U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office

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

FY2012 Annual Report
(October 1, 2011 – September 30, 2012)

Final

Marshall G. Barrows, Ryan Koch, Donald R. Anglin, Steven L. Haeseker

U.S. Fish and Wildlife Service
Columbia River Fisheries Program Office
Vancouver, WA 98683

Prepared for:

The U.S. Army Corps of Engineers
Walla Walla District
201 North 3rd Avenue
Walla Walla, WA 99362

MIPR Contract Number: W68SBV12861437

May 28, 2014

On the cover: *The cover photograph depicts the mainstem Columbia River downstream from the Wallula Gap near the mouth of the Walla Walla River. Photograph by Ryan Koch (USFWS).*

The correct citation for this report is:

Barrows, M.G., R. Koch, D.R. Anglin and S.L. Haeseker. 2014. Use of the Mainstem Columbia River by Walla Walla Basin Bull Trout. 2012 Annual Report to the U.S. Army Corps of Engineers, Walla Walla District. Project BT-W-10-2. www.fws.gov/columbiariver/publications.html.

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Disclaimers

USE OF THE MAINSTEM COLUMBIA RIVER BY WALLA WALLA BASIN BULL TROUT

FY2012 ANNUAL REPORT

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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 2011 through February 2012 during the time period when most of the emigration from the Walla Walla Basin occurs. Twenty bull trout were captured in the lower Walla Walla River between 16 November 2011 and 9 February 2012, fifteen of which were subsequently tagged with acoustic transmitters and full duplex ISO 134 kHz passive integrated transponder (PIT) tags. Tagged bull trout ranged in fork length from 215 to 438 mm and their weight varied from 102.0 to 797.5 g. Six of those fish moved into the Columbia River and we were able to obtain locations on two during mobile tracking surveys. Emigration of acoustic tagged bull trout from the Walla Walla River occurred between 19 December 2011 and 31 January 2012. The two bull trout we located moved upstream toward the confluence of the Snake River, but were not relocated further than 13 river kilometers (rkm) upstream from the mouth of the Walla Walla River. One additional bull trout was detected on the Wallula Gap fixed hydrophone array approximately four rkm downstream of the mouth of the Walla Walla River heading toward McNary Dam. Only one acoustic-tagged bull trout was detected while returning to the Walla Walla River from the mainstem on 18 February 2012. In addition, 96 migratory bull trout were PIT-tagged in middle Basin areas. Emigration of PIT-tagged bull trout occurred between 31 October 2011 and 30 January 2012. Our quantitative estimate of the number of Walla Walla Basin bull trout that may have used the Columbia River during the 2011/12 migration season was 41 (95% CI 21-87). Immigration of PIT-tagged bull trout occurred between 10 April 2012 and 29 May 2012. One PIT-tagged bull trout from the Walla Walla River was detected while ascending the adult ladder at McNary Dam from 26 June through 29 June 2012. Another bull trout PIT-tagged in the Walla Walla River as part of this project, was recaptured while ascending the adult fish ladder at Three Mile Falls Dam in the Umatilla River. Subsequent genetic assignment of this fish and seven other bull trout captured at this location since 2007 indicated that all eight of the bull trout captured originated from outside the Umatilla Basin. Most (N = 7) originated in the South Fork Walla Walla River, and one was from the Tucannon River. It is unknown if this connectivity with the Umatilla River was intrinsic, or induced by the presence of McNary Dam. Weather and river conditions in addition to the large size of the study area limited our ability to determine the extent of movements and distribution, and to collect detailed habitat use data.

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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) identify the action of improving connectivity between populations of Columbia River bull trout as an essential 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 avian and aquatic 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 and northeast Oregon. 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. 2012a, 2012b).

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).

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, passive integrated transponder (PIT) tag detections at some of the projects (USACE 2012; Fish Passage Center 2012; Anglea et al. 2004; PTAGIS website (www.ptagis.org)). From 1991 through 2012, there have been at least 488 bull trout observations in the adult ladders of the lower Snake River hydropower projects, and at least eight bull trout observations in the adult ladders of the lower Columbia River hydropower projects. From 1998 through 2012, there have been 14 bull trout observations in the juvenile bypass systems of the lower Snake River dams, and two bull trout observations in the juvenile bypass systems of the lower Columbia River dams. There have been eight PIT tagged bull trout detected in the fish ladders and juvenile bypass systems of the lower Snake River dams, and there have been six PIT tagged bull trout detected in the fish ladders and juvenile bypass systems at Columbia River dams, including Priest Rapids and McNary dams (Table 1). Four of these are a result of PIT tagging migratory bull trout in the Walla Walla Basin.

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

Tagging Site	Detection Location	Tagging Date	Detection Date
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
Entiat River	Priest Rapids adult ladder (east)	9/23/2009	5/24/2012
Walla Walla River	McNary adult ladder (Oregon)	10/24/2012	6/26-29/2012

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; Barrows et al. 2012a, 2012b), 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 largely unknown. There are two primary routes of downstream 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 to what extent 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 goals of this project are to determine migration patterns, spatial and temporal distribution, habitat use, and passage behavior of Walla Walla Basin migratory bull trout in the mainstem FCRPS reservoirs (e.g. McNary Reservoir) and around mainstem FCRPS hydropower projects (e.g. McNary Dam). An additional, longer term goal is to develop operational alternatives to accommodate migratory bull trout if research indicates such alternatives are necessary. The objectives to accomplish the aforementioned goals include:

1. Capture and apply acoustic transmitters to migratory bull trout that are emigrating out of the Walla Walla Basin and into the mainstem Columbia River (McNary Pool) for subsequent tracking.

2. Determine the migratory locations and fates of acoustically tagged bull trout in the Columbia River and near the mainstem projects using a combination of stationary and mobile acoustic tracking methods.

3. Determine habitat conditions used by bull trout in the McNary Pool and around McNary Dam or other mainstem hydropower projects.

4. Maintain and upgrade the PIT detection array at the mouth of the Walla Walla River (Oasis Road Bridge) to monitor the timing of migratory bull trout movements into the Columbia River, to estimate the size of the migratory population moving into the Columbia River, and to supplement acoustic tracking data.

5. PIT tag Walla Walla Basin bull trout to support the acoustic telemetry research including maintaining a tagged population of bull trout for detection at the Oasis Road Bridge (ORB) PIT detection array for detection at the mainstem hydro projects, and to estimate migratory population size.

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, the Confederated Tribes of the Umatilla Indian Reservation (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). Beginning in 2005, the CTUIR has annually released roughly 250,000 out of basin hatchery spring Chinook smolts (Carson Stock) into the South Fork Walla Walla River at Harris Park Bridge to augment the newly established population.

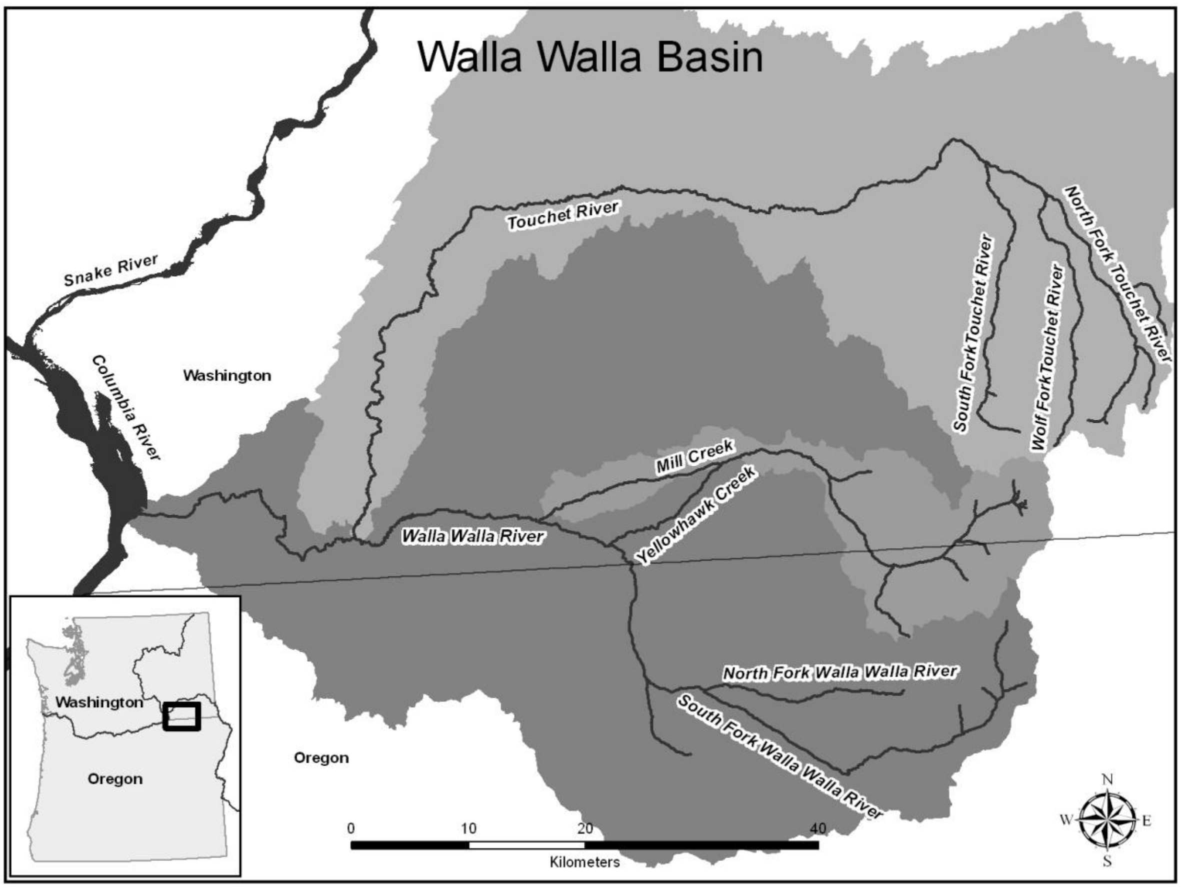

Figure 1. Study area map depicting the Walla Walla Basin with the Touchet River, Mill Creek, and Walla Walla River subbasins.

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 reservoir formed by McNary Dam (Figure 2), and the secondary study area is the lower Walla Walla River. McNary Dam is located 470 river kilometers (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).

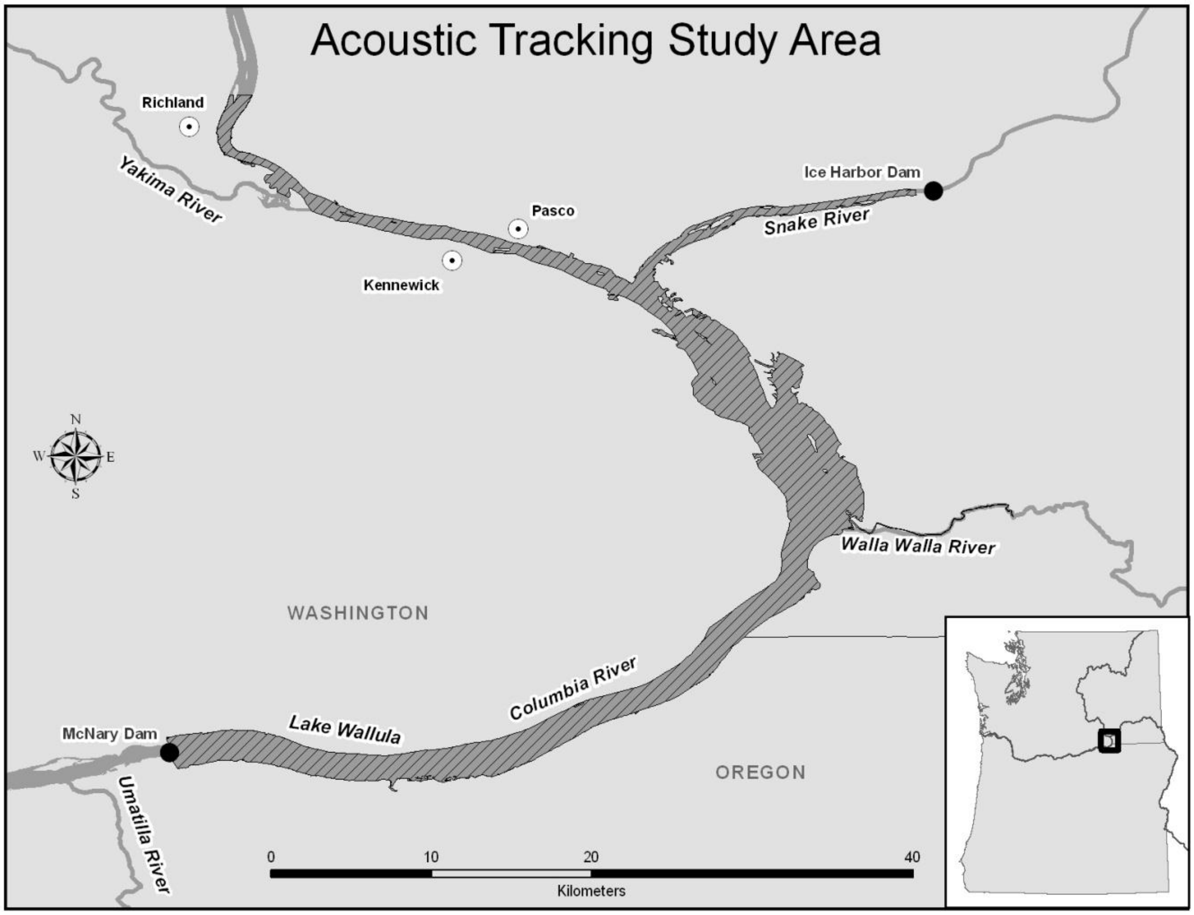

Figure 2. Mainstem Columbia River study area depicting Lake Wallula (McNary Reservoir), the lower Snake River and the lower Walla Walla River.

