Effective Population Size and Connectivity of Bull Trout in the Imnaha River Subbasin

2006 Annual Report

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Introduction

Bull trout (*Salvelinus confluentus*) were listed as threatened on November 1, 1999 (USFWS 1999). Previously, the Columbia River distinct population segment (DPS) of bull trout had been listed as threatened since June 10, 1998. Factors contributing to the listing of bull trout include range wide declines in distribution, abundance and habitat quality. Land and water uses that alter or disrupt habitat requirements of bull trout can threaten the persistence of the species. Examples of such activities include: water diversions, dams, timber extraction, mining, grazing, agriculture, and channelization of streams. These threats are prevalent throughout the Columbia River basin (USFWS 2000, 2002a) in addition to other threats such as nonnative fish competition and/or hybridization, poaching, and past fish eradication projects.

Within the Columbia River DPS and Imnaha-Snake Recovery Unit, there are three core areas, one of which is the Imnaha Core Area which consists of five putative local populations (the Imnaha River above the mouth of Big Sheep Creek, upper Big Sheep Creek above the Wallowa Valley Improvement Canal (WVIC) and in the canal, lower Big Sheep Creek below the WVIC, Little Sheep Creek, and McCully Creek; Figure 1). The resident population in Big Sheep Creek is estimated at less than 2,000 individuals, above and below the WVIC and including all tributaries (USFS 2001). The resident population in Little Sheep Creek is estimated at fewer than 500 (USFS 2003). The resident population of McCully Creek, which formerly flowed into Little Sheep Creek, is estimated at approximately 2,500 individuals (Smith and Knox as referenced in Buchanan et al. 1997). Historically, these populations could have been connected by migratory individuals and functioned as a single meta-population. However, the construction of the WVIC has potentially prevented gene flow or allowed only unidirectional movement downstream for over a century.

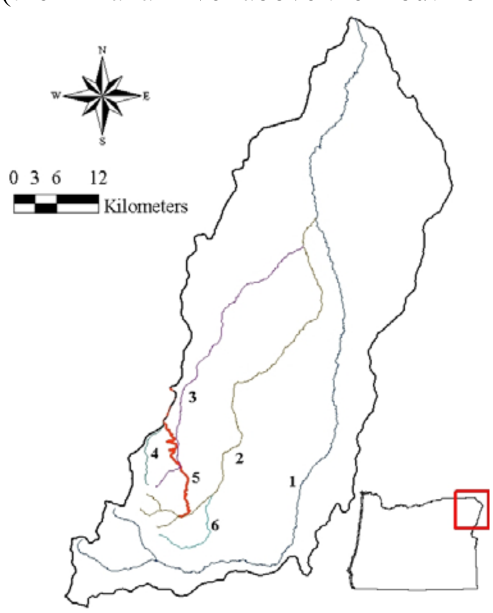


Figure 1. Study Area - 1. Imnaha River; 2. Big Sheep Creek; 3. Little Sheep Creek; 4. McCully Creek; 5. WVIC; 6. Lick Creek

The WVIC is a water diversion in northeastern Oregon that has impacted bull trout and their habitat. The canal was constructed in the 1880s and diverts water from several Imnaha River subbasin streams between Big Sheep Creek and McCully Creek to Prairie Creek in the Wallowa River basin (Figure 1). The diverted water is primarily used for irrigation purposes.

During the construction of the WVIC, structures were built that create potential barriers for fish passage. These structures allow downstream passage while potentially blocking upstream migrations. Big Sheep Creek is the most upstream tributary that is diverted by the WVIC. Possible barriers are located at the diversion on Big Sheep Creek and within the canal at the Salt Creek summit spillway (Figure 2a-2b), approximately one kilometer above the confluence of the WVIC and Little Sheep Creek. The construction of these sites have potentially created and isolated a population of bull trout in upper Big Sheep Creek for the past century. The canal has also diverted and isolated numerous small tributaries and streams from their historic drainages, including Salt Creek, Cabin Creek, Little Sheep Creek, Redmont Creek, Canal Creek, and Ferguson Creek. At Little Sheep Creek there is a culvert approximately 200 m above where the WVIC diverts the stream that could impact upstream migration of bull trout and isolate a population above (Figure 2c). The WVIC does not divert McCully Creek. Instead, the WVIC has been carried over the top of McCully Creek since the 1880s and some water from the canal is diverted into the creek (Figure 2d) between May and October, during irrigation season. It is not likely that much, if any, immigration into McCully Creek is occurring through this diversion given the physical structure being used. This diversion outlet is believed to be impassable from

a) b)

c) d)

