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 wild Steelhead *Oncorhynchus mykiss* in the Wind River subbasin, WA. No hatchery Steelhead have been planted in the Wind River subbasin since 1997, and hatchery adults are estimated to be less than one percent of adults in most years (pers comm. Thomas Buehrens, Washington Department of Fish and Wildlife). Numerous restoration actions have been implemented in the subbasin, including Hemlock Dam removal on Trout Creek in 2009. Data from our study, and companion work by Washington Department of Fish and Wildlife (WDFW), are contributing 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. Our headwaters parr PIT tagging, WDFW parr, smolt, and adult tagging and our instream PTISs are providing data movements and life histories of parr, smolt, and adult Steelhead.

During summer 2017, we PIT-tagged age-0 and age-1 Steelhead parr in headwater areas of the Wind River subbasin to characterize population traits and investigate life-history diversity, including growth and pre-smolt downstream movement. 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. This included adding the second array to our upper Wind River PITS, increasing solar capacity and adding improved power cables to some sites.

Detections at the instream PTISs have demonstrated trends of age-0 and age-1 parr emigration from natal areas 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 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.

Movements of PIT-tagged adult Steelhead were also recorded at instream PTISs. These data have allowed 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. The dam had had contributed to hydrologic impairment of Trout Creek and had potential negative effects on Steelhead. The improved upper Wind River PTIS (better site characteristics and grid power) will allow estimates of subbasin adult escapement upstream of that site.

Evaluating and planning restoration efforts are of interest to many managers and agencies to ensure efficient use of resources. 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 operate 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 2017 through December 2017. Funding for activities during this time was provided by Bonneville Power Administration (BPA) under contracts 73884 and 77688 as part of the Wind River Subbasin Project (BPA Project Number 1998-019-00). The Wind River Subbasin Project is a collaborative effort to restore, research, and monitor wild Lower Columbia River steelhead in the Wind River, WA. The four collaborative 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 and has allowed extensive habitat restoration, research, monitoring, and coordination 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.

Long-term research in the Wind River has focused on assessing Steelhead *O. mykiss* abundance 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 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 migrate from headwater rearing areas as young as age-0 and do so throughout the year. Our sampling efforts provide data to inform life-cycle modeling, estimate life-stage specific survival, and identify potential population bottlenecks. Additionally, these data are contributing to evaluation of Steelhead abundance and behavior in response to the removal of Hemlock Dam from Trout Creek.

During the period covered by this report, we tagged Steelhead parr in headwater sites in 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. Steelhead parr PIT tagged in headwater habitats and at smolt traps are providing growth, movement, and life history data through recapture events, detections at instream PTISs within the Wind River subbasin, and 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. Data from fish that are not PIT-tagged are submitted to the StreamNet database. 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 abundance. 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.

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 Steelhead 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 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 sites since 2011. Repeat sampling across years provides data on growth and movement and serves to track shifts in growth or fish size and condition at these sites as habitat or climatic conditions change due to restoration or climatic effects.

We used backpack electrofishing (Smith Root, Inc., Vancouver, Washington; model LR-24 or 12B) to capture age-0 and age-1 Steelhead. 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. All PIT-tagging procedures followed the guidelines outlined by Columbia Basin Fish and Wildlife Authority (1999). Untagged fish that were at least 70-mm fork length, and in good 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, which were inserted into a scalpel incision. Several studies have reported that a scalpel incision was preferable to use of a 12-gage syringe on small fish (Baras et al. 2000; Archdeacon et al. 2009; Dixon and Mesa 2011). After work up, fish were held in fresh ambient-temperature stream

water, allowed to recover, 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.

Repeat sampling of sites within and between years provides the opportunity to recapture PIT-tagged parr and collect growth data from fish tagged as age-0 and age-1. During 2013, we began using 9-mm PIT tags, which allowed us to tag many age-0 fish. We measured relative growth as % change in FL and weight per-day from recaptured parr (Lugert et al. 2016). Relative growth of age-0 and age-1 parr (FL and weight) is calculated both within summer recapture periods between years.

During 2017, we also PIT tagged some age-0 Steelhead with 8-mm tags to assess tagging effects on very small fish. Many laboratory studies have been conducted on PIT-tagging effects (Prentice et al. 1990; Acolas et al. 2007; Tiffan et al. 2015), but field trials are difficult and rare. Our sampling design, small streams, and recapture rate provided good conditions for a field trial. We PIT tagged age-0 Steelhead with 8-mm tags in Upper Layout Creek, Trapper Creek, Paradise Creek, and the upper Mine Reach section of the Wind River and resampled those sections in the fall to assess growth and survival. During the tagging event, we PIT tagged Steelhead between 42 and 69-mm FL with an 8-mm 134.2 kHz tag. Because the 8-mm tags are very small and difficult to handle, the tags were inserted into the body cavity with a 14-gauge syringe (smaller diameter than the 12-gage syringe for 12 or 9-mm tags) from the ventral side, anterior to the ventral fin. Every other fish in the size range was given a ventral fin clip and these fish served as a control group.

The recapture event for each sample site occurred 57 days after the tagging event. Each complete site was resampled by electrofishing. To estimate joint probability of survival and site fidelity of PIT-tagged and control fish we needed to determine capture probabilities by the removal method (Zippen 1958; Otis et al. 1978). We conducted a three-pass removal estimate in a representative subsection at each site, which allowed us to determine capture probabilities (White et al. 1982; Riley and Fausch 1992). Removal subsections were between 80 and 100-m long and were block netted at the upstream and downstream ends to prevent immigration or emigration during sampling (Peterson et al. 2005). Subsections were chosen to be representative of the overall site. Each removal subsection was electrofished with three upstream passes. After each pass, fish were worked up and held in a cooler with ambient stream water until all passes were complete. The remainder of each sample site was electrofished in an upstream pass.

Capture probability from the first pass of the removal section at each site could be applied to the entire site to determine joint probability of survival and site fidelity. During the recapture event fish workup, all fish were scanned for PIT tags and checked for fin clips. Fish were measured for FL to the nearest mm and weighed to the nearest 0.1 g. All fish were released at or near the point of capture after the recapture sampling. Data from this 8-mm tag trial are currently being analyzed and will be written up for journal publication.

During the period covered by this report, we operated and maintained six PTISs (Figure 2) to track PIT-tagged juvenile and adult Steelhead. Two PTIS sites were 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 transceivers at the PTIS sites.

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, which are more efficient with better diagnostics than the RM310 units. Power limitations at PAD and UMD (both solar supported) allow for only one antenna (3-m long by 0.6-m wide) at each site. Because of solar-power charging and winter access limitations, we missed some monitoring time at the PAD and UMD sites during winter. We removed the solar panels at the PAD site because they are subject to snowplow damage. We began operation at PAD on 22 March 2017 and concluded operations on 8 November 2017.

The transceivers at TRC, TC4, and WRU were Biomark 1001M units capable of operating six antennas. All 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 provide the opportunity to estimate detection efficiency of adult salmonids following Connolly et al. (2008). Detections of PIT-tagged adult Steelhead at TRC and TC4 are providing WDFW with data to generate adult abundance estimates in Trout Creek to monitor response of adult population to removal of Hemlock Dam. Specifics on adult abundance methods can be found in WDFW reporting (Buehrens and Cochran 2018).

Six antennas were used at 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). We added a second antenna array to WRU on 8 September 2017, which followed site relocation and initial antenna array installation in October 2016 (Jezorek and Connolly 2018). Since relocation of WRU in October 2016, power was provided by solar panels. On 21 September 2017, we connected to grid power to improve consistency of operation. New power cables were installed at both WRU and TRC during fall 2017. These new "twisted pair" cables reduced noise and should improve detection ability at both sites.

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 headwater areas (Tables 2 and 3). Additionally, instream PTISs are providing migration information on parr PIT tagged at WDFW screw traps in Trout Creek and the upper Wind River. These parr are primarily age-1 fish and questions exist regarding their behavior and contribution to smolt and adult abundance. All PTIS interrogation data were submitted to the PTAGIS database (uploads 2 to 4 times per month). Due to frequent interruptions to operations, data from MAD, PAD, and UMD were submitted as Passive Observation Recaptures (can be found as recaptures in PTAGIS).

8. Results

Fish Tagging -- During 2017, we PIT-tagged 1,585 Steelhead. In the Trout Creek watershed, we PIT-tagged in Martha, Layout, and Crater creeks, and a section of mainstem Trout Creek (rkm 11.0 – 11.3; Figure 1; Table 1). In the upper Wind River watershed, we PIT-tagged in Trapper and Paradise creeks, in the Wind River upstream of the Paradise Creek confluence, and in the Mine Reach of the mainstem Wind River (rkm 36.1 – 36.5; Figure 1; Table 1). We tagged 779 fish with 9-mm PIT tags and 458 with 12-mm PIT tags. An additional 348 age-0 fish were tagged with 8-mm tags. Most sites were sampled in summer, then again in early fall (Table 1; Appendix Figures 1 – 9). A week of rain in late September 2017 prevented us from resampling two of our sites in early fall 2017 (Martha Creek and mainstem Trout Creek at rkm 11.0).

Length and weight data were collected from any fish that we did not PIT tag, including fry too small to tag (Appendix Figures 1 – 9). Length frequency data were used to determine age-

0 and age-1 breaks at each site and date during each sample year (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 -- Twenty-two PIT-tagged adult Steelhead were detected at the TRC PTIS from 01 January 2017 through 31 December 2017 (Figure 6). Adult detection efficiency, derived by the methods of Connolly et al. (2008), of the TRC PTIS was 93.1% (SE = 3.7) over this time (Table 2). We also calculated TRC detection efficiency of PIT-tagged adult Steelhead by checking for detections of them at TC4, which is upstream of TRC, thus adult Steelhead must pass TRC to reach TC4. During the period 1 January 2017 through 31 December 2017, 24 of 28 adult Steelhead detected at the TC4 PTIS had been detected at TRC for an efficiency estimate of 85.7%.

Fifteen 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 2017 through 31 December 2017 (Figure 6). Several factors prevented estimating juvenile detection efficiency of TRC with fish known to have passed. Due to a wet winter and spring, water levels were high, two antennas were running at lowered amperage due to leakage or cable damage, and WDFW smolt tagging numbers were down due to high water and reduced trap efficiency due to hydraulic changes at the trap site. Additionally, we tagged fewer age-1 fish during 2016 than normal. We have slowly increased proportion of age-0 fish tagged, but did not capture as many age-1 fish during 2016 sampling. We generated an efficiency estimate for the screw trapping period by assuming that smolts PIT-tagged and released by WDFW upstream migrated past TRC. TRC detected 7 of 205 smolts that were released upstream for an efficiency of 3.4%.

The malfunctioning antennas at TRC were replaced during summer and an improved power cable was installed in fall. A new trap site was identified for WDFW beginning in 2018. We anticipate improved operation and detection in the future.

Twenty-eight PIT-tagged adult Steelhead were detected at the TC4 PTIS from 1 January 2017 to 31 December 2017 (Figure 7). Adult detection efficiency, derived by the methods of Connolly et al. (2008), of the TC4 PTIS was 98.7% (SE = 1.1; Table 2). Initial detections of adult PIT-tagged steelhead at TC4 happened primarily during winter with some during fall (Figure 7).

Six PIT-tagged juvenile Steelhead, tagged as parr by USGS in the Trout Creek watershed upstream of the TC4 site during 2015, 2016, or 2017, were detected at the TC4 PTIS from 1 January 2017 to 31 December 2017 (Figure 7). Downstream moving Steelhead parr were detected at TC4 during spring, summer, and fall. (Figure 7). An additional 11 PIT-tagged juvenile Steelhead, which were tagged as parr at a site about 250 m downstream of TC4 in 2016 or 2017 were detected at TC4. Initial detections of fish from the downstream site were primarily during fall (8 of 11). We were unable to calculate juvenile detection efficiency in 2017 at TC4 due to sustained high flow in the Wind and Columbia Rivers resulting in low capture or detection rates elsewhere, and few age-1 fish tagged in 2016,

Thirty-three PIT-tagged adult Steelhead were detected at the upper Wind River PTIS during 2017 (Figure 8). We were unable to calculate detection efficiency by the method of Connolly et al. (2008) because the second antenna array was not installed until September of 2017. However, detections of adult PIT-tagged Steelhead at the tributary PTIS sites UMD and PAD provided a measure of efficiency because adult Steelhead pass the WRU site to reach them. Fourteen PIT-tagged adult steelhead were detected at UMD and PAD, of these, 8 (57%) were detected at WRU. Some of the steelhead detected at UMD and PAD may have passed WRU prior to its relocation and reactivation on 6 October 2016. Using only those fish that were not tagged or known to be downstream of WRU until after 6 October 2016, 4 of 6 (67%) detected at UMD or PAD were detected at WRU. Initial detections of adult Steelhead at WRU were primarily in winter or spring (Figure 8), with only two adult Steelhead detected during fall 2017.

Thirty-nine juvenile Steelhead, PIT tagged as age-0 or age-1 parr in tributaries of the upper Wind River during 2015, 2016, and 2017, were detected at WRU during 2017 (Figure 8). Thirteen of these fish had been tagged during summer 2017 and were detected as fall migrants. An additional 5 fish that were PIT tagged during 2016 (of 25 detected) were also detected during summer or fall. Despite this relatively high number of juvenile detections, we were unable to calculate detection efficiency using known downstream detections or recaptures. High water in the Wind and Columbia Rivers resulted in low capture and detection efficiency at other sites. Additionally, those juveniles detected at WRU during fall and early winter and may not yet have migrated to downstream detection locations. We could use smolts PIT tagged by WDFW at the upper Wind River screw trap to estimate detection efficiency of WRU for smolt movement during spring. Twenty smolts were detected or recaptured at downstream locations, four of which were detected at WRU for an efficiency of 20%. We can also generate an efficiency

estimate for the screw trapping period by assuming that smolts PIT-tagged and released upstream by WDFW migrated past WRU. WRU detected 27 of 242 smolts released for an efficiency of 11.1%. The difference in the two estimates could be reflective of a change in efficiency through the smolt season as flow drops and later migrating fish are more subject to detections and recaptures.

Additional detections of PIT-tagged juvenile and adult Steelhead were recorded at the three tributary Passive Observation Recapture sites (MAD, PAD, and UMD; Figures 9-11). Operation at PAD began on 22 March 2017 and continued until 8 November 2017. The MAD site has experienced chronic interference, 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) or other ambient noise in the surrounding residential area.

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 and adults at Bonneville Dam (Tables 3 and 4). As the number of tagged fish in the subbasin has increased, so too have detections at Bonneville, although high water during spring 2017 reduced detection efficiency at Bonneville. Ten steelhead PIT-tagged as parr in the Wind River headwaters were detected at Bonneville Dam or the estuary trawl during 2017.

We have detected two parr, which were PIT tagged in the Wind River as age-0 fish, as age-1 fish the following fall at Bonneville Dam in the adult ladders. One tagged in the Mine Reach of the Wind River in September 2015 (FL = 72) and detected at BO4 in November 2016. The other tagged in Trapper Creek in August 2016 (FL = 60) and detected at BO4 in October 2017. It is unknown when these two fish left the Wind River.

During 2017, smolt detections at Bonneville Dam of Wind River Steelhead included a Steelhead PIT-tagged as a parr in a section of Layout Creek upstream of a site where the U.S. Forest Service replaced an undersized culvert with a bridge to improve stream connectivity (Coffin 2015). The fish was PIT tagged in October 2015 (FL = 97 mm) and detected in the Bonneville Juvenile Bypass (B2J) in June 2017. Though it is unknown if Steelhead previously used habitat upstream of the culvert, this confirms use of the section of Layout Creek with improved passage by steelhead.

