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Assessment of Bull Trout Passage during Operation of the Imnaha River Weir

2019 Annual Progress Report

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On the cover: *Fluvial bull trout from the North Fork Imnaha River. Photograph by Justin R. Cook*

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Disclaimers

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Abstract – Bull Trout are listed across their entire range in the U.S. (coterminously) under the Endangered Species Act as a threatened species. A potential threat to Bull Trout that has recently received considerable attention is the operation of weirs and the resulting influence on Bull Trout migrations. Some Bull Trout in the Imnaha River Core Area migrate from the Snake or lower Imnaha rivers, past a weir operating to collect Chinook Salmon, to spawning areas in the upper Imnaha River. A team of biologists investigated whether the operation of the Imnaha River weir impacted (based on previously derived benchmarks) Bull Trout during their spawning migration. Marking of bull trout with individual unique Passive Integrated Transponder (PIT) tags and monitoring their detections at PIT tag arrays were used to monitor the migratory behavior of Bull Trout when the weir was in operation. The percentage of Bull Trout that passed the weir (conversion) was estimated to be 93.8%, higher than the yearly benchmark (76.5%) and the 4-year running average benchmark (92.9%) for conversion. Overall, the median time it took Bull Trout to move from just below to just above the weir was one day. The benchmarks for median delay in June and July (6 and 4 days, respectively) were met, whereas the benchmark for median delay in August (2 days) was not. However, only a small portion (3%) of the individuals included in the analysis passed through the study area in August. Maximum delay in June (16 days), July (12 days), and August (25 days) exceeded the benchmark for maximum delay (8 days). In addition, Bull Trout detected moving upstream just below the weir were more likely to subsequently exhibit downstream movement (before the spawning period) than those detected at sites above the weir and well below it. Thus, in 2019, the operation of the weir may have slowed the rate at which some Bull Trout moved past the weir during their spawning migration. Overall, Bull Trout passage at the weir was similar to that in 2018 and improved relative to that in 2017, perhaps due at least partly to improved passage conditions in openings at the base of the weir designed to provide passage for resident fish, and to the modification of the design of the trap entrance.

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Preface

This report is intended to document annual work and activities associated with Bull Trout passing the weir in the Imnaha River (Oregon), which is operated for the Chinook Salmon program of the Lower Snake River Compensation Program. This report is for the calendar year 2019. This report is generally technical in nature and, for context, references and discusses operations and benchmarks that were previously established by co-managers. This report is not a policy document and, while its contents may inform the process, is not for the direct purpose of establishing final policy.

Introduction

Bull Trout (*Salvelinus confluentus*) are listed under the Endangered Species Act as a threatened species. Bull Trout were listed across their entire range in the U.S. (coterminously) on November 1, 1999 (see USFWS 2015a). Factors contributing to the listing of Bull Trout included range-wide declines in distribution, abundance and habitat quality. Land and water uses that alter or disrupt the habitat requirements of Bull Trout can be a threat to the persistence of bull trout. Commonly considered examples of such threats include dams, timber harvest, and nonnative fish (USFWS 2015a). A potential threat that has recently received considerable attention (for example, see Kelly Ringel et al. 2014) is the operation of weirs and the resulting influence on Bull Trout migrations. The operation of weirs is prevalent throughout the part of the Columbia River basin that is accessible to anadromous fish.

The Mid-Columbia Recovery Unit (MCRU) is one component of the coterminous Distinct Population Segment (DPS). The MCRU has numerous core areas, one of which is the Imnaha Core Area (Figure 1). The Imnaha Core Area consists of at least five putative local populations of bull trout (Barrows et al. 2016). Spawning and early rearing for the Upper Imnaha Population is focused in the North Fork Imnaha River, South Fork Imnaha River, and the portion of the mainstem just below the confluence of these two forks (Buchanan et al. 1997). While the absolute number of Bull Trout that spawn likely varies between years, the majority of Bull Trout spawning in the Imnaha River occurs upstream of river kilometer (rkm) 80 (Sausen 2017), generally in headwater areas (ODFW 2005). Some bull trout from the Upper Imnaha Population express a fluvial life history, migrating between the spawning areas and lower Imnaha River or mainstem of the Snake River.

This investigation focused specifically on Bull Trout that had been tagged previously with passive integrated transponders (PIT) and were migrating from the Snake or lower Imnaha rivers to the spawning areas. The majority of this migration occurs between May and August. Bull Trout that move from the lower Imnaha River to their spawning area pass through the entire area where Chinook Salmon (*Oncorhynchus tshawytscha*) spawn. Chinook Salmon spawning in the Imnaha River includes hatchery- and natural- origin spawners. A weir to implement the Chinook Salmon hatchery program exists (see Hoffnagle 2005), below the headwater areas where Bull Trout are generally believed to spawn (Buchanan et al. 1997, ODFW 2005). The weir is permitted to operate from May 1 to October 1 per the Section 10 permit 18030, with the understanding that flow conditions actually control when installation and operation occurs. However, the weir generally operates from June or July into mid-September each year.

