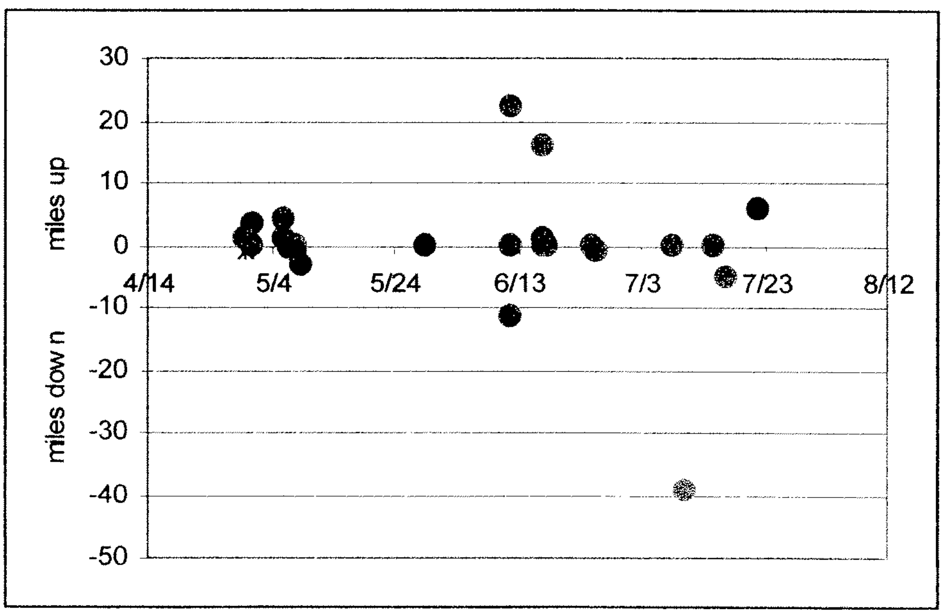

Figure 8. Mountain whitefish movement patterns. Colors represent individual fish.

Habitat selection results

A large majority of the fish remained in the main channel of the Big Hole River during the study (Figure 9). While all of the grayling remained in the main channel, we did locate brook trout in irrigation ditches and mountain whitefish in tributaries connected to the Big Hole River (Figure 9). The two brook trout that were located in the irrigation ditches were later located back in the main channel of the Big Hole River. The mountain whitefish that was located in North Fork of Big Hole River on two occasions also returned to the main channel of the river.

Stream channel selection patterns were similar for the three study species. Approximately 70 % of stream channel unit locations for individuals of each species were in pools and 30 % were in runs (Figure 10). We did locate one grayling in the tail of a riffle, which we believed to be spawning. While the pattern for cover type selection for grayling and whitefish was similar, their pattern was markedly distinct from brook trout (Figure 11). While grayling and whitefish relied heavily on water depth for cover, brook trout were usually found using water depth, undercut banks, and woody debris as a source of cover. The selection of cover type may be a critical component of the life history strategy of the three study species.

Greater than 50 % of the transmitters deployed for the study were found near some sign of predation (i.e. carcass on bank, claw, or teeth marks on transmitter..) or were believed to have been expelled by the fish (Table 5). The fish that expelled transmitters may also have been preyed upon, but the final location site lacked any definitive evidence.

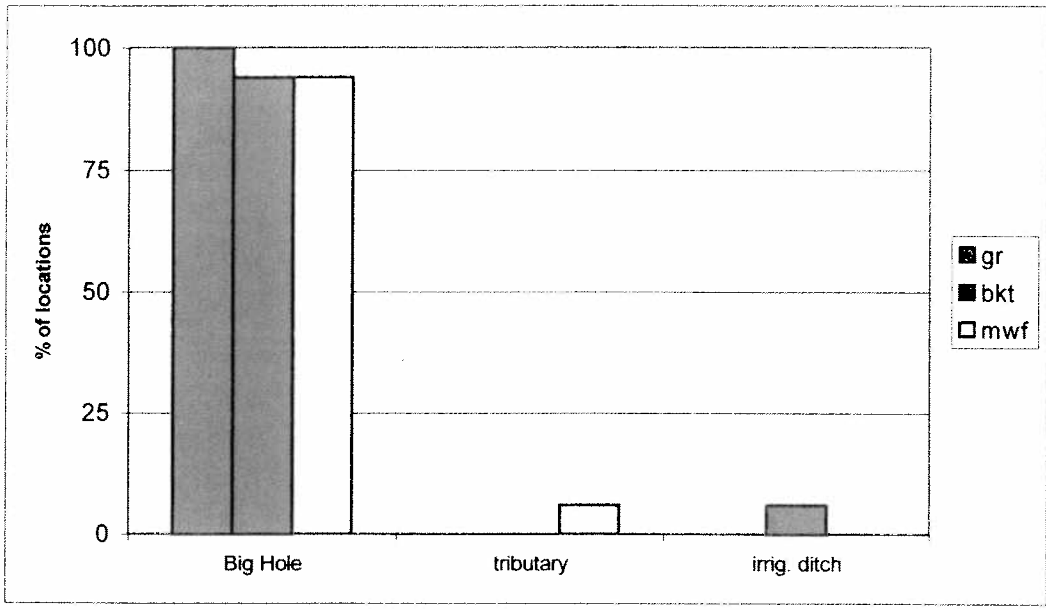

Figure 9. Large scale habitat selection results (n = 148). Arctic grayling = gr, brook trout = bkt, and mountain whitefish = mwf.

