Lower Methow Tributaries Intensive Effectiveness Monitoring Study

Interim Report

For the period: July 2004-November 2006

January 2008

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Introduction

Actions have been taken to replace diversion dams in lower Beaver Creek with a series of rock vortex weirs. Some of these diversion dams have been in place for over 100 years, and they have impaired or completely blocked upstream migration of fish. Three diversion dams were replaced in 2003 (Lower Stokes, Thurlow Transfer, and Upper Stokes), and a forth diversion dam was replaced in 2004 (Fort-Thurlow). These vortex weirs were designed and installed under the supervision of U.S. Bureau of Reclamation (BOR) engineers and completed in accordance to National Marine Fisheries Service (NMFS) and Washington Department of Fisheries and Wildlife (WDFW) fish passage criteria. The projects were designed to meet fish species recovery needs described by the Endangered Species Act (ESA) and the "BiOp" issued by NMFS (2000a). Since no specific guidelines have been identified to date specifically addressing diversion dams, WDFW and NMFS guidelines are being considered as the target design and performance criteria for the sites monitored as part of this project. Where used, the vortex weirs were designed to maintain irrigation diversion capabilities while improving fish passage.

Because installing rock vortex weirs represents a relatively new methodology and little information was available for their effectiveness of passing fish species of the Pacific Northwest, an effectiveness monitoring effort was warranted. Effectiveness monitoring evaluates whether the management action achieved the desired effect or goal. Success is measured against a pre-determined performance standard or a desired future condition. The change (or effect of a project) is measured against controls or pre-treatment conditions, and aims to develop a mechanistic understanding of the relationships between fish population response and various habitat management actions (Hillman and Giorgi 2002). The habitat improvement actions in the study area were not coupled with a fisheries management action, such as stocking. Therefore, recolonization of newly opened habitat by fish, especially salmon, steelhead, and bull trout, will rely on adult straying or juvenile migration into treatment basins.

The U.S. Geological Survey's Columbia River Research Laboratory was contracted to assess the effectiveness of the vortex weirs for providing the desired fish passage. The specific objectives of the study were to: 1) Assess current and potential anadromous fish and bull trout production in Gold, Libby, and Beaver creeks associated with presence or removal of irrigation diversion passage barriers, 2) Assess effectiveness of modified irrigation diversion structures for passage of fish and subsequent changes in fish populations in Beaver Creek, 3) Relate hydraulic and sediment transport responses to and effectiveness of the installation of new irrigation diversion structures at 3-4 locations on Beaver, Libby, and/or Gold creeks [This objective was conducted through a CESU agreement with the Ecohydraulics Research Group at University of Idaho-Boise, the results of which are contained within a Master's thesis (Ruttenberg 2007).], and 4) Work with cooperating agencies and established interagency groups to develop and implement a basin-wide research and monitoring plan for the Methow River and supplement project activities to further Objectives 1-3.

Important fish species that stand to benefit from these actions include ESA-listed species of steelhead *Oncorhynchus mykiss* (endangered), Chinook salmon *O. tshawytscha* (endangered), and bull trout *Salvelinus confluentus* (threatened). Effectiveness is being measured by changes in physical stream characteristics upstream and downstream of the structures, by monitoring upstream passage of fish, and by measuring change in fish assemblage, productivity, and genetics above the modified structures. To complement the fish productivity measures, the study includes extensive sampling to understand the relationships between stream habitat, life history aspects of various fish species, and genetic diversity, which will help to explain potential success or limitation to the fish community response in the treatment and non-treatment streams. The effectiveness of the modification of existing irrigation diversion structures is being measured by changes in fish assemblage and fish production. Isotope ratios in plants and aquatic life are being measured to detect change in anadromous fish use of the tributary systems. In a separate study, genetics of fish are being monitored to help us determine which of the many possible fish venturing into the newly opened tributaries were the most successful in producing offspring.

The study documents the physical and biological responses to the modifications of diversion dams that were implemented by the BOR at four sites on Beaver Creek: Lower Stokes (BOR 2004a), Thurlow Transfer (BOR 2004b), Upper Stokes (BOR 2004c), and Fort-Thurlow. A series of other barrier removal projects, such as culvert removals by the U.S. Forest Service (USFS), have been coincident with modifying these diversion dams. This study was designed to specifically measure important parameters listed in the Research, Monitoring, and Evaluation (RME) Plan (Jordan et al. 2003): size and age structure of fish populations, freshwater productivity, proportions of hatchery and wild spawners, biological and physical condition of spawning and rearing habitat, and habitat conditions and fish passage at the diversion structures.

Similar data are being gathered in the Libby Creek and Gold Creek watersheds. These two watersheds were sampled to serve as controls to help us judge the fish response to actions taken in Beaver Creek. However, the suitability of Libby and Gold creeks to serve as true controls were diminished when existing push-up dams were not maintained. Without these control streams, the project's focus is more concentrated on the specific performance of rock vortex weirs and the biological response in Beaver Creek. Tracking what transpires in Libby and Gold creeks was still considered important to increase our understanding of the variability in the recolonization process.

Fish passage through rock vortex weirs, such as those used in Beaver Creek of this project, have received little attention in lab and field studies. This may be due to their relatively recent use for fish passage compared to traditional approaches. Previous research has documented burst and sustained swimming speeds of salmonids and their ability to navigate through turbulence (Nikora et al. 2003). Similarly, jumping abilities of salmonids are well documented (WDFW 1999), including differences in species and life stages (Katopodis 1992, NMFS 2000b, Holthe et al. 2005). Results from these studies have been applied to the design of traditional fish passage structures (Katopodis 1992). Rock vortex weirs are likely to have complex hydraulics with more variables than some traditional fish passage structures controlling geometry, energy dissipation, and discharge.

Small diversion dams can limit the movement, distribution, and abundance of fish in a watershed. They can affect the composition of the fish community and the genetic interactions within and between fish species. In addition, diversion dams can have physical effects on local hydraulics, sediment composition, sediment transport, and quality of spawning and rearing habitat (Ruttenberg 2007). Removal of these diversion dams could have various positive and negative effects on fish populations. Positive effects of barrier removal could include access to previously blocked habitat, re-establishment of native fish populations, increased marine derived nutrients in the ecosystem, improved spawning and rearing habitat, and re-established connectivity of disjunct fish populations. Potential negative effects of barrier removal include colonization of less successful stocks of fish (such as hatchery strays), introduction of non-native species, introduction of disease by incoming fish, increased negative interactions among fish species, and increased intraspecific and interspecific hybridization rates. In addition to these biological constraints to success of the vortex weirs as a replacement, the modifications themselves may not succeed as promised. The current performance standard for diversion passage is to pass all fish at all flows (Hillman and Giorgi 2002), although some agency guidelines (e.g., NMFS 2000b) are slightly less restrictive. To assure that the standard is reached requires rigorous monitoring, especially for innovative designs that are not common to the landscape. Before designs are perpetuated across the landscape, their effectiveness needs to be assessed before large expenditures are made and potentially replicating flawed design elsewhere.

This interim report documents sampling efforts and preliminary findings from work conducted directly by USGS during summer 2004 through spring 2006. Collaborative work with personnel from UI (physical measures of hydrodynamics associated with the rock vortex weirs, fish passage past rock vortex weirs) and BOR (genetic analysis) that is ongoing or completed is largely not covered in this interim report.

Study Area

The Methow River is a fifth order stream in north central Washington State that drains into the Columbia River at river kilometer (rkm) 843 in the Upper Columbia River Basin. This study is focused on Beaver, Libby, and Gold creeks, three tributaries of the Lower Methow River subbasin (Figure 1). Beaver Creek is a third order stream that drains westward into the Methow River just south of Twisp, WA. Libby Creek is a third order stream that drains eastward into the Methow River at rkm 42, while Gold Creek is a forth order stream that drains eastward to the Methow River at rkm 35. Libby and Gold creeks drain off the east side of the Cascade Mountains, while Beaver Creek drains off a largely separated range to the east. Beaver, Libby and Gold creeks have much increased flows in early summer caused by snow melt, which is followed by low summer flows that are further decreased by numerous water diversions.

Various artificial and natural barriers exist in Beaver, Libby, and Gold watersheds (Table 1). Some of the artificial barriers were relatively permanent concrete dams, while others are, or were, "push-up" type structures. The degree of passage impediment that these concrete and push-up structures represent has likely varied much within and between years.

Upstream and downstream migrating fish need to travel through nine Columbia River dams to reach the Pacific Ocean. Out-migrating fish tagged with passive integrated transponders (PIT tags) have the potential to be detected on PIT-tag interrogators located at Rocky Reach, McNary, John Day, and Bonneville dams. Upstream-moving PIT-tagged fish have the potential to be detected on PIT-tag interrogators at Wells, Rock Island, Priest Rapids, McNary, and Bonneville dams.

Methods

Fish assemblage: electrofishing and trapping

Electrofishing: We used electrofishers to survey and collect fish throughout Beaver, Libby and Gold creeks. Getting fish to the hand allowed us to gain positive identification of species, to take basic fish metrics (length, weight), and to PIT tag fish for assessing fish movement within and among reaches and streams.

All electrofishing was conducted with a Smith-Root LR-24 backpack electrofisher with a setting of 90 Hz and 1-ms duty cycle. The voltage was largely determined by the suggested setting from the manufacturer's calibration setting.

Weir: A fish trap was installed in fall 2004 near rkm 1 in Beaver Creek, which was below all fish diversions (Figure 2). The trap consisted of four wings of 0.25-in aluminum conduit spaced 0.25 in apart that directed fish to the upstream or downstream trap (Figure 3). The trap had an upstream and downstream box that was located in the deepest part of the stream. In spring 2005, the trap was modified to prevent fish from escaping the downstream trap. The modification consisted of moving the two upstream wings above a riffle, just upstream of the trap, and attaching them to an aluminum plate with a large hole in the bottom. We then inserted a large PVC pipe that connected the aluminum plate to the downstream trap. After modification, the water would fall from the pipe into the trap preventing fish from swimming back up the pipe. In fall 2006, we attached an additional one-directional box trap, without the wire-mesh back, in front of the upstream two-directional trap. This resulted in a two-staged trap design, which was devised to catch adult fish in the downstream section of the trap and juvenile fish in the upstream section of the trap (Figure 3).

The USGS field crew checked the trap at least once a day to collect fish and remove debris. During the fall, when leaves and other debris were more abundant in the stream, the trap was cleaned twice a day. To clean the trap, the conduit pieces were pulled up from the weir frame to wash the debris past the trap and relieve pressure that could result in trap blowout. Most fish collected at the trap were fin clipped for genetic samples and tagged with passive integrated transponder (PIT) tags.

<u>Fish handling:</u> Fish collected by electrofishing or in the trap were anesthetized with a light dose of MS-222 before handling. All fish captured were measured for fork length to the nearest mm, weighed to the nearest 0.1 g, and inspected for external signs of disease. A small number of scales were taken from larger fish (>250 mm), from fish that appeared to be between age-0 and age-1 or older, and from recaptured fish. Tissue for genetic analysis were clipped from the caudal fin of salmonids collected at the trap (with few exceptions) and from some salmonids at selected reaches. They were then stored in small plastic vials of 100% non-denatured ethyl alcohol. When possible, fish that died during sampling or abnormal looking fish were frozen and sent to U.S. Fish and Wildlife Service's Lower Columbia River Fish Health Center (USFWS-LCRFHC) for disease analysis. In order to track movements, growth, and survival of juvenile steelhead trout, we PIT-tagged fish that were 65-mm fork length or longer. After handling, fish were held in fresh ambient-temperature stream water and released near their point of capture after regaining equilibrium.

Fish movement: tagging and detecting

<u>PIT-tagging:</u> All PIT tagging followed the procedures and guidelines outlined by Columbia Basin Fish and Wildlife Authority (1999). Most fish were PIT tagged using a thin-walled, 12-gauge needle to insert a 134.2 kHz, 12-mm tag, but 27 fish were tagged with similar but larger, 23-mm tags, which required a scalpel to make a small slit for manual insertion of the tag. For small juvenile fish (65-200 mm), the PIT tag was inserted just beneath the pectoral fin and into the fish's abdomen. With large juvenile (>200 mm) or adult fish, we inserted the tag into the dorsal sinus to prevent tag loss that could occur with abdomen-inserted tags during spawning events. Because PIT tags have an effective life of over 10 years (Prentice et al. 1990), salmonids implanted with PIT tags provide the opportunity for recapture and data collection throughout the life of a fish. All PIT-tag and recapture data were submitted to the PTAGIS database administered by Pacific States Marine Fisheries Commission (PSMFC).

<u>PIT-tag interrogator systems:</u> Interrogation systems were installed in three lower Methow subbasin tributaries at ten sites from September 2004 to November 2005. We maintained and operated two large PIT-tag interrogation systems that could detect directional fish movement and eight small single-antenna PIT-tag interrogation systems to help determine fish presence and determine fish movement (Figures 2, 4, and 5).

The two large PIT-tag interrogation systems were installed in Beaver and Gold creeks. One system was placed in Beaver Creek above the second lowest water diversion (Figure 2), and the second system was installed in Gold Creek about 100-m upstream from the confluence with the Methow River (Figure 5). These large systems consisted of a FS 1001M Digital Angel multiplexing PIT-tag transceiver, six custom-made antennas, and a DC power source. These systems were built and installed by a crew from NOAA Fisheries led by Earl Prentice. A crew from USGS helped with site selection and installation of the systems. The six antennas were arranged in three arrays, with two antennas in each array. This was done to assess direction of moving fish and to cover most, if not all of the stream. The antennas were installed using two configurations. The first and most common configuration was where all four corners were tied to the stream bed creating a "pass-by" configuration. In the second configuration, the upstream side of the antenna was attached to the stream bed. This configuration allowed the downstream side of the antenna to rise and fall in the current, which would potentially increase read range, but also left the antenna more vulnerable to debris and high water. The Beaver Creek interrogator, and a similar unit deployed in Rattlesnake Creek in southern Washington, have been shown to have detection efficiencies that exceed 96% during high flow periods and approach 100% during low flow periods (Connolly et al. *In press*).

Eight small interrogators were distributed throughout Beaver, Libby, and Gold creeks. The small PIT-tag interrogators consisted of a 2001F-ISO Digital Angel PIT-tag transceiver, a 12-volt battery, and a single antenna. Initially we used rectangular antennas manufactured by Biomark (0.8-m length by 0.3-m width), but by the second year of the study, we were using our own custom-made rectangular antennas. These antennas allowed increased flexibility in the size of the antenna, so that an antenna could be custom-fit to a specific site. Maximum size was limited to 1.8-m in length and 0.3-m in width to insure desired electronic properties. Three of these small systems were deployed in each of Beaver and Gold creeks, and two systems were deployed in Libby Creek. In Beaver Creek, one system was installed just upstream of the fish trap, which was below all water diversions. A second system was installed just below a water diversion that was near our lowermost index site (R1), and a third system was installed in the upper watershed below the confluence with South Fork Beaver Creek (Figure 2). One of the Libby Creek systems was deployed near the Highway 153 Bridge, below the lowermost water diversion, and the other was deployed above the lowermost diversion (Figure 4). The small systems deployed in Gold Creek were located just above the confluence with Foggy Dew Creek, in Foggy Dew Creek just above its mouth, and in South Fork Gold Creek above the last parcel of private land (Figure 5). Batteries were swapped at the small interrogators twice a week.

Fish population estimates

Six sites dispersed among the three watersheds were sampled to obtain population estimates. The location of these sites within watersheds was based largely on geomorphology. University of Idaho personnel provided us the information on geomorphic reach breaks. One site was located in each of the lowermost reach of each watershed, and no reach contained more than one site. Final location of sites was largely determined by access, which required gaining written landowner permission in some cases. Three 500-m sites were selected in Beaver Creek (Figure 2), one 1000-m site in Libby Creek (Figure 4), and three 500-m sites in the Gold Creek (Figure 5). An additional 500-m site was added to Libby Creek in 2005.

Population assessments began with a habitat survey, which was used to stratify the fish sampling effort based on habitat unit types (e.g., pools, glides, riffles, and side channels). In cases where a habitat unit was unable to be sampled, the next unit within the same stratum was sampled. Habitat units chosen for electrofishing were blocked off with nets to insure no immigration or emigration of fish. A backpack electrofisher was used to conduct two or more passes using the removal-depletion methodology (Zippin 1956; Bohlin et al. 1982; White et al. 1982). The field guides of Connolly (1996) were used to determine the number of passes necessary to insure that a controlled level of precision in the population estimate was achieved (CV < 25% for age-0 salmonids and CV < 12.5% for age-1 or older salmonids) within each sampling unit for each salmonid species (steelhead/rainbow trout, brook trout, bull trout, cutthroat trout, and Chinook salmon) and age group (age-0 and age-1 or older). These methods were chosen to minimize the number of units sampled and the number of passes per unit. This approach lessened the chance that individual fish would be exposed to the effects of electrofishing while it insured a high degree of precision in our estimates. When not obvious in the field, we used a fork length of 80 mm as a separation point between age-0 from age-1 or older fish.

Fish growth

Surveys were conducted during the spring, summer, and fall to collect previously PIT-tagged fish to determine growth of individual fish. Electrofishing was used to collect fish from our three Beaver Creek, two Libby Creek, and three Gold Creek index sites. In addition, we were able to collect growth data from fish collected at the Beaver Creek fish weir. Recapture data were collected and sorted into the season of year they were collected. Recapture events were used when a fish was captured within the next season from its tagging or last recapture event. Since no sampling occurred during winter, we assessed growth for fish tagged (or recaptured) in the fall and recaptured in the spring. Recaptured fish were used only if they were recaptured after 10 days of their tagging or last recapture date. We defined seasons as: spring (March-May), summer (June-August), fall (September-November), and winter (December-February).

Isotope study

We chose three sites in Beaver Creek and two sites in Gold Creek for isotope analysis (Figures 6 and 7). The lowest Beaver Creek site (rkm 3) was picked because it was above two water diversions, and we expected to see a large increase in anadromous fish in this reach after the diversions were reconstructed. The middle Beaver Creek site (rkm 13) was selected because we expected to see some but limited anadromous fish use after the water diversions had been reconstructed. The upper most site, located in South Fork Beaver Creek (rkm 3), was selected because we did not expect to see an influence from anadromous fish, and thus, it would serve as a control. The lowest Gold Creek (rkm 5) site was selected because we expected to have anadromous fish present when no downstream barriers were present. An upper Gold Creek site (rkm 11) was selected as a control site because it was expected to remain inaccessible to anadromous fish.

Samples for isotope analysis were collected from fish, algae, leaves (cottonwood, red alder), and insects during fall 2004, spring 2005, and fall 2005. At each site, we collected six fish from the dominate fish species at each site, including three age-0 fish and three age-1 or older fish. We attempted to collect three samples from other fish species present if they could be collected in a reasonable amount of time. Algal samples were collected at each site by scraping rocks and picking filamentous algae. Samples of decomposing leaves were collected from red alder and cottonwood foliage found within the bankfull width of the stream. We disturbed the substrate from the stream bed to disperse insects into a D-net to collect insect samples. All samples were taken back to the field station and placed in a small freezer until the samples could be further prepared for analysis.

In the laboratory, the insect samples were allowed to thaw before they were processed. The insects were separated into three feeding groups (predators, shredders, and collector/gathers). We then selected samples that were found at multiple sites for further processing. In cases where we did not have enough of a sample from one species of insect, we used a combination of different species from the same feeding group to get a larger sample. All fish, algae, leaves, and insects were dried in an oven at 60 C for at least 48 hours. A mortal and pestle were used to crush the samples into a fine power. The samples were weighed to 0.002 – 0.003 g for plant tissue or 0.0008 – 0.0012 g for animal tissue, and sealed in aluminum capsules for analysis. The samples were then sent to the University of California – Davis, Department of Plant Sciences, for dual isotope analysis of Carbon 13 and Nitrogen 15 levels.

Diversion study

During summer 2005, we tested the effectiveness of a fish screen within a diversion canal designed to return fish to the stream after being in the first 20 m of the canal. We installed two small PIT-tag interrogation systems in the diversion canal, which was co-located above the uppermost rock vortex weir in Beaver Creek at rkm 5. The upper interrogator was located at the downstream end of the inlet pipe. A second interrogator was installed downstream of the fish screen and bypass pipe of the diversion canal. These interrogation systems ran from 28 July 2005 until 31 August 2005.

To collect test fish, we used a backpack electrofisher in the section of stream adjacent to the water diversion. We tagged and released a minimum of 30 fish on three occasions. Releases were approximately one week apart. The first release was on 28 July 2005, and the final release was on 12 August 2005. Data from the interrogators were downloaded every third day. On 31 August 2005, the fish remaining in the canal were removed with a backpack electrofisher. When we were reasonably confident that no fish remained in the diversion, we removed the small interrogation systems from the diversion canal. We used the number of fish returned to the stream and those recaptured in the upper diversion canal to assess the number of fish that were not diverted back to the stream by the screen as desired.

Results

The results we present below are intended to characterize the kinds, breadth, and variability of data collected to date. In general, it was considered too early in the study to present an analysis of the data to directly assess the effectiveness of the restoration action being tested, i.e., replacement of diversion dams with rock vortex weirs. This planned analysis will be the subject of a final report, which will include the data presented here plus data collected during additional years, 2007-2008.

Fish assemblage: electrofishing and trapping
We encountered at least ten species of fish in 2004-2005 (Table 2). Rainbow trout/juvenile steelhead was the most common fish species collected (Table 3), followed by brook trout and sculpin (which may have been represented by one or more species). From 2004 to 2006, the percentage of mortalities from the weir ranged from 0 to 2.0 percent per year, while the percent of mortalities from electrofishing ranged from 1.2 to 4.9 percent per year.

Beaver Creek: From 2004 to 2005, we tagged 3,300 rainbow trout/steelhead, 312 brook trout, 265 Chinook salmon, 16 coho salmon, 13 bull trout, and 5 cutthroat trout in Beaver Creek (Table 3). Juvenile Chinook salmon were encountered below the first diversion in 2004 and 2005. In 2005, two juvenile Chinook were collected near the R1 index site, above the two rock vortex weir structures. One adult Chinook was spotted in a water diversion (rkm 10) above all reconstructed water diversions during the summer 2006. Bull trout were found in Beaver Creek above the confluence with South Fork Beaver Creek, and they were collected in the fish trap. The largest number of bull trout (10) was found in Blue Buck Creek. Bull trout (>176 mm) were collected at the fish trap, located 1 km from the mouth of Beaver Creek. Westslope cutthroat trout were collected in Lightning Creek and the upper reaches of Beaver Creek. Sculpin were found in Beaver Creek from the mouth up to rkm 15, but were not found in any of the Beaver Creek tributaries. All other species were encountered within 1 rkm of the confluence with the Methow River.

Libby Creek: We found rainbow trout/juvenile steelhead in every reach and tributary sampled in the Libby Creek watershed (Table 2). From 2004 to 2005, we tagged 1,217 rainbow trout/steelhead, 2 Chinook, 1 bull trout, 82 westslope cutthroat trout, and 10 brook trout (Table 3). In 2004, one juvenile Chinook was collected above the water diversion in the R1 index section. In 2005, we collected one juvenile bull trout in R4 index site of Libby Creek. Westslope cutthroat trout were found in South Fork Libby Creek, North Fork Libby Creek and smaller numbers existed in the upper reaches of Libby Creek. Brook trout were present in low numbers, most found near the connection with Mission Pond. No sculpin were collected or observed in Libby Creek.

Gold Creek: Rainbow trout/steelhead were found at every site sampled in the Gold Creek Watershed (Table 2). From 2004-2005, we tagged 1,359 rainbow trout/steelhead, 4 Chinook, 64 bull trout, 70 westslope cutthroat trout, and 9 brook trout (Table 3). Juvenile Chinook were collected above the water diversion at rkm 4.4 in 2005. Bull trout and westslope cutthroat trout were encountered above rkm 7.4 in Gold Creek and in Foggy Dew and Crater creeks. Brook trout were limited to the Middle Fork Gold Creek.

Fish movement: tagging and detecting
Beaver Creek weir: We collected 133, 1,965, and 980 fish from at least ten species at the weir in Beaver Creek during 2004, 2005, and 2006 respectively (Table 4). Rainbow trout/juvenile steelhead made up 66% of the fish collected at the trap from 2004 to 2006. In 2006, we collected increased numbers of brook trout and longnose dace with the trap, and we collected a cutthroat trout for the first time.

Rainbow trout/juvenile steelhead emigration was prominent in April through June and in September through November (Figure 8). A large emigration of rainbow trout/juvenile steelhead and juvenile Chinook occurred during fall 2005. Most juvenile fish immigration started in early spring and lasted into early summer.

In 2005, downstream-moving adult steelhead started showing up at the Beaver Creek weir near the end of March, and they were detected through May (Figure 9). It was apparent that adult steelhead had already moved upstream before the trap was put in place in mid-March. In 2006, adult steelhead were trapped starting in mid-March and lasting into April. All fish except one was collected in the upstream trap. The low catch of downstream moving fish was likely due to high flows that washed out the trap for parts of April and the last half of May, but was reinstalled by end of June. In July 2006, we collected the first adult Chinook in the upstream trap. We later collected three adult Chinook in the downstream section of the trap. We could have missed some or most of the upstream migration for adult Chinook, and possible a few adult steelhead, while the trap was inoperable during high flows.

<u>Beaver Creek watershed:</u> In Beaver Creek, a total of 3,702 PIT-tagged rainbow trout/juvenile steelhead were available for our analysis of movement, which included fish tagged through spring 2006 (Figure 10). As of spring 2006, 93 rainbow trout/juvenile steelhead had been detected outside of Beaver Creek watershed: at the Lower Methow River smolt trap or at one or more of the detection sites in the Columbia River. In May 2006, only one rainbow trout/juvenile steelhead tagged above rkm 6 was detected, at Bonneville Dam, outside of Beaver Creek watershed. Over 30% of the emigrating fish were released at our R1, 500-m index site located at rkm 5.

Upstream migrating adult steelhead moved from Bonneville Dam to the lower Methow River tributaries between 122 to 334 days. The median number of days spent above Wells Dam, the last Columbia River dam before its confluence with the Methow River, ranged from 177 to 209 days (Table 5). Beaver Creek juvenile steelhead had the largest number of emigrants in the spring and fall (Figure 11). Spring movers made up 48% of the total emigrants, while fall movers made up 46% of the total emigrants. The spring emigrants traveled past John Day Dam in a median of 19 days, while fall emigrants traveled in a median of 200 days (Table 6). Most juvenile Chinook emigration in Beaver Creek occurred in the fall and winter (Table 7). Gold Creek juvenile steelhead had similar patterns as those in Beaver Creek, although spring migrating fish from Gold Creek moved into the Columbia River quicker. The large PIT-tag interrogator in Gold Creek was installed in late fall 2005 (10 November 2005), possibly missing most if not all of the fall emigration that occurred in Beaver Creek (Table 8).