Project Goal

To provide information that can be used to minimize the incidental take of ESA-listed Bull Trout in the Imnaha River during operation and management of the Imnaha River weir and acclimation site for brood collection of spring/summer Chinook Salmon.

Project Objectives

1. During 2017-2020, assess the passage rate (conversion) of Bull Trout that is associated with the operation of the Imnaha River weir for collection and enumeration of adult spring/summer Chinook Salmon. Target benchmarks for conversion are an average across the four study years of at least 92.9% of PIT-tagged adults passing with no less than 76.5% in any given year (point estimates).

2. During 2017-2020, assess the migration delay (delay) of Bull Trout that is associated with the operation of the Imnaha River weir for collection and enumeration of adult spring/summer Chinook Salmon. Target benchmarks for delay (of Bull Trout that pass the weir) are median passage (between lower [IR4] and upper [IR5] antenna arrays) of no longer than 8 days for May, 6 days for June, 4 days for July and 2 days for August and September, with no individual taking longer than 8 days in any month.

3. Minimize and standardize impacts to Bull Trout during operation of the Imnaha River Weir through adaptive management during planned monitoring activities of passage and delay. This will be done through ongoing and continued discussions and coordination between the U.S. Fish & Wildlife Service (USFWS), National Oceanic & Atmospheric Administration (NOAA)-Fisheries, co-managers, and cooperators and may involve revising benchmarks, implementing operational changes or modification of structures.

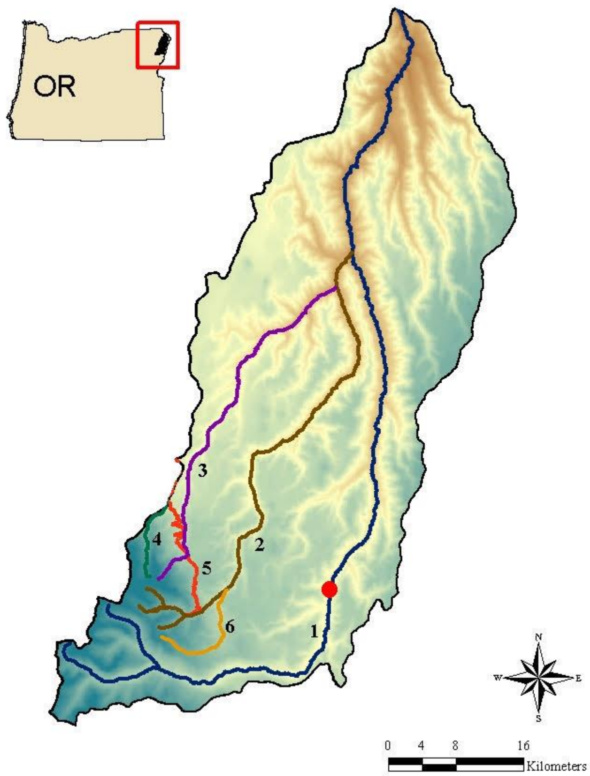

Figure 1. Local populations of Bull Trout in the Imnaha River subbasin can be found in the Imnaha River (1), Big Sheep Creek (2), McCully Creek (4) (currently a tributary to the Grande Ronde River subbasin), and Lick Creek (6); Bull Trout can also be found rearing in Little Sheep Creek (3), and the Wallowa Valley Improvement Canal (5). The Imnaha River weir and acclimation site is identified (red dot).

Endangered Species Act

Operation of the Imnaha River weir must result in acceptable and, ideally, minimal impacts to listed Bull Trout (USFWS 2016). Results from this investigation will be used to gauge weir impacts and inform weir operations in the Imnaha River and may also be used to help gauge impacts and inform operations in similar situations where weirs are operated. Specifically, this investigation addresses Terms and Conditions 2.1 and 3.1 within the USFWS Biological Opinion (USFWS 2016, also see USFWS 2015b) on the Imnaha River Satellite Facility Weir modification:

> *(2.1) Within 6 months of the issuance of this opinion, a small group of subject matter experts will be convened, including representatives from the Service, ODFW, IPC, and the NPT, to develop and recommend a feasible sampling strategy for identifying the potential impacts from operation of the new weir and quantitatively evaluating bull trout movement past the Imnaha Satellite Facility when the weir is blocking the channel. It is expected that this strategy will capitalize on the large number of PIT- tagged bull trout in the river. The agreed-upon approach must be intensive enough to assess the duration of potential migration delays in the immediate vicinity of the weir.*
>
> *Within one year of the date of the sampling strategy being finalized, the agreed-to sampling strategy will be implemented for a four year period. Data collected from this sampling effort will be shared with the La Grande Field Office and adaptive management procedures will be used to adjust weir operations, as needed, if serious migration problems are observed.*
>
> *(3.1) Establish a monitoring program, in coordination with the La Grande Field Office and based on the sampling strategy described in Term and Condition 2.1, to evaluate bull trout passage and help assess incidental take from operation of the new weir. The monitoring program shall be intensive enough to identify any subadult or adult passage problems, should they be occurring. Adaptive management procedures will be used to adjust weir operations, as needed, if serious fish passage problems are identified through this monitoring program.*

