B O N N E V I L L E   P O W E R   A D M I N I S T R A T I O N

# Assess Current and Potential Salmonid Production in Rattlesnake Creek in Association with Restoration Efforts

## US Geological Survey Reports

Annual Report 2004 - 2005 | June 2006 | DOE/BP-00005068-4

This Document should be cited as follows:

*Allen, M., Patrick Connolly, Ian Jezorek, Carrie Munz, Jodi Charrier, "Assess Current and Potential Salmonid Production in Rattlesnake Creek in Association with Restoration Efforts; US Geological Survey Reports", 2004-2005 Annual Report, Project No. 200102500, 101 electronic pages, (BPA Report DOE/BP-00005068-4)*

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This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

# Assess Current and Potential Salmonid Production in Rattlesnake Creek Associated with Restoration Efforts

**Draft Annual Report**

**May 2004—April 2005**

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BPA Project Number: 2001-025-00
Contract Number: 00005068

**June 2006**

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## Executive summary

This project was designed to document existing habitat conditions and fish populations within the Rattlesnake Creek watershed (White Salmon River subbasin, Washington) before major habitat restoration activities are implemented and prior to the reintroduction of salmon and steelhead above Condit Dam. Returning adult salmon *Oncorhynchus* spp. and steelhead *O. mykiss* have not had access to Rattlesnake Creek since 1913. An assessment of resident trout populations should serve as a good surrogate for evaluation of factors that would limit salmon and steelhead production in the watershed.

Personnel from United States Geological Survey's Columbia River Research Laboratory (USGS-CRRL) attended to three main objectives of the Rattlesnake Creek project. The first objective was to characterize stream and riparian habitat conditions. This effort included measures of water quality, water quantity, stream habitat, and riparian conditions. The second objective was to determine the status of fish populations in the Rattlesnake Creek drainage. To accomplish this, we derived estimates of salmonid population abundance, determined fish species composition, assessed distribution and life history attributes, obtained tissue samples for genetic analysis, and assessed fish diseases in the watershed. The third objective was to use the collected habitat and fisheries information to help identify and prioritize areas in need of restoration. As this report covers the fourth year of a five-year study, it is largely restricted to describing our efforts and findings for the first two objectives.

Pool frequencies were low and pool quality was typically poor. Large woody debris (LWD) was low in frequency in all surveyed reaches. Adequate shading and

LWD are likely to continue to be limited in the near future because of a lack of large trees, particularly conifers, in the riparian zone. Water temperatures were above the preferred range for rainbow trout throughout much of the summer in 2004, as they were in 2001, 2002, and 2003, particularly in the section immediately above the confluence with Indian Creek (rkm 0.8).

Although fish habitat was degraded, we found a relatively robust population of rainbow trout in Rattlesnake Creek. All reaches appeared to have some successful reproduction, with age-0 trout collected in every reach except upper Mill Creek. The reach below the lowermost waterfall (rkm 2.4) appears to rear substantially more age-0 trout. The riffles in many sections were nearly dry during summer of all sampling years, which provided little habitat for older fish. Recaptured Passive Integrated Transponder (PIT)-tagged fish showed annual growth, but little or no growth during the summer months, likely attributable to poor flow and temperature conditions.

Longnose dace were highly abundant in most reaches of Rattlesnake Creek but were not present in Indian and Mill creeks. Dace population estimates were conduced in lower and middle sections of Rattlesnake Creek in 2002 and 2004. Results indicate that the population is quite variable and that the number and biomass of longnose dace equals or exceeds that of the trout.

Several water falls in the watershed are full or partial barriers to upstream migration. The lower set of three waterfalls on Rattlesnake Creek (highest was 3.6 m in height) appear to be a barrier to resident fish. Lamprey and cutthroat trout were not found above these falls. Only rainbow trout, longnose dace, and shorthead sculpin were found above and below the lower waterfalls. Indian Creek had even fewer species than

Rattlesnake Creek, with cutthroat trout dominating the assemblage. The uppermost trout distribution was determined to be a plunge pool at the base of a 2.5 m waterfall at rkm 16.6. If anadromous fish were to jump these falls, they would meet a pair of falls, at rkm 17.2, that are each over 22 m in height and are certainly fish barriers.

Results from genetic analysis showed that all of the Indian Creek trout submitted for analysis were hybrids of coastal cutthroat trout and rainbow trout (Graziano and Nielsen, in Allen 2006). It also showed that there was little evidence of interbreeding with hatchery fish and that there was a high degree of genetic structure in the White Salmon River and Rattlesnake Creek systems.

Analyses conducted by personnel at the Lower Columbia River Fish Health Center showed heavy infections of diagenic trematodes and suspect cases of BKD in some of the rainbow trout tested. Longnose dace tested positive for BKD and some sculpin were suspected of being infected with BKD, but in general both species appeared healthy. In 2005, we will continue to track the changes in disease presence and severity across time and among reaches.

We conducted extensive PIT-tagging efforts in the Rattlesnake Creek watershed and the mainstem White Salmon River. Over 1,100 PIT tags were inserted in fish in the White Salmon River and Rattlesnake Creek watersheds during 2004, adding to the nearly 4,000 fish that were PIT-tagged in 2001, 2002, and 2003. The instream PIT-tag detector, installed in lower Rattlesnake Creek (rkm 0.3), near its confluence with the White Salmon River in August 2001, has been a success in documenting the number, timing, and spatial extent of juvenile fish outmigration into the White Salmon River and the migration of a spawning population of trout into Rattlesnake Creek. We continued to

partner with NOAA fisheries to maintain and upgrade an instream PIT-tag detector system. With additional tagging and detection efforts in 2005, we will continue to assess patterns of habitat use and population links between the Rattlesnake Creek watershed and the White Salmon River.

During redd surveys, we observed large rainbow trout on redds. These fish were much larger than those we observed during our population survey work in the summer months. As validated by our PIT-tagging efforts and the PIT-tag detector deployed in lower Rattlesnake Creek, it appears that a population of large rainbow trout that reside in the White Salmon River for most of the year migrate up Rattlesnake Creek for overwintering habitat and spawning on an annual basis. This documents an important life history linkage for rainbow trout between the mainstem White Salmon River and one of its largest tributaries, Rattlesnake Creek. It also demonstrates that these rainbow trout are good surrogates for estimating Rattlesnake Creek's potential productivity for steelhead if and when reintroduced above Condit Dam.

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# Introduction

This project was designed to document existing habitat conditions and fish populations within the Rattlesnake Creek watershed (White Salmon River subbasin, Washington) before major habitat restoration activities are implemented in response to the reintroduction of salmon and steelhead above Condit Dam. Returning adult salmon *Oncorhynchus* spp. and steelhead *O. mykiss* have not had access to Rattlesnake Creek since 1914. An assessment of resident trout populations should serve as a good surrogate for evaluation of factors that would limit salmon and steelhead production in the watershed.

Before the construction of Condit Dam in 1913 on the mainstem White Salmon River (at river km 5.1), Rattlesnake Creek (a principal tributary of the White Salmon River at river km 13.8) was likely a productive stream for anadromous salmon, steelhead, and cutthroat trout *O. clarki* (Western Watershed Analysts 1997). With the proposed removal of Condit Dam scheduled for 2008, Rattlesnake Creek has high potential to support reintroduced or naturally colonizing populations of anadromous salmon and steelhead, however, the potential productivity and abundance of anadromous fish is currently limited by existing habitat conditions (Haring 2003).

As noted in previous reports on the Rattlesnake Creek watershed (Stampfli 1994; Western Watershed Analysts 1997; Rawding 2000; Haring 2003, Normandeau Associates 2004), fish habitat has been severely degraded by a number of land-use activities in the watershed. These reports indicated fish habitat conditions in Rattlesnake Creek are compromised by high stream temperatures, low summer flows, lack of woody debris, and

lack of riparian vegetation (affecting both stream shade and potential for recruitment of LWD).

Personnel from United States Geological Survey's Columbia River Research Laboratory (USGS-CRRL) attended to three main objectives within the BPA-funded Rattlesnake Creek project. The first objective was to characterize stream and riparian habitat conditions. This effort included measures of water quality, water quantity, stream habitat, and riparian conditions. The second objective is to determine the status of fish populations in the Rattlesnake Creek watershed. To accomplish this, we derived estimates of salmonid population abundance, determined fish species composition, assessed distribution and life history attributes, obtained tissue samples for future genetic analysis, and assessed fish diseases in the watershed. The third objective is to use the collected habitat and fisheries information to help identify and prioritize areas in need of restoration.

To investigate the potential linkage between Rattlesnake Creek and the White Salmon River, we desired the ability to track movement of fish between the two streams. We cooperated with National Marine Fisheries Service's (NMFS) Manchester Research Station to develop an instream Passive Integrated Transponder (PIT) tag detection system in Rattlesnake Creek. Personnel from NMFS, under the direction of Earl Prentice, installed the system hardware and software. The PIT-tag detection system was installed at the downstream end of our study area in Rattlesnake Creek (rkm 0.2), near its confluence with the White Salmon River.

Tagging fish with PIT tags allows the tracking of individuals within a population. The PIT tags consist of a copper coil and a circuit chip encased in glass. Those used in

fish are generally 10 – 32 mm in length and 2 – 4 mm in diameter. When energized by an electromagnetic signal, the tag returns a unique alphanumeric code of 10 digits with $34 \times 10^9$ possible combinations. Because PIT tags are passive (no battery power) and can uniquely identify individual fish over many years, they have potential to provide information throughout the life span of a fish, which can be 10 years or more for some species. The tags can be read at speeds over an antenna of up to 3.6 m/s (Prentice et al. 1990). They are generally placed in the body cavity of a fish by injection or surgically (Prentice et al. 1990; Gries and Letcher 2002). The tags have not adversely affected growth or survival of fish in laboratory or field tests (Prentice et al. 1990; Achord et al. 1996; Ombredane et al. 1998; Gries and Letcher 2002). Their long life and lack of adverse affect on fish make PIT tags good tools for monitoring of individuals. The range at which PIT tags can be read is small, necessitating the need to physically capture the fish or have the fish pass very close to an antenna.

Use of PIT tags in fish research has recently increased, particularly in the Columbia River basin of the Pacific Northwest. The tags have become a primary method for monitoring juvenile salmonid passage through dams and for computing survival past these dams (Prentice et al. 1986; Nunnalle et al. 1998; Skalski et al. 1998; Muir et al. 2001a). With their long life, PIT tags can also provide information on returning adult anadromous fish. Because of interest in monitoring the fate of individual fish for studies of habitat use, population structure, survival, and responses to environmental variables, the use of PIT tags has large potential and appeal (Prentice et al. 1986, Prentice et al. 1990, Juanes et al. 2000).

Movement and growth of individual fish can be ascertained by subsequent recapture of previously PIT-tagged fish (Ombredane at al. 1998, Juanes et al. 2000). The amount of information gained, however, can be limited by the ability to recapture fish. Additional movement information has been gained by placing PIT-tag detector systems in a stream to detect passing fish (Armstrong et al. 1996, Greenberg and Giller 2000, Zydlewski et al. 2001, Riley et al. 2002). A stationary system has promise to operate continuous and long periods of time, and possibly during times such as high flows and ice cover that are difficult to sample by conventional means.

The detection system was installed to provide life history information such as movement and habitat use of PIT-tagged salmonids at the reach and watershed scale. The Rattlesnake Creek work occurred in concert with a companion study, funded by the U.S. Forest Service for 2001-2003, of rainbow trout in the White Salmon River. The White Salmon River study was an investigation of rainbow trout seasonal habitat use and migration in the White Salmon River, its tributaries, and Northwestern Lake.

As this report covers the fourth year of a five-year study, the data collected are partial and the results presented are preliminary. Reach-scale habitat surveys (hereafter referred to as “reach surveys”), intensive large woody debris (LWD) surveys, redd surveys, and other information collected in 2001-2003 are not included, but can be found in the Rattlesnake Creek annual report of May 2003 to April 2004 (Allen et al. 2006). Information collected in 2001 and 2002 can be found in the annual reports for those years (Connolly 2003a, Connolly 2003b).

Stream temperature, flow, and fish population information that we gathered at key sites in Rattlesnake Creek from May 2004 to April 2005 are presented in this report.

Stable isotope samples were collected by the Underwood Conservation District. These samples were being processed at the time of this writing, but the USGS will analyze and report the findings when the data are available. This report covers the portion of the work completed by USGS under Task 1*a* of Objective 1 (water quantity, stream habitat and riparian conditions) and Tasks 2*a*, 2*b*, and 2*c* of Objective 2 as stated in the Statement of Work submitted in May 2001 by the USGS-CRRL. This report presents our findings from the data we collected through fall 2004.

We used results from habitat surveying, temperature profiling, and flow monitoring to characterize physical habitat conditions and their variation among and within streams of the watershed. Habitat characterization in concert with efforts to assess the fish populations will allow us to assess potential rearing conditions for salmon and steelhead within the watershed. These data should help prioritize sites in need of restoration.

## Study Area

The Rattlesnake Creek watershed covers 143 $km^2$ and supports a third-order stream system with the largest tributary watersheds being the second order systems of Mill and Indian creeks (Figure 1). Rattlesnake Creek enters the White Salmon River at river kilometer (rkm) 13.8, near the town of Husum. Elevations range from 114 m at the mouth of Rattlesnake Creek, which is at the watershed's western boundary, to 927 m at ridge tops near its eastern edge. The watershed's climate is temperate with 75 to 85% of the annual precipitation occurring between October and March. The average annual

precipitation at the western downstream end of the watershed is about 127 cm and decreases to about 80 cm in the eastern upstream extension of the watershed (Western Watershed Analysts 1997). Due to the relatively low elevation of the watershed, precipitation in the winter is largely delivered as rain in the lower elevations and as rain or snow in the higher elevations.

There are two sets of waterfalls in Rattlesnake Creek. The lower set of falls, at rkm 2.4, has three individual drops, with the middle one being the largest (about 3.6 m total height, but with a step and 1.5 m deep pocket at 2.1 m). It is most likely a barrier to the resident fish, but may not have been a barrier to salmon and steelhead. Reiser and Peacock (1985) reported a maximum jumping height of 3.3 m for steelhead, and 2.4 m for Chinook salmon. The upper falls, at rkm 17, has two separate drops of about 22 - 25 m each and is certainly a fish barrier.

There are two main tributaries of Rattlesnake Creek. Indian Creek is a tributary entering Rattlesnake Creek at rkm 0.8. There is a culvert approximately 0.1 km from the mouth of Indian Creek and three other culverts at 1.3 km, 1.8 km, and 1.9 km from Indian Creek's confluence that may be resident fish barriers. Mill Creek is a tributary entering at rkm 14 of Rattlesnake Creek. It has a relatively high gradient section not far from its confluence. Both creeks enter from the north and are fish bearing.

We divided the drainage into four reaches based on geomorphology and potential fish barriers (Figure 1). The lowermost reach (LRAT) starts at the mouth of Rattlesnake Creek and extends upstream about 2.4 km to the lower set of waterfalls. We had permission to sample 1,100 m at the downstream end of this reach and 440 m at the upstream end of the reach. The next reach (BRAT) is confined by canyon walls and

extends from above the lower falls for about 3.1 km to the start of a much less confined section of stream. We had permission to sample all six adjacent sections in this reach totaling 3,140 m. The middle reach (MRAT) is a less constrained alluvial reach that extends 5.3 km between two confined reaches. We had permission to sample on a private landowners section totaling 1,820 m and on Department of Natural Resources (DNR) land totaling 580 m. The uppermost reach (URAT) starts at the base of a canyon and extends about 6.6 km to the base of the upper falls. We had permission to sample the full length of this reach. We had permission to sample two sections of Indian Creek, with the lower section (LIND) being 800-m long and the upper section (MIND) being 880-m long. The two sections were defined by landowner boundaries, but they also constituted parts of two separate reaches defined by their geomorphology.

## Methods

### Habitat Surveys

To conduct habitat surveys at the reach scale, we walked the stream channel and measured a series of variables at 20-m intervals and 100-m intervals. At each 20-m interval, we measured stream width and took a densitometer reading from the stream center. Within each 20-m interval, we measured stream gradient, and counted boulders (diameter $\geq$ 0.5 m), pools, and pieces of LWD. We measured maximum depth in each pool and estimated percent cover for each pool. We also estimated percent spawning area and percent canopy closure within each of these 20-m intervals. At 100-m intervals, we characterized riparian vegetation within a 10-m x 10-m transect and we assessed channel confinement. Within a transect, we documented dominant species of riparian

vegetation. Channel confinement was assessed from estimates of distance to terraces and hill slopes. Much of the reach surveys were completed in 2002. We conducted a more intensive wood survey in 2003 that physically measured each piece larger than 10-cm diameter and 2-m long within the bankfull width. These results are summarized in Allen et al. (2006).

**Temperature**

Personnel from the Underwood Conservation District (UCD) maintained a network of eight thermographs in the Rattlesnake Creek watershed from June 2001 through the present. Sites were chosen to provide extensive coverage of the watershed (Figure 2). All thermograph units deployed and maintained by UCD personnel were Optic StowAway thermograph devices from Onset Computer Corporation (OCC). Prior to deployment, the units were tested for accuracy and adequacy of response time to change in temperature as per instructions from OCC's operating manual.

Thermographs recorded temperature every two hours. Temperature data were downloaded twice a year (spring and fall). To minimize time out of water and missed readings, downloads occurred in the field with use of an OCC optic shuttle. However, the thermographs were removed from the stream in the spring, for up to a week, to be re-calibrated annually. We calculated the daily mean temperature as the mean of the 12 daily readings. We derived the daily minimum and maximum temperatures from the minimum and maximum reading of the 12 daily readings.

**Flow**

Personnel from CRRL established four flow-monitoring stations in the Rattlesnake Creek subbasin (Figure 3). These stations consisted of a site in the lower Rattlesnake Creek (LRAT), a site in Rattlesnake Creek above the Indian Creek confluence (RAIN), a site in the middle section of Rattlesnake Creek within DNR land (MRAT), and site in the middle section of Indian Creek within DNR land (MIND). These stations were visited about every three weeks during June through October.

An additional air bubbler type automated flow gage was installed, at river kilometer 0.6, in 2003 by the UCD and operated by a subcontractor (Figure 3). With this unit, stage measurements were automatically collected every 15 minutes and a rating curve is established to convert the stage measurements to discharge. These data are collected and reported in a method that is consistent with USGS standards for stream flow measurement.

The manual stream flow measurements conducted by USGS were measured following the protocol of Bain and Stevenson (1999). This protocol entailed anchoring a measuring tape perpendicular to stream flow and recording the distance at the left and right wetted edge. We measured water depth and water velocity with a Marsh-McBirney flow meter at a minimum of 10 (usually about 20) intervals along the measuring tape. Because water depths were always less than 1 m, water velocities were measured at 60% of the depth at each interval. The flow at each interval was computed using the equation:

$$Q_n = d_n \times \left( \frac{b_{n+1} - b_{n-1}}{2} \right) \times v_n$$

Where $Q_n$ = discharge at interval *n*, $d_n$ = depth at interval *n*, $b_n$ = distance along the tape measure from the left wetted edge to point *n*, and $v_n$ = mean velocity of interval *n*. Total flow was calculated by summing the flow of each interval.

**Fish**

To obtain estimates of salmonid population, density, and biomass, we first conducted intensive habitat surveys of sampling sections, generally following Bisson et al. (1982) for declaring habitat types. Habitat surveys were performed by measuring the length, width, average depth, and maximum depth of each habitat type (e.g., pools, glides, and riffles) from the start to the end of a fish-sampling site. These surveys were usually performed within a few days of fish sampling. For pools, we estimated the percent cover and types of cover (e.g., substrate, undercut bank, instream and overhead wood). In sections of the LRAT and MRAT reaches, we electrofished a systematic sample of habitat units within strata of habitat types. Habitat units chosen for sampling were blocked off with nets to insure no movement into or out of the unit during sampling. A backpack electrofisher was used to conduct two or more passes under the removal-depletion methodology (Zippin 1956; Bohlin et al. 1982; White et al. 1982). The field guides of Connolly (1996) were used to insure a controlled level of precision in the population estimate (CV < 25% for age-0; CV < 12.5% for age-1 or older trout) was achieved within each sampling unit for each age group considered (two age groups for salmonids age-0 and age-1 or older). These methods were chosen specifically to minimize the number of units sampled by electrofishing and to minimize the number of electrofishing passes conducted. This approach serves to lessen the chance that

individual fish will be exposed to potentially harmful effects of electrofishing while insuring a high degree of precision in our estimates.

In addition to the stratified systematic sampling described above, a less intensive method that we termed "index shocking" was used in other sections sampled for fish. The same intensive habitat survey was conducted as described in the population estimate sampling. We then restricted our sampling to pools. One pass was conducted (upstream and back) with no block nets in place. This method allowed us to sample lengths of stream more quickly, while providing information on the fish population within pools and giving us the ability to measure, weigh, insert PIT tags, and recapture previously PIT-tagged fish. In the early spring as soon as the flow was low enough and in the late fall before the flows increased, we electrofished in select reaches without block nets to gain information on fish movement and growth at additional time periods.

Captured fish were anesthetized with the lightest possible dose of MS-222 before handling and were released to their approximate point of capture after handling. The exception to this protocol was when a fish died before or during handling. These mortalities were given to the U.S. Fish and Wildlife Service's Lower Columbia River Fish Health Center (LCRFHC) for disease profiling. All fish captured were measured for fork length to the nearest mm, weighed to the nearest 0.01 g, and inspected for external signs of disease. Scale samples were collected from fish measuring 70 – 100 mm and over 150 mm to estimate age classes. Because of the difficulty identifying rainbow trout from cutthroat trout when the fork length was less than 80 mm, all those collected below this size were simply called "trout". All trout above this size were identified as either rainbow trout or cutthroat trout, and if the fish had hybrid characteristics, it was typically

classified as a rainbow trout for our population estimates. In order to track movements, growth, and survival of the trout, we inserted PIT tags (12 mm; 134.2 kHz) in most of the trout that exceeded 80-mm in fork length.

The fish provided to the LCRFHC were given a rigorous inspection for disease. Diseases screened at the LCRFHC by testing or microscopic observations included bacterial (bacterial kidney disease, coldwater disease, columnaris, emphysematous putrefactive disease, furunculosis, enteric redmouth), viral (infectious pancreatic necrosis, infectious hematopoietic necrosis, viral hemorrhagic septicemia), and parasitic agents (whirling disease, *Ceratomyxa*, digenetic trematodes, *Myxobolus kisutchi, Myxidium minteri, Hexamita, Gyrodactulus, Scyphidia, Heteropolaria*). During fish collections, all salmonids over 80-mm fork length were visually observed for the presence and severity of black spot (*Neascus).*

Spawning surveys were conducted from 29 March 2002 until no new redds were observed for two consecutive weeks which occurred by 9 May 2002. The LRAT reach was surveyed once a week, with MIND and MRAT surveyed every other week. When redds or spawning fish were seen, we recorded and flagged the location, measured the redd (length, width, depth), estimated dominant and subdominant substrate size, approximated redd age, and recorded the size and species of fish if observed on the redd. To reduce observer error, the same person was involved in all surveys.

**Instream PIT-tag reader**

In August 2001, USGS installed an instream PIT-tag detection system near the mouth of Rattlesnake Creek (rkm 0.2). Grid electrical power was provided to operate the

system. Fiber optic cables were installed and connected to a data-storage computer with software designed to record PIT-tag information. The data storage computer was located in an outbuilding about 100 m from the transceiver(s).

The antennas, designed and built by NMFS, were structured to provide the largest read distance as possible for a 12-mm PIT tag. The antenna wiring and capacitors were housed in 10-cm diameter PVC pipe arranged in rectangular shapes with the interior of the rectangle measuring 200-400 cm in length and 80-100 cm in width. Detection (read) distances for 12-mm PIT tags were variable between antennas and was greatly affected by electronic noise and transceiver tuning. Additionally, during the study period, new PIT-tag models were introduced with corresponding increases in read range. In general, we were able to get read distances in the 10-25 cm range, which was considered acceptable and which allowed any tag passing through the antenna's interior area to be detected.

To determine direction of fish movement and allow calculation of detection efficiency (Connolly et al. 2005), we anchored multiple antennas in the stream in an upstream-downstream configuration about 15 m apart. We began operation with 2 antennas separated by about 15 m (2x1). Each antenna was placed in the thalweg. Initially each antenna was connected to a separate transceiver, FS 1001-A models from Digital Angel, Inc. With subsequent availability of a multiplexing transceiver (FS 1001-M, auto tune, from Digital Angel, Inc.) capable of running up to 6 antennas, we were able to add more antennas without much additional cost. On 17 May 2003, we added 2 antennas, each one next to a previously deployed antenna giving 2 arrays of 2 antennas (2x2). On 4 November 2003, we added another array of two antennas to give a 3x2

system (Figure 4). The antennas were anchored with bolts drilled into large boulders and used as tie downs.

