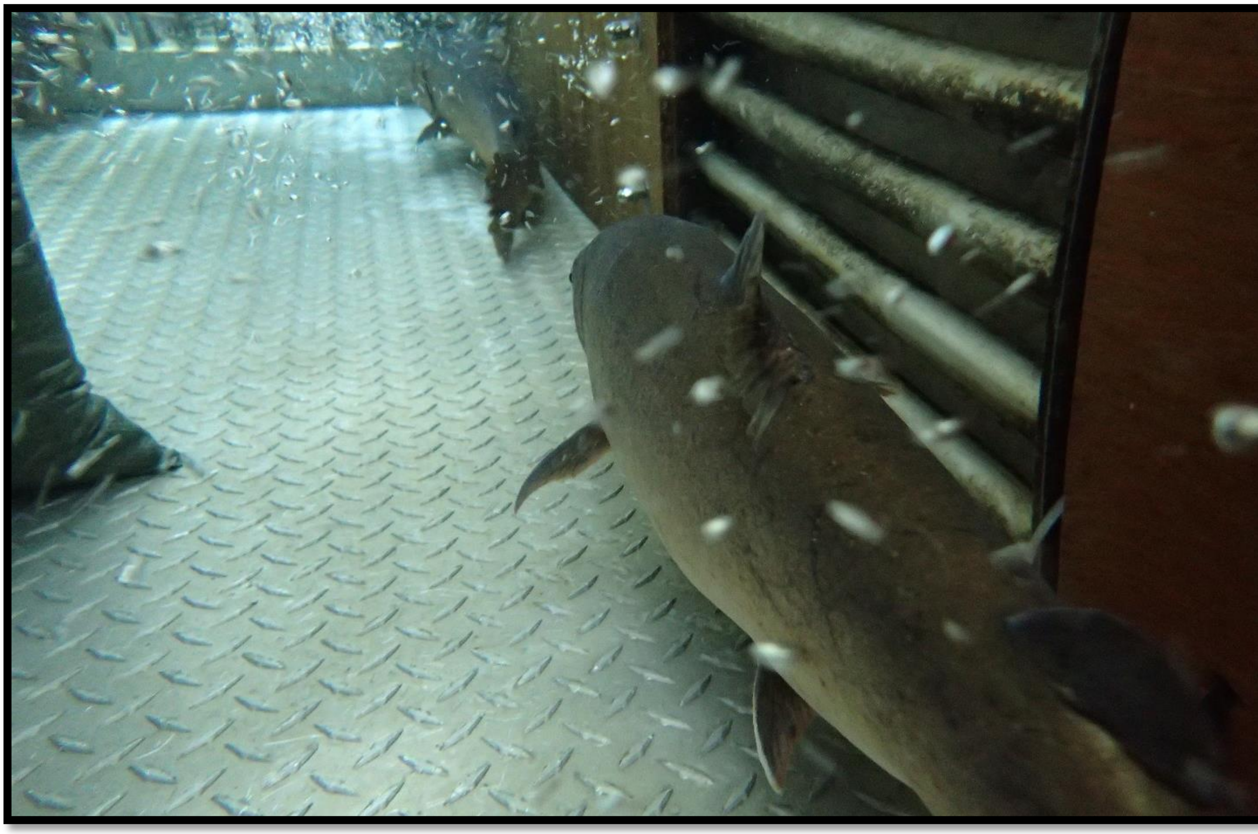
U.S. Fish and Wildlife Service

Clackamas River Bull Trout Reintroduction Project

2018



Annual Report

Marshall G. Barrows, J. Michael Hudson, and Kevin Hauser

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

On the cover: *Bull Trout in the Pinhead Creek adult trap, Clackamas River Subbasin (Photo by M. Barrows, USFWS)*

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CLACKAMAS RIVER BULL TROUT REINTRODUCTION PROJECT 2018 ANNUAL REPORT

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and authored by

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

August 20, 2019

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CLACKAMAS BULL TROUT REINTRODUCTION PROJECT
2018 ANNUAL REPORT

Marshall G. Barrows, J. Michael Hudson, Kevin Hauser

U.S. Fish and Wildlife Service
Columbia River Fish and Wildlife Conservation Office, Vancouver, WA

Over four decades 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 favorable candidate for Bull Trout reintroduction. A reintroduction effort launched 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 reaches in the upper Clackamas River and select tributaries was 2016. The primary objectives during the eighth year of the project (second phase) were to monitor and evaluate the reintroduction effort. During 2018, progress was 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 individuals that had been translocated of multiple life stages in 2012 – 2016, confirming survival and recruitment into the adult population. The 25 individuals subsampled at the weir trap were large, migratory fish and ranged in size from 440 – 705 mm TL. A total of 101 individual Bull Trout were captured or observed at the weir of which 54 (53%) were female and 47 (47%) were male. Of the 54 females, 27 (50%) had been previously tagged. Forty-two (89%) of the 47 males had been previously tagged. Since all translocated fish were PIT-tagged, the presence of untagged fish suggests at least some of the spawners may have been locally-born offspring, though the disparity between the ratio of tagged to untagged males and females may indicate an elevated rate of tag shedding among the females. During 2018, 95% of tagged Bull Trout that encountered the Pinhead Creek weir successfully passed upstream during the spawning season. Seventy-three percent of the Bull Trout that encountered the weir, passed during their first encounter and 91% passed upstream by their second encounter. Redd counts have increased substantially since the inception of the reintroduction program and the 84 redds counted during 2018 were near the highest counts to date. Caudal fin tissue was collected from five additional untagged Bull Trout captured at the Pinhead Creek weir during 2018. Combined with samples from 2017, this collection will provide the opportunity for subsequent parentage analysis and possibly the confirmation of naturally produced progeny and recruitment into the spawning population. Monitoring efforts to date 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 and Canada. A general decline in abundance across their native range impelled the U.S. Fish and Wildlife Service (USFWS) to list Bull Trout as threatened under the Endangered Species Act (ESA) in 1999 (64FR 58910). Bull Trout exhibit a very complex and veritable continuum of life histories involving movements, migrations, spawning, rearing and foraging on time scales ranging from daily to annually or longer, and over different spatial scales (Schaller et al. 2014). Bull Trout also require very specific habitat conditions including clean and cold water with complex, connected habitats (Rieman and McIntyre 1995; Selong et al. 2001; USFWS 2015a). Various anthropogenic actions, including but not limited to habitat degradation, migration barriers and the introduction of non-native species have negatively influenced Bull Trout populations (Fraley and Shepard 1989; Leary et al. 1993; Schaller et al. 2014). Bull Trout were estimated to occupy only 40 percent of their historical range within Oregon, Washington, Idaho, Montana and Nevada at the time of listing in 1999 (USFWS 2002a).

A primary goal in the USFWS's Final Bull Trout Recovery Plan (USFWS 2015a) is to reestablish self-sustaining populations in watersheds where Bull Trout have been extirpated. In some watersheds, natural recolonization is unlikely or insufficient due to connectivity impairments (e.g., instream barriers, distance, etc.). Translocation and reintroduction efforts from more robust populations may be necessary in some watersheds to establish populations at sustainable levels (Dunham et al. 2014). Bull Trout have been extirpated in multiple Willamette River subbasins, including the Clackamas River (Figure 1). Willamette River Basin Bull Trout recovery efforts have focused primarily on reducing the threats affecting Bull Trout and their habitat. Due to widespread extirpations across the expansive basin that includes multiple hydrosystem projects, natural recolonization may be unlikely, thus necessitating reintroduction in some areas to establish self-sustaining populations. One or more established Bull Trout local populations through a successful reintroduction effort will expand Bull Trout distribution and may increase population connectivity within the Coastal Recovery Unit (USFWS 2015b).

The progress in the eighth year (2018) 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 is detailed in this report. This project was implemented 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). Bull Trout were transferred to the Clackamas River Core Area from healthy populations in the Metolius River Subbasin from 2011 through 2016 (ODFW 2012; Barrows et al. 2016). 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).

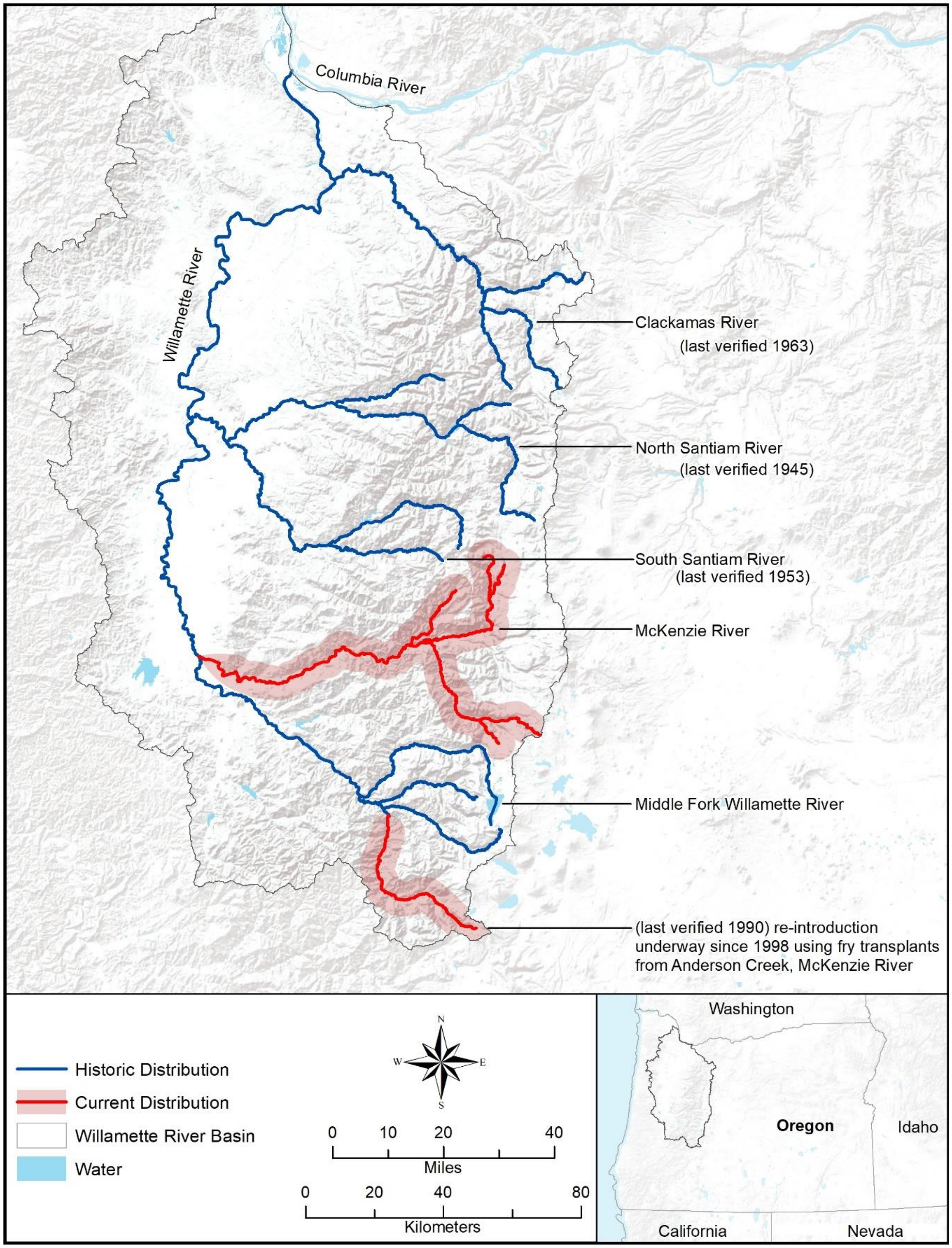


Figure 1. Historical and current Bull Trout distribution in the Willamette River Basin.

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. For this project, a self-sustaining population is defined as one that maintains a minimum annual spawning abundance of 100 adults, contains a level of genetic diversity representative of the donor stock, and requires little or no additional transfers. 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. 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 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).

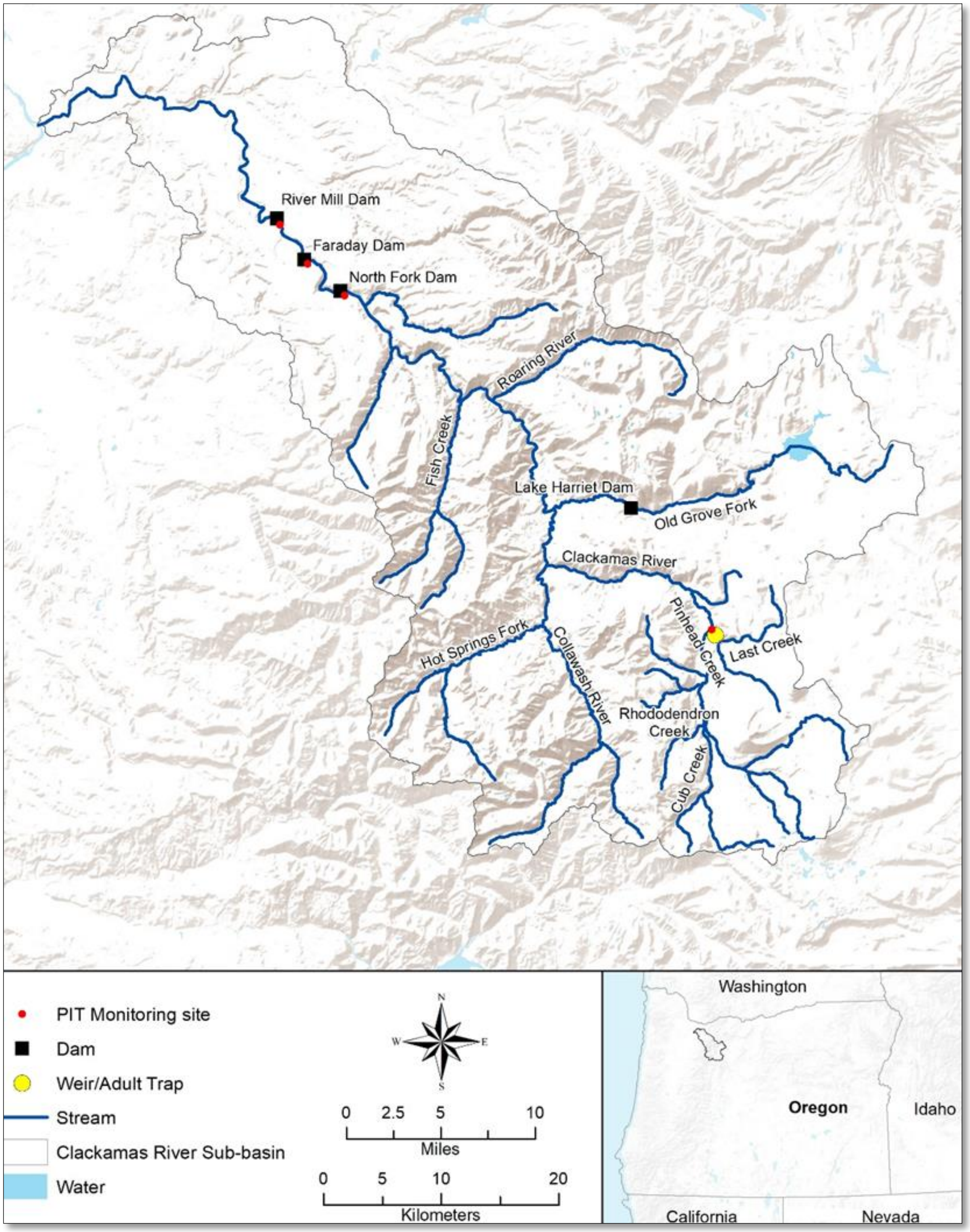


Figure 2. Locations of current monitoring sites in the study area. Multiple PIT monitoring antennas are located throughout PGE's hydro power facilities. A PIT tag monitoring site was installed with the Pinhead Creek weir and was operational from mid-July to early October 2017 while the weir was deployed.

Methods

Implementation

Beginning in 2011, and continuing through 2016, Bull Trout were transferred to the Clackamas River Subbasin from robust populations in the Metolius River Subbasin. Juvenile Bull Trout were translocated to select tributaries, and subadults and adults were released directly into the upper Clackamas River. No additional translocations are currently planned for phase two of the reintroduction.

Monitoring and Evaluation

We used an instream half-duplex (HDX) passive integrated transponder (PIT) tag detection array near the mouth of Pinhead Creek, observations at the Pinhead Creek video weir and trap, and the PIT tag monitoring sites at PGE facilities 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-born 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

Prior to 2014, a radio-telemetry program allowed us to monitor movement patterns and seasonal distribution of radio-tagged individuals, but since this program ended, our ability to obtain this information has been limited. However, movement patterns and seasonal distribution of juvenile, subadult and adult Bull Trout can be inferred from PIT tag detections in Pinhead Creek, observations at the Pinhead Creek weir and at Clackamas Hydro Project PIT antennas.

In 2018, a channel-spanning HDX PIT tag antenna was used to monitor Bull Trout presence and movement approximately 150 meters upstream from the Pinhead-Clackamas confluence, just below the Pinhead Creek video weir (Figures 2 and 3). In addition to the instream PIT antenna, a small antenna was operated within the Pinhead Creek weir video chute. Both antennas were powered by a bank of 12-volt batteries and an Oregon RFID Multi-Antenna HDX Reader. The instream PIT antenna was in place from July 19 to November 9, 2018 and was non-operational during only one day due to technological malfunction. The antenna located in the video chute operated continuously from July 19 to October 9, 2018.

Figure 3. Channel-spanning HDX PIT tag antenna located 150 meters upstream from the Pinhead-Clackamas confluence, approximately 10 m below the Pinhead Creek weir.

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 4). 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.

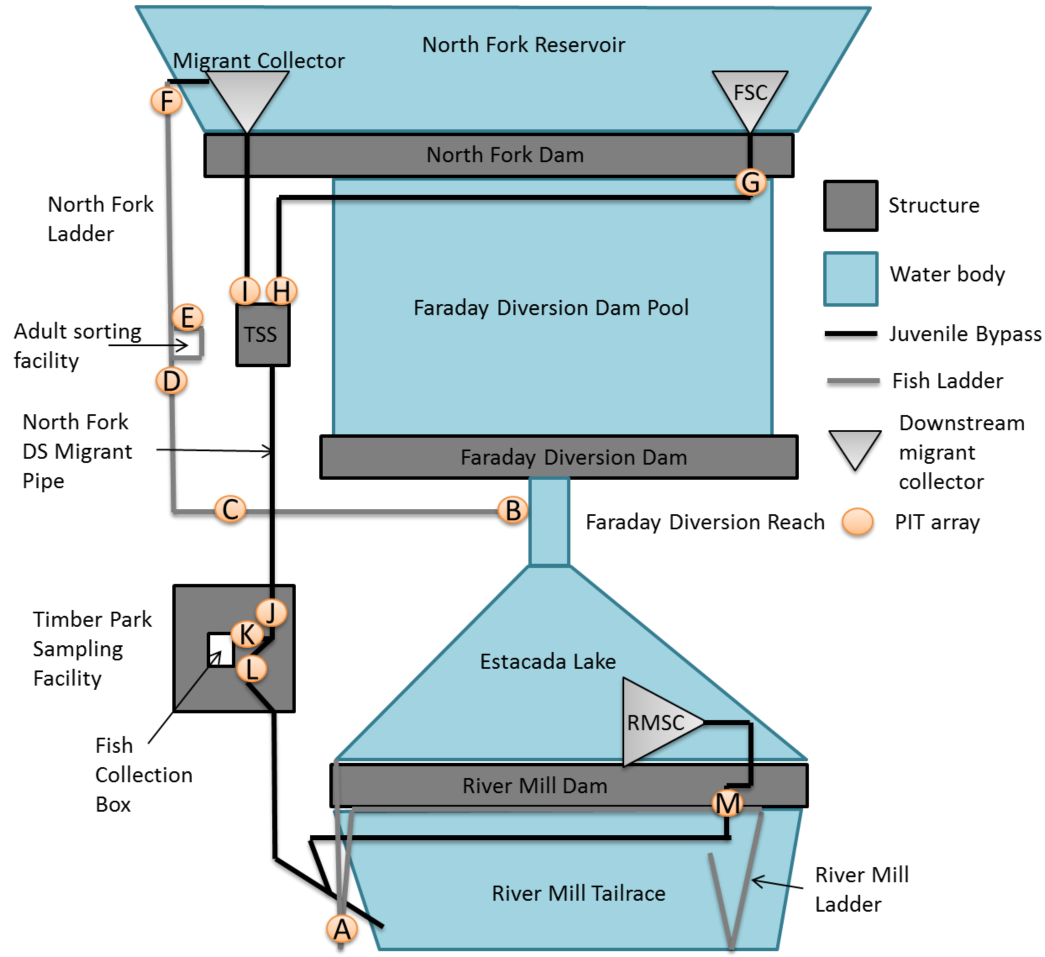


Figure 4. Schematic of PIT antenna array at the Clackamas Hydro Project. FSC = Floating surface collector; TSS = Tertiary screen structure; RMSC = River Mill surface collector. (Figure provided by Portland General Electric.)

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 by ODFW in potential Bull Trout spawning habitat in the upper Clackamas River and several major tributaries. Surveys were conducted approximately every two weeks, beginning prior to the spawning season (mid-August) and continuing through October 2018. 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 broad objectives identified in the Clackamas River Bull Trout Reintroduction IM&E Plan (USFWS 2011a). During 2018, the following objectives were addressed:

Objective 1). Estimate the number of Bull Trout spawners in Pinhead Creek.

Objective 1a). Estimate the tagged to untagged ratio of adult Bull Trout.

Objective 1b). Calibrate Bull Trout redd counts in Pinhead Creek.

Objective 2). Document natural production in Pinhead Creek.

Objective 3). Determine growth rates of translocated Bull Trout captured Pinhead Creek.

Objective 4). Estimate tag retention rate of translocated Bull Trout captured in Pinhead Creek.

Objective 5). Evaluate passage through the Pinhead Creek weir.

Objective 5a). Assess the passage rate of PIT-tagged Bull Trout associated with the operation of the Pinhead Creek weir.

