U.S. Fish and Wildlife Service

Clackamas River Bull Trout Reintroduction Project

2023 Annual Report

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U.S. Fish and Wildlife Service

Columbia River Fish and Wildlife Conservation Office

On the cover: *Silhouette of a large female Bull Trout approaching the adult trap at the Pinhead Creek video weir, Clackamas River Subbasin (Photo by M. Barrows, USFWS).*

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CLACKAMAS RIVER BULL TROUT REINTRODUCTION PROJECT 2023 ANNUAL REPORT

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CLACKAMAS BULL TROUT REINTRODUCTION PROJECT
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Bull Trout (*Salvelinus confluentus*) were last documented in the Clackamas River in 1963. Over four decades later, a 2007 feasibility study determined the Clackamas River Subbasin to be a promising candidate for Bull Trout reintroduction. In 2011, the first phase of a multi-agency reintroduction effort began, with the overall goal of re-establishing a self-sustaining population of spawning adults by the year 2030. Releases of translocated Bull Trout from the Metolius River Subbasin to the upper Clackamas River and select tributaries began in 2011 and continued through 2016. During 2023, we continued to make progress toward the project's goal by monitoring and evaluating the reintroduction effort. Bull Trout spawning activity, population trends and recruitment of locally-born progeny into the spawning population were assessed. A video monitoring weir with an adult trap and passive integrated transponder (PIT) antennas were employed to assess the spawning population in Pinhead Creek. A population of 35 individuals was estimated from fish that were captured, detected, or observed at the weir. Thirteen (37%) were female and an estimated 22 (63%) were male. None of the males possessed PIT tags and seven (54%) of the females were translocated fish that had retained their PIT tag following their release as juveniles and subadults in 2013 – 2016, confirming their survival and recruitment into the spawning adult population. Nine migratory fish, ranging in size from 322 – 720 mm in total length were subsampled at the weir trap, of which five were female and four were male. The females (mean, 704 mm TL; range, 685 – 720 mm TL) were on average much larger in length than the males (mean, 425 mm TL; range, 322 – 482 mm TL). Measurements from trapped fish and laser scaling estimates from video determined that small adult Bull Trout (ie., 300 – 500 mm TL) comprised 63% of the total spawning population in 2023. This percentage was a notable increase from 19% in 2022 and very few fish smaller than 500 mm were observed from 2017 – 2021. This may suggest an upward trend in natural recruitment into the spawning population. Redd counts reached a high of 89 during 2017 but declined to 18 in 2023 for a spawner/redd ratio of 1.9. Thirty-three tissue samples from untagged fish collected at the weir from 2017 – 2023 were submitted for genetic analysis and to evaluate the recruitment of locally-born progeny into the spawning population. Of the 33 samples, 24 were translocated fish that had shed their tags, 7 had at least one translocated fish as a parent, indicating they were locally-born and 2 could not be categorized as translocated or locally-born (i.e., origin unknown). All of the locally-born fish were sampled during 2022 and 2023 and 71% were less than 500 mm in length. Translocation fish represented both parents for three of the samples and a single parent for four of the samples. No notable trends in parentage were evident. Monitoring via eDNA was used to compare the temporal patterns of presumed occupancy in Pinhead Creek and two reference streams containing stable, self-sustaining populations of Bull Trout. Monthly sampling yielded differences between the Pinhead Creek system and Cougar Creek (N.F. Lewis River) and Jack Creek (Metolius River). Bull Trout DNA was consistently and repeatably detectible in the reference streams year-round, indicating the presence of spawners, embryos, rearing juveniles or residents. However, DNA was consistently and repeatably detectible in the Pinhead system only during the spawning season and was intermittently detectable around the spawning season and not detected during some months. This pattern may suggest very few or no Bull Trout rear year-

round in Pinhead and Last creeks. Implementation, monitoring and evaluation of the reintroduction project will continue in 2024 and will be adaptively managed.

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Introduction

Bull Trout (*Salvelinus confluentus*) are native to the Pacific Northwest and Canada. A widespread decline in abundance across their native range compelled the U.S. Fish and Wildlife Service (USFWS) to list Bull Trout as threatened under the Endangered Species Act (ESA) in 1999 (64FR 58910). Bull Trout also require very specific habitat conditions including clean and cold water with complex, connected habitats (Rieman and McIntyre 1995; Selong et al. 2001; USFWS 2015a). Bull Trout exhibit a very complex continuum of life histories involving movements, migrations, spawning, rearing and foraging on time scales ranging from daily to annually or longer, and over different spatial scales (Schaller et al. 2014). A range of human activities, including but not limited to habitat degradation, migration barriers and the introduction of non-native species have negatively influenced Bull Trout populations (Fraley and Shepard 1989; Leary et al. 1993; Schaller et al. 2014). At the time of listing in 1999, Bull Trout were estimated to occupy only 40 percent of their historical range within Oregon, Washington, Idaho, Montana and Nevada (USFWS 2002a).

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

Progress has continued in the thirteenth year (2023) of the joint effort between the Oregon Department of Fish and Wildlife (ODFW), USFWS, U.S. Forest Service (USFS), and other collaborators (i.e., the Confederated Tribes of Warm Springs Reservation [CTWSR], National Marine Fisheries Service [NMFS], Portland General Electric [PGE], and the U.S. Geological Survey [USGS)]) to reintroduce Bull Trout into the Clackamas River. This project was implemented following publication of a final rule establishing a nonessential experimental population of Bull Trout in the Clackamas River under section 10(j) of the ESA (76 FR 35979 on June 21, 2011). Bull Trout were translocated to the Clackamas River Core Area from healthy populations in the Metolius River Subbasin from 2011 through 2016 (ODFW 2012; Barrows et al. 2016). During this timeframe, 2417 juvenile, 371 subadult and 80 adult Bull Trout were released into the upper Clackamas River and select tributaries (Table 1). No additional Bull Trout translocations to the Clackamas River Subbasin are currently planned.

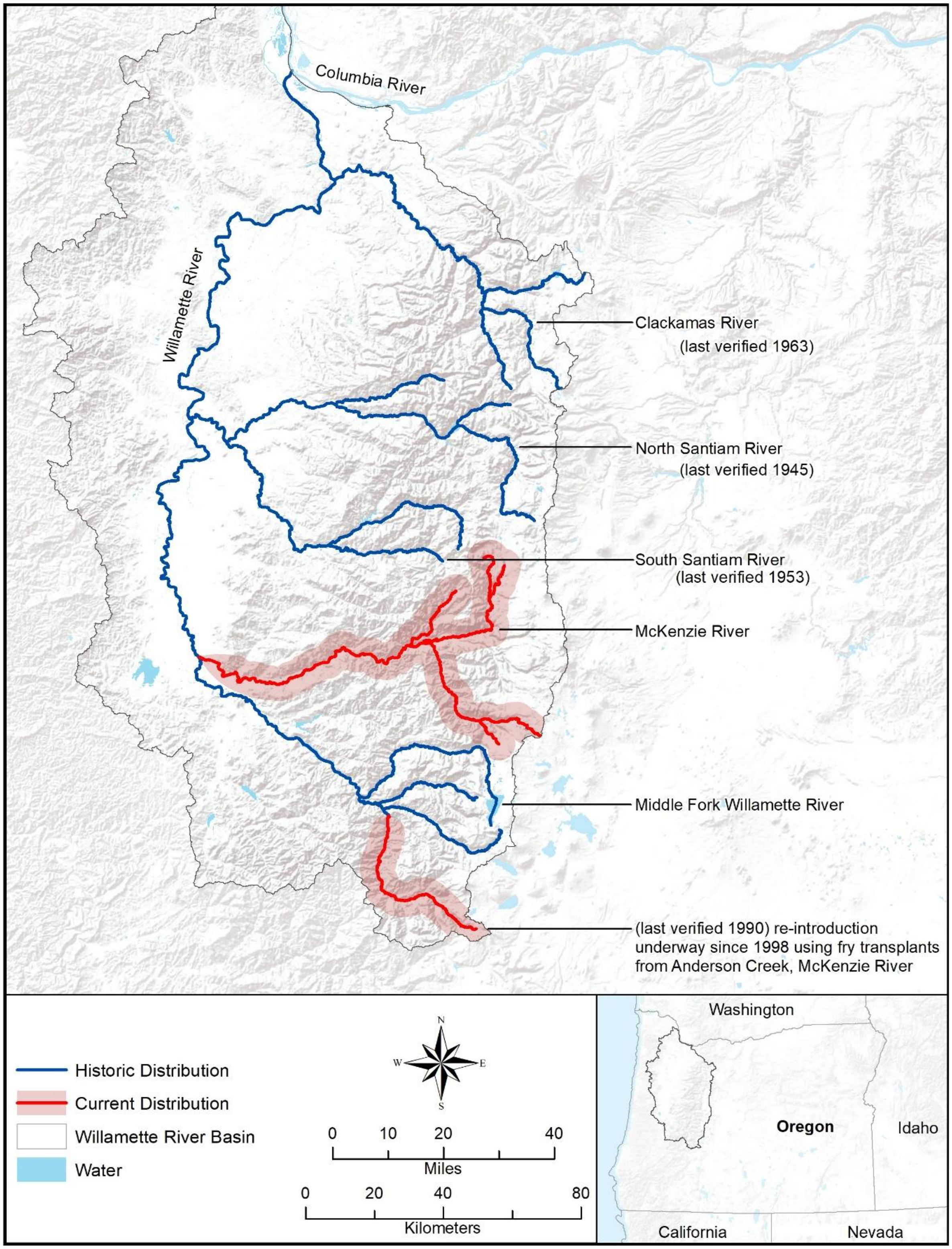

Figure 1. Historical and current Bull Trout distribution in the Willamette River Basin.

Table 1. PIT-tagged Bull Trout translocated from the Metolius River Subbasin to the Clackamas River Subbasin during the first phase of the reintroduction project. Lifestage was defined by the size classes 70-250 mm (juvenile), 251-450 mm (subadult), 451-650 mm (adult). Table is from Clackamas River Bull Trout Reintroduction Project: Characterizing status and thermal habitat suitability in 2017 with census redd counts, PIT tag technology, eDNA surveys, and water temperature data loggers (Table 1 in Starcevich 2018).

Year	Location	Juvenile	Subadult	Adult	Date (Min)	Date (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**

The overall goal of the Clackamas River Bull Trout reintroduction is to re-establish a self-sustaining Bull Trout population of 300 – 500 spawning adults in the Clackamas River Subbasin by 2030. For this project, a self-sustaining population is defined as one that maintains an annual spawning abundance greater than 100 adults, exhibits a level of genetic diversity similar to the donor stock, and requires no additional translocations. The amount of suitable habitat within the Clackamas River Subbasin suggests there is the necessary habitat to support a population of 300 – 500 spawning adults. However, 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 goal of 300 – 500 spawning adults originated with recovery planning targets set in the Bull Trout Draft Recovery Plan (USFWS 2002b) for the abundance necessary to achieve these characteristics. Accomplishing this goal will help achieve conservation and recovery goals within the Coastal Recovery Unit (USFWS 2015b).

This report summarizes the results of operating a video weir, adult trap and PIT detection antennas to estimate the abundance and composition (tagged or untagged) of the fluvial Bull Trout spawning population in Pinhead Creek during 2023. The relationship between the population estimate and 2023 redd counts in Pinhead Creek was used to estimate the spawner to redd ratio in Pinhead Creek. Results from the genetic analysis to evaluate recruitment of locally-born progeny and to assess parentage from tissue samples from untagged fish collected at the weir from 2017 – 2023 are summarized. Additionally, results from monthly eDNA sampling (conducted in 2021 – 2022), in part to determine its efficacy as a tool, but specifically to compare the DNA pattern in Pinhead Creek with that of stable and self-sustaining population of Bull Trout are summarized.

Study Area

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

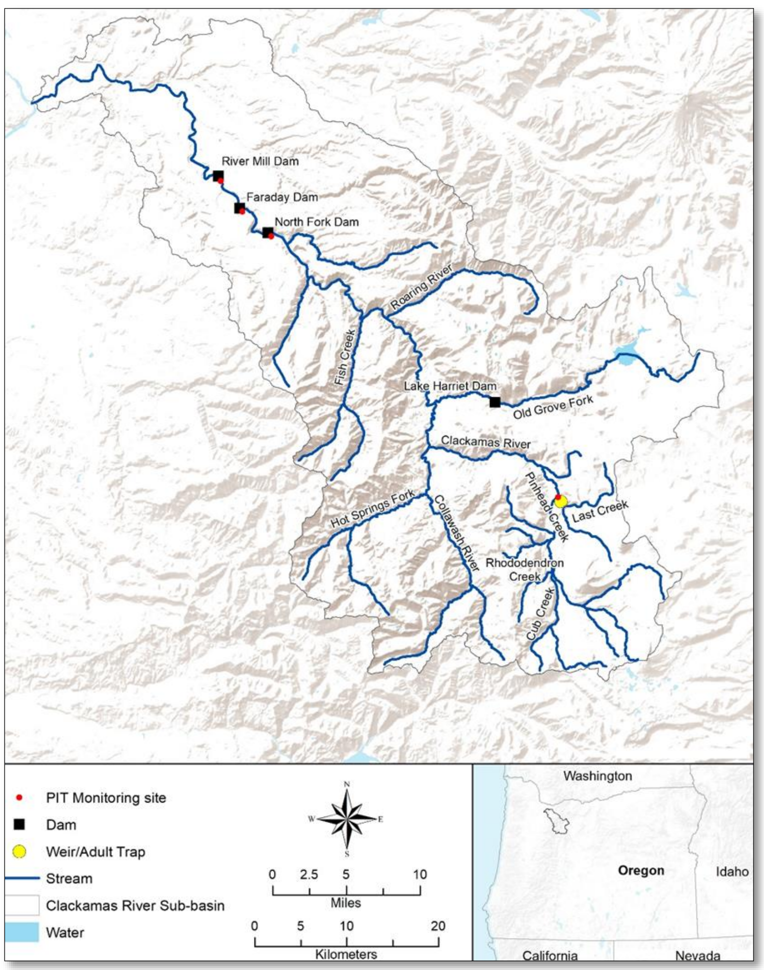

Figure 2. Locations of current monitoring sites in the study area. Multiple PIT monitoring antennas are located throughout PGE's hydro power facilities. A PIT tag monitoring site was installed with the Pinhead Creek weir and was operational from mid-July through early October 2023.