The number of fish in Beaver Creek moving between PIT-tag interrogators increased in the spring and fall. During the winter months, there was little or no movement, with interrogations showing mostly local movement. In summer 2005, from July to mid-August, we observed a small number of fish emigrating. While most downstream movement occurred in April through May, we detected a second round of movement starting in mid to late September and lasting into early December (Figure 12). In early spring 2005, juvenile steelhead and Chinook emigrants from Beaver Creek started showing up downstream at detectors in Columbia River dams. The majority of these fish were detected at McNary and John Day dams in May (Figure 13).

We detected 10 hatchery steelhead in Beaver Creek, 3 as adult strays and 7 as juveniles, moving upstream from the Methow River (Table 9). All hatchery strays were either raised in Wells Hatchery (5 fish) or at the Winthrop Hatchery (5 fish). Fish from the Winthrop Hatchery were all released at the hatchery. Stray fish from Wells Hatchery had been released in the Twisp River, except one of these stray fish had been released in the Chewuch River.

After the reconstruction of the lowermost remaining water diversion in Beaver Creek, we collected or detected mountain whitefish, coho, and juvenile and adult Chinook at the R1 index site or large interrogator (Figure 14). As of 2005, five tagged fish had made multiple trips between rkm 5 and rkm 1, bracketing two reconstructed water diversions (Figure 15). Of the five fish, only one fish (brook trout) traveled down to rkm 1 and then moved back upstream to rkm 5, the rest moved upstream and then moved back down. Two fish (1 adult steelhead, 1 rainbow trout/juvenile steelhead) moved upstream to at least rkm 5 and then moved back down to the trap site in less than two months. Two rainbow trout/juvenile steelhead moved independently upstream past rkm 5 from June-July and held above the interrogator until October-November when they moved back downstream past the trap site.

Of those detected, most rainbow trout/juvenile steelhead traveled from the trap site (rkm 1) upstream to the detector site above the Fort-Thurlow (rkm 2) and Lower Stokes rock vortex (rkm 3) weirs in the first 20 days after handling at the trap. The fastest moving juvenile fish traveled upstream through the two rock vortex weir structures in two days. Four fish took 101 to 300 days to move upstream past the R1 index site (Figure 2). Most upstream movement of rainbow trout/juvenile steelhead occurred from June to July (22 of 27 fish), with two or fewer fish moving in April, May, September, and November. Of the 18 juvenile rainbow trout/steelhead that were observed to move upstream through the rock vortex weir structures, from the small PIT-tag interrogator (just below the Lower Stokes diversion) to the large PIT-tag interrogator (just above the Lower Stokes diversion), five did so within 10 hours. Half of the upstream moving juvenile fish moved above the diversion within 40 hours. The rest of the juvenile steelhead that definitively passed the diversion took over 50 hours (up to 2,400 hours). Rainbow trout/ juvenile steelhead moved upstream past one diversion with flows as low as 2.3 cfs (Figure 16). Most of the upstream movement from rainbow trout/juvenile steelhead occurred in June and July.

Two adult steelhead moved up within two days of being released from the trap, while most held between the trap and our first index site (R1) from 17-50 days before moving past the two rock vortex weir structures (Figure 17). All adult steelhead detected at the interrogator just below Lower Stokes moved upstream through the Lower Stokes rock vortex weir structure in less than one hour (Figure 18).

Libby Creek watershed: Juvenile steelhead emigrants were tagged up to rkm 5 in Libby Creek (Figure 19). One adult steelhead was spotted at rkm 10 while shocking in spring 2005. Less than 1% of fish tagged near rkm 1.0, above the first water diversion barrier, were detected outside of Libby Creek. Eight percent of the fish tagged below this barrier were detected outside of Libby Creek.

Interrogators in Libby Creek detected seven hatchery steelhead (6 adults, 1 juvenile) migrating into Libby Creek. Two of the adult hatchery fish detected in Libby Creek were originally released as juveniles in Nason Creek of Wenatchee River Watershed (Table 9). Only one of the seven hatchery strays moved in Libby Creek as a juvenile. Four of the hatchery fish were raised at the Wells Creek Hatchery, while one fish was raised at the Winthrop Hatchery. We did not detect any fish that were PIT tagged above rkm 3 at any of the instream interrogators, or at any of the Columbia River dams. A field crew spotted an adult steelhead near rkm 10 during spring 2005.

Gold Creek watershed: Juvenile steelhead emigrants were interrogated at Columbia River dams from fish released in North Fork Gold Creek, Foggy Dew Creek, and South Fork Gold Creek (Figure 20). We detected 14 hatchery steelhead (12 adults, 2 juvenile) in Gold Creek; all but 1, detected at the South Fork Gold Creek interrogator, after installation of the large PIT-tag interrogator was installed in late fall 2005 (Table 9). Ten hatchery fish were raised at Wells Hatchery and released in various locations in the Methow River watershed or the Wells Hatchery. One fish was raised and released at the Winthrop Hatchery. Three hatchery fish were detected from outside the Methow River watershed: two fish were released in the Wenatchee River watershed, and one fish was raised and released at the Ringold Hatchery. Two adult hatchery fish have been detected by the South Fork Gold PIT-tag interrogating system.

Population estimates

Beaver Creek: In Beaver Creek, age-0 and age-1 or older rainbow trout/juvenile steelhead were most prevalent at the lowermost (R1) index site (Figure 21). The age-1 and older rainbow trout/steelhead biomass at the R1 index site had almost double the biomass of the other index sites sampled in the Methow watershed. We found similar results of age-1 or older fish/m from 2004 to 2005. The population of age-0 rainbow trout/juvenile steelhead decreased in the R1 and R2 index sites in 2005, while the R4 index site's population increased (Figure 21). The biomass of rainbow trout/juvenile steelhead in R1 and R2 decreased from 2004 to 2005, while the biomass increased in R4 (Figure 22). The population of age-0 and age-1 or older rainbow trout/juvenile steelhead in Beaver Creek decreased at each upstream sampling site (Figure 23).

Brook trout were commonly found at all of our Beaver Creek index sites (Figure 22). The largest concentration of brook trout was found at the R4 index site (0.21 age-0 fish/m and 0.13 age-1 or older fish/m) in 2005. This was an increase from the 0.04 age-0 fish/m and 0.04 age-1 or older fish/m in 2004. Age-0 brook trout increased four fold in R1, from 0.03 fish/m in 2004 to 0.12 fish/m in 2005.

Libby Creek: The lower Libby Creek (R1) index site population of age-0 and age-1 or older rainbow trout/juvenile steelhead increased over 30% in 2005. This R1 index site was the only index site in the Methow River watershed to show an increase in both age-0 and age-1 or older steelhead from 2004 to 2005. In 2005, we added a new site in upper Libby Creek (R4), which contained 0.37 fish/m of age-0 rainbow trout/juvenile steelhead compared to 1.04 fish/m age-0 rainbow trout/juvenile steelhead in R1. The population of age-1 or older rainbow trout/juvenile steelhead were similar between the two Libby Creek sites (0.85 fish/m in R4 and 0.99 fish/m in R1). Rainbow trout/juvenile steelhead collected in R4 (4.06 g/m^2) had higher biomass estimates than fish in R1 (3.6263 g/m^2) even though R1 contained more fish (Figure 24). No other fish species had a population over 10 fish at the R1, 1,000-m site or the R4 500-m site.

Gold Creek: In 2004, North Fork Gold Creek index site (NF) had more age-0 rainbow trout/juvenile steelhead (1.66 fish/m) than any other index site in the Methow River watershed. The Foggy Dew (FG) and South Fork Gold (SF) index sites had similar numbers of age-0 and age-1 and older rainbow trout/juvenile steelhead for 2004 and 2005. The 2004 population estimates for age-1 or older rainbow trout/juvenile steelhead in the NF, FG, and SF sites ranged between 0.57-0.60 fish/m. In 2005, the NF index site's age-1 and older population increased, while the FG and SF populations were similar to the 2004 estimates (Figure 21).

Bull trout have been collected at NF and FG index sites in the Gold Creek watershed. The population of age-0 of bull trout in the FG index site decreased in 2005. We did not collect any age-1 or older bull trout in 2004, but several were collected in 2005. In 2004, no bull trout were detected in the NF site, but we had a population of 0.02 fish/m in 2005 (Figure 25).

Fish growth

Recapturing PIT-tagged fish allowed measuring growth over time for individual fish (Figure 26). Growth of rainbow trout/juvenile steelhead expressed a highly seasonal pattern, with most growth occurring during the spring-summer time period and the least growth during winter (Figures 27 and 28; Appendix Tables 1-9).

Isotope analysis

Because of the infancy of our analysis, we did not attempt a statistical analysis of the isotope data. Rather, we present a brief qualitative analysis. Five sites (three in Beaver Creek, two in Gold Creek) were sampled on three occasions, in fall 2004, spring 2005, and fall 2005. The ratio of Nitrogen 15 to Nitrogen 14 were highest for the lower Beaver Creek site, while the ratio of Carbon 13 to Carbon 12 were similar between sites within a watershed, but generally higher in Beaver Creek than in Gold Creek. For the dominate age-1 fish, marine derived 15N ratios were highest at the lowest site on Beaver Creek, with an average delta 15N just under 11‰. All other sites including the lower Gold site had levels <9‰ (Figure 29). The isotope levels remained relatively consistent during all three sampling periods. Age-0 fish had similar patterns to the age-1 fish with high levels of 15N in the lowest Beaver Creek site (Figure 29). In sites where sculpin were present, they had similar results to the age-1 and age-0 fish (Figure 29). Marine-derived 13C ratios had relatively similar levels at three sites in Beaver Creek with a lower level in the two Gold Creek sites. The levels appear to be consistent during all three sampling occasions (Figure 30).

Vegetation samples showed a similar pattern of Nitrogen ratios in fish, but a different pattern for Carbon. Algae samples had a consistently higher nitrogen level at the lower Beaver Creek site through all three sampling occasions (Figure 31). Cottonwood leaves collected at the sites were inconsistent at several sites due to trouble finding enough samples at each site (Figure 31). The ratio of Carbon 13 was higher in all Beaver Creek sites than the Gold Creek sites (Figure 32). The ratios of N15 in algae were higher in the two Gold Creek sites during the fall than in spring, while the highest levels were found in R1 of Beaver Creek.

The predator insect group had a high nitrogen ratio in fall 2005, slightly higher than the ratio in spring 2005 (Figure 33). The collector-gather group had the highest nitrogen ratios for all three sampling occasions at the lowest Beaver Creek site. We had one sample of collector-gathers at the upper Beaver Creek site in fall 2004 that had a ratio similar to the samples at the lower Beaver Creek site (Figure 33). The fall 2005 sample of scrapers, from the lowest Beaver Creek site, had a wide range of nitrogen with one sample having higher 15N ratio typical of other samples at this site (Figure 33). The insect samples collected in Gold Creek had lower levels of Carbon 13 than the samples collected at Beaver Creek (Figure 34).

Diversion study

Three trials of 33, 30 and 30 fish were planted in the middle of the water diversion canal. Most fish planted in the water bypass section of the water diversion, left the diversion by moving upstream and exiting through the upper section of the diversion. In 2005, 75% of all fish released in the diversion were detected leaving the diversion, 16% of the fish were later recaptured in the water diversion, and 5% of the fish were never detected again (Figure 35). Of the 91% of fish with known origins, the majority of fish left the diversion with-in the first day of being released and 70% of the fish left the diversion within five day of being released (Figure 36). In all three of the trials, there were times when the reader was not operating, which could possibly account for all or some of the fish never detected.

Discussion

Much of data presented in this interim report will be used as baseline information to assess effectiveness of replacing diversion dams with vortex weirs to enable or enhance fish passage. Although this assessment did not have the luxury of pre-treatment years, the recolonization process is expected to take years to mature. The slow pace of the process in the initial years should allow an analysis of change over time. The role of monitoring Libby and Gold creeks, which were originally to be control streams with diversion dams in place, changed to “treatment-like” streams themselves when diversion dams eroded naturally (as in Libby Creek) or with human assistance (as in Gold Creek).

The primary goal of this report was to describe the methodologies, describe the types of data being collected, and summarize some initial findings so that the reader can gain a sense for the potential that this effort has to meet the objective of assessing effectiveness. Limited analyses beyond the observational and a summary treatment of data are offered at this time. We feel it much too preliminary of data to allow in-depth interpretation, and to do otherwise could result in spurious results.

Beaver, Libby, and Gold creeks were dominated by rainbow trout/juvenile steelhead. Brook trout were found in the upper reaches of Beaver Creek, and they dominate the South Fork Beaver and Middle Fork Beaver creeks. Brook trout were more limited in distribution in Libby Creek, with the only two individuals found around its confluence with Mission pond, and in Gold Creek, with all fish found in the Middle Fork of Gold Creek. We found bull trout in all three watersheds. In Beaver Creek, bull trout were found in Blue Buck Creek and the upper reaches of the mainstem Beaver Creek, as well as a total of four bull trout collected at the trap. Bull trout collected and PIT tagged at the trap were not subsequently detected in the upper section of the Beaver Creek watershed. One juvenile bull trout was collected in the upper Libby Creek index site. No other bull trout have been found in Libby Creek after several years of sampling suggesting limited use of Libby Creek. We found bull trout in all sections and tributaries of Gold Creek watershed above rkm 8. We have generally avoided sampling in areas with known populations of bull trout.

Juvenile Chinook were found above the water diversions in both Libby and Gold creeks. This suggests that the diversions are either seasonal or not barriers at all to adult Chinook or juvenile Chinook upstream migrants. Heavy winter run-off and unknown maintenance of these diversions has likely led to an improved condition of these water diversions for fish passage.

Modifications to the fish trap between fall 2004 and spring 2006 are believed to have increased our efficiency for fish collection. The large number of fish collected in 2005 (1,965) compared to 2006 (980) is likely due the trap being run for 253 days compared to 220 days in 2006. In spring 2006, we missed a critical period of time for fish immigration and emigration due to a long sustained spring run-off that prevented us from using the trap.

Downstream fish movement data along with isotope data suggest that steelhead were present in R1 of Beaver Creek prior to reconstruction of the water diversions. Little to no evidence of anadromy has been found above R1. This may be due to a large beaver dam at the upstream end of our lowest index site creating a temporary or seasonal barrier. This dam was removed by high flows during spring run-off in 2006, and an adult Chinook was subsequently spotted in an upper water diversion several kilometers above the beaver dam after it had washed out.

Rainbow trout/juvenile steelhead emigration occurred in the spring and fall. Most spring emigrants would immediately move downstream toward the Pacific Ocean, while fall migrants would hold over 100 days between rkm 1 of Beaver Creek and WDFW's smolt trap in the Methow River (rkm 30, which is 27 rkm downstream of the mouth of Beaver Creek). Juvenile Chinook emigration would occur in the spring and early winter. Most juvenile Chinook would leave Beaver Creek in the winter and would most likely hold in the mainstem Methow River until spring before they would emigrate to the ocean.

Juvenile steelhead outmigrants have been detected from all index sites in the Gold Creek watershed. However, we have not detected a strong anadromous signature in our isotope samples. This may be due to the location of the sites, but we would not expect to see a signature in our upper site, and the middle site may be more of a migration corridor than a spawning area. This idea is reinforced by juvenile outmigration data, where we found outmigrants from Foggy Dew and South Fork Gold creeks, but none from the mainstem Gold Creek between these streams. The lowest Gold Creek PIT-tag interrogator was installed in late fall 2005, which may have missed the fall migration from Gold Creek. More emigration data will help assess the life history strategies expressed in Gold Creek.

We found juvenile steelhead outmigrants in Libby Creek up to rkm 5. Although we did not find any juvenile fish outmigrants that originated above rkm 5, a crew observed an adult steelhead at rkm 10 in 2005.

From PIT-tag detections, most adult steelhead that entered Beaver, Libby, and Gold creeks migrated past Wells Dam from September to October and then would hold somewhere between Wells Dam and tributaries during fall to early spring. In the spring, the adults moved into the tributaries and spawned. Rainbow trout/juvenile steelhead PIT tagging started in the summer of 2004. We expect to see our first fish PIT-tagged as a juvenile steelhead to be detected at the Columbia River dams in fall 2007 and at the tributary interrogation sites in spring 2008.

The rock vortex weir structures have successfully allowed upstream passage of adult and juvenile steelhead, adult and juvenile Chinook, juvenile coho, and mountain whitefish. Adult fish have moved from just below the diversion to over the diversion in less than an hour. Similarly, juvenile fish have moved past the diversion in less than ten hours at flows as low as 2.3 cfs. Much more data should be available for this analysis after the spring and early summer fish migration period.

Most fish diverted into the water canal should successfully pass through the water diversion. The five percent of unknown fish could have been due to predation in the diversion or from periods when interrogator malfunction created lost of operation during short time periods. Unfortunately, all three trials in 2005 had small gaps in the detection data. Additional trials were planned in 2006.

Future Research Efforts

While this report covers sampling efforts through spring 2006, additional and essentially replicate efforts will continue at least through fall 2007. These additional efforts will allow tracking the fish recolonization processes, which will be used to judge the effectiveness of and value of the modification of fish passage barriers.

Acknowledgements

Funding was provided by BOR. Dana Weigel, Greg Knott, and Michael Newsom of BOR helped with contracting and getting this project on the ground. Landowners who allowed us to maintain PIT-tag interrogation systems and weirs on their land included Vick Stokes, Gary Ott, and Carloyn Clancy. Michael Notaro coordinated land owner access and permitting for sites. Earl Prentice, Sandra Downing, and Bruce Jonasson of NMFS designed and installed the two PIT-tag interrogation systems. Brian Fisher, Wes Tibbits, Ben Lentz, Joe Martin, Nick Glaser, Russell Barabe, Adam StSaviour, and Michael Langhorn assisted with data collection, tagging, and downloading equipment. Steve Clayton and Denis Ruttenberg, University of Idaho, provided flow and reach break information.

Disclaimer

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Table 1. Passage barriers to upstream migration of fish in mainstem Beaver, Libby, and Gold creeks and their larger tributaries. The artificial barriers listed may or may not have been complete barriers. The list does not contain natural barriers upstream of the first one to be encountered by upstream migrating fish from the mouth, and it does not contain artificial barriers, such as culverts, that are upstream of natural barriers. Based on best available information at time of report.

Watershed Tributary	River mile	Barrier type[a]	Name of barrier	Height of barrier (ft)	Date removed	Nonadromous fish above barriers prior to 2000[b]
Beaver Creek	0.4	Culvert	Hwy 53	Unknown	Fall 2000	RBT, BLT, CTT, BRK, SCP, WHT, LND
	1.6	Concrete	Fort-Thurlow	6	Nov 2004	RBT, BLT, CTT, BRK, SCP, WHT
	2.8	Push-up	Lower Stokes	3	Sep 2003	RBT, BLT, CTT, BRK, SCP, WHT
	4.7	Push-up	Thurlow Transfer	3.5	Fall 2003	RBT, BLT, CTT, BRK, SCP
	5.3	Push-up	Upper Stokes	3	Fall 2003	RBT, BLT, CTT, BRK, SCP
	8.0	Push-up	Mirracci	1.5	Fall 2005	RBT, BLT, CTT, BRK, SCP
	8.0	Push-up	Baetty	3	Still there	RBT, BLT, CTT, BRK, SCP
	8.4	Push-up	Redshirt	4	Still there	RBT, BLT, CTT, BRK, SCP
	9.0	Culvert	FR 4225	2	Aug 2006	RBT, BLT, CTT, BRK, SCP
	13.7	Natural falls	(Unknown)	35	Still there	BRK
Blue Buck Cr.		(None)				BLT
Lightning Cr.	0.3	Natural falls	(Unknown)	(Unknown)	Still there	CTT, BRK
Middle Fork	1.0	Natural falls	(Unknown)	(Unknown)	Still there	BRK
South Fork		(None)				RBT, BRK
Frazer Creek		(None)				RBT, BRK
Libby Creek	0.8	Push-up	Libby-Peterson	3	Jun 2005	RBT, CTT (rarely BLT, BRK)
South Fork	4.0	Natural falls	(Unknown)	75	Still there	CTT
South Fork	1.0	Natural falls	(Unknown)	6	Still there	RBT
Gold Creek	0.8	Push-up	Campbell	(variable)	Jun 2005	RBT, BLT, CCT, SCP
	7.4	Gradient	(Unknown)	100	Still there	no fish
Crater Cr.	0.1	Natural falls	(Unknown)	70	Still there	RBT
Foggy Dew Cr.	4.3	Natural falls	(Unknown)	60	Still there	CTT
South Fork	3.8	Culvert	FR4330	4	Still there	RBT
	7.4	Natural falls	(Unknown)	20	Still there	(unknown)

[a] Push-up barriers may or may not be there year-round nor every year depending on landowner or water user efforts.
[b] RBT=rainbow trout, BLT=bull trout, CTT=cutthroat trout BRK=brook trout, SCP=sculpin, WHT=mountain whitefish, LND=longnose dace.

Table 2. Presence and absence of fish species sampled in the lower Methow tributaries by the U. S. Geological Survey during the 2004 and 2005 field season. Watersheds and streams are listed in an upstream to downstream pattern within a watershed. P = present, A = absent.

Watershed Reach or section	Distance upstream from mouth (km)	**Rainbow trout/ steelhead** *Oncorhynchus mykiss*	**Brook trout** *Salvelinus fontinalis*	**Cutthroat trout** *Oncorhynchus clarkii*	**Chinook salmon** *Oncorhynchus tschawytscha*	**Bull trout** *Salvelinus confluentus*	**Sculpin** *Cottus spp.*	Other species observed
Beaver Creek								
Blue Buck Creek		A	A	A	A	P	A	A
Beaver Creek - Reach 5	17.5	P	P	P	A	A	A	A
Lightning Creek		P	P	P	A	A	A	A
Beaver Creek - Reach 4	15.6	P	P	P[a]	A	P[a]	P	A
Middle Fork Beaver Creek		A	P	A	A	A	A	A
South Fork Beaver Creek		P	P	A	A	A	A	A
Beaver Creek - Reach 2b	12.8	P	P	A	A	A	P	A
Beaver Creek - Reach 2a	5.7	P	P	A	A	A	P	A
Frazer Creek		P	P	A	A	A	A	A
Beaver Creek - ab Diversion	4.6	P	P	A	P	A	P	A
Beaver Creek - bl. Diversion	1.3	P	P	A	P	P	P	P[b]
Libby Creek								
North Fork Libby Creek		P	P	P	A	A	A	A
South Fork Libby Creek		P	A	P	A	A	A	A
Libby Creek - Reach 5	10.0	P	P[a]	P	A	P[a]	A	A
Libby Creek - Reach 3	7.2	P	A	P[a]	A	A	A	A
Libby Creek - Reach 1 ab. Diversion	2.6	P	A	P	P[a]	A	A	A
Gold Creek								
Crater Creek		P	A	P	A	P	A	A
Gold Creek - Reach 4-5	8.9	P	A	P	A	P	P	A
Foggy Dew		P	A	P	A	P	P	A
Gold Creek - Reach 3	7.4	P	A	A	A	P	P	A
Middle Fork Gold Creek		P	P	A	A	A	A	A
Gold Creek - Reach 2	4.4	P	A	A	P	A	P	A
South Fork Gold Creek		P	A	A	A	A	P	A
Gold Creek - Reach 1	0.2	P	A	A	A	A	P	A

[a] Only one individual was observed during surveys at this site.
[b] Coho salmon, longnose dace, mountain whitefish, bridgelip sucker.

Table 3. Total number of salmonids that were captured and PIT-tagged in the Methow River subbasin 2004-2005. Watersheds and streams are listed in an upstream to downstream pattern within a watershed. RBT/STH=Rainbow trout/juvenile steelhead, CHN=Chinook, BRK=Brook trout, BLT= bull trout, CTT= westslope cutthroat trout, and COH=coho.

Watershed	River	RBT/STH		CHN		BRK		BLT		CTT		COH	
Stream reach or section	Kilometer	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Beaver Creek													
Blue Buck Creek	3.3	0	0	0	0	0	0	0	9	0	0	0	0
Beaver Creek - Reach 5	17.5	0	49	0	0	0	13	0	0	0	0	0	0
Lightning Creek	0.2	0	2	0	0	13	21	0	0	1	3	0	0
Beaver Creek - Reach 4	15.6	103	88	0	0	17	22	0	1	0	1	0	0
Beaver Creek - Reach 3	14.1	263	89	0	0	10	8	0	0	0	0	0	0
South Fork Beaver - Reach 2	8.7	0	3	0	0	0	28	0	0	0	0	0	0
Middle Fork Beaver Creek	4.9	0	0	0	0	18	13	0	0	0	0	0	0
South Fork Beaver - Reach 1	0.9	56	15	0	0	12	8	0	0	0	0	0	0
Beaver Creek - Reach 2	12.8	254	197	0	0	11	15	0	0	0	0	0	0
Frazer Creek	4.5	0	18	0	0	0	14	0	0	0	0	0	0
Beaver Creek - Reach 1 ab. Diversion	4.6	265	387	0	0	10	26	0	0	0	0	0	0
Beaver Creek - Reach 1 bl. Diversion	1.3	105	37	42	0	1	0	0	0	0	0	0	0
Beaver Creek Weir	1.3	94	1,275[a]	31	192	1	27	1	2	0	0	0	16
Beaver Creek Subtotal		**1,140**	**2,160**	**73**	**192**	**112**	**200**	**1**	**12**	**1**	**4**	**0**	**16**
Libby Creek													
South Fork Libby Creek	2.1	0	43	0	0	0	0	0	0	0	33	0	0
North Fork Libby Creek	0.8	3	6	0	0	9	1	0	0	17	23	0	0
Libby Creek - Reach 5	10.0	56	212	0	0	0	0	0	1	0	5	0	0
Libby Creek - Reach 3	7.2	84	53	0	0	0	0	0	0	1	1	0	0
Libby Creek - Reach 1 av. Diversion	2.6	408	328	1	0	0	0	0	0	0	2	0	0
Libby Creek - Reach 1 bl. Diversion	0.2	24	0	1	0	0	0	0	0	0	0	0	0
Libby Creek Subtotal		**575**	**642**	**2**	**0**	**9**	**1**	**0**	**1**	**18**	**64**	**0**	**0**
Gold Creek													
Gold Creek - Reach 5	10.9	0	14	0	0	0	0	0	0	0	0	0	0
Crater Creek	3.0	5	52	0	0	0	0	0	11	0	18	0	0
Gold Creek - Reach 4	8.4	148	180	0	0	0	0	1	4	3	0	0	0
Foggy Dew Creek	0.7	149	147	0	0	0	0	7	39	13	36	0	0
Gold Creek - Reach 3	7.4	0	55	0	0	0	0	0	2	0	0	0	0
Middle Fork Gold Creek	1.8	0	29	0	0	0	9	0	0	0	0	0	0
Gold Creek - Reach 2	4.4	0	84	0	2	0	0	0	0	0	0	0	0
South Fork Gold - Reach 2	9.3	132	58	0	0	0	0	0	0	0	0	0	0
South Fork Gold - Reach 1	4.2	101	156	0	0	0	0	0	0	0	0	0	0
Gold Creek - Reach 1 bl. Diversion	0.2	20	29	2	0	0	0	0	0	0	0	0	0
Gold Creek Subtotal		**555**	**804**	**2**	**2**	**0**	**9**	**8**	**56**	**16**	**54**	**0**	**0**
Grand Total		2,270	3,606	77	194	121	210	9	69	35	122	0	16

[a] Includes 27 adult steelhead.

