INFORMATION REPORTS

NUMBER 2010-01

FISH DIVISION
Oregon Department of Fish and Wildlife

Abundance, Life History, and Distribution of Bull Trout in the Hood River Basin: A Summary of Findings from 2006 to 2009

Abundance, Life History, and Distribution of Bull Trout in the Hood River Basin: A Summary of Findings from 2006 to 2009

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April 2010

This work was financed in part through the following funding:
US Fish and Wildlife Service – Sport Fish Restoration Program, Oregon State Office
US Forest Service – Mt. Hood National Forest
Middle Fork Irrigation District

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PROJECT SUMMARY

Bull trout *Salvelinus confluentus* in Hood River basin currently are thought to exist as two independent reproductive units and both local populations are thought to be at high risk of extinction. The U.S. Fish and Wildlife Service draft recovery plan for bull trout sets out research and monitoring needs critical to the recovery of these populations. From 2006 to 2009, we attempted to address many of these needs. For the upper Clear Branch population, we estimated adult bull trout abundance, described juvenile and adult life history, and assessed some of the potential threats to the population. For the Hood River local population, we determined the current distribution of spawning and rearing and assessed the abundance, life history, and migratory patterns of adult bull trout captured at Powerdale Dam. This report describes our findings, summarizes previous studies in the context of new information, and recommends a standardized monitoring protocol and future research needs.

Upper Clear Branch local population

We estimated the adult population in upper Clear Branch using a mark-resight protocol in 2007 and 2008. We used an upstream-migrant weir trap to capture and mark adult bull trout migrating upstream from Laurance Lake reservoir to spawn in the stream and an extensive night snorkel survey to count marked and unmarked adults. The total number (and 95% confidence interval) of bull trout adults upstream of the weir trap was estimated to be 93 (±5) in 2007 and 91 (±22) in 2008. Census redd counts were also conducted in upper Clear Branch and Pinnacle Creek and were a consistent index of the adult population (~4 adults per redd). Using this index to expand the census redd count into adult numbers in Clear Branch downstream of the traps and in Pinnacle Creek, we estimated the adult population in upper Clear Branch to be 101 (±5) in 2007 and 115 (±22) in 2008.

A downstream-migrant weir trap was maintained in Clear Branch from April to October in 2006 to 2008. PIT tag technology was also employed at the trap site to gain a better understanding of juvenile and adult bull trout life history in upper Clear Branch and Laurance Lake reservoir. Juveniles migrated, usually at age-2 (mean, 126 mm FL; range, 88-176), to the reservoir throughout the spring freshet. They reared in the reservoir for one to three years before returning to Clear Branch as adults. We found no evidence of year-round stream residency of adult bull trout. Adfluvial adults generally displayed consecutive-year migrations and spent a median of 44 days (range, 7 to 137) in Clear Branch for spawning and the rest of the year in the reservoir. Upper Clear Branch adfluvial adults (mean, 274 mm FL; range, 177-545) were small relative to the fluvial population in Hood River basin.

Many risks to Hood River bull trout are associated with Clear Branch Dam, which is 41 m tall, provides intermittent downstream passage during periods of spill, no voluntary upstream fish passage, and isolates this bull trout population in a small habitat patch comprised of 4.5 km of spawning habitat and a 48.5 ha reservoir. The potential loss of genetic diversity in the short-term and population extirpation in the long-term from persistent isolation and low abundance are obvious risks to this population. Additional risks include population reduction through emigration over the dam during spill at the surface spillway and the recent illegal introduction of smallmouth bass (*Micropterus dolomieu*) into the reservoir. We sought to document bull trout emigration by maintaining a screw trap in lower Clear Branch near the base of the dam during

periods of spill in spring in 2008 and 2009. During spring snowmelt from May to July in these years, we operated a screw trap 200 m downstream of the dam and caught 26 bull trout and over 250 other trout, including 5 fin-clipped hatchery rainbow trout (*Oncorhynchus mykiss*) from the stocking program that occurs in the reservoir each April. These bull trout averaged 180 mm FL (range, 148-370). We PIT tagged 21 of these bull trout, 3 of which were detected 13 km downstream at the lower Middle Fork Hood River PIT tag reader several hours to four months later.

In order to understand the potential impact on bull trout of an illegal introduction of smallmouth bass in Laurance Lake reservoir, we attempted in 2007 to collect bass stomachs for diet analysis via angling and conduct a mark-recapture population estimate using an electrofishing boat. In June, we caught no bass during 42 hours of angling by experienced bass anglers who were targeting this species. In the August night-time mark-recapture sampling, an insufficient number of bass were captured during the marking phase to complete the estimate. During 2.25 hours of electrofishing by boat in potential bass habitat and avoiding colder sections near stream inlets, 2 juvenile bass, 6 bull trout, and 89 other trout were captured. The juvenile bass were determined later through scale analysis to be age-2 and were substantially smaller than same age bass in other Oregon reservoirs.

Low abundance of the upper Clear Branch bull trout population puts this population at high risk in the short term of inbreeding and the loss of genetic diversity may threaten its long-term persistence. This population has shifted to an adfluvial life history in which subadult rearing and adult foraging occur mostly in Laurance Lake reservoir. Limiting factors and the effect of reservoir management on bull trout and forage fish populations are currently unknown and merit examination. The reservoir is currently providing poor habitat for smallmouth bass and the current impact of this species on bull trout is minimal. We suggest repeating the same sampling effort we used for bass at least every five years to ensure that this population is consistently small and growth continues to be unusually slow. Periodic sampling of the reservoir may have the added benefit of detecting early any future illegal introductions.

The mark-resight protocol used for estimation of adult bull trout abundance in Clear Branch was practical to implement in the field and statistical simulations suggest it will be effective for monitoring population trend. Future population estimates should minimize sampling variation and potential risks to the population posed by this protocol by following recommendations provided in this report. One such recommendation is to conduct census redd counts every year and the mark-resight population estimate in alternate years to reduce potential negative trap effects and to calibrate redd counts to adult abundance. If census redd counts continue to be a consistent index of adult abundance, the frequency of the mark-resight population estimate can be reduced further.

Hood River local population

We found no information on historical distribution of bull trout in the Hood River basin prior to the 1950s; however, information from East, West, and Middle fork basins from the 1950-60s suggests the only known bull trout rearing area was Clear Branch. Two observations of adult bull trout have occurred more recently – one in the East Fork and another in Lake Creek in the West Fork basin – but current evidence suggests that reproduction is limited to the Middle Fork basin. Screw traps have been operated by ODFW from April to July in the mainstem and all forks of the Hood River since 1995. During this period, juvenile bull trout have been caught exclusively in the Middle Fork. The catch for each trapping season ranged from 0 to 22 bull trout.

The fluvial component of the Hood River local population that forages in or near the Columbia River has been at a low abundance, consisting of fewer than 28 adult bull trout since at least 1992, when ODFW began capturing all upstream migrating salmonids in the fish ladder at Powerdale Dam (RK 7). The single bull trout caught in 2008 was the lowest number on record and was a recapture from 2007. Most adult bull trout were captured migrating upstream in May and June and were substantially larger (mean, 483 mm FL; range; 355-615) than adults in upper Clear Branch. Individually marked adults have been caught migrating upstream at Powerdale Dam in consecutive years (up to four years in a row), suggesting these large adults generally return each year to winter foraging areas downstream of Powerdale Dam.

Adult bull trout captured at Powerdale Dam were strongly associated with the Middle Fork Hood River basin and in some cases Clear Branch. We used PIT tag technology in 2006 to 2009 and radio telemetry in 2007 to 2009 to gain more information on the migration patterns, potential barriers, and spawning distribution of these fluvial adults in the upper Middle Fork basin. In 2006, three of four adults PIT-tagged at Powerdale Dam homed to the Middle Fork and one was recaptured in a weir trap in Clear Branch near the base of the dam. Further study of the upper Middle Fork migration patterns was precluded by two new impassable falls scoured into the lower Middle Fork channel during a glacial outburst in November 2006. In 2007 and 2008, three adult bull trout radio-tagged at Powerdale Dam entered the Middle Fork by early July and spent several weeks within 200 m of the first new falls. Unable to ascend the falls, these fish then exhibited a range of movement patterns, which included one fish moving downstream below Powerdale Dam and returning again to the same new falls and another moving into upper West Fork basin during the spawning period. In 2009, all four PIT-tagged adults were detected near the base of the first new falls on the Middle Fork, generally by mid-July. One of these bull trout, which was also radio-tagged, climbed the first falls by late August, spent six weeks within 200 m of the second falls, and returned downstream on 11 October.

Currently, the only known area of consistent bull trout reproduction and juvenile rearing in the Hood River basin is upstream of the dam in the Clear Branch watershed. The only historical observations of potential production elsewhere in the Middle Fork basin were in Compass Creek, a Coe Branch tributary, during electrofishing and snorkel surveys from 1995 to 1999. Individual bull trout sightings also occurred in Eliot Branch, Coe Branch, Bear Creek, and Tony Creek within 100 to 1,000 m of their confluence with the Middle Fork. In 2006, during extensive presence/absence electrofishing surveys in lower Clear Branch, Coe Branch, Compass Creek, and Elliott Branch, no bull trout were observed except in the first kilometer of Coe Branch, in which four bull trout were captured. This was a small number relative to the 128 bull trout caught during a 2006 electrofishing survey of upper Clear Branch. Moreover, we found evidence that the upper Clear Branch population is a source of recruitment for the Hood River population. One of the juvenile bull trout PIT-tagged in 2007 at the downstream-migrant weir trap in upper Clear Branch spilled over the dam and was captured as an upstream-migrant adult at Powerdale Dam in 2009. Lower Clear Branch screw trap results in 2008 and 2009 suggested that substantial numbers of bull trout are passing over Clear Branch Dam during spill associated with the spring freshet. One of these juveniles, PIT-tagged in June 2008, was re-captured a year later as an upstream-migrant adult at Powerdale Dam.

These results emphasize the importance of the upper Clear Branch population to the persistence of bull trout in the Hood River basin. Currently, the upper Clear Branch population is the only known source of recruitment for the fluvial Hood River population. In order to better understand the magnitude of this source, we recommend fishing the lower Clear Branch screw trap during periods of spill (including fall and winter) and calculating its trap efficiency using more numerous cutthroat and rainbow trout. Returning adults are blocked from reaching their natal spawning grounds by at least one new falls in the Middle Fork and Clear Branch Dam. It is unknown if upper Clear Branch spill-over bull trout, or any adult caught at Powerdale Dam, are consistently spawning elsewhere in the Hood River basin. We recommend continuing to radio tag Powerdale adults to gain at least one more year of migration data and attempt to determine if and where they are spawning. In order to determine if Powerdale adults are producing offspring that return as adults or the degree to which upper Clear Branch is the source of the Hood River fluvial population, we suggest genetically analyzing Powerdale bull trout parentage and comparing allele frequencies between Clear Branch and Powerdale populations.

INTRODUCTION

Bull trout have been adversely affected by many land, water, and fisheries management activities throughout the range of the species. Degraded and fragmented habitat and negative interactions with nonnative fishes have led to a decline in bull trout distribution and abundance, several local extirpations, and a federal listing in 1998 as a threatened species under the Endangered Species Act (USFWS 2002). Distribution and abundance of bull trout also have declined in Oregon, and most management units in the state are considered to be threatened by conservation risks (ODFW 2005). One of these at-risk management units exists in the Hood River basin (ODFW 2005).

Bull trout in Hood River basin currently are thought to exist as two independent reproductive units (USFWS 2002), known as local populations (Rieman and McIntyre 1995). The Clear Branch local population was isolated from the rest of the basin by the construction of Clear Branch Dam in 1968. This dam provides limited downstream fish passage during periods of spill and no voluntary upstream passage. Bull trout in this population inhabit Laurance Lake reservoir and the tributaries Pinnacle Creek and upper Clear Branch, which flow into the reservoir. The Hood River local population is distributed in the mainstem Hood River, Middle Fork Hood River (Middle Fork), and a few Middle Fork tributaries. Fluvial migrants from Hood River basin also forage and winter in the Columbia River (Pribyl et al. 1996, Buchanan et al. 1997). Bull trout have been observed in the East and West Fork basins of the Hood River, but these sightings have been rare. Presently, there is little evidence to suggest local populations exist in these tributary basins (USFWS 2002, Reagan and Olsen 2008).

The status of both local populations is extremely precarious. Threats that put the Clear Branch population at risk of extirpation include low abundance, negative interactions with illegally introduced smallmouth bass, isolation from upstream migration and immigration, and diminished spawning and rearing habitat (USFW 1998). The Hood River population also appears to be small and is affected by passage barriers, unscreened irrigation diversions, impaired water quality, and periodic debris flows during glacial outbursts (USFWS 1998). As mandated by their federally designated threatened status, recovery plans were drafted by the US Fish and Wildlife Service (USFWS) for each distinct population segment, including for Hood River bull trout in 2002. This draft plan listed four goals for recovery in this basin: 1) establish at least one more local population in addition to the two existing populations, 2) increase the estimated adult population in the basin to at least 500 individuals, 3) achieve a stable or increasing trend at the population recovery level for at least two generations (≥10 years), and 4) improve habitat connectivity by addressing problems with passage and screening at diversions and seasonal water quality barriers (USFWS 2002). The recovery plan also sets out research and monitoring needs critical to the recovery of these populations. Needed are accurate adult abundance estimates; a standardized monitoring program; more life history information for each local population, including how Hood River bull trout use of the Columbia River and the effects of potential passage obstructions on movement; and more information on the threat posed to the Clear Branch population by the illegal introduction of smallmouth bass in Lake Laurance reservoir.

The Oregon Department of Fish and Wildlife (ODFW), with the help of the USDA Forest Service (USFS), initiated a four-year study in 2006 seeking to address these needs by synthesizing available data and conducting further studies to improve our understanding of the abundance, life history, and potential limiting factors of bull trout in the Hood River recovery unit. This report describes our findings, summarizes previous studies in the context of new information, and recommends a standardized monitoring protocol and future research. Our specific study objectives were as follows:

1. Assess adult abundance of the Clear Branch local population and develop a monitoring protocol to track abundance trends that is statistically reliable, cost-effective, and that minimizes potential adverse effects on this small isolated population.

2. Describe the juvenile and adult life history patterns of the Clear Branch local population.

3. Assess the potential impact of smallmouth bass on bull trout in Laurance Lake reservoir.

4. Determine current distribution of bull trout reproduction and early rearing in potential bull trout streams in the Hood River basin.

5. Describe the migratory life history of Hood River bull trout and assess the potential impacts of Coe Diversion and two new falls on the Middle Fork Hood River (scoured by the November 2006 glacial outburst) on bull trout migrations.

STUDY AREA

The Hood River basin is located in north central Oregon and has a drainage area of 1,248 km^2 (Figure 1). There are three major tributaries, the East, Middle, and West Forks, which originate from the northeast flanks of Mount Hood and unite to form the mainstem Hood River 19.5 km from its confluence with the Columbia River. The basin is situated in steep terrain in a transition zone between the moist maritime climate typical of the western Cascade Mountains and the drier continental climate east of this mountain range. In summer, melting glaciers influence stream discharge, sediment load, and temperatures. Much of the winter precipitation falls as snow, and rain-on-snow events are common, causing periodic flooding (Coccoli 1999). In November 2006, a debris flow caused by a glacial outburst emanating from the Eliot glacier deposited an enormous amount of sediment and debris downriver and scoured two new falls in the Middle Fork (Figure 1). Within the basin, approximately half of the land is managed by the USFS, and substantial portions are privately-owned forest lands (20,235 ha) or in agricultural production (6,880 ha). There are several dams in the basin that divert water for agricultural and municipal use, power production, or both purposes. Construction of Powerdale Dam in the mainstem Hood River (RK 7) was completed in 1923 and its removal is scheduled to begin in 2010. This dam diverted water to a downstream powerhouse until the penstock was damaged in the 2006 debris flow and ceased operation. From 1992 to the present all adult salmon, steelhead trout, and bull trout migrating upstream were caught in a fish ladder trap at the dam. Clear Branch Dam (RK 39, from the mouth of Hood River) is located on a tributary of the Middle Fork and was constructed in 1968 to provide irrigation for agriculture in the upper basin. The dam stores water from two streams, Pinnacle Creek and Clear Branch, in a 48.5 ha reservoir called Laurance Lake. The 41m tall dam provides no voluntary upstream fish passage and limited downstream passage during intermittent spill at a surface spillway.