The antennas were placed in various orientations. The upstream most and downstream most antenna arrays were laid flat and secured to the substrate. With our initial 2x1 array we anchored an antenna placed upright, presenting itself much like a window. This upright orientation proved vulnerable to damage or loss from high flows or debris. Therefore, we developed a pivoting design. The antennas in the middle array of the 3x2 system were anchored only by the upstream edge of the antenna, with hinges to produce a pivoting "hybrid" design. Use of pivots allowed these antennas to buoy themselves with rising and falling water levels.

We used MultiMon and MiniMon software on the data collection computer to catalog data into daily files. Files were submitted to the PTAGIS database, administered by Pacific States Marine Fisheries Commission.

## Results

### Habitat Surveys

Reach surveys were completed on 4.1 km of stream in 2001 and 8.0 km of stream in 2002. In 2003, we completed the URAT reach survey (rkm 14.4 to 17.2) past the uppermost fish distribution to the large waterfalls (Figure 1). We also gained permission to sample and surveyed 1.2 km of additional private property in the BRAT and MRAT reaches. The locations of these reach surveys are shown in Figure 2, Table 1, and described in Allen et al. 2006. No new reach surveys were conducted in 2004, but habitat surveys associated with fish population estimates were completed. Reach surveys have

been completed on all lands that USGS had permission to sample and this data set should serve as a thorough baseline for assessing future habitat change and determining site specific restoration needs.

A more intensive wood survey, which included any piece greater than 0.1 m in diameter and 2 m long and covered 12.1 km of the Rattlesnake Creek watershed, was conducted in 2003. The refined wood survey was collected in high resolution (the data set contains the size, location, stability, and function of each qualifying piece) and is intended to be used to help managers with site specific restoration needs and as a reference to assess the degree of change in future conditions. This information is summarized in Allen et al. (2006).

Habitat surveys were conducted in the LRAT, BRAT , MRAT, and MIND reaches prior to each fish population and indexing effort to quantify the area of each habitat type for systematic sampling. The LRAT reach had the highest proportion of riffles (62% low and high gradient riffle combined) in the mainstem and the MIND reach also had very high proportion of riffle (82%, Table 2). The BRAT3 section had a higher proportion of deep pool (42%), however much of this deep pool area was due to one pool that was over 130 m long. The information was collected to be used in estimating fish population characteristics by habitat type, but it can also be used to quantify the amount of each habitat type that was available.

**Temperature**

In the second week of June 2001, UCD placed eight thermographs throughout the Rattlesnake Creek watershed (Table 3, Figure 2). Data from these thermographs were

retrieved in the fall of 2001, 2002, 2003 and 2004, and the thermographs remained in place to collect temperature information. The thermographs were downloaded again in the spring of 2002, 2003, and 2004, and removed from their sites for about one week to calibrate. The analysis in this report covers data collected from June 2001 through November 2004, primarily concentrating on the summer months.

In 2004, the Rattlesnake Creek mainstem site above Indian Creek (RAIN, see Figure 2 for location) consistently had the highest daily maximum temperature, and the TOML site consistently had the lowest daily maximum temperature compared with the other mainstem sites (Figure 5). The RAIN thermograph site also had the highest mean temperature of any of the mainstem sites during July and August of 2001 through 2004 (Figure 6). The mean water temperature in 2004 was warmer than 2001 through 2003 at all sites (Figure 6). In 2004, similar to 2001 through 2003, the coolest mainstem sites were located in the upper BRAT reach (TOML) and the upper drainage (URAT, Figure 2). There was a period in mid-July when there was a temperature shift at the TOML site compared to the other thermograph sites. During that period, it was the coolest site and remained the coolest through late August (Figure 5). This site also has the smallest diel range during that period (Figure 7). This was a similar trend as seen in 2001, 2002 and 2003, although TOML was the coolest site for only a week in August 2001. The temperature shift at this site coincided with the lowest flows of the year. The diel temperature range at the TOML site began to mirror the other sites in late August following cooler weather a few days prior. It remains to be determined if the difference at this thermograph site is due to pool stratification or spring water influence.

Rattlesnake Creek warmed from rkm 17 downstream to its mouth. The rate of warming during July and August varied between sites, but was generally consistent among years (Figure 6). The most variable mean water temperature occurs at the TOML site in July . In July and August of 2001 through 2004, but particularly in July 2003 and August 2002, the monthly mean temperature at the TOML site was much cooler than the upstream site (MRAT). The highest rate of warming was in July 2003 from TOML to the RAIN thermograph site, due to the unusually low mean temperature at TOML. During the summer 2003, a hand held thermometer was used to determine the extent of cooling at the TOML site. The surface water entering and leaving the TOML thermograph pool was notably warmer that the bottom of the pool where the thermograph was and there was no difference between water temperature in the riffles above and below this pool. The bottoms of other large pools in this area were also substantially cooler than the surface water, possibly due to stratification. This illustrates the availability of coldwater refugia in some portions of Rattlesnake Creek. The highest rate of cooling was in August from the RAIN site to the LRAT site, possibly due to the cooling influence of the surface and hyporheic flow from Indian Creek, this cooling effect was consistent from 2001 through 2004. Further study is needed to quantify the extent of cool water refugia available throughout the creek.

The water temperatures in the summer 2004 were above 20 °C for a longer period than in 2001 through 2003. During June through September 2001 through 2004, we recorded many daily water temperatures that exceeded 16 °C at all the mainstem Rattlesnake Creek sites and Indian Creek (Table 4). Only Mill Creek did not exceed 16 °C in 2001, 2002, or 2003; however it did have one day with temperatures above 16 °C in

2004. This 16 °C limit has been set by the Washington Department of Ecology (Washington Department of Ecology, November 18 1997, Chapter 173-201A, Water Quality Standards for the Surface Waters of the State of Washington) as an indicator of stream health. By comparing either the number of days exceeding 16 °C, 18 °C, and 20 °C, 2003 was a warmer summer than 2001 or 2002. In general 2002 had a higher maximum temperature than 2001, 2003, or 2004 (Table 4). However, 2004 had more days with water temperatures above 20 °C than 2001, 2002, or 2003 at nearly all the mainstem sites (Table 4). The highest temperature recorded (23.6) was at Rattlesnake Creek just above the confluence of Indian Creek (RAIN), this was also the case in 2001-2003. This site recorded temperatures higher than 20 °C for 26 days in July, and 22 days in August (Table 5). July was the warmest month in 2004 with the most days above 20 °C among mainstem sites. The mainstem location with the lowest maximum temperatures, in the upper canyon below the waterfalls (URAT), still had many days above 18°C and many days with temperatures above those preferred by salmonids (Table 5).

Most thermograph sites had a diel water temperature range of about 5.5 to 6 °C in July. Most of the other sites matched the annual pattern shown in at the MRAT site with low diel temperature range during the winter and higher fluctuations during the spring and summer (Figure 7). The two sites that are exceptions to this pattern are the thermograph sites in Mill Creek (LMIL) and at TOML. The low annual diel range in Mill Creek is attributed to its well-shaded, high gradient, and north-facing drainage and has been a consistent pattern from 2001 through 2004. The pattern at the TOML site is interesting because it mirrors the diel fluctuations of the other sites in the early spring, but

in early July through late September, the diel range becomes smaller associated with decreasing flows. The duration of reduced diel range at the TOML site was shorter in 2004 than in previous years. The increase in diel range corresponds to fall rains, possibly disrupting the thermocline, or reducing the amount of spring influence.

**Flow**

Five flow measurement sites were sampled in 2004, with three sites on Rattlesnake Creek, one on Indian Creek, and one automated flow gage (Table 6, Figure 3). After June, flow was manually measured every three weeks until late September when flows increased due to fall rains. In addition, an automated flow meter, which became operational on 9 March 2003, was collecting 15-minute stage height continuously from early March until the present with an outage on 2 May 2003 to 15 May 2003 due to power loss. The stage height was transformed, via a rating curve, to discharge (Figure 8). The automated flow station measured a maximum flow of 301 cfs on 30 January 2004 and a minimum flow of 0.51 cfs on 2 July 2004. Rattlesnake Creek at this site was consistently at or below 1 cfs from 14 July 2004 to 21 August 2004. During the summer low flow period the MRAT flow site had essentially no surface flow, and the other sites were well below 1 cfs (Figure 9, Appendix table 4). The 2004 baseline low flow in Rattlesnake Creek was similar to 2001 through 2003 (Figure 10). See Appendix Tables 1 through 4 for manual flow measurements at each site from 2001 through 2004.

During July through October 2004, the upper falls (rkm 17) had no surface flow over the lip of the falls; however, water flowed from the plunge pool at the bottom of the

falls throughout the summer. Many of the riffles between pools or glides had no surface flow from July through October of 2004 in all reaches.

**Fish**

A total of 4.1 km of Rattlesnake Creek and 0.5 km of Indian Creek was sampled for fish by electrofishing in 2004 (Table 7, Figure 3). This compares with a total of 5.3 km on Rattlesnake Creek, 0.8 km on Indian Creek in 2003; 5.4 km on Rattlesnake Creek, 0.9 km on Indian Creek and 0.8 km on Mill Creek in 2002; and total of 3.2 km on Rattlesnake Creek and 0.5 km on Indian Creek during summer 2001. We also hook-and-line sampled on two occasions in the White Salmon River from Husum (rkm 12.7) to about rkm 8.5 in 2004. A total of 5,974 fish were sampled with these combined methods in 2004. This is 1,563 more fish than in 2003. We deployed 1,105 PIT tags, including 100 in MIND and 68 in the White Salmon River near the Rattlesnake Creek confluence (rkm 5.0 and 12.2, Table 7). Mill Creek was not sampled in 2004. A total of 1,501, 751 and 574 PIT tags were deployed in 2003, 2002 and 2001, respectively, in the Rattlesnake Creek watershed. Ninety-three PIT-tagged trout were recaptured in 2002, 282 PIT-tagged trout were recaptured in 2003, and 426 PIT-tagged trout were recaptured in 2004. Life histories of specific fish will be analyzed as additional data becomes available.

We found six fish species in our sampling areas in from 2001 through 2004 (Table 8): rainbow trout, cutthroat trout, longnose dace, shorthead sculpin *Cottus confusus*, brook lamprey *Lampetra richardsoni*, and brook trout *Salvelinus fontinalis.* The brook trout were collected infrequently in the White Salmon River, and limited to two individuals, which were collected in LRAT on 15 October 2002 (151 mm fork

length) and 27 October 2004 (163 mm fork length), presumably on spawning migrations. However, no age-0 brook trout were ever collected in Rattlesnake Creek. Crayfish were present and often abundant in all reaches of the mainstem. Crayfish were low in abundance in Indian and Mill creeks. All fish species listed above were found in the LRAT reach. The fish species present in Indian Creek were limited to cutthroat trout, rainbow trout, and shorthead sculpin. Because brook trout, cutthroat trout, and brook lamprey were not collected above the falls in lower Rattlesnake Creek, these falls appear to be a barrier to resident fish. Sculpin and rainbow trout were present in lower Mill Creek, but only rainbow trout were present in upper Mill Creek.

Pacific giant salamanders *Dicamptodon tenebrosus,* were present, but rare, in Rattlesnake Creek. Three salamanders were observed during sampling efforts from 2001-2004. One was collected in the BRAT reach while electrofishing in 2002, one was observed while electrofishing in the lower 500 m of Mill Creek in 2002, and another was observed in the upper URAT reach (rkm 16.8) during reach surveys in 2003. No salamanders were seen during surveys in 2004. We have not found Pacific giant salamanders in Indian Creek, but more intense sampling would be required to verify their absence.

Mill Creek was sampled in 2002 in a lower reach and an upper reach (Figure 3). In the lower reach, all pools in 500 m were electrofished. Many pools had no fish present, however 8 age-0 and 13 age-1 or older rainbow trout were collected (maximum size 185 mm). There was low sculpin and crayfish abundance, and no longnose dace were found. There was a 460-m long section, 400 m upstream of Mill Creek's confluence, with an average gradient of 11% and several 20 m intervals with 14% to 16%

gradient. These areas were likely barriers to the upstream movement of resident fish. In the upper Mill Creek site all pools and riffles in 180 m were electrofished. Most of the section had no fish and zero age-0 trout and eight age-1 or older rainbow trout were collected (100 mm to 204 mm fork length) in two pools. No crayfish or sculpin were observed. The larger pools appeared to have fish but the stream bed was coated in fine sediment and the pools were easily muddied. Because of this poor visibility our electrofishing effort in 2002 in upper Mill Creek was not extensive, so there may be other species present in that reach that were not found at that particular site.

The uppermost fish distribution in the mainstem of Rattlesnake Creek was determined when conducting reach surveys in the upper URAT reach. As we were collecting habitat data in the URAT reach, rainbow trout were readily visible in many pools. The uppermost pool that fish were visible was a plunge pool directly below a 2.5 meter high waterfall at rkm 16.6 (Figure 3). Approximately 20 m above this waterfall was an unnamed tributary entering from the southeast. This tributary was in a relatively deep canyon that is easily visible on a topographic map. This tributary was nearly dry and had a 10-m waterfall 60 m from its confluence with Rattlesnake Creek. There were several bedrock pools in the tributary with crayfish but no fish visible. In the mainstem Rattlesnake Creek above the 2.5 m high waterfall, there were several bedrock pools, where many crayfish and one Pacific giant salamander were sighted. No longnose dace, sculpin, or trout were visible in the remainder of the pools up to and including the large plunge pool below the 27-m waterfall (the lower of two large waterfalls that mark the upper end of our survey).

To assess the genetic population structure and hybridization of rainbow and cutthroat trout, fin clips of these trout collected from above Husum Falls, from below Husum Falls, from Rattlesnake Creek, and from Indian Creek in 2001 and 2002 were submitted for genetic analysis (Graziano and Nielsen, in Allen 2006). The Graziano and Nielsen report found that all of the samples submitted from the MIND reach were coastal cutthroat and rainbow trout hybrids (n=13), and 6 of 14 samples from the LRAT reach were hybrids.

The trout populations in most reaches of Rattlesnake Creek appear to be robust. We conducted population estimates for trout in the LRAT reach in 2001, 2002, 2003 and 2004 (Figure 11a). There was a substantial age-0 trout population and biomass in each year. There was a decrease in the age-1 or older rainbow trout population from 2001 to 2002, but the population rebounded slightly in 2003 and remained at a similar abundance for 2004(Figure 11a). Differences between years for cutthroat trout in the LRAT reach were not as clear, given the small numbers collected in each year. However, the cutthroat population decreased from 2001 through 2004. The MRAT reach had population estimates conducted in 2002, 2003, and 2004, with an "index" of the population in 2001 (Figure 11b). From 2002 to 2003, both the age-0 and age-1 or older trout populations decreased. The population of age.-1 rainbow trout rebounded slightly in 2004. The index shocking method was used in the LRAT2, BRAT3, BRAT6, MRAT1, and MIND sections in 2004. Population shocking methods were conducted in the LRAT1 and MRAT 2 sections in 2004. Figure 12 illustrates the variability in the trout population and biomass among the all the reaches sampled in 2004. As with previous years, there were substantially more age-0 trout in the LRAT reach compared to all other reaches. As was

found during the other years of sampling, there was also a notably larger biomass of cutthroat trout per square meter in the MIND reach compared with all sites sampled. Trout populations and age structure varied from year-to-year, and age-0 trout were persistent.

The longnose dace population was highly variable in Rattlesnake Creek. Longnose dace populations in the LRAT and MRAT reaches were estimated in 2002 and again in 2004. There was a nearly four-fold increase in the number and biomass of longnose dace from 2002 to 2004 in the LRAT reach (Figure 11a). At the same time there was a greater than 13-fold decrease in the number and biomass of longnose dace in the MRAT reach from 2002 to 2004 (Figure 11b). These data suggest that the longnose dace population was variable and influenced by localized biotic and abiotic factors.

As in 2003, the maximum fork length recorded for an age-0 trout was 90 mm (collected in 29 September 2004 for m the BRAT1 section, Table 9). The maximum fork length for an age-0 trout in 2001 was 92 mm from the BRAT reach. In 2002, it was 95 mm from the MRAT reach, and in 2003 it was 90 mm from the BRAT reach. Similar to previous years, the minimum length of an age-1 fish on Rattlesnake Creek was 81 mm in late June from the LRAT1 site. The minimum length of an age-1 fish in 2003 was 80 mm from the LRAT1 section, in 2002 it was 88 mm from the MRAT2 section in July, and in 2001, and it was 78 mm in the LRAT1 reach in August. The tributaries had smaller fish with a maximum age-0 trout fork length of 58 mm in MIND and 65 in LIND. No age-0 trout were sampled in the URAT reach in June 2004 indicating that the age-0 trout had not yet come out of the gravel. In late September 2004 the maximum age-0 trout fork length was 80 mm. Ages were determined with length-frequency analysis

(Figures 13a-e) and by aging scales from those fish near the estimated fork-length limits for each age. Because of the difficulty differentiating between rainbow and cutthroat trout that are smaller than 80 mm, we did not estimate the maximum length of age-0 cutthroat trout in LRAT.

During our fish sampling efforts in 2004, we recaptured 426 trout that had been previously PIT tagged (Tables 10 and 11), this does not include detections of fish on the instream PIT-tag detection system. The MRAT reach had highest number of recaptured fish in 2004 (143 trout tagged in 2003 and 49 trout tagged earlier in 2004). In the URAT reach most fish were recaptured within a few pools of their original tagging location, but two fish tagged in the URAT reach were recaptured in the BRAT reach. No fish tagged in either lower or upper Mill Creek were recaptured, however those sites were not re-sampled. In the MRAT reach a few trout were recaptured in the downstream adjacent BRAT reach, but most were recaptured in the same reach they were tagged. One relatively large cutthroat trout (235 mm) was tagged in the LRAT1 section on 10 October 2003 and recaptured, presumably on a spawning migration, on 17 March 2004 in the MIND reach. When recaptured, it was 2-mm longer and 0.3 grams lighter. This recapture event provides evidence that the culverts on Indian Creek between it's confluence and the MIND reach (rkm 2.4 to 3.28) are not barriers to upstream migrations of larger resident fish. Fish tagged in the MIND and LIND reaches were recaptured in the same reaches they were tagged (Table 11). Fish tagged in the White Salmon River between rkm 5.0 and 12.2 were not recaptured during electrofishing efforts in Rattlesnake Creek. There are many individual fish recapture histories that could be analyzed in future reports. In general fish were recaptured in the same reach that they were tagged, however

this does not mean that they did not migrate between electrofishing occasions. Most of the recaptures were of fish tagged the year before, or fish tagged earlier in the same year (Tables 10 and 11).

The change in length of recaptured PIT-tagged fish from initial tagging to each time of recapture at the LRAT1 site showed growth had occurred from year to year, but not during the summer months (Figure 14a). This pattern of negligible summer growth is also demonstrated at the MRAT2 site and the MIND site (Figures 14b and 14c). The typical growth rate, determined by the slope of the lines connecting individual fish recapture events, appeared to be fastest in the MRAT2 site and slowest in the MIND site. We plan to more fully analyze these growth data with additional recaptures and include movement information where available.

Fish were submitted to the LCRFHC for disease assessments from four reaches and six sampling dates in 2004 (Appendix B). A total of 78 rainbow trout were submitted from Rattlesnake Creek and 1 rainbow trout from the White Salmon River. In general, the trout were in good health with some suspected or confirmed presence of bacterial kidney disease (BKD), *Renibacterium salmoninarum* found in most reaches. *Aeromonas* was found in June in the LRAT reach and mid-July in the MRAT reach. *Henneguya* spores and digenetic trematodes were also present in low intensity in some samples.. As in previous years the trout sampled had the parasite *Nanophyetus* in the hind-gut or gills. Black spot, caused by the parasite *Neascus,* was regularly seen by USGS personnel on salmonids and longnose dace in every reach. In some cases the black spot infections made the fish appear as if they had been rolled in pepper. This parasite was confirmed in the fish health surveys. The one trout submitted from the White

Salmon River was in good health with no parasites. These findings were similar to the types and intensity of parasites found in previous years.

Spawning surveys were conducted from 29 March 2004 to 3 May 2004 in the LRAT1 and LIND sections. During the first survey, the water turbidity and high flow made redd detection difficult. As flows subsided and the water cleared, the small patches of suitable substrate, dark substrate color, and lack of algae on the submerged rocks continued to make redd identification difficult. Therefore, only definitive redds and fish seen exhibiting spawning behavior are reported here. Thirteen redds were observed and three fish with spawning behavior were observed from 29 March 2004 to 19 April 2004 in LRAT1. In the LIND reach three redds were observed, but the small patches of appropriate substrate made redd identification difficult. During that time, water temperatures were between 7 °C and 10 °C. As in previous years, several trout (300 – 500 mm total length), much larger than those handled during our surveys in the summer, were observed and documented in spawning areas, or on redds in the lower LRAT reach. It is believed that these fish entered Rattlesnake Creek from the White Salmon River for spawning purposes.

The importance of Rattlesnake Creek as a substantial spawning tributary for the White Salmon River trout population was supported by data collected with the instream PIT- tag detector located at rkm 0.2 in the LRAT1 reach. Between 25 August and 31 December 2004, we have detected 169 individual fish at our system (Table 12; Figure 15). The majority of these fish (110) were from the lower 1.3 km of Rattlesnake Creek. Eighteen fish from Indian Creek have been detected outmigrating. We believe these fish are outmigrating to the White Salmon River. Two fish from Rattlesnake Creek have

migrated downstream past the detector and later returned, and three fish from Indian Creek have migrated past the detector and later returned. We have recorded 31 PIT-tagged trout from the White Salmon River migrating up Rattlesnake Creek, presumably for spawning. Three of these fish have made two migrations into and out of Rattlesnake Creek. Many of the fish that have been tagged may out-migrate in coming months or years and many that have already passed the detector may yet return as they mature.

We examined the seasonal timing of the first detections of migrants. The majority of migrants from Rattlesnake and Indian Creeks (n = 138) passed during spring (March, April, May; 57%), but migrants from both upper and lower Rattlesnake Creek passed during winter (December, January, February; 21.7%), summer (June, July, August; 8.7%), and fall (September, October, November; 12.3%). No Indian Creek fish were detected during summer or fall (Figure 16). The majority of migrants from the White Salmon River (n = 31) also passed during spring (41.9%), but combined migrants during winter (35.5%) and fall (22.6%) exceeded spring detections.

We have begun investigating the efficiency of the system with different antenna-array configurations and at different flows. In the first year of operation with our 2x1 design the detection efficiency of downstream-moving fish during low flows (<14 cfs) was 94% (SE = 4.2; n = 18), but was reduced to 69% (SE = 19.8, n = 15) during high flows. By adding antennas lateral to the original antennas (2x2 design; Figure 4) and with improvements in the tags themselves, the detection efficiency of downstream-moving fish increased at both high and low flows, across all flows it was 98.8% (SE = 0.4; n = 173). Detection efficiency of upstream-moving fish was good in both the 2x1 (88%; SE = 8.8; n = 17) and 2x2 (98%; SE = 2.4; n = 14) systems during all flows. Our

estimates of efficiencies at high flows may be an overestimate due to low sample size and lack of interrogations at the highest flows. Further data collection will allow greater exploration of efficiencies at different flow and antenna configuration scenarios.

## Discussion

All areas that USGS had permission to survey for habitat variables have been completed. These data have been collected in much finer resolution than could be reported in an annual report format. These data have been entered and stored electronically at the USGS Columbia River Research Laboratory and are available to ascertain specific locations for habitat restoration work.

In general the habitat surveys showed that large wood and pools were low in frequency throughout the system. Similar to what others have concluded about habitat conditions on Rattlesnake Creek (Western Watershed Analysts 1997; Stampfli 1994; Rawding 2000, Normandeau Associates 2004), these factors indicate degraded fish habitat conditions in Rattlesnake Creek. Our reach and wood surveys showed that the reach with the highest amount of LWD (MRAT) still had less than half of the minimum amount of LWD that NMFS (1996) recommend for a stream to be described as "properly functioning". Likely a result of low levels instream LWD, the creek channel has long low-gradient riffles and few high-quality rearing pools for fish (see Johnson et al. 1985 as referenced in Meehan 1991). Habitat surveys conducted in 2004 associated with fish population efforts confirmed that there were fewer pools in the drainage than the recommended minimum. Many of the existing pools were of poor quality, they were shallow and glide like, with little instream fish cover. Bisson and Sedell (1984) observed

elongated riffles and a reduction in the number of pools in streams where LWD quantities were low. This condition and process appears to fit Rattlesnake Creek.

