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

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

2020 Annual Progress Report

Paul M. Sankovich and Timothy A. Whitesel
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On the cover: *Fluvial Bull Trout from the North Fork Imnaha River. Picture credit: Justin R. Cook, U.S. Fish & Wildlife Service.*

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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 assess 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 91.9%, higher than the yearly benchmark (76.5%) for conversion. Through the 2020 migration year, the 4-year running average for conversion was 91.4%, slightly less than the benchmark (92.9%). Overall, the median time it took Bull Trout to move from approximately 50 m below to approximately 100 m above the weir was 1.0 days. The benchmarks for median delay in June, July, and August (6, 4, and 2 days, respectively) were met. Maximum delay in June (43 days) and July (13 days) exceeded the benchmark for maximum delay (8 days), whereas maximum delay in August (1 day) met the benchmark. In addition, Bull Trout detected moving upstream to within approximately 50 m of the weir were more likely to exhibit milling behavior than those detected at sites approximately 100 m upstream and approximately 43 km downstream of the weir. Thus, in 2020, the operation of the weir may have slowed the rate at which some Bull Trout moved past the weir. Overall, Bull Trout passage at the weir was similar to that in 2018 and 2019 and improved relative to that in 2017. These improvements were 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 in 2018.

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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 2020. This report is generally technical in nature and, for context, references and discusses operations and benchmarks that were previously established by co-managers of the Imnaha River weir and acclimation ponds. This report is not a co-manager policy document and, while its contents may inform the process, is not for the direct purpose of establishing final policy for the co-managers.

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 agriculture (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) of Bull Trout. 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 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 on Bull Trout that had been tagged previously with passive integrated transponders (PIT) either in the Snake River or at traps in the Imnaha River and were migrating from the Snake or lower Imnaha rivers to spawning areas in the upper Imnaha River. 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 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 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 antennas downstream [IR4] and upstream [IR5] of the weir) 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.

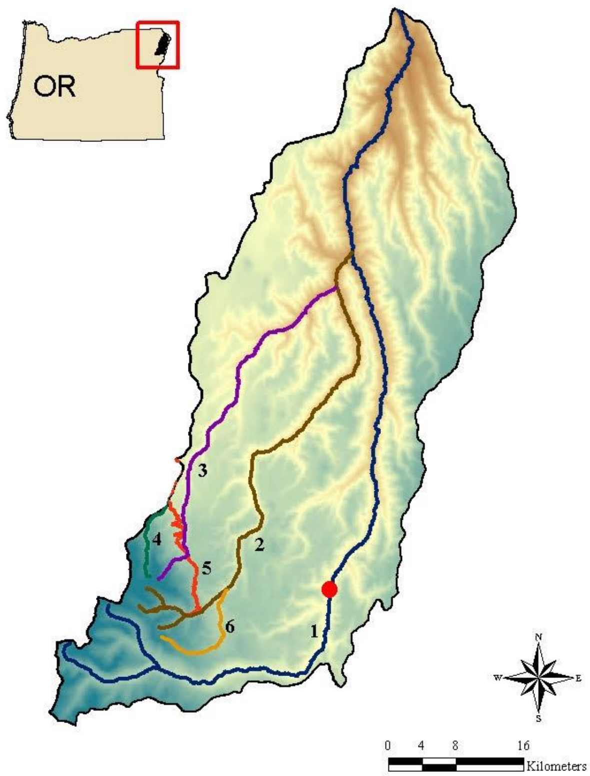

Figure 1. The Imnaha River subbasin supports local populations of Bull Trout in the Imnaha River (1), Big Sheep Creek (2), McCully Creek (4) (currently a tributary to the Grande Ronde River subbasin), and Lick Creek (6). Bull Trout also rear in the Wallowa Valley Improvement Canal (5) and rear in and possibly exist as a local population in Little Sheep Creek (3). The Imnaha River weir and acclimation site is identified (red dot). The population of Bull Trout in the mainstem Imnaha River is the most robust of the populations in the subbasin, and the Imnaha River is considered a stronghold for Bull Trout in Oregon.

