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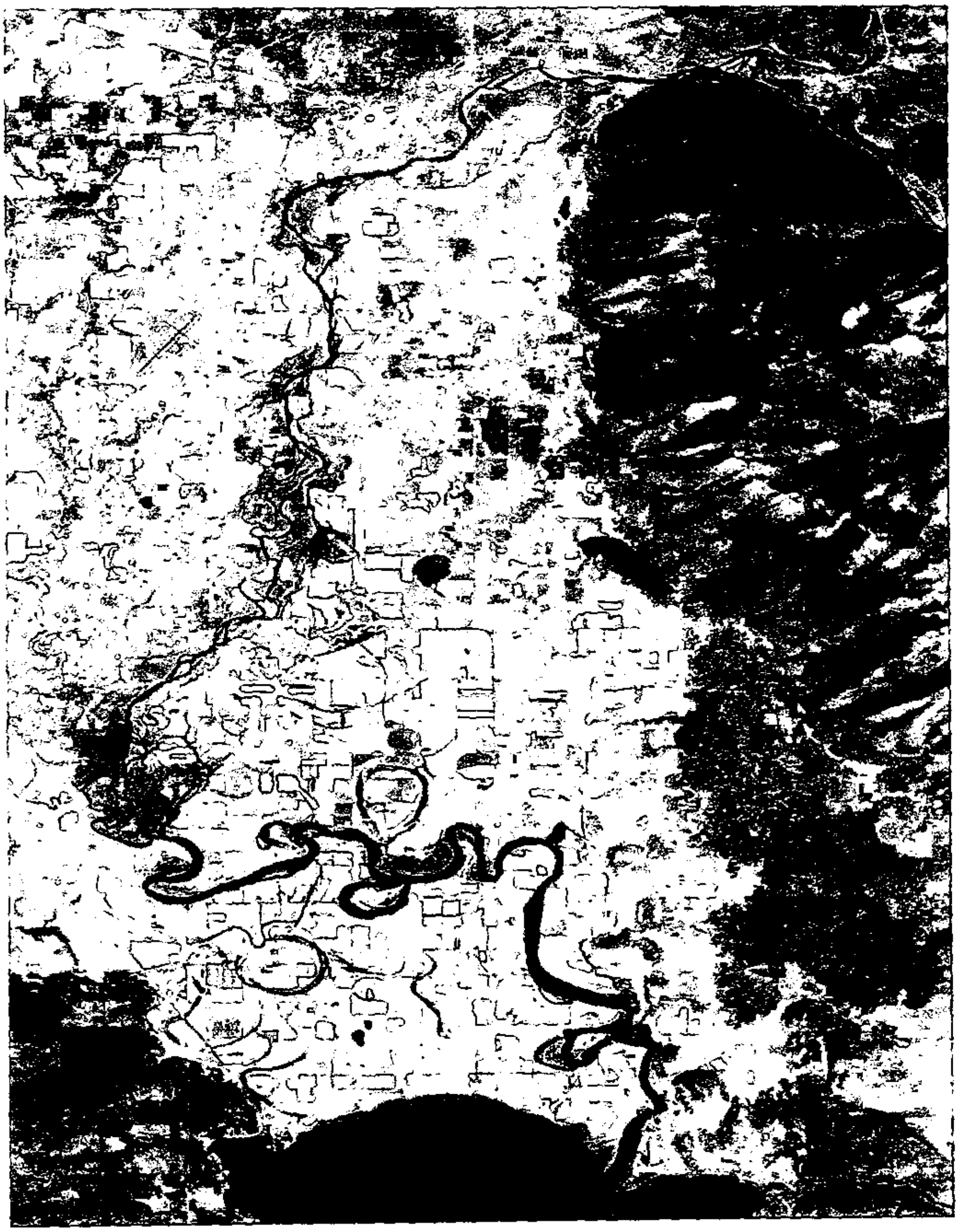
# Seasonal Distribution and Movements of Native and Non-native Fishes in the Upper Flathead River System, Montana



September 2000

# SEASONAL DISTRIBUTION AND MOVEMENTS OF NATIVE AND NON-NATIVE FISHES IN THE UPPER FLATHEAD RIVER, MONTANA

Flathead River Native Species Project
Montana Department of Fish, Wildlife and Parks
Kalispell, Montana

Summary Report 1997-1999

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## EXECUTIVE SUMMARY

The installation of Hungry Horse Dam in the South Fork Flathead River changed the physical and biological characteristics of the aquatic ecosystem by affecting water quality, fish and insect habitat and imposing barriers to fish migration. This study is part of the Northwest Power Planning council's resident fish and wildlife program that is designed to protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of hydroelectric projects in the Columbia River watershed. Pursuant to the council's program, this study was designed to determine the influences of flow and temperature on the seasonal movements and interactions of native and non-native fish stocks in the Flathead River below Hungry Horse Dam in Montana. Knowledge pertaining to the seasonal movements and habitat use by target fish species will aid in the management of dam operations. Critical habitat and environmental conditions will be improved for native trout recovery.

Fall and winter movements of 14 sub-adult (254 mm – 304 mm) and 8 adult (> 305 mm) migratory westslope cutthroat trout were described using radio-telemetry in the North Fork, Middle Fork and mainstem Flathead River from October 1998 through February 1999. Most fish (73%) displayed net downstream movements, however the timing and magnitude differed within the drainage. Considering all fish together, average home range was 12,619 m (range: 521-54,766 m) and average total distance moved was 17,340 m (range: 1,072-55,320 m). Movements were not significantly different by month and home ranges did not differ among streams during the winter (October-February). Six of the ten fish tagged in the North Fork migrated to overwintering areas lower in the drainage; peak outmigration occurred in October and early November as temperatures declined from 9.7°C to 4.0 °C. In the Middle Fork, fish moved both upstream and downstream from their release locations, but none left the study stream. Most fish tagged in the mainstem made downstream movements primarily occurring in November and January. Fish commonly occupied deep pools and areas near tributary inlets. None of the tagged fish migrated downstream to Flathead Lake suggesting a fluvial life-history form. Variation in the timing and directions moved within the drainage may be in response to differences in habitat and food availability or may reflect unique stocks of westslope cutthroat trout within the Flathead River drainage.

We used radiotelemetry to describe the distribution of migratory westslope cutthroat trout (> 250 mm) during spring 1998 in the upper Flathead River drainage Montana. Of the 12 radio-tagged fish (mean T.L. = 348 mm; range: 264-447 mm), nine (75%) made migrations that were related to spawning whereas 3 (25%) remained relatively sedentary. Spawning migrations commenced in April and early May during the rising limb of the hydrograph and as water temperatures increased from 5°C to 8°C. Seven of the nine spawners migrated to upper reaches of the North Fork Flathead River (U.S. and Canada), one fish ascended the Middle Fork Flathead River and the remaining fish moved upstream to the upper mainstem Flathead River. Tagged fish presumably spawned in tributaries during May and June as flows subsided after peak run-off and as water temperatures approached 10°C. Average upstream movement was 56.3 km (range: 9.7-125.8 km). Four postspawned fish made long, rapid downstream movements to Flathead Lake and the Flathead River, indicating both fluvial and adfluvial life history components of the migratory population.

We used radio-telemetry to describe the seasonal movements of 36 lake trout (mean total length = 478; range: 411-538) from 1996 through 1998 in the Flathead River upstream of Flathead Lake. The combined movement patterns suggest that lake trout seasonally utilized the lake and river system according to changes in water temperature, river discharge and possibly food. Peak downstream movements by lake trout from the Flathead River to Flathead Lake occurred during July and throughout the fall and winter (November-February). Downstream movements during July occurred as water temperatures rose toward 15°C and as river discharge subsided and reached base flow after spring runoff. Fall and winter downstream movements occurred as water temperatures declined from 4°C to 2°C. Peak upstream movements from the lake to the river occurred in late October when water temperatures declined to 6°C and coincided with the upstream spawning migration of pygmy whitefish. Information gained from this study may enable fisheries managers to reduce lake trout abundance in the Flathead River by manipulating dam discharge and temperature using the selective withdrawl structure on Hungry Horse Dam. Habitat manipulation and regulations may also be useful tools for managing lake trout predation on native species.

Radio-telemetry was used to monitor the seasonal movements and habitat use by 12 northern pike in the Flathead River system above Flathead Lake, Montana. Fish displayed both restricted and migratory behavior during the study period. Eight fish (67%) commonly occupied river sloughs and 4 fish (33%) displayed movements to other areas of the river-lake system. Average home range for sedentary fish was 3,258 m (range: 637-7,734 m) and average total distance moved was 13,478 m (range: 1,224-57,937 m). Mobile fish occupied an average home range of 18,621 m (range: 7,273-32,315 m) and moved an average total distance of 61,148 m (range: 22,355-146,901 m). Northern pike moved significantly less during winter as compared to spring, summer and fall. Migratory pike generally overwintered in the lower river and upper Flathead Lake. As flows increased in the spring, migratory pike made upstream migrations to river sloughs that were probably related to spawning. Northern pike found suitable habitat in the form of slow-moving, warm and well-vegetated areas of the river-lake system. Results from this study is useful for evaluating species interactions in the Flathead River drainage and for describing seasonal habitat use in a riverine-lacustrine environment.

The movements and distribution of eight bull trout (<500 mm) were described using radio-telemetry from March 1998 through December 1999 in the Flathead River downstream of Hungry Horse Dam. Seven sub-adult bull trout displayed variable movement patterns throughout the mainstem Flathead River, whereas one bull trout exhibited a pronounced upstream and subsequent downstream migration during the late summer and fall that was likely related to spawning. Preliminary results suggest that there is a fluvial life history form within the metapopulation of bull trout in the upper Flathead system. This study continues to investigate the seasonal movements and habitat use by bull trout in the Flathead River system.

Merwin traps, a pontoon-mounted trap with leads, were deployed in Fennon, Half Moon and Church sloughs to estimate the relative abundance and population structure of fishes inhabiting the lower Flathead River sloughs during spring, summer and fall 1997. We captured 19 fish species and 8,903 fish. Total combined catch for all species was highest during spring (93.5%) and declined during summer (5.2%) and fall (1.3%). During spring, peamouth dominated the species composition (34.2%), followed in abundance by northern pikeminnow (19.3%) and large scale suckers (14.1%). Bull trout comprised 1.5% of the spring catch followed by westslope cutthroat trout 0.2%, and northern pike 0.8%. A wide range of size-classes of bull trout, westslope cutthroat trout, northern pike and northern pikeminnow were captured in the sloughs during May and June. The occurrence of bull trout, westslope cutthroat trout, northern pike and northern pikeminnow in river sloughs was positively correlated to river discharge. Past studies revealed that northern pikeminnow did not disproportionately consume bull trout and westslope cutthroat trout in the lower Flathead River. Thus, the spatial overlap of adfluvial juvenile bull trout, westslope cutthroat trout and northern pike, a non-native opportunistic predator, may increase the probability of predation by northern pike on juvenile trout as they emigrate from natal tributaries to Flathead Lake. Future investigations will focus on the food habits of northern pike during spring to determine if predation on juvenile trout is impacting migratory populations.

## ACKNOWLEDGEMENTS

Many people contributed to the design and implementation of this project. We are especially grateful to Ron Morinaka from Bonneville Power Administration for providing funding and administration of the project. Hungry Horse Dam Mitigation crew, Ladd Knotek, John Cavigli, John Wachsmuth, Gary Michael, Tim Taylor and Russ Macal assisted with data collection for several aspects of the project. Tom Weaver provided invaluable information and direction on the bull trout and westslope cutthroat trout research. Montana, Fish, Wildlife and Parks management biologists Jim Vashro, Mark Deleray and Scott Rumsey provided information and guidance throughout the project. Lydia Bailey, Jeff Hutten and Angie Schmidt, MFWP employees with the Geographical Information Services Unit, provided GIS and GPS technical assistance with the production of the maps. Dave Hoerner of Red Eagle Aviation provided safe and dependable flight services for all aerial surveys. Steve Glutting, Rick Hunt and Rick Malta were responsible for the design and implementation of all data collected throughout the study. Steve Glutting produced all maps using Geographic Information systems (Arc View).

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## INTRODUCTION

Hungry Horse Dam was constructed in 1952 for hydroelectric power production and flood control storage in the South Fork Flathead River approximately 8.4 km upstream of the confluence with the mainstem Flathead River. The dam isolated approximately 38 percent of the Flathead Lake drainage (Evarts et al. 1994) and changed the physical and biological characteristics of the lake-riverine system (Appert and Graham 1982; Fraley and Graham 1982; Fraley and Decker-Hess 1987; Fraley et al. 1989; Hauer et al. 1994; Marotz et al. 1996).

In 1980, the U.S. Congress passed the Pacific Northwest Electric Power Planning Act to balance hydropower development and operation with other natural resources in the Columbia River Basin and directed Bonneville Power Administration to "protect, mitigate, and enhance fish and wildlife to the extent affected by the development and operation of any hydroelectric project of the Columbia River and its tributaries...". Under the Act, the Northwest Power Planning Council was created to accept and review management recommendations from state, federal and tribal fish and wildlife agencies to develop a comprehensive fish and wildlife plan. Drawdown and discharge limits were placed on Hungry Horse and Libby Dams by measures 903(a) and (b) of the Northwest Power Planning Council's Fish and Wildlife Program (NPPC 1987). The Fish and Wildlife Program was amended in 1995 and is currently being revised.

Deep drawdown and refill failure reduced biological production in Hungry Horse Reservoir and created unnatural flow and temperature fluctuations in the Flathead River downstream of Hungry Horse Dam (Chisholm et al. 1989; Christenson et al. 1996; Marotz et al. 1996; Cavigli et al. 1998). Dam operations affected reservoir morphometry through alterations in surface area, water volume, shoreline length and water depth (Marotz et al. 1996). Combined, these changes adversely affected primary productivity, benthic invertebrates, and fish production in the reservoir. Hypolimnetic releases in the tailwater artificially cooled the Flathead River from 1952 through 1996. In August 1996, a selective withdrawl structure was installed on Hungry Horse Dam, as part of the Hungry Horse Mitigation Program, to control water temperatures in the tailwater. As a result, a more normative temperature regime was established in the Flathead River downstream of the dam (Christenson et al. 1996; Marotz et al. 1996). Dam operations essentially reversed the natural hydrograph resulting in the storage of spring melt during spring and summer and releasing it during fall and winter when flows were historically low. Consequently, dam operations produced an unproductive varial zone, increased substrate embeddedness, and a less diverse and productive invertebrate community downstream of the dam (Hauer et al. 1994). Upon completion of an in-stream flow study (IFIM), this project will recommend dam operations to balance the requirements of fish in the river and reservoir.

Native fish populations have declined due to a complex combination of anthropogenic influences (i.e. construction and operation of dams, logging, mining etc.) and hybridization, predation and competition with non-native species (Williams et al. 1989). In 1999, bull trout were listed as a threatened species under the Endangered Species Act (ESA). Currently, Montana Fish, Wildlife and Parks and the American Fisheries Society classify westslope cutthroat trout as a species of special concern. Mitigation efforts to offset the impacts of Hungry Horse Dam were designed to identify limiting factors and implement rehabilitation projects to improve instream habitat, fish growth and survival. Research and monitoring projects by the Flathead River Native Species Project were established to correlate seasonal distribution, movements and predator-prey interactions of native and non-native species with flow and temperature. This report highlights results from January 1997 through December 1999. The specific objectives were to:

1. Describe fall and winter movements and habitat use by westslope cutthroat trout in the North Fork, Middle Fork and mainstem Flathead River;

2. Describe spring movements and habitat use by westslope cutthroat trout in the North Fork, Middle Fork and mainstem Flathead River;

3. Describe the distribution and seasonal movements of lake trout in the mainstem Flathead River;

4. Describe the movements, distribution, and food habits of northern pike in Halfmoon, Church, and Fennon Sloughs and in the mainstem Flathead River;

5. Assess the community composition of fish species inhabiting the lower Flathead River sloughs during spring, summer and fall and correlate presence/absence with flow and temperature; and

6. Describe the movements and distribution of bull trout (<500 mm) in the mainstem, North Fork and Middle Fork Flathead River.

# CHAPTER 1 – FALL TO WINTER MOVEMENTS BY WESTSLOPE CUTTHROAT TROUT IN THE FLATHEAD RIVER DRAINAGE, MONTANA

*Abstract.*— Fall and winter movements of 14 sub-adult (254 mm – 304 mm) and 8 adult (> 305 mm) migratory westslope cutthroat trout were described using radio-telemetry in the North Fork, Middle Fork and mainstem Flathead River from October 1998 through February 1999. Most fish (73%) displayed net downstream movements, however the timing and magnitude differed within the drainage. Considering all fish together, average home range was 12,619 m (range: 521-54,766 m) and average total distance moved was 17,340 m (range: 1,072-55,320 m). Movements were not significantly different by month and home ranges did not differ among streams during the winter (October-February). Six of the ten fish tagged in the North Fork migrated to overwintering areas lower in the drainage; peak outmigration occurred in October and early November as temperatures declined from 9.7°C to 4.0 °C. In the Middle Fork, fish moved both upstream and downstream from their release locations, but none left the study stream. Most fish tagged in the mainstem made downstream movements primarily occurring in November and January. Fish commonly occupied deep pools and areas near tributary inlets. None of the tagged fish migrated downstream to Flathead Lake suggesting a fluvial life-history form. Variation in the timing and directions moved within the drainage may be in response to differences in habitat and food availability or may reflect unique stocks of westslope cutthroat trout within the Flathead River drainage.

## Introduction

Populations of westslope cutthroat trout have drastically declined throughout their historic range in the past century (Liknes and Graham 1988). In light of the apparent declines, several state and federal agencies have classified westslope cutthroat trout as a sensitive species or a species of special concern. Concerns increased in 1999 when westslope cutthroat trout were petitioned for listing as a threatened species under the Endangered Species Act of 1973.

Few studies have assessed fall to winter movements of migratory westslope cutthroat trout in northern Rocky Mountain streams using radiotelemetry. Winter conditions can limit trout populations in mountain streams (Chisholm et al. 1987) and adequate overwintering refuge habitat from inclement stream conditions may govern trout production (Bustard and Narver 1975). If winter habitat conditions indeed limit cutthroat trout production and influence movement patterns, identification of critical overwintering areas is crucial for developing effective conservation and management programs. The objective of this study was to describe the fall to winter movements of sub-adult and adult westslope cutthroat trout using radiotelemetry throughout the upper Flathead River drainage, Montana.

## Study Area

The Flathead River drainage originates in the Rocky Mountains of British Columbia, Canada and northwestern Montana, USA (Figure 1). The drainage area is approximately 18,400 km$^2$ and comprises the headwaters of the upper Columbia River Basin. The drainage is known for its high water quality (Zackheim 1983). The underlying geology is mostly comprised of nutrient poor Precambrian sedimentary rock (Deleray et al. 1999). The soil material is derived from alpine and continental glaciation, glacio-fluvial deposits and residual material. The drainage includes the North Fork, Middle Fork, South Fork and the mainstem Flathead River.

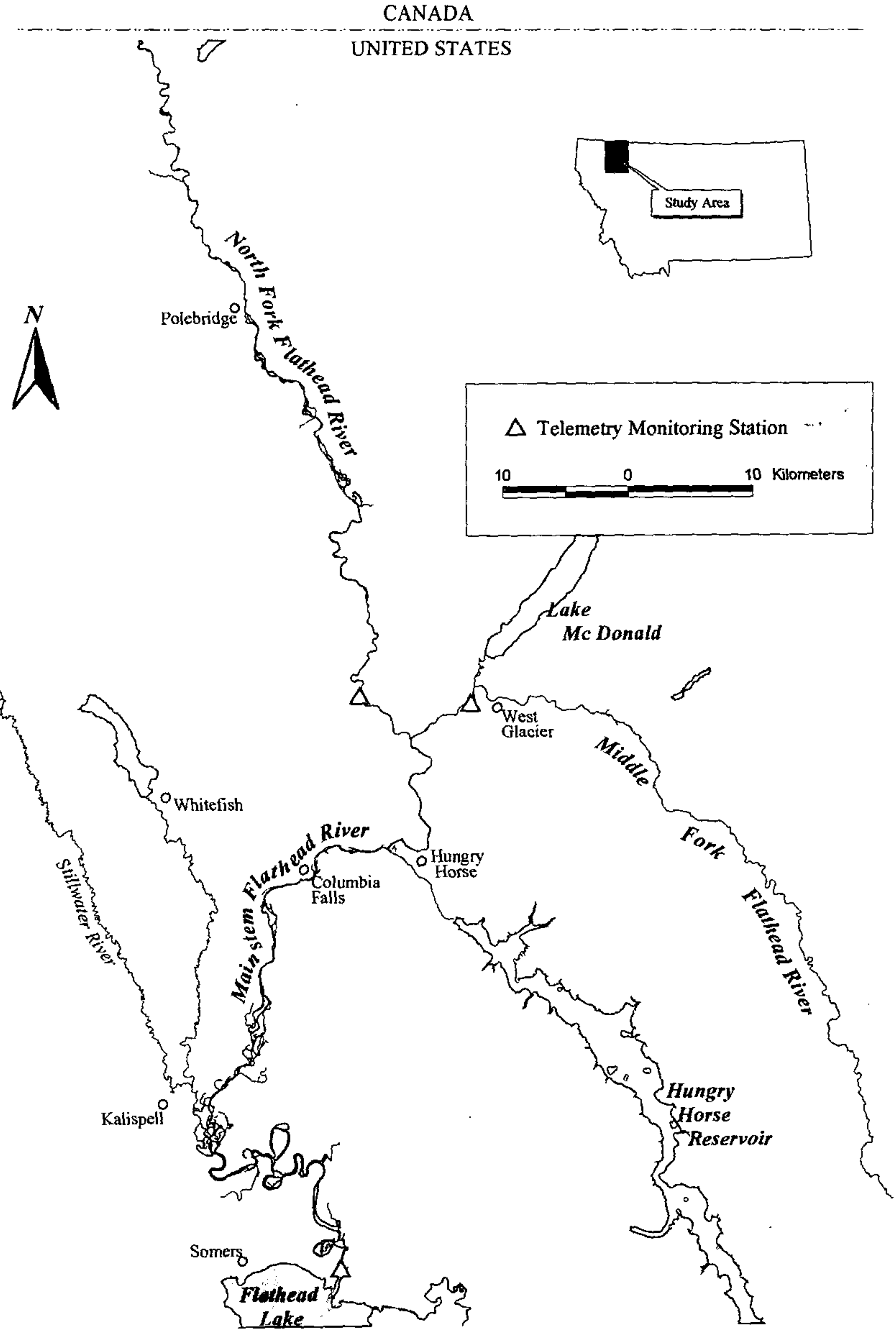


Figure 1. The upper Flathead River drainage study area including Flathead Lake and the mainstem, north, middle and south forks of the Flathead River.

The three forks of the Flathead River supply an estimated 80 percent of the annual discharge in the Flathead system (Zackheim 1983). The North Fork is a fifth-order stream that originates in British Columbia and flows in a southerly direction for approximately 94 km to its confluence with the Middle Fork and forms the western boundary of Glacier National Park (GNP). The Middle Fork of the Flathead River originates in the Bob Marshall Wilderness and flows in a northwesterly direction for approximately 146 km to its confluence with the North Fork. The Middle Fork is a fifth-order stream that forms most of the southern boundary of GNP from the wilderness boundary downstream. Both the North Fork and Middle Fork are designated as part of the National Wild and Scenic River System. The South Fork of the Flathead River flows approximately 160 km to its confluence with the main stem Flathead River near Hungry Horse, Montana. Hungry Horse Dam (completed 1952) impounds the South Fork Flathead River 8.5 km upstream from the confluence with the mainstem Flathead River. Hungry Horse Dam precludes upstream fish migration and isolates fish populations above the dam from the rest of the system. The mainstem Flathead River begins at the confluence of the North and Middle Forks near Coram, Montana and flows in a southerly direction for 89 km where it enters the north end of Flathead Lake. Kerr Dam heavily influences the water levels in the lower 32 km of the mainstem at the south end of Flathead Lake. This river is a sixth-order stream and flows predominantly through agricultural and forested lands of the Flathead Valley.

Land in the Flathead drainage is comprised of forests managed by GNP, Flathead National Forest (FNF) and other state and private enterprises. Timber production and associated road construction, agriculture, and hydropower regulation are the primary land-use practices impacting this portion of the drainage.

Westslope cutthroat trout have evolved three life history strategies in the Flathead River system (Shepard et al. 1984). Life history forms include: (1) adfluvial stocks that spawn and rear in river tributaries and move downstream to mature and reside in Flathead Lake; (2) fluvial stocks that spawn and rear in river tributaries then move downstream to mature and reside in the Flathead River, and (3) tributary stocks that spend their entire lives in tributary streams. Juvenile cutthroat trout remain in tributary streams for 1-3 years before migrating downstream to the river or lake (Shepard et al. 1984). Adfluvial stocks reach the largest size due to improved forage and growth rates in the lake.

## Methods

We used radiotelemetry to monitor movements of westslope cutthroat trout from October 1998 through February 1999. Twenty-seven westslope cutthroat trout (255-355 mm T.L.) were captured by hook and line (fly-fishing), surgically implanted with radio transmitters and released in close proximity to their capture location (Table 1). Fish were tagged throughout the North Fork, Middle Fork and mainstem Flathead River to test whether fish moved upstream or downstream to seek overwintering areas and to test if movements differed among sub-adult (254 mm – 305 mm) and adult (> 306 mm) size-classes. We implanted and released 7 sub-adult (mean total length = 280 mm, range: 256-303 mm) and 3 adult westslope cutthroat trout (mean total length = 315 mm, range:

Table 1. Summary of radiotagged westslope cutthroat trout monitored in the Flathead River drainage during fall and winter 1998-1999.

| Transmitter Code | Length (mm) | Weight (g) | Capture Location | Final Location | Release Date | Date of last signal | Number of relocations | Number of days tracked tracked | Net distance moved (m) | Home range (m) | Total distance moved (m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 137 | 258 | 152 | Mainstem | Mainstem | 10/20 | 2/8 | 5 | 111 | 1610 | 1633 | 1785 |
| 138 | 268 | 182 | Mainstem | Mainstem | 10/20 | 12/11 | 6 | 52 | -10786 | 10786 | 10998 |
| 139 | 293 | 226 | Mainstem | Mainstem | 10/27 | 1/11 | 4 | 76 | -5261 | 6257 | 7252 |
| 140 | 274 | 180 | Mainstem | Mainstem | 11/17 | 2/8 | 6 | 83 | -21357 | 21357 | 21357 |
| 150 | 310 | 278 | Mainstem | Mainstem | 10/20 | 1/11 | 7 | 83 | 5217 | 5442 | 5667 |
| 151 | 347 | 409 | Mainstem | Mainstem | 10/27 | 2/8 | 6 | 104 | -3999 | 3999 | 3999 |
| 152 | 322 | 322 | Mainstem | Mainstem | 10/27 | 2/8 | 6 | 104 | -15286 | 15822 | 17088 |
| 123* | 269 | 184 | North Fork | Unknown | 9/30 | 10/14 | 3 | 14 | -7851 | 7851 | 7851 |
| 124 | 303 | 236 | North Fork | North Fork | 9/30 | 2/8 | 10 | 131 | -1415 | 1474 | 3507 |
| 125 | 256 | 160 | North Fork | McDonald Lake | 9/30 | 2/8 | 8 | 131 | -34507 | 34546 | 34585 |
| 126 | 290 | 228 | North Fork | Mainstem | 9/30 | 12/30 | 5 | 91 | -20814 | 20893 | 21597 |
| 127 | 265 | 155 | North Fork | North Fork | 9/30 | 2/8 | 9 | 131 | 29 | 521 | 1072 |
| 128 | 300 | 248 | North Fork | Mainstem | 9/30 | 2/8 | 14 | 131 | -22130 | 23167 | 37143 |
| 129* | 275 | 189 | North Fork | Unknown | 10/7 | 10/27 | 6 | 20 | -13830 | 14495 | 15160 |
| 144 | 314 | 280 | North Fork | North Fork | 9/30 | 2/8 | 8 | 131 | -1900 | 2578 | 6308 |
| 145 | 311 | 276 | North Fork | Mainstem | 9/30 | 1/11 | 5 | 103 | -54212 | 54766 | 55320 |
| 146 | 319 | 296 | North Fork | North Fork | 10/7 | 2/8 | 10 | 124 | -9677 | 10571 | 12957 |
| 130* | 287 | 220 | Middle Fork | Middle Fork | 10/6 | 10/14 | 2 | 8 | 2518 | 2518 | 2518 |
| 131* | 263 | 164 | Middle Fork | Middle Fork | 10/6 | 10/21 | 2 | 15 | 9659 | 11870 | 14082 |
| 132 | 300 | 246 | Middle Fork | Middle Fork | 10/6 | 2/8 | 10 | 123 | 1993 | 18895 | 52163 |
| 133 | 290 | 206 | Middle Fork | Middle Fork | 10/6 | 2/8 | 10 | 123 | -6123 | 15013 | 28965 |
| 134 | 273 | 181 | Middle Fork | Middle Fork | 10/6 | 1/11 | 9 | 96 | -717 | 4136 | 8565 |
| 135 | 255 | 150 | Middle Fork | Middle Fork | 10/6 | 2/8 | 8 | 123 | 5133 | 6955 | 8777 |
| 136 | 293 | 223 | Middle Fork | Middle Fork | 10/6 | 1/13 | 5 | 125 | -220 | 3819 | 7965 |
| 147* | 355 | 445 | Middle Fork | Middle Fork | 10/6 | 10/9 | 1 | 3 | -6784 | 6784 | 6784 |
| 148 | 337 | 377 | Middle Fork | Middle Fork | 10/6 | 2/8 | 12 | 123 | 3118 | 9242 | 28101 |
| 149 | 346 | 385 | Middle Fork | Middle Fork | 10/6 | 2/8 | 12 | 123 | -5555 | 5752 | 6319 |

311-319 mm) from September 30- October 7 in the North Fork Flathead River. Seven sub-adult (mean total length = 280 mm, range: 255-300 mm) and 3 adult westslope cutthroat trout (mean total length = 346 mm, range: 337-355 mm) were implanted and released on October 6 in the Middle Fork Flathead River. Four sub-adult (mean total length = 273 mm, range: 258-293 mm) and 3 adult (mean total length = 326 mm, range: 310-347 mm) fish were implanted and released in the mainstem Flathead River from October 20- November 17.

Two types of transmitters were used to monitor fish movements to maintain a low (<2%) transmitter to body weight ratio (Winter 1983). Sub-adult fish were implanted with transmitters that weighed 3.7 g in air and had a predicted life expectancy of 90 days (model MCFT-3D, Lotek Engineering, Inc.). Adult fish were implanted with transmitters that weighed 6.7 g in air and had a predicted life expectancy of 170 days (model MCFT-3CM, Lotek Engineering, Inc.). Each tag emitted a unique coded signal (12 pulses/minute) in the frequency range of 148.770 mHz.

Fish were anesthetized with tricaine methane sulfonate (MS-222) and transmitters were surgically implanted into the body cavity. Each anesthetized fish was placed in a padded V-shaped trough and gills were irrigated with a 60 mg/l solution of MS-222 during surgery. We made a 10 mm incision immediately anterior of the pelvic girdle and a sterilized transmitter was admitted into the body cavity and the antenna was extended through the body wall immediately posterior of the pelvic girdle. Each incision was closed with three to four synthetic absorbable sutures. Fish were placed in a 0.25% salt solution immediately after surgery to stimulate mucous production and osmoregulation (G. Klontz, personal communication, University of Idaho, Moscow). Each surgery lasted approximately 8-10 minutes and no mortalities occurred during surgery or during the 0.5 hour recovery period.

We monitored fish movements using fixed-wing aerial surveys, ground tracking and remote ground receiver stations. A coded Lotek radio receiver (Model SRX 400-W5) and a three-element directional Yagi antenna were used to locate fish during ground and aerial surveys. Tracking surveys were usually conducted twice a month during the daytime. For ground surveys, fish locations were triangulated from vehicle access points along the road and from the streambank. Aerial surveys were conducted at approximately 100 m in elevation and at an average speed of 27-31 m/sec. Once a signal was detected, the pilot circled until the point location was verified. Three permanent telemetry ground stations were installed near the mouths of the North Fork, Middle Fork and mainstem Flathead River that were used to continuously monitor (24-hours/7 days per week) fish movements when fish came within 250 m of the stations (Figure 1). Each ground station consisted of a Lotek data-logging receiver equipped with a 3-element directional Yagi antenna powered by a 12-volt deep-cycle marine battery.

For each location, we recorded the direction moved and calculated the distance moved from the previous location. Each location was recorded on a USGS topographic map (1:24,000). Location points were later transferred into ArcView (Version 3.1). Movements were calculated by measuring the distance along the thalweg from each consecutive location in ArcView. Total movement was the sum of all movements for the duration of the study. During the study, home range was defined as the linear distance between the fish's most upstream and downstream location (Young 1995). Net movement was considered as the overall direction and distance moved from the original point of release over the study period. Mean daily water temperature data were obtained from the USGS flow monitoring stations located in the North Fork (Glacier Rim), Middle Fork (West Glacier) and mainstem Flathead River (Columbia Falls).

Because the movement data were non-normal and sample sizes were low, we used non-parametric statistical procedures to test movement patterns (Zar 1996). We used a one-way Kruskal-Wallis test to compare study period home ranges between streams and total distances among months. A Mann-Whitney U test was used to compare home ranges among size-classes of fish. Statistical analyses were conducted with SPSS/PC+, version 10.0 (Norusis 1990). Significance was considered at the $\alpha = 0.05$ for all statistical tests.

## Results

Twenty-seven radio-tagged fish were tracked an average of 92 days (range: 3-131 d) and each fish was relocated an average of 7 times (range: 1-14) during the study period (Table 1). A total of 189 relocations were obtained during the study period; 102 (54%) relocations were obtained from aerial surveys, 75 (40%) from ground surveys and 12 (6%) from ground stations. Of the 27 implanted fish, 22 (81%) were successfully tracked for the duration of the guaranteed transmitter battery life. The five lost transmitters were tracked an average of 12 days (range: 3-20) and relocated an average of 3 times (range: 1-7). Lost transmitters either failed prematurely or the fish migrated into Lake McDonald (Glacier National Park) where deep water precluded signal detection. Lost fish were removed from subsequent analyses.

Radio-tagged westslope cutthroat trout moved more extensively than expected throughout the fall and winter study period. Considering all fish together, average home range was 12,619 m (range: 521-54,766) and average total movement was 17,340 m (range: 1,072-55,320). We found no differences in home ranges occupied by fish among streams ($\chi^2 = 0.377$, $P = 0.828$) and between sub-adult and adult size-classes ($U = 54.0$, $P = 0.891$). No significant differences were found among mean monthly total distances from October through February ($\chi^2 = 7.3$, $P = 0.120$). Net direction moved of all monitored fish was predominantly downstream (73%), however results varied between river reaches.