Study Area and Weir Operation

The Imnaha River Satellite Facility is located on the Imnaha River approximately 48 km south of the town of Imnaha, Oregon, near rkm 73. The facility is located on U.S. Forest Service (USFS) property. The Imnaha River Satellite Facility serves as the adult collection and juvenile acclimation and release facility for the Imnaha River spring/summer Chinook Salmon hatchery program within the USFWS-Lower Snake River Compensation Plan (LSRCP) Program. The existing facility was constructed in 1988 and is operated by the Oregon Department of Fish and Wildlife (ODFW) with assistance from the Nez Perce Tribe (NPT) through co-operative agreements with the LSRCP Office. Spawning, incubation and early rearing for this program occurs at Lookingglass Fish Hatchery, operated by ODFW. Lead management entities identified in the current 2008 – 2017 U.S. v. Oregon Management Agreement include the Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and ODFW.

From 1982 to 2015, a picket weir was installed for brood stock collection at the site with a target installation period in early to mid-May. The picket barriers required manual installation accomplished by workers wading into water that was often high and fast flowing, which led to precarious situations. Installation of the picket weir occurred anytime from late-May to late-July when river flows subsided following the spring runoff. This often resulted in a significant portion of the spring/summer Chinook Salmon run passing the weir site before installation occurred and compromised management objectives and introduced concerns identified by NOAA-Fisheries for this ESA-listed population and corresponding hatchery program.

A new bridge-style weir and structure was completed in fall 2015 (Figure 2). Picket panels can be installed manually onto the structure from the bridge. The new weir can be operated under a wider range of river flows, and the need for workers to enter the river during potentially unsafe flows should be eliminated. This modification assists in meeting management objectives and addresses NOAA-Fisheries permitting and incidental take concerns regarding the Imnaha River spring/summer Chinook Salmon program.

Figure 2. Pictures of the new bridge-style weir installed at the Imnaha River acclimation facility and brood collection ponds during October 2015. Weir panels are in the “down” position and pivot from the lower portion of the bridge to operate. Photos by USFWS – Lower Snake River Compensation Plan Office.

Methods

Per the USFWS Biological Opinion, Bull Trout PIT-tagged as part of ongoing investigations by co-managers and cooperating agencies were used to address the objectives. During or prior to 2019, Idaho Power Company (IPC) biologists PIT-tagged Bull Trout captured in the Snake River, ODFW personnel PIT-tagged Bull Trout captured moving upstream at the weir during Chinook Salmon operations, and the Nez Perce Tribe (NPT) biologists PIT-tagged Bull Trout captured in a screw trap operated downstream of the town of Imnaha. Overall, each effort put tagged Bull Trout that may be observed for multiple years into the Imnaha River subbasin. We used detections of PIT-tagged Bull Trout that moved through the Imnaha River in 2019, specifically at or between PIT tag arrays located downstream (IR4) and upstream (IR5) of the Imnaha river weir (Figure 3) as well as those detected at IR3 (rkm 41) to achieve the objectives of the study. Detection histories for the PIT-tagged bull trout were evaluated to determine whether they exhibited a pattern reflective of the behavior of interest, Bull Trout migrating upstream past the weir site when the weir was operating (for example, detected during weir operation, not pre- or post-operation, detected moving upstream rather than only downstream, and tagged prior to capture at the weir in 2019).