To date, eight Steelhead that were 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 four in 2013. Using age at tagging, (by length frequency analysis; Jezorek and Connolly 2015b) we can determine age at return to Bonneville Dam, though we do not know age at smolting. At detection at Bonneville as adults, three of these adults were age-4, four were age-5 and one was age-6. One of the age-5 fish (tagged in 2011 at age-1) was detected during September 2015 at The Dalles Dam. These fish would be an additional year old at time of spawning the spring following their return to Bonneville Dam.

Detections of Parr Tagged at Screw Traps -- 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 are providing data on extent of migration and movement rates, contributing to our understanding of migrant parr.

Table 5 presents detection data from parr Steelhead that were PIT tagged by WDFW at screw traps in Trout Creek and the upper Wind River, released upstream of the PTIS sites, but not recaptured at screw traps. During seven of eight years of monitoring at TRC, 70 percent or more of the PIT-tagged parr detected were detected within a week of their release date and 80 percent or more were detected within one month. During those seven 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 the TRC PTIS was not functional for 18 days during the trapping season. 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.

Growth data -- At the sites we sampled twice in 2017, relative growth (% change in weight per day) of age-0 Steelhead during late summer was higher than in many previous years (Figure 12). Relative growth in weight of age-0 Steelhead during the late summer period has been positive for all sites and years except for 2015 in Crater Creek, though that sample comprised only two fish. Relative growth in weight over a year (age-0 fish tagged in 2016 and recapture in 2017) was similar to previous years. There is higher variation between years and sites for late summer growth of age-0 Steelhead than yearly growth of those tagged at age-0 and recaptured at age-1.

Late summer relative growth in weight for age-1 Steelhead parr in the two Trout Creek tributaries where we sampled in 2017 (Upper Layout Creek and Crater Creek) was negative, which has been common over the years (Figure 13). The only site within the Trout Creek watershed with consistent weight gain for age-1 Steelhead parr in late summer is mainstem Trout Creek downstream of the 43 Road Bridge (Figure 13). Age-1 steelhead at sites within the upper Wind watershed (Trapper Creek, Mine Reach, Paradise Creek, and Upper Mine Reach) all had positive growth during late summer, though less so than in other years. Change in weight of age-1 steelhead over a year is more consistent between streams and years than is the late summer change in weight. Martha Creek, in the Trout Creek watershed, regularly has the lowest yearly growth rates for steelhead tagged at age-1.

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 to evaluate efficacy of the removal of Hemlock Dam toward increased steelhead abundance upstream of the former dam site. Preliminary data show a likely positive influence on adult and smolt Steelhead abundance in Trout Creek relative to the rest of the subbasin since Hemlock Dam removal (Buehrens and Cochran 2018).

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 tools for quantifying movement, they are limited to time periods when river flows allow operation. Too much or too little flow can impede or stop operations. In the Wind River subbasin, smolt traps generally operate from April through June. Instream PIT-tag interrogation systems in the Wind River are 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 is unknown. Many more smolts emigrate from the Wind River subbasin than are accounted for by the three smolt traps in upstream areas (Trout Creek, Upper Wind, and Panther Creek; Buehrens and Cochran 2018). Most years the estimate of smolts from the upper watershed areas is around 20 – 30% of the subbasin total. The contribution of migratory parr to the total smolt output of the Wind River is unknown but may be sizable. Steelhead spawning in the Wind River downstream of the upper three smolt traps also likely contribute to subbasin smolt totals. Frequency of steelhead spawning in the river downstream of the upper three smolt traps is unknown and difficult to determine. Continued monitoring of parr movements will contribute to the understanding of this dynamic. 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. Data from these fish will contribute to understanding of movement of parr, their use of downstream reaches for rearing, and their contribution to smolt and adult populations.

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 at WDFW smolt traps), which will be essential to developing methods to quantify parr populations and their

contribution to subsequent smolt populations. A goal of the current study is to work towards methods to estimate parr migration with use of both screw traps and instream PTISs.

It is unknown if downstream movement of Steelhead parr is a result of limited headwater habitat capacity or is a life-history strategy independent of fish abundance or habitat quality. To date, we have seen movement of age-0 and older parr from headwater areas, and through mid-basin areas throughout the year. Movement of juveniles into downstream reaches of mainstem rivers has important implications for population assessments, habitat and water management and could improve the ability to target restoration actions for greatest cost-benefit.

The upstream movement of parr Steelhead PIT-tagged downstream of the TC4 site is an interesting finding. We have documented this each year since deployment of the site, but do not know the extent to which upstream movement may happen elsewhere in the subbasin. This is certainly a question worthy of investigation as is factors that may influence such movement.

It is unknown if juvenile Steelhead are leaving the Wind River subbasin to the Columbia River during time periods other than spring. The detection of two age-1 Steelhead parr, tagged at age-0 in the Wind River, at Bonneville Dam adult ladders raises interesting questions regarding potential migration of parr from the Wind River to the Columbia; why, what age, what time of year, and can they successfully rear to smolt stage? 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.

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 Steelhead parr. 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 affect 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 parr tagging 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 Steelhead 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 like work done with other Steelhead populations (Hayes et al. 2008; Sogard et al. 2009) and with life history diversity work with 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 abundance 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.

Data from tagging of Steelhead parr at various sites in the watershed is also confirming anadromous use of stream sections where restoration actions have occurred. Documentation of PIT tagged juvenile Steelhead at Bonneville Dam from areas on Martha Creek and Layout Creek where the Forest Service has removed potential passage barriers has confirmed Steelhead use of these areas.

10. Acknowledgements

Many people helped with this work. Jamie Cleveland was our BPA Contracting Officers. Shane Amen, Brad Bickford, John Erhardt, Jill Hardiman, Rulon Hemingway, Brad Liedtke, Rachel Ohnemus, Tobyn Rhodes, and Ken Tiffan were fellow USGS-CRRL employees who helped in the field and office. Charlie Cochran and Rulon Hemingway provided helpful reviews. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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.

Acolas, M. L., J. M. Roussel, J. M. Lebel, and J. L. Bagliniere. 2007. Laboratory experiment on survival, growth, and tag retention following PIT injection into the body cavity of juvenile Brown Trout (*Salmon trutta*). Fisheries Research 86:280-284.

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.

Buehrens, T. W., and P. Cochran. 2018. Abundance and productivity of Wind River Steelhead and preliminary assessment of their response to Hemlock Dam removal, 2017. Washington Department of Fish and Wildlife Annual Report. Project 19981900. Contract 74314. Submitted to Bonneville Power Administration, Portland, OR. https://www.cbfish.org/Document.mvc/Viewer/P161303

Cochran, P., T. W. 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

Coffin, B. 2015. Combined annual report calendar years 2013 and 2014 Forest Service Activities under the Wind River Watershed Project – Non-technical report. BPA Project Number 1998-019-00. Contract 65582. Submitted to Bonneville Power Administration, Portland, OR. https://www.cbfish.org/Document.mvc/Viewer/P149591

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.

Jezorek, I. G., and P. J. Connolly. 2018. Wind River subbasin restoration. Annual Report of U.S. Geological Survey activities January 2016 through December 2016, 1998-019-00. Submitted to Bonneville Power Administration, Portland, OR.

Lugert, V., Thaller, G., Tetens, J., Schulz, C. and Krieter, J. 2016. A review on fish growth calculation: multiple functions in fish production and their specific application. Rev Aquacult, 8:30-42. doi:10.1111/raq.12071

Otis, D. L., K. P. Burnham, G. C. White, and D. R. Anderson. 1978. Statistical inference from capture data on closed animal populations. Wildlife Monographs 62:1-135.

Peterson, J. T. N. P. Banish, and R. F. Thurow. 2005. Are block nets necessary? Movement of stream-dwelling salmonids in response to three common survey methods. North American Journal of Fisheries Management 25:732-743.

Prentice, E. F., T. A. Flagg, and C. S. McCutcheon. 1990. Feasibility of using passive integrated transponder (PIT) tags in salmonids. Pages 317-322 *in* N. C. Parker, A. E. Giorgi, R. C.

Heidinger, D. B. Jester Jr, E. D. Prince, and G. A. Winans, editors, Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Riley, S. C., and K. D. Fausch. 1992. Underestimation of trout population size by maximum likelihood removal estimates in small streams. North American Journal of Fisheries Management 12:768-776.

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.

Tiffan, K. F., R. W. Perry, W. P. Connor, F. L. Mullins, C. D. Rabe, and D. D. Nelson. 2015. Survival, growth, and tag retention in age-0 Chinook salmon implanted with 8-, 9-, and 12-mm PIT tags. North American Journal of Fisheries Management 35:4:845-852.

White, G. C., D. R. Anderson, K. P, Burnham, and D. L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos National Laboratory, Report LA-8787-NERP, Los Alamos, New Mexico.

Zippin, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22:82-90.

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.

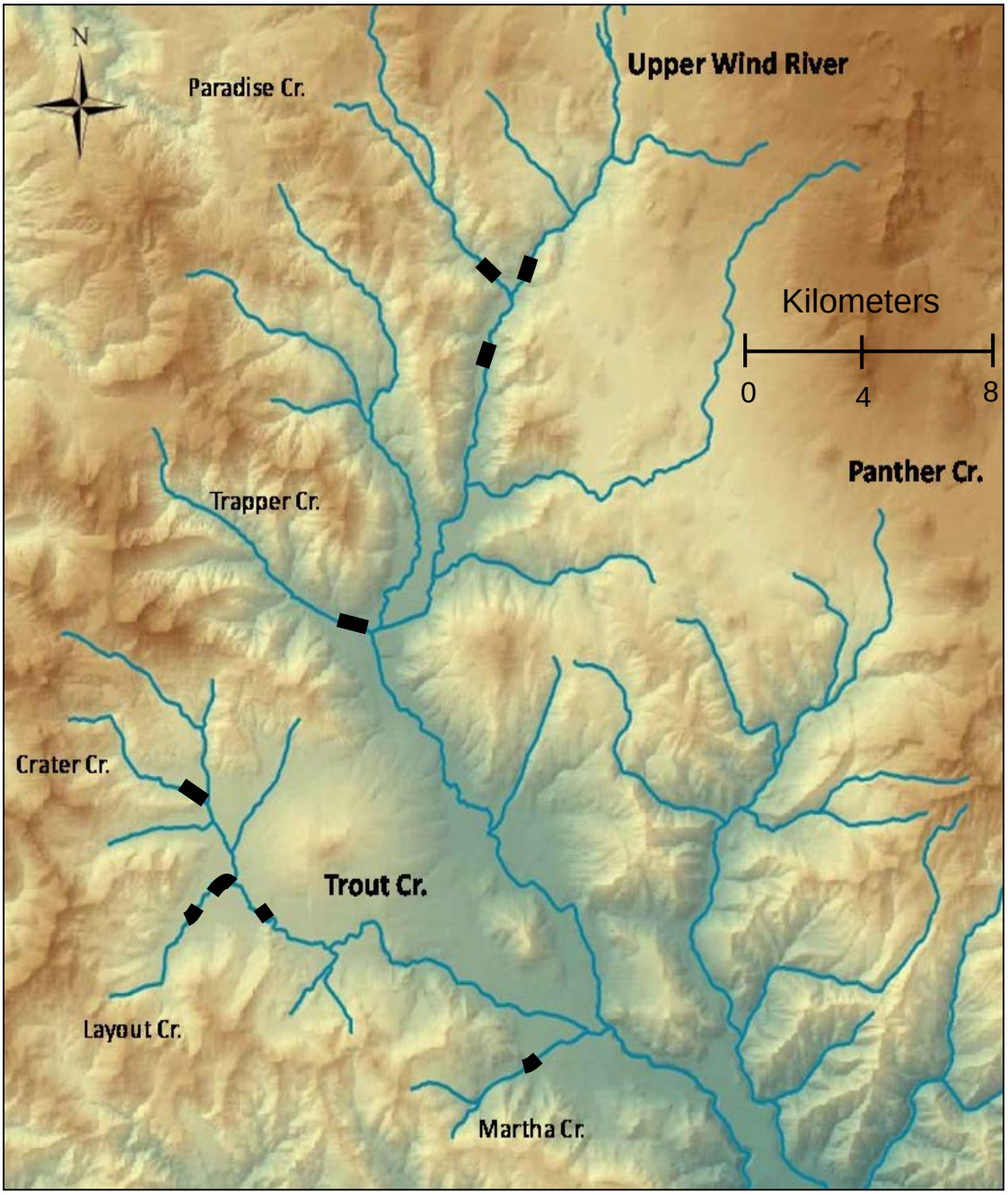


Figure 1. Stream sections (denoted by bold lines) where we tagged parr Steelhead *Oncorhynchus mykiss* with Passive Integrated Transponder tags during summer 2017.

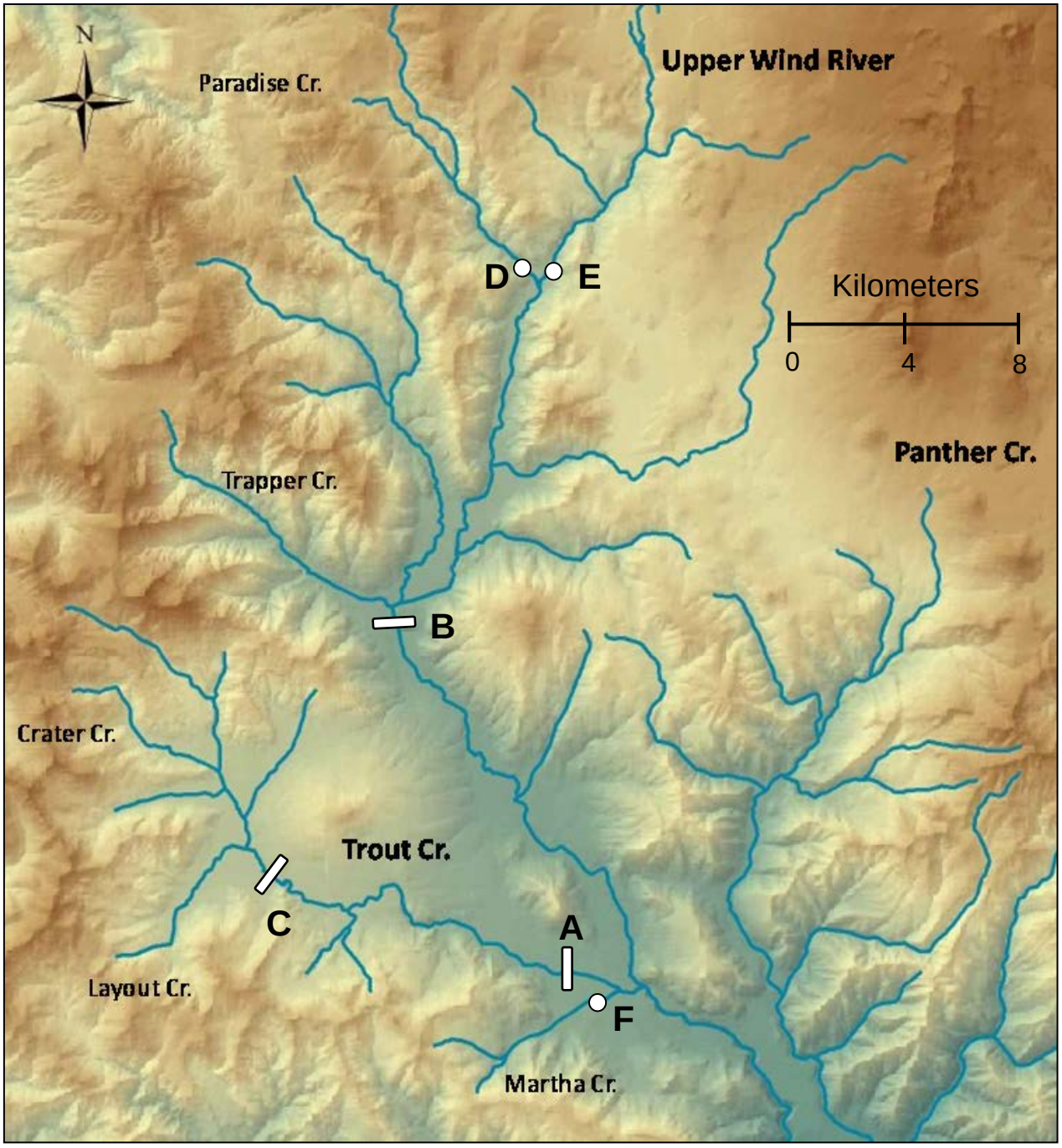


Figure 2. Locations of instream PIT-tag interrogation systems operated in the Wind River subbasin from January 2017 through December 2017. A) Trout Creek (TRC, 1001M Transceiver, 3 arrays of 2 antennas each); B) upper Wind River (WRU, 1001M Transceiver, 2 arrays of 3 antennas each); C) Trout Creek at 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).

