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Seasonal Movements of Adult Fluvial Bull Trout in Icicle Creek, WA 2008 Annual Report



U.S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
Leavenworth, WA 98826

On the cover: Adult female fluvial bull trout code 22, hidden under a boulder in French Creek, on September 8, 2008. USFWS photograph by M.C. Nelson.

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2008 ANNUAL REPORT

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SEASONAL MOVEMENTS OF ADULT FLUVIAL
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2008 ANNUAL REPORT

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Abstract- Radio telemetry was used to monitor the movements of 3 fluvial bull trout in Icicle Creek in 2008. Two bull trout were radio-tagged in lower Icicle Creek and one was tagged in upper Icicle Creek. On April 7, 2008, bull trout code 20 was captured and radio-tagged in Icicle Creek at rkm 4.3 in the spillway pool of Leavenworth National Fish Hatchery. Code 20 was present in or around the spillway pool from April 7 to December 29 and exhibited several local movements during the period before moving a relatively short distance downstream. Bull trout code 23 was captured and radio-tagged at rkm 4.3 on July 30, 2008. It was present in or near the spillway pool until August 15, when it moved downstream and exited Icicle Creek. On August 19, the motionless signal was detected in the Wenatchee River 3.4 km downstream of the confluence with Icicle Creek, and on August 25, the carcass and tag were recovered. Bull trout code 22 was captured and radio-tagged in upper Icicle Creek at rkm 26 in the Icicle Creek Gorge on July 25, 2008. It was present in the gorge until it jumped the gorge waterfalls sometime between August 12 and 22, when flows (as measured at the USGS gage station at rkm 9.4) declined to 210 – 286 ft³/sec. Code 22 passed waterfalls at rkm 29.1 and rkm 34.3 as it moved upstream. It was located in lower French Creek on September 8 and was observed digging a redd while paired with a small resident-sized bull trout on September 22. After spawning, code 22 moved back downstream to the Icicle Gorge, where it held from September 30 to November 3, and then began to slowly move downstream again. On December 1, the motionless signal was detected and the radio tag was recovered in the tail-out of a pool at rkm 19.3. Eight fluvial bull trout redds were counted during spawning ground surveys in French Creek (rkm 0.0 – 7.2). No redds were detected during surveys in upper Icicle Creek (rkm 29.1 – 34.7) or in the lower 3.2 km of Jack Creek (rkm 27.6).

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Introduction

Bull trout in the Columbia River basin were listed as threatened in 1998 (USDOJ 1998) and recovery planning focused solely on migratory populations (USFWS 2002a). Icicle Creek bull trout were initially identified as a resident population and were not included as a local population in the draft bull trout recovery plan (USFWS 2002b). The rugged canyon and boulder falls beginning at river kilometer 9.2 (rkm)¹ were considered a barrier to migratory fish (WDF 1938), but in autumn of 2002, migratory sized bull trout were observed immediately upstream of the presumed barrier (USFWS 2004). Therefore, Icicle Creek bull trout were added as a local migratory population in the 2004 version of the draft bull trout recovery plan (USFWS 2004). The potential use of Icicle Creek by migratory bull trout and their status and interaction with the resident component is considered a research need (USFWS 2004).

The Upper Columbia Bull Trout Recovery Unit encompasses the Wenatchee, Entiat and Methow core areas (Figure 1). Icicle Creek bull trout are one of seven local migratory populations designated in the Wenatchee Core Area. The other local bull trout populations are located in Peshastin Creek (including Ingalls Creek), Chiwaukum Creek, Nason Creek (including Mill Creek), Chiwawa River (including Chikamin, Phelps, Rock, Alpine, Buck, and James creeks), White River (including Canyon and Panther creeks), and Little Wenatchee River (USFWS 2004).

During the recovery planning process it was determined that 50 pairs of spawning bull trout, or 50 redds, constituted the recovered abundance of Icicle Creek migratory bull trout (USFWS 2004). However, spawning areas in Icicle Creek have not been identified and spawning ground surveys to enumerate bull trout redds were not conducted in Icicle Creek prior to 2008. Thus, there are no data on which to base estimates of the effective population size of Icicle Creek bull trout.

A total of 12 bull trout (134 to 240 mm in length) were captured in lower Icicle Creek during studies conducted in 1937 prior to construction of Leavenworth National Fish Hatchery (NFH) (WDF 1938), and biologists thought the population was small (Chapman and Quistorff 1938). At that time migratory bull trout faced many of the same conditions that resulted in the decline of all migratory salmonines, and numbers of fluvial bull trout were apparently very low. For example, at Rock Island Dam on the Columbia River, no bull trout were counted ascending the fish ladders from 1934 to 1936, and during 1937 only 6 were counted (WDF 1938). At Tumwater Dam on the Wenatchee River, only 9 bull trout were counted ascending the fish ladder in 1935, and none were counted in 1936 and 1937 (WDF 1938). There are no known bull trout records in Icicle Creek from 1938 to 1968, but anecdotal reports from local anglers indicate some large bull trout were caught in the upper Icicle in the 1960s and the 1980s (Anon., pers comm., D. Davies, pers. comm.).

¹ Note that all river kilometer designations in this report are approximate. See methods section.

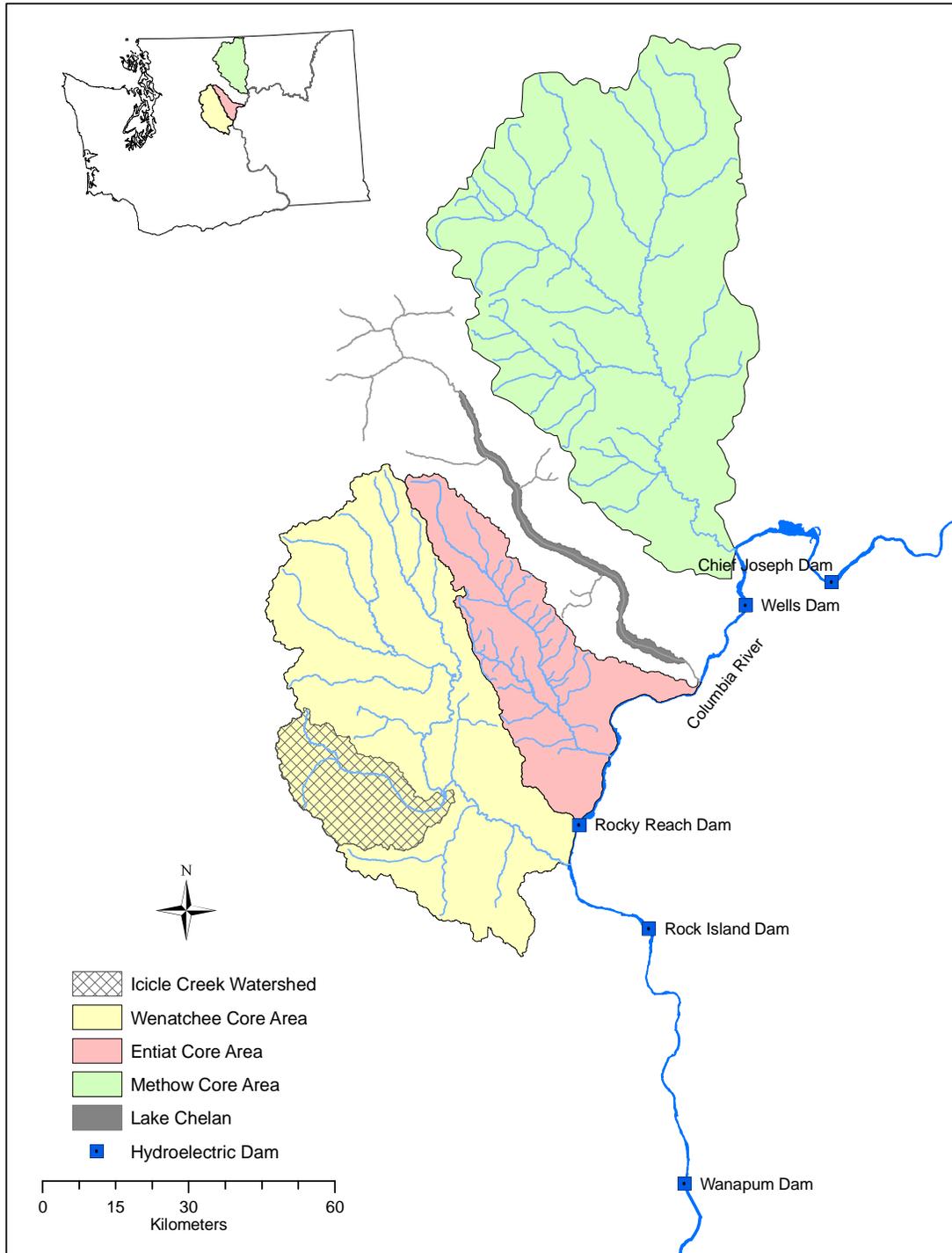


Figure 1. Map of the Upper Columbia Bull Trout Recovery Unit, showing the location of the Icicle Creek watershed within the Wenatchee Core Area.

The first recorded observation of migratory-sized adult bull trout in Icicle Creek occurred in October 1969, when several dozen were observed in the Leavenworth NFH spillway pool at rkm 4.3 (Brown 1992). An adult bull trout was captured in an out-migrant smolt trap at Leavenworth NFH structure 5 in 1987 (Mullan et al. 1992) and 7 sub-adults (167 mm to 238 mm) were collected in the historic channel during biomass studies at the hatchery in 1985 and 1986 (Mullan et al. 1992, MCRFRO data from files). From 1994 - 2007, snorkel counts of bull trout in the spillway pool ranged from 3 to 125 individuals, including juvenile, sub-adult and adult migratory fish (USFWS 2006, MCRFRO 2007). Although no large or obvious migratory-sized bull trout were observed in Icicle Creek upstream of Leavenworth NFH during the few surveys conducted prior to 2001, a large bull trout was observed jumping at the Icicle Gorge falls (rkm 26.2) in 1995 (B. Cates, pers. comm.). After changes in the operations of in-stream hatchery structures in 2001 and from 2005 to the present, migratory-sized bull trout were observed upstream of the hatchery in 2001, 2002, 2004, 2005, 2006, and 2007, and upstream of the boulder falls (rkm 9.2) in 2002, 2004, 2006, and 2007 (USFWS 2004, MCRFRO 2005, USFWS 2005, USFWS 2006, WFC 2007a).

Surveys to detect bull trout in upper Icicle Creek and tributaries were conducted in 1990, 1994, 1995, 1998, and 2004. Resident bull trout were found only in Eightmile Creek and French Creek during presence/absence electro-fishing surveys in 1990 (Brown 1992). Low numbers of resident bull trout were observed during snorkel surveys in Jack Creek in 1994 and in upper Icicle Creek in 1995 (Free 1995, Kelly Ringel 1997). A resident bull trout and a bull trout redd (size not recorded) were observed during a snorkel survey in lower French Creek in 1998 (Kelly Ringel and Murphy 1999). In 2004, a snorkel survey was conducted in the same reaches of Jack Creek that were snorkeled in 1994 (USFWS 2005). Although the number of bull trout observed in Jack Creek was still low, when the data are corrected for day and night snorkeling efficiencies, the density and distributional extent of bull trout was double the 1994 survey. In 2006 and 2007, as part of the Integrated Status and Effectiveness Monitoring Program for the Wenatchee River watershed, the U.S. Forest Service conducted snorkel surveys in French Creek at two randomly selected locations and found relatively high numbers of bull trout (J. Call, pers. comm.). The estimated total densities ranged from 1.8 to 11.8 bull trout per 100 m² (Nelson 2007), which exceeded the minimum criteria of 1.5 per 100 m² used to determine areas critical to the maintenance of healthy populations of bull trout (Shepard et al. 1982) and compared favorably to known strongholds of bull trout in the Wenatchee Core Area.

From 2004 to 2007, a total of 6 migratory bull trout radio-tagged for studies at other locations in the Upper Columbia Recovery Unit migrated into Icicle Creek. These radio-tagged bull trout were recorded in the spillway pool on August 4, 2004 (Nelson and Nelle 2008), sometime after July 10, 2005 (exact date unknown, MCRFRO 2005), on June 26, July 22, and July 25, 2006 (MCRFRO 2006), and on July 7, 2007 (data from files). In general, these dates are consistent with observations of bull trout at Tumwater Dam on the Wenatchee River (rkm 49.7), where movements begin on the declining hydrograph, the migration peak averages 45 days after the peak spring runoff, and the average migration peak date is July 7 (based on data from 1998 – 2006, Nelson 2008). Four of the tagged bull trout spent a day or less in or near the spillway pool before exiting Icicle

Creek. Two of the tagged bull trout passed the Leavenworth NFH headgate; one passed the hatchery intake diversion, but none passed the boulder falls. However, the tags of those two bull trout were recovered and presumed expelled (MCRFRO 2005, 2006).

Little is known about the movements, migration timing, and numbers of migratory bull trout in Icicle Creek upstream of Leavenworth NFH. In 2000, bull trout were radio-tagged as part of a larger USFWS Mid Columbia River Fishery Resource Office telemetry study of the movements of spring Chinook salmon and steelhead in Icicle Creek (Cappellini 2001). Five bull trout captured by rod and reel in the Leavenworth NFH spillway pool (rkm 4.3) were radio-tagged and released upstream of the hatchery headgate (rkm 6.1). Three of the fish moved upstream to the hatchery intake diversion (rkm 7.2), but none were tracked further upstream. While one bull trout remained at the hatchery diversion for 14 days, the others quickly moved downstream, suggesting it was likely that none of these bull trout were from the Icicle Creek local population. However, it is also possible tagging and transporting or low water conditions affected their behavior.

In 2007, the USFWS Mid Columbia River Fishery Resource Office developed a multiyear radio-telemetry study to investigate the migratory form of bull trout in Icicle Creek. Only one charr was radio-tagged in Icicle Creek during 2007- a probable hybrid bull x brook trout *Salvelinus confluentus x fontinalis* (Appendix 1).

The objectives of this radio-telemetry study are to determine migration timing and distance, identify migration barriers and obstacles, document passage windows at natural and artificial obstacles, monitor seasonal movements, and locate spawning areas of adult migratory bull trout in Icicle Creek. The movements and migrations of adult fluvial bull trout will be tracked throughout the year and the patterns should provide insights into bull trout life history forms in Icicle Creek.

Study Area

Icicle Creek originates in Josephine Lake (elevation 1,427 meters) near the crest of the Cascade Mountains in Chelan County of north-central Washington. It flows easterly for 51.2 rkm, drains a watershed area of 555 km², and enters the Wenatchee River at rkm 41.2 near the town of Leavenworth (Figure 2). Eighty seven percent of the watershed is in public ownership (74% of which is in the Alpine Lakes Wilderness Area), and 13% is in private ownership (USFS 1995).

