Use of the Mainstem Columbia River by Walla Walla Basin Bull Trout

Annual Report
(October 1, 2010 – September 30, 2011)

Final

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Abstract

A significant gap in our knowledge of migratory bull trout *Salvelinus confluentus* life history is associated with their use of the mainstem Columbia and Snake rivers. Few data are available regarding movements within the mainstem, the use of various mainstem habitats, or bull trout presence and passage at mainstem dams. We conducted our sampling effort for bull trout from October 2010 through February 2011 during the time period when most of the emigration from the Walla Walla Basin occurs. Twelve bull trout were captured between 9 November 2010 and 18 February 2011, all of which were subsequently tagged with PT-4 acoustic transmitters and full duplex ISO 134 kHz PIT tags. Tagged bull trout ranged in fork length from 225 to 311 mm and their weight varied from 135.0 to 281.1 g. Seven of the tagged bull trout were detected entering the Columbia River from November through February. Two of these fish were located during mobile tracking surveys between the mouth of the Walla Walla River and McNary Dam. Both fish used mainstem habitats that ranged from 12 to 20 m in depth, with an average water velocity of 0.37 m/s. Four of the seven bull trout that entered the Columbia River were subsequently detected returning to the Walla Walla River between March and June 2011. No acoustic tagged or PIT tagged bull trout from the Walla Walla Basin have been detected to date, at or near any mainstem dams since tagging began in the fall of 2010. A PIT tag from one of the bull trout tagged for this study was recovered on Foundation Island, apparently a consequence of avian predation. Weather and river conditions limited our ability to conduct mobile tracking surveys in the Columbia River to determine the extent of movements and distribution, and to collect detailed habitat use data.

Acknowledgements

We would like to thank and acknowledge the contributions of other individuals who provided assistance on this study. Brian Mahoney, Rey Weldert, Joelle Olsen and other field staff of the Confederated Tribes of the Umatilla Indian Reservation greatly increased the sampling effort for the project by monitoring an additional rotary screw trap for bull trout. Stuart Durfee of Gardena Farms Irrigation District 13 facilitated our access to sampling sites and provided equipment storage. We would also like to acknowledge Paul Sankovich (U.S. Fish and Wildlife Service) for his contributions to the project. Project funding for FY2011 was provided by the U.S. Army Corp of Engineers-Walla Walla District. Dean Holocek provided technical and administrative support for the Corps of Engineers.

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Introduction

A general decline in bull trout abundance across their native range resulted in the listing of all populations in the Columbia River Distinct Population Segment (DPS) as threatened under the Endangered Species Act in June 1998 (63 FR 31647). The U.S. Fish and Wildlife Service (FWS) Biological Opinion (USFWS 2000) and Draft Recovery Plan for the Umatilla-Walla Walla Recovery Unit (USFWS 2002) identifies the action of improving connectivity between populations of Columbia River bull trout as a necessary step to help protect against localized extinctions. Both documents specifically discuss the need for monitoring and research on bull trout use of the Columbia River. Mainstem Columbia and Snake River dams that comprise the Federal Columbia River Power System (FCRPS) have the potential to adversely impact both bull trout connectivity within migratory corridors as well as between core areas (metapopulations), and these mainstem habitats may serve an important role in bull trout recovery. Dams lacking sufficient passage for bull trout may impede migration and contribute to the isolation of historically connected populations. In addition, dams and their respective impoundments have altered the natural hydrograph and riverine habitats that were historically used by migratory bull trout, resulting in slow velocity, warm-water reservoirs. These altered habitats may affect migration timing, and they are more suitable for exotic predators and competitors (Williams et al. 2005; Ferguson et al. 2005) than they historically were. In 2010, the mainstem Columbia and lower Snake rivers were designated as critical habitat for bull trout (USFWS 2010).

Walla Walla Basin Bull Trout

Several tributaries to the Snake and Columbia rivers contain migratory bull trout populations, including the Walla Walla River in southeast Washington. The Walla Walla Basin is comprised of five bull trout local populations within two core areas (USFWS 2002). Three local populations are located in the Touchet River Subbasin (Touchet River Core Area), and two local populations are located in the Walla Walla River Subbasin (Walla Walla River Core Area).
Each local population in the Walla Walla Basin has a resident and migratory (fluvial) component (USFWS 2002). Resident bull trout complete their entire life cycle in the headwater streams in which they spawn and rear (Rieman and McIntyre 1995; Pratt 1992; Shepard et al. 1984). Migratory bull trout spawn in headwater streams along with resident bull trout, and their progeny rear from one to four years before migrating downstream as subadults to mainstem river habitats (Fraley and Shepard 1989, Goetz 1989). Migratory adult bull trout return to headwater spawning areas in September and October, and most individuals migrate back downstream to overwintering areas from October through December following spawning. Resident and migratory forms may be found together and either form may give rise to offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993). Both migratory subadult and adult bull trout use the lower Walla Walla River during the fall, winter, and spring for rearing and overwintering. Recently, use of the mainstem Columbia River by migratory adults and subadults has also been documented (Anglin et al. 2009a, 2009b, 2010, 2010a; Barrows et al. 2012).

Bull Trout Use of the Mainstem Columbia and Snake Rivers

The use of the mainstem Columbia and Snake rivers by anadromous salmonids is well-documented, but the relatively smaller populations of migratory bull trout have not received the same degree of study. Whereas nearly all wild and hatchery-produced salmon and steelhead smolts eventually migrate downstream to the ocean, only a fraction of the total population of bull trout (i.e. migratory) produced in the Walla Walla Basin actually enters the mainstem Columbia River. Nonetheless, the migratory bull trout that use the mainstem corridors are essential for maintaining gene flow between core area metapopulations and for recolonizing areas where local populations have been extirpated (USFWS 2002). Anglin et al. (2010a) estimated 192 bull trout (95% CI 50-345) left the Walla Walla Basin for the Columbia River from 2007-2009.

Current knowledge regarding migratory bull trout presence and passage at FCRPS projects consists primarily of observations at adult fish ladder counting stations, juvenile fish bypass facilities, and more recently, PIT tag detections at some of the projects (USACE 2011, Fish Passage Center 2011, Anglea et al. 2004, PTAGIS website (www.ptagis.org)). From 1991 through 2011, there have been at least 482 bull trout observations in the adult ladders of the lower Snake River hydro projects, and at least seven bull trout observations in the adult ladders of the lower Columbia River hydro projects. From 1998 through 2011, there have been at least 65 bull trout observations in the juvenile bypass systems of the lower Snake River dams, and at least two bull trout observations in the juvenile bypass systems of the lower Columbia River dams. There have been five detections of PIT tagged bull trout at Columbia River dams, including Priest Rapids (Table 1), four of which are a result of PIT tagging migratory bull trout in the Walla Walla Basin in 2008 and 2009. There have also been 12 detections of PIT tagged bull trout in the fish ladders and juvenile bypass systems of the lower Snake River dams.

Table 1. Migratory bull trout PIT detections at mainstem Columbia River projects.

Tagging Site	Detection Location	Tagging Date	Detection Date
Touchet River	John Day juvenile bypass	4/24/2008	5/12/2008
Walla Walla River	McNary juvenile bypass	7/30/2008	4/15/2009
Walla Walla River	McNary adult ladder (Oregon)	10/23/2008	05/25/09 & 06/19/09
Walla Walla River	Priest Rapids adult ladder (east)	1/28/2009	7/5/2009
Entiat River	Priest Rapids adult ladder (east)	11/16/2008	11/21/2009

Migratory Walla Walla Basin bull trout with PIT tags have been detected dispersing into the Columbia River during the fall and winter (Anglin et al. 2009a, 2009b; 2010; 2010a), which generally coincides with the shutdown of the juvenile salmonid fish bypass systems at the FCRPS projects. The movements and disposition of bull trout that enter the Columbia River are largely unknown, including the specific temporal and spatial aspects of migration through McNary Reservoir. Details regarding movements around, or passage through the mainstem hydropower projects are also unknown. There are two primary routes of passage at mainstem dams during the winter: 1) adult ladders, which are primarily designed for upstream passage, and 2) turbines, which are not monitored for PIT tags. It is unknown if bull trout pass successfully but undetected, if they attempt to pass the dams and fail, or if they are fatally injured while attempting to pass. The objectives of this study are to: 1) Capture and implant acoustic tags in migratory bull trout from the Walla Walla River, 2) monitor movements of bull trout within the mainstem corridor, and 3) determine habitat use of bull trout in the Columbia and Snake rivers.

Study Area

Walla Walla Basin

The Walla Walla Basin in northeastern Oregon and southeastern Washington drains an area of 4,553 km^2 (NPCC 2004) into the mainstem Columbia River. The Basin is comprised of the Touchet River Subbasin, the Mill Creek Subbasin, and the Walla Walla River Subbasin. The primary headwater tributaries originate in the Blue Mountains and include the North and South Forks of the Walla Walla River, upper Mill Creek, and the North Fork, South Fork, and Wolf Fork of the Touchet River (Figure 1). The Walla Walla Basin historically supported a number of anadromous and resident, native salmonid populations including; spring and fall Chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*O. keta*), coho salmon (*O. kisutch*), redband trout (*O. mykiss* subpopulation), bull trout (*S. confluentus*), mountain whitefish (*Prosopium williamsoni*), and summer steelhead (*O. mykiss*) (NPCC 2004). Currently, *O. mykiss* are the only remaining native anadromous salmonid in the Walla Walla Basin. In 2000, however, CTUIR began outplanting local Carson stock spring Chinook adults into natural production areas of the South Fork Walla Walla River and Mill Creek to establish a naturally producing population in the subbasin (Mahoney et al. 2008).

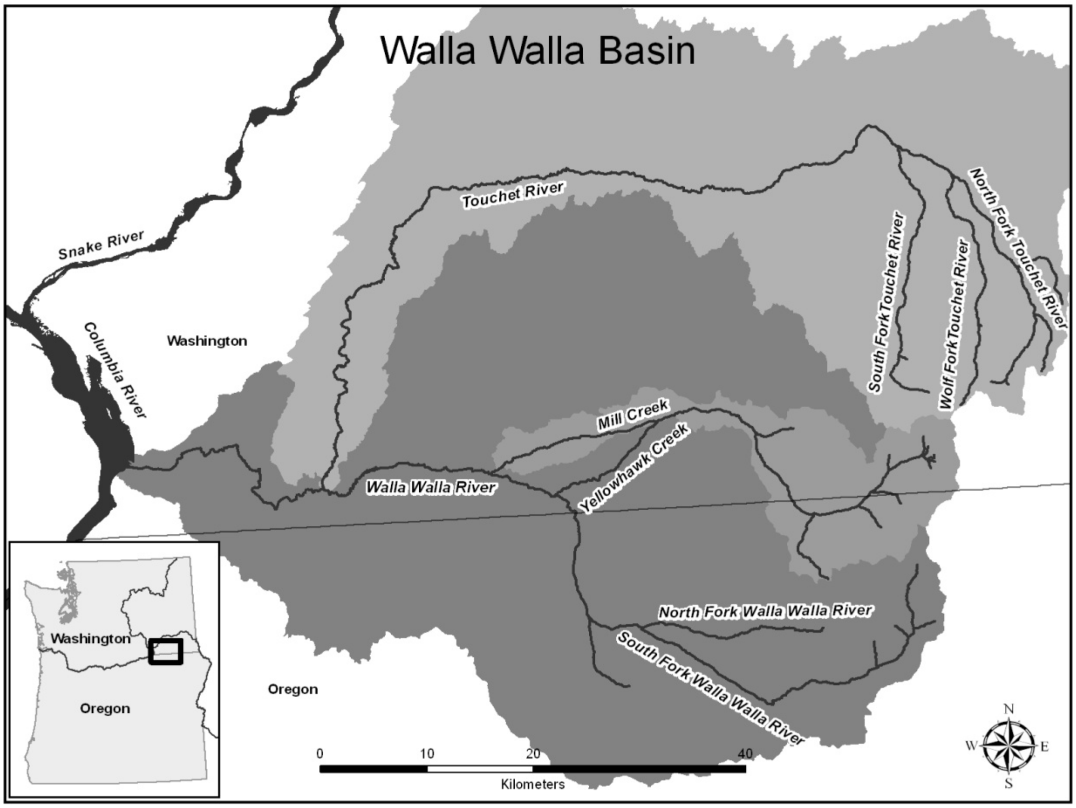

Figure 1. Study area map depicting the Walla Walla Basin with the Touchet River, Mill Creek, and Walla Walla River subbasins.

Mainstem Columbia River

The primary study area for this project is the portion of the mainstem Columbia River known as Lake Wallula, which is the large reservoir formed by McNary Dam (Figure 2), and the secondary study area is the lower Walla Walla River proper. McNary Dam is located 470 rkm upstream from the Pacific Ocean and 52 rkm downstream of the confluence of the Columbia and Snake rivers. Lake Wallula extends 98 rkm upstream from McNary Dam to the Hanford Reach near Richland, Washington on the Columbia River, and impounds 16 rkm of the Snake River upstream to Ice Harbor Dam (Evans et al. 2010).

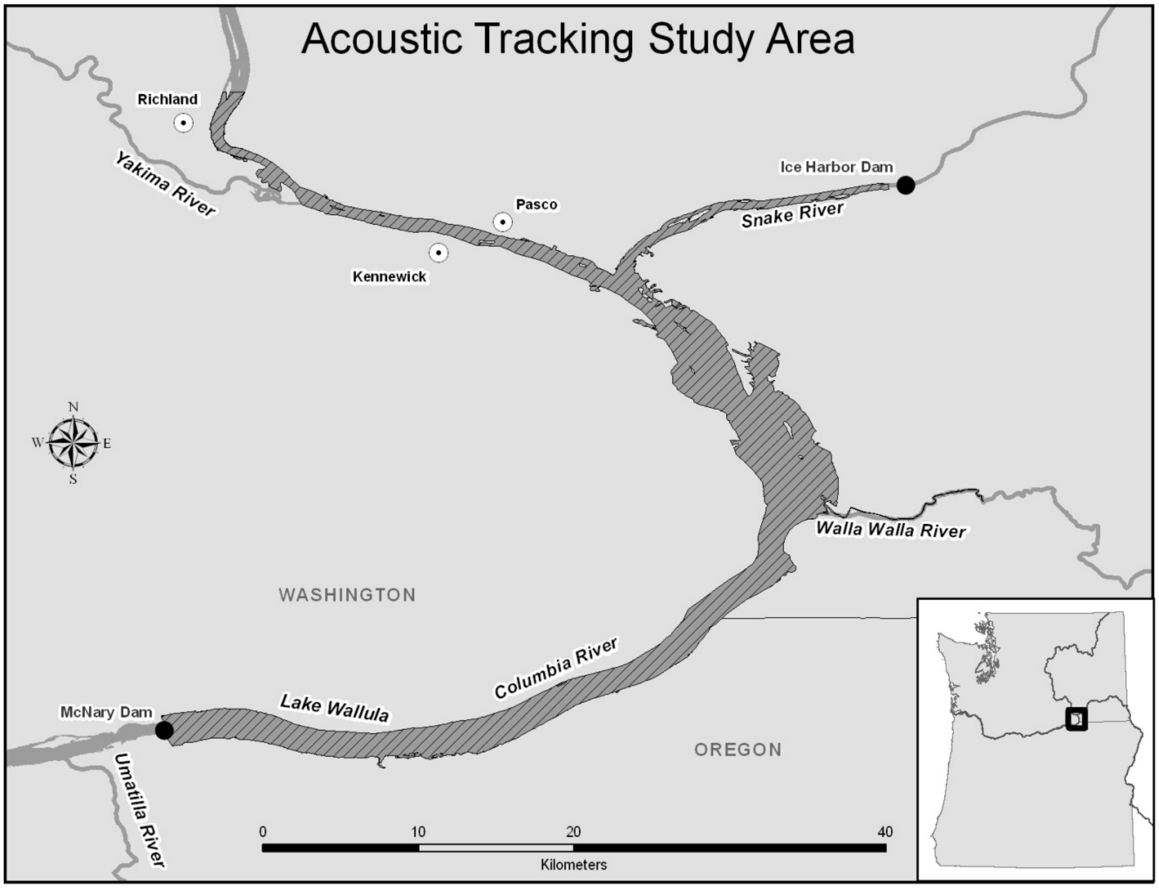

Figure 2. Mainstem Columbia River study area depicting Lake Wallula (McNary Reservoir), the lower Snake River and the lower Walla Walla River.