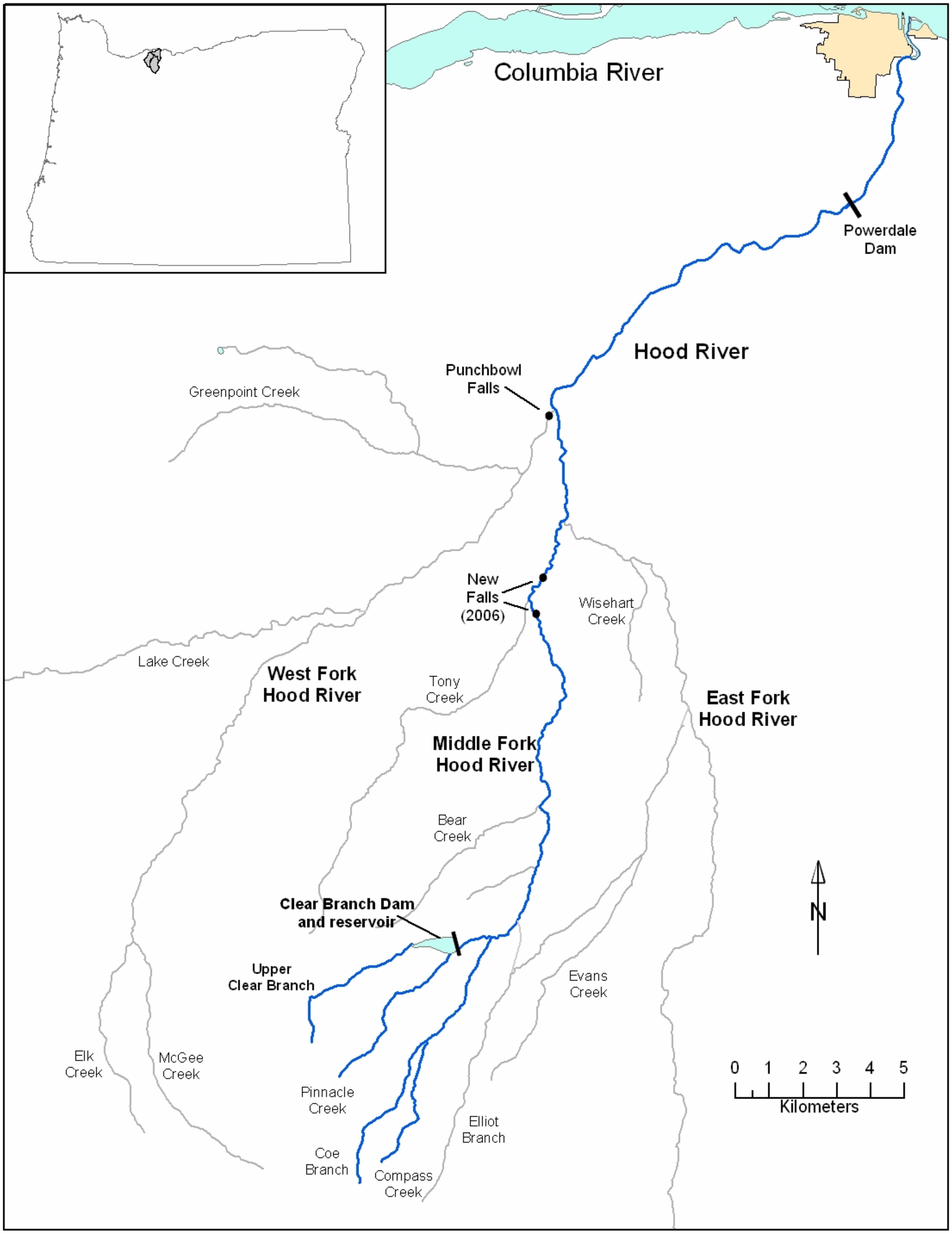

Figure 1. Map of Hood River basin, including major forks and tributaries and suspected bull trout distribution (bold line).

METHODS

<u>Clear Branch local population</u>

Life history and adult abundance

From 2006 to 2008, weir traps spanning the active channel of upper Clear Branch were used to monitor movements between the creek and reservoir and to mark adults for population estimates (Figure 2). Weir traps were also installed in Pinnacle Creek in 2006. The weirs consisted of screened panels anchored to the stream bottom and angled from each bank to a trap box adjacent to the thalweg. The upstream-migrant weir trap was located in a pool tailout about 450 m upstream of the reservoir at full pool. The trap was comprised of a single-fyked steel mesh box (1 x 1 x 1.5 m) in 2006 and a longer (3 m) double-fyked box in 2007 and 2008. At the head of the same pool (20 m upstream), we installed a downstream-migrant weir trap to capture fish moving from the creek to the reservoir. In 2008 and 2009, a 1.5 m-diameter screw trap was installed in lower Clear Branch, 200 m downstream of the dam (Figure 2), and operated during periods of spring spill in order to monitor bull trout passage downstream of the dam. Additionally, the ODFW Hood River Production Program operated screw traps (Figure 2) every year (since 1996) from April through July in the lower Middle Fork, East Fork, West Fork, and Lake Branch and recorded all bull trout that were captured.

All bull trout captured were measured for fork length (FL) and scanned for half-duplex Passive Integrated Transponder (PIT) tags. Untagged bull trout >100 mm FL were given an interperitoneal PIT tag. Generally, fish caught in the downstream-migrant trap and screw trap were released in a pool 50 m downstream and fish caught in the upstream-migrant trap were released in a complex pool 75 m upstream. In 2007, we estimated the efficiency of the downstream-migrant trap by releasing PIT-tagged bull trout in the upstream pool and recording recaptures at the trap. All upstream-migrating bull trout we captured were also PIT-tagged, either in the interperitoneal cavity (180-300 mm FL) or dorsal sinus (>300 mm).

From 2007 through 2009, a half-duplex PIT tag array was installed near the weir trap site on upper Clear Branch to detect tagged fish when the traps were damaged or removed. All arrays were powered by deep cycle batteries that were charged by a solar panel. In 2007, the PIT tag array was installed on 10 October and two antennas monitored fish movement: One located 2 m downstream of the trap site and one 25 m upstream. In 2008, this PIT tag array was installed on 21 May with a single antenna in the downstream location; the upstream antenna was added on 13 October. In 2009, the PIT tag array with both antennas was installed 8 June. In all three years this antenna array was operated until the first week of December, after which there was not enough solar radiation to recharge the array batteries.

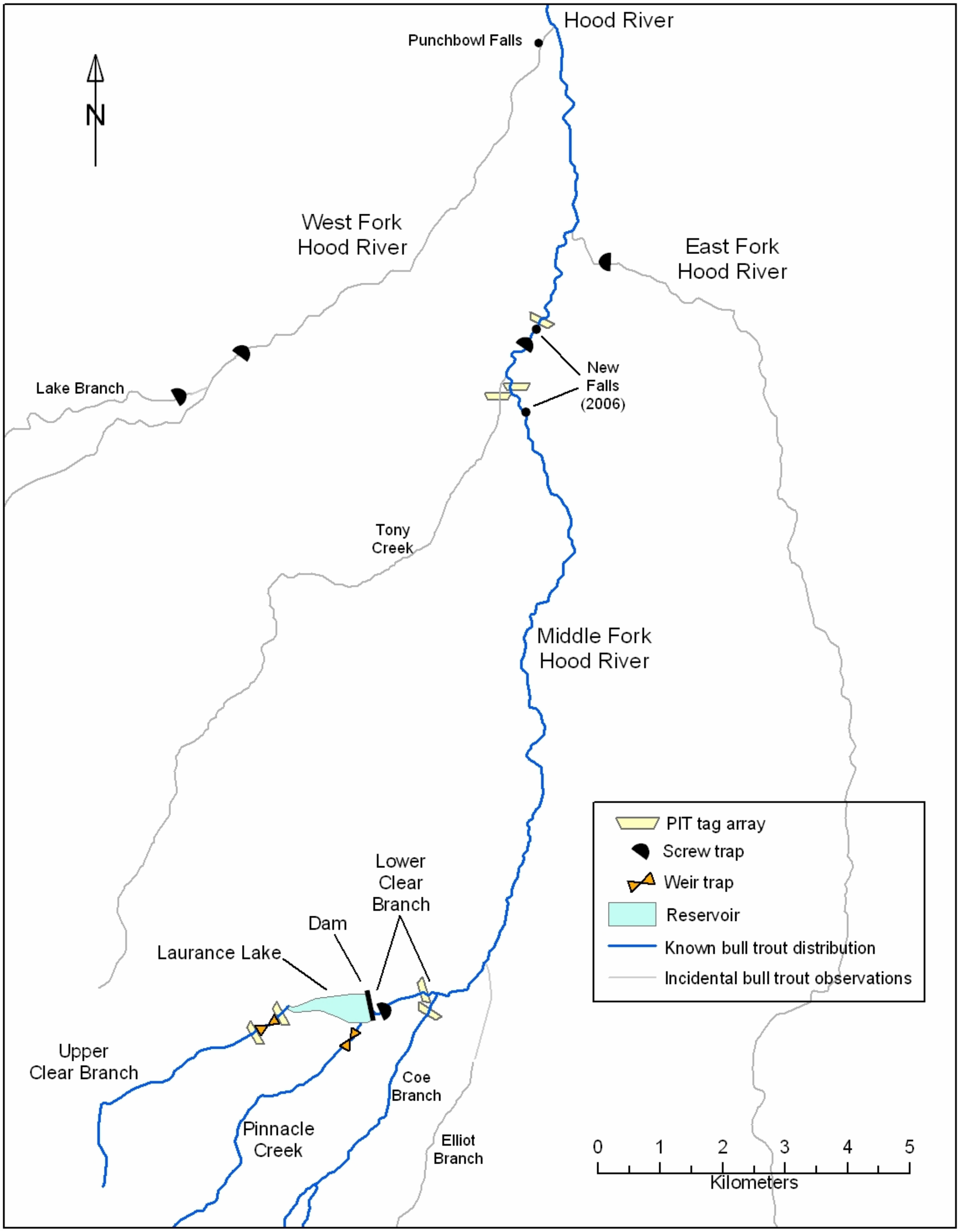

Figure 2. Map of the Middle Fork Hood River, other forks, upper and lower Clear Branch, and locations of traps and PIT tag arrays.

From 17-21 July 2006, a mark-recapture population estimate was used to estimate bull trout abundance in Clear Branch. We used two electrofishing teams to sample and mark fish (≥90 mm FL) in a single pass of the entire known distribution of bull trout upstream of the traps. Fish were given upper caudal fin clips, measured for fork length, and then released near the capture location. We repeated the electrofishing survey two days later and counted all marked and unmarked bull trout and measured fork lengths.

In 2007 and 2008, we estimated the abundance of adult bull trout in Upper Clear Branch using a mark-resight protocol. We marked adults (>180 mm FL) caught in the upstream-migrant weir trap with a hole-punch in the upper caudal fin. We then conducted a snorkel survey to count marked and unmarked adults. The following Lincoln-Peterson equations were used to estimate 1) adult abundance (N_{LP}) and 2) the associated standard error (SE):

1) $N_{LP} = (M+1)(C+1)/(R+1) - 1$

2) $SE = \text{sqrt}[(M+1)(C+1)(M - R)(C - R)/(R+1)^2(R+2)]$;

where, M = fish initially marked at the trap and released upstream, C = adult bull trout observed during snorkel survey, and R = marked fish observed during the resight snorkel survey (White et al. 1982). We continued to catch adult bull trout in the upstream-migrant weir trap after the snorkel surveys were done. These fish were added to the abundance estimate (N_{LP}) to obtain total adult abundance on Clear Branch upstream of the traps during the spawning season.

We defined subadult bull trout as outmigrating juveniles between 90-179 mm FL and adults as ≥180 mm. Since actual maturity generally was not assessed, the definitions were based on the catch at the weir traps. During the spring freshet (April through June), the largest bull trout caught in the downstream-migrant trap was 178 mm FL. With one exception (177 mm FL), all bull trout caught at the upstream-migrant trap were ≥180 mm FL. Milt was expressed from a male bull trout as small as 189 mm FL.

Day and night snorkel surveys were conducted to determine the most effective time for observing fish during the resight surveys. The survey began at the upstream migrant trap and ended 2.2 to 2.5 km upstream, near the largest fork. All bull trout observed were counted, with adults and juveniles tallied separately. For each adult fish, body length was measured with a graduated staff or, when necessary, estimated. Adults were recorded as marked or unmarked; or, if the snorkeler could not view the caudal fin of an adult, as unknown. Paired day and night surveys were done 48 hours apart between 28-30 August and 10-12 September in 2007 and 10 hours apart 15-16 September in 2008. Also in 2008, an unpaired night survey was conducted on 10 September. All pools, glides, and pockets large enough for an observer were snorkeled. The same snorkeler conducted all the surveys, using equal effort on each survey.

From 2006 to 2008, we also conducted census redd counts in upper Clear Branch and Pinnacle Creek for use as a potential index of adult abundance. We began redd surveys in August to obtain a zero count and to flag the redds of coastal cutthroat trout (*O. clarkii clarkii*) so that they were not counted as bull trout redds. Surveys continued until November on a weekly basis in 2006 and 2007 and fortnightly in 2008. In 2009, surveys were done monthly. Surveys began at the reservoir shoreline and ended at fish barriers on the mainstem and unnamed south fork of Clear Branch (3.1 km upstream). Pinnacle Creek was surveyed from the reservoir to a decommissioned road crossing (2 km upstream). We wore polarized glasses and carried a depth staff during the survey. All new redds (pocket and mound) were measured for length and width and flagged. In 2008, redds were georeferenced using a global positioning system.

Statistical power to detect a declining trend

We simulated several scenarios, using four annual rates of population decline (-2 to -20%) and two levels of statistical variation, to evaluate the statistical power of our adult abundance estimates to detect declining trends in the population. To describe statistical variation, we used the coefficients of variation (CVs) of 0.08 and 0.18. These were derived by calculating the CV for the Lincoln-Petersen population estimate in 2007 (CV=0.06) and 2008 (CV=0.16), using the equation $CV = SE(N_{LP})/N_{LP}$ (Gerrodette 1993); and then adding these to the CV of the mean adult population (N_{TOTAL}), which begins to account for the combined sampling error and temporal variation we observed during these years (CV=0.02). To determine the power of our monitoring protocol to detect a declining trend, we used one-tailed tests and set $\alpha = 0.2$ and $\beta=0.1$ to reduce the chance of a Type II error (i.e., not detecting an actual decline in the population), which has been recommended for monitoring small populations of endangered species (Gryska et al. 1997). We evaluated the statistical power of our scenarios with the software program Trends (Gerrodette 1987).

Smallmouth bass in Lake Laurance reservoir

Two sampling methods were used to learn more about smallmouth bass diet, their population age structure, and abundance in Lake Laurance reservoir. In order to collect bass stomachs for diet analysis, hook and line sampling was conducted on 12 and 20 June 2007 by a group of experienced bass anglers. This was timed to coincide with water temperatures in which bass and bull trout were most likely to interact in the reservoir (~15 C). Secondly, we sampled the shoreline of the reservoir on 20 August 2007 at night using an electrofishing boat and the expertise of ODFW warmwater fish biologist Terry Shrader to attempt a mark-recapture population estimate. A recapture phase was planned but not conducted because only two juvenile bass were captured during the marking phase. We recorded total length and collected scales for bass and recorded species and fork length for other fishes caught.

Hood River local population

Distribution

Electrofishing distribution surveys were conducted from April to June 2006 to assess the current distribution of bull trout and determine where future monitoring should be focused. We surveyed Eliot Branch, Coe Branch and its unnamed tributaries, Compass Creek, and lower Clear Branch downstream of the dam. Electrofishing surveys consisted of a single-pass directed upstream throughout all habitat units and subunits (pockets) likely to provide rearing habitat. All salmonids captured were identified to species and measured for fork length. In October of 2006 and 2007, exploratory redd surveys also were done in several potential spawning streams in the Hood River basin. These surveys involved hiking in the stream in an upstream direction, wearing polarized glasses, and examining gravel patches for spawning activity. They were scheduled to coincide with peak spawning in Clear Branch and were done only once during the spawning season.

Life history

Movement patterns of adult bull trout captured at Powerdale Dam (RK 7) were tracked with PIT tag technology in 2006 and both PIT tags and radio telemetry from 2007 to 2009. Fish migrating upstream were captured at the dam, anesthetized, measured, weighed, and given PIT tags by making a small (<1 cm) incision at the base of the dorsal fin and inserting the tag into the dorsal sinus. Radio transmitters (Lotek, Inc., coded nanotags, 200-day battery life) were surgically implanted into the interperitoneal cavity. Radio-tagged bull trout were tracked by vehicle or by foot at weekly intervals. GPS coordinates and a description of the habitat were recorded when a tag was located. These coordinates were converted to river kilometers.

In 2006, half-duplex PIT tag readers (Oregon RFID) and antenna arrays were set up to detect movement of PIT-tagged fish in two locations: 1) Middle Fork Hood River (RK 26, from the Columbia River) upstream of the town of Dee, and 2) Coe Branch–Clear Branch confluence (RK 39), which is about 1 km downstream of Clear Branch Dam (Figure 2). Also, in 2006, because of repeated malfunctions with the PIT tag reader in the second location, an upstream-migrant weir trap was installed 200 m downstream of Clear Branch Dam to monitor adult homing to this tributary. This trap was similar in design to the upstream-migrant trap operated in upper Clear Branch.

From 2007 to 2009, in order to monitor movement over the two new falls on the Middle Fork, the PIT tag array was installed about 150 m downstream of the first new falls, and a second array was added (in 2007 only) on the Middle Fork upstream of the Tony Creek confluence (RK 28), which is about halfway between the two falls.

RESULTS

<u>Clear Branch local population</u>

Adult population estimates

In 2006, the electrofishing mark-recapture protocol for bull trout ≥90 mm FL resulted in a population estimate (and 95% confidence interval) of 513 bull trout (± 313). Of the 128 bull trout captured during the estimate, only 9 were adults (> 180 mm). No adults were recaptured so the estimate could not be divided into juvenile and adult components.

In 2007 and 2008, substantially more adults were observed during night snorkeling surveys than during the day, and juvenile bull trout were only seen at night (Figure 3). Since a greater proportion of the marked adults were observed at night, resulting in lower standard error and more reliable abundance estimates, we will focus on the results of the night snorkel surveys.

