Cougar Creek Bull Trout Video Weir

2019 Annual Report

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U.S. Fish and Wildlife Service
Columbia River Fish and Wildlife Conservation Office
On the cover:  Cougar Creek weir near Cougar, WA (Photo from NW Kokanee Addicts)

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and authored by

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U.S. Fish and Wildlife Service
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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. 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 monitor and assess the adfluvial Bull Trout spawning population, a two-way fixed-picket weir and underwater video system were operated on Cougar Creek, a tributary to Yale Reservoir on the North Fork Lewis River, from July 17, 2019 through October 30, 2019. A total of 93 observations of adults moving upstream through the weir were recorded primarily from mid-August through early October, with the peak occurring in mid-September. 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 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 2019 was 76 unique individuals. The estimated number of males and females in the spawning population was 35 and 41, respectively. These data, combined with a redd count of 19 during 2019, suggest a spawner/redd ratio of 4.0. In future years, adjustments to the weir design that better accommodate high streamflows will facilitate weir operation and should 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 impelled the U.S. Fish and Wildlife Service (USFWS) to list Bull Trout as threatened under the Endangered Species Act (ESA) in 1999 (64FR 58910). Bull Trout 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 an 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 (Dunham et al. 2001; 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 2019. The relationship between the population estimate resulting from the video weir, and 2019 redd counts in Cougar Creek, will be 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 resulting from 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 2,100 m, 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 additional known Bull Trout populations in the Lewis River subbasin, both are upstream of Swift Dam in Pine and Rush creeks. In the Lewis River subbasin, only the adfluvial life history has been documented in the Bull Trout populations and each population 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 approximately 30 m downstream from the weir site in Cougar Creek.
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. An important component of this effort was to determine the suitability of the weir location and design for sampling in Cougar Creek. To address this objective, a two-way fixed-picket weir and underwater video system was operated in Cougar Creek from July 17, 2019 through October 30, 2019 in collaboration with PacifiCorp. The confluence of Cougar Creek is located at river kilometer (rkm) 62 of the North Fork Lewis River. The weir was installed approximately 200 meters upstream from the mouth (Figure 2).

Weir Location and Design Suitability

A video weir to monitor Bull Trout in Cougar Creek had not been used previously. Locating a reasonable site, designing a functional weir, and evaluating the suitability of the method for future monitoring were important aspects of this effort. Easy access to the stream is limited, and the lower portion of the study area is heavily used for recreation (e.g., camping, swimming). We chose to install the weir at an easily accessible location approximately 200 m from Cougar Creek’s mouth. 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). The camera chamber was fabricated out of aluminum and the sturdy construction of the video chute and aluminum picket leads were intended to withstand elevated streamflow and debris.

The video chute and attached camera chamber were positioned on river right and the leads of the weir were angled to funnel the fish into the chute (Figure 3). Fish were able to move in either direction through the monitored video chute. The 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.
The design for the underwater video system closely resembled that of Barrows et al. (2018, 2019) 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). The interface between the video chute and the camera chamber was a safety glass window sealed to the camera chamber by rubber gaskets. 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 Paramount 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 with an identical second DVR regularly 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 3. Photo depicting the aluminum picket leads, video chute and camera chamber deployed in Cougar Creek (photo from NW Kokanee Addicts).
Spawning Population Estimate

The spawning population of Bull Trout in Cougar Creek was estimated as the number of unique adults 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). Since an individual could pass through the weir multiple times, the total number of recorded detections 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. PIT tags have been used to identify individual Bull Trout moving through video weirs (Barrows et al. 2018, 2019), but very few individuals with PIT tags exist in the Cougar Creek population. As an alternative, we used distinguishing features (such as color variation, spots, scars and fin shapes) to differentiate between 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). Video footage of each adult Bull Trout that successfully moved upstream through the video chute was thoroughly examined for identifiable characteristics. 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 distinguishable characteristics were categorized as marked males (\( M_m \)) or marked females (\( F_m \)). We made three assumptions worth noting. First, we assumed that marks were not gained or lost during the season. Second, we assumed that marks were always correctly detected. Third, we assumed that marked and unmarked fish had the same probability of passing the weir either once or twice.
We used detections of unique marked males ($M_m$) and unique marked females ($F_m$) to estimate the number of unique unmarked males ($M_u$) and unique unmarked females ($F_u$) that passed the weir. Most marked fish were only detected once, but some were detected twice at the weir; thus, we made the assumption that all unmarked males and females also passed the weir either once or twice. To estimate probabilities that a detection at the weir was a unique male ($p_m$) or unique female ($p_f$), we used binomial models. For males, the number of unique marked males ($M_m$) was a function of the total number of detections of marked males (some were detected once and some were detected twice) and the probability that a detection represented a unique male ($p_m$). The probability that a detection was a unique female ($p_f$) was similarly estimated using a binomial model. By multiplying raw counts (i.e., total number of detections) of unmarked males ($M_C$) and females ($F_C$) by the probability a detection was a unique fish ($p_m$ or $p_f$), we could estimate the number of unique unmarked males ($M_u$) and unique unmarked females ($F_u$). We then added the total number of unique marked males and the estimated number of unique unmarked males to get an estimate of the total number of males in the run. We did the same calculations for females in the run and then summed both values to estimate the total number of fish in the 2019 run.

