U.S. Fish and Wildlife Service

Estimating the Abundance of Adfluvial Bull Trout Spawning in Cougar Creek

2020 Annual Report

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Columbia River Fish and Wildlife Conservation Office

On the cover: *Cougar Creek Weir near Cougar, WA (Photo by Marshall Barrows, FWS)*

The correct citation for this report is:

Barrows, M.G. 2021. Estimating the Abundance of Adfluvial Bull Trout Spawning in Cougar Creek, 2020 Annual Report. U.S. Fish and Wildlife Service, Columbia River Fish and Wildlife Conservation Office, Vancouver, Washington.

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2020 ANNUAL REPORT

Funding provided by

PacifiCorp

Conducted pursuant to

Section 7 of the Endangered Species Act of 1973
Sec. 9.6.2 of the Lewis River Settlement Agreement
Sec. 2.17, Objective 17 of the Lewis River M&E Plan

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Columbia River Fish and Wildlife Conservation Office

December 31, 2021

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ESTIMATING THE ABUNDANCE OF ADFLUVIAL BULL TROUT SPAWNING IN COUGAR CREEK
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Abstract – In response to a general decline in abundance across their native range, Bull Trout (*Salvelinus confluentus*) were listed as threatened under the Endangered Species Act in 1999. Gaining a better understanding of the reproductive component of a population is important for Bull Trout recovery and persistence. Accurately monitoring the trend in abundance of spawners is essential to inform future management actions that may affect populations in the North Fork Lewis River subbasin. To estimate the abundance of the adfluvial Bull Trout spawning population, a resistance board weir and underwater video system were operated on Cougar Creek, a tributary to Yale Reservoir on the North Fork Lewis River, from July 29, 2020 through November 12, 2020. A total of 36 observations of adults moving upstream through the weir were recorded primarily from mid-August through late September, with the peak occurring in mid-September. The Bull Trout observed were all relatively large, migratory fish and length estimates derived from laser scaling ranged from 507 – 790 mm FL (mean, 695 mm FL). Since an individual could pass the weir multiple times during the spawning season, the number of recorded upstream observations may have been an overestimate of the true population size. To address this concern, we used PIT tag detections in addition to a photo-identification technique to allow recognition of individuals based on natural marks, such as colors, spots, scars, and fin shapes and to estimate the number of individuals that passed upstream of the weir. The estimated total number of spawning Bull Trout in Cougar Creek during 2020 was 34 unique individuals. The estimated number of males and females in the spawning population was 14 and 20, respectively. These data, combined with a redd count of 27 during 2020, suggest a spawner/redd ratio of 1.3. In future years, additional PIT-tagging efforts and improved PIT tag detection capability should further improve population estimates.

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Introduction

Bull Trout (*Salvelinus confluentus*) are native to the Pacific Northwest, but a general 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 require complex, connected habitat characterized by clean and cold water (Rieman and McIntyre 1995; Baxter and McPhail 1996; USFWS 2015). Habitat degradation, migration barriers (e.g., dams), the introduction of non-native species, and other anthropogenic actions have negatively affected Bull Trout populations (Fraley and Shepard 1989; Leary et al. 1993; Barrows et al. 2016). When Bull Trout were listed in 1999, they were estimated to occupy only 40 percent of their historical range (USFWS 2002).

New operating licenses for the Lewis River hydroelectric projects were issued by the Federal Energy Regulatory Commission (FERC) during 2008. Subsequently, an Aquatic Monitoring and Evaluation Plan (M&E Plan) for the Lewis River was developed and first implemented in 2010. The original M&E Plan has recently been evaluated and rewritten (PacifiCorp and Cowlitz County PUD 2017). New Bull Trout monitoring mandates were established and integrated into the Annual Operating Plan (AOP). Multiple programs and associated tasks were proposed for action under the AOP. One such task was to estimate the number of adult Bull Trout present in known spawning locations (i.e., Pine Creek, Rush Creek and Cougar Creek).

Bull Trout populations often exhibit a continuum of life histories involving movements, migrations, spawning, rearing and foraging over a wide range of time and spatial scales (Schaller et al. 2014). Successful monitoring of Bull Trout populations requires a sufficient understanding of these characteristics and is essential to inform future management actions that may affect populations in the North Fork Lewis River subbasin. The ability to accurately monitor the trend in abundance of the reproductive component of a population is exceedingly important in Bull Trout recovery efforts (Al-Chokhachy et al. 2005). Cumulative redd counts are commonly used to monitor spawning populations due to their relatively low cost and time effectiveness when compared to other methods. However, observer variability and other factors including turbidity, habitat complexity and streamflow can reduce accuracy (Maxell 1999; Al-Chokhachy et al. 2005).