Table 4. Species and number of fish collected at a two-way fish trapping weir located at rkm 1 in Beaver Creek, September 2004 to November 2006.

	Total number of individual fish captured		
Beaver Creek trap	2004	2005	2006
Number of days operated:	60	253	220
Rainbow trout/juvenile steelhead	46	1,423	567
Trout –juvenile, <80 mm	52	199	2
Steelhead - adult	0	31	26
Cutthroat trout	0	0	4
Chinook - juvenile	32	222	188
Chinook - adult	0	0	4
Coho - juvenile	0	18	26
Bull trout	1	2	3
Brook trout	1	42	118
Sculpin	1	13	0
Bridgelip sucker	0	10	16
Longnosed dace	0	4	25
Mountain whitefish	0	1	1
Total	133	1,965	980

Table 5. The number of days between interrogation for upstream moving adult steelhead at one or more Columbia River dams before their first interrogation in a tributary of the Lower Methow River subwatershed. The dam codes are: BON = Bonneville Dam, MCN = McNary Dam, PRA = Priest Rapids Dam, RIS = Rock Island Dam, RRE = Rocky Reach Dam, WEL = Wells Dam.

		Detection at dams (rkm)					
Tributary	Type of information	BON (234)	MCN (470)	PRA (639)	RIS (730)	RRE (763)	WEL (830)
Beaver Creek							
	No. of fish	4	3	4	4	0	3
	Mean (d)	231	201	184	180	--	174
	Median (d)	236	196	188	184	--	177
	Range (d)	205-246	190-218	148-213	145-208	--	139-206
Libby Creek							
	No. of fish	9	9	8	6	0	9
	Mean (d)	276	261	252	238	--	204
	Median (d)	270	253	246	235	--	209
	Range (d)	236-334	229-327	223-318	216-262	--	4-273
Gold Creek							
	No. of fish	18	18	16	14	1	17
	Mean (d)	259	237	228	214	104	193
	Median (d)	262	240	234	220	--	203
	Range (d)	122-303	116-295	108-288	105-282	--	36-277

Table 6. Number of days for juvenile steelhead emigrating from Beaver Creek to be recaptured or interrogated at one or more sites in the Methow and Columbia rivers as of 22 January 2007. The detections site codes are: MR = Methow River screw trap, RRE = Rocky Reach Dam, RIS = Rock Island Dam, MCN = McNary Dam, JDA = John Day Dam, BON = Bonneville Dam, TWX = Estuary Trawl.

			Detection Sites (Rkm)						
Season	Months		MR (843.003)	RRE (763)	RIS (730)	MCN (470)	JDA (347)	BON (234)	TWX (40)
Spring	March-May	No. of fish	4	3	4	30	20	5	2
		Mean (d)	15	139	131	45	61	94	191
		Median (d)	4	62	55	21	19	23	--
		Range (d)	1-51	3-353	24-390	9-352	12-402	17-362	18-363
Summer	June-August	No. of fish	0	0	2	1	1	1	0
		Mean (d)	--	--	333	319	345	336	--
		Median (d)	--	--	--	--	--	--	--
		Range (d)	--	--	317-350	--	--	--	--
Fall	September-November	No. of fish	2	1	4	7	23	11	0
		Mean (d)	169	189	205	208	211	205	--
		Median (d)	--	--	203	213	200	202	--
		Range (d)	160-178	--	188-225	184-243	177-251	182-236	--
Winter	December-February	No. of fish	0	1	0	2	1	0	0
		Mean (d)	--	174	--	142	524	--	--
		Median (d)	--	--	--	--	--	--	--
		Range (d)	--	--	--	135-149	--	--	--

Table 7. Number of days for juvenile Chinook emigrating from Beaver Creek to be recaptured or interrogated at one or more sites in the Methow and Columbia rivers as of 22 January 2007. The detections site codes are: MR = Methow River screw trap, RRE = Rocky Reach Dam, RIS = Rock Island Dam, MCN = McNary Dam, JDA = John Day Dam, BON = Bonneville Dam, TWX = Estuary Trawl.

			Detection Sites (rkm)						
Season	Months		MR (843.003)	RRE (763)	RIS (730)	MCN (470)	JDA (347)	BON (234)	TWX (40)
Spring	March-May	No. of fish	0	0	0	2	0	0	0
		Mean (d)	--	--	--	26	--	--	--
		Median (d)	--	--	--	--	--	--	--
		Range (d)	--	--	--	19-36	--	--	--
Summer	June-August	No. of fish	0	0	0	0	0	1	0
		Mean (d)	--	--	--	--	--	299	--
		Median (d)	--	--	--	--	--	--	--
		Range (d)	--	--	--	--	--	--	--
Fall	September-November	No. of fish	0	2	1	10	6	8	1
		Mean (d)	--	175	171	197	195	192	190
		Median (d)	--	--	--	194	189	189	--
		Range (d)	--	155-196	--	168-231	167-247	176-221	--
Winter	December-February	No. of fish	1	2	1	2	2	2	2
		Mean (d)	132	155	162	168	163	165	168
		Median (d)	--	--	--	--	--	--	--
		Range (d)	--	146-165	--	156-180	160-165	163-167	165-171

Table 8. Number of days for juvenile steelhead emigrating from Gold Creek to be recaptured or interrogated at one or more sites in the Methow and Columbia rivers as of 22 January 2007. The detections site codes are: MR = Methow River screw trap, RRE = Rocky Reach Dam, RIS = Rock Island Dam, MCN = McNary Dam, JDA = John Day Dam, BON = Bonneville Dam, TWX = Estuary Trawl. Caution Large PIT-tag detector was installed in the winter of 2005, after fall emigration.

			Detection Sites (rkm)						
Season	Months		MR (843.003)	RRE (763)	RIS (730)	MCN (470)	JDA (347)	BON (234)	TWX (40)
Spring	March-May	No. of fish	1	0	2	4	5	1	1
		Mean (d)	1	--	32	28	31	13	32
		Median (d)	--	--	--	28	29	--	--
		Range (d)	--	--	20-43	21-36	24-41	--	--
Summer	June-August	No. of fish	0	0	0	0	0	0	0
		Mean (d)	--	--	--	--	--	--	--
		Median (d)	--	--	--	--	--	--	--
		Range (d)	--	--	--	--	--	--	--
Fall	September-November	No. of fish	0	0	0	0	0	0	0
		Mean (d)	--	--	--	--	--	--	--
		Median (d)	--	--	--	--	--	--	--
		Range (d)	--	--	--	--	--	--	--
Winter	December-February	No. of fish	0	0	0	0	0	0	--
		Mean (d)	--	--	--	--	--	--	--
		Median (d)	--	--	--	--	--	--	--
		Range (d)	--	--	--	--	--	--	--

Table 9. Hatchery steelhead detected at one or more of ten PIT-tag interrogation sites in Beaver, Libby, and Gold creeks in the Methow River watershed. Species: STH=steelhead. Location: TwispR= Twisp River @rkm 18, ChewuR=Chewuch River, Twis2P=Twisp River @rkm 2, WINT=Winthrop Fish Hatchery, WELH=Wells Hatchery, METHR=Methow River, CHIWAR=Chiwawa River, RINH=Ringold Hachery, WENATR=Wenatchee River, NASONC=Nason Creek. Hatchery: WELH=Wells Hatchery, WINT=Winthrop Hatchery, EBNK=Eastbank Hatchery, RINH=Ringold Hatchery. Site Encountered: A6=Lower Beaver Creek Interrogator, B0=Large Beaver Creek Interrogator, C2=Middle Libby Creek interrogator, C4=Lower Libby Creek interrogator, D6=South Fork Gold Interrogator, E0=Large Gold Creek Interrogator, D6=South Fork Gold Interrogator.

Hatchery steelhead at release						Hatchery steelhead at Methow PIT tag detectors					
Species	Length (mm)	Location	Hatchery	RKM	Date	Watershed	Lifestage	Sites encountered	RKM	First detection	Last detection
STH	120	TwispR	WELH	843.066.018	5/1/2003	Beaver	Adult	A6-B0-A6	843.057.005	4/7/2005	4/25/2005
STH	91	TwispR	WELH	843.066.018	5/2/2003	Beaver	Adult	A6	843.057.001	4/7/2005	4/18/2005
STH	83	ChewuR	WELH	843.080.026	4/26/2004	Beaver	Adult	A6	843.057.001	4/2/2006	4/26/2006
STH	75	TwispR	WELH	843.066.018	5/7/2004	Beaver	Juv	A6	843.057.001	2/2/2005	3/21/2005
STH	99	WINT	WINT	843.081	4/22/2005	Beaver	Juv	A6	843.057.001	5/5/2005	
STH	90	WINT	WINT	843.081	4/22/2005	Beaver	Juv	A6	843.057.001	5/6/2005	6/20/2005
STH	84	WINT	WINT	843.081	4/22/2005	Beaver	Juv	A6	843.057.001	5/13/2005	5/17/2005
STH	79	WINT	WINT	843.081	4/22/2005	Beaver	Juv	B0	843.057.005	6/13/2005	
STH	90	WINT	WINT	843.081	4/22/2005	Beaver	Juv	A6	843.057.001	10/18/2005	
STH	110	Twis2P	WELH	843.066.002	6/2/2005	Beaver	Juv	A6-B0	843.057.005	4/26/2006	4/28/2006
STH	96	WELH	WELH	830	4/15/2003	Gold	Adult	E0	843.035.001	4/22/2006	
STH	103	WELH	WELH	830	4/15/2003	Gold	Adult	E0	843.035.001	4/22/2006	
STH	104	METHR	WELH	843.104	4/25/2003	Gold	Adult	E0	843.035.001	4/23/2006	
STH	--	CHIWAR	EBNK	754.077.013	4/29/2003	Gold	Adult	E0	843.035.001	4/9/2006	4/17/2006
STH	98	TwispR	WELH	843.066.018	5/2/2003	Gold	Adult	E0	843.035.001	3/31/2006	
STH	--	TwispR	WELH	843.066.018	5/2/2003	Gold	Adult	E0	843.035.001	4/6/2006	
STH	122	TwispR	WELH	843.066.018	5/6/2003	Gold	Adult	E0	843.035.001	4/20/2006	
STH	116	TwispR	WELH	843.066.018	5/8/2003	Gold	Adult	D6	843.035.002.002	5/5/2005	
STH	112	Twis2P	WELH	843.066.002	5/12/2003	Gold	Adult	E0	843.035.001	3/26/2006	
STH	90	RINH	RINH	567	4/12/2004	Gold	Adult	E0	843.035.001	4/7/2006	

Continued.

Table 9. Continued.

Hatchery steelhead at release						Hatchery steelhead at Methow PIT tag detectors					
Species	Length (mm)	Location	Hatchery	RKM	Date	Watershed	Lifestage	Sites encountered	RKM	First detection	Last detection
STH	92	METHR	WELH	843	4/21/2004	Gold	Adult	E0-D6	843.035.002.002	4/22/2006	5/3/2006
STH	104	WENATR	EBNK	754.052	5/5/2005	Gold	Adult	E0	843.035.001	4/24/2006	
STH	97	WINT	WINT	843.081	4/22/2005	Gold	Juv	E0	843.035.001	4/3/2006	
STH	82	TwspR	WELH	843.066.018	5/10/2005	Gold	Juv	E0	843.035.001	4/3/2006	
STH	94	WELH	WELH	830	4/15/2003	Libby	Adult	C4	843.042.001	5/1/2006	
STH	103	WELH	WELH	830	4/15/2003	Libby	Adult	C4	843.042.001	4/26/2006	
STH	--	NASONC	EBNK	754.089.012	4/30/2003	Libby	Adult	C4	843.042.001	4/27/2006	
STH	--	NASONC	EBNK	754.089.012	4/30/2003	Libby	Adult	C2	843.042.002	6/9/2005	
STH	122	TwispR	WELH	843.066.018	5/1/2003	Libby	Adult	C4	843.042.001	4/26/2006	
STH	92	METHR	WELH	843.104	4/28/2004	Libby	Adult	C2-C4	843.042.002	4/8/2006	4/20/2006
STH	85	METHR	WELH	843.104	4/21/2005	Libby	Adult	C2	843.042.002	6/8/2005	
STH	82	WINT	WINT	843.081	4/22/2005	Libby	Juv	C4	843.042.001	10/23/2005	

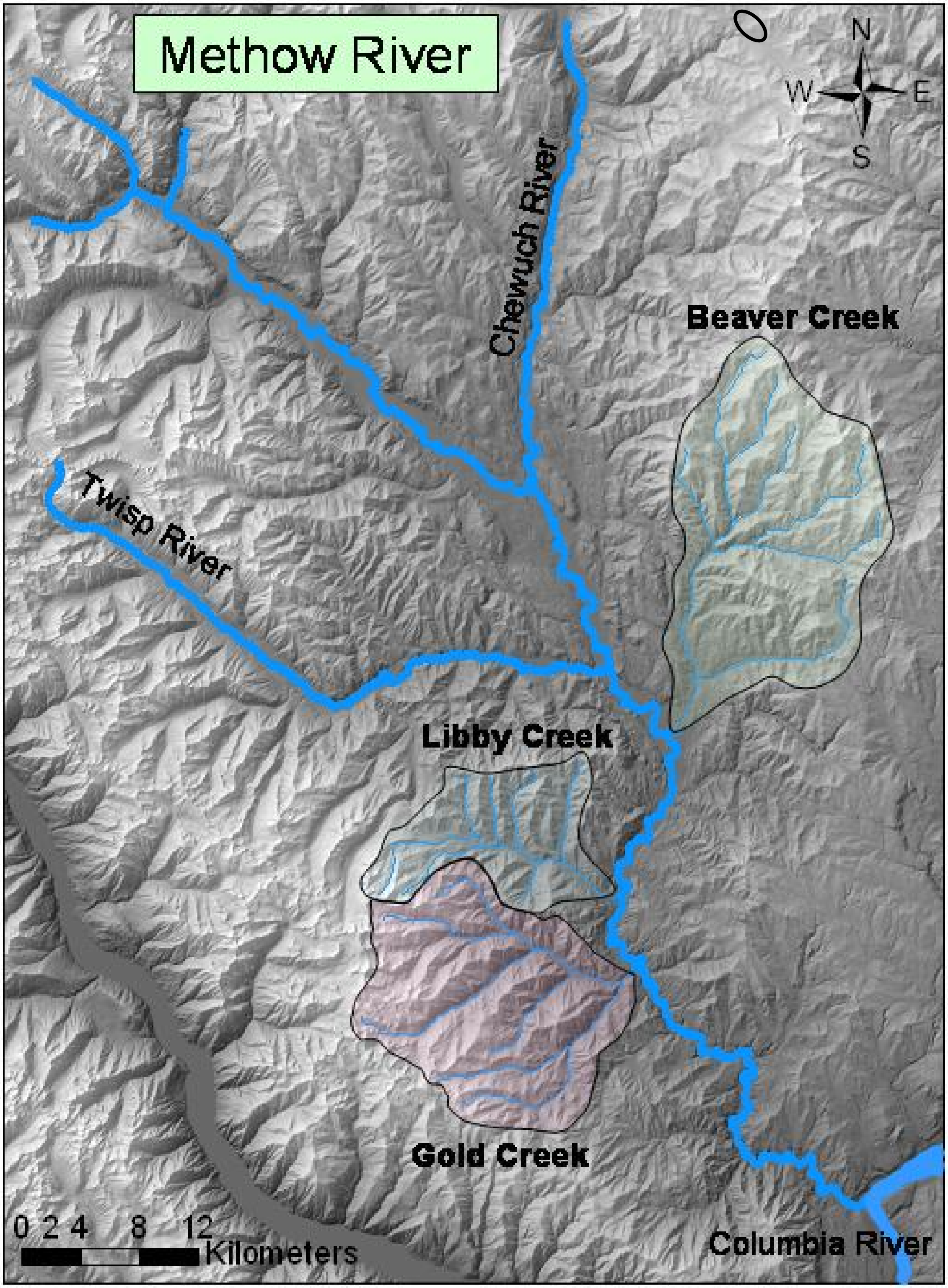


Figure 1. Map of the Methow River with Beaver Creek, Libby Creek, and Gold Creek watersheds outlined.

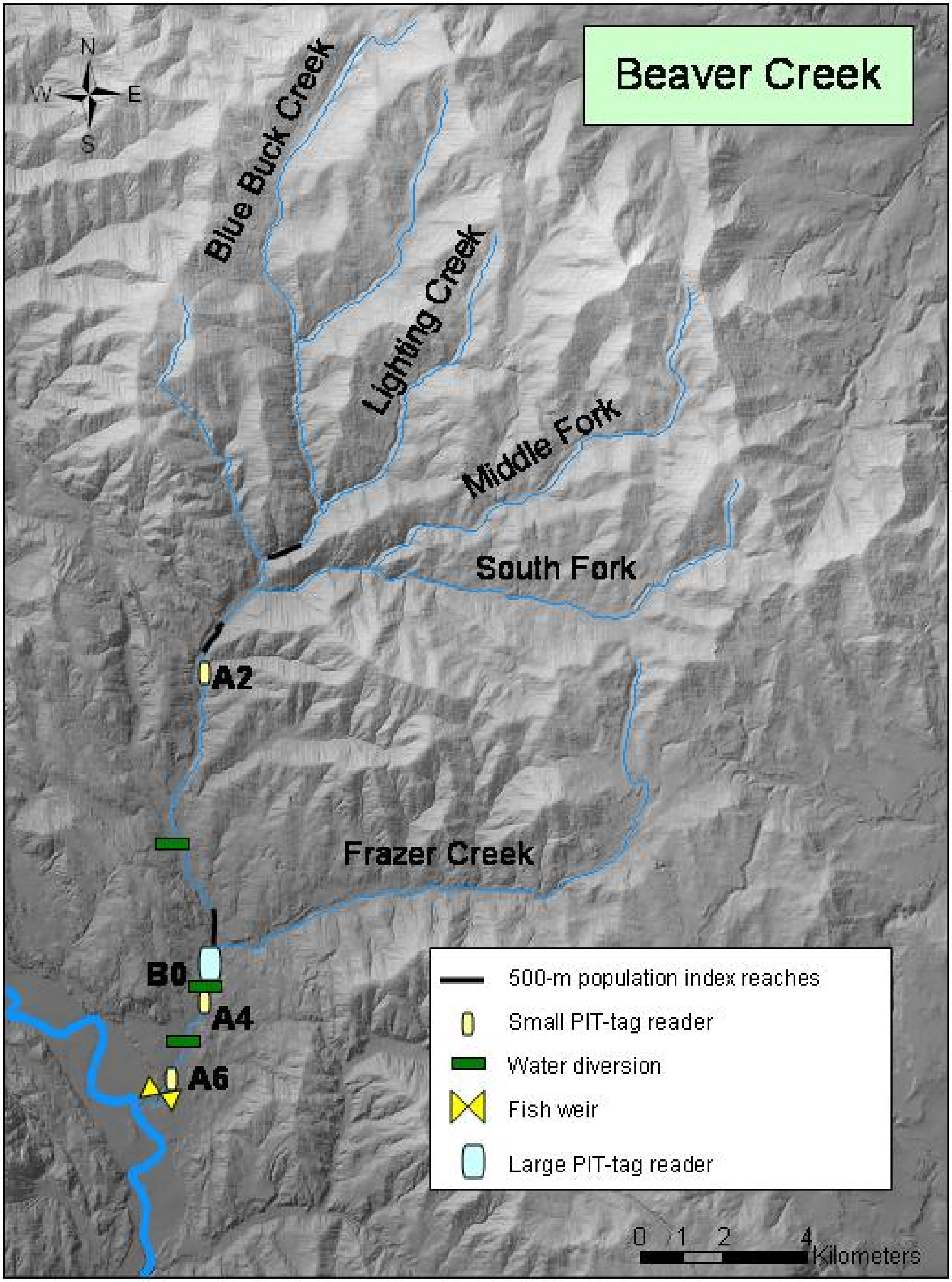


Figure 2. Sites for locations of PIT-tag interrogators, fish trap, and 500-m population electrofishing surveys in Beaver Creek. A2=Upper Beaver Creek small interrogator, B0=R1 large interrogator, A4=R1 small interrogator, and A6=Lower Beaver Creek small interrogator

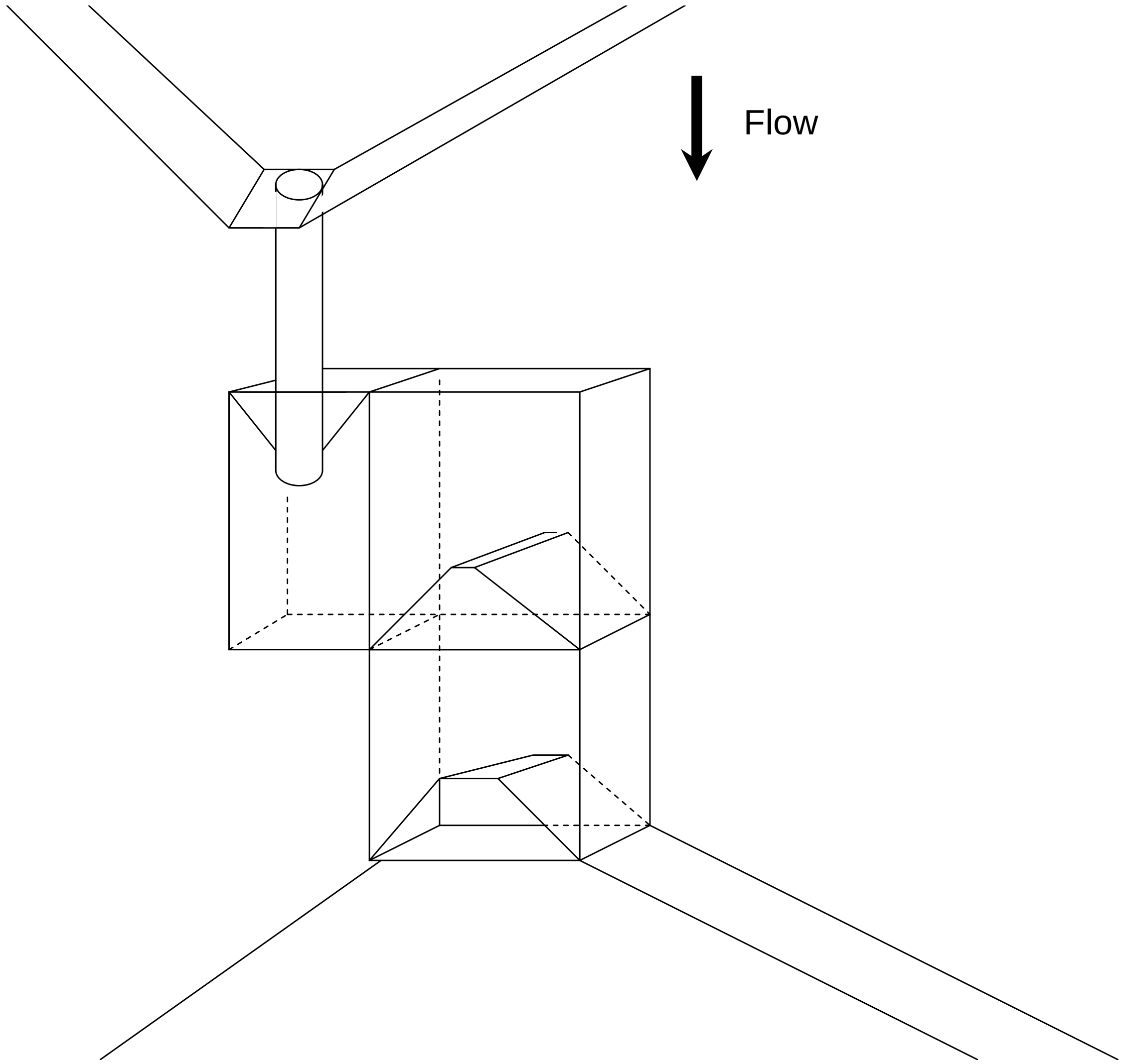


Figure 3. Diagram of the two-way, multi-life stage fish collection trap with picket-style weir installed in Beaver Creek (rkm 1).

