U.S. Fish and Wildlife Service

Clackamas River Bull Trout Reintroduction Project

2017 Annual Report

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U.S. Fish and Wildlife Service
Columbia River Fish and Wildlife Conservation Office

On the cover: *Pinhead Creek weir, Clackamas River Subbasin (Photo by M. Barrows, USFWS)*

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CLACKAMAS RIVER BULL TROUT REINTRODUCTION PROJECT 2017 ANNUAL REPORT

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Over 40 years after the last bull trout (*Salvelinus confluentus*) was documented in the Clackamas River in 1963, a 2007 feasibility study determined the Clackamas River Subbasin to be a promising candidate for bull trout reintroduction. A reintroduction effort began in 2011, with the goal of re-establishing a self-sustaining population of spawning adults (between 300 and 500) by the year 2030. The final year of translocating bull trout from the Metolius River Subbasin to designated locations in the upper Clackamas River and select tributaries was 2016. The seventh year of the project marks the beginning of the second phase where the primary objectives were to monitor and evaluate the reintroduction effort. During 2017, progress has continued to be made toward the project's goal. The effectiveness of the reintroduction strategy was assessed by describing the seasonal distribution of translocated bull trout, assessing reproduction, and characterizing potential impacts to Endangered Species Act-listed salmon and steelhead that currently occupy the Clackamas River Subbasin. A video monitoring weir with an associated adult trap and passive integrated transponder (PIT) antenna was employed in Pinhead Creek to assess the spawning population. The spawning population was comprised of translocated individuals released at every lifestage during the years of 2012 – 2016, confirming survival and recruitment into the adult population. The 34 individuals subsampled at the weir trap were relatively large, migratory fish and ranged in size from 462 – 653 mm TL. Of the bull trout observed at the weir, 92% of males and 55% of females were previously PIT-tagged. Since all translocated fish were PIT-tagged, the presence of untagged fish suggests at least some of the spawners may be naturally produced offspring, though the disparity between the ratio of tagged to untagged males and females may indicate an elevated rate of tag shedding in females. There were six translocated fish with PIT detection histories that suggested a possible resident component of the Pinhead Creek population. The number of bull trout using Pinhead Creek during the spawning season has increased since the early years of the reintroduction effort. We estimated nearly 100 individuals in 2017, and redd counts throughout the study area reached their highest (N = 89) since the initiation of the reintroduction effort. In addition, in 2017 we confirmed multiple bull trout redds in Pinhead Creek resulted in viable embryos and hatching (i.e., alevins). However, monitoring efforts have not provided evidence of post-emergent juveniles, or confirmed the recruitment of naturally-reproduced individuals into the spawning population, both of which are major benchmarks in the overall goal of establishing a self-sustaining population of bull trout in the Clackamas River Subbasin. These benchmarks may be achieved over time as the reintroduction effort progresses and the population develops. Implementation and monitoring of the reintroduction project will continue to be evaluated on an annual basis and the reintroduction strategy will be adaptively managed.

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Introduction

Bull trout (*Salvelinus confluentus*) are native to the Pacific Northwest, but in response to a general decline in abundance across their native range, the U.S. Fish and Wildlife Service (USFWS) listed bull trout as threatened under the Endangered Species Act (ESA) in 1999 (64FR 58910). Bull trout have very specific habitat requirements including clean and cold water with complex and connected habitats (Rieman and McIntyre 1995; USFWS 2015a). Barriers to migration, habitat degradation, the introduction of non-native species, and other anthropogenic actions have negatively affected bull trout populations (Fraley and Shepard 1989; Leary et al. 1993). At the time of listing in 1999, bull trout were estimated to occupy only 40 percent of their historical range within portions of Oregon, Washington, Montana, Idaho and Nevada (USFWS 2002a).

The reestablishment of viable local populations in watersheds where bull trout have been extirpated is a primary recovery goal in the USFWS's Final Bull Trout Recovery Plan (USFWS 2015a). In watersheds where connectivity impairment (e.g., barriers, distance, etc.) is likely to prevent natural recolonization, reintroduction activities such as direct translocation from more robust populations may be warranted. Bull trout have been extirpated in multiple Willamette River subbasins, including the Clackamas River (Figure 1). Bull trout recovery in the Willamette River Basin is focused primarily on reducing and minimizing threats affecting bull trout and their habitat, but due to widespread extirpations and the size of the basin, natural recolonization may be unlikely, thus requiring reintroduction into some areas to establish self-sustaining populations. A successful reintroduction leading to one or more established bull trout local populations in the Clackamas River Core Area will help to expand bull trout distribution and possibly increase population connectivity within the Coastal Recovery Unit (USFWS 2015b).

This report details the progress in the seventh year (2017) of the joint effort between the Oregon Department of Fish and Wildlife (ODFW), USFWS, U.S. Forest Service (USFS), and other collaborators (i.e., the Confederated Tribes of Warm Springs Reservation [CTWSR], National Marine Fisheries Service [NMFS], Portland General Electric [PGE], and the U.S. Geological Survey [USGS]) to reintroduce bull trout into the Clackamas River. Implementation of this project began following publication of a final rule establishing a nonessential experimental population of bull trout in the Clackamas River under section 10(j) of the ESA (76 FR 35979 on June 21, 2011). The first transfers of bull trout to the Clackamas River Core Area from robust populations in the Metolius River Subbasin occurred during the spring and summer of 2011 (ODFW 2012). The final transfers of bull trout to the Clackamas River Core Area occurred during the spring and summer of 2016 (Barrows et al. 2017). This report format is structured, where appropriate, to address the questions listed in sections 3.2 and 3.3 of the Implementation, Monitoring, and Evaluation (IM&E) Plan developed by the USFWS Oregon Fish and Wildlife Office and Columbia River Fish and Wildlife Conservation Office (USFWS 2011a). Additional reintroduction project background and management strategy information can be found in that plan (www.fws.gov/oregonfwo/Species/Data/BullTrout/Documents/ClackamasBT_IME_Plan.pdf).

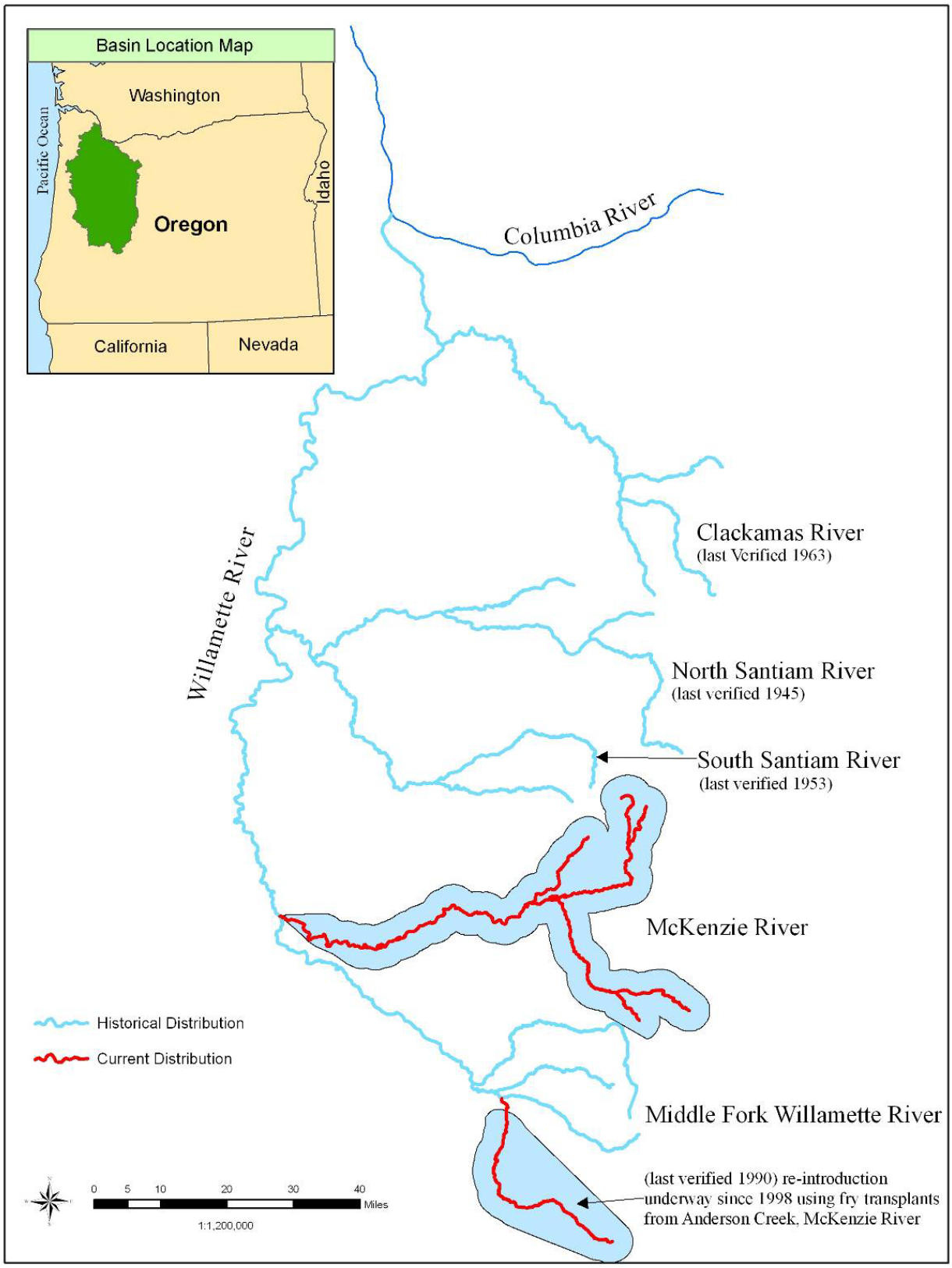


Figure 1. Historical and current bull trout distribution in the Willamette River Basin.

The goal of this project is to re-establish a self-sustaining bull trout population of 300 – 500 spawning adults in the Clackamas River Subbasin by 2030. The amount of suitable habitat within the Clackamas River Subbasin suggests there is the necessary habitat to support a population of 300 – 500 spawning adults, but even in core areas with abundant suitable habitat, distribution is often patchy; thus, the actual capacity of the Clackamas River Subbasin for bull trout is not known. For this project, we define a self-sustaining population as one that maintains a minimum adult annual spawning abundance of 100 individuals, contains a level of genetic diversity representative of the donor stock, and requires little or no additional transfers. The numerical goal of 300-500 spawning adults originated with recovery planning targets set in the Bull Trout Draft Recovery Plan (USFWS 2002b) for the abundance necessary to achieve these characteristics. Accomplishing this goal will help achieve conservation and recovery goals within the Coastal Recovery Unit (USFWS 2015b).

The actions described in this report are intended to address the following broad objectives:

1) Monitor and evaluate the effectiveness of the bull trout reintroduction strategy for re-establishing a self-sustaining bull trout population in the Clackamas River Subbasin.

2) Evaluate the effects of bull trout reintroduction on ESA-listed salmonids in the Clackamas River Subbasin.

Study Area

The study area includes the Clackamas River Subbasin upstream of River Mill Dam (Figure 2).

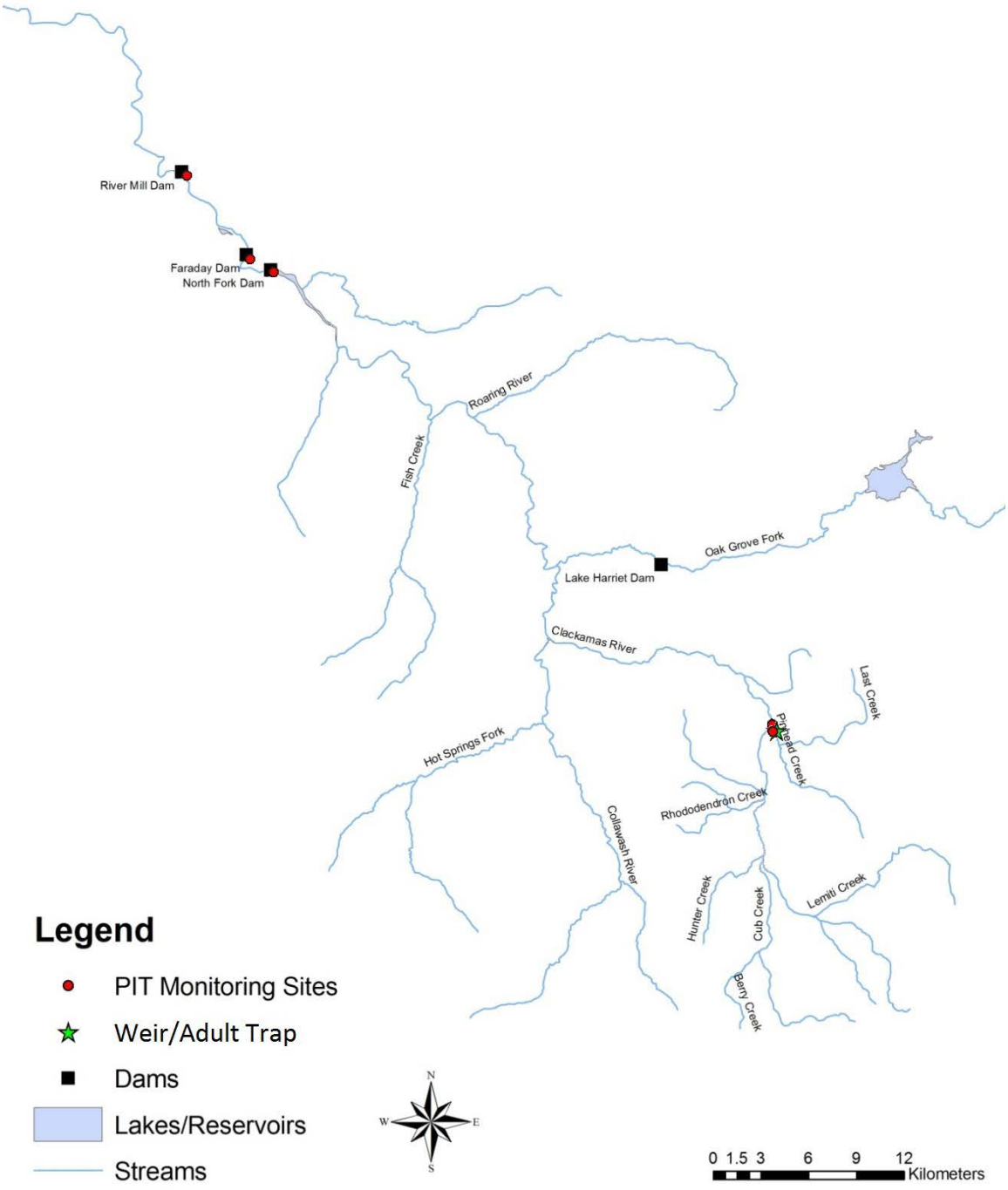


Figure 2. Locations of current monitoring sites in the study area. Multiple PIT monitoring antennas were located throughout PGE's hydro power facilities. A PIT tag monitoring site was installed with the Pinhead Creek weir and was operational from mid-July to early October 2017 while the weir was deployed.

Methods

Implementation

The final year of translocating bull trout from the Metolius River Subbasin to the Clackamas River Subbasin was 2016. Beginning in 2011 and continuing through 2016, juvenile bull trout were translocated to select tributaries, and subadults and adults were released directly into the upper Clackamas River. No additional translocations are planned for phase two of the reintroduction.

Monitoring and Evaluation

We used an established instream half-duplex (HDX) passive integrated transponder (PIT) tag detection array at the mouth of Pinhead Creek, observations at the Pinhead Creek video weir and trap, the PIT tag monitoring sites at PGE facilities and other monitoring efforts to document the behavior and seasonal distribution of juvenile, subadult and adult fish and to help address the following broad questions identified in the IM&E Plan (USFWS 2011a):

1) Do translocated bull trout remain in the upper Clackamas River Subbasin (above River Mill Dam), and if they leave the study area, do they return?

2) What are the seasonal movement patterns and distribution of bull trout in the Clackamas River Subbasin?

3) Which release groups constituted the current spawning population in the Clackamas River Subbasin?

4) Is there evidence of locally produced of progeny, and if so, were they recruited into the spawning population?

5) Which individuals (and release groups) produced offspring?

6) Do bull trout occupy areas in High Vulnerability Zones (HVZs) in which they could impact listed salmon and steelhead?

Movement and Seasonal Distribution

The radio-telemetry program ended in 2014, limiting our ability to monitor movement patterns and seasonal distribution. However, movement patterns and seasonal distribution of juvenile, subadult and adult bull trout can be inferred from PIT tag detections at the mouth of Pinhead Creek, observations at the Pinhead Creek weir and at Clackamas Hydro Project PIT antennas.

In 2017, four HDX PIT tag antennas were used to monitor bull trout presence and movement at the mouth of Pinhead Creek (two antennas per channel). In addition to the PIT array at the mouth, a single PIT antenna was operated within the Pinhead Creek weir video chute

approximately 150 meters upstream of the Pinhead-Clackamas confluence. Both the mouth and the weir PIT sites were powered by solar panels and utilized a Xantrex solar charge controller (XW-MPPT60-150), a battery switcher from West Fork Environmental (WFE-1c-AV), two 12-volt battery banks, and an Oregon RFID Multi-Antenna HDX Reader. The Pinhead mouth PIT array operated continuously from April 4 to November 6, 2017. The antenna located in the weir was in place from July 13 to October 1, 2017, but was not operational for 14 days due to technological malfunction (see Table 4).

In addition to the Pinhead Creek detection sites, a total of 13 established PIT detection arrays were operated by PGE at various facilities associated with the Clackamas Hydro Project (Figure 3). Eight of the arrays (9 antennas) were operated with KarlTek (KLK5000) PIT tag readers and five (12 antennas) with Oregon RFID readers. Table 1 is a summary of the PIT detection arrays at the Clackamas Hydro Project.

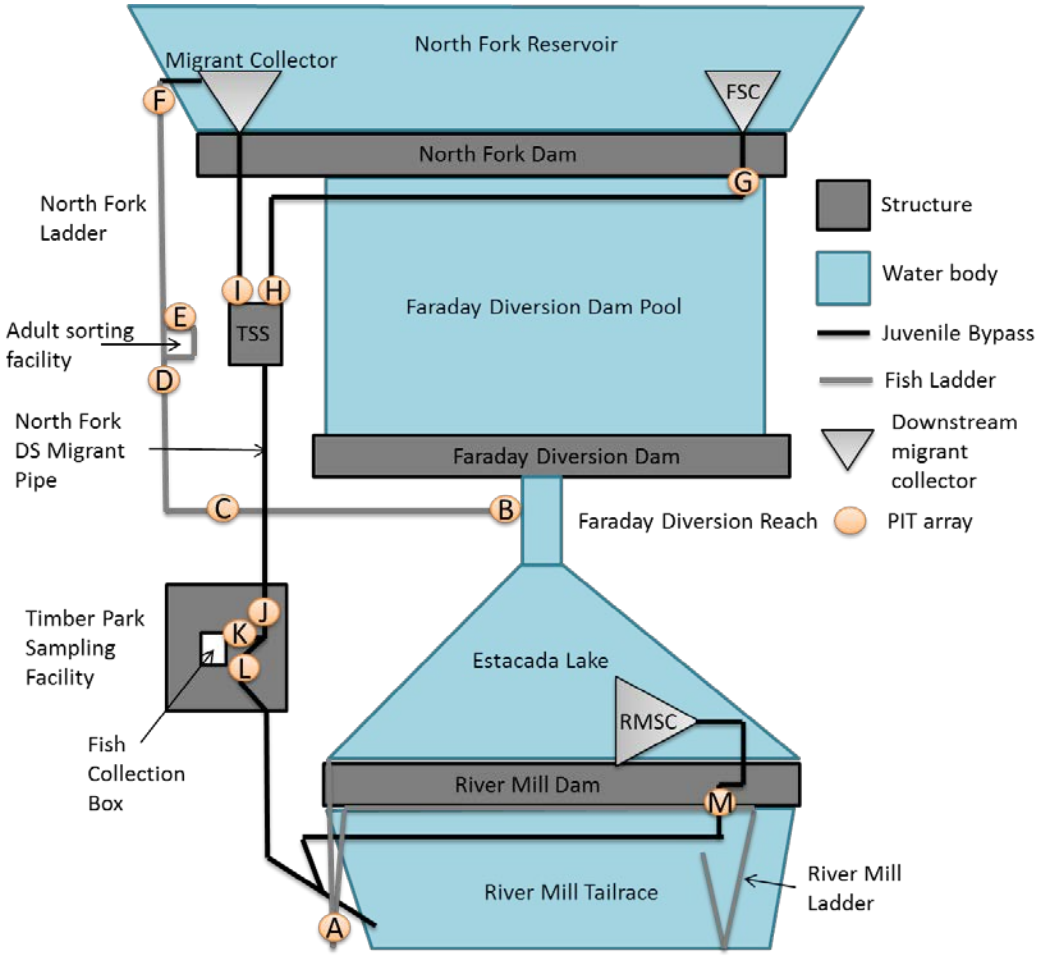


Figure 3. Schematic of PIT antenna array at the Clackamas Hydro Project. FSC = Floating surface collector; TSS = Tertiary screen structure; RMSC = River Mill surface collector. (Figure provided by Portland General Electric.)

Table 1. PIT detection arrays at the Clackamas Hydro Project. (Information provided by Portland General Electric)

Array	Datalogger	Operated Since	Antennas	Site Purpose
A	KarlTek KLK5000	Apr 2013	2	Detect fish passing through the River Mill ladder.
B	Oregon RFID	May 2015/16	2	Detect fish at the entrance of the North Fork fish ladder.
C	OregonRFID	May 2013	4	Detect fish near (upstream and downstream) the old adult sorting facility (North Fork ladder).
D	OregonRFID	Apr 2017	2	Detect fish approaching the adult sorting facility
E	OregonRFID	May 2016	1	Detect fish exiting the adult sorting facility.
F	OregonRFID	May 2015	3	Detect fish exiting the North Fork ladder.
G	KarlTek KLK5000	Oct 2015	1	Detect fish from the FSC just downstream of the flow control structure.
H	KarlTek KLK5000	Oct 2015	1	Detect fish from the FSC just upstream of the tertiary screen structure.
I	KarlTek KLK5000	Oct 2015	1	Detect fish from the North Fork migrant collector just prior to entering the tertiary screen structure.
J	KarlTek KLK5000	Dec 2011	1	Detect fish in flume entering Timber Park.
K	KarlTek KLK5000	Dec 2011	1	Detect fish diverted into the sampling box at Timber Park.
L	KarlTek KLK5000	Dec 2011	1	Detect fish bypassed back to the pipeline at Timber Park.
M	KarlTek KLK5000	Jan 2013	1	Detect fish in the River Mill Surface Collector.

Reproduction

Redd Surveys

Census redd surveys were conducted in potential bull trout spawning habitat in the upper Clackamas River and several major tributaries. Surveys were conducted every two weeks, beginning prior to the spawning season (mid-August) and continued through October 2017. Details concerning the specific methods and survey locations can be found in Appendix C.

Video Weir and Trap

The goal of this effort was to monitor and assess the spawning bull trout population in Pinhead Creek with respect to the objectives identified in the Clackamas River Bull Trout Reintroduction IM&E Plan (USFWS 2011a). This inaugural sampling effort was intended to address the following objectives:

Objective 1). Determine the suitability of weir location in Pinhead Creek.