Methods

Bull Trout Sampling and Tagging

Bull Trout Sampling

We used multiple sampling methods in several locations to capture migratory bull trout as they moved through the lower Walla Walla River to the Columbia River (Figure 3). Various fyke net configurations, rotary screw traps, and angling were used to capture bull trout for subsequent PIT and acoustic tagging.

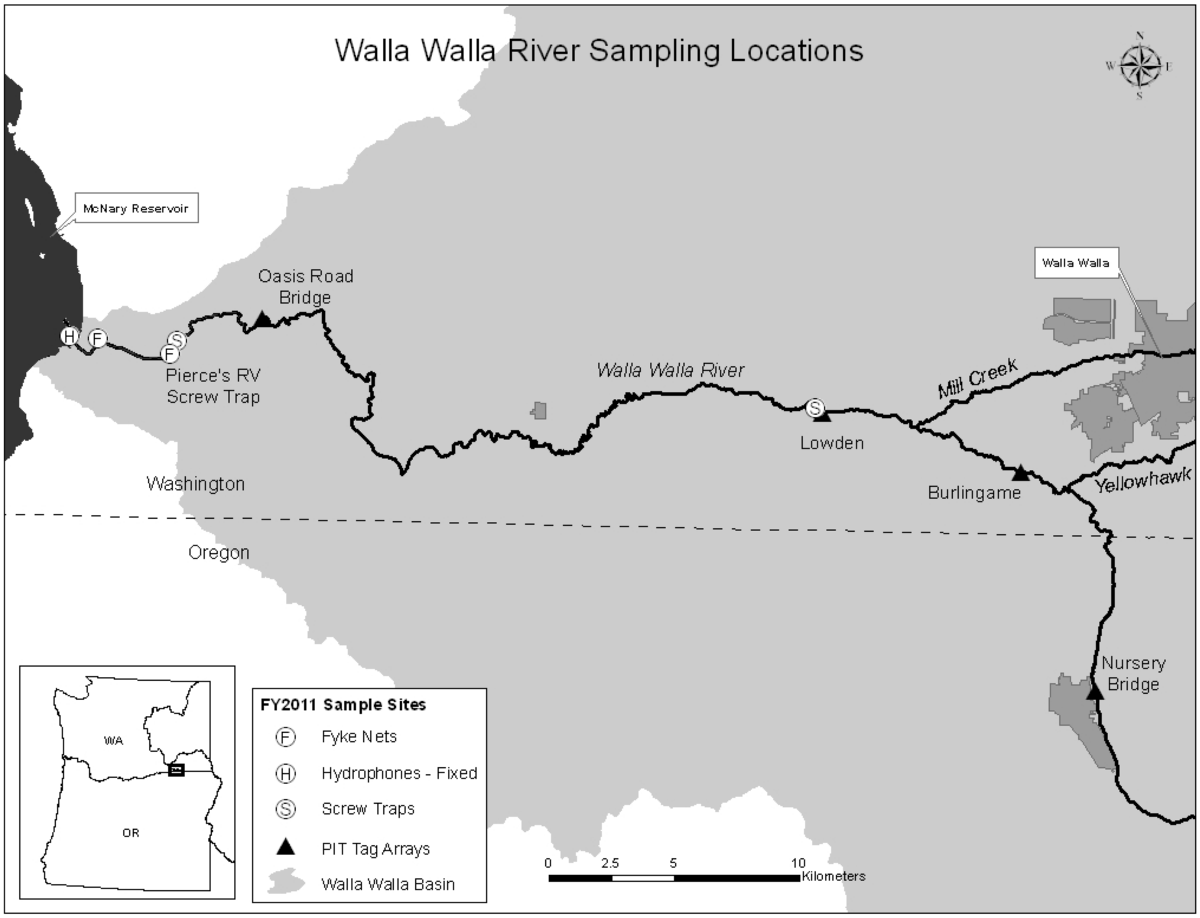

Figure 3. Lower Walla Walla River sampling area showing locations of fyke nets, rotary screw trap sites, fixed hydrophones and PIT detection arrays.

Lower Walla Walla River fyke nets – Fyke nets with attached leads were used in the backwatered portion of the lower Walla Walla River (approximately rkm 6.5) as an additional method to capture downstream migrating bull trout. Fyke net sampling was conducted when streamflows and debris loads were relatively low. Each fyke net was composed of two rectangular conduit frames measuring 0.9 m tall by 1.5 m wide, five steel hoops, two throats, two 7.5 m leads, and was constructed with 1.3 cm knotless netting. The fyke nets were deployed perpendicular to the river channel from a boat and were anchored in the current by 3 m anchor pipes driven into the substrate. The fyke nets were checked at least once each day to remove fish and debris and to ensure proper function.

Pierce's RV Park fyke net – A second fyke net with rigid leads was deployed at a site in the lower Walla Walla River near Pierce's RV Park (rkm 8) while streamflows and debris loads were suitable. The fyke net was composed of two rectangular conduit frames measuring 0.9 m tall by 1.5 m wide, five steel hoops, two throats, two leads, and was constructed with 1.3 cm knotless netting. The fyke net was operated continuously and checked at least once, but usually twice each day to remove fish and debris and to ensure proper function.

FWS rotary screw trap, Pierce's RV Park – Screw trap sampling at the Pierce's RV Park trap site was conducted from October 2010 through March 2011. When river depth and discharge consistently exceeded 0.8 m and 100 ft^3/s, respectively, a 5-foot rotary screw trap was deployed just upstream of the fyke net site (rkm 8). In mid-December, when river depth and discharge consistently exceeded 1.2 m and 500 ft^3/s, respectively, the 5-foot trap was replaced by an 8-foot rotary screw trap. The traps were operated continuously and were checked twice daily to remove fish and debris and to adjust trap position to maximize trapping efficiency.

CTUIR rotary screw trap, Lowden – The CTUIR established a rotary screw trapping site near Lowden (rkm 51) and operated it from October 2010 through June 2011 as part of their ongoing anadromous salmonid monitoring program. Either a 5-foot, or an 8-foot rotary screw trap was used depending on streamflow levels. When a bull trout was captured, CTUIR field staff obtained a weight (g), fork length (mm), scanned the fish for an existing PIT tag, and placed it into a perforated holding vessel inside the screw trap live well. FWS field staff were then contacted via cell phone and arrangements were made for experienced personnel to tag the bull trout in a timely manner.

Angling – Angling was used at various locations in the lower Walla Walla River (rkm 0-51) by experienced personnel using lures fitted with barbless hooks in an attempt to catch bull trout when streamflows were low and thus conducive to bank angling. When streamflows were high, angling was conducted from a boat in the lower, backwatered portion of the Walla Walla River.

Bull Trout Tagging

Acoustic tags – We initially considered using transmitters and equipment compatible with the Juvenile Salmon Acoustic Telemetry System (McMichael et al. 2010) in 2009/10 when this project began. We elected not to employ Juvenile Salmon Acoustic Telemetry System (JSATS) compatible equipment due to many factors, but primarily because of the lack of established, year round hydrophone arrays within the study area. Additionally, the JSATS transmitters utilize a high frequency that transmits through water less effectively than lower frequencies, limiting their detection range during mobile tracking surveys. We considered JSATS equipment again, for the current year of the study (2010/11), but chose to continue using the equipment purchased during the first year of the project because the issues described above had not been resolved. We intend to review equipment options each year as technology advances to determine if the JSATS system or other equipment options are available that can provide the detail necessary to better address project objectives.

Since acoustic tags were ordered but not used during the first year of the study, they were available for the current year. Our 20 acoustic transmitters were comprised of three different sizes to accommodate the range of bull trout sizes we expected to capture. The transmitters included two PT-3 sub-miniature Pico Tags, 15 PT-4 sub-miniature Pico Tags, and three miniature IBT tags. Transmitter specifics are summarized in Table 2.

Table 2. Manufacturer (Sonotronics Inc.) specifications for acoustic transmitters.

Model	PT-3	PT-4	PT-4	IBT-96-9-I
Transmitter Weight in Air (g)	2.2	4.0	4.0	8.8
Transmitter Length (mm)	19.0	25.0	25.0	47.0
Transmitter Diameter (mm)	7.8	9.0	9.0	10.5
Ping Rate (s)	20	10	20	3
Frequency (kHz)	75.0	75.0	75.0	75.0
Transmitter Life (days)	60	170	270	270
Quantity Acquired	2	8	7	3

Tagging procedures – Immediately following capture, bull trout were anesthetized for tagging in a bath containing 40 mg/l of tricaine methanesulfonate (MS-222) buffered with sodium bicarbonate at a concentration of 80 mg/l. Bull trout were measured to the nearest mm (fork length), weighed to the nearest 0.1 g, and received both a PIT tag and an acoustic transmitter. The PIT tags were approximately 23 mm long and were inserted subcutaneously at the abdomen through a shallow 3-mm incision made with a surgical scalpel slightly off the mid-line and anterior to the pelvic girdle. Our acoustic tagging methods closely followed, and were adapted from radio tagging methods described by Sankovich et al. (2003). Three sizes of acoustic transmitters (Table 2) were acquired for this study to accommodate a range of bull trout sizes. Based on a length/weight relationship developed for bull trout in the South Fork Walla Walla River by Budy et al. (2004), we estimated that the PT-3, PT-4, and IBT tag models in combination with a 23-mm PIT tag (0.38 g), would be appropriate for bull trout with minimum fork lengths of 210, 253, and 320 mm, respectively, at 3% of the host fish weight. We exceeded the “2% rule” described in Winter (1996) because no justification was offered for it, and Brown et al. (1999) indicated that host fish (rainbow trout) with tag sizes exceeding a tag to weight ratio of 2% demonstrated normal swimming performance. By tagging at 3% of the host fish weight, it enabled us to both tag more and a wider range of fish sizes while achieving shorter ping rates and attaining longer tag lives. Following surgery, tagged bull trout were recovered from anesthesia in an aerated bath of river water and released in an area of reduced water velocity near the capture site.

Monitoring Bull Trout Movements

To monitor bull trout spatial and temporal movements both in the lower Walla Walla River and in the mainstem Columbia River we used fixed and mobile hydrophones to detect acoustic tags, and fixed antenna arrays to detect PIT tags.

Acoustic Tag Monitoring

Fixed hydrophone stations – Two submersible ultrasonic receiver/hydrophones (SUR) were attached to bridges near the mouth of the Walla Walla River for continuous, fixed-station, remote monitoring of acoustic tagged bull trout migrating to and from the Columbia River (Figure 3).

The SUR's were deployed approximately 200 m apart to determine upstream or downstream movement for each fish detected. After the initial deployment date, each SUR was downloaded and redeployed bi-weekly. The SUR's were operated continuously throughout the active battery life of all deployed acoustic tags.

Mobile tracking surveys – Mobile tracking surveys were planned bi-weekly by boat, commencing when acoustic transmitters were first deployed and continuing for the battery life of the tags. During 2011, both the backwatered portion of the lower Walla Walla River (approximately 6.5 rkm), and the mainstem Columbia River (Lake Wallula) were surveyed when weather conditions were conducive to effective tracking. To assure systematic sampling of the Columbia River study area, a grid pattern of monitoring points or listening posts that incorporated a sufficient acoustic signal overlap distance was established using ArcMap (Figure 4). Initially, monitoring point spacing was 350 m based on the minimum detectable tag range of 200 m determined during equipment testing. Further testing and field observations of acoustic-tagged bull trout in the Columbia River resulted in an adjustment to a 500 m monitoring point spacing. Field staff navigated via GPS to each monitoring point in a survey boat. When the point was reached, the boat was brought to a low idle and a TH-2 omnidirectional hydrophone was deployed approximately one meter below the keel of the boat. Field staff listened through headphones connected to a USR-08 mobile receiver for the sound of an activated acoustic transmitter for a period of 45 seconds to ensure multiple iterations for audible detection. If no transmitter was audibly detected, the hydrophone was retracted and the boat navigated to the next monitoring point. If a transmitter was detected, field staff deployed a DH-4 directional hydrophone to decode the signal and more accurately locate the tagged bull trout. A GPS position and date/time stamp were recorded at the location of the acoustic tag signal.

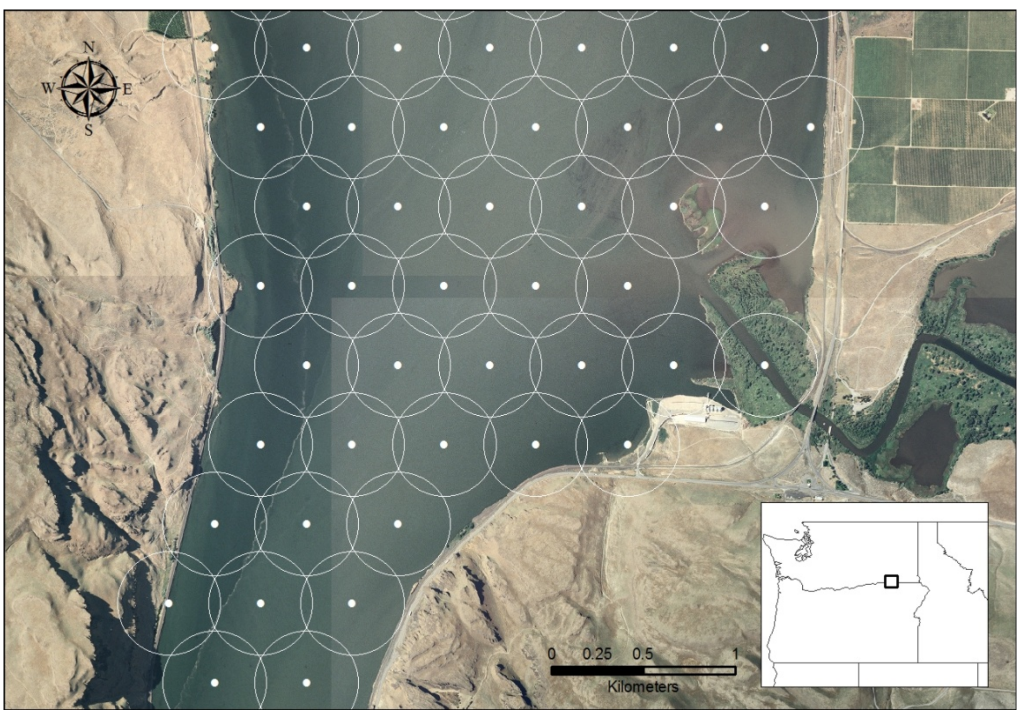

Figure 4. Grid pattern of monitoring points established in ArcMap for mobile tracking.