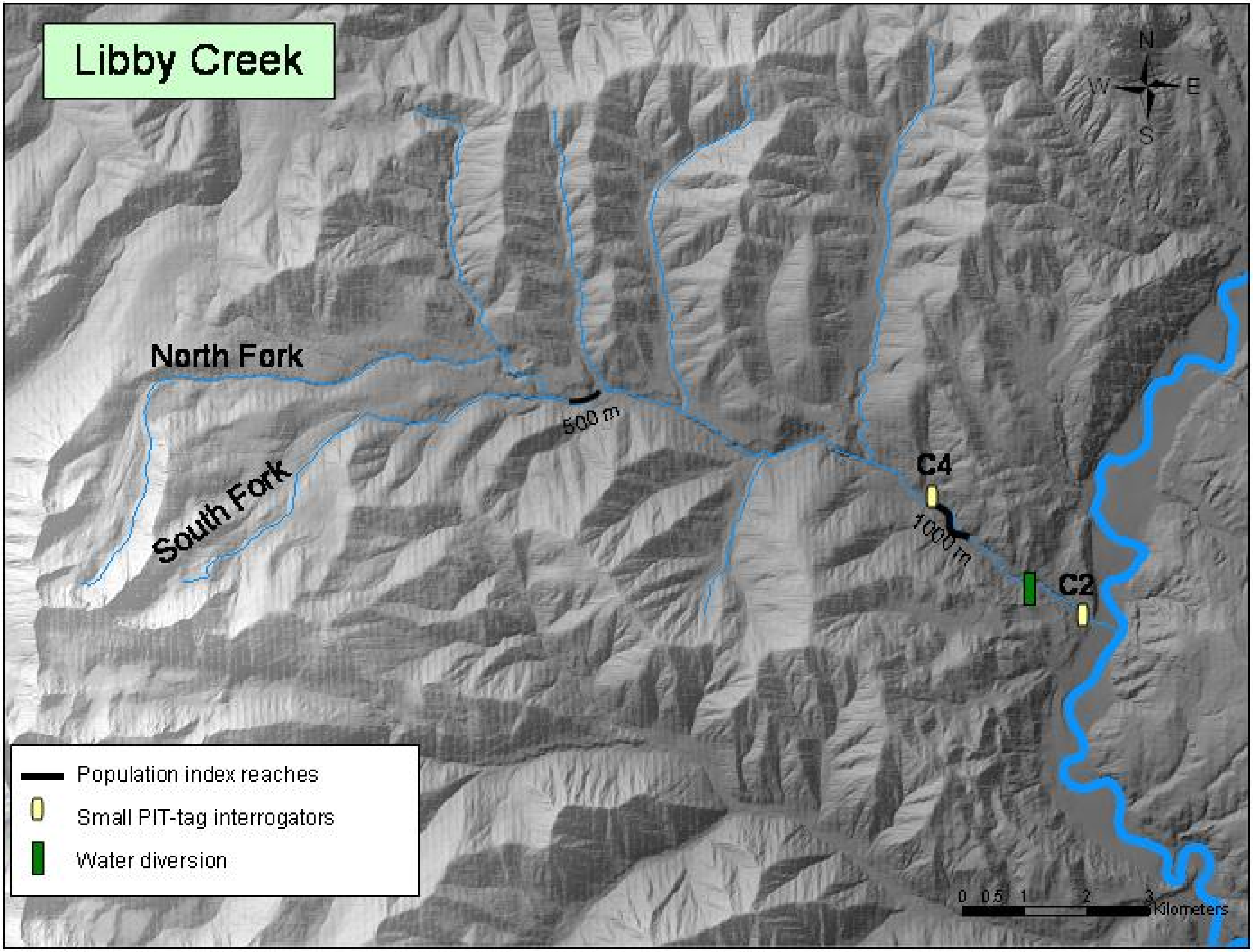


Figure 4. Locations of PIT-tag interrogators and population electrofishing surveys in Libby Creek. C4=Middle Libby Creek small interrogators and C2=Lower Libby Creek small interrogators

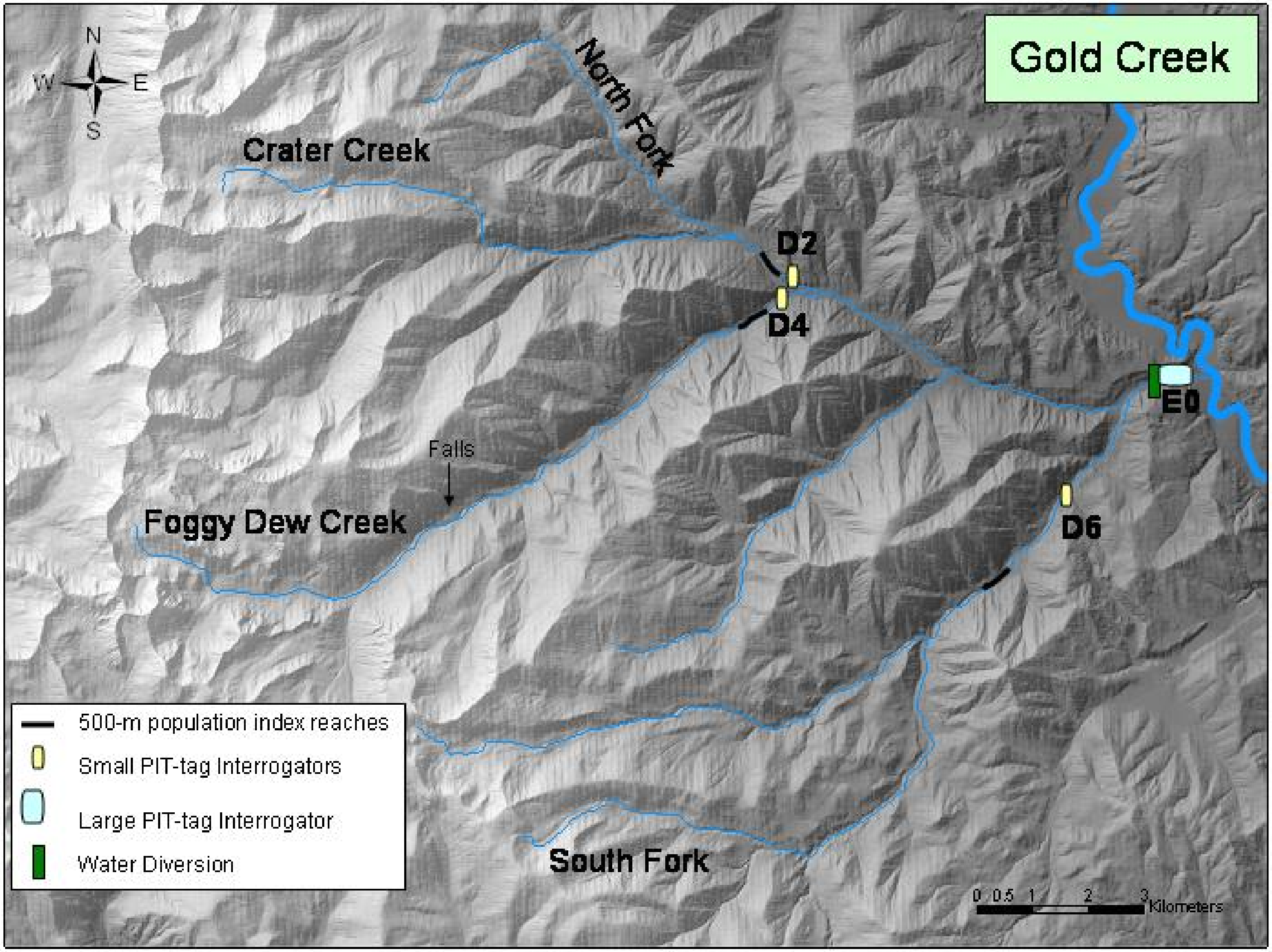


Figure 5. Locations of PIT-tag interrogators and 500-m sites for population electrofishing surveys in Gold Creek. D2=Upper Gold Creek small interrogator, D4=Foggy Dew Creek small interrogators, D6=South Fork Gold Creek small interrogator, and E0=Lower Gold Creek large interrogator

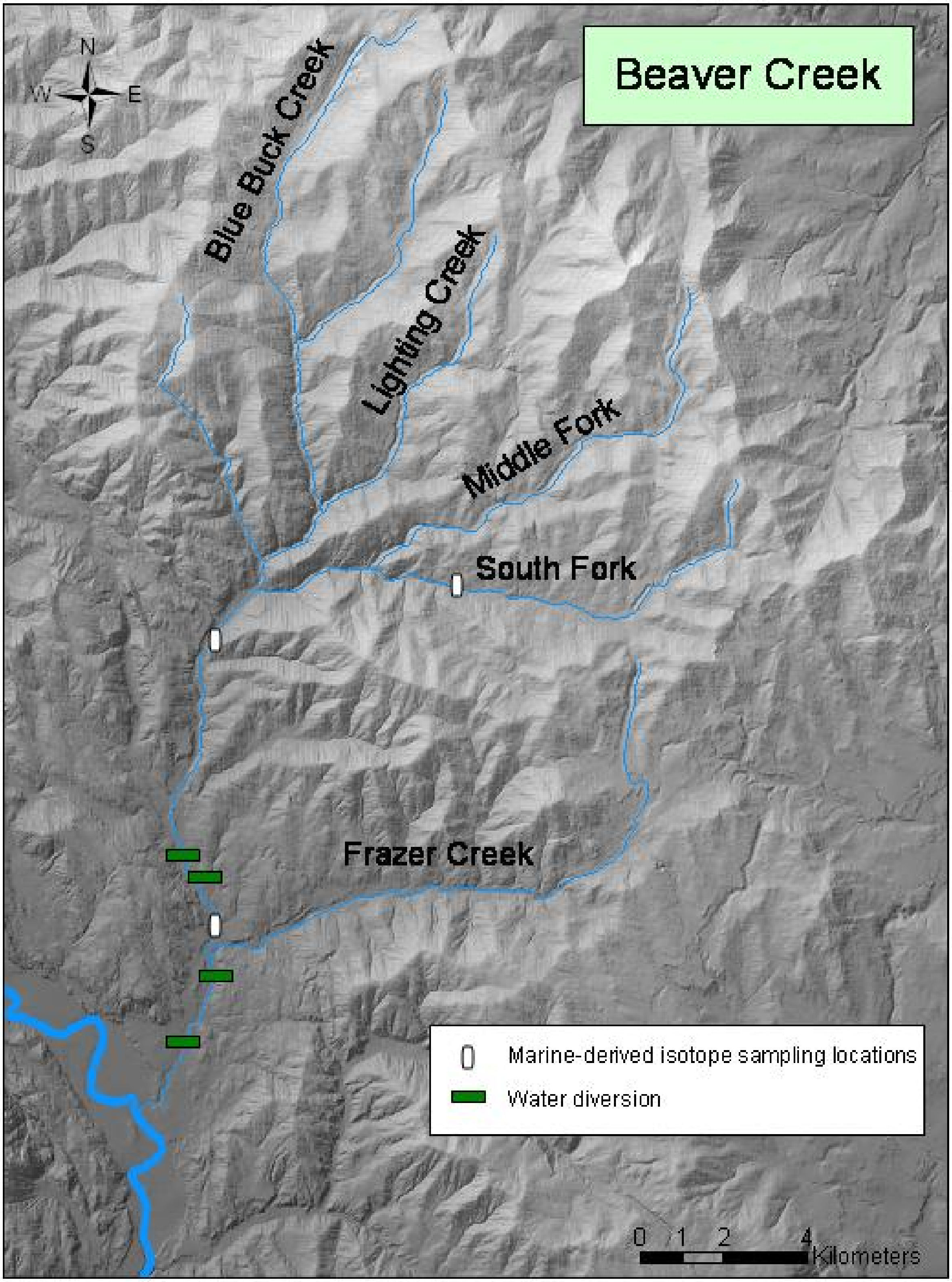


Figure 6. Locations of isotope sampling locations in Beaver Creek.

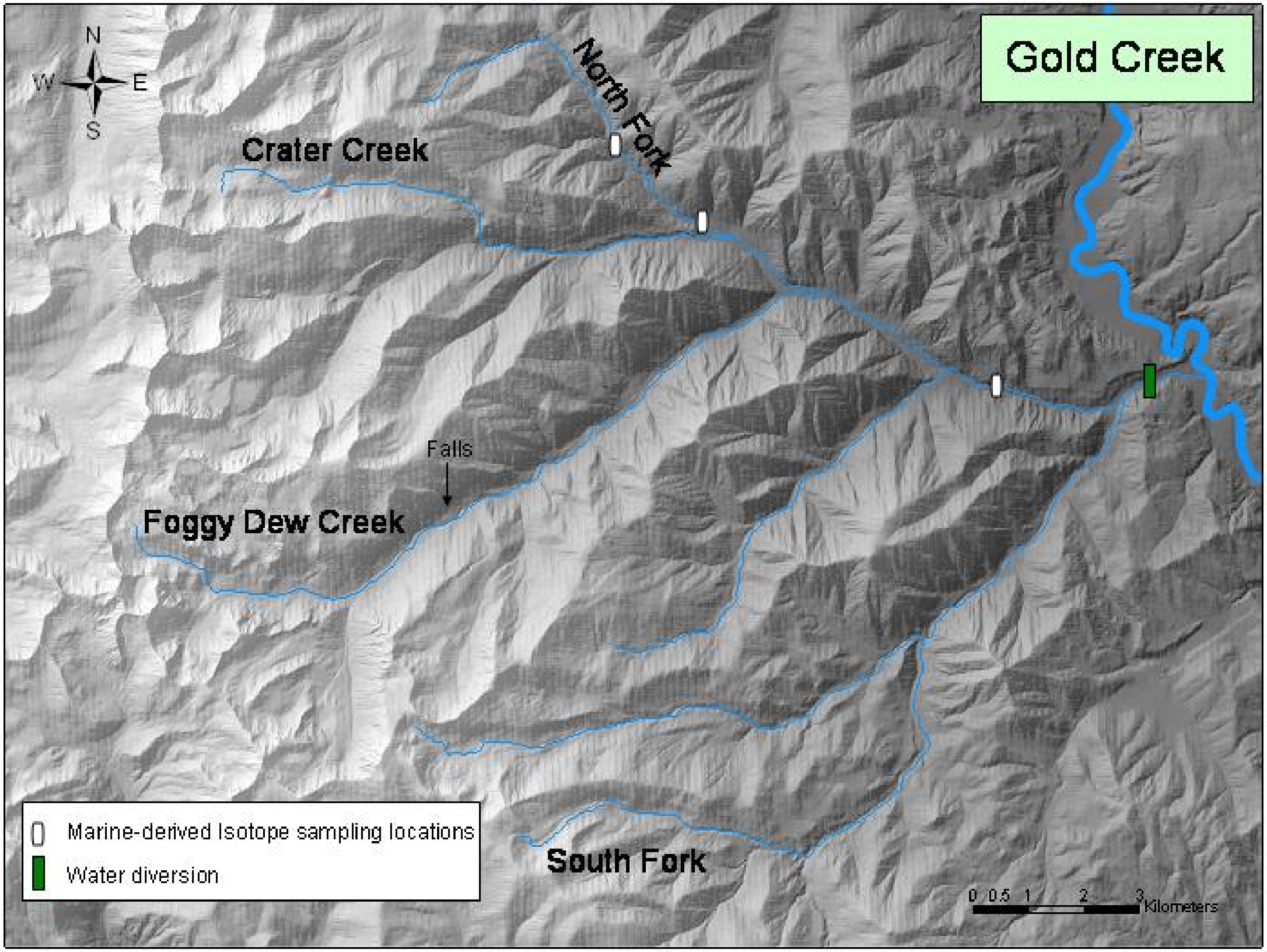


Figure 7. Locations of isotope sampling locations in Gold Creek.

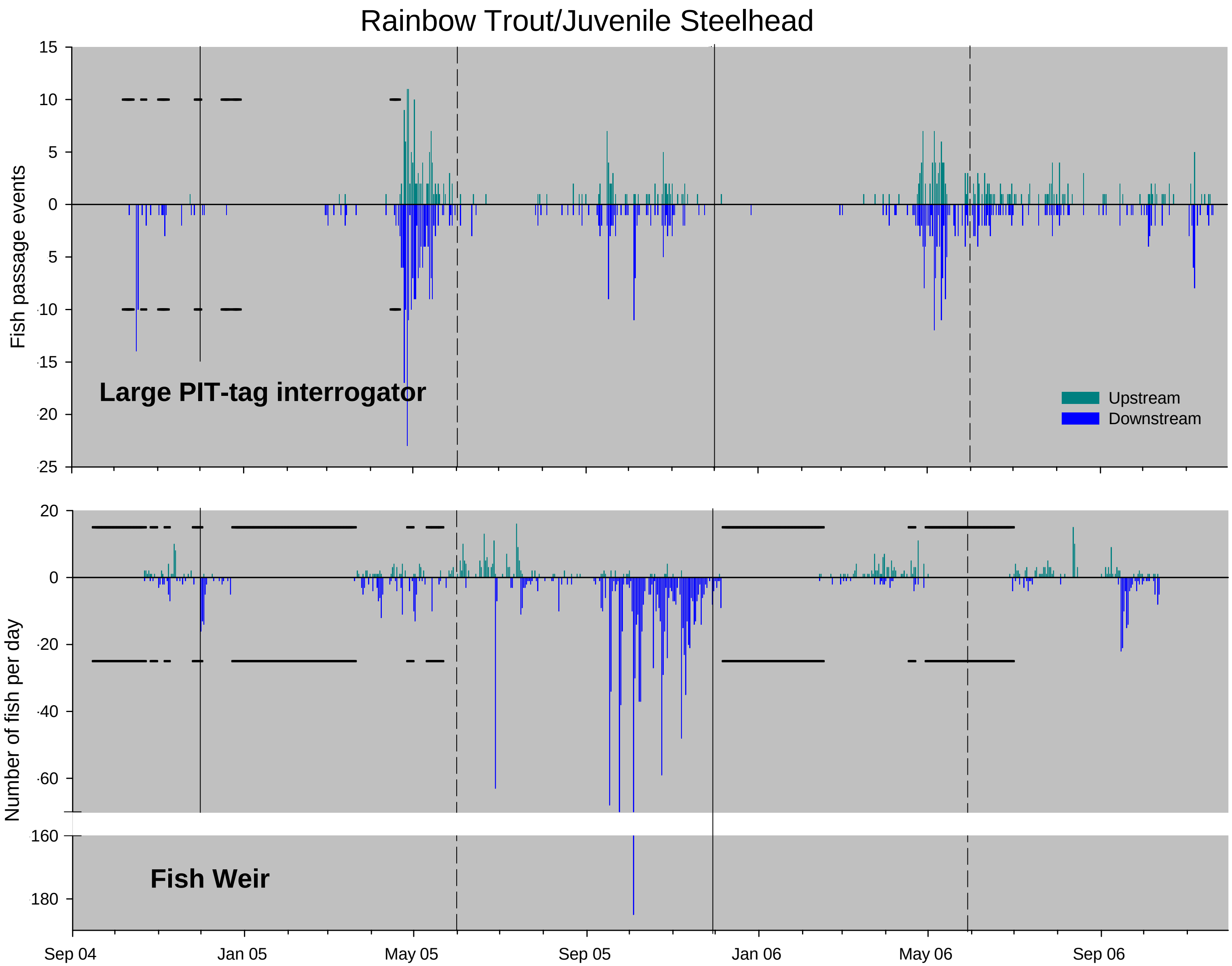


Figure 8. Rainbow trout/juvenile steelhead collected at two-way fish trap in Beaver Creek, fall 2004 to 2006. The black dashes (▬) indicate days when the fish trap or PIT-tag interrogator was not operating.

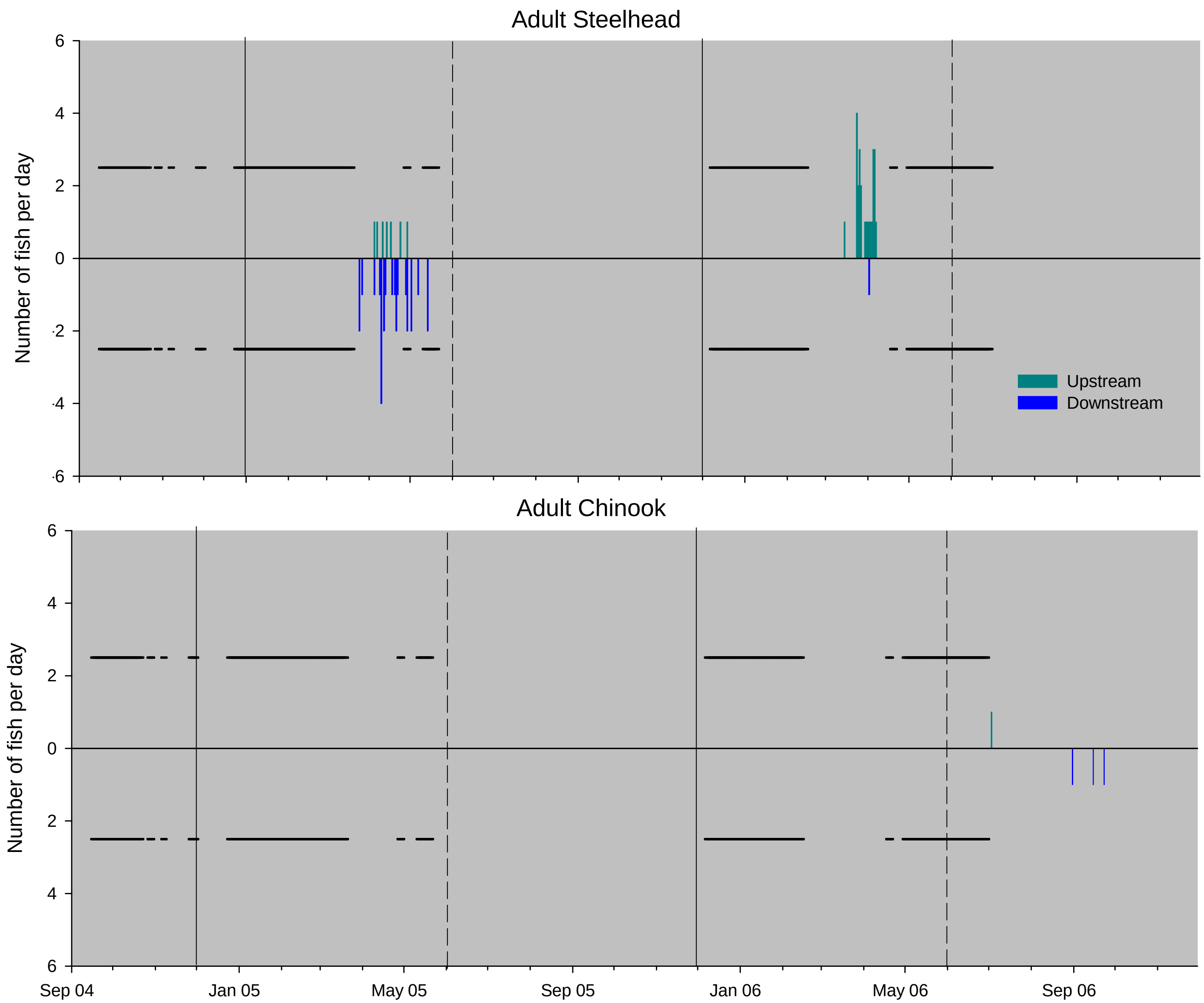


Figure 9. Adult steelhead and adult Chinook collected at two-way fish trap in Beaver Creek, fall 2004 to 2006. The black dashes (▬) indicate days when the fish weir was not operating.

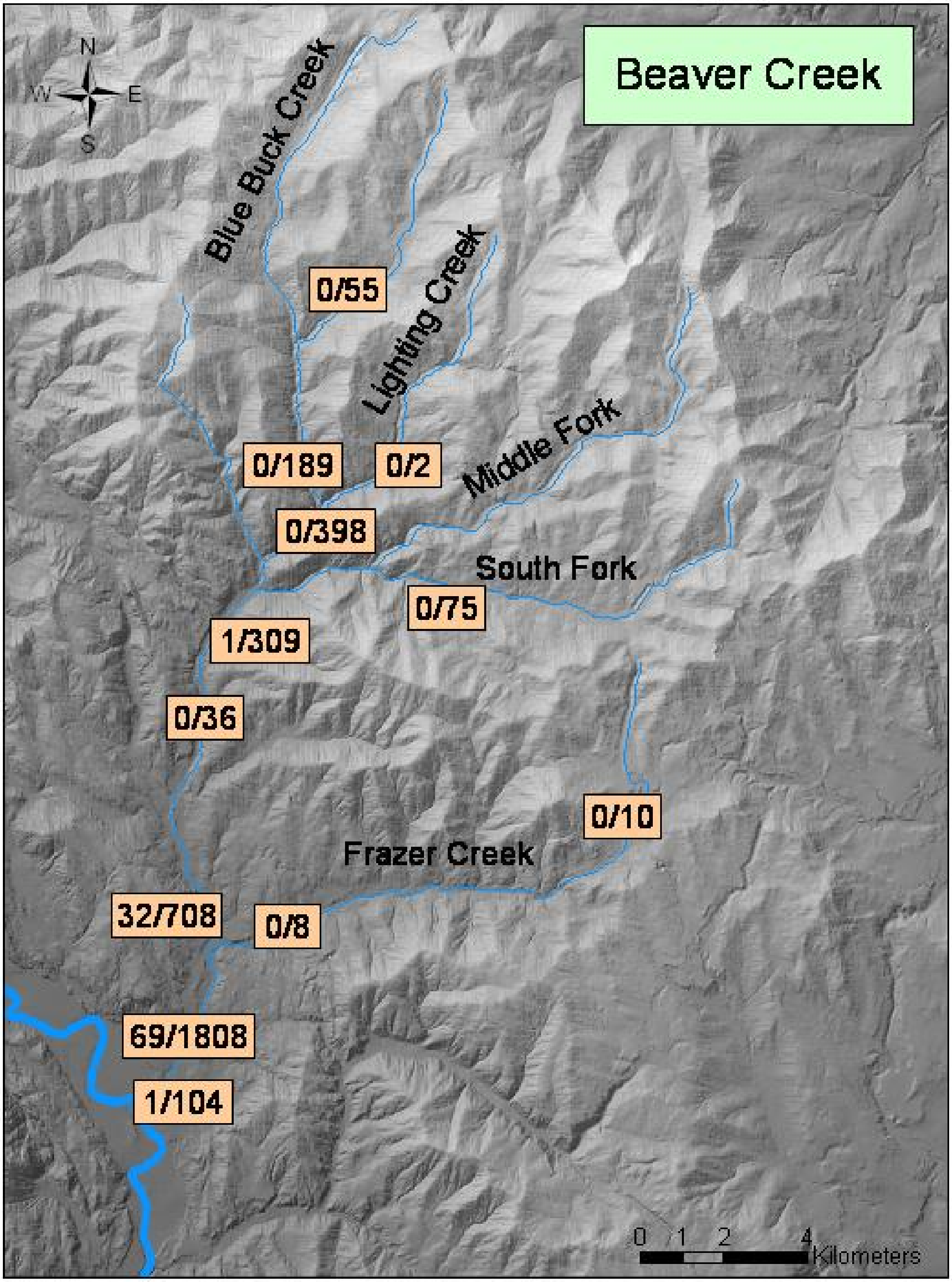


Figure 10. Rainbow trout/juvenile steelhead tagged and released in Beaver Creek from 2004 into 2006, and the number of fish detected in the mainstem Methow River or a PIT-tag interrogation site in the Columbia River.