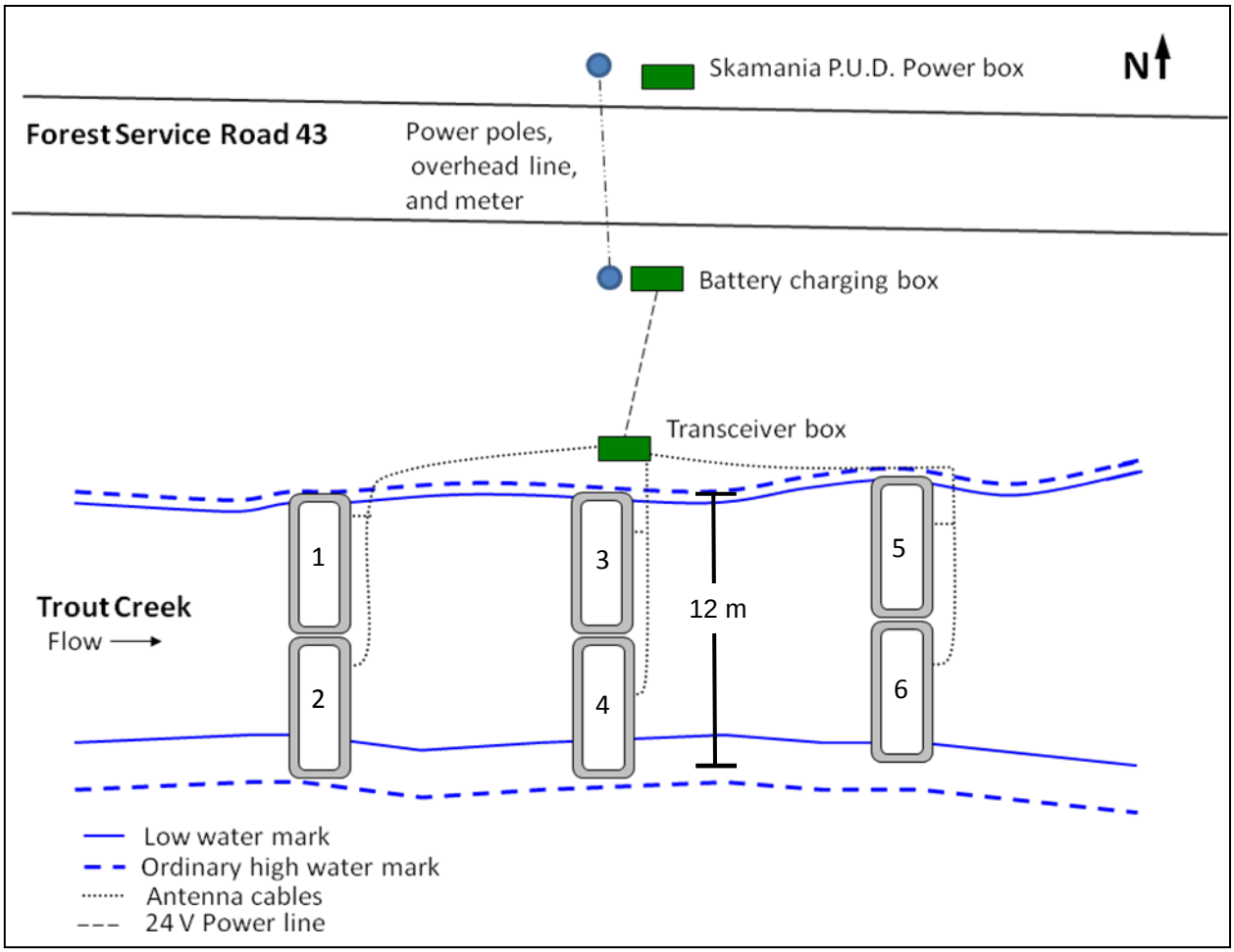


Figure 3. The Trout Creek PIT-tag interrogation system site (located at rkm 2.0 of Trout Creek), showing the three arrays of two antennas each and supporting infrastructure. Data from this site were submitted to the PTAGIS database under site code TRC.

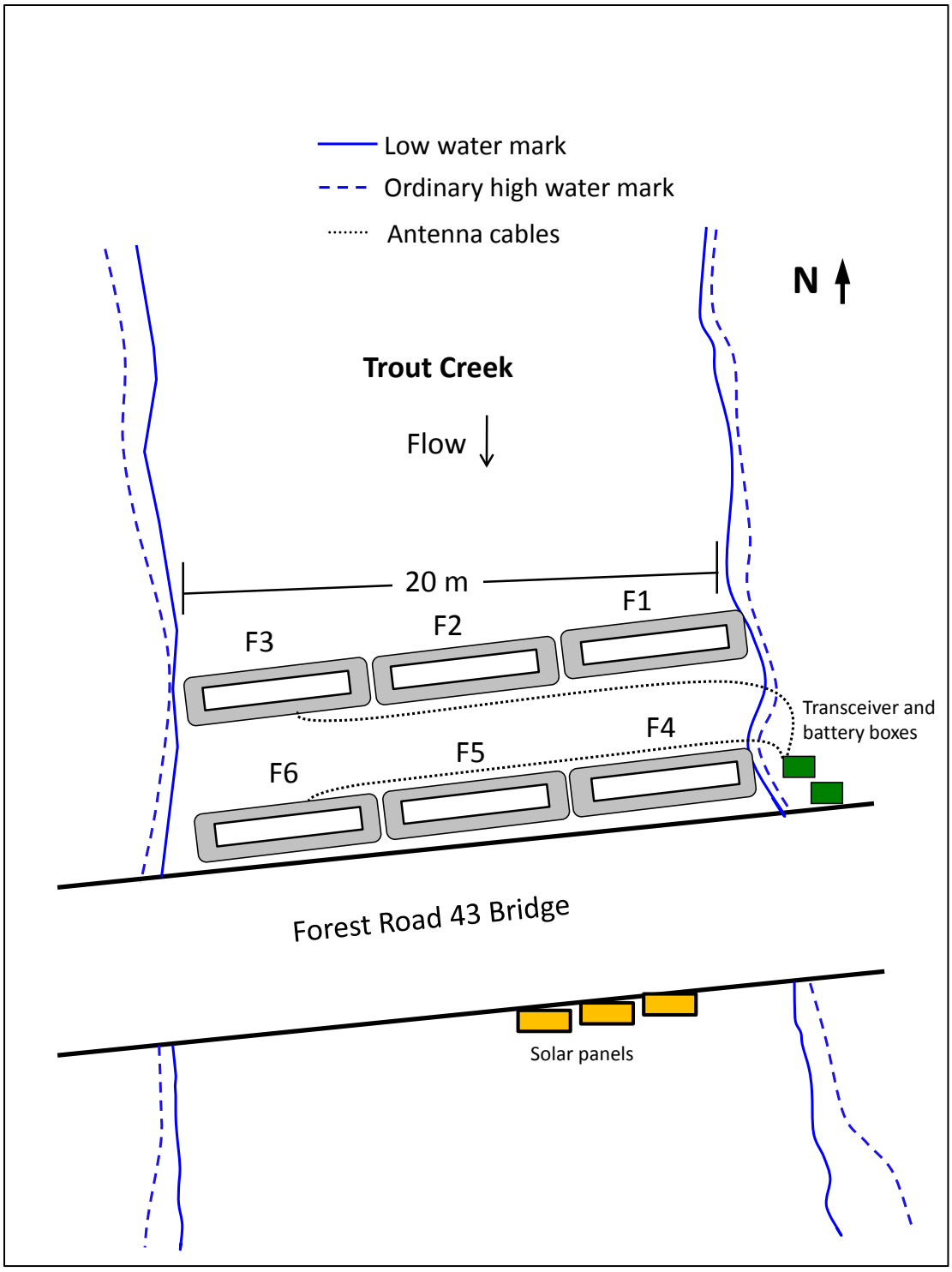


Figure 4. The PIT tag interrogation system in Trout Creek at the 43 Road Bridge (rkm 11.0) showing the two arrays of three antennas each and the supporting infrastructure. Data from this site were submitted to the PTAGIS database under site code TC4.

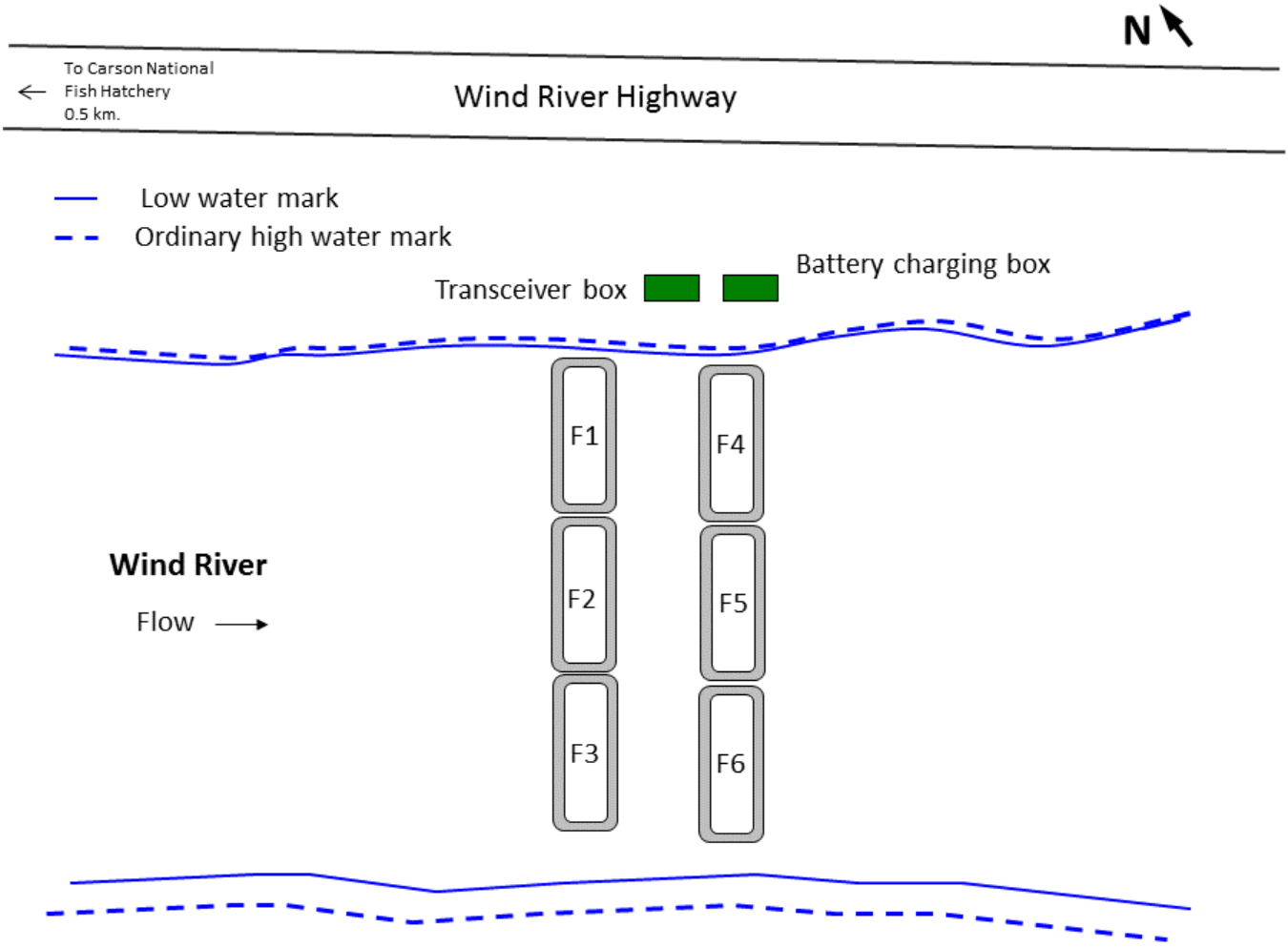


Figure 5. The upper Wind River PIT-tag interrogation site (located at rkm 28.3 of the Wind River), which began operation on October 6, 2016 (second array was added in September 2017). Data from this site were submitted to the PTAGIS database under site code WRU.

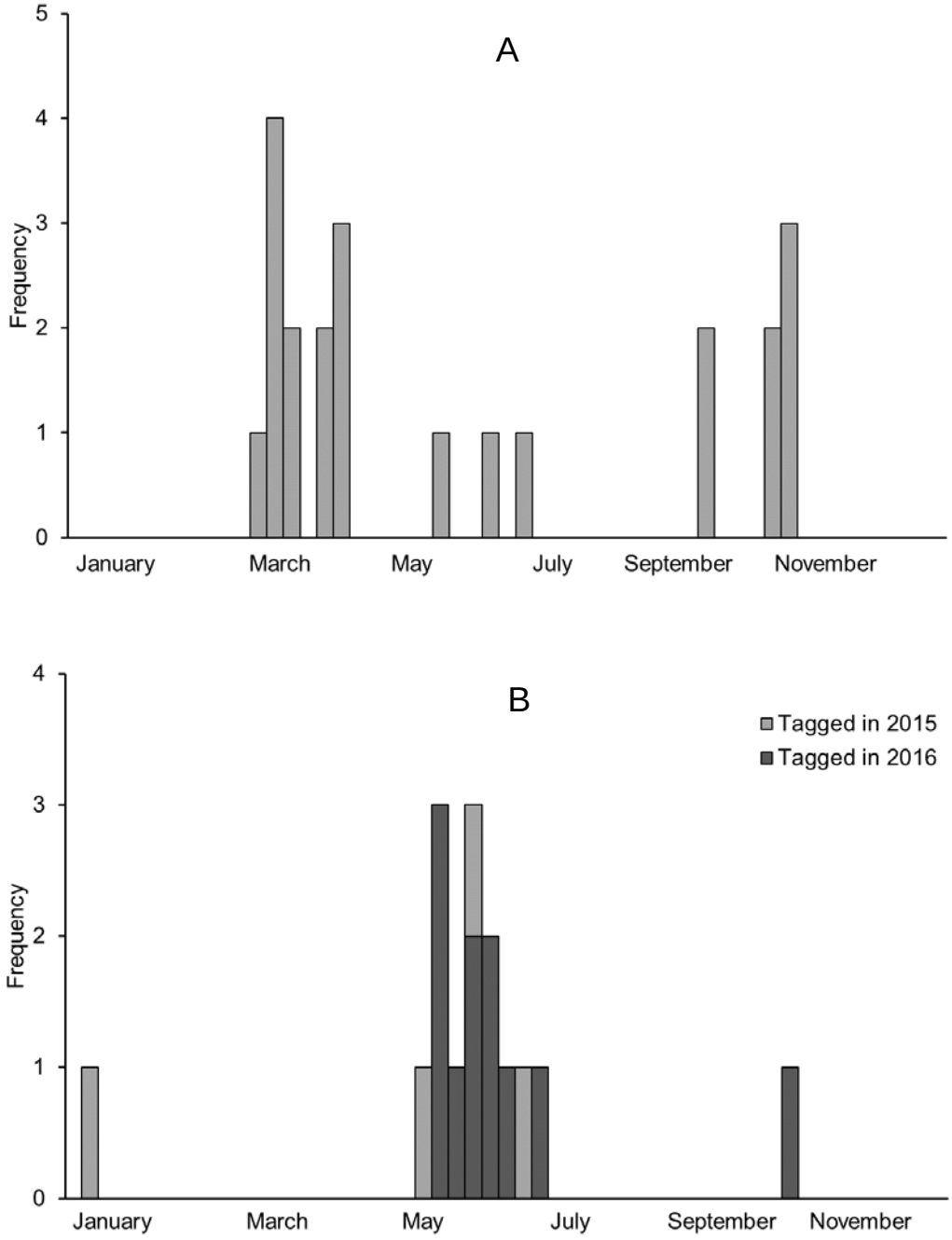


Figure 6. Detections of PIT-tagged adult (Graph A) and juvenile (Graph B) Steelhead *Oncorhynchus mykiss*, by week, at the Trout Creek PIT-tag interrogation system (site code TRC), at rkm 2.0, from 1 January 2017 through 31 December 2017. Juvenile fish were PIT tagged as parr in the Trout Creek watershed during August or September 2015 and 2016. Shown are dates of first detection. Many fish were detected on multiple days. All detection data were submitted to the PTAGIS database.

