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Oregon Department of Fish and Wildlife

Clackamas River Bull Trout Reintroduction Project

2016 Annual Report

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

Oregon Department of Fish and Wildlife
Native Fish Investigations Program

On the cover: *Pinhead Creek, tributary to the Clackamas River (Photo by M. Barrows, FWS)*

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CLACKAMAS BULL TROUT REINTRODUCTION PROJECT
2016 ANNUAL REPORT

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The last bull trout *Salvelinus confluentus* documented in the Clackamas River was in 1963. Over 40 years later, a 2007 feasibility study suggested the Clackamas River Subbasin could support bull trout and would be a good reintroduction candidate. A reintroduction effort was first implemented in 2011, with the goal of establishing a naturally reproducing population of spawning adults (between 300 and 500) by the year 2030. In 2016, we continued bull trout reintroduction efforts by collecting and transferring 595 juveniles, 94 subadults, and 6 adults from the Metolius River Subbasin to designated locations in the upper Clackamas River. Monitoring and evaluation efforts were conducted to assess the effectiveness of the reintroduction strategy 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. The sixth year of the project marks the end of the first phase of the reintroduction effort. Progress has continued to be made toward reaching the project's goal. Individuals from each translocated life stage have survived, appear to be thriving, and are recruiting into the adult population. The number of adult translocated bull trout using Pinhead Creek during the spawning season has noticeably increased from 15 adults in 2013 to 72 in 2016, and redd counts throughout the study area are at their highest (N = 68) since the initiation of the reintroduction effort. However, there continue to be notable data gaps. Despite multiple years of documented spawning behavior, monitoring efforts have not produced evidence of successful natural reproduction and more robust evaluations of the impacts to listed salmon and steelhead both inside and outside the High Vulnerability Zones are lacking. 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. Bull trout have very specific habitat requirements including clean and cold water with complex and connected habitats (Rieman and McIntyre 1995; FWS 2015). Barriers to migration, habitat degradation, the introduction of non-native species, and other anthropogenic actions have negatively affected bull trout populations (Fraley and Shepard 1989; Leary et al. 1993). In response to a general decline in abundance across their native range, the U.S. Fish and Wildlife Service (FWS) listed them as threatened under the Endangered Species Act (ESA) in 1999 (64FR 58910). At the time of listing in 1999, bull trout were estimated to occupy only 40 percent of their historical range within portions of Oregon, Washington, Montana, Idaho and Nevada (FWS 2002a).

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

This report details the progress in the sixth year (2016) of a joint effort between the Oregon Department of Fish and Wildlife (ODFW), FWS, U.S. Forest Service (USFS), and other collaborators (i.e., the Confederated Tribes of Warm Springs Reservation (CTWSR), National Marine Fisheries Service (NMFS), Portland General Electric (PGE), and the U.S. Geological Survey (USGS)) to reintroduce bull trout into the Clackamas River. Implementation of this project began following publication of a final rule establishing a nonessential experimental population of bull trout in the Clackamas River under section 10(j) of the ESA (76 FR 35979 on June 21, 2011). The first transfers of bull trout to the Clackamas River Subbasin from robust populations in the Metolius River Subbasin occurred during the spring and summer of 2011 (ODFW 2012). This report format is structured, where appropriate, to address the questions listed in sections 3.2, 3.3, and 3.4 of the Implementation, Monitoring, and Evaluation Plan developed by the FWS Oregon Fish and Wildlife Office and Columbia River Fish and Wildlife Conservation Office (FWS 2011). 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).

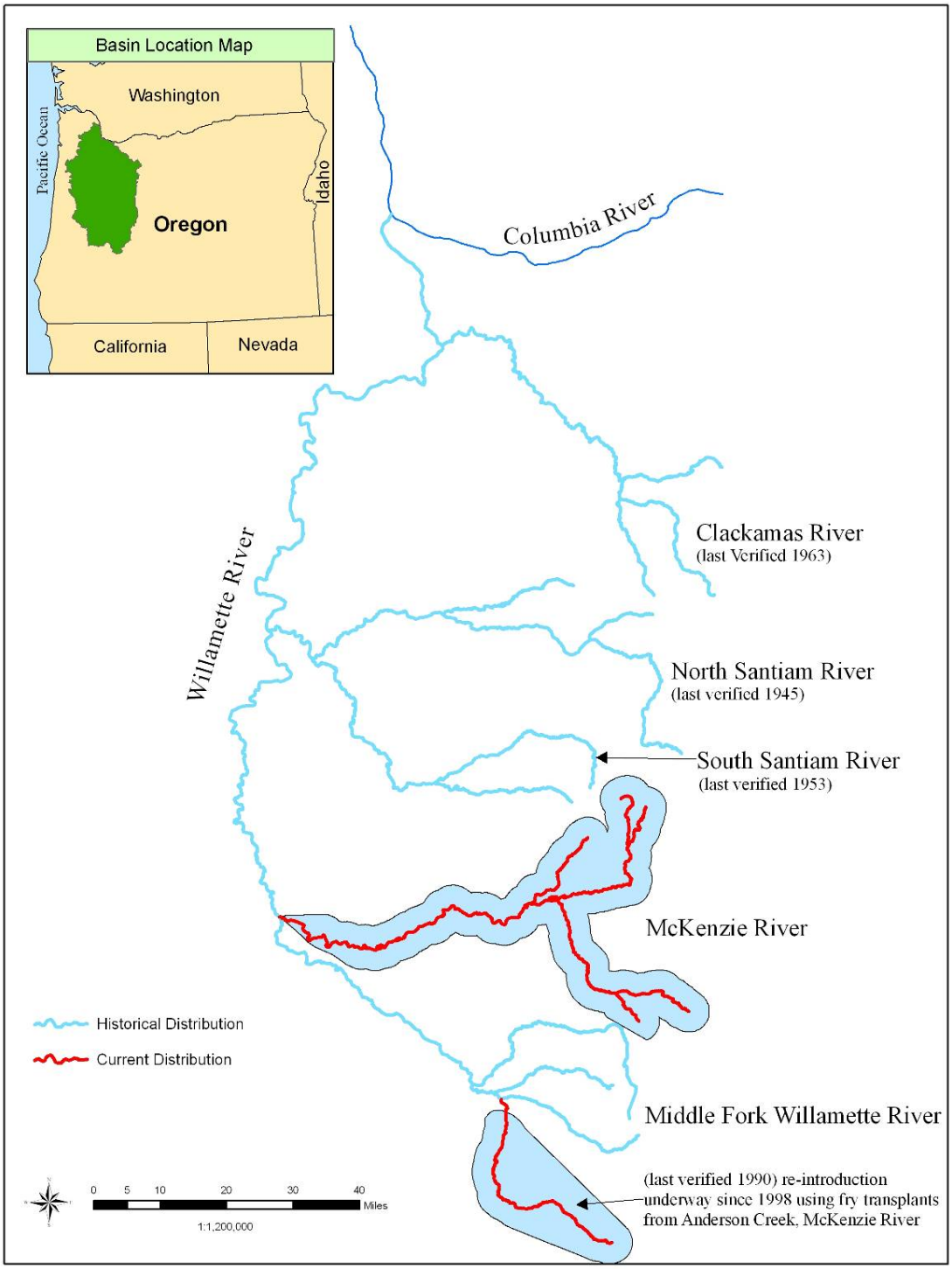

Figure 1. Historical and current bull trout distribution in the Willamette River Basin.

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. Accomplishing this goal will help achieve conservation and recovery goals within the Coastal Recovery Unit (FWS 2015). We define a self-sustaining population as one that maintains a minimum adult annual spawning abundance of 100 individuals, contains a level of genetic diversity representative of the donor stock, and requires few or no additional transfers. The numerical goal of 300-500 spawning adults was established to be consistent with recovery planning targets set in the Bull Trout Draft Recovery Plan (FWS 2002b) for the abundance necessary to achieve these characteristics. While the amount of suitable habitat in the Clackamas River Subbasin suggests it could support a population of 300-500 spawning adults, 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 actions described in this report are intended to address the following three main objectives:

1) Ensure that actions associated with the reintroduction project in the Clackamas River Subbasin do not threaten donor stock populations in the Metolius River Subbasin.

2) 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.

3) 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).

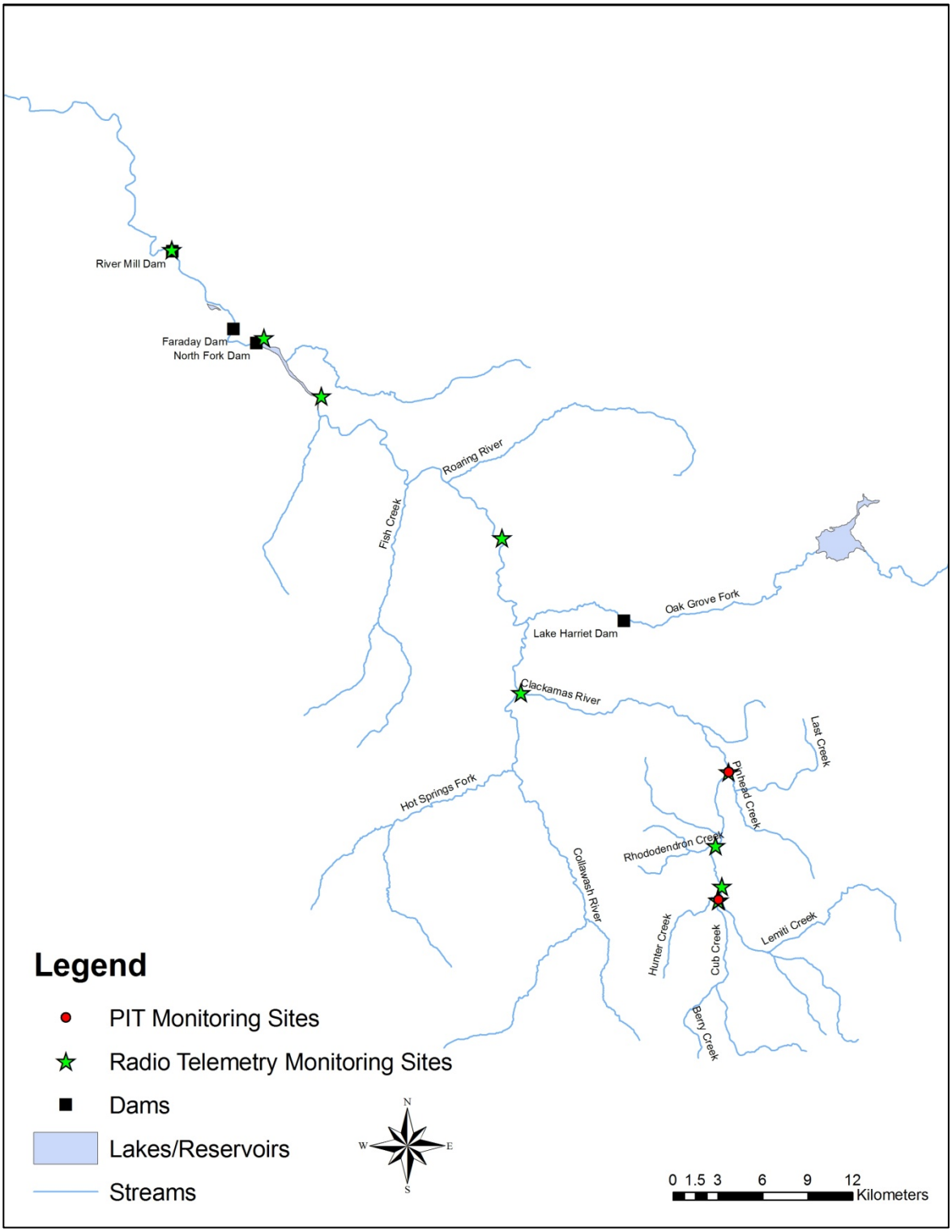

Figure 2. Locations of current and past fixed monitoring sites in the study area. Radio telemetry monitoring sites and the PIT tag monitoring site at the confluence of Cub Creek have been decommissioned.

Methods

Implementation

Donor Stock Availability

The donor stock was determined to be sufficiently healthy for bull trout to be transferred to the Clackamas River Subbasin during 2016 (Barrows et al. 2016). There are currently no plans for continuing translocations in 2017, but the health of the donor population was assessed in the event that future transfers are deemed necessary. ODFW conducted annual spawning ground surveys in fall 2016 on the Metolius River and its tributaries (Jack Creek, Heising Springs, Canyon Creek/Roaring Creek, Candle Creek, Jefferson Creek; see Harrington and Wise 2012). The threshold for determining whether the donor population is sufficiently healthy (as determined through redd counts) is currently 800 spawning individuals (FWS 2011).

Pathogen Screening

In accord with the Clackamas Bull Trout Reintroduction Implementation, Monitoring and Evaluation Plan (IM&E Plan) protocols (FWS 2011), 150 bull trout fry, and 60 bull trout juveniles were collected via electrofishing in Jack and Canyon Creeks on March 8 and 9, 2016. Screening for pathogens was conducted by ODFW (fry) and FWS (juveniles). Fish health staff screened for IHNV, IPNV, VHSV, OMV, ISAV, and *M. cerebralis*, as well as other treatable pathogens and parasites (Barry et al. 2014).

Donor Stock Collection

Juveniles

Juvenile (70 – 250 mm TL) bull trout were collected between April 5 and May 11, 2016. The principal method of collection was electrofishing. An ETS model ABP-3 backpack electrofisher was used (settings 12% duty, 30 pps and 350 – 400 v). Bull trout fry and all by-catch were enumerated and immediately released. Bull trout were held in an aerated bucket during electrofishing and water temperature was monitored and maintained. After electrofishing was complete bull trout were transferred and held streamside in larger perforated barrels that were submerged in Jack Creek. All juveniles were PIT-tagged at the end of each week and transferred to the Clackamas River Subbasin the following day. Juvenile bull trout were also incidentally captured in trap nets during subadult and adult collection efforts (see below).

Subadults and Adults

Subadult (251 – 450 mm TL) and adult (451 – 650 mm TL) bull trout were captured using Oneida trap nets or angling. Oneida trap nets were the principal method of collection, and they were set and checked Monday through Thursday each week from May 17, 2016 to June 10, 2016 in the Metolius arm of Lake Billy Chinook (downstream of the Eyerly property). Following capture, bull trout were transported in oxygen-supplemented tanks to the Round Butte Fish Isolation Facility where they were held in circular tanks (2,500 L) supplied with flow through water from Lake Billy

Chinook. Each fish was checked for injury before being placed in a tank, and fish of the appropriate size (251 – 650 mm TL) were held for a minimum 48 hr depuration period as a precaution against transfer of New Zealand mud snails that have been recently documented in Lake Billy Chinook. Bull trout that exhibited injury or other prior trauma upon visual inspection by FWS Fish Health staff on site at Round Butte Isolation Facility were returned to their original capture location and released, or sacrificed and necropsied by FWS Fish Health.

Tagging

At the end of each week, all captured bull trout were tagged with a half-duplex (HDX) passive integrated transponder (PIT) tag (ORFID, Portland, OR and Biomark, Boise, ID). Fish were anesthetized using Aqui-S 20E (20 – 25 ppm). Individuals ≥ 300 mm TL received a dorsal sinus implanted 23 mm tag, bull trout 151 – 299 mm received an abdominally implanted 23-mm tag, and 70 – 150 mm fish received an abdominally injected 12-mm HDX PIT tag. All tags were sanitized in ethanol and betadine, then rinsed with distilled water prior to insertion. The bull trout were also administered a prophylaxis of 20 mg/kg azithromycin. Following tag insertion, the fish were allowed to recover for a minimum of 18 hours before being transported to the Clackamas River Subbasin.

Transport

Fish were transferred to release sites in the upper Clackamas River using a 700 – 1100 L water tank with supplemental oxygen and 4.5 – 4.9 ppm of Aqui-S 20E. During late May and June, juveniles were transported concurrently with subadults and adults but held in 15 L buckets with small holes drilled in the sides and top to allow water exchange. The buckets were suspended in the transport tanks to prevent injury to fish. The fish were netted from their holding tanks in the morning and transported for 2 – 5 hours by highway to the release sites. Water temperature was monitored in transit. Frozen blocks of Lake Billy Chinook water were added to the transport tank periodically during transport to ensure the temperature did not increase and to slowly acclimate fish to the temperature at the release location.

Release Locations and Timing

During 2016, most juvenile bull trout were released into habitat identified in the Feasibility Assessment (Shively et al. 2007) as suitable for spawning and early juvenile rearing in the Upper Clackamas River upstream from the Berry Creek confluence (Patch 3 Figure 3 and Figure 4). Subadult and adult bull trout were released in the Big Bottom area (Patch 1 Figures 3 and Figure 4).

Juvenile bull trout were placed in 18.9 L buckets with aerators, or large plastic bags with supplemental oxygen and hiked into the release locations. Snow was a factor during juvenile releases and restricted access into the upper Clackamas River. As it melted, releases further upstream were possible. To prevent predation, fish were sorted into groups of similarly sized individuals. Hike in time varied from 10 – 40 min. Cold air temperatures allowed water temperatures to remain cool during transport. During longer hikes, temperature was checked periodically and snow was added to cool the water when necessary. Once at the stream, the buckets or bags were allowed to acclimate to the stream temperature before the fish were released.

Subadults and adults were transferred individually from the transport tank to the river using a rubber bagged dip net. Every effort was made to release fish in slow moving water in close proximity to cover (large woody debris) and fish were given as much time as needed (usually 2 – 10 s) to recover from the mild anesthesia (4.5 – 4.9 ppm Aqui-S 20E) used in transport before being released from the net. Fish were never out of the water for more than several seconds.