Objective 5b). Assess migration delay of PIT-tagged Bull Trout associated with the operation of the Pinhead Creek weir.

To address the objectives, a two-way fixed picket weir and underwater video system was operated in Pinhead Creek, a tributary to the Clackamas River, from July 19, 2018 through October 9, 2018 in cooperation with ODFW (NOAA 4[d] and Oregon Scientific Take Permit #21002). The confluence of Pinhead Creek and the Clackamas River is located at river kilometer 109. The weir was installed between Last Creek and the NF-46 bridge, about 0.1 kilometers from the mouth of Pinhead Creek. The weir layout in 2018 closely resembled the design used in 2017 (Barrows et al. 2018). The video chute and upstream trap box were positioned in parallel on river right and both leads of the weir were angled to lead fish to the chute and trap box (Figure 5). 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. As previously described in the Movement and Seasonal Distribution section, a channel-spanning HDX PIT tag antenna was installed just below the Pinhead Creek video weir as well. When the upstream trap box was set (i.e., open), an exclusion gate (Figure 6) was added to the video chute to prevent fish from moving upstream while allowing fish to migrate downstream unimpeded 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 7). T-posts were used to support the leads, 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.

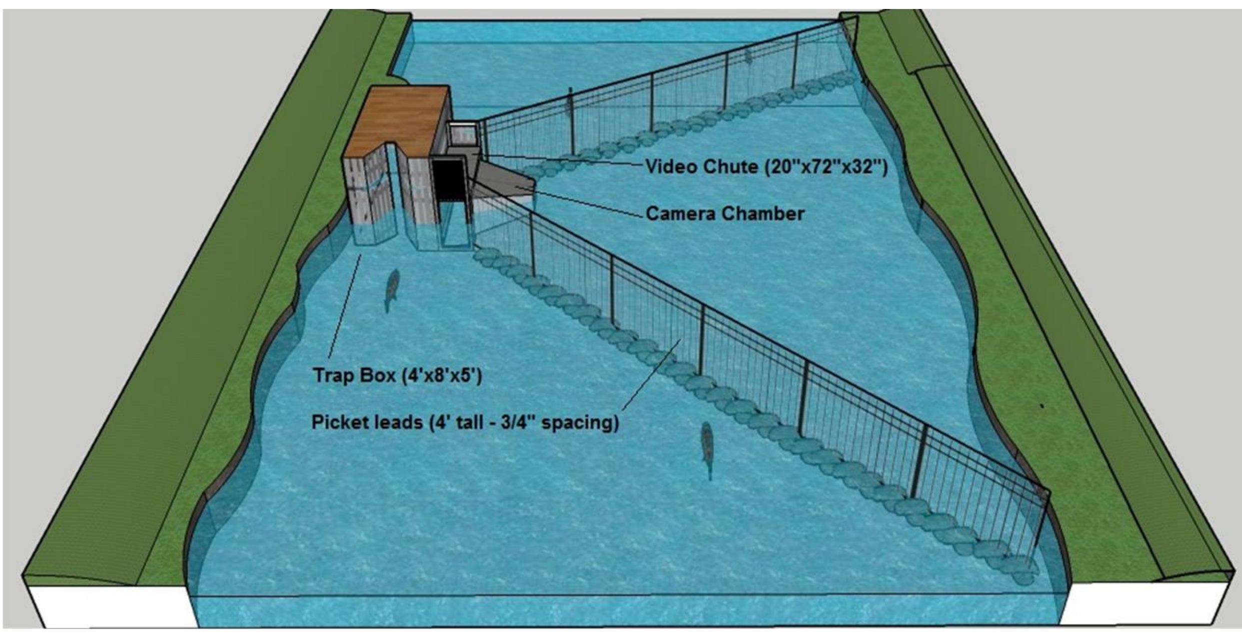


Figure 5. Schematic of the Pinhead Creek weir and trap.

Figure 6. Exclusion gate for video chute.

Figure 7. Photo depicting the aluminum picket leads, video chute and trap box deployed in Pinhead Creek.

The underwater video system that was used during 2017 was again employed in 2018 (Barrows et al. 2018) and the design 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 aluminum camera box and attached to the video chute (Figure 8). Safety glass separated the camera box and the video chute. The camera box was filled with clear water and sealed to provide clear viewing into the video chute. Laminate flooring provided a backdrop inside the video chute. Vertical lines (10 cm spacing) were placed on the backdrop to allow the video viewer to estimate fish size. A PIT tag antenna was incorporated into the upstream end of the video chute. The PIT tag antennas were tested and data were downloaded from the site during each visit (from two to four times each 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 video clips of fish activity through the video chute. A portable TFT 12 VDC color monitor was used to scan the video footage while 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 system was powered by two battery banks, one to operate the video equipment and the other to power the PIT detection antennas. Each battery bank had three 12-V DC batteries (connected in parallel) with a combined 300 Ampere-hours.

Figure 8. 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 13, 2018 and September 15, 2018 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) buffered with 80 mg/L sodium bicarbonate. All Bull Trout were scanned for PIT tags. Sampling of previously tagged Bull Trout consisted of recording their PIT ID, determining their sex, measuring their total length to the nearest 1 mm and their weight 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.

Spawning Population Estimate

We used the trap count, video and PIT tag monitoring data to estimate the number of spawners that moved upstream of the weir in Pinhead Creek. There was no lapse in monitoring, so no adjustments to the data were required to account for down time.

Documenting Natural Production

Locally-born Bull Trout have not been detected during past electrofishing and minnow-trapping efforts (Barrows et al. 2017; Barrows et al. 2016; 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 analysis to determine if they were naturally produced progeny (Objective 2).

Growth Rates

Length and weight data were collected from Bull Trout captured at the weir. These data were used to calculate growth rates for all translocated individuals that were sampled (Objective 3). 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.

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 (Objective 4). 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.

Weir Passage

Concerns were voiced by members of the Clackamas River Bull Trout Working Group regarding how the Pinhead Creek weir may delay or deter migrating fish from moving past the weir to upstream spawning areas. The Pinhead Creek weir, by design, funnels migrating Bull Trout through a small passageway for video observation or into a trap box. These constricted passageways could affect migrating fish. To address this concern, we installed an instream PIT detection antenna approximately 10 m downstream of the weir to help assess upstream fish passage at the weir. For this assessment, we defined an upstream weir encounter as a detection at the instream PIT antenna without a preceding PIT detection within two hours in the video chute, to ensure we were evaluating an individual that was encountering the weir from downstream.

Objective 5a. Assess the passage rate of PIT-tagged Bull Trout associated with the operation of the Pinhead Creek weir.

To address Objective 5a, the percent of PIT-tagged Bull Trout that passed upstream of the weir was calculated as:

$$((V + T) / D) \times 100$$

Where D = the number of individual PIT-tagged Bull Trout detected encountering the weir moving upstream; V = the number of individual PIT-tagged Bull Trout first detected passing successfully through the video chute; and T = the number of individual PIT-tagged Bull Trout first captured in the adult trap. We defined an upstream weir encounter as a detection at the instream PIT antenna without a preceding PIT detection at the video chute within two hours. This criterion helped to ensure we were evaluating an individual that encountered the weir from downstream.

Objective 5b. Assess migration delay of PIT-tagged Bull Trout associated with the operation of the Pinhead Creek weir.

To address Objective 5b, we used PIT-tagged Bull Trout that encountered the Pinhead Creek weir from downstream. The time (in days) for an individual PIT-tagged Bull Trout to successfully pass upstream of the weir via the video chute or the adult trap was calculated as:

$$date_v - date_d \text{ (or) } date_{trap} - date_d$$

Where $date_d$ = the date a PIT-tagged Bull Trout was first detected at the instream PIT antenna downstream of the weir; $date_v$ = the date a PIT-tagged Bull Trout first successfully passed upstream via the video chute; and $date_{trap}$ = the date a PIT-tagged Bull Trout first successfully passed upstream via the adult trap. Mean passage times (in days) were calculated from individual passage times from the above equations.

We also assessed passage by documenting the number of weir encounters for each individual. The number of encounters before successfully passing upstream was also documented. In addition, we compared passage rates of upstream encounters when the trap was operating with passage rates when the trap was not operated (i.e., Bull Trout could pass upstream through the video chute). Passage rates were calculated as:

$$(E_s / E_{tot}) \times 100$$

Where E_{tot} = the total number of upstream encounters during a given timeframe; and E_s = the number of encounters resulting in successful passage upstream of the weir during the same timeframe.

Genetics

From 2011 to 2016, caudal fin tissue (approximately 1 cm^2) was collected from each Bull Trout 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 and 2018. This collection of samples will provide the opportunity to address the following questions:

Question 1). Are unknown origin Bull Trout from the Clackamas River Subbasin fish that were translocated from the Metolius River Basin, or fish that were locally-born?

Question 2). Which translocation strategy (e.g., life stage, year, location) was the most successful?

Question 3). Are the genetic characteristics of the post-translocation donor stock (within one generation after translocation ended) and the newly formed Clackamas River stock similar?

It is important to note that answering questions 1 and 2 for all individuals is dependent on locating approximately 400 missing Metolius River donor stock samples.

Impacts to Listed Salmon and Steelhead

In years following the termination of the radio-telemetry program in 2014, our ability to monitor Bull Trout use of the HVZ has been limited. We no longer can detect when translocated Bull Trout have entered the HVZ, nor can we determine the total time each fish spent in the HVZ. Similarly, untagged locally-born progeny and translocated Bull Trout that have shed their PIT tags 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).

Monitoring and Evaluation

Movement and Seasonal Distribution

During 2018, a total of 53 unique PIT tags associated with translocated Bull Trout were detected at the Pinhead Creek weir from July through October (Figure 9). In addition, four of the six adult Bull Trout PIT-tagged at the Pinhead Creek weir during 2017 were detected during 2018. All five of the untagged Bull Trout tagged at the trap during 2018 were subsequently detected passing the weir. Most of the tags detected in 2018 represented translocated Bull Trout released into the Clackamas River Subbasin in 2012-2016 (Table 2). The majority of individuals that migrated into Pinhead Creek were relatively large, migratory adult-sized fish (see Video Weir and Trap results and discussion). Fish from the juvenile release groups in 2015 and 2016 appeared to be sexually mature when observed moving through the video chute, but were notably smaller than fish originally released as subadults or juveniles from release groups prior to 2015. Despite appearing mature, it is possible that fish from these release groups were not yet mature spawners, and may have entered Pinhead Creek to seek rearing and foraging habitat.

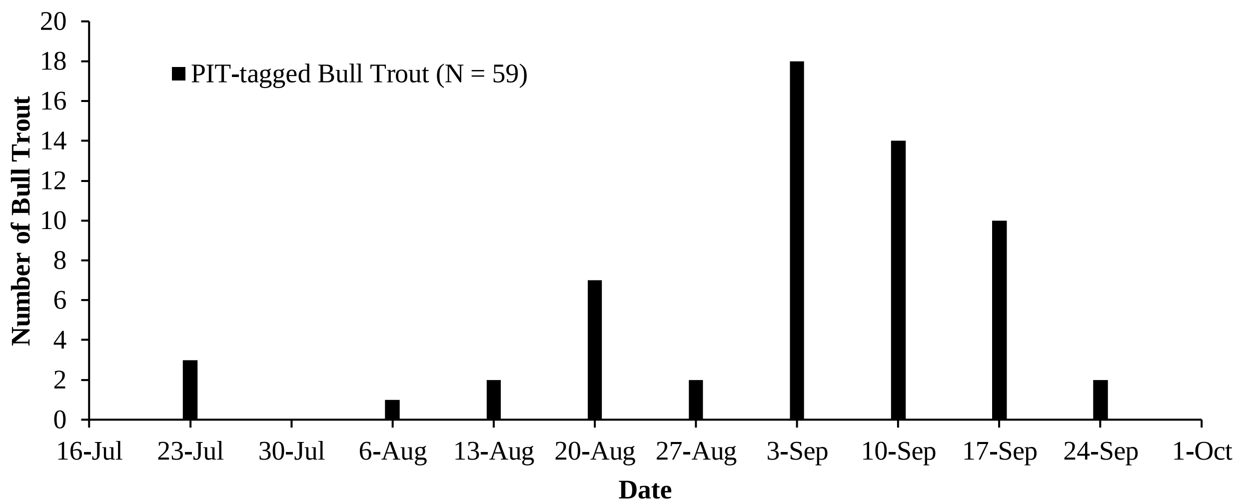


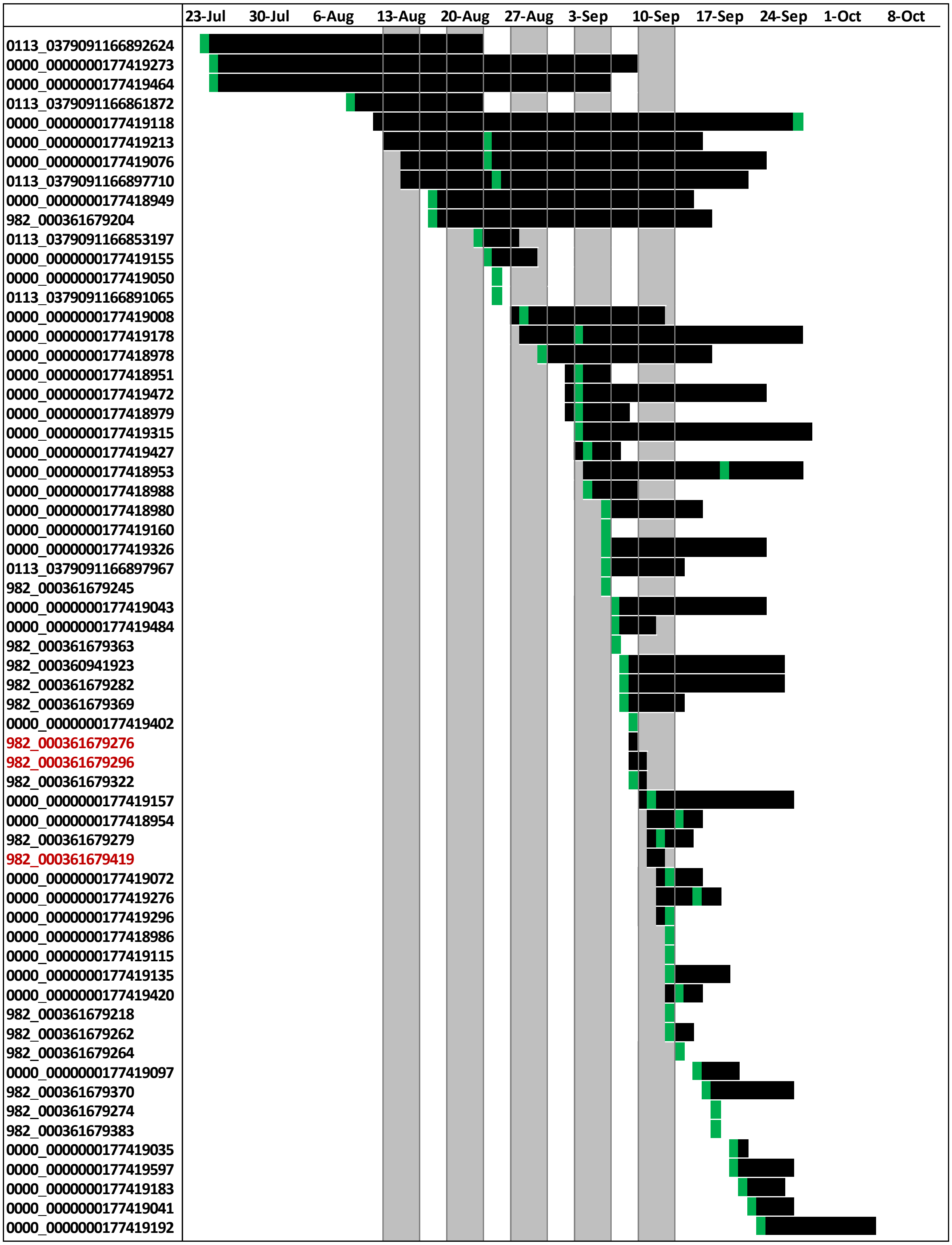
Figure 9. First successful passage attempts by unique PIT-tagged Bull Trout moving upstream past the Pinhead Creek weir. Each bar represents one week. This includes all detected tags in 2018 from fish that moved upstream past the Pinhead Creek Weir via the video chute or the adult trap.

Table 2. Unique PIT tag detections of translocated Bull Trout from release groups in 2012 – 2016 detected in Pinhead Creek during 2018.

Lifestage	**2012**	**2013**	**2014**	**2015**	**2016**	**Totals**
Juvenile	3	13	3	3	4	26
Subadult	1	1	3	10	10	25
Adult	0	0	0	1	1	2
Totals	**4**	**14**	**6**	**14**	**15**	**53**

The PIT detection site at the mouth of Pinhead Creek was not operated during 2018, limiting our ability to determine the total amount of time individuals spent in Pinhead Creek during the spawning season. However, the time between the first and last PIT detection at the Pinhead Creek weir gives us an idea of how long individuals spent on the spawning grounds upstream of the weir. Fish that were detected more than once at the weir spent an average of 11.2 days (range, 1 – 46 days) in Pinhead Creek. Several Bull Trout were only detected moving upstream at the weir, suggesting that they either died upstream of the weir, or did not return downstream before the PIT antennas were removed for the season on November 9, 2018. Table 3 shows the time span between the first and last detection of each PIT-tagged Bull Trout detected at the Pinhead Creek weir during 2018.

Table 3. Each row of the periodicity table represents the time span between the first and last detection of each PIT-tagged Bull Trout detected at the Pinhead Creek weir. The green cell indicates the first successful passage attempt by each individual either through the trap or the video chute. The gray bars indicate days the adult trap was operated. PIT tags denoted in red are Bull Trout that were detected, but did not pass upstream of the Pinhead Creek weir during 2018.



In addition to the PIT detections in Pinhead Creek, nine translocated Bull Trout were detected at PIT arrays within PGE's hydro project facilities during 2018 (Table 4). This is the highest number of detections since 2015 when nine individual Bull Trout were also detected. During 2016 and 2017, six and five Bull Trout were detected at PGE facilities, respectively. Detection histories for the PIT-tagged Bull Trout detected during 2018 are summarized in Appendix A. In many cases, an individual was detected at multiple PIT arrays on multiple dates. One was originally released as a juvenile (70 – 250 mm TL) in the Upper Clackamas River in 2016 and the other eight were released as subadults (251 – 450 mm TL) into the mainstem Clackamas River from 2012 to 2016. An examination of the detection histories and observations of these fish since translocation (Appendix A) indicated eight were likely adults and one that was released as a juvenile (91 mm TL) into the upper Clackamas River (PIT ID 982_000360937173) was likely a subadult when detected.

Table 4. Individual PIT-tagged Bull Trout detected at PGE facilities during 2018.

PIT ID	Length at Release (TL)	Release Date	Release Site
0000_0000000177419108	257 mm	5/27/2016	4650 Bridge
982_000361679227	393 mm	5/29/2015	4650 Bridge
982_000360937173	91 mm	5/6/2016	Upper Clackamas
0000_0000000177419561	335 mm	7/12/2012	4670 Side Channel
0000_0000000177419000	320 mm	6/13/2016	4650 Bridge
0000_0000000177419312	353 mm	6/20/2013	4650 Bridge
982_000361679350	364 mm	5/22/2015	4650 Bridge
0000_0000000177419151	273 mm	5/20/2016	4650 Bridge
0000_0000000177419129	266 mm	4/29/2016	4650 Bridge

In past years, multiple adult Bull Trout were observed at the North Fork Adult Sorting Facility. Despite multiple detections of likely adult translocated Bull Trout at PGE's PIT antennas in various ladders and bypass facilities, no adult Bull Trout were observed while re-entering the upper Clackamas River during 2018. It is important to note that PIT detections represent only a portion of the actual number of Bull Trout that may encounter PGE facilities and enter HVZ's. Locally-born progeny (if they exist) do not have PIT tags and results from the Pinhead Creek weir suggest that a portion of translocated adults (primarily females) may have shed their PIT tags (see Video Weir and Trap results and discussion).

A majority of the PIT detections were of Bull Trout moving downstream through the surface collection and bypass facilities associated with the PGE dams from April to October, 2018 (Appendix A). However, an adult Bull Trout (PIT ID 982_000361679227) that was captured at the Pinhead Weir Trap in 2017 was detected while moving downstream via the Floating Surface Collector in early July, subsequently ascended the River Mill Ladder before passing back downstream of River Mill Dam on July 12, 2018, and was not subsequently detected. Similarly, another adult Bull Trout was detected while passing downstream via the Floating Surface

Collector on June 14, 2018 and subsequently ascended the River Mill Ladder on July 7, 2018. This fish also entered the North Fork Ladder but did not successfully pass upstream of North Fork Dam before returning downstream of River Mill Dam via the surface collector. This fish was last detected in the River Mill Ladder on August 5, 2018.

It should be noted that not all Bull Trout in the Clackamas River Basin have PIT tags, thus PIT-detections at sites within the basin represent an unknown portion of the total number of Bull Trout. The presence of untagged, locally-born juveniles, subadults and adults has not been verified in the basin, but have possibly been recruited into the population. In addition, Pinhead Creek Weir data suggests many of the translocated Bull Trout may have shed their PIT tags following their transfer to the basin. This appears to be more prevalent in the female portion of the population (see Video Weir and Trap results section)

Reproduction

The number of translocated Bull Trout using spawning tributaries has increased since the reintroduction program began. Bull Trout spawning has often been observed and redd counts have increased from a total of 5 in 2011 to a high of 89 in 2017 (Starcevich 2018). During 2018, a total of 84 redds were counted in Pinhead Creek, Last Creek and in the Clackamas River (Appendix C). Bull Trout detected at the weir in 2018 were translocated to the Clackamas River as juveniles and subadults in 2012 – 2016, and as adults in 2015 and 2016. 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.