Methods

Pinhead Creek Spawning

Throughout the reintroduction effort, Pinhead Creek has appeared to be the primary spawning tributary for Bull Trout in the Clackamas River Subbasin. A video weir and an incorporated adult trap were operated to monitor and assess the spawning Bull Trout population in Pinhead Creek. Census redd surveys were also used to monitor the spawning Bull Trout population in Pinhead Creek and other known spawning tributaries and reaches within the Clackamas River Subbasin in 2023 (Starcevich 2022). During 2023, the following objectives were addressed:

1. Estimate the number of Bull Trout spawners in tributaries and select reaches in the upper Clackamas River.
2. Determine the spawner/redd ratio for Pinhead and Last creeks
3. Document whether natural production occurred in Pinhead Creek.

Video Weir and Adult Trap

Since 2017, a two-way fixed picket weir and underwater video detection system has been operated in Pinhead Creek, a tributary to the Clackamas River during the spawning season. In 2023, the weir was installed between Last Creek and the NF-46 bridge, about 150 m upstream from the mouth of Pinhead Creek on July 24, 2023 (Figure 2). The weir layout in 2023 closely resembled the design used from 2017 – 2022 (Barrows et al. 2018, 2019, 2021, 2022, 2023). The video chute and upstream trap box were positioned in parallel on river right and both picket leads were angled to direct fish to the chute and trap box (Figure 3). During periods when fish were not sampled via the trap box, fish were able to migrate in either direction through the video chute. A PIT antenna was attached to the upstream opening of the video chute to monitor movements of individual PIT-tagged fish. A channel-spanning HDX PIT tag antenna was installed just below the Pinhead Creek video weir as well. When the upstream trap box was set (i.e., open), an exclusion gate (Figure 4) was added to the video chute to prevent fish from moving upstream while allowing fish to migrate downstream unimpeded and be monitored. The leads were constructed using schedule 40 aluminum pipe strung together with two 9.5 mm (3/8 inch) cables with 19 mm (¾ inch) spacers between each picket (Figure 5). T-posts were used to support the leads while sandbags were placed along the bottom of each of the leads and along the banks to make the weir fish-tight. A velocity break was installed just downstream of the video chute and trap entrance. Thiscreated an area of slower velocity where a fish could stage before moving into the trap or upstream through the video chute.

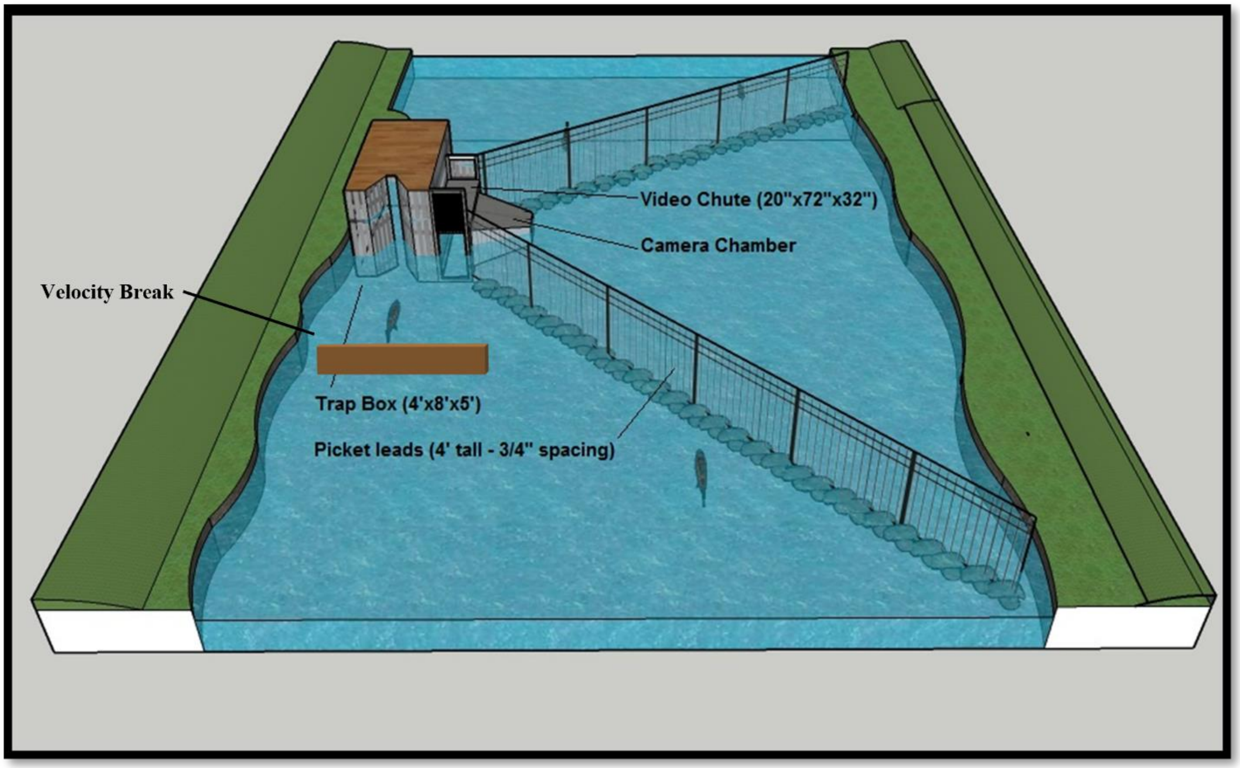

Figure 3. Schematic of the Pinhead Creek weir and trap.

Figure 4. Exclusion gate for video chute.

Figure 5. Photo depicting the aluminum picket leads, video chute and trap box deployed in Pinhead Creek.

Components of the underwater video monitoring system that was used from 2017 through 2022 (Barrows et al. 2018, 2019, 2021, 2022, 2023) were upgraded to incorporate an Avalonix 4 channel 4K XVR digital video recorder (DVR) with a 4TB hard drive. The DVR was equipped with motion detection calibrated to record fish movement. The camera was also upgraded to an underwater 1080P HD video camera with a 2MP Sony Image Sensor, motorized zoom lens and a 98ft SR-PVC enclosed Siamese video power cable (model: UWC2812). Four 12-V LED pond lights were mounted inside the video chamber to illuminate the viewing area. The camera chamber was made of aluminum sheeting and attached to the video chute (Figure 6). A pane of safety glass was sealed to the camera chamber to form the interface between the chamber and the video chute. The camera chamber was filled with water to provide clear viewing into the video chute. The backdrop inside the video chute was constructed with white plastic secured to plywood. A color monitor was used to review video footage when in the field and the office. Video footage was reviewed and PIT antennas were tested regularly during site visits (from two to five times each week) to ensure the equipment was functioning properly. The system was powered by two battery banks, one to operate the video equipment and the other to power the PIT detection antennas. The battery bank for the video equipment consisted of four 12-V DC batteries (connected in parallel) with a combined 400 Ampere-hours. The PIT detection equipment was powered by a bank of three 12-V DC batteries with a combined 300 Ampere-hours.

Figure 6. Photo depicting the camera chamber (right), video chute (middle) and trap box (left).

An upstream trap was used to sample a portion of the adult Bull Trout spawners that used Pinhead Creek during 2023. The fyke of the trap box and the exclusion gate were set every Monday through Friday between August 28, 2023 and September 22, 2023. In addition, two weekend days (September 23rd and 24th) were added at the end of the trapping season. The trap was checked daily to ensure no fish were held in the box more than 24 hours. The Bull Trout were removed from the trap by dip net and anesthetized for sampling in a river water bath that contained 40 mg/l of tricaine methanesulfonate (MS-222) buffered with 80 mg/L sodium bicarbonate. All Bull Trout were scanned for PIT tags. Sampling consisted of recording their PIT ID (if previously tagged), determining their sex (phenotypic characteristics) and measuring their total length to the nearest 1 mm (Barrows et al. 2014). If a Bull Trout without a tag was encountered, a 23-mm long PIT tag was inserted subcutaneously through a 3-mm incision made with a surgical scalpel anterior to the pelvic girdle (Barrows et al. 2014). In addition, a tissue sample (upper lobe of the caudal fin) was collected and preserved in a vial containing alcohol for DNA analysis. All Bull Trout recovered following sampling in a large cooler circulated with aerated river water. After recovering to an upright position, Bull Trout were released to an area with slow water velocity upstream of the weir. Spring Chinook and Coho Salmon captured would be removed from the trap by dip net, scanned for preexisting PIT tags and immediately released without being anesthetized.

Bull Trout presence and movement was monitored by a channel-spanning HDX PIT tag antenna installed approximately 150 meters upstream from the Pinhead-Clackamas confluence, 10 meters downstream of the Pinhead Creek video weir (Figures 2 and 7). In addition to the instream PIT antenna, a second antenna was installed around the upstream end of the video chute. Operating these two antennas allowed us to match individual fish images to their unique PIT tag, as well as confirm passage direction if the video system was not functioning. Both antennas were powered by a bank of 12-volt batteries and an Oregon RFID Multi-Antenna HDX Reader. Both antennas became operational on July 24, 2023 and were removed with the rest of the weir on October 11, 2023.

Figure 7. Channel-spanning HDX PIT tag antenna located 150 meters upstream from the Pinhead-Clackamas confluence, approximately 10 m below the Pinhead Creek weir.

Spawning Population Estimate

The abundance of the spawning population in Pinhead Creek has been previously estimated from 2017 through 2022 (Barrows et al. 2018, 2019, 2021, 2022, 2023a). As in past years, the spawning population of Bull Trout in Pinhead Creek was estimated as the number of unique adults that moved upstream through the video weir and adult trap during the spawning season. Some individuals pass through the weir multiple times, so the total number of Bull Trout observed overestimates the true population size. To account for this, it was necessary to estimate the number of unique individuals that passed the weir. We used two methods to identify individuals, PIT detections at the weir antennas and the distinguishing features of fish observed on the video. PIT tags have been used to identify individual Bull Trout moving through video weirs (Barrows et al. 2023a, 2023b). A portion of the Bull Trout in the spawning population have been previously tagged. Fish that were translocated to the Clackamas River Subbasin were PIT-tagged prior to release and untagged fish captured at the weir trap each year (since 2017) have been PIT-tagged. Timestamps allowed PIT detections to be paired with video footage of tagged fish during passage. However, since many individuals in the Pinhead Creek spawning population are not PIT-tagged, we used distinguishing features (such as color variation, spots, scars, fin shapes, and size) to differentiate between individuals. Barrows et al. 2023 successfully used this technique to distinguish individual Bull Trout in Cougar Creek (Lewis River, WA) and similar techniques have been used to distinguish individuals in studies of various other fish species (Bachman 1984; Marshall and Pierce 2012; Giglio et al. 2014; Dala-Corte et al. 2001).

In some Bull Trout populations, sexual dimorphism is more obvious during the reproductive period and less clear during non-reproductive periods (Nitychoruk et al. 2013). Experienced biologists used phenotypic characteristics including head shape, jaw characteristics, body form, and coloration to categorize fish as male or female. To estimate numbers of spawning male and female Bull Trout in Pinhead Creek in 2023 from total counts of fish passing the weir, we needed to account for individuals that passed the weir more than once (individuals passed 1-5 times). We did this by systematically examining video images of males and females that passed upstream through the video chute for the presence of naturally distinguishing characteristics, such as color variation, spots, scars, and distinct fin shapes. Those with distinguishable characteristics or PIT tags were categorized as marked males or marked females. To estimate the spawning population, we made four main assumptions. First, we assumed detection of Bull Trout passing the weir was 100%. Second, we assumed markings were not gained or lost during the season. Third, we assumed marks were always correctly detected. Fourth, we assumed there was no difference in passage behavior between marked and unmarked fish at the weir.

As in Barrows et al. 2023b, we used the number of individuals (M; defined as Bull Trout with PIT tags or untagged fish with distinct visual characteristics), the number of observations resulting from marked individuals (m), and the number of observations from unmarked individuals (u), to estimate the total number of unmarked individuals ($\widehat{U}$) and the total number of spawning individuals ($\widehat{N}$). All fish were identified as either male or female, so we estimated the total numbers of males and females separately using the same analysis method (described below). Separate estimates of males and females helped to better assess the spawning population and potentially increased accuracy, since males passed the weir more times than females. First, we estimated the proportion of the observations of marked fish that were unique individuals ($\hat{p}$):

$$M \sim Binomial\ (\hat{p}, m)$$

We then used this proportion to estimate the number of unique unmarked individuals ($\widehat{U}$) expected to produce the counted number of unmarked observations:

$$\widehat{U} \sim Binomial\ (\hat{p}, u)$$

The total number of individuals ($\widehat{N}$) was then estimated as a combination of marked and unmarked fish:

$$\widehat{N} = M + \widehat{U}$$

The total number of spawning adults was estimated by summing the number of spawning females and the number of spawning males.

Models were analyzed by Bayesian methods using JAGS software (Plummer 2003) called from Program R (R Core Team 2013). We used package jagsUI (Kellner, 2018), three chains, adaption and burn-in values of 5,000, an iteration interval of 20,000, and saved enough iterations to meet convergence (Rhat scores <1.1 for all estimated parameters; Gelman & Hill, 2007; Kéry & Schaub, 2012). Medians of the posterior distributions were reported for estimated parameters, along with 95% credible intervals ("95%") to describe variability. We used an uninformative uniform prior (range 0-1) to estimate $\hat{p}$ for both males and females.

Redd Surveys

Census redd surveys were led by ODFW and conducted by experienced personnel in potential Bull Trout spawning habitat in several major upper Clackamas River tributaries. During 2023, surveys were conducted every three weeks from the middle of September until the end of October (Steve Starcevich, ODFW, pers. comm. 2024). The estimated number of spawners from the weir was compared with redd counts in Pinhead and Last creeks to estimate the spawner/ redd ratio.