*North Fork*- For fish captured and released in the North Fork, net direction moved was predominately downstream (88%) throughout the study period (Table 1; Figures 2-3). Six of the ten monitored fish migrated downstream past the permanent ground station between October 9 and November 10 (mean = October 23) as mean daily water temperatures declined from 9.7 °C to 4.0°C (Figure 2). Three fish (#126, #128 and #145) eventually moved downstream to deep pools within confined (e.g. canyon) reaches of the mainstem. One fish (#125) was found 14 km downstream from it's release location on November 11 and then moved 22 km upstream into Lake McDonald where it remained to the end of the tracking period in February. The remaining two fish (#123, #129) were not relocated after they migrated downstream of the ground station. Fish that remained in the North Fork (#124, #127, #144, and #146) commonly occupied deep pools in Fool Hen Canyon and the mouth of

Canyon Creek, a tributary to the North Fork Flathead River (Figure 1). Average home range for fish that left the North Fork was 33,343 m (range: 20,893-54,766 m) and average home range for fish that remained was 3,789 m (521-10,571 m). Mean monthly distances moved were highest in October-December and peaked in December (Figure 2). Fish remained relatively sedentary during January and February.

*Middle Fork-* Net direction moved varied for the Middle Fork study fish; 3 fish moved upstream and 4 fish moved downstream from their release sites (Table 1; Figures 4-5). However, no fish were found downstream of the confluence with the North Fork throughout the study. For all fish radio-tagged in the Middle Fork, average home range was 8,498 m (range: 2,518-18,895 m) and total distance moved was 16,424 m (2,518-52,163 m). Fish were consistently relocated in the following three general areas (Figure 5): the mouth of McDonald, Harrison and Mocassin Creeks and in a canyon reach immediately downstream of Kootenai Creek. Two fish (#134 and #136) generally occupied deep areas within the canyon reach during their respective monitoring periods. Three fish (#132, #133 and #134) were commonly found in deep pools immediately downstream of Harrison Creek. One fish (#132) was found approximately 22 km upstream of it's release site during October and on November 16 was found approximately 19 km downstream at the mouth of Harrison Creek where it remained to the end of the tracking period. The remaining fish (#148) moved progressively upstream during the study and occupied the same general areas as the other study fish. Mean monthly movement was upstream in October and downstream from November through February, peaking in November and February (Figure 4).

*Mainstem-* The seven cutthroat trout monitored in the mainstem moved an average total distance of 9,735 m (range: 1,785-21,357 m) and occupied an average home range of 9,328 m (1,633-21,357 m). Five of the seven fish (71%) made net downstream movements (Table 1; Figures 6-7). However, movement patterns were sporadic throughout the study (Figures 6-7). Of the four fish released at Eleanor Island, two fish (# 139, #151) made net movements less than 5,300 m downstream and one fish (#150) moved upstream a net total distance of 5,217 m. The remaining fish remained in a braided section at Eleanor Island throughout the study period and moved a total distance of 1,785 m. Both fish tagged near Presentine Bar (#138, #152) made net downstream movements (10,785 m and 15,286 m, respectively). One fish tagged near Columbia Falls made the furthest downstream movement with a net total distance of 21,357 m. All fish released in the mainstem were commonly associated with pool areas of the river near their respective release locations. Mean monthly movement was highest in November and January (downstream) and, in contrast, relatively low in October, December and February (Figure 6).

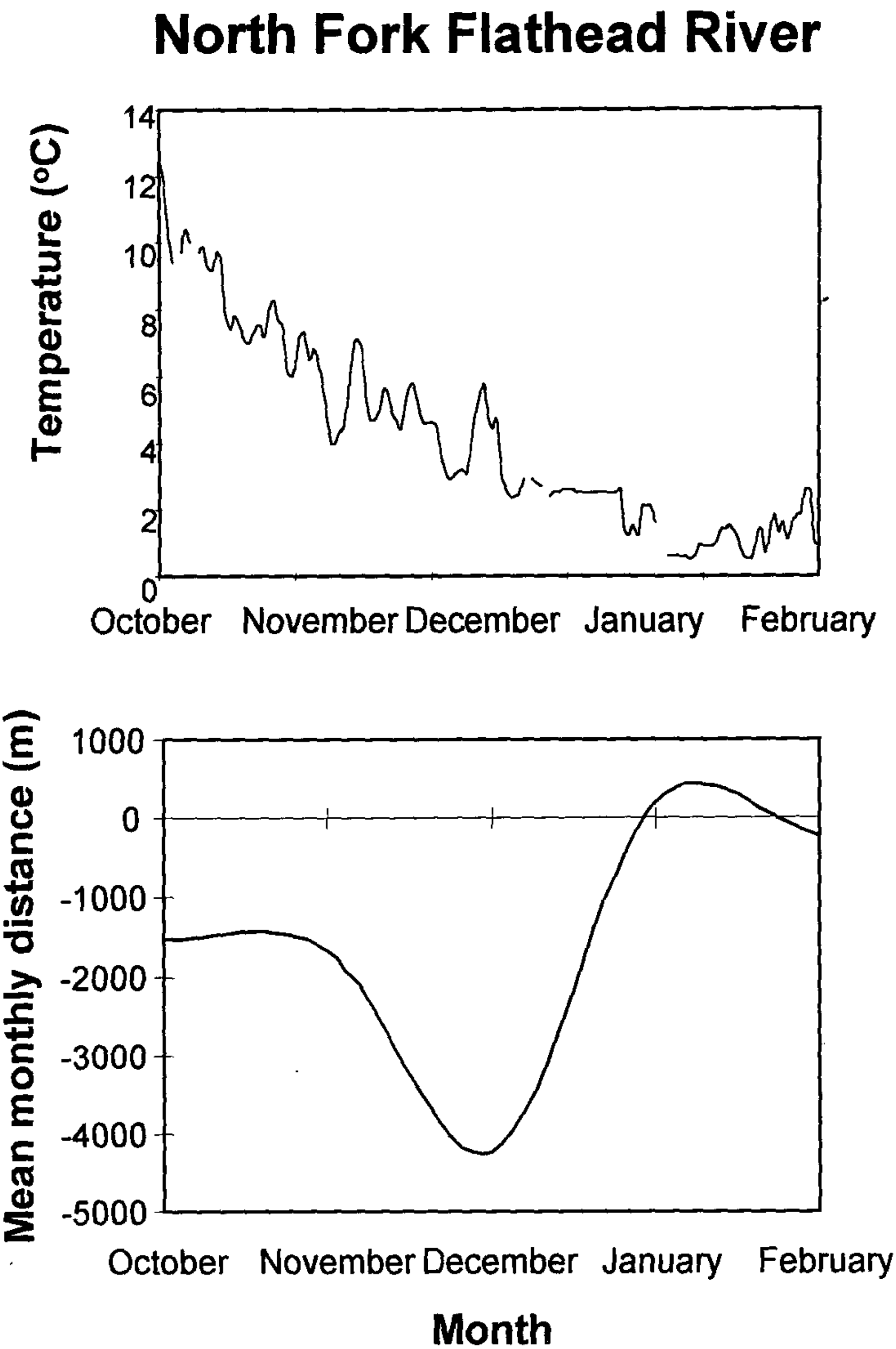


Figure 2. Mean monthly movement (m) by westslope cutthroat trout as related to mean daily water temperature (°C) in the North Fork Flathead River from October 1998 through February 1999.

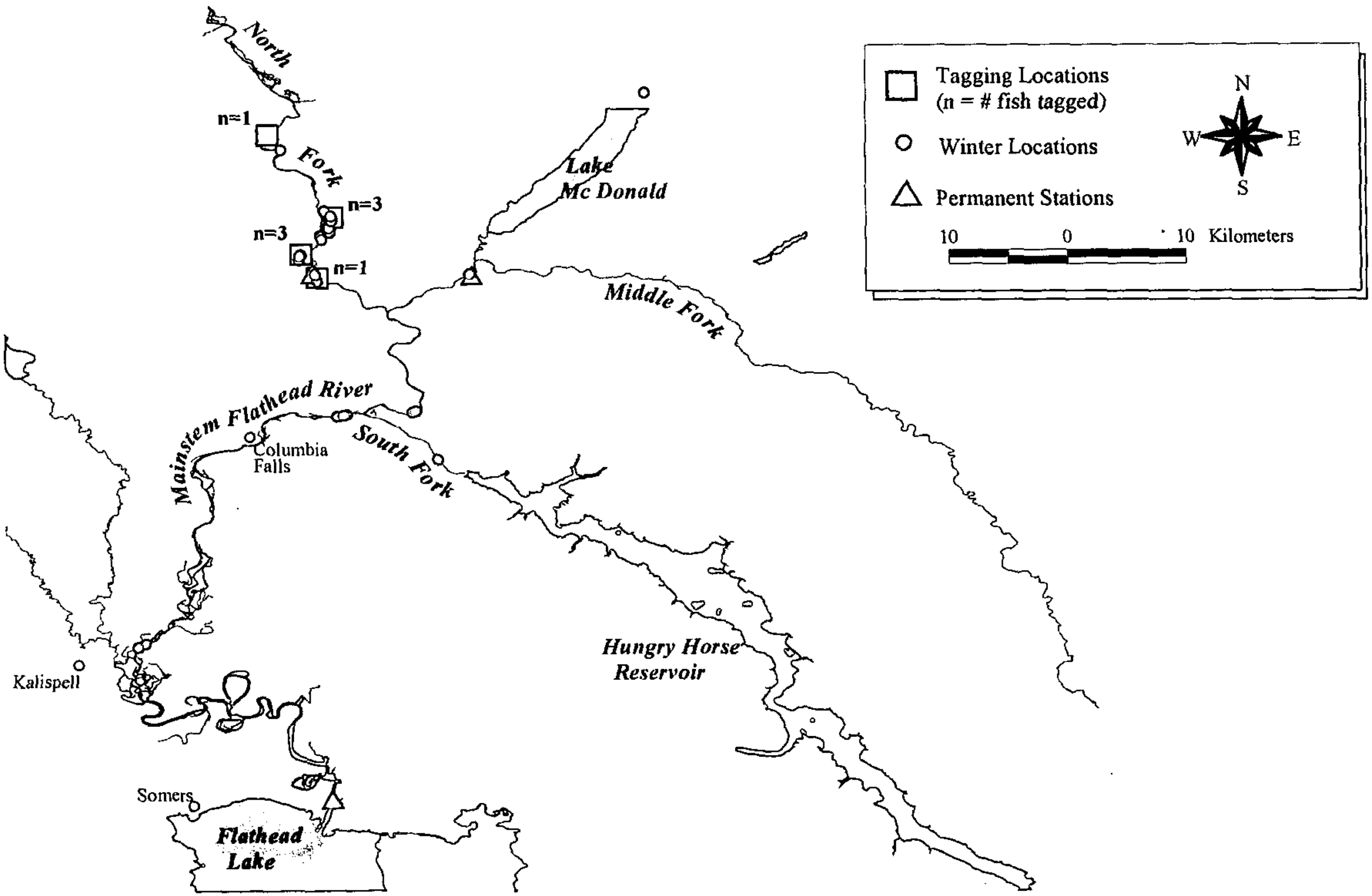


Figure 3. Fall and winter locations of westslope cutthrout radio-tagged in the North Fork Flathead River during 1998.

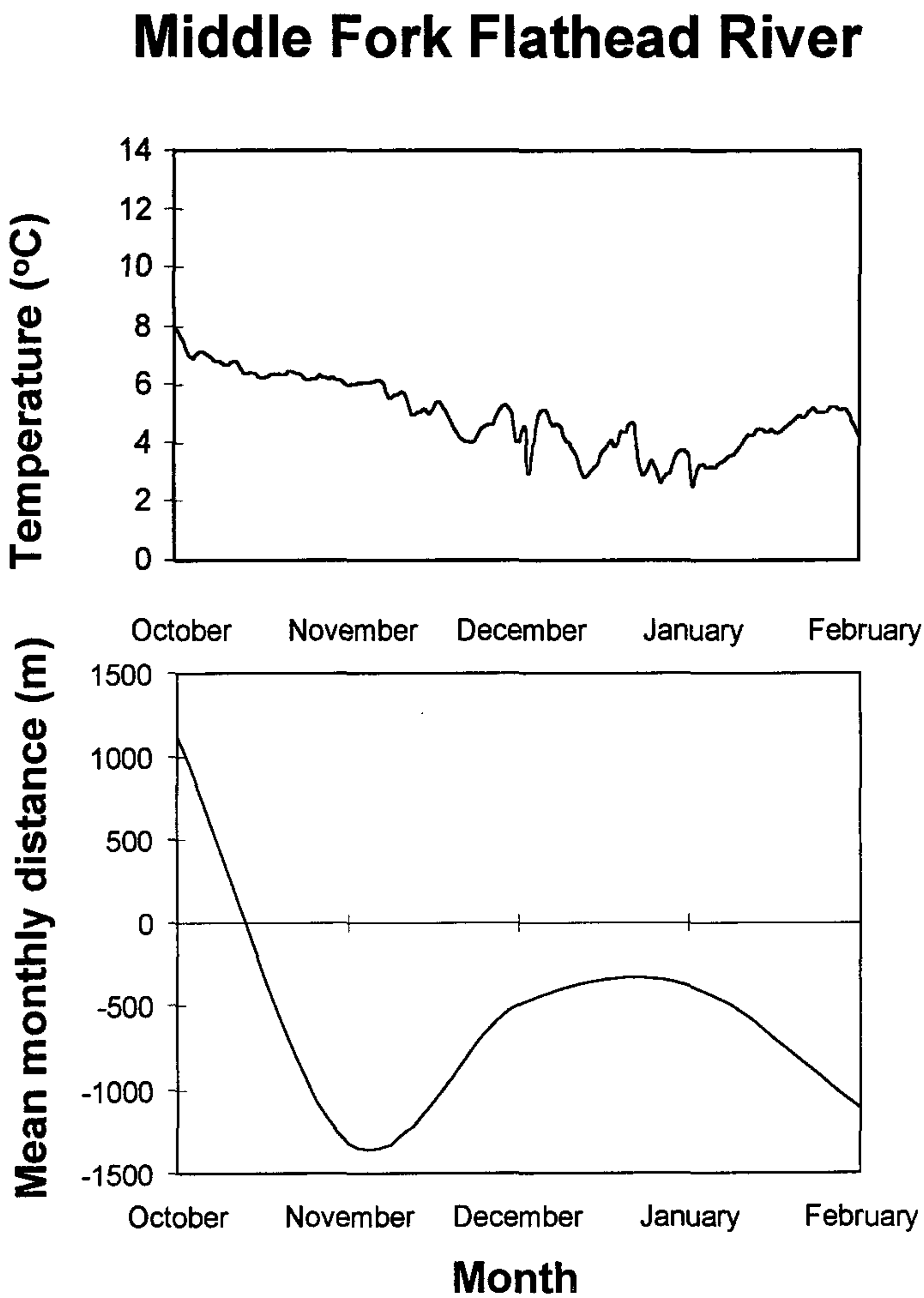


Figure 4. Mean monthly movement (m) by westslope cutthroat trout as related to mean daily water temperature (°C) in the Middle Fork Flathead River from October 1998 through February 1999.

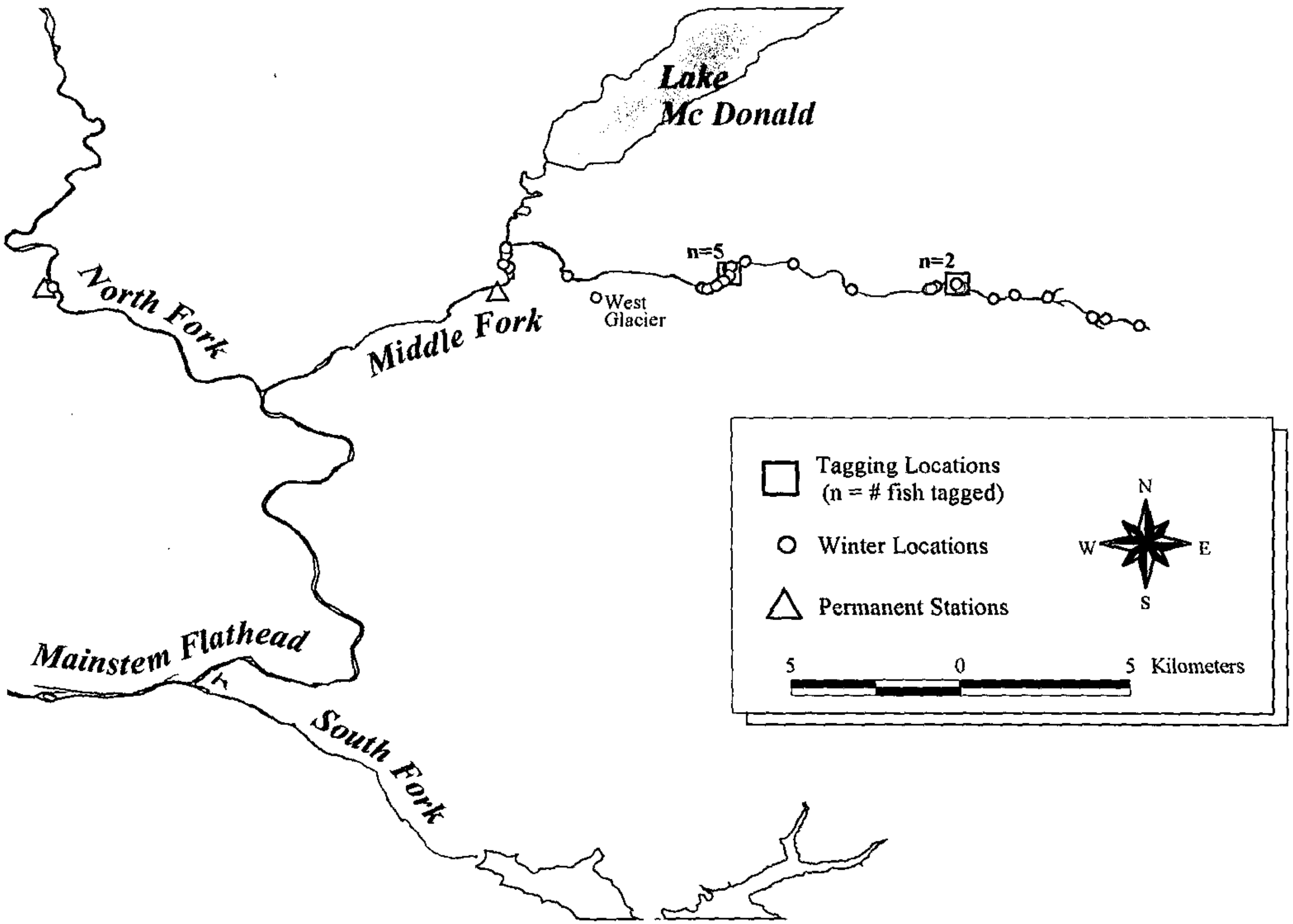


Figure 5. Fall and winter locations of westslope cutthroat radio-tagged in the Middle Fork Flathead River 1998.

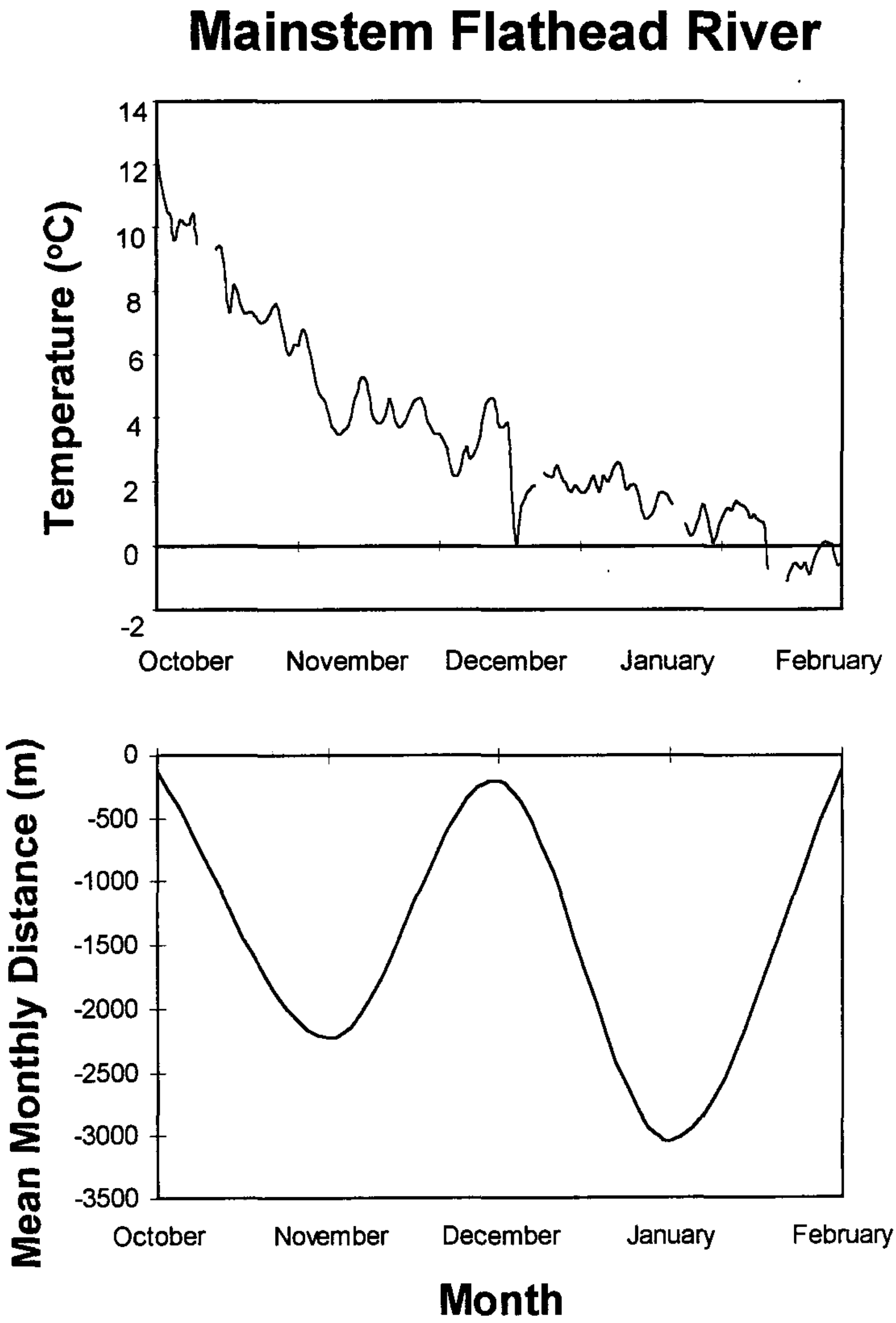


Figure 6. Mean monthly movement (m) by westslope cutthroat trout as related to mean daily water temperature (°C) in the mainstem Flathead River from October 1998 through February 1999.

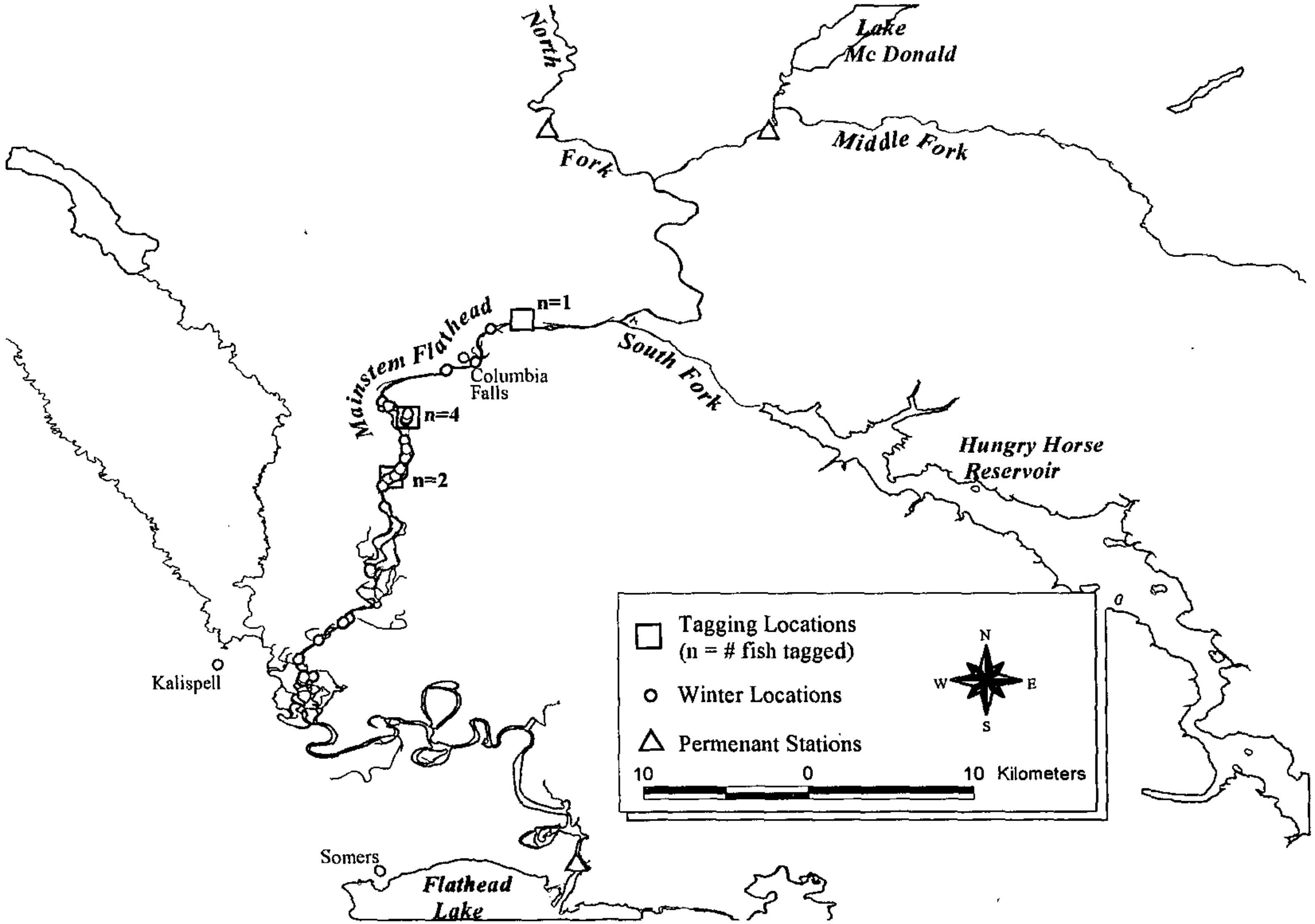


Figure 7. Fall and winter locations of westslope cutthroat radio-tagged in the Mainstem Flathead River 1998.

## Discussion

As winter approached, some cutthroat trout made long downstream migrations (up to 55 km), whereas others exhibited relatively sedentary behavior. Long downstream movements exhibited by some study fish are consistent with those observed for cutthroat trout and brown trout (Bjornn and Mallet 1964; Bjornn 1971; Mejers et al. 1992). Temperature declines in the fall can illicit trout to make extensive movements to suitable overwintering habitat (Bjornn and Mallet 1964; Bjornn 1971; Cunjak and Power 1986; Clapp et al. 1990; Brown and Mackay 1995). Bjornn and Mallet (1964) found that fluvial cutthroat trout migrated up to 101 km downstream to overwintering areas in Idaho. Brown and Mackay (1995) found that cutthroat trout moved (up to 7.6 km) to deep, ice covered pools where water temperatures were warmer than the rest of the stream during winter. Conversely, the relatively sedentary behavior observed during our study by some fish is consistent with those reported for brook trout and cutthroat trout (Chisholm et al. 1987; Jackober et al. 1998; Young 1998) where adequate overwintering habitat was available. Young (1998) reported that resident Colorado River cutthroat trout failed to change habitat location from summer to autumn (<155 m) due to the availability of coarse substrates for concealment and year-round low water temperatures. Jackober et al. (1998) found that westslope cutthroat trout overwintered within 185 m from their release location in two headwater streams in the Bitterroot River drainage, Montana. Similarly, in a Wyoming stream, Chisholm et al. (1987) found that with the onset of winter conditions brook trout moved less than 500 m to low-gradient stream reaches during late fall and winter. As temperatures approach 4-6°C, trout may remain in suitable habitat areas within a small stream section if adequate overwintering habitat is locally available or move to other areas of the drainage if population numbers exceed the winter cover capacity of the stream (Bjornn 1971).

Decreasing temperatures coincided with a general downstream trend in migration throughout the fall to winter period. Low stream temperatures (4°C to 10°C) trigger fall migrations of salmonid species (Bjornn 1971). However, we found that the timing and magnitude of movements by cutthroat trout varied among the study streams. For example, six of the ten radio-tagged fish in the North Fork moved downstream and left the study stream during October and early November when water temperatures ranged from 9.7 °C to 4.0°C. In contrast, all fish tagged in the Middle Fork and mainstem remained in their respective streams where they were originally tagged and released. Therefore, our results suggest that there may be a stronger migratory population of cutthroat trout inhabiting the North Fork and mainstem Flathead River compared to the Middle Fork. Nonetheless, we found that most fish (73%) displayed net downstream movement during the study period. Similarly, several studies reported that low stream temperatures may illicit trout to make downstream migrations to overwintering areas (Bjornn and Mallet 1964; Chapman and Bjornn 1969; Chisholm et al. 1987). Conversely, trout may move upstream to seek overwintering areas depending on the availability and proximity of suitable overwintering habitat (Clapp et al. 1990; Brown and Mackay 1995).

Our study fish commonly congregated in the same general hydraulic units during the study period. Two fish that left the North Fork staged in deep sections of Hungry Horse Canyon in December before moving further downstream to the mainstem, whereas those that remained were commonly found in a deep canyon reach and in a large pool at the mouth of Canyon Creek. In the Middle Fork, fish congregated in four distinct areas of the river from the mouth of McDonald Creek to the mouth of Mocassin Creek. Three of these areas were near tributary mouths and one was located in a deep canyon reach. Other studies have also found that salmonids tend to congregate during periods of low stream temperatures (Cunjak and Power 1986; Brown and Mackay 1995).

We observed that cutthroat trout generally overwintered in deep pools, incised canyon reaches and near confluence areas. In addition, one fish migrated approximately 36 km downstream from the North Fork and entered Lake McDonald (Glacier National Park) where it remained throughout the winter. Temperatures below 4-6°C stimulate winter concealment by some salmonid species (Chapman and Bjornn 1969; Bjornn 1971) because as water temperatures reach near freezing temperatures, metabolic rates of trout are reduced, food requirements are lowered and less energy is available for activity. Hence, during relatively inactive periods trout require deep-low velocity areas (i.e. pools and deep runs) which maximize energy conservation (Fausch 1984). Pools also provide areas of concealment from inhospitable conditions such as anchor and frazil ice formation (Brown and Mackay 1995) and from potential predators (Chapman and Bjornn 1969) which may increase overwintering survival. Similarly, Muhlfeld et al. (In press) reported that redband trout (*Oncorhynchus mykiss gairdneri*) occupied large, deep pools with extensive amounts of cover during the fall to winter period in Callahan Creek, Montana.

Although we did not monitor water temperatures in tributary streams during the study, we speculate that areas of the stream influenced by tributaries may provide thermal refugia during harsh winter conditions. Brown and Mackay (1995) and Cunjak and Power (1986) reported that fish congregated in areas of the stream that were influenced by warmer groundwater. Tributary confluence areas in the Middle Fork and North Fork may also provide more abundant food resources compared to other areas that would make winter residency more profitable during less productive times of the year. Effluent groundwater and surfacewater from tributaries directly or from the floodplain contain relatively stable flows, moderated temperature regimes, high water clarity and elevated concentrations of plant growth nutrients (Stanford and Ward 1991). Consequently, the density and biomass of attached benthic algae and zoobenthos are dramatically increased in these productive areas which may concentrate fish during winter months (Stanford and Ward 1991).

Our movement data suggests that westslope cutthroat trout monitored during our study appear to conform to a fluvial life history strategy because none of the study fish entered Flathead Lake. We radio-tagged fish that ranged from 255 mm – 355 mm in total length which is generally characteristic of a fluvial life history form (Shepard et al. 1984). Adults greater than 350 mm are generally classified as adfluvial fish in the Flathead River system (Shepard et al. 1984) but were not readily available in the sample. Previous electrofishing surveys documented a composite population of adfluvial cutthroat trout (>350 mm) and smaller fish (<350 mm) fish inhabiting the lower Flathead River during winter (McMullin and Graham 1980; Deleray et al. 1999). Therefore, evidence suggests that there is a component of the westslope cutthroat trout metapopulation that resides for extended periods of time, if not their entire lives, in the river system after emigrating from their natal tributaries into the Flathead River system. However, we were unable to successfully monitor fish for more than 170 days due to the size of the transmitter we used in order to maintain a low transmitter to body weight ratio (Winter 1983). Consequently, some fish may have developed an adfluvial life history strategy as they grew and matured in the river.

We did not observe a significant difference in home ranges occupied by sub-adult and adult westslope cutthroat trout. Our results may have differed if we conducted our study using a higher resolution methodology. Microhabitat assessments may prove useful to identify spatial segregation among size-classes based on specific habitat characteristics at fish locations in the stream (i.e. water depth, focal velocity, substrate etc.). Other studies have demonstrated size-specific spatial segregation among stream-dwelling salmonids (Baltz and Moyle 1984; Moyle and Baltz 1985).

Our results indicate that some cutthroat trout made downstream migrations to overwintering areas as stream temperatures declined during the fall and winter period (Bjornn and Mallet 1964). Our study also demonstrates that species assemblages are complex and movement patterns are difficult to predict. Cutthroat trout inhabiting the upper Flathead River drainage appear to be a highly migratory metapopulation that seasonally utilizes contiguous tracts of river and tributary habitat. Therefore, fish passage habitat improvement and conservation programs may prove useful throughout the range of westslope cutthroat trout in the Flathead River drainage.

Throughout their native range, populations of westslope cutthroat trout have declined due to a combination of non-native introductions, habitat fragmentation and degradation, and angler exploitation. Consequently, many populations are restricted to headwater streams that may serve as refugia until conservation strategies are implemented. Conservation and preservation of unique migratory life history forms in the Flathead River drainage may be imperative to the persistence of this species throughout its historic range. Minimizing land-use practices (e.g. logging and associated road construction) that reduce cover and depth of pools (Burns 1972; Hartman et al. 1996) and decreasing the potential of habitat fragmentation may maintain suitable winter habitat and habitat connectivity that would likely increase the survival of westslope cutthroat trout. Fisheries managers may modify fishing regulations to reduce the susceptibility of angler harvest in areas where cutthroat trout congregate during the fall and winter period.

## CHAPTER 2 – SPRING MOVMENTS BY RADIO-TAGGED WESTSLOPE CUTTHROAT TROUT IN THE UPPER FLATHEAD RIVER DRAINAGE, MONTANA

*Abstract.*— We used radiotelemetry to describe the distribution of migratory westslope cutthroat trout (> 250 mm) during spring 1998 in the upper Flathead River drainage Montana. Of the 12 radio-tagged fish (mean T.L. = 348 mm; range: 264-447 mm), nine (75%) made migrations that were related to spawning whereas 3 (25%) remained relatively sedentary. Spawning migrations commenced in April and early May during the rising limb of the hydrograph and as water temperatures increased from 5°C to 8°C. Seven of the nine spawners migrated to upper reaches of the North Fork Flathead River (U.S. and Canada), one fish ascended the Middle Fork Flathead River and the remaining fish moved upstream to the upper mainstem Flathead River. Tagged fish presumably spawned in tributaries during May and June as flows subsided after peak run-off and as water temperatures approached 10°C. Average upstream movement was 56.3 km (range: 9.7-125.8 km). Four postspawned fish made long, rapid downstream movements to Flathead Lake and the Flathead River, indicating both fluvial and adfluvial life history components of the migratory population.