Our riparian canopy survey showed that most of the Rattlesnake Creek was dominated by small-diameter red alder. There appears to be limited potential for recruitment of LWD large enough to persist in the near future. The small-diameter deciduous trees do not likely provide adequate shading, as discussed below.

The automated flow gage installed in Rattlesnake Creek provided much more detailed view of the flow regime in Rattlesnake Creek. It confirmed our summer low flow measurements and our winter high flow observations. In both years of operation summer low flows dipped below 0.5 cfs during the hottest portion of the year. Winter peak flows were more than 1000 times higher than low flows. Winter peak flows were not particularly high for both 2003 and 2004 throughout our region, but the low flows may be lower than typical due to regional drought. Changes in the timing and quantity of flow are strongly related to stream health. Changes in vegetation, forest maturity, soil compaction, grazing, and road density all influence both high and low flow extremes. Removal of beavers and ditching in the Panakanic plateau has reduced the acreage of associated wetland complexes (Western Watershed Analysts 1997). This and the reduced instream LWD, and floodplain disassociation combine to reduce the streams ability to buffer high flow events and reduce infiltration and groundwater recharge to reduce the duration and severity of low flow extremes in this watershed.

Water temperatures in Rattlesnake Creek are a concern because they were regularly above the preferred range for rainbow trout throughout the summer of 2001, 2002, 2003, and 2004 particularly in the section above the confluence with Indian Creek.

These high temperatures combined with low base flows could make summer a stressful and potentially lethal time for trout in Rattlesnake Creek. Water from the plateau above the upper waterfall, when flowing, was warm (up to 20 °C) upon entering the fish bearing sections of Rattlesnake Creek. Water in the upper canyon had daily maximum temperatures that were above 16 °C nearly all of the days in July and nearly half of August. These warm temperatures coincided with very low flows. The riffles in many sections were nearly dry throughout the summer and did not provide much habitat for adult fish. Many of the larger fish are then concentrated in to the pools. Optimum feeding temperature for rainbow trout is between 13 °C and 16 °C (Cherry et al. 1975; Kaya 1977). As water temperatures increase beyond about 15 °C, metabolic costs escalate rapidly and available food resources support progressively lower densities of juvenile salmonids (Li et al. 1995). At temperatures above 20 °C, rainbow trout can experience high metabolic demands and stress, which can lead to suppressed growth and increased early mortality (Hokanson 1977; Nielsen et al. 1994). At temperatures above 24 °C, high mortalities can occur (Cherry et al. 1975), with the upper incipient lethal temperature reported as 25.6 °C (Bidgood and Berst 1969; Hokanson 1977). Rattlesnake Creek approached lethal temperatures with the highest temperature recorded of 23.6 °C just above the confluence with Indian Creek. These temperatures were similar to those recorded in 2001 through 2003.

The thermograph site above the confluence with Indian Creek (RAIN) recorded the warmest water temperatures found throughout the summer of 2001, 2002, 2003 and 2004. There were many long shallow glides that were exposed to the sun in the BRAT and LRAT reaches, between the TOML and RAIN thermograph sites. However, the

temperatures were reduced below the Indian Creek confluence (LRAT), probably due to the surface and hyporheic inflow from Indian Creek. The lack of sufficient canopy shade (ranging by reach from 30% to 67%) likely exacerbates this water temperature problem. There were no 100-m averages, and only a few 20-m sites surveyed in mainstem Rattlesnake Creek that approached 90% shading, the recommended level by Western Watershed Analysts (1997).

The water in Mill Creek (rkm 14) was substantially cooler than Rattlesnake Creek or Indian Creek (rkm 0.8). Mill Creek had some of the highest riparian shade and had low diel temperature variation. Stream temperatures can be affected by characteristics such as ambient air temperature, water velocity, flow, depth, riparian canopy cover, and groundwater inflow. Although Mill Creek and Indian Creek have a similar aspect and similar amounts of shading, Mill Creek has a higher elevation (360 m vs. 128 m at mouth), a steeper gradient (8.1% vs. 2.8% in the lower 1000 m), and is in a deeper valley than Indian Creek. These geomorphic features may be a primary explanatory factor for the low diel variation and coolness of Mill Creek relative to Indian Creek.

As in 2001 through 2003, water temperatures at the TOML site were cooler than the sites either upstream or downstream. This may be due to groundwater inflow or pool stratification. This thermograph site was at the downstream end of a 5-km long alluvial reach and just upstream from the more confined BRAT reach. Bounded alluvial valley segments have been associated with increased groundwater inflow (Baxter et al. 1999; Stanford and Ward 1993). In streams with higher than optimal temperatures, salmonids have been shown to use thermal refugia such as coldwater patches created by

groundwater seeps, springs, and thermal stratification within stream channels (Nielsen et al. 1994; Ebersole 2001).

Although fish habitat was degraded, we found a relatively robust population of rainbow trout in Rattlesnake Creek, with many pools containing over 30 age-1 rainbow trout. In 2002, 2003, and 2004, the length and weight of the recaptured fish in Rattlesnake Creek showed annual growth, but a lack of growth during the summer months. High metabolic costs due to higher than optimal temperatures may be a factor limiting growth in the summer.

Results from disease profiling provided by U. S. Fish and Wildlife Service's Lower Columbia River Fish Health Center indicate that longnose dace and shorthead sculpin were relatively healthy. Most trout were healthy, but some individuals had heavy infections of diagenic trematodes and BKD. Black spot infections were common in the longnose dace and trout handled by USGS personnel. There are a variety of chemical, physical, biological, and ecological parameters that influence a fish population's ability to withstand disease (Snieszko, 1974). The elevated parasitic infections of these fish may be due to increased stress during times of high temperature and low flow. Disease can directly influence success of reproduction, performance, susceptibility to predation, and other critical factors required for the survival of a species (Hedrick, 1998). There will be additional disease samples in 2005, and we will track the changes in disease presence and severity over time and among reaches.

All reaches seemed to have some successful reproduction, with age-0 trout collected in every reach except upper Mill Creek. In 2001, 2002, and 2003 there was a higher number of age-0 trout in the LRAT reach than other reaches. This was likely to be

due to trout in the White Salmon River using lower Rattlesnake Creek as a spawning tributary rather than habitat availability.

We have collected two brook trout, but no bull trout in Rattlesnake Creek. The brook trout were collected in the LRAT1 section of Rattlesnake Creek on 15 October 2002 and 27 October 2004. Brook trout are known to inhabit the White Salmon basin, and we believe these fish may have been on spawning migrations (brook trout are fall spawners). No bull trout have been collected in Rattlesnake Creek and water temperature would indicate that it is not suitable for bull trout during the summer months. We have not collected any age-0 brook trout or bull trout throughout four years of intensive sampling, so we do not believe there is a reproducing population of either species of trout in Rattlesnake Creek.

The lower waterfalls on Rattlesnake Creek appear to be an upstream passage barrier to resident fish. Lamprey and cutthroat trout were not found above these falls. Only rainbow trout, longnose dace, and shorthead sculpin were found above and below the lower waterfall. Only three PIT-tagged fish were recaptured in an upstream reach (two fish migrated from BRAT to MRAT and one fish migrated from LRAT to MIND), and no LRAT fish have been recaptured above the lower falls. The majority of fish (99%) were recaptured in the same reach that they were initially tagged and a few (n = 7) were recaptured in a downstream reach. Based on our electrofishing recapture data, which occurred in the lower flow time of year, most of the rainbow and cutthroat exhibited a resident trout, stationary life history, with little movement detected among reaches. One exception was a cutthroat trout, which was tagged in LRAT and recaptured in MIND, likely during a spawning migration. This fish's recapture provides evidence

that the culverts on Indian Creek are not total upstream migration barriers (at least for a larger resident trout) and that there may be brief upstream spawning migrations that we typically would not detect unless the fish remained into the low flow period of the year. This was where the instream stationary PIT-tag detector provided evidence of otherwise undetected life history traits.

The idea that Rattlesnake Creek is an important spawning tributary for the rainbow trout population in the White Salmon River has been supported by PIT tagging data and three years of spawning surveys. During spawning surveys, large rainbow trout were observed on redds. These trout were much larger than those we capture during our population survey work in the summer months. These fish, believed to be from the White Salmon River, use Rattlesnake Creek for spawning. The instream PIT-tag detector has confirmed the importance of Rattlesnake as a spawning and rearing tributary. Without the instream PIT-tag detector information, our PIT-tag recapture data would support evidence of a resident, non-migratory fish population in Rattlesnake and Indian Creeks. The instream reader detected fish traveling into and out of Rattlesnake Creek during times of the year when electrofishing would not have been feasible due to high, cold water. The instream PIT-tag reader has proved invaluable in establishing the life histories expressed in the fish population.

Much of the movement past the instream PIT-tag detector was during high flow events and in the spring. However, many of the fish initially tagged in the White Salmon were detected entering Rattlesnake Creek during fall and early winter and spent much of the winter and spring residing in Rattlesnake Creek. It is unknown whether there is winter spawning occurring or if Rattlesnake Creek is a winter refugia from high flows in

the White Salmon River. These data bear further investigation to relate movement to environmental variables such as temperature and flow.

The sample size for detections of migrating fish is likely to increase in 2005. Many of the juvenile trout we captured and PIT-tagged in 2003 and 2004 would not have had time to grow for a year or two and return past the detector. Also, to learn about potential age-0 outmigration timing, we began tagging trout greater than 70 mm, but less than 80 mm for the first time in fall of 2004. These fish would not have had a chance to be detected if they migrated spring of 2005. We anticipate much more data on movement, return of migrants as adults, and duration of use of Rattlesnake Creek for spawning or overwintering to be collected during the next two years. This information will help determine the significance and persistence of what appears to be a potadromous spawning population. We will continue to monitor the remote PIT-tag reader at the mouth of Rattlesnake Creek, and the PTAGIS database will be queried for detections of fish passing by.

## Acknowledgements

We would like to thank many people who assisted us with this project. Jim Petersen served as the Project Leader and helped with the administration and planning of the project. We thank Ian Jezorek and Kyle Martens as crew leaders, and Joe Feldhaus, Sarah Rose, Scott Sebring, and Brian Beardsley for performing data collection, data entry, and assisting with report preparation. Thanks to the many CRRL employees who helped intermittently with our fish sampling. Jim White, Tova Cochran, and Roz Plumb

of Underwood Conservation District provided the thermograph data reported here and served as great sources of historical information about the watershed. Ken Lujan and Susan Gutenberger of the USFWS's Lower Columbia River Fish Health Center provided the fish health profiles. Earl Prentice, Sandra Downing, Bruce Jonasson, and Ed Nunallee of NOAA Fisheries were instrumental for the hardware and software installation and troubleshooting. Thanks to Steve Stampfli for allowing use of his property for the PIT-tagging system, the automated flow gage, and fish and habitat sampling. Many other private landowners granted us permission to sample on their property and they deserve large thanks for the inconvenience and hospitality. Without their help, this project would not be possible. Thanks to John Baugher, our BPA Contracting Officer Technical Representative.

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Table 1. Locations of reach surveys (rapid-reach type) conducted within the Rattlesnake Creek watershed 2001 through 2004. Coordinates were obtained from a hand-held Global Positioning System (GPS) using North American Datum 1927. Sites are listed from upstream to downstream within a watershed.

| **Watershed** Site | Survey year | Start point distance from from mouth (km) | Length of survey (km) | Coordinates at start Northing | Coordinates at start Easting | Coordinates at end Northing | Coordinates at end Easting |
|---|---|---|---|---|---|---|---|
| **Rattlesnake Creek** | | | | | | | |
| URAT 2 | 2003 | 14.4 | 2.9 | 5079978[a] | 626878 | 5081699[a] | 628262 |
| URAT 1 | 2002 | 10.8 | 3.6 | 5078524 | 624154 | 5079978[a] | 626878 |
| MRAT 2 | 2001 | 7.2 | 0.6 | 5076347 | 622077 | 5076668 | 622403 |
| MRAT 1 | 2002 | 6.0 | 1.2 | 5074988[a] | 620994 | 5076351 | 622064 |
| BRAT 6 | 2003 | 4.8 | 1.2 | 5074953 | 620709 | 5075846 | 621240 |
| BRAT 5 | 2002 | 4.3 | 0.5 | 5074092 | 620731 | 5074953[a] | 620709 |
| BRAT 3 and 4 | 2001 | 3.3 | 1.0 | 5074176 | 620038 | 5074390 | 620640 |
| BRAT 2 | 2002 | 2.9 | 0.4 | 5073959 | 619687 | 5074176 | 620038 |
| BRAT 1 | 2001 | 2.4 | 0.5 | 5073738 | 619276 | 5074077 | 619658 |
| LRAT 2 | 2002 | 2.0 | 0.4 | 5073589[a] | 618900 | 5073743 | 619284 |
| LRAT 1 | 2001 | 0.2 | 1.1 | 5072424 | 617997 | 5073141[a] | 618415 |
| **Mill Creek** | | | | | | | |
| LMIL | 2002 | 0.0 | 1.0 | 5079735 | 626489 | 5079033 | 627106 |
| **Indian Creek** | | | | | | | |
| MIND | 2001 | 2.2 | 0.9 | 5071551 | 620085 | 5071699 | 620025 |
| LIND | 2002 | 0.1 | 0.8 | 5072713 | 618456 | 5072560[a] | 619234 |

[a] Position obtained with mapping software, all others obtained with hand held GPS device in the field..

Table 2. Location, length, area, and percent of each habitat type from surveyed locations in the Rattlesnake Creek watershed, 2004. Shallow pools were defined as having a depth of ≤90 cm for Rattlesnake Creek and ≤60 cm for tributary streams. Percent habitat was calculated using area. Backwater pools and side-channels were not included in total survey length, but were included for total surface area. Sites are listed in an upstream to downstream pattern.

| | | | | Habitat type (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Watershed** Site | Start distance from mouth (km) | Total survey length (m) | Total surface area ($m^2$) | Shallow pool | Deep pool | Back water pool | Glide | High gradient riffle | Low gradient riffle | Side channel | Step |
| **Rattlesnake Creek** | | | | | | | | | | | |
| MRAT 2 | 7.35 | 625 | 3,756 | 31 | 14 | 2 | 10 | 0 | 41 | 2 | 0 |
| MRAT 1 | 6.09 | 695 | 3,165 | 28 | 16 | 4 | 10 | 0 | 43 | 0 | 0 |
| BRAT 6 | 4.81 | 458 | 3,080 | 24 | 20 | 0 | 22 | 13 | 21 | 0 | 0 |
| BRAT 3 | 3.31 | 792 | 4,876 | 19 | 42 | 1 | 12 | 0 | 26 | 1 | 0[a] |
| LRAT 2 | 1.95 | 414 | 2,671 | 37 | 6 | 1 | 3 | 15 | 26 | 11 | 1 |
| LRAT1 | 0.20 | 1,081 | 7,998 | 26 | 8 | 0 | 3 | 14 | 48 | 0[a] | 0[a] |
| **Rattlesnake Cr. overall** | | **4,065** | **25,546** | **26** | **18** | **1** | **9** | **8** | **36** | **2** | **0**[a] |
| **Indian Creek** | | | | | | | | | | | |
| MIND | 2.40 | 473 | 1,123 | 17 | 0 | 0[a] | 1 | 69 | 13 | 0 | 0 |

[a] Habitat type present, but consisted of < 0.5% of surveyed habitat area.

Table 3. Locations of thermographs deployed and maintained by Underwood Conservation District within the Rattlesnake Creek watershed. Sites are listed from upstream to downstream within a subbasin. For additional information on thermograph locations see Figure 2.

| Watershed<br>Subwatershed | Code | Coordinates | | Elevation (m) | Distance upstream from mouth (km) | Date | |
|---|---|---|---|---|---|---|---|
| | | Northing | Easting | | | Start dd/mm/yy | End[a] dd/mm/yy |
| Upper Rattlesnake Creek | URAT | 5081213 | 628410 | 457 | 16.9 | 07/06/01 | ongoing |
| Mill Creek | LMIL | 5079549 | 626619 | 396 | 0.2 | 08/06/01 | ongoing |
| Upper Rattlesnake Creek below canyon | BUPC | 5078753 | 624011 | 292 | 11.3 | 08/06/01 | ongoing |
| Middle Rattlesnake Creek | MRAT | 5076576 | 622218 | 250 | 7.7 | 08/06/01 | ongoing |
| Tomlin property | TOML | 5074768 | 620819 | 226 | 5.6 | 07/06/01 | ongoing |
| Lower Rattlesnake above Indian Creek | RAIN | 5072747 | 618418 | 131 | 0.8 | 07/06/01 | ongoing[b] |
| Indian Creek | LIND | 5072689 | 618451 | 131 | 0.0 | 07/06/01 | ongoing |
| Lower Rattlesnake Creek | LRAT | 5072419 | 617933 | 122 | 0.1 | 07/06/01 | ongoing |

[a]Thermographs were removed annually in the spring for calibration.
[b]The RAIN thermograph was lost over winter 2003, replaced 19 May 2003.

Table 4. Number of days when maximum water temperature exceeded 16, 18, and 20 °C, and yearly maximum water temperature recorded at locations in the Rattlesnake Creek watershed, 2001-2004. Thermograph locations are listed from upstream to downstream. Refer to Table 3 and Figure 2 for additional site information.

| Site | RKM | Number of days ≥ 16°C | | | | Number of days ≥ 18°C | | | | Number of days ≥ 20°C | | | | Maximum (°C) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2001 | 2002 | 2003 | 2004 | 2001 | 2002 | 2003 | 2004 | 2001 | 2002 | 2003 | 2004 | 2001 | 2002 | 2003 | 2004 |
| Mainstem | | | | | | | | | | | | | | | | | |
| URAT | 16.9 | 47 | 59 | 75 | 62 | 15 | 22 | 26 | 33 | 0 | 2 | 1 | 0 | 19.5 | 20.3 | 20.5 | 19.5 |
| BUPC | 11.3 | 81 | 80 | 89 | 83 | 48 | 50 | 58 | 61 | 16 | 19 | 11 | 36 | 21.4 | 22.4 | 21.6 | 22.6 |
| MRAT | 7.7 | 87 | 91 | 98 | 90 | 51 | 62 | 70 | 63 | 11 | 27 | 31 | 38 | 21.7 | 22.3 | 22.7 | 23.0 |
| TOML | 5.6 | 78 | 56 | 14 | 88 | 23 | 31 | 3 | 37 | 0 | 6 | 0 | 7 | 19.5 | 21.3 | 19.2 | 20.7 |
| RAIN | 0.8 | 103 | 101 | 110 | 93 | 72 | 72 | 83 | 76 | 38 | 39 | 51 | 57 | 23.2 | 24.1 | 23.8 | 23.6 |
| LRAT | 0.1 | 97 | 96 | 109 | 93 | 57 | 62 | 67 | 75 | 10 | 25 | 25 | 36 | 21.1 | 23.5 | 22.1 | 21.7 |
| Tributaries | | | | | | | | | | | | | | | | | |
| LMIL | 0.1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15.7 | 15.4 | 15.4 | 16.0 |
| LIND | 0.0 | 85 | 86 | 96 | 89 | 41 | 54 | 66 | 60 | 9 | 14 | 18 | 30 | 20.8 | 21.8 | 21.8 | 21.6 |

Table 5. Number of days per month when maximum water temperature exceeded 16, 18, and 20 °C and the monthly maximum water temperature recorded at locations in the Rattlesnake Creek watershed during 2004. Locations are listed from upstream to downstream. Refer to Table 3 and Figure 2 for additional site information.

| Site | RKM | Number of days ≥ 16°C | | | | Number of days ≥ 18°C | | | | Number of days ≥ 20°C | | | | Maximum (°C) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep | Jun | Jul | Aug | Sep |
| Mainstem | | | | | | | | | | | | | | | | | |
| URAT | 16.9 | 10 | 29 | 23 | 0 | 1 | 19 | 13 | 0 | 0 | 0 | 0 | 0 | 18.1 | 19.5 | 19.2 | 15.5 |
| BUPC | 11.3 | 14 | 31 | 31 | 7 | 9 | 27 | 25 | 0 | 0 | 19 | 17 | 0 | 19.1 | 22.6 | 22.1 | 17.7 |
| MRAT | 7.7 | 16 | 31 | 31 | 12 | 9 | 28 | 26 | 0 | 0 | 19 | 19 | 0 | 19.7 | 23.0 | 22.2 | 17.8 |
| TOML | 5.6 | 20 | 31 | 31 | 6 | 13 | 21 | 3 | 0 | 1 | 6 | 0 | 0 | 20.0 | 20.7 | 18.5 | 17.6 |
| RAIN | 0.8 | 19 | 31 | 31 | 12 | 14 | 31 | 30 | 1 | 9 | 26 | 22 | 0 | 22.0 | 23.6 | 23.0 | 18.5 |
| LRAT | 0.1 | 19 | 31 | 31 | 12 | 14 | 30 | 30 | 1 | 8 | 19 | 9 | 0 | 21.5 | 21.7 | 21.0 | 18.7 |
| Tributaries | | | | | | | | | | | | | | | | | |
| LMIL | 0.1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13.7 | 15.5 | 16.0 | 14.1 |
| LIND | 0.0 | 16 | 31 | 31 | 11 | 9 | 26 | 25 | 0 | 0 | 16 | 14 | 0 | 19.5 | 21.6 | 21.5 | 17.4 |

Table 6. Locations of flow measurements taken within the Rattlesnake Creek watershed[a]. Coordinates were obtained from a hand-held global positioning system (GPS) using North American Datum 1927. Sites are listed from upstream to downstream within the watershed.

| Watershed | Coordinates | | Elevation | Distance upstream of | Year sampled (Y=Yes, N=No) | | | |
|---|---|---|---|---|---|---|---|---|
| Site | Northing | Easting | (ft) | mouth (km) | 2001 | 2002 | 2003 | 2004 |
| **Rattlesnake Creek** | | | | | | | | |
| URAT - upper | 5081436 | 628496 | 1,500 | 16.9 | Y[b] | N | N | N |
| URAT - lower | 5078524 | 624154 | 900 | 11.2 | Y | Y[c] | Y[d] | N |
| MRAT | 5076614 | 622231 | 820 | 7.7 | Y | Y | Y | Y |
| LRAT - above Indian Cr. | 5072742 | 618411 | 430 | 0.8 | Y | Y | Y | Y |
| LRAT - lower | 5072429 | 617898 | 400 | 0.1 | Y | Y | Y | Y |
| Mill Creek | | | | | | | | |
| LMIL - DNR | 5079664 | 626548 | 1,300 | 0.1 | Y[e] | N | N | N |
| Indian Creek | | | | | | | | |
| MIND - middle | 5071671 | 620054 | 730 | 2.2 | Y | Y | Y | N |
| LIND - lower | 5072687 | 618423 | 430 | 0.0 | Y[b] | N | Y | Y |

[a] Flows taken from June to October approximately once every two weeks in 2001 and 2002, and every three weeks in 2003 and 2004 unless noted otherwise..
[b] Flow measured only on 06/07/01.
[c] Flow measured only on 10/22/02.
[d] Flow measured only on 06/08/01.
[e] Flow measured only on 6/10/03.

Table 7. Sites sampled for fish in the Rattlesnake Creek and White Salmon River watershed during summer 2004. Watersheds and streams are listed in an upstream to downstream pattern within the watershed.

| Watershed<br>Stream reach or section | Method and length surveyed | Start point distance from mouth (km) | Number of 134.2 kHz PIT tags deployed[a] | Number of fish handled |
|---|---|---|---|---|
| **Rattlesnake Creek** | | | | |
| URAT | FSNP[b] | 11.2 | 114 | 294 |
| MRAT2 | Population survey, 624 m; FSNP | 7.1 | 144 | 1,373 [c] |
| MRAT1 | Index survey; 694 m; FSNP | 5.9 | 235 | 513 |
| BRAT6 | Index survey, 457 m; FSNP | 5.0 | 52 | 82 |
| BRAT3 | Index survey, 791 m | 4.5 | 103 | 158 |
| BRAT1 | FSNP | 2.5 | 17 | 24 |
| LRAT2 | Index survey, 414 m; FSNP | 2.1 | 67 | 252 |
| LRAT1 | Population survey, 1,082 m; FSNP | 0.1 | 187 | 2,898 [c] |
| **Indian Creek** | | | | |
| MIND | Index survey, 473 m; FSNP | 2.2 | 100 | 243 |
| LIND | FSNP | 0.1 | 18 | 29 |
| **White Salmon River** | | | | |
| WSR3 | FSNP | 8.5 | 68 | 108 |
| | | | **Total 1,105** | **Total 5,974** [c] |

[a] Fish tagged were limited to rainbow trout and cutthroat trout with fork length of 80 mm or longer.
[b] FSNP = Fish sampled by electrofishing, not a population survey.
[c] The number of fish handled includes Longnose dace sampled for population estimates.