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). Fyke nets, rotary screw traps, and angling were used to capture bull trout for subsequent PIT and acoustic tagging.

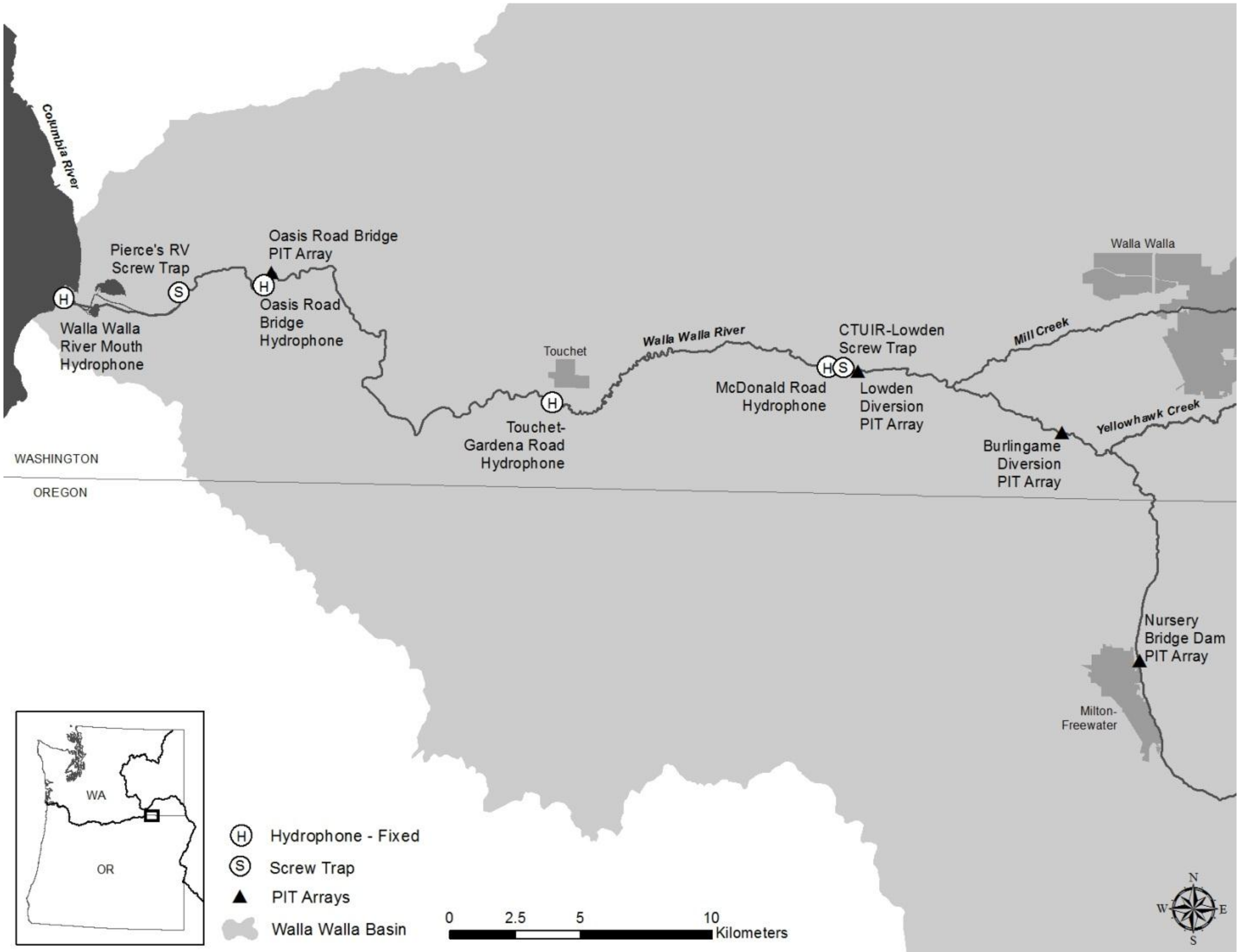

Figure 3. Lower Walla Walla River sampling area showing locations of rotary screw trap sites, fixed hydrophones and PIT detection arrays.

FWS rotary screw trap, Pierce's RV Park – Screw trap sampling at the Pierce's RV Park trap site was conducted from 9 November 2011 through 21 February 2012. When river depth and discharge consistently exceeded 0.8 m and 100 ft^3/s, respectively, a 5-foot rotary screw trap was deployed at rkm 8. In late-January, when river discharge consistently exceeded 500 ft^3/s, the 5-foot trap was replaced by an 8-foot rotary screw trap. The traps were operated six days per week 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, WA (rkm 51) and operated it from 16 November 2011 through 13 April 2012 as part of their ongoing anadromous salmonid monitoring program. A 5-foot rotary screw trap was operated when streamflow and debris conditions were favorable for effective sampling. When a bull trout was captured, CTUIR field staff obtained a weight (g), fork length (FL, mm), scanned the fish for an existing PIT tag, and placed it into a perforated holding vessel inside the screw trap live well. FWS and COE field staff were then contacted via cell phone and arrangements were made for experienced personnel to tag the bull trout in a timely manner.

Fyke Net, Lowden – A fyke net was also deployed downstream of the CTUIR rotary screw trap site near Lowden, WA (rkm 51). Fyke net sampling was conducted when streamflows and debris loads were relatively low. 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 deployed perpendicular to the river channel in the thalweg and was supported by fence posts driven into the substrate. Rigid, picket-style leads were installed to help direct downstream migrating fish to the fyke net opening. The fyke net was operated six days per week and checked twice each day to remove fish and debris and to ensure proper function.

Angling, acoustic tags – Angling was used to capture bull trout for subsequent acoustic transmitter deployment at various locations in the lower Walla Walla River (rkm 0-51) using lures fitted with barbless hooks to catch bull trout when streamflows were relatively low and thus conducive to bank angling.

Angling, PIT tags – Angling was used to capture bull trout for PIT tag deployment at middle Basin locations in the Walla Walla River (rkm 51-82) and in Mill Creek. Sampling was conducted by experienced personnel using lures fitted with barbless hooks.

Bull Trout Tagging

Acoustic tags – We initially considered using transmitters and equipment compatible with the Juvenile Salmon Acoustic Telemetry System (JSATS, McMichael et al. 2010) in 2009/10 when this project began. We elected not to employ 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 (2011/12), 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.

For the current year of the study (2011/12), 30 acoustic tags were ordered. Our 30 acoustic transmitters were comprised of two different sizes to accommodate the range of bull trout sizes we expected to capture. The transmitters included 20 miniature IBT-96-6-I tags and 10 PT-4 sub-miniature Pico Tags. In addition to the newly acquired tags, eight acoustic transmitters which were not deployed during the previous year of the study were also available for deployment if needed. This group of transmitters included two PT-3 sub-miniature Pico Tags, three PT-4 sub-miniature Pico Tags and three miniature IBT-96-9-I 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-96-6-I	IBT-96-9-I
Transmitter Weight in Air (g)	2.2	4.0	4.0	7.7	8.8
Transmitter Length (mm)	19.0	25.0	25.0	42	47.0
Transmitter Diameter (mm)	7.8	9.0	9.0	11	10.5
Ping Rate (s)	20	10	20	5	3
Frequency (kHz)	75.0	75.0	75.0	75.0	75.0
Transmitter Life (days)	60	170	270	270	270
Quantity Available For Use	2	11	2	20	3

PIT tags – All bull trout tagged as part of this study were tagged with full duplex ISO 134 kHz PIT tags which were approximately 23 mm long.

Tagging, acoustic tags – 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 (FL), weighed to the nearest 0.1 g, and received both a PIT tag and an acoustic transmitter. Our acoustic tagging methods closely followed, and were adapted from radio tagging methods described by Sankovich et al. (2003). Four sizes of acoustic transmitters (Table 2) were acquired for this study to accommodate a range of bull trout sizes. 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. Several studies have recommended that maximum tag burdens should be flexible for each species studied and take into account the study's objectives (Collins et al. 2013; Cooke et al. 2011; Jepsen et al. 2005). By tagging at up to 5% of the host fish weight, it enabled us to tag more fish and a wider range of fish sizes while achieving shorter ping rates and attaining longer tag lives. A maximum fork length of 450 mm was used as a cutoff length for acoustic tagging. This length was chosen because PIT data collected in the lower Walla Walla River suggests that emigration into the Columbia River is rare in large bull trout (Anglin et al. 2010a; Barrows et al. 2012a, 2012b). 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.

Tagging, PIT tags – Following capture, bull trout were immediately anesthetized, measured and weighed following the aforementioned acoustic tagging methods. The 23 mm long PIT tags were inserted subcutaneously at the abdomen, slightly off the mid-line and anterior to the pelvic girdle through a shallow 3-mm incision. Following surgery, PIT-tagged bull trout were recovered from anesthesia in aerated river water and released near the capture site in an area of reduced water velocity.

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, Walla Walla River – Four submersible ultrasonic receivers (SUR) with integrated hydrophones were deployed at bridges in the lower Walla Walla River downstream from the CTUIR screw trap site near Lowden, WA to 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, Table 3). Fixed-station equipment testing was conducted during FY2010 (Barrows et al. 2012a). SUR's at monitoring sites within the non-backwatered portion of the lower Walla Walla River were deployed in protective stilling wells constructed from PVC pipe (Figure 4). After the initial deployment date, each SUR in the Walla Walla River was downloaded and redeployed approximately bi-weekly. The SUR's deployed in the Walla Walla River were operated continuously throughout the active battery life of all deployed acoustic tags.

Table 3. Deployment locations, identification numbers and river kilometers for SUR's deployed in the lower Walla Walla River.

SUR Deployment Location	SUR ID	RKM
McDonald RD Bridge	10247	47.9
Touchet-Gardena RD Bridge	10451	33.1
Oasis Road Bridge	10450	10.1
WW River Mouth	10445	0.0

Figure 4. Photograph depicting a PVC stilling well used for in-river SUR deployment at sites in the lower Walla Walla River.