<u>Redd Surveys</u>

A total of 84 presumed Bull Trout redds were observed in 2018 (Starcevich 2019). Of the 84 redds, most (N = 80) were observed in Pinhead Creek, 1 was counted in Last Creek and 3 were observed in the mainstem Clackamas River (Figure 10). Redd counts have increased each year since the inception of the reintroduction program, but decreased slightly in 2018 (Starcevich 2019). Additional details concerning 2018 census redd counts associated with this project are described, summarized and discussed in Appendix C.

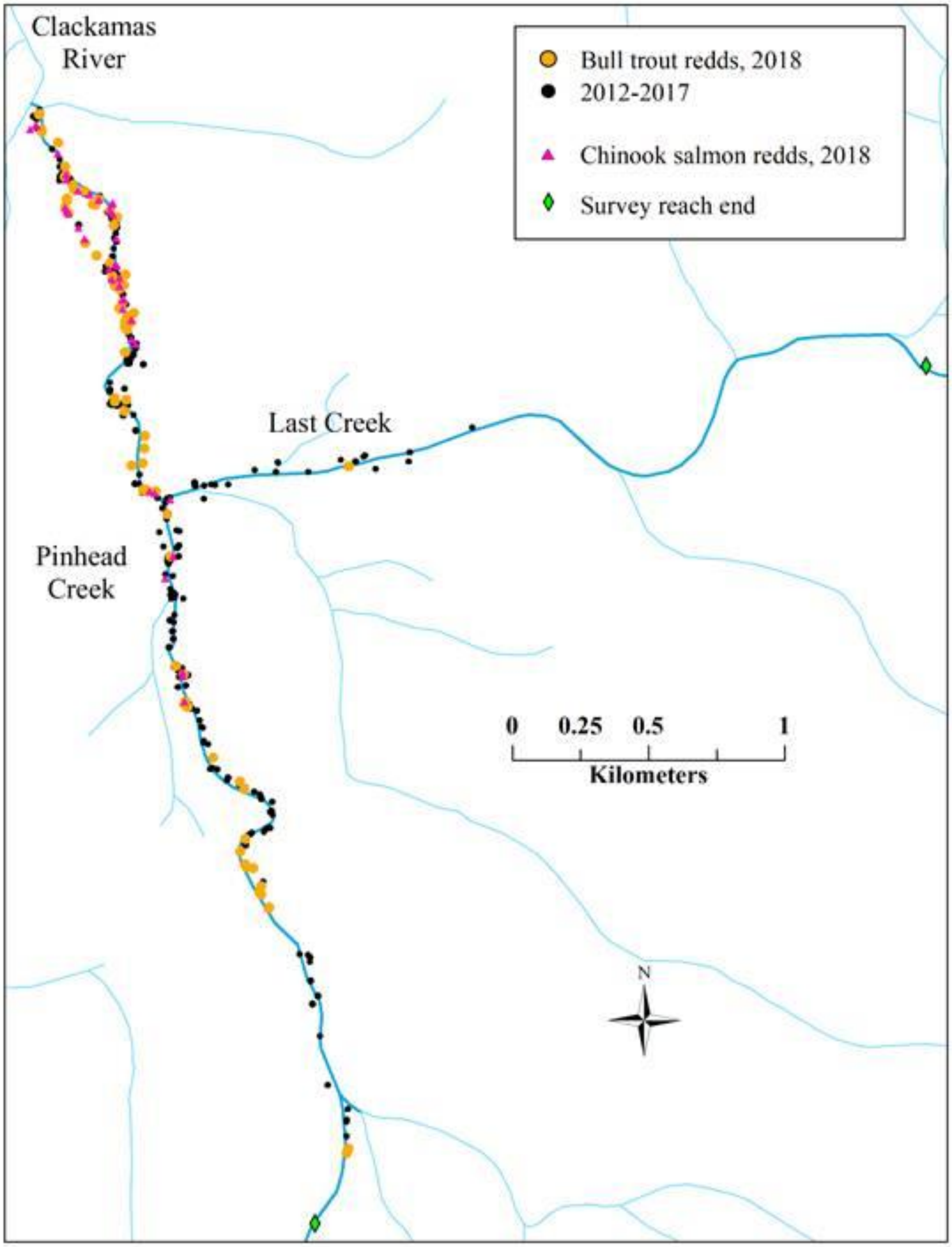
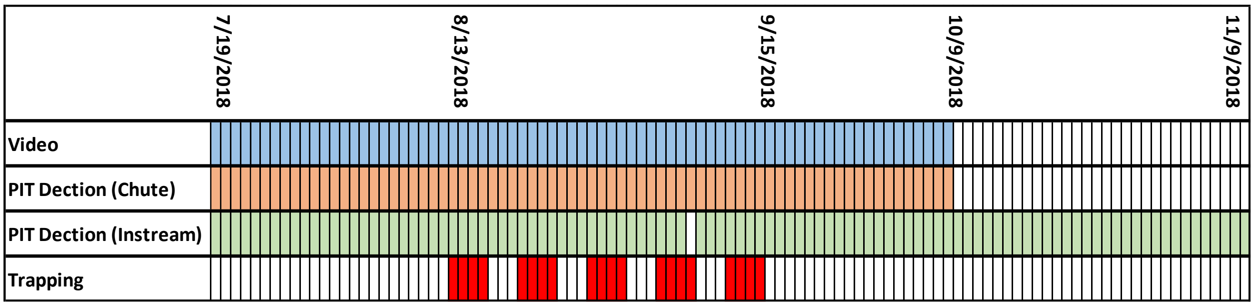


Figure 10. Locations of redds in Pinhead and Last creeks and the Clackamas River in 2012 – 2018. Bull Trout redds observed during 2018 are depicted as orange circles. (Map from Clackamas River Bull Trout monitoring update 2018-2019, Starcevich 2019)

Video Weir and Trap

The Pinhead Creek weir was installed in mid-July and was fully operational by July 19, 2018. Fish passing the weir were continuously monitored via video and a PIT antenna from July 19, 2018 to October 9, 2018 (Table 5). In addition, the channel-spanning PIT antenna located just downstream of the weir was operational from July 19, 2018 to November 9, 2018. A PIT antenna malfunction resulted in a 24 hr lapse of detection capability at this antenna from September 6, 2018 to September 7, 2018. The upstream trap was operated Monday through Friday between August 13, 2018 and September 14, 2018.

Table 5. Pinhead Creek weir operation periodicity table during 2018.



During 2018, there were a total of 273 (130 upstream and 143 downstream) video observations of Bull Trout at the Pinhead Creek weir (Table 6). There were also 2 video observations of Chinook Salmon (*Oncorhynchus tshawytscha*) moving upstream through 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 mid-September, the majority of Bull Trout observed moving upstream past the weir were female, but male upstream observations were more prevalent after mid-September (Figures 11 and 12).

Table 6. Video observations of Bull Trout and Chinook Salmon at the Pinhead Creek video weir during 2018.

Species (Sex)	Upstream	Downstream	Total
Bull Trout (Male)	70	81	151
Bull Trout (Female)	60	62	122
Chinook Salmon (Male)	2	0	2
Chinook Salmon (Female)	0	0	0

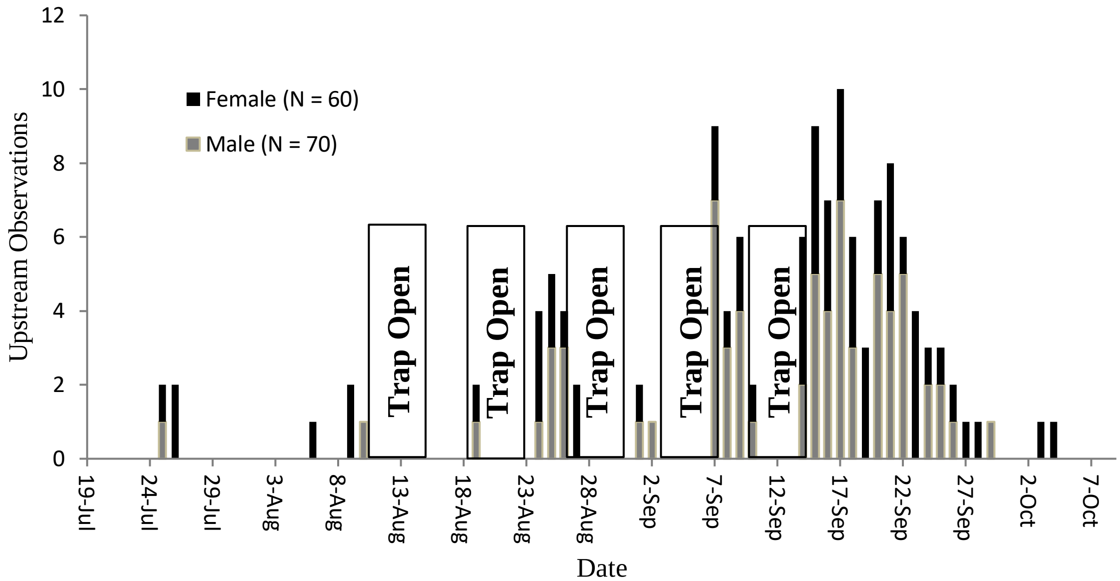


Figure 11. Upstream observations of male and female Bull Trout at the Pinhead Creek weir during 2018.

Fifty-nine individual PIT-tagged Bull Trout were detected while passing either upstream or downstream (or both) through the video chute PIT antenna. There were three additional PIT-tagged Bull Trout that were only detected on the instream PIT antenna downstream of the weir, which indicates they did not pass upstream of the weir.

By pairing video observations and corresponding PIT detections, we were able to identify 49 individual, PIT-tagged Bull Trout that passed upstream through the video chute. There were also 30 total observations of untagged Bull Trout passing upstream through the video chute. A detailed analysis of the video observations suggested that 27 untagged individuals were responsible for the 30 upstream observations. Table 7 is a summary of individual Bull Trout observed moving upstream through the video chute at the Pinhead Creek weir.

Table 7. Individual Bull Trout observed moving upstream through the video chute at the Pinhead Creek weir.

Sex	Video Observations (PIT-tagged)	Video Observations (Untagged)	Totals
Male	28	3	31
Female	21	24	45
Totals	**49**	**27**	**76**

Twenty-five individual Bull Trout were captured in the trap at the Pinhead Creek weir from August 16, 2018 to September 14, 2018. Sixteen fish were male and nine fish were female. Nine of the Bull Trout were also subsequently recaptured following their initial capture. A majority of the Bull Trout were captured in early to mid-September (Figure 12). No Chinook Salmon were captured in the trap during 2018.

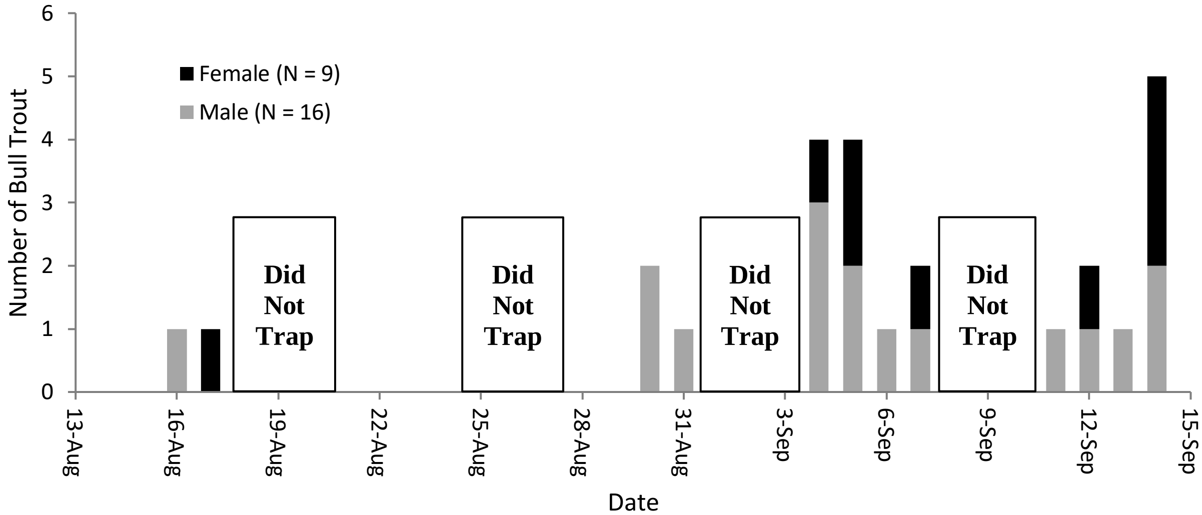


Figure 12. Bull Trout trapped by date and sex at the Pinhead Creek weir during 2018.

The Bull Trout captured in the trap were all relatively large, migratory fish and ranged in length from 440 – 705 mm TL. Many fish were between 550 and 675 mm TL (Figure 13). Female Bull Trout (mean, 628 mm TL; range, 562 – 701 mm TL) were on average longer than the males (mean, 570 mm TL; range, 440 – 705 mm TL). Tagged females (mean, 627 mm TL; range, 562 – 701 mm TL) were on average very similar in length to untagged females (mean, 625 mm TL: range, 575 – 700 mm TL) but tagged males (mean, 575 mm TL; range, 440 – 705 mm TL) were slightly longer on average than untagged males (mean, 540 mm TL; range, 494 - 585). Lengths and weights of Bull Trout captured in the trap are summarized in Table 8.

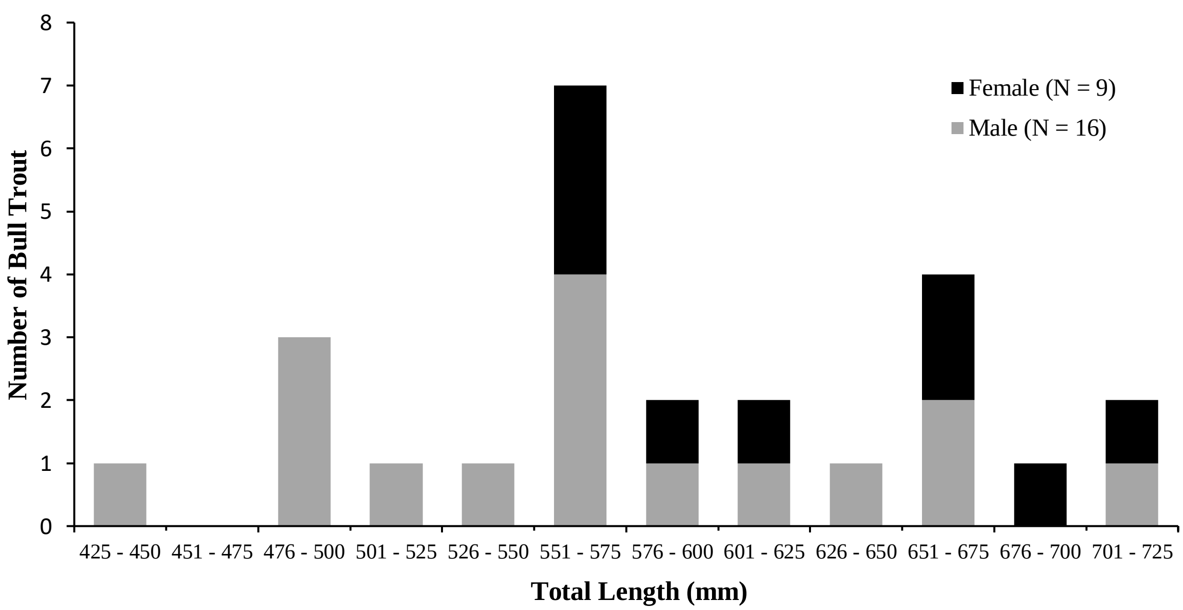


Figure 13. Total lengths by sex of Bull Trout captured at the Pinhead Creek weir during 2018.

Table 8. Lengths and weights of Bull Trout 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)	440	705	575	864	> 3000	NA
Females (Tagged)	562	701	628	1831	> 3000	NA
Males (Untagged)	494	585	540	1225	1906	1565
Females (Untagged)	575	700	625	1100	> 3000	NA

* Multiple individuals were heavier than the upper range of the scale (3000 g).
** Mean weights were not calculated for groups where individuals exceeded the upper range of the scale (3000 g).

Spawning Population Estimate

A total of 101 individual Bull Trout were captured or observed at the weir of which 54 (53%) were female and 47 (47%) were male (Table 9). Of the 54 females, 27 (50%) were previously tagged and 42 (89%) of the 47 males were tagged. In addition, there were three PIT-tagged Bull Trout detected at the instream PIT antenna just downstream of the weir that were not subsequently captured in the trap or detected while passing upstream of the weir. The total number of Bull Trout that entered Pinhead Creek, but did not pass upstream of the weir to spawn is unknown.

Table 9.. 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	14	2	6	3	20	5
Weir Video Only	28	3	21	24	49	27
Combined	42	5	27	27	69	32
Total	**47**		**54**		**101**	

Documenting Natural Production

Twenty-five individual Bull Trout were captured in the adult trap during 2018. Five of these fish were untagged prior to capture. Tissue samples were collected from each untagged Bull Trout for future genetic analysis to determine if they were locally-born progeny. Similar to trapping results in 2017 (Barrows et al. 2018), a relatively high percentage of tagged males were observed at the video weir (90%) and captured in the trap (88%). This suggests that only a small portion of the males in the spawning population may have been locally-born progeny. As in 2017, a lower percentage of tagged females were observed at the video weir (47%) and captured in the trap (67%), suggesting a portion of the females may have been locally-born, but the notable disparity between the percentages 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 of the 25 adult Bull Trout trapped at the Pinhead Creek weir were previously PIT-tagged. One of the 20 previously tagged fish was tagged at the Pinhead Creek weir as an adult in 2017 (Barrows et al. 2018). The other 19 PIT-tagged fish were translocated individuals. The fish were originally released as juveniles (N = 9), subadults (N = 8), and adults (N = 2) and on average grew at rates of 83.0 mm, 87.7 mm and 37.5 mm per year, respectively (Table 10). One subadult was not included in the analysis because its length was not recorded when originally tagged. These growth rates are generally consistent with findings reported in Harris et al. (2018) in that larger (older) individuals grew in length at a slower rate than smaller (younger) fish, although, subadults grew at a slightly faster rate than the fish originally released as juveniles. We also found that male and female Bull Trout grew at a similar rate following release (Table 11). In addition, the fish that was PIT-tagged at the weir in 2017 and recaptured during 2018 grew 35 mm, consistent with the average growth rates of the translocated adult fish. 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 10. Growth rates since release of translocated Bull Trout captured at the Pinhead Creek weir during 2018.

Lifestage at Release	# of Samples	Growth / Day (mm)	Growth / Year (mm)
Juveniles (70 – 250 mm)	9	0.23	83.0
Subadults (252 – 450 mm)	7	0.24	87.7
Adults (> 450 mm)	2	0.10	37.5

Table 11. Growth rates since release of male and female bull translocated Bull Trout captured at the Pinhead Creek weir during 2018.

Sex	# of Samples	Growth / Day (mm)	Growth / Year (mm)
Male	13	0.22	79.74
Female	5	0.20	81.0
Combined	18	0.22	76.6

Tag Retention

Tissue samples were collected from all five untagged Bull Trout for future genetic analysis to determine if they were locally-born progeny or simply translocated Bull Trout that had shed their tags. The disparity in tagged to untagged ratios for male and female fish observed at the weir during both 2017 (Barrows et al. 2018) and 2018, suggests tag retention may be substantially lower for females (see Documenting Natural Production results and discussion).

Weir Passage

During 2018, 62 individual, PIT-tagged Bull Trout encountered the Pinhead Creek weir from July 25, 2018 to October 5, 2018. Of the 62 individuals that encountered the weir, 95% (N = 59) successfully passed upstream of the weir. Three PIT-tagged individuals that did not subsequently pass upstream during the spawning period may have spawned downstream of the weir or in other locations within the study area. On average, each Bull Trout encountered the weir moving upstream 3.5 times (range: 1 – 12) and encountered the weir 1.4 times (range: 1 – 4) before successfully passing upstream through the adult trap or the video chute. A similar pattern was observed during 2017 (Barrows et al. 2018). We presume this behavior may occur naturally in the absence of a weir, but little is known of Bull Trout micro-movements within spawning tributaries prior to spawning. Seventy-three percent of the Bull Trout that encountered the weir, passed during their first encounter, and 91% passed upstream by their second encounter. Of the 62 fish that encountered the weir, 82% passed upstream of the weir in one day or less following their initial encounter. Starcevich et al. (2012) found that most adult Bull Trout in Mill Creek (tributary to the Walla Walla River) paused during their prespawning migration for an extended period in the forebay pool of a dam just below the spawning grounds. They also found that Bull Trout that arrived at the pool earlier tended to remain in the pool longer. Similarly, we found that Bull Trout that encountered the Pinhead Creek weir earlier in the spawning season (July – August) tended to take more time to pass upstream and remained within the vicinity of the weir for a longer period of time than fish that encountered the weir later in the season (see Table 3).

We found a notable difference between the passage rates (per attempt) when the adult trap was operated and when the trap was closed. When the trap was operated (upstream passage through the video chute was not possible) the passage rate was 30% (N = 90 attempts). When the trap was closed and passage through the video chute was possible, the passage rate per attempt rose to 79% (N = 39 attempts). Bull Trout have been suspected of being trap-shy (Nelson et al. 2011) but many factors may have influenced weir passage and timing, including, but not limited to, weather patterns (e.g., rain events), run timing, and fish density below the weir. Despite being informative, a more thorough assessment would be required to make a definitive statement concerning delay at the Pinhead Creek weir.

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 have been taken from translocated Bull Trout. Tissue samples have been archived at the USFWS Abernathy Fish Technology Center in Longview, Washington (Table 12). In addition, caudal fin tissue was collected from 11 untagged Bull Trout captured at the Pinhead Creek weir during 2017 (N = 6) and 2018 (N = 5). This collection of samples will provide the opportunity for subsequent parentage analysis and the determination of naturally reproduced progeny. As of December 2018, genetic analysis has not been completed.