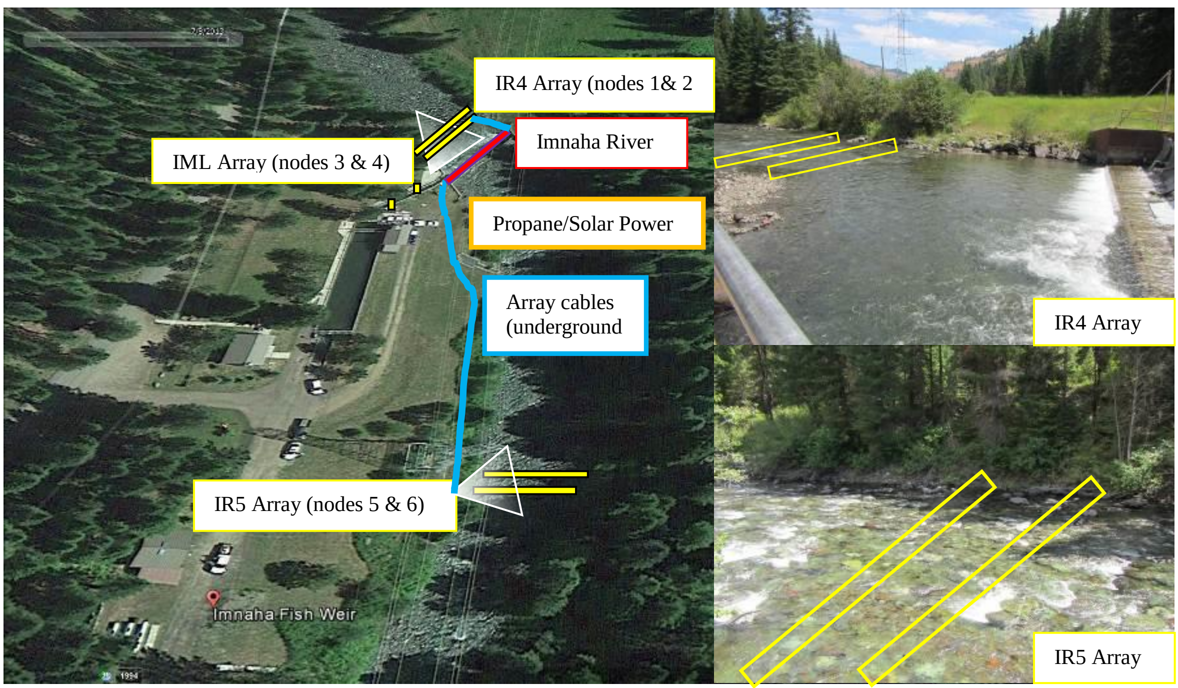

Figure 3. Location of the six Passive Integrated Transponder (PIT) tag detection arrays near the Imnaha River weir site. The IR4 array (nodes 1 [IR4B0, downstream] & 2 [IR4A0, upstream]), IR5 array (nodes 5 [IR5B0, downstream] & 6 [IR5A0, upstream]) are within the bankfull area of the Imnaha River. The IML array (nodes 3 & 4) is located in the adult ladder leading to the adult collection trap. Photos on the right show where the IR4 array (top right) and IR5 array (bottom right) are positioned and correspond to shaded triangles showing a perspective from the bank. The orange block is the location of the transceiver and power. All locations are approximations.

Objective 1. During 2019, assess the passage rate (conversion) of Bull Trout that is associated with the operation of the Imnaha River weir for collection and enumeration of adult spring/summer Chinook Salmon.

To address Objective 1, both during and after the Chinook Salmon spawning season, data on Bull Trout conversion were summarized, analyzed and disseminated to the subject matter experts from coordinating agencies for discussion during coordination calls. Relative to Objective 1, the *observed percent* of Bull Trout that passed the weir was calculated as:

a) $((IRS + IRT_D + IRT_U) / IR4) \times 100$

Where *IRS* = the number of PIT-tagged Bull Trout that were not trapped, presumably got above the weir by swimming through or under weir panels, and were determined through detection histories to have passed upstream of IR5 (the PIT tag antenna array upstream of the weir); IRT_D = the number of PIT-tagged Bull Trout that were captured in the trap and released downstream from IR5; IRT_U = the number of PIT-tagged Bull Trout that were captured in the trap, transported and released upstream of IR5; and *IR4* = the number of uniquely PIT-tagged Bull Trout determined through detection histories to have reached IR4 (the PIT tag antenna array downstream of the weir). This approach was designed to calculate the *observed percent* (no expansions or adjustments) of tags passing the weir (conversion). Although detection efficiency was intended to be relatively high and similar at both IR4 and IR5, we also calculated the *expanded percent* of Bull Trout passing the weir (helping to avoid bias in calculations of conversion). This was done using a Lincoln-Petersen, mark-recapture approach (see Krebs 1999) to estimate the total number of PIT-tagged Bull Trout passing both IR4B0 (downstream node at IR4) and IR5B0 (downstream node at IR5) (Figure 3; nodes 1 and 5). The estimated total number (*N*) of PIT-tagged Bull Trout passing a site of interest (e.g. IR5B0) was calculated as:

b) $(C \times M) / R$

Where *C* = the total number of unique Bull Trout PIT tag codes detected upstream of the site of interest; *M* = the total number of unique Bull Trout PIT tag codes detected moving upstream at the site of interest; and *R* = the total number of unique Bull Trout PIT tag codes that were detected moving upstream at, and upstream of, the site of interest. The *expanded percent* (based on the estimated total numbers) of tags passing the weir (conversion) was calculated as:

c) $(N_{IR4B0} / N_{IR5B0}) \times 100$

Where N_{IR4B0} = the estimated total number of PIT-tagged Bull Trout passing IR4B0 and N_{IR5B0} = the estimated total number of PIT-tagged Bull Trout passing IR5B0. Finally, some Bull Trout were also detected moving between IR4 and the ladder or trap, but not detected at IR5 (for example, a fish may have entered the trap only to exit it later and get detected again at IR4). It is possible that managers may be able to adjust operations so that these fish are trapped when they initially enter the ladder or trap (cannot or do not swim back out). If these fish then were released above the weir and migrated upstream past IR5, this would impact the estimated percent of Bull Trout passing the weir. Thus, we also calculated *expanded percent - possible* of Bull