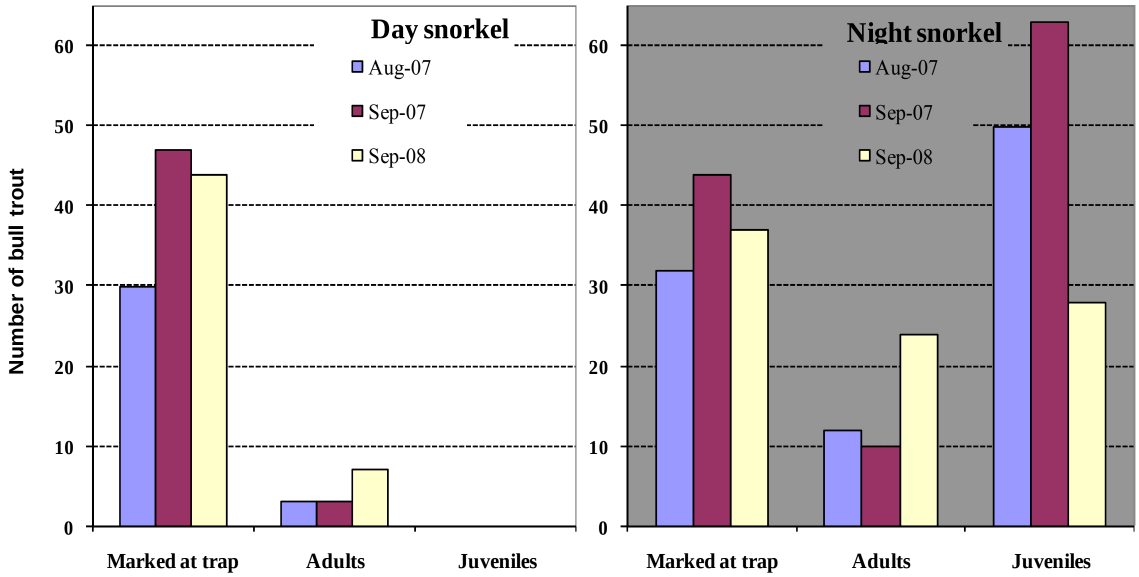

Figure 3. The number of adult bull trout marked at the upstream migrant trap for mark-resight population estimates and the subsequent number of adults and juveniles observed during day and night snorkel surveys in 2007-08.

In 2007, the night snorkel surveys on 30 August and 10 September resulted in adult population estimates (N_{LP}) and 95% confidence intervals of 37 ±5 and 51 ±9 bull trout, respectively (Table 1). After the snorkel survey on 30 August, the upstream-migrant weir trap caught 56 additional adults (N_{TRAP}), which summed to a total estimated abundance (N_{TOTAL}) of 93 adult bull trout. This estimate was similar to the total upstream-migrant trap catch ($M + N_{TRAP} = 90$), suggesting that this trap was installed early enough (29 May 2007) that almost all of the adults moving from the reservoir to upper Clear Branch were caught at the trap and there was no significant population of stream-resident adults in Clear Branch. In 2008, adult population estimates based on night snorkel surveys and the trap catch were 91 ±22 and 93 ±26. The upstream-migrant trap was installed in Clear Branch on 21 July 2008 and we marked a smaller proportion of the adult population than in 2007. The 2007 and 2008 population estimates represent the number of adults in Clear Branch upstream of the weir traps. Additional adults spawned in Clear Branch downstream of our trap and in Pinnacle Creek but were not part of this abundance estimate.

Table 1. Abundance estimates of adult bull trout upstream of the traps on Clear Branch in 2007 to 2008. The sum of the Lincoln-Peterson estimate (N_{LP}) and the post-estimate trap catch (N_{TRAP}) is the total estimated abundance (N_{TOTAL}). See text for definitions of C, M and R.

Date	C	M	R	N_{LP}	SE	N_{TRAP}	N_{TOTAL}	95% Confidence Interval
8/30/07	12	34	11	37	2	56	93	5
9/10/07	9	46	8	51	5	44	95	9
9/10/08	24	37	12	72	11	19	91	22
9/15/08	21	44	11	82	13	11	93	26

Redd abundance and characteristics

In 2006, redd surveys on Clear Branch were conducted weekly from 9 August until the first redd was observed on 26 September. Surveys were then conducted twice a week until 1 November. We did not observe a new redd after 9 October. In total, 16 redds were observed in upper Clear Branch (Figure 4), 4 of which were counted downstream of the traps. Median length and width of the pocket and mound was 74 cm (range, 40-130) and 35 cm (range, 15-60), respectively. Redd surveys in Pinnacle Creek were done on the same schedule but were started on 28 July. Four redds were observed on Pinnacle Creek. The first redd was seen on 25 September and the last on 9 October. Bull trout in Pinnacle Creek and Clear Branch each constructed a redd in stream channel exposed by lowered reservoir levels. Both of these redds were inundated under at least one meter of standing water as the reservoir water level rose in November.

In 2007, spawning surveys began on 21 August and were completed every week on Clear Branch and every two weeks on Pinnacle Creek. The first redds were seen in Clear Branch on 24 September and the last redd was counted on 30 October. In total, 25 redds were counted, which included 1 redd downstream of the traps. Seven redds were counted upstream of the abandoned USFS bridge, including two on the unnamed south fork and four on Clear Branch upstream of this fork. Median redd length was 76 cm (range, 45-180) and width was 35 cm (range, 23-60). Only one small redd was counted on Pinnacle Creek.

In 2008, redd surveys were done every two weeks, beginning with a zero count in August and finishing on 29 October. The first redd was observed on 15 September. We counted 23 redds in Clear Branch upstream of the traps and 5 between the reservoir and the traps (Figure 5). Median redd length was 80 cm (range, 45-180 cm) and width was 40 cm (range, 25-95 cm). Pinnacle Creek was surveyed once, on 14 October, and only one redd was counted. Redd surveys were also conducted in lower Clear Branch from the confluence with Coe Branch to Clear Branch Dam on 14 and 30 October. No redds were observed.

In 2009, we completed a zero count of Clear Branch and Pinnacle Creek on 18 August and redd surveys occurred on 29 September, 20 October, and 2 November. We counted 26 redds in Clear Branch. Median redd length was 95 cm (range, 40-190) and median width was 55 cm (range, 10-180). In Pinnacle Creek, a single redd survey was done by the USFS on 4 November and four redds were counted.

From 2006 to 2009, redds were distributed throughout 3 km of upper Clear Branch, from 50 m upstream of the reservoir, to within 200 m of an impassable waterfall on the mainstem, and to the base of a steep series of steps on the unnamed south fork, which is assumed to be passage barrier (Figure 5). We surveyed 500 m upstream of these steps during peak spawning in 2006 and 2007 and observed no redds. The single redd counted on Pinnacle Creek in 2008 was in the same location as in 2006 and 2007 and marked the upstream end of observed redds within our survey reach (Figure 5).

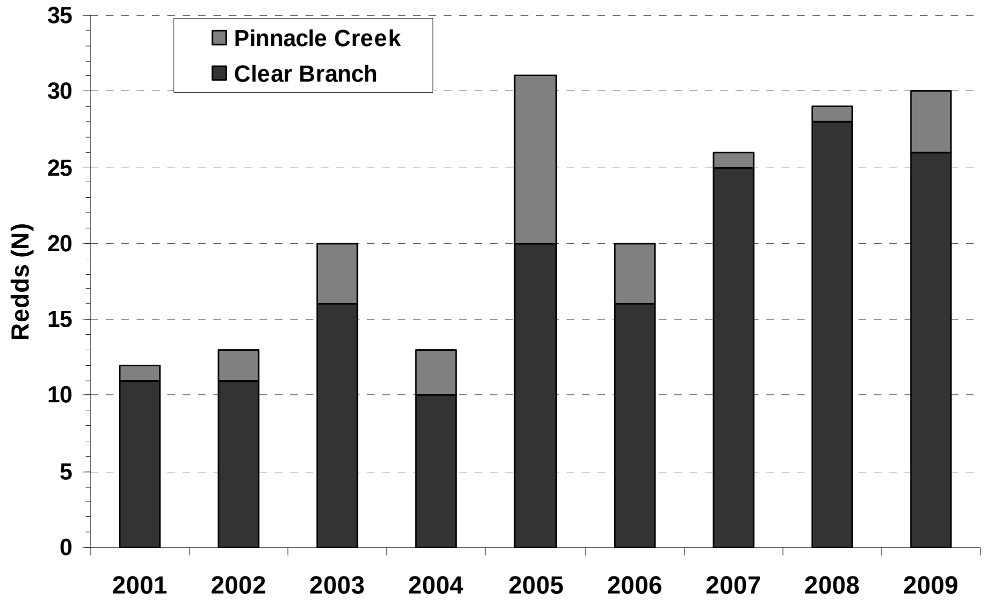

Figure 4. Bull trout redds counts conducted by the USFS (2001-05 and Pinnacle Creek in 2009) and ODFW (2006-08 and Clear Branch only in 2009).

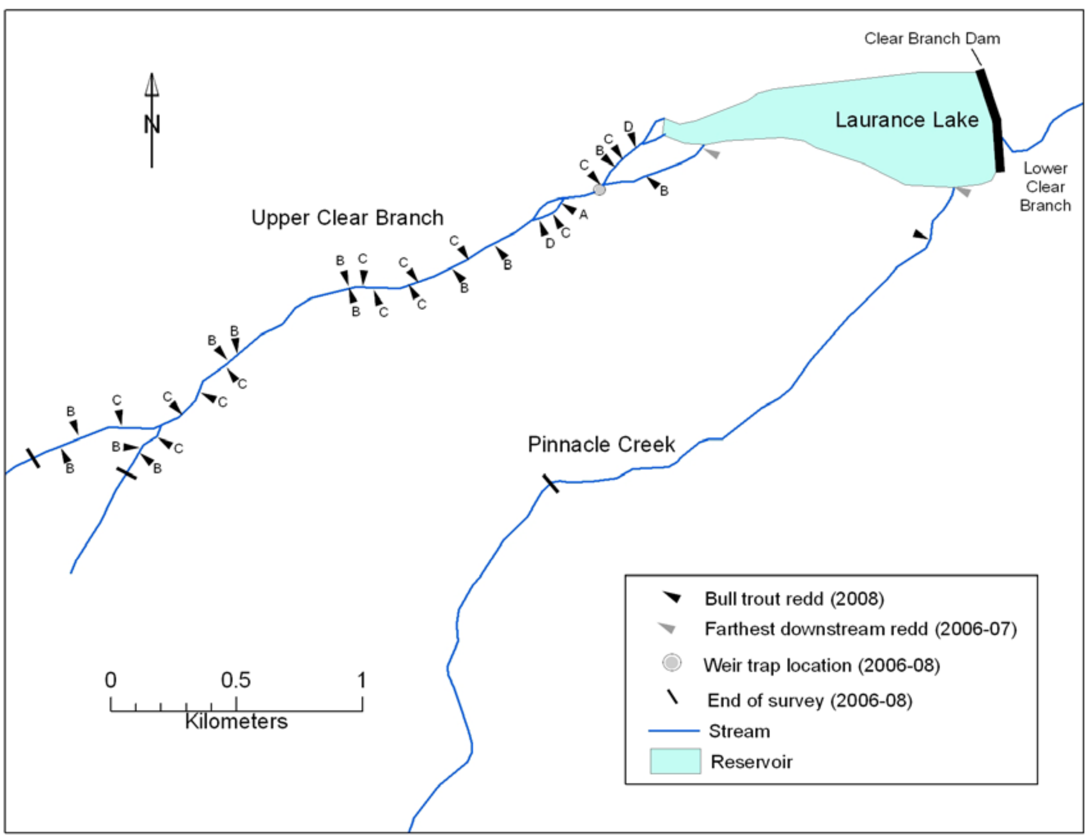

Figure 5. Upper Clear Branch and Pinnacle Creek redd distribution in 2008. Letters refer to the survey date that specific redds first were counted: 15 (A) and 28 (B) September, and 13 (C) and 29 (D) October.

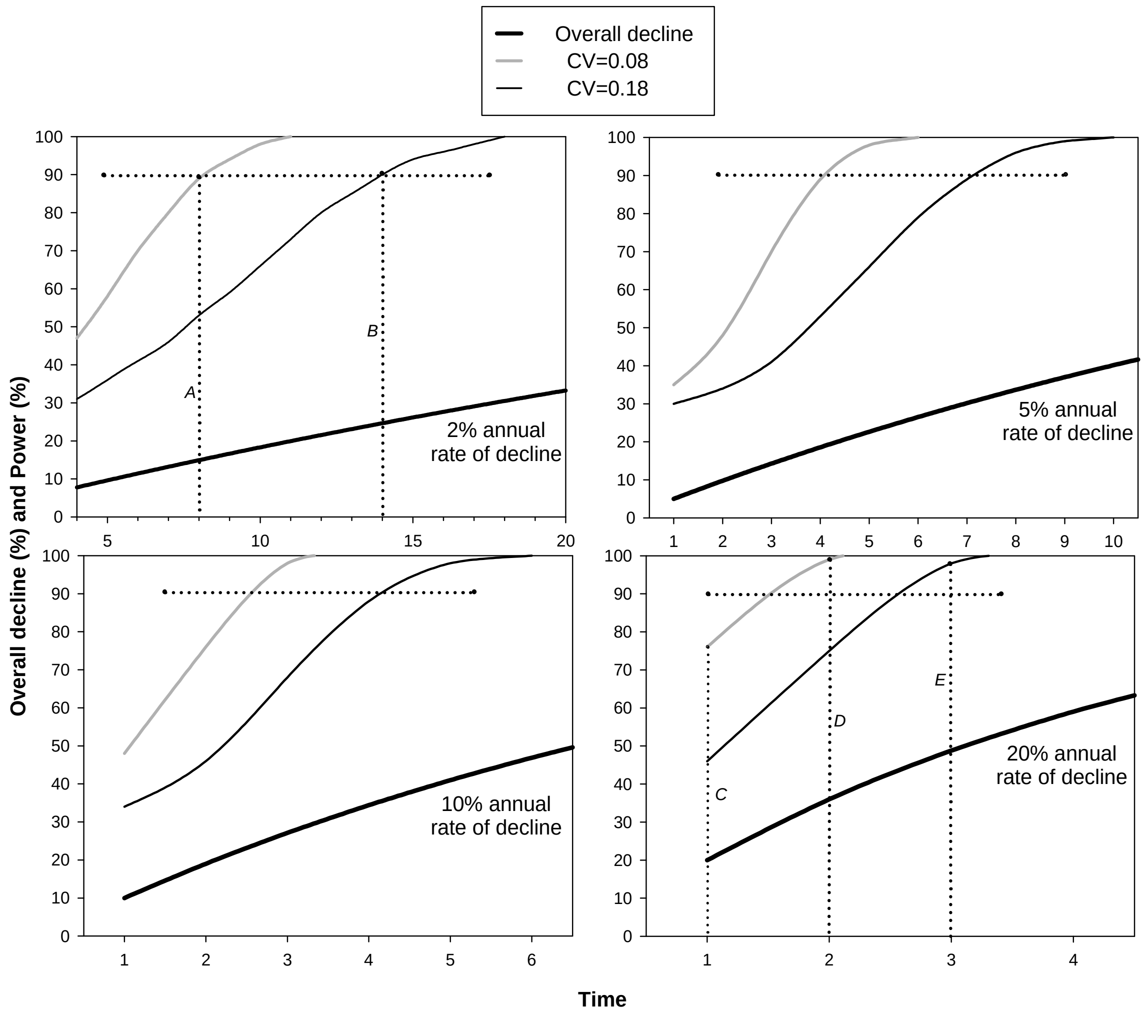

Figure 6. Simulations of statistical power (α=0.2, one-tailed test) to detect a 2 to 20% annual decline in the population at two realistic levels of statistical variation (CV=0.08, 0.18) with annual population estimates. We used 90% power (β=0.1; horizontal dashed line) to evaluate the effectiveness of our monitoring protocol. Some of the simulated scenarios are discussed in the text (vertical dashed lines *A*-*E*).

Statistical power to detect a declining trend

When there is a relatively slow annual decline (-2%), low statistical variation in the abundance estimate (CV=0.08, as observed in 2007), and abundance is estimated annually, the mark-resight protocol we used would have approximately 90% power to detect a 15% overall decline in migrating adults in 8 years (Figure 6, vertical dashed line *A*). With greater statistical variation (CV=0.18, as observed in 2008), 90% power would be reached in 14 years after the population had declined by 25% (Figure 6, line *B*). If there were a more rapid annual decline (-20%), and assuming low statistical variation, we would have 76% power to detect the 20% decline in the first year (Figure 6, line *C*) and over 90% power in the second year to detect a 36% decline (Figure 6, line *D*). With greater statistical variation, we would have 75% power in the second year to detect a 36% decline (Figure 6, line *D*) and over 90% confidence to detect a 50% decline in the third year (Figure 6, line *E*).