Table 12. 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 2018 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 nine PIT-tagged Bull Trout detected at various PIT antennas at PGE's hydro project facilities during 2018 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. Detection histories of PIT-tagged Bull Trout detected at PGE facilities during 2018 confirmed Bull Trout were present during the months of April through October, but data from previous years indicate Bull Trout encounter PGE facilities and occupy the HVZ during all months (Barry et al. 2014; Barrows et al. 2016, 2017, 2018). It is important to note that a portion of the translocated population has likely shed their PIT tags (see the Documenting Natural Production discussion) and locally-born individuals have not been PIT-tagged, thus, detections may only represent some unknown portion of the actual number of Bull Trout occupying the HVZ and encountering PGE facilities.

Despite multiple detections of individual PIT-tagged Bull Trout at PGE facilities (N = 9), no Bull Trout were observed or detected while passing upstream of North Fork Dam during 2018. This is the first year since 2013 where no Bull Trout successfully reentered the study area upstream of North Fork Dam from downstream areas. This was unexpected given the relatively high number of PIT-detections recorded at the downstream bypass facilities and the River Mill Ladder. For example, an adult Bull Trout (PIT ID 982_000361679227) that presumably spawned while in Pinhead Creek during 2017 was detected moving downstream of North Fork Dam via the Floating Surface Collector in early July 2018 (Appendix A). After brief detections ascending the River Mill Fish Ladder and moving back downstream via the River Mill Surface Collector, this fish was not subsequently detected. Similarly, another adult Bull Trout (PIT ID 0000_0000000177419312) moved downstream of North Fork Dam via the Floating Surface Collector in mid-June 2018. This fish was detected multiple times ascending the adult ladders and passing downstream via the River Mill Surface Collector in July and August, but never passed upstream of North Fork Dam en route to known spawning grounds.

Some Bull Trout detected at PGE facilities have sparse detection histories, limiting what can be inferred from the detections. For example, three Bull Trout (PIT ID's 0000_0000000177419000; 982_000361679350; 0000_0000000177419129) released as subadults in the mainstem Clackamas River in 2016 were detected passing downstream of North Fork Dam via the Floating Surface Collector in 2018. These were the first detections of these fish since release and offer very little information pertaining to their whereabouts over the past two years. The detections provide only a snapshot of where they were located at a single moment. It remains unknown whether these fish had been residing in the mainstem Clackamas River or foraging in the North Fork Reservoir following release. Similarly, it is unknown where they went after leaving the study area.

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). An understanding of these fundamental characteristics is required 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. A highpoint of the reintroduction effort's second phase (2018 – 2024) has been the recruitment of translocated fish into the adult spawning population as evidenced by weir observations and detections of PIT-tagged individuals 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 an estimate of 101 individuals during 2018. Moreover, redd counts during 2018 (N = 84) were near their highest since the initiation of the reintroduction effort. However, there continue to be notable data gaps. Sampling during 2017 confirmed a portion of the Bull Trout redds in Pinhead Creek produced viable embryos and alevins, but efforts to provide definitive evidence of post-emergent juveniles have been unsuccessful to date. In addition, adults without PIT-tags have been observed and captured at the weir in Pinhead Creek lending the possibility that locally-born individuals have been recruited into the adult spawning population. However, a substantial disparity between the percentage of tagged males and females suggests an elevated rate of tag shedding in the female portion of the population, indicating many of the untagged fish may actually be translocated individuals. These important benchmarks are crucial 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 2018.

The 53 unique PIT tags associated with translocated Bull Trout detected at the Pinhead Creek weir in 2018 represent primarily translocated Bull Trout released into the Clackamas River Subbasin in 2012-2016. As in 2016 and 2017, juveniles released into Pinhead and Last creeks during 2013 contributed the most PIT detections of any specific release group. 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, have not yet matured, or shed their PIT tag. In addition, spawning and rearing have occurred elsewhere in the subbasin, explaining why some fish may not have been detected in Pinhead Creek.

The vast majority of Bull Trout observed at the Pinhead Creek weir were likely adults intending to spawn. However, a few fish were released as juveniles in 2016 and may not have been mature spawners, but rather subadults entering Pinhead Creek to rear and forage.

Unlike in past years (e.g., 2014 – 2017), no Bull Trout returned to the study area upstream of North Fork Dam during 2018 after previously exiting the study area (i.e., downstream of River Mill Dam). This was unexpected given that nine individual PIT-tagged Bull Trout were detected at PGE facilities during 2018. Observations from past years provided evidence that Bull Trout exiting the study area were able to use foraging, migration and overwintering habitat downstream from the study area and successfully return upstream to spawning areas. It is likely that the lack of observations during 2018 was an anomaly, and we expect adult Bull Trout to be observed successfully moving upstream of North Fork Dam in future years.

We considered 2017 to be a successful pilot year for operating a Bull Trout weir and trap in Pinhead Creek. During 2018, we made only slight modifications to the weir and trap design and operation. The modifications contributed to eliminating downtime and allowed for more accurate monitoring of the spawning Bull Trout population in Pinhead Creek.

We found that translocated Bull Trout released as subadults and juveniles on average grew at faster rates than fish released as adults. Subadults on average grew at a slightly faster rate than fish released as juveniles, but 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. A more robust growth rate analysis may be warranted in the future as the translocated population matures.

A total of 101 individual Bull Trout were captured or observed at the weir of which 54 (53%) were female and 47 (47%) were male. Of the 54 females, 27 (50%) were previously tagged and 42 (89%) of the 47 males were tagged. Given the relatively high percentage of tagged males, it may be likely that only a small portion of the males in the spawning population were locally-born progeny. The lower percentage of tagged female fish suggests a portion of the fish may be locally-born, but the disparity between the percentage of tagged males and females suggests an elevated rate of tag shedding in females.

During 2018, 95% of tagged Bull Trout that encountered the Pinhead Creek weir successfully passed upstream during the spawning season. Seventy-three percent of the Bull Trout that encountered the weir, passed during their first encounter and 91% passed upstream by their second encounter. In addition, 82% passed upstream of the weir in one day or less following their initial encounter. However, passage rates (per attempt) were lower when the adult trap was operated as opposed to when the trap was closed and fish could move upstream through the video chute. Whenever an impediment (e.g., picket weir and trap) is placed within a stream, some level of delay is to be expected. Weir passage should continue to be monitored in future years to help minimalize the effects of monitoring the spawning population.

Redd counts have increased substantially since the inception of the reintroduction program and 2018 counts (N = 84) are near the highest to date. As translocated individuals and locally-born offspring (if they exist) continue to mature, we expect further recruitment into the spawning population and, thus, increased redd counts in future years.

Caudal fin tissue was collected from five untagged Bull Trout captured at the Pinhead Creek weir during 2018. 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 2018 is largely unknown. However, the detection histories of nine 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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Appendix A

Comprehensive Detection Histories for Bull Trout Detected at PGE Facilities During 2018

Telemetry Code	PIT Tag Code	Size at Tagging or Recapture (TL)	Date Released (*), Detected or Recaptured	Location Released (*), Detected, or Recaptured
NA	**0000_0000000177419108**	**257 mm**	**5/27/2016***	**4650 Bridge***
			4/23/2018	PIT Detect – Fl. Surface Collector (NF Dam)
			4/23/2018	PIT Detect – Timber Park D/S Sampling Fac.
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)
			7/7/2018	PIT Detect – Fl. Surface Collector (NF Dam)
			7/8/2018	PIT Detect – Timber Park D/S Sampling Fac.
			7/11/2018	PIT Detection – River Mill Ladder
			7/12/2018	PIT Detection – River Mill Surface Collector
NA	**982_000360937173**	**91 mm**	**5/6/2016***	**Upper Clackamas***
			5/17/2018	PIT Detect – DS Migrant Collector (NF Dam)
			5/17/2018	PIT Detect – Timber Park D/S Sampling Fac.
			1/7 to 1/8 (2019)	PIT Detection – River Mill Ladder
			1/21/2019	PIT Detection – N. F. Old Sorting Facility
164	**0000_0000000177419561**	**335 mm**	**7/12/2012***	**4670 Side Channel***
			7/16 to 11/20 (2012)	Radio – Big Bottom area
			5/14 to 9/17 (2013)	Radio - 0.2 to 1.0 mi d/s of Pinhead Cr. Confl.
			9/6 to 9-17 (2013)	PIT Detection – Pinhead Cr. Array (mouth)
			9/23/2013	Radio – Near mouth of Oak Grove
			9/30 to 11/12 (2013)	Radio – Near Job corp
			8/11/2014	PIT Detection – Pinhead Cr. Array (mouth)
			9/10 to 9/29 (2015)	PIT Detection – Pinhead Cr. Array (mouth)
			5/25/2018	PIT Detect – Fl. Surface Collector (NF Dam)
			5/25/2018	PIT Detect – Timber Park D/S Sampling Fac.
NA	**0000_0000000177419000**	**320 mm**	**6/13/2016**	**4650 Bridge***
			6/10/2018	PIT Detect – Fl. Surface Collector (NF Dam)
			6/11/2018	PIT Detect – Timber Park D/S Sampling Fac.
			6/28/2018	PIT Detect – Timber Park D/S Sampling Fac.
13	**0000_0000000177419312**	**353 mm**	**6/20/2013**	**4650 Bridge***
			8/19/2013	1.3 mi U/S Austin

Telemetry Code	PIT Tag Code	Size at Tagging or Recapture (TL)	Date Released (*), Detected or Recaptured	Location Released (*), Detected, or Recaptured
			6/14/2018	PIT Detect – Fl. Surface Collector (NF Dam)
			6/14/2018	PIT Detect – Timber Park D/S Sampling Fac.
			6/21/2018	PIT Detection – River Mill Ladder
			6/26/2018	PIT Detection – North Fork Ladder Entrance
			7/7/2018	PIT Detection – River Mill Surface Collector
			7/11/2018	PIT Detection – N. F. Old Sorting Facility
			7/11/2018	PIT Detection – N. F. Adult Sorting Facility
			7/18/2018	PIT Detection – North Fork Ladder Entrance
			7/18/2018	PIT Detection – River Mill Ladder
			7/19/2018	PIT Detection – River Mill Surface Collector
			8/1/2018	PIT Detection – River Mill Surface Collector
			8/2 to 8/5 (2018)	PIT Detection – River Mill Ladder
NA	**982_000361679350**	**364 mm**	**5/22/2015**	**4650 Bridge***
			6/19/2018	PIT Detect – Fl. Surface Collector (NF Dam)
			7/14/2018	PIT Detect – Timber Park D/S Sampling Fac.
NA	**0000_0000000177419151**	**273**	**5/20/2016**	**4650 Bridge***
			8/9/2018	PIT Detect – Fl. Surface Collector (NF Dam)
			8/9/2018	PIT Detect – Timber Park D/S Sampling Fac.
NA	**0000_0000000177419129**	**266**	**5/27/2016**	**4650 Bridge***
			10/12/2018	PIT Detect – Fl. Surface Collector (NF Dam)
			10/12/2018	PIT Detect – Timber Park D/S Sampling Fac.

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, spring 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 life stage 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 xx) 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	2018*
Coho	Adult	2,160	The adult counts were above the threshold for the fourth year (2013, 2014, 2017, 2018) 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.
Spring Chinook	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.

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 2018

PROJECT NUMBER: Portland General Electric Agreement # 2016-08

PROJECT PERIOD: 2018

Prepared by: Steven J. Starcevich

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4034 Fairview Industrial Drive SE
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Abstract

Bull Trout were extirpated from the Clackamas River basin over forty years ago by human activities. 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 2,836 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 with a continuing focus on monitoring progress toward the reintroduction goal, through census redd surveys, the use of PIT tag technology, eDNA surveys, and water temperature monitoring.

Adult abundance was estimated in 2017 and 2018 from PIT-tag-detected adults and untagged adults caught in the weir trap or passing through the video station. The adult abundance estimate in Pinhead Creek was 96 in 2017 and 104 in 2018. While overall abundance increased in this time period, the number of PIT-tagged adults detected peaked at 72 in 2016 and decreased to 62 in 2017 and 51 in 2018, most likely due to tag ejection in spawning females, and adult mortality. Overall, adult abundance in Pinhead Creek in 2018 was higher than 2017, but the proportional increase in abundance was lower than in previous years. This is likely related to the following factors: 1) translocations ended in 2016, 2) translocations in 2014-2016 were composed of mainly age-1 fish (with few reaching adulthood by 2018) and released relatively far from Pinhead Creek, and 3) a large influx of locally-born adults is not expected until 2021 or 2022.

The estimated redd abundance in Pinhead Creek basin increased from 16 redds in 2012 to 85 redds in 2017 and decreased to 81 in 2018. There was a strong linear relationship between the annual adult abundance estimates and census redd counts in Pinhead Creek, suggesting census redd counts continue to be a useful proxy for adult abundance in this small watershed. Most adults had entered Pinhead Creek by mid-September and were last detected by mid-October, with the redd count peaking in late September. PIT-tagged adults spent a median of 11 d in Pinhead Creek during the spawning period.

Translocated Bull Trout released at an older ages (≥age-2) were much more likely to be detected than fish released at age-1. Fish released at age-1 contributed only 3% of all PIT-detected adults in Pinhead Creek since the project began in 2011, even though age-1 fish composed 32% of all translocations. In 2018, translocated fish released at age-1 contributed only a single adult to the total count (N=51) of PIT-detected adults in Pinhead Creek. Fish released at age-2 composed 46% of all translocated fish and 26% of all PIT-tagged adults. Fish age-3 and older composed 22% of all translocations and 71% of all adults detected in Pinhead Creek. This survival pattern hold when only data from Pinhead Creek and Last Creek are considered and suggests greater survival of older age-classes after translocation.

In the analysis of eDNA samples from 2017, Bull Trout eDNA was detected in the upper Clackamas River, Berry Creek, and Cub Creek. These detections were near release sites in 2014-2016. Since most of these fish have not yet reached adulthood, these detections suggest translocated fish are still rearing near their release points. Bull Trout eDNA was also detected in Roaring River even though there were no releases in or near this river. Temperature monitoring revealed extensive high quality thermal habitat for juvenile Bull Trout in the Clackamas River upstream of the Collawash River confluence. Highly suitable thermal habitat for spawning occurred in Pinhead Creek, Last Creek, Oak Grove Fork, Hunter Creek, Berry Creek, and reaches 1, 4, and 5 of the Clackamas River. Maximum and mean temperatures in the lower Collawash River, Hot Spring Fork, and in the Clackamas River downstream of the Collawash River confluence exceeded the criteria for thermally suitable juvenile rearing and spawning habitat.

In 2019, census spawning surveys will continue in Pinhead Creek, Last Creek, and upper Clackamas River (from Cub Creek to the first falls). Exploratory redd surveys will be added to Roaring Creek and a cold-water Clackamas River section. Snorkel surveys will occur in May in Pinhead Creek and, depending on discharge and turbidity, reach 3 of the Clackamas. Environmental DNA surveys will continue in suitable streams; a portion will be conducted during peak water temperatures in late July to focus on the juvenile rearing distribution. Temperature monitoring will continue, currently maintaining 35 temperature loggers, in the upper Clackamas River basin.

Introduction

Bull Trout (*Salvelinus confluentus*) was once abundant and widely distributed in the Clackamas River basin (Shively et al. 2007). Dam construction with no or inadequate fish passage facilities, overfishing, habitat alteration,and the introduction of non-native species are some of the factors that contributed to the extirpation of Bull Trout from this basin over forty years ago (Shively et al. 2007). Range-wide conservation concern and renewed local interest in this species in the 1990s led to extensive Bull Trout surveys in the Clackamas River basin, during which no remaining populations were located, and instigated efforts to reintroduce the species. These efforts produced a feasibility assessment (Shively et al. 2007) and an implementation plan (US Fish and Wildlife Service [USFWS] 2011), which provided the foundation for the methods and protocols for the reintroduction of Bull Trout. The goal of the reintroduction project was to establish a self-sustaining population of 300-500 adults in Clackamas River basin. The first phase of the project involved translocating Bull Trout from the Metolius River basin to various locations in the upper Clackamas River basin (Table 1, Figure 1) and monitoring progress toward the reintroduction goal. Translocations occurred annually from 2011 through 2016 and totaled 2,836 fish, 82% of which were age-1 or age-2 (Figure 2). Each translocated fish was given a unique passive integrated transponder (PIT) tag, and some were radio-tagged, and then monitored using radio telemetry, PIT tag detection arrays, environmental DNA (eDNA) surveys, and redd surveys. The second phase began in 2017 and entailed continued monitoring of progress toward the reintroduction goal.

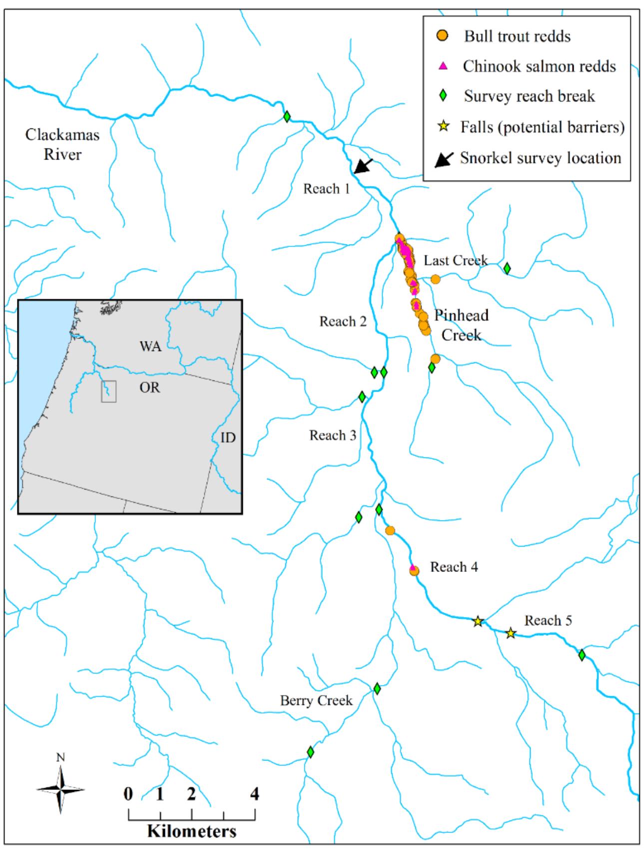


Figure 1. Census survey extent for all survey years and Pinhead Creek, Last Creek, and Reach 4 of the Clackamas River and redd distribution in 2018.

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. Age-class-at-release was defined by size-at-age studies (see text) and were 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. Annual translocations occurred from 2011 through 2016.

		Age (Year Class)					Release Date	
Year	Release Location	1	2	3	4	≥5	Min	Max
2011	Clackamas River	0	0	0	0	12	30-Jun	30-Jun
	Clackamas River 1	0	0	2	10	5	30-Jun	30-Jun
	Clackamas River 2	0	0	0	6	26	30-Jun	15-Jul
	Last Creek	5	22	15	0	0	30-Jun	15-Jul
	Pinhead Creek	6	10	0	0	0	21-Jul	21-Jul
	2011 Subtotal	*11*	*32*	*17*	*16*	*43*		
2012	Clackamas River 1	0	0	3	6	1	14-Jun	14-Jun
	Clackamas River 2	0	0	4	31	17	14-Jun	12-Jul
	Last Creek	64	84	2	0	0	3-May	28-Jun
	Pinhead Creek	226	131	0	0	0	10-May	31-May
	2012 Subtotal	*290*	*215*	*9*	*37*	*18*		
2013	Clackamas River	0	0	10	23	4	6-Jun	13-Jun
	Clackamas River 1	0	0	17	33	15	6-Jun	27-Jun
	Last Creek	93	230	7	0	0	11-Apr	27-Jun
	Pinhead Creek	101	179	1	0	0	2-May	30-May
	2013 Subtotal	*194*	*409*	*35*	*56*	*19*		
2014	Berry Creek	152	129	0	0	0	24-Apr	29-May
	Clackamas River 1	0	23	21	21	14	5-Jun	25-Jun
	2014 Subtotal	*152*	*152*	*21*	*21*	*14*		
2015	Berry Creek	97	187	3	0	0	10-Apr	5-Jun
	Clackamas River 1	0	3	32	45	13	15-May	5-Jun
	2015 Subtotal	*97*	*190*	*35*	*45*	*13*		
2016	Clackamas River 1	0	77	77	31	10	20-May	13-Jun
	Clackamas River 5	429	70	1	0	0	8-Apr	13-May
	2016 Subtotal	*429*	*147*	*78*	*31*	*10*		
	Life Stage Total	*1173*	*1145*	*195*	*206*	*117*	*Grand Total*	*2836*

Since the project began, redd surveys have been the primary method of monitoring adult abundance and distribution. From 2011 through 2014, redd surveys were conducted in Pinhead and Last creeks by an *ad hoc* multi-agency group of observers. In 2015 and 2016, the sample frame was expanded to include all potential spawning habitat in the upper Clackamas River basin and census redd surveys were conducted by a crew of five experienced observers from the Oregon Department of Fish and Wildlife (ODFW), with assistance from other agencies and volunteers. In 2017 and 2018, the redd survey sampling frame was reduced to Pinhead Creek, Last Creek, and reach 4 of the Clackamas River, which are areas where Bull Trout spawning was consistently observed in 2015 and 2016. These census surveys were conducted by three ODFW

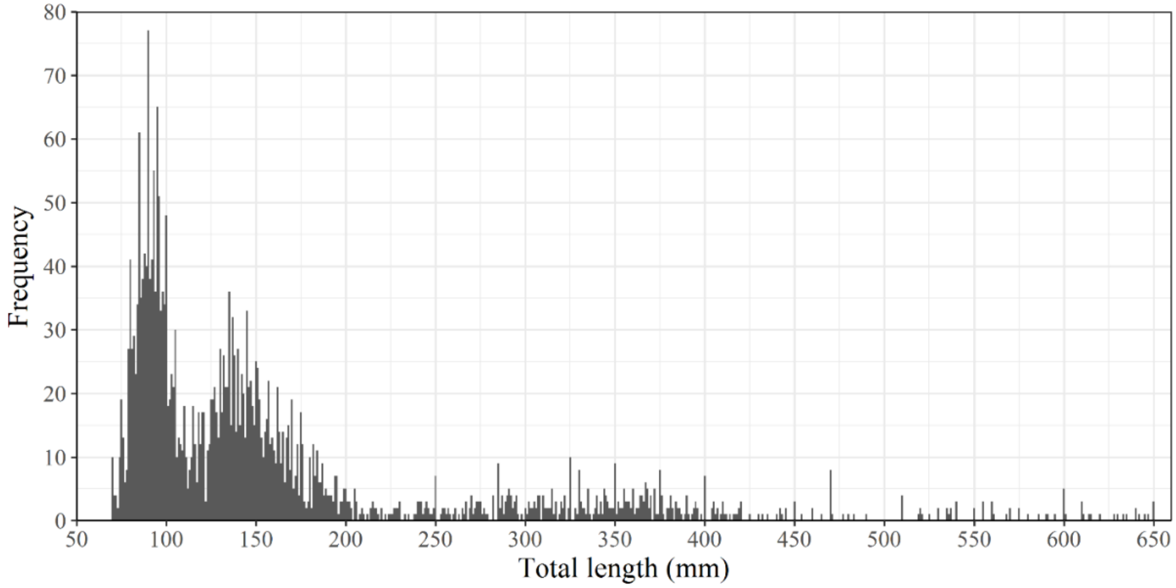


Figure 2. Length-frequency histogram of Bull Trout captured in the Metolius River basin, PIT-tagged, and translocated to the upper Clackamas River basin, 2011-2016.

surveyors of varying experience, with additional help from experienced surveyors from the U.S Forest Service (USFS), USFWS, and Portland General Electric (PGE). The areas dropped from the census in 2017 and 2018 either were 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 eDNA surveys. Water temperature data loggers have been used since 2015 to evaluate thermal habitat suitability throughout the upper Clackamas River basin.