### Introduction

Westslope cutthroat trout represent an important biological and cultural component of aquatic ecosystems throughout western North America. The Flathead River system in northwest Montana is recognized as a regional stronghold for migratory (e.g. adfluvial and fluvial) westslope cutthroat trout throughout its historic range (Liknes and Graham 1988; Shepard et al. 1984). Migratory forms are important life-history strategies for maintaining genetic diversity and dispersal among populations (Rieman and McIntyre 1995) which is critical to the long-term persistence and preservation of a species (Allendorf and Leary 1988). However, the distribution and abundance of migratory life-history forms have declined due to habitat fragmentation, habitat degradation, genetic introgression, and migration barriers such as dams, irrigation diversions and culverts (Liknes and Graham 1988; Behnke 1992). Consequently, westslope cutthroat trout occupy 27.4% of their original range in Montana, and genetically pure populations occupy only 2.5% of their historic range (Liknes and Graham 1988).

Despite recognition of apparent population declines, little is known about the spatial and temporal distribution of migratory westslope cutthroat trout during spawning in the upper Flathead River system in northwest Montana. Several tagging studies described the distribution of migratory adult cutthroat trout in the Flathead River (Block 1955; Johnson 1963; Shepard et al. 1984). These studies reported that westslope cutthroat trout generally moved into tributary streams during spring when streamflows were high, spawned during May and June after peak run-off and left tributaries usually by early July as flows declined. Other studies in Montana and Idaho have reported similar movement patterns by westslope cutthroat trout during spawning by migratory (Bjornn and Mallet 1964; Bjornn 1971; Schmetterling In press) and resident forms (Magee et al. 1996; Jakober et al. 1997). Although these studies provide valuable information, tagging studies may provide us with little insight on the specific movement patterns by individual fish during spawning.

Populations of westslope cutthroat trout have declined in recent years in the Flathead River drainage (Deleray et al. 1999) despite being recognized as an important recreational fishery. In light of these declines, fishery managers have initiated basin-wide habitat improvement projects to improve and restore critical habitat and have established catch and release restrictions in the mainstem, North Fork and Middle Fork Flathead River in an effort to boost population abundance. The purpose of our study was to describe the movements of adult cutthroat trout in the Flathead River system to determine the temporal and spatial distribution of migratory cutthroat trout in the Flathead River system during spring 1998. Information gained from this study will be used to aid in restoration programs and to develop sound management strategies for the recovery of this species and unique life-history forms in the Flathead system.

## Study Area

The study area encompasses the Flathead River system including the North Fork, Middle Fork and mainstem Flathead River above Flathead Lake, Montana. The Flathead River drainage originates in the Rocky Mountains of British Columbia, Canada and northwestern Montana, USA (Figure 1). The drainage area is approximately 18,400 $km^2$ and comprises the headwaters of the upper Columbia River Basin.

The North Fork originates in British Columbia and flows in a southerly direction for approximately 94 km to its confluence with the Middle Fork near Coram, Montana. This river is a fifth order stream and forms the western boundary of Glacier National Park (GNP). The Middle Fork of the Flathead River is a fifth-order stream that originates in the Bob Marshall Wilderness and flows in a northwesterly direction for 146 km to its confluence with the North Fork and forms most of the southern boundary of GNP from the wilderness boundary downstream. Both the North Fork and Middle Fork are designated as part of the National Wild and Scenic River System. The South Fork of the Flathead River flows approximately 160 km to its confluence with the main stem Flathead River near Hungry Horse, Montana where it is impounded 8.5 km upstream of the confluence by Hungry Horse Dam (completed in 1953). Hungry Horse Dam precludes upstream fish migration and isolates fish populations above the dam from the rest of the system. Land in the upper portions of the Flathead drainage is comprised of forests managed by GNP, Flathead National Forest (FNF) and other state and private enterprises. Timber production and associated road construction, and hydropower regulation are the primary land-use practices impacting this portion of the drainage.

The mainstem Flathead River begins at the confluence of the North and Middle Forks near Coram, Montana and flows in a southerly direction for 89 km where it enters the north end of Flathead Lake. Kerr Dam heavily influences the water levels in the lower 32 km of the mainstem at the south end of Flathead Lake. This river is a sixth-order stream and flows predominantly through agricultural and forested lands of the Flathead Valley.

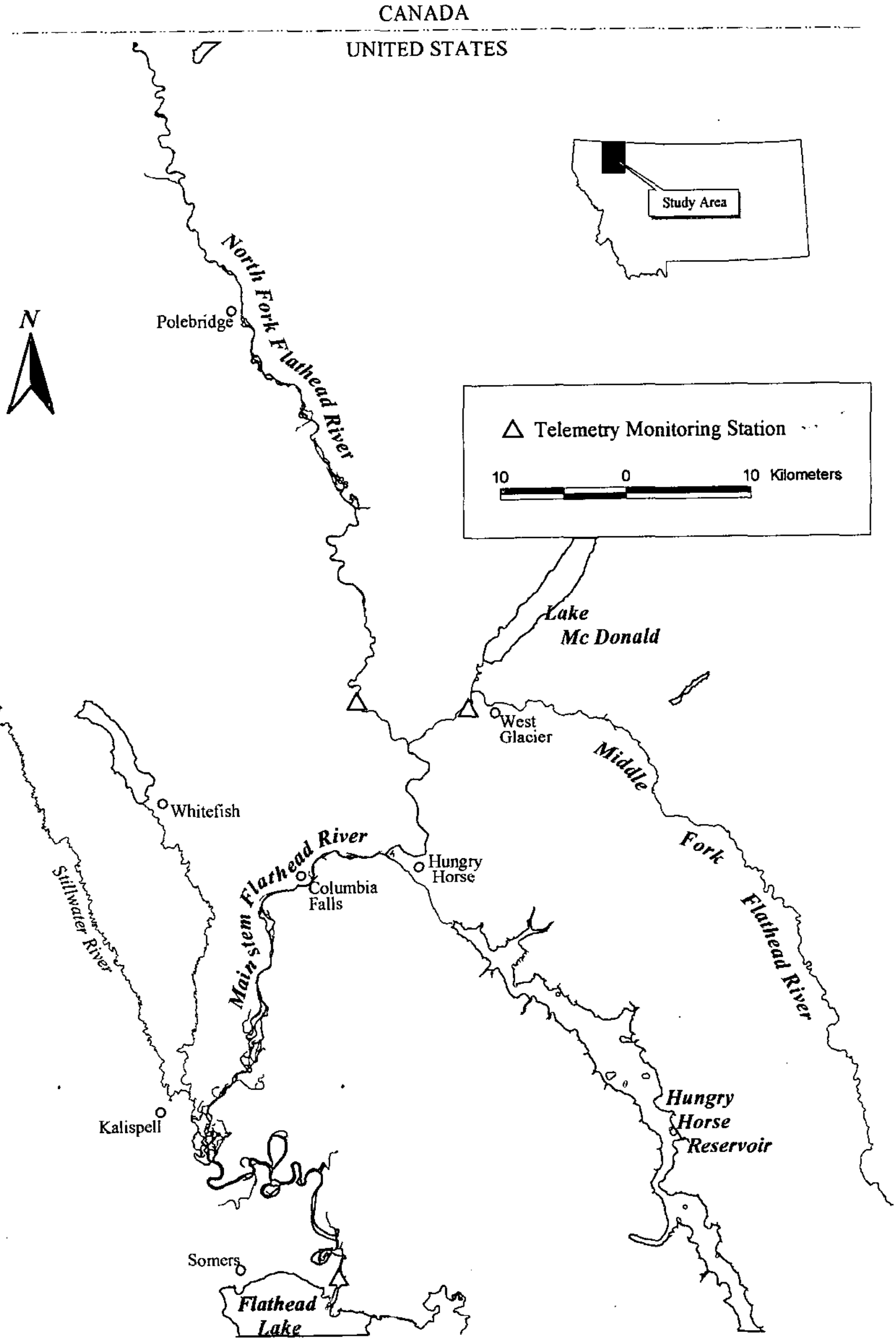


Figure 1. The upper Flathead River drainage study area including Flathead Lake and the mainstem, north, middle and south forks of the Flathead River.

Common fish fauna found in the upper Flathead River include native bull trout, westslope cutthroat trout, mountain whitefish (*Prosopium williamsoni*) and non-native rainbow trout (*Oncorhynchus mykiss*). Non-native lake trout (*Salvelinus namaycush*) occupy the river system during spring and fall, however their abundance is relatively low (Malta et al. 1997). For a more detailed of description of species present in the Flathead system see Fredenberg and Graham (1983).

## Methods

We used radiotelemetry to monitor movements of westslope cutthroat trout during late winter and spring 1998 in the Flathead River drainage. Twelve adult westslope cutthroat trout (mean length = 339 mm; range: 264-447 mm T.L.) were captured by hook and line (fly-fishing) and electrofishing, surgically implanted with radio transmitters and released in close proximity to their capture location (Table 1). Fish were tagged in the mainstem Flathead River to test whether fish moved upstream or downstream to seek spawning areas in the drainage; two fish were implanted and released on March 19, seven on April 1 and 3, and four on April 21. Fish were implanted with transmitters that weighed 6.7 g in air and had a predicted life expectancy of 170 days (model MCFT-3CM, Lotek Engineering, Inc.) in order to maintain a low (<2%) transmitter to body weight ratio (Winter 1983). Each tag emitted a unique coded signal (12 pulses/minute) in the frequency range of 148.770 mHz.

Fish were anesthetized with tricaine methane sulfonate (MS-222) and transmitters were surgically implanted into the body cavity. Each anesthetized fish was placed in a padded V-shaped trough and gills were irrigated with a 60 mg/l solution of MS-222 during surgery. We made a 10 mm incision immediately anterior of the pelvic girdle and a sterilized transmitter was admitted into the body cavity and the antenna was extended through the body wall immediately posterior of the pelvic girdle. Each incision was closed with three to four synthetic absorbable sutures. Fish were placed in a 0.25% salt solution immediately after surgery to stimulate mucous production and osmoregulation (G. Klontz, personal communication, University of Idaho, Moscow). Each surgery lasted approximately 8-10 minutes and no mortalities occurred during surgery or during the 0.5 hour recovery period.

We monitored fish movements using fixed-wing aerial surveys, ground tracking and remote ground receiver stations. A coded Lotek radio receiver (Model SRX 400-W5) and a three-element directional Yagi antenna were used to locate fish during ground and aerial surveys. Tracking surveys were usually conducted twice a month during the daytime. For ground surveys, fish locations were triangulated from vehicle access points along the road and from the streambank. Aerial surveys were conducted at approximately 100 m in elevation and at an average speed of 27-31 m/sec. Once a signal was detected, the pilot circled until the point location was verified. Three permanent telemetry ground stations were installed near the mouths of the North Fork, Middle Fork and mainstem Flathead River that were used to continuously monitor (24-hours/7 days per week) fish movements when fish came within 250 m of the stations (Figure 1). Each ground station consisted of a Lotek data-logging receiver equipped with a 3-element directional Yagi antenna powered by a 12-volt deep-cycle marine battery.

Table 1. Summary of radiotagged westslope cutthroat trout monitored during spring 1998 in the Flathead drainage, Montana

| Transmitter Code | Length (mm) | Weight (g) | Spawning Migration (y/n) | Release Date | Date of last signal | Number of days tracked | Number of relocations | Net distance moved upstream (km) | Net distance moved downstream (km) |
|---|---|---|---|---|---|---|---|---|---|
| 110 | 447 | 828 | y | 19-Mar | 15-May | 57 | 7 | 85.2 | na |
| 111 | 409 | 648 | y | 19-Mar | 5-Jul | 108 | 11 | 74.1 | 110.0 |
| 112 | 386 | 592 | y | 1-Apr | 26-May | 55 | 8 | 59.5 | 95.5 |
| 113 | 360 | 456 | y | 1-Apr | 24-Jul | 114 | 9 | 125.8 | 6.9* |
| 114 | 395 | 629 | y | 21-Apr | 19-Jun | 59 | 6 | 77.9 | 161.8 |
| 115 | 317 | 303 | n | 1-Apr | 24-Jul | 114 | 10 | 8.5 | 5.5 |
| 116 | 335 | 384 | n | 21-Apr | 24-Jul | 94 | 8 | 1.7 | 1.7 |
| 117 | 286 | 218 | n | 1-Apr | 24-Jul | 114 | 7 | 7.6 | 0.5 |
| 118 | 285 | 227 | y | 1-Apr | 23-May | 52 | 4 | 52.3 | na |
| 119 | 264 | 160 | y | 21-Apr | 24-Jul | 94 | 6 | 11.3 | 0.0 |
| 120 | 276 | na | y | 3-Apr | 24-Jul | 112 | 5 | 13 | 2.3 |
| 122 | 310 | 301 | y | 21-Apr | 24-Jul | 94 | 8 | 10 | 46.6 |

(Note: na = fish was lost, * = fish died)

For each location, we recorded the time, location, direction moved and calculated the distance moved from the previous location. Each location was recorded on a USGS topographic map (1:24,000). Location points were later transferred into ArcView (Version 3.1). Movements were calculated by measuring the distance along the thalweg from each consecutive location in ArcView. We assumed mean error was approximately 4.5 m using aerial and ground tracking techniques from average distances of approximately 100 m (Simpkins and Hubert 1998). Net movement was considered as the overall direction and distance moved (both upstream and downstream) from the original point of release and furthest upstream location throughout the study period. Mean daily discharge and temperature data were obtained from the USGS flow monitoring station located in the mainstem Flathead River (Columbia Falls) throughout the study period.

We divided westslope cutthroat trout into two categories, spawners (whose movements were > 10 km) and non-spawners (fish that moved < 10 km). All study fish >250 mm (T.L) were classified as adults and fish < 250 mm were classified as juveniles (Shepard et al. 1984). We used Spearman's Rank of Correlation analysis to correlate total fish length to the total upstream distance moved. The statistical analysis was conducted with SPSS/PC+, version 10.0 (Norusis 1990). Significance was considered at the $\alpha = 0.05$.

## Results

Twelve radio-tagged westslope cutthroat trout were successfully tracked an average of 85 days (range: 52-114 d) and each fish was relocated an average of 7 times (range: 4-11) during the study period. One radio-tagged fish was found dead 55 d after implantation and two fish were lost 52 and 57 d after implantation. The two lost transmitters either failed prematurely or the fish moved to tributaries in the upper North Fork Flathead River (US and Canada) where signal detection was difficult. Considering all fish together, average total distance moved upstream that we documented was 44 km (range: 1.7-125.8 km) and average total distance moved downstream was 47 km (range: 0-161.8 km). A total of 89 relocations were obtained during the study period.

Of the 12 radio-tagged fish, nine made spawning migrations (mean T.L. = 348 mm). Average upstream movement for fish that presumably spawned was 56.3 km (range: 9.7-125.8 km). Seven of the nine migratory spawners moved upstream to upper reaches of the North Fork Flathead River (U.S. and Canada), one fish moved upstream to the Middle Fork Flathead River and the remaining fish moved upstream to the upper mainstem Flathead River (near Sekokini Springs Natural Rearing Facility).

Spawning migrations commenced during the rising limb of the hydrograph and as water temperatures increased from 5°C to 8°C. Spawning presumably occurred in May and June as flows subsided after peak run-off and as water temperatures approached 10°C. In general, peak upstream movement of spawning cutthroat trout occurred in late April and peak downstream movement occurred in late June and early July (Figure 2).

Our movement results suggest that the timing and total distance moved differed among the radio-tagged westslope cutthroat trout (Figure 3). Five of the spawners tagged during March and early April displayed upstream movements past the North Fork permanent ground station between April 15 and May 23 (mean = April 29). The remaining fish was found near Sekokini Springs on May 21 and was not subsequently relocated until July 7 in Hungry Horse Canyon. Of the three spawners tagged in late April, two fish moved past the North Fork permanent ground station on May 7 and May 29, respectively, and the remaining fish moved past the Middle Fork ground station on May 17. River discharge generally *increased from 5,000 to 25,000 $ft^3/s$ during the upstream spawning migration* (Figure 2).

We did not determine when the study fish entered tributaries to spawn or the specific tributaries they presumably spawned in. However, our gross movement data suggests spawning occurred as flows subsided after peak run-off in late May and June in tributaries to the upper North Fork Flathead River. The furthest upstream locations in North Fork were found in late May and early June near Red Meadow Creek, Coal Creek, and Kishenehn Creek (Figure 3).

Postspawned cutthroat trout made long, rapid movements downstream to the mainstem Flathead River and to Flathead Lake; four fish moved downstream past the North Fork and Middle Fork ground stations between May 21 and June 16. Three of the four fish (#111, #112 & #144) exhibited an adfluvial life history strategy, moving from 47 km to 162 km (mean =104 km) downstream to Flathead Lake following spawning; downstream migration rates for two of the adfluvial fish were 17.5 and 29.2 km/day. The remaining fish (# 122) exhibited a fluvial life history, moving 47 km downstream from the North Fork to a braided section (near Presentine Bar) of the mainstem Flathead River following spawning.

Fish length was positively correlated with distance traveled upstream ($r = 0.58$, $P = 0.048$). Therefore, larger fish exhibited a tendency to migrate greater distances to spawning areas. The four largest study fish (> 375 mm) made pronounced upstream movements (> 59.5-125.8 km), two of which made long, rapid movements downstream to Flathead Lake following spawning (e.g. adfluvial).

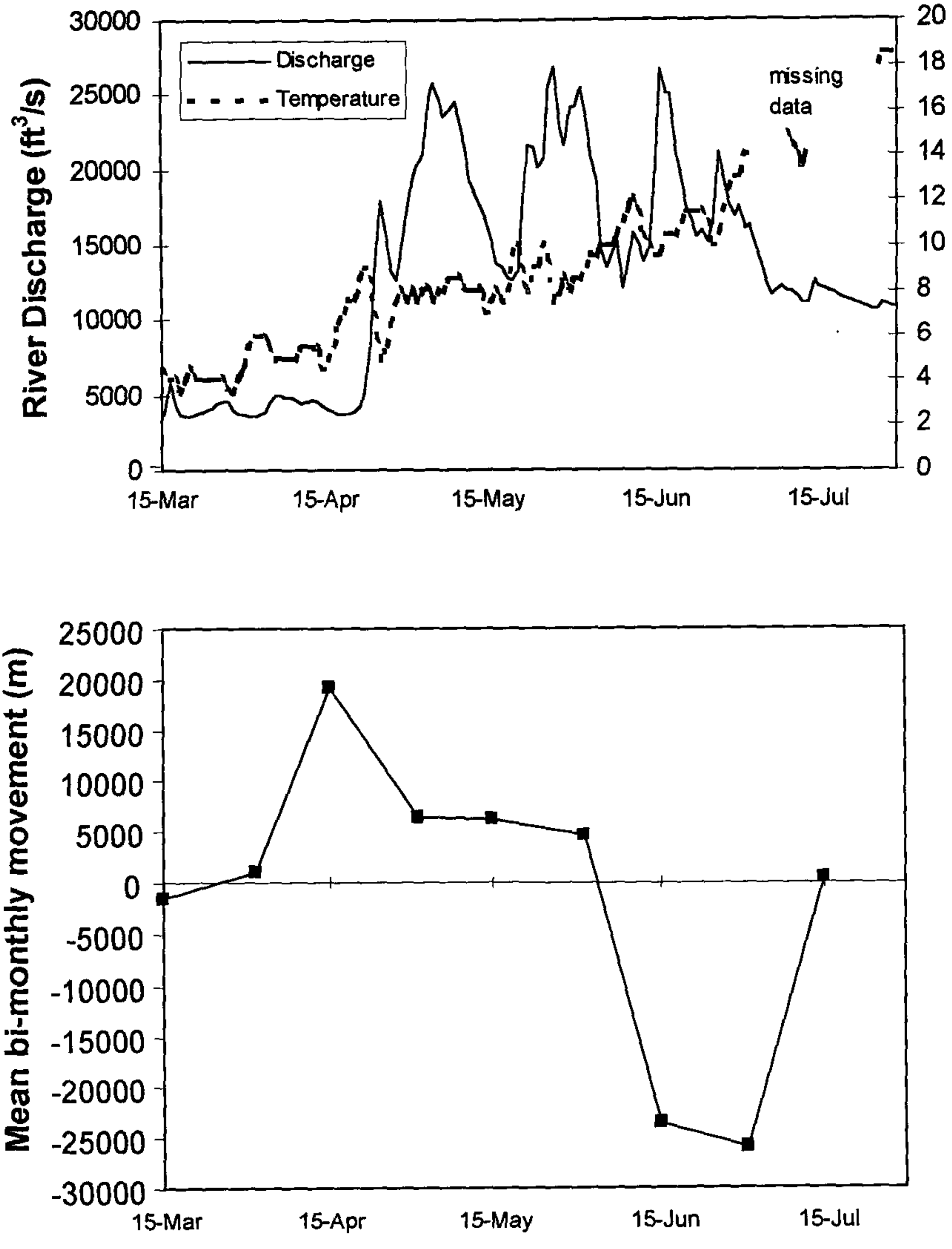


Figure 2. Mean bi-monthly movement (m) by spawning westslope cutthroat trout in relation to mean daily water temperature and river discharge in the Flathead River drainage during 1998 .

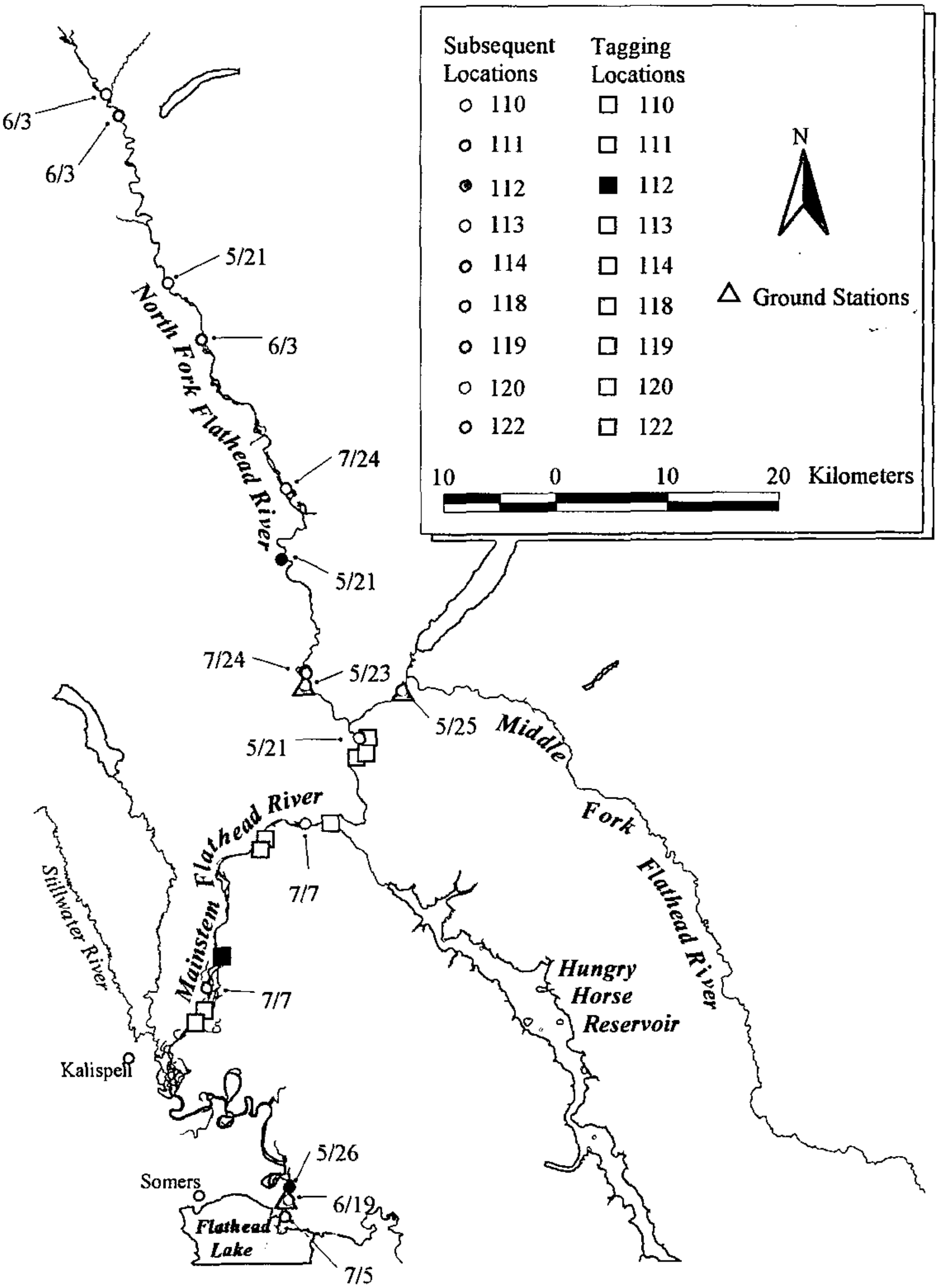


Figure 3. Release, furthest upstream and final locations for westslope cutthroat monitored in the upper Flathead River drainage during spring (March-June) 1998.

## Discussion

Results from this study indicate that migratory westslope cutthroat trout made extensive upstream movements (up to 126 km) to the upper Flathead River drainage during spawning. Similarly, other researchers found that cutthroat trout display long, upstream migrations to spawning areas with some migrations exceeding 150 km (Bjornn and Mallet 1964; Bjornn 1971; Shepard et al. 1984). Conversely, trout may move downstream to spawning areas depending on the availability of suitable spawning habitat (Brown and Mackay 1995). Schmetterling (In press) and Brown and Mackay (1995) found that cutthroat trout moved both up and downstream to reach spawning areas in Montana and Alberta, respectively. Nonetheless, our results indicate that westlope cutthroat trout utilize large contiguous tracts of aquatic habitat demonstrating the importance of stream connectivity and quality habitat throughout the Flathead River system.

Spring upstream movements of the radio-tagged cutthroat trout were related to streamflow and water temperature. Spawning migrations commenced during the rising limb of the hydrograph and gradual increase in water temperatures from 5°C to 8°C. Spawning presumably occurred in May and June as river discharge generally declined and as water temperatures approached 10°C. Streamflow and water temperature are important variables that trigger spawning movements and redd construction by migratory cutthroat trout in Montana (Huston et al. 1984; Shepard et al. 1984; Schmetterling 2000; Schmetterling In press). Similarly, Schmetterling (In press) reported that westslope cutthroat trout migrated to tributaries during the rising limb of the hydrograph and spawned in May as flows subsided after peak discharge in the Blackfoot River drainage, Montana. Westslope cutthroat trout have adapted to migrate during high spring flows permitting access to upper reaches of the watershed.

We believe that long-range movements during spawning are important to the production and persistence of westslope cutthroat trout in the Flathead River drainage. Similar to Shepard et al. (1984), our results suggest that a majority of spawning occurs in the upper reaches of the North Fork Flathead River in Montana (U.S.) and British Columbia (Canada). Widespread hybridization between westslope cutthroat trout and introduced rainbow trout has occurred in the lower portions of the upper Flathead River drainage (Deleray et al. 1999) and may substantially contribute to the loss of genetic integrity within the native range of *O. c. lewisi*. Thus, there is likely some degree of spatial and temporal segregation between rainbow trout and westslope cutthroat trout during spawning with hybridization occurring in lower and transitional areas of the watershed. Colder water temperatures in the upper Flathead River drainage may not be suitable to the production of rainbow trout. In addition, other environmental (biotic and abiotic) variables such as drainage elevation, stream productivity, channel geomorphology etc. and anthropogenic influences (i.e. stocking, hatchery leakage) may be related to the spatial distribution of westslope cutthroat trout, rainbow trout, and WCTxRBT hybrids in the Flathead River drainage. A graduate project has been launched to investigate the spatial extent of rainbow trout and rainbow-cutthroat hybrids and the influence of environmental factors on hybridization.

Our results corroborate the contention that mature adults of each life history strategy may be differentiated based on size (Shepard et al. 1984). We found that three post-spawned fish (386 mm – 409 mm) exhibited an adfluvial life history moving to Flathead Lake and three postspawned fish (264 mm – 310 mm) exhibited a fluvial life history moving to the lower Flathead River. Shepard et al. (1984) classified mature adults ($\geq$ 4 years) as fish (>350 mm) being adfluvial, medium sized fish (250 mm – 350 mm) being fluvial and fish less than 250 mm being resident fish.

Variation in the timing of spawning movements among the study fish was related to when we tagged each group during the spawning migration. Fish tagged during March tended to migrate earlier compared to fish implanted in April. Therefore, our results may represent migratory components of the entire migratory population of the system during the spawning run. However, results should be viewed cautiously because they are based on small sample sizes.

Results from this study indicate that westslope cutthroat constructed redds in May and June as flow subsided following peak runoff. However, the timing and location of redd construction was based on locations obtained in the mainstem North Fork and Middle Fork Flathead River. Schmetterling (In press) reported that westslope cutthroat spawned in May in tributaries to the Blackfoot River as flows subsided after peak discharge. Future efforts by this project will determine the exact timing, location and characteristics of spawning sites to further understand the habitat requirements of this subspecies.

Three mature study fish did not exhibit pronounced movements related to spawning during the study. These results suggest that a proportion of the adult population may spawn intermittently or that radio-tagging procedures may alter spawning behavior.

Radio-tagged fluvial and adfluvial westslope cutthroat trout made extensive migrations during spring to access spawning areas in the upper Flathead River drainage. Migration barriers, such as poorly engineered culverts and dams that do not accommodate fish passage at high flows may be detrimental to the long-term persistence of this migratory metapopulation. Fish passage habitat conservation and improvement programs should concentrate on maintaining stream connectivity and quality spawning habitat throughout the Flathead River system. In western Montana, the fishing season opens the third weekend of May coinciding with the peak of the cutthroat trout spawning period. Catch and release regulations have been established by Montana Department of Fish, Wildlife and Parks, however, losses due to illegal harvest (e.g. poaching) or misidentification may have significant negative impacts to the population as a whole. Finally, our results show that spawning movements by migratory westslope cutthroat varied both spatially and temporally. Therefore, future management decisions should pertain to all life-history forms within the metapopulation.

# CHAPTER 3- SEASONAL MOVEMENTS BY LAKE TROUT IN THE UPPER FLATHEAD RIVER, MONTANA

*Abstract.*— We used radio-telemetry to describe the seasonal movements of 36 lake trout (mean total length = 478; range: 411-538) from 1996 through 1998 in the Flathead River upstream of Flathead Lake. The combined movement patterns suggest that lake trout seasonally utilized the lake and river system according to changes in water temperature, river discharge and possibly food. Peak downstream movements by lake trout from the Flathead River to Flathead Lake occurred during July and throughout the fall and winter (November-February). Downstream movements during July occurred as water temperatures rose toward 15°C and as river discharge subsided and reached base flow after spring runoff. Fall and winter downstream movements occurred as water temperatures declined from 4°C to 2°C. Peak upstream movements from the lake to the river occurred in late October when water temperatures declined to 6°C and coincided with the upstream spawning migration of pygmy whitefish. Information gained from this study may enable fisheries managers to reduce lake trout abundance in the Flathead River by manipulating dam discharge and temperature using the selective withdrawl structure on Hungry Horse Dam. Habitat manipulation and regulations may also be useful tools for managing lake trout predation on native species.

## Introduction

The seasonal movements and habitat requirements of lake-dwelling lake trout (*Salvelinus namaycush*) have been well described in North America with a substantial emphasis on populations inhabiting the Great Lakes. Research on lacustrine forms of lake trout indicates that temperature, oxygen and food availability are important factors in habitat utilization (Martin 1952; Peck 1982; MacLean et al. 1990). However, less is known about the seasonal movements and habitat use by lake trout in a lacustrine-fluvial system (Malta et al. 1997).

Introductions of lake trout into several lakes in western North America have resulted in the decline of native salmonids (Behnke 1992). In 1905, lake trout were introduced into Flathead Lake, Montana (Deleray et al. 1999). The abundance and distribution of lake trout dramatically increased in the late 1980's coinciding with the establishment of *Mysis* shrimp in Flathead Lake. The incidence of lake trout entering the Flathead River was rarely observed prior to 1989, however, recent information suggests that use of the Flathead River has substantially increased (MDFWP, unpublished data, Kalispell, Montana). During the same period, native bull trout and cutthroat trout populations declined alarmingly. Migratory juvenile bull trout and westslope cutthroat trout emigrate from their natal tributaries in the upper reaches of the Flathead drainage downstream to Flathead Lake and the lower Flathead River primarily from June through August (Shepard et al. 1982; Shepard et al. 1984). Pygmy whitefish enter the Flathead River during the fall spawning period (MDFWP, unpublished data, Kalispell, Montana). Little is known how these native fishes utilize the river, but once they enter the Flathead River they must survive a "predator trap" consisting of numerous native (i.e. northern pikeminnow) and non-native (i.e. lake trout and northern pike) predators. Interactions between predators and prey vary seasonally. This project initiated actions to assess whether the increasing trends in lake trout occurrence was related to declines in native trout.

Native populations of bull trout and westslope cutthroat trout have declined in recent years due to a complex combination of anthropogenic influences (i.e. logging, dams, mining), hybridization with non-native salmonids and competition and predation by introduced species (Liknes and Graham 1988; Rieman and McIntyre 1995). Prior to the establishment of lake trout, Flathead Lake supported healthy populations of migratory bull trout and westslope cutthroat trout. Knowledge of the spatial and temporal distribution of lake trout inhabiting the Flathead River system will enable fisheries managers to better understand the potential interactions of lake trout with native bull trout and westslope cutthroat trout. In 1996, a selective withdrawl structure was installed at Hungry Horse Dam in the South Fork Flathead River (Christenson et al. 1996; Marotz et al. 1996) that returned a more normative temperature regime in the Flathead River. Temperatures in excess of the preferred range for lake trout may influence their distribution and movements thereby minimizing predator-prey interactions in the Flathead River during spring and summer. Results of this study may be used to assess the feasibility of manipulating temperature and flow to reduce the abundance of lake trout in the Flathead River system. The objectives of this study were to describe the seasonal movements and distribution of lake trout in the Flathead River and to identify biotic and abiotic factors related to movements.