Table 8. Presence and absence of the fish species found in the Rattlesnake Creek watershed by U.S. Geological Survey personnel, 2004. Sites are listed in an upstream to downstream pattern. P = present, A = absent. See Figure 3 and Table 7 for information on fish sampling sites.

| **Watershed** Site | Rainbow trout | Coastal Cutthroat trout | Eastern Brook trout | Longnose dace | Shorthead Sculpin | Brook lamprey |
|---|---|---|---|---|---|---|
| **Rattlesnake Creek** | | | | | | |
| URAT | P | A | A | P | P | A |
| MRAT | P | A | A | P | P | A |
| BRAT | P | A | A | P | P | A |
| LRAT | P | P | P[a] | P | P | P |
| **Mill Creek** | | | | | | |
| UMIL | P | A | A | A | A | A |
| LMIL | P | A | A | A | P | A |
| **Indian Creek** | | | | | | |
| MIND | P | P | A | A | P | A |
| LIND | P | P | A | A | P | A |

[a] Two individuals captured and PIT-tagged. One on 15 October 2002 and one on 27 October 2004.

Table 9. Delimits of age classes of rainbow trout (RBT) and cutthroat trout (CTT) in Rattlesnake Creek and its tributaries during summer 2004. Sites are listed in an upstream to downstream pattern within the watershed. See Figure 3 and Table 7 for information on fish sampling sites. Age classes were estimated by length-frequency analysis. FL= fork length.

| **Watershed** Site | Date | Length of stream surveyed (km) | Start point distance from mouth (km) | Species | Max FL age 0 | Min FL age 1 |
|---|---|---|---|---|---|---|
| **Rattlesnake Creek** | | | | | | |
| URAT | 24 Sep | 0.36 | 12.0 | RBT | 80 | 103 |
| MRAT 2 | 12 Jul-15 Jul | 0.62 | 7.2 | RBT | 66 | 104 |
| MRAT 1 | 9 Sep-13 Sep | 0.69 | 6.0 | RBT | 77 | 85 |
| BRAT 6 | 14 Sep-15 Sep | 0.46 | 4.8 | RBT | 74 | 85 |
| BRAT 3 | 22 Sep-23 Sep | 0.79 | 3.4 | RBT | 89 | 95 |
| BRAT 1 | 29 Sep | 0.50 | 3.4 | RBT | 90 | 102 |
| LRAT 2 | 27 Sep-29 Sep | 0.41 | 2.0 | RBT | 77 | 91 |
| LRAT 1 | 21 Jun-29 Jun | 1.10 | 0.2 | RBT | 77 | 81 |
| **Indian Creek** | | | | | | |
| MIND | 15 Sep-16 Sep | 0.47 | 2.4 | CTT | 58 | 88 |
| MIND | 15 Sep-16 Sep | 0.47 | 2.4 | RBT | --- | 84 |
| LIND | 21 Sep | 0.50 | 0.1 | CTT | --- | 165 |
| LIND | 21 Sep | 0.50 | 0.1 | RBT | 65 | 95 |

Table 10. Recapture events of fish with PIT tags in the Rattlesnake Creek subwatershed, 2001-2004. Sites are listed from upstream to downstream within a watershed relative to the mainstem. See Figure 3 and Table 7 for information on fish sampling sites.

| | | Instream Recaptures | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | PIT tags | LRAT | | | | BRAT | | | | MRAT | | | | URAT | | | | MIND | | | |
| Year | deployed | 01 | 02 | 03 | 04 | 01 | 02 | 03 | 04 | 01 | 02 | 03 | 04 | 01 | 02 | 03 | 04 | 01 | 02 | 03 | 04 |
| URAT | | | | | | | | | | | | | | | | | | | | | |
| 2002 | 51 | -- | 0 | 0 | 0 | -- | 0 | 2 | 0 | -- | 0 | 0 | 0 | -- | 2 | 3 | 6 | -- | 0 | 0 | 0 |
| 2003 | 71 | -- | -- | 0 | 0 | -- | -- | 0 | 0 | -- | -- | 0 | 0 | -- | -- | 0 | 29 | -- | -- | 0 | 0 |
| 2004 | 114 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 31 | -- | -- | -- | 0 |
| LMIL[a] | | | | | | | | | | | | | | | | | | | | | |
| 2002 | 12 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 |
| UMIL[a] | | | | | | | | | | | | | | | | | | | | | |
| 2002 | 8 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 |
| MRAT | | | | | | | | | | | | | | | | | | | | | |
| 2001 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 86 | -- | 0 | 0 | 0 | -- | 0 | 1 | 1 | -- | 0 | 13 | 6 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 |
| 2003 | 509 | -- | -- | 0 | 0 | -- | -- | 0 | 3 | -- | -- | 35 | 143 | -- | -- | 0 | 0 | -- | -- | 0 | 0 |
| 2004 | 379 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 49 | -- | -- | -- | 0 | -- | -- | -- | 0 |
| BRAT | | | | | | | | | | | | | | | | | | | | | |
| 2001 | 318 | 0 | 0 | 0 | 0 | 1 | 43 | 5 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 348 | -- | 0 | 0 | 0 | -- | 15 | 48 | 7 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 |
| 2003 | 491 | -- | -- | 0 | 0 | -- | -- | 95 | 52 | -- | -- | 0 | 1 | -- | -- | 0 | 0 | -- | -- | 0 | 0 |
| 2004 | 172 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 |
| LRAT[b] | | | | | | | | | | | | | | | | | | | | | |
| 2001 | 190 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 174 | -- | 10 | 13 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 |
| 2003 | 238 | -- | -- | 17 | 24 | -- | -- | 0 | 0 | -- | -- | 0 | 0 | -- | -- | 0 | 0 | -- | -- | 0 | 1 |
| 2004 | 254 | -- | -- | -- | 23 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 |

[a] Sites were sampled once in 2002, and not at all in 2003 or 2004.
[b] One 2001 fish was captured in the White Salmon River in 2003.

Table 11. Recapture events of fish with PIT tags in lower Indian Creek (LIND), middle Indian Creek (MIND), and the White Salmon River (WSR, rkm 8.5 to 12.7), 2001-2004. Sites are listed from upstream to downstream within a watershed relative to the mainstem. See Figure 3 and Table 7 for information on fish sampling sites.

| | | Instream Recaptures | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Section | PIT tags | LRAT | | | | BRAT | | | | MRAT | | | | URAT | | | | LIND and MIND | | | |
| Year | deployed | 01 | 02 | 03 | 04 | 01 | 02 | 03 | 04 | 01 | 02 | 03 | 04 | 01 | 02 | 03 | 04 | 01 | 02 | 03 | 04 |
| MIND[c] | | | | | | | | | | | | | | | | | | | | | |
| 2001 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 1 |
| 2002 | 15 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 7 | 3 |
| 2003 | 96 | -- | -- | 0 | 0 | -- | -- | 0 | 0 | -- | -- | 0 | 0 | -- | -- | 0 | 0 | -- | -- | 34 | 26 |
| 2004 | 100 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 45 |
| LIND[d] | | | | | | | | | | | | | | | | | | | | | |
| 2002 | 57 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 2 | 1 |
| 2004 | 18 | -- | -- | -- | 0 | -- | -- | -- | -- | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 |
| WSR | | | | | | | | | | | | | | | | | | | | | |
| 2001 | 59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2002 | 125 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 | -- | 0 | 0 | 0 |
| 2003 | 96 | -- | -- | 0 | 0 | -- | -- | 0 | 0 | -- | -- | 0 | 0 | -- | -- | 0 | 0 | -- | -- | 0 | 0 |
| 2004 | 68 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 | -- | -- | -- | 0 |

[c] All fish were recaptured in middle Indian Creek.
[d] All fish were recaptured in lower Indian Creek.

Table 12. Number of fish PIT tagged by stream section and year, and year of first detections from each section at the detector system at rkm 0.2. Upper Rattlesnake Creek includes any fish tagged upstream of the waterfall at rkm 2.4. From 25 August 2001 to 16 May 2003 the detection system included two antennas, from 17 May 2003 to 3 November 2003 the system included four antennas, and from 4 November 2003 to 31 December 2004 the system included six antennas. With system improvements, detection efficiencies have generally increased through the period of operation. Efficiencies for downstream moving fish have ranged from 16% (when one antenna of the two-antenna system was lost) to greater than 99% (six-antenna system at low water).

| **Stream section** | Number of fish PIT | Number of first detections by year at rkm 0.2 | | | | |
|---|---|---|---|---|---|---|
| Year | tagged | 2001 | 2002 | 2003 | 2004 | Total (%) |
| **Upper Rattlesnake Cr. (BRAT, MRAT, URAT)** | | | | | | |
| 2001 | 354 | 0 | 3 | 0 | 0 | 3 (0.8) |
| 2002 | 515 | -- | 1 | 0 | 0 | 1 (0.2) |
| 2003 | 1,071 | -- | -- | 1 | 4 | 5 (0.5) |
| 2004 | 665 | -- | -- | -- | 1 | 1 (0.2) |
| **L. Rattlesnake Cr. (LRAT)** | | | | | | |
| 2001 | 190 | 3 | 11 | 2 | 0 | 16 (8.4) |
| 2002 | 177 | -- | 10 | 9 | 0 | 19 (10.7) |
| 2003 | 238 | -- | -- | 8 | 32 | 40 (16.8) |
| 2004 | 254 | -- | -- | -- | 35 | 35 (13.8) |
| **Indian Cr. (LIND, MIND)** | | | | | | |
| 2001 | 30 | 0 | 1 | 0 | 0 | 1 (3.3) |
| 2002 | 73 | -- | 0 | 4 | 0 | 4 (5.5) |
| 2003 | 96 | -- | -- | 0 | 12 | 12 (12.5) |
| 2004 | 118 | -- | -- | -- | 1 | 1 (0.8) |
| **White Salmon R. (rkm 5.0 to 12.2)** | | | | | | |
| 2001 | 16 | 0 | 4 | 0 | 0 | 4 (25.0) |
| 2002 | 93 | -- | 6 | 4 | 0 | 10 (10.8) |
| 2003 | 96 | -- | -- | 5 | 7 | 12 (12.5) |
| 2004 | 68 | -- | -- | -- | 5 | 5 (7.4) |

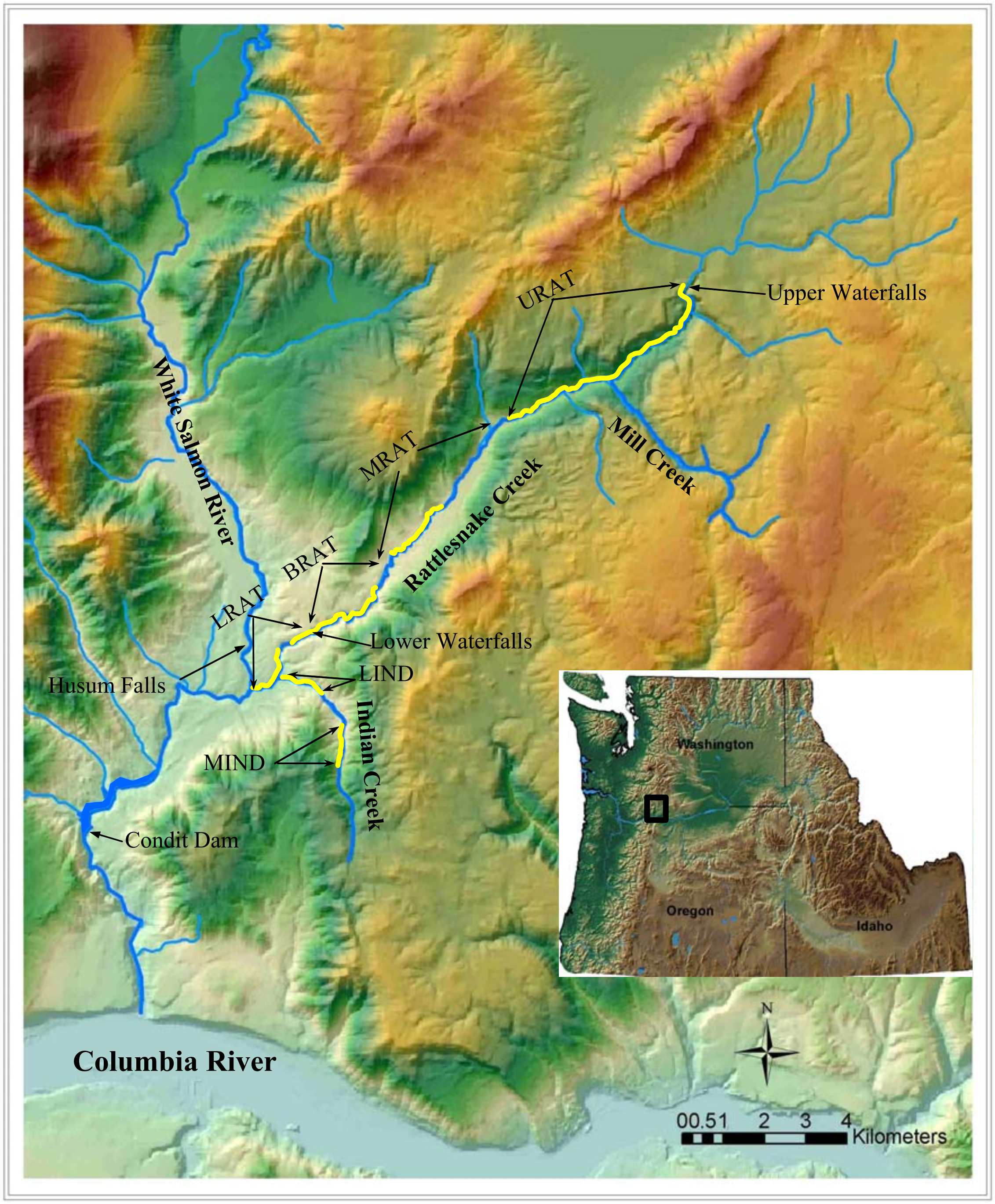


Figure 1. Location of Rattlesnake Creek, WA and study reaches within the Columbia River Gorge. Study reaches are: LRAT = lower Rattlesnake Creek below lower waterfall; BRAT = lower Rattlesnake Creek above lower waterfall; MRAT = middle Rattlesnake Creek; URAT = upper Rattlesnake Creek to upper waterfall. Indian Creek study reaches are LIND = lower Indian Creek, and MIND = middle Indian Creek.

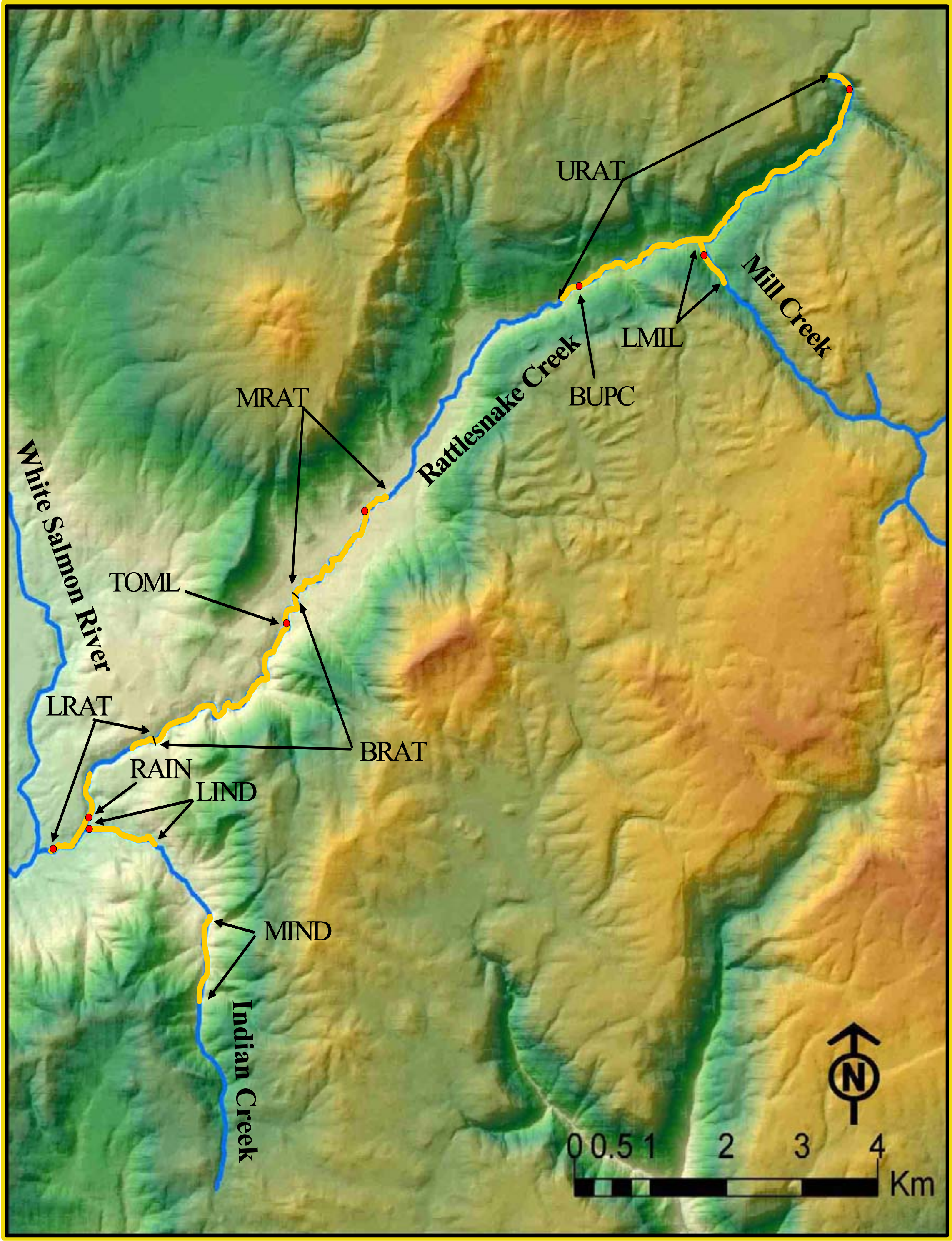


Figure 2. Locations of reach surveys and thermograph sites within the Rattlesnake Creek watershed, 2001-2004. ▬ = Location of reach surveys. ● = Location of thermograph sites. See table 1 for additional information on reach survey sites. Table 3 provides additional information on thermograph sites.

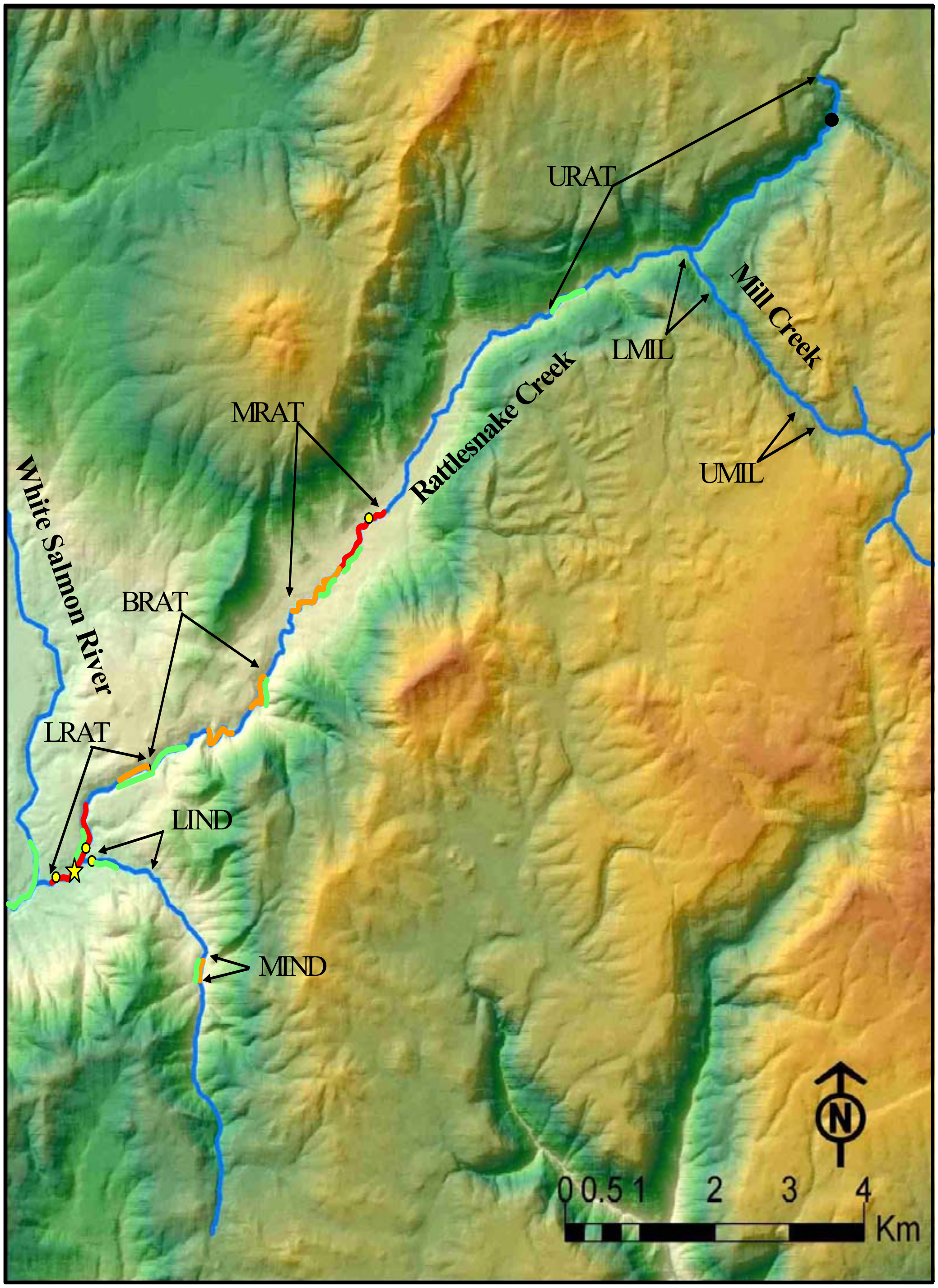


Figure 3. Locations of fish sampling and flow sites within the Rattlesnake Creek watershed, 2004. ○ = Flow measurement locations. ▬ =Location of population surveys (used a systematic sample of habitat units within different habitat types (e.g., pool, glide, riffle) with multiple pass, removal- depletion electrofishing with block nets. ▬ =Locations of index shocking (only pool habitats were sampled, one pass was conducted (upstream and back) with no block nets). ▬ =Additional fish collections conducted without a population estimate or habitat survey. ● =Uppermost fish distribution in 2004. ☆ =Automated flow gauge location.

