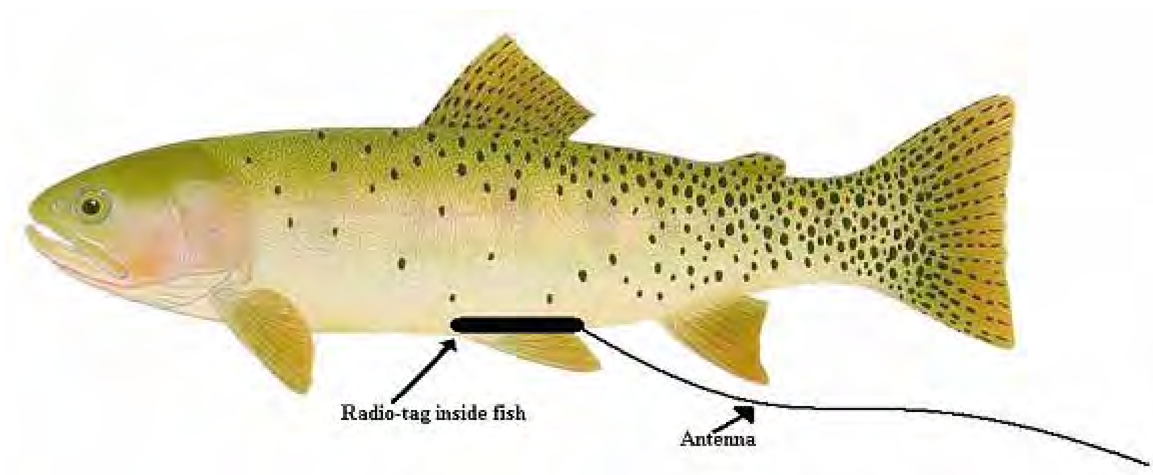
FISHERY MANAGEMENT INVESTIGATIONS

TETON RIVER INVESTIGATIONS
PART III: FISH MOVEMENTS AND LIFE HISTORY 25 YEARS AFTER TETON DAM

Final Progress Report

September 1997 to September 2002



William C. Schrader, Senior Fisheries Research Biologist

and

Michael D. Jones, Fishery Technician

Cooperative Agreement #1425-7-FC-10-03590

IDFG Report Number 04-45
December 2004

TABLE OF CONTENTS

Page

List of Tables

List of Figures

List of Figures, continued.

List of Appendices

List of Appendices, continued.

Page

List of Appendices, continued.

List of Appendices, continued.

Page

List of Appendices, continued.

Page

List of Appendices, continued.

Page

List of Appendices, continued.

List of Appendices, continued.

Page

ABSTRACT

This report is the third part of a three-part series assessing the Teton River fishery 25 years after the collapse of Teton Dam, particularly in the Teton Canyon above the dam. We quantified fish movements throughout the drainage by using a combination of marking and tagging, radio telemetry, and upstream and downstream migrant trapping. We also conducted spawner surveys in Canyon Creek, one of the major tributaries in the Teton Canyon. Of 854 trout that were jaw tagged from 1987 to 1996, 17 of 18 returns (94%) came from the same study section where they were released. This was similar to pre-dam study results in 1974-1975 (99% of 426 returns). Of 5,134 trout, mountain whitefish, and suckers that were fin-clipped from 1997 to 1999, 27 of 34 returns (79%) came from the same study section where they were released. However, some of the returns were questionable. Of 174 trout that had visible implant (VI) tags implanted in 1999, one was recaptured in the same Teton Canyon pool where it was released.

In general, radio-tagged adult cutthroat, rainbow, and hybrid trout (≥385 mm, TL) did not move between the three Teton River study sections, although they were observed moving long distances within sections to spawn. Two distinct spawning strategies were observed in all sections during 1999, a total of 16 fish spawned in tributaries and 15 fish spawned in the mainstem. An additional 10 fish did not move but may have spawned in the mainstem. Cutthroat trout spawned mostly in tributaries, whereas rainbow and hybrid trout spawned mostly in the mainstem. The most important spawning tributary was Teton Creek, where eight cutthroat and one hybrid trout spawned. Fluvial cutthroat trout also spawned in Moody, Canyon, Bitch, and Trail creeks, and one fluvial rainbow trout spawned in Fox Creek. In general, spawning periods overlapped between the taxa. Radio-tagged trout moved very little during fall and winter. One third of the 79 fish that were radio tagged died within eight weeks of surgery, an estimate made possible by the use of mortality switches.

Only seven adult trout and two adult mountain whitefish (≥350 mm, TL) were trapped moving upstream at the Felt Dam fish ladder in 1998 and 1999 combined. In contrast, and despite trap failures both years, 1,440 adult fish were trapped moving upstream at the South Fork fish ladder in 1995 and 1999 combined. The 1,353 suckers, 73 cutthroat trout, and 9 rainbow trout trapped in the South Fork were migrating to spawn. The remaining five fish were non-spawning mountain whitefish. For all taxa over both years, the spawning run started April 13 and probably extended through May. The South Fork Teton River may contain one of the last remnants of an early-spawning, large-sized, Snake River fluvial strain of cutthroat trout (average size was 458 mm, TL). For downstream migrants, 17,481 fish were captured at the Narrows screw trap in 1998. Similar to pre-dam results, 74% were dace, 23% were redside shiners, 2% were suckers and cottids, and 1% was unknown non-salmonid fry, mountain whitefish, and trout (cutthroat, rainbow, brook, and unknown taxa). A total of 8,098 fish were captured moving downstream at the Hog Hollow screw trap in 1999. Like the Narrows, 53% were dace, 19% were redside shiners, 16% were unknown non-salmonid fry, 6% were mountain whitefish, 5% were suckers and cottids, and 1% was Utah chubs and trout (cutthroat, rainbow, and unknown taxa). Although we did not adjust our numbers for screw trap efficiency—estimated to be from one to five percent—we conclude that downstream movements of juvenile game fish in the Teton River is inconsequential.

Adult, fluvial cutthroat trout (≥350 mm) were observed in upper Canyon Creek in May and June 2000 (n = 18), and in its tributary Calamity Creek in May 2001 (n = 14). Despite Canyon Creek being completely dewatered below the Canyon Creek Canal diversion, fish were

obviously spawning as several kelts and numerous redds were observed. One radio-tagged fish also spawned above the diversion in 1999.

In conclusion, very few adult or juvenile game fish moved between the three Teton River study sections, and these mainstem populations are fragmented into three independent and isolated populations. Whether isolation occurred naturally prior to Teton Dam is not known. Irrigation diversion structures in the Lower Teton—most of which were rebuilt by the U.S. Bureau of Reclamation without fish passage facilities following the dam collapse—and Felt Dam in the Teton Canyon have further fragmented these populations. The new pools and rapids created in the Teton Canyon and in Canyon Creek following the dam collapse did not change game fish migration patterns, block fish passage, nor further isolate these populations.

Authors:

William C. Schrader
Senior Fisheries Research Biologist

Michael D. Jones
Fishery Technician

INTRODUCTION AND STUDY AREA

This report is the third and final part of a three-part series assessing the Teton River fishery 25 years after the collapse of Teton Dam, particularly in the Teton Canyon above the dam. The first report (Schrader, in press) assesses the overall impacts of the dam collapse on the recreational fishery using creel survey data. Also included are water temperature and streamflow data. The second report (Schrader and Brenden, in press) presents fish population survey information. Here, we present fish movement and life history results. Although our focus is on the Teton Canyon, we include two other Teton River sections as field controls—one below Teton Dam (hereafter Lower Teton, which was also affected by the dam) and one above the Teton Canyon (hereafter Teton Valley, which was unaffected). Our overall strategy was to examine the Teton Canyon fishery, its fish populations, and fish movements over time (pre- versus post-Teton Dam) and space (between sections). This was necessary, as pre-dam information was often limited or lacking altogether.

Prior to this study, fish movement information was limited, and fish life history strategies were undocumented. Irving et al. (1977) report minimal pre-dam trout movements with almost no trout moving between study sections based on angler tag returns and limited trapping data. After the dam collapsed, Idaho Department of Fish and Game (IDFG) personnel tagged trout throughout the drainage, including tributaries, from 1988 to 1995, and we present those unpublished results in this report. In 1987 and 1988 at Felt Dam (31 km above the dam site and 3 km above the old Teton Reservoir), fish were tagged below and trapped moving through a new fish ladder as part of a hydroelectric relicensing study (ERI 1987, 1988).

Fish movements and life history strategies may have changed with the extensive changes in hydrology and geomorphology caused by the dam collapse (Moore and Andrews 1983; Randle et al. 2000). For example, loss of mainstem spawning habitat in the Teton Canyon and Lower Teton may have required a shift to a fluvial life history strategy, i.e. migration to tributaries to reproduce. Conversely, new pool habitat created in the Teton Canyon may have led to adult or juvenile migrations from other sections, possibly to overwinter or to rear. Moore and Andrews (1983) asserted that irrigation diversion structures rebuilt by the U.S. Bureau of Reclamation (BOR) following the Teton flood lacked adequate juvenile or adult fish passage facilities, which may have isolated populations. A major goal of this research was to determine if fish move between or within the three study sections, i.e. if the populations can now be considered independent or isolated.

Background for this study and detailed descriptions of the Teton River drainage—including the three major study sections with several reaches in each section—can be found in Schrader (in press). Preliminary radio telemetry work was reported at a symposium in 1999 (Schrader and Jones 2000).

OBJECTIVE

1) Describe fish movements and life history strategies in the Teton River 25 years after the Teton Dam failure.

METHODS

We quantified fish movements throughout the drainage using a combination of marking and tagging, radio telemetry, and upstream and downstream migrant trapping. We also conducted spawner surveys in Canyon Creek, one of the major tributaries in the Teton Canyon. Different methods were used to achieve different objectives and to corroborate results. Where possible, we used the same methods and sites as previous studies.

Marking and Tagging

Jaw Tags

As part of earlier IDFG fisheries investigations, field crews used non-reward jaw tags to mark trout throughout the Teton River drainage from 1987 to 1996. Our objective in retrieving these historic data was to describe large-scale movements between study sections with the same methods used in 1974 and 1975 (Irving et al. 1977). Non-reward jaw tags were also used in 1987 and 1988 as part of a hydropower relicensing study at Felt Dam (ERI 1987, 1988).

Of 854 fish jaw tagged by IDFG from 1987 to 1996, 430 were cutthroat trout and 418 were wild rainbow trout (Appendix A). Only two hatchery rainbow trout and four brook trout were tagged. About 150 fish were tagged in the Lower Teton, mostly at Hog Hollow with electrofishing gear. Another 440 fish were tagged in the Teton Canyon, mostly below Felt Dam with hook-and-line gear. About 260 fish were tagged in the Teton Valley at a variety of locations with a variety of gear.

Jaw tags (National Band and Tag Co., Newport, Kentucky) were the butt-end, bird band type (model 1242M). They were made of rustproof Monel, had unique alphanumeric codes, and ranged in size from number 6 to 18. We found size 6 worked well on trout from 175-210 mm, size 8 from 210-280 mm, size 10 from 280-350 mm, size 12 from 350-420 mm, size 14 from 420-500 mm, size 16 from 500-570 mm, and size 18 for fish >570 mm. Tags were attached to the left mandible of the fish.

Fin Clips and VI Tags

As part of the present study, field crews clipped the right or left, pelvic or pectoral, fin to mark trout, mountain whitefish, and suckers throughout the Teton River drainage from 1997 to 1999. As our objective was to describe large-scale movements between study sections, right pectoral fin clips were used in the Lower Teton and left pectoral fin clips were used in the Teton Canyon. In the Teton Valley, right pelvic fin clips were used in the mainstem and left pelvic fin clips were used in tributaries. Pelvic clips were recorded as "ventral" clips (RV or LV) to avoid confusion with pectoral clips (RP or LP). Fins were clipped next to the body for a permanent mark, and generally only age-1 and older fish were marked. Fin clipping was discontinued in July 1999 prior to the basinwide electrofishing surveys (Schrader and Brenden, in press).

Field crews also used visible implant (VI) tags to mark >300 mm cutthroat and rainbow trout in the Teton Canyon pools during electrofishing surveys in 1999. Our objective was to describe small-scale movements between pools at Spring Hollow to assess population closure. As individual fish needed to be identified, as many fish as possible were tagged in each pool. VI tags (Northwest Marine Technology, Inc., Shaw Island, Washington) were the original (hard) type, measuring 1.5 mm wide x 3.5 mm long, and each had a unique alphanumeric code. Tags were injected with a special syringe into the post-ocular adipose eyelid tissue just behind the left eye.

Of 5,308 fish marked during the study period, 5,134 were fin clipped and 174 were VI tagged (Appendix B). Of the fin clipped fish, 2,249 were mountain whitefish, 1,633 were suckers, 560 were cutthroat trout, 329 were brook trout, 168 were wild rainbow trout, and 161 were Utah chubs. Less than 20 hatchery rainbow trout or unknown trout fry were clipped. Many dace, redside shiners, and sculpins were captured but none were clipped. A total of 1,077 fish were clipped in the Lower Teton, almost all at the South Fork ladder trap. Another 1,212 fish were clipped in the Teton Canyon, mostly at the Narrows screw trap and Borrow Ponds. Another 2,845 fish were clipped in the Teton Valley at a variety of locations.

<u>Radio Telemetry</u>

Sample Selection

Seventy-nine adult trout (>600 g or >385 mm) were radio tagged in the Teton River from August 5, 1998, to May 23, 1999 (Figure 1). Initially, tagging was equally stratified by study section during August and September 1998 (20 fish in the Lower Teton, 20 in the Teton Canyon, and 20 in the Teton Valley). We were able to tag an additional 19 fish with transmitters retrieved from fish mortalities (Figure 2). Eight transmitters were reused in the Teton Valley prior to winter, and 11 were reused in the spring prior to spawning (two in the Lower Teton, four in the Teton Canyon, and five in the Teton Valley). Overall, 22 fish were tagged in the Lower Teton, 24 were in the Teton Canyon, and 33 were in the Teton Valley.

We radio tagged the first suitable cutthroat, rainbow, or hybrid trout captured in each 1.6 km of river (Figure 1). Stratification by 1.6 river km was somewhat compromised in the Teton Canyon and Lower Teton, where access and sampling efficiency are poor. Fish criteria for tagging were healthy appearance and at least 575 g body weight (for the tag-to-body weight ratio to be less than 2.0%). Overall, 57 cutthroat, 9 rainbow, and 13 hybrid trout were tagged. Sixty-four fish were captured by electrofishing from a drift boat, 13 were caught by hook-and-line gear, and two were trapped at the South Fork fish ladder.

Total length of all 79 fish ranged from 385 to 579 mm (mean = 450 mm), weight ranged from 600 to 2300 g (mean = 972 g), and relative tag weight ranged from 0.5 to 1.9% (mean = 1.3%; Appendix C, D, and E). Forty-three fish had blackspot disease, and 16 had some type of hooking scar. We were unable to assess sex and maturity of the 68 fish radio tagged in 1998. Of the 11 fish radio tagged in 1999, five were green females, four were green males, one was a ripe male, and one was unknown.

We initially assumed that capturing a fish or having it carry a radio transmitter would not influence its future behavior or survival (White and Garrott 1990). However, 27 of the 60 fish that died during this study did so within eight weeks after tagging (Figure 3). An angler harvested one of these fish nine days after tagging. The remaining 26 fish were considered post-surgery mortalities and excluded from the original 79 fish sample (Appendix C, D, and E). We arbitrarily chose eight weeks as the "conditioning period" (Pollock et al. 1989), and we were able to estimate time to mortality because transmitters had mortality switches. Of the final 53 fish sample, 20 were in the Lower Teton, 8 were in the Teton Canyon, and 25 were in the Teton Valley. Post-surgery mortality was 67% in the Teton Canyon, compared to 24% in the Teton Valley and 9% in the Lower Teton. The final sample included 35 cutthroat, 8 rainbow, and 10 hybrid trout.

We modified standard surgery techniques for the field and used standard “beeper” radio transmitters (Appendix F).

Location and Movement

Fixed-wing aircraft were used to locate radio-tagged fish at least once a month and as often as twice per week depending on movements. Excluding the 26 post-surgery mortalities plus another five fish that were lost or harvested within 56 d of surgery, 1,167 locations were recorded from September 2, 1998 to October 16, 1999. More than 94% of these locations were recorded during aerial flights. Most locations were in the Teton Valley (520 locations for 23 fish) followed by the Lower Teton (463 for 18 fish) and the Teton Canyon (184 locations for 7 fish). Radio telemetry week numbers were used to map fish locations, beginning in August 1998 (Appendix G). All location data were entered by Universal Transverse Mercator (UTM) coordinates into an ArcView GIS database (ESRI, Inc., Redlands, California) to produce maps for each fish.

A 235 hp Maule M6 airplane was contracted through Mountain Air Research (Driggs, Idaho), a company that specializes in fish and wildlife applications. The aircraft was equipped with a Telonics (Mesa, Arizona) model TR-2 radio telemetry receiver with TS-1 scanner, Global Positioning System (GPS) navigation and recording gear, all interfaced with an on-board computer. The aircraft was also equipped with three sets of exterior radio telemetry antennae. A Yagi 3-element antenna was mounted forward and used for precise forward locations. Two wing-strut mounted, 2-element H antennae, pointing right and left, were used for directional control.

Although GPS has been used successfully for locating radio-tagged fish from aircraft, accuracy and precision may be low (Hockersmith and Peterson 1997). To evaluate accuracy and precision, we measured the absolute distance of aircraft GPS locations from known-location transmitters on the ground. Accuracy was high and precision was generally + 0.2 km, but was as much as + 0.7 km, depending on weather and flying conditions (Appendix H and I). We assumed this was adequate to describe large-scale fish movements.

For ground locations, we used an ATS model R4000 radio telemetry scanning receiver with a Yagi 3-element folding antenna, a Garmin model 12 handheld GPS receiver, and an accessory DC converter to keep batteries charged while en route. Precision of this configuration was less than one meter and enabled retrieval of 25 transmitters from fish that died.

We used spawning-migration variables and criteria reported by Henderson et al. (2000) to describe where and when radio-tagged trout spawned. We were unable to determine the spawning status of an individual fish because of high and turbid flow conditions. Therefore, from March to early July, all fish that either migrated into tributaries or moved more than 1.6 km in the mainstem were assumed to have spawned. All remaining fish were considered non-spawners.

The location and timing of spawning for each fish were determined from its movements. The spawning location was defined by the farthest extent of movement, either upstream or downstream. The beginning migration date was midway between the date each fish was first observed migrating and its previous location date (Swanberg 1996, Henderson et al. 2000). The same approach was used to determine the date each fish entered and left its spawning location. The spawning period extended from the date each fish entered its spawning location until the date it left. The midpoint of the spawning period defined the spawning date. Finally, the overall spawning period for each study group began when the first fish entered its spawning area and ended when the last fish left.

Migrant Trapping

Felt Dam Ladder Trap

The 3-4 m high concrete Felt Dam is a complete migration barrier, and fish must navigate to and through a fish ladder (constructed in 1986) to move upstream (Figure 4). Just below the dam, the channel is high-gradient and partially dewatered, possibly being another barrier. We had a funnel trap custom designed and fabricated to fit inside the ladder. Due to concerns about high runoff, we used electrical conduit for pickets that could be easily removed and cleaned. Pickets were spaced to leave as much gap as possible (32 mm) and still capture adult fish (>350 mm). In 1998, the trap was operated from April 30 through October 30. Field crews checked and cleaned the trap daily through July 18 and then generally several times a week thereafter. Volunteer Zane Larsen, the dam caretaker, checked the trap from September 16 to the end of October. In 1999, the trap was operated from March 29 through June 5 to collect data in April (which we missed in 1998 due to snow and trap design problems) and to radio tag adult trout. Field crews generally checked and cleaned the trap daily.

All fish captured were anesthetized, identified, and measured to the nearest millimeter. Trout, mountain whitefish, and suckers were marked with fin clips. Each fish was examined for other marks or tags, and signs of blackspot or whirling disease were noted. Field crews also tried to determine sex and maturity. Fish were released above the trap. Fish were also weighed (g) with a Pesola or spring scale in 1999.

South Fork Ladder Trap

The 1-2 m high concrete Rexburg City Ditch diversion is a complete migration barrier, and fish must navigate to and through a fish ladder (constructed by TREP in 1994) to move upstream (Figure 4). However, since flood damage in 1997, fish can sometimes move past the diversion in a bypass channel during high water. We had a new funnel trap fabricated to fit inside the ladder, replacing the old trap destroyed during high water in 1995. The new trap design was essentially the same as at Felt Dam. Compared to the 1995 trap, we used pickets spaced a little wider (6 mm greater gap). In 1995, the trap was installed April 20 but blew out overnight on May 7 due to sudden high runoff. In 1999, the trap was operated March 30 through May 31, although the bypass channel breached on May 1. Field crews checked and cleaned the trap daily both years.

All fish captured were anesthetized, identified, measured to the nearest millimeter, and weighed to the nearest gram with a Pesola or spring scale. Trout, mountain whitefish, and suckers were marked with fin clips. Each fish was examined for other marks or tags, and signs of blackspot or whirling disease were noted. Field crews also tried to determine sex and maturity. Fish were released above the trap.

Narrows and Hog Hollow Screw Traps

We used a floating screw trap placed at the old Tetonia USGS gauging station in the Narrows and at the USGS St. Anthony gage near Hog Hollow to quantify downstream movement of juvenile and other small fish (<160 mm, TL; Figure 4). The Narrows trap was near the location where Irving et al. (1977) trapped downstream migrants in 1975. It was operated March 31 through November 2, 1998. The Hog Hollow trap was operated April 23 through October 29, 1999. Field crews checked and cleaned the traps daily through the end of June, then generally every other day thereafter.

All fish captured were identified and measured to the nearest millimeter, except that field crews sometimes subsampled 20 dace or shiners and tallied the remainder. Fish were not generally anesthetized or weighed. Trout, mountain whitefish, and suckers were marked with fin clips. Each fish was examined for other marks or tags, and signs of blackspot or whirling disease were noted. Field crews also tried to determine sex and maturity. Fish were released below the trap.

Estimated screw trap efficiencies ranged from 0.5 to 4.0% based on radish tests conducted at different streamflows. For each test, 200 radishes were released 1 to 2 km upstream and, because they are neutrally buoyant, floated downstream. The proportion captured by the screw trap was the estimated trap efficiency.

Canyon Creek Spawner Surveys

Besides habitat changes from the Teton Dam failure, lower Canyon Creek suffers from several irrigation diversions that dewater the stream and are likely migration barriers. After observing a radio-tagged fish move above the lower diversion in spring 1999, we conducted surveys in upper Canyon Creek and several of its tributaries to look for large (≥350 mm), spawning cutthroat trout. Adult fish this size are believed to have originated from the Teton River. On June 29, 1999, field crews walked Canyon Creek upstream from the Calamity Creek confluence (about 0.8 km), as well as lower Wright Creek (about 1.2 km), lower Warm Creek (about 1.4 km), and lower Calamity Creek (about 0.8 km). On May 18 and June 15, 2000, field crews electrofished Canyon Creek upstream from the Calamity Creek confluence (about 1.6 km) and upstream from the Kirkham Hollow road bridge (USFS road 218; about 1.6 km). On May 31, 2001, we walked Calamity Creek upstream from USFS road 218 (about 2.0 km). All surveys were upstream from the landslides and from Green Canyon Hot Springs, where the uppermost irrigation diversion is located.

RESULTS

Marking and Tagging

Jaw tags were recovered from 18 (or 2%) of the 854 fish tagged from 1987 to 1996 (Appendix A). Fish movement between sections was minor, as 17 of the 18 recovered tags (94%) came from the same section where they were released. Only one tagged cutthroat trout moved upstream—from the Lower Teton (at Hog Hollow) to the Teton Canyon (at Parkinson). Overall, five tags were recovered from the Lower Teton, five from the Teton Canyon, and eight from the Teton Valley. These were from eight cutthroat trout and 10 wild rainbow trout. Anglers returned 14 of the tags, and the remaining four were recovered from other surveys. No tags were recovered later than two years from the tagging date, and no tags have been recovered since 1995.

Similar lack of movement between sections was observed prior to the dam failure. Jaw tags were recovered from 426 (or 8%) of the 5,267 fish that were tagged from 1974 to 1975 (Irving et al. 1977). Fish movement between sections was minor as 423 of the 426 tags (99%) came from the same section where they were released. Three tagged cutthroat trout had moved. One moved upstream from the Lower Teton (at Hog Hollow) to the Teton Canyon (at Linderman Dam). Another two moved downstream—one from the Lower Teton (at Hog Hollow) to the Snake River (at Idaho Falls), and one from the Teton Canyon to the Lower Teton (at Hog Hollow). We excluded their 1976 jaw-tag return data due to the Teton Dam collapse and its confounding effects.

We recaptured 34 (or less than 1%) of the 5,134 fish that were fin-clipped from 1997 to 1999 (Appendix B). Fish movement between sections was minor, as 27 of the 34 recaptures (79%) came from the same section where they were released. The seven fish that moved had gone upstream as well as downstream, but some of the returns were questionable. Overall, four fish were recaptured in the Lower Teton, two in the Teton Canyon, and 28 in the Teton Valley. Fifteen fin-clipped mountain whitefish were recaptured, as well as 13 cutthroat trout, three suckers, two brook trout, and one wild rainbow trout. Of the 174 trout VI tagged in 1999, one cutthroat trout was recaptured in the same Teton Canyon pool where it was tagged.

Radio Telemetry

In general, radio-tagged trout did not move between study sections, although they were observed moving long distances within study sections to spawn. Only one cutthroat trout (150.013) moved between sections; it was radio tagged just below Teton Dam and moved upstream into the Borrow Ponds to overwinter and spawn. Another rainbow trout (150.883) may have moved from the Teton Valley to the entrance of the Teton Canyon to overwinter, although it more likely died and floated downstream. Five fish moved out of the Teton River and into the lower Henrys Fork Snake River to overwinter or spawn. Four were from the North Fork, where upstream movement was never observed, and the fifth was from the South Fork. These fish included two cutthroat trout (150.045 and 150.713), two rainbow trout (150.383 and 150.823), and one hybrid trout (150.103). In general, trout throughout the Teton River moved very little during fall and winter (September to February).

In all study sections, radio-tagged fish displayed two distinct spawning strategies during spring and early summer (March to mid-July). Fourteen cutthroat, one rainbow, and one hybrid trout moved to tributaries to spawn (Moody, Canyon, Bitch, Teton, Fox, and Trail creeks; Figure 5; Appendix J). Most of these cutthroat trout (n = 8) and the hybrid trout spawned in Teton Creek, whereas the rainbow trout spawned in Fox Creek. In contrast, eight cutthroat, three rainbow, and four hybrid trout moved to mainstem sites to spawn (Appendix K). One of these cutthroat trout spawned in the lower Henrys Fork Snake River, six spawned in the Lower Teton (five in the South Fork), and one spawned in the Teton Valley. Two rainbow trout spawned in the lower Henrys Fork Snake River, and one spawned in the Teton Valley. Two hybrid trout spawned in the Teton Canyon (all above Canyon Creek), and two spawned in the Teton Valley. Most mainstem spawners moved upstream, but some moved downstream. Ten additional fish did not move but may have spawned near their mainstem release locations (Appendix L). These results exclude seven fish that died or were lost prior to the 1999 spawning season (Appendix M), five fish that were lost or harvested within 56 days of surgery (Appendix N), and the 26 post-surgery mortalities (Appendix O).

For tributary spawners in all sections combined, cutthroat trout began moving between March 6 and June 11, and their migration period averaged 28 d (range 0 to 98 d; Table 1). They entered their spawning area between May 1 and July 3, spawned between May 17 and July 7, left their spawning area between June 2 and July 11, and their spawning period averaged 19 d (range 7 to 41 d). In Teton Creek, cutthroat and hybrid trout spawning periods overlapped, providing an opportunity for introgression (Figure 6). In Fox Creek, the rainbow trout spawning period was earlier and did not overlap with cutthroat trout from other tributaries.

For mainstem spawners in all sections combined, cutthroat trout began moving between March 6 and May 23, and their migration period averaged 7 d (range 0 to 28 d; Table 2). They entered their spawning area between March 6 and June 19, spawned between April 2 and June 26, left their spawning area between April 8 and July 3, and their spawning period averaged 28 d (range 11 to 64 d). Rainbow trout began moving between April 18 and May 23, and their migration period averaged 12 d (range 0 to 27 d). They entered their spawning area between April 18 and June 19, spawned between April 21 and June 26, left their spawning area between April 24 and July 3, and their spawning period averaged 23 d (range 7 to 48 d). Hybrid trout began moving between March 28 and May 23, and their migration period averaged 13 d (range 0 to 34 d). They entered their spawning area between March 28 and June 25, spawned between April 4 and July 3, left their spawning area between April 12 and August 8, and their spawning period averaged 36 d (range 15 to 94 d). Both rainbow and hybrid trout spawning periods overlapped with cutthroat trout, providing an opportunity for introgression (Figure 6).

Migrant Trapping

Felt Dam Ladder Trap

Although the Felt Dam ladder trap was operated six months in 1998 (April 30 to October 30), and two months in 1999 (March 29 to June 5), only nine adult fish (≥350 mm) were captured moving upstream over both years (Figure 7). A ripe female rainbow trout (386 mm) was trapped on May 8, 1999, and a ripe male rainbow trout (414 mm) was trapped on May 20, 1998. Six more non-ripe adults were trapped in 1998 (one cutthroat trout, three rainbow trout, and two mountain whitefish), and another rainbow trout was trapped in 1999. The remaining 63 fish caught in 1998 and 24 fish caught in 1999 were too small to be fully recruited to the trap gear (Table 3). Therefore, they are probably not representative of all fish movements. Most of these fish were small mountain whitefish, but they were not moving to spawn since they spawn in the fall. No suckers were trapped. Average fish size was 236 mm (range 155 to 440 mm) in 1998 (Appendix P), and 182 mm (range 131 to 386 mm) in 1999 (Appendix Q).

South Fork Ladder Trap

Although the South Fork ladder trap was operated less than a month in 1995 (April 20 to May 7), and two months in 1999 (March 30 to May 31), 1,440 adult fish were captured moving upstream over both years. They included 73 cutthroat trout, nine rainbow trout, and five mountain whitefish (Figure 7). Another 1,353 adult suckers were also trapped (Figure 8). The remaining six fish caught in 1995 and 14 fish caught in 1999 were too small to be fully recruited to the trap gear (Table 3). Therefore, they are probably not representative of all fish movements.

Average fish size was 460 mm (range 298 to 570 mm) in 1995 (Appendix R) and 476 mm (range 190 to 600 mm) in 1999 (Appendix S).

Upstream movement of cutthroat trout, suckers, and rainbow trout was for spawning. Over both years, the cutthroat trout spawning run started April 13 and continued through May 5, near the time the trap blew out or the bypass channel breached (Figure 7). At least 15 ripe cutthroat trout males and three ripe females were trapped over this time period. The sucker spawning run started April 13 and continued through May 29 (Figure 8). At least 665 ripe sucker males (448 had tubercles) and 35 ripe females were trapped over this time period. Rainbow trout were trapped from April 13 to May 6, overlapping cutthroat trout run timing almost to the day (Figure 7). None were obviously ripe. Run timing for all species would likely have been longer if trapping had continued.

Narrows Screw Trap

A total of 17,481 fish were captured moving downstream at the Narrows screw trap in 1998 (Table 3). Most were dace (74%) and redside shiners (23%), whereas 2% were suckers and cottids and 1% was unknown non-salmonid fry, mountain whitefish, and trout (cutthroat, rainbow, brook, and unknown taxa). Of 8,507 fish trapped in 1975, 93% were dace, 1% was redside shiners, 5% were suckers and cottids, and 1% was trout (Irving et al. 1977). However, they trapped in late summer and fall just upstream of our site and used a different trap design. Average fish size was 67 mm (range 11 to 390 mm; n = 3,984) in 1998 (Appendix T) but was not reported for 1975 (Irving et al. 1977).

In 1998, most redside shiners were trapped in June and July (Figure 9), whereas most dace (Figure 10) and suckers (Figure 11) were trapped in August and September. Downstream movements of the remaining taxa, including juvenile trout, were random based on the few fish captured (Figures 12 to 15).

We did not adjust our numbers for screw trap efficiency, from 1 to 5% at both screw traps, but this would not likely change our conclusions.

Hog Hollow Screw Trap

A total of 8,098 fish were captured moving downstream at the Hog Hollow screw trap in 1999 (Table 3). Most were dace (53%) and redside shiners (19%), whereas 16% were unknown non-salmonid fry, 6% were mountain whitefish, 5% were suckers and cottids, and 1% was Utah chubs and trout (cutthroat, rainbow, and unknown taxa). Average fish size was 46 mm (range 8 to 385 mm; n = 4,012; Appendix U).

Most redside shiners (Figure 9), dace (Figure 10), and mountain whitefish (Figure 12) were trapped in May and June, whereas most suckers (Figure 11), cottids (Figure 13), and unknown non-salmonid fry (Figure 14) were trapped from August to October. Downstream movements of juvenile trout were random based on the few fish captured (Figure 15).

We did not adjust our numbers for screw trap efficiency, from 1 to 5% at both screw traps, but this would not likely change our conclusions.

Canyon Creek Spawner Survey

Adult cutthroat trout (>350 mm) were not observed spawning in Canyon Creek or its tributaries in 1999. However, the survey was conducted in late June, and they may have returned to the Teton River. In 2000, 12 adult cutthroat trout were electrofished in Canyon Creek just above the Calamity Creek confluence, and three more above the Kirkham Hollow road bridge, on May 18. Most were ripe and ready to spawn. Another three fish were captured on June 15. Canyon Creek was dry below the Canyon Creek Canal diversion on this date. In 2001, we counted 12 adult cutthroat trout spawning in upper Calamity Creek and two female kelts on May 31. Numerous redds were also observed, and fish were paired on several of them. The ranch manager reported seeing several hundred spawners the week before (C. Ferney, personal communication).

DISCUSSION

Like pre-dam observations reported by Irving et al. (1977), we observed very few adult or juvenile game fish moving between the three Teton River study sections. Radio-tagged adult trout did move from just below to just above Teton Dam, but this connectivity was observed prior to the dam being built (Irving et al. 1977). Adult trout also moved from the lower Teton River to the lower Henrys Fork Snake River—which was also observed historically (S. Elle, IDFG, personal communication)—to spawn and perhaps to overwinter. Many other adult trout moved long distances within, but not between, study sections to spawn. In general, adult trout overwinter movements were minimal. Few juvenile trout, but very large numbers of adult dace and redside shiners, were trapped moving downstream between sections, both pre-dam (Irving et al. 1977) and post-dam. Some of the dace and redside shiners were ripe, but the timing and duration of their movements suggests they were not necessarily moving to spawn. Moving downstream makes them more vulnerable to predation and may explain why Teton River trout grow to such a large size (Schrader and Brenden, in press).

Game fish in the mainstem Teton River are fragmented into three independent and isolated populations. Based on our movement data, these include: 1) the lower Teton River and lower Henrys Fork Snake River population, including Moody Creek upstream to Webster Dam; 2) the Teton Canyon population (from the Wilford irrigation diversion upstream to Felt Dam), including Canyon, Bitch, and possibly lower Badger creeks; and 3) the Teton Valley population, including lower Teton, Fox, and Trail creeks. These populations are not entirely isolated as downstream movement is always possible given adequate streamflows. Whether isolation occurred naturally prior to Teton Dam is not known.

The dramatic changes in hydrology and geomorphology caused by the dam collapse (Randle et al. 2000) have not changed game fish migration patterns, blocked fish passage, nor further isolated these populations. Neither do game fish migrate to the new pool habitat that was created in the Teton Canyon to rear or overwinter. Whether adult suckers move from the Lower Teton into the Teton Canyon to spawn, to the detriment of game fish populations, is unknown.

Numerous irrigation diversion structures in the Lower Teton—most of which were rebuilt by BOR after the dam collapsed—and Felt Dam in the Teton Canyon have probably further fragmented and isolated these populations. The irrigation diversions were rebuilt without adequate adult or juvenile fish passage facilities (Moore and Andrews 1983), and they may have further isolated Lower Teton fish populations from those in the Teton Canyon. For example, no radio-tagged trout moved upstream in the North Fork or in the South Fork above the fish ladder during this study (one fish did move downstream from Hog Hollow to spawn near the fish ladder). Most of the diversion structures are located in these areas of the Lower Teton where fish did not move. In the Teton Canyon, no radio-tagged trout moved upstream to Felt Dam, and few adult fish of any taxa were trapped there during the study period. Similar findings were reported from tagging and ladder trapping in the late 1980s (ERI 1987, 1988). Felt Dam was known to be a complete barrier to fish from the early 1900s to 1986.

In contrast to Felt Dam, many spawning cutthroat trout and suckers moved upstream through the South Fork fish ladder. The ladder was built by IDFG in 1994 to bypass a major irrigation diversion (the Rexburg City Ditch). At least some of these cutthroat trout spawn in Moody Creek, but where the remainder spawn is unknown. Our trap catch numbers are not run sizes because of trap failures in both 1995 and 1999 (corroborated by two radio-tagged cutthroat trout that bypassed the trap the week of May 23, 1999). Downstream, the Rexburg Canal diversion is not a complete barrier to these fish except when it completely dewaters the channel. Cutthroat trout trapped in the South Fork ladder were relatively large fish, averaging 458 mm in total length. They were about 100 mm larger on average than fluvial fish at the Burns Creek and Palisades Creek weirs in the South Fork Snake River drainage (Figure 16), and about 28 mm smaller than adfluvial fish at the Blackfoot River weir (Figure 17).

Radio-tagged trout were observed moving to both tributary and mainstem spawning sites in all Teton River study sections. Like the South Fork Snake River (Henderson et al. 2000), most cutthroat trout in the Teton River spawned in tributaries and most rainbow and hybrid trout spawned in the mainstem. Overlapping spawning times and locations of the two taxa have led to hybridization and genetic introgression. Irving et al. (1977) recognized the importance of tributaries to spawning cutthroat trout prior to the Teton Dam collapse, as did Jeppson (1981) shortly thereafter. We have no evidence that life history strategies of cutthroat trout or any other taxa changed following the dam collapse, i.e. from resident to fluvial or mainstem to tributary spawning. The dam collapse resulted in spawning riffles being replaced by pools in the Teton Canyon (Randle et al. 2000) and being filled with sediment in the Lower Teton (Moore and Andrews 1983).

In the Teton Canyon, several radio-tagged cutthroat trout spawned in Bitch Creek, which is currently the only pristine tributary with permanent flow in the Teton River drainage. This stream has long been recognized as, and probably continues to be, the major spawning and rearing area for cutthroat trout (Jeppson 1981). Another radio-tagged cutthroat trout spawned in Canyon Creek in 1999, and over 30 spawners and numerous redds were observed there in 2000 and 2001. Recruitment from Canyon Creek is limited by irrigation water withdrawals at two diversions, which completely dewatered the stream in 2000 and 2001. BOR should consider restoring permanent flows in Canyon Creek as the best and most cost-effective way to increase the cutthroat trout population in the Teton Canyon.

In the Lower Teton, most radio-tagged fish spawned in the South Fork or in the lower Henrys Fork Snake River. No fish spawned in the degraded North Fork. Only two cutthroat trout spawned in Moody Creek (just below Webster Dam, which is a complete barrier) after they passed through three suspected irrigation diversion barriers and a large amount of degraded habitat. Although habitat in the entire Lower Teton has been severely degraded, restoring permanent flows in the South Fork Teton River and Moody Creek is the best and most cost-effective way to increase the cutthroat trout population.

In the Teton Valley, most radio-tagged fish spawned in tributaries, although a few fish spawned in the mainstem. Teton Creek is, by far, the most important spawning tributary, but fish also spawned in Fox and Trail creeks. These three tributaries continue to need protection from overharvest and housing development, and much of the severely degraded habitat needs restoration. Why fish did not spawn in numerous other Teton Valley tributaries is not known, but it may be related to irrigation dewatering.

ACKNOWLEDGEMENTS

Mark Gamblin, Jody Brostrom, and a number of volunteers jaw tagged fish from 1987-1992. Jeff Dillon, Doug Megargle, John Anderson, and Jason Hammond sampled the mainstem and Steve Elle and crew sampled tributaries to fin clip fish in 1997. Kevin Brenden and Gillian Crymes VI-tagged fish in 1999. Brian Spicer, Lee Jones, and a number of volunteers helped with radio tagging in 1998 and 1999. Becky Lish ran the fish traps in 1995, Brian Spicer and Lee Jones ran them in 1998, and Gillian Crymes ran them in 1999. Clint Rasmussen rebuilt the South Fork ladder trap and entered data in 1999. Kevin Brenden, Gillian Crymes, Scott Host, and Curtis Ferney helped with Canyon Creek spawning surveys from 1999-2001. Jim DeRito provided the picture for the cover page. Jim Fredericks edited earlier drafts of this report, and Steve Yundt, Fred Partridge, and Dick Bauman reviewed the final draft.

Partial funding for this study was provided by the U.S. Department of Interior, Bureau of Reclamation, under cooperative agreement #1425-7-FC-10-03590.

Table 1. Spawning-migration statistics for the 16 radio-tagged trout that spawned in tributaries of the Teton River, Idaho, 1999.

Variable	Rainbow trout Range	Rainbow trout Mean	Hybrid trout Range	Hybrid trout Mean	Cutthroat trout Range	Cutthroat trout Mean
Lower Teton						
Begin migration	ND[a]	ND	ND	ND	Mar 6-Apr 4	Mar 20
Enter spawning area	ND	ND	ND	ND	Jun 11	Jun 11
Spawning date	ND	ND	ND	ND	Jun 15	Jun 15
Leave spawning area	ND	ND	ND	ND	Jun 19	Jun 19
Migration period (d)	ND	ND	ND	ND	69-98	83
Spawning period (d)	ND	ND	ND	ND	8	8
Sample size	ND	ND	ND	ND	2	2
Teton Canyon						
Begin migration	ND	ND	ND	ND	Apr 24-May 23	May 8
Enter spawning area	ND	ND	ND	ND	Jun 11-Jun 25	Jun 18
Spawning date	ND	ND	ND	ND	Jun 16-Jun 29	Jun 22
Leave spawning area	ND	ND	ND	ND	Jun 22-Jul 3	Jun 26
Migration period (d)	ND	ND	ND	ND	34-48	41
Spawning period (d)	ND	ND	ND	ND	7-11	8
Sample size	ND	ND	ND	ND	3	3
Teton Valley						
Begin migration	Mar 6	Mar 6	May 23	May 23	Apr 24-Jun 11	May 24
Enter spawning area	Mar 6	Mar 6	Jun 25	Jun 25	May 1-Jul 3	Jun 4
Spawning date	Mar 24	Mar 24	Jun 29	Jun 29	May 17-Jul 7	Jun 17
Leave spawning area	Apr 12	Apr 12	Jul 3	Jul 3	Jun 2-Jul 11	Jun 30
Migration period (d)	0	0	34	34	0-32	11
Spawning period (d)	37	37	8	8	9-41	26
Sample size	1	1	1	1	9	9
All Sections Combined						
Begin migration	Mar 6	Mar 6	May 23	May 23	Mar 6-Jun 11	May 11
Enter spawning area	Mar 6	Mar 6	Jun 25	Jun 25	May 1-Jul 3	Jun 8
Spawning date	Mar 24	Mar 24	Jun 29	Jun 29	May 17-Jul 7	Jun 18
Leave spawning area	Apr 12	Apr 12	Jul 3	Jul 3	Jun 2-Jul 11	Jun 28
Migration period (d)	0	0	34	34	0-98	28
Spawning period (d)	37	37	8	8	7-41	19
Sample size	1	1	1	1	14	14

[a] ND = No data; no radio-tagged trout was observed to spawn.

Table 2. Spawning-migration statistics for the 15 radio-tagged trout that spawned in the mainstem Teton River and lower Henrys Fork Snake River, Idaho, 1999.

Variable	Rainbow trout Range	Rainbow trout Mean	Hybrid trout Range	Hybrid trout Mean	Cutthroat trout Range	Cutthroat trout Mean
			Lower Teton			
Begin migration	May 1-May 23	May 12	ND[a]	ND	Mar 6-May 23	Apr 4
Enter spawning area	May 9-Jun 19	May 29	ND	ND	Mar 6-Jun 19	Apr 11
Spawning date	Jun 1-Jun 26	Jun 13	ND	ND	Apr 2-Jun 26	Apr 26
Leave spawning area	Jun 25-Jul 3	Jun 29	ND	ND	Apr 8-Jul 3	May 11
Migration period (d)	8-27	17	ND	ND	0-28	8
Spawning period (d)	14-48	31	ND	ND	11-64	29
Sample size	2	2	ND	ND	7	7
			Teton Canyon			
Begin migration	ND	ND	Mar 28-May 23	Apr 25	ND	ND
Enter spawning area	ND	ND	Apr 14-Jun 25	May 20	ND	ND
Spawning date	ND	ND	Apr 23-Jul 3	May 28	ND	ND
Leave spawning area	ND	ND	May 2-Jul 11	Jun 6	ND	ND
Migration period (d)	ND	ND	17-34	25	ND	ND
Spawning period (d)	ND	ND	16-18	17	ND	ND
Sample size	ND	ND	2	2	ND	ND
			Teton Valley			
Begin migration	Apr 18	Apr 18	Mar 28-May 6	Apr 17	May 16	May 16
Enter spawning area	Apr 18	Apr 18	Mar 28-May 6	Apr 17	May 16	May 16
Spawning date	Apr 21	Apr 21	Apr 4-Jun 22	May 14	May 24	May 24
Leave spawning area	Apr 24	Apr 24	Apr 12-Aug 8	Jun 10	Jun 1	Jun 1
Migration period (d)	0	0	0	0	0	0
Spawning period (d)	7	7	15-94	54	17	17
Sample size	1	1	2	2	1	1
			All Sections Combined			
Begin migration	Apr 18-May 23	May 4	Mar 28-May 23	Apr 21	Mar 6-May 23	Apr 9
Enter spawning area	Apr 18-Jun 19	May 15	Mar 28-Jun 25	May 3	Mar 6-Jun 19	Apr 16
Spawning date	Apr 21-Jun 26	May 27	Apr 4-Jul 3	May 21	Apr 2-Jun 26	Apr 30
Leave spawning area	Apr 24-Jul 3	Jun 7	Apr 12-Aug 8	Jun 8	Apr 8-Jul 3	May 13
Migration period (d)	0-27	12	0-34	13	0-28	7
Spawning period (d)	7-48	23	15-94	36	11-64	28
Sample size	3	3	4	4	8	8

[a] ND = No data; no radio-tagged trout was observed to spawn.