Documenting Natural Production

Spawning by locally-born progeny of translocated individuals is a primary indicator of a successful translocation project. Locally spawned Bull Trout have not been detected during past electrofishing and minnow-trapping efforts (Barrows et al. 2017; Barrows et al. 2016; Barry et al. 2014). Similarly, juveniles have not been observed in previous night snorkel surveys (Starcevich 2019a, 2019b, 2020). This apparent absence of juvenile Bull Trout in the system suggests very low natural recruitment and has hindered our ability to assess recruitment into the spawning population. Therefore, we used environmental DNA (eDNA) occupancy sampling, PIT tag redetection of fish that encountered the weir, observations of small Bull Trout at the weir and genetic samples to address the following questions:

1. Is there evidence of locally-spawned progeny rearing in Pinhead Creek?

2. Is there evidence of locally-spawned progeny recruitment into the spawning population?

3. Are unknown origin Bull Trout (non-tagged) moving past the weir fish that were translocated from the Metolius River Subbasin, or locally-spawned progeny recruited into the spawning population?

Monthly eDNA Samples

Migratory adult Bull Trout have been documented in Pinhead and Last creeks from July through October (Barrows et al. 2023a; Starcevich 2021). However, temporal occupancy of Pinhead and Last creeks by Bull Trout is largely unknown. From September 2021 through September 2022, we attempted to collect monthly eDNA samples at multiple locations within Pinhead and Last creeks, no further than 1 km downstream of spawning areas (Figure 8 and Table 2). This was done to observe how patterns in Bull Trout occupancy appear to change after spawning adults presumably leave the system. Samples were collected at each location following established methods described in Carim et al. (2015). In general, three samples were collected within the river right 1/3 of the stream channel, the fourth sample was taken from the approximate middle 1/3 of the stream, and the fifth sample was collected from the river left 1/3 of the channel. In addition, monthly eDNA samples were collected in two reference streams, Jack Creek (Metolius River) and Cougar Creek (Lewis River) for comparison with stable, self-sustaining Bull Trout populations. Jack Creek was also selected because it represented the donor stock and the population has a resident component. Cougar Creek was selected because it represented a small adfluvial population where most Bull Trout are thought to migrate from the natal stream to the lake. Following collection, samples were stored in a freezer at -20 °C before being sent to the Rocky Mountain Research Station in Missoula, Montana for analysis.

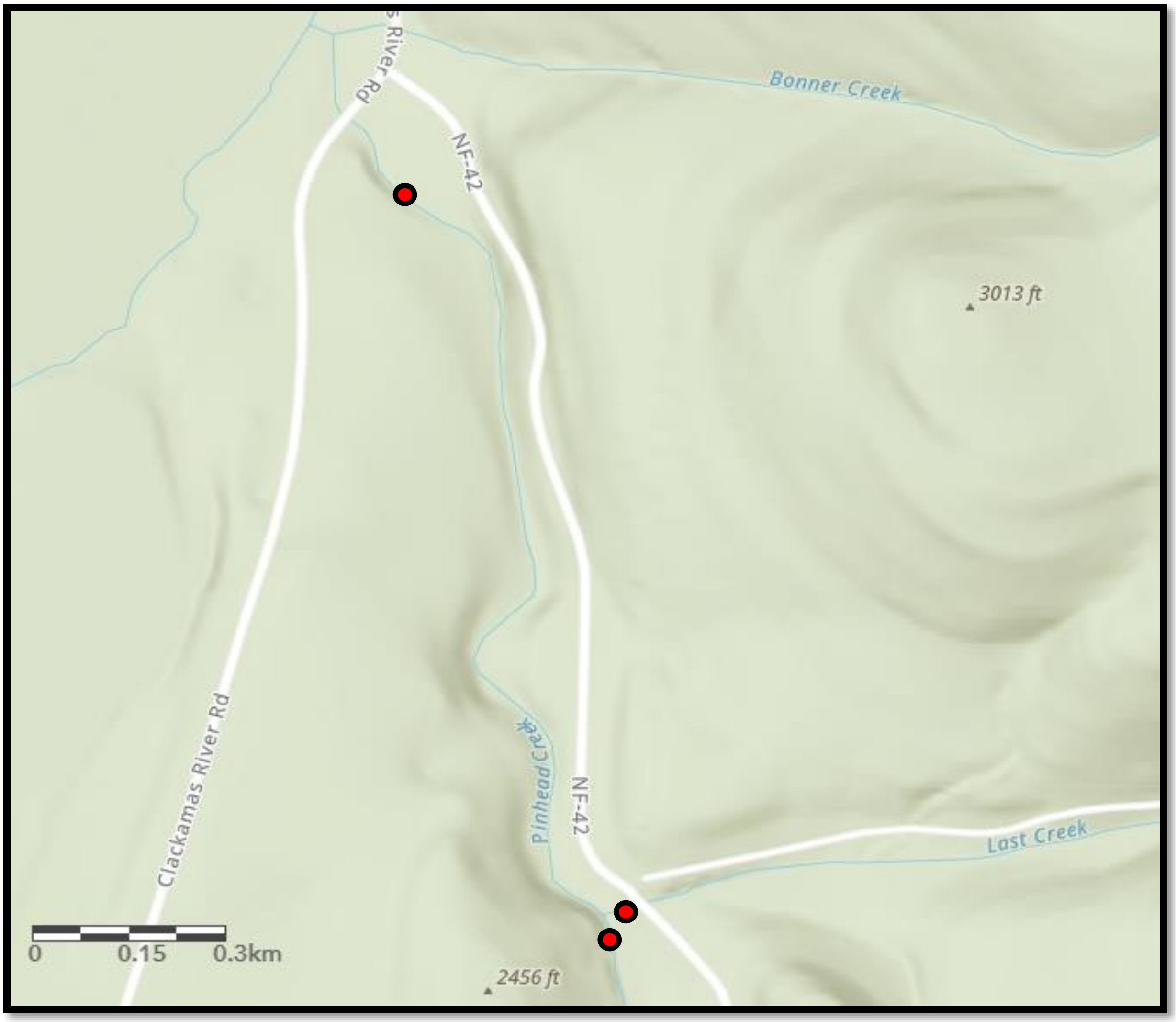

Figure 8. Locations of monthly eDNA sampling sites in Pinhead and Last creeks from September 2021 through September 2022.

Table 2. Collection sites for eDNA samples within Pinhead and Last creeks (Clackamas River Subbasin), Jack Creek (Metolius River Subbasin), and Cougar Creek (Lewis River Subbasin).

Stream	Site Description	Easting	Northing
Pinhead Creek	Near Clackamas River Confluence	588227	4981461
Pinhead Creek	Upstream of Last Creek Confluence	588566	4980251
Last Creek	Downstream of NR-42 Bridge	588566	4980251
Jack Creek	SW Warm Springs Road	604712	4927354
Cougar Creek	1 km Downstream of Spawning	588227	4981461

Tag Retention and Redetection

Monitoring studies of translocated Bull Trout rely heavily upon PIT tag detection. We examined the proportion of the Bull Trout in the Pinhead Creek spawning population that did not have PIT tags. Since all translocated fish were PIT-tagged, untagged fish passing through the weir may be translocated fish that have previously shed their tag, or locally-born individuals that were naturally recruited into the spawning population. We also examined the disparities in tag encounter rates between male and female fish to understand if tag shedding in translocated fish is related to the sex of the fish. Relatively high tag encounter rates in male fish could be evidence that untagged fish are a result of tag shedding in female fish rather than locally-produced offspring, since female spawning often results in shedding of abdominally implanted PIT tags (Elizabeth et al. 2016; Meyer et al. 2011).

Small Adult Observations

From 2017 through 2021, only relatively large adult Bull Trout were observed at the Pinhead Creek weir. However, in 2022, we observed seven notably smaller adults that moved upstream through the video chute (Barrows et al. 2023a). In 2023, we used concepts similar to those described in Yoshihara (1997) and in Barrows et al. 2021 to develop a laser scaling method for passively estimating lengths from video of Bull Trout passing through the Pinhead Creek video weir. Since accurate measurements were taken from fish captured in the adult trap, lengths from video were only estimated for fish moving upstream through the video chute. We hypothesized that the smaller adults (i.e., < 500 mm TL) may be more likely to be locally-born.

Two 16 mm x 65 mm 5V DC submersible red laser line generator modules (output power 100mW) were mounted within a waterproof plastic container. The laser lines were aligned vertically and in parallel at a distance of 39 mm apart from each other (Figure 9). The laser modules were placed in the camera chamber and projected through the video chute. As a fish passed through the video chute, two verticle laser lines were projected on the body of the fish. Regardless of the distance between the fish and the camera, the measurement between the laser lines was consistently 39 mm. Video footage corresponding to each Bull Trout moving upstream through the video chute was reviewed and a still frame photo was captured at a point when the entire fish was visible and was as parallel to the camera as possible. The relative proportion of the distance measured on the still frame photo between the two laser lines and of the length of the fish was used to estimate the total length of the fish as follows:

$$W_v / L_w = W_k / L_e$$

Where W_v = width measured between the laser lines from the video; L_w = the length of the fish measured from the video; W_k = the actual width measured between the laser lines (i.e., 39 mm) and L_e = the estimated total length of the fish. The estimated total lengths of each fish were then compared to the total lengths obtained from the trap.

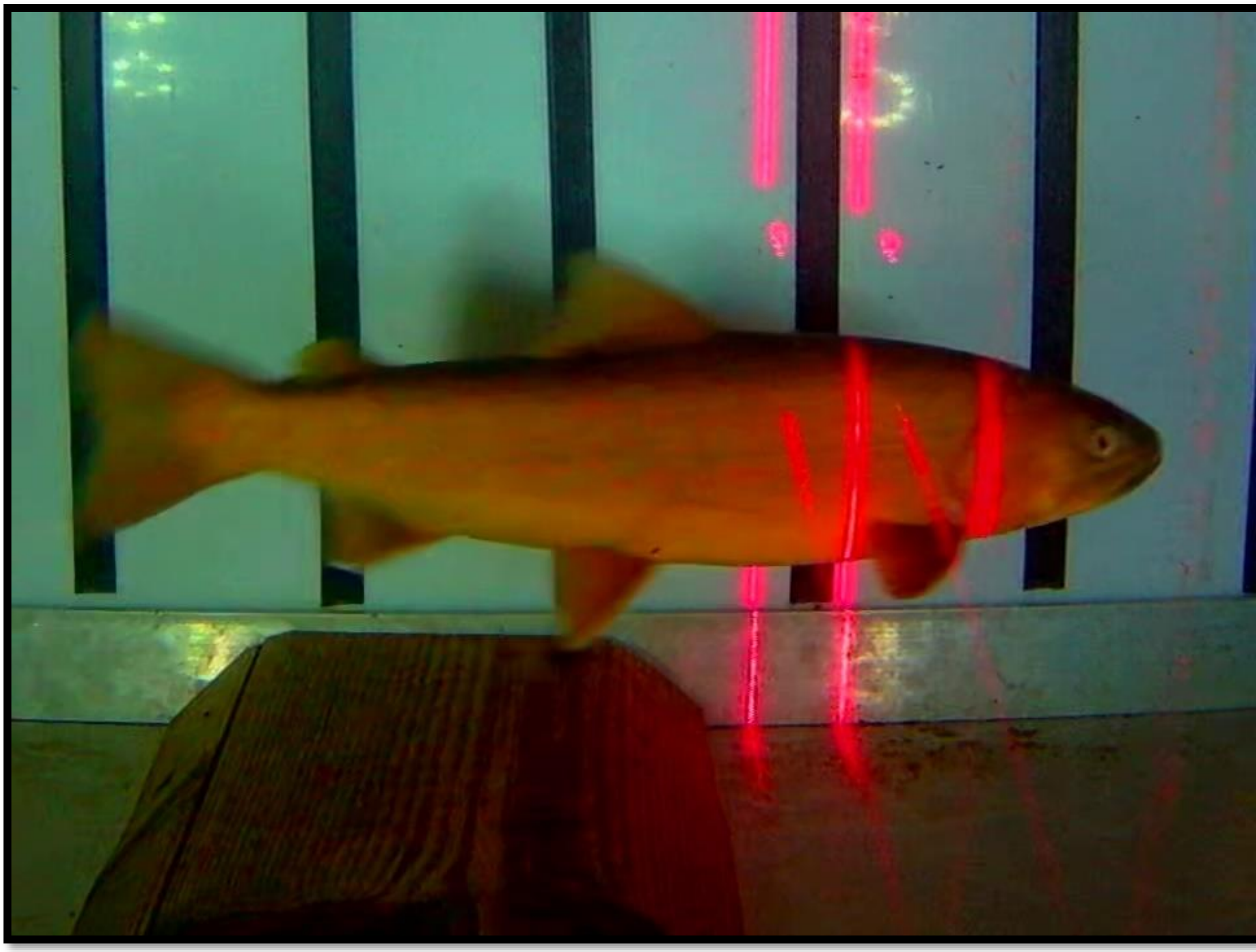

Figure 9. The laser lines were aligned vertically and in parallel at a distance of 39 mm apart from each other. The laser modules were placed in the camera chamber and projected through the video chute. As a fish passed through the video chute, two vertical laser lines were projected on the body of the fish. W_v is the width measured between the laser lines from the video and L_w is the total length of the fish measured from the video.

Genetic Analysis

We used genetic markers to characterize the parents (translocated, not translocated, unknown) of untagged Bull Trout returning to spawn within the system. Fin clips were collected from every translocated individual prior to release. Over 90% of those were successfully genotyped. Tissue samples were also collected for genetic analysis from untagged Bull Trout captured at the weir from 2017 through 2023. One additional sample was collected from a small male Bull Trout that was found as a mortality on one of the weir's picket leads. These samples were analyzed to determine whether genotypes of untagged individuals matched any of those for translocated individuals. If they match, they were determined to be translocated fish that had simply shed their PIT tag. If they did not match the genotypes of translocated fish, a parentage analysis was performed to document within-basin reproduction and to confirm recruitment of locally-born individuals into the spawning population.