This report discusses the suitability of the weir location and design for sampling in Cougar Creek and summarizes the results of operating a video weir to estimate the adfluvial Bull Trout spawning population in Cougar Creek during 2020. Fork lengths for the spawning population were estimated. The relationship between the population estimate resulting from the video weir, and 2020 redd counts in Cougar Creek, were used to estimate the spawner to redd ratio in Cougar Creek. However, this estimate from Cougar Creek may be used to help evaluate other spawning Bull Trout populations in the subbasin (i.e., Pine and Rush creeks).

Study Area

The study area includes Cougar Creek, a tributary to Yale Lake, which is the second of three reservoirs formed by hydroelectric dams owned and operated by PacifiCorp and Cowlitz Public Utilities District (PUD) on the North Fork Lewis River (Figure 1). The subbasin is located on the western slopes of the Cascade Mountains, southwest of Mount St. Helens National Volcanic Monument in southwest Washington. Cougar Creek emerges from a lava tube and flows approximately 2.1 river kilometers (rkm), draining a 10.4 square kilometer watershed before entering the reservoir (Stevens 1910; Doyle 2018) (Figure 2). Cougar Creek is the only tributary of Yale Reservoir where Bull Trout spawning is known to occur. There are two other known Bull Trout populations in the Lewis River subbasin, both of which are upstream of Swift Dam in Pine and Rush creeks (Figure 1). Only the adfluvial life history has been documented in the Lewis River populations and each is genetically distinct (DeHaan and Adams 2011; Hudson et al. 2019). Occasionally, migratory Bull Trout are captured by recreational anglers targeting the kokanee salmon and resident trout populations in Yale Reservoir, but retention of Bull Trout is prohibited (reviewed in Hudson et al. 2019).