Icicle Creek is in a narrow, steep, glaciated valley characterized by a cascading water course that plunges downstream in a series of cataracts, riffles, and rapids. Stream discharge has been recorded by the U.S. Geological Survey (Gage Station 12458000 Icicle Creek above Snow Creek, near Leavenworth WA; rkm 9.4) from 1936 to 1971 and from 1993 to the present. The average discharge for the period of record is 614 ft³/sec; the minimum discharge was 44 ft³/sec on Nov. 30, 1936 and the maximum discharge was 19,800 ft³/sec on Nov. 29, 1995 (USGS 2008). Stream gradient is variable and ranges from 0.12% to 9.0% (Figure 3). Several natural and artificial obstructions to fish migrations occur in Icicle Creek. Among the many natural obstacles (Figure 3) are

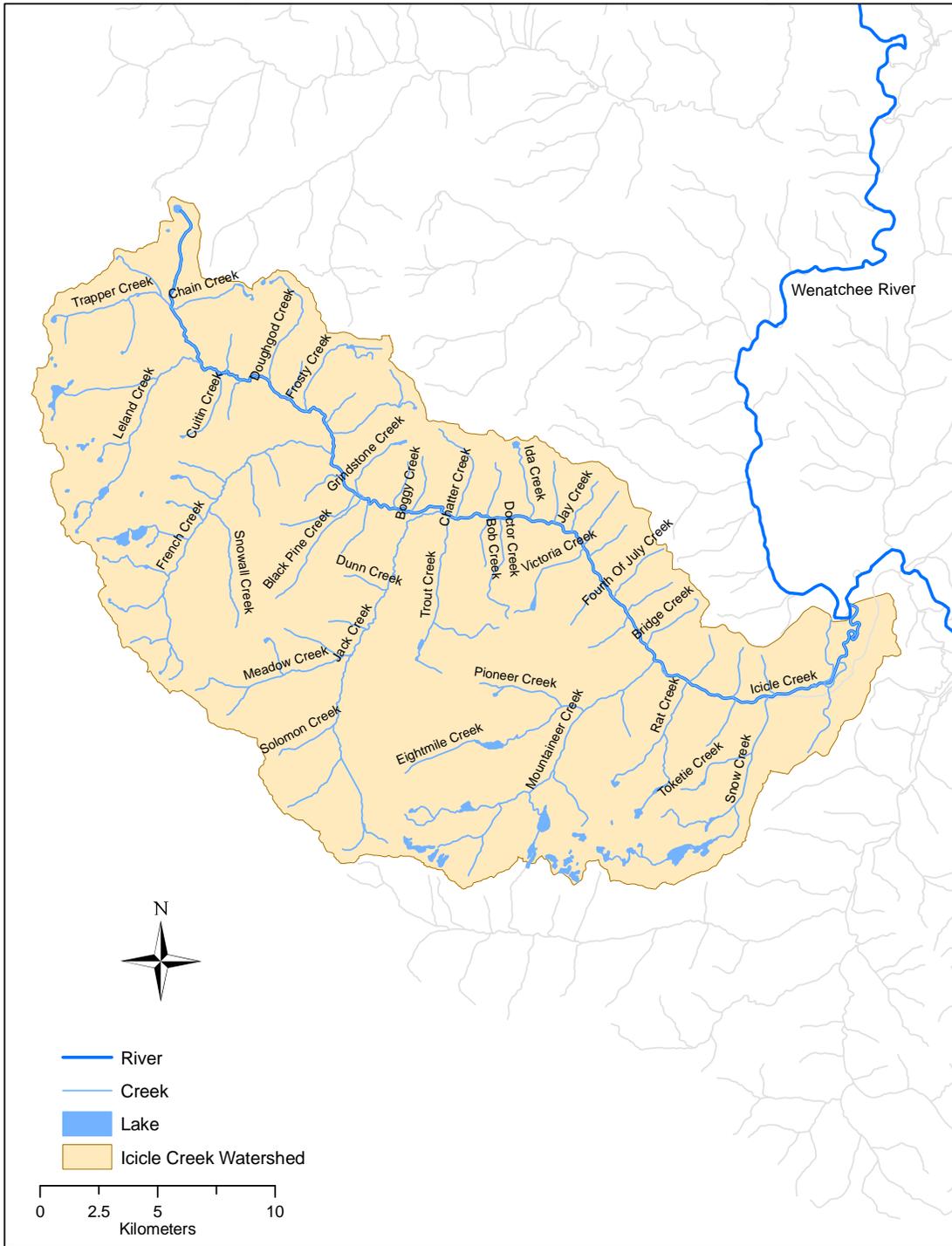


Figure 2. Map of the Icicle Creek watershed.

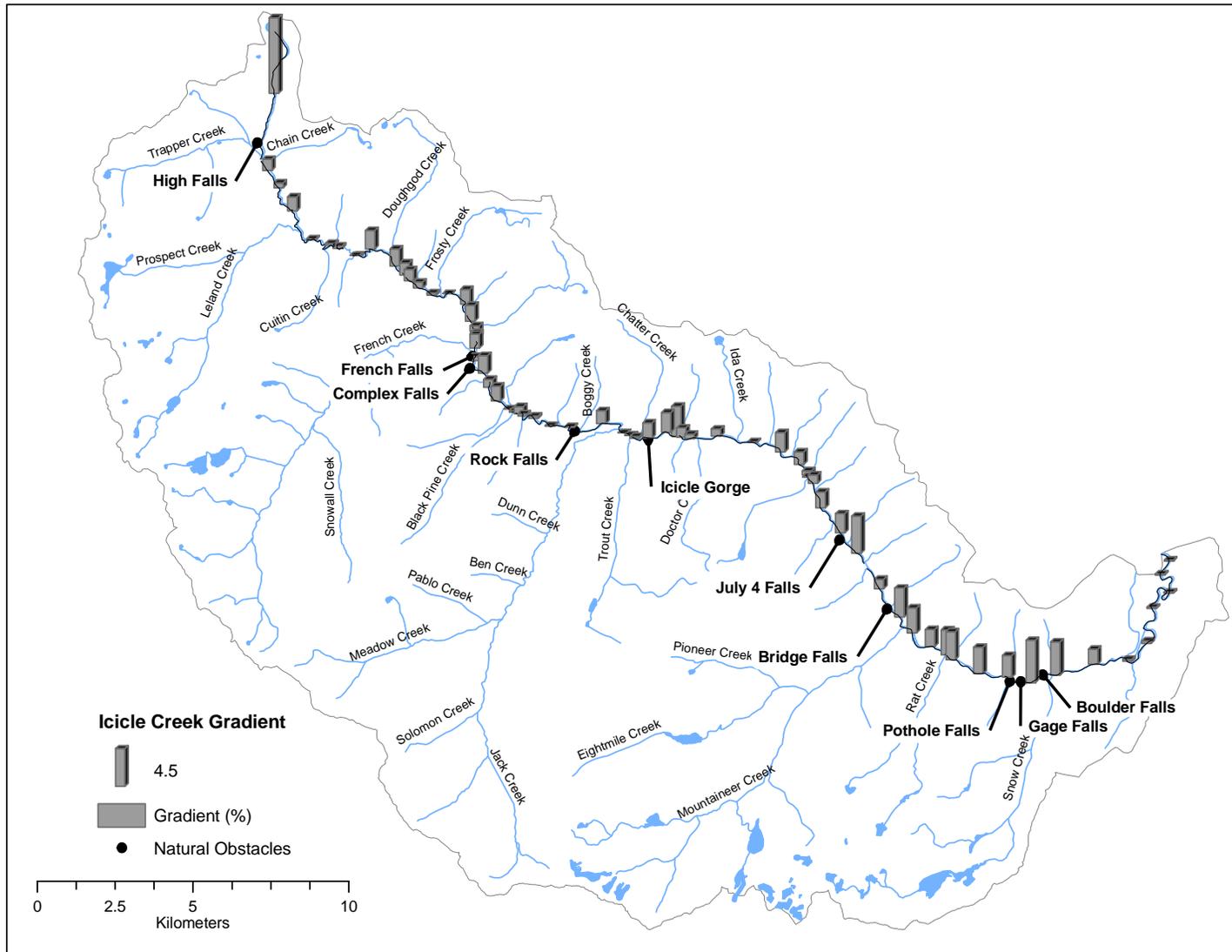


Figure 3. Map of Icicle Creek watershed, showing gradient (within stream segments as calculated in GIS) and locations of select natural obstacles.

the boulder falls found both upstream of Snow Creek at rkm 9.2 and near Bridge Creek at rkm 14.3, the chute and flume falls at the Icicle Gorge (rkm 26.2), water falls at Rock Island Campground (rkm 29.1), and complex falls (step pool morphology over bedrock substrate) at rkm 34.3 and at French Creek (rkm 34.7). The high falls upstream of Leland Creek at rkm 46.8 are considered impassable to migrating fish (Bryant and Parkhurst 1950). Many of the tributaries, particularly the smaller ones, are inaccessible to migratory fish due to waterfalls and steep gradient (Mullan et al. 1992).

Artificial obstructions in Icicle Creek include structures associated with the operation of Leavenworth NFH (structure 5 at rkm 4.4, headgate at rkm 6.1, and intake diversion dam at rkm 7.2) and the Icicle Peshastin Irrigation District (IPID) diversion dam at rkm 9.3 (Figure 4). Management of the hatchery attempts to balance both hatchery operations and fish movements. Structure 5 is open except from May 15 to July 7, when it is operated as a seasonal dam during the hatchery's spring Chinook salmon brood stock collection period. The headgate is open except during brood stock collection or when operated to control flooding and recharge groundwater wells, and a fish ladder is operated at the intake diversion dam (USFWS 2006).

The Icicle Creek watershed sustains the heaviest recreational use of any watershed within the Wenatchee River subbasin (USFS 1995). Recreational activities include kayaking, rock climbing, hiking, backpacking, bicycling, horse riding, hunting, fishing, bird watching, sightseeing, and camping. Six of the seven U.S. Forest Service (USFS) developed campgrounds are located in the riparian zone of Icicle Creek (Figure 5) and several primitive campsites are dispersed throughout the valley. The lower 32 kilometers of the river are accessible by road, and the upper 19 km by trail (Figure 5). Forest Service Road 7600 closely parallels Icicle Creek for much of its route and in some locations prevents the stream from using its floodplain (USFS 1995). In 2008, a landslide near Doctor Creek (rkm 24.9) redirected Icicle Creek flows down the roadway and the Forest Service closed the Forest Road 7600 at rkm 23.5.

For descriptive purposes in this study, the boulder falls at rkm 9.2 is considered the division between upper and lower Icicle Creek. Salmonines known to inhabit upper Icicle Creek are bull trout *Salvelinus confluentus*, brook trout *S. fontinalis*, westslope cutthroat trout *Oncorhynchus clarki lewisi*, rainbow trout *O. mykiss*, and redband rainbow trout *O. mykiss gairdneri*. Salmonids found only in lower Icicle Creek include steelhead *O. mykiss*, spring and summer hatchery Chinook salmon *O. tshawytscha*, hatchery coho salmon *O. kisutch*, stray hatchery sockeye salmon *O. nerka*, and mountain whitefish *Prosopium williamsoni*. Non-salmonid species in lower Icicle Creek include northern pikeminnow *Ptychocheilus oregonensis*, longnose dace *Rhinichthys cataractae*, speckled dace *Rhinichthys osculus*, redband shiner *Richardsonius balteatus*, various sculpin species *Cottus spp.*, and various sucker species *Catostomus spp.*

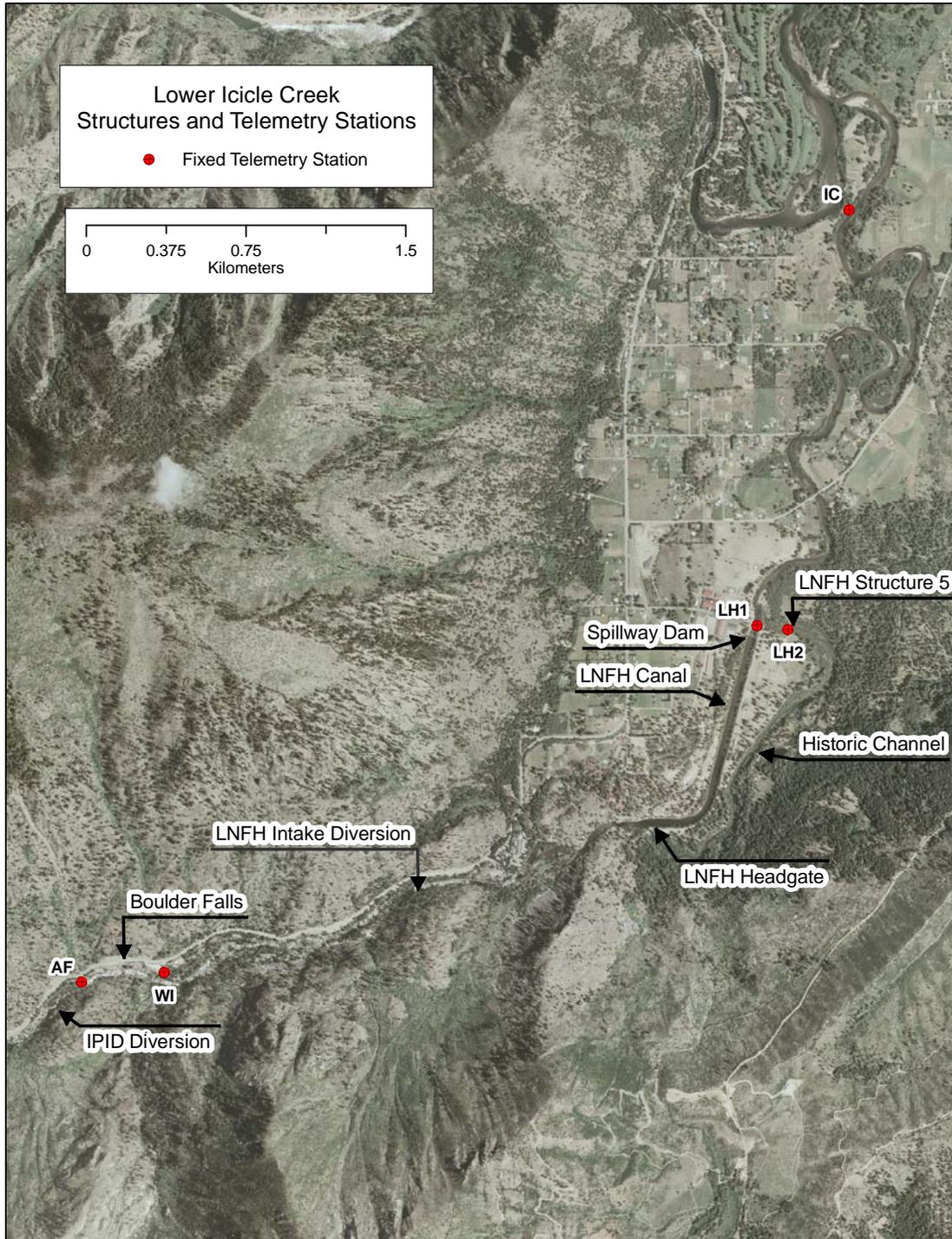


Figure 4. Aerial photograph of lower Icicle Creek, showing locations of natural and artificial obstacles and structures in the creek.

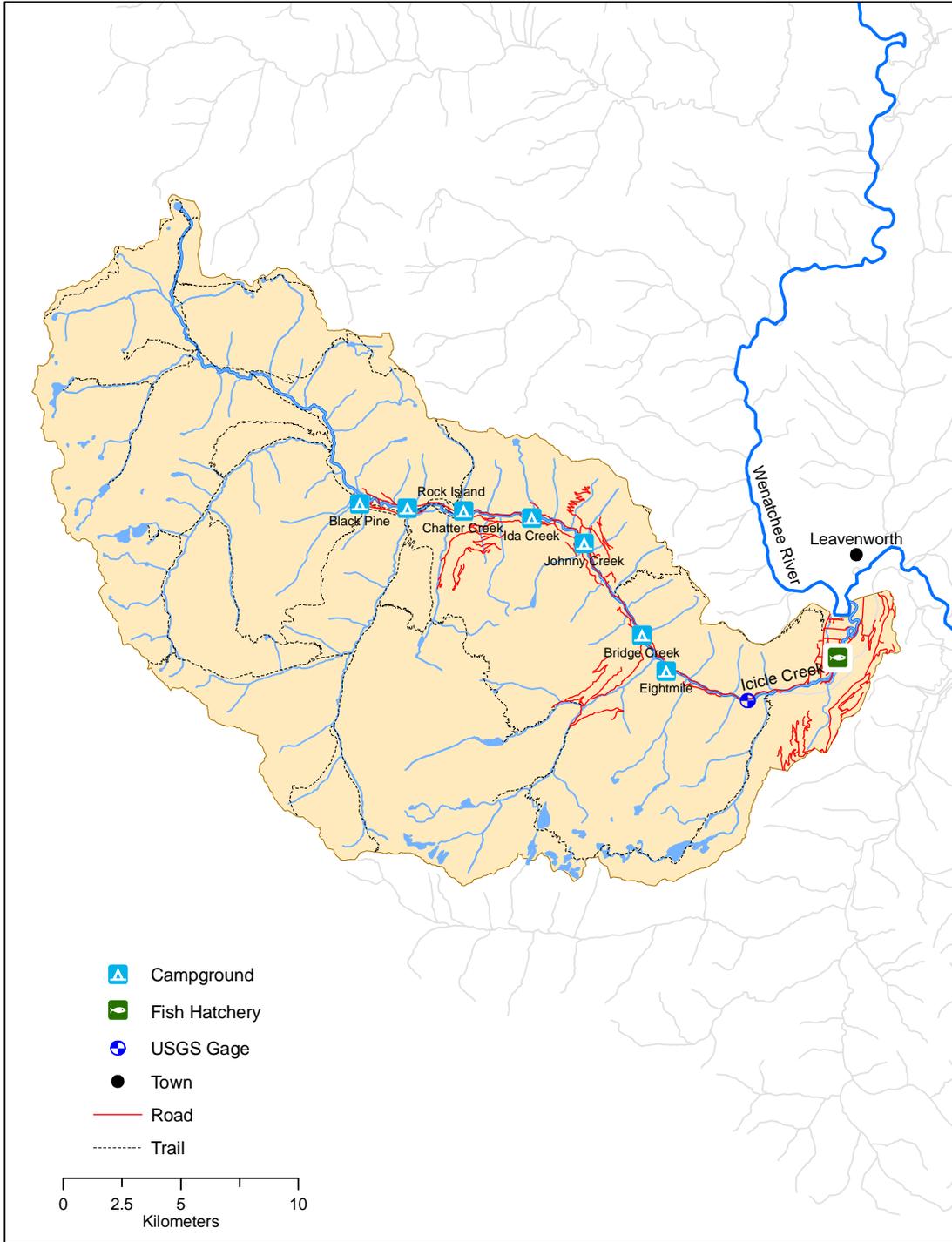


Figure 5. Locations of USFS campgrounds, Leavenworth NFH, USGS gage station, roads, and trails in the Icicle Creek watershed.