Juvenile life history

In 2006, the downstream-migrant trap began fishing 50% of the Clear Branch width on 24 May. Weir panels were added as the snowmelt-driven flows subsided and the weir spanned the entire stream by 7 July. The trap was removed on 17 October. In total, 136 juvenile bull trout were caught (Figure 7), averaging 129 mm FL (range, 88-176 mm); and 124 were PIT-tagged. Six postspawning adults were captured in the first half of October. Trap efficiency was not estimated in 2006. The Pinnacle Creek traps were installed the same time as in Clear Branch. The downstream-migrant trap caught 31 juvenile bull trout with mean fork length of 100 mm (range, 83-131 mm) and 1 adult (290 mm). This adult was captured moving downstream on 20 September, during the same week that the first redd was observed in Pinnacle Creek 200 m upstream of the trap.

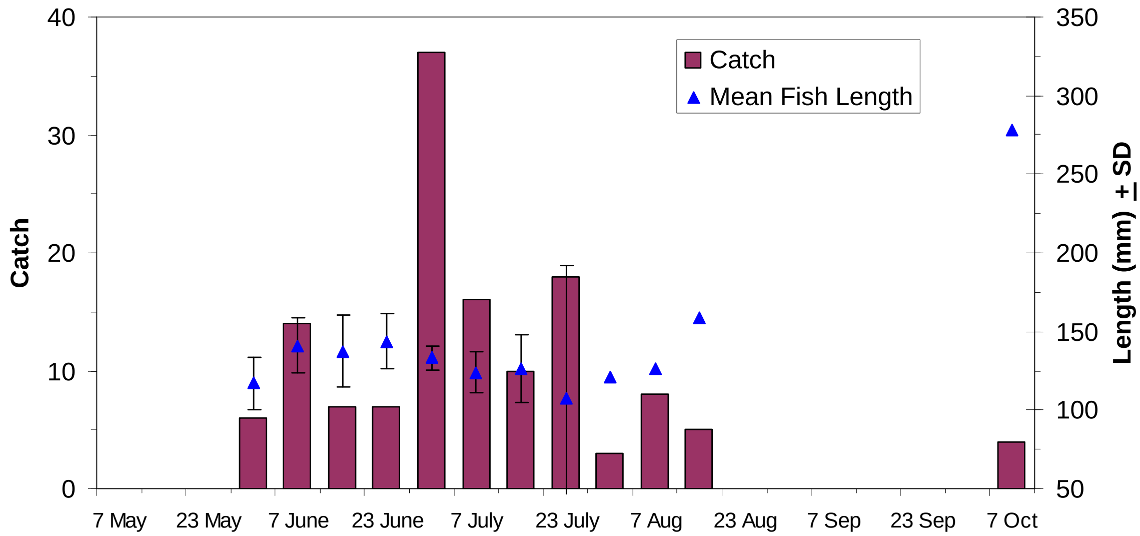

Figure 7. Bull trout captured in Clear Branch downstream-migrant weir trap in 2006. Catches and lengths are grouped by weekly intervals. The trap was installed on 25 May and first spanned the entire channel width on 7 July. The trap was removed on 17 October.

In 2007, the downstream-migrant trap fished 80% of the stream width from 24 April to 28 May (Figure 8). To estimate trap efficiency during this period, 42 juvenile bull trout were marked and released upstream. We recaptured 52% and estimated that about 81 juvenile bull trout migrated past the trap during this period. From 29 May to 21 October, the weir trap spanned the stream and an additional 84 juvenile fish were caught. Trap efficiency was not estimated during this period. Combining the totals from these two periods, we estimated that 207 juvenile bull trout moved past our trap site, with the majority of migration occurring prior to the end of June. They averaged 123 mm FL (range, 92-171 mm) and 78 fish were PIT-tagged. A postspawning adult was captured on 28 September. The weir was damaged by a high water event and debris accumulation on 2 October. Postspawning adults were able to pass this trap until the weir panels were repaired on 7 October. By 21 October, flow and debris load were too high to continue running this trap.

In 2006 and 2007, we conducted night snorkel surveys in Clear Branch between the trap and the reservoir at least once per month from July through October. No juvenile bull trout were observed, suggesting that juveniles caught in the downstream-migrant trap were migrating to the reservoir. Comparing the length frequency histogram of the downstream-migrant trap catch with a scale analysis from this local population, juvenile bull trout outmigrate to the reservoir mostly at age-2 (Figure 9).

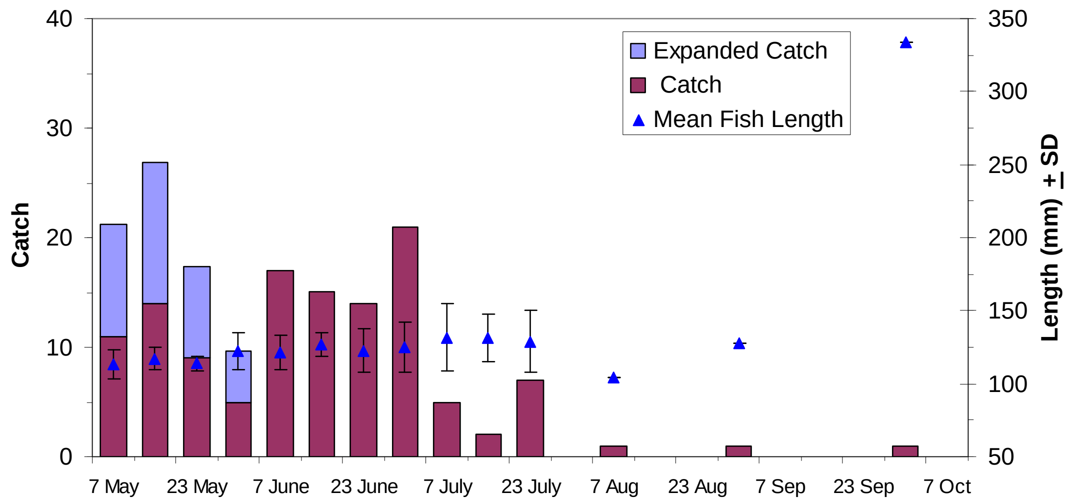

Figure 8. Bull trout captured in Clear Branch downstream-migrant weir trap in 2007. Catches and lengths are grouped by weekly intervals. The trap was installed on 24 April and the weir first blocked the entire channel width on 29 May. Trap capture efficiency was estimated during this period and used to expand the catch. This trap was removed on 21 October.

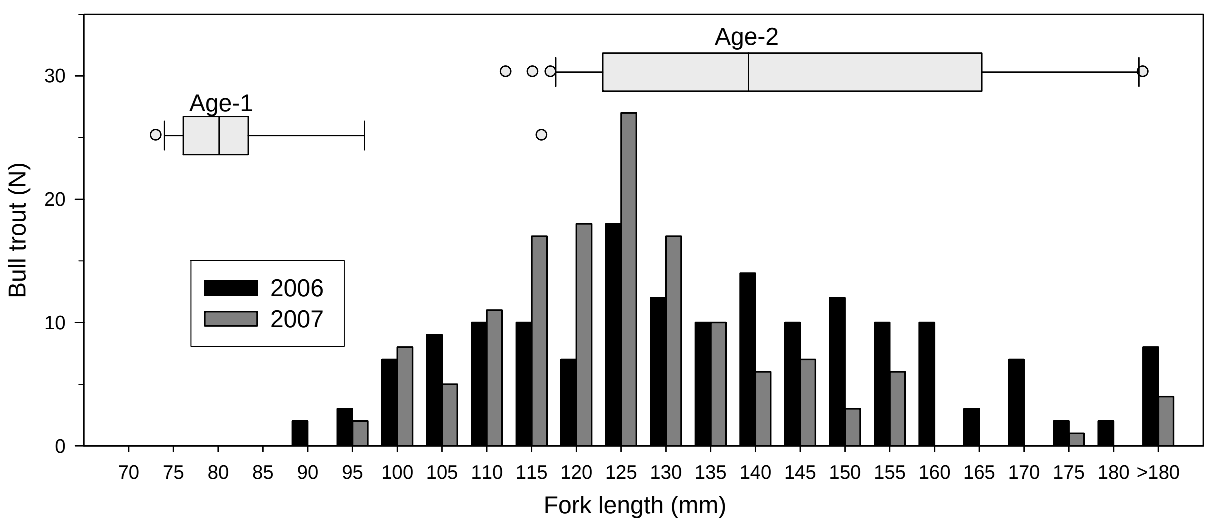

Figure 9. Length frequency histogram of the downstream-migrant trap in upper Clear Branch from 2006 and 2007 and boxplots of the length-at-age scale analysis of this local population from sampling efforts in 1995, 1998, and 2008. The box plot displays median (solid line), two middle quartiles (box), 5th and 95th percentiles (whiskers), and outliers (black dots).

In 2008, this trap was installed to span a third of the channel on 21 May. Because of an unusually deep snowpack this year, Clear Branch experienced prolonged snowmelt and high flows, and we did not trap the entire stream width until 21 July. Only four juvenile bull trout were captured moving downstream during the spring freshet and six for the entire period. We adjusted the location and inflow of the fyke three times, but no adjustment affected the trap catch. Two postspawning bull trout were captured on 28 September and 1 October.

Nine juvenile bull trout initially caught in the downstream-migrant trap and PIT tagged in 2006 and 2007 were either detected by the PIT tag reader moving upstream or recaptured in the upstream-migrant trap between 337 and 1086 days (median, 732 days) after moving to the reservoir to rear as subadults (**Appendix A**).

Adult life history

In 2006, the upstream-migrant trap was installed on 7 July and spanned the entire Clear Branch channel until it was removed on 21 October. This trap caught 27 adult bull trout (Figure 10), the mean fork length was 293 mm (range, 202-545 mm), and all were PIT-tagged. The upstream-migrant trap in Pinnacle Creek caught one adult (228 mm FL) on 16 October.

In 2007, this trap was installed on 29 May, about five weeks earlier than in the previous year (Figure 11). The trap operated continuously until high water events damaged it repeatedly in early October. Adults may have been able to pass this trap without capture between 2-7 October and after 16 October; however, the trap continued to catch fish until it was removed completely on 23 October. In total, 90 adult bull trout were captured in this trap, averaging about 284 mm in fork length (range, 192-530 mm), and 86 were PIT-tagged.

In 2008, this trap was operated from 21 July to 30 October. High flows combined with leaf accumulation on the weir panels damaged the trap from 28-29 August and from 4-10 October and fish were able to pass the trap during these periods. The upstream-migrant trap caught 67 bull trout, averaging 255 mm FL (range, 180-500 mm), and all were PIT-tagged (Figure 12). We did not run weir traps in 2009.

From 2006 to 2009, adult bull trout were captured or their PIT tags detected migrating upstream past the Clear Branch trap as early as 20 May and as late 22 October (Figure 13), with an overall median date of 2 September. PIT-tagged adult bull trout returning to the reservoir were detected migrating downstream past the trap site from 13 September to 30 October, with an overall median date of 11 October (Figure 14). Adult bull trout spent a median of 44 days (range, 7 to 137) upstream of the traps in Clear Branch during the spawning season.

From 2007 to 2009, we observed 52 adult bull trout that had been PIT-tagged in a previous year: 10 were recaptured in the upstream-migrant trap and 42 detected at the PIT tag array (see **Appendix A** for individual recapture histories). Of these fish, 48 (92%) migrated from the reservoir and into upper Clear Branch in consecutive years. Only four adults were detected moving upstream in alternate years. Nine adults migrated upstream of the trap location in three consecutive years and one fish migrated four years in a row. Individual adult bull trout repeating their migration into Clear Branch from the reservoir began their upstream migration significantly earlier than their previous migration start date, passing the trap site an average 19 days earlier than the previous year (±7 days, 95% confidence interval). The downstream migration date for individual adults was not significantly different in consecutive years, occurring on average 3 (±8) days earlier than the previous year (N=16).

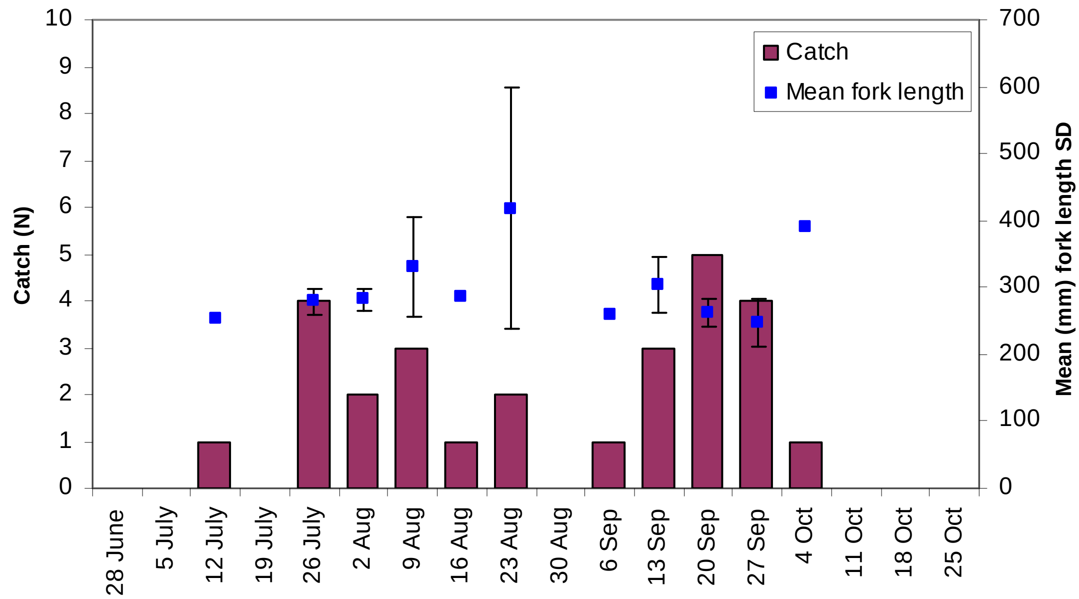

Figure 10. Weekly catch of bull trout in the upstream-migrant trap in 2006. This trap was maintained from 7 July to 21 October.

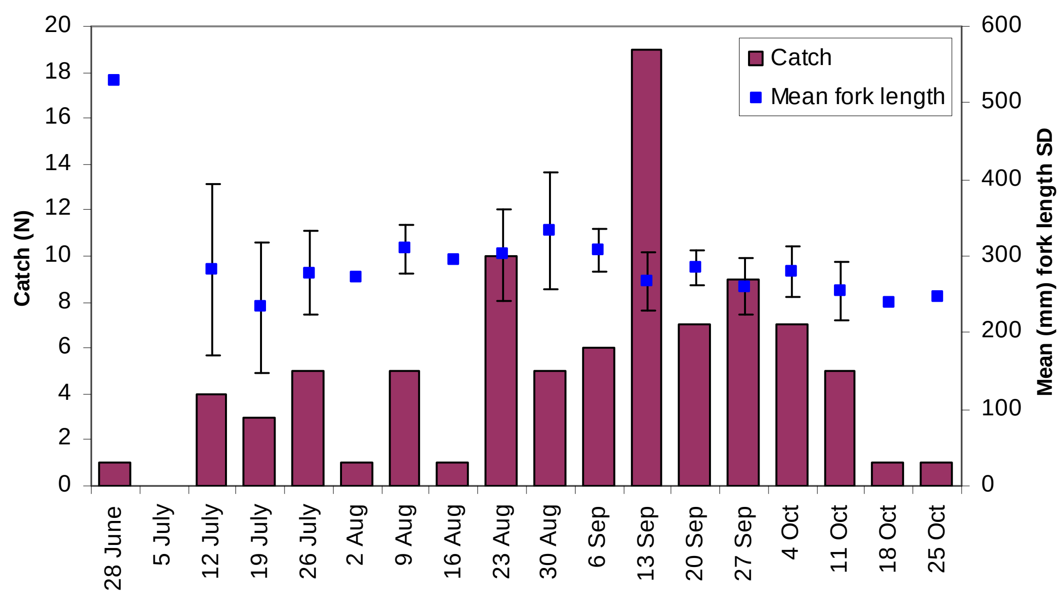

Figure 11. Weekly catch of bull trout in the upstream-migrant trap in 2007. The trap was maintained from 29 May to 23 October. Fish were able to pass the trap from 2-6 October and from 16-23 October. This trap was still functional but weir panels were damaged by high flows and debris accumulation.

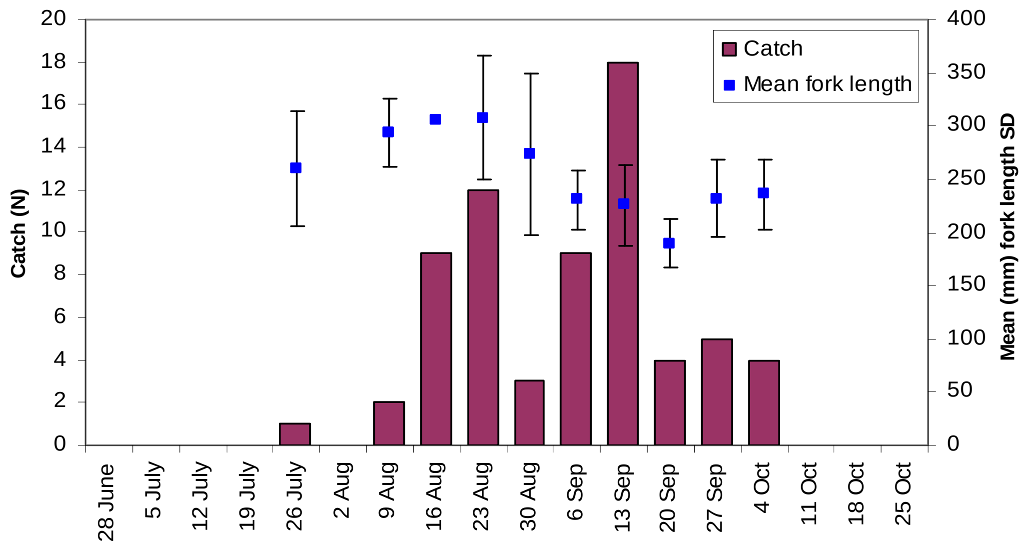

Figure 12. Weekly catch of bull trout in the upstream-migrant trap in 2008. Trapping began on 21 July and ended 30 October. The trap was damaged by high flows and debris accumulation from 4 to 10 October and bull trout were able to move upstream with a low probability of capture.

