Wind River Subbasin Restoration

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5. Executive Summary

We used Passive Integrated Transponder (PIT)-tagging and a series of instream PIT-tag interrogation systems (PTISs) to investigate life-histories, populations, and efficacy of habitat restoration actions for steelhead *Oncorhynchus mykiss* in the Wind River subbasin, WA. Our tagging focused on parr in headwaters areas of the subbasin and our instream readers provided information on movement of these parr and other life-stages of tagged steelhead. The Wind River subbasin in southwest Washington State provides habitat for a population of wild Lower Columbia River steelhead and is an excellent watershed for long-term studies of population dynamics and responses to restoration of this wild population. No hatchery steelhead have been planted in the Wind River subbasin since 1994, and hatchery adults are estimated to be less than one percent of adults in any year (pers comm. Thomas Buehrens, Washington Department of Fish and Wildlife). Numerous restoration actions have been implemented in the subbasin, including the removal of Hemlock Dam on Trout Creek in 2009. Data from our study, and companion work by Washington Department of Fish and Wildlife (WDFW), will contribute to Bonneville Power Administration's (BPA) Research Monitoring and Evaluation (RM&E) Program Strategy of Fish Population Status Monitoring (www.cbfish.org/ProgramStrategy.mvc/ViewProgramStrategySummary/1), specifically the sub-strategies of: 1) Assessing the Status and Trends of Diversity of Natural Origin Fish Populations and to Uncertainties Research regarding differing life histories of a wild steelhead population, 2) Assessing the Status and Trend of Adult Natural Origin Fish Populations, and 3) Monitoring and Evaluating the Effectiveness of Tributary Habitat Actions Relative to Environmental, Physical, or Biological Performance Objectives.

During summer 2016, we sampled and PIT-tagged age-0 and age-1 steelhead parr in headwater areas of the Wind River subbasin to characterize population traits and investigate variable life-histories, including growth and parr movement downstream prior to smolting. Repeat sampling and smolt traps provide opportunities for recapture, and instream PTISs and Columbia River infrastructure provide opportunity for detection of PIT-tagged fish.

Throughout the year, we maintained a series of instream PTISs to monitor movement of tagged steelhead parr, smolts, and adults. During 2016, we repaired or replaced much of our instream PTIS infrastructure that had been damaged or destroyed during a large flood event in December 2015. This included moving our upper Wind River detection site (WRU) about a kilometer downstream to a location we hope to be less susceptible to damage in high flows and that will allow grid power connection for more reliable winter operations.

Detections at the instream PTISs showed trends of parr emigration during summer and fall, in addition to the expected movement of parr and smolts in spring. These data are increasing our understanding of varied life histories of juvenile steelhead; paired with other steelhead population work in the subbasin we hope to begin to understand some of the factors which may influence parr movements. Long-term monitoring of PIT-tagged fish over multiple years is providing information on contribution of various life-history strategies to smolt production and adult returns, as well as helping to identify factors influencing parr movement.

Movements of PIT-tagged adult steelhead were also tracked with our instream PTISs. These data have provided information on timing of adult movements to various parts of the watershed, which is allowing us to assess adult returns to tributary watersheds within the Wind River subbasin. Determination of adult use of tributary watersheds is providing data to contribute to evaluation of the efficacy of the removal of Hemlock Dam on Trout Creek. Hemlock Dam, located at rkm 2.0 of Trout Creek was removed in summer 2009 and had contributed to hydrologic impairment of Trout Creek.

Evaluating restoration efforts is of interest to many managers and agencies so that funding and time are allocated for best results. The evaluation of various life-histories of Lower Columbia River steelhead within the Wind River subbasin will provide information to better track populations, and to direct habitat restoration and water allocation planning. Increasingly detailed Viable Salmonid Population information, such as that provided by PIT-tagging and instream PTISs networks like those we are building and operating in the Wind River subbasin, will provide data to inform policy and management, as life-history strategies and production bottlenecks are identified and understood.

6. Introduction

This report summarizes work by U.S. Geological Survey's Columbia River Research Laboratory (USGS-CRRL), in the Wind River subbasin, from January 2016 through December 2016. Funding for activities during this time was provided by Bonneville Power Administration (BPA) under contracts 70963 and 73884 as part of the Wind River Subbasin project partnership (BPA Project Number 1998-019-00). The Wind River Subbasin project is a collaborative effort to restore, monitor, and research wild Lower Columbia River steelhead in the Wind River, WA. The four partner agencies are the U.S. Forest Service (USFS), Washington Department of Fish and Wildlife (WDFW), Underwood Conservation District (UCD), and USGS-CRRL.

This partnership was established in the early 1990s with support from BPA, and has allowed extensive habitat, research, monitoring, and coordination activities across the Wind River subbasin. The project works at multiple levels to identify and characterize key limiting habitat factors in the Wind River; restore degraded habitats and watershed processes; document fish populations, life histories, and interactions; investigate efficacy of restoration actions; and to share information across agency and non-agency boundaries. Long-term research in the Wind River has focused on assessing steelhead/rainbow trout *O. mykiss* populations and life history (Connolly and Jezorek 2007; Cochran et al. 2013; Jezorek and Connolly 2014), their relationships with introduced populations of spring Chinook salmon *O. tshawytscha* and brook trout *Salvelinus fontinalis* (Connolly and Jezorek 2007; Jezorek and Connolly 2010; Jezorek and Connolly 2015a), documenting habitat variables, and assessing habitat restoration efficacy (Connolly and Jezorek 2007; Coffin 2011).

There are several goals of the ongoing research presented in this report. These data and efforts will contribute to a greater understanding of the diversity of steelhead life-histories and the

factors driving different life-history expressions in a wild steelhead population. Of particular interest are migratory parr and their fates compared to headwater rearing parr that do not migrate until smolting. Efforts to date have demonstrated that parr steelhead can migrate from headwater rearing areas as young as age-0 and throughout the year. Our sampling efforts are providing data that will inform life-cycle modeling and estimate life-stage specific survival, and identify potential population bottlenecks. Additionally, these data are contributing to evaluation of the response of steelhead populations to the removal of Hemlock Dam from Trout Creek.

During the period covered by this report, we tagged steelhead parr in headwater sections of the Wind River subbasin with Passive Integrated Transponder (PIT) tags (Figure 1) and maintained a network of instream PIT-tag interrogation systems (PTISs; Figure 2). Past monitoring in the Wind River subbasin has suggested a large downstream migration of parr to the lower river (Cochran et al. 2013) and we are further documenting and understanding this life-history strategy and its implications to the population. The PIT-tagged steelhead parr are providing growth, movement, and life history data through recapture events, detections at instream PTISs within the Wind River subbasin, and through detections at Bonneville Dam as smolts and adults. All PIT-tag data are submitted to the PIT Tag Information System (PTAGIS) database administered by Pacific States Marine Fisheries Commission. These data will contribute to the BPA Research Monitoring & Evaluation (RM&E; www.cbfish.org/ProgramStrategy.mvc/ViewProgramStrategySummary/1) Program Strategy of: Assessing the Status and Trends of Diversity of Natural Origin Fish Populations and contribute to Uncertainties Research by exploring the diversity of life histories of a wild steelhead population.

Adult steelhead data from the PTISs are providing data toward the RM&E Program Strategy of: Assessing the Status and Trends of Adult Natural Origin Fish Populations. The PTISs will allow estimation of adult steelhead returns to Trout Creek and the Wind River, aiding in evaluation of the effects of removal of Hemlock Dam from rkm 2.0 Trout Creek (removed summer 2009; Coffin 2011) on steelhead populations. This habitat restoration assessment is helping inform the RM&E Program Strategy of Monitoring and Evaluating the Effectiveness of Tributary Habitat Actions Relative to Environmental, Physical, or Biological Performance Objectives. Additionally we maintained thermologgers to collect water temperature data near the PIT-tagging sites.

7. Study Area and Methods

The Wind River is a fifth-order tributary of the Columbia River in southwest Washington's Columbia River Gorge. The Wind River subbasin extends north nearly 50 km from the Columbia River. Elevations range from 29 m at the mouth to 1,190 m on ridge tops in

the northern portion of the subbasin. The climate is temperate with most of the average annual precipitation of 280 cm occurring between November and April.

We PIT-tagged *O. mykiss* parr (age-0 and age-1) at headwater sites in the Trout Creek and upper Wind River watersheds (Figure 1). Our fish-sampling sites were between 300 and 600-m long. We sampled these sites in summer and again in early fall, when we could recapture previously tagged fish and PIT-tag age-0 fish. We have consistently sampled most of these sites since 2011. Repeat sampling in multiple years provides for recaptures of fish tagged in previous years, providing data on growth and movement.

All fish were captured by backpack electrofishing. Captured fish were anesthetized with the lightest possible dose of 100g/L mixture of MS-222 before handling. All fish were measured for fork length to the nearest mm, weighed to the nearest 0.1 g, inspected for external signs of disease, and scanned for PIT tags. Untagged fish that were at least 70-mm fork length, and were not injured or in poor condition, were PIT-tagged with a 12-mm 134.2 kHz tag, which was inserted by syringe. Fish between 55 and 70-mm were PIT tagged with 9-mm 134.2 kHz tags. The 9-mm tags were inserted into an incision made with a scalpel. Several studies have reported that creating an incision with a scalpel was more effective on small fish than using a syringe (Baras et al. 2000; Archdeacon et al. 2009; Dixon and Mesa 2011). All PIT-tagging procedures followed the guidelines outlined by Columbia Basin Fish and Wildlife Authority (1999). After work up, fish were held in fresh ambient-temperature stream water, allowed to recover and regain equilibrium, and released at or near their point of capture. All tagging and recapture data followed PTAGIS database protocols and were submitted to the PTAGIS database.

During the period covered by this report, we operated six PTISs (Figure 2) to track PIT-tagged juvenile and adult steelhead. Two PTIS sites were located in mainstem Trout Creek (site TRC at rkm 2.0, and site TC4 at rkm 11.5), one in Martha Creek (site MAD at rkm 1.0), two in the mainstem Wind River (site WRU at rkm 30.0, and site UMD at rkm 40.5) and one in Paradise Creek (site PAD at rkm 0.5). We used three different types of transceivers at the PTIS sites.

The transceivers at TRC, TC4, and WRU were Biomark 1001M units capable of operating six individual antennas. Six antennas were used to span these larger sites (three arrays of two antennas each at TRC, and two arrays of three antennas each at TC4 and WRU; Figures 3 - 5). All of the antennas operated by the MUX transceivers are 6-m long by 0.6-m wide. Because PTISs in streams as large as Trout Creek and the mainstem of the Wind River rarely detect every passing fish (Zydlewski et al. 2006; Achord et al. 2012), an estimate of detection efficiency must be made to estimate run size of PIT-tagged fish. Multiple antenna arrays provided us the opportunity to generate detection efficiency estimates of adult salmonids following the methods outlined in Connolly et al. (2008).

The two transceivers at MAD were Allflex RM310 units. Each operated a single antenna, as described by Bond et al. (2007). The site at Martha Creek had grid power, enabling us to operate two transceivers and antennas (3-m long by 0.6-m wide). At PAD and UMD we operated Biomark ACN transceivers. These transceivers were more efficient and provide greater

diagnostics than the RM310 units. Limitations on power at PAD and UMD (both solar supported) allow for operation of only one antenna (3-m long by 0.6-m wide) at each site. Because of limitations of solar-power charging and access issues due to snowfall, we missed some monitoring time at the PAD and UMD sites during winter conditions. The solar panels at the PAD site are near the road and would be subject to snowplow damage so they must be removed during winter. We began operation at PAD on 28 April 2016 and shut down the site for winter on 10 November 2016.

On 8 December 2015, the Wind River experienced a high flow event that damaged our PTIS infrastructure. Estimated flow was about 25,000 cfs at the Shipherd Falls gage (rkm 2.7), which was about a 25 – 30 year event (pers comm. Bengt Coffin, Hydrologist, U.S Forest Service). Damaged antennas included, the single antennas at UMD and PAD, two antennas at TRC, three antennas at TC4, and five antennas at WRU. Due to the damages incurred, detection ability was compromised during portions of 2016. As of this writing, all antennas have been replaced at TRC, TC4, UMD, and PAD. TRC was operated as a two-array system until 15 July 2016 at which point the upper array was repaired. At TC4, we replaced antennas 1 and 2 on 5 May 2016 and antenna 4 on 21 June 2016. The single antennas at UMD and PAD were replaced on 28 April 2016. We relocated the WRU site about a kilometer downstream of its present location to a site that should be less vulnerable to flood damage. The new WRU site became operational on 6 October 2016 with one array of three antennas. A second array will be installed at WRU in 2017.

To investigate parr life histories and movements, we are compiling data from electrofishing recapture events, WDFW smolt trapping, instream PTISs, and detections at Columbia River infrastructure. The PTISs provided data on parr movement timing from headwaters areas (Tables 3 and 4). Additionally, instream PTISs are providing migration information on parr PIT tagged by WDFW at their screw trap on Trout Creek and the upper Wind River. These parr are primarily age-1 fish and many questions exist regarding their behavior and contribution to smolt and adult populations. All interrogation data from the PTISs were submitted to the PTAGIS database (file uploads 2 to 4 times per month). Interrogation data from the TRC, TC4, and WRU were submitted as interrogation files. Due to more frequent interruptions to operations, data from MAD, PAD, and UMD were submitted as Passive Observation Recaptures (can be found as recaptures in PTAGIS).

We operated five thermologgers during the period covered by this report (Table 1). These thermologgers were deployed to provide water temperature data near our parr PIT-tagging locations. All thermologgers were Onset Optic Stowaway units set to record water temperature hourly. The units were downloaded twice per year.

8. Results

Fish Tagging -- During summer 2016, we PIT-tagged 1,309 steelhead parr in the headwaters of the Wind River subbasin. In the Trout Creek watershed, we PIT-tagged *O. mykiss* parr in Martha,

Layout, and Crater creeks, and one section (rkm 11.0 – 11.3) of mainstem Trout Creek (Figure 1; Table 2). In the upper Wind River watershed, we PIT-tagged *O. mykiss* parr in Trapper and Paradise creeks, in the Wind River upstream of its confluence with Paradise Creek, and in one section of the mainstem Wind River (the Mine Reach; rkm 36.1 – 36.5) 3 km downstream of the Paradise Creek confluence (Figure 1; Table 2). We tagged 894 fish with 9-mm PIT tags and 415 with 12-mm PIT tags. The smaller tags allowed tagging of age-0 fish between 55 and 70 mm fork length. Most sites were sampled in summer, then again in early fall (Table 2; Appendix Figures 1 – 9).

Length and weight data were collected from *O. mykiss* that we did not PIT tag, including those fry too small to tag (Appendix Figures 1 – 9). Length frequency data were used to determine age-0 and age-1 length breaks for each sample site and date during each year we have sampled (Appendix Tables 1 and 2). Brook trout, a non-native species, were present in Layout, Crater, and Trout creeks, and length and weight data were collected from those captured. Shorthead sculpin *Cottus confusus* were present in Trapper and Paradise creeks and the mainstem Wind River.

PIT Tag Interrogations and Recaptures – Eighty-nine PIT-tagged adult steelhead were detected at the TRC PTIS from 01 January 2016 through 31 December 2016 (Figure 6). Adult detection efficiency, derived by the methods of Connolly et al. (2008), of the TRC PTIS was 92.1% (SE = 1.8) over this time period (Table 5). Additionally, we were able to calculate TRC detection efficiency of PIT-tagged adult steelhead by checking for detections of those adult steelhead detected at TC4, which is upstream of TRC, thus adult steelhead must pass TRC to reach TC4. During the period 1 January 2016 through 31 December 2016, there were 42 adult steelhead detected at the TC4 PTIS, 38 of these adults had been detected at TRC for an efficiency estimate of 90.5%. Adult steelhead were detected at TRC during each month of 2016 except August (Figure 6). October saw the greatest number of initial detections with 39 fish.

Forty-four PIT-tagged juvenile steelhead, tagged as parr by USGS in the Trout Creek watershed upstream of the TRC site, were detected at the TRC PTIS from 1 January 2016 through 31 December 2016 (Figure 7). Because the detection efficiency method of Connolly et al. (2008) can overestimate efficiency when water over the antennas exceeds read ranges, we estimated juvenile detection efficiency as the percentage of fish PIT tagged upstream of TRC and detected at downstream locations that were also detected at TRC. During 2016, this was 6 of 11 fish giving a juvenile downstream migrant detection efficiency estimate of 54.6%. Juvenile steelhead, tagged as parr in the upper watershed were detected at TRC during spring, summer and fall with 36 detections in spring and 8 during summer and fall.

Forty-two PIT-tagged adult steelhead were detected at the TC4 PTIS from 1 January 2016 to 31 December 2016 (Figure 8). Due to the damage to antennas from the December 2015 flood event we were not able to generate detection efficiencies for TC4 until after June 2016. Adult detection efficiency, derived by the methods of Connolly et al. (2008), of the TC4 PTIS was 76.6% (SE = 11.4) for the 21 PIT-tagged adult steelhead detected from October through December 2016 (Table 6). Initial detections of adult PIT-tagged steelhead at TC4 happened in winter, spring, and fall (Figure 8). A pulse of initial detections occurred during October.

Forty-nine PIT-tagged juvenile steelhead, tagged as parr by USGS in the Trout Creek watershed upstream of the TC4 site during 2014, 2015, or 2016, were detected at the TC4 PTIS from 1 January 2016 to 31 December 2016 (Figure 9). Because the detection efficiency method of Connolly et al. (2008) can overestimate efficiency when water over the antennas exceeds read ranges, we estimated juvenile detection efficiency as the percentage of fish PIT tagged upstream of TC4 and detected at downstream locations that were also detected at TC4. During 2015, this was 22 of 42 fish giving a juvenile downstream migrant detection efficiency estimate of 52.4%. Downstream moving steelhead parr were detected at TC4 primarily during spring, summer, and fall. (Figure 9). An additional 32 PIT-tagged juvenile steelhead, which were tagged as parr at a site about 250 m downstream of TC4 in 2014, 2015, or 2016, were detected at TC4.

Few fish were detected at WRU during 2016 because the site was destroyed in the December 2015 flood and the new site not built and activated until 6 October 2016 (single array). Three adult steelhead were detected during fall 2016. Four juvenile steelhead were detected during fall 2016 that had been PIT tagged upstream of the site, two during 2015 and two during 2016. An additional 10 fish were detected, but as of this writing are Orphan tags (no tagging data submitted to PTAGIS) of unknown origin.

The instream PTISs at Trout Creek (TRC) and the upper Wind River (WRU) have also provided detection data on steelhead parr PIT tagged during spring by WDFW at screw traps and released upstream of these sites. Some of the released parr are recaptured at screw traps, but many are not and assumptions about migratory behavior for smolts do not necessarily apply to parr migrants. Detections of these tagged parr have potential to provide data on migration rates and contribute to efforts to quantify migrant parr populations. Table 7 presents detection data on parr steelhead PIT tagged by WDFW at screw traps in Trout Creek and the upper Wind River, released upstream of PTIS sites, but not recaptured at screw traps. During six of the seven years of monitoring at TRC, 70 percent or more of the PIT-tagged parr detected were detected within a week of their release date. During those six years, median travel time from the release site to the PTIS was 0 or 1 day. The exception year was 2010 when sample size was low and there were 18 days during the trapping season when the TRC PTIS was not functioning. During three years of monitoring at the WRU PTIS median travel time has been 0 – 2 days. During two of the years, 86 percent or more of detections occurred within one week of release.

Additional detections of PIT-tagged juvenile and adult steelhead were recorded at the three tributary Passive Observation Recapture sites (MAD, PAD, and UMD). Operation at UMD began late in spring due to the previous December flood and operation during fall 2016 was intermittent due to challenges of solar power and site access. Six PIT-tagged juvenile steelhead were detected at UMD from 28 April 2016 through 31 December 2016 (Figure 10), one of which had been tagged in Paradise Creek. Four adult PIT-tagged steelhead were detected at UMD during spring 2016. Operation at PAD also began late in the spring due to flood damage and ended for winter on 10 November 2016. Fourteen juvenile steelhead were detected at the PAD site during 2016, five of these during fall (Figure 11). All 14 were tagged in Paradise Creek during 2014, 2015, or 2016. Eight juvenile steelhead, which had been PIT-tagged as parr in Martha Creek, were detected at MAD from 1 January 2016 through 31 December 2016 (Figure

12). The MAD site experienced some high noise events during 2016, possibly related to a U.S. Navy transmitter in California that was causing noise issues for numerous PIT tag detection systems in the Northwest (PTAGIS News and Announcements October 2015. https://www.ptagis.org/resources/news-and-announcements/2015/10/28/new-radio-transmit-station-could-impact-interrogation-sites).