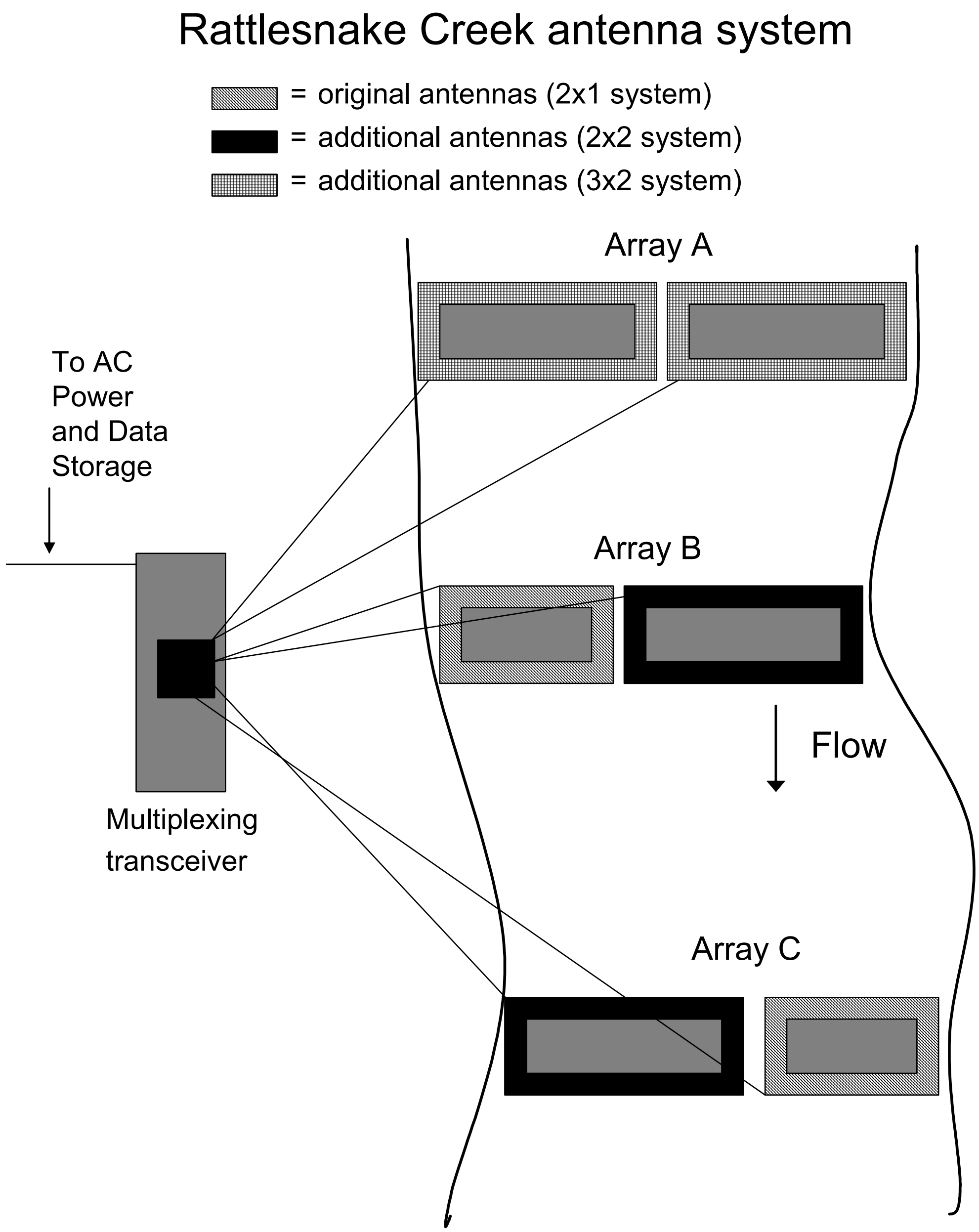


Figure 4. Plan view of the Rattlesnake Creek instream PIT-tag detection site. Antenna arrays A and C were pass-by antennas, array B were hybrid (pivoting) antennas.

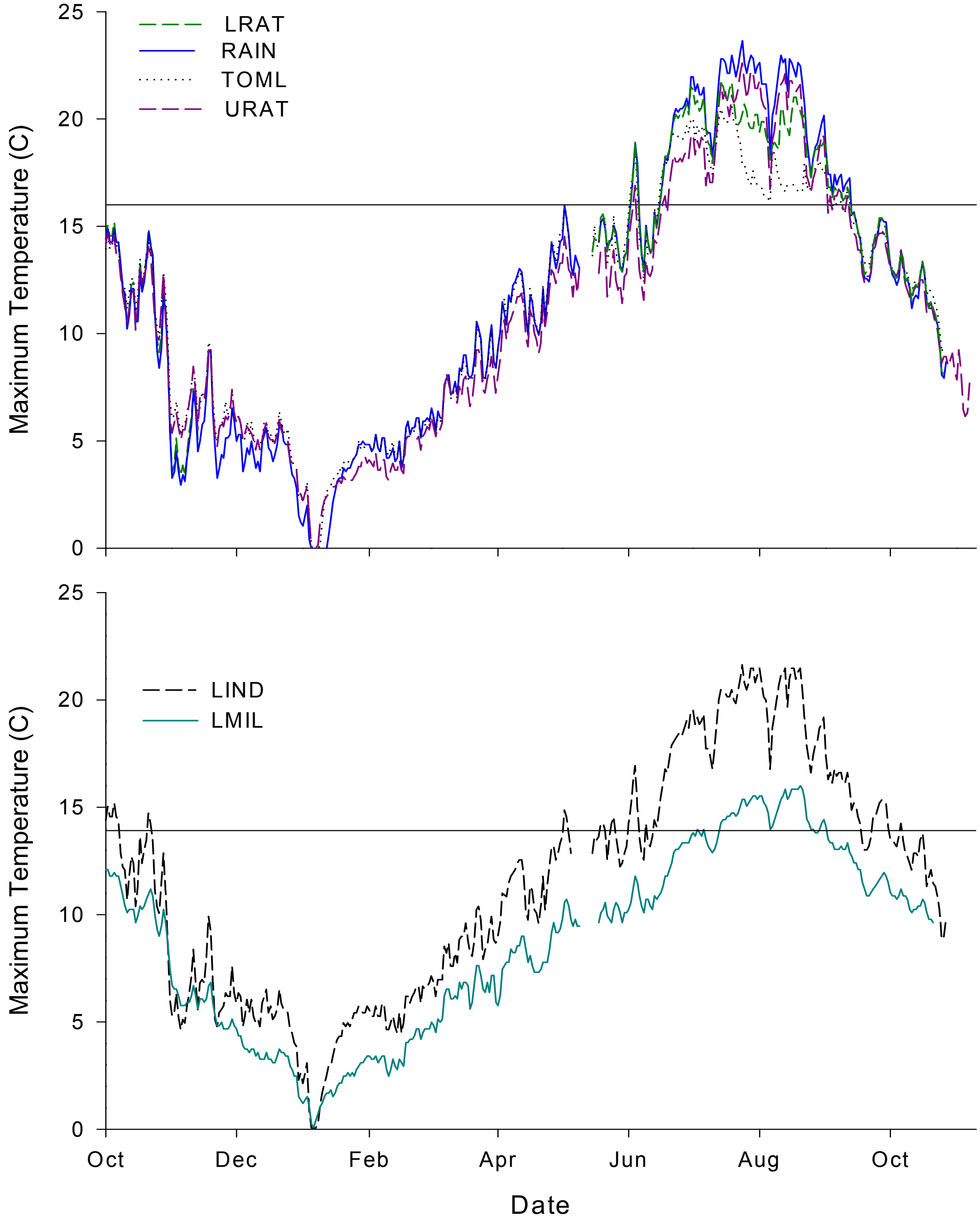


Figure 5. Daily maximum temperatures at six sites in Rattlesnake Creek from October 1, 2003 to November 10, 2004. For information on thermograph measurement locations and dates, see Table 3 and Figure 2. The line at 16$^{o}$ C marks the maximum surface water temperature standard set by the Washington Department of Ecology (Chapter 173-201A, Nov. 18, 1997, Water Quality Standards for the Surface Waters of the State of Washington. Thermographs were removed annually in the spring for calibration.

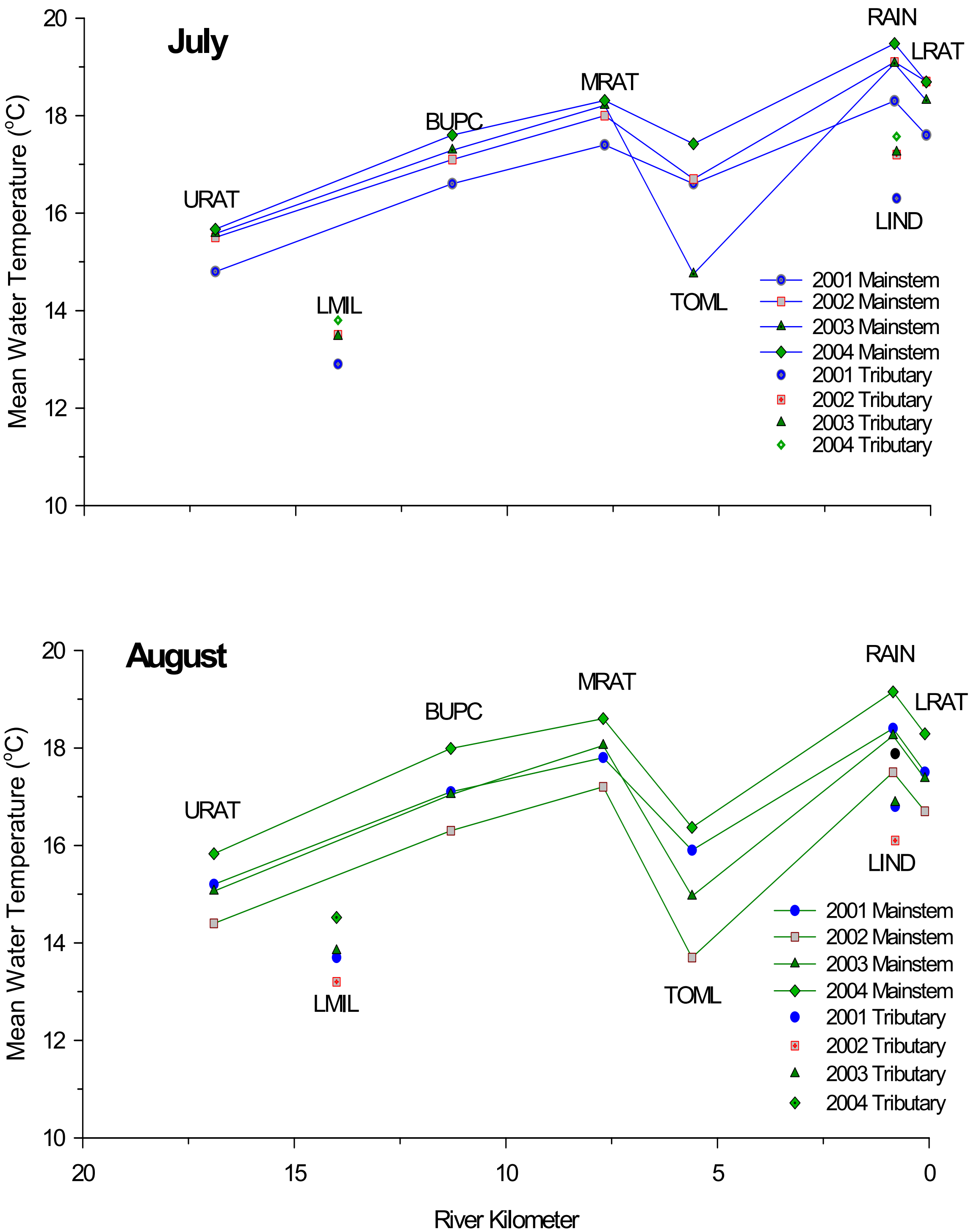


Figure 6. Mean water temperature during July and August 2001 through 2004 in the mainstem Rattlesnake Creek and its tributaries. Sites, from left to right, are shown from upstream to downstream. River kilometer zero is the mouth of Rattlesnake Creek. For information on thermograph measurement locations and dates, see Table 3 and Figure 2.

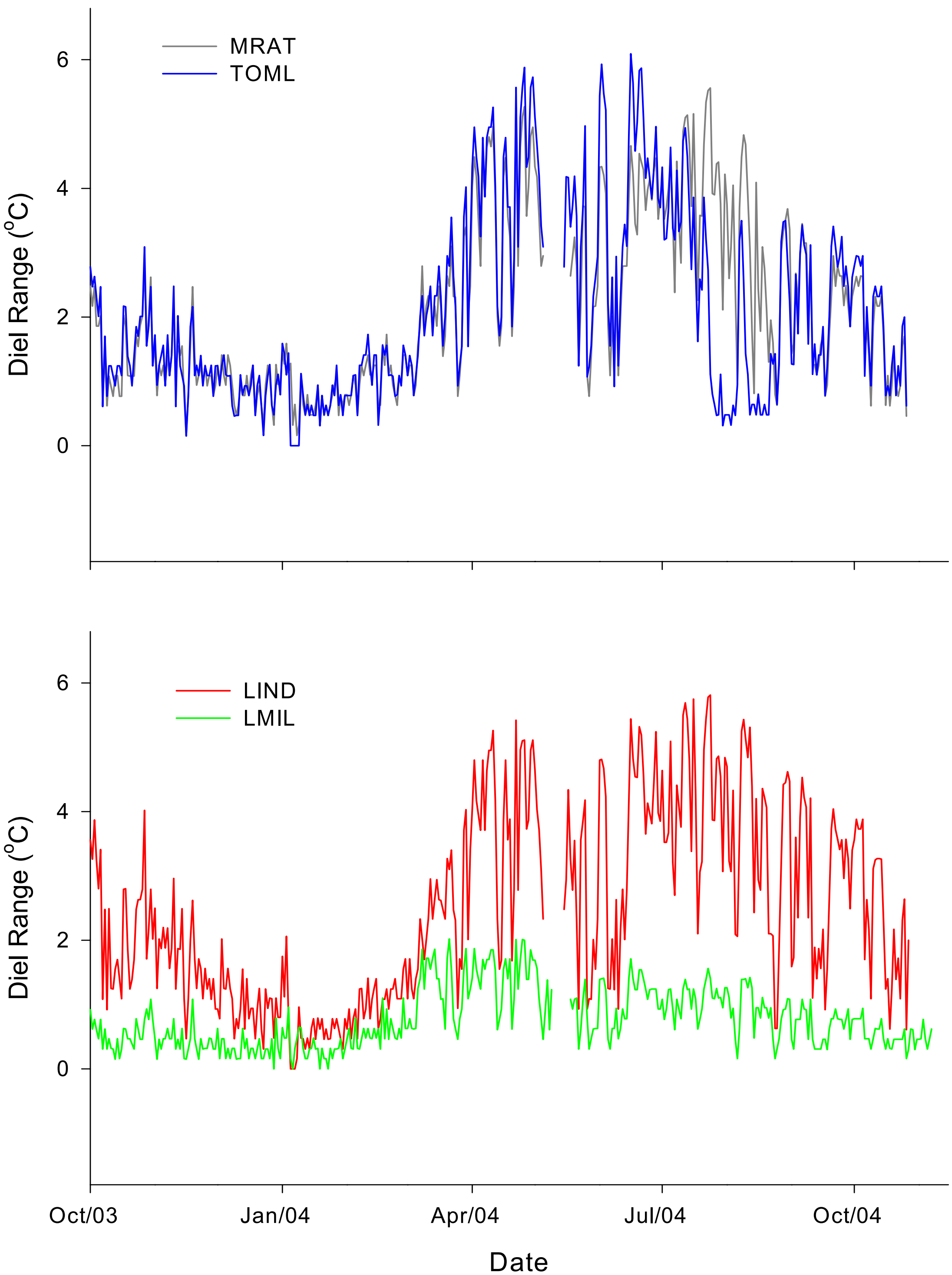


Figure 7. Diel water temperature range at select sites in Rattlesnake (MRAT, TOML), Indian (LIND), and Mill (LMIL) creeks. For information on thermograph measurement locations and dates, see Table 3 and Figure 2. Thermographs were removed annually in the spring for calibration.

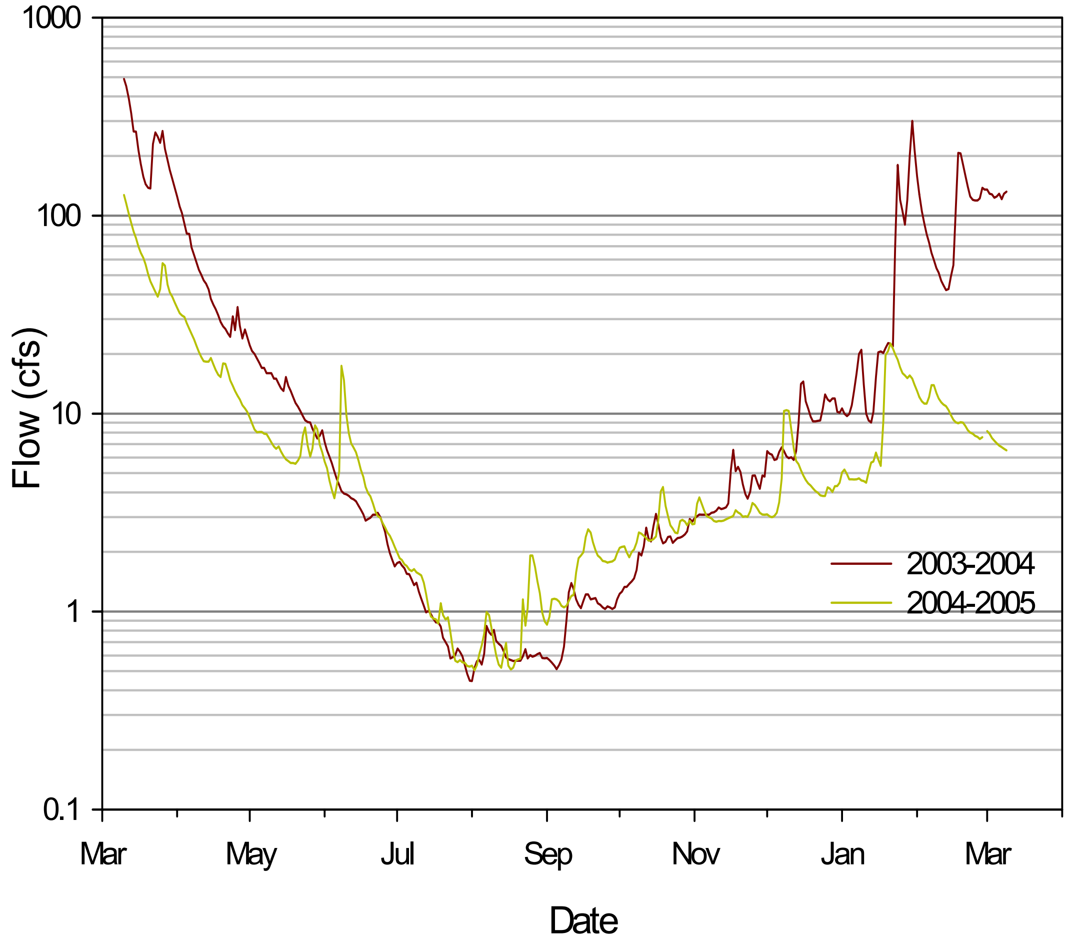


Figure 8. Mean daily flow measured in 15 minute intervals at the LRAT automated gaging station (rkm 0.2) from March 03- March 05. For information on flow measurement locations, see Table 6 and Figure 3.

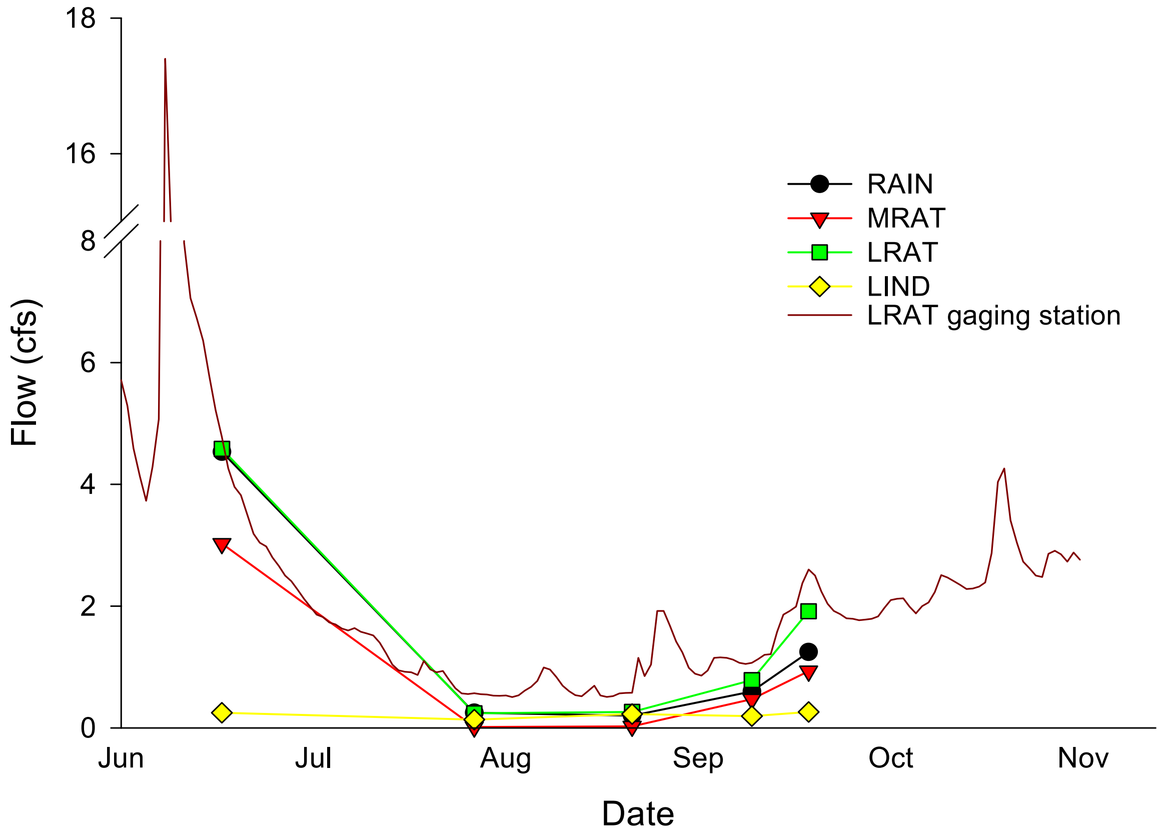


Figure 9. Flow measured at three sites on Rattlesnake Creek (LRAT, rkm 0.2; RAIN, rkm 0.8; MRAT, rkm 7.7) and one site on Indian Creek (LIND, rkm 0.1) in 2004. For information on flow measurement locations, see Table 6 and Figure 3. See Appendix Table 4 for flow measurements and dates in 2004.

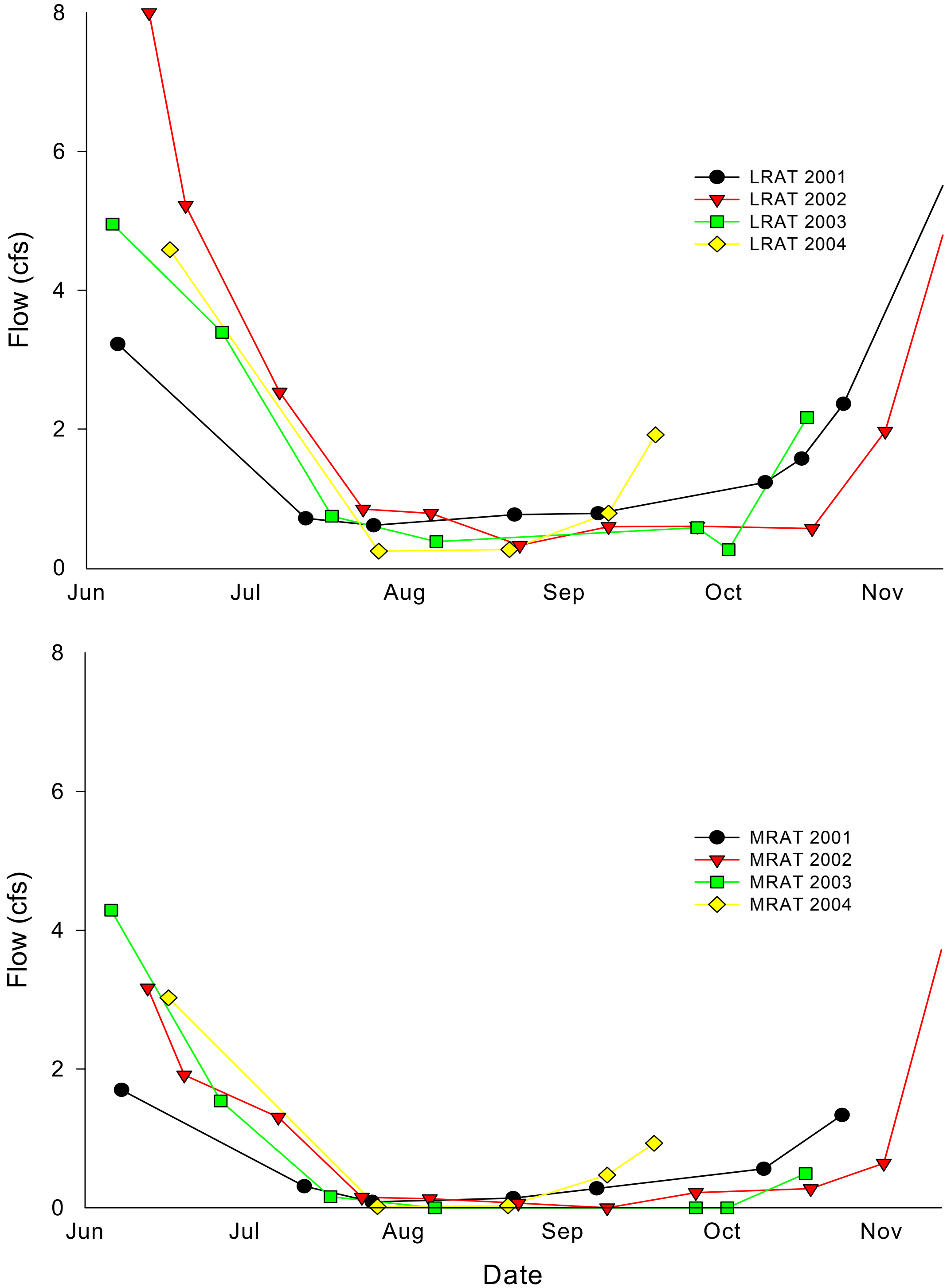


Figure 10. Flow for LRAT (rkm 0.2) and MRAT (rkm 7.7) from June through November, 2001-2004. For information on flow measurement locations, see Table 6 and Figure 3. See Appendix Tables 1-4 for flow measurements and dates.