Results and Discussion

Pinhead Creek Spawning

Translocated adult Bull Trout in the Clackamas River exhibit a migratory life history and utilize habitat in the mainstem Clackamas River and lower subbasin reservoirs (e.g., North Fork Reservoir) for foraging and overwintering before migrating to upper-subbasin tributaries to spawn (Barrows et al. 2018, 2019, 2021). Video observations, PIT tag detections, trap captures and redd counts were used to describe Bull Trout spawning in Pinhead Creek.

Video Weir and Adult Trap

The Pinhead Creek weir was installed on July 24, 2023 and fish passing through thevideo chute were monitored via video and the PIT antennas until October 11, 2023 (Figure 10). The video monitoring system experienced approximately 72 hours of downtime between September 8, 2023 and September 11, 2023, however, the PIT detection system remained operational during that time. The PIT detection system also experienced approximately 52 hours of downtime between September 18, 2023 and September 20, 2023 due to vandalism. The upstream adult trap was operated primarily Monday through Friday beginning on August 28, 2023 and ending on September 23, 2023.

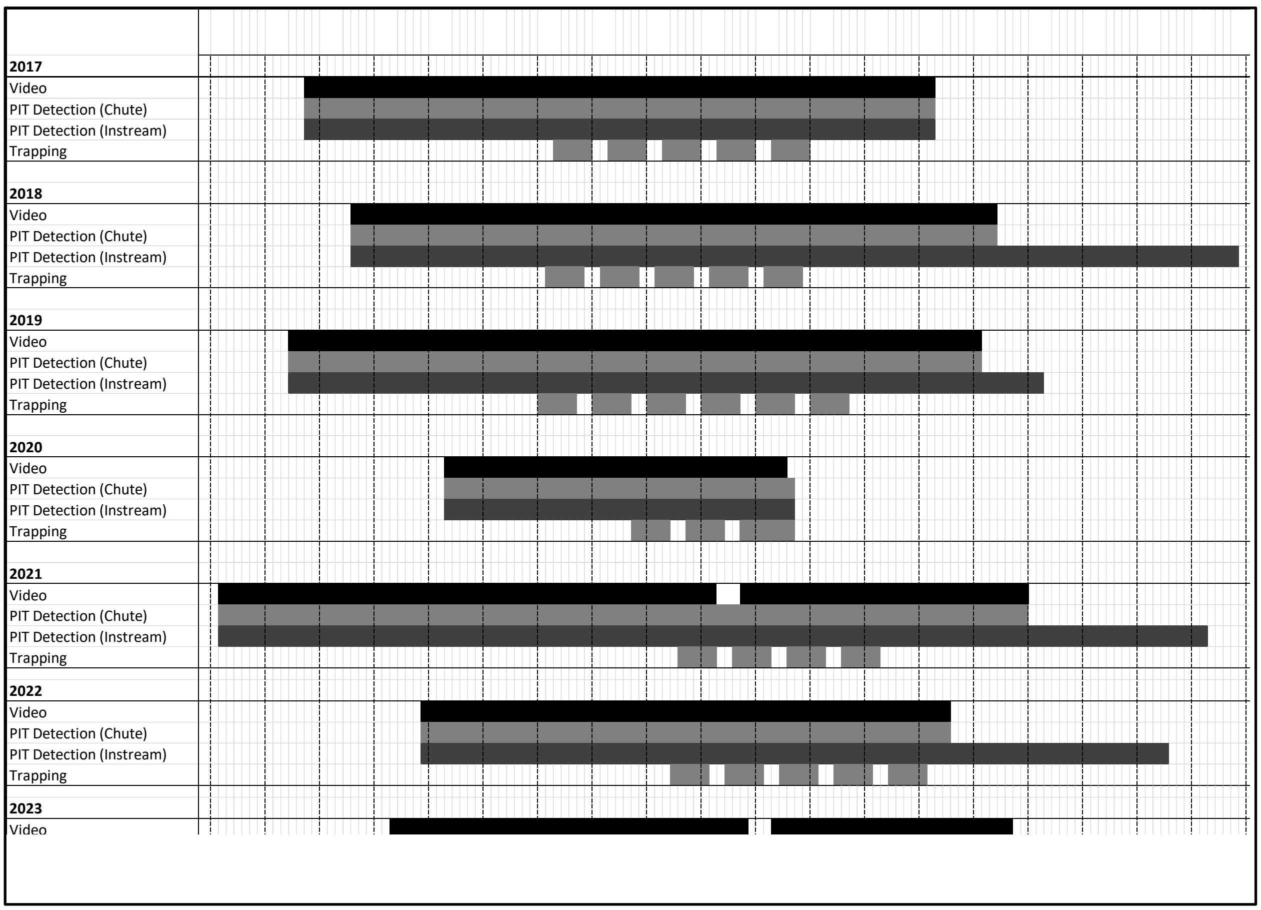

Figure 10. Pinhead Creek weir operation periodicity from 2017 through 2023.

During 2023, there were a total of 39 video observations of Bull Trout moving upstream through the Pinhead Creek weir (Table 3). There were also 56 video observations of Chinook Salmon moving upstream through the weir. Additionally, there were 14 Coho Salmon and 26 Cutthroat Trout upstream observations. Individual Bull Trout were observed moving both upstream and downstream past the weir multiple times. Some fish were also captured in the trap before or after being observed on video passing the weir. The first Bull Trout was observed moving upstream of the weir on August 23, 2023. Upstream Bull Trout observations peaked by mid-September and ended on September 29, 2023 (Figures 11 and 12).

Table 3. Video observations of Bull Trout, Coho Salmon and Chinook Salmon passing the Pinhead Creek video weir during 2023.

Species (Sex)	Upstream Observations
Bull Trout (Male)	32
Bull Trout (Female)	7
Coho Salmon	14
Chinook Salmon	56
Cutthroat Trout	26

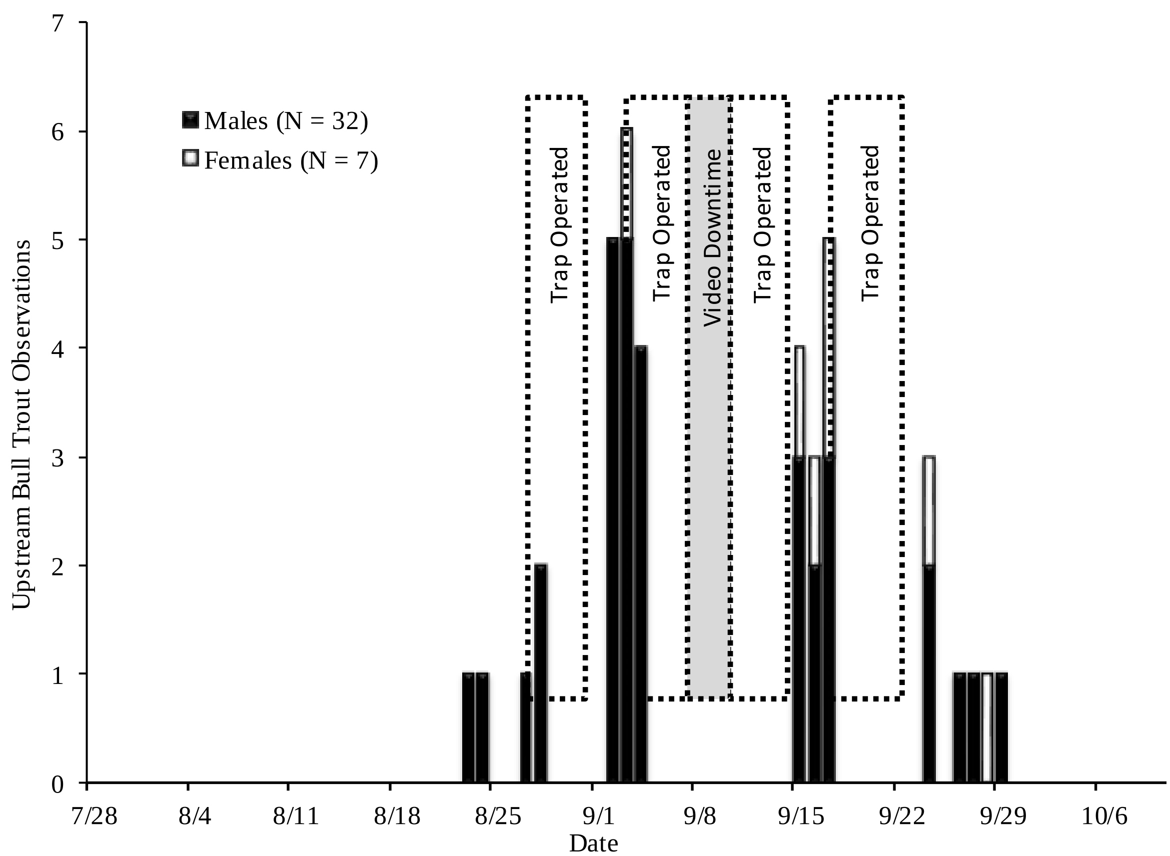

Figure 11. Upstream video observations of male and female Bull Trout at the Pinhead Creek weir during 2023.

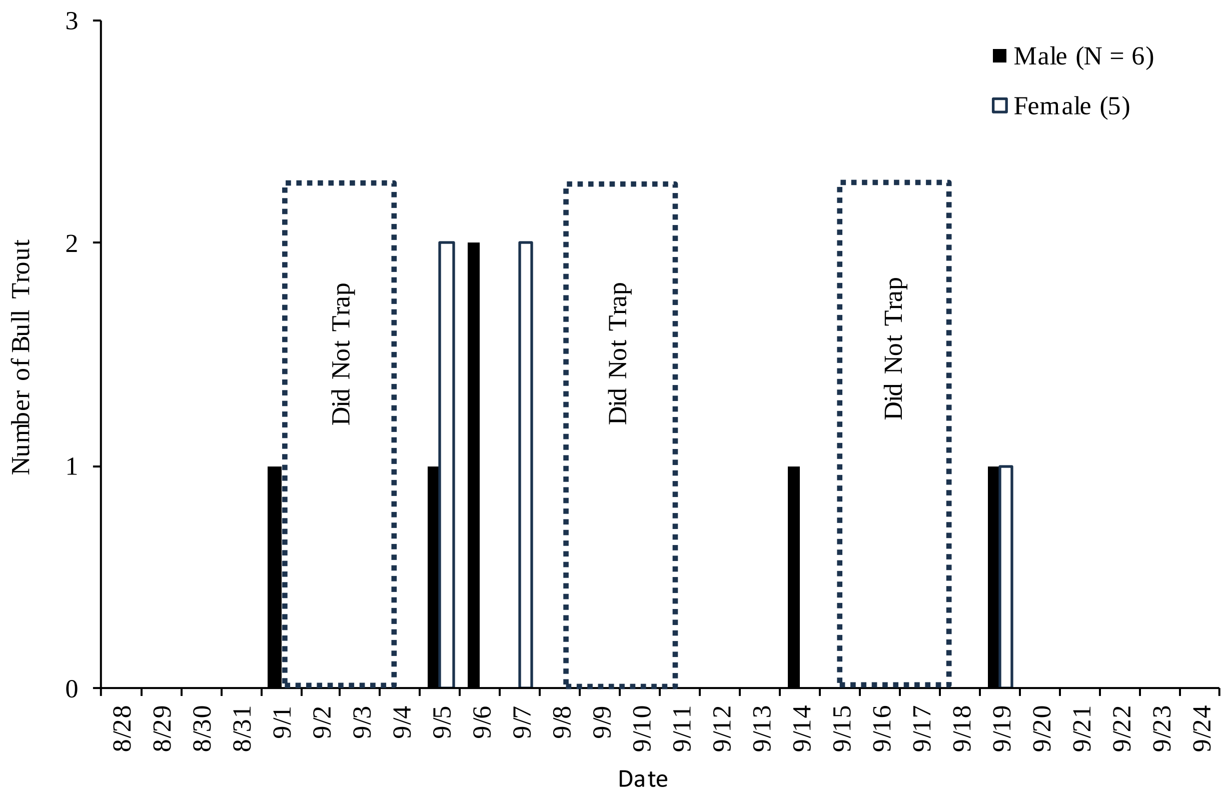

Figure 12. Bull Trout trapped by date and sex at the Pinhead Creek weir during 2023.

Seven of the 39 upstream observations of Bull Trout passing through the video chute were female. Of the seven females observed, four were PIT-tagged individuals and three were untagged. There were also 32 observations of male Bull Trout that moved upstream through the video chute. Of the 32 male observations, 5 were of fish tagged at the adult trap in 2023 (Table 4). All of the male Bull Trout that moved through the video chute were relatively small fish (i.e., < 500 mm TL) and all but one of the females were estimated to be > 500 mm TL. One additional female Bull Trout was detected at the PIT antenna downstream of the weir but did not pass upstream during the spawning season.

Table 4. Bull Trout observations moving upstream through the video chute at the Pinhead Creek weir during 2023.

Sex	Video Observations (PIT-tagged)	Video Observations (Untagged)	Totals
Male	27	5	32
Female	4	3	7
Totals	**31**	**8**	**39**

Nine individual Bull Trout were captured in the trap at the Pinhead Creek weir of which one was caught three times for a total of 11 captures (Figure 12). The first fish was captured on September 1, 2023 and the last Bull Trout was captured on September 19, 2023. Of the nine unique Bull Trout captured, four were males and five were females. None of the males had been

PIT-tagged previously and three of the five females captured had previously been tagged. Tissue samples from the untagged fish were collected for genetic analysis.