In addition to detections at our instream PTISs, PIT-tagged parr steelhead from Wind River headwaters are subject to recapture in Wind River smolt traps and interrogation as juveniles at Bonneville Dam. Figure 13 shows timing of smolts, which were PIT tagged as parr in the Wind River headwaters, at Bonneville Dam during 2012 through 2016. As our number of tagged fish in the subbasin has increased, so too have detections at Bonneville (Figure 13). Twenty-seven steelhead PIT-tagged as parr in the Wind River headwaters were detected at Bonneville Dam during 2016.

Steelhead, PIT tagged as age-0 and age-1 parr in the Wind River headwaters, are subject to recapture at smolt traps and detections at Bonneville Dam allowing us to assess age at smolting. To date, 61 steelhead PIT tagged as age-1 parr have been detected at screw traps (Figure 14), and 62 have been detected at Bonneville (Figure 15). During 2013, we began PIT tagging age-0 steelhead as small as 55-mm FL. Of the 365 age-0 steelhead PIT tagged in 2013, 7 were captured at smolt traps in 2014 as age-1 migratory parr, one as an age-2 smolt in 2015, and one as an age-3 smolt in 2016. Four of the 365 age-0 steelhead PIT tagged in 2013 were detected at Bonneville Dam as age-2 smolts and one as age-3. Of the 738 age-0 steelhead PIT tagged in 2014, 6 were recapped as age-1 parr migrants at screw traps in 2015, one was recaptured as an age-2 parr migrant in 2016, and 4 were recapped at age-2 smolts. Five were detected as age-2 smolts at Bonneville in 2016.

To date, 7 steelhead PIT tagged as parr in the Wind River headwaters sampling have been detected as adults at Bonneville Dam. Two of these adults were initially tagged in 2011, two in 2012, and three in 2013. Using age at tagging, (by length frequency analysis; Jezorek and Connolly 2015b) three of these adults were age-4, three were age-5 and one was age-6.

Growth data -- Repeated sampling of sites within and between years has provided the opportunity to recapture PIT-tagged parr and collect growth data from fish tagged as age-1 and age-0. Recaptures of fish a year later have begun to yield data on variability between streams and years. During 2013, we began using 9-mm PIT tags, which allowed us to tag many more age-0 fish. We had 300 9-mm tags during 2013 and most were deployed in Martha and Trapper Creeks.

We measured relative growth as % change in FL and weight per-day from recaptured parr (within years and after one year) that were PIT tagged at age-0 or age-1. Data to date for age-0 parr suggest relative yearly growth was greater from 2015 to 2016 than in either of the previous two years (Figure 15). Data from PIT tagging of age-1 parr suggest that relative yearly growth was less in Martha Creek than many of the other sample sites (Figure 16). Recapture data within summer suggest that relative growth of parr PIT tagged at age-0 is less in the Upper Mine Reach of the Wind River and in Upper Layout Creek than in other locations (Figure 17). Relative

growth of age-0 parr was greatest in the Wind River Mine Reach during all three years. Relative growth data of age-1 parr within summer show high variability between sites and years (Figure 18). Age-1 parr lost weight during summer at many of the sites in the Trout Creek watershed.

Evaluation of restoration -- Data from our PIT-tagging efforts and instream PTIS operation is contributing to evaluation of restoration efforts. Detections of adult steelhead at TRC, TC4, and WRU are providing data that are allowing us to evaluate efficacy of the removal of Hemlock Dam toward increased steelhead populations upstream of the former dam site.

Water temperature -- Thermologger data collected during the period covered by this report (Table 1) have been archived. Previous USGS temperature data have been combined with data from UCD and provided to the NorWest database. The goal of the NorWest database is to collate stream temperature data to contribute to analyses of climate change scenarios and identify sources of coldwater for refugia. An initial release of some of the NorWest modeling has been released for Washington State and includes data from our temperature monitoring.

9. Synthesis of Findings: Discussion/Conclusions

RM&E Program Strategy of Assessing the Status and Trends of Diversity of Natural Origin Fish Populations and Contribute to Uncertainties Research Regarding Differing Life Histories of a Wild Steelhead Population.

Instream PIT-tag interrogation systems in the Wind River, WA are providing data to assess movements of wild lower Columbia River steelhead that were PIT-tagged either as parr in headwater areas or at smolt traps. Although smolt traps are excellent for quantifying movement, they are limited to time periods when river flows allow their operation. In the Wind River subbasin, smolt traps generally operate from April through June. Instream PIT-tag interrogation systems in the Wind River are mostly operated year round.

Smolt trapping in the Wind River has identified movement of steelhead parr during spring, but the extent of movement outside of the smolt-trapping period was unknown. It is known that the lower portion of the Wind River produces more smolts than are accounted for by the three smolt traps in upstream areas. Steelhead parr, PIT tagged in headwaters at age-0 and age-1 have been detected migrating throughout the year as both age-0 and age-1 and older fish. These data will contribute to understanding of movement of parr, their use of downstream reaches for rearing, and their contribution to smolt and adult populations. The contribution of migratory parr to the total smolt output of the Wind River is unknown. Steelhead spawning downstream of the upper three smolt traps, which has been considered minimal (but is unknown), also may produce juvenile steelhead that contribute to subbasin smolt totals.

It is currently unknown if downstream movement of steelhead parr is a result of limited headwater habitat capacity, or is a life-history strategy employed by a given percentage of fish regardless of fish abundance or habitat quality. Movement of juveniles into downstream reaches of the mainstem Wind River, or in other Columbia River subbasins, has important implications

for habitat and water management and could improve the ability to target restoration actions for greatest cost-benefit. To date, we have seen movement of age-0 and older parr from headwater areas, and through mid-basin areas throughout the year. It is unknown if juvenile steelhead are leaving the Wind River subbasin as parr or smolts during time periods other than spring. Additional instream PIT tag detection capability at the mouth of the Wind River would greatly help to address questions about potential movement of juvenile steelhead outside of the smolt trapping window. Because of the plasticity of steelhead life-histories, managers need a better understanding of the complete range of behaviors and migratory patterns to accurately assess population metrics that may be missed by solely focusing on spring movements of smolts.

Data from our PIT tagging and instream detections should help to design more robust monitoring networks and contribute toward estimating migrant parr populations. Because much is unknown about timing and rate of parr movements, developing good abundance estimates is difficult, even with smolt trapping. Instream PIT tag detection is contributing data on the movement habits of parr during spring (parr tagged in both headwater areas and and at WDFW smolt traps), which will be essential to developing methods to quantify parr populations and their contribution to subsequent smolt populations.

Recapture data of PIT-tagged juvenile steelhead, through electrofishing and smolt trapping, is providing the opportunity to compare growth rates between different areas and years. These data will help assess whether growth rates or tributary conditions influence the extent, timing, and fate of migratory parr steelhead. Whether differences in relative growth between years and sites are the result of habitat or environmental conditions or of fish densities and whether these differences in growth carry an effect to recruitment to smolt stage are questions we hope to explore with these data. Recapture data from electrofishing and smolt trapping are also contributing to parr life-history research by providing additional location information on individual fish.

The combination of tagging parr in headwater areas at age-0 and age-1, recapture potential, instream detection, and out of basin detection is providing data that will contribute to life-cycle models currently under development. Data collection at instream detectors over a period of years will allow us to address uncertainties about the contribution of migratory parr and the consistency of downstream movements across years. With adequate data, we hope to identify different life-history strategies of juvenile steelhead in the Wind River subbasin and their contributions to smolt and adult populations similar to work done with other steelhead populations (Hayes et al. 2008; Sogard et al. 2009) as well as work investigating life history diversity of Chinook salmon (Connor et al. 2005; Copeland and Venditti 2009).

RM&E Program Strategy of Assessing the Status and Trend of Adult Natural Origin Fish Populations.

The PTISs in the Wind River subbasin are providing an increasing level of detail about natural origin adult steelhead populations. Timing of adult movements, spawning locations, and pre-spawn mortality are all being explored. Preliminary data suggest that some adult steelhead

that spawn in Trout Creek migrate upstream during fall and overwinter in Trout Creek. We are assessing to what extent adult steelhead that spawn in the upper Wind River move upstream during fall. The ability to determine spawner populations within specific watersheds in the Wind River subbasin will help contribute to the calculation of smolt production per adult and smolt-to-adult return rates by specific watershed. Also, data from the PTISs, in conjunction with adult detections at Bonneville Dam, and recaptures within the Wind River subbasin, should help identify spatial and temporal locations where pre-spawn mortality may be occurring.

RM&E Program Strategy of Monitoring and Evaluating the Effectiveness of Tributary Habitat Actions Relative to Environmental, Physical, or Biological Performance Objectives.

Adult steelhead escapement estimates to Trout Creek and the upper Wind watersheds that are generated with data from PTISs are helping evaluate the efficacy of the removal of Hemlock Dam from Trout Creek (removed 2009). This evaluation conforms to a BACI design, using the upper Wind River watershed as the control (Cochran et al. 2013). The PTISs are also providing data on juvenile movement outside of the smolt trapping period, and these data will inform us of the potential production of juveniles unaccounted for by smolt trapping, thus increasing our ability to evaluate this restoration action.

During 2016, USGS staff provided information to help guide watershed restoration. We met with the Wind River Workgroup to provide information on steelhead life-histories, stream use, and habitat condition. This information is used by the Workgroup to prioritize restoration reaches. This Workgroup consists of members of the Lower Columbia Fish Enhancement Group, Yakama Tribe, WDFW, Inter-Fluve Inc., UCD, and local citizens.

10. Acknowledgements

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11. References

Achord, S., B. P. Sandford, S. G. Smith, W. R. Wassard, and E. F. Prentice. 2012. In-stream monitoring of PIT-tagged wild spring/summer Chinook salmon juveniles in Valley Creek, Idaho. American Fisheries Society Symposium 76:163-176.

Archdeacon, T. P., W. J. Remshardt, and T. L. Knecht. 2009. Comparison of two methods for implanting passive integrated transponders in Rio Grande silvery minnow. North American Journal of Fisheries Management 29:346-351.

Baras, E., C. Malbrouck, M. Houbart, P. Kestermont, and C. Melard. 2000. The effect of PIT tags on growth and physiology of age-0 cultured Eurasian perch *Perca fluviatilis* of variable size. Aquaculture 185:159-173.

Bond, M. H., C. V. Hanson, R. Baertsch, S. A. Hayes, and R. B. MacFarlane. 2007. A new low-cost instream antenna system for tracking passive integrated transponder (PIT)-tagged fish in small streams. Transactions of the American Fisheries Society 136:562-566.

Cochran, P., T. Buehrens, and D. Rawding. 2013. Steelhead smolt and adult population estimates from trapping data in the Wind River, 2012. Washington Department of Fish and Wildlife Annual Report. Project 199801900. Contract 58664. Submitted to Bonneville Power Administration, Portland, OR. https://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P133046

Coffin, B. 2011. Hemlock Dam removal project Final Report for the period June 15, 2007 through April 4, 2011. U.S. Forest Service. Project 2007-077-00. Contract 00033564. Submitted to Bonneville Power Administration, Portland, OR. https://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P122401

Columbia Basin Fish and Wildlife Authority, PIT Tag Steering Committee. 1999. PIT Tag Marking Procedures Manual. http://php.ptagis.org/wiki/images/e/ed/MPM.pdf

Connolly, P. J., and I. G. Jezorek. 2007. Wind River Watershed Restoration. U.S. Geological Survey Annual Report. April 2004 – March 2005. Project number 1998-019-00. Contract 00004937. Submitted to Bonneville Power Administration, Portland, OR. https://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P108963

Connolly, P. J., I. G. Jezorek, K. Martens, and E. F. Prentice. 2008. Measuring performance of two stationary interrogation systems for detecting downstream and upstream movement of PIT-tagged salmonids. North American Journal of Fisheries Management 28:402–417.

Connor, W. P., J. G. Sneva, K. F. Tiffan, R. K. Steinhorst, and D. Ross. 2005. Two alternative juvenile life history types for fall Chinook salmon in the Snake River basin. Transactions of the American Fisheries Society 134:291-304.

Copeland T., and D. A. Venditii. 2009. Contribution of three life-history types to smolt production in a Chinook salmon (Oncorhynchus tshawytscha) population. Canadian Journal of Fisheries and Aquatic Sciences 66:1658-1665.

Dixon, C. J., and M. G. Mesa. 2011. Survival and tag loss in Moapa White River springfish implanted with passive integrated transponder tags. Transactions of the American Fisheries Society 140:1375-1379.

Hayes, S. A., M. H. Bond, C. V. Hanson, E. V. Freund, J. J. Smith, E. C. Anderson, A. J. Ammann, and R. B. MacFarlane. 2008. Steelhead growth in a small central California watershed: Upstream and estuarine rearing patterns. Transactions of the American Fisheries Society 137:114-128.

Jezorek, I. G., and P. J. Connolly. 2010. Wild steelhead and introduced spring Chinook Salmon in the Wind River, Washington; Overlapping Populations and Interactions. Final U. S. Geological Survey Report. Project number 1998-019-00. Contract number 00046102. Submitted to Bonneville Power Administration, Portland, OR. https://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P116331

Jezorek, I. G., and P. J. Connolly. 2014. Wind River subbasin restoration U.S. Geological Survey Annual Report November 2013 through December 2013, 1998-019-00. Submitted to Bonneville Power Administration, Portland, OR. https://pisces.bpa.gov/release/documents/documentviewer.aspx?doc=P138064

Jezorek, I.G., and P. J. Connolly. 2015a. Biotic and abiotic influences on abundance and distribution of nonnative Chinook salmon and native ESA-listed steelhead in the Wind River, Washington. Northwest Science 89:58-74.

Jezorek, I. G., and P. J. Connolly. 2015b. Wind River subbasin restoration. Annual Report of U.S. Geological Survey activities January 2014 through December 2014, 1998-019-00. Submitted to Bonneville Power Administration, Portland, OR.

Sogard, S. M., T. H. Williams, and H. Fish. 2009. Seasonal patterns of abundance, growth, and site fidelity of juvenile steelhead in a small coastal California stream. Transactions of the American Fisheries Society 138:549-563.

Zydlewski, G. B., G. Horton, T. Dubreuil, B. Letcher, S. Casey, and J. Zydlewski. 2006. Remote monitoring of fish in small streams: A unified approach using PIT tags. Fisheries 31:492-502.

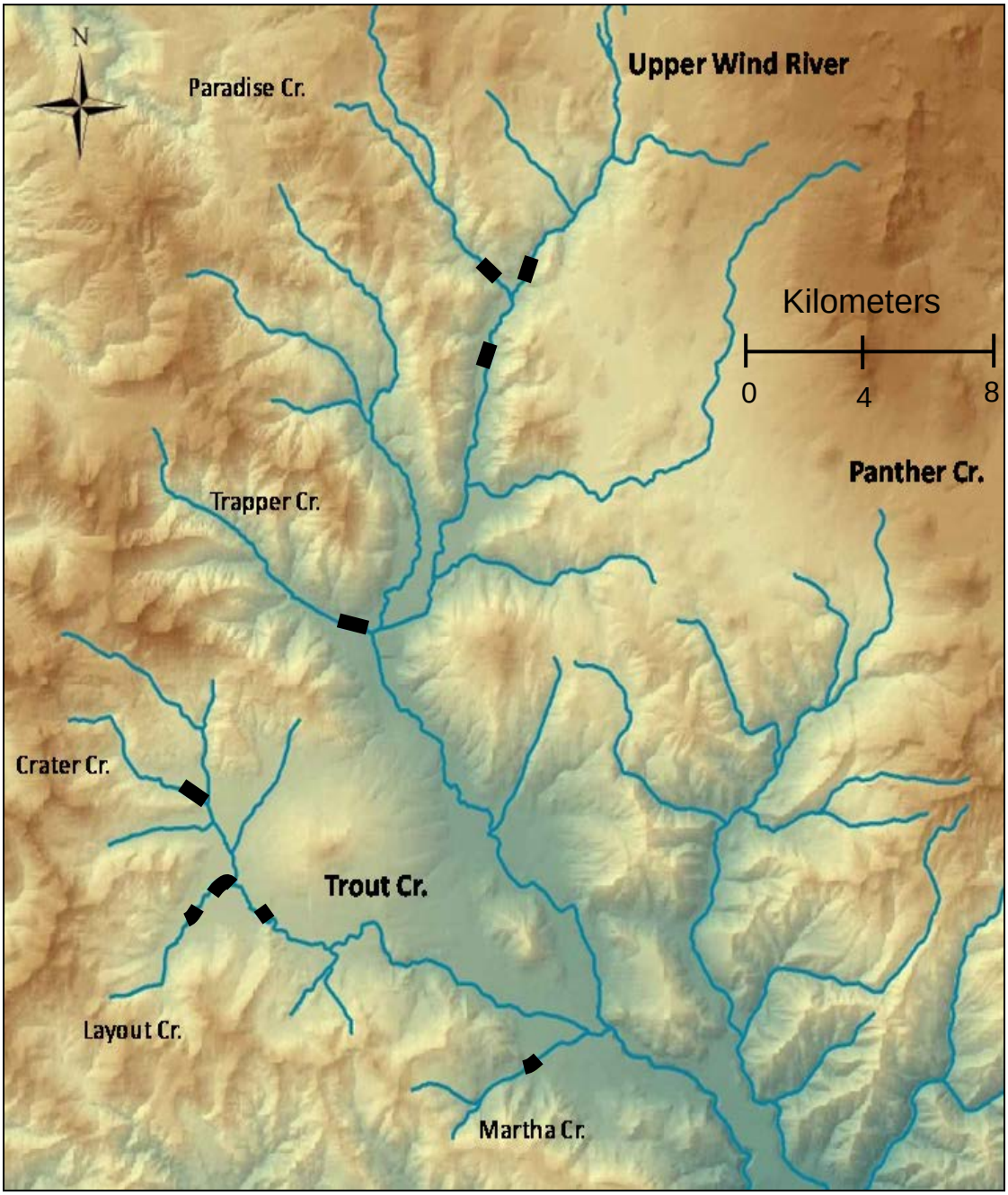


Figure 1. Stream sections (denoted by bold lines) where we tagged parr steelhead *Oncorhynchus mykiss* with Passive Integrated Transponder tags during summer 2016.

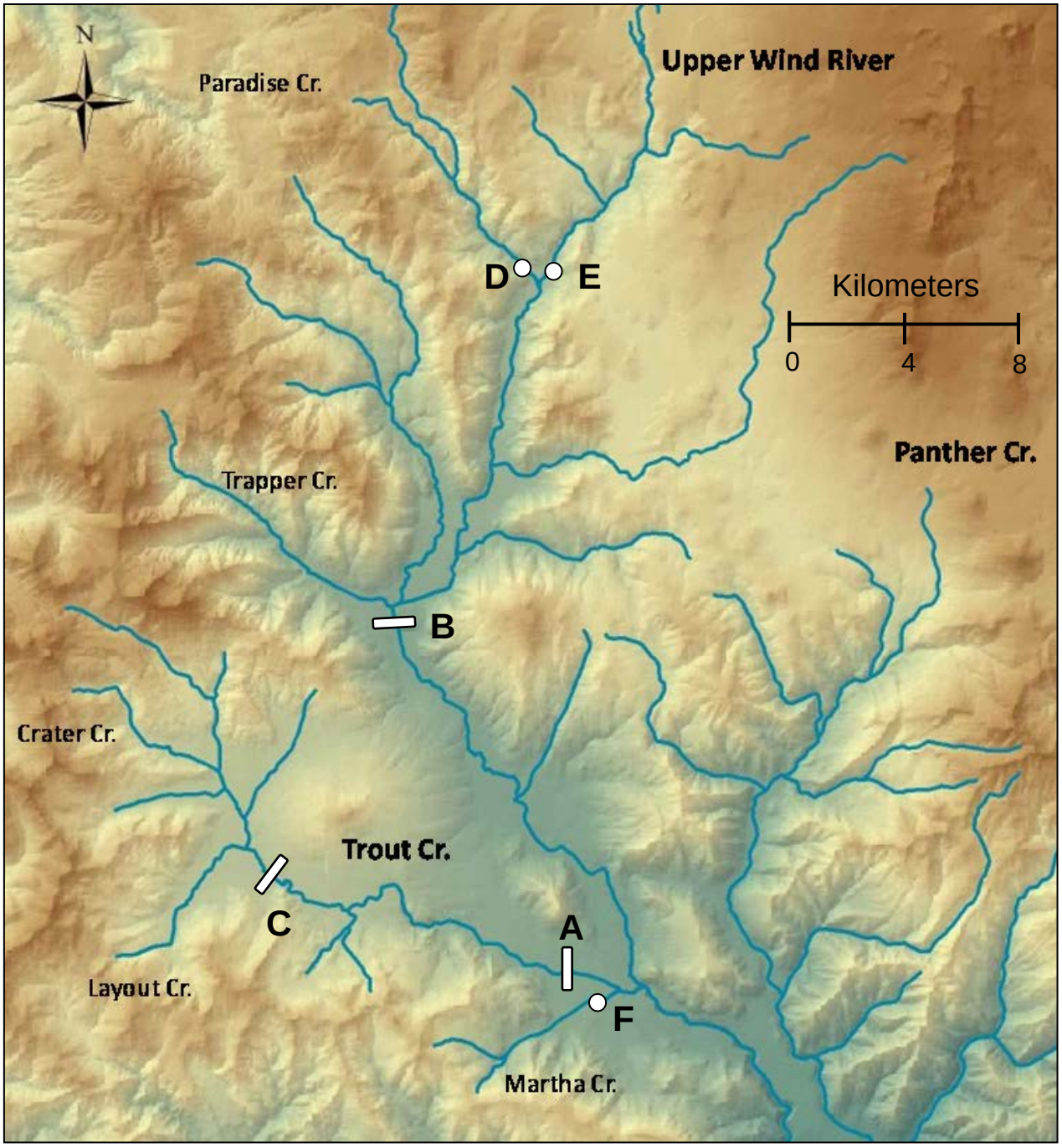


Figure 2. Locations of instream PIT-tag interrogation systems operated in the Wind River subbasin from January 2016 through December 2016. A) Trout Creek (TRC, 1001M Transceiver, 3 arrays of 2 antennas each); B) upper Wind River (WRU, 1001M Transceiver, 2 arrays of 3 antennas each); C) Trout Creek at 43 Bridge (TC4, 1001M Transceiver, 2 arrays of 3 antennas each); D) Paradise Creek (PAR, Biomark ACN Transceiver, 1 antenna); E) upper Mine Reach (UMI, Biomark ACN Transceiver, 1 antenna); F) Martha Creek (MAR, RM310 Transceivers, 2 antennas).