In 2018, the specific objectives were to 1) characterize Bull Trout abundance using census spawning surveys in known or high potential spawning areas, 2) examine the relationship between redd counts and PIT-tagged adults detected in the Pinhead Creek watershed, 3) document juvenile Bull Trout rearing in the Clackamas River downstream of the confluence with Pinhead Creek using night snorkel surveys, 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.

Methods

Census redd surveys

Census redd surveys were conducted in Pinhead Creek, Last Creek, and Reach 4 of the upper Clackamas River (Figure 1). Census surveys were generally completed every two weeks from August 28 to November 6, 2018 (Table 2). The first survey, conducted prior to the putative start of Bull Trout and Chinook Salmon spawning, was used to familiarize the field crew with redd identification by analyzing characteristics of old redds from a previous season (i.e., salmonid

Table 2. Census survey reaches and 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	12-Sep	NS	NS	24-Oct	NS
Pinhead Creek 1	28-Aug	10-Sep	24-Sep	9-Oct	23-Oct	6-Nov
Pinhead Creek 2	29-Aug	11-Sep	25-Sep	8-Oct	22-Oct	5-Nov
Last Creek	28-Aug	10-Sep	25-Sep	8-Oct	22-Oct	5-Nov
Total Bull Trout redds	0	11	33	21	12	7
Total Chinook Salmon redds	0	2	2	2	5	35

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, gravel size (2-64 mm in diameter), and the contrast of brighter disturbed gravel relative to a darker surrounding matrix. Salmon redds were distinguished by their relatively large surface area and substrate size and, on occupied redds, by identifying the species of adult salmon. The crew flagged new Bull Trout redds and recorded the following data: GPS location, maximum length and width, species and number of adults occupying the redd, and brief descriptions of the redd and observer certainty.

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 2015-2018, observers were trained to include a brief description of, and reasons for, their certainty in each new redd identified so that an experienced surveyor could review redds identified with high uncertainty. These descriptions were entered as a comment in the database. (See Appendix I for dataset from 2018.)

Pinhead Creek adult monitoring

The use of Pinhead Creek by PIT-tagged fish was monitored with a 4-antenna PIT tag array installed near the creek’s confluence with the Clackamas River. The USFWS has usually activated the array in June and the maintained it through November. PIT tag detection data from Pinhead Creek were used to describe the annual number, duration, timing, age-at-release, and release location of PIT-tagged adults present in Pinhead Creek during the spawning season.

From 2011 through 2016, as a relative measure of annual 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). To count the number of PIT-tagged adults using Pinhead Creek annually, age-class at detection was approximated. Age-class at release was approximated for age-1 and age-2 fish based on a length-frequency histogram of translocated fish (Figure 2) and length-at-age studies of Bull Trout throughout their range (see Fraley and Sheppard 1989, Ratliff et al. 1996, and Salow 2004). Age was 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. More specifically, 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.

In 2017 and 2018, along with the PIT tag detection array, a weir trap and video monitoring station were installed and maintained by the USFWS in Pinhead Creek about 250 m upstream from the confluence with the Clackamas River. Trapping results in 2017 showed that 45% of female adults and 8% of males did not have PIT tags (Barrows et al. 2018). Since female salmonids tagged in the body cavity are known to be more likely than males to eject their tags during spawning (Meyer et al. 2011, Mamer and Meyer 2016), the discrepancy between sexes likely resulted from higher rates of tag ejection by females. Another potential source of untagged adults was from locally-born offspring of translocated Bull Trout surviving to adulthood. Considering these sources of untagged adults, an accurate count of adults using Pinhead Creek during the spawning season could not rely solely on PIT tag detections. Therefore, the annual adult count in these years was composed of two sources: 1) unique PIT-tagged adults detected at the PIT tag array (installed at the weir site in 2018) and the weir trap, and 2) unique untagged adults identified at the trap or moving upstream through the video station (Barrows et al. 2018).

Simple linear regression was used to assess the relationship of the annual adult count in Pinhead Creek (the explanatory variable, X), and the annual count of Bull Trout redds in Pinhead and Last creeks (the response variable, Y), from 2011-2018 (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 (2011-2018) or trap (2017-2018) in a single monitoring season. Duration was summarized by year but excluded individuals detected for ≤1 d. This exclusion attempted to reduce, likely without eliminating, the influence of short-term non-spawning use, and tag ejections and mortalities upstream of the array, on the estimated duration of adults in Pinhead Creek. Timing of adult use of Pinhead Creek was represented by boxplots of first and last detections of individuals for each annual monitoring season.

The annual count of PIT-tagged adults was plotted by release location and age-at-release. Age-at-release class was assigned to translocated fish by the five size classes described above and then linked by PIT-tag code to each adult detected in Pinhead Creek. To evaluate the relationship between PIT-tagged adults in Pinhead Creek and their age-at-release, adults were counted by the five age-at-release classes and each class was compared to the total number of PIT-tagged adults detected in Pinhead Creek (N=215). These adult ratios (i.e., individual age-at-release classes to total adults) were also compared to those of translocated fish.

Distribution surveys

Night snorkeling and eDNA surveys were used to determine Bull Trout distribution in this study area. A single snorkel survey was conducted by a 4-person crew on September 24-25 between 10 PM and 2 AM. The survey covered 500 m within reach 1 of the Clackamas River (commonly known as Big Bottom). Each snorkeler used a dive light and all habitat within the main channel of this multi-channel reach was snorkeled.

The eDNA surveys were conducted according to the field collection protocol and sampling equipment recommended by Carim et al. (2016). A peristaltic pump (Geopump, Geotech, Colorado, USA) was powered by a lithium ion battery. 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 desiccant. Within 10-48 hours, these samples were placed in a –20 °C freezer for storage until analysis 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 for Bull Trout distribution. High priority streams were known to be thermally suitable (i.e., <16 °C maximum), lacking fish barriers, and within the suitable patches identified in the reintroduction feasibility study (Shively et al. 2007). Second priority streams, outside of known suitable thermal patches, were identified through historical anecdotes as occupied streams (Shively et al. 2007). All high priority streams were surveyed and second priority streams will be surveyed for eDNA in the future, if thermal habitat monitoring shows these areas to be suitable.

Probability of detection of fish present in the stream is positively related to fish density and negatively related to stream discharge (Wilcox et al. 2016). The minimum number of sample sites to reach a detection probability greater than 0.85 in a survey stream was calculated using baseflow discharge estimates and an assumed density of 1 Bull Trout per 100m, using parameterized models from Wilcox et al. (2016). Sites were allocated systematically every 2 km to Cub Creek, Berry Creek, and the upper Clackamas River reaches to determine presence and distribution of Bull Trout in tributaries where Bull Trout were previously translocated.

The National Genomics Center (NGC) for Wildlife and Fish Conservation (U.S. Forest Service, Rocky Mountain Research Station, Missoula, MT) conducted the analysis of the 2017 eDNA samples. At the NGC, samples were stored at –20 °C until analysis. The extraction of eDNA followed a modified protocol described in Franklin et al. (2019). All samples were analyzed for Bull Trout eDNA markers developed at the NGC (Dysthe et al. 2018). Each sample was analyzed in triplicate on a StepOne Plus qPCR Instrument (Life Technologies) or a QuantStudio 3 qPCR System (Life Technologies). A sample was considered positive for the presence of the target species if at least one of the three qPCR reactions amplified DNA of that species. According to Jennifer Hernandez, NGC eDNA Program Coordinator, all reactions included an internal positive control to ensure that the reaction was effective and sensitive to the presence of Bull Trout DNA and all laboratory experiments were conducted with negative controls to insure there was no contamination during DNA extraction or qPCR setup.

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*

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 35 locations in the upper Clackamas River basin by June, 2018. Of these, 30 were successfully downloaded between late September and early November, 2018. Five loggers were lost because of bed scour or human tampering, three of which were replaced in a more secure nearby location. Data were discarded from one data logger (in Berry Creek) because it was exposed to air. An additional three data loggers were deployed during this time period. 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 early September to respectively classify spawning habitat as high, medium, and low thermal suitability (Starcevich et al. 2017).

Results and Discussion

Census redd surveys

In census redd surveys, we identified 81 putative Bull Trout redds in Pinhead Creek and Last Creek (Figure 3, Table 4) and 3 redds in reach 4 of the upper Clackamas River (Figure 1, Table 4, Appendix I). This represented a 5% decrease in the census count relative to 2017 and was the first decline since 2013. The first Bull Trout redd was observed in early September and 77% of the redds were counted by early October (Table 2). Bull Trout were seen actively spawning on or occupying only a single redd (1% of total).

Since 2014, the highest census redd count at the reach-level alternated between reaches 1 and 2 of Pinhead Creek; this year reach 1 had the highest count (Figure 3, Table 4). This spatio-temporal pattern may be indicative of an adult cohort that spawns every other year (i.e., in alternate years). However, based on an evaluation of annual PIT-tag detections, 94% of adults were detected entering Pinhead Creek in consecutive years. There have been 189 PIT-tagged adults detected in Pinhead Creek from 2014 through 2018, and 71 (38%) of these have been detected in more than one year (Appendix II). Of these, 67 adults were detected in consecutive years and composed 94% of repeat annual detections (N=160). Only 4 adults were detected in Pinhead Creek in alternate years and their small number of annual detections (N=11) does not correspond to the magnitude of the alternating spatial pattern of spawning, which on average changes annually 25% (range, 12-32%; Table 4). Since some adults may be entering Pinhead Creek briefly without spawning or for reasons other than spawning (e.g., thermoregulation), it is unknown if PIT-tag detections alone can accurately assess repeat spawning characteristics. Direct information on individual spawning maturity is needed for this assessment.

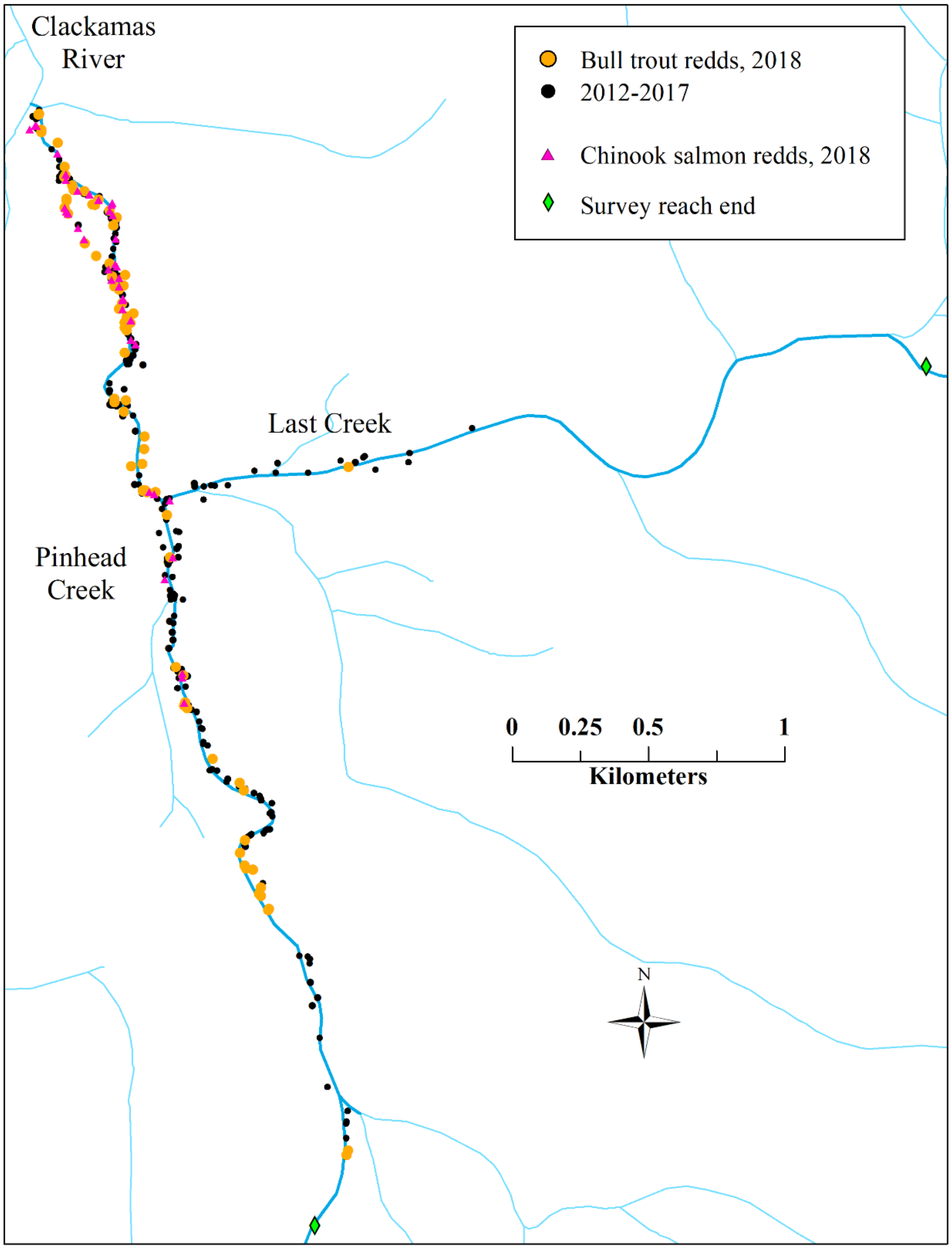


Figure 3. Georeferenced redds in Pinhead Creek and Last Creek from 2012-2018. Redds were georeferenced in secondary channels; these channels are not shown on this map.

Table 4. Bull Trout redds counted during census surveys in the upper Clackamas River basin, 2011-2018. In certain years, some stream reaches were not surveyed (NS).

		Bull Trout redd count								
Stream	Reach	2011	2012	2013	2014	2015	2016	2017	2018	Riverscape marks
Pinhead Creek	1	3	9	10	21	13	34	33	57	To Last Cr
Pinhead Creek	2	2	5	2	14	34	25	40	23	Last Cr - FS140 Rd
Last Creek	1	0	2	3	2	0	3	12	1	To Camp Cr
Clackamas River	1	NS	NS	NS	NS	2	0	NS	NS	Big Bottom - Pinhead
Clackamas River	2	NS	NS	NS	NS	5	2	NS	NS	Pinhead - Lowe Cr.
Clackamas River	3	NS	NS	NS	NS	2	0	NS	NS	Lowe Cr. - Cub Cr.
Clackamas River	4	NS	NS	1	NS	2	4	4	3	Cub Cr. - First falls
Clackamas River	5	NS	NS	NS	NS	0	NS	NS	NS	First falls - Ollalie Cr.
Oak Grove Fork	1	NS	NS	2	NS	1	0	NS	NS	First 2.5 km
Lowe Creek	1	NS	NS	NS	NS	0	0	NS	NS	First 1 km
Rhododendron Cr.	1	NS	NS	NS	NS	0	0	NS	NS	First 1 km
Hunter Creek	1	NS	NS	NS	NS	0	0	NS	NS	First 1.5 km
Cub Creek	1	NS	NS	NS	NS	0	0	NS	NS	To Berry Cr.
Cub Creek	2	NS	NS	NS	NS	0	NS	NS	NS	2.5 km from Berry Cr.
Berry Creek	1	NS	NS	NS	NS	0	0	NS	NS	First 3 km
TOTAL		5	16	18	37	59	68	89	84	

In Pinhead and Last creeks, 46 Chinook Salmon redds were counted (Figure 3, Appendix I). The first salmon redd was observed in early September and salmon spawning increased substantially in late October (Table 2). Chinook Salmon were observed actively spawning on or occupying 9 redds (20% of total). Most Bull Trout redds had been identified prior to the increase in salmon spawning in Pinhead Creek, which decreases the influence of salmon redds as a confounding factor.

Pinhead Creek adult monitoring

The number of translocated PIT-tagged Bull Trout adults detected in Pinhead Creek during the spawning season steadily increased from 20 adults in 2013 to a peak count of 72 in 2016 (Table 5). Since then, the count of translocated PIT-tagged adults declined to 62 in 2017 and 51 in 2018 (Table 5). This decline was expected given that translocations ended in 2016 and adults may eject their tag, or experience natural mortality.

When the adult count included both tagged and untagged adults, the adult abundance estimate in Pinhead Creek was 96 in 2017 and 104 in 2018 (Table 5; Barrows et al. 2018, 2019), which represented an annual increase of 33% and 8% in respective years. The decline in the rate of increase could be attributable to at least four factors. First, translocations ended in 2016; therefore, unlike previous years, no translocated adults were added in 2017 and 2018. Second, from 2014 through 2016, most of the translocations occurred in Berry Creek and reach 5 of the Clackamas River. These are thermally suitable rearing areas, which decreases the need for dispersal in search of better thermal habitat. They are also relatively far from Pinhead Creek, which likely prolongs their discovery and use of Pinhead Creek. Third, most of these fish were released at age-1 and have not yet reached adulthood (i.e., < age-5 in 2018). If these fish survive to adulthood and cannot find suitable spawning habitat near their release location, they may contribute to the Pinhead Creek adult count in the future. Finally, the main assumption of this project is that translocated fish will produce locally-born offspring that reach adulthood and eventually supplant out-of-basin adults, thereby becoming a self-sustaining population. This expected influx of locally-born adults may still be a couple of years away because the fish born from the 5 redds counted in Pinhead Creek in the first year of the project would be age-0 in 2012 and, provided some of this cohort survives to adulthood, age-6 in 2018. Given the low redd and adult counts in 2011 through 2013, one would expect the locally-born adult cohort of 2018 to be small. The redd and adult count in Pinhead Creek increased substantially in 2014 and 2015 (Table 5 and 6); the adult (i.e., age-6) cohorts from these redds are not expected to contribute to the adult population until 2021 and 2022, respectively.

Table 5. Census survey redd counts in relation to the number of adult Bull Trout (i.e., age-5 and older) detected in Pinhead Creek and the estimated duration PIT-tagged adults spent in this watershed. From 2011-2016, the count was composed of only translocated PIT-tagged adults. In 2017-2018, the count was composed of tagged and untagged adults detected at the PIT-tag array, caught in the weir trap, or observed passing upstream through the video station. (The number and percent annual change of translocated PIT-tag adults in 2017-2018 are in parentheses.) 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		PIT/Trap/Video		Duration		
Year	Redds	Annual Change	Adults	Annual Change	Median	Min	Max
2011	5	NA	19	NA	26	3	78
2012	16	220%	17	-11%	35	12	55
2013	15	-6%	20	18%	26	3	68
2014	37	147%	35	75%	13	2	93
2015	47	27%	53	51%	18	2	87
2016	62	32%	72	36%	26	3	88
2017	85	37%	96 (62)	33% (-14%)	16	2	91
2018	81	-5%	104 (51)	8% (-18%)	11	2	47

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). PIT-tagged fish were not released in every year in each location (represented by NAs).

	Age (yr)					Release Location						
Year	≥ 5	4	3	2	1	Lower Clackamas River	Clackamas Reach 1	Pinhead/Last creeks	Pinhead Creek Trap	Clackamas Reach 2	Clackamas Reach 5	Berry Creek
2011	19	1	3	8	0	6	2	11	NA	12	NA	NA
2012	17	2	3	2	7	1	2	13	NA	15	NA	NA
2013	20	1	16	177	9	0	4	205	NA	14	NA	NA
2014	35	12	21	17	5	6	16	38	NA	9	NA	21
2015	53	32	2	2	1	9	30	41	NA	5	NA	5
2016	72	5	2	0	0	0	29	44	NA	2	0	4
2017	68	1	2	3	0	1	29	32	6	0	3	3

2018	60	2	0	0	0	0	34	16	9	1	0	2

There was a strong linear relationship (Y=0.85X – 0.92, R^2=0.96, P-value<0.001) between the number of adults detected (x) and the annual census redd count (y) in Pinhead Creek (Figure 4). The relationship of 1.3 adults per redd in 2018 was similar to previous years (mean, 1.1; range, 0.9-1.3; 2012-2017). Although the adult-to-redd ratio was low relative to other Bull Trout populations (see Howell and Sankovich 2012), the census redd count continued to be a useful monitoring tool because it was a consistent proxy for adult abundance in the Pinhead Creek watershed.