PIT Tag Monitoring

Oasis Road Bridge PIT detection array - The COE funded the installation and operation of the Oasis Road Bridge (ORB) PIT detection array near the mouth of the Walla Walla River (rkm 10) from 2005 through 2009 to monitor bull trout use of the Columbia River, and to estimate the number of Walla Walla Basin bull trout that were using the Columbia River (Figure 3). The FWS continued operation and maintenance of the site to provide bull trout migration timing data for PIT tagged fish moving downstream toward the Columbia River. These data are useful to help establish movement trends for emigrating bull trout to more precisely focus our sampling efforts. Since all acoustic tagged bull trout in this study were also fitted with a PIT tag, monitoring the ORB PIT detection array may provide additional movement data in the case of an acoustic transmitter failure, shedding, or tag life expiration. In addition, since fish will be double tagged (i.e. acoustic and PIT), estimates of the efficiency or detection probability for the ORB PIT detection site may be improved. We also chose to maintain the site to continue the time series of quantitative estimates of bull trout moving into the Columbia River each year. The methods describing the process we used to estimate the total number of migratory bull trout that may be using the Columbia River are presented in Appendix C. PIT tag detection data for bull trout at this site were queried on a regular basis from the PTAGIS database (www.ptagis.org).

Columbia and Snake River PIT detections – The PTAGIS database was queried regularly for detections of bull trout in the adult fish ladders and juvenile bypass systems at Bonneville, The Dalles, John Day, McNary, and Priest Rapids dams on the Columbia River, and Ice Harbor Dam on the Snake River. No additional dams above Ice Harbor on the Snake River or above Priest Rapids on the Columbia River were queried. The adult ladders at Priest Rapids and Ice Harbor are highly efficient and it is likely any PIT tagged bull trout migrating upstream through those facilities would be detected.

Avian predation mortalities — In recent years, PIT tags from Walla Walla Basin migratory bull trout have been recovered from avian nesting colonies in the mainstem Columbia River. We queried the PTAGIS database for bull trout mortalities associated with the established avian nesting colonies on mainstem islands near the mouth of the Walla Walla River to determine if any tagged bull trout from this study were eliminated by avian predators.

Bull Trout Habitat Use in the Mainstem Columbia River

Physical habitat used by Walla Walla Basin bull trout in the Columbia River was characterized at point locations determined from tracking of the acoustic tags. Habitat metrics were recorded each time an acoustic-tagged bull trout was located. Metrics included water depth, substrate characteristics, water temperature, and a water velocity profile. Water depth was measured with a Hummingbird 997SI Combo side-scan sonar unit. Substrate was characterized with underwater video. A Delta Vision Splashcam underwater video camera was lowered from the boat to the river bottom. A 0.5 m length of chain with 25.4 mm links was tethered to the camera to use for size reference when categorizing substrate. Surveyors classified dominant and subdominant substrate size and percent fines at each location. Substrate was categorized into six classes by diameter (Table 3). Percent fines was categorized into four classes (0 – 25%, 26 –

50%, 51 - 75% and 76 – 100%). Water temperature was measured near the surface with a Fisher Scientific digital thermometer (°C), and the velocity profile was recorded with a Teledyne RD Instruments Workhorse Rio Grande acoustic Doppler current profiler (ADCP).

Table 3. Substrate types and particle sizes used to classify dominant and subdominant substrates for each bull trout location.

Substrate Type	**Particle size** (cm)	**Particle size** (inch)
Sand/Fines	<0.64	<.25
Pebble	0.65 – 2.54	0.25 - 1.0
Small Gravel	2.55 – 5.08	1.0 - 2.0
Large Gravel	5.09 – 7.62	2.0 - 3.0
Cobble	7.63 – 15.24	3.0 - 6.0
Boulder	>15.24	>6.0

Results

Bull Trout Sampling and Tagging

Bull Trout Sampling

We captured and subsequently tagged 12 migratory bull trout during late fall and winter in the lower Walla Walla River during FY2011 (1 October 2010 – 30 September 2011). Multiple sampling methods were used, but only the rotary screw traps were successful at capturing migratory bull trout.

Lower Walla Walla River fyke nets – Fyke net sampling was conducted in the lower, backwatered portion of the Walla Walla River during November 2010. When streamflows and debris loads were relatively low, the fyke nets effectively captured many downstream dispersing fish species. When streamflows substantially increased, the resulting high debris loads (e.g. fallen leaves, tumbleweeds) effectively clogged the fyke nets and they were subsequently removed. During the 57.5 total hours that the fyke nets were deployed, no bull trout or other salmonids were captured. Non-salmonids captured during this time period are listed in Appendix A, Table A3.

Pierce's RV Park fyke net – Sampling with the fyke net deployed near Pierce's RV Park (rkm 8) was conducted from 19 October through 8 November 2010, a period of approximately three weeks for a total of 323 hours (Table 4). Sampling was terminated when streamflows and the corresponding debris loads increased and prevented stable deployment of the gear. No bull trout or other salmonids were captured during this time period. Non-salmonids captured during this time period are listed in Appendix A, Table A1.

Table 4. Monthly summary of hours sampled via rotary screw trap and fyke net at the Pierce's RV park trap site. Sampling was conducted from 26 October 2010 through 3 March 2011.

	Hours Sampled	
Month/Year	Screw Trap	Fyke Net
October/2010	36	194
November/2010	428	129
December/2010	386	0
January/2011	35	0
February/2011	495	0
March/2011	55	0
Total	**1435**	**323**

FWS rotary screw trap, Pierce's RV Park – Screw trap sampling at the Pierce's RV Park trap site commenced on 26 October 2010 and continued through 3 March 2011, a period of approximately 4 months for a total of 1435 hours (Table 4). A total of three bull trout were captured by the rotary screw trap during the sample period as well as other salmonids (Table 5) and non-salmonids (Appendix A, Table A2). Consistently above average streamflows, occasional ice flows and high debris loads resulted in sampling downtime and reduced screw trap efficiency. No bull trout were captured at this trap site when streamflow exceeded 600 cfs (Figure 5). All three bull trout were captured within a narrow temperature range when average daily water temperatures were between 4 and 7 °C (Figure 5).

Table 5. Monthly summary of salmonids captured by the Pierce's RV park rotary screw trap. Sampling was conducted from 26 October 2010 through 3 March 2011.

Month/Year	Bull Trout	Juvenile Chinook Salmon	Juvenile Steelhead	Juvenile Coho Salmon	Adult Coho Salmon
October/2010	0	0	0	0	0
November/2010	0	12	9	0	1
December/2010	2	30	120	4	0
January/2011	0	0	1	0	0
February/2011	1	15	40	1	0
March/2011	0	2	16	0	0
Total	**3**	**59**	**186**	**5**	**1**

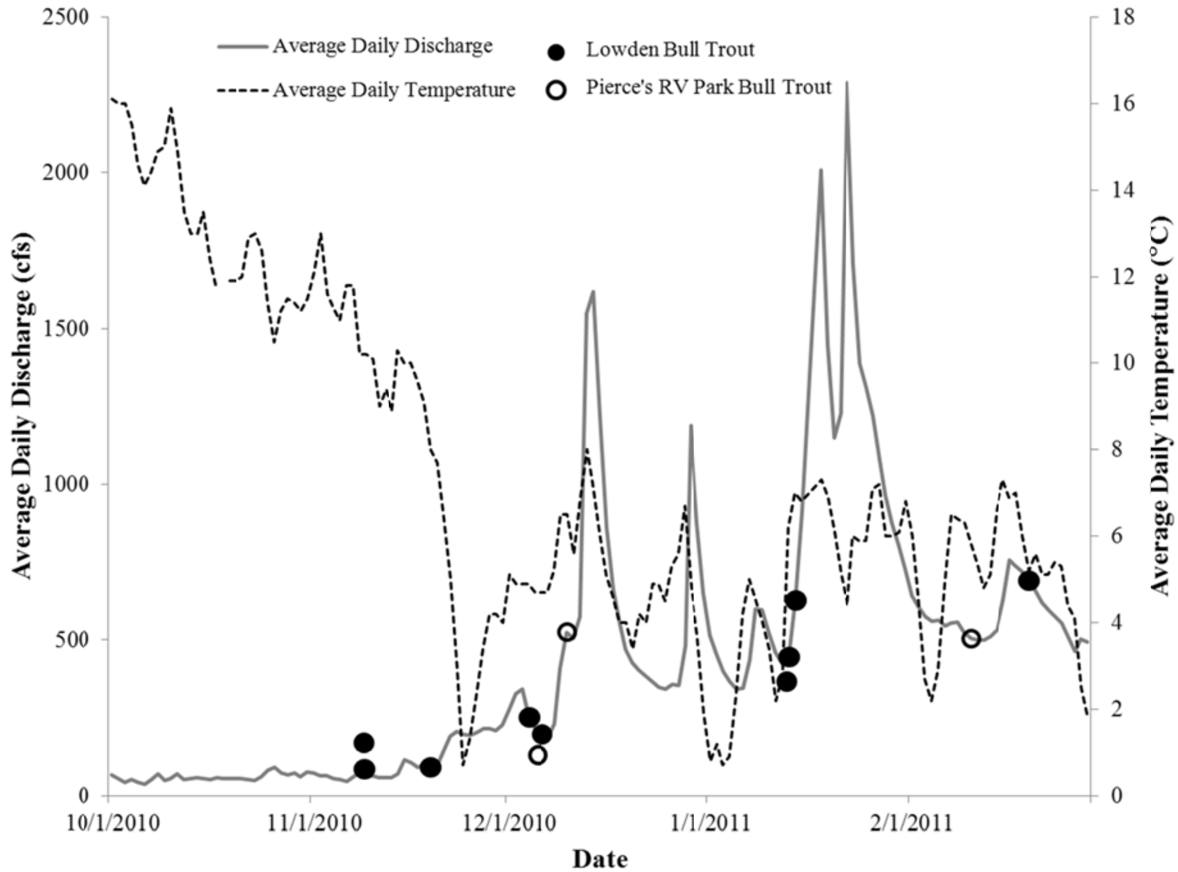

Figure 5. Bull trout captured at the Lowden and Pierce's RV park rotary screw trap sites in relation to average daily stream discharge and water temperature.

<u>CTUIR rotary screw trap, Lowden</u> – The CTUIR rotary screw trap at rkm 51 near Lowden was operated for approximately 7 months from 29 October 2010 through 7 June 2011. Consistently above average streamflows, occasional ice flows, and high debris loads resulted in sampling downtime and reduced screw trap efficiency, similar to the conditions at the Pierce's RV Park site. A total of nine bull trout were captured at this site (Table 6). No bull trout were captured at this trap site when streamflow exceeded 800 cfs (Figure 5). Bull trout were captured when average daily water temperatures were between 3 and 10 °C (Figure 5).

Table 6. Monthly summary of bull trout captured by the CTUIR Lowden rotary screw trap. Sampling was conducted from 29 October 2010 through 7 June 2011.

Month/Year	Bull Trout
October/2010	0
November/2010	3
December/2010	2
January/2011	3
February/2011	1
March/2011	0
April/2011	0
May/2011	0
June/2011	0
Total	**9**

Angling – Field staff angled for bull trout in the lower Walla Walla River from October 2010 through February 2011. River access throughout the lower Walla Walla River was limited and streamflows were not conducive to angling most of the time. Field staff also angled from a boat in the lower 8 km of the Walla Walla River. During a total of 5.5 hours of sampling, no bull trout were captured. Adult steelhead and northern pikeminnow were among the incidental captures.

Bull Trout Tagging

Sampling efforts throughout the migration period resulted in a total of 12 bull trout captured between 9 November 2010 and 18 February 2011, all of which were subsequently tagged with PT-4 acoustic transmitters and 23 mm PIT tags (Table 7). Tagged bull trout ranged in fork length from 225 to 311 mm and their weight varied from 135.0 to 281.1 g. A total of nine bull trout were tagged and released just downstream from the CTUIR Lowden rotary screw trap site (rkm 51) and three were tagged and released just downstream from the Pierce's RV park rotary screw trap site at rkm 8.

Table 7. Acoustic tag code, PIT tag code, tagging date, tagging location, tag life, fish length, and fish weight for bull trout tagged during FY2011.

Acoustic Tag code	PIT tag code	Tagging date	Tagging location	Tag life (days)	Fork length (mm)	Weight (g)
217	384.1B795B26E1	11/9/2010	Lowden	270	264	196.0
232	384.1B795B26AF	11/9/2010	Lowden	270	311	270.9
67	384.1B795B265E	11/18/2010	Lowden	170	293	275.5
202	384.1B795B268A	12/3/2010	Lowden	270	305	281.1
82	3D9.1BF1B2E892	12/6/2010	Lowden	170	269	186.3
262	384.1B795B26A6	12/6/2010	Pierce's	270	272	169.2
187	3D9.257C69841C	12/10/2010	Pierce's	170	288	146.2
97	3D9.1BF1B2979A	1/12/2011	Lowden	170	225	175.4
127	3D9.1BF1B2EAAE	1/12/2011	Lowden	170	275	195.4
157	3D9.1BF1B2F7EA	1/14/2011	Lowden	170	268	192.3
172	384.1B795B268C	2/10/2011	Pierce's	170	300	171.9
247	3D9.1BF1B2F1CF	2/18/2011	Lowden	270	242	135.0

Monitoring Bull Trout Movements

Bull trout tagged during the fall and winter of FY2011 were detected at our Walla Walla Basin PIT detection arrays, fixed hydrophone stations, and during mobile hydrophone surveys in both the Walla Walla River and the Columbia River. Complete detection histories were assembled for each tagged bull trout (Appendix B, Table B1) for a comprehensive description of the temporal and spatial movement patterns.

Acoustic Tag Monitoring

Fixed hydrophone stations – Seven (58%) of the 12 bull trout tagged during the year were detected migrating into the Columbia River between 22 November 2010 and 27 February 2011 (Table 8) by the two SURs at the mouth of the Walla Walla River. Four of these fish were detected returning to the Walla Walla River, and three were not. Two of the three (#217, #82) were never detected again following their emigration. One of the three (#187) was detected twice in the Columbia River (Figure 7), but its ultimate fate is unknown.