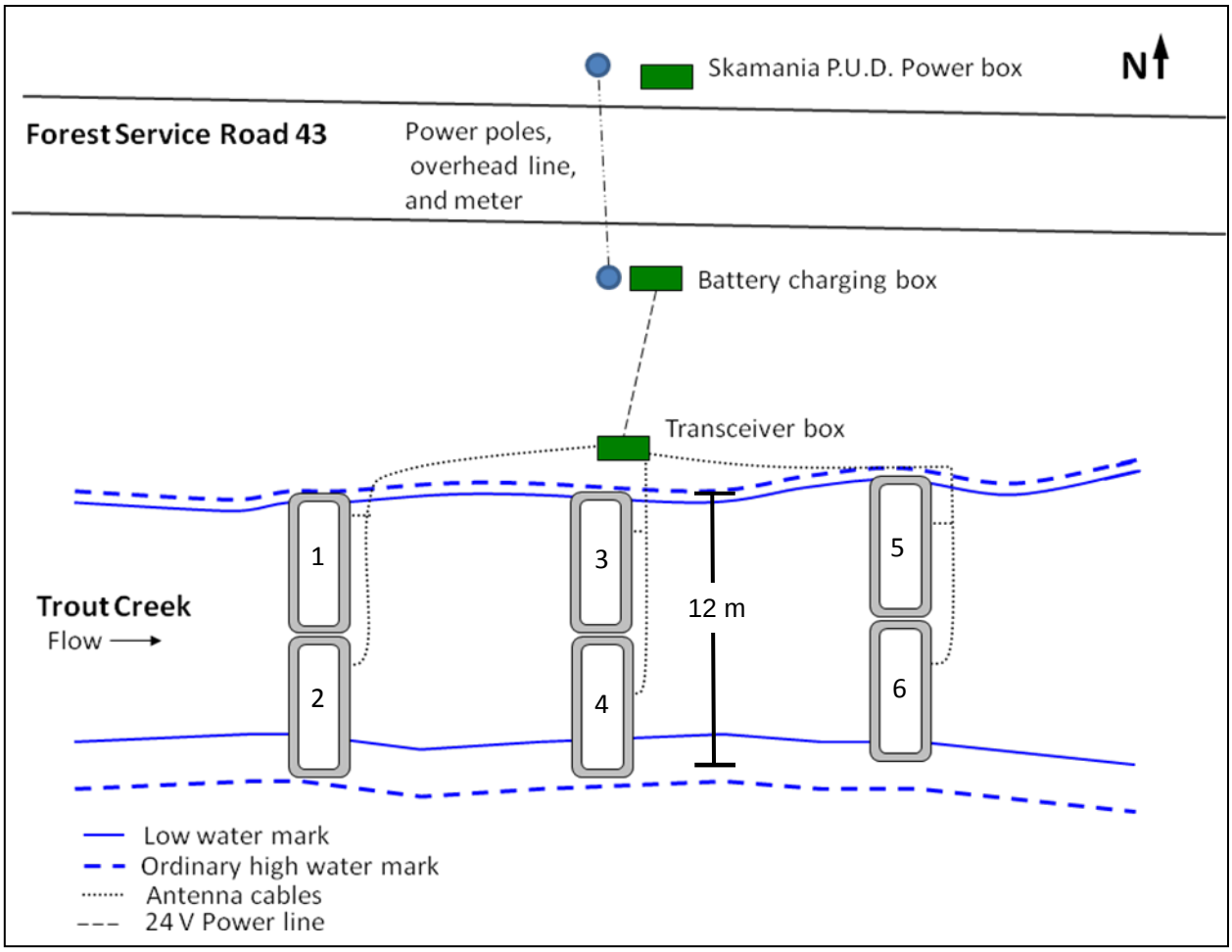


Figure 3. The Trout Creek PIT-tag interrogation system site (located at rkm 2.0 of Trout Creek), showing the three arrays of two antennas each and supporting infrastructure. Data from this site were submitted to the PTAGIS database under site code TRC.

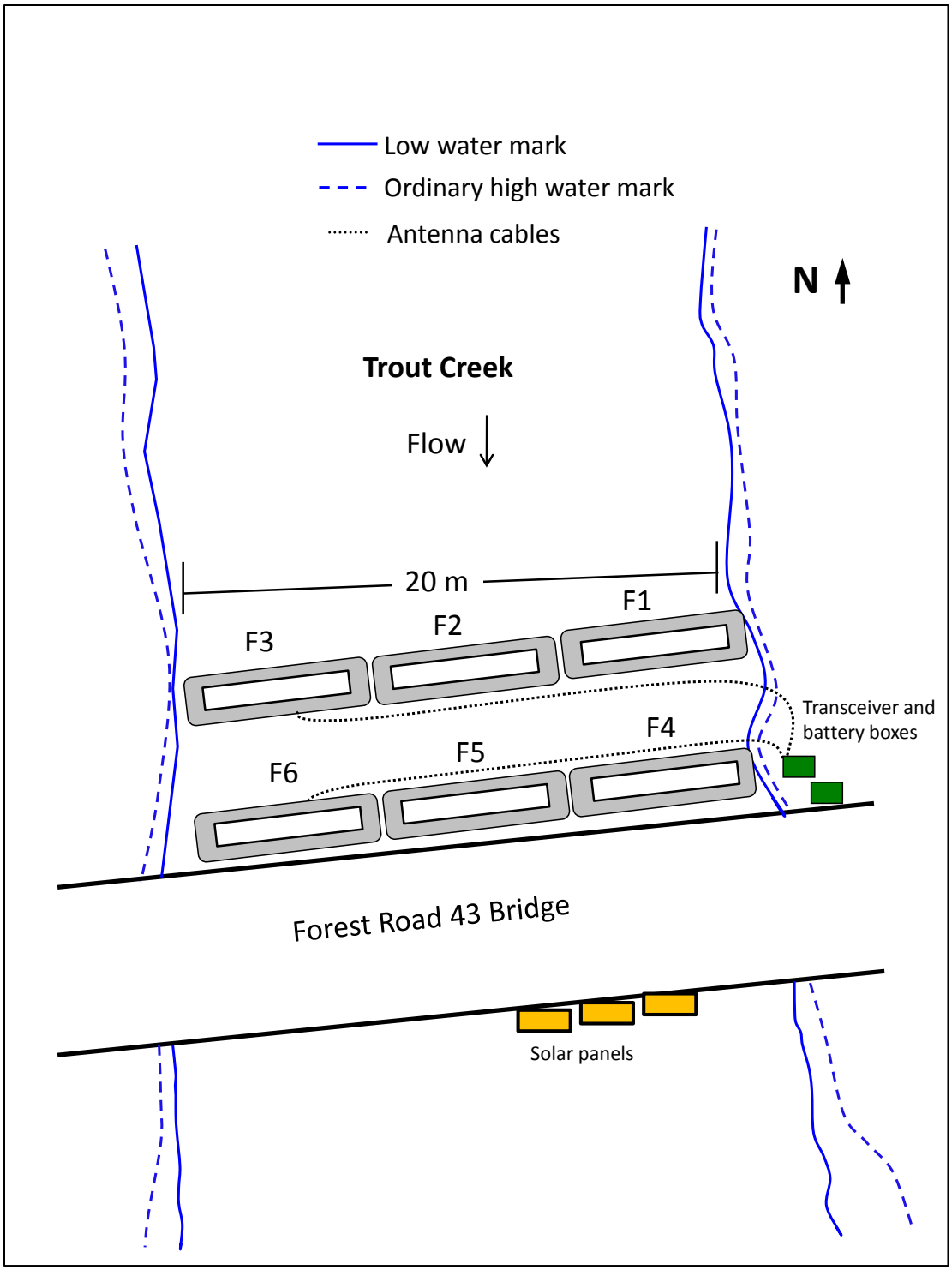


Figure 4. The PIT tag interrogation system in Trout Creek at the 43 Road Bridge (rkm 11.0) showing the two arrays of three antennas each and the supporting infrastructure. Data from this site were submitted to the PTAGIS database under site code TC4.

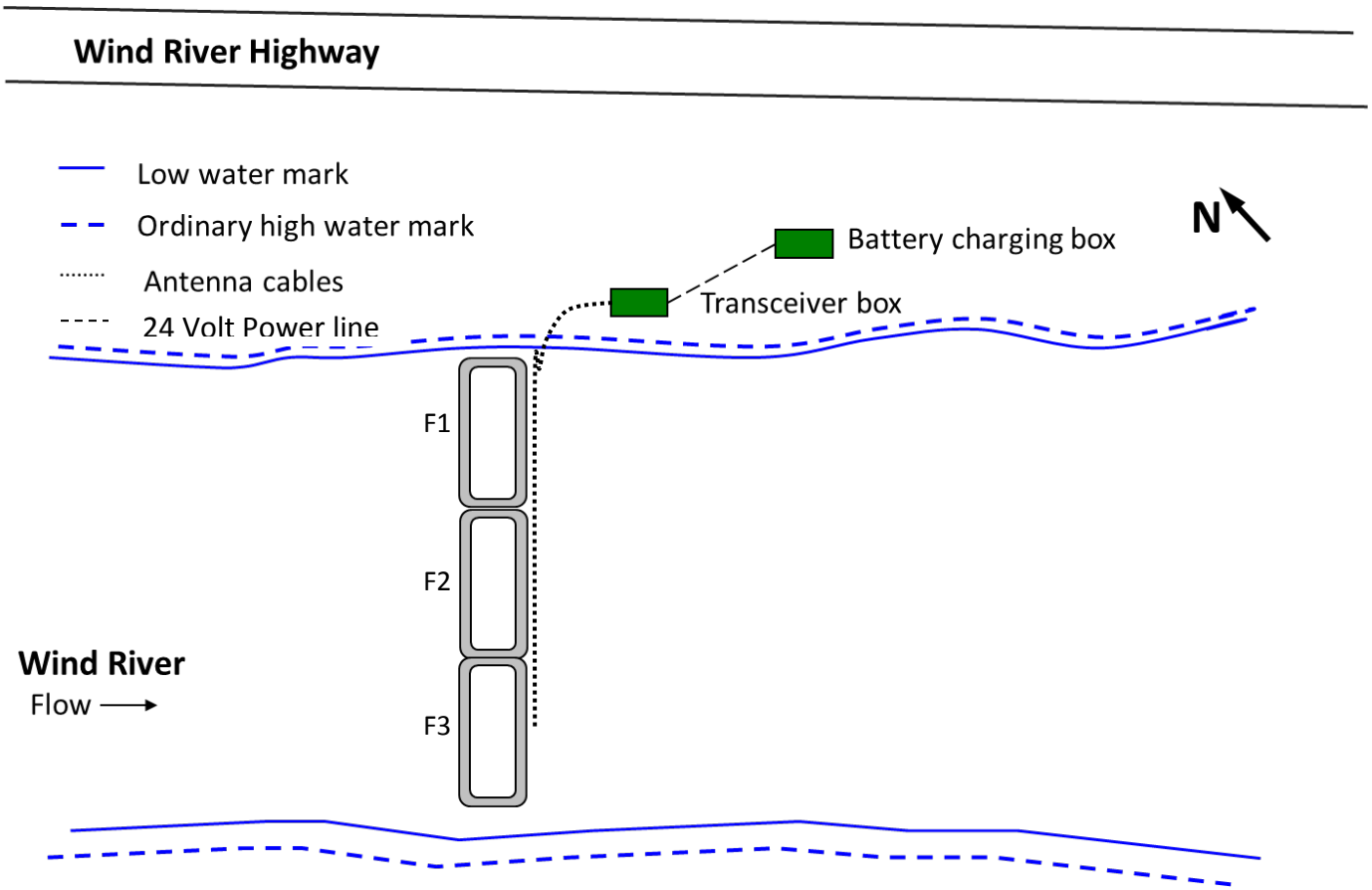


Figure 5. The upper Wind River PIT-tag interrogation site (located at rkm 28.3 of the Wind River) showing the single array of three antennas and the supporting infrastructure, which began operation on October 6, 2016. A second antenna array will be added during 2017. Data from this site were submitted to the PTAGIS database under site code WRU.

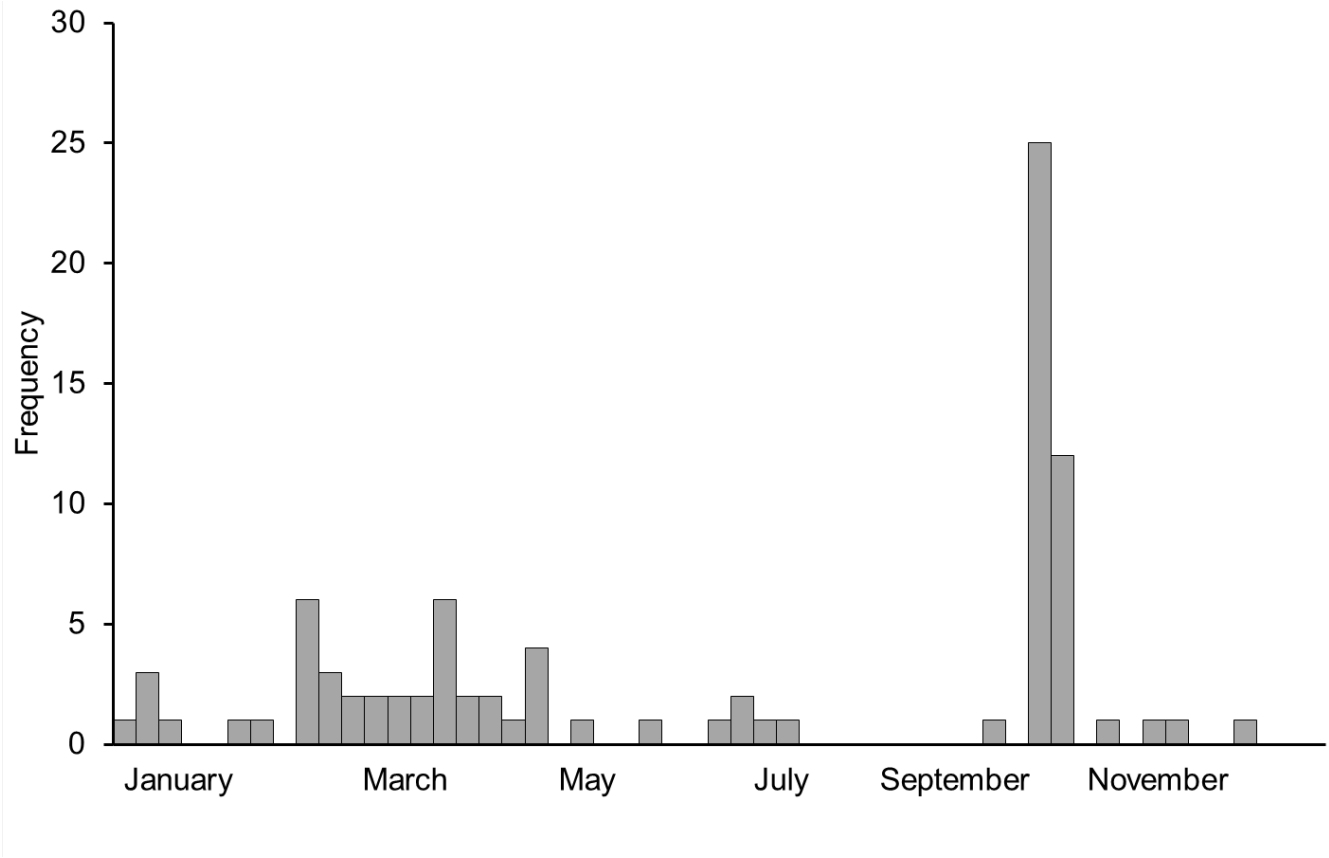


Figure 6. Detections of PIT-tagged adult steelhead *Oncorhynchus mykiss*, by week, at the Trout Creek PIT-tag interrogation system (site code TRC), at rkm 2.0, from 1 January 2016 through 7 December 2016. Shown are dates of first detection. Many fish were detected on multiple days. All detection data were submitted to the PTAGIS database.

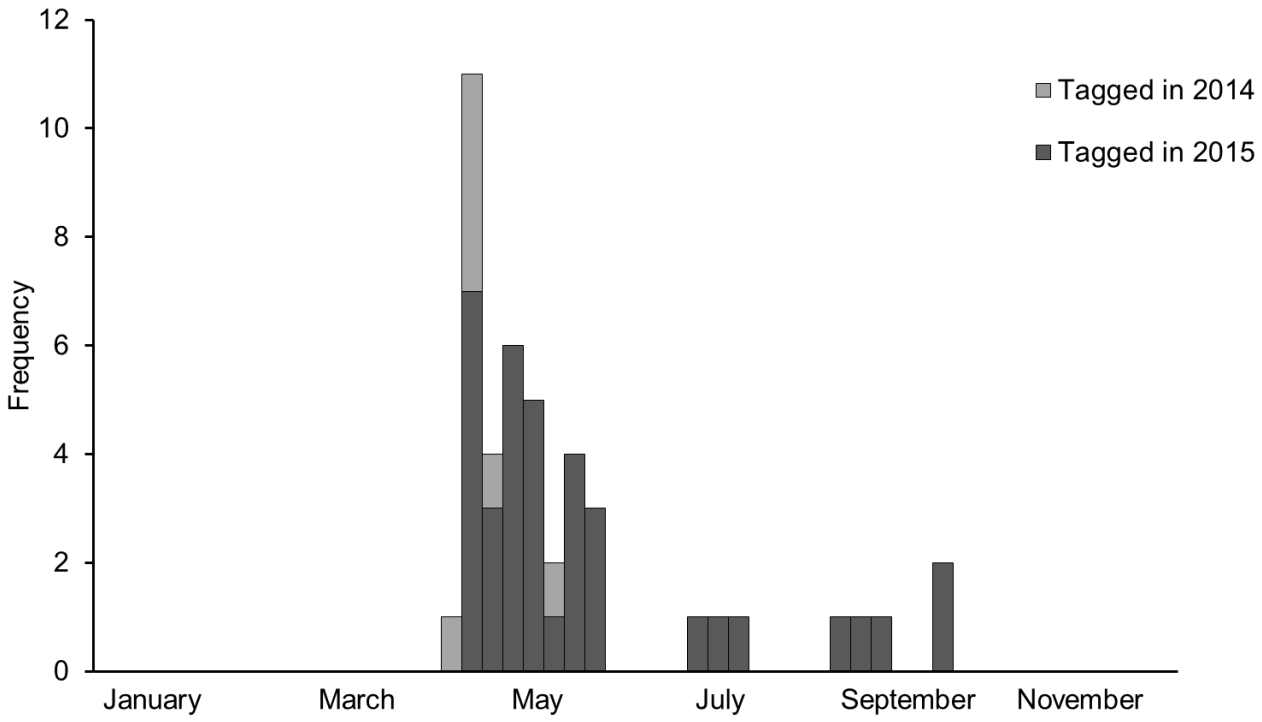


Figure 7. Detections of juvenile steelhead *Oncorhynchus mykiss*, by week, at the Trout Creek PIT-tag interrogation system (TRC), at rkm 2.0, from 1 January 2016 through 7 December 2016. The fish were tagged in the Trout Creek watershed during August or September 2014 and 2015. Shown are first detection dates. Many fish were detected on multiple days. All detection data were submitted to the PTAGIS database under site code TRC.