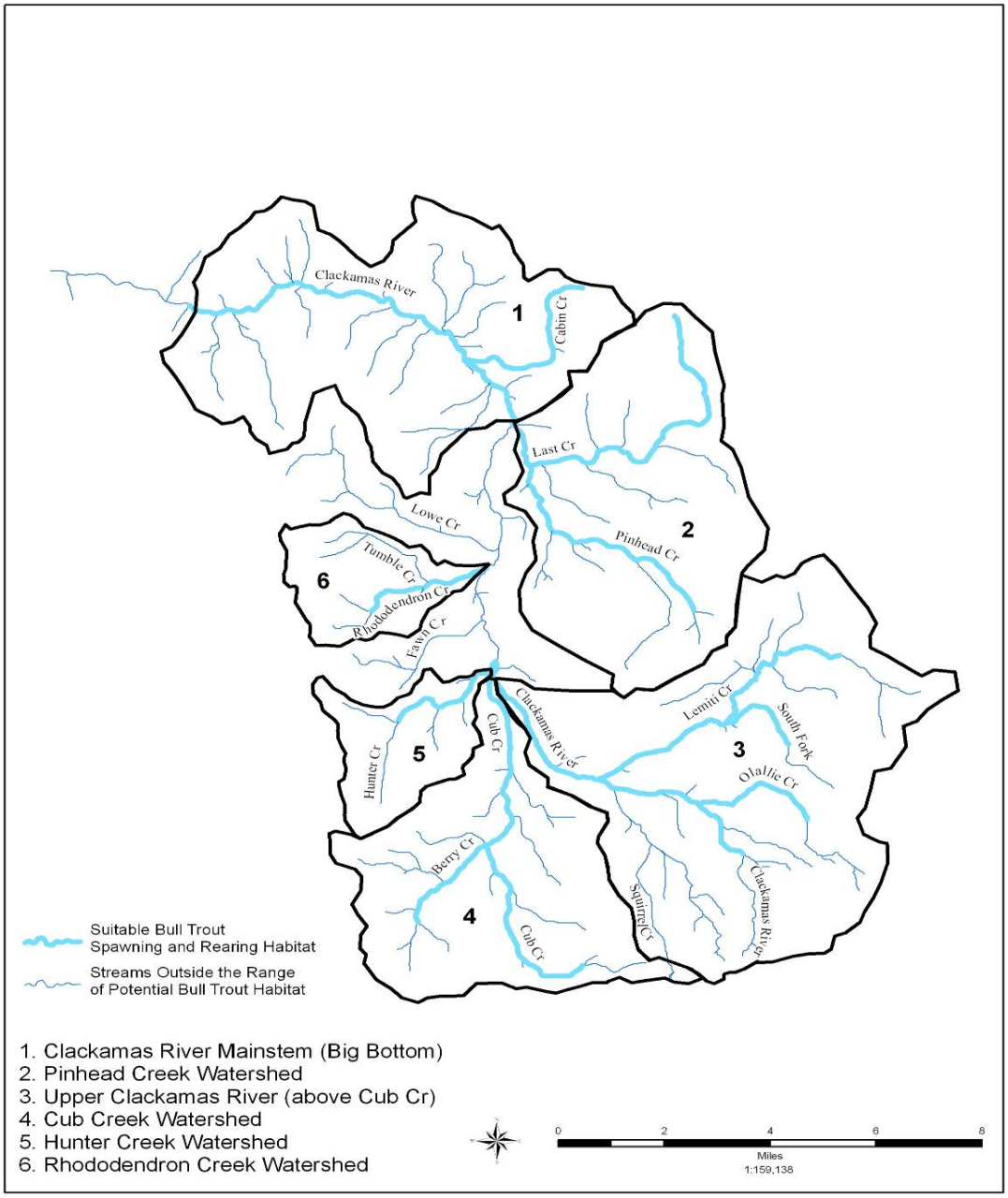

Figure 3. Suitable habitat patches for spawning and juvenile rearing based on Shively et al. 2007.

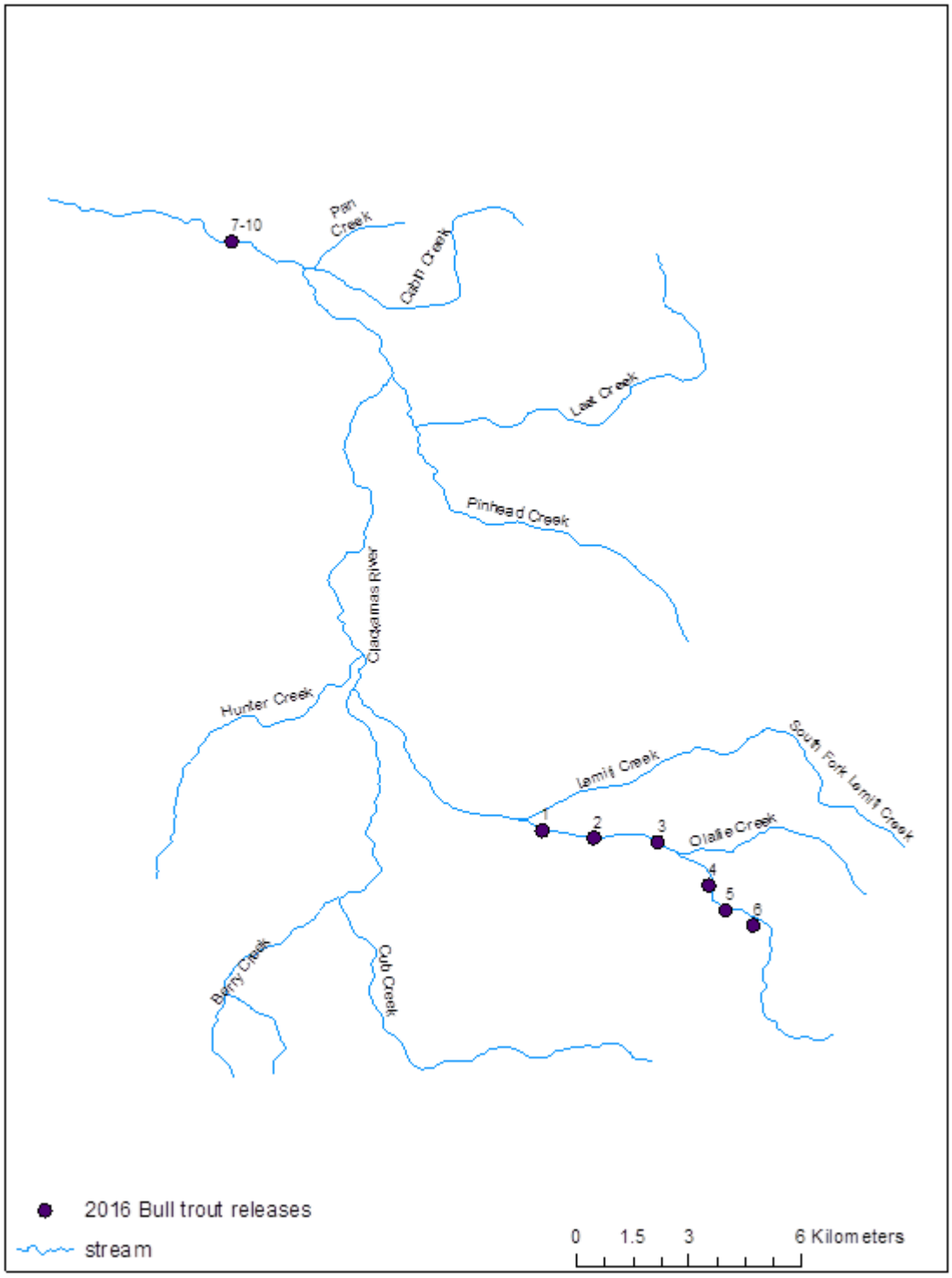

Figure 4. Release locations for bull trout in the Clackamas River in 2016. Adults and subadults were released in the Big Bottom area near the 4650 bridge (7-10), and juveniles were released into the upper reaches of the Clackamas River (1-6).

Monitoring and Evaluation

Bull Trout Reintroduction Effectiveness

We used an instream PIT detection array in Pinhead Creek and the PIT tag monitoring sites at PGE facilities to document the behavior and seasonal distribution of juvenile, subadult and adult fish and address the following questions (IM&E Plan, FWS and ODFW 2011):

1) Do translocated subadult and adult bull trout remain in the upper Clackamas River Subbasin (above River Mill Dam)?

   1a) If yes, what is their seasonal distribution?
   1b) If yes, is there evidence of spawning activity?
   1c) If no, do they return?

2) Is there successful production of progeny?

   2a) If yes, which life stage(s) produced them?

In 2016, Clackamas bull trout PIT tag monitoring consisted of four half duplex antennas in Pinhead Creek. Two antennas monitored the main channel of Pinhead Creek, and the others monitored a side channel; both channels are tributaries to the Clackamas River. The four antennas were monitored with an Oregon RFID Multi-Antenna Half Duplex Reader and powered by two 12 v battery banks that were charged via solar panels. The Pinhead Creek detection site operated continuously from March 3 to November 22 in 2016, with the exception of eight days in May due to a technical malfunction (Figure 5).

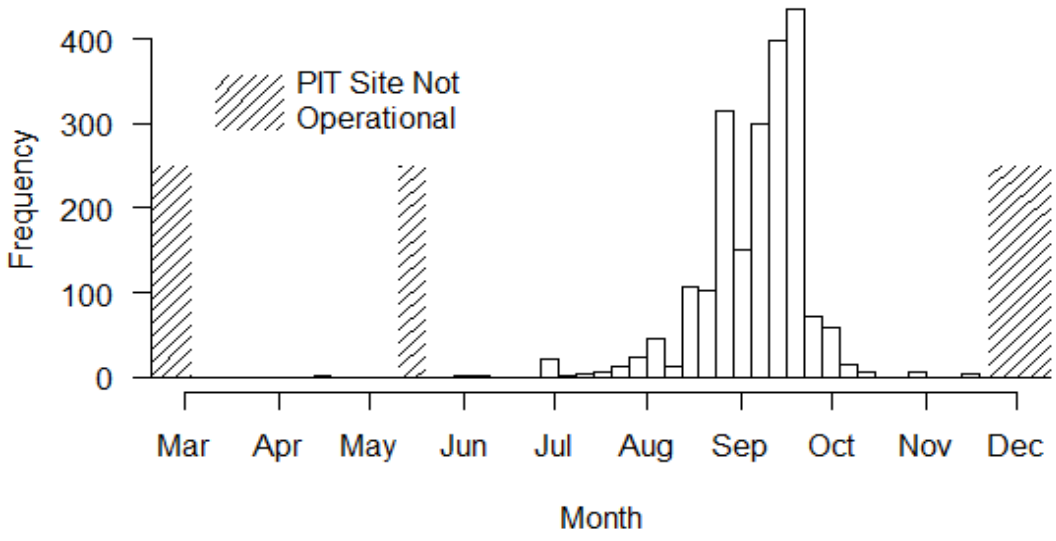

Figure 5. Histogram of Pinhead Creek PIT detections and lapses in site operation during 2016.

In addition to the Pinhead Creek detection site, a total of 11 established PIT detection arrays were operated by PGE at various facilities associated with the Clackamas Hydro Project. Eight of the arrays were operated with KarlTek (KLK5000) PIT tag readers and three with Oregon RFID readers. Table 1 is a summary of the PIT detection arrays at the Clackamas Hydro Project.

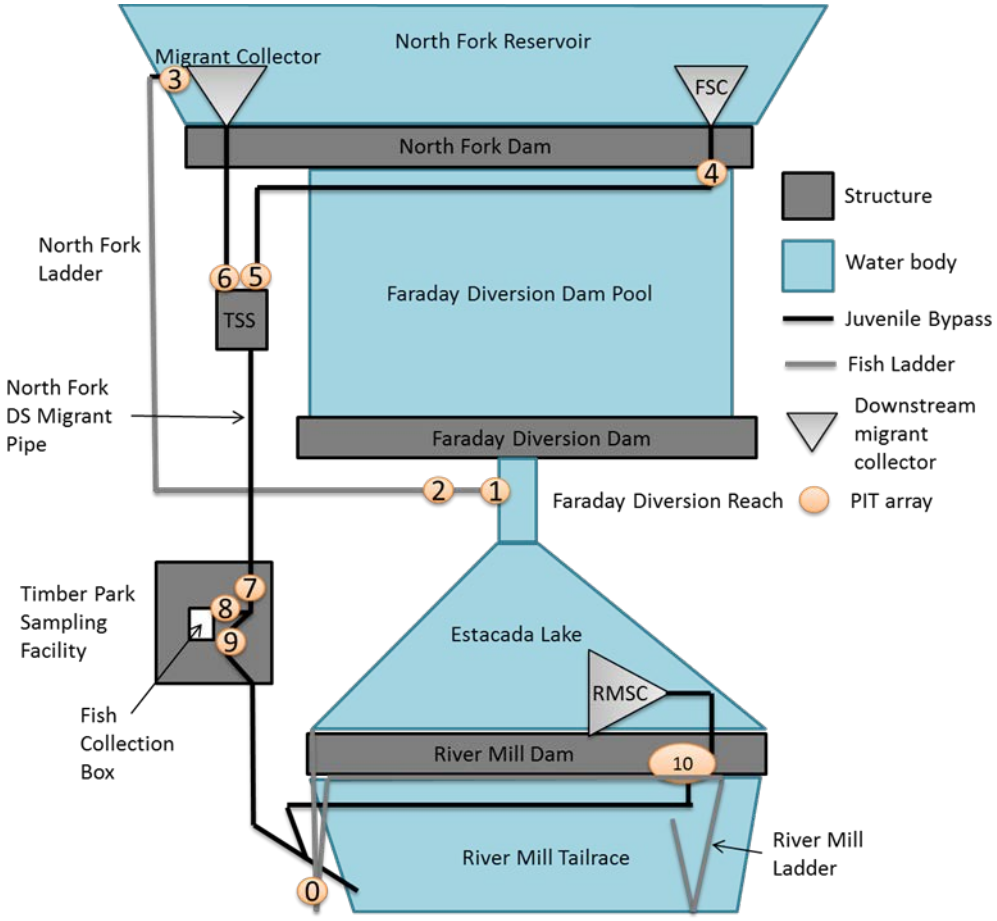

Figure 6. Schematic of PIT antenna array at the Clackamas Hydro Project. FSC = Floating surface collector; TSS = Tertiary screen structure; RMSC = River Mill surface collector. (Figure provided by Portland General Electric.)

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

Array Number	Datalogger	Operated Since	Antennas	Site Purpose
0	KarlTek KLK5000	Apr 2013	2	Detect fish passing through the River Mill ladder.
1	Oregon RFID	May 2015	1	Detect fish at the entrance of the North Fork fish ladder.
2	OregonRFID	May 2013	4	Detect fish near (upstream and downstream) the old adult sorting facility on the North Fork ladder.
3	OregonRFID	May 2015	3	Detect fish exiting the North Fork ladder.
4	KarlTek KLK5000	Oct 2015	1	Detect fish from the FSC just downstream of the flow control structure.
5	KarlTek KLK5000	Oct 2015	1	Detect fish from the FSC just upstream of the tertiary screen structure.
6	KarlTek KLK5000	Oct 2015	1	Detect fish from the North Fork migrant collector just prior to entering the tertiary screen structure.
7	KarlTek KLK5000	Dec 2011	1	Detect fish in flume entering Timber Park.
8	KarlTek KLK5000	Dec 2011	1	Detect fish diverted into the sampling box at Timber Park.
9	KarlTek KLK5000	Dec 2011	1	Detect fish bypassed back to the pipeline at Timber Park.
10	KarlTek KLK5000	Jan 2013	1	Detect fish in the River Mill Surface Collector.

Seasonal Distribution

The radio-telemetry program ended in 2014, diminishing our ability to monitor seasonal movement patterns and to determine whether subadult and adult fish remained in the study area upstream from River Mill Dam or if fish had left and subsequently re-entered the study area. However, we can infer movement patterns and distribution from PIT tag detections at the mouth of Pinhead Creek and at Clackamas Hydro Project PIT arrays.

Reproduction

Redd Surveys

Census redd surveys were conducted in potential bull trout spawning habitat in the upper Clackamas River and several major tributaries. Surveys were conducted approximately every two weeks, beginning prior to the spawning season in mid-August through October 26, 2016. Details concerning the specific methods and survey locations can be found in Appendix A.

Detecting Natural Reproduction in Pinhead Creek

During 2015, the Monitoring and Evaluation (M&E) Committee determined that it was necessary to document natural reproduction and recruitment of progeny into the population to evaluate the success of this project. This need is well aligned with actions described in section 3.3-c in the IM&E Plan (FWS 2011). In a recent review of the potential methods and strategies for sampling

bull trout in Pinhead Creek, it was suggested that specifically targeting small juveniles (≤ 70 mm TL) may be the most practical, definitive method for confirming successful natural reproduction since there are currently no translocated bull trout ≤ 70 mm TL in the Clackamas River Subbasin. Only one individual < 70 mm TL (62 mm TL in 2012) had been translocated as part of this project, and it undoubtedly would exceed 70 mm TL if it remains in the basin. Various sampling techniques were discussed (e.g., screw traps, fyke nets, snorkeling), but backpack electrofishing and minnow trapping were believed to be the most effective and feasible techniques to employ during 2016. It was also decided that sampling would be most effective if areas with high concentrations of redds were targeted. This sampling effort was proposed to address the following objective and its associated components:

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

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

We used multiple methods to address the objectives. To detect natural reproduction, targeted electrofishing and minnow/fry traps were used to sample areas where juvenile bull trout (≤ 70 mm TL) were likely to be rearing based on georeferenced redd locations. We also electrofished random, spatially-balanced reaches within Pinhead Creek to assess the probability of occupancy if at least two age classes of naturally produced bull trout were not detected during the targeted electrofishing and minnow trapping.