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 was considered an unsafe situation. 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 was 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 2020, 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, Oregon. 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 2020, 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

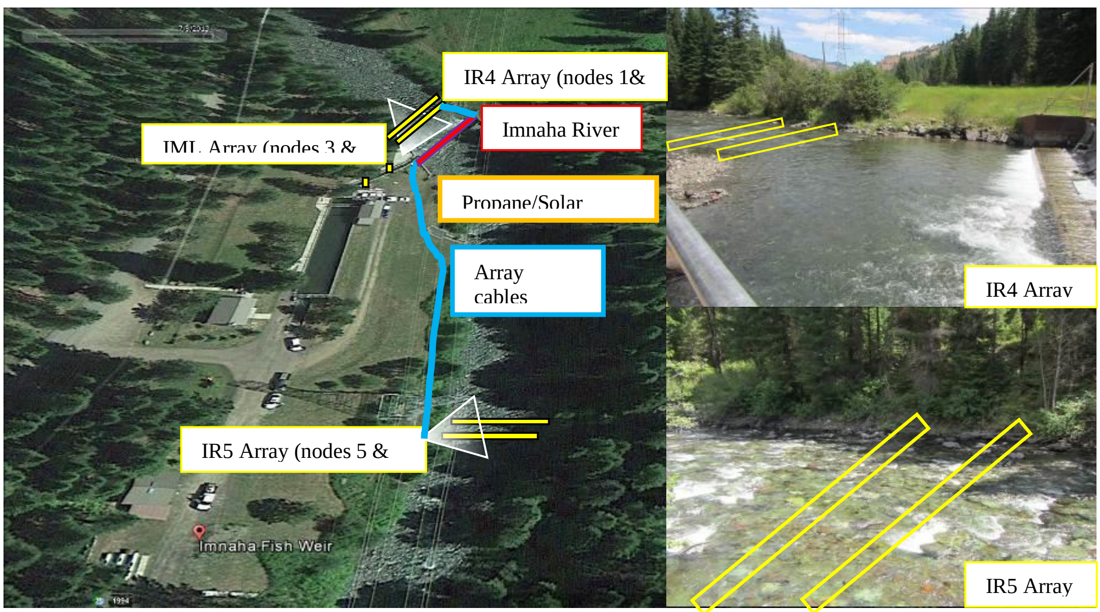

Figure 3. Location of the six Passive Integrated Transponder (PIT) tag detection arrays near the Imnaha River weir site. The IR4 array (nodes 1 [IR4B0, downstream] & 2 [IR4A0, upstream]), IR5 array (nodes 5 [IR5B0, downstream] & 6 [IR5A0, upstream]) are within the bank full area of the Imnaha River. 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.

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 2020).

Objective 1. During 2020, assess the passage rate (conversion) of Bull Trout 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 or via email correspondence. 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 managers may continue to 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 2020, assess the migration delay (delay) of Bull Trout 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 d and e.

To further inform Objective 2, we evaluated “milling” behavior. Milling behavior was defined as movement to an upstream point followed by subsequent movement downstream during the time of the spawning migration (March 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 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) within the following 8 days (the benchmark for maximum delay); 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 detected at IR5B0 within the following 8 days, 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 assumptions about detection efficiency). Differences in milling behavior were determined by evaluating whether the confidence intervals around the estimated proportions overlapped.

When this study was initiated, those involved were unaware the weir was designed to allow for the passage of smaller resident fish via one of three rectangular openings or “chutes” (each approximately 10 cm high and 30 cm wide) at the base of the weir. Once it became apparent some migratory adult-sized Bull Trout might pass the weir using the chutes, comparing the sizes of migratory adult Bull Trout that were trapped and that passed through the chutes became an additional objective of the study. Thus, to further evaluate Bull Trout passage at the weir, we compared the measured total lengths of Bull Trout that passed the weir via the trap to the estimated total lengths of Bull Trout that passed through the chutes. We used a growth model developed by IPC (R. Wilkison, personal communication) to estimate the total lengths of the Bull Trout that passed the weir via the chutes. These fish had been measured previously when they were PIT tagged, thus allowing for estimation of their total length when they arrived at the weir.