Objective 2). Estimate the number of bull trout spawners in Pinhead Creek.

Objective 2a). Estimate the tagged to untagged ratio of adult bull trout.

Objective 2b). Calibrate bull trout redd surveys in Pinhead Creek.

Objective 3). Document natural production in Pinhead Creek.

Objective 4). Determine growth rates of translocated bull trout in Pinhead Creek.

Objective 5). Estimate tag retention rate of translocated bull trout in Pinhead Creek.

To address the objectives, a two-way fixed picket weir and underwater video system was operated on Pinhead Creek, a tributary to the Clackamas River, from July 13, 2017 through October 1, 2017 in cooperation with ODFW (NOAA 4[d] and Oregon Scientific Take Permit #21002). The confluence of Pinhead Creek is located at river kilometer 109 and the weir was installed between Last Creek and the NF-46 bridge, about 0.1 kilometers from the mouth. The video chute and upstream trap box were positioned in parallel on river right and both leads of the weir were angled to funnel the fish to the chute and trap box (Figure 4). During periods when fish were not sampled via the trap box, fish were able to migrate in either direction through the video chute. A PIT antenna was incorporated into the video chute to monitor movements of individual PIT-tagged fish. While the upstream trap box was set, an exclusion gate (Figure 5) was added to the video chute to prevent fish from moving upstream while allowing fish to freely migrate downstream and be monitored. The leads were constructed using schedule 40 aluminum pipe held together with two 3/8 inch cables with ¾ inch spacers between each picket (Figure 6). T-posts were secured into the large cobble substrate to support the leads upright, and additional T-posts were installed at an angle to provide resistance to downstream pressure. Sandbags and rocks were placed where needed along the bottom of each of the leads and along the banks to make the weir fish-tight.

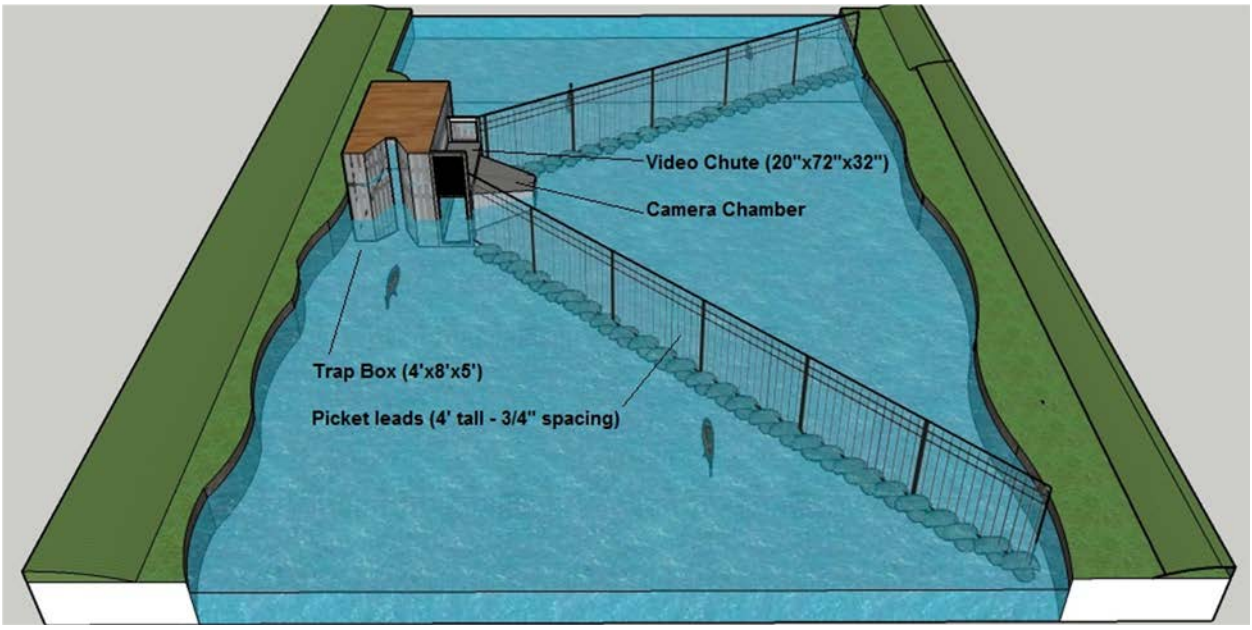


Figure 4. Schematic of the Pinhead Creek weir and trap.

Figure 5. Exclusion gate for video chute.

Figure 6. Photo depicting the aluminum picket leads, video chute and trap box deployed in Pinhead Creek.

The underwater video system design closely resembled that of Anderson et al. (2006) on Big Creek near King Salmon, Alaska. A Sony 291,000 pixel Super hole-accumulation diode (HAD) charged-coupled device imager with an auto-iris 3.6-mm wide angle lens and three 12-V LED pond lights were mounted inside a sealed video box made of aluminum sheeting and attached to the video chute (Figure 7). On the front of the camera box parallel to the video chute was a safety glass window sealed by rubber gaskets. The camera box was filled with water and sealed to prevent river water from entering the camera box and to provide clear viewing into the video

chute. The backdrop inside the video chute was constructed with white laminate flooring mounted on a sheet of plywood. Vertical lines (10 cm spacing) were placed on the backdrop to allow the video viewer to make an estimate of fish size. A PIT tag antenna was incorporated into the video chute. The PIT detection data was downloaded from the site once a week and correlated to the video footage. All video images were recorded on two SecuMate Mini Portable DVRs and stored on 8 GB SDHC memory cards. Both the primary and backup DVRs were equipped with motion detection to record all fish activity. The primary DVR was set to cease recording when the memory card was full. The backup DVR was set to record in a loop when the memory card was full, recording at the beginning, erasing previously recorded materials and replacing with new content if needed. This ensured no footage would be missed if the memory cards reached capacity. A portable TFT 12 VDC color monitor was used to scan the motion detection footage in the field. Memory cards were exchanged in the DVRs and brought back to the office for viewing. Windows Media Player was used to view the footage. The whole system was powered by two Sharp ND-N2ECUC 142-watt solar panels. The solar panels were connected to a charge controller and a West Fork Environmental battery switcher that would charge two battery banks. Each battery bank had three 12-V DC batteries (connected in parallel) with a combined 300 Ampere-hours.

Figure 7. Photo depicting the camera chamber (right), video chute (middle) and trap box (left).

The fyke of the trap box and the exclusion gate were set every Monday through Friday between August 14, 2017 and September 15, 2017 for capturing upstream migrating bull trout. The bull trout were removed from the trap by dip net and anesthetized for sampling in a river water bath that contained 40 mg/l of tricaine methanesulfonate (MS-222) and buffered with sodium bicarbonate at a concentration of 80 mg/l. All bull trout were scanned for PIT tags. Sampling of previously tagged bull trout consisted of recording the PIT ID, determining the sex, measuring to

the nearest 1 mm in total length and weighing to the nearest 0.1 g (Barrows et al. 2014). The bull trout without tags were injected subcutaneously with a 23 mm long PIT tag through a 3-mm incision made with a surgical scalpel anterior to the pelvic girdle (Barrows et al. 2014). We collected a tissue sample (upper lobe of the caudal fin) from these fish for DNA analysis and preserved the samples in vials containing alcohol. We then determined the sex , total length, and weight of each fish. All bull trout recovered following sampling in a large tote circulated with aerated river water. After recovering to an upright position, bull trout were released to an area with reduced water velocity upstream of the weir.

Weir Location Suitability

A weir to capture adult bull trout in Pinhead Creek had not been used previous to 2017. Locating a reasonable site, designing a functional weir and trap, and evaluating the suitability of the method for future monitoring, were important aspects of this effort. Steep banks, dense riparian vegetation, large woody debris and swift water velocity limit the locations in Pinhead Creek that are conducive to operating a weir. Easy access to the stream is limited, and the study area is also heavily used for recreation (e.g., camping). We chose to install the weir at a location just upstream of the NF-46 bridge, approximately 0.1 river kilometer (rkm) from the confluence of Pinhead Creek and the Clackamas River.

Spawning Population Estimate

Two methods were used for estimating the bull trout spawning population in Pinhead Creek. For the first method, we used estimates of the tagged to untagged ratio of bull trout in the population to expand PIT detections at the Pinhead mouth PIT array. Tagged to untagged ratios were determined by trapping a portion of the bull trout and by using video monitoring in conjunction with a PIT antenna to estimate the ratio of tagged to untagged fish moving past the weir. Only individual bull trout sampled at the trap and observed moving upstream on video while the PIT antenna at the weir was functional were used to derive the sex and the tagged to untagged ratios.

The second method utilized empirical data from the trap in addition to video and PIT tag monitoring at the weir. Electrical malfunction resulted in a lapse in video monitoring and PIT detection at the weir from September 19, 2017 to September 26, 2017. To account for the number of bull trout that may have passed upstream of the weir during the downtime, we averaged the number of fish that passed upstream the day before the downtime began and the day following the downtime to estimate the number of fish per day. We then applied the average fish per day estimate to the seven days of downtime to estimate the number of bull trout that may have been missed when passage was not monitored at the weir. The two estimates were then compared.

Documenting Natural Production

Locally spawned bull trout have not been detected during past electrofishing and minnow-trapping efforts (Barrows et al. 2017; Barrows et al. 2016a; Barry et al. 2014). A portion of the bull trout in the Pinhead Creek spawning population do not have PIT tags, indicating they may be translocated fish that have previously shed their tag, or naturally recruited individuals (see

Tag Retention results and discussion). We collected genetic samples from untagged bull trout captured at the weir for subsequent genetic analysis to determine if they were naturally produced progeny.

Growth Rates

Data on growth rates can be used for various purposes. For example, growth provides a broad assessment of the environment and the conditions affecting fish. Comparisons between growth rates of translocated individuals of differing release groups or donor tributaries may help inform future management actions or other reintroduction projects. Length and weight data were collected from bull trout captured at the weir. Growth rates were calculated for all translocated individuals that were sampled.

Tag Retention

Monitoring studies of translocated bull trout rely heavily upon PIT tag detection. Estimating the tag retention rate for translocated bull trout will help evaluate use of Pinhead Creek (e.g., redd surveys) and better inform bull trout detections at PGE facilities. We collected genetic samples from untagged bull trout captured at the weir for subsequent genetic analysis to determine whether they were naturally produced progeny or if they were translocated fish that did not retain their tag.

Detecting Natural Reproduction in Pinhead Creek

The Monitoring and Evaluation (M&E) Committee determined that documentation of natural reproduction and recruitment of progeny into the population was necessary to evaluate the success of this project. This need is aligned with actions described in section 3.3-c in the IM&E Plan (USFWS 2011a). In a review of the potential methods and strategies for sampling bull trout in Pinhead Creek, it was suggested that specifically targeting small juveniles (≤ 70 mm TL) may be a practical, definitive method for confirming natural reproduction since there are currently no translocated bull trout ≤ 70 mm TL in the Clackamas River Subbasin. In recent years, backpack electrofishing and minnow trapping had been used to sample for small juvenile bull trout in Pinhead Creek, but none were found (Barrows et al. 2017; Barrows et al. 2016a). During 2017, our sampling efforts intended to address the following objective and its associated components:

Objective 1). Determine if documented bull trout spawning activity in Pinhead Creek has resulted in the recruitment of naturally reproduced progeny into the population.

> Objective 1a). Determine if there is evidence of natural reproduction in Pinhead Creek. Successful natural reproduction is defined as the presence of at least one naturally produced bull trout within Pinhead Creek.
>
> Objective 1b). Determine if Pinhead Creek is occupied by a naturally reproducing bull trout population. Occupancy is defined as at least one naturally produced fish from each of two age classes (> 30 mm TL difference in size) in Pinhead Creek.

Multiple methods were used to address the objectives. To detect naturally produced progeny, night snorkel surveys, stream margin fry surveys, and non-lethal cutthroat trout (*Oncorhynchus clarkii*) stomach lavage were used. To assess whether bull trout redds contained viable embryos, hydraulic redd pumping was employed.

Snorkel Surveys

Night snorkeling surveys were conducted on September 21 − 22 and October 30 − 31, 2017 to document juvenile bull trout rearing in high density spawning reaches of Pinhead Creek. Snorkel surveys were conducted between 10 PM and 2 AM, by 4-person crews, with each snorkeler using a dive light. All habitat was snorkeled, including side channels and backwaters. On the first night, approximately 1 rkm of Pinhead Creek was snorkeled moving upstream from the mouth. On the second night, the snorkel survey started at the Last Creek confluence and the crew surveyed upstream in Pinhead Creek for 0.5 km.

Fry Surveys

Fry detection methods developed by ODFW in the Middle Fork Willamette and McKenzie rivers were used to document natural reproduction of bull trout in the Clackamas River Subbasin by collecting and observing fry expected to be utilizing the margins of Pinhead Creek, currently the primary spawning tributary for bull trout in the subbasin (Barrows et al. 2017). Eight surveyors sampled all low to zero velocity margin habitats and undercut banks in two reaches of Pinhead Creek on May 9, 2017. Surveyors spent three hours in each reach. Reach 1 was from the Highway 46 Bridge working upstream. The second reach was at the confluence of Pinhead and Last creeks with four surveyors working upstream and four working downstream. The lower 50 meters of Last Creek were also surveyed. Surveyors in waders utilized small aquarium dip-nets and dive lights to probe all low to zero velocity habitats including undercut banks.

Non-lethal Stomach Lavage

Conventional methods (e.g., electrofishing, minnow trapping) previously used in Pinhead Creek to capture juvenile bull trout have been largely unsuccessful to date. One hypothesis is that the resident cutthroat predation on bull trout fry in Pinhead Creek reduces bull trout numbers to a level that is undetectable by previously used sampling methods. Assuming bull trout are spawning successfully and embryos are surviving to emergence, bull trout fry should be abundant during the spring. We deployed minnow traps to target cutthroat trout and used non-lethal stomach lavage to evacuate stomach contents to determine if cutthroat trout were feeding on bull trout fry. If bull trout fry are present in stomach samples, then documentation of natural production and survival to this lifestage would be confirmed.

Specimen Capture ─ Minnow traps were deployed March 1 − 4, 2017 in an attempt to take advantage of peak emergence of bull trout fry (Figure 8). It was expected that this would result in the highest likelihood of observing predation interactions. Twelve to fourteen baited traps were set up daily in relatively calm water beginning at the Last Creek confluence (approximately rkm 1.7) to about one km downstream (rkm 0.7) towards the mouth of Pinhead Creek. The

minnow traps were baited with cured salmon roe and left for twenty-four hours before being checked and relocated at subsequent sampling sites.

Figure 8. Wire mesh minnow traps were used to target cutthroat trout in Pinhead Creek for non-lethal stomach lavage.

Sampling and Lavage ─ After twenty-four hours, cutthroat trout and coho salmon (*Oncorhynchus kisutch*) captured in the minnow traps were removed and anesthetized for sampling in a bath of river water containing 40 mg/l MS-222 and buffered sodieum bicarbonate at a concentration of 80 mg/l. After anesthetization, fork lengths were measured on all individuals sampled (Figure 9). The lavage process involved inserting a blunt syringe filled with water into the esophagus of the anesthetized fish. The stomach contents were flushed by inverting the fish while the syringe was inserted. The contents were then sorted to determine what each individual fish was preying on. Fish were then allowed a sufficient amount of time to recover from anesthesia before being released.

Figure 9. Cutthroat trout were anesthetized, measured, lavaged and released following recovery.

Hydraulic Redd Sampling

We used hydraulic sampling as described by McNeil (1964) and Berejikian et al. (2011) to sample presumed bull trout redds and determine if embryos were present in the redds and viable. Four redds somewhat evenly distributed in the upper extent of Pinhead Creek were selected for sampling. Collected specimens were analyzed for genetic species identification.

Genetics

From 2011 to 2016, caudal fin tissue (approximately 1 cm^2) was collected from each fish that was translocated to the Clackamas River Subbasin. These samples were archived at the USFWS Abernathy Fish Technology Center (Longview, Washington). In addition, caudal fin tissue was collected from untagged bull trout captured at the Pinhead Creek weir during 2017. This collection of samples will provide the opportunity for subsequent parentage analysis and the confirmation of naturally reproduced progeny, however, these samples have not been processed as of December 2017.

Impacts to Listed Salmon and Steelhead

Following the termination of the radio-telemetry program in 2014, we can no longer determine whether translocated subadult and adult bull trout have entered a HVZ, nor determine the total time each fish spent in the HVZ. Similarly, untagged naturally reproduced progeny may also enter and forage within the HVZ. However, detections of bull trout at Clackamas Hydro Project PIT antennas and observations at the adult sorting facility were used to help infer when bull trout entered North Fork Reservoir and other areas within PGE's hydro project facilities. Monitoring by PGE outside the scope of the bull trout reintroduction plan is also considered to determine if minimum thresholds for salmon and steelhead lifestages are being met in accordance with the Stepwise Impact Reduction Plan (USFWS 2011b).

Results and Discussion

Implementation

From 2011 to 2016, 2417 juvenile, 371 subadult and 80 adult bull trout were released into the upper Clackamas River and select tributaries (Appendix C). At this time, no additional translocations are planned during phase two of the reintroduction project.

Monitoring and Evaluation

Movement and Seasonal Distribution

During 2017, a total of 67 unique PIT tags associated with translocated bull trout were detected at the Pinhead mouth PIT array from June through October (Figure 10). Of these 67 tags, 54 were also detected at the Pinhead Creek weir. There was a single weir detection not detected at

the mouth, for a total of 55 weir detections (not including newly tagged fish). Tags detected in 2017 represent translocated bull trout released into the Clackamas River Subbasin at every lifestage during the years 2012-2016 (Table 2). The majority of individuals that migrated into Pinhead Creek were relatively large, adult-sized fish (see Video Weir and Trap results and discussion). The fish from juvenile release groups in 2015 and 2016 were likely not mature spawners, and may have entered Pinhead Creek seeking rearing and foraging habitat.

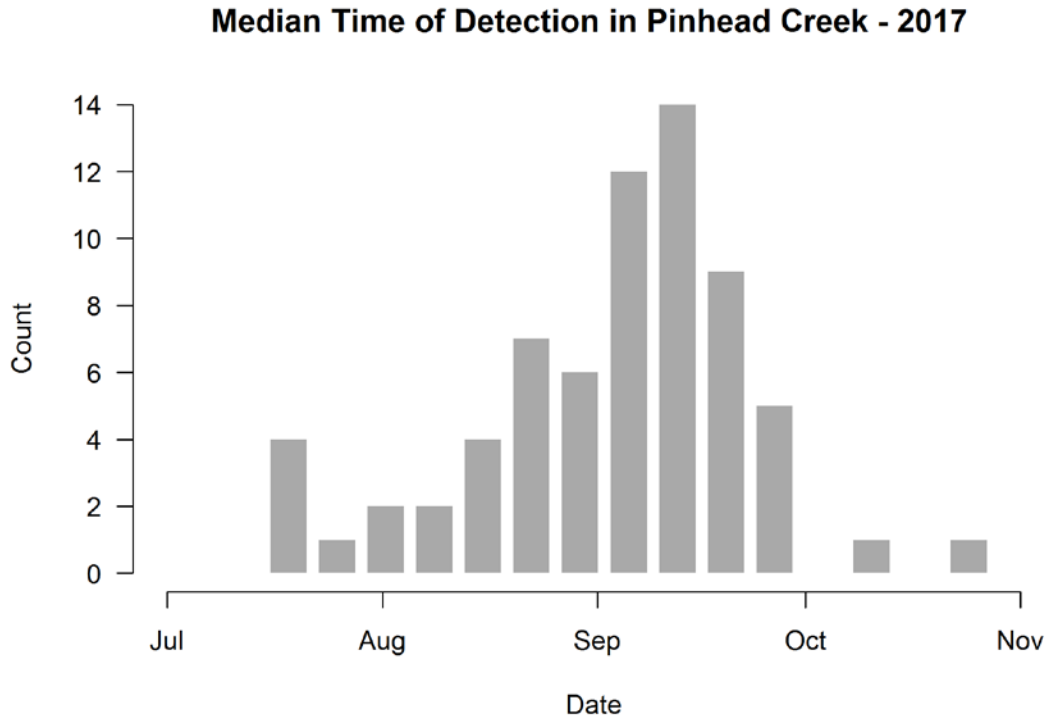


Figure 10. Median detection time of unique PIT tags in Pinhead Creek. Each bar represents one week. This includes all detected tags in 2017 from both the mouth and weir arrays.

Table 2. Unique PIT tag detections of translocated bull trout from release groups in 2012 – 2016 detected in Pinhead Creek during 2017.

Lifestage	2012	2013	2014	2015	2016	Totals
Juvenile	7	25	4	2	5	43
Subadult	0	3	6	12	3	24
Adult	0	0	0	1	0	1
Totals	**7**	**28**	**10**	**15**	**8**	**68**

The amount of time individuals spent in Pinhead Creek during the spawning season varied from only a day to multiple months (Figure 11). Of the PIT tags that were first detected at the mouth array then subsequently at the weir, median travel time was 10 hours with the longest time being 224 hours (9.33 days). Seventy-seven percent of these fish reached the weir within two days

(Figure 12). Downtime at the weir PIT antenna likely resulted in missed detections while fish moved past the weir, but in general, bull trout that entered Pinhead Creek moved upstream to known spawning areas relatively quickly.

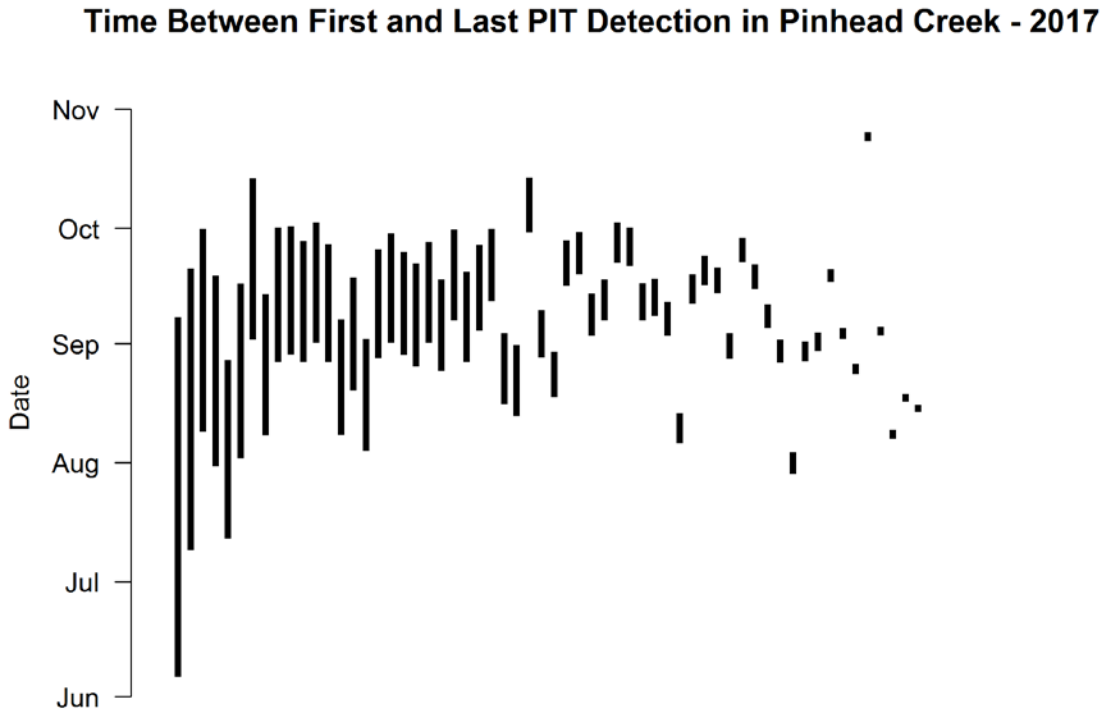


Figure 11. Each line represents a single PIT tag detection spanning the length of time between its first and last detection in Pinhead Creek.