Targeted Electrofishing

Electrofishing is a feasible method for capturing small juvenile bull trout. By using this method to sample the areas where juvenile bull trout likely rear, we may increase our chances of capturing naturally produced individuals (Objective 1a). To help identify areas where naturally produced juvenile bull trout may be most prevalent, we acquired 2015 georeferenced putative bull trout redd locations in Pinhead Creek (Steve Starcevich, ODFW, unpublished data). During 2015, there were 47 redds counted in Pinhead Creek, of which four were not georeferenced and three were given erroneous GPS points that were not located near the stream. Thus, 40 redds were used for this exercise.

Studies that evaluate movements of bull trout fry are uncommon, but Bowerman (2013) evaluated juvenile bull trout movement patterns in a small tributary (Skiphorton Creek) to the South Fork Walla Walla River in northeast Oregon. Generally, Bowerman (2013) found that juvenile bull trout predominantly moved downstream from their initial capture location within their natal stream. Maximum movement upstream was 0.2 km and the majority of juveniles remained within 0.5 km of their initial capture location prior to eventual migration. For this exercise, we made the following assumptions:

1. Juvenile bull trout will likely be within 0.2 km upstream and 0.5 km downstream of a given redd location.

2. Juvenile bull trout density will decrease with increasing distance from the redd.

The 4.4 km study area in Pinhead Creek was delineated into 88 50-meter segments. If a 2015 geo-referenced redd location fell within a given segment, that segment received a score of "10." The next downstream segment was assigned a score of "9." The next consecutive segment received an "8" and so on. In addition, the segment immediately upstream from the redd location received a score of "9" and the next three consecutive upstream segments received scores of 8, 7 and 6, respectively. The total score for each 50-meter segment was summed and then ranked from highest to lowest. The top 15 ranked segments were used to determine the reaches for targeted electrofishing (Figure 7). Reach 1 was 450 meters long and consisted of nine 50-meter segments. Reach 2 was 300 meters long and consisted of six 50-meter segments. Reaches were sampled from downstream to upstream by experienced personnel using a Smith-Root LR-24 shocker. Sampling occurred in July and targeted small juvenile bull trout (≤ 70 mm TL) in habitat that included slow velocity and shallow areas (10 – 50 cm deep) with unembedded cobble/rubble substrate (Baxter and McPhail 1996).

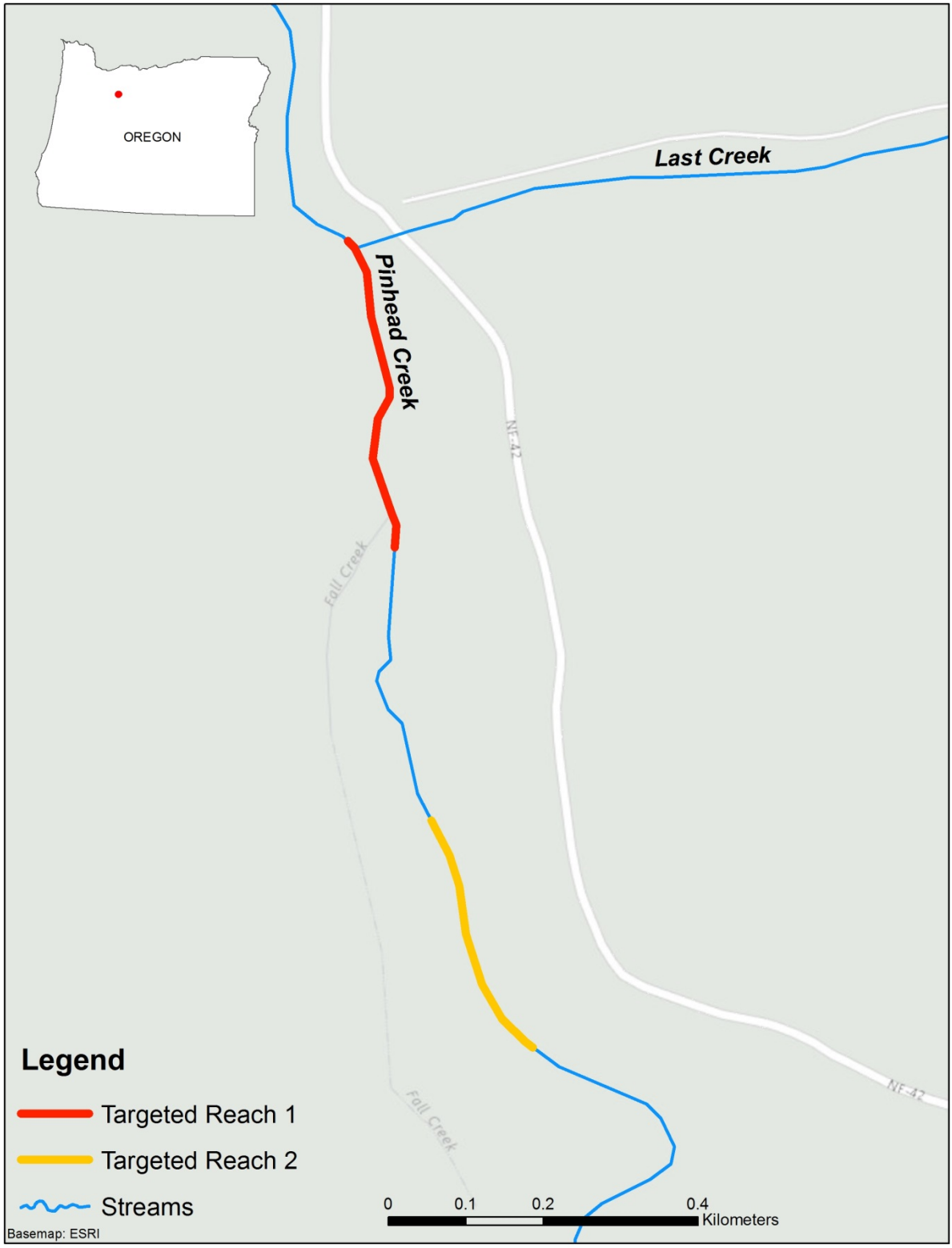

Figure 7. Targeted electrofishing reaches in Pinhead Creek.

Minnow Trapping

To increase our chances of capturing naturally produced individuals, baited (cured salmon roe) minnow traps were deployed primarily within Targeted Reach 1 at 55 locations and fished for 24 hours (Figure 10). Up to 12 wire mesh minnow traps were deployed each day in slow velocity and shallow habitat (10 – 50 cm deep) with unembedded cobble/rubble substrate (Figure 8). In addition, two smaller, soda bottle fry traps (Figure 9) were deployed each day where habitat conditions were appropriate (e.g., shallow, sidechannel habitat).

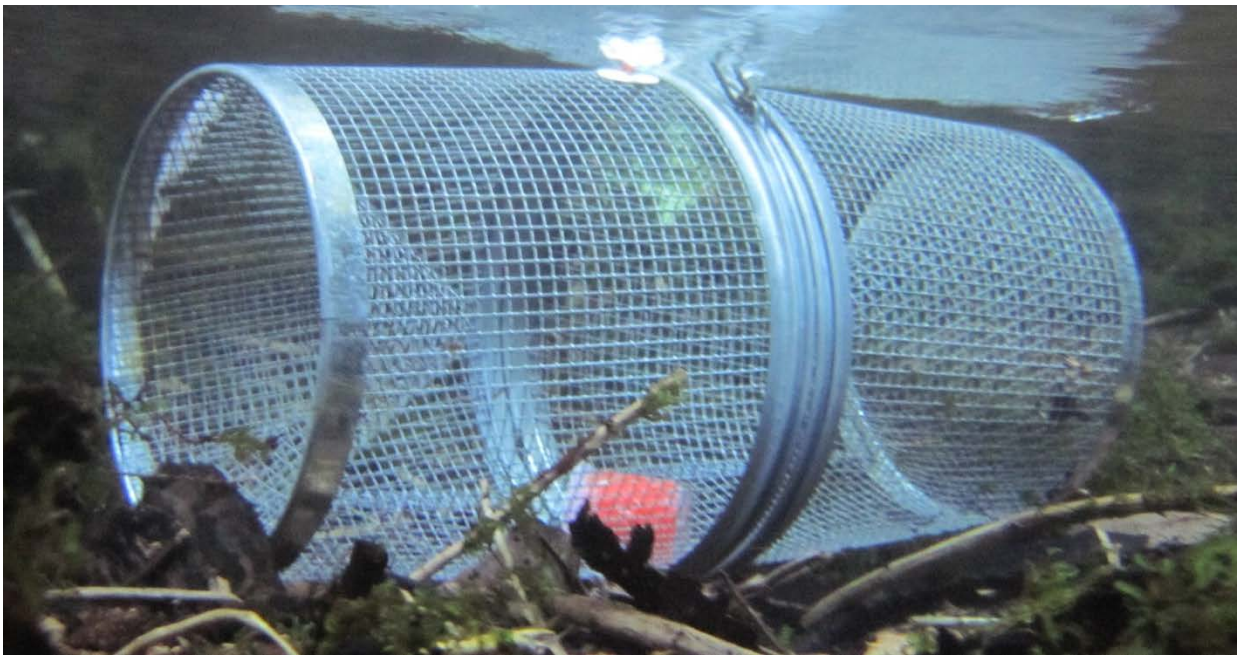

Figure 8. Wire mesh minnow traps used to capture juvenile fish in Pinhead Creek.

Figure 9. Soda bottle minnow traps used to sample juvenile fish in Pinhead Creek.

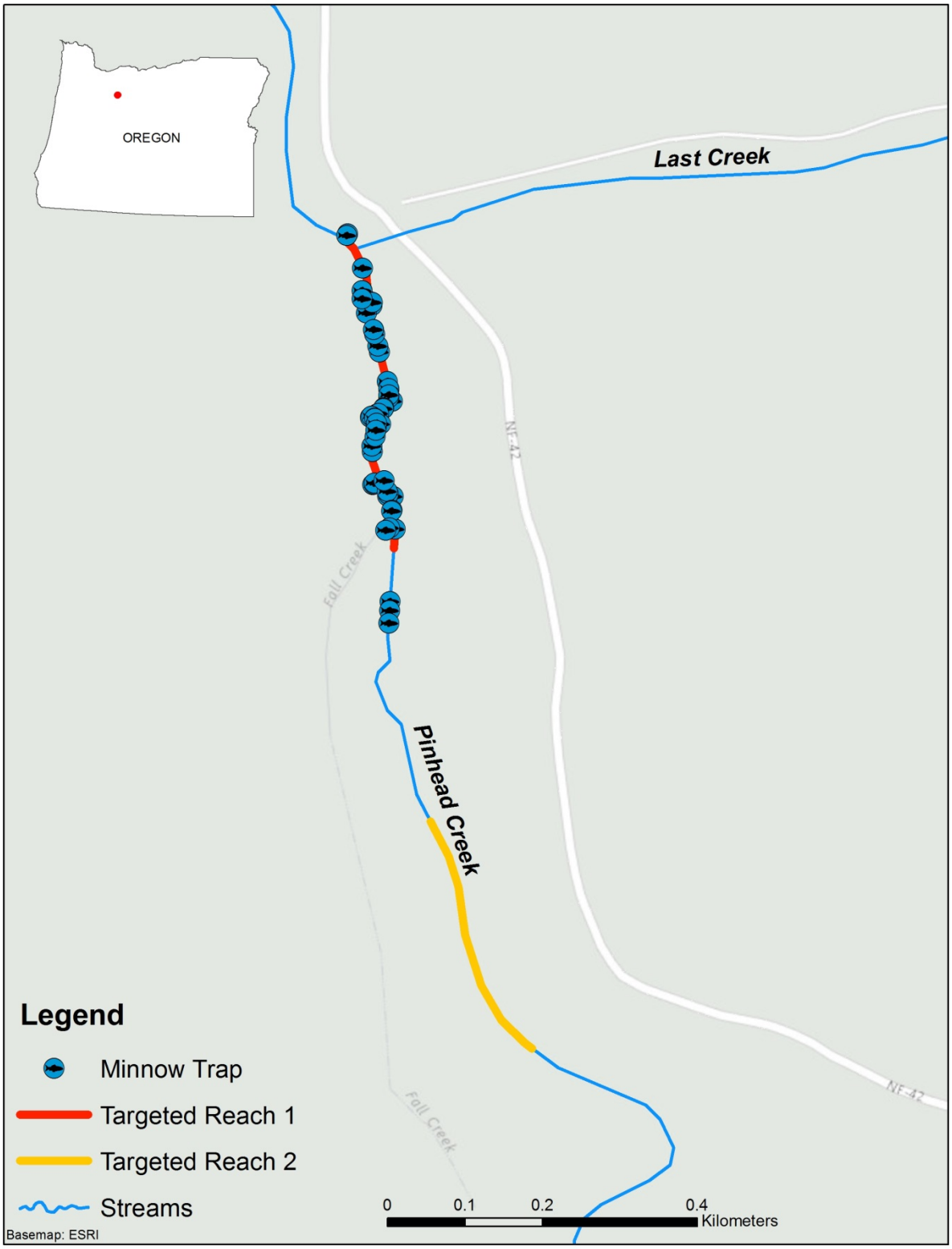

Figure 10. Minnow trap locations in Pinhead Creek.

Spatially-balanced Electrofishing

A probabilistic and spatially-balanced approach was used to determine how many (and which) 50-meter reaches we needed to sample by backpack electrofishing to assess the probability of occupancy by naturally produced bull trout in Pinhead Creek (Objective 1b). Our approach allowed us to assess the probability of occupancy, if no individuals were detected P($F|C_o$), given assumptions, using a model developed by Peterson and Dunham (2003):

$$P(F|C_o) = \frac{P(C_o|F) \cdot P(F)}{P(C_o|F) \cdot P(F) + P(C_o|\sim F) \cdot P(\sim F)},$$

where P(F) is the prior probability of presence and P(~F) is the prior probability of absence, which is always 1- P(F). We set P(F) and P(~F) at 0.5 (i.e., uninformed). P($C_o|F$) is the probability of not detecting an individual when the area is occupied and is a function of detection probability, d, and the number of reaches sampled, n. P($C_o|F$) is estimated as $(1- d)^n$, where d is the probability of detecting at least one individual in a reach in an occupied area. Peterson et al. (2004) estimated the probability of capturing an individual bull trout 70-99 mm in total length using similar backpack electrofishing methods to be 0.114. Making the assumption of at least one individual bull trout per 50-meter reach (on average), P($C_o|F$) would be less than 0.20 if sampling was completed in at least 12 50-m reaches. Thus, we assume that if we were to observe no bull trout after sampling n = 12 reaches, we would be at least 80% certain the area is unoccupied (if d is at least 0.114). We selected 12 of the 88 50-meter reaches in Pinhead Creek in a random, spatially-balanced way using the Generalized Random Tessellation Stratified method (Stevens and Olsen 2004) to sample via electrofishing (Figure 11).

In addition to evaluating the probability of occupancy by naturally produced bull trout, we also wanted to assess the probability that Pinhead Creek was occupied by a naturally reproducing bull trout population. We assumed that Pinhead Creek was occupied by a naturally reproducing population if at least two naturally produced fish in different age classes (> 30 mm TL difference in size) were detected by electrofishing.

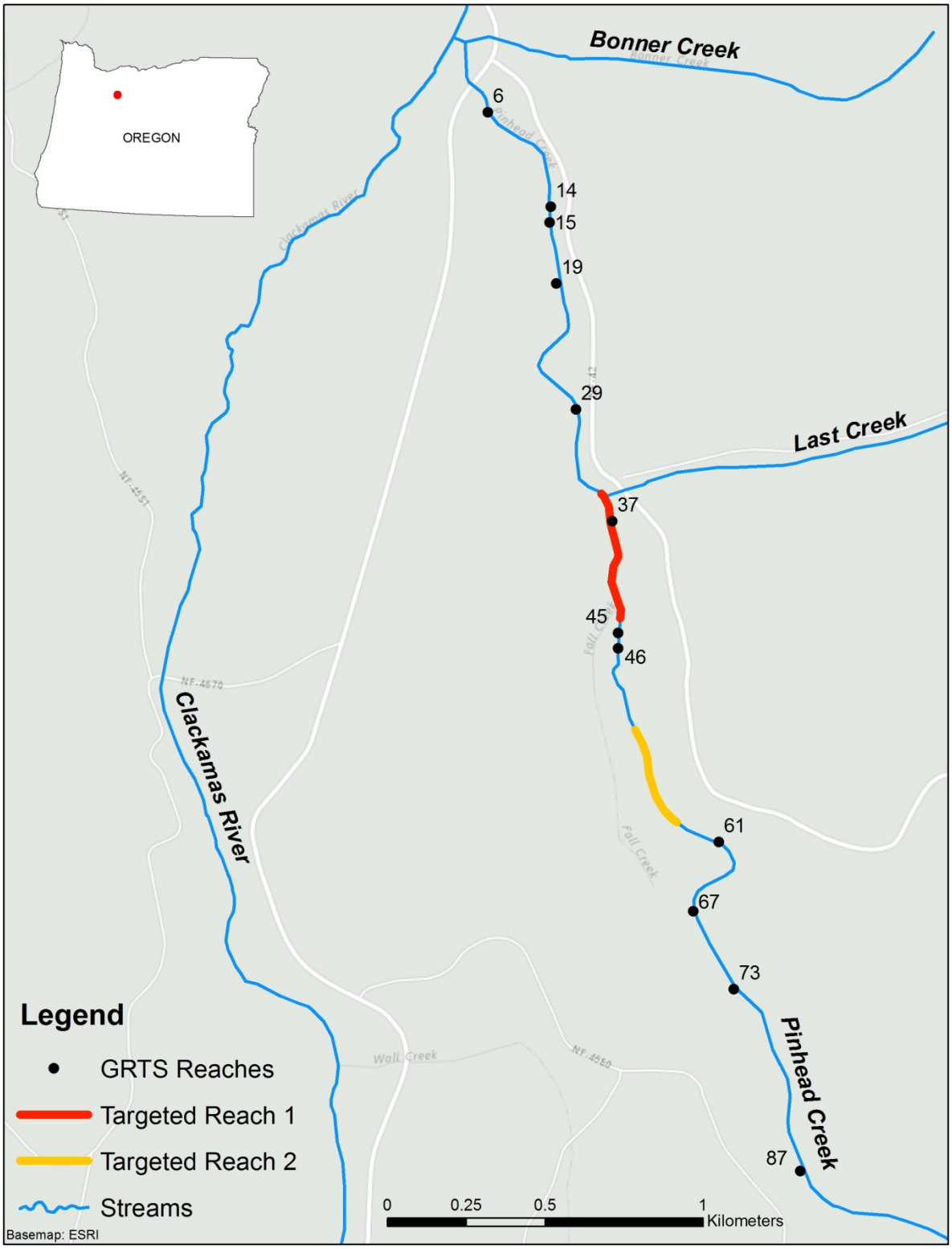

Figure 11. Spatially-balanced electrofishing reaches in Pinhead Creek.