Figure 2. Potential barriers to upstream migration of bull trout in the Big Sheep Creek drainage of the Imnaha River subbasin – a) WVIC diversion at Big Sheep Creek; b) WVIC diversion at Salt Creek Summit; c) culverts under USFS road #130 on Little Sheep Creek, d) WVIC diversion at McCully Creek.

the downstream side as well, preventing any movement from McCully Creek into the WVIC. In addition, McCully Creek no longer drains into the Imnaha subbasin. The stream bed was shifted near the beginning of the 20th century so that the creek now drains directly into the Wallowa Valley and provides for irrigation. Therefore, another potential but unlikely source of bull trout immigration into McCully Creek would be from the Grande Ronde River subbasin, through a series of irrigation canals that most likely act as temperature barriers. Thus, it is reasonable to speculate that the bull trout population in McCully Creek is isolated. Despite the existence of these potential isolating mechanisms, small bull trout populations persist in all of these streams above the WVIC. A more detailed physical description of the Imnaha River subbasin and the streams supporting bull trout can be found in Chapter 12 of the Draft Bull Trout Recovery Plan (USFWS 2002b).

Population genetic theory indicates that an effective population size (N_e) ≥ 50 is necessary to prevent inbreeding depression, and an $N_e \geq 500$ is necessary for sustainability over ecological time (Franklin 1980, Soulé 1980, Allendorf and Ryman 2002). It is likely that this theory holds true for bull trout, although exceptions do exist (Rieman et al. 1997, Whitesel et al. 2004). However, departures from the 50/500 concept associated with N_e should be supported by empirical data that is robust and well described (Whitesel et al. 2004). Potential information that relates effective population size theory to absolute abundance and population genetic variability would provide information toward defining minimum viable population objectives.

The goal of this project is to provide empirical data toward defining minimum viable population objectives and limit factors that can be used for restoration and recovery of bull trout across the range. The objectives toward this end are to: 1) Determine abundance of bull trout populations above the WVIC; 2) Determine bull trout connectivity (movement) between populations; 3) Determine within and among population genetic variability for the four local populations of the Imnaha Core Area; 4) Determine effective population size for isolated populations above the WVIC.

The study area provides a unique opportunity to test population genetic theory and provide empirical data toward bull trout recovery. There are several barriers that act as potential points of isolation and that have existed for known periods of time. These barriers lend themselves to remote monitoring via PIT tag technology. Taking this approach will provide the opportunity to confirm if and when movement is occurring between populations and that the movement is unidirectional.

The amount of time these populations have potentially been isolated from one another can be determined from historical records. If these small populations have been isolated without any influx of gene flow, genetic drift has likely occurred over the past century (Hartl 1988). These populations have continued to persist, however, after the construction of the WVIC. They now exist in a series of populations differing in abundance (Buchanan et al. 1997). Reduced effective population sizes (N_e) and continued persistence of small, isolated populations in this study area provide the opportunity to look at various levels of N_e to absolute population size ratios (N) in bull trout. These N_e:N ratios can then be compared to genetic variability present. The resulting dataset will provide guidance toward defining minimum viable population objectives.

Recovery actions are identified that, if implemented, will restore connectivity and opportunities for migration between these streams (Ecovista 2004, USFWS 2002a). Though desirable and beneficial to the resource, the restored connectivity will cease to present the unique situation described above where separate populations with known isolation dates exist to test fundamental genetic theories and issues associated with population viability. Currently, there exists presumably, small populations that are potentially isolated and have been persisting in the current state for over 100 years. Therefore, the study area provides the opportunity to investigate how these populations are persisting, with respect to degrees of immigration/isolation and effective population size, investigate how well these populations are persisting, with respect to population size and genetic variability, and provide empirical data to verify theoretical models of effective population size and persistence. Understanding these relationships will provide information toward range wide restoration and recovery of bull trout populations.