Methods

Capture

Adult bull trout were captured by hook and line. All hooked bull trout were quickly netted with a knotless hand net and placed in perforated PVC tubes. The holding tubes were tethered in a calm area of the river while the surgery field was prepared. Each capture site was geo-referenced using a hand held global positioning system (GPS) unit (GPSMap76, Garmin Corp.). A trap was operated by Leavenworth NFH at structure 5 from May 19 to July 7 in an attempt to capture additional fish for tagging.

Radio transmitters and PIT tags

The radio tags implanted in the bull trout were Lotek Engineering model SR-M16-25 digitally-encoded radio transmitters using frequency 148.320 MHz (channel 01) and tag codes 20 to 23. The radio tags are DSP compatible and contain a motion option, set at sensitivity level 4 or 5 with time delay to initiate motion signal of 24 or 48 hours and include motion reactivation. When the tag becomes motionless, the option is activated, and a base of 100 is added to the code (i.e. code 20 will transmit as code 120). This model radio tag is 16 mm in diameter and 51 mm in length, weighs 17 g in air and has an expected battery life of 3 years at a 5 second burst rate. Each fish was also tagged with a passive integrated transponder (PIT) tag model TX1415 (3.4 x 23 mm) operating at 134.2 kHz.

Tag implantation procedure

Radio transmitters and PIT tags were surgically implanted in bull trout following the guidelines of Mulcahy (2003) and the methods described by Summerfelt and Smith (1990) and Ross and Kleiner (1982). For a detailed description of the procedures used, see Nelson et al. (2007). Although the “2% rule” (Winter 1996) has been used as a guideline for selecting the size of fish suitable for tagging, Adams et al. (1998) suggest a transmitter to body weight ratio of up to 5.6 % may be used without additional behavioral affects. However, for this study only bull trout greater than 450 mm were tagged, due to concerns related to potential negative effects of the large transmitter in the body cavity of smaller fish (Chisholm and Hubert 1985, Paukert et al. 2001).

Monitoring of radio-tagged bull trout

Bull trout movements were recorded using four monitoring methods: fixed receiver telemetry stations, truck tracking surveys, mountain bike surveys, and foot surveys.

Fixed stations- Telemetry receivers (Lotek Wireless model SRX400 W7 or W31) equipped with antenna switching units (Lotek ASP-8 or Grant Engineering Hydra) and yagi-type antennas (Grant Engineering model 4LYVT) were used at fixed receiver telemetry stations. Solar panels (85 watt, Kyocera Solar, Inc.) equipped with charge controllers (SunSaver 10, Morningstar Corp.) were used to charge 12 V batteries at fixed stations. Small 18 amp hour batteries were used at remote fixed stations and deep cycle flooded lead acid batteries (Trojan® T-105) were used at easily accessible fixed stations. AC power was utilized to charge batteries connected to the receivers at two stations.

Fixed receiver telemetry stations were set up at key locations in Icicle Creek (Figures 4 and 6). These locations, referenced by a 2 letter code, were just upstream of the Icicle Creek confluence (IC) with the Wenatchee River, at the Leavenworth National Fish Hatchery (LH), at the City of Leavenworth water intake treatment building (WI) downstream of the boulder falls, just upstream above the boulder falls (AF), at the Icicle Creek Gorge (IG) near Chatter Creek Campground, and at the road's end (RE) of the FR7609 spur road (Table 1). Two antennas were used at the LH station: LH1 monitored the Leavenworth NFH spillway pool and LH2 monitored structure 5 (Figure 4).

Mobile surveys- For truck surveys 2 electronically amplified (P150VDG, AR2) yagi-type antennas were attached to a mast mounted on the receiver hitch, and a switch installed in the cabling to the telemetry receiver allowed switching between right and left antennas (Nelson 2006). Mountain bikes were used to conduct mobile surveys between the road closure and the wilderness boundary. A collapsible yagi 3-element antenna (AF Antronics F150-3FB) was used during foot and bike surveys. Team tracking techniques were used during in-stream surveys to avoid disturbance to tagged and untagged bull trout (Nelson 2004). Location coordinates were recorded with a GPS unit (GPSMap76, Garmin Corp.) or placed by hand on 1:24,000 U.S. Geological Survey (USGS) topographic maps. Data were recorded on daily tracking forms and in Rite-in-the-Rain field notebooks, and included the river, date and time, river mile, location description and other notes. GPS waypoints were downloaded into topographic mapping software (MapTech® Terrain Navigator 2002) and the marker files were exported into GIS (ESRI™ ArcGIS® v9.2) for creation of maps. The river mile (rm) of a location in Icicle Creek was interpolated from river mile markers on USGS 1:24,000 topographic maps. In tributaries the river mile markers were approximated using the linear distance tool in MapTech® Terrain Navigator. Therefore, the river mile used at locations in this study may differ from those used in other documents or by other agencies. River miles were converted to river kilometers (rkm) for use in this study. Telemetry data were entered into a relational database (Microsoft Office Access 2003) and paper copies archived at the Mid Columbia River Fishery Resource Office.

Spawning ground surveys

Spawning ground surveys were conducted by experienced observers in Icicle Creek (rkm 29.1 – 34.7), Jack Creek (rkm 0.0 – 3.2), and French Creek (rkm 0.0 – 7.2). The surveys in French Creek were partitioned into 3 reaches based on hiking distance and recognizable tributaries as definition of the reach breaks: Reach A (rkm 0 – 3.2), Reach B (rkm 3.2 – 5.6) and Reach C (rkm 5.6 – 7.2). Redds were categorized as definite, probable, or possible, with only definite and probable redds included in the final count (Bonar et al. 1997). Redd dimensions were measured with a wading staff graduated in 0.05 m increments; locations were geo-referenced with GPS units (Rino530HCx®, Garmin Corp.), and waypoints downloaded onto a digital topographic map (MapTech® Terrain Navigator 2002). Redd area (m²) was approximated as length multiplied by width. The t-test tool in a statistical software package (STATGRAPHICS Plus for Windows 2.0, Statistical Graphics Corp. 1996) was used to compare size of redds between reaches in French Creek, with the significance level set at $p < 0.05$.

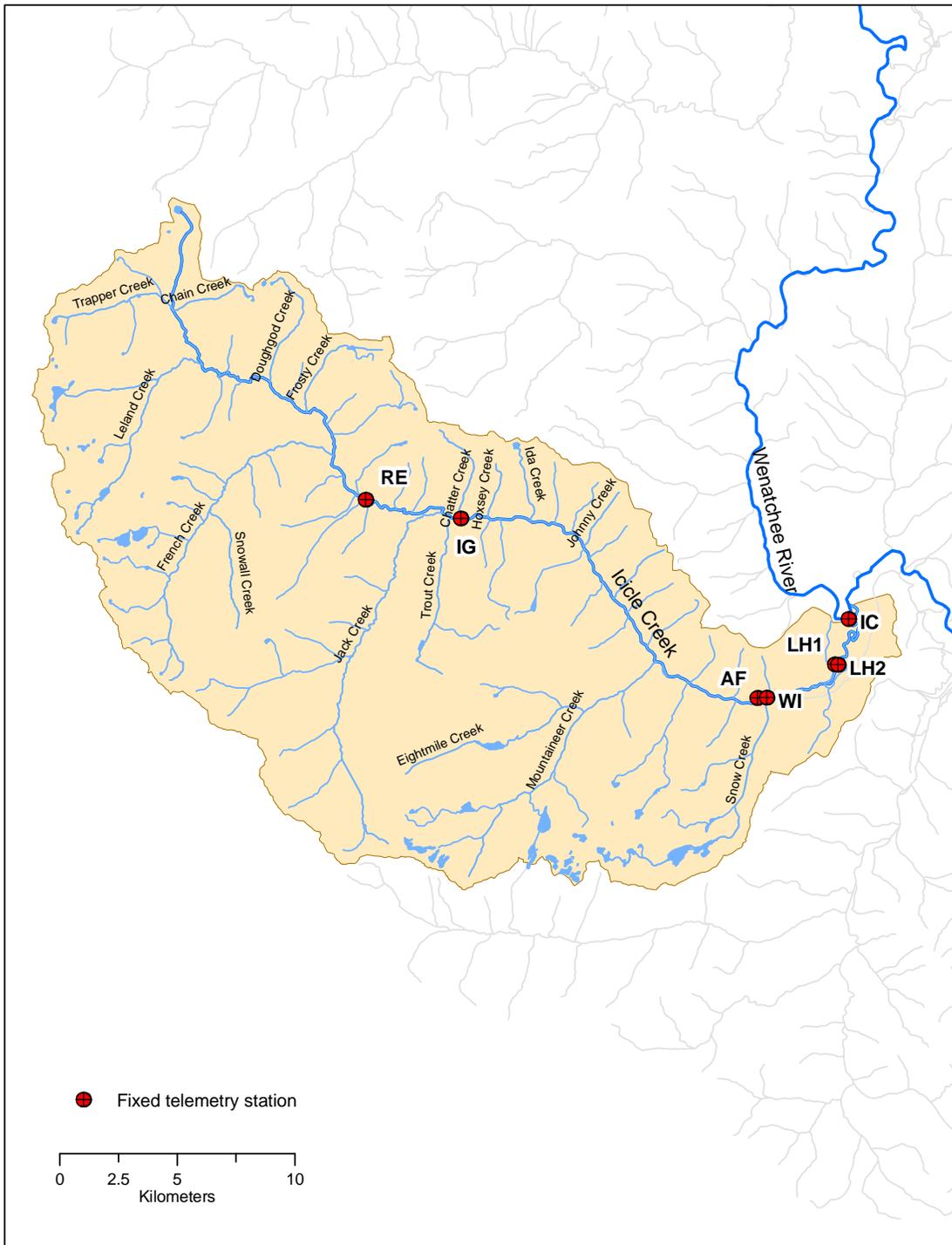


Figure 6. Locations of fixed telemetry ground stations in the Icicle Creek watershed.

Table 1. Fixed receiver telemetry stations, river kilometer (rkm) of location in Icicle Creek, and dates of operation, 2008

| Station ^a | rkm | Dates operated | Notes |
|----------------------|------|---------------------------------------|---|
| IC | 0.8 | 1/1 – 12/31 | At Two Rivers Farm |
| LH | 4.3 | 1/1 – 12/31 | At Leavenworth NFH: 2 antennas LH1 – spillway pool, LH2 – structure 5 |
| WI | 9.1 | 1/1 – 12/31 | Downstream of boulder falls at City of Leavenworth water intake treatment facility |
| AF | 9.3 | 1/1 – 12/31 | Upstream of boulder falls at City of Leavenworth intake building |
| IG | 26.2 | 8/8 – 8/12 ^b ; 8/22 – 11/5 | At Icicle Gorge; Chatter Cr. Campground |
| RE | 32 | 8/22 – 10/24 | At road's end of 7609 spur off FR 7600 |

Note: a – see text for description and Figure 6 for map location of stations. b – power failure interrupted operation between August 12 and August 22.

Water temperature

The water temperature data were collected with electronic data loggers (Onset Hobo®) for an ongoing USFWS Icicle Creek temperature monitoring program (Kelly Ringel 2007).

Results

Angling effort

Five species of fish (bull trout, rainbow trout, northern pikeminnow, westslope cutthroat trout, and Chinook salmon) were captured during a total angling effort of 64.3 hours in Icicle Creek (Table 2). Angling occurred on 15 dates, from March 21 to August 7, with the majority in July (Table 3). A total of 14 bull trout were caught and sizes ranged from 175 mm to 552 mm (Figure 7). Only 3 bull trout were larger than 450 mm and therefore radio-tagged. Genetic tissue samples were taken from all tagged bull trout, from 4 small bull trout captured downstream of the LNFH head gate, and from 1 small bull trout caught in the Icicle Gorge. The highest catch per unit effort was in the pool downstream of the head gate (0.95 bull trout/hour), followed by the Icicle Gorge (0.49), and the spillway pool (0.21) (Table 4). No bull trout were caught in the pools downstream of the boulder falls, although the highest angling effort was focused there (Table 4). Five adult spring Chinook salmon and 0 bull trout were captured in the trap at structure 5. No bull trout were caught in the adult fish ladder and holding ponds at Leavenworth NFH.

Capture locations, numbers of individuals, and estimated total lengths of all species of fish caught during angling are listed in Appendix 2.

Table 2. Angler effort (hours), number of each species of fish captured (n), and catch per unit effort (cpue) during angling for bull trout in Icicle Creek, 2008.

| angler effort (hours) | n BT | BT cpue | n RBT | RBT cpue | n NPM | NPM cpue | n WCT | WCT cpue | n SCS | SCS cpue |
|-----------------------|------|---------|-------|----------|-------|----------|-------|----------|-------|----------|
| 64.3 | 14 | 0.22 | 8 | 0.12 | 6 | 0.09 | 2 | 0.03 | 1 | 0.02 |

Note: BT = bull trout, RBT = rainbow trout, NPM = northern pike minnow, WCT = westslope cutthroat trout, SCS = juvenile spring Chinook salmon.

Table 3. Angler effort (hours), number of bull trout captured (n), and catch per unit effort (cpue) by date in Icicle Creek, 2008.

| Date | Angler effort (hours) | n BT | cpue BT |
|-----------|-----------------------|------|---------|
| 3/21/2008 | 2.3 | 0 | 0.00 |
| 4/7/2008 | 2.8 | 1 | 0.36 |
| 4/14/2008 | 4.2 | 0 | 0.00 |
| 4/28/2008 | 4.3 | 0 | 0.00 |
| 7/14/2008 | 5.2 | 1 | 0.19 |
| 7/21/2008 | 4.7 | 1 | 0.21 |
| 7/22/2008 | 5.0 | 0 | 0.00 |
| 7/25/2008 | 4.0 | 1 | 0.25 |
| 7/28/2008 | 3.8 | 2 | 0.52 |
| 7/29/2008 | 3.3 | 2 | 0.60 |
| 7/30/2008 | 5.2 | 1 | 0.19 |
| 7/31/2008 | 3.2 | 0 | 0.00 |
| 8/4/2008 | 3.5 | 1 | 0.29 |
| 8/5/2008 | 2.5 | 0 | 0.00 |
| 8/7/2008 | 10.3 | 4 | 0.39 |

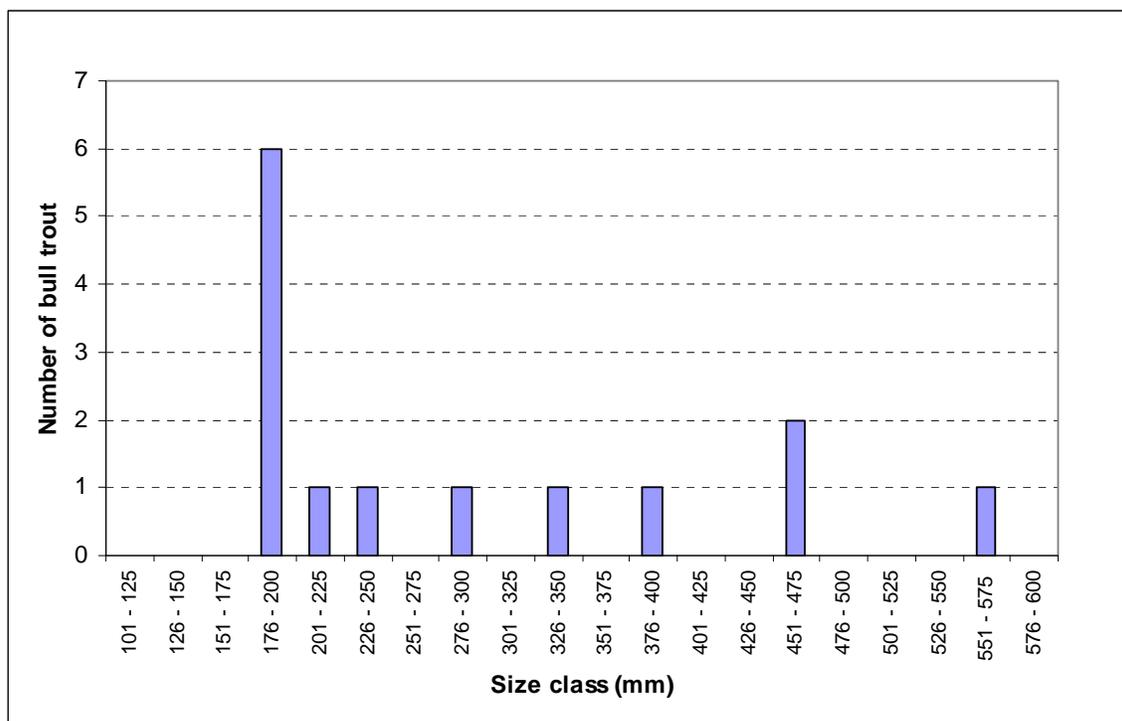


Figure 7. Sizes classes (25 mm increments) of all bull trout captured while angling in Icicle Creek during 2008.

