Wind River Subbasin Restoration

U.S. Geological Survey Annual Report

November 2012 through December 2013

BPA Project # 1998-019-00

Report covers work performed under BPA contract #(s) 59821, 63276

Report was completed under BPA contract 63276

11/1/2012 - 12/31/2013

Ian G. Jezorek, Fishery Biologist

and

Patrick J. Connolly, Lead Research Fishery Biologist

US Geological Survey (USGS), Cook, WA, 98605

Report Created 5-2014

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

This report should be cited as follows: Ian G. Jezorek and Patrick J. Connolly, 2014, Wind River Subbasin Restoration, 11/01/2013 - 12/31/2013 Annual Report, 1998-019-00

Table of Contents

Table of Contents 2
1. List of Figures 2
2. List of Tables 3
3. List of Appendix Figures 4
4. Executive Summary 4
5. Introduction 6
6. Study Area and Methods 8
7. Results 10
8. Synthesis of Findings: Discussion/Conclusions 13
9. Acknowledgements 15
10. References 16
Appendix A: Use of Data & Products 34
Appendix B: Detailed Results – Length frequency histograms 35

1. List of Figures

Figure 1. Stream sections (denoted by bold lines) where we tagged parr steelhead/rainbow trout *Oncorhynchus mykiss* with Passive Integrated Transponder tags during summer 2013 18

Figure 2. Locations of instream PIT-tag interrogation systems operated in the Wind River subbasin from November 2012 through December 2013 19

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 20

Figure 4. The upper Wind River PIT-tag interrogation site (located at rkm 30.0 of the Wind River) showing the two arrays of three antennas each and the supporting infrastructure.. 21

Figure 5. Detections of PIT-tagged adult steelhead *Oncorhynchus mykiss*, by week, at the Trout Creek PIT-tag interrogation system from 1 October 2012 through 9 December 2013. The site was located at rkm 2.0.. 22

Figure 6. Detections of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* (PIT-tagged as parr in the Trout Creek watershed during August and September 2011, 2012, and 2013), by month, at the Trout Creek PIT-tag interrogation system from 1 September 2011 to 9 December 2013.....23

Figure 7. Detections of PIT-tagged adult steelhead *Oncorhynchus mykiss*, by week, at the upper Wind River PIT-tag interrogation system from 1 October 2012 through 9 December 2013. The site was located at rkm 30.0 of the Wind River 24

Figure 8. Detections of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* (PIT-tagged as parr in the upper Wind River watershed during August and September 2011, 2012, and 2013), by week, at the upper Wind River PIT-tag interrogation system 25

Figure 9. Detections of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* (PIT-tagged as parr in the Wind River between rkm 41.0 and 41.6 during August and September 2011, 2012, and 2013), by week, at the upper Mine PIT-tag interrogation system....26

Figure 10. Detections of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* (PIT-tagged as parr in Paradise Creek during August and September 2011, 2012, and 2013), by week, at the Paradise Creek PIT-tag interrogation system 27

Figure 11. Detections of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* (PIT-tagged as parr in Martha Creek between rkm 1.3 and 2.6 during August and September 2011, 2012, and 2013), by week, at the Martha Creek PIT-tag interrogation system....28

2. List of Tables

Table 1. Locations of thermologgers in the Wind River subbasin maintained by U.S. Geological Survey's Columbia River Research Laboratory 29

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 2013. Tags used were 12-mm and 9-mm 134.2 kHz 30

Table 3. Re-contacts, through November 2013, of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* that were PIT-tagged as parr during August and September 2011 in headwater areas of two watersheds in the Wind River subbasin 31

Table 4. Re-contacts, through November 2013, of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* that were PIT-tagged as parr during August and September 2012 in headwater areas of two watersheds in the Wind River subbasin. 31

Table 5. Re-contacts, through November 2013, of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* that were PIT-tagged as parr during August and September 2013 in headwater areas of two watersheds in the Wind River subbasin 32

Table 6. Detection efficiency estimates, for PIT-tagged adult steelhead *Oncorhynchus mykiss*, at the new Trout Creek PIT-tag interrogation site (relocated on October 1, 2012)....32

Table 7. Detection efficiency estimates, for PIT-tagged juvenile steelhead/rainbow trout *Oncorhynchus mykiss*, at the new Trout Creek PIT-tag interrogation site. 33

3. List of Appendix Figures

Appendix Figure 1. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Crater Creek (rkm 0 – 0.6), sampled by electrofishing during 2013 35

Appendix Figure 2. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Layout Creek (rkm 0 – 0.6), sampled by electrofishing during 2013.....36

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 2013.....37

Appendix Figure 4. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Way Upper Layout Creek (rkm 4.0 – 4.5), sampled by electrofishing during 2013 38

Appendix Figure 5. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Martha Creek (rkm 1.3 – 2.0), sampled by electrofishing during 2013 39

Appendix Figure 6.Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Martha Creek (rkm 2.3 – 2.6), sampled by electrofishing during 2013 40

Appendix Figure 7. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Trout Creek (rkm 11.0 – 11.3), sampled by electrofishing during 2013 41

Appendix Figure 8. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Paradise Creek (rkm 0.5 – 1.0), sampled by electrofishing during 2013 42

Appendix Figure 9. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Trapper Creek (rkm 0.1 – 0.6), sampled by electrofishing during 2013 43

Appendix Figure 10. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in the Wind River upstream of the confluence with Paradise Creek (rkm 41.0 – 41.6), sampled by electrofishing during 2013.....44

Appendix Figure 11. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in the Wind River (rkm 37.0 – 37.4), sampled by electrofishing during 2013 45

4. Executive Summary

The Wind River subbasin in southwest Washington State provides habitat for a population of wild Lower Columbia River steelhead *Oncorhynchus mykiss*. There have been no hatchery steelhead 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 Wilflife). We used Passive Integrated Transponder (PIT)-tagging and a series of instream PIT-tag interrogation systems (PTIS) to investigate life-histories, populations, and efficacy of habitat restoration actions for these steelhead. 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 2013, we PIT-tagged parr steelhead in headwater areas of the Wind River subbasin to investigate variable life-histories, specifically to compare fate of those juvenile steelhead that move downstream prior to smolting with those that remain in their natal areas until smolting. A series of instream PTISs monitored movement of these fish. 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. Long-term monitoring of PIT-tagged fish over multiple years will provide 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 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 has provided data that will contribute to evaluating the efficacy of the removal of Hemlock Dam from 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.

5. Introduction

This report summarizes work by U.S. Geological Survey's Columbia River Research Laboratory (USGS-CRRL), in the Wind River subbasin, from November 2012 through December 2013. Funding for activities during this time was provided by Bonneville Power Administration (BPA) under contracts 59821 (November 2012 through October 2013) and 63276 (November and December 2013) 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 *Oncorhynchus mykiss* populations (Connolly and Jezorek 2007; Cochran et al. 2013), their relationships with introduced populations of spring Chinook salmon *O. tshawytscha* and brook trout *Salvelinus fontinalis* (Connolly and Jezorek 2007; Jezorek and Connolly 2010), and documenting habitat variables and habitat restoration efforts for evaluation (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. These efforts are also providing data that will be used to estimate life-stage specific survival and identify potential population bottlenecks. Additionally, these data are contributing to evaluation of the effect on steelhead populations of 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 (PTIS; 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 hope to further document and understand this life-history. The PIT-tagged steelhead parr will provide movement and life history data through recapture events, detections at instream PTIS systems within the Wind River subbasin, and through detections at Bonneville Dam as smolts and adults. 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 will provide 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 will help 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.

6. 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 in the Trout Creek and upper Wind River watersheds (Figure 1). All fish were captured by backpack electrofishing. Captured fish were anesthetized with the lightest possible dose 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. If they did not have a PIT tag, were at least 70-mm fork length, and were not injured or in poor condition, we PIT-tagged them with a 12-mm 134.2 kHz tag that was inserted by syringe. In some cases, we PIT-tagged fish between 55 and 70 mm 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.

Our fish-sampling sites were between 300 and 600-m long. We sampled these sites in August and again in September, when we could recapture previously tagged fish and PIT-tag young-of-year fish. 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 five PTISs (Figure 2) to track PIT-tagged juvenile and adult steelhead. We had previously installed four PTISs (Trout Creek, site code= TRC; upper Wind River, site code = WRU; Paradise Creek, site code = PAR; and upper Mine Reach, site code = UMI), and a fifth was installed in late March 2013 (Martha Creek, site code = MAR). We used two different types of transceivers at the PTIS sites. Multiplexing transceivers were used for larger sites (TRC and WRU) because they could power multiple antennas and smaller Allflex transceivers for the smaller tributary sites (PAR, UMI, and MAR).

The transceivers at TRC and WRU were Biomark 1001M units capable of operating six individual antennas. Both used six antennas to span these larger sites (three arrays of two antennas each at TRC, and two arrays of three antennas each at WRU; Figures 3 and 4). 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 following the methods outlined in Connolly et al. (2008).

The transceivers at MAR, PAR, and UMI were Allflex RM310 units. Each operated a single antenna, as described by Bond et al. (2007). Limitations on power at PAR and UMI (both solar supported) allow for operation of only one antenna (3-m long by 0.6-m wide) at each site. The site at Martha Creek had grid power, enabling us to operate two transceivers and antennas (3-m long by 0.6-m wide).

Because of limitations of solar-power charging and access issues due to snowfall, we missed some monitoring time at the PAR and UMI sites during winter 2012/2013. A flood at the WRU site during November 2012 damaged two antennas and one antenna cable. High water during the winter prevented immediate repair, but Antenna 4 was replaced on 20 February 2013 and Antenna 1 and the Antenna 2 cable were replaced on 3 September 2013.

To investigate parr life histories and movements, we compiled information from recapture events during electrofishing, and from WDFW smolt trapping. The PTISs provided data on parr movement timing from tributaries. All interrogation data from TRC and WRU were submitted to the PTAGIS database (file uploads 2 to 4 times per month). Interrogation data from the PTISs MAR, PAR, and UMI are not yet submitted to the PTAGIS database due to interruptions in operations. However, we do plan to submit these data, which have already been made available to our project partners.

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.

7. Results

Fish sampling -- During summer 2013, we PIT-tagged 1,457 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, as well as in a mainstem section (rkm 11.0 – 11.3) of 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 a mainstem section of the Wind River (the Mine Reach) 3 km downstream of the Paradise Creek confluence (Figure 1; Table 2). We tagged 295 fish with 9-mm PIT tags (in Martha Creek, n = 136; Trapper Creek, n = 115; and the Mine Reach of the Wind River, n = 44). These smaller tags allowed tagging of young-of-year fish between 55 and 70 mm. Most sites were sampled in late summer, then again in early fall (Appendix Figures 1 – 11).

Repeat sampling in fall presented the opportunity to recapture previously PIT-tagged fish, which provided data on late summer growth rates (Table 2). In addition to the recapture data on fish that were PIT-tagged during the first sampling session, we recaptured PIT-tagged fish from previous years sampling (Table 3). Additional re-contacts of PIT-tagged parr came from recaptures at Wind River subbasin smolt traps, detections at instream PTISs in the Wind River subbasin, and detections of juveniles at Bonneville Dam and the estuary trawl sampling (Tables 3, 4, and 5).

Length and weight data were collected from *O. mykiss* fry that were too small to PIT tag. We also took genetic samples from 100 age-0 steelhead during our September 2013 sampling (25 samples each from Martha Creek, Crater Creek, Trapper Creek, and the upper Wind River). These known-origin samples were added to WDFW's collection of Wind River steelhead samples for their Wind River subbasin genetic archive project. 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. No Chinook salmon *O. tshawytscha* juveniles were found at our electrofishing sites during 2013.

PTISs -- Sixty-two PIT-tagged adult steelhead were detected at the TRC PTIS from 1 October 2012 through 6 December 2013 (Figure 5). First detections of individual fish occurred primarily during fall and spring. Adult detection efficiency, derived by the methods of Connolly et al.

(2008), of the TRC PTIS was 89.3% (SE = 3) over the entire time period from October 2012 through 6 December 2013 (Table 6). Due to initial difficulties with antennas and with interference at the TRC site during fall 2012, we generated a separate efficiency estimate for that time of 65.7% (SE = 11.4; Table 6) for that time period. By January 2013, the early operational problems had been rectified, and the adult steelhead detection efficiency estimate for 1 January 2013 to 6 December 2013 was 99.0% (SE = 0.8; Table 6).

Twenty-one juvenile steelhead (PIT-tagged as parr in the Trout Creek watershed) were detected at the TRC PTIS between 1 January 2013 and 6 December 2013 (Figure 6). Eight of the 21 fish were detected during summer or fall. Juvenile detection efficiency at the TRC PTIS, derived by the methods of Connolly et al. (2008), was 68.8% (SE = 11.8; Table 7).

Thirty-five PIT-tagged adult steelhead were detected at the WRU PTIS from 1 October 2012 through 6 December 2013 (Figure 7). Most fish were first detected during spring 2013 (*n* = 28). We were unable to estimate efficiency for the WRU PTIS by the methods of Connolly et al. (2008) because three antennas were damaged during a flood in November 2012, which rendered our array structure incomplete. However, we did detect eight adult steelhead at the PAR and UMI sites, which are both upstream of WRU. Five of the eight adult steelhead were detected at WRU, suggesting that adult steelhead detection efficiency was about 63%.

Despite the November 2012 flood, WRU detected PIT-tagged juvenile steelhead during the time it was damaged. Twenty-seven steelhead (PIT-tagged as parr in the upper Wind River watershed) were detected from 1 October 2012 to 6 December 2013 (Figure 8). Sixteen of these juveniles were detected during fall 2012 or summer 2013, and the remaining 11 during spring 2013. Because of flood damage to the antennas, we could not generate juvenile detection efficiency estimates by the methods of Connolly et al. (2008).