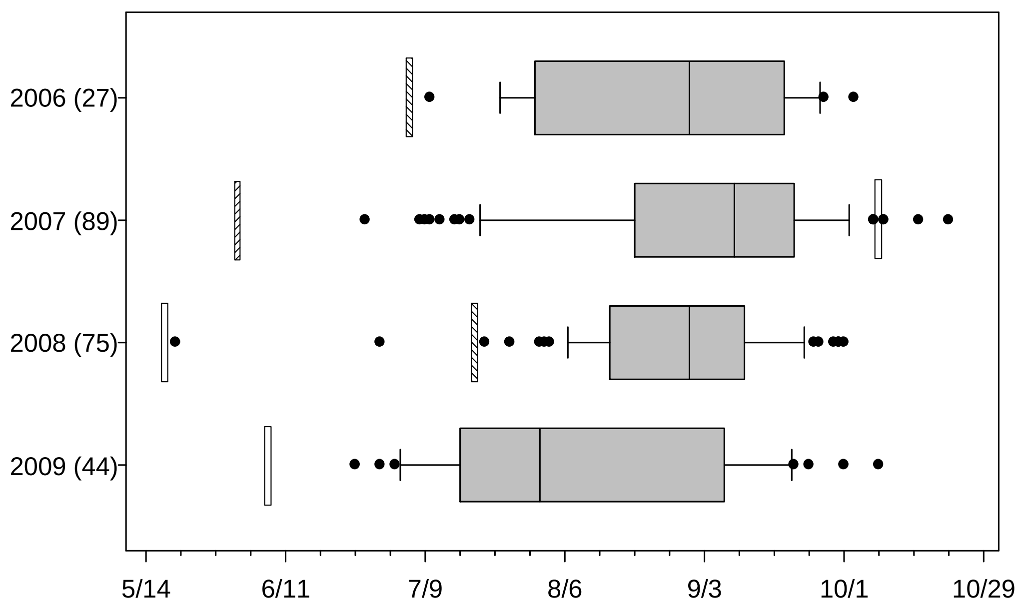

Figure 13. Timing of adult upstream migration from the reservoir to upper Clear Branch from 2006 to 2009 (sample size in parentheses). Installation dates for the upstream-migrant weir trap (lined bars) and PIT tag reader array (hollow bars) are indicated. No PIT tag array was installed in 2006, there was no trapping in 2009, and the PIT tag array was removed by each year by 7 December. The box plot displays median (solid line), two middle quartiles (box), 5th and 95th percentiles (whiskers), and outliers (black dots).

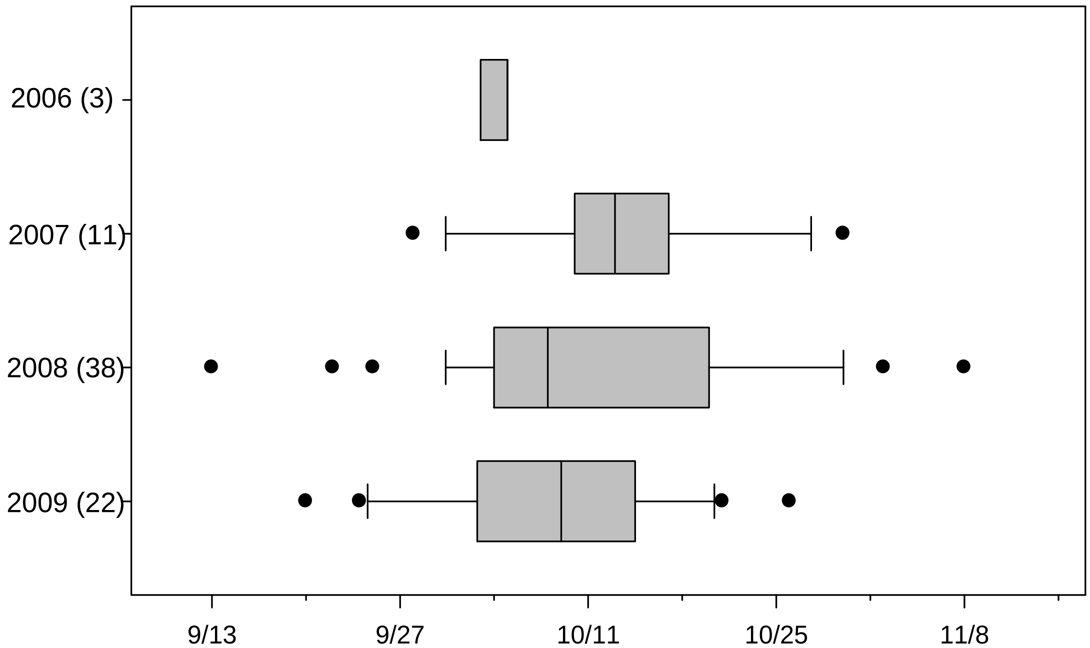

Figure 14. Timing of adult downstream migration from upper Clear Branch based on PIT tag detections (93%) and downstream-migrant trap capture of adult bull trout from 2006-09 (sample size in parentheses). The box plot displays median (solid line), two middle quartiles (box), 5^{th} and 95^{th} percentiles (whiskers), and outliers (black dots).

Through trap avoidance or escape, the weir traps may have delayed or prevented some fish from upstream and downstream movement. In 2008, 13 PIT-tagged adults were detected at the upper Clear Branch PIT tag array. Three passed the pool tailout antenna before the traps were installed in the pool and were detected for a few seconds. The other 10 were first detected when the weir traps spanned the stream. These bull trout were detected repeatedly during the hours of darkness for a median of 4 days (range, 1 hour to 28 days) and only 5 were captured in the trap. Twenty-two postspawning adults were detected moving downstream past the traps during the period when weir panels were damaged by leaf accumulation and high flows; only two postspawning adults were recaptured in the downstream-migrant trap. In 2009, when no weir traps were used in Clear Branch, 16 adult bull trout passed upstream through the trap site (and were detected at the two PIT tag antennas 60 m apart) in a median of 29 minutes (range, 12 minutes to 27 days). The downstream migration through the trap site was more rapid, taking a median of 6 minutes (N=7; range, 2 minutes to 4 days).

Downstream movement past Clear Branch Dam

In 2008, spill associated with spring snowmelt at Clear Branch Dam began on 15 May and continued until 4 August (Figure 15). The rotary screw trap fished continuously from 30 May to 28 July, when the trap cone no longer had enough depth to rotate. This trap caught 18 bull trout and 58 other trout, including a fin-clipped hatchery rainbow trout that had been stocked in the reservoir during April (Figure 15). We PIT tagged 15 of the bull trout caught in this trap.

Seventeen of the bull trout were between 148-200 mm FL (mean, 162 mm) and one was 370 mm. In 2009, Clear Branch Dam spilled from 25 April to 2 July and the screw trap fished from 4 May to 5 July. The trap caught six bull trout (mean, 200 mm FL; range, 151-253) and all were given PIT tags prior to release. The trap also caught 154 other trout, including 4 adipose fin-clipped hatchery rainbow trout that had been stocked in Lake Laurance reservoir.

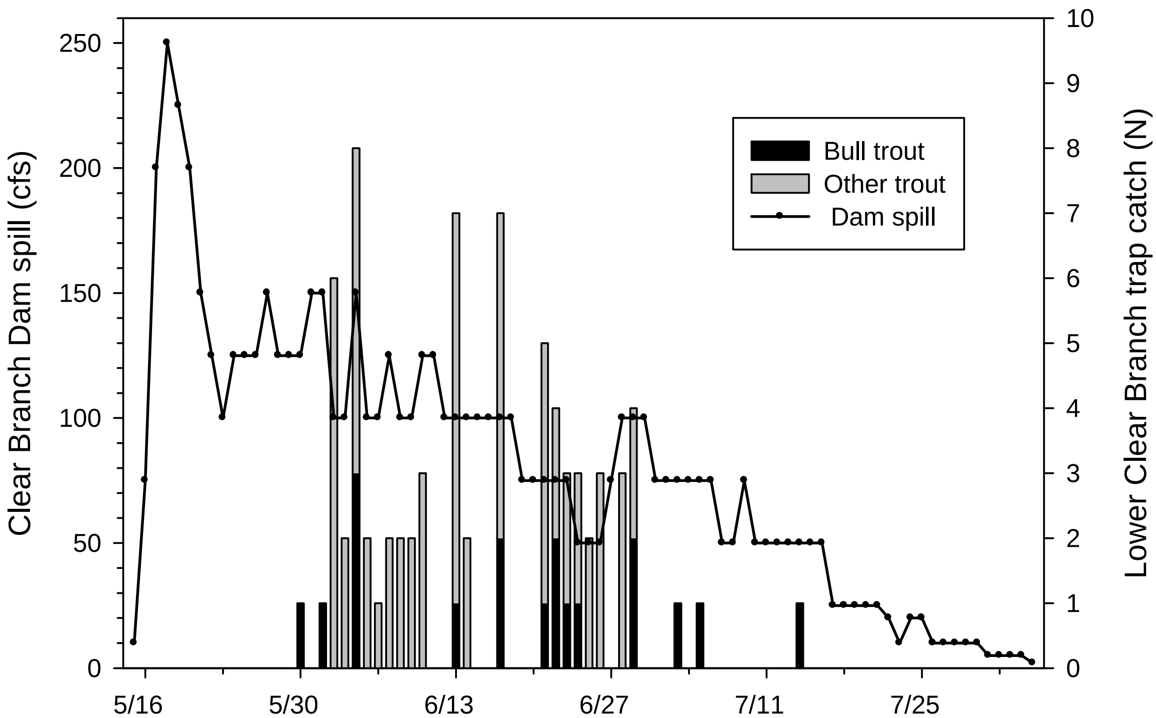

Figure 15. Clear Branch Dam spill and daily catch of a screw trap located in lower Clear Branch (200 m downstream of the dam) in 2008. The trap fished from 30 May to 28 July. Flow data for dam spill, cubic feet per second (cfs), was obtained from Middle Fork Irrigation District.

Smallmouth Bass in Lake Laurance Reservoir

A group of experienced bass anglers fished for smallmouth bass a total of 42 hours on 12 and 20 June 2007. No bass were caught so stomach sampling could not be done. They caught an uncounted number of hatchery rainbow trout, two cutthroat trout, and five bull trout (250-325 mm FL). Water temperature throughout the water column was 15.5° C.

The first sampling event in the mark-recapture population estimate began shortly after dusk on 20 August. It lasted 2.25 hours, during which the reservoir surface temperature was 17° C. We sampled the reservoir shoreline, avoiding colder sections near the mouth of Clear Branch and Pinnacle Creek to minimize the chance of catching bull trout. We captured 2 juvenile smallmouth bass, 6 bull trout (mean, 212 mm FL; range, 179-263 mm), and 89 other trout (mean, 201 mm; range, 70-345 mm). The bass measured 90 and 110 mm total length and later were determined through scale analysis to be age-2. Crawfish, a common prey item for smallmouth bass, appeared to be plentiful.

Hood River local population

Distribution

Electrofishing surveys were conducted in April and June 2006. We caught only four bull trout (range, 152-213 mm FL), all within lower Coe Branch from its confluence with Clear Branch to 500 m upstream of Coe Diversion. Bull trout were not observed in lower Clear Branch, Compass Creek, upper Coe Branch, or Eliot Branch. No bull trout redds were observed during exploratory surveys in Middle Fork tributaries lower Clear Branch, Tony Creek, Bear Creek, Squeegee Creek, Compass Creek, Coe Branch (and one of its unnamed tributaries where cutthroat trout redds were observed), Green Point Creek, and Boomer Creek; in West Fork tributaries McGee Creek and Elk Creek; and in the East Fork tributary Cold Springs Creek.

Capture and tagging at Powerdale Dam

In 2006, four bull trout were captured moving upstream into the Powerdale Dam fish ladder trap (Figure 16). The fish were captured between 22 May and 16 June and ranged from 380 to 580 mm FL. We PIT tagged three, and one was a recapture that was PIT-tagged in 2005 (see **Appendix B** for individual recapture histories from the Hood River population).

In 2007, six adult bull trout were captured in the fish ladder trap between 13 May and 1 July. They ranged from 390 to 530 mm FL. One of these was initially captured and PIT-tagged on 6 September 2006 (223 mm FL) in the Middle Fork Hood River screw trap and recaptured in the Powerdale Dam trap on 1 July 2007 (390 mm FL). The rest were PIT-tagged in the dorsal sinus and two also were given interperitoneal radio transmitters. One bull trout shed its PIT tag in the recovery pen, which was discovered after the fish was released. In 2008, only one bull trout (485 mm FL) was caught in the trap, on 10 June. It was the same adult that had been recaptured in 2007.

In 2009, four adult bull trout were captured at the Powerdale Dam trap between 15 and 22 June, two of which had been PIT-tagged previously during their downstream migration. One fish, recaptured on 16 June 2009 (370 mm FL), was first caught in the lower Clear Branch screw trap on 22 June 2008 (200 mm FL) during the heavy spill period at the dam. The other, recaptured on 22 June 2009 (400 mm FL), was first captured in the downstream-migrant trap in upper Clear Branch (upstream of Laurance Lake reservoir) on 28 May 2007 (123 mm FL). Three of the four fish caught at the dam were given interperitoneal radio transmitters.

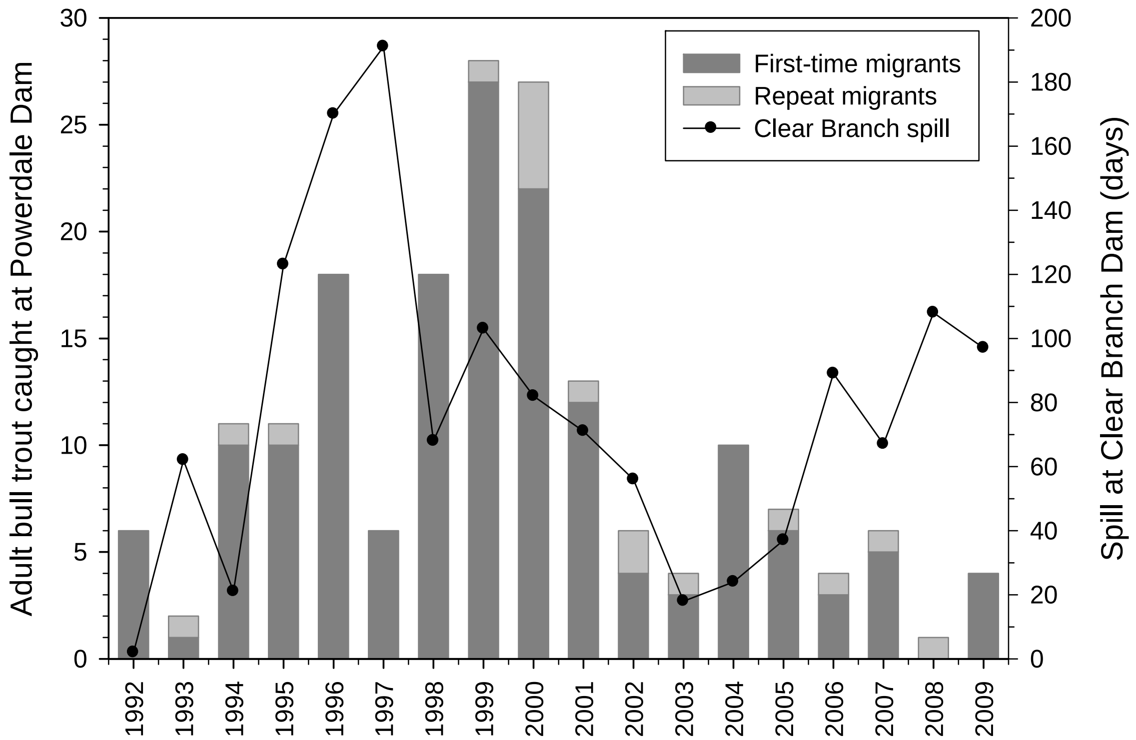

Figure 16. Catch of upstream-migrating adult bull trout at Powerdale Dam (left y-axis) on the mainstem Hood River (RK7) and the number of days per year (1 January – 31 December) spill occurred at Clear Branch Dam (RK 39) from 1992 to 2009. Spill in 2009 has been summed only through July.

Abundance and life history

Since ODFW began trapping all upstream migrants at Powerdale Dam in 1992, the trap catch has ranged from 28 adult bull trout in 1999 to a single fish in 2008. From 1992 to 2008, there have been 15 adults recaptured (Figure 16). All migrated upstream over the dam in consecutive years, two adults migrated three years in a row, and one migrated upstream in four consecutive years.