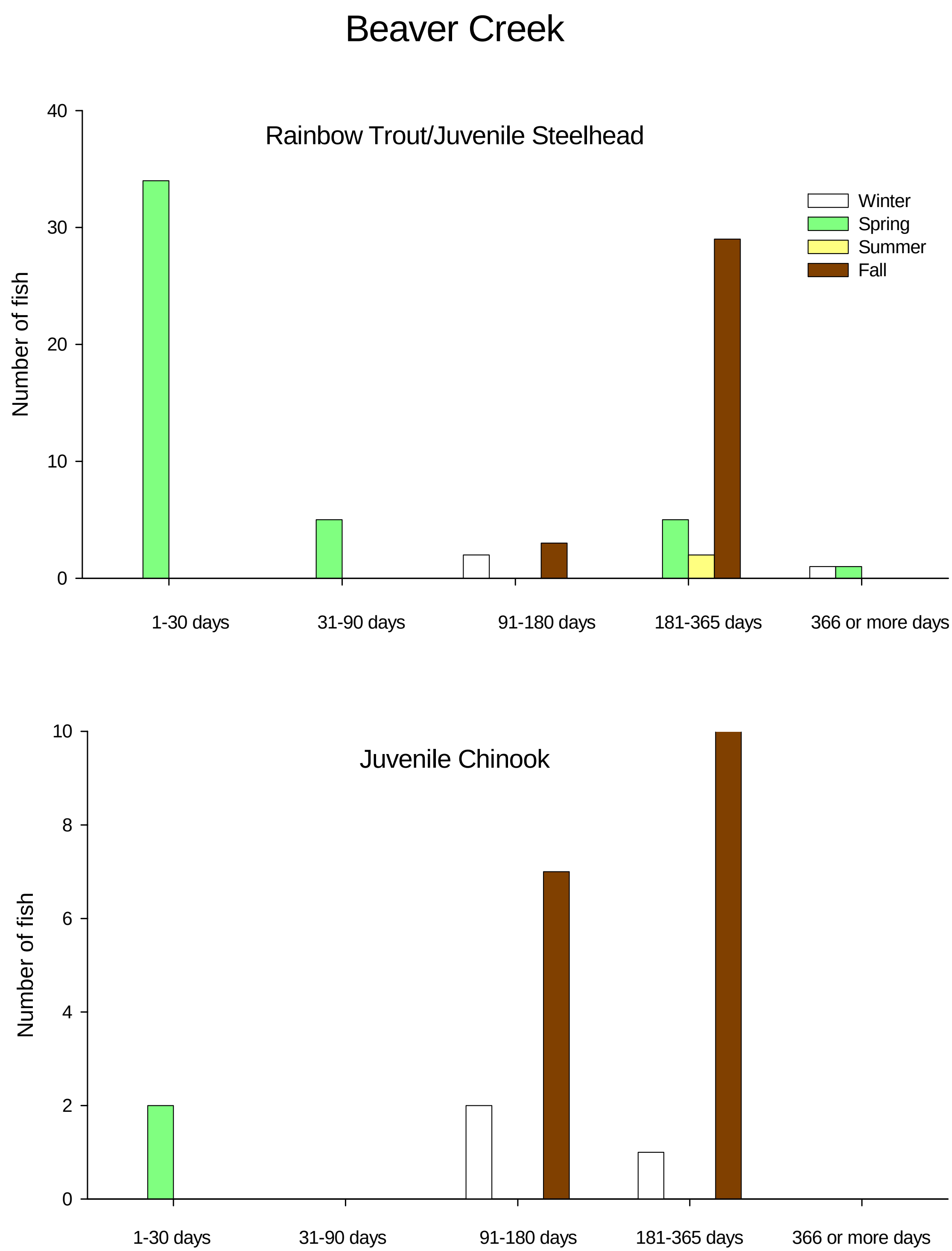


Figure 11. The number of days between the migration of rainbow trout/juvenile steelhead and juvenile Chinook from Beaver Creek and the first detection in the Columbia River.

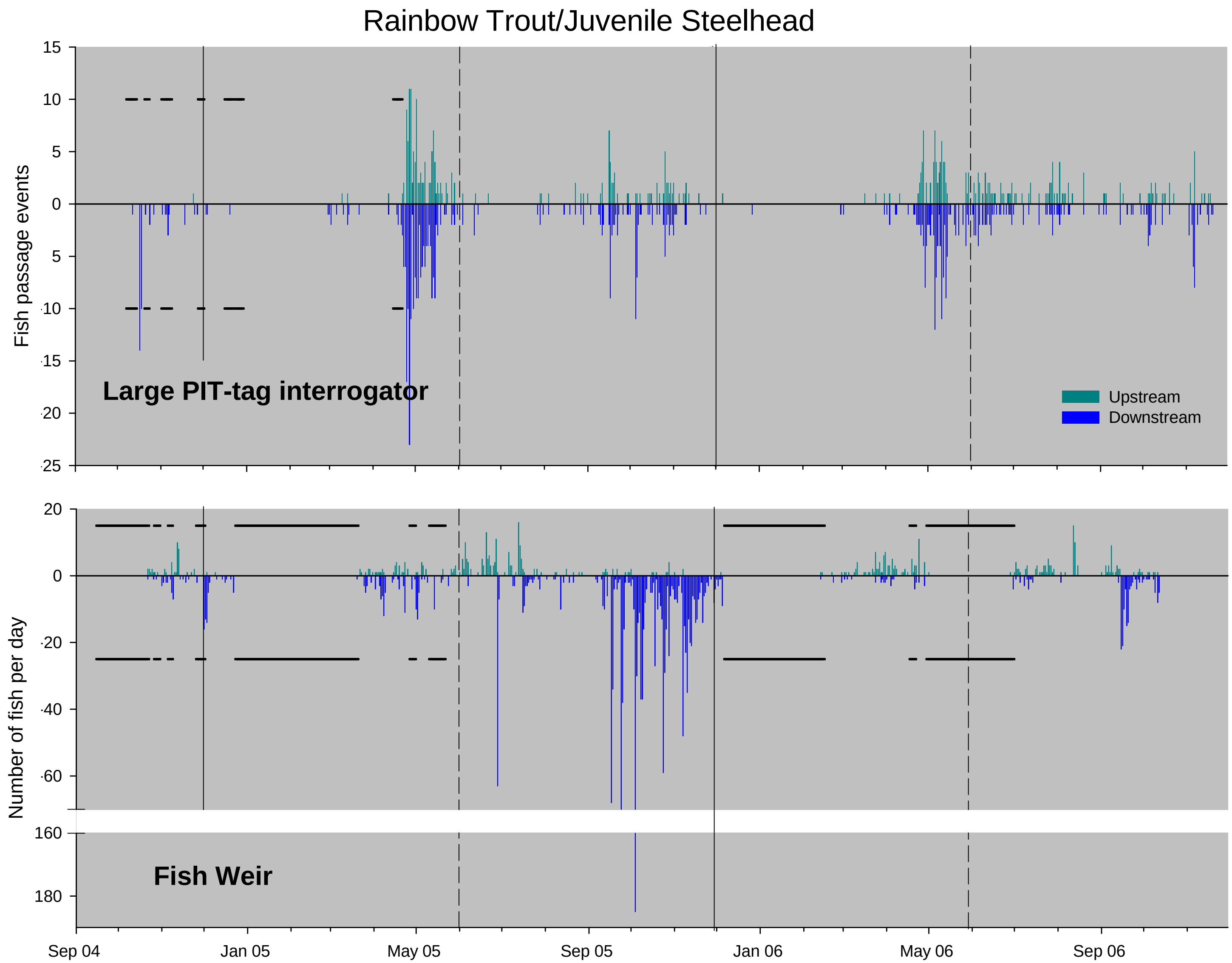


Figure 12. Rainbow trout/juvenile steelhead detected at the large PIT-tag interrogator or collected at the fish trap in Beaver Creek. The black dashes ▬ indicate days when the fish trap or large PIT-tag interrogator was not operating.

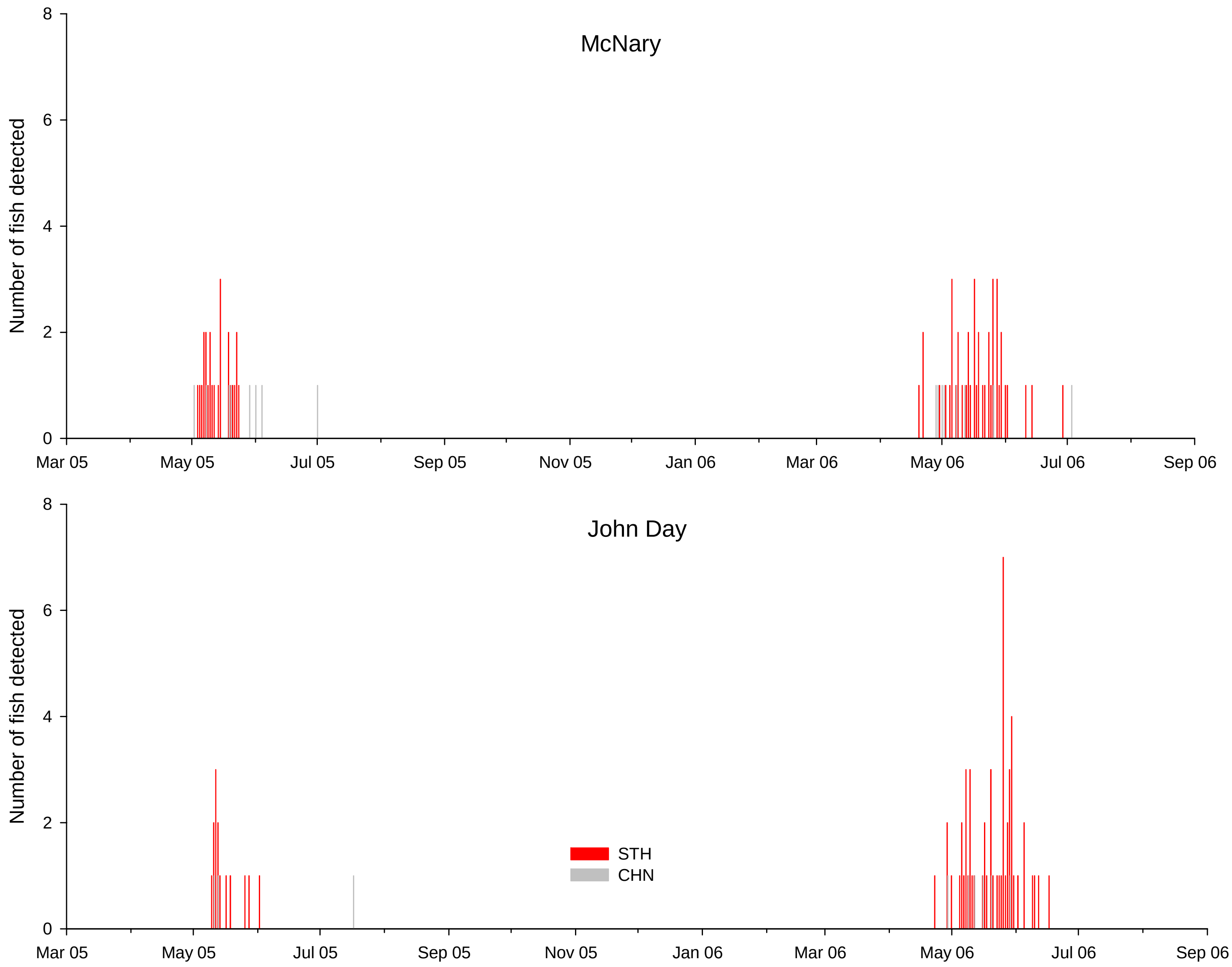


Figure 13. Rainbow trout/juvenile steelhead tagged and released in Beaver Creek from 2004-2005 and the number of fish detected at McNary and John Day dams.

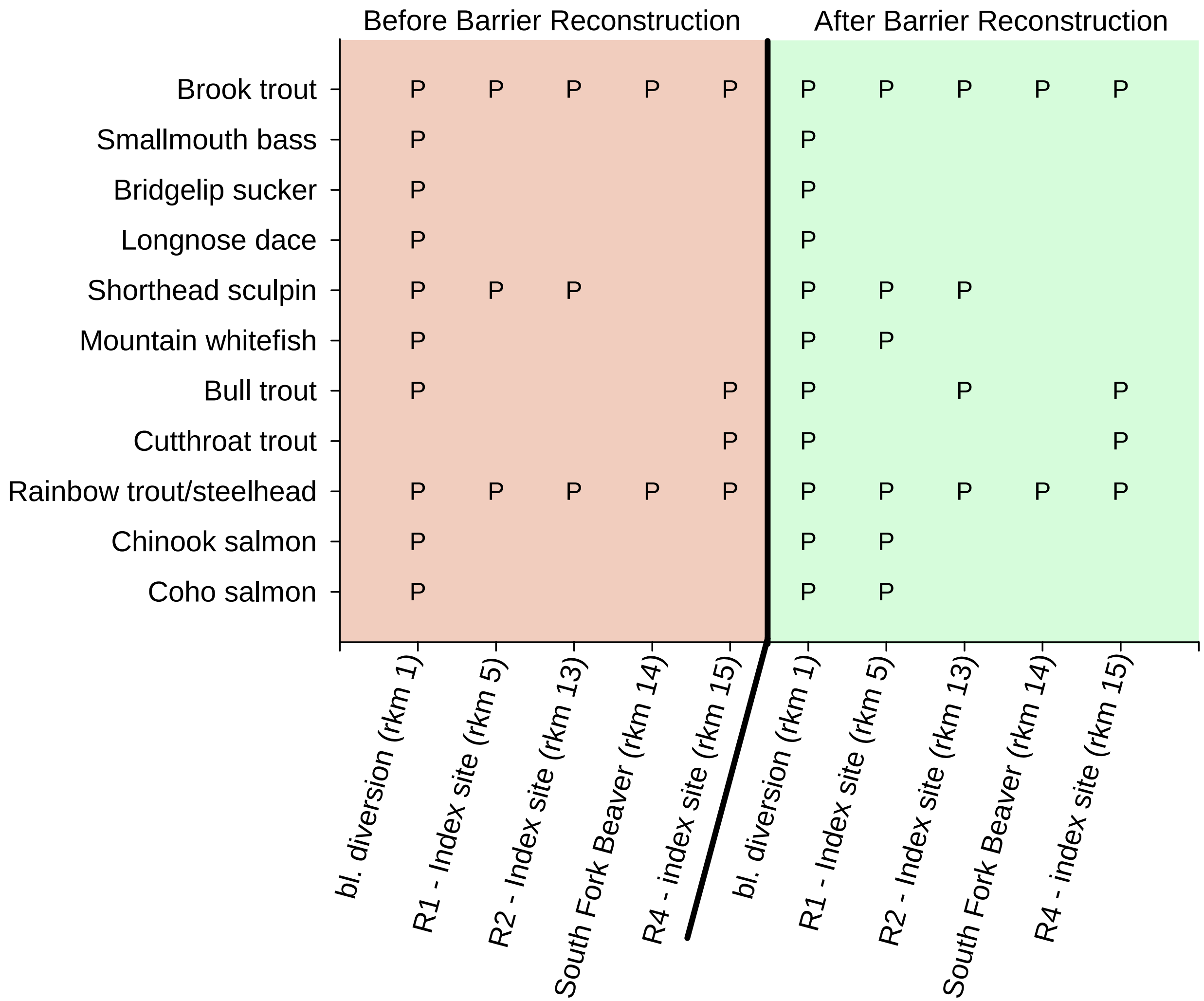


Figure 14. The presence of fish species in selected sections of Beaver Creek before and after the reconstruction of the lowest remaining water diversion.

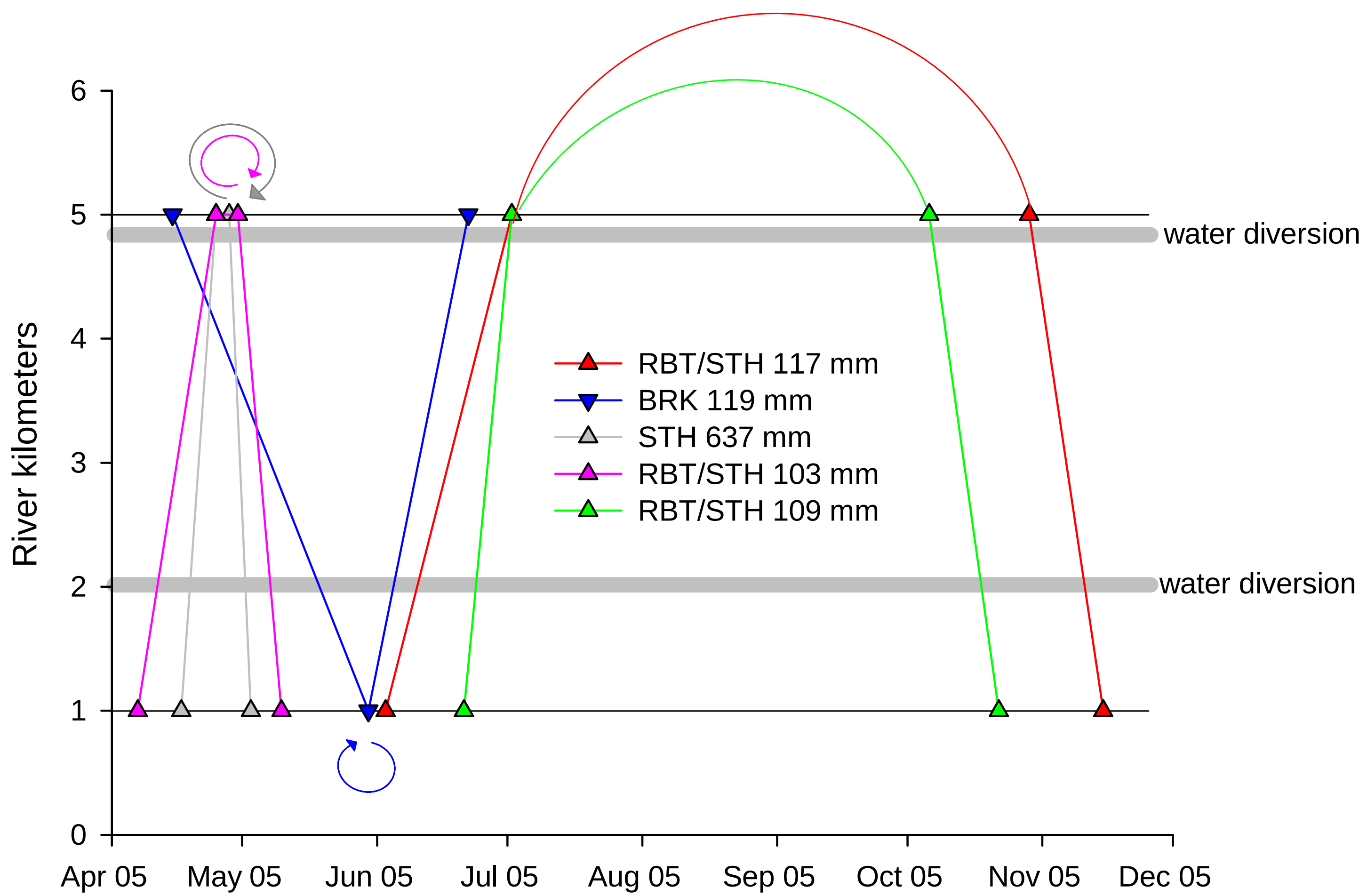


Figure 15. Movement of five fish that were successfully detected moving from rkm 1 to rkm 5, or from rkm 5 to rkm 1, and then back again across two reconstructed water diversions in Beaver Creek.

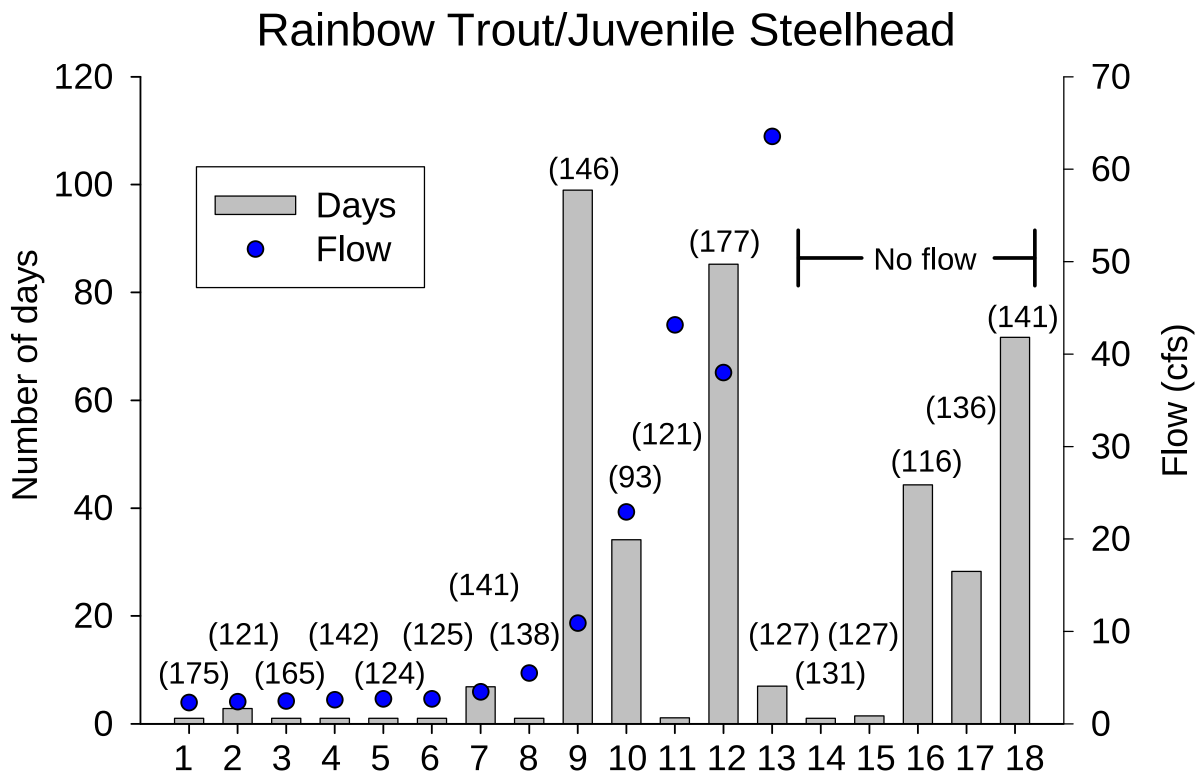


Figure 16. The amount of time and flow for rainbow trout/juvenile steelhead and to move upstream over one reconstructed water diversion. Fish length (mm) is indicated above each fish's travel times.

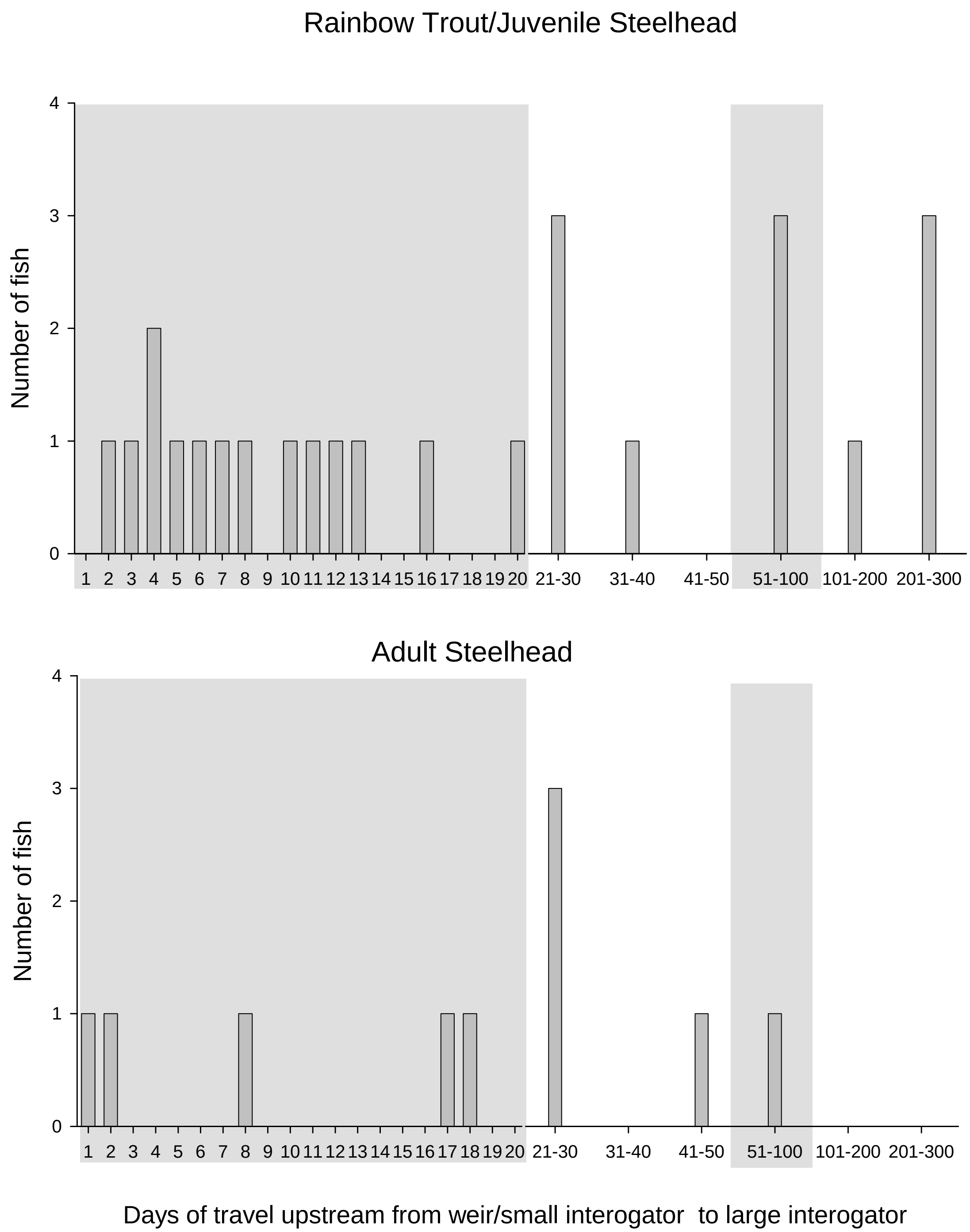
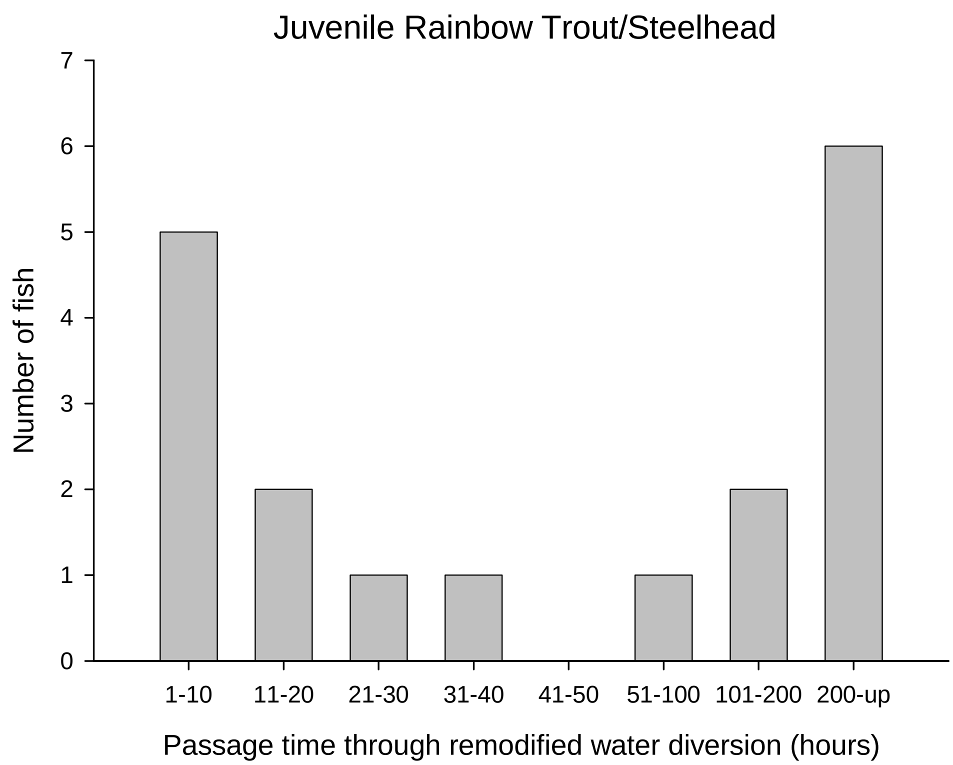


Figure 17. The number of days for juvenile steelhead and adult steelhead to move upstream from the trap/small PIT tag interrogator (rkm 1) to the large PIT-tag interrogator (rkm 5) over two reconstructed water diversions in Beaver Creek.