Table 4. Bull trout catch per unit effort (cpue) at each angling location in Icicle Creek, 2008.

| Area name | rkm | Angler effort (hours) | n Bull Trout | cpue |
|--------------------------|------|-----------------------|--------------|------|
| Corner hole d/s LNFH | 4.0 | 1.0 | 0 | 0.00 |
| LNFH spillway pool | 4.3 | 14.1 | 3 | 0.21 |
| Headgate pool | 6.1 | 7.4 | 7 | 0.95 |
| CCC pool | 6.3 | 7.7 | 1 | 0.13 |
| Hatchery intake pool | 7.4 | 1.0 | 0 | 0.00 |
| Boulder Falls pools | 9.2 | 15.0 | 0 | 0.00 |
| IPID pools | 9.3 | 1.5 | 0 | 0.00 |
| Gage station pools | 9.5 | 3.2 | 0 | 0.00 |
| Bridge Creek Falls pools | 14.3 | 4.3 | 0 | 0.00 |
| Johnny Creek Camp | 20.8 | 1.7 | 0 | 0.00 |
| Icicle Gorge | 26.2 | 6.2 | 3 | 0.49 |
| Rock Island Camp | 29.1 | 1.3 | 0 | 0.00 |

Radio-tagging

A total of 3 fluvial bull trout were radio-tagged during 2008. Code 20 was captured and tagged at the LNFH spillway pool (rkm 4.3) on April 7, code 22 in the Icicle Gorge (rkm 26.2) on July 25, and code 23 in the LNFH spillway pool (rkm 4.3) on July 30 (Figure 8). Size of tagged bull trout ranged from 465 mm to 552 mm and 1000 g to 1650 g (Table 5).

Table 5. Tagging date, tagging location, weight (g), total length (mm), and condition factor (K) of bull trout radio-tagged in Icicle Creek, 2008.

| Code | Date | Location | Weight (g) | Length (mm) | K ^a |
|------|----------|---------------|------------|-------------|----------------|
| 20 | 04/07/08 | Spillway pool | 1200 | 465 | 1.194 |
| 22 | 07/25/08 | Icicle Gorge | 1000 | 475 | 0.933 |
| 23 | 07/30/08 | Spillway pool | 1650 | 552 | 0.981 |

Note: a- Condition factor $K = (W/L^3)*100,000$

Movements

Bull trout code 20- On April 7, 2008 bull trout code 20 was captured and tagged in Icicle Creek at the Leavenworth NFH spillway pool (rkm 4.3). The fish was recaptured the following week, and appeared healthy with no ill effects from the implantation surgery. Code 20 was present in and around the spillway pool from April 4 to December 29 (Figure 9) and exhibited several local movements during the period (Figure 9, Table 6). From April 4 to May 16, it was present in the spillway pool and detected on antenna LH1. On May 16, when high flows began with snow melt and spring runoff, it moved into the historic channel and was detected on antenna LH2 at structure 5 until May 18 (Table 6). During the day on May 20 it was tracked in the historic channel midway between the spillway pool and structure 5 (Figure 9). From May 21 to June 7, code 20 exhibited a regular pattern of daily movements of detection at the LH1 antenna (spillway pool) during daylight hours and detection at the LH2 antenna (structure 5) during the nighttime (Table 6). From June 7 to June 28, code 20 was detected only in the spillway pool. Then from June 28 to July 2 it was again detected at LH2 during the night and at LH1 during the day (Table 6). During both these movement periods, the only daytime movements detected at LH2 were made on the rapidly increasing hydrograph as discharge rose above 2500 ft³/sec (Figure 10). When structure 5 was opened as scheduled after July 7 to permit fish passage, code 20 stayed in or near the spillway pool until November 12 (Figure 9), when heavy rains resulted in high discharge and code 20 moved upstream past structure 5 (Figure 11). It was located in the historic channel at 13:55 hours during a mobile survey on November 12 (Figure 9). On November 13, it moved downstream past structure 5 and returned to the vicinity of the spillway pool, where it was detected until December 29 (Table 6). Code 20 then moved downstream and was located at rkm 1.6 in Icicle Creek on December 30 (Figure 9).

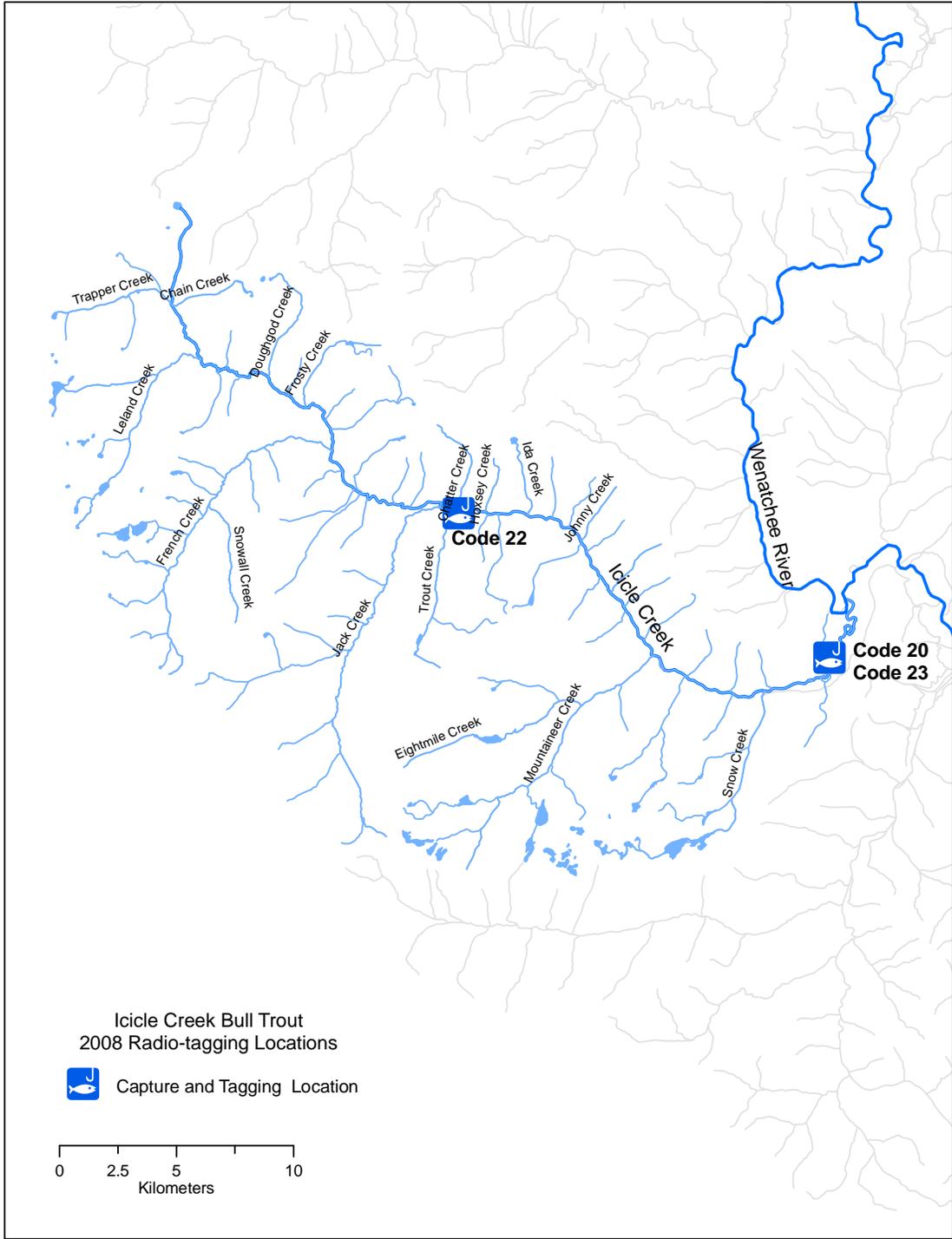


Figure 8. Locations where fluvial bull trout were radio-tagged in Icicle Creek during 2008.

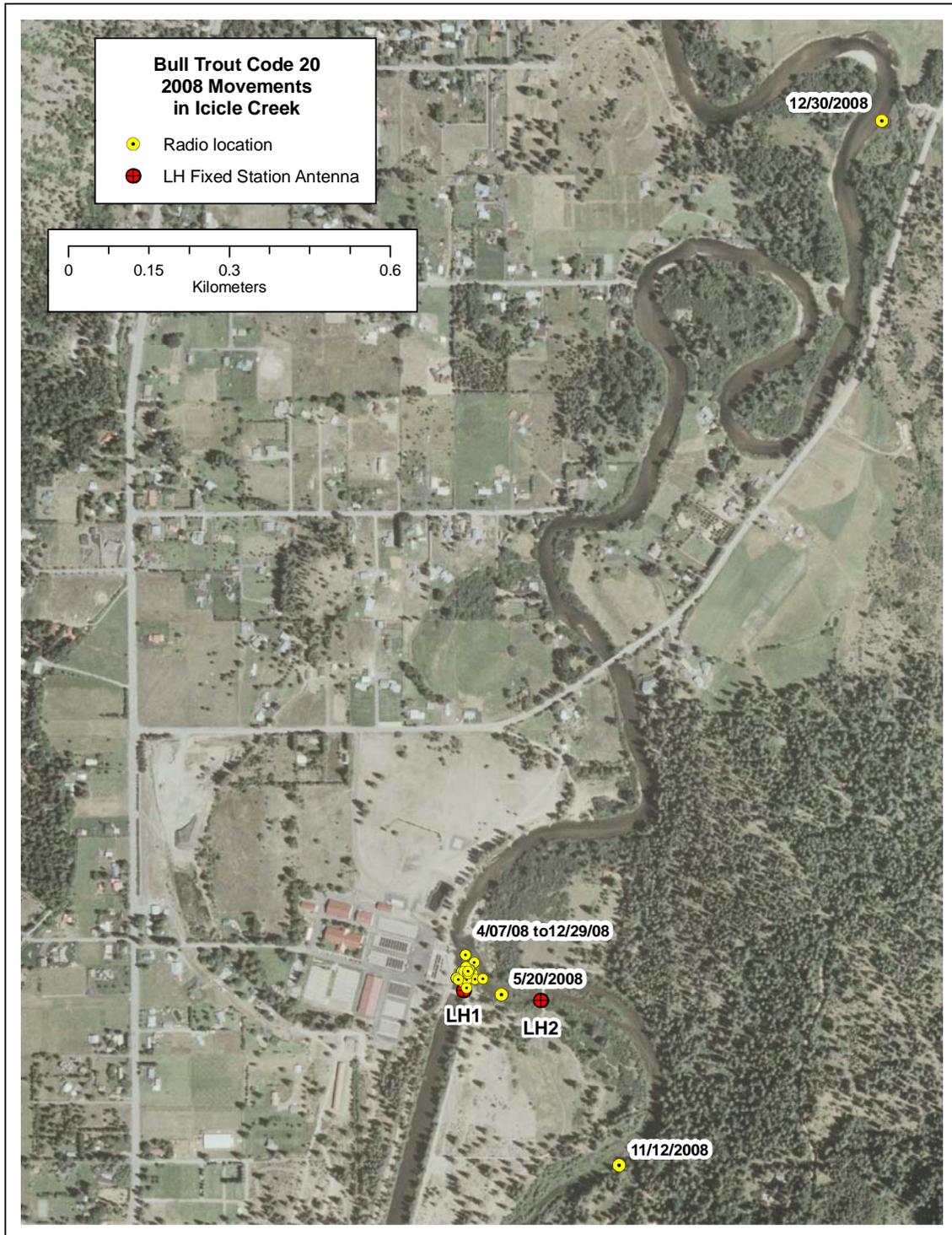


Figure 9. Radio-locations of bull trout code 20 in lower Icicle Creek, as detected during mobile surveys, April 4 to December 30, 2008.

Table 6. Date, time, and signal power of radio-telemetry detections of bull trout code 20 at antennas LH1 and LH2 in lower Icicle Creek, 2008.

| Antenna | First hit date/time | Last hit date/time | High power date/time | High power |
|---------|---------------------|--------------------|----------------------|------------|
| LH1 | 04/07/08 15:09 | 05/16/08 16:39 | | |
| LH2 | 05/16/08 16:55 | 05/18/08 10:49 | 05/16/08 19:57 | 199 |
| LH1 | 05/18/08 10:55 | 05/18/08 15:32 | 05/18/08 15:16 | 124 |
| LH2 | 05/18/08 15:45 | 05/21/08 08:14 | 05/18/08 16:29 | 196 |
| LH1 | 05/21/08 08:19 | 05/21/08 21:35 | 05/21/08 13:41 | 121 |
| LH2 | 05/21/08 22:01 | 05/22/08 05:07 | 05/22/08 02:25 | 170 |
| LH1 | 05/22/08 09:26 | 05/23/08 21:58 | 05/22/08 14:48 | 162 |
| LH2 | 05/23/08 23:01 | 05/24/08 04:59 | 05/24/08 04:59 | 131 |
| LH1 | 05/24/08 05:09 | 05/24/08 21:03 | 05/24/08 20:04 | 153 |
| LH2 | 05/24/08 21:35 | 05/25/08 05:00 | 05/24/08 22:15 | 182 |
| LH1 | 05/25/08 05:04 | 05/25/08 20:27 | 05/25/08 17:00 | 133 |
| LH2 | 05/25/08 20:37 | 05/26/08 05:07 | 05/25/08 21:43 | 196 |
| LH1 | 05/26/08 05:34 | 05/26/08 15:12 | 05/26/08 14:08 | 176 |
| LH1 | 05/26/08 20:25 | 05/26/08 20:40 | 05/26/08 20:40 | 78 |
| LH2 | 05/26/08 21:20 | 05/27/08 07:43 | 05/27/08 04:42 | 188 |
| LH1 | 05/27/08 08:49 | 05/27/08 17:09 | 05/27/08 15:54 | 153 |
| LH2 | 05/27/08 17:34 | 05/28/08 04:43 | 05/27/08 19:45 | 196 |
| LH1 | 05/28/08 07:00 | 05/28/08 13:08 | 05/28/08 12:45 | 141 |
| LH2 | 05/28/07 19:32 | 05/29/08 05:01 | 05/28/08 19:52 | 214 |
| LH1 | 05/29/08 12:09 | 05/29/08 21:03 | 05/29/08 19:25 | 139 |
| LH2 | 05/29/08 21:12 | 05/30/08 04:52 | 05/29/08 23:29 | 172 |
| LH1 | 05/30/08 11:39 | 05/30/08 21:46 | 05/30/08 19:24 | 136 |
| LH2 | 05/30/08 21:57 | 05/31/08 04:22 | 05/30/08 22:05 | 194 |
| LH1 | 05/31/08 04:27 | 05/31/08 21:13 | 05/31/08 17:39 | 133 |
| LH2 | 05/31/08 21:24 | 06/01/08 04:43 | 06/01/08 00:22 | 178 |
| LH1 | 06/01/08 04:50 | 06/01/08 21:02 | 06/01/08 13:56 | 162 |
| LH2 | 06/01/08 21:19 | 06/02/08 04:39 | 06/01/08 21:59 | 190 |
| LH1 | 06/02/08 04:52 | 06/02/08 20:52 | 06/02/08 11:23 | 148 |
| LH2 | 06/02/08 21:14 | 06/03/08 04:31 | 06/02/08 23:46 | 178 |
| LH1 | 06/03/08 13:11 | 06/03/08 21:46 | 06/03/08 21:42 | 118 |
| LH2 | 06/03/08 21:59 | 06/04/08 04:47 | 06/04/08 00:03 | 177 |
| LH1 | 06/04/08 04:51 | 06/04/08 21:58 | 06/04/08 16:04 | 115 |
| LH2 | 06/04/08 21:32 | 06/05/08 04:48 | 06/05/08 03:48 | 173 |
| LH1 | 06/05/08 05:04 | 06/05/08 21:23 | 06/05/08 20:53 | 125 |
| LH2 | 06/05/08 21:41 | 06/06/08 04:34 | 06/05/08 22:13 | 182 |
| LH1 | 06/06/08 05:08 | 06/06/08 21:31 | 06/06/08 15:06 | 116 |
| LH2 | 06/06/08 21:49 | 06/07/08 04:38 | 06/06/08 23:51 | 163 |
| LH1 | 06/07/08 05:03 | 06/28/08 23:06 | 06/12/08 11:12 | 173 |
| LH2 | 06/28/08 23:16 | 06/29/08 05:17 | 06/29/08 01:01 | 178 |
| LH1 | 06/29/08 05:28 | 07/01/08 04:13 | 06/29/08 09:08 | 135 |
| LH2 | 07/01/08 04:39 | 07/01/08 05:29 | 07/01/08 04:56 | 167 |
| LH1 | 07/01/08 08:42 | 07/02/08 04:25 | 07/01/08 09:44 | 80 |
| LH2 | 07/02/08 04:38 | 07/02/08 05:11 | 07/02/08 05:03 | 152 |
| LH1 | 07/02/08 05:20 | 11/12/08 08:10 | 09/02/08 00:16 | 167 |
| LH2 | 11/12/08 08:57 | 11/12/08 09:36 | 11/12/08 08:57 | 146 |
| LH2 | 11/13/08 03:39 | 11/13/08 03:41 | 11/13/08 03:39 | 141 |
| LH1 | 11/13/08 03:49 | 12/29/08 19:40 | 12/29/08 03:21 | 148 |