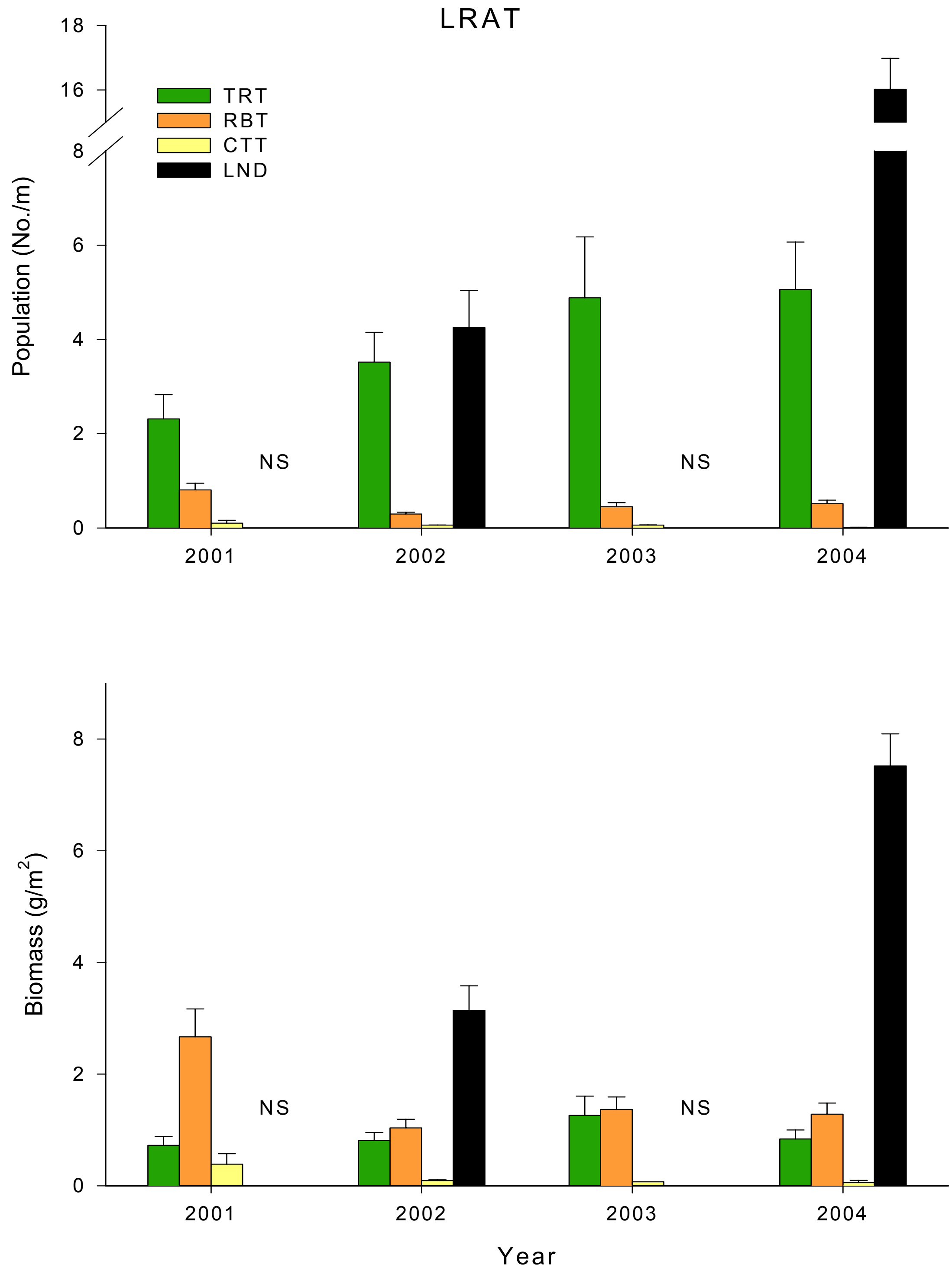


Figure 11a. Comparison of fish population and biomass estimates in lower Rattlesnake creek (LRAT1; rkm 0.2-1.3). Salmonids <80 mm long were considered trout (TRT). Rainbow trout (RBT) and cutthroat trout (CTT) were collected in 2001-2004. Longnose dace (LND) were not sampled (NS) in 2001 or 2003, but were in 2002 and 2004. Error bars represent 2 SE, which is approximately a 95 % confidence interval.

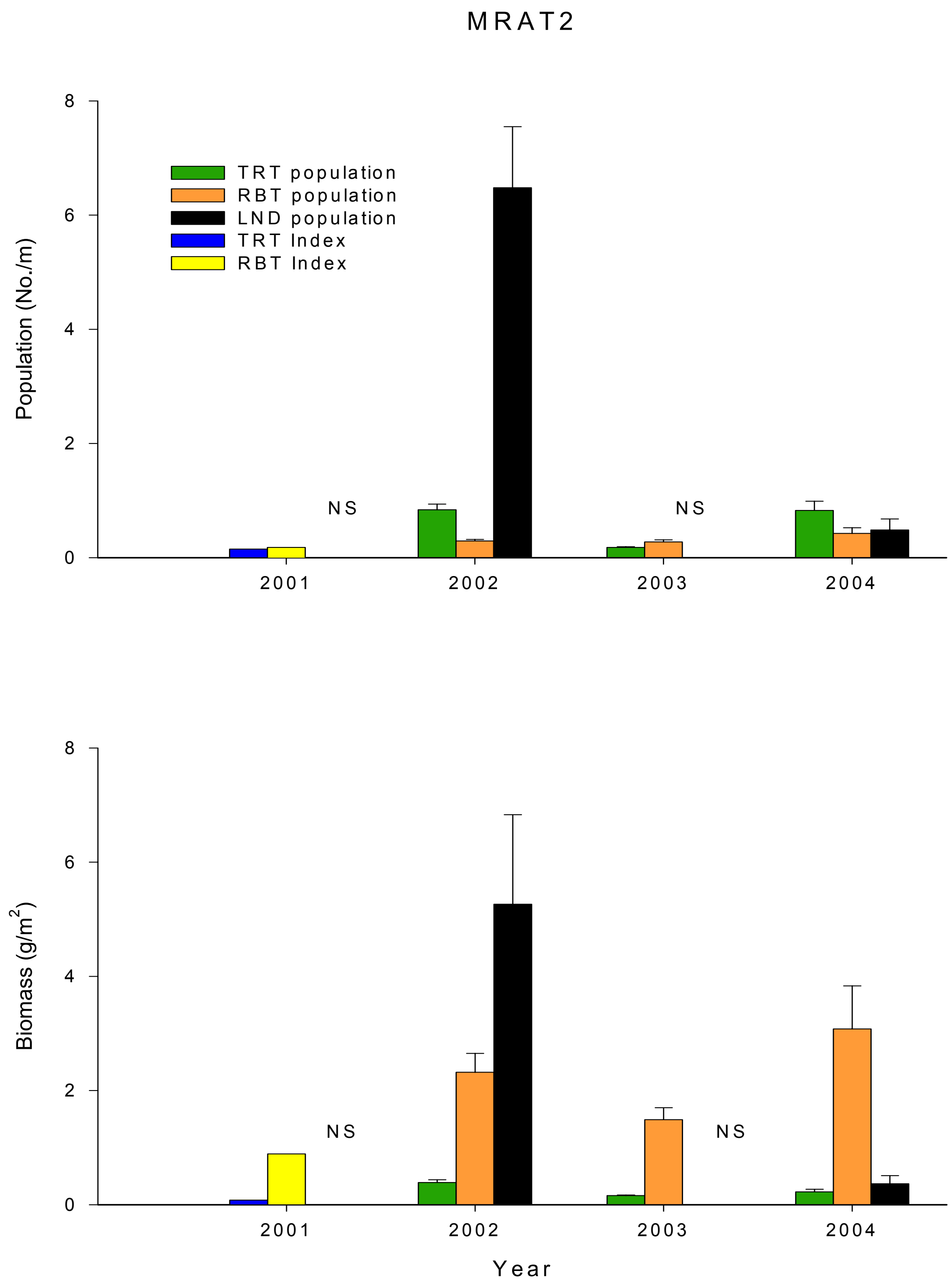


Figure 11b. Comparison of fish population and biomass estimates in middle Rattlesnake creek (MRAT2; rkm 7.35-7.91). Salmonids <80 mm long were considered trout (TRT). Rainbow trout (RBT) and cutthroat trout (CTT) were collected in 2001-2004. Longnose dace (LND) were not sampled (NS) in 2001 or 2003, but were in 2002 and 2004. Error bars represent 2 SE, which is approximately a 95 % confidence interval.

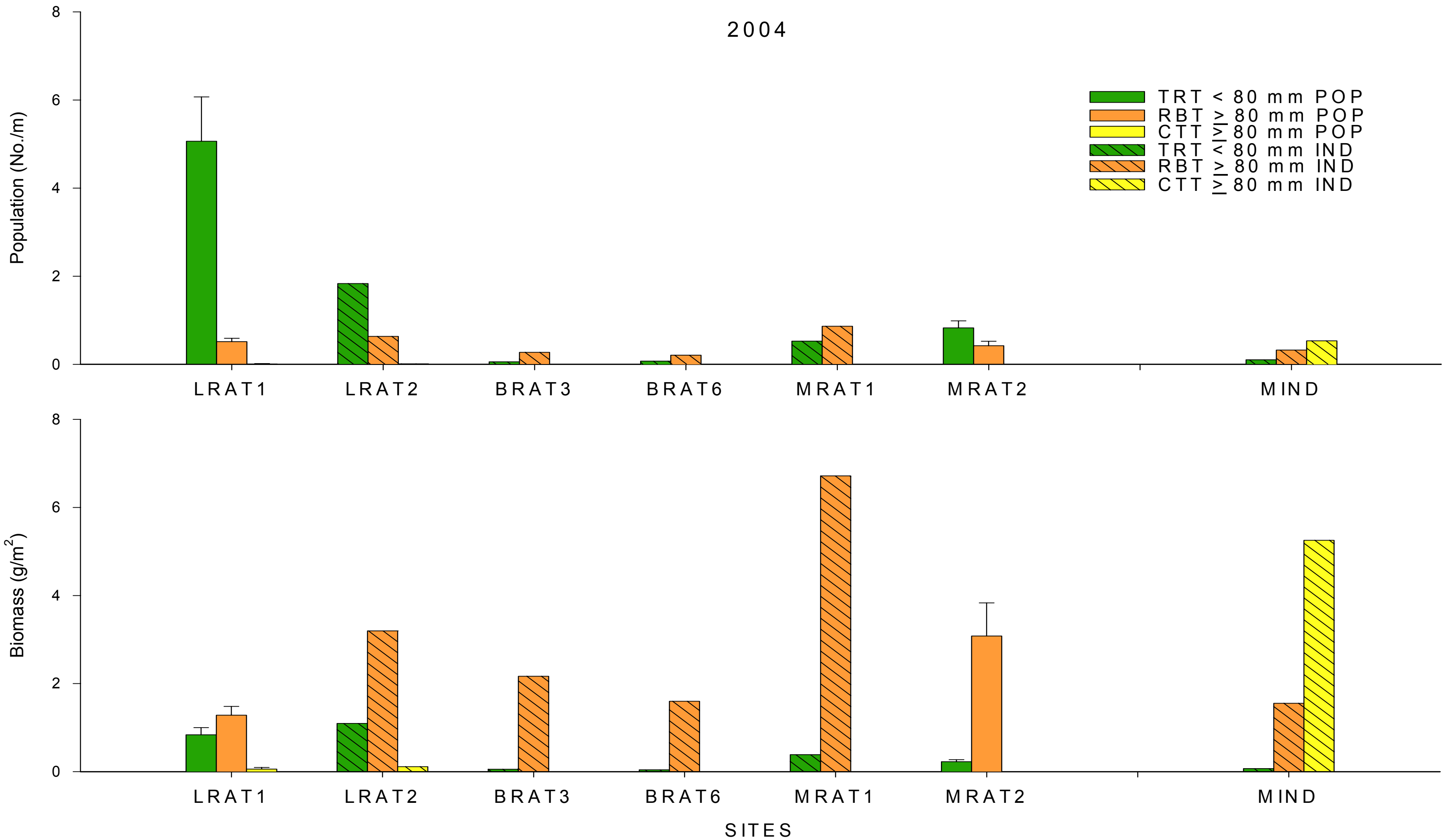


Figure 12. Population (POP) and Index (IND) electrofishing population and biomass estimates (with 1 SE bars for population estimates) of rainbow trout (RBT), and cutthroat trout (CTT) found in Rattlesnake Creek watershed, 2004. Stream codes are: LRAT1 = section 1 of lower Rattlesnake Cr., LRAT2 = Rattlesnake Cr. below 1st waterfall, BRAT3 = Rattlesnake Cr. 1000 m above falls, BRAT6 = rkm 4.8-5.5, MRAT1 = Rattlesnake Cr. rkm 5.6-7.2, MRAT2 = Rattlesnake Cr. rkm 7.2-7.8, MIND = Indian Cr. rkm 2.4-3.3. Additional information on stream code locations are provided on Figure 3 and Table 7.

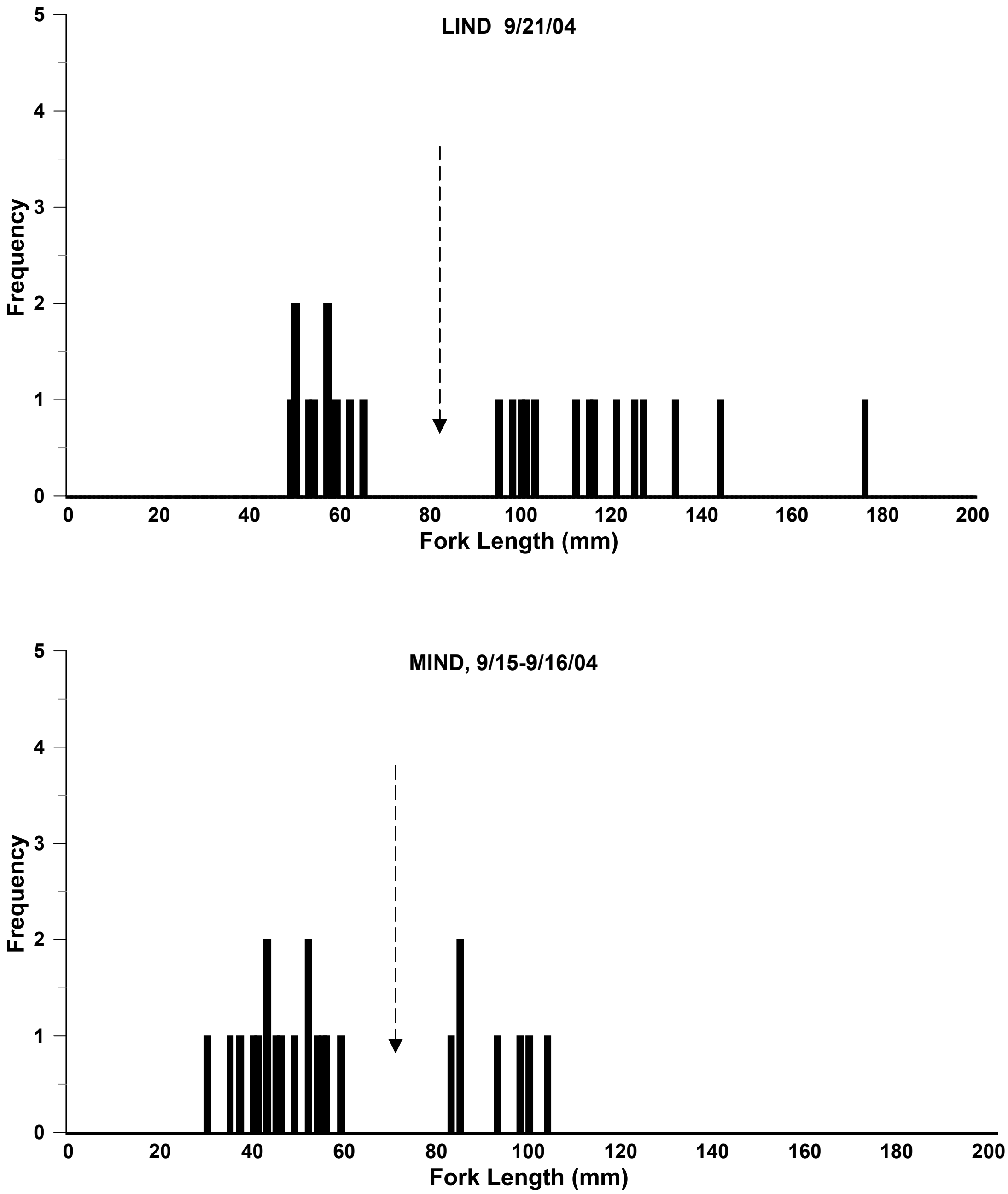


Figure 13a. Length frequency in 1-mm increments of rainbow trout sampled in LIND (rkm 0.0-0.9) and MIND (rkm 2.40-3.28) reaches of Indian Creek of the Rattlesnake watershed in 2004. The arrow indicates the break between age-0 and age-1 or older fish.

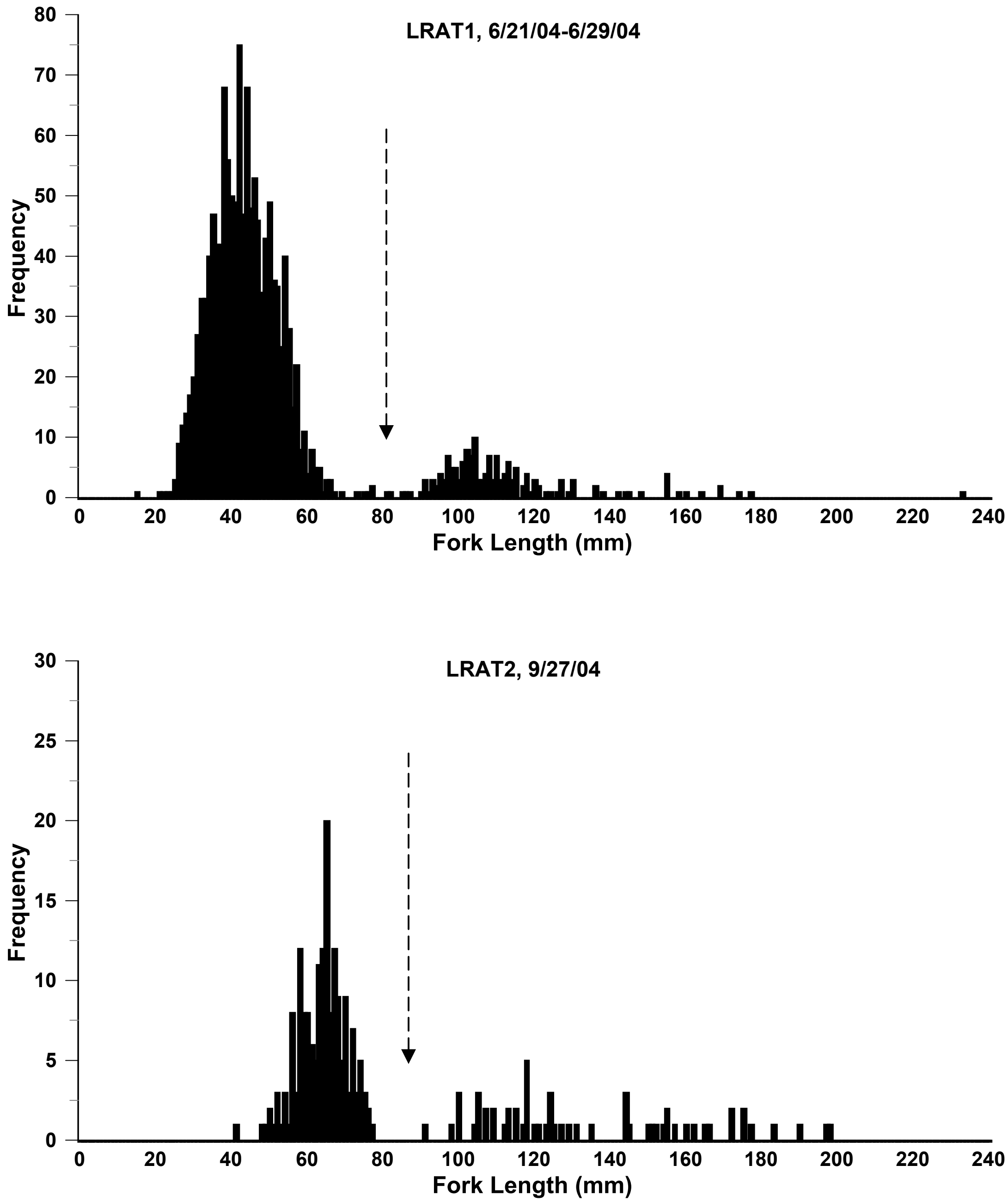


Figure 13b. Length frequency in 1-mm increments of rainbow trout sampled in section 1 (rkm 0.2-1.3) and section 2 (rkm 1.9-2.4) of the LRAT reach of Rattlesnake Creek in 2004. The arrow indicates the break between age-0 and age-1 or older fish.

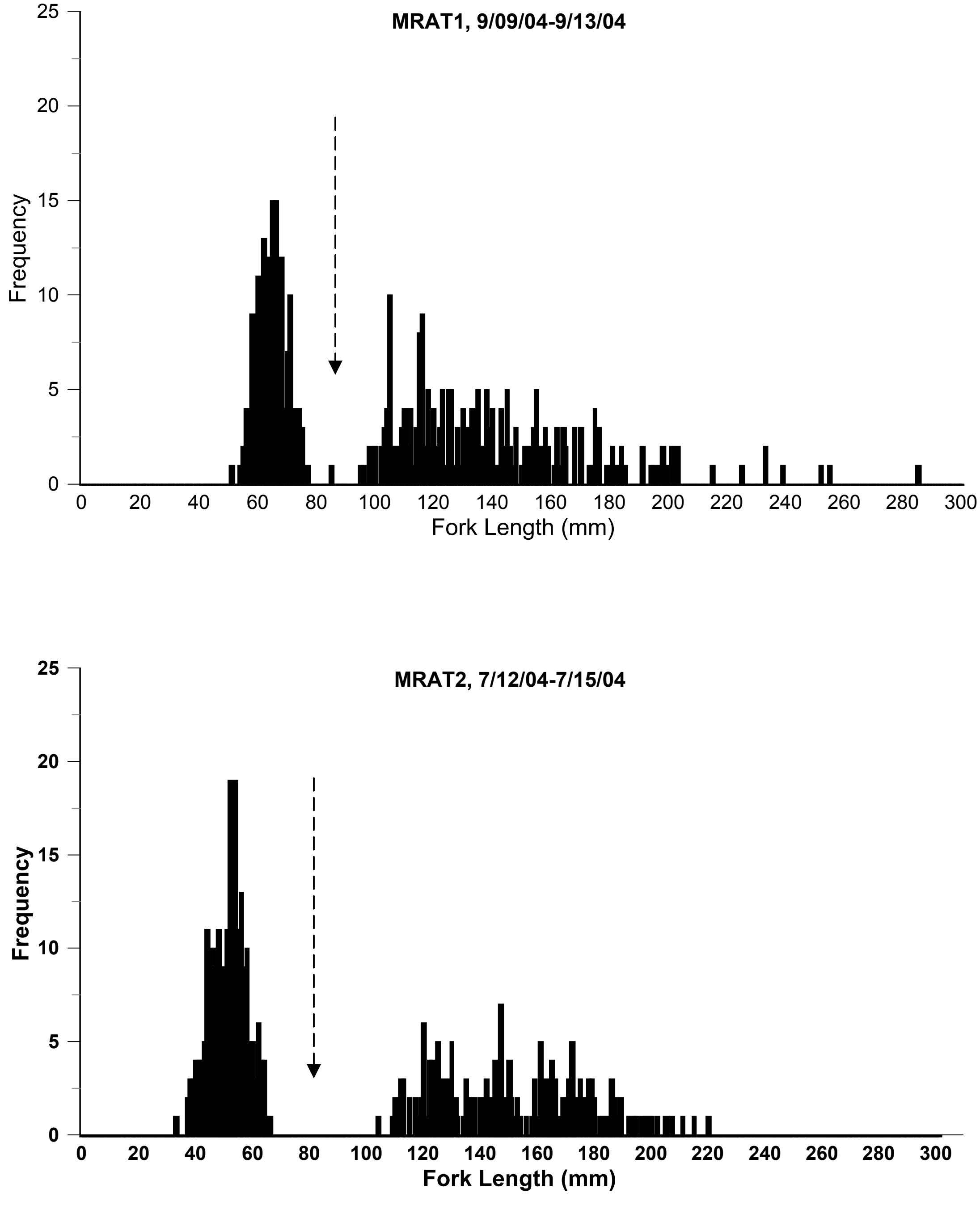


Figure 13c. Length frequency in 1-mm increments of rainbow trout sampled in section 1 (rkm 6.0-7.2) and section 2 (rkm 7.2-7.8) of the MRAT reach of Rattlesnake Creek in 2004. The arrow indicates the break between age-0 and age-1 or older fish.