Genetics

Caudal fin tissue (approximately 1 cm^2) was collected from each fish that was translocated to the Clackamas River Subbasin during 2016. These samples were archived at the FWS Abernathy Fish Technology Center (Longview, Washington). This collection of samples will provide the opportunity for subsequent parentage analysis and the confirmation of naturally reproduced progeny.

Impacts to Listed Salmon and Steelhead

Following the termination of the radio-telemetry program in 2014, we can no longer determine whether translocated subadult and adult bull trout have entered a High Vulnerability Zone (HVZ), nor determine the total time each fish spent in the HVZ. However, detections of bull trout at Clackamas Hydro Project PIT arrays 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.

Results and Discussion

Implementation

Donor Stock Availability

A total of 629 bull trout redds were documented in the Metolius River Subbasin in 2016 (E. Moberly, ODFW, personal communication). The estimated abundance of spawning adults was 1446 in 2016 (E. Moberly, ODFW, personal communication), satisfying the criteria (> 800 spawning adults) to continue transfers to the Clackamas River Subbasin if deemed necessary. No additional translocations to the Clackamas River Subbasin are planned in 2017. Figure 12 is a summary of redd counts and abundance estimates of spawning adults in the Metolius River Subbasin from 1986 – 2016.

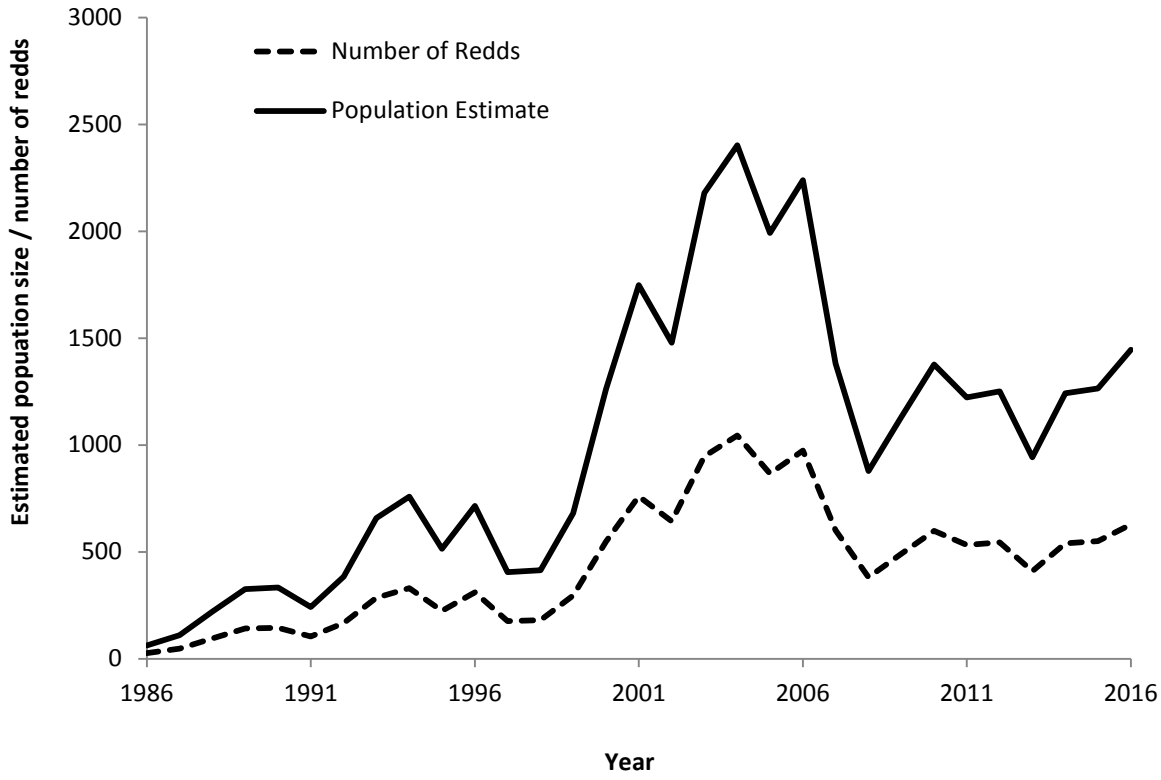

Figure 12. Raw redd counts and population estimates through 2016 for the Metolius River Subbasin bull trout population (E. Moberly, ODFW, personal communication).

Pathogen Screening

All samples screened in 2016 tested negative for IHN, IPN, VHS, paramyxo, and aquareo virus. However, all 60 juveniles tested positive for *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease (BKD). All transplanted fish were treated with a prophylaxis of azithromycin to mitigate for the effects of BKD.

Donor Stock Collection

Juveniles

During 2016, 595 PIT-tagged juveniles (70 – 250 mm TL) were translocated to the upper Clackamas River (Table 2). In addition, 18 juveniles died (7 from an accidental overdose of azithromycin) during collection and tagging efforts prior to transport. Two juvenile brook trout x bull trout hybrids were also captured during collection efforts (one in Canyon Creek and one in Candle Creek). One was euthanized, and one was released. Since reintroduction efforts began in 2011, 2382 juvenile bull trout have been translocated to the Clackamas River Subbasin (Table 3).

Table 2. Release date, capture location, number and release location (Figure 4) of juvenile bull trout relocated to the Clackamas drainage in 2016. This table does not include mortalities, all of which occurred prior to transfer.

Release Date	Capture Location					# Transferred	Release Location
	Jack Cr	Canyon Cr	Candle Cr	Roaring Cr	Lake Billy Chinook		
April 8	44		59			103	Upper Clackamas 1
April 15	54	26				80	Upper Clackamas 2
April 22	41		10			51	Upper Clackamas 3
April 29	14	8	60			82	Upper Clackamas 4
May 6	45			35		80	Upper Clackamas 5
May 13	46		58			104	Upper Clackamas 6
May 20					15	15	100m DS of 4650 bridge
May 27					35	35	100m DS of 4650 bridge
June 3					6	6	100m DS of 4650 bridge
June 13					39	39	100m DS of 4650 bridge
Totals:	**244**	**34**	**187**	**35**	**95**	**595**	

Table 3. Count by year and life stage of bull trout captured in the Metolius River Subbasin and translocated to the Clackamas River Subbasin.

Life stage	Number of Bull Trout Translocated						
	2011	2012	2013	2014	2015	2016	Total
Juvenile	58	509	615	305	300	595	2382
Subadult	24	43	91	46	74	94	372
Adult	36	17	8	7	7	6	81
Totals	**118**	**569**	**714**	**358**	**381**	**695**	**2835**

Subadults and Adults

One hundred and twenty-two subadult and adult bull trout (251 – 650 mm TL) were captured for translocation (16 via angling and 106 via trap). Of these, three were immediately released because they had been previously PIT-tagged by another research project or were over 650 mm TL, making them too large for translocation. In addition, one fish died due to a hooking injury, and one fish was sacrificed by fish health staff due to health concerns. Seventeen others were held overnight at Round Butte Hatchery, then released back into Lake Billy Chinook at the original capture location when the 100 fish quota had been reached. During 2016, a total of 94 subadult and 6 adult bull trout were translocated to the Clackamas River Subbasin (Table 4).

Table 4. Date of capture, method of capture, and number of subadult and adult bull trout collected in the Metolius arm of Lake Billy Chinook for transport to the Clackamas River.

Capture dates (2016)	Angling	Trap Nets	Total
May 17-19	2	14	16
May 24-26	6	36	42
June1-2	1	9	10
June7-10	3	29	32
Totals	**12**	**88**	**100**

Release Locations and Timing

During 2016, there were six releases of juveniles (releases 1 – 6) in the Upper Clackamas River and four releases of primarily subadult and adult bull trout in the mainstem Clackamas River (releases 7 – 10) near the 4650 Bridge (Tables 2 and 5; Figure 4). Any juveniles that were captured during the adult collections were released at the subadult/adult release location in areas of slow moving water due to transport constraints.

Table 5. Date of release, method of capture, total released, and release location of subadult and adult bull trout in 2016.

Release Date	Subadult/adult count and collection method	Count transferred	Release Location
May 20	14 subadults trap net; 2 subadults angling	16	Release 7: 100 m downstream of 4650 bridge
May 27	35/1 subadults/adults trap net; 5/1 subadults/adults angling	42	Release 8: 100 m downstream of 4650 bridge
June 3	9 subadults trap net; 1 adult angling	10	Release 9: 100 m downstream of 4650 bridge
June 13	26/3 subadults/adults trap net; 3 subadults angling	32	Release 10: 100 m downstream of 4650 bridge

Monitoring and Evaluation

Bull Trout Reintroduction Effectiveness

Seasonal Distribution

During 2016, five translocated fish were detected at various PIT arrays within PGE's hydro project facilities and one untagged bull trout was observed and subsequently PIT-tagged at the North Fork Adult Sorting Facility (Table 6). Detection histories for the translocated fish are summarized in Appendix B. In many cases, an individual was detected at multiple PIT arrays on multiple dates. The five PIT-tagged, translocated fish were originally released as juveniles (N = 1) and subadults (N = 4) between July 2012 and May 2015. Growth rates for migratory bull trout in the Clackamas River Subbasin are largely unknown, but an examination of the detection histories and observations of fish since translocation (Appendix B) indicated most were either adult or near adult-sized fish at the time they were detected at PGE's hydro project facilities in 2016. The one exception may have been the bull trout (PIT ID 982_00361679388) released in May 2015 into Berry Creek as a juvenile.

Table 6. Individual PIT-tagged bull trout detected at PGE facilities during 2016.

PIT ID	Length at Release (TL)	Release Date	Release Site
982_000361679388	157 mm	5/1/2015	Berry Creek Bridge
0000_0000000177419566	368 mm	7/12/2012	4670 Side Channel
0000_0000000177419300	381 mm	6/20/2013	Lower 4650 Bridge D/S
900_228000527852	640 mm	5/31/2016	PGE N.F. Adult Sorting Facility
0000_0000000177419401	354 mm	6/6/2013	DS of Austin H.S.
982_000361679147	289 mm	6/5/2014	D/S of 4650 Bridge

Three of the six bull trout moved upstream past North Fork Dam, re-entering the upper Clackamas River in May and June. The first fish (PIT ID 0000_0000000177419566) was observed at the North Fork Adult Sorting Facility on May 1, 2016, was approximately 660 mm TL, and appeared to be in very good condition (Figure 13). This fish was originally released on July 12, 2012 in the Clackamas River as a subadult fish at 368 mm TL. This fish was also radio-tagged (code 166, frequency 150.350) and had grown approximately 292 mm since translocation. This fish subsequently entered Pinhead Creek on June 8, 2016, presumably to eventually spawn. The second fish, a large adult bull trout (640 mm TL) without a PIT tag, was captured at the North Fork Adult Sorting Facility on May 31, 2016 and was PIT-tagged in the dorsal sinus with a 23-mm HD PIT tag (PIT ID 900_228000527852) (Figure 14). It is unknown whether this fish was a translocated fish that had shed its PIT tag or if it had been naturally produced in the Clackamas River Subbasin. This fish was not subsequently detected in 2016. The third fish (PIT ID 0000_0000000177419300) was observed on June 9, 2016 at the North Fork Adult Sorting Facility and was originally translocated on June 20, 2013 as a subadult (381 mm TL) (Figure 15). The fish was also radio-tagged (code 20, frequency 150.390) and was 570 mm TL, having grown 189 mm since it was

released. This bull trout also entered Pinhead Creek (July 28, 2016), presumably to subsequently spawn.

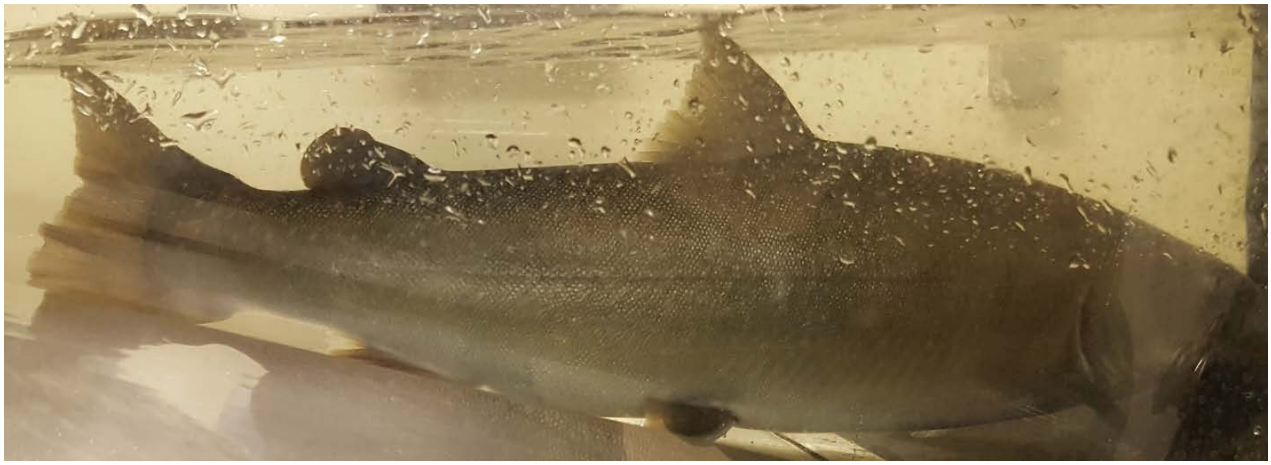

Figure 13. Bull trout # 0000_0000000177419566 (660 mm TL) at North Fork Adult Sorting Facility.

Figure 14. Bull trout # 900_228000527852 (640 mm TL) observed at North Fork Adult Sorting Facility with no evidence indicating it having been previously tagged.

Figure 15. Bull trout # 0000_0000000177419300 at North Fork Adult Sorting Facility (570 mm TL).

Three of the six bull trout detected at PGE facilities did not move upstream into the study area after being detected. A bull trout (PIT ID 0000_0000000177419401) originally released into the Clackamas River on June 6, 2013 at 354 mm TL was detected as it moved downstream of North Fork Dam in late July 2016 and was not subsequently detected (Appendix B). At the time of detection, this was likely an adult fish, but migratory bull trout generally move upstream toward spawning areas during this time period (Swanberg 1997; Downs et al. 2006), making this movement unusual, although not unprecedented (Dupont et al. 2007). Another likely adult fish (PIT ID 982_000361679147) was detected sporadically in the North Fork Ladder, the River Mill Surface Collector and the River Mill Ladder between July 30, 2016 and September 21, 2016, but did not move upstream of North Fork Dam during 2016 (Appendix B). The only likely non-adult bull trout (PIT ID 982_000361679388) detected at PGE facilities during 2016 was originally released as a juvenile (157 mm TL) into Berry Creek on May 1, 2015. This fish was detected moving downstream via North Fork Dam's Downstream Migrant Collector on February 18, 2016. This likely subadult-sized bull trout may have been migrating downstream to overwinter in habitat downstream of the hydro project.

In addition to PIT tag detections at PGE facilities, there were 80 tags associated with translocated bull trout detected in Pinhead Creek during the 2016 monitoring season. Thirty-three unique tags were detected in the main channel, five were detected in the side channel and 42 were detected in both. Of the 80 tags detected, 44 originated from Pinhead Creek releases, 31 were released in locations downstream of the Pinhead Creek confluence and only 5 originated from upstream releases. Most tags were detected during hours of darkness with 66 % detections occurring between 1800 and 0000 hours. Juveniles have not been released into Pinhead Creek since 2013 and the majority of 2016 detections occurred in August and September suggesting that most of the returning fish were doing so to spawn (Figure 5). Summaries of translocated bull trout and detection histories by year and life stage at release are given in Tables 3 and 7, respectively.

Table 7. 2016 Pinhead Creek PIT detection totals by year and age class at release.