We analyzed the binomial models using Bayesian methods with JAGS software (Plummer 2003) called from Program R (R Core Team 2013). We used Package jagsUI with function autojags (Kellner 2018) with three chains, an adaption of 1,000, a burn-in of 5,000, an iteration interval of 10,000, and enough iterations saved to meet convergence, as assessed by all Rhat scores less than 1.1 for all estimated parameters (Gelman and Hill 2007; Kéry and Schaub 2012). For each estimated parameter, the mean of the posterior distribution was considered the expected value and 95% credible intervals were used to describe precision. Estimates for numbers of fish were rounded to the nearest whole number for reporting. Prior distributions for $p_m$ and $p_f$ were selected to be uninformative using a uniform over the range of 0 to 1.

Results

Weir Location and Design Suitability

Given the uncertainty associated with operating a video weir for the first time in Cougar Creek, we decided that the best course of action was to select an easily accessible site that met the physical qualities and spatial requirements for installing and operating a Bull Trout weir. The suitability of the weir site was qualitatively evaluated based on sampling results and observations throughout the season. The selected location was near the mouth of Cougar Creek, ensuring most bull trout would spawn upstream of the weir. The site was accessible by vehicle, facilitating installation, operation and removal activities. The site was near a campground and day-use areas, increasing the potential for vandalism; however, it was in the vicinity of occupied maintenance buildings, offsetting the vandalism risk. This was evidenced by a lack of damage to the weir and monitoring equipment during the season. Throughout the summer months, water depth at the video chute was low (generally less than 0.3 m) which required the video camera to be mounted in the camera chamber at a lower than ideal position. The combination of low water depth and velocity prompted minor modifications to the video chute openings. As the monitoring season entered September and leaf-fall (primarily from Alder trees) increased
substantially, the need to clean the leads became more frequent. By mid-September, unseasonably high rainfall events combined with extensive leaf-fall resulted in short time periods where the picket leads were occasionally overtopped, water skirted around the weir margins, and some unknown number of fish may have passed the weir site un-monitored (Figure 7). The elevated streamflow, combined with excessive debris, eventually made cleaning the weir unsafe toward the end of October.

Figure 5. Examples of high debris levels and elevated streamflows in late September 2019 at the Cougar Creek video weir.

**Spawning Population Estimate**

The Cougar Creek video weir was installed in mid-July and was fully operational by July 23, 2019. Fish passing the weir were continuously monitored via video from July 23, 2019 to October 30, 2019 (Table 1). The video chute remained the only route of passage for adult Bull Trout to pass upstream or downstream through September 17, 2019, at which point water occasionally flowed over and around the picket leads between cleanings. It appeared that the majority of fish continued to pass through the video chute during these conditions, but the temporary breaches may have provided opportunities for Bull Trout to pass undetected. On October 19, 2019, a substantial rain and wind event resulted in stream conditions where debris removal and repair were not possible. The video equipment remained operational, but portions of the picket leads became submerged, compromising the effectiveness of the weir until its removal at the end of October.
While the weir was operational during 2019, there were a total of 157 (93 upstream and 64 downstream) video observations of Bull Trout at the Cougar Creek video weir (Table 2). There were also 7,811 (7,197 upstream and 614 downstream) observations of kokanee salmon \((Oncorhynchus nerka)\) at the weir. Mountain Whitefish \((Prosopium williamsoni)\), rainbow trout \((Oncorhynchus mykiss)\), Western brook lamprey \((Lampetra richardsonii)\) and adult Chinook Salmon \((Oncorhynchus tshawytscha)\) were also occasionally observed throughout the season.

### Table 1. Cougar Creek video weir operation periodicity table during 2019.

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<td>Video Uncertainty</td>
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<td>Video Fully Operational</td>
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<td>Increased Debris</td>
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<td>Water Topped Leads at Times</td>
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<tr>
<td>Kokanee Numbers Increased</td>
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<td>Weir Integrity Compromised</td>
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</table>

From late July to early August, there were only a few adult Bull Trout observed moving upstream of the video weir. The number of upstream observations increased during late August and peaked in September. Adult Bull Trout continued to move upstream past the weir through mid-October before the integrity of the weir was compromised in late October (Figure 5).