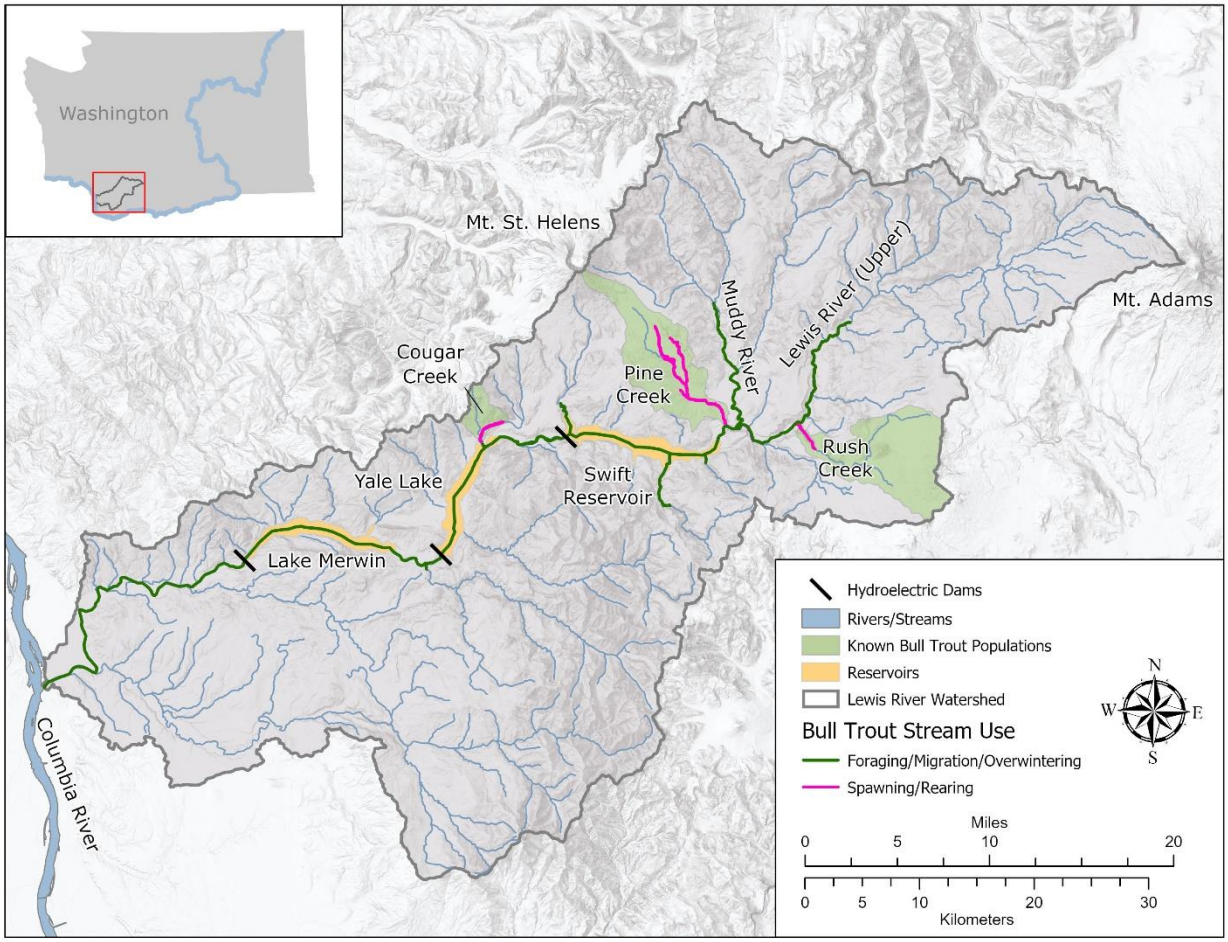


Figure 1. Bull Trout distribution in the Lewis River subbasin.

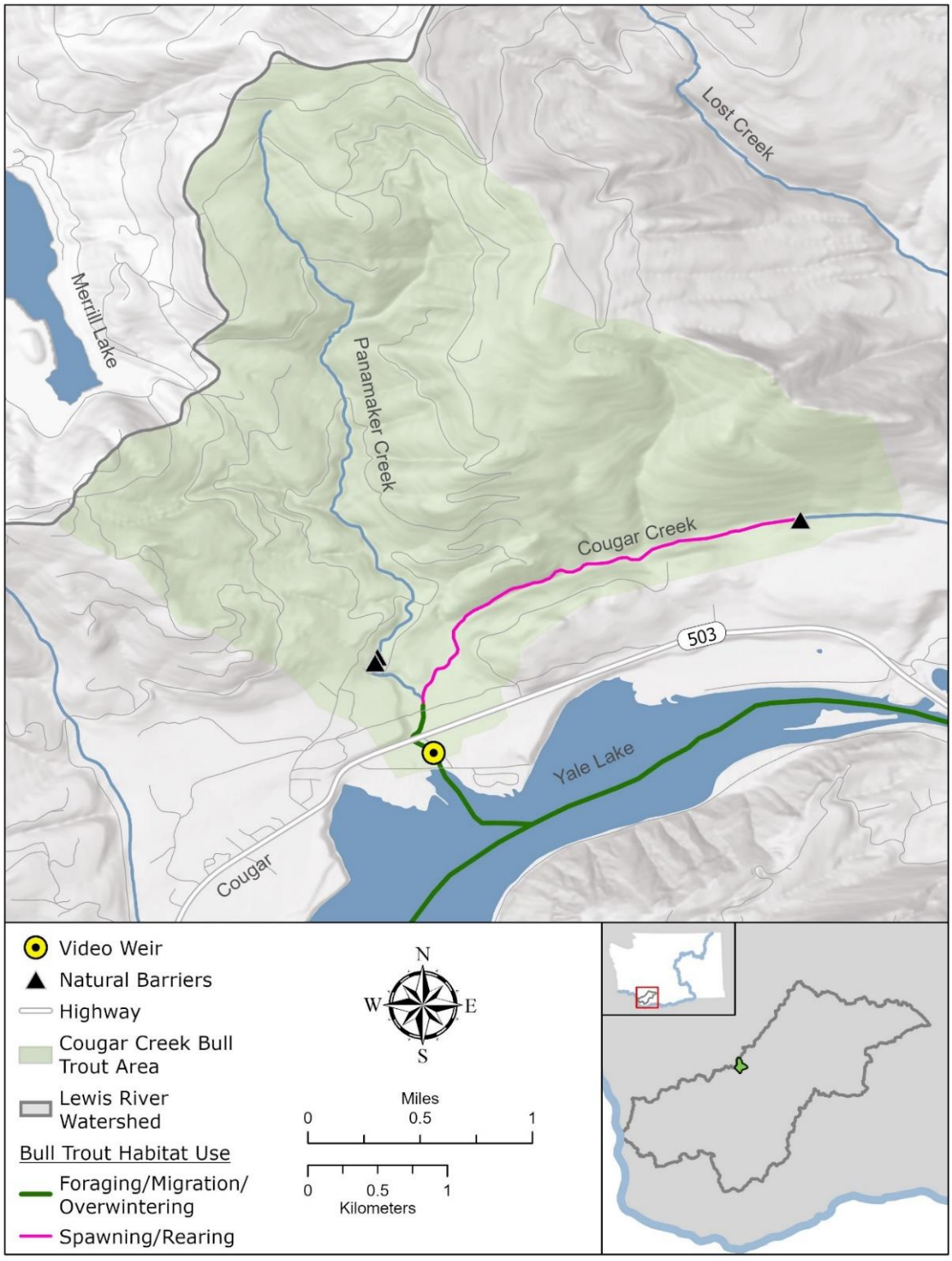


Figure 2. Location of the video weir within the study area. A PIT monitoring antenna (operated by PacifiCorp) was located both 30 m upstream and downstream from the weir site in Cougar Creek during 2020.