The Bull Trout captured in the trap were mature, adult fish and ranged in length from 322 – 720 mm TL. Female Bull Trout (mean, 704 mm TL; range, 685 – 720 mm TL) were larger in length than the males (mean, 425 mm TL; range, 322 – 482 mm TL). All but two of the females captured in the trap during 2023 had PIT-tags that confirmed they were translocated to the Clackamas River Subbasin from Lake Billy Chinook as subadults (251-450 mm TL). All of the males captured in the trap during 2023 were untagged and smaller than the females, indicating they may have been locally-born fish, not translocated individuals from the Metolius River Subbasin. Lengths of Bull Trout captured in the trap are summarized in Figure 13 and Table 5.

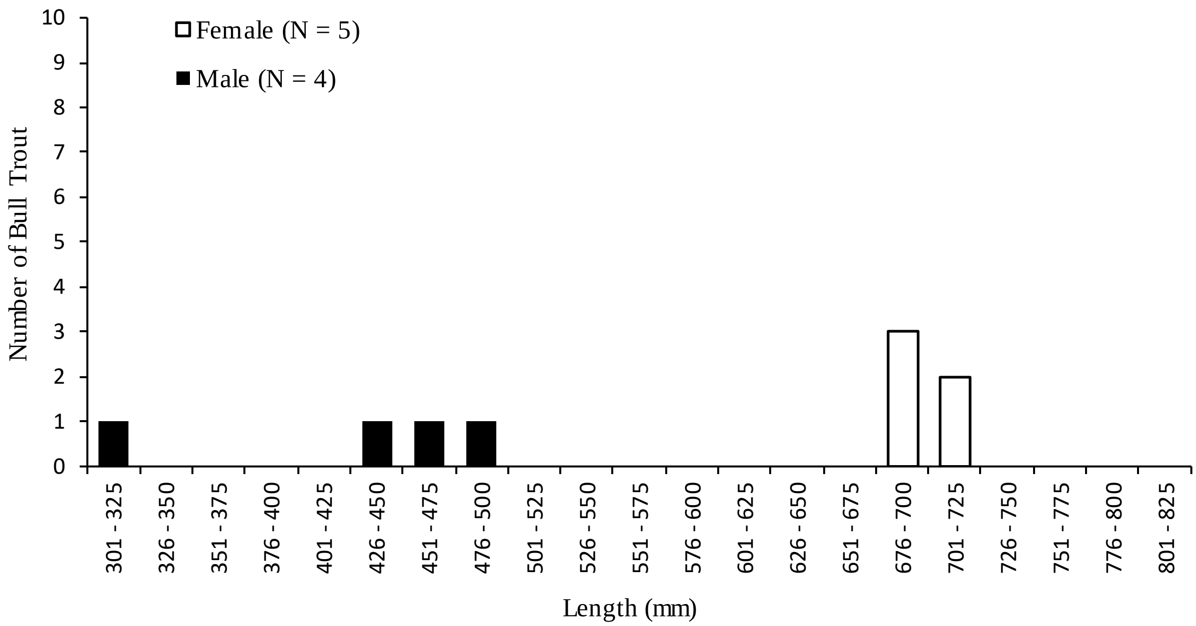

Figure 13. Total lengths by sex of Bull Trout captured at the Pinhead Creek weir during 2023.

Table 5. Lengths of Bull Trout captured in the trap at the Pinhead Creek weir during 2023.

Sex (Tagged/Untagged)	**Total Length (mm)**		
	Min	**Max**	**Mean**
Males (Tagged) *	*	*	*
Females (Tagged)	685	720	702
Males (Untagged)	322	482	425
Females (Untagged)	695	719	707

* No tagged male Bull Trout were captured during 2023.

Operating a weir and adult trap for multiple years in Pinhead Creek has provided the opportunity to observe trends in the population. Fish length often correlates with age of individuals in a population. As a population matures, mean lengths would be expected to trend upward. If younger (i.e., smaller) individuals were recruited into the adult population, we would expect to see mean lengths trend downward. We examined mean lengths for tagged and untagged male and female Bull Trout sampled from 2017 to 2023 in the Pinhead Creek weir trap (Figure 14). As expected, we found that mean lengths for tagged male and female Bull Trout trended upward, indicating these fish are primarily older (and therefore larger) translocated individuals. We also found that mean lengths for untagged females trended upward with the exception of 2022 when the mean length for untagged females was notably lower, not following the trend from other years. This may simply be an anomaly, or it may suggest younger, untagged females (i.e., locally-born fish) may have been recruited into the spawning population. Similarly, the mean length of untagged males in 2023 was much lower than previous years, suggesting recruitment of locally-born males into the spawning population.

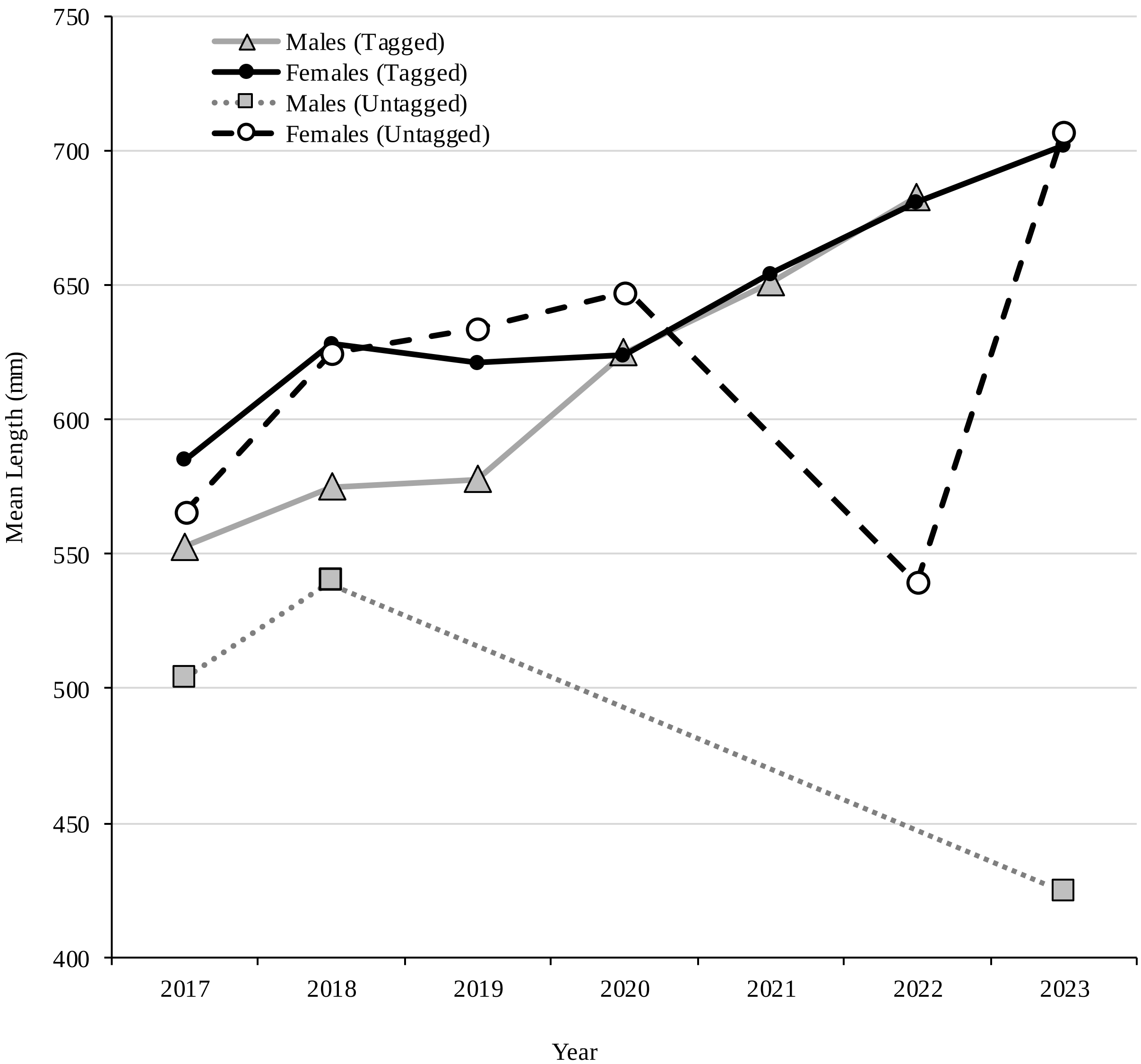

Figure 14. Mean lengths of tagged and untagged male and female Bull Trout sampled at the Pinhead Creek weir from 2017 to 2023.

In 2023, seven of the Bull Trout detected at the weir were translocated fish. Six of the seven fish were subadults captured in Lake Billy Chinook and released in the Clackamas River near the 4650 bridge in 2014, 2015 and 2016 (Table 6). One fish was released as a juvenile into Pinhead Creek in 2013. The other eight Bull Trout were adults PIT-tagged at the Pinhead Creek weir trap in 2022 (N = 2) and 2023 (N = 6). No translocated fish released as adults and no juveniles released into Berry Creek or the upper Clackamas River were detected in 2023.

Table 6. Release years and locations by life stage of PIT-tagged Bull Trout detected via PIT antennas at the Pinhead Creek video weir or captured in the adult trap during 2023.

Release Location	Lifestage	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Totals
Clack. R.	Juvenile	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	**0**
Clack. R.	Subadult	0	2	2	2	NA	NA	NA	NA	NA	NA	NA	**6**
Clack. R.	Adult	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	**0**
Pin./Last Cr.	Juvenile	1	0	0	0	NA	NA	NA	NA	NA	NA	NA	**1**
Up.Clack.	Juvenile	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	**0**
Berry Cr.	Juvenile	0	0	0	0	NA	NA	NA	NA	NA	NA	NA	**0**
Pin. Weir	Adult	NA	NA	NA	NA	0	0	0	0	0	2	**6**	**8**
	Totals	**1**	**2**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**2**	**6**	**15**

Spawning Population Estimate

Following a thorough, systematic review of upstream observations through the video chute and the adult trap, we observed 12 marked females a total of 14 times, and no observations were made of unmarked females. There was one additional PIT-tagged female that was detected at the weir but did not move upstream, therefore, the total number of unique females in the population was 13. At the weir, we observed 17 marked males a total of 31 times, and we made 9 observations of unmarked males. The estimated number of spawning males was 22 (95% CI: 19 – 25). The total spawning population in Pinhead Creek was estimated as 35 (95% CI: 31-37). It should be noted that determining the sex of the small adults was difficult in some cases. The spawning population estimate of 35 was very similar to estimates in 2021 and 2022, but was notably less than estimates for previous years (Figure 15). A reason for the decline in adult spawners from a high of 101 in 2018 is not apparent. However, there continues to be indications that recruitment of naturally produced fish to the spawning population is low (see Documenting Natural Production Results and Discussion).

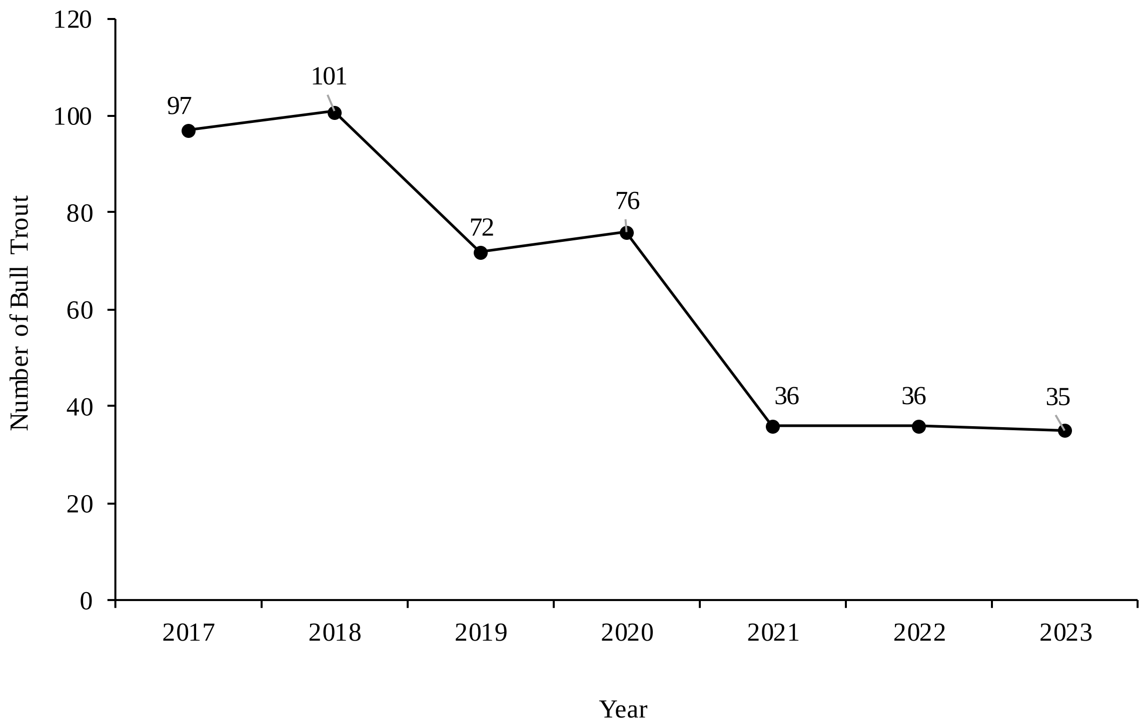

Figure 15. Pinhead Creek spawning population estimates from 2017 through 2023.

Redd Surveys

The number of Bull Trout redds recorded in the Clackamas River Subbasin has ranged from just 5 in 2011 to a high of 89 in 2017 (Starcevich 2021). Since the beginning of the reintroduction project, most of the redds counted during census spawning surveys were recorded in Pinhead Creek, Last Creek and the upper Clackamas River. However, 13 redds were counted in Berry Creek during 2019 (Starcevich 2020). Pinhead Creek remained the primary spawning tributary for Bull Trout during 2023. A total of 18 redds were observed in Pinhead and Last creeks. Two redds were observed in Last Creek and the rest were in Pinhead Creek downstream of the Last Creek confluence (Figure 16). Our spawning population estimate and census redd count data suggest a spawner/redd ratio of 1.9 in 2023, which was higher than past seasons that ranged from 1.0 to 1.5 (Figure 17).