<u>*Fixed hydrophone stations, Columbia River*</u> – Seven fixed-station hydrophone arrays incorporating 14 SUR's were established at locations within the mainstem study area for continuous, remote monitoring of acoustic-tagged bull trout migrating throughout the reservoir and in the vicinity of McNary Dam (Figure 5). SUR's that were deployed just downstream of McNary Dam were tethered to the downstream side of I-82 bridge columns. Similar deployment methods were utilized at railroad bridge locations upstream from the Walla Walla River confluence. For the three fixed-station hydrophone arrays that were established between McNary Dam and the mouth of the Walla Walla River, SUR's were deployed using concrete anchors, acoustic releases and floats (Figure 6). At each of these locations, SUR's were deployed across a transect perpendicular to the river channel, and spaced equally to enhance channel coverage. Previous testing and field observations suggested that the SUR's be spaced no more than 400 m apart within each array to increase the likelihood that an acoustic-tagged bull trout would be detected as it passed. Details for each mainstem fixed-station hydrophone array are provided in Table 4). After the initial deployment date, SUR's within the mainstem study area were downloaded and redeployed approximately bi-weekly when river conditions permitted.

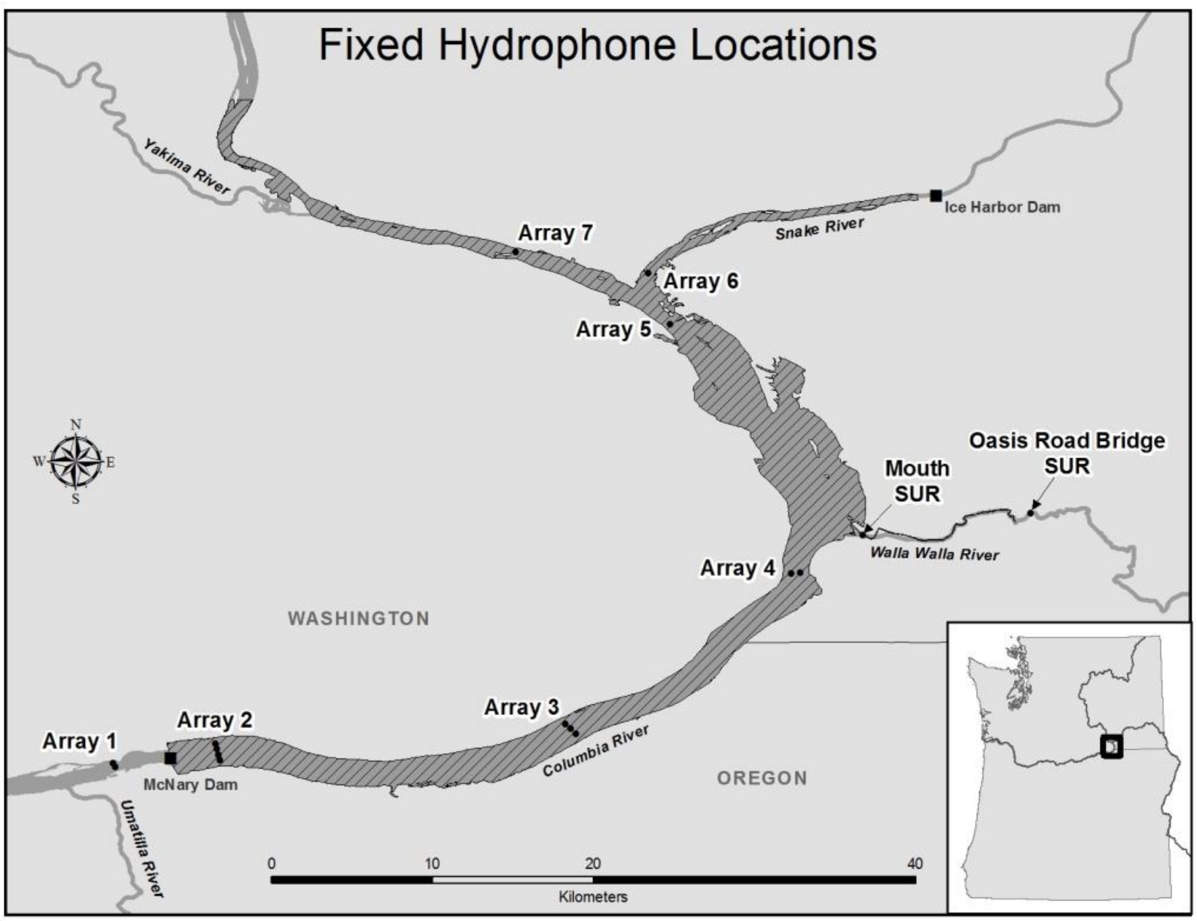

Figure 5. Mainstem Columbia River study area showing the location of fixed-station hydrophone arrays.

Figure 6. Photograph depicting mainstem submersible ultrasonic receiver setup incorporating a concrete anchor, acoustic release and float.

Table 4. Descriptions, locations, deployment methods and dates of deployment for fixed-station hydrophone arrays at locations within the mainstem study area.

Array Description	Deployment Method	Date of Initial Deployment	Removal Date
Below McNary Dam	Tethered	12/22/2011	9/19/2012
Above McNary Dam	Acoustic Release	1/11/2012	9/19/2012
Mid-Point	Acoustic Release	12/22/2011	9/19/2012
Wallula Gap	Acoustic Release	12/22/2011	9/19/2012
UP RR Bridge (Columbia R)	Tethered	1/24/2012	9/19/2012
BNSF RR Bridge (Snake R.)	Tethered	1/24/2012	9/19/2012
BNSF RR Bridge (Columbia R.)	Tethered	1/24/2012	9/19/2012

Mobile tracking surveys – Mobile tracking surveys were planned bi-weekly by boat, commencing when acoustic-tagged bull trout were first detected entering the mainstem study area. During FY2012 (1 October 2011 – 30 September 2012), the mainstem Columbia River (Lake Wallula) was 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 7). Monitoring point spacing was 500 m based on previous testing and field observations. When a monitoring 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. During previous testing (Barrows et al. 2012a), acoustic frequencies emitted by the boat motor while stationary and at a low idle did not notably affect audible detection ranges with the omnidirectional hydrophone. 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.

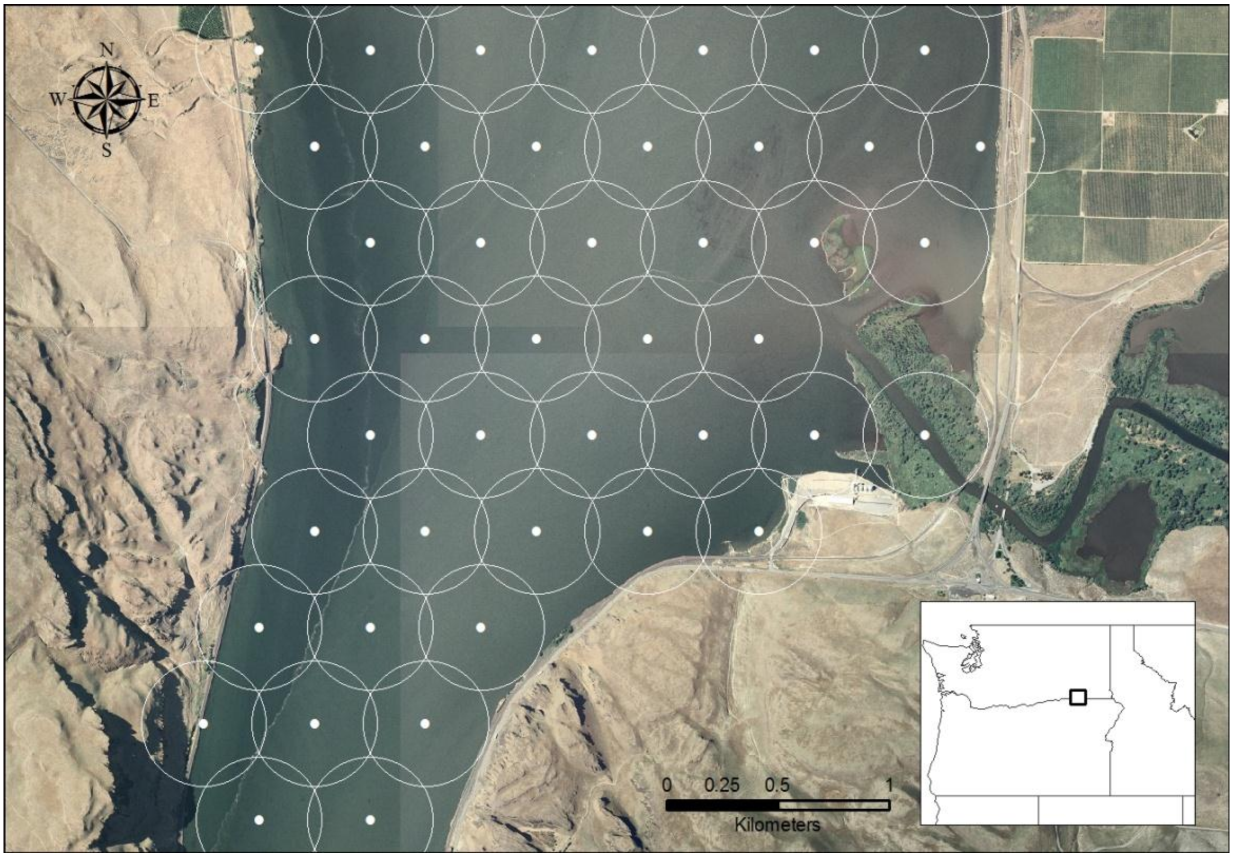

Figure 7. Grid pattern of monitoring points established in ArcMap for mobile tracking.

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 COE resumed funding for the continued operation and maintenance of the site during FY2012 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 provided additional movement data in the case of an acoustic transmitter failure, shedding, or tag life expiration. PIT tag detection data for bull trout at this site were queried on a regular basis from the PTAGIS database (www.ptagis.org). The ORB array uses a Destron Fearing 1001M multiplexing transceiver to detect full duplex PIT tags. The array consists of four 1.8 x 3.3 m hybrid dual loop pass through/pass over antennas anchored to the bedrock in the center of the channel and two 0.6 x 4.6 m pass over antennas secured to each bank. In addition, four 0.6 x 3.3 m pass over antennas were secured to the bedrock in the main channel directly upstream from the dual loop antennas as backup in the event that high flows disabled the hybrid antennas. The layout of the ORB PIT array is shown in Figure 8 and Figure 9.

Figure 8. Oasis Road Bridge PIT detection array.

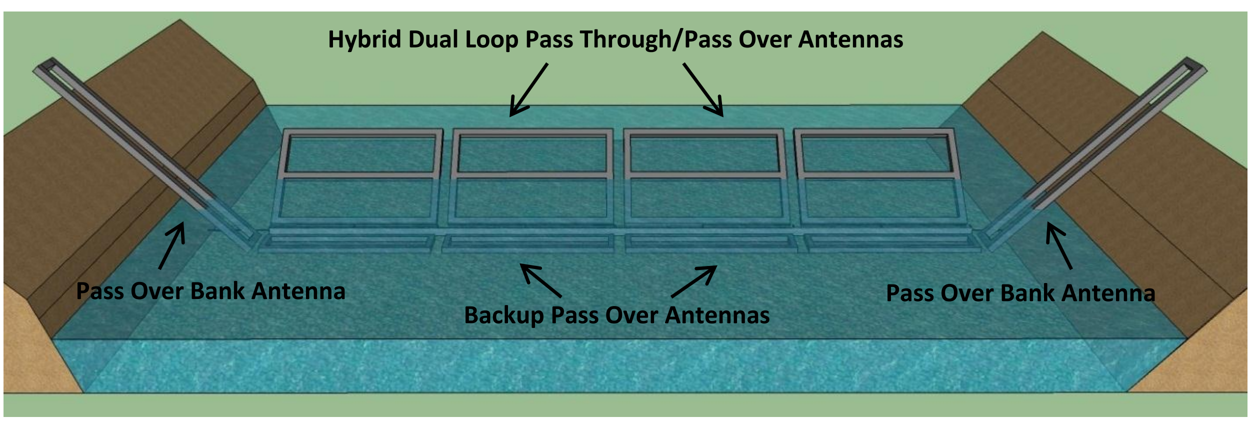

Figure 9. Schematic of the Oasis Road Bridge PIT detection array.

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.

Quantitative Emigration Abundance Estimates

Maintaining the ORB PIT detection array during FY2012 allowed us to continue the time series of quantitative estimates of bull trout moving into the Columbia River each year. 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 at rkm 8 and rkm 51 (Figure 3).