Methods

The goal of this project was to monitor and assess the Bull Trout spawning population in Cougar Creek. The primary objective was to estimate the number of Bull Trout spawning in Cougar Creek. This objective was initially addressed in 2019 by operating a two-way fixed- picket weir and underwater video system. The weir was installed approximately 200 meters upstream from the mouth (Figure 2). An important component of this effort was to determine the suitability of the weir location and design for sampling in Cougar Creek. Since high debris and elevated streamflows beginning in late September 2019 made operating this type of weir challenging (Barrows et al. 2020), the design was altered in 2020 to incorporate resistance board weir panels that are presumably better at accommodating higher seasonal flows and debris.

Weir Location and Design Suitability

A video weir to monitor Bull Trout in Cougar Creek had not been used prior to this project. Locating a reasonable site, designing a functional weir, and evaluating the suitability of the method for future monitoring were important aspects of this effort. We consider a functional weir to be one that efficiently allows Bull Trout to pass both upstream and downstream through the video chute during various flows and conditions. Easy access to the stream is limited, and the lower portion of the study area is heavily used for recreation (e.g., camping, swimming). In 2019, we chose to install the weir at a location approximately 200 m from Cougar Creek's mouth. The weir site was easily accessible, and no vandalism occurred. In addition, no redds were observed downstream of the weir location during 2019, suggesting the site was located below the Bull Trout spawning grounds in Cougar Creek. For these reasons, we reused the same site for the weir in 2020. In 2019, the weir design closely resembled an aluminum picket weir used to estimate the spawning Bull Trout population in the Clackamas River subbasin, Oregon (Barrows et al. 2018, 2019). This design worked well prior to the onset of unseasonably high streamflows and debris loads in October. In an effort to better accommodate the adverse conditions, channel-spanning resistance board weir panels were incorporated in 2020 (Figure 3). The camera chamber, video chute and picket leads were fabricated out of aluminum and of sturdy construction to withstand elevated streamflow and debris.

Figure 3. Photo depicting the aluminum picket leads, resistance board weir panels, video chute and camera chamber deployed in Cougar Creek.

The video chute and attached camera chamber were positioned on river right and picket leads were angled to funnel fish to the chute (Figure 3). Fish were able to move in either direction through the monitored video chute. The picket leads were constructed using schedule 40 aluminum pipe strung together with two ⅜ inch cables with ¾ inch PVC spacers between each picket. T-posts were secured into the substrate to support the leads, and additional T-posts were installed at an angle to provide support from downstream water pressure. Sandbags and rocks were placed where needed along the bottom of each of the leads and along the banks to make the weir fish-tight to adult Bull Trout. Resistance board weir panels spanned the center of the stream between two plywood bulkheads. The weir panels blocked passage and forced adult fish to find the video chute to pass.

The design for the underwater video system closely resembled that of Barrows et al. (2018, 2019, 2020) on Pinhead Creek near Estacada, Oregon. A full HD (1920 x 1080P) stainless steel bullet camera with a Sony Exmor CMOS image sensor with a 3.6-mm megapixel lens and three 12-V LED pond lights were mounted inside a sealed video chamber made of aluminum sheeting and attached to the video chute (Figure 4). 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. Video images were recorded on a Paramont DVR from InVid Technologies (model: PD1A-42TB) with four channels and two TB of memory. The DVR was equipped with motion detection to record all fish activity. The DVR was exchanged regularly with an identical second DVR to download and review video footage. A color monitor was used to review video footage when in the field and the office. The AC power source at the weir site was provided by PacifiCorp.

Figure 4. Photo depicting the camera chamber (left) and video chute (right).

We also used a laser scaling method, as described in Barrows et al. 2021, to passively estimate lengths from video of Bull Trout passing through the Cougar Creek video weir. Two 16 mm x 65 mm 5V DC submersible red laser line generator modules (output power 100mW) were mounted within a 2 gang type-FSC PVC Electrical Box for 1.9 cm conduit. The laser lines were aligned vertically and in parallel at a distance of 65 mm apart from each other (Figure 5). The laser modules were positioned 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 (Figure 5). Regardless of the distance between the fish and the camera, the measurement between the laser lines was consistently 65 mm. Video footage corresponding to each Bull Trout that passed upstream of the weir 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:

$$L_e = W_k \left(\frac{L_w}{W_y} \right)$$

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 and L_e = the estimated total length of the fish.