Table 3. Number of fish captured at Teton River, Idaho, trapping locations, 1995-1999. Species relative proportions are in parentheses. Traps are listed going upstream.

Location, gear, date, and total fish	Cutthroat trout	Rainbow trout	Unknown trout fry[a]	Brook trout	Mountain white-fish	Sucker	Cottid	Dace	Red-side shiner	Utah chub	Unknown other fry[b]
					Lower Teton						
South Fork Ladder Trap 1995 Total=394	12 (3)	6 (2)	ND[c]	ND	5 (1)	371 (94)	ND	ND	ND	ND	ND
South Fork Ladder Trap 1999 Total=1,066[d]	64[d] (6)	3 (<1)	ND	ND	10 (1)	989 (93)	ND	ND	ND	ND	ND
Hog Hollow Screw Trap 1999 Total=8,098	19 (<1)	3 (<1)	42 (<1)	ND	515 (6)	224 (3)	213 (3)	4,255 (53)	1,553 (19)	9 (<1)	1,265 (16)
					Teton Canyon						
Felt Dam Ladder Trap 1998 Total=70	2 (3)	6 (9)	ND	ND	62 (89)	ND	ND	ND	ND	ND	ND
Felt Dam Ladder Trap 1999 Total=26	1 (4)	7 (27)	ND	ND	18 (69)	ND	ND	ND	ND	ND	ND
Narrows Screw Trap 1998 Total=17,481	57 (<1)	24 (<1)	14 (<1)	4 (<1)	37 (<1)	402 (2)	62 (<1)	12,893 (74)	3,947 (23)	ND	41 (<1)
Total=27,136	**155 (<1)**	**49 (<1)**	**56 (<1)**	**4 (<1)**	**648 (2)**	**1,986 (7)**	**275 (1)**	**17,148 (63)**	**5,500 (20)**	**9 (<1)**	**1,306 (5)**

[a] Cutthroat, rainbow, or hybrid trout fry too small to identify.
[b] Non-salmonid fry too small to identify.
[c] ND = no data; no fish captured.
[d] Excludes two cutthroat trout that were later radio tagged.

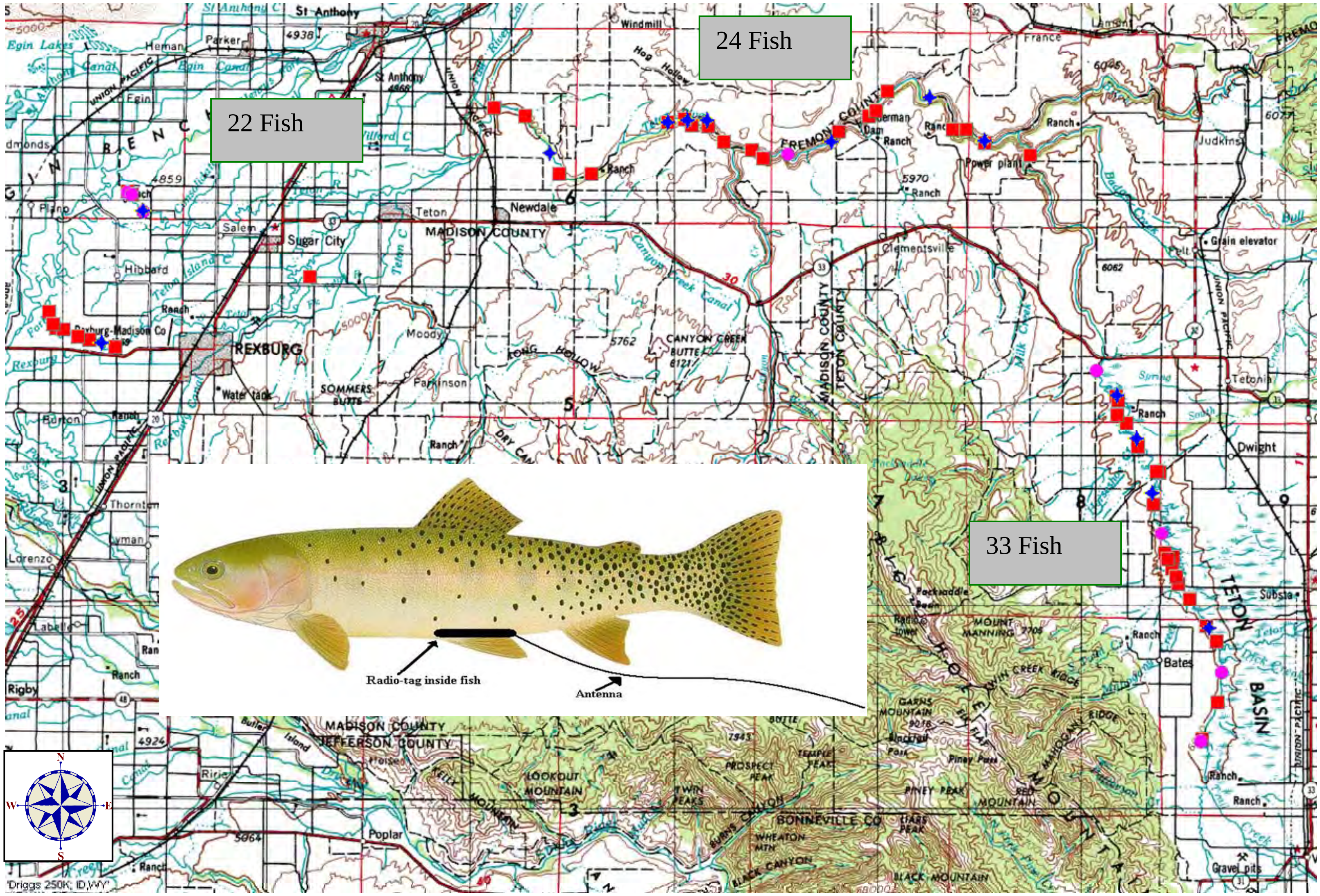


Figure 1. Location of the 79 adult trout radio tagged and released in the Teton River, Idaho, August 5, 1998 to May 23, 1999 (n = 22 in Lower Teton, n = 24 in Teton Canyon, and n = 33 in Teton Valley). Squares are cutthroat trout, circles are rainbow trout, and diamonds are hybrid trout.

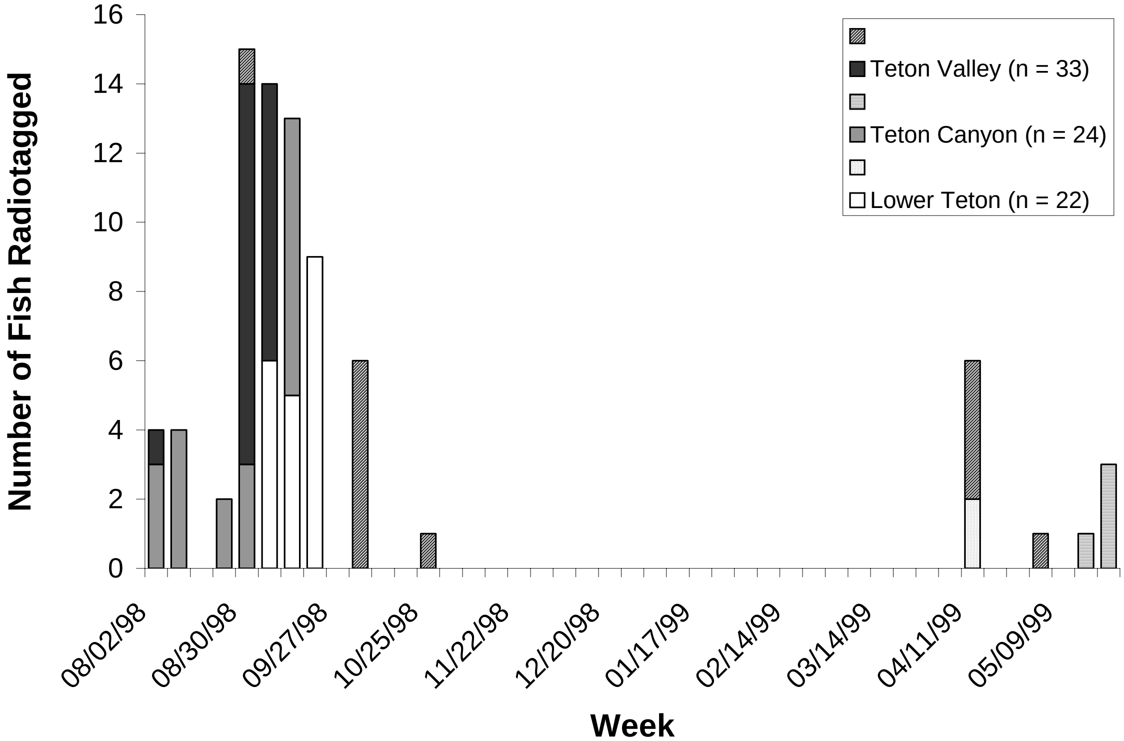


Figure 2. Number of fish radio tagged each week in the mainstem Teton River, Idaho, August 5, 1998 to May 23, 1999. Solid bars are the original 60 fish that were radio tagged (20 in each section); patterned bars are the 19 fish that were fitted with reused transmitters.

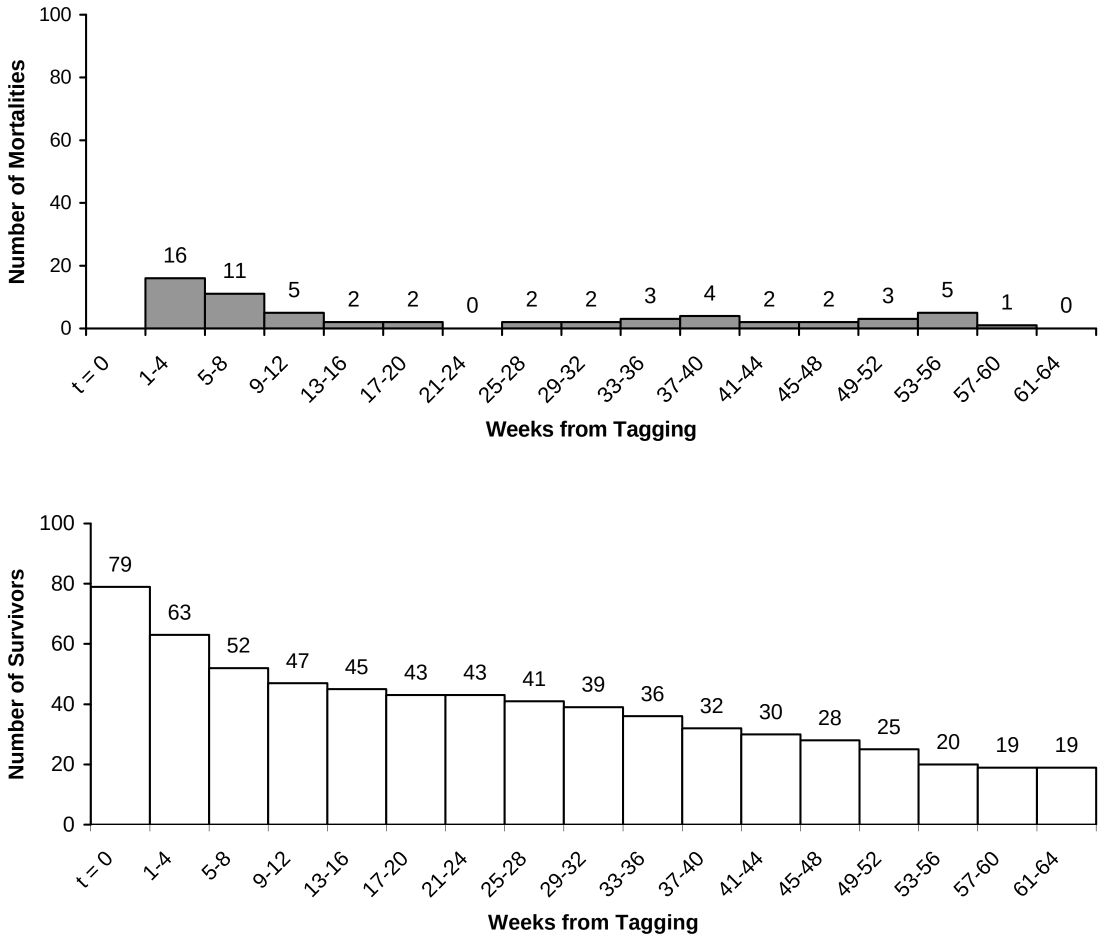


Figure 3. Number of radio-tagged fish that died or survived from initial time of tagging (t = 0) to consecutive four-week intervals, mainstem Teton River, Idaho, 1998-1999. Total fish that were radio tagged = 79.

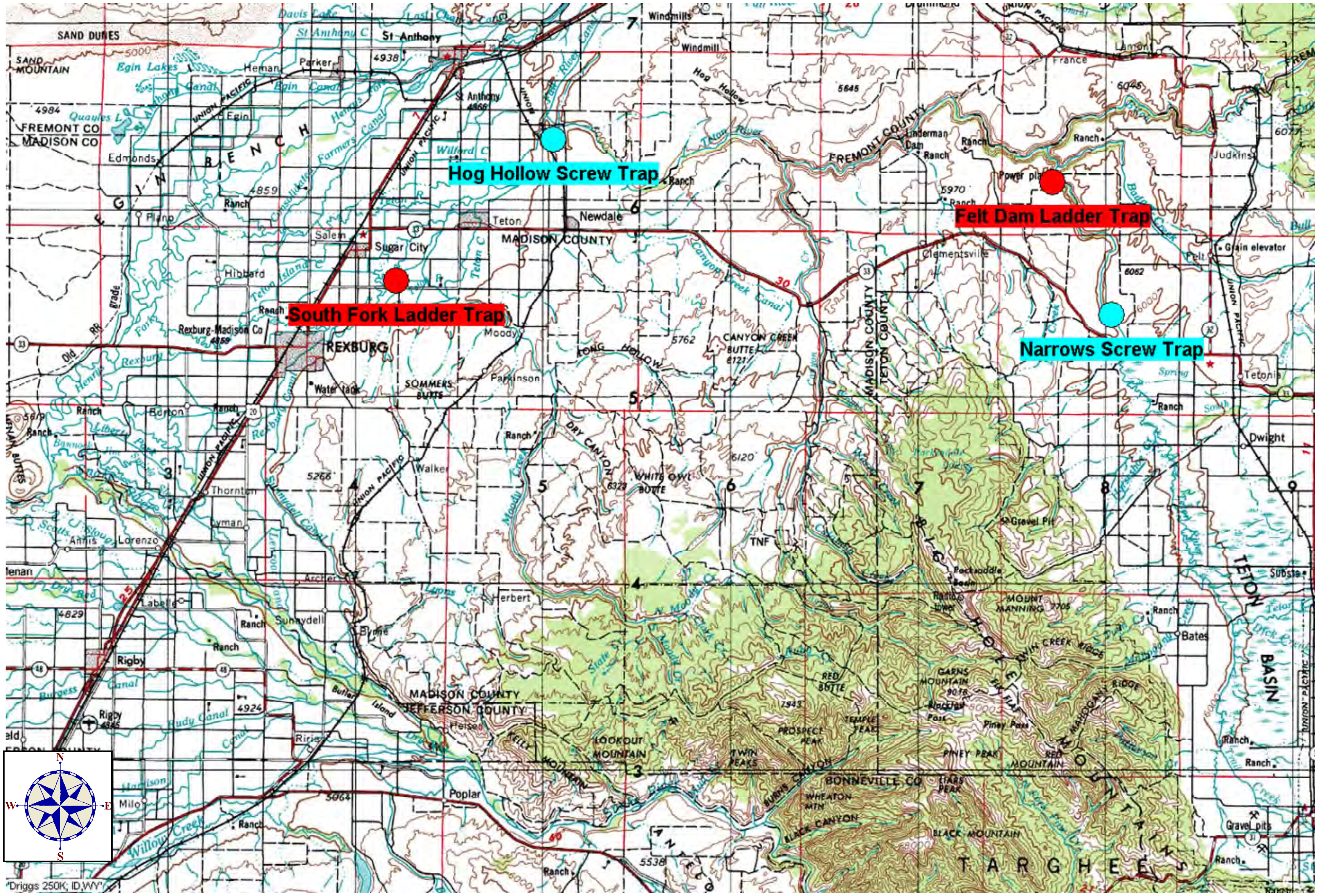


Figure 4. Location of ladder traps and screw traps used in the Teton River, Idaho, 1998-1999. The ladder traps (red) captured adult upstream migrants, whereas the screw traps (blue) captured juvenile and other small fish downstream migrants.

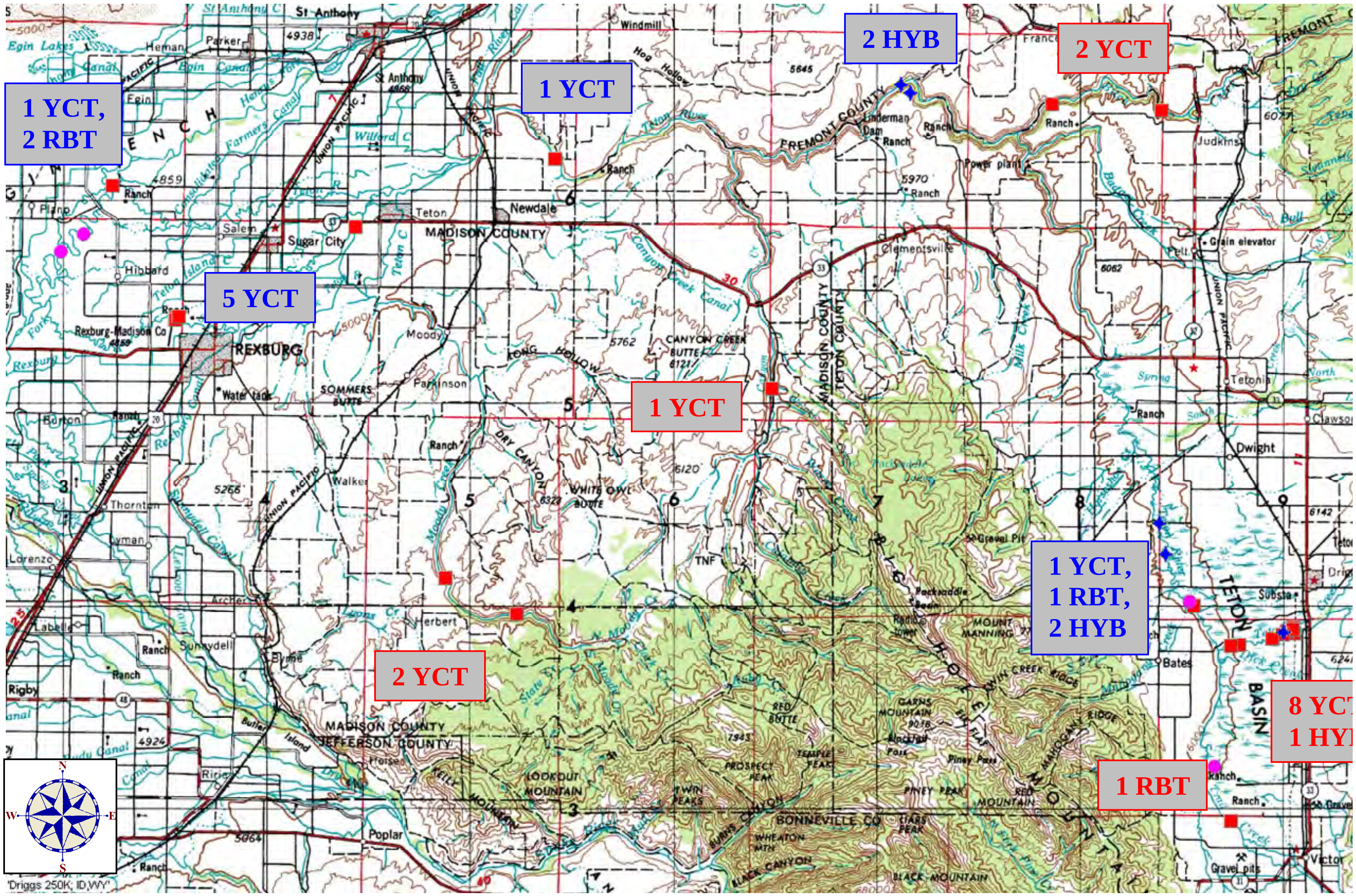


Figure 5. Spawning locations of 31 radio-tagged trout that spawned in the Teton River and lower Henrys Fork Snake River, Idaho, 1999. Sixteen fish spawned in tributaries (red)—14 cutthroat (squares), one rainbow (circle), and one hybrid trout (diamond). Fifteen fish spawned in the mainstem (blue)—eight cutthroat, three rainbow, and four hybrid trout.

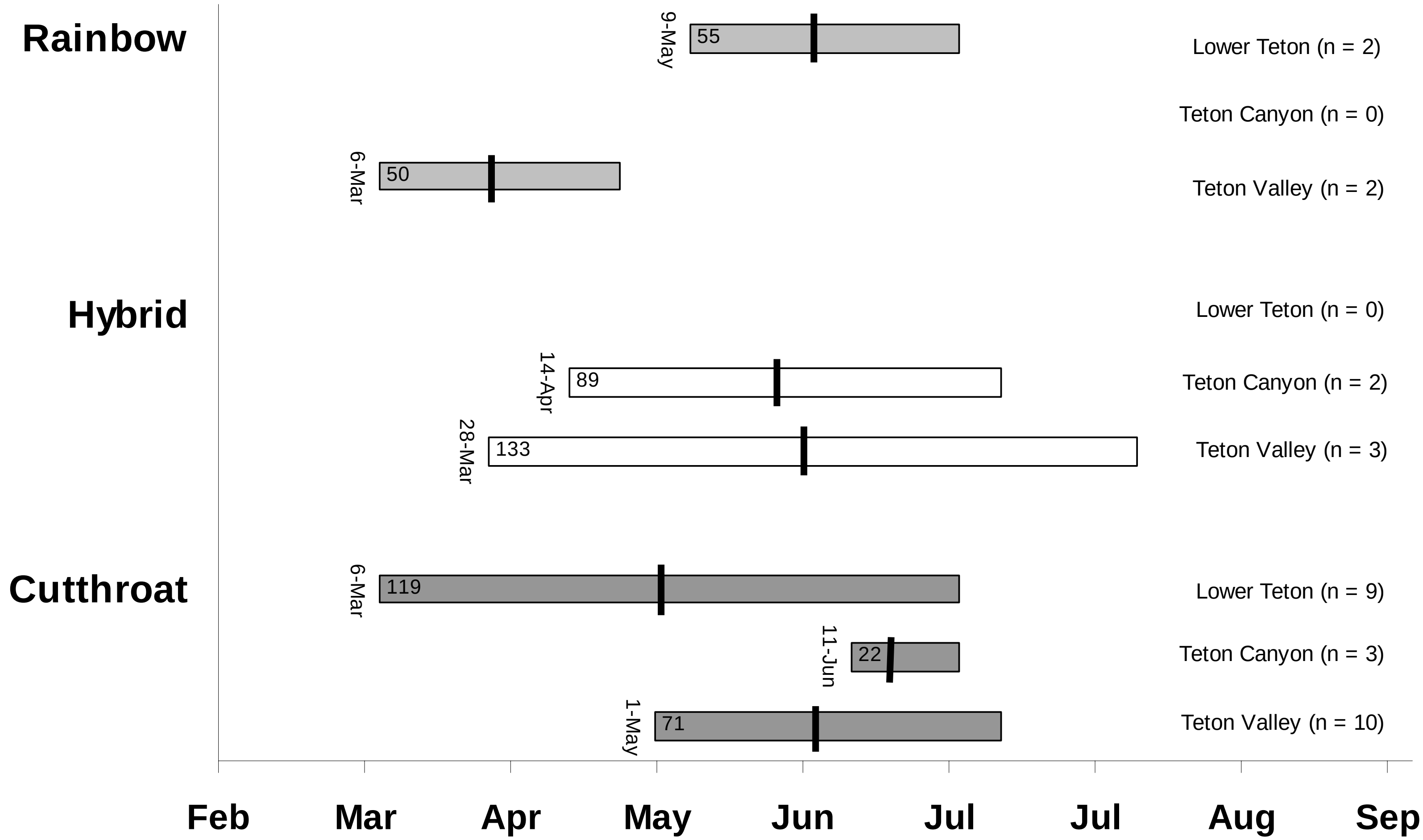
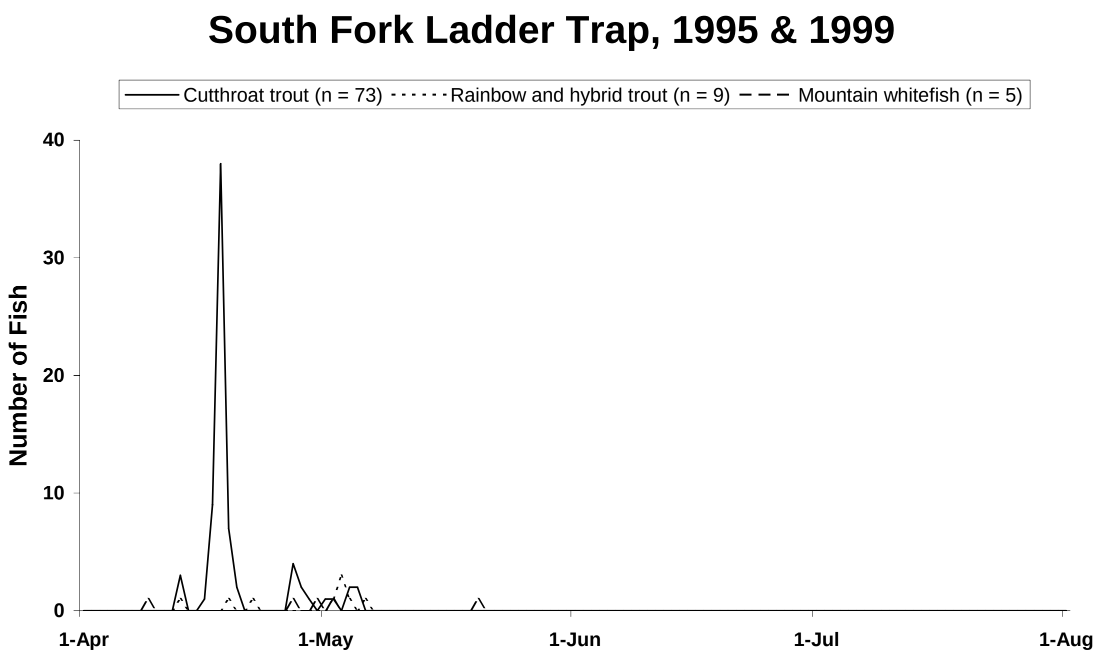


Figure 6. Spawning periods by taxa and section of the 31 radio-tagged trout that spawned in the Teton River (including tributaries) and lower Henrys Fork Snake River, Idaho, 1999. Lines represent the average spawning date.



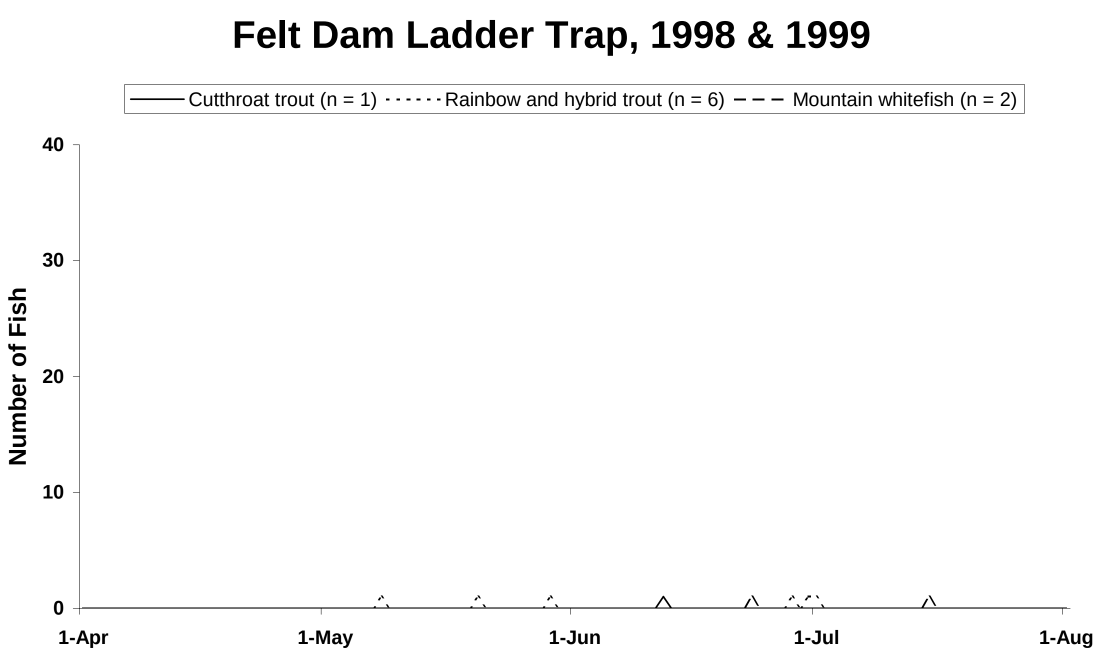


Figure 7. Comparison of adult (≥350 mm) trout and mountain whitefish migration timing at the South Fork (1995 and 1999 combined) and Felt Dam (1998 and 1999 combined) ladder traps, Teton River, Idaho. Fish ≥350 mm were considered fully recruited to the trap gear.

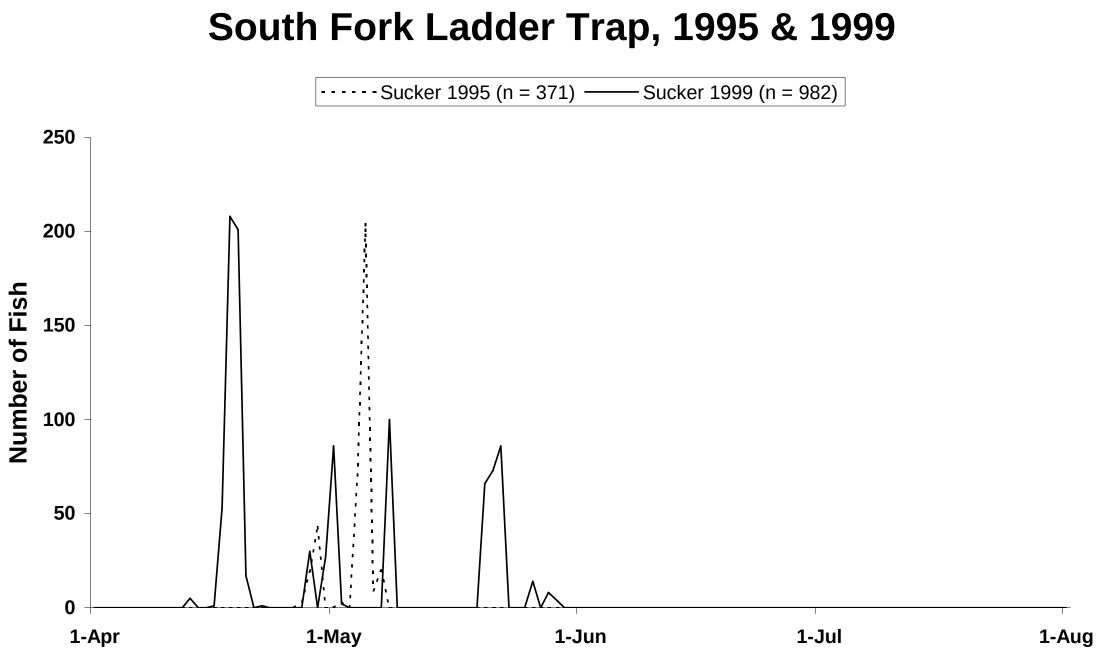
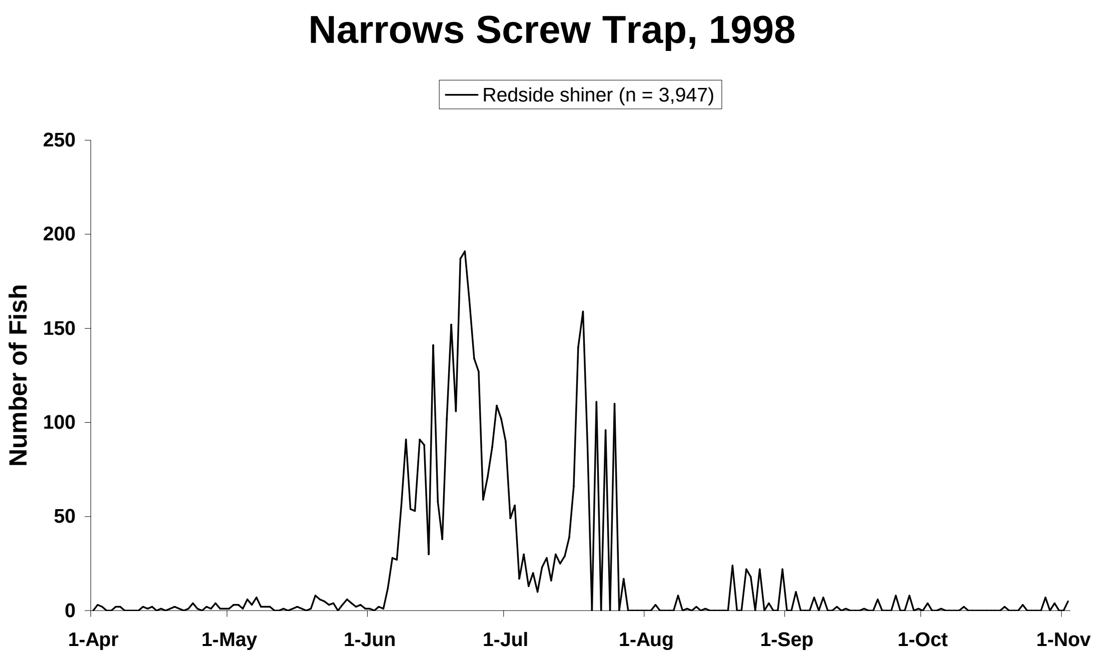


Figure 8. Adult (≥350 mm) sucker migration timing at the South Fork ladder trap, 1995 and 1999, Teton River, Idaho. Fish ≥350 mm were considered fully recruited to the trap gear.



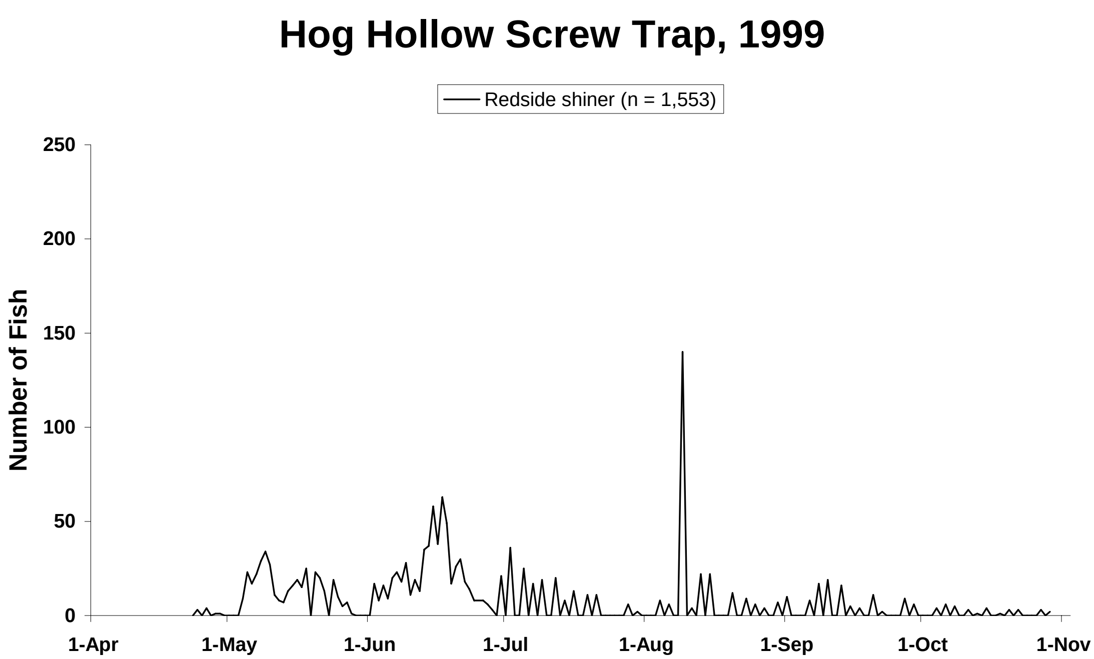


Figure 9. Comparison of redside shiner migration timing at the Narrows (1998) and Hog Hollow (1999) screw traps, Teton River, Idaho. Fish <150 mm were considered fully recruited to the trap gear.

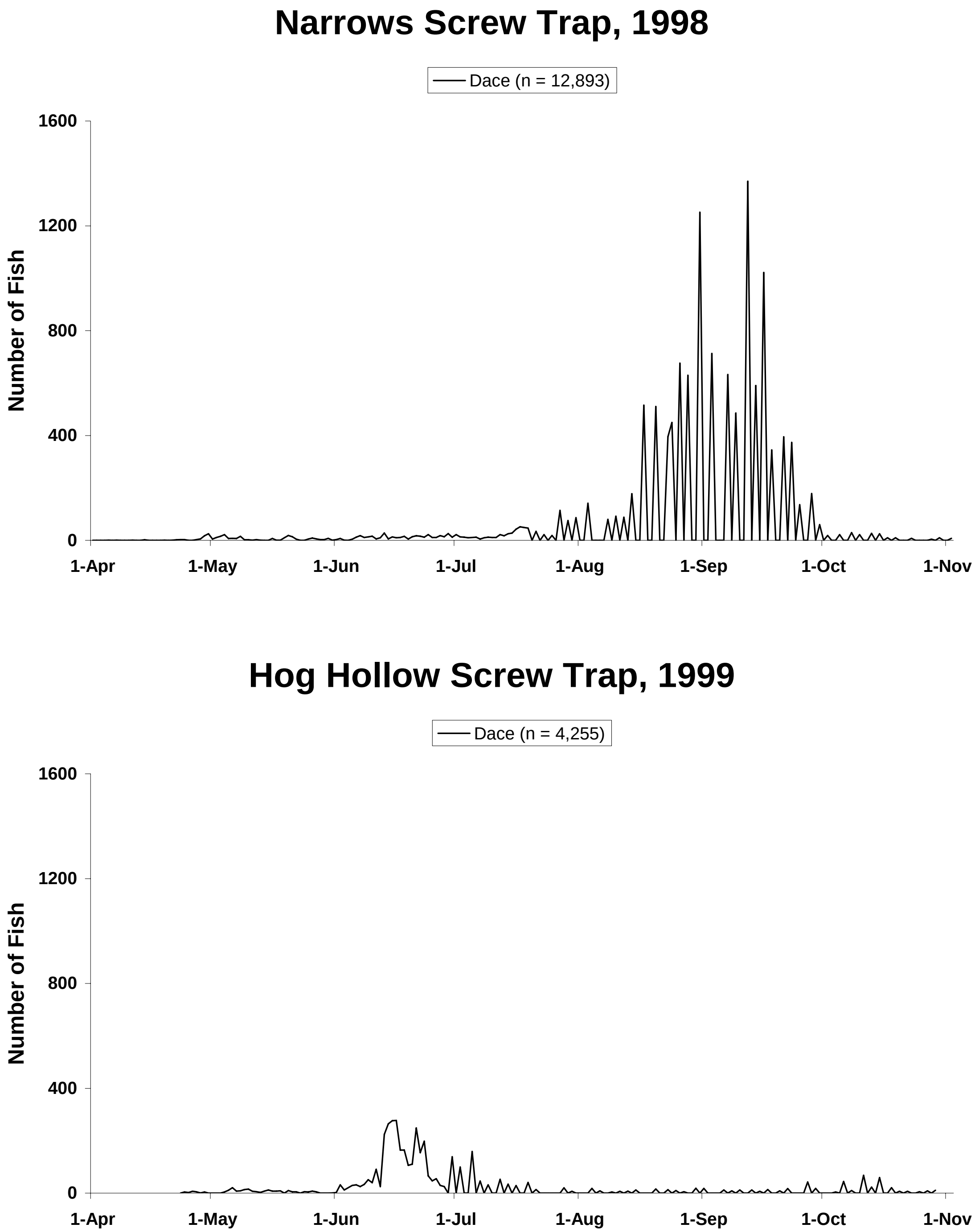
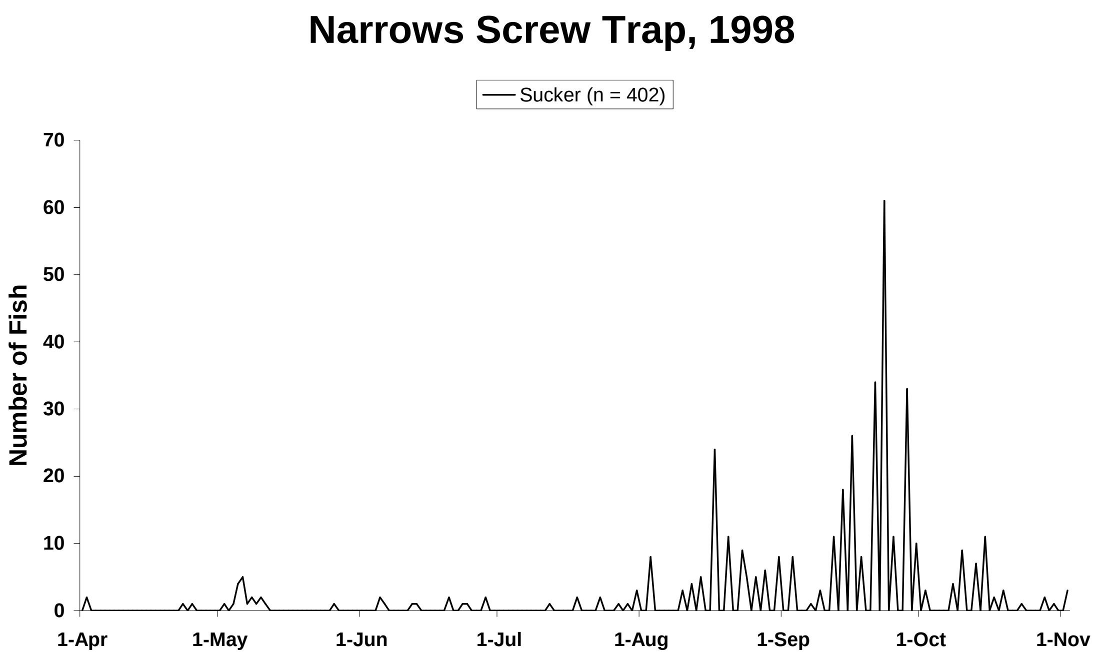


Figure 10. Comparison of dace migration timing at the Narrows (1998) and Hog Hollow (1999) screw traps, Teton River, Idaho. Fish <150 mm were considered fully recruited to the trap gear.