Methods

Abundance

To estimate abundance of adult bull trout, three consecutive mark-recapture trips were completed between July 7 and August 20, 2006 in upper Big Sheep Creek. Trips ranged from five to eight days in length, allowing five to six days between trips with no sampling to provide for population mixing. All probable and accessible habitats were sampled including tributaries, springs, and side channels within the system.

The primary sampling site was approximately an 8 kilometer portion of Big Sheep Creek, beginning at the WVIC diversion structure and continuing upstream to a series of impassable natural waterfalls. The 8 kilometers were then divided into 30 individual reaches including the mainstem, the south fork, the north fork, and a large side channel that circumvents a series of barrier falls. These reaches represented nothing other than a sampling segment. The 24 reaches on the mainstem ranged from 78 m to 310 m, averaging 230 m. There was one reach on the south fork that was 165 meters, ending at the crossing of US Forest Service Road 100. There were two reaches on the north fork that were 61 m and 232 m. There were three reaches on the side channel of the main-stem that were 311 m, 290 m and 368 m. Sampling also occurred in the first 100 meters of the un-named tributary entering Big Sheep Creek at reach UBSC15 near the first set of meadows. The north fork was not sampled after the first pass because no bull trout were captured during the first pass and habitat was not considered suitable. Due to dangerous access, the reach between the first and second major waterfall (approximately 3 km above the WVIC diversion), around which the side channel flows, was not sampled. However, the majority of this reach is high gradient cascades and is not accessible from downstream, both of which decrease the likelihood that a large number of fish hold in this reach long.

The multiple pass mark-recapture approach was determined to be the most effective and efficient sampling method to estimate accurate and precise population abundances (Cook and Hudson 2008). The sampling method consisted of backpack electrofishing upstream, using a Smith-Root model LR-24 shocker. Electrofishing was conducted using a technique to reduce potential harm to the sampled population. Specifically, only areas considered holding habitat (plunge pools, overhanging banks, eddies, large woody debris, and pocket pools within riffles) were sampled in a “stalk and shock” approach. Two to three netters worked with one electrofisher and fishing efforts were similarly conducted for each pass. The LR-24 shocker used pulsed direct current set at a frequency of 25 Hz, 14-16% duty cycle, and voltage between 300 and 500 V. All settings were subject to modification depending on conditions (i.e. water depth, conductivity, flow).

At the completion of each reach, all captured fish were identified, measured (fork length), weighed, and scanned for passive integrated transponder (PIT) tags. Fish were anesthetized using

25 ppm clove oil. Scissors were used to collect a genetic sample from the left pelvic fin of all bull trout upon initial capture. The samples were preserved in a vial of ethyl alcohol. For bull trout greater than 120 mm, a PIT tag (23 mm long, 3.84 mm diameter, 0.6 g, full duplex) was surgically implanted on the ventral side, anterior to the pectoral fins (Zydlewski and Hill *unpublished protocol*). After full recovery within an aerated bucket, fish were released near their point of capture.

Capture-recapture data was analyzed using CAPTURE (Otis et al. 1978; White et al. 1982; Rexstad and Burnham 1991) within MARK (White and Burnham 1999). CAPTURE was used to help determine the most appropriate estimator (M_o [null estimator], Jackknife M_h, Darroch M_t , Chao M_{th}, Chao M_t , and Chao M_h), but assumptions and variables associated with the choice of the most appropriate estimator were also considered. CAPTURE was used to determine confidence intervals around the estimate, the coefficient of variation, and the probability of capture. Length-frequency histograms and linear regression were also used to qualitatively and quantitatively analyze the relationship between probability of capture and size class.

Movement

Movement within streams was assessed between multiple pass sampling efforts. Recaptured individuals were analyzed with respect to size and distance in meters each moved to determine if there was a relationship. Direction (i.e., upstream or downstream) of movement was also considered. Movement was determined by calculating the distance to the midpoint of each reach as well as total reach length. These measures were then used to sum up an approximate distance a fish travelled from one reach to another. Movement data between each pass was analyzed using linear regression to determine if there was a significant relationship between size and distance moved. If that relationship was not statistically significant, but the y-intercept was significant, then distance moved by fish on average is reported.