## Study Area

Flathead River drainage located in northwest Montana consists of Flathead Lake, the Flathead River above Kerr Dam and major tributaries including the North Fork, Middle Fork and South Fork (Figure 1). The drainage area is approximately 18,400 $km^2$ and comprises the headwaters of the upper Columbia River Basin. Flathead Lake is an oligomesotrophic lake and has a surface area of approximately 510 $km^2$, a mean depth of 50.2 m and a maximum depth of 113 m (Zackheim 1983). The top three meters of the lake is regulated by Kerr Dam located at the southern end of Flathead Lake. The three forks of the Flathead River supply an estimated 80 percent of the annual discharge in the Flathead system (Zackheim 1983). The North Fork originates in British Columbia and flows in a southerly direction for 94 km to its confluence with the Middle Fork near Coram, Montana. The North Fork is a fifth-order stream and forms the western boundary of Glacier National Park (GNP). The Middle Fork of the Flathead River originates in the Bob Marshall Wilderness and flows in a northwesterly direction for 146 km to its confluence with the North Fork. This Middle Fork is a fifth-order stream that forms most of the southern boundary of GNP from the wilderness boundary downstream. The South Fork Flathead River flows approximately 95 km through the Bob Marshal Wilderness Area to Hungry Horse Reservoir (56 km in length). The South Fork was impounded in 1952 with the construction of Hungry Horse Dam located approximately 8 km upstream of the confluence of the South Fork and mainstem of the Flathead River. The mainstem Flathead River begins at the confluence of the North and Middle Forks near Coram, Montana and flows in a southerly direction for 89 km where it enters the north end of Flathead Lake (Fredenberg and Graham 1983). Kerr Dam regulates water levels in the lower 32 km of the mainstem at the south end of Flathead Lake. This river is a sixth-order stream and flows predominantly through agricultural and forested lands of the Flathead Valley. Land in the Flathead drainage is comprised of forests managed by GNP, Flathead National Forest (FNF) and other state and private enterprises. Timber production and

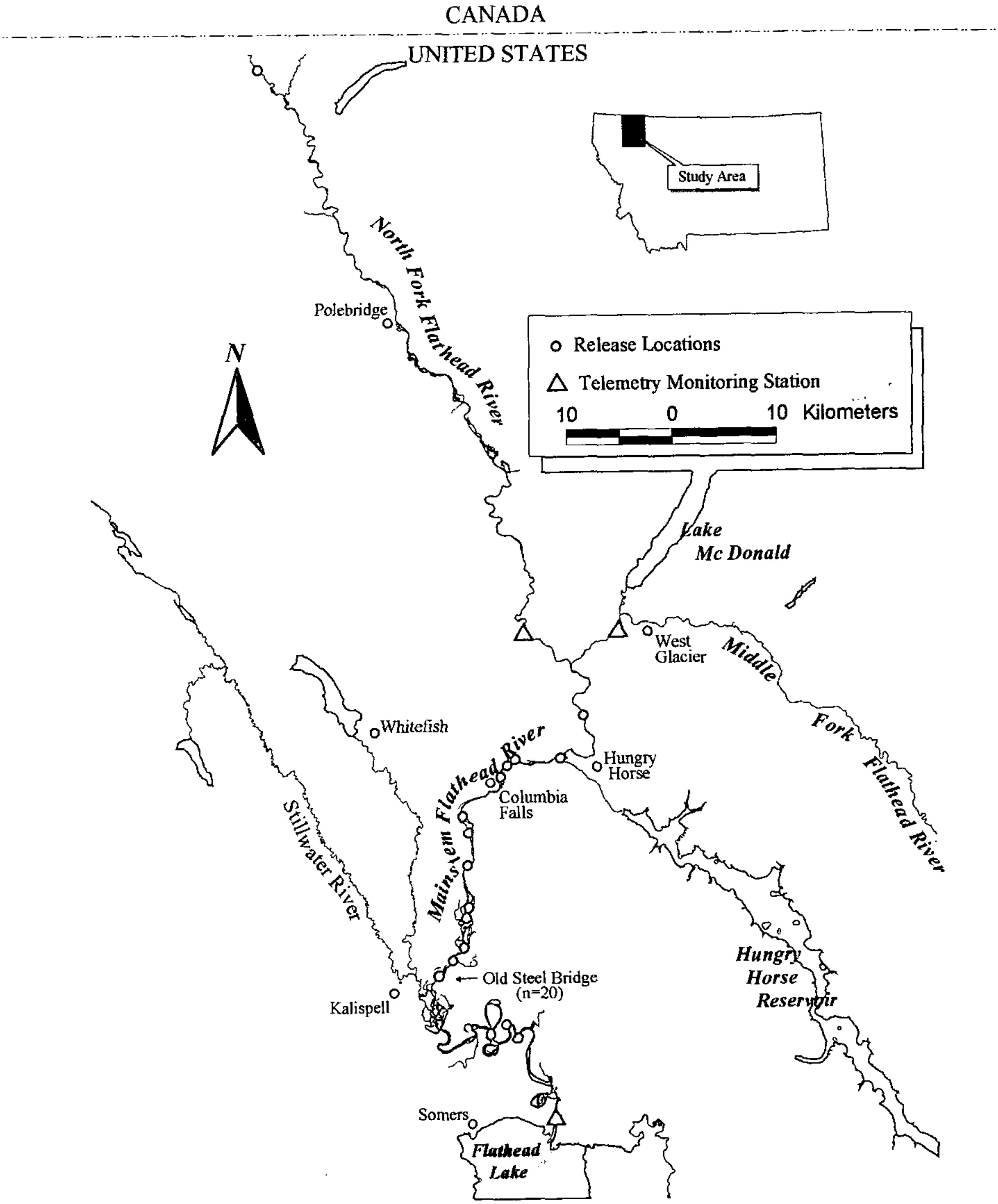


Figure 1. Study area of the Flathead River drainage and release locations of radio-tagged juvenile lake trout from 1996 through 1998.

associated road construction and hydropower regulation are the primary land-use practices impacting this portion of the drainage.

Hungry Horse Dam precludes upstream fish migration and isolates fish populations above the dam from the rest of the system. Hypolimetic releases from the dam artificially cooled the river from 1952 through 1995. Installation of the selective withdrawl system at Hungry Horse Dam in 1995 returned a more normative thermal regime to the Flathead River upstream of Flathead Lake (Deleray et al. 1999). Isothermal dam discharge releases were replaced by warmer water to closely mimic normative temperatures in the South Fork Flathead River and the mainstem Flathead River.

## Methods

We used radiotelemetry to monitor movements of lake trout (<550 mm) inhabiting the Flathead River system above Flathead Lake from 1996 through 1998. Thirty-six lake trout were captured by hook and line and merwin trapping, surgically implanted with radio transmitters and released in close proximity to their capture location (Figure 1).

Captured fish were anesthetized with tricaine methane sulfonate (MS-222) and transmitters were surgically implanted into the body cavity. Each anesthetized fish was placed in a padded V-shaped trough and gills were irrigated with a 60 mg/l solution of MS-222 during surgery. We made a 10 mm incision immediately anterior of the pelvic girdle and a sterilized transmitter was admitted into the body cavity and the antenna was extended through the body wall immediately posterior of the pelvic girdle. Each incision was closed with three to four synthetic absorbable sutures. Fish were placed in a 0.25% salt solution immediately after surgery to stimulate mucous production and osmoregulation (G. Klontz, personal communication, University of Idaho, Moscow). Each surgery lasted approximately 8-10 minutes and no mortalities occurred during surgery or during the 0.5 hour recovery period. Study fish were implanted with transmitters that weighed 9.0 g in air and had a predicted life expectancy of 395 days (model MCFT-3EM, Lotek Engineering, Inc.). Each tag emitted a unique coded signal (12 pulses/minute) in the frequency range of 148.750 MHz.

We tracked radiotagged fish from the ground, aircraft and stationary ground tracking, fixed-wing aerial surveys and remote ground receiver stations to monitor fish movements throughout the study period. A coded Lotek radio receiver (Model SRX 400-W5) and a three-element directional Yagi antenna were used to locate fish during ground and aerial surveys. Tracking surveys were usually conducted twice a month during the daytime. For ground surveys, fish locations were triangulated from vehicle access points along the road and from the streambank. Aerial surveys were conducted at approximately 100 m in elevation and at an average speed of 27-31 m/sec. Once a signal was detected, the pilot circled until the point location was verified. Three permanent telemetry ground stations were installed near the mouths of the North Fork, Middle Fork and mainstem Flathead River. Fish were detected by the ground station when they

Table 1. Lake trout monitored in the Flathead River system above Flathead Lake from 1996 through 1998.

| Code | Release Date | Final Date | Number of relocations | Capture Method | Length (mm) | Weight (g) |
|---|---|---|---|---|---|---|
| 165 | 10/29/96 | 8/11/97 | 4 | AN | 411 | 764 |
| 159 | 10/30/96 | 11/14/96 | 3 | CR | 413 | 647 |
| 168 | 10/30/96 | 12/6/96 | 3 | AN | 416 | 856 |
| 152 | 10/31/96 | 12/15/97 | 3 | CR | 423 | 613 |
| 155 | 10/31/96 | 12/4/97 | 13 | CR | 446 | 777 |
| 163 | 10/31/96 | 3/10/97 | 4 | MT | 454 | 982 |
| 170 | 10/31/96 | 8/21/97 | 10 | CR | 456 | 945 |
| 150 | 11/1/96 | 6/20/97 | 24 | AN | 456 | 622 |
| 154 | 11/2/96 | 12/11/96 | 5 | CR | 456 | 892 |
| 157 | 11/2/96 | 12/6/96 | 3 | CR | 463 | 531 |
| 169 | 11/2/96 | 11/26/96 | 4 | CR | 468 | 701 |
| 166 | 11/2/96 | 11/14/96 | 2 | CR | 468 | 662 |
| 75 | 12/9/96 | 5/23/97 | 16 | CR | 474 | 712 |
| 166i | 12/9/96 | 12/15/97 | 10 | CR | 475 | 856 |
| 77 | 12/9/96 | 12/20/96 | 2 | CR | 476 | 744 |
| 78 | 12/12/96 | 2/25/97 | 5 | CR | 480 | 886 |
| 81 | 7/11/97 | 8/11/97 | 4 | AN | 483 | 712 |
| 76 | 7/15/97 | 7/30/97 | 2 | AN | 486 | 651 |
| 79 | 7/23/97 | 8/26/97 | 3 | AN | 487 | 711 |
| 80 | 7/23/97 | 7/27/97 | 2 | AN | 487 | 781 |
| 84 | 10/22/97 | 12/25/97 | 6 | CR | 490 | 723 |
| 85 | 10/22/97 | 12/26/97 | 4 | AN | 490 | 731 |
| 90 | 11/7/97 | 11/19/97 | 2 | CR | 492 | 837 |
| 93 | 11/7/97 | 12/15/97 | 3 | CR | 493 | 811 |
| 83 | 11/10/97 | 6/2/98 | 5 | CR | 494 | 958 |
| 87 | 11/10/97 | 11/23/97 | 1 | CR | 494 | 706 |
| 89 | 6/22/98 | 10/26/98 | 4 | AN | 495 | 794 |
| 91 | 6/24/98 | 8/7/98 | 2 | AN | 496 | 408 |
| 88 | 7/2/98 | 7/5/98 | 1 | AN | 496 | 816 |
| 73 | 7/6/98 | 7/8/98 | 1 | AN | 500 | 553 |
| 92 | 7/6/98 | 12/3/98 | 2 | AN | 500 | 686 |
| 94 | 7/6/98 | 7/8/98 | 1 | AN | 502 | 456 |
| 74 | 7/7/98 | 4/8/99 | 13 | AN | 509 | 814 |
| 72 | 7/8/98 | 7/21/98 | 2 | AN | 513 | 835 |
| 69 | 7/21/98 | 12/4/98 | 11 | AN | 523 | 990 |
| 88i | 6/22/98 | 6/25/98 | 1 | AN | 538 | 896 |

Note: Capture method abbreviations are: AN = angling, CR = creel survey, and MT = merwin trap.

moved within 250 m of the receiver. The stations continuously monitored (24-hours/7 days per week) fish movements (Figure 1). Each ground station consisted of a Lotek data-logging receiver equipped with a 3-element directional Yagi antenna powered by a 12-volt deep-cycle marine battery.

For each location, we recorded the direction moved and calculated the distance moved from the previous location. Each location was recorded on a USGS topographic map (1:24,000). Location points were later transferred into ArcView (Version 3.1). Movements were calculated using ArcView by measuring the distance along the thalweg from each consecutive location. We considered that fish moved from the Flathead River downstream to Flathead Lake if a signal was not obtained once a fish passed through the ground station at Holt. We also recorded movements of fish that entered Flathead Lake or were harvested by reliable anglers. Given that location error increases with distance between the transmitter and receiver, we assumed that mean error was approximately 4.5 m using aerial and ground tracking techniques (Simpkins and Hubert 1998). Daily water temperature data were obtained from the USGS flow monitoring station located in the mainstem Flathead River (Columbia Falls) during the study period.

## Results

The combined movement patterns suggest that lake trout seasonally utilized the lake and river system according to changes in water temperature, river discharge and possibly food. Peak downstream movements by lake trout from the Flathead River to Flathead Lake occurred during July and throughout the fall and winter (November-February). Downstream movements during July occurred as water temperatures rose toward 15°C and as river discharge subsided and reached base flow after spring runoff. Fall and winter downstream movements occurred as water temperatures declined from 4°C to 2°C. Peak upstream movements from the lake to the river occurred in late October when water temperatures declined to 6°C and coincided with the upstream spawning migration of pygmy whitefish.

*1996*

We implanted and released 16 lake trout (mean total length = 475; range: 413-523) in the Flathead River near Kalispell (Old Steel Bridge) during the fall and winter (October 29-December 12) of 1996 (Table 1). Of the 16 implanted lake trout, 13 were relocated an average of 7 times (range: 2-24) and tracked an average of 158 d (range: 11-410). Two of the three lost transmitters apparently failed prematurely and an angler harvested one lake trout shortly after implantation.

Ten of the 13 lake trout tagged during fall and winter moved approximately 39 km downstream to Flathead Lake following implantation. Nearly all downstream movements occurred from November 8 to December 20 as water temperatures declined from 4°C to 2°C (Figure 3). One lake trout moved 37 km upstream to Hungry Horse Dam (South Fork Flathead River) following implantation before migrating 72 km downstream to Flathead Lake in January. One migrant to Flathead Lake was harvested by an angler in the north end of Flathead Lake during summer 1997. Following implantation, two lake trout moved 34 km downstream to the mouth of the river near Flathead Lake where they remained through late

May and early June prior to loss of signal. The remaining fish overwintered 13-18 km downstream of the release site in the Flathead River, then moved 17 km downstream near the mouth in June and entered Flathead Lake in early July.

Two lake trout tagged in 1996 that migrated to Flathead Lake returned to the Flathead River during late October 1997 (Figure 4). One lake trout migrated 46 km upstream in the Flathead River during October and then progressively moved downstream from November through December (total downstream movement = 19.6 km). The other lake trout was located in the river near the ground station at Holt and at the mouth of Church Slough during November prior to signal loss.

*1997*—We surgically implanted 10 lake trout (mean total length = 480 mm; range 456-500) during summer and fall of 1997 (Table 1). Four lake trout were captured and implanted in the Columbia Falls and Kalispell sections of the Flathead River from July 11 through July 23 and six lake trout were radio-tagged at Old Steel Bridge from October 22 through December 12 (Figure 1). Three lake trout tagged during the summer were presumed dead on the streambed shortly after implantation and one fish tagged during the fall was not relocated following its release. The six remaining lake trout were located an average of 3 times (range: 1-6) and tracked an average of 48 d (range: 4-204 d).

The six lake trout tagged during 1997 in the Flathead River moved downstream to Flathead Lake following implantation (Figure 4). One lake trout tagged in late July moved 67 km downstream to Flathead Lake (3 days post-release) as water temperatures approached 15°C. The five lake trout tagged during fall and winter entered Flathead Lake from November 23 through February 11. Total downstream movements averaged 43 days (range: 12-93 d). Water temperatures declined from 4°C to 2°C during the fall and winter downstream migration period.

*1998*—During 1998, we surgically implanted 10 lake trout (mean length = 481 mm; range: 411-538) from June 22 through July 21; 9 were tagged throughout the Flathead River and 1 fish was implanted in the upper North Fork Flathead River (Figure 1). Three lake trout were presumed dead in the Flathead River 13-126 d after implantation and one fish was harvested by an angler in Flathead Lake 3 d after implantation. The 10 tagged lake trout during summer 1998 were located an average of 5 times (range: 1-13) and tracked an average of 106 d (range: 2-317).

Five of the radio-tagged lake trout moved downstream to Flathead Lake from July 5 through July 9 an average of 2 d (range: 1-3) following implantation (Figure 4). Mean total distance moved from their respective capture and release locations to Flathead Lake was 44.6 km (range: 37-64.5). The summer downstream migration period corresponded with an increase in mean daily water temperatures toward 15°C. One lake trout tagged near the mouth of the South Fork Flathead River was found 8.2 km upstream at the base of Hungry Horse Dam during August and September and then moved 23 km downstream to the Flathead River near Eleanor Island where it was presumed dead in October. Three

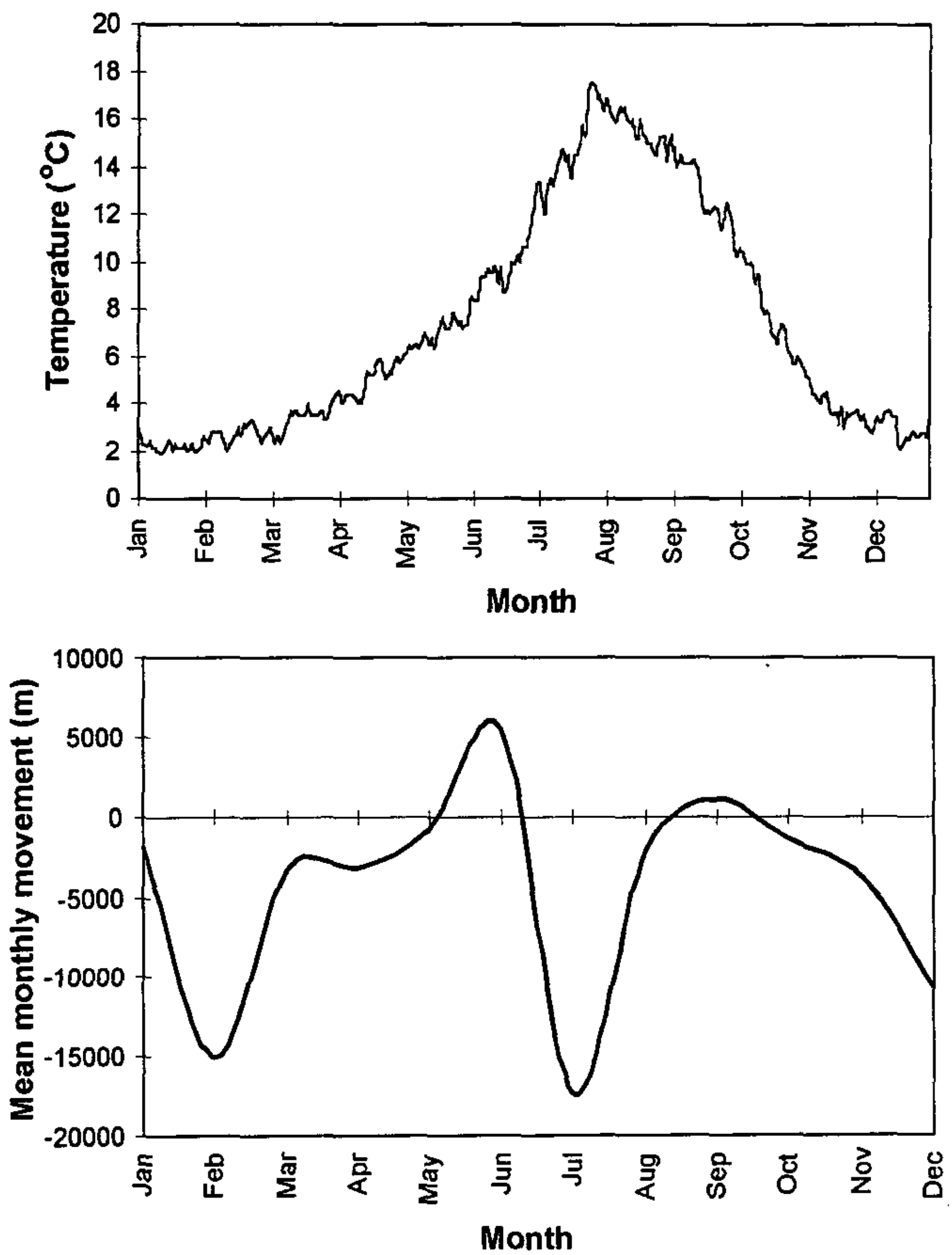


Figure 2. Mean monthly movements (m) by lake trout in relation to mean daily water temperature from 1996 through 1998 in the Flathead River, Montana.

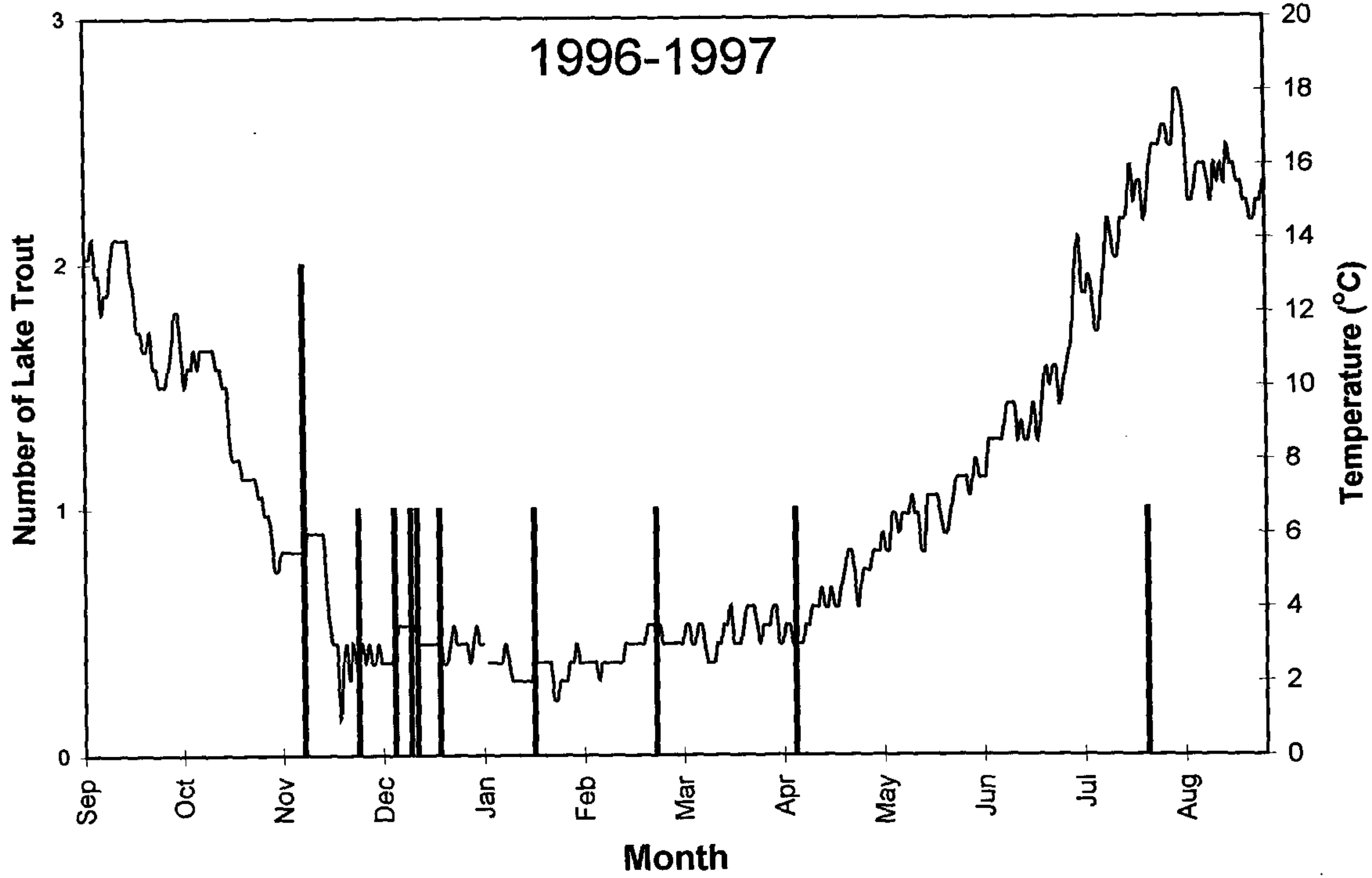


Figure 3. Number of lake trout that moved downstream to Flathead Lake from the Flathead River in relation to water temperature from fall 1996 through summer 1997.

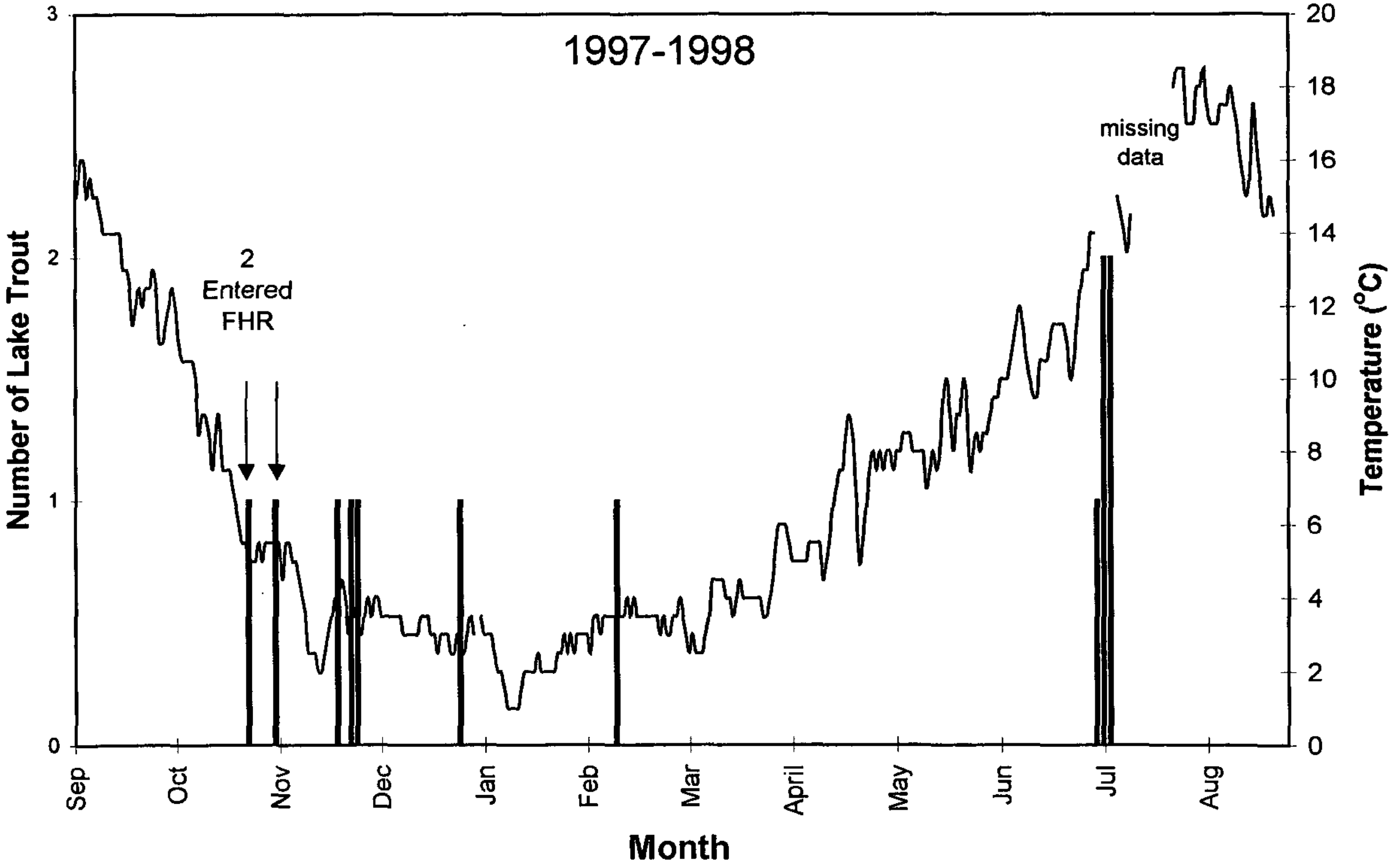


Figure 4. Number of lake trout that moved downstream and upstream between the Flathead River and Flathead Lake in relation to water temperature during from fall 1997 through summer 1998.

fish moved downstream to the lower Flathead River and were presumed dead in late July and early August.

One lake trout tagged in the North Fork Flathead River (near Polebridge) moved to the mainstem Flathead River during fall and winter. On August 31, it was found 39 km upstream from its original tag site in British Columbia (Canada). During September, it migrated 127 km downstream to the confluence with the Middle Fork and then moved 6 km upstream through the Middle Fork ground station where it remained in the Middle Fork, and possibly Lake McDonald, through mid-October. November surveys revealed that this fish moved downstream to the Flathead River near Kalispell and was later harvested by an angler in early December at Old Steel Bridge (Kalispell).

## Discussion

Our telemetry results show that lake trout moved between Flathead Lake and River on a seasonal basis. Lake trout generally migrated from the Flathead River downstream to Flathead Lake during summer and winter and made upstream migrations from Flathead Lake to the Flathead River during late-fall. Lake trout movements were best related to water temperature, flow and possibly food availability. Although these results provide insight into the movements of lake trout in an inter-connected lake and river system, results are based on small sample sizes and may not be representative of the entire lake trout population in Flathead Lake.

Results from this study indicate that 15°C approximates the maximum water temperature that lake trout will inhabit the Flathead River before migrating downstream to Flathead Lake to seek cooler water temperatures during summer. This migration is probably a temperature-induced response related to rising water temperatures in the Flathead River. Lake trout migration from shallow water in the Flathead River to deeper water in Flathead Lake initiated at temperatures between 10°C to 15°C. Similarly, other researchers found that lake trout moved to deeper water during summer as water temperatures approached 15°C (Kennedy 1941; Martin 1952; Rawson 1961). In general, adult lake trout prefer temperatures of about 10°C (Scott and Crossman 1973) whereas juvenile lake trout select deeper water and cooler temperatures of approximately 6°C (MacLean et al. 1990). Due to the operation of the selective withdrawl system at Hungry Horse Dam, in most years summer water temperatures (late June through early September) in the Flathead River exceed the preferred temperature range of lake trout. Thus, the Flathead River is probably not preferred by lake trout as water temperatures exceed 10°C and probably unsuitable as temperatures approach 15°C.

Fall upstream migrations from Flathead Lake to the Flathead River by the radio-tagged lake trout were probably related to food availability. Pygmy whitefish migrate from Flathead Lake to the Flathead River to spawn during late-fall and early winter (MDFWP, unpublished data, Kalispell, Montana). Food habit studies conducted during fall and winter revealed that pygmy whitefish comprise a majority (> 95%) of the percent biomass of prey items consumed by lake trout (450-550 mm) (MDFWP, unpublished data, Kalispell, Montana). Thus, our results suggest that lake trout migrate into the Flathead River to feed on concentrations of pygmy whitefish during their fall spawning migration. Lake trout are highly piscivorous and will take advantage of almost any available food source, generally in proportion to prey availability (Scott and Crossman 1973).

Large lake trout (>550 mm) were not readily captured during the study period and are infrequently encountered in the Flathead River (MDFWP, unpublished data, Kalispell, Montana). Annual gillnetting and creel information suggests that adult lake trout represent a relatively smaller proportion of the "catchable" population in Flathead Lake (Deleray et al. 1999). In contrast, juvenile lake trout (<550 mm) were readily captured during our study and constitute a majority of the "catchable" population in Flathead Lake and the river. Thus, the relatively higher incidence of juvenile lake trout in the Flathead River appears to be proportional to the size-class structure of the lake-river population.

Some lake trout displayed long-distance random movements throughout the upper Flathead River drainage. For example, one fish captured and released in the upper North Fork migrated a total distance of 225 km throughout the upper North Fork (Canada and U.S.), Middle Fork and mainstem Flathead River during its monitoring period. Other lake trout utilized upper portions of the Flathead River and South Fork Flathead River below Hungry Horse Dam. We believe that lake trout "pioneering" areas throughout the Flathead River system may reflect the recent increase in the abundance of lake trout in Flathead Lake. Another possibility is that these fish originated from lakes in Glacier National Park and subsequently migrated downstream into the Flathead River system. Regardless, we speculate that the threat of population expansion and full-time residency by lake trout in the Flathead River system is minimal due to unsuitable environmental conditions in the riverine environment (i.e. warm summer temperatures, high spring flows).

Two radio-tagged lake trout moved directly below Hungry Horse Dam in the South Fork Flathead River. It is possible that lake trout used the South Fork below Hungry Horse Dam as a cold water refuge prior to the installation of the selective withdrawl system in 1995. However, one of the fish did not remain at the base of the dam for an extended period of time during the summer suggesting that temperature regimes under the selective withdrawl system may be unsuitable for lake trout occupying the river during summer months. Another possible explanation for this behavior is that these fish may have been seeking cooler water seeping around the base of Hungry Horse Dam.

Our tagging results suggest that lake trout implanted during summer months experienced relatively high mortality rates. Performing implantations at a time when water temperatures ranged from 11°C to 14°C probably contributed to the low lake trout survival rates for fish tagged during summer (50% survival).

Three lake trout remained in the lower Flathead River from May through June as flows and turbidity subsided after spring run-off. Juvenile bull trout and cutthroat trout emigrate from their natal tributaries to the Flathead River and Flathead Lake primarily from May through July (Shepard et al. 1982; Shepard et al. 1984; Fraley and Shepard 1989). Thus, the spatial and temporal overlap of juvenile bull trout and westslope cutthroat trout and lake trout, a non-native opportunistic predator, may increase the probability of predation by lake trout on juvenile native salmonids migrating downstream to Flathead Lake. Future studies will investigate the food habits of lake trout during spring to quantify the types and relative proportions of fish species consumed by lake trout in the Flathead River. The introduction of lake trout into Yellowstone Lake in Yellowstone National Park, Wyoming resulted in the decline of native stocks of yellowstone cutthroat trout (*Oncoryhnchus clarki bouvieri*) (Mahoney and Ruzycki 1997; Ruzycki and Beauchamp 1997). It is possible that a similar species interaction is occurring in the Flathead system.

We believe that cooler water temperatures in the Flathead River prior to 1995 probably permitted lake trout to occupy the Flathead River for most of the summer. Installation of the selective withdrawl system at Hungry Horse Reservoir in 1995 returned a more normative thermal regime to the Flathead River upstream of Flathead Lake (Deleray et al. 1999). Isothermal dam discharge releases were replaced by warmer water to closely mimic normative temperatures in the South Fork Flathead River and ultimately the mainstem Flathead River. Prior to selective withdrawl, water temperatures in the mainstem Flathead River sporadically exceeded 10°C from June through early August depending on the timing and magnitude of peaking operations (Marotz et al. 1996; Deleray et al. 1999). In contrast, examination of the 1996 temperature data (post-selective withdrawl) revealed that water temperatures consistently exceeded 10°C from June through early October. Thus, restoration of normative temperatures in the Flathead River may reduce the likelihood of lake trout inhabiting the Flathead River.

# CHAPTER 4 – SEASONAL MOVEMENTS, DISTRIBUTION AND HABITAT USE BY NORTHERN PIKE IN THE FLATHEAD RIVER, MONTANA

*Abstract*.— Radio-telemetry was used to monitor the seasonal movements and habitat use by 12 northern pike in the Flathead River system above Flathead Lake, Montana. Fish displayed both restricted and migratory behavior during the study period. Eight fish (67%) commonly occupied river sloughs and 4 fish (33%) displayed movements to other areas of the river-lake system. Average home range for sedentary fish was 3,258 m (range: 637-7,734 m) and average total distance moved was 13,478 m (range: 1,224-57,937 m). Mobile fish occupied an average home range of 18,621 m (range: 7,273-32,315 m) and moved an average total distance of 61,148 m (range: 22,355-146,901 m). Northern pike moved significantly less during winter as compared to spring, summer and fall. Migratory pike generally overwintered in the lower river and upper Flathead Lake. As flows increased in the spring, migratory pike made upstream migrations to river sloughs that were probably related to spawning. Northern pike found suitable habitat in the form of slow-moving, warm and well-vegetated areas of the river-lake system. Results from this study is useful for evaluating species interactions in the Flathead River drainage and for describing seasonal habitat use in a riverine-lacustrine environment.