Figure 5. Observation of a female Bull Trout moving upstream through the video chute at the Cougar Creek weir during 2020. Laser lines from the laser scaling system were projected onto the side of the fish.

PacifiCorp installed a Biomark 1.53 m diameter IS1001 fully submersible PIT tag detection antenna both 30 m upstream and 30 m downstream of the weir at pinch points within the thalweg where fish detection was probable. In addition, a PIT antenna powered by a Biomark IS1001 Master Controller and IS1001 Reader was added to the upstream entrance of the video chute on September 24, 2020 to enhance the identification of individual Bull Trout.

Spawning Population Estimate

The spawning population of Bull Trout in Cougar Creek was estimated as the number of unique adults (i.e., Bull Trout with fork lengths > 550 mm) that moved upstream through the video weir during the spawning season. Bull Trout may move upstream and downstream through a video weir multiple times during a spawning season (Barrows et al. 2018, 2019, 2020). Since an individual could pass through the weir multiple times, the total number of Bull Trout observed could be an overestimation of the true population size; thus, it was necessary to estimate the number of unique individuals that passed the video weir. We used two methods to identify individual Bull Trout, PIT detections at the weir antenna 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. 2018, 2019, 2021). In 2020, PacifiCorp biologists PIT-tagged 16 Bull Trout in the bypass channel at the head of Yale reservoir prior to the spawning season. Eleven of the tagged fish were adult-sized (> 550 mm) and five were considered subadults and not expected to spawn during 2020. There were also an unknown number of remnant PIT-tagged individuals in the population resulting from previously conducted studies in the system (J. Doyle, personal communication, 2021). Timestamps allowed PIT detections to be assigned to video footage of tagged adult Bull Trout during passage. However, since the majority of individuals in the Cougar Creek population are not PIT-tagged, we used

distinguishing features (such as color variation, spots, scars, fin shapes, and size) to differentiate between most individuals. Similar techniques have been successfully 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. 2016).

Sexual dimorphism in Bull Trout may be more obvious during the reproductive period and less clear during non-reproductive periods in some populations (Nitychoruk et al. 2013). Experienced biologists used phenotypic characteristics including body form, head shape, jaw characteristics and coloration to categorize fish as male or female. Those fish with PIT tags or distinguishable characteristics were categorized as marked males (M_m) or marked females (F_m). Fish without PIT tags or distiguishable characteristics were categorized as unmarked males (M_u) and unmarked females (F_u). We made four assumptions worth noting: 1) PIT-tagged fish would be detected by the antenna around the upstream opening of the video chute (when operational), 2) distinguishing marks were not gained or lost during the season, 3) marks were always correctly detected, and 4) estimates of fork length were accurate for each fish observed. In 2019, multiple unmarked fish were observed at the weir, requiring us to use binomial models to estimate the number of unique unmarked individuals. This was not necessary during the 2020 monitoring season.

Results

Weir Location and Design Suitability

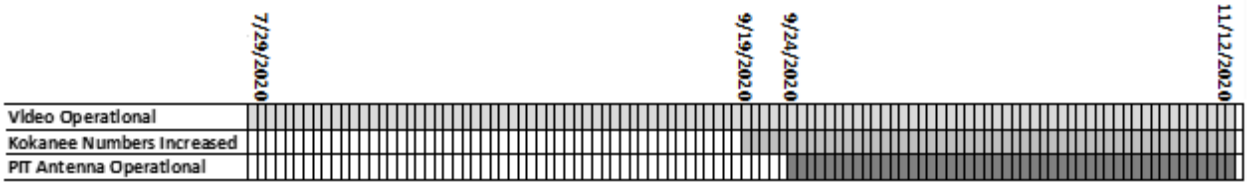
Given the success of operating a weir at the chosen site in 2019, we decided that the best course of action was to use the same site during 2020. The suitability of the site for operating a resistance board weir was qualitatively evaluated based on sampling results and observations throughout the season. As in 2019, the selected location was near the mouth of Cougar Creek, ensuring most Bull Trout would spawn upstream of the weir. No vandalism of the weir and monitoring equipment was observed during both the 2019 and 2020 seasons, and no redds were observed downstream of the weir in either year suggesting we observed most of the spawners in the system. Water depth was low throughout the summer months, requiring dam boards to be installed downstream of the weir to increase depth at the video chute. As in 2019, September brought extensive leaf-fall (primarily from Alder trees). However, the redesigned resistance board weir handled the increased debris load well. By early October, rainfall events combined with extensive leaf-fall, required more frequent cleaning, but there was no damage to the leads or weir panels (Figure 6). Toward the end of the monitoring season, there were infrequent, short timeperiods where the weir panels were overtopped. However, it was unlikely that fish passed upstream of the weir site un-monitored.