Movement among streams was determined using PIT tag technology (Zydlewski et al. 2001). Remote PIT tag antennae arrays were used to monitor the movement of PIT tagged fish at three locations: the Big Sheep Creek/WVIC diversion, the Salt Creek summit spillway (5.9 kilometers down the canal), and the intersection of the WVIC and McCully Creek (21.2 kilometers down canal). Each location presented challenges associated with physical structures, remoteness, and seasonal accessibility and functionality.

Antennas were constructed as open coil inductor loops with PVC-coated multi-strand wire strung through PVC pipe, or encased within a flat panel PVC sheet design. The antennas were then connected to a transceiver (Destron Fearing FS1001M) that emits a 134.2 kHz electromagnetic energizing signal through the antenna. A field PC received serial data output from the reader at each site; detected tag identification numbers, date and time of detection were recorded. The transceivers, batteries and/or power supplies, and PCs were housed within a weather-proof box located outside of the immediate flood zone of the streams. Antennas located at remote sites were powered with propane fueled thermoelectric generators.

A PIT tag antenna was installed at the McCully Creek/WVIC junction in April 2006. The purpose of this antenna is to detect movement from the WVIC into McCully Creek. Movement back into the WVIC from McCully Creek is improbable due to the diversion structure (Figure 2d). The antenna was operated from the time of installation prior to the diversion gate being opened in late May until October subsequent to closing the diversion gate for the year.

In October 2006, two sets of PIT tag antennas, or arrays, were installed downstream of the Big Sheep Creek sampling area. The first array was installed at the WVIC diversion on Big Sheep Creek, directly below the start of sampling for the mark-recapture component of the study (Figure 6). The second array was built on a structure within the WVIC at the Salt Creek summit spillway, approximately 8 kilometers down the canal from Big Sheep Creek (Figure 7). At both study locations, two sets of antennas, one upstream and one downstream, were installed allowing for determination of directional movement. Monitoring began at the Salt Creek summit site on October 16, 2006 and was maintained through the end of 2006. The Big Sheep Creek antennas operated only one week following their installation on October 27, 2006. Snow and severe weather conditions prevented access to this remote site on a regular basis. Resumed operation of the array is scheduled for June 2007.

Population Genetic Structure

The implementation of tissue collection tasks associated with this objective was coordinated with activities being conducted to determine movement and population abundances. Genetic variability within and among populations will be determined using an approach similar to Spruell et al. (2003). Microsatellite markers that have been developed for bull trout molecular analysis will be utilized to describe within and among population genetic variability (DeHaan and Ardren 2005) on two geographic scales; one that considers the entire Imnaha subbasin a single metapopulation and one that considers bull trout in each tributary a distinct, potentially isolated, population. Genetic measures to be examined include absolute diversity, diversity and relatedness between putative populations, and observed and expected Hardy-Weinberg relationships.

Effective Population Size

Effective population size will be estimated using demographic and genetic approaches. Using a multi-faceted approach will help identify and eliminate any confounding factors in the data analysis. Demographic estimation of effective population size will follow Hill (1972) and Nunney (1993). Population parameters that will be used to estimate effective population size will be sex ratio, adult life span, generation time, standardized variance in life span, and standardized variance in reproductive success. Effective population size will be estimated using genetic tools (for example, see Nielsen 1997). Using a maximum likelihood approach, effective population size can be estimated from microsatellite markers that will be utilized for population genetic structuring along with demographic information. The implementation of fish and tissue sampling tasks associated with this objective will be coordinated with activities being conducted to determine movement and estimates of population abundance.

Results

Tasks accomplished in 2006 included completed population abundance estimate of Big Sheep Creek above the WVIC; sampled high meadow reaches of Big Sheep Creek to assess the upper distribution threshold of bull trout; increased sample efforts in various areas of the WVIC to expand sample size of PIT-tagged bull trout in the canal and Little Sheep Creek; installation of PIT tag antenna arrays at McCully Creek/WVIC junction, Salt Creek summit spillway, and Big Sheep Creek diversion; and gathered genetic samples from Big Sheep Creek and Little Sheep Creek as well as numerous locations throughout the WVIC.