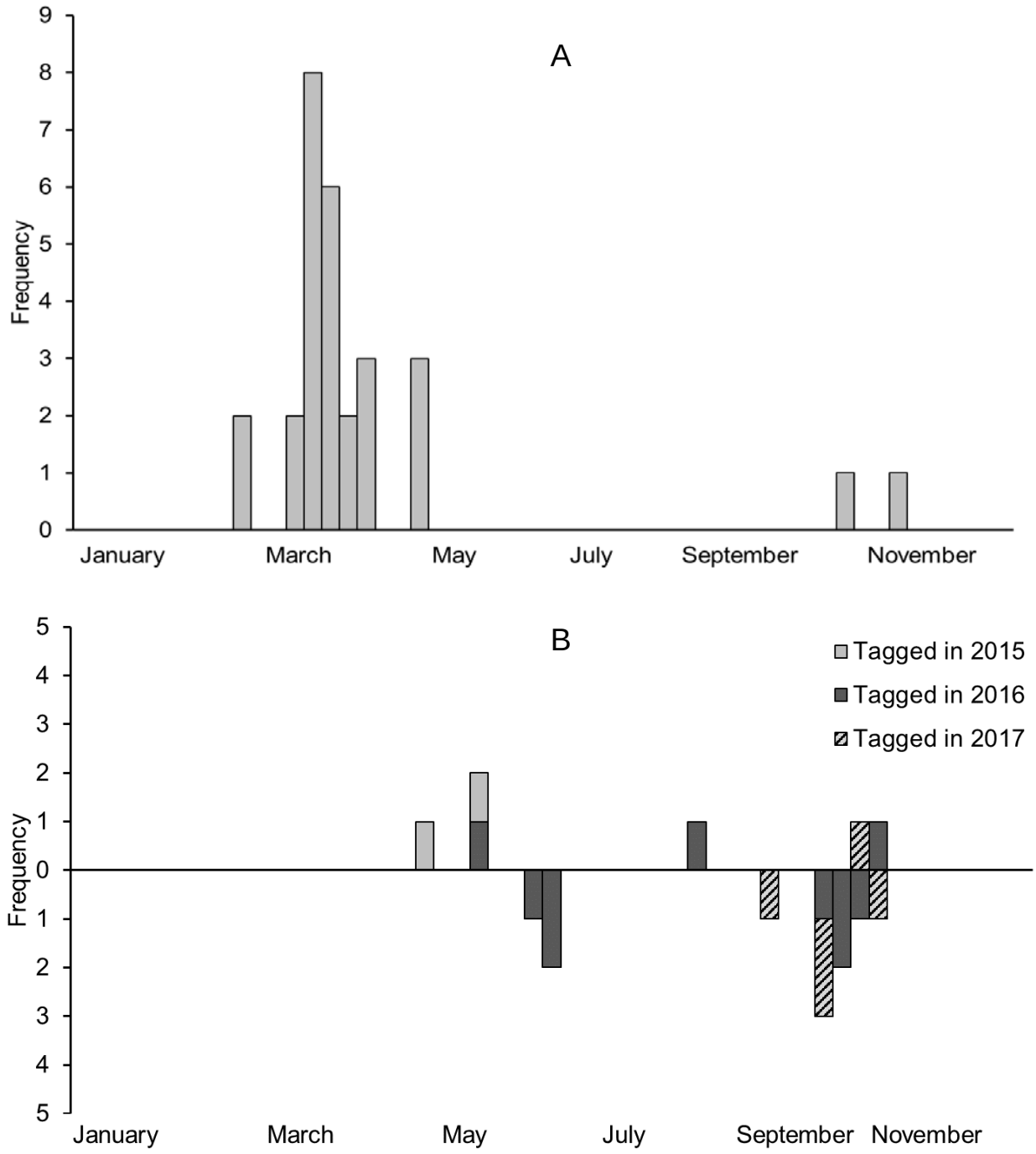


Figure 7. Detections of PIT-tagged adult (Graph A) and juvenile (Graph B) Steelhead *Oncorhynchus mykiss*, by week, at the Trout Creek at 43 Road PIT-tag interrogation system (site code TC4) from 1 January 2017 through 31 December 2017. Juvenile fish were PIT-tagged as parr in the Trout Creek watershed during August and September 2015, 2016, and 2017. Juvenile 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 for these fish. Many fish were detected on multiple days. All detection data were submitted to the PTAGIS database.

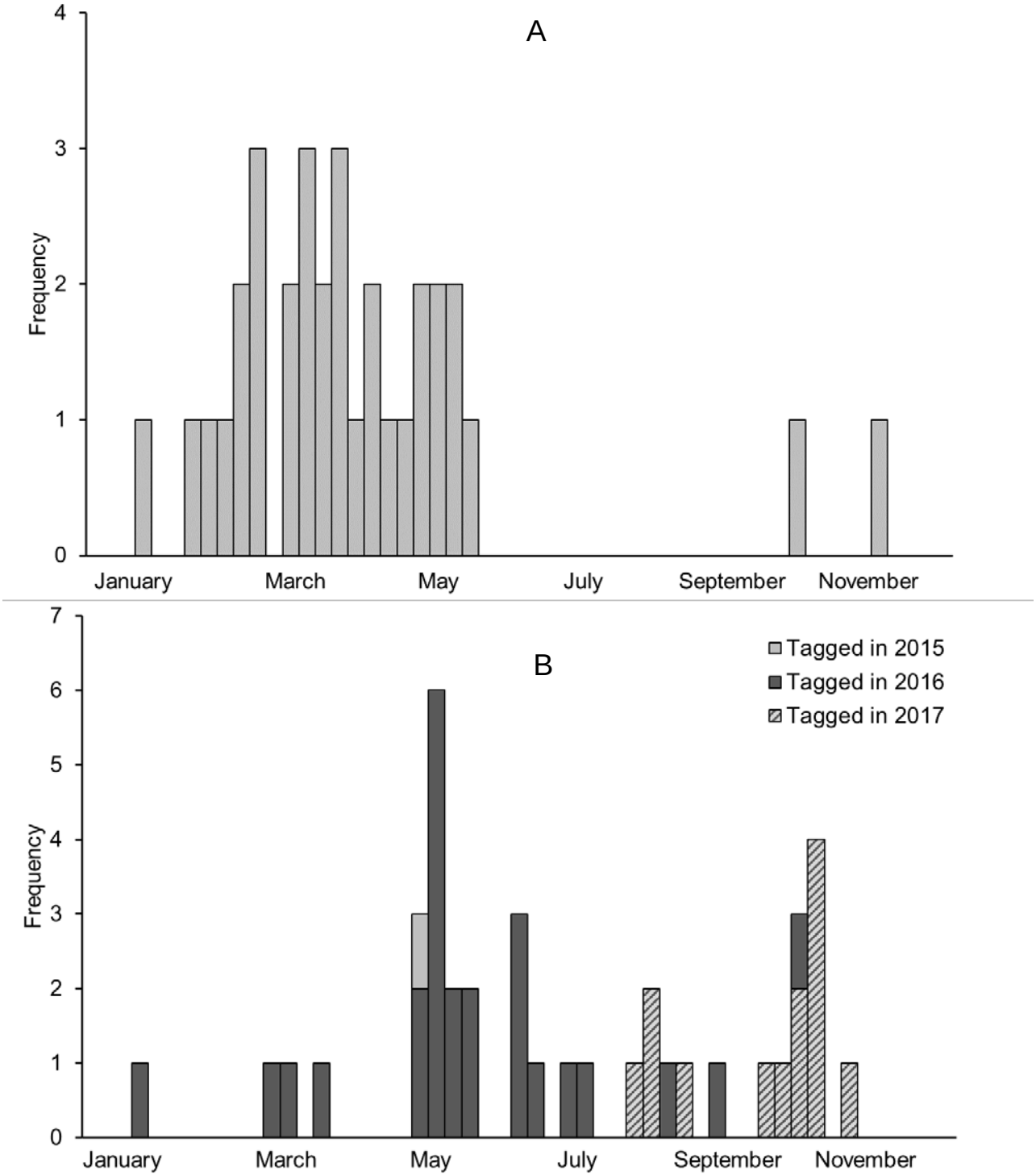


Figure 8. Detections of PIT-tagged adult (Graph A) and juvenile (Graph B) Steelhead *Oncorhynchus mykiss*, by week, at the upper Wind River PIT-tag interrogation system (site code WRU) from 1 January 2017 through 31 December 2017. Juvenile fish were PIT tagged as parr in the upper Wind watershed during 2015, 2016, and 2017. The site was located at rkm 28.3 of Wind River. Shown are first detection dates for these fish. Many fish were detected on multiple days. All detection data were submitted to the PTAGIS database.

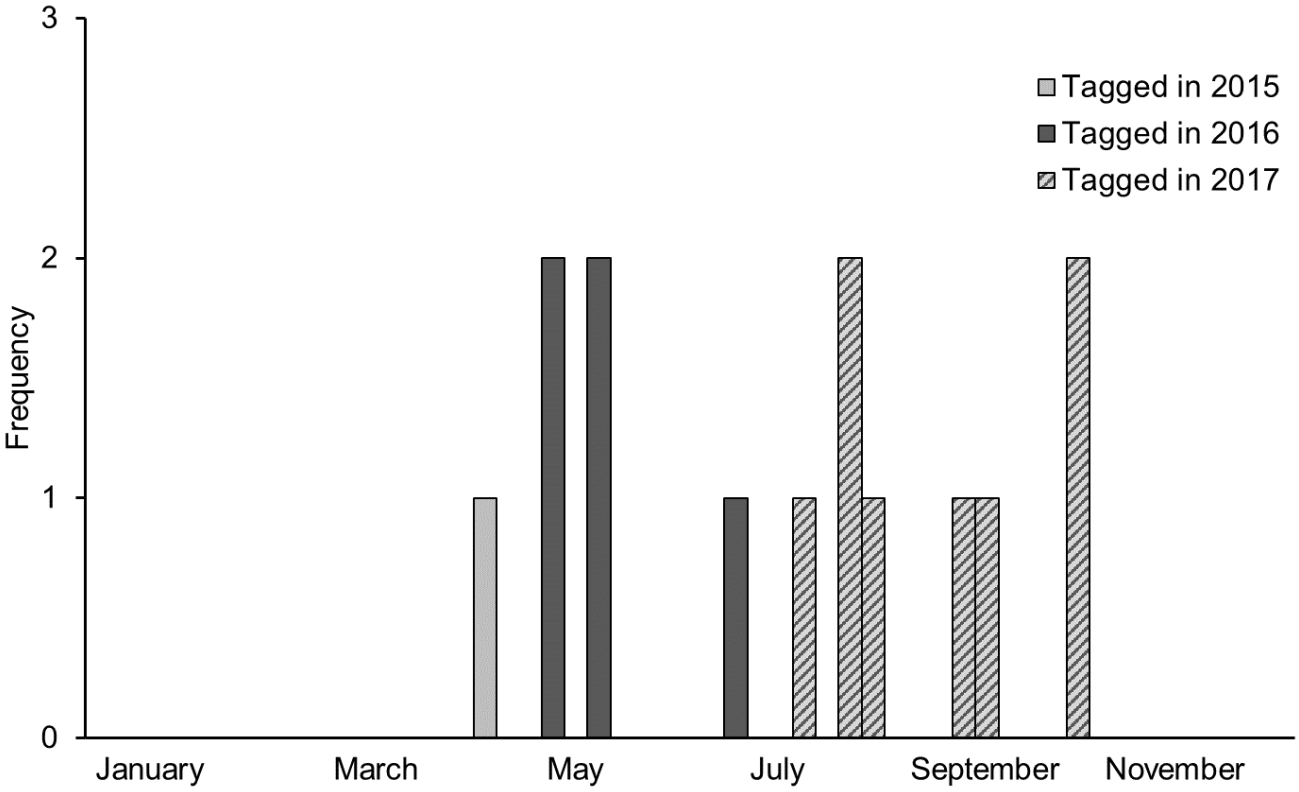


Figure 9. Detections of juvenile Steelhead *Oncorhynchus mykiss*, by week, at the upper Mine PIT-tag interrogation system from 1 January 2017 to 31 December 2017. The fish were PIT-tagged as parr in the Wind River between rkm 41.0 and 41.6 during August and September 2015, 2016, and 2017. The system 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.

