Tieton and Upper Yakima Bull Trout Trap, Transport, and Monitoring Project

2021 Progress Report

U.S. Fish and Wildlife Service
Mid-Columbia Fish and Wildlife Conservation Office
Yakima Sub-Office
1917 Marsh Road
Yakima, WA 98901

December 9, 2022

Authors:

Craig Haskell and Jason Romine (USFWS, Mid-Columbia Fish and Wildlife Conservation Office)

and

Jennifer Von Bargen (USFWS, Abernathy Fish Technology Center)

Foreword

Bull Trout (*Salvelinus confluentus*) are listed as Threatened under the Endangered Species Act and the Yakima River is considered a core area within the Mid-Columbia River Recovery Unit. Historically, the Yakima River Basin was home to 15 genetically distinct populations of Bull Trout, three of which have been extirpated. There are three generally accepted life history types exhibited by Bull Trout: resident, fluvial, and adfluvial, but in the Yakima River Basin, most Bull Trout populations exhibit an adfluvial life history. Adfluvial Bull Trout spawn, and juveniles rear in tributary habitats, however, sub-adults and adults forage and reside in lakes and reservoirs. One of the primary threats to Yakima Basin Bull Trout is entrainment at dams and fish not being able to return to their spawning grounds in the absence of fish passage (U.S. Fish and Wildlife Service 2015). Impoundment has fragmented Bull Trout habitat and interim trap and haul measures are used to move Bull Trout upstream of dams to reach their natal spawning tributaries. A study of Bull Trout passage at Clear Creek Dam on the North Fork Tieton River began in 2012. In 2016, trap and haul began at Clear Creek Dam as an interim fish passage measure. These efforts were successful in providing passage (Thomas and Monk 2015, 2016; Thomas et al. 2017, 2018).

In 2019, we expanded trap and haul to include Bumping, Kachess, and Keechelus dams, and in 2020, Tieton Dam was added to the locations where we attempted to collect Bull Trout. Twenty-five Bull Trout were collected below Clear Creek Dam in 2019 and 11 were collected there in 2020. In 2019, we collected 15 Bull Trout below Keechelus Dam but none at Bumping or Kachess dams (Haskell et al. 2020). During 2020, we collected two Bull Trout below Tieton Dam, one below Keechelus Dam, and one below Bumping Dam (Haskell et al. 2021). As reported here for 2021, we collected 25 Bull Trout below Clear Creek Dam, four below Keechelus Dam, but none elsewhere. We have yet to encounter any Bull Trout at Kachess Dam. However, a fish captured below Keechelus Dam has been genetically identified as originating from Kachess reservoir, indicating that Bull Trout are being entrained at Kachess Dam. We did not collect any Bull Trout below Tieton Dam in 2021, and although we observed two Bull Trout below Bumping Dam while snorkeling, we were unable to capture them.

Monitoring data indicated that all the Bull Trout transported above Clear Creek Dam in 2021 were detected at our PIT antennas in the upper North Fork Tieton River, presumably to spawn. Alternatively, the three fish collected and transported above Keechelus Dam in 2021 were not detected. Annual dewatering of lower Gold Creek between July and October could prevent fish from reaching their spawning grounds upstream of our upper Gold Creek antenna array. Of the 14 fish transported above Keechelus Dam in 2019, we detected two in upper Gold Creek during 2021, indicating that if Bull Trout do not reach their spawning grounds the year they are transported, some may return in subsequent years provided they migrate upstream before or after Gold Creek dewaters.

Goals and Objectives

The ongoing goal of the Bull Trout Transport Project is to increase the viability of Bull Trout populations by maintaining genetic diversity and providing connectivity for fish currently excluded from natal spawning tributaries upstream of Bumping, Clear Creek, Kachess, Keechelus, and Tieton dams. Our specific objectives were to: 1) capture adult Bull Trout in the stilling basins directly below Bumping, Clear Creek, Kachess, Keechelus, and Tieton dams, 2) implant Passive Integrated Transponder (PIT)-tags in captured Bull Trout and obtain tissue samples for rapid response genetic testing, 3) snorkel sampling areas when feasible to evaluate the efficacy of collection methods and to estimate the number of other fish, 4) transport and release tagged fish above the dams into their natal tributaries or reservoirs as determined from rapid response genetic testing, and 5), use PIT-tag interrogation sites in spawning tributaries to monitor the movement of transported fish.

Methods

Study Area and Monitoring Locations

We conducted Bull Trout trap and haul in two areas of the Yakima River Basin- the upper Yakima River Basin and the upper Naches River Basin. In the Naches River Basin, we attempted to collect Bull Trout in the Bumping Dam, Clear Creek Dam, and Tieton Dam stilling basins. Bumping Dam impounds Bumping Reservoir and is located on the Bumping River, a tributary of the Naches River. The Bumping River flows northeast, joins the American River and then the Little Naches River, to form the Naches River. The Bumping and Little Naches confluence is about 89 km upstream of where the Naches River enters the Yakima River near Yakima, Washington. Tieton Dam, which impounds Rimrock Reservoir, is located on the Tieton River 35 km upstream of the Tieton and Naches river confluence near the town of Naches, Washington. About 1 km upstream of Rimrock Reservoir, Clear Creek Dam impounds the North Fork Tieton River to form Clear Creek Reservoir. Bull Trout originating from Rimrock Reservoir tributaries (Indian Creek, South Fork Tieton River) routinely migrate upstream to Clear Creek Dam but are not transported above the dam to Clear Creek Reservoir. However, many Bull Trout originating in the North Fork Tieton River move downstream through Clear Creek Dam or an adjacent spillway channel, migrate back upstream to the base of the dam where they are collected, and are transported upstream and released into Clear Creek Reservoir. (Thomas et al. 2017).

In the upper Yakima River Basin, we attempted to collect Bull Trout in the Kachess and Keechelus Dam stilling basins. Keechelus and Kachess dams are located upstream of Easton Dam, which impounds Easton Reservoir near Easton, Washington. The 'Keechelus Arm' of the Yakima River extends upstream from Easton Reservoir about 18 km to Keechelus Dam. Here, we refer to the section of the Kachess River that flows south into Kachess Reservoir as the

Upper Kachess River and the shorter, 1-km section flowing from Kachess Reservoir to Lake Easton as the Lower Kachess River. (Figure 1).

We used PIT antennas to monitor the movement of Bull Trout in our study area, except in Deep Creek. Deep Creek is a tributary of Bumping Reservoir where Bull Trout spawn and rear, but annual dewatering of Deep Creek results in flow in either a west or east channel, but not both. We do not monitor Bull Trout in Deep Creek because thus far we have only been able to capture and tag a single fish and the difficulties associated with monitoring in multiple stream channels. Should we collect more Deep Creek Bull Trout during future years sampling below Bumping Dam, we will reconsider the possibility of PIT monitoring in Deep Creek. In the upper Upper Kachess River, lower Box Canyon Creek, upper Gold Creek, and lower Indian Creek, we maintained antenna 'arrays' consisting of two antennas at a site. In lower Gold Creek, the upper South Fork Tieton River, the upper North Fork Tieton River, the outlet channel at Clear Creek Dam, the upper fish ladder at Clear Creek Dam, and the lower North Fork Tieton River we maintained single antennas. In 2021, we added single antennas at sites in the lower portion of the upper Kachess River and in the lower South Fork Tieton River (Figure 1).

The upper Gold Creek array was located about 4 km upstream from the Gold Creek mouth at Keechelus Reservoir. The lower Gold Creek antenna was located about 0.5 km upstream from its mouth, between the eastern span of I-90 and National Forest Road 4832. The antenna array in the upper Upper Kachess River was located about 1 km upstream of the Upper Kachess River mouth while the antenna in the lower Upper Kachess River was located 0.2 km upstream of its mouth. The Box Canyon Creek array was located 0.2 km upstream of the Box Canyon Creek mouth at Kachess Reservoir. In the upper Naches Basin, the upper South Fork Tieton River was 8.5 km upstream of its mouth at Rimrock Reservoir while the antenna in the lower South Fork Tieton River was 0.5 km upstream of its mouth. The array in lower Indian Creek was about 0.9 km upstream of its mouth at Rimrock Reservoir. The upper North Fork Tieton River antenna was 9.5 km upstream of its mouth at Clear Creek Reservoir just downstream of the Scatter Creek confluence, while the antenna in the lower North Fork Tieton River was 1.2 km upstream of its mouth. At Clear Creek Dam, our antenna in the outlet channel was located 80 m downstream of the dam while our antenna in the upper fish ladder was located at the upstream end of the fish ladder within the spillway channel, north of the dam (Figure 1). Throughout the Yakima Basin, we work collaboratively with Yakama Nation Fisheries Program to install and maintain PIT antennas.