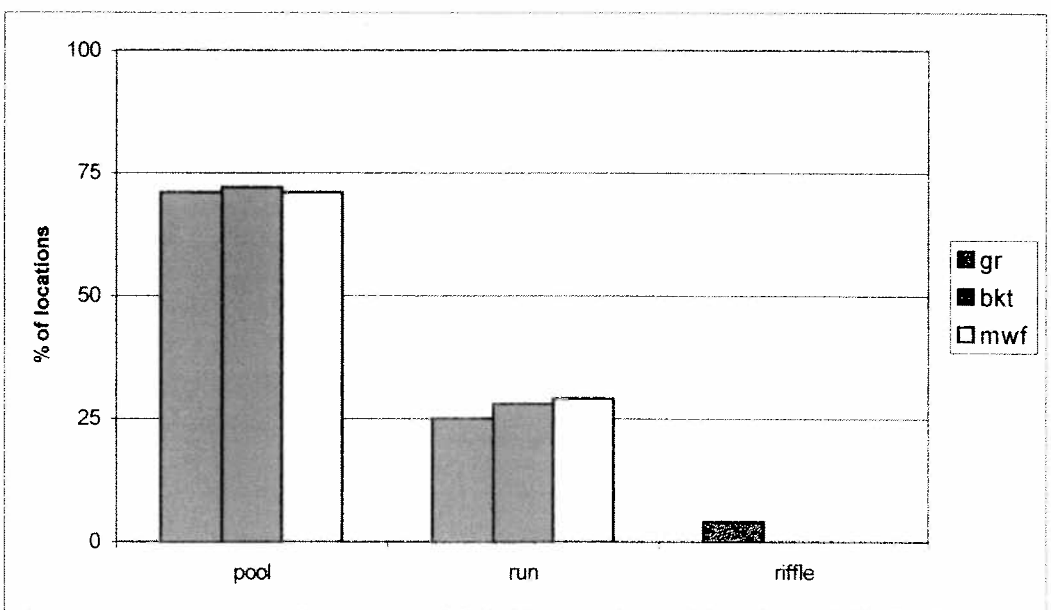

Figure 10. Stream channel unit selection results (n = 77). Arctic grayling = gr, brook trout = bkt, and mountain whitefish = mwf.

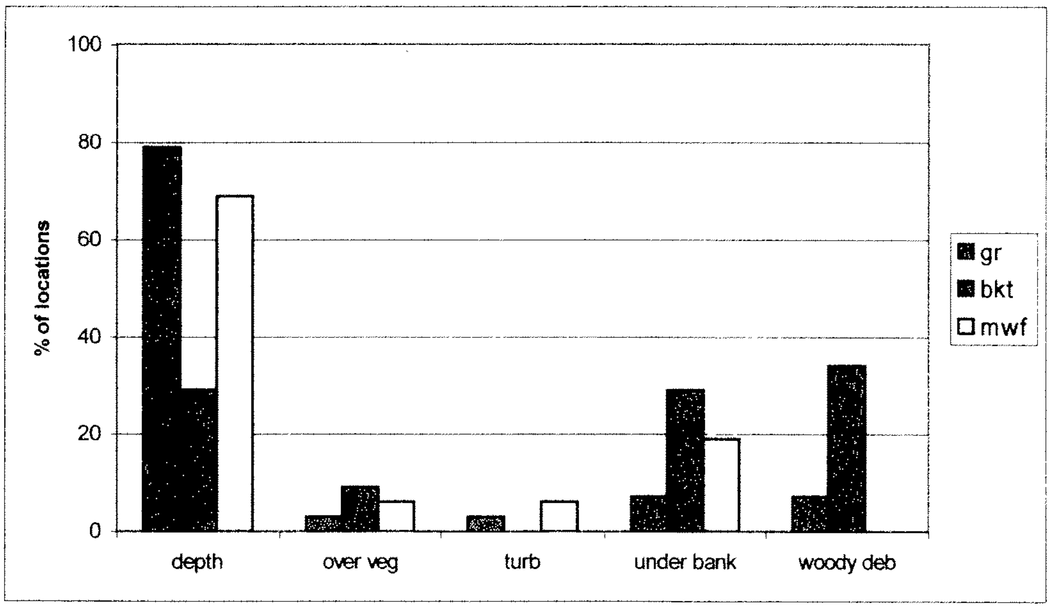

Figure 11. Cover type selection results (n = 77). Depth = water depth, over veg = overhanging vegetation, turb = surface water turbulence, under bank = undercut bank, and woody deb = large woody debris. Arctic grayling = gr, brook trout = bkt, and mountain whitefish = mwf.