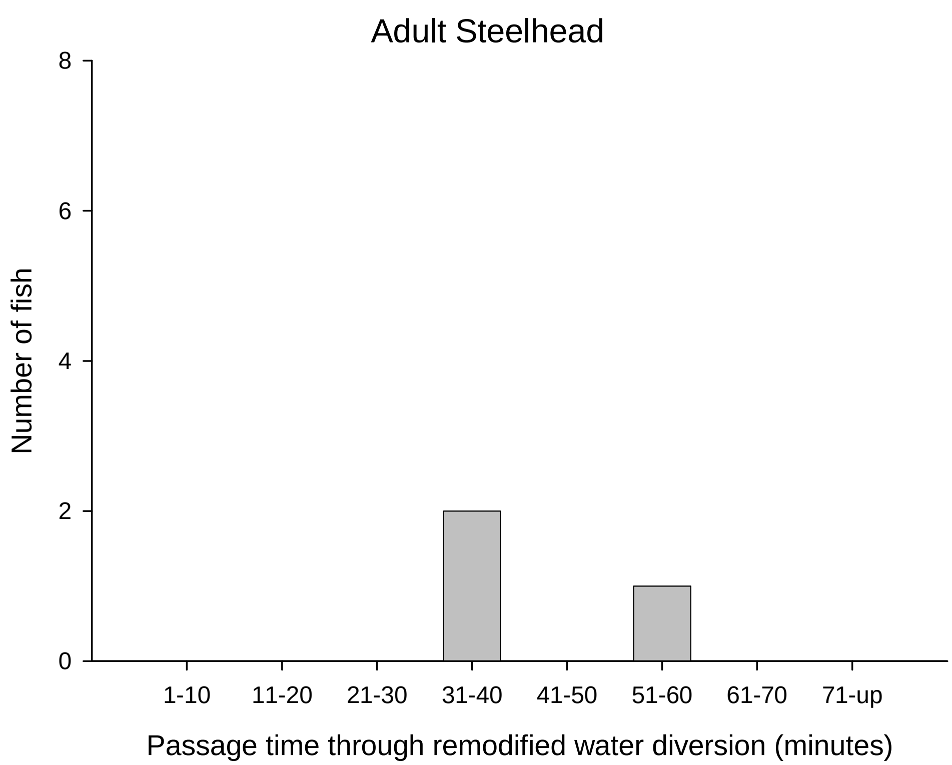


Figure 18. The amount of time for rainbow trout/juvenile steelhead and adult steelhead to move upstream over one reconstructed water diversion.

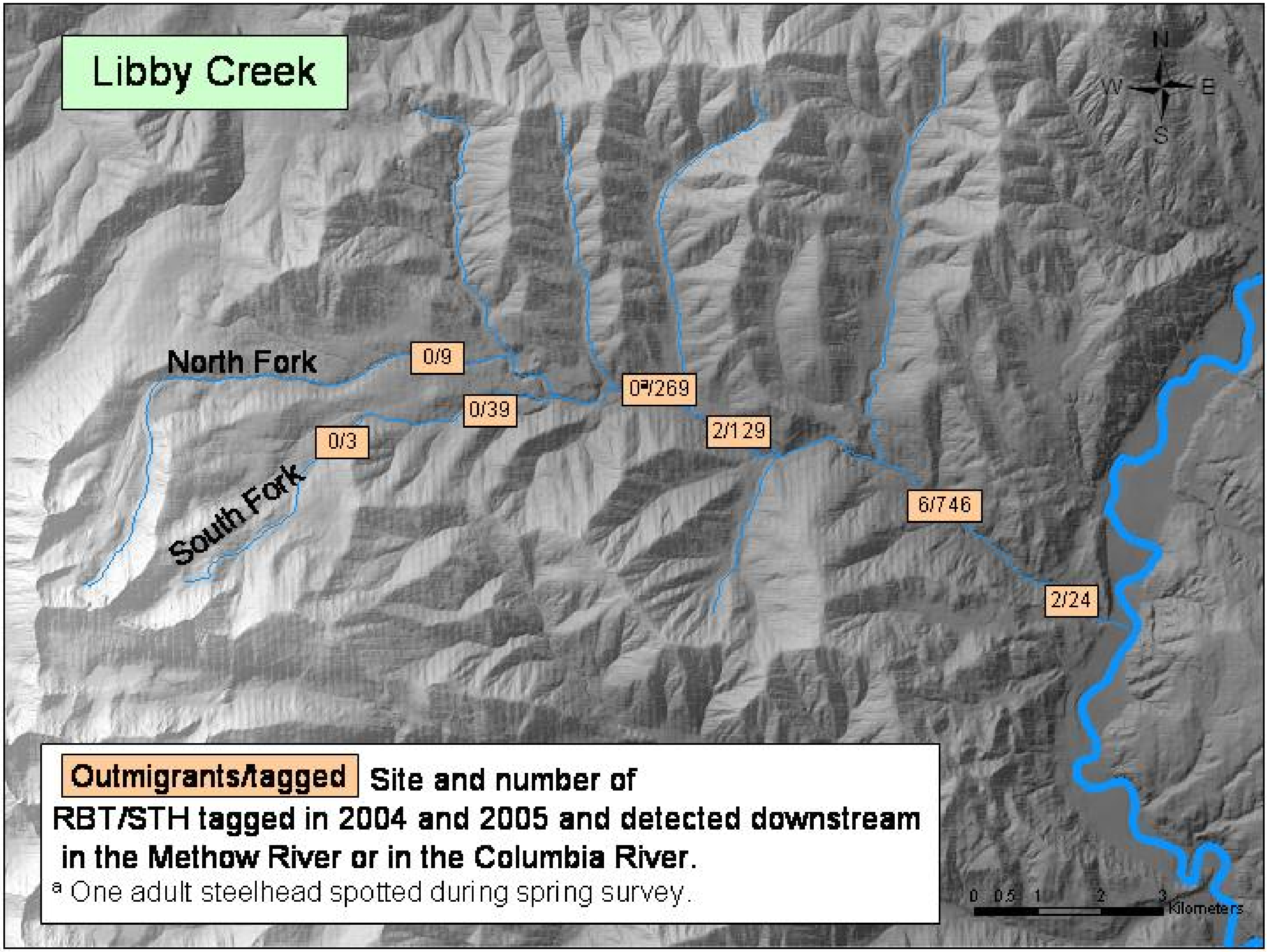


Figure 19. Rainbow trout/juvenile steelhead tagged and released in Libby Creek from 2004 to 2005 and the number of fish detected in the mainstem Methow River or a PIT-tag interrogation site in the Columbia River.

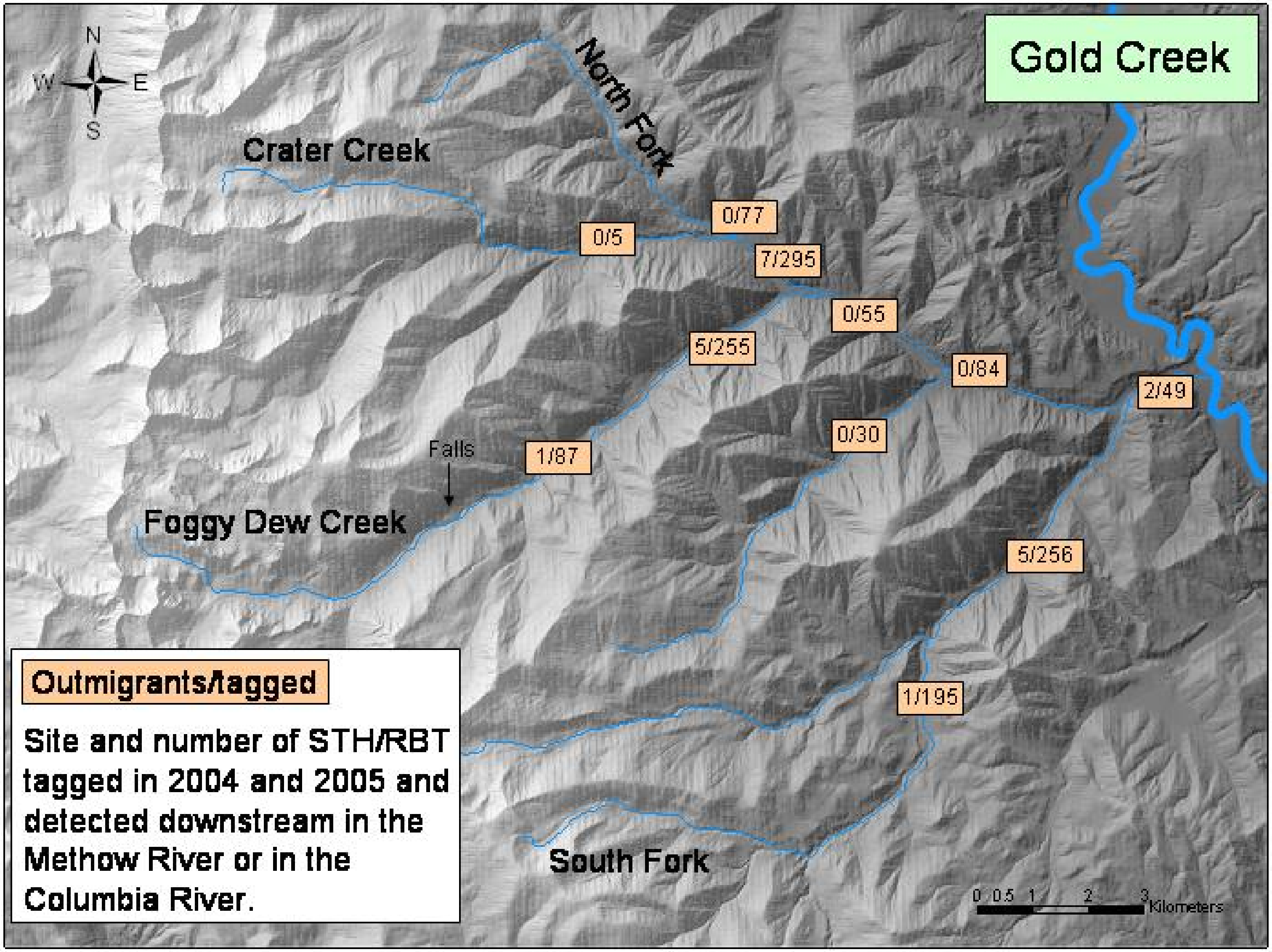


Figure 20. Rainbow trout/juvenile steelhead tagged and released in Gold Creek from 2004 to 2005 and the number of fish detected in the mainstem Methow River or a PIT-tag interrogation site in the Columbia River.

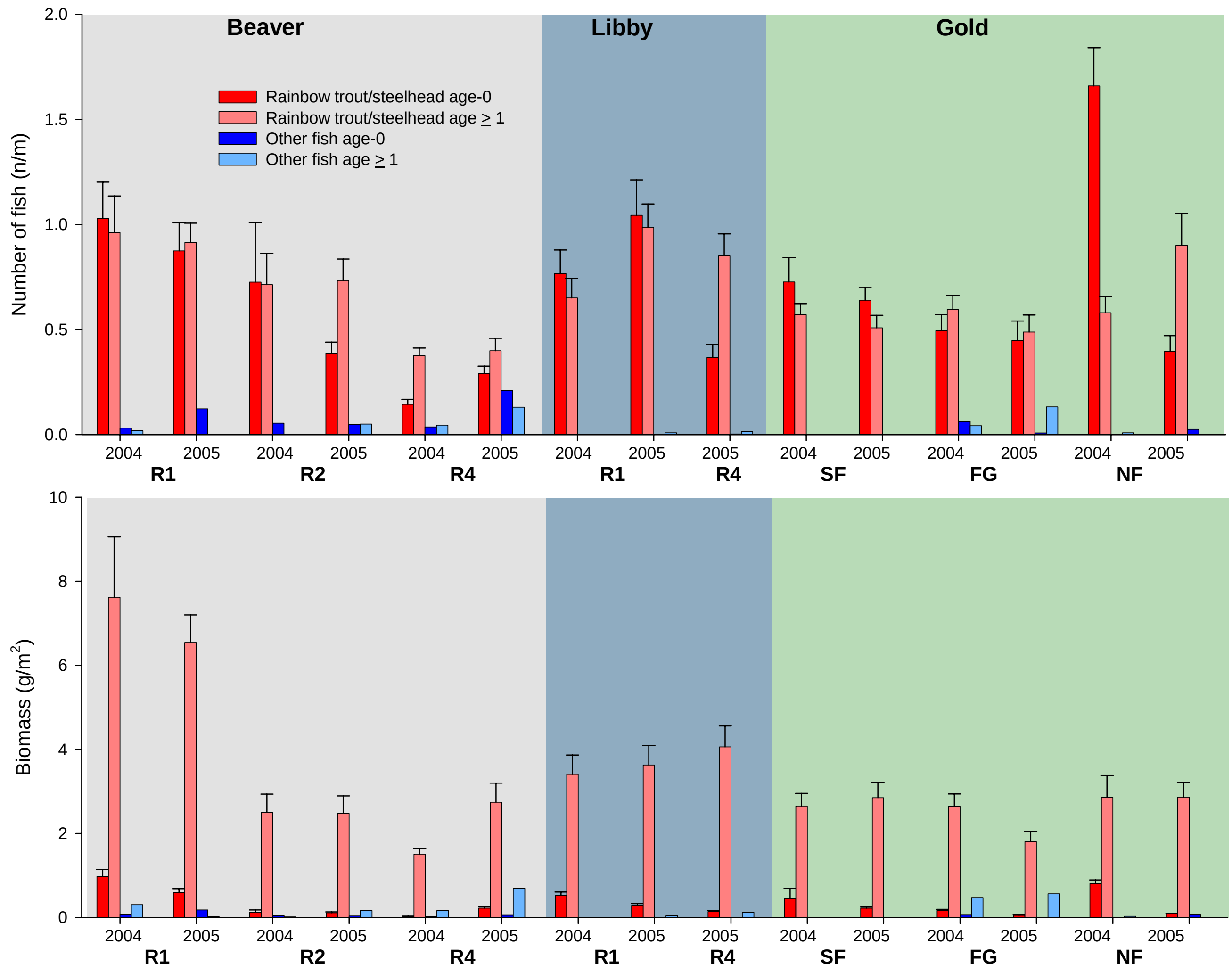


Figure 21. The number of fish per meter and biomass per meter squared of rainbow trout/steelhead and other species encountered at eight index population sites during 2004 and 2005. R1= Reach 1, R2= Reach 2 (rkm 13) R4= Reach 4 (rkm 15) SF=South Fork Gold Creek FG=Foggy Dew Creek NF=North Fork Gold Creek.

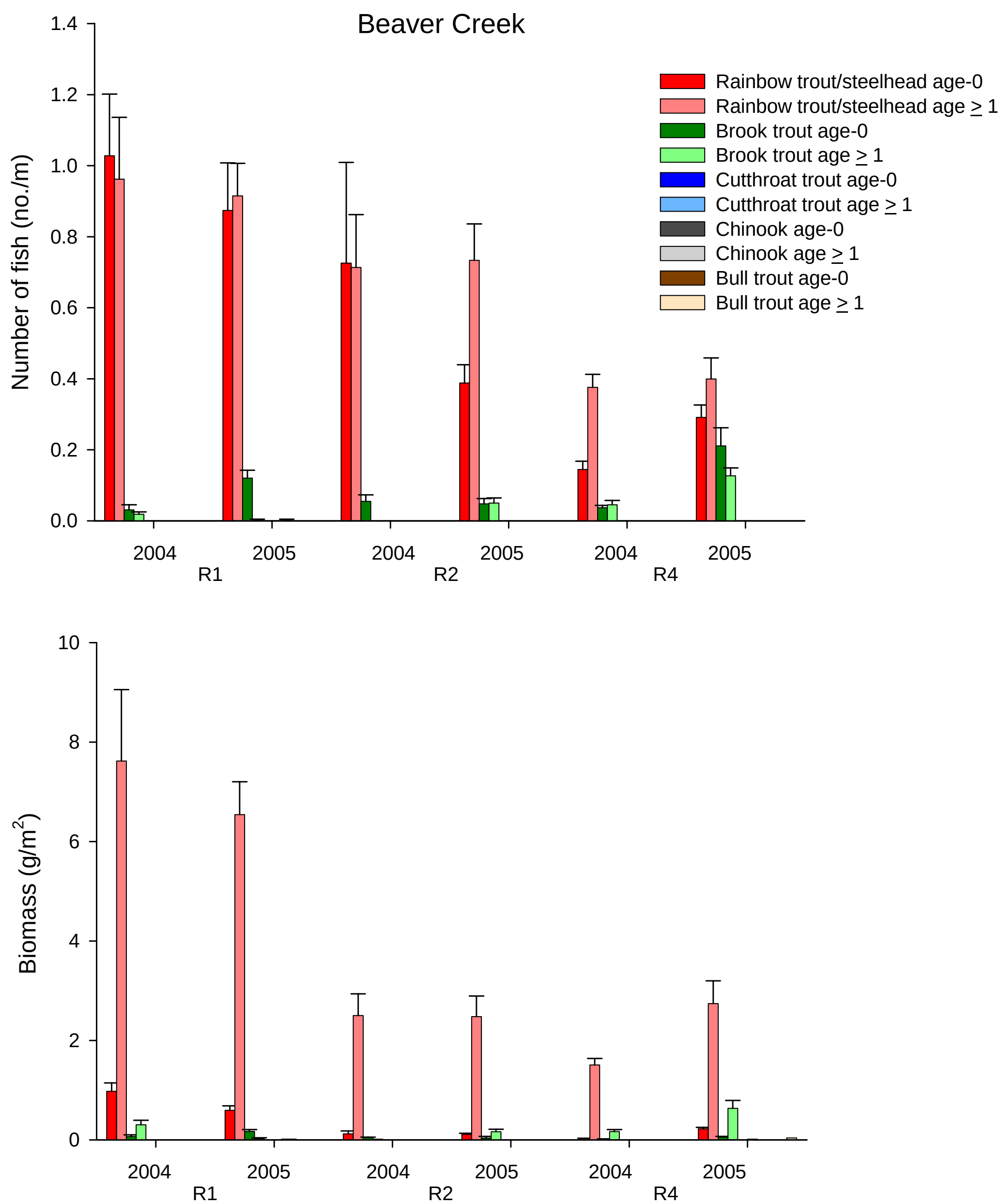


Figure 22. The number and biomass of fish sampled in Beaver Creek during summer 2004 and 2005. R1=Beaver Creek Reach 1 (rkm 5) R2= Beaver Creek Reach 2 (rkm 13) R4=Beaver Creek Reach 4 (rkm 15).

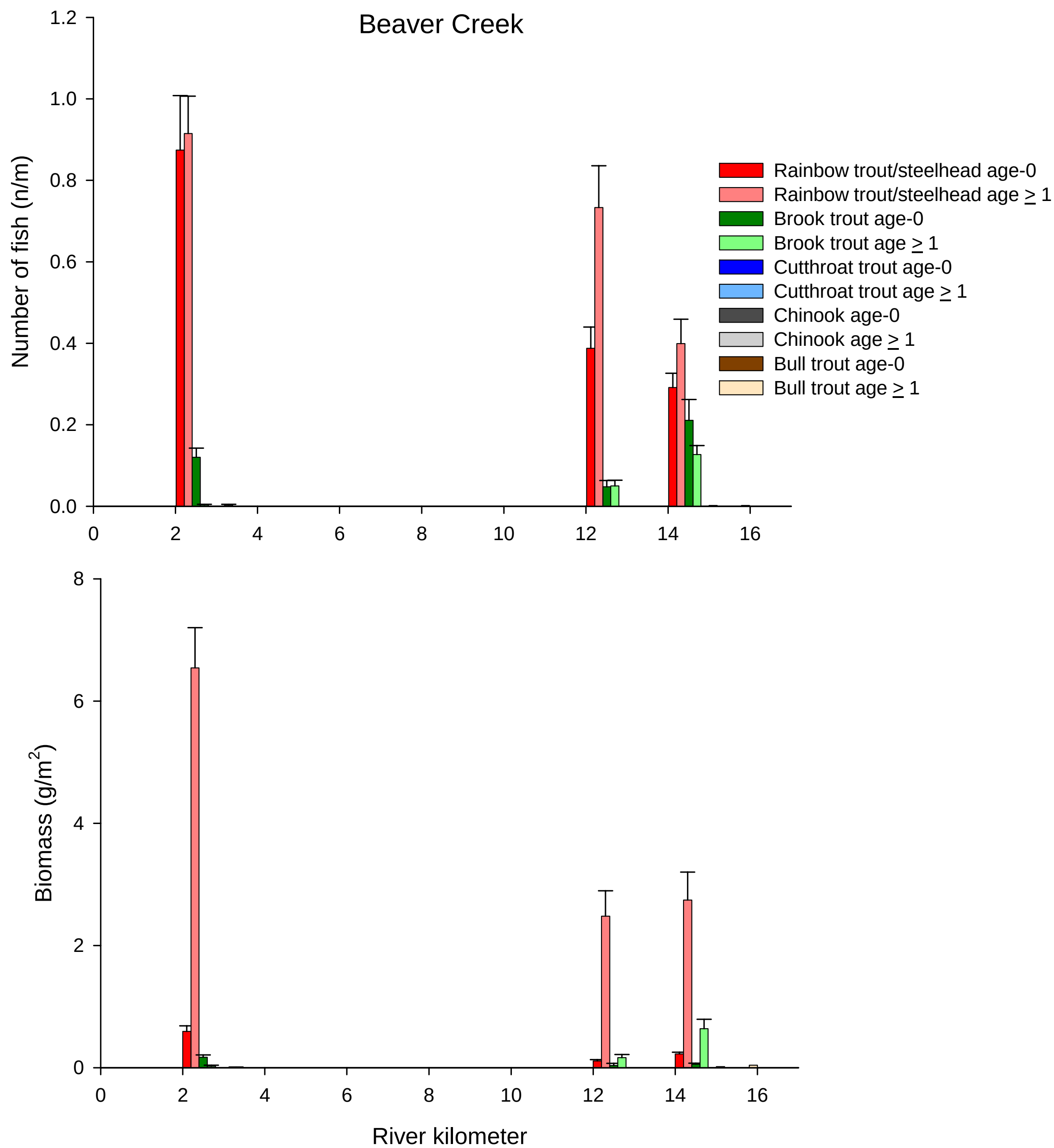


Figure 23. The number and biomass of fish sampled at three index sites during 2005 field season in Beaver Creek.

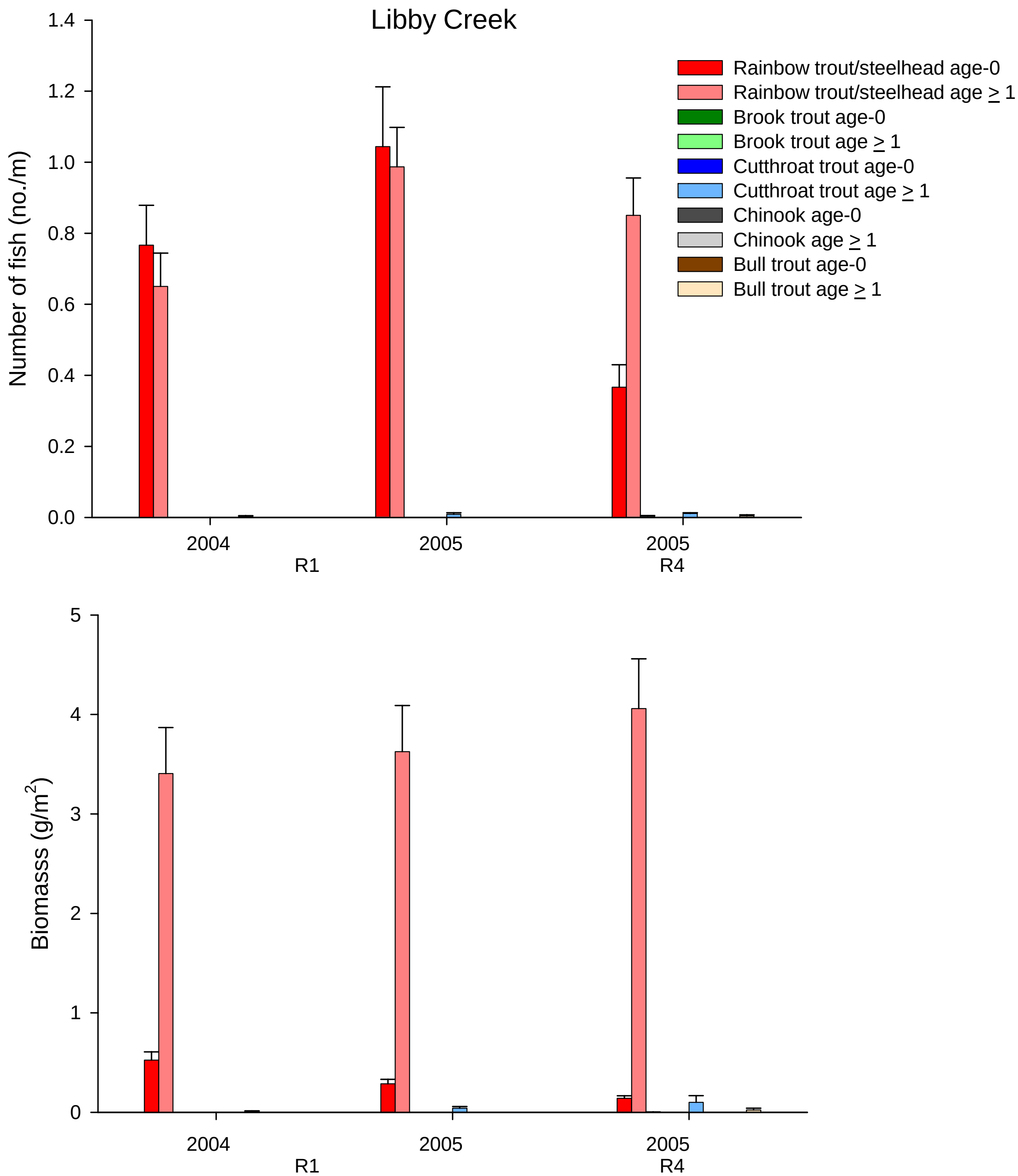


Figure 24. The number and biomass of fish sampled in Libby Creek during summer 2004 and 2005. R1=Libby Creek Reach 1 (rkm 2) R4= Libby Creek Reach 4 (rkm 10).