	2011	2012	2013	2014	2015	2016	**Totals**
Juvenile	2	13	29	6	2	0	**52**
Subadult	0	2	7	9	5	0	**23**
Adult	0	0	0	1	1	3	**5**
Totals	**2**	**15**	**36**	**16**	**8**	**3**	**80**

We used a binomial model to assess the probability of detection given life stage at time of release (Figure 16). Although neither adults nor subadults had been released into Pinhead Creek during this project, they were more likely to be detected at the mouth of Pinhead Creek than fish released as juveniles. The probability of detecting a fish released as a juvenile remained fairly constant with an estimate of 3% for all years (Figure 16). The probability of detecting fish released as subadults and adults averaged 12% and 6.5%, respectively, across years (Figure 16). Possibly, estimates were lower for juveniles because 76% of them were tagged with 12-mm PIT tags whereas 100% of subadults and adults were tagged with 23-mm tags. That said, antenna tests performed in 2015 and 2016 indicated the detection efficiency of 12-mm tags was 100%.

Detections in 2016 represented fish released at all life stages from every release group. The largest contributors of PIT detections in 2016 were juveniles released in 2013. Notably, this has been true every year since the release of this cohort in 2013. More juveniles were released in 2013 (N = 614) than any other year and 99.5% of them were released into Pinhead Creek. Although juvenile bull trout represented the largest proportion of translocated fish translating into the greatest number of detections, data currently show that fish released as subadults are more likely to be detected in Pinhead Creek.

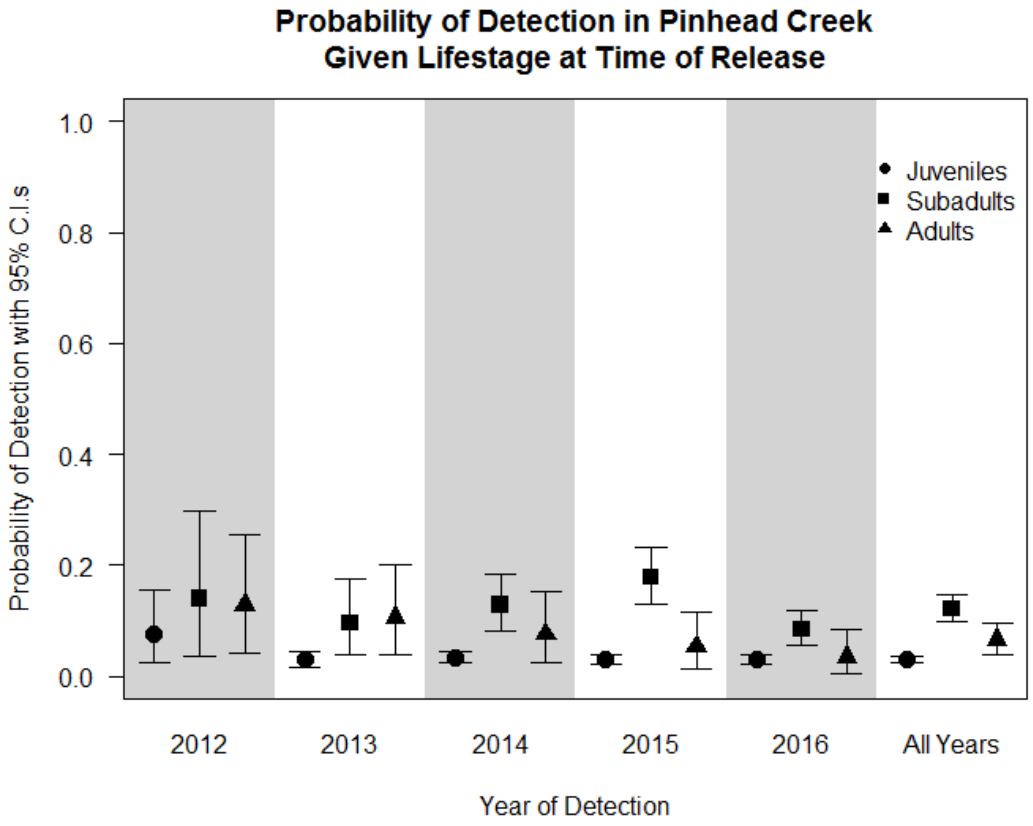

Figure 16. Posterior means with 95% credible intervals. Detections account for bull trout released one or more years prior to the detection date. For example, the 2015 column accounts for the detection of fish released in the years 2011-2014.

Reproduction

Redd Surveys

Only one bull trout was observed on a redd during spawning surveys conducted in the upper Clackamas River and associated tributaries. However, a total of 68 presumed bull trout redds were observed in 2016. This is the highest count since the initiation of the reintroduction program in 2011. Census redd counts are described and results are summarized and discussed in Appendix A.

Detecting Natural Reproduction in Pinhead Creek

Targeted Electrofishing

Targeted electrofishing surveys in Pinhead Creek commenced on July 11, 2016 and continued through July 13, 2016. A total of 750 meters were sampled, but no bull trout were captured or observed. Coastal cutthroat trout (N = 65), juvenile coho salmon (N = 48), and sculpin (N = 375) were captured as bycatch (Table 8).

Table 8. Fish captured during targeted electrofishing surveys in Pinhead Creek during 2016.

Species	Reach 1 (450 m)	Reach 2 (300 m)	Totals
Cutthroat	39	26	65
Coho	37	11	48
Sculpin	187	188	375
Bull Trout	0	0	0

Minnow Trapping

Minnow trap sampling in Pinhead Creek was initiated on June 28, 2016 and continued through July 1, 2016 for a total of 55 24-hour deployments. No bull trout were sampled, but 98 coastal cutthroat trout, 55 coho salmon and 5 sculpin were captured (Table 9).

Table 9. Fish captured during minnow trap sampling in Pinhead Creek during 2016.

Species	Wire Mesh Trap (N = 47)	Soda Bottle Trap (N = 8)	Totals
Cutthroat	81	17	98
Coho	44	11	55
Sculpin	2	3	5
Bull Trout	0	0	0

Spatially-balanced Electrofishing

Spatially-balanced electrofishing surveys were conducted from July 11, 2016 to July 18, 2016. No bull trout were captured or observed. However, coastal cutthroat trout (N = 65), coho salmon (N = 64), sculpin (N = 462) and *O. mykiss* (N = 1) were captured, enumerated and released (Table 10). Based on the approach we used, we can infer with an 80% certainty that Pinhead Creek is not occupied by naturally produced juvenile bull trout. We can also infer a naturally reproducing population in Pinhead Creek is unlikely, but we cannot rule out the possibility since our probability of capturing bull trout within the study area was less than 100% and we have no information on

behavior of bull trout fry (e.g., immediate migration from Pinhead Creek into the mainstem Clackamas River).

Table 10. Fish captured during spatially balanced electrofishing in Pinhead Creek during 2016.

Species	Reach 6	Reach 14	Reach 15	Reach 19	Reach 29	Reach 37	Reach 45	Reach 46	Reach 61	Reach 67	Reach 73	Reach 87	Totals
Cutthroat	4	7	2	3	6	2	3	4	6	3	10	15	65
Coho		16	8	24	7	6		3					64
O. mykiss				1									1
Sculpin	36	72	56	72	65	28	16	18	24	15	22	38	462
Bull Trout													0

Genetics

Tissues were collected from 695 bull trout in 2016. Samples were archived at the FWS operated Abernathy Fish Technology Center (Abernathy, Washington).

Impacts to Listed Salmon and Steelhead

Bull trout use of North Fork Reservoir and occupancy of the HVZ during 2016 is largely unknown. The radio-telemetry program associated with the bull trout reintroduction project ended in 2014, fundamentally limiting monitoring efforts. However, the comprehensive detection histories of six PIT-tagged bull trout detected at various PIT antennas throughout PGE's hydro project facilities during 2016 provide some degree of insight into when and where both subadult and adult bull trout occupy habitat in the Clackamas River extending from downstream of River Mill Dam to North Fork Reservoir (Appendix B).

It is reasonable to speculate 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. In many cases, it is unclear how long a particular bull trout has occupied a given area prior to its detection moving upstream or downstream through the hydro project. In other instances, occupancy timing can be inferred through an examination of detection histories. For example, one individual (PIT ID 0000_0000000177419566) that was outplanted on July 12, 2012 as a 368 mm TL subadult, was detected while migrating downstream of North Fork and River Mill dams in July of 2014. Subsequent PIT detections at PGE facilities suggest this fish occupied habitat within and downstream of the hydro project for about 659 days before being detected and observed at the North Fork adult sorting facility on May 1, 2016. It had grown to 660 mm TL and subsequently moved upstream into Pinhead Creek on June 8, 2016, presumably staging to spawn. In addition, an adult bull trout (PIT ID 0000_0000000177419300) that was released as a subadult on June 20, 2013, moved downstream of North Fork Dam on May 23, 2016 before returning upstream through the River Mill and North Fork ladders in early June (Appendix B). On June 9, 2016 the fish was observed at the North Fork Sorting Facility and was 570 mm TL. This fish subsequently entered Pinhead Creek in late August. It is unclear how long it resided in North

Fork Reservoir prior to its detections at PGE facilities or how long it remained in the reservoir prior to moving upstream to presumably spawn in Pinhead Creek.

A likely adult bull trout (PIT ID 982_000361679147) that was released on June 5, 2014 as a subadult, was first detected entering the River Mill Ladder on July 30, 2016 and after spending time in the vicinity of River Mill Dam, eventually was detected entering the North Fork Ladder on Septemeber 2016, but has not been subsequently detected. This fish will likely overwinter at the hydro project or in habitat downstream. Another likely adult bull trout (PIT ID 0000_0000000177419401) that was released as a subadult on June 6, 2013, was detected moving downstream of North Fork Dam on July 30, 2016, and has not been subsequently detected. It is unknown how long this fish occupied the North Fork Reservoir prior to entering the Floating Surface Collector at North Fork Dam on July 29, 2017. Similarly, a likely subadult-sized bull trout (PIT ID 982_000361679388) was released on May 1, 2015 as a 157 mm juvenile in Berry Creek. This fish moved downstream of North Fork Dam via the Downstream Migrant Collector on February 18, 2016 and has not been subsequently detected. Also, a large untagged bull trout (640 mm TL) was captured at the North Fork Sorting Facility on May 31, 2016 and received a PIT tag. It has not been subsequently detected. It is currently unknown how long it remained in the vicinity of the hydro project before or after being captured.

In addition, counts of adult and juvenile coho, spring Chinook, and 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. A summary of this information is provided in Appendix C.

Conclusions

Successful reintroduction and effective management of bull trout in the Clackamas River Subbasin requires the establishment of a naturally reproducing population, and an understanding of migratory patterns and spatial and temporal habitat use ranging from headwater spawning areas to foraging, migration and overwintering habitat in the mainstem Clackamas River. As the first phase of the reintroduction effort comes to an end, progress continues to be made toward reaching the project's goal. Individuals from each translocated life stage are surviving and recruiting into the adult population as evidenced by observations at PGE hydro project facilities and PIT detections in Pinhead Creek. The number of PIT-tagged adult bull trout using Pinhead Creek during the spawning season has markedly increased from 15 adults in 2013 to 72 in 2016 (Appendix A), and redd counts throughout the study area are at their highest (N = 68) since the initiation of the reintroduction effort. However, there continue to be notable data gaps including evidence of successful natural reproduction, survival from egg to juvenile life stages, and potential impacts to listed salmon and steelhead both inside and outside the HVZ. We were able to draw the following conclusions from activities conducted during 2016.

The Metolius River Subbasin donor population was determined to be sufficiently healthy to allow transfers to the Clackamas River Subbasin to continue in 2016. Screening for pathogens resulted in negative tests for all but *Renibacterium salmoninarum*, the causative agent of BKD. All transferred fish were treated to mitigate for the effects of BKD.

The combined number of adult and subadult bull trout translocated to the Clackamas River during 2016 was the most since the project was initiated in 2011. Similarly, the number of juvenile bull trout translocated to the upper Clackamas River (N = 595) was almost twice the number transferred in each of the two previous years (N = 305 and N = 300, respectively). Electrofishing was the principal method of collection for juveniles during 2016 and appears to be an effective collection method when compared with results from previous years where rotary screw traps were the primary capture method.

The presence of snow restricted access to intended juvenile release locations in the upper Clackamas River. As the snow melted and access improved, fish were released progressively further upstream.

Eighty unique tags from fish released at all life stages and release group were detected at Pinhead Creek in 2016. Juveniles released into Pinhead Creek during 2013 contributed the most to detections in 2016. This is not surprising, given they were the largest release group since transfers began. The fate of most translocated bull trout is largely unknown. It is possible that a portion of the transferred fish did not survive, many may not yet be mature, and some fish may have shed their PIT tags. In addition, spawning and rearing has occurred elsewhere in the basin, explaining why some fish would not be detected in Pinhead Creek.

The majority of detections occurred in the fall, suggesting most of the fish entering Pinhead Creek are doing so to subsequently spawn. In addition, most tags were detected during hours of darkness. This is consistent with diel movements of migratory adult bull trout in other populations (Swanberg 1997; Downs et al. 2006).

The number of PIT-tagged adult bull trout using Pinhead Creek during the spawning season has markedly increased from 15 adults in 2013 to 72 in 2016 and redd counts throughout the study area are at their highest (N = 68) since the initiation of the reintroduction effort (Appendix A).

Multiple bull trout returned to the study area upstream of North Fork Dam in 2016 after previously exiting the study area (i.e., downstream of River Mill Dam). Two of these individuals were subsequently detected while entering Pinhead Creek, presumably to spawn. This provides further evidence that bull trout exiting the study area are successfully using foraging, migration and overwintering habitat downstream from the study area and should not necessarily be considered lost to the population.

Evidence confirming successful natural production has not been documented in the Clackamas River to date. Based on the approaches we used to investigate the presence of successful natural reproduction, we cannot rule out the possibility that natural reproduction is occurring; however, this may be unlikely. It is conceivable that the large untagged adult bull trout captured at the North Fork adult sorting facility in May was naturally produced, but it is more likely that it was a translocated fish that had shed its PIT tag. The oldest possible natural progeny in the Clackamas River Subbasin resulting from translocated individuals would have been slightly less than five years old as of May 2016. Length at age studies from other fluvial and adfluvial populations suggest a 640 mm TL bull trout would very likely be older than age five (McCubbins et al. 2016; Al-Chokhachy and Budy 2008).

Bull trout use of North Fork Reservoir and occupancy of the HVZ during 2016 is largely unknown. However, the comprehensive detection histories of six PIT-tagged bull trout detected by various 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 B). It is reasonable to speculate that bull trout likely foraged on juvenile anadromous salmonids and other prey species while occupying areas near the hydro project.

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Appendix A

Clackamas River Bull Trout Reintroduction Project: Monitoring bull trout with census redd counts and PIT tag technology, 2011-2016

Steve Starcevich, ODFW Native Fish Investigations Program Corvallis Research Lab,
December, 2016

Abstract

Bull trout were extirpated from the Clackamas River basin by the 1960s. A reintroduction feasibility assessment and an implementation plan were completed in 2007 and 2011, respectively, with the goal of establishing a self-sustaining population of 300-500 adults in the Clackamas River basin. Phase one of the project (2011-2016) involved translocating 2,868 bull trout (80% as age-1 and 2) 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. Monitoring methods included census redd counts and detection of PIT-tagged bull trout at a PIT detection site in Pinhead Creek. The number of redds observed and adult PIT-tagged bull trout (defined as age-5 and older) detected have steadily increased from 18 redds and 15 adults in 2013 to 68 redds and 72 adults in 2016. There was a strong linear relationship between the annual redd count and the number of adults detected in Pinhead Creek, suggesting that redd counts may be useful in tracking trend in adult abundance. In 2016, adults detected in Pinhead Creek were translocated mainly at age-1 and 2 (i.e., 70-210 mm), released at locations both in Pinhead Creek and the Clackamas River, and spent a median of 26 d in Pinhead Creek during the spawning period. The second phase of the project begins in 2017 and entails continued monitoring of progress toward the reintroduction goal, at least in part through census redd surveys and the use of PIT tag technology, of producing naturally-reproducing, self-sustaining population of bull trout in the Clackamas River basin.

Introduction

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

Redd surveys from 2011 to 2014 were conducted by an *ad hoc* multi-agency group of observers. In 2015 and 2016, census redd surveys were conducted by a crew of five experienced observers from the Oregon Department of Fish and Wildlife (ODFW), with additional help from other agencies and volunteers. In 2015, a long interval (44 d) between censuses may have increased uncertainty and observer error in identifying new bull trout redds and discerning them from redds constructed during a previous season or by other fall-spawning fish species such as Chinook salmon (*Oncorhynchus tshawytscha*) or coho salmon (*O. kisutch*). In 2016, the objectives were to 1) evaluate the effectiveness of a two-week interval between each census conducted throughout the potential spawning period, 2) use thermographs to refine the sampling frame and focus surveys in thermal habitat suitable for bull trout spawning, 3) examine relationships between redd counts and PIT-tagged bull trout detected in the Pinhead Creek watershed, and 4) characterize the spatial and temporal distribution of salmon spawning.

Methods

Census redd surveys

A five-person crew conducted census redd surveys in all potential bull trout spawning habitat in the upper Clackamas River and major tributary basins (Figure 1). Census surveys were generally completed every two weeks (Table 2). The first census survey was conducted in mid-August, prior to the putative start of bull trout and Chinook salmon spawning. This survey was used to familiarize the field crew with bull trout redd identification by analyzing characteristics of old redds from a previous season (i.e., redds constructed prior to August) and flagging areas that could be mistaken for new redds. A new bull trout redd was identified by its pocket-mound structure, smaller gravel size relative to substrate in Chinook salmon redds, and the contrast of brighter disturbed gravel relative to darker surrounding substrate matrix. Chinook and coho salmon redds were distinguished by larger dimensions and substrate size and by identifying the species of adult salmon occupying a redd. The crew flagged new bull trout redds and recorded the following data: GPS location, maximum length and width, species and number of adults occupying redd, and brief descriptions of observer certainty.