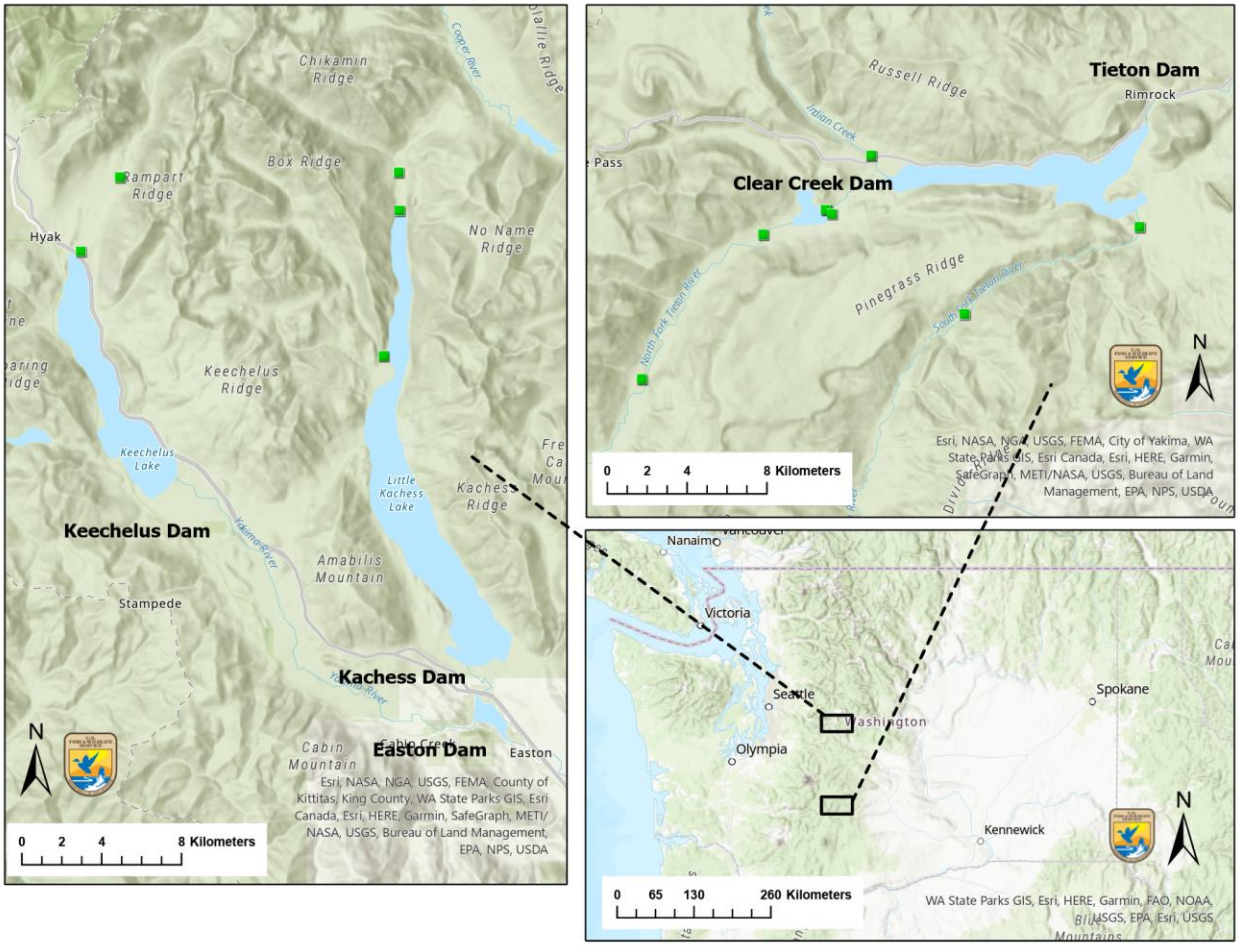

Figure 1. Map of the study site in the Upper Yakima (left map) and Upper Tieton (upper right map) river basins, Washington. Green squares represent PIT-tag antenna locations. The map includes Kachess, Keechelus, Easton, Clear Creek, and Tieton dams. Bumping Dam (upper Naches River Basin) is not pictured.

Fish Collection and Tagging

Our survey crew consisted of snorkelers and a data collector following Thurow and Schill (1996). We quantified the number of adult Bull Trout present, with the survey starting point below each stilling basin as determined by the predominate instream conditions at the time of the survey. Thurow and Schill (1996) found no significant difference between day and night abundances of adult Bull Trout, therefore we conducted our surveys during mid-morning. During 2021 we attempted to sample at least three times at each of the five stilling basins, but the sampling frequency was also based on the number of fish encountered. At Clear Creek Dam, there are more Bull Trout present and therefore we sample with greater frequency (Thomas et al. 2017). Our sampling was also dependent on water temperature being less than 15 °C, water clarity was good enough for snorkeling, and flows were low enough to safely

deploy nets and snorkel. In addition to Bull Trout, we also estimated the number of other fish in our surveys, however, snorkeling and estimation of non-Bull Trout was not conducted at Clear Creek and Tieton dams because of their depth and turbulence.

After snorkeling, Bull Trout were collected using gill nets with 7.5-cm stretch mesh and 3.5-kg (8-lb test) monofilament. Nets were fished using one of two methods, either by placing them across stream reaches where snorkelers directed fish towards nets, or by letting them fish passively without snorkelers. In both cases, nets were constantly monitored, and fish were immediately removed from gill nets using standard dip nets. Net meshes were cut as needed to minimize fish injury during removal. Captured Bull Trout were placed in a holding pen prior to processing. The holding pen was constructed of perforated stainless steel with lockable latches and submerged in the river where there was generally good flow (Figure 2).

Figure 2. Stainless steel pen (0.9 m x 1.2 m x 1.8 m) used for holding Bull Trout after collection and before rapid response genetic testing and transport.

After collecting Bull Trout, we prepared an anesthetic solution of MS-222 at 50 mg/L using river water and a 75.7-liter (80-quart) cooler. Since MS-222 is acidic, a buffer ($NaHCO_3$; i.e., baking soda) was added to raise the pH, which was measured using a Eutech Instruments pHTestr20 (Cole-Parmer, Vernon Hills, Illinois). Individual Bull Trout were removed from the pen using a dip net and placed in the cooler where the fish were anesthetized until sedation (3-5 min). After sedation, we recorded total length (TL; mm), collected a small tissue sample from the anal fin using sterilized surgical scissors, and inserted a PIT-tag into the base of the dorsal fin (dorsal sinus) using a sterilized hollow needle. Tissue samples were placed in vials with ethanol. PIT-tags were full duplex (FDX-B), measured 12.5 x 2.1 mm, and operated at a frequency of 134.2 kHz (APT-12, Biomark, Boise, Idaho). Processing generally took less than 2 min.

After processing, Bull Trout were placed in a perforated PVC recovery tube (1-m length, 15-cm diameter) with adequate flow to allow fish to recover and regain equilibrium before returning them to the holding pen. Tagged and processed fish were separated from unprocessed fish in the holding pen until all fish were processed. Vials were shipped to the US Fish and Wildlife Service (USFWS) Abernathy Fish Technology Center (AFTC) for rapid response genetic assessment to determine population origin.

Genetic Testing, Transport, and Release

To meet the USFWS requirements of natal origin and hybrid (Brook Trout x Bull Trout) identification prior to transport, we used a real-time genotyping and analysis method, hereafter rapid response (DeHaan et al. 2011). The field identification of hybrids can be difficult; therefore, we euthanized hybrids based solely on the results from rapid response. Upon arrival in the laboratory, genomic DNA was extracted twice from each individual fin clip to ensure consistency using a modified chelex extraction protocol (Miller and Kapuscinski 1996) with incubation at 55°C for 15 min, and then at 103°C for 8 min. Individuals were genotyped at the following 16 microsatellite loci: *Omm1128, Omm1130* (Rexroad et al. 2001), *Sco102, Sco105, Sco106, Sco107, Sco109*, [Washington Department of Fish and Wildlife (WDFW) unpublished], *Sco200, Sco202, Sco212, Sco215, Sco216, Sco218, Sco220* (Dehaan and Ardren 2005), *Sfo18* (Angers et al. 1995) and *Smm22* (Crane et al. 2004). Allele calling at each of these loci was previously standardized between our laboratory and WDFW Molecular Genetics Laboratory using a protocol similar to the one described by Stephenson (2009) to facilitate data sharing. Several Bull Trout and Brook Trout loci have diagnostically different allele sizes and can be used to identify species and individuals with hybrid ancestry.

We used the baseline genotypes described by Small et al. (2016) to assign fish to population groups and evaluated the power of the baseline to accurately assign individuals using a simulation approach. The probability of an individual originating from each baseline population was estimated following Rannala and Mountain (1997) as implemented in the computer program ONCOR (Steven Kalinowski; available: http://www.montana.edu/kalinowski/software/oncor.html). Preliminary leave-one-out simulations suggested a high probability (95 % - 100 %) of correct assignment to the twelve populations in the baseline (Table 1). Based on these results, we decided that the baseline had enough power to assign individual Bull Trout to one of twelve populations. Each of the Bull Trout captured in 2021 were thus assigned to one of these populations.

The next day, Bull Trout were transported to their natal stream based on rapid response results. Bull Trout were loaded by hand into a transport vehicle outfitted with a large cooler filled with river water and oxygenated with a battery powered aerator and air stones. We hand loaded and removed fish using a hand dip net.

Table 1. Results of simulations used to assess the accuracy with which the genetic baseline could be used to assign Bull Trout to 13 reporting groups. The left column indicates the true origin, and subsequent columns indicate numbers of fish assigned to each reporting group. Bold values indicate correct assignments.