Five (42%) of the 12 bull trout tagged during the year were detected by the SURs returning to the Walla Walla River from 9 March to 15 June 2011 (Table 8, Figure 7). Four of these fish were previously detected by the SURs leaving the Walla Walla River, and one was not (#247), indicating that it had been missed during its downstream emigration.

In total, eight of the 12 acoustic-tagged bull trout (67%) were known to have entered the Columbia River, and five subsequently returned to the Walla Walla River.

Table 8. Detections of acoustic tagged bull trout at fixed hydrophone stations at the mouth of the Walla Walla River during FY2011.

Acoustic Tag code	Downstream Detection Date	Upstream Detection Date
217	11/22/2010	N/A
187	12/10/2010	N/A
82	1/13/2011	N/A
172	2/11/2011	5/15/2011
157	2/26/2011	5/19/2011
202	2/26/2011	6/15/2011
232	2/27/2011	3/9/2011
247	N/A	5/15/2011

Mobile Tracking Surveys – Mobile tracking surveys in the backwatered portion of the Walla Walla River commenced immediately following deployment of the first acoustic transmitter in early November 2010, and continued through May 2011 (Table 9). Although detections at the fixed hydrophone stations confirmed that eight acoustic tagged bull trout were known to have passed through this 6.5 km portion of the lower Walla Walla River, no bull trout were located during the mobile surveys in this area.

Table 9. Survey dates and relocations during mobile tracking surveys in the 6.5 rkm backwatered portion of the Walla Walla River during FY2011.

Survey Date	Locations
11/18/2010	0
12/17/2010	0
2/1/2011	0
3/8/2011	0
3/21/2011	0
4/19/2011	0
5/3/2011	0

Mobile tracking surveys in the mainstem Columbia River were initiated in December following the first Columbia River bound bull trout detection at the fixed hydrophones at the mouth of the

Walla Walla River on 22 November 2010. Surveys were conducted approximately bi-weekly through May 2011 (Figure 6). Inclement weather and river conditions including high winds and rough water conditions affected the spatial extent of the surveys more so than the bi-weekly frequency of the surveys. Individual tracking surveys covered between 8 and 24% of the total study area.

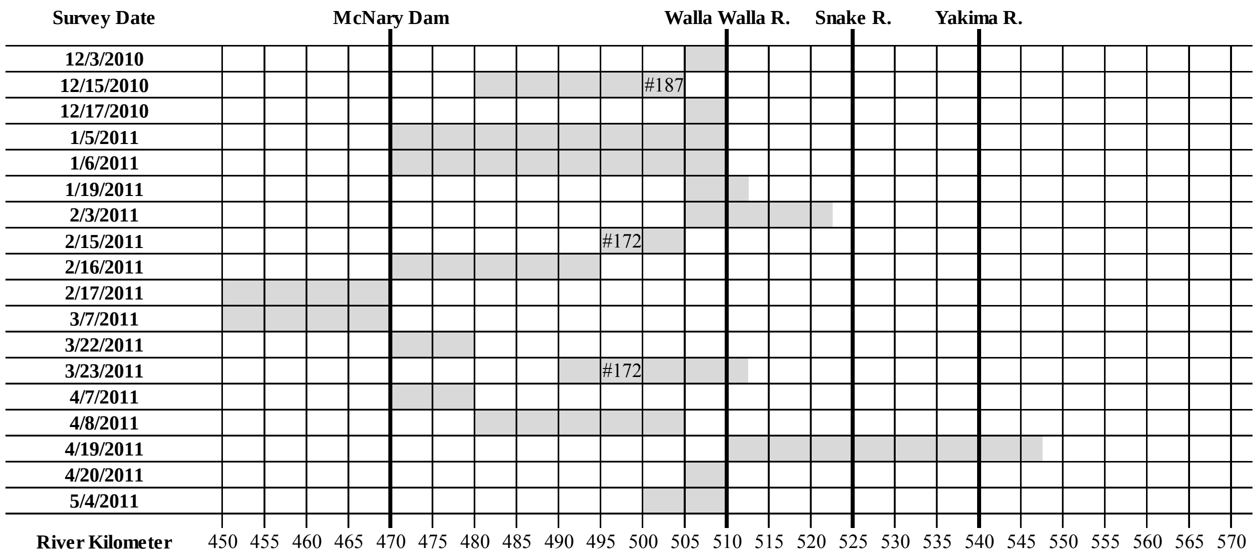

Figure 6. Survey dates and relocations during mobile tracking surveys in the mainstem Columbia River during FY2011. River kilometers tracked during each survey are shaded in gray.

We obtained five relocations from two of the eight acoustic tagged bull trout known to have entered the mainstem study area (Figure 7). Bull trout #187 was captured, tagged and released at the Pierce's RV trap site on 10 December 2010. Following release, the fish moved 8 rkm downstream and was detected on the SURs later the same day. We were able to conduct a mobile tracking survey on 15 December, and the fish was relocated in the mainstem Columbia River approximately 3 rkm downstream from the mouth of the Walla Walla River (Figure 7). The bull trout was occupying deep water habitat (12.2 m) and was located approximately 300 m from the shoreline. Rough water prevented field staff from recording a velocity profile with the ADCP at this location. Water temperature was 7.5 °C and substrate was observed to be primarily fines. Approximately eight hours after the initial observation, field staff relocated this fish and it had not moved from the initial location. The next mobile tracking survey was conducted on 17 December, and the fish was no longer in the vicinity of the previous location. This survey extended approximately 3 rkm upstream, and 1 rkm downstream from the original location, and the signal from #187 was not detected. River conditions during the survey restricted the extent of the area searched to a total of 4 rkm. This bull trout was not detected in any subsequent mobile tracking surveys (total of nine) that spanned the Columbia from rkm 470 at McNary Dam to the Snake River at rkm 522. In addition, this fish was not detected on the fixed hydrophone stations at the mouth of the Walla Walla River. Thus, its disposition is unknown.

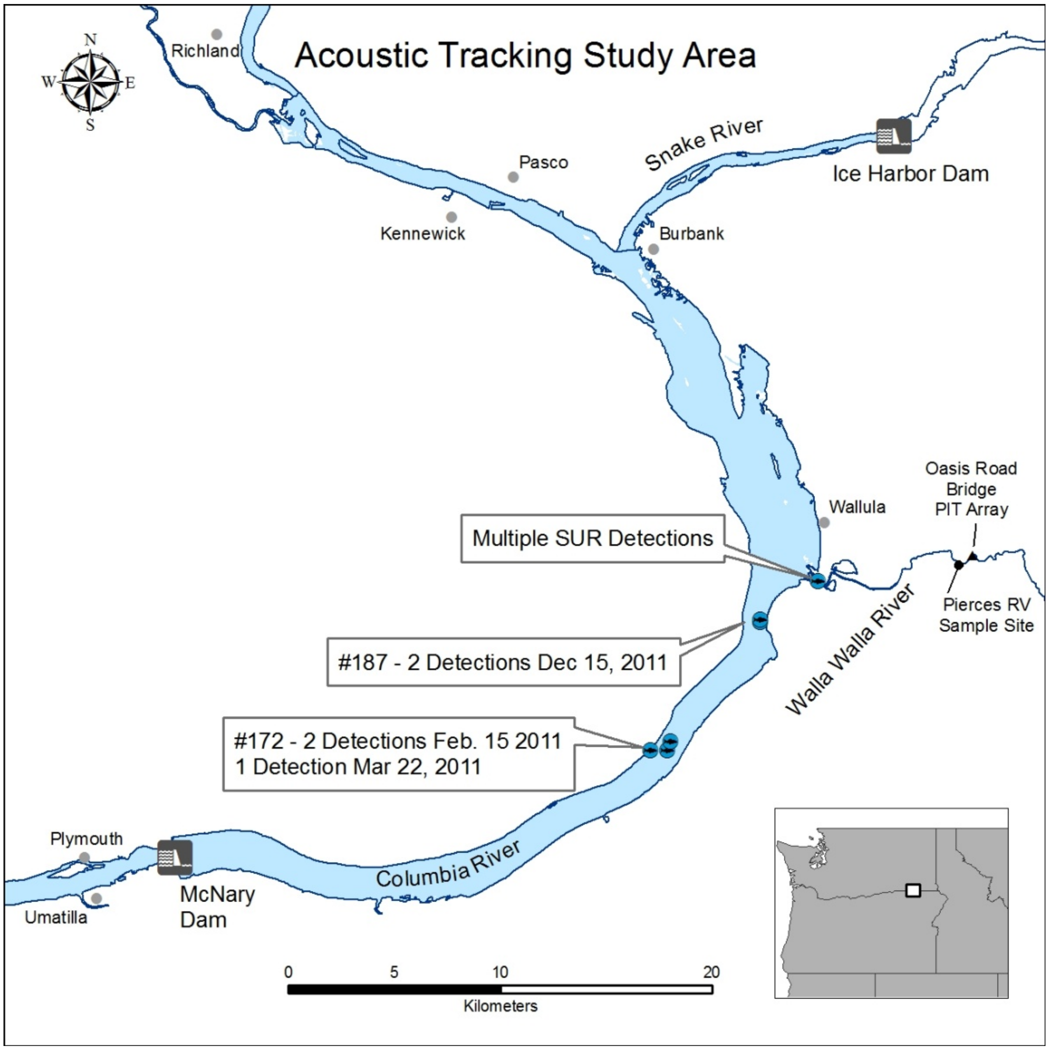

Figure 7. Detections of bull trout on the SURs at the mouth of the Walla Walla River, and mainstem Columbia River relocations during mobile tracking surveys in 2011.

Bull trout #172 was also captured, tagged, and released at the Pierce's RV trap site on 10 February 2011. Following release, the fish moved 8 rkm downstream and was detected the next day on the SURs entering the Columbia River. A mobile tracking survey was conducted on 15 February, and the bull trout was relocated in the mainstem Columbia River approximately 12 rkm downstream from the mouth of the Walla Walla River, and 27 rkm upstream from McNary Dam (Figure 7). The fish was occupying deep water habitat (16.8 m) and was located mid-channel, approximately 650 m from the shoreline. Substrate at this location could not be observed due to the combination of water depth and reduced water clarity. Water temperature was 3.4 °C. At the end of the tracking survey, six hours later (just before sunset), the bull trout had moved to the north shoreline. It was within 10 m from shore, adjacent to a steep rock outcropping, occupying deep water habitat (16.0 m). As with the previous location, field staff were unable to determine substrate composition. The location of this fish adjacent to an underwater rocky outcropping may suggest that the cover afforded by the structure was a more relevant bottom characteristic than substrate. This bull trout was not relocated during the next tracking survey on 8 March, although high winds and rough water restricted the survey to only 2 rkm. The next tracking survey was conducted on 23 March, and this bull trout was located approximately 11 rkm downstream from the mouth of the Walla Walla River, near the location it had been previously observed (Figure 7). It was occupying deep water habitat (16.0 m) and was located mid-channel. Substrate composition and cover characteristics were not discernible. Water temperature was 5.0 °C. This bull trout was not located during the next three tracking surveys in April and early May. However, it was detected on the SURs, re-entering the Walla Walla River on 15 May 2011, nearly two months after the last Columbia River location. It then successfully ascended the Walla Walla River before being recaptured via angling on 19 July 2011, 74 rkm upstream from the mouth.

Movement Summary – We observed several patterns of movement into, within, and out of the mainstem Columbia River using detection data from both the fixed hydrophones (SURs) and mobile tracking (Table 10).

Table 10. Movement patterns for acoustic tagged bull trout that used the Columbia River during 2011. ND = not detected; NL = not located.

Acoustic Tag code	Emigration Date (SUR-Fixed)	Columbia River Location Date (Mobile)	Immigration Date (SUR-Fixed)
217	11/22/2010	NL	ND
82	1/13/2011	NL	ND
187	12/10/2010	12/15/2010	ND
172	2/11/2011	2/15/2011 3/23/2011	5/15/2011
157	2/26/2011	NL	5/19/2011
202	2/26/2011	NL	6/15/2011
232	2/27/2011	NL	3/9/2011
247	ND	NL	5/15/2011

PIT Tag Monitoring

Oasis Road Bridge (ORB) PIT detection array – The ORB PIT detection array was in operation during all months of the sampling season in 2011. However, elevated streamflows and the associated debris loads damaged some of the individual PIT antennas comprising the array. Nonetheless, a total of 34 individual PIT tagged bull trout were detected at the array (Table 11). Of the 34 bull trout detected, 25 were detected moving downstream towards the Columbia River, five were detected moving upstream, returning from the Columbia River, and four were detected both entering and returning from the Columbia River. Twenty three of the bull trout detected at the ORB array were tagged in the middle and lower portions of the Walla Walla River from Milton-Freewater downstream to Pierce's RV Park. Of the 11 bull trout detected at the ORB array that were tagged in upper basin areas, four were tagged in Mill Creek and seven were tagged in the South Fork Walla Walla River. Three of the bull trout detected at the array were tagged (both PIT and acoustic) in the lower Walla Walla River as part of this project (Table 12). All three of these fish were detected moving downstream toward the Columbia River, but only two (#217, #232) were subsequently detected on the SUR at the mouth. One of these two bull trout (#232) was detected by the SUR and the ORB array while returning upstream.

An estimate of the number of Walla Walla Basin bull trout that may be using the Columbia River was developed using monthly PIT array detections, estimates of physical detection efficiency, and an estimate of the proportion of the population that was tagged based on rotary screw trap sampling. Specific methods and results from this analysis are presented in Appendix C.

Table 11. Migratory bull trout detected at the Oasis Road Bridge (ORB) PIT detection array (rkm 10.1) during 2011. Bull trout detected moving both downstream and upstream past the array are listed by month for the downstream movement, with the upstream movement month in parentheses.

Month/Year	Downstream Only	Upstream Only	Downstream AND Upstream
October/2010	2	0	
November/2010	9	0	
December/2010	13	0	1 (May)
January/2011	1	0	1 (February)
February/2011	0	0	2 (February, March)
March/2011	0	1	
April/2011	0	1	
May/20011	0	3	
June/2011	0	0	
Total	**25**	**5**	**4**

Table 12. Acoustic tagged bull trout detected at the Oasis Road Bridge (ORB) PIT detection array (rkm 10.1) during 2011.

Acoustic Tag Code	PIT Tag Code	ORB Detection Date (Downstream)	ORB Detection Date (Upstream)
217	384.1B795B26E1	11/17/2010	NA
262	384.1B795B26A6	12/6/2010	NA
232	384.1B795B26AF	2/26/2011	3/25/2011

Columbia and Snake River PIT detections – The query of the PTAGIS database did not result in any detections of Walla Walla Basin bull trout at any of the Columbia or Snake river mainstem dams during 2011. Although no Walla Walla Basin bull trout were detected at mainstem dams, two PIT tagged bull trout were detected moving downstream through the juvenile bypass system at Lower Monumental Dam, and subsequently through the full flow bypass system at Ice Harbor Dam in the Snake River. These fish were originally PIT tagged in the Tucannon River during fall 2010, and they both passed downstream from Ice Harbor in June 2011. One of these fish was recovered as a mortality on Foundation Island (see next section).