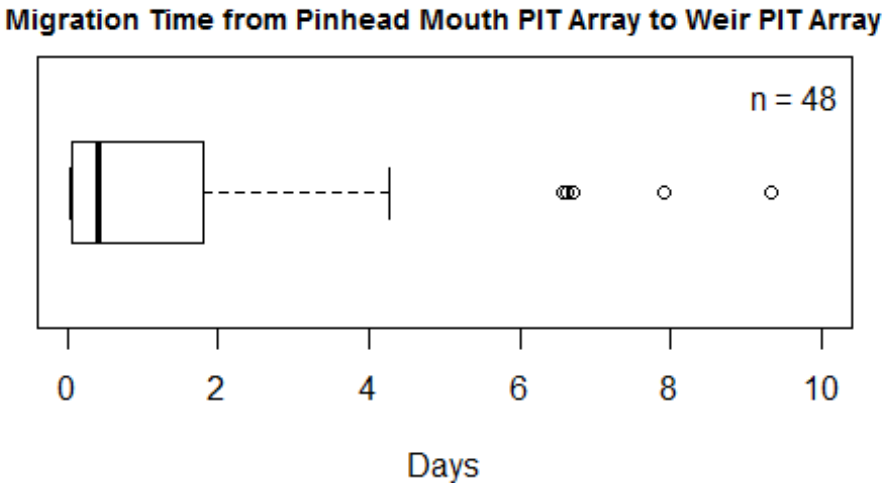


Figure 12. Bull trout migration time from the Pinhead Mouth PIT Array upstream to the weir PIT array during 2017.

There were six fish total that were first and last detected at the weir PIT antenna, suggesting a possible Pinhead Creek resident component of the population. The establishment of both migratory and resident components would be consistent with many other bull trout local populations across their range (Barrows et al. 2016b; Schaller et al. 2014). Of these six fish, five were released into Pinhead Creek or Last Creek (a tributary to Pinhead) in 2013 and one was released in the Clackamas River approximately 2.5 river kilometers upstream of Pinhead Creek's mouth in 2015.

In addition to the PIT detections in Pinhead Creek, five translocated bull trout were detected at PIT arrays within PGE's hydro project facilities during 2017 (Table 3). Detection histories for the PIT-tagged bull trout are summarized in Appendix A. In many cases, an individual was detected at multiple PIT arrays on multiple dates. Two were originally released as juveniles (70 – 250 mm TL) and three were released as subadults (251 – 450 mm TL). An examination of the detection histories and observations of these fish since translocation (Appendix A) indicated three were adults, one was likely a subadult and one released as a juvenile (84 mm TL) into the upper Clackamas River (PIT ID 982_000360937217) was likely still a juvenile-sized fish when detected.

Table 3. Individual PIT-tagged bull trout detected at PGE facilities during 2017.

PIT ID	Length at Release (TL)	Release Date	Release Site
0000_000000177419441	150 mm	5/23/2013	Last Creek us of 42 Bridge
982_000361679227	393 mm	5/29/2015	4650 Bridge
0000_0000000177419152	285 mm	5/20/2016	4650 Bridge
0000_0000000177419402	393 mm	6/6/2013	Lower 4650 Bridge D/S
982_000360937217	84 mm	4/29/2016	Upper Clackamas

Three of the five bull trout moved upstream past North Fork Dam, re-entering the upper Clackamas River in March, June and August. The first fish (PIT ID 0000_0000000177419441) was observed at the North Fork Adult Sorting Facility on March 24, 2017 and was approximately 585 mm TL (Figure 13). This fish was initially released on May 23, 2013 in Last Creek (tributary to Pinhead Creek) as a juvenile fish at 150 mm TL and had grown approximately 435 mm since translocation. There had been no prior PIT detections of this fish at sites within the study area. The second fish (PIT ID 982_000361679227) was observed at the North Fork Adult Sorting Facility on June 19, 2017 and was estimated to be 600 mm TL (Figure 14). It was released on May 29, 2015 near the 4650 bridge in the mainstem Clackamas River as a subadult-sized bull trout (393 mm TL) and was next detected passing downstream at PGE's Clackamas Hydro Project via the Floating Surface Collector on June 7, 2017. This fish was subsequently detected moving upstream through the hydro project at the River Mill and North Fork fish ladders on June 12, 2017 and June 19, 2017, respectively. From August 17 through September 2, 2017, this fish was detected passing upstream and downstream at the PIT detection antennas at the mouth of Pinhead Creek and through the Pinhead Creek weir (Appendix A). This fish was trapped at the weir on August 29, 2017, was identified as a male measuring 591 mm TL, and was

released upstream of the weir. The fish had grown 198 mm since translocation. The third bull trout (PIT ID 0000_0000000177419402) was originally released as a subadult (325 mm TL) in the Clackamas River on June 6, 2013. This fish appeared to have entered Pinhead Creek to presumably spawn during both 2015 and 2016 before moving downstream of the Clackamas Hydro Project via the Floating Surface Collector on July 30, 2017 (Appendix A). The bull trout was detected moving upstream through the hydro project via the fish ladders from August 2, 2017 to August 23, 2017 and had grown approximately 275 mm since release to an estimated 600 mm TL at the North Fork Adult Sorting Facility (Figure 15). This fish was subsequently detected entering Pinhead Creek on September 21, 2017 and apparently moved upstream of the Pinhead Creek weir during a corresponding gap in monitoring due to a power outage. The fish was then observed and detected on September 30, 2017 moving downstream through the video chute at the weir, after presumably spawning upstream.

Figure 13. Bull trout # 0000_0000000177419441 (585 mm TL) at North Fork Adult Sorting Facility.

Figure 14. Bull trout # 982_0003616789227 (600 mm TL) observed at North Fork Adult Sorting Facility.

Figure 15. Bull trout # 0000_0000000177419402 (600 mm TL) at North Fork Adult Sorting Facility.

Two of the five bull trout detected at the PGE facilities during 2017 did not move upstream into the study area after being detected. A bull trout (PIT ID 0000_0000000177419152) originally released into the Clackamas River as a subadult (285 mm TL) on May 20, 2016 was detected as it moved downstream of North Fork Dam via the Floating Surface Collector on June 6, 2017 and was not subsequently detected (Appendix A). At the time of detection, this fish was likely subadult-sized and may have moved downstream of the hydro project in search of rearing habitat. The other fish (PIT ID 982_000360937217) was detected while in the North Fork Ladder from October 24, 2017 to December 3, 2017, but had not moved upstream past North Fork Dam as of December 31, 2017. This fish was originally released in the upper Clackamas River as a juvenile (84 mm TL) and had apparently moved downstream of North Fork Dam undetected. This fish was likely juvenile-sized at the time of its detections in 2017.

An additional adult bull trout was observed upstream of the North Fork Ladder exit in late June 2017. The fish was very large and estimated to be 700 – 750 mm TL. It also appeared to have fungus covering portions of its head and pectoral fins (Figure 16).

Figure 16. Large bull trout observed upstream of PGE's North Fork Fish Ladder exit.

Reproduction

The number of translocated bull trout using spawning tributaries (e.g., Pinhead Creek) has increased since the reintroduction program began in 2011. Bull trout spawning has often been observed and redd counts have increased from year to year (Starcevich 2018). In addition, tags detected in 2017 represent translocated bull trout released into the Clackamas River Subbasin at every lifestage during the years 2012 − 2016 (see Table 2 in Movement and Seasonal Distribution section). Despite ample evidence of bull trout spawning in Pinhead Creek and the recent collection of alevins from redds, documenting survival from embryo to juvenile lifestages and recruitment into the spawning population have been major benchmarks we have yet to achieve.

Redd Surveys

A total of 89 presumed bull trout redds were observed in 2017 (Starcevich 2018). Of the 89 redds, most (N = 73) were observed in Pinhead Creek, 12 were counted in Last Creek and four were observed in the mainstem Clackamas River (Figure 17). Redd counts have increased each year since the inception of the reintroduction program, and 2017 marks the highest count to date (Starcevich 2018). Additional details concerning 2017 census redd counts associated with this project are described, summarized and discussed in Appendix C.

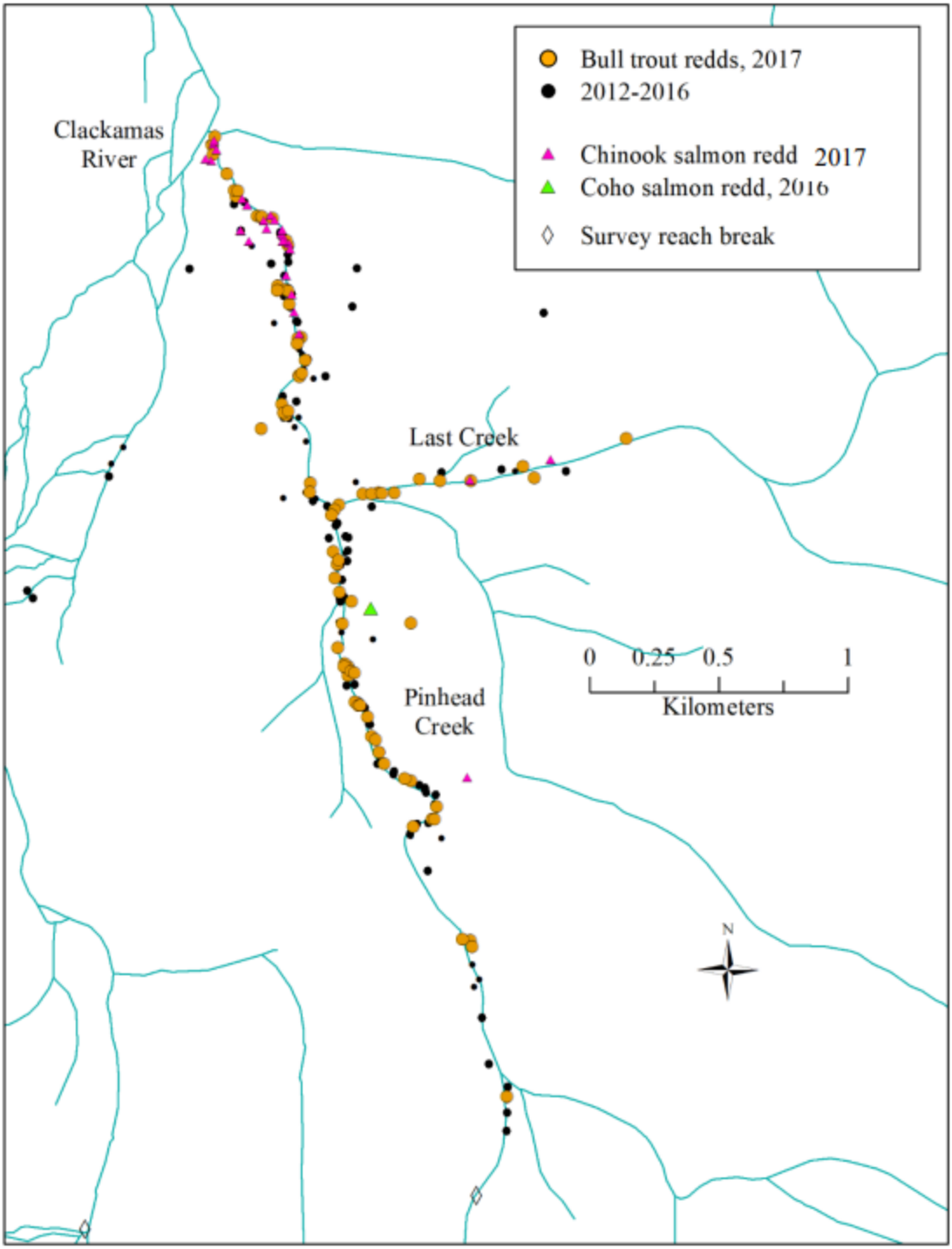
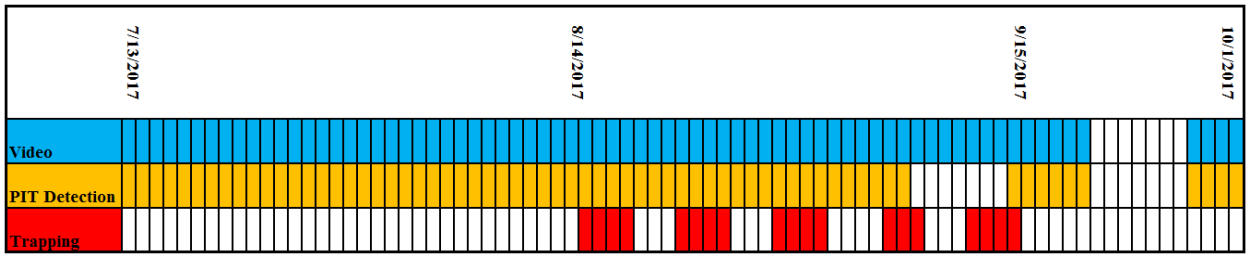


Figure 17. Locations of redds in Pinhead and Last creeks and the Clackamas River in 2012 – 2017. Bull trout redds observed during 2017 are depicted as orange circles. (Map from Clackamas River bull trout monitoring update 2017-2018, Starcevich 2018)

Video Weir and Trap

The Pinhead Creek weir was installed in early July and was fully operational by July 13, 2017. Fish passing the weir were continuously monitored via video and a PIT antenna from July 13, 2017 to October 1, 2017 with a period of downtime resulting from electrical issues from September 19, 2017 to September 26, 2017 (Table 4). In addition, a PIT antenna malfunction at the weir resulted in a lapse of detection capability from September 7, 2017 to September 14, 2017. The upstream trap was operated Monday through Friday between August 14, 2017 and September 15, 2017 with the exception of September 4, 2017.

Table 4. Pinhead Creek weir operation periodicity table during 2017.



During 2017, there were a total of 125 (61 upstream and 64 downstream) video observations of bull trout at the Pinhead Creek weir (Table 5). There were also 14 video observations of Chinook Salmon (*Oncorhynchus tshawytscha*) at the weir. Many individuals were observed moving both upstream and downstream past the weir multiple times. Some fish were also captured in the trap before or after being observed via video passing the weir. From late July to early September, the majority of bull trout observed moving upstream past the weir were male, but female observations were more prevalent through most of September (Figures 18 and 19).

Table 5. Video observations of bull trout and Chinook Salmon at the Pinhead Creek video weir during 2017.

Species (Sex)	Upstream	Downstream	Total
Bull Trout (Male)	35	35	70
Bull Trout (Female)	26	29	55
Chinook Salmon (Male)	6	5	11
Chinook Salmon (Female)	2	1	3

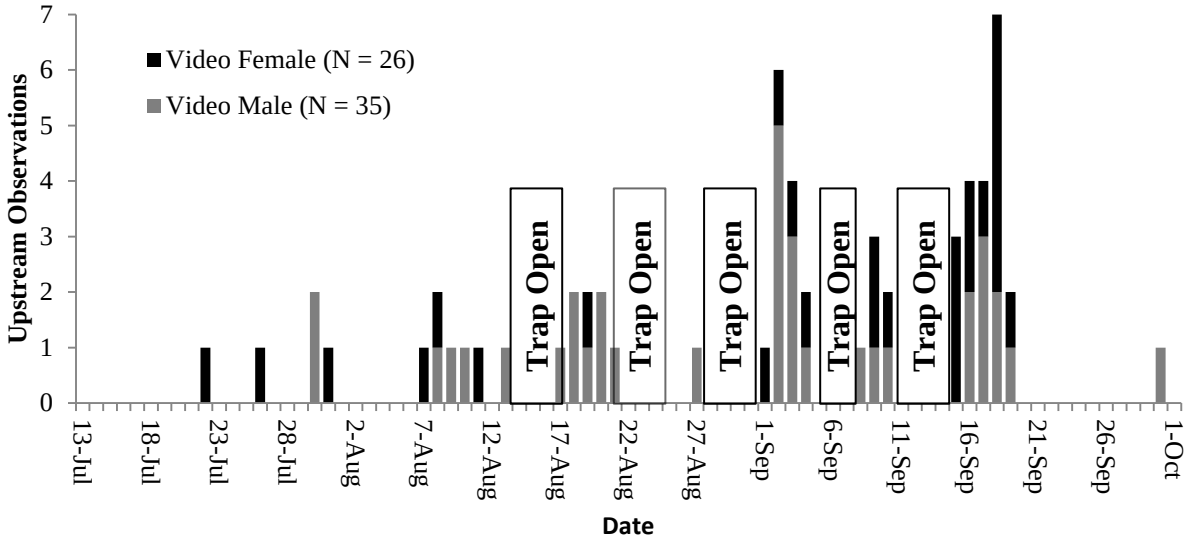


Figure 18. Upstream observations of male and female bull trout at the Pinhead Creek weir during 2017.

Fifty-nine individual PIT-tagged bull trout were detected while passing either upstream or downstream (or both) through the video chute PIT antenna. By pairing video observations and corresponding PIT detections, we were able to identify individual, tagged bull trout that passed upstream through the weir. Ten untagged bull trout were also observed passing upstream through the video chute while the PIT antenna was functional. In addition, there were six bull trout that passed upstream through the video chute when the PIT antenna was not functional. Table 6 is a summary of individual bull trout observed moving upstream through the video chute at the Pinhead Creek weir.

Table 6. Individual bull trout observed moving upstream through the video chute at the Pinhead Creek weir.

Species (Sex)	Video Observations (PIT-tagged)	Video Observations (Untagged)	PIT Detection (No Video)	Video (PIT Ant. Down)	Totals
Male	26	2	0	3	**31**
Female	14	8	0	3	**25**
Unknown	0	0	1	0	**1**
Totals	**40**	**10**	**1**	**6**	**57**

Thirty-four individual bull trout were captured in the trap at the Pinhead Creek weir from August 15, 2017 to September 15, 2017. Nineteen fish were male and 15 fish were female. Three of the bull trout were also subsequently recaptured following their initial capture. A majority of the male bull trout were captured in late August and most of the females were captured in September (Figure 19). Two male Chinook Salmon were also captured in the trap.

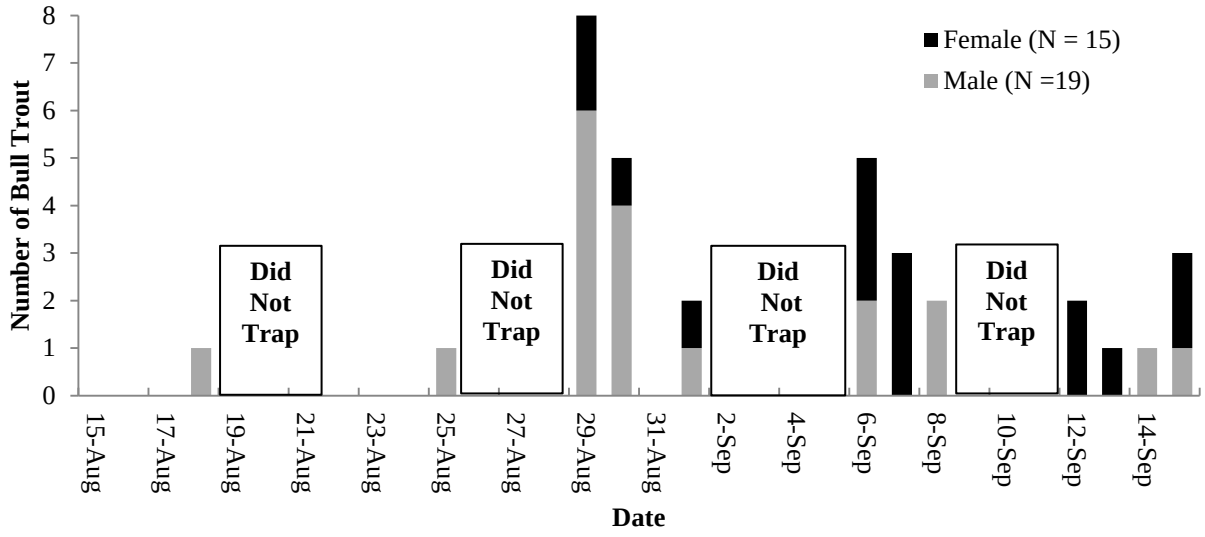


Figure 19. Bull trout trapped by date and sex at the Pinhead Creek weir during 2017.

The bull trout captured in the trap were all relatively large, migratory fish and ranged in size from 462 – 653 mm TL. Many fish were between 550 and 600 mm TL (Figure 20). Female bull trout (mean, 585 mm TL; range, 474 – 653 mm TL) were on average larger than the males (mean, 549 mm TL; range, 462 – 615 mm TL). Tagged females (mean, 584 mm TL; range, 484 – 653 mm TL) were on average slightly larger than untagged females (mean, 566 mm TL: range, 474 – 630 mm TL) and tagged males (mean, 553 mm TL; range, 462 – 615 mm TL) averaged larger than the single untagged male (504 mm TL). Lengths and weights of bull trout captured in the trap are summarized in Table 7.

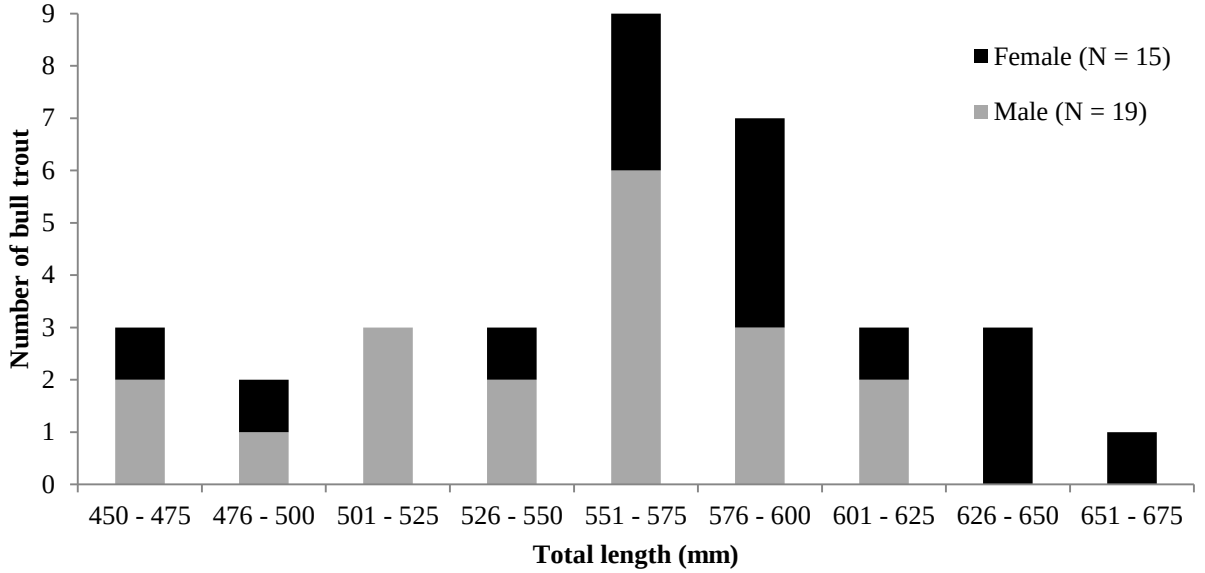


Figure 20. Total lengths by sex of bull trout captured at the Pinhead Creek weir during 2017.