Reporting Groups	Brook	Gold Creek	Box Canyon	Kachess River	NF Teanaway	Deep	American/ Union	Rattlesnake	Crow	NF Tieton	Indian	SF Tieton	Ahtanum	Percent Correct
Brook	**25**	0	0	0	0	0	0	0	0	0	0	0	0	100%
Gold Creek	0	**46**	0	0	0	0	0	0	0	0	0	0	0	100%
Box Canyon	0	0	**18**	1	0	0	0	0	0	0	0	0	0	95%
Kachess	0	0	0	**28**	0	0	0	0	0	0	0	0	0	100%
NF Teanaway	0	0	0	0	**10**	0	0	0	0	0	0	0	0	100%
Deep	0	0	0	0	0	**57**	0	0	0	0	0	0	0	100%
American Union	0	0	0	0	0	0	**56**	0	0	0	0	0	0	100%
Rattlesnake	0	0	0	0	0	0	1	**36**	0	0	0	0	0	97%
Crow	0	0	0	0	0	0	0	0	**24**	0	0	0	0	100%
NF Tieton	0	0	0	0	0	0	0	0	0	**46**	1	0	0	98%
Indian	0	0	0	0	0	0	0	0	0	1	**108**	3	0	96%
SF Tieton	0	0	0	0	0	0	0	0	0	0	1	**75**	0	99%
Ahtanum	0	0	0	0	0	0	0	0	0	0	0	0	**54**	100%

Fish Monitoring and Water Quality

At each antenna site we deployed either a single PIT antenna or a two-antenna 'array'. Arrays consisted of two antennas placed about 20 m apart along the course of the stream bed. Each antenna consisted of an IS1001, 24V antenna control node (Biomark Inc., Boise, Idaho) housed within a waterproof case (Pelican Products, Inc., Torrance, California). External power cords and antenna wires were attached to the control board within the case. Power was supplied to the control board using DC power from four, 6V batteries wired together in a 24V configuration. Batteries were charged by 300W/24V solar panels (Grape Solar, Eugene, Oregon) mounted to a wooden frame that faced 120° - 150° (Southeast). The output of the solar panels was regulated by solar controllers (ProStar PS-15 or PS-30, Morningstar Inc., Newtown, Pennsylvania). The batteries and solar controller were housed in a steel storage chest (Ridge Tool Company, Elyria, Ohio). In Box Canyon Creek, the array was powered by a thermoelectric generator (TEG; Global Power Technologies, Calgary, Alberta, Canada). Propane from a 94.6-L (25-gal) tank powered the TEG, which supplied 24 V of continuous DC power to the array. Antenna coils consisted of 12-gauge copper 'Litz' wire housed within polyethylene piping. The piping was connected to a waterproof case via a 5.1-cm (2-in) PVC 'T' fitting, which contained both ends of the coil, a hydrovolt cable (AK Industries, Rancho Domingo, California), and the appropriate capacitor based on the inductance of the antenna coil.

We employed two antenna configurations for antenna coils at our interrogation sites. Antenna coils were installed in either a 'pass-through' or flat-plate ('pass-by') configuration. Generally, 'pass-through' antennas are better for detecting fish across a range of water levels but are more susceptible to damage during high water events, whereas flat-plate antennas are less susceptible to being displaced by high water events and associated debris. The upper Upper Kachess River (KR1, KR2), lower Upper Kachess River (KAC), Indian Creek (IND1, IND2), and Gold Creek (G90) antennas were setup in a rectangular 'pass-through' configuration and measured about 3 m x 2 m depending on stream width. The upper ladder site at Clear Creek Dam (ULD) also had a pass-through configuration, but it was sized to fit the upstream terminus of the fish ladder, which was an exit point for upstream migrating fish (although we have yet to encounter any) and an entry point for downstream migrating fish. An antenna support cable was affixed from one bank to the other with each end attached to a 3.1-m (10-ft) T-post. Zip ties or straps were used to affix the antenna to the support cable. The upper Gold Creek (UGC1, UGC2), Box Canyon Creek (BOX1, BOX2), upper South Fork Tieton River (SFT), lower South Fork Tieton River (LSFT), upper North Fork Tieton River (UPNFT), lower North Fork Tieton River (NFT), and Clear Creek Dam outlet channel (OCH) antennas were setup in a flat-plate configuration, lying flat on the creek bed in a rectangular shape about 11 x 1 m (Figure 3). For both configurations, piping was affixed to the stream bed with 0.8-cm (5/16-in) barbed rebar anchors with 2.5-cm (1-in) thread-less eye nuts welded near the top of the rebar. The anchors were driven into the stream bed using a gas-powered post driver (Titan, Nevada, Missouri), and antenna piping was secured to the anchors with nylon straps (NRS Inc., Moscow, Idaho).

Figure 3. Example of a flat-plate antenna design to monitor the movement of PIT-tagged Bull Trout in upper Gold Creek.

Antennas were installed at various times based on snow depth/access to the site, or when flows were low enough to allow in-river work. A large rain event in late October, dislodged and destroyed many of our antenna sites, affecting operations afterward. In Gold Creek, our upper Gold Creek site (UGC2) operated continuously from June 6 until November 1. At our lower Gold Creek site (G90), our antenna operated continuously from March 9 to October 26, when it was blown out, was reinstalled on November 3, but was blown out again on November 23. In the upper Upper Kachess River, both the downstream (KR2) and upstream (KR1) antennas operated continuously from August 9 to November 29. Our single antenna in the lower Upper Kachess River (KAC) operated continuously from July 21 to August 12 when the solar panel was stolen, and then from October 7 to October 26 when high water destroyed the antenna. Our antennas in Box Canyon Creek (BOX1, BOX2) began operation on June 17 and had some outages from propane power disruption, however, at least one of the antennas was operation from June 17 to October 27. In the Naches River Basin, our antennas in the North Fork Tieton River operated continuously from the time they were turned on (NFT- April 30, UPNFT- May 13) until they were

blown out on October 25. In the South Fork Tieton River, our antenna in the upper river (SFT) operated continuously from June 15 to August 19 and then from September 21 to October 26, when high flows blew out the antenna. We also installed an antenna in the lower South Fork Tieton (LSFT) on September 14 and it operated continuously until we shut it down on December 9. In Indian Creek, our antenna operation was more intermittent but generally operated from April 23 to October 26. Our antennas at Clear Creek Dam (OCH, ULD) operated nearly continuously for the entire year except for a few small outages from lack of sunlight to power our solar panels (Figure 4). We also deployed water temperature loggers at our antenna sites to continuously log water temperature every 15 min (Onset, Bourne, Massachusetts).

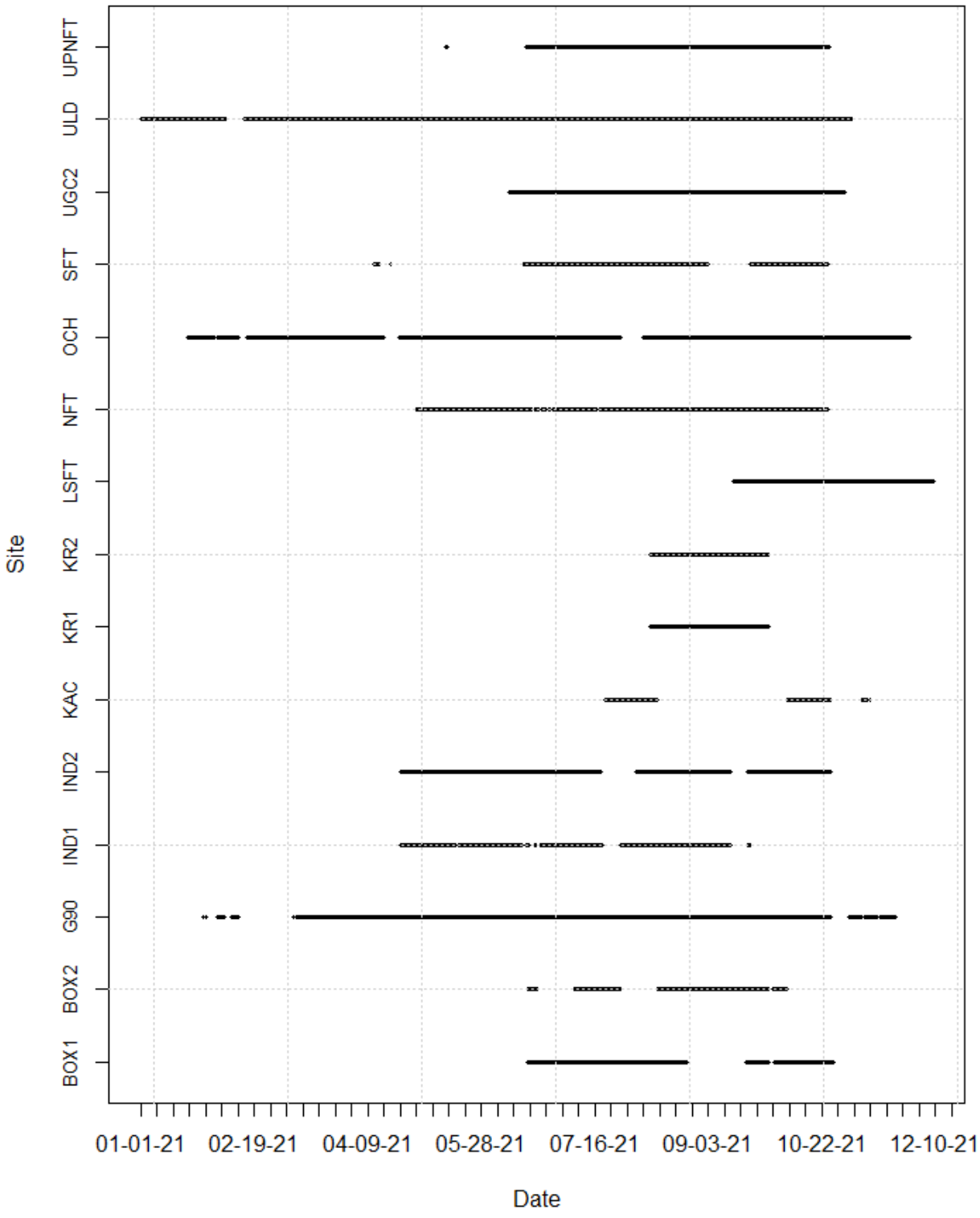
Site
UPNFT
ULD
UGC2
SFT
OCH
NFT
LSFT
KR2
KR1
KAC
IND2
IND1
G90
BOX2
BOX1
01-01-21
02-19-21
04-09-21
05-28-21
07-16-21
09-03-21
10-22-21
12-10-21
Date

Figure 4. Antenna operations during the 2021 field season. Each 'dot' represents an hour in which the antenna was operational (BOX1= Box Canyon Creek upstream antenna, BOX2 = Box Canyon Creek downstream antenna, G90 = lower Gold Creek antenna, IND1= Indian Creek upstream antenna, IND2= Indian Creek downstream antenna, OCH = outlet channel at Clear Creek Dam, KAC = lower upper Kachess River, KR1= upper Upper Kachess River upstream antenna, KR2 = upper Upper Kachess River downstream antenna, NFT = lower North Fork Tieton River antenna, SFT = South Fork Tieton River antenna, LSFT= lower South Fork Tieton, GC2 = upper Gold Creek downstream antenna, ULD = upper ladder in the spillway channel at Clear Creek Dam, and UPNFT = upper North Fork Tieton River antenna).