Results

In 2020, the weir and trap were operated between June 12 and September 10. Based on their detection histories during that period, 147 individual, PIT-tagged Bull Trout moved upstream past IR4 (see Appendix A). These were the individuals included in the evaluation.

Objective 1. Conversion

Of the 147 Bull Trout that moved upstream past IR4 between June 12 and September 10, 59 were trapped, released above the weir, and detected at IR5, 11 were never detected at IR5 (two of which were trapped and released upstream of the weir), and 77 were detected at IR5 after passing through the weir, presumably via one of the three chutes. Thus, based on the *observed percent*, the conversion rate from below the weir to above the weir was 92.5% (136/147). Seventy-five PIT-tagged Bull Trout were detected at IR4B0 (*M*), 71 of those were also detected upstream from IR4B0 (*R*), and a total of 141 were detected upstream from IR4B0 (*C*). Thus, 149 ((141 x 75)/71) PIT-tagged Bull Trout were estimated to have moved upstream past IR4B0 (N_{IR4B0}). One hundred and twenty-one PIT-tagged Bull Trout were detected at IR5B0 (*M*), 108 of those were also detected upstream from IR5B0 (*R*), and a total of 122 were detected upstream from IR5B0 (*C*). Thus, 137 ((122 x 121)/108) PIT-tagged Bull Trout were estimated to have moved upstream past IR5B0 (N_{IR5B0}). Based on the *expanded percent*, the conversion rate from below the weir to above the weir was 91.9% (137/149). Two Bull Trout entered the ladder but were not trapped or subsequently detected at IR5. Thus, the *expanded percent - possible* ((137 + 2)/149) would have been 93.3%. Based on the number of PIT-tagged fish detected at IR4B0 (n=75) and IR5B0 (n = 121) and the estimated number of fish passing those sites (149 and 137), the detection efficiencies at those sites were estimated to be 50% (75/149) and 88% (121/137), respectively.

Objective 2. Delay

Eighty-three 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 0-43 days with a median of 1 day (Figure 4). Delay in June (n = 19) ranged from 0-43.

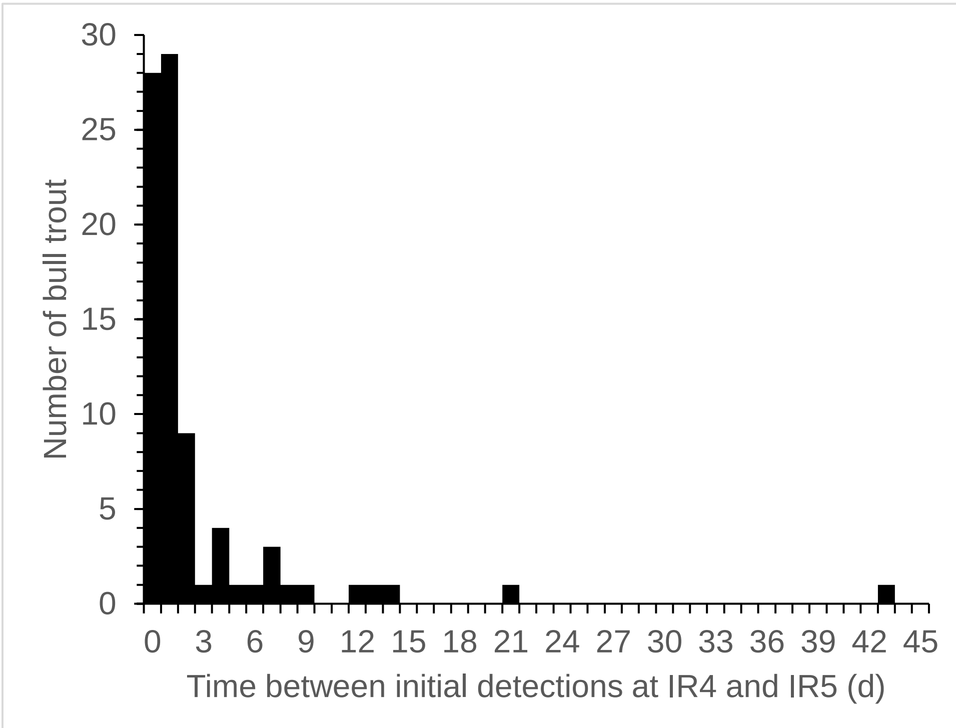

Figure 4. The number of days it took Bull Trout to move from IR4 to IR5. The number of days represents the time between the initial detection at IR4 and initial detection at IR5.