Table 7. Lengths and weights of bull trout and Chinook Salmon captured in the trap at the Pinhead Creek weir.

Species (Tagged/Untagged)	Total Length (mm)			Weight (g)		
	Min	Max	Mean	Min	Max	Mean
Males (Tagged)	462	615	553	1068	2853	1773
Females (Tagged)	484	653	585	1106	2935	2146
Males (Untagged)	504	504	504	1320	1320	1320
Females (Untagged)	474	630	566	1100	2526	1960
Chinook (Untagged)	795	820	808	–	–	–

Weir Location Suitability

Given the uncertainty associated with operating a fish weir for the first time in Pinhead Creek, it was decided that the best course of action was to select an easily accessible site that met the physical qualities and spatial requirements for installing and operating a bull trout weir. The suitability of the weir site was qualitatively evaluated based on sampling results and observations throughout the season. The selected location was near the mouth of Pinhead Creek, ensuring most bull trout would spawn upstream of the weir. The site was accessible by vehicle, facilitating installation, operation and removal activities. The site was also easily accessible to the public, increasing the potential for vandalism; however, there was no damage to the weir and the monitoring equipment during the season. Water velocity at this location prompted minor modifications to the weir configuration, video chute and trap box. Deflection panels were installed upstream of the video chute and trap box to shunt water toward the center of the channel, reducing velocity through the trap and decreasing turbulence within the video chute (Figure 21). Other modifications were made to the video chute and the trap box entrance to remedy velocity-related issues (Figure 22). Overall, the location and weir configuration were conducive to monitoring the bull trout spawning population in Pinhead Creek, but further adjustments to the trap box and the video chute may be needed to improve its operation at this location in future years.

Figure 21. Deflection panel installed upstream of Pinhead Creek weir.

Figure 22. Trap box entrance modification to facilitate fish entry into the trap.

Spawning Population Estimate

The first method we used for estimating the number of spawners used estimates of the tagged to untagged ratio of bull trout in the population to expand PIT detections at the Pinhead Creek PIT detection site near the mouth. A total of 66 individual bull trout were captured or observed at the weir of which 37 (56%) were male and 29 (44%) were female (Table 8). Of the 37 males, 34 (92%) were tagged and 16 (55%) of the 29 females were tagged. We applied the sex ratio to the 67 individual PIT detections at the mouth to estimate that approximately 38 male and 29 female translocated bull trout entered Pinhead Creek during 2017. By expanding the estimated number of male and female translocated bull trout by the corresponding tagged to untagged ratios, we estimated that 41 male and 54 female bull trout entered Pinhead Creek, for a total estimate of 95 spawners during 2017 (Table 9).

Table 8. Tagged and untagged male and female bull trout captured at the trap and observed on video at the Pinhead Creek weir.

Sampling Method	**Male**		**Female**		**Combined**	
	Tagged	Untagged	Tagged	Untagged	Tagged	Untagged
Weir Trap	18	1	10	5	28	6
Weir Video/PIT	16	2	6	8	22	10
Combined	34	3	16	13	50	16
Total	**37**		**29**		**66**	

Table 9. Estimated sex ratios, tagged to untagged ratios and estimated number of spawning bull trout in Pinhead Creek during 2017.

Sex	Estimated Sex Percentage	Estimated Sex of Translocated Fish (N = 67)	Estimated Percentage of PIT-tagged Fish	Estimated Number of Spawning Bull Trout
Male	0.56	38	0.92	41
Female	0.44	29	0.55	54
Total				**95**

The second method we used for estimating the number of spawners utilized empirical data from the trap in addition to video and PIT tag monitoring at the weir. We captured 34 individual bull trout in the trap. Twenty-two PIT-tagged individuals and 10 untagged bull trout were observed passing upstream of the weir when the PIT antenna at the weir was functional (Table 10). Six fish were also observed passing upstream while the PIT antenna was not functional. In addition, bull trout may have passed upstream of the weir when electrical issues caused a lapse in video monitoring and PIT detection at the weir from September 19, 2017 to September 26, 2017. To account for the number of bull trout that may have passed upstream of the weir during the downtime, we averaged the number of fish that passed upstream the day before the downtime began (N = 7) and the day following the downtime (N = 0) to estimate the number of fish per day. We then applied the average fish per day to the seven days of downtime to estimate that 25 bull trout may have been missed when passage was not monitored at the weir. Using this method, we estimated that 97 bull trout (47 males and 50 females) may have moved upstream of the weir to spawn during 2017 (Table 10).

Table 10. Estimated number of spawners in Pinhead Creek during 2017 using empirical data from the trap in addition to video and PIT tag monitoring at the weir.

Sex	Trapped Fish	US Video (PIT-tagged)	US Video (Untagged)	US Video (PIT Ant. Down)	Fish Missed (Estimated)	Total
Male	19	16	2	3	7	47
Female	15	6	8	3	18	50
Total	**34**	**22**	**10**	**6**	**25**	**97**

Results from both methods for estimating the total number of spawning bull trout in Pinhead Creek were very similar. Both methods suggested that the population consisted of a higher number of females than males, but the second method indicated less of a disparity. In future years, decreasing or eliminating the monitoring downtime at the weir would better facilitate improved spawning population estimates in Pinhead Creek.

Documenting Natural Production

Thirty-four individual bull trout were captured in the adult trap during 2017. Of the 34 individuals, six fish were untagged prior to capture. Tissue samples were collected from each untagged bull trout for future genetic analysis to determine if they were naturally produced progeny. Given the relatively high percentage of tagged males that were observed at the video weir (89%) and captured in the trap (95%), it may be likely that only a small portion of the males in the spawning population were naturally reproduced progeny. The lower percentage of tagged female fish observed at the video weir (43%) and captured in the trap (67%) suggests a portion of the fish may be naturally produced, but the notable disparity between the percentage of tagged males and females suggests an elevated rate of tag shedding in females. Significantly lower PIT tag retention rates in female salmonids have been previously documented (Meyer et al. 2011; Prentice 1990).

Growth Rates

Twenty-eight of the 34 adult-sized (> 450 mm TL) bull trout trapped at the Pinhead Creek weir were previously PIT-tagged, indicating they were translocated individuals. The fish were originally released as juveniles (N = 20), subadults (N = 7), and adults (N = 1) and on average grew at rates of 99.1 mm, 79.9 mm and 18.4 mm per year, respectively (Table 11). These growth rates are generally consistent with findings reported in Harris et al. (2018) in that larger (e.g., older) individuals grew in length at a slower rate than smaller (e.g., younger) fish. We also found that male and female bull trout grew at approximately the same rate following release (Table 12). Bull trout growth within a population likely varies due to many factors including, but not limited to, genetics, life history form, habitat use, sex and age (Harris et al. 2018; Al-Chokhachy and Budy 2008). In future years, as the translocated population matures, and as we recapture additional fish, a more robust growth rate analysis may be warranted to further assess the reintroduction effort.

Table 11. Growth rates since release of translocated bull trout captured at the Pinhead Creek weir during 2017.

Lifestage at Release	# of Samples	Growth / Day (mm)	Growth / Year (mm)
Juveniles (70 – 250 mm)	20	0.27	99.1
Subadults (252 – 450 mm)	7	0.22	79.9
Adults (> 450 mm)	1	0.05	18.4

Table 12. Growth rates since release of male and female bull translocated bull trout captured at the Pinhead Creek weir during 2017.

Sex	# of Samples	Growth / Day (mm)	Growth / Year (mm)
Male	18	0.25	91.9
Female	10	0.25	90.5
Combined	28	0.25	91.4

Tag Retention

Six of the 34 individual bull trout captured at the adult trap during 2017 were untagged prior to capture. Tissue samples were collected from each untagged bull trout for future genetic analysis to determine if they were naturally produced progeny or translocated bull trout that had shed their tags. The disparity in tagged to untagged ratios for male and female fish observed at the weir suggests tag retention may be lower for females (see Documenting Natural Production results and discussion)

Detecting Natural Reproduction in Pinhead Creek

Snorkel Surveys

No bull trout were observed during the two surveys. Juvenile Chinook Salmon were the most common fish observed. Other species observed included juvenile coastal cutthroat trout, juvenile rainbow or steelhead trout (*Oncorhynchus mykiss*), and cottids. One adult Chinook Salmon was observed in the upper survey reach of Pinhead Creek.

We observed several areas within the Pinhead Creek survey reaches that appeared to be high quality bull trout rearing habitat. These areas included low velocity pockets and pools with complex structure such as cobble, large wood and organic debris, and undercut banks. Given that we snorkeled in reaches that contained the highest density bull trout redd counts in 2015 and 2016, we expected to see bull trout rearing in these areas. No bull trout were observed; instead, these areas were usually dominated by juvenile Chinook Salmon. Within a single complex pool in Pinhead Creek, as many as 22 Chinook Salmon juveniles were counted.

Fry Surveys

Numerous young-of-year and older coho salmon, coastal cutthroat trout and sculpin (*Cottus spp.*) were observed but no bull trout fry or juveniles. One otter was observed. Given the number of redds tallied in Pinhead Creek the prior fall, and the timing of the May fry survey, it was expected bull trout fry would be observed. Surveys for bull trout fry in spawning tributaries of the McKenzie and Middle Fork Willamette rivers using similar methods have yielded observations and capture of dozens of bull trout fry. Our inability to observe or collect bull trout fry does not confirm bull trout fry and juveniles are not present, but if present, it does suggest

low abundance. Potential explanations for not observing or collecting bull trout fry or juveniles from this effort include lower than expected fry abundance due to our having over-estimated the actual number of redds, compounded by the challenges of sampling complex habitat; low egg-to-fry survival; high post-emergence predation by sculpin, cutthroat trout, and other juvenile salmonids (coho, steelhead, Chinook); increased competition from trout and salmon cause bull trout fry/juveniles to adopt increased concealment behavior or emigration out of Pinhead Creek to the mainstem Clackamas River.

Several recommendations following this unsuccessful attempt to document bull trout fry include replicating the survey effort earlier in the spring closer to the time bull trout are expected to emerge from the gravel (March/April); verifying that at least some of the redds identified as bull trout redds contain bull trout embryos after they have been identified in autumn; sampling several verified bull trout redds on multiple occasions between October and February to track development of embryos; operating a rotary screw trap to capture fry emigrating from Pinhead Creek in the spring; and conducting additional night-snorkel surveys in optimal bull trout rearing areas.

Non-lethal Stomach Lavage

Specimen Capture ─ From May 1, 2017 to May 4, 2017, we captured 32 cutthroat trout, 29 coho salmon, and one each of sculpin, rainbow trout, and a salmonid that we were unable to difinitively determine whether it was a rainbow or cutthroat trout (Table 13). In addition, one pacific giant salamander *Dicamptodon tenebrosus* was captured and released.

Table 13. Average fork lengths for species trapped during non-lethal stomach lavage sampling in Pinhead Creek during 2017.

Species	Number of Specimens	Average Fork Length (mm)
Cutthroat Trout	32	126
Coho Salmon	29	84
Sculpin	1	81
Rainbow/Cutthroat (unsure)	1	94
Rainbow Trout	1	132
Pacific Giant Salamander	1	225

Sampling and Lavage ─ Over the course of four days no trout fry were identified in the stomachs of any of the cutthroat trout specimens captured. Fish species such as rainbow trout and coho salmon were not targeted for lavage. The contents of cutthroat trout stomachs were mainly found to contain partially digested (i.e., unidentified) insects (Table 14). The coho salmon fry identified was thought to be regurgitated by a captured cutthroat trout prior to it being lavaged.

Table 14. Individual occurrences of stomach contents found during non-lethal stomach lavage sampling in Pinhead Creek during 2017.

Stomach Contents Found	Individual Occurrences
None	11
Coho Salmon Fry	1
Mayfly Nymph	1
Caddis Fly	1
Unidentified Insects	21

Ultimately, these results, when combined with previous electrofishing and minnow trapping efforts, suggest it is likely bull trout fry occur in densities so low as to be undetectable by conventional sampling methods. Contrary to the hypothesis, predation of bull trout fry by cutthroat trout was not detected and appears not to be a major factor in the absence of bull trout fry. Although juvenile and adult cutthroat trout are known to be opportunistic feeders (Morrow 1980), our results suggest that during our sampling period in Pinhead Creek they largely preferred insects as opposed to fry, algae, or crustaceans.

Like many other salmonid species, cutthroat trout exhibit ontogenetic shifts in prey preference with their size being a limiting factor for the type of prey they can ingest (Jones et al. 2008). Although coastal cutthroat trout have been found to reach a length of 500 mm, the specimens captured during this study were much smaller and may not have been as likely to successfully prey on bull trout fry. Jones et al. 2008 found that percent biomass of fish prey increased significantly with fork length in bull trout populations. Bull trout with fork lengths in the 130-219 mm range had a higher percentage of invertebrate stomach biomass compared to fish biomass. This trend continued until fish reached the 280 mm fork length threshold, when fish stomach biomass was greater than invertebrate stomach biomass by an 8:1 ratio.

One possibility for the lack of observed predation on bull trout may be that bull trout fry had migrated out of the study area prior to our sampling efforts. Although this is an uncommon pattern it has been seen in other juvenile populations (Buchanan et al. 1997). Generally, juvenile bull trout remain in headwater areas near their natal spawning grounds until migrating downstream, typically between age 1 and 3, with the majority migrating at age 2 (Oliver 1979; McPhail and Baxter 1996).

Stomach lavage techniques are typically used to assess stomach content and have historically been used to evaluate the effects of piscivorous predation on ESA listed species (Hogberg and Pegg 2013; USFWS 2014). The use of stomach lavage to detect natural reproduction is an unconventional sampling method. Sympatric native salmonids (e.g., cutthroat trout) were found to be significant predators of juvenile salmonids (Nowak et al. 2004), but our results suggest that cutthroat trout in Pinhead Creek may not commonly target bull trout fry during early May.

Hydraulic Redd Sampling

After sampling two redds and 10 alevins from each redd were collected for genetic analysis, we decided to minimize the impact on the population and not sample the final two redds (Figure 23). This was due to the belief that embryos are less likely than alevins to be injured or killed via hydraulic redd sampling. The first redd sampled showed evidence of recent hatching (i.e., visible egg casings) and the alevins from the second redd were more developed as evident by the increased level of yolk sack absorption. Progeny in the two redds sampled had hatched suggesting that the timing of our sampling was later than necessary to collect embryos. In the future, if hydraulic redd sampling is to be conducted, a more accurate estimate of development timing should be determined from existing temperature and redd survey data.

Figure 23. Bull trout alevin collected from a redd in Pinhead Creek during hydraulic redd sampling.

Gel electrophoresis was conducted on DNA that was extracted from the larval fish for genetic species identification (Chris Allen, USFWS, personal communication). All specimens were determined to be of the genus *Salvelinus*, indicating they were either bull trout or brook trout (*Salvelinus fontinalis*). The DNA fragment used in the analysis was unable to provide definitive resolution for identification among closely related species. Since the redds that were sampled were large and no brook trout have been observed in Pinhead Creek during prior sampling efforts, it is unlikely the samples were brook trout. Moreover, based on the results, the opinion of the geneticist was that they were all bull trout (M. Piteo, USFWS, personal communication). The collection of alevins from bull trout redds confirms that viable eggs and hatching occurs in Pinhead Creek. However, post-emergent juveniles have yet to be documented.

Genetics

From 2011 to 2016, caudal fin tissue was collected from each fish that was translocated to the Clackamas River Subbasin. In total, 2868 tissue samples from translocated bull trout have been archived at the USFWS Abernathy Fish Technology Center in Longview, Washington (Table 15). In addition, caudal fin tissue was collected from six untagged bull trout captured at the

Pinhead Creek weir during 2017. This collection of samples will provide the opportunity for subsequent parentage analysis and the determination of naturally reproduced progeny.

Table 15. Count by year and lifestage of bull trout captured in the Metolius River Subbasin and translocated to the Clackamas River Subbasin (Appendix C).

Lifestage	Number of Bull Trout Translocated						
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**
Juvenile	58	517	624	322	300	596	2417
Subadult	25	43	90	45	74	94	371
Adult	35	17	8	7	7	6	80
Totals	**118**	**577**	**722**	**374**	**381**	**696**	**2868**

Impacts to Listed Salmon and Steelhead

Bull trout use of North Fork Reservoir and occupancy of the HVZ during 2017 is largely unknown. Monitoring efforts have been limited following the end of the reintroduction project's radio-telemetry program in 2014. However, the detection histories of five PIT-tagged bull trout detected at various PIT antennas at PGE's hydro project facilities during 2017 provide some degree of insight into when and where bull trout occupy habitat in the Clackamas River extending from downstream of River Mill Dam to North Fork Reservoir (Appendix A).

It is reasonable to assume that bull trout opportunistically forage on salmon, steelhead and other species while in the vicinity of PGE's hydro project facilities, so it is important to understand how long bull trout reside there. It is often unclear how long a particular bull trout has occupied a given area prior to its detection moving upstream or downstream through the hydro project, but in some instances, occupancy timing can be inferred through an examination of detection histories. For example, one individual (PIT ID 982_000361679227) that was outplanted on May 29, 2015 as a 393 mm TL subadult, was detected while migrating downstream of North Fork and River Mill dams on June 7, 2017. It is unclear how long it had resided and foraged in the reservoir prior to entering the surface collector. Subsequent PIT detections at PGE facilities suggest this fish occupied habitat within and downstream of the hydro project for about 13 days before being detected and observed at the North Fork adult sorting facility on June 19, 2017. It had grown to 591 mm TL and subsequently moved upstream into Pinhead Creek, presumably staging to spawn on August 17, 2017. It is also unclear how long the fish remained in North Fork Reservoir prior to migrating to Pinhead Creek to spawn. In addition, an adult bull trout (PIT ID 0000_0000000177419402) that was released as a 393 mm subadult on June 6, 2013, moved downstream of North Fork Dam via the surface collector on July 30, 2017 before immediately entering the River Mill Ladder on August 2, 2017 (Appendix A). This fish resided in the vicinity of the project's fish ladders until August 23, 2017 when it was viewed at the North Fork Sorting Facility. The fish had grown to approximately 600 mm TL and was next detected in Pinhead Creek at the end of September to spawn. As with the first example, the amount of time this bull trout resided in North Fork Reservoir before and after being detected at PGE PIT

antennas is unknown. Given the aforementioned detection histories, it is not unreasonable to assume a portion of the translocated bull trout population resides in North Fork Reservoir and in the vicinity of PGE's hydro project facilities during most months.

Some bull trout detected at PGE facilities have sparse detection histories, limiting what can be inferred from the detections. For example, an approximately 585 mm adult bull trout (PIT ID 0000_000000177419441) that was released on May 23, 2013 into Last Creek as a 150 mm TL juvenile was observed moving upstream at the Adult Sorting Facility on March 24, 2017. It is unknown where it had resided since its release and how long it had occupied habitat in the vicinity of PGE facilities and the HVZ. In addition, a subadult bull trout (PIT ID 0000_0000000177419152) that was released at 285 mm and detected moving downstream of the dams via the Floating Surface Collector during early June 2017, provides very little insight into its whereabouts before and after the detection. This fish was likely not mature at the time of detection and may reside downstream of the hydro project facilities until a possible upstream spawning migration in future years. Similarly, a bull trout (PIT ID 982_000360937217) that was released as an 85 mm TL juvenile on April 29, 2016 in the upper Clackamas River resided in and around the North Fork Ladder for about 41 days from October 24, 2017 to December 3, 2017. This fish was likely juvenile-sized at the time of detection and may not impact listed salmonids until it matures.

In addition, counts of adult and juvenile salmonids (e.g., coho, Chinook, steelhead) are annually recorded through the hydro project in accordance with BiOp Term and Condition 1b (NMFS 2011). This monitoring is conducted by PGE outside the scope of the bull trout reintroduction project (Appendix B).

Conclusions

Bull trout populations often exhibit a continuum of life histories involving movements, migrations, spawning, rearing and foraging over a wide range of time and spatial scales (Schaller et al. 2014). Successful reintroduction of bull trout requires a sufficient knowledge of these fundamental characteristics. An understanding of these characteristics is essential to inform future management actions and for continued progress toward the project's goal of re-establishing a self-sustaining bull trout population in the Clackamas River Subbasin. As the first phase of the reintroduction effort transitions to the second phase, individuals from each translocated lifestage are surviving and recruiting into the adult population as evidenced by observations at PGE hydro project facilities and at the weir and PIT detection antennas in Pinhead Creek. The number of adult bull trout using Pinhead Creek during the spawning season has markedly increased since the early years of the reintroduction effort to estimates of almost 100 individuals. Moreover, redd counts throughout the study area are at their highest (N = 89) since the initiation of the reintroduction effort. However, there continue to be notable data gaps. Despite confirming a portion of the bull trout redds in Pinhead Creek produced viable embryos and hatching (i.e., alevins), efforts to provide evidence of post-emergent juveniles, or confirm recruitment of naturally reproduced individuals into the spawning population have been unsuccessful to date. Both of these benchmarks are important to the overall goal of establishing a self-sustaining population of bull trout in the Clackamas River Subbasin and may be achieved

over time as the reintroduction effort progresses and the population develops. We were able to draw the following conclusions from activities conducted during 2017.

Sixty-seven unique tags detected at the Pinhead mouth PIT detection site in 2017 represent translocated bull trout released at every lifestage during the years 2012 − 2016. As in 2016, juveniles released into Pinhead and Last creeks during 2013 contributed the most to detections in 2017. This is not surprising, given they were the largest release group since transfers began. The fates of many translocated bull trout are largely unknown. It is possible that a portion of the transferred fish did not survive, many may not yet be mature, and some may have shed their PIT tag. In addition, spawning and rearing have occurred elsewhere in the subbasin, explaining why some fish would not be detected in Pinhead Creek.

The majority of bull trout detections at the Pinhead mouth PIT array occurred in late summer and early fall, suggesting most of the fish entering Pinhead Creek are doing so to subsequently spawn. However, a portion of the individuals detected were fish from juvenile release groups in 2015 and 2016 and were likely not mature spawners, but instead may have entered Pinhead Creek seeking rearing and foraging habitat.

In general, bull trout moved relatively quickly to upstream spawning areas once they entered Pinhead Creek. Of the PIT tags that were first detected at the mouth array then subsequently at the weir, median travel time was 10 hours with the longest time being 224 hours (9.33 days). More than 75 percent of these fish reached the weir within two days.

There were six translocated bull trout that were first and last detected at the weir PIT antenna (i.e., they were not detected entering Pinhead Creek at the mouth PIT antenna), suggesting the possible development of a resident component of the population. Many local populations throughout the range of bull trout have both migratory and resident components (Barrows et al. 2016; Schaller et al. 2014).