Results

Fish Collection and Transport

We conducted fish collection from June to October 2021 at Clear Creek, Bumping, Kachess, Keechelus, and Tieton dams. We sampled on three days at the Bumping Dam Stilling Basin, three days at the Clear Creek Stilling Basin, one day at the Kachess Dam Stilling Basin, three days at the Keechelus Dam Stilling Basin, and two days at the Tieton Dam Stilling Basin. Our single sampling event at Kachess Dam required snorkeling in the stilling basin and electrofishing downstream of the stilling basin to collect fish for Safety of Dams work by the US Bureau of Reclamation (USBR).

We captured 25 Bull Trout at Clear Creek Dam, four Bull Trout at Keechelus Dam, but none elsewhere, although we observed two Bull Trout at Bumping Dam that we were unable to collect (Table 2). We also collected three Brook Trout x Bull Trout hybrids at Clear Creek Dam on June 07, 2021, which were euthanized in accordance with our section 10 permit. Of the 25 fish collected at Clear Creek Dam, 15 were identified as North Fork Tieton origin (Table 3). One of the North Fork Tieton fish died after capture and was reported to USFWS Ecological Services on July 13, 2021. Subsequently, 14 North Fork Tieton fish were transported upstream of the dam and released. Four fish were identified as South Fork Tieton origin and released below the dam. One of these fish was a 362-mm recapture that was 255 mm when we tagged it in 2020. Three fish were identified as Indian Creek origin and were also released below the dam.

Table 2. Stilling basin, date, number of Bull Trout observed, and the number of Bull Trout collected during trap and haul in 2021.

Stilling Basin	Survey Date	Bull Trout Observed	Bull Trout Collected (Recaptures)	Brook Trout/Bull Trout Hybrids Collected and Euthanized
Tieton Dam	05/17/2021	0	0	0
Bumping Dam	06/16/2021	1	0	0
Clear Creek Dam	07/07/2021	11	11 (1)	3
Clear Creek Dam	07/12/2021	11	11	0
Bumping Dam	07/14/2021	0	0	0
Clear Creek Dam	07/19/2021	3	3	0
Tieton Dam	07/28/2021	0	0	0
Keechelus Dam	09/15/2021	2	2	0
Bumping Dam	09/29/2021	1	0	0
Keechelus Dam	10/04/2021	1	1	0
Keechelus Dam	10/18/2021	1	1	0
Kachess Dam	10/27/2021	0	0	0
Total		**32**	**29 (1)**	**3**

Table 3. Stilling basin, date, PIT-Tag ID, length, and stock of Bull Trout collected in 2021.

Stilling Basin	Date	PIT-Tag ID	Total Length (mm)	Stock
Clear Creek Dam	07/07/2021	3DD.003D48117E	661	North Fork Tieton
Clear Creek Dam	07/07/2021	3DD.003D481199	427	North Fork Tieton
Clear Creek Dam	07/07/2021	3DD.003D481160	785	Hybrid
Clear Creek Dam	07/07/2021	3DD.003D48116F	630	North Fork Tieton
Clear Creek Dam	07/07/2021	000.000AC3B2E5*	362	South Fork Tieton
Clear Creek Dam	07/07/2021	3DD.003D4811C2	386	Hybrid
Clear Creek Dam	07/07/2021	3DD.003D48116B	411	Hybrid
Clear Creek Dam	07/07/2021	3DD.003D48115F	565	North Fork Tieton
Clear Creek Dam	07/07/2021	3DD.003D48116C	581	North Fork Tieton
Clear Creek Dam	07/07/2021	3DD.003D4811C0	344	South Fork Tieton
Clear Creek Dam	07/07/2021	3DD.003D48118C	586	North Fork Tieton
Clear Creek Dam	07/12/2021	3DD.003D4811A1	445	North Fork Tieton
Clear Creek Dam	07/12/2021	3DD.003D481193	535	North Fork Tieton
Clear Creek Dam	07/12/2021	3DD.003D48118D	638	Indian Creek
Clear Creek Dam	07/12/2021	3DD.003D481185[&]	424	North Fork Tieton
Clear Creek Dam	07/12/2021	3DD.003D481175	576	North Fork Tieton
Clear Creek Dam	07/12/2021	3DD.003D4811B8	600	Indian Creek
Clear Creek Dam	07/12/2021	3DD.003D481170	281	South Fork Tieton
Clear Creek Dam	07/12/2021	3DD.003D4811AE	582	North Fork Tieton
Clear Creek Dam	07/12/2021	3DD.003D4811AD	375	South Fork Tieton
Clear Creek Dam	07/12/2021	3DD.003D4811BC	445	North Fork Tieton
Clear Creek Dam	07/12/2021	3DD.003D4811A2	557	North Fork Tieton
Clear Creek Dam	07/19/2021	3DD.003D48117A	N/A	Indian Creek
Clear Creek Dam	07/19/2021	3DD.003D481161	N/A	North Fork Tieton

Clear Creek Dam	07/19/2021	3DD.003D481169	N/A	North Fork Tieton
Keechelus Dam	09/15/2021	3DD.003D481189[#]	720	Box Canyon Creek
Keechelus Dam	09/15/2021	3DD.003D481165	520	Gold Creek
Keechelus Dam	10/04/2021	3DD.003D4811A3[#]	625	Gold Creek
Keechelus Dam	10/18/2021	3DD.003D48119E[#]	396	Gold Creek

[*]Recapture
[&]Died prior to release
[#]Also implanted with an acoustic tag
N/A - data not collected

At Keechelus Dam, four Bull Trout were collected, tagged, and released. One fish captured on September 15, originated from Box Canyon Creek in Kachess Reservoir and was released at the mouth of Box Canyon Creek. The two additional Bull Trout collected on September 15 and October 4, were identified as Gold Creek origin, and released at the upstream end of Keechelus Reservoir. Fish were not released at the mouth of Gold Creek as in previous years because water depth was generally shallow, and we feared that they would be vulnerable to stranding or predation. The single Bull Trout collected on October 18 was released into Keechelus Reservoir just upstream of the dam.

In addition to observing Bull Trout during snorkeling, we also observed Brook Trout, Burbot, Chinook Salmon adults and juveniles, Cutthroat Trout, Mountain Whitefish, Rainbow Trout, unidentified Dace, Sculpin, and Suckers. Overall, we observed relatively large numbers of Mountain Whitefish and lesser numbers of Rainbow Trout, adult Chinook Salmon, and Sculpin. At Kachess Dam we observed Burbot and large numbers of Sculpin likely because these fish are more vulnerable to backpack electrofishing compared to our typical snorkeling and netting methods (Table 4).

Table 4. Common and scientific names of fish observed while snorkeling in the stilling basins of Bumping, Kachess, and Keechelus, and Tieton dams during trap and haul efforts in 2021. Numbers observed from the Tieton Dam Stilling Basin are from fish collected and released during hook-and-line sampling.

Common Name	Scientific Name	Bumping	Kachess	Keechelus	Tieton[#]
Brook Trout	*Salvelinus fontinalis*	-	2	1	-
Burbot	*Lota lota*	-	3	-	-
Chinook Salmon	*Oncorhynchus tshawytscha*				
Adults		21	-	-	-
Juveniles		*	-	-	-
Cutthroat Trout	*Oncorhynchus clarkii*	***	-	-	-
Mountain Whitefish	*Prosopium williamsoni*	***	**	**	-
Rainbow Trout	*Oncorhynchus mykiss*	**	6	8	1
Unidentified Dace	*Rhinichthys* spp.	-	5	-	-
Unidentified Sculpin	*Cottus* spp.	-	***	-	-
Unidentified Sucker	*Catostomus spp.*		1	-	-

[#]no snorkeling, fish collected from hook and line sampling

*estimated less than 10
**estimated between 10 and 100
***estimated more than 100

Fish Movements and Water Temperature

Tieton River Basin

We detected all 14 of the North Fork Tieton fish that we transported above Clear Creek Dam in 2021 at both our lower and upper North Fork Tieton antennas. In addition to the 14 fish from 2021, we also detected three fish transported in 2020, five fish transported in 2019, and seven fish transported in 2018 (Table 5). In total, we detected 29 Bull Trout at the upper North Fork Tieton antenna site (UPNFT) but only 27 Bull Trout at the lower North Fork antenna site (NFT) in 2021. At the lower site we did not detect a fish that was transported in 2018 (000.000AC3B2F2) and a fish that was transported in 2020 (000.000AC3B234). We did not detect any Indian Creek or South Fork Tieton Bull Trout at our North Fork Tieton antenna sites.

Table 5. Number of unique Bull Trout detected at the North Fork Tieton antenna sites in 2021.