The functional status of the antennas (operational, not operational, not present), the cross sectional area of the antennas, and the cross sectional area of the river were used to determine the PDE of the ORB array. The daily functional status of the antennas was determined by examining status reports from the transceiver. Since the antennas were designed to detect PIT tags throughout the entire pass-through area of each antenna (i.e. no "holes"), the detection efficiency was assumed to be 100% as long as the antennas were present and operational. The cross sectional area of the stream at the site was compared to the cross sectional area of the antenna array to determine the proportion monitored as a function of the streamflow level. The cross sectional area of the stream at the site was calculated using the cross section profile and average daily stage data from USGS gage #14018500 (Walla Walla River near Touchet). The gage is located 15 rkm upstream from the array, and there are no major tributaries between the gage and the array. Paired observations at both the gage and at the ORB array site suggested stage heights responded similarly over a range of streamflows. We estimated the monthly PDE of the array by combining the average daily functional status from the transceiver with the average of the daily proportions of the water column monitored by the antennas in the array. Detailed methods (i.e. calculations) are described in Gallion and Anglin (2009).

To estimate the proportion of the assumed outmigrant population that was previously PIT tagged, we combined the captures from both screw traps due to the relatively small sample size from each. 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 95% confidence limits calculated as ±1.96·SE.

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. Water depth was measured with a Hummingbird 997SI Combo side-scan sonar unit. Water temperature was measured near the surface with a Fisher Scientific digital thermometer (°C).

Results

Bull Trout Sampling and Tagging

Bull Trout Sampling

We captured 20 bull trout during late fall and winter in the lower Walla Walla River during FY2012. Fifteen of the bull trout captured were subsequently tagged with acoustic transmitters. Multiple sampling methods were used, but the rotary screw traps were most successful at capturing migratory bull trout in the lower Walla Walla River. In addition, sampling efforts in middle Basin locations within the mainstem Walla Walla River and Mill Creek throughout the year resulted in a total of 139 bull trout, 96 of which were subsequently tagged with PIT tags. Angling was the most successful method for capturing migratory bull trout in middle Basin locations.

FWS rotary screw trap, Pierce's RV Park – Screw trap sampling at the Pierce's RV Park trap site commenced on 15 November 2011 and continued through 21 February 2012, a period of approximately three months for a total of 1737 hours (Table 5). A total of two 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 A1). Intermittently high 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 until streamflow exceeded 350 ft^3/s (Figure 10). In addition, no bull trout were captured at this site when streamflow exceeded 650 ft^3/s (Figure 10). All bull trout were captured within a narrow temperature range when average daily water temperatures were between 4.9 and 5.1 °C (Figure 10).

Table 5. Monthly summary of salmonids captured by the Pierce's RV park rotary screw trap and hours sampled. Sampling was conducted from 15 November 2011 through 21 February 2012.

Month/Year	**Salmonids Captured**			**Hours Sampled**
	Bull Trout	Juvenile Chinook Salmon	Juvenile Steelhead	Rotary Screw Trap (Pierce's RV Park)
Nov-11	0	6	1	298
Dec-11	1	42	48	499
Jan-12	0	41	62	457
Feb-12	1	20	70	483
Total	**2**	**109**	**181**	**1737**

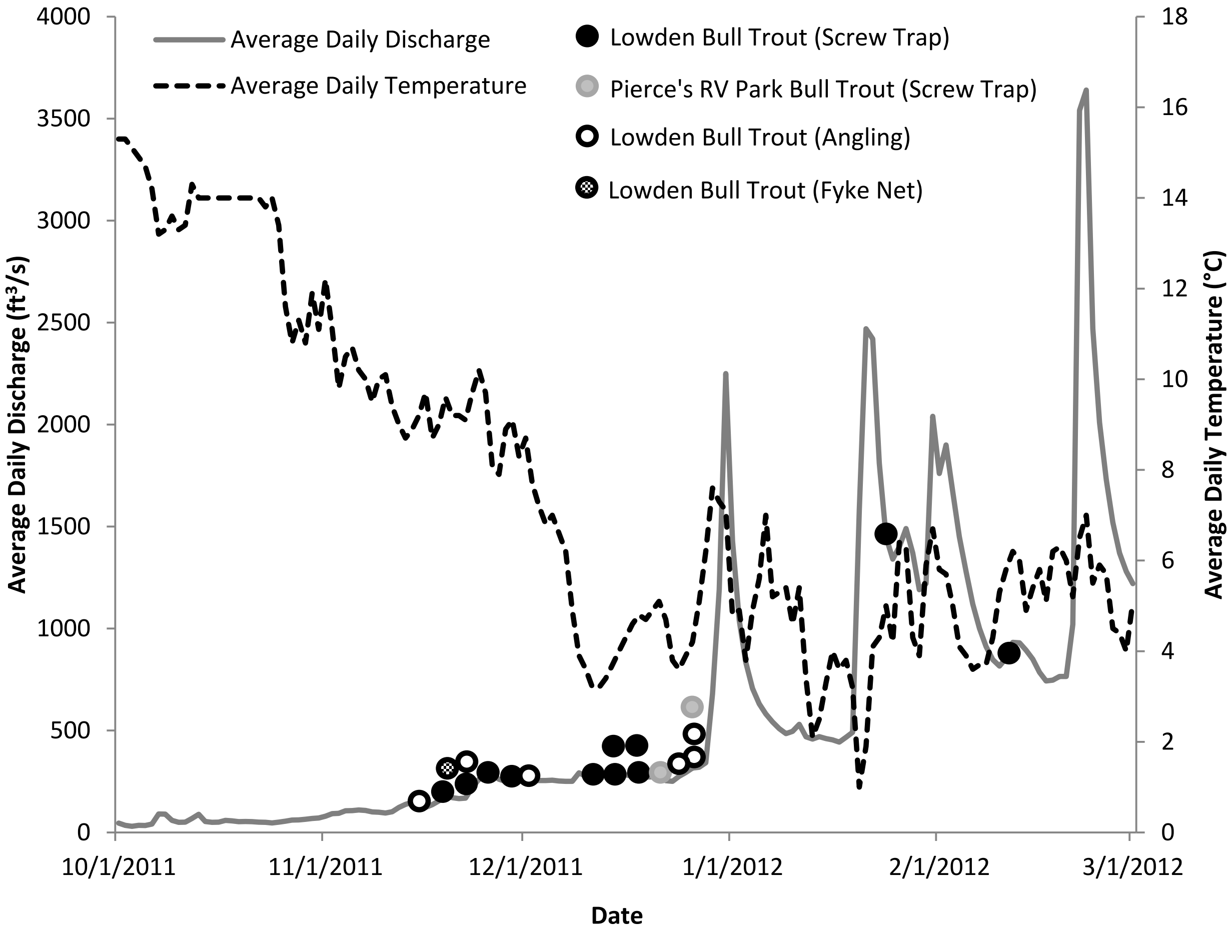

Figure 10. Bull trout captured at the Lowden and Pierce's RV park rotary screw trap sites in relation to average daily stream discharge and water temperature.

<u>CTUIR rotary screw trap, Lowden</u> – The CTUIR rotary screw trap at rkm 51 near Lowden was operated for approximately five months from 16 November 2011 through 13 April 2012. A total of 11 bull trout were captured at this site (Table 6). Intermittently high streamflows, occasional ice flows, and high debris loads resulted in sampling downtime and reduced screw trap efficiency, similar to conditions at the Pierce's RV Park site. Only two bull trout were captured at this trap site when streamflow exceeded 500 ft^3/s and none were captured at flows exceeding 1450 ft^3/s (Figure 10). Bull trout were captured when average daily water temperatures were between 3.2 and 9.0 °C (Figure 10).

Table 6. Monthly summary of bull trout captured by the CTUIR Lowden rotary screw trap. Sampling was conducted from 16 November 2011 through 13 April 2012.

Month/Year	Bull Trout
November/2011	4
December/2011	5
January/2012	1
February/2012	1
March/2012	0
April/2012	0
May/2012	0
June/2012	0
Total	**11**

<u>*Fyke Net, Lowden*</u> – Fyke net sampling, just downstream of the CTUIR rotary screw trap site near Lowden, WA (rkm 51) was conducted from 25 October through 22 November 2011, a period of approximately four weeks for a total of 454 hours (Table 7). Sampling was terminated when streamflows and the corresponding debris loads increased and prevented stable deployment of the gear. One bull trout, 25 juvenile Chinook salmon, 72 juvenile *O. mykiss* and one adult coho salmon were captured during this time period (Table 7). Non-salmonids captured during this time period are listed in Appendix A, Table A2.

Table 7. Monthly summary of salmonids captured by the Lowden fyke net and hours sampled. Sampling was conducted from 25 October 2011 through 22 November 2011.

Month/Year	Lowden Fyke Net			Hours Sampled
	Bull Trout	Juvenile Chinook Salmon	Juvenile Steelhead	Fyke Net (Lowden)
Oct-11	0	3	15	114
Nov-11	1	22	57	340
Total	**1**	**25**	**72**	**454**

<u>*Angling, acoustic tags*</u> – Field staff angled for bull trout in the lower Walla Walla River from 13 October 2011 through 10 February 2012. River access throughout the lower Walla Walla River was limited and streamflows were often not conducive to angling. During a total of 99.25 hours of sampling, six bull trout were captured. Adult steelhead, juvenile *O. mykiss*, juvenile spring Chinook salmon and northern pikeminnow were among the incidental captures.

<u>*Angling, PIT tags*</u> – Field staff angled for bull trout in middle Basin locations in the Walla Walla River and Mill Creek from 12 October 2011 through 20 September 2012. During a total of 48.5 hours of sampling, 139 bull trout were captured, of which 96 were subsequently PIT-tagged. The remaining 43 were recaptures, having previously been PIT-tagged. Juvenile steelhead and spring Chinook salmon were the most common incidental captures.

Bull Trout Tagging

Tagging, acoustic tags – A total of 15 bull trout were tagged with acoustic transmitters and PIT tags in the lower Walla Walla River between 16 November 2011 and 9 February 2012 (Table 8). Tagged bull trout ranged in from 215 to 438 mm FL and their weight varied from 102.0 to 797.5 g. A total of 13 bull trout were tagged and released just downstream from the CTUIR Lowden rotary screw trap site (rkm 51) and two were tagged and released just downstream from the Pierce's RV Park rotary screw trap site at rkm 8. The estimated tag life and expiration date for each deployed acoustic transmitter is provided in Appendix B.

Table 8. Acoustic tag code, PIT tag code, tagging date, tagging location, fish length, and fish weight for bull trout tagged during FY2012.

Acoustic Tag code	PIT tag code	Tagging date	Tagging location	Fork length (mm)	Weight (g)
142	384.1B795B26AD	11/16/2011	Lowden [a]	438	797.5
247	384.1B795B2709	11/18/2011	Lowden [b]	267	180.0
67	384.1B795B26DC	11/22/2011	Lowden [b]	293	275.5
52	3D9.1C2C6C2633	11/28/2011	Lowden [b]	254	157.0
98W	384.1B795B26CD	11/30/2011	Lowden [b]	281	203.0
232	3D9.1C2C68849E	12/12/2011	Lowden [b]	275	190.0
277	3D9.1C2CBE0ED1	12/15/2011	Lowden [b]	259	165.0
37	3D9.1C2CBE475B	12/17/2011	Lowden [b]	258	156.0
22	3D9.1C2C6883A1	12/17/2011	Lowden [b]	261	167.0
113W	3D9.1C2C6C6F79	12/21/2011	Pierce [b]	295	227.0
217	384.1B795B26F4	12/27/2011	Lowden [a]	294	229.3
262	3D9.1C2C69205C	12/27/2011	Lowden [a]	382	513.3
202	3D9.1C2C688C65	12/28/2011	Pierce [b]	270	229.8
112	3D9.1C2C692D41	1/24/2012	Lowden [b]	228	120.4
21W	3D9.1C2C6C9C53	2/9/2012	Lowden [b]	215	102.0

[a] Captured by hook and line sampling
[b] Captured by screw trap

Tagging, PIT tags – A total of 96 bull trout from middle Basin locations in the Walla Walla River and Mill Creek were PIT-tagged throughout the year (Table 9). Tagged bull trout varied from 155 to 645 mm FL and their weight ranged from 36 to 2090 g. An additional 43 bull trout were captured that had previously been PIT-tagged. Table 9 provides a summary of bull trout captured, recaptured, and PIT-tagged in middle Basin locations during FY2012.