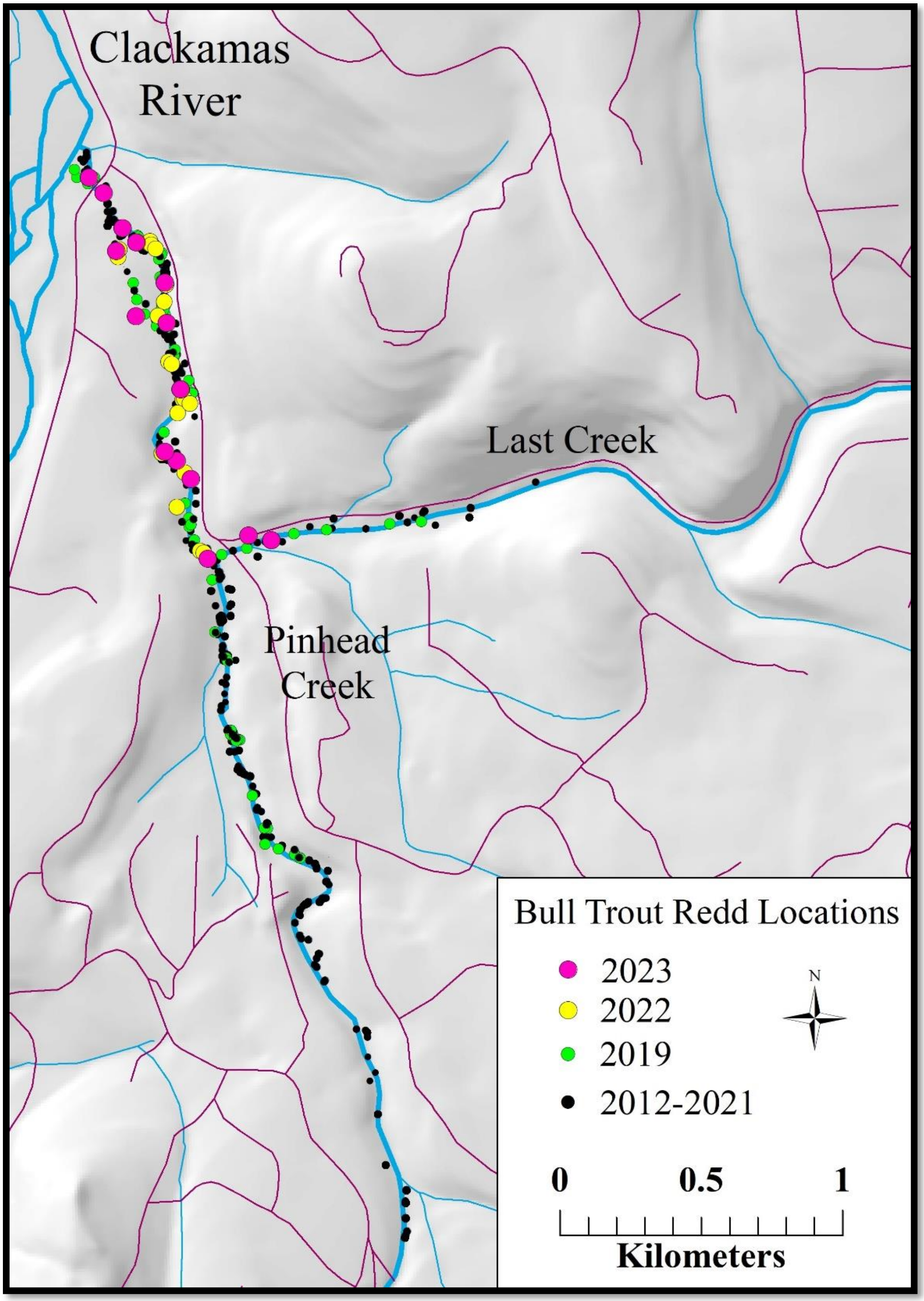

Figure 16. Georeferenced redds in Pinhead and Last creeks 2023. Bull Trout redds observed during 2023 are depicted as pink circles. (Figure from Starcevich 2024).

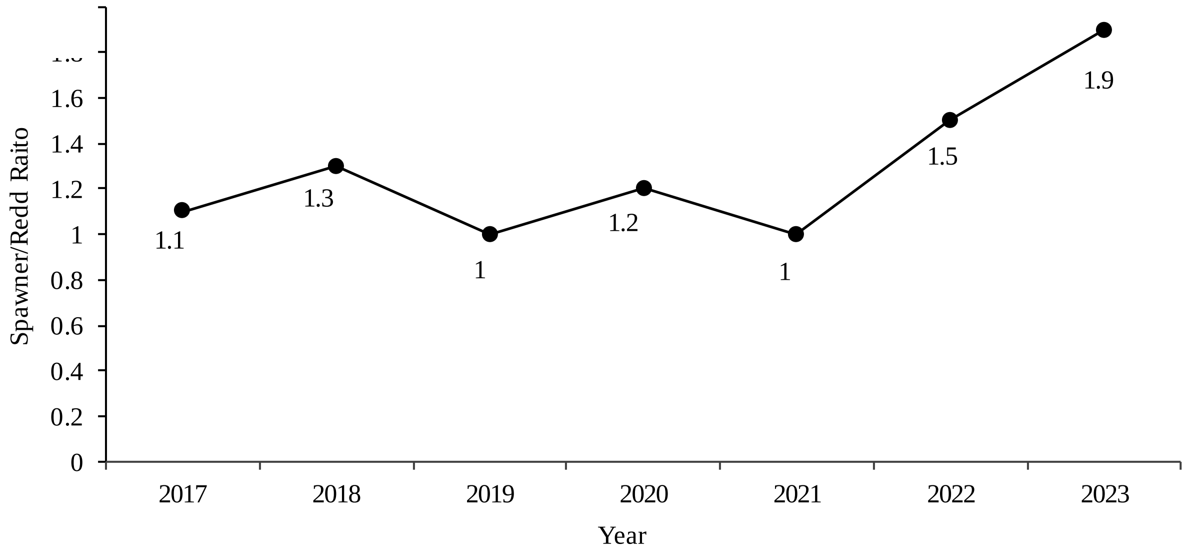

Figure 17. Pinhead Creek spawner/redd ratios from 2017 through 2023.

Documenting Natural Production

Monthly eDNA Samples

From September 2021 through early September 2022, eDNA samples were collected approximately monthly in Pinhead, Last, Cougar and Jack creeks. At each site, five samples were collected and DNA analysis was performed in triplicate on each sample. If Bull Trout DNA was detected in any of the triplicates, that sample was considered positive (Bull Trout DNA present). Samples were collected at varying intervals and are summarized in Table 7.

Table 7. Positive sample replicates for each month that eDNA sites were sampled in Pinhead, Last, Cougar and Jack creeks from September 2021 – August 2022. The proportion of positive sample replicates per site is also reported.

		Sep. 2021*	**Oct. 2021***	**Nov. 2021***	**Dec. 2021***	**Jan. 2022***	**Feb. 2022***	**Mar. 2022***	**Apr. 2022***	**May 2022***	**Jun. 2022***	**Jul. 2022***	**Aug. 2022***
Site Name	Sample Replicates	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells
Up. Pinhead	1	YES	NO	NO	NO	NA	NA	YES	NO	NO	NO	YES	NO
Up. Pinhead	2	YES	NO	NO	NO	NA	NA	YES	NO	NO	NO	NO	YES
Up. Pinhead	3	YES	NO	NO	NO	NA	NA	YES	NO	NO	NO	NO	NO
Up. Pinhead	4	YES	NO	NO	NO	NA	NA	YES	NO	NO	NO	YES	NO
Up. Pinhead	5	YES	NO	NO	YES	NA	NA	YES	NO	NO	NO	NO	NO
Up. Pinhead	Pos./Site	5/5	0/5	0/5	1/5	NA	NA	5/5	0/5	0/5	0/5	2/5	1/5
	Proportion	1.0	0.0	0.0	0.2	NA	NA	1.0	0.0	0.0	0.0	0.4	0.2
Low Pinhead	1	YES	NO	YES	NO	NA	YES	YES	NO	NO	NO	NO	NO
Low Pinhead	2	YES	YES	NO	NO	NA	NO	YES	NO	NO	NO	NO	YES
Low Pinhead	3	YES	YES	YES	YES	NA	YES	NO	NO	NO	NO	NO	NO
Low Pinhead	4	YES	YES	NO	NO	NA	YES	NO	NO	NO	NO	YES	YES
Low Pinhead	5	YES	YES	YES	YES	NA	NO	YES	YES	NO	YES	NO	YES
Low Pinhead	Pos./Site	5/5	4/5	3/5	2/5	NA	3/5	3/5	1/5	0/5	1/5	1/5	3/5
	Proportion	1.0	0.8	0.6	0.4	NA	0.6	0.6	0.2	0.0	0.2	0.2	0.6
Last Cr.	1	NO	NO	NO	NO	NA	NA	NO	NO	NO	YES	NO	NO
Last Cr.	2	NO	NO	NO	NO	NA	NA	NO	NO	NO	NO	NO	NO
Last Cr.	3	NO	NO	NO	NO	NA	NA	NO	NO	NO	NO	YES	NO
Last Cr.	4	NO	NO	NO	NO	NA	NA	NO	NO	NO	NO	YES	NO

		Sep. 2021*	Oct. 2021*	Nov. 2021*	Dec. 2021*	Jan. 2022*	Feb. 2022*	Mar. 2022*	Apr. 2022*	May 2022*	Jun. 2022*	Jul. 2022*	Aug. 2022*
Site Name	Sample Replicates	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells	Pos. Wells
Last Cr.	5	NO	NO	NO	NO	NA	NA	NO	NO	NO	NO	NO	NO
Last Cr.	Pos./Site	0/5	0/5	0/5	0/5	NA	NA	0/5	0/5	0/5	1/5	2/5	0/5
	Proportion	0.0	0.0	0.0	0.0	NA	NA	0.0	0.0	0.0	0.2	0.4	0.0
Cougar Cr.	1	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cougar Cr.	2	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cougar Cr.	3	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cougar Cr.	4	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES
Cougar Cr.	5	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cougar Cr.	Pos./Site	5/5	5/5	5/5	5/5	5/5	5/5	5/5	4/5	5/5	5/5	5/5	5/5
	Proportion	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8	1.0	1.0	1.0	1.0
Jack Cr.	1	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Jack Cr	2	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Jack Cr	3	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Jack Cr	4	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Jack Cr	5	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Jack Cr	Pos./Site	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5	5/5
	Proportion	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

* Samples were collected at varying intervals and are summarized approximately monthly.

Spikes in DNA shed during various life history stages in salmonids have been documented (Ostberg et al. 2021). For example, a relatively high abundance of DNA may be shed into the environment during activities associated with reproduction (i.e., spawning), resulting in increased detectability (Bylemans et al. 2017; Ostberg et al. 2021). In contrast, fertilized salmonid eggs do not shed much DNA, resulting in decreased detectability (Ostberg et al. 2021). Ostberg et al. (2021) also detected spikes in eDNA during hatching and others have inferred abundance from eDNA quantity and detectability (Doi et al. 2017; Spear at al. 2020). The presence of multiple year classes of rearing Bull Trout in or near their natal spawning grounds likely results in abundant DNA for detection during all months. However, if very few juveniles survive or if they migrate from the spawning grounds, spikes in eDNA from the aforementioned life history stages may be discernable.

Cougar and Jack creeks served as reference streams and were used to help provide context for results from Pinhead Creek. Both reference streams have relatively small but relatively stable, self-sustaining Bull Trout populations. Bull Trout in Jack Creek reflect the genetic characteristics of the donor stock that was translocated to the Clackamas River and express, at least in part, a life history where multiple age classes of juveniles rear in their natal stream during all months. Bull Trout in Cougar Creek reflect a population from the western slope of the Cascade Mountain Range and express a life history in which most or all juveniles appear to eventually migrate from natal spawning reaches to rear in reservoir/lake habitat. Bull Trout DNA was detected in all or most of the samples collected in Cougar and Jack creeks (Table 8). In both streams, the probability of detecting Bull Trout DNA was 1.0 in all months sampled, and generally, all sites/month. The single exception was for the April samples from Cougar Creek, when the probability of detecting Bull Trout DNA was 0.8 (detected in four of the five samples). In Pinhead and Last creeks, the probability of detecting Bull Trout DNA was variable. During a given month, detection probability ranged from 0.0 – 1.0 at the mouth of Pinhead Creek (not detected from approximately late May – June), upper Pinhead Creek (not detected in early November, May or July) and the mouth of Last Creek (only detected in July – August). The detection probability for sites/month was also variable, ranging from 0.0 – 1.0 at the mouth of Pinhead Creek (not detected in June), 0.0 – 1.0 at upper Pinhead Creek (not detected in early November, May and June), and from 0.0 – 0.4 at the mouth of Last Creek (only detected in July – August and at a maximum of two of five replicate samples). This finding is consistent with no evidence of locally-born, post emergent juvenile rearing (Barrows et al. 2018, 2019, 2021, 2022, 2023a) and suggests a low or absent juvenile population to consistently shed DNA year-round. In these streams we hypothesized there would be low eDNA detectability during much of the year with notable spikes during the spawning season, and lesser spikes during hatching and emergence. At both the upper and lower Pinhead Creek sites, high DNA detectability coincided with the peak spawning season (i.e., September). Moderate DNA detectability occurred during months when incubation, hatching and emergence was expected (October – March) in lower Pinhead Creek, but DNA was very low or not detected at the upper Pinhead Creek site during this timeframe. It was notable that no Bull Trout DNA was detected in Last Creek during the spawning season or during the hatching or emergence timeframes, suggesting very little spawning (if any) occurred in Last Creek. Similarly, DNA was either not detected, or detection was also very low from April – August indicating no or few rearing juveniles.

Table 8. Detection Probability of DNA for Pinhead, Last, Cougar and Jack creeks from September 2021 – August 2022. Detection probabilities are summarized by color and estimated periodocity for Bull Trout life stages is provided for reference.