days with a median of 4 days. Delay in July (n = 62) ranged from 0-13 days with a median of 1 day. Delay in August (n = 2) ranged from 0-1 days with a median of 0.5 days

The *pM* (or proportion that exhibited milling behavior) at IR3 was 0.068 (95% CI = 0.019-0.165; n = 59), which was similar to the milling behavior at IR5 of 0.000 (95% CI = 0.000-0.030; n = 121). At IR4 the milling behavior was 0.278 (95% CI = 0.179-0.396; n = 72) and significantly higher than that at IR3 or IR5.

Bull Trout that passed through the chutes in the weir were significantly shorter (*t*-test, P < 0.01) than those that were trapped and released upstream of the weir in 2020 (Figure

5). Bull Trout that passed through the chutes had estimated total lengths ranging from 321 to 705 mm (mean = 505 mm), and those measured at the trap had total lengths ranging from 350 to 720 mm (mean = 543 mm).

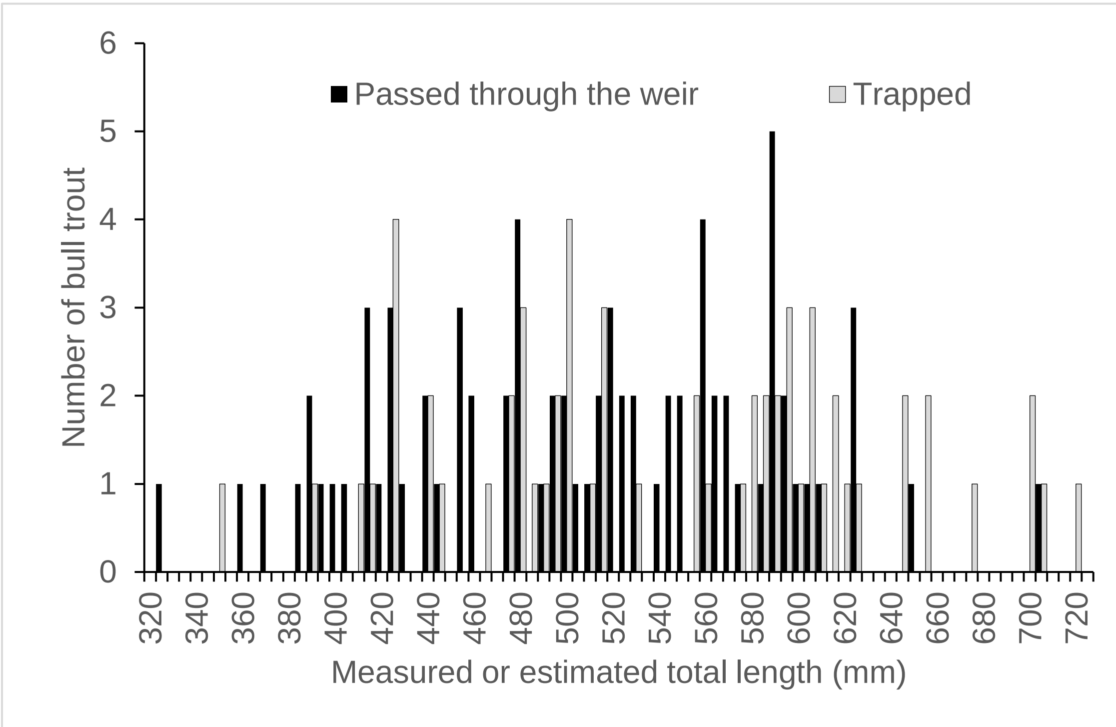

Figure 5. Length frequency distribution of Bull Trout that were trapped and released above or passed through the Imnaha River weir in 2020.