Trout passing the weir by including the additional detections that would have been anticipated at IR5 after releasing these fish. To do this, we added the number of fish that entered the ladder or trap, but appeared based on their detection history to have remained below the weir, to the expanded number of Bull Trout detected at IR5. We then divided this sum by the expanded number of PIT-tagged Bull Trout that passed IR4 moving upstream during the study period.

Objective 2. During 2019, assess the migration delay (delay) of Bull Trout that is associated with the operation of the Imnaha River weir for collection and enumeration of adult spring/summer Chinook Salmon.

To address Objective 2, we also used PIT-tagged Bull Trout that moved through the Imnaha River. As in Objective 1, we specifically used tagged fish detected at or between the lower and upper PIT arrays (IR4 and IR5) during the trapping season. Development of the target delay benchmarks was also outlined in the monitoring proposal. Relative to Objective 2, the time (in days) for an individual Bull Trout to pass the weir site was calculated as:

d) $date_{IR5} - date_{IR4}$ (or)

e) $date_{trans} - date_{IR4}$

Where $date_{IR5}$ = the Julian day a PIT-tagged Bull Trout was first detected at IR5; $date_{IR4}$ = the Julian day a PIT-tagged Bull Trout was first detected at IR4; $date_{trans}$ = the Julian day a PIT-tagged Bull Trout that had been captured at the weir facility was transported and released into the Imnaha River above IR5. Only Bull Trout that were detected at i) IR4 and IR5 or ii) IR4 and released above IR5 were used in this analysis. Median passage times (in days) for each month were calculated from individual passage times from equations b and c.

To further inform Objective 2, we evaluated "milling" behavior. Milling behavior was defined as movement upstream followed by movement downstream during the time of the spawning migration (April 1-August 15). Conceptually, milling behavior could be contrasted to continuous movement upstream (directional behavior). We used tagged fish detected at the lower and upper nodes of the IR3, IR4 and IR5 PIT arrays, during the spawning migration (e.g., not including fish moving downstream in September). There are no target benchmarks for milling behavior. Instead, given that the area in which Bull Trout spawn is significantly upstream of IR3, IR4 or IR5, we hypothesized that the proportion of Bull Trout that would exhibit downstream movement at each site would be similar. The proportion of fish that exhibited milling behavior at each location was calculated as:

a) $pM = D/U$

Where D = the number of unique PIT tag detections of Bull Trout that, after being detected at the upper node of an array (e.g. IR5A0) were subsequently detected at the lower node of an array (e.g., IR5B0) before being detected at any upstream site; and U = the number of unique PIT tag detections of Bull Trout at the upper node of an array (e.g,. IR5A0). For example, if 100 Bull trout were detected at IR5A0 and 10 of those were next detected at IR5B0, then pM = 10/100 or 0.10. All Bull Trout were assumed to, ultimately, be trying to move upstream. In this case, given reports suggest detection efficiencies at IR5B0 and IR4B0 are > 0.50, it is reasonable to anticipate there would be 100% detection of any tagged fish that moved downstream and then, ultimately, back upstream over these nodes. In addition, given that IR3 is not a channel-spanning antenna and is known (or presumed) to have incomplete detections, the detection efficiency is generally estimated to be < 0.50. Thus, calculation of *pM* was based on actual detections (with no expansion for detection efficiency).

Results

Bull Trout

In 2019, the weir and trap were operated between June 21 and September 11. During this period, 107 bull trout were detected moving upstream at IR4 (see Appendix A). These were the individuals included in the evaluation.