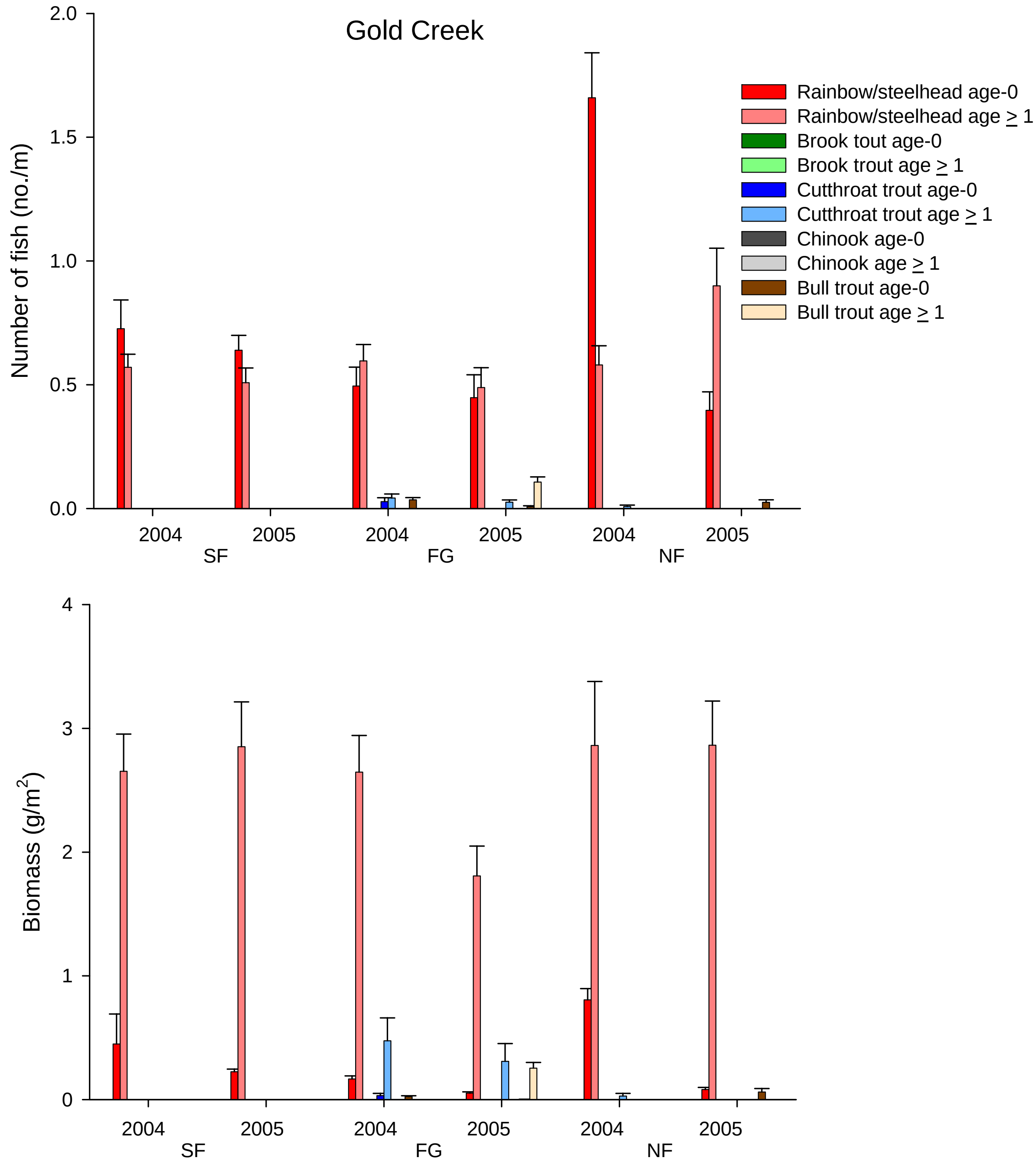


Figure 25. The number and biomass of fish sampled in Gold Creek during summer 2004 and 2005. SF=South Fork Gold Creek (rkm 2) FG= Foggy Dew Creek (rkm 2) NF=North Fork Gold Creek (rkm 9).

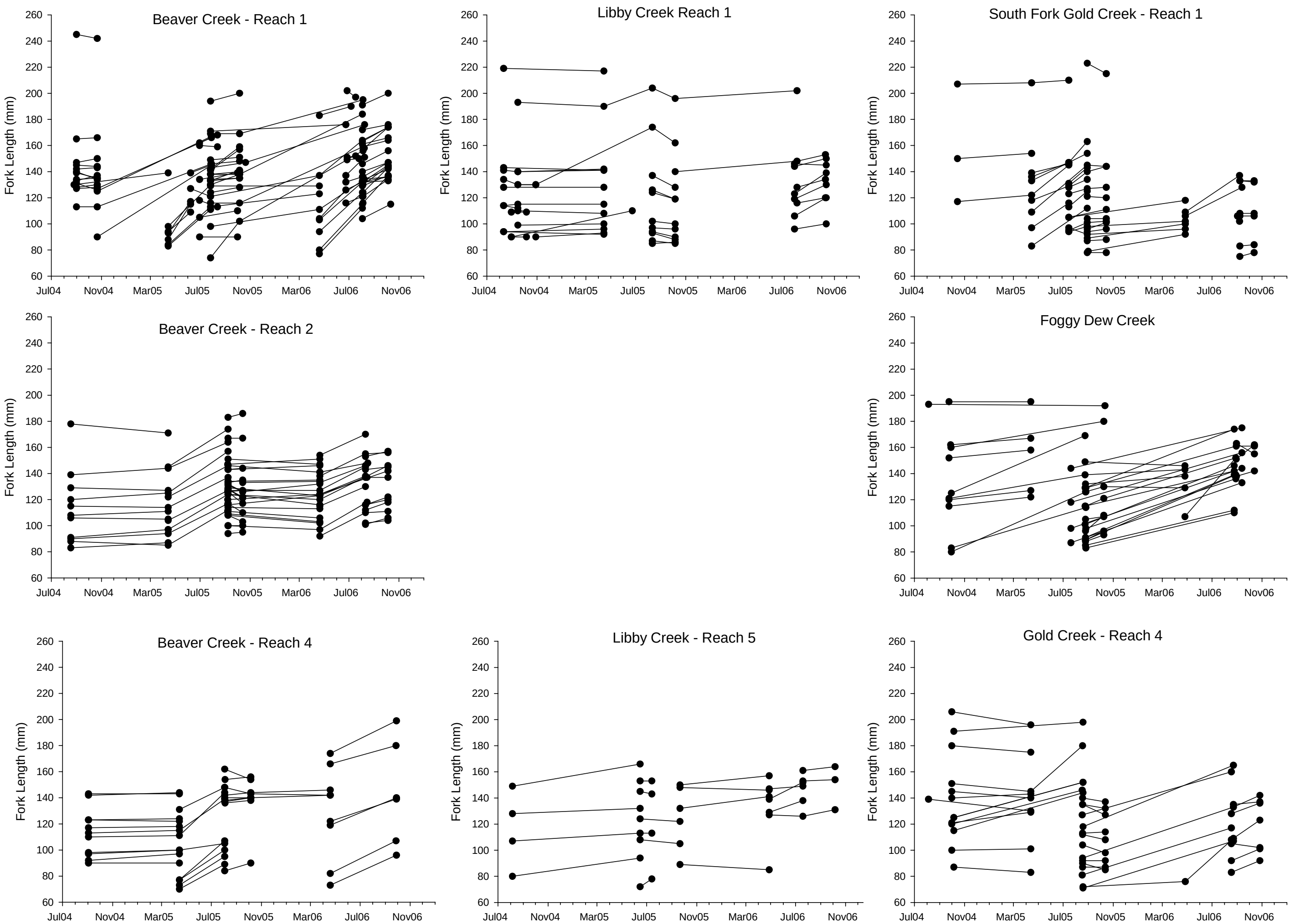


Figure 26. Fork length (mm) of rainbow trout/juvenile steelhead at tagging and at recapture times in reaches of Beaver, Libby, and Gold creeks.

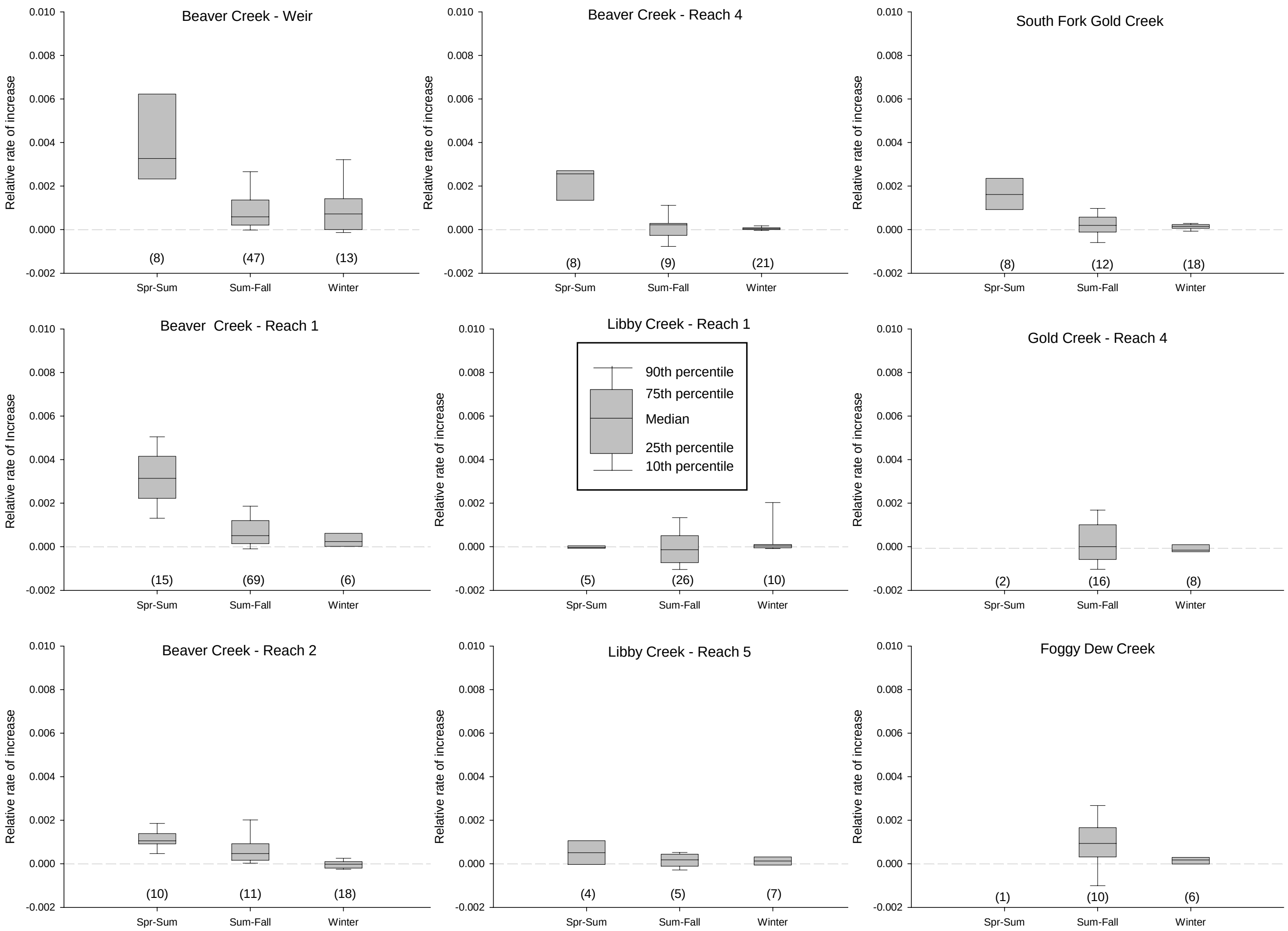


Figure 27. Seasonal relative rate of growth (mm) per day for rainbow trout/juvenile steelhead in reaches of Beaver, Libby, and Gold creeks.

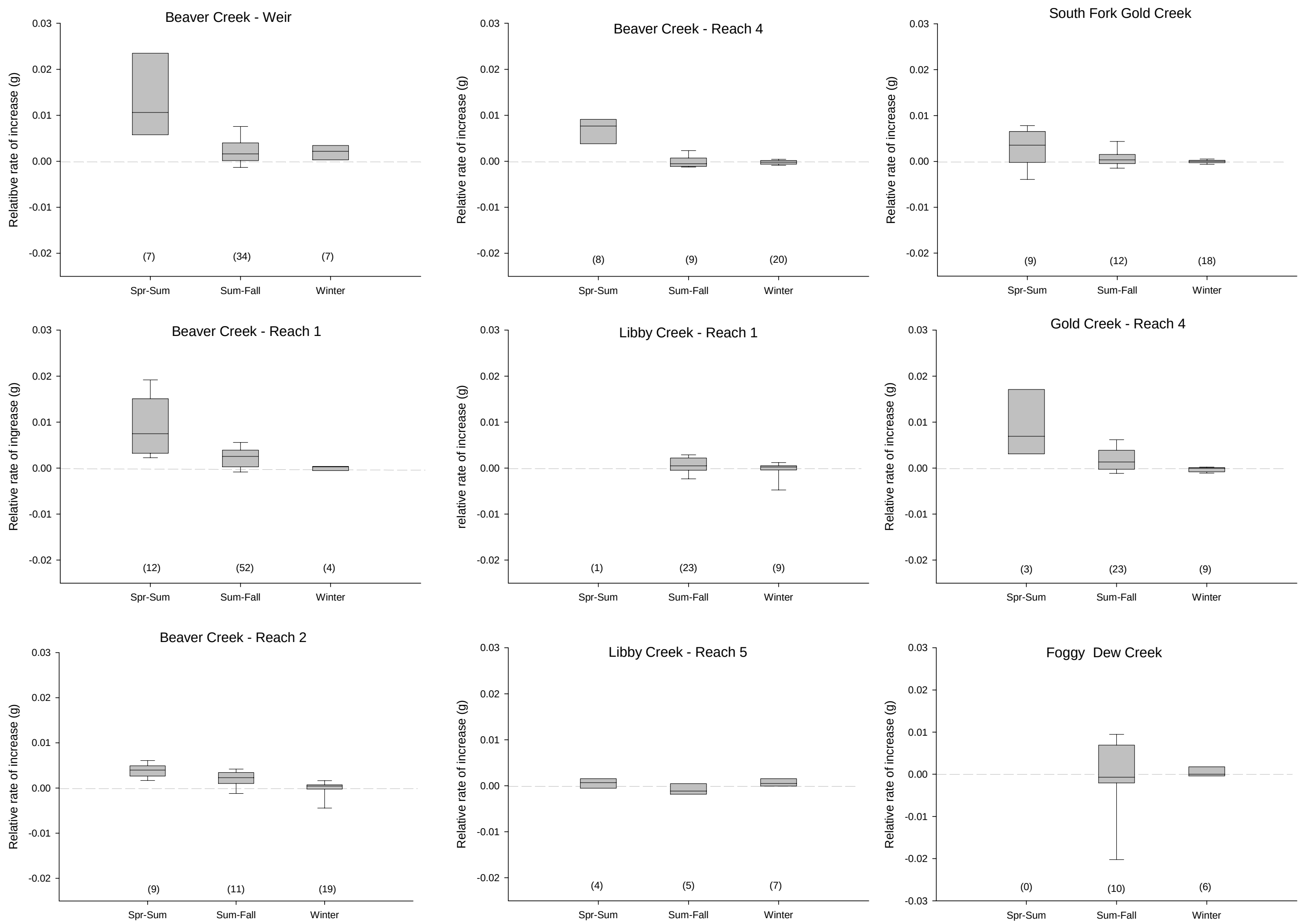


Figure 28. Seasonal relative rate of growth (g) per day for rainbow trout/juvenile steelhead in reaches of Beaver, Libby, and Gold creeks.

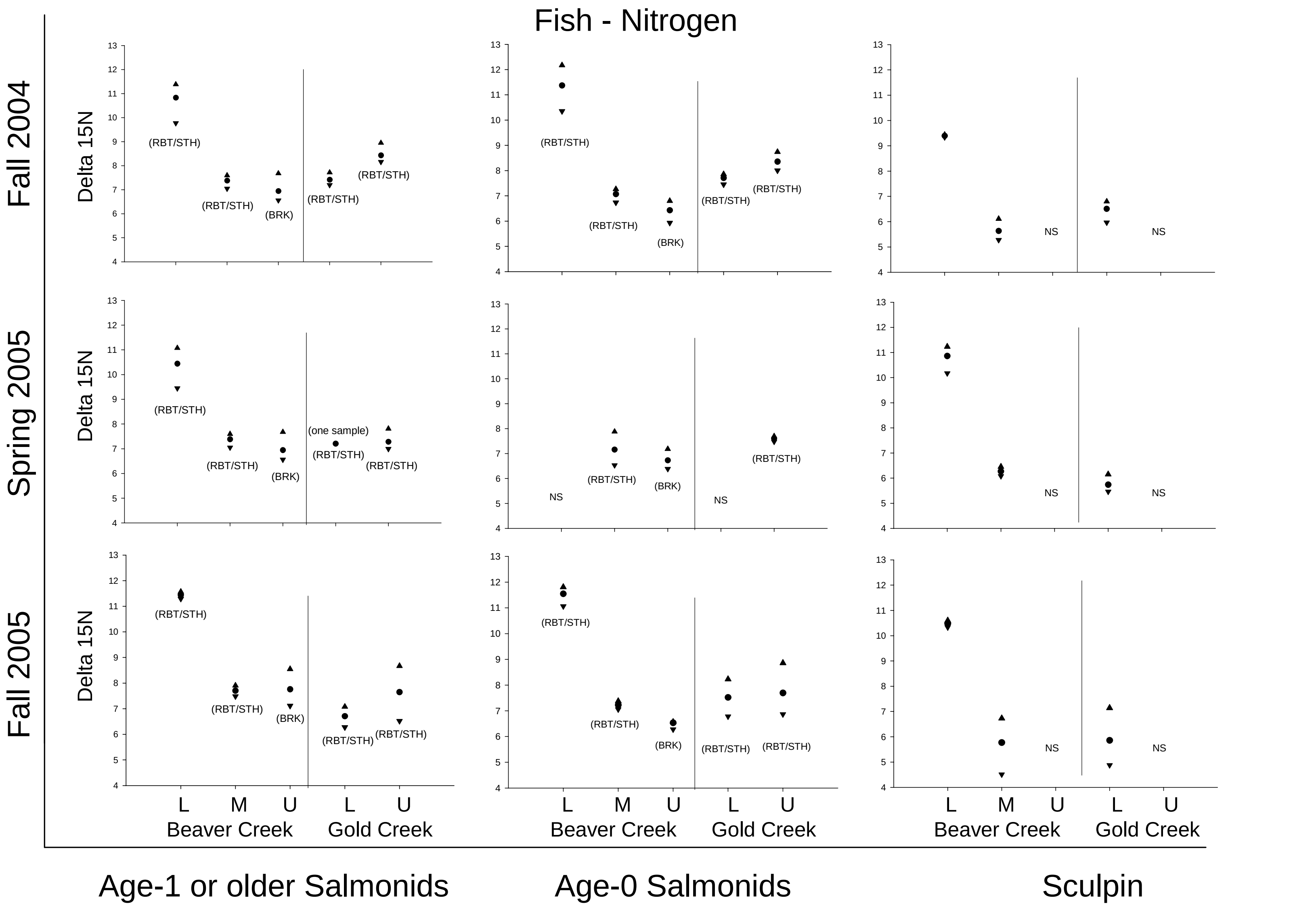


Figure 29. The minimum, average, and minimum ratio of Nitrogen 15 in fish at five sites in two subwatersheds of the Methow River watershed for three sampling times: Fall 2004, Spring 2005, and Fall 2005. L=Lower sampling site, M=Middle sampling site. U=Upper sampling site. RBT/STH=rainbow trout/juvenile steelhead, and BRK=brook trout. NS= No sample.

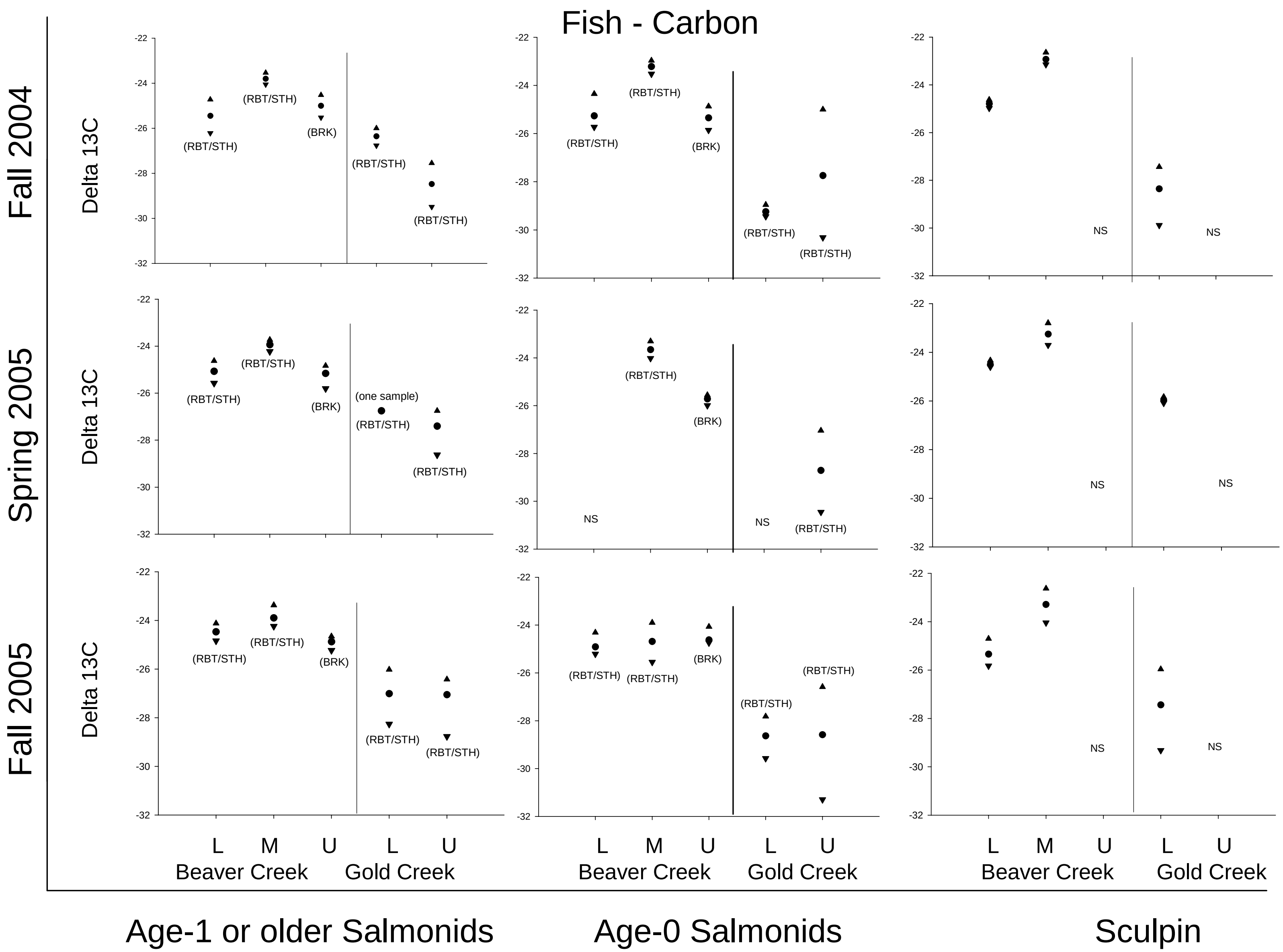


Figure 30. The minimum, maximum, and average ratio of Carbon 13 in fish at five sites in two subwatersheds of the Methow River watershed three sampling times: Fall 2004, Spring 2005, and Fall 2005. L=Lower sampling site, M=Middle sampling site. U=Upper sampling site. RBT/STH=rainbow trout/juvenile steelhead, and BRK=brook trout. NS= No sample.

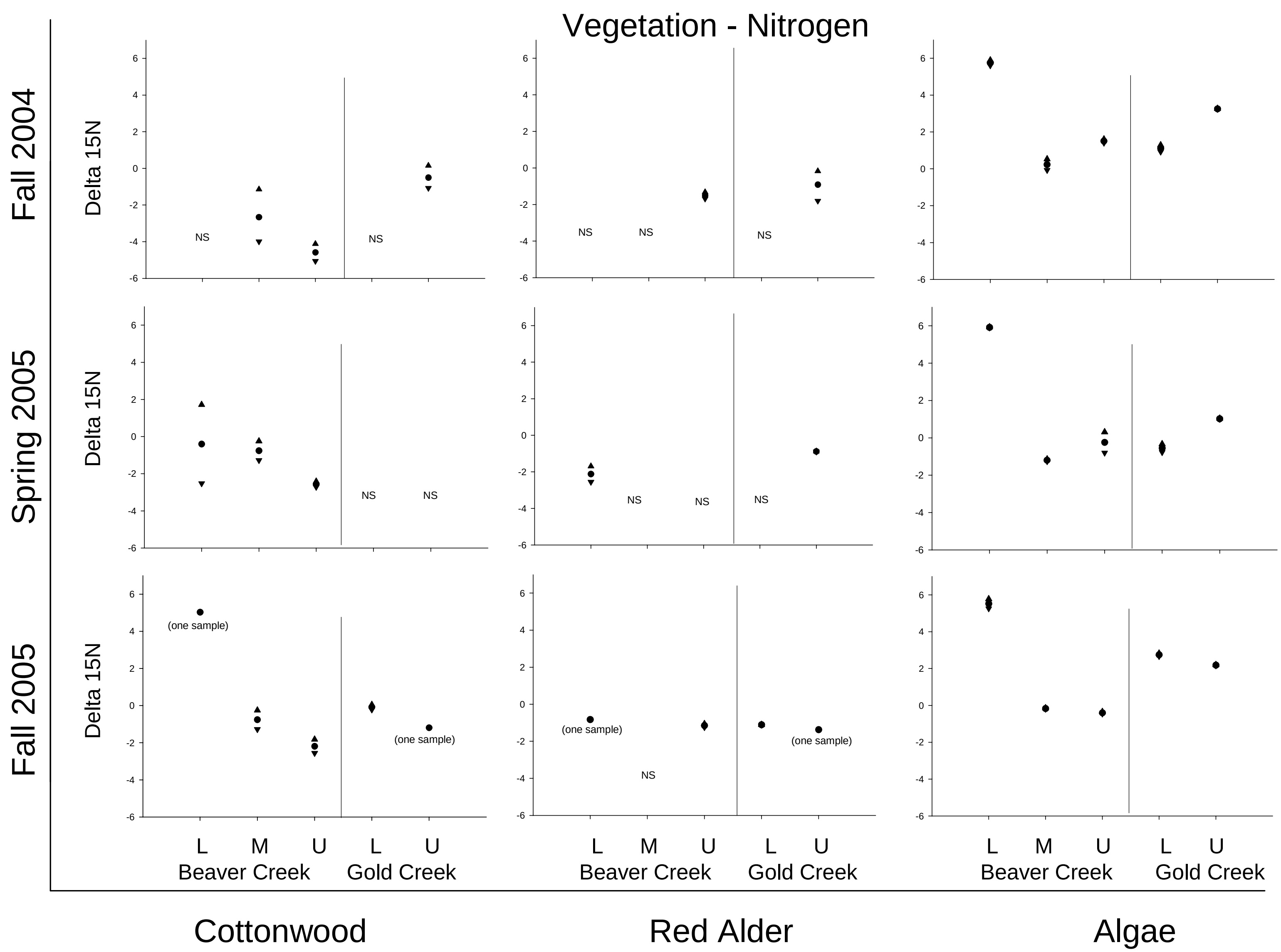


Figure 31. The minimum, maximum, and average ratio of Nitrogen 15 in vegetation found at five sites in two subwatersheds of the Methow River watershed three sampling times: Fall 2004, Spring 2005, and Fall 2005 L=Lower sampling site, M=Middle sampling site. U=Upper sampling site. NS= No sample.