	Sep. 2021*	Oct. 2021*	Nov. 2021*	Dec. 2021*	Jan. 2022*	Feb. 2022*	Mar. 2022*	Apr. 2022*	May 2022*	Jun. 2022*	Jul. 2022*	Aug. 2022*
Upper Pinhead Cr.	1.0	0.0	0.0	0.2	NA	NA	1.0	0.0	0.0	0.0	0.4	0.2
Lower Pinhead Cr.	1.0	0.8	0.6	0.4	NA	0.6	0.6	0.2	0.0	0.2	0.2	0.6
Last Cr.	0.0	0.0	0.0	0.0	NA	NA	0.0	0.0	0.0	0.2	0.4	0.0
Cougar Cr.	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.8	1.0	1.0	1.0	1.0
Jack Cr	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Adult Spawning	■	■										■
Embryo Incubation	■	■	■	■	■							
Hatching				■	■	■						
Emergence						■	■	■				
Juvenile Rearing	■	■	■	■	■	■	■	■	■	■	■	■

DNA Detection Probability — **None (0.0)** **Low (0.1 – 0.3)** **Medium (0.4 – 0.7)** **High (0.8 – 1.0)**

Tag Retention and Redetection

During 2023, we estimated that 22 untagged individual male Bull Trout moved upstream through the adult trap or observed on video (see Spawning Population Estimate results and discussion). Of the males observed, none had been previously PIT-tagged (Table 9). This was the first year that no previously PIT-tagged male fish were observed. There were also 12 female Bull Trout that moved upstream past the weir, of which 8 (66 %) had been previously PIT-tagged.

The relatively higher numbers of untagged individuals (especially males) passing the weir in 2023 compared to past years suggests locally-born individuals may have been recruited into the spawning population. In previous years (i.e., 2017 – 2022), the disparity in tagged to untagged ratios for male and female fish was likely a result of lower tag retention for females (Barrows et al. 2018, 2019, 2021, 2022). The lower overall percentage of PIT-tagged individuals observed in 2023 together with the lack of tagged males may indicate natural recruitment into the spawning population has increased, and as a result the percent of tagged fish may continue to decrease in future years as locally-born females recruit into the spawning population (Figure 18).

Table 9. Tagged and untagged male and female Bull Trout captured at the trap and observed on video at the Pinhead Creek weir from 2017 to 2023.

Year	Males (Tagged)	Males (Untagged)	Females (Tagged)	Females (Untagged)	Males (% Tagged)	Female (% Tagged)
2017	44	3	11	9	94	55
2018	42	5	27	27	88	50
2019	25	0	31	15	100	67
2020*	14*	0*	14*	9*	100*	61*
2021	9	0	15	8	100	65
2022	6	2	10	18	75	36
2023	0	22**	8	4	0	66

* Monitoring season was shortened due to COVID-19 restrictions and forest fires in the subbasin.

** The number of untagged male Bull Trout was estimated.

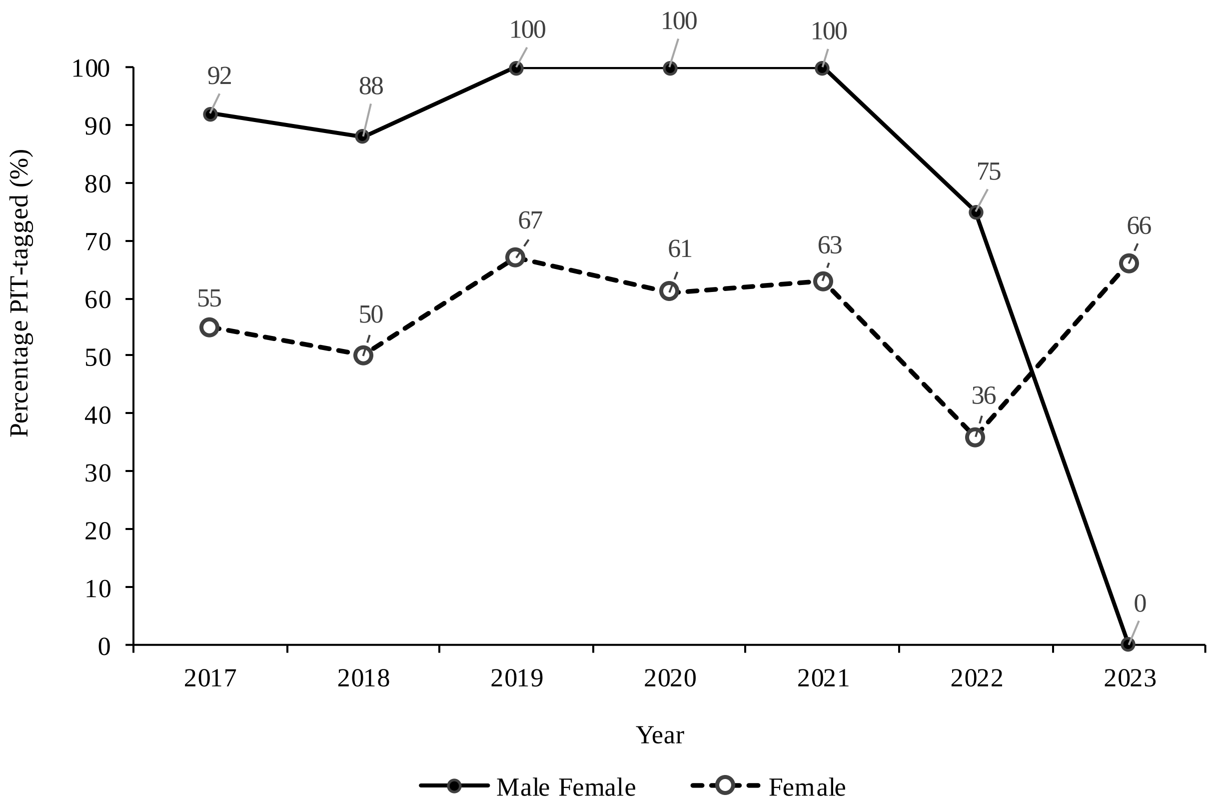

Figure 18. Percentage of PIT-tagged adult Bull Trout observed at the Pinhead Creek weir from 2017 through 2023.

Small Adult Observations

To summarize the lengths of Bull Trout in the Pinhead Creek spawning population, weused measured lengths (TL) from the nine individual Bull Trout captured in the Pinhead Creek trap and estimated lengths (via laser scaling) for 25 fish that moved upstream through the video chute (Table 10 and Figure 19). There were four fish that were observed both on video and captured in the trap. This allowed us to compare the accuracy of the laser scaling technique to actual measurements. On average, the length measurement error was -7.25 mm and ranged from -17 to +4, suggesting estimates were fairly accurate (Table 10). On average, males were much smaller (mean, 370 mm TL; range, 300 – 495 mm TL) than females (mean, 637 mm TL; range, 497 – 720 mm TL). Minimum, maximum and mean lengths are summarized in Table 11. None of the 25 males were over 500 mm TL while only 1 of the 11 females was slightly less than 500 mm TL (497 mm TL). The disparity in size between males and females suggests an influx of younger males into the spawning population. This information, together with the genetic analysis and the absence of large PIT-tagged males provides evidence for locally-born fish in the population. The apparent lack of small females suggests males may mature at a younger age. In addition, definitively determining the sex of the small Bull Trout from video footage was challenging and may have resulted in some unknown degree of error.

Table 10. Summary of measured lengths (of trapped fish) and estimated lengths (via laser scaling) of male and female Bull Trout that moved through the video chute in 2023. Laser scaling error for fish that were both measured at the trap and estimated via laser scaling is also provided.

Fish ID	Sex	Trap Measurement (mm TL)	Laser Scaling Estimate (mm TL)	Laser Scaling Estimate Error (mm)
0000_0000000177418967	female	719	-	-
0000_0000000177418969	male	482	-	-
0000_0000000177418971	male	436	429	-7
0000_0000000177418991	male	460	451	-9
0000_0000000177418993	male	322	305	-17
0000_0000000177418994	female	695	-	-
0000_0000000177419068	female	-	674	-
0000_0000000177419117	female	720	-	-
0000_0000000177419192	female	-	605	-
0000_0000000177419210	female	-	549	-
0000_0000000177419420	female	-	683	-
982_000361679277	female	700	-	-
982_000361679296	female	685	689	+4
Untagged 1	male	-	332	-
Untagged 2	male	-	301	-
Untagged 3	male	-	410	-
Untagged 4	male	-	309	-
Untagged 5	male	-	325	-
Untagged 6	male	-	308	-
Untagged 7	male	-	303	-
Untagged 8	male	-	300	-
Untagged 9	male	-	471	-

Fish ID	Sex	Trap Measurement (mm TL)	Laser Scaling Estimate (mm TL)	Laser Scaling Estimate Error (mm)
Untagged 10	female	-	497	-
Untagged 11	male	-	315	-
Untagged 12	male	-	467	-
Untagged 13	female	-	517	-
Untagged 14	male	-	314	-
Untagged 15	male	-	395	-
Untagged 16	male	-	495	-
Untagged 17	male	-	323	-
Untagged 18	male	-	329	-
Untagged 19	male	-	444	-
Untagged 20	male	-	380	-
Untagged 21	male	-	302	-
Untagged 22	male	-	421	-
Untagged 23	male	-	314	-

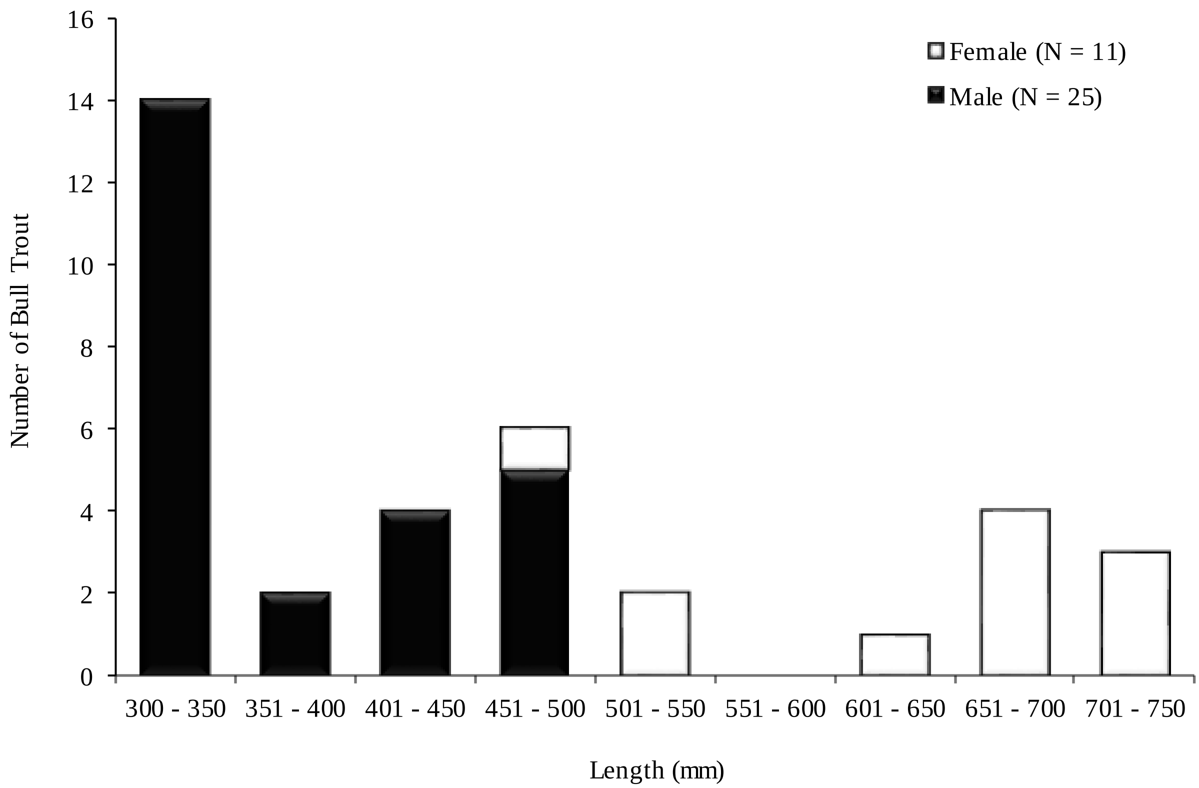

Figure 19. Summary of lengths (TL) for male and female Bull Trout observed in the Pinhead Creek spawning population during 2023. This summary includes lengths measured at the adult trap and lengths estimated for non-trapped individuals via laser scaling.

Table 11. Maximum, minimum and mean total lengths for male and female Bull Trout observed in Pinhead Creek during 2023.

Sex	Maximum TL (mm)	Minimum TL (mm)	Mean TL (mm)
Males	495	300	370
Females	720	497	637
Combined	720	300	453

Genetic Analysis

Caudal fin tissue samples were collected from 33 untagged adult Bull Trout (25 females and 8 males) captured at the weir from 2017 through 2023. These samples were used for genetic analysis to determine whether their genotypes matched any of those for translocated individuals (i.e., translocated fish that had shed their PIT tag) or genotypes indicating they were progeny of a translocated parent. From 2017 through 2020, almost all (96%) of the untagged Bull Trout sampled at the weir matched genotypes of translocated individuals (Table 12). Of this group, only one fish did not match any of the genotypes for translocated fish. However, parentageanalysis indicated it did not have translocated parents, suggesting it was likely not locally-born in the Clackamas River Subbasin. Another possibility is that it was one of the translocated fish that did not originally genotype. Of the nine untagged fish sampled from 2022 and 2023, one was determined to be a translocated fish and another did not match genotpyes for translocated fish or for progeny of translocated parents. However, theother seven (78%) did not match genotypes of translocated fish but did have a genotype suggesting at least one translocated parent (Table 13). This confirmed that some locally-born progeny from translocated parents had survived to be recruited into the putative spawning population. This is a cruicial benchmark that had not previously been documented during this reintroduction project

Table 12. Caudal fin tissue samples collected from untagged Bull Trout captured at the Pinhead Creek weir from 2017 to 2023. Demographics and genetic status are provided.