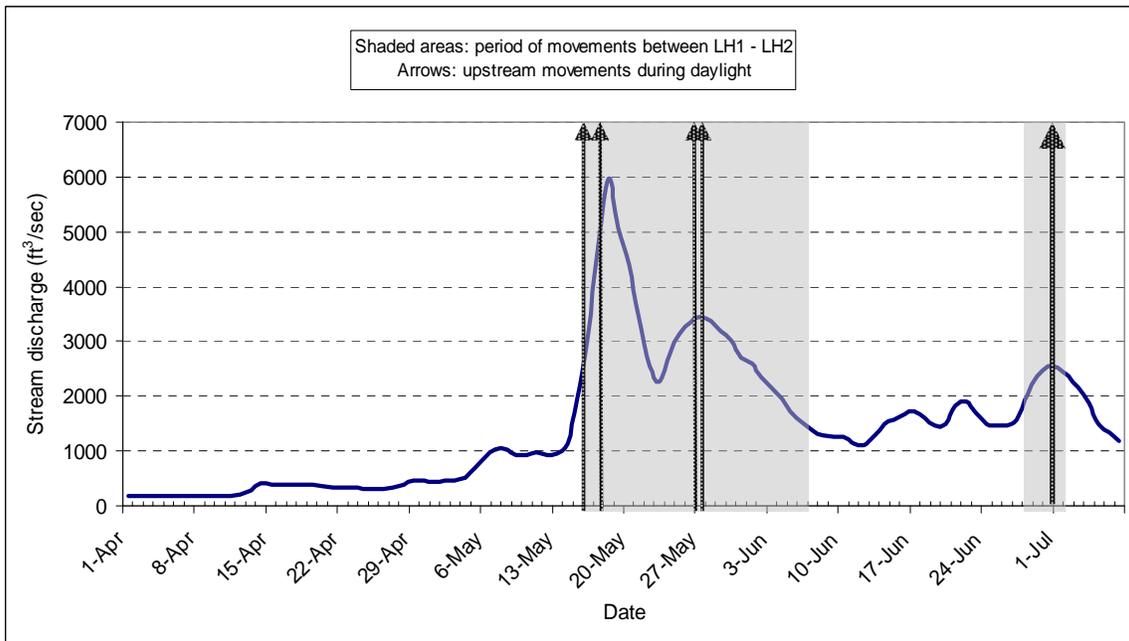


Figure 10. Icicle Creek discharge and periods (shaded areas) that bull trout code 20 was detected moving between antennas LH1 and LH2 in lower Icicle Creek, May 16 to June 7 and June 28 to July 2, 2008.

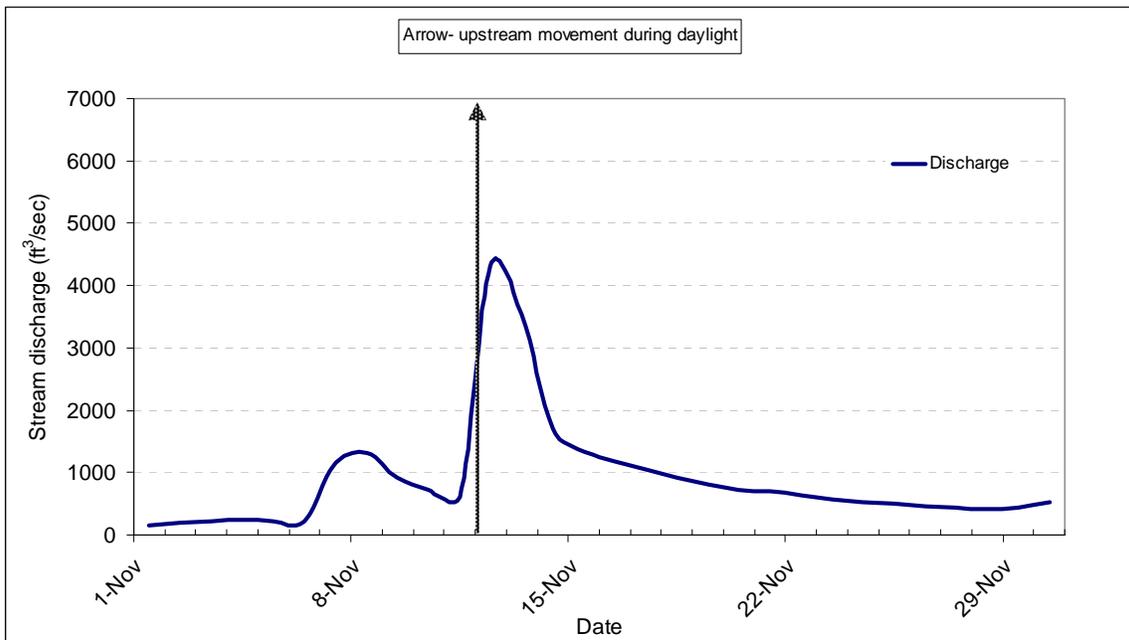


Figure 11. Icicle Creek discharge and bull trout code 20 movement past LNFH structure 5, November 2008.

Bull trout code 22- On July 25, 2008 bull trout code 22 was captured and radio-tagged in the Icicle Gorge (rkm 26.2) near Chatter Creek Campground. Code 22 remained downstream of the chute and flume falls in the gorge until it jumped the falls sometime between August 12 and 22. It was present just upstream of the falls and detected on the IG station at the gorge until August 28, when it moved quickly upstream and passed the RE station (rkm 32) on August 29 (Table 7). During foot tracking surveys code 22 was located in Icicle Creek downstream of French Creek on September 3 (Figures 12 and 13). On September 8, it was located in lower French Creek (under a boulder, see cover photo). It was in the same general area on September 11 and September 17 (Figure 14). On September 22, code 22 was observed in lower French Creek, digging a redd and paired with a resident-sized male (estimated total length = 200 mm). No migratory sized male bull trout were observed. After spawning, code 22 moved downstream, passed the RE station on September 29 and was detected back in the Icicle Gorge on the IG station on September 30 (Table 7). It was detected in or near the Icicle Gorge until November 3, when it started to slowly move downstream. On December 1, the motionless signal was detected, and the tags were recovered in the tail out of a pool at rkm 19.3 where the last active signal was tracked on November 26 (Figure 14). Circumstantial evidence (no carcass, PIT tag and radio tag next to each other on stream bottom, mid stream in the eddy of a boulder, closed fishing season) suggested the tags were shed from the live bull trout.

Table 7. Date and time of radio detections of bull trout code 22 moving past telemetry stations in Icicle Creek, 2008.

| Code | Station | Movement | First Hit Date and Time | Last Hit Date and Time |
|------|---------|----------------------|-----------------------------|------------------------|
| 22 | IG | holding ^a | 08/08/08 12:04 ^b | 08/28/08 06:06 |
| 22 | RE | upstream | 08/29/08 22:21 | 08/29/08 23:48 |
| 22 | RE | downstream | 09/29/08 03:10 | 09/29/08 03:55 |
| 22 | IG | holding ^c | 09/30/08 00:40 | 11/03/08 13:29 |

Notes: a- holding until moved upstream; b- date that IG station was first operational (code 22 present since tagged on July 25); c- holding until moved downstream.

Code 22 passed at least 3 waterfall obstacles during its upstream migration. For most obstacles a range of discharges, but not the exact discharge, is known. It jumped the falls in Icicle Gorge when discharge ranged between 210 and 286 ft³/sec, passed Rock Island Falls between 212 and 223 ft³/sec, and negotiated the complex falls downstream of French Creek between 114 and 165 ft³/sec (Figure 15). Note that the only available stream gage station is downstream at rkm 9.4, so actual discharge at these upstream obstacles is lower by an unknown factor.

Bull trout code 22 traveled 9 km upstream from the tagging location to its spawning location in French Creek. Based on departure and arrival times at the IG and RE stations, it traveled 3.5 km/day between the stations during the upstream migration and 6.7 km during the downstream movement between stations. Overall, code 22 moved downstream a total of 15.9 km between spawning and tag recovery, and moved with an average speed of 0.3 km/day.



Figure 12. Photograph of pool and complex falls in Icicle Creek downstream of French Creek at rkm 34.3, October 1, 2008 (view is looking upstream).



Figure 13. Photograph of the upper portion of the complex falls at rkm 34.3, with 2 snorkelers (center and left of center) shown standing at top of falls for scale, on September 8, 2008.

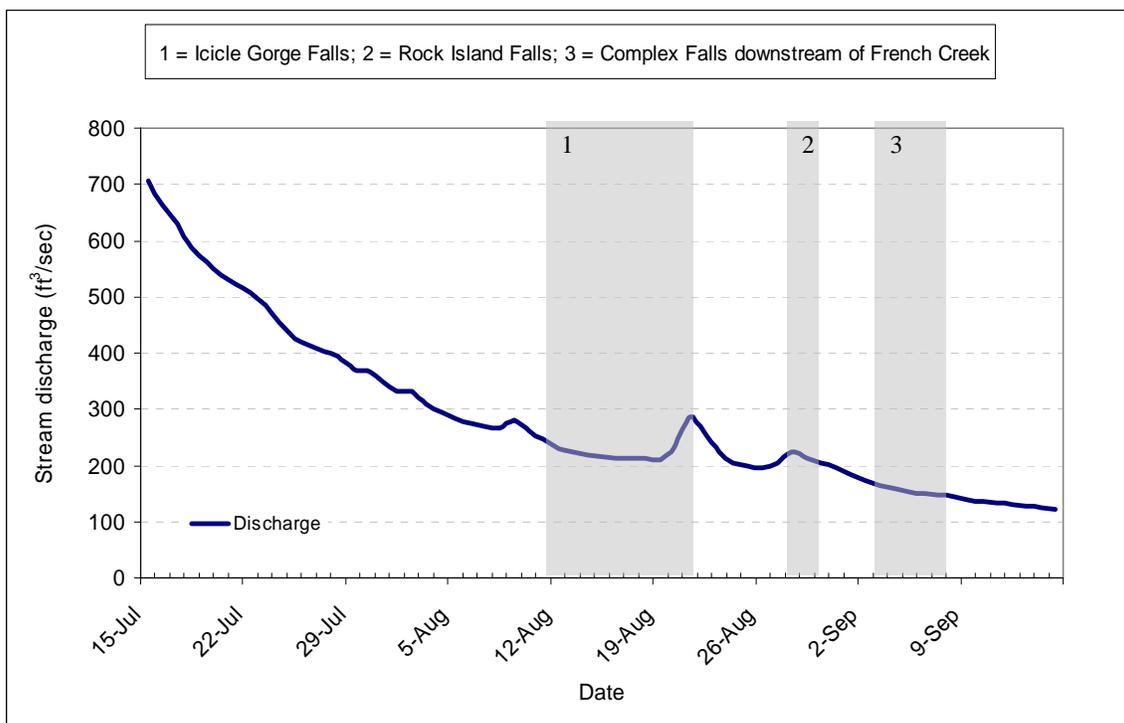


Figure 15. Icicle Creek discharge and passage periods (shaded areas) of bull trout code 22 at the falls at Icicle Gorge, Rock Island, and downstream of French Creek, 2008.

Bull trout code 23- On July 30, 2008 code 23 was tagged in Icicle Creek at the spillway pool. It appeared healthy when observed with 3 other fluvial bull trout during a snorkel survey on August 6. Code 23 did not move upstream from the spillway pool and was never detected on the LH2 antenna at structure 5. Code 23 remained in or near the spillway pool until it moved downstream at 20:46 hours on August 15 (Table 8). It passed the IC station at 22:22 hours on August 15 and moved into the Wenatchee River. On August 19, the motionless signal was detected downstream of the Highway 2 bridge, and on August 25, the carcass and tag were recovered (Figure 16). A dead Chinook salmon and a dead rainbow trout were found in the immediate vicinity.

Bull trout code 23 rapidly moved downstream after leaving the spillway pool. Based on the departure time at LH station and the arrival at the IC station, code 23 traveled 53.1 km/day as it moved out of Icicle Creek on August 15.

Table 8. Date and time of radio detections of bull trout code 23 at telemetry stations in lower Icicle Creek, 2008.

| Code | Station | Movement | First Hit Date and Time | Last Hit Date and Time |
|------|---------|------------|-------------------------|------------------------|
| 23 | LH1 | holding | 07/30/08 09:38 | 08/15/08 20:46 |
| 23 | IC | downstream | 08/15/08 22:21 | 08/15/08 22:22 |

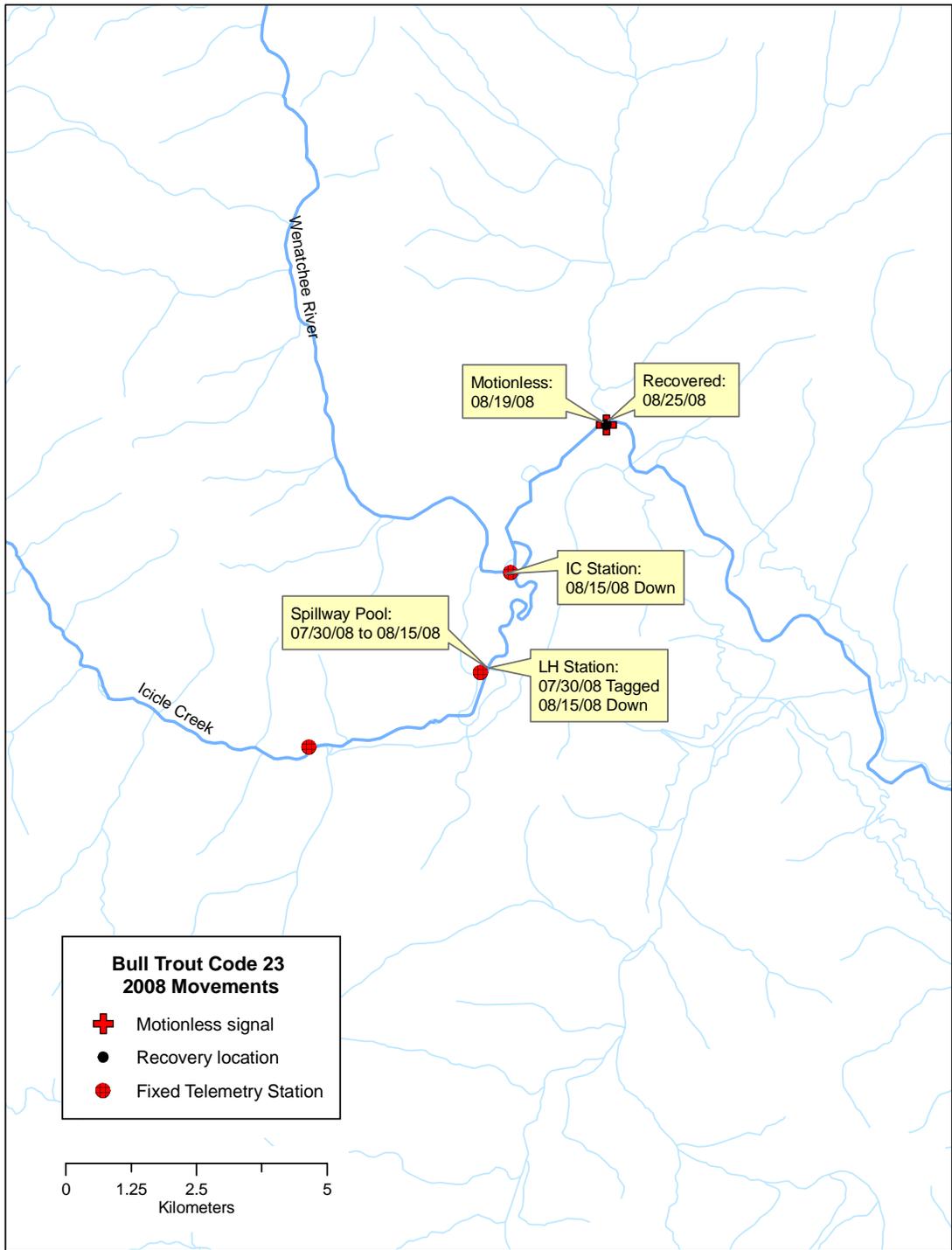


Figure 16. Map of the movements of bull trout code 23 in lower Icicle Creek and Wenatchee River, July 30 to August 25, 2008.