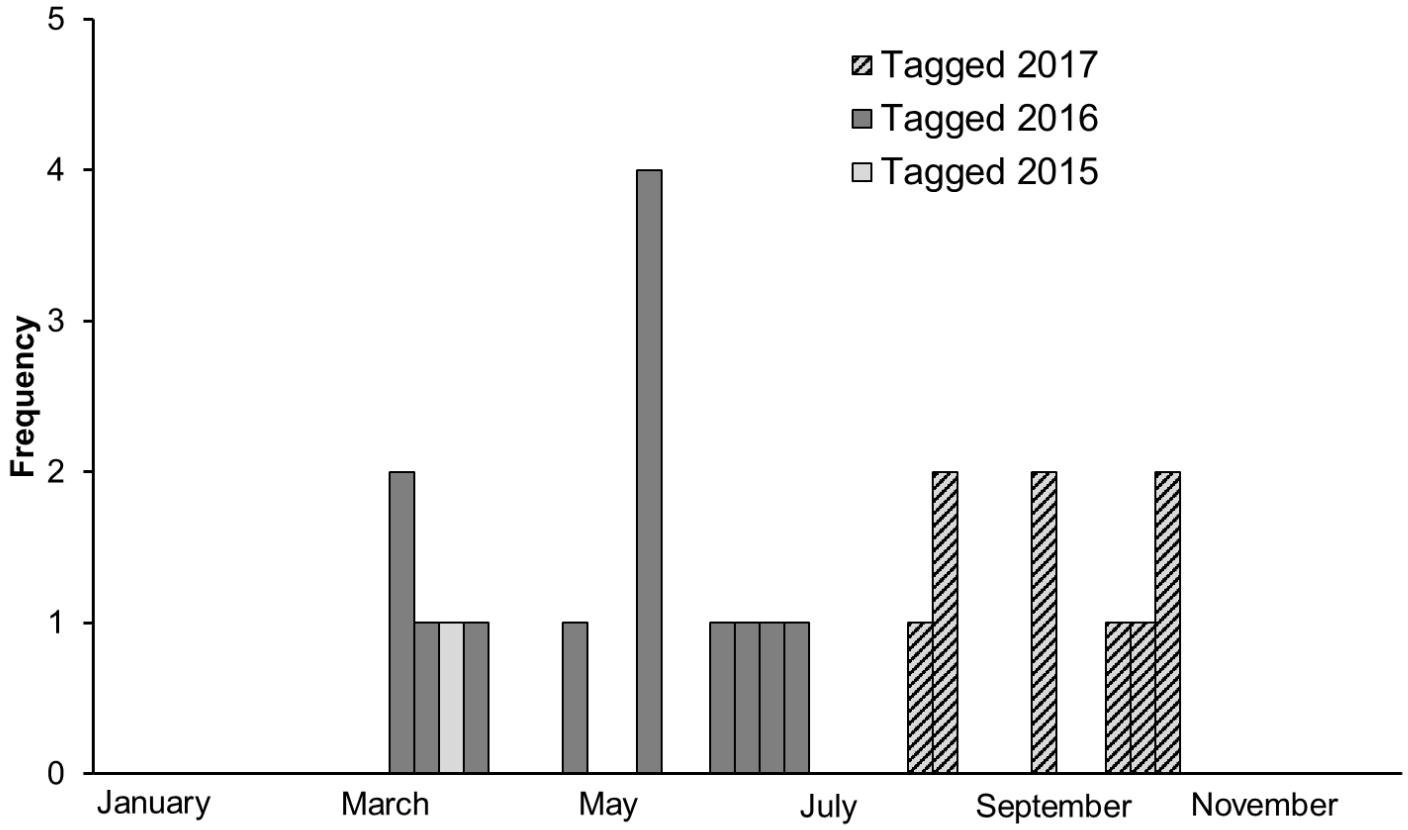


Figure 10. Detections of juvenile Steelhead *Oncorhynchus mykiss*, by week, at the Paradise Creek PIT-tag interrogation system from 22 March 2017 to 8 November 2017. The fish were PIT-tagged as parr in Paradise Creek during August and September 2015, 2016, and 2017. The site was located at rkm 0.5 of 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.

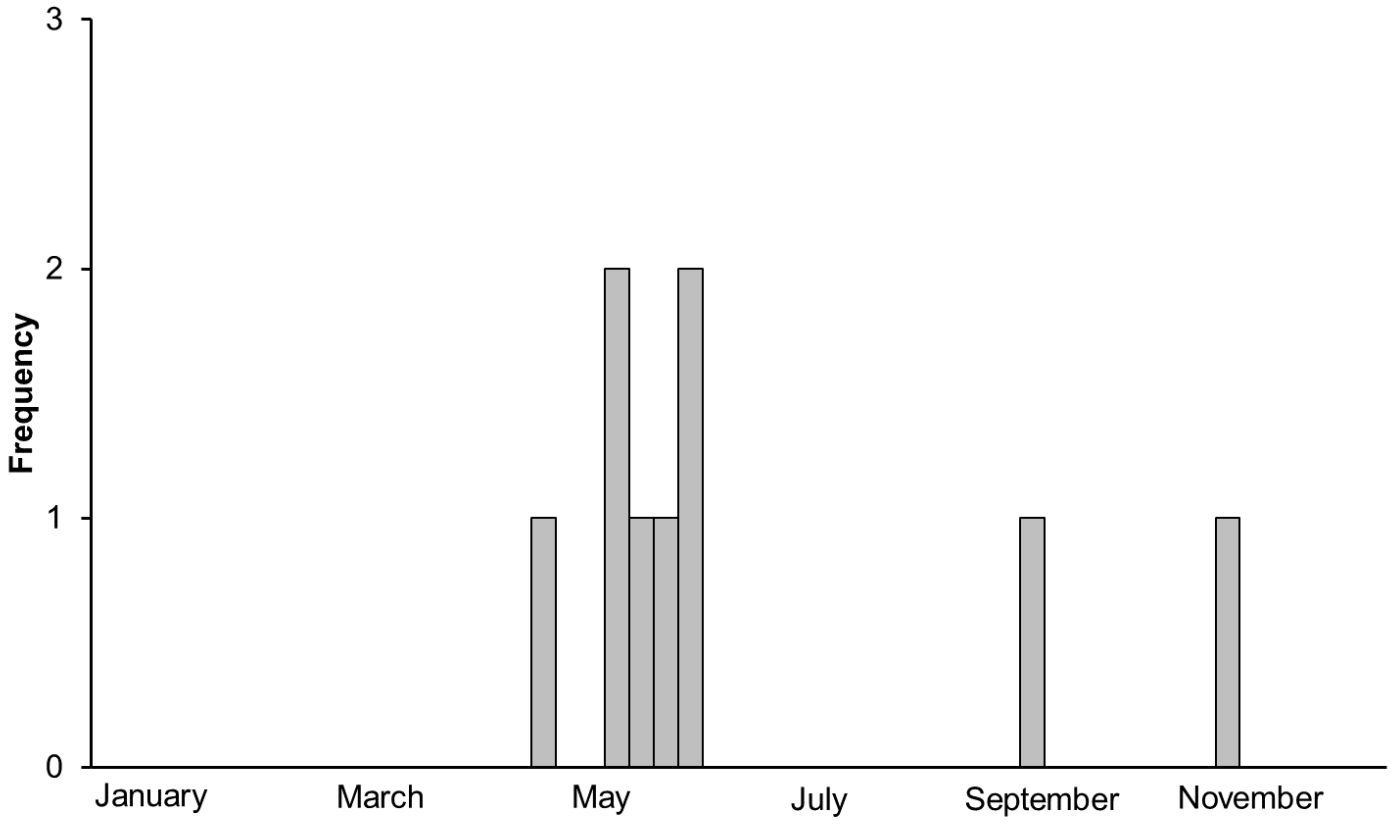


Figure 11. Detections of juvenile Steelhead *Oncorhynchus mykiss*, by week, at the Martha Creek PIT-tag interrogation system from 1 January 2017 to 31 December 2017. The fish were PIT-tagged as parr in Martha Creek during August and September 2016. The site was located at rkm 0.5 of Martha Creek. Shown 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.

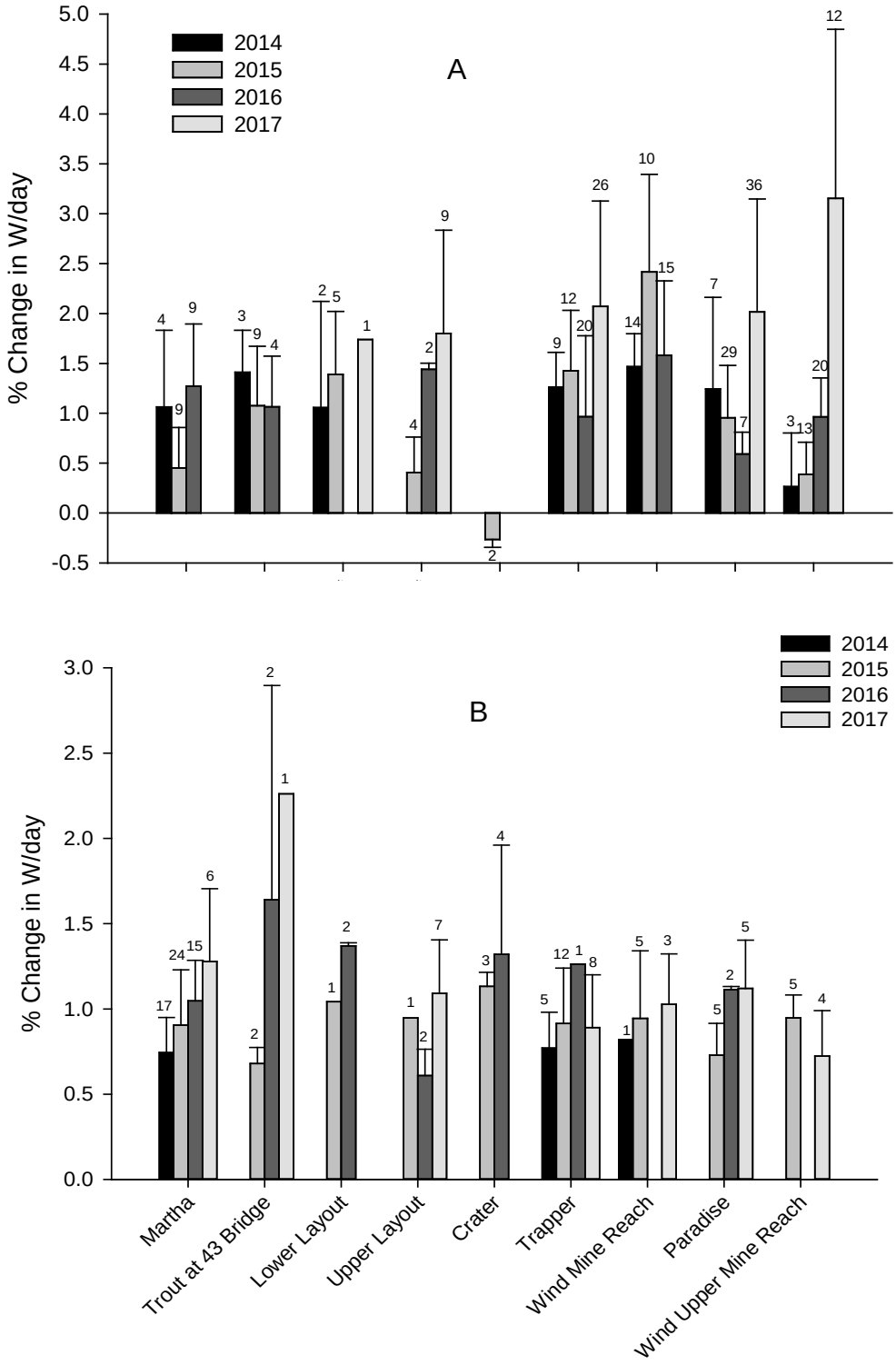


Figure 12. Mean relative growth + SD, shown as % change-per-day weight, of Steelhead *Oncorhynchus mykiss* that were PIT tagged at age-0 in headwater sites in the Wind River subbasin and recaptured at the same site within the same summer (about 5 weeks after tagging; Graph A) or during the following year (Graph B). All fish were sampled by electrofishing. Legend indicates recapture year. Numbers at the bars are sample size.

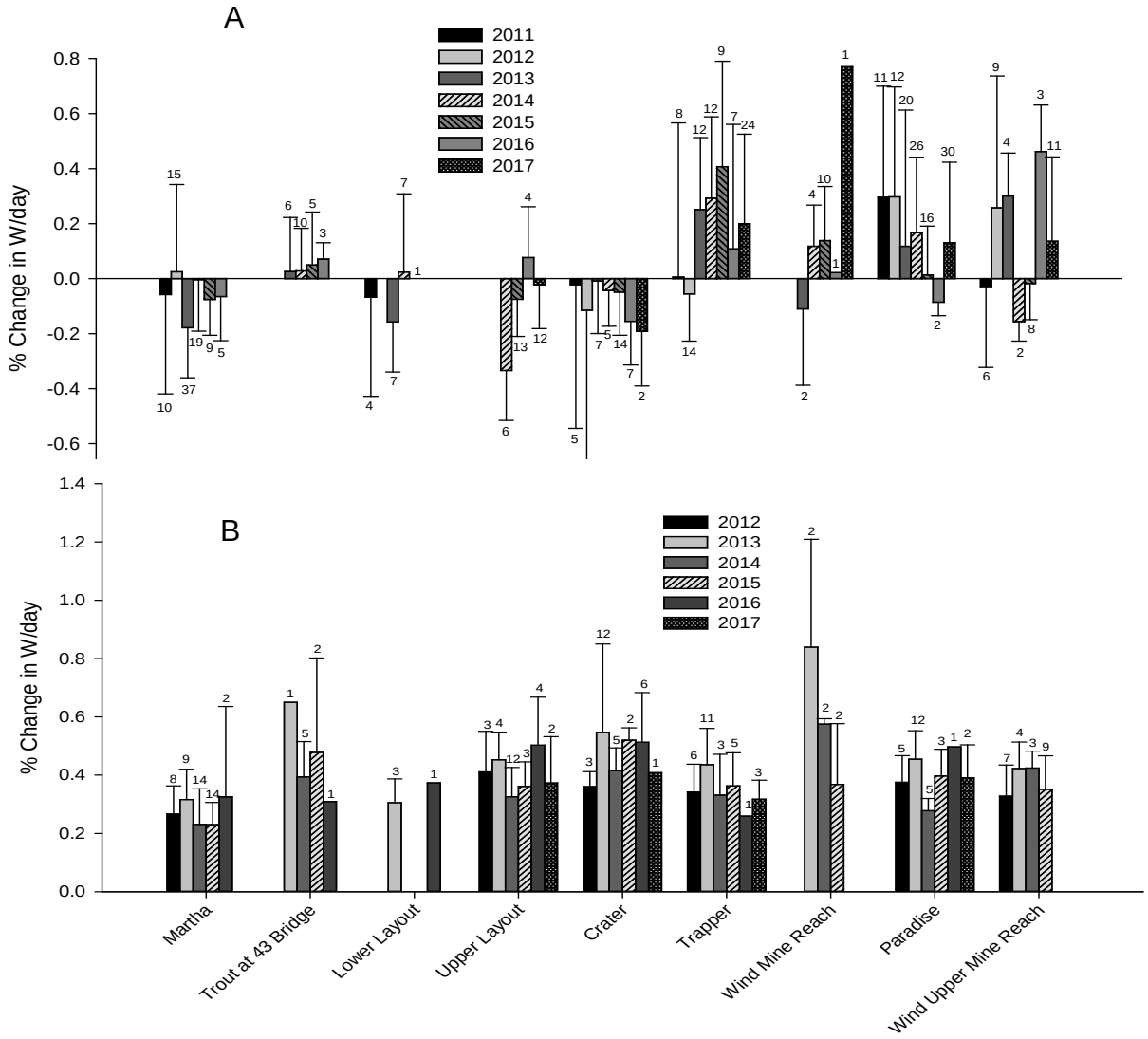


Figure 13. Mean relative growth +SD, shown as % change-per-day in weight, of Steelhead *Oncorhynchus mykiss* that were PIT tagged at age-1 in headwater sites in the Wind River subbasin and recaptured at the same site within the same summer (about 5 weeks after tagging; Graph A) or during the following year (Graph B). All fish were sampled by electrofishing. Legend indicates recapture year. Numbers at the bars are sample size.