Abundance Estimates

An abundance estimate of Big Sheep Creek above the WVIC was conducted from mid-July through August. Three mark-recapture passes were conducted through Big Sheep Creek from the canal diversion structure upstream 5.9 kilometers to the impassable gradient falls that come down from Bonnie Lakes. High meadow reaches of Big Sheep Creek, above the gradient falls, were sampled to assess the upper distribution limit of bull trout within the watershed. No fish were collected in this sampling effort. The only aquatic species observed were amphibians.

Over the three passes, a total of 652 fish ≥ 120 mm were captured, 197 of which were recaptures of fish captured and tagged in 2006, and therefore were considered in the abundance estimate (Table 1). In addition, a total of 44 bull trout were captured in 2006 that were previously tagged in 2005 (Cook and Hudson 2008). These fish were considered a capture on the initial 2006 capture, not a recapture (Table 1). The three pass abundance estimate for bull trout ≥ 120 mm was N=610 ± 24.3 (95% CI 569-664) (Table 2). The abundance estimate determined from the first two passes only was not significantly different than the three pass estimate (N=615 ± 50.2; 95% CI 534-732). Both of these estimates resulted in similar probability of capture across passes (Table 2). Three pass abundance estimates were also generated for bull trout ≥ 150 mm (N=388 ± 16.0; 95% CI 362-425) and bull trout ≥ 180 mm (N=213 ± 10.8; 95% CI 197-239). Abundances estimated for discrete size classes (Table 3) indicate the population size approaches 50 individuals for bull trout greater than or equal to 210 mm.

Table 1. Capture results for all 2006 electrofishing efforts; 2006 recaptures are the number of unique tags captured from the prior pass/passes (does not include duplicate recaps within a pass); 2005 recaps were collected from fish tagged during 2005 efforts.

Site	Pass	Number Captured ≥ 120 mm	Number Tagged	2006 Unique Recaps	2005 Unique Recaps	Genetic Samples ≥ 100 mm
Big Sheep	1	173	158	0	13	172
	2	238	156	68	14	170
	3	241	96	128	17	114
	Total	652	410	196	44	456
Canal	1	8	7	0	1	7
	2	19	19	0	0	26
	3	15	11	4	0	18
	Total	42	37	4	1	51
Little Sheep	1	5	5	0	0	5
	2	11	9	2	0	12
	3	14	11	4	0	13
	Total	30	25	6	0	30
Overall Total		724	472	206	45	537

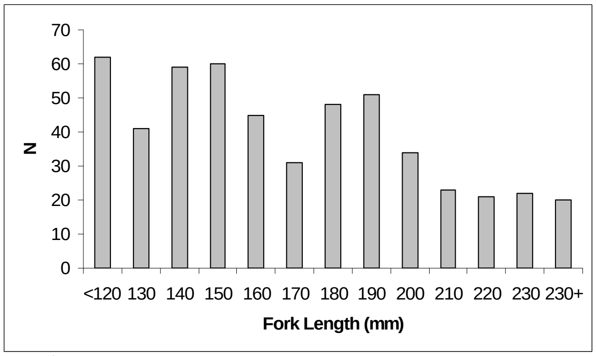
Table 2. Abundance estimates, standard error, confidence intervals, probability of capture and coefficient of variation around the mean for all bull trout ≥120 mm – 3 pass, all bull trout ≥120 mm – 2 pass, all bull trout ≥150 mm – 3 pass, and all bull trout ≥180 mm – 3 pass.

Abundance Estimate	N	SE (±)	95% CI	Probability of Capture	Coeffecient of Variation
≥120 mm 3 pass	610	24.3	569-664	.35	4.0%
≥120 mm 2 pass	615	50.2	534-732	.33	8.2%
≥150 mm 3 pass	388	16.0	362-425	.39	4.1%
≥180 mm 3 pass	213	10.9	197-239	.41	5.1%

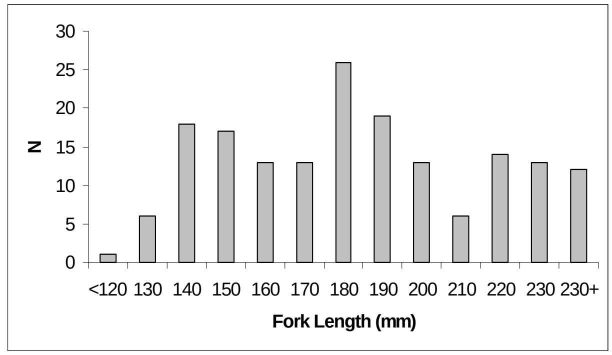
Table 3. Abundance estimates, standard error, confidence intervals, probability of capture and coefficient of variation around the mean for bull trout 120-149 mm, 150-179 mm, 180-209 mm and ≥ 210 mm. All data based on three passes through study area.