Table 5. Summary information for transmitters located independent of study fish.

Frequency	Species	Date of surgery	Date of last contact	Believed reason for failure
560.01	brook trout	4/29/02	9/09/02	transmitter expelled
560.02	whitefish	4/15/02	7/22/02	predation
560.05	grayling	4/25/02	7/23/02	predation
560.06	brook trout	4/29/02	7/16/02	predation
560.07	whitefish	4/25/02	6/18/02	predation
560.08	grayling	4/25/02	8/05/02	predation
580.02	grayling	4/25/02	8/05/02	predation
580.04	grayling	4/26/02	8/13/02	transmitter expelled
580.06	grayling	4/25/02	8/05/02	predation
580.08	grayling	4/24/02	6/25/02	transmitter expelled
580.10	grayling	4/26/02	7/08/02	predation
600.01	grayling	4/25/02	7/08/02	predation
600.03	whitefish	4/24/02	4/30/02	transmitter expelled
600.04	whitefish	4/29/02	7/15/02	predation
600.05	brook trout	4/29/02	7/09/02	predation
600.08	whitefish	4/29/02	7/08/02	transmitter expelled

Discussion

The major point to make about our results is that each of our study species is capable of long distance movements, in excess of ten miles, in a very short period of time. The management implication of these long distance movements is that species must be managed at the scale of the Big Hole watershed. Individual fish are using different parts of the watershed during different times. Specifically, some Arctic grayling are moving downstream after spawning, possibly to access more productive feeding areas. Ridder (1998) and Buzby and Deegan (2000) showed that inter-annual fidelity to summer feeding locations for Arctic grayling in an Alaskan rivers was high (>32%) and we believe a similar behavioral pattern is occurring in the Big Hole River. The lower sections of the Big Hole River also provide abundant access to the deep pools that grayling showed a preference for during our study. Another possible explanation for fish moving into this section of the watershed is that the smaller tributaries in this area may serve as important refugia during periods of thermal extreme. This point is supported by our observation of high densities of grayling in LaMarche Creek during late summer. Water temperatures in LaMarche Creek were observed to be consistently cooler than the main channel of the Big Hole River.

Specific management needs that arise from these findings are: 1) the need to identify and remove any major migration barriers that may be denying fish access to different sections of the Big Hole River or its tributaries. Barriers may deny fish access to important complementary habitats such as spawning, feeding, and refugia. Denial of access to these habitats may have serious implications to population numbers especially during prolonged periods of climatic extremes. 2) The need to maintain and improve habitat quality throughout the watershed. The long-distance movements of these fish suggest that these populations access different parts of the watershed seasonally to complete the annual life cycle (i.e. spawning, feeding, seeking refuge). Degradation of habitat quality in any section of the watershed will have a negative impact on population numbers throughout the watershed.

The habitat and cover type selection results show that Arctic grayling and mountain whitefish behave in a similar pattern. Both species preferred pools and were observed using water depth as a source of cover. Brook trout also were found most often in pools but showed a preference for undercut banks and woody debris as a source of cover. These results show that adult brook trout and grayling are not competing for habitat at the microhabitat level. These findings support the results of the competitive interaction study of Byorth and Magee (1998).

We believe the high rate of apparent mortality is a cause for some concern. If the mortality rates in our study are truly reflective of the predatory pressure on fish in the Big Hole watershed then this issue should be addressed. We believe that this may also be an indicator of stream habitat health since the availability of preferred cover types should help fish avoid predation. Specifically, the low flow conditions that we are currently experiencing may be reducing the number of or limiting access to the deeper pools of the Big Hole River. The reduction in depth, size, and number of these pools is increasing the vulnerability of these fish to predation.

If the mortality rates during our study are not reflective of what is occurring in fish populations in the Big Hole River, the problem may lie within our methods. Perhaps the added stress of the implanted radio transmitters during time of drought leads to a higher relative rate of predation and mortality . This idea is supported by the fact that many of our fish died during the peak water temperatures of mid-July. We fully intend to test this theory, by implanting transmitters into fish and holding them in a controlled environment. This will allow us to better understand the effects of the implantation process on these fish. Additional tests will include the combined effects of surgery and warm water conditions, similar to those experienced by our study fish this summer. We feel this is an important experiment to conduct prior to using surgically implanted transmitters in future studies.

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