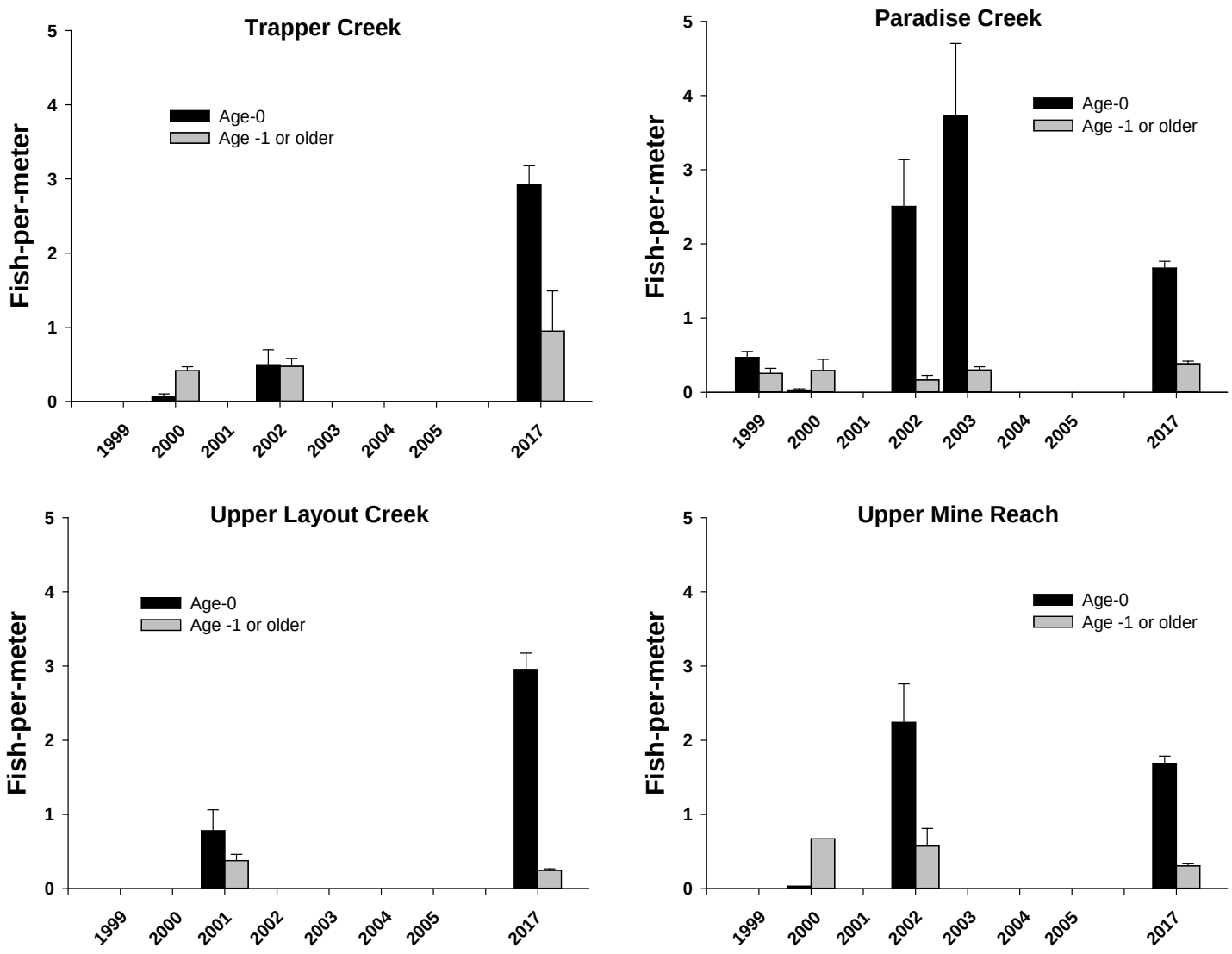


Figure 14. Juvenile Steelhead *Oncorhynchus mykiss* abundance +95% CI in sections of four streams in the Wind River Subbasin. Shown are estimates taken during 1999 – 2005 and during 2017. Sections sampled in 2017 were within previously sampled sections except Trapper Creek where the 2000 and 2002 sample were at rkm 2.9-3.5 and the 2017 sample was at rkm 0.3-0.4. The 2017 abundance sampling sites were within longer sample sections where fish were PIT tagged.

Table 1. Total number of juvenile Steelhead *Oncorhynchus mykiss* parr that were captured and PIT-tagged in two watersheds in the Wind River subbasin during 2017.

Watershed Stream	Dates sampled (month/day)	Rkm sampled, from stream mouth	Number of fish tagged	Number of recaptured tagged fish
Trout Creek				
Martha	8/15	1.3 – 1.8	56	11
Layout	8/14	0.0 – 0.5	37	0
	10/02	0.0 – 0.5	112	1
	7/31	2.2 – 3.0	150	5
	9/25	2.2 – 3.0	113	32
Trout	8/09	11.0 – 11.3	15	1
Crater	7/28	0.0 – 0.4	34	0
	9/22	0.0 – 0.4	60	4
Wind River				
Trapper	8/01	0.1 – 0.6	182	5
	9/27	0.1 – 0.6	129	56
Paradise	8/03	0.5 – 1.4	207	3
	9/28	0.5 – 1.4	131	73
Wind River	8/08	37.0 – 37.3	37	2
	10/30	37.0 – 37.3	75	2
	8/02	41.0 – 41.8	132	1
	9/26	41.0 – 41.8	115	28
Total			**1,585**	**224**

Table 2. 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) and the Trout Creek at 43 Bridge PIT-tag interrogation site (TC4).

Site	Year	Number of fish detected	Efficiency estimate %	SE	Lower 95% CI	Upper 95% CI
TRC	2017	22	93.3	3.7	82.5	98.0
TC4	2017	28	98.7	1.1	94.5	99.8

Table 3. Re-contacts, through December 2017, of juvenile Steelhead *Oncorhynchus mykiss* that were PIT-tagged as parr during August and September of 2011 through 2017 in headwater areas of the Trout Creek watershed in the Wind River subbasin.

		Recapture and detection events through December 2017					
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	136	14	4	26	14	3
2014	784	130	24	4	121	21	0
2015	924	135	13	2	129	13	-
2016	667	45	1	0	22	3	-

[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, 2016 = 140.
[b] PTIS = Instream PIT-tag interrogation systems 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 2017, of juvenile Steelhead *Oncorhynchus mykiss* that were PIT-tagged as parr during August and September of 2011 through 2016 in headwater areas the Upper Wind River watershed in the Wind River subbasin.

		Recapture and detection events through December 2017					
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	13	5	84	22	0
2015	725	121	11	2	34[c]	13	-
2016	601	100	7	1	43	4	-

[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 was installed until October of 2016.

Table 5. 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 upstream of smolt trap and detection at the PIT-tag interrogation site.

				% of detections, by week, after release date				
Site	Tagging Year	Number of parr detected	Median travel time (d)	Week 1	Week 2	Week 3	Week 4	> 4 Weeks
TRC[a]	2008	30	0	70	10	0	3	17
	2009	51	1	76	4	2	0	18
	2010[b]	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
	2016	195	0	96	0	1	1	2
WRU[c]	2013	63	1	87	3	3	2	5
	2014	68	2	57	3	3	0	36
	2015	102	0	86	1	1	1	11

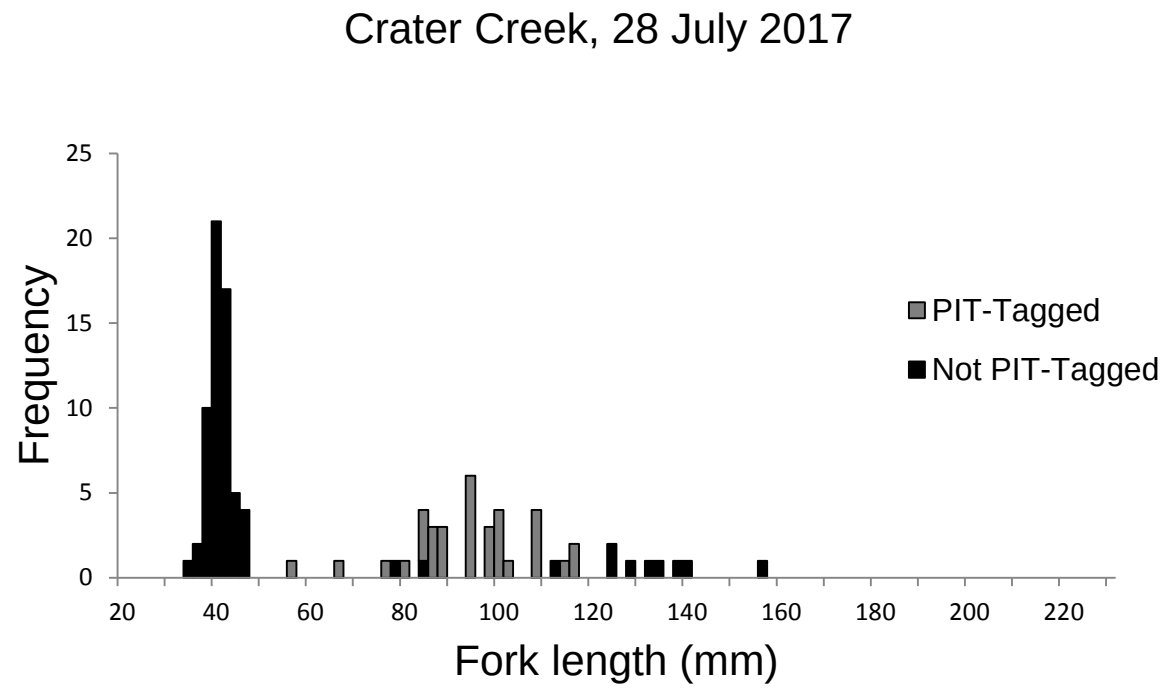
[a] Few parr were tagged during 2011 and only one detected.
[b] During 2010, TRC was not operating for 18 days during the trapping season.
[c] No data at WRU during 2016 due to flood damage to site.

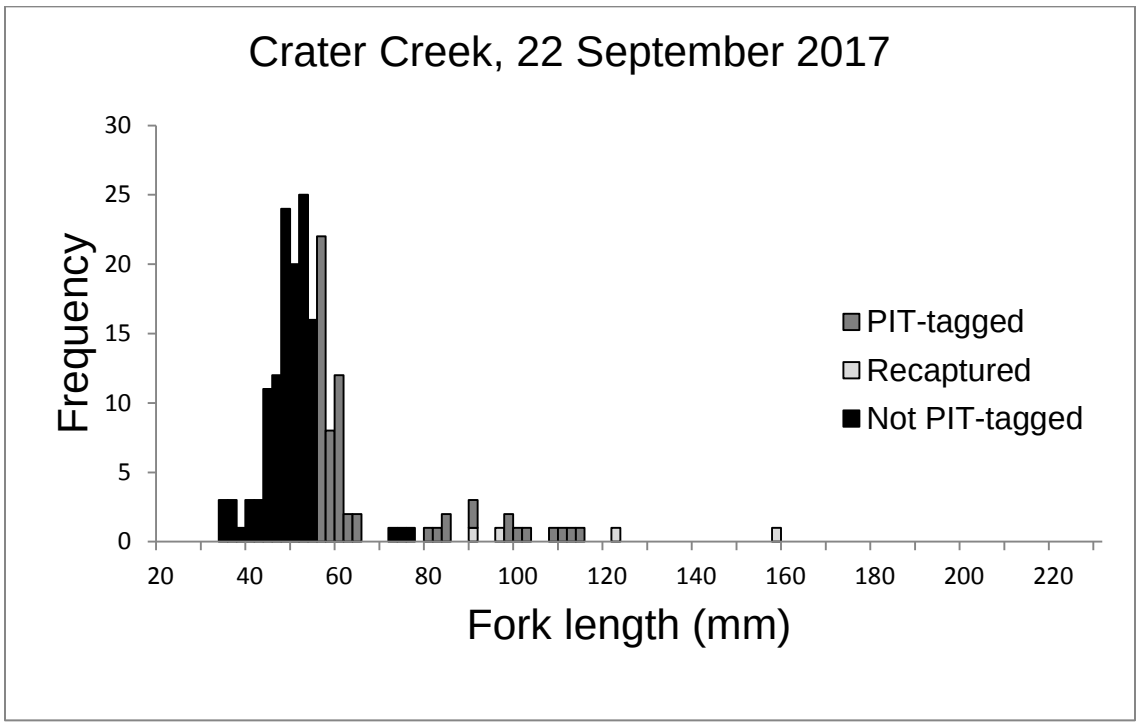
Appendix A: Use of Data & Products

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

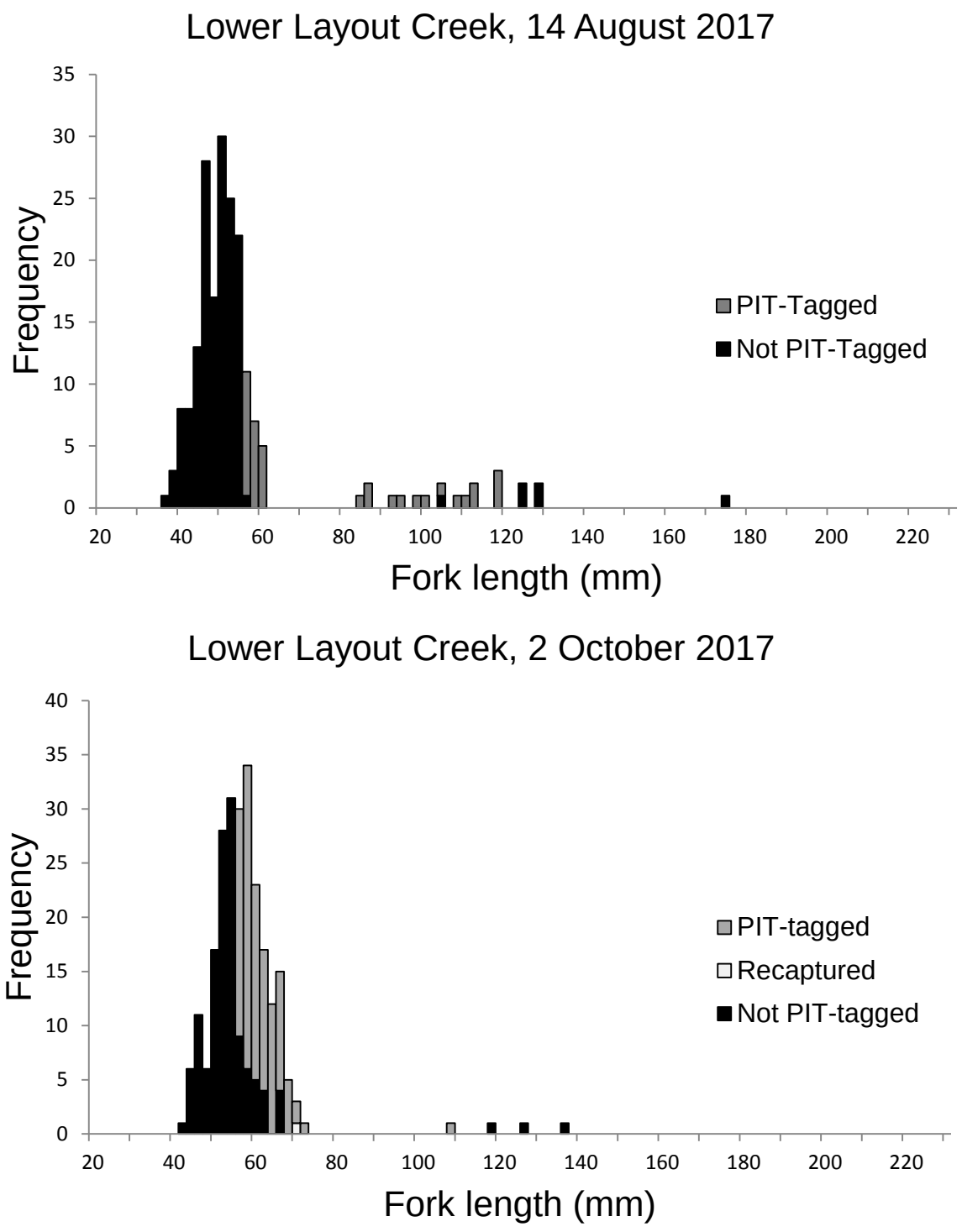
We have submitted fish data for those fish captured but not PIT-tagged to StreamNet.
http://old.streamnet.org/datastore_search_classic.cfm?id=667