Abundance Estimate	N	SE (±)	95% CI	Probability of Capture	Coeffecient of Variation
120-149 mm	239	24.9	201-300	.25	10.4%
150-179 mm	176	12.3	158-207	.36	7.0%
180-209 mm	148	12.1	130-178	.35	8.2%
≥210 mm	73	3.9	68-84	.52	5.3%

Qualitative comparison of length-frequency between all fish captured and all fish that were recaptured suggest differences in capture probability by size due to the dissimilarity of the two histograms (Figure 3). Linear regression of capture probability against size class indicate a positive relationship between the two that is not statistically significant ($r = 0.92$, $p = 0.075$; Figure 4). Abundances estimated for discrete size classes support this information, indicating higher capture probabilities for larger size classes (Table 3).



a.)



b.)

Figure 3. 2006 length-frequency histograms of a) all bull trout captured and b) bull trout that were recaptured.

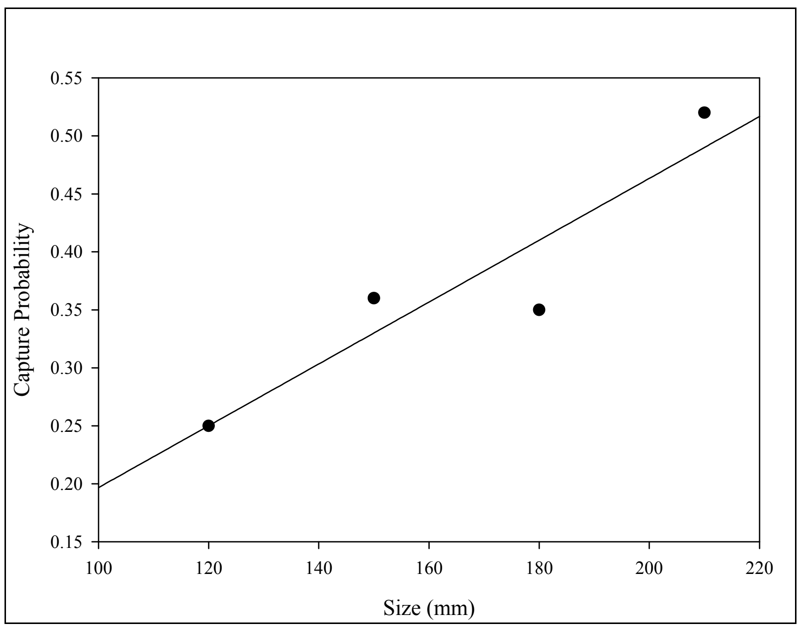
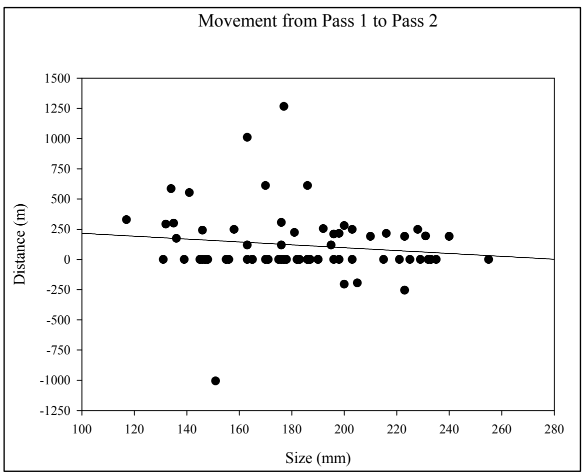


Figure 4. Linear regression of capture probability against size for bull trout captured in Big Sheep Creek, 2006.