Objective 1. Conversion

Of the 107 bull trout detected moving upstream at IR4 between June 21 and September 11, six remained below the weir throughout the study period, nine entered the trap and passed IR5 following their release, and 92 were detected at IR5 after passing through the weir, presumably via one of three "chutes" (rectangular openings, approximately 30 cm wide and 10 cm high, designed to allow passage of smaller resident fish). Two of the bull trout detected at IR5 after passing through the weir were last detected at IR4 less than an hour after having been detected at IR5. When calculating conversion, we considered these fish to have successfully passed through the project area. Thus, based on the *observed percent* (101/107), the conversion rate from below the weir to above the weir was 94.4%. Sixty-one PIT-tagged bull trout were detected at IR4B0 (*M*), 60 of those were also detected upstream from IR4B0 (*R*), and a total of 109 were detected upstream from IR4B0 (*C*). Thus, 111 ((109 x 61)/60) PIT-tagged bull trout were estimated to have moved upstream past IR4B0 (N_{IR4B0}). Ninety-seven PIT-tagged bull trout were detected at IR5B0 (*M*), 82 of those were also detected upstream from IR5B0 (*R*), and a total of 88 were detected upstream from IR5B0 (*C*). Thus, 104 ((88 x 97)/98) PIT-tagged bull trout were estimated to have moved upstream past IR5B0 (N_{IR5B0}). Based on the *expanded percent* (104/111), the conversion rate from below the weir to above the weir was 93.7%. Eighteen bull trout were detected at IR4 and subsequently in the ladder. Eight of these bull trout moved downstream out of the ladder, but only two of them failed to pass IR5. Thus, the *expanded percent - possible* ((104 + 2)/110 would have been 96.4%. Based on the number of PIT-tagged fish detected at IR4B0 (n=61) and IR5B0 (n = 97) and the estimated number of fish passing those sites (111 and 104), the detection efficiencies at those sites were estimated to be 54.9%(61/111) and 93.3%(97/104), respectively.

Objective 2. Delay

One hundred and one individual Bull Trout were detected at both IR4 and IR5 and had detection histories indicating they were suitable for calculating delay. Overall delay ranged from 0-14 days with a median of 0.5 day (Figure 4). Delay in June (based on 13 Bull Trout) ranged from 0-

7 days with a median of 1 day. Delay in July (based on 81 Bull Trout) ranged from 0-10 days with a median of 0 days. Delay in August (based on seven Bull Trout) ranged from 0-14 days with a median of 0 days.

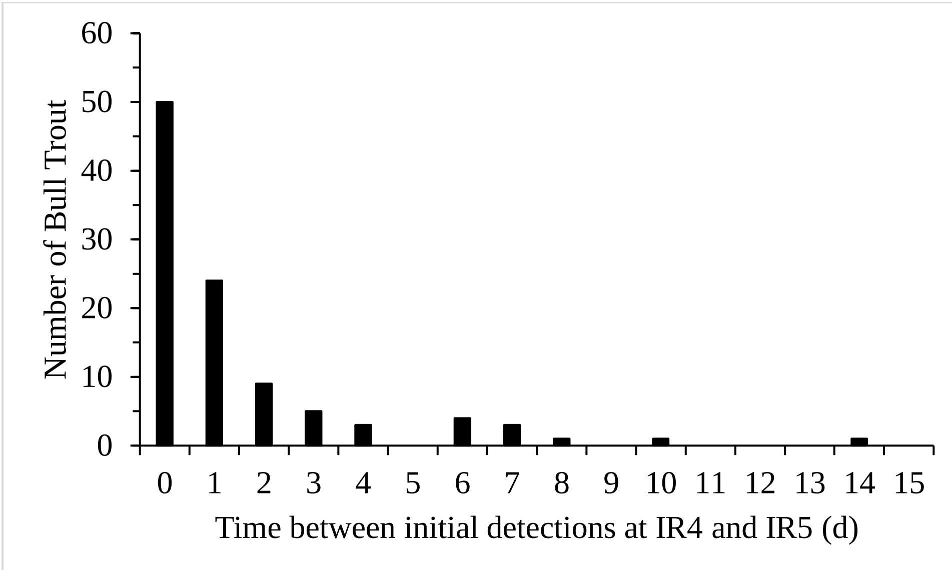

Figure 4. The number of days it took Bull Trout to move from IR4 to IR5. The number of days represents the time between the initial detection at IR4 and initial detection at IR5.

The rate of milling behavior (or *pM*) at IR3 was 0.039 (3/78; 95% CI = 0.008-0.108), which was similar to the milling behavior rate of 0.022 at IR5 (2/91; 95% CI = 0.003-0.077). At IR4 the rate of milling behavior was 0.198 (17/86; 95% CI = 0.120-0.298). As indicated by overlapping confidence intervals, the *pM* at IR3 was similar to that IR5. As indicated by non-overlapping confidence intervals, the *p*M at IR4 was higher than that at IR3 or IR5.

Findings

In 2019, the operation of the weir allowed Bull Trout to meet the yearly benchmark for converting from below the weir to above the weir. This was evidenced by the 93.7% (expanded percent) conversion rate. The benchmark that has been established for an acceptable conversion is no less than 76.5% in a given year. The conversion rate in 2019 was above that benchmark and the benchmark for the 4-year running average (92.9%). Most (86%) Bull Trout that passed the weir appeared to do so through the chutes. Only a relatively small number of Bull Trout were detected in the ladder or trap. This pattern was quite different from that observed in 2017 (Whitesel and Sankovich 2018), but similar to that in 2018 (Sankovich and Whitesel 2019). This could have been at least partly a result of the chutes being less obstructed in 2018 and 2019 than in 2017. Modifications to the trap entrance in 2018 also could have played a role, although to a lesser extent, since only 18 of the PIT-tagged Bull Trout detected at IR4 in 2019 subsequently entered the ladder.