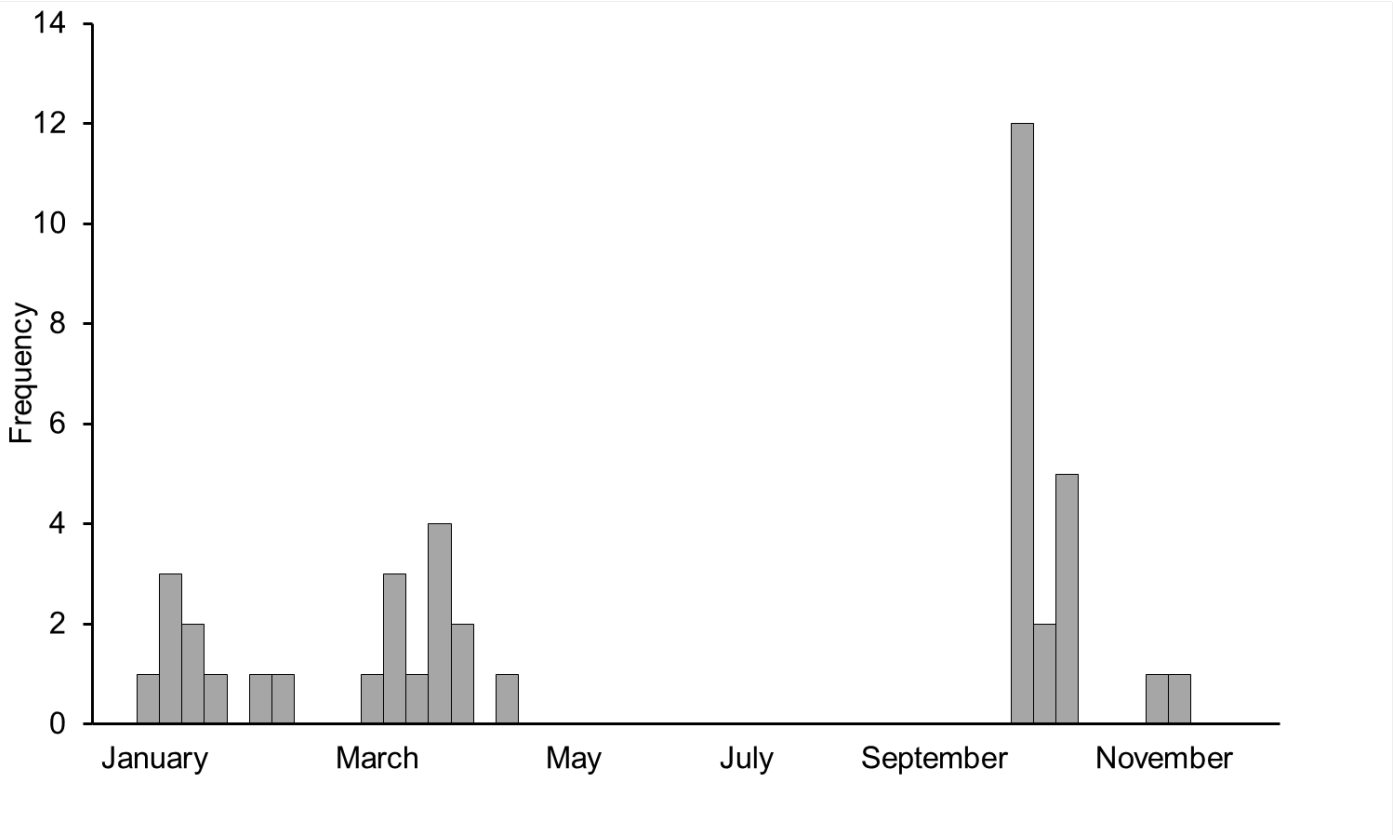


Figure 8. Detections of PIT-tagged adult steelhead *Oncorhynchus mykiss*, by week, at the Trout Creek at 43 Road PIT-tag interrogation system (site code TC4) from 1 January 2016 through 31 December 2016. The site was located at rkm 11.5 of Trout Creek. Shown are first detection dates for these fish. Many fish were detected on multiple days. All detection data were submitted to the PTAGIS database.

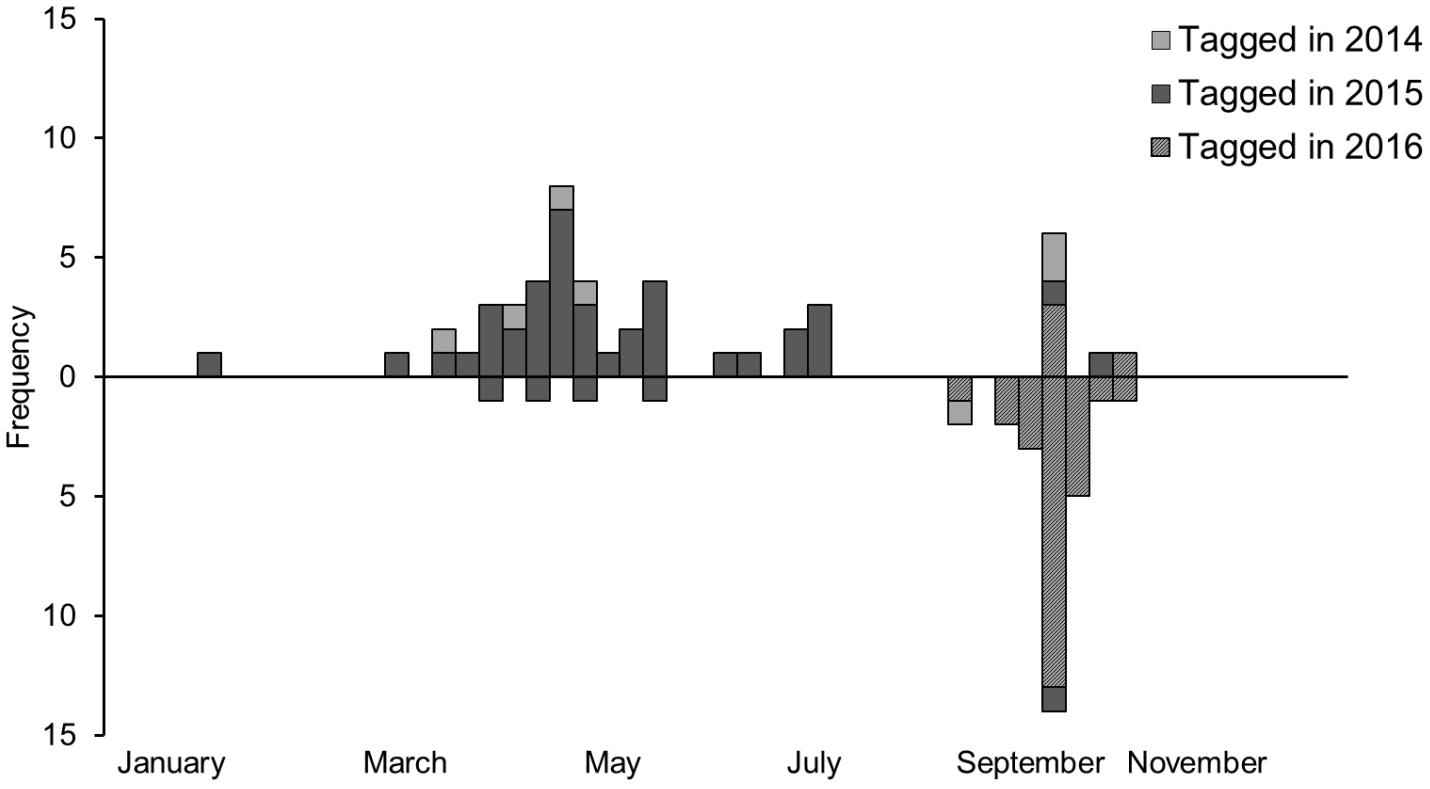


Figure 9. Detections of juvenile steelhead *Oncorhynchus mykiss* (PIT-tagged as parr in the Trout Creek watershed during August and September 2014, 2015, and 2016), by week, at the Trout Creek at 43 Bridge PIT-tag interrogation system (site code TC4) from 1 January 2016 through 31 December 2016. Fish indicated above the zero axis were tagged upstream of the site, fish indicated below were tagged downstream of the site. The site was located at rkm 11.5 of Trout Creek. Shown are first detection dates, many fish were detected on multiple days. All detection data were submitted to the PTAGIS database.

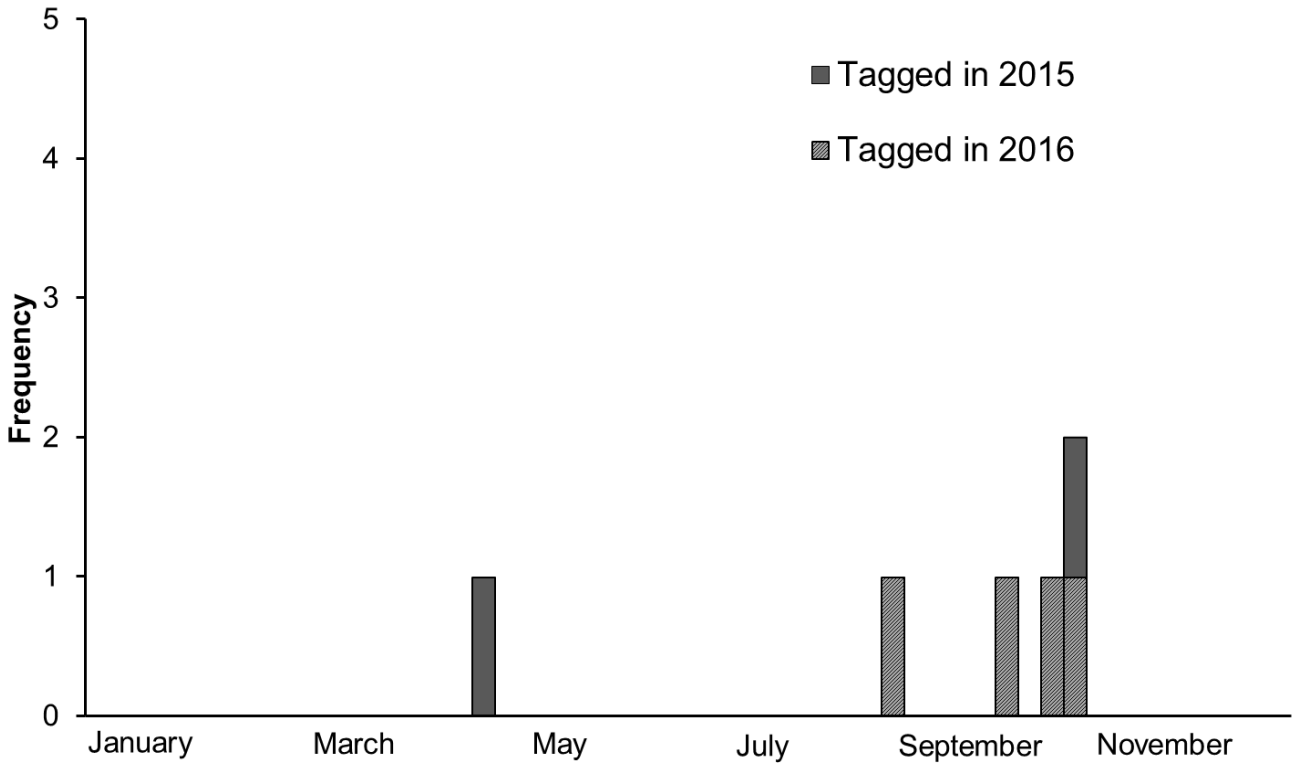


Figure 10. Detections of juvenile steelhead *Oncorhynchus mykiss*, by week, at the upper Mine PIT-tag interrogation system from 1 January 2016 to 8 December 2016. The fish were PIT-tagged as parr in the Wind River between rkm 41.0 and 41.6 during August and September 2015, and 2016. The system was located at rkm 40.5 of the Wind River. Shown are first detection dates for these fish. Some fish were detected over multiple days. All detection data were submitted to the PTAGIS database as Passive Observation Recaptures with file extension UMD.

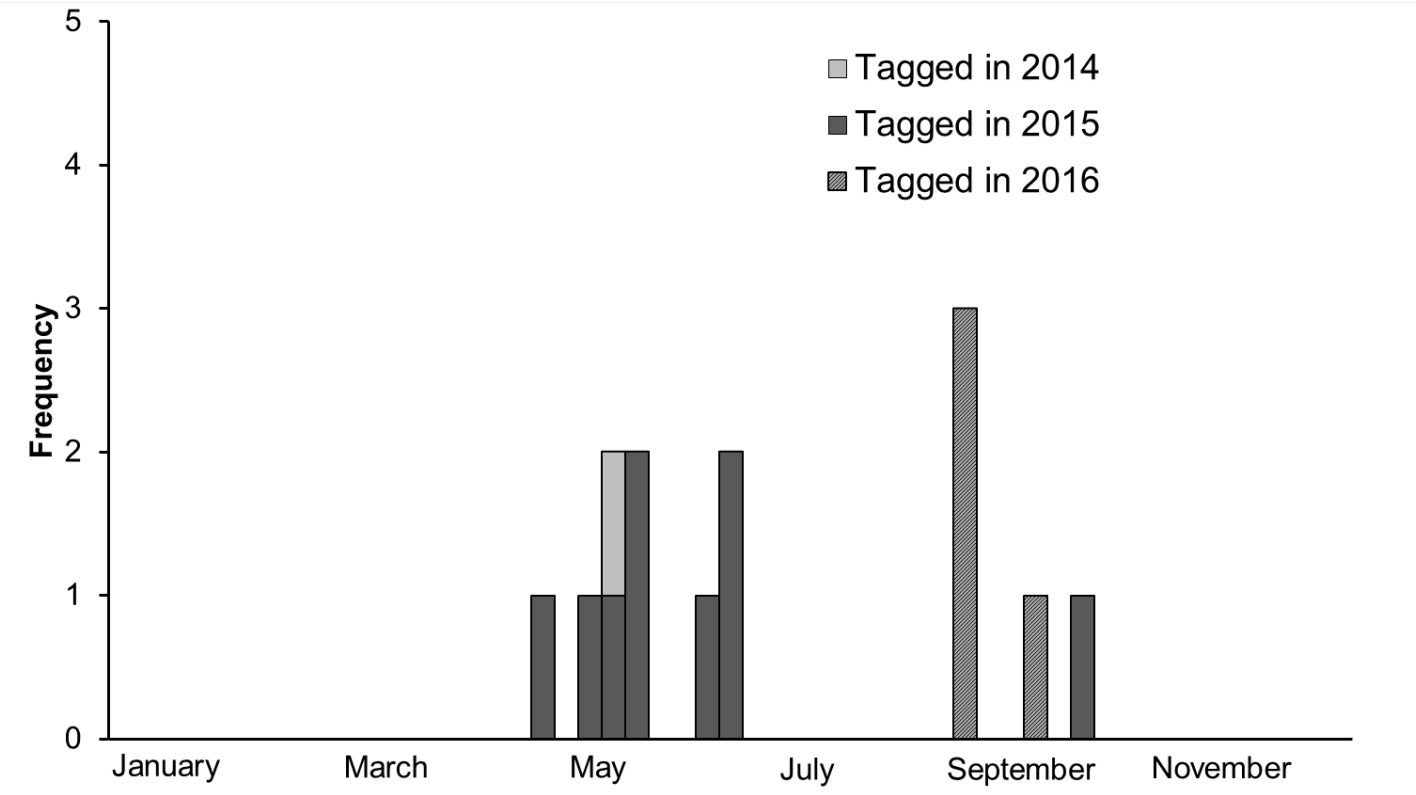


Figure 11. Detections of juvenile steelhead *Oncorhynchus mykiss*, by week, at the Paradise Creek PIT-tag interrogation system from 3 March 2016 to 24 November 2016. The fish were PIT-tagged as parr in Paradise Creek during August and September 2014, 2015, and 2016. The site was located at rkm 0.5 of Paradise Creek. Shown are first detection dates. Some fish were detected on multiple days. All detection data were submitted to the PTAGIS database as Passive Observation recaptures with file extension PAD.

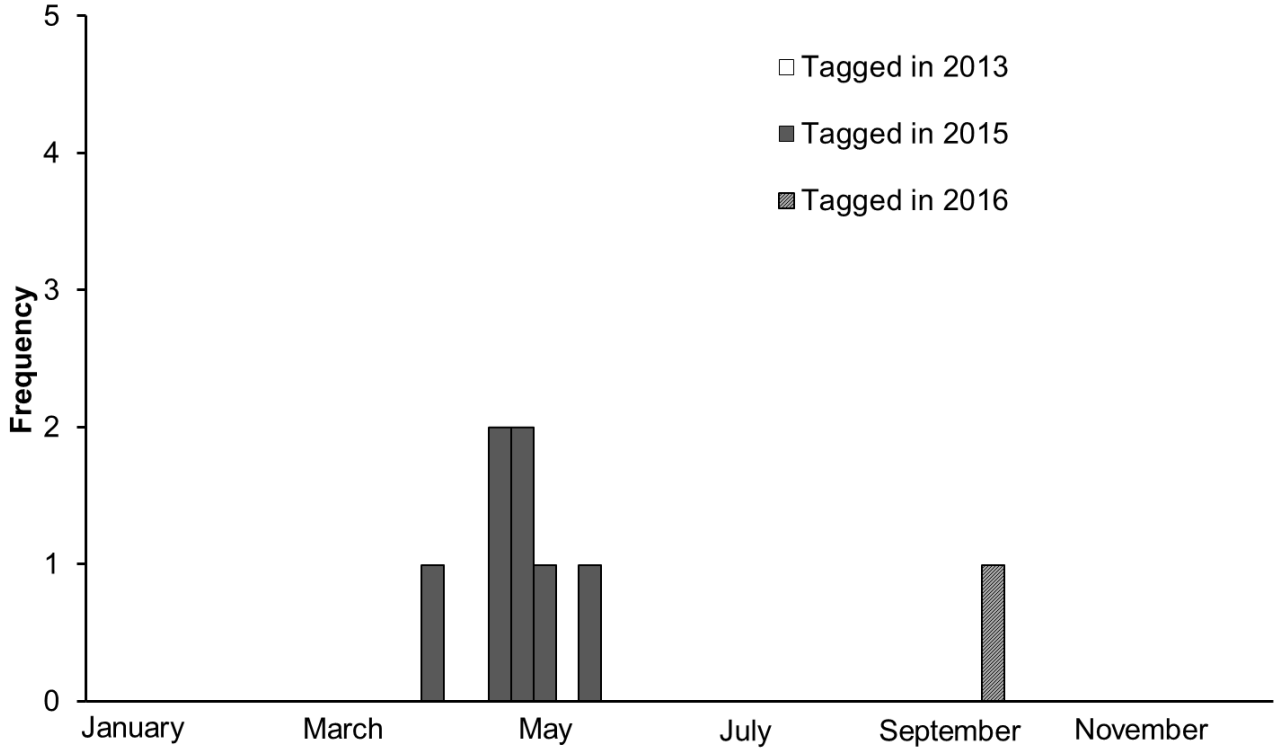


Figure 12. Detections of juvenile steelhead Oncorhynchus mykiss, by week, at the Martha Creek PIT-tag interrogation system from 3 March 2016 to 24 November 2016. The fish were PIT-tagged as parr in Martha Creek during August and September 2015 and 2016. The site was located at rkm 0.5 of Martha Creek. Shown are first detection dates. Some fish were detected on multiple days. All detection data were submitted to the PTAGIS database as Passive Observation recaptures with file extension MAD.