Figure 6. Example of high debris levels and elevated streamflows in early November 2020 at the Cougar Creek video weir.

Spawning Population Estimate

The Cougar Creek video weir was installed in late-July and fish passing the weir were continuously monitored via video from July 29, 2020 to November 12, 2020 (Table 1). A PIT detection antenna was installed on the upstream entrance to the video chute on September 24, 2020 to enhance the identification of individual Bull Trout.

Table 1. Cougar Creek video weir operation periodicity table during 2020.



During 2020, there were a total of 92 (48 upstream and 44 downstream) video observations of attempts by adult Bull Trout to pass the Cougar Creek video weir. Of these attempts, there were 36 observations of Bull Trout successfully passing upstream and 29 successfully passing downstream of the weir (Table 2). There were also 10,691 (8,190 upstream and 2,501 downstream) observations of Kokanee Salmon (*Oncorhynchus nerka*) at the weir. Juvenile Bull Trout, Mountain Whitefish (*Prosopium williamsoni*), Rainbow Trout (*Oncorhynchus mykiss*), Coastal Cutthroat Trout (Oncorhynchus clarkii clarkii) and adult Chinook Salmon

(*Oncorhynchus tshawytscha*) were also occasionally observed throughout the season. It is important to note that the 25.4 mm spacing between the PVC pickets of the weir panels allowed a portion of the smaller Kokanee Salmon and juvenile fish to pass the weir unmonitored.

Table 2. Upstream and downstream video observations of adult Bull Trout and Kokanee Salmon at the Cougar Creek video weir during 2019 and 2020.

Species (Sex)	Year	Upstream	Downstream	Total
Bull Trout (Male)	2020	15	7	22
Bull Trout (Male)	2019	43	35	78
Bull Trout (Female)	2020	21	17	38
Bull Trout (Female)	2019	50	29	79
Bull Trout (Unknown)	2020	0	5	5
Bull Trout (Unknown)	2019	0	0	0
Kokanee Salmon	2020	8,190	2,501	10,691
Kokanee Salmon	2019	7,197	614	7,811

Only one adult Bull Trout was observed moving upstream of the video weir between the weir's installation (July 29, 2020) and August 22, 2020. Comparatively, 9 adult Bull Trout had passed upstream of the weir during the same time period in 2019. The number of upstream observations increased during late August and peaked in late September. Adult Bull Trout continued to move upstream past the weir through mid-October (Figure 5).

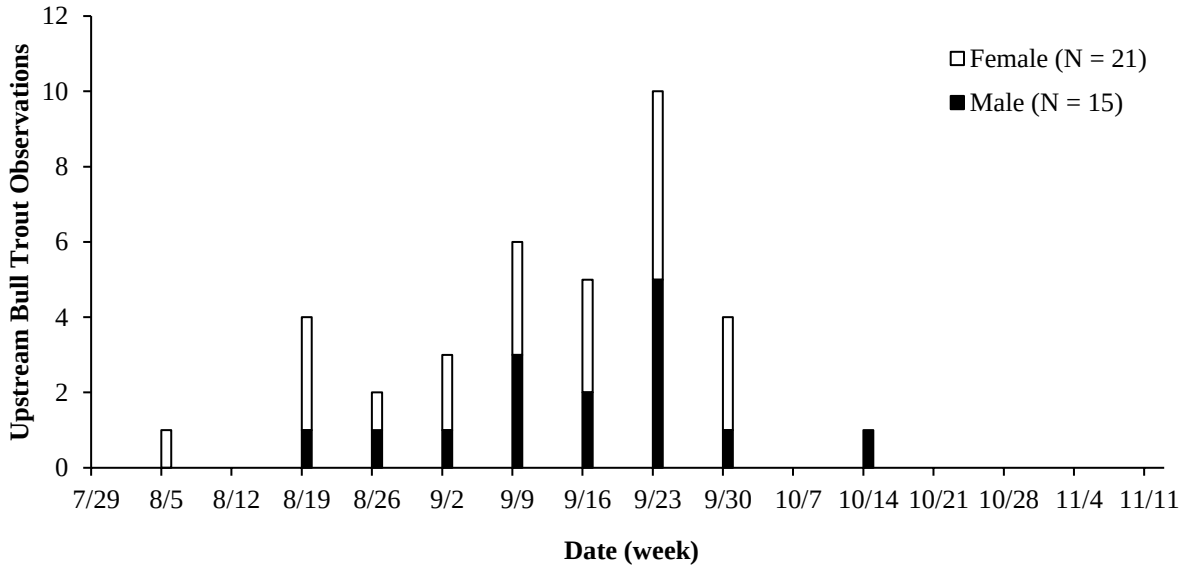


Figure 7. Observations of male and female Bull Trout moving upstream through the video chute at the Cougar Creek weir during 2020.