The PIT-tagged Bull Trout that passed through the chutes in 2019 had estimated total lengths ranging from 345 to 720 mm (Figure 5). Through video monitoring, it was determined the Bull Trout passed through the chutes quickly and without struggling while swimming on their side (K. Bratcher, ODFW, personal communication). There was no evidence of injuries occurring to individuals in the videos. In addition, no Bull Trout were observed holding for an extended period upstream of the weir, and no mortalities were recovered on the weir, so there was no evidence of post-passage effects due to injury.

Only a small percentage of the PIT-tagged Bull Trout detected at IR4 (5.6%) remained below the weir throughout the study period in 2019, as in 2017 (Whitesel and Sankovich 2018) and 2018 (Sankovich and Whitesel 2019). Given Bull Trout are not believed to spawn in the vicinity of the weir, it may be useful to explore why some do not pass the weir.

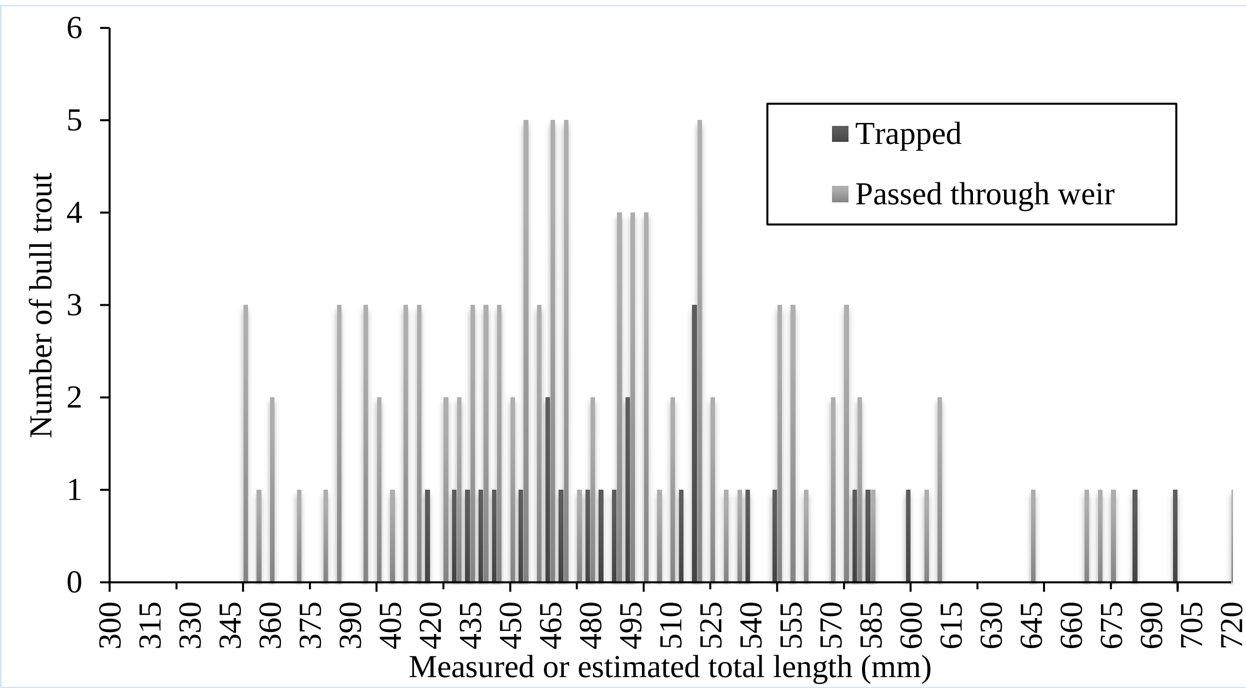

Figure 5. Length frequency distribution of Bull Trout that were trapped and released above or passed through the Imnaha River weir in 2019.

The vast majority of the PIT-tagged Bull Trout passed from IR4 to IR5 in a day or less in 2019 (Figure 4). Overall, the median travel time was 0.5 days, with a range of 0 to 14 days. In June, July, and August median travel times were 1 (maximum of 7), 0 (maximum of 10), and 0 (maximum of 14) days, respectively. The benchmarks for delay are median travel times of 6, 4, and 2 days (all with a maximum of 8 days) during June, July, and August, respectively. Thus, the median travel time benchmarks were achieved in all months, while the maximum travel time benchmark was not achieved in July and August. The improvement in delay in 2018 (Sankovich and Whitesel 2019) and 2019 relative to that in 2017 (Whitesel and Sankovich 2018) may have been at least partly due to improved passage conditions in the openings in the weir and modification of the trap entrance in 2018. In 2019, travel between IR4 and IR5 exceeded 8, 6, 4, and 2 days for approximately 2.0%, 5.9%, 9.9% and 17.8% of the fish, respectively.