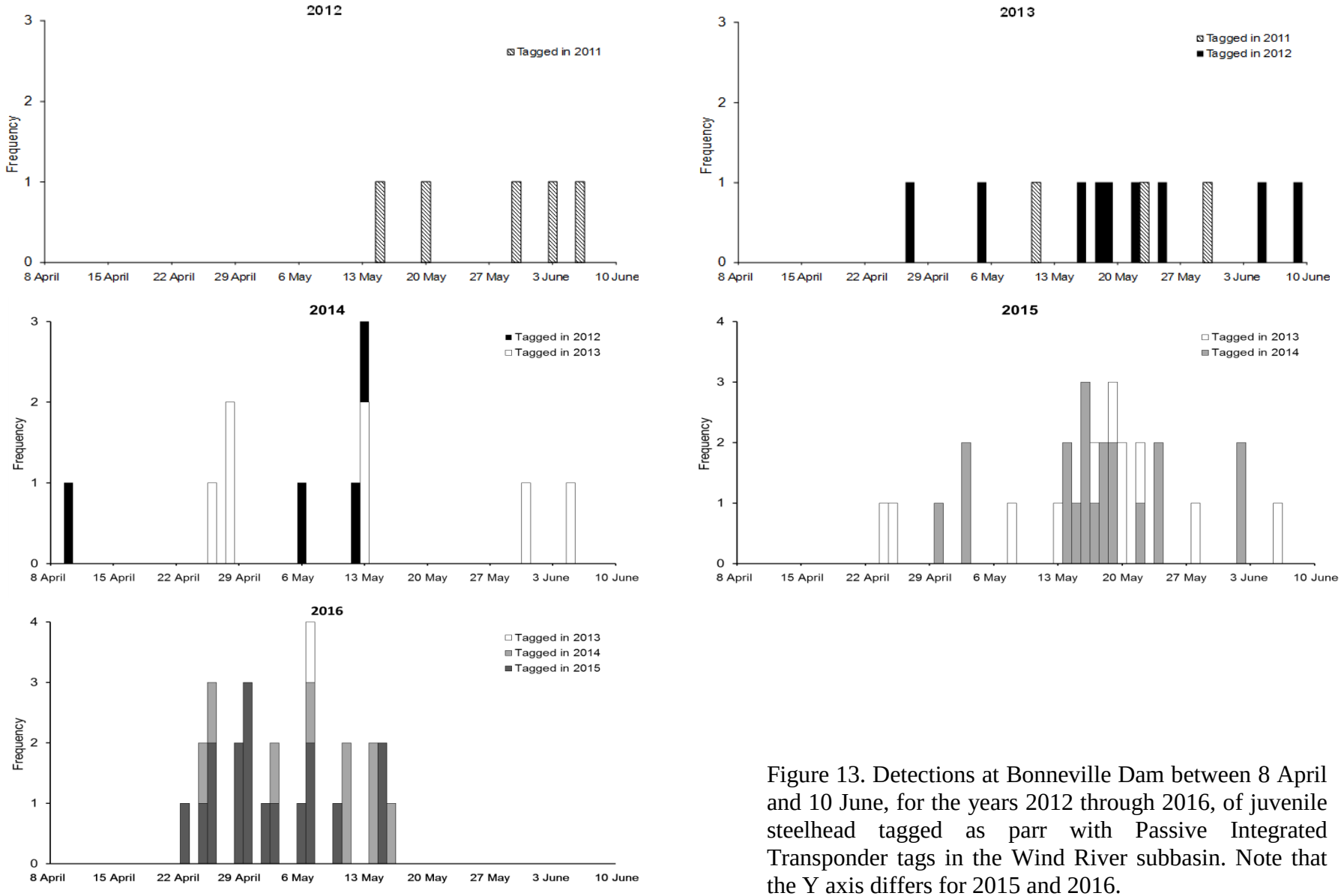


Figure 13. Detections at Bonneville Dam between 8 April and 10 June, for the years 2012 through 2016, of juvenile steelhead tagged as parr with Passive Integrated Transponder tags in the Wind River subbasin. Note that the Y axis differs for 2015 and 2016.

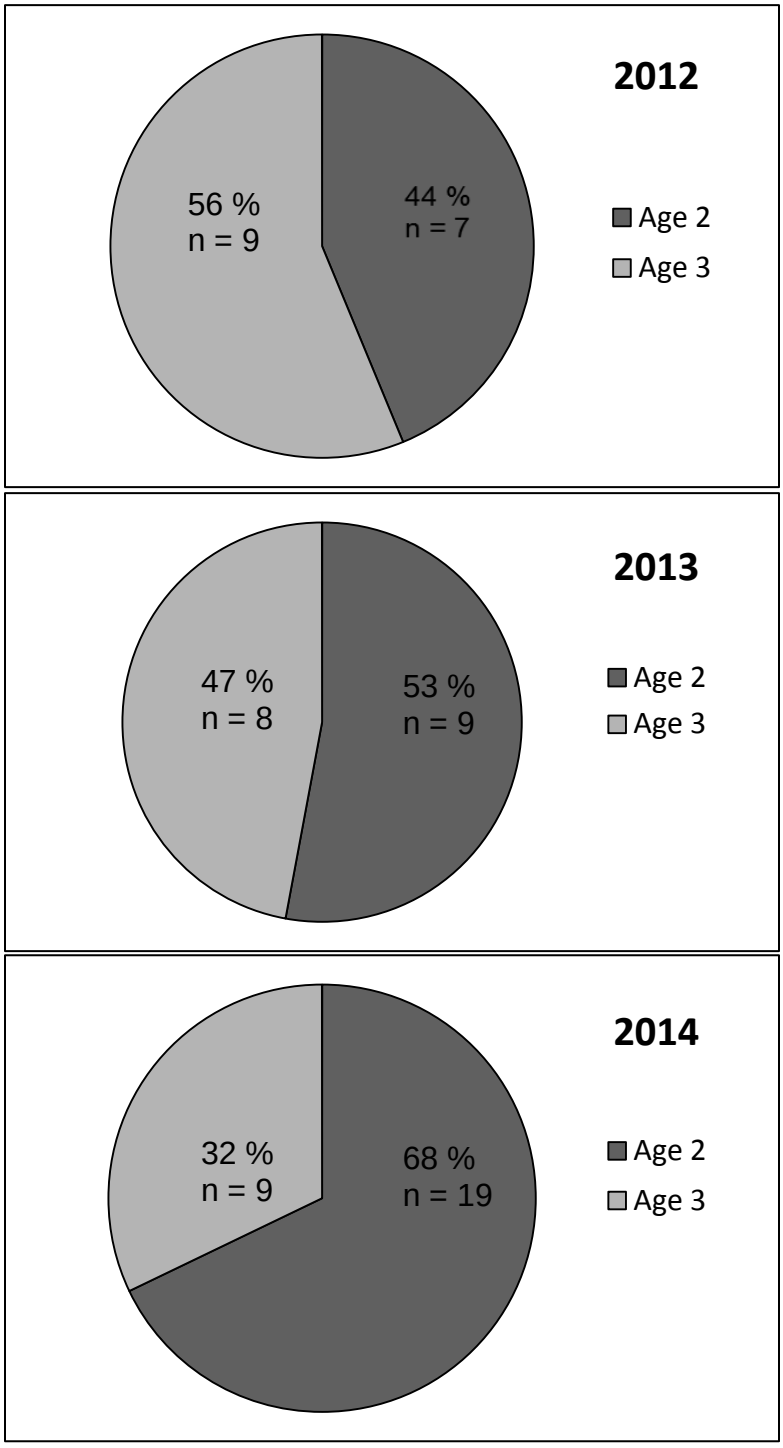


Figure 14. Smolt age, at Wind River smolt traps, of age-1 steelhead parr tagged during 2012, 2013, and 2014 with Passive Integrated Transponder (PIT) tags in headwaters areas of the Wind River. Age-1 parr were PIT tagged in the Wind River headwaters during 2011, but only seven were captured at a smolt trap (all at the Trout Creek trap); six of the seven were age-2 at capture.

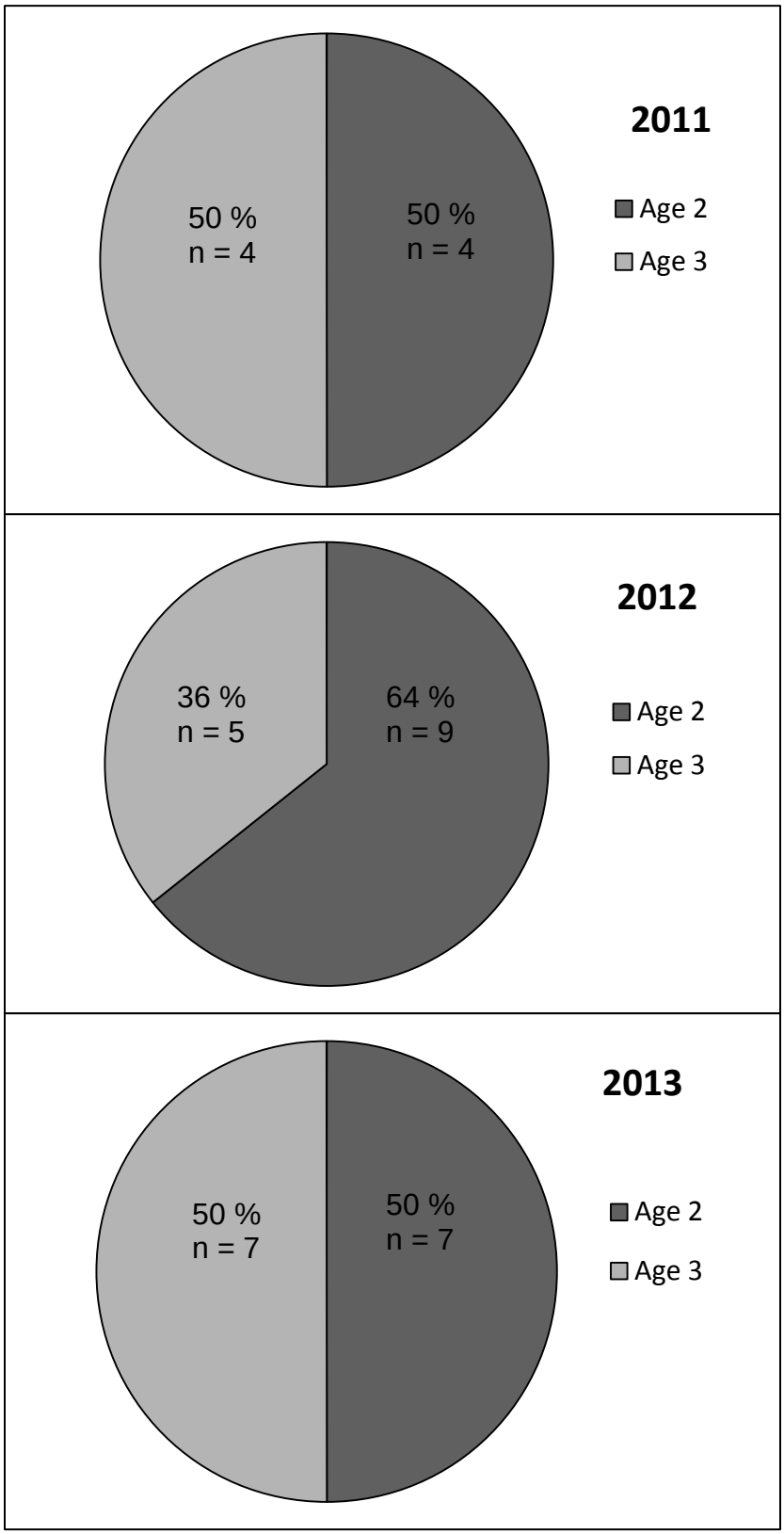


Figure 15. Smolt age, at Bonneville Dam, of steelhead tagged with Passive Integrated Transponder (PIT) tags as age-1 parr in headwaters areas of the Wind River during 2011, 2012, and 2013.

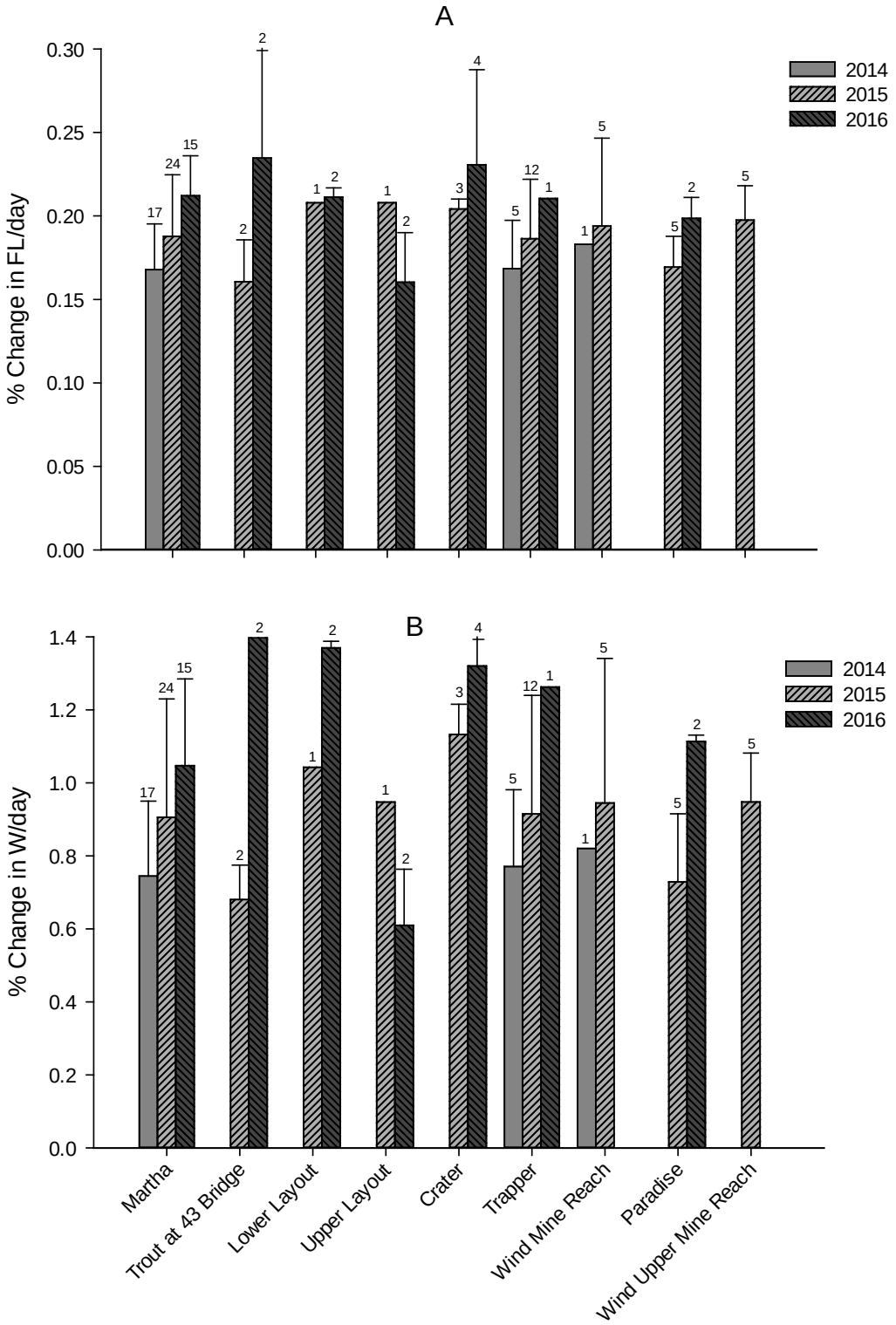


Figure 16. Mean relative growth + SD, shown as % change-per-day in fork length (Graph A) and weight (Graph B), of steelhead that were PIT tagged at age-0 in headwater sites in the Wind River subbasin and recaptured at the same location a year later. All fish were captured and recaptured by electrofishing during late summer. Year indicated in the legend is the year of recapture. Numbers at the bars are sample size.

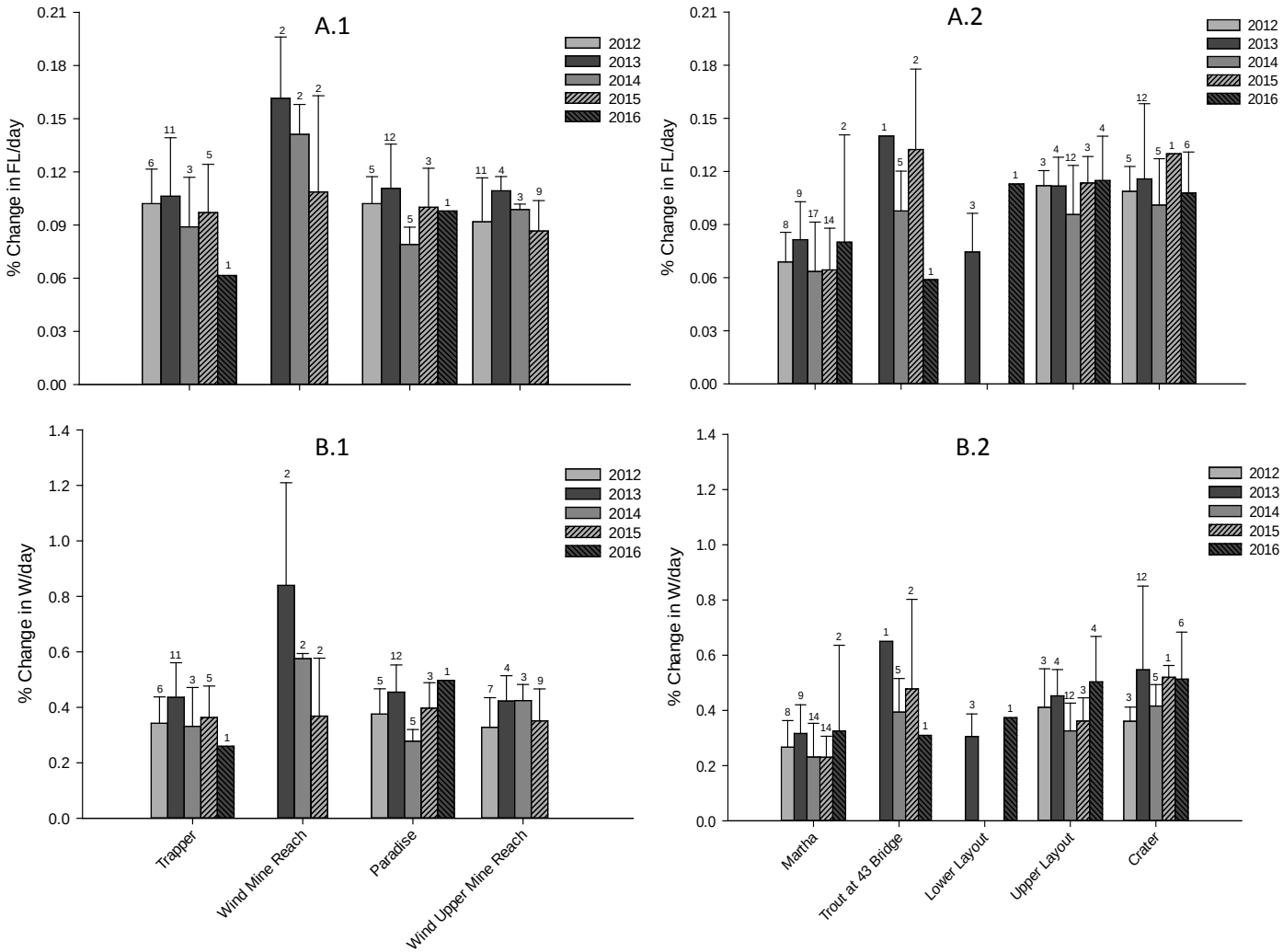


Figure 17. Mean relative growth +SD, shown as % change-per-day in fork length (Graph A.1, A.2) and weight (Graph B.1, B.2), of steelhead that were PIT tagged at age-1 in headwater sites in the Upper Wind River subbasin (left) and Trout Creek subbasin (right). The tagged steelhead were recaptured at the same location a year later. All fish were captured and recaptured by electrofishing during late summer. Year indicated in the legend is the year of recapture. Numbers at the bars are sample size.