In 2006, three (of the four) bull trout PIT-tagged at the Powerdale Dam trap (RK 7) were detected upstream at the Middle Fork PIT tag reader near Dee (RK 26). Detections occurred between 29 June and 29 July and travel time over this 19 km reach ranged from 27 to 44 days. One bull trout was captured again 13 km upstream (44 days later) at the upstream-migrant trap in lower Clear Branch (RK 39) near the base of the dam.

In 2007, the Middle Fork Dee PIT tag array detected three of the five bull trout PIT-tagged at Powerdale Dam. One fish (radio-tagged "C33" in Figure 17) took three weeks to swim the 19 km to this array and was detected there repeatedly from 4 July to 16 August. The second fish ("C13" in Figure 17) made the journey in 44 days and was detected at the array from 10 to 22

July. The third fish also took three weeks to reach the Dee array, arriving on 12 July, and was detected almost daily until 16 August. The array on the Middle Fork at the mouth of Tony Creek had no detections, suggesting no tagged bull trout passed above the first new falls despite spending substantial time near its base.

Two adult bull trout radio-tagged in 2007 at Powerdale Dam were tracked at least weekly via streamside and vehicle tracking (Figure 17). Both fish spent substantial time at the base of the new falls, but never passed upstream, suggesting it was a barrier to bull trout passage. Both fish appeared to home to the Middle Fork and both also used the West Fork. Fish C13 (470 mm FL) entered the West Fork and spent about two weeks holding in the pool below Punchbowl Falls before spending at least 12 days near the base of the first new falls on the Middle Fork. This fish then fell back downstream, was recaptured ascending the Powerdale Dam fish ladder on 29 July, and moved into the Middle Fork a second time. Fish C33 moved quickly to the base of first falls, remained there at least 43 days when the transmitter signal was lost temporarily. This fish was relocated during a tracking flight on 2 October in the West Fork Hood River, near the Lake Branch confluence. It was last tracked to the West Fork on 12 October downstream 11.5 km from its previous location.

In 2008, the Dee array detected the PIT tag of C33 on 26 July and repeatedly over the next 19 days, showing similar behavior as the previous year. C33 was not recaptured at the Powerdale Dam trap in 2008, suggesting that this fish wintered in the Hood River basin upstream of the dam. The one adult bull trout radio tagged at Powerdale Dam on 10 June 2008 was observed about three weeks later in the Middle Fork (Figure 17). It spent a week about 500 m downstream of the first new falls and then was last observed in the East Fork near the Middle Fork confluence on 8 July.

Also, in 2008, three bull trout caught in the lower Clear Branch screw trap during spill were detected downstream in the Hood River basin. Two (147 and 150 mm FL) were captured in the screw trap and PIT-tagged on 21 and 23 June. One was detected at the Middle Fork Dee array several hours later that night and the other was detected months later, on 14 September. The third bull trout was PIT-tagged at the screw trap on 1 July and detected at the mouth of Clear Branch on 19 August (see Appendix B).

In 2009, all four bull trout caught at Powerdale Dam were detected at the Middle Fork Dee PIT tag reader between 2 July and 31 August, 10 to 74 days later. One was detected for a few seconds and one was repeatedly detected over nine days. The other two bull trout were also radio tagged (C99 and C100) and, after arriving at the base of the first falls, remained near there for at least 15 days (Figure 17). After this pause, C99 moved upstream of the first falls on 23 August and spent all of September within 200 m of the second falls before returning downstream of the first falls on 11 October. C100 remained in the lower Middle Fork from 4 August to 30 October.

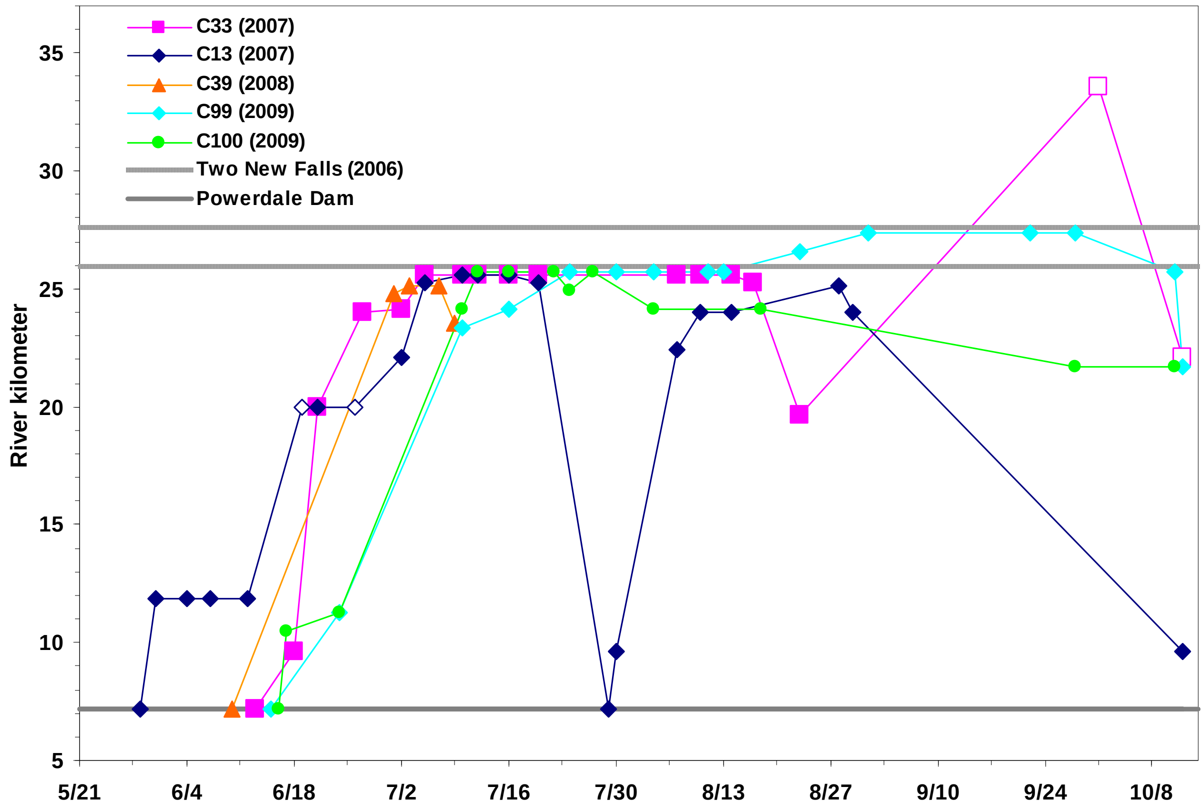

Figure 17. Tracking histories of bull trout radio tagged at Powerdale Dam fish ladder trap in 2007 (tags C33 and C13), 2008 (C39), and 2009 (C99 and C100). Open symbols for C33 and C13 represent observations in the West Fork Hood River (RK 19.5). All other observations were in the main stem Hood River and Middle Fork (RK 23). River kilometer (RK) represents distance from the Columbia River.

DISCUSSION AND CONCLUSIONS

Clear Branch local population

Population abundance

In Clear Branch and Pinnacle Creek, we estimated a total (and 95% confidence interval) of 101 (±5) adult bull trout in 2007 and 115 (±22) adults in 2008. These estimates were derived from two sources. First, we used the upstream-migrant trap count and mark-resight adult abundance estimate in Clear Branch to derive adult abundance upstream of the traps. We also conducted census redd counts and calculated adult to redd ratios in Clear Branch in 2007 (3.9 adults per redd) and 2008 (4.0). Second, assuming a similar ratio in Clear Branch downstream of the traps and in Pinnacle Creek, we expanded the census redd counts in this area to an adult abundance estimate and then summed the adult abundance estimates from the two areas.

For short periods in October in both years, leaf fall coupled with rain events damaged the weirs. As a result, some bull trout may have passed the traps uncounted. However, based on the timing of the run and trap damage, we probably missed a small number of adult fish (*N*<10). In genetic conservation criteria recommended for bull trout by Rieman and Allendorf (2001), a population size of at least 100 adults is required in order to minimize the risks of inbreeding and 1,000 adults to maintain long-term genetic diversity. Using these criteria, this small isolated bull trout population is at high risk in the short term of inbreeding and the loss of genetic diversity may threaten its long-term persistence.

In comparing the adult population estimate with the redd count in 2007 and 2008, there were approximately four adults per redd, which is unusually high compared to other bull trout populations (unpublished data, ODFW). Given the relatively small size of upper Clear Branch adults and their redds, the high adult:redd ratio may be a result of undercounting redds. It is also possible that some of the bull trout migrating from the reservoir to the creek are not successfully spawning or not attempting to spawn; rather they may be moving into the creek for other reasons (e.g., thermoregulation or food resources). Field observations suggested that mature males, which we determined by expressing milt, constituted a disproportionate number of the smaller bull trout (180-250 mm FL) caught in the upstream-migrant trap. We recommend future research to investigate if these two observations are linked and if there is a disparity in the sex ratio of this population. Such demographic issues can affect the estimate of the effective population size and increase genetic concerns associated with small population size (Rieman and Allendorf 2001).

Statistical power to detect declining trends in abundance

We focused the power analysis on declining trends because there is typically less power to detect increasing trends (Gerrodette 1987) and maximizing power to detect a decrease in this small population was the priority. The power analysis is only an approximation of our ability to detect population trend because the linear regression model itself and parameter values we chose to simulate are only an approximation of the biological reality (Gerrodette 1993). For example, assuming that the population size will change by regular increments over a period of time is almost certainly an oversimplification of what may occur naturally (Gerrodette 1993). The CVs we chose to simulate were based on the range of actual statistical and temporal variation we observed over a two year period. As a more realistic notion of sampling and temporal variation in adult population size emerges from future population estimates, we recommend that this actual variation be factored into a more complex simulation of the statistical power of this monitoring protocol to detect a population decline.

In the meantime, minimizing the sampling variation where possible is critically important. Variation can be minimized by marking a large proportion of the population or resighting a high proportion of marked fish, both of which require greater relative time and effort in the field. In 2007, we trapped from June through October, caught nearly all the adults migrating out of the reservoir and into Clear Branch, and obtained a relatively precise estimate. In 2008, we essentially shortened the trapping season by two months by beginning to mark adult fish on 18 August and still marked enough fish for an effective (although less precise) population estimate. In both years, the effort expended on the snorkel resight surveys was consistent. This effort could be expanded in the future to include all side channels, more pocket and glide habitats, and the entire spawning distribution upstream of the USFS bridge on Clear Branch. This would require an additional snorkel team or survey night. Increasing the snorkeling effort would likely result in a higher resight percentage of marked adults and would lead to a more precise estimate and improved statistical power to detect population changes.

Adult abundance estimation protocol effectiveness

The mark-resight protocol we used for estimation of adult abundance in Clear Branch was practical and effective; however, the protocol should be modified to minimize the potential problems and risks to the population. Adult bull trout were easily approached and measured by the snorkeler during night surveys. The upper caudal fin hole-punch was immediately recognizable underwater and grew back by the next year. With some caveats, weir traps worked well for both fish capture and blocking the stream. Some difficulties with the traps were the potentially long trapping period (June-October) and organic debris load and high discharge caused by early fall precipitation. When the weir traps block the entire stream, they should be checked and maintained every day (including weekends) to reduce the time bull trout are in the traps and debris accumulation on the weir. In October of both 2007 and 2008, the traps were damaged by rain events. We cleaned the trap in the morning and late afternoon when heavy rain began, but debris build up (mainly leaf fall) on the weir panels coupled with high discharge in Clear Branch made the weirs impossible to maintain for short periods when adult bull trout were still moving upstream past the traps. Although no evidence of river otters was seen in the same channel unit as the traps, otters were present nearby in Clear Branch and one may have preyed on an adult bull trout a month after it was PIT-tagged. This PIT tag was detected at the lower Clear Branch site despite no spill occurring between tagging and detection dates. Reducing the time bull trout are in the traps would reduce the risk of otters feeding at the traps.

Although we observed no decline in the number of adults and redds from 2006 to 2009, we observed negative trap effects on adults. For example, traps delayed some fish passage in both upstream and downstream directions and may have deterred some upstream passage. Also, we observed a small number of trap related injuries and two direct mortalities. We suggest using a large hoopnet with multiple fykes (at least two) in order to reduce abrasions caused by the steel-mesh traps and eliminate the risk of small adults wedging between the fyke and trap floor. Multiple fykes may reduce delay at the trap by reducing fish escape from the traps. We also recommend using the shortest trapping period possible that still results in an unbiased and relatively precise abundance estimate and increasing the snorkel effort during the resight surveys. Based on trap catches from 2007 to 2008, trapping should begin no later than mid-August to ensure a representative sample and that enough adults are marked for the resight snorkel survey.

Another option is to conduct extensive night-time snorkel surveys with large dipnets in mid-August to capture and mark adult bull trout. Then install the upstream-migrant weir trap in the first week of September (after marking >30 adults) and conduct the night-time snorkel resight survey in the second week of September. This would reduce the trapping season to less than 50 days and not require installation of the downstream-migrant trap. During the trapping season, we used a two-person night snorkeling crew to remove several adult bull trout from the deep (>1.5 m), complex pool between the traps. Adult bull trout were calm and remained in the pool as we maneuvered in position to net them.

To further reduce the risk to the population, we recommend conducting the mark-resight population estimate every second or third year and using calibrated census redd counts as an index to monitor adult abundance every year. In 2007 and 2008, census redd counts were a consistent index of adult abundance in Clear Branch upstream of the traps and merit further examination. We suggest conducting extensive redd surveys every year and the mark-resight population estimate in alternate years to calibrate redd counts to adult abundance. If redd counts continue to be a consistent index of adult abundance, the frequency of the direct population estimate can be reduced further (see **Appendix C** for census redd count recommendations).

Adfluvial life history

The bull trout population in upper Clear Branch has shifted to an adfluvial life history, using Laurance Lake reservoir for an extensive subadult period (one to two years) and throughout their adulthood. Based on scale analysis of bull trout from upper Clear Branch local population (Figure 9) and comparisons with other size-at-age studies (e.g., Fraley and Sheppard 1989), juveniles outmigrated from upper Clear Branch during the spring freshet usually at age-2. Then they reared in the reservoir for one to three years before returning to Clear Branch as adults. Adults displayed consecutive-year migrations and generally spent 30 to 50 days in Clear Branch for spawning and the rest of the year foraging in the reservoir. We found little evidence of adult bull trout residing in the stream year-round. Adult bull trout in the upper Clear Branch population were relatively small (mean, 274 mm FL; range, 177-545) when compared to fluvial adults captured at Powerdale Dam on the lower Hood River (mean, 483 mm FL; range; 355-615) (Figure 18). The relatively small size of adults was reflected in the redd size (see **Appendix C**).

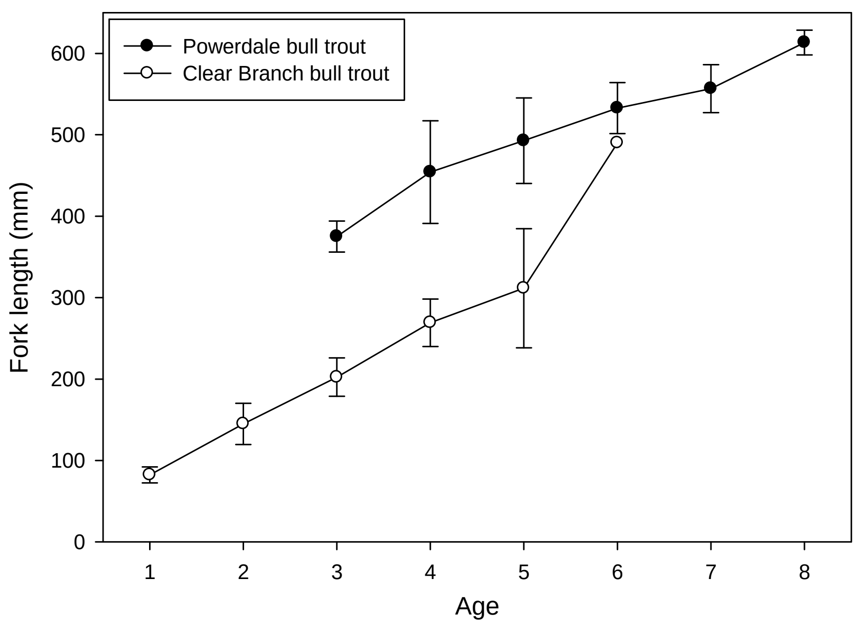

Figure 18. Mean length (with SD) at age, based on scale analysis, for bull trout caught in the Powerdale Dam trap from 1992 to 2006 (N=139) and for bull trout caught during 1995 and 1998 electro-fishing surveys of the Clear Branch local population and for bull trout caught in the weir traps in 2008 (N=117).

Limiting factors and the effect of Laurance Lake reservoir management on bull trout is currently unknown. For example, during periods of spill at Clear Branch Dam, subadult and adult bull trout (and other fish species) get entrained in the spill and are removed from the upper Clear Branch population. The magnitude of this loss and its effect on the population are unknown. Summer drawdowns are another example of a potential limiting factor that may affect bull trout growth and survival or that of forage fishes. In years with below average snowpack, such as 2006 and 2007, the reservoir was drawn down substantially during the summer and fall for power production and irrigation (Figure 19). In years with above average snowpack, like 2008, the reservoir remains full for most of the year. The Clear Branch population has been isolated by the dam in a relatively small habitat patch and at low abundance, and currently depends on the reservoir for much of its life history. Therefore, understanding limiting factors and how reservoir management may be affecting production and survival in the reservoir merits examination.