### Table 2. Upstream and downstream video observations at the Cougar Creek video weir during 2019.

<table>
<thead>
<tr>
<th>Species (Sex)</th>
<th>Upstream</th>
<th>Downstream</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bull Trout (Male)</td>
<td>43</td>
<td>35</td>
<td>78</td>
</tr>
<tr>
<td>Bull Trout (Female)</td>
<td>50</td>
<td>29</td>
<td>79</td>
</tr>
<tr>
<td>Kokanee</td>
<td>7,197</td>
<td>614</td>
<td>7,811</td>
</tr>
<tr>
<td>Rainbow Trout</td>
<td>50</td>
<td>44</td>
<td>94</td>
</tr>
<tr>
<td>Brook Lamprey</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Mountain Whitefish</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Chinook Salmon</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>
Although fork lengths were not specifically estimated as part of this study, the adult Bull Trout observed at the video weir were generally large adfluvial fish. A laser scaling system was used to aid in the photo-identification effort (Figure 6).

Following a thorough, systematic review of the 93 upstream observations of adult Bull Trout at the video weir, we identified 22 unique marked males ($M_m$) and 23 unique marked females ($F_m$). Five unique males and five unique females were detected twice at the weir; thus, the total number of detections of marked males was 27 and the total number of detections of marked females was 28. The probability that a detection at the weir was a unique fish was estimated by a binomial model to be 0.80 (95%: 0.63 – 0.92) for males ($p_m$) and 0.81 (0.64 – 0.92) for females.

**Figure 6.** Observations of male and female Bull Trout moving upstream through the video chute at the Cougar Creek weir during 2019.

**Figure 7.** Observations of female (left) and male (right) Bull Trout moving upstream through the video chute at the Cougar Creek weir during 2019.
Raw counts (i.e., total number of detections) of unmarked males $M_C$ and females $F_C$ were 16 and 22. Using estimates of $p_m$ and $p_f$, we estimated the number of unique unmarked males ($M_u$) as 13 (95%: 10 – 15) and the number of unique unmarked females ($F_u$) as 18 (95%: 14 – 20). The estimated total number of unique males in Cougar Creek in 2019 was 35 (95%: 32 – 37), the estimated total number of unique females was 41 (95%: 37 – 43) and estimated total number of spawning Bull Trout in Cougar Creek in 2019 was 76 (95%: 69 – 80).

Findings

The initial effort during 2019 to estimate the Cougar Creek spawning population with a video weir was an important first step toward improving the accuracy of redd counts. Improvements to the weir design and monitoring capability during 2020 may provide additional and more accurate information to 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 2019.

The majority of Bull Trout observations at the Cougar Creek video weir 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. The vast majority of kokanee salmon moved upstream past the video weir at night, averaging about one fish every 3 seconds at times during the peak of the run. This made reviewing video footage an arduous task at times. In future years, 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 this effort. Many individuals were identified from the video observations, but a subset were found to have only very subtle, if any, noticeable distinguishing characteristics. In addition, although we assumed marks were not lost or gained, fish may have acquired additional marks (i.e., scratches, split fins) following their initial detection, resulting in misidentification during subsequent observations. This may have influenced the final population estimate. PIT-tagging a portion of the adult population would likely increase the accuracy of identifying individuals as they pass upstream of the weir.

We estimated a total of 76 Bull Trout in the Cougar Creek spawning population. A total of 19 redds were counted in the redd surveys during 2019 (J. Doyle, personal communication, 2020). These data suggest a spawner/redd ratio of 4.0. While some studies have recorded spawner/redd ratios of around 1.2 (Baxter and Westover 2000; Barrows et al. 2019), others have reported spawner/redd ratios as high as 4.3 (Taylor and Reasoner 2000; Al-Chokhachy et al. 2005). While our spawner/redd ratio is within this reported range, there is still uncertainty in this ratio. There are a number of possible factors influencing variability 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 stemming from unseasonably high streamflows during much of the spawning season may have affected the estimated spawner to
reredd ratio. Improvements to the weir design and PIT-tagging a portion of the adult population may improve the accuracy of the population estimates at the weir during 2020.

The 2019 year was the first for operating a Bull Trout video weir in Cougar Creek. The selected design and location, though not ideal, allowed for the successful operation of the weir during most of the 2019 spawning season. We believe that adjusting the weir design to incorporate resistance board weir panels may be necessary to better accommodate the higher late-season streamflows and debris loads. We believe these changes may ultimately result in more accurate estimates of the spawning Bull Trout population in Cougar Creek in future years.

**Acknowledgments**

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