As in past years, multiple bull trout returned to the study area upstream of North Fork Dam during 2017 after previously exiting the study area (i.e., downstream of River Mill Dam). Two of these individuals were subsequently detected while entering Pinhead Creek, presumably to spawn. This provides further evidence that bull trout exiting the study area are able to use foraging, migration and overwintering habitat downstream from the study area and successfully return upstream to spawning areas.

We considered 2017 to be the pilot year for operating a bull trout weir and trap in Pinhead Creek. The selected location, though not ideal, allowed for the successful deployment and operation of a weir. We made impromptu modifications and adjustments to the weir, trap and video monitoring equipment as the season progressed and with additional improvements, we believe the weir will be a useful tool for monitoring the spawning bull trout population in Pinhead Creek in future years.

Thirty-four individual bull trout were captured in the trap at the Pinhead Creek weir from August 15, 2017 to September 15, 2017. Of the 34 bull trout, six were untagged. Future genetic

analysis may confirm whether the untagged fish are naturally produced individuals recruited into the spawning population or translocated fish that have shed their PIT tag.

Given the relatively high percentage of tagged males that were observed at the video weir (89%) and captured in the trap (95%), it may be likely that only a small portion of the males in the spawning population were naturally reproduced progeny. The lower percentage of tagged female fish observed at the video weir (43%) and captured in the trap (67%) suggests a portion of the fish may be naturally produced, but the notable disparity between the percentage of tagged males and females suggests an elevated rate of tag shedding in females.

We found that translocated bull trout released as juveniles on average grew at a faster rate than fish released as subadults and adults. These results were generally consistent with findings reported in Harris et al. (2018) in that larger (e.g., older) individuals grew at a slower rate than smaller (e.g., younger) fish. A more robust growth rate analysis may be warranted in the future as the translocated population matures.

Two methods were used for estimating the bull trout spawning population in Pinhead Creek and very comparable estimates were produced. The first method used the tagged to untagged ratio of bull trout in the population to expand PIT detections at the PIT detection site near the mouth to estimate 95 total spawners. The second method used empirical data from the video, PIT tag and adult trap at the Pinhead Creek weir to estimate 97 total spawners.

Redd counts have increased each year since the inception of the reintroduction program and 2017 marks the highest count to date (N = 89). As translocated individuals and naturally produced offspring (if they exist) continue to mature, we expect further recruitment into the spawning population and, thus, increased redd counts in future years.

Despite ample evidence of bull trout spawning in Pinhead Creek, and that we collected multiple alevins from redds during hydraulic redd sampling, documenting survival from the embryo to juvenile lifestages is a benchmark we had yet to reach. Our inability to observe or collect bull trout fry during night snorkeling, fry surveys, cutthroat stomach lavage, minnow trapping and extensive electrofishing efforts in past years does not confirm bull trout fry and juveniles are not present, but it suggests they exist in low number if they are present.

No bull trout fry were found in the stomach contents of lavaged cutthroat trout. This suggests recently emerged fry may not be a common food source for cutthroat trout during early May in Pinhead Creek. This also may suggest a low abundance of bull trout fry available as a prey base. The underlying reason for this apparent low abundance is unknown, but survival of bull trout fry may be low for a variety of reasons. Environmental factors may influence embryo-to-fry survival in bull trout (e.g., temperature, flow, siltation, etc.). In addition, vitamin deficiencies (e.g., thiamine) have been linked to early mortality syndrome (EMS) in fish species (e.g., lake trout, brook trout) at the swim-up stage and in post swim-up fry (Honeyfield et al. 2005). EMS has been linked to reproductive failure of lake trout populations in the Great Lakes and is often associated with changes in the forage fish community (Honeyfield et al. 2005). Hydraulic redd pumping of embryos and testing them for thiamine deficiency may be a reasonable future step if natural production continues to be low or non-detectable in Pinhead Creek.

Caudal fin tissue was collected from six untagged bull trout captured at the Pinhead Creek weir during 2017. This collection of samples will provide the opportunity for subsequent parentage analysis and possibly the confirmation of naturally produced progeny and recruitment into the spawning population.

Bull trout use of North Fork Reservoir and occupancy of the HVZ during 2017 is largely unknown. However, the detection histories of five PIT-tagged bull trout detected at PIT antennas throughout PGE's hydro project facilities confirm that translocated bull trout were in the vicinity of the hydro power facilities during most months (Appendix A). It is reasonable to assume that bull trout may have foraged on juvenile anadromous salmonids and other prey species while occupying areas near the hydro project.

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Literature Cited

Al-Chokhachy, R. and P. Budy. 2008. Demographic Characteristics, Population Structure, and Vital Rates of a Fluvial Population of Bull Trout in Oregon. Transactions of the American Fisheries Society 137: 1709-1722.

Anderson, J.L., N. J. Hetrick, D. Spencer, J. P. Larson, and M. Santos. 2006. Design and Performance of a Digital Video Monitoring Station Incorporated in a V-Shaped Resistance Board Weir. Alaska Fisheries Technical Report Number 91. U.S. Fish and Wildlife Service (King Salmon Fish and Wildlife Office, King Salmon, AK.

Barrows, M.G., R.C. Koch, and B.P. Silver. 2014. North Fork Walla Walla River Bull Trout Occupancy and Habitat Use Assessment. 2012-2013 Annual Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA.

Barrows, M. G., R.C. Koch, J. Johnson, M.L. Koski, and E. Bailey. 2016a. Clackamas River Bull Trout Reintroduction Project, 2015 Annual Report. U.S. Fish and Wildlife Service (Columbia River Fisheries Program Office, Vancouver, WA) and Oregon Department of Fish and Wildlife (Corvallis, OR), 41 pp.

Barrows, M.G., D.R. Anglin, P.M. Sankovich, J.M. Hudson, R.C. Koch, J.J. Skalicky, D.A. Wills and B.P. Silver. 2016b. Use of the Mainstem Columbia and Lower Snake Rivers by Migratory Bull Trout. Data Synthesis and Analyses. Final Report. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA.

Barrows, M.G., B. Davis, J. Harris, E. Bailey, M.L. Koski, and S. Starcevich. 2017. Clackamas River Bull Trout Reintroduction Project. FY2016 Annual Report. U.S. Fish and Wildife Service, Columbia River Fish and Wildlife Conservation Office, Vancouver, Washington, and Oregon Department of Fish and Wildlife, Native Fish Investigations Program, Corvallis, Oregon. 65 pp.

Barry, P.M., J.M. Hudson, J.D. Williamson, M.L. Koski, and S.P. Clements. 2014. Clackamas River Bull Trout Reintroduction Project, 2013 Annual Report. Oregon Department of Fish and Wildlife and U.S. Fish and Wildlife Service, 46 pp.

Baxter, J.S., and J.D. McPhail. 1996. Bull trout spawning and rearing habitat requirements: summary of the literature. Fisheries Technical Circular No. 98, 27 p.

Berejikian BA, Gable J, Vidergar D (2011) Effectiveness and trade-offs associated with hydraulic egg collections from natural salmon and steelhead redds for conservation hatchery 398 Environ Biol Fish (2018) 101:383–401 programs. Trans Am Fish Soc 140(3):549–556. https://doi.org/10.1080/00028487.2011.583540

Buchanan, D., M. L. Hanson, R. M. Hooton. 1997. Status Of Oregon's Bull Trout, Distribution, Life History, Limiting Factors, Management Considerations, and Status, Oregon Department of Fish and Wildlife. Technical Report, Report to Bonneville Power Administration, Contract No. 1994BI34342, Project No. 199505400, 185 electronic pages (BPA Report DOE/BP-34342-5)

Fraley, J. J. and B. B. Shepard 1989. Life history, ecology, and population status of migratory bull trout (Salvelinus confluentus) in the Flathead Lake and River system, Montana. Northwest Science 63: 133-143.

USFWS. 2002a. Chapter 1, Introduction. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. Portland, Oregon, U.S. Fish and Wildlife Service: 137 pps.

USFWS. 2002b. Chapter 5, Willamette River Recovery Unit, Oregon. U.S. Fish and Wildlife Service. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. Portland, Oregon: 96 pp.

USFWS. 2011a. Clackamas River bull trout reintroduction implementation, monitoring, and evaluation plan. Oregon. Portland, Oregon, Oregon Fish and Wildlife Office, U.S. Fish and Wildlife Service in collaboration with Oregon Department of Fish and Wildlife: 63 pps.

USFWS. 2011b. Stepwise Impact Reduction Plan. USFWS Amendment to the 12/10/2010 Biological Assessment on the Reintroduction of Bull Trout to the Clackamas River.

USFWS. 2014. Revised Recovery Plan for the Pallid Sturgeon (*Scaphirhynchus albus*). U.S. Fish and Wildlife Service, Denver, Colorado. 115 pp.

USFWS. 2015a. Recovery Plan for the Coterminous United States Population of Bull Trout (*Salvelinus confluentus*). Portland, Oregon xiii + 179pp.

USFWS. 2015b. Coastal Recovery Unit Implementation Plan for Bull Trout (*Salvelinus confluentus*). Portland, Oregon. 160pp.

Harris, J. E., C. Newlon, P. J. Howell, R. C. Koch, S. L. Haeseker. 2018. Modelling individual variability in growth of bull trout in the Walla Walla River Basin using a hierarchical von Bertalanffy growth model. Ecol Freshw Fish. 2018;27:103–115.

Hogberg, N. P. and M. A. Pegg. 2016. Flathead catfish Pylodictis olivaris diet composition during extreme flow events in a large river. Journal of Freshwater Ecology Vol. 31, NO. 3, 431-441.

Honeyfield, D.C., J. P. Hinterkopf, J. D. Fitzsimons, D. E. Tillitt, J. L. Zajicek and S.B. Brown. 2005. Development of Thiamine Deficiencies and Early Mortality Syndrome in Lake Trout by Feeding Experimental and Feral Fish Diets Containing Thiaminase. Journal of Aquatic Animal Health Volume 17, Issue 1.

Jones, D. S., I. A. Fleming, L. K. McLaughlin and K. K. Jones. 2008. Feeding Ecology of Cutthroat Trout in the Salmon River Estuary, Oregon. Coastal Cutthroat Trout Symposium: Status, Management, Biology, and Conservation. Oregon Chapter, American Fisheries Society, 2008.

Leary, R. F., F. W. Allendorf and S. H. Forbes. 1993. Conservation genetics of bull trout in the Columbia and Klamath river drainages. Conservation Biology 7: 856-865.

McNeil WJ (1964) A method of measuring mortality of pink salmon eggs and larvae. Fish Bull 63:575–588

McPhail J. D. and J. S. Baxter. 1996. A Review of Bull Trout (*Salvelinus confluentus*) Life-history and Habitat Use in Relation to Compensation and Improvement Opportunities. Department of Zoology, University of British Columbia, Vancouver, B.C. Fisheries Management Report No. 104.

Meyer, K A. , B. High, N. Gastelecutto, E. R. J. Mamer, F. S. Elle. 2011. Retention of Passive Integrated Transponder Tags in Stream-Dwelling Rainbow Trout. North American Journal of Fisheries Management, 31: 2, 236-239

Morrow, J. 1980. The Freshwater Fishes of Alaska. University of British Columbia Resource Ecology Library: University of British Columbia.

NMFS 2011. Endangered Species Act Section 7 Formal Consultation Magnuson-Stevens Act Essential Fish Habitat Consultation for the U.S. Fish and Wildlife Service, Oregon Fish and Wildlife Office. Proposal to Reintroduce Bull Trout (*Salvelinus confluentus*) to the Clackamas River, Oregon. Biological Opinion. June 27, 2011.

Nowak, G. M., R. A. Tabor, E. J. Warner, K. L. Fresh, and T. P. Quinn. 2004. Ontogenetic shifts in habitat and diet of cutthroat trout in Lake Washington, Washington. North American Journal of Fisheries Management 24: 624-635.

ODFW 2012. Clackamas River Bull Trout Reintroduction Annual Progress Report for 21 June 2011 – 15 December 2011. Contracts 13420-AJ030 and 11-CS-11060600-003. Salem, Oregon: 22 pp.

Oliver, G. 1979. A final report on the present fisheries use of the Wigwam River with an emphasis on the migration, life history and spawning behavior of Dolly Varden char, *Salvelinus malma* (Walbaum). Fisheries investigations in tributaries of the Canadian portion of Libby Reservoir, B.C. Fish and Wildlife Branch, Victoria, British Columbia, Canada.

Prentice, E., T. Flagg, and C. McCutcheon. 1990. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. Pages 317–322 in N. Parker, A. Giorgi, R. Heidinger, D. Jester, E. Prince, and G. Winans, editors. Fish-marking techniques. American Fisheries Society, Symposium 7, Bethesda, Maryland.

Rieman, B. E. and J. D. McIntyre 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124: 285-296.

Schaller, H.A., P. Budy, C. Newlon, S.L. Haeseker, J.E. Harris, M. Barrows, D. Gallion, R.C. Koch, T. Bowerman, M. Conner, R. Al-Chokhachy, J. Skalicky and D. Anglin. 2014. Walla Walla River Bull Trout Ten Year Retrospective Analysis and Implications for Recovery Planning. U.S. Fish and Wildlife Service, Columbia River Fisheries Program Office, Vancouver, WA. 520 pp.

Starcevich, S. 2018. Clackamas River bull trout monitoring update 2017 - 2018. ODFW Native Fish Investigations Program. Clackmas River Bull Trout Working Group Meeting. February 14, 2018.

Appendix A

Comprehensive Detection Histories for Bull Trout Detected at PGE Facilities During 2017

Telemetry Code	PIT Tag Code	Size at Tagging or Recapture (TL)	Date Released (*), Detected or Recaptured	Location Released (*), Detected, or Recaptured
NA	**0000_000000177419441**	**150 mm**	**5/23/2013***	**Last Creek us of 42 Bridge***
			3/22/2017	North Fork Adult Sorting Facility
			3/24/2017	PIT Detection – return ladder
		~585 mm	3/24/2017	PIT Detection – North Fork Ladder Exit
NA	**982_000361679227**	**393 mm**	**5/29/2015***	**4650 Bridge***
			6/6/2017	PIT Detect – Fl. Surface Collector (NF Dam)
			6/6/2017	PIT Detect – DS Migrant Collector (NF Dam)
			6/6/2017	PIT Detect – Fl. Surface Collector (NF Dam)
			6/7/2017	PIT Detect – Fl. Surface Collector (NF Dam)
			6/7/2017	PIT Detect – Timber Park D/S Sampling Fac.
			6/12/2017	PIT Detection – River Mill Ladder
			6/18/2017	PIT Detection – North Fork Ladder Entrance
			6/18/2017	PIT Detection – N. F. Old Sorting Facility
			6/19/2017	North Fork Adult Sorting Facility
		~600 mm	6/19/2017	PIT Detection – North Fork Ladder Exit
			8/17/2017	PIT Detection – Pinhead Weir PIT/Video (US)
			8/27/2017	PIT Detection – Pinhead Weir PIT/Video (DS)
			8/27/2017	PIT Detection – Pinhead Cr. Array (mouth)
		591 mm	8/29/2017	Pinhead Weir Trap (Male)
			9/1/2017	PIT Detection – Pinhead Weir PIT/Video (DS)
			9/2/2017	PIT Detection – Pinhead Weir PIT/Video (US)
			9/2/2017	PIT Detection – Pinhead Weir PIT/Video (DS)
			9/2/2017	PIT Detection – Pinhead Cr. Array (mouth)
NA	**0000_0000000177419152**	**285 mm**	**5/20/2016***	**4650 Bridge***
			6/6/2017	PIT Detect – Fl. Surface Collector (NF Dam)
			6/6/2017	PIT Detect – Timber Park D/S Sampling Fac.
NA	**0000_0000000177419402**	**325 mm**	**6/6/2013***	**Lower 4650 Bridge D/S***
			9/9 to 9-13 (2015)	PIT Detection – Pinhead Cr. Array (mouth)
			8/31 to 9/10 (2016)	PIT Detection – Pinhead Cr. Array (mouth)
			7/30/2017	PIT Detect – DS Migrant Collector (NF Dam)
			7/30/2017	PIT Detect – Timber Park D/S Sampling Fac.
			8/2/2017	PIT Detection – River Mill Ladder
			8/5/2017	PIT Detection – North Fork Ladder Entrance
			8/17/2017	PIT Detection – River Mill Ladder
			8/20/2017	PIT Detection – North Fork Ladder Entrance
			8/21/2017	PIT Detection – N. F. Old Sorting Facility
			8/22/2017	PIT Detection – N. F. Old Sorting Facility
		~600 mm	8/23/2017	PIT Detection – return ladder
			8/24/2017	PIT Detection – North Fork Ladder Exit
			9/21 to 9/25 (2017)	PIT Detection – Pinhead Cr. Array (mouth)
			9/30/2017	PIT Detection – Pinhead Weir PIT/Video (DS) (Female)
			9/30/2017	PIT Detection – Pinhead Cr. Array (mouth)
33	**982_000360937217**	**84 mm**	**4/29/2016***	**Upper Clackamas***
			10/24/2017	PIT Detection – North Fork Ladder Exit
			11/20/2017	North Fork Adult Sorting Facility
			11/30/2017	PIT Detection – N. F. Old Sorting Facility
			12/3/2017	PIT Detection – North Fork Ladder Entrance

Appendix B

Counts for Anadromous Salmonids Through the PGE Hydro Facility on the Clackamas River

In accordance with BiOp Term and Condition 1b (NMFS 2011), through monitoring that PGE conducts outside the scope of the bull trout reintroduction project, counts of adult and juvenile coho, Chinook, and steelhead are annually recorded through the hydro project. This summary is not intended to be an analysis of trends in salmon and steelhead lifestage metrics, given the changes in how monitoring has been conducted by PGE over time (Nick Ackerman, PGE, pers. comm.), and is not intended to fulfill any reporting requirements of PGE. Rather, the information provided by PGE is summarized below (Table C1) relative to the Stepwise Impact Reduction Plan (USFWS 2011) and the minimum thresholds identified in Table 2 therein.

Table C1. Summary of adult, juvenile and smolt/adult counts for coho salmon, Chinook Salmon and steelhead through the PGE hydro facility on the Clackamas River, Oregon, relative to thresholds identified in the Stepwise Impact Reduction Plan (USFWS 2011).

Species	Metric	Threshold	2017*
Coho Salmon	Adult	2,160	The adult counts were above the threshold for the third year (2013, 2014, 2017) since implementation of this project.
	Juvenile	54,431	The juvenile counts were above the threshold and have exceeded the threshold in all years since implementation of this project.
	Smolts/adult	38.1	The estimated smolts/adults were above the threshold and have exceeded the threshold in all years since implementation of this project.
Chinook Salmon	Adult	780	The adult counts were above the threshold and have exceeded the threshold in all years since implementation of this project.
	Juvenile	6,237	The juvenile counts were above the threshold and have exceeded the threshold in all years since implementation of this project.
	Smolts/adult	3.1	The estimated smolts/adults were above the threshold and have exceeded the threshold in all years since implementation of this project.
Steelhead	Adult	600	The adult counts were above the threshold and have exceeded the threshold in all years since implementation of this project.
	Juvenile	20,374	The juvenile counts were above the threshold and have exceeded the threshold in all years since implementation of this project.
	Smolts/adult	10.2	The estimated smolts/adults were above the threshold and have exceeded the threshold in all years since implementation of this project.

* Annual data provided by Nick Ackerman, PGE.

References:

NMFS 2011. Endangered Species Act Section 7 Formal Consultation Magnuson-Stevens Act Essential Fish Habitat Consultation for the U.S. Fish and Wildlife Service, Oregon Fish and Wildlife Office. Proposal to Reintroduce Bull Trout (Salvelinus confluentus) to the Clackamas River, Oregon. Biological Opinion. June 27, 2011.

USFWS. 2011. Stepwise Impact Reduction Plan. USFWS Amendment to the 12/10/2010 Biological Assessment on the Reintroduction of Bull Trout to the Clackamas River.

Appendix C

ANNUAL PROGRESS REPORT
FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: Clackamas River Bull Trout Reintroduction Project: Characterizing status and thermal habitat suitability in 2017 with census redd counts, PIT tag technology, eDNA surveys, and water temperature data loggers

PROJECT NUMBER: Portland General Electric Agreement # 2016-08

PROJECT PERIOD: 2017

Prepared by: Steven J. Starcevich

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Clackamas River Bull Trout Reintroduction Project: Characterizing status and thermal habitat suitability in 2017 with census redd counts, PIT tag technology, eDNA surveys, and water temperature data loggers

Steven J. Starcevich, ODFW Native Fish Investigations Program
Corvallis Research Lab, May, 2018

Abstract

Bull Trout were extirpated from the Clackamas River basin by the 1960s. A reintroduction feasibility assessment and an implementation plan were completed in 2007 and 2011, respectively, with the goal of establishing a self-sustaining population of 300-500 adults in the Clackamas River basin. The first phase of the project (2011-2016) involved translocating 2,868 Bull Trout from the Metolius River basin, tagging each with a passive integrated transponder (PIT) tag, releasing them in the upper Clackamas River basin, and monitoring them using a variety of methods. The second phase of the project began in 2017 and continued monitoring progress toward the reintroduction goal, through census redd surveys, the use of PIT tag technology, night snorkel surveys, water temperature monitoring, and eDNA surveys. Redd abundance in Pinhead Creek basin steadily increased from 16 redds in 2012 to 85 redds in 2017. In 2017, 62 PIT-tagged adults (estimated age at detection ≥ age-5) were detected in Pinhead Creek, a decline from 73 PIT-tagged adults in 2016. The abundance of PIT-tagged adults is expected to decline over time as translocated fish are replaced by locally produced adults. PIT-tagged adults spent a median of 17 d in Pinhead Creek during the spawning period; these fish were translocated mainly at age-1 and 2 (i.e., 70-210 mm) and released at locations primarily in Pinhead Creek and the Clackamas River. Most Bull Trout spawning occurred in September and the last PIT-tagged adult detection was in mid-October. Temperature monitoring revealed extensive high quality thermal habitat for juvenile Bull Trout (maximum <14°C) in the Clackamas River upstream of the Collawash River confluence. Thermal habitat quality for spawning (daily mean <9°C in September) was high in the Clackamas River upstream of the Cub Creek confluence, Pinhead Creek, and Last Creek; and medium in the Clackamas River between the confluences of Cub Creek and Collawash River and a few tributaries of the Clackamas River. No Bull Trout were observed during night snorkeling surveys in 1.5 km of Pinhead Creek. Surveys for eDNA occurred in 31 sample sites within 11 streams. The eDNA samples have not been analyzed yet. Census spawning surveys, eDNA and night snorkel surveys, and temperature monitoring will continue in 2018.

Introduction

Bull Trout (*Salvelinus confluentus*) were extirpated from the Clackamas River basin by the 1960s. A feasibility assessment (Shively et al. 2007) and an implementation plan (US Fish and Wildlife Service [USFWS] 2011) for Bull Trout reintroduction were completed with the goal of establishing a self-sustaining population of 300-500 adult in Clackamas River basin. The implementation plan was divided into 3 phases of approximately 6-7 years each (USFWS 2011). The first phase was from 2011 through 2016 and involved translocating 2,868 Bull Trout from the Metolius River basin (Figure 1, Table 1), giving each one a unique passive integrated transponder (PIT) tag, releasing them at various locations and lifestages (80% of which were between 70-250 mm total length) in the upper Clackamas River basin, and then monitoring them using radio telemetry, PIT tags, electrofishing, and redd surveys. The second phase began in 2017 and entailed continued monitoring of progress toward the reintroduction goal, at least in part through census redd surveys and the use of PIT tag technology.