Of the 11 adfluvial adult-sized (i.e., > 550 mm FL) Bull Trout PIT-tagged in the bypass reach at the head of Yale Reservoir during 2020, 9 (82 %) were subsequently detected at PIT antennas in

Cougar Creek. There were also three Bull Trout that were PIT-tagged during previous studies in the system (i.e., tagged prior to PacifiCorp's effort in 2020) that were detected. PIT detections indicated most (75 %) of the PIT-tagged Bull Trout detected downstream of the video weir were subsequently detected upstream of the weir. The true percentage of PIT-tagged Bull Trout that successfully passed upstream of the weir to the spawning grounds is unknown due to multiple factors. One factor is that the detection probability at each instream PIT antenna is unknown and presumed to be < 100 % because each monitored only a portion of the stream channel. Another factor is that the video chute antenna was not operational until September 24, 2020, after most of the upstream movement at the weir occurred.

The 36 Bull Trout observed passing upstream of the weir were all relatively large, migratory fish with lengths ranging from 507 – 790 mm (mean, 695 mm). The majority of fish were between 650 and 750 mm (Figure 8). Female Bull Trout (mean, 687 mm; range, 507 – 761 mm) were on average slightly shorter than the males (mean, 706 mm; range, 521 – 790 mm). Estimated fork lengths of Bull Trout observed moving upstream of the Cougar Creek weir are summarized in Table 3.

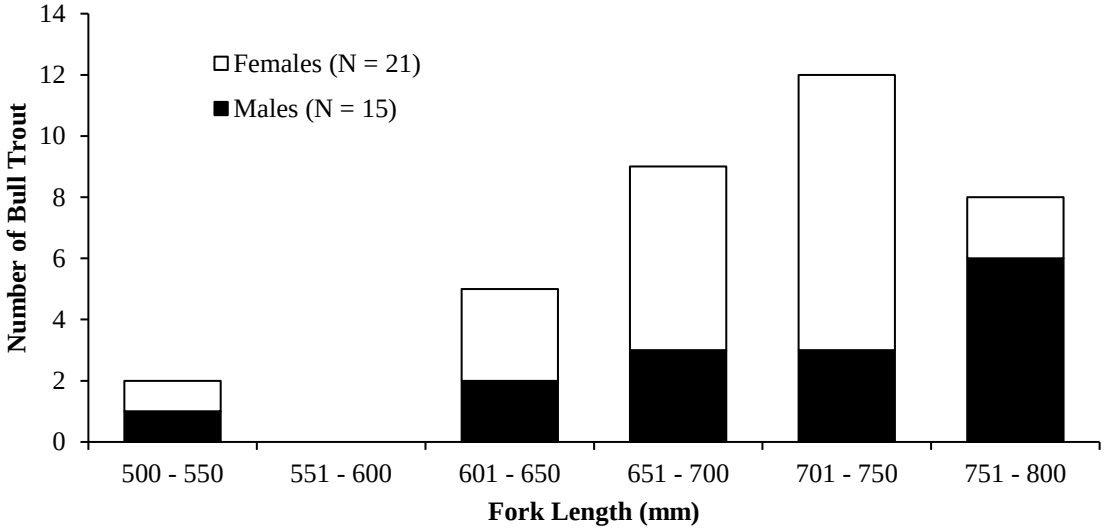


Figure 8. Summary of estimated fork lengths by sex of Bull Trout observed moving upstream of the Cougar Creek weir during 2020.

Table 3. Summary of Estimated fork lengths of Bull Trout observed moving upstream of the Cougar Creek weir during 2020.

Species (Sex)	Fork Length (mm)		
	Min	Max	Mean
Bull Trout (Male)	521	790	706
Bull Trout (Female)	507	761	687

Following a thorough, systematic review of the 36 upstream observations of adult Bull Trout at the video weir, we identified 14 unique marked males (M_m) and one unmarked male (M_u); thus, the total number of unique male Bull Trout was 15. Of the 21 female observations, we identified 18 unique marked females (F_m) and one unmarked female (F_u); thus, the total number of unique female Bull Trout was 19. Two of the marked females were observed passing upstream of the weir twice. There was no need to estimate the probability that a detection at the weir was a unique fish because only one male and one female were unmarked, indicating they were both unique individuals. The total estimated number of spawning Bull Trout in Cougar Creek in 2020 was 34.