Table 9. Monthly summary of adult and subadult bull trout captured, recaptured and PIT tagged in lower and middle Basin locations in the Walla Walla River and Mill Creek. Sampling was conducted from October 2011 through September 2012.

Month/Year	Subadult Bull Trout PIT Tagged (< 300 mm)	Adult Bull Trout PIT Tagged (≥ 300 mm)	Subadult Bull Trout Recaptures (< 300 mm)	Adult Bull Trout Recaptures (≥ 300 mm)	Total Bull Trout Captured (All Sizes)
Oct-11	6	9	1	9	25
Nov-11	15	14	3	13	45
Dec-11	4	5	2	5	16
Jan-12	0	0	0	3	3
Feb-12	0	0	0	0	0
Mar-12	0	0	0	0	0
Apr-12	0	0	0	0	0
May-12	0	0	0	0	0
Jun-12	16	7	2	1	26
Jul-12	7	6	1	2	16
Aug-12	2	0	0	0	4
Sep-12	5	0	1	0	6
Totals	**55**	**41**	**10**	**33**	**139**

Monitoring Bull Trout Movements

Bull trout tagged during the fall and winter of FY2012 were detected at our Walla Walla Basin PIT detection arrays, during mobile hydrophone surveys and at fixed hydrophone stations in both the Walla Walla River and the Columbia River. Complete detection histories were assembled for each acoustic tagged bull trout for a comprehensive description of the temporal and spatial movement patterns.

Acoustic Tag Monitoring

Fixed hydrophone stations, Walla Walla River – Seven (47%) of the 15 bull trout tagged with an acoustic transmitter during the year were detected while migrating past fixed hydrophone stations deployed throughout the lower Walla Walla River. Of the seven fish, four were detected only while moving downstream toward the mainstem Columbia River, two were detected only while migrating upstream past fixed hydrophone stations and one was detected while both moving downstream then subsequently upstream. In total, five (33%) of the 15 acoustic-tagged bull trout were detected while entering the mainstem Columbia River between 19 December 2011 and 31 January 2012. One of the five (#142) was detected at the hydrophone station at the mouth of the Walla Walla River moving out to the Columbia River on 18 January 2012. It was subsequently detected on the same hydrophone on 25 January 2012, and again on 18 February 2012. The detection history for this fish indicated it continued to move upstream following the February detection. Since this fish was not detected at any of the Columbia River hydrophone arrays, or during mobile tracking, the extent of its movements in the Columbia River is unknown. Two of the five (#22, #112) were subsequently detected in the mainstem Columbia, but were never detected again, and their ultimate fate is unknown. Two of the five (#232, #277) were not subsequently detected in the Columbia River after they were detected by the SUR at the mouth of the Walla Walla River. One of these fish was never detected again, and may not have returned from the Columbia River. The other fish was detected at the ORB and Burlingame PIT arrays in the Walla Walla River in May and June, respectively, but the lack of subsequent PIT detections suggests that it did not reach the spawning grounds in the headwaters. One additional acoustic-tagged bull trout (#247, Lowden) was not detected at any of the fixed hydrophone stations in the Walla Walla River prior to being detected in the mainstem Columbia River, but was eventually detected passing upstream of Burlingame Dam (rkm 60) in early June. In total, six of the 15 acoustic-tagged bull trout (40%) were known to have entered the Columbia River, and two subsequently returned to the Walla Walla River. Table 10 provides a summary of in-river fixed hydrophone station detections of acoustic tagged bull trout.

Table 10. Detections of acoustic tagged bull trout at fixed hydrophone stations in the lower Walla Walla River during FY2012.

Tag code #	Tagging Location	TAG Start Date	McDonald RD SUR (10247) Rkm 47.9	Touchet-Gardena RD SUR (10451) Rkm 33.1	Oasis Road Bridge SUR (10450) Rkm 10.1	WW River Mouth SUR (10445) Rkm 0
142	Lowden (Rkm 51)	11/16/2011	11/26/2011 [a]	11/28/2011 [a]	12/17/2011 [a]	1/18/12 [a] -1/25/12 [c] -2/18/12[b]
247	Lowden (Rkm 51)	11/18/2011				
67	Lowden (Rkm 51)	11/22/2011				
52	Lowden (Rkm 51)	11/28/2011				
98W	Lowden (Rkm 51)	11/30/2011				
232	Lowden (Rkm 51)	12/12/2011		12/16/2011 [a]	12/18/2011 [a]	12/19/2011 [a]
277	Lowden (Rkm 51)	12/15/2011			12/21/2011 [a]	1/9/2012 [a]
37	Lowden (Rkm 51)	12/17/2011				
22	Lowden (Rkm 51)	12/17/2011			1/6/2012 [a]	1/7/2012 [a]
113W	Pierce (Rkm 9)	12/21/2011				
217	Lowden (Rkm 51)	12/27/2011				
262	Lowden (Rkm 51)	12/27/2011				
202	Pierce (Rkm 9)	12/28/2011			1/4/2012 [b]	
112	Lowden (Rkm 51)	1/24/2012		1/26/2012 [a]		1/31/2012 [a]
21W	Lowden (Rkm 51)	2/9/2012			4/10/2012 [b]	

[a] Detected while moving downstream
[b] Detected while likely moving upstream
[c] Unknown direction when detected

<u>Fixed hydrophone stations, Columbia River</u> – One (#22) of the six bull trout tagged with an acoustic transmitter that were known to have entered the Columbia River was detected on node #1 at the Wallula Gap Array (#4) on 11 January 2012 after being detected while entering the

Columbia River on 7 January 2012. No other fish were detected at fixed hydrophone stations located in the mainstem Columbia River during FY2012.

Mobile Tracking Surveys – Mobile tracking surveys in the mainstem Columbia River were initiated in February 2012 and were conducted regularly when weather and river conditions permitted through April 2012 (Figure 11). Inclement conditions included high winds and rough water conditions that affected the frequency and spatial extent of the surveys. Individual tracking surveys covered between 2 and 10 % of the total study area.

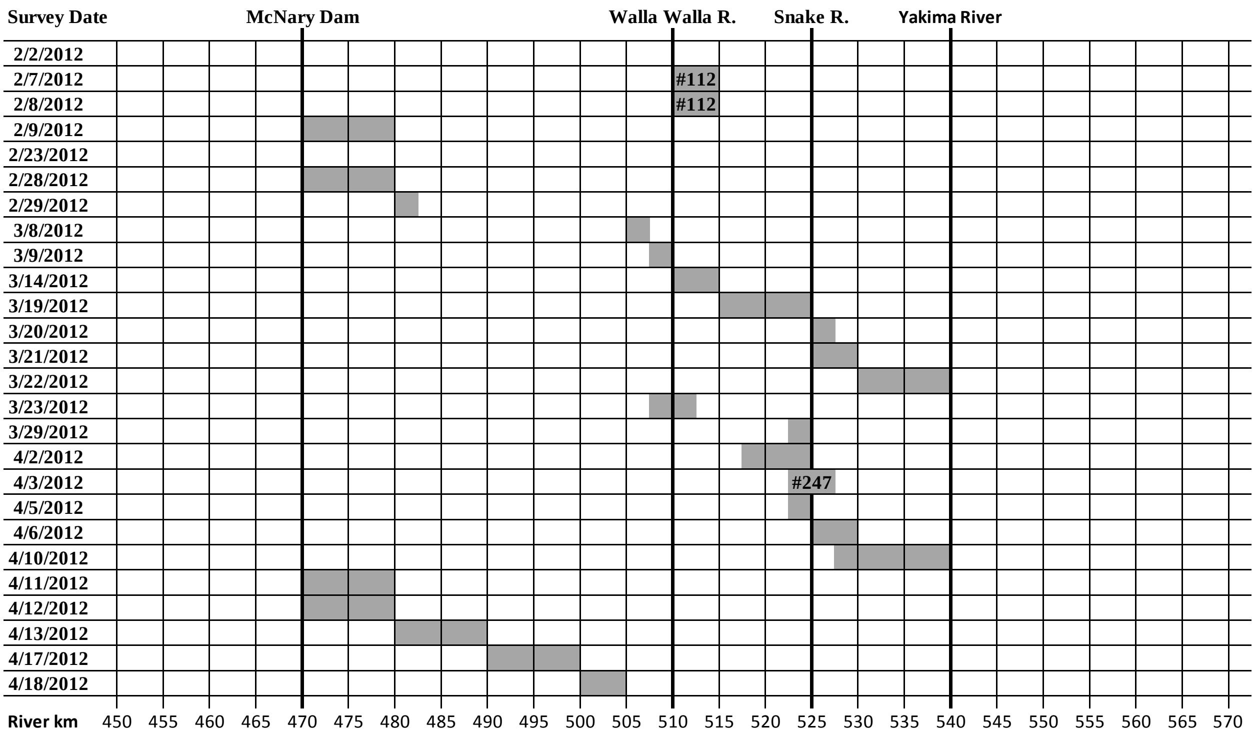

Figure 11. Survey dates and relocations during mobile tracking surveys in the mainstem Columbia River during FY2012. River kilometers tracked during each survey are shaded in gray.

We obtained three relocations from two of the six acoustic-tagged bull trout known to have entered the mainstem study area (Figure 12). Bull trout #112 was captured, tagged and released at the CTUIR Lowden rotary screw trap site on 24 January 2012. Following release, the fish rapidly moved 19.9 km downstream and was detected at the Touchet-Gardena Road in-river, fixed hydrophone location (rkm 33.1) on 26 January 2012. Following this detection, #112 was next detected at the Oasis Road Bridge PIT detection array (rkm 10.1) on 30 January 2012, having continued to rapidly move downstream 23 km. The next day (31 January 2012) bull trout #112 had moved downstream an additional 10.1 km and was detected on the Walla Walla River SUR at the mouth, indicating it had entered the mainstem Columbia River. Seven days later, bull trout #112 was relocated during a mobile tracking survey on 7 February 2012 approximately four rkm upstream from the mouth of the Walla Walla River and northwest of Crescent Island (Figure 12). The bull trout was occupying deep water habitat (10.7 m). Surface water temperature at this location was 3.3 °C. Field staff again relocated this fish in approximately the same location during a mobile tracking survey on 8 February 2012. Following this survey, bull trout #112 was not subsequently relocated in the mainstem Columbia River, or detected at any other location, and its ultimate fate is unknown.