Appendix B: Detailed Results – Length frequency histograms

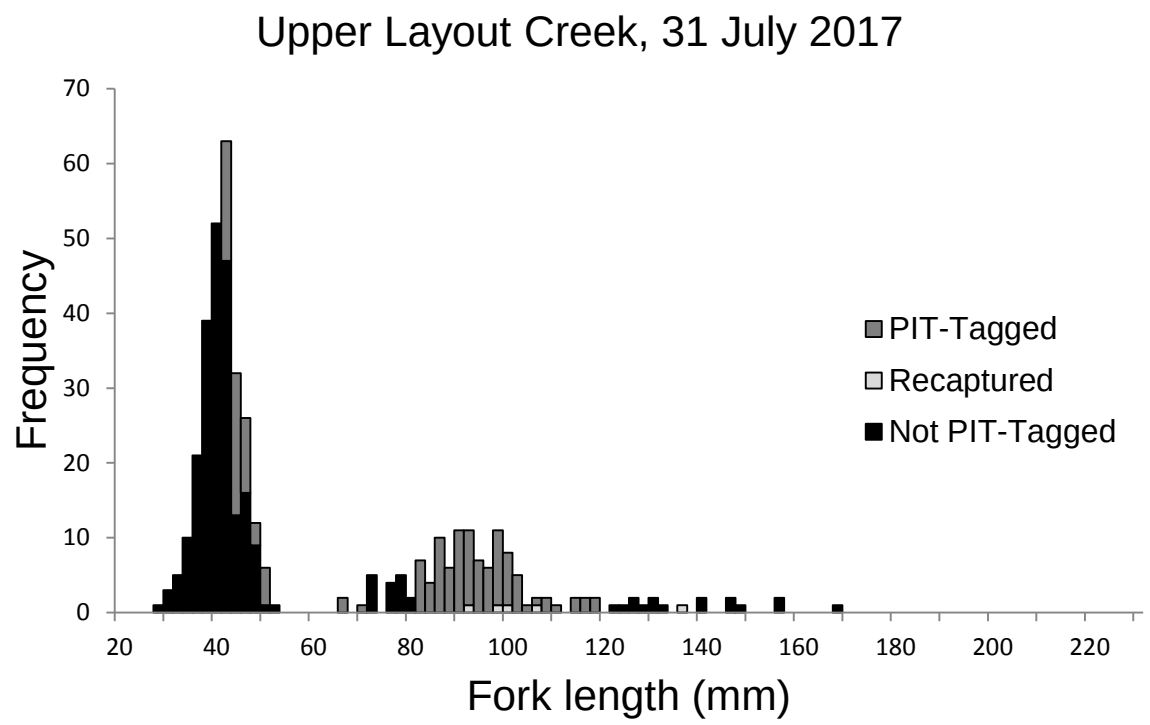


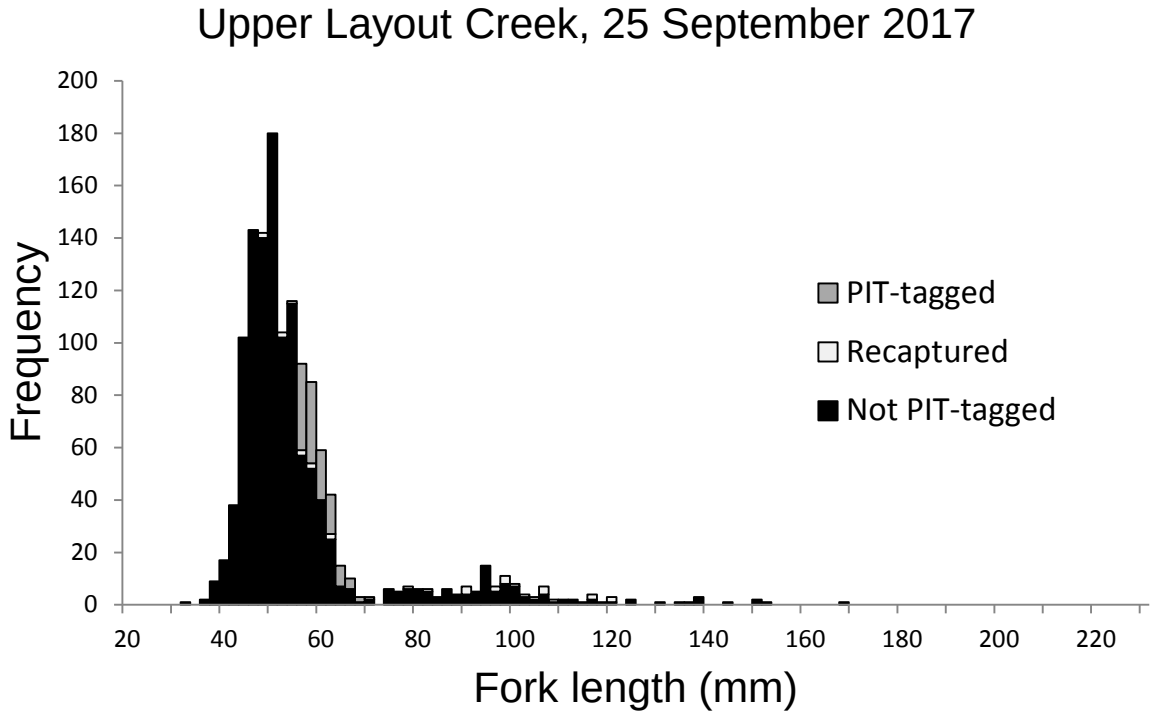


Appendix Figure 1. Length frequencies of juvenile Steelhead *Oncorhynchus mykiss* in Crater Creek (rkm 0 – 0.5), sampled by electrofishing during 2017. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

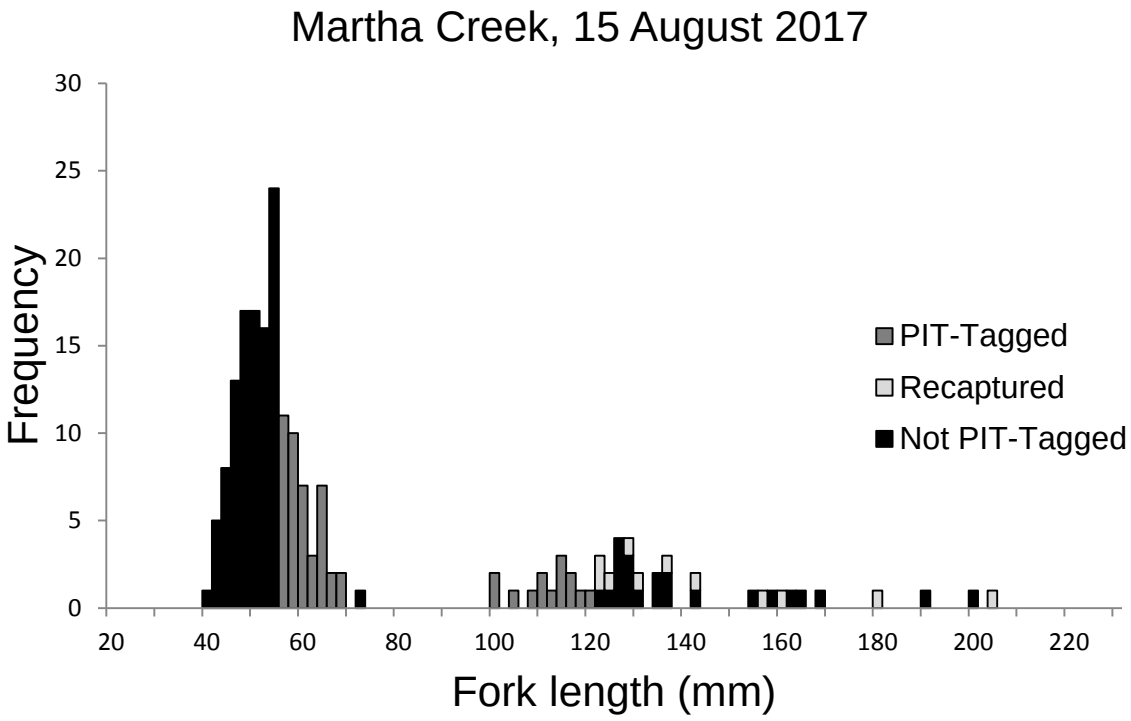


Appendix Figure 2. Length frequencies of juvenile Steelhead *Oncorhynchus mykiss* in lower Layout Creek (rkm 0 – 0.5), sampled by electrofishing during 2017. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

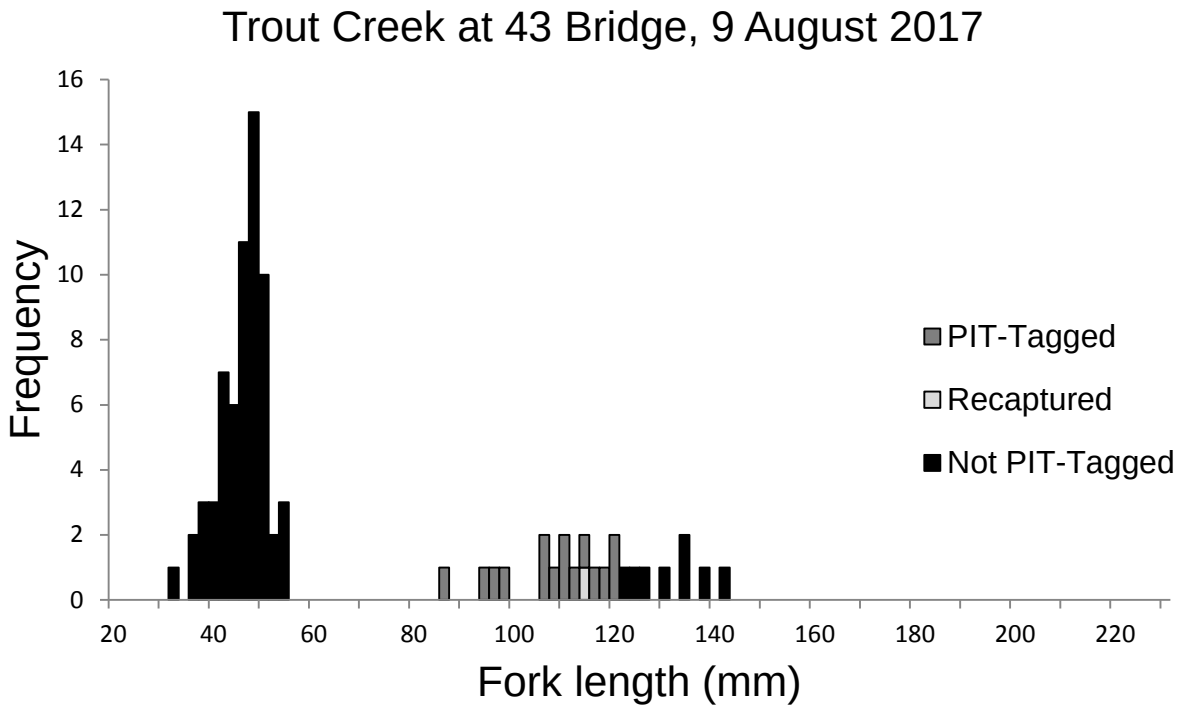




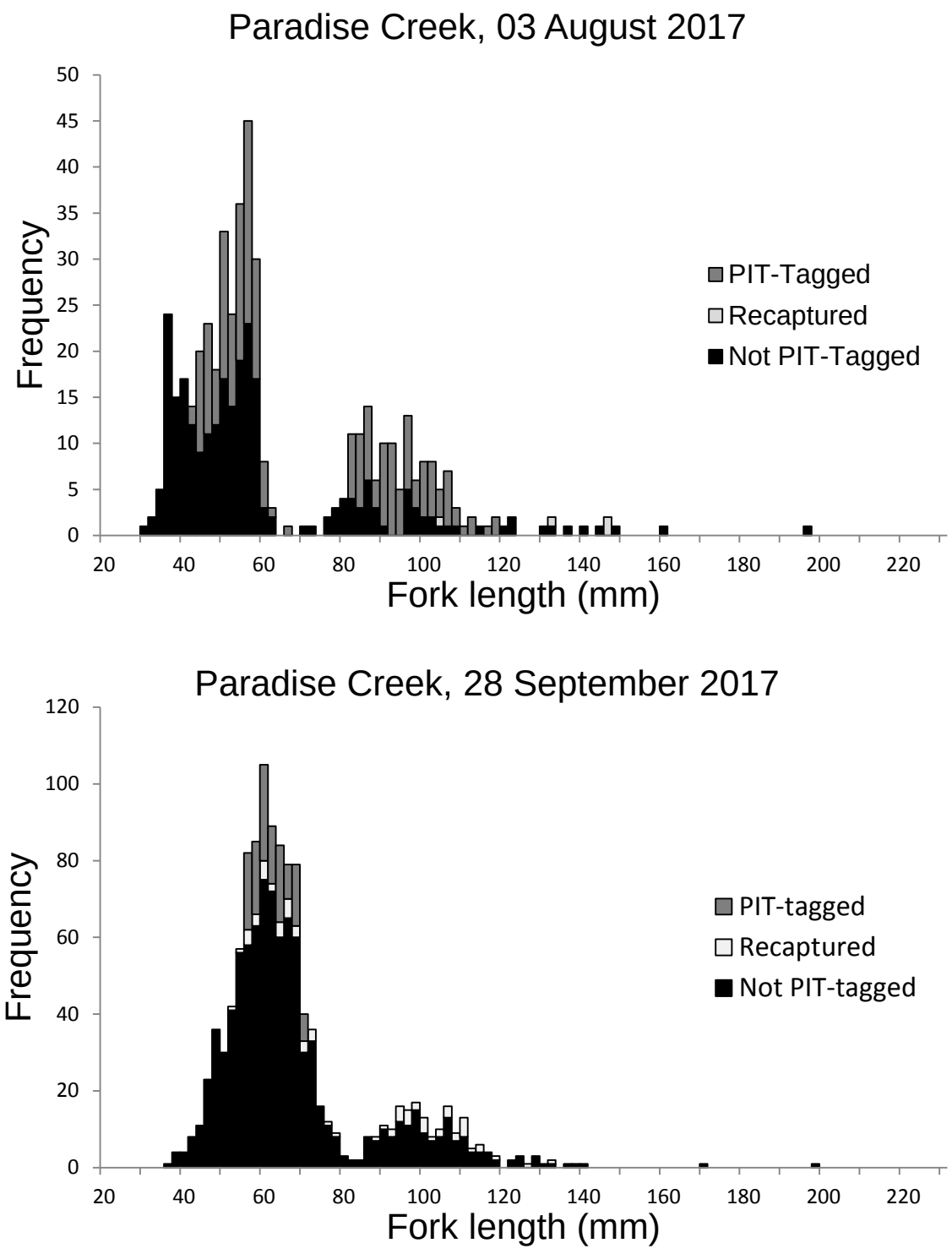
Appendix Figure 3. Length frequencies of juvenile Steelhead *Oncorhynchus mykiss* in Upper Layout Creek (rkm 2.5 – 3.0), sampled by electrofishing during 2017. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.