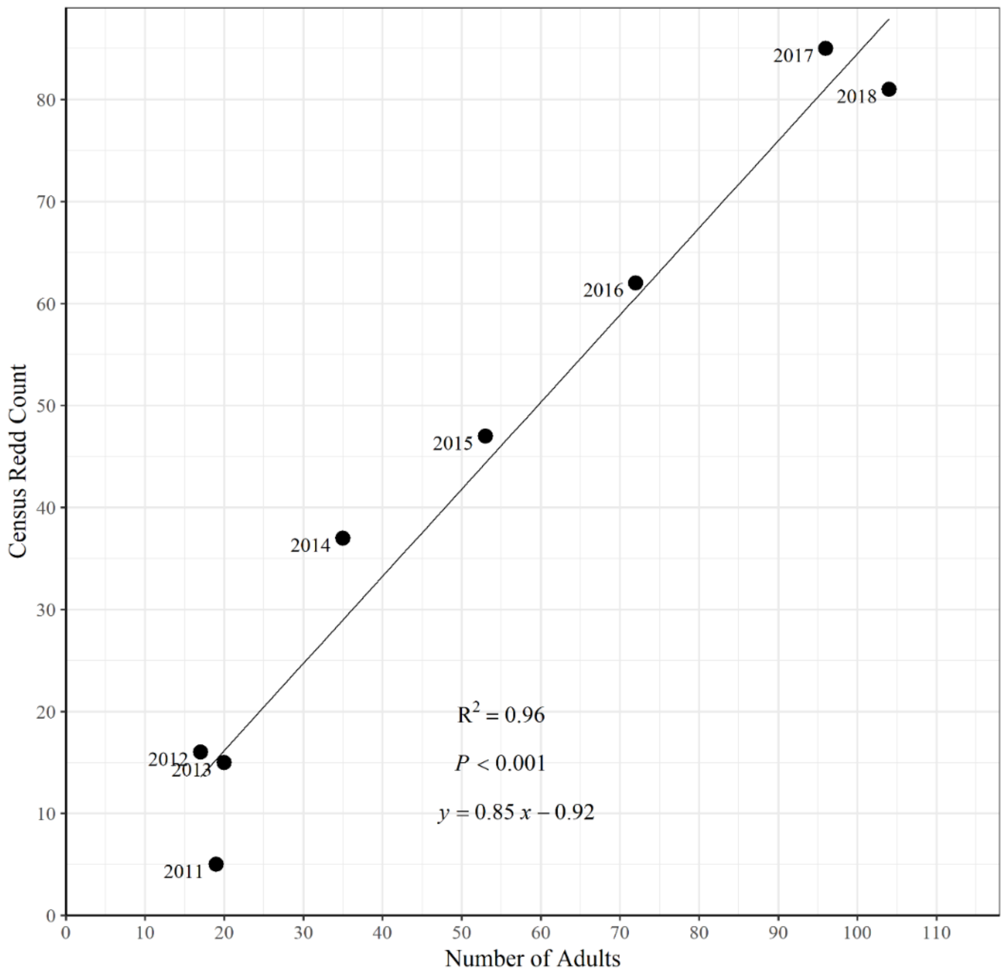


Figure 4. Annual number of Bull Trout redds counted in Pinhead and Last creeks as a function of the annual number of adult Bull Trout (i.e., age-5 and older) detected entering Pinhead Creek during the spawning period. From 2011-2016, the adult count consisted of PIT-tagged adults detected at the PIT array (solid circles). In 2017 and 2018, the adult count consisted of an adult estimate from the weir trap, video station, and PIT-tag detections. The line and its equation were estimated using simple linear regression.

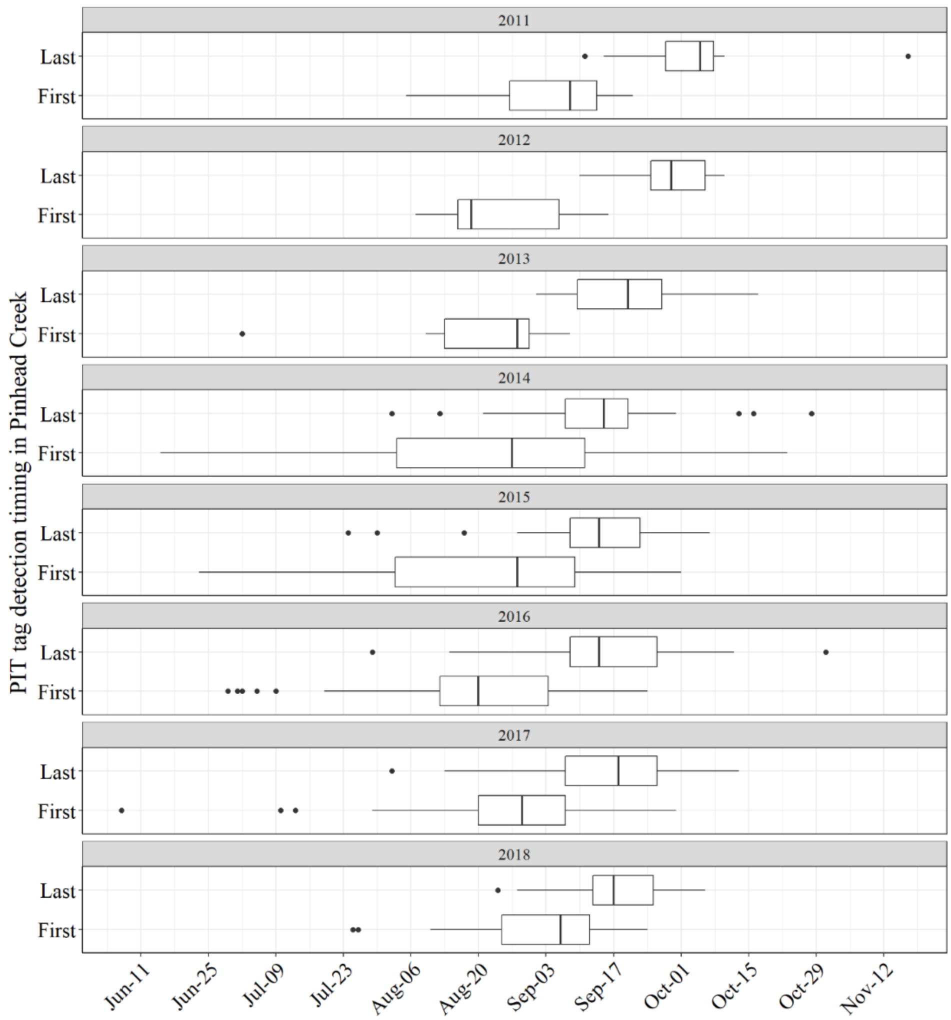


Figure 5. Timing of first and last detection of PIT-tagged Bull Trout, age-5 and older, at the PIT array near the mouth of Pinhead Creek. The boxplot displays a median line and two middle quartile boxes; the whiskers are defined as 1.5*interquartile range (IQR), outliers are beyond this spread, and together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

In 2018, 75% of PIT-tagged adults were first detected in Pinhead Creek by September 12 and the last PIT-tag detection was on October 6 (Figure 5), which corresponded to the spawning peak observed during redd surveys (Table 2). PIT-tagged adults generally spent 11-35 d in Pinhead Creek during the spawning season (Table 5). Similar to previous years, this timing information suggests that Bull Trout likely have completed spawning by mid-October; however, in 2018, 19 Bull Trout redds were counted in late October and early November (Table 2). This mismatch in the timing of spawning and the redd count, which occurred in every year since 2015, has at least two potential explanations. First, these late-identified Bull Trout redds may have been missed during previous surveys. Pinhead Creek has a large amount of instream wood and several multi-channel reaches, which are factors that can increase the probability of observers missing new redds during an individual survey. However, the protocol of repeating the census survey every two weeks is used expressly to correct these errors of omission in subsequent surveys. Second, small salmon redds and test digs may have been misidentified. The potential influence of this confounding factor was greatest during the last round of census surveys when salmon spawning increased dramatically (Table 2); however, misidentification may be unlikely because of interspecific size differences in redd dimensions and spawning gravel and the relatively high frequency in which Chinook adults were observed on redds.

PIT-tagged Bull Trout detected in Pinhead Creek in 2018 consisted of 2 fish age-4 fish and 60 age-5 or older (Table 6). Their release locations were mainly in reach 1 of the Clackamas River and Pinhead and Last creeks and included two fish released as far away as Berry Creek (Table 6). At the Pinhead Creek weir trap, 6 adults were tagged in 2017 and 5 in 2018 (Barrows et al. 2018). These adults provide an additional source of PIT tag detections in Pinhead Creek and added 9 to the adult count in 2018 (Table 6).

PIT-tagged adults detected in Pinhead Creek in 2018 were mainly released as age-2 or older translocated fish (Figure 6). The apparent peak in the number of released-at-age-2 adults in Pinhead Creek was in 2016 (Figure 6). Relative to older age-at-release classes, the steep decline in subsequent years was likely influenced by higher tag ejection rates because the small size of age-2 fish necessitated intraperitoneal tag insertion, which has a substantially lower rate of tag retention than insertion in the dorsal musculature (Mamer and Meyer 2016). Among the 13 fish that were PIT-tagged and released at age-5 and older, 9 were tagged at the Pinhead Creek weir trap (Figure 6).

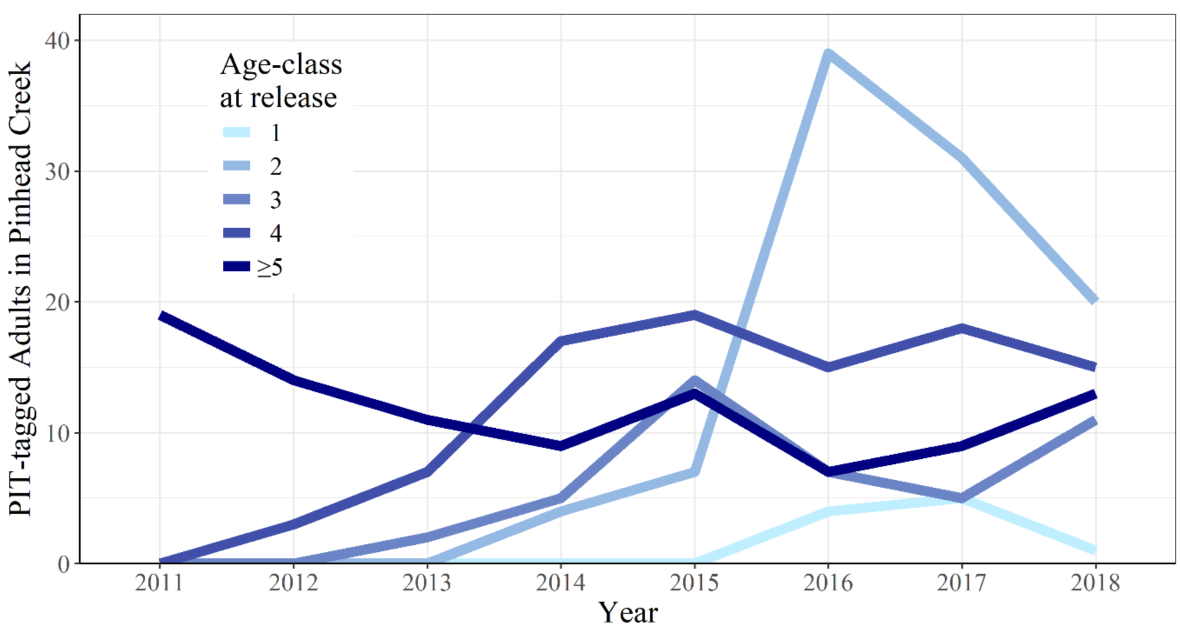


Figure 6. Age class at which PIT-tagged Bull Trout were released into the upper Clackamas River basin and subsequently detected at the Pinhead Creek PIT-array prior to and during the spawning season as adults (i.e., age-5 and older).

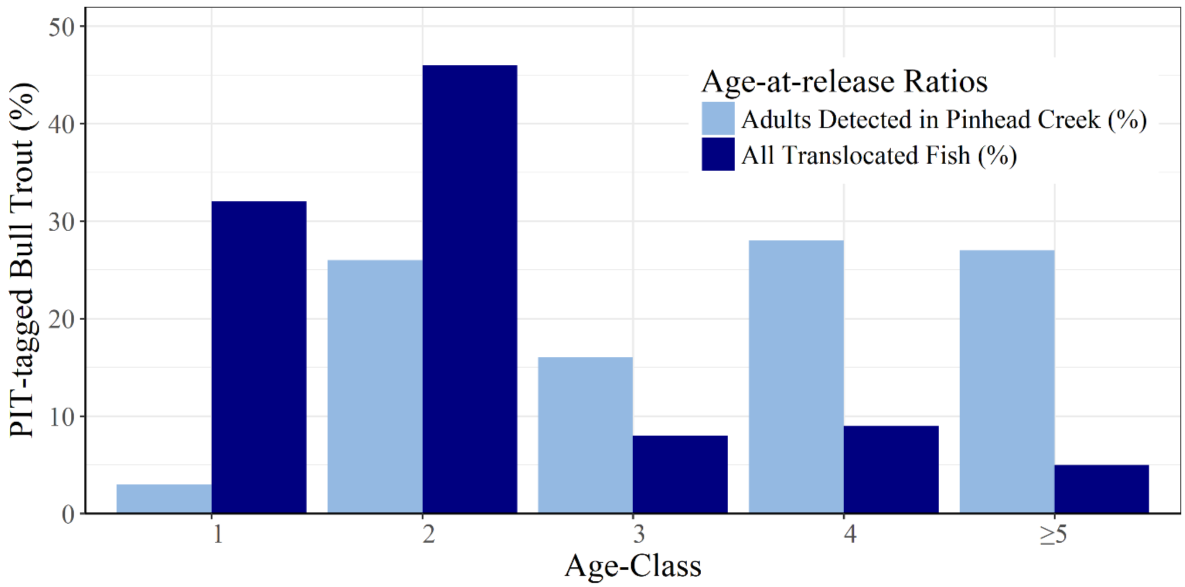


Figure 7. Comparison of the ratio of adult PIT-tagged Bull Trout detected in Pinhead Creek by age-at-release classes to the total number of adults detected in Pinhead Creek (N=215) and the ratio of translocated fish by age-at-release classes to the number of all translocated fish (N=2,336). (Fish translocated to reach 5 of the Clackamas River in 2016 were omitted because none was estimated to be age-5 or older in 2018.)

Pinhead Creek has emerged as the primary spawning area and attracted spawning adults from most of the areas where Bull Trout were translocated (Table 6). This makes the Pinhead Creek weir and PIT-tag detection array a good place to evaluate the relationship between translocation age-at-release and eventual recruitment to adulthood. For all translocations (except for reach 5 of the Clackamas River in 2016), fish released at age-1 contributed only 3% of all PIT-detected adults in Pinhead Creek since translocations and monitoring began in 2011 (Figure 7). The small contribution to adult abundance is surprising given that age-1 fish composed 32% of all translocated fish (Figure 7). In 2018, translocated fish released at age-1 contributed only a single adult to the total count (N=51) of PIT-detected adults in Pinhead Creek. Fish released at age-2, which composed 46% of all translocated fish, contributed 26% of all PIT-tagged adults detected in Pinhead Creek (Figure 7). This suggests that fish translocated at age-2 have had substantially higher survival to adulthood than age-1 fish. (These percentages do not include fish translocated to reach 5 of the Clackamas River in 2016 because none of these fish would have been age-5 or older by 2018.) When only data from Pinhead Creek and Last Creek are considered, the same survival patterns were observed. From 2011 through 2013, 495 age-1 and 656 age-2 fish were released in these creeks (Table 1, Appendix III), all of which would have reached adulthood by 2018. Of these, 7 (1%) released at age-1 and 50 (8%) released at age-2 have been detected returning as adults to Pinhead Creek (Appendix III). Older translocated fish contributed a disproportionate number of adults to the Pinhead Creek spawning population relative to how many were translocated. Age-3 fish composed 8% (N=194) of all translocated fish and 16% (N=34) of all adults detected in Pinhead Creek. Fish age-4 and older composed 14% (N=323) of translocations and 55% (N=118) of all adults.

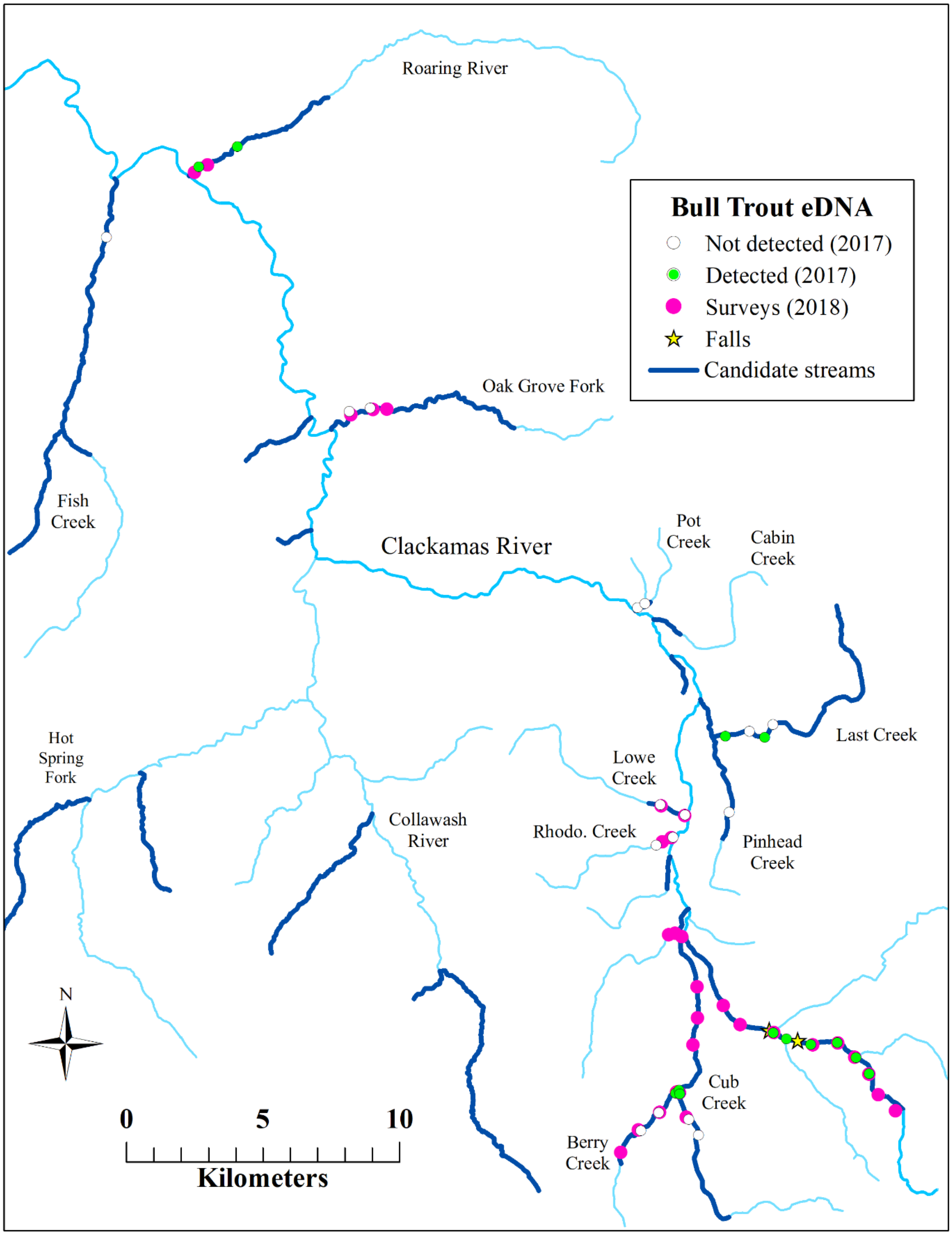


Figure 8. Environmental DNA survey results from 2017 and survey sites in 2018. Candidate streams were identified to be thermally suitable and lacking fish barriers or through historical anecdotes of Bull Trout presence.

Distribution surveys

In a 500 m snorkel survey of reach 1 of the Clackamas River, we observed no juvenile Bull Trout, two adult Bull Trout, and high densities of juvenile Chinook Salmon. To date, no juvenile Bull Trout have been observed during juvenile fish surveys in 2016 (see Barrows et al. 2017), young-of-the-year surveys in the lateral habitat of Pinhead Creek in 2017, and snorkel surveys in Pinhead Creek in 2016 and 2017. This is surprising given that much smaller spawning populations in Oregon produce offspring that are readily detected during night snorkel surveys (e.g., Starcevich et al. 2017). The lack of detection of juvenile Bull Trout in Pinhead Creek is further puzzling because viable alevins and nearly-emergent fry were observed in two redds in Pinhead Creek in 2018 (Barrows et al. 2018) and some translocated fish released at age-1 and age-2 in Pinhead Creek survived to adulthood, both of which suggest there should be at least some survival of locally-born juvenile fish.

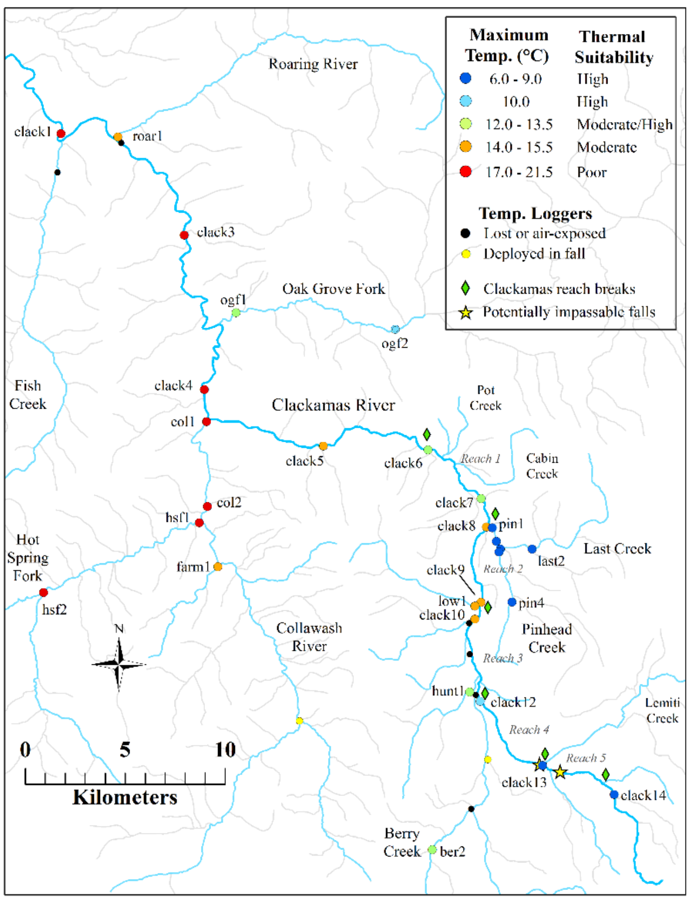
In the analysis of eDNA samples from 2017, Bull Trout eDNA was detected at all six sites sampled in the upper Clackamas River and only at the three sites on Berry Creek and Cub Creek that were closest to the release location in Berry Creek (Figure 8). The translocation releases in Berry Creek occurred in 2014 and 2015 and in the upper Clackamas River in 2016. Most of these fish were age-1 at release and had not yet reached adulthood in 2018. These eDNA detection results suggest that these translocated fish are still rearing near their release points.