Findings

In 2020, 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 91.9% (expanded percent) conversion rate. The benchmark that has been established for an acceptable conversion is no less than 76.5% in a given year. Based on the expanded percent conversion derived from the Lincoln-Petersen approach, the 4-year running average for conversion was 91.4%. Through the 2020 migration year the 4-year running average was slightly less than the benchmark (92.9%). Most (57%) Bull Trout that passed the weir appeared to do so through the chutes. This pattern was quite different from that observed in 2017 (Whitesel and Sankovich 2018), but similar to those observed in 2018 and 2019 (Sankovich and Whitesel 2019; Sankovich and Whitesel

2020). This could have been at least partly a result of the chutes being less obstructed in 2018-2020 than in 2017. Modifications to the trap entrance in 2018 also could have played a role. While it is possible for relatively large Bull Trout to pass through the chutes, the Bull Trout that were trapped in 2020 were significantly longer than those that passed through the chutes. This suggests passage via the trap remains important, particularly for large fish. In addition, while there has been no evidence to date of Bull Trout being injured or falling back to the weir, the condition of Bull Trout after they pass through the chutes has not been well evaluated. To ensure adequate conversion in the future it will be important to maintain unobstructed chutes and the current trap entrance configuration.

Only a small percentage of the PIT-tagged Bull Trout that moved upstream to IR4 (7.5%) remained below the weir throughout the study period in 2020, as in the three previous years of this study (Whitesel and Sankovich 2018; Sankovich and Whitesel 2019; Sankovich and Whitesel 2020). Given Bull Trout are not believed to spawn in the vicinity of the weir, it may be useful in the future to explore why some do not pass the weir. It may be that certain fish are ultimately precluded from passing the weir. Alternatively, this may be a natural part of their behavior where some are not intending to migrate to the spawning areas (e.g., are not mature). Most of the PIT-tagged Bull Trout that remained below the weir in 2020 were not detected subsequently at any detection sites, indicating, perhaps, they were removed from the Imnaha River by legal harvest in the tribal fishery below the weir or illegal harvest and that either or both may also play a role.

A vast majority of the PIT-tagged Bull Trout passed from IR4 to IR5 in a day or less in 2020. The median travel time benchmarks (6, 4, and 2 days in June, July, and August, respectively) were achieved, but the maximum travel time benchmark (8 days) was not met in June and July. The reduced delay in 2018-2020 (overall median ≤ 1 day) relative to the delay observed in 2017 (overall median = 8 days) (Whitesel and Sankovich 2018; Sankovich and Whitesel 2019; Sankovich and Whitesel 2020) may have been at least partly due to improved passage conditions in the chutes in the weir due to increased cleaning efforts by operational staff, and modification of the trap entrance in 2018. In 2020, travel time between IR4 and IR5 exceeded 8, 6, 4, and 2 days for approximately 7.2%, 12.0%, 14.5% and 20.5% of the fish, respectively. It is possible extended delay (> 8 days) is a normal behavior (i.e., not related to the weir) for a relatively small proportion of the fish that pass the section of river between IR4 and IR5. However, Bull Trout near IR4 were also more likely to exhibit a pause in their upstream movement (milling behavior) than those near IR3 or IR5. This suggests the presence of a weir may have a measurable and real influence on their behavior. In either event, it would be useful to characterize whether Bull Trout that exhibit extended delay are a specific component of the population (e.g., the largest fish). Given the overall delay is meeting many of the benchmarks, it is unclear whether the delay and milling behavior are significant enough to have a biological impact on the population. In the future, it may also 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) and to revisit the benchmark for maximum delay.