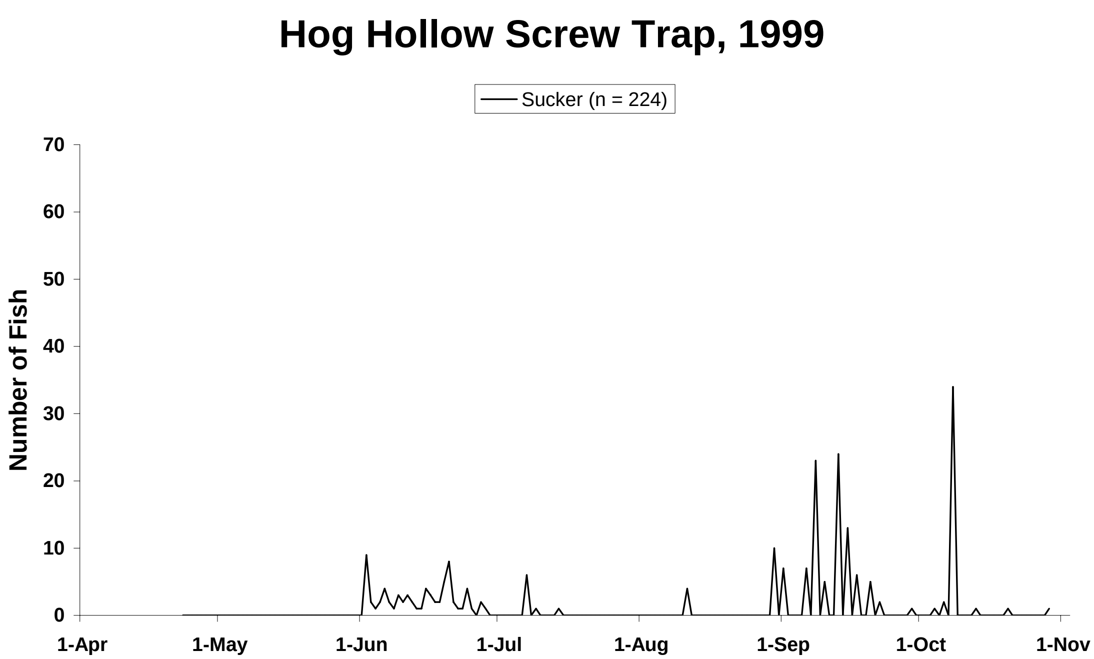
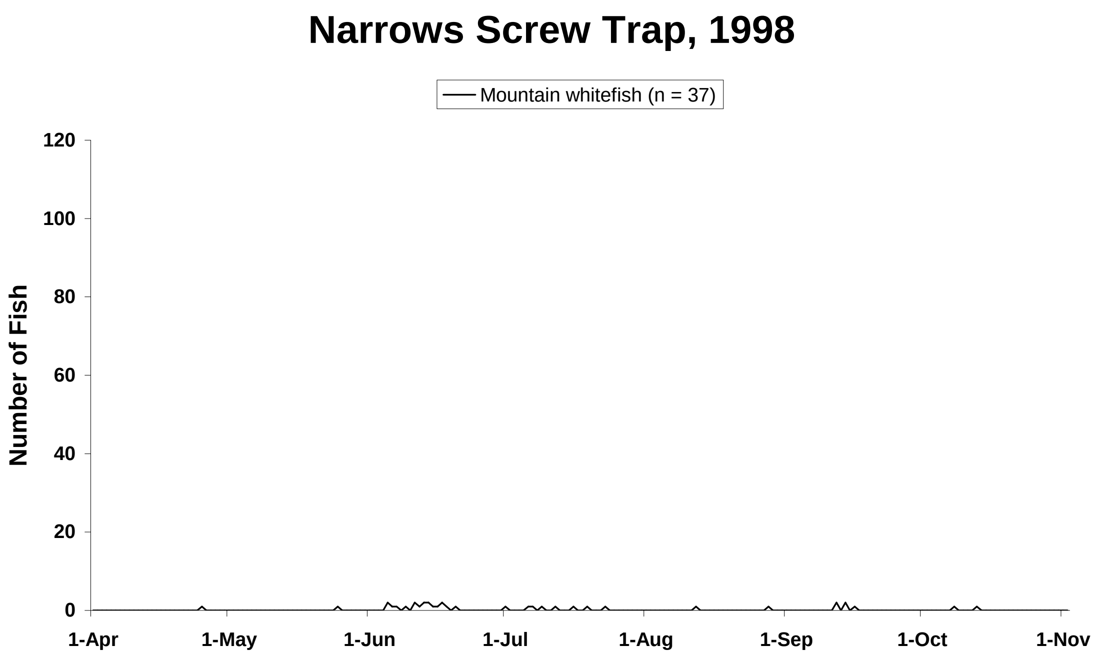


Figure 11. Comparison of sucker migration timing at the Narrows (1998) and Hog Hollow (1999) screw traps, Teton River, Idaho. Fish <150 mm were considered fully recruited to the trap gear.



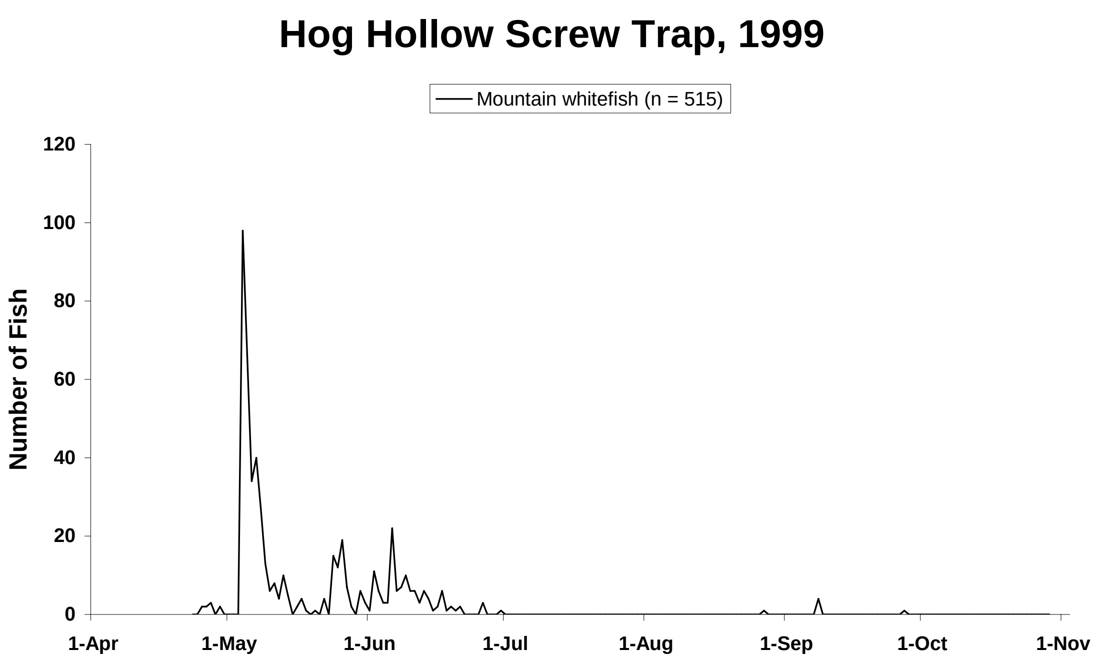
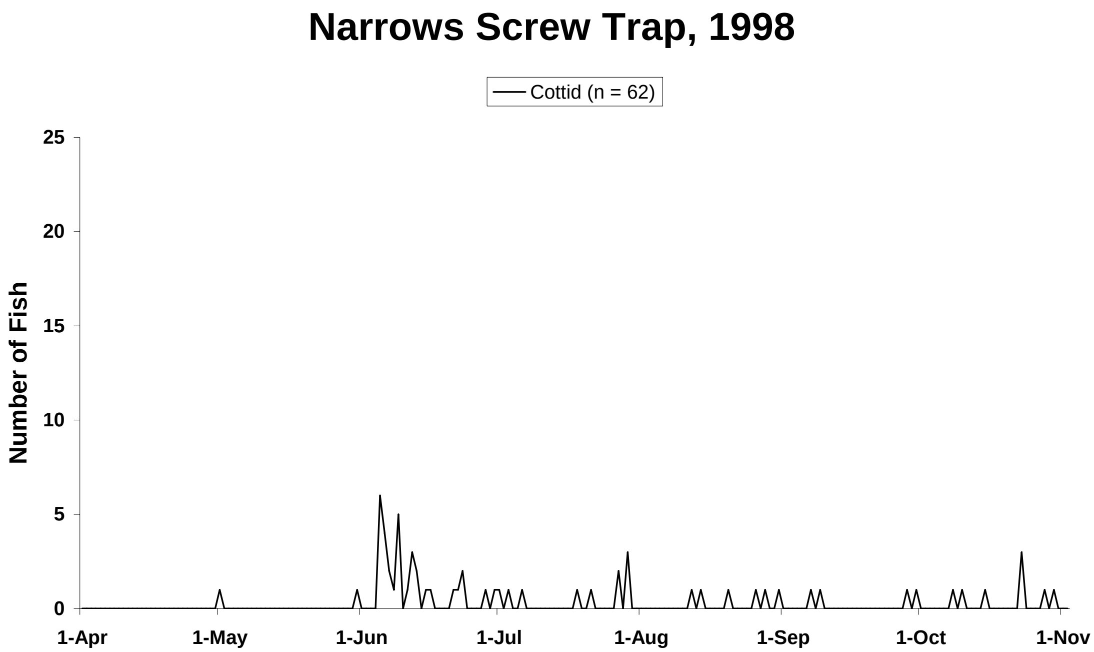


Figure 12. Comparison of mountain whitefish migration timing at the Narrows (1998) and Hog Hollow (1999) screw traps, Teton River, Idaho. Fish <150 mm were considered fully recruited to the trap gear.



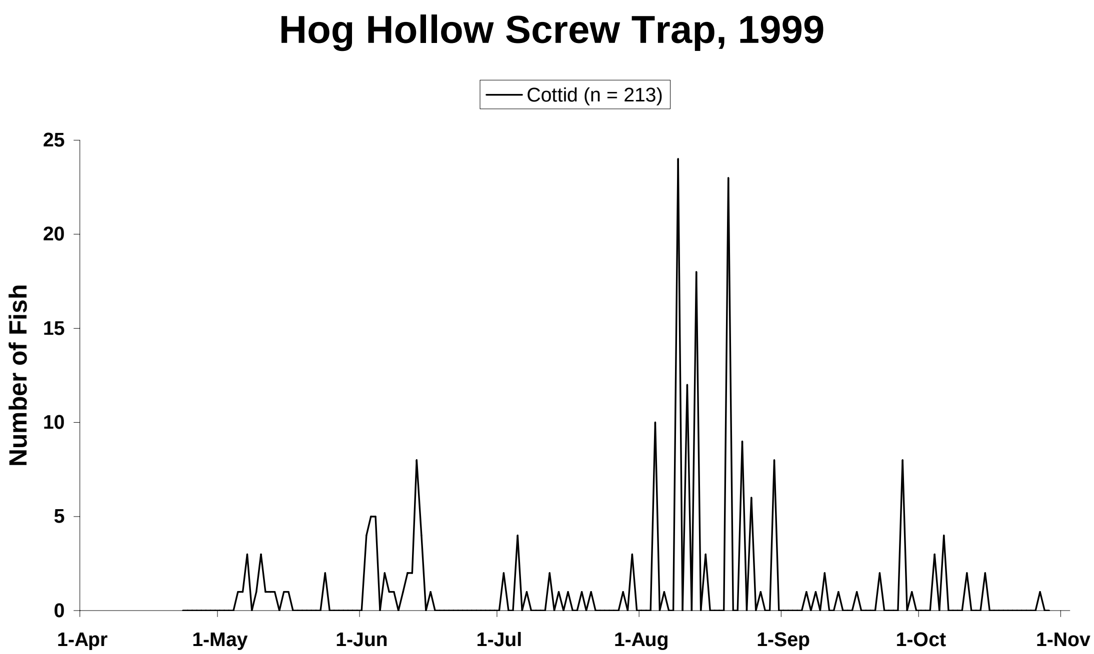
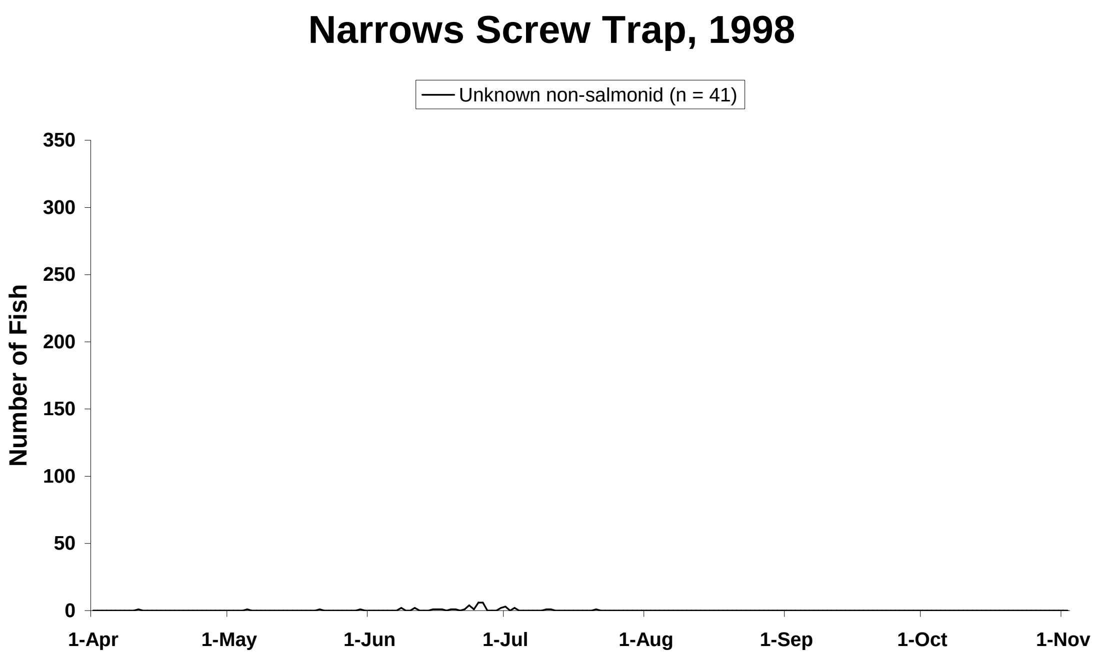


Figure 13. Comparison of cottid migration timing at the Narrows (1998) and Hog Hollow (1999) screw traps, Teton River, Idaho. Fish <150 mm were considered fully recruited to the trap gear.



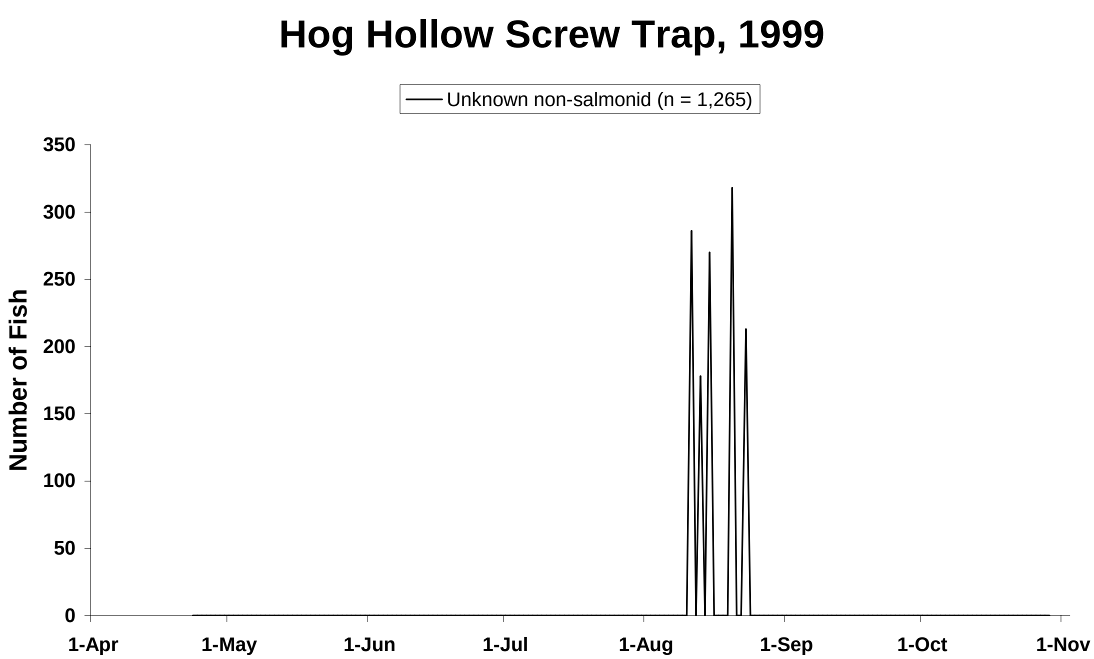
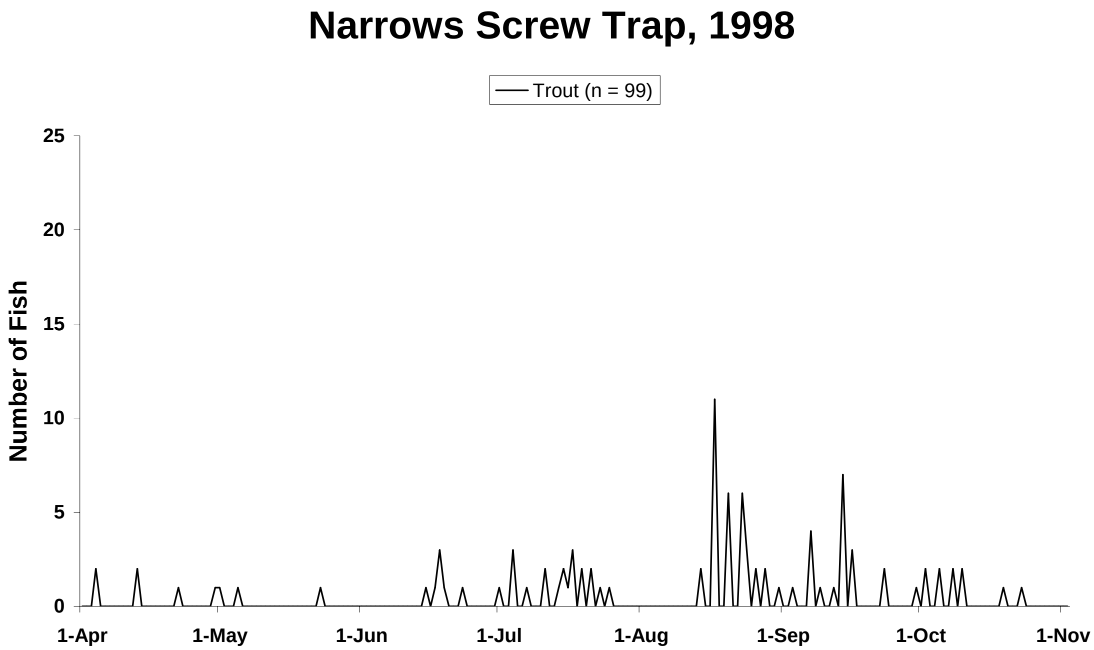


Figure 14. Comparison of unknown non-salmonid fry migration timing at the Narrows (1998) and Hog Hollow (1999) screw traps, Teton River, Idaho. Fish <150 mm were considered fully recruited to the trap gear.



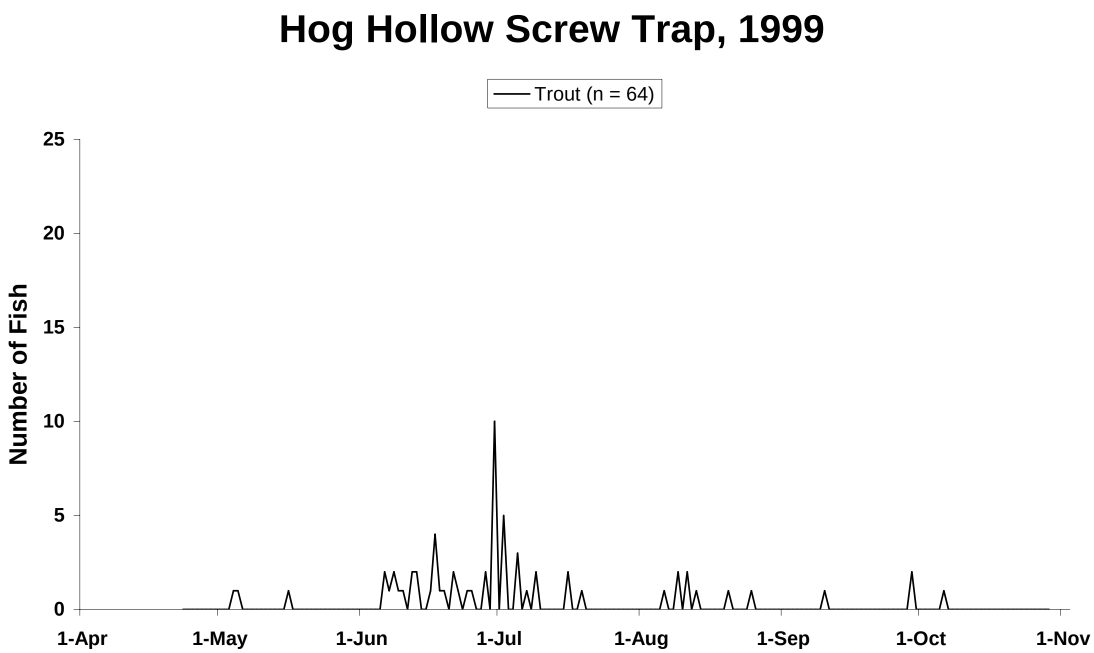
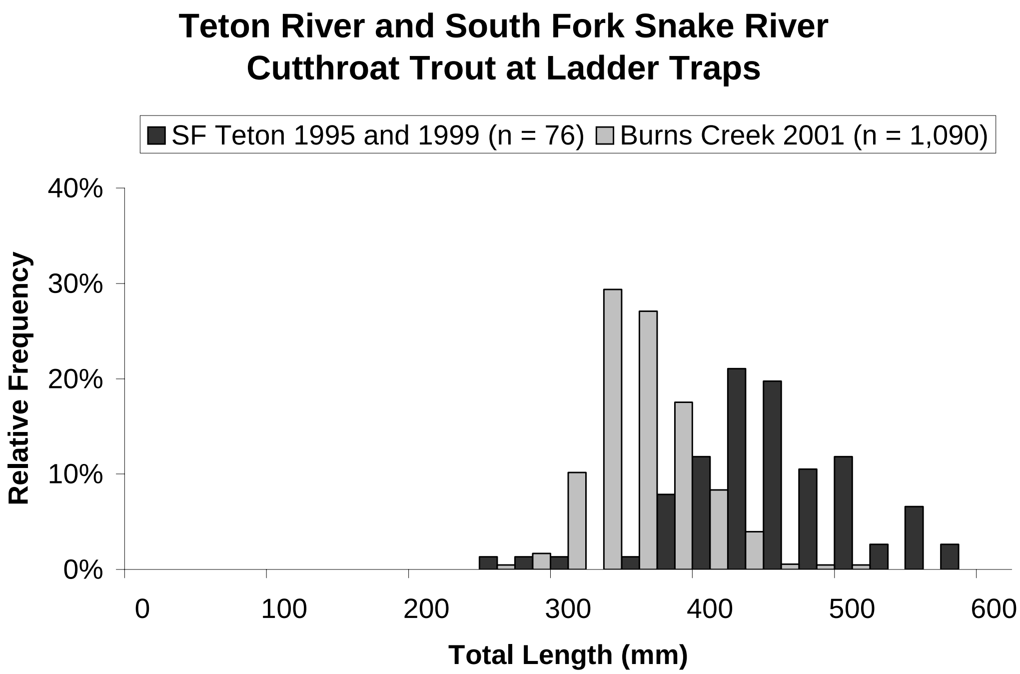


Figure 15. Comparison of trout migration timing at the Narrows (1998) and Hog Hollow (1999) screw traps, Teton River, Idaho. Fish <150 mm were considered fully recruited to the trap gear.



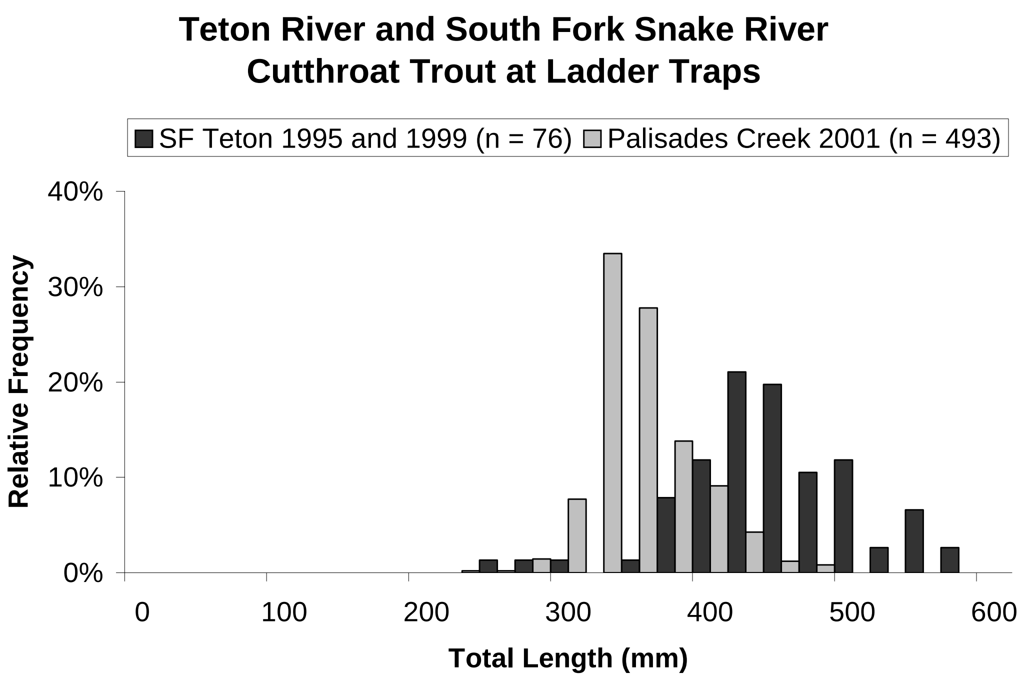


Figure 16. Comparison of cutthroat trout relative length frequency distributions from ladder traps in the Teton River, Idaho (South Fork Teton, 1995 and 1999 combined, present study), and the South Fork Snake River, Idaho (Burns Creek and Palisades Creek, 2001, Scott Host unpublished data).

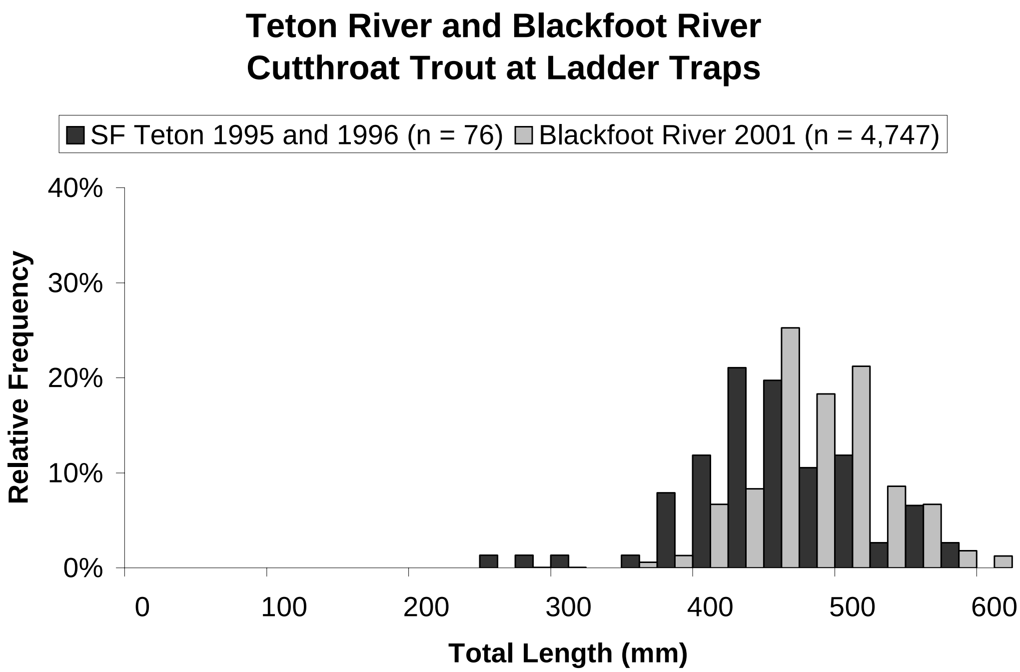


Figure 17. Comparison of cutthroat trout relative length frequency distributions from ladder traps in the Teton River, Idaho (South Fork Teton, 1995 and 1999 combined, present study), and the Blackfoot River, Idaho (2001, Dave Teuscher unpublished data).

LITERATURE CITED

Ecosystems Research Institute (ERI). 1987. Investigation of fish migration at the Felt hydroelectric project in satisfaction of Article 34 agreements under FERC license No. 5089. ERI, Logan, Utah.

Ecosystems Research Institute (ERI). 1988. Investigation of fish migration at the Felt hydroelectric project in satisfaction of Article 34 agreements under FERC license No. 5089. ERI, Logan, Utah.

Henderson, R., J. L. Kershner, and C. A. Toline. 2000. Timing and location of spawning by nonnative wild rainbow trout and native cutthroat trout in the South Fork Snake River, Idaho, with implications for hybridization. North American Journal of Fisheries Management 20:584-596.

Hockersmith, E. E., and B. W. Peterson. 1997. Use of the Global Positioning System for locating radio-tagged fish from aircraft. North American Journal of Fisheries Management 17:457-460.

Irving, J. S., F. S. Elle, and T. C. Bjornn. 1977. The fish populations and fishery in the Teton River prior to impoundment by Teton Dam. Idaho Cooperative Fishery Research Unit, Contribution Number 68, Moscow, Idaho.

Jeppson, P. 1981. Teton River fisheries investigations. Idaho Department of Fish and Game, Job Completion Report, Project F-73-R-3, Boise, Idaho.

Moore, V. K, and D.A. Andrews. 1983. Fishery productivity and economic value changes as a result of the Teton flood modifying streambeds. Idaho Department of Fish and Game, Boise, Idaho.

Pollock, K. H., S. R. Winterstein, C. M. Bunck, and P. D. Curtis. 1989. Survival analysis in telemetry studies: The staggered entry design. Journal of Wildlife Management, 53:7-15.

Randle, T. J, J. A. Bountry, R. Klinger, and A. Lockhart. 2000. Geomorphology and river hydraulics of the Teton River upstream of Teton Dam, Teton River, Idaho. U.S. Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Schrader, W. C. In press. Teton River investigations—Part I: Fishery assessment 25 years after Teton Dam. Idaho Department of Fish and Game, Boise, Idaho.

Schrader, W. C., and K. R. Brenden. In press. Teton River investigations—Part II: Fish population surveys. Idaho Department of Fish and Game, Boise, Idaho.

Schrader, W. C., and M. D. Jones. 2000. Use of radio telemetry to describe movement patterns of adult trout in the Teton River, Idaho. Pages 59-67 *in* J. H. Eiler, D. J. Alcorn, and M. R. Neuman, editors. Biotelemetry 15: Proceedings of the 15th international symposium on Biotelemetry. International Society on Biotelemetry, Wageningen, The Netherlands.

Swanberg, T. 1996. The movement and habitat use of fluvial bull trout in the upper Clark Fork River drainage. Master's thesis. University of Montana, Missoula, Montana.

White, G. C., and R. A. Garrott. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, California.

APPENDICES

Appendix A. Number of trout that were permanently jaw tagged (M) and number of tag returns (R, shaded) in the Teton River drainage, Idaho, 1987-1996 (excluding 1987-1988 ERI data). Locations are listed going upstream.

Location, gear, and year of tagging[a]	Cutthroat trout		Wild rainbow trout		Hatchery rainbow trout		Brook trout		Total	
	M	R	M	R	M	R	M	R	M	R
Lower Teton										
South Fork LT: 1995	10	0	6	0	0	0	0	0	16	0
Moody Cr EF: 1988-1994	17	1(Lower)[b]	2	0	0	0	0	0	19	1
Hog Hollow H&L: 1988	1	0	0	0	0	0	0	0	1	0
Hog Hollow EF: 1991	67	1(Lower) 1(Canyon)[c]	47	3(Lower)	0	0	0	0	114	5
Badger Cr H&L: 1988	0	0	2	0	0	0	0	0	2	0
Total:	95	3	57	3	0	0	0	0	152	6
Teton Canyon										
Teton Dam to Felt Dam H&L: 1988-1991	151	0	146	3(Canyon)	0	0	0	0	297	3
Parkinson EF: 1992	23	0	108	1(Canyon)	0	0	0	0	131	1
Canyon Cr H&L: 1991	4	0	1	0	0	0	0	0	5	0
Bitch Cr H&L: 1991	1	0	7	0	0	0	0	0	8	0
Total:	179	0	262	4	0	0	0	0	441	4
Teton Valley										
Breckenridge H&L: 1990	7	1(Valley)	17	0	0	0	0	0	24	1
Rainier and Buxton H&L: 1988	5	0	4	0	2	0	3	0	14	0
Rainier and Buxton SN: 1988	63	2(Valley)[d]	14	2(Valley)	0	0	1	0	78	4
Rainier and Buxton EF: 1989	21	1(Valley)	27	1(Valley)[e]	0	0	0	0	48	2
Nickerson EF: 1989	23	1(Valley)	5	0	0	0	0	0	28	1
Fox Cr EF: 1991	37	0	27	0	0	0	0	0	64	0
Warm Cr EF: 1989	0	0	5	0	0	0	0	0	5	0
Total:	156	5	99	3	2	0	4	0	261	8
Grand Total:	**430**	**8**	**418**	**10**	**2**	**0**	**4**	**0**	**854**	**18**

[a] LT = ladder trap; EF = electrofishing; H&L = hook and line; SN = seine; ST = screw trap; GN = gill net.
[b] Tagged and recaptured twice during 1994 electrofishing below Moody Creek railroad culvert.
[c] Recaptured during 1992 electrofishing at Parkinson.
[d] One returned from lower Trail Creek.
[e] Returned from lower Warm Creek.

Appendix B. Number of fish that were permanently fin-clipped (M) and number of recaptured fish with clips (R, shaded) in the Teton River drainage, Idaho, 1997-99. Locations are listed going upstream.

Location, gear, and year of clipping[a]	Cutthroat trout		Wild rainbow trout		Hatchery rainbow trout		Unidentified trout fry		Brook trout		Mountain whitefish		Sucker		Utah chub		Total	
	M	**R**	**M**	**R**	**M**	**R**	**M**	**R**	**M**	**R**	**M**	**R**	**M**	**R**	**M**	**R**	**M**	**R**
Lower Teton (Right Pectoral, RP, clip)																		
South Fork LT: 1999	64	1(RV)	2	0	0	0	0	0	0	0	9	0	986	2(RP) 1(LV)	0	0	1,061	4
Hog Hollow ST: 1999	11	0	2	0	0	0	3	0	0	0	0	0	0	0	0	0	16	0
Total:	75	1	4	0	0	0	3	0	0	0	9	0	986	3	0	0	1,077	4
Teton Canyon (Left Pectoral, LP, clip)																		
Borrow Ponds GN: 1998	34	0	0	0	0	0	0	0	0	0	56	0	169	0	161	0	420	0
Parkinson EF: 1998	31	0	7	0	0	0	0	0	0	0	129	0	27	0	0	0	194	0
Parkinson EF: 1999	0	1(LP)	0	0	0	0	0	0	0	0	0	1(LV)	0	0	0	0	0	2
Spring Hollow SN: 1997	5	0	1	0	11	0	0	0	0	0	7	0	2	0	0	0	26	0
Felt Dam LT: 1998	2	0	4	0	0	0	0	0	0	0	58	0	0	0	0	0	64	0
Felt Dam LT: 1999	1	0	7	0	0	0	0	0	0	0	11	0	0	0	0	0	19	0
Narrows ST: 1998	49	0	24	0	0	0	14	0	4	0	8	0	390	0	0	0	489	0
Total:	122	1	43	0	11	0	14	0	4	0	269	1	588	0	161	0	1,212	2
Teton Valley (Right Ventral, RV, or Left Ventral, LV, clip)																		
Breckenridge EF: 1997	70	0	60	0	1	0	0	0	113	1(LV)	306	0	3	0	0	0	553	1
Breckenridge EF: 1999	0	1(RP)	0	0	0	0	0	0	0	0	0	1(RP) 3(RV) 2(LV)	0	0	0	0	0	7
Nickerson EF: 1997	159	0	19	0	1	0	0	0	70	0	509	0	56	0	0	0	814	0
Nickerson EF: 1999	0	1(LV) 9(RV)	0	1(LP 7RP)	0	0	0	0	0	1(LP)	0	1(LV) 7(RV)	0	0	0	0	0	20
Teton Cr EF: 1997	87	0	6	0	3	0	0	0	44	0	810	0	0	0	0	0	950	0
Fox Cr EF: 1997	47	0	36	0	1	0	0	0	98	0	346	0	0	0	0	0	528	0
Total:	363	11	121	1	6	0	0	0	325	2	1,971	14	59	0	0	0	2,845	28
Grand Total:	**560**	**13**	**168**	**1**	**17**	**0**	**17**	**0**	**329**	**2**	**2,249**	**15**	**1,633**	**3**	**161**	**0**	**5,134**	**34**

[a] LT = ladder trap; EF = electrofishing; H&L = hook and line; SN = seine; ST = screw trap; GN = gill net.

Appendix C. Status of 22 adult trout radio tagged in the Lower Teton study section, Idaho, as of October 26, 1999. Records are sorted by transmitter frequency, where those differing by 1-2 KHz are the same transmitters that were reused (the lowest is the true frequency). Two reused transmitter frequencies are shaded; their antenna lengths were not altered.

Radio frequency (MHz)	Tag week number	Tag date	Last location date	Days to last location[a]	Species	Total length (mm)	Weight (g)	Relative tag weight	Surgery time (min)	Antenna Length	Capture Method[b]	Blackspot disease?	Hook scar?	Notes
Alive (N = 3)														
150.074	8	09/24/98	10/16/99	387	Cutthroat	435	685	1.7%	5	Cut	Shock			Old Bird Mark
150.383	6	09/10/98	10/16/99	401	Rainbow	436	720	1.6%	5	Cut	Shock			Right Head Dent
150.722	8	09/24/98	10/16/99	387	Cutthroat	488	1250	0.9%	5	Long	Shock			
Alive Then Lost (Censored; N = 7)														
150.013	7	09/17/98	04/08/99	203	Cutthroat	479	1325	0.9%	7	Long	Shock	Y		
150.023	37	04/13/99	05/04/99	21	Cutthroat	429	940	1.2%	9	Long	Trap	Y	Y	Green Female; Shredded Antenna
150.124	6	09/10/98	09/18/98	8	Cutthroat	438	920	1.3%	6	Cut	Shock	Y		
150.403	7	09/17/98	06/06/99	262	Cutthroat	467	1025	1.1%	6	Cut	Shock	Y		Old Bird Mark
150.523	8	09/24/98	08/19/99	329	Cutthroat	428	685	1.7%	6	Cut	Shock			Old Bird Mark
150.713	8	09/23/98	07/16/99	296	Cutthroat	489	1400	0.8%	4	Long	Shock	Y		Photo w/o Freq Number
150.764	6	09/10/98	01/26/99	138	Rainbow	465	1400	0.8%	6	Long	Shock			
Natural Mortality (>56 D; N = 10)														
150.045	6	09/10/98	07/16/99	309	Cutthroat	554	1650	0.7%	6	Long	Shock	Y		
150.085	8	09/23/98	01/26/99	125	Cutthroat	411	740	1.6%	5	Cut	Shock			Left Opercle Incomplete
150.094	8	09/23/98	04/08/99	197	Hybrid	417	670	1.7%	5	Cut	Shock			
150.103	6	09/10/98	11/18/98	69	Hybrid	468	1250	0.9%	6	Long	Shock			Missing Right Eye; Old Bird Mark
150.494	8	09/23/98	10/16/99	388	Cutthroat	521	1375	0.8%	4	Long	Shock			Strange Behavior On Release
150.823	6	09/10/98	08/19/99	343	Rainbow	428	690	1.7%	7	Cut	Shock			
150.843	8	09/23/98	09/18/99	360	Cutthroat	442	760	1.5%	5	Long	Shock	Y		Whirling Disease?
150.923	7	09/17/98	05/18/99	243	Hybrid	433	995	1.2%	5	Long	Shock	Y		
150.983	8	09/24/98	10/16/99	387	Cutthroat	464	960	1.2%	5	Long	Shock	Y		
151.073	7	09/17/98	09/18/99	366	Cutthroat	408	720	1.6%	5	Cut	Shock	Y	Y	
Post-Surgery Mortality (≤56 D; N = 2)														
150.022	7	09/17/98	10/16/98	29	Cutthroat	423	710	1.6%	5	Long	Shock	Y	Y	
150.104	37	04/13/99	05/18/99	35	Cutthroat	560	2300	0.5%	7	Long	Trap	Y		Green Female

[a] Days to last alive signal or first mortality signal.
[b] Shock = electrofished; trap = ladder trapped; H&L = hook and lined.

Appendix D. Status of 24 adult trout radio tagged in the Teton Canyon study section, Idaho, as of October 26, 1999. Records are sorted by transmitter frequency, where those differing by 1-2 KHz are the same transmitters that were reused (the lowest is the true frequency). Four reused transmitter frequencies are shaded; their antenna lengths were not altered.

Radio frequency (MHz)	Tag week number	Tag date	Last location date	Days to last location[a]	Species	Total length (mm)	Weight (g)	Relative tag weight	Surgery time (min)	Antenna Length	Capture Method[b]	Blackspot disease?	Hook scar?	Notes
Alive (N = 2)														
150.463	7	09/16/98	10/16/99	395	Hybrid	440	600	1.9%	5	Cut	Shock			
150.515	43	05/23/99	10/16/99	146	Cutthroat	414	720	1.6%	4	Cut	Shock			Green Male
Alive Then Lost (Censored; N = 2)														
150.542	7	09/15/98	10/02/98	17	Cutthroat	406	660	1.7%	5	Long	Shock	Y		Slow Recovery
150.783	7	09/15/98	06/22/99	280	Hybrid	434	755	1.5%	5	Long	Shock	Y		
Natural Mortality (>56 D; N = 4)														
150.133	7	09/16/98	06/22/99	279	Cutthroat	433	720	1.6%	5	Long	Shock	Y	Y	
150.373	7	09/15/98	09/18/99	368	Cutthroat	418	720	1.6%	5	Cut	Shock	Y		Slow Recovery
150.673	5	09/04/98	10/16/99	407	Cutthroat	438	735	1.6%	5	Long	H&L	Y		
151.054	7	09/16/98	07/16/99	303	Hybrid	388	655	1.8%	8	Cut	Shock	Y	Y	
Post-Surgery Mortality (≤56 D; N = 16)														
150.034	2	08/11/98	09/11/98	31	Hybrid	400	650	1.8%	12	Cut	H&L			
150.053	7	09/15/98	09/25/98	10	Cutthroat	385	610	1.9%	6	Cut	Shock	Y		Cut Intestine; Anal Fin Damage
150.064	2	08/11/98	09/11/98	31	Hybrid	424	820	1.4%	5	Cut	H&L			
150.145	2	08/14/98	09/18/98	35	Cutthroat	415	695	1.7%	5	Cut	H&L			
150.161	1	08/07/98	09/25/98	49	Cutthroat	409	650	1.8%	12	Cut	H&L			
150.162	43	05/23/99	06/17/99	25	Cutthroat	419	815	1.4%	5	Cut	Shock	Y		Green Male
150.173	4	08/27/98	09/11/98	15	Hybrid	435	875	1.3%	8	Long	H&L	Y		
150.352	5	09/04/98	09/25/98	21	Cutthroat	418	745	1.5%	5	Long	H&L	Y		
150.353	42	05/19/99	06/06/99	18	Cutthroat	467	1200	1.0%	4	Long	Shock	Y		Green Male; L Raker Out & Clipped
150.483	2	08/11/98	09/11/98	31	Cutthroat	417	630	1.8%	10	Cut	H&L			
150.514	5	09/04/98	09/25/98	21	Cutthroat	421	680	1.7%	5	Cut	H&L	Y		
150.653	1	08/07/98	09/11/98	35	Cutthroat	392	650	1.8%	15	Cut	H&L			
150.733	4	08/27/98	09/18/98	22	Cutthroat	396	600	1.9%	6	Long	H&L	Y		
150.734	43	05/23/99	06/06/99	14	Rainbow	474	1200	1.0%	5	Long	Shock	Y		Green Male; Burn Mark; Sunk Boat
150.993	7	09/16/98	09/18/98	2	Cutthroat	479	1325	0.9%	8	Long	Shock	Y	Y	Fungus
151.034	1	08/07/98	09/11/98	35	Cutthroat	465	1250	0.9%	20	Cut	H&L			Doug's Fish

[a] Days to last alive signal or first mortality signal.
[b] Shock = electrofished; trap = ladder trapped; H&L = hook and lined.

Appendix E. Status of 33 adult trout radio tagged in the Teton Valley study section, Idaho, as of October 26, 1999. Records are sorted by transmitter frequency, where those differing by 1-2 KHz are the same transmitters that were reused (the lowest is the true frequency). Thirteen reused transmitter frequencies are shaded; their antenna lengths were not altered.