Stream temperatures

Water temperatures were monitored at the mouth of Icicle Creek, the spillway pool, and upstream of Jack Creek (rkm 27.6) during the times tagged bull trout were in those areas. Maximum stream temperatures at all locations were recorded in the period from August 13 to August 18, when a heat wave resulted in air temperatures as high as 43°C (Figure 17). On August 15, when bull trout code 23 passed the IC station and exited Icicle Creek, the maximum daily water temperature at the mouth was 19.3°C (Figure 18). In contrast, when code 23 left the spillway pool earlier that day, maximum water temperature there was only 16.4°C (Figure 19). Water temperatures while code 23 was in the Wenatchee River are unknown, but the heat wave and the presence of other dead fish at the recovery site suggests temperatures were relatively high.

During the heat wave, bull trout code 20 stayed in the spillway pool, where maximum daily water temperatures in both the pool and the hatchery outfall ranged from 15.7 to 17.0°C (Figure 19). Maximum daily water temperatures at structure 5 ranged from 17.2 to 19.2°C (Figure 19), indicating the spillway pool acted as a thermal refuge for bull trout during this period. This refuge was possible due to the cool water entering the pool at the hatchery outfall from the hatchery supplemental water supplies (Figure 19).

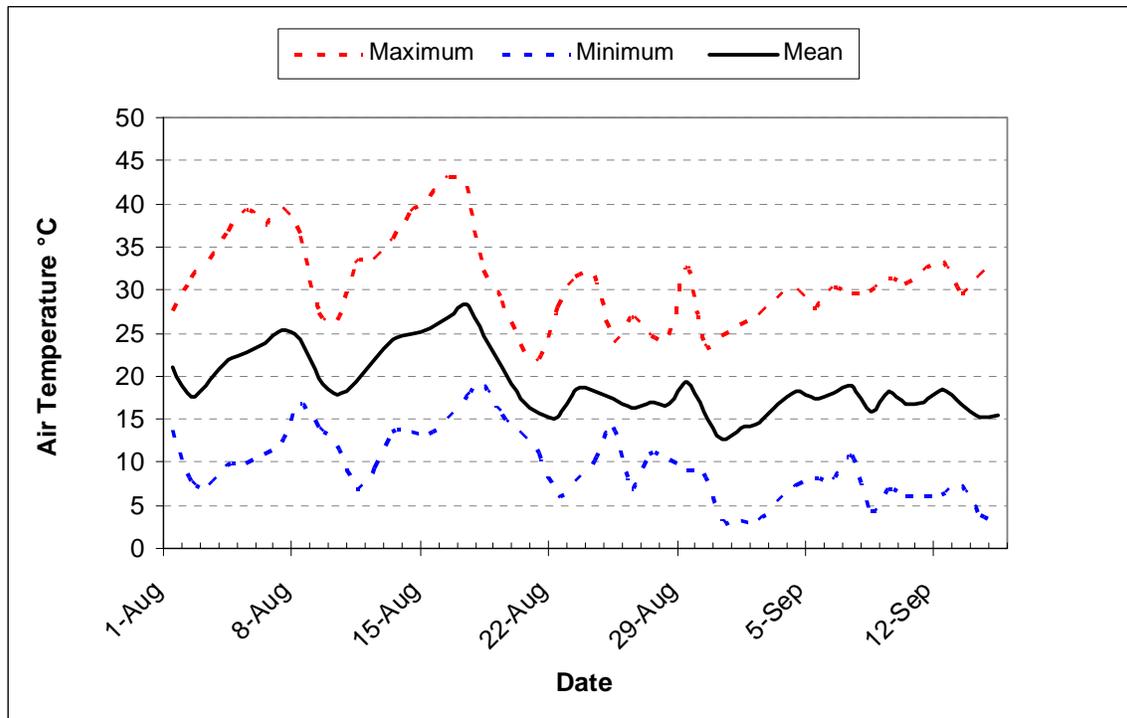


Figure 17. Maximum, minimum, and mean daily air temperatures at Leavenworth NFH, August 1 to September 15, 2008.

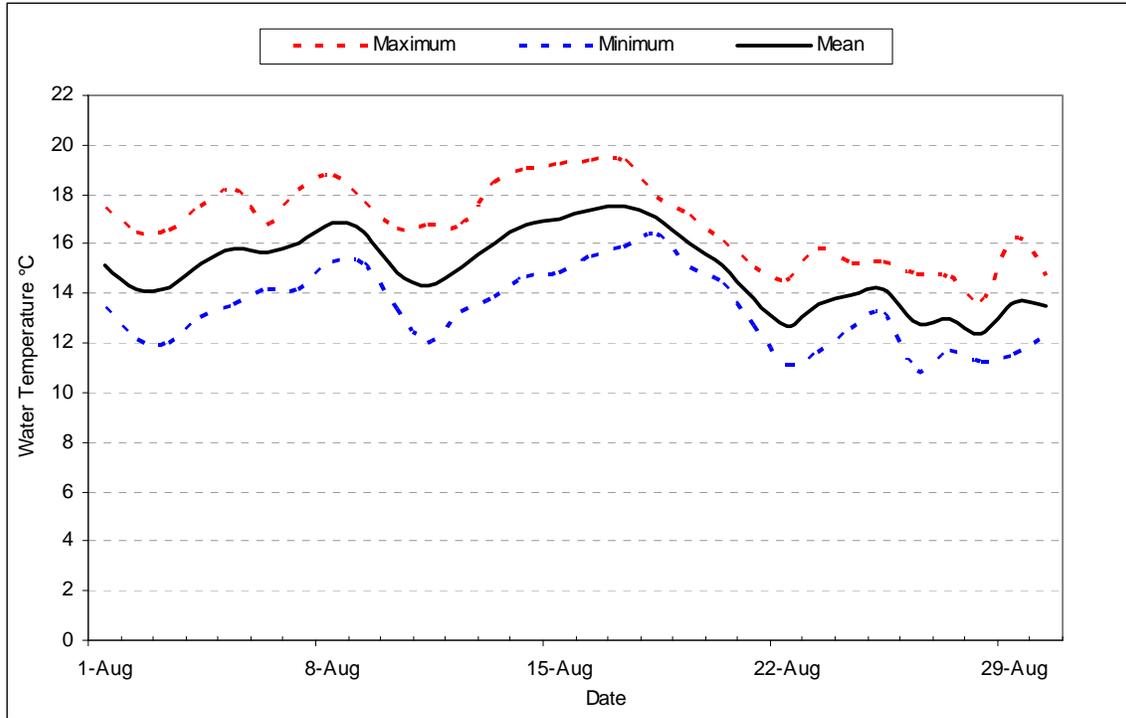


Figure 18. Maximum, minimum, and mean daily water temperature of Icicle Creek at the confluence of the Wenatchee River, August 1 to August 31, 2008.

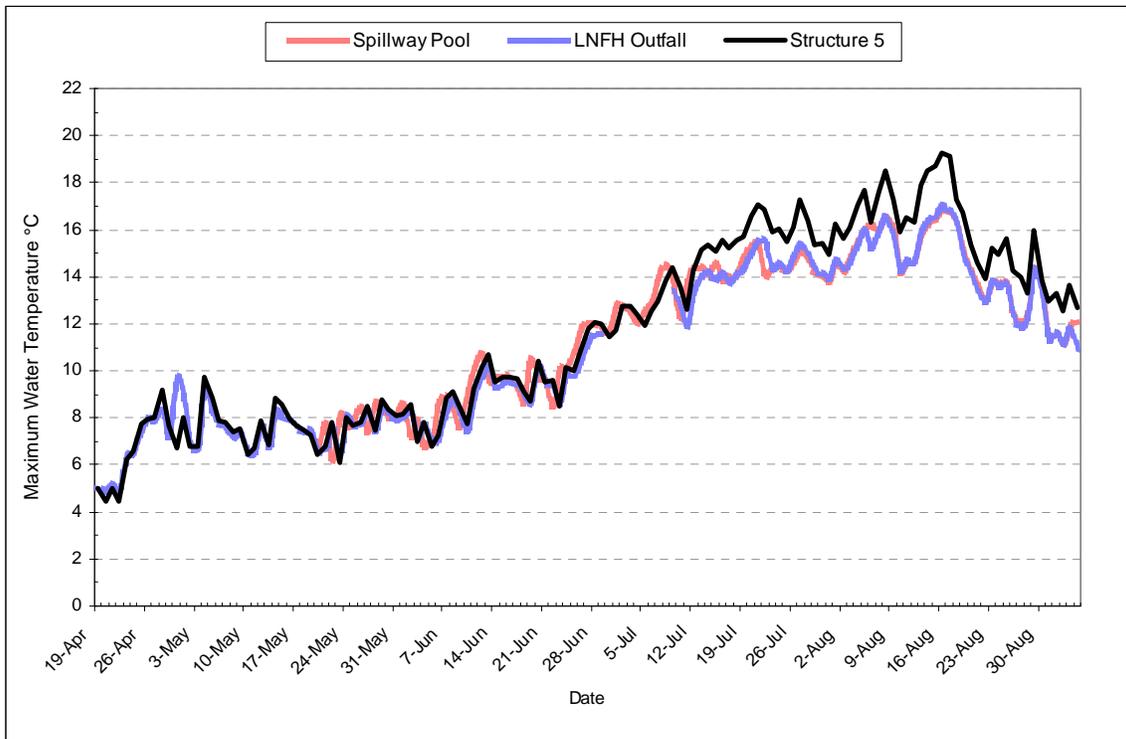


Figure 19. Maximum daily water temperature of Icicle Creek at the spillway pool, hatchery outfall, and structure 5, April 19 to September 4, 2008.

Stream temperatures in upper Icicle Creek (upstream of Jack Creek at rkm 27.6) were also highest during the heat wave, and maximum daily water temperatures ranged from 15.1 to 16.5°C (Figure 20). During this period, bull trout code 22 was present in the Icicle Gorge, 1.5 km downstream of Jack Creek. Upper Icicle Creek daily maximum water temperatures were only about 0.5°C lower than the daily maximums in the spillway pool, again illustrating the cold water influence of the hatchery's supplemental water supplies in late summer. After the heat wave, maximum daily water temperatures generally dropped to below 13°C in upper Icicle Creek (Figure 20).

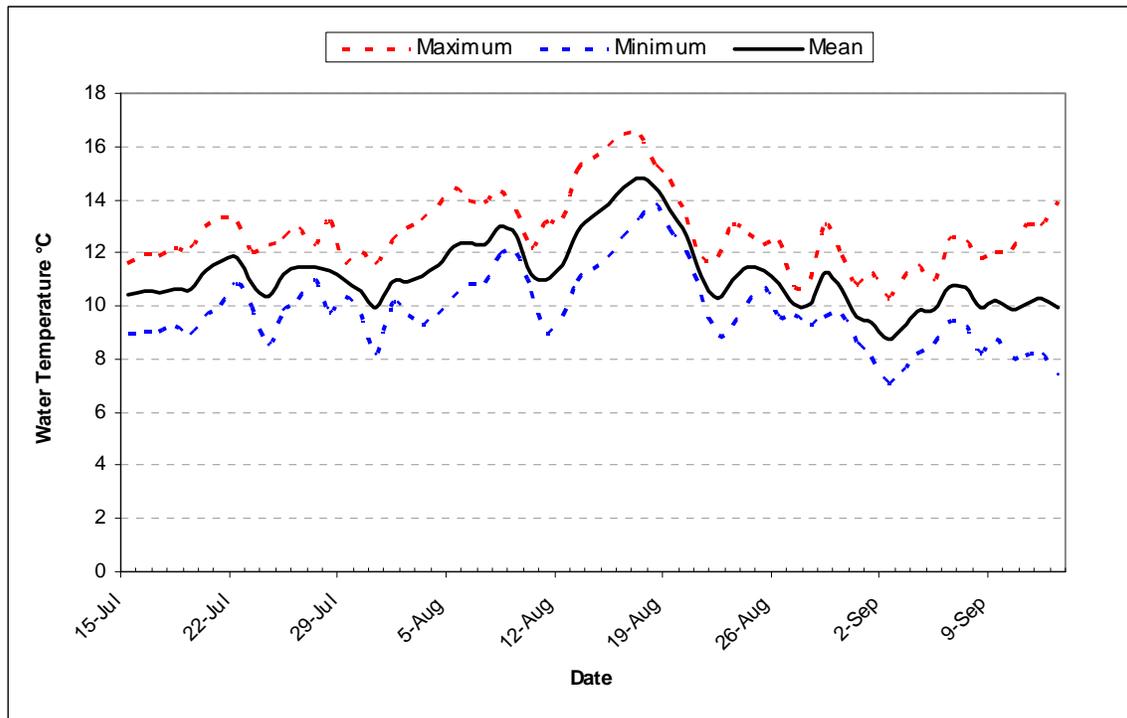


Figure 20. Maximum, minimum, and mean daily water temperature of Icicle Creek upstream of Jack Creek, July 15 to September 13, 2008.

Spawning ground surveys

Bull trout spawning surveys were conducted in 3 areas in the Icicle Creek watershed. French Creek was surveyed twice while Icicle Creek and Jack Creek were surveyed once during the spawning season.

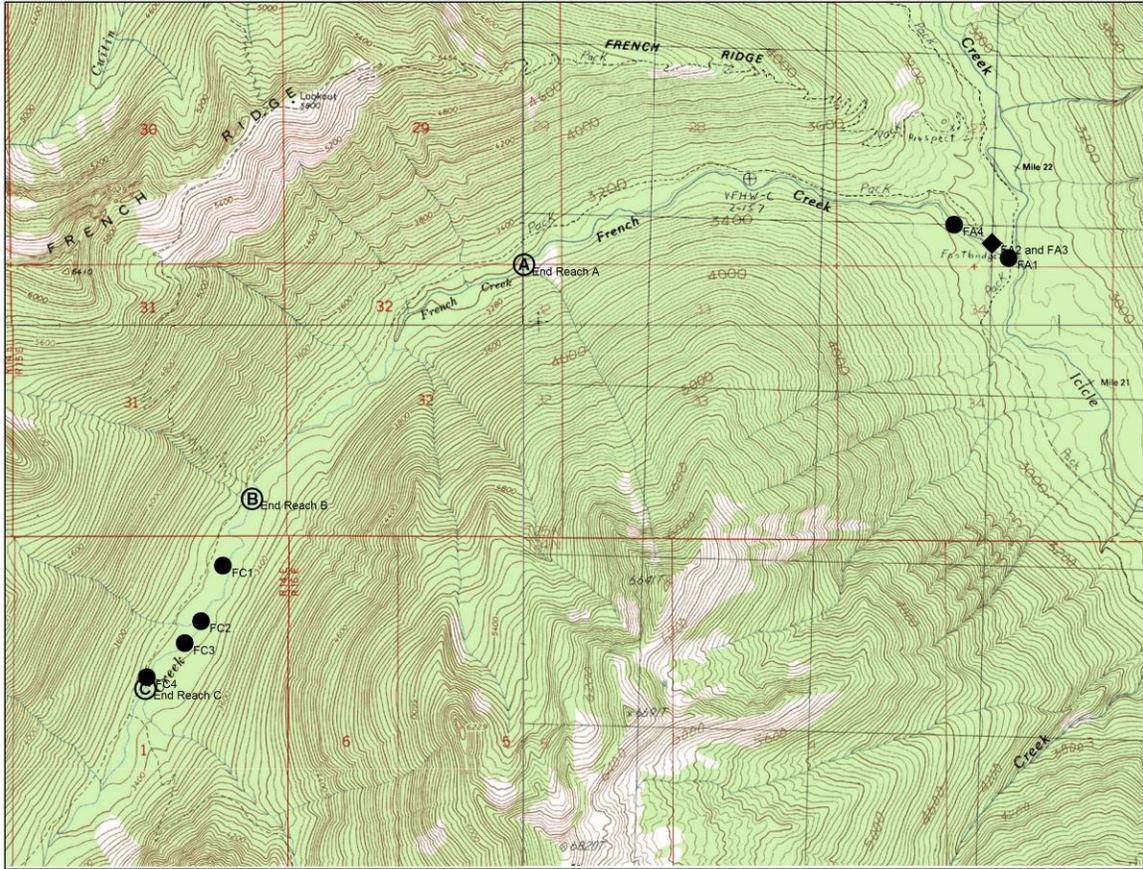
Icicle Creek (rkm 29.1 – 34.7)- On October 1, Icicle Creek upstream of Rock Island Campground to French Creek was surveyed by 2 experienced surveyors. No redds were observed.