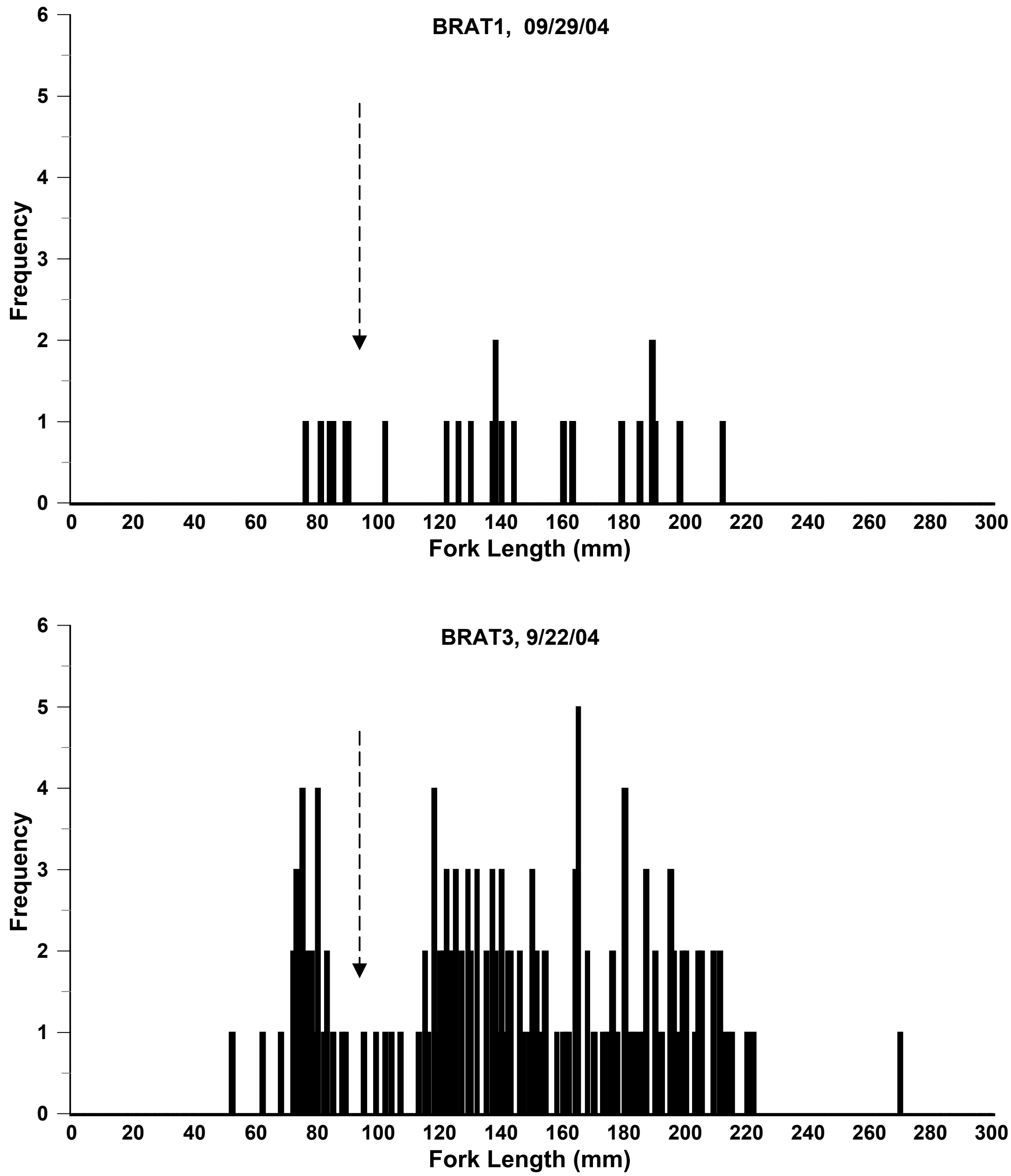


Figure 13d. Length frequency in 1-mm increments of rainbow trout sampled in section 1 (rkm 3.3-3.8) and section 3 (rkm 3.3-3.8) of the BRAT reach of Rattlesnake Creek in 2004. The arrow indicates the break between age-0 and age-1 or older fish.

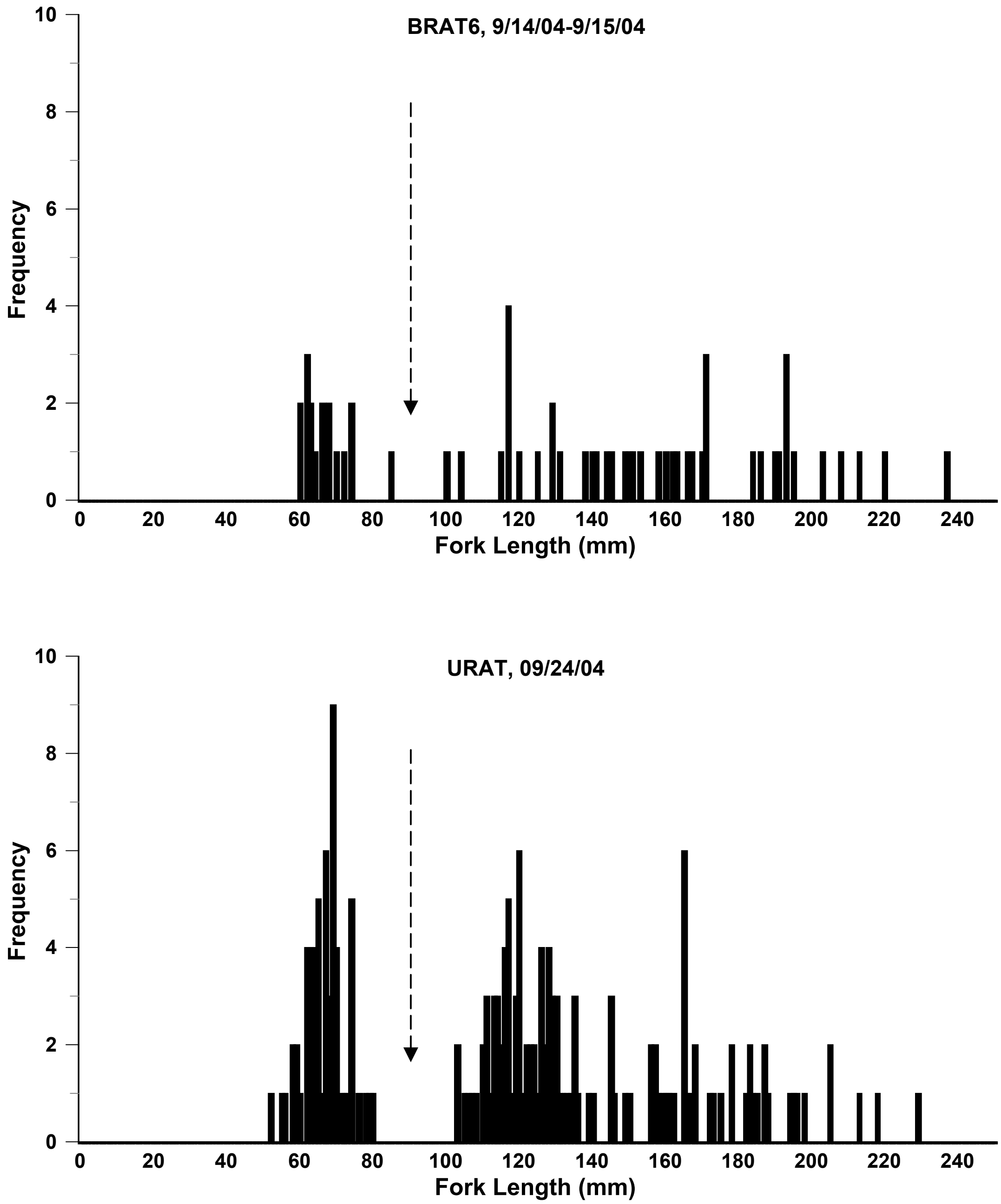


Figure 13e. Length frequency in 1-mm increments of rainbow trout sampled in section 6 (rkm 4.81-5.51) of the BRAT reach and the URAT reach (rkm 10.77-17.21) of Rattlesnake Creek in 2004. The arrow indicates the break between age-0 and age-1 or older fish.

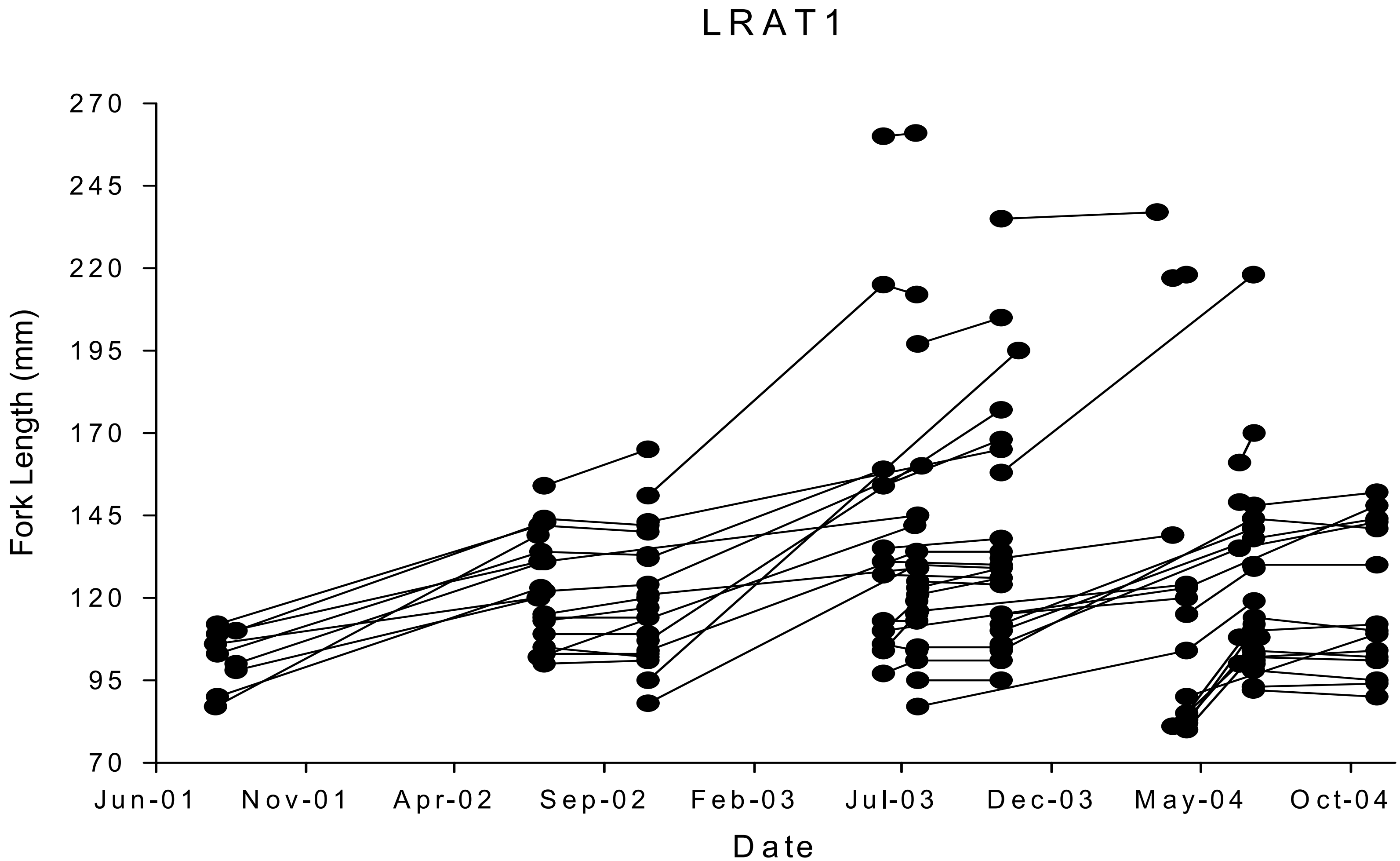


Figure 14a. Length of PIT-tagged rainbow trout within lower Rattlesnake Creek (LRAT1; rkm 0.2-1.3) at initial tagging and at each time of recapture.

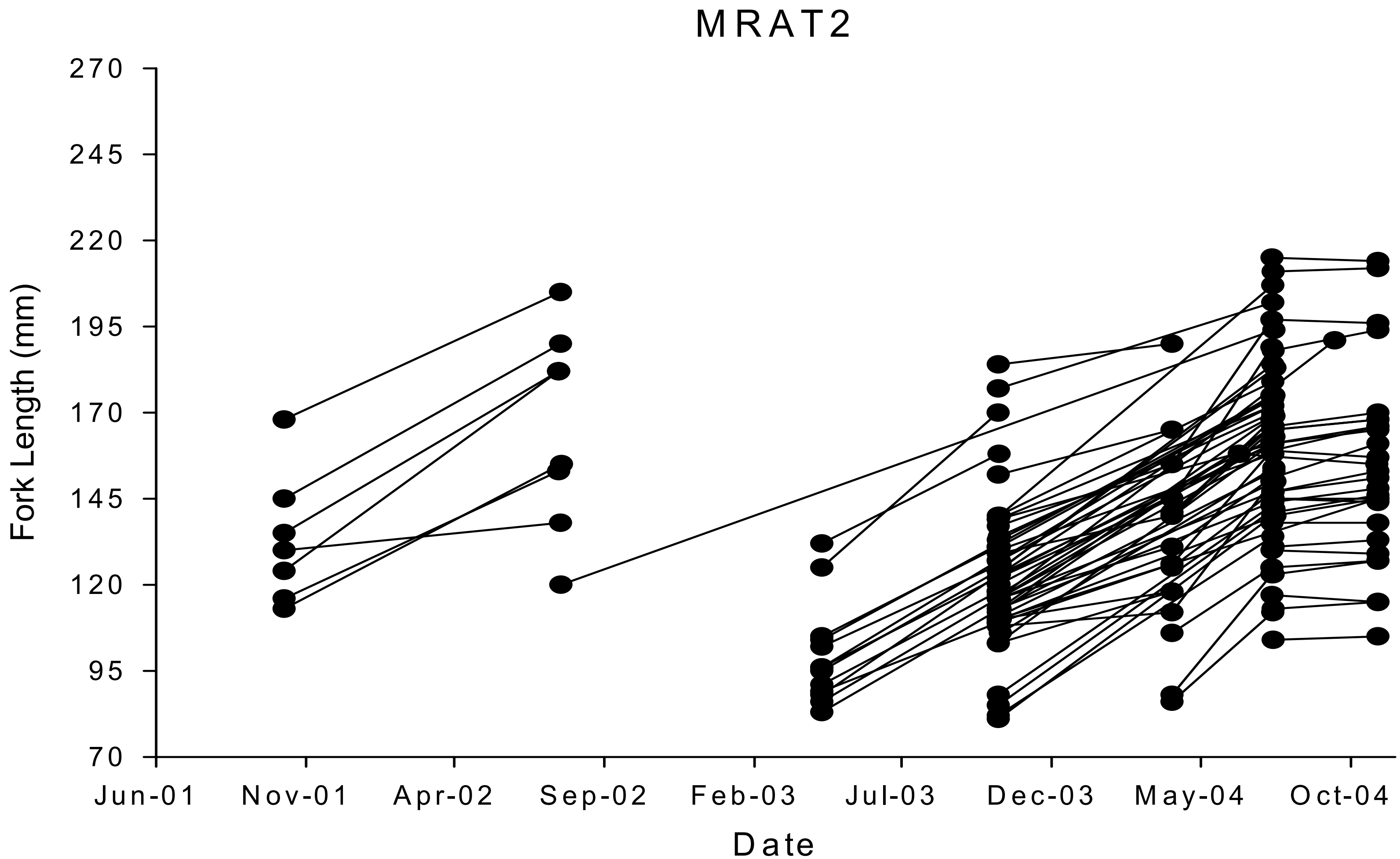


Figure 14b. Length of PIT-tagged rainbow trout within middle Rattlesnake Creek (MRAT2; rkm 7.3-7.9) at initial tagging and at each time of recapture.

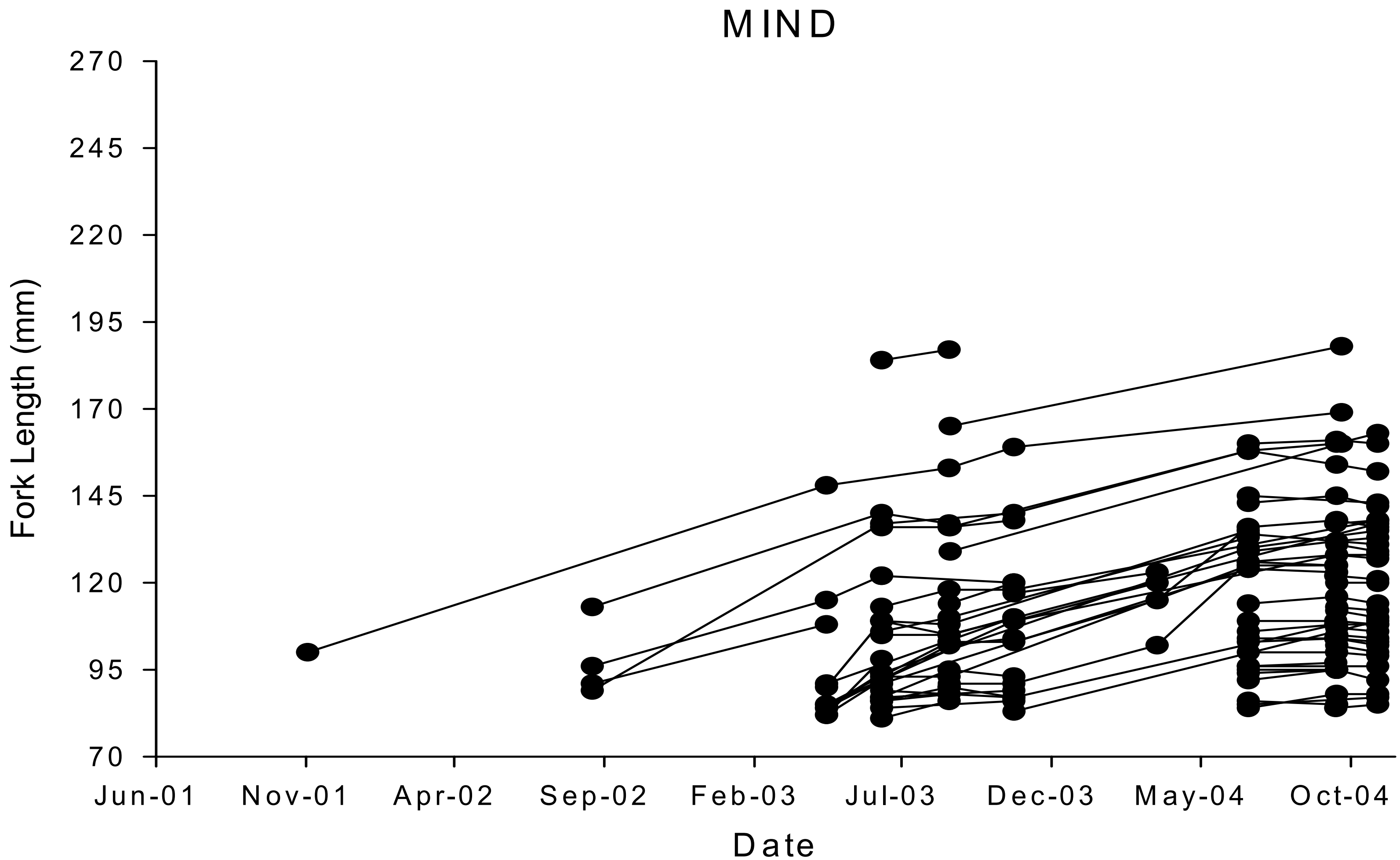


Figure 14c. Length of PIT-tagged rainbow trout within middle Indian Creek (MIND; rkm 2.4-3.3) at initial tagging and at each time of recapture.

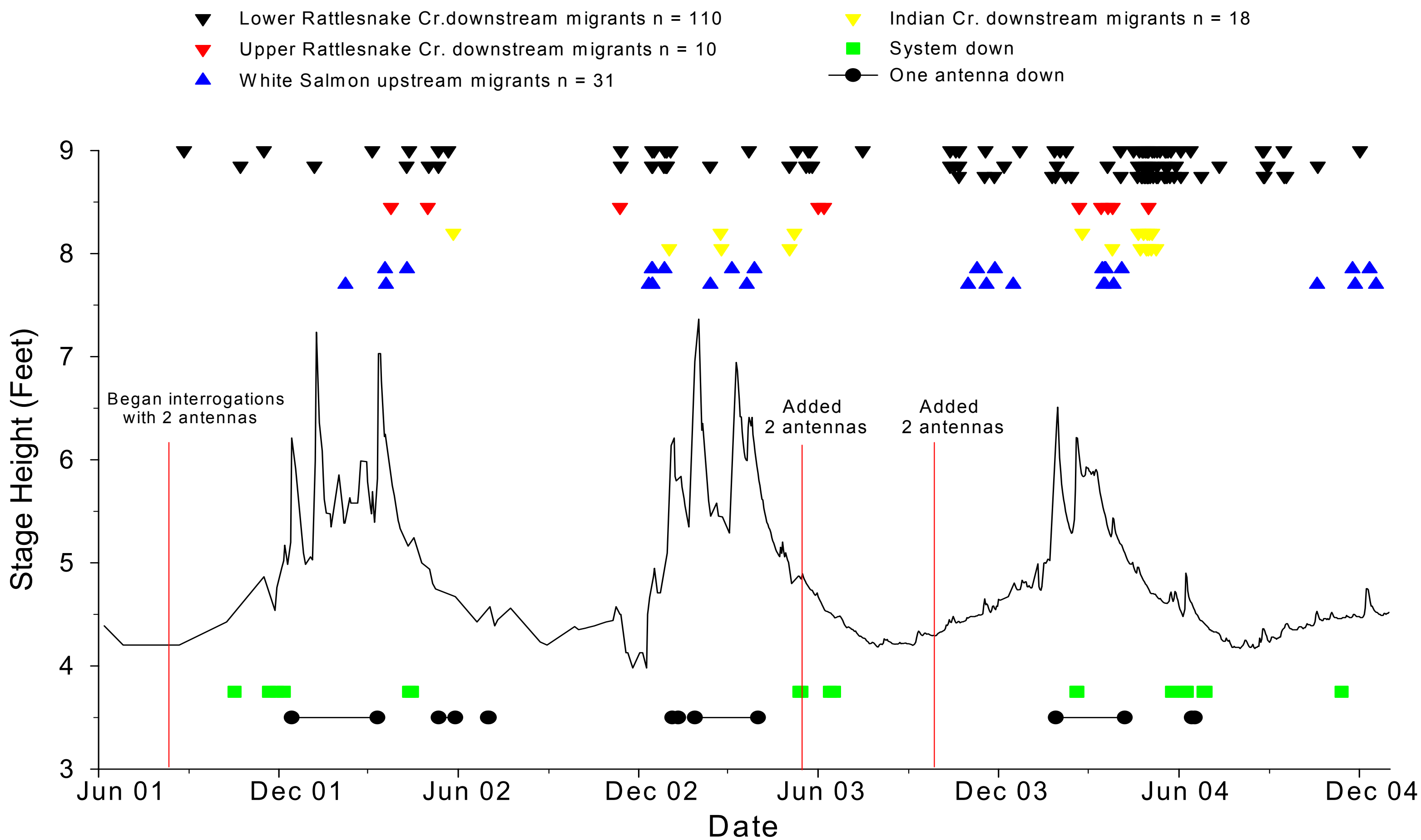


Figure 15. Migration timing of PIT-tagged rainbow and cutthroat trout at a stationary PIT-tag detection system at rkm 0.2 in Rattlesnake Creek, with stage height from a gage at rkm 0.3. All fish reported were considered non-local (tagged and released over 50 m from the interrogation site) and were assumed to be migrating. Stream sections were: upper Rattlesnake Creek (above rkm 2.4), lower Rattlesnake Creek (rkm 0.2 – 2.4), Indian Creek (a tributary of Rattlesnake Creek at rkm 0.8) and the White Salmon River (rkm 5.0 to 12.2). Rattlesnake Creek entered the White Salmon at rkm 12.0. From 25 August 2001 to 16 May 2003, the system had 2 antennas. From 17 May 2003 to 3 November 2003, the system had 4 antennas. After 4 November 2003, the system operated with 6 antennas.