Year Tagged	Number Transported	Number Detected at NFT	Number Detected at UPNFT
2018	23	6	7
2019	19	5	5
2020	3	2	3
2021	14	14	14

During the time when Bull Trout were present, June 5 to October 3, the mean water temperature ranged from 4.8 to 13.2 °C and the maximum temperature was 15.6 °C on August 16 (Figure 5). The median detection date was August 12 which generally corresponded with peak seasonal water temperature.

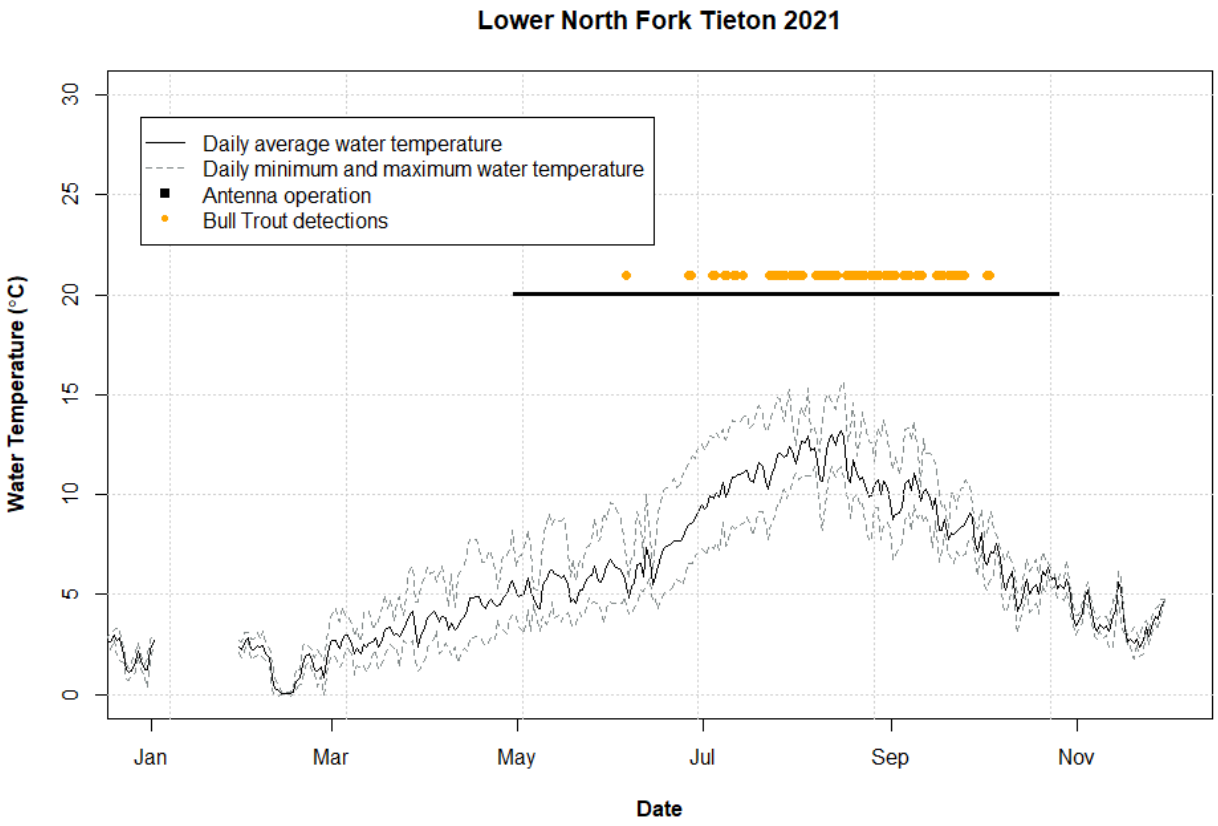

Figure 5. Seasonal change in water temperature, antenna operation, and detections of PIT-tagged adult Bull Trout at the lower North Fork Tieton antenna (NFT) during 2021.

During the time when Bull Trout were present at the upper North Fork Tieton site, July 2 to October 2, the mean water temperature ranged from 6.0 to 12.2 °C and the maximum temperature was 14.4 °C on August 11 (Figure 6). The median detection date was August 24, 12 days later than the median detection date at the lower North Fork Tieton antenna site.

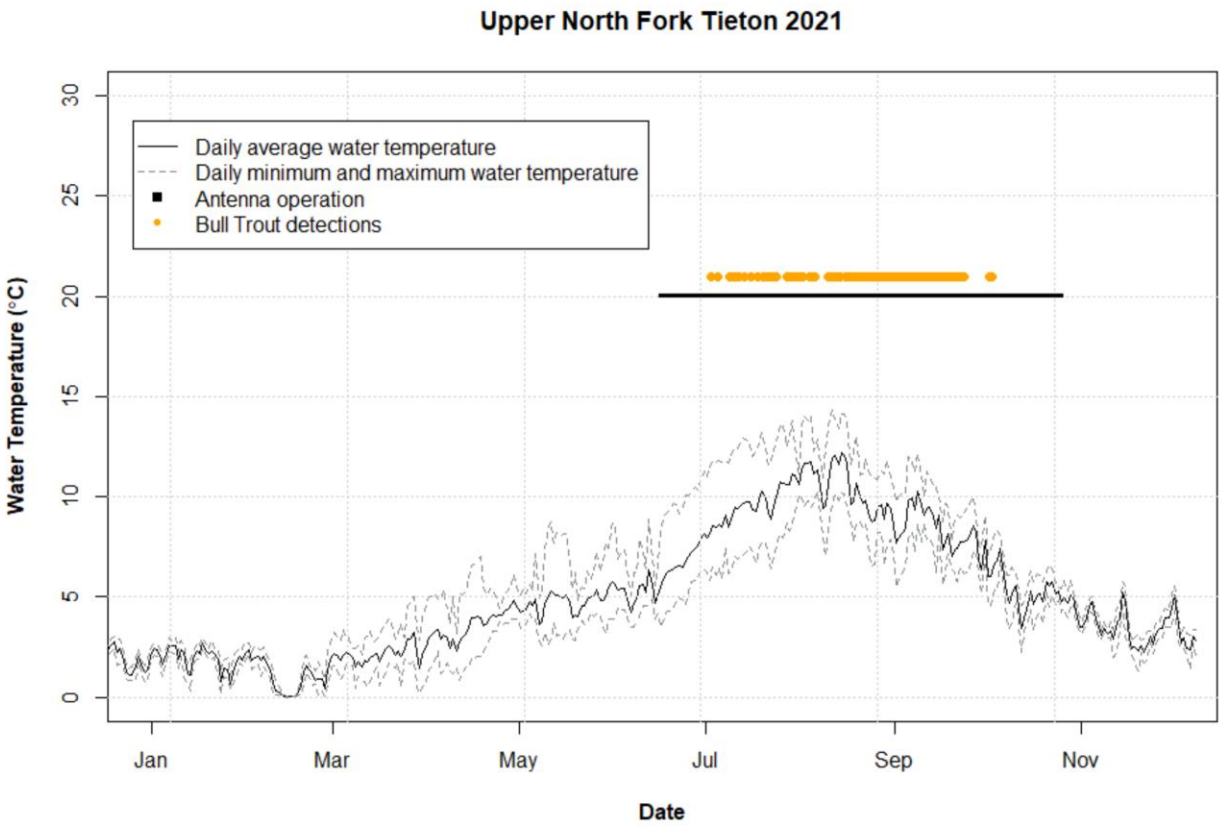

Figure 6. Seasonal change in water temperature, antenna operation, and detections of PIT-tagged adult Bull Trout at the Upper North Fork Tieton antenna (UPNFT) during 2021. The UPNFT antenna was installed in 2018.

At our antenna site in the outlet channel downstream of Clear Creek Dam (OCH), we detected nine Bull Trout in 2021, six of these fish were Indian and South Fork Tieton origin fish, collected and released just upstream in the Clear Creek Dam Stilling Basin during 2021, one was a recapture tagged in 2020, while the other five were collected and tagged in 2021. The other three Bull Trout that we detected at this site were a fish from Indian Creek that was tagged in 2019, one fish from Indian Creek that was tagged in 2020, and one fish originating in the North Fork Tieton that was tagged and released into Clear Lake in 2019, passed the dam, and then returned to the outlet channel where we detected it. Of the four fish that we detected in 2021 at the outlet channel antenna site that were tagged in previous years, we only collected one (000.000AC3B2E5) during 2021. While it's possible that these fish did not continue another 50 m upstream to the stilling basin, it's likely that they were present but were not collected. There was little daily water temperature variation in the outlet channel but mean daily water temperature varied from 3.3 °C in late November to 13.2 °C in late July. Fish were detected at the site from May 18 to September 30 (Figure 7).