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. Lifestages were defined by the size classes 70-250 mm (juvenile), 251-450 mm (subadult), 451-650 mm (adult).

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

Salmon redds generally were not treated individually, except in Pinhead Creek and Last Creek, where they were treated like bull trout redds. Elsewhere, the crew usually recorded the number of salmon redds tallied over 100-300 m survey sections and a GPS location for each section mid-point.

Bull trout and salmon redd data were entered in an Access database that contains data from previous bull trout spawning surveys in the upper Clackamas River basin. Each year spawning surveyors recorded observations of some bull trout redds described as “potential”, “possible”, “likely”, “test dig?” or some other variant registering uncertainty in their observations; these descriptions were included in the database. In 2015 and 2016, observers were trained to include a

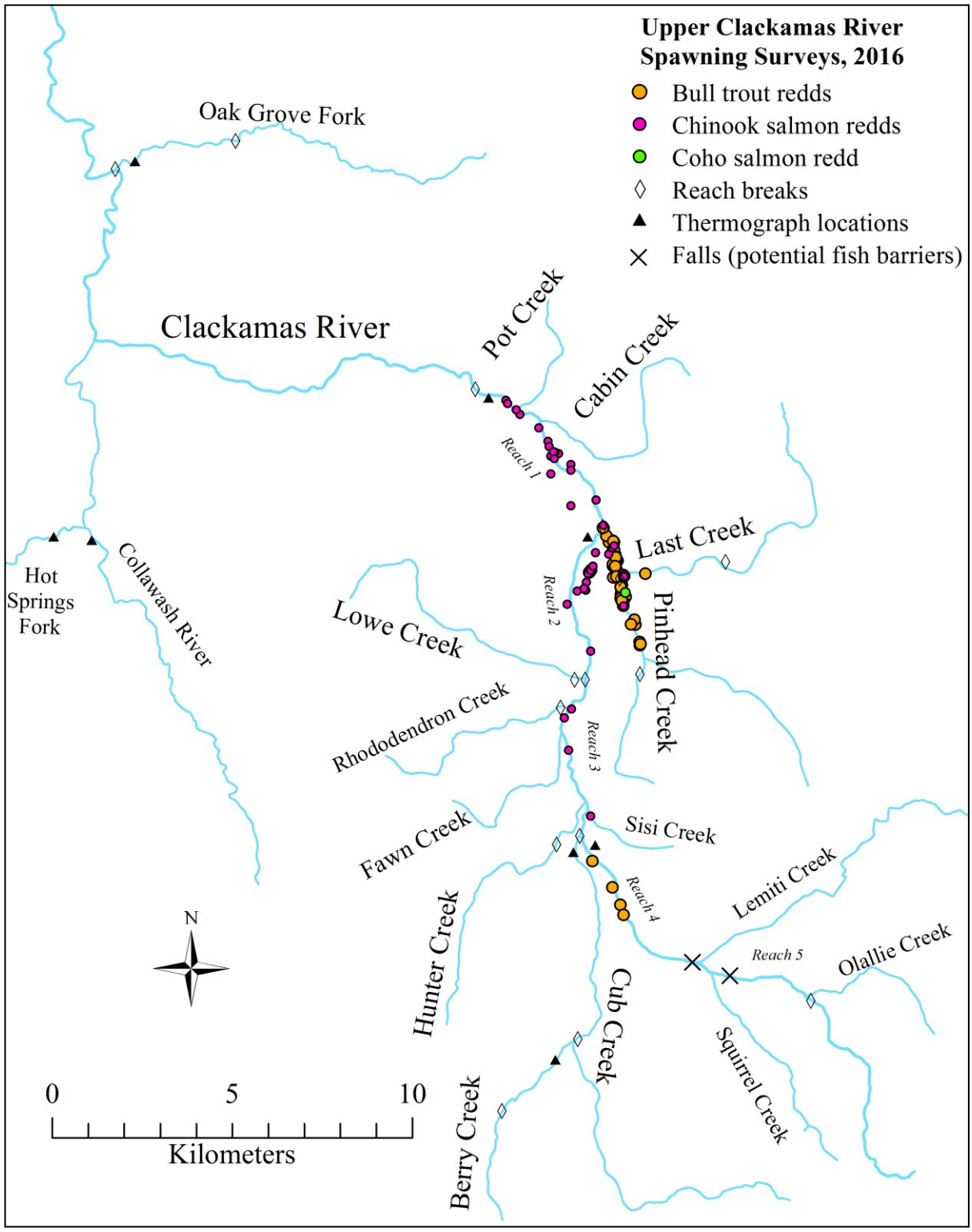

Figure 1. Survey extent, potential natural fish barriers, and salmon and bull trout redds observed during census redd surveys in the upper Clackamas River basin. Each bull trout and coho salmon marker represents a single observed redd. Chinook salmon redds were not individually georeferenced, thus an individual Chinook marker may represent multiple redds (range, 1-30 redds) counted over a survey extent (range, 100-200m). Secondary channels are not shown and redd markers have not been snapped to the stream line.

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

	Census					
Reach	1	2	3	4	5	6
Clackamas River 1	18-Aug	30-Aug	13-Sep	27-Sep	NS	NS
Clackamas River 2	16-Aug	1-Sep	15-Sep	28-Sep	12-Oct	NS
Lowe Creek	16-Aug	1-Sep	15-Sep	28-Sep	12-Oct	NS
Clackamas River 3	16-Aug	NS	15-Sep	28-Sep	12-Oct	NS
Hunter Creek	16-Aug	NS	15-Sep	28-Sep	12-Oct	NS
Rhododendron Cr.	16-Aug	NS	15-Sep	28-Sep	12-Oct	NS
Clackamas River 4	15-Aug	31-Aug	14-Sep	29-Sep	12-Oct	NS
Pinhead Creek 1	17-Aug	29-Aug	12-Sep	26-Sep	12-Oct	26-Oct
Pinhead Creek 2	17-Aug	29-Aug	12-Sep	26-Sep	12-Oct	26-Oct
Last Creek	17-Aug	29-Aug	12-Sep	26-Sep	12-Oct	26-Oct
Cub Creek	15-Aug	NS	14-Sep	NS	NS	26-Oct
Berry Creek	15-Aug	NS	14-Sep	29-Sep	NS	26-Oct
Oak Grove Fork	18-Aug	30-Aug	13-Sep	27-Sep	NS	NS
Total bull trout redds	0	6	16	24	14	8

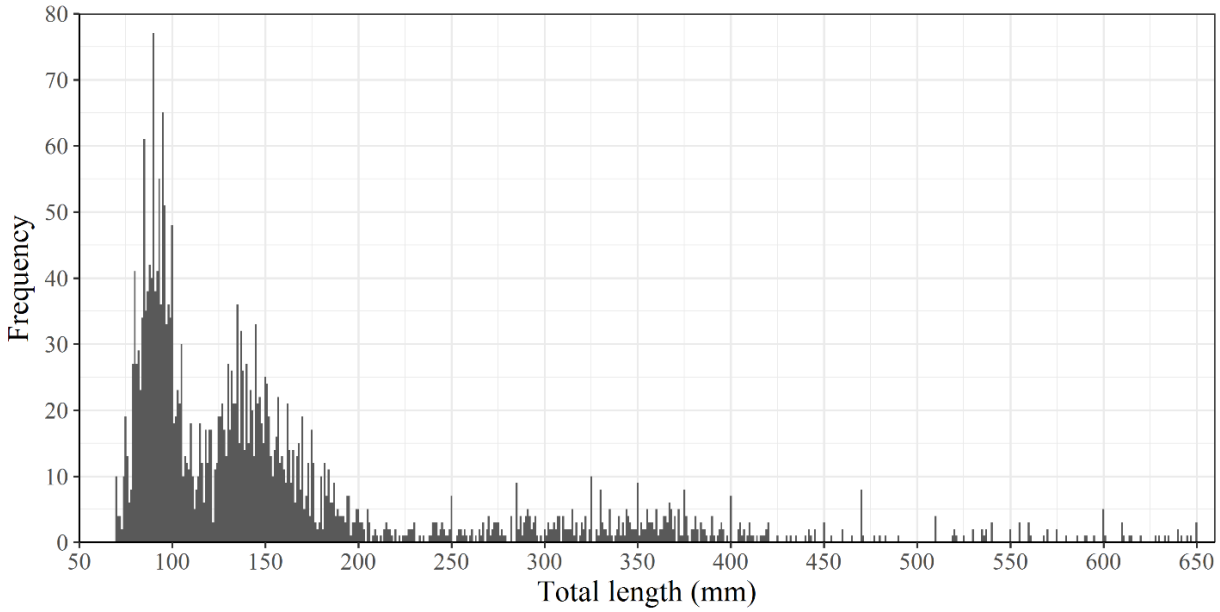

Figure 2. Length-frequency histogram of bull trout captured in the Metolius River basin, PIT-tagged, and translocated to the upper Clackamas River basin, 2011-2016.

brief description of their certainty in each new redd identified and the reason for their uncertainty. These descriptions were entered as a variable in the database. Differing from previous years, only redds identified with descriptors connoting high certainty or likelihood were included in the 2016 count. (See Appendix AI for dataset from 2016.)

Stream temperature

Digital temperature data loggers (Onset™ Hobo Water Temp Pro v2 U-22), or thermographs, set to record stream temperature every 30 minutes, were deployed in 8 locations in the upper Clackamas River on August 18 and recovered on October 10 (Figure 1). Thermographs were successfully recovered from Hot Spring Fork, Collawash River, Clackamas River (Reaches 1, 2, and 4), Cub Creek, and Berry Creek. The thermograph in Oak Grove Fork was not found.

Pinhead Creek monitoring

In the first phase of the reintroduction, bull trout translocated from the Metolius River basin and released in the Clackamas River basin were given PIT tags and a 4-antenna PIT tag array was maintained in Pinhead Creek, near its confluence with the Clackamas River, usually from June through November. The PIT detection site and database are maintained by the USFWS. PIT tag detections in Pinhead Creek were used to describe the annual number, duration, timing, lifestage-at-release, and release location of PIT-tagged bull trout present in Pinhead Creek during the spawning season.

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

Simple linear regression was used to assess the relationship of the annual number of adult PIT-tagged bull trout detected in Pinhead Creek, the response variable (Y), and the total annual count of bull trout redds in Pinhead and Last creeks, the explanatory variable (X), from 2011-2016 (Ramsey and Schafer 1997). The simple linear regression model used is as follows: $\{Y|X\} = \beta_0 + \beta_1 X$. 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 in a monitoring season. This was summarized by year using median, maximum, and minimum duration, excluding individuals detected for ≤1 d. This exclusion attempted to reduce, likely without eliminating, the influence of short-term non-spawning use on the estimated timing of adult use in Pinhead Creek. Timing of adult use of Pinhead Creek was represented by boxplots of first and last detections of individuals during the monitoring season. The annual adult count was displayed by the lifestage at which these fish were released and by their release location. Lifestage was defined in the PIT tag database by the following categories: juvenile, 70-250 mm; subadult, 251-450 mm; and adult, 451-650 mm.

Results and Discussion

Census redd surveys

In 2016 census redd surveys, 68 bull trout redds were counted in the upper Clackamas River basin (Figure 1, Table 3, Appendix AI). This was a 15% increase compared to the number of redds counted in 2015 and an 84% increase compared the redd count in 2014. Similar to previous years, most of the redds were observed in the Pinhead Creek watershed (N=62, Figure 3). The redd count in Pinhead Creek and Last Creek in 2016 exceeded the count in 2015 by 45% (Table 4). Bull trout redds were also observed in reach 2 (Figure 3) and reach 4 (Figure 1) of the Clackamas River. The first bull trout redds were observed in late August, the highest number of new redds were observed in late September census survey, and new redds were observed during the last survey on October 26 (Table 2). Bull trout were seen actively spawning on or occupying three redds. Bull trout redds were distinguished from salmon redds mainly by their dimensions. Chinook and coho salmon redds were on average more than 6 and 4 times larger in area, respectively, than bull trout redds.

Chinook redds were highly abundant in reaches 1 and 2, and present in lower numbers in reach 3, of the Clackamas River (Figure 1). The crew observed three Chinook redds in Pinhead Creek, two of which were occupied by Chinook salmon; a single occupied Chinook redd in Last Creek; and an occupied coho salmon redd in the upper section of Pinhead Creek (Figure 3). The spawning timing of Chinook salmon was the same as bull trout, with the first Chinook redds noted in late August and occupied redds noted during the last survey. The occupied coho redd was recorded during the last survey on October 26.

The temporal and spatial overlap of bull trout and salmon spawning poses challenges to monitoring bull trout abundance with census redd counts. The main challenge is the bull trout redd count could be confounded by a number of factors; some examples include salmon test digs the size of bull

trout redds, small salmon redds counted as large bull trout redds (or vice versa), redd superimposition by salmon may obscure bull trout redds, and higher observer error-rates (depending on variation in observer experience and skill) because observers will be asked to discern redds of multiple salmonid species. This challenge appears to be more acute in reach 1 and 2 of the Clackamas River, where Chinook spawning is highly abundant, than in Pinhead Creek where only five salmon redds were identified. In 2016, census surveys were completed every two weeks throughout the spawning period (August through October), which was more frequent than previous survey intervals. This relatively short interval likely reduced observer uncertainty and error in identifying bull trout redds by increasing the probability of seeing salmon occupying their redds. In 2015, a longer interval led to ambiguity in distinguishing between new redds and some old redds (Starcevich and Clements 2015). This shorter interval likely decreased ambiguity by allowing surveyors to encounter redds sooner after, or during, their construction when redds appear more visible and in higher contrast to undisturbed sediment and redds from a previous season.

Table 3. Bull trout redds counted during census surveys in the upper Clackamas River basin, 2011-2016. In certain years, some stream reaches were not surveyed (NS).

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

Stream temperature

Bull trout are thought to begin spawning as stream temperature drops below 9°C (see Pratt 1992). This temperature threshold can be used to assess when and where there is potential for bull trout spawning in individual reaches of the sampling frame. In 2015, stream temperature was measured and recorded at the start and end of each survey. These data showed that Pinhead Creek, Last Creek, and reaches 1, 4, and 5 of the Clackamas River were below 9°C throughout the bull trout spawning season. Other reaches were near or exceeded the 9°C threshold during the spawning season. In 2016, thermographs were deployed in several of these borderline survey reaches to gain continuous temperature data and better assess these reaches as suitable spawning habitat (Figure 4). These temperature profiles showed that Hot Spring Fork and the Collawash River, based on the 9°C threshold, likely would be too warm for spawning during the spawning period. Reaches 1 and 2 of the Clackamas River, Cub Creek, and Berry Creek did not reach 9°C until early to mid-September and then bordered and occasionally exceeded the threshold during the remainder of the spawning period. Although maximum and minimum temperature thresholds are not known for bull trout spawning, these temperature profiles suggest that currently these reaches may not be ideal spawning habitat every year and climate warming scenarios suggest that borderline areas like these reaches may become even less thermally suitable in the near future (Rieman et al. 2007, Ruesch et al. 2012, Jones et al. 2014). Cub Creek and Berry Creek also have relatively few patches of spawning gravel (personal observation), which further reduces their relative potential to support bull trout reproduction. Reach 4 of the Clackamas River was below 9°C during the spawning period and four bull trout redds were counted; however, it is relatively high gradient and limited in spawning gravel availability (personal observation). The production of a more detailed thermal habitat map and a predictive stream temperature model of the upper Clackamas River basin are recommended to understand better how the current distribution and availability of thermal habitat may be influencing reintroduction progress and how a warming climate may affect future availability of suitable thermal habitat in this basin and region.

Table 4. Census survey redd counts in relation to the number of PIT-tagged adult bull trout detected in the Pinhead Creek watershed and the estimated duration each PIT-tagged adult spent in this watershed basin. Adulthood was defined as fish estimated to be ≥ age-5. Duration was defined as the number of days between the first and last detection at the PIT array in Pinhead Creek.

Census survey		Tagged adult bull trout	Duration (d)		
Year	Redds		Median	Max	Min
2011	5	17	26	78	3
2012	16	17	35	55	12
2013	15	15	25	68	3
2014	37	32	22	93	3
2015	47	53	18	87	2
2016	62	72	26	88	3

Table 5. 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-class at release and the number of days between their release and detection dates (see text for more details).

	Age (yr)					Release location				
Year	≥5	4	3	2	1	Lower Clackamas	Clackamas Reach 1	Pinhead/Last creeks	Clackamas Reach 2	Berry Creek
2011	17	1	2	8	7	5	2	11	11	0
2012	17	2	3	2	8	1	2	13	15	0
2013	15	1	16	276	17	0	2	205	11	0
2014	32	12	21	2	8	5	14	38	9	1
2015	53	32	2	2	10	9	30	41	5	5
2016	72	5	2	0	5	0	29	44	2	4

Pinhead Creek monitoring

The number of adult PIT-tagged bull trout using Pinhead Creek during the spawning season has steadily increased from 15 adults in 2013 to 72 in 2016 (Table 4). The adult count is a subset of the total count of PIT-tagged bull trout detected in Pinhead Creek that also includes fish age-1 through age-4 (Table 5). The total count suggests that bull trout may be using Pinhead Creek watershed for spawning prior to age-5 and for reasons other than spawning, such as juvenile rearing and subadult foraging or thermoregulation.