Run Year	Sex	Length at Capture (mm)	Genetic Status	Release Location	Release Year	Length at Release (mm)	Release Stage
2017	Female	587	Translocated	Pinhead Cr.	2013	148	Juvenile
2017	Female	630	Translocated	Pinhead Cr.	2012	95	Juvenile
2017	Female	588	Translocated	Pinhead Cr.	2013	147	Juvenile
2017	Male	504	Translocated	Last Cr.	2013	138	Juvenile
2017	Female	474	Translocated	Last Cr.	2013	114	Juvenile
2017	Female	552	Translocated	Clackamas R.	2014	277	Subadult
2018	Female	700	Translocated	Clackamas R.	2014	210	Juvenile
2018	Female	575	Translocated	Berry Cr.	2014	137	Juvenile
2018	Female	600	Translocated	Pinhead Cr.	2013	146	Juvenile
2018	Male	585	Translocated	Pinhead Cr.	2012	100	Juvenile
2018	Male	494	Unknown Origin	NA	NA	NA	NA
2019	Female	617	Translocated	Clackamas R.	2015	293	Subadult
2019	Female	728	Translocated	Last Cr.	2013	159	Juvenile

Run Year	Sex	Length at Capture (mm)	Genetic Status	Release Location	Release Year	Length at Release (mm)	Release Stage
2019	Female	606	Translocated	Clackamas R.	2015	249	Juvenile
2019	Female	690	Translocated	Pinhead Cr.	2012	145	Juvenile
2019	Female	618	Translocated	Pinhead Cr.	2013	185	Juvenile
2019	Female	595	Translocated	Clackamas R.	2016	244	Juvenile
2019	Female	583	Translocated	Clackamas R.	2016	273	Subadult
2019	Female	635	Translocated	Clackamas R.	2016	274	Subadult
2019	Female	636	Translocated	Clackamas R.	2016	287	Subadult
2020	Female	650	Translocated	Pinhead Cr.	2013	138	Juvenile
2020	Female	594	Translocated	Berry Cr.	2015	146	Juvenile
2020	Female	670	Translocated	Clackamas R.	2016	199	Juvenile
2020	Female	675	Translocated	Berry Cr.	2015	235	Juvenile
2022	Female	570	Translocated	Clackamas R.	2016	229	Juvenile
2022	Female	555	Locally-born	NA	NA	NA	NA
2022	Female	495	Locally-born	NA	NA	NA	NA
2023	Male	322	Locally-born	NA	NA	NA	NA
2023	Female	695	Locally-born	NA	NA	NA	NA
2023	Male	482	Locally-born	NA	NA	NA	NA
2023	Male	436	Locally-born	NA	NA	NA	NA
2023	Male	315	Locally-born	NA	NA	NA	NA
2023	Male	460	Unknown Origin	NA	NA	NA	NA

The vast majority of translocated individuals that had shed their PIT tags were females that had been tagged in the abdominal cavity as juveniles or small subadult-sized fish (range; 95 – 293 mm TL). This is consistent with other studies where female spawning has resulted in shedding of abdominally implanted PIT tags (Elizabeth et al. 2016). In addition, the mean length of translocated fish that had shed their tags (611 mm TL; range 474 – 728 mm TL) was higher than the mean length of locally-born fish (471 mm TL; range 315 – 695 mm TL). This size disparity may suggest locally-born individuals were generally younger than the translocated fish when sampled. The two Bull Trout of unknown origin (i.e., not confirmed to be translocated or locally-born) were more similar in length (mean 477 mm TL; range 460 – 494 mm TL) to the locally-born fish than to the translocated fish that had shed their PIT tag (Figure 20).

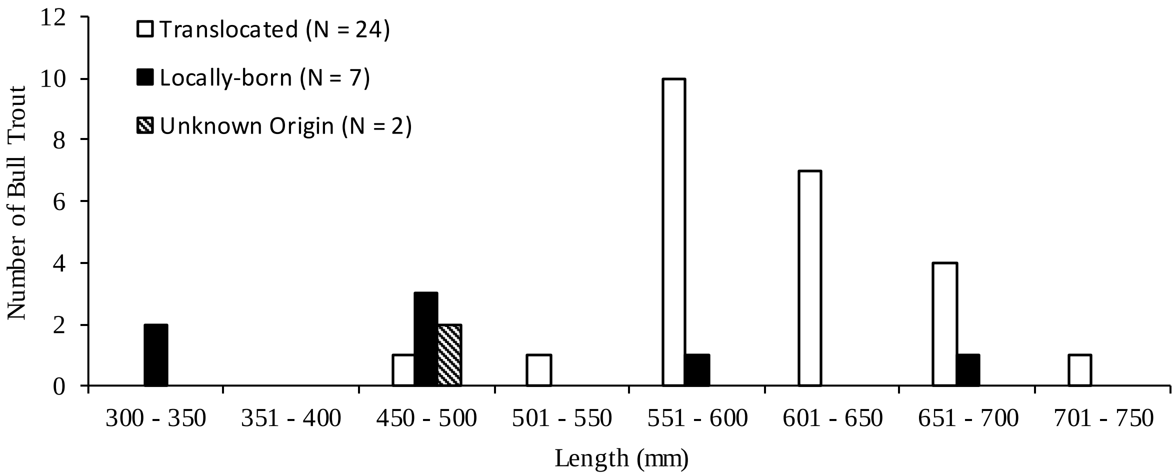

Figure 20. Summary of fish lengths for untagged individuals that were sampled at the Pinhead Creek weir from 2017 – 2023 and were determined to be translocated, locally-born, or of unknown origin through genetic analysis.

As mentioned previously, a parentage analysis was performed for the nine fish that did not match translocated fish genotypes to document within-basin recruitment of individuals into the spawning population. Seven of the nine (78%) were found to have at least one parent that was a fish translocated to the Clackamas River Subbasin, indicating they were locally-born (i.e., born within the basin). For three of the seven locally-born fish, both parents were identified as translocated fish. For the remaining four of the locally-born fish, only a single translocated parent could be identified (Table 13). It could not be confirmed whether the other two individuals were locally-born or translocated fish. Due to the small sample size, it is difficult to determine which translocated release groups, locations or lifestages may have resulted in the most successful recruitment into the spawning population. However, six of the seven locally-born fish had at least one parent that was captured in Lake Billy Chinook and released into the mainstem Clackamas River. As more samples are collected, data will continue to be analyzed to discern patterns that may indicate which translocation strategies were the most successful.

Table 13. Identified parents of the seven locally-born Bull Trout sampled in Pinhead Creek. The capture location, release location, lifestage at release and release year for the parents are provided.

Year Collected	TL/Sex of Progeny	Parent	Capture Location	Release Location	Release Lifestage	Release Year
2022	495 (female)	Father	Candle Cr.	Last Cr.	Juvenile	2013
		Mother	Lake Billy Chinook	Mainstem Clack. R.	Adult	2014
2022	555 (female)	Father	Lake Billy Chinook	Mainstem Clack. R.	Subadult	2014
		Mother	NA	NA	NA	NA
2023	482 (male)	Father	Lake Billy Chinook	Mainstem Clack. R.	Subadult	2016
		Mother	Jack Cr.	Pinhead Cr.	Juvenile	2012
2023	315 (male)	Father	Lake Billy Chinook	Mainstem Clack. R.	Subadult	2014
		Mother	Lake Billy Chinook	Mainstem Clack. R.	Adult	2015
2023	322 (male)	Father	NA	NA	NA	NA
		Mother	Lake Billy Chinook	Mainstem Clack. R.	Subadult	2015
2023	695 (female)	Father	NA	NA	NA	NA
		Mother	Jack Cr.	Pinhead Cr.	Juvenile	2012
2023	436 (male)	Father	Lake Billy Chinook	Mainstem Clack. R.	Juvenile	2014
		Mother	NA	NA	NA	NA

Summary of Findings

Bull Trout populations are known to exhibit life histories involving movements, migrations, spawning, rearing and foraging over a range of temporal and spatial scales (Schaller et al. 2014). An understanding of these fundamental characteristics is required to inform future management actions and for continued progress toward the project's goal of re-establishing a self-sustaining Bull Trout population in the Clackamas River Subbasin. Since this project's inception, numerous important milestones have been achieved. Notable findings have been the recruitment of translocated fish into the spawning population and the confirmation of viable embryos and healthy alevins in redds (Barrows et al. 2018). Another encouraging finding was the first observations of redds in Berry Creek during 2019 (Starcevich 2020). Arguably, the most crucial benchmark reached to date was the long-awaited confirmation of locally-born offspring being recruited into the spawning population in 2022 and 2023. However, there continue to be notable uncertainties and indicators that may be cause for concern. For example, prior sampling efforts (e.g., electrofishing, minnow-trapping, snorkel surveys and temporal eDNA sampling) suggest a lack of juveniles rearing in Pinhead Creek. In addition, despite confirming recruitment of locally-born individuals, population estimates and associated redd counts remain low. Many of these uncertainties may be realized and informed as the reintroduction monitoring effort progresses and the population develops. The following is a summary of findings from monitoring activities conducted during 2023:

Bull Trout began moving into Pinhead Creek to spawn on August 23, 2023, appeared to peak in mid-September, and the last fish moved upstream on September 29, 2023. Migration timing in 2023 was similar to previous years.

Since 2017, there have been no indications that the Pinhead Creek weir has negatively influenced salmonid access to upstream spawning grounds (Barrows et al. 2018 – 2023). The installation and operation of the weir during 2023 was nearly identical to past years, so passage and delay were not evaluated in detail. All but one of the PIT-tagged Bull Trout that encountered the weir during 2023 successfully passed upstream of the weir. This fish was a female, and redd counts indicated that a Bull Trout redd was found in Pinhead Creek downstream of the weir, suggesting the fish may have chosen to spawn in the lower portion of the creek. We also used additional submersible video cameras to monitor the trap and video chute entrances. Though limited, we were able to observe Bull Trout and Chinook Salmon behavior as they approached and moved into the trap and video chute. As expected, most fish on video hesitated (i.e., staged) before moving into the trap and video chute, but seemed to pass easily once they decided to enter. Despite the apparent minimal delay, we believe some minor modifications to the trap entrance to facilitate passage would be beneficial.

Our estimate of the spawning population in 2023 was 35 fish, which was very similar to estimates from 2021 and 2022 (both estimates were 36 individuals). However, spawning population estimates in recent years have been much lower than a high of 101 fish in 2018.

A spawning population estimate of 35 fish and a total of 18 redds resulted in an estimated spawner/redd ratio of 1.9. This value is higher than estimates from 2017 – 2022 that ranged from 1.0 to 1.5. Spawner/redd ratios have gradually trended higher since 2021.

The percentage of females in the Pinhead Creek spawning population had consistently increased from 52% in 2017 to 78% in 2022. However, this apparent trend failed to continue in 2023 due to the recruitment of smaller (and presumably younger) males into the spawning population. The percentage of females declined to 37% in 2023.

The surviving translocated individuals in the system are all mature adults. We know this because 2016 was the final year of translocations and the youngest juveniles of that group would have been at least age 1, making all of the individuals eight years old or older. As this component of the population ages, redd counts have steadily declined in recent years. However, we have now confirmed that locally-born offspring have begun to recruit into the spawning population and increased redd counts are expected if more locally-born offspring continue to mature.

From 2017 – 2023, mean lengths for tagged (translocated) and untagged females have trended upward, suggesting many of the untagged fish may have been translocated fish that have shed their PIT tags. This hypothesis was supported through the genetic analysis conducted in 2023. However, this analysis also indicated that a small portion (12%) of the untagged females sampled from 2017 – 2023 were locally-born.

Small Bull Trout (ie., 300 – 500 mm TL) comprised 63% of the total spawning population in 2023. This percentage was a notable increase from 19% in 2022 and very few fish smaller than 500 mm were observed from 2017 – 2021. This is likely an upward trend of natural recruitment into the spawning population based on the genetic analysis of trapped male spawners.

Prior to 2022, there had been no untagged male Bull Trout observed at the Pinhead Creek weir since 2018, strongly suggesting a lack of recruitment of locally-born individuals into the spawning population. However, the number of small, untagged males in 2022 (N =2) and 2023 (N = 22) provided additional evidence that an increasing number of locally-born fish have been recruited into the spawning population.

When compared with the reference streams (Cougar and Jack creeks), temporal occupancies in Pinhead and Last creeks were clearly different. Bull Trout DNA was highly detectible in the reference streams year-round, strongly indicating the presence of rearing juveniles. However, Bull Trout DNA was highly detectible in the Pinhead system during the spawning season, waned during incubation and emergence time periods, and low or not detected during the spring and early summer months when multiple year classes of juveniles would be expected to be present. These results suggest the Bull Trout population in Pinhead Creek may not yet be abundant, stable and self-sustaining. It seems likely that very few (if any) juvenile Bull Trout rear year-round in Pinhead and Last creeks.

Of the 33 tissue samples from untagged Bull Trout captured at the weir from 2017 through 2023, 24 were translocated fish that had shed their tags. Seven samples had at least one translocated fish as a parent, indicating they were locally-born. Two samples could not be categorized as translocated or locally-born (i.e., origin unknown). All of the locally-born fish were sampled during 2022 and 2023 and the vast majority were less than 500 mm.

A parentage analysis was conducted for the seven locally-born individuals. Both parents were identified for three of the samples and a single parent was identified for four of the samples. Another notable finding was that two of the locally-born fish shared a parent. At this time, no notable trends in parentage were evident. However, as more samples are collected, we may be able to determine which release strategies and lifestages contribute the most to the recruitment of locally-born adults into the spawning population.

Future Plans

In cooperation with our partners in the Clackamas River Subbasin, we intend to continue monitoring the effectiveness of the Bull Trout reintroduction program during 2024. We anticipate that the spawning population will continue to be monitored via redd counts and by operating a video weir near the mouth of Pinhead Creek in 2024. Continuing these activities will ensure the goals and objectives of the reintroduction project are met.

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