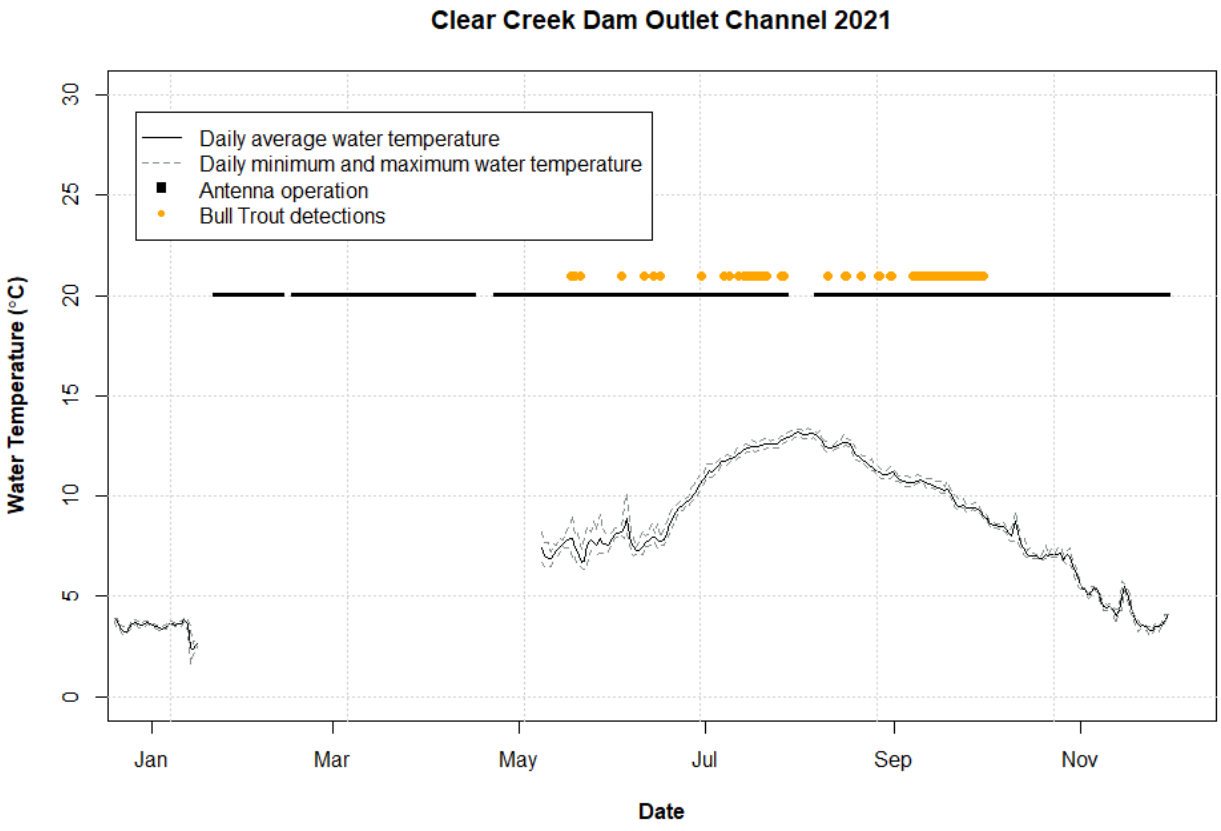

Figure 7. Seasonal change in water temperature, antenna operation, and detections of PIT-tagged adult Bull Trout at the Clear Creek Dam Outlet Channel antenna (OCH) during 2021.

Although we did not detect any of the South Fork Tieton fish released below Clear Creek Dam in 2021 at our South Fork Tieton antenna sites, we detected five fish from previous years' trap and haul efforts at both our upper (SFT) and lower (LSFT) sites. Four of the five fish were natal to the South Fork Tieton River and one fish was natal to North Fork Tieton River. The North Fork Tieton fish was transported upstream of Clear Creek Dam in 2016. One of the South Fork Tieton fish was a fish transported from below Tieton Dam in 2020. This fish was detected in both 2020 and 2021 at the South Fork Tieton site. The first fish was detected at the South Fork Tieton site on June 27. All fish passed the lower South Fork Tieton site between September 20 and September 29 and likely represent post-spawn outmigration.

At our South Fork Tieton River antenna, mean daily water temperatures ranged from a low of 0.0 °C in late January/early February to 17.8 °C in mid-August (Figure 8). We detected four Bull Trout, three that originated in the South Fork Tieton River and one that originated in the North Fork Tieton River. The fish originating in the North Fork Tieton River was collected in the stilling basin below Clear Creek Dam, tagged, and then released upstream of the dam into Clear Creek Reservoir. That same year it migrated into the North Fork Tieton River where it was detected at

our NFT antenna in the lower river. Afterward, it apparently passed Clear Creek Dam a second time and but was not detected at any of our antenna sites until it was detected at our upper South Fork antenna site in 2020. It was detected again in the South Fork River at both our lower and upper antenna sites in 2021. We also detected three fish that were collected and released into the Clear Creek Dam Stilling Basin that originated in the South Fork Tieton River, one from 2018, and two others from 2020. Overall, the range of detections was from June 27 to September 28, with a median detection date of August 15. In 2021, we installed another antenna in the lower South Fork Tieton River (LSFT) on September 14, after which we detected the same four fish detected at the upper South Fork Tieton antenna site.

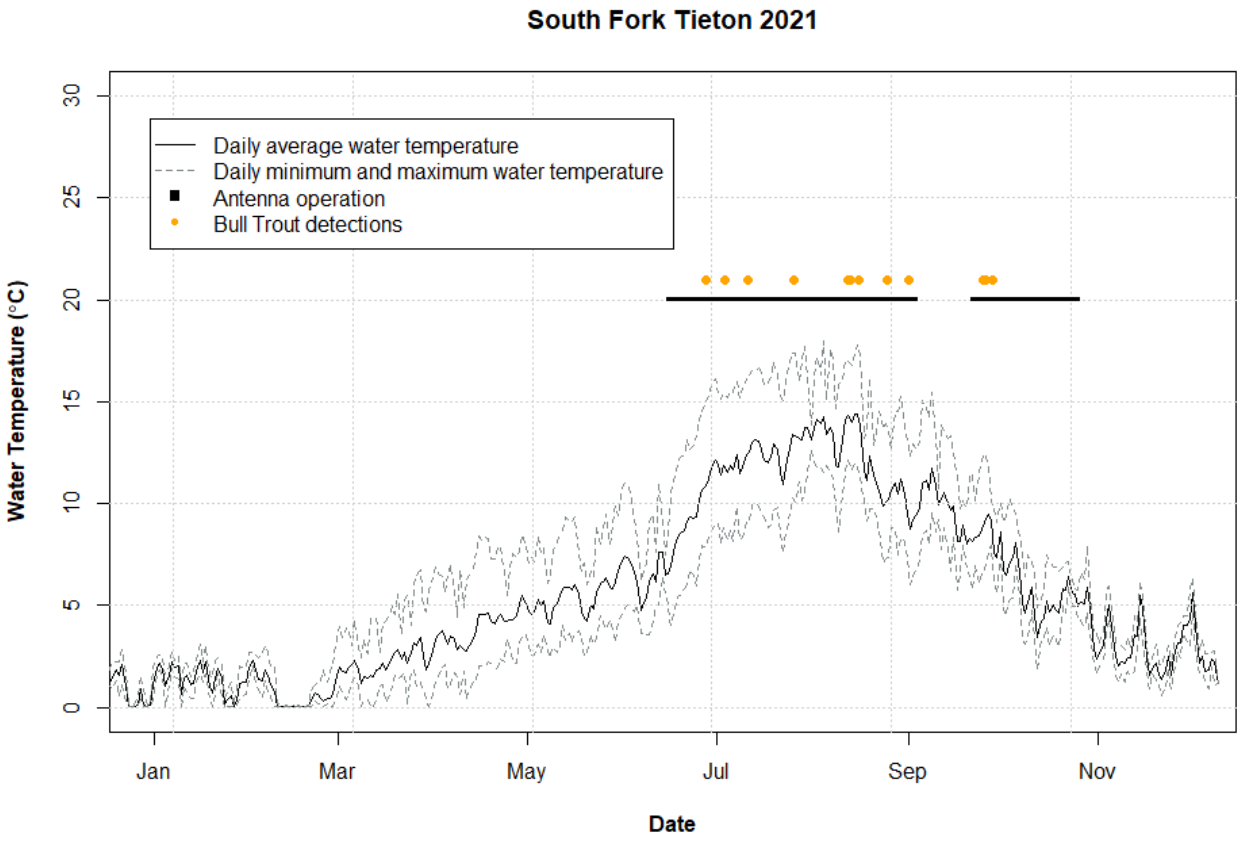

Figure 8. Seasonal change in water temperature, antenna operation, and detections of PIT-tagged adult Bull Trout at the upper South Fork Tieton antenna (SFT) during 2021.

In 2021, we detected four Bull Trout at the Indian Creek PIT-tag antenna array (IND1, IND2), all of which were natal to Indian Creek. Three of the fish were collected and released below Clear Creek Dam in 2021 and one was released there in 2019. Upstream movement occurred between June 30 and August 9. Three of the fish were detected leaving Indian Creek between September 27 and October 6, but one was not detected leaving Indian Creek. The three fish that were observed entering and leaving the system were all tagged below Clear Creek Dam in

2021, while the fourth that was detected entering but not leaving the system, was tagged in 2019.

Upper Yakima

Since we began trap and haul in the upper Yakima River in 2019, we have collected 20 fish below Keechelus Dam and none below Kachess Dam. We did not detect any of the Gold Creek origin fish released upstream of Keechelus Dam from either 2021 (n=3) or 2020 (n=1), however we detected three fish that we tagged and transported in 2019. Two of these fish were also detected in 2020, but it was the first year we detected the other fish. We did not detect either of the two fish that we collected below Keechelus and released into Kachess Reservoir that had Box Canyon Creek (2021) and upper Kachess River (2019) origins. At our lower Gold Creek antenna (G90), water temperatures fluctuated daily but ranged from 4.4 °C in mid-June to 16.4 °C in early August during the time when Bull Trout were present. During this time frame, mean daily water temperatures ranged from 4.9 °C to 14.3 °C (Figure 9). Bull Trout presence at the G90 antenna ranged from June 12 to September 18, with a median detection date of September 15.