Avian predation mortalities – We queried the PTAGIS database and found 14 bull trout mortalities (PIT tag recoveries) associated with the avian nesting colonies in the mainstem Columbia River during 2011 (Table 13). Eleven recoveries were from bull trout originally PIT tagged in the Walla Walla River or Mill Creek, two recoveries came from bull trout tagged in the Touchet River, a tributary of the Walla Walla River, and one recovery was from a bull trout tagged in the Tucannon River which is a tributary to the Snake River between Little Goose and Lower Monumental dams (see previous section). One of the Walla Walla bull trout mortalities recovered on Foundation Island also had an acoustic tag (#262). This fish was PIT tagged in Mill Creek on 11/04/2010, and subsequently detected at the ORB PIT array on 12/06/2010. It was then recaptured at the Pierce's RV screw trap on 12/07/10, and an acoustic tag (#262) was implanted. The acoustic tag was not detected on the SURs at the mouth of the Walla Walla, or during any of the mobile tracking surveys. This may indicate the bull trout was taken in the lower Walla Walla River rather than the Columbia River.

All recovered PIT tags were from nesting sites inhabited by either American white pelicans (Badger Island) or double-crested cormorants (Foundation Island). An analysis of detection histories indicated that bull trout could have been taken in either the Walla Walla River or the Columbia River. The Tucannon River bull trout was detected going downstream through both Lower Monumental and Ice Harbor Dam bypass facilities in the Snake River. This fish passed Ice Harbor on 2 June 2011, and the PIT tag was recovered on Foundation Island on 28 September 2011. This bull trout could have been taken either in the lower Snake River or in the Columbia River.

Table 13. Bull trout PIT tag ID, tag date, release site, recovery site, and avian colony type for PIT tags recovered from avian nesting sites in the mainstem Columbia River during 2011.

PIT Tag ID	Tag Date	Release Site	Recovery Site (Columbia rkm)	Avian Colony Type
3D9.1C2C6CB62F	9/23/2009	Nursery Bridge Dam (Walla Walla River)	Badger Island (512)	American White Pelican
3D9.1C2C687F65	10/7/2009	Nursery Bridge Dam (Walla Walla River)	Badger Island (512)	American White Pelican
3D9.1C2CBABFCE	5/1/2010	Touchet River near Dayton, WA	Badger Island (512)	American White Pelican
3D9.1C2C6885AF	6/15/2010	Little WW River diversion canal (Walla Walla River)	Foundation Island (518)	Double-crested Cormorant
3D9.1C2C438C56	6/21/2010	Touchet River near Dayton, WA	Badger Island (512)	American White Pelican
3D9.1BF1F30AF2	7/15/2010	Nursery Bridge Dam (Walla Walla River)	Foundation Island (518)	Double-crested Cormorant
3D9.1BF1F30EF1	7/15/2010	Nursery Bridge Dam (Walla Walla River)	Foundation Island (518)	Double-crested Cormorant
3D9.1BF1FDD28E	7/15/2010	Nursery Bridge Dam (Walla Walla River)	Foundation Island (518)	Double-crested Cormorant
3D9.1BF1FC9448	9/23/2010	Nursery Bridge Dam (Walla Walla River)	Foundation Island (518)	Double-crested Cormorant
384.1B795B268B	10/21/2010	Little WW River diversion canal (Walla Walla River)	Badger Island (512)	American White Pelican
384.1B795B2679	11/2/2010	Nursery Bridge Dam (Walla Walla River)	Foundation Island (518)	Double-crested Cormorant
384.1B795B26A6 (Acoustic tag #262)	**11/4/2010**	**Mill Creek (Walla Walla River)**	**Foundation Island (518)**	**Double-crested Cormorant**
384.1B795B2680	11/5/2010	Little WW River diversion canal (Walla Walla River)	Foundation Island (518)	Double-crested Cormorant
3D9.1C2CFC542B	12/15/2010	Tucannon River (non-Walla Walla Basin)	Foundation Island (518)	Double-crested Cormorant

Bull Trout Habitat Use in the Mainstem Columbia River

We collected physical habitat data (Table 14) at five locations used by bull trout in the Columbia River (McNary Pool). Rough river conditions prevented successful deployment of the ADCP at all but one location, and water clarity was not sufficient to observe substrate conditions at three locations.

Bull trout were located in deep-water areas ranging from 12.2-19.8 m (average 16.5 m). We presume the specific fish locations were near the river bottom since bull trout tend to be bottom oriented (Al-Chokhachy and Budy 2007; Montana Bull Trout Restoration Team 2000), but we did not have the capability to measure the exact location of the fish in the water column. The single velocity profile we measured indicated water column velocities ranged from 0.01-0.66 m/s, and the mean column velocity was 0.37 m/s. Surface water temperatures varied between 3.4 °C and 7.5°C, and averaged 5.4 °C. Substrate conditions were observed to be fines at the two locations where observations were made.

Table 14. Habitat metrics recorded at acoustic tagged bull trout relocations in the mainstem Columbia River during 2011.

Acoustic Tag Code	Date	Time	Depth (m)	Mean Column Velocity (m/s)	Water Temp. (°C)	Substrate
187	12/15/10	0900	12.2	N/A	7.5	Fines
187	12/15/10	1500	12.2	N/A	7.5	Fines
172	2/15/11	1100	19.8	0.37	3.4	N/A
172	2/15/11	1700	19.8	N/A	3.4	N/A
172	3/23/11	1600	18.3	N/A	5.0	N/A

Discussion

Connectivity between bull trout core area metapopulations in the Columbia River DPS is required to maintain the genetic diversity and fitness of the DPS over the long term. Restoration, preservation, and/or enhancement of the connectivity in the mainstem Columbia and Snake river corridors is required to accomplish the goal of metapopulation connectivity, and to make progress towards recovery. Understanding the migratory behavior of Walla Walla Basin bull trout and their use of the mainstem Columbia and Snake rivers will help to determine the actions that may be required to restore or facilitate connectivity and passage in these corridors.

Abundance estimates of Walla Walla Basin migratory bull trout using the Columbia River and migration timing between the Walla Walla River and Columbia River have been previously reported (Anglin et al. 2010a), but prior to this study, the movement patterns and habitat use of bull trout that enter this portion of the Columbia River were not evaluated.

Our ability to describe Walla Walla Basin bull trout use of the mainstem Columbia River from October 2010 to June 2011 for this study were a function of three main factors: 1) the number of migratory bull trout captured and tagged in the lower Walla Walla River, 2) the quantity and frequency of relocation events, and 3) the quantity and frequency of observations of habitat conditions used by migratory bull trout.

Acoustic telemetry data collected in 2011 confirmed that migratory Walla Walla Basin bull trout use the mainstem Columbia River as rearing and overwintering habitat, and as a migratory corridor to access those habitats. Although no acoustic tagged bull trout were detected near McNary or Ice Harbor dams, the sample size of fish observed in the mainstem was small (n = 2) and whether Walla Walla bull trout attempt to connect to other lower Columbia or Snake river core area metapopulations, remains unknown.

Bull Trout Sampling and Tagging

The significant effort expended on sampling with the rotary screw traps, fyke nets, and angling in the lower Walla Walla River resulted in a sample size of 12 acoustic tagged bull trout. Considering the relatively low abundance of bull trout in the lower Walla Walla River, these results were not particularly surprising. Our minimum target for tagged bull trout was 20 fish, and this target was based on the abundance of bull trout in the lower Walla Walla River, and the variability in their spatial and temporal migration patterns. Since this was the first full year for the field sampling program, we plan to refine our sampling locations and time periods in future years to determine if we can increase sample size with the same array of sampling methods.

Fyke Net Sampling

Fyke nets can be used as an effective sampling method under suitable conditions that include relatively low streamflows and/or water velocities, and low debris loads. Fyke nets are commonly used when sampling for littoral fish (Weaver 1993; Coble 1982), and they have been used to capture bull trout in lakes or reservoirs that lack significant current (Prisciandaro and Harbison 2007). We captured 11 different fish species, including bottom-oriented species in the lower Walla Walla River when conditions were suitable. During 2011, streamflows, velocities, and debris loads increased to unsuitable conditions prior to the time period when most bull trout movement through the lower river occurred. In addition, Breen and Ruetz (2006) found that escape probabilities increased with soak time of fyke nets. By checking fyke nets more often, we may increase the probability of capturing and retaining bull trout. Although we did not capture any bull trout, fyke nets may still be a viable sampling method.

Rotary Screw Trap Sampling

Rotary screw traps have been used in many locations in the Walla Walla Basin to obtain samples of salmonid downstream migrants, including bull trout. We captured both anadromous salmonids and bull trout at the two sampling locations we used. We also captured a wide array of non-salmonids. The physical sampling efficiency for our screw traps as a function of river cross section was low. The efficiency was lower at the Pierce’s RV site than at the Lowden site because the streamflow includes the Touchet River, and the river is wider and less channelized than at the Lowden site. These factors may have been associated with the reduced number of bull trout captured at the Pierce’s RV site. We did not have sufficient numbers of bull trout to estimate biological sampling efficiency at either site.

Angling

We have used angling as a sampling method for bull trout in many areas around the Walla Walla Basin with variable success (e.g. Anglin et al. 2010a). Two important factors that have been associated with consistent angling success are bull trout abundance, and specific local river conditions. Based on our bull trout sampling throughout the Basin over 10 years, we have found that bull trout abundance is consistently lower in lower Basin areas. In addition, we have not identified specific areas in the lower river that have conditions and structure that attract and hold bull trout. Angling could have potential as a productive sampling method if we can identify locations that "concentrate" the low number of individuals in this area, and if streamflows are low enough for effective sampling.

Bull Trout Tagging

We deployed acoustic and PIT tags in 12 bull trout during the year. No problems were encountered with surgical procedures, and all fish recovered and behaved normally during release. We did not observe any apparent evidence of mortality or other tag effects, although it was not specifically evaluated.

Monitoring Bull Trout Movements

The relatively large study area (lower Walla Walla River, Lake Wallula), depth of the reservoir, and often inclement weather and river conditions during the migration period all posed considerable challenges to monitoring bull trout movement. To contend with these challenges, we used both PIT tags and acoustic tags. Passive PIT tag detection array data and fixed and mobile acoustic tracking data were used to describe movements throughout the study area.

Considering fish size and the corresponding acoustic tag size, the tags we deployed (PT-4) were configured to maximize battery life. To accomplish this, ping rates were set to either a 10 or 20 second interval resulting in estimated tag lives of 170 and 270 days, respectively. Data recorded on the fixed hydrophones indicated the intervals may be too long, especially for fast-moving fish. We expected to have multiple detections of each tag code to verify the tag code ID, but often, only a few and occasionally only one sequence was recorded. During mobile tracking surveys, the 10 and 20 second intervals required relatively long listening times at each station to ensure sufficient time was allotted for detecting multiple ping sequences. The time spent at each listening station limited the number of stations that could be monitored, thus reducing the percentage of the study area tracked during each survey. Similarly, once a tagged bull trout was detected, the relatively long interval between ping sequences decreased our ability to efficiently determine fish locations and confirm tag code ID. We plan on testing shorter ping intervals to determine if fixed hydrophone data and tracking results can more certain and easier to interpret.

Initially, we planned to capture bull trout and apply acoustic tags only at the Pierce's RV site (rkm 8) which is located closer to the Columbia River than the alternate site at Lowden (rkm 51). We assumed a larger proportion of the fish captured at the Pierce's RV site may be en route to the Columbia River compared to bull trout captured at the Lowden site. Since the capture rate at Pierce's was low, we opted to deploy tags at the Lowden site given the opportunity. Seventy-five percent of the bull trout that were acoustic tagged (9 of 12), were tagged at the Lowden site, and 25% were tagged at the Pierce's site. Sixty-seven percent of each group was subsequently detected moving into the Columbia River. Thus, the addition of the upriver site at Lowden did not compromise our goal of monitoring bull trout movement in the Columbia River.

Acoustic Tag Monitoring

The two fixed hydrophones at the mouth of the Walla Walla River provided data on acoustic tagged bull trout that used the Columbia River. Pairing of the hydrophones allowed us to determine upstream or downstream movement, and verification that a tagged fish had entered the mainstem Columbia River. There was a single bull trout that was not detected moving downstream into the Columbia River, but was detected returning. This was likely associated with the ping rate configuration of the acoustic tags discussed previously. The timing of bull trout emigration from the Walla Walla Basin based on the hydrophone data was similar to observations from the ORB PIT detection array between 2007 and 2010 (Anglin et al. 2010a). In FY2011, the ORB PIT array detected most of the downstream movement during November and December, while the hydrophones detected most of the downstream movement in February. Damage to the ORB array from high flows and debris in January compromised detection efficiency which may have resulted in reduced detections of PIT tagged bull trout from January forward. Bull trout returning to the Walla Walla River were detected on the hydrophones from March through June, with four of five detections occurring in May and June. Although the efficiency at the ORB array was reduced after January, PIT tagged bull trout were detected at the array from March through May. This time period coincides with the timing of the upstream spawning migration for bull trout in the Basin. Subsequent recapture and PIT detection array data indicate that although bull trout that have returned from the Columbia River ascend the Walla Walla River, most do not continue to the spawning areas. Instead, they occupy habitat between rkm 74 and 97. Swanberg (1997) observed that a majority of bull trout that migrated upstream in the Blackfoot River drainage did not spawn but instead held less than a month in tributaries or upper river reaches before returning downriver. We hypothesize that the majority of bull trout returning from the Columbia River may not be mature adults and that this upstream migratory pattern may be a strategy to avoid unfavorable conditions in the lower Walla Walla River. Bull trout that were detected on the hydrophones leaving the Basin, but not returning (38%), could be the result of a missed detection at the mouth, tag expiration/loss, mortality, avian predation, or emigration out of the study area.

We used mobile tracking in the backwatered portion of the lower Walla Walla River in an attempt to document bull trout movement prior to entering the Columbia River and immediately following their return to the Walla Walla River. No bull trout were located within the lower Walla Walla River during any tracking surveys. Emigrating bull trout movement can be variable, including rapid downstream movements during the fall and winter months (Fraley and Shepard 1989, Muhlfeld and Marotz 2005, Anglin et al. 2010a). The two bull trout that were re-located in the Columbia River (#172, #187) had been acoustic tagged at the Pierce's RV site, and were detected on the fixed hydrophones approximately 8 rkm downstream within one day of release. A lower Walla Walla River tracking survey would have located these fish only if it had occurred on the single day they were present in the lower river. This suggests outmigrant bull trout exit the lower portion of the Walla Walla River quickly, and acoustic tagged bull trout may only be available for detection for a very limited time period.