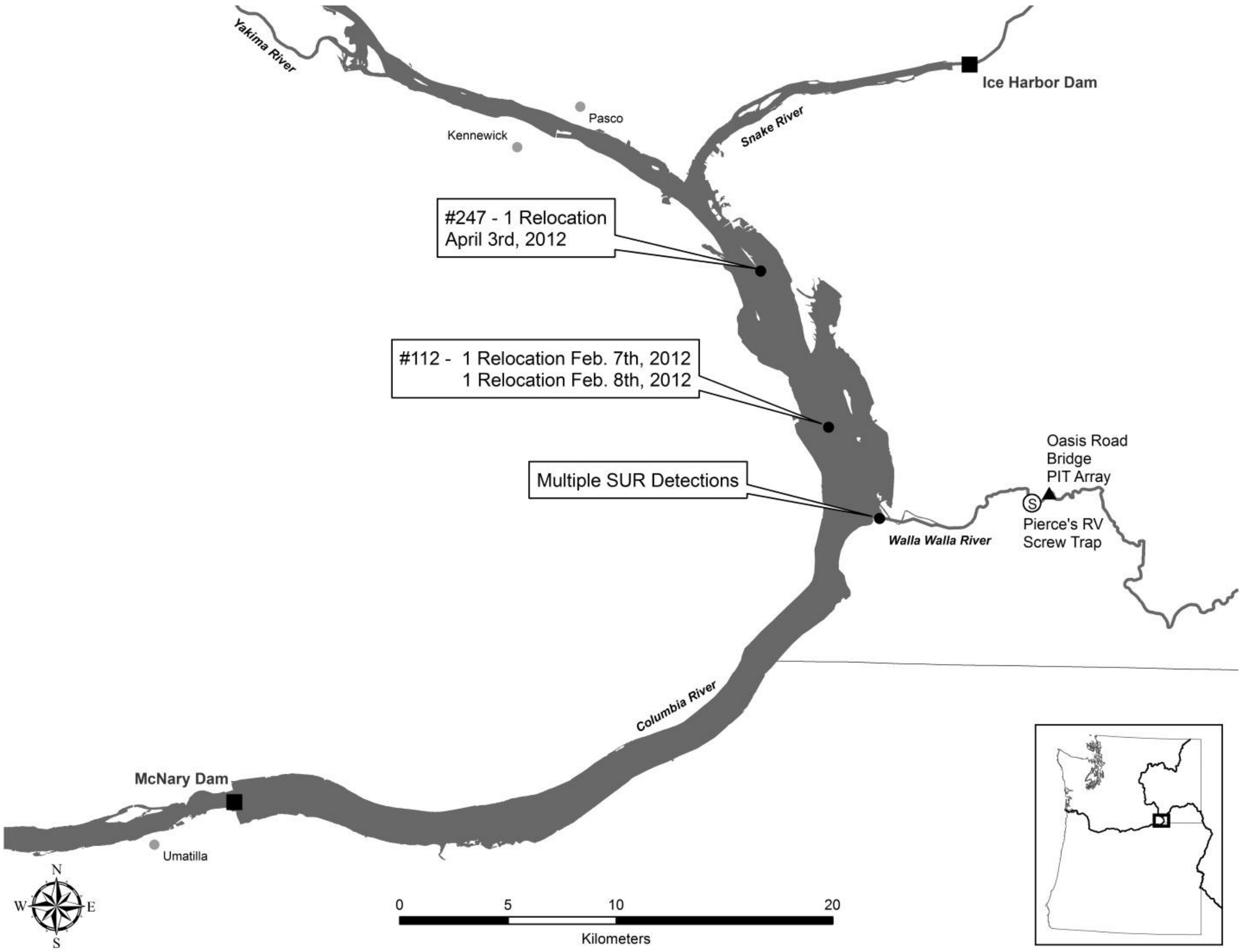

Figure 12. Detections of bull trout on the SUR at the mouth of the Walla Walla River, and mainstem Columbia River relocations during mobile tracking surveys in 2012.

Bull trout #247 was captured, tagged and released at the CTUIR Lowden rotary screw trap site on 18 November 2011. Following release, the fish was not detected at any of the in-river fixed hydrophone locations or at the mainstem hydrophone arrays. It was relocated during a mainstem mobile tracking survey on 3 April 2012 approximately 13 km upstream from the mouth of the Walla Walla River near Foundation Island (Figure 12). It was not subsequently relocated or detected on any of the mainstem or in-river SUR's, but eventually was detected moving upstream past a PIT detection site at Burlingame Dam (rkm 60) in the Walla Walla River on 4 June 2012. Its detection history indicates that it had moved to the mainstem Columbia River and returned to ascend the Walla Walla River undetected.

PIT Tag Monitoring

<u>*Oasis Road Bridge (ORB) PIT detection array*</u> – The ORB PIT detection array was in operation during all months of the sampling season during FY2012. Despite elevated streamflows at times, the PIT antennas comprising the array remained intact and operational. A total of 24 individual PIT-tagged bull trout were detected at the array (Table 11). Of the 24 bull trout detected, 18 were detected moving downstream towards the Columbia River, three were detected moving upstream, returning from the Columbia River, and three were detected both entering and returning from the Columbia River. Twenty-two of the bull trout detected at the ORB PIT array were tagged in middle and lower portions of the Walla Walla River from Milton-Freewater downstream to Pierce's RV Park. The two bull trout detected at the ORB array that were tagged in upper Basin areas were both tagged in the South Fork Walla Walla River. No fish PIT-tagged in the Touchet or Mill Creek subbasins were detected at the ORB PIT array during FY2012. Six of the 24 bull trout detected at the array were tagged with both an acoustic transmitter and PIT tag in the lower Walla Walla River as part of this project (Table 12). Of the six bull trout detected, three were detected moving downstream towards the Columbia River, two were detected moving upstream, and one was detected while moving both downstream and subsequently returning upstream past the array. Three of these fish (#142, #232, #112) were subsequently detected on the SUR at the mouth entering the Columbia River following detection at the ORB PIT array. One fish (#277) was detected moving upstream past the ORB PIT array in May, returning from the Columbia River following a previous detection on the SUR at the mouth in January entering the Columbia River. One bull trout (#202) was tagged at the Pierce's RV park trap site and subsequently moved upstream past the ORB array in late January.

Table 11. Migratory bull trout detected at the Oasis Road Bridge (ORB) PIT detection array (rkm 10.1) during FY2012. 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/2011	1	0	
November/2011	4	0	1 (May)
December/2011	12	0	2 (April, May)
January/2012	1	1	
February/2012	0	0	
March/2012	0	0	
April/2012	0	1	
May/2012	0	1	
June/2012	0	0	
Total	**18**	**3**	**3**

Table 12. Acoustic tagged bull trout detected at the Oasis Road Bridge (ORB) PIT detection array (rkm 10.1) during 2012.

Acoustic Tag Code	PIT Tag Code	ORB Detection Date (Downstream)	ORB Detection Date (Upstream)
142	384.1B795B26AD	12/17/2011	4/15/2012
232	3D9.1C2C68849E	12/18/2011	NA
113W	3D9.1C2C6C6F79	12/20/2011	NA
112	3D9.1C2C692D41	1/30/2012	NA
21W	3D9.1C2C6C9C53	NA	4/10/2012
277	3D9.1C2CBE0ED1	NA	5/8/2012

Columbia and Snake River PIT detections – The query of the PTAGIS database resulted in three mainstem Columbia River PIT detections during FY2012, one each at McNary, Priest Rapids and Bonneville dams (Table 13). No PIT-tagged bull trout were detected in the Snake River at Ice Harbor Dam during FY2012. All fish were detected ascending adult ladders. The bull trout (#384.1B795B2660) detected in the adult ladder at McNary Dam was a fish PIT-tagged as part of this project on 24 October 2011 near the Burlingame Diversion Dam (rkm 60) in the Walla Walla River. Following tagging, the bull trout migrated rapidly downstream and was detected at the ORB PIT detection array (rkm 10) on 10 November 2011 prior to entering the Columbia River. This fish likely passed downstream of McNary Dam through the turbines during the fall or winter months prior to being detected while ascending the adult ladder from 26 June 2012 through 29 June 2012. There were no subsequent detections of this bull trout, indicating that it did not return to the Walla Walla River and its ultimate fate is unknown. One fish (#3D9.1C2CCD42DD) was tagged on 23 September 2009 in the Entiat River and was detected during FY2012 while ascending the adult ladder at Priest rapids dam on 24 May 2012. The other bull trout (#3D9.1C2DA12CD8) was originally tagged in the Middle Fork Hood River on 3 July 2011, prior to being detected at Bonneville Dam. It was next detected ascending the adult ladder from 30 May 2012 through 31 May 2012 and its return to Hood River was confirmed by a detection on 13 July 2012 at the Hood River mainstem PIT detection array.

In addition to mainstem detections, one bull trout PIT-tagged in the Walla Walla River as part of this project, was subsequently recaptured while ascending the adult fish ladder at Three Mile Falls Dam in the Umatilla River. The fish was PIT-tagged on 17 November 2011 at Nursery Bridge Dam in the Walla Walla River (rkm 74), was detected at the ORB PIT detection array on 28 December 2011 and was recaptured at Three Mile Falls Dam on 10 May 2012 (Table 14).

Table 13. Migratory bull trout PIT detections at mainstem Columbia River projects.

Tagging Site	Detection Location	Tagging Date	Detection Date
Walla Walla River	McNary adult ladder (Oregon)	10/24/2011	6/26-29/2012
Entiat River	Priest Rapids adult ladder (east)	9/23/2009	5/24/2012
Middle Fork Hood River	Bonneville adult ladder (Bradford Island)	7/3/2011	5/30-31/2012

Table 14. Walla Walla River PIT tagged bull trout recaptured at Three Mile Falls Dam on the Umatilla River.

Tagging Site	Recapture Location	Tagging Date	Detection Date
Walla Walla River (Nursery Bridge Dam)	Umatilla River (Three Mile Falls Dam)	11/17/2011	5/10/2012

Avian predation mortalities – We queried the PTAGIS database and found two bull trout mortalities (PIT tag recoveries) associated with the avian nesting colonies in the mainstem Columbia River during FY2012 (Table 15). Neither bull trout was tagged during FY2012 as part of this project. One bull trout (#3D9.1BF1FDD3D1) was originally tagged in the Walla Walla River near the Little Walla Walla River Diversion Dam (rkm 76) on 23 October 2008 and was last detected on 23 November 2008 passing downstream of the ORB PIT detection array near the mouth of the Walla Walla River (rkm 10). The PIT tag was recovered in September on Foundation Island where double-crested cormorants generally nest. The lack of detections following the ORB detection indicate that the fish may have been taken in the extreme lower portion of the Walla Walla River or in the mainstem Columbia River. The other recovered PIT tag belonged to a bull trout (#3D9.239F834BA7) which was originally tagged in the headwaters of the South Fork Walla Walla River on 7 July 2008. The detection history of this fish indicated that it was last detected passing downstream of the Burlingame Diversion Dam (rkm 60) on 17 December, 2010, indicating that is was likely taken somewhere in the lower Walla Walla River. The tag was recovered in August 2012 on Crescent Island, a nesting area used primarily by Caspian Terns and gulls.

Table 15. 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 2012.

PIT Tag ID	Tag Date	Release Site	Recovery Site (Columbia rkm)	Avian Colony Type
3D9.1BF1FDD3D1	10/23/2008	Little WW River Diversion Dam (Walla Walla River)	Foundation Island (518)	Double-crested Cormorant
3D9.239F834BA7	7/7/2008	S. F. Walla Walla River (Walla Walla River Basin)	Crescent Island (511)	Caspian Tern

Comprehensive Detection Histories of Acoustic Tagged Bull Trout

Detections from fixed hydrophone stations within the Walla Walla River, fixed mainstem Columbia River hydrophone arrays, mobile tracking and PIT arrays were combined to describe the movements of each individual acoustic tagged bull trout as they migrated to, within and returned from the Columbia River to ascend the Walla Walla River. A summary of detection histories is provided in Table 16.

Code 142 – Bull trout code 142 was originally PIT-tagged and released near the Burlingame Diversion Dam (rkm 60) in the mainstem Walla Walla River on 12 October 2011. It was an adult-sized (≥ 300 mm FL) bull trout measuring 435 mm FL at the time of capture. The bull trout was recaptured near the initial tagging location approximately two weeks later and was released. After residing and foraging in the vicinity of the Burlingame Diversion Canal for 22 days, the fish left the facility via the fish bypass on 3 November 2011. After 13 days, bull trout code 142 was recaptured via hook and line near the CTUIR trap site (rkm 51) on 16 November 2011. The fish had grown slightly since its previous capture, to 438 mm FL. At this time, an acoustic transmitter was surgically implanted and the fish was released. Shortly following release, this fish moved upstream past the Lowden PIT detection array in the Garden City – Old Lowden #2 diversion dam fish ladder. The fish next passed downstream of the McDonald Rd. Bridge SUR (rkm 48) 10 days later (26 November 2011) as well as the Touchet-Gardena Rd. SUR (rkm 33) on 28 November 2011. After 19 days, bull trout code 142 was detected by the ORB PIT detection array and the Oasis Road Bridge SUR on 17 December 2011. Following this detection, 32 days elapsed before the fish was detected at the Walla Walla River Mouth SUR (rkm 0) as it entered the Columbia River on 18 January 2012. Seven days later, it was detected by the SUR at the mouth again, possibly indicating that it had not ventured far into the mainstem Columbia and instead was residing near the mouth of the Walla Walla River. After 24 days, this fish was again detected by the SUR at the mouth as it likely reentered the lower Walla Walla River on 18 February 2012. Fifty-seven days elapsed before this fish was detected moving upstream at the ORB PIT detection array on 15 April 2012. On 26 May 2012, the bull trout was detected at the Burlingame Dam PIT detection array (rkm 60) indicating that it successfully ascended the lower Walla Walla River. There were no subsequent observations of this fish in the Walla Walla River indicating that the fish likely did not survive to subsequently spawn.