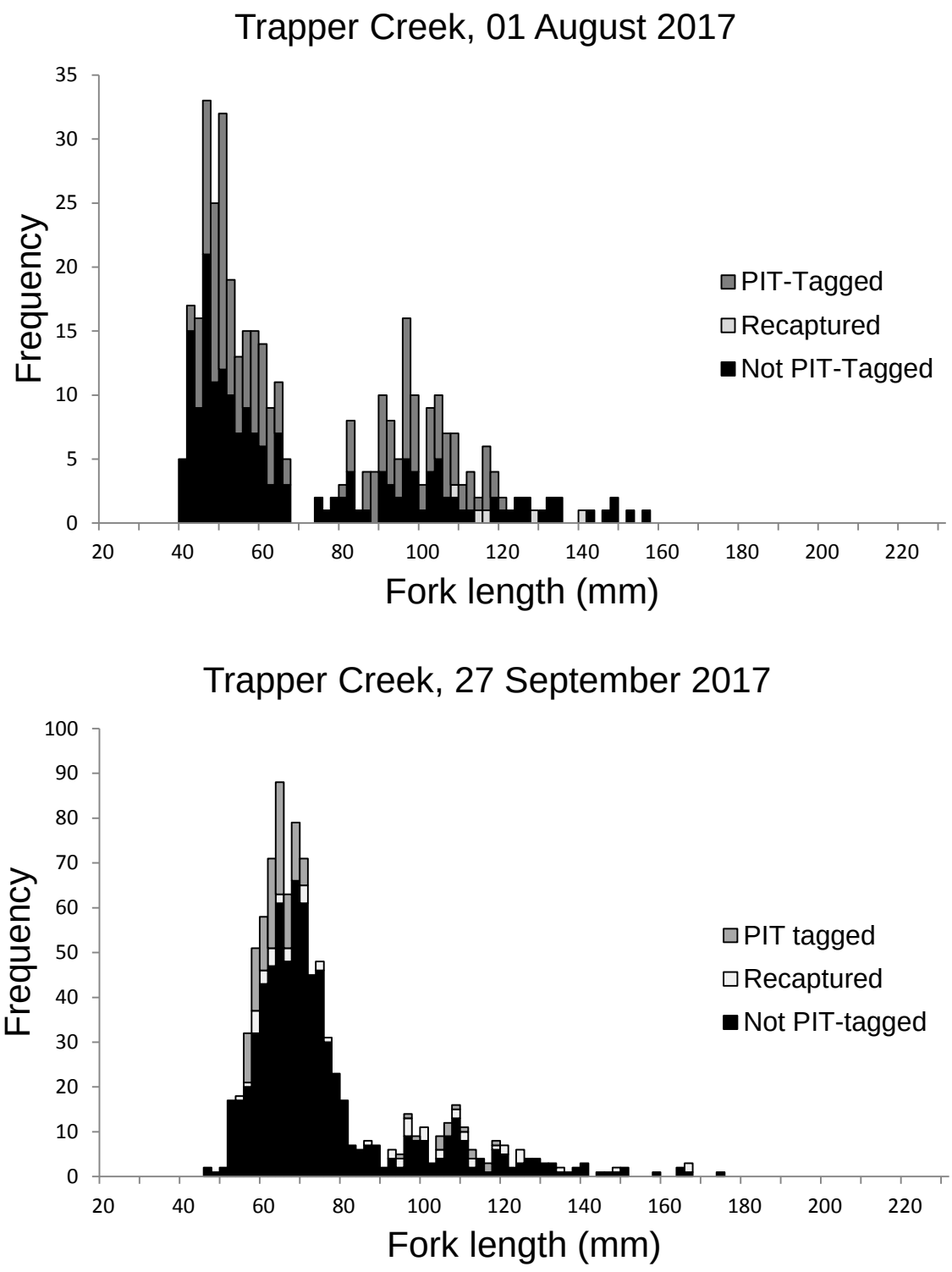
Appendix Figure 4. Length frequencies of juvenile Steelhead *Oncorhynchus mykiss* in Martha Creek (rkm 1.3 – 1.9), sampled by electrofishing during 2017. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.



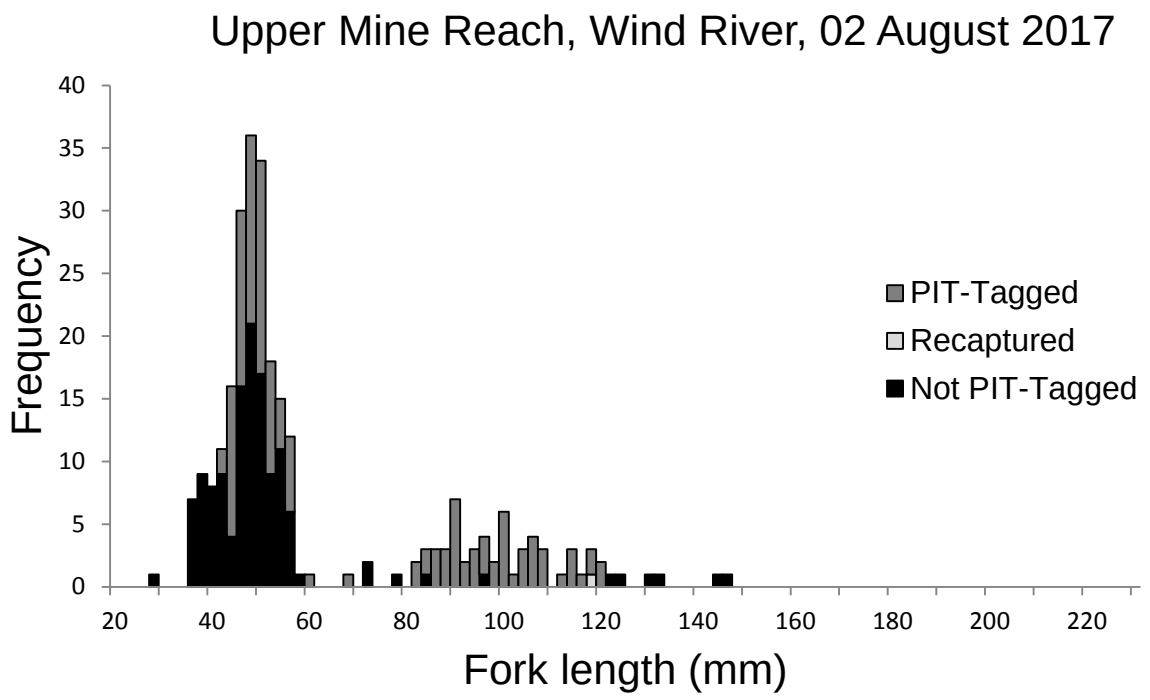
Appendix Figure 5. Length frequencies of juvenile Steelhead *Oncorhynchus mykiss* in Trout Creek (rkm 11.0 – 11.3), sampled by electrofishing during 2017. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

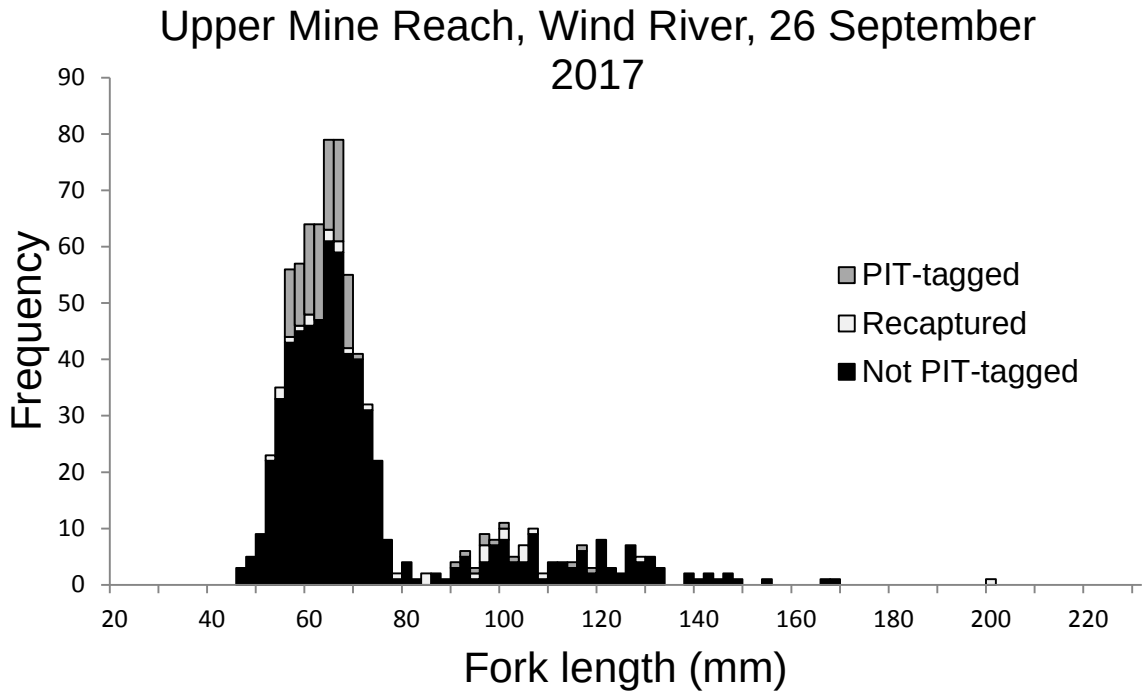


Appendix Figure 6. Length frequencies of juvenile Steelhead *Oncorhynchus mykiss* in Paradise Creek (rkm 0.5 – 1.0), sampled by electrofishing during 2017. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

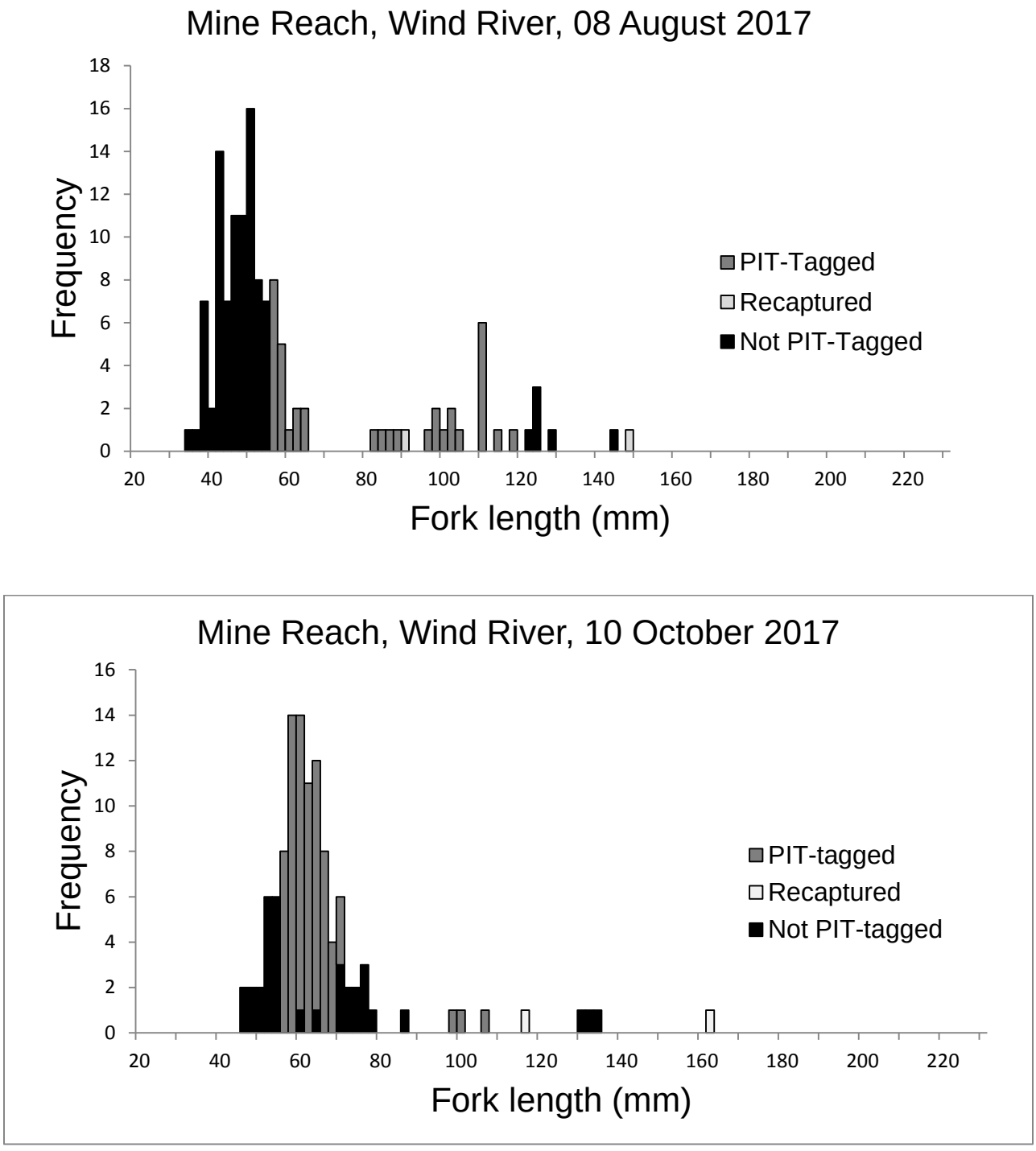


Appendix Figure 7. Length frequencies of juvenile Steelhead *Oncorhynchus mykiss* in Trapper Creek (rkm 0.1 – 0.6), sampled by electrofishing during 2017. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.





Appendix Figure 8. Length frequencies of juvenile Steelhead *Oncorhynchus mykiss* in the Wind River upstream of the confluence with Paradise Creek (rkm 41.0 – 41.5), sampled by electrofishing during 2017. 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 *Oncorhynchus mykiss* in the Wind River (rkm 37.0 – 37.4), sampled by electrofishing during 2017. 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 *Oncorhynchus mykiss* parr sampled in the Wind River subbasin during 2017.

Site	Date sampled	Rkm from mouth	n	Range	Median	Mean	SD
Martha	8/15	1.3 – 1.8	144	39 - 71	52	52	6.3
Layout	8/14	0.0 – 0.5	178	36 - 60	49	49	5.2
	10/02	0.0 – 0.5	240	41 - 71	56	56	6.0
	7/31	2.1 – 3.0	271	28 - 51	41	40	4.1
	9/25	2.1 – 3.0	1163	32 - 70	50	51	5.9
Trout	8/09	11.0 – 11.3	63	31 - 54	46	45	4.6
Crater	7/28	0.0 – 0.4	61	33 - 55	40	40	3.1
	9/22	0.0 – 0.4	167	33 - 64	51	50	6.1
Trapper	8/01	0.1 – 0.6	229	39 - 66	50	51	6.8
	9/27	0.1 – 0.6	724	45 - 84	65	65	7.0
Paradise	8/03	0.5 – 1.4	319	30 - 65	50	48	7.5
	9/28	0.5 – 1.4	935	36 - 80	60	60	7.8
Wind R.	8/08	37.0 – 37.3	103	34 - 63	48	48	6.5
	10/30	37.0 – 37.3	103	45 - 77	60	61	6.8
	8/02	41.0 – 41.8	199	27 - 59	47	47	5.2
	9/26	41.0 – 41.8	634	45 - 78	63	62	6.3

Appendix Table 2. Summary fork-length data (mm) for age-1 Steelhead *Oncorhynchus mykiss* parr sampled in the Wind River subbasin during 2017.

Site	Date Sampled	Rkm from mouth	n	Range	Median	Mean	SD
Martha	8/15	1.3 – 1.8	34	99 - 136	122	121	10.3
Layout	8/14	0.0 – 0.5	20	83 - 127	108	107	14.1
	10/02	0.0 – 0.5	4	107 - 136	121	121	12.3
	7/31	2.1 – 3.0	111	66 - 109	90	89	9.6
	9/25	2.1 – 3.0	113	73 - 109	93	91	9.7
Trout	8/09	11.0 – 11.3	19	85 - 125	112	110	11.0
Crater	7/28	0.0 – 0.4	36	65-116	93	94	12.2
	9/22	0.0 – 0.4	19	72-113	90	93	13.0
Trapper	8/01	0.1 – 0.6	142	73 - 133	98	100	13.3
	9/27	0.1 – 0.6	171	85 - 140	106	107	13.5
Paradise	8/03	0.5 – 1.4	138	70-122	92	93	10.6
	9/28	0.5 – 1.4	176	82-117	98	99	8.6
Wind R.	8/08	37.0 – 37.3	25	82 - 127	109	105	13.4
	10/30	37.0 – 37.3	6	85 - 129	103	105	15.3
	8/15	41.0 – 41.8	62	68 - 124	97	98	13.0
	9/26	41.0 – 41.8	130	80 - 131	105	107	13.7