The limited extent of the mobile surveys as a result of river conditions combined with the large size of the study area (~50 rkm) and small acoustic tagged bull trout sample size limited the number of individuals and relocations we were able to obtain. Nonetheless, we were able to locate two bull trout in the mainstem Columbia River, downstream from the mouth of the Walla Walla River. Both of these fish were initially located within 12 rkm of the mouth of the Walla Walla River within five days of tagging. One fish (#187) was only detected once, and mobile tracking surveys conducted two days later indicated that the fish had moved from its previously documented location. This bull trout was not subsequently detected during mobile tracking surveys within the study area and did not return to the Walla Walla River. The lack of subsequent detections may indicate that this fish moved beyond the study area soon after the initial detection. Migratory bull trout have been documented moving downstream throughout the winter (Swanberg 1997; Anglin et al. 2009a, 2009b, 2010, 2010a; Barrows et al. 2012). Swanberg (1997) observed rapid downriver movements by migratory bull trout in the fall, one of which traveled 90 km in less than four days. Anglin et al. (2010a) observed detections of PIT tagged bull trout ascending fish ladders at both McNary and Priest Rapids dams indicating that some Walla Walla Basin bull trout make extensive migrations within the mainstem corridor. The second bull trout (#172) was initially located in a mid-channel area, followed by a movement to the shoreline in the evening. This diel movement pattern is similar to foraging movements observed in other studies (Baxter and McPhail 1997, Goetz 1997). During subsequent surveys, #172 had moved from the vicinity of its initial location, but was relocated in roughly the same area over a month later. Nearly two months following its initial detection in the mainstem Columbia River, #172 was detected on the fixed hydrophones as it entered and subsequently ascended the Walla Walla River (Appendix B, Table B1). Despite limited relocations, the timing and extent of their movements suggests Walla Walla Basin bull trout may use the mainstem Columbia River as a migratory corridor and as foraging and overwintering habitat.

PIT Tag Monitoring

The ORB PIT detection array provided real-time bull trout migration timing observations for the lower Walla Walla River, thus enabling us to focus our sampling efforts. In addition, PIT detections for three of the acoustic tagged bull trout enabled us to further describe their movements. Although the array was damaged for much of the migration season, the 29 PIT tagged bull trout detected moving downstream past the site exceeded the number bull trout detected during the previous four years combined (25). Our quantitative estimate of the number of Walla Walla Basin bull trout that may have used the Columbia River during the 2010/11 migration season was 263 (95% CI 59-466) (Appendix C). Movement past the ORB array into the mainstem Columbia River occurred from October 2010 through February 2011, peaking during December. This estimate far exceeds the annual estimates of 49, 120, and 23 for migration years 2007/08, 2008/09, and 2009/10, respectively (Anglin et al. 2010a). Among the factors that may have affected bull trout migration into the Columbia River this year was the timing of fall rain events and the associated increases in river flow. Rain events in September and October of 2010 caused the Walla Walla River to rise from summer base flows by early to mid-October, eliminating low-flow passage barriers about one month earlier than normal. Bull trout initiate downstream dispersal/migration during this time period, and higher flows along with decreasing water temperatures improve conditions for bull trout dispersal to lower portions of the Walla Walla River and to the mainstem Columbia River. Our quantitative monthly estimates of the number of Walla Walla Basin bull trout that migrated past the ORB PIT detection array were strongly correlated with mean monthly streamflow ($R^2 = 0.9855$) during the initial portion of the migration season from October through December (Figure 8). Our findings are similar to other studies that identified streamflow as a key factor influencing bull trout migrations (Jakober et al. 1998; Muhlfeld and Marotz 2005). Similarly, high streamflows and the associated declines in water temperatures during winter months may induce salmonids to make extensive movements to larger river systems where conditions may be more hospitable (Muhlfeld and Marotz 2005; Brown and Mackay 1995; Meka et al. 2003). Although we observed a correlation between the pattern of increasing streamflow and increasing bull trout emigration, there are other additional factors that likely contributed to the increased number of emigrants relative to previous years.

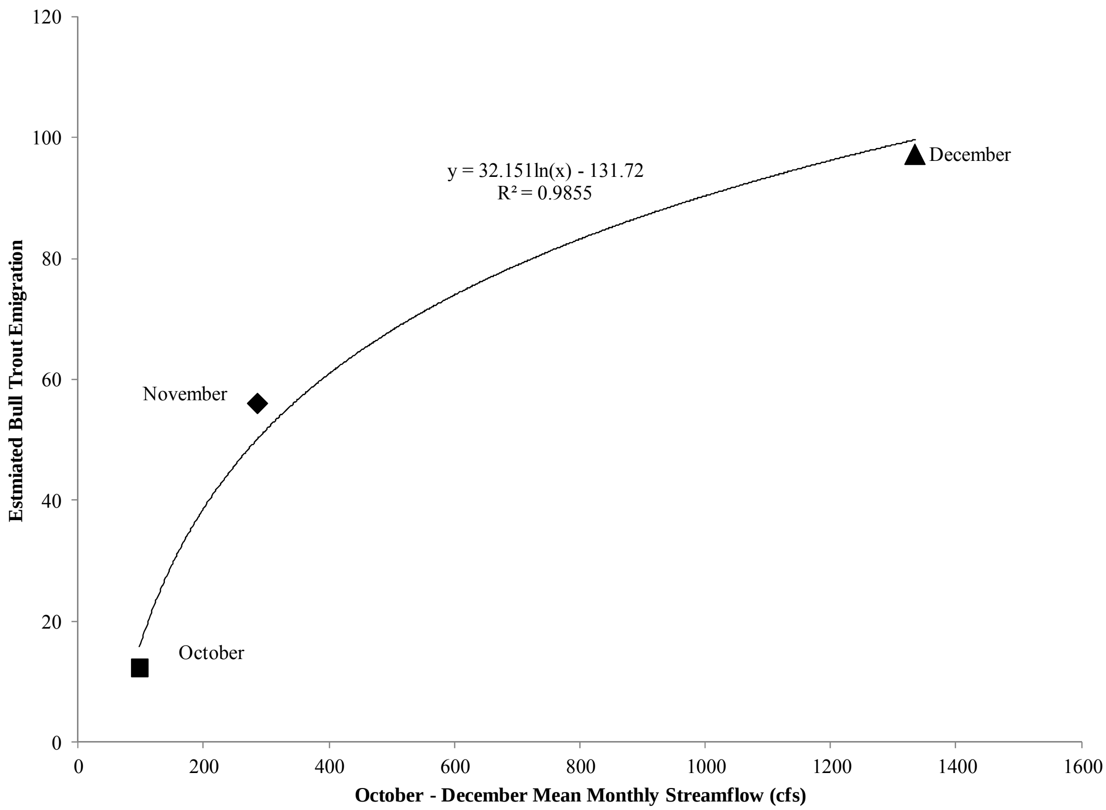

Figure 8. Correlation between estimated monthly bull trout emigration at the Oasis Road Bridge PIT detection array and the mean monthly discharge from the USGS gage #14018500 near Touchet, WA for October through December 2010.

It is interesting to note that a high number of bull trout (N=167) were enumerated in the adult ladder counts at Little Goose Dam on the Snake River during this reporting period (D. Holecek, pers. comm. 2012). Those bull trout were likely emigrants from the Tucannon River Basin. The high number of outmigrants from both the Walla Walla and Tucannon basins during the same time period may be the result of similar factors or conditions, but those factors have not currently been identified.

Considering the relatively high numbers of PIT tagged bull trout that emigrated from the Walla Walla Basin in 2011, we hypothesized that there would also be bull trout PIT detections at one or more mainstem dams. However, no Walla Walla Basin bull trout were detected at any mainstem dam. It is possible that none of the PIT tagged bull trout from the Walla Walla Basin migrated far enough to encounter any of the mainstem dams. Another possible explanation is that the most likely downstream route of passage for bull trout is through the turbines (e.g. McNary) since they are bottom-oriented, and the turbines are not equipped with PIT detection capabilities. It is currently unknown whether the two PIT tagged bull trout from the Tucannon River that were detected moving downstream past Lower Monumental and Ice Harbor dams in the Snake River between March and June 2011 entered the Columbia River. One of the two fish is still at large and future queries of the PTAGIS database may reveal additional detections at other mainstem dams for this fish or possibly a detection at the ORB array.

Avian Predation Mortalities – The recovery of bull trout PIT tags on Foundation and Badger Islands is noteworthy given their relative abundance. Recovery of PIT tags on the islands has increased since 2006 when we intensified our efforts to PIT tag Walla Walla Basin bull trout for both COE-funded studies and FWS research. Of the 61 individual PIT tagged bull trout detected at the Oasis Rd Bridge PIT detection array between 1 January 2006 and 31 December 2011, PIT tags from five (8.2 %) were subsequently recovered on Foundation and Badger islands. It is unclear whether the predation is occurring in the Columbia River, the Walla Walla River, or both. In most cases, a lengthy time period transpired between the last PIT tag detection for each bull trout at a Walla Walla River PIT array, and the collection of the PIT tag on one of the islands in September 2011. The elapsed time from the last PIT detection to the recovery of the PIT tag on the islands for each bull trout ranged from three months to 17 months, although it is unknown exactly when each PIT tag was deposited on the islands. These time periods included all seasons, although spring and summer were the most common seasons between the last detection and recovery of the PIT tag. In addition, the migration behavior of bull trout is highly variable. Some fish move great distances in short periods of time, and others occupy a specific river reach for months. Considering the relatively low abundance of the migratory bull trout population, and the proportion that have been taken by avian predators, additional work may be in order to determine the conditions and locations that lead to successful avian predation.

Habitat Use of Acoustic Tagged Bull Trout

Physical and hydraulic conditions in the Walla Walla River are often harsh during winter and spring months as a result of fall/winter storm events, ice flows, and spring snowmelt conditions. The deep, slow velocity habitat that acoustic tagged bull trout used in the mainstem Columbia River could have provided more favorable overwintering and foraging conditions during fall, winter, and spring than conditions within the Walla Walla Basin. One of the bull trout we tracked in the mainstem Columbia River was initially located in a mid-channel area, followed by a movement to the shoreline in the evening. A diel shift in habitat use has been observed in other populations of bull trout (Baxter and McPhail 1997, Goetz 1997, Thurow 1997, Bonneau and Scarnecchia 1998, Jakober et al. 1998, Muhlfeld et al. 2003). This movement from deeper, mid-channel areas to shoreline habitat could be related to foraging, energy conservation, or predator avoidance. The limited substrate composition data we collected from relocation sites indicated that fines were the dominant substrate type. Cover conditions may be the functional aspect of the river bottom that bull trout use rather than the specific substrate type. We intend to characterize cover along with substrate in the future to determine if there is an association between bull trout locations and cover conditions.

Summary

We were able to capture and implant acoustic tags into 12 bull trout during 2011. Eight of those fish moved into the Columbia River and we were able to obtain locations on two. Emigration of acoustic tagged bull trout from the Walla Walla River occurred between 22 November 2010 and 27 February 2011, and emigration of PIT tagged bull trout occurred between 16 October 2010 and 27 February 2011. Immigration of acoustic tagged bull trout back into the Walla Walla River occurred between 9 March and 15 June 2011, and immigration of PIT tagged bull trout occurred between 25 March and 22 May 2011. The two bull trout we located in the Columbia River moved downstream towards McNary Dam, but were not relocated further than 12 rkm downstream from the mouth of the Walla Walla River (27 rkm upstream from McNary Dam). One of these fish remained in the Columbia River in the same general vicinity for just over three months, returning to the Walla Walla River on 15 May 2011. Both bull trout used deep-water, slow-velocity conditions with fine substrates. One of these fish moved to a near-shore location in the evening, possibly for foraging. Our quantitative estimate of Walla Walla Basin bull trout using the Columbia River during the 2010/2011 migration season based on PIT tag detections at the ORB PIT detection array was 263 with a 95% confidence interval of (59, 466). There were no PIT detections of Walla Walla Basin bull trout at any of the mainstem dams during 2011. However, two PIT tagged Tucannon River bull trout were detected moving downstream past Lower Monumental and Ice Harbor dams in the Snake River between March and June 2011. PIT tags from 13 Walla Walla Basin bull trout and one Tucannon River bull trout were recovered on Foundation and Badger Islands, apparently the result of avian predation. It is unknown whether the predation occurred in the Columbia/Snake rivers, or the Walla Walla River.

Plans for FY2012

We plan to continue the migratory bull trout sampling program during all months of the migration season (October through March) in FY2012. We will continue to implant acoustic transmitters into bull trout captured at both the CTUIR rotary screw trap near Lowden and the FWS Pierce's RV park rotary screw trap, and we will continue sampling with fyke nets and angling when river conditions allow. Project staff will continue to refine sampling techniques and adjust efforts under varying streamflows to improve sampling efficiency for bull trout in lower basin areas.

We propose to make significant changes to our acoustic tracking approach by adding a network of fixed hydrophone monitoring sites throughout the mainstem Columbia River study area for passive monitoring of bull trout movements. Rough river conditions were the primary factor that reduced the extent of our mobile tracking surveys during the year. Fixed hydrophones and passive monitoring should assure that bull trout movements are recorded in the absence of mobile tracking surveys. Data downloaded from the fixed hydrophones will then be used to focus mobile tracking efforts. In addition, we plan to reduce the interval between ping sequences on our acoustic tags. A continuous signal from the tags should provide more comprehensive and verifiable data on the fixed hydrophones, and mobile tracking should be more efficient.

We plan to continue the maintenance and operation of the Oasis Road Bridge PIT detection array near the mouth of the Walla Walla River to provide bull trout migration timing data for PIT tagged fish moving downstream toward the Columbia River and for estimating migratory bull trout abundance. We will query the PTAGIS database regularly for Walla Walla Basin bull trout PIT detections at adult fish ladders and juvenile bypass systems at Bonneville, The Dalles, John Day, McNary and Priest Rapids dams on the Columbia River, and Ice Harbor Dam on the Snake River. We will also query for bull trout mortalities and the associated PIT tags that have been recovered from avian nesting colonies.

References

Al-Chokhachy, R. and P. Budy. 2007. Summer Microhabitat Use of Fluvial Bull Trout in Eastern Oregon Streams. North American Journal of Fisheries Management 27: 1068-1081.

Anglea, S.M, R.J. Richmond, R.S. Brown, J.L. Newell. 2004. Summary of Bull Trout Studies in the Lower Snake River and McNary Reservoir. Final Report to the U.S. Army Corps of Engineers, Walla Walla District. Project 44376.

Anglin, D.R., D. Gallion, M. Barrows, R. Koch, and C. Newlon. 2009a. Monitoring the Use of the Mainstem Columbia River by Bull Trout from the Walla Walla Basin. 2007 Annual Report to the U.S. Army Corps of Engineers, Walla Walla District. Project BT-W-05-6.

Anglin, D.R., D. Gallion, M. Barrows, R. Koch, and C. Newlon. 2009b. Monitoring the Use of the Mainstem Columbia River by Bull Trout from the Walla Walla Basin. 2008 Annual Report to the U.S. Army Corps of Engineers, Walla Walla District. Project BT-W-05-6.