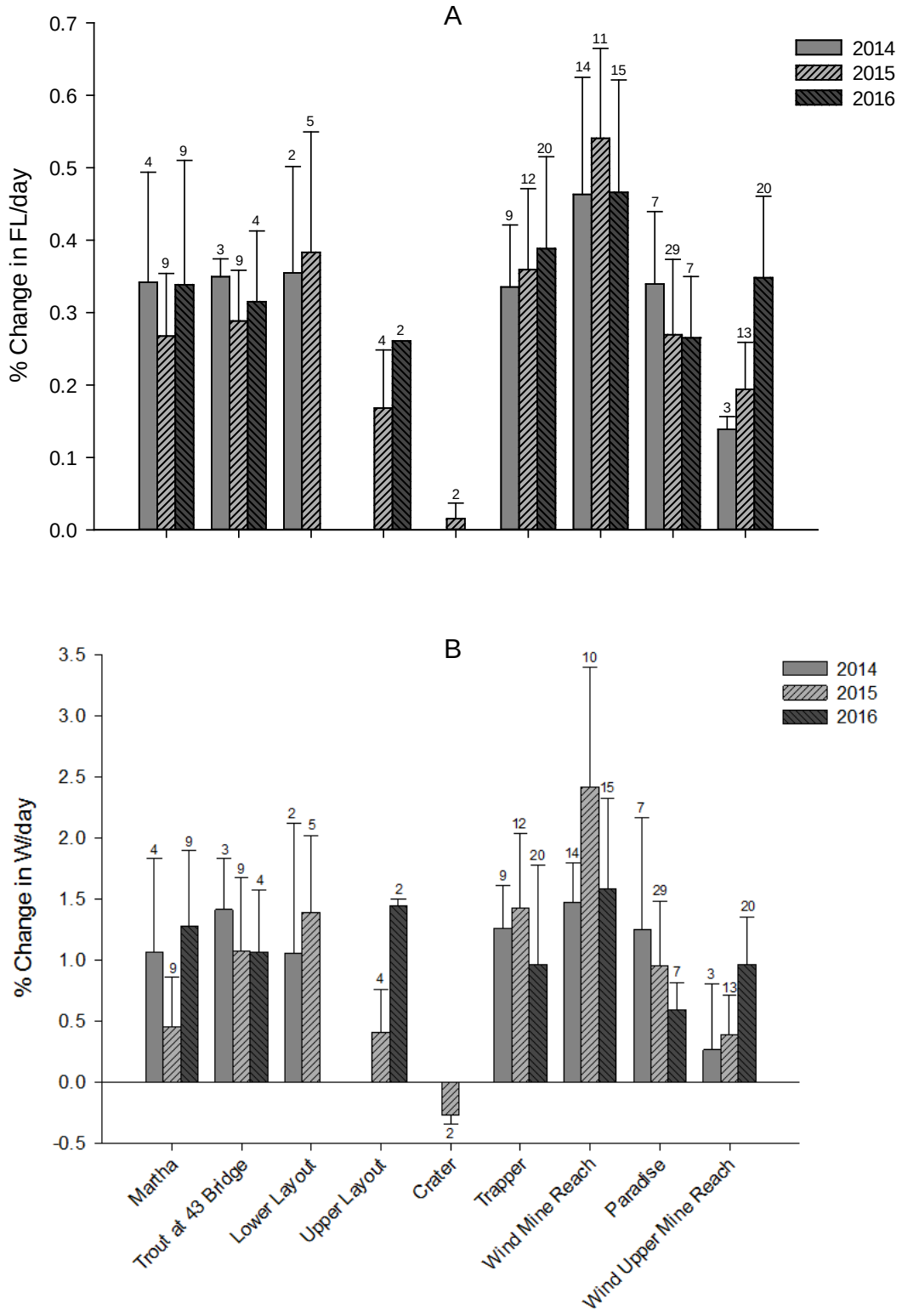


Figure 18. Mean relative growth +SD, shown as % change-per-day in fork length (Graph A) and weight (Graph B), of steelhead that were PIT tagged at age-0 in headwater sites in the Wind River subbasin and recaptured at the same location during the same summer (about 5 weeks later). All fish were captured and recaptured by electrofishing during late summer. Numbers at the bars are sample size.

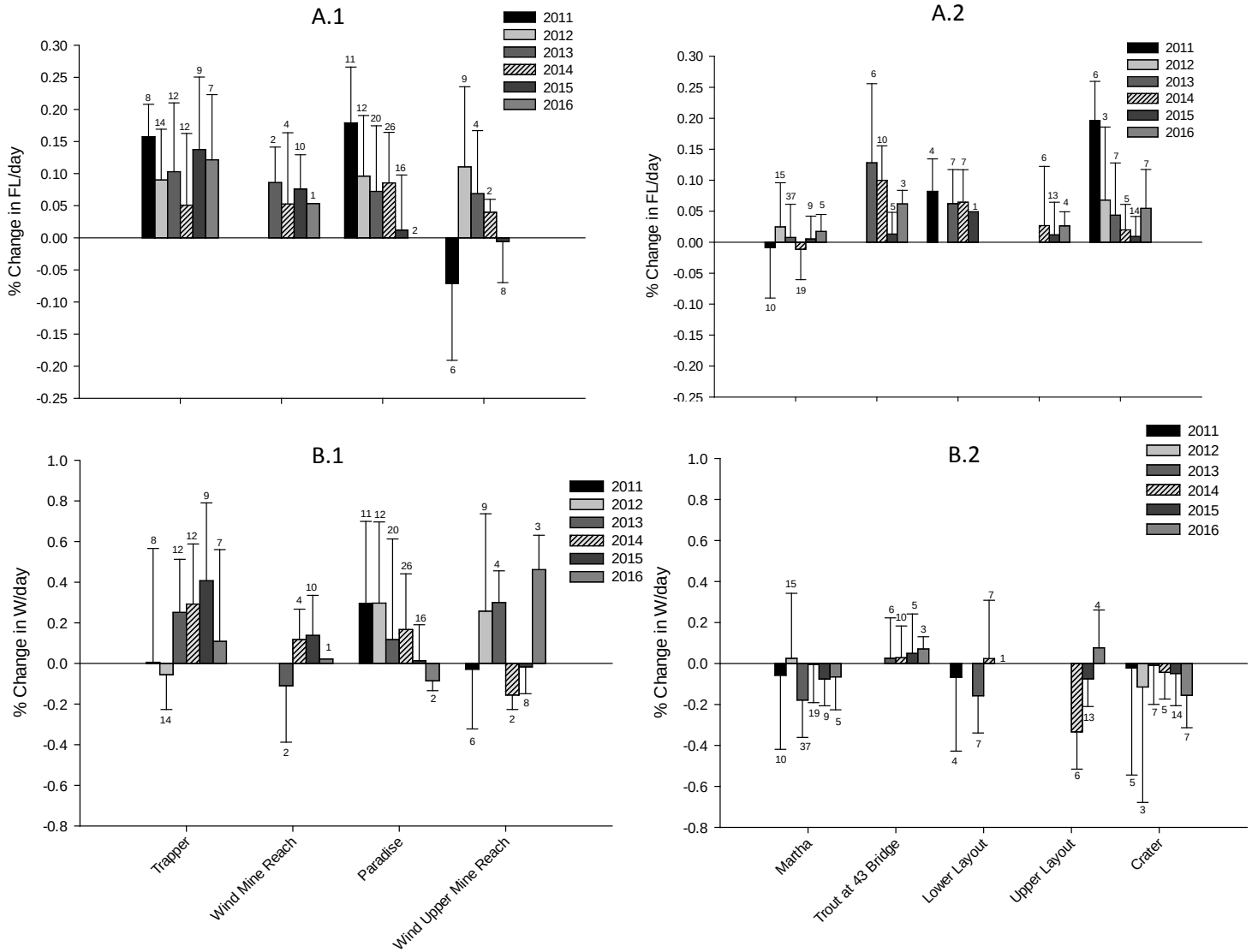


Figure 19. Mean relative growth +SD, shown as % change-per-day in fork length (Graph A.1, A.2) and weight (Graph B.1, B.2), of steelhead that were PIT tagged at age-1 in headwater sites in the Upper Wind River subbasin (left) and Trout Creek subbasin (right). Tagged steelhead were recaptured at the same location during the same summer (about 5 weeks later). All fish were captured and recaptured by electrofishing during late summer. Numbers at the bars are sample size.

Table 1. Locations of thermologgers in the Wind River subbasin maintained by U.S. Geological Survey's Columbia River Research Laboratory. Sites are listed from upstream to downstream within a watershed. Coordinates were obtained from Google Earth using World Geodetic System 1984.

Watershed Subwatershed	Coordinates North	Coordinates West	Elevation (m)	Distance upstream from mouth (km)	Date start (mm/yy)	Date end (mm/yy)
Trout Creek						
Crater Cr.	45º 50.761'	122º 02.083'	587	0.1	10/11	present
Layout Cr.	45º 49.451	122º 01.334'	559	0.7	08/14	present
Martha Cr.	45º 47.576'	121º 55.659'	344	1.5	07/12	present
Upper Wind River						
Wind R.	45º 56.985'	121º 55.897'	472	41.0	07/14	present
Paradise Cr.	45º 56.939'	121º 56.218'	469	0.4	07/12[b]	present

Table 2. Total number of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* that were captured and PIT-tagged in two watersheds in the Wind River subbasin during 2016. Tags used were 12-mm and 9-mm 134.2 kHz.

Watershed Stream	Dates sampled (month/day)	Rkm sampled, from stream mouth	Number of fish tagged	Number of recaptured tagged fish
Trout Creek				
Martha	8/16	1.3 – 1.8	80	15
	9/27	1.3 – 1.8	40	19
Layout	9/21	0.0 – 0.5	118	3
	8/10	2.5 – 3.0	58	3
	9/19	2.5 – 3.0	92	9
Trout	8/17	11.0 – 11.3	83	4
	9/28	11.0 – 11.3	71	8
Crater	8/08	0.0 – 0.4	48	5
	9/14	0.0 – 0.4	77	13
Wind River				
Trapper	8/18	0.1 – 0.5	155	2
	9/29	0.1 – 0.5	0	33
Paradise	8/09	0.5 – 1.0	70	2
	9/15	0.5 – 1.0	85	13
Wind River	8/11	37.0 – 37.3	77	0
	9/19	37.0 – 37.3	65	16
	8/15	41.0 – 41.5	102	0
	9/19	41.0 – 41.5	47	26
Total			**1,309**	**171**

Table 3. Re-contacts, through December 2016, of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* that were PIT-tagged as parr during August and September of 2011 through 2015 in headwater areas of the Trout Creek watershed in the Wind River subbasin.

		Recapture and detection events through December 2016					
Tag year	Number tagged[a]	Instream recapture	Trout Creek smolt trap	Lower Wind smolt trap	Detected at a PTIS[b]	Juveniles detected in Columbia River[c]	Adults detected in Columbia River
2011	494	53	7	0	7	4	0
2012	628	81	15	1	41	12	0
2013	813	135	14	4	26	13	2
2014	784	130	24	4	121	21	0
2015	924	130	13	1	123	10	-

[a] Include fish tagged in Martha Creek, downstream of the Trout smolt trap and PTISs. Fish tagged in Martha: 2011 = 127; 2012 = 121; 2013 = 384; 2014 = 384; 2015 = 187.
[b] PTIS = Instream PIT-tag interrogation system (PTIS) in mainstem Trout Creek (rkm 2.0 from 2011 – 2014; rkm 11.0 installed September 2014) and Martha Creek.
[c] Bonneville Dam, estuary trawl, or avian-mortality sampling.

Table 4. Re-contacts, through December 2016, of juvenile steelhead/rainbow trout Oncorhynchus mykiss that were PIT-tagged as parr during August and September of 2011 through 2015 in headwater areas the Upper Wind River watershed in the Wind River subbasin.

		Recapture and detection events through December 2016					
Tag year	Number tagged	Instream Recapture	Upper Wind smolt trap	Lower Wind smolt trap	Detected at a PTIS[a]	Juveniles detected in Columbia River[b]	Adults detected in Columbia River
2011	497	60	0	0	10	10	2
2012	623	96	8	3	50	10	2
2013	644	74	9	3	46	15	1
2014	720	134	12	5	84	22	0
2015	725	121	11	1	31[c]	13	-

[a] PTIS = Instream PIT-tag interrogation system (PTIS) located at rkm 30.0 of the Wind River, rkm 40.5 of the Wind River, and rkm 0.5 of Paradise Creek.
[b] Bonneville Dam, estuary trawl, or avian-mortality sampling.
[c] The Wind River PTIS at rkm 30.0 was heavily damaged in Dec. 2015 and a partial replacement could not be installed until October of 2016.

Table 5. Detection efficiency estimates, by the Connolly et al. (2008) method, for PIT-tagged adult steelhead *Oncorhynchus mykiss*, at the Trout Creek PIT-tag interrogation site (TRC).

Detection Period	Number of fish detected	Efficiency estimate %	SE	Lower 95% CI	Upper 95% CI
01/01/2016 – 12/31/16	89	92.1	1.8	87.1	95.2

Table 6. Detection efficiency estimates, by the Connolly et al. (2008) method, for PIT-tagged adult steelhead *Oncorhynchus mykiss*, at the Trout Creek at 43 Road Bridge PIT-tag interrogation site (TC4) following repairs from December 2015 flood damage

Detection Period	Number of fish detected	Efficiency estimate %	SE	Lower 95% CI	Upper 95% CI
07/01/16 – 12/31/16	21	76.6	11.4	48.9	92.5

Table 7. Detections of steelhead *Oncorhynchus mykiss* parr, which were PIT tagged at WDFW screw traps and not subsequently recaptured, at Trout Creek (TRC) and upper Wind River (WRU) PIT-tag interrogation sites. Both PIT-tag interrogation sites are within 1.5 km downstream of the release site for parr. Median travel time denotes the number of days between release at upstream smolt trap and detection at the PIT-tag interrogation site.

				% of detections, by week, after release date				
Site	Year	Number of parr detected	Median travel time (d)	Week 1	Week 2	Week 3	Week 4	> 4 Weeks
TRC[a, b]	2008	30	0	70	10	0	3	17
	2009	51	1	76	4	2	0	18
	2010	16	6	56	0	0	6	37
	2012	73	0	82	0	3	1	14
	2013	195	1	79	3	3	2	13
	2014	129	1	72	2	4	3	19
	2015	109	1	79	5	1	1	15
WRU	2013	63	1	87	3	3	2	5
	2014	68	2	57	3	3	0	36
	2015	102	0	86	1	1	1	11

[a] During 2010, TRC was not operating for 18 days during the trapping season.
[b] Few parr were tagged during 2011 and only one detected.

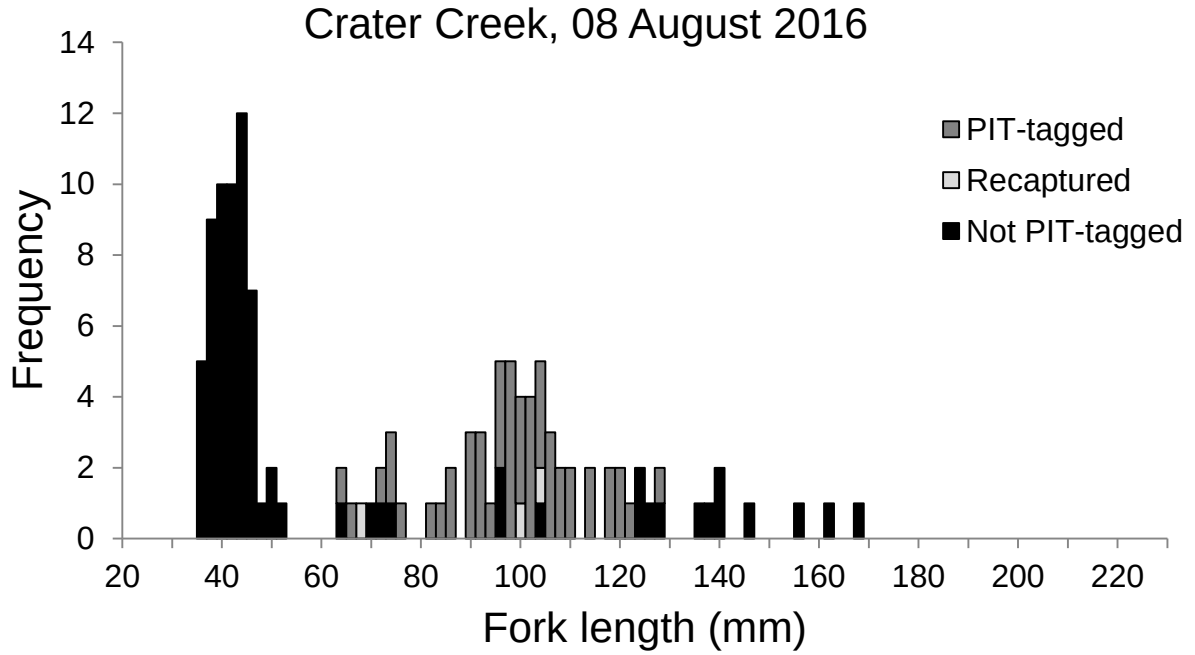
Appendix A: Use of Data & Products

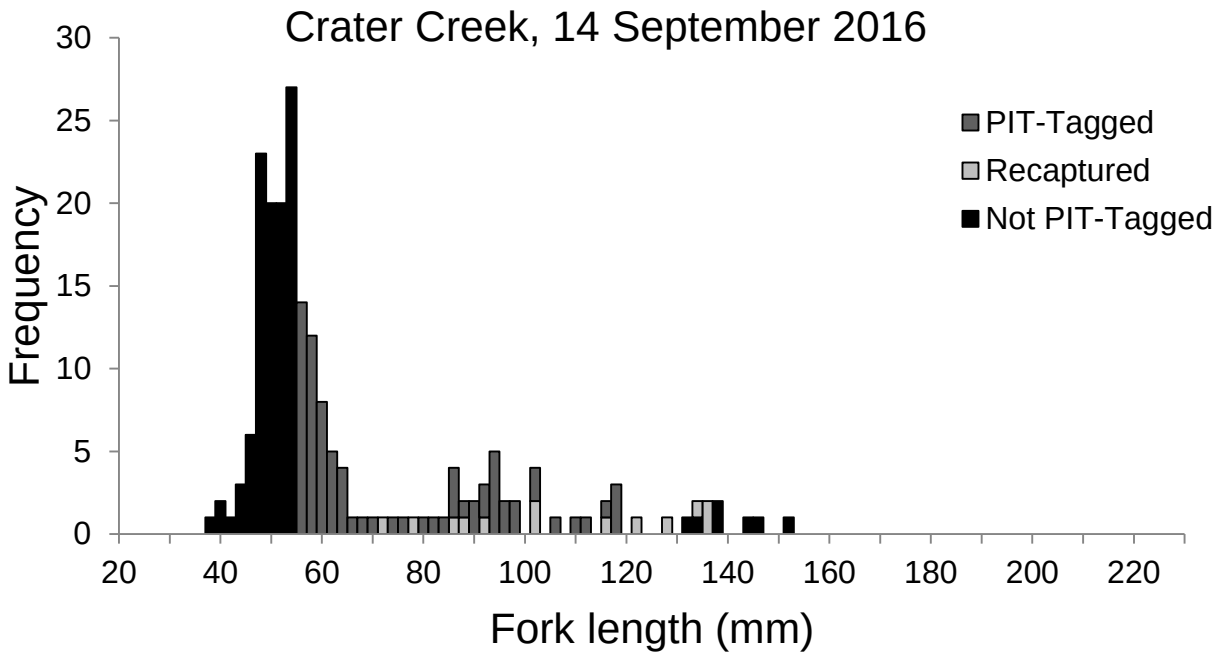
We have submitted PIT tagging data to the PTAGIS database.
http://ptagis.org/

We have submitted water temperature data to the NorWest database.
http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html

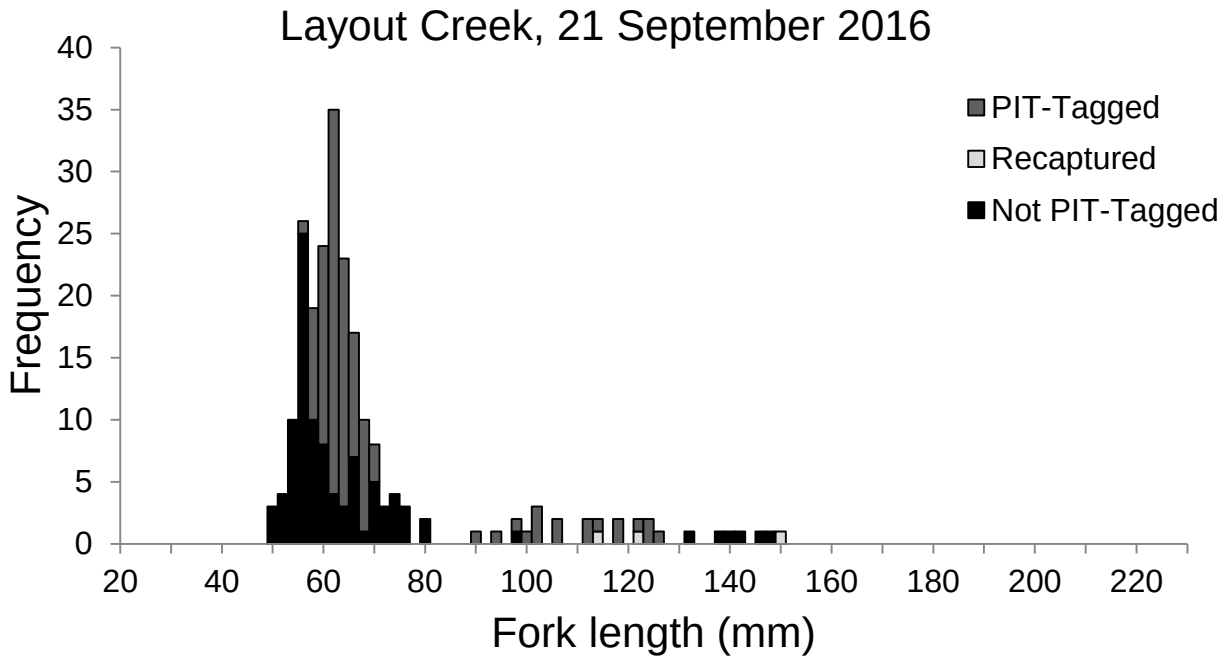
We have submitted fish data for those fish captured but not PIT-tagged to Streamnet.
http://old.streamnet.org/datastore_search_classic.cfm?id=667