In 2020, there were 27 Bull Trout redds counted in Cougar Creek (J. Doyle, personal communication, 2021), an increase from the 19 redds counted during 2019 (Table 4). These data suggest a spawner/redd ratio of 1.3, much lower than the 4.0 spawner/redd ratio from 2019.

Table 4. Estimated Bull Trout spawner/Redd ratios from 2020 and 2019.

Year	Population Estimate	Redd Count	Spawner/Redd Ratio
2020	34	27	1.3
2019	76	19	4.0

Findings

The effort during 2020 to estimate the Cougar Creek spawning population with a video weir was an important step toward improving the accuracy of redd counts. The combined findings from 2019, 2020 and 2021 will inform interpretation of past and future redd counts in Cougar Creek and throughout the Lewis River subbasin. The following are findings from activities conducted during 2020.

We estimated spawner/redd ratios to be 1.3 and 4.0 in 2020 and 2019 respectively. Studies have recorded spawner/redd ratios ranging from 1.2 to as high as 4.3 (Baxter and Westover 2000; Barrows et al. 2019; Taylor and Reasoner 2000; Al-Chokhachy et al. 2005). While our spawner/redd ratio was within this reported range during both years, values differed substantially between years in Cougar Creek. There are several factors potentially contributing to these interannual differences in the relationship of adult counts to redd counts, including measurement error in both counts (Howell and Sankovich 2012). In this study, errors in the population estimate and redd counts may have affected the estimated spawner to redd ratio. Improvements to the weir design, increased PIT-tagging and better PIT detection capability may improve our ability to demonstrate the accuracy of population estimates at the weir during 2021.

As in 2019, the majority of Bull Trout observations at the Cougar Creek video weir in 2020 were of adult fish and occurred in late summer and early fall, suggesting most of the fish entering the tributary were doing so to subsequently spawn. However, a portion of the Bull Trout observed on video were juvenile fish and may have been using Cougar Creek for rearing and foraging habitat.

Thousands of kokanee salmon moved upstream past the video weir beginning in mid-September. This run continued past weir removal in November. During the peak of the run, night observations of kokanee occurred every few seconds and made reviewing the video footage an arduous task. Using machine learning software to locate adult Bull Trout in the video footage may facilitate the video review process.

Photo-identification had not been used to identify individual Bull Trout in the Cougar Creek population prior to the initiation of this project. In 2019, many individuals were identified from the video observations, but a subset were found to have only very subtle, if any, noticeable distinguishing characteristics. However, during 2020, only two Bull Trout that moved upstream through the weir lacked distinguishing characteristics. Despite being informative, the PIT detections from instream wagon wheel antennas and the video chute antenna (installed in late September) were of little use for identifying individuals that moved upstream through the video weir. Additional PIT-tagging of the adult population and bolstering PIT tag detection capability at the video weir would likely increase the accuracy of identifying individuals as they pass upstream of the weir.

Prior to this study, length estimates for the spawning population in Cougar Creek have not been previously reported. The Bull Trout observed were all relatively large, migratory fish and length estimates ranged from 507 – 790 mm FL (mean, 695 mm FL). The laser scaling method we used for passively obtaining lengths from video of Bull Trout passing through the Cougar weir was demonstrated to have an average relative accuracy of 98.2% (range: 95.8 – 100%) by Barrows et al. 2020. However, accuracy of the laser scaling system has not been assessed for the Cougar Creek weir and may have been affected by multiple variables (e.g., fish orientation, camera position, lighting, etc.)

Monitoring in 2020 was the second year of operating a Bull Trout video weir in Cougar Creek. Adding resistance board weir panels to the design allowed for successful operation of the weir during the entire 2020 spawning season. The panels allowed the weir to better accommodate the higher late-season streamflows and debris loads. We believe these changes ultimately resulted in more accurate estimates of the spawning Bull Trout population in Cougar Creek and we intend to use this design during 2021.

Acknowledgments

We would like to thank and acknowledge the following individuals for their assistance in planning, implementation, document review and monitoring efforts: Jeremiah Doyle, Andrea Houts, Mike Hudson, Paul Sankovich, Brian Davis, Will Simpson, Ben Lee, Jonathan White, Tim Blubaugh, Rachael Thomas, Cyle Malcolm, Nate Queisser and Tim Whitesel.

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December 2021