Anglin, D.R., D. Gallion, M. Barrows, R. Koch, and C. Newlon. 2010. Monitoring the Use of the Mainstem Columbia River by Bull Trout from the Walla Walla Basin. 2009 Annual Report to the U.S. Army Corps of Engineers, Walla Walla District. Project BT-W-05-6.

Anglin, D.R., D. Gallion, M. Barrows, R. Koch, and C. Newlon. 2010a. Monitoring the Use of the Mainstem Columbia River by Bull Trout from the Walla Walla Basin. Final Report to the U.S. Army Corps of Engineers, Walla Walla District. Project BT-W-05-6.

Barrows, M.G., R. Koch, C. Newlon, J.J. Skalicky, and D.R. Anglin. 2012. Use of the Mainstem Columbia River by Walla Walla Basin Bull Trout. 2010 Annual Report to the U.S. Army Corps of Engineers, Walla Walla District. Project BT-W-10-2.

Baxter, J.S. and J.D. McPhail. 1997. Diel microhabitat preferences of juvenile bull trout in an artificial stream channel. North American Journal of Fisheries Management 17:975–980.

Bonneau, J.L., and D.L. Scarnecchia. 1998. Seasonal and diel changes in habitat use by juvenile bull trout (*Salvelinus confluentus*) and cutthroat trout (*Oncorhynchus clarki*) in a mountain stream. Canadian Journal of Zoology 76:783–790.

Breen, J.B. and C.R. Ruetz III. 2006. Gear Bias in Fyke Netting: Evaluating Soak Time, Fish Density, and Predators. North American Journal of Fisheries Management 26: 32-41.

Brown, R.S., and W.C. Mackay. 1995. Fall and winter movements of and habitat use by cutthroat trout in the Ram River, Alberta. Transactions of the American Fisheries Society 124: 873-885.

Brown, R.S., S.J. Cooke, W.G. Anderson, and R.S. McKinley. 1999. Evidence to Challenge the "2% Rule" for biotelemetry. North American Journal of Fisheries Management 19:867-871.

Budy, P., R. Al-Chokhachy, and G.P. Thiede. 2004. Bull trout population assessment and life-history characteristics in association with habitat quality and land use: a template for recovery planning. Annual Progress Report for 2003. USGS Utah Cooperative Fish and Wildlife Research Unit, Utah State University, Logan, Utah.

Coble, W.C. 1982. Fish Populations in Relation to Dissolved Oxygen in the Wisconsin River. Transactions of the American Fisheries Society 111:612-623.

Evans, S.D., C.E. Walker, S.J. Brewer, and N.S. Adams. 2010. Assessing survival of Mid-Columbia River released juvenile salmonids at McNary Dam, Washington, 2008–09: U.S. Geological Survey Open-File Report 2010-1237, 60 p.

Ferguson, J.W., G.M. Matthews, R.L. McComas, R.F. Absolon, D.A. Brege, M.H. Gessel, and L.G. Gilbreath. 2005. Passage of adult and juvenile salmonids through Federal Columbia River Power System dams. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-64.

Fish Passage Center. 2011. Juvenile Bypass System Fish Counts – Fish Passage Center Website. Available: http://www.fpc.org/bulltrout/bulltrout_queries/smp.

Fraley, J.J. and B.B. Shepard. 1989. Life history, ecology, and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake and River system. Montana Northwest Science 63:133–143.

Goetz, F. 1989. Biology of the bull trout. United States Department of Agriculture, Forest Service, Willamette National Forest, literature review. Eugene, Oregon.

Goetz, F.A. 1997. Diel behavior of juvenile bull trout and its influences on selection of appropriate sampling techniques. Pages 387–402 *in* W. C. Mackay, M. K. Brewin, and M. Monita, editors. Friends of the Bull Trout conference proceedings. Trout Unlimited Canada, Bull Trout Task Force, Calgary, Alberta.

Holecek, D. 2012. Personal Communication. U.S. Army Corps of Engineers, Walla Walla District. Walla Walla, WA, USA.

Jakober, M.J., T.E. McMahon, R.F. Thurow, and C.G. Clancy. 1998. Role of stream ice on fall and winter movements and habitat use by bull trout and cutthroat trout in Montana headwater streams. Transactions of the American Fisheries Society 127: 223-235.

Mahoney B.D., M.B. Lambert, T.J. Olsen, P. Bronson, and J.D.M. Schwartz. 2008. Walla Walla Basin Natural Production Monitoring and Evaluation Project Progress Report, FY 2006. Confederated Tribes of the Umatilla Indian Reservation, report submitted to Bonneville Power Administration, Project No. 2000-039-00.

McMichael, G.A., M.B. Eppard, T.J. Carlson, J.A. Carter, B.D. Epparts, R.S. Brown, M. Weiland, G.R. Ploskey, R.A. Harnish, and Z.D. Deng. 2010. The Juvenile salmon acoustic telemetry system: a new tool. Fisheries 23:9-22.

Meka, J.M., E.E. Knudsen, D.C. Douglas, and R. B. Benter. 2003. Variable migratory patterns of different adult rainbow trout life history types in a southwest Alaska watershed. Transactions of the American Fisheries Society 132: 717-732.

Montana Bull Trout Restoration Team. 2000. Restoration Plan for Bull Trout in the Clark Fork River Basin and Kootenai River Basin Montana. Prepared by the Montana Bull Trout Restoration Team for Governor Marc Racicot c/o Montana Department of Fish, Wildlife and Parks. Helena, MT.

Muhlfeld, C.C., S. Glutting, R. Hunt, D. Daniels, and B. Marotz. 2003. Winter diel habitat use and movement by subadult bull trout in the upper Flathead River, Montana. North American Journal of Fisheries Management 23: 163-171.

Muhlfeld, C.C. and B. Marotz. 2005. Seasonal movement and habitat use by subadult bull trout in the upper Flathead River System, Montana. North American Journal of Fisheries Management 25:797-810.

NPCC; Northwest Power and Conservation Council. 2004. Draft Umatilla/Walla Walla Subbasin Plan.

Pratt, K.L. 1992. A review of bull trout life history. Proceedings of the Gearhart Mountain Bull Trout Workshop. Edited by: Howell, P.J. and Buchanan, D.V. pp. 5-9. Oregon Chapter, Corvallis: American Fisheries Society.

Prisciandaro, A. and A. Harbison. 2007. Deadwood River Bull Trout Monitoring Activities. United States Department of the Interior Bureau of Reclamation Annual Report Snake River Area Office. Technical Report for Idaho Department of Fish and Game Permit No. F-10-99. Boise, Idaho.

PTAGIS. The Columbia Basin PIT Tag Information System. Available: www.ptagis.org.

Rieman, B.E. and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. United States Department of Agriculture, Forest Service, Intermountain Research Station. General Technical Report INT-302. Ogden, Utah.

Rieman, B.E. and J.D. McIntyre. 1995. Occurrence of bull trout in naturally fragmented habitat patches of varied size. Transactions of the American Fisheries Society 124:285-296.

Sankovich, P.M., S.L. Gunckel, A.R. Hemmingsen, I.A. Tattam, and P.J. Howell. 2003. Migratory patterns, structure, abundance, and status of bull trout populations from subbasins in the Columbia Plateau. 2002 Annual Report. Bonneville Power Administration. Portland, Oregon.

Shepard, B.B., Pratt, K.L. and Graham, P.J. 1984. Life histories of westslope cutthroat trout and bull trout in the upper Flathead River basin, Montana. Helena: Montana Department of Fish, Wildlife and Parks.

Swanberg, T.R. 1997. Movements of and Habitat Use by Fluvial Bull Trout in the Blackfoot River, Montana. Transactions of the American Fisheries Society, 126:735-746.

Thurow, R.F. 1997. Habitat utilization and diel behavior of juvenile bull trout (*Salvelinus confluentus*) at the onset of winter. Ecology of Freshwater Fish 6:1–7.

USACE. 2011. Miscellaneous Fish Counts Spreadsheet. Available: http://www.nwp.usace.army.mil/environment/Adult Fish Count Database.

USFWS. 2000. Biological opinion on the effects to listed species from operations of the Federal Columbia River Power System. U.S. Fish and Wildlife Service, Region 1 and 6. Portland, OR. 97 pages.

USFWS. 2002. Chapter 10, Draft Umatilla-Walla Walla Recovery Unit, Oregon and Washington. 149 pp. In: U.S. Fish and Wildlife Service, Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. Portland, Oregon.

USFWS. 2010. Revised designation of critical habitat for bull trout in the coterminous United States, Final Rule. *Federal Register,* 75 (210): 63898-64070. 18 October 2010.

Weaver, M.J. 1993. Analyses for Differentiating Littoral Fish Assemblages with Catch Data from Multiple Sampling Gears. Transactions of the American Fisheries Society 122:1111-1119.

Williams, J.G., S.G. Smith, R.W. Zabel, W.D. Muir, M.D. Scheuerell, B.P. Sandford, D.M. Marsh, R.A. McNatt, and S. Achord. 2005. Effects of the Federal Columbia River Power System on salmonid populations. U.S. Dept. of Commerce. NOAA Tech. Memo., NMFS-NWFSC-63.

Winter, J. 1996. Advances in underwater biotelemetry. Pages 555-590 *in* B. R. Murphy and D. W. Willis, editors. Fisheries Techniques, Second Edition. American Fisheries Society. Bethesda, Maryland.

Appendix A

Non-salmonids Captured in Fyke Nets and Rotary Screw Traps, October 2010-March 2011

Table A1. Monthly summary of fish captured in the lower Walla Walla River using a fyke net and rigid leads at the Pierce's RV Park site. Sampling was conducted from 19 October through 9 November 2010.

Month/Year	Northern Pikeminnow	Tadpole Madtom	*Lepomis* spp.	Smallmouth Bass	Largemouth Bass	Sucker	Bullhead Catfish	Channel Catfish	Chiselmouth
October/2010	10	14	17	52	4	64	2	1	29
November/2010	0	8	2	9	1	17	0	0	5
Total	**10**	**22**	**19**	**61**	**5**	**81**	**2**	**1**	**34**

Table A2. Monthly summary of non-salmonids captured in the lower Walla Walla River using a rotary screw trap at the Pierce's RV Park site. Sampling was conducted from 26 October 2010 through 3 March 2011.

Month/Year	Northern Pikeminnow	Tadpole Madtom	*Lepomis* spp.	Smallmouth Bass	Largemouth Bass	Sucker	Bullhead Catfish	Channel Catfish	Chisel mouth	Sculpin	Peamouth	Carp	Crappie
October/2010	0	4	7	21	4	14	0	0	10	0	0	0	0
November/2010	4	10	36	25	10	488	1	2	161	0	0	1	1
December/2010	22	11	35	56	6	2196	0	11	247	0	1	14	7
January/2011	1	0	3	21	0	175	0	1	4	0	0	0	0
February/2011	13	7	2	37	0	323	7	0	17	1	0	0	0
March/2011	0	0	0	1	0	9	0	0	0	0	0	0	0
Total	**40**	**32**	**83**	**161**	**20**	**3205**	**8**	**14**	**439**	**1**	**1**	**15**	**8**

Table A3. Fish captured in the lower Walla Walla River using fyke nets. Sampling was conducted during November 2010.

Month/Year	Northern Pikeminnow	Tadpole Madtom	*Lepomis* spp.	Yellow Perch	Smallmouth Bass	Largemouth Bass	Sucker	Bullhead Catfish	Sculpin	Chiselmouth
November/2010	6	13	11	3	3	1	89	1	3	1

Appendix B

Complete Detection Histories of Acoustic Tagged Bull Trout

Detections from the fixed hydrophone stations, mobile tracking surveys, and PIT detection arrays were combined to describe the movements of each individual acoustic tagged bull trout as it migrated to and within the Columbia River, and returned to the Walla Walla River. Subsequent recaptures and mortalities are also included. Refer to Figure 3 for locations of detection sites.

Code 217 – Bull trout code 217 was tagged and released at the CTUIR trap site (rkm 51) on 9 November 2010. Immediately following release, the fish was detected moving upstream past the PIT detection array located in the adult fish ladder at the Garden City – Old Lowden #2 Diversion Dam, just upstream from the trap site. On 17 November 2010, the bull trout was detected at the ORB PIT detection array (rkm 10.1), having moved 41 rkm downstream in approximately seven days. This fish was detected while entering the mainstem Columbia River on 22 November 2010 by the fixed hydrophones at the mouth of the Walla Walla River. There were no other subsequent observations of this fish.

Code 232 – Bull trout code 232 was tagged and released at the CTUIR trap site (rkm 51) on 9 November 2010. The fish was detected moving upstream past the PIT detection array in the adult fish ladder at the Garden City – Old Lowden #2 Diversion Dam located upstream from the trap site. On 26 February 2011, the fish was detected at the ORB PIT detection array (rkm 10.1) and at the fixed hydrophones at the mouth of the Walla Walla River, entering the Columbia River on 27 February 2011. This fish was not observed again until it was detected reentering the Walla Walla River by the fixed hydrophones on 9 March 2011. It passed upstream of the ORB PIT detection array on 25 March 2011. It continued ascending the Walla Walla River, passing upstream of the Burlingame Diversion Dam PIT detection array (BGM) at rkm 60 on 10 May 2011 and into the mid-Basin portion of the Walla Walla River passing the Nursery Bridge Dam array (NBD) at rkm 74.3 near Milton-Freewater, OR on 9 June 2011.

Code 67 – Bull trout code 67 was captured, tagged and released at the CTUIR trap site (rkm 51) on 18 November 2010. Following release, the fish was not observed again until it was detected moving upstream past BGM (rkm 60) on 24 June 2011 and NBD (rkm 74.3) on 29 June 2011. The bull trout was recaptured by FWS field staff during hook and line surveys at rkm 76.3 on 12 October 2011. The fish was last detected moving downstream past NBD on 3 November 2011.

Code 202 – Bull trout code 202 was released at the CTUIR trap site (rkm 51) on 3 December 2010. The fish was detected by the fixed hydrophones at the mouth of the Walla Walla River while entering the Columbia River on 26 February 2011. This bull trout was not detected during mobile tracking surveys, but it was detected reentering the Walla Walla River by the fixed hydrophones on 15 June 2011.

Code 82 – Bull trout code 82 was released at the CTUIR trap site (rkm 51) on 6 December 2010 and was first detected at the mouth of the Walla Walla River by the fixed hydrophones on 3 January 2011. It briefly moved back upstream in the Walla Walla river before reentering the mainstem Columbia River on 13 January 2011. There were no subsequent detections of this bull trout.