Redd surveys in 2011 through 2014 were conducted by an *ad hoc* multi-agency group of observers. In 2015 and 2016, census redd surveys were conducted in all potential spawning habitat in the upper Clackamas River basin by a crew of five experienced observers from the Oregon Department of Fish and Wildlife (ODFW), with additional help from other agencies and volunteers. In 2017, the redd survey sampling frame was reduced to areas where Bull Trout spawning was consistently observed in 2015 and 2016, which were Pinhead Creek, Last Creek, and the upper Clackamas reach. The census surveys were conducted with four ODFW surveyors of varying experience, with additional help from two experienced surveyors from the U.S Forest Service (USFS) and U.S. Fish and Wildlife Service. The areas dropped from the sampling frame in 2017 were either confounded by high density Chinook Salmon (*Oncorhynchus tshawytscha*) spawning with few to no Bull Trout redds observed in previous surveys or consisted of relatively poor spawning habitat with no redds observed previously. Bull Trout occupancy in these areas will be monitored from 2017 through 2020 using environmental DNA (eDNA) surveys and water temperature data loggers were deployed to evaluate thermal habitat suitability throughout the upper Clackamas River basin. In 2017, the specific objectives were to 1) characterize Bull Trout abundance using census spawning surveys in known or high potential spawning areas, 2) examine relationships between redd counts and PIT-tagged adults detected in the Pinhead Creek watershed, 3) document juvenile Bull Trout rearing in Pinhead Creek using night snorkel surveys, and 4) refine the sampling frame using water temperature data loggers to focus spawning and eDNA surveys in thermal habitat suitable for Bull Trout spawning and rearing, and 5) characterize Bull Trout distribution using eDNA surveys in potential spawning and rearing areas. Funding for objectives 1 and 5 was provided by Portland General Electric (Agreement # 2016-08). Funding for additional objectives was provided by ODFW – Native Fish Investigations Program.

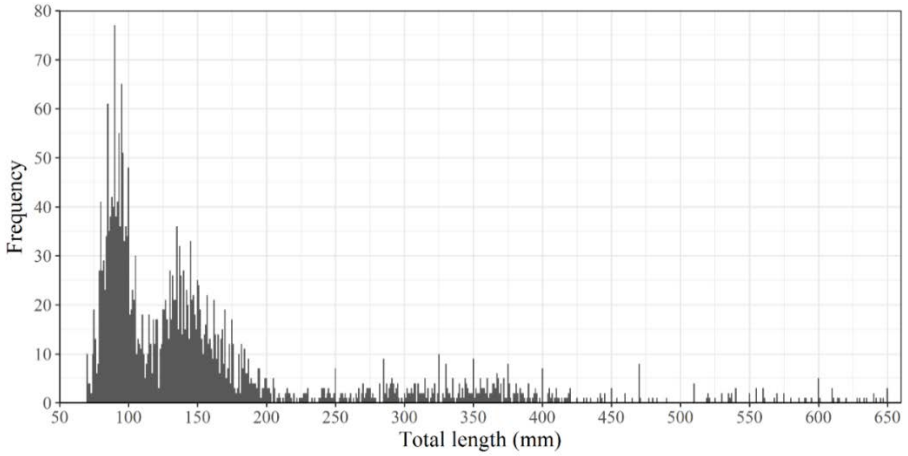

Figure 1. Length-frequency histogram of Bull Trout captured in the Metolius River basin, PIT-tagged, and translocated to the upper Clackamas River basin, 2011-2016.

Methods

Census redd surveys

A five-person crew conducted census redd surveys in Pinhead Creek, Last Creek, and Reach 4 of the upper Clackamas River (Figure 2). Census surveys were generally completed every two weeks (Table 2). The first census survey was conducted in mid-August, prior to the putative start of Bull Trout and Chinook Salmon spawning. This survey was used to familiarize the field crew with Bull Trout redd identification by analyzing characteristics of old redds from a previous season (i.e., redds constructed prior to August) and flagging areas that could be mistaken for new redds. A new Bull Trout redd was identified by its pocket-mound structure, smaller gravel size relative to substrate in Chinook Salmon redds, and the contrast of brighter disturbed gravel relative to darker surrounding substrate matrix. Chinook and Coho salmon redds were distinguished by their relatively large surface area and substrate size and by identifying the species of adult salmon occupying a redd. The crew flagged new Bull Trout redds and recorded the following data: geographic location, maximum length and width of the redd, species and number of adults occupying the redd, and brief descriptions of the redd and surveyor confidence in the redd observation. Welch's t-test was used to compare redd surface area (i.e., redd length * redd width) of Chinook Salmon and Bull Trout.

Bull Trout and salmon redd data were entered in an Access database that contained data from previous Bull Trout spawning surveys in the upper Clackamas River basin. From 2011-2014, some spawning surveyors recorded observations of some redds described as "potential", "possible", "likely", "test dig?" or some other variant registering uncertainty in their observations; these descriptions were included in the database. From 2015-2017, observers were trained to include a brief description of their certainty in each new redd identified and the reason for their uncertainty. These descriptions were entered as a comment in the database. Differing from 2011-2014, only features described as redds (i.e., as opposed to test dig) and with descriptors connoting relatively high certainty (e.g., >50%) were included in the 2017 count. (See Appendix I for dataset from 2017.)

Table 1. PIT-tagged Bull Trout translocated from the Metolius River basin to the Clackamas River basin in the first phase of the reintroduction project. Lifestage was defined by the size classes 70-250 mm (juvenile), 251-450 mm (subadult), 451-650 mm (adult). Annual translocations occurred from 2011 through 2016.

		Lifestage			Date	
Year	Location	Juvenile	Subadult	Adult	Min	Max
2011	Clackamas River	0	0	11	30-Jun	30-Jun
	Clackamas River 1	0	14	3	30-Jun	30-Jun
	Clackamas River 2	0	11	21	30-Jun	15-Jul
	Last Creek	42	0	0	30-Jun	15-Jul
	Pinhead Creek	16	0	0	21-Jul	21-Jul
	2011 Subtotal	*58*	*25*	*35*		
2012	Clackamas River 1	0	9	1	14-Jun	14-Jun
	Clackamas River 2	2	34	16	14-Jun	12-Jul
	Last Creek	151	0	0	3-May	28-Jun
	Pinhead Creek	364	0	0	10-May	31-May
	2012 Subtotal	*517*	*43*	*17*		
2013	Clackamas River	3	30	3	6-Jun	13-Jun
	Clackamas River 1	0	60	5	6-Jun	27-Jun
	Last Creek	338	0	0	11-Apr	27-Jun
	Pinhead Creek	283	0	0	2-May	30-May
	2013 Subtotal	*624*	*90*	*8*		
2014	Berry Creek	296	0	0	24-Apr	29-May
	Clackamas River 1	26	45	7	5-Jun	25-Jun
	2014 Subtotal	*322*	*45*	*7*		
2015	Berry Creek	287	1	0	10-Apr	5-Jun
	Clackamas River 1	13	73	7	15-May	5-Jun
	2015 Subtotal	*300*	*74*	*7*		
2016	Clackamas River 1	95	94	6	20-May	13-Jun
	Clackamas River 5	501	0	0	8-Apr	13-May
	2016 Subtotal	*596*	*94*	*6*		
	Total	*2417*	*371*	*80*	*Grand total*	2868

Table 2. Census redd survey reaches, schedule, and the number of redds counted in each census. Some reaches were not surveyed (NS) in each census.

	Census					
Reach	1	2	3	4	5	6
Clackamas River 4	5-Sep	17-Sep	NS	NS	16-Oct	NS
Pinhead Creek 1	28-Aug	19-Sep	27-Sep	3-Oct	17-Oct	31-Oct
Pinhead Creek 2	28-Aug	18-Sep	27-Sep	2-Oct	16-Oct	31-Oct
Last Creek	29-Aug	18-Sep	27-Sep	3-Oct	17-Oct	30-Oct
Total Bull Trout redds	1	35	15	15	13	10
Total Chinook Salmon redds	0	0	1	1	4	24

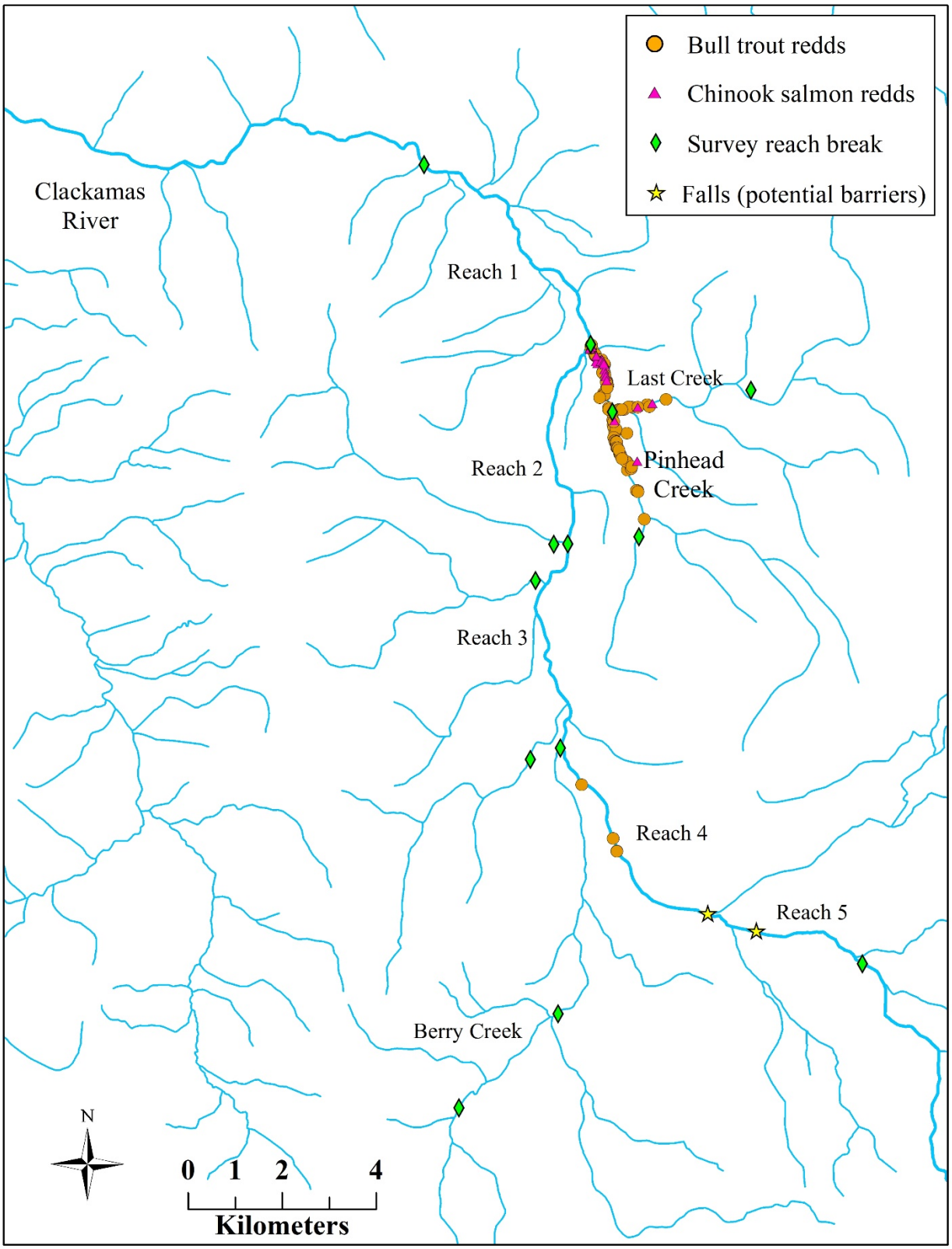

Figure 2. Census survey extent for all survey years and Pinhead Creek, Last Creek, and Reach 4 of the Clackamas River and redd distribution in 2017.

Pinhead Creek PIT-tagged adult monitoring

In the first phase of the reintroduction, Bull Trout translocated from the Metolius River basin were given PIT tags and released in the Clackamas River basin. A solar-powered, 4-antenna PIT array has been installed in Pinhead Creek, near its confluence with the Clackamas River, to monitor PIT-tagged Bull Trout use of this watershed. The PIT array is usually activated by early April and maintained through November. The PIT detection site and database are maintained by the USFWS. PIT tag detections in Pinhead Creek were used to describe the annual number, duration, timing, lifestage-at-release, and release location of PIT-tagged Bull Trout present in Pinhead Creek during the spawning season.

As a relative measure of annual adult Bull Trout abundance, age-5 and older fish (hereafter referred to as "adults") detected at the PIT array were counted by year. This age cutoff was used because migratory Bull Trout in the Metolius River basin are thought to begin to mature at age-5 (Ratliff et al. 1996), which is similar to Bull Trout populations in other basins. For example, a study in the Lake Pend Oreille basin showed that at least 50% of age-5 Bull Trout had reached adulthood (McCubbins et al. 2016). In a study in the Flathead Lake basin, Bull Trout first matured at age-5 and all individuals age-6 and older were mature (Fraley and Sheppard 1989). Age-1 through age-4 Bull Trout detected at the PIT array were also counted to show use of Pinhead Creek by either immature fish or mature younger fish. To count the number of PIT-tagged fish using Pinhead Creek annually, age-class at release of PIT-tagged fish and at detection in Pinhead Creek were approximated. Age-class at release was approximated for age-1 and age-2 fish based on a length-frequency histogram of translocated fish (Figure 1) and length-at-age studies of Bull Trout throughout their range for older fish (Fraley and Sheppard 1989, Ratliff et al. 1996, see Table 2 of Salow 2004). Bull Trout ages were approximated as follows: age-1, 70-115 mm; age-2, 116-210 mm; age-3, 211-320 mm; age-4, 321-400 mm; and age-5 and older, >400 mm. Age-class at detection was estimated by summing age-class at release and the interval between the date of release in the Clackamas River basin and date of detection in Pinhead Creek. For example, to estimate the annual number of PIT-tagged Bull Trout age-5 or older detected in Pinhead Creek, the following detection intervals were used: >1,360 d (i.e., 3 yr and 265 d) for age-1 at release, >995 d for age-2, >630 d for age-3, >265 d for age-4, and >0 d for age-5 and older.

Simple linear regression was used to quantify the relationship between the annual number of adult PIT-tagged Bull Trout detected in Pinhead Creek, the response variable (Y), and the total annual count of Bull Trout redds in Pinhead and Last creeks, the explanatory variable (X), from 2011-2016 (Ramsey and Schafer 1997). The simple linear regression model used is as follows: $\mu\{Y|X\} = \beta_0 + \beta_1 X$. The parameter β_0 is the y-intercept of the line. The parameter β_1 represents the slope of the line.

Duration of detection of PIT-tagged adult Bull Trout in Pinhead Creek was calculated as the number of days between the first detection and last detection of each fish at the Pinhead Creek PIT array in a single monitoring season. This was summarized by year using median, maximum, and minimum duration, excluding individuals detected for ≤1 d. This exclusion attempted to reduce, likely without eliminating, the influence of short-term non-spawning use on the estimated timing of adult use in Pinhead Creek. Timing of adult use of Pinhead Creek was represented by boxplots of first and last detections of individuals during the monitoring season.

The annual adult count was displayed by the lifestage at which these fish were released and by their release location. Lifestage was defined by the following categories: juvenile, 70-250 mm; subadult, 251-450 mm; and adult, 451-650 mm.

eDNA surveys

The eDNA surveys were conducted according to the field collection protocol and sampling equipment suggested by Carim et al. (2016). The peristaltic pump (Geopump, Geotech, Colorado, USA) was powered by either a lithium ion battery or cordless drill (DeWalt, Maryland, USA). At each study site, the pump pulled 5 L of stream water through a 1.5-µm-pore fiberglass filter. The filters were immediately stored in a plastic bag with silica dessicant. Within 10-48 hours, these samples were placed in a -20°C freezer for storage until they can be analyzed for the presence of Bull Trout eDNA by the National Genomics Center for Fish and Wildlife Conservation (USFS Rocky Mountain Research Station, Fort Collins, Colorado).

Candidate eDNA survey streams were classified by two priority levels for monitoring Bull Trout distribution. The highest priority streams were known to be thermally suitable (i.e., maximum <16°C), lacked fish barriers, and were within the suitable patches identified in the reintroduction feasibility study (Shively et al. 2007). Other candidate streams were identified either through historical anecdotes as occupied streams outside of the identified suitable habitat patches (Shively et al. 2007) or by survey gaps in the range-wide Bull Trout distribution research effort led by the USFS Rocky Mountain Research Station (see McKelvey et al. 2016). These streams, currently lacking stream width and thermal habitat data, will be surveyed in the future if thermal habitat monitoring shows these areas to be suitable. Probability of detection of eDNA presence in streams is positively related to fish density and negatively related to stream discharge (Wilcox et al. 2016). Therefore, the number of sample sites allocated to a survey stream depended on estimated stream baseflow discharge and total stream detection probability >0.85, assuming a minimum Bull Trout density of 1 fish per 100 m. Sample site allocation was based on detection probability estimates from simulations using parameterized models from Wilcox et al. (2016).

Night snorkel surveys

Night snorkeling surveys were conducted by 4-person crews on September 21-22 and October 30-31, 2017, between 10 PM and 2 AM. Each snorkeler used a dive light and all habitat in two high density spawning reaches was snorkeled, including side channels and backwaters. On the first night, the 1 km of Pinhead Creek was snorkeled moving upstream from the mouth. On the second night, the crew surveyed 0.5 km of Pinhead Creek, starting at the mouth of Last Creek.

Stream temperature

Digital temperature data loggers (Onset™ Hobo Water Temp Pro v2 U-22) were set to record stream temperature every 30 minutes and deployed in 30 locations in the upper Clackamas River basin in June and downloaded in October. Four data loggers were lost because of bed scour or human tampering; these were replaced in October with new data loggers. An additional 6 data loggers were deployed in October. Juvenile rearing habitat was evaluated with two maximum daily temperature criteria used to delineate suitable habitat patches (Table 3). Bull Trout are generally thought to initiate spawning when stream temperature declines below 9°C (McPhail

and Murray 1979; Weaver and White 1985; Fraley and Shepard 1989; Kitano 1994). More specifically, Bull Trout initiated spawning at mean daily stream temperatures between 9.3 and 11.5°C in Pine Creek, Oregon (Chandler et al. 2001), and 9.4 and 11.7°C in the Lostine River, Oregon (Howell et al. 2010). As peak Bull Trout spawning in Pinhead Creek and elsewhere in northeast Oregon (Starcevich et al. 2012) generally occurs in September, we used mean daily temperatures of <9°C, 9-12°C, >12°C in September to respectively classify spawning habitat as high, medium, and low thermal suitability (Starcevich et al. 2017).

Table 3. Stream temperature metrics used to delineate Bull Trout habitat patches (from Isaak et al. 2009). Italicized temperatures are delineations for Bull Trout patches with sympatric Redband Trout reported in Haas (2001).

Thermal suitability	Summer maximum (°C)	
High	≤16	*≤12*
Medium	>16 to ≤19	*>12 to ≤16*
Low	>19	*>16*

Table 4. Bull Trout redds counted during census surveys in the upper Clackamas River basin, 2011-2017. In certain years, some stream reaches were not surveyed (NS).

		Bull Trout redd count							
Stream	Reach	2011	2012	2013	2014	2015	2016	2017	Riverscape marks
Pinhead Creek	1	3	9	10	21	13	34	33	Mouth to Last Cr.
Pinhead Creek	2	2	5	2	14	34	25	40	Last Cr. to FS140 Road
Last Creek	1	0	2	3	2	0	3	12	Mouth to Camp Cr.
Clackamas River	1	NS	NS	NS	NS	2	0	NS	Big Bottom to Pinhead Cr.
Clackamas River	2	NS	NS	NS	NS	5	2	NS	Pinhead Cr. to Lowe Cr.
Clackamas River	3	NS	NS	NS	NS	2	0	NS	Lowe Cr. to Cub Cr.
Clackamas River	4	NS	NS	1	NS	2	4	4	Cub Cr. to First falls
Clackamas River	5	NS	NS	NS	NS	0	NS	NS	First falls to Ollalie Cr.
Oak Grove Fork	1	NS	NS	2	NS	1	0	NS	First 2.5 km
Lowe Creek	1	NS	NS	NS	NS	0	0	NS	First 1 km
Rhododendron Cr.	1	NS	NS	NS	NS	0	0	NS	First 1 km
Hunter Creek	1	NS	NS	NS	NS	0	0	NS	First 1.5 km
Cub Creek	1	NS	NS	NS	NS	0	0	NS	Mouth to Berry Cr.
Cub Creek	2	NS	NS	NS	NS	0	NS	NS	2.5 km up from Berry Cr.
Berry Creek	1	NS	NS	NS	NS	0	0	NS	First 3 km
TOTAL		5	16	18	37	59	68	89	

Results and Discussion

Census redd surveys

During 2017 census redd surveys, 85 putative Bull Trout redds were counted in Pinhead Creek and Last Creek and 4 redds were counted in reach 4 of the upper Clackamas River (Figure 2, Table 4, Appendix I). Bull Trout redd numbers increased in Reach 2 of Pinhead Creek and Last Creek relative to census counts in 2016. Overall, the census count from Pinhead and Last creeks increased 37% from the previous year (Table 5). The first Bull Trout redd was observed in late August and 74% of the redds were counted by early October (Table 2). Bull Trout were seen occupying or actively spawning on 8 redds (9% of total). Bull Trout redds were 58% the surface area of Chinook Salmon redds ($t = -3.21$, $df = 35.7$, $P = 0.003$).