Figure 19. Lake Laurance reservoir photographed near full pool in 2007 (A1 and A2) and during summer drawdowns (B1 and B2) in 2006. Photos were taken from approximately the same location looking across the confluence of Clear Branch and the reservoir (A1 and B1) and toward Clear Branch Dam (A2 and B2).

Smallmouth bass in Lake Laurance reservoir

Our sampling in Laurance Lake reservoir in 2006 suggests the reservoir is currently providing poor habitat for smallmouth bass and the current impact of smallmouth bass on bull trout in the reservoir is minimal. Only two juvenile bass were caught during an extensive boat electrofishing effort in the reservoir. Bass were in low abundance relative to bull trout and other trout despite avoiding colder areas of the reservoir (near the mouths of Clear Branch and Pinnacle Creek) and focusing the effort on the best bass habitat during sampling. Both juveniles were age-2 and measured 90 and 110 mm total length, which represents unusually slow growth for bass relative to growth in other Oregon reservoirs. Age-2 smallmouth bass in Prineville reservoir average about 171mm and about 150 mm in Lake Billy Chinook and Brownlee reservoirs (Terry Shrader, ODFW, personal communication). This research represents a snapshot during a single year and because of the potential impact of non-native bass on native fish populations, we suggest repeating this sampling effort every five years to ensure that the bass population is consistently small and growth continues to be unusually slow. Periodic sampling of the reservoir may have the added benefit of detecting early any future illegal introductions.

Hood River fluvial bull trout

Distribution

Historical distribution of bull trout in Hood River basin is unknown as census sampling for bull trout was not done anywhere in the basin before human activities may have affected distribution. We reviewed ODFW stream survey reports from 1959 to 1993, which were conducted in East, West, and Middle fork basins. The only reference to bull trout was from an electrofishing survey in 1961 (unpublished data, ODFW) of Clear Branch upstream from its confluence with Pinnacle Creek to its forks (4 km), in which "several dozen [cutthroat trout and Dolly Varden], from two to five inches in fork length, were obtained." Furthermore, Punchbowl Falls fish ladder on the West Fork only recorded one adult bull trout capture from 1957 to 1964 (Rod French, ODFW, personal communication).

Although two observations of adult bull trout have occurred more recently – one in the East Fork (Robert Reagan, ODFW, personal communication) and another in Lake Creek in the West Fork basin (Reagan and Olsen 2008) – evidence from screw traps suggests that bull trout reproduction is limited to the Middle Fork basin. Screw traps have been operated by the ODFW Hood River Production Program in the mainstem and all forks of Hood River since 1995. During that period, juvenile bull trout have been caught exclusively in the Middle Fork trap (Reagan and Olsen 2008). Through mark-recapture of wild steelhead juveniles, trap efficiencies and population abundances have been estimated for the trapping season (April through July; median, 114 days). The Middle Fork screw trap, from 1996 to 2008, had a median trap efficiency of 9% (range, 3-18%) and median wild production in this basin was 1,050 steelhead trout and varied annually from 129 to 3,228 (Figure 20). At the same trap over the same period, this trap has captured 61 bull trout (mean, 169 mm FL) and the trap season catch ranged from 0 to 22 fish. Assuming similar outmigration timing and trap efficiency between the two species, we estimated a median of 28 bull trout pass downstream of this trap each spring, varying annually from 0 to 345 individuals (Figure 20). Screw traps in the East and West fork basins, operated from 1994 to 2008, have never caught a juvenile bull trout. These data suggest that bull trout reproduction only occurs in the Middle Fork basin and, even in this basin, appears to be limited relative to wild steelhead.

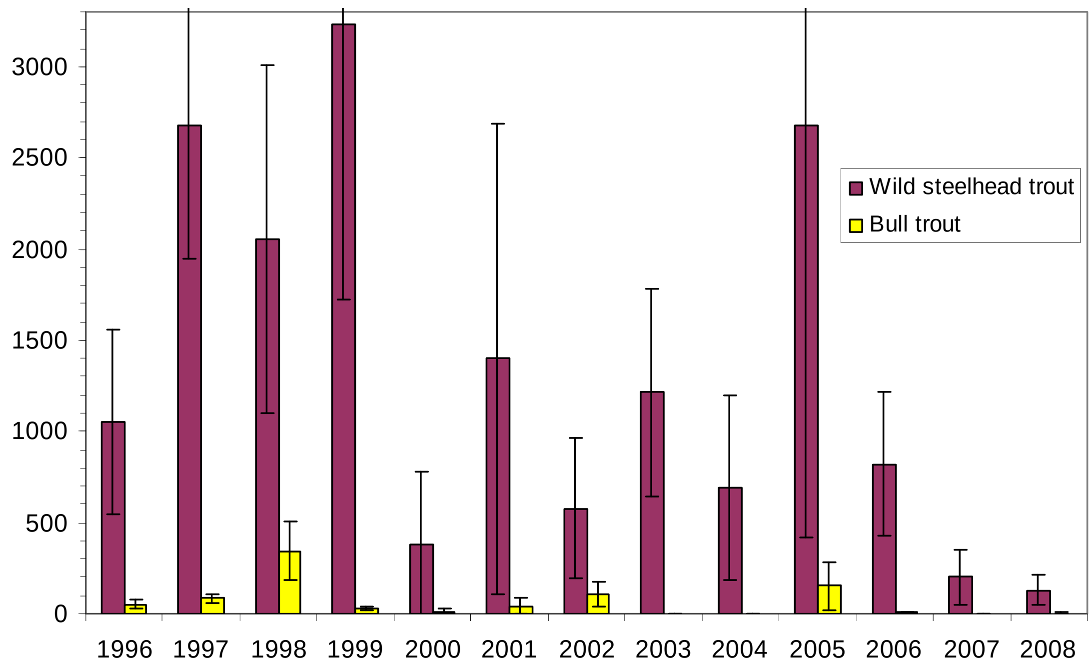

Figure 20. Estimated number (and 95% confidence intervals) of wild steelhead trout and bull trout caught in Middle Fork Hood River screw trap from 1996 to 2008.

Within the Middle Fork basin, the only known area of consistent bull trout reproduction is upstream of the dam in the Clear Branch watershed. Recent incidental sightings of bull trout have occurred in Bear Creek, Eliot Branch, and Tony Creek (unpublished data, USFS). In seven years of USFS snorkel surveys in Bear Creek, one juvenile bull trout was observed in 2000 and eggs were taken from two small redds in 1999 that were later determined to be bull trout eggs. A single bull trout was observed in 1998 in Eliot Branch near its Middle Fork confluence. In Tony Creek, a USFS snorkel surveys from 1996 to 2001 revealed no bull trout. However, during a salmon spawning survey on 7 October 2009, a solo female bull trout (~350 mm FL) was observed digging a redd in Tony Creek (Lyndsay Brewer, Confederated Tribes of the Warm Springs Indians, personal observation). Bull trout production may have also occurred recently in Compass Creek (a Coe Branch tributary). In June and July 1995, during a survey to collect samples for genetic analysis (unpublished data, ODFW), 19 bull trout were caught, ranging from 203-264 mm FL. During a USFS night snorkel survey on 20 September 1995, a USFS snorkel surveys counted nine adult-sized bull trout (range, 250-510 mm FL). Subsequent surveys in 1996 to 1999 observed zero to two bull trout. We did not observe any bull trout during electrofishing and snorkel surveys of Compass Creek in 2006. An extensive electrofishing survey was repeated in 2009 by one of the original surveyors from the genetic sampling effort in

1995 and he found no bull trout and habitat that had been dramatically simplified, probably through scouring floods (Rod French, ODFW, personal communication).
Our results from electrofishing distribution surveys and exploratory redd surveys do not prove an absence of bull trout spawning and rearing elsewhere in the Hood River basin, but they do strongly suggest that they are at least rare and inconsistent in other parts of the basin. Until the screw trap catch in the West Fork and East Fork confirms bull trout production and begin catching outmigrating juveniles, we recommend focusing any future spawning or rearing distribution surveys on Middle Fork tributaries.

Abundance and life history

The fluvial component of the Hood River local population has been at a low abundance since at least 1992, when ODFW began capturing all upstream migrating salmonids at Powerdale Dam. The single bull trout caught in 2008, which was a recapture from 2007, was the lowest abundance on record. Most adult bull trout were captured migrating upstream in May and June and were substantially larger (mean, 483 mm FL; range; 355-615) than adults in upper Clear Branch. Individual adults marked externally while ascending the Powerdale Dam fish ladder have been captured occasionally at various locations in the Columbia River (Pribyl et al. 1996). Marked adults have been caught migrating upstream in the Hood River in consecutive years (up to four years in a row), suggesting these fluvial adults generally return each year to winter foraging areas in either the Hood River below the dam or Columbia River. However, a radio-tagged bull trout in our study wintered in the Hood River basin upstream of Powerdale Dam, showing that an alternative fluvial life history pattern in the basin was at least possible.

Migrating adults caught at Powerdale Dam in this study, and in previous studies, were strongly associated with the Middle Fork basin. A telemetry study from 1997 to 2001 showed adults tagged at Powerdale Dam homed exclusively to the Middle Fork (unpublished data, USFS). However, external transmitters were lost or shed by September and no spawning information was obtained. One adult bull trout (555 mm FL) floy tagged at Powerdale Dam on 19 May 1992 was subsequently observed by a snorkeler on 26 August 1992 at the base of Clear Branch Dam (Pribyl et al. 1996). Our PIT tag tracking results confirmed this homing pattern and, in 2006, provided additional evidence of adult homing to Clear Branch.

Our objective was to gain more information on fluvial adult movement, potential passage barriers, and spawning distribution in the upper Middle Fork basin, but this was precluded by two new falls scoured into the lower Middle Fork channel in November 2006 that blocked bull trout movement to the upper basin. In 2007 and 2008, three adult bull trout radio-tagged at Powerdale Dam entered the Middle Fork by early July and spent several weeks within 200 m of the first new falls. Unable to ascend the falls, these fish then exhibited a range of movement patterns, which included one fish moving downstream below Powerdale Dam and returning again to the same new falls and another moving into upper West Fork basin during the spawning period. We did not track this fish closely enough to know if it was attempting to find other spawning habitat or thermal refugium. In 2009, all four PIT-tagged adults were detected near the base of the first new falls on the Middle Fork, generally by mid-July. One of these bull trout, which was also radio-tagged, climbed the first falls by late August, spent six weeks within 200 m of the second falls, and returned downstream on 11 October.

Source (Clear Branch) and sink (Hood River) relationship

The only known source of bull trout for the Hood River local population is from the upper Clear Branch local population. The juvenile bull trout (123 mm FL) PIT-tagged in 2007 from upper Clear Branch and and lower Clear Branch in 2008 (200 mm) that were captured as an adults (400 and 370 mm, respectively) at Powerdale Dam in 2009 demonstrated that the Hood River local population may not be an independent population. One PIT-tagged bull trout in our study caught dispersing downstream in the Middle Fork screw trap was subsequently captured at Powerdale Dam in consecutive years as a returning adult. Our detections in the lower Middle Fork of two bull trout PIT-tagged in the lower Clear Branch screw trap showed a range of downstream dispersal behavior that was consistent with the hypothesis that Clear Branch spillover bull trout may be recruited into the Hood River population. The screw trap catch in Lower Clear Branch in 2008 and 2009 suggests that substantial numbers of bull trout are passing over the dam during periods of spill. In 2008, we caught 18 bull trout despite a trapping efficiency under 30%, not trapping during the first two weeks of the eight week period of high-discharge spill, and the spill duration in 2008 was moderate compared to historical records. Also, fall and winter spill events occurred in 2008 and 2009, including the highest discharge (450 cfs), and were not evaluated in this study. Therefore, total annual number of potential spillover bull trout was likely much larger than the raw catch.

Previous studies provide additional evidence of upper Clear Branch as a source for the Hood River local population. In one study, an upstream-migrant trap operated at the base of Clear Branch Dam from 1996 to 2004 showed bull trout homing to upper Clear Branch (unpublished data, ODFW). Bull trout were only captured in this trap in 1997 and 1998, which followed two years with longest annual spill duration at Clear Branch Dam. Twelve bull trout were captured, mainly in September and October. These fish had a median fork length of 233 mm, the largest was 347mm. They were not from Powerdale Dam trap as the smallest bull trout ever caught there was 355 mm FL.

These results emphasize the importance of the upper Clear Branch population to the persistence of bull trout in the Hood River basin. They show that the upper Clear Branch population is currently the only relatively consistent source of recruitment known for the fluvial Hood River population. In order to better understand the magnitude of bull trout emigration from the upper Clear Branch population, we recommend fishing the lower Clear Branch screw trap during periods of spill (including fall and winter) and calculating its trap efficiency using other trout. Another option, in order to ensure that only (and potentially a higher percentage of) spill-over bull trout are captured is to explore the use of traps in the Clear Branch spillway settling bay. Returning adults are currently blocked from reaching their natal upper Clear Branch spawning grounds by two new falls in the Middle Fork and, should the falls erode or be breached, they are still blocked by Clear Branch Dam. It is unknown if Clear Branch spill-over bull trout, or any adult caught at Powerdale Dam, are consistently spawning and contributing to the fluvial migrant population. It is also unknown if a Hood River resident population exists and is an additional source of fluvial migrants; however, we have found no evidence that such a population exists. To account for some of these uncertainties, we recommend radio tagging Powerdale adults to gain at least one more year of migration data and attempt to determine if and where they are spawning before the removal of Powerdale Dam is scheduled to begin. In order to determine if Powerdale adults are producing offspring that return as adults or the degree to which upper Clear

Branch is the source of the Hood River fluvial population, we suggest genetically analyzing Powerdale bull trout parentage (Araki et al. 2007) and comparing allele frequencies between Clear Branch and Powerdale populations (Patrick DeHaan, USFWS, personal communication). Currently, the USFWS Abernathy Lab has genotyped 168 Powerdale bull trout and 28 upper Clear Branch bull trout for their range-wide assessment, and 40-50 more Clear Branch samples would have to be genotyped for completion of this analysis.

ACKNOWLEDGEMENTS

We appreciated the cooperation and assistance from Trent Hartill (ODFW Native Fish Investigations Project); Terry Shrader (ODFW warmwater fish biologist); Rod French and Jason Seals (ODFW District Office in The Dalles); Robert Reagan, Erik Olsen, Shane Keep, and Justin McLaughlin (ODFW Hood River Production Program); Bob Edwards and Megan Heinrich (ODFW Powerdale Dam crew); Gary Asbridge, Darcy Morgan, Katie Serres, Lauren Barcas, Kevin Swager, and Kelly Clayton (USFS Parkdale Ranger District); Dan Shively (USFS); Brad Goehring (USFWS); Pat Connely (USGS); Susan Gutenberger (USFS); Steve Stampfli and Jamie Gomez (Hood River Watershed Group); Chris Brun, Ryan Gerstenberger, Blaine Hunter, and Lyndsay Brewer (Confederated Tribes of the Warm Springs Indians); and Matt Weeber and Lisa Borgerson (ODFW). This project was funded by USFWS, USFS, and Middle Fork Irrigation District.

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APPENDIX A. Initial trap or electrofishing capture (PE) and subsequent recaptures at an upstream (US) or downstream (DS) migrant trap and PIT tag reader detections (Det) in Clear Branch 450 m upstream of Lake Laurance reservoir.