Code 247 – Bull trout code 247 was acoustic and PIT-tagged and released at the CTUIR trap site (rkm 51) on 18 November 2011. This subadult-sized (< 300 mm FL) bull trout was 267 mm FL. Similar to bull trout code 142, this 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 the same day as being tagged. No other detections or relocations of this fish occurred until it was briefly detected during mobile tracking surveys on 3 April 2012 in the Columbia River upstream from the mouth of the Walla Walla River at approximately rkm 522. This fish was not subsequently detected until it moved upstream through the adult fish ladder at the Burlingame Diversion Dam (rkm 60) on 4 June 2012. Fourteen days later, it ascended the adult ladder at the Nursery Bridge Dam (rkm 74) on 18 June 2012. There were no detections at upstream PIT arrays, indicating that it likely did not spawn. The final detection of this fish was as it returned back downstream past Nursery Bridge Dam on 15 October 2012, likely to overwinter.

Code 67 – Bull trout code 67 was originally captured via hook and line and PIT tagged near the Nursery Bridge Dam (rkm 74) on 8 November 2011. The subadult-sized bull trout was 277 mm FL. Following release, this fish rapidly moved downstream through the Nursery Bridge Dam fish ladder on 11 November 2011 and was detected at the Burlingame Dam PIT array (rkm 60) on 16 November before being recaptured on 22 November 2011 at the CTUIR trap site (rkm 51). The bull trout received an acoustic tag and was released but was not subsequently relocated or detected.

Code 52 – Bull trout code 52 was a subadult-sized fish that measured 254 mm FL when it was acoustic-tagged and released at the CTUIR trap site (rkm 51) on 28 November 2011. This fish was not subsequently detected at any location.

Code 98W – Bull trout code 98W was a subadult-sized fish (277 mm FL) that was originally captured via hook and line and PIT-tagged in the Burlingame Diversion Dam Canal (rkm 60) on 9 November 2011. It was last detected in the vicinity of Burlingame Dam on 11 November 2011 and was recaptured at the CTUIR trap site (rkm 51) where it received an acoustic transmitter and was released on 30 November 2011. Similar to previously mentioned fish, bull trout code 98W also moved upstream soon after release and was detected while ascending the adult fish ladder at the Garden City – Lowden #2 Diversion Dam PIT array. This fish was not subsequently detected at any location.

Code 232 – Bull trout code 232 was originally captured, tagged, and released at the CTUIR trap site (rkm 51) on 12 December 2011. This was a subadult-sized bull trout measuring 275 mm FL. Following release, the fish moved very rapidly downstream being detected at the Touchet-Gardena Rd. SUR (rkm 33) on 16 December 2011 as well as at the ORB PIT detection array (rkm 10) and the Oasis Rd. Bridge SUR on 18 December 2011. This bull trout continued rapidly moving downstream, covering 10 km in one day to enter the Columbia River on 19 December 2011. This fish was not subsequently detected at any location following its entry into the mainstem Columbia River. Following its release, this fish migrated 51 km through the lower Walla Walla River in just seven days (an average of 7.3 km per day). If it had continued on a similar trajectory once in the Columbia River, it would have passed downstream of McNary Dam and out of the study area within approximately 5.5 days.

Code 277 – Bull trout code 277 was originally PIT-tagged as a juvenile (103 mm FL) in the South Fork Walla Walla River headwaters on 14 July 2009. This fish was next detected moving upstream at the Nursery Bridge Dam PIT detection array (rkm 74) 742 days later on 26 July 2011 to likely escape inclement habitat conditions (i.e. depleted streamflows and elevated water temperatures) that develop annually downstream of Nursery Bridge Dam. After spending summer months upstream of Nursery Bridge Dam, this fish moved downstream past the Nursery Bridge PIT detection array on 10 September 2011 and was detected 92 days later at the Burlingame Dam PIT detection array on 9 December 2011. Four days later, bull trout code 277 was recaptured at the CTUIR trap site (rkm 51) on 15 December 2011. After receiving an acoustic transmitter, bull trout code 277 (259 mm FL) migrated rapidly downstream and was detected passing the Oasis Rd. Bridge SUR (rkm 10) six days later on 21 December 2011. This bull trout was detected on 9 January 2012 entering the mainstem Columbia River at the Walla

Walla River Mouth SUR (rkm 0). Bull trout code 277 was not detected returning from the Columbia River, but was detected moving back upstream past the ORB PIT detection array (rkm 10) 120 days later on 8 May 2012. The last detection of this fish was moving upstream past the Burlingame Dam PIT detection array on 6 June 2012.

Code 37 – Bull trout code 37 was originally PIT-tagged as a juvenile (92 mm FL) in the South Fork Walla Walla River headwaters on 13 July 2009. This fish was next detected moving downstream at the Burlingame Dam PIT detection array (rkm 60) 846 days later on 5 November 2011 and was recaptured at the CTUIR trap site (rkm 51) on 17 December 2011. At the time of recapture, the fish was 258 mm (FL). After being tagged and released, this fish was not subsequently detected at any location. This fish was tagged with a PT-3 acoustic transmitter with an estimated expiration date of 4 February 2012 (Appendix B, Table 1B). The relatively short expected tag life may have contributed to the lack of subsequent detections.

Code 22 – Bull trout code 22 was a subadult-sized fish (261 mm FL) and was acoustic-tagged and released at the CTUIR trap site (rkm 51) on 17 December 2011. Twenty days later, this fish was detected moving downstream past the Oasis Rd. Bridge SUR on 6 January 2012 and entered the Columbia River the next day (7 January 2012). This fish was detected at the Wallula Gap fixed hydrophone array on 11 January 2012 indicating that it continued to move downstream after entering the Columbia River. This fish was not subsequently detected at any location following the detection at the Wallula Gap hydrophone array. This fish received a PT-3 tag that was purchased during FY2010. We estimated the tag to expire on approximately 4 February 2012, possibly contributing to the lack of subsequent detections (Appendix B, Table 1B).

Code 113W – Bull trout code 113W was originally PIT-tagged as a subadult-sized fish (215 mm FL) in the middle Basin portion of the Walla Walla River near the Little Walla Walla Diversion (rkm 76) on 27 June 2011. After spending the summer months in this area, bull trout code 113W migrated downstream past the Nursery Bridge Dam (rkm 74) on 3 November 2011 and was detected at the Burlingame Dam PIT detection array (rkm 60) 14 days later on 16 November 2011. On 20 December, this fish was detected moving downstream past the ORB PIT detection site (rkm 10) and was recaptured at the Pierce's RV Park trap site (rkm 8) the following day (21 December 2011). Bull trout code 113W (295 mm FL) received an acoustic transmitter, but this fish was not subsequently detected at any location following release.

Code 217 – Bull trout code 217 was originally PIT-tagged as a subadult-sized fish (290 mm FL) near Burlingame Dam (rkm 60) on 1 December 2011. This fish remained in the Burlingame Dam vicinity for 24 days before continuing its migration downstream. On 27 December 2011 the fish was recaptured at the CTUIR trap site (rkm 51). After receiving an acoustic transmitter, this fish was not subsequently detected at any location after release.

Code 262 – Bull trout code 262 was acoustic-tagged as an adult-sized fish (382 mm FL) and released at the CTUIR trap site (rkm 51) on 27 December 2011. Following release, this fish was not detected again until it passed upstream of Burlingame Dam 134 days later via the adult fish ladder on 9 May 2012. Bull trout code 262 was next detected while ascending the adult fish ladder at Nursery Bridge Dam (rkm 74) 12 days later (20 May 2012). On 26 June 2012, the fish was detected at the Bear Creek PIT detection array (rkm 106) indicating that it had reached known spawning grounds in the headwaters of the South Fork Walla Walla River. The fish was next detected moving back downstream past the Bear Creek PIT array on 25 September 2012, presumably following spawning. The fish was last detected passing downstream of the Harris Park Bridge PIT detection array (rkm 97) on 25 September 2012.

Code 202 – Bull trout code 202 was acoustic-tagged as a subadult-sized fish (270 mm FL) and released at the Pierce's RV Park trap site (rkm 8) on 28 December 2011. Seven days following release, the fish moved upstream and was detected at the Oasis Rd. Bridge SUR (rkm 10) on 4 January 2012. This fish was not subsequently detected at any location.

Code 112 – Bull trout code 112 was tagged as a subadult-sized fish (228 mm FL) and released at the CTUIR trap site (rkm 51) on 24 January 2012. Following release, it was detected moving downstream past the Touchet-Gardena Rd. SUR (rkm 33) two days later on 26 January 2012. This fish was next detected at the ORB PIT array on 30 January 2012. It was detected while entering the mainstem Columbia River by the Walla Walla River Mouth SUR (rkm 0) on 31 January 2012. Seven days after entering the Columbia River, bull trout code 112 was relocated on 7 February 2012 upstream from the mouth of the Walla Walla River at approximately rkm 522 during a mobile tracking survey. This fish was again relocated the following day (8 February 2012) in approximately the same location. The fish was not subsequently detected at any location.

Code 21W – Bull trout code 21W was tagged as a subadult-sized fish (215 mm FL) and released at the CTUIR trap site (rkm 51) on 9 February 2012. This fish was not detected for 61 days until 10 April 2012 when it was detected as it was likely moving upstream past both the Oasis Rd. Bridge SUR and ORB PIT detection array (rkm 10). This fish was not subsequently detected at any location.

Table 16. Comprehensive detection histories for acoustic tagged bull trout.

Acoustic Tag code	PIT tag code	Date Acoustic Tagged (*) / Detected / Recaptured	Elapsed Time (days)	Location Acoustic Tagged (*) / Detected / Recaptured
142	384.1B795B26AD	10/12/2011 - 11/3/2012	N/A	Burlingame PIT Array (rkm 60)
		11/16/2011*	13	Recapture - CTUIR trap site (rkm 51)*
		11/16/2011	0	Lowden PIT Array (rkm 51)
		11/26/2011	10	McDonald RD SUR (rkm 48)
		11/28/2011	2	Touchet-Gardena RD SUR (rkm 33)
		12/17/2011	19	Oasis Road Bridge SUR (rkm 10)
		12/17/2011	0	Oasis Rd. Bridge PIT Array (rkm 10)
		1/18/2012	32	WW River Mouth SUR (rkm 0)
		1/25/2012	7	WW River Mouth SUR (rkm 0)
		2/18/2012	24	WW River Mouth SUR (rkm 0)
		4/15/2012	57	Oasis Rd. Bridge PIT Array (rkm 10)
		5/26/2012	41	Burlingame PIT Array (rkm 60)
247	384.1B795B2709	11/18/2011*	N/A	CTUIR trap site (rkm 51)*
		11/18/2011	0	Lowden PIT Array (rkm 51)
		4/3/2012	137	CR Detection (rkm 522)
		6/4/2012	62	Burlingame PIT Array (rkm 60)
		6/18/2012	14	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
		10/15/2012	119	Nursery Bridge PIT Array (rkm 74)
67	384.1B795B26DC	11/8/2011	N/A	Nursery Bridge Dam (rkm 74)
		11/11/2011	3	Nursery Bridge PIT Array (rkm 74)
		11/16/2011 -11/17/2011	5	Burlingame PIT Array (rkm 60)
		11/22/2011*	5	CTUIR trap site (rkm 51)*
52	3D9.1C2C6C2633	11/28/2011*	N/A	CTUIR trap site (rkm 51)*
98W	384.1B795B26CD	11/9/2011	N/A	Burlingame Diversion Canal (rkm 60)
		11/9/2011 - 11/11/2011	2	Burlingame PIT Array (rkm 60)
		11/30/2011*	19	Recapture - CTUIR trap site (rkm 51)*
		11/30/2011	0	Lowden PIT Array (rkm 51)
232	3D9.1C2C68849E	12/12/2011*	N/A	CTUIR trap site (rkm 51)*
		12/16/2011	4	Touchet-Gardena RD SUR (rkm 33)
		12/18/2011	2	Oasis Road Bridge SUR (rkm 10)
		12/18/2011	0	Oasis Rd. Bridge PIT Array (rkm 10)
		12/19/2011	1	WW River Mouth SUR (rkm 0)
277	3D9.1C2CBE0ED1	7/14/2009	N/A	South Fork Walla Walla Headwaters
		7/26/2011	742	Nursery Bridge PIT Array (rkm 74)
		9/10/2011	46	Nursery Bridge PIT Array (rkm 74)
		12/9/2011 – 12/11/2011	92	Burlingame PIT Array (rkm 60)
		12/15/2011*	4	Recapture - CTUIR trap site (rkm 51)*
		12/21/2011	6	Oasis Road Bridge SUR (rkm 10)
		1/9/2012	19	WW River Mouth SUR (rkm 0)
		5/8/2012	120	Oasis Rd. Bridge PIT Array (rkm 10)
		6/6/2012	29	Burlingame PIT Array (rkm 60)
37	3D9.1C2CBE475B	7/13/2009	N/A	South Fork Walla Walla Headwaters
		11/5/2011 – 11/6/2011	846	Burlingame PIT Array (rkm 60)
		12/17/2011*	41	Recapture - CTUIR trap site (rkm 51)*
22	3D9.1C2C6883A1	12/17/2011*	N/A	CTUIR trap site (rkm 51)*
		1/6/2012	20	Oasis Road Bridge SUR (rkm 10)
		1/7/2012	1	WW River Mouth SUR (rkm 0)
		1/11/2012	4	Wallula Gap Fixed Array (rkm 503)
113W	3D9.1C2C6C6F79	6/27/2011	N/A	Cemetery Bridge Dam (rkm 76)
		11/3/2011	129	Nursery Bridge PIT Array (rkm 74)
		11/16/2011 – 11/17/2011	14	Burlingame PIT Array (rkm 60)
		12/20/2011	33	Oasis Rd. Bridge PIT Array (rkm 10)
		12/21/2011*	1	Recapture - Pierce’s Trap Site (rkm 8)*
217	384.1B795B26F4	12/1/2011	N/A	Burlingame Diversion Canal (rkm 60)
		12/20/2011 – 12/25/2011	24	Burlingame PIT Array (rkm 60)
		12/27/2011*	2	Recapture - CTUIR trap site (rkm 51)*
262	3D9.1C2C69205C	12/27/2011*	N/A	CTUIR trap site (rkm 51)*