Additional detections of PIT-tagged fish were recorded at the three Allflex interrogation sites. We kept the PAR and UMI site running when possible, but power consumption was greater than expected, and the UMI site incurred some damage during the high flows of November 2012. We were not able to access and replace the damaged antenna at UMI until April 2013. From 1 April 2013 through 9 December 2013, eight steelhead were detected at UMI. These fish had been PIT-tagged as parr in the Wind River between rkm 41.0 and 41.6. Three of these fish were detected during fall 2012, the other five during spring 2013 (Figure 9). We were unable to operate the PAR site during winter 2012/2013 because the solar panels were adjacent to the

Wind River Highway and had to be removed from 29 November 2012 to 28 March 2013 to prevent damage or destruction from snowplowing. Despite this gap in monitoring, the PAR site detected 28 steelhead parr, which had been PIT-tagged in Paradise Creek during 2011, 2012, and 2013. Eleven of these fish were detected during summer or fall period of 2013 (Figure 10).

We installed a new PTIS in Martha Creek during late March 2013. This site had access to grid power and should provide reliable year-round coverage. Twenty-three juvenile steelhead, which had been PIT-tagged as parr in Martha Creek, were detected at MAR from 1 April 2013 to 9 December 2013. Twenty-one of these fish were detected during spring and the other two during fall (Figure 11).

Evaluation of restoration -- Data from these PIT-tagging efforts will contribute to evaluation of restoration efforts. During 2012 and 2013, we PIT-tagged *O. mykiss* parr at a site in Martha Creek where USFS has since removed a small diversion dam (the dam was removed in fall 2012). Three of the steelhead parr tagged and released upstream of the dam prior to its removal in 2012 were detected at the MAR PTIS during spring 2013. Secondly, in 2012 and 2013, we PIT tagged *O. mykiss* parr above a road culvert on Layout Creek (rkm 4.0; Figure 1; Table 2). The culvert is scheduled to be replaced during summer 2014 with a bridge that meets state and federal fish passage requirements. No fish PIT-tagged upstream of the culvert have been detected downstream as of this writing. Thirdly, detections of adult steelhead at TRC and WRU are providing data that are allowing us to evaluate whether the removal of Hemlock Dam has increased adult steelhead populations upstream of the former dam site.

Water temperature -- Thermologger data collected during the period covered by this report (Table 1) have been provided to personnel at UCD, who are compiling temperature data from multiple agencies working in the Wind River subbasin. These data and previous USGS temperature data have been 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.

8. 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 have allowed assessment of movements of wild Lower Columbia River steelhead that were PIT-tagged as parr in headwaters of the Wind River, WA. 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.

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. 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. 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.

Because instream PIT-tag interrogation systems can operate year-round, they can provide data on juvenile steelhead movement outside of conventional smolt trapping periods. Data collected to date in the Wind River have shown considerable juvenile steelhead movement during summer and fall. 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 compare escapement to adulthood from the different life-history strategies of juvenile steelhead in the Wind River subbasin.

It is currently unknown if downstream movement of steelhead parr is a result of limited headwater habitat capacity or quality, or is a life-history strategy employed by a given percentage of fish regardless of fish abundance or habitat condition. 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 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.

Recapture data of PIT-tagged juvenile steelhead, through electrofishing and smolt trapping, will provide the opportunity to compare growth rates between different areas and years. These data should help assess whether growth rates or tributary conditions influence the extent, timing, and fate of migratory parr steelhead. Recapture data will also contribute to parr life history research by providing additional location information on individuals fish.

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 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. It is unknown 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 can 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.

Our PTISs are also contributing to evaluation of some smaller-scale restoration projects in the Wind River subbasin. During 2012, the USFS removed a small relic diversion dam on Martha Creek. We PIT-tagged juvenile *O. mykiss* upstream of this dam prior to removal. Detection of several of these fish at the MAR PTIS suggests steelhead use of the area upstream of the former dam, or that non-anadromous *O. mykiss* were moving downstream. Additionally, we PIT-tagged fish upstream of a culvert on Layout Creek that is proposed for replacement during summer 2014. The culvert is a partial barrier to upstream fish movement. To date, we have not detected any fish PIT-tagged upstream of the culvert at any downstream recapture or detection locations. We will continue to PIT-tag fish from both of these restoration locations to gain further insight into their effects on steelhead.

9. Acknowledgements

A number of people helped with this work. Mary Todd Haight was our BPA Contracting Officer. Pete Kofoot, Brad Liedtke, Cole Lysgaard, Kyle Martens, Carrie Munz, Matt Schult, and Joe Warren were fellow USGS-CRRL employees who helped in the field and office. Stephanie Caballero and David Hu of the U.S. Forest Service provided some personnel for field help. Elaine Harvey and Stephanie Caballero 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.

10. 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.

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.

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

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.

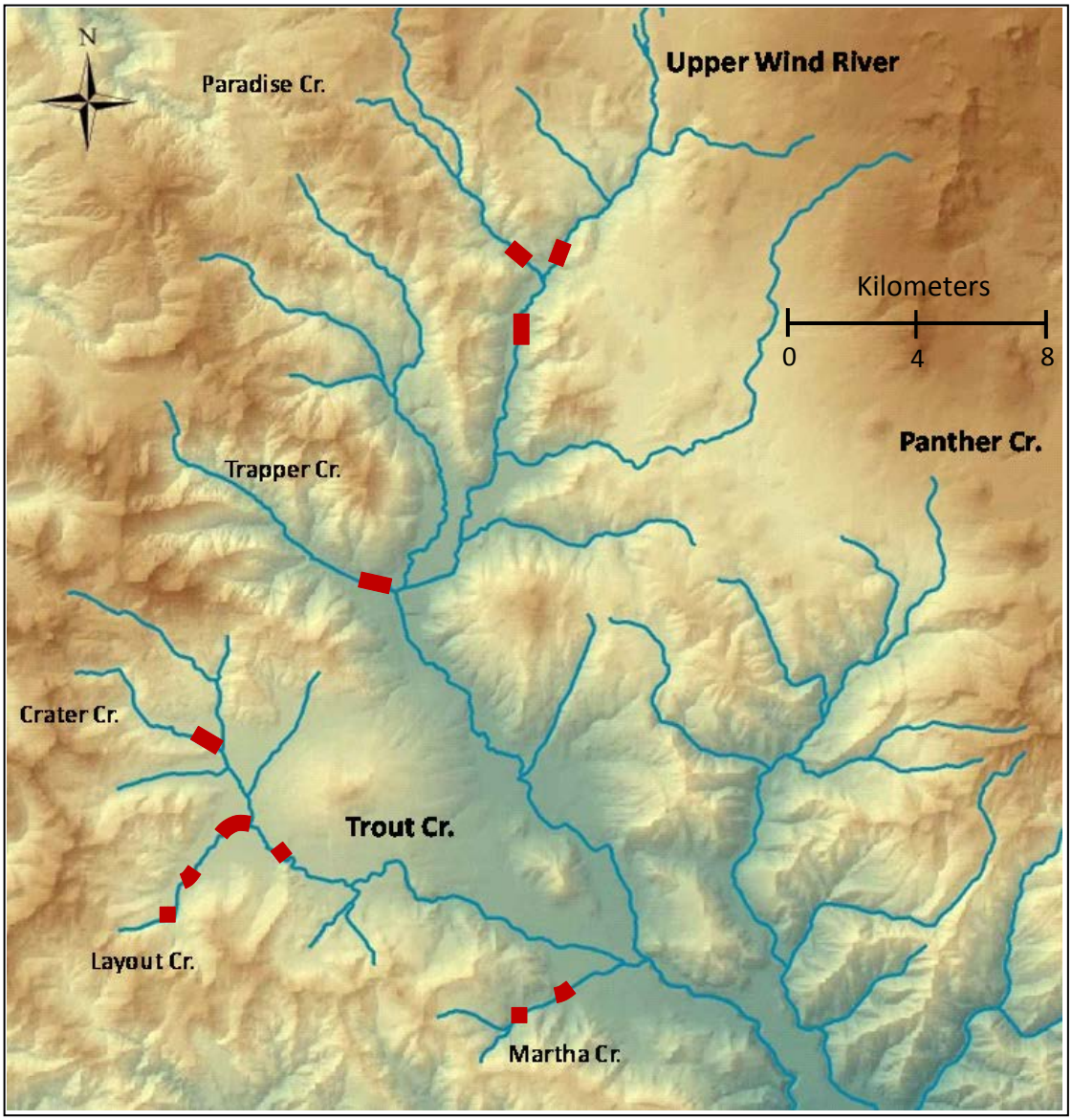


Figure 1. Stream sections (denoted by bold lines) where we tagged parr steelhead *Oncorhynchus mykiss* with Passive Integrated Transponder tags during summer 2013.

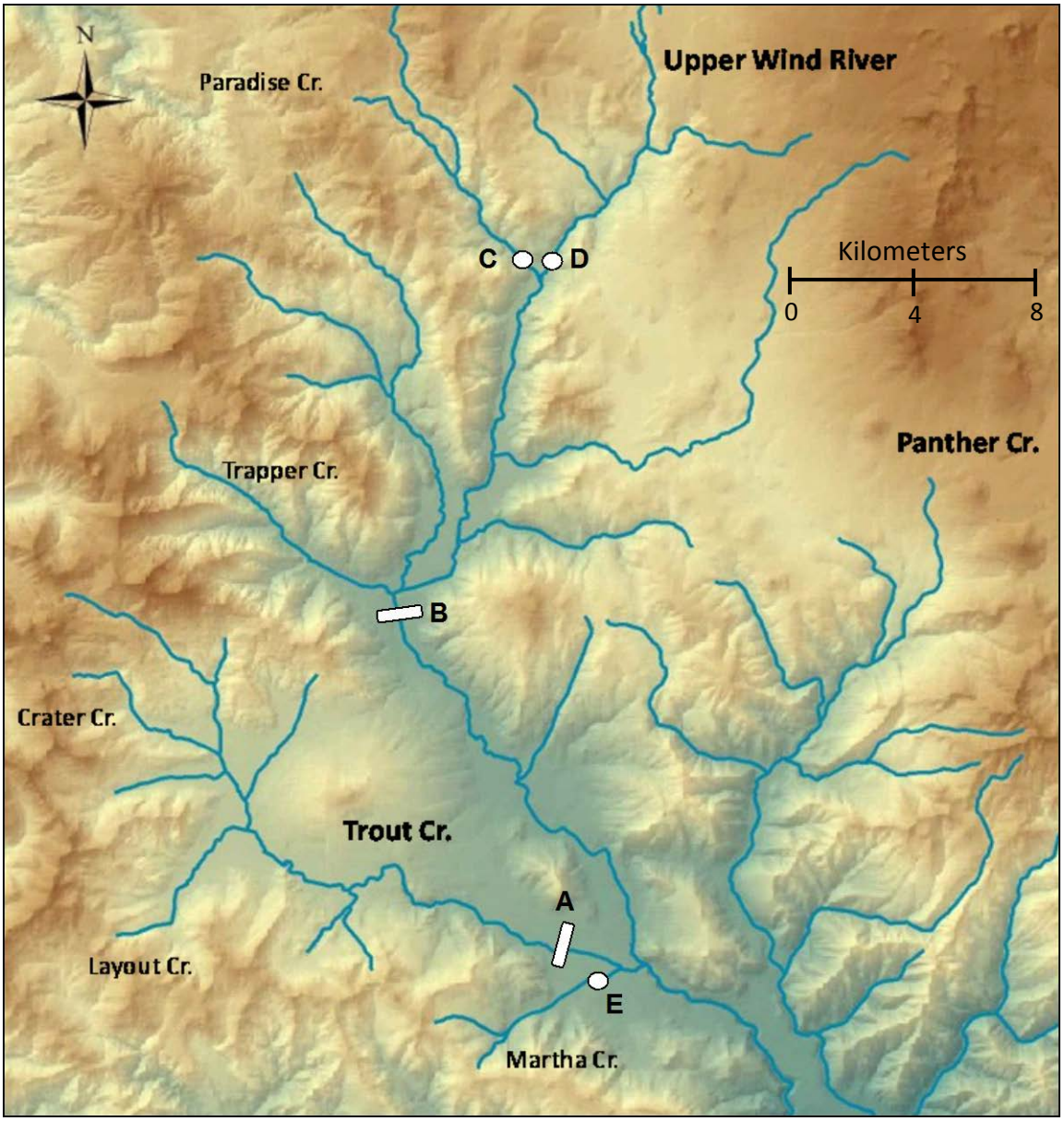


Figure 2. Locations of instream PIT-tag interrogation systems operated in the Wind River subbasin from November 2012 through December 2013. A) Trout Creek (TRC, 1001M Transceiver, 3 arrays of 2 antennas each); B) upper Wind River (WRU, 1001M Transceiver, 2 arrays of 3 antennas each); C) Paradise Creek (PAR, Allflex RM310 Transceiver, 1 antenna); D) upper Mine Reach (UMI, Allflex RM310 Transceiver, 1 antenna); E) Martha Creek (MAR, RM310 Transceivers, 2 antennas, began operation in April 2013).