	Initial capture		1st recapture		2nd recapture		3rd recapture		4th recapture		5th recapture		6th recapture	
PIT tag code	Trap (FL)	Date	Trap (FL)/ Det (time)	Date	Trap (FL)/ Det (time)	Date	Trap (FL)/ Det (time)	Date	Trap (FL)/ Det (time)	Date	Trap (FL)/ Det (time)	Date	Trap (FL)/ Det (time)	Date
132591112	DS (110)	5/10/07	PIT (28 min)	7/27/09	PIT (1 sec)	10/3/09								
132592790	DS (119)	8/17/06	PIT (49 d)	3/21/07	PIT (5 d)	10/24/07	PIT (4 d)	8/21/08						
132628779	DS (121)	7/5/06	PIT (20 d)	6/25/09										
132591044	DS (121)	6/21/07	US (215)	9/25/08										
132591066	DS (122)	5/10/07	PIT (53 d)	10/10/07	PIT (1 min)	5/18/08								
132591050	DS (122)	6/12/07	PIT (1 min)	5/21/08										
132591069	DS (125)	5/11/07	PIT (2 hr)	8/21/09										
132590948	DS (125)	7/19/07	PIT (1 min)	5/20/08	PIT (1 min)	10/4/08								
132628729	DS (130)	6/20/06	PIT (4 d)	8/13/08	US (395)	8/18/08	PIT (1 sec)	7/18/09						
132628769	DS (138)	6/29/06	PIT (1 sec)	6/30/09	PE (138)	7/20/06	PIT (12 min)	6/30/08	PIT (1 sec)	10/10/08	PIT (1 sec)	6/30/09		
132592783	DS (140)	8/17/06	US (194)	7/20/07	PIT (1 min)	10/10/07								
132628709	DS (143)	6/26/06	US (229)	10/7/07	PIT (12 hr)	10/14/07								
132628716	DS (150)	6/26/06	US (232)	9/27/07	PIT (1 min)	10/17/07	PIT (1 d)	9/7/08	US (253)	9/8/08	PIT (5 min)	10/27/08	PIT(3 sec)	7/29/09
152366268	DS (158)	7/21/08	PIT (49 d)	8/26/08	PIT (28 hr)	9/24/09								
132589180	DS (274)	10/3/06	US (305)	8/20/07										
132590774	DS (277)	10/5/06	US (286)	7/20/07										
132628703	PE (103)	7/19/06	PIT (1 sec)	4/26/07										
132628669	PE (105)	7/19/06	PIT (2 mo)	8/2/09	PIT (18 d)	10/7/09								
132628790	PE (107)	7/19/06	PIT (1 sec)	5/10/07										
132628662	PE (108)	7/19/06	PIT (6 d)	4/23/07										
132628825	PE (108)	7/19/06	PIT (1 sec)	5/20/07										
132628666	PE (111)	7/19/06	PIT (8 d)	4/24/07										
132628817	PE (137)	7/19/06	PIT (1 sec)	9/7/09	PIT (4 min)	10/14/09								
152366244	US (180)	9/4/08	PIT (9 d)	9/25/08										
152366218	US (182)	9/19/08	PIT (2 sec)	9/12/09	PIT (3 min)	10/18/09								
152366224	US (183)	9/13/08	PIT (2 min)	8/27/09	PIT (1 sec)	10/26/09								
152366231	US (186)	9/9/08	PIT (1 sec)	9/7/09	PIT (6 min)	10/19/09								
132590931	US (190)	9/9/07	PIT (44 d)	10/18/07	US (200)	7/21/08								
152366228	US (193)	9/12/08	PIT (2 min)	11/2/08	PIT (1 sec)	9/9/09	PIT (1 sec)	10/11/09						
152366213	US (197)	9/29/08	PIT (5 min)	11/8/08	PIT (6 sec)	9/13/09	PIT (1 sec)	10/6/09						
152366232	US (200)	9/11/08	PIT (2 sec)	9/3/09	PIT (4 d)	10/7/09								
152366230	US (205)	9/10/08	PIT (1 sec)	9/16/09										
152366249	US (206)	8/31/08	PIT (5 min)	10/20/08										
152366220	US (209)	9/23/08	PIT (40 min)	10/21/08	PIT (1 d)	10/8/09	PIT (1 sec)	10/16/09						
132590889	US (212)	9/12/07	PIT (1 min)	10/11/07										

APPENDIX A. Continued.

PIT tag code	Initial capture Trap (FL)	Date	1st recapture Trap (FL)/ Detect (time)	Date	2nd recapture Trap (FL)/ Detect (time)	Date	3rd recapture Trap (FL)/ Detect (time)	Date	4th recapture Trap (FL)/ Detect (time)	Date	5th recapture Trap (FL)/ Detect (time)	Date	6th recapture Trap (FL)/ Detect (time)	Date
152366250	US (212)	8/31/08	PIT (9 d)	10/5/08										
152366223	US (213)	9/14/08	PIT (12 min)	10/20/08										
152366245	US (221)	9/4/08	PIT (1 min)	10/10/08	PIT (1 sec)	9/17/09								
152366238	US (236)	9/8/08	PIT (1 min)	10/7/08	PIT (15 min)	7/30/09								
152366284	US (240)	10/16/07	PIT (1.5 hr)	8/22/08	PIT (4 min)	10/20/08	PIT (4 hr)	7/31/09	PIT (1 sec)	10/8/09				
152366237	US (244)	9/8/08	PIT (1 min)	10/11/08	PIT (1 sec)	9/20/09	PIT (12 min)	10/10/09						
152366285	US (247)	10/22/07	PIT (1 hr)	8/18/08	US (271)	8/18/08	PIT (5 min)	10/18/08	PIT (1 sec)	7/14/09				
152366255	US (252)	8/18/08	PIT (1 min)	10/7/08	PIT (4 hr)	7/21/09								
152366247	US (254)	8/31/08	PIT (1 min)	10/4/08										
152366267	US (255)	8/12/08	PIT (1 min)	10/6/08										
152366234	US (255)	9/9/08	PIT (1 min)	10/14/08										
152366253	US (258)	8/28/08	PIT (7 min)	10/20/08	PIT (6 sec)	9/4/09	PIT (1 sec)	10/14/09						
152366219	US (258)	9/23/08	PIT (6 hr)	10/21/08										
132590925	US (260)	9/7/07	US (260)	7/26/08										
152366260	US (260)	8/18/08	PIT (1 min)	9/22/08	PIT (52 min)	7/12/09								
152366258	US (265)	8/12/08	PIT (1 min)	10/12/08										
152366242	US (267)	9/7/08	PIT (1 min)	10/7/08	PIT (21 min)	7/3/09								
152366264	US (271)	8/18/08	PIT (1 min)	10/4/08	PIT (22 min)	8/7/09	PIT (1 sec)	10/14/09						
152366257	US (277)	8/18/08	PIT (1 min)	10/7/08	PIT (31 min)	7/16/09								
152366280	US (278)	10/9/07	PIT (1 min)	10/30/07	PIT (6 days)	9/19/08	US (295)	9/25/08	PIT (14 min)	10/18/08	PIT (2 hr)	7/11/09		
152366262	US (280)	8/12/08	PIT (1 min)	10/30/08	PIT (2 hr)	7/16/09								
152366263	US (280)	8/18/08	PIT (1 min)	10/7/08	PIT (22 min)	7/4/09								
152366254	US (281)	8/29/08	PIT (1 min)	10/7/08	PIT (12 min)	7/17/09								
132590914	US (285)	8/20/07	PIT (1 hour)	10/10/07	US (294)	8/11/08	PIT (1 min)	10/9/08	PIT (1 sec)	7/23/09				
132590884	US (289)	9/11/07	PIT (1 min)	10/13/07										
132628793	US (294)	7/28/06	US (350)	9/4/07										
132590901	US (297)	9/17/07	PIT (8 d)	10/10/07	PIT (11 hr)	8/20/08	PIT (1 sec)	10/30/08	PIT (27 d)	7/27/09	PIT (10 d)	10/7/09		
152366266	US (297)	8/18/08	PIT (1 min)	10/4/08	PIT (1 sec)	7/4/09								
132592789	US (307)	8/8/06	DS (305)	10/5/06										
152366303	US (309)	9/26/07	PIT (1 sec)	10/1/09										
132590923	US (310)	8/27/07	PIT (1 sec)	8/14/09										
152366297	US (314)	9/23/07	PIT (4 hr)	8/20/09										
132590917	US (315)	8/22/07	PIT (5 d)	8/15/08	PIT (1 min)	10/4/08	PIT (1 sec)	7/9/09						
132590912	US (340)	8/9/07	DS (334)	9/28/07										
132590920	US (343)	8/26/07	PIT (1 sec)	8/12/09	PIT (1 sec)	10/2/09								
132590947	US (345)	7/26/07	PIT (18 d)	8/2/08	US (410)	8/20/08	PIT (1 min)	10/4/08	PIT (12 min)	7/20/09	PIT (2 min)	9/20/09		
132592069	US (380)	10/3/06	US (458)	8/24/07	US(500)	8/12/08	PIT (1 sec)	8/12/09	PIT (2 min)	10/13/09				
152366210	US (490)	8/20/08	DS (490)	10/1/08										
132590941	US (530)	6/27/07	PIT (28 d)	8/1/08	PIT (7 d)	9/13/08	PIT (16 min)	7/13/09	PIT (1 sec)	9/26/09				
152366241	US (222)	9/5/08	PIT (1 min)	10/7/08	PIT (1 sec)	9/21/09	PIT (3 min)	10/21/09						

APPENDIX B. Initial trapping and subsequent recaptures at Powerdale Dam fish ladder trap (US), Middle Fork Hood River (near the town of Dee) PIT tag reader or screw trap (DS), an upstream (US) or downstream (DS) migrant trap on Clear Branch 200 m downstream of the dam.

PIT tag code	Initial capture			1st recapture			2nd recapture			3rd recapture		
	Location	Trap(FL)	Date	Location	Trap (FL)/ Detect (duration)	Date	Location	Trap (FL)/ Detect (duration)	Date	Location	Trap (FL)/ Detect (duration)	Date
132591079	Upper Clear	DS (123)	5/28/07	***Powerdale***	Adult (400)	6/22/09	MFHR (Dee)	PIT (1 sec)	7/2/09			
152366291	Lower Clear	DS (147)	6/21/08	MFHR (Dee)	PIT (1 sec)	9/14/08						
152366292	Lower Clear	DS (200)	6/22/08	***Powerdale***	Adult (370)	6/16/09	MFHR (Dee)	PIT (15 days)	7/12/09			
152366279	Lower Clear	DS (150)	6/23/08	MFHR (Dee)	PIT (<1 min.)	6/23/08						
152366275	Lower Clear	DS (158)	7/1/08	Clear/Coe	PIT (6 min.)	8/19/08						
152366013	Lower Clear	DS (174)	6/5/09	Clear/Coe	PIT (1 sec)	10/12/09						
152366012	Lower Clear	DS (220)	6/29/09	Clear/Coe	PIT (2 sec)	10/25/09						
152366011	Lower Clear	DS (253)	5/19/09	MFHR (Dee)	PIT (3 sec)	7/1/09						
126967371	MFHR (Dee)	DS (223)	9/6/06	***Powerdale***	US (390)	7/1/07	Powerdale	US (485)	6/10/08			
126969350	***Powerdale***	US (530)	5/20/05	***Powerdale***	US (570)	5/22/06	MFHR (Dee)	PIT (<1min)	6/29/06			
126968232	***Powerdale***	US (505)	6/1/05	***Powerdale***	US (580)	6/16/06	MFHR (Dee)	PIT (<1 min)	7/13/06			
126968178	***Powerdale***	US (380)	6/16/06	MFHR (Dee)	PIT (<1 min)	7/29/06	Lower Clear	US (380)	9/11/06			
132591127	***Powerdale***	US (480)	5/27/07	MFHR (Dee)	PIT (17 days)	7/5/07						
126969935	***Powerdale***	US (455)	6/21/07	MFHR (Dee)	PIT (34 days)	7/12/07						
132591083	***Powerdale***	US (530)	6/13/08	MFHR (Dee)	PIT (41 days)	7/4/07	WFHR	Radiotracked	10/10/07	MFHR (Dee)	PIT (>19 days)	7/26/08
152366209	***Powerdale***	US (370)	6/15/09	MFHR (Dee)	PIT (11 days)	7/24/09	MFHR (Dee)	PIT (1 sec)	10/11/09			
152366203	***Powerdale***	US (430)	6/18/09	MFHR (Dee)	PIT (8 days)	8/31/09						

APPENDIX C. Upper Clear Branch and Pinnacle Creek census redd survey recommendations.

Zero counts: During August spawning surveys in 2006 to 2009, shortly before bull trout began spawning in Clear Branch and Pinnacle Creek, 2 to 10 cutthroat or rainbow trout redds still had the characteristics of countable redds and could possibly be confused as bull trout redds if surveys began in September. This requires that before bull trout spawning begins zero counts must be conducted. This entails flagging still visible redds from other trout. These spawning areas still need to be checked during bull trout spawning surveys because bull trout often spawned later in the same location. Ideally, the same surveyor will be used throughout the census, including the zero count, to maximize consistency and accuracy of the redd count.

Spawning timing and survey timing: From 2006 to 2008, bull trout began spawning in mid-September and ended from mid-October to early-November. Spawning surveys should occur at two or three week intervals to minimize the risk that new redds are not observed because high water events obliterate them or natural aging of the redd obscures its visibility to the observer.

Redd dimensions and shapes: Redds in Clear Branch and Pinnacle Creek varied from fluvial migrant- to resident-sized and also varied in shape (Figure 21). We measured maximum lengths and widths for each redd. For adjacent redds, also known as clusters, we counted each distinct pocket-mound complex. Test digs were counted and were generally shorter than 40 cm in length.

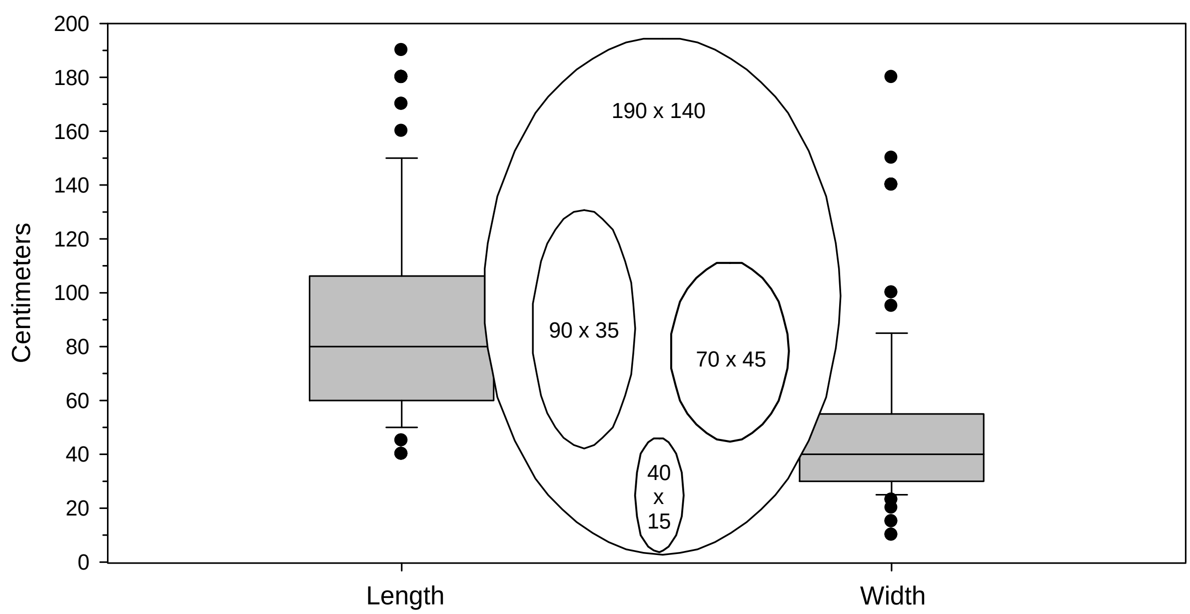

Figure 21. Length and width of all redds measured in Clear Branch from 2006 to 2009 and idealized representations of the smallest, two median, and the largest redds (cm) observed during this period. Box plots display the median (solid line), two middle quartiles (box), 5th and 95th percentiles (whiskers), and outliers (black dots).

Spawning distribution and habitat: From 2006 to 2008, bull trout spawned in gravel exposed by summer reservoir drawdowns to impassable barriers at the upstream end of the bull trout distribution. Bull trout redds were observed in most of the large secondary channels and under overhanging vegetation and instream large wood. Extensive surveys should therefore start at the reservoir shoreline, continue upstream to these barriers in the Clear Branch forks and all major secondary channels should be surveyed.

Redd clusters and superimposition: If there were two (or more) distinct but adjacent pocket/mound complexes, each complex was counted as an individual redd. If there was embedded cobble or boulder splitting an apparent cluster, it was assumed one female was digging and worked around embedded substrate and one redd was counted. As consistency is most important for calibrating census redd counts with the adult population estimate, the criteria for dealing with potential redd clusters should be discussed prior to each survey season.

Spawning substrate: Spawning gravel size generally ranges from 2-64 mm. In general, redd gravel size is positively correlated to the size of the redd-building fish.

Redd location: Spawning gravels tend to settle in low velocity areas in the stream such as pool tailouts, stream margin, low slope reaches (0-1.5%), reaches with groundwater infiltration or springs, behind instream large wood and boulders. Water depth is generally 20-80 cm. *Caveat*: Veteran surveyors continue to be surprised by the unexpected location of a new bull trout redd. Bull trout redds have been seen in water depth as shallow as 5 cm and on gravel patches as small as 75 cm^2. Also, bull trout often dig redds under cover so one must look under overhanging riparian vegetation, instream large wood and boulders, and undercut banks.

Pocket and mound: Females dig in the gravel, gravel is briefly suspended in the water column and settles out just downstream, thereby creating a pocket upstream and an adjacent mound of gravel downstream. *Caveat*: Sometimes the pocket-mound shape is not discernible. Depending on the size of the fish building the redd, a redd can be 15 to 250 cm long.

Color contrast: New redds usually appear brighter than the surrounding stream bottom. Most stream substrate has a thin (and slippery) layer of photosynthetic algae (and other microorganisms) growing on the side exposed to the sun. In contrast, no algae grow on the unexposed side. When substrate is turned over by a redd-building fish, the redd appears as a bright patch surrounded by a darker matrix. *Caveats*: With time, algae grows and the brightness of the redd will fade to the same shade as the matrix. Water flow (hydraulic scour) can also turn over substrate and create a color contrast similar to redds. In basins with light colored substrate, such as granite, the color contrast between the redd and the surrounding matrix is not as distinct. Foot or hoof prints in the gravel may also produce the color contrast.

Redd gravel orientation: Relative to the surrounding substrate matrix, gravel in a redd mound appears unembedded and disordered, some say it looks "fluffed up." *Caveat:* This is probably the most subjective of the redd characteristics and difficult to recognize, but in small redds (in which the pocket and mound may not be discernible) it is an important characteristic to be aware of.

Redd pocket edge: Along the edge of the redd pocket, there are two things to look for. First, there is often a distinct erosional line where the fish stopped digging; and second, on individual, recently-exposed cobbles and boulders embedded in the pocket, a light/dark contrast line may be discernible. *Caveat:* It is easier to see than it is to explain.

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