Jack Creek (rkm 0.0 – 3.2)- On October 2, lower Jack Creek was surveyed by 2 experienced surveyors. No redds were observed.

French Creek (rkm 0.0 – 7.2)- On September 30, reaches A, B, and C in the lower 7.2 km of French Creek were surveyed, with a single experienced surveyor in each reach. Water temperature was 5°C at the start and 6°C at end of the survey. A total of 8 bull trout redds were counted and measured (Table 9). Five redds were categorized as definite redds and 3 as probable. Four redds were found in reach A and 4 redds were located in reach C (Figure 21). The redd of bull trout code 22 and the resident-sized male in reach A was in an unusual location in the back eddy of pool, along a cliff wall in deeper water, and probably would not have been detected as a redd if digging had not been observed during the foot tracking survey on September 22.

During the follow up survey on October 23, water temperatures were 1.5 to 2.5°C, and no new bull trout redds were detected. All 8 previously detected redds were faded and flattened, and only 2 were visible enough to be readily identified as redds.

Dimensions of redds were variable and size ranged from 0.36 m² to 4.8 m² (Table 9). The size of redds constructed in reach C (mean 3.10 m²) was larger than those in reach A (mean 0.93 m²) and the difference was significant (2 tailed t-test, p = 0.029).



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Figure 21. Locations of fluvial bull trout redds in French Creek found during surveys in 2008. Solid circles indicate location of single redd, solid diamond indicates location of 2 redds, and circled letter indicates end of survey reaches.

Table 9. Length (m), width (m), water depth (m) at pit and at top of pit, redd area (m²), and category of bull trout redds in French Creek, 2008.

| Redd | Length (m) | Width (m) | Depth of pit (m) | Depth at top of pit (m) | Redd area (m ²) | Category |
|------------------|------------|-----------|------------------|-------------------------|-----------------------------|----------|
| FA1 | 1.1 | 0.5 | 0.25 | 0.125 | 0.55 | Definite |
| FA2 | 1.7 | 0.8 | 0.2 | 0.1 | 1.36 | Definite |
| FA3 | 0.9 | 0.4 | 0.18 | 0.1 | 0.36 | Definite |
| FA4 ^a | 1.8 | 0.8 | 0.45 | 0.3 | 1.44 | Definite |
| FC1 | 1.5 | 1 | 0.35 | 0.31 | 1.5 | Definite |
| FC2 | 3 | 1.2 | 0.275 | 0.2 | 3.6 | Probable |
| FC3 | 4 | 1.2 | 0.275 | 0.25 | 4.8 | Probable |
| FC4 | 2.5 | 1 | 0.3 | -- | 2.5 | Probable |

Note: a- radio-tagged bull trout code 22 observed digging on redd on September 22.

Discussion

Bull trout have complex life histories with differing spawning and rearing strategies (McPhail and Baxter 1996) and migration patterns can vary in both distance and timing (Fraley and Shepard 1989, Swanberg 1997, Nelson et al. 2007, Al-Chokhachy and Budy 2008, Homel and Budy 2008, Monnot et al. 2008, Nelson and Nelle 2008). Telemetry is a useful tool to examine these patterns, particularly in relation to environmental variables, but the technique has several inherent limitations (Cooke et al. 2008). Relatively large numbers of fish should be tagged, and observations of individuals over several seasons are required to elucidate the patterns exhibited in a local population (Nelson et al. 2007, Nelson and Nelle 2008). To date, it has been difficult to capture and tag bull trout in Icicle Creek, but the few tagged fish have revealed some interesting patterns. However, given the limited data, it must be emphasized that preliminary discussion is somewhat speculative and subject to change in the final report to be issued at the end of the study.

Of the 3 tagged bull trout, only code 22 exhibited reproductive behavior and is therefore considered to belong to the Icicle Creek local population. Baseline genetic profiles are being developed for the local populations in the Upper Columbia Recovery Unit (J. Delavergne, pers. comm.), and genotypic comparisons to those profiles eventually may provide additional insights into bull trout movement patterns and population structure in Icicle Creek.

Although code 22 was tracked for only 129 days and only in the upper watershed, several important movement patterns were documented. It is now conclusively known that the waterfalls at Icicle Gorge (rkm 26.2), Rock Island (rkm 29.1), and downstream of French Creek (rkm 34.3) are not barriers to bull trout migration. It is also now known that French Creek is an important fluvial bull trout spawning area.

The observations of code 22 in 2008 also provided some insights into recent observations of bull trout in upper Icicle Creek. Based on the movement patterns of code 22, it appears that other large bull trout observed in 2007 and 2008 in the Icicle Gorge were also able to migrate to potential spawning locations. As documented by Wild Fish Conservancy (2007a and 2007b), on August 16, 2007 two bull trout (est. 485 mm and 610 mm) and on September 13, 2007 four bull trout (est. 610 mm to 710 mm) were observed jumping at the Icicle Gorge Falls. Discharge of Icicle Creek (as measured at the USGS gage station at rkm 9.4) during this period ranged from 111 to 164 ft³/sec in 2007 (Figure 22). These discharges are within the observed range that allowed passage in 2008, so it is probable that all 6 bull trout passed the falls in 2007. It is known that large bull trout are more likely to negotiate an obstacle than smaller individuals (Nelson and Nelle 2008), further supporting the likelihood that the large bull trout in 2007 successfully passed. Based on code 22's migration speed in relation to the observation dates, it is likely all the 2007 bull trout reached at least lower French Creek in time for the spawning period, as confirmed for a least one large fluvial bull trout in 2007 (WFC 2007a). In late August 2008, two large bull trout were observed jumping in Icicle Gorge (A. Thompson, pers. comm.) just after code 22 had passed, so it is also likely these bull trout passed and migrated further upstream in time for spawning.

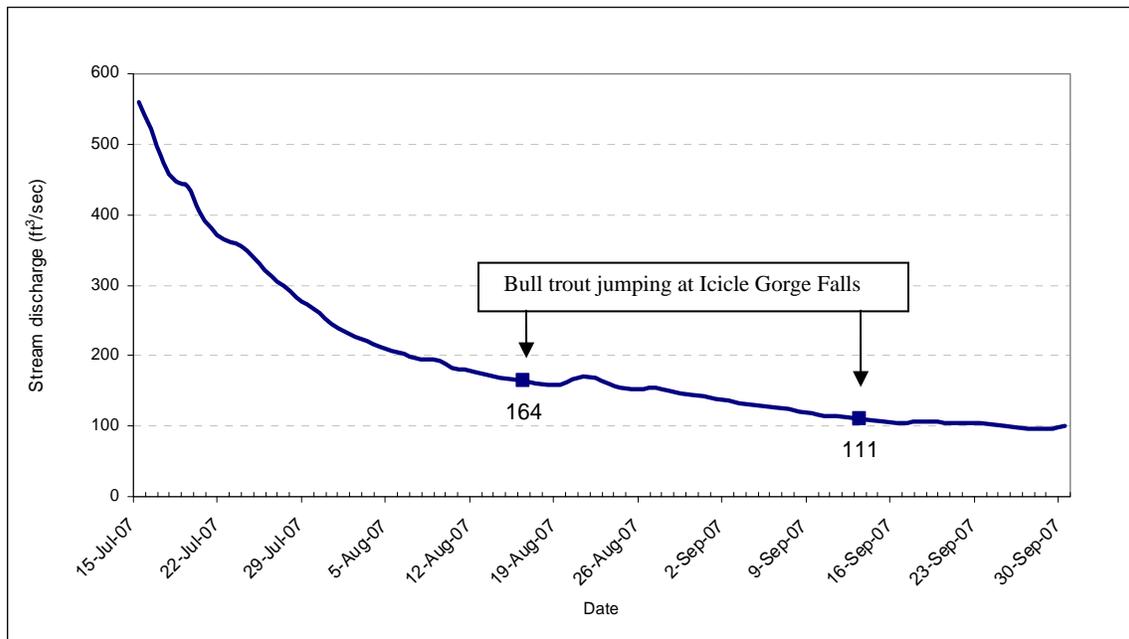


Figure 22. Icicle Creek discharge and dates fluvial bull trout were observed jumping at the Icicle Gorge Falls during 2007.

No large males were observed in the vicinity of code 22 while she was excavating her redd in lower French Creek. The resident-sized male observed with code 22 was located in the normal courtship position near her caudal region, indicating the pairing was intentional and not typical of sneaker behavior (James and Sexauer 1997). Small male bull trout adopting sneaking behavior in an attempt to join larger spawning pairs have been reported in Indian Creek and the Mad River of Washington (James and Sexauer 1997, Nelson and Nelle 2008) but records of intentional coupling are unknown. A study conducted by Homel et al. (2008) in the South Fork Walla Walla River of Oregon found no genetic differences between known resident and migratory bull trout, and “interbreeding” of the behavioral forms was thought due to either male sneaker tactics or the unintentional result of overlapping spawning site selection. Although the complete spawning act of code 22 was not observed, it appears migratory females will accept resident-sized males as partners when large males are absent. Redd sizes in French Creek were within the range recorded in other fluvial bull trout populations (James and Sexauer 1997, Nelson and Nelle 2007), indicating all were constructed by migratory females. As is common in most bull trout spawning ground surveys, no resident-sized redds were observed, due to their small size and cryptic locations.

Circumstantial evidence indicates code 22 shed her radio transmitter and PIT tag after spawning. Code 22 was tagged in late July, and it is possible tag expulsion may be related to warmer water temperature at or after tagging (Knights and Lasee 1996, Bunnell and Isely 1999). For example, during other telemetry studies conducted by MCRFRO, all bull trout tagged in spring at colder water temperatures retained their tags and survived, while bull trout tagged in summer at warmer temperatures had variable rates of apparent

expulsion and survival (e.g. Nelson et al. 2007). Tagging closer to the spawning season may also increase expulsion, particularly for a female digging her redd which could tear open the incision or enlarge the antenna fistula, the most common pathways of tag expulsion in salmonines (Bunnell and Isely 1999).

The movements of bull trout code 20 between the spillway pool and structure 5 may have been related to migratory behavior or they could have been local in nature. It cannot be conclusively determined with telemetry data from only one bull trout (that has not yet been genotyped or confirmed to be from the local population) but several factors suggest the movements were related to stream conditions and foraging opportunities rather than spawning migration. Code 20 was tagged in the pool before the spring migration period, and the initial upstream movements detected at structure 5 began during rapidly increasing discharge, rather than several days after peak flow as is usual during spring migrations of adult fluvial bull trout (Nelson 2008, Nelson and Nelle 2008). During peak discharge, the amount of water flowing down the canal into the spillway pool is 5 to 10 times the amount flowing in the historic channel (T. Collier, pers. comm.) and the initial movements seem most likely related to refuge from high flows, detritus, and turbulent conditions in the spillway pool. The first movements detected on LH2 at structure 5 occurred when the dam was flooded and the bull trout could have swam past, but no movements were detected upstream of the structure. The only daylight detections on LH2 at structure 5 occurred when flows increased to 2500 ft³/sec and above (Figure 10). As flows declined, code 20 exhibited a regular pattern of night time detections on LH2 and daylight detections at LH1 in the spillway pool. Bull trout usually attempt to pass obstacles in daylight during upstream migrations (Brown 1994, Nelson and Nelle 2008) but code 20 consistently went back to the pool before sunrise during this period. This pattern may reflect increased foraging movements into the calmer water and cover habitat of the historic channel, particularly since most of the released hatchery salmon smolts that had been present in the spillway pool exited Icicle Creek with the high flows (T. Collier, pers. comm.). Adult salmon were observed upstream at the headgate during late June (A. Jensen, pers. comm.) indicating structure 5 is passable during brood stock collection. When structure 5 was opened after July 7 code 20 did not attempt to move upstream during the latter half of the potential migration period. In contrast, most migrating adult bull trout in the Entiat River tenaciously attempt to migrate past obstacles and barriers until successful or until the end of the spawning season (Nelson and Nelle 2008). Instead code 20 stayed in the spillway pool until high flows in November when it made another short upstream movement. Code 20 did not exhibit downstream migratory behavior in autumn and remained in the spillway pool until the end of December, when it moved a short distance downstream. Considering that the size of code 20 was intermediate of immature and mature migratory bull trout (see Brown 1992), the overall movement patterns were more consistent with sub-adult bull trout rearing behavior (Muhlfeld and Marotz 2005) rather than adult spawning migration behavior. However, it is not known whether or not migratory movements would have developed if initially code 20 had moved upstream of structure 5. Monitoring of code 20 may reveal insights into this if it moves upstream in Icicle Creek during 2009.

Radio-tagged bull trout provided some initial information that addresses concerns of incidental harvest of bull trout during the tribal and sport salmon fisheries in Icicle Creek (USFWS 2008). Code 20 was present in or near the spillway pool during the entire spring Chinook salmon tribal fishery and apparently was not hooked or harmed. This telemetry data corroborates the Icicle Creek salmon fisheries creel reports. On average, 6 hours of effort were required to catch a single salmon during the Colville Confederated Tribes fishery (CCT 2008). Using this figure, an estimated 5,016 hours was spent by fishers in the combined Colville Confederated Tribes and Yakama Indian Nation fisheries to catch 836 salmon at the spillway pool in 2008 (CCT 2008, R. Dick pers. comm.), and no incidental catches of bull trout were recorded. In addition, no bull trout were reported as incidental catch during the estimated 7,144 angler hours spent to catch 347 salmon in the sport fishery of Icicle Creek downstream of the spillway pool in 2008 (WDFW 2008). This suggests that the terminal tackle and fishing techniques used during the salmon fisheries do not target bull trout, or that few fluvial bull trout were present in Icicle Creek at those times, or both.

Concerns have also been raised on the effects of the Icicle Creek recreational trout fishery on bull trout (WFC 2007a). In response to those concerns, USFWS angler education and bull trout identification posters were posted during the trout and salmon fisheries (Appendix 3). No bull trout were reported in the creel survey conducted by Washington Department of Fish and Wildlife during the trout season in upper Icicle Creek in 2008 (A. Viola, pers. comm.). Bull trout code 22 was present in upper Icicle Creek during the trout fishery, and apparently was not hooked or harmed.

The movements of bull trout code 23 were similar to known movements of Entiat River bull trout tracked to Icicle Creek in previous years (Nelson and Nelle 2008). It is not certain why Entiat River bull trout visit Icicle Creek, but it appears to occur in individuals spawning in alternate years and may be related to foraging movements. It is also possible these are returning Icicle Creek bull trout that spawned in the Entiat River the previous season because of the migration obstacles and barriers in Icicle Creek. The high speed of code 23 during its downstream movement was similar to the speed of tagged bull trout exiting the Entiat River before the spawning season (Nelson and Nelle 2008). Early downstream migration of bull trout has also been documented in Rapid River, Idaho (Schill et al. 1994). The reasons for early out migrations are unknown, but the behavior could expose those bull trout to warmer than optimal seasonal water temperatures. If the movement occurs during a heat wave the results could potentially be lethal as may have been the case with code 23. It is also possible that delayed effects of tagging in combination with elevated temperatures may have played a role in its death (Clapp et al. 1990).

Several aspects of the fluvial bull trout population in Icicle Creek are still unknown, including the timing of migration into Icicle Creek and movements past Leavenworth NFH, the boulder falls and other areas downstream of Icicle Gorge. It is still unknown if the migrants observed in upper Icicle Creek reared above the obstacles of lower Icicle Creek, how far upstream and downstream fluvial bull trout can migrate, and where they spawn besides French Creek. An observation of a faded large redd near Chain Creek

(rkm 48) in 2008 (N. Gayeski, pers. comm.) suggests there are additional fluvial spawning areas in upper Icicle Creek.