Radio frequency (MHz)	Tag week number	Tag date	Last location date	Days to last location[a]	Species	Total length (mm)	Weight (g)	Relative tag weight	Surgery time (min)	Antenna Length	Capture Method[b]	Black-spot disease?	Hook scar?	Notes
Alive (N = 4)														
150.313	6	09/08/98	10/16/99	403	Cutthroat	434	820	1.4%	5	Long	Shock			
150.433	10	10/07/98	10/16/99	374	Cutthroat	478	1150	1.0%	5	Long	Shock		Y	Old Sore Behind R Opercle
150.694	10	10/09/98	10/16/99	372	Hybrid	526	1500	0.8%	5	Long	Shock	Y		
150.973	6	09/09/98	10/16/99	402	Cutthroat	427	660	1.7%	4	Long	Shock			Bloody Right Eye
Alive Then Lost (Censored; N = 1)														
150.954[c]	5	09/02/98	04/16/99	226	Hybrid	452	1150	1.0%	6	Cut	Shock	Y		Duty Cycle Timing Off
Fishing Mortality (N = 3)														
150.643	6	09/08/98	08/19/99	345	Rainbow	412	710	1.6%	9	Cut	Shock			Lots Blood
150.904	5	09/02/98	08/02/99	334	Cutthroat	523	1700	0.7%	5	Long	Shock		Y	Bill's Fish
150.963	5	09/03/98	09/12/98	9	Cutthroat	517	1300	0.9%	5	Cut	Shock			Slow Recovery
Natural Mortality (>56 D; N = 17)														
150.114	10	10/09/98	05/28/99	231	Cutthroat	427	800	1.4%	6	Cut	Shock			
150.154	13	10/27/98	07/07/99	253	Cutthroat	527	1500	0.8%	4	Cut	Shock			Red Sores Along Sides
150.412	5	09/03/98	11/18/98	76	Cutthroat	512	1650	0.7%	5	Long	Shock		Y	
150.413	37	04/15/99	07/07/99	83	Cutthroat	423	800	1.4%	7	Long	Shock			Unknown Sex; Caudal Fin Chewed
150.423	10	10/07/98	07/07/99	273	Cutthroat	461	970	1.2%	6	Long	Shock		Y	
150.452	6	09/08/98	04/16/99	220	Rainbow	460	960	1.2%	6	Long	Shock		Y	
150.453	40	05/05/99	08/19/99	106	Hybrid	475	1000	1.2%	6	Long	Shock	Y		Green Female
150.472	6	09/09/98	01/26/99	139	Cutthroat	439	670	1.7%	6	Cut	Shock	Y		Fly In Mouth
150.473	37	04/16/99	06/16/99	61	Cutthroat	484	1200	1.0%	5	Cut	Shock	Y		Green Female
150.503	6	09/08/98	05/14/99	248	Rainbow	398	630	1.8%	5	Long	Shock			
150.553	37	04/16/99	07/07/99	82	Cutthroat	500	1250	0.9%	5	Long	Shock	Y		Ripe Male
150.563	6	09/08/98	07/07/99	302	Cutthroat	440	870	1.3%	5	Cut	Shock		Y	
150.883	5	09/03/98	12/16/98	104	Rainbow	549	1800	0.6%	5	Cut	Shock	Y		Lower Caudal Raw
150.942	5	09/02/98	02/22/99	173	Rainbow	579	2000	0.6%	5	Cut	Shock	Y	Y	Mike's Fish
150.943	37	04/15/99	10/16/99	184	Hybrid	494	1295	0.9%	7	Cut	Shock	Y		Green Female
150.964	10	10/08/98	10/16/99	373	Cutthroat	464	1150	1.0%	4	Cut	Shock	Y		
151.003	10	10/07/98	06/22/99	258	Cutthroat	411	620	1.9%	4	Long	Shock		Y	
Post-Surgery Mortality (≤56 D; N = 8)														
150.112	1	08/05/98	09/03/98	29	Cutthroat	408	600	1.9%	20	Cut	H&L			Talon Marks On Back
150.113	5	09/03/98	10/08/98	35	Cutthroat	414	685	1.7%	7	Cut	Shock	Y		
150.153	5	09/02/98	09/18/98	16	Cutthroat	430	800	1.4%	5	Cut	Shock	Y	Y	
150.422	5	09/02/98	09/18/98	16	Cutthroat	408	660	1.7%	3	Long	Shock	Y		
150.432	5	09/02/98	09/24/98	22	Cutthroat	409	610	1.9%	6	Long	Shock	Y		Caught Upstream
150.552	6	09/09/98	10/02/98	23	Cutthroat	424	725	1.6%	6	Long	Shock		Y	Rv Clip; Sore Jaw
150.693	5	09/02/98	09/18/98	16	Cutthroat	472	1250	0.9%	4	Long	Shock	Y		
151.002	5	09/03/98	09/18/98	15	Cutthroat	476	1200	1.0%	6	Long	Shock	Y		Sore On Peduncle

[a] Days to last alive signal or first mortality signal.

[b] Shock = electrofished; trap = ladder trapped; H&L = hook and lined.

[c] Transmitter malfunctioned within nine days after implantation (duty cycle timing was off), but was later located.

Appendix F. Fish surgery techniques and radio transmitter specifications, Teton River, Idaho, 1998-1999.

After catching a suitable fish, the radio transmitter was surgically implanted into the intraperitoneal cavity using the following techniques:

Presurgery setup consisted of sterilizing all surgical tools and the transmitter with a 10% solution of Amerse brand germicide and distilled water. Transmitter function was tested with the radio receiver. An adjustable sling (2 x 2 in boards with soft nylon net mesh) was placed over a tub containing 80 mg/l MS-222 solution. We used a small bilge pump, with a variable-flow garden sprinkler head attached to the outflow hose, to control anesthesia passing over the gills. The pump had weights attached (to keep it on the bottom of the tub) and was powered by a 12 V dry cell battery. An ordinary turkey baster served as a backup. A bucket of fresh water was also available to bring the fish out of anesthesia toward the end of surgery, generally during the last suture. A live car was placed in the river for fish recovery.

The fish was then placed in the tub of anesthesia, identified, measured to the nearest millimeter, and weighed to the nearest gram. Each side of the fish was photographed alongside an identifying label. A small piece of caudal fin was clipped and preserved in a vial of 100% ethanol (Everclear) with another identifying label for genetic analysis. The surgeon placed the fish in the sling with the caudal fin elevated above the head to keep water out of the incision area. An assistant controlled the flow of anesthesia over the gills, keeping solution out of the incision, and monitored the status of the fish throughout surgery.

A small incision was made through the ventral body wall about 50 mm anterior to the pelvic fins and off the midline 2-3 mm. The incision was probed with the blunt end of the scalpel handle to insure opening into the intraperitoneal cavity. Internal organs were checked for an accidental cut or puncture, and sex and maturity were determined if possible. A small scupula was inserted through the incision and pushed posterior and ventral until it could be felt under the skin just posterior to the pelvic girdle. A 12 gauge, 4 in hypodermic needle was then inserted through the ventral body wall, just posterior to the pelvic girdle, until it connected with the scupula. The needle was then pushed anterior along the scupula until it protruded from the incision. The transmitter whip antenna was threaded through the needle, starting from the incision end, and the needle and scupula were removed. The transmitter was then inserted by gently pulling the antenna with one hand and pushing the transmitter through the incision with the other hand. Two or three catgut sutures were used to close the incision. When finished, the external whip antenna extruded through the ventral body wall immediately behind the pelvic fins. We experimented with signal strength and fish survival by cutting half (n = 30) of the antennas at the base of the caudal peduncle while leaving the other half long to trail behind the caudal fin. Antennas on the 19 transmitters that were reused were not disturbed. The fish was then placed into the live car.

Each fish was allowed to recover until it was capable of swimming away under its own volition (usually 10-15 min). Each was released where it was captured, in gentle current and with nearby cover. Other information recorded at the surgery site included transmitter frequency, surgery time, release time, and UTM coordinates. We practiced surgery techniques on similar-sized fish at a hatchery. Surgery time in the field ranged from 3 to 20 min (mean 6 min).

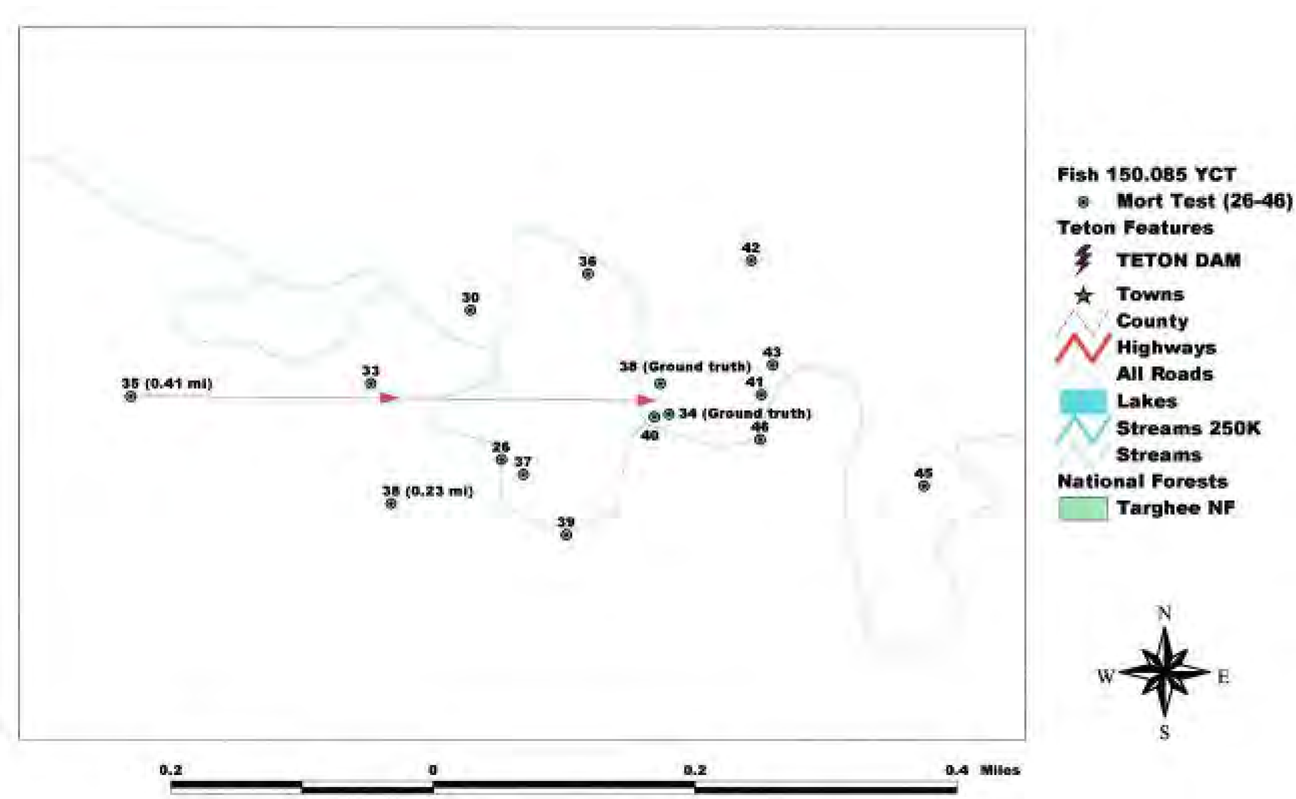
We used Advanced Telemetry Systems (ATS, Isanti, Minnesota) model 10/35 radio telemetry transmitters configured to our specifications. Each of the 60 internal implant transmitters weighed 11.5 g in air, was equipped with an external whip antenna, and had a unique frequency in the 150-151 MHz band. Transmitters were equipped with a mortality switch, which was activated 24 hours after being motionless. The “alive” pulse rate was 40 pulses per minute (ppm) whereas the “dead” rate was 20 ppm. Removing the magnet activated the start time for an eight-hour duty cycle (8 hr on—from 0800 hr to 1600 hr Mountain Daylight Time—then 16 hr off). This configuration allowed maximum daylight for winter tracking while conserving battery life. The 3 V lithium batteries are warranted to operate at least 360 d. Each transmitter had a courtesy return label with the IDFG address embedded on its surface.

Transmitter mortality switches helped increase sample size and saved considerable time searching for fish. Transmitters were easily recovered in the Lower Teton and Teton Valley but not in the Teton Canyon due to the deep pools. The adage "once dead, always dead" reflects that false mortality signals were never detected. However, false alive signals were common; they were generally caused by birds, muskrats, and cattle moving the transmitter after the fish had died. One transmitter (150.954) malfunctioned resulting in the duty cycle timing being outside the 8 hr detection window (0700 to 1500, MST). Coincidently it was found alive. Two percent of the transmitters can be expected to malfunction (Chris Kochanny, ATS, personal communication).

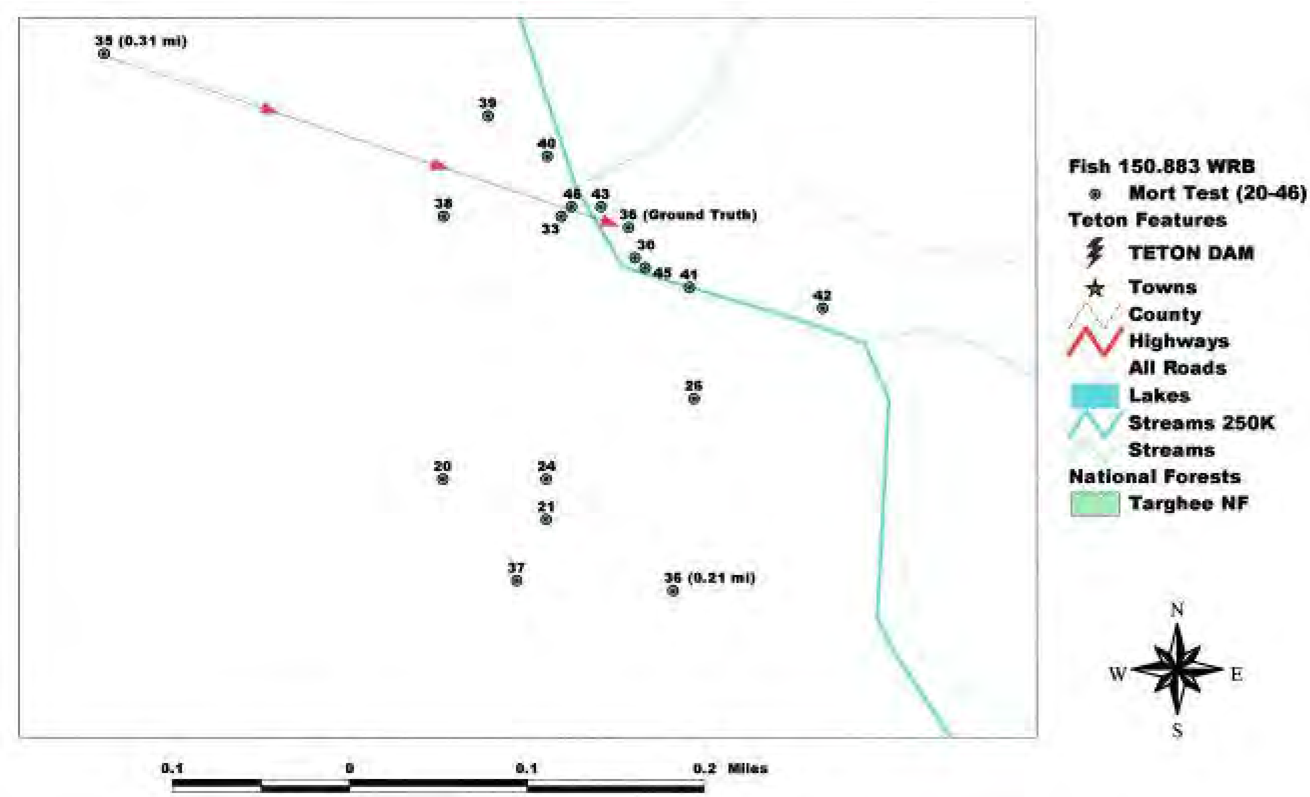
Appendix G. Key to radio telemetry week numbers in the Teton River, Idaho, 1998-1999.

Week number	Beginning	Ending	Week number	Beginning	Ending
1	August 2, 1998	August 8, 1998	34	March 21, 1999	March 27, 1999
2	August 9, 1998	August 15, 1998	35	March 28, 1999	April 3, 1999
3	August 16, 1998	August 22, 1998	36	April 4, 1999	April 10, 1999
4	August 23, 1998	August 29, 1998	37	April 11, 1999	April 17, 1999
5	August 30, 1998	September 5, 1998	38	April 18, 1999	April 24, 1999
6	September 6, 1998	September 12, 1998	39	April 25, 1999	May 1, 1999
7	September 13, 1998	September 19, 1998	40	May 2, 1999	May 8, 1999
8	September 20, 1998	September 26, 1998	41	May 9, 1999	May 15, 1999
9	September 27, 1998	October 3, 1998	42	May 16, 1999	May 22, 1999
10	October 4, 1998	October 10, 1998	43	May 23, 1999	May 29, 1999
11	October 11, 1998	October 17, 1998	44	May 30, 1999	June 5, 1999
12	October 18, 1998	October 24, 1998	45	June 6, 1999	June 12, 1999
13	October 25, 1998	October 31, 1998	46	June 13, 1999	June 19, 1999
14	November 1, 1998	November 7, 1998	47	June 20, 1999	June 26, 1999
15	November 8, 1998	November 14, 1998	48	June 27, 1999	July 3, 1999
16	November 15, 1998	November 21, 1998	49	July 4, 1999	July 10, 1999
17	November 22, 1998	November 28, 1998	50	July 11, 1999	July 17, 1999
18	November 29, 1998	December 5, 1998	51	July 18, 1999	July 24, 1999
19	December 6, 1998	December 12, 1998	52	July 25, 1999	July 31, 1999
20	December 13, 1998	December 19, 1998	53	August 1, 1999	August 7, 1999
21	December 20, 1998	December 26, 1998	54	August 8, 1999	August 14, 1999
22	December 27, 1998	January 2, 1999	55	August 15, 1999	August 21, 1999
23	January 3, 1999	January 9, 1999	56	August 22, 1999	August 28, 1999
24	January 10, 1999	January 16, 1999	57	August 29, 1999	September 4, 1999
25	January 17, 1999	January 23, 1999	58	September 5, 1999	September 11, 1999
26	January 24, 1999	January 30, 1999	59	September 12, 1999	September 18, 1999
27	January 31, 1999	February 6, 1999	60	September 19, 1999	September 25, 1999
28	February 7, 1999	February 13, 1999	61	September 26, 1999	October 2, 1999
29	February 14, 1999	February 20, 1999	62	October 3, 1999	October 9, 1999
30	February 21, 1999	February 27, 1999	63	October 10, 1999	October 16, 1999
31	February 28, 1999	March 6, 1999	64	October 17, 1999	October 23, 1999
32	March 7, 1999	March 13, 1999	65	October 24, 1999	October 30, 1999
33	March 14, 1999	March 20, 1999			

Appendix H. Location of radio telemetry transmitter 150.085 as determined on the ground (ground truth) versus in the air by fixed-wing aircraft. The transmitter was stuck in a logjam in the South Fork Teton River, Idaho, and did not move between locations. The arrow represents the maximum measured error (0.41 mi), whereas numbers are radio telemetry week numbers.

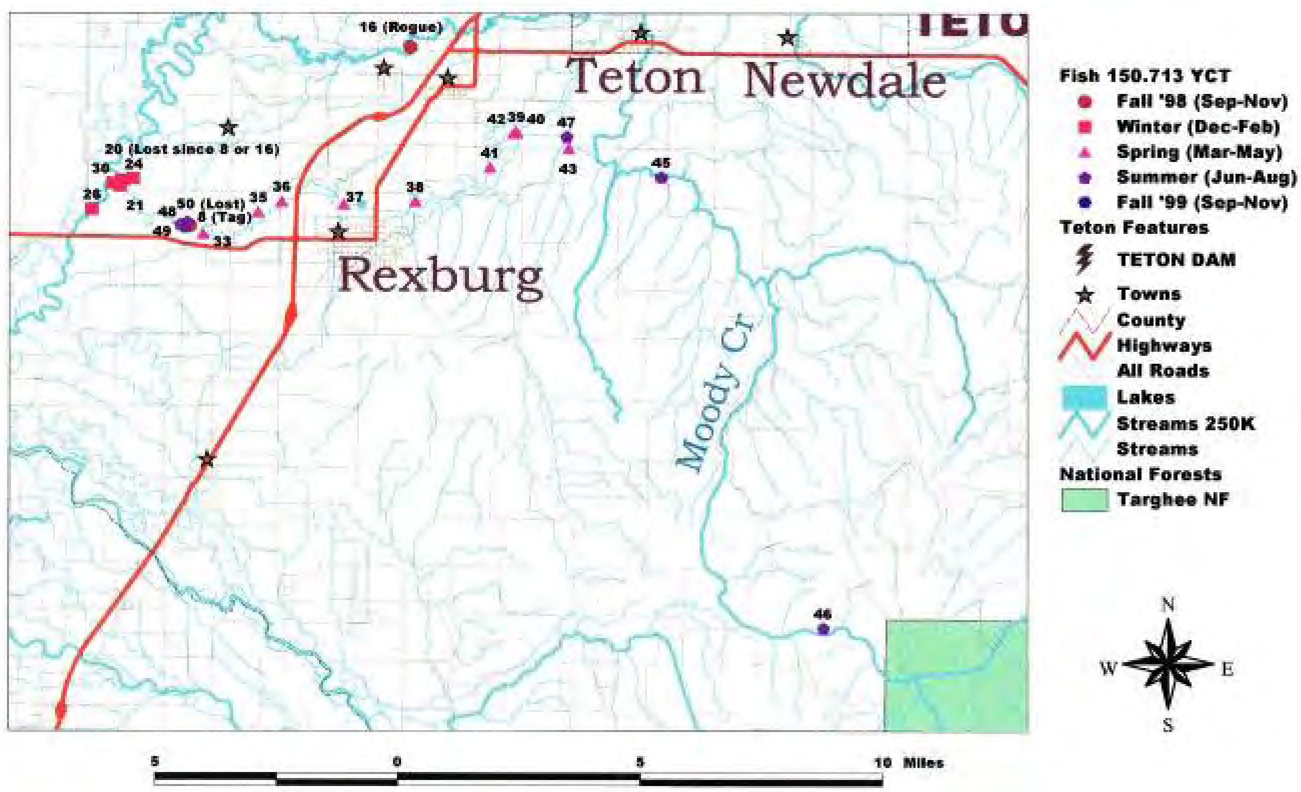


Appendix I. Location of radio telemetry transmitter 150.883 as determined on the ground (ground truth) versus in the air by fixed-wing aircraft. The transmitter was stuck in a muskrat hole in the lower Teton Valley study section, Idaho, and did not move between locations. The arrow represents the maximum measured error (0.31 mi), whereas numbers are radio telemetry week numbers.

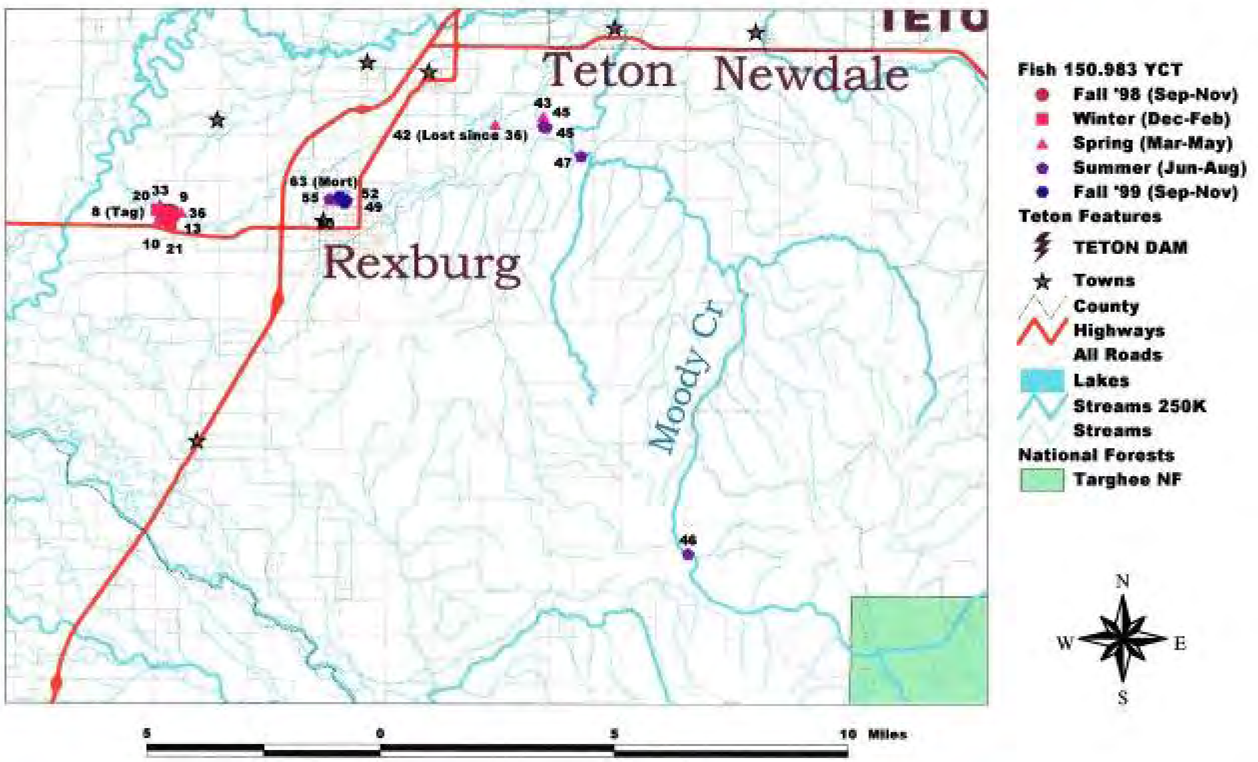


Appendix J. Radio telemetry locations of 14 cutthroat, one rainbow, and one hybrid trout that migrated to tributaries to spawn during the 1999 spawning season (March-July), Teton River, Idaho. First and last locations are in parentheses.

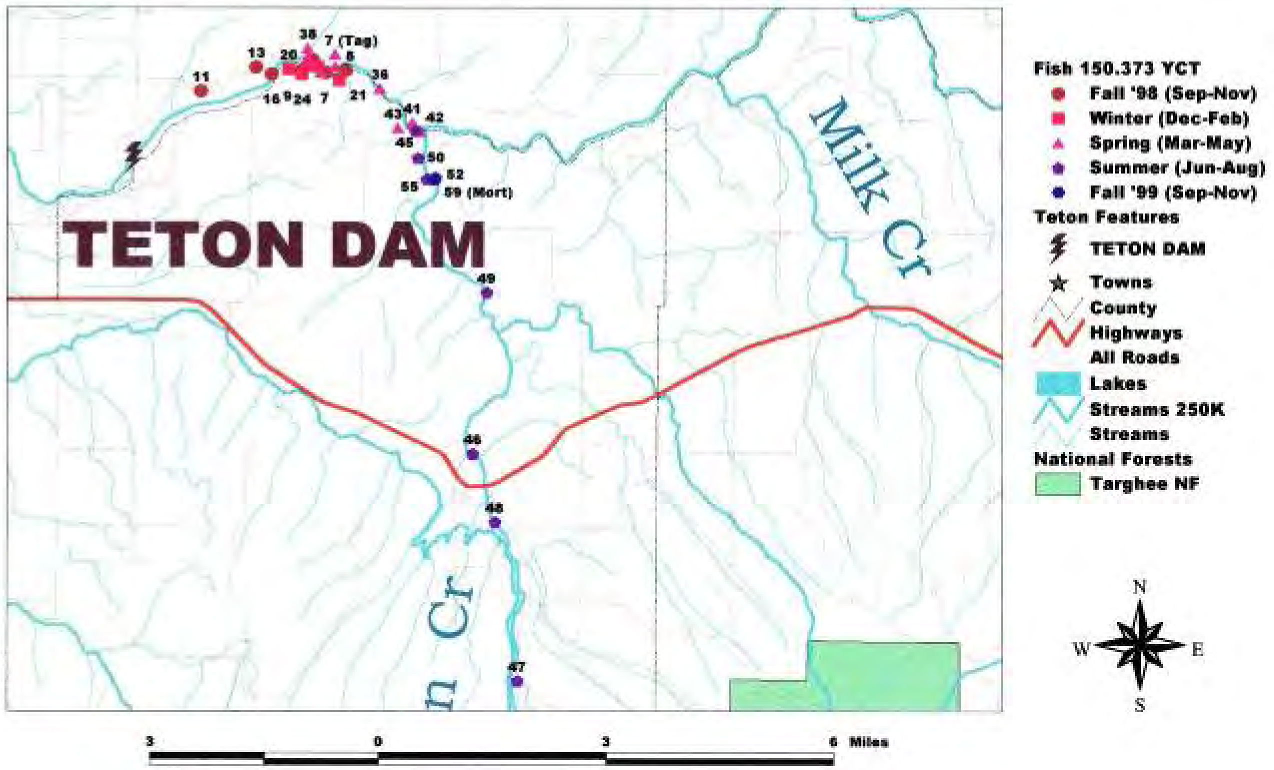
Appendix J-1. Radio telemetry locations of cutthroat trout 150.713 that was tagged in the South Fork Teton River and spawned in Moody Creek, Idaho.



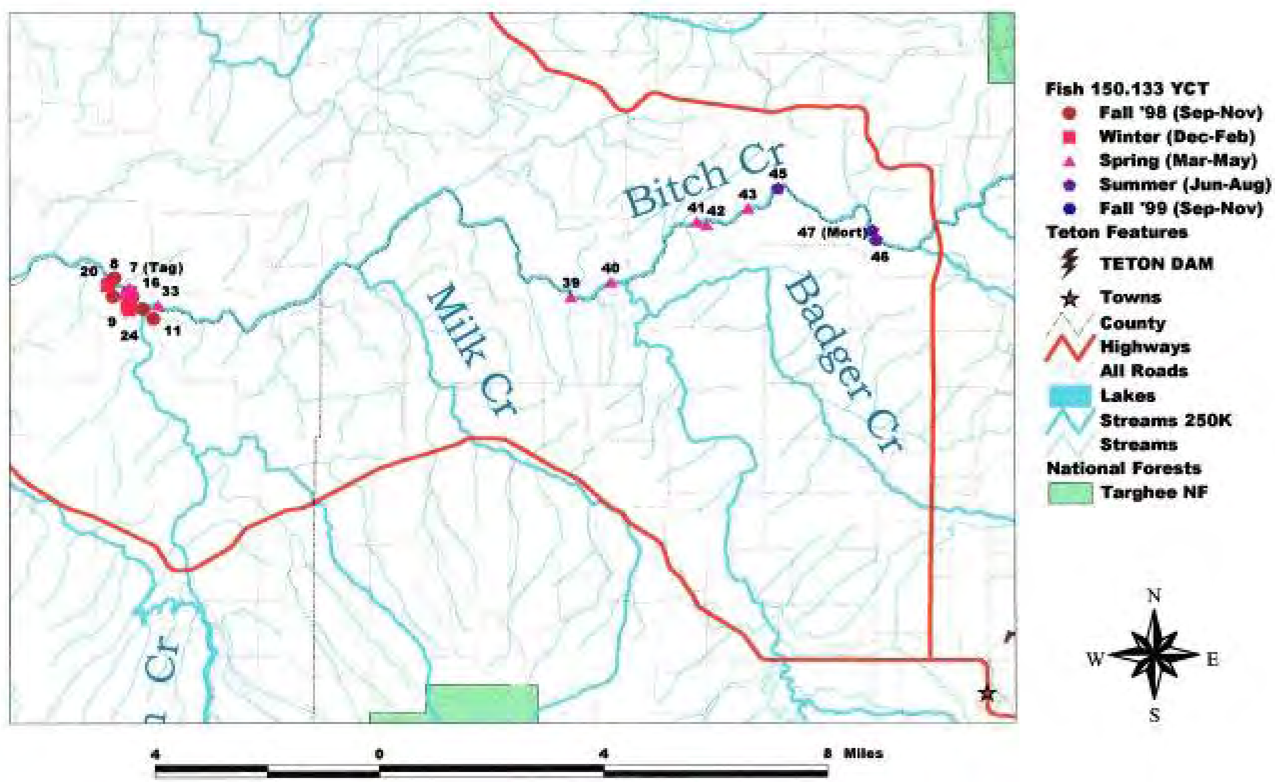
Appendix J-2. Radio telemetry locations of cutthroat trout 150.983 that was tagged in the South Fork Teton River and spawned in Moody Creek, Idaho.



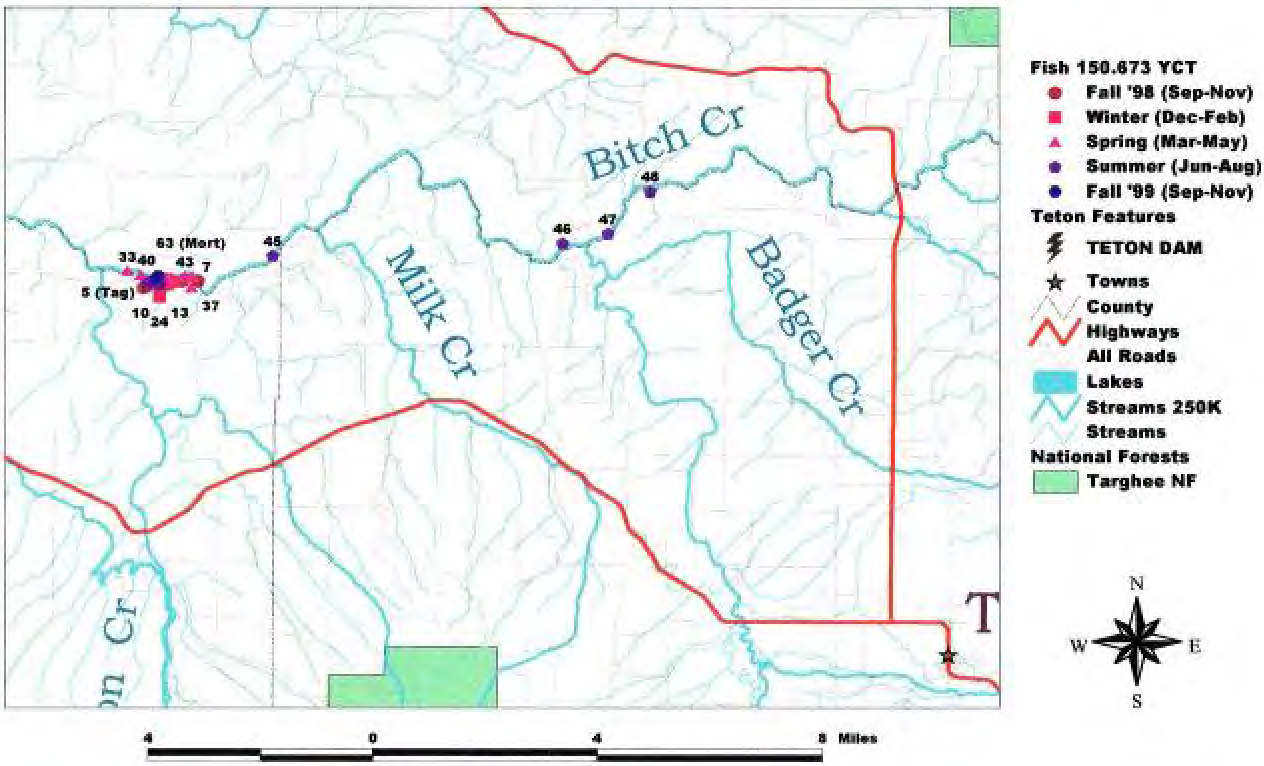
Appendix J-3. Radio telemetry locations of cutthroat trout 150.373 that was tagged in the Teton Canyon study section, Idaho, and spawned in Canyon Creek, Idaho.



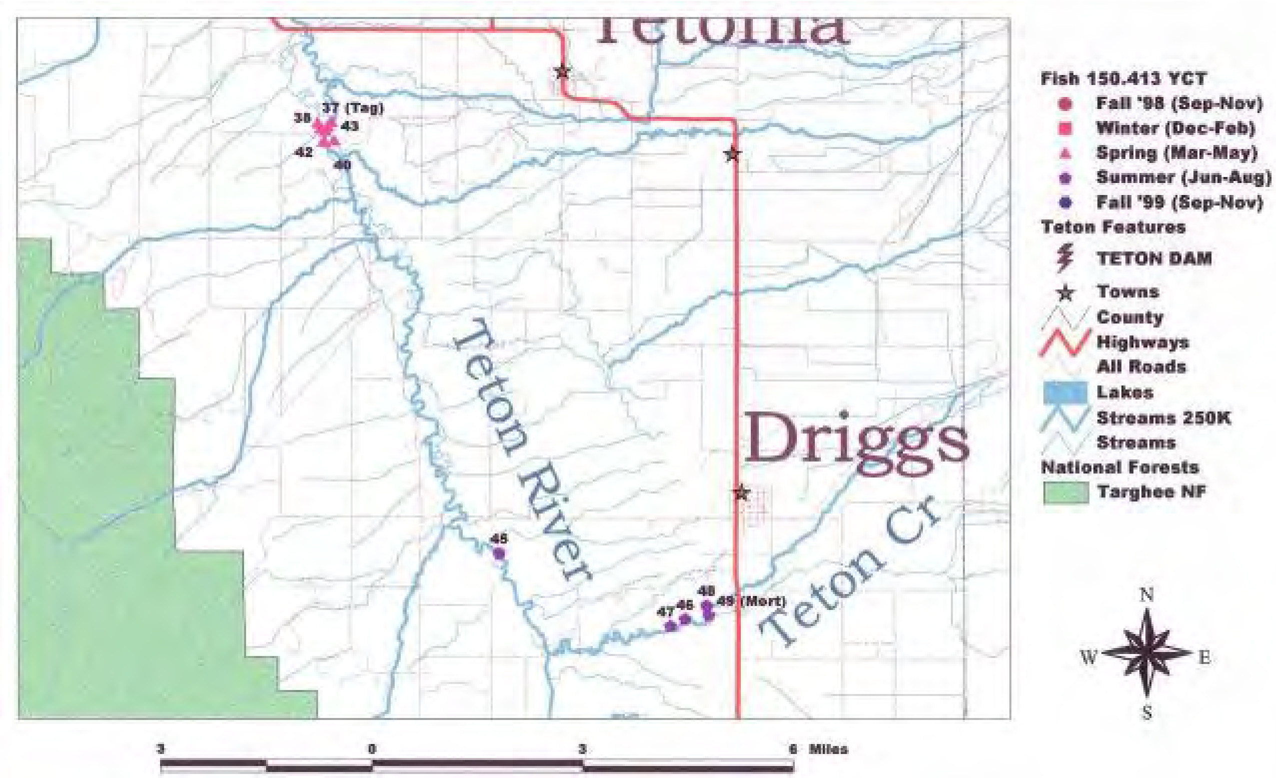
Appendix J-4. Radio telemetry locations of cutthroat trout 150.133 that was tagged in the Teton Canyon study section, Idaho, and spawned in Bitch Creek, Idaho.



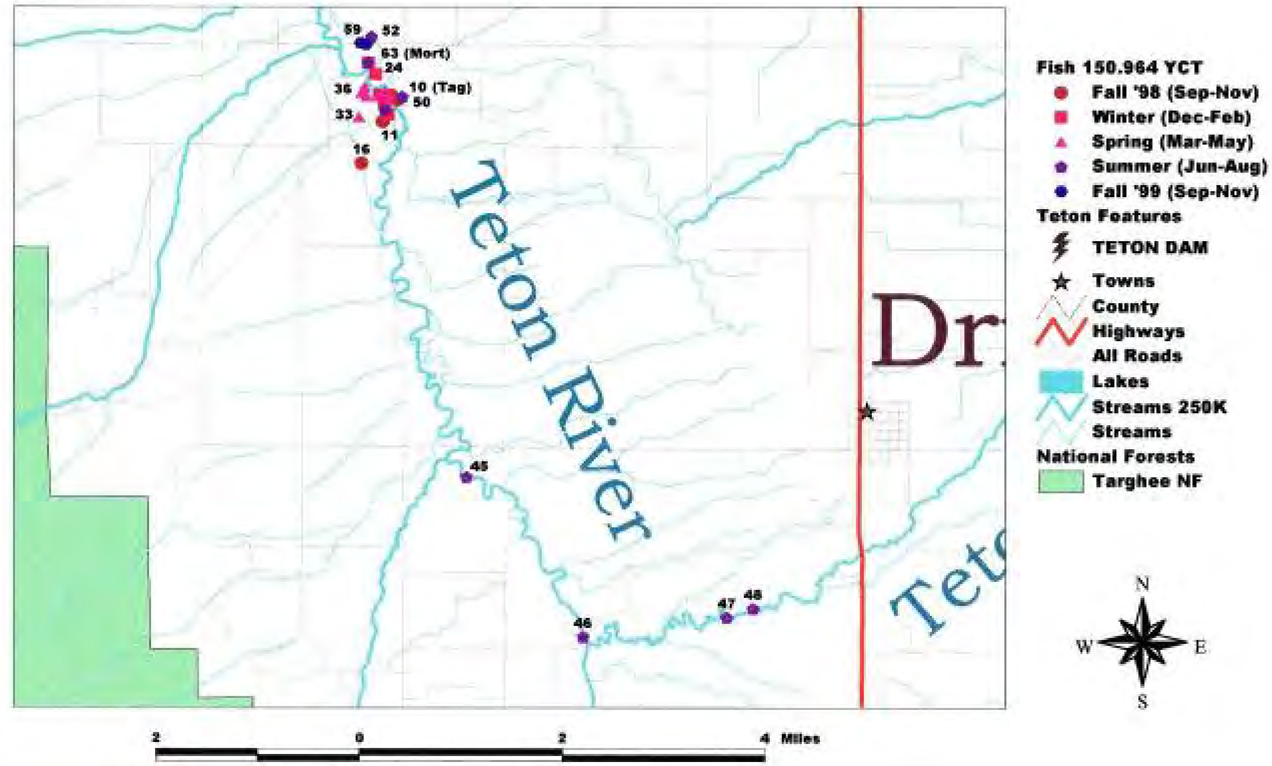
Appendix J-5. Radio telemetry locations of cutthroat trout 150.673 that was tagged in the Teton Canyon study section, Idaho, and spawned in Bitch Creek, Idaho.



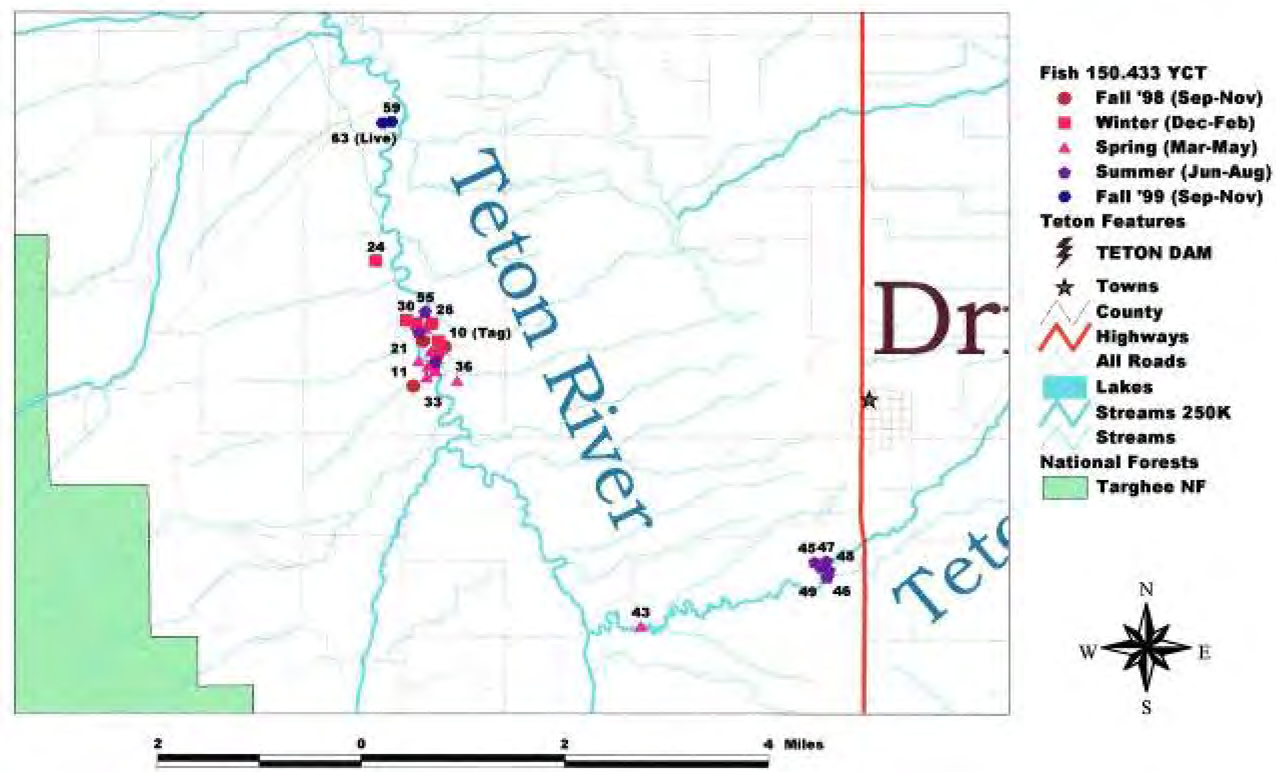
Appendix J-6. Radio telemetry locations of cutthroat trout 150.413 that was tagged in the Teton Valley study section, Idaho, and spawned in Teton Creek, Idaho.