There was a strong linear relationship ($y=1.3x+3.2$, R-squared=0.92, P-value=0.002) between the annual redd count (x) and the number of adults detected (y) in Pinhead Creek (Figure 5). This suggests that redd counts, which were conducted by experienced surveyors familiar with bull trout and salmon spawning surveys in this basin and region, may be useful in estimating the abundance of adult bull trout in the Pinhead Creek watershed. The linear model shows an almost 1:1 relationship between adults detected and redds counted ($\beta=1.03$). More survey effort in census redd counts did not affect this ratio. Even though census redd surveys in 2016 were conducted much more often than in 2015, the adult to redd ratio was similar in both years (1.12 in 2015 and 1.16 in 2016). This adult to redd ratio is low relative to those of other bull trout populations (see Howell and Sankovich 2012) and may be the result of overestimating redd abundance or underestimating adult abundance. It is possible that some of the redds counted may not be actual bull trout redds; for example, the count may include test digs or, despite efforts to limit these sources of error, redds from a previous season or constructed by salmon. There likely has been some tag loss in translocated fish that have reached adulthood (Meyer et al. 2011). In 2011, the first year of translocations, five redds were counted in Pinhead Creek. Recruits from these redds would be age-5 this season, which is the age at which a proportion of Metolius River bull trout first mature (Ratliff et al. 1996), and these recruits may be undetected members of the adult population. Locally spawned bull trout recruiting to adulthood in Pinhead Creek will increasingly affect this ratio in succeeding years; however, local progeny were not detected during recent electrofishing and minnow-trapping efforts (Brian Davis, USFWS, personal communication). As 2016 is expected to be the last year of translocating PIT-tagged bull trout, the proportion of PIT-tagged bull trout in the spawning population will shrink over time as locally spawned fish enter the adult population and PIT-tagged adults die. As this process occurs, a new method of calibrating

adult abundance to redd counts will be needed.

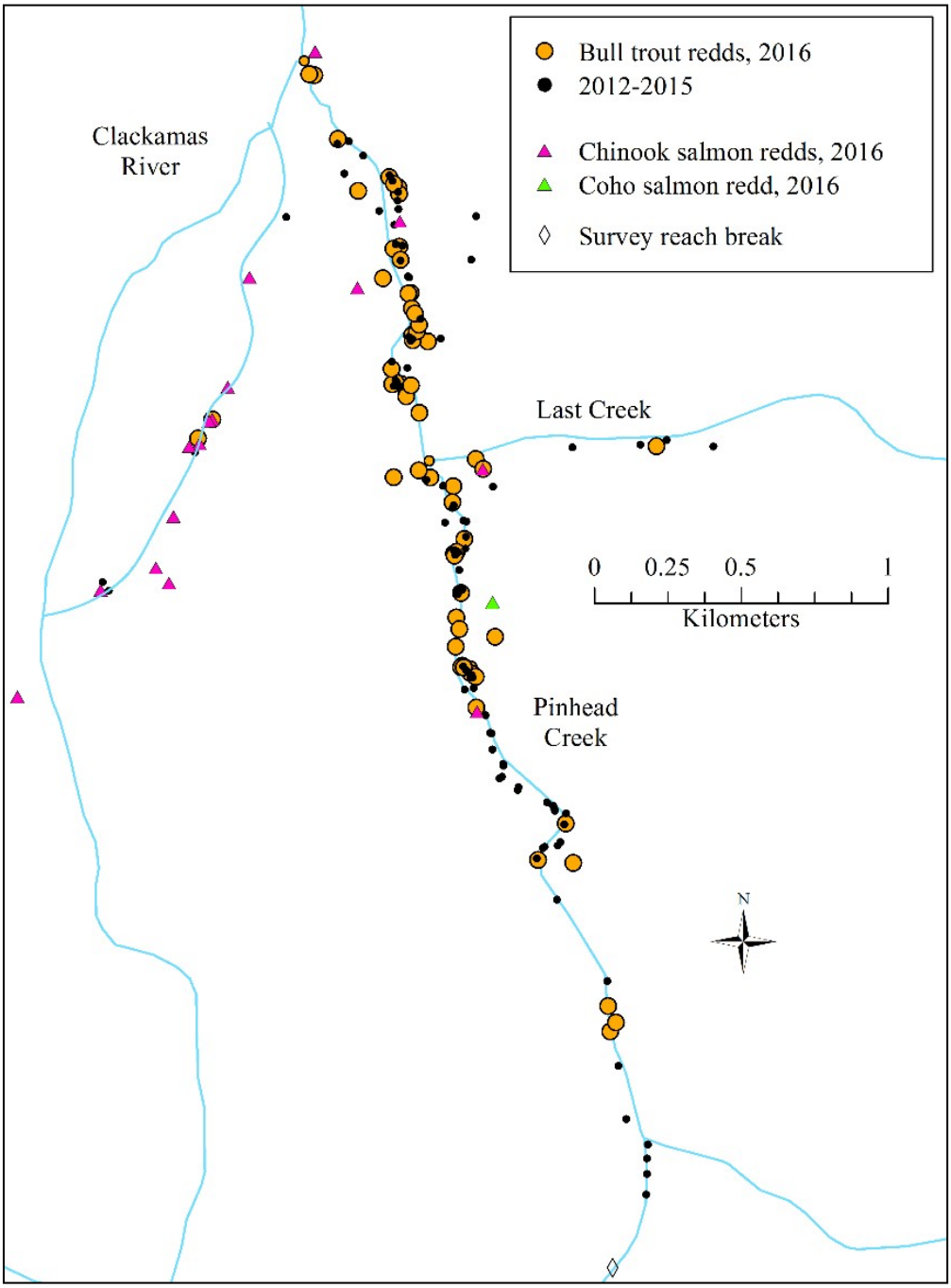

Figure 3. Georeferenced redds in Pinhead Creek, Last Creek, and Reach 2 of the Clackamas River. Each bull trout marker represents a single observed redd. Each Chinook and coho salmon marker represents a single observed redd on Pinhead and Last creeks. In Reach 2 of the Clackamas River, a Chinook marker represent 1 to 15 redds (median, 5). Most secondary channels are not shown and redd markers have not been snapped to the stream line.

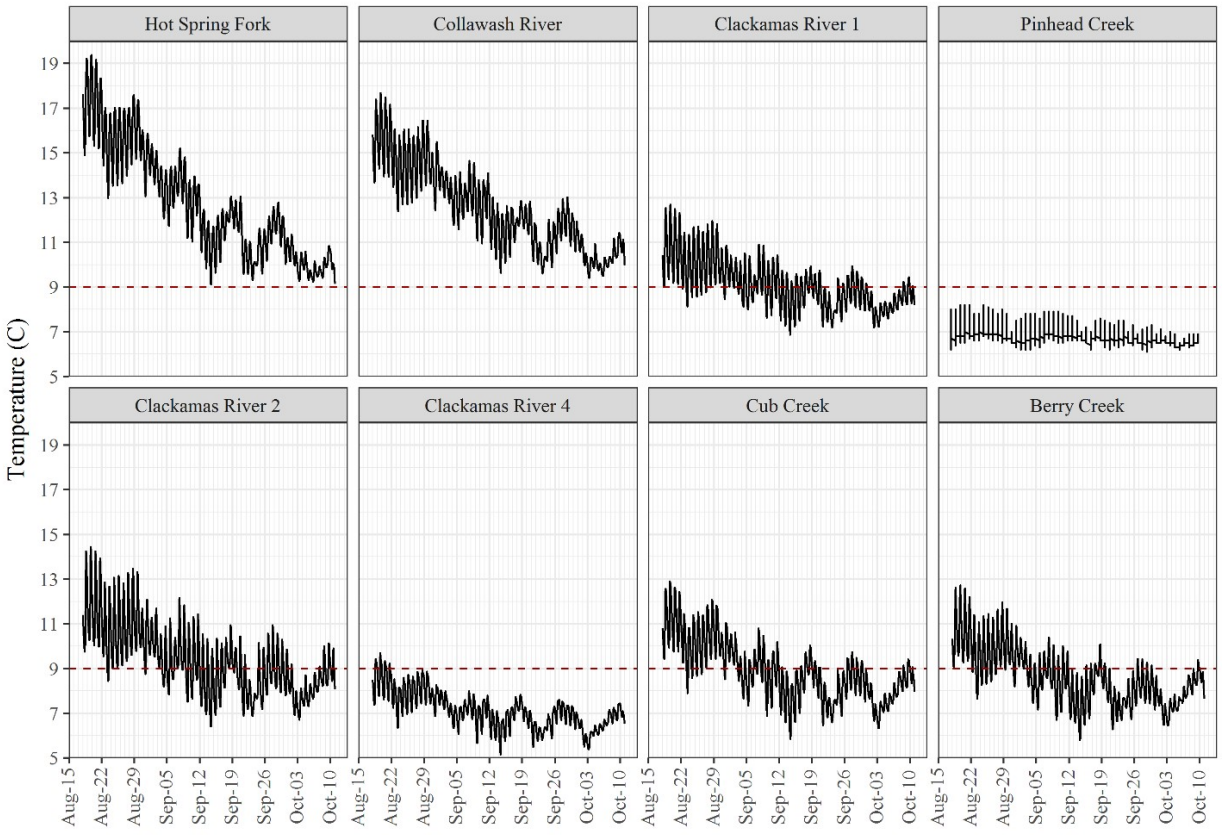

Figure 4. Stream temperatures recorded during bull trout spawning surveys in the upper Clackamas River basin, August 18 to October 10, 2016. Temperature data for Pinhead Creek are from 2011. Red dotted line represents the 9° C threshold considered to be the temperature below which bull trout begin spawning.

The lifestage at which PIT-tagged bull trout were released in the upper Clackamas River basin and subsequently detected at the Pinhead Creek PIT detection site during the spawning season as adults shifted from mostly adult in 2011-2012, to mostly subadult by 2015, and to mostly juvenile by 2016 (Figure 6). The release location of PIT-tagged bull trout (all ages) detected at Pinhead has shifted from mainly the Clackamas River to Pinhead Creek and Last Creek in 2016 and includes fish released as far away as Berry Creek (Table 5). These data show that at least some translocated juveniles and subadults are surviving to adulthood and either returning near their release locations in the Pinhead Creek watershed during the spawning season or finding and using Pinhead Creek during the spawning season even if released in the Clackamas River.

In each year, most PIT-tagged adults were first detected in Pinhead Creek in August and last detected in mid-October (Figure 7), which corresponds to the spawning season seen during redd surveys. It is assumed that adults with detection duration >1 d entered Pinhead Creek to spawn because a high percentage of bull trout redds were observed in this watershed. Based on the detection duration during individual year, adults generally spend 18-35 d in Pinhead Creek during the spawning season (Table 4). This timing information suggests that bull trout have likely completed spawning by mid-October; although, in 2016, eight bull trout redds were counted on

October 26. Adults have been detected in Pinhead Creek as late as November 17; in 2016, the last detection was October 31. This suggest that bull trout could be spawning in the second half of October in Pinhead Creek and may account for at least some of these redds counted during the last survey. It is possible that these redds were constructed by bull trout without PIT tags. Alternatively, these redds may have been missed during previous surveys. These redds were unlikely to be salmon redds because of their relatively small size. PIT tag detection timing at Pinhead Creek provides an approximation of when bull trout are using Pinhead Creek and the Clackamas River and could be useful in designing redd monitoring schedules, training, and protocols that minimize errors in identifying bull trout redds.

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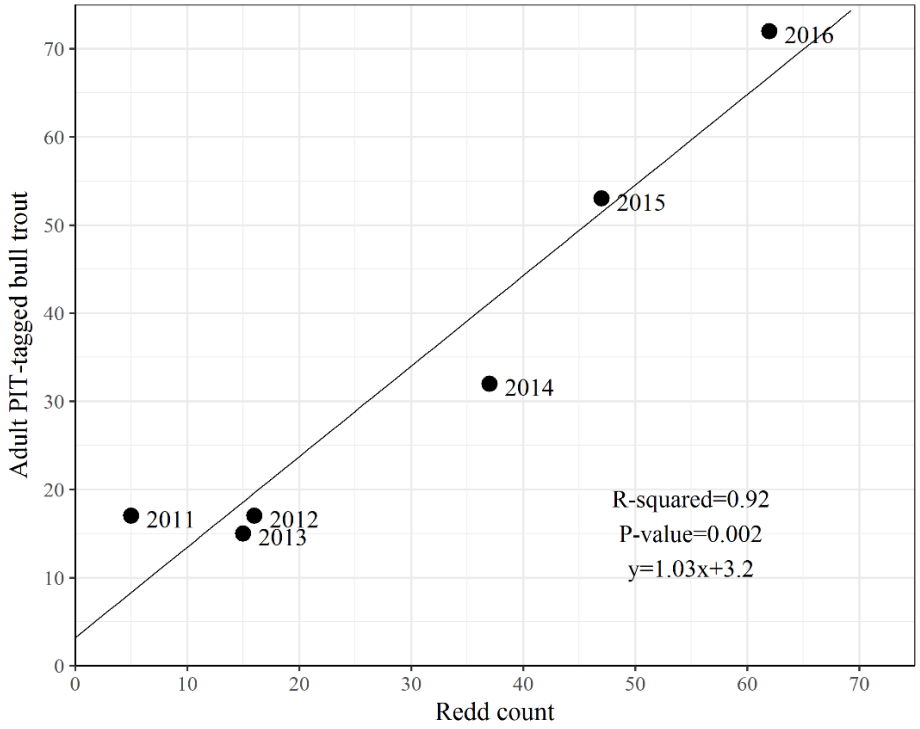

Figure 5. Annual number of adult PIT-tagged bull trout (i.e., age-5 and older) detected in Pinhead Creek during the spawning period as a function of the annual bull trout redd count in Pinhead Creek and Last Creek.

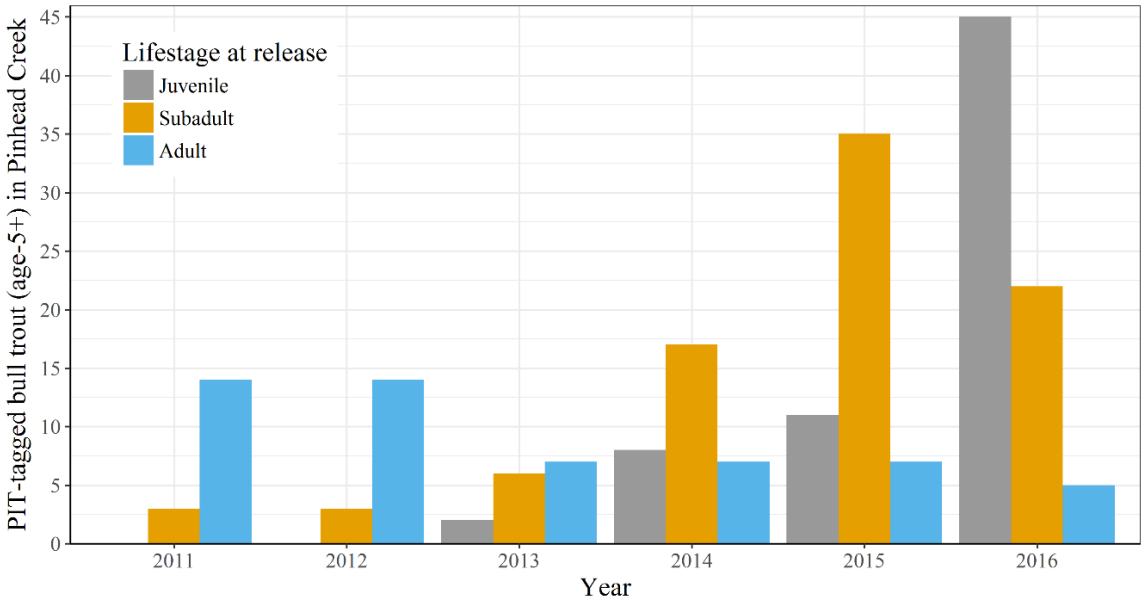

Figure 6. Lifestage at which PIT-tagged bull trout were released into the upper Clackamas River basin and subsequently detected at the Pinhead Creek PIT-array prior to and during the spawning season as adult bull trout (i.e., age-5 and older).