In 2009 USFWS Mid Columbia River Fishery Resource Office will increase efforts to tag more bull trout in the Icicle Creek watershed. Bull trout code 20 will continue to be monitored to collect additional movement information. The Mid Columbia River Fishery Resource Office will conduct formal spawning ground surveys in French Creek, as well as any additional areas that may be indicated by telemetry.

Acknowledgments

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Appendix 1. Movements of a radio-tagged probable hybrid bull x brook trout in 2007 and 2008

On November 7, 2007, a probable hybrid bull x brook trout *Salvelinus confluentus x fontinalis* was captured in the Leavenworth NFH sand settling basin. The characteristics of the fish suggested it was a hybrid (Figures 23 - 25) as notes made at the time indicate:

“Markings: some wormy, brownish yellow vermiculations on the dark back between the head and dorsal fin. Yellow spots and black vermic. in dorsal fin and tail. Pectoral & pelvic fins are dark w/ pigment fading through fin. Leading edge is light/whitish. Blue-ish grey cast to flanks. Spots on side are yellow beige; appear defined w/ faintly darker margins. Some of spots on side appear orangish no blue halos” (Notes made by M. Nelson).

“Spots on side are yellowish and pink. Vermiculations anterior of dorsal are longer 1-2 cm near crest of back, vermiculations posterior to dorsal are shorter, less than 1 cm and comma-like. From side view has the look of a bull trout- size, shape of head, and spots- shape and color. Though more dark coloring” (Notes made by B. Kelly-Ringel).

In order to learn more about the movements of hybrid bull trout and gain insights into their possible impacts on bull trout in Icicle Creek, we decided to radio-tag the fish.



Figure 23. Photograph showing dorsal fin mottling, spot coloration and pattern, and head shape of probable hybrid bull x brook trout.

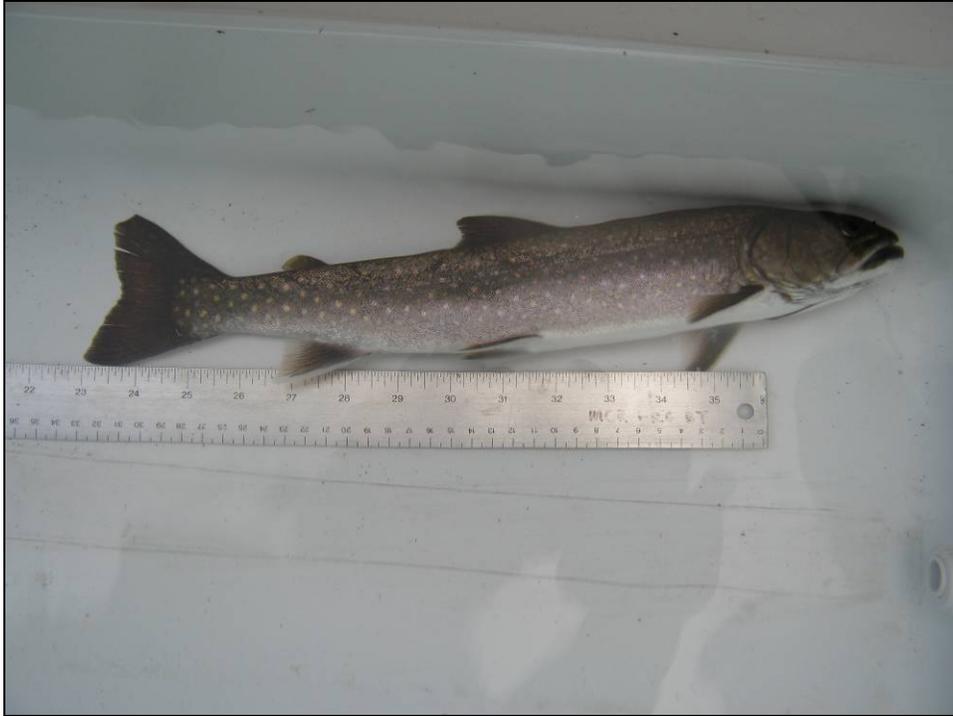


Figure 24. Photograph of flank and fin coloration of probable hybrid trout.



Figure 25. Photograph of vermiculation patterns on dorsum of probable hybrid trout.

The mass of the probable hybrid was 500 g and the fork length was 440 mm. A genetic sample was taken from the dorsal lobe of the caudal fin (sample #681-001). The tissue was sent to the USFWS Abernathy Fish Technology Center for genotypic determination of hybridization and results are pending. Radio transmitter code 21 (channel 01) was surgically implanted in the fish following the techniques detailed in Nelson et al. (2007).

Code 21 was released in Icicle Creek at the Leavenworth NFH spillway pool (rkm 4.3) on November 7, 2007 at 17:02 hours. The fish swam normally and the signal was recording on antenna 1 of the LH fixed station. It left the pool at 19:07 hours, moved downstream, and passed the IC station (rkm 0.8) at 22:57 hours (Figure 26). From November 9 to November 21, code 21 was detected in the Wenatchee River at rkm 44.3, upstream of the confluence with Icicle Creek. It moved downstream and was located at rkm 42.2 on November 28 and December 4 near the Icicle Creek confluence. From December 5 to January 9, it was located in the Wenatchee River downstream of the confluence at rkm 39.9. It then moved downstream and was detected at the WR fixed station at rkm 12.5 on January 11 and entered the Columbia River (Figure 26). It was not detected in the Columbia River during several boat and aerial surveys conducted for the Chelan PUD bull trout monitoring program (J. Stevenson, pers. comm.), but on August 8, code 21 was detected in the Columbia River downstream of Rock Island Dam (rkm 729.7) during a Chelan PUD aerial survey (Denny Snyder, pers. comm.). It was transmitting the motionless signal code 121, but the tag could not be recovered and the fate of the fish is unknown.

No telemetry studies have focused on hybrid bull x brook trout, but observations in Montana indicate they are common in the mainstem Swan River and delta at Swan Lake, and that they behave intermediate to adfluvial bull trout and stream resident brook trout (W. Fredenberg, pers. comm.). Code 21 traveled 69 kilometers to its final location in the Columbia River, comparable to the migration distances recorded for Entiat River tagged bull trout (Nelson and Nelle 2008). It is unknown if hybrids exhibit fidelity to their natal stream, but the movement of code 21 suggests it is feasible that hybrid individuals could move back to or between local populations and even core areas. Most hybrids are sterile males, but some can reproduce (Kanda et al. 2002), and migratory behavior could conceivably increase the range of hybridization into areas where brook trout are currently not present.

Hybridization occurs mainly between male brook trout and fluvial female bull trout (Kanda et al. 2002). Although code 21 was captured in Icicle Creek, it is unknown where it reared. However, if it was bred in upper Icicle Creek, that suggests a fluvial female bull trout was present in 2003 or earlier (based on size of code 21, an estimated age is 4 – 5 years). If so, the reproductive effort of that female bull trout was wasted.

To learn more about migratory behavior of hybrid bull x brook trout, any additional large individuals encountered during the study will be radio-tagged and monitored.

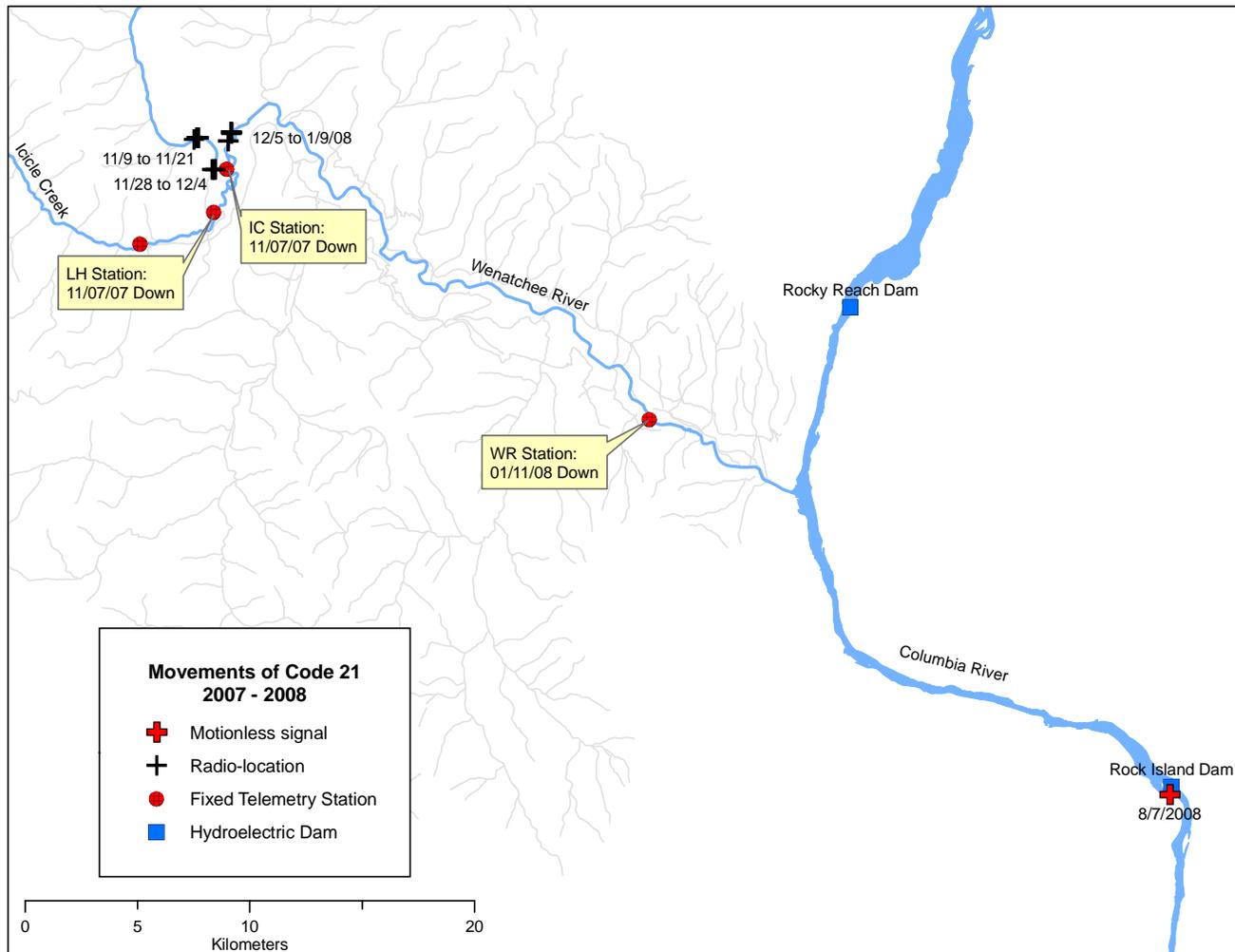


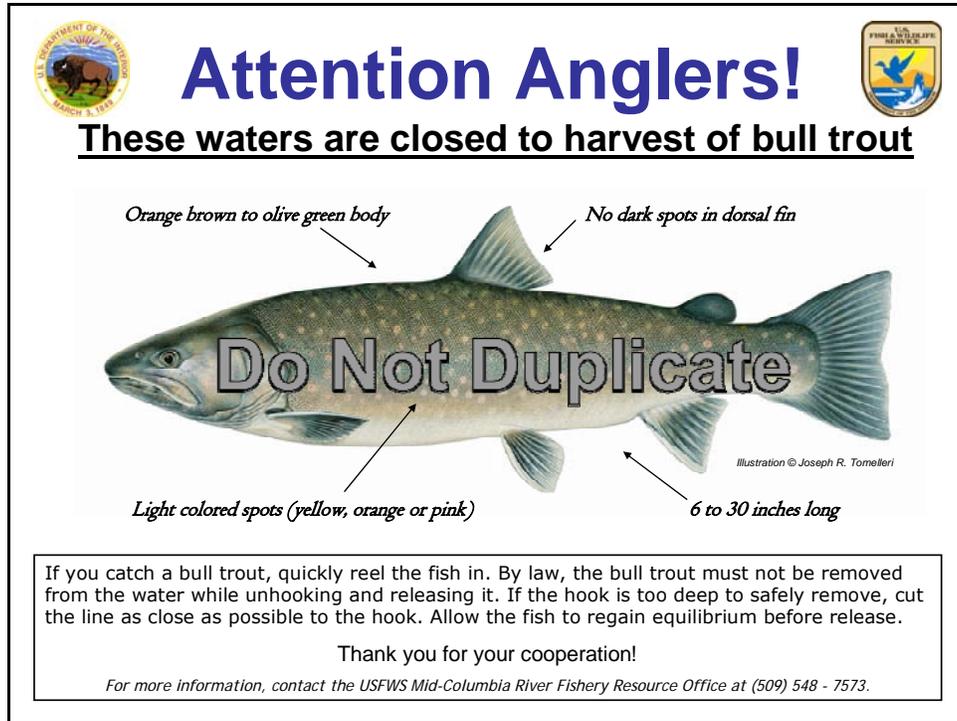
Figure 26. Map of the movements of probable hybrid bull x brook trout code 21, November 7, 2007 to August 7, 2008.

Appendix 2. Capture location, river kilometer (rkm), date, water temperature, numbers, and total lengths (estimated mm) of all fish species caught during angling in Icicle Creek, 2008.

| Location | rkm | Date | T°C | BT | RBT | NPM | WCT | SCS | Total lengths (estimated mm) and notes |
|---------------|------|----------|------|----|-----|-----|-----|-----|---|
| Spillway pool | 4.3 | 04/07/08 | 4.5 | 1 | | | | | tagged code 20 (gen sample) |
| Spillway pool | 4.3 | 07/21/08 | 14 | | 1 | | | | RBT = 170 mm |
| Spillway pool | 4.3 | 07/29/08 | 12 | | | | 1 | | WCT = 250 mm |
| Spillway pool | 4.3 | 07/30/08 | 12.5 | 1 | | 2 | 1 | | tagged code 23 (gen sample); WCT = 250 mm; NPM = 400 mm |
| Spillway pool | 4.3 | 08/04/08 | 12 | | | 2 | | | NPM = 300 - 420 mm |
| Spillway pool | 4.3 | 08/07/08 | 13 | 1 | 1 | 2 | | | BT = 300 mm (gen sample); RBT = 350 mm; NPM = 350 mm |
| Headgate pool | 6.1 | 07/14/08 | 13 | | | | | 1 | SCS = 180mm |
| Headgate pool | 6.1 | 07/21/08 | 14 | 1 | 2 | | | | BT = 350 mm; RBT = 200 mm |
| Headgate pool | 6.1 | 07/28/08 | 12 | 1 | 2 | | | | BT = 200 mm; RBT = 200 mm |
| Headgate pool | 6.1 | 07/29/08 | 12 | 1 | | | | | BT = 225 mm |
| Headgate pool | 6.1 | 08/04/08 | 13 | 1 | | | | | BT = 200 mm |
| Headgate pool | 6.1 | 08/07/08 | 13 | 3 | | | | | BT = 175 - 200 mm (gen samples) |
| CCC pool | 6.3 | 07/14/08 | 13.5 | 1 | | | | | BT = 200 mm |
| u/s CCC pool | 6.4 | 07/14/08 | 13.5 | | 1 | | | | RBT = 150 mm |
| Icicle Gorge | 26.2 | 07/25/08 | 11.5 | 1 | | | | | tagged code 22 (gen sample) |
| Icicle Gorge | 26.2 | 07/28/08 | 12.5 | 1 | | | | | BT = 382 mm (gen sample) |
| Icicle Gorge | 26.2 | 07/29/08 | 11.5 | 1 | | | | | BT = 250 mm |
| u/s IG Bridge | 26.4 | 07/31/08 | 10 | | 1 | | | | RBT = 150 mm |

Note: BT = bull trout, RBT = rainbow trout, NPM = northern pike minnow, WCT = westslope cutthroat trout, SCS = juvenile spring Chinook salmon.

Appendix 3. Example of USFWS angler education/bull trout identification poster.



This poster was created by the USFWS Mid Columbia River Fishery Resource Office to educate anglers on bull trout identification and the proper release of incidentally caught fish. It was posted by the USFS Wenatchee River Ranger District on Forest Service information boards in upper Icicle Creek during the trout fishery and by USFWS at Leavenworth NFH and other downstream locations during the tribal and sport salmon fisheries in lower Icicle Creek in 2008.

The copyrighted fluvial bull trout illustration is licensed from artist Joseph R. Tomelleri for use on the poster, which is included here only as an example. Contact Mid Columbia River Fishery Resource Office for information on how to obtain authorized copies of the poster and the licensing restrictions on its use.

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