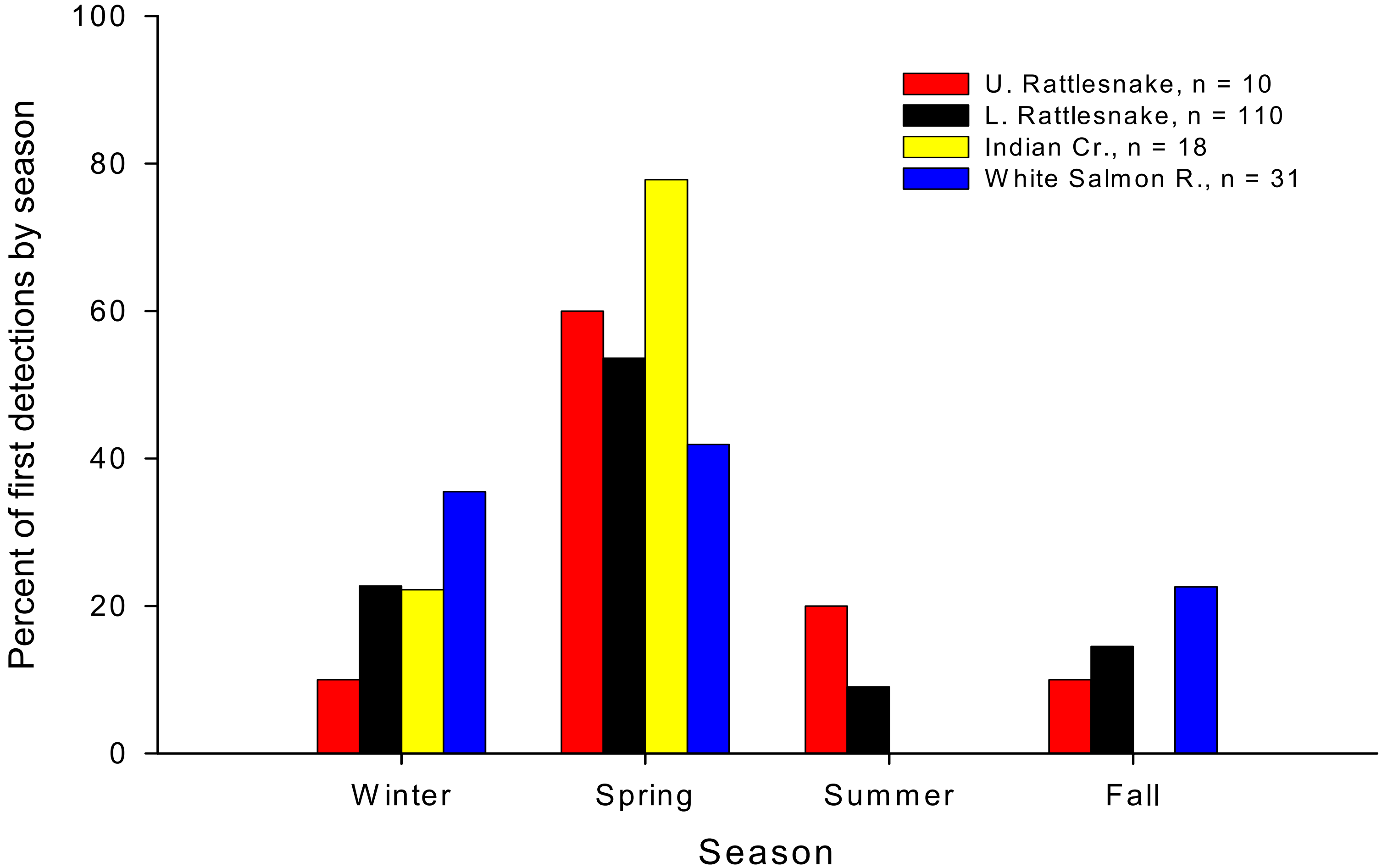


Figure 16. Percent of first detections by season, of PIT-tagged fish from four stream sections during the period 25 August 2001 to 31 December 2004 at a fixed PIT-tag-detection system at rkm 0.2 in Rattlesnake Creek. Stream sections are: U. Rattlesnake (above rkm 2.4), L. Rattlesnake (rkm 0.2 – 2.4), Indian Creek, a tributary of Rattlesnake Creek at rkm 0.8 and the White Salmon River (rkm 5.0 to 12.2). Rattlesnake Creek enters the White Salmon at rkm 12.0. Seasons were: Winter = December, January, February; Spring = March, April, May; Summer = June, July, August; Fall = September, October, November.

# Appendixes

## Appendix A



## Appendix B

Appendix Table 1. Actual flow measures during 2001-2002 for dates and sites listed below. Sites are listed in an upstream to downstream order. See Table 6 and Figure 3 for additional information on flow site locations.

| **Watershed** | | | | **Date** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | 6/7/01 | 7/13/01 | 7/26/01 | 8/22/01 | 9/7/01 | 10/9/01 | 10/16/01 | 10/24/01 | 11/14/01 | 11/16/01 | 12/13/01 |
| **Rattlesnake Creek** | | | | | | | | | | | |
| URAT | 0.39 | | | | | | | | | | |
| MRAT | 1.70 | 0.31 | 0.08 | 0.14 | 0.28 | 0.28 | | 1.34 | | | |
| RAIN | 2.75 | 0.46 | 0.28 | 0.43 | 0.56 | 1.02 | | 2.18 | | | |
| LRAT | 3.22 | 0.71 | 0.61 | 0.77 | 0.78 | 1.23 | 1.57 | 2.36 | 5.84 | 4.84 | 52.86 |
| **Indian Creek** | | | | | | | | | | | |
| MIND | 0.32 | | | | | 0.13 | | 0.26 | | | |
| LIND | 0.72 | | | | | | | | | | |

| **Watershed** | | | | | | |
|---|---|---|---|---|---|---|
| Site | 1/8/02 | 1/14/02 | 1/22/02 | 2/4/02 | 3/4/02 | 3/25/02 |
| **Rattlesnake Creek** | | | | | | |
| LRAT | | 160.31 | 93.88 | 85.05 | 86.57 | 109.54 |
| **Indian Creek** | | | | | | |
| MIND | 19.53 | | | | | |

Appendix Table 2. Actual flow measures for during 2002 for dates and sites listed below. Sites are listed in an upstream to downstream order. See Table 6 and Figure 3 for additional information on flow site locations.

| **Watershed** | | | | **Date** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site | 6/13/02 | 6/20/02 | 7/8/02 | 7/24/02 | 8/6/02 | 8/23/02 | 9/9/02 | 9/26/02 | 10/18/02 | 10/22/02 | 11/1/02 | 12/17/02 | 12/30/02 |
| **Rattlesnake Creek** | | | | | | | | | | | | | |
| URAT | | | | | | | | | | 0.66 | | | |
| MRAT | 3.17 | 1.91 | 1.30 | 0.15 | 0.13 | 0.07 | 0.00 | 0.22 | 0.27 | | 0.64 | 13.50 | |
| RAIN | 5.20 | 5.22 | 2.23 | 0.56 | 0.62 | 0.20 | 0.52 | 0.54 | 0.56 | | 1.15 | 17.76 | |
| LRAT | 8.00 | 5.22 | 2.53 | 0.85 | 0.78 | 0.32 | 0.59 | 0.60 | 0.56 | | 1.97 | 13.79 | 34.82 |
| **Indian Creek** | | | | | | | | | | | | | |
| MIND | 0.65 | 0.49 | 0.37 | 0.11 | 0.18 | 0.01 | 0.08 | 0.10 | 0.08 | | 0.05 | 0.65 | |
| LIND | | | | | | | | | | | | | |

Appendix Table 3. Actual flow measures during 2003 for dates and sites listed below. Sites are listed in an upstream to downstream order. See Table 6 and Figure 3 for additional information on flow site locations.

| **Watershed** | | | | | **Date** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site | 01/06/03 | 06/06/03 | 6/10/03 | 06/27/03 | 07/18/03 | 08/07/03 | 09/02/03 | 09/26/03 | 10/02/03 | 10/17/03 |
| **Rattlesnake Creek** | | | | | | | | | | |
| URAT | | | 2.84 | | | | | | | |
| MRAT | | 4.29 | | 1.54 | 0.16 | 0.00 | | 0.00 | 0.00 | 0.49 |
| RAIN | | 4.70 | | 2.25 | 0.79 | 0.31 | 0.09 | 0.39 | | 1.72 |
| LRAT | 150.96 | 4.95 | | 3.39 | 0.74 | 0.38 | | 0.58 | 0.26 | 2.16 |
| **Indian Creek** | | | | | | | | | | |
| MIND | | | | | 0.15 | 0.08 | | 0.03 | | 0.06 |
| LIND | | 0.33 | | 0.43 | 0.26 | 0.27 | | 0.18 | 0.18 | 0.40 |

Appendix Table 4. Actual flow measures during 2004 for dates and sites listed below. Sites are listed in an upstream to downstream order. See Table 6 and Figure 3 for additional information on flow site locations.

| **Watershed** | **Date** | | | | |
|---|---|---|---|---|---|
| Site | 6/17/04 | 7/27/04 | 8/21/04 | 9/09/04 | 9/18/04 |
| **Rattlesnake Creek** | | | | | |
| MRAT | 3.03 | 0.02 | 0.03 | 0.47 | 0.93 |
| RAIN | 4.53 | 0.25 | 0.20 | 0.60 | 1.25 |
| LRAT | 4.58 | 0.24 | 0.26 | 0.79 | 1.92 |
| **Indian Creek** | | | | | |
| LIND | 0.25 | 0.13 | 0.23 | 0.20 | 0.26 |

# Appendix B

Results from the U. S. Fish and Wildlife Service's Lower Columbia River Fish Health Center disease profiling for rainbow trout collected in Rattlesnake Creek during 2004.

**U.S. FISH & WILDLIFE SERVICE**
**LOWER COLUMBIA RIVER FISH HEALTH CENTER**
**61552 S.R. 14**
**Underwood, WA 98651**
**Phone: 509-493-3156**
**Fax: 509-493-2748**

# FISH HEALTH REPORT 2004

| FISH SOURCE | FISH EXAMINED |
|---|---|
| **Location:** Rattlesnake Creek<br>**County**: Klickitat<br>**Contact Person:** Pat Connolly<br>**Affiliation:** USGS CRRL<br>**Phone:** (509) 538-2299 ext 269 | **Species:** Rainbow trout<br>**Age:** Adult and Juvenile<br>**CHN:** W04-084<br>**Number of fish:** 60<br>**Date Sampled:** 06-21-04 |

| DISEASE AGENT [1] | SAMPLE SIZE | RESULTS | COMMENTS |
|---|---|---|---|
| IPNV | 60 | negative | EPC and CHSE-214 cells |
| IHNV | 60 | negative | EPC and CHSE-214 cells |
| VHS | 60 | negative | EPC and CHSE-214 cells |
| AS | 30 | negative | BHIA medium |
| YR | 30 | negative | BHIA medium |
| RS | 30 | **suspect** | +8/10 pools detected by ELISA, not confirmed by PCR 0/3 |
| BCD | 30 | negative | TYES medium |
| CD | 30 | negative | TYES medium |
| ESC | 30 | negative | BHIA medium |
| WD | 60 | negative | Pepsin/Trypsin Digest |
| CS | - | not tested | microscopic examination |
| Comments | 115 morts, worked up 60 fish. *Nanophyetus* on the skin and gills (low levels). *Aeromonas* bacterial growth on BHIA medium in a couple of fish. *Henneguya* spores in heads (low). | | |

[1] **IPNV** Infectious Pancreatic Necrosis Virus, **IHNV** Infectious Hematopoietic Necrosis Virus, **VHS** Viral HemorrhagicSepticemia Virus, **AS** Furunculosis (*Aeromonas salmonicida)* , **YR** Enteric Redmouth (*Yersinia ruckeri),* **RS** BKD (*Renibacterium salmoninarum*), **BCD** Coldwater Disease (*Flavobacterium psychrophilum)*, **CD** Columnaris (*Flavobacterium columnare)*, **ESC** Emphysematous Putrefactive Disease *(Edwardsiella ictaluri),* **WD** Whirling Disease (*Myxobolus cerebralis*), **CS** Salmonid Ceratomyxosis (*Ceratomyxa shasta).*

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# FISH HEALTH REPORT 2004

| FISH SOURCE | FISH EXAMINED |
|---|---|
| **Location:** Rattlesnake Creek<br>**County**: Klickitat<br>**Contact Person:** Pat Connolly<br>**Affiliation:** USGS CRRL<br>**Phone:** (509) 538-2299 ext 269 | **Species:** Rainbow trout<br>**Age:** Juvenile<br>**CHN:** W04-093<br>**Number of fish:** 6<br>**Date Sampled:** 07-13-04 |

| DISEASE AGENT [1] | SAMPLE SIZE | RESULTS | COMMENTS |
|---|---|---|---|
| IPNV | 6 | negative | EPC and CHSE-214 cells |
| IHNV | 6 | negative | EPC and CHSE-214 cells |
| VHS | 6 | negative | EPC and CHSE-214 cells |
| AS | 6 | negative | BHIA medium |
| YR | 6 | negative | BHIA medium |
| RS | - | not tested | ELISA |
| BCD | 6 | negative | TYES medium |
| CD | 6 | negative | TYES medium |
| ESC | 6 | negative | BHIA medium |
| WD | 6 | negative | Pepsin/Trypsin Digest |
| CS | - | not tested | microscopic examination |
| Comments | Fish appeared to be in good health. | | |

[1] **IPNV** Infectious Pancreatic Necrosis Virus, **IHNV** Infectious Hematopoietic Necrosis Virus, **VHS** Viral HemorrhagicSepticemia Virus, **AS** Furunculosis (*Aeromonas salmonicida)* , **YR** Enteric Redmouth (*Yersinia ruckeri),* **RS** BKD (*Renibacterium salmoninarum*), **BCD** Coldwater Disease (*Flavobacterium psychrophilum)*, **CD** Columnaris (*Flavobacterium columnare)*, **ESC** Emphysematous Putrefactive Disease *(Edwardsiella ictaluri),* **WD** Whirling Disease (*Myxobolus cerebralis*), **CS** Salmonid Ceratomyxosis (*Ceratomyxa shasta).*

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# FISH HEALTH REPORT 2004

| FISH SOURCE | FISH EXAMINED |
|---|---|
| **Location:** Rattlesnake Creek<br>**County**: Klickitat<br>**Contact Person:** Pat Connolly<br>**Affiliation:** USGS CRRL<br>**Phone:** (509) 538-2299 ext 269 | **Species:** Rainbow trout<br>**Age:** Juvenile<br>**CHN:** W04-097<br>**Number of fish:** 3<br>**Date Sampled:** 07-15-04 |

| DISEASE AGENT [1] | SAMPLE SIZE | RESULTS | COMMENTS |
|---|---|---|---|
| IPNV | 3 | negative | EPC and CHSE-214 cells |
| IHNV | 3 | negative | EPC and CHSE-214 cells |
| VHS | 3 | negative | EPC and CHSE-214 cells |
| AS | 3 | negative | BHIA medium |
| YR | 3 | negative | BHIA medium |
| RS | - | not tested | ELISA |
| BCD | 3 | negative | TYES medium |
| CD | 3 | negative | TYES medium |
| ESC | 3 | negative | BHIA medium |
| WD | 3 | negative | Pepsin/Trypsin Digest |
| CS | - | not tested | microscopic examination |
| Comments | *Nanophyetus* and *Loma* in the gills (heavy). *Loma* on the skin (low). One fish had *Aeromonas* bacterial growth on BHIA medium. *Henneguya* spores in the heads (low). | | |

[1] **IPNV** Infectious Pancreatic Necrosis Virus, **IHNV** Infectious Hematopoietic Necrosis Virus, **VHS** Viral HemorrhagicSepticemia Virus, **AS** Furunculosis (*Aeromonas salmonicida)* , **YR** Enteric Redmouth (*Yersinia ruckeri),* **RS** BKD (*Renibacterium salmoninarum*), **BCD** Coldwater Disease (*Flavobacterium psychrophilum)*, **CD** Columnaris (*Flavobacterium columnare)*, **ESC** Emphysematous Putrefactive Disease *(Edwardsiella ictaluri),* **WD** Whirling Disease (*Myxobolus cerebralis*), **CS** Salmonid Ceratomyxosis (*Ceratomyxa shasta).*

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# FISH HEALTH REPORT 2004

| FISH SOURCE | FISH EXAMINED |
|---|---|
| **Location:** Rattlesnake Creek<br>**County**: Klickitat<br>**Contact Person:** Pat Connolly<br>**Affiliation:** USGS CRRL<br>**Phone:** (509) 538-2299 ext 269 | **Species:** Rainbow trout<br>**Age:** Juvenile<br>**CHN:** W04-113<br>**Number of fish:** 1<br>**Date Sampled:** 08-03-04 |

| DISEASE AGENT [1] | SAMPLE SIZE | RESULTS | COMMENTS |
|---|---|---|---|
| IPNV | 1 | negative | EPC and CHSE-214 cells |
| IHNV | 1 | negative | EPC and CHSE-214 cells |
| VHS | 1 | negative | EPC and CHSE-214 cells |
| AS | 1 | negative | BHIA medium |
| YR | 1 | negative | BHIA medium |
| RS | 1 | not detected | ELISA |
| BCD | 1 | negative | TYES medium |
| CD | 1 | negative | TYES medium |
| ESC | 1 | negative | BHIA medium |
| WD | 1 | negative | Pepsin/Trypsin Digest |
| CS | 1 | negative | microscopic examination |
| Comments | Fish appeared to be in good health. | | |

[1] **IPNV** Infectious Pancreatic Necrosis Virus, **IHNV** Infectious Hematopoietic Necrosis Virus, **VHS** Viral HemorrhagicSepticemia Virus, **AS** Furunculosis (*Aeromonas salmonicida)* , **YR** Enteric Redmouth (*Yersinia ruckeri),* **RS** BKD (*Renibacterium salmoninarum*), **BCD** Coldwater Disease (*Flavobacterium psychrophilum)*, **CD** Columnaris (*Flavobacterium columnare)*, **ESC** Emphysematous Putrefactive Disease *(Edwardsiella ictaluri),* **WD** Whirling Disease (*Myxobolus cerebralis*), **CS** Salmonid Ceratomyxosis (*Ceratomyxa shasta).*

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# FISH HEALTH REPORT 2004

| FISH SOURCE | FISH EXAMINED |
|---|---|
| **Location:** Rattlesnake Creek<br>**County**: Klickitat<br>**Contact Person:** Pat Connolly<br>**Affiliation:** USGS CRRL<br>**Phone:** (509) 538-2299 ext 269 | **Species:** Rainbow trout<br>**Age:** Juvenile<br>**CHN:** W04-141<br>**Number of fish:** 6<br>**Date Sampled:** 09-09-04 |

| DISEASE AGENT [1] | SAMPLE SIZE | RESULTS | COMMENTS |
|---|---|---|---|
| IPNV | 6 | negative | EPC and CHSE-214 cells |
| IHNV | 6 | negative | EPC and CHSE-214 cells |
| VHS | 6 | negative | EPC and CHSE-214 cells |
| AS | 6 | negative | BHIA medium |
| YR | 6 | negative | BHIA medium |
| RS | 6 | **positive** | +2/3 pools detected by ELISA, confirmed by PCR +1/2 |
| BCD | 6 | negative | TYES medium |
| CD | 6 | negative | TYES medium |
| ESC | 6 | negative | BHIA medium |
| WD | 6 | negative | Pepsin/Trypsin Digest |
| CS | 3 | negative | microscopic examination |
| Comments | Black spot (*Neascus*) on the skin (heavy). *Nanophyetus* in the gills and kidneys (heavy). One fish with missing caudal and dorsal fins. Digenetic trematode in the hind-gut (low). | | |

[1] **IPNV** Infectious Pancreatic Necrosis Virus, **IHNV** Infectious Hematopoietic Necrosis Virus, **VHS** Viral HemorrhagicSepticemia Virus, **AS** Furunculosis (*Aeromonas salmonicida)* , **YR** Enteric Redmouth (*Yersinia ruckeri),* **RS** BKD (*Renibacterium salmoninarum*), **BCD** Coldwater Disease (*Flavobacterium psychrophilum)*, **CD** Columnaris (*Flavobacterium columnare)*, **ESC** Emphysematous Putrefactive Disease *(Edwardsiella ictaluri),* **WD** Whirling Disease (*Myxobolus cerebralis*), **CS** Salmonid Ceratomyxosis (*Ceratomyxa shasta).*

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# FISH HEALTH REPORT 2004

| FISH SOURCE | FISH EXAMINED |
|---|---|
| **Location:** Rattlesnake Creek<br>**County**: Klickitat<br>**Contact Person:** Pat Connolly<br>**Affiliation:** USGS CRRL<br>**Phone:** (509) 538-2299 ext 269 | **Species:** Rainbow trout<br>**Age:** Juvenile<br>**CHN:** W04-144<br>**Number of fish:** 3<br>**Date Sampled:** 09-15-04 |

| DISEASE AGENT [1] | SAMPLE SIZE | RESULTS | COMMENTS |
|---|---|---|---|
| IPNV | 3 | negative | EPC and CHSE-214 cells |
| IHNV | 3 | negative | EPC and CHSE-214 cells |
| VHS | 3 | negative | EPC and CHSE-214 cells |
| AS | 3 | negative | BHIA medium |
| YR | 3 | negative | BHIA medium |
| RS | 2 | **suspect** | Detected by ELISA, not confirmed by PCR 0/2 |
| BCD | 3 | negative | TYES medium |
| CD | 3 | negative | TYES medium |
| ESC | 3 | negative | BHIA medium |
| WD | 3 | negative | Pepsin/Trypsin Digest |
| CS | 2 | negative | microscopic examination |
| Comments | *Nanophyetus* in the gills (moderate). Digenetic trematode in the hind-gut (low). *Nanophyetus* in the eyes of the fish (heavy). Fish eating well, crayfish in belly of one fish. | | |

[1] **IPNV** Infectious Pancreatic Necrosis Virus, **IHNV** Infectious Hematopoietic Necrosis Virus, **VHS** Viral HemorrhagicSepticemia Virus, **AS** Furunculosis (*Aeromonas salmonicida)* , **YR** Enteric Redmouth (*Yersinia ruckeri),* **RS** BKD (*Renibacterium salmoninarum*), **BCD** Coldwater Disease (*Flavobacterium psychrophilum)*, **CD** Columnaris (*Flavobacterium columnare)*, **ESC** Emphysematous Putrefactive Disease *(Edwardsiella ictaluri),* **WD** Whirling Disease (*Myxobolus cerebralis*), **CS** Salmonid Ceratomyxosis (*Ceratomyxa shasta).*