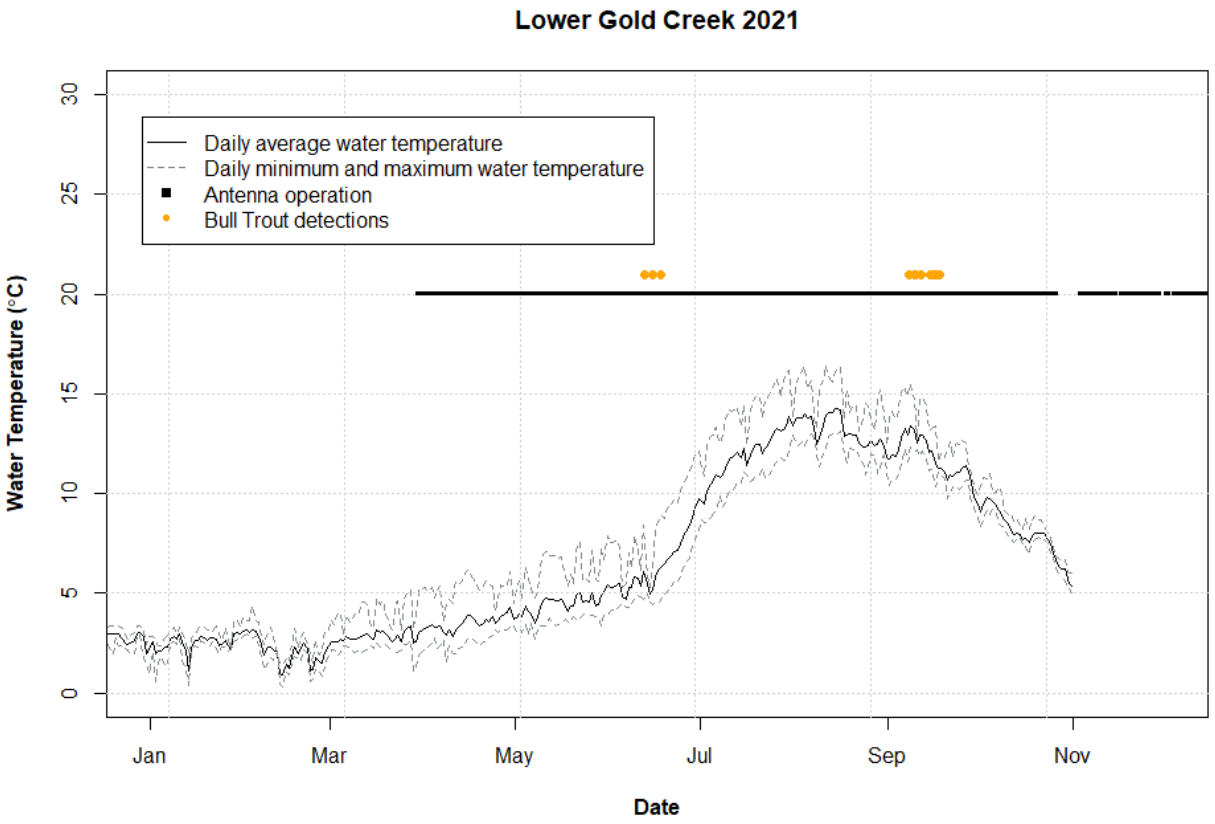

Figure 9. Seasonal change in water temperature, antenna operation, and detections of PIT-tagged adult Bull Trout at the lower Gold Creek antenna (G90) during 2021.

At our upper Gold Creek antenna, water temperature fluctuated daily and approached its mean daily peak of 12.4 °C on August 15 after both fish that we detected had passed the antenna. We detected two Bull Trout, both released in 2019. The first Bull Trout passed the site on June 23 when mean daily water temperature was 5.9 °C and the second passed the antenna on July 3 when the mean daily water temperature was 9.1 °C. Overall, mean daily water temperatures ranged from a high of 12.4 °C in mid-August to a low of 2.5 °C in mid-November (Figure 10).

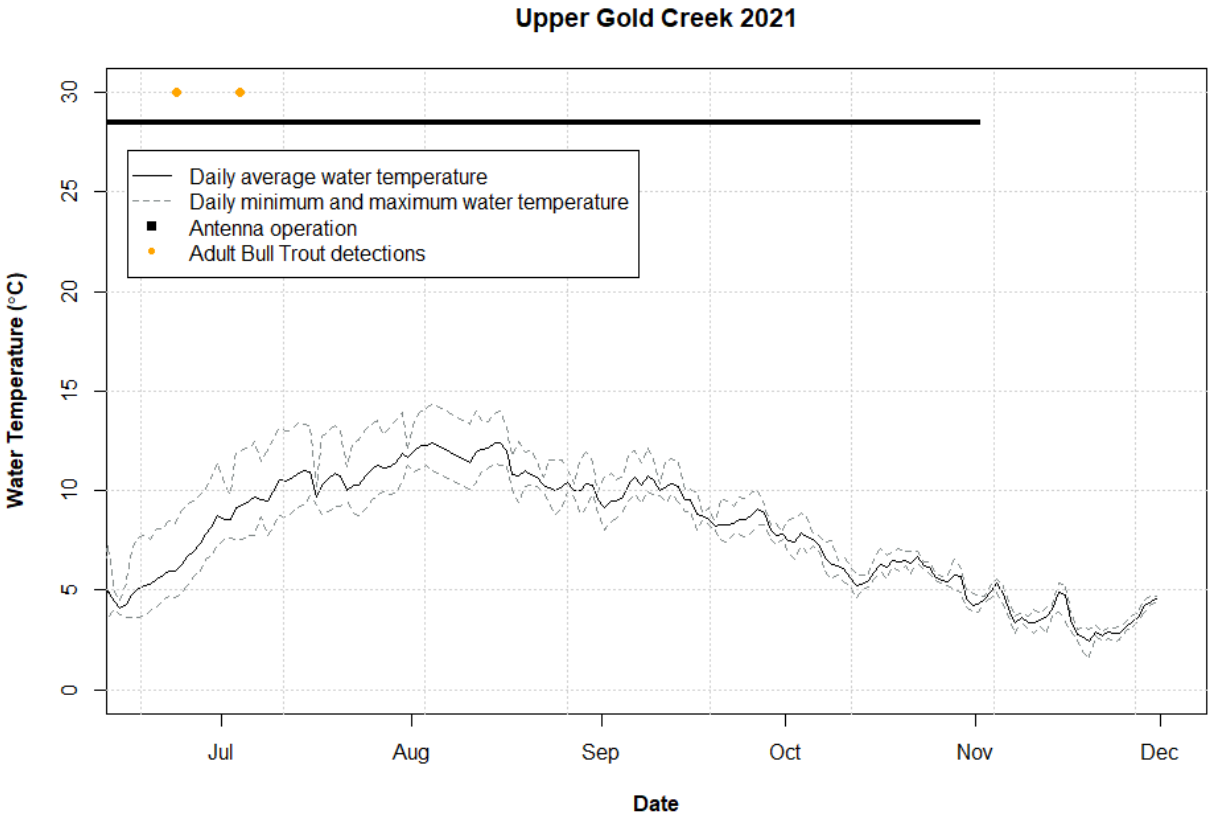

Figure 10. Seasonal change in water temperature, antenna operation, and detections of PIT-tagged adult Bull Trout at the upper Gold Creek antenna (UGC2) during 2021. Our upstream antenna at this site (UGC1) was not operable in 2021.

Discussion

Clear Creek Dam continues to be the primary dam where trap and haul indicates the largest number of Bull Trout entrained and returning to the base of dam. Data suggest fish exit Clear Creek Reservoir through the dysfunctional fish ladder in late fall. Designs for a fish ladder are

now complete and construction is anticipated in 2024. Once ladder construction is complete and PIT antennas installed within, we will be able to evaluate passage at the fish ladder relative to our trap and haul efforts. Although previous studies have indicated relatively large numbers of Bull Trout below Tieton Dam (Hiebert et al. 2003; Ackerman 2005), we collected no fish there in three attempts during 2021 after collecting two fish in 2020. The depth and turbulence of the Tieton Dam Stilling Basin both inhibits our fish collection and doesn't allow us to evaluate it by snorkeling. Although we collected a single Bull Trout below Bumping Dam in 2020, we were unable to collect any fish there in 2021, though we did observe two Bull Trout during snorkel surveys. Given these observations, future surveys conducted earlier in the year might yield better results.

Our data continue to indicate that some Bull Trout originating in tributaries of Kachess, Keechelus, Bumping, Clear Creek, and Rimrock reservoirs pass downstream of dams and then attempt to return upstream, presumably to spawn. In 2021, we collected twenty-five Bull Trout below Clear Creek dam, fifteen of which originated upstream in the North Fork Tieton River and four Bull Trout below Keechelus Dam that originated upstream of Keechelus and Kachess dams. For the third year in a row, we observed no Bull Trout below Kachess Dam. However, the fact that we collected one Bull Trout collected below Keechelus this year (Box Canyon Creek origin) and another in 2019 (Kachess River origin) indicates that Bull Trout pass Kachess Dam before ascending the Keechelus Arm to the base of Keechelus Dam. The mechanism of downstream movement is poorly understood. The Kachess Sam spillway gates haven't been operated since the early 2000's and therefore, fish likely pass downstream through the outlet works during seasonally low flow periods. In 2019 we collected 15 Bull Trout below Keechelus Dam, in 2020 we only collected one, and here in 2021, we collected four. Unlike many of the Bull Trout we collected below Keechelus in 2019, the Bull Trout we collected there in 2021 did not exhibit injuries to the caudal peduncle, maxillaries, and opercles; injuries that we previously associated with rubbing against concrete surfaces.