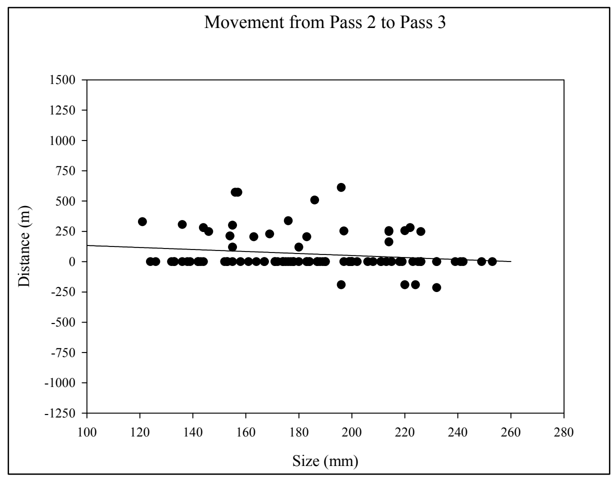
Electrofishing effort was similar for the first two passes and higher for the third pass. Total electrofishing effort was 7.1 hours (0.23 hours/reach) for pass one, 7.5 hours (0.26 hours/reach) for pass two, and 11.0 hours (0.39 hours/reach) for pass three. The increased effort on the third pass does not affect estimates of abundance, given that the assumptions of the mark-recapture estimator were not violated: 1) a closed population; 2) random distribution of marked and unmarked individuals; and 3) no difference in capture probability between marked and unmarked fish (White et al. 1982; Rosenberger and Dunham 2005).

Movement

Movement of individuals within Big Sheep Creek between pass 1 and pass 2 ($r = 0.13$, $p > 0.05$) as well as between pass 2 and 3 ($r = 0.18$, $p > 0.05$) did not indicate that there was a relationship between bull trout length and distance moved (Figure 4). These analyses did not include one outlier (427 mm) that moved upstream 2,211 m between pass 1 and pass 2 and did not move between pass 2 and 3. Linear regression of the residuals supported removing this individual from analysis. Interestingly, this same fish is further referenced below in a detection at a PIT tag antenna on McCully Creek. With the exception of 18 individuals, all bull trout were recaptured within 300 m above or below the previous point of capture. The distance and direction that fish moved on average between pass 1 and pass 2 was not significant. However, on average, fish moved upstream 216 m between pass 2 and pass 3 ($p = 0.02$). Movement over all three passes varied from as much as 2,211 m of upstream migration to 1,006 m of downstream migration with a mean travelling distance of 99 m ± 21.4 (95% CI 42-56). All documented movement was upstream, with the exception of eight bull trout that were recaptured between 191 to 1,006 m downstream from their initial point of capture.



a)



b)

Figure 4. Migration of recaptured bull trout from passes 1-2 (a) and from passes 2-3 (b).

Various areas of the WVIC below Salt Creek summit were sampled to increase the number of bull trout PIT-tagged in the canal. Little Sheep Creek was also sampled on all three of the trips from the confluence with the canal up to the culvert (Table 1).

Five antenna arrays were constructed in 2006 at three separate locations (Big Sheep Creek diversion, Salt Creek summit, and McCully Creek). Through the detection of tagged fish at these sites we were able to begin tracking directional and temporal movement patterns within the system. They also provided data regarding the potential connectivity between upper and lower McCully Creek, upper and lower Big Sheep Creek, as well as above and below the Salt Creek summit structure and throughout the WVIC.

Fish movements have been detected at two of our PIT tag antenna sites. The first detection occurred at the McCully Creek/WVIC intersection on October 19, 2006 and involved one of the largest fish captured all year. A bull trout that was estimated to be 427 mm was caught on all three trips within Big Sheep Creek and was detected passing through the small diversion structure that dumps water from the WVIC into McCully Creek. This individual traveled 24.7 km from its last known point of capture to the McCully Creek location.

The lower of the original two antennas at the Salt Creek summit spillway recorded multiple detections of four individuals in the spillway plunge pool during October and November of 2006. All of these fish were captured, tagged, and released within the WVIC in 2006 between 0.5 and 3.2 km below Salt Creek summit. The upper antennas did not detect these fish and is evidence that these fish did not pass the spillway.