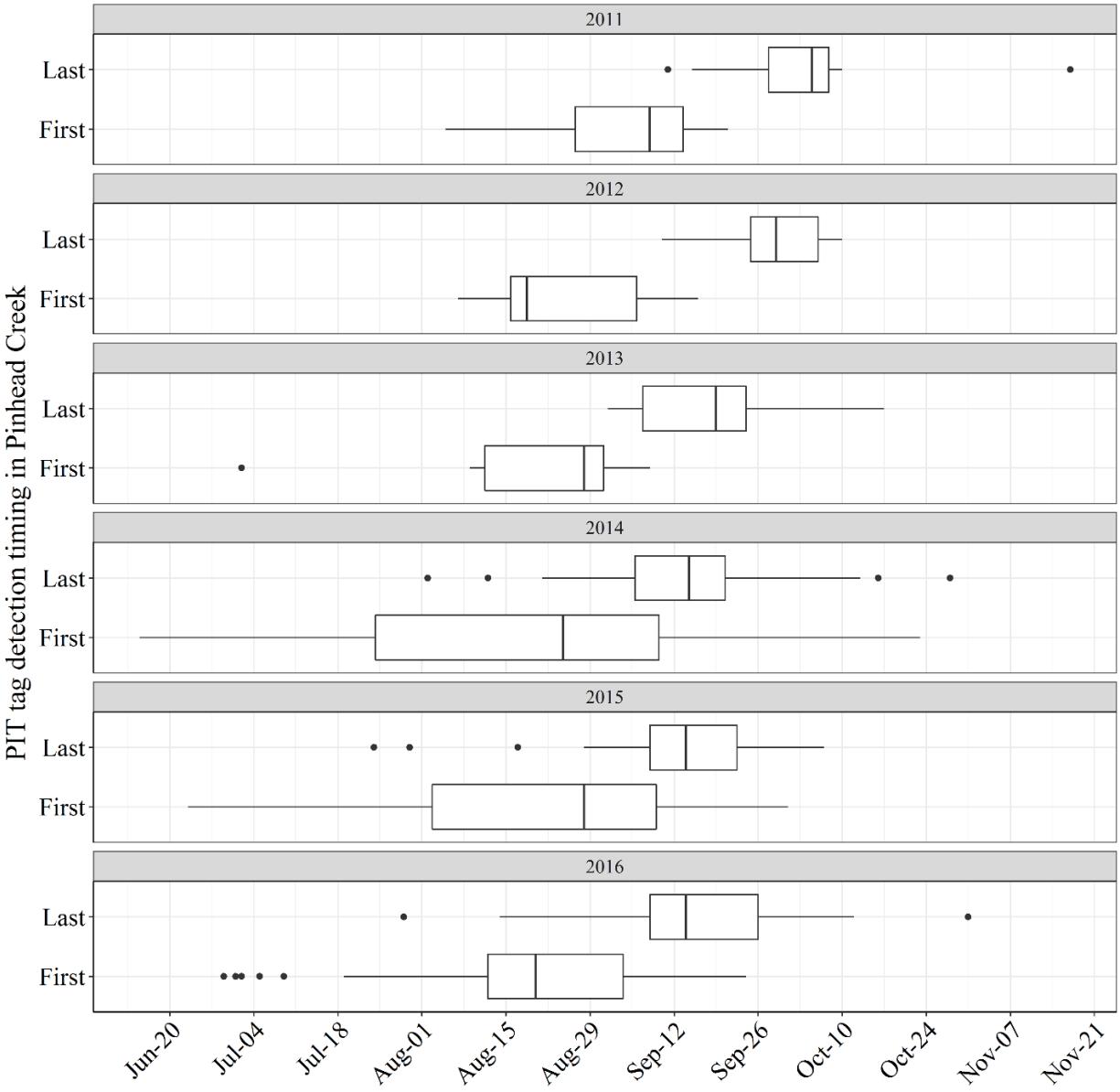

Figure 7. Timing of first and last detection of PIT-tagged bull trout, age-5 and older, at the PIT array near the mouth of Pinhead Creek. The boxplot displays a median line and two middle quartile boxes; the whiskers are defined as 1.5*interquartile range (IQR), outliers are beyond this spread, and together they represent the early and late quartiles. PIT-tagged adults detected ≤1 d were not included in timing analyses.

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Appendix AI. Bull trout redd count data from the Clackamas River basin, 2016.

Stream	Reach	Date	ID	Easting	Northing	LN (cm)	WD (cm)	Feature note
Clackamas River	2	9/28/2016	C1RH	587700	4980471	140	70	BT redd?
Clackamas River	2	9/28/2016	C2RH	587748	4980536	140	100	BT redd, moderate confidence, SS:side channel, unlikely to be chk redd
Clackamas River	4	9/29/2016	C1TC	588565	4971236	200	140	possible chk redd
Clackamas River	4	9/29/2016	C2TC	587788	4972454	180	90	possible chk redd
Clackamas River	4	10/12/2016	D2TCSS	588342	4971719	70	50	Low uncertainty, not well defined pile of gravel but good undercut wood nearby, flagged
Clackamas River	4	10/12/2016	D4TCSS	588652	4970957	110	80	Nice pile of rocks, low uncertainty
Last Creek	1	9/12/2016	B1DP	588570	4980308	190	140	bull trout redd, possibly 2 redds
Last Creek	1	9/26/2016	C1JW	589262	4980444	230	95	0.5m from left bank
Last Creek	1	10/26/2016	E2SS	588671	4980367	250	100	Maybe old redd, but not flagged previously
Pinhead Creek	1	8/29/2016	A1RH	588351	4981361	130	85	new redd on top of old
Pinhead Creek	1	8/29/2016	A1SS	588646	4980401	65	23	small redd
Pinhead Creek	1	9/12/2016	B1TC	588330	4981016	120	110	
Pinhead Creek	1	9/12/2016	B1RH	588483	4980801	140	120	bt redd, possible old redd
Pinhead Creek	1	9/12/2016	B2RH	588424	4980967	100	80	bt redd, small but fresh
Pinhead Creek	1	9/12/2016	B3RH	588393	4980656	140	100	bt redd (gravel not sorted)
Pinhead Creek	1	9/12/2016	B1SS	588491	4980338	55	70	redd/probably test dig/not well sorted/some algaed rocks
Pinhead Creek	1	9/12/2016	B1GM	588373	4980662	130	100	
Pinhead Creek	1	9/26/2016	C1TC	588383	4981326	140	70	
Pinhead Creek	1	9/26/2016	C2TC	588383	4981326	110	60	
Pinhead Creek	1	9/26/2016	C3TC	588416	4980965	170	60	
Pinhead Creek	1	9/26/2016	C4TC	588429	4980823	120	70	
Pinhead Creek	1	9/26/2016	C5TC	588431	4980805	200	90	BT on redd, confirmed
Pinhead Creek	1	9/26/2016	C2SS	588090	4981711	200	95	definite redd, good pocket/mound
Pinhead Creek	1	9/26/2016	C3SS	588096	4981708	170	90	definite redd
Pinhead Creek	1	9/26/2016	C4SS	588361	4980656	70	70	small, clear digging, test dig?
Pinhead Creek	1	9/26/2016	C1RH	588385	4981304	240	130	BT redd, confident
Pinhead Creek	1	9/26/2016	C3RH	588386	4981124	200	150	BT redd, bull trout on redd

Stream	Reach	Date	ID	Easting	Northing	LN (cm)	WD (cm)	Feature note
Pinhead Creek	1	9/26/2016	C4RH	588446	4980836	180	100	BT redd? Small, fine substrate, small pebbles
Pinhead Creek	1	10/12/2016	D2PL	588245	4981314	180	110	large redd, no fines
Pinhead Creek	1	10/12/2016	D6PL	588365	4981117	80	50	100% certain, small but defined
Pinhead Creek	1	10/12/2016	D7PL	588409	4980614	60	30	SS:new redd?
Pinhead Creek	1	10/12/2016	D8PL	588454	4980558	100	60	confirmed new redd by ss
Pinhead Creek	1	10/12/2016	D1JW	588390	4981079	180	100	best defined redd of day, same loc at 2014
Pinhead Creek	1	10/12/2016	D1RH	588176	4981491	120	60	BT redd, moderate confidence
Pinhead Creek	1	10/12/2016	D1TC	588453	4980858	100	70	Possible BT redd, kind of small
Pinhead Creek	1	10/12/2016	D2RH	588359	4980708	140	60	BT redd, confident
Pinhead Creek	1	10/12/2016	D3RH	588366	4980339	160	80	BT redd, 75% confident
Pinhead Creek	1	10/12/2016	D1SS	588079	4981712	100	60	under log, definite redd
Pinhead Creek	1	10/26/2016	E2TC	588367	4981338	160	150	50/50 redd/test; maybe old chk next to new BT
Pinhead Creek	1	10/26/2016	E3TC	588428	4980914	190	90	90% confident of BT or coho redd (if coho spawn here)
Pinhead Creek	1	10/26/2016	E4TC	588438	4980897	160	100	90% confident of BT redd
Pinhead Creek	1	10/26/2016	E5TC	588425	4980652	130	90	60% confident of BT redd
Pinhead Creek	1	10/26/2016	E6TC	588452	4980362	200	100	75% confident of BT redd
Pinhead Creek	2	8/29/2016	A1RH	588596	4979944	130	80	BT redd?
Pinhead Creek	2	8/29/2016	A2RH	588712	4979795	300	120	confident BT redd
Pinhead Creek	2	8/29/2016	A3RH	588712	4979795	110	90	confident BT redd
Pinhead Creek	2	8/29/2016	A4RH	588978	4979025	240	110	
Pinhead Creek	2	9/12/2016	B1RH	588572	4980079	200	130	bt redd, large redd, gravel sorted
Pinhead Creek	2	9/12/2016	B2RH	588600	4979696	200	130	bt redd, confident
Pinhead Creek	2	9/12/2016	B3RH	588596	4979691	190	100	bt redd, confident
Pinhead Creek	2	9/12/2016	B4RH	588624	4979685	230	130	bt redd, large gravel and cobble kicked up
Pinhead Creek	2	9/12/2016	B5RH	588628	4979671	210	120	
Pinhead Creek	2	9/12/2016	B6RH	588646	4979659	130	60	bt redd, finer gravel substrate
Pinhead Creek	2	9/12/2016	B7RH	588648	4979554	180	110	bt redd
Pinhead Creek	2	9/12/2016	B1SS	589104	4978451	80	40	small redd, distinct digging edge, clean gravel, not well sorted

Stream	Reach	Date	ID	Easting	Northing	LN (cm)	WD (cm)	Feature note
Pinhead Creek	2	9/12/2016	B2SS	589097	4978537	170	60	not fluffed up, some algaed rocks, maybe last seasons redd?
Pinhead Creek	2	9/26/2016	C6TC	588566	4980253	110	80	BT redd, confident
Pinhead Creek	2	9/26/2016	C5RH	588580	4979861	120	60	BT redd, confident
Pinhead Creek	2	9/26/2016	C7TC	588590	4979821	130	90	BT redd, confident
Pinhead Creek	2	9/26/2016	C8TC	588578	4979761	110	80	BT redds side by side
Pinhead Creek	2	9/26/2016	C9TC	588578	4979761	160	90	Bt redds side by side
Pinhead Creek	2	9/26/2016	C10TC	588605	4979690	180	120	
Pinhead Creek	2	9/26/2016	C11TC	588953	4979159	150	80	BT redd?
Pinhead Creek	2	9/26/2016	C1SS	589123	4978481	95	120	95% certain redd, left bank, OHV
Pinhead Creek	2	10/12/2016	D4RH	588607	4980128	120	80	BT redd 90% confident
Pinhead Creek	2	10/12/2016	D5RH	588581	4980085	150	90	BT redd/Chk redd 50/50 call
Pinhead Creek	2	10/26/2016	E7TC	588574	4980071	180	80	80% confident BT/maybe Chk
Pinhead Creek	2	10/26/2016	E1EM	588858	4979035	200	90	90% confident BT redd

Appendix B

Comprehensive Detection Histories for Bull Trout Detected at PGE Facilities During 2016

Telemetry Code	PIT Tag Code	Size at Tagging or Recapture (TL)	Date Released (*), Detected or Recaptured	Location Released (*), Detected, or Recaptured
NA	**982_000361679388**	**157 mm**	**5/1/2015**	**Berry Creek Bridge***
			2/18/2016	PIT Detect – DS Migrant Collector (NF Dam)
			2/18/2016	Timber Park D/S Sampling Facility
166	**0000_0000000177419566**	**368 mm**	**7/12/2012***	**Clackamas R. (4670 Side Channel)***
			7/14/2012	PIT Detection – Pinhead Cr. Array (mouth)
			8/2/2012 to 11/6/2012	Mobile Telem. 1-2 mi US of 4670
			11/13/2012	Mobile Telem. 1 mi US of 4680 rd.
			11/20/2012	Mobile Telem. US of Pinhead Cr. in Clack.
			2/8/2013	Mobile Telem. 2 mi US from Collawash
			3/7/2013	Mobile Telem. 1.2 mi DS Austin HS Gate
			5/14/2013	Mobile Telem. 1.5 mi US of Collawash
			5/24/2013	Fixed Telem. Near Pinhead Cr. Mouth
			6/19/2013 to 6/21/2013	Fixed Telem. Near Pinhead Cr. Mouth
			7/15/2013 to 7/30/2013	Mobile Telem. Near 4670 Bridge
			8/11/2013	Fixed Telem. Collawash Confluence
			8/12/2013	Fixed Telem. Oak Grove Powerhouse
			8/12/2013	Mobile Telem. 1.5 mi DS of Oak Grove
			8/28/2012 to 8/29/2012	Fixed Telem. North Fork Dam
			9/9/2013	Mobile Telem. Lazy Bend Campground
			9/16/2013 to 11/12/2013	Mobile Telem. Big Eddy area
			7/12/2014	Timber Park D/S Sampling Facility
			7/17/2014	PIT Detection – River Mill Ladder
			7/27/2014	PIT Detection – River Mill Surface Collector
			8/1/2014	PIT Detection – River Mill Ladder
			5/9/2015	PIT Detection – North Fork Ladder Entrance
			5/13/2015 to 5/14/2015	PIT Detection – North Fork Old Sort Facility
			5/17/2015	PIT Detection – River Mill Surface Collector
			5/28/2015	PIT Detection – River Mill Ladder
			9/6/2015	PIT Detection – River Mill Surface Collector
			9/11/2015	PIT Detection – River Mill Ladder
			4/26/2016 to 4/29/2016	PIT Detection – North Fork Ladder Entrance
			4/29/2016	PIT Detection – N. F. Old Sorting Facility
		~ 660 mm	5/1/2016	North Fork Adult Sorting Facility
			6/8/2016	PIT Detection – Pinhead Cr. Array (mouth)
20	**0000_0000000177419300**	**381 mm**	**6/20/2013**	**Lower 4650 Bridge D/S***
			6/27/2013 to 7/16/2013	Fixed Telem. Oak Grove Powerhouse
			7/15/2013 to 11/4/2013	0.1 to 4.4 miles US of Austin/4650 Br.
			11/18/2013	In Collawash, near 1st Bridge (0.5 miles US)
			7/7/2015	PIT Detection – Pinhead Cr. Array (mouth)
			8/31/2015	PIT Detection – Pinhead Cr. Array (mouth)
			5/23/2016	PIT Detect – DS Migrant Collector (NF Dam)
			5/23/2016	Timber Park D/S Sampling Facility
			6/7/2016	PIT Detection – River Mill Ladder
			6/8/2016	PIT Detection – North Fork Old Sort Facility
		570 mm	6/9/2016	North Fork Adult Sorting Facility
			6/9/2016	PIT Detection – North Fork Ladder Exit
			7/28/2016 to 7/30/2016	PIT Detection – Pinhead Cr. Array (mouth)
			8/27/2016 to 8/29/2016	PIT Detection – Pinhead Cr. Array (mouth)
			9/10/2016 to 9/15/2016	PIT Detection – Pinhead Cr. Array (mouth)
NA	**900_228000527852**	**640 mm**	**5/31/2016**	**North Fork Adult Sorting Facility***
			5/31/2016	PIT Detection – North Fork Ladder Exist

Telemetry Code	PIT Tag Code	Size at Tagging or Recapture (TL)	Date Released (*), Detected or Recaptured	Location Released (*), Detected, or Recaptured
33	**0000_0000000177419401**	**354 mm**	**6/6/2013**	**DS of Austin H.S.***
			7/15/2013 to 9/30/2013	Mobile Telem. US of Collawash Confluence
			9/28/2013 to 9/30/2013	Fixed Telem. Collawash Confluence
			10/22/2013 to 12/2/2013	Fixed Telem. Collawash Confluence
			11/4/2013	Mobile Telem. Riverside CG
			1/7/2014To 10/30/2014	Fixed Telem. Collawash Confluence
			8/30/2015 to 9/17/2015	PIT Detection – Pinhead Cr. Array (mouth)
			7/29/2016	PIT Detect – Fl. Surface Collector (NF Dam)
			7/30/2016	Timber Park D/S Sampling Facility
NA	**982_000361679147**	**289 mm**	**6/5/2014**	**D/S of 4650 Bridge***
			7/30/2016	PIT Detection – River Mill Ladder
			8/1/2016	PIT Detection – North Fork Ladder Entrance
			8/1/2016	PIT Detection – North Fork Old Sort Facility
			8/3/2016	PIT Detection – River Mill Surface Collector
			8/6/2016	PIT Detection – River Mill Ladder
			8/8/2016	PIT Detection – River Mill Surface Collector
			8/7/2016	PIT Detection – River Mill Ladder
			9/21/2016	PIT Detection – North Fork Ladder Entrance

Appendix C

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 C1) relative to the Stepwise Impact Reduction Plan (USFWS 2011) and the minimum thresholds identified in Table 2 therein.

Table C1. Summary of adult, juvenile and smolt/adult counts for coho salmon, spring 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	2016*
Coho	Adult	2,160	The adult counts are below the threshold and have only exceeded the threshold (2013, 2014) in two years since implementation of this project.
	Juvenile	54,431	The juvenile counts are above the threshold and have exceeded the threshold in all years since implementation of this project.
	Smolts/adult	38.1	The estimated smolts/adult are above the threshold and have exceeded the threshold in all years since implementation of this project.
Spring Chinook	Adult	780	The adult counts are above the threshold and have exceeded the threshold in all years since implementation of this project.
	Juvenile	6,237	The juvenile counts are above the threshold and have exceeded the threshold in all years since implementation of this project.
	Smolts/adult	3.1	The estimated smolts/adult are above the threshold and have exceeded the threshold in all years since implementation of this project.
Steelhead	Adult	600	The adult counts are above the threshold and have exceeded the threshold in all years since implementation of this project.
	Juvenile	20,374	The juvenile counts are above the threshold and have exceeded the threshold in all years since implementation of this project.
	Smolts/adult	10.2	The estimated smolts/adult are above the threshold and have exceeded the threshold in all years since implementation of this project.

* Annual data provided by Nick Ackerman, PGE.

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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.

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Oregon Department of Fish and Wildlife

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