Of the three Bull Trout that we detected at our lower Gold Creek antenna, two appeared to have migrated upstream past our upper Gold Creek antenna and presumably spawned in upper Gold Creek in 2021. The stretch of Gold Creek between our upper and lower antennas regularly dewaters between July and October and could have prevented upstream migration to spawning grounds. The other Bull Trout that we detected in Gold Creek passed our lower Gold Creek antenna on September 7 and was not detected at our upper Gold Creek antenna but was detected again at our lower Gold Greek antenna on September 17. Therefore, of the three Bull Trout detected at our lower Gold Creek antenna, it is likely that one (3D9.1C2DFE5673) was prevented from migrating upstream due to dewatering as Gold Creek dewatered between our antennas during September. However, it is possible that it could have moved upstream and was not detected.

In 2022 we will continue our efforts to collect Bull Trout below USBR Dams at the five stilling basins outlined here and look for operational windows to sample when reduced flows outside

the typical low flow periods allow us to do so. We are hopeful to complete design and begin fabrication of a mobile steep pass to collect Bull Trout passively, in addition to the netting and hook-and-line sampling outlined here. Although slowed by contracting delays, we anticipate that designs will be complete by fall 2022. The steep pass would operate from a double-axle trailer equipped with a generator, pump, false weir, and 0.9-m (3-ft) fishway sections. Depending on initial results, the mobile steep pass could be used at Tieton Dam, and if warranted, at Kachess Narrows to collect Bull Trout concurrent with implementation of the Kachess Drought Relief Pumping Plant.

During 2022 we hope to develop survival estimates for Bull Trout in the North Fork Tieton River and potentially other spawning tributaries depending on our ability to keep our PIT antennas in place. These estimates are another way to monitor annual trends in Bull Trout in the Yakima River Basin. Thus far our biggest challenge has been maintaining antenna sites during periods of high flows. However, this year we received a 1.8 m (6 ft) submersible antenna from Biomark and our cooperators have plans to acquire more. These antennas are more portable and better suited for short term deployments where high water flows have previously destroyed our permanent anchored antennas (Figure 11).

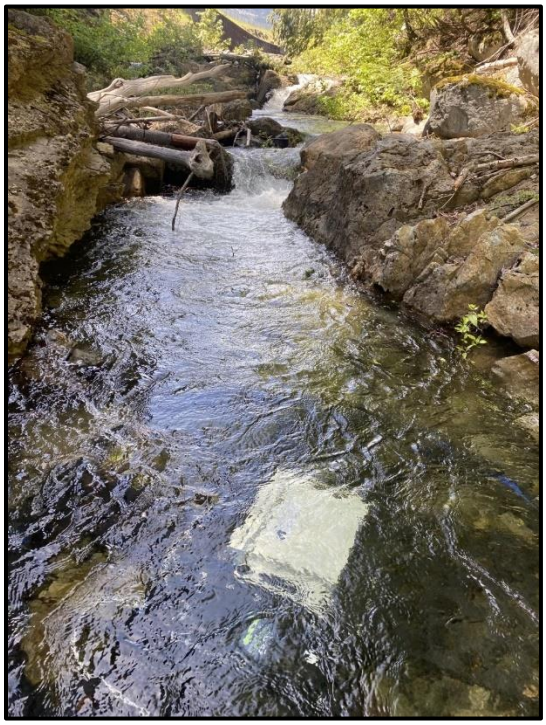

Figure 11. Example of a Biomark submersible antenna that can be used for shorter term deployments compared to the flat plate and pass-through antennas that we construct.

Acknowledgements

Patrick Monk (USBR) coordinated much of this work with the USBR Yakima Field Office, developed the trap and haul concept for Yakima Basin Bull Trout, and provided helpful comments on this report. We had many individuals assist with snorkeling and fish collection including Scott Kline (WDFW) and Alex Conley (Yakima Basin Fish and Wildlife Recovery Board). We thank Robert Randall and Aimee Taylor (Bull Trout Task Force) for field assistance including antenna construction, maintenance, downloading, fish collection, and fish tagging. We appreciate the continued cooperation of Zack Mays, Russ Byington, and Todd Newsome (Yakama Nation) in antenna construction, monitoring, and data collection. We thank Scott Wiley (USBR) for obtaining and coordinating permits for this work which was conducted under USFWS Section 10 recovery permit TE-38362D-0, reassigned to PER0019854-1 on September 23, 2021, granted to the USBR for work at Bumping, Kachess, Keechelus, and Tieton dams and TE-702631 granted to the USFWS for work at Clear Creek Dam. Scott also provided helpful comments on this report. Fish were collected under permit# 21-187 and transported under permit# 8537-03-22-21 granted by WDFW. Funding for this program was provided by the USBR Yakima River Basin Water Enhancement Project administered by Wendy Christensen and is a fulfillment of our contractual obligations under Interagency Agreement# R17PG00108 between the USBR and the USFWS Mid-Columbia Fish and Wildlife Conservation Office.

References

Ackerman, N. K. 2005. Fish Salvage from the Tieton Dam Stilling Basin, Tieton River, Washington. S.P. Cramer & Associates, Inc, Prepared for Tieton Hydropower, LLC, Gresham, Oregon. 13 pp.

Angers, B., L. Bernatchez, A. Angers, and L. Desgroseillers. 1995. Specific microsatellite loci for brook charr reveal strong population subdivision on a microgeographic scale. Journal of Fish Biology 47(Supplement A):177–185.

Crane, P. A., C. J. Lewis, E. J. Kretschmer, S. J. Miller, W. J. Spearman, A. L. DeCicco, M. J. Lisac, and J. K. Wenburg. 2004. Characterization and inheritance of seven microsatellite loci from Dolly Varden, *Salvelinus malma*, and cross-species amplification in Arctic char, *S. alpinus*. Conservation Genetics 5(5):737–741.

Dehaan, P. W., and W. R. Ardren. 2005. Characterization of 20 highly variable tetranucleotide microsatellite loci for bull trout (*Salvelinus confluentus*) and cross-amplification in other Salvelinus species. Molecular Ecology Notes 5(3):582–585.

DeHaan, P. W., S. R. Bernall, J. M. DosSantos, L. L. Lockard, and W. R. Ardren. 2011. Use of genetic markers to aid in re-establishing migratory connectivity in a fragmented metapopulation of bull trout (*Salvelinus confluentus*). Canadian Journal of Fisheries and Aquatic Sciences 68(11):1952–1969.

Haskell, C., R. Randall, J. Romine, P. Monk, and J. Von Bargen. 2020. Trap and Haul at Kachess, Keechelus, and Bumping Dams. U.S. Fish and Wildlife Service, 2019 Progress Report to the U.S. Bureau of Reclamation, Yakima, Washington. 17 pp.

Haskell, C., R. Randall, J. Romine, and J. Von Bargen. 2021. Upper Yakima and Tieton Basin Bull Trout Transport Project. U.S Fish and Wildlife Service, 2020 Progress Report to the U.S Bureau of Reclamation, Yakima, Washington. 19 pp.

Hiebert, S., E. Best, J. Sechrist, R. Swartz, D. Moore, J. Wilson, and S. Kennedy. 2003. Fish Entrainment from Rimrock Reservoir Tieton River, Washington 2002. U.S. Bureau of Reclamation, Denver, CO.

Miller, L. M., and A. R. Kapuscinski. 1996. Microsatellite DNA Markers Reveal New Levels of Genetic Variation in Northern Pike. Transactions of the American Fisheries Society 126:971–977.

Rannala, B., and J. L. Mountain. 1997. Detecting immigration by using multilocus genotypes. Proceedings of the National Academy of Sciences 94(17):9197–9201.

Rexroad, C. E., R. L. Coleman, A. M. Martin, W. K. Hershberger, and J. Killefer. 2001. Thirty-five polymorphic microsatellite markers for rainbow trout (*Oncorhynchus mykiss*). Animal Genetics 32(5):317–319.

Small, M. P., J. A. Thomas, P. A. Monk, and C. Bowman. 2016. 2016 North Fork Tieton Bull Trout Transport Project. U.S. Fish and Wildlife Service, Mid Columbia Fish and Wildlife Conservation Office, Yakima, Washington. 9 pp.

Stephenson, J. J., M. R. Campbell, J. E. Hess, C. Kozfkay, A. P. Matala, M. V. McPhee, P. Moran, S. R. Narum, M. M. Paquin, O. Schlei, M. P. Small, D. M. Van Doornik, and J. K. Wenburg. 2009. A centralized model for creating shared, standardized, microsatellite data that simplifies inter-laboratory collaboration. Conservation Genetics 10(4):1145–1149.

Thomas, J. A., and P. A. Monk. 2015. Clear Creek Dam Fish Passage Assessment. U.S. Fish and Wildlife Service, Third Annual Progress Report, Yakima, Washington. 38 pp.

Thomas, J. A., and P. A. Monk. 2016. Clear Creek Dam Fish Passage Assessment. Final Report, Yakima, Washington. 64 pp.

Thomas, J. A., P. Monk, and R. Randall. 2017. NF tieton bull trout transport project. U.S. Fish and Wildlife Service, 2016 Progress Report, Yakima, Washington. 19 pp.

Thomas, J. A., R. Randall, J. Romine, P. Monk, and J. Von Bargen. 2018. North Fork Tieton Bull Trout Transport Project. U.S. Fish and Wildlife Service, 2017 Progress Report, Yakima, Washington. 23 pp.

Thurow, R. F., and D. J. Schill. 1996. Comparison of day snorkeling, night snorkeling, and electrofishing to estimate bull trout abundance and size structure in a second-order Idaho stream. North American Journal of Fisheries Management 16:314–323.

U.S. Fish and Wildlife Service. 2015. Mid-Columbia Recovery Unit Implementation Plan for Bull Trout (*Salvelinus confluentus*). Portland, Oregon. 346 pp.