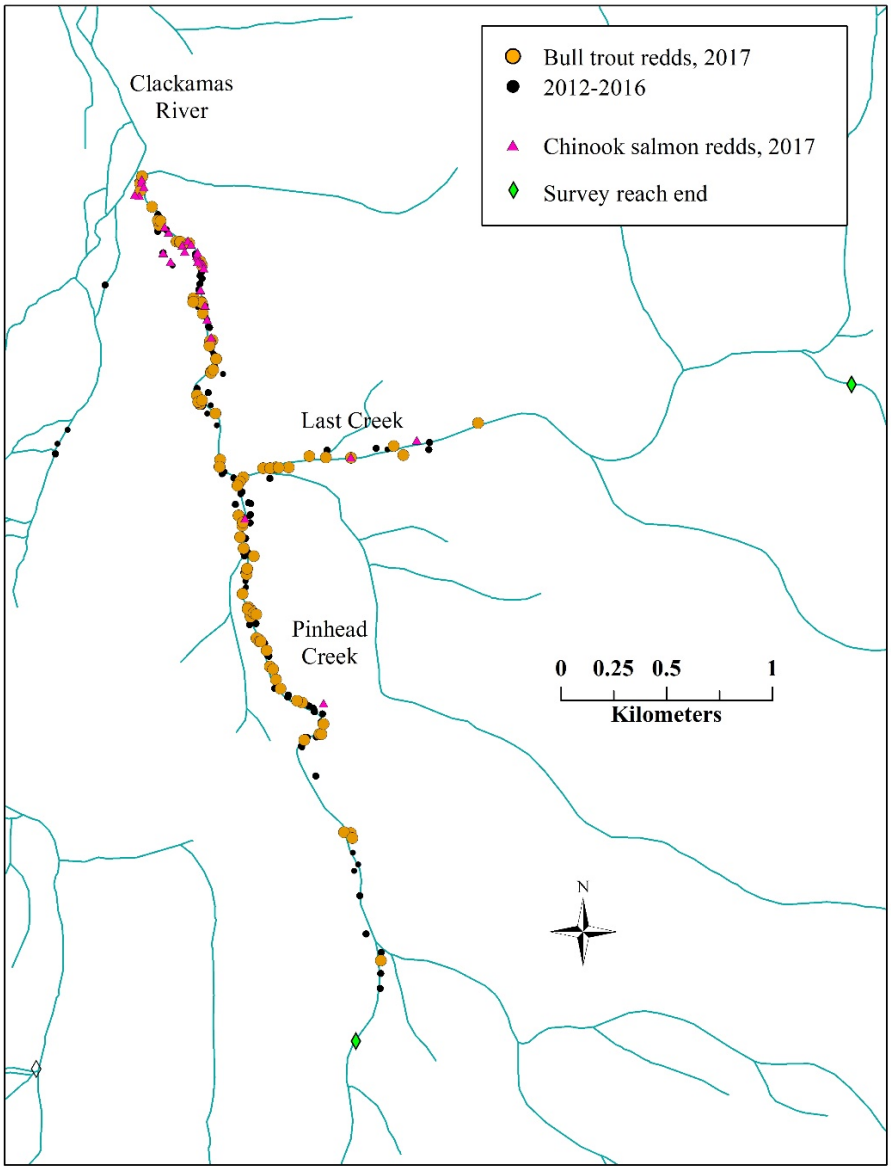

Figure 3. Georeferenced redds in Pinhead Creek and Last Creek from 2012-2017. Redds were georeferenced in secondary channels; these channels are not shown.

Table 5. Census survey redd counts in relation to the number of PIT-tagged adult Bull Trout detected in the Pinhead Creek watershed and the estimated duration each PIT-tagged adult spent in this watershed. Adulthood was defined as fish estimated to be ≥ age-5. Duration was defined as the number of days between the first and last detection (>1 day) at the PIT array in Pinhead Creek.

Census Survey			Tagged Adults	Duration		
Year	Redds	Annual Increase		Median	Min	Max
2011	5	NA	5	20	3	26
2012	16	220%	17	35	12	55
2013	15	-6%	13	30	3	68
2014	37	147%	32	22	3	93
2015	47	27%	53	18	2	87
2016	62	32%	73	26	3	88
2017	85	37%	62	17	2	91

In Pinhead and Last creeks, 30 Chinook Salmon redds were counted, 87% of which were observed in Reach 1 of Pinhead Creek (Figure 3, Appendix I). The first salmon redd was observed in late September and salmon spawning increased substantially in the latter half of October (Table 2). Chinook Salmon were observed actively spawning on or occupying 6 redds (20% of total). Most of the Bull Trout redds had been constructed prior to the increase in salmon spawning in Pinhead Creek and therefore did not act as a confounding variable until the final round of surveys.

Pinhead Creek PIT-tagged adult monitoring

The number of adult PIT-tagged Bull Trout using Pinhead Creek during the spawning season steadily increased from 13 adults in 2013 to 72 in 2016 and declined to 62 in 2017 (Table 5). There was a still strong linear relationship ($y=0.85x+3.9$, $R^2=0.83$, $P=0.003$) between the annual census redd count (x) and the number of adults detected (y) in Pinhead Creek (Figure 4). Prior to 2017, the linear model shows an almost 1:1 relationship between adults detected and the census redd count ($\beta_1=1.03$). For individual years, the adult to redd ratio was similar in 2015 (1.12 adults:redd) and 2016 (1.16). In 2017 the adult to redd ratio declined to 0.73 and the relationship no longer appears linear. This was expected at some point because the proportion of PIT-tagged Bull Trout in the spawning population will shrink over time as locally spawned fish enter the adult population and PIT-tagged adults die. Recruits from the 21 redds observed in Pinhead Creek in 2011 and 2012, the first two years of translocations, would be age-5 or 6 this season, which is the age at which a proportion of the donor population first matures in the Metolius River basin (Ratliff et al. 1996), and these recruits may contribute undetected members to the adult population. Tag loss is also expected to contribute to the proportional decline of tagged adults in the population, especially among repeat spawning females (Meyer et al. 2011).

Although the adult to redd ratio was low relative to other Bull Trout populations (see Howell and Sankovich 2012), the census redd count was a useful monitoring tool from 2012-2016 because it was a consistent proxy for PIT-tagged adult abundance in the Pinhead Creek watershed. This suggests that the 2017 increase in the census redd count likely reflected an increase in adult

abundance even though abundance of PIT-tagged adults declined. If census redd counts continue to be used as an abundance monitoring tool in this basin, then periodic calibration to adult abundance may be necessary to ensure that redd counts are tracking actual adult population trend. Given the diminishing number of translocated adults with PIT tags, new calibration methods may need to be considered.

In 2016 and 2017, 75% of PIT-tagged adults were first detected in Pinhead Creek by early September and last detected by late September (Figure 5), which corresponded to the spawning peak observed during redd surveys (Table 2). PIT-tagged adults generally spend 17-35 d in Pinhead Creek during the spawning season (Table 5). Similar to 2015 and 2016, this timing information suggests that Bull Trout likely have completed spawning by mid-October; although, 10 new Bull Trout redds were counted on October 30-31, 2017. It is possible that these redds were constructed by Bull Trout without PIT tags. Alternatively, these redds may have been missed during previous surveys. These redds were unlikely to be salmon redds because of their relatively small size; however, this last round of census surveys was most confounded by salmon spawning (Table 2). PIT tag detection timing at Pinhead Creek provides an approximation of when Bull Trout are using Pinhead Creek and the Clackamas River and could be useful in designing redd monitoring schedules, training, and protocols that minimize errors in identifying Bull Trout redds.

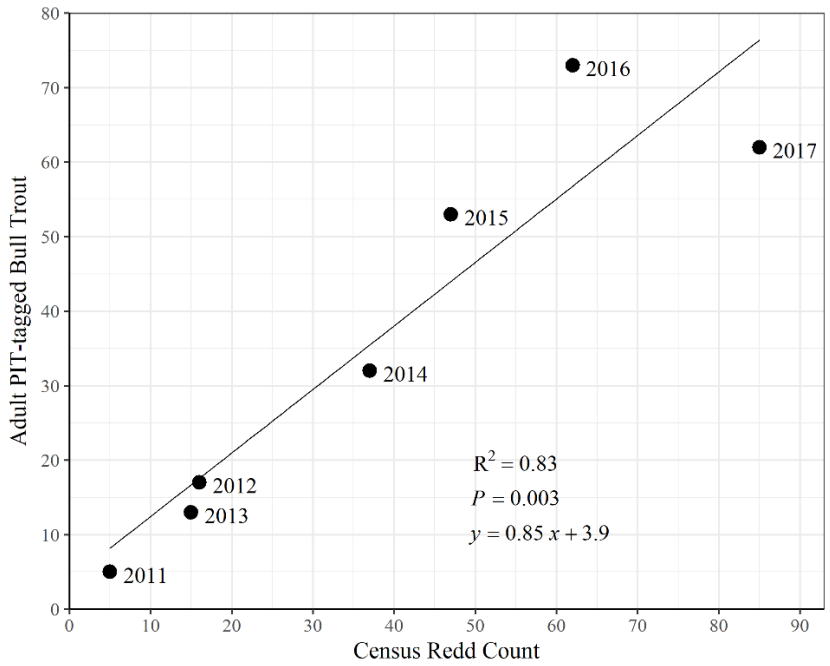

Figure 4. Annual number of adult PIT-tagged Bull Trout (i.e., age-5 and older) detected in Pinhead Creek during the spawning period as a function of the annual Bull Trout redd count in Pinhead Creek and Last Creek. The line and its equation were estimated using simple linear regression.

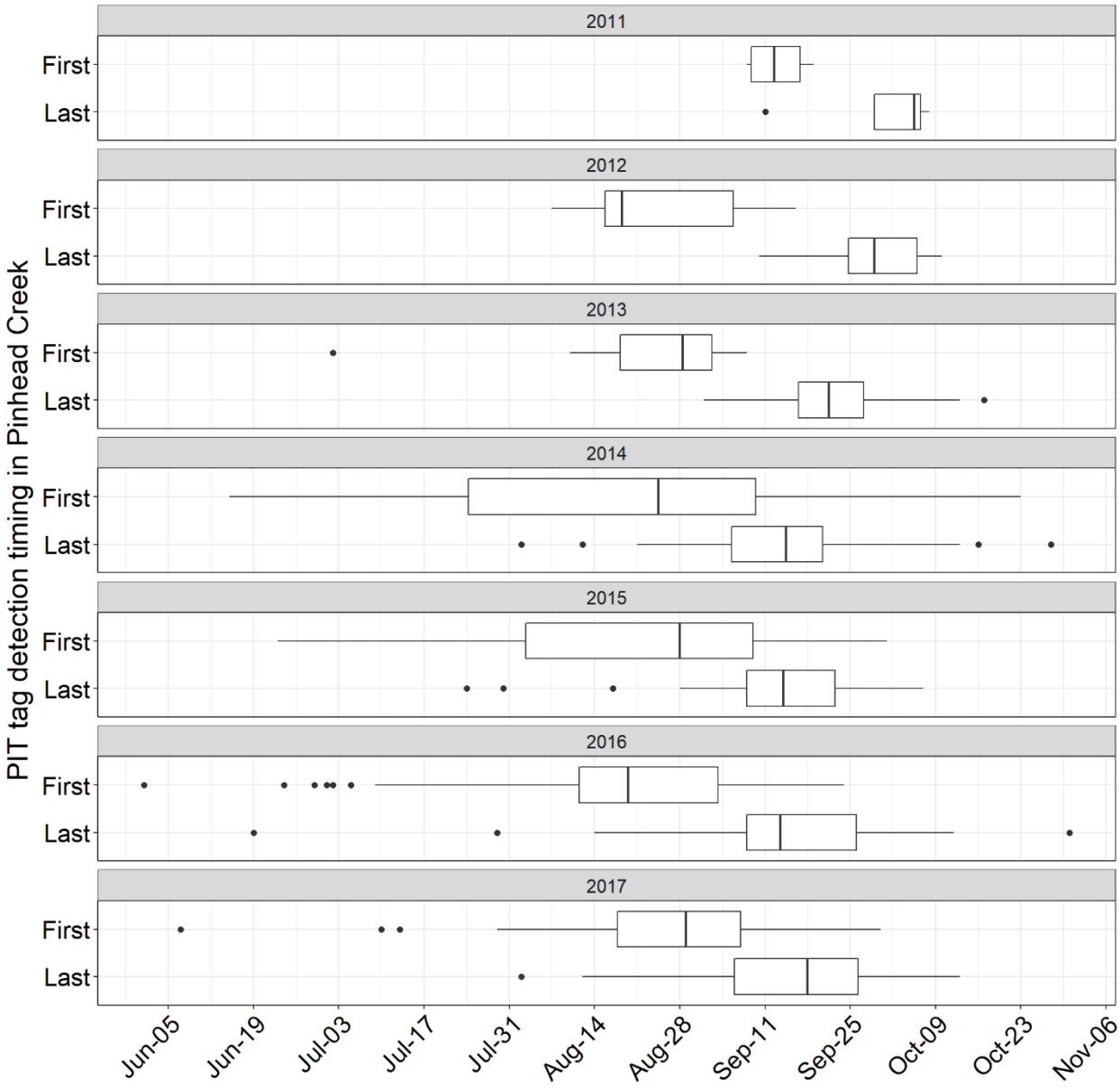

Figure 5. Timing of first and last detection of PIT-tagged Bull Trout, age-5 and older, at the PIT array near the mouth of Pinhead Creek. The boxplot displays a median line and two middle quartile boxes; the whiskers are defined as 1.5*interquartile range (IQR), outliers are beyond this spread, and together they represent the early and late quartiles. PIT-tagged adults detected ≤1 d were not included in timing analyses.

Table 6. Age-class and release location of all PIT-tagged Bull Trout detected in Pinhead Creek during the spawning season. Age-class was approximated from their age at release and the number of days between their release and detection dates (see text for more details).

	Age (yr)					Release Location					
Year	≥ 5	4	3	2	1	Lower Clackamas	Clackamas Reach 1	Pinhead/Last creeks	Clackamas Reach 2	Clackamas Reach 5	Berry Creek
2011	5	1	2	8	0	1	0	11	5	0	0
2012	17	2	3	2	7	1	2	13	15	0	0
2013	13	1	16	177	9	0	1	206	10	0	0
2014	32	12	21	2	0	5	14	38	9	0	1
2015	53	32	2	2	1	9	30	41	5	0	5
2016	73	5	2	0	0	0	30	44	2	0	4
2017	62	1	2	3	0	1	29	32	0	3	3

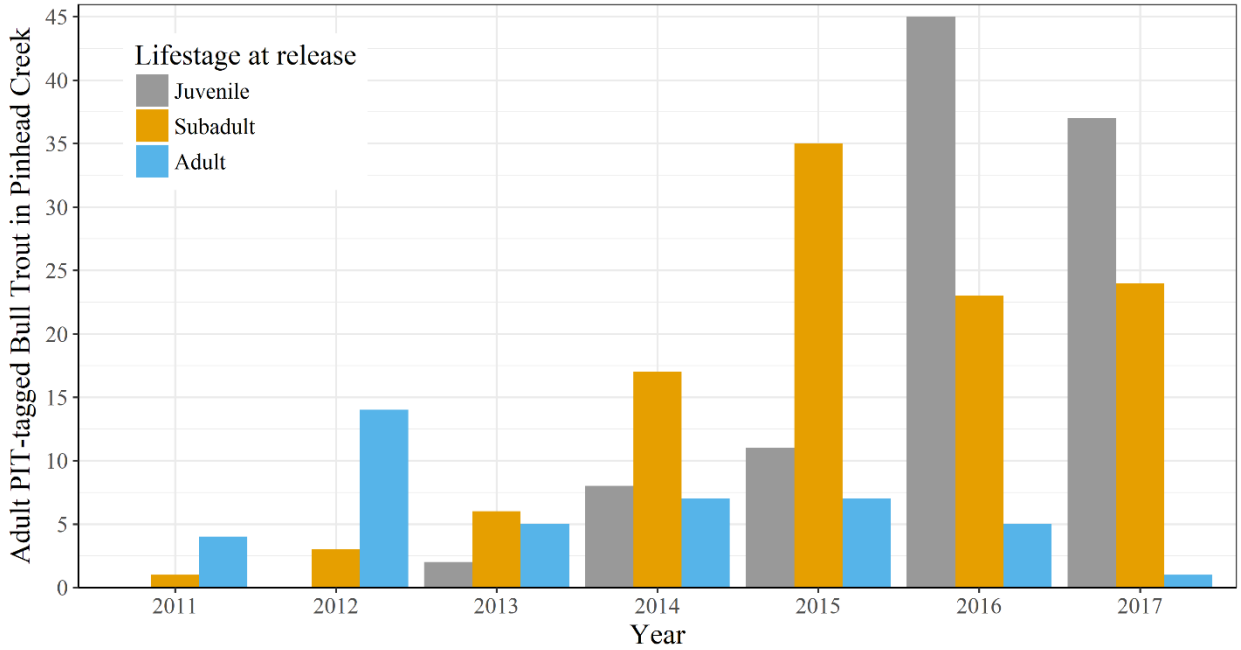

Figure 6. Lifestage at which PIT-tagged Bull Trout were released into the upper Clackamas River basin and subsequently detected at the Pinhead Creek PIT-array prior to and during the spawning season as adult Bull Trout (i.e., age-5 and older).

The total count of PIT-tagged Bull Trout detected in Pinhead Creek also included some PIT-tagged fish between age-1 and 4 (Table 6). The number of younger PIT-tagged fish using Pinhead Creek during the spawning season was low in 2016 and 2017 relative to previous years. The release location of PIT-tagged Bull Trout (all ages) detected at Pinhead Creek in 2017 was mainly Reach 1 of the Clackamas River and Pinhead and Last creeks and included a few fish released as far away as Berry Creek, Reach 5 of the Clackamas River, and the Lower Clackamas River (Table 6). The lifestage at which PIT-tagged Bull Trout were released in the upper Clackamas River basin and subsequently detected at the Pinhead Creek PIT array as an adult

during the spawning season shifted from mostly adult in 2011-2012, to mostly subadult in 2015, and to mostly juvenile and subadult by 2017 (Figure 6). These data show that at least some translocated juveniles and subadults are surviving to adulthood and either returning near their release locations in the Pinhead Creek watershed during the spawning season or finding and using Pinhead Creek during the spawning season predominantly from Reach 1 of the Clackamas River.

Night snorkel surveys

Even though translocated age-1 and age-2 Bull Trout are surviving to adulthood in the upper Clackamas River basin, extensive juvenile fish surveys in 2016 using a variety of capture methods did not detect locally produced juvenile Bull Trout in Pinhead Creek (Barrows et al. 2017). Night snorkel surveys were not used in 2016 but have been shown to be an effective way to document juvenile Bull Trout rearing (Thurow et al. 2006). The night snorkel surveys in 2017 in Pinhead Creek did not detect juvenile Bull Trout. Juvenile Chinook Salmon was the dominant fish species observed; for example, within a single complex pool in Pinhead Creek as many as 22 salmon juveniles were counted. Other species observed included juvenile Coastal Cutthroat Trout (*O. clarki clarki*), juvenile Rainbow Trout or steelhead (*O. mykiss*), and sculpins (*Cottid sp*). Several areas within the Pinhead Creek survey reaches appeared to be high quality Bull Trout rearing habitat. These areas included low velocity pockets and pools with complex structure such as cobble, large wood and organic debris, and undercut banks. Recent genetic confirmation of Bull Trout alevins sampled from redds identified during census surveys in 2017 in Pinhead and Last creeks (Chris Allen, USFWS, personal communication) suggest that Bull Trout are successfully spawning and eggs are developing into alevins in redds, but it is still unknown if juvenile early rearing is successfully occurring in Pinhead Creek.

Stream temperature

Maximum daily temperatures recorded on 26 temperature data loggers distributed throughout the upper Clackamas River basin (Figure 7, left panel) suggest there is extensive medium and high quality thermal habitat for juvenile Bull Trout rearing. Upstream of the Collawash River confluence, maximum temperatures in the Clackamas River and most of its tributaries were between 12-14°C, well below the 16°C criterion for high quality thermal habitat patches (Isaak et al. 2009). Pinhead Creek is the coldest stream and primary Bull Trout spawning area in the basin so it is surprising that juveniles have not been detected rearing in this stream.

High quality thermal habitat for spawning (i.e., <9°C in September) occurred in Pinhead Creek, Last Creek, and the upper reaches of the Clackamas River (Figure 7, upper right panel); and medium quality spawning habitat (i.e., <12°C in September) existed in the Clackamas River upstream of the Collawash River confluence, Hunter Creek, Berry Creek, Rhododendron Creek, and lower Oak Grove Fork (Figure 7, lower right panel). Low quality spawning habitat occurred in the Collawash River basin, the Clackamas River downstream of the Collawash River, lower Roaring Creek, and Lowe Creek (Figure 7). In 2018, temperature monitoring will be extended to include the tributaries of the upper Collawash River and these data will aid in selecting and prioritizing streams for future distribution sampling using night snorkeling and eDNA surveys.

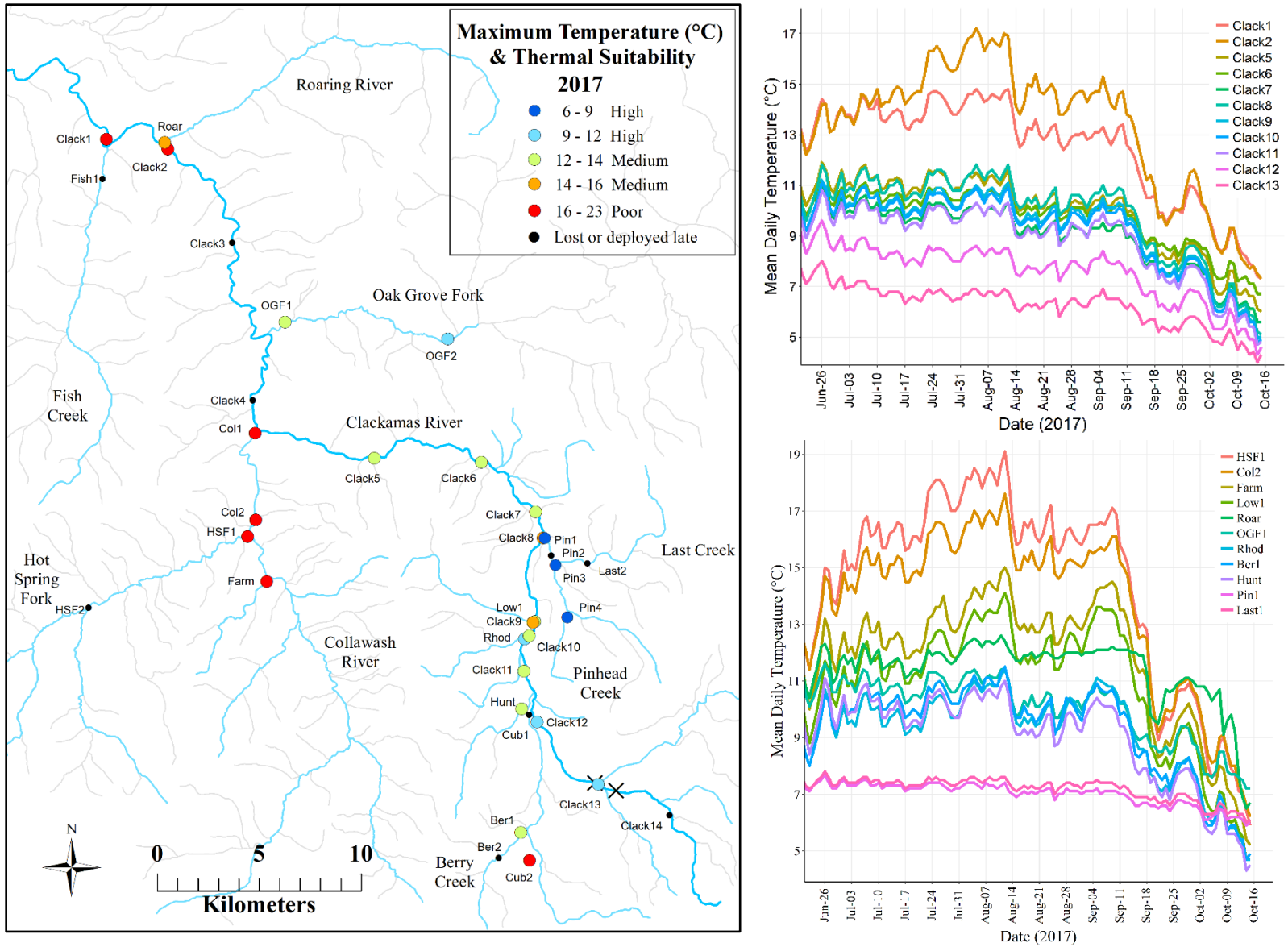

Figure 7. Maximum daily water temperatures recorded with data loggers in the upper Clackamas River basin, June 20 to October 15, 2017.

eDNA surveys

Environmental DNA surveys were conducted to determine the extent and degree of Bull Trout use in Pinhead Creek and Last Creek, to determine if Bull Trout were still rearing in or near reintroduction areas in the upper Clackamas River and Berry Creek, and to monitor potential increase in distribution in Roaring River, Fish Creek, Oak Grove Fork, Pot Creek, Lowe Creek, Rhododendron Creek, and Cub Creek (Figure 8). These samples will be analyzed in 2018.