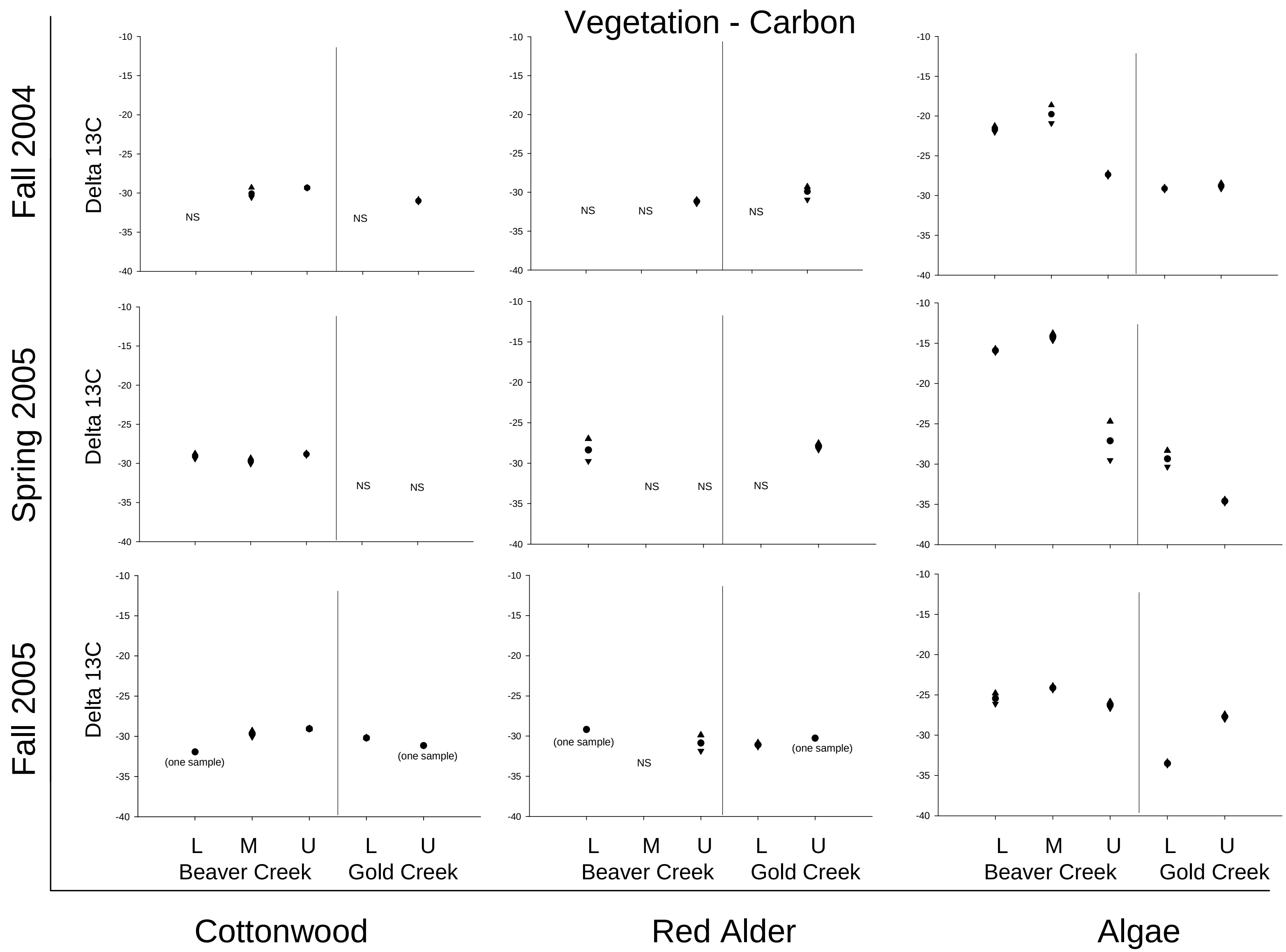


Figure 32. The minimum, maximum, and average ratio of Carbon 13 in vegetation found at five sites in two subwatersheds of the Methow River watershed three sampling times: Fall 2004, Spring 2005, and Fall 2005. L=Lower sampling site, M=Middle sampling site. U=Upper sampling site. NS= No sample.

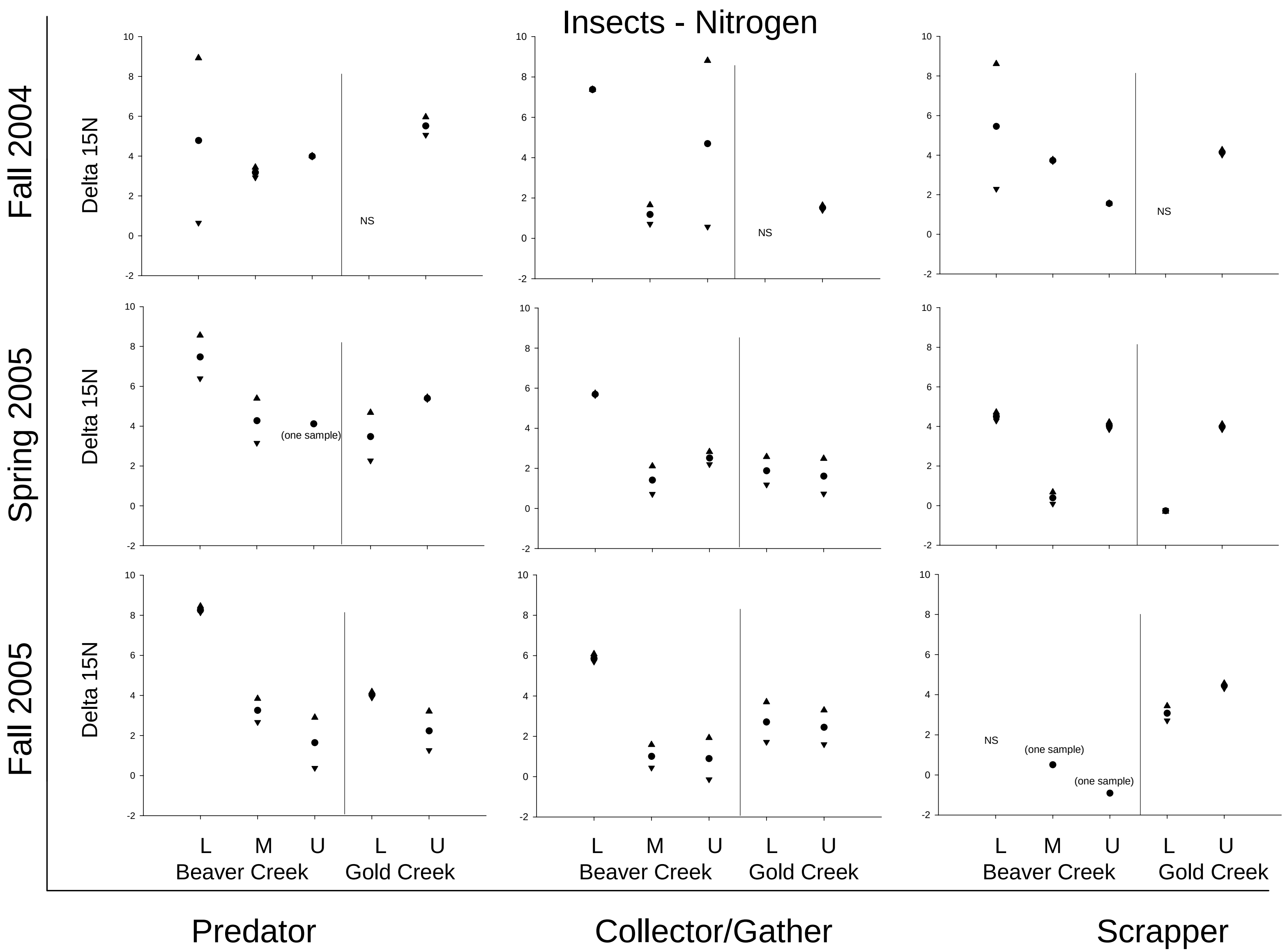


Figure 33. The minimum, maximum, and average ratio of Nitrogen 15 in insects at five sites in two subwatersheds of the Methow River watershed three sampling times: Fall 2004, Spring 2005, and Fall 2005. L=Lower sampling site, M=Middle sampling site. U=Upper sampling site. NS= No sample.

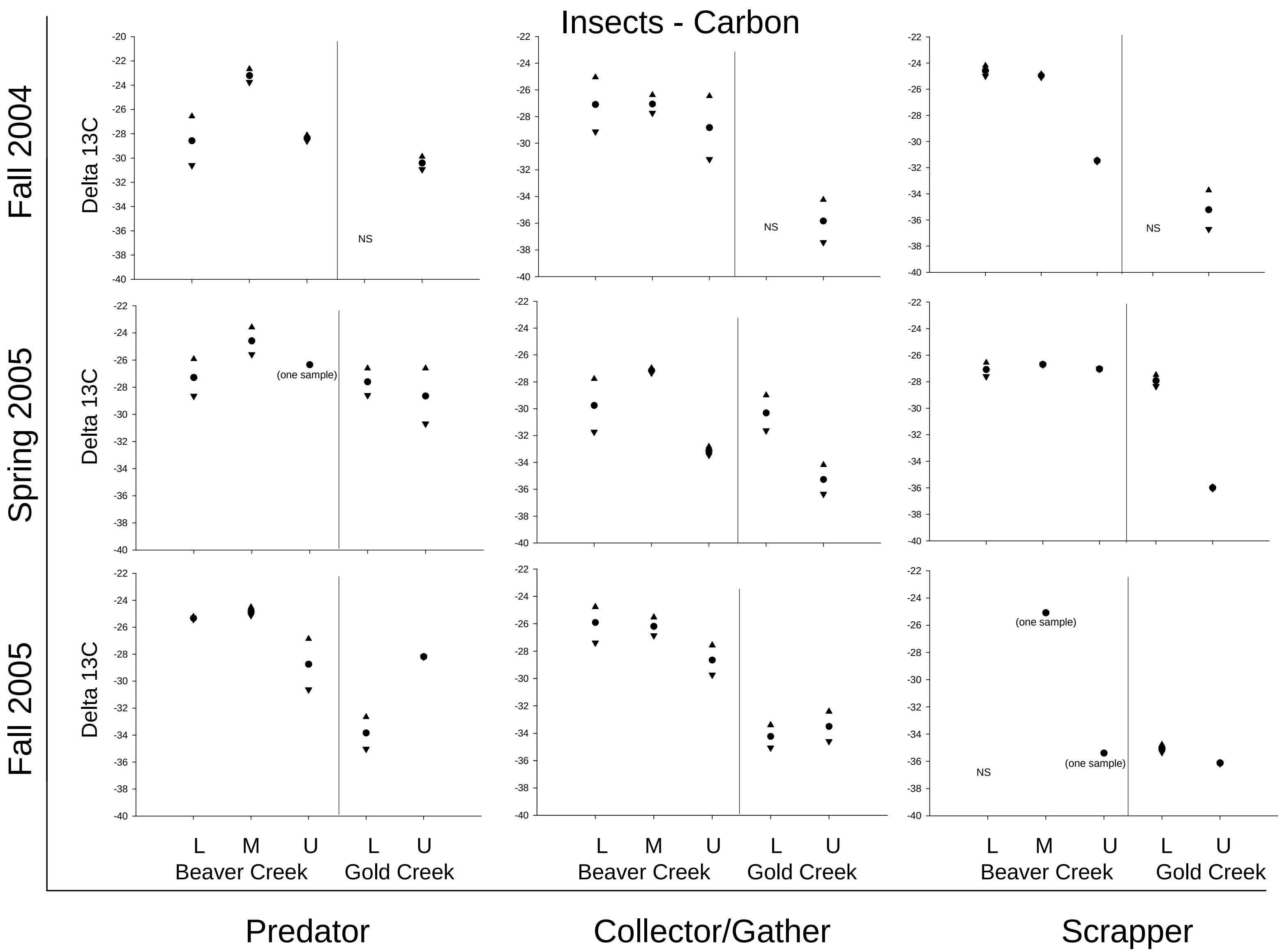


Figure 34. The minimum, maximum, and average ratio of Carbon 13 in insects at five sites in two subwatersheds of the Methow River watershed three sampling times: Fall 2004, Spring 2005, and Fall 2005. L=Lower sampling site, M=Middle sampling site. U=Upper sampling site. NS= No sample.

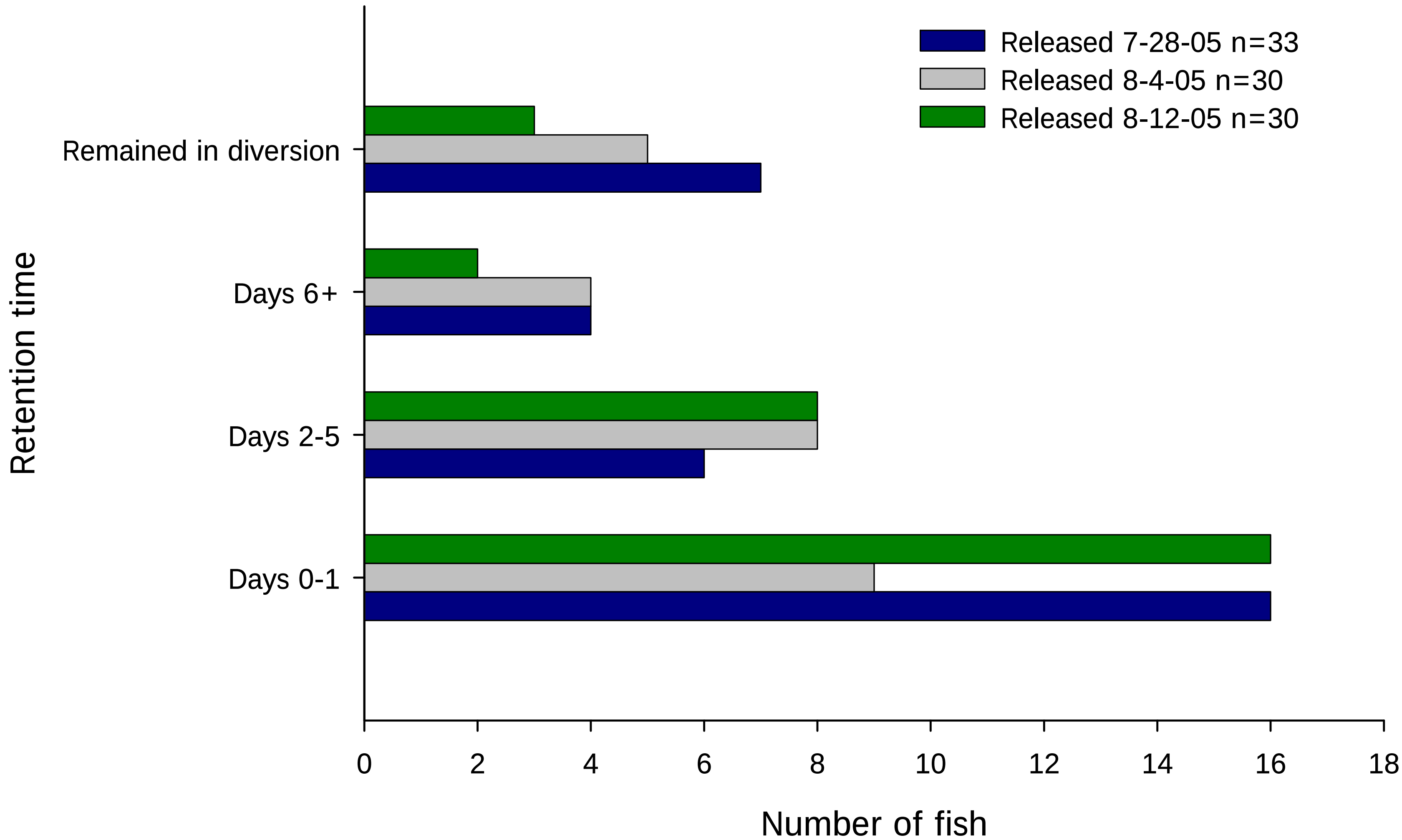


Figure 35. The retention time of fish released into a water diversion water canal for three trials in 2005 at reach one of Beaver Creek.

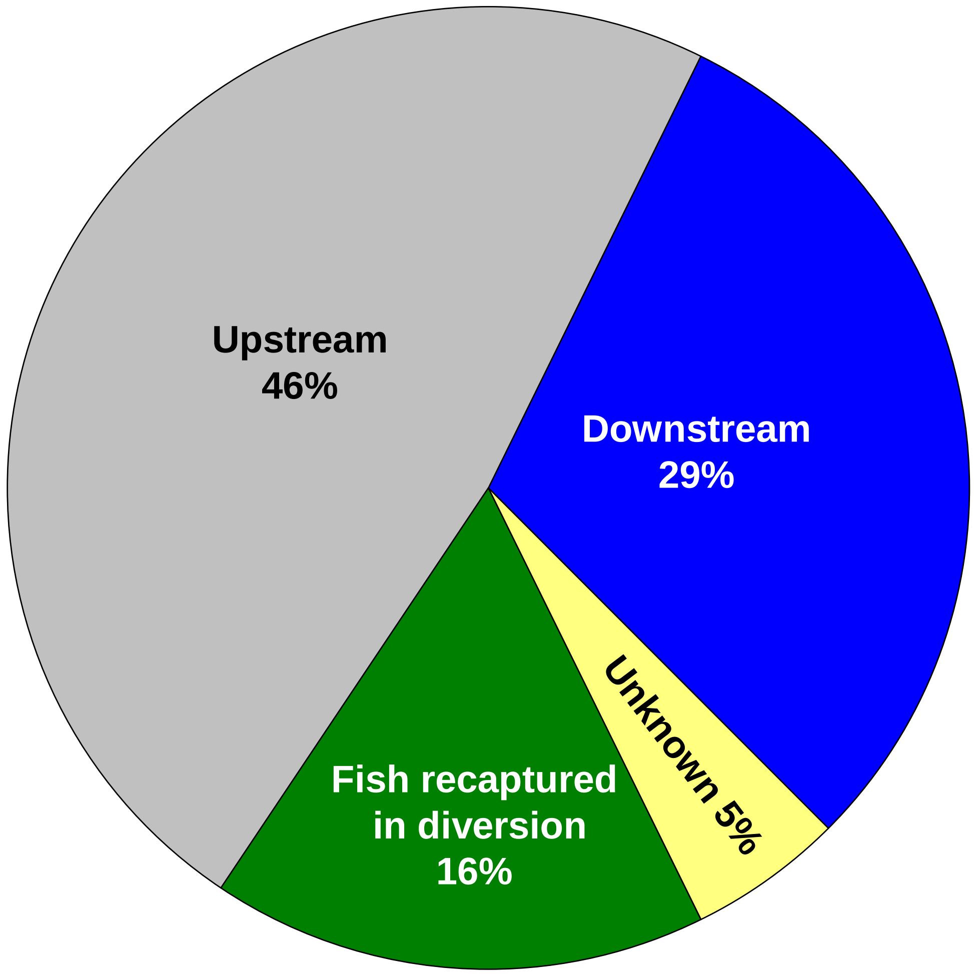


Figure 36. The outcomes of fish released into a water diversion water canal for three combined trials in 2005 at reach one of Beaver Creek.

Appendix Table 1. Total growth (mm) and daily relative rate of increase (mm) for PIT-tagged and recaptured rainbow trout/juvenile steelhead in reach 1 of Beaver Creek, 2004-2006.

Season of growth	Total growth (mm)					Avg. daily relative rate of increase (mm)				
	n	Mean	Median	Min	Max	n	Mean	Median	Min	Max
Spring -summer	15	25	27.0	7	35	15	0.0031	0.0031	0.0005	0.0056
Summer- Fall	69	7	5.0	-6	59	69	0.0009	0.0005	-0.0008	0.0089
Winter	6	9	5.5	-1	33	6	0.0003	0.0002	-0.0001	0.0010

Appendix Table 2. Total growth (mm) and daily relative rate of increase (mm) for PIT-tagged rainbow trout/juvenile steelhead that were recaptured in a weir in Beaver Creek, 2004-2006.

Season of growth	Total growth (mm)					Avg. daily relative rate of increase (mm)				
	n	Mean	Median	Min	Max	n	Mean	Median	Min	Max
Spring -Summer	8	24	22.0	7	44	8	0.0039	0.0033	0.0015	0.0071
Summer- Fall	47	10	9.0	-11	31	47	0.0010	0.0006	-0.0008	0.0051
Winter	13	16	10.0	-4	73	13	0.0009	0.0007	-0.0001	0.0037

Appendix Table 3. Total growth (mm) and daily relative rate of increase (mm) for PIT-tagged and recaptured rainbow trout/juvenile steelhead in reach 2 of Beaver Creek, 2004-2006.

Season of growth	Total growth (mm)					Daily relative rate of increase (mm)				
	n	Mean	Median	Min	Max	n	Mean	Median	Min	Max
Spring -Summer	10	15	15.5	7	21	10	0.0011	0.0010	0.0004	0.0019
Summer- Fall	11	4	4	0	17	11	0.0007	0.0005	0	0.0023
Winter	18	-1	-0.5	-8	7	18	-0.0000	0.0000	-0.0003	0.0003

Appendix Table 4. Total growth (mm) and daily relative rate of increase (mm) for PIT-tagged and recaptured rainbow trout/juvenile steelhead in reach 4 of Beaver Creek, 2004-2006.

Season of growth	Total growth (mm)					Avg. daily relative rate of increase (mm)				
	n	Mean	Median	Min	Max	n	Mean	Median	Min	Max
Spring -Summer	8	22	22.5	5	33	8	0.0022	0.0026	0.0004	0.0035
Summer- Fall	9	0.4	2	-8	6	9	0.0001	0.0002	-0.0008	0.0011
Winter	21	1	1	-1	5	21	0.0001	0.0000	0.0000	0.0002

Appendix Table 5. Total growth (mm) and daily relative rate of increase (mm) for PIT-tagged and recaptured rainbow trout/juvenile steelhead in reach 1 of Libby Creek, 2004-2006.

Season of growth	Total growth (mm)					Avg. daily relative rate of increase (mm)				
	n	Mean	Median	Min	Max	n	Mean	Median	Min	Max
Spring -Summer	1			14	14	1			0.0006	0.0006
Summer- Fall	26	0	-1	-12	16	26	-0.0001	-0.0001	-0.0012	0.0017
Winter	10	8	1	-3	74	10	0.0002	0.0000	-0.0001	0.0022

Appendix Table 6. Total growth (mm) and daily relative rate of increase (mm) for PIT-tagged and recaptured rainbow trout/juvenile steelhead in reach 5 of Libby Creek, 2004-2006.

Season of growth	Total growth (mm)					Avg. daily relative rate of increase (mm)				
	n	Mean	Median	Min	Max	n	Mean	Median	Min	Max
Spring -Summer	4	6	5.5	-1	13	4	0.0005	0.0005	-0.0001	0.0011
Summer- Fall	5	1	1	-3	5	5	0.0001	0.0001	-0.0003	0.0005
Winter	7	5	4.0	-4	20	7	0.0001	0.0001	-0.0002	0.0005

Appendix Table 7. Total growth (mm) and daily relative rate of increase (mm) for PIT-tagged and recaptured rainbow trout/juvenile steelhead in North Fork Gold Creek of Gold Creek watershed, 2004-2006.

Season of growth	Total growth (mm)					Avg. daily relative rate of increase (mm)				
	n	Mean	Median	Min	Max	n	Mean	Median	Min	Max
Spring -Summer	2	34	34	33	35	2	0.0028	0.0028	0.0019	0.0037
Summer- Fall	16	1	0	-8	15	16	0.0001	0	-0.0011	0.0020
Winter	8	-2	-4.5	-10	8	8	-0.0001	-0.0002	-0.0003	0.0003

Appendix Table 8. Total growth (mm) and daily relative rate of increase (mm) for PIT-tagged and recaptured rainbow trout/juvenile steelhead in South Fork Gold Creek of Gold Creek watershed, 2004-2006.

Season of growth	Total growth (mm)					Avg. daily relative rate of increase (mm)				
	n	Mean	Median	Min	Max	n	Mean	Median	Min	Max
Spring -Summer	8	18	16.5	2	36	8	0.0015	0.0016	0.0001	0.0026
Summer- Fall	12	1	1	-8	6	12	0.0002	0.0002	-0.0008	0.0011
Winter	18	3	3.5	-2	7	18	0.0001	0.0001	-0.0001	0.0003

Appendix Table 9. Total growth (mm) and daily relative rate of increase (mm) for PIT-tagged and recaptured rainbow trout/juvenile steelhead in Foggy Dew Creek of Gold Creek watershed, 2004-2006.

Season of growth	Total growth (mm)					Avg. daily relative rate of increase (mm)				
	n	Mean	Median	Min	Max	n	Mean	Median	Min	Max
Spring -Summer	1			45	45	1			0.0034	0.0034
Summer- Fall	10	4	4.5	-8	12	10	0.0013	0.0009	-0.0011	0.0028
Winter	6	4	5.5	-1	7	6	0.0002	0.0002	-0.0000	0.0003