## Introduction

Northern pike are a piscivorous predator usually found in warm, slow moving water within meandering vegetated rivers or warm, weedy bays of lakes (Scott and Crossman 1973). Northern pike have a circumpolar distribution in the Northern Hemisphere. In North America, the native distribution of northern pike extends from Alaska south to Nebraska and east to Missouri, east of the Rocky Mountains and west of the Appalachian Mountains. However, northern pike have been widely introduced (both illegally and legally) outside their native range to provide a recreational sport fishery and as a control predator throughout North America.

Northern pike were illegally introduced and have become self-sustaining in the lower Flathead River above Flathead Lake, Montana. In 1953, northern pike were illegally planted into Lone Pine Reservoir near Hot Springs, Montana from Lake Sherburne, Glacier National Park (MDFWP, unpublished data, Kalispell, Montana). In the early 1970's, northern pike were illegally introduced to the upper Flathead River drainage (above Kerr Dam) and became a popular sport fishery beginning in the 1980's. Northern pike abundance probably peaked in the 1980's (J. Vashro, MTFWP, personal communication), a time of peak bull trout abundance. The distribution of northern pike in the upper Flathead River system includes Flathead Lake, the Flathead River downstream of the Stillwater River, and the Stillwater, Whitefish and Swan River drainages.

The Flathead River drainage harbors migratory populations of native bull trout and westslope cutthroat trout. Currently, bull trout are listed as a threatened species under the Endangered Species Act (ESA) and westslope cutthroat trout are recognized as a species of special concern by the American Fisheries Society and Montana Fish, Wildlife & Parks. Due to apparent declines in native trout populations, concerns have recently increased regarding the potential effects of northern pike predation. Increasing local popularity of the northern pike fishery and the potential adverse effects on native species has prompted fisheries managers to collect baseline ecological information on northern pike in the Flathead River drainage. The purpose of our study was to determine the seasonal movements and habitat use by northern pike in the Flathead River above Flathead Lake.

## Study Area

The lower section of the Flathead River (above Kerr Dam) begins at the confluence of the Stillwater River and mainstem Flathead River and flows in a southerly direction for 32 km before entering the north end of Flathead Lake, Flathead County, Montana. The lower Flathead River is a low-gradient (< 0.4 m/km) sinuous channel dominated by deep run habitat in the main channel with connected slough habitats present in lateral areas of the floodplain. This reach is characterized by sand, silt and gravel substrates and dominated by rooted and floating aquatic vegetation in the summer. Maximum recorded depth of the lower Flathead River is 27.5 m. This portion of the river is influenced by seasonal backwater affects (vertical fluctuations of approximately 3 m) caused by the impoundment of Flathead Lake by Kerr Dam. Because Flathead Lake is held near full pool for water storage from June through September, water levels in the lower portion of the Flathead River increase during summer transforming the lower river from a lotic to a lentic dominated aquatic environment. When Flathead Lake is at full pool, approximately 35 km of the Flathead River becomes a backwater. The mainstem Flathead River is regulated by water releases from Hungry Horse Dam downstream of the confluence with the South Fork Flathead River. Dam operations have essentially reversed the natural hydrograph resulting in the storage of spring melt during spring and summer and releasing water in the fall and winter when flows were historically low.

Native fish in the lower river include northern pikeminnow (*Ptychocheilus oregonensis*), largescale sucker (*Catostomus macrocheilus*), longnose sucker (*Catostomus catostomus*), peamouth (*Mylocheilus caurinus*), redside shiner (*Richardsonius balteatus*), bull trout, westslope cutthroat trout, mountain whitefish, pygmy whitefish (*Prosopium coulteri*), and sculpins (*Cottus spp.*). Non-native fish species found in the lower Flathead River include lake trout, lake whitefish (*Coregonus clupeaformis*), kokanee (*Oncorhynchus nerka*), yellow perch (*Perca flavescens*), northern pike, rainbow trout, largemouth bass (*Micropterus salmoides*), pumpkinseed (*Lepomis gibbosus*), and black bullhead (*Ameiurus melas*).

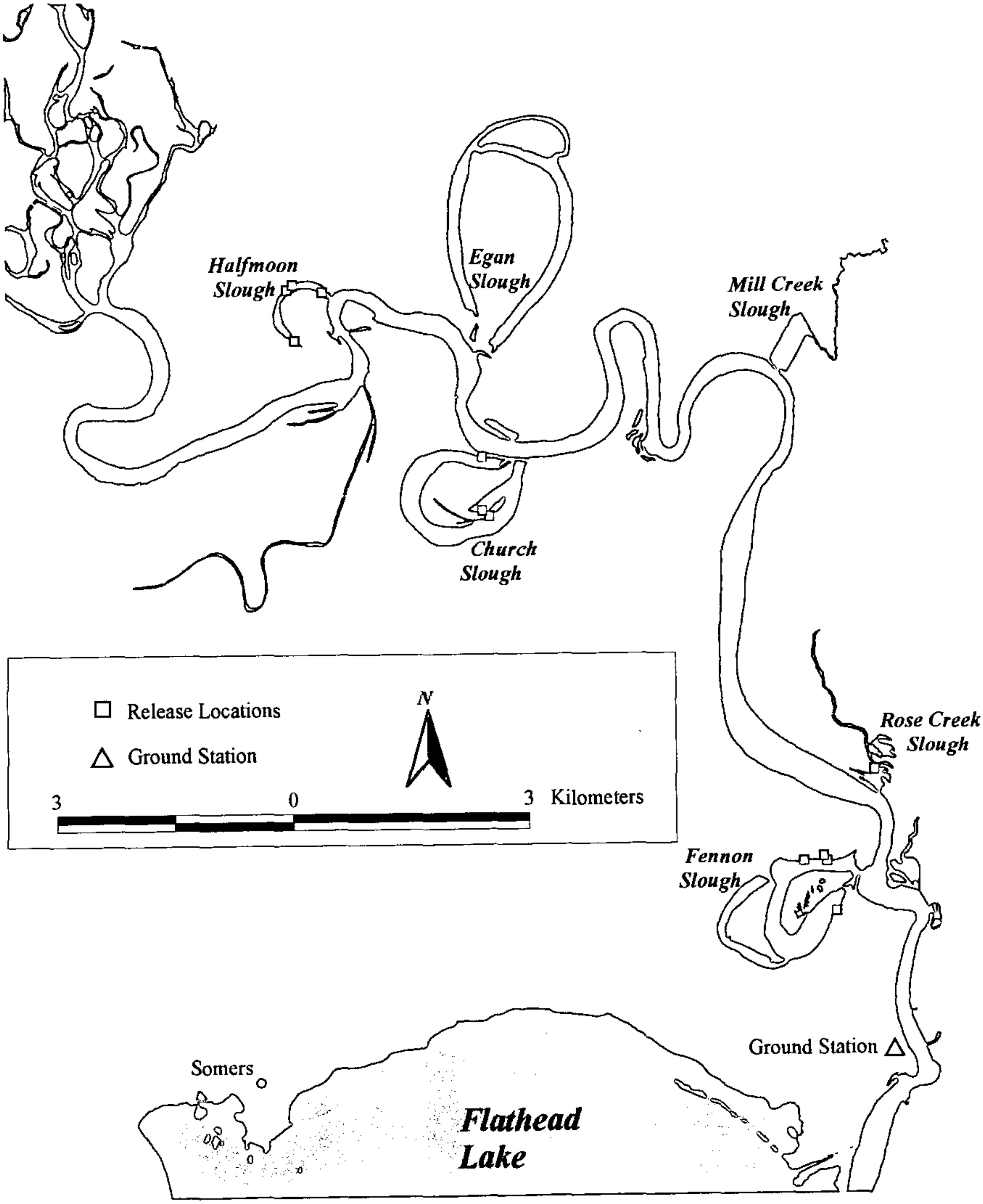


Figure 1. Lower Flathead River study area and release locations for radio-tagged pike from 1997 through 1998.

## Methods

Radio-transmitters were surgically implanted (Young 1995) in 12 northern pike captured in merwin traps in the lower Flathead River sloughs from May 1997 through October 1998 (Table 1). Implanted fish averaged 764 mm in total length (range: 602-957 mm) and 3,665 g in weight (range: 1,640-1,784 g). Fish were captured and released in Fennon Slough (n = 4), Halfmoon Slough (n = 4), Church Slough (n = 3) and Rose Creek Slough (n = 1) to test whether fish remained sedentary or migrated outside the river sloughs during the study period. Transmitters weighed 16 g in air and had a predicted life expectancy of 750 days (model CFRT-3A, Lotek Engineering, Inc.). Each tag emitted a unique coded signal (12 pulses/minute) in the frequency range of 148.740 mHz.

Table 1. Summary of radio-tagged northern pike monitored in the Flathead River from 1997 through 1999.

| Code | Length (mm) | Weight (g) | Release Date | Date of last signal | Number of relocations | Number of days tracked tracked | Home range (m) | Total distance moved (m) |
|---|---|---|---|---|---|---|---|---|
| 52 | 794 | 3,674 | 5/6/98 | 1/14/99 | 18 | 253 | 637 | 4,508 |
| 53 | 875 | 6,532 | 5/7/98 | 10/26/98 | 15 | 172 | 1,201 | 5,187 |
| 54i | 695 | 2,700 | 5/7/97 | 7/24/97 | 6 | 78 | 2,649 | 7,051 |
| 58 | 611 | 1,750 | 5/6/97 | 7/17/97 | 5 | 72 | 814 | 1,224 |
| 60 | 602 | 1,640 | 6/2/98 | 1/15/99 | 15 | 227 | 1,008 | 2,563 |
| 55i | 908 | N/A | 5/23/97 | 12/24/97 | 11 | 215 | 5,334 | 20,327 |
| 59ii | 685 | 2,542 | 9/28/98 | 10/26/98 | 4 | 28 | 6,689 | 9,027 |
| 59i | 755 | 3,550 | 5/6/97 | 8/19/98 | 27 | 470 | 7,734 | 57,937 |
| 54ii | 743 | 3,049 | 10/22/97 | 7/28/98 | 18 | 279 | 7,273 | 22,355 |
| 55ii | 655 | 2,253 | 5/6/98 | 9/3/98 | 7 | 120 | 23,531 | 24,386 |
| 61 | 957 | 7,484 | 10/1/98 | 6/2/99 | 27 | 244 | 32,315 | 50,948 |
| 56 | 885 | 5,140 | 5/22/97 | 12/30/99 | 90 | 952 | 11,364 | 146,901 |

Radio-tagged northern pike movements were monitored from May 1997 through December 1999. Fish were tracked using an airplane equipped with a Lotek scanning receiver (model W-17) and two directional 2-element Yagi antennas mounted on each wing strut. Tracking surveys were usually conducted twice a month at approximately 100 m in elevation and at an average speed of 27-31 m/sec. Once a signal was detected, the pilot circled until the point location was verified. A permanent telemetry ground station (PST) was installed approximately 3.2 kilometers upstream of the mouth of the Flathead River at Flathead Lake which allowed us to continuously monitor (24-hours/7 days per week) fish that moved downstream of the study area throughout the study period (Figure 1). The ground station consisted of a Lotek data-logging receiver equipped with a 3-element directional Yagi antenna powered by a 12-volt deep-cycle marine battery.

For each location, we recorded the direction moved, time of day, habitat used (river, lake or sloughs) and calculated the distance moved from the previous location. Each location was recorded on a USGS topographic map (1:24,000). Location points were later transferred into ArcView (Version 3.1). Movements were calculated by measuring the distance along the thalweg from each consecutive location in ArcView. Assuming location error increased with distance between the transmitter and receiver, mean error was approximately 4.5 m using aerial tracking techniques (Simpkins and Hubert 1998). Total movement was the sum of all movements for the duration of the study. Study home range was defined as the linear distance between the fish's most upstream and downstream location (Young 1995). Mean daily water temperature data were obtained from the USGS flow monitoring station located in the mainstem Flathead River (Columbia Falls).

We used Mann-Whitney tests to compare home ranges among the study fish. Spearman's Rank of Correlation procedure was used for correlation analyses. A Kruskal-Wallis test was used to test for differences in total distances moved among seasons and Mann Whitney U-tests were used for multiple comparisons. Seasons were defined as: fall (October-November), winter (December-March), spring (April-June), and summer (July-September). Statistical analyses were conducted with SPSS/PC+, version 10.0 (Norusis 1990). Significance was considered at the $\alpha = 0.05$ for all statistical tests.

**Results**

The twelve northern pike monitored from 1997-1999 were successfully radio-tracked for an average of 254 d (range: 28-952) and relocated an average of 20 times (range 4-90) throughout the study period (Table 1). Four fish were tracked until battery expiration, three fish were found dead along the streambank, four were harvested by anglers, and the remaining transmitter was not detected after 172 d due to apparent premature battery failure. Examination of fish recaptured in merwin traps showed that shortly after implantation fish displayed normal behavior and appeared to heal quickly from the surgery.

Fish displayed both sedentary and migratory behavior during the study period. Considering all fish together, 8 fish (67%) commonly occupied sloughs (e.g. sedentary) (Figures 2-3) and 4 fish (33%) displayed movements to other areas of the river-lake system (e.g. mobile) during the study period (Figures 4-7). Average home range for all fish combined was 8,379 m (range: 637-32,315 m) and average total distance moved was 29,368 m (1,224-146,901 m). Average home range for sedentary fish was 3,258 m (range: 637-7,734 m) and average total distance moved was 13,478 m (range: 1,224-57,937 m). Mobile fish occupied an average home range of 18,621 m (range: 7,273-32,315 m) and moved an average total distance of 61,148 m (range: 22,355-146,901 m). Mobile fish occupied significantly larger home ranges than sedentary fish ($U = 1.0$, $P = 0.011$). Furthermore, home range size was not correlated with the number of days a fish was tracked ($r = 0.31$, one-tailed $P = 0.17$) or the number of relocations ($r = 0.39$, one-tailed $P = 0.11$). Hence, failure to radio-track some fish until battery expiration did not appear to bias our movement results.

There were significant differences in total distances moved among seasons ($\chi^2 = 20.4$, $P = 0.000$). Multiple comparisons revealed that northern pike moved significantly greater distances in the spring and summer and moved less during winter ($P < 0.05$). Fall distances moved were significantly greater than the winter ($P = 0.006$). No

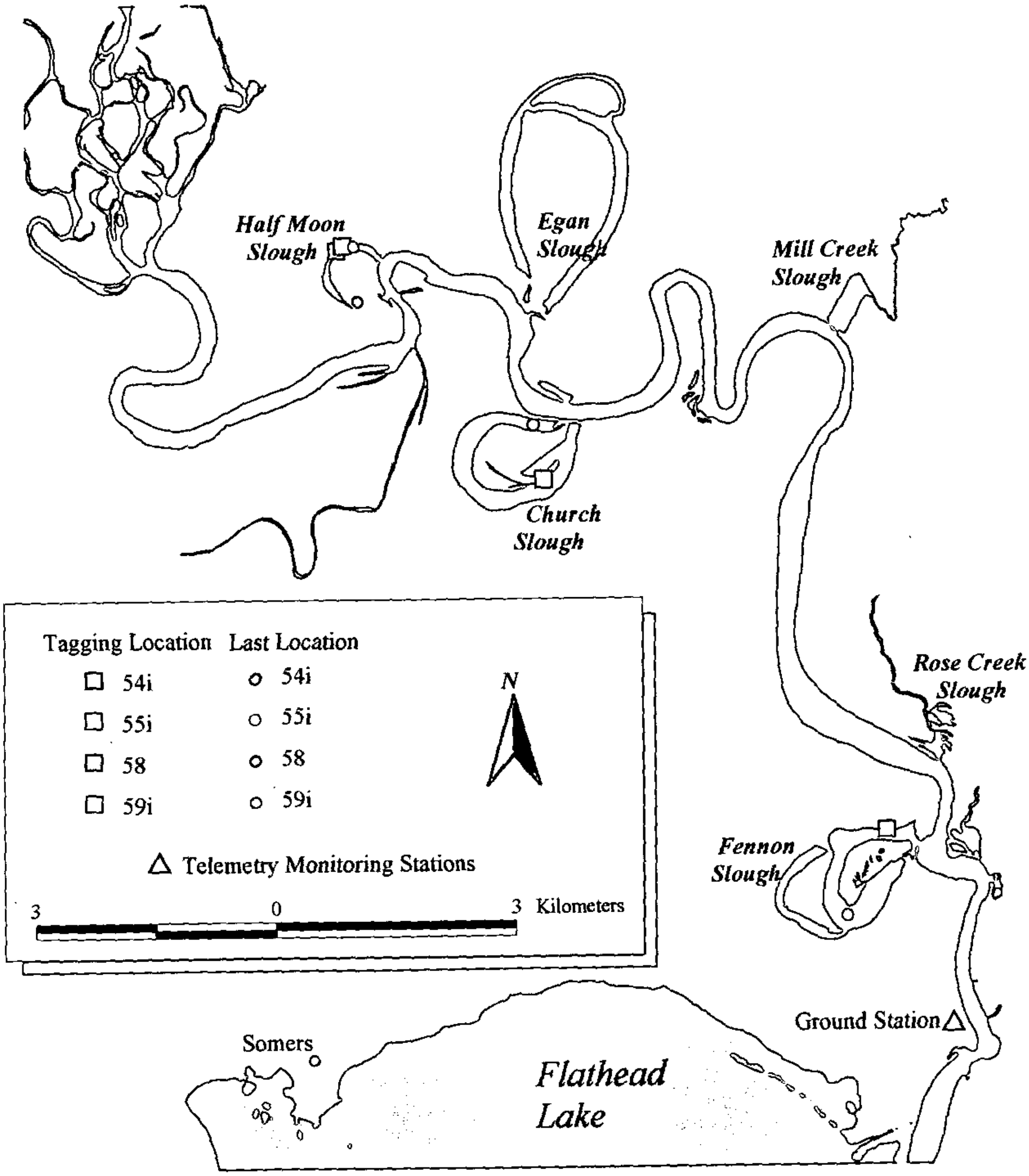


Figure 2. Release and final locations of sedentary northern pike in 1997.

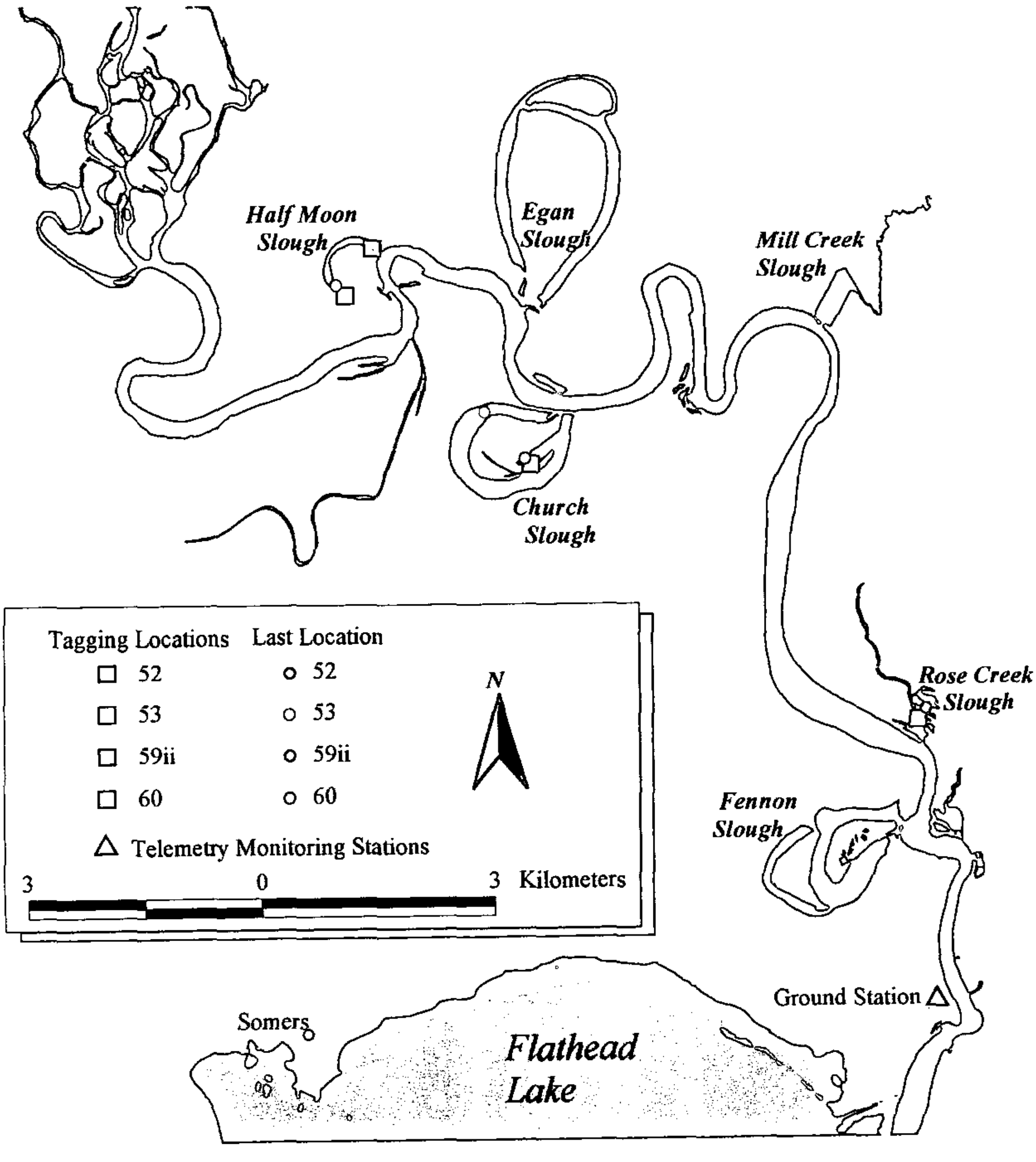


Figure 3. Release and final locations of sedentary northern pike in 1998.

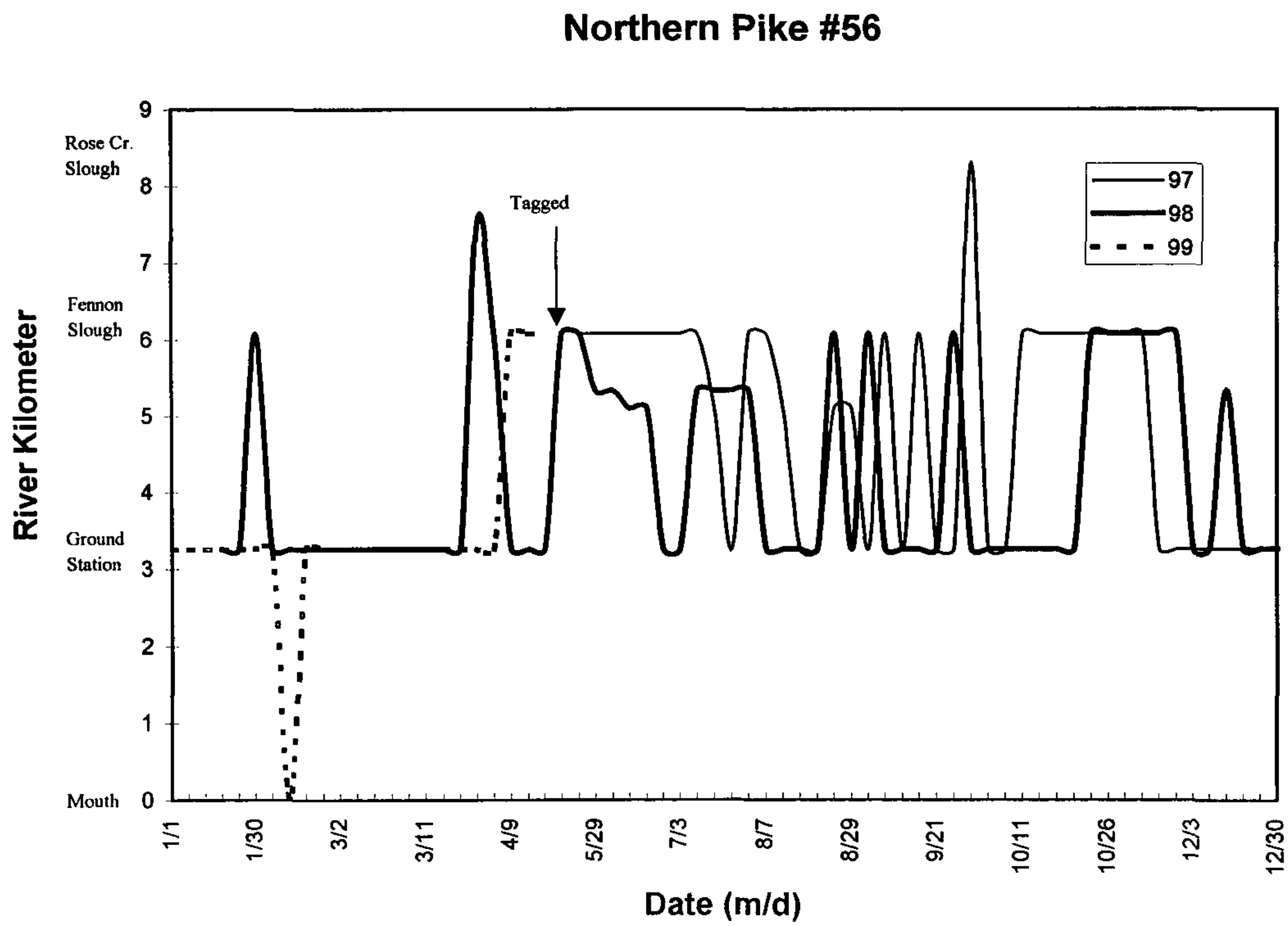


Figure 4. Seasonal movements of northern pike #56 monitored in the Flathead River from 1997 through 1999.

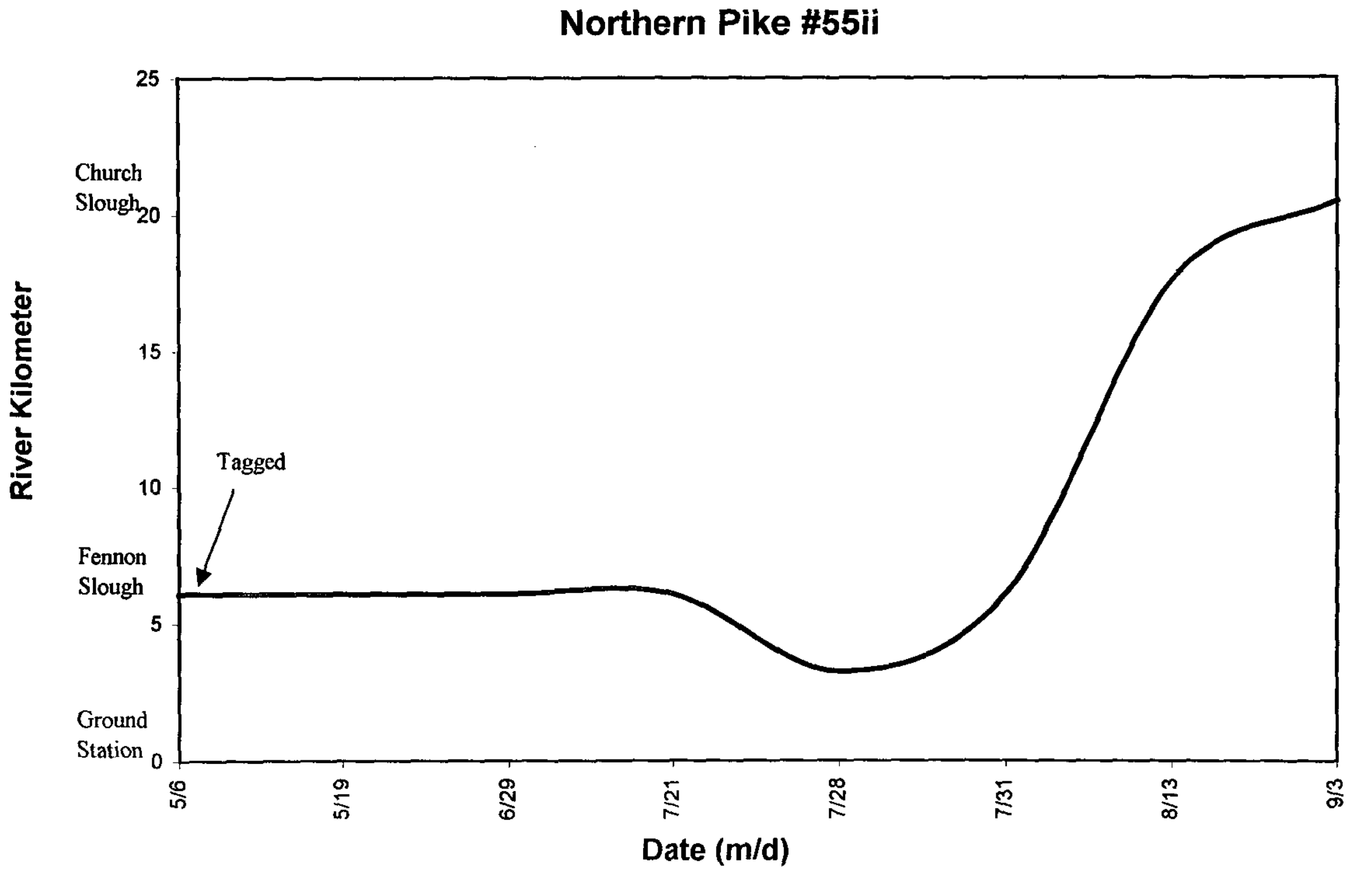


Figure 5. Movements by northern pike #55ii monitored in the Flathead River during 1997.

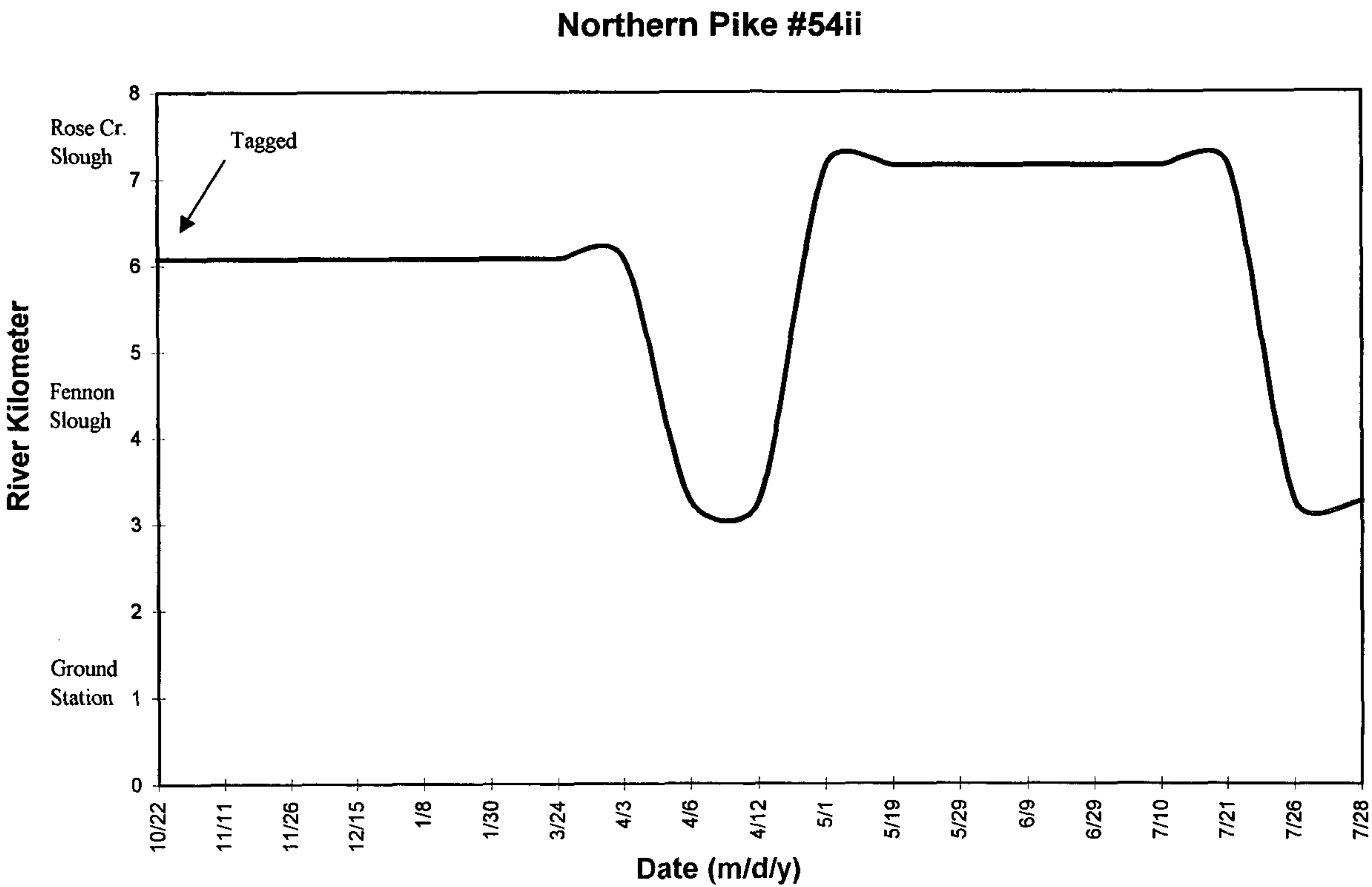


Figure 6. Movements by northern pike #54ii monitored in the Flathead River during 1997 and 1998.

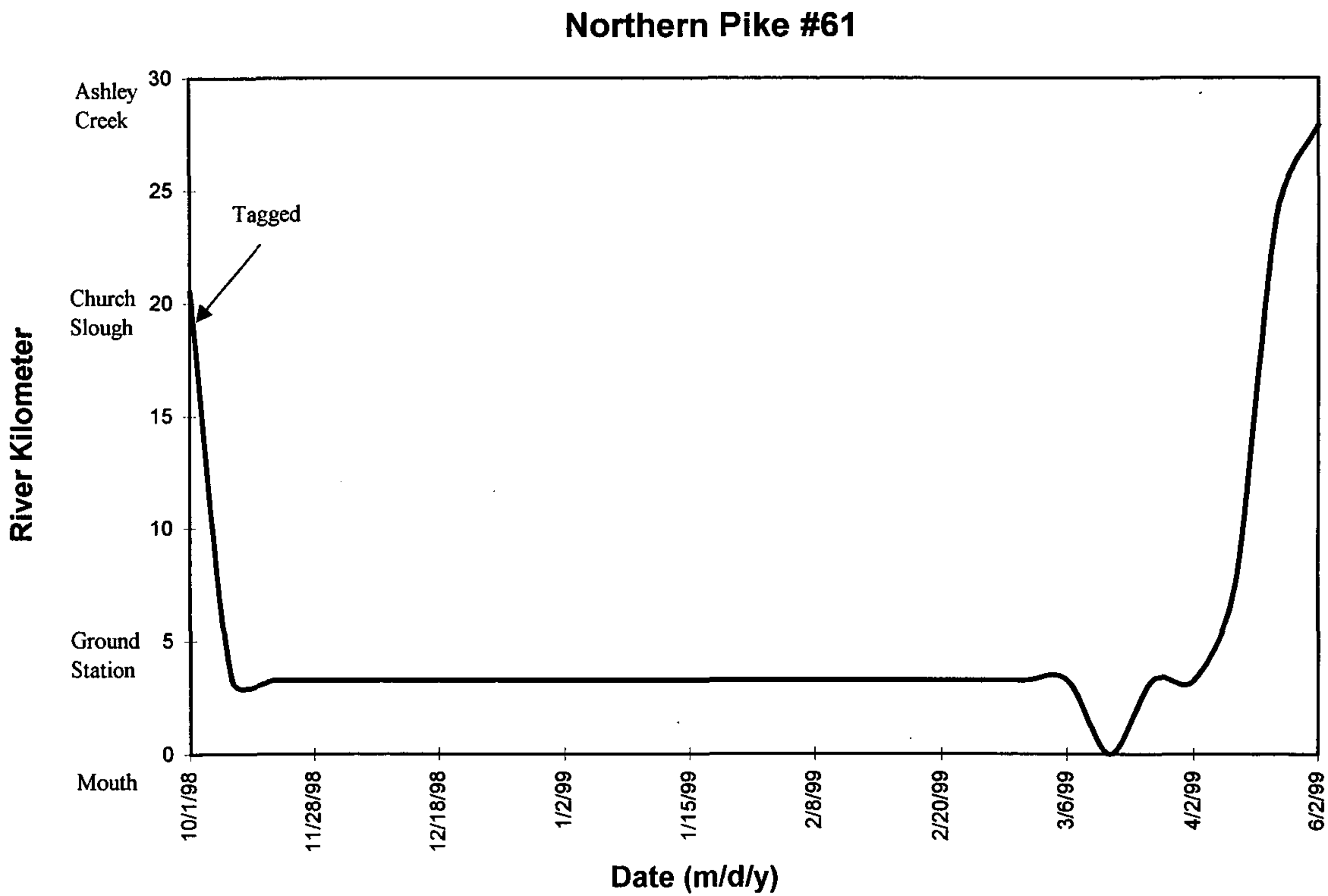


Figure 7. Movements by northern pike #61 monitored in the Flathead River during 1998 and 1999.

differences were found in total distances moved between spring and summer ($P$ = 0.182), fall and summer ($P$ = 0.354) and fall and spring ($P$ = 0.840).

*Summer*

Eight northern pike were monitored for the majority of the summer months. Four fish were either harvested by anglers in river sloughs or found dead near the streambank. In July 1997, one sedentary fish (#58) was found dead near the streambank and another (#54i) was harvested by an angler. In 1998, two fish (#59i and 55ii) were harvested in late summer by anglers.

In 1997, one fish (#59i) moved approximately 7.4 kilometers downstream from Halfmoon to Church slough and remained in Church Slough throughout the summer. Fish #56 moved three times from Fennon Slough (kilometer 6.0) downstream to the PST (kilometer 3.2) and then back upstream to Fennon Slough from July through August. In September, fish #56 moved upstream from PST (kilometer 3.2) to Rose Creek Slough (kilometer 8.3) and then back downstream to the lower river (PST) at the end of September.

In 1998, fish #56 displayed sporadic movements between Fennon Slough (kilometer 6.2) and the lower river (kilometer 3.0) throughout the summer. Near the end of July, fish #55ii moved downstream from Fennon Slough to the lower river (PST) and then moved 17 km upstream to Fennon Slough and then to Church Slough at the end of July. In August, fish #56 was harvested by an angler in Church Slough. In late July, one fish (#54ii) moved downstream from Rose Creek slough to the lower river (PST) and was not relocated again after July 28 due to premature transmitter failure or it went to Flathead Lake where deep water precluded signal detection.

*Fall*

Three tagged northern pike were monitored during fall 1997; two remained in Church Slough and one (#56) moved between Fennon Slough and the lower river (PST). In October, fish #56 moved upstream from PST (kilometer 3.2) to Fennon Slough (kilometer 6.0) and then downstream to PST at the end of November as mean daily water temperatures approached 4°C. Mean daily water temperatures generally declined from 10°C in October to 4°C in November. One fish (54ii) was captured and tagged in Fennon Slough in October.

We monitored six northern pike during fall 1998; four fish remained in sloughs and two fish moved from river sloughs to the lower river during October. Fish #61 moved approximately 17 km downstream to the lower river (PST) in early October and remained there throughout the fall. During October, fish #56 moved 3 km downstream from Fennon Slough to the lower river (PST) and then moved back into Fennon Slough in late October. Fish #59ii moved 17 km from Halfmoon to Church Slough in October prior to signal loss. Two fish (#59ii and #61) were tagged and released in Halfmoon and Church sloughs, respectively. One fish (#53) was not relocated again after October 26 probably due to premature battery failure.

*Winter*

Four northern pike were monitored during winter 1997-1998; two fish remained in Church and Fennon Sloughs, one fish moved between Church and Halfmoon Sloughs, and one fish generally remained in the lower river. Fish #59i moved from Church to Halfmoon Slough in November and then back to Church Slough in December as water temperatures approached 3°C. Fish #56 was primarily relocated near the mouth throughout the winter with the exception of one location in Fennon Slough in late January.

Of the six northern pike monitored during winter 1998-1999, four fish remained in sloughs and two fish remained in the lower river and upper Flathead Lake. Fish #61 remained in the lower river (PST) during winter, though was located near the mouth of the Flathead River once in March. In December, one fish (#56) moved from Fennon Slough to the lower river (PST) and mouth where it remained through March. Mean daily water temperatures declined from 4°C to 2°C during December.

*Spring*

Eight radio-tagged northern pike were monitored during spring 1998; six fish were consistently found in sloughs and two fish displayed upstream migrations from the lower river to river sloughs. Four of the eight monitored fish were tagged and released in Rose, Church and Halfmoon Sloughs during May. Two mobile fish (#56 and #54ii) moved upstream from the lower river (PST) to sloughs during rising water temperatures and increased river discharge. In late March, fish #56 moved from the lower river to Fennon Slough and returned to the lower river in early April. In late April, this fish moved upstream to Fennon Slough where it was found again in May. In late March, fish #54ii moved downstream from Fennon Slough to the lower river near the mouth and in early April it moved upstream to Rose Creek Slough where it was found during May. Both mobile fish moved upstream to sloughs as water temperatures approached 8°C and river discharge peaked (~28,000 cfs) during runoff.

The two radio-tagged northern pike monitored during spring 1999 displayed long upstream migrations from the lower Flathead River to river sloughs. Fish #56 moved 6 km upstream from PST to Fennon Slough in April. Fish #61 left the lower river in early April and was found 20.5 km upstream in Halfmoon Slough in May. In June, fish #61 was found an additional 4 km upstream in Ashley Creek.

## Discussion

Our movement results suggest that the Flathead River population of northern pike consists of two components, one that occupies restricted homeranges and another that moves extensively throughout the river-lake system. Sedentary fish commonly occupied the same slough where they were originally captured and released, whereas migratory northern pike moved throughout the river, sloughs and upper Flathead Lake. Population density is likely the key factor determining the number of transients and residents present in a population (Chapman and Bjornn 1969).

Our results suggest that northern pike occupied defined home ranges in the lower Flathead River within areas of contiguous suitable habitat. Seasonal movement patterns exhibited by one mobile fish were similar from 1996 through 1999, demonstrating a high degree of site fidelity to various areas of the lake-river system. Diana et al. (1977), Chapman and Mackay (1984) and Cook and Bergerson (1988) reported that northern pike did not occupy defined home ranges throughout the particular lake or reservoir possibly because these systems were relatively small and shallow or due to short tracking periods. Conversely, Rich (1992) found that home ranges occupied by northern pike were positively related to the area of continuous suitable habitat in a given area in Coeur d' Alene Lake, Idaho. In the Flathead system, suitable pike habitat is probably limited to sloughs and deep, slow-moving areas of the lower Flathead River and Flathead Lake.

The increased distances that radio-tagged northern pike moved during spring were likely related to spawning. During spring, three pike displayed pronounced upstream migrations to river sloughs coinciding with rising water temperatures and increased river discharge. Prespawning movements occurred during late March and April and spawning migrations commenced during late April and May. Northern pike spawn during April and May during the daylight hours and prefer submerged vegetation in floodplains of rivers, marshes and bays of lakes (Scott and Crossman 1973). Therefore, Flathead River sloughs probably contain suitable spawning and rearing habitat for northern pike due to their shallow and well-vegetated characteristics. However, because Flathead Lake reaches full pool in June, Flathead River pike may have to wait until late May or early June to find suitable spawning substrate in the lateral areas of the river sloughs that is otherwise inacessable at lower lake elevations.

Four radio-tagged northern pike used various areas of the lower Flathead River-Lake system. Northern pike commonly occupied lentic habitats within the river-lake system consisting of sloughs, the lower mainstem of the Flathead River and upper Flathead Lake. The combined movements of the transmitter-tagged mobile northern pike suggest a seasonal trend in migratory behavior. In general, mobile fish moved downstream during the fall and early winter and overwintered in the lower river and Flathead Lake and made pronounced upstream movements to river sloughs during spring presumably to spawn.

Our results suggest that slough habitat was used more than expected by northern pike in the Flathead River system above Flathead Lake. Sedentary fish were consistently relocated in the same slough where they were originally captured and released in or displayed movements to other sloughs during their respective monitoring periods. Furthermore, mobile northern pike frequently moved between sloughs and the main river. In the Flathead River, slough habitat likely provides northern pike with abundant prey and contain relatively warm, slow moving water with abundant aquatic vegetation. Cook and Bergersen (1988) found that northern pike preferred vegetated littoral areas and would adjust their locations in response to changes in macrophyte density and distribution in Eleven Mile Reservoir, Colorado. Diana et al. (1977) also found that pike were frequently located in vegetated, near shore areas in Lac Ste. Anne, Alberta.

We found that northern pike moved significantly greater distances during the spring, summer and fall and moved significantly less during winter. Similarly, Cook and Bergerson (1988) reported that northern pike in Eleven Mile Reservoir in Colorado moved shorter distances during the winter than those in the summer, yet the fish in their study were significantly more active during winter. At Eleven Mile Reservoir, increased activity during winter was probably related to more active foraging by northern pike. In contrast, Diana et al. (1977) did not find significant differences between summer and winter in the distance pike moved but the pike moved longer distances more frequently in the summer. In the Flathead River, the observed decrease in distance moved during winter was presumably related to declining water temperatures and concentrated prey sources.

Radio-tagged northern pike were not found in the Flathead River upstream of the confluence of the Stillwater River throughout the study period. We believe that the upper portion of the river is probably unsuitable for northern pike because the river transforms from a lentic to a lotic dominated river environment.

Some radio-tagged northern pike displayed frequent long-distance (up to 25 km) movements throughout the lower river and associated sloughs during summer. The lower portion of the Flathead is influenced by seasonal backwater affects (vertical fluctuations of approximately 3 m) caused by the impoundment of Flathead Lake at Kerr Dam. Flathead Lake is held near full pool for water storage from June through September. Thus, water levels in the river rise creating a slow-moving lentic environment. We believe that increasing water levels caused by Kerr Dam probably promotes suitable habitat conditions (i.e. slow-moving water) for northern pike and permits access to river sloughs in the lower Flathead River.

## CHAPTER 5 – SEASONAL MOVEMENTS BY BULL TROUT IN THE UPPER FLATHEAD RIVER SYSTEM, MONTANA

*Abstract*.— The movements and distribution of eight bull trout (<500 mm) were described using radio-telemetry in the Flathead River downstream of Hungry Horse Dam. Seven bull trout displayed variable movement patterns throughout the mainstem Flathead River, whereas one bull trout exhibited a pronounced upstream and subsequent downstream migration during the late summer and fall that was likely related to spawning. Preliminary movement results suggest that there is a fluvial life history form within the metapopulation of bull trout in the Flathead system. This ongoing study will further investigate the seasonal movements and habitat use by bull trout to better identify critical habitat and unique life history forms in the Flathead River system.

### Introduction

Life history strategies and the habitat requirements of adult bull trout have been well described in western Montana (Shepard et al. 1982; Shepard et al. 1984; Fraley and Shepard 1989; Swanberg 1997). However, the seasonal movement patterns and habitat use by migratory forms of sub-adult bull trout (< 457 mm) is less well understood.

In response to population declines, in 1999 bull trout were listed as a threatened species under the Endangered Species Act. Identification of the seasonal distribution patterns of sub-adult bull trout will enable resource managers to better understand the habitat requirements of sub-adult bull trout to develop successful conservation and management strategies that will conserve and protect critical habitat and unique life history forms. The objective of this ongoing study is to describe the seasonal movements and habitat use by sub-adult bull trout. This study is ongoing. Results presented herein are preliminary and further data collection is required.

### Study Area

The study area encompasses the Flathead River system including the North Fork, Middle Fork and mainstem Flathead River above Flathead Lake, in northwestern Montana (Figure 1). Our study focused on bull trout inhabiting the mainstem Flathead River from Flathead Lake upstream to the confluence of the Middle Fork and North Fork Flathead River. The mainstem Flathead River begins at the confluence of the North and Middle Forks near Coram, Montana and flows in a southerly direction for 89 km where it enters the north end of Flathead Lake (Fredenberg and Graham 1983). This portion of the Flathead River is regulated by Hungry Horse Dam in the South Fork Flathead River. The water levels in the lower 32 km of the mainstem are heavily influenced by Kerr Dam at the south end of Flathead Lake. This river is a sixth-order stream and flows predominantly through agricultural and forested lands of the Flathead Valley.

### Methods

We used radio-telemetry to monitor the seasonal movements of sub-adult bull trout in the mainstem Flathead River during 1998 and 1999. Eight bull trout (mean total length = 435, range 370-467 mm) were captured by hook and line, surgically implanted with radio-transmitters (Young 1995), and released in close proximity to their capture

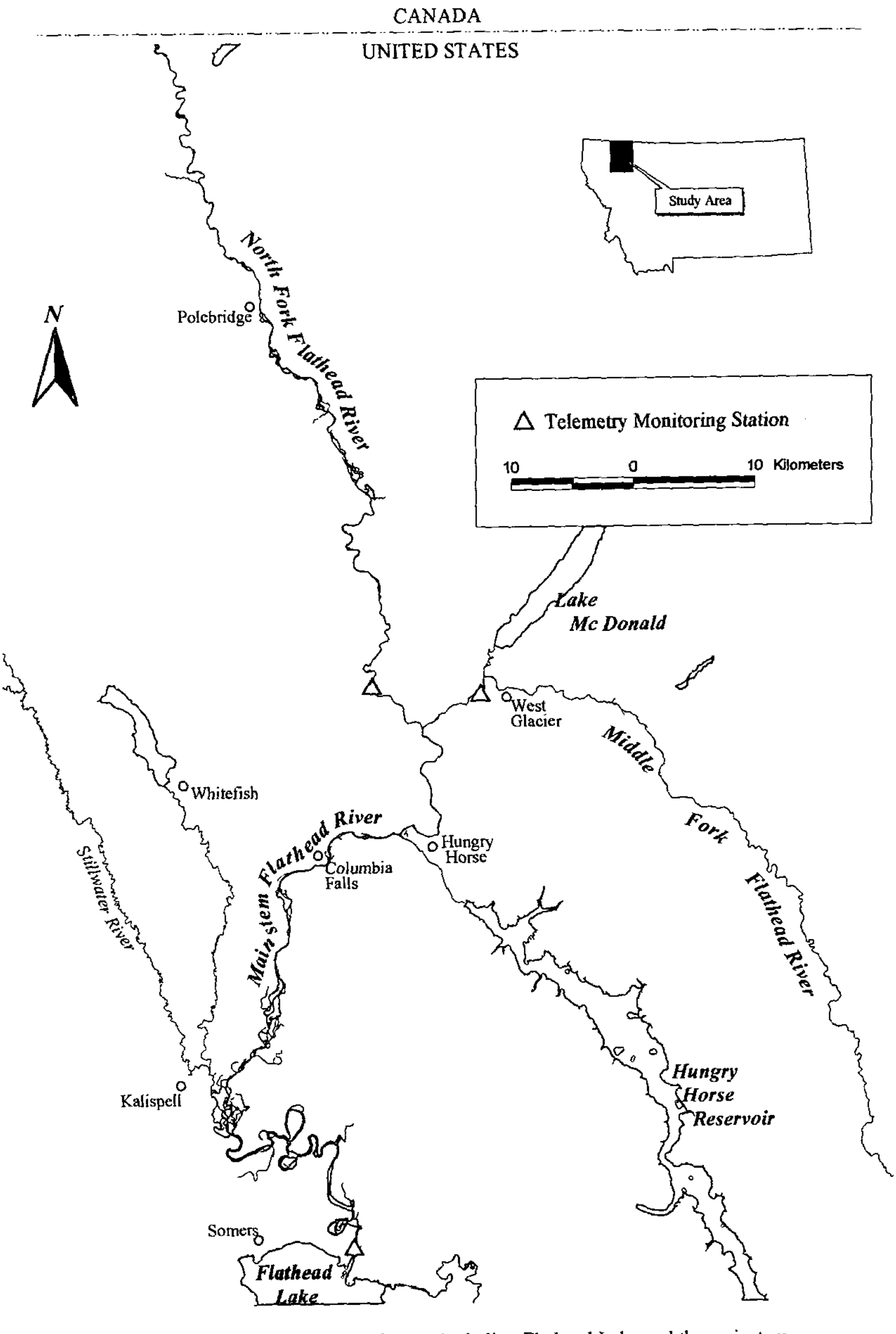


Figure 1. The upper Flathead River drainage study area including Flathead Lake and the mainstem, north, middle and south forks of the Flathead River.

location (Table 1). We implanted and released three bull trout during March and April, four fish during June and July and one fish during September. All study fish were implanted with transmitters that weighed 9.0 g in air and had a predicted life expectancy of 395 days (model MCFT-3EM, Lotek Engineering, Inc.). Each tag emitted a unique coded signal (12 pulses/minute) in the frequency range of 148.750 MHz.

Table 1. Sub-adult bull trout (280-457 mm) tagged in the Flathead River during 1998.

| Code | Date Deployed | Last Location | Number of days tracked | Fate | Number of Locations | Length (mm) | Weight (g) |
|---|---|---|---|---|---|---|---|
| 30 | 3/12/98 | 4/20/99 | 404 | battery expired | 26 | 467 | 867 |
| 31 | 3/19/98 | 9/11/98 | 176 | dead | 13 | 370 | 453 |
| 32 | 4/1/98 | 6/9/99 | 434 | battery expired | 29 | 444 | 797 |
| 34 | 7/1/98 | 6/9/99 | 343 | battery expired | 19 | 455 | 787 |
| 35 | 7/8/98 | 4/16/99 | 282 | dead | 15 | 442 | 748 |
| 36 | 7/17/98 | 12/10/98 | 146 | battery expired | 43 | 445 | 774 |
| 33i | 6/22/98 | 8/19/98 | 58 | dead | 8 | 453 | 718 |
| 33ii | 9/15/98 | 3/24/99 | 190 | dead | 24 | 406 | 618 |

We used a combination of ground tracking, fixed-wing aerial surveys and remote stationary ground stations to monitor fish movements. A coded Lotek radio receiver (Model SRX 400-W5) and a three-element directional Yagi antenna were used to locate fish during ground and aerial surveys. Tracking surveys were usually conducted once a week during the daytime. For ground surveys, fish locations were triangulated from vehicle access points along the road and from the streambank. Aerial surveys were conducted at approximately 100 m in elevation and at an average speed of 27-31 m/sec. Once a signal was detected, the pilot circled until the point location was verified. Three permanent telemetry ground stations were installed near the mouths of the North Fork, Middle Fork and mainstem Flathead River that were used to continuously monitor (24-hours/7 days per week) fish movements (Figure 1). Each ground station consisted of a Lotek data-logging receiver equipped with a 3-element directional Yagi antenna powered by a 12-volt deep-cycle marine battery.

## Preliminary Results and Discussion

The eight radio-tagged sub-adult bull trout were tracked an average of 254 d (range: 58-434 d) and relocated an average of 22 times (range: 8-29). Four of the fish were found dead an average of 177 d (range: 58-282 d) following implantation.

### *Bull Trout # 30*

Bull trout # 30 (Figure 2) was implanted and released on March 3, 1998 in the mainstem Flathead River immediately downstream of the mouth of the South Fork. Relocations were not obtained until June 27 when it was located via the ground station near the mouth of the Flathead River. The juvenile bull trout moved 66 km downstream from its release site. During July, it moved progressively upstream approximately 88 km, passing through the North Fork ground station on July 30 and August 7. On August 27, 1999 it was relocated 22 km downstream, in the same pool where it was originally tagged, where it remained through April 14 then the battery expired.

*Bull Trout #31*

On March 19, 1998 bull trout #31 (Figure 3) was radio-tagged in the Flathead River at the Highway 2 bridge near Columbia Falls. On May 19, it was found 29 km upstream at the North Fork ground station. Ten days later, the study fish moved 27 km downstream to the Flathead River where it was consistently relocated through July 7. On July 24, it was relocated 21 km upstream near the mouth of Abbott Creek, a tributary to the Flathead River. The fish was later found dead on the streambed approximately 5 km downstream from the confluence of Abbott Creek.

*Bull Trout #32*

Bull trout #32 (Figure 4) was originally captured and released on April 1, 1998 near Eleanor Island approximately 6.5 km downstream of Columbia Falls. Spring surveys revealed that the fish remained within the vicinity of Eleanor Island (± 3.6 km) during April and May. On June 22, it passed through the Middle Fork ground station moving a total distance of 37 km upstream of Eleanor Island. On September 28, the fish moved back through the Middle Fork ground station and 8 days later returned to Eleanor Island. It was consistently relocated near Eleanor Island through June 6, 1999 when the battery expired.

Based on the timing, direction, and magnitude of the summer to fall movements, this fish may have spawned in the upper portions of the Middle Fork Flathead River. Shepard et al. (1982) reported that adult bull trout moved slowly upstream during late June and July spawn during late August and September and then move rapidly downstream to the lower river and lake immediately following spawning. Our results suggest that some bull trout exhibit a high degree of site fidelity. This fish moved back to the exact release location following a migration that is typical for spawning adults. In addition, because this individual did not migrate to Flathead Lake following spawning, a fluvial life history form may exist in the Flathead River drainage.

*Bull Trout #34*

Bull trout #34 (Figure 5) was implanted and released on July 1, 1998 approximately 6.5 km upstream of Hungry Horse Canyon in the mainstem Flathead River near Coram, Montana. One month later, the fish was located 7.5 km downstream in Hungry Horse Canyon and remained there through May 9, 1999 until battery expiration.

*Bull Trout #35*

On July 24, 1998 bull trout #35 (Figure 6) was implanted in the mainstem Flathead River near Coram, Montana. The study fish was consistently relocated at various locations within 1.5 km of its release site during its monitoring period. It was found dead on the streambed on April 16, 1999.

*Bull Trout #36*

Bull trout #36 (Figure 7) was implanted and released on July 17, 1998 in the mainstem Flathead River approximately 3 km upstream from the Highway 2 bridge near Columbia Falls. Two days following implantation the fish moved approximately 62 km downstream through the ground station near the mouth of the Flathead River and entered Flathead Lake. The study fish returned to the Flathead River on October 2 and was consistently located near the ground station through December 10. The fish was not relocated again during the study either due to battery expiration or it entered Flathead Lake where deep water precluded signal detection. Interestingly, examination of the ground station data revealed that bull #36 exhibited diel movement patterns; in general the study fish tended to leave the vicinity of the ground station during the evening and returned the following morning.

*Bull Trout #33i*

On June 22, 1998 bull trout #33i (Figure 8) was tagged at the same location as bull trout #36 in the Flathead River. On August 19, the fish was found dead on the streambed approximately 22 km downstream from its release site; consequently, we recovered the transmitter for future use.

*Bull Trout #33ii*

Bull trout #33ii (Figure 9) was radio-tagged in the Flathead River on September 15 approximately 0.5 km downstream of the confluence of the Middle Fork and North Fork Flathead River at Blanketship Bridge. Ten days following implantation, the study fish was relocated approximately 29 km downstream near Eleanor Island in the Flathead River. The fish was located at various locations around Eleanor Island through March 24, 1999 and later found dead on the streambed.

Our preliminary results suggest that the sub-adult bull trout monitored during the study exhibited variable movement patterns in the Flathead River system. Although our data is preliminary, results suggest that there may be a fluvial life history form of the population of bull trout inhabiting the Flathead River drainage. We intend to further investigate the seasonal movements and habitat use by sub-adult bull trout to better identify critical habitat and unique life history forms in the Flathead system.

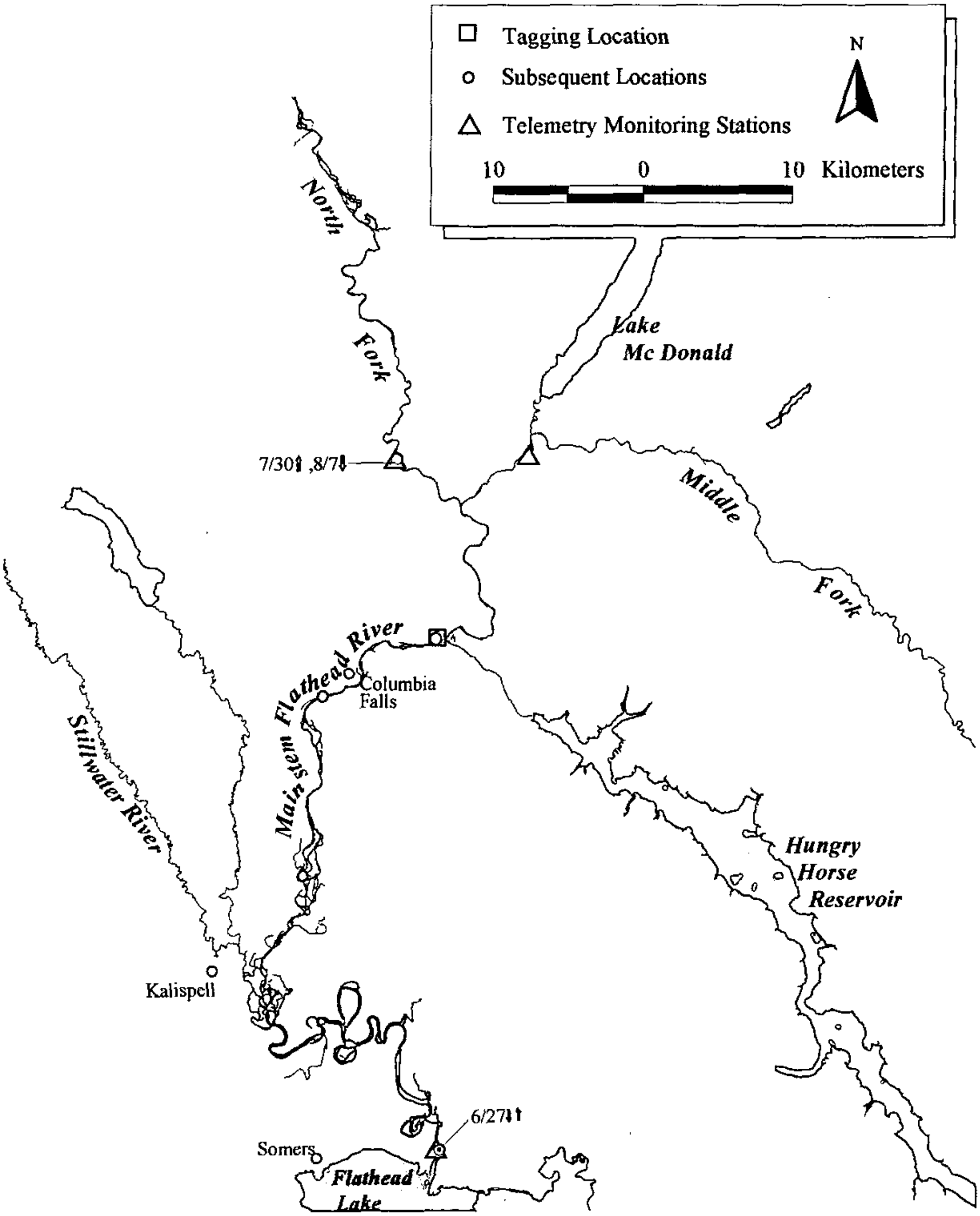


Figure 2. Radio-tracking locations of bull trout #30 monitored in the upper Flathead River drainage during 1998 and 1999.

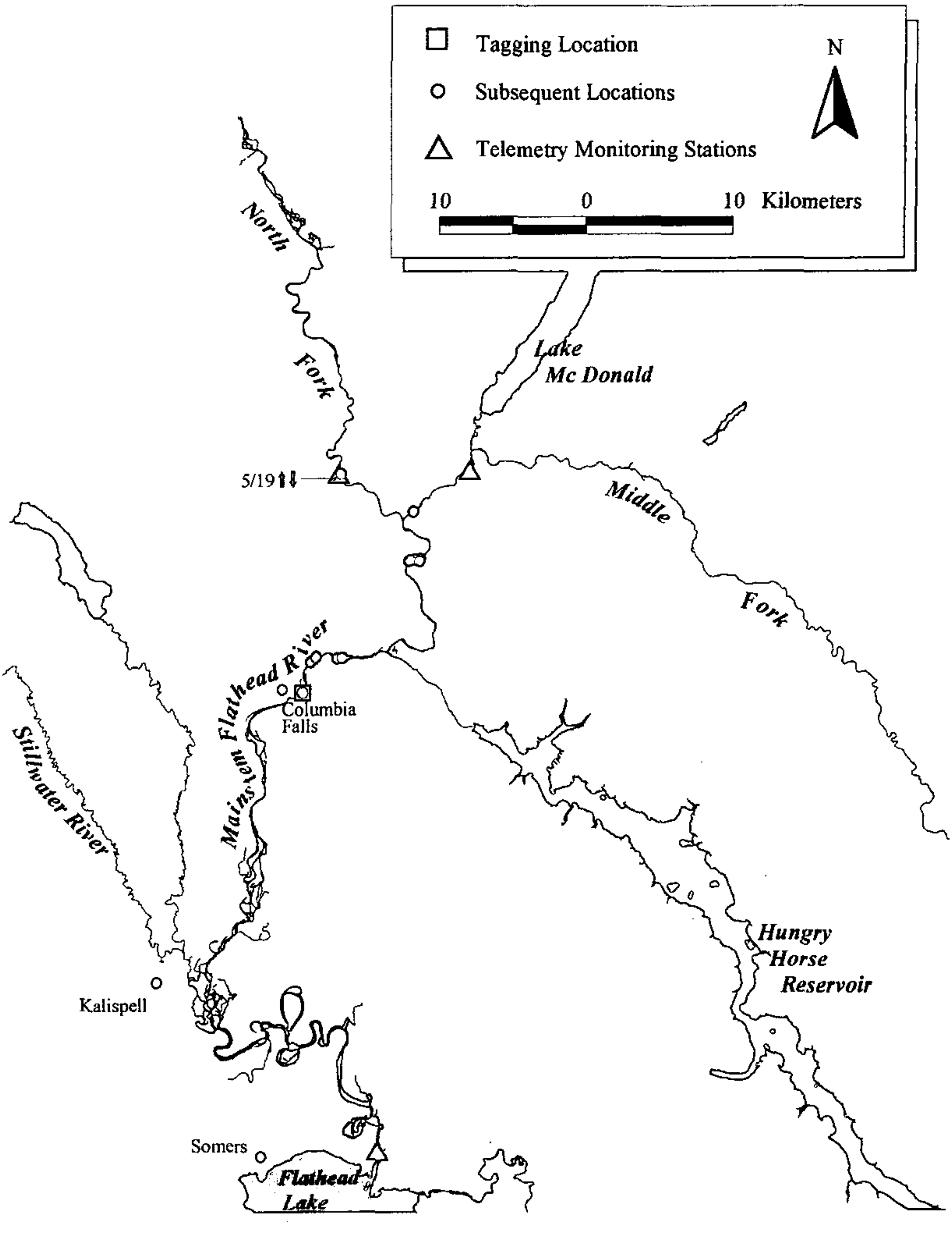


Figure 3. Radio-tracking locations of bull trout #31 monitored in the upper Flathead River drainage during 1998 and 1999.

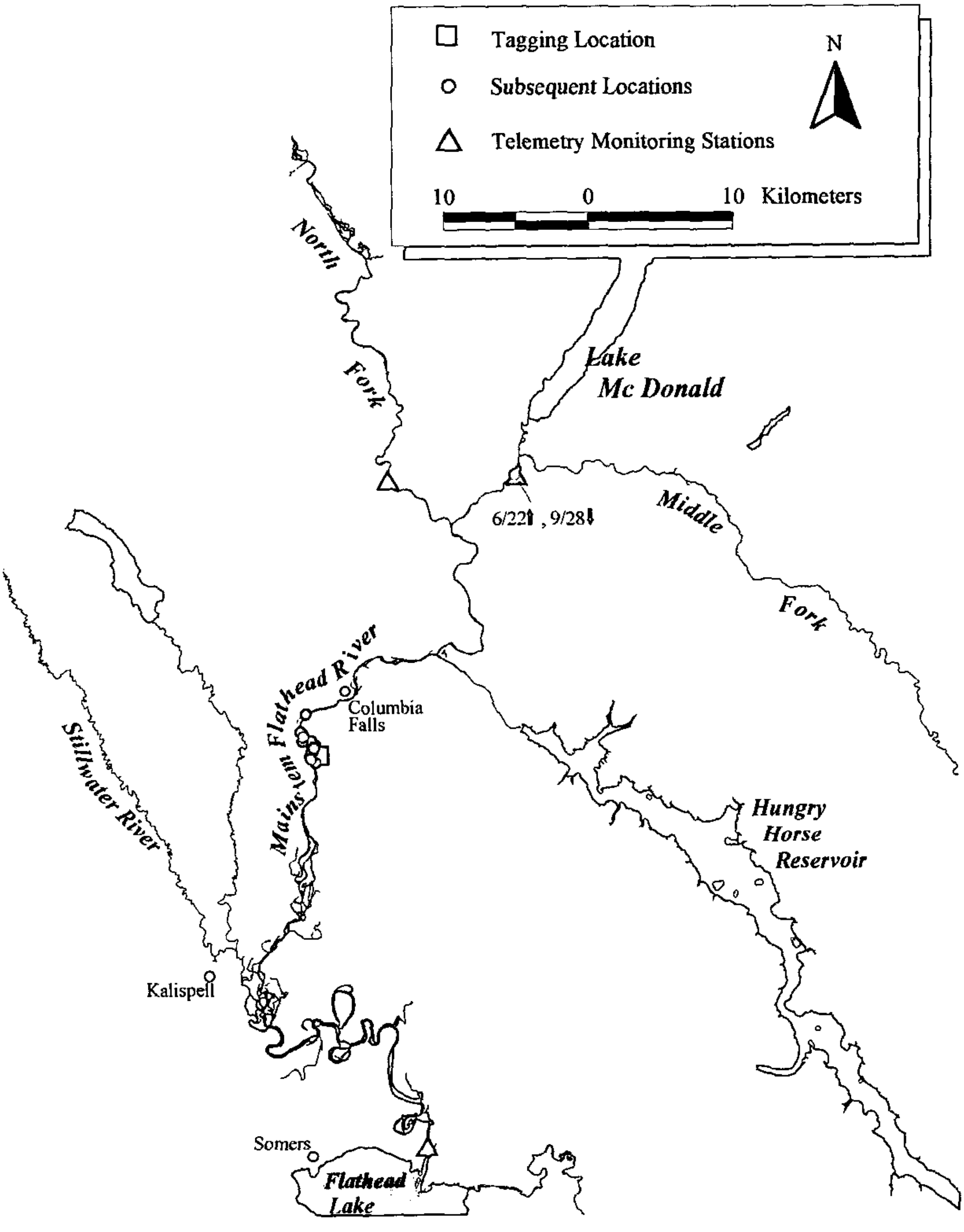


Figure 4. Radio-tracking locations of bull trout #32 monitored in the upper Flathead River drainage during 1998 and 1999.

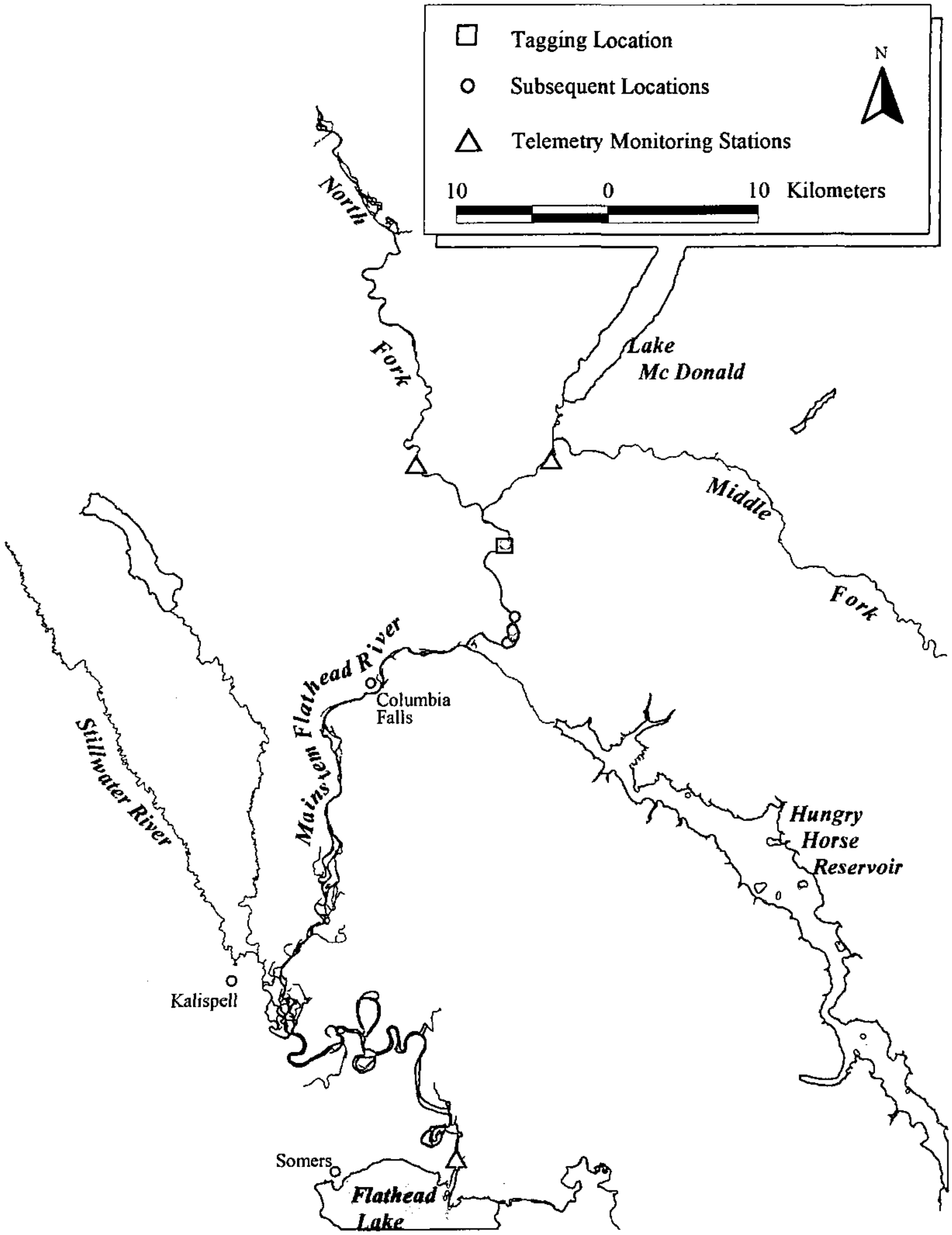


Figure 5. Radio-tracking locations for bull trout #34 monitored in the upper Flathead River drainage during 1998 and 1999.

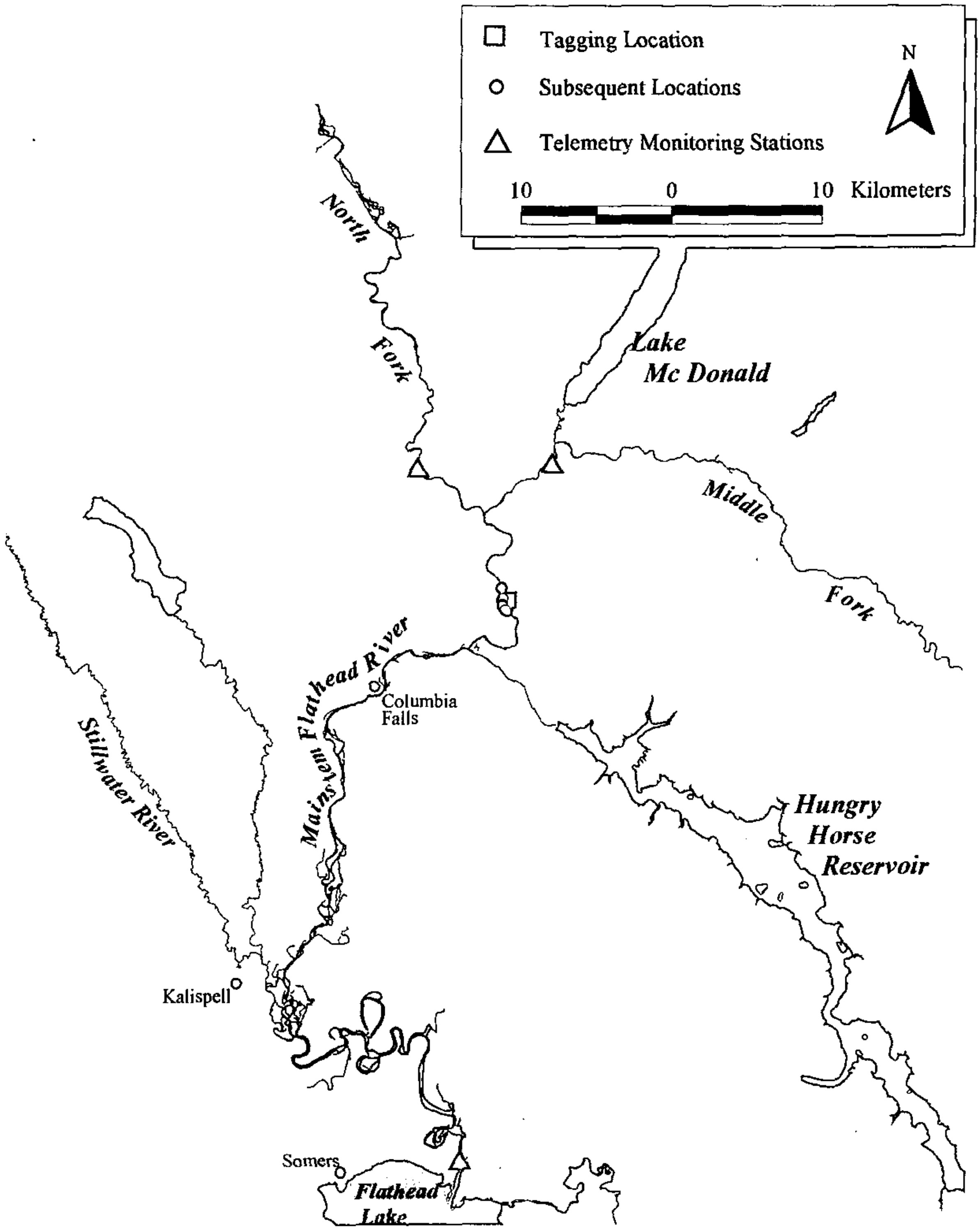


Figure 6. Radio-tracking locations of bull trout #35 monitored in the Flathead River drainage during 1998 and 1999.

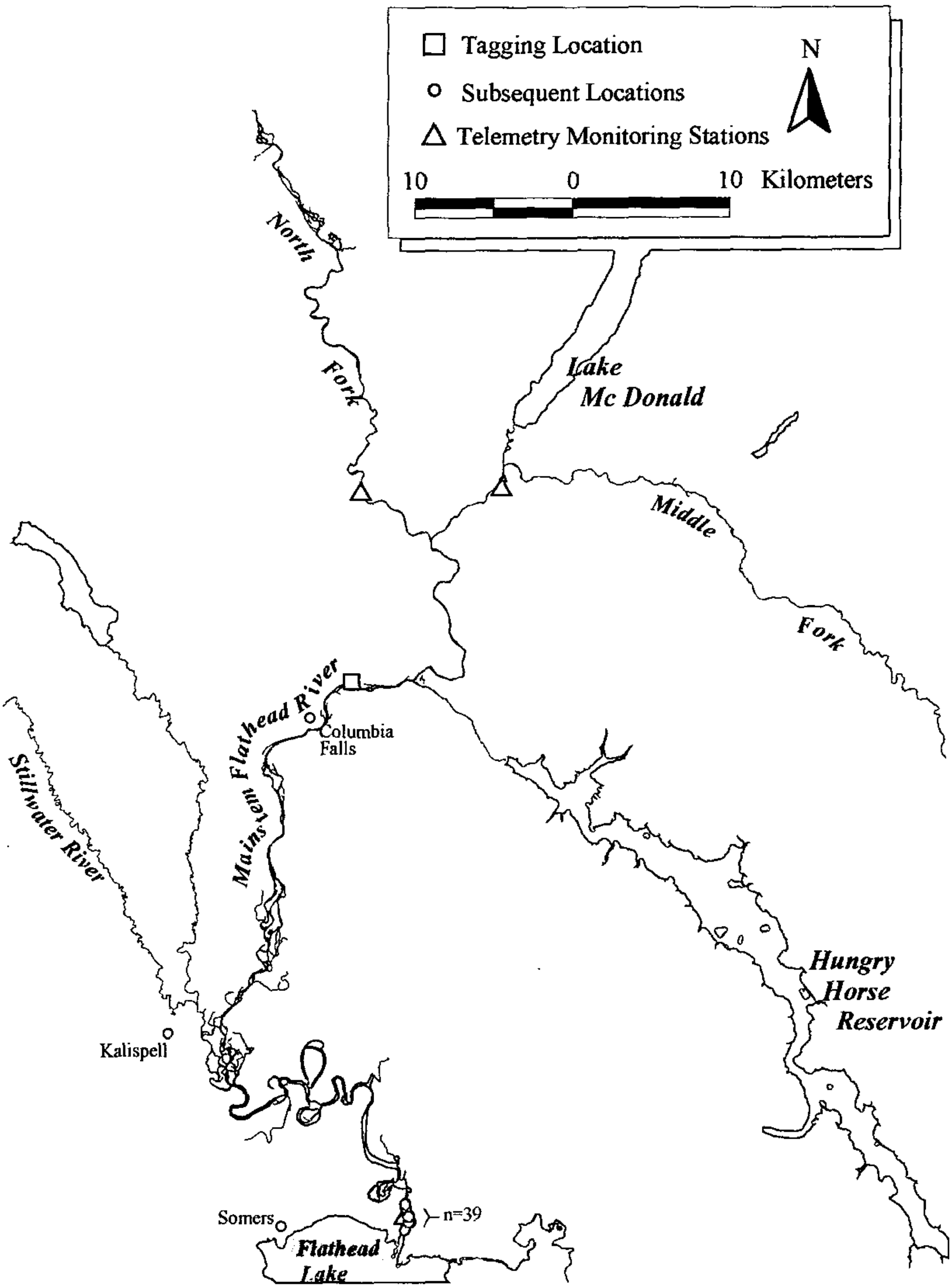


Figure 7. Radio-tracking locations of bull trout #36 monitored in the Flathead River drainage during 1998 and 1999.

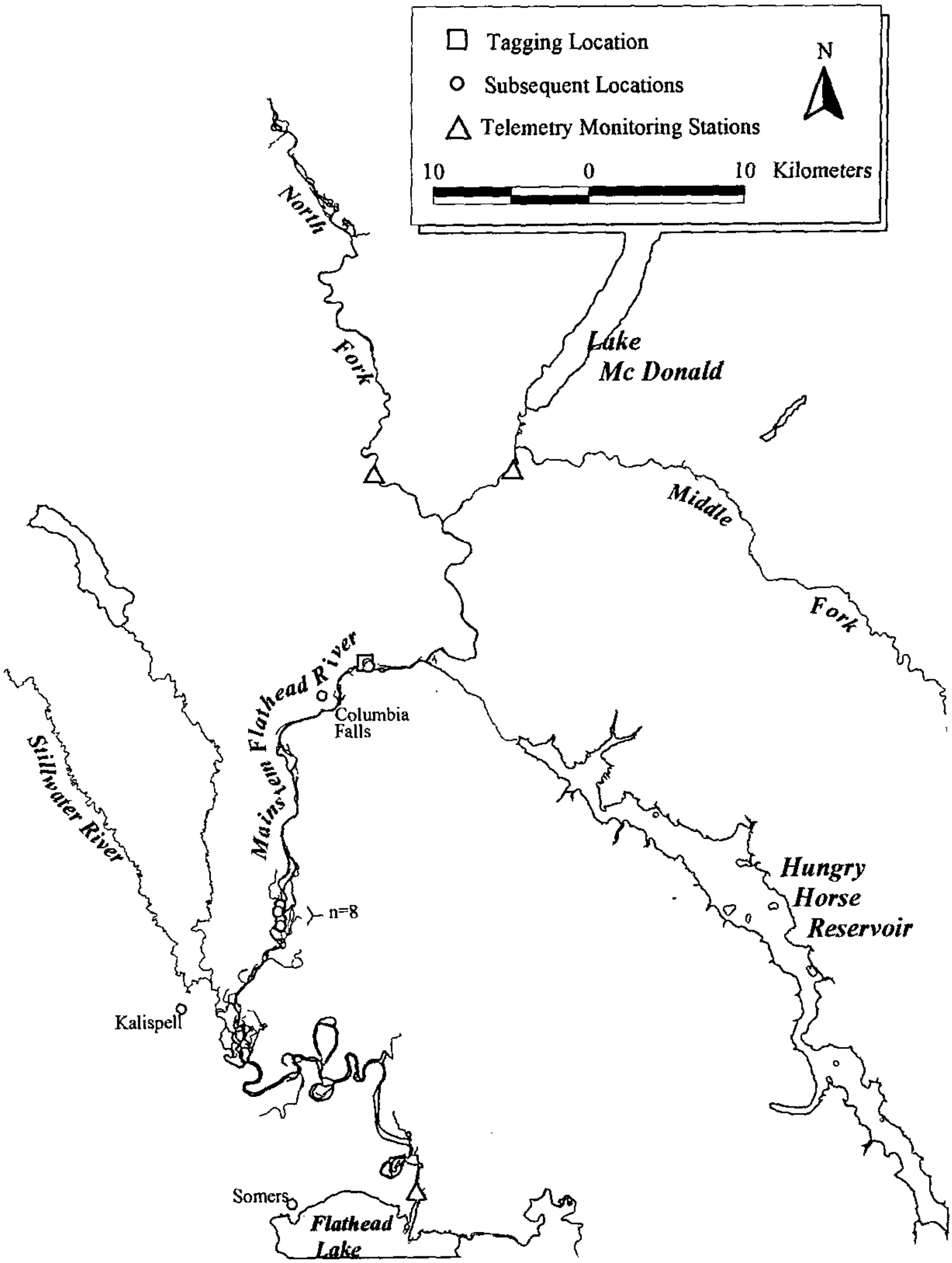


Figure 8. Radio-tracking locations of bull trout #33i in the Flathead River drainage during 1998 and 1999.

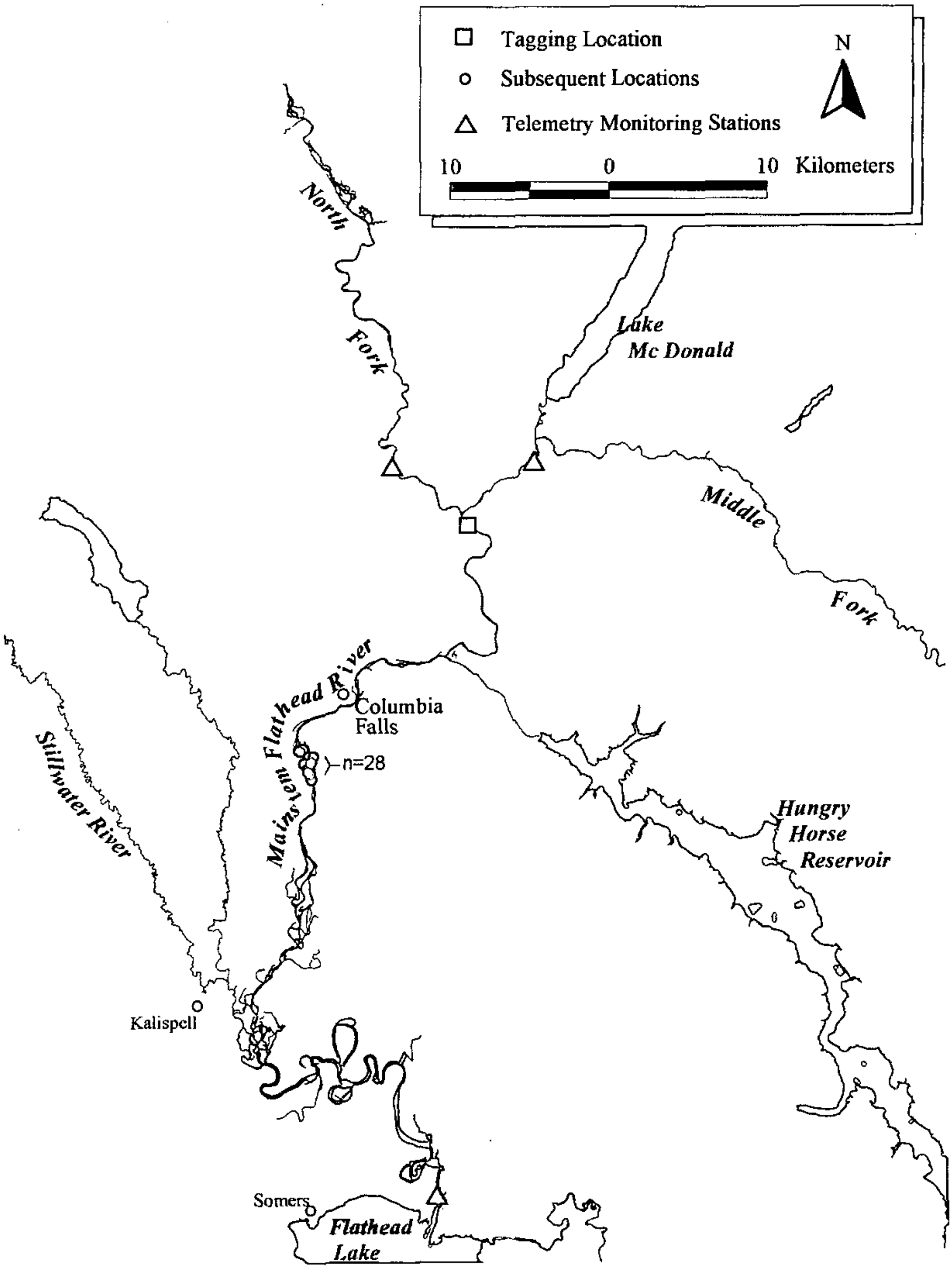


Figure 9. Radio-tracking locations of bull trout #33ii in the Flathead River drainage during 1998 and 1999.

# CHAPTER 6- SEASONAL COMPOSITION OF FISH SPECIES INHABITING THE FLATHEAD RIVER SLOUGHS ABOVE FLATHEAD LAKE, MONTANA

*Abstract*.—Merwin traps, a pontoon-mounted trap with leads, were deployed in Fennon, Half Moon and Church sloughs to estimate the relative abundance and population structure of fishes inhabiting the lower Flathead River sloughs during spring, summer and fall 1997. We captured 19 fish species and 8,903 fish. Total combined catch for all species was highest during spring (93.5%) and declined during summer (5.2%) and fall (1.3%). During spring, peamouth dominated the species composition (34.2%), followed in abundance by northern pikeminnow (19.3%) and large scale suckers (14.1%). Bull trout comprised 1.5% of the spring catch followed by westslope cutthroat trout 0.2%, and northern pike 0.8%. A wide range of size-classes of bull trout, westslope cutthroat trout, northern pike and northern pikeminnow were captured in the sloughs during May and June. The occurrence of bull trout, westslope cutthroat trout, northern pike and northern pikeminnow in river sloughs was positively correlated to river discharge. Past studies revealed that northern pikeminnow did not disproportionately consume bull trout and westslope cutthroat trout in the lower Flathead River. Thus, the spatial overlap of adfluvial juvenile bull trout, westslope cutthroat trout and northern pike, a non-native opportunistic predator, may increase the probability of predation by northern pike on juvenile trout as they emigrate from natal tributaries to Flathead Lake. Future investigations will focus on the food habits of northern pike during spring to determine if predation on juvenile trout is impacting migratory populations.

## Introduction and Methods

Field crews deployed merwin traps in Fennon, Half Moon and Church Sloughs to estimate the relative abundance and population structure of fishes in the lower Flathead River sloughs during 1997 (Figure 1). Trapping occurred in the spring (May-June) during runoff and continued, as conditions allowed, throughout late summer and fall. Ice formation in the sloughs precluded sampling during winter. Each trap consisted of a 30 m long lead net with floats equipped with a 3 x 3 m spiller with floating wing nets. The wing nets guide fish into a 3 x 3 m floating trap frame supported by two 6 m long aluminum pontoon floats. Traps were set with the lead net extended from the shoreline to the center of the trap mouth. A jet boat was used to tow each trap until the lead net was stretched perpendicular to the shoreline. Consequently, fish moving in either direction along the zone intersected by the lead net were directed into the wings and forced into the spiller, and ultimately the main trap. We fished traps 24-hours per day, usually 4 days each week. Field crews checked each trap once a day between 1000 and 1500 hours. We identified each captured fish species, measured total length (to the nearest mm) and subsampled stomach. Malta et al. (1997) provides a detailed description of merwin trap specifications.

Catch per unit effort (CPUE) was calculated as the total number of fish, by species, in all sloughs combined divided by the total number of trap hours for each sampling week. CPUE data was similar among all three sloughs; hence, the data were pooled for subsequent analyses. Percent composition and number of catch by species was reported for each slough and by season. Spearman's rank of correlation analysis was used to correlate the occurrence of bull trout, westslope cutthroat trout, and northern pike in the river sloughs to mean weekly discharge and temperature in the mainstem Flathead River. Stream temperature and discharge information was obtained from the Columbia Falls USGS monitoring site on the Flathead River.

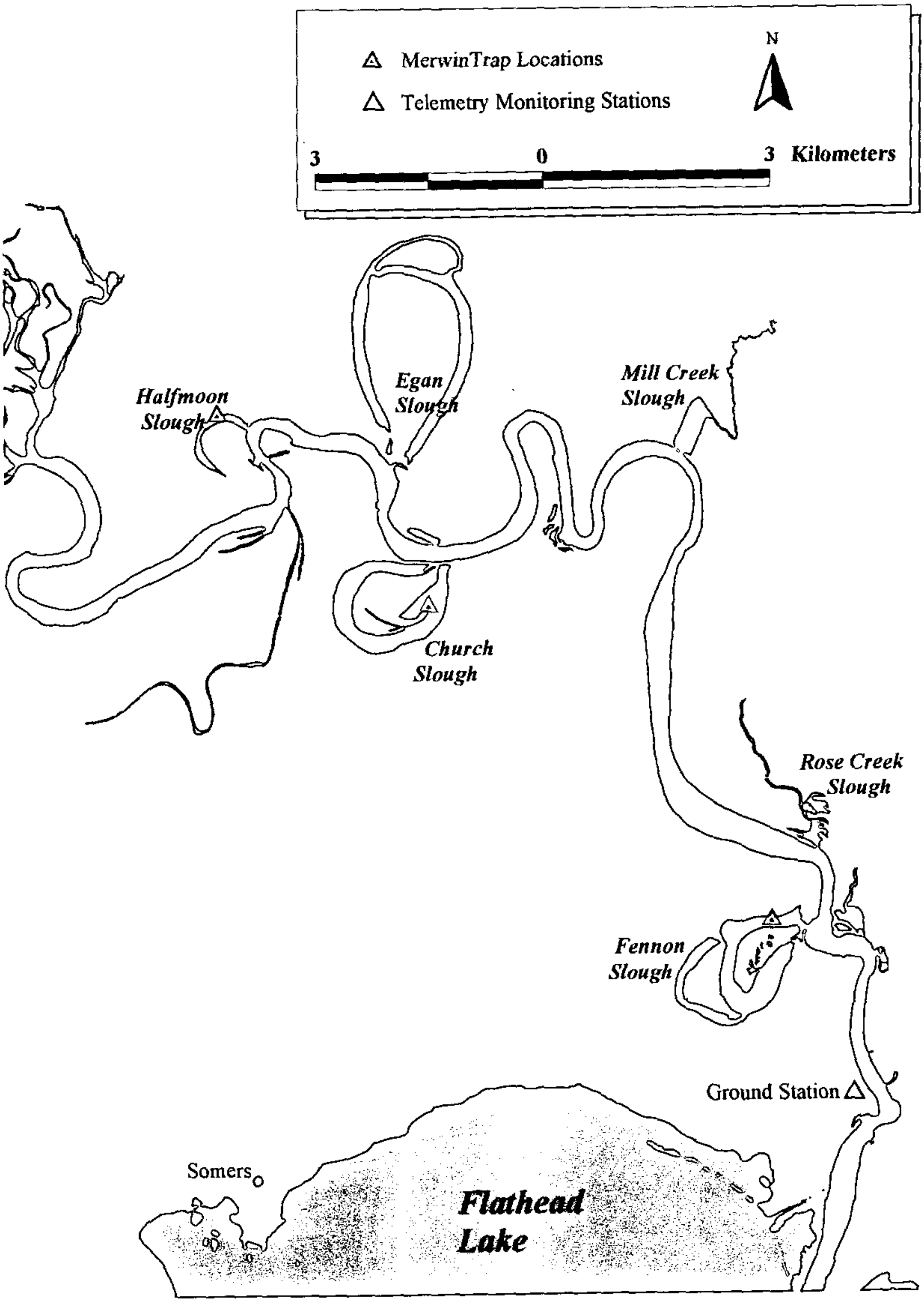


Figure 1. Study area of lower Flathead River above Flathead Lake indicating merwin trap locations during 1998.

## Results and Discussion

Merwin traps were deployed in Halfmoon, Church and Fennon sloughs for a total of 2,156.5 trapping hours during the 1997 study period; we successfully trapped 1,109.25 hours during spring (May-June), 482.5 hours during summer (September) and 564.75 hours during fall (October-November). Total combined catch of all species captured in merwin traps declined from spring to fall sampling periods, whereas species composition remained more consistent (Table 1). We did not observe a substantial difference in seasonal species composition and total combined catch among the three study sloughs (Appendices 1-3); hence we combined the data by season for subsequent results (Table 1). We captured a total of 19 fish species and 8,903 fish during the study period. Total combined catch for all species was substantially higher during spring (n = 8,325; 93.5% of total catch) and dramatically declined during summer (n = 463; 5.2% of total catch) and fall (n = 115; 1.3% of total catch). Trends in CPUE values for bull trout, westslope cutthroat trout, northern pikeminnow and northern pike were similar as observed in the total catch information (Table 2). Weekly CPUE values for all three species were highest in the spring and declined during summer and fall.

Native non-game fish dominated the species assemblage in the Flathead River sloughs during the spring, summer and fall 1997 (Table 1). During spring, peamouth dominated the percent species composition (34.2%), followed by northern pikeminnow (19.3%) and large scale suckers (14.1%). Pumpkinseeds, longnose suckers and yellow perch made up the majority of the remaining catch (10.9%, 7.3%, 4.4%, respectively). Bull trout comprised 1.5% of the spring catch (n = 125), westslope cutthroat trout comprised 0.2% (n = 16) and northern pike comprised 0.8% (n = 65). Largescale suckers dominated the percent composition during summer (57.5%) followed by northern pikeminnow (29.4%) and peamouth (8.0%). In the fall, kokanee, mountain whitefish, peamouth, and largescale suckers dominated the catch (22.6%, 13.9%, 13.9%, 11.3%, 9.6%, respectively), however, the number of fish captured during the fall sampling period was low (n = 115). Five adult bull trout (>457 mm) were captured during fall which comprised 5.2% of the catch; these individuals were likely post-spawned fish returning to Flathead Lake. Higher numbers of kokanee captured during fall may reflect a small spawning migration up the Flathead River. However, the kokanee population has dramatically declined in Flathead Lake in the late 1980s due to several factors including the establishment of *Mysis* shrimp in the lake (Deleray et al. 1999).

Surprisingly, we captured one adult female walleye (*Stizostedion vitreum*) (647 mm T.L., 3,325 g) during spring in Church Slough. This was the first walleye documented in the Flathead River drainage. We are concerned that this illegally introduced species could become established in the Flathead system.

We captured bull trout, northern pike and northern pikeminnow in a wide range of sizes in the Flathead River sloughs during May and June (Figures 2-5). Bull trout ranged from 139 mm to 692 mm with a variety of size-classes present in the catch; five distinct modes were identified in the length frequency distribution (Figure 2). Westslope cutthroat trout ranged from 233 mm to 434 mm with two distinct size-classes present in the sample

(Figure 3). Northern pike ranged from 282 mm to 1,234 mm with a majority of individuals greater than 550 mm in length (Figure 4). We caught a variety of size classes of northern pikeminnow ranging from 57 mm to 620 mm in length (Figure 5).

The occurrence of bull trout ($r = 0.638$, $P = 0.014$), westslope cutthroat trout ($r = 0.782$, $P = 0.001$), northern pike ($r = 0.616$, $P = 0.019$) and northern pikeminnow ($r = 0.873$, $P = 0.000$) was significantly correlated to river discharge in the Flathead River sloughs during 1997 (Table 3). In general, as river discharge increased the occurrence of bull trout, westslope cutthroat trout, northern pikeminnow, and northern pike increased (Appendices 4-5). Water temperature in the Flathead River was not significantly related to the occurrence of bull trout, westslope cutthroat trout, northern pike, and northern pikeminnow ($P > 0.05$).

We do not believe that predation by northern pikeminnow is limiting the bull trout population in the Flathead River system. Malta et al. (1997) and Zollweg (1998) examined the stomach contents of 728 northern pikeminnow and found that 2 contained probable *Salvelinus spp.* in their stomach contents.

As river discharge increased during spring runoff, we found the presence of bull trout and northern pike increased and then decreased as flows receded throughout the summer and fall (Figure 6). Slough habitat likely provides emigrating juvenile bull trout adequate refugia from fast velocities and high turbidity found in the Flathead River during spring high flows. Juvenile bull trout migrate from river tributaries to Flathead Lake during spring runoff (Shepard et al. 1982). Similarly, Zollweg (1998) found that bull trout were most abundant in the spring during highwater in the lake-influenced section of the lower Flathead River above Flathead Lake. Thus, the spatial overlap of juvenile bull trout and northern pike, a non-native opportunistic predator, may increase the probability of predation by northern pike on juvenile bull trout migrating downstream to Flathead Lake. Future sampling will focus on interspecific interactions during spring.

Table 1. Number and percent species composition (in parentheses) of fish captured in merwin traps in Halfmoon, Church, and Fennon sloughs (combined) during 1997. Species abbreviations are as follows: BLBH = black bullhead, BULL = bull trout, KOK = kokanee salmon, LCSU = largescale sucker, LMB = largemouth bass, LNSU = longnose sucker, LT = lake trout, LWF lake whitefish, MWF = mountain whitefish, NP = northern pike, NPM = northern pikeminnow, NPMxPEA = northern pikeminnow/peamouth hybrid, PEA = peamouth, PUMP = pumkinseed, PWF = pygmy whitefish, RSSH = redside shiner, WCT = westslope cutthroat trout, WE = walleye, YP = yellow perch.

| Species | Spring | | Summer | | Fall | | Total | |
|---|---|---|---|---|---|---|---|---|
| BLBH | 279 | (3.4) | 0 | (0.0) | 11 | (9.6) | 290 | (3.3) |
| BULL | 125 | (1.5) | 0 | (0.0) | 6 | (5.2) | 131 | (1.5) |
| KOK | 2 | (0.0) | 3 | (0.6) | 26 | (22.6) | 31 | (0.3) |
| LCSU | 1,176 | (14.1) | 266 | (57.5) | 11 | (9.6) | 1,453 | (16.3) |
| LMB | 0 | (0.0) | 2 | (0.4) | 0 | (0.0) | 2 | (0.0) |
| LNSU | 611 | (7.3) | 3 | (0.6) | 0 | (0.0) | 614 | (6.9) |
| LT | 7 | (0.1) | 0 | (0.0) | 0 | (0.0) | 7 | (0.1) |
| LWF | 197 | (2.4) | 0 | (0.0) | 10 | (8.7) | 207 | (2.3) |
| MWF | 52 | (0.6) | 1 | (0.2) | 16 | (13.9) | 69 | (0.8) |
| NP | 65 | (0.8) | 2 | (0.4) | 4 | (3.5) | 71 | (0.8) |
| NPM | 1,606 | (19.3) | 136 | (29.4) | 13 | (11.3) | 1,755 | (19.7) |
| NPMxPEA | 4 | (0.0) | 0 | (0.0) | 0 | (0.0) | 4 | (0.0) |
| PEA | 2,846 | (34.2) | 37 | (8.0) | 16 | (13.9) | 2,899 | (32.6) |
| PUMP | 906 | (10.9) | 9 | (1.9) | 0 | (0.0) | 915 | (10.3) |
| PWF | 0 | (0.0) | 0 | (0.0) | 1 | (0.9) | 1 | (0.0) |
| RSSH | 65 | (0.8) | 0 | (0.0) | 1 | (0.9) | 66 | (0.7) |
| WCT | 16 | (0.2) | 1 | (0.2) | 0 | (0.0) | 17 | (0.2) |
| WE | 1 | (0.0) | 0 | (0.0) | 0 | (0.0) | 1 | (0.0) |
| YP | 367 | (4.4) | 3 | (0.6) | 0 | (0.0) | 370 | (4.2) |
| **Total** | **8,325** | | **463** | | **115** | | **8,903** | |

Table 2. Catch per unit effort (CPUE) values for bull trout (BULL), westslope cutthroat trout (WCT), northern pike (NP), and northern pikeminnow (NPM) captured in merwin traps in Fennon, Halfmoon, and Church sloughs (combined) during 1997 as related to mean weekly river temperature and discharge.

| Week Deployed | Julian Date | Total Trap Hours | Mean Weekly Temperature (°C) | Mean Weekly Discharge ($ft^3$/sec) | BULL CPUE | NP CPUE | NPM CPUE | WCT CPUE |
|---|---|---|---|---|---|---|---|---|
| 5-May | 125 | 190 | 5.9 | 21,043 | 0.110 | 0.084 | 0.50 | 0 |
| 12-May | 132 | 118.5 | 6.4 | 44,486 | 0.093 | 0.059 | 1.25 | 0.008 |
| 19-May | 139 | 232 | 6.6 | 33,071 | 0.211 | 0.099 | 2.21 | 0.022 |
| 26-May | 146 | 208.5 | 7.1 | 36,057 | 0.091 | 0.038 | 1.47 | 0.029 |
| 2-Jun | 153 | 141.5 | 7.6 | 40,900 | 0.064 | 0.007 | 1.85 | 0.007 |
| 9-Jun | 160 | 218.75 | 8.9 | 39,843 | 0.073 | 0.046 | 1.30 | 0.014 |
| 1-Sep | 244 | 140.75 | 15.4 | 6,577 | 0 | 0.007 | 0.70 | 0 |
| 8-Sep | 251 | 201 | 14.2 | 6,436 | 0 | 0.005 | 0.09 | 0 |
| 15-Sep | 258 | 140.75 | 12.6 | 7,357 | 0 | 0 | 0.14 | 0.007 |
| 20-Oct | 294 | 119 | 5.7 | 4,217 | 0.008 | 0.017 | 0.04 | 0 |
| 27-Oct | 300 | 54.75 | 5.4 | 4,147 | 0.037 | 0 | 0.02 | 0 |
| 3-Nov | 307 | 195 | 4.9 | 4,246 | 0.010 | 0.01 | 0.02 | 0 |
| 10-Nov | 314 | 170 | 2.5 | 4,013 | 0 | 0 | 0.00 | 0 |
| 17-Nov | 321 | 26 | 3.7 | 5,957 | 0.039 | 0 | 0.00 | 0 |

Table 3. Results of Spearman's rank of correlation analysis between catch per unit effort values (CPUE) for target fish species and mean weekly stream temperature (°C), mean weekly discharge ($ft^3/sec$), and Julian date of fish captured in Fennon, Halfmoon and Church sloughs (combined) in the Flathead River during 1997.

| Variables | Rank of correlation (r) | Probability (P) | Sample size (n) |
|---|---|---|---|
| | | **Bull Trout** | |
| Temperature (°C) | -0.122 | 0.677 | 14 |
| Discharge ($ft^3/sec$) | 0.638 | 0.014 | 14 |
| Julian Date | -0.693 | 0.006 | 14 |
| | | **Westslope Cutthroat Trout** | |
| Temperature (°C) | 0.373 | 0.189 | 14 |
| Discharge ($ft^3/sec$) | 0.782 | 0.001 | 14 |
| Julian Date | -0.602 | 0.023 | 14 |
| | | **Northern Pike** | |
| Temperature (°C) | 0.156 | 0.595 | 14 |
| Discharge ($ft^3/sec$) | 0.616 | 0.019 | 14 |
| Julian Date | -0.805 | 0.001 | 14 |
| | | **Pikeminnow** | |
| Temperature (°C) | 0.629 | 0.016 | 14 |
| Discharge ($ft^3/sec$) | 0.873 | 0.000 | 14 |
| Julian Date | -0.849 | 0.000 | 14 |

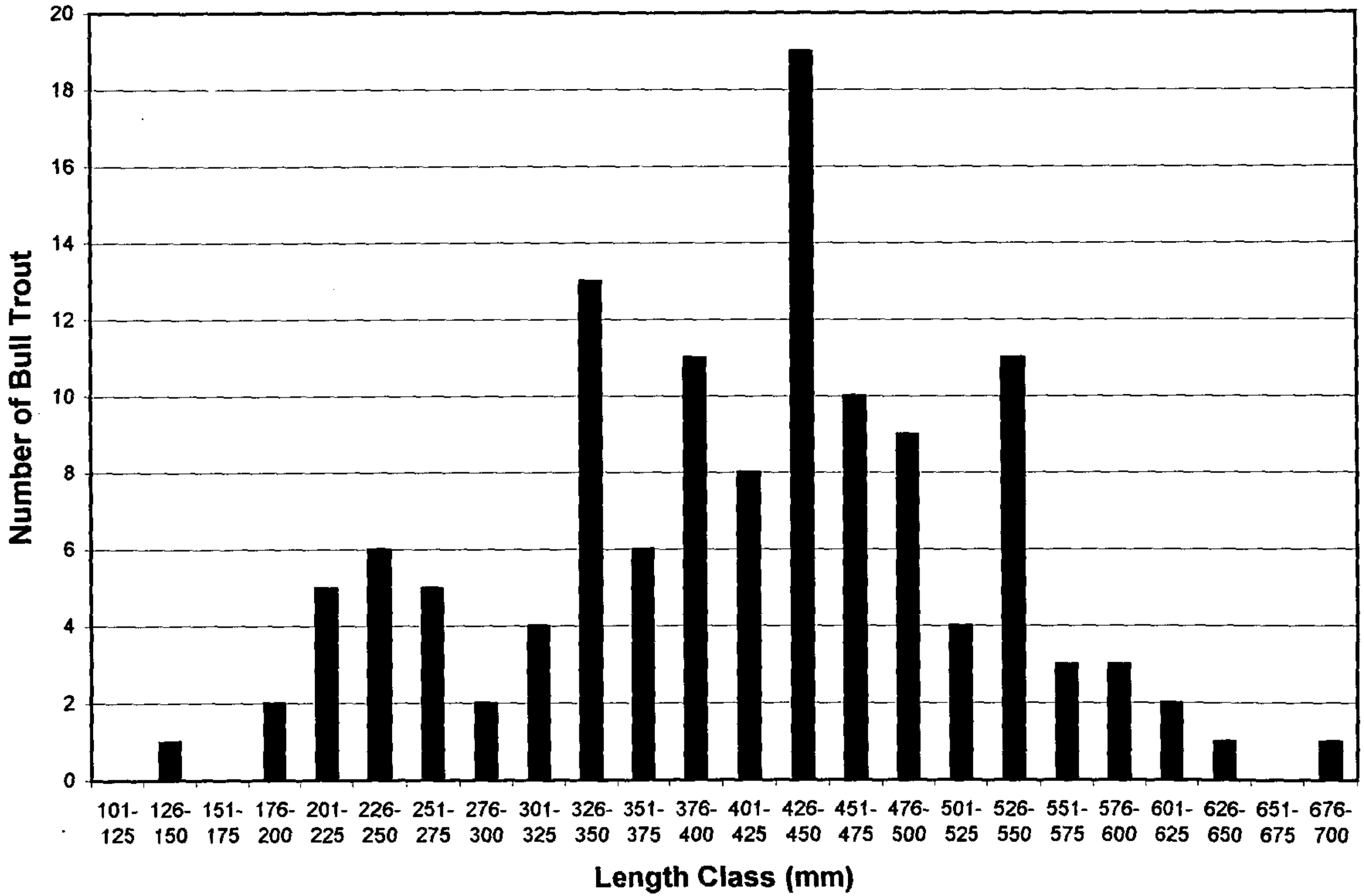


Figure 2. Length frequency distribution of bull trout captured in Flathead River sloughs during 1997.

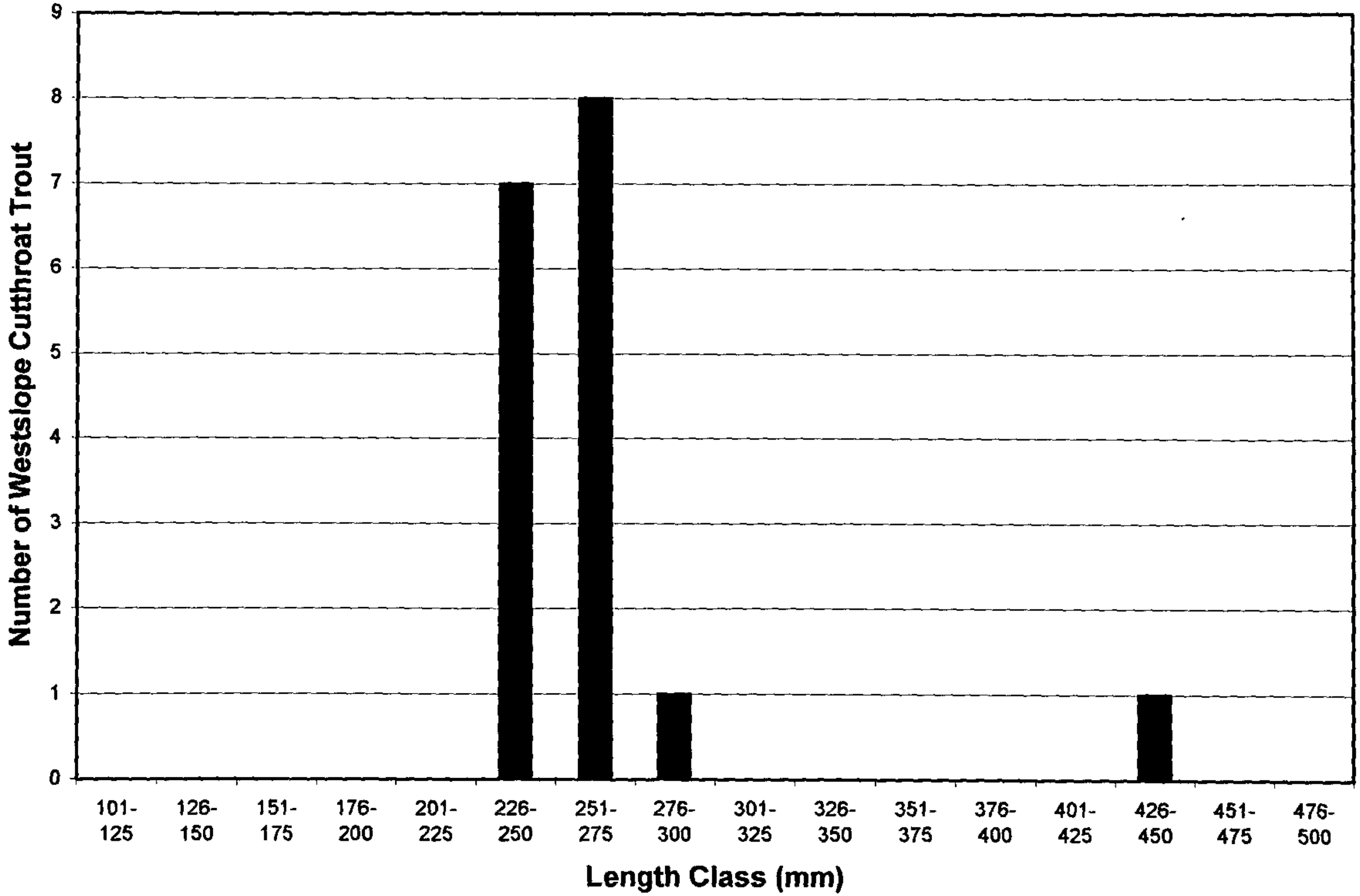


Figure 3. Length frequency distribution of westslope cutthroat trout captured in Flathead River sloughs during 1997.

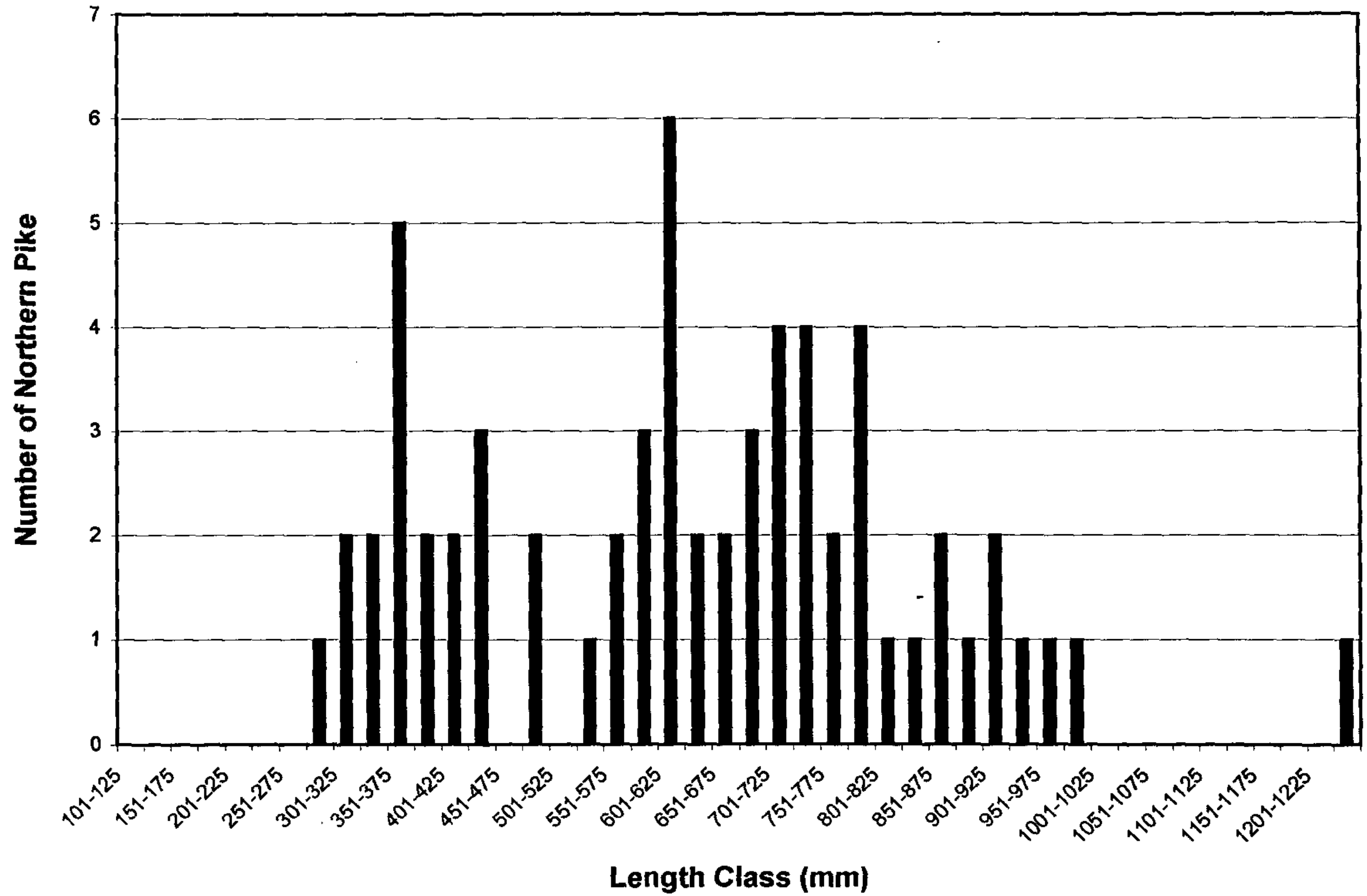


Figure 4. Length frequency distribution of northern pike captured in Flathead River sloughs during 1997.

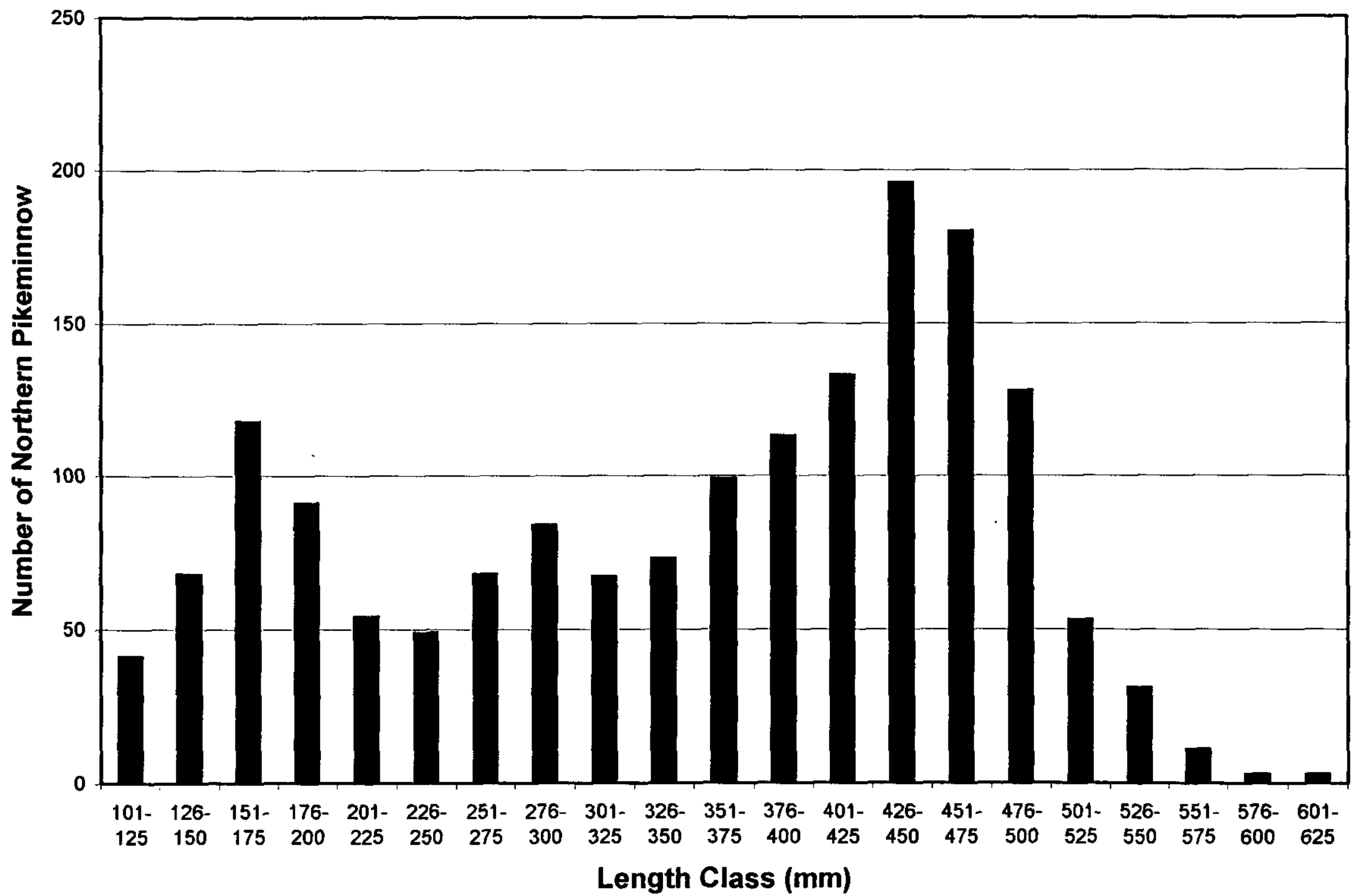


Figure 5. Length frequency distribution of northern pikeminnow captured in Flathead River sloughs during 1997.

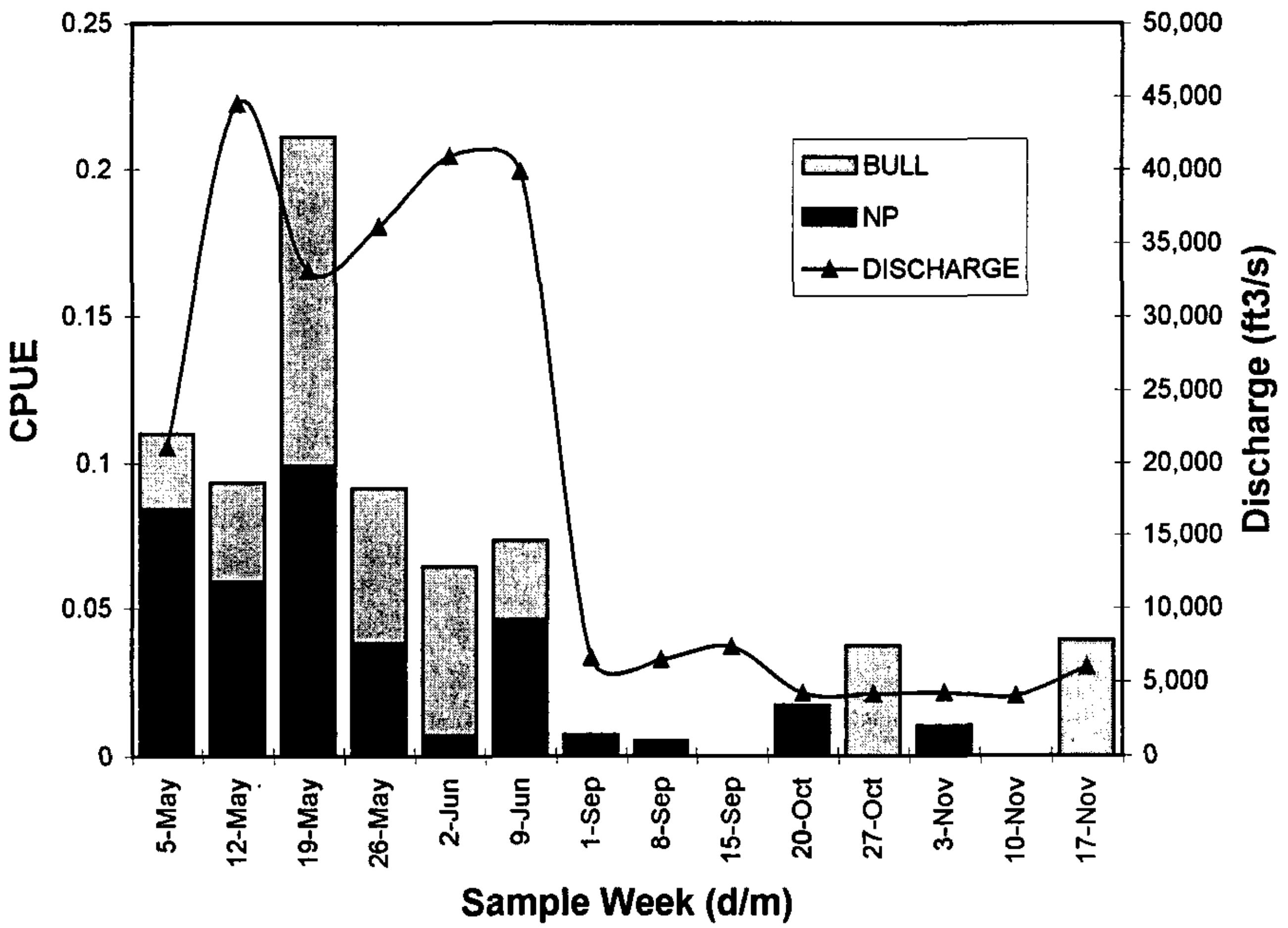


Figure 6. Weekly catch per unit effort (CPUE) values for bull trout and northern pike captured in the lower Flathead River sloughs during 1997.

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# APPENDIX

Appendix 1. Number and percent species composition (in parentheses) of fish captured in merwin traps in Church Slough during 1997. Species abbreviations are as follows: BLBH = black bullhead, BULL = bull trout, KOK = kokanee salmon, LCSU = largescale sucker, LMB = largemouth bass, LNSU = longnose sucker, LT = lake trout, LWF lake whitefish, MWF = mountain whitefish, NP = northern pike, NPM = northern pikeminnow, NPMxPEA = northern pikeminnow/peamouth hybrid, PEA = peamouth, PUMP = pumkinseed, PWF = pygmy whitefish, RSSH = redside shiner, WCT = westslope cutthroat trout, WE = walleye, YP = yellow perch.

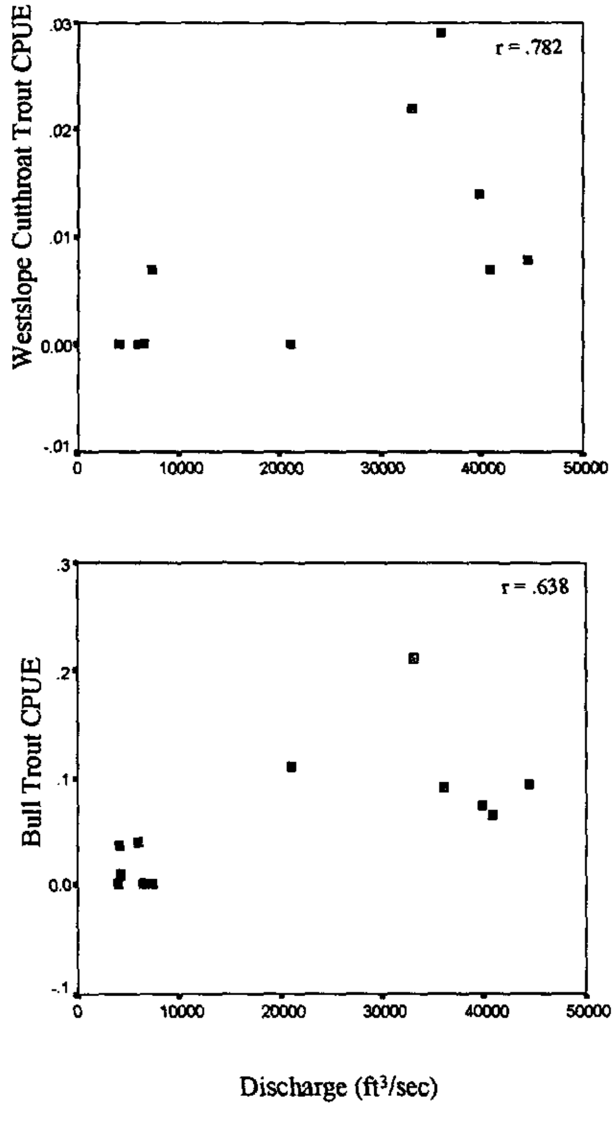
| Species | Spring | | Summer | | Fall | Total | |
|---|---|---|---|---|---|---|---|
| BLBH | 145 | (4.3) | 0 | (0.0) | 0 | 145 | (4.0) |
| BULL | 14 | (0.4) | 0 | (0.0) | 0 | 14 | (0.4) |
| KOK | 0 | (0.0) | 0 | (0.0) | 0 | 0 | (0.0) |
| LCSU | 265 | (7.8) | 117 | (48.8) | 0 | 382 | (10.5) |
| LMB | 0 | (0.0) | 2 | (0.8) | 0 | 2 | (0.1) |
| LNSU | 135 | (4.0) | 1 | (0.4) | 0 | 136 | (3.7) |
| LT | 1 | (0.0) | 0 | (0.0) | 0 | 1 | (0.0) |
| LWF | 7 | (0.2) | 0 | (0.0) | 0 | 7 | (0.2) |
| MWF | 10 | (0.3) | 0 | (0.0) | 0 | 10 | (0.3) |
| NP | 3 | (0.1) | 0 | (0.0) | 0 | 3 | (0.1) |
| NPM | 887 | (26.1) | 81 | (33.8) | 0 | 968 | (26.6) |
| NPMxPEA | 2 | (0.1) | 0 | (0.0) | 0 | 2 | (0.1) |
| PEA | 1,247 | (36.6) | 30 | (12.5) | 0 | 1,277 | (35.1) |
| PUMP | 494 | (14.5) | 6 | (2.5) | 0 | 500 | (13.7) |
| PWF | 0 | (0.0) | 0 | (0.0) | 0 | 0 | (0.0) |
| RSSH | 2 | (0.1) | 0 | (0.0) | 0 | 2 | (0.1) |
| WCT | 1 | (0.0) | 0 | (0.0) | 0 | 1 | (0.0) |
| WE | 1 | (0.0) | 0 | (0.0) | 0 | 1 | (0.0) |
| YP | 189 | (5.6) | 3 | (1.3) | 0 | 192 | (5.3) |
| **Total** | **3,403** | | **240** | | **0** | **3,643** | |

Appendix 2. Number and percent species composition (in parentheses) of fish captured in merwin traps in Fennon Slough during 1997. Species abbreviations are as follows: BLBH = black bullhead, BULL = bull trout, KOK = kokanee salmon, LCSU = largescale sucker, LMB = largemouth bass, LNSU = longnose sucker, LT = lake trout, LWF lake whitefish, MWF = mountain whitefish, NP = northern pike, NPM = northern pikeminnow, NPMxPEA = northern pikeminnow/peamouth hybrid, PEA = peamouth, PUMP = pumkinseed, PWF = pygmy whitefish, RSSH = redside shiner, WCT = westslope cutthroat trout, WE = walleye, YP = yellow perch.

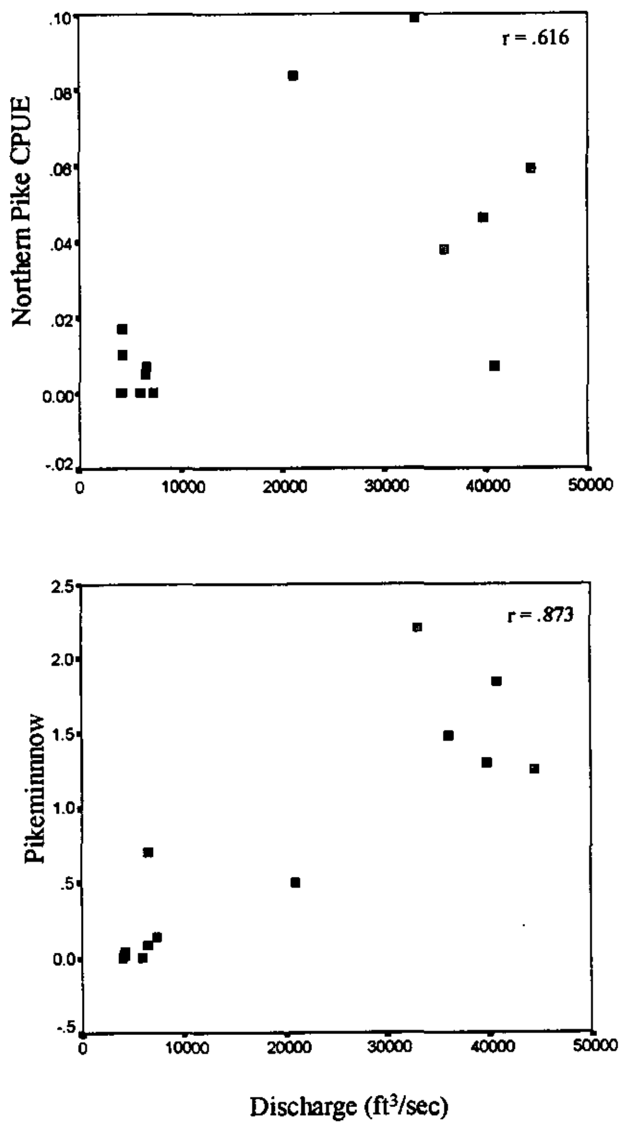
| **Species** | **Spring** | | **Summer** | | **Fall** | | **Total** | |
|---|---|---|---|---|---|---|---|---|
| BLBH | 5 | (0.2) | 0 | (0.0) | 0 | (0.0) | 5 | (0.2) |
| BULL | 86 | (3.4) | 0 | (0.0) | 6 | (6.3) | 92 | (3.4) |
| KOK | 2 | (0.1) | 3 | (3.8) | 24 | (25.3) | 29 | (1.1 |
| LCSU | 464 | (18.2) | 47 | (60.3) | 7 | (7.4) | 518 | (19.0) |
| LMB | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) |
| LNSU | 384 | (15.0) | 0 | (0.0) | 0 | (0.0) | 384 | (14.1) |
| LT | 4 | (0.2) | 0 | (0.0) | 0 | (0.0) | 4 | (0.1) |
| LWF | 96 | (3.8) | 0 | (0.0) | 9 | (9.5) | 105 | (3.9) |
| MWF | 15 | (0.6) | 0 | (0.0) | 16 | (16.8) | 31 | (1.1) |
| NP | 12 | (0.5) | 1 | (1.3) | 3 | (3.2) | 16 | (0.6) |
| NPM | 548 | (21.5) | 19 | (24.4) | 13 | (13.7) | 580 | (21.3) |
| NPMxPEA | 2 | (0.1) | 0 | (0.0) | 0 | (0.0) | 2 | (0.1) |
| PEA | 363 | (14.2) | 7 | (9.0) | 15 | (15.8) | 385 | (14.1) |
| PUMP | 406 | (15.9) | 0 | (0.0) | 0 | (0.0) | 406 | (14.9) |
| PWF | 0 | (0.0) | 0 | (0.0) | 1 | (1.1) | 1 | (0.0) |
| RSSH | 18 | (0.7) | 0 | (0.0) | 1 | (1.1) | 19 | (0.7) |
| WCT | 5 | (0.2) | 1 | (1.3) | 0 | (0.0) | 6 | (0.2) |
| WE | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) |
| YP | 143 | (5.6) | 0 | (0.0) | 0 | (0.0) | 143 | (5.2) |
| **Total** | **2,553** | | **78** | | **95** | | **2,726** | |

Appendix 3. Number and percent species composition (in parentheses) of fish captured in merwin traps in Halfmoon Slough during 1997. Species abbreviations are as follows: BLBH = black bullhead, BULL = bull trout, KOK = kokanee salmon, LCSU = largescale sucker, LMB = largemouth bass, LNSU = longnose sucker, LT = lake trout, LWF lake whitefish, MWF = mountain whitefish, NP = northern pike, NPM = northern pikeminnow, NPMxPEA = northern pikeminnow/peamouth hybrid, PEA = peamouth, PUMP = pumkinseed, PWF = pygmy whitefish, RSSH = redside shiner, WCT = westslope cutthroat trout, WE = walleye, YP = yellow perch.

| Species | Spring | | Summer | | Fall | | Total | |
|---|---|---|---|---|---|---|---|---|
| BLBH | 129 | (5.4) | 0 | (0.0) | 11 | (55.0) | 140 | (5.5) |
| BULL | 25 | (1.1) | 0 | (0.0) | 0 | (0.0) | 25 | (1.0) |
| KOK | 0 | (0.0) | 0 | (0.0) | 2 | (10.0) | 2 | (0.1) |
| LCSU | 447 | (18.9) | 102 | (70.3) | 4 | (20.0) | 553 | (21.8) |
| LMB | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) |
| LNSU | 92 | (3.9) | 2 | (1.4) | 0 | (0.0) | 94 | (3.7) |
| LT | 2 | (0.1) | 0 | (0.0) | 0 | (0.0) | 2 | (0.1) |
| LWF | 94 | (4.0) | 0 | (0.0) | 1 | (5.0) | 95 | (3.7) |
| MWF | 27 | (1.1) | 1 | (0.7) | 0 | (0.0) | 28 | (1.1) |
| NP | 50 | (2.1) | 1 | (0.7) | 1 | (5.0) | 52 | (2.1) |
| NPM | 171 | (7.2) | 36 | (24.8) | 0 | (0.0) | 207 | (8.2) |
| NPMxPEA | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) |
| PEA | 1,236 | (52.2) | 0 | (0.0) | 1 | (5.0) | 1,237 | (48.8) |
| PUMP | 6 | (0.3) | 3 | (2.1) | 0 | (0.0) | 9 | (0.4) |
| PWF | 0 | (0.0) | 0 | (0.0) | 0 | 90.0) | 0 | (0.0) |
| RSSH | 45 | (1.9) | 0 | (0.0) | 0 | (0.0) | 45 | (1.8) |
| WCT | 10 | (0.4) | 0 | (0.0) | 0 | (0.0) | 10 | (0.4) |
| WE | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) | 0 | (0.0) |
| YP | 35 | (1.5) | 0 | (0.0) | 0 | (0.0) | 35 | (1.4) |
| **Total** | **2,369** | | **145** | | **20** | | **2,534** | |




Appendix 4. Scatter-plots of the relationship between river discharge and catch per unit effort (CPUE) for westslope cutthroat trout and bull trout captured in merwin traps in Fennon, Halfmoon and Church sloughs (combined) during 1997.




Appendix 5. Scatter-plots of the relationship between river discharge and catch per unit effort (CPUE) for northern pikeminnow and northern pike captured in merwin traps in Fennon, Halfmoon and Church sloughs (combined) during 1997.