This report represents the fourth year of a planned, four-year investigation. The ability of Bull Trout to negotiate the Imnaha River weir may reflect a number of variables that are not entirely clear at this point. For example, the behavior we observed from Bull Trout may be specific to conditions associated with flow, temperature, and Chinook Salmon (e.g., abundance, density) in the river. During 2018-2020, the results for conversion were similar as were the results for delay (Whitesel and Sankovich 2018; Sankovich and Whitesel 2019; Sankovich and Whitesel 2020); however, it is unclear whether the four years of this investigation adequately capture annual variation that may be important.

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Appendix A

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

3D9.1C2DE138D6	3DD.0077750322	3DD.007791C030	3DD.007792A540
3D9.1C2DE228FC	3DD.0077752D63	3DD.007791C5ED	3DD.007792AC37
3D9.1C2DE24ABB	3DD.007775530D	3DD.007791C618	3DD.007792BAA0
3D9.1C2DE24DF8	3DD.0077756E93	3DD.007791D459	3DD.007792C151
3D9.1C2DE27C79	3DD.0077758030	3DD.007791D602	3DD.007792C1EC
3D9.1C2DE28B38	3DD.0077758823	3DD.007791D973	3DD.007792DC89
3DD.007771A6D8	3DD.0077759BB5	3DD.007791DA32	3DD.007793006D
3DD.007771D1DA	3DD.007775A3F3	3DD.007791DAC8	3DD.00779329C5
3DD.007771D9E3	3DD.007775A6CE	3DD.007791F06F	3DD.0077934730
3DD.007771EA47	3DD.007775B941	3DD.007791F281	3DD.00779364FB
3DD.007771FE7F	3DD.007775B9FA	3DD.007791FDF5	3DD.0077937718
3DD.0077720013	3DD.007775BD8F	3DD.0077920062	3DD.007793D09D
3DD.0077720A4C	3DD.007775C78F	3DD.0077920414	3DD.0077943C19
3DD.0077720A5E	3DD.007775CFB5	3DD.007792045D	3DD.00779445CF
3DD.00777213D5	3DD.007775D4CE	3DD.0077921598	3DD.007794488B
3DD.00777219D6	3DD.007775D50D	3DD.00779215DD	3DD.0077944C50
3DD.0077721EBF	3DD.007775EDC3	3DD.0077921AD3	3DD.0077945101
3DD.0077722F0A	3DD.007775F394	3DD.0077921DDD	3DD.007794678F
3DD.0077723173	3DD.007775F5BC	3DD.00779220BF	3DD.0077947F8C
3DD.0077724360	3DD.007775F65A	3DD.0077923395	3DD.007794803D
3DD.0077724393	3DD.00777A400C	3DD.0077924099	3DD.0077949544
3DD.0077724C9E	3DD.00778411AA	3DD.0077924142	3DD.007794AE26
3DD.00777252A8	3DD.00778BF556	3DD.0077924146	3DD.007794D9E0
3DD.0077725D55	3DD.00778CE331	3DD.00779241AB	3DD.007794E38F
3DD.00777284DA	3DD.007790CB6E	3DD.0077924792	3DD.007794E755
3DD.0077728510	3DD.0077911A9B	3DD.00779252AA	3DD.007794E889
3DD.007772860B	3DD.0077911DF6	3DD.0077925548	3DD.007794ED9D
3DD.0077729012	3DD.00779137E1	3DD.0077925C12	3DD.007794F518
3DD.00777297BE	3DD.0077919372	3DD.007792870B	3DD.007794FBDB
3DD.0077729C1E	3DD.007791950C	3DD.0077928713	3DD.007795045A
3DD.007772AD52	3DD.007791A4D0	3DD.0077928BF7	3DD.0077951E58
3DD.007772C619	3DD.007791A590	3DD.007792924F	3DD.0077952A62
3DD.007772C91B	3DD.007791AECC	3DD.0077929563	3DD.0077952C7D
3DD.007772CFE4	3DD.007791B238	3DD.0077929C14	3DD.0077952CEF
3DD.007774B2D3	3DD.007791B37F	3DD.0077929FA7	3DD.0077953B90
3DD.007774E909	3DD.007791B804	3DD.007792A263	3DD.0077954305
3DD.007774F833	3DD.007791C00F	3DD.007792A4F7	

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