Bull Trout eDNA was detected at both sites sampled in Roaring River (Figure 8). There were no translocation releases in or near this river. The timing of these samples (surveyed in late September) was close to the peak of spawning in Pinhead Creek. Bull Trout may be spawning in Roaring River and the eDNA could be from adults or their offspring; it also could be from temporary occupancy by foraging subadults or adults. Bull Trout eDNA was not detected at either site sampled in Oak Grove Fork even though it is situated closer to translocation release points and colder than Roaring River. The results from Rhododendron, Lowe, Pot creeks suggest Bull Trout are not using them. These streams may be too small (1-3 m wide) to support Bull Trout rearing or spawning. Bull Trout eDNA was not detected upstream of the culvert in Pinhead Creek. In regard to these results, it is important to acknowledge that false positives and negatives are possible. The following steps were taken to reduce the chance of false results: 1) the field crew received extensive training in eDNA protocols, which are designed to prevent contamination by the crew, and these protocols were assiduously followed; 2) survey sites were allocated to ensure detection probabilities for individuals streams were over 0.85; 3) eDNA surveys were conducted prior to spawning surveys or temperature logger maintenance in any given location to ensure samples sites were not contaminated by the crew; and 4) high priority streams are sampled annually, which allows us to evaluate the consistency of results.

In 2018, eDNA surveys were conducted to determine the presence of Bull Trout rearing in Roaring River, Oak Grove Fork, Lowe Creek, Rhododendron Creek, Hunter Creek, Cub Creek, Berry Creek, and upper Clackamas River (Figure 8). These samples will be analyzed in 2019.

Stream temperature

Continuous water temperatures were recorded on 30 data loggers distributed throughout the upper Clackamas River and Collawash River basins (Figure 9, left panel). Maximum temperatures in the lower Collawash River, Hot Spring Fork, and in the Clackamas River downstream of the Collawash River confluence were between 17.0-21.5°C, which exceeded the 16°C juvenile rearing criterion for suitable thermal habitat. Upstream of this confluence, maximum temperatures in the Clackamas River and its tributaries were below the 16°C criterion. As maximum temperature increases above this temperature criterion, the occupancy probability of juvenile Bull Trout decreases in these thermal habitat patches (Isaak et al. 2009); as temperatures decrease below this threshold, the probability of occupancy increases (Isaak et al. 2009, Dunham et al. 2003). Using this thermal suitability scale, highly suitable habitat was present in Pinhead Creek, Last Creek, and reaches 4 and 5 of the Clackamas River. Habitat with moderately high suitability for juvenile rearing included Oak Grove Fork, Hunter Creek, Berry Creek and reaches 1 and 3 of the Clackamas River.



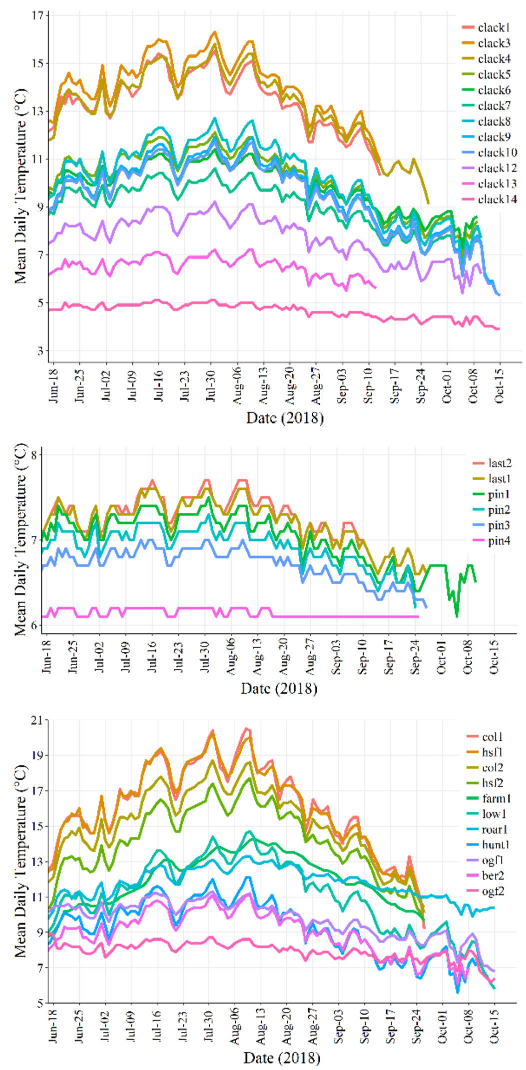


Figure 9. Maximum water temperature at each data logger location (above) and mean daily temperatures at each location in the Clackamas River (top right), Pinhead and Last creeks (middle right), and other tributaries (lower right) in 2018.

Thermal suitability for spawning has not been defined as precisely as it has for rearing habitat (Starcevich et al. 2017). Thermal suitability descriptions in this report were based on criteria derived from two case studies conducted in Oregon (see Chandler et al. 2001, Howell et al. 2010), which are among the few studies that reported the temperature metric used to describe the initiation of spawning. Highly suitable thermal habitat for spawning (i.e., <9°C daily mean in early September) occurred in Pinhead Creek, Last Creek, Oak Grove Fork, Hunter Creek, Berry Creek, and reaches 1, 4, and 5 of the Clackamas River (Figure 7, right panels). Moderately suitable thermal habitat for spawning (i.e., <12°C daily mean in early September) occurred in Lowe Creek and reach 2 of the Clackamas River. Cub Creek and reach 3 of the Clackamas River were likely near the moderate-to-high suitability borderline, but the data loggers at these sites were lost. The Collawash River basin did not contain any suitable thermal habitat for spawning; however, water temperature in the upper section of this river has not been monitored. To correct this monitoring gap, data loggers were placed in 2018 in the upper Collawash River. Low quality spawning habitat occurred in the Collawash River basin, the Clackamas River downstream of the Collawash River, lower Roaring Creek, and Lowe Creek.

Monitoring in 2019

Census spawning surveys will continue in Pinhead Creek, Last Creek, reach 4 of the Clackamas River (Cub Creek to the first falls). Based on eDNA results and an anecdotal observation by ODFW salmon spawning surveyors, exploratory redd surveys will be added to Roaring Creek and the upper section of reach 3 of the Clackamas River (Rhododendron Creek to Cub Creek). Snorkel surveys will occur in May in Pinhead Creek and, depending on discharge and turbidity, reach 3 of the Clackamas. Environmental DNA surveys will continue in suitable streams; a portion of them will be conducted during peak water temperatures in late July to focus on the juvenile rearing distribution. Temperature monitoring will continue in the upper Clackamas River basin. We currently are maintaining 35 temperature loggers.

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Appendix I. Bull Trout and Chinook Salmon redd count data from the upper Clackamas River basin, 2018. First of 3 pages.

Stream	Reach	Date	Species	Redd ID	Easting	Northing	LN (cm)	WD (cm)	Description
Clackamas River	4	9/12/2018	BT	B1JF	588570	4971205	120	55	clear p/m, bright gravel 90% certainty
Clackamas River	4	9/12/2018	BT	B3BP	588567	4971229	70	50	Bt redd, 60%
Clackamas River	4	10/23/2018	BT	E5JF	587801	4972495	220	110	Definite redd, bright, maybe older, some rocks with algae
Last Creek	1	9/25/2018	BT	C8JF	589237	4980427	70	60	50%, def digging, small mound, clear pocket, almost a test dig
Pinhead Creek	1	9/10/2018	BT	B1SS	588193	4981489	140	65	Clear p/m 95% certain
Pinhead Creek	1	9/10/2018	BT	B2SS	588223	4981459	250	120	Clear digging, 75%
Pinhead Creek	1	9/10/2018	BT	B3SS	588417	4981130	170	90	clear p/m, some fines, bright, 80%
Pinhead Creek	1	9/10/2018	BT	B1JW	588422	4980928	150	110	good-great
Pinhead Creek	1	9/24/2018	BT	C3JF	588377	4980664	170	90	100% big mound
Pinhead Creek	1	9/24/2018	BT	C3SS	588415	4980956	130	100	100% nice redd
Pinhead Creek	1	9/24/2018	BT	C7MC	588496	4989327	100	65	50-75%, at first look an old redd, not bright
Pinhead Creek	1	9/24/2018	BT	C1BP	588297	4981389	180	90	bt redd under log
Pinhead Creek	1	9/24/2018	BT	C2BP	588374	4981312	190	110	clear p/m
Pinhead Creek	1	9/24/2018	BT	C3BP	588378	4981089	130	90	Bt, clear p/m
Pinhead Creek	1	9/24/2018	BT	C4BP	588416	4980938	120	70	
Pinhead Creek	1	9/24/2018	BT	C5BP	588416	4980845	170	70	clear p/m
Pinhead Creek	1	9/24/2018	BT	C2JF	588395	4981078	200	90	100%, nice mound, 2 BT!
Pinhead Creek	1	9/24/2018	BT	C2CA	588109	4981654	140	50	100%
Pinhead Creek	1	9/24/2018	BT	C1CN	588169	4981616	150	100	100%
Pinhead Creek	1	9/24/2018	BT	C1JF	588306	4981387	240	120	70% bt gravel, big redd
Pinhead Creek	1	9/24/2018	BT	C4CA	588198	4981497	100	75	100%
Pinhead Creek	1	9/24/2018	BT	C2CN	588099	4981719	100	100	100%
Pinhead Creek	1	9/24/2018	BT	C1SS	588195	4981376	150	120	100% nice redd
Pinhead Creek	1	9/24/2018	BT	C3CA	588194	4981528	100	60	100%
Pinhead Creek	1	9/24/2018	BT	C9CA	588448	4980989	100	100	100%
Pinhead Creek	1	9/24/2018	BT	C5CA	588228	4981442	175	100	50%, digging
Pinhead Creek	1	9/24/2018	BT	C6CA	588267	4981438	180	100	100%
Pinhead Creek	1	9/24/2018	BT	C7CA	588319	4981407	100	80	100%
Pinhead Creek	1	9/24/2018	BT	C8CA	588386	4981342	80	50	50/50 small
Pinhead Creek	1	9/24/2018	BT	C10CA	588420	4980671	200	150	100%
Pinhead Creek	1	9/24/2018	BT	C11CA	588488	4980539	150	50	100%
Pinhead Creek	1	9/24/2018	BT	C1CA	588109	4981663	200	100	100%
Pinhead Creek	1	9/24/2018	BT	C3CN	588100	4981719	150	100	100%
Pinhead Creek	1	10/9/2018	BT	D6BP	588479	4980438	140	70	perfect BT redd
Pinhead Creek	1	10/9/2018	BT	D5SS	588360	4981367	170	130	small redd, test dig?, good mound, >50%
Pinhead Creek	1	10/9/2018	BT	D7SS	588411	4981092	130	90	nice, p/m, clean gravel
Pinhead Creek	1	10/9/2018	BT	D9SS	588487	4980492	120	60	p/m, 75%, flattened
Pinhead Creek	1	10/9/2018	BT	D5BP	588439	4980429	100	60	50%bt
Pinhead Creek	1	10/9/2018	BT	D3BP	588201	4981410	190	130	possible chk redd
Pinhead Creek	1	10/9/2018	BT	D4BP	588370	4981125	110	70	bt redd

Appendix I. Continued, 2 of 3 pages.

Stream	Reach	Date	Species	Redd ID	Easting	Northing	LN (cm)	WD (cm)	Description
Pinhead Creek	1	10/9/2018	BT	D10SS	588483	4980341	160	100	Nice redd
Pinhead Creek	1	10/9/2018	BT	D11SS	588101	4981722	160	100	Nice redd, called on 10/10, ds of bridge
Pinhead Creek	1	10/9/2018	BT	D2MD	588360	4981172	90	60	bt redd
Pinhead Creek	1	10/9/2018	BT	D3MD	588395	4981006			under log, no dimensions
Pinhead Creek	1	10/9/2018	BT	D4MD	588489	4980342	110	65	against log
Pinhead Creek	1	10/9/2018	BT	D2JF	588269	4981247	150	120	80%
Pinhead Creek	1	10/9/2018	BT	D8SS	588430	4980971	120	70	nice redd, underlog, relat. Fine gravel
Pinhead Creek	1	10/23/2018	BT	E4JF	588496	4980334	170	100	80% BT redd
Pinhead Creek	1	10/23/2018	BT	E1JW	588424	4980978	75	35	BT redd
Pinhead Creek	1	10/23/2018	BT	E8SS	588528	4980334	130	80	BT redd
Pinhead Creek	1	10/23/2018	BT	E7SS	588415	4980956	170	55	SW called test, changed to BT redd, big pocket, clear dig, flat mound
Pinhead Creek	1	10/23/2018	BT	E6SS	588310	4981200	105	40	small, P/m present
Pinhead Creek	1	10/23/2018	BT	E3SS	588202	4981403	110	30	clear dig, p/m, BT redd
Pinhead Creek	1	10/23/2018	BT	E3JF	588437	4980955	120	70	70% BT redd
Pinhead Creek	1	10/23/2018	BT	E5SS	588207	4981355	170	80	smaller gravel than nearby CHK redd, small, P/M present
Pinhead Creek	1	11/6/2018	BT	F3SS	588483	4980338	80	45	bt redd, same pt as F4ss
Pinhead Creek	1	11/6/2018	BT	F1SS	588377	4980676	80	35	bt redd
Pinhead Creek	1	11/6/2018	BT	F15BP	588406	4981027	110	80	bt redd
Pinhead Creek	1	11/6/2018	BT	F6JF	588498	4980335	120	50	Bt under debris
Pinhead Creek	1	11/6/2018	BT	F5JF	588413	4980629	100	70	Bt redd
Pinhead Creek	1	11/6/2018	BT	F4SS	588483	4980339	160	60	bt redd, same pt as F3ss
Pinhead Creek	2	9/11/2018	BT	B4SS	588644	4979543	170	75	obvious fish dig, mound with lots of sand, 50-75% certain
Pinhead Creek	2	9/11/2018	BT	B1BP	588915	4978854	150	110	Big redd
Pinhead Creek	2	9/11/2018	BT	B8SS	588915	4978884	160	100	nice redd, 95%
Pinhead Creek	2	9/11/2018	BT	B7SS	588861	4978954	120	50	clear p/m, small, 90% certain
Pinhead Creek	2	9/11/2018	BT	B6SS	588837	4979269	100	40	test dig
Pinhead Creek	2	9/25/2018	BT	C4JF	588582	4980095	160	80	70% p/m
Pinhead Creek	2	9/25/2018	BT	C7BP	588634	4979552	150	100	northing wrong added 9, clear p/m
Pinhead Creek	2	9/25/2018	BT	C7SS	588857	4979057	70	40	small redd, small mound, definite digging, 50-75%
Pinhead Creek	2	9/25/2018	BT	C6SS	588838	4979011	90	60	nice small redd, 80-90%
Pinhead Creek	2	9/25/2018	BT	C5SS	588886	4978950	90	45	small, lots of fines, decent mound, 50-75%
Pinhead Creek	2	9/25/2018	BT	C4SS	588945	4978806	85	55	small, clear digging, 75%
Pinhead Creek	2	9/25/2018	BT	C5JF	588602	4979693	100	60	60%, bt near redd, clear bright mound

Appendix I. Continued, 3 of 3 pages.

Stream	Reach	Date	Species	Redd ID	Easting	Northing	LN (cm)	WD (cm)	Description
Pinhead Creek	2	9/25/2018	BT	C5JF	588602	4979693	100	60	60%, bt near redd, clear bright mound
Pinhead Creek	2	10/8/2018	BT	D1BP	588631	4979663	200	100	Possible chinook redd
Pinhead Creek	2	10/8/2018	BT	D4SS	588908	4978862	130	50	nice redd, no algae on mound gravel, next to B1BP
Pinhead Creek	2	10/8/2018	BT	D3SS	588942	4978802	90	60	nice small redd
Pinhead Creek	2	10/8/2018	BT	D2SS	589235	4977920	100	55	possible test dig, p/m present 50%
Pinhead Creek	2	10/8/2018	BT	D1JF	588738	4979357	150	80	small redd, some larger rocks 60%
Pinhead Creek	2	10/8/2018	BT	D1SS	589230	4977904	100	80	nice redd
Pinhead Creek	2	10/8/2018	BT	D2BP	588631	4979663	110	60	Bull Trout redd, same coords as D1BP
Pinhead Creek	2	10/22/2018	BT	E1SS	588571	4980251	90	50	Clear p/m, 75%
Pinhead Creek	2	10/22/2018	BT	E2CA	588855	4978965	150	50	nice redd
Pinhead Creek	2	10/22/2018	BT	E1CA	588638	4979564	100	90	nice redd
Pinhead Creek	2	11/5/2018	BT	F4JF	588853	4979241	140	80	bt redd, 70%
Clackamas River	4	9/12/2018	CHK	B2BP	588508	4971376	65	50	CHK test dig; small dig, large substrate, <50% certainty of being a redd
Clackamas River	4	9/12/2018	CHK	B9SS	588521	4971321	160	120	CHK test dig
Pinhead Creek	1	10/9/2018	CHK	D1MD	588370	4981395			CHK redd
Pinhead Creek	1	10/9/2018	CHK	D7BP	588195	4981376	220	180	chinook redd on top of C1SS
Pinhead Creek	1	10/23/2018	CHK	E1JF	588395	4981120	240	120	CHK redd
Pinhead Creek	1	10/23/2018	CHK	E2JF	588407	4981038	150	60	50% CHK, small mound, definite digging line
Pinhead Creek	1	10/23/2018	CHK	E2SS	588168	4981576	150	30	CHK test dig
Pinhead Creek	1	10/23/2018	CHK	E4SS	588207	4981355	300	100	CHK redd
Pinhead Creek	1	10/23/2018	CHK	E2JW	588086	4981677	340	140	CHK test dig?
Pinhead Creek	1	11/6/2018	CHK	F7JF	588091	4981677	170	130	chk redd
Pinhead Creek	1	11/6/2018	CHK	F8JF	588088	4981677	300	240	chk redd, 1 adult on
Pinhead Creek	1	11/6/2018	CHK	F9JF	588200	4981364	300	150	chk redd
Pinhead Creek	1	11/6/2018	CHK	F9aJF	588207	4981355	350	200	Superimposed on Bt redd E5SS
Pinhead Creek	1	11/6/2018	CHK	F10JF	588243	4981303	150	150	chk redd
Pinhead Creek	1	11/6/2018	CHK	F11JF	588266	4981262	150	190	chk redd
Pinhead Creek	1	11/6/2018	CHK	F12JF	588367	4981113	200	140	chk redd
Pinhead Creek	1	11/6/2018	CHK	F13JF	588407	4981005	300	220	chk redd, 1 adult on
Pinhead Creek	1	11/6/2018	CHK	F14JF	588438	4980893	270	130	chk redd
Pinhead Creek	1	11/6/2018	CHK	F2BP	588505	4980334	550	140	chk on redd, actively spawning
Pinhead Creek	1	11/6/2018	CHK	F3BP	588523	4980328	400	80	chk redd
Pinhead Creek	1	11/6/2018	CHK	F4BP	588066	4981664	400	180	2 chk on redd
Pinhead Creek	1	11/6/2018	CHK	F5BP	588199	4981500	180	90	chk redd
Pinhead Creek	1	11/6/2018	CHK	F6BP	588199	4981479	110	80	chk redd, big cobble

Appendix II. Annual detection duration of adult PIT-tagged Bull Trout (i.e., age-5 and older) in Pinhead Creek, during or near the spawning period, from 2011 through 2018. Duration was calculated as the difference in days (d) between the last and first dates of detection; the value "0" means the adult was detected on a single day. Sex was determined in 2017 and 2018 either in the weir trap or video chute. This is the first of 5 table pages.