Appendix B: Detailed Results – Length frequency histograms

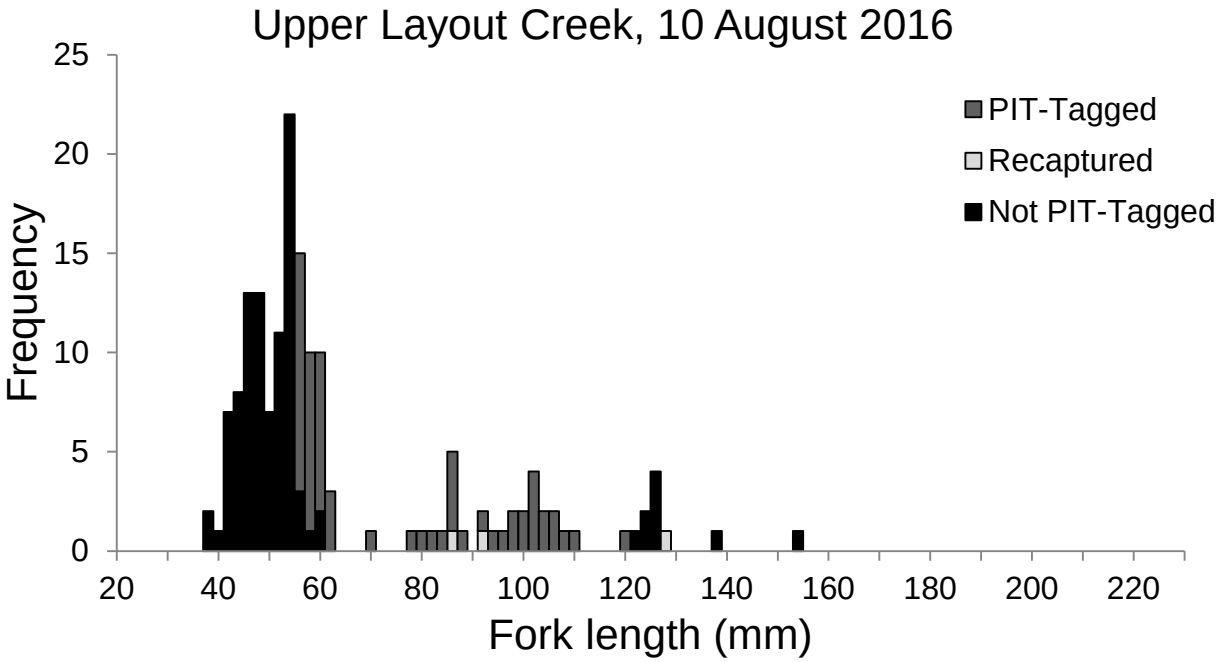


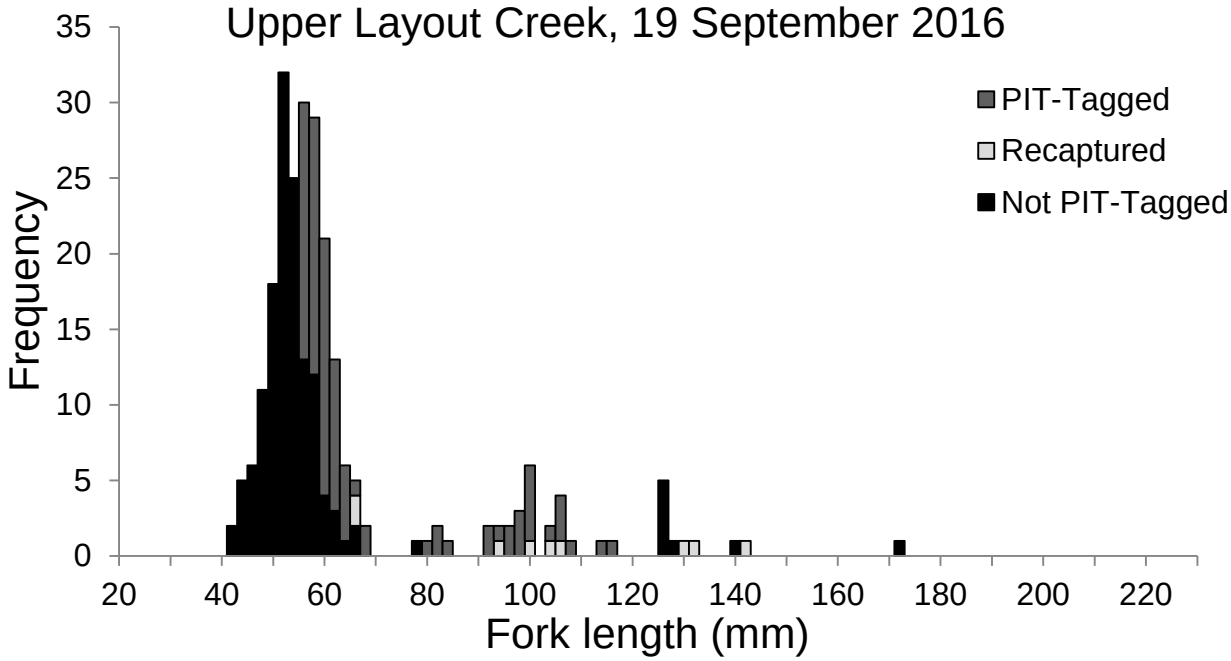


Appendix Figure 1. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Crater Creek (rkm 0 – 0.5), sampled by electrofishing during 2016. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

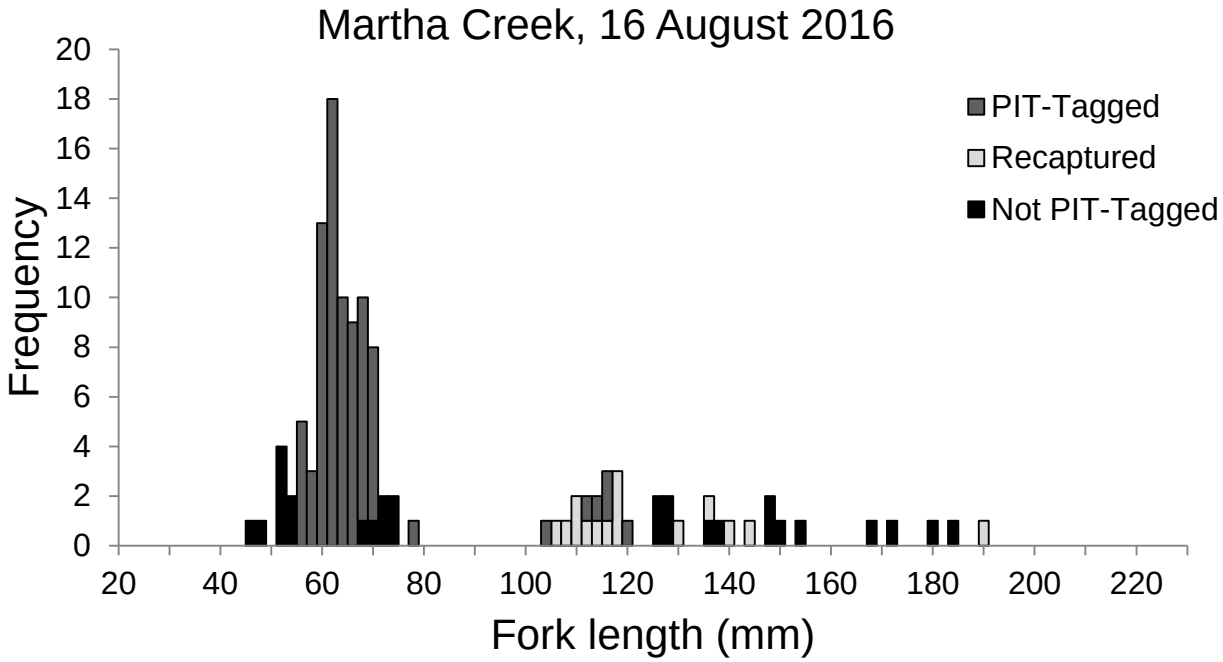


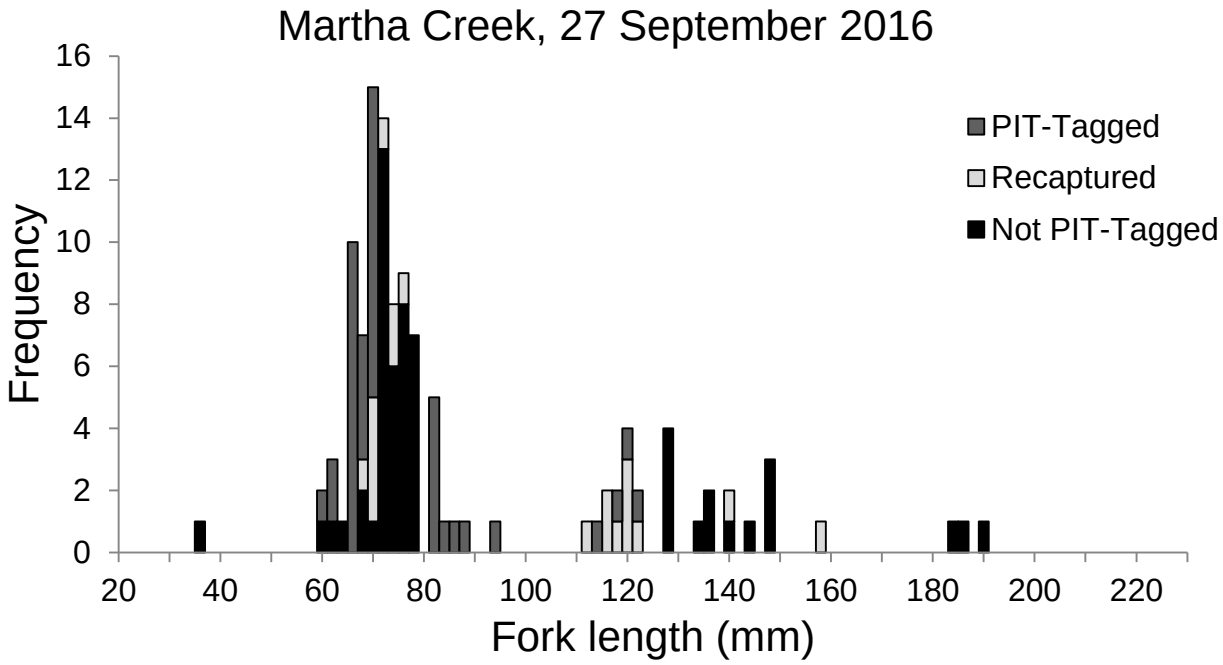
Appendix Figure 2. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Layout Creek (rkm 0 – 0.5), sampled by electrofishing during 2016. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.



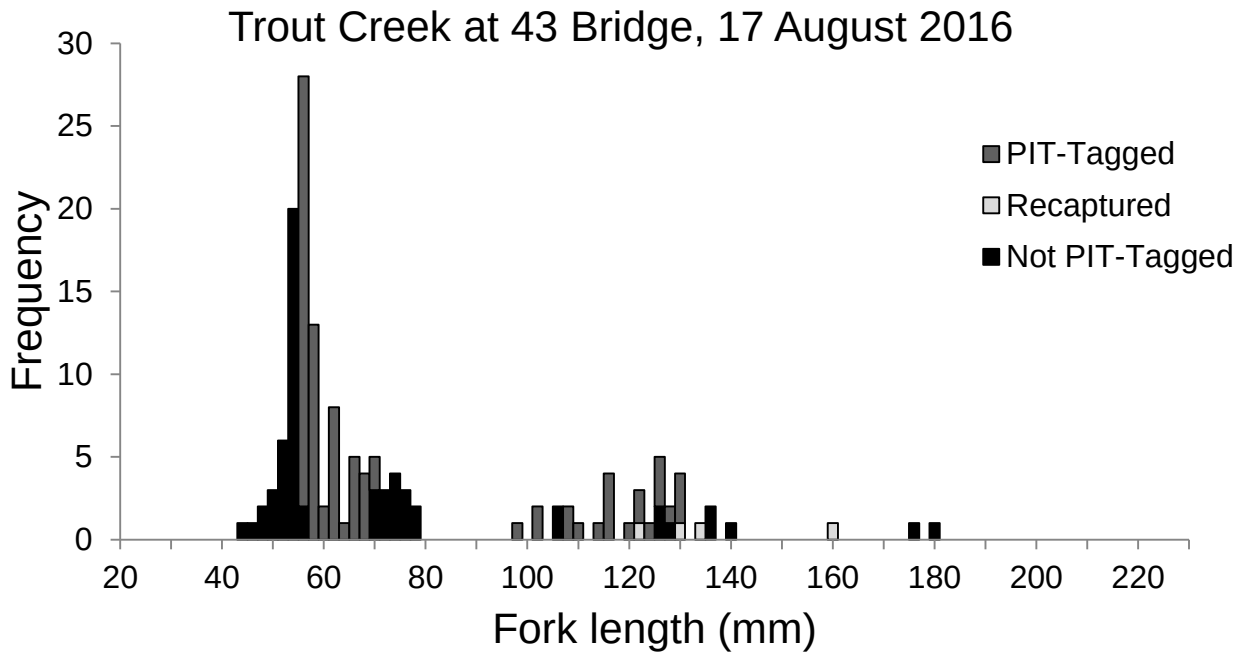


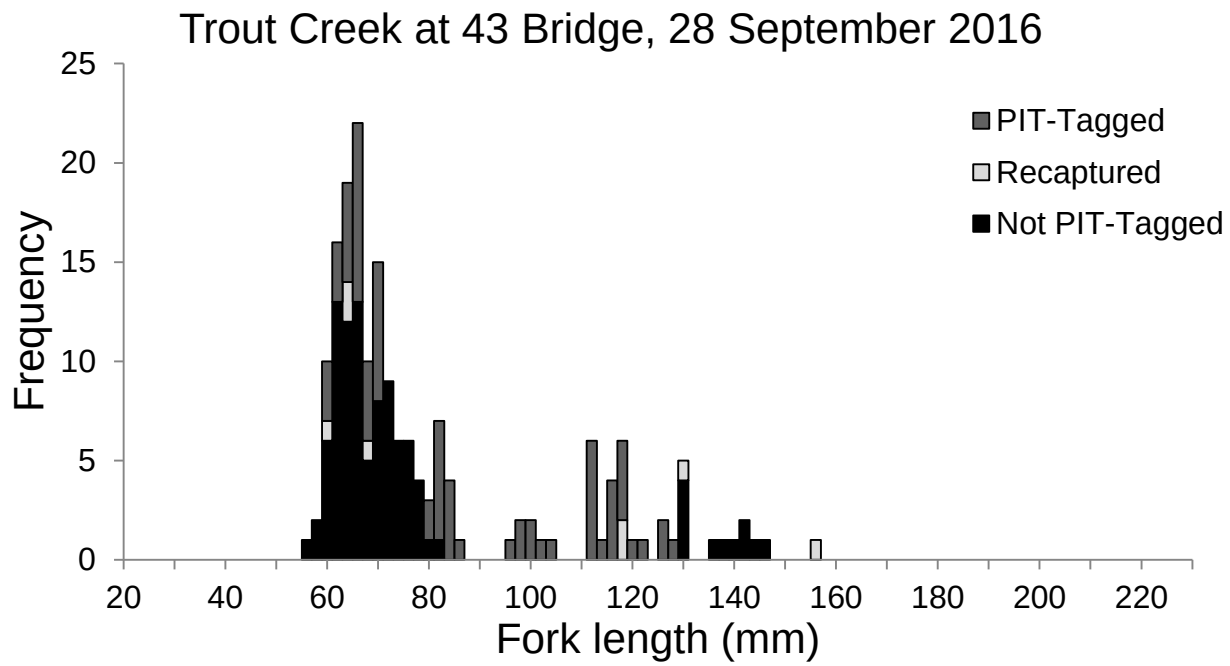
Appendix Figure 3. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Upper Layout Creek (rkm 2.5 – 3.0), sampled by electrofishing during 2016. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.



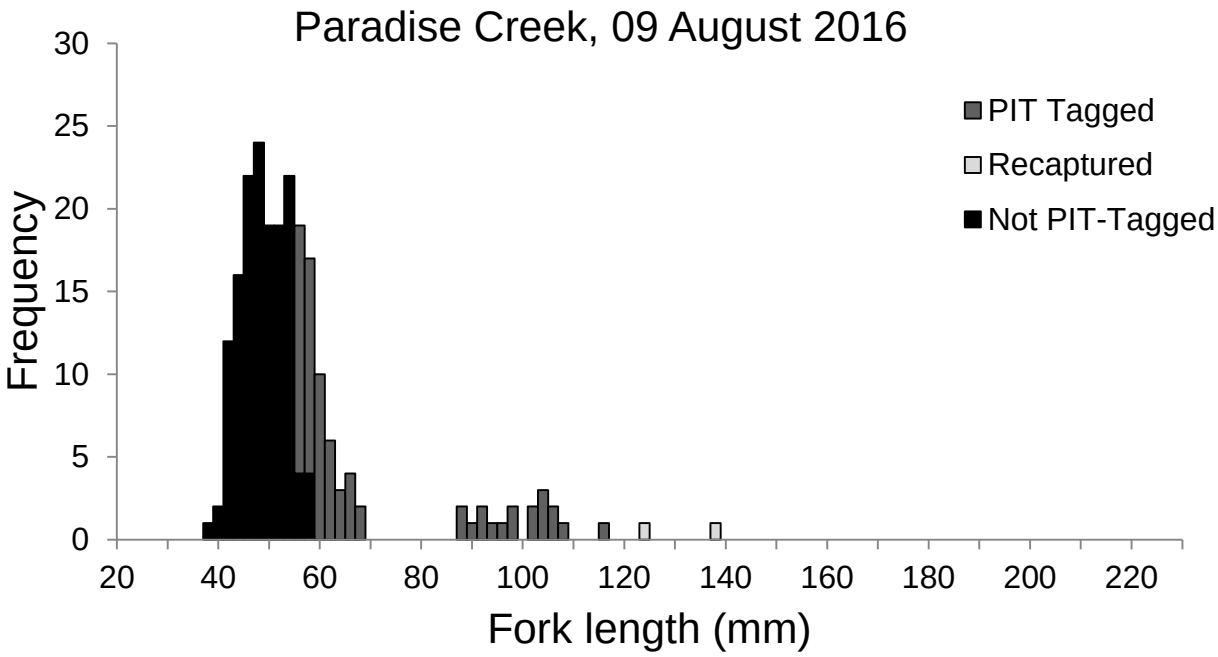


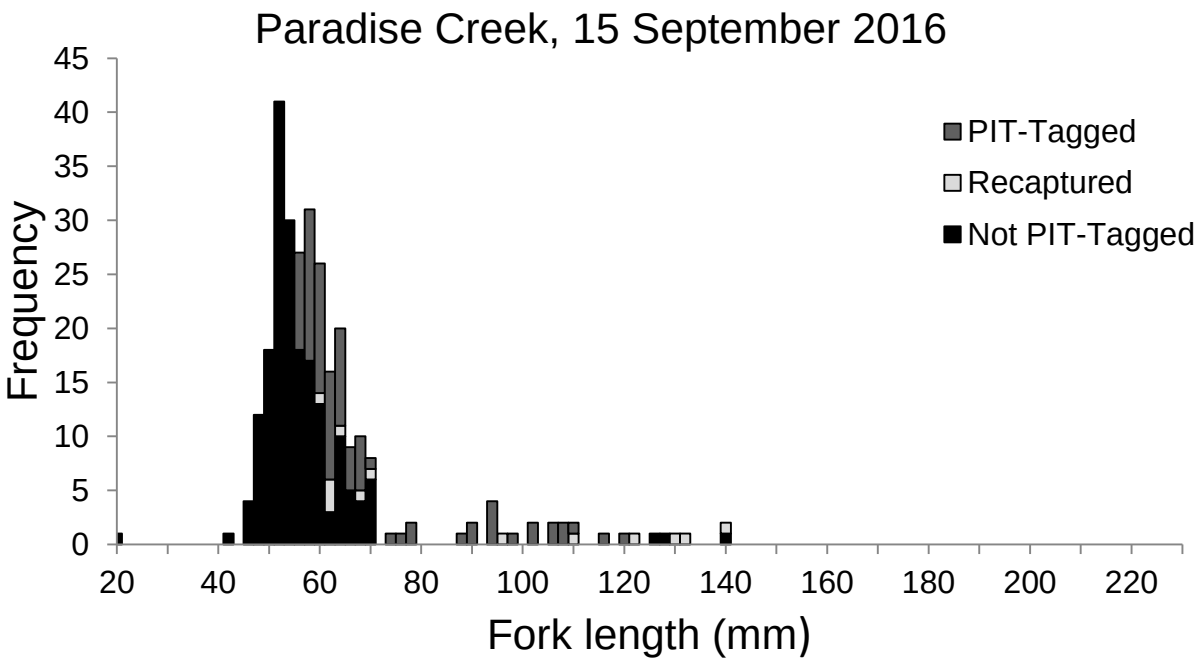
Appendix Figure 4. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Martha Creek (rkm 1.3 – 1.9), sampled by electrofishing during 2016. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.