Problems did arise with successfully maintaining all the antennas throughout the season. Due to winter weather conditions and remote access, antennas were difficult to keep in functioning condition. The inability to get into Big Sheep Creek prevented maintenance of that array through the winter months, resulting in no power source (i.e., no propane) to operate the equipment. Also, the suspended antennas often collected heavy snowfall and ice buildup causing them to collapse (Figure 5), with the exception of two antennas at Big Sheep Creek that are sheltered by a catwalk over the diversion structure.

a)

b)

Figure 5. Antenna arrays constructed at Big Sheep Creek (a) and Salt Creek summit (b) and the subsequent damage caused by snow and ice.

Population Genetic Structure

As part of the electrofishing sampling efforts, fin clips were taken for genetic analysis. Samples were collected from 456 individuals in Big Sheep Creek, 30 in Little Sheep Creek, and 51 in the WVIC below Salt Creek summit (Table 1). Genetic analysis has yet to commence for these collected samples.

Findings

Sampling during 2006 provided a variety of interesting findings. The absence of bull trout above the upper set of waterfalls (5.9 km above the diversion structure) provided evidence that a natural boundary for the upper distribution limit of bull trout occurs in Big Sheep Creek. By finding fish above the other two substantial waterfalls within the system, we can assume that the long side channel is or has historically been used to bypass these barriers and utilize available habitats above and below. This is also supported by the capture of one individual in the side channel on the first two passes and on the third pass the fish was recaptured in the mainstem, downstream of the side-channel.

According to population genetic theory, Big Sheep Creek's bull trout population could be large enough to prevent inbreeding depression (Ne $\geq$ 50) and may be sustainable over ecological time (Ne $\geq$ 500). Determining what the current Ne is using demographic means, is dependent on defining the size of the adult population and sex ratio. There appears to be an annual emigration of at least a few fish, but we have yet to determine if there is any form of immigration to the population, which would ultimately affect population persistence.

The only evidence of any possible migration into Big Sheep Creek above the WVIC is from the captures of two substantially larger and potentially fluvial individuals. These two fish had estimated lengths of 427 mm and 465 mm with the third largest fish measuring 327 mm. These large fish may indicate that passage might occur during certain conditions at either the diversion at Big Sheep Creek or at the spillway at Salt Creek Summit.

The 427 mm bull trout was the individual which was detected passing through the diversion structure from the canal into McCully Creek. This could suggest that these larger fish do have some form of fluvial migration that may be restricted to ideal conditions for upstream movement. Given the known available habitat for a large fluvial fish downstream of upper Big Sheep Creek, we would expect these fish to migrate further down Big Sheep Creek and into the Imnaha River rather than head down the canal and into irrigation ditches where temperature limitations exist. It is unlikely this fish will return to upper Big Sheep Creek because of the improbability of returning the way in which it left. The detection of this particular fish moving into McCully Creek also provided evidence that McCully Creek is not an isolated system. Immigration to McCully Creek does occur from sources upstream on the canal, but it has yet to be determined if these bull trout migrate upstream in McCully Creek to spawn.

With the installation and year-around maintenance of our PIT tag antennas at all planned sites we hope to gain more insight on abundance and movement of bull trout. Further sampling in future years will increase our knowledge of this unique series of systems and the bull trout populations that inhabit them. Ultimately, this information will be utilized toward recovery of the species.

2007 Tasks

- Maintain PIT tag antenna arrays year around.

- Install new PIT tag antennas at the Big Sheep diversion site, the McCully Creek site, and at Salt Creek summit – June 2007

- Test PIT tag antenna efficiencies year around.

- Estimate population abundance of McCully Creek above the WVIC using the two pass mark-recapture approach – July/August 2007

- Sample high meadow reaches of McCully Creek to assess upper distribution limit of bull trout in drainage – July/August 2007

- Conduct one sampling pass of Big Sheep Creek above the diversion structure for single pass abundance estimate – July/August 2007

- Intensify sampling efforts in various areas of the WVIC to increase sample size of PIT tagged bull trout in the WVIC – July/August 2007

- Collect genetic samples from bull trout in the upper Imnaha River above the falls and throughout McCully Creek – July/August 2007.

- Visit with local biologists and irrigation company personnel to compile an explicit history of WVIC construction and operation – October 2006-September 2007.

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