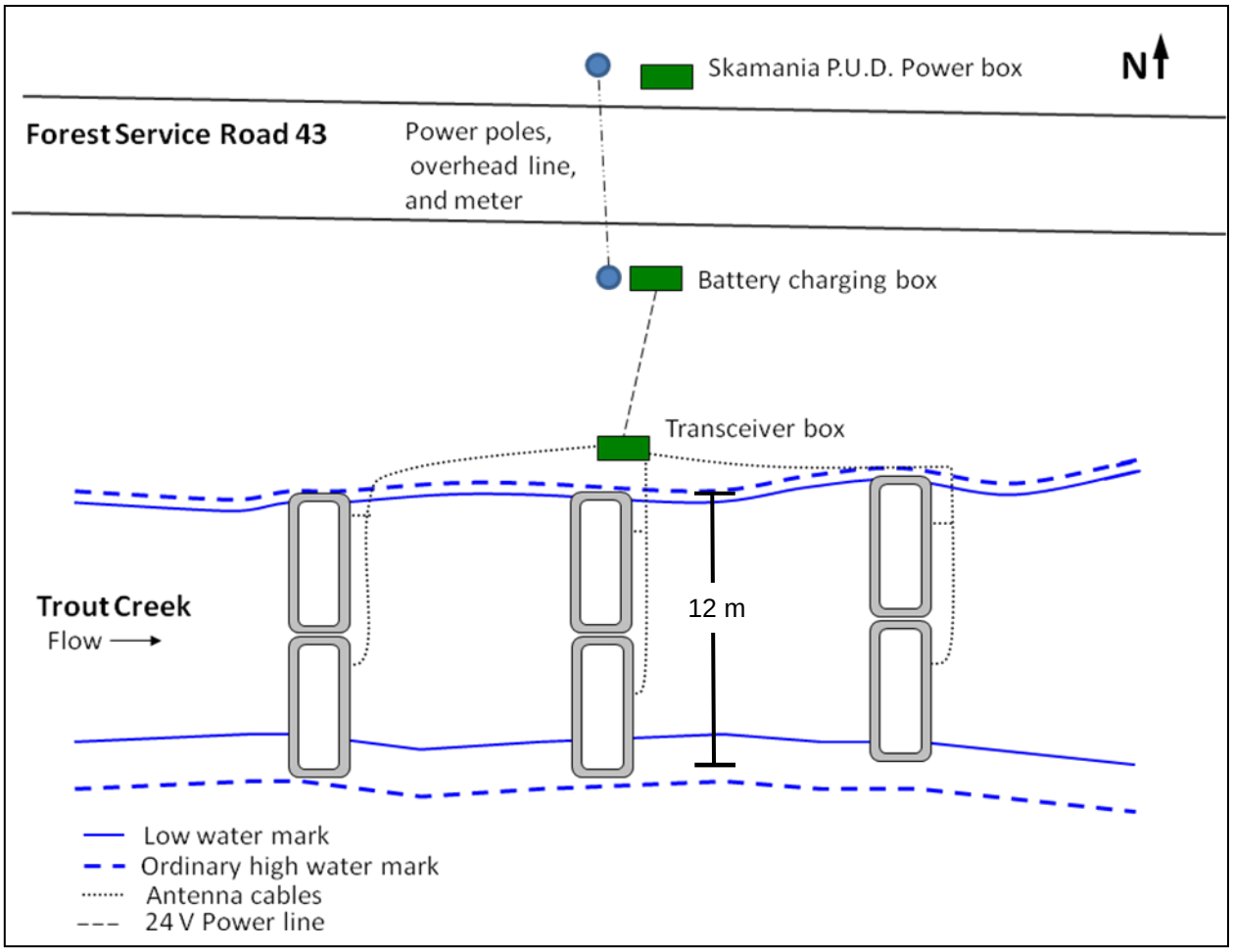


Figure 3. The Trout Creek PIT-tag interrogation system site (located at rkm 2.0 of Trout Creek), showing the three arrays of two antennas each and supporting infrastructure. Data from this site were submitted to the PTAGIS database under site code TRC.

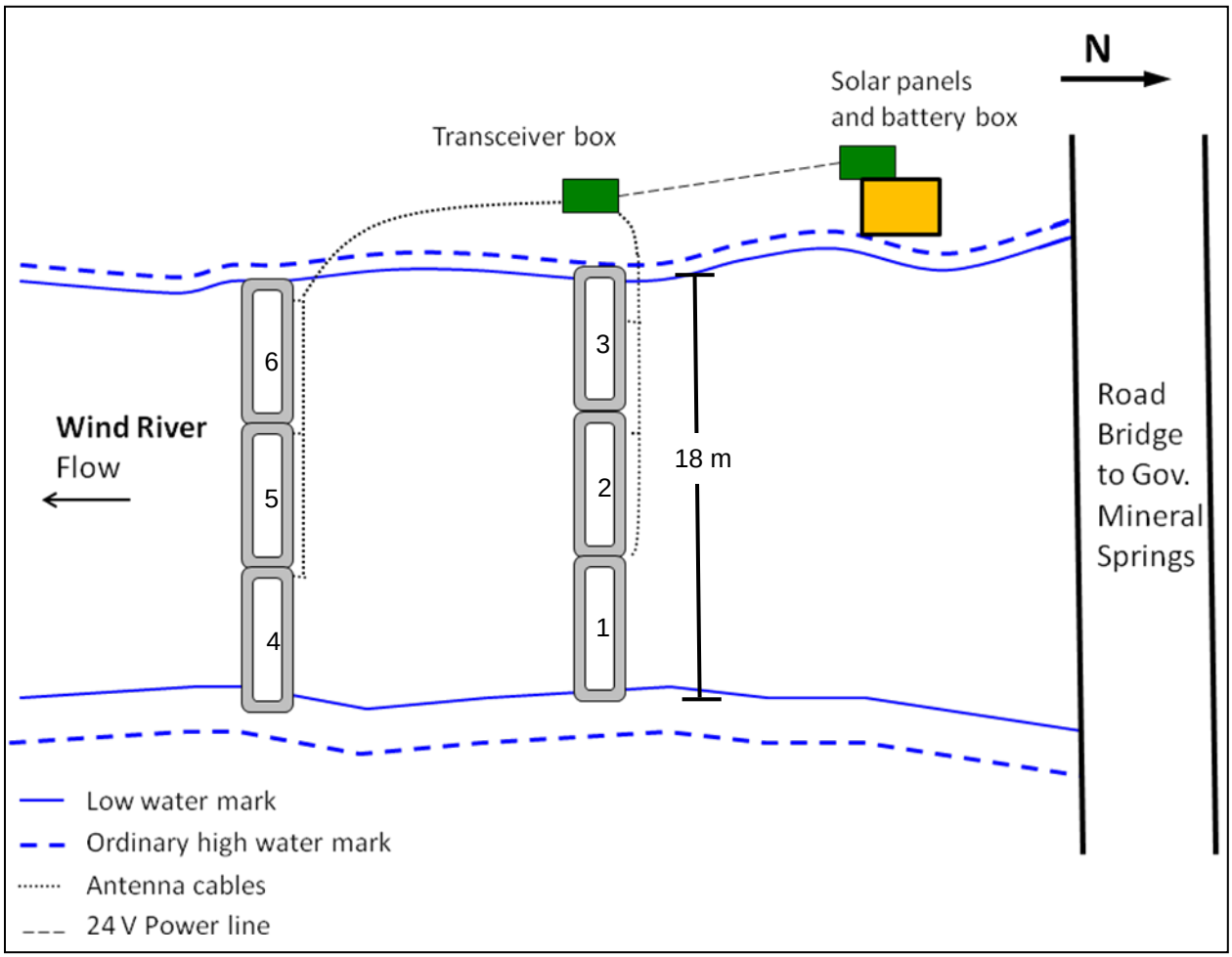


Figure 4. The upper Wind River PIT-tag interrogation site (located at rkm 30.0 of the Wind River) showing the two arrays of three antennas each and the supporting infrastructure. Data from this site were submitted to the PTAGIS database under site code WRU.

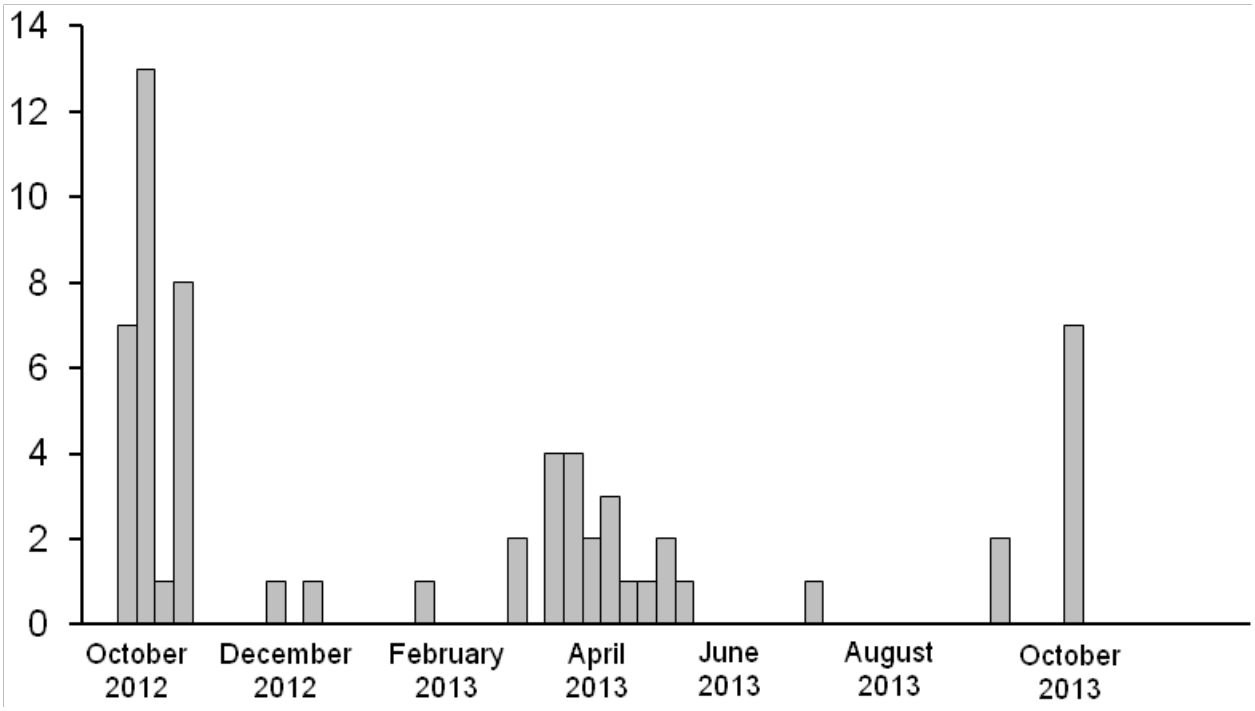


Figure 5. Detections of PIT-tagged adult steelhead *Oncorhynchus mykiss*, by week, at the Trout Creek PIT-tag interrogation system from 1 October 2012 through 6 December 2013. The site was located at rkm 2.0 of Trout Creek. Shown are first detection dates. Many fish were detected on multiple days. All detection data were submitted to the PTAGIS database under site code TRC.

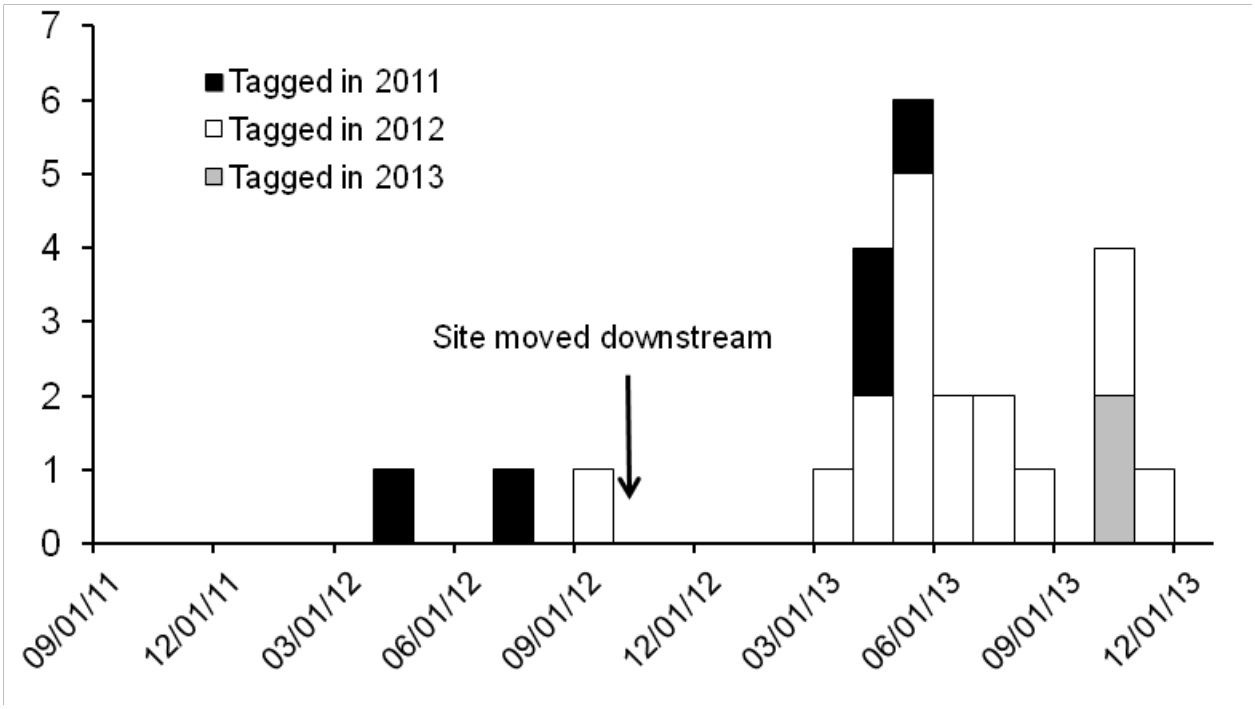


Figure 6. Detections of juvenile steelhead *Oncorhynchus mykiss*, by month, at the Trout Creek PIT-tag interrogation system from 1 September 2011 to 6 December 2013. The fish were tagged in the Trout Creek watershed during August or September 2011, 2012, and 2013.The Trout Creek PIT-tag interrogation system was originally located at rkm 4.0, but was relocated to rkm 2.0 on 2 October 2012. The new location provided grid power for more consistent operation. 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.

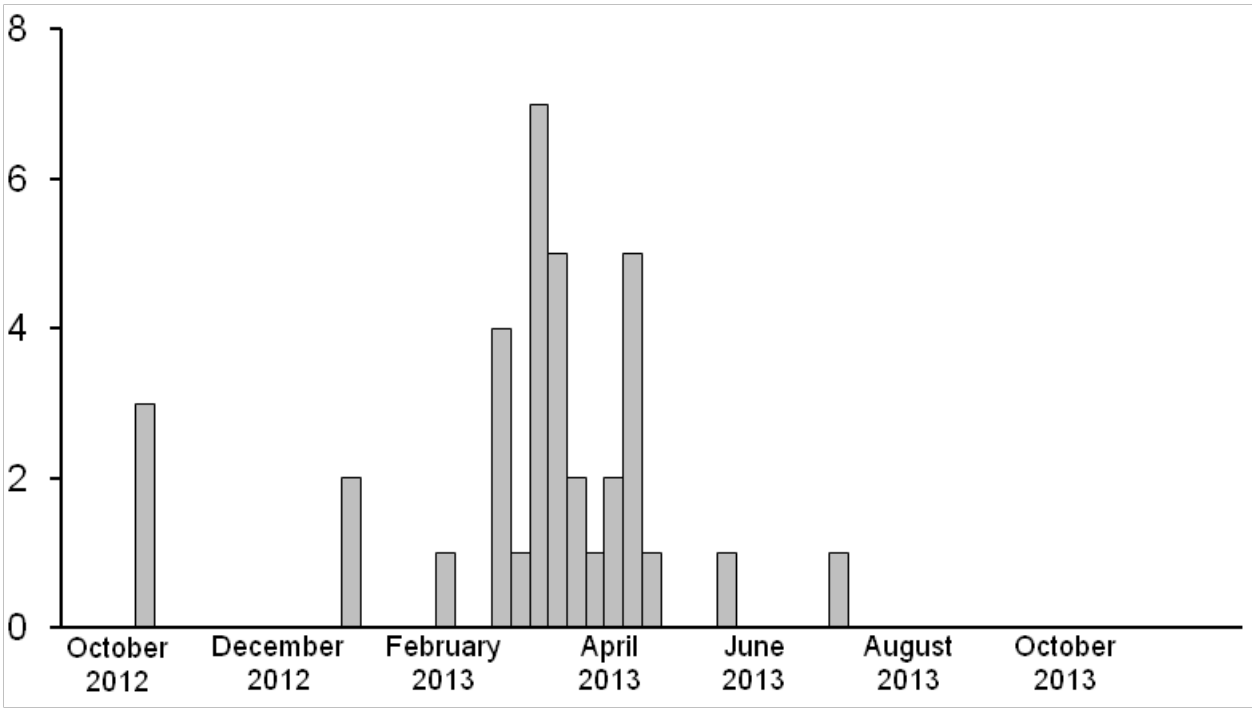


Figure 7. Detections of PIT-tagged adult steelhead *Oncorhynchus mykiss*, by week, at the upper Wind River PIT-tag interrogation system from 1 October 2012 through 6 December 2013. The site was located at rkm 30.0 of the Wind River. Shown are first detection dates for these fish. Many fish were detected on multiple days. All detection data were submitted to the PTAGIS database under site code WRU.

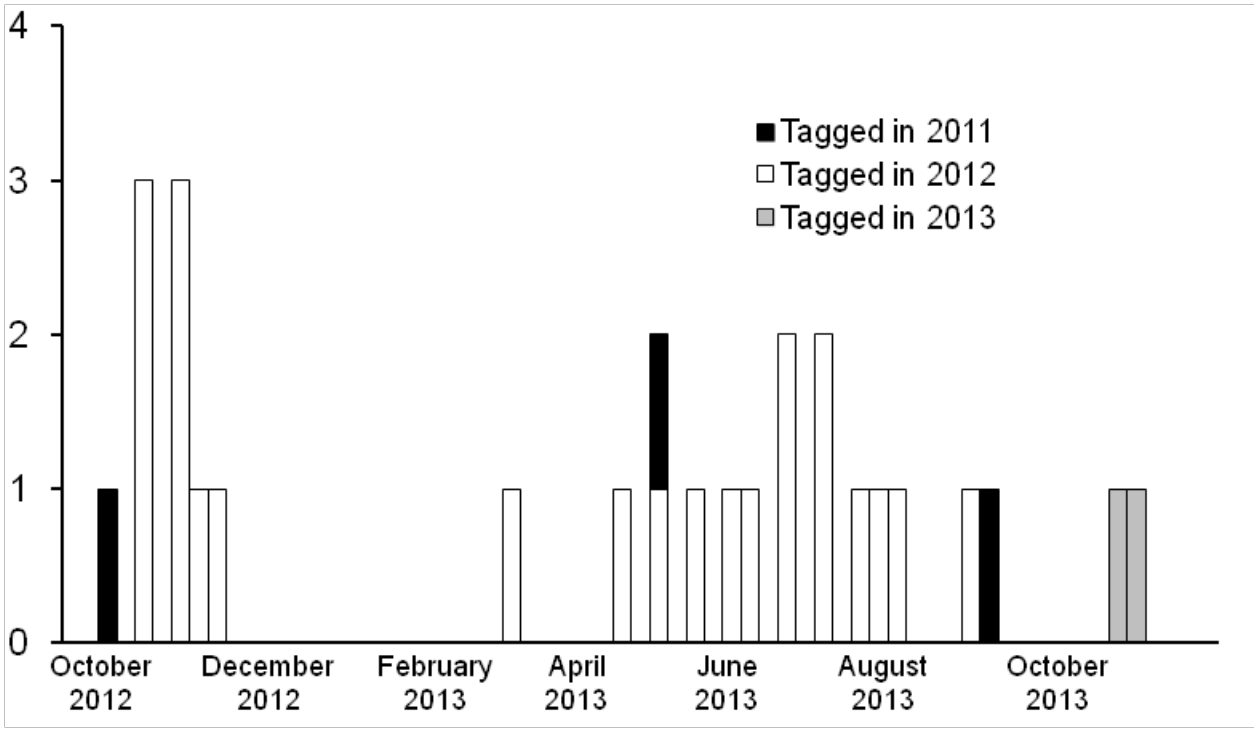


Figure 8. Detections of juvenile steelhead *Oncorhynchus mykiss* (PIT-tagged as parr in the upper Wind River watershed during August and September 2011, 2012, and 2013), by week, at the upper Wind River PIT-tag interrogation system from 1 October 2012 to 6 December 2013. The site was located at rkm 30.0 of the Wind River. Shown are first detection dates, many fish were detected on multiple days. All detection data were submitted to the PTAGIS database under site code WRU.

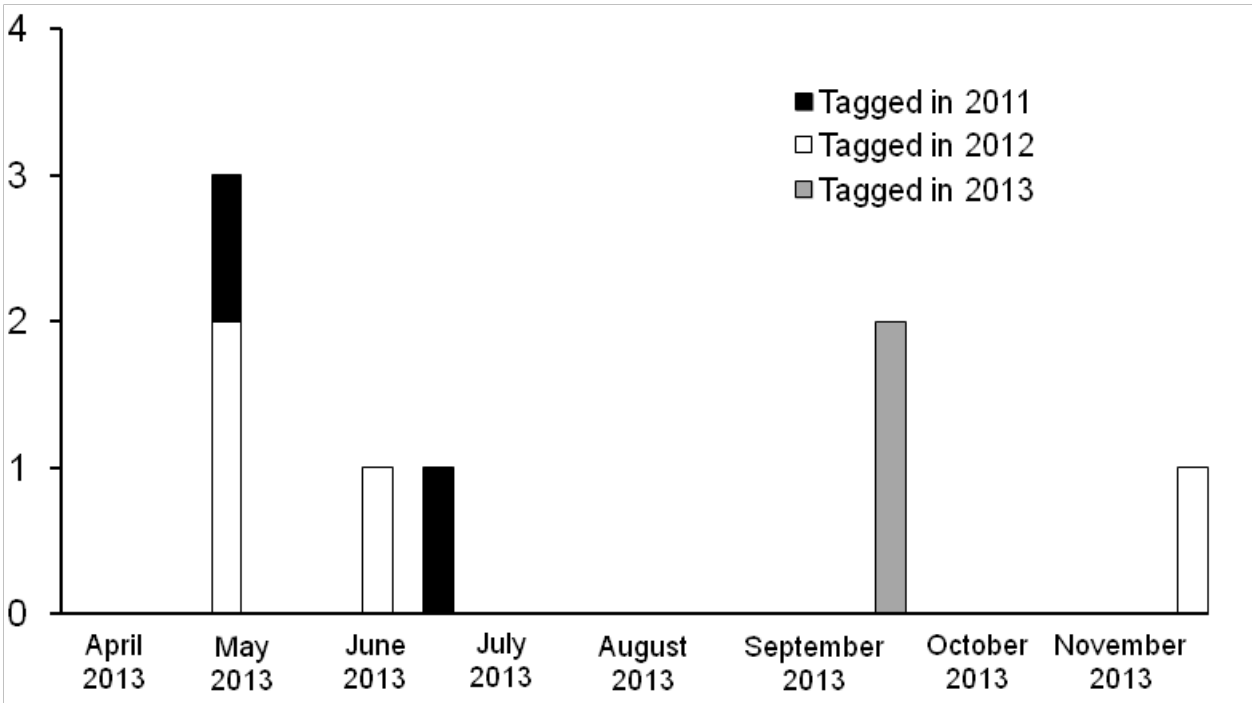


Figure 9. Detections of juvenile steelhead *Oncorhynchus mykiss*, by week, at the upper Mine PIT-tag interrogation system from 1 April 2013 to 6 December 2013. The fish were PIT-tagged as parr in the Wind River between rkm 41.0 and 41.6 during August and September 2011, 2012, and 2013. The system was located at rkm 40.5 of the Wind River. Shown are first detection dates for these fish. Some fish were detected over multiple days.

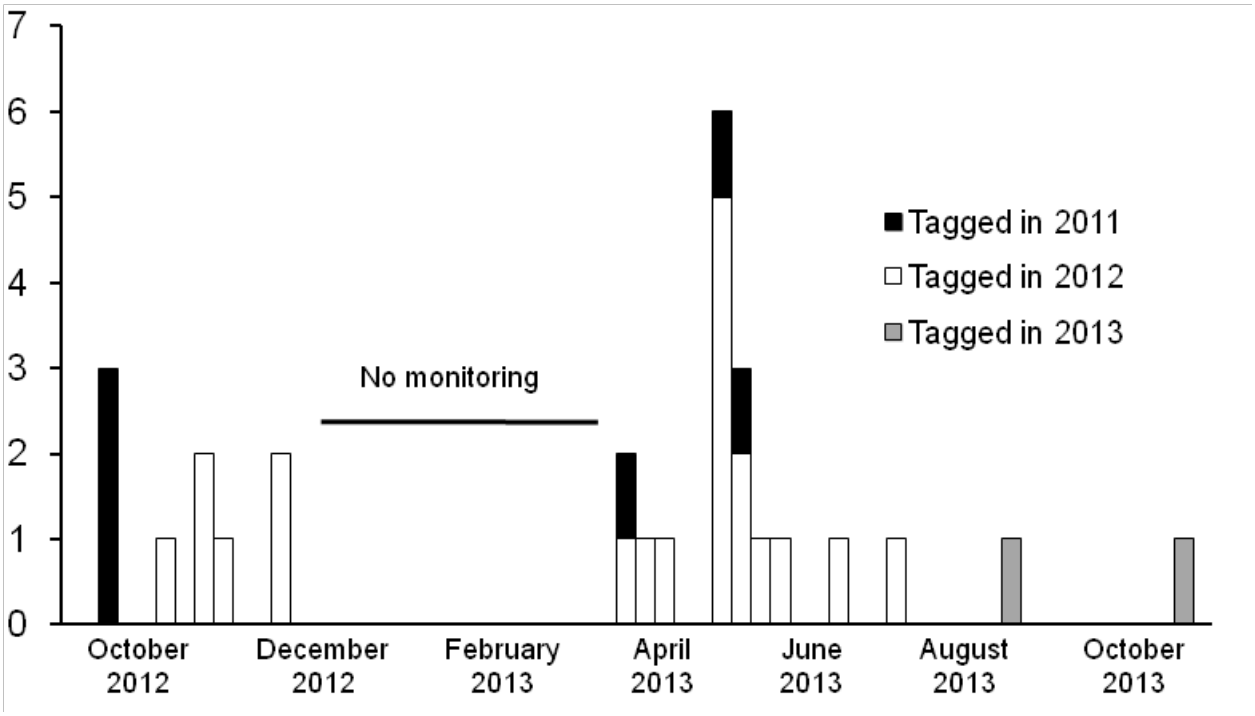


Figure 10. Detections of juvenile steelhead *Oncorhynchus mykiss*, by week, at the Paradise Creek PIT-tag interrogation system from 1 October 2012 to 22 October 2013. The fish were PIT-tagged as parr in Paradise Creek during August and September 2011, 2012, and 2013. Due to snowfall and access issues, the site was not operated from 29 November 2012 to 28 March 2013 and was taken offline for the winter on 22 October 2013. The site was located at rkm 0.5 of Paradise Creek. Shown are first detection dates. Some fish were detected on multiple days.

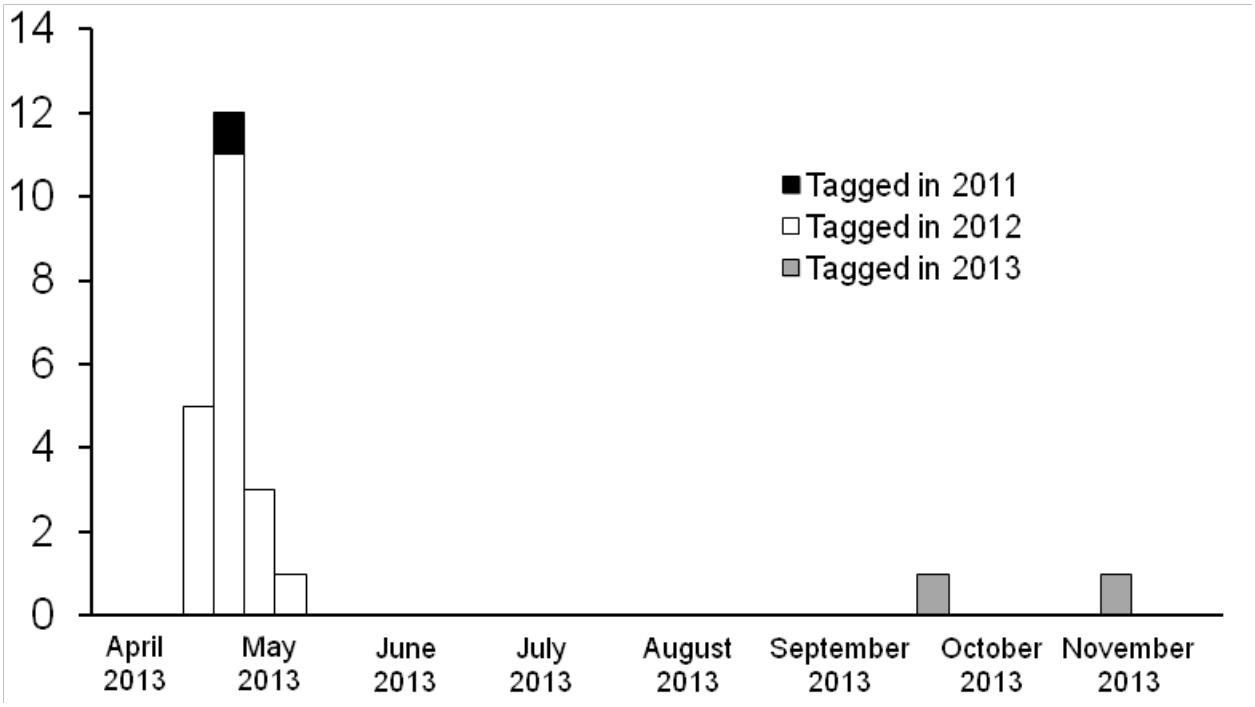


Figure 11. Detections of juvenile steelhead *Oncorhynchus mykiss* (PIT-tagged as parr in Martha Creek between rkm 1.3 and 2.6 during August and September 2011, 2012, and 2013), by week, at the Martha Creek PIT-tag interrogation system from 1 April 2013 to 6 December 2013. The site was located at rkm 1.0 of Martha Creek. Shown are first detection dates for these fish, some fish were detected on multiple days.

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	09/11	06/12[a]
Martha Cr.	45º 47.576'	121º 55.659'	344	1.5	07/12[a]	present
Upper Wind River						
Wind R.	45º 56.985'	121º 55.897'	472	41.0	10/11	07/12[b]
Paradise Cr.	45º 56.939'	121º 56.218'	469	0.4	07/12[b]	present

[a] The Layout Creek thermologger was lost to high flow during winter 2012/2013. It will be replaced during 2013.
[b] The Wind River thermologger was lost to high flow during winter 2012/2013. It will be replaced during 2013.

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 2013. 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	8/6	1.3 - 1.8	149	5
	9/12 & 9/13	1.3 – 2.0	137[a]	47
	8/7	2.3 - 2.6	98	3
Layout	8/8	0.0 - 0.6	79	0
	9/16	0.0 - 0.6	12	9
	8/2	2.5 - 3.0	117	5
	8/16	4.0 - 4.5	37	9
Trout	8/20	11.0 - 11.3	49	2
	9/25	11.0 – 11.3	33	6
Crater	7/30	0.0 - 0.5	77	10
	9/9	0.0 - 0.6	25	15
Wind River				
Trapper	8/15	0.1 - 0.6	95	9
	9/24	0.1 - 0.6	139[b]	20
Paradise	8/13	0.5 - 1.0	66	10
	9/18	0.5 - 1.0	29	30
Wind River	8/19	37.0 - 37.4	97	2
	9/18	37.0 – 37.4	103[c]	3
	8/14	41.0 - 41.5	76	3
	9/19	41.0 - 41.6	39	9
Total			**1,457**	**197**

[a] = includes 136 9-mm PIT tags
[b] = includes 115 9-mm PIT tags
[c] = includes 44 9-mm PIT tags

Table 3. Re-contacts, through November 2013, of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* that were PIT-tagged as parr during August and September 2011 in headwater areas of two watersheds in the Wind River subbasin.

		Re-contacted through November 2013		
Watershed	Number of fish tagged in 2011	Instream recapture	Detected at a PTIS[a]	Detected in Columbia R.[b]
Trout Creek	494[c]	46	5	4
Upper Wind	497	52	3[d]	8

[a] PTIS = PIT-tag interrogation systems (PTIS) in mainstem Trout Creek and Wind River. The Trout Creek PTIS is at rkm 2.0 of Trout Creek, the Upper Wind PTIS is located at rkm 30.0 of the Wind River.
[b] Bonneville Dam or estuary trawl sampling.
[c] Includes 127 fish tagged in Martha Creek, which is downstream of the Trout Creek PTIS.
[d] The upper Wind PTIS began operation in October 2012.

Table 4. Re-contacts, through November 2013, of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* that were PIT-tagged as parr during August and September 2012 in headwater areas of two watersheds in the Wind River subbasin.

		Re-contacted through November 2013		
Watershed	Number of fish tagged in 2012	Instream recapture	Detected at a PTIS[a]	Detected in Columbia R.[b]
Trout Creek	628[c]	69	17	6
Upper Wind	623	74	22[d]	7

[a] PTIS = PIT-tag interrogation systems (PTIS) in mainstem Trout Creek and Wind River. The Trout Creek PTIS is at rkm 2.0 of Trout Creek, the Upper Wind PTIS is located at rkm 30.0 of the Wind River.
[b] Bonneville Dam or estuary trawl sampling.
[c] Includes 121 fish tagged in Martha Creek, which is downstream of the Trout Creek PTIS.
[d] The upper Wind PTIS began operation in October 2012.

Table 5. Re-contacts, through November 2013, of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* that were PIT-tagged as parr during August and September 2013 in headwater areas of two watersheds in the Wind River subbasin.

		Re-contacted through November 2013		
Watershed	Number of fish tagged in 2013	Instream recapture	Detected at a PTIS[a]	Detected in Columbia R[b].
Trout Creek	813[c]	63	2	-[d]
Upper Wind	644	46	2	-

[a] PTIS = Instream PIT-tag interrogation systems (PTIS) in mainstem Trout Creek and Wind River. The Trout Creek PTIS is at rkm 2.0 of Trout Creek, the Upper Wind PTIS is located at rkm 30.0 of the Wind River.
[b] Bonneville Dam or estuary trawl sampling.
[c] Includes 384 fish tagged in Martha Creek, which is downstream of the Trout Creek PTIS.
[d] Juvenile steelhead tagged in 2013 in the Wind River subbasin would not be expected to be subject to detection in the Columbia River as of this writing.

Table 6. Detection efficiency estimates, for PIT-tagged adult steelhead *Oncorhynchus mykiss*, at the new Trout Creek PIT-tag interrogation site (relocated on October 1, 2012). During fall of 2012, some antenna difficulties resulted in decreased detection efficiency. However, by January 2013 the problems had been rectified and system detection efficiency was much increased.

Detection Period	Number of fish detected	Efficiency estimate %	SE	Lower 95% CI	Upper 95% CI
10/01/12 – 12/06/13	62	89.3	3.0	82.0	94.1
10/01/12 – 12/31/12	31	65.7	11.4	41.4	84.1
01/01/13 – 12/06/13	31	99.0	0.8	96.4	99.9

Table 7. Detection efficiency estimates, for PIT-tagged juvenile steelhead/rainbow trout *Oncorhynchus mykiss*, at the new Trout Creek PIT-tag interrogation site (relocated on October 1, 2012) from 1 January 2013 to 6 December 2013. No juvenile PIT-tagged steelhead were detected at the site from October through December 2012.

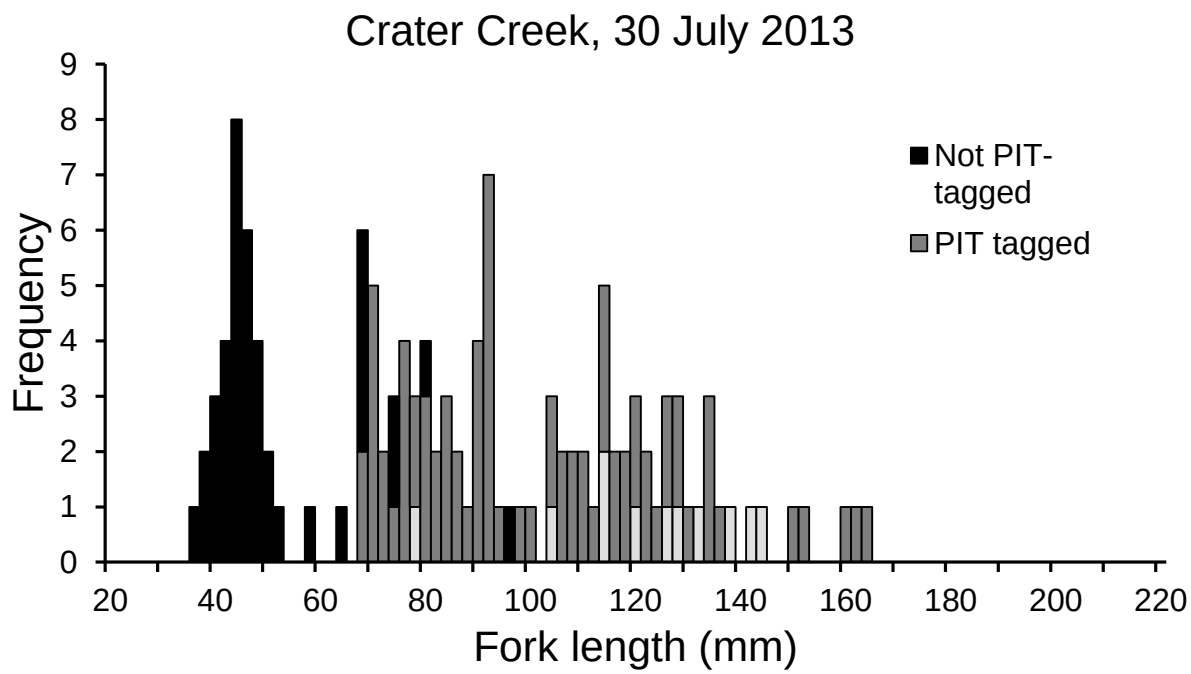
Detection Period	Number of fish detected	Efficiency estimate %	SE	Lower 95% CI	Upper 95% CI
01/01/13 – 12/06/13	21	68.8	11.8	43.0	86.8

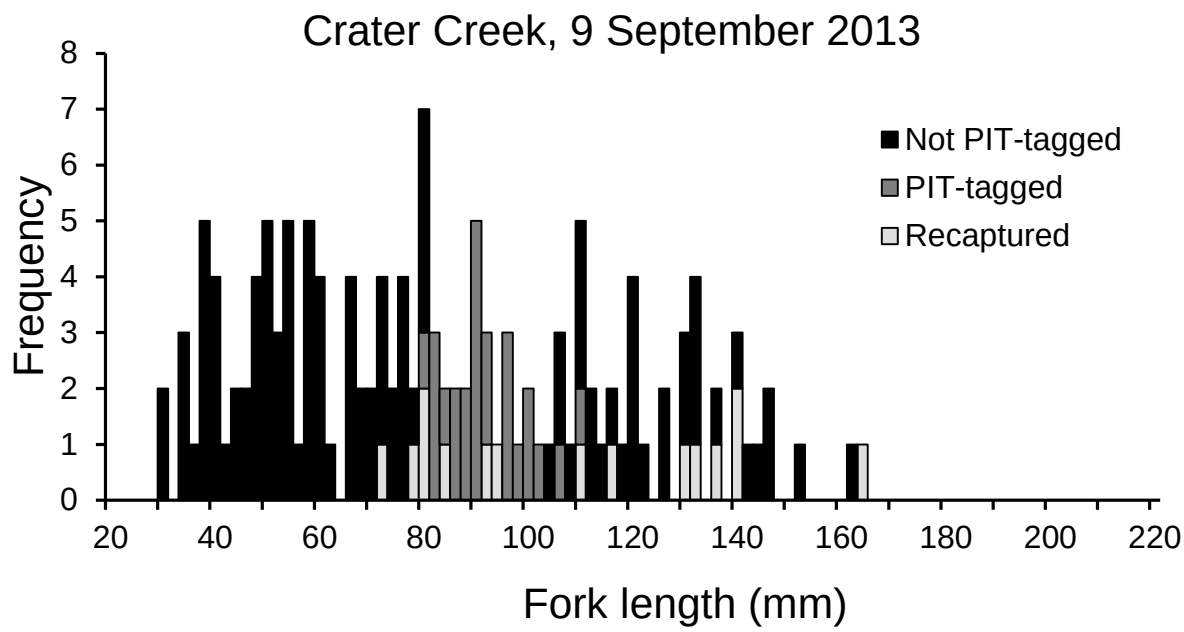
Appendix A: Use of Data & Products

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

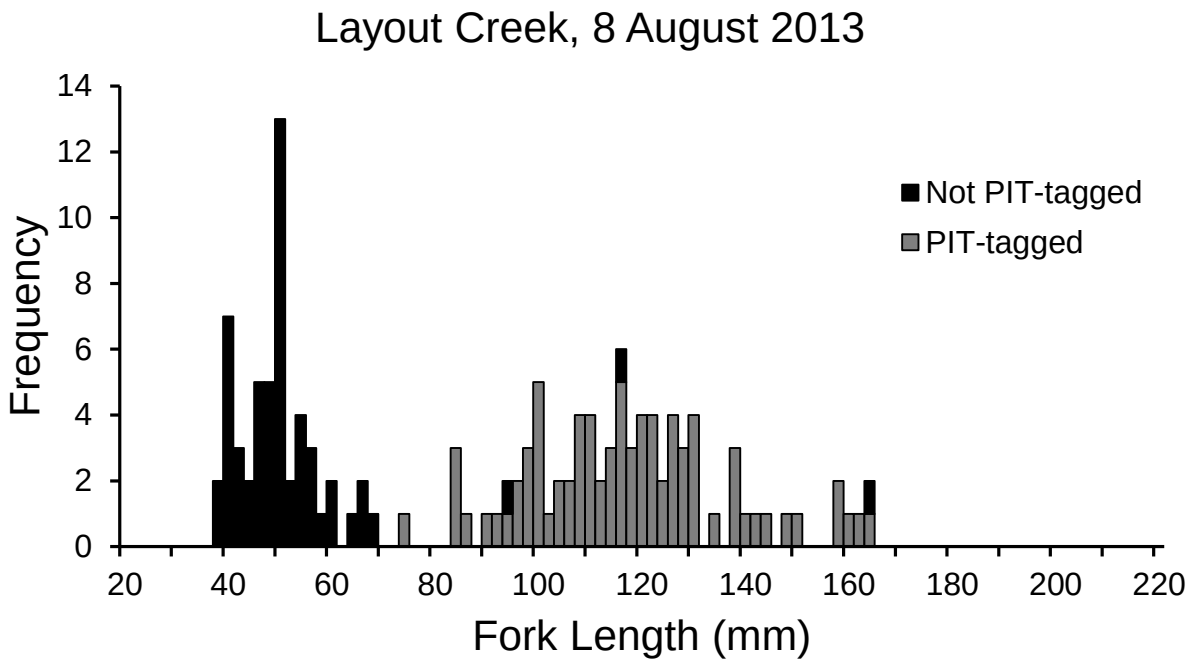
We have submitted water temperature data to the NorWest database.
http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html

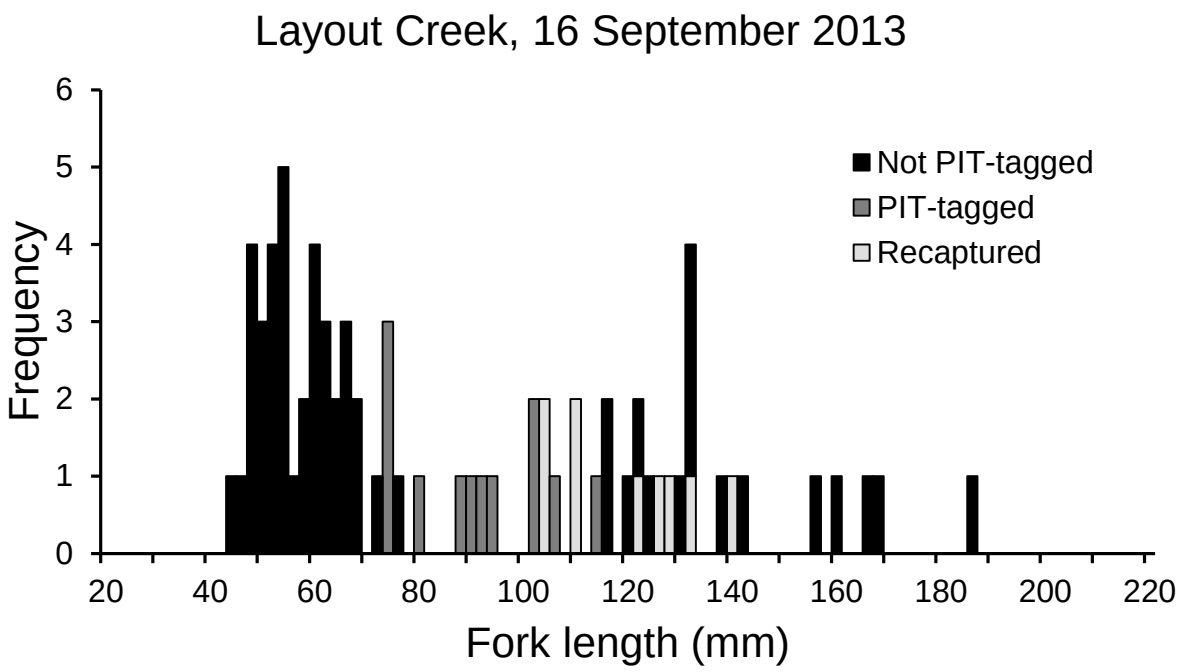
Appendix B: Detailed Results – Length frequency histograms



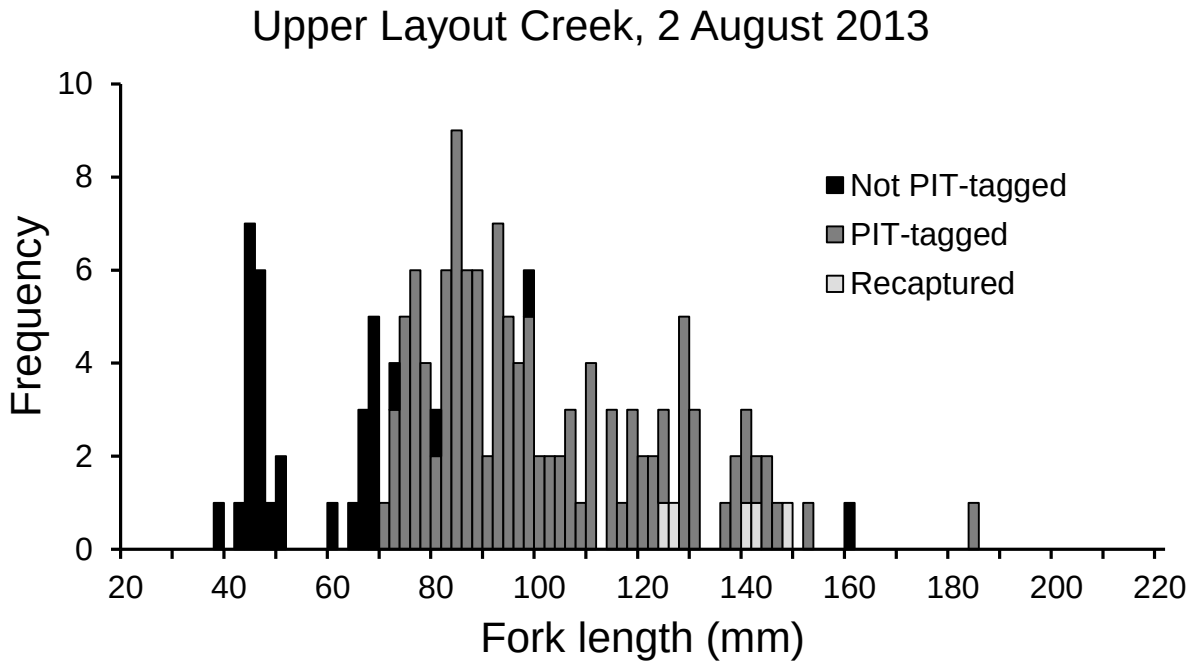


Appendix Figure 1. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Crater Creek (rkm 0 – 0.6), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

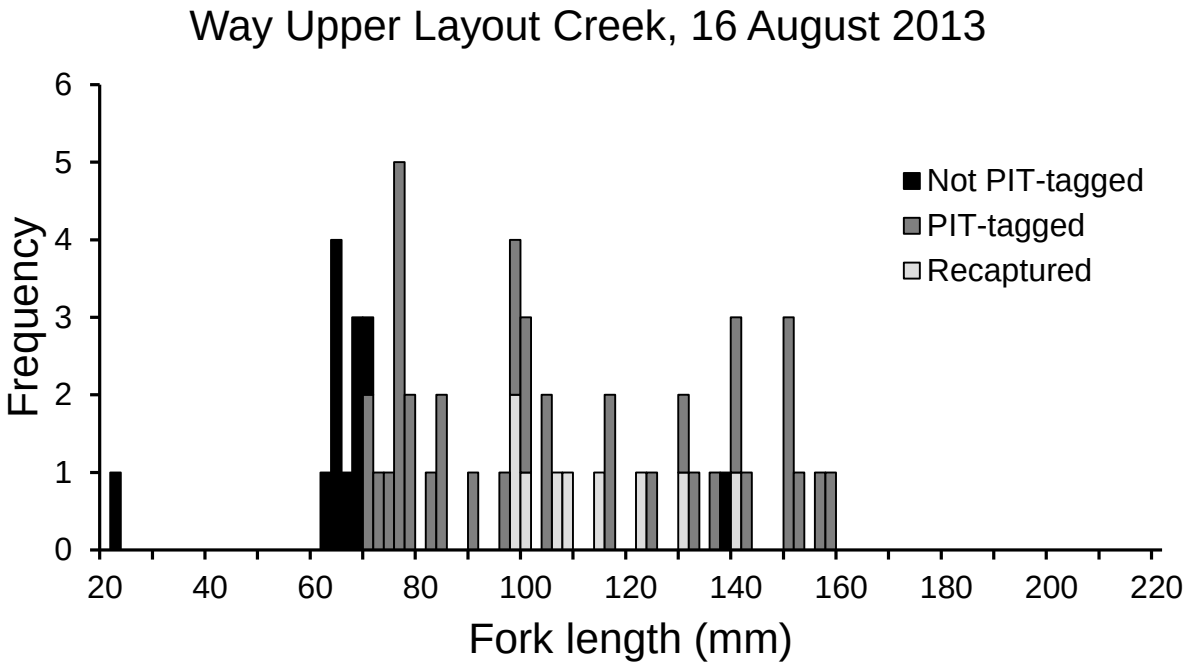




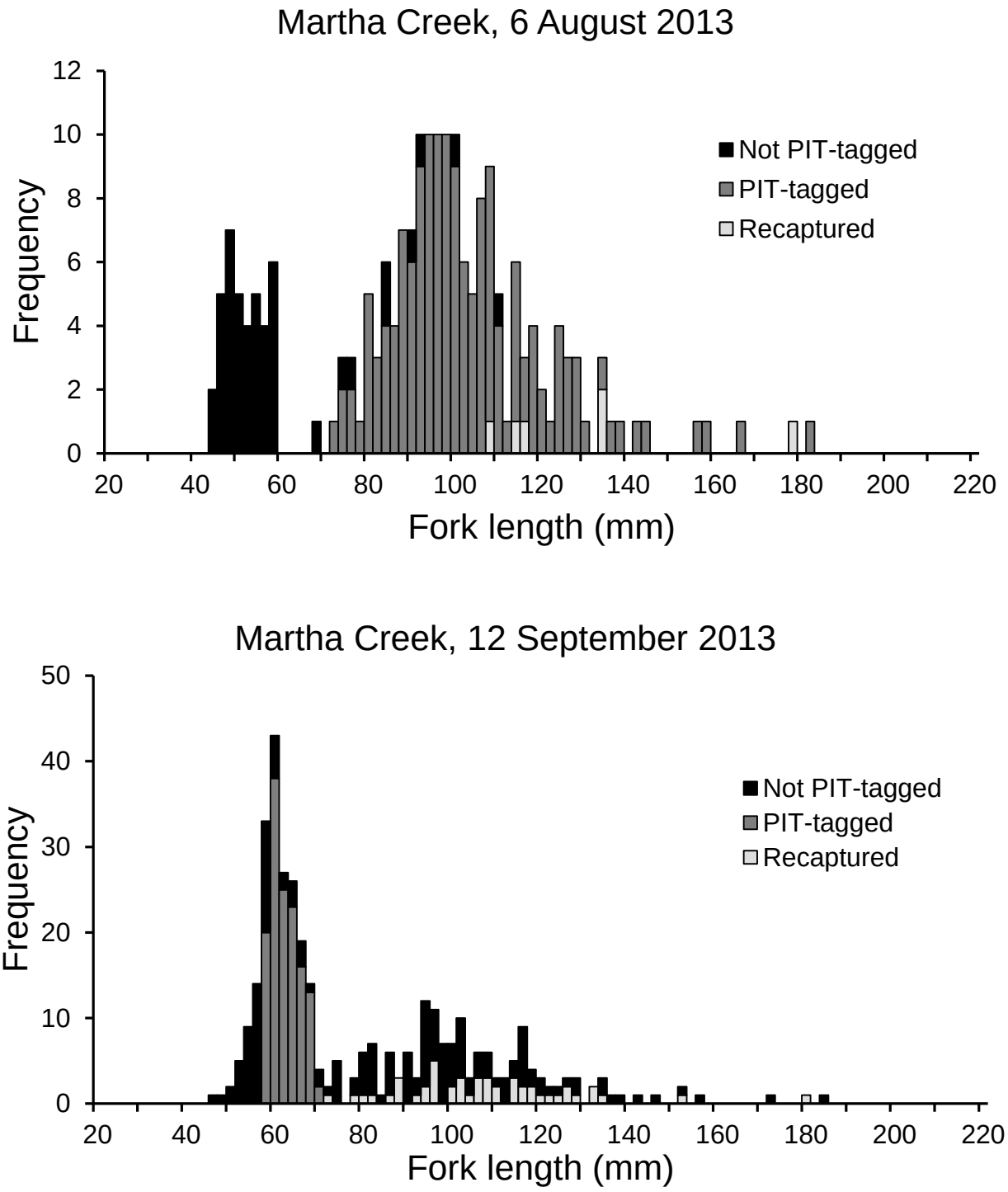
Appendix Figure 2. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Layout Creek (rkm 0 – 0.6), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.



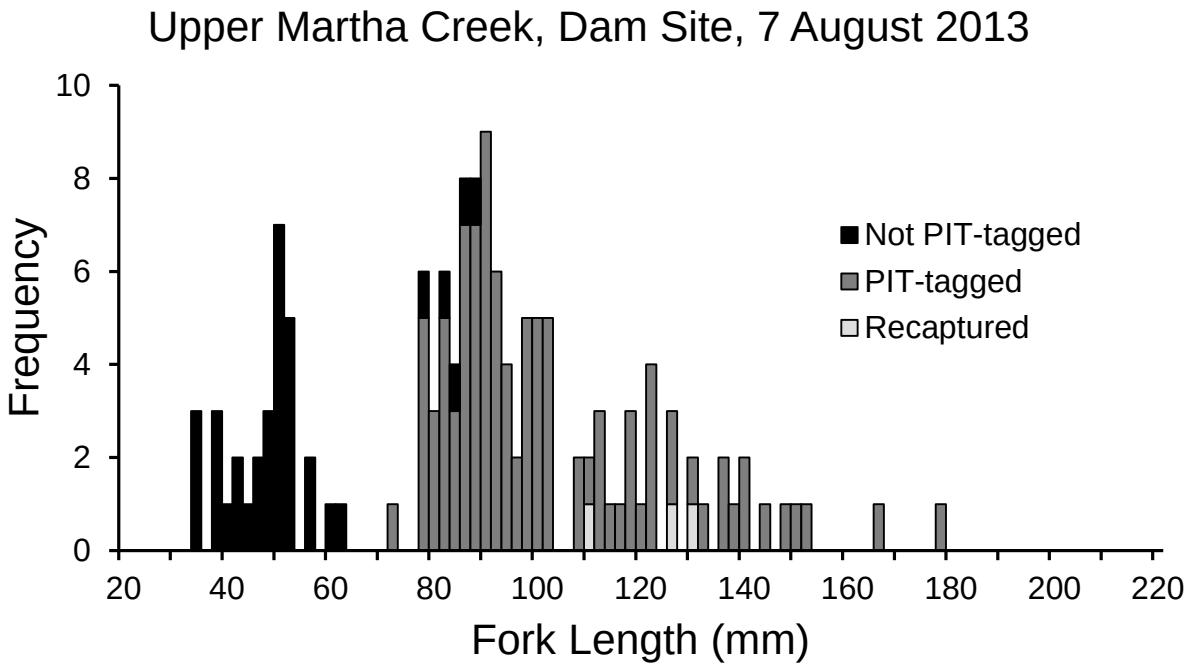
Appendix Figure 3. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Upper Layout Creek (rkm 2.5 – 3.0), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.



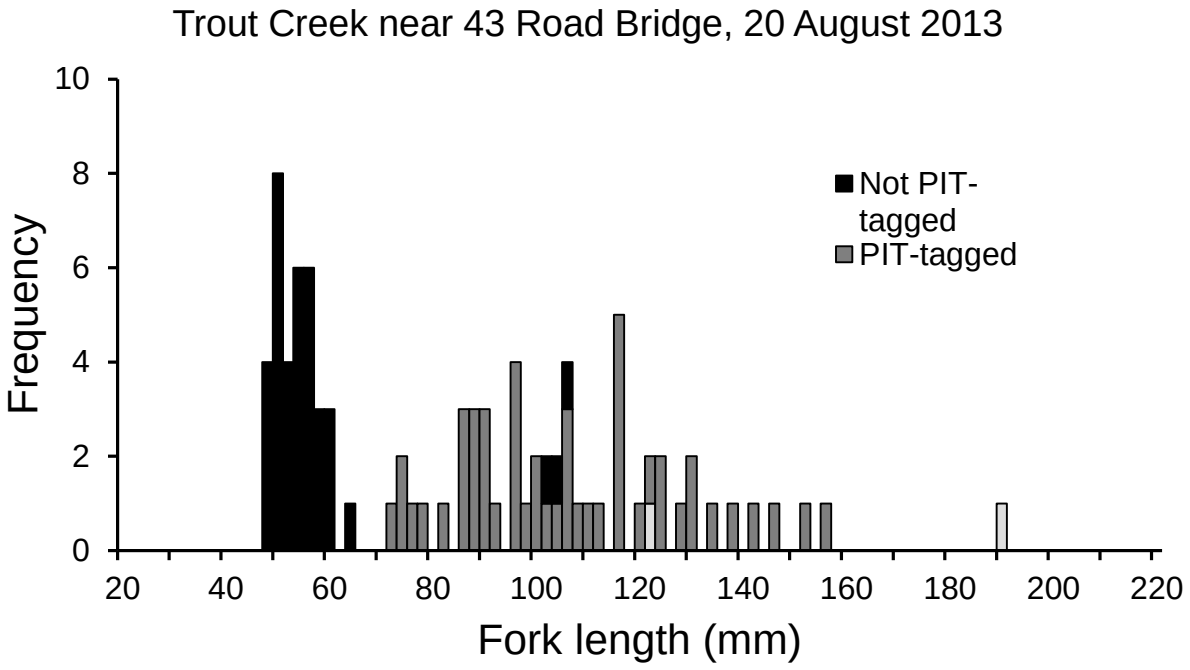
Appendix Figure 4. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Way Upper Layout Creek (rkm 4.0 – 4.5), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

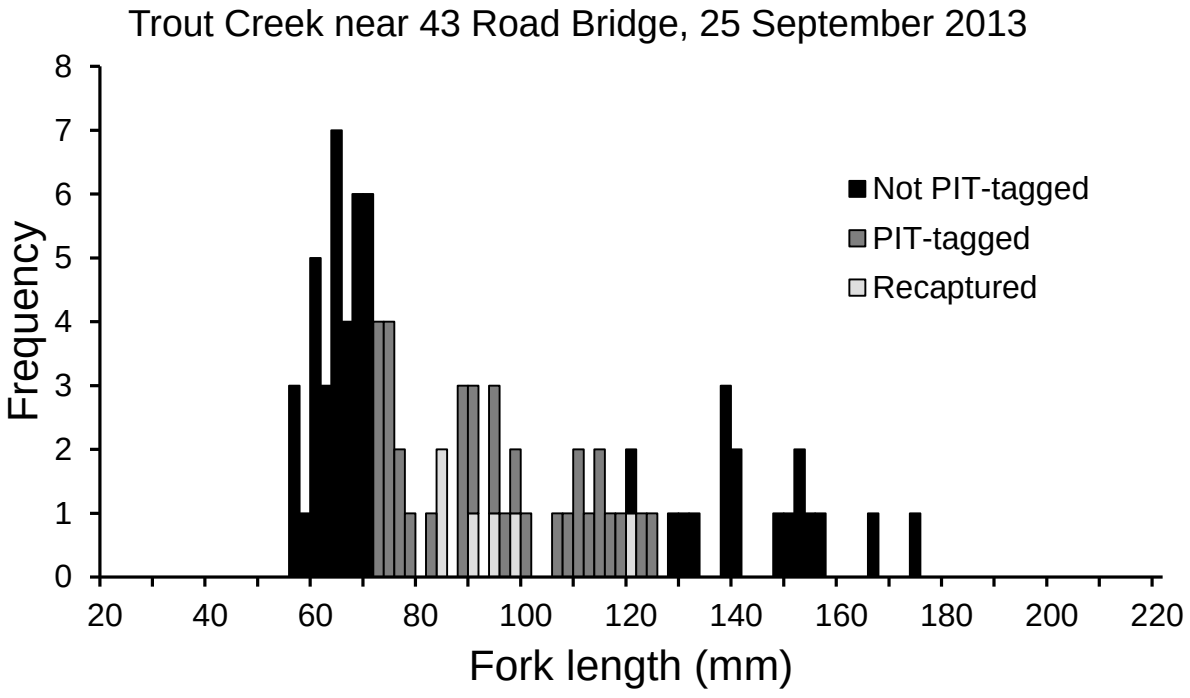


Appendix Figure 5. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Martha Creek (rkm 1.3 – 2.0), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

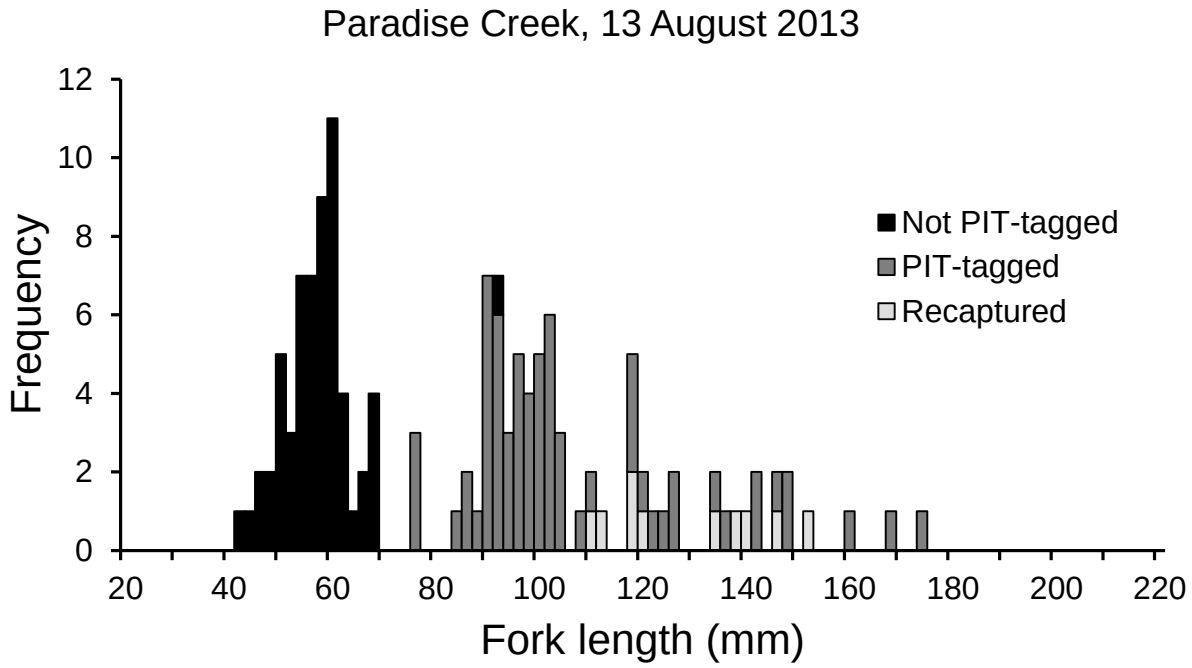


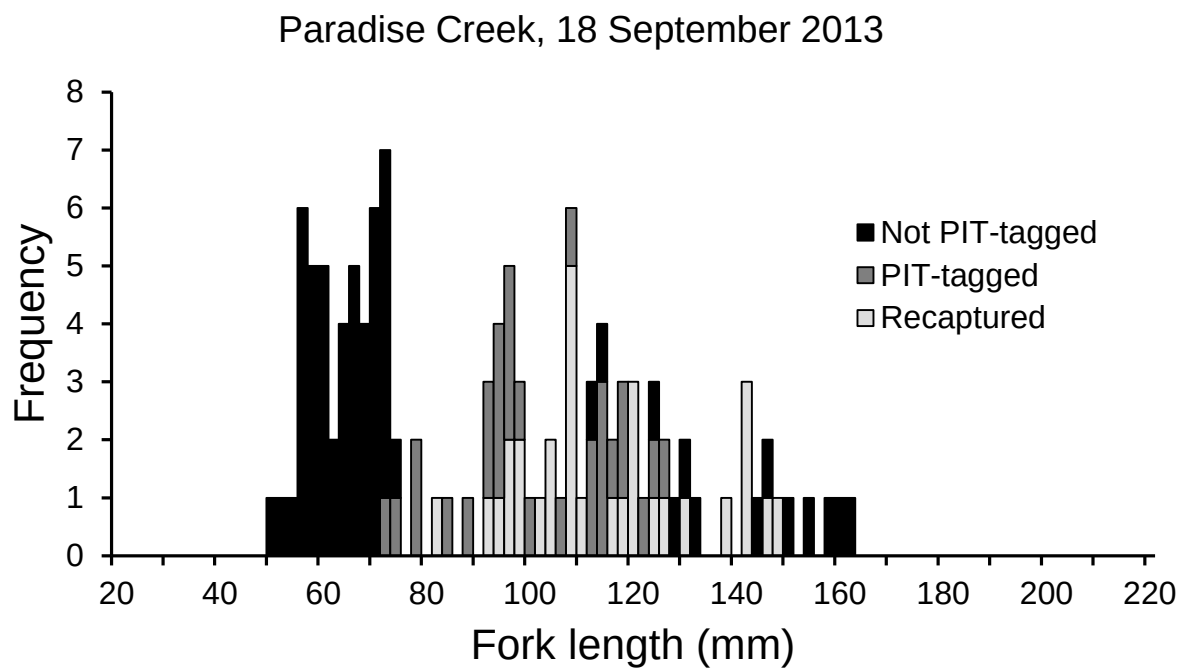
Appendix Figure 6.Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Martha Creek (rkm 2.3 – 2.6), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.



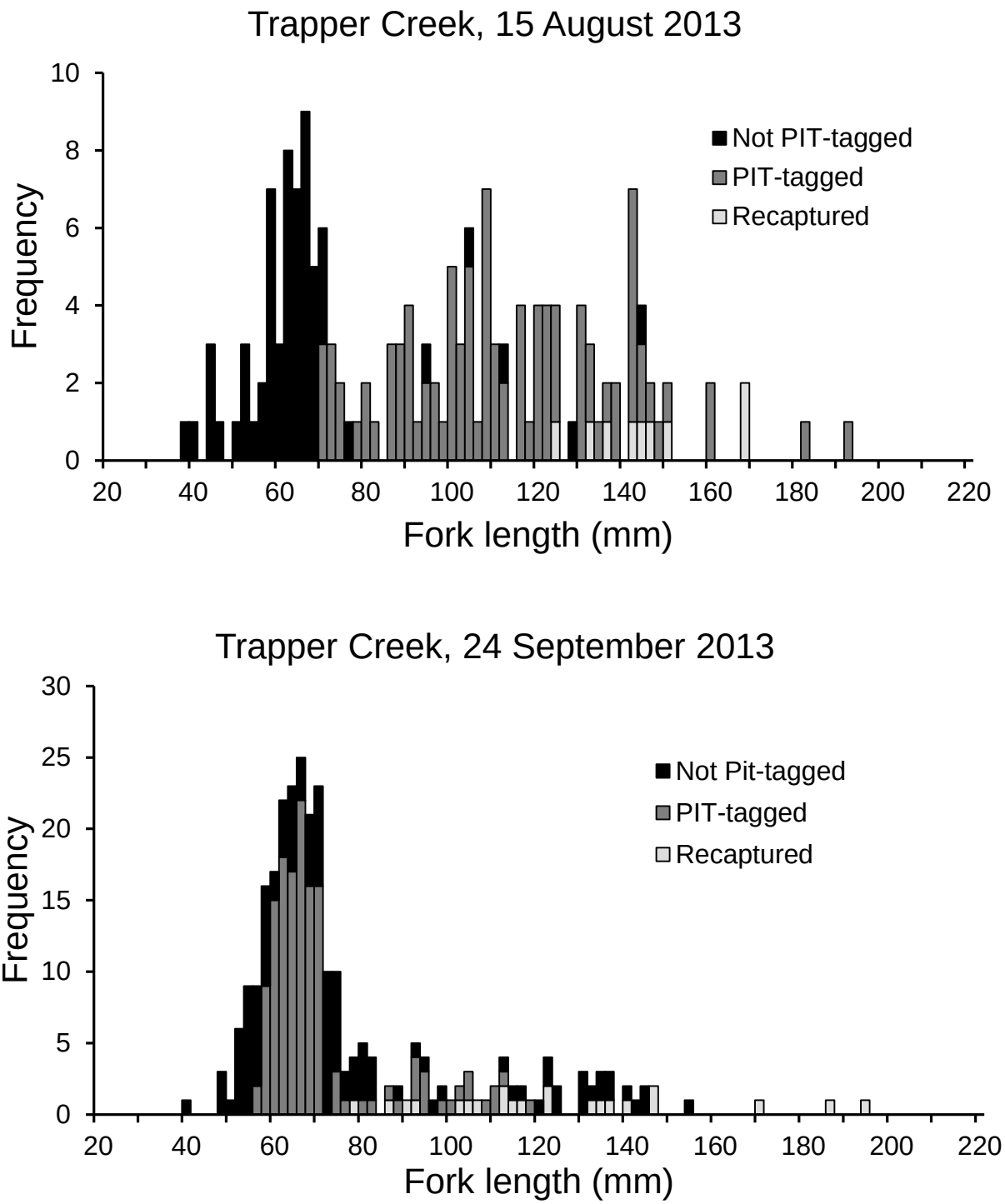


Appendix Figure 7. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Trout Creek (rkm 11.0 – 11.3), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

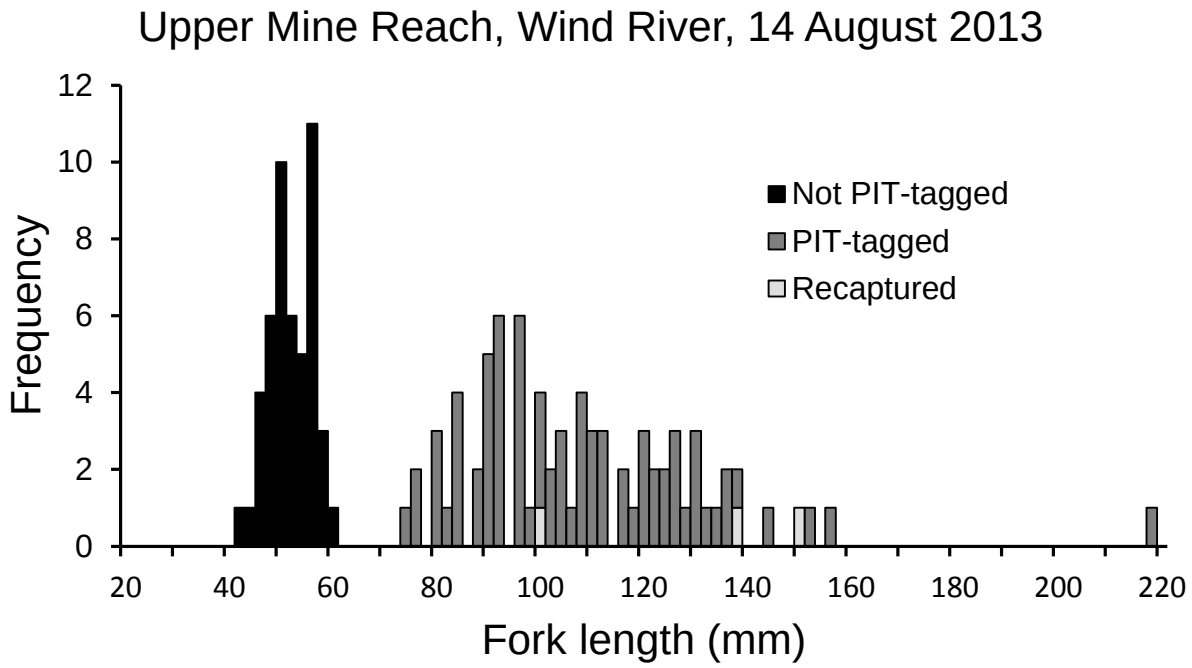


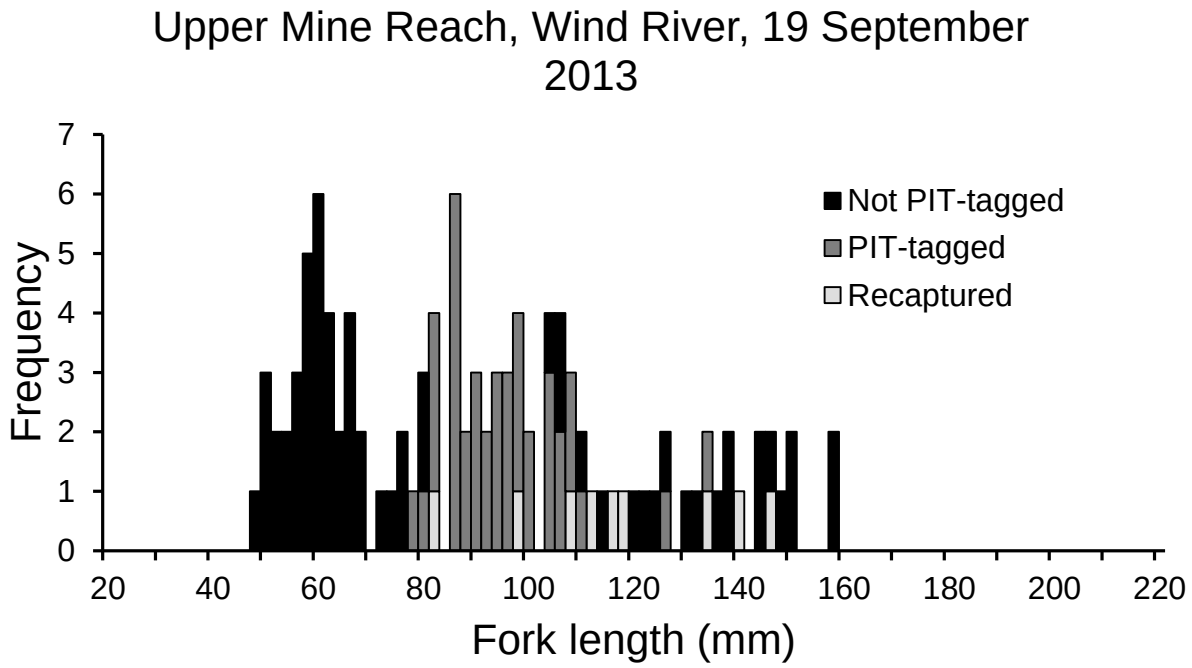


Appendix Figure 8. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Paradise Creek (rkm 0.5 – 1.0), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.

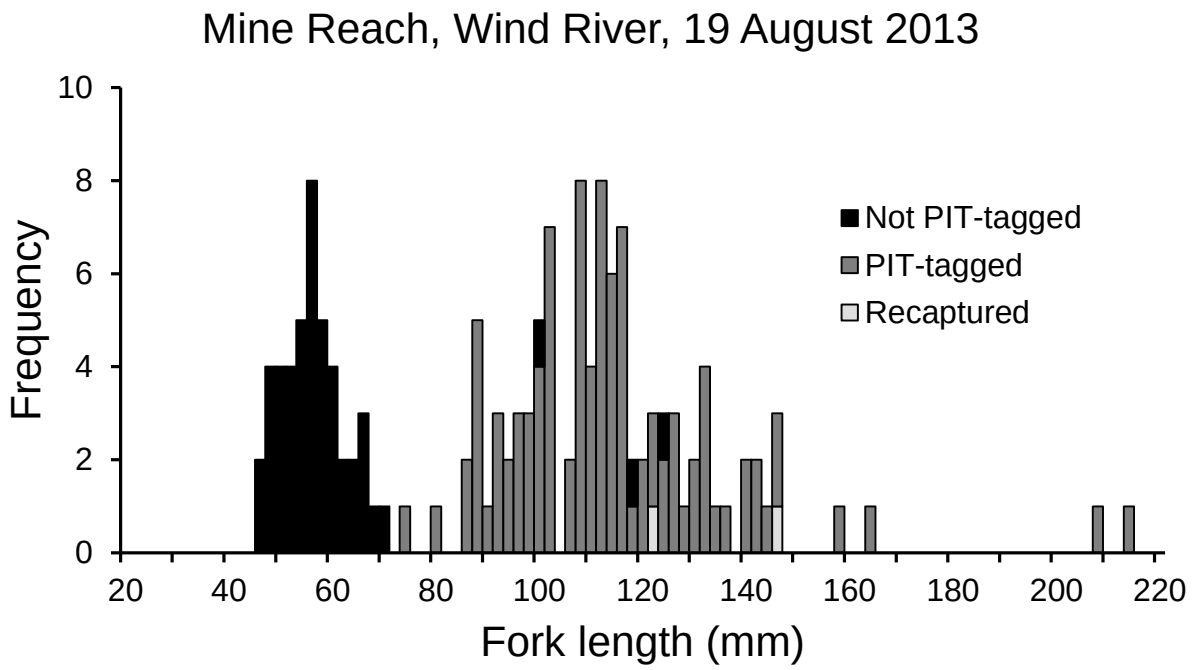


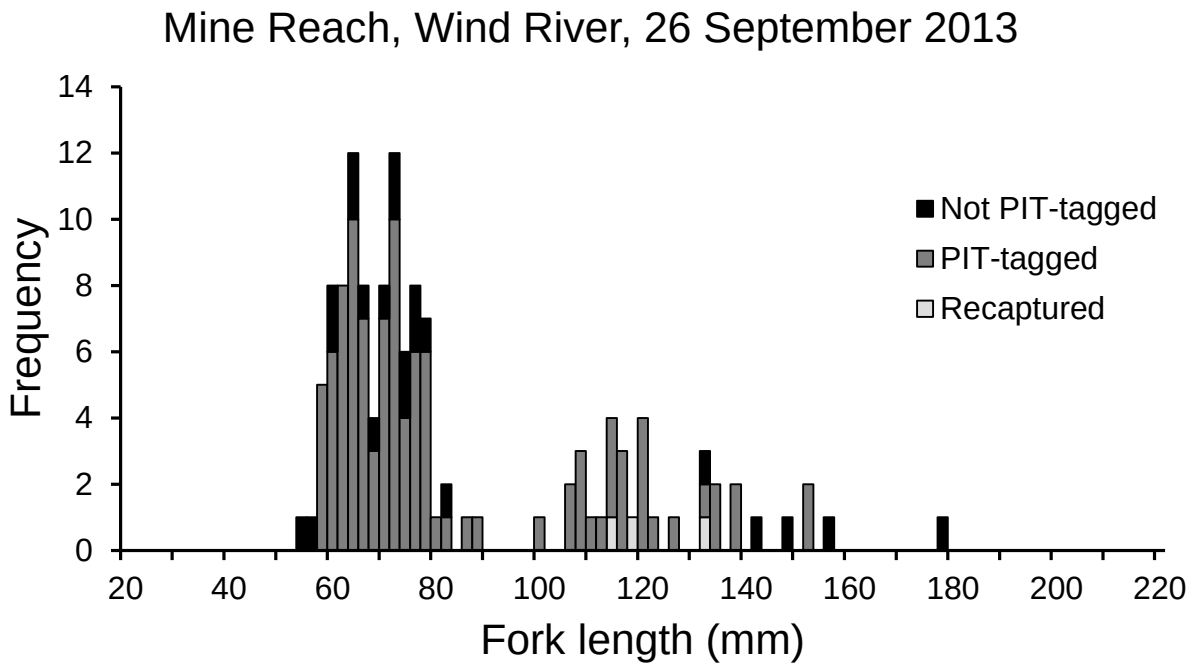
Appendix Figure 9. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in Trapper Creek (rkm 0.1 – 0.6), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.





Appendix Figure 10. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in the Wind River upstream of the confluence with Paradise Creek (rkm 41.0 – 41.6), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.





Appendix Figure 11. Length frequencies of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* in the Wind River (rkm 37.0 – 37.4), sampled by electrofishing during 2013. Some fish were tagged with Passive Integrated Transponder (PIT) tags and some were recaptures of fish previously PIT-tagged.