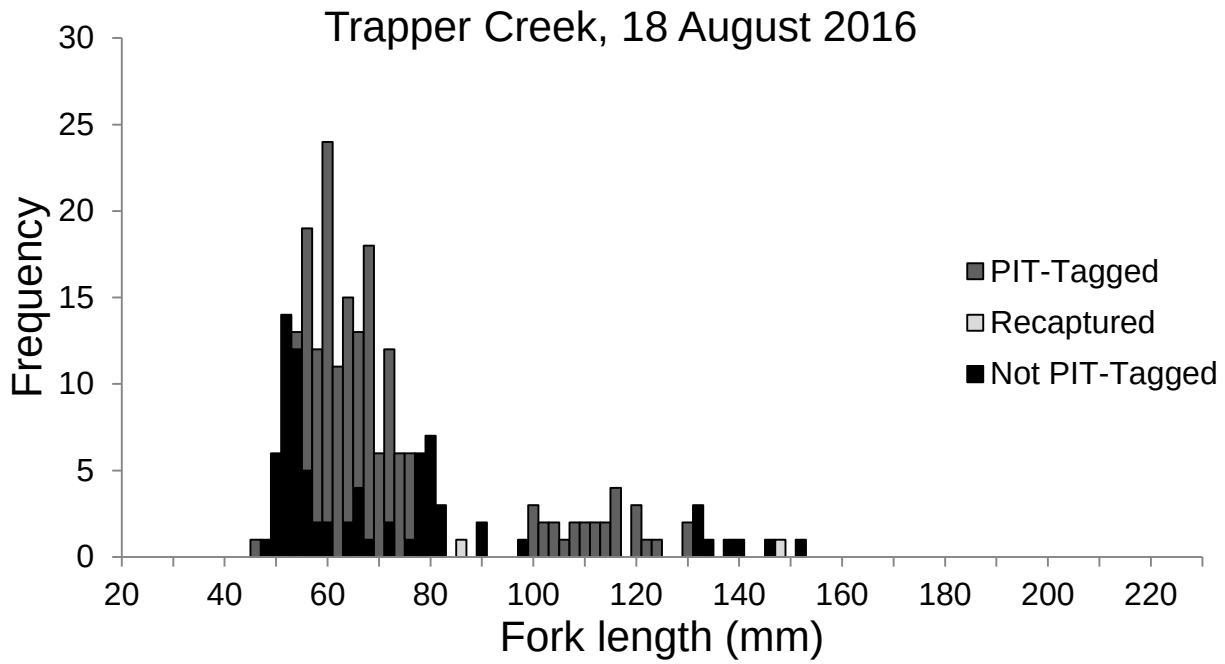


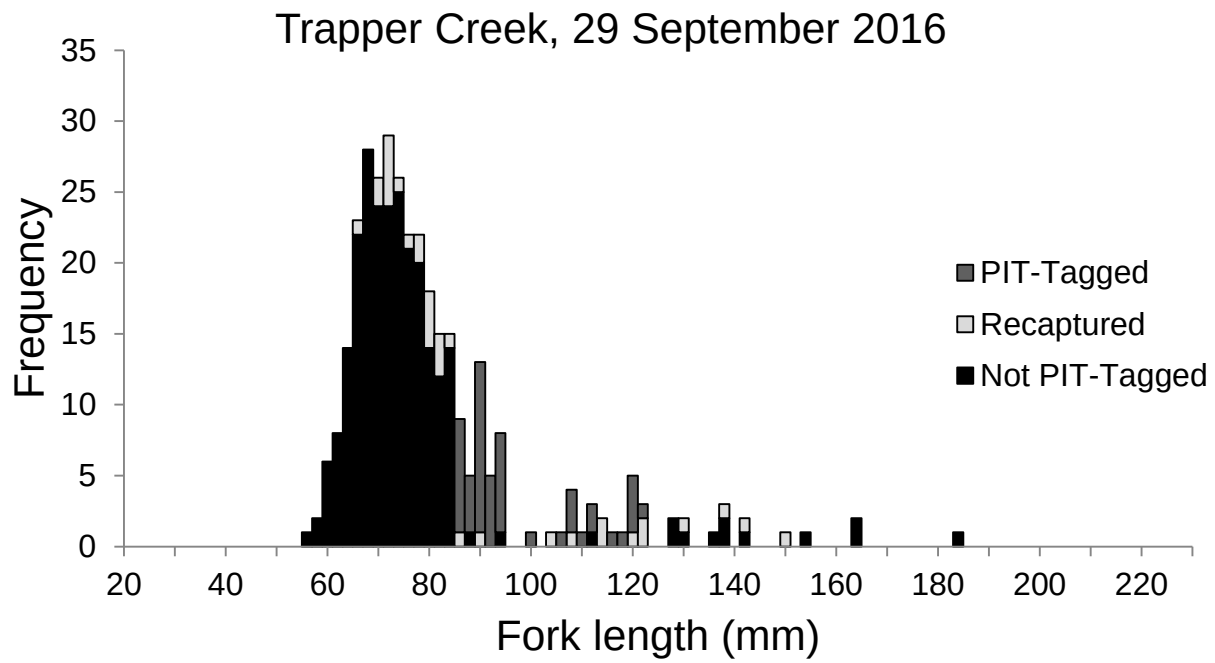
Appendix Figure 5. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Trout Creek (rkm 11.0 – 11.3), sampled by electrofishing during 2016. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.



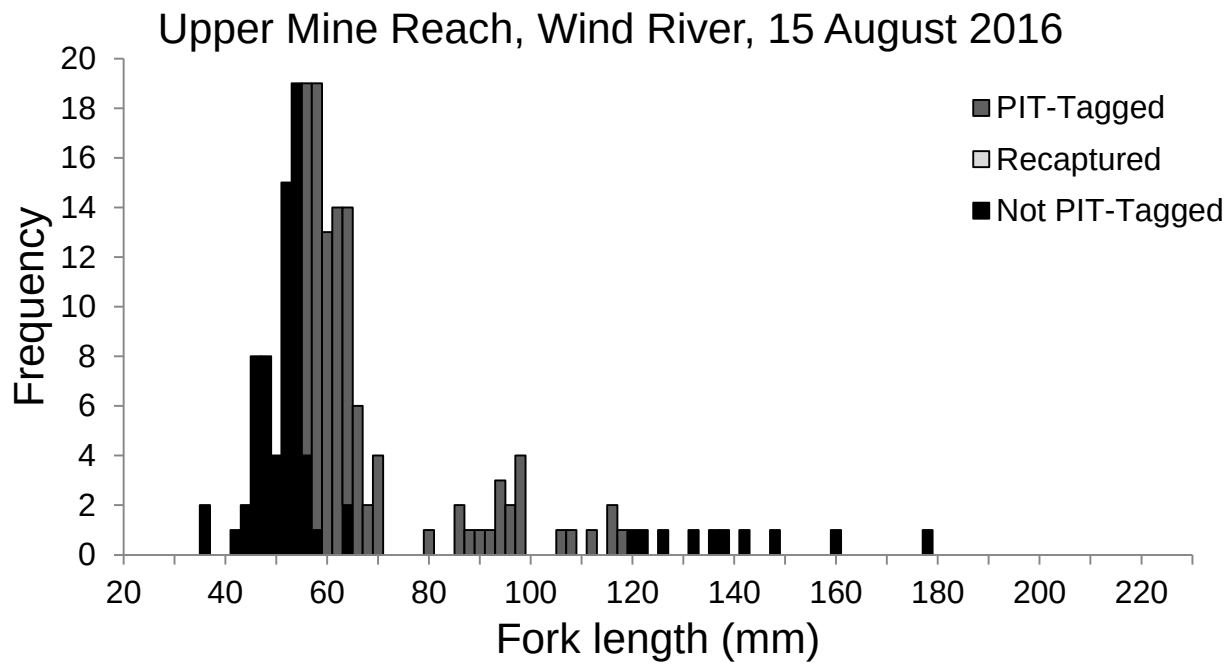


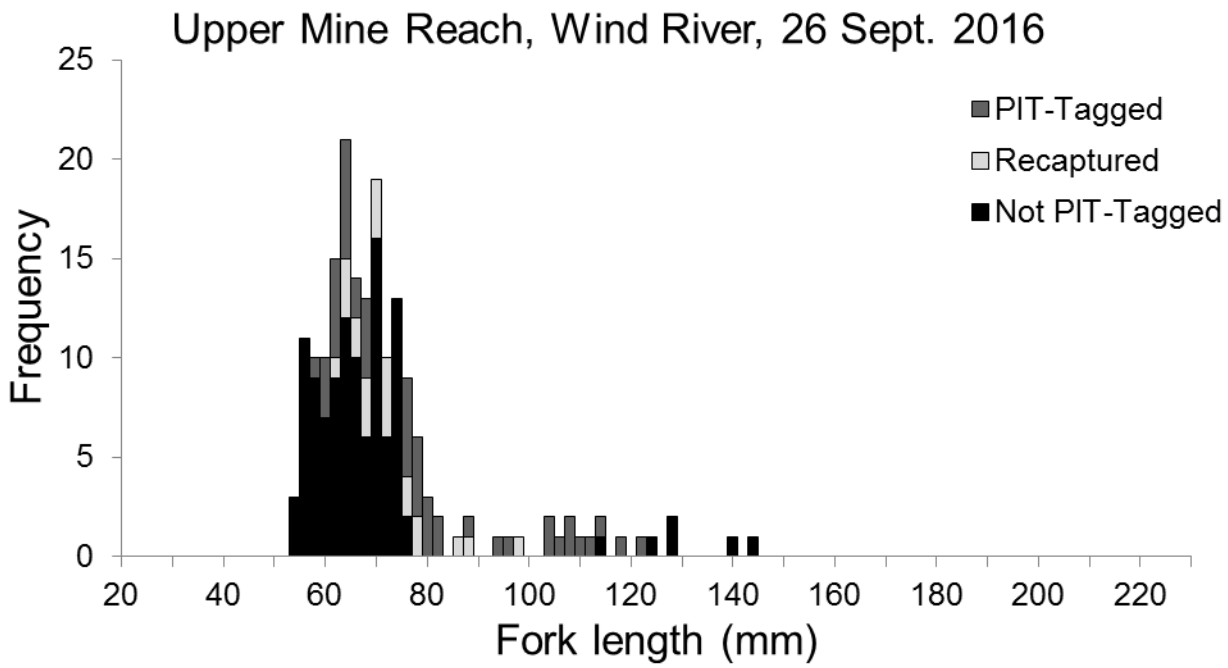
Appendix Figure 6. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Paradise Creek (rkm 0.5 – 1.0), sampled by electrofishing during 2016. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.



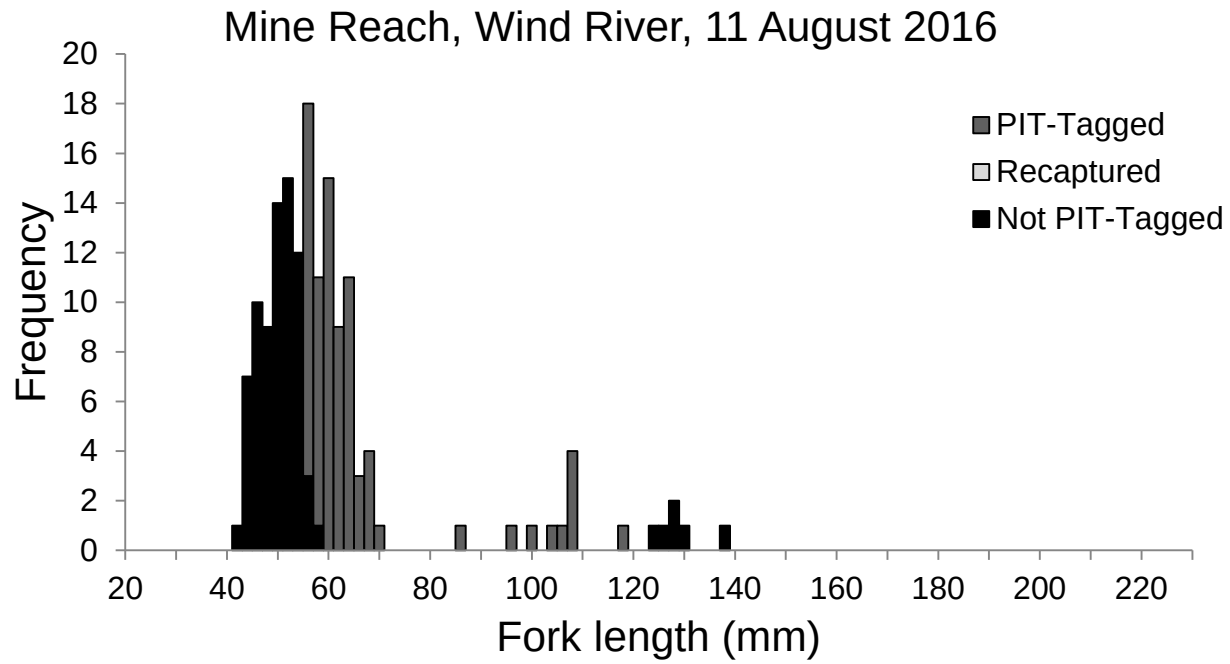


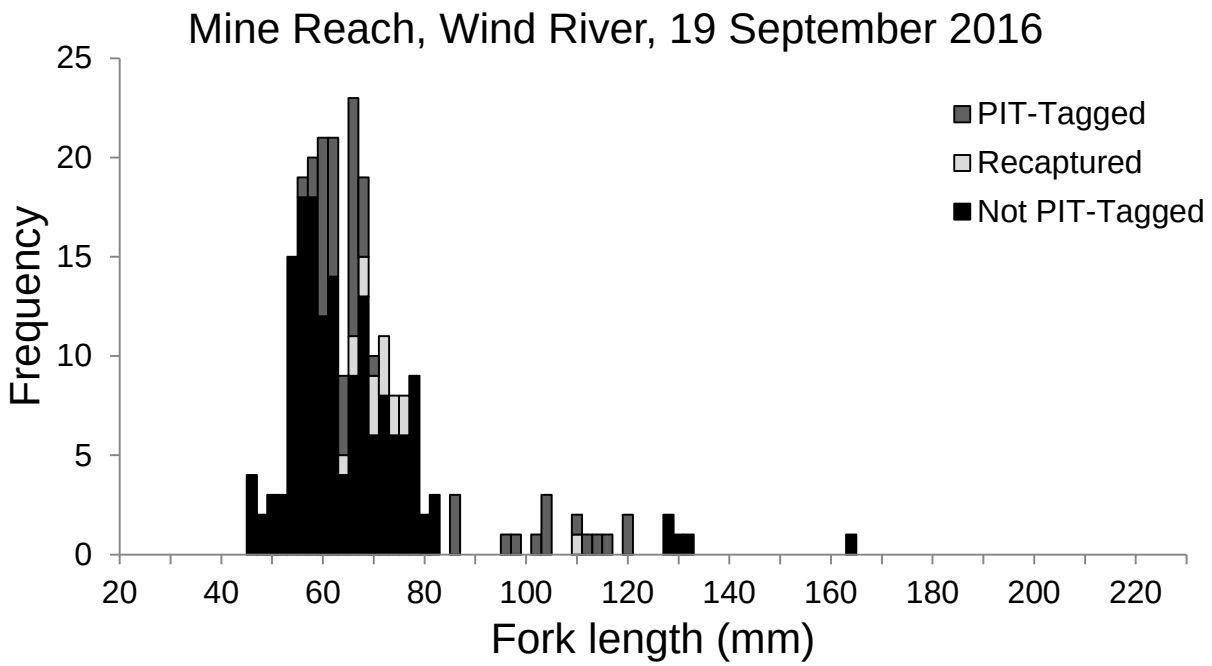
Appendix Figure 7. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Trapper Creek (rkm 0.1 – 0.6), sampled by electrofishing during 2016. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.





Appendix Figure 8. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in the Wind River upstream of the confluence with Paradise Creek (rkm 41.0 – 41.5), sampled by electrofishing during 2016. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.





Appendix Figure 9. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in the Wind River (rkm 37.0 – 37.4), sampled by electrofishing during 2016. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

Appendix C: Detailed Results – Fork-length data

Appendix Table 1. Summary fork-length data (mm) for age-0 steelhead parr sampled in the Wind River subbasin during 2016.

Site	Date sampled	Rkm from mouth	n	Range	Median	Mean	SD
Martha	8/16	1.3 – 1.8	89	46-77	62	62	5.7
	9/27	1.3 – 1.8	86	59-94	72	72	6.2
Layout	9/21	0.0 – 0.5	192	49-80	61	61	5.8
	8/10	2.5 – 3.0	123	38-69	52	51	5.9
	9/19	2.5 – 3.0	205	41-68	55	55	5.2
Trout	8/17	11.0 – 11.3	111	43-77	56	59	7.5
	9/28	11.0 – 11.3	135	56-85	66	68	6.8
Crater	8/08	0.0 – 0.4	57	35-52	41	41	3.8
	9/14	0.0 – 0.4	148	38-67	52	52	5.2
Trapper	8/18	0.1 – 0.5	193	45-82	62	63	8.4
	9/29	0.1 – 0.5	300	55-94	73	74	8.5
Paradise	8/09	0.5 – 1.0	198	38-67	51	51	6.4
	9/15	0.5 – 1.0	258	42-78	56	57	6.4
Wind R.	8/11	37.0 – 37.3	140	42-69	55	55	6.5
	9/16	37.0 – 37.3	214	45-86	62	63	8.4
	8/15	41.0 – 41.5	150	36-70	56	56	6.5
	9/26	41.0 – 41.5	159	53-82	66	66	6.8

Appendix Table 2. Summary fork-length data (mm) for age-1 steelhead parr sampled in the Wind River subbasin during 2016.

Site	Date Sampled	Rkm from mouth	n	Range	Median	Mean	SD
Martha	8/16	1.3 – 1.8	26	103-143	118	120	11.1
	9/27	1.3 – 1.8	25	111-148	127	128	11.6
Layout	9/21	0.0 – 0.5	21	90-126	111	109	10.9
	8/10	2.5 – 3.0	28	78-109	97	94	9.4
	9/19	2.5 – 3.0	29	78-115	99	97	9.5
Trout	8/17	11.0 – 11.3	33	98-140	122	120	10.9
	9/28	11.0 – 11.3	41	96-145	117	119	13.4
Crater	8/08	0.0 – 0.4	44	64-105	96	91	11.8
	9/14	0.0 – 0.4	35	70-111	92	91	10.3
Trapper	8/18	0.1 – 0.5	35	85-133	111	112	12.7
	9/29	0.1 – 0.5	28	99-130	114	115	8.5
Paradise	8/09	0.5 – 1.0	17	87-107	98	98	6.5
	9/15	0.5 – 1.0	17	87-112	98	99	7.8
Wind R.	8/11	37.0 – 37.3	10	85-118	106	104	8.7
	9/16	37.0 – 37.3	13	96-120	109	108	7.9
	8/15	41.0 – 41.5	24	79-125	97	101	13.2
	9/26	41.0 – 41.5	20	85-128	108	107	13.0