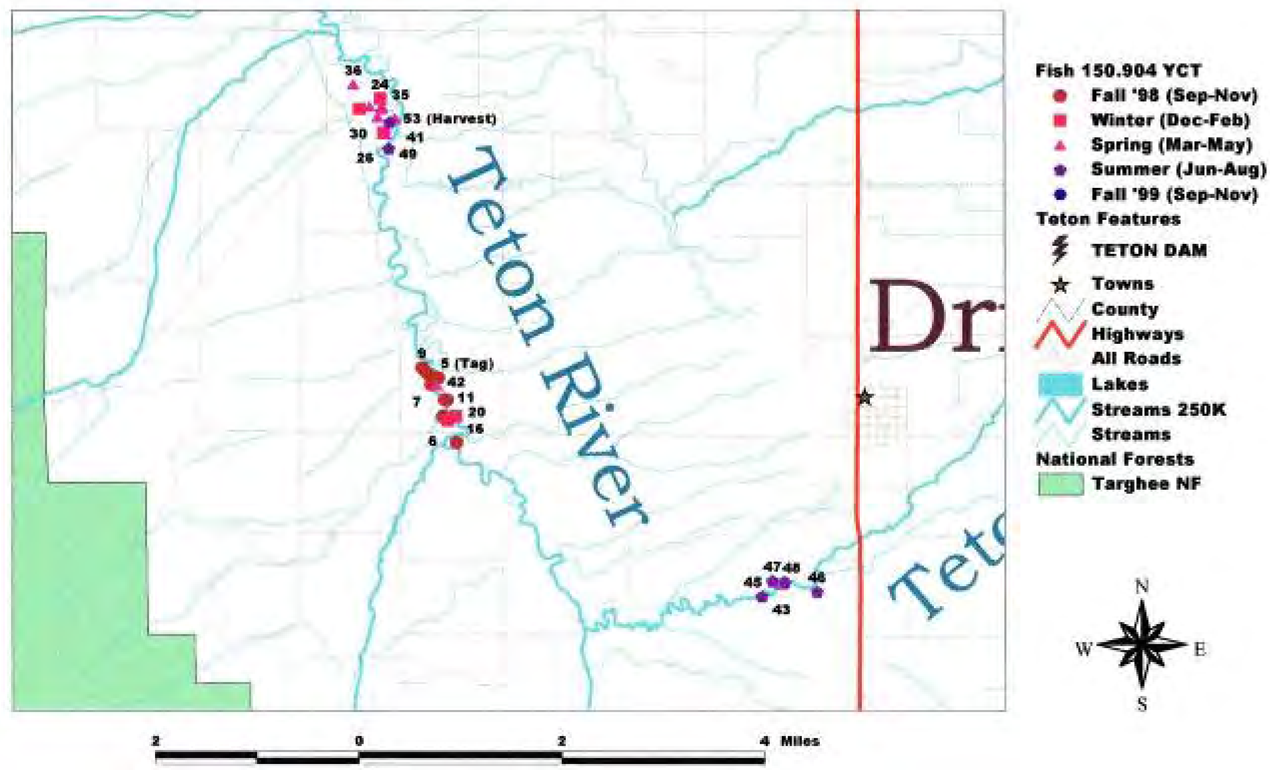
Appendix J-7. Radio telemetry locations of cutthroat trout 150.964 that was tagged in the Teton Valley study section, Idaho, and spawned in Teton Creek, Idaho.



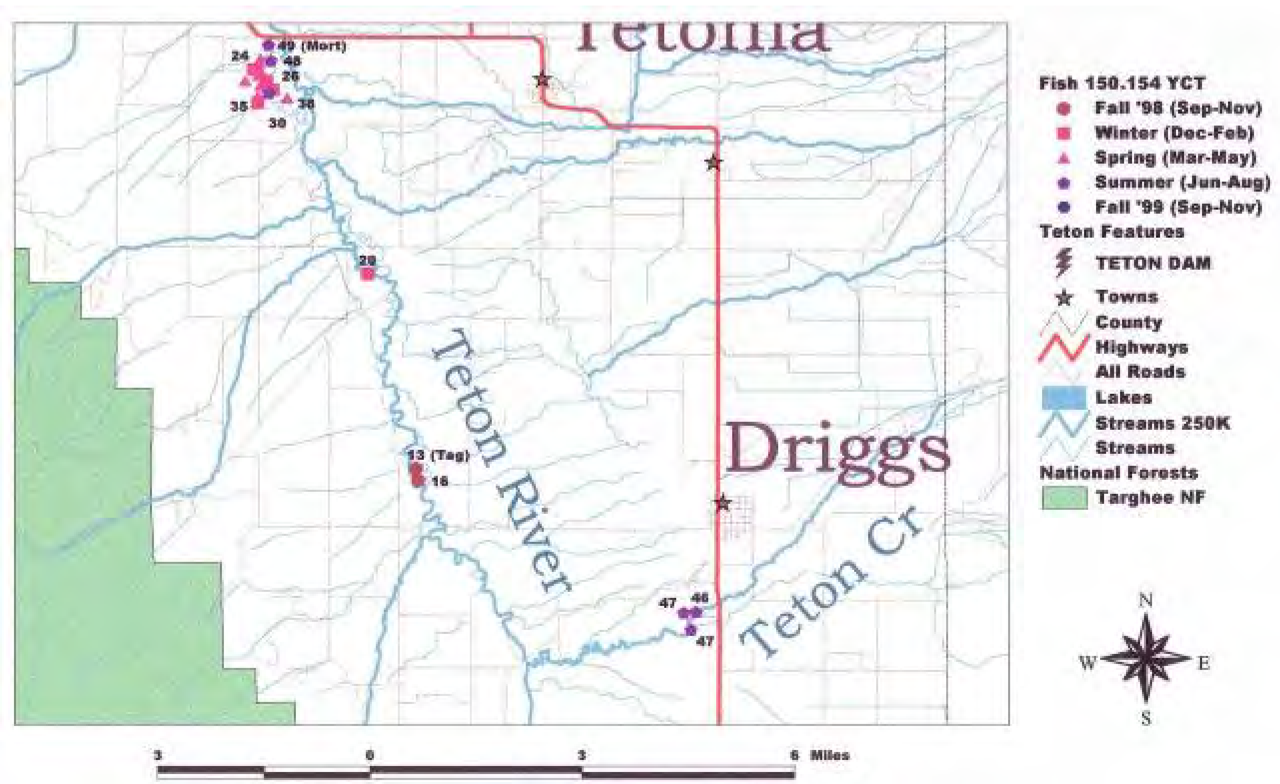
Appendix J-8. Radio telemetry locations of cutthroat trout 150.433 that was tagged in the Teton Valley study section, Idaho, and spawned in Teton Creek, Idaho.



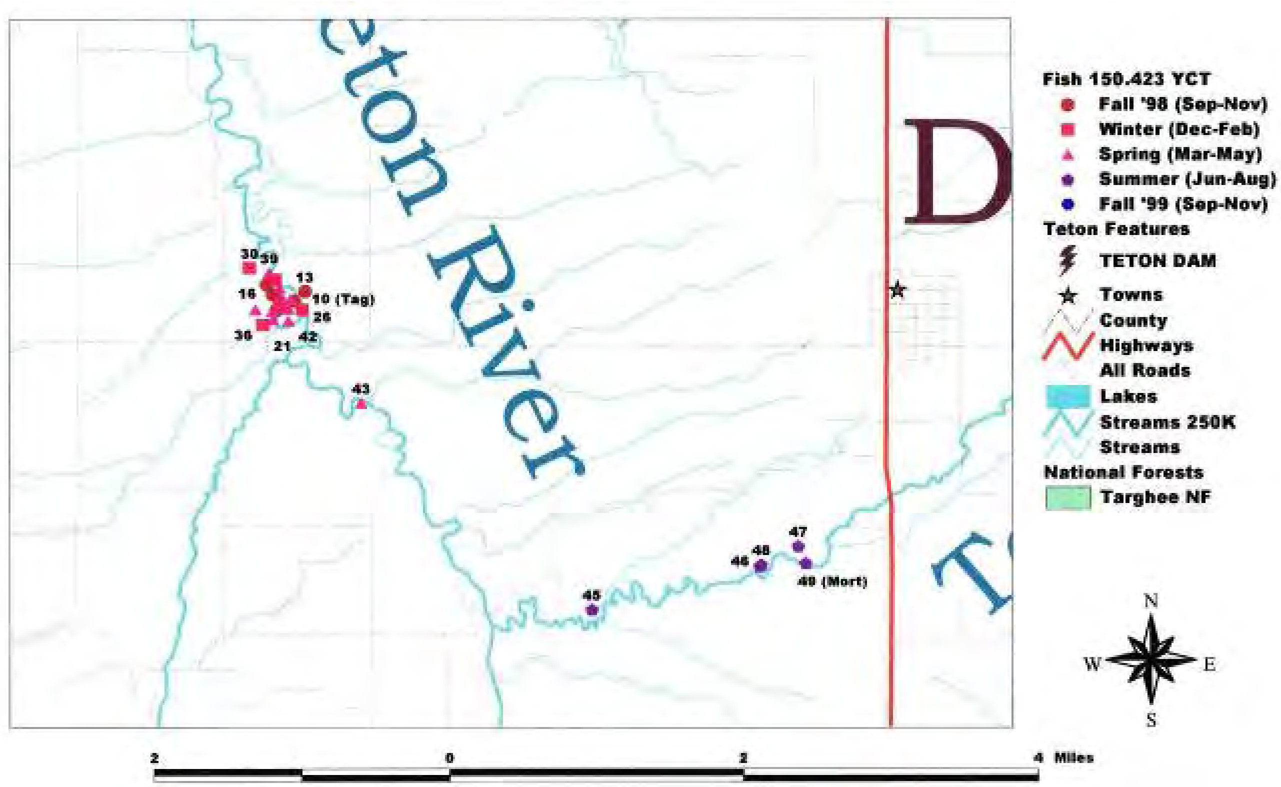
Appendix J-9. Radio telemetry locations of cutthroat trout 150.904 that was tagged in the Teton Valley study section, Idaho, and spawned in Teton Creek, Idaho.



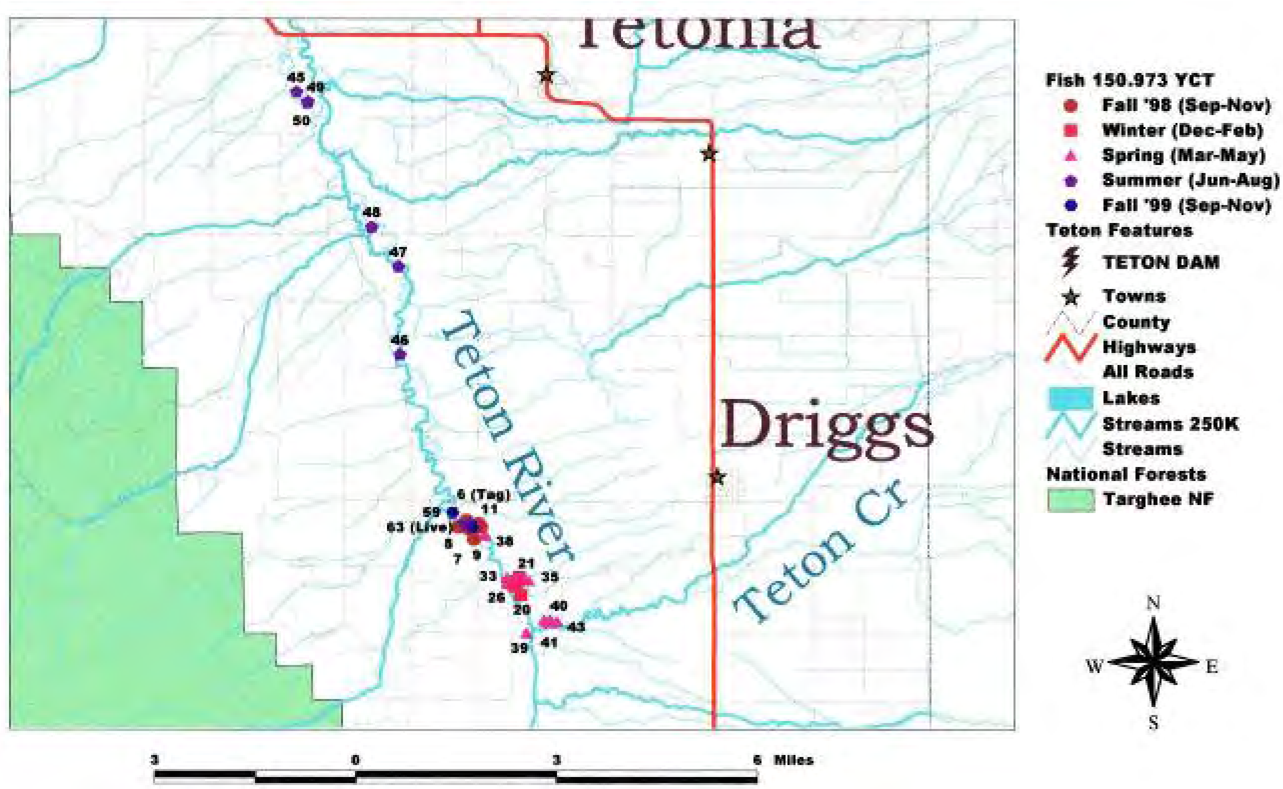
Appendix J-10. Radio telemetry locations of cutthroat trout 150.154 that was tagged in the Teton Valley study section, Idaho, and spawned in Teton Creek, Idaho.



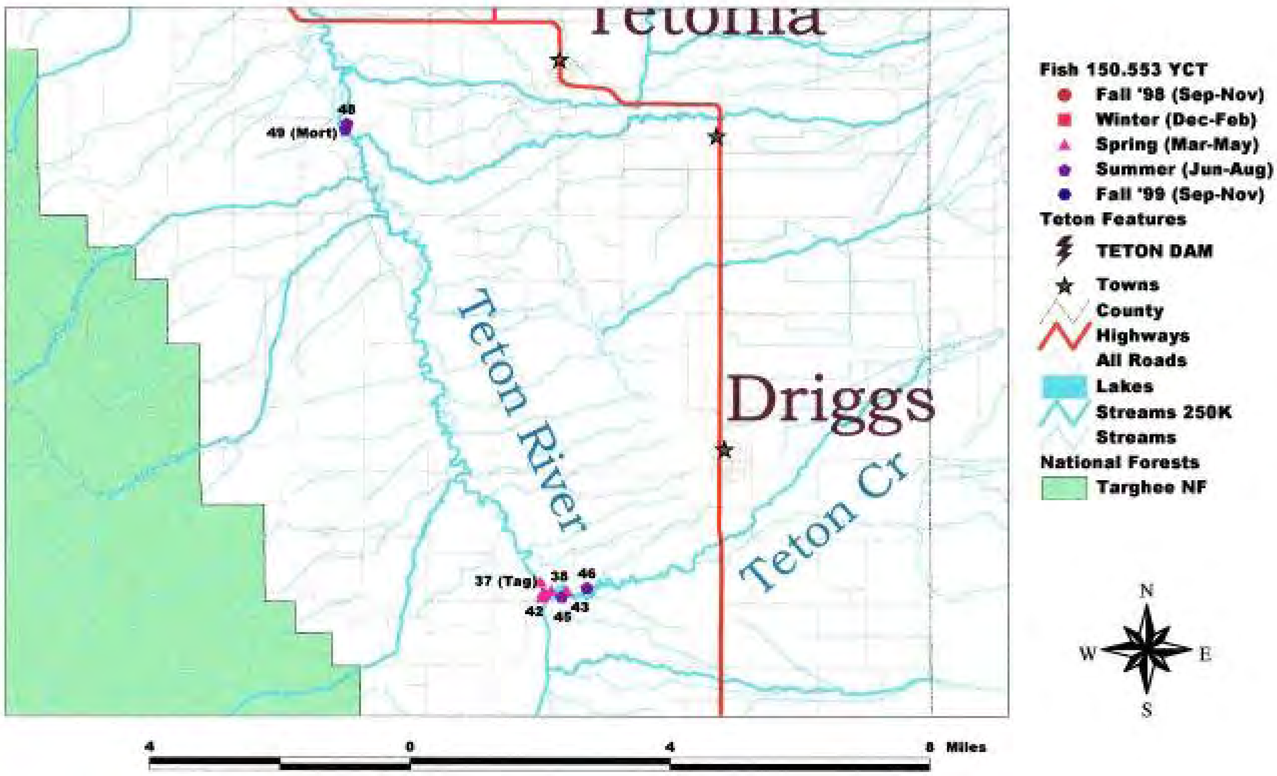
Appendix J-11. Radio telemetry locations of cutthroat trout 150.423 that was tagged in the Teton Valley study section, Idaho, and spawned in Teton Creek, Idaho.



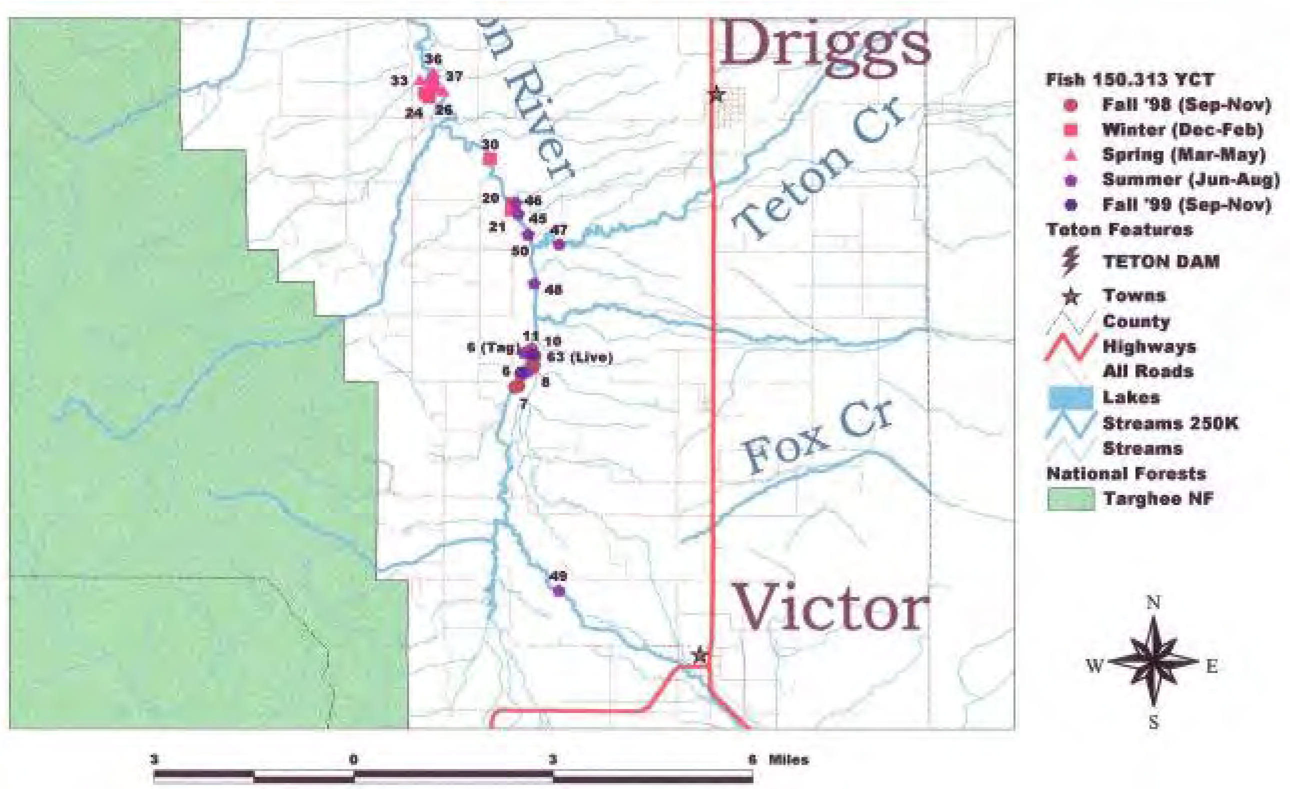
Appendix J-12. Radio telemetry locations of cutthroat trout 150.973 that was tagged in the Teton Valley study section, Idaho, and spawned in Teton Creek, Idaho.



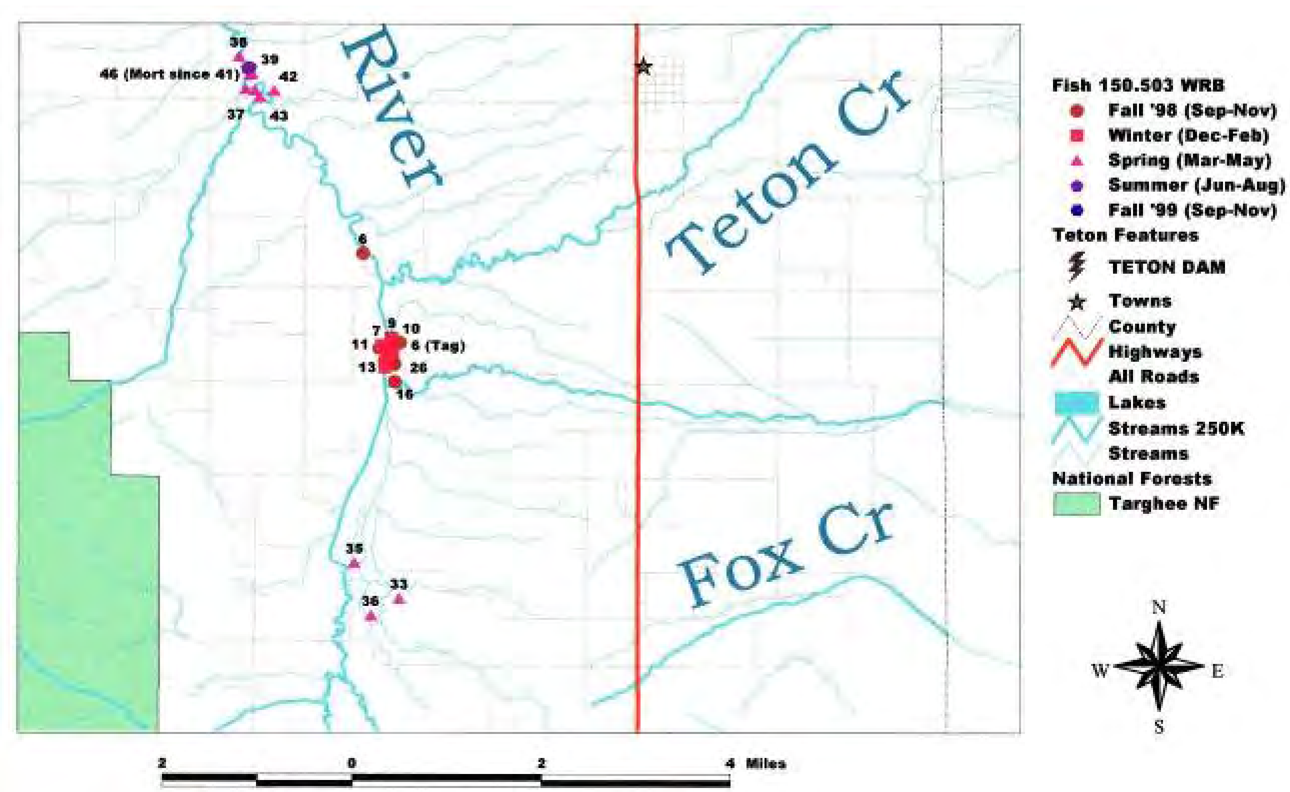
Appendix J-13. Radio telemetry locations of cutthroat trout 150.553 that was tagged in the Teton Valley study section, Idaho, and spawned in Teton Creek, Idaho.



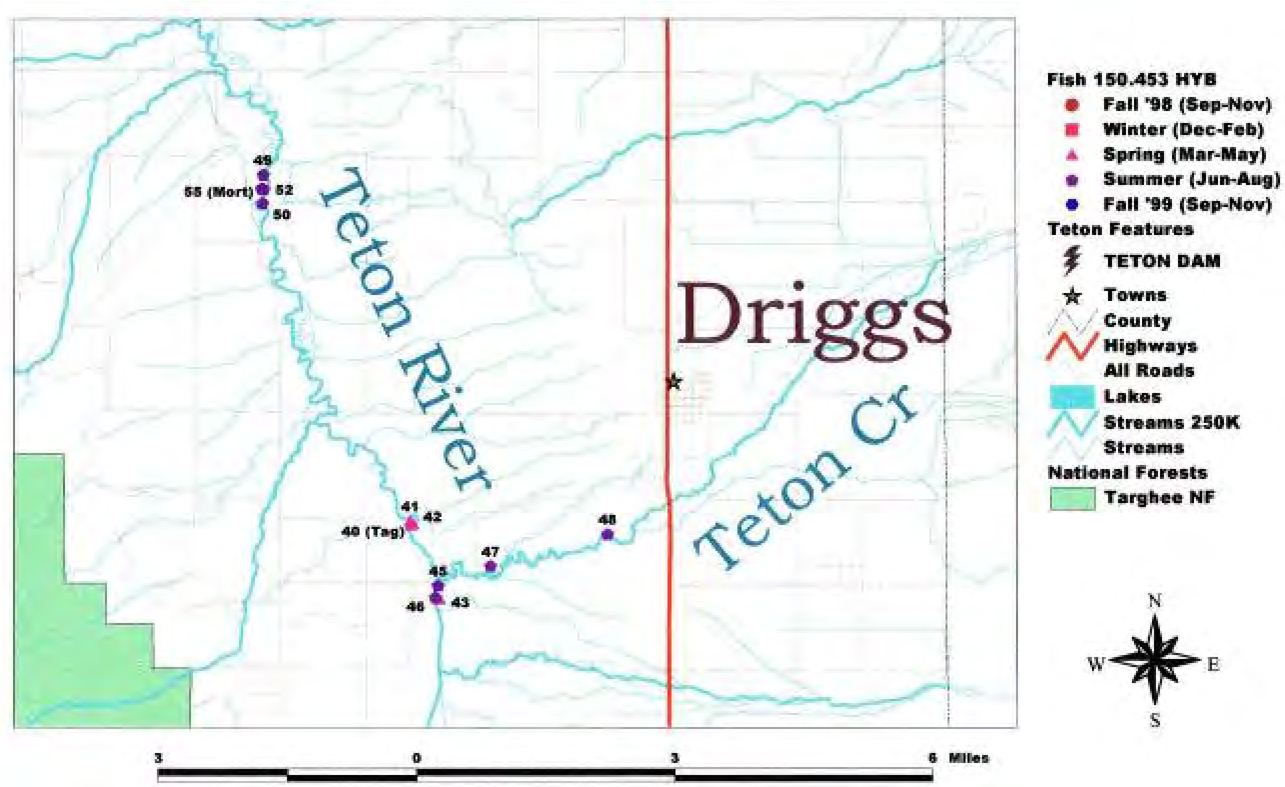
Appendix J-14. Radio telemetry locations of cutthroat trout 150.313 that was tagged in the Teton Valley study section, Idaho, and spawned in Trail Creek, Idaho.



Appendix J-15. Radio telemetry locations of rainbow trout 150.503 that was tagged in the Teton Valley study section, Idaho, and spawned in Fox Creek, Idaho.

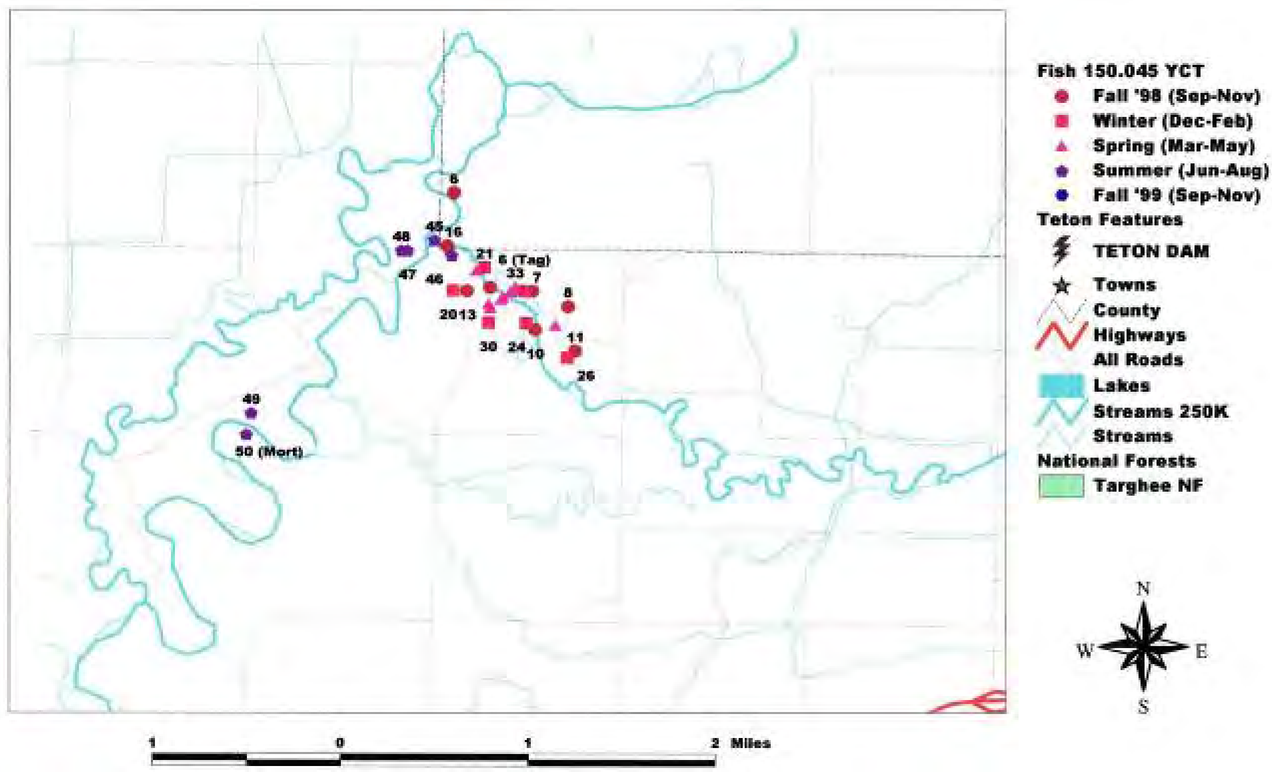


Appendix J-16. Radio telemetry locations of hybrid trout 150.453 that was tagged in the Teton Valley study section, Idaho, and spawned in Teton Creek, Idaho.

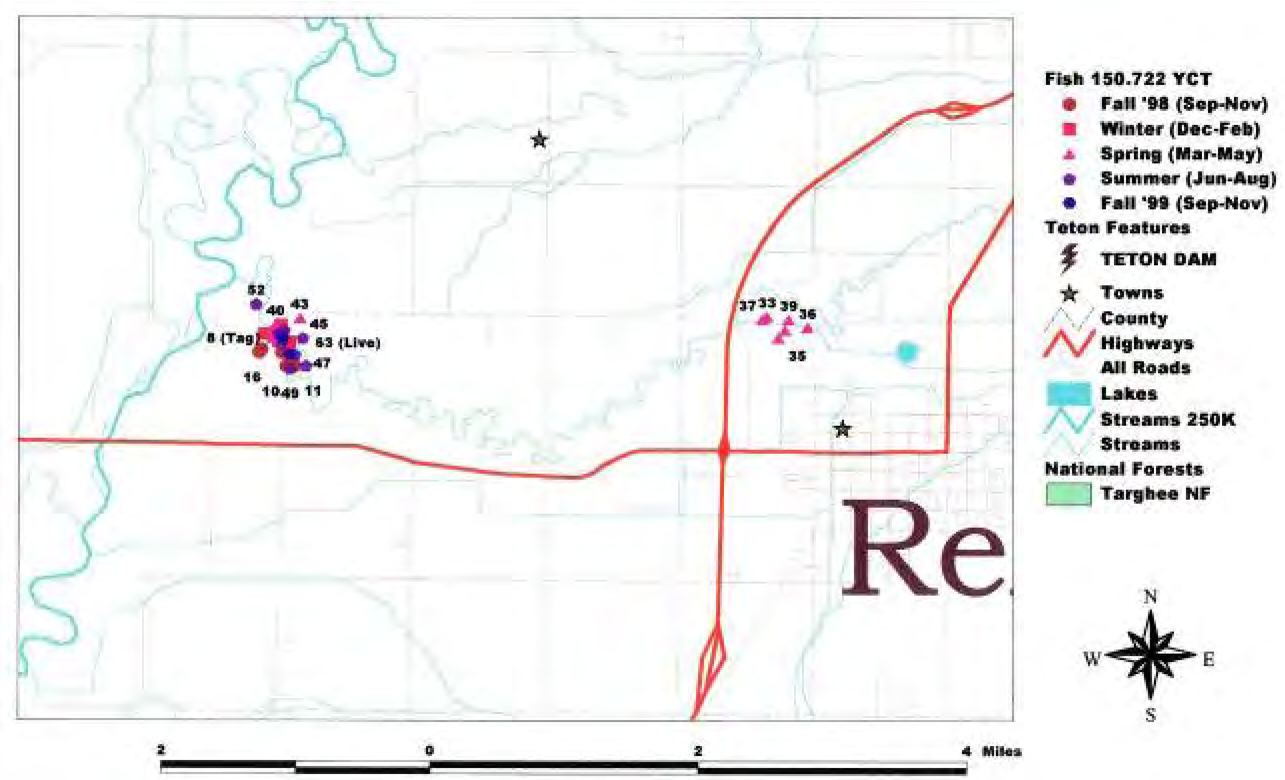


Appendix K. Radio telemetry locations of eight cutthroat, three rainbow, and four hybrid trout that migrated to mainstem sites to spawn during the 1999 spawning season (March-July), Teton River and Henrys Fork Snake River, Idaho. First and last locations are in parentheses.

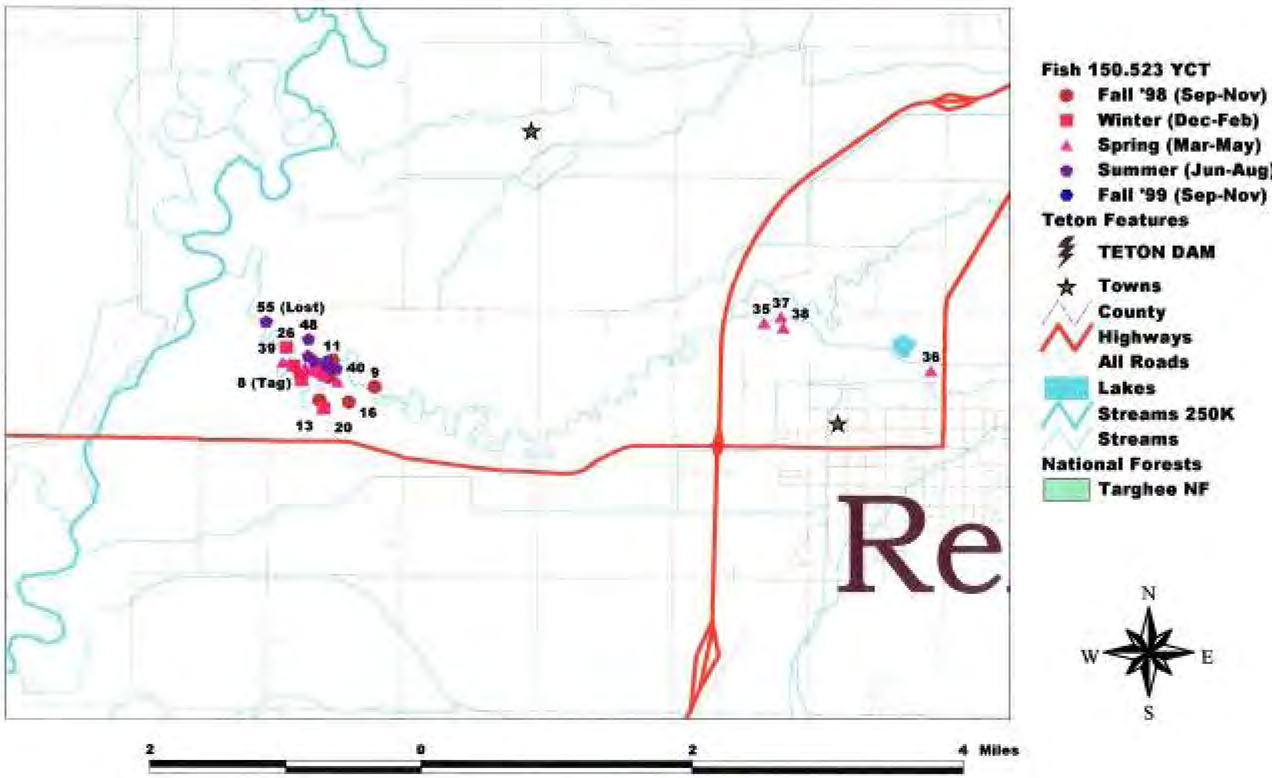
Appendix K-1. Radio telemetry locations of cutthroat trout 150.045 that was tagged in the North Fork Teton River and spawned downstream in the Henrys Fork Snake River, Idaho.



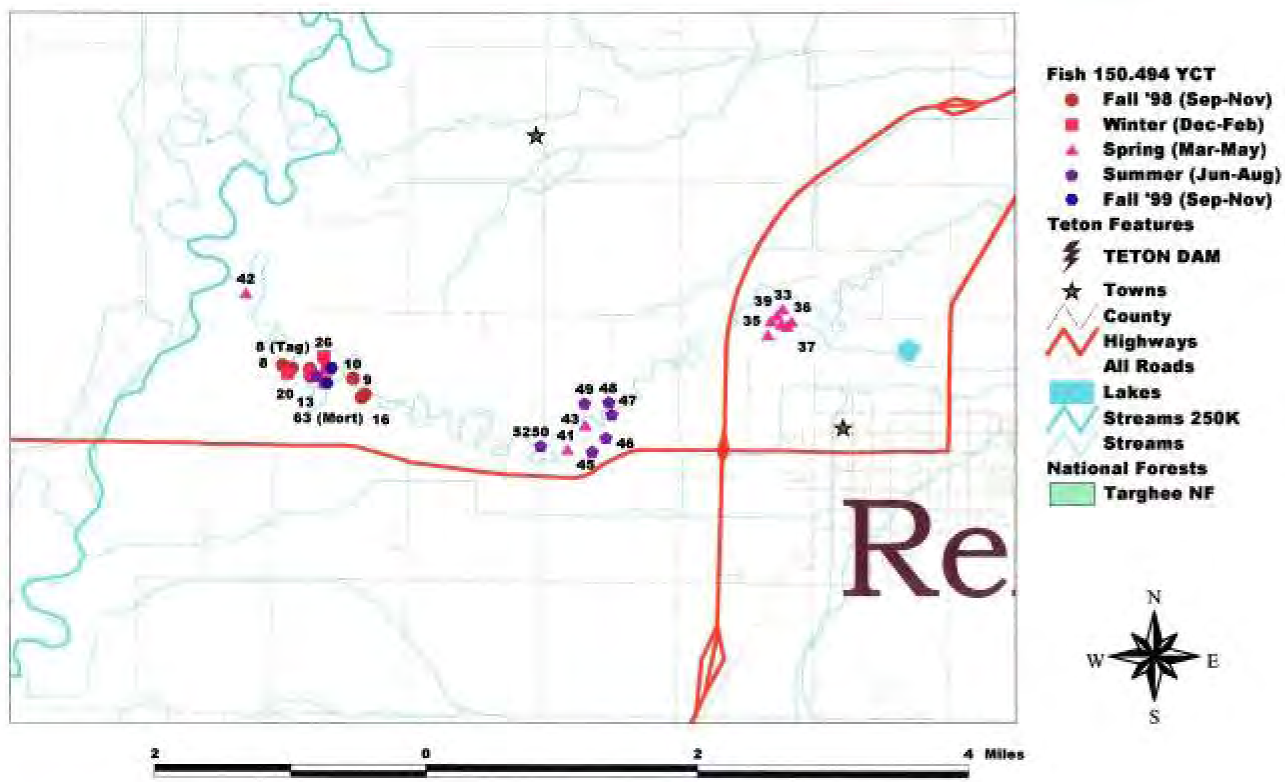
Appendix K-2. Radio telemetry locations of cutthroat trout 150.722 that was tagged in the South Fork Teton River, Idaho, and spawned upstream.



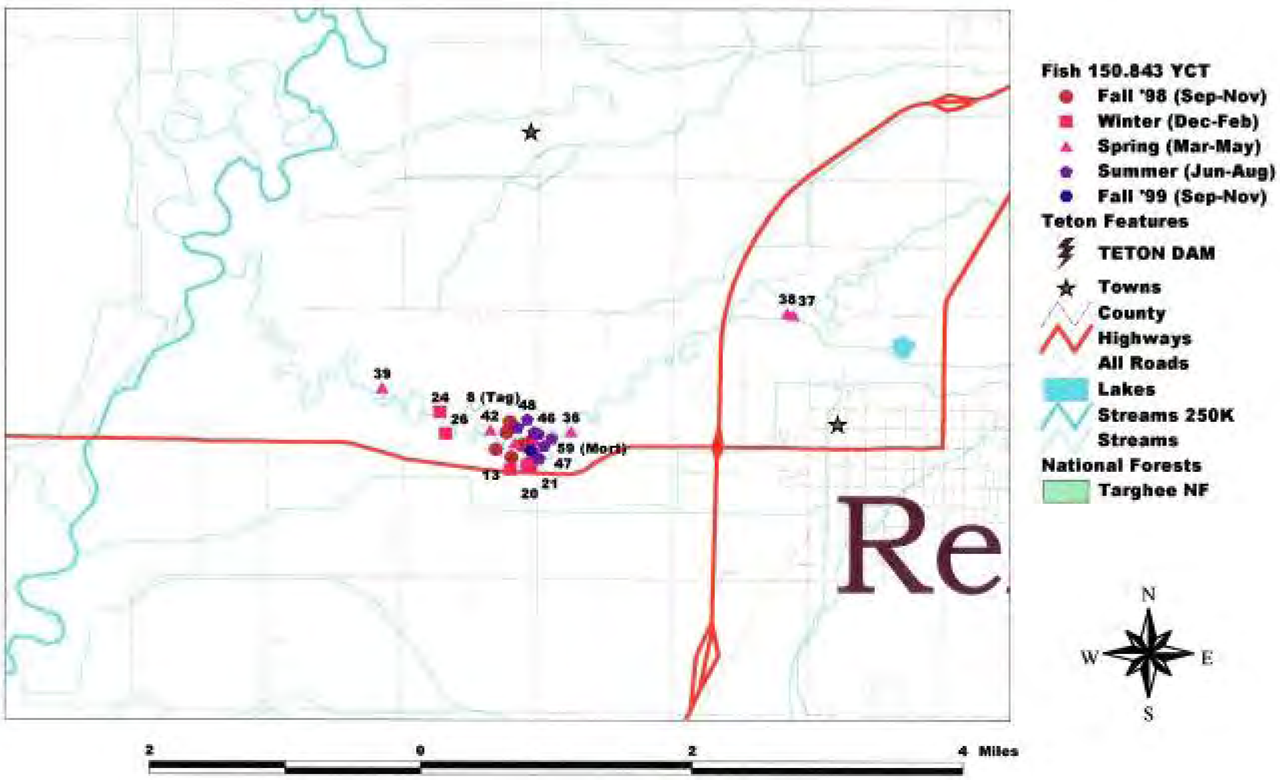
Appendix K-3. Radio telemetry locations of cutthroat trout 150.523 that was tagged in the South Fork Teton River, Idaho, and spawned upstream.



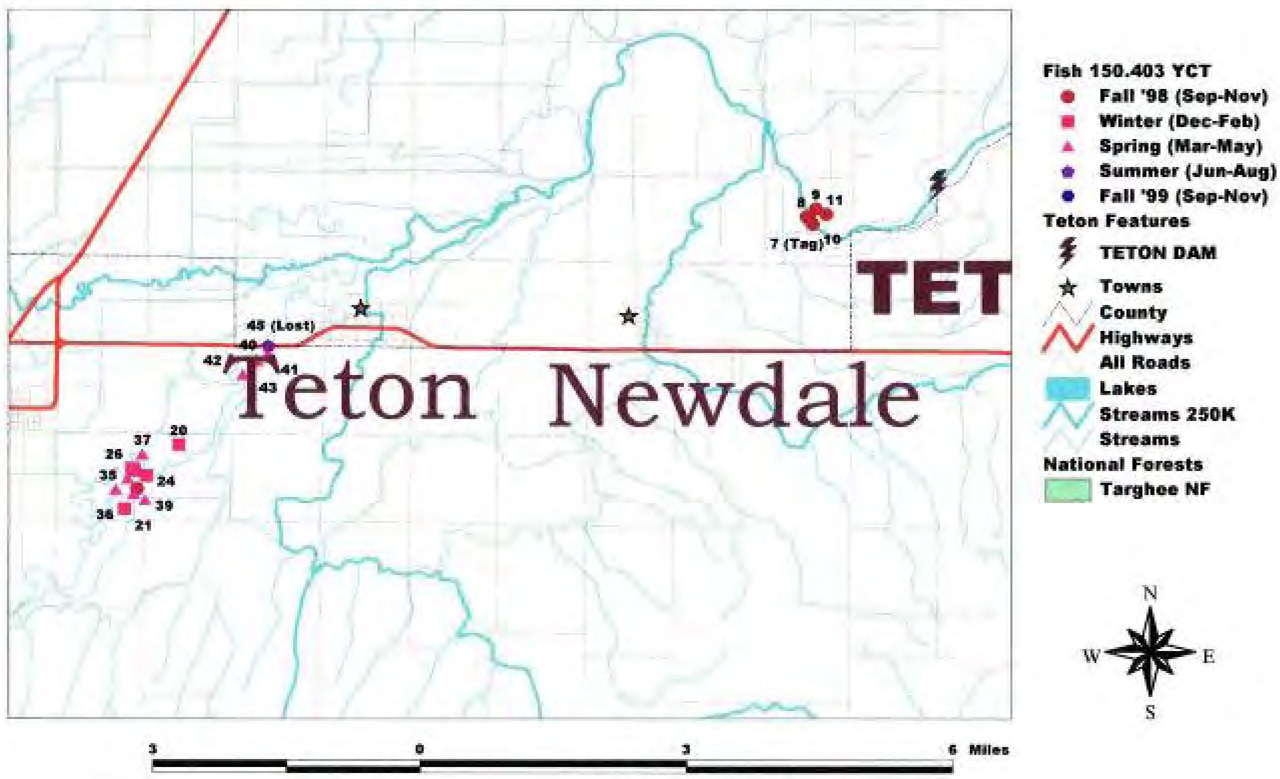
Appendix K-4. Radio telemetry locations of cutthroat trout 150.494 that was tagged in the South Fork Teton River, Idaho, and spawned upstream.