Furthermore, in 2017 there were a number of Bull Trout that exceeded the maximum delay benchmark (8 days) for each month. It is possible that extended delay (> 8 days) is a normal behavior for a relatively small proportion of the fish that pass the section of river between IR4 and IR5. However, Bull Trout near IR4 were more likely to exhibit downstream movement (pause their upstream movement) than those near IR3 or IR5. This suggests that the presence of a weir may be having a measurable influence on their behavior. Given that the overall delay is meeting many of the benchmarks, it is unclear whether this increased milling behavior is significant enough to have a biological impact on the population. In the future, it may be useful to explore whether benchmarks for delay should be specific to periods other than monthly time intervals (e.g. two week intervals or intervals determined by flows). After all data are available for the 2017-2020 spawning years, it would also be prudent to revisit the benchmark for maximum delay.

This report represents year three of a four-year investigation. The ability of Bull Trout to negotiate the Imnaha River weir in 2019 may reflect a number of variables that are not entirely clear at this point. For example, the behavior we observed by Bull Trout may be specific to the flow, temperature and Chinook Salmon conditions in the river in 2019. Furthermore, 2019 is only the third year data have been collected, and it is not yet possible to more fully consider annual variation in these metrics.

Acknowledgements

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Appendix A

Codes associated with PIT-tagged Bull Trout used in this analysis.

3DD.0077720D1C	3DD.00777246E2	3DD.0077753CD6	3DD.0077951E58
3DD.007772C6B1	3DD.0077724C44	3DD.007775434F	
3DD.007772CEE6	3DD.00777252A8	3DD.0077754417	
3DD.007772CFE4	3DD.0077725D55	3DD.0077754A45	
3D9.1C2D91220E	3DD.0077726807	3DD.00777550C3	
3D9.1C2D9140CF	3DD.00777268AE	3DD.00777565EE	
3D9.1C2D915A1B	3DD.007772721B	3DD.0077756E93	
3D9.1C2DE10CEE	3DD.007772860B	3DD.0077757286	
3D9.1C2DE16C44	3DD.0077729012	3DD.00777581DF	
3D9.1C2DE18911	3DD.0077729053	3DD.007775823C	
3D9.1C2DE1E28C	3DD.00777297ED	3DD.0077758F51	
3D9.1C2DE228FC	3DD.0077729C1E	3DD.007775A00D	
3D9.1C2DE23650	3DD.0077729F6A	3DD.007775A33E	
3D9.1C2DE24ABB	3DD.007772B56B	3DD.007775A3F3	
3D9.1C2DE255D5	3DD.007772B742	3DD.007775ACF7	
3D9.1C2DE27C79	3DD.007772BBC9	3DD.007775B54A	
3D9.1C2DE28B38	3DD.007772C75C	3DD.007775B7AB	
3D9.1C2DE29F31	3DD.007772C91B	3DD.007775B8B5	
3D9.1C2DE30BBB	3DD.007772DC60	3DD.007775B8C8	
3DD.00776F5863	3DD.007773201D	3DD.007775B9FA	
3DD.007771A6D8	3DD.0077736100	3DD.007775BAAA	
3DD.007771B968	3DD.0077736798	3DD.007775C27B	
3DD.007771BBB5	3DD.0077743335	3DD.007775C608	
3DD.007771C738	3DD.007774614E	3DD.007775CFB5	
3DD.007771D2CA	3DD.007774A8EA	3DD.007775D4CE	
3DD.007771E0C0	3DD.007774B1E8	3DD.007775EDC3	
3DD.007771E499	3DD.007774CB0A	3DD.007775F5BC	
3DD.007771F187	3DD.007774D017	3DD.0077911DF6	
3DD.0077720A5E	3DD.007774DB7E	3DD.00779224F5	
3DD.0077720E04	3DD.007774FEBE	3DD.0077938C7D	
3DD.00777213D5	3DD.007774FFE5	3DD.007793B1D7	
3DD.00777219D6	3DD.0077750322	3DD.0077943C19	
3DD.0077721EBF	3DD.00777504B8	3DD.0077944C50	
3DD.0077722AC8	3DD.0077750F11	3DD.0077946A48	
3DD.0077722F0A	3DD.0077750FB0	3DD.0077947F8C	
3DD.0077723173	3DD.0077751EC7	3DD.007794B655	
3DD.0077724666	3DD.0077752D63	3DD.007794D9E0	

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