Acoustic Tag code	PIT tag code	Date Acoustic Tagged (*) / Detected / Recaptured	Elapsed Time (days)	Location Acoustic Tagged (*) / Detected / Recaptured
		5/9/2012	134	Burlingame PIT Array (rkm 60)
		5/20/2012 – 5/21/2012	12	Nursery Bridge PIT Array (rkm 74)
		6/26/2012	36	Bear Creek PIT Array (rkm 106)
		9/25/2012	91	Bear Creek PIT Array (rkm 106)
		9/25/2012	0	Harris Park Bridge PIT Array (rkm 97)
202	3D9.1C2C688C65	12/28/2011*	N/A	Pierce's Trap Site (rkm 8)*
		1/4/2012	7	Oasis Road Bridge SUR (rkm 10)
112	3D9.1C2C692D41	1/24/2012*	N/A	CTUIR trap site (rkm 51)*
		1/26/2012	2	Touchet-Gardena RD SUR (rkm 33)
		1/30/2012	4	Oasis Rd. Bridge PIT Array (rkm 10)
		1/31/2012	1	WW River Mouth SUR (rkm 0)
		2/7/2012	7	CR Detection (rkm 522)
		2/8/2012	1	CR Detection (rkm 522)
21W	3D9.1C2C6C9C53	2/9/2012*	N/A	CTUIR trap site (rkm 51)*
		4/10/2012	61	Oasis Road Bridge SUR (rkm 10)
		4/10/2012	0	Oasis Rd. Bridge PIT Array (rkm 10)

Quantitative Emigration Abundance Estimates

We used monthly PIT detections at the ORB PIT array together with estimates of PDE and the proportion of the outmigrant population that was PIT tagged ($\hat{p}$) to estimate the total number of outmigrant bull trout during the 2011/12 migration season. Monthly PIT detections and PDE estimates are shown in Table 17.

Fish sampling data were used to develop the estimate of the proportion of the assumed outmigrant population that had previously been PIT tagged ($\hat{p}$). A total of 19 bull trout were captured in the lower Walla Walla River during fish sampling, 10 of which were previously PIT tagged. The resulting estimate of the proportion of the total population tagged in the lower river was 0.526 (Table 17). Incorporating 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 41 outmigrant bull trout during the 2011/12 migration season (Table 17), with a calculated 95% confidence interval of (-6, 87). Because the actual number of detections (21) was greater than the lower 95% confidence level (-6), we replaced the lower confidence level with the number of observed detections, resulting in a confidence interval of (21, 87).

Table 17. Monthly PIT detections at ORB, estimates of the annual proportion of the outmigrant population with PIT tags ($\hat{p}$), resulting monthly estimates of the population of outmigrants ($\hat{\tau}$) and their variance (var($\hat{\tau}$)), monthly estimates of physical detection efficiency (PDE), and monthly estimates of the total population of outmigrants adjusted for PDE (1/PDE*$\hat{\tau}$) and their variance (var(1/PDE*$\hat{\tau}$)) for the FY2012 migration season.

Month/year	Detections	$\hat{p}$	$\hat{\tau}$	var($\hat{\tau}$)	PDE	1/PDE*$\hat{\tau}$	var(1/PDE*$\hat{\tau}$)
October/2011	1	.526	1.9	11.0	0.99	1.9	11.3
November/2011	5	.526	9.5	85.0	0.99	9.6	87.1
December/2011	14	.526	26.6	427.2	0.97	27.4	452.2
January/2012	1	.526	1.9	11.0	0.95	2.0	12.2
Total	**21**		**39.9**			**40.9**	

Table 18 summarizes the number of outmigrants for every year the ORB PIT detection array was operational and detected a suitable number of PIT tags to calculate abundance. The array was installed during 2005 (Anglin et al. 2010). The array detected its first bull trout during the 2006/07 migration season and an abundance calculation was not attempted.

Table 18. 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	6-96
2008/09	12	0.174	69.2	120	38-203
2009/10	6	0.286	21.0	23	6-46
2010/11	29	0.167	173.7	263	59-466
2011/12	21	0.526	39.9	41	21-87
Total	**74**		**351.8**	**496**	**130-898**

Bull Trout Habitat Use in the Mainstem Columbia River

We recorded surface water temperature and depth at only one of the two locations used by bull trout in the Columbia River (McNary Pool). 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. Bull trout #112 was relocated during a mobile tracking survey on 7 February 2012 approximately four km upstream from the mouth of the Walla Walla River and northwest of Crescent Island. The bull trout was occupying deep water habitat (10.7 m). Surface water temperature at this location was 3.3 °C. Field staff again relocated this fish occupying the same location during a mobile tracking survey the following day (8 February 2012). Additional physical habitat data was not collected at the second relocation due to the temporal and spatial proximity to the previous relocation. Bull trout #247 was briefly relocated during a mainstem mobile tracking survey on 3 April 2012 approximately 13 km upstream from the mouth of the Walla Walla River near Foundation Island. The fish was only detected with acoustic equipment briefly so the locality of this relocation was approximate, and no physical habitat data were recorded.

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 bull trout and their use of the mainstem Columbia and Snake rivers will help to determine the actions that may be required to maintain, 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 the initiation of this study (FY2010) the movement patterns and habitat use of bull trout that enter this portion of the mainstem Columbia River were not evaluated. Information collected during the first three years of this study (FY2010 - FY2012), in conjunction with findings from previous years (Anglin et al. 2010a) furthers our spatial and temporal understanding of bull trout use of the mainstem Columbia River for rearing and overwintering habitat and as a migratory corridor between core area metapopulations.

Our ability to build upon previous findings and further describe Walla Walla Basin bull trout use of the mainstem Columbia River from October 2011 to June 2012 were a function of multiple factors including: 1) the number of migratory bull trout captured and tagged with acoustic transmitters and PIT tags in the lower Walla Walla River, 2) in-river hydrophone and PIT array detections, 3) mainstem relocations and PIT tag detections at hydropower projects, and 4) observations of habitat conditions used by migratory bull trout.

Acoustic telemetry data collected in FY2012 provided further confirmation that migratory Walla Walla Basin bull trout use the mainstem Columbia River, both upstream and downstream of the Walla Walla River confluence, as rearing and/or overwintering habitat, and as a migratory corridor to access those habitats. No acoustic tagged bull trout were detected near McNary or Ice Harbor dams, although the sample size of fish relocated in the mainstem was small (N = 3).

The detection of a PIT tagged Walla Walla Basin bull trout ascending the adult ladder at McNary Dam during FY2012 provides further evidence that bull trout not only encounter the dam, but at least a portion of bull trout that encounter the dam successfully pass downstream and survive. Despite the confirmation that at least a portion of the bull trout that encounter McNary Dam successfully pass downstream, it is currently unknown to what extent the dam and associated reservoir may delay, impede or otherwise influence upstream or downstream bull trout passage. It is also unknown if bull trout attempt to pass the dam and fail or if fish are fatally injured while attempting to pass.

One of the important findings from this study was the confirmation that bull trout tagged in the Walla Walla Basin attempted to connect to other lower Columbia River core area metapopulations (i.e. Umatilla River Basin). It is unknown if this connectivity with the Umatilla River was a natural occurrence, or if it was influenced by upstream passage conditions at McNary Dam (fish unable to locate fish ladder entrances to pass back upstream to return to their natal river system).

The FY2012 sampling season marked the midpoint of this proposed six year study. Thus, conclusions and specific management recommendations derived from results to date should be considered preliminary.

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 15 acoustic-tagged bull trout. Considering the relatively low abundance of bull trout in the lower Walla Walla River, these results were not particularly surprising and were consistent with the sample size of 12 during FY2011. Our minimum target sample size for acoustic-tagged bull trout was 30 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. Although we improved upon sampling results from the previous year, our targeted sample size was not attained. Thus, we plan to significantly refine our sampling methods, locations and time periods in future years in an attempt to increase the number of acoustic transmitters deployed. Our angling results and PIT detection data suggest that acoustic transmitters could likely be deployed more efficiently at locations further upstream. Unfortunately, PIT detection histories indicate that bull trout PIT tagged in middle and upper Basin areas are less likely to migrate to the Columbia River than fish tagged in lower Basin areas. It may be necessary to sample and deploy acoustic transmitters into bull trout in areas upstream from rkm 51 (Lowden) which may require deploying more than our current tagging target of 30 fish to compensate for those bull trout that do not enter the mainstem Columbia River study area.

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. Relatively low discharge resulted in shallow water depths that inhibited our ability to effectively operate either trap until mid-November 2011 when streamflows became more conducive to sampling. 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.

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). While sampling during suitable conditions with a fyke net deployed just downstream of the CTUIR rotary screw trap site near Lowden, WA (rkm 51), we captured 10 different fish species, including bottom-oriented species, salmonids and a single bull trout. During FY2012, streamflows, velocities and debris loads were fairly conducive to sampling with a fyke net during a time period when bull trout were commonly moving through the lower river, but success was limited. Since escape probabilities have been found to increase with fyke net soak times (Breen and Ruetz (2006), checking the fyke nets once or twice per day may have been too infrequent, and may have contributed to the low capture rates we experienced.

We have used angling as an effective sampling method for bull trout in many areas around the Walla Walla Basin (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 12 years, we have found that bull trout abundance is consistently lower in lower Basin areas. In addition, sampling locations where the low numbers of individuals are “concentrated” within accessible habitat, are less abundant in the lower river. During FY2012, we captured six bull trout in the lower river, improving upon sampling results from previous years where no bull trout were captured via angling downstream from the Burlingame Diversion Dam (rkm 60). Angling could have potential as a productive sampling method to deploy acoustic transmitters if we can continue to identify locations in the lower river where bull trout are concentrated, and streamflows are low enough for effective sampling. As in past years, angling was a very effective and efficient sampling method for PIT tag deployment in middle Basin areