Seasonal Migrations of Bull Trout, Westslope Cutthroat Trout, and Rainbow Trout In the Upper Salmon River Basin, Idaho

Report
2003, 2004, 2005

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ABSTRACT

Information on the movements, behavior, and critical habitats of native resident salmonids in the Salmon River basin, Idaho is lacking. Additionally, concerns have been raised by the public regarding the lack of angling opportunities in the mainstem of the Salmon River. In an effort to identify migration patterns, corridors, and timing, as well as identify critical spawning and wintering habitats, fluvial populations of bull trout *Salvelinus confluentus*, westslope cutthroat trout *Oncorhynchus clarki lewisi* and rainbow trout *O. mykiss* were monitored using radio telemetry. During 2003 and 2004, 80 bull trout, 54 westslope cutthroat, and 56 rainbow trout were implanted with radio transmitters. Movements were monitored through 2005 by ground relocations and fixed telemetry stations located at major tributaries. Fish were relocated on a weekly basis, allowing for the spatial and temporal identification of spawning areas, migration timing, movement corridors, and over wintering habitats. During this study, 15, 13, and 6 spawning tributaries used by bull trout, westslope cutthroat trout, and rainbow trout, respectively, were identified. Information from this study also identified Redfish Lake and Little Redfish Lake as wintering habitat for bull trout populations that generally demonstrated fluvial life history characteristics. This information will be used in future management decisions by agencies working in the Upper Salmon River basin and help guide habitat conservation and improvement projects.

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INTRODUCTION

The listing of bull trout *Salvelinus confluentus* under the Endangered Species Act (ESA) and petitions for the listing of westslope cutthroat *Oncorhynchus clarki lewisi* have generated concerns regarding the status of salmonids throughout their native range. Assessments of native salmonids across watersheds throughout the Interior Columbia River Basin suggest that the Salmon River basin contains a large portion of the occupied salmonid habitat and a high proportion of species strongholds relative to other basins in the region (Servheen 2001). Many (38%) of the subwatersheds within the Salmon River basin support strong populations of one or more native species of salmonids, including populations with migratory (fluvial) adults (ICBEMP 2000). Fluvial trout represent an important ecological and recreational component of river systems by providing population resiliency (Rieman and McIntyre 1993; McIntyre and Rieman 1995) and the majority of angling opportunities (Rieman and Apperson 1989; Thiesfeld et al. 1996). Despite these important aspects and the goals of the Idaho Department of Fish and Game (IDFG) to improve angling in the mainstem Salmon River (IDFG 2001), very little is known about the fluvial trout populations in the Upper Salmon River Basin (USRB).

Fluvial populations of bull, westslope cutthroat, and rainbow/steelhead trout *O. mykiss* have suffered declines throughout the USRB and the rest of their historic range (Rieman et al. 1997; Behnke 1992). Numerous factors have contributed to the decline of fluvial trout populations, including the degradation of spawning and rearing habitats (Fraley and Shepard 1989), overfishing (Fraley and Shepard 1989; Behnke 1992; McPhail and Baxter 1996), effects of land use management and development, the introduction and expansion of exotic species (Behnke 1992), and the isolation of habitats by barriers such as dams, diversions, and culverts (Behnke 1992; Rieman et al. 1997). Major concerns in the USRB include the disconnection of tributary streams from mainstem rivers (i.e. fragmentation), degradation of riparian habitat, dewatering due to irrigation withdrawals, unscreened irrigation ditches, and the introduction of non-native species (USRITAT 1999).

Fragmentation and isolation of fluvial trout populations can lead to loss of persistence of some populations (Rieman and McIntyre 1993). Currently, very little is known about the migratory patterns and habitat needs of migratory trout in the USRB. Agency professionals will not be able to sufficiently estimate the potential effects of land management activities on fluvial populations of bull trout, westslope cutthroat trout, and rainbow trout throughout the USRB until they have detailed knowledge of the migratory patterns and critical habitat needs of these fish.

The goal of this project was to obtain information on the life history characteristics of fluvial trout populations in the USRB. This information is intended for use in further habitat protection and enhancement projects through the Upper Salmon Basin Watershed Project (USBWP) (formerly Lemhi Model Watershed Project) and for more informed decision making by all agencies working in the USRB. Migratory information will also be critical for further identification and prioritization of future diversion screening projects throughout the basin.

OBJECTIVES

1. Identify migration patterns and timing of bull trout, westslope cutthroat trout, and rainbow trout within the Upper Salmon River Basin.

2. Identify habitat variables associated with the migration patterns of bull trout, westslope cutthroat trout, and rainbow trout in the Upper Salmon River Basin.

3. Document the use of spawning tributaries by migratory bull trout, westslope cutthroat trout, and rainbow trout in the Upper Salmon River Basin.

STUDY AREA

The USRB lies within the Rocky Mountains of central Idaho and encompasses five major watersheds: the North Fork Salmon, Lemhi, Pahsimeroi, East Fork Salmon, and Yankee Fork Salmon Rivers (Figure 1). The USRB covers approximately 16,356 km^2 and has 595 named streams with a combined length of 11,954 km of stream. Public land is predominant in the USRB (91%), with the majority under management by the U.S. Forest Service (USFS) (60%). The Bureau of Land Management (BLM) (29%) and the State of Idaho (2%) also manage public lands in the USRB. Public lands throughout the USRB are managed to produce forage for domestic livestock, mineral commodities, and wood products, and to provide recreation, wilderness, and terrestrial and aquatic habitats. Private lands throughout the USRB are primarily used for agricultural purposes and are concentrated in valley bottoms. Water quality throughout the basin is generally high, although degradation from sedimentation and high concentrations of nutrients and metals has occurred in some streams affected by improper road construction and location, past and present mining activities, and excessive or improper livestock grazing. Irrigation withdrawals seasonally disconnect numerous tributaries in the USRB, preventing or restricting passage between mainstem rivers and tributary habitats. Entrainment in unscreened irrigation diversions also is a threat to migratory fish populations in the USRB. Elevated water temperatures in the Salmon River and major tributaries resulting from dewatering may also represent seasonal migration barriers.

The USRB contains spawning and rearing habitats for a variety of native and non-native game fish species. Native resident salmonid fish includes bull trout, westslope cutthroat trout, rainbow trout *O. mykiss*, and mountain whitefish *Prosopium williamsoni*. Anadromous fish present in the USRB include migratory rainbow (steelhead) trout, Chinook salmon *O. tshawytscha*, Pacific lamprey *Lampetra tridentata*, and the last remaining population of anadromous sockeye salmon *O. nerka* within the Snake River drainage. Native non-game species include bridgelip sucker *Catostomus columbianus*, largescale sucker *C. macrocheilus*, northern pikeminnow *Ptychocheilus oregonensis*, longnose dace *Rhinichthys cataractae*, speckled dace *R. osculus*, redside shiner *Richardsonius balteatus*, chiselmouth *Acrocheilus alutaceus*, and sculpin spp. *Cottus spp*. Introduced brook trout *S. fontinalis* are also present in the USRB.

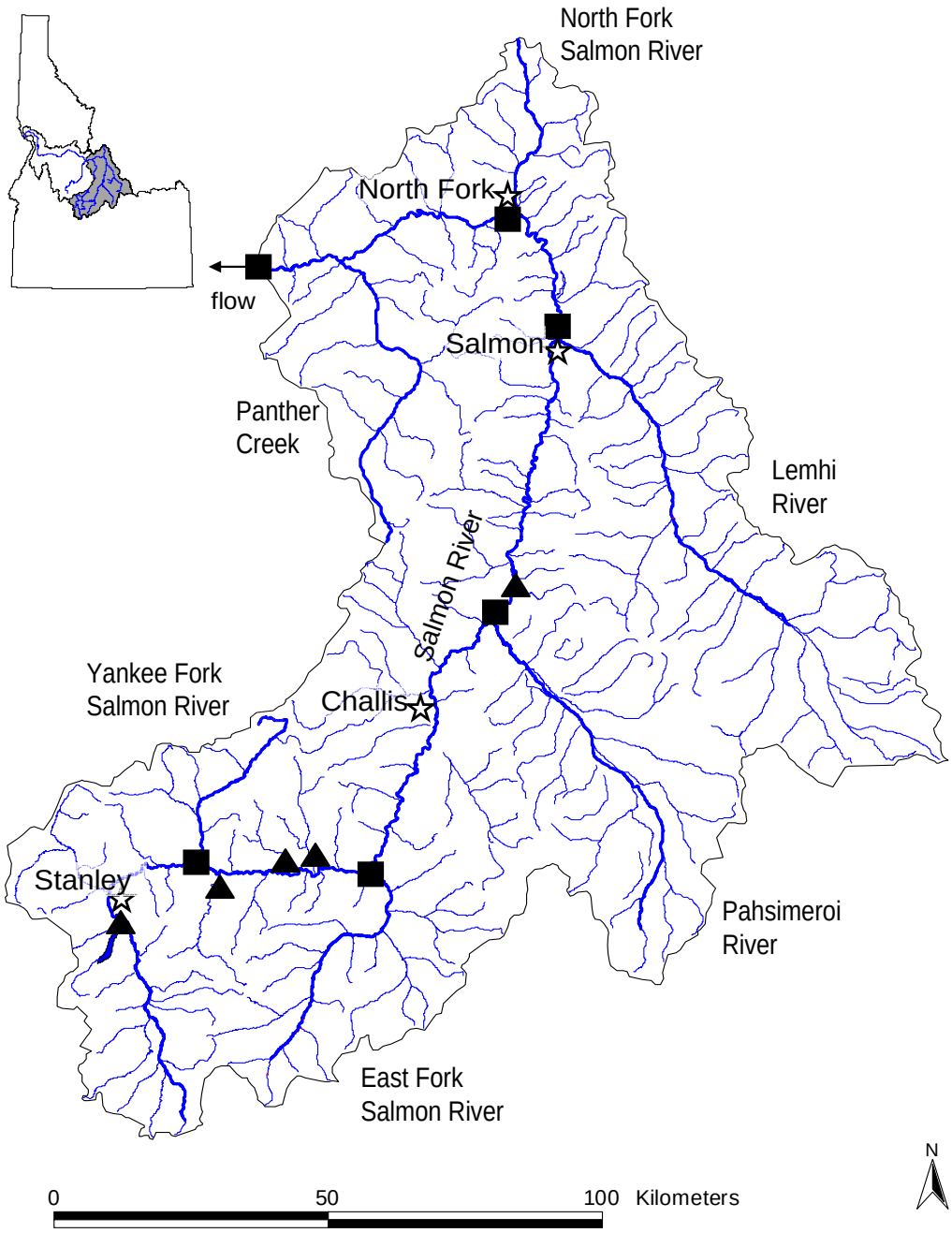

Figure 1. The Upper Salmon River Basin, Idaho, and its major watersheds. Towns are marked with stars. Locations of initial fixed telemetry sites are marked with black squares. Seasonal telemetry sites established after the first year of the study are marked with black triangles.

METHODS

To observe movement patterns of fluvial trout populations, individuals were implanted with radio transmitters throughout the USRB during 2003 and 2004 (see *Tagging* tables in species reports for more details). Fish were tagged throughout a 270 km reach of the Salmon River, from the town of North Fork, ID upstream to Stanley, ID. In some cases, additional fish were captured and tagged in tributaries to increase sample size (see *Tagging* in species reports for more details). While most fish were captured with hook and line, a Coffelt model VVP-15 drift-boat mounted electrofishing unit was used on three occasions (see *Tagging* in species reports for more details).

All fish receiving radio transmitters were anaesthetized in a 60 mg/L solution of tricaine methanesulfonate (MS-222) and measured for total length (mm), fork length (mm), and wet mass (g). To maintain anesthesia and implant radio transmitters, unconscious fish were placed in a V-shaped operating tray and their gills irrigated with a solution containing MS-222 using a battery operated pump. Once under anesthesia, radio transmitters were implanted using a surgical procedure similar to that described by Ross and Kleiner (1982). To provide a second means of identifying fish, Passive Integrated Transponder (PIT) tags were implanted into most individuals. All fish undergoing transmitter implantation were recovered in freshwater for at least 20 minutes. After recovery, radio tagged fish were released within 1 km of their capture location.

Fish were implanted with coded microprocessor transmitters manufactured by Lotek Wireless (Newmarket, ON, Canada). Transmitters operated at 149.780 MHz or 151.340 MHz and emitted digitally encoded signals every 5 seconds. Three different sizes of transmitters, models MCFT-3BM, MCFT-3EM, and MCFT-3FM, weighing 7.7, 8.9, and 10.0 grams, respectively, were used to provide a large size range of fish for implantation. Following the 2% transmitter-to-body mass ratio advised by Winter (1996), fish as small as 385 g were able to be radio tagged. Battery life of transmitters was 278, 399, and 560 days, respectively.

Radio tagged fish were relocated on a weekly basis by vehicle, fixed-wing aircraft, and boat using Lotek model SRX_400 radio telemetry receivers. When ground tracking, a truck-mounted three-element yagi antenna was used in areas with roads. In areas lacking roads, aerial telemetry flights were conducted to determine the extent of migration into headwater tributaries and to relocate those fish not observed during routine ground tracking. In stretches of the Salmon River where radio tagged fish were unable to be detected from roads, tagged fish were located by drift boat or raft. When radio tagged fish remained in unlikely holding locations or showed a lack of movement for extended periods (>2 months), snorkeling was used to determine if fish were alive and/or recover transmitters. Locations of radio tagged fish in the Salmon River and its tributaries were marked with a handheld Global Positioning System (GPS) unit and comments about the location were noted.

In addition to manual tracking efforts, five fixed telemetry stations also monitored the movements of radio tagged fish. Data logging telemetry stations were placed at the mouths of the Middle Fork Salmon (MFSR), North Fork Salmon (NFSR), Lemhi, Pahsimeroi, East Fork Salmon (EFSR), and Yankee Fork Salmon Rivers (YFSR) (Figure 1). Data logging stations consisted of a Lotek SRX_400 receiver connected to three 3-element yagi antennas mounted at each site: one pointing upstream on the Salmon River, one downstream on the Salmon River, and one upstream on the tributary at where the station was located. This allowed for the observation of directional movements into and out of the Salmon River and tributaries. Stations were powered by two 12V deep cycle batteries and two 50W solar panels. After the first year of study, additional stations with one 3-element yagi antenna were established at Cow Creek,

Squaw Creek, Thompson Creek, Warm Springs Creek, and Redfish Lake Creek (Figure 1). Stations at these locations were established and operated on a seasonal basis to identify timing of tributary use by fluvial trout based on data collected during the first year of the study.

Bull Trout

Tagging

To observe movement patterns of bull trout, 80 individuals were implanted with radio transmitters throughout the USRB. Fifty-six (56) bull trout were tagged throughout a 270 km reach of the Salmon River, from the town of North Fork, ID upstream to Stanley, ID. To increase sample size, additional bull trout (n=15) were captured and tagged throughout the Lemhi River drainage and at the IDFG hatchery weir in the EFSR (n=9). The majority of fish were captured with hook and line (n=79), while one (n=1) was captured using a Coffelt model VVP-15 drift-boat mounted electrofishing unit.

Radio tagged bull trout (n=80) averaged 466 ± 82 mm (mean ± SD) total length (TL) (range 330 – 680) and 1022 ± 598 g (range 320 – 2947) mass (Figure 2, Table 1). Five (5) bull trout were tagged that did not meet the 2% transmitter to body mass guideline advised by Winter (1996). These fish weighed less than 385 g at the time of capture and tagging, but the transmitter to body ratio never exceeded 3%. Average surgery time for fish implanted with radio transmitters was 5 minutes. The length-weight relationship for bull trout captured and tagged in the USRB was described by the equation: $\log_{10}$ weight (g) = 2.98 $\log_{10}$ total length (mm) – 4.99 (r^2 = 0.97, n=80) (Figure 3).

In spring 2003, 29 bull trout were implanted with radio transmitters (Figures 4 and 5). The mean total length was 444 ± 68 mm (range 330 – 610) and mean mass was 880 ± 415 g (range 320 – 2122) (Table 2). During fall 2003, 21 bull trout (mean TL: 457 ± 74 mm, range 332 – 602; mean mass: 902 ± 436 g, range 365 - 2150) were implanted with radio transmitters (Figure 6, Table 2). Seven of the bull trout tagged during the fall of 2003 were tagged in Lemhi River tributaries. An additional 20 bull trout (mean TL: 510 ± 104 mm, range 333 – 680; mean mass: 1411 ± 836 g, range 355 - 2947) were implanted with radio transmitters during spring 2004 (Figure 7, Table 2). Nine of these bull trout were tagged in the EFSR at the IDFG East Fork Satellite Facility weir located approximately 27 km upstream from the confluence with the Salmon River. Also, three bull trout were tagged in Bear Valley Creek, a tributary to the Lemhi River, during the spring of 2004. During fall 2004, 10 bull trout (mean TL: 459 ± 66 mm, range 418 – 640; mean mass: 910 ± 506 g, range 550 - 2300) were implanted with radio transmitters (Figure 8, Table 2).

Table 1. Summary statistics of total length (mm) and weight (g) of all bull trout captured and tagged (n=80) in the Upper Salmon River Basin, Idaho during 2003 and 2004.

	Total Length (mm)	**Weight (g)**
Mean	466	1022
Median	454	858
Mode	420	640
Standard Deviation	82	598
Minimum	330	320
Maximum	680	2947

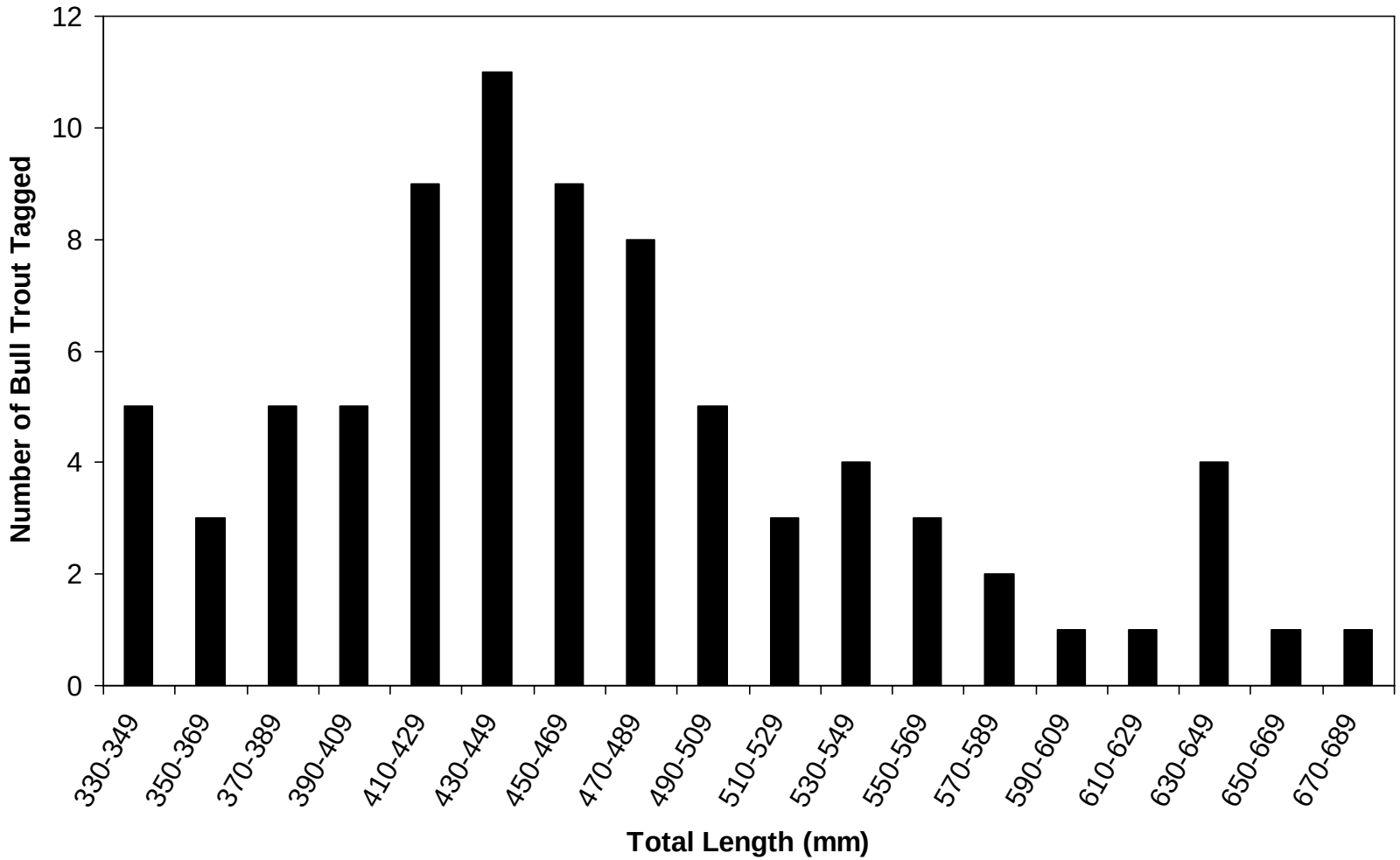

Figure 2. Length frequency distribution of radio tagged bull trout in the Upper Salmon River Basin, ID.

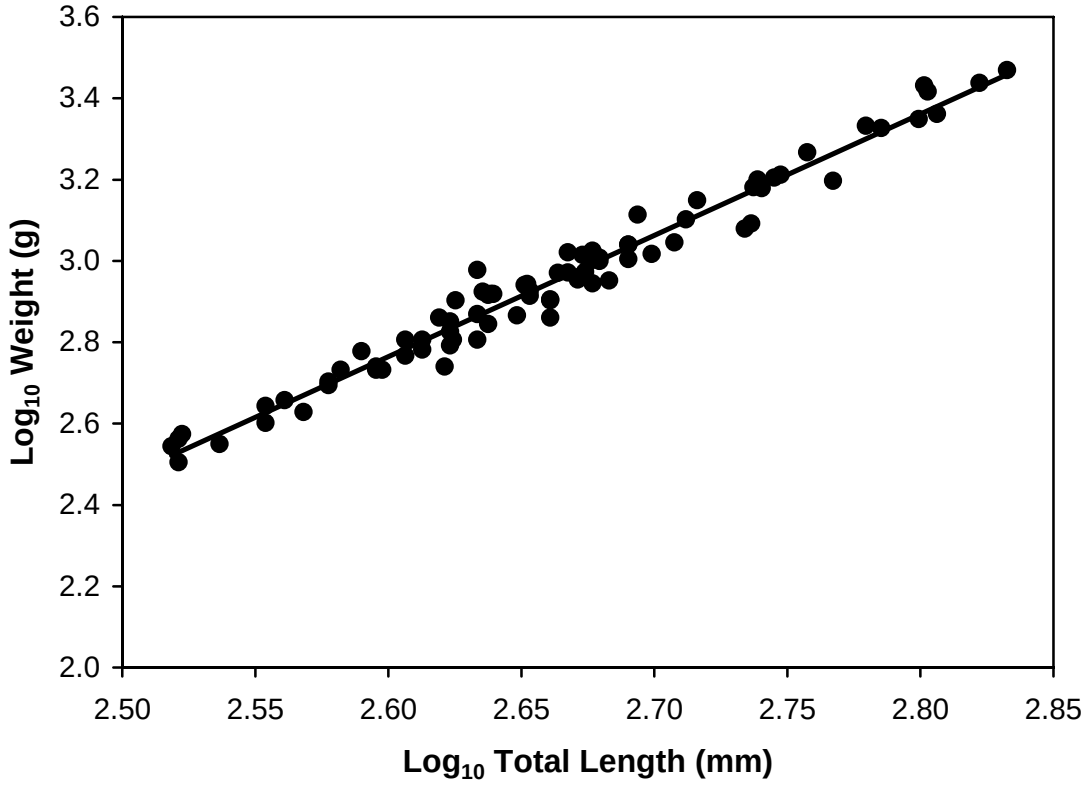

Figure 3. The length-weight relationship for bull trout captured and tagged in the Upper Salmon River Basin, Idaho during 2003 and 2004: $\log_{10}$ weight (g) = 2.98 $\log_{10}$ total length (mm) – 4.99 (r^2 = 0.97, n=80).

Table 2. Number of bull trout radio tagged, and mean total length (mm) and weight (g), in the Upper Salmon River Basin, Idaho, during the spring and fall of 2003 and 2004.

	2003		**2004**	
	Spring	**Fall**	**Spring**	**Fall**
Number of Bull Trout Tagged	29	21	20	10
Mean Total Length (mm)	444	457	510	459
Mean Weight (g)	880	902	1412	910

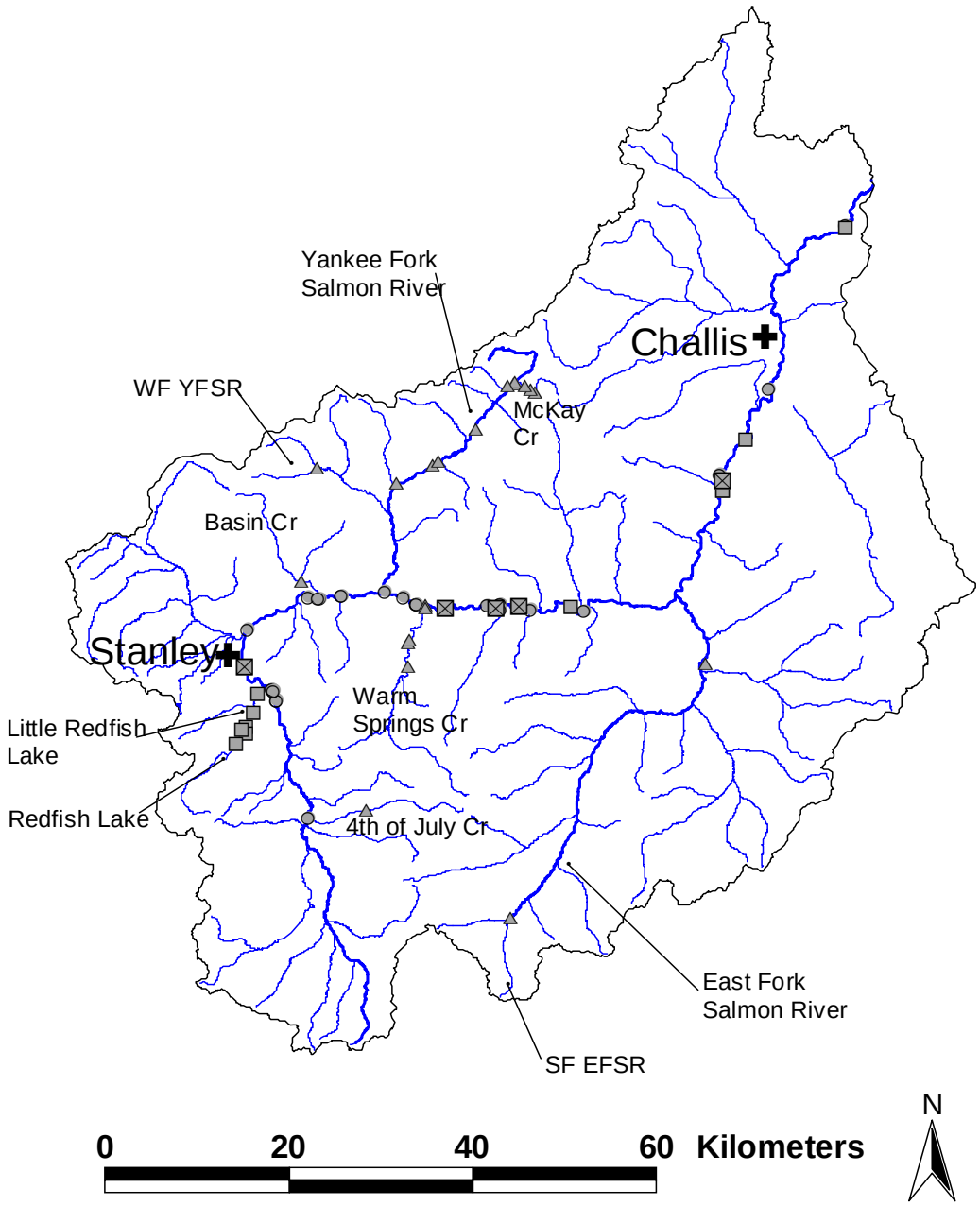

Figure 4. Tagging location (circles), spawning location (triangles), and winter location (squares) of bull trout tagged during the spring of 2003 in the upper reaches of the Upper Salmon River Basin, Idaho. Winter locations (squares) with X's represent winter or post-spawning related mortalities.

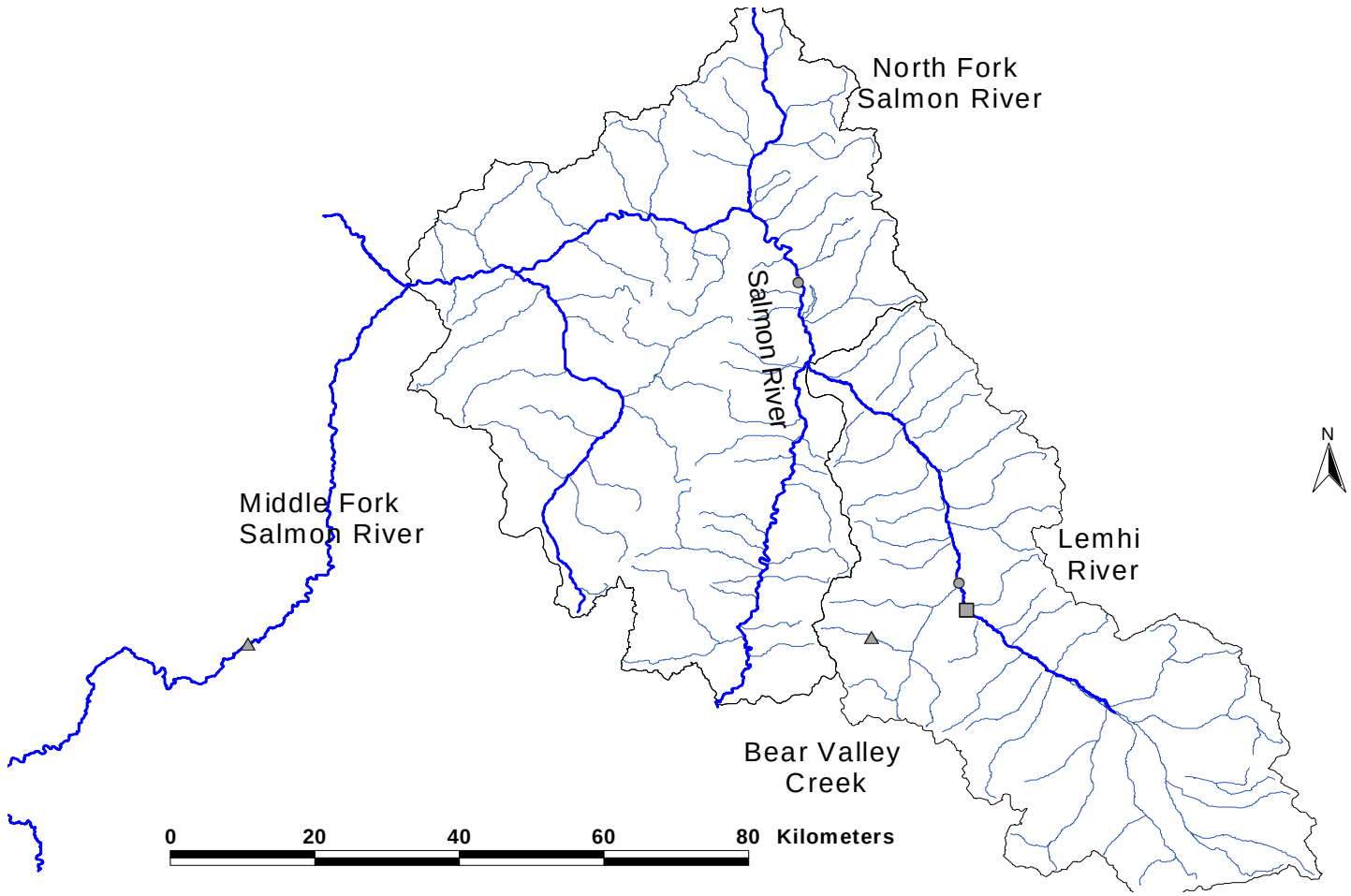

Figure 5. Tagging location (circles), spawning location (triangles), and winter location (squares) of bull trout tagged during the spring of 2003 in the lower portion of the study area in the Upper Salmon River Basin, Idaho.

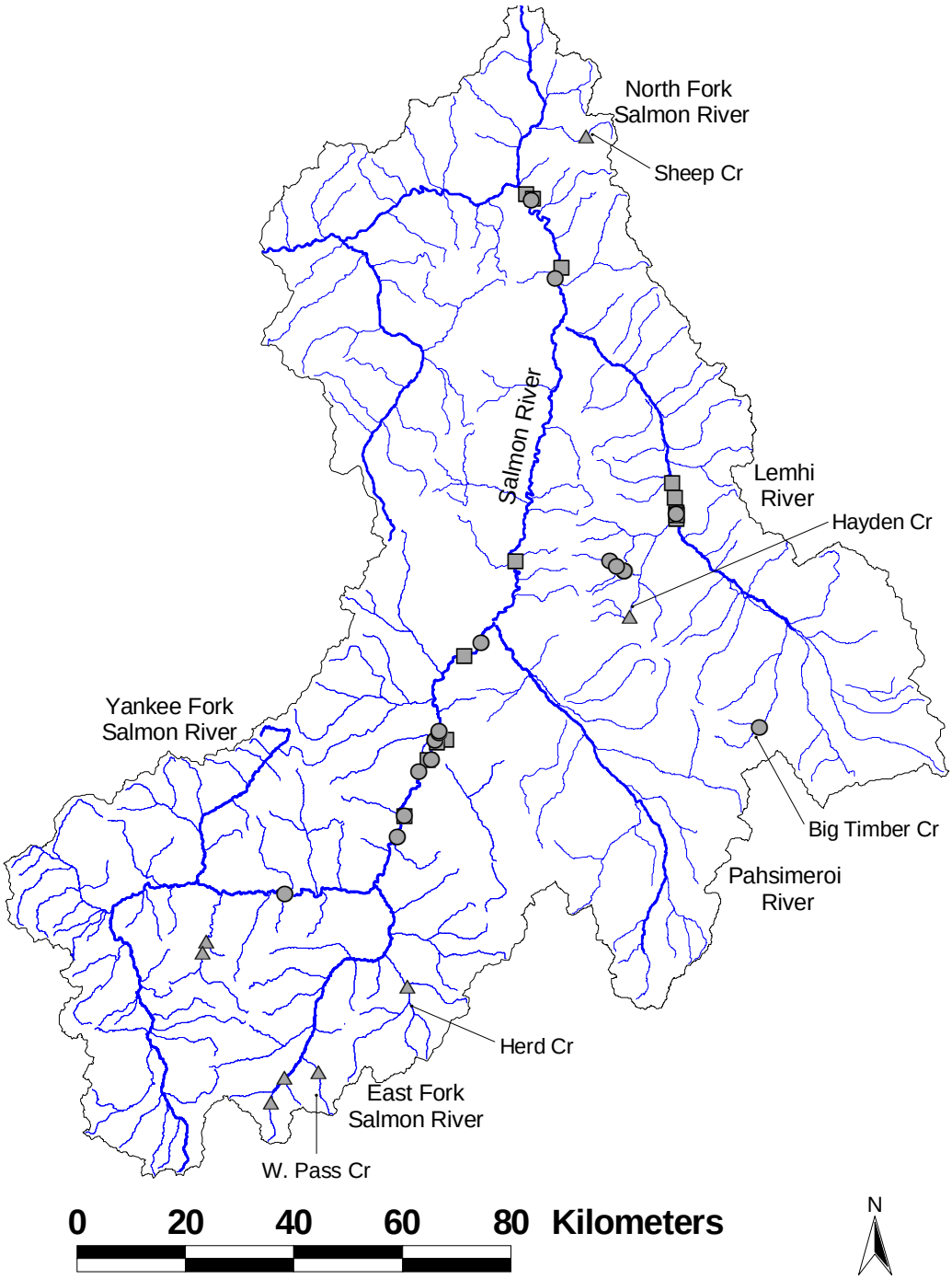

Figure 6. Tagging location (circles), spawning location (triangles), and winter location (squares) of bull trout tagged during the fall of 2003 in the Upper Salmon River Basin, Idaho.

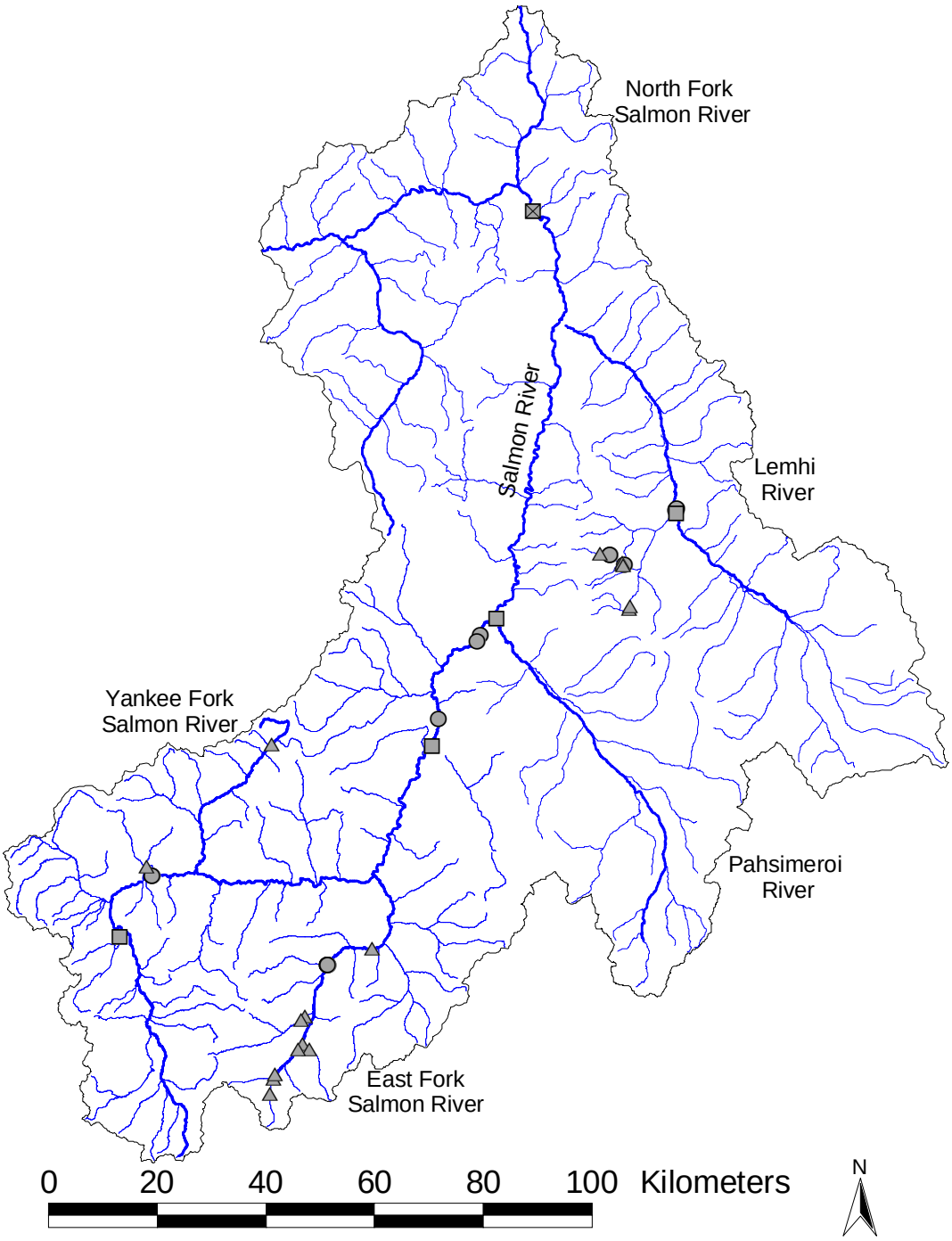

Figure 7. Tagging location (circles), spawning location (triangles), and winter location (squares) of bull trout tagged during the spring of 2004 in the Upper Salmon River Basin, Idaho.

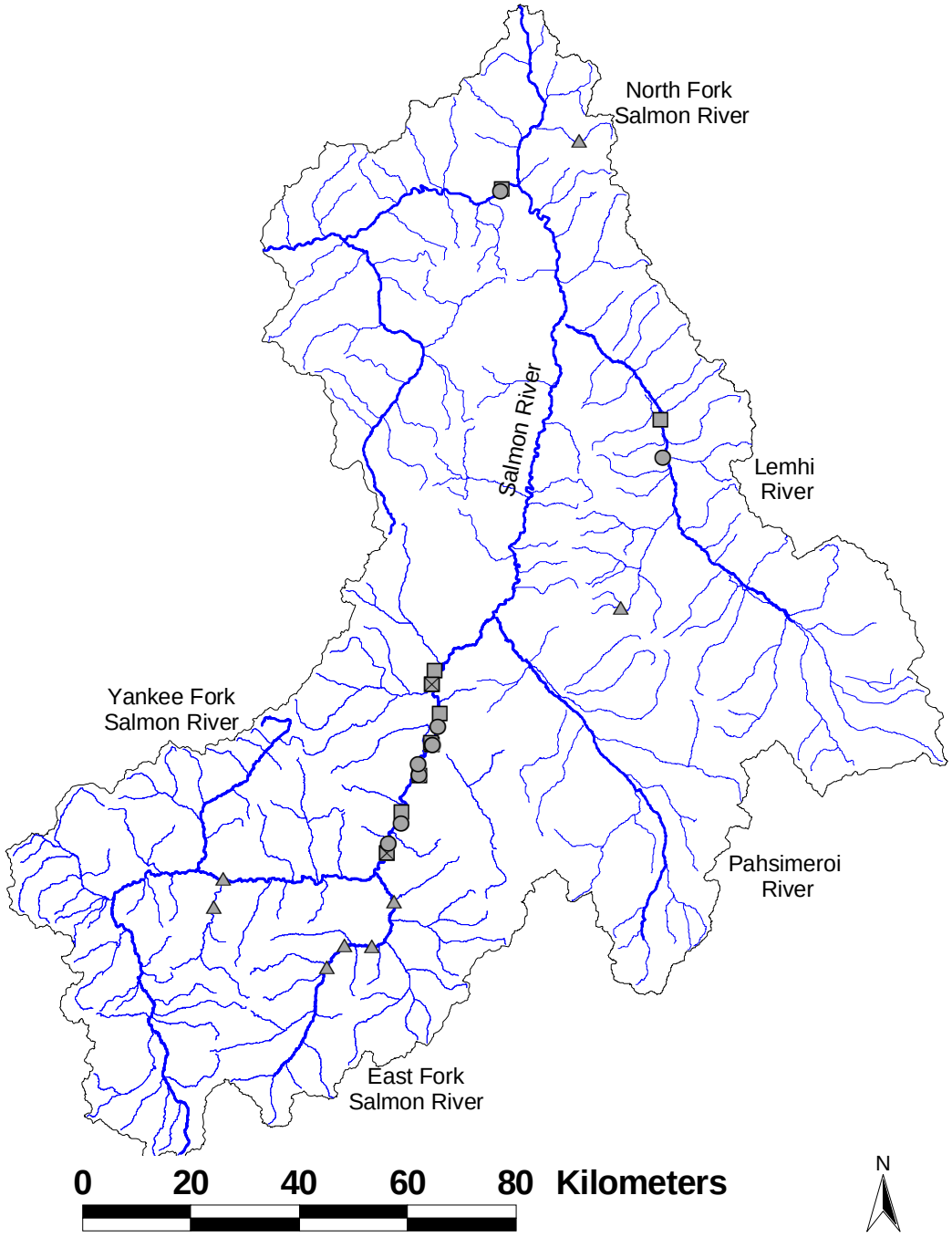

Figure 8. Tagging location (circles), spawning location (triangles), and winter location (squares) of bull trout tagged during the fall of 2004 in the Upper Salmon River Basin, Idaho. Winter locations (squares) with X's represent winter or post spawning related mortalities.

Tracking

We tracked radio tagged bull trout for 16 – 494 days (mean = 302.1 d), depending on transmitter size and the fate of individual fish. For the 80 radio tagged fish, 2,365 relocations were established. Radio telemetry relocations of the 80 radio tagged bull trout averaged 29.6 per fish (range: 3 - 66). Access to some portions of the study area limited the number of relocations for some fish, particularly, those fish migrating into WSC, the upper EFSR and its tributaries, and the Redfish Lake system. Over the course of the study, aerial tracking was used on 12 occasions to relocate fish in these areas. Although the frequency of aerial tracking was limited, it did provide some information on the extent of upstream migration into more remote regions of the study area. In addition, the presence of fixed telemetry sites documented migration timing between adjacent tributary streams and the Salmon River. Similarly, fish using the Redfish Lake system during winter were rarely relocated during this time period (November - April) due to access; however, the fixed telemetry site on Redfish Lake Creek documented the return of radio tagged fish to the Salmon River and confirmed their use of the Redfish Lake system as winter habitat.

Results

Migration Timing and Patterns

2003-During 2003, radio tagged bull trout generally began migrations within the Salmon River towards tributaries during April and May. Bull trout entered spawning tributaries between June 7 and July 20. Migrations into tributaries generally occurred during or after the peak of spring runoff in the Salmon River, with most bull trout entering tributaries on the descending limb of the hydrograph (Figure 9). Of the 29 bull trout tagged during the spring of 2003, spawning migrations into tributary streams were documented by 24 of these fish (Figures 4 and 5; Table 3). Of the five bull trout in which migrations were not observed, two were documented alive during this period; one bull trout (149.78.184) was not relocated during the migratory period, but was relocated in the fall when it returned to the Salmon River near its tagging location, and the other (149.78.154) remained in the Salmon River near its tagging location throughout the summer and was presumed to be immature (TL: 330mm). Of the other three bull trout, two transmitters were recovered; one mortality (149.78.187) was related to the surgical procedure, and based on the location and condition of the other recovered transmitter (149.78.151), the fish was predated. The final non-migrating bull trout (149.78.185) disappeared approximately 6 weeks after tagging. This fish had been relocated near its tagging location 10 times and then was unable to be found. The abrupt disappearance of this fish may have been due to transmitter failure or this fish may have been poached, as it was last located in a pool adjacent to a popular camping and fishing spot on the upper Salmon River.

Most bull trout captured during the spring of 2003 were tagged in the upper reaches of the study area, from the EFSR, upstream to the Sawtooth Fish Hatchery weir, therefore, spawning migrations were concentrated into tributaries within this reach (Figure 4; Table 3). The majority of the spawning migrations made by tagged bull trout in 2003 were into the YFSR (n=12) and WSC drainages (n=6). Also in the upper reaches of the study area, bull trout migrated into Basin Creek (n=1) and Fourth of July Creek (n=1). Two radio tagged bull trout also migrated into the EFSR. In the lower reach of the study area, one bull trout migrated into the MFSR, after briefly entering Panther Creek. The one bull trout tagged in the Lemhi River migrated into Bear Valley Creek (Hayden Creek drainage).

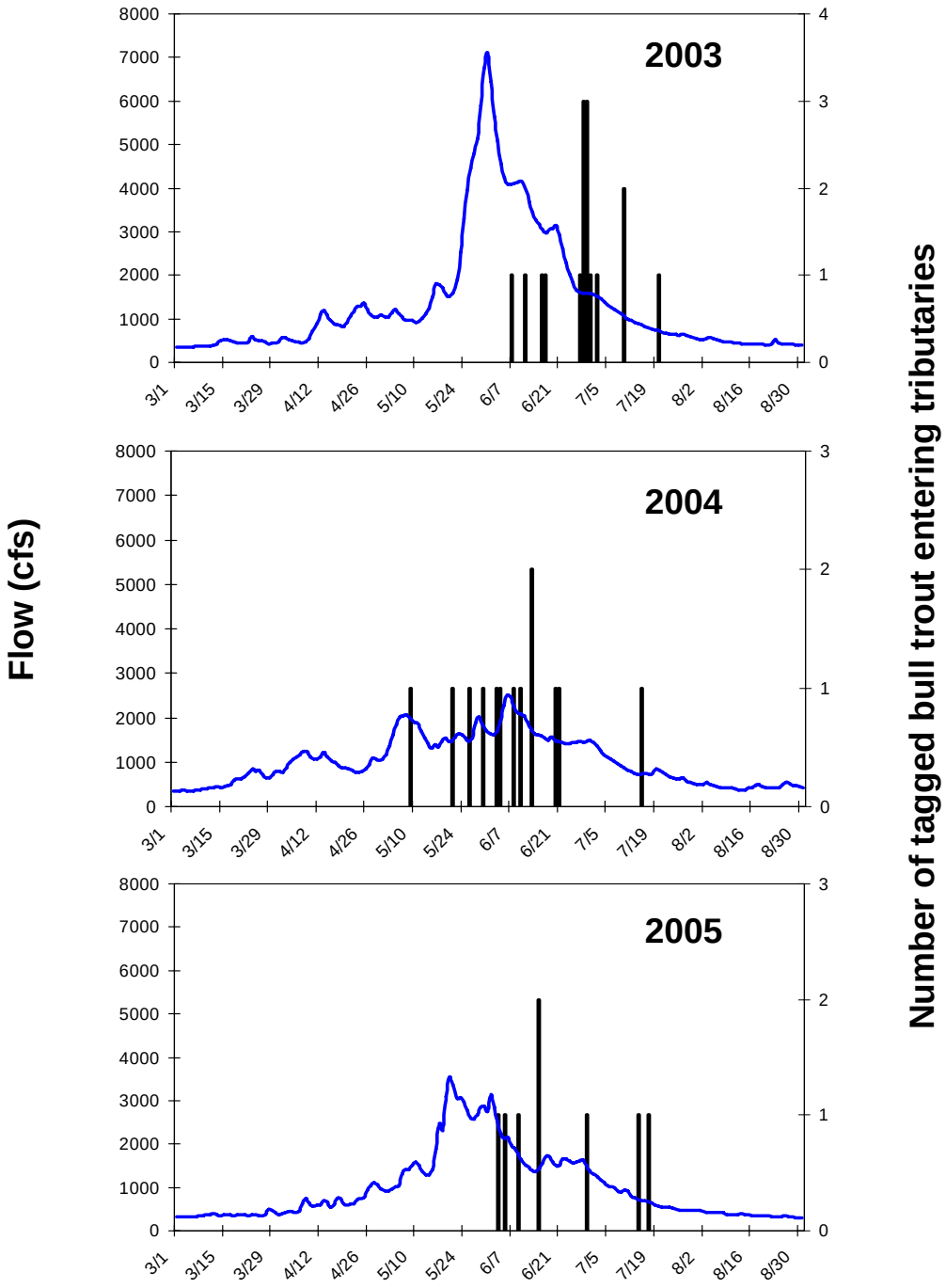

Figure 9. Migration of bull trout into tributary streams in relation to the Salmon River hydrograph during 2003-2005. The blue line represents discharge (cubic feet per second) on the primary y-axis. Discharge data was obtained from the USGS gage (#13296500) located on the Salmon River below the Yankee Fork Salmon River confluence. Vertical bars on the secondary y-axis represent the number of radio tagged bull trout entering tributaries in the upper portion of the study area (East Fork, Yankee Fork, Warm Springs, Basin, and 4th of July).

Table 3. Number of radio tagged bull trout detected in Upper Salmon River tributaries during 2003-2005.

Subbasin	Tributary	Number of Bull Trout 2003	2004	2005
Middle Fork Salmon River		1		
North Fork Salmon River	Sheep Creek		1	1
Lemhi River	Hayden Creek		3	2*
	Bear Valley Creek	1	2*	
East Fork Salmon River	Mainstem	2	2*	5*
	West Pass Creek		3	
	Germania Creek		2	
	Herd Creek		1	
	South Fork East Fork		5	
Warm Springs Creek	Mainstem	6	2	2
Yankee Fork Salmon River	Mainstem	8	3*	1*
	West Fork Yankee Fork	1	3	
	McKay Creek	3		
Basin Creek	Mainstem	1	1	
Fourth of July Creek	Mainstem	1		

* Includes repeat spawners from previous year.

Bull trout spawning in the YFSR returned to the Salmon River as early as August 23, with the last tagged fish passing the fixed station on September 19. Of the 12 bull trout using the YFSR, nine returned to the Salmon River. Tags were recovered from two of the three that did not return and were believed to be spawning related mortalities. Of the nine bull trout that returned to the Salmon River, six migrated upstream, with three each entering Redfish and Little Redfish Lake in early October (Figure 4). Tags were recovered from the three fish that did not enter either of the Redfish Lakes; two tags (149.78.200 and 149.78.189) were recovered from the Salmon River approximately 9.7 km downstream from the mouth of the YFSR, while one tag (149.78.192) was recovered 6.5 km downstream from the mouth of Redfish Lake Creek. Tags were not recovered until the spring of 2004 after ice conditions subsided, and no movement was observed throughout the winter. Additionally, the radio tagged bull trout using Basin Creek and 4th of July Creek also migrated into the Redfish Lake system during October, as did bull trout #149.78.184, whose spawning location is unknown.

Eight of the nine radio tagged bull trout that migrated into the Redfish Lake system for winter habitat returned to the Salmon River in the spring of 2004. We believe the transmitter expired in the fish that was not detected returning to the Salmon River. The fixed telemetry station on Redfish Lake Creek documented radio tagged fish returning to the Salmon River between 4/1/04 and 5/12/04.

Radio tagged bull trout spawning in WSC and the EFSR returned to the Salmon River between 9/2/03 and 9/14/03. Fish using these drainages migrated downstream in the Salmon River to wintering habitats near the town of Challis (Figure 4).

In the lower reaches of the study area, the radio tagged bull trout using Bear Valley Creek in the Lemhi drainage returned to the Lemhi River on 9/17/03. Also, the bull trout in the MFSR was last located 80.1 km upstream from the mouth on 10/26/03 (Figure 5). This fish remained in the same location until the following spring when the transmitter expired. It is unknown if this fish died after spawning or if the tag was shed, but no movement was detected after 10/26/03.

Of the 24 migratory bull trout observed in 2003, repeat spawning migrations were observed by four fish (*see Migration Patterns and Timing - 2004*). Seven fish died shortly after the 2003 spawning season, one was predated while spawning, and an additional two bull trout died during the winter. Also, four transmitters expired before the 2004 spawning season. The remaining seven fish either shed their transmitters or died by various or unknown reasons.

2004-During 2004, migration timing was similar to that seen in 2003, with bull trout entering Salmon River tributaries between 5/9/04 and 7/15/04. Bull trout tagged in the Lemhi River migrated into the Hayden Creek drainage between 4/7/04 and 6/5/04. During 2004, spring runoff was protracted and peak discharge was much less than in 2003, and bull trout migration into tributaries was spread over this reduced peak in spring flows (Figure 9). After spawning, bull trout returned to the Salmon River from tributaries between 9/5/04 and 9/24/04. In the Lemhi River drainage, bull trout returned from the Hayden Creek watershed between 9/30/04 and 12/1/04. Migrations observed during 2004 were by fish tagged during the fall of 2003 and spring of 2004, as well by some bull trout that still carried active transmitters from the tag group of spring 2003.

Repeat spawning migrations were observed by four bull trout tagged during the spring of 2003. All repeat migrations observed were into the same watershed as was used during the 2003 spawning season. Two bull trout (149.78.180 and 149.78.186) returned to the YFSR drainage, while one returned to the EFSR drainage (149.78.177) and to Bear Valley Creek (149.78.178) in the Lemhi drainage. All tags of repeat spawning bull trout expired during the summer of 2004, therefore detailed information of repeat spawning locations was undocumented.

Of the 21 fish tagged in the fall of 2003, migrations were observed in 8 of these fish. Migrations into WSC (2), the NFSR drainage (Sheep Creek [1]), and the EFSR drainage (Herd Creek [1], West Pass Creek [1], South Fork EFSR [1], and the upper mainstem of the EFSR [1]) were observed (Figure 6; Table 3). One bull trout also migrated from its tag location in the Lemhi River to the upper reaches of Hayden Creek. Of the remaining 13 non-tributary migrating bull trout, tags were recovered from 10 of these fish. The remaining 3 tagged fish were observed alive in mainstem rivers; two in the Salmon River and one in the Lemhi River. One of these non-tributary migrants was observed moving ~165km from its winter location in the Salmon River, upstream near the mouth of the EFSR. This transmitter expired before this fish entered a tributary. Of the 10 tags recovered, seven were tagging related mortalities. These seven fish were tagged in Lemhi River tributaries (six in Bear Valley Creek, one in Big Timber Creek) near the end of the spawning period to increase the sample size within this drainage. The other three tag recoveries were in the Salmon River and believed to be winter or predation related mortalities. Of the 8 spawning migrants, one died after spawning and the other seven tags expired during the winter, therefore no repeat migrants were observed in 2005.

Eight of the 20 bull trout tagged during the spring of 2004 were tagged in the Lemhi River (n=3) and Salmon River (n=5) and migrations were observed in six of these fish (Figure 7; Table 3). In the Lemhi River drainage, bull trout migrated into Hayden Creek (n=2) and Bear Valley Creek (n=1). Salmon River tributaries used included the EFSR (n=1), the YFSR (n=1), and Basin Creek (n=1) (Figure 7). Of the two bull trout tagged in the Salmon River that did not migrate, one was believed to be predated, while the other either shed its transmitter or was predated. The other twelve bull trout tagged during the spring of 2004 were already in tributaries (EFSR, n=9; Bear Valley Creek, n=3) when tagged. Of the nine bull trout tagged at the East Fork Weir, migrations to the South Fork EFSR (n=4), West Pass Creek (n=2), and Germania Creek (n=2) were observed (Figure 7; Table 3). One bull trout tagged at the East Fork Weir returned to the Salmon River shortly after tagging and was believed to be predated. All three bull trout tagged in Bear Valley Creek remained in this drainage and spawning was documented. After spawning, two transmitters were recovered; one was found on the bank and appeared to be predated, while the other was found midstream, just downstream of a redd, and appeared to be a spawning related mortality. The last remaining bull trout was last observed alive in Bear Valley Creek on 10/30/04. It was presumed that this fish wintered in Bear Valley Creek; it was not observed during routine tracking of the Lemhi River and Bear Valley Creek was inaccessible after this time. This may have been a non-migratory resident fish (TL: 333mm). Of the 17 migratory fish tagged during the spring of 2004, three survived to repeat spawning migrations in 2005 (*see Migration Patterns and Timing – 2005*). Of the other 14 fish, five tags expired, five fish died related to post-spawning stress, three were believed predated, and one was entrained in an irrigation ditch in the EFSR.

2005-Three radio tagged bull trout that made spawning migrations in 2004 made repeat migrations in 2005. All three radio tagged bull trout entered the same tributaries in 2005 as in 2004 (151.34.055: Hayden Creek; 151.34.063: YFSR; 151.34.076: EFSR). Migrations were observed by eight of the ten fish tagged during the fall of 2004 (Figure 8; Table 3). Bull trout entered Salmon River tributaries between 5/25/05 and 7/9/05 (Figure 9), and returned to the Salmon River between 9/2/05 and 9/30/05. The remaining tagged bull trout in the Lemhi system during 2005 entered Hayden Creek on 6/26 and returned to the Lemhi River on 9/6. Spawning migrations into the East Fork Salmon River (n=4), Warm Springs Creek (n=2), Sheep Creek (North Fork Salmon River; n=1), and Hayden Creek (Lemhi River; n=1) were observed (Figure 8). The two non-migrants during 2005 were believed to be winter mortalities.

Migration Distances

The average one-way migration distance between winter habitat and spawning habitat for radio tagged bull trout in the Upper Salmon River Basin was 69.3 km. The longest migration between winter and spawning habitats was 220.2 km, observed in a bull trout spawning in the upper EFSR and wintering in the Salmon River between the towns of Salmon and North Fork. The shortest migration was 11.7 km, by a bull trout spawning in Warm Springs Creek and wintering near Peach Creek (Torrey's Hole) in the Salmon River. See Table 4 for a summary of all tagged bull trout, including migration distance and spawning location.

Table 4. Tagging and migration data for all radio tagged bull trout in the Upper Salmon River Basin, Idaho, between 2003 and 2005.

Frequency /Code	Tag Date	Total Length (mm)	Mass (g)	Tag Location	Tributary Ascended	Winter Location	# of Relocations	Days Tracked	Distance Between Spawn and Winter Location (km)
Spring 2003									
149.78.176	03-21-03	420	710	Salmon	MFSR	Unk	19	432	171.9
149.78.151	04-17-03	370	425	Salmon	EFSR	*predated*	30	138	--
149.78.177	04-25-03	449	878	Salmon	EFSR	Salmon	66	434	119.6
149.78.178	05-17-03	469	900	Lemhi	BVC (Hayden Cr)	Lemhi	59	425	26.0
149.78.179	05-21-03	430	740	Salmon	YFSR	*Spawn Mort*	25	133	--
149.78.156	06-03-03	332	320	Salmon	Basin Cr	Redfish Lake	30	358	40.2
149.78.180	06-03-03	610	2122	Salmon	YFSR	Little Redfish Lake	61	446	66.5
149.78.183	06-09-03	490	1097	Salmon	YFSR	*Spawn Mort*	16	137	--
149.78.181	06-09-03	546	1519	Salmon	Warm Springs Cr	Salmon[a]	31	264	66.7
149.78.184	06-10-03	465	937	Salmon	Unk	Redfish Lake	30	419	--
149.78.185	06-10-03	382	540	Salmon	*Unk-Trans Failure or Poached*		10	51	--
149.78.187	06-10-03	430	640	Salmon	*Surgery mortality*		20	85	--
149.78.193	06-10-03	559	1630	Salmon	McKay Cr (YFSR)	*Post Spawn Mort*	20	439	--
149.78.182	06-10-03	490	1097	Salmon	YFSR	Redfish Lake	41	419	77.9
149.78.186	06-10-03	434	825	Salmon	McKay Cr (YFSR)	Redfish Lake	43	413	77.9
149.78.189	06-10-03	430	950	Salmon	YFSR	Salmon[a]	62	419	74.5
149.78.190	06-10-03	450	820	Salmon	4th of July Cr	Redfish Lake	30	419	40.2
149.78.192	06-10-03	478	1018	Salmon	YFSR	Salmon[a]	39	294	59.7
149.78.152	06-11-03	358	400	Salmon	YFSR	Redfish Lake	32	248	56.3
149.78.191	06-11-03	394	550	Salmon	YFSR	Little Redfish Lake	43	402	103.5
149.78.153	06-17-03	358	440	Salmon	EFSR	*Predated in EF*	18	271	--
149.78.154	06-19-03	330	350	Salmon	None	Salmon	43	309	--
149.78.155	06-19-03	556	1604	Salmon	McKay Cr (YFSR)	Little Redfish Lake	37	329	71.9
149.78.194	06-19-03	478	1000	Salmon	Warm Springs Cr	Salmon	25	282	60.8
149.78.195	06-19-03	416	725	Salmon	Warm Springs Cr	Salmon	60	437	70.7
149.78.196	06-19-03	436	830	Salmon	Warm Springs Cr	Salmon[a]	46	367	66.3
149.78.197	06-19-03	404	640	Salmon	Warm Springs Cr	Salmon[a]	65	410	11.7
149.78.198	06-19-03	448	872	Salmon	Warm Springs Cr	Salmon[a]	56	431	22.2
149.78.200	06-19-03	461	935	Salmon	YFSR	Salmon[a]	43	285	59.3
Fall 2003									
151.34.026	09-13-03	550	1510	Bear Valley Cr	*Tagging Mortality*		3	16	--
151.34.027	09-13-03	475	880	Bear Valley Cr	*Tagging Mortality*		15	244	--
151.34.028	09-13-03	510	1110	Bear Valley Cr	BVC	Lemhi[b]	34	282	19.3
151.34.029	09-13-03	500	1040	Bear Valley Cr	BVC	Lemhi[b]	36	374	20.3
151.34.030	09-13-03	394	540	Bear Valley Cr	BVC	*Spawn Tagging Mort*	7	69	--
151.34.031	09-13-03	458	800	Bear Valley Cr	*Tagging mortality*		6	399	--

Table 4, Continued.

Frequency /Code	Tag Date	Total Length (mm)	Mass (g)	Tag Location	Tributary Ascended	Winter Location	# of Relocations	Days Tracked	Distance Between Spawn and Winter Location (km)
Fall 2003 Continued									
151.34.032	09-14-03	474	1000	Big Timber Cr	*Tagging Mortality*		7	281	--
151.34.038	09-20-03	404	585	Salmon	Herd Cr (EFSR)	Salmon	41	339	110.1
151.34.041	09-25-03	490	1010	Salmon	*Winter Mortality*		53	408	--
151.34.040	09-25-03	445	735	Salmon	Warm Springs Cr	Salmon	54	442	66.7
149.78.172	10-19-03	378	495	Salmon	EFSR[c]	Salmon	37	274	165.2
149.78.174	10-25-03	364	455	Salmon	*Predated*		25	243	--
151.34.047	10-25-03	472	940	Salmon	EFSR	Salmon	22	408	90.9
151.34.048	11-13-03	585	1575	Salmon	NFSR	Salmon	26	418	32.1
151.34.049	11-16-03	602	2150	Lemhi	Hayden Cr (Lemhi)	Lemhi	32	431	22.6
151.34.050	11-16-03	422	800	Lemhi	None	Lemhi	41	468	--
151.34.001	11-20-03	542	1200	Salmon	Warm Springs Cr	Salmon	38	293	84.3
151.34.002	11-20-03	410	605	Salmon	West Pass Cr (EFSR)	Salmon	37	289	93.0
151.34.003	11-20-03	410	640	Salmon	SFEF (EFSR)	Salmon	31	293	118.7
151.34.004	12-05-03	332	365	Salmon	*Winter Mortality*			27	214
151.34.053	12-06-03	378	505	Salmon	None	Salmon	50	425	47.5
Spring 2004									
151.34.055	02-20-04	482	895	Lemhi	BVC (Hayden Cr)	Lemhi	34	456	23.3
151.34.056	02-20-04	450	845	Lemhi	Hayden Cr (Lemhi)	Lemhi	21	341	12.4
151.34.057	02-26-04	630	2235	Salmon	*Mortality or Possible Shed Tag*		38	454	--
151.34.010	03-19-04	389	600	Salmon	EFSR	Salmon	41	264	96.2
151.34.014	04-22-04	344	355	Salmon	*Predated*		11	139	--
151.34.016	04-23-04	545	1235	Lemhi	Hayden Cr (Lemhi)	*spawning mort*	14	187	21.7
151.34.061	05-18-04	633	2700	Salmon	Basin Cr	*Predated*	15	98	--
151.34.063	05-27-04	664	2742	Salmon	YFSR	Redfish Lake	36	384	64.8
151.34.072	06-10-04	520	1410	EF Weir	*Predated*		27	271	--
151.34.073	06-10-04	420	620	EF Weir	SFEF (EFSR)	*Post-Spawn Mort*	9	141	--
151.34.074	06-10-04	465	1050	EF Weir	West Pass Cr (EFSR)	*Post-Spawn Mort*	12	141	--
151.34.076	06-10-04	494	1300	EF Weir	SFEF (EFSR)	Pahsimeroi	40	453	130.2
149.78.164	06-11-04	572	1850	EF Weir		*Transmitter Expired*	5	53	--
149.78.192	06-11-04	475	1060	EF Weir		*Transmitter Expired*	9	79	--
151.34.027	06-11-04	548	1585	EF Weir	SFEF (EFSR)	*Transmitter Expired*	8	140	--
151.34.078	06-11-04	635	2609	EF Weir	Germania Cr (EFSR)	*Entrained*	10	270	--
151.34.077	06-11-04	680	2947	EF Weir	EFSR	Salmon	26	298	220.2
151.34.013	07-19-04	333	375	Bear Valley Cr	BVC	BVC-*Tag Expired*	10	101	--
151.34.091	07-19-04	396	540	Bear Valley Cr	BVC	*Predation*	9	87	--
151.34.092	07-19-04	515	1265	Bear Valley Cr	BVC	*Post-Spawn Mort*	9	87	--

Table 4, Continued.

Frequency /Code	Tag Date	Total Length (mm)	Mass (g)	Tag Location	Tributary Ascended	Winter Location	# of Relocations	Days Tracked	Distance Between Spawn and Winter Location (km)
Fall 2004									
151.34.103	10-07-04	458	725	Salmon	*winter mortality*		29	326	--
151.34.107	10-07-04	420	670	Salmon	EFSR	Salmon	32	494	25.3
151.34.108	10-09-04	418	550	Salmon	Sheep Cr (NFSR)	Salmon	20	364	27.2
151.34.116	10-21-04	435	830	Salmon	*winter mortality*		32	286	--
151.34.117	10-21-04	471	1035	Salmon	EFSR	Salmon	27	428	65.6
151.34.120	10-30-04	421	640	Lemhi	Hayden Cr	Lemhi	22	337	42.6
151.34.121	11-02-04	432	840	Salmon	EFSR	Salmon	23	469	64.4
151.34.125	11-13-04	640	2300	Salmon	Warm Springs Cr	Salmon	25	234	--
151.34.126	11-13-04	434	700	Salmon	EFSR	Salmon	23	458	86.7
151.34.127	12-14-04	458	805	Salmon	Warm Springs Cr	Salmon	26	231	92.9

a Post-spawn or winter mortality: tag recovered from Salmon River.
b Post-spawn or winter mortality; tag recovered from Lemhi River.
c Migration into tributary not documented; fish last located near mouth, then unable to be found.

The average distance between spawning and wintering locations of bull trout in the Upper Salmon River Basin varied by tributary use. Generally, bull trout spawning in the upper reaches of the study area (YFSR and tributaries upstream, including Basin Creek and Fourth of July Creek), migrated into the Redfish Lake system for winter habitat, and migration distances averaged 66.1 km. Bull trout spawning in tributaries downstream of the YFSR, including WSC, EFSR, NFSR, and the MFSR, migrated an average of 86.4 km to winter habitat in the Salmon River. Bull trout spawning in Lemhi River tributaries migrated an average of 23.8 km to winter habitat within the Lemhi River. No migrations were observed from the Lemhi River drainage into the Salmon River.

Discussion

The results of this study indicate that bull trout in the Upper Salmon River Basin show a high degree of variability in the spatial separation and migration distance between spawning and wintering habitat. Although movements were variable, distinct migration patterns were delineated by location of spawning habitat. Bull trout spawning in tributaries in the upper reaches of the study area (YFSR and upstream) migrated into Redfish and Little Redfish Lake. Bull trout spawning in tributaries of the Salmon River downstream of the YFSR (EFSR and WSC) migrated downstream to winter habitat in the middle reaches of the Salmon River near Challis. Bull trout spawning in tributaries to the Lemhi River returned to wintering habitat in the Lemhi River.

Throughout the course of the study, spawning migrations were observed in the majority of bull trout that were of migratory size. Migrations from wintering habitat in the Salmon River to spawning habitat in the MFSR were confirmed, as previously documented in a mark-recapture study by Bjornn and Mallet (1964). Large bodied bull trout have been documented in Lemhi River tributaries (Bear Valley Creek and Hayden Creek) and it was assumed that these bull trout spent a portion of their lives in the Salmon River. No migrations between the Salmon River and the Lemhi drainage were observed in this study. Also, no spawning migrations from the Salmon River into the Pahsimeroi River drainage were observed, although one EFSR spawning bull trout wintered near the mouth of the Pahsimeroi River and entered the lower Pahsimeroi repeatedly throughout the winter. These movements may have been related to higher winter water temperatures than those available in the Salmon River, also the relatively high density of juvenile Chinook salmon in the Pahsimeroi River may have encouraged bull trout to enter the Pahsimeroi River to exploit this seasonally abundant food source.

Suitable winter habitat may be lacking in the upper reaches of the Salmon River (above the EFSR) to support large migratory bull trout. This idea is supported by the documented use of Redfish and Little Redfish Lake as winter habitat. Bahr and Shrimpton (2004) documented the use of lakes as winter habitat by apparently fluvial bull trout populations in British Columbia, although fish primarily used Morice Lake as a corridor between river systems in their study. Bull trout may be entering the Redfish Lake system for warmer water temperatures, a higher abundance of prey items, or a combination of the two factors. Presumably, bull trout historically concentrated in this system due to an abundance of food available in the form of juvenile sockeye salmon and adult carcasses. The documentation of bull trout migrating into the Redfish Lake system for winter habitat may have significant effects on the predator-prey interactions in these lakes. Future research of endangered sockeye salmon, as well as kokanee salmon population management, should consider the impacts of an increase in bull trout density throughout the winter.

Bull trout that wintered in the Redfish Lake system passed the telemetry station at the mouth of Redfish Lake Creek and returned to the Salmon River between early April and late May. Of the eight bull trout that returned to the Salmon River from the Redfish Lakes, two transmitters expired within one month of their return. Repeat spawning migrations were only documented in two of the remaining six bull trout. Of the remaining four fish no movement towards tributaries was observed after returning to the Salmon River in the spring and the tags from two of these fish were subsequently recovered in the early summer. The other two tags were unable to be recovered and the lack of movement suggests that these fish had also died. It is unlikely that transmitters were shed at this point. The cause of mortality of these bull trout is unknown and may be related to predators keying on the concentration of bull trout returning to the Salmon River. It is also possible that some of these mortalities may be associated with angling. Steelhead angling pressure on the upper Salmon River is heavy throughout this reach, particularly between WSC and Sawtooth Hatchery. Bull trout mortalities in this reach may be related to poaching or incidental hooking during periods of intense angling pressure and future studies of incidental exploitation should be considered.

The lack of spawning migrations by some individuals may be attributed to immaturity, predation, or alternate year spawning. Transmitter expulsion also may have lead to the lack of migrations observed, but no evidence of expulsion by bull trout was documented (i.e. recaptures w/ scars and/or PIT tag but no transmitter) in this study. Chisholm and Hubert (1985) documented high expulsion rates of transmitters by rainbow trout, but no laboratory studies of expulsion rates by bull trout have been conducted. During this study, several bull trout were recaptured up to 3 years after transmitter implantation and still carried (inactive) transmitters. Most fish tagged during the study were assumed to be mature based on body size, but at least one non-migratory fish was believed to be immature. Predation of bull trout was suspected in several cases, based on the location of transmitter recoveries (i.e. mink dens) and teeth marks found on recovered transmitters. While other bull trout migration studies have documented alternate year spawning (Fraley and Shepard 1989, Hvenegaard and Thera 2001, Bahr and Shrimpton 2004), it is unknown if this life history trait occurs in the Upper Salmon River Basin. Repeat spawning migrations were documented in a limited number of bull trout (four fish tagged in 2003 and three fish tagged in 2004), and the observation of spawning frequency by radio tagged bull trout may have been limited due to various sources of mortality. Future studies of spawning frequency, possibly in conjunction with the EFSR weir operation, could give further insight into spawning migration patterns of bull trout in the Upper Salmon River Basin.

Westslope Cutthroat Trout

Tagging

To observe movement patterns of westslope cutthroat trout, 54 individuals were implanted with radio transmitters throughout the Upper Salmon River Basin, Idaho. All westslope cutthroat trout were tagged throughout a 270 km reach of the Salmon River, from the town of North Fork, ID upstream to Stanley, ID. One westslope cutthroat trout (#149.78.166) was recaptured in the EFSR at the IDFG East Fork Satellite Hatchery Facility weir located approximately 27 km upstream from the confluence with the Salmon River. At the time of recapture, this fish had healed scars from the transmitter implantation surgery, but carried no transmitter. The fish was identified by the presence of a PIT tag and was implanted w/ another transmitter (#151.34.075). The majority of fish were captured with hook and line (n=51), while three (n=3) were captured using a Coffelt model VVP-15 drift-boat mounted electrofishing unit.

Radio tagged westslope cutthroat trout (n=54) averaged 380 ± 34 mm (mean ± SD) total length (TL) (range 330 – 480) and 566 ± 164 g (range 345 – 1200) mass (Figure 10; Table 5). Four (4) westslope cutthroat trout were tagged that did not meet the 2% transmitter to body mass guideline advised by Winter (1996). The transmitter to body weight ratio never exceeded 2.5% in these individuals. Average surgery time for fish implanted with radio transmitters was 5 minutes. The length-weight relationship for westslope cutthroat trout captured and tagged in the Upper Salmon River Basin was described by the equation: $\log_{10}$ weight (g) = 2.79 $\log_{10}$ total length (mm) – 4.46 (r^2 = 0.83, n=54) (Figure 11).

In fall 2003, 26 westslope cutthroat trout were implanted with radio transmitters (Figure 12). The mean total length was 376 ± 32 mm (range 330 – 448) and mean mass was 538 ± 160 g (range 345 – 955) (Table 6). We implanted 13 westslope cutthroat trout (mean TL: 365 ± 20 mm, range 340 – 404; mean mass: 507 ± 96 g, range 420 - 715) with radio transmitters during spring 2004 (Figure 13; Table 6). During fall 2004, 16 westslope cutthroat trout (mean TL: 399 ± 38 mm, range 358 – 480; mean mass: 658 ± 182 g, range 490 - 1200) were implanted with radio transmitters (Figure 14; Table 6).

Tracking

We tracked radio tagged westslope cutthroat trout for 61 - 506 days (mean = 309.1 d), depending on transmitter size and the fate of individual fish. For the 54 radio tagged fish, we established 1,714 relocations. Radio telemetry relocations of the 54 radio tagged westslope cutthroat trout averaged 31.7 per fish (range: 6 - 54). Access to some portions of the study area limited the number of relocations for some fish, particularly, those fish migrating into WSC, the upper EFSR and its tributaries, and the Redfish Lake system. Over the course of the study, we used aerial tracking on 12 occasions to relocate fish in these areas. Although the frequency of such tracking was limited, it did provide some general information on the extent of upstream migration into more remote regions of the study area. In addition, the presence of fixed telemetry sites documented migration timing between adjacent tributary streams and the Salmon River. After migrations observed in 2004, additional fixed telemetry sites were established at Thompson Creek and at Squaw Creek during 2005 to better document timing and movement patterns of westslope cutthroat trout.

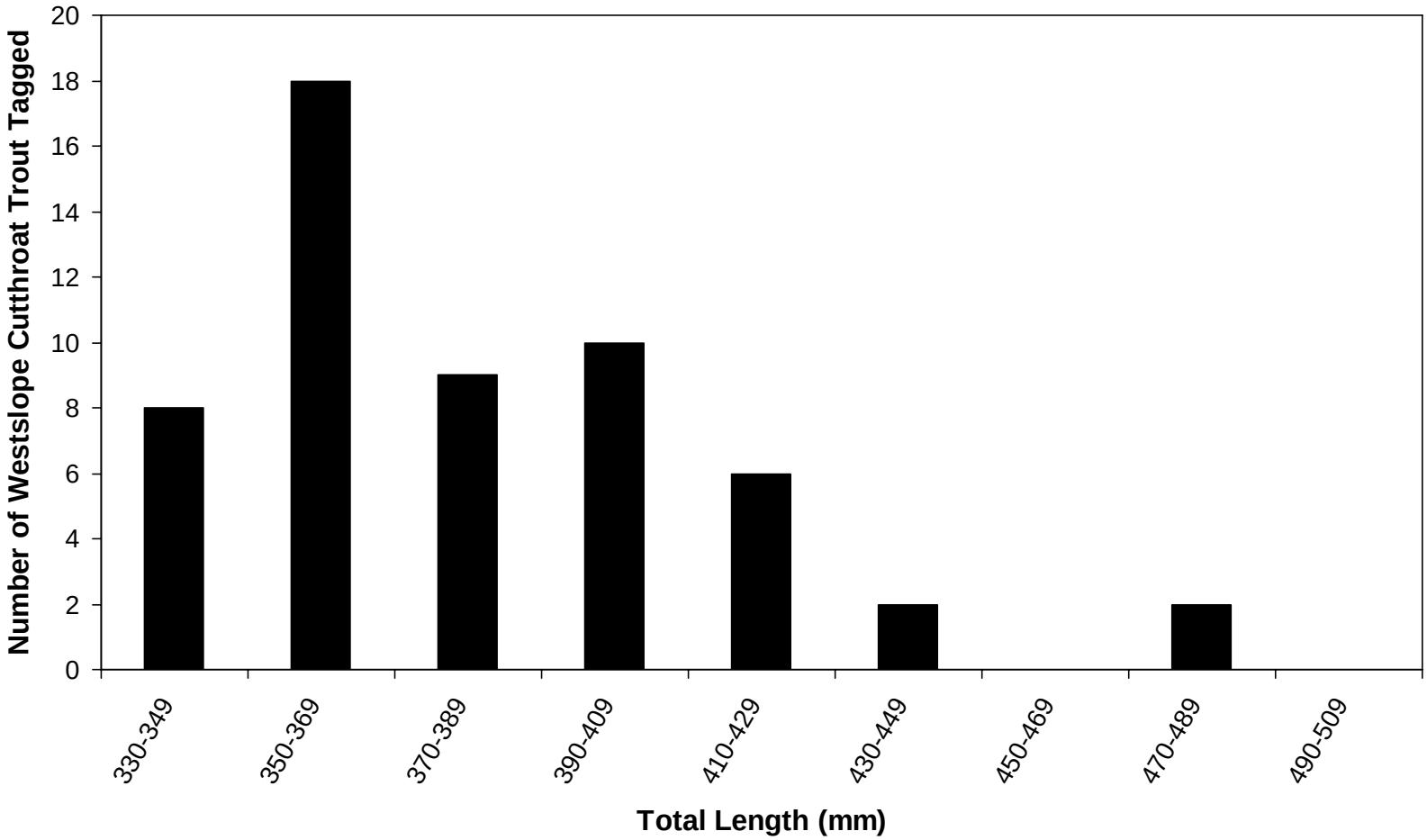

Figure 10. Length frequency distribution of radio tagged westslope cutthroat trout in the Upper Salmon River Basin, Idaho.

Table 5 Summary statistics of total length (mm) and weight (g) of all westslope cutthroat trout captured and tagged (n=54) in the Upper Salmon River Basin, Idaho during 2003 and 2004.

	Total Length (mm)	**Weight (g)**
Mean	380	566
Median	373	500
Mode	352	490
Standard Deviation	34	164
Minimum	330	345
Maximum	480	1200

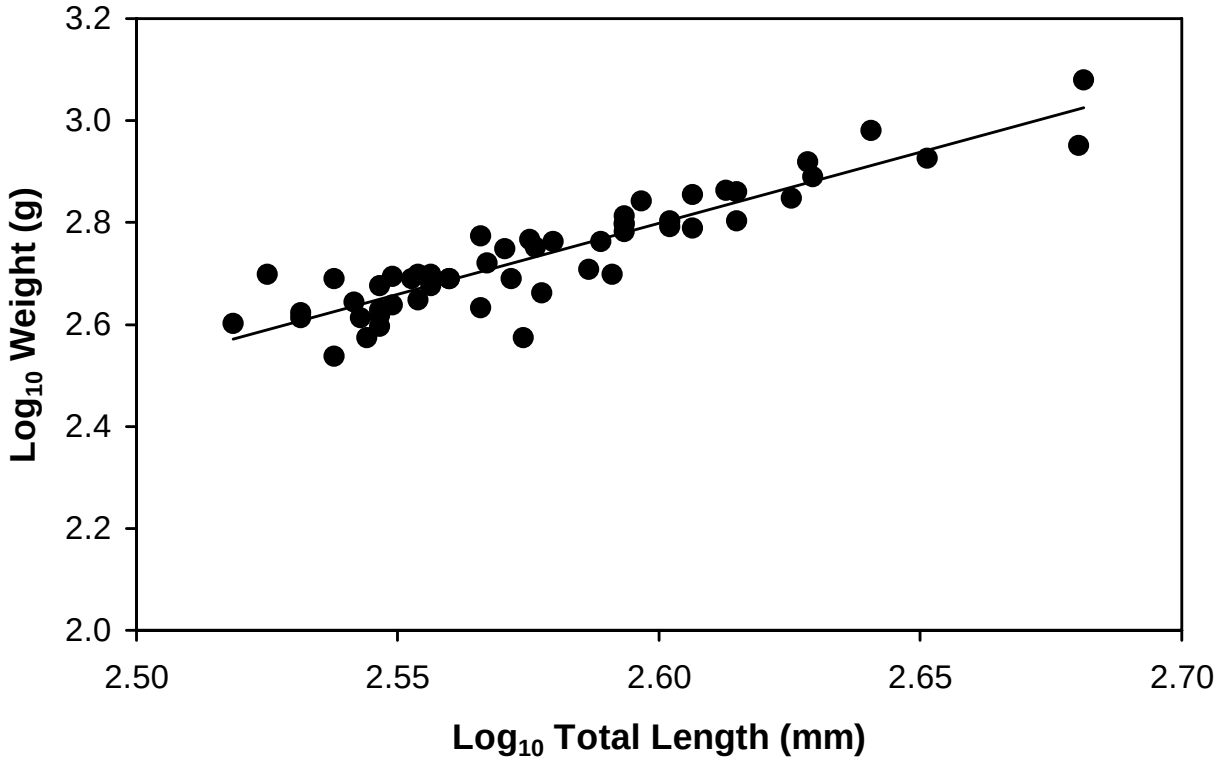

Figure 11. The length-weight relationship for westslope cutthroat trout captured and tagged in the Upper Salmon River Basin, Idaho during 2003 and 2004: $\log_{10}$ weight (g) = 2.79 $\log_{10}$ total length (mm) – 4.46 (r^2 = 0.83, n=54).

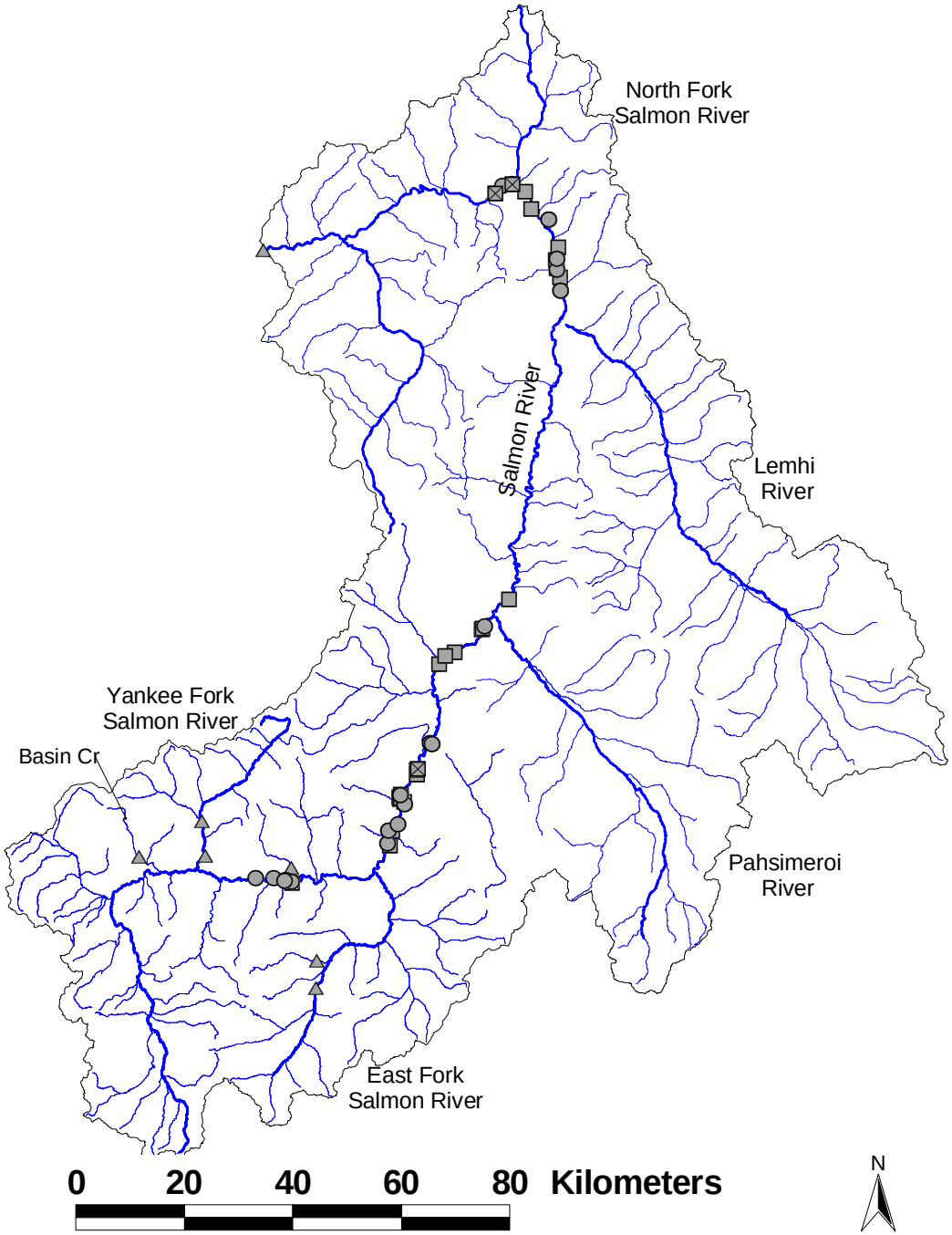

Figure 12. Tagging location (circles), spawning location (triangles), and winter location (squares) of westslope cutthroat trout tagged during the fall of 2003 in the Upper Salmon River Basin, Idaho. Winter locations (squares) with X's represent winter related mortalities.

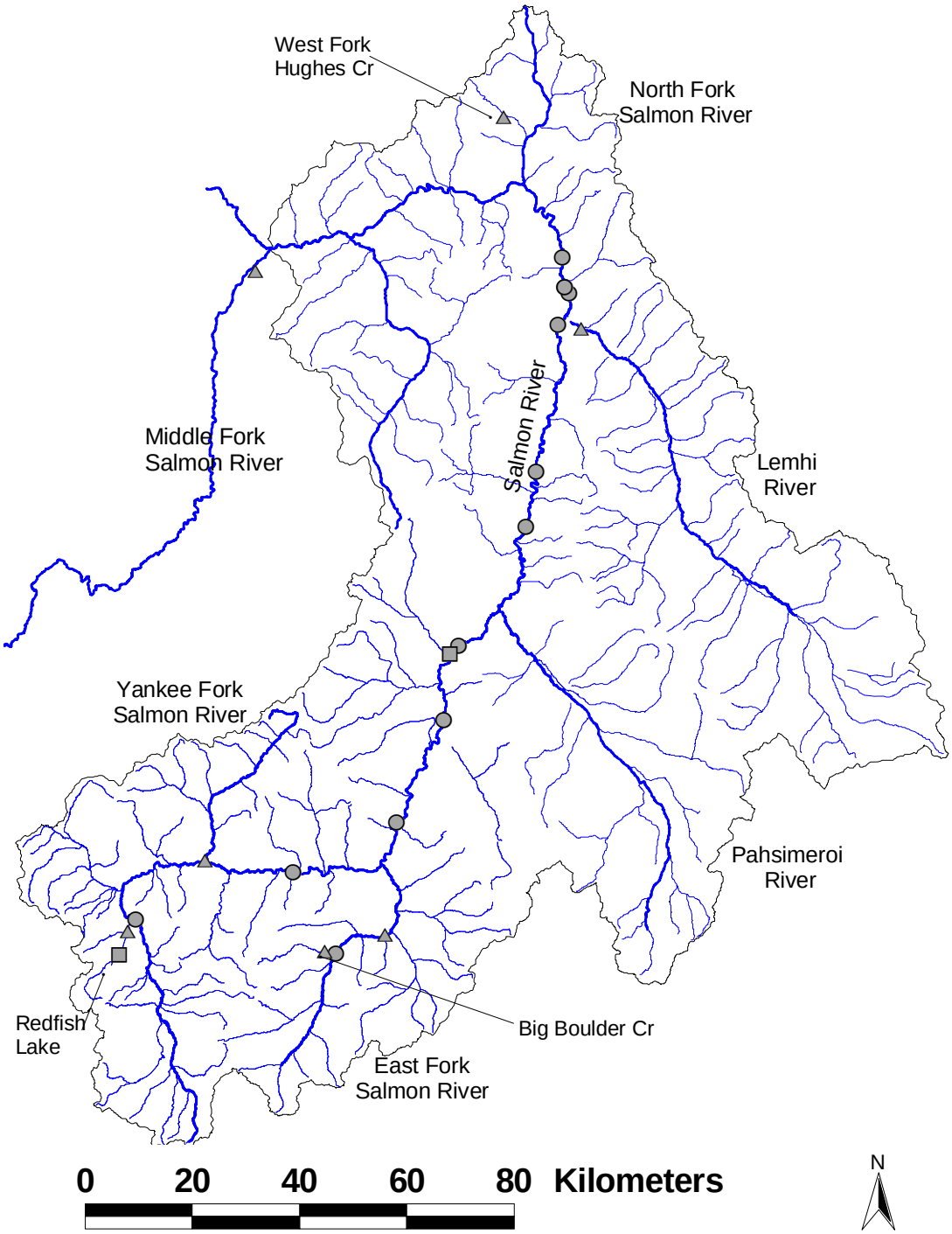

Figure13. Tagging location (circles), spawning location (triangles), and winter location (squares) of westslope cutthroat trout tagged during the spring of 2004 in the Upper Salmon River Basin, Idaho.

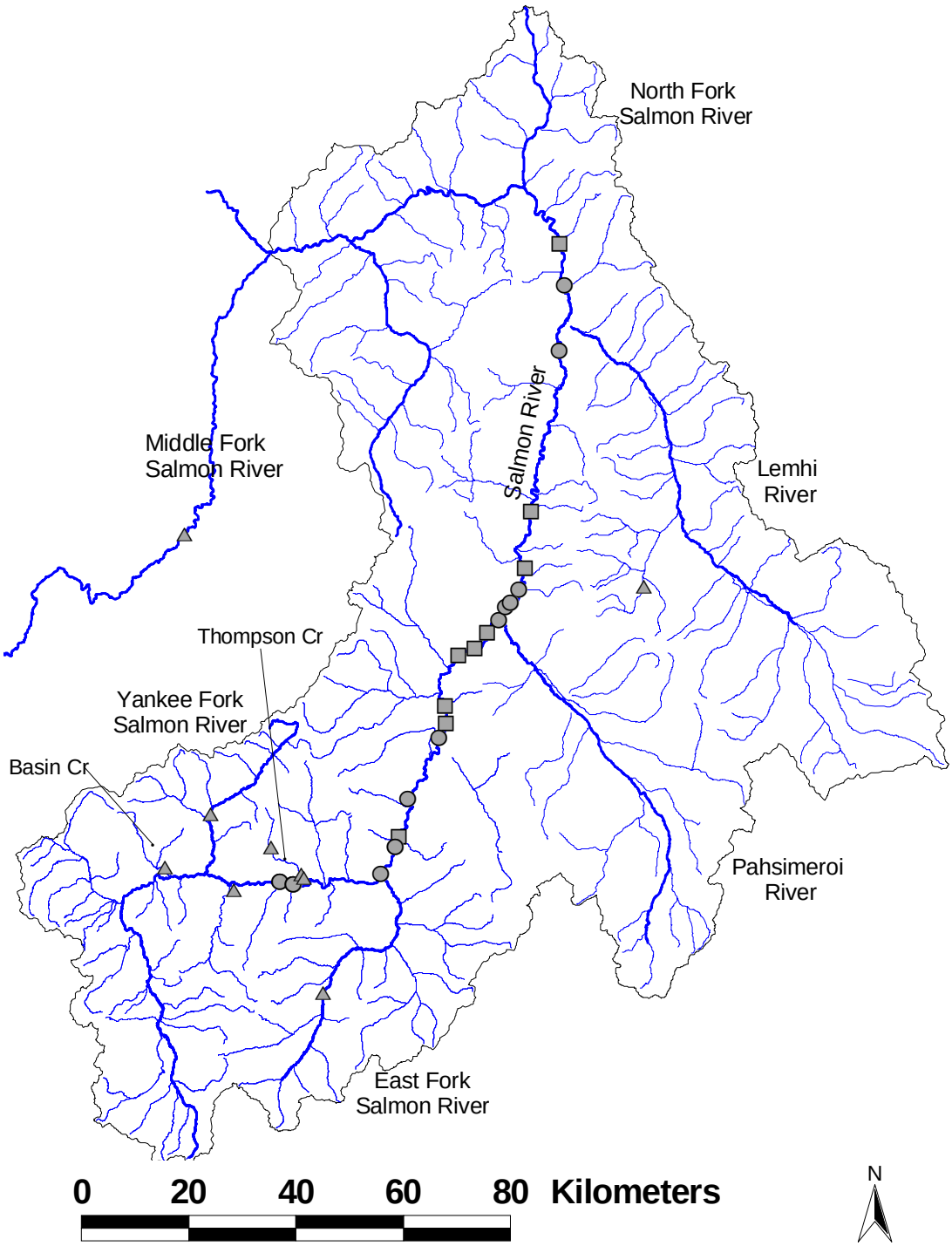

Figure 14. Tagging location (circles), spawning location (triangles), and winter location (squares) of westslope cutthroat trout tagged during the fall of 2004 in the Upper Salmon River Basin, Idaho.

Table 6. Number of westslope cutthroat trout radio tagged, and mean total length (mm) and weight (g), in the Upper Salmon River Basin, Idaho, during the spring and fall of 2003 and 2004.

	2003	2004	
	Fall	**Spring**	**Fall**
Number of Westslope Cutthroat Trout Tagged	26	13	16
Mean Total Length (mm)	376	365	399
Mean Weight (g)	538	507	685

Results

Migration Timing and Patterns

2004-Of the 26 westslope cutthroat trout tagged during the fall of 2003, migrations into tributary environments were observed in only eight fish (Figure 12). Two westslope cutthroat trout migrated into the YFSR and two migrated into the EFSR. Three individual westslope cutthroat trout each migrated into Thompson Creek, Basin Creek and the MFSR. Also, fish #151.34.030 may have entered either Thompson Creek or Slate Creek, but was undocumented; this fish moved nearly 60km in the Salmon River and was last located downstream of the mouth of Slate Creek on 5/30/04. Westslope cutthroat trout #151.34.030 was then unable to be located for 14 days and later found on 6/13/04, approximately 2.0km downstream of Thompson Creek. The lack of migration seen in other westslope cutthroat trout tagged during the fall of 2003 may be related to winter mortalities, immature fish, alternate year spawning cycles, and/or transmitter expulsion (*see Discussion for more information*). Westslope cutthroat trout entered spawning tributaries between 4/18/04 (MFSR) and 6/8/04 (YFSR) (Figure 15) and returned to the Salmon River shortly after spawning (<1 month). Westslope cutthroat trout #149.78.168 was last observed entering the MFSR on 4/18/04 (fixed telemetry station) and was unable to be located after this date, therefore the extent of migration into this drainage and the location of spawning is unknown. Most westslope cutthroat trout returned to the Salmon River between 5/7/04 and 6/8/04, although one westslope cutthroat trout remained in the EFSR for the duration of the summer, returning the Salmon River on 9/13/04. The presence of the fixed telemetry station on the YFSR documented one westslope cutthroat trout entering (and presumably spawning) and exiting the YFSR in 7 days (5/1-5/7/04).

Of the 13 westslope cutthroat trout tagged during the spring of 2004, migrations were observed in seven of these fish (Figure 13; Table 7). Two westslope cutthroat trout from this tag group were likely predated; one transmitter was found in a heron nest, while another was recovered from a mink den on the stream bank. Migratory westslope cutthroat trout from this tag group entered the MFSR, Lemhi River, YFSR, West Fork Hughes Creek in the North Fork Salmon River drainage, the EFSR and Big Boulder Creek in the EFSR drainage, and Redfish Lake Creek. Migratory westslope cutthroat trout from this tag group entered tributaries between 5/05/04 (Lemhi) and 6/24/04 (MFSR) (Figure 15). Westslope cutthroat trout #151.34.018 passed the North Fork Salmon River fixed station at 2:08 am on 6/24/04 before entering the MFSR at 10:35pm the same day. This fish traveled nearly 62 km in just over 20 hours. Cutthroat trout generally returned to the Salmon River within one month after entering tributaries. Similar to cutthroat trout tagged in the fall of 2003, one fish (#151.34.009) remained in the EFSR throughout the summer and returned to the Salmon River on 8/27/04. Of the fish not migrating

into or towards tributaries, some movement was observed within the Salmon River. Tags were recovered from four fish; one of which may have been related to the surgical procedure as the tag was recovered near the tagging location. The other three tags were recovered in areas that suggest they may have been shed.

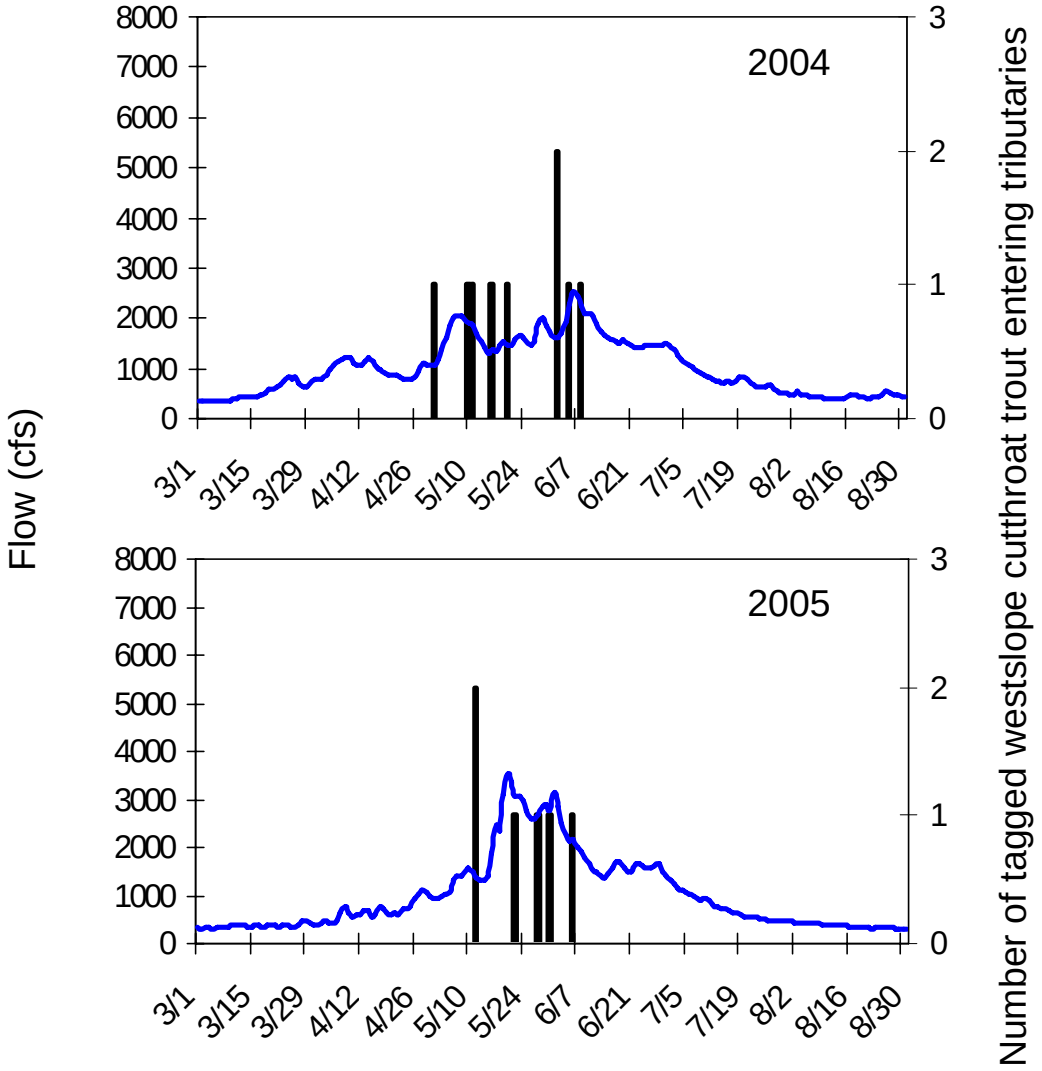

Figure 15. Migration of westslope cutthroat trout into tributary streams in relation to the Salmon River hydrograph during 2004 and 2005. The blue line represents discharge (cubic feet per second) on the primary y-axis. Discharge data was obtained from the USGS gage (#13296500) located on the Salmon River below the Yankee Fork Salmon River confluence. Vertical bars on the secondary y-axis represent the number of radio tagged westslope cutthroat trout entering tributaries in the upper portion of the study area (East Fork Salmon River, Thompson Creek, Warm Spring Creek, Yankee Fork Salmon River, and Basin Creek).

Table 7. Number of radio tagged westslope cutthroat trout detected in Upper Salmon River tributaries during 2004 and 2005.

Subbasin	Tributary	Number of Westslope Cutthroat Trout 2004	2005
Middle Fork Salmon River		2	1
North Fork Salmon River	WF Hughes Creek	1	0
Lemhi River	Mainstem	1	0
	Hayden Creek		1
East Fork Salmon River		3	1
	Boulder Creek	1	0
Squaw Creek		0	1*
Thompson Creek		1	2
Slate Creek		1*	0
Warm Springs Creek		0	1*
Yankee Fork Salmon River		2	1
Basin Creek		1	1
Redfish Lake Creek		1	0

* Includes possible migration into this tributary (not documented – but fish last observed near mouth).

2005 -Sixteen (16) westslope cutthroat trout were tagged in the fall of 2004, and migrations were observed in nine of these fish (Figure 14; Table 7). Westslope cutthroat trout were documented migrating into Basin Creek, YFSR, Thompson Creek (2), EFSR, Lemhi River (Hayden Creek), and the MFSR (Figure 14). Also, westslope cutthroat trout (#151.34.102) may have migrated into either Thompson Creek or Squaw Creek. It was last located downstream of the mouth of Thompson Creek on 6/13/05 and was not seen again until 6/21/05, where it was found just downstream of the mouth of Squaw Creek. An additional cutthroat trout (#151.34.105) was believed to migrate into Warm Springs Creek, as it was last seen on 5/11/05 near the mouth and not found again until 6/17/05, where it was located in the Salmon River just upstream of this tributary. Cutthroat trout spawning in 2005 entered tributaries as early as 4/26/05 (Lemhi River) and as late 6/6/05 (YFSR) (Figure 15). Most cutthroat trout returned to the Salmon River by mid-June, although #151.34.099 remained in the YFSR until 8/22/05, similar to other tagged cutthroat trout using the EFSR for summer habitat in the previous year of the study. Westslope cutthroat #151.34.101 entered Thompson Creek on 5/31/05 and returned to the Salmon River on 6/14/05. This fish then migrated downstream 20.2km to the EFSR and entered this tributary on 6/21/05, where it migrated 6 km upstream and remained through the summer (*see Discussion for more information*).

Migration Distances

The average one-way migration distance between winter habitat and spawning habitat for radio tagged westslope cutthroat trout in the Upper Salmon River Basin was 84.1 km. The longest migration between winter and spawning habitats was 235.9 km, by a westslope cutthroat trout spawning in the MFSR and wintering in the Salmon River near Allison Creek. The shortest migration was 8.5 km, by a westslope cutthroat trout that migrated into Redfish Lake Creek after being tagged in the Salmon River near the mouth of this tributary. This fish was located in Redfish Lake Creek between Little Redfish and Redfish Lake in early June and then migrated into Redfish Lake where it remained throughout the summer and following winter. It is unknown if this fish spawned in Redfish Lake Creek. Although migrations into tributaries were not documented in the majority of westslope cutthroat trout, considerable movements within the Salmon River were observed. The average movement within the Salmon River for westslope cutthroat trout not documented entering tributaries was 22.9 km, with the largest migration within the Salmon River being 86 km. These movements may have been associated with the search for suitable winter or summer habitat, or may have been movements preceding tributary spawning migrations before transmitters were shed or mortality occurred. See Table 8 for a summary of all tagged westslope cutthroat trout, including migration distance and spawning location.

Discussion

Westslope cutthroat trout populations in the Salmon River seemed concentrated in the middle reach of the study area (from the EFSR to the Pahsimeroi River), although no westslope cutthroat trout were documented migrating into the Pahsimeroi River and very few were captured above the EFSR. Westslope cutthroat trout ascension into tributary habitats was rapid, with most fish entering and exiting tributaries within 1 month, although several fish remained in tributaries (EFSR and YFSR) throughout the summer, possibly as thermal refuge. Spawning activity was concentrated in the upper portion of the study area (the EFSR and Salmon River tributaries upstream) and occurred later (mid-May through June) than rainbow trout spawning (see Rainbow trout), indicating that both spatial and temporal mechanisms prevent extensive hybridization between the two species.

Twelve westslope cutthroat trout were captured and tagged between the NFSR and Lemhi River, but spawning migrations were only documented in six individuals. Three westslope cutthroat trout tagged in this area migrated to the MFSR, similar to what Bjornn and Mallet (1964) and Zurstadt and Stephan (2004) observed in studies of cutthroat trout in the MFSR. We attempted to avoid this pattern by not tagging westslope cutthroat trout below the mouth of the NFSR. Future research in this portion of the study area is necessary to determine if fluvial westslope cutthroat trout spawn in other steams within the North Fork Salmon River drainage or other Salmon River tributaries such as Tower, Carmen, or Fourth of July Creeks.

A large portion of westslope cutthroat trout that were radio tagged throughout the study did not migrate into tributary habitat. Fish that showed no movement through late winter and into spring were generally classified as winter mortalities. Other fish migrated from winter habitat and then abruptly stopped in spring, and it is believed that these fish either shed their transmitters or were predated. Westslope cutthroat trout #149.78.166 was first located at Watts bridge (~10 km N of Challis, ID) on 4/8/04 and was relocated at this location until 6/9/04. On 6/10/04 this fish (minus transmitter) was captured at the EFSR weir, and was identified by the PIT tag that it still

carried. Scars from the transmitter implantation surgery were present and this fish appeared healthy. Chisholm and Hubert (1985) documented high rates of transmitter expulsion by rainbow trout via encapsulation of the transmitter by the intestine and passage through the anus. The lack of movement combined with the recovery of transmitters from winter locations was common during the westslope cutthroat trout portion of the study and indicates that winter mortality and shed transmitters can significantly affect long term migration studies of cutthroat trout. Also, spawning migrations may have been missed in some cases, as other studies have reported spawning migrations into and out of tributary habitats occurring in less than one week (Brown and Mackay 1995; Schmetterling 2001). Many transmitters were recovered mid-stream in relatively deep, flowing water, leading us to believe that transmitters were shed, rather than fish dying. These areas seemed unlikely for the carcass of radio tagged fish to be deposited by stream flow. Some transmitters were recovered from the bank and/or deep slow-moving holes, indicating that predation or natural mortality may be cited for the loss of these fish. Other studies have shown an alternate year spawning cycle for westslope cutthroat trout (Brown and Mackay 1995; Schmetterling 2001) and this may also have contributed to the lack of movement seen during the first year of our study.

Table 8. Tagging and migration data for all radio tagged westslope cutthroat trout in the Upper Salmon River Basin, Idaho, between 2003 and 2005.

Frequency /Code	Tag Date	Total Length (mm)	Mass (g)	Tag Location	Tributary Ascended	Winter Location	# Of Relocations	Days Tracked	Distance Between Spawn and Winter Location (km)	Movement Within Salmon River
Fall 2003										
149.78.158	07-02-03	412	725	Salmon River	-	Salmon River	33	218	-	70.6
149.78.159	07-05-03	335	500	Salmon River	-	Salmon River	49	334	-	9.3
149.78.199	09-04-03	395	695	Salmon River	-	Salmon River	45	292	-	8.9
149.78.157	09-04-03	348	440	Salmon River	-	Salmon River	43	305	-	19.0
149.78.161	09-04-03	377	565	Salmon River	--	Salmon River	32	290	--	17.5
149.78.188	09-04-03	437	955	Salmon River	--	Salmon River	54	384	--	6.8
149.78.164	09-25-03	350	375	Salmon River	--	Salmon River	16	182	--	36.6
151.34.039	09-25-03	448	845	Salmon River	--	Salmon River	52	408	--	9.7
149.78.151	10-02-03	330	400	Salmon River	--	Salmon River	8	170	--	19.7
149.78.166	10-02-03	358	445	Salmon River	EFSR (Big Boulder Cr)	Salmon River	33	247	100.8	--
149.78.167	10-09-03	345	345	Salmon River	--	Salmon River	11	110	--	77.8
149.78.187	10-09-03	386	510	Salmon River	--	Salmon River	42	319	--	84.0
151.34.044	10-09-03	372	560	Salmon River	Thompson Cr	Salmon River	51	403	52.6	--
149.78.168	10-11-03	349	310	Salmon River	MFSR	Salmon River	19	206	118.9	--
151.34.045	10-11-03	373	490	Salmon River	--	Salmon River	37	362	--	16.9
149.78.169	10-16-03	340	410	Salmon River	--	Salmon River	29	291	--	1.3
149.78.170	10-16-03	352	415	Salmon River	--	Salmon River	29	291	--	2.4
149.78.171	10-17-03	352	395	Salmon River	--	Salmon River	34	317	--	22.2
151.34.031	10-23-03	378	460	Salmon River	--	Salmon River	31	284	--	11.0
149.78.173	10-23-03	375	375	Salmon River	--	Salmon River	30	284	--	15.2
151.34.026	10-24-03	360	475	Salmon River	--	Salmon River	33	333	--	0.2
151.34.046	10-25-03	410	730	Salmon River	Basin Cr	Salmon River	42	412	123.1	--
151.34.030	12-05-03	388	580	Salmon River	Thompson Cr/Slate Cr[a]	Salmon River	41	347	--	59.5
151.34.051	12-05-03	390	500	Salmon River	EFSR	Salmon River	51	455	62.3	--
151.34.052	12-06-03	392	605	Salmon River	YFSR	Salmon River	25	175	42.5	--
151.34.054	12-14-03	426	775	Salmon River	YFSR	Salmon River	50	467	65.0	--
Spring 2004										
151.34.060	03-12-04	392	650	Salmon River	--	Salmon River	51	459	--	23.3
151.34.008	03-16-04	368	430	Salmon River	--	Salmon River	22	207	--	20.4
151.34.009	03-18-04	354	435	Salmon River	EFSR	Salmon River	24	244	73.6	--
151.34.013	04-02-04	352	425	Salmon River	NFSR (WF Hughes Cr)	Salmon River	10	93	53.2	--
151.34.017	04-23-04	354	495	Salmon River	--	Salmon River	6	108	--	0.3
151.34.018	04-23-04	357	490	Salmon River	MFSR	Salmon River	9	61	90.0	--

Table 8, Continued.

Frequency /Code	Tag Date	Total Length (mm)	Mass (g)	Tag Location	Tributary Ascended	Winter Location	# of Relocations	Days Tracked	Distance Between Spawn and Winter Location (km)	Movement Within Salmon River
Spring 2004 Continued										
151.34.020	04-23-04	363	490	Salmon River	Lemhi	Salmon River	12	230	9.9	--
151.34.011	05-01-04	340	420	Salmon River	YFSR	Salmon River	38	226	52.2	--
151.34.066	05-28-04	392	630	Salmon River	--	Salmon River	29	282	--	40.8
151.34.070	05-30-04	352	475	Salmon River	Redfish Lake Creek	Redfish Lake	9	193	8.5	--
151.34.075	06-10-04	368	450	EF Weir	EFSR (Big Boulder Cr)		8	126	See Trans #149.78.166	
151.34.080	06-12-04	345	490	Salmon River	--	Salmon River	46	434	--	5.1
151.34.086	06-15-04	404	715	Salmon River	--	Salmon River	25	291	--	1.4
Fall 2004										
151.34.093	09-30-04	422	705	Salmon River	Basin Creek	Salmon River	35	337	147.1	--
151.34.098	10-02-04	392	625	Salmon River	--	Salmon River	29	335	--	21.9
151.34.097	10-02-04	363	490	Salmon River	--	Salmon River	37	350	--	86.0
151.34.099	10-02-04	360	500	Salmon River	YFSR	Salmon River	46	506	97.9	--
151.34.100	10-02-04	480	1200	Salmon River	Thompson Creek	Salmon River	41	499	95.5	--
151.34.101	10-02-04	369	525	Salmon River	Thompson Creek	Salmon River	46	499	95.6	--
151.34.104	10-07-04	400	635	Salmon River	--	Salmon River	31	279	--	10.3
151.34.102	10-07-04	368	595	Salmon River	Squaw Creek[a]	Salmon River	40	494	64.7	--
151.34.105	10-07-04	380	580	Salmon River	Warm Springs Creek[a]	Salmon River	25	362	93.2	--
151.34.110	10-12-04	376	585	Salmon River	--	Salmon River	31	314	--	15.2
151.34.111	10-12-04	479	895	Salmon River	Predated – Mink/Otter		34	358	-	10.7
151.34.114	10-14-04	425	830	Salmon River	ESFR	Salmon River	24	488	76.7	-
151.34.115	10-19-04	400	620	Salmon River	Predated – Heron		11	229	-	2.4
151.34.119	10-25-04	358	500	Salmon River	Lemhi (Hayden Cr)	Salmon River	29	320	91.5	--
151.34.124	11-11-04	404	615	Salmon River	MFSR	Salmon River	16	187	235.9	--
151.34.071	12-14-04	412	635	Salmon River	--	Salmon River	30	296	--	7.6

[a] Migration into tributary not documented; fish last located near mouth, then unable to be found.

Rainbow Trout

Tagging

To observe movement patterns of rainbow trout, 56 individuals were implanted with radio transmitters throughout the Upper Salmon River Basin, Idaho. Fifty-four (54) rainbow trout were tagged in the Salmon River. Two rainbow trout were captured and tagged in the Lemhi River. All rainbow trout were captured with hook and line (n=56).

Radio tagged rainbow trout (n=56) averaged 404 ± 31 mm (mean ± SD) total length (TL) (range 336 – 478) and 686 ± 153 g (range 380 – 1035) mass (Figure 16; Table 9). Two (2) rainbow trout were tagged that did not meet the 2% transmitter to body mass guideline advised by Winter (1996). These fish weighed less than 385g (380g each) at the time of capture and tagging, but the transmitter to body ratio never exceeded 2.2%. Average surgery time for fish implanted with radio transmitters was 5 minutes. The length-weight relationship for rainbow trout captured and tagged in the Upper Salmon River Basin was described by the equation: $\log_{10}$ weight (g) = 2.77 $\log_{10}$ total length (mm) – 4.38 (r^2 = 0.85, n=56) (Figure 17).

In fall 2003, 12 rainbow trout were implanted with radio transmitters. The mean total length was 402 ± 43 mm (range 340 – 478) and mean mass was 671 ± 206 g (range 380 – 1035) (Table 10). Thirty-one (31) rainbow trout (mean TL: 406 ± 29 mm, range 336 – 442; mean mass: 689 ± 139 g, range 420 - 1000) were implanted with radio transmitters during spring 2004 (Table 10). Two of these rainbow trout were tagged in the Lemhi River, approximately 50 km upstream from the confluence with the Salmon River. During fall 2004, 13 rainbow trout (mean TL: 402 ± 27 mm, range 358 – 440; mean mass: 694 ± 140 g, range 465 - 900) were implanted with radio transmitters (Table 10).

Tracking

We tracked radio tagged rainbow trout for 2 – 505 days (mean = 334.6 d), depending on transmitter size and the fate of individual fish. For the 54 radio tagged fish, we established 1,610 relocations. Radio telemetry relocations of the 54 radio tagged rainbow trout averaged 28.8 per fish (range: 2 - 51). Access to some portions of the study area limited the number of relocations for some fish, particularly, those fish migrating into Cow Creek and the Pahsimeroi River. Over the course of the study, we used aerial tracking on 12 occasions to relocate fish in these areas. Although such tracking was limited, it did provide some information on the extent of upstream migration into more remote regions of the study area. In addition, the presence of fixed telemetry sites documented migration timing between adjacent tributary streams and the Salmon River. After the first rainbow trout spawning migrations (2004), two additional fixed telemetry stations were established, one at the mouth of Cow Creek and one on the Pahsimeroi River, approximately 1.4 km upstream from its confluence with the Salmon River.

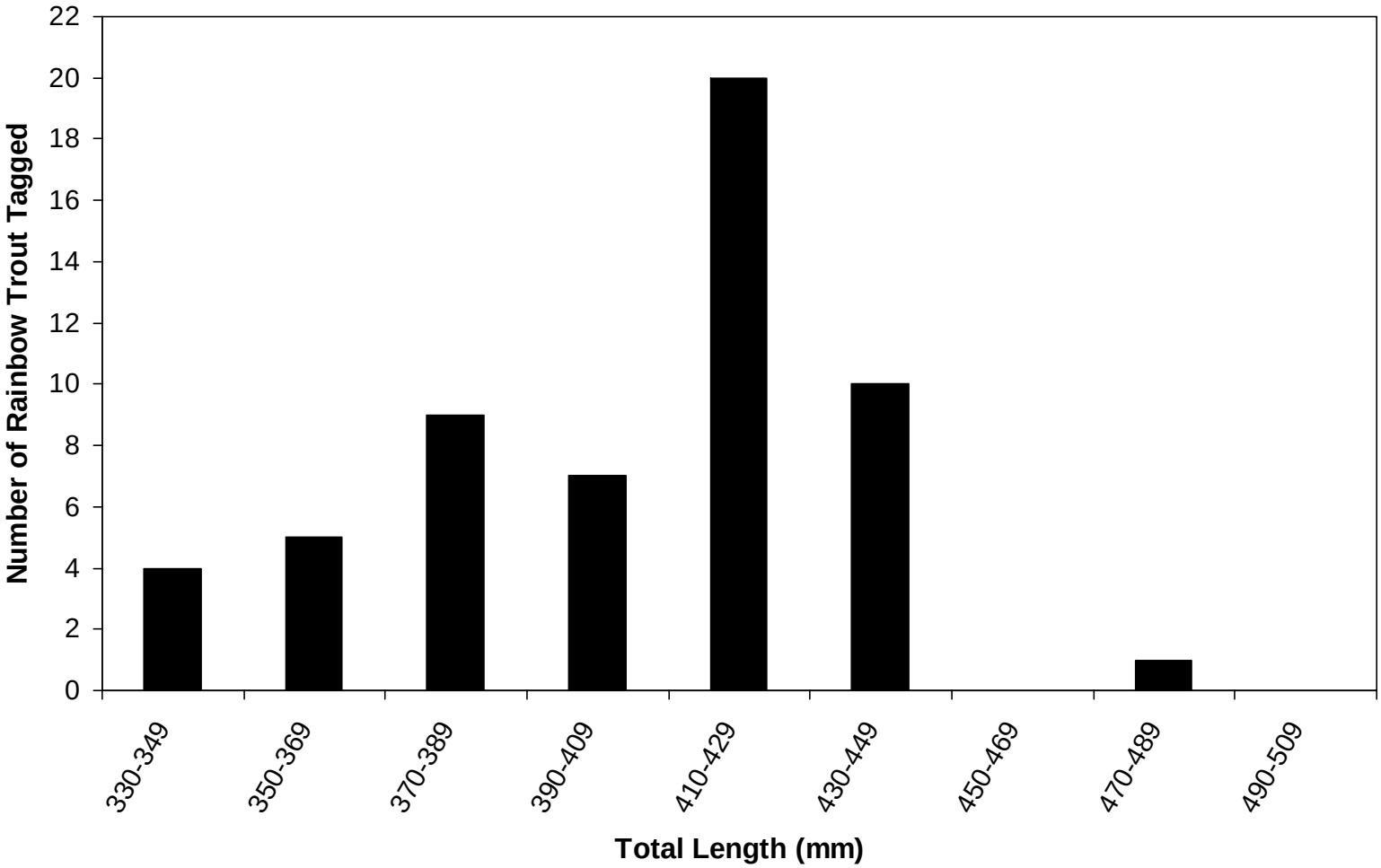

Figure 16. Length frequency distribution of radio tagged rainbow trout in the Upper Salmon River Basin, Idaho.

Table 9. Summary statistics of total length (mm) and weight (g) of all rainbow trout captured and tagged (*n*=56) in the Upper Salmon River Basin, Idaho during 2003 and 2004.

	Total Length (mm)	**Weight (g)**
Mean	404	686
Median	415	710
Mode	420	710
Standard Deviation	31	153
Minimum	336	380
Maximum	478	1035

Table 10. Number of rainbow trout radio tagged, and mean total length (mm) and weight (g), in the Upper Salmon River Basin, Idaho, during the spring and fall of 2003 and 2004.

	2003	**2004**	
	Fall	**Spring**	**Fall**
Number of Westslope Cutthroat Trout Tagged	12	31	13
Mean Total Length (mm)	402	406	402
Mean Weight (g)	671	689	694

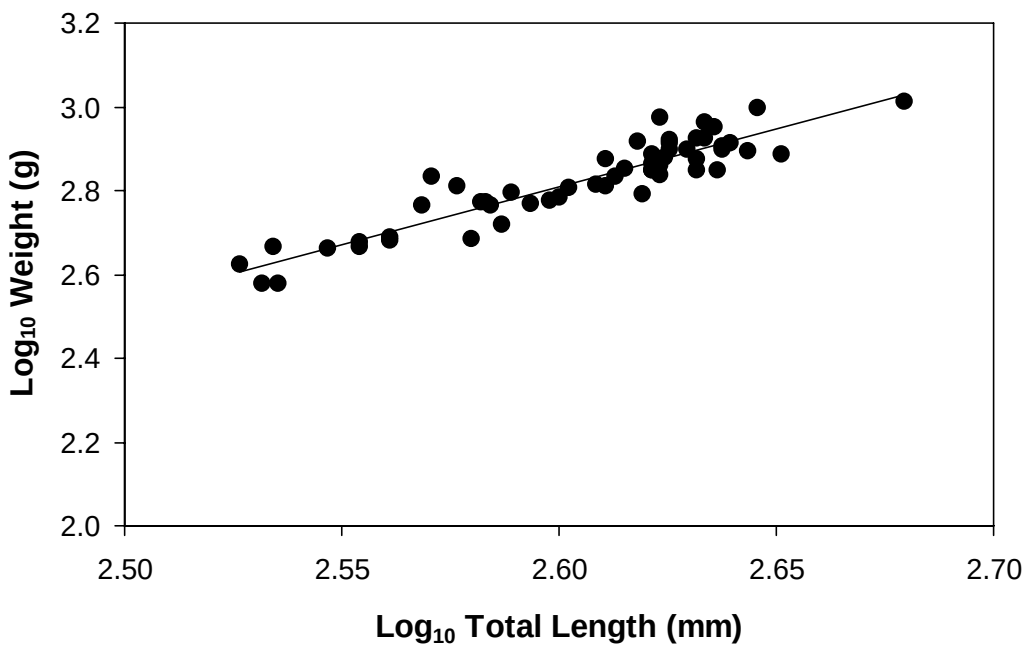

Figure 17. The length-weight relationship for rainbow trout captured and tagged in the Upper Salmon River Basin, Idaho during 2003 and 2004: $\log_{10}$ weight (g) = 2.77 $\log_{10}$ total length (mm) – 4.38 (r^2 = 0.85, *n*=56).

Results

Migration Timing and Patterns

2004-Of the 12 rainbow trout radio tagged in the fall of 2003, migrations were observed in nine fish (Figure 18; Table 11). Not all migratory fish moved into tributaries to access spawning locations. Movement was observed within the Salmon River and some fish were located in areas where spawning may have occurred in the mainstem and/or slough habitat adjacent to the Salmon River. Also, some fish were located near the mouths of suspected spawning tributaries but were not documented entering tributaries. Three rainbow trout entered the Pahsimeroi River between 3/12/04 and 3/23/04, and only one returned to the Salmon River (on 4/1/04). The other two remained in the Pahsimeroi River until their transmitters expired (10/6/04). At least one rainbow trout entered Cow Creek while two additional rainbow trout were located near the mouth before disappearing for up to three weeks. These two rainbow trout were later found at the mouth of Cow Creek and believed to have migrated into this tributary. This also occurred at Thompson Creek were one rainbow trout was last seen near the mouth on 4/28/04 and not observed again until 5/12/04 when it passed the EFSR station on its way downstream. One rainbow trout migrated into Henderson Slough (near Challis) on 3/14/04 and another was in the area and believed to enter as well, although it was not documented. Of the three fish that did not migrate, one tag failed, one may have been a winter mortality (but was last located near sloughs) and the fate of the last fish is unknown. It may have been predated as it was located near a heron rookery but we were unable to recover the transmitter before it expired.

Spawning migrations were observed by eight of the 31 rainbow trout tagged in the spring of 2004 (Figure 19; Table 11). Four migrations were observed during the spring of 2004, while the other four fish migrated during the spring of 2005 (*see Migration Patterns and Timing - 2005*). Of the 2004 migrants, one entered the Pahsimeroi River, one moved from the lower Lemhi River upstream to the mouth of Kirtley Creek, one migrated from the upper Lemhi River into Big Springs Creek, and one entered Henderson Slough. Herons predated three rainbow trout; one while it was spawning in Big Springs Creek (Lemhi River tributary). Eleven rainbow trout remained relatively stationary, inhabiting the same location in which they were tagged until either their transmitter expired or was recovered. Also, four transmitters expired before the 2005 spawning season. The remaining non-migratory fish either shed their transmitters or died by various or unknown reasons (see *Discussion*).

2005 -During 2005, five rainbow trout tagged during the spring of 2004 made spawning migrations. Seven of the 13 rainbow trout tagged in the fall of 2004 made spawning migrations (Figure 20; Table 11). Five rainbow trout entered the Pahsimeroi River, one entered Cow Creek, and one entered the Lemhi River and eventually migrated into Pattee Creek.

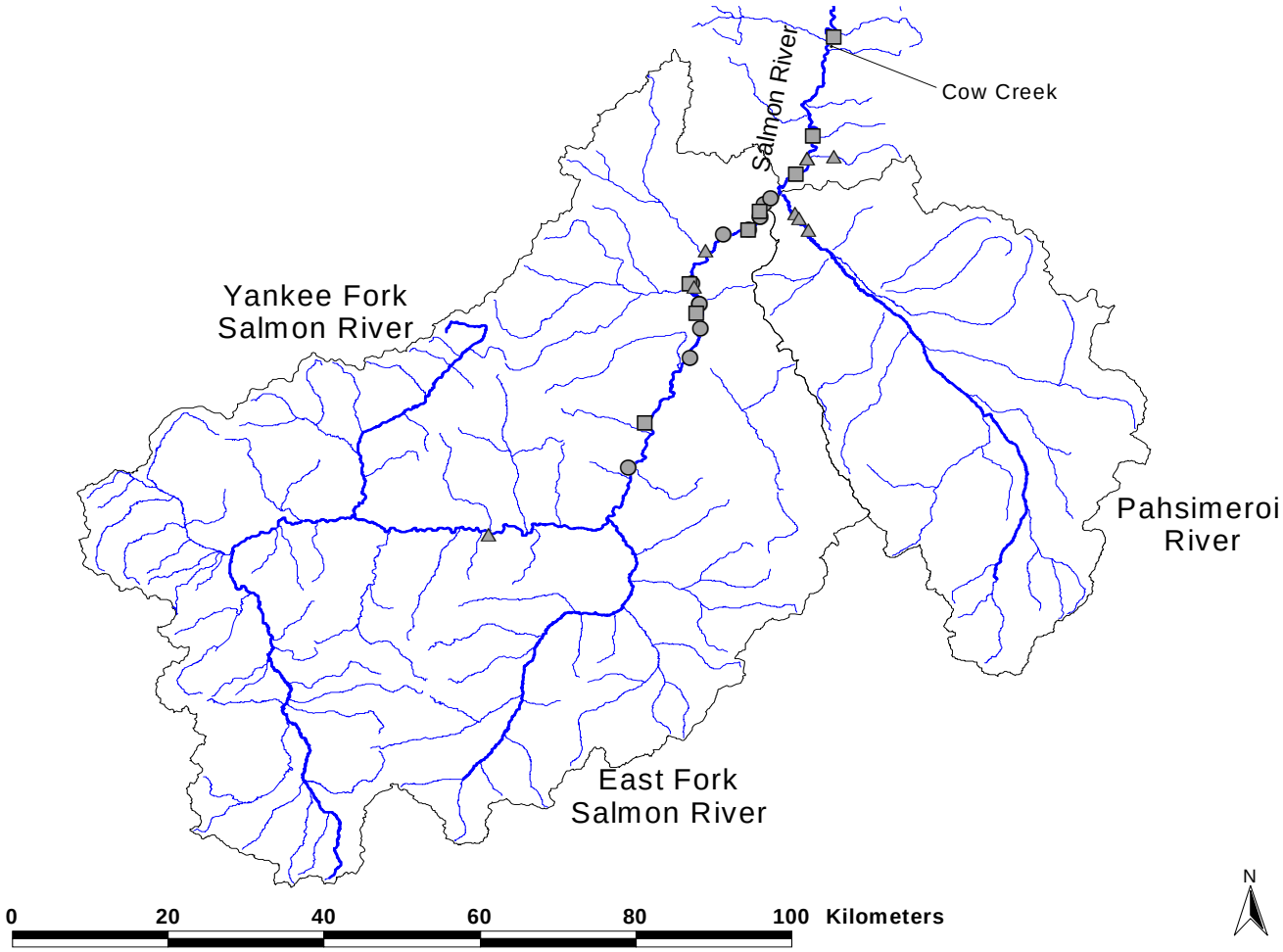

Figure 18. Tagging location (circles), spawning location (triangles), and winter location (squares) of rainbow trout tagged during the fall of 2003 in the Upper Salmon River Basin, Idaho.

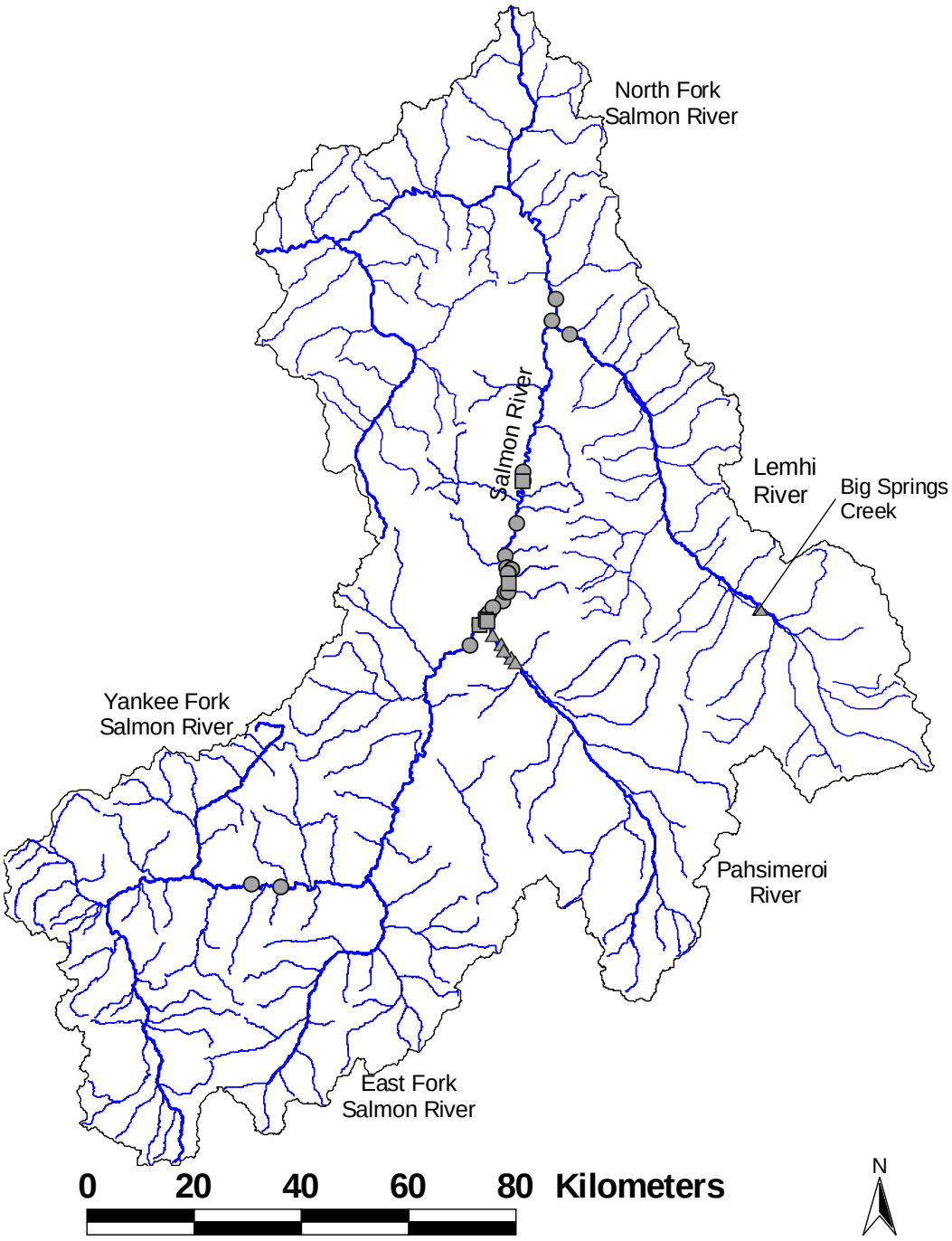

Figure 19. Tagging location (circles), spawning location (triangles), and winter location (squares) of rainbow trout tagged during the spring of 2004 in the Upper Salmon River Basin, Idaho.

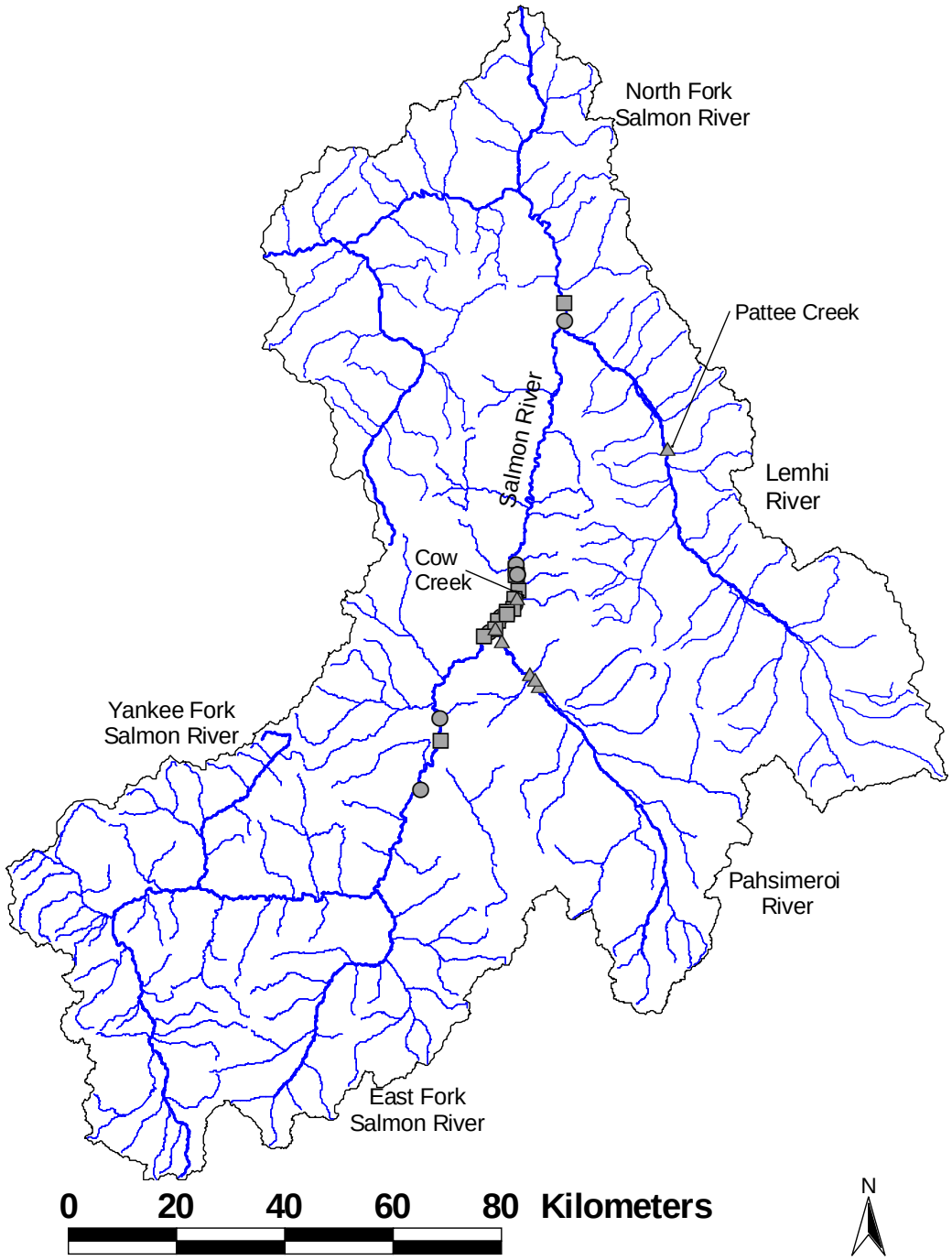

Figure 20. Tagging location (circles), spawning location (triangles), and winter location (squares) of rainbow trout tagged during the fall of 2004 in the Upper Salmon River Basin, Idaho.

Migration Distances

The average one-way migration distance between winter habitat and spawning habitat for radio tagged rainbow trout in the Upper Salmon River Basin was 25.6 km. The longest migration between winter and spawning habitats was 46.1 km, by a rainbow trout spawning in the Pahsimeroi River and wintering in the Salmon River upstream of Challis. The shortest migration was 3.2 km, by a rainbow trout spawning in Cow Creek and wintering in the Salmon River near the mouth of this tributary. See Table 12 for a summary of all tagged rainbow trout, including migration distance and spawning location.

Similar to westslope cutthroat trout, rainbow trout that did not enter tributaries showed considerable movements within the Salmon River. The average movement within the Salmon River for rainbow trout not documented entering tributaries was 8.3 km, with the largest migration within the Salmon River being 65.6 km. These movements may have been associated with the search for suitable winter or summer habitat, or may have been movements preceding tributary spawning migrations before transmitters were shed or mortality occurred. Some rainbow trout inhabited the same location in which they were tagged (generally large deep pool associated with shallow riffles at the upstream end) throughout the course of the year, moving less than 1 km. Although movements out of these locations were not documented, many fish were documented alive as evidenced by their movements within the pool.

Table 11. Number of radio tagged rainbow trout detected in Upper Salmon River tributaries during 2004 and 2005.

Subbasin	Tributary	Number of Rainbow Trout 2004	2005
Lemhi River		2[a]	0
	Big Springs Creek	1	0
	Pattee Creek	0	1
Pahsimeroi River		4	9
Cow Creek		3[b]	1
Thompson Creek		1[b]	0
Sloughs (Challis Area)		3[b]	0

[a] 1 tagged in Lemhi, 1 tagged in Salmon River, migrated into Lemhi; spawning location unknown.
[b] Not all fish documented in tributary; see Table 12 for more information.

Discussion

Based on the capture efforts to implant rainbow trout with radio transmitters in the upper Salmon River, their primary distribution seems currently limited to the middle reaches of the study area. While rainbow trout were captured as far upstream as Thompson Creek and downstream as the Lemhi River, most rainbow trout were captured 20 km upstream and downstream of the Pahsimeroi River. As mentioned in the westslope cutthroat trout portion of the study, spawning activity by rainbow trout and cutthroat trout appears to be separated by timing and the location of tributaries used. Although future research is necessary to document the extent of tributaries used for spawning by each species.

While rainbow trout tributary migrations were limited, spawning may occur in braided areas of Salmon River and adjacent sloughs. Hockersmith et al (1995) used radio telemetry to document rainbow trout spawning in the mainstem of the Yakima River, WA. In the middle reach of the Salmon River near Challis, two fish were located in Henderson Slough and presumably spawned, while several others were located near similar habitat in this area. Hannah Slough and several other unnamed sloughs enter the Salmon River near Challis and may provide additional spawning habitat for rainbow trout. Further research of the use of these habitats by fluvial rainbow trout is warranted and may help provide justification for enhancement and protection of these habitats.

At least three known rainbow trout mortalities were caused by heron predation and other unknown mortalities may also have been attributed to this. Hodgens et al (2004) documented rainbow trout comprising 65% of heron diet biomass in their study and also found that 85% of the rainbow trout captured by herons were between 105 and 280 mm; the largest trout captured during their study was 390 mm. The three documented rainbow trout predated by herons in the USRB ranged between 336 and 420 mm, indicating that herons are capable of capturing adult rainbow trout. Heron daily energy demands peak during the breeding season (March – May) (Hodgens et al 2004), which coincides with rainbow trout spawning activity in the USRB when rainbow trout are presumably most vulnerable to aerial predation. The amount of predation on juvenile rainbow trout by herons is unknown, but given the documented losses of adult rainbow trout to heron predation, future research of this mortality for all age classes of rainbow trout is recommended.

Table 12. Tagging and migration data for all radio tagged rainbow trout in the Upper Salmon River Basin, Idaho.

Frequency /Code	Tag Date	Total Length (mm)	Mass (g)	Tag Location	Tributary Ascended	Winter Location	# Of Relocations	Days Tracked	Distance Between Spawn And Winter Location (km)	Movemen Within Salmon River (km)
Fall 2003										
149.78.160	09-04-03	430	845	Salmon River	Thompson Cr[a]	Salmon River	34	294	39.1	--
151.34.033	09-18-03	448	770	Salmon River	Cow Creek[a]	Salmon River	34	431	38.5	--
151.34.034	09-18-03	420	725	Salmon River	Pahsimeroi R	Salmon River	34	407	35.0	--
151.34.035	09-18-03	478	1035	Salmon River	Slough	Salmon River	43	404	<1.0	--
149.78.162	09-20-03	364	490	Salmon River	Slough[a]	Salmon River	35	291	10.1	--
149.78.163	09-20-03	364	480	Salmon River	Cow Cr	Salmon River	38	325	39.0	--
149.78.165	09-20-03	343	380	Salmon River	--	Salmon River	35	291	--	6.2
149.78.175	09-20-03	340	380	Salmon River	Cow Cr[a]	Salmon River	28	291	20.6	--
151.34.036	09-20-03	422	835	Salmon River	Pahsimeroi R	Salmon River	26	382	9.6	--
151.34.037	09-20-03	406	655	Salmon River	Pahsimeroi R	Salmon River	16	382	46.1	--
151.34.042	09-25-03	388	625	Salmon River	--	Salmon River	12	352	--	7.6
151.34.043	09-25-03	415	830	Salmon River	--	Salmon River	6	147	--	<1.0
Spring 2004										
151.34.005	03-04-04	336	420	Salmon River	*predated - heron*		32	239	--	2.7
151.34.058	03-11-04	433	710	Salmon River	Pahsimeroi R	Pahsimeroi	17	281	15.9	--
151.34.059	03-11-04	400	640	Salmon River	Pahsimeroi R	Salmon River	46	445	15.3	--
151.34.006	03-15-04	420	945	Salmon River	--	Salmon River	33	273	--	63.4
151.34.007	03-15-04	428	840	Salmon River	*transmitter failure*		2	1	--	--
151.34.011	03-25-04	420	690	Lemhi River	Big Springs Cr	*Predated -Heron*	4	34	12.3	--
151.34.012	04-21-04	392	590	Lemhi River	Lemhi River	*Tag Expired--*	10	236	<1.0	
151.34.015	04-22-04	416	620	Salmon River	--	Salmon River	27	266	--	8.7
151.34.021	04-29-04	418	735	Salmon River	--	Salmon River	27	259	--	<1.0
151.34.022	04-29-04	384	585	Salmon River	Slough	Salmon River	23	259	29.7	--
151.34.023	04-29-04	442	1000	Salmon River	--	Salmon River	26	259	--	<1.0
151.34.024	04-29-04	342	465	Salmon River	--	Salmon River	24	228	--	<1.0
151.34.025	04-29-04	352	460	Salmon River	*Predated - Heron*		13	231	--	<1.1
151.34.062	05-27-04	396	600	Salmon River	*Unk Mortality or Shed Tag*		24	287	--	4.1
151.34.064	05-28-04	358	475	Salmon River	--	Salmon River	45	473	--	<1.0
151.34.065	05-28-04	398	610	Salmon River	--	Salmon River	24	436	--	65.6
151.34.067	05-29-04	383	595	Salmon River	--	Salmon River	49	454	--	2.4

Table 12, Continued.

Frequency /Code	Tag Date	Total Length (mm)	Mass (g)	Tag Location	Tributary Ascended	Winter Location	# Of Relocations	Days Tracked	Distance Between Spawn And Winter Location (km)	Movement Within Salmon River (km)
Spring 2004 (continued)										
151.34.068	05-30-04	410	680	Salmon River	--	Salmon River	51	489	--	2.7
151.34.069	05-30-04	418	710	Salmon River	--	Salmon River	44	408	--	22.1
151.34.071	06-02-04	408	650	Salmon River	*mort - found by angler*		3	67	--	2.2
151.34.079	06-12-04	426	790	Salmon River	Pahsimeroi R	Salmon River	41	414	38.4	--
151.34.081	06-12-04	434	810	Salmon River	--	Salmon River	42	440	--	1.5
151.34.082	06-12-04	421	760	Salmon River	Lemhi R – *unk mortality*		35	415	--	<1.0
151.34.083	06-14-04	418	710	Salmon River	--	Salmon River	35	350	--	6.2
151.34.084	06-15-04	428	710	Salmon River	Pahsimeroi R	Salmon River	31	437	13.1	--
151.34.085	06-15-04	428	755	Salmon River	--	Salmon River	45	437	--	3.2
151.34.019	06-16-04	370	585	Salmon River	--	Salmon River	26	313	--	<1.0
151.34.087	06-16-04	412	715	Salmon River	--	Salmon River	43	436	--	<1.0
151.34.088	06-20-04	436	820	Salmon River	--	Salmon River	40	505	--	8.7
151.34.089	06-20-04	430	920	Salmon River	--	Salmon River	45	432	--	11.4
151.34.090	06-22-04	420	750	Salmon River	Pahsimeroi R	Salmon River	36	456	5.6	--
Fall 2004										
151.34.094	09-30-04	440	785	Salmon River	Cow Creek	Salmon River	35	375	3.2	--
151.34.095	10-01-04	434	795	Salmon River	Pahsimeroi River	Salmon River	10	178	32.3	--
151.34.096	10-01-04	422	820	Salmon River	*predated - mink*		13	177	--	
151.34.109	10-10-04	422	795	Salmon River	Pahsimeroi River	Salmon River	20	445	32.1	--
151.34.112	10-12-04	418	775	Salmon River	--	Salmon River	37	497	--	15.3
151.34.113	10-12-04	382	595	Salmon River	Pahsimeroi River	Salmon River	35	318	21.8	--
151.34.118	10-21-04	372	685	Salmon River	*shed or winter mortality*		9	290	--	<1.0
151.34.106	10-29-04	432	900	Salmon River	Pahsimeroi River	Salmon River	26	480	20.3	--
151.34.122	11-10-04	408	750	Salmon River	--	Salmon River	28	334	--	<1.0
151.34.061	11-11-04	358	465	Salmon River	--	Salmon River	27	343	--	3.1
151.34.123	11-11-04	377	645	Salmon River	--	Salmon River	35	467	--	4.4
151.34.091	11-13-04	380	485	Salmon River	Pahsimeroi River	Salmon River	27	298	43.7	--
151.34.092	11-16-04	386	525	Salmon River	Lemhi R (Pattee Cr)	Salmon River	24	281	41.9	--

[a] Migration into tributary not documented; fish last located near mouth, then unable to be found.

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LITERATURE CITED

Bahr, M.A., and J.M. Shrimpton. 2004. Spatial and quantitative patterns of movement in large bull trout (Salvelinus confluentus) from a watershed in north-western British Columbia, Canada, are due to habitat selection and not differences in life history. Ecology of Freshwater Fish 13: 294-304.

Behnke, R.J. 1992. Native trout of western North America. Monograph 6. American Fisheries Society, Bethesda, Maryland.

Bjornn, T.C., and J. Mallet. 1964. Movements of planted and wild trout in an Idaho river system. Transactions of the American Fisheries Society 93: 70-76.

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

Chisholm, I.A., and W.A. Hubert. 1985. Expulsion of dummy transmitters by rainbow trout. Transactions of the American Fisheries Society 114: 766-767.

Fraley, J.J. and B.B. Shepard. 1989. Life history, ecology, and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and River system, Montana. Northwest Science 63:133-143.

Hockersmith, E., J. Vella, and L. Stuehrenberg. 1995. Yakima River radio-telemetry study. Rainbow trout. Annual report 1993. Bonneville Power Administration, Division of Fish and Wildlife, Project Number 89-089. Contract Number DE-AI79-BP00276.

Hodgens, L.S., S.C. Blumenshine, and J.C. Bednarz. 2004. Great blue heron predation on stocked rainbow trout in an Arkansas tailwater fishery. North American Journal of Fisheries Management 24: 63-75.

Hvenegaard, P.J., and T.M. Thera. 2001. Monitoring the bull trout (*Salvelinus confluentus*) spawning run in Lynx Creek, a tributary to the Kakwa River, West Central Alberta. Pages 147-151 *in* Brewin, M.K., A.J. Paul, and M. Monita, editors. Bull Trout II Conference Proceedings. Trout Unlimited Canada, Calgary, Alberta.

Idaho Department of Fish and Game. 2001. Fisheries Management Plan 2001-2006. Boise.

Interior Columbia Basin Ecosystem Management Project (ICBEMP). 2000. http://www.icbemp.gov/spatial/.

McIntyre, J.D., and B.E. Rieman. 1995. Westslope Cutthroat Trout. Pages 1-15 in M.K Young, technical editor. Conservation Assessment for Inland Cutthroat Trout. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-GTR-256.

LITERATURE CITED, Continued

McPhail, J.D., and J.S. Baxter. 1996. A Review of Bull Trout (*Salvelinus confluentus*) Life-history and Habitat Use in Relation to Compensation and Improvement Opportunities. Fisheries Management Report No. 104, Department of Zoology, University of British Columbia, Vancouver.

Rieman, B.E., and K.A. Apperson. 1989. Status and analysis of salmonid fisheries: westslope cutthroat trout synopsis and analysis of fishery information. Job Performance Report, Project F-73-R-11, Subproject II, Study 1, Job 1. Idaho Department of Fish and Game, Boise.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements of bull trout *Salvelinus confluentus*. U.S. Forest Service, Intermountain Research Station, General Technical Report INT-302.

Rieman, B.E., D.C. Lee, and R.F. Thurow. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River Basins. North American Journal of Fisheries Management 17:1111-1125.

Ross, M. J., and C. F. Kleiner. 1982. Shielded-needle technique for surgically implanting radio-frequency transmitters in fish. Progressive Fish Culturist 44:41-43.

Schmetterling, D.A. 2001. Seasonal movements of fluvial westslope cutthroat trout in the Blackfoot River drainage, Montana. North American Journal of Fisheries Management 20:507-520.

Servheen, G. 2001. Salmon Subbasin Summary. Idaho Department of Fish and Game. Prepared for the Northwest Power Planning Council.

Thiesfeld, S.L., A.M Stuart, D.E. Ratliff, and B.D. Lampman. 1996. Migration Patterns of Adult Bull Trout in the Metolius River and Lake Billy Chinook, Oregon. Information Report 96-1. Oregon Department of Fish and Wildlife, Portland.

Upper Salmon River Interagency Technical Advisory Team (USRITAT). 1999. Upper Salmon River key watershed bull trout problem assessment. Prepared for the State of Idaho, Idaho Department of Environmental Quality, Idaho Falls.

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

Zurstadt, C.F., and K. Stephan. 2004. Seasonal migration of westslope cutthroat trout in the Middle Fork Salmon River drainage, Idaho. Northwest Science 78: 278-285.

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