Code 262 – Bull trout code 262 was originally PIT tagged in the mid-Basin portion of Mill Creek near Walla Walla, WA prior to receiving an acoustic transmitter. FWS PIT detection data indicated that it migrated downstream from Mill Creek into the Yellowhawk Creek distributary prior to being detected moving downstream at the BGM PIT detection array in the Walla Walla River (rkm 60) on 28 November 2010. The fish was detected migrating past the ORB PIT detection array (rkm 10.1) on 6 December 2010 just prior to being recaptured, acoustic-tagged and subsequently released on 7 December 2010 at the Pierce's RV trap site (rkm 8). This bull trout was not observed again until its PIT tag was recovered on 28 September 2011 at an avian nesting colony (double-crested cormorants) on Foundation Island in the Columbia River. The PIT tag was recovered as part of a study evaluating the impacts of avian colonies on emigrating juvenile salmonids in the Columbia River.

Code 187 – Bull trout code 187 was originally captured, tagged, and released at the Pierce's RV trap site (rkm 8) on 10 December 2010. Following release, the fish moved rapidly downstream and entered the Columbia River later the same day. On 15 December 2010, the fish was relocated in the mainstem Columbia River approximately three rkm downstream from the mouth of the Walla Walla River. The bull trout was occupying deep water habitat (12.2 m) and was located approximately 300 m from the shoreline. Sizeable waves prevented field staff from recording a velocity profile with the ADCP at this location. Water temperature was 7.5 °C and substrate was observed to be primarily fines. Approximately 8 hours after the initial observation, field staff relocated this fish and it had not moved from the previous location. A mobile tracking survey conducted on 17 December 2010 confirmed that the fish had moved from the previously recorded location, but was not relocated or detected again.

Code 97 – Bull trout code 97 was tagged and released at the CTUIR trap site (rkm 51) on 12 January 2011. This fish was not subsequently detected at any location.

Code 127 – Bull trout code 127 was tagged and released at the CTUIR trap site (rkm 51) on 12 January 2011. This fish was not subsequently detected at any location.

Code 157 – Bull trout code 157 was tagged and released at the CTUIR trap site (rkm 51) on 14 January 2011. Immediately following release, the fish was detected moving upstream past the PIT detection array located in the adult fish ladder at the Garden City – Old Lowden #2 Diversion Dam, located just upstream from the trap site. The fish was then detected at the mouth of the Walla Walla River by the fixed hydrophones on 24 February 2011 entering the Columbia River. On 26 February 2011, this bull trout moved back upstream, then downstream into the Columbia again on the same day. After not being detected during mobile tracking surveys, it was detected reentering the Walla Walla River by the fixed hydrophones on 19 May 2011.

Code 172 – Bull trout code 172 was originally tagged and released at the Pierce's RV trap site (rkm 8) on 10 February 2011. Following release, the fish moved downstream and entered the Columbia River on 11 February 2011. The bull trout was relocated in the mainstem Columbia River approximately 12 rkm downstream from the mouth of the Walla Walla River and 23 km upstream from McNary Dam. The fish was occupying deep water habitat (16.8 m) and was located mid-channel, approximately 650 m from the shoreline. Substrate at this location could not be observed due to the combination of water depth and reduced water clarity. Water temperature at this location was 3.4 °C. A water velocity profile was recorded. The bull trout was occupying relatively slow water habitat. During a subsequent survey, six hours later (just before sunset) on 15 February 2011, the bull trout had moved to the north shoreline. It was within 10 m from shore, adjacent to a steep rock outcropping, occupying deep water habitat (16 m). As with the previous location, field staff were unable to determine substrate composition. This acoustic-tagged bull trout was not relocated during subsequent mainstem tracking surveys until 23 March 2011, approximately 11 rkm downstream from the mouth of the Walla Walla River near the location it had been previously observed. It was occupying deep water habitat and was located mid-channel. Substrate composition was not discernible. Water temperature at this location was 5 °C. The water velocity profile indicated that the fish was occupying relatively slow water habitat. This bull trout was detected reentering the Walla Walla River on 15 May 2011 and successfully ascended the Walla Walla River before being recaptured via angling on 19 July 2011, 74 rkm upstream from the mouth of the Walla Walla River.

Code 247 – Bull trout code 247 was tagged and released at the CTUIR trap site (rkm 51) on 18 February 2011. It was recaptured the following day on 19 February in the rotary screw trap indicating that it had briefly moved back upstream. The fish was next observed moving upstream past the PIT detection array located in the adult fish ladder at the Garden City – Old Lowden #2 Diversion Dam on 15 March 2011. And finally, on 15 May 2011 this fish was detected moving back into the Walla Walla River from the Columbia River. The placement of the two SURs at the mouth of the Walla Walla River allowed us to determine direction of movement. Apparently, this bull trout moved back down the Walla Walla River following its ascent over the fish ladder at Lowden. The likely route would have been back downstream over the diversion dam at Lowden, downstream past the ORB PIT array (likely during higher flows and no detection), downstream past the SURs and to the Columbia River (not detected), then detected by the SURs returning upstream.

Table B1. PIT tag and acoustic tag detections, dates, and locations for all bull trout that were acoustic tagged during 2011.

Acoustic Tag code	PIT tag code	Date Acoustic Tagged(*)/Detected/ Recaptured	Elapsed Time (days)	Location Acoustic Tagged (*) / Detected / Recaptured
217	384.1B795B26E1	11/9/2010*	N/A	CTUIR trap site (rkm 51)*
		11/9/2010	0	Lowden PIT Array (rkm 51)
		11/17/2010	7	Oasis Rd. Bridge PIT Array (rkm 10)
		11/22/2010	5	Fixed Hydrophones – DS (rkm 0)
232	384.1B795B26AF	11/9/2010*	N/A	CTUIR trap site (rkm 51)*
		11/9/2010	0	Lowden PIT Array (rkm 51)
		2/26/2011	109	Oasis Rd. Bridge PIT Array (rkm 10)
		2/26/2011	0	Fixed Hydrophones - DS (rkm 0)
		3/9/2011	11	Fixed Hydrophones - US (rkm 0)
		3/25/2011	16	Oasis Rd. Bridge PIT Array (rkm 10)
		5/10/2011	46	Burlingame PIT Array (rkm 60)
		6/9/2011	30	Nursery Bridge PIT Array (rkm 74)
67	384.1B795B265E	11/18/2010*	N/A	CTUIR trap site (rkm 51)*
		6/24/2011	218	Burlingame PIT Array (rkm 60)
		6/29/2011	5	Nursery Bridge PIT Array (rkm 74)
		10/12/2011	105	Recapture – Angling (rkm 76)
		11/3/2011	22	Nursery Bridge PIT Array (rkm 74)
202	384.1B795B268A	12/3/2010*	N/A	CTUIR trap site (rkm 51)*
		2/26/2011	85	Fixed Hydrophones - DS (rkm 0)
		6/15/2011	109	Fixed Hydrophones - US (rkm 0)
82	3D9.1BF1B2E892	12/6/2010*	N/A	CTUIR trap site (rkm 51)*
		1/3/2011	28	Fixed Hydrophones - DS (rkm 0)
		1/13/2011	10	Fixed Hydrophones - US (rkm 0)
		1/13/2011	0	Fixed Hydrophones - DS (rkm 0)

Acoustic Tag code	PIT tag code	Date Acoustic Tagged(*)/Detected/ Recaptured	Elapsed Time (days)	Location Acoustic Tagged (*) / Detected / Recaptured
262	384.1B795B26A6	11/4/2010	N/A	Mill Creek – PIT tagged Only
		11/22/2010	18	Yellowhawk Creek PIT Array
		11/28/2010	6	Burlingame PIT Array (rkm 60)
		12/6/2010	8	Oasis Rd. Bridge PIT Array (rkm 10)
		12/7/2010*		Recapture - Pierce's Trap Site (rkm 8)*
		9/28/2011		Mortality (Avian) – Foundation Island
187	3D9.257C69841C	12/10/2010*	N/A	Pierce's Trap Site (rkm 8)*
		12/10/2010	0	Fixed Hydrophones - DS (rkm 0)
		12/15/2010	1	CR Detection (rkm 506)
		12/15/2010	0	CR Detection (rkm 506)
97	3D9.1BF1B2979A	1/12/2011*	N/A	CTUIR trap site (rkm 51)*
127	3D9.1BF1B2EAAE	1/12/2011*	N/A	CTUIR trap site (rkm 51)*
157	3D9.1BF1B2F7EA	1/14/2011*	N/A	CTUIR trap site (rkm 51)*
		1/14/2011	0	Lowden PIT Array (rkm 51)
		2/24/2011	41	Fixed Hydrophones - DS (rkm 0)
		2/26/2011	2	Fixed Hydrophones - US (rkm 0)
		2/26/2011	0	Fixed Hydrophones - DS (rkm 0)
		05/19/2011	82	Fixed Hydrophones - US (rkm 0)
172	384.1B795B268C	2/10/2011*	N/A	Pierce's Trap Site (rkm 8)*
		2/11/2011	1	Fixed Hydrophones - DS (rkm 0)
		2/15/2011	4	CR Detection (rkm 497)
		2/15/2011	0	CR Detection (rkm 497)
		3/23/2011	36	CR Detection (rkm 498)
		5/15/2011	53	Fixed Hydrophones - US (rkm 0)
		6/1/2011	17	Burlingame PIT Array (rkm 60)
		7/3/2011	32	Nursery Bridge PIT Array (rkm 74)
		7/19/2011	16	Recapture – Angling (rkm 74)
		10/14/2011	87	Nursery Bridge PIT Array (rkm 74)

Acoustic Tag code	PIT tag code	Date Acoustic Tagged(*)/Detected/ Recaptured	Elapsed Time (days)	Location Acoustic Tagged (*) / Detected / Recaptured
247	3D9.1BF1B2F1CF	2/18/2011*	N/A	CTUIR trap site (rkm 51)*
		2/19/2011	1	Recapture – CTUIR trap site (rkm 51)
		3/15/2011	24	Lowden PIT Array (rkm 51)
		5/15/2011	61	Fixed Hydrophones - US (rkm 0)

Appendix C

Quantitative Estimate of Walla Walla Basin Bull Trout Using the Columbia River

One of the Objectives of the previous COE-funded project was to develop an estimate of the number of Walla Walla Basin bull trout that may be using the Columbia River. We chose to continue this effort in FY2011. These methods describe the process we used to estimate the total number of migratory bull trout that may be using the Columbia River.

Methods

Abundance Estimates

To estimate the total number of outmigrants that may have moved past the ORB detection array, we utilized the empirical data consisting of monthly PIT array detections in combination with estimates of physical detection efficiency (PDE) and an estimate of the proportion of the population that was PIT tagged based on rotary screw trap sampling. The screw trap sites were located at rkm 8 and rkm 51. We combined the captures from both screw traps due to the relatively small sample size. The screw trap sampling provided an annual estimate of the proportion of the assumed outmigrant population that had previously been PIT tagged. We treated this proportion as an estimate of the detection probability for the outmigrant population. From Thompson (1992, p. 165-166), an estimate of the monthly number of outmigrants ($\hat{\tau}$) is:

$$\hat{\tau} = \frac{y}{\hat{p}}$$

where y is the number of PIT detections each month at ORB and $\hat{p}$ is the annual estimate of the proportion of the outmigrant population that was PIT tagged, estimated as the number of screw trap samples with PIT tags divided by the total number sampled (n). The variance of $\hat{\tau}$ is:

$$var(\hat{\tau}) \approx \tau\left(\frac{1-p}{p}\right) + \frac{\tau^2}{p^2} var(\hat{p}).$$

The variance of the proportion tagged ($var(\hat{p})$) was assumed to follow a binomial distribution with variance,

$$var(\hat{p}) = p(1-p)/n.$$

The monthly PIT detections were influenced by variation in the PDE of the array over time. To incorporate monthly PDE and its uncertainty into the estimates, we expanded the estimates of the monthly number of outmigrants ($\hat{\tau}$) by PDE,

$$\hat{\tau}_{PDE} = \frac{1}{PDE}\hat{\tau}.$$

The variance of $\hat{\tau}_{PDE}$ is then,

$$var(\hat{\tau}_{PDE}) = var\left(\frac{1}{PDE}\hat{\tau}\right) = \frac{1}{PDE^2}var(\hat{\tau}).$$

Finally, we summed the estimates of the monthly number of outmigrants (expanded for PDE) to estimate the annual number of outmigrants. The variance of the total number of estimated outmigrants was the sum of the monthly variance estimates, with confidence limits calculated as ±1.96·SE.

Results

Migratory Bull Trout Abundance

Rotary screw trap sampling at the Pierce's RV Park and CTUIR trap sites collected a total of 12 bull trout, of which, two were previously PIT tagged. These data were used to develop the estimate of the proportion of the assumed outmigrant population that had previously been PIT tagged ($\hat{p}$). The resulting estimate of the proportion tagged was 0.167 (Table C1).

Combining PIT detections, the proportion of the outmigrant population that was PIT tagged, and monthly variation in PDE at the ORB PIT detection array, we estimated that there were 263 outmigrant bull trout during the 2010/2011 migration season (Table C1), with a 95% confidence interval of (59, 466). This estimate was more than double the previous highest annual estimate of 120 bull trout in migration year 2008/09 (Table C2).

Table C1. Monthly PIT detections at ORB, estimates of the annual proportion of the outmigrant population with PIT tags ($\hat{\boldsymbol{p}}$), resulting monthly estimates of the population of outmigrants ($\hat{\boldsymbol{\tau}}$) and their variance (var($\hat{\boldsymbol{\tau}}$)), monthly estimates of physical detection efficiency (PDE), and monthly estimates of the total population of outmigrants adjusted for PDE (1/PDE*$\hat{\boldsymbol{\tau}}$) and their variance (var(1/PDE*$\hat{\boldsymbol{\tau}}$))for the 2011 migration season.

Month/year	**Detections**	$\hat{\boldsymbol{p}}$	$\hat{\boldsymbol{\tau}}$	**var($\hat{\boldsymbol{\tau}}$)**	**PDE**	**1/PDE*$\hat{\boldsymbol{\tau}}$**	**var(1/PDE*$\hat{\boldsymbol{\tau}}$)**
October/2010	2	.167	11.97	119.35	.975	12.28	125.55
November/2010	9	.167	53.89	1476.07	.962	56.02	1594.98
December/2010	14	.167	83.83	3339.41	.862	97.25	4494.23
January/2011	2	.167	11.97	119.35	.418	28.65	683.10
February/2011	2	.167	11.97	119.35	.175	68.43	3897.27
Total	**29**		**173.65**			**262.64**	

Table C2. Migration year PIT detections at ORB, estimates of the annual proportion of the outmigrant population with PIT tags ($\hat{p}$), resulting estimates of the population of outmigrants ($\hat{\tau}$), estimates of the total population of outmigrants adjusted for physical detection efficiency (PDE) (1/PDE*$\hat{\tau}$), and the 95% confidence interval (CI).

Migration Year	PIT Tags Detected	($\hat{p}$)	($\hat{\tau}$)	Estimated Number of Outmigrants adjusted for PDE (1/PDE*$\hat{\tau}$)	95% CI
2007/08	6	0.125	48.0	49.3	6-96
2008/09	12	0.174	69.2	120.3	38-203
2009/10	6	0.286	21.0	23.2	6-46
2010/11	29	0.167	173.7	262.6	59-466