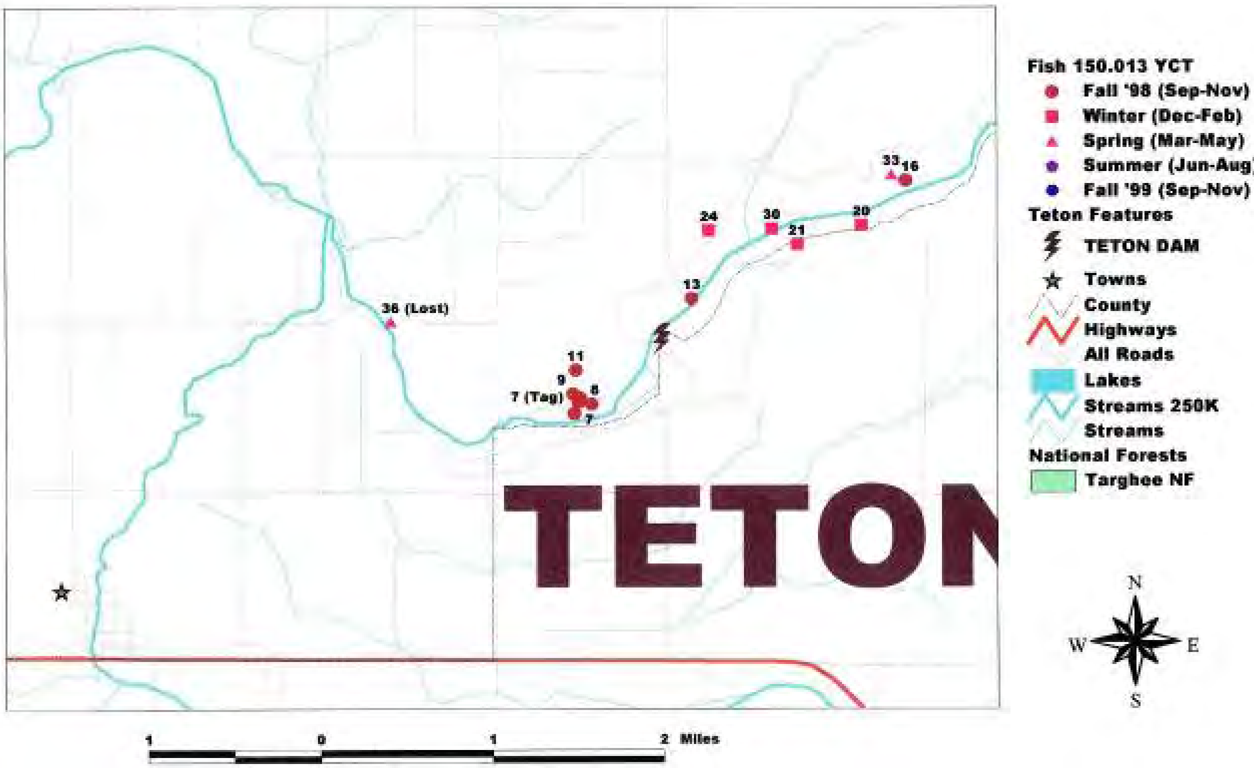
Appendix K-5. Radio telemetry locations of cutthroat trout 150.843 that was tagged in the South Fork Teton River, Idaho, and spawned upstream.



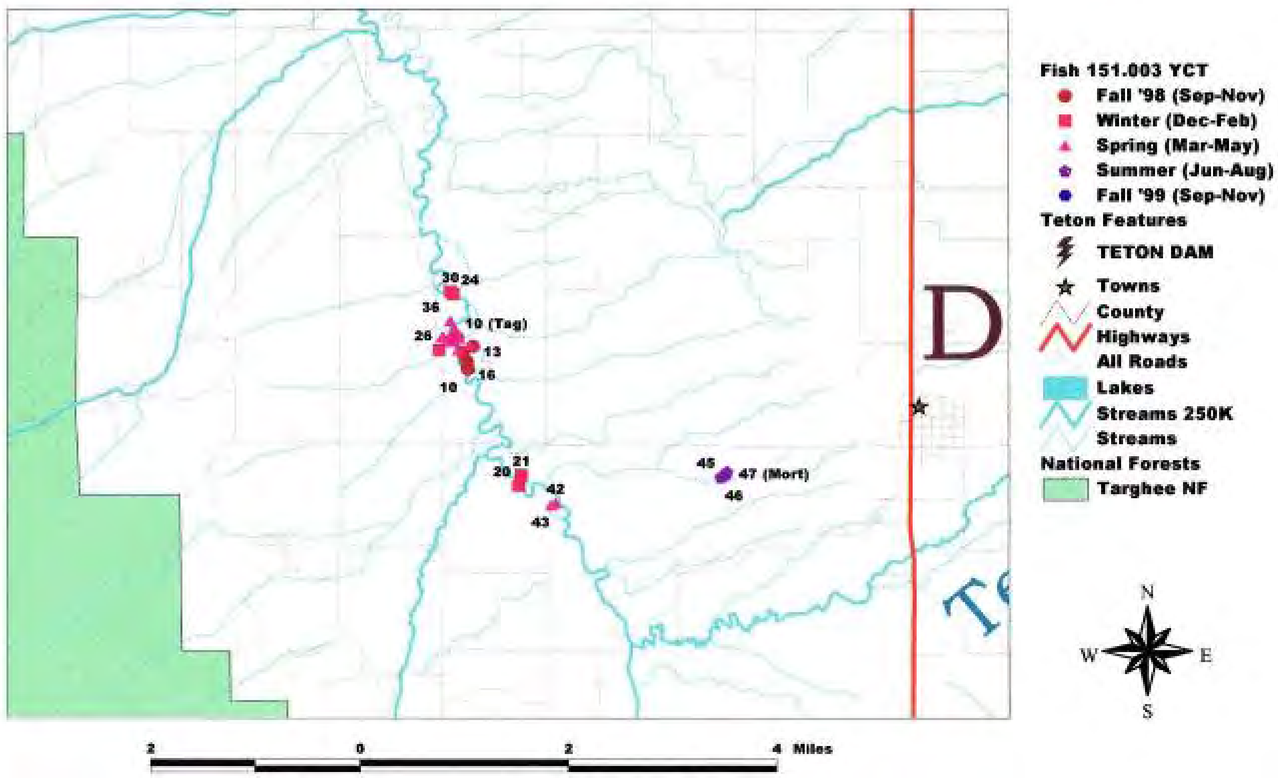
Appendix K-6. Radio telemetry locations of cutthroat trout 150.403 that was tagged in the Lower Teton study section and spawned downstream in the South Fork Teton River, Idaho.



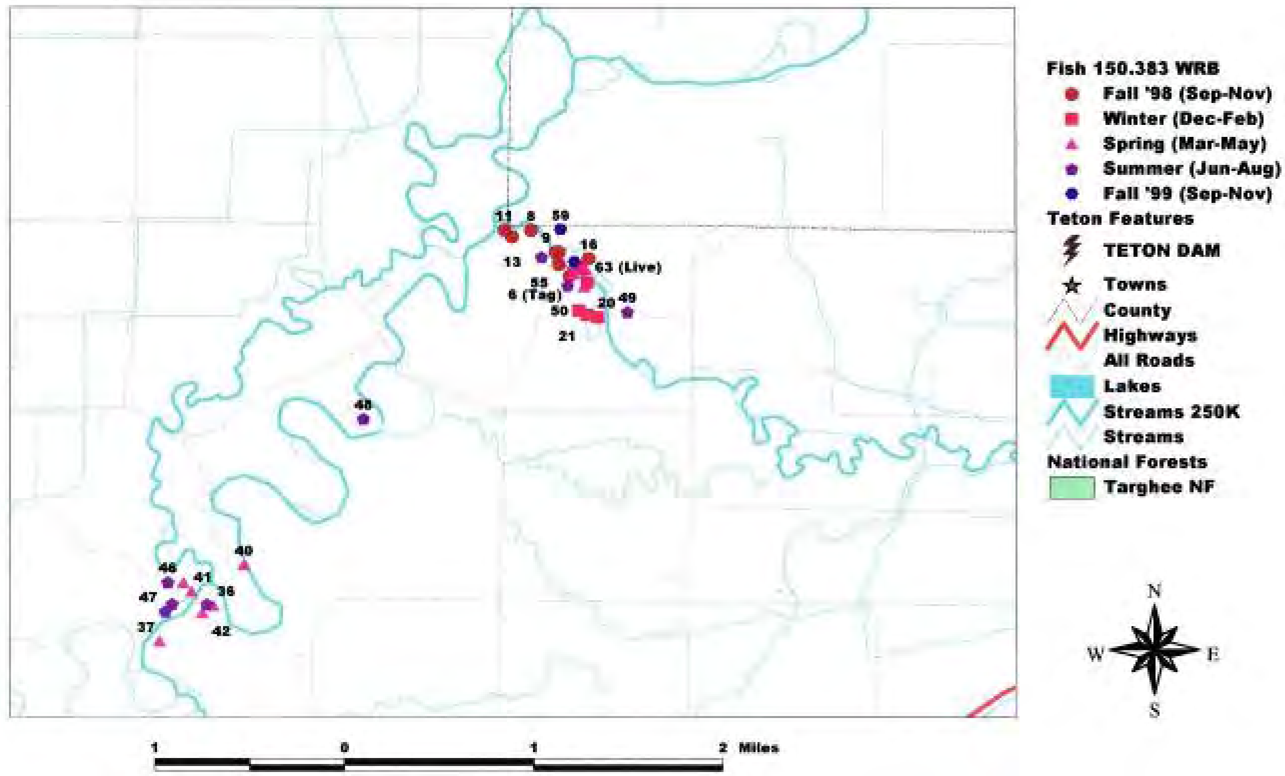
Appendix K-7. Radio telemetry locations of cutthroat trout 150.013 that was tagged in the Lower Teton study section and spawned upstream in the Teton Canyon study section, Idaho.



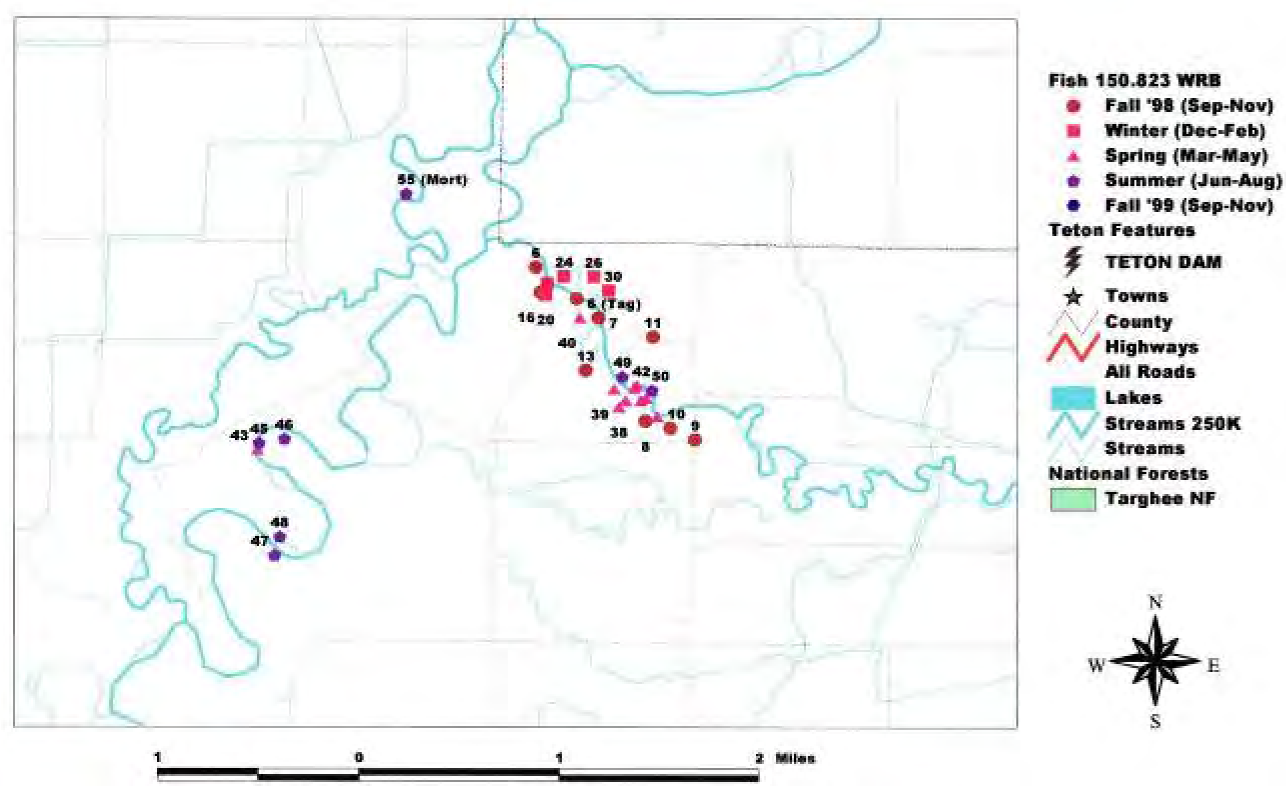
Appendix K-8. Radio telemetry locations of cutthroat trout 151.003 that was tagged in the Teton Valley study section, Idaho, and spawned upstream. Locations 45-47 were at a great blue heron rookery where the tag was recovered.



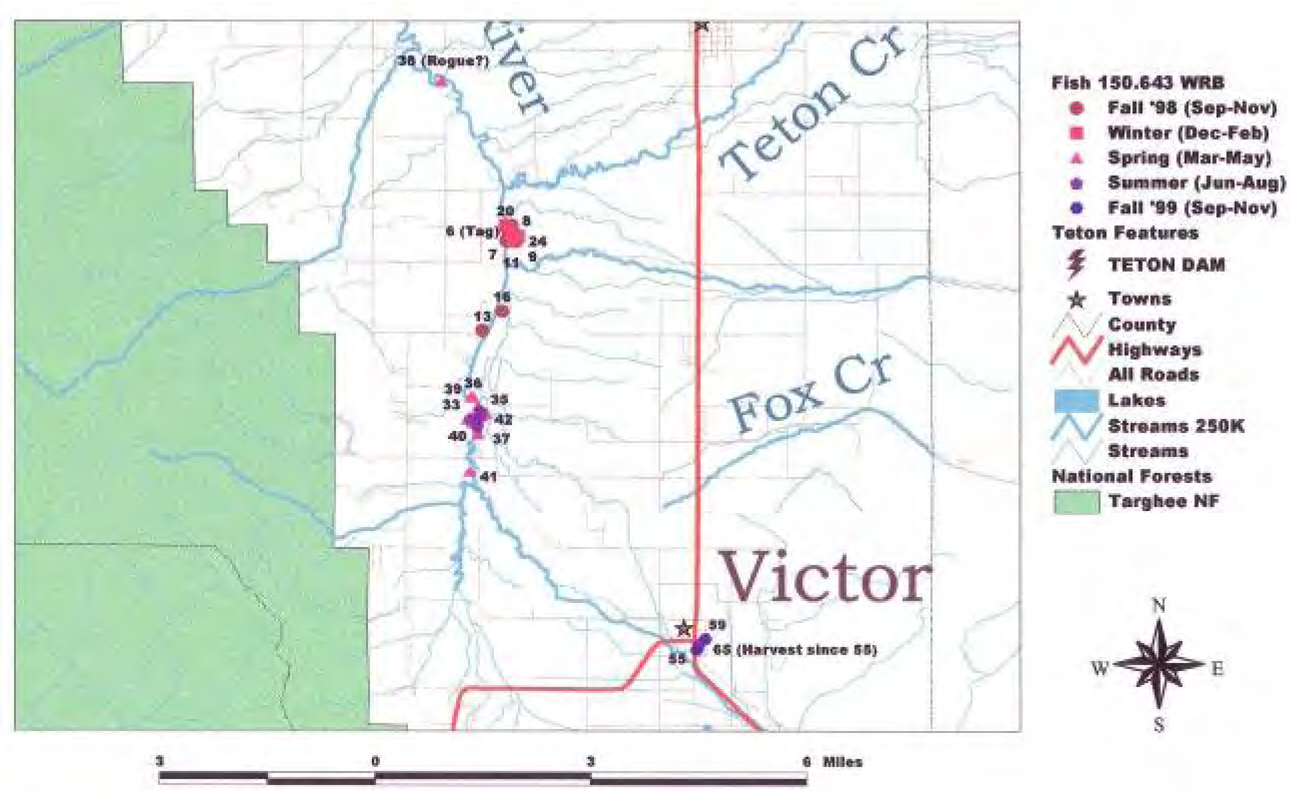
Appendix K-9. Radio telemetry locations of rainbow trout 150.383 that was tagged in the North Fork Teton River and spawned downstream in the Henrys Fork Snake River, Idaho.



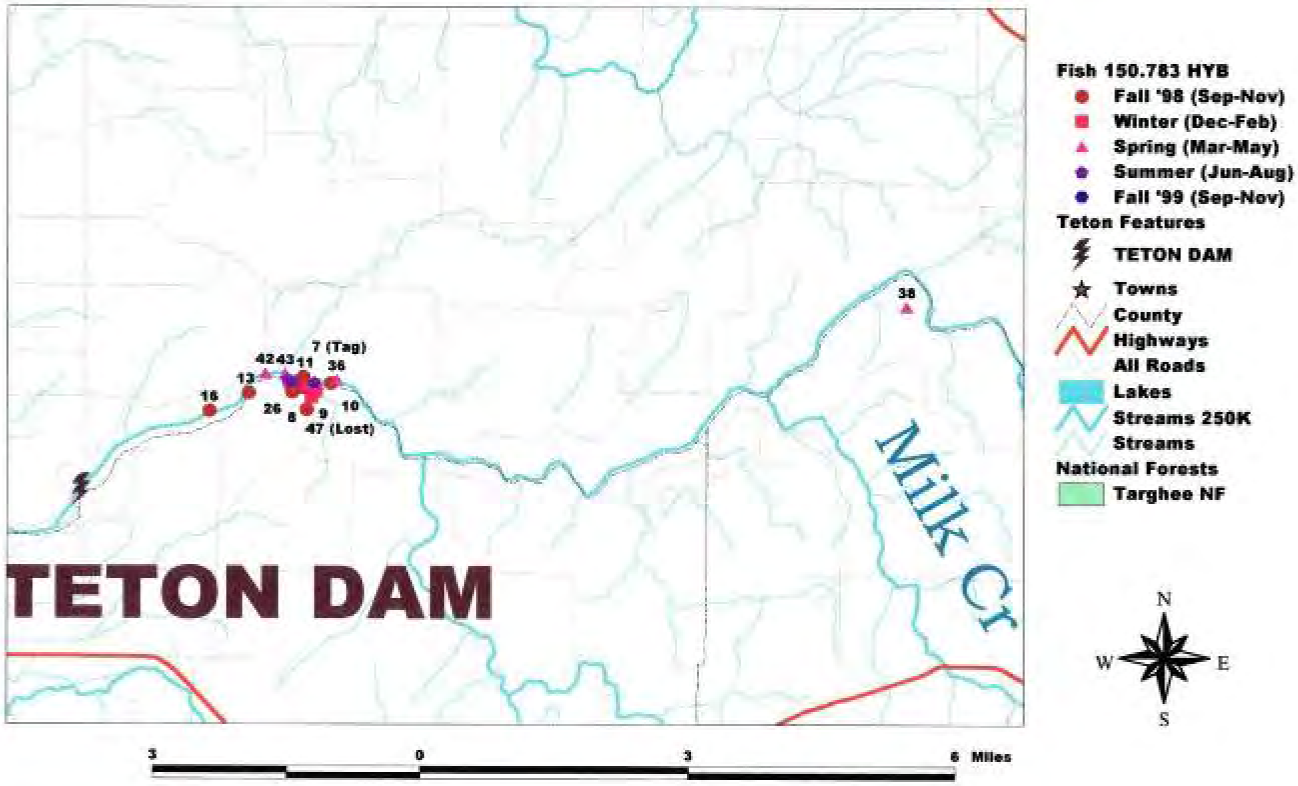
Appendix K-10. Radio telemetry locations of rainbow trout 150.823 that was tagged in the North Fork Teton River and spawned downstream in the Henrys Fork Snake River, Idaho.



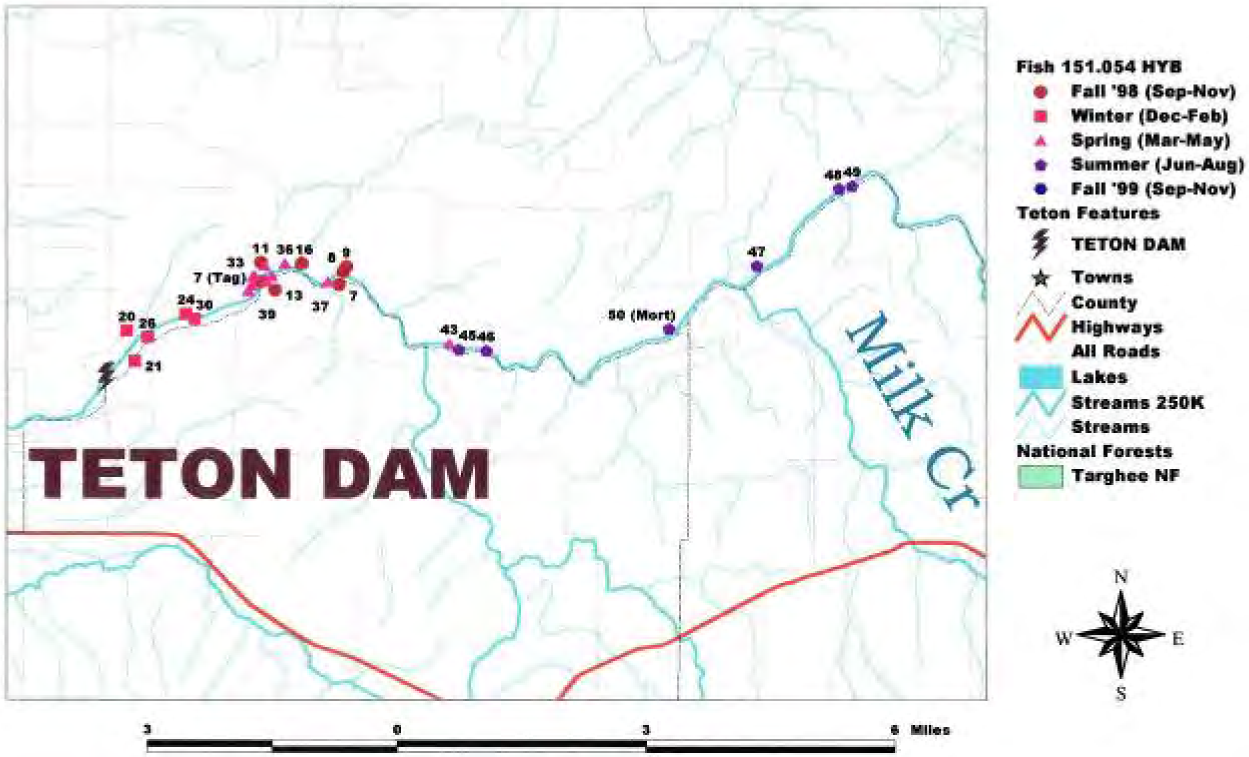
Appendix K-11. Radio telemetry locations of rainbow trout 150.643 that was tagged in the Teton Valley study section, Idaho, and spawned upstream. Locations 55-65 were at the Victor post office where the tag was recovered.



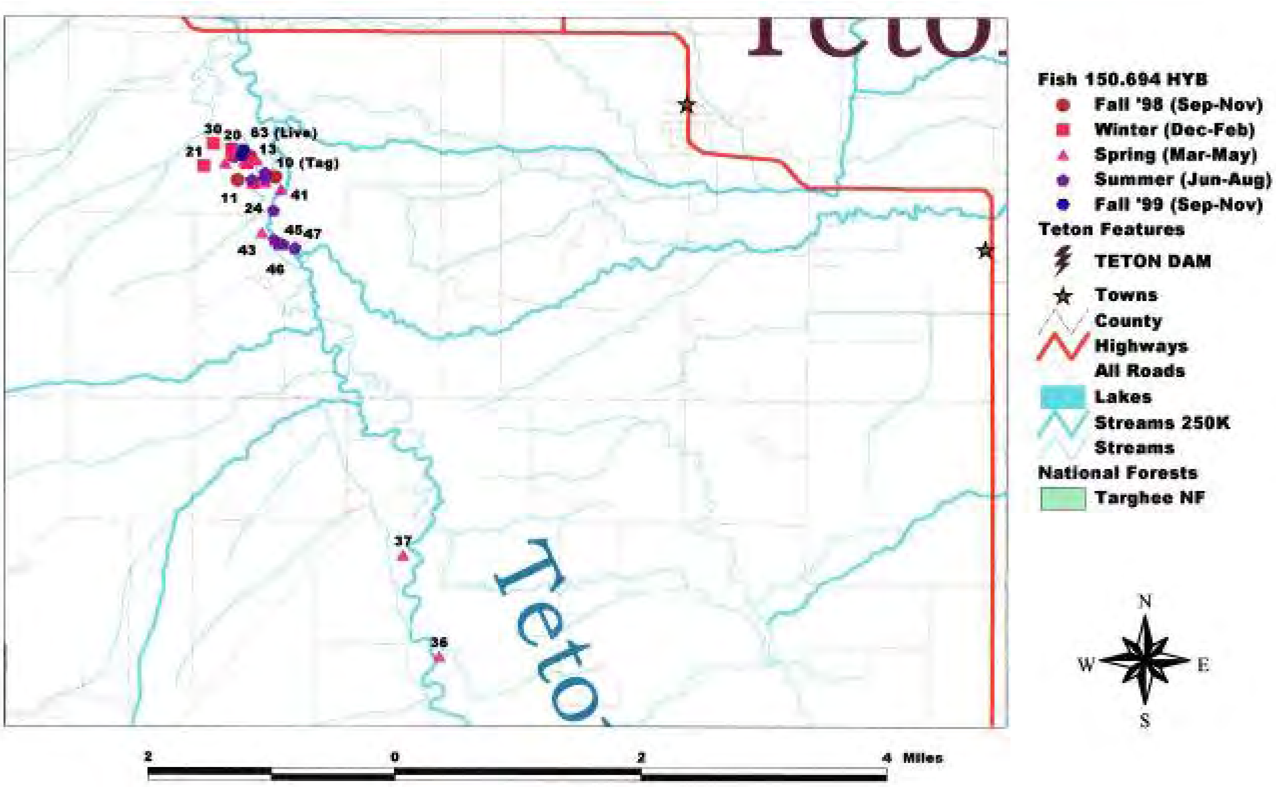
Appendix K-12. Radio telemetry locations of hybrid trout 150.783 that was tagged in the Teton Canyon study section, Idaho, and spawned upstream.



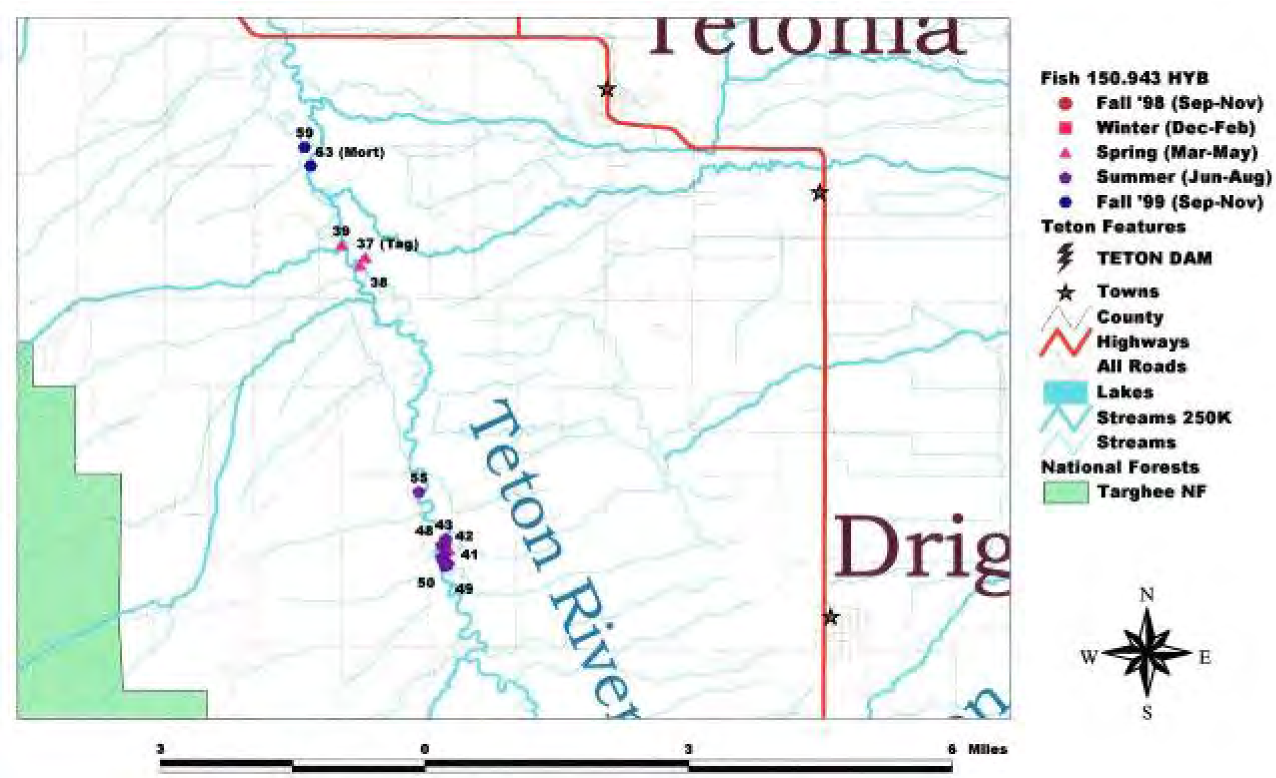
Appendix K-13. Radio telemetry locations of hybrid trout 151.054 that was tagged in the Teton Canyon study section, Idaho, and spawned upstream.



Appendix K-14. Radio telemetry locations of hybrid trout 150.694 that was tagged in the Teton Valley study section, Idaho, and spawned upstream.

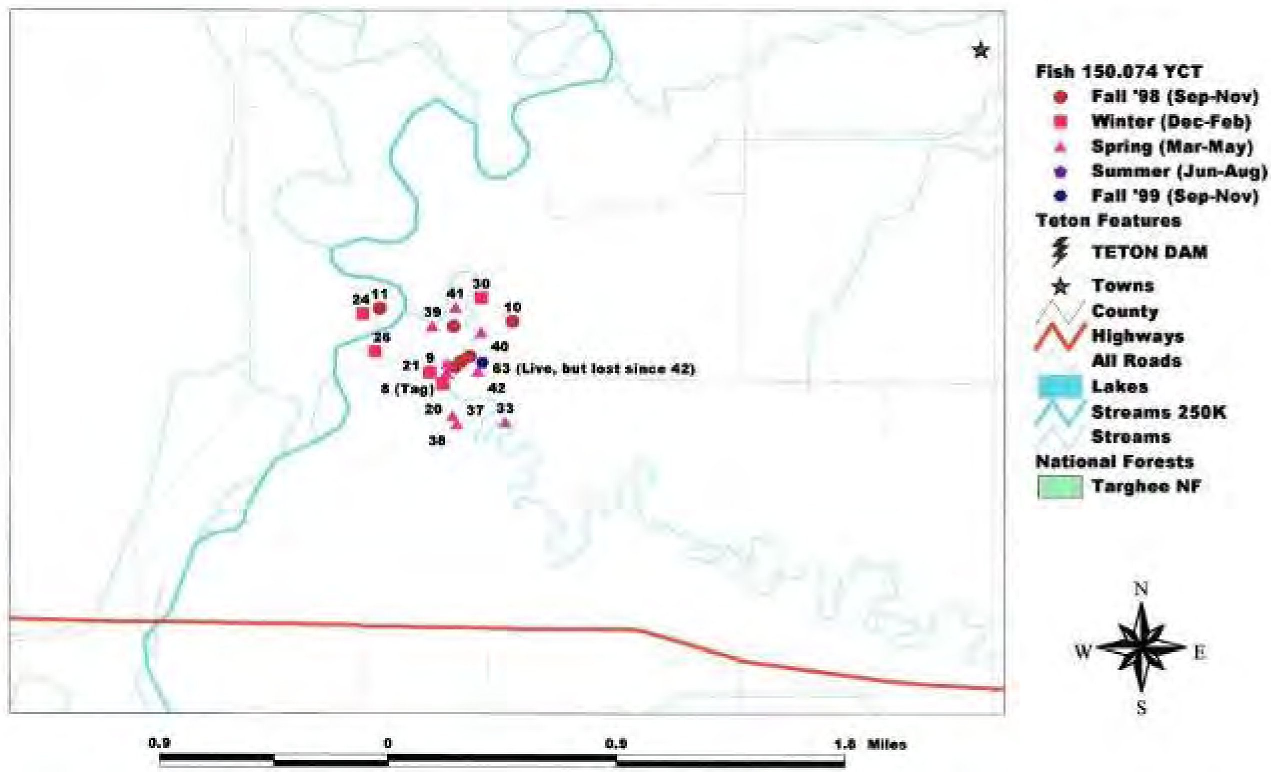


Appendix K-15. Radio telemetry locations of hybrid trout 150.943 that was tagged in the Teton Valley study section, Idaho, and spawned upstream.

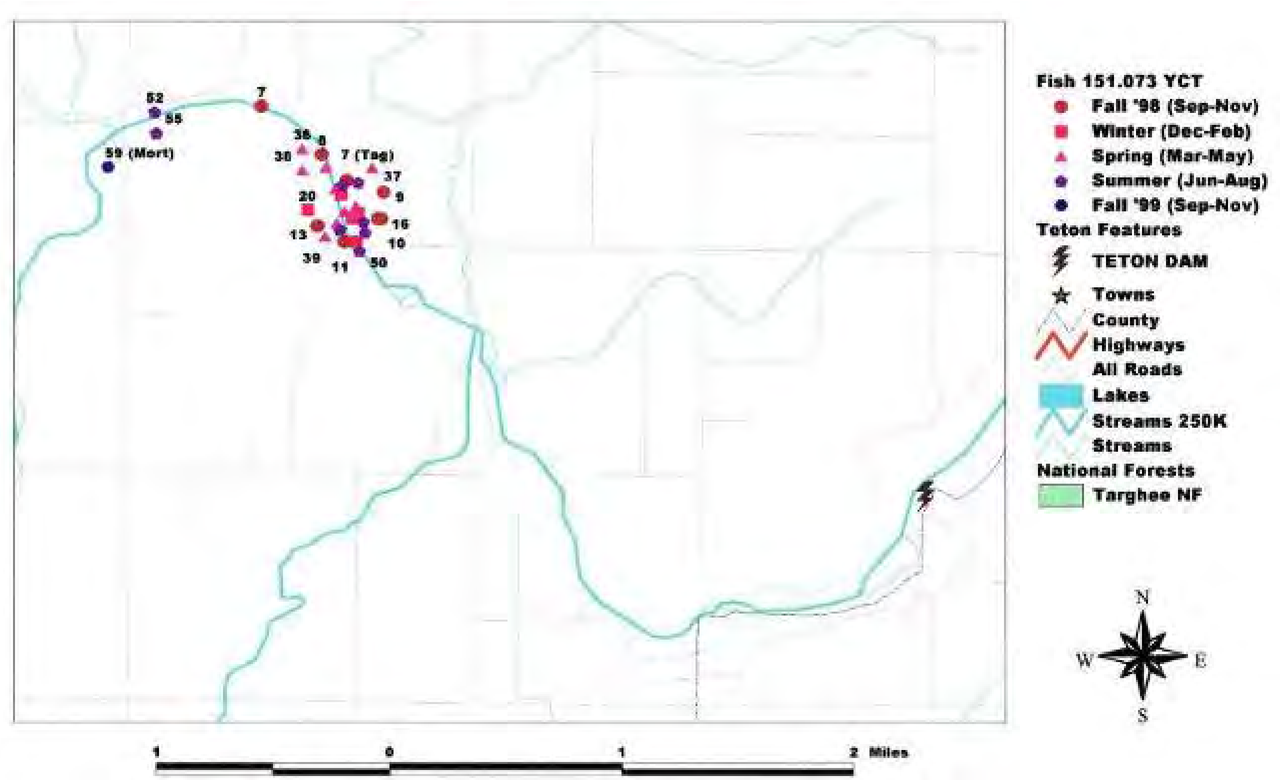


Appendix L. Radio telemetry locations of six cutthroat, one rainbow, and three hybrid trout that did not move but may have spawned during the 1999 spawning season (March-July), Teton River, Idaho. First and last locations are in parentheses.

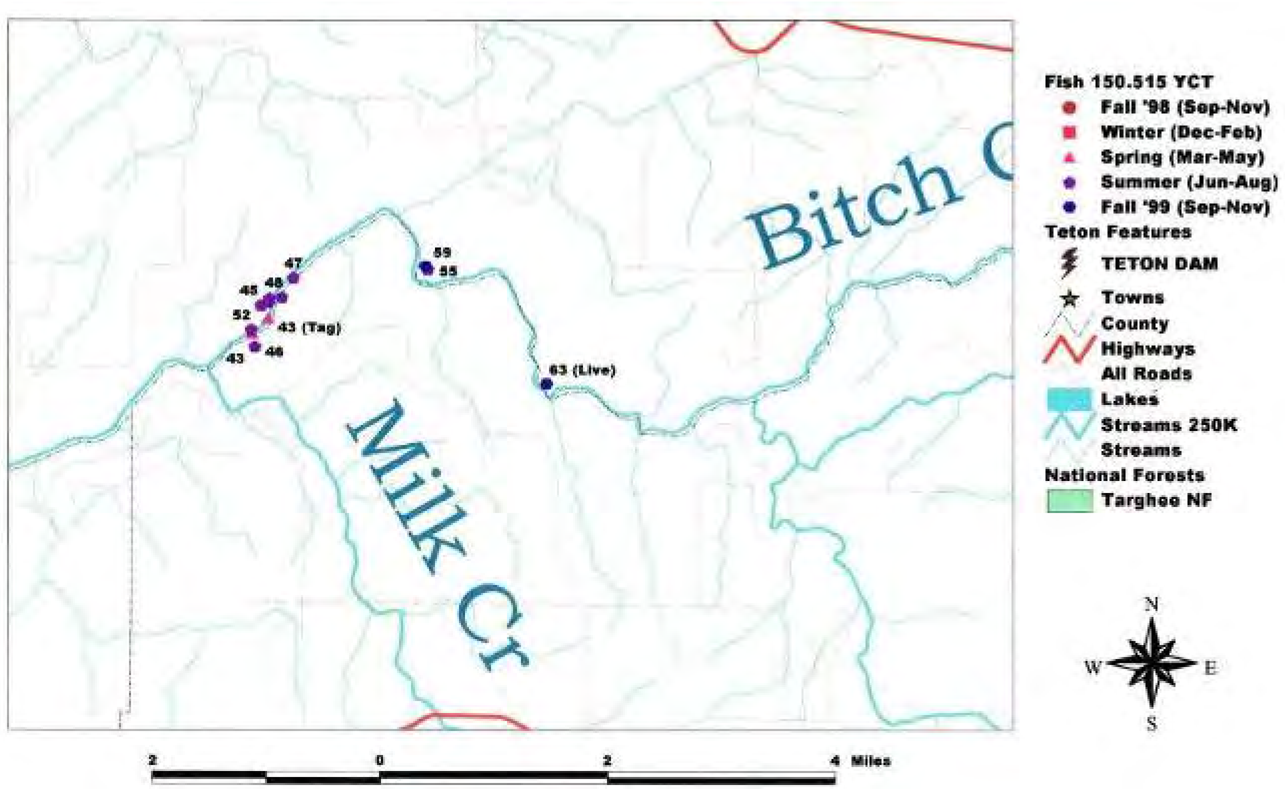
Appendix L-1. Radio telemetry locations of cutthroat trout 150.074 that was tagged in the South Fork Teton River, Idaho, and did not move during the 1999 spawning season (March-July).



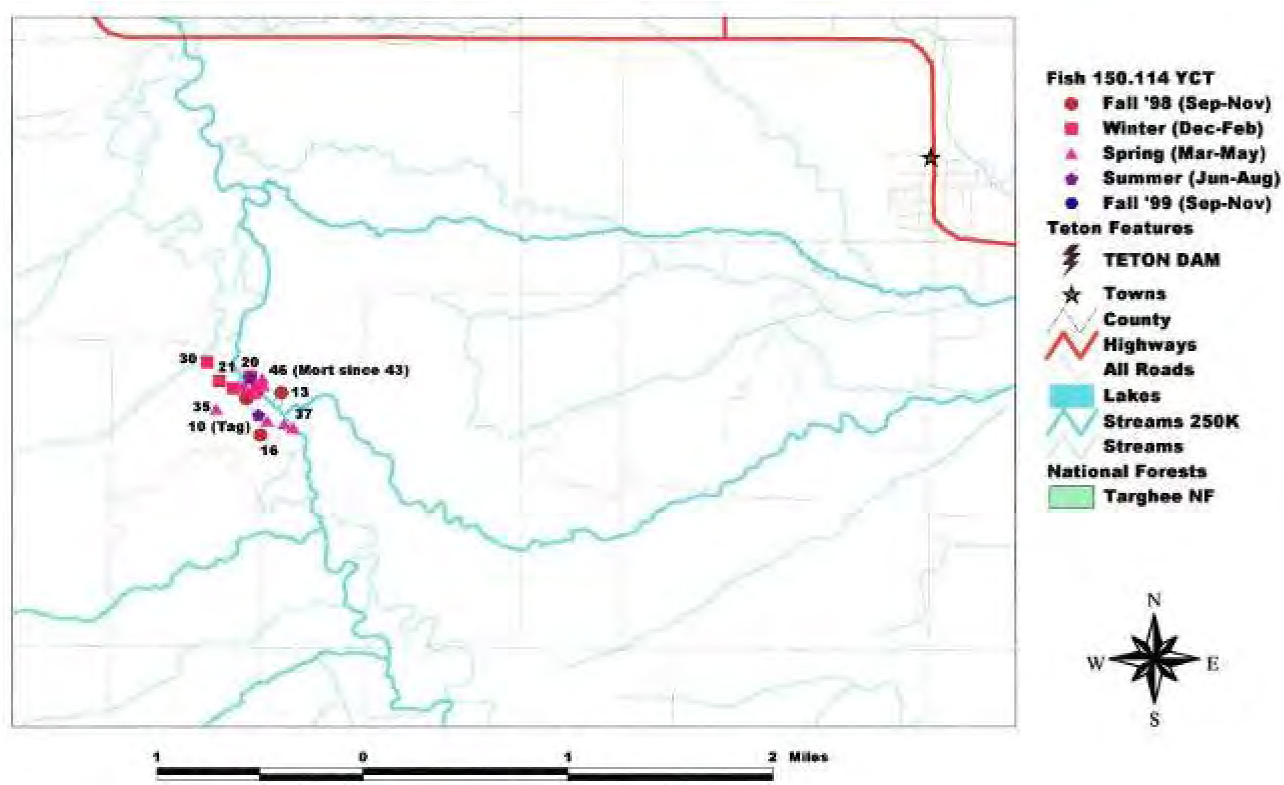
Appendix L-2. Radio telemetry locations of cutthroat trout 151.073 that was tagged in the Lower Teton study section, Idaho, and did not move during the 1999 spawning season (March-July).



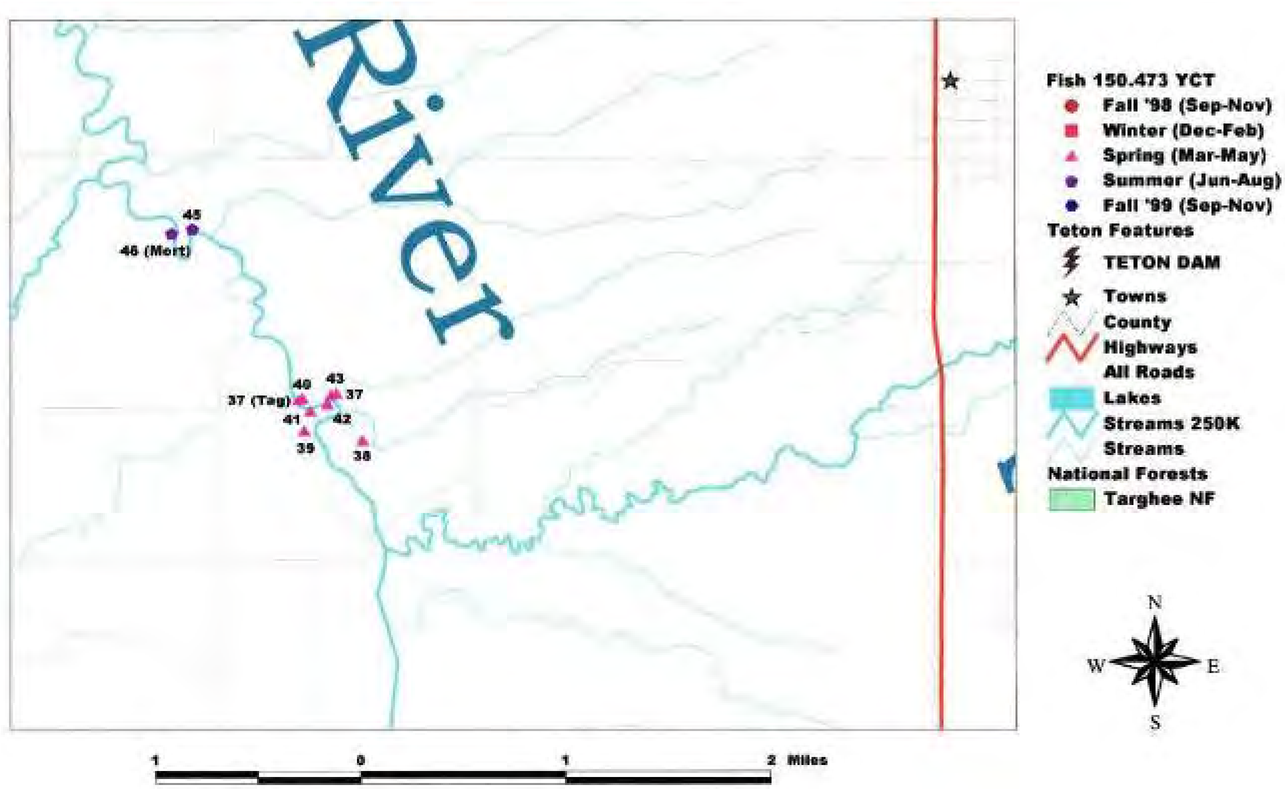
Appendix L-3. Radio telemetry locations of cutthroat trout 150.515 that was tagged in the Teton Canyon study section, Idaho, and did not move during the 1999 spawning season (March-July).



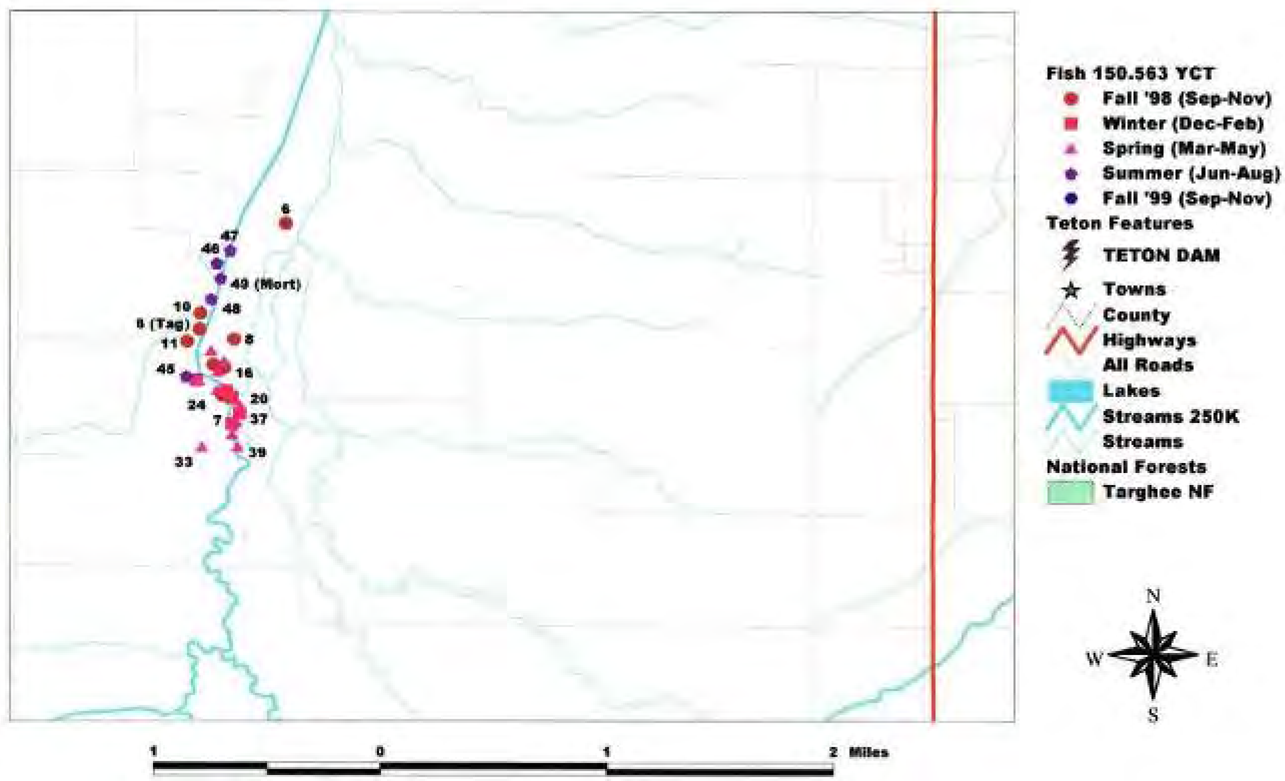
Appendix L-4. Radio telemetry locations of cutthroat trout 150.114 that was tagged in the Teton Valley study section, Idaho, and did not move during the 1999 spawning season (March-July).



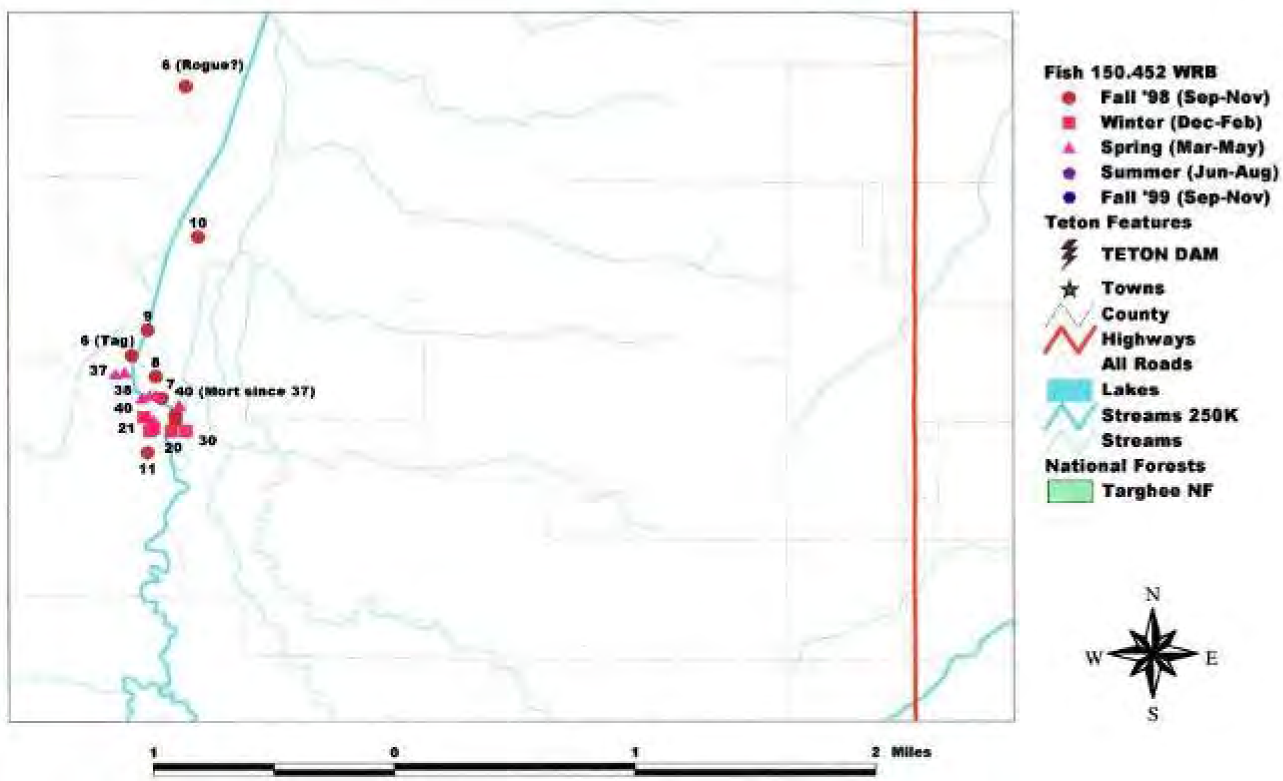
Appendix L-5. Radio telemetry locations of cutthroat trout 150.473 that was tagged in the Teton Valley study section, Idaho, and did not move during the 1999 spawning season (March-July).



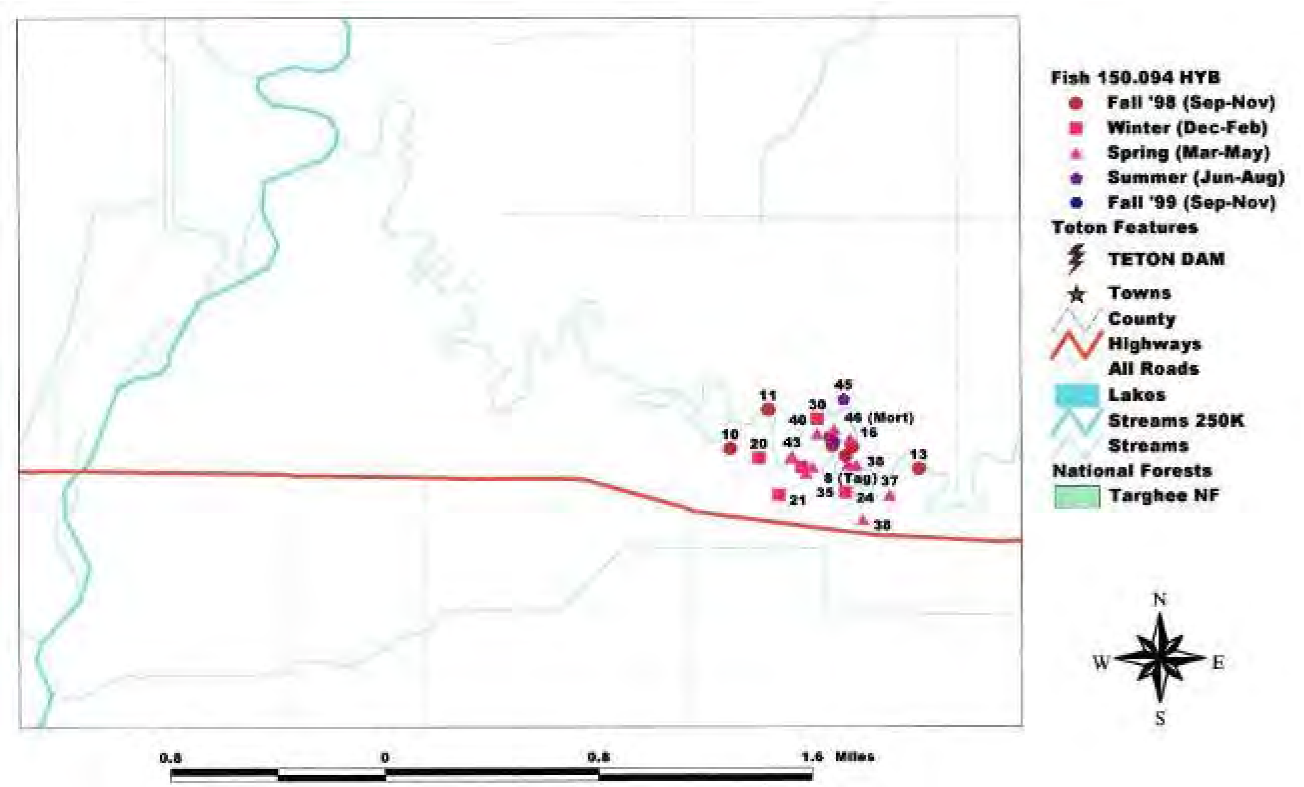
Appendix L-6. Radio telemetry locations of cutthroat trout 150.563 that was tagged in the Teton Valley study section, Idaho, and did not move during the 1999 spawning season (March-July).



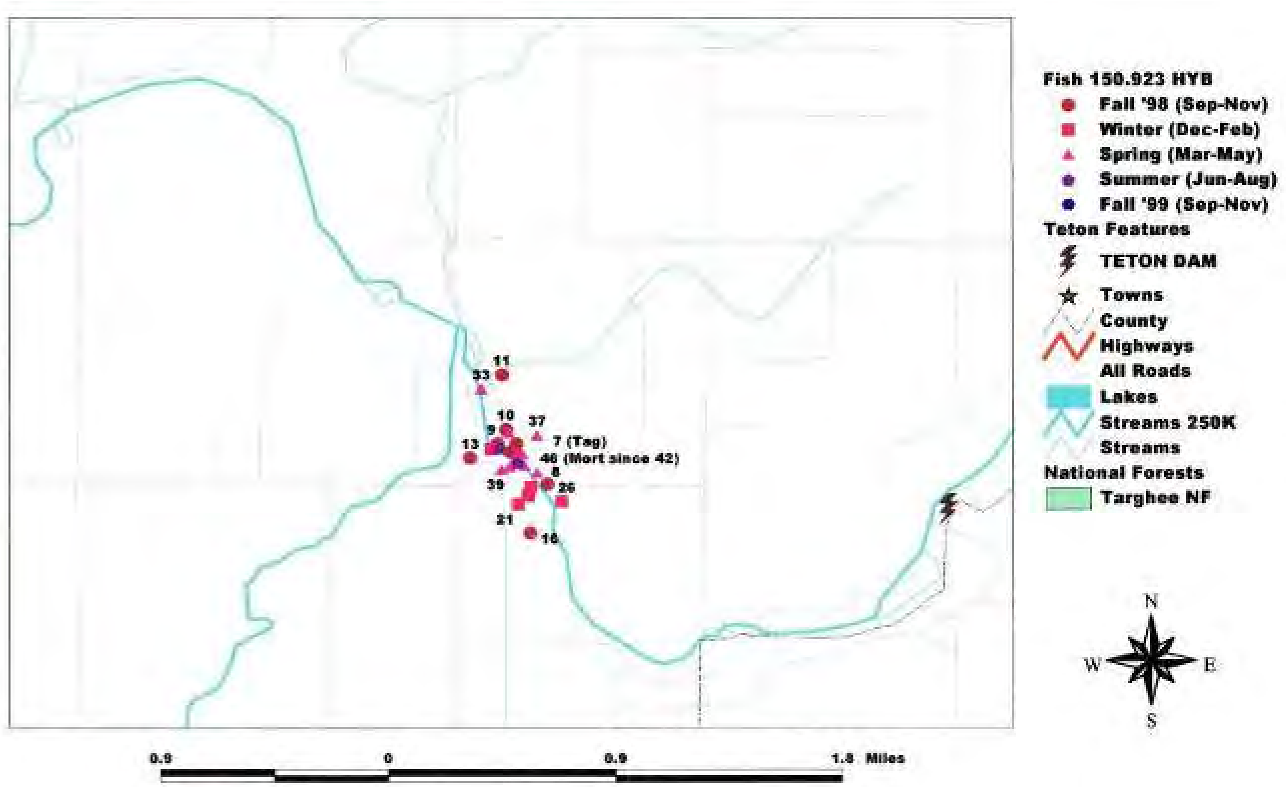
Appendix L-7. Radio telemetry locations of rainbow trout 150.452 that was tagged in the Teton Valley study section, Idaho, and did not move during the 1999 spawning season (March-July).



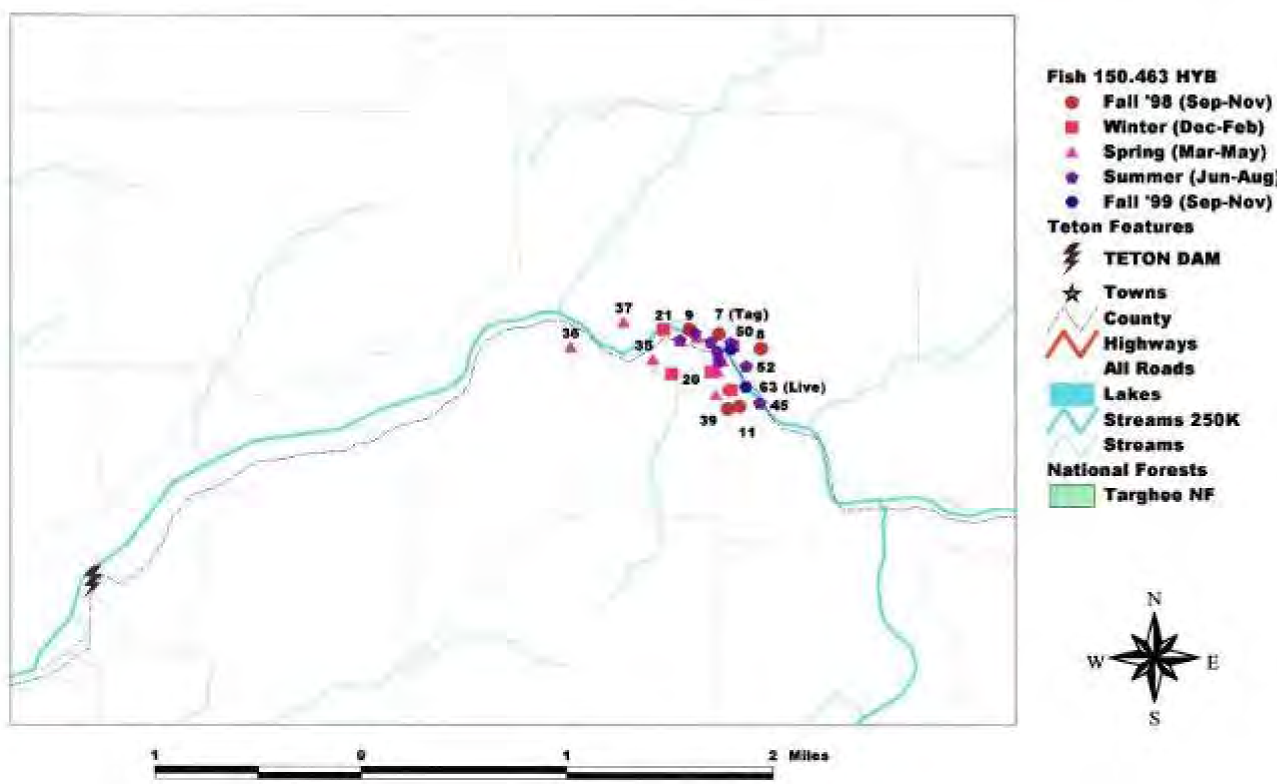
Appendix L-8. Radio telemetry locations of hybrid trout 150.094 that was tagged in the South Fork Teton River, Idaho, and did not move during the 1999 spawning season (March-July).



Appendix L-9. Radio telemetry locations of hybrid trout 150.923 that was tagged in the Lower Teton study section, Idaho, and did not move during the 1999 spawning season (March-July).

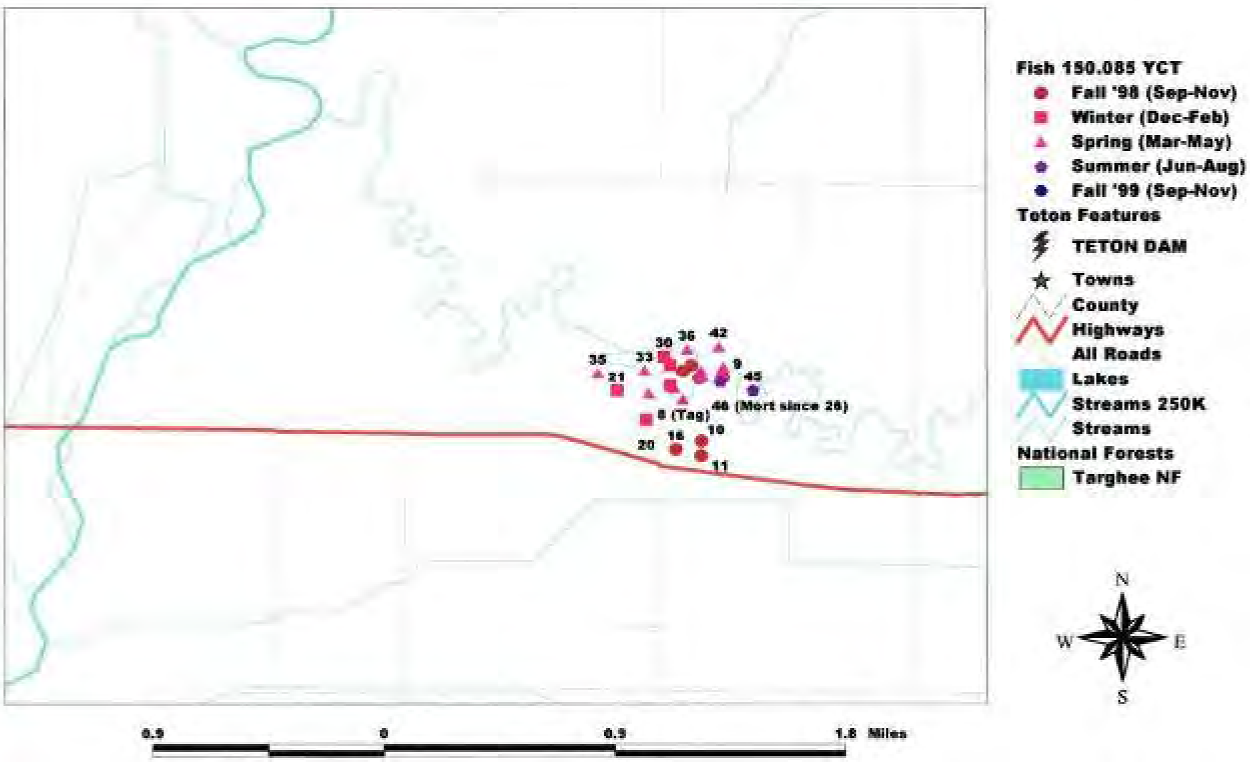


Appendix L-10. Radio telemetry locations of hybrid trout 150.463 that was tagged in the Teton Canyon study section, Idaho, and did not move during the 1999 spawning season (March-July).

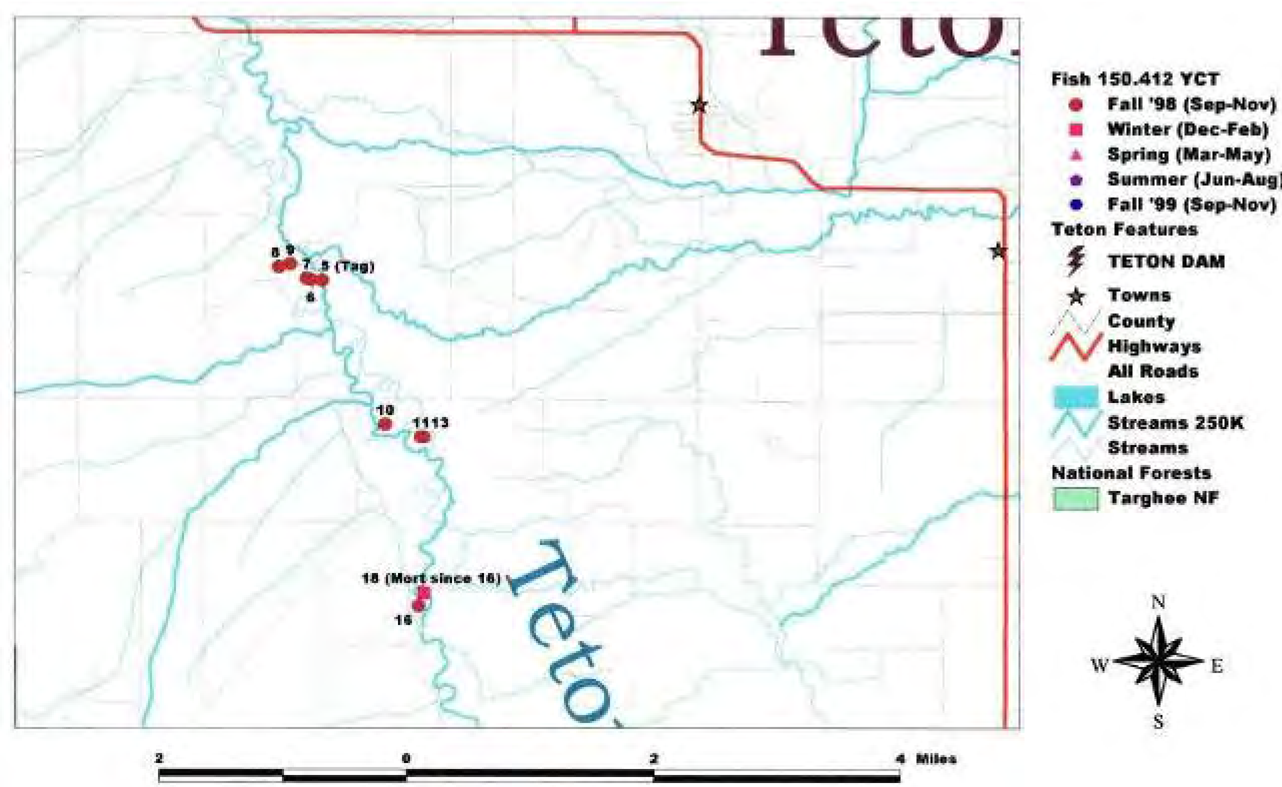


Appendix M. Radio telemetry locations of three cutthroat, three rainbow, and one hybrid trout that died or were lost prior to the 1999 spawning season (March-July), Teton River, Idaho. First and last locations are in parentheses.

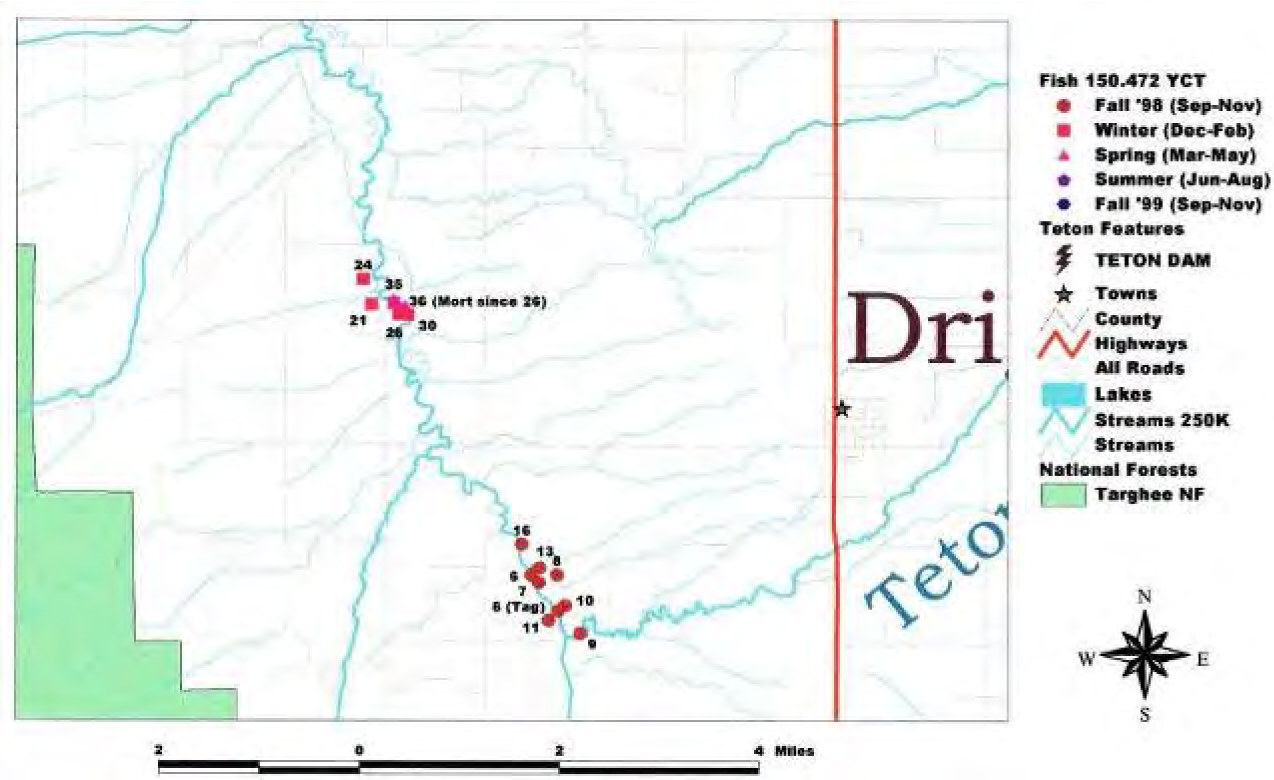
Appendix M-1. Radio telemetry locations of cutthroat trout 150.085 that was tagged in the South Fork Teton River, Idaho, and died prior to the 1999 spawning season (March-July).



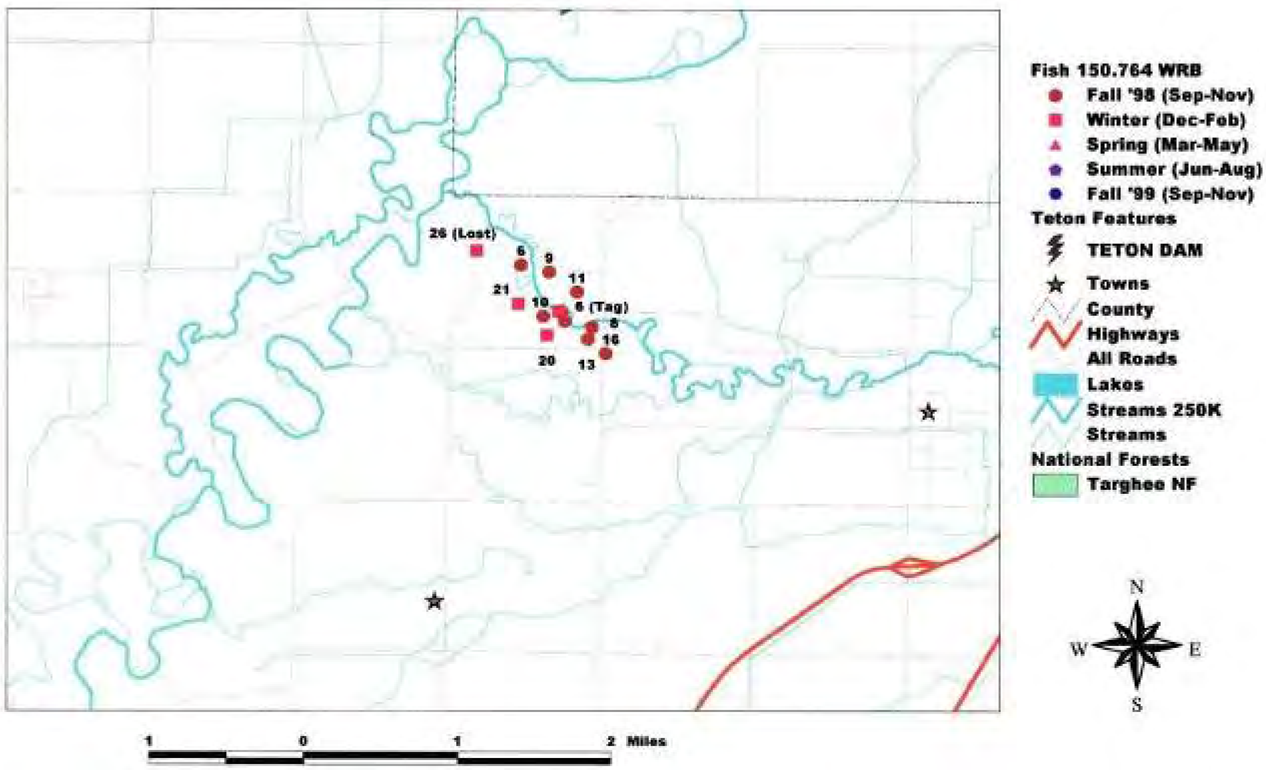
Appendix M-2. Radio telemetry locations of cutthroat trout 150.412 that was tagged in the Teton Valley study section, Idaho, and died prior to the 1999 spawning season (March-July).



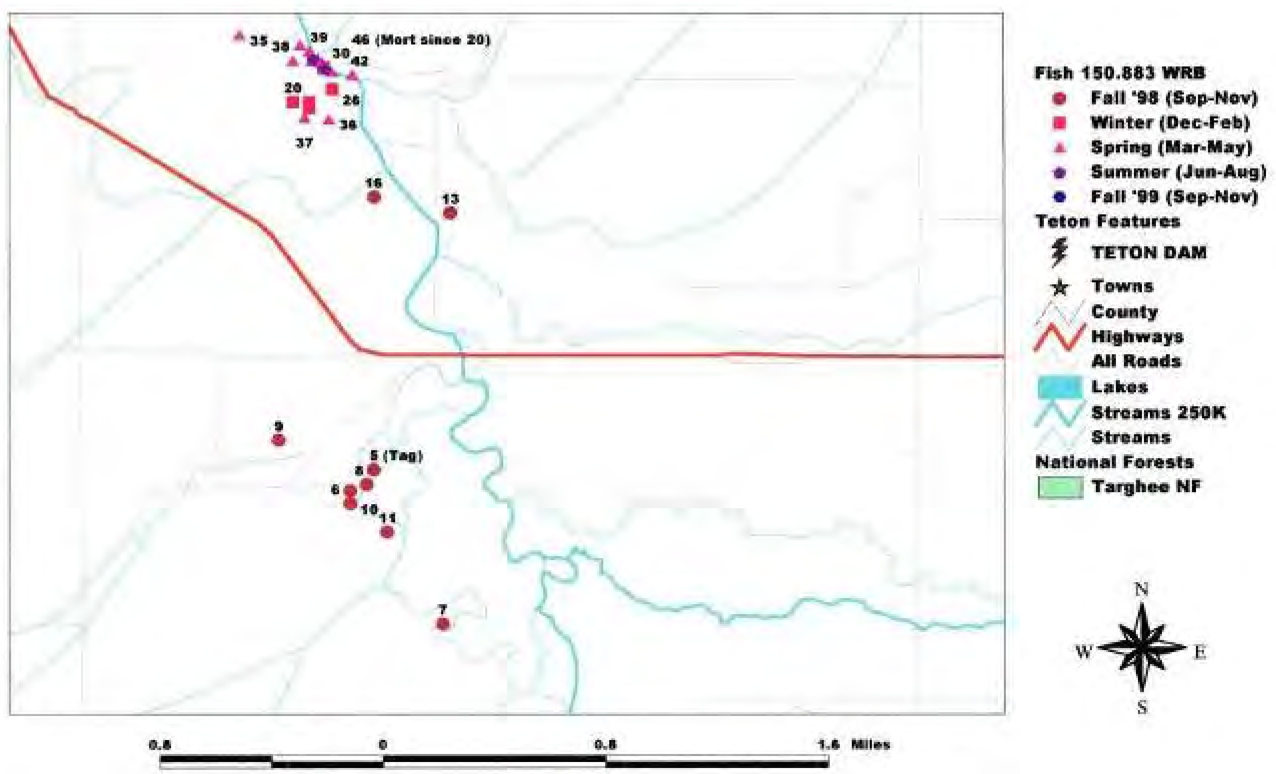
Appendix M-3. Radio telemetry locations of cutthroat trout 150.472 that was tagged in the Teton Valley study section, Idaho, and died prior to the 1999 spawning season (March-July).



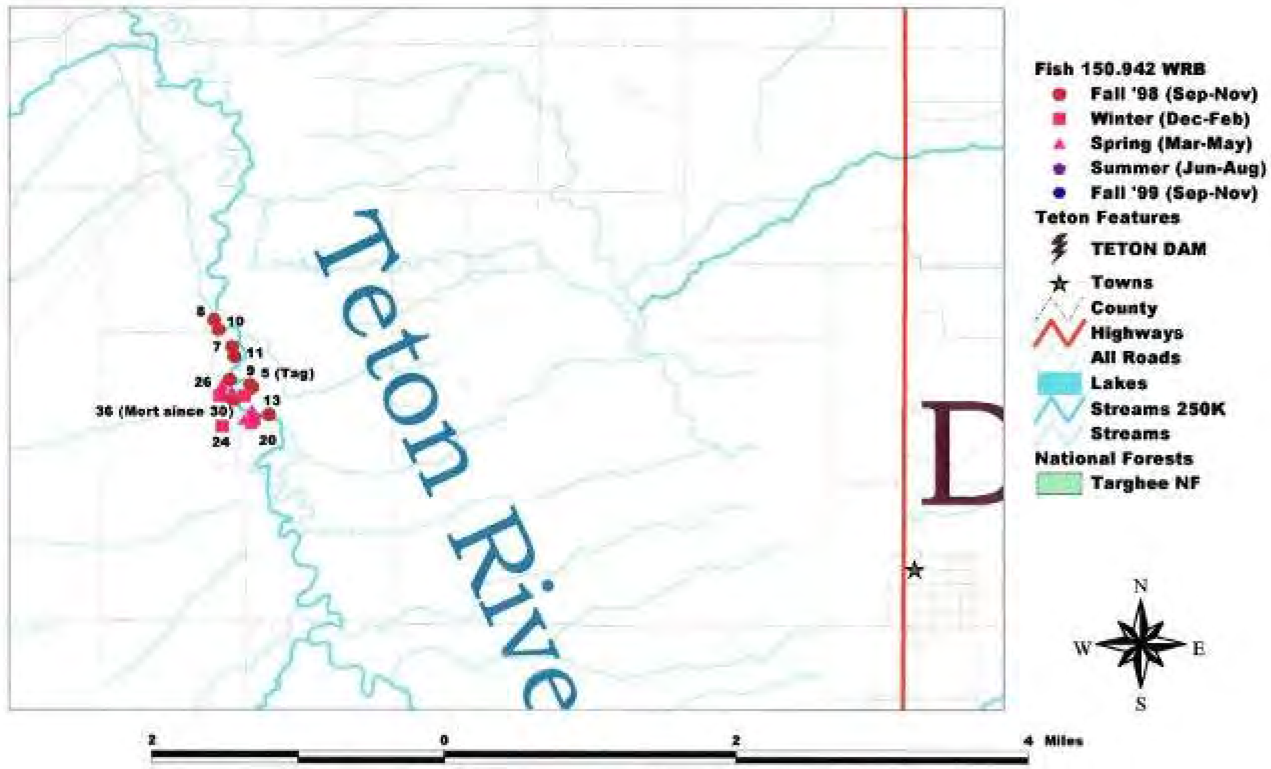
Appendix M-4. Radio telemetry locations of rainbow trout 150.764 that was tagged in the North Fork Teton River, Idaho, and was lost prior to the 1999 spawning season (March-July).



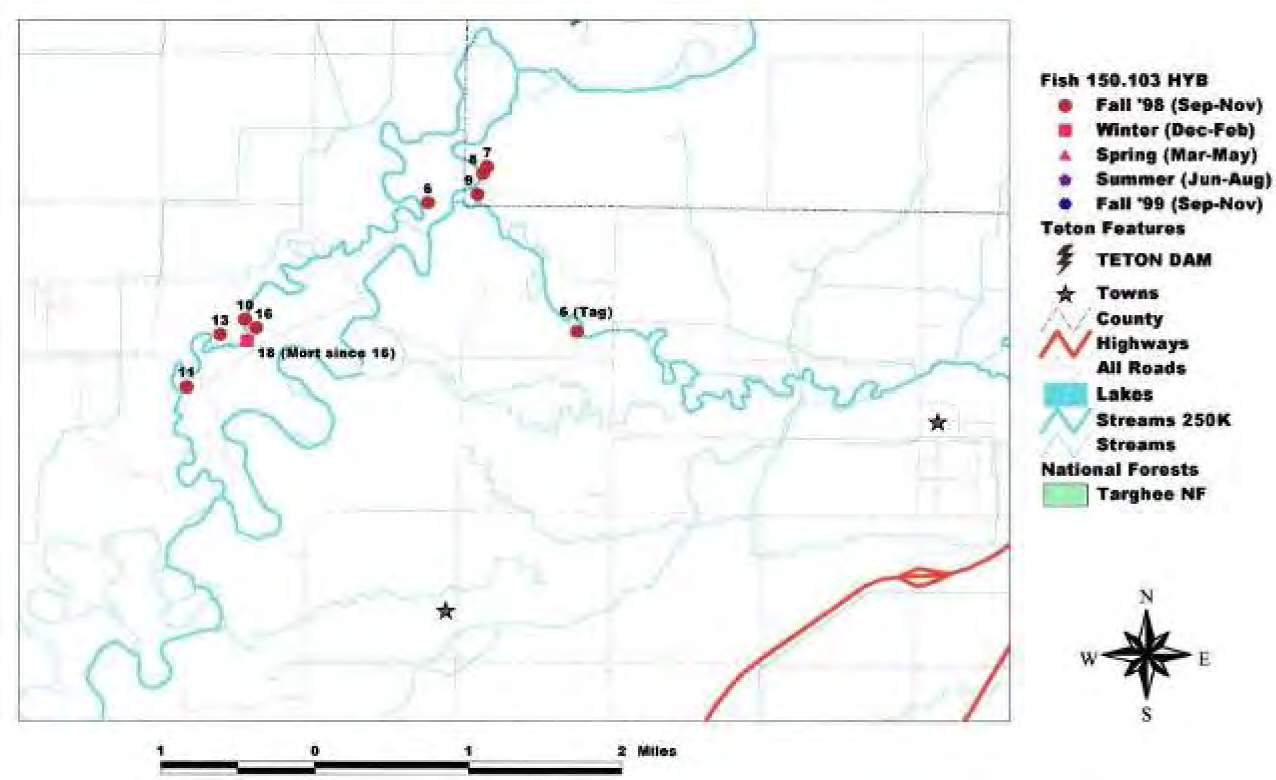
Appendix M-5. Radio telemetry locations of rainbow trout 150.883 that was tagged in the Teton Valley study section, Idaho, and died prior to the 1999 spawning season (March-July).



Appendix M-6. Radio telemetry locations of rainbow trout 150.942 that was tagged in the Teton Valley study section, Idaho, and died prior to the 1999 spawning season (March-July).

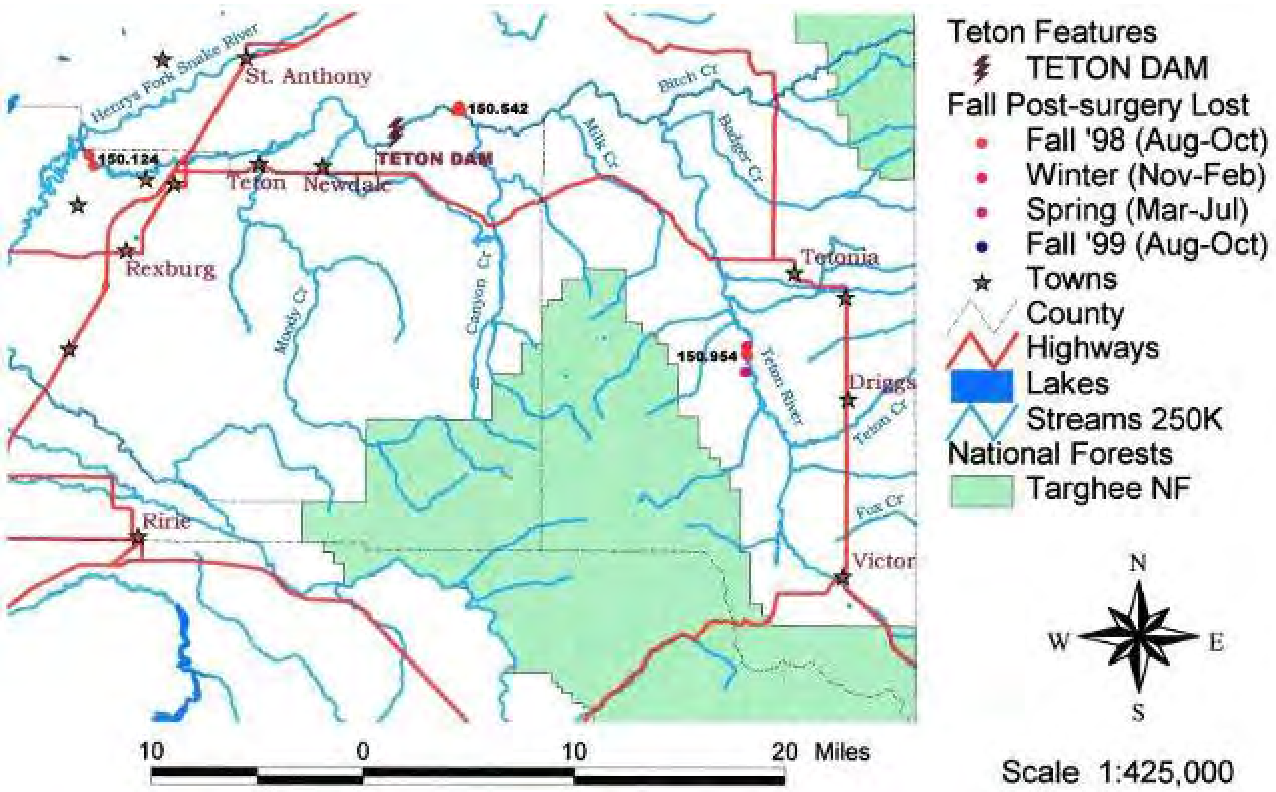


Appendix M-7. Radio telemetry locations of hybrid trout 150.103 that was tagged in the North Fork Teton River, Idaho, and died prior to the 1999 spawning season (March-July).

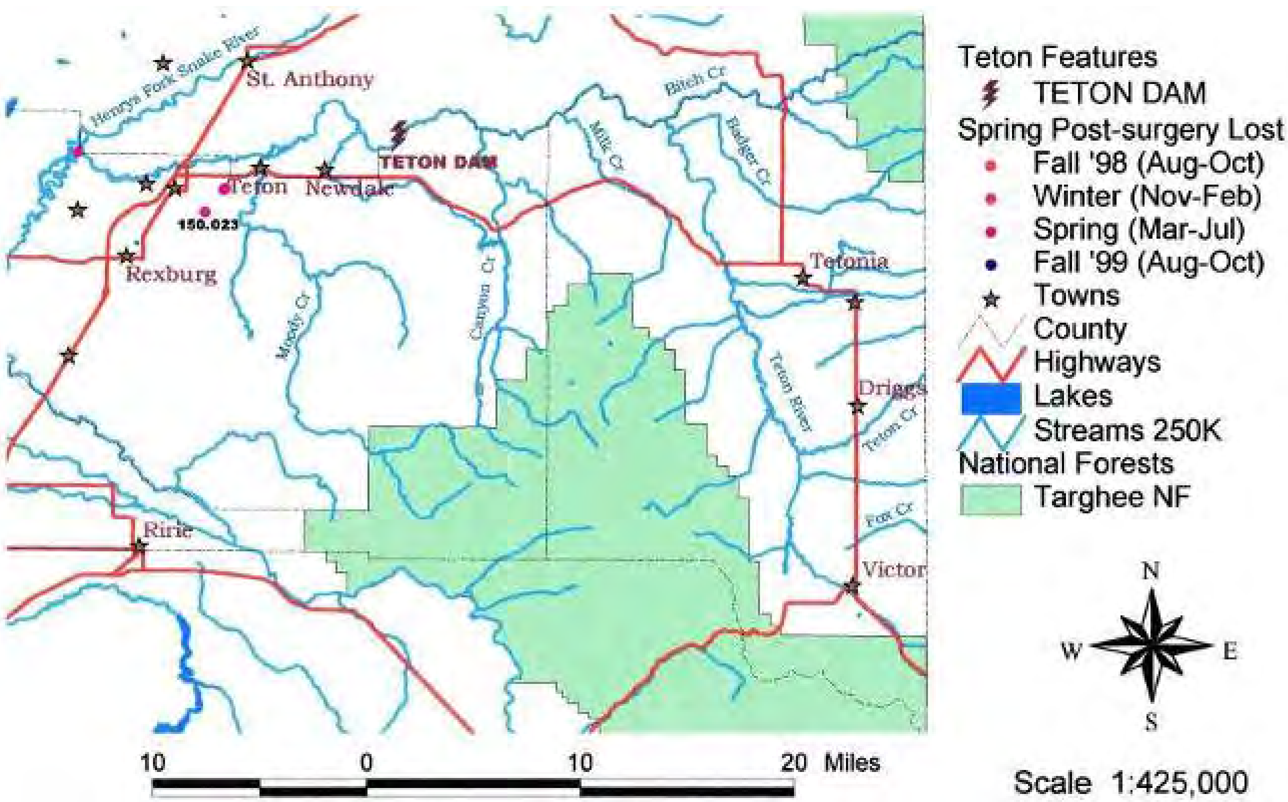


Appendix N. Radio telemetry locations of four cutthroat and one hybrid trout lost or harvested within 56 days of surgery, Teton River, Idaho, 1998-1999. Frequency numbers indicate tagging locations.

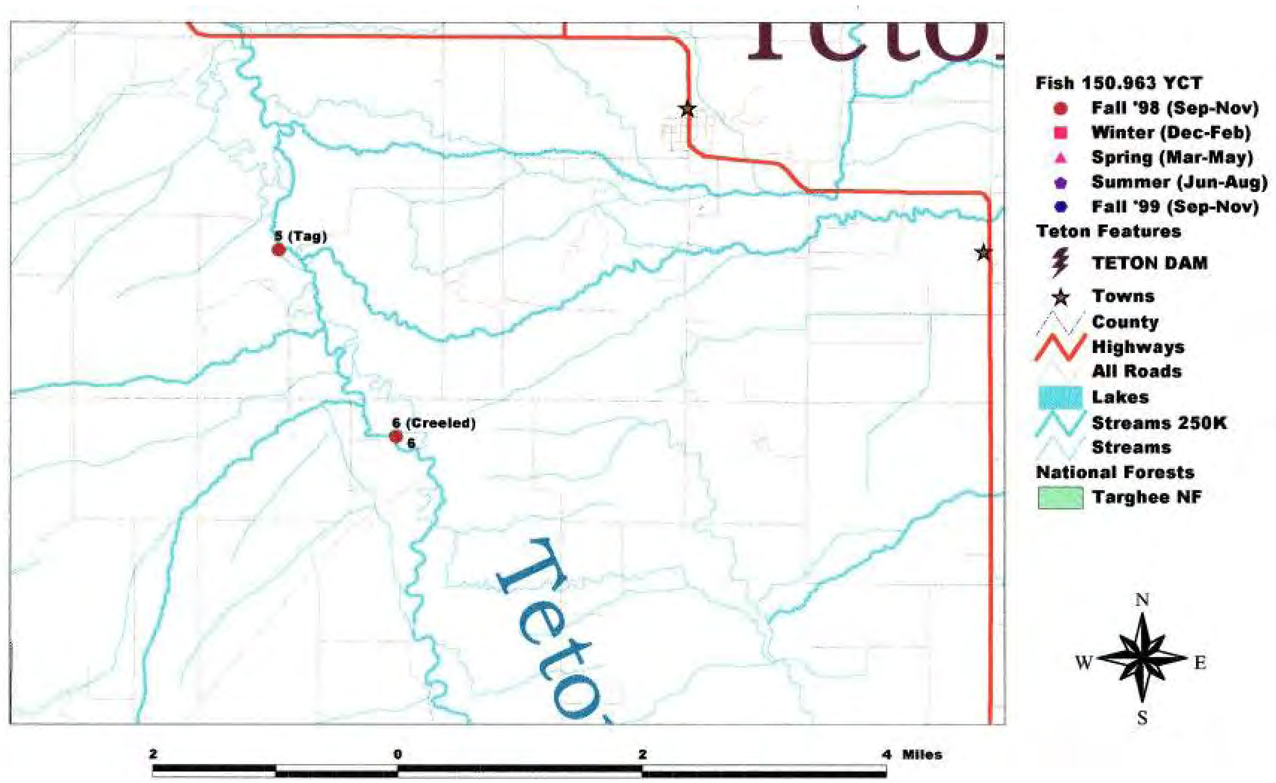
Appendix N-1. Radio telemetry locations of cutthroat trout 150.124 and 150.542 and hybrid trout 150.954 tagged in the Teton River, Idaho, and lost within 56 days of surgery. Radio transmitter 150.954 malfunctioned within nine days of implantation (duty cycle timing was off) but was later located.



Appendix N-2. Radio telemetry locations of cutthroat trout 150.023 tagged at the fish ladder in the South Fork Teton River, Idaho, and lost within 56 days of surgery. The fish moved upstream to the highway bridge and was last located at the confluence of the North Fork Teton River and Henrys Fork Snake River. There were too few locations to ascertain its spawning status.

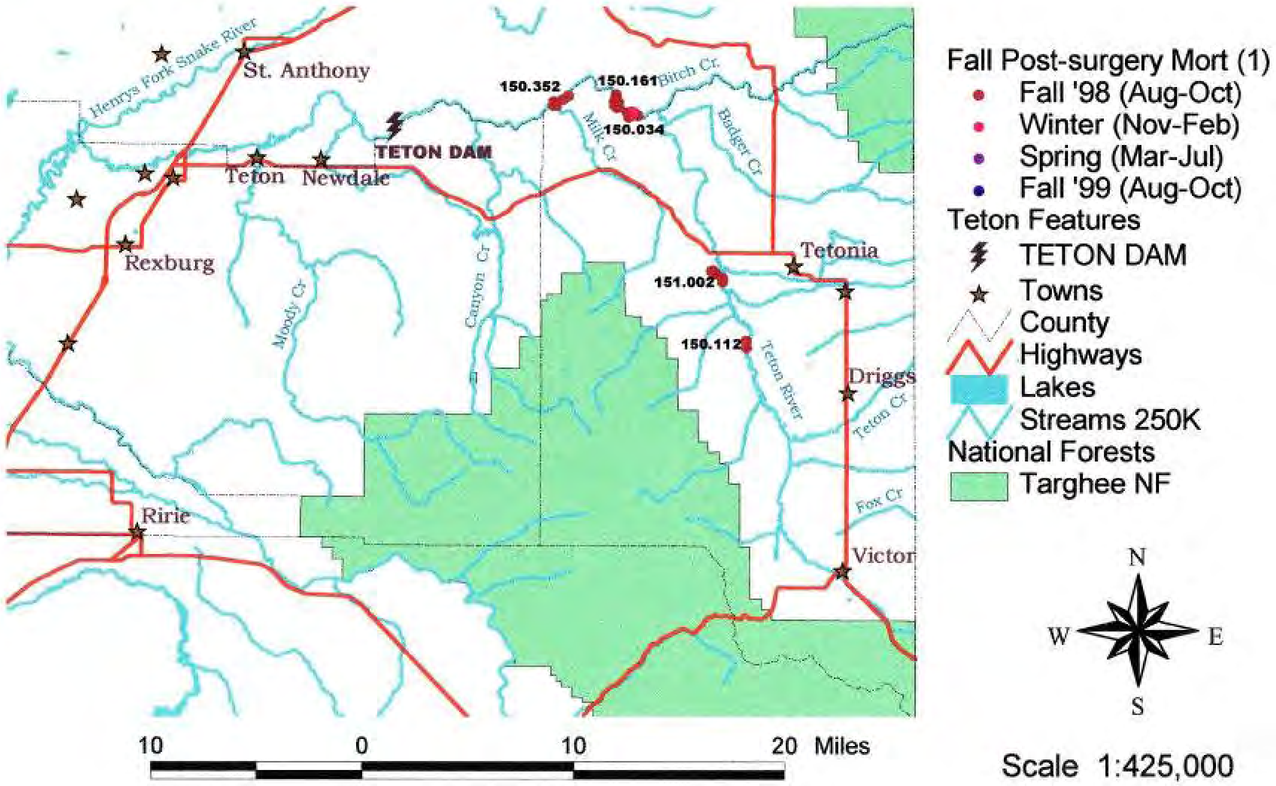


Appendix N-3. Radio telemetry locations of cutthroat trout 150.963 tagged in the Teton Valley study section, Idaho, and harvested within 56 days of surgery.

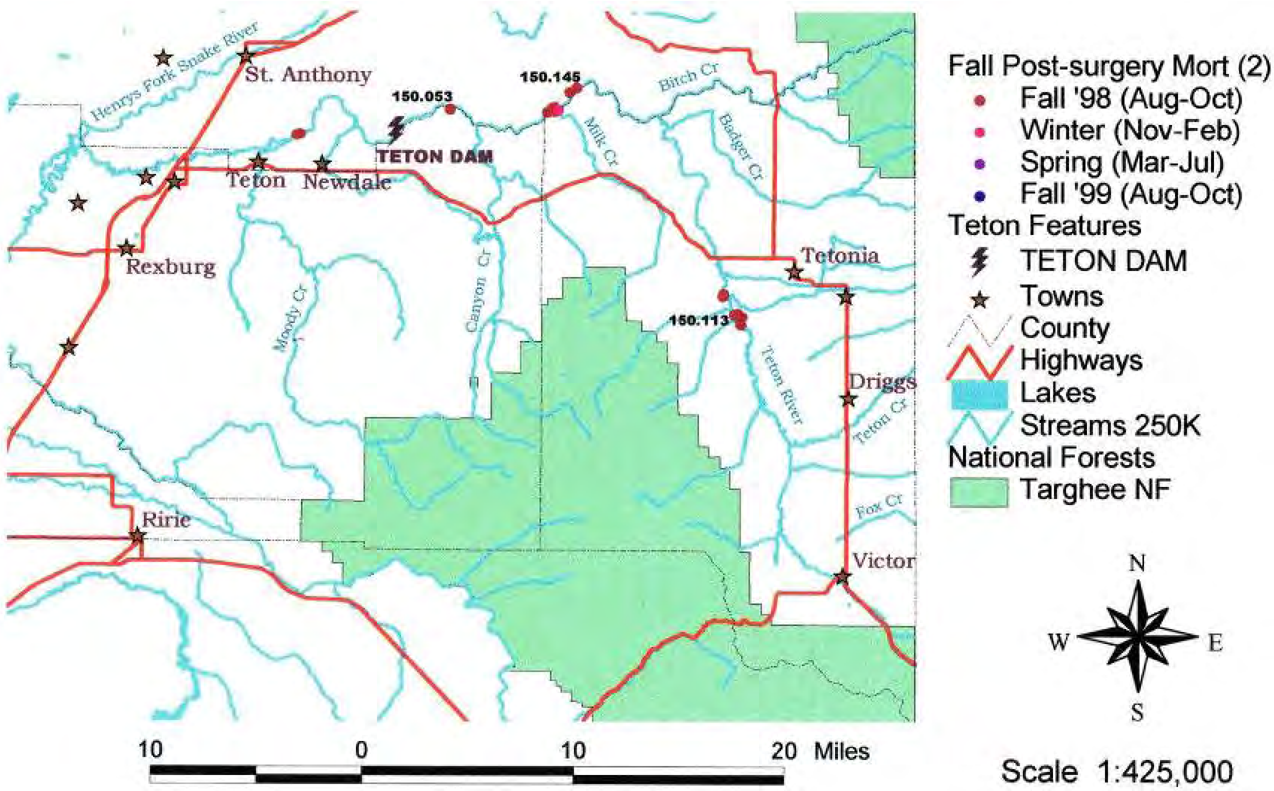


Appendix O. Radio telemetry locations of 22 cutthroat, one rainbow, and three hybrid trout that died within 56 days of surgery, Teton River, Idaho, 1998-1999. Frequency numbers indicate tagging locations.

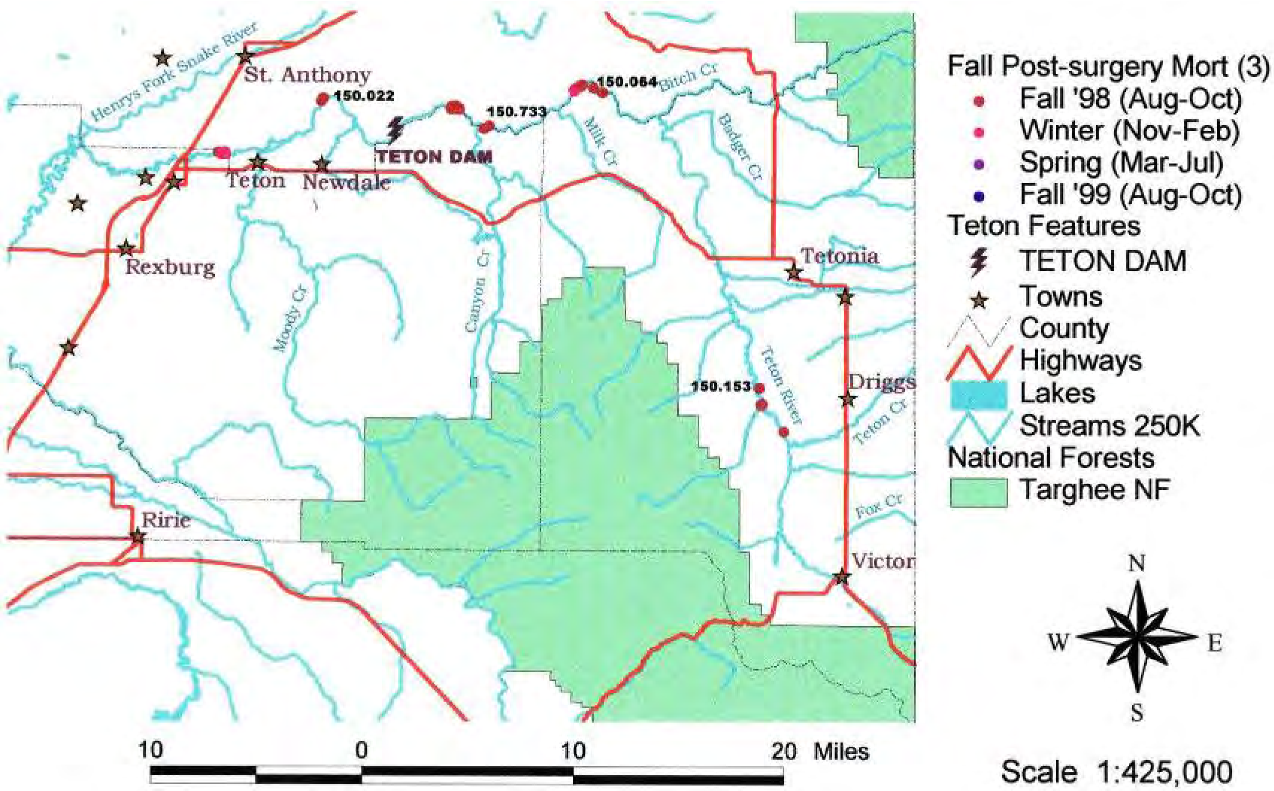
Appendix O-1. Radio telemetry locations of cutthroat trout 150.352, 150.161, 151.002 and 150.112 and hybrid trout 150.034 that were tagged in the Teton River, Idaho, and died within 56 days of surgery.



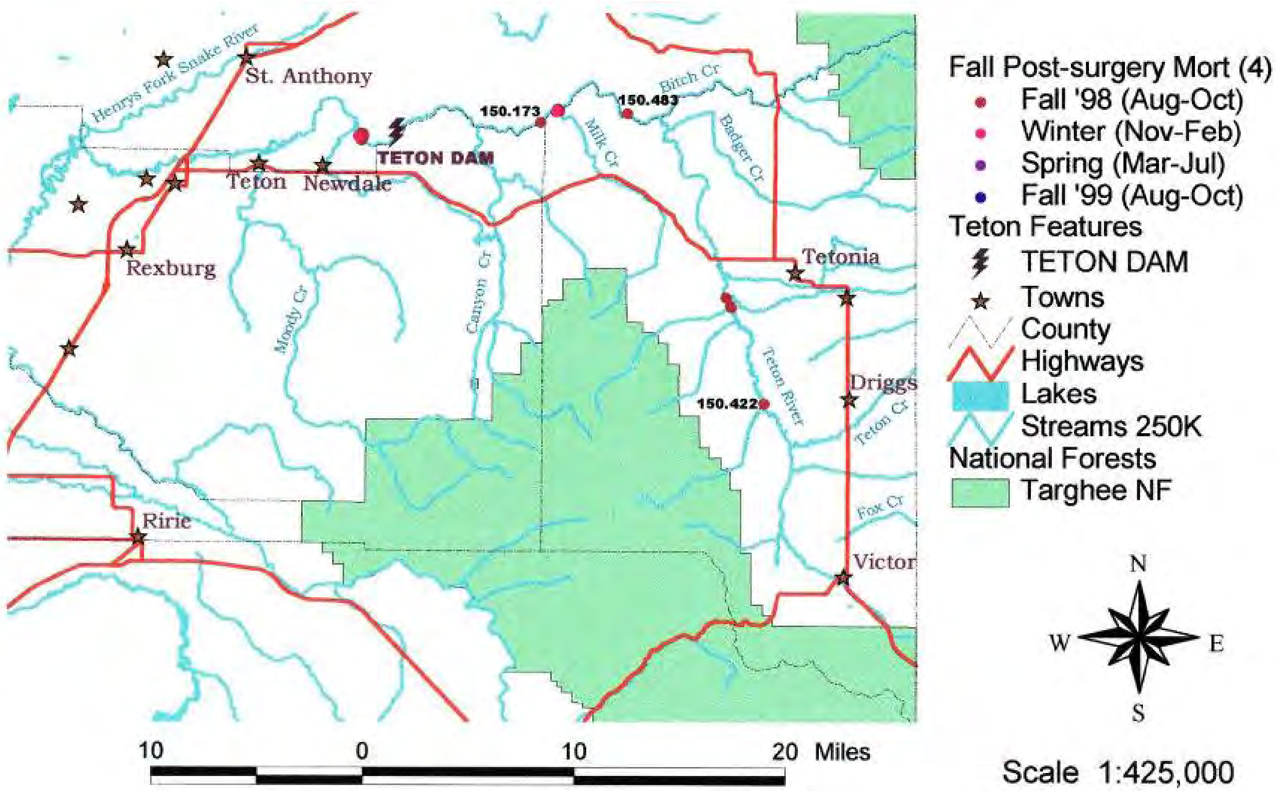
Appendix O-2. Radio telemetry locations of cutthroat trout 150.053, 150.145, and 150.113 that were tagged in the Teton River, Idaho, and died within 56 days of surgery.



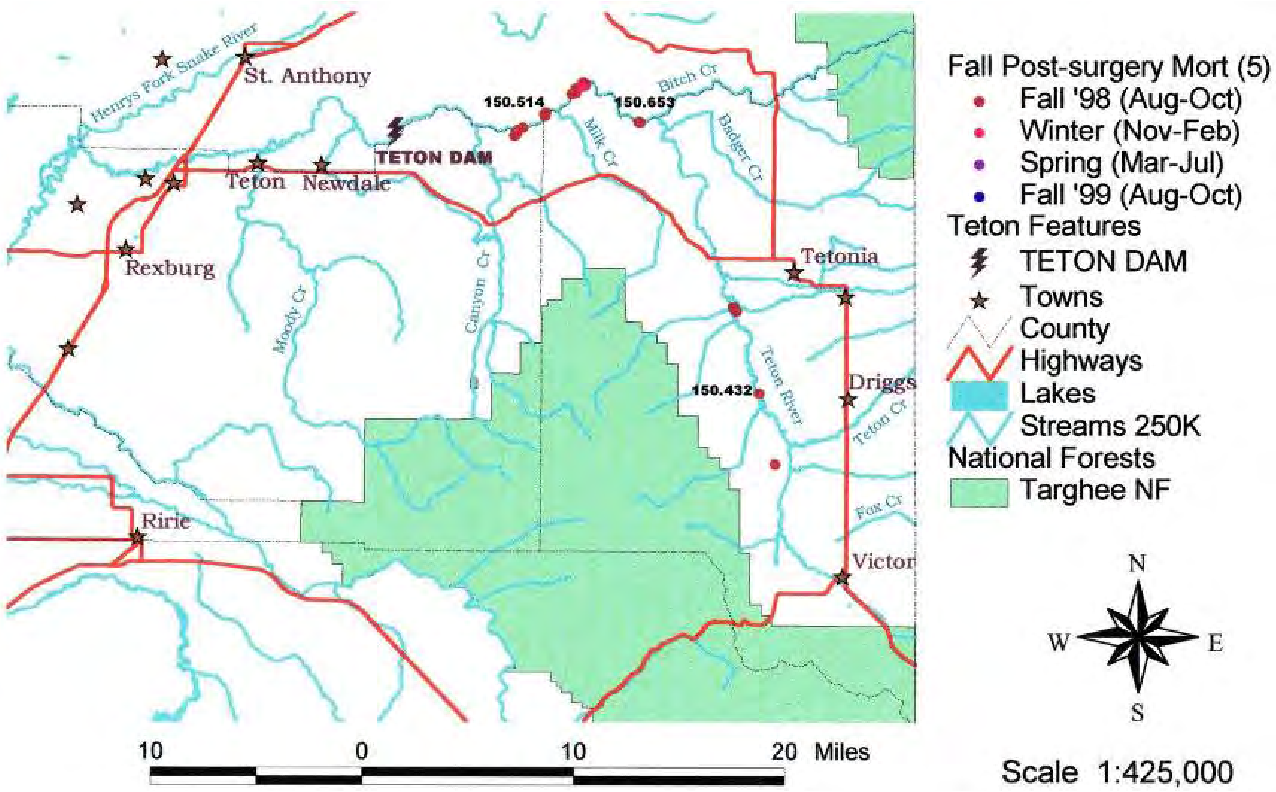
Appendix O-3. Radio telemetry locations of cutthroat trout 150.022, 150.733 and 150.153 and hybrid trout 150.064 that were tagged in the Teton River, Idaho, and died within 56 days of surgery.



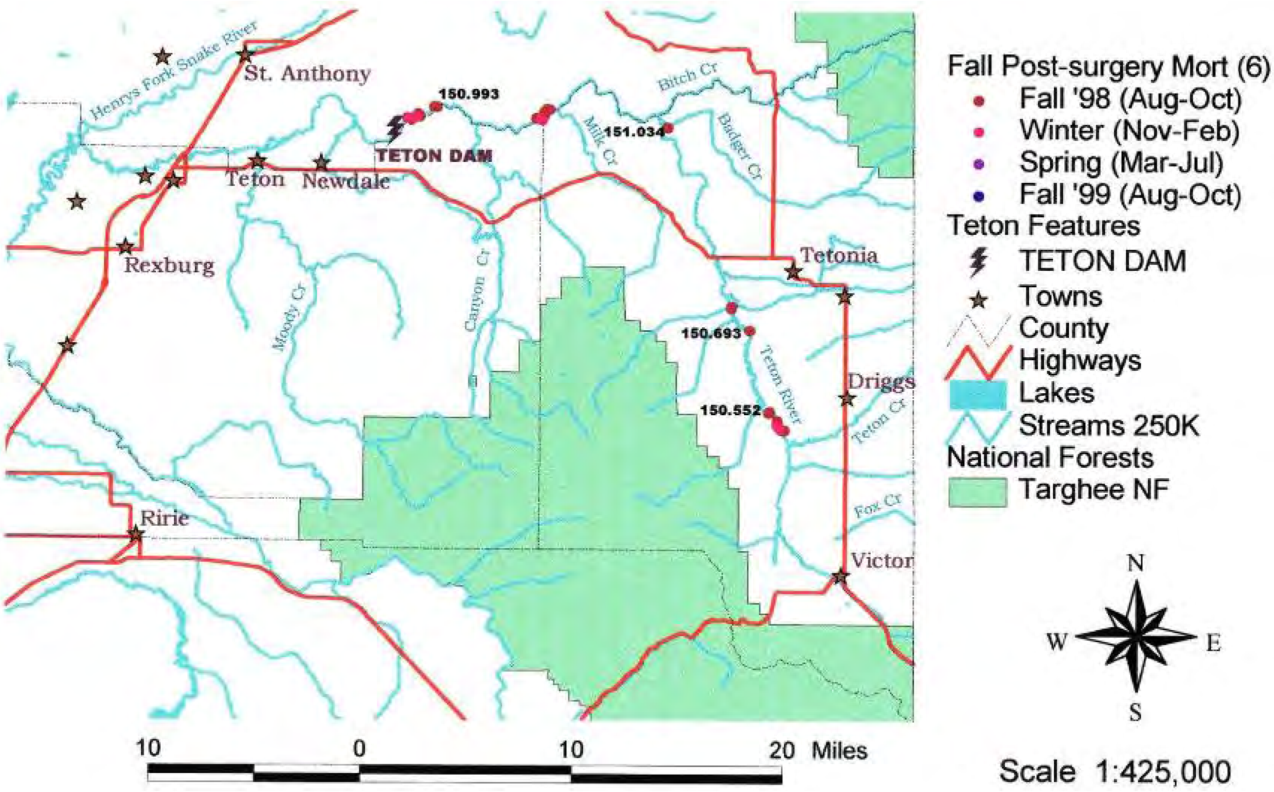
Appendix O-4. Radio telemetry locations of cutthroat trout 150.483 and 150.422 and hybrid trout 150.173 that were tagged in the Teton River, Idaho, and died within 56 days of surgery.



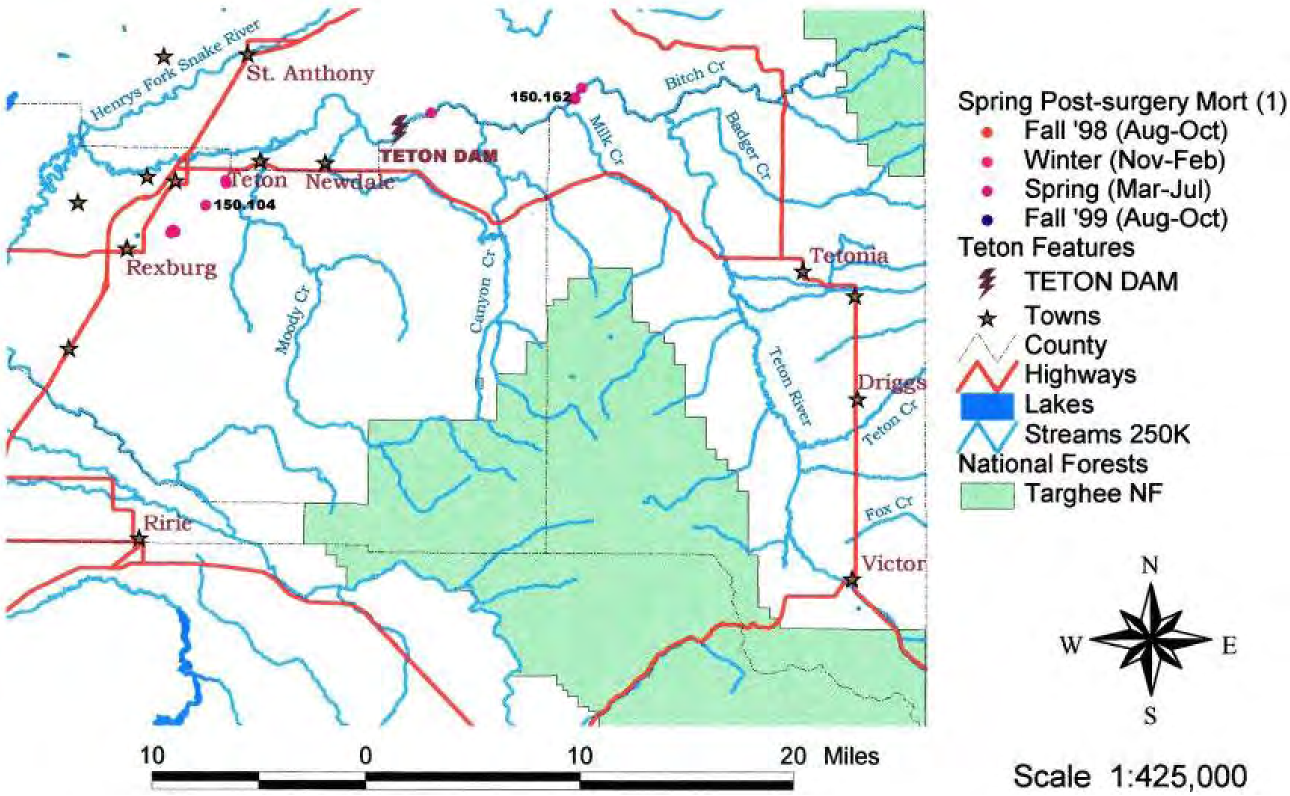
Appendix O-5. Radio telemetry locations of cutthroat trout 150.514, 150.653, and 150.432 that were tagged in the Teton River, Idaho, and died within 56 days of surgery.



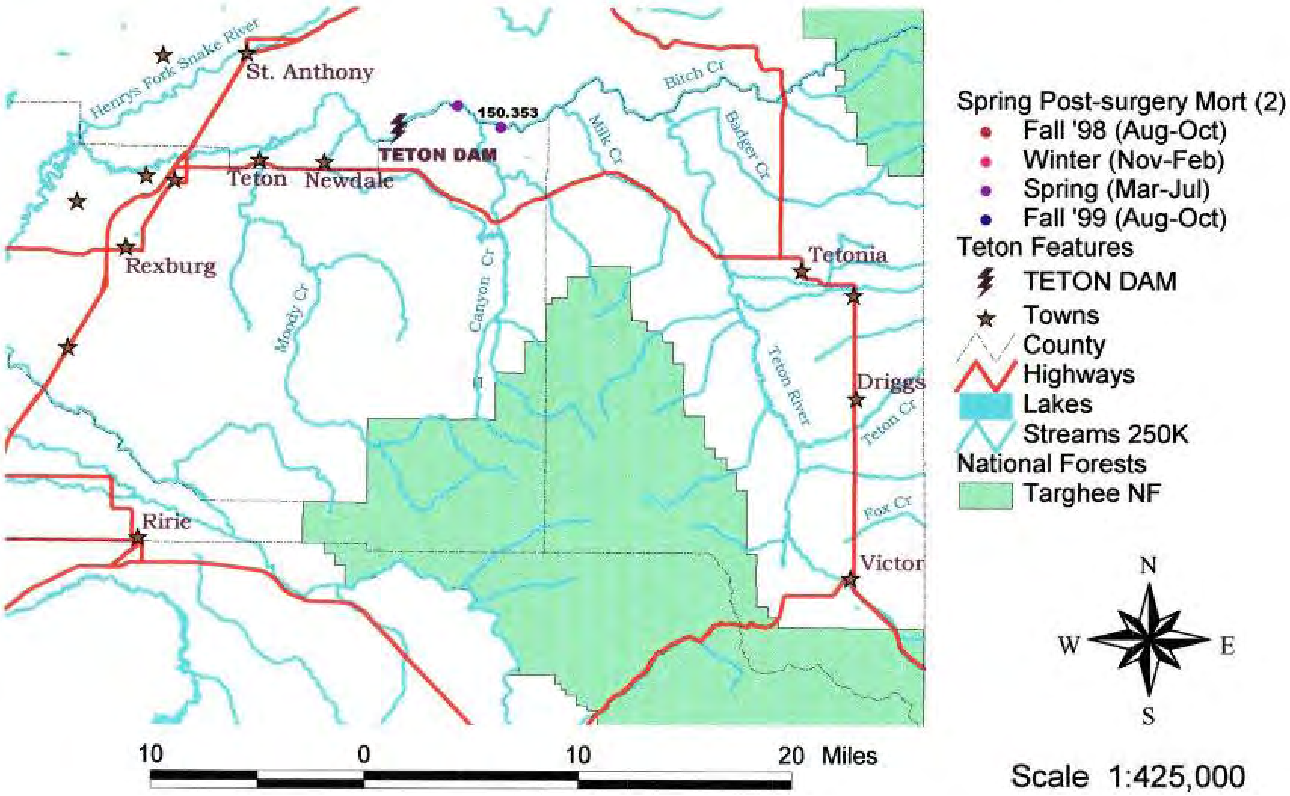
Appendix O-6. Radio telemetry locations of cutthroat trout 150.993, 151.034, 150.693, and 150.552 that were tagged in the Teton River, Idaho, and died within 56 days of surgery.



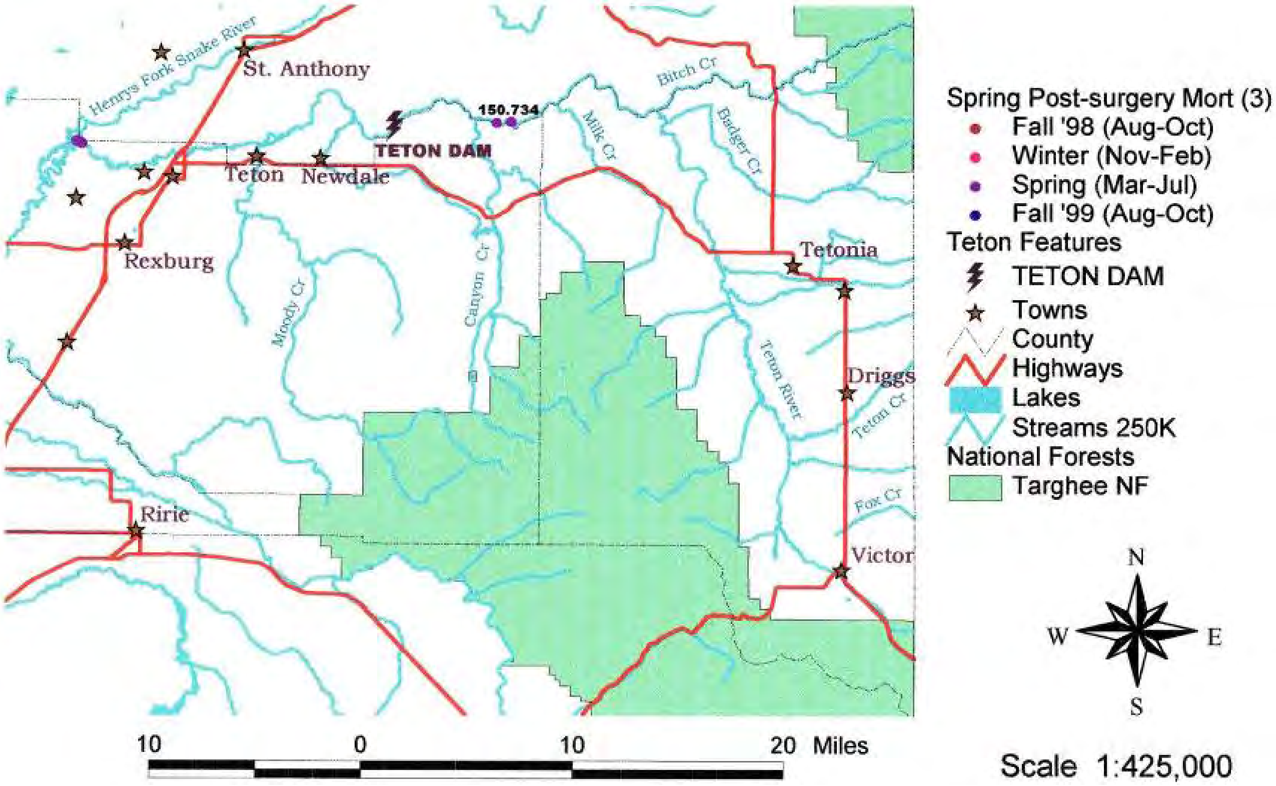
Appendix O-7. Radio telemetry locations of cutthroat trout 150.104 and 150.162 that were tagged in the Teton River, Idaho, and died within 56 days of surgery.



Appendix O-8. Radio telemetry locations of cutthroat trout 150.353 that was tagged in the Teton River, Idaho, and died within 56 days of surgery.



Appendix O-9. Radio telemetry locations of rainbow trout 150.734 that was tagged in the Teton River, Idaho, and died within 56 days of surgery.



Appendix P. Length frequency distributions of 70 fish captured at the Felt Dam ladder trap in the Teton Canyon study section, Idaho, April 30 to October 30, 1998. Fish fully recruited to the trap gear (≥350 mm) are shaded.

Total length (mm)	Cutthroat trout	Rainbow and hybrid trout	Mountain whitefish	Sucker
0-9				
10-19				
20-29				
30-39				
40-49				
50-59				
60-69				
70-79				
80-89				
90-99				
100-109				
110-119				
120-129				
130-139				
140-149				
150-159			1	
160-169				
170-179				
180-189			3	
190-199			12	
200-209			13	
210-219			20	
220-229			6	
230-239			1	
240-249			1	
250-259				
260-269				
270-279	1			
280-289				
290-299				
300-309				
310-319		1	2	
320-329			1	
330-339				
340-349		1		
350-359				
360-369				
370-379		1		
380-389				
390-399				
400-409			2	
410-419		1		
420-429				
430-439	1	1		
440-449		1		
450-459				
460-469				
470-479				
480-489				
490-499				
500+				
Total (n):	2	6	62	0
≥350 mm:	50%	67%	3%	0%
Average (mm):	354	387	218	0

Appendix Q. Length frequency distributions of 26 fish captured at the Felt Dam ladder trap in the Teton Canyon study section, Idaho, March 29 to June 5, 1999. Fish fully recruited to the trap gear (≥350 mm) are shaded.

Total length (mm)	Cutthroat trout	Rainbow and hybrid trout	Mountain whitefish	Sucker
0-9				
10-19				
20-29				
30-39				
40-49				
50-59				
60-69				
70-79				
80-89				
90-99				
100-109				
110-119				
120-129				
130-139		1		
140-149			5	
150-159		1	5	
160-169		1	3	
170-179		1	3	
180-189		1	2	
190-199				
200-209				
210-219				
220-229				
230-239				
240-249				
250-259				
260-269				
270-279				
280-289				
290-299				
300-309				
310-319				
320-329	1			
330-339				
340-349				
350-359		1		
360-369				
370-379				
380-389		1		
390-399				
400-409				
410-419				
420-429				
430-439				
440-449				
450-459				
460-469				
470-479				
480-489				
490-499				
500+				
Total (n):	1	7	18	0
≥350 mm:	0%	29%	0%	0%
Average (mm):	324	220	160	0

Appendix R. Length frequency distributions of 394 fish captured at the South Fork ladder trap in the Lower Teton study section, Idaho, April 20 to May 7, 1995. Fish fully recruited to the trap gear (≥350 mm) are shaded.

Total length (mm)	Cutthroat trout	Rainbow and hybrid trout	Mountain whitefish	Sucker
0-9				
10-19				
20-29				
30-39				
40-49				
50-59				
60-69				
70-79				
80-89				
90-99				
100-109				
110-119				
120-129				
130-139				
140-149				
150-159				
160-169				
170-179				
180-189				
190-199				
200-209				
210-219				
220-229				
230-239				
240-249				
250-259				
260-269				
270-279				
280-289				
290-299	1			
300-309			1	
310-319	1		1	
320-329			1	
330-339				
340-349			1	
350-359		1		
360-369			1	
370-379	1			
380-389	1			
390-399		1		1
400-409		2		2
410-419		1		19
420-429	1			17
430-439		1		38
440-449	1			45
450-459	1			48
460-469	3			50
470-479				48
480-489	1			32
490-499	1			26
500+				45
Total (n):	12	6	5	371
≥350 mm:	83%	100%	20%	100%
Average (mm):	422	400	334	464

Appendix S. Length frequency distributions of 1,066 fish captured at the South Fork ladder trap in the Lower Teton study section, Idaho, March 30 to May 31, 1999. Excluded are two cutthroat trout that were later radio tagged. Fish fully recruited to the trap gear (≥350 mm) are shaded.

Total length (mm)	Cutthroat trout	Rainbow and hybrid trout	Mountain whitefish	Sucker
0-9				
10-19				
20-29				
30-39				
40-49				
50-59				
60-69				
70-79				
80-89				
90-99				
100-109				
110-119				
120-129				
130-139				
140-149				
150-159				
160-169				
170-179				
180-189				
190-199			1	
200-209				
210-219			1	
220-229			1	
230-239			1	
240-249				
250-259	1			
260-269			1	
270-279				
280-289				
290-299				
300-309				
310-319				
320-329			1	3
330-339				1
340-349				3
350-359				6
360-369		1		2
370-379	2			3
380-389				7
390-399	3		3	6
400-409	4	1		9
410-419	2			15
420-429	9			23
430-439	1	1	1	40
440-449	7			85
450-459	5			76
460-469	2			108
470-479	4			122
480-489	2			103
490-499	4			93
500+	18			284
Total (n):	64	3	10	989
≥350 mm:	98%	100%	40%	99%
Average (mm):	465	401	305	479

Appendix T. Length frequency distributions of 3,984 fish captured at the Narrows screw trap in the Teton Canyon study section, Idaho, March 31 to November 2, 1998. Excluded are 13,497 fish that were tallied but not measured. Fish fully recruited to the trap gear (<150 mm) are shaded.

Total length (mm)	Cutthroat trout	Rainbow and hybrid trout	Unknown trout fry[a]	Brook trout	Mountain whitefish	Sucker	Cottid	Dace	Red-side shiner	Unknown other fry[b]
0-9										
10-19								8	48	
20-29			4					24	443	32
30-39		1	5		4	1		70	332	7
40-49	2	2	3		8		1	113	357	2
50-59	9		1	1	6	1	1	159	256	
60-69	16	7	1				4	286	132	
70-79	7	4			1	2	25	249	42	
80-89	12	3				9	18	298	15	
90-99	4	1				25	10	217	4	
100-109	2	2				33	3	154	1	
110-119	1	1				72		101		
120-129		1		1		82		39	1	
130-139	1					46		2		
140-149	1				1	67		5		
150-159					1	34				
160-169				1		7				
170-179				1		6				
180-189						2				
190-199		1			2	1				
200-209					1					
210-219										
220-229	1				3	1				
230-239										
240-249										
250-259					2					
260-269					2					
270-279					1					
280-289										
290-299										
300-309					1					
310-319	1									
320-329										
330-339					1					
340-349										
350-359										
360-369					1					
370-379		1			1					
380-389										
390-399					1					
400-409										
410-419										
420-429										
430-439										
440-449										
450-459										
460-469										
470-479										
480-489										
490-499										
500+										
Total (n):	57	24	14	4	37	389	62	1,725	1,631	41
<150 mm:	96%	92%	100%	50%	54%	87%	100%	100%	100%	100%
Average (mm):	81	93	37	131	150	127	80	76	40	28

[a] Cutthroat, rainbow, or hybrid trout fry too small to identify.
[b] Non-salmonid fry too small to identify.

Appendix U. Length frequency distributions of 4,012 fish captured at the Hog Hollow screw trap in the Lower Teton study section, Idaho, April 23 to October 29, 1999. Excluded are 4,086 fish that were tallied but not measured. Fish fully recruited to the trap gear (<150 mm) are shaded.

Total length (mm)	Cutthroat trout	Rainbow and hybrid trout	Unknown trout fry[a]	Mountain whitefish	Sucker	Cottid	Dace	Red-side shiner	Utah chub	Unknown other fry[b]
0-9						7				
10-19						20	8	22		5
20-29			20	132	102	64	409	172		15
30-39			9	214	47	21	765	134		
40-49	1		3	81	42	10	192	130	2	
50-59		1	2	3	6	1	183	237		
60-69			3	1	11	6	168	145		
70-79			2		6	23	67	145	2	
80-89	1		2		5	14	33	120	1	
90-99	1				3	17	9	80	1	
100-109	1		1	3		4	4	39	1	
110-119	3			2	2	2	3	2		
120-129	1	1		1						
130-139	1							1		
140-149	3									
150-159	2								1	
160-169										
170-179	1									
180-189	1									
190-199										
200-209										
210-219										
220-229										
230-239										
240-249									1	
250-259				1						
260-269										
270-279										
280-289										
290-299	1									
300-309										
310-319										
320-329										
330-339	1	1								
340-349										
350-359										
360-369										
370-379										
380-389	1									
390-399										
400-409										
410-419										
420-429										
430-439										
440-449										
450-459										
460-469										
470-479										
480-489										
490-499										
500+										
Total (n):	19	3	42	438	224	189	1,841	1,227	9	20
<150 mm:	63%	67%	100%	100%	100%	100%	100%	100%	78%	100%
Average (mm):	161	170	40	35	37	46	41	57	102	21

[a] Cutthroat, rainbow, or hybrid trout fry too small to identify.
[b] Non-salmonid fry too small to identify.

Prepared by:	**Approved by:**
	IDAHO DEPARTMENT OF FISH AND GAME
William C. Schrader Senior Fisheries Research Biologist	Virgil K. Moore, Chief Bureau of Fisheries
Michael D. Jones Fishery Technician	Steve Yundt Resident Fish Manager