Translocation				Detection Duration in Pinhead Creek (d)							
Location	Year	TL (mm)	Sex	2011	2012	2013	2014	2015	2016	2017	2018
Clackamas 2	2011	450	NA	0	--	33	--	--	--	--	--
Clackamas 2	2011	540	NA	0	--	--	--	--	--	--	--
Clackamas 2	2011	580	NA	0	--	--	--	--	--	--	--
Clackamas 2	2011	510	NA	1	--	--	--	--	--	--	--
Clackamas 2	2011	470	NA	3	--	0	--	--	--	--	--
Clackamas 1	2011	450	NA	6	--	--	--	--	--	--	--
Clackamas 2	2011	470	NA	17	55	3	--	--	--	--	--
Clackamas 2	2011	510	NA	21	--	--	--	--	--	--	--
L. Clackamas	2011	470	NA	22	24	--	--	--	--	--	--
L. Clackamas	2011	640	NA	25	--	--	--	--	--	--	--
Clackamas 1	2011	650	NA	25	--	--	--	--	--	--	--
Clackamas 2	2011	550	NA	26	21	36	--	--	--	--	--
L. Clackamas	2011	601	NA	27	--	--	--	--	--	--	--
L. Clackamas	2011	590	NA	31	--	--	--	--	--	--	--
Clackamas 2	2011	460	NA	39	--	23	--	--	--	--	--
L. Clackamas	2011	535	NA	48	--	--	--	--	--	--	--
L. Clackamas	2011	575	NA	59	--	--	--	--	--	--	--
Clackamas 2	2011	420	NA	70	--	--	--	--	--	--	--
Clackamas 2	2011	470	NA	78	--	--	--	--	--	--	--
Clackamas 2	2011	400	NA	--	20	--	--	--	--	--	--
Clackamas 1	2011	360	NA	--	34	--	--	--	--	--	--
Clackamas 1	2011	340	NA	--	35	--	--	--	--	--	--
Clackamas 2	2011	540	NA	--	35	--	--	--	--	--	--
Clackamas 1	2011	370	NA	--	--	0	--	--	--	--	--
Last Creek	2011	212	NA	--	--	64	0	5	--	--	--
Last Creek	2011	305	NA	--	--	68	93	17	28	--	--
Last Creek	2011	195	NA	--	--	--	0	73	--	--	--
Last Creek	2011	270	NA	--	--	--	0	--	--	--	--
Last Creek	2011	246	NA	--	--	--	4	--	--	--	--
Last Creek	2011	170	NA	--	--	--	35	--	--	--	--
Last Creek	2011	170	NA	--	--	--	48	--	--	--	--
Last Creek	2011	175	NA	--	--	--	84	--	--	--	--
Pinhead Creek	2011	118	NA	--	--	--	--	17	28	--	--
Clackamas 2	2012	520	NA	*NA*	0	--	--	0	--	--	--
Clackamas 2	2012	536	NA	*NA*	12	--	--	--	--	--	--
Clackamas 2	2012	555	NA	*NA*	28	45	0	--	--	--	--
Clackamas 2	2012	611	NA	*NA*	31	23	--	--	--	--	--
Clackamas 2	2012	620	NA	*NA*	37	--	--	--	--	--	--
Clackamas 2	2012	615	NA	*NA*	40	--	--	--	--	--	--
Clackamas 2	2012	586	NA	*NA*	47	--	9	--	--	--	--
Clackamas 2	2012	633	NA	*NA*	47	--	--	--	--	--	--
Clackamas 2	2012	628	NA	*NA*	49	--	--	--	--	--	--
Clackamas 2	2012	614	NA	*NA*	51	--	--	--	--	--	--

Appendix II. Continued, 2 of 5 pages.

Translocation				Detection Duration in Pinhead Creek (d)							
Location	Year	TL (mm)	Sex	2011	2012	2013	2014	2015	2016	2017	2018
Clackamas 2	2012	376	NA	*NA*	--	0	39	--	--	--	--
Clackamas 2	2012	645	NA	*NA*	--	0	--	--	--	--	--
Clackamas 2	2012	350	NA	*NA*	--	7	--	--	--	--	--
Clackamas 2	2012	335	NA	*NA*	--	11	0	19	--	--	--
Clackamas 2	2012	381	NA	*NA*	--	11	--	1	--	--	--
Clackamas 2	2012	345	NA	*NA*	--	34	--	--	--	--	--
Clackamas 2	2012	350	NA	*NA*	--	45	--	--	--	--	--
Clackamas 2	2012	325	F	*NA*	--	--	0	--	4	--	3
Clackamas 2	2012	537	NA	*NA*	--	--	0	--	--	--	--
Clackamas 1	2012	376	NA	*NA*	--	--	2	--	--	--	--
Clackamas 2	2012	354	NA	*NA*	--	--	5	5	--	--	--
Clackamas 2	2012	317	NA	*NA*	--	--	35	--	--	--	--
Clackamas 2	2012	325	NA	*NA*	--	--	60	11	--	--	--
Last Creek	2012	184	NA	*NA*	--	--	--	8	--	--	--
Pinhead Creek	2012	143	M	*NA*	--	--	--	10	30	26	--
Clackamas 1	2012	290	NA	*NA*	--	--	--	11	--	--	--
Pinhead Creek	2012	144	NA	*NA*	--	--	--	25	12	--	--
Last Creek	2012	174	NA	*NA*	--	--	--	31	24	44	4
Pinhead Creek	2012	158	NA	*NA*	--	--	--	39	14	--	--
Pinhead Creek	2012	130	M	*NA*	--	--	--	--	0	0	30
Pinhead Creek	2012	150	NA	*NA*	--	--	--	--	0	--	--
Clackamas 2	2012	368	NA	*NA*	--	--	--	--	0	--	--
Pinhead Creek	2012	145	M	*NA*	--	--	--	--	21	5	--
Pinhead Creek	2012	99	NA	*NA*	--	--	--	--	32	--	--
Pinhead Creek	2012	92	M	*NA*	--	--	--	--	39	7	--
Pinhead Creek	2012	89	M	*NA*	--	--	--	--	47	5	--
Pinhead Creek	2012	133	NA	*NA*	--	--	--	--	55	--	--
Pinhead Creek	2012	129	NA	*NA*	--	--	--	--	71	--	--
Pinhead Creek	2012	109	NA	*NA*	--	--	--	--	88	--	--
Pinhead Creek	2012	111	F	*NA*	--	--	--	--	--	9	0
Clackamas 1	2013	530	NA	*NA*	*NA*	0	--	--	--	--	--
Clackamas 1	2013	600	NA	*NA*	*NA*	19	--	--	--	--	--
Clackamas 1	2013	610	NA	*NA*	*NA*	26	3	--	--	--	--
Clackamas 1	2013	357	NA	*NA*	*NA*	--	0	--	--	--	--
L. Clackamas	2013	358	NA	*NA*	*NA*	--	0	--	--	--	--
L. Clackamas	2013	325	NA	*NA*	*NA*	--	5	--	--	--	--
Clackamas 1	2013	340	NA	*NA*	*NA*	--	7	--	--	--	--
Clackamas 1	2013	330	NA	*NA*	*NA*	--	8	--	--	--	--
Clackamas 1	2013	367	NA	*NA*	*NA*	--	9	1	0	--	--
L. Clackamas	2013	376	NA	*NA*	*NA*	--	10	--	--	--	--
Clackamas 1	2013	396	NA	*NA*	*NA*	--	13	--	--	--	--
Clackamas 1	2013	342	NA	*NA*	*NA*	--	21	18	26	--	--
L. Clackamas	2013	332	NA	*NA*	*NA*	--	23	--	--	--	--
Clackamas 1	2013	390	NA	*NA*	*NA*	--	25	28	--	--	--
Clackamas 1	2013	419	NA	*NA*	*NA*	--	41	--	--	--	--

Appendix II. Continued, 3 of 5 pages.

Translocation				Detection Duration in Pinhead Creek (d)							
Location	Year	TL (mm)	Sex	2011	2012	2013	2014	2015	2016	2017	2018
L. Clackamas	2013	321	F	*NA*	*NA*	--	--	0	--	9	--
L. Clackamas	2013	249	NA	*NA*	*NA*	--	--	0	--	--	--
L. Clackamas	2013	285	NA	*NA*	*NA*	--	--	0	--	--	--
Clackamas 1	2013	310	NA	*NA*	*NA*	--	--	0	--	--	--
Clackamas 1	2013	405	NA	*NA*	*NA*	--	--	0	--	--	--
Clackamas 1	2013	405	NA	*NA*	*NA*	--	--	0	--	--	--
Clackamas 1	2013	285	NA	*NA*	*NA*	--	--	2	--	--	--
Clackamas 1	2013	320	NA	*NA*	*NA*	--	--	2	--	--	--
Clackamas 1	2013	325	F	*NA*	*NA*	--	--	4	10	9	0
Clackamas 1	2013	363	NA	*NA*	*NA*	--	--	5	--	--	--
Clackamas 1	2013	261	NA	*NA*	*NA*	--	--	8	--	--	--
Clackamas 1	2013	407	NA	*NA*	*NA*	--	--	9	--	--	--
L. Clackamas	2013	258	NA	*NA*	*NA*	--	--	10	--	--	--
L. Clackamas	2013	271	NA	*NA*	*NA*	--	--	10	--	--	--
L. Clackamas	2013	354	NA	*NA*	*NA*	--	--	18	--	--	--
Clackamas 1	2013	410	NA	*NA*	*NA*	--	--	23	--	--	--
L. Clackamas	2013	389	NA	*NA*	*NA*	--	--	26	--	--	--
Clackamas 1	2013	362	NA	*NA*	*NA*	--	--	29	--	--	--
Last Creek	2013	240	NA	*NA*	*NA*	--	--	30	--	--	--
L. Clackamas	2013	277	NA	*NA*	*NA*	--	--	31	--	--	--
Clackamas 1	2013	384	NA	*NA*	*NA*	--	--	41	--	--	--
Clackamas 1	2013	381	F	*NA*	*NA*	--	--	55	49	25	--
L. Clackamas	2013	364	NA	*NA*	*NA*	--	--	65	--	--	--
Clackamas 1	2013	306	NA	*NA*	*NA*	--	--	87	1	--	--
Last Creek	2013	156	F	*NA*	*NA*	--	--	--	0	71	--
Last Creek	2013	145	NA	*NA*	*NA*	--	--	--	0	--	--
Pinhead Creek	2013	165	NA	*NA*	*NA*	--	--	--	0	--	--
Pinhead Creek	2013	130	NA	*NA*	*NA*	--	--	--	3	--	--
Last Creek	2013	188	NA	*NA*	*NA*	--	--	--	9	--	--
Pinhead Creek	2013	158	F	*NA*	*NA*	--	--	--	11	6	3
Pinhead Creek	2013	134	NA	*NA*	*NA*	--	--	--	15	--	--
Last Creek	2013	170	F	*NA*	*NA*	--	--	--	17	8	4
Last Creek	2013	170	M	*NA*	*NA*	--	--	--	17	32	18
Pinhead Creek	2013	168	NA	*NA*	*NA*	--	--	--	20	27	--
Last Creek	2013	208	F	*NA*	*NA*	--	--	--	22	22	1
Pinhead Creek	2013	161	F	*NA*	*NA*	--	--	--	24	8	4
Last Creek	2013	173	M	*NA*	*NA*	--	--	--	26	28	--
Last Creek	2013	139	M	*NA*	*NA*	--	--	--	27	17	--
Pinhead Creek	2013	187	NA	*NA*	*NA*	--	--	--	27	35	43
Pinhead Creek	2013	160	NA	*NA*	*NA*	--	--	--	28	--	--
Last Creek	2013	200	M	*NA*	*NA*	--	--	--	30	--	6
Pinhead Creek	2013	152	M	*NA*	*NA*	--	--	--	31	30	21
Last Creek	2013	136	M	*NA*	*NA*	--	--	--	32	28	37
Last Creek	2013	149	M	*NA*	*NA*	--	--	--	33	11	--
Last Creek	2013	145	M	*NA*	*NA*	--	--	--	34	1	14

Appendix II. Continued, 4 of 5 pages.

Translocation				Detection Duration in Pinhead Creek (d)							
Location	Year	TL (mm)	Sex	2011	2012	2013	2014	2015	2016	2017	2018
Last Creek	2013	120	NA	*NA*	*NA*	--	--	--	35	--	--
Pinhead Creek	2013	187	NA	*NA*	*NA*	--	--	--	36	--	--
Last Creek	2013	130	NA	*NA*	*NA*	--	--	--	39	--	--
Clackamas 1	2013	315	NA	*NA*	*NA*	--	--	--	39	--	--
Last Creek	2013	200	NA	*NA*	*NA*	--	--	--	42	--	--
Last Creek	2013	176	M	*NA*	*NA*	--	--	--	43	51	25
Last Creek	2013	136	M	*NA*	*NA*	--	--	--	45	33	--
Last Creek	2013	184	M	*NA*	*NA*	--	--	--	47	1	--
Last Creek	2013	140	NA	*NA*	*NA*	--	--	--	47	--	--
Last Creek	2013	153	NA	*NA*	*NA*	--	--	--	--	0	--
Last Creek	2013	136	M	*NA*	*NA*	--	--	--	--	4	--
Pinhead Creek	2013	106	F	*NA*	*NA*	--	--	--	--	6	--
Last Creek	2013	150	F	*NA*	*NA*	--	--	--	--	22	--
Last Creek	2013	162	M	*NA*	*NA*	--	--	--	--	28	--
Pinhead Creek	2013	102	M	*NA*	*NA*	--	--	--	--	29	--
Pinhead Creek	2013	138	F	*NA*	*NA*	--	--	--	--	48	8
Last Creek	2013	202	F	*NA*	*NA*	--	--	--	--	91	46
Clackamas 1	2014	510	NA	*NA*	*NA*	*NA*	0	2	3	--	--
Clackamas 1	2014	425	NA	*NA*	*NA*	*NA*	8	--	--	--	--
Clackamas 1	2014	490	NA	*NA*	*NA*	*NA*	10	38	--	--	--
Clackamas 1	2014	483	NA	*NA*	*NA*	*NA*	24	--	--	--	--
Clackamas 1	2014	445	NA	*NA*	*NA*	*NA*	--	0	4	--	--
Clackamas 1	2014	394	F	*NA*	*NA*	*NA*	--	2	7	5	--
Clackamas 1	2014	432	NA	*NA*	*NA*	*NA*	--	12	--	--	--
Clackamas 1	2014	360	NA	*NA*	*NA*	*NA*	--	15	--	--	--
Clackamas 1	2014	366	NA	*NA*	*NA*	*NA*	--	45	0	--	--
Clackamas 1	2014	380	NA	*NA*	*NA*	*NA*	--	--	5	--	--
Clackamas 1	2014	372	NA	*NA*	*NA*	*NA*	--	--	6	--	--
Clackamas 1	2014	238	NA	*NA*	*NA*	*NA*	--	--	8	--	--
Clackamas 1	2014	270	NA	*NA*	*NA*	*NA*	--	--	10	--	--
Clackamas 1	2014	298	M	*NA*	*NA*	*NA*	--	--	18	22	4
Clackamas 1	2014	315	NA	*NA*	*NA*	*NA*	--	--	20	0	--
Clackamas 1	2014	372	M	*NA*	*NA*	*NA*	--	--	48	41	30
Berry Creek	2014	147	NA	*NA*	*NA*	*NA*	--	--	--	0	--
Berry Creek	2014	151	M	*NA*	*NA*	*NA*	--	--	--	1	30
Clackamas 1	2014	287	F	*NA*	*NA*	*NA*	--	--	--	2	--
Clackamas 1	2014	195	M	*NA*	*NA*	*NA*	--	--	--	3	34
Clackamas 1	2014	328	NA	*NA*	*NA*	*NA*	--	--	--	9	--
Clackamas 1	2014	134	M	*NA*	*NA*	*NA*	--	--	--	30	17
Clackamas 1	2014	358	F	*NA*	*NA*	*NA*	--	--	--	--	12
Clackamas 1	2015	561	NA	*NA*	*NA*	*NA*	*NA*	0	--	--	--
Clackamas 1	2015	510	F	*NA*	*NA*	*NA*	*NA*	24	--	10	6
Clackamas 1	2015	600	NA	*NA*	*NA*	*NA*	*NA*	46	--	--	--
Clackamas 1	2015	568	NA	*NA*	*NA*	*NA*	*NA*	58	24	--	--
Clackamas 1	2015	379	M	*NA*	*NA*	*NA*	*NA*	--	5	24	17
Clackamas 1	2015	358	M	*NA*	*NA*	*NA*	*NA*	--	12	20	--
Clackamas 1	2015	342	M	*NA*	*NA*	*NA*	*NA*	--	15	25	7

Appendix II. Continued, 5 of 5 pages.

Translocation				Detection Duration in Pinhead Creek (d)							
Location	Year	TL (mm)	Sex	2011	2012	2013	2014	2015	2016	2017	2018
Clackamas 1	2015	411	NA	*NA*	*NA*	*NA*	*NA*	--	20	--	--
Clackamas 1	2015	345	NA	*NA*	*NA*	*NA*	*NA*	--	21	--	--
Clackamas 1	2015	353	F	*NA*	*NA*	*NA*	*NA*	--	--	0	0
Clackamas 1	2015	242	F	*NA*	*NA*	*NA*	*NA*	--	--	3	--
Clackamas 1	2015	409	NA	*NA*	*NA*	*NA*	*NA*	--	--	4	1
Clackamas 1	2015	396	NA	*NA*	*NA*	*NA*	*NA*	--	--	4	--
Clackamas 1	2015	341	F	*NA*	*NA*	*NA*	*NA*	--	--	10	--
Clackamas 1	2015	414	M	*NA*	*NA*	*NA*	*NA*	--	--	10	--
Clackamas 1	2015	301	NA	*NA*	*NA*	*NA*	*NA*	--	--	13	9
Clackamas 1	2015	393	M	*NA*	*NA*	*NA*	*NA*	--	--	16	--
Clackamas 1	2015	333	M	*NA*	*NA*	*NA*	*NA*	--	--	17	2
Clackamas 1	2015	331	F	*NA*	*NA*	*NA*	*NA*	--	--	44	1
Berry Creek	2015	194	F	*NA*	*NA*	*NA*	*NA*	--	--	--	0
Clackamas 1	2015	209	M	*NA*	*NA*	*NA*	*NA*	--	--	--	0
Clackamas 1	2015	241	F	*NA*	*NA*	*NA*	*NA*	--	--	--	0
Clackamas 1	2015	267	NA	*NA*	*NA*	*NA*	*NA*	--	--	--	0
Clackamas 1	2015	308	M	*NA*	*NA*	*NA*	*NA*	--	--	--	0
Clackamas 1	2015	352	M	*NA*	*NA*	*NA*	*NA*	--	--	--	0
Clackamas 1	2016	575	M	*NA*	*NA*	*NA*	*NA*	*NA*	25	--	40
Clackamas 1	2016	535	NA	*NA*	*NA*	*NA*	*NA*	*NA*	26	--	--
Clackamas 1	2016	560	NA	*NA*	*NA*	*NA*	*NA*	*NA*	26	--	--
Clackamas 1	2016	372	NA	*NA*	*NA*	*NA*	*NA*	*NA*	--	0	--
Clackamas 1	2016	386	M	*NA*	*NA*	*NA*	*NA*	*NA*	--	2	--
Clackamas 1	2016	322	F	*NA*	*NA*	*NA*	*NA*	*NA*	--	5	5
Clackamas 1	2016	256	M	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	0
Clackamas 1	2016	346	M	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	0
Clackamas 1	2016	443	F	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	1
Clackamas 1	2016	229	F	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	4
Clackamas 1	2016	350	F	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	4
Clackamas 1	2016	357	F	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	4
Clackamas 1	2016	304	M	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	6
Clackamas 1	2016	230	M	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	16
Clackamas 1	2016	314	M	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	16
Clackamas 1	2016	340	M	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	16
Clackamas 1	2016	267	M	*NA*	*NA*	*NA*	*NA*	*NA*	--	--	47
Pinhead Creek	2017	536	F	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	0	--
Pinhead Creek	2017	568	F	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	0	--
Pinhead Creek	2017	575	F	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	7	5
Pinhead Creek	2017	605	F	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	9	4
Pinhead Creek	2017	459	F	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	14	28
Pinhead Creek	2017	493	M	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	22	23
Pinhead Creek	2018	700	F	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	0
Pinhead Creek	2018	494	M	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	5
Pinhead Creek	2018	575	F	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	5
Pinhead Creek	2018	600	F	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	10
Pinhead Creek	2018	585	M	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	18

Appendix III. A comparison of translocated Bull Trout detected as adults (age-5 and older) in Pinhead Creek and all fish translocated from the Metolius River basin to the Clackamas River basin by release location and age-at-release. Three ratios were calculated: 1) the number adults detected in Pinhead Creek for each combination of location and age-class to the number of translocated fish for each combination of location and age-class (Ad:Trans); 2) the number adults detected in Pinhead Creek for each age-class and location combination to the total number (N=215) of detected adults (Ad:Total Ad); and 3) the number translocated fish for each age-class and location combination to the total number (N=2,836) of translocated fish (Trans:Total Trans). Age-class-at-release was defined by size-at-age studies and were 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.

Release Location	Age-Class	Adults in Pinhead Creek				Translocated				Ratios		
		N	Mean	Min	Max	N	Mean	Min	Max	Ad:Trans	Ad:Total Ad	Trans:Total Trans
Pinhead Creek	1	7	101	89	111	333	94	74	115	0.02	0.03	0.12
	2	20	150	118	187	320	146	116	205	0.06	0.09	0.11
	3	0	NA	NA	NA	1	215	215	215	0.00	0.00	0.00
Last Creek	1	0	NA	NA	NA	162	98	70	115	0.00	0.00	0.06
	2	30	165	120	208	336	155	116	208	0.09	0.14	0.12
	3	5	255	212	305	24	247	212	305	0.21	0.02	0.01
L. Clackamas River	3	5	268	249	285	10	270	225	310	0.50	0.02	0.00
	4	8	352	321	389	23	357	321	400	0.35	0.04	0.01
	≥5	6	568	470	640	16	572	410	642	0.38	0.03	0.01
Clackamas River 1	2	3	179	134	209	103	162	118	210	0.03	0.01	0.04
	3	23	281	229	320	152	279	214	320	0.15	0.11	0.05
	4	42	360	322	396	146	357	321	400	0.29	0.20	0.05
	≥5	27	491	405	650	58	479	404	650	0.47	0.13	0.02
Clackamas River 2	3	1	317	317	317	4	276	250	317	0.25	0.00	0.00
	4	11	355	325	400	37	362	324	400	0.30	0.05	0.01
	≥5	24	545	420	645	43	540	420	650	0.56	0.11	0.02
Berry Creek	1	0	NA	NA	NA	249	93	74	115	0.00	0.00	0.09
	2	3	164	147	194	316	148	116	206	0.01	0.01	0.11
	3	0	NA	NA	NA	3	247	216	291	0.00	0.00	0.00
Clackamas River 5	1	0	NA	NA	NA	429	88	70	115	0.00	0.00	0.15
	2	0	NA	NA	NA	70	135	116	182	0.00	0.00	0.02
	3	0	NA	NA	NA	1	218	218	218	0.00	0.00	0.00

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