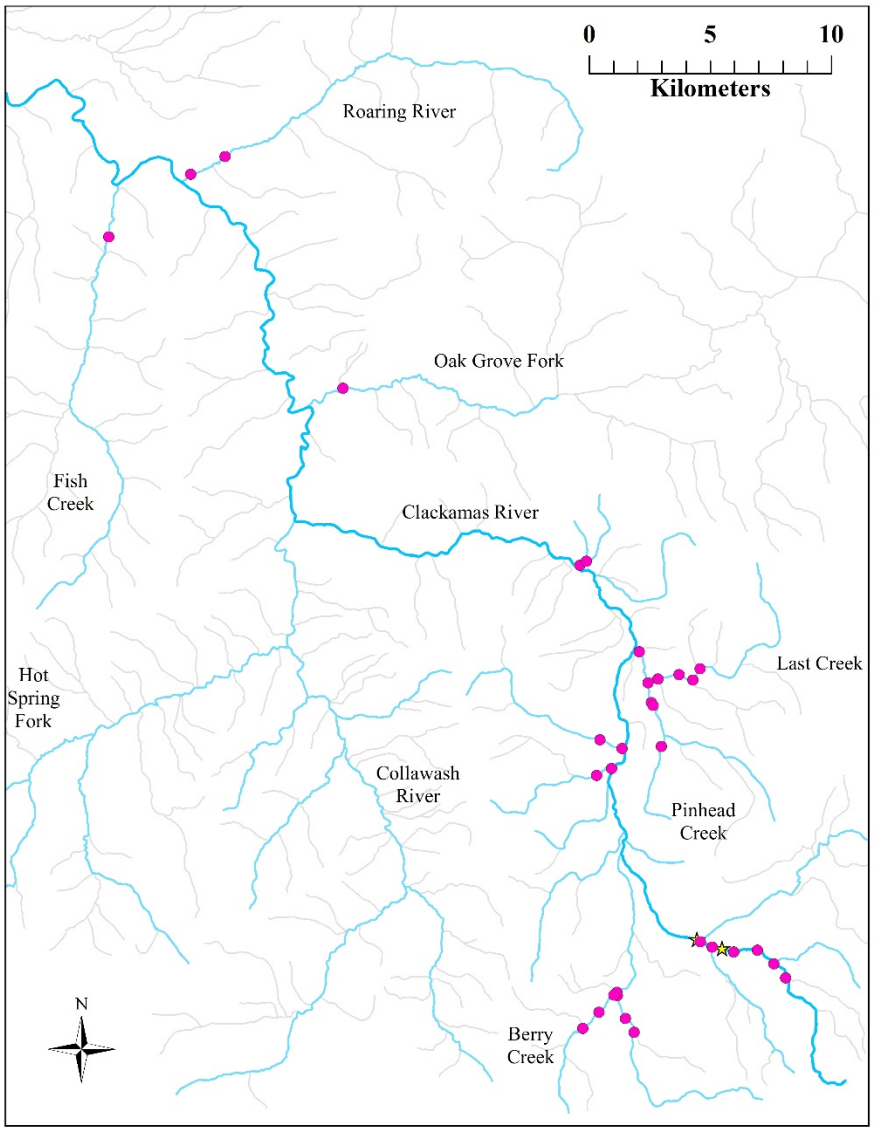

Figure 8. Environmental DNA survey sites (pink dots) and natural falls (yellow stars) that potentially act as fish passage barriers.

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References

Barrows, M. G., B. Davis, J. Harris, E. Bailey, M. L. Koski and S. Starcevich. 2017. Clackamas River Bull Trout Reintroduction Project, 2016 Annual Report. U.S. Fish and Wildlife Service and Oregon Department of Fish and Wildlife.

Carim, K. J., K. S. Mckelvey, M. K. Young, T. M. Wilcox, and M. K. Schwartz. 2016. A Protocol for Collecting Environmental DNA Samples From Streams (August).

Fraley, J. J., and B. B. Shepard. 1989. Life history, ecology and population status of migratory Bull Trout (*Salvelinus confluentus*) in the Flathead Lake and River System, Montana. Northwest Science 63:133-143.

Haas, G. R. 2001. The mediated associations and preferences of native Bull Trout and Rainbow Trout with respect to maximum water temperature, its measurement standards, and habitat in Bull Trout II Conference Proceedings, pages 53–55. Editors, Brewin, M.K., A.J. Paul, and M. Monita.

Howell, P. J., and P. M. Sankovich. 2012. An evaluation of redd counts as a measure of Bull Trout population size and trend. North American Journal of Fisheries Management 32:1–13.

Isaak, D., B. Rieman, and D. Horan. 2009. A watershed-scale monitoring protocol for Bull Trout. General Technical Report RMRS-GTR-224. Fort Collins, CO.

McCubbins, J. L., M. J. Hansen, J. M. Dos Santos, and A. M. Dux. 2016. Demographic characteristics of an adfluvial Bull Trout population in Lake Pend Oreille, Idaho. North American Journal of Fisheries Management 36:1269–1277.

McKelvey, K. S., M. K. Young, W. L. Knotek, and K. J. Carim. 2016. Sampling large geographic areas for rare species using environmental DNA : a study of Bull Trout *Salvelinus confluentus* occupancy in western Montana. Journal of Fish Biology 88:1215–1222.

Meyer, K. A., B. High, N. Gastelecutto, E. R. J. Mamer, and F. S. Elle. 2011. Retention of passive integrated transponder tags in stream-dwelling Rainbow Trout. North American Journal of Fisheries Management 31:236–239.

Ramsey, F.L., and D.W. Schafer. 1997. The statistical sleuth: a course in methods of data analysis. Wadsworth Publishing Company, Belmont, CA, 742 pages.

Ratliff, D. E., S. L. Thiesfeld, W. G. Weber, A. M. Stuart, M. D. Riehle, and D. V. Buchanan. 1996. Distribution, life history, abundance, harvest, habitat, and limiting factors of Bull Trout in the Metolius River and Lake Billy Chinook, Oregon, 1983-94. Portland, Oregon.

Salow, T. D. 2004. Population structure and movement patterns of adfluvial Bull Trout (*Salvelinus confluentus*) in the North Fork Boise River Basin, Idaho. Master's thesis, Boise State University. Boise, Idaho.

Shively, D., C. Allen, T. Alsbury, B. Bergamini, B. Goehring, T. Horning, and B. Strobel. 2007. Clackamas river Bull Trout reintroduction feasibility assessment. Published by USDA

Forest Service, Mt. Hood National Forest; U.S. Fish and Wildlife Service, Oregon State Office; and Oregon Department of Fish and Wildlife, North Willamette Region. December, 2007.

Starcevich S.J., P.J. Howell, and S.G. Jacobs. 2012. Seasonal movement and distribution of fluvial adult Bull Trout in selected watersheds in the Mid-Columbia River and Snake River basins. PLoS ONE 7(5): e37257. doi:10.1371/journal.pone.0037257.

Starcevich, S., E.J. Bailey, and M.H. Meeuwig. 2017 Bull Trout conservation and recovery in the Odell Lake Core Area: Adult status in Trapper Creek and thermal and physical habitat suitability in 2016. ODFW Progress Report, Corvallis Research Lab, Native Fish Investigations Program.

Thurow, R. F., J. T. Peterson, and J. W. Guzevich. 2006. Utility and validation of day and night snorkel counts for estimating Bull Trout abundance in first- to third-order streams. North American Journal of Fisheries Management 26:217–232.

USFWS 2011. Clackamas River Bull Trout reintroduction implementation, monitoring, and evaluation plan. Oregon. Portland, Oregon, Oregon Fish and Wildlife Office, U.S. Fish and Wildlife Service in collaboration with Oregon Department of Fish and Wildlife: 63 pps.

Wilcox, T. M., K. S. McKelvey, M. K. Young, A. J. Sepulveda, B. B. Shepard, S. F. Jane, A. R. Whiteley, W. H. Lowe, and M. K. Schwartz. 2016. Understanding environmental DNA detection probabilities: A case study using a stream-dwelling char *Salvelinus fontinalis*. Biological Conservation 194:209–216.

Appendix I. Bull Trout and Chinook Salmon redd count data from the upper Clackamas River basin, 2017.

Stream	Reach	Date	Species	Redd ID	Easting	Northing	LN (cm)	WD (cm)	Comment
Last Creek	1	10/30/2017	CHK	G2HH	589400	4980487	200	100	chinook redd on old redd
Last Creek	1	10/30/2017	CHK	G3HH	589076	4979259	300	150	chinook redd on this year's Bull Trout redd!
Last Creek	1	10/30/2017	CHK	G1AK	589088	4980408	150	40	chinook redd by large substrate
Pinhead Creek	1	10/31/2017	CHK	G8HH	588369	4981334	150	80	100% redd
Pinhead Creek	1	9/27/2017	CHK	D1TH	588387	4981323	120	130	*probably B2BB, two small mounds closes together
Pinhead Creek	1	10/3/2017	CHK	E2AK	588096	4981706	100	280	Chinook on redd
Pinhead Creek	1	10/17/2017	CHK	F1HH	588098	4981720	250	120	chinook redd; most likely chinook 18" fish on, couldn't make out species
Pinhead Creek	1	10/17/2017	CHK	F1AK	588087	4981643	140	100	lg substrate, mostly chinook redd
Pinhead Creek	1	10/17/2017	CHK	F2AK	588226	4981470	170	250	chinook redd, larger substrate huge redd
Pinhead Creek	1	10/17/2017	CHK	F1CA	588234	4981331	350	180	chinook redd, fish on
Pinhead Creek	1	10/31/2017	CHK	G2HH	588290	4981410	260	100	chinook redd
Pinhead Creek	1	10/31/2017	CHK	G3HH	588317	4981431	300	140	chinook redd
Pinhead Creek	1	10/31/2017	CHK	G5HH	588332	4981413	130	40	50/50 bt redd, obvious digging
Pinhead Creek	1	10/31/2017	CHK	G7HH	588365	4981351	140	90	100% redd
Pinhead Creek	1	10/31/2017	CHK	G1AK	588108	4981685	170	90	chinook redd
Pinhead Creek	1	10/31/2017	CHK	G5SS	588363	4981331	220	130	chinook redd, 2 chk on redd
Pinhead Creek	1	10/31/2017	CHK	G4SS	588362	4981376	290	90	chinook redd, femal chk 5 m upstream
Pinhead Creek	1	10/31/2017	CHK	G3SS	588302	4981379	120	50	chinook redd, gravel large
Pinhead Creek	1	10/31/2017	CHK	G1SS	588207	4981495	250	250	chinook redd, 2 chinook on redd
Pinhead Creek	1	10/31/2017	CHK	G1CA	588065	4981649	200	100	chinook redd, high probability
Pinhead Creek	1	10/31/2017	CHK	G6HH	588359	4981359	130	80	nice redd
Pinhead Creek	1	10/31/2017	CHK	G2AK	588201	4981372	250	60	chinook redd
Pinhead Creek	1	10/31/2017	CHK	G7SS	NA	NA	200	170	chk redd
Pinhead Creek	1	10/31/2017	CHK	G13HH	588427	4980974	170	80	100% redd
Pinhead Creek	1	10/31/2017	CHK	G12HH	588407	4981058	230	60	50/50 redd, obvious digging
Pinhead Creek	1	10/31/2017	CHK	G11HH	588398	4981125	160	90	100% redd

Stream	Reach	Date	Species	Redd ID	Easting	Northing	LN (cm)	WD (cm)	Comment
Pinhead Creek	1	10/31/2017	CHK	G10HH	588376	4981198	150	80	fresh digging on old redd
Pinhead Creek	1	10/31/2017	CHK	G9HH	588391	4981301	140	60	100% redd
Pinhead Creek	1	10/31/2017	CHK	G3AK	588199	4981373	800	300	chinook redd
Pinhead Creek	2	10/31/2017	CHK	G2AK	588569	5980094	260	200	chinook redd on old redd
Clackamas River	5	9/5/2017	BT	B1HH	588646	4970964	170	70	<50% certainty, fresh digging observed, some algaed gravels in mound, not well fluffed
Pinhead Creek	1	9/19/2017	BT	B1SS	588183	4981503	120	70	
Pinhead Creek	1	9/19/2017	BT	B2SS	588433	4980961	70	50	fish digging, small pocket mound, maybe too small for eggs
Pinhead Creek	1	9/19/2017	BT	B3SS	588450	4980872	140	90	nice redd, a little dark
Pinhead Creek	1	9/19/2017	BT	B4SS	588426	4980812	NA	NA	active digging, 2 large Bull Trout on redds, 1 sneaker?
Pinhead Creek	1	9/19/2017	BT	B5SS	588427	4980807	NA	NA	3 fish active digging nice redd
Pinhead Creek	1	9/19/2017	BT	B6SS	588469	4980396	140	100	nice redd
Pinhead Creek	1	9/19/2017	BT	B1AK	588175	4981527	95	80	100% redd, side channel
Pinhead Creek	1	9/19/2017	BT	B1BB	588264	4981428	100	100	60% redd, fresh dig on old redd
Pinhead Creek	1	9/19/2017	BT	B2BB	588383	4981315	50	150	fresh dig on old redd
Pinhead Creek	1	9/19/2017	BT	B4BB	588375	4980660	170	200	100%redd
Pinhead Creek	1	9/19/2017	BT	B1CA	588421	4980956	140	70	definite redd, high confidence
Pinhead Creek	1	9/19/2017	BT	B2CA	588419	4980935	140	100	2 Bull Trout on redd
Pinhead Creek	2	9/18/2017	BT	B1AK	588705	4979418	100	80	fresh redd, bt carcass on site, otter kill
Pinhead Creek	2	9/18/2017	BT	B2AK	588720	4979405	90	50	fresh redd, under log
Pinhead Creek	2	9/18/2017	BT	B3AK	588940	4979098	100	60	reused site, new redd
Pinhead Creek	2	9/18/2017	BT	B4AK	588867	4979070	120	70	nice redd
Pinhead Creek	2	9/18/2017	BT	B5AK	589088	4978631	100	150	poorly formed, possible test redd
Pinhead Creek	2	9/18/2017	BT	B6AK	589230	4978027	80	140	little gravel, 40%
Pinhead Creek	2	9/18/2017	BT	B1BB	588949	4979098	100	160	100% redd
Pinhead Creek	2	9/18/2017	BT	B2BB	589056	4978634	120	100	75% redd, loks small but good mound
Last Creek	1	9/18/2017	BT	B1BB	588794	4980359	310	130	huge redd
Last Creek	1	9/18/2017	BT	B2BB	588580	4980312	230	120	nice redd

Stream	Reach	Date	Species	Redd ID	Easting	Northing	LN (cm)	WD (cm)	Comment
Pinhead Creek	2	9/19/2017	BT	B7AK	588574	4980084	170	70	50% redd on old redd, some fresh digging
Pinhead Creek	2	9/19/2017	BT	B8AK	588564	4980030	110	20	50% redd, lacks mound, narrow width, test?
Pinhead Creek	2	9/19/2017	BT	B9AK	588581	4979976	150	50	50% redd, lacks mound, narrow width, test?
Pinhead Creek	2	9/19/2017	BT	B10AK	588594	4979854	160	160	90% redd, circle cleared debris
Pinhead Creek	2	9/19/2017	BT	B11AK	588858	4979855	160	40	100%, two Bull Trout on redd, under cutbank
Pinhead Creek	2	9/19/2017	BT	B12AK	588631	4979666	240	140	Huge redd
Pinhead Creek	2	9/19/2017	BT	B13AK	588631	4979665	150	50	80%, small, possible test
Pinhead Creek	2	9/19/2017	BT	B14AK	588629	4979940	210	120	large redd 2m ds of 7B, under log, 100%
Pinhead Creek	2	9/19/2017	BT	B2HH	588557	4980132	60	100	85% confidence
Pinhead Creek	2	9/19/2017	BT	B3HH	588614	4979687	160	210	nice redd
Pinhead Creek	2	9/19/2017	BT	B4HH	588610	4979677	40	100	small redd, 50-50
Pinhead Creek	2	9/19/2017	BT	B5HH	588614	4979653	160	220	nice redd, 400mm Bull Trout on redd
Pinhead Creek	2	9/19/2017	BT	B6HH	588652	4979547	160	150	nice redd
Pinhead Creek	1	9/27/2017	BT	D1CW	588147	4981592	150	80	just upstream of weir, nice redd
Pinhead Creek	1	9/27/2017	BT	D2CW	588359	4980701	150	150	nice new redd
Pinhead Creek	1	9/27/2017	BT	D3CW	588366	4980669	160	180	big redd, 2 tails touching
Pinhead Creek	1	9/27/2017	BT	D1SS	588344	4981160	70	45	small redd, obvious digging, p/m clear
Pinhead Creek	1	9/27/2017	BT	D2SS	588378	4981143	150	145	nice redd
Pinhead Creek	1	9/27/2017	BT	D3SS	588383	4980676	70	40	minimal mound, clear digging, borderline, 50% confidence
Last Creek	1	9/27/2017	BT	D1NS	588673	4980355	230	100	Bull Trout on redd
Last Creek	1	9/27/2017	BT	D2NS	588970	4980406	190	100	Bull Trout on redd
Last Creek	1	9/27/2017	BT	D3NS	589291	4980461	100	60	75% sure
Last Creek	1	9/27/2017	BT	D4NS	589336	4980417	150	90	maybe, 50-50 call
Pinhead Creek	2	9/27/2017	BT	D1PB	588576	4979762	120	60	mound ln 70cm, on previous redd site
Pinhead Creek	2	9/27/2017	BT	D2PB	588602	4979698	80	60	mound ln 45cm, on previous redd site
Pinhead Creek	2	9/27/2017	BT	D3PB	588600	4979689	100	35	mound ln 35cm
Pinhead Creek	2	9/27/2017	BT	D4PB	588627	4979671	90	70	mound ln 65cm
Pinhead Creek	2	9/27/2017	BT	D5PB	588858	4979247	90	75	mound ln 70cm
Last Creek	1	10/3/2017	BT	E1HH	588733	4980359	130	80	small redd

Stream	Reach	Date	Species	Redd ID	Easting	Northing	LN (cm)	WD (cm)	Comment
Pinhead Creek	1	10/3/2017	BT	E1HH	588371	4981143	220	120	possible digging, 50-50, fresh redd
Pinhead Creek	1	10/3/2017	BT	E2HH	588382	4981138	130	70	pocket under log
Pinhead Creek	1	10/3/2017	BT	E1AK	588188	4981525	50	180	
Pinhead Creek	1	10/3/2017	BT	E3AK	588090	4981702	120	170	possibly three redds at one loc
Pinhead Creek	1	10/3/2017	BT	E4AK	588387	4981088	130	170	nice redd
Pinhead Creek	1	10/3/2017	BT	E1BB	588437	4980821	200	100	certain, mid-chan rel, compared to other two redds
Pinhead Creek	2	10/2/2017	BT	E1AK	588563	4980293	80	50	Classic redd
Pinhead Creek	2	10/2/2017	BT	E2AK	588640	4979664	120	190	90% certainty, on old redd
Pinhead Creek	2	10/2/2017	BT	E3AK	588641	4979552	160	170	50% fresh mound under log
Pinhead Creek	2	10/2/2017	BT	E4AK	588655	4979537	160	220	100% large redd, classic
Pinhead Creek	2	10/2/2017	BT	E5AK	588661	4979537	50	130	100%, 5 m us of E4 between logjam
Pinhead Creek	2	10/2/2017	BT	E6AK	588734	4979356	120	230	large redd, double mound
Pinhead Creek	2	10/2/2017	BT	E1SS	589095	4978606	210	75	nice redd, under log
Pinhead Creek	2	10/2/2017	BT	E2SS	588834	4979256	170	110	nice redd
Pinhead Creek	2	10/16/2017	BT	F1HH	588552	4980273	140	70	90% confident bt redd
Pinhead Creek	2	10/16/2017	BT	F1AK	589217	4798067	150	60	on top of flagged 2015 redd
Clackamas River	5	10/16/2017	BT	F1AK	587900	4972376	90	160	confluence of main/left chans
Clackamas River	5	10/16/2017	BT	F1SS	588645	4970962	160	65	nice redd, at previous location
Clackamas River	5	10/16/2017	BT	F2SS	588566	4971231	160	150	nice redd, bt gravel
Pinhead Creek	1	10/17/2017	BT	F2HH	588093	4981667	140	50	small good redd, under with pocket under log
Pinhead Creek	1	10/17/2017	BT	F3AK	588279	4981423	140	130	100% bt redd, previously marked, no ink, check GPS coords with B survey
Pinhead Creek	1	10/17/2017	BT	F4AK	588279	4980607	80	60	90% small redd, fines filled in when sediments above disturbed
Pinhead Creek	1	10/17/2017	BT	F1JW	588281	4981426	120	50	75% confidence, near submerged log
Last Creek	1	10/17/2017	BT	F1AK	588706	4980356	180	100	Nice redd under log
Last Creek	1	10/17/2017	BT	F2AK	588892	4980412	170	120	50% nice redd, no algae surrounded by algae, could be last year but fresh digging
Last Creek	1	10/17/2017	BT	F3AK	589691	4980569	100	80	100% small redd, above small debris jam, nice redd

Stream	Reach	Date	Species	Redd ID	Easting	Northing	LN (cm)	WD (cm)	Comment
Last Creek	1	10/17/2017	BT	F1HH	588746	4980358	60	40	50% bt redd, very small, obvious pocket mound. Lg redd upstream
Last Creek	1	10/30/2017	BT	G1HH	589089	4980405	170	90	clearly fresh digging around pocket bu mound is not bright. 75% bt redd
Pinhead Creek	2	10/31/2017	BT	G1AK	588577	4980099	60	90	100%, small bt redd, nice mound
Pinhead Creek	2	10/31/2017	BT	G3AK	588689	4979494	90	50	100% bt redd, deep pool
Pinhead Creek	2	10/31/2017	BT	G4AK	588755	4979313	110	70	100% bt redd, nice mound!
Pinhead Creek	2	10/31/2017	BT	G1HH	588958	4979146	150	80	100% bt redd
Pinhead Creek	1	10/31/2017	BT	G1HH	588101	4981736	180	60	100% bt redd
Pinhead Creek	1	10/31/2017	BT	G4HH	588323	4981420	140	40	100% bt redd
Pinhead Creek	1	10/31/2017	BT	G4AK	588342	4981142	150	90	small bt redd 90%
Pinhead Creek	1	10/31/2017	BT	G6AK	588467	4980362	130	70	100% bt redd and gravel
Pinhead Creek	1	10/31/2017	BT	G6SS	588376	4981333	150	100	50/50 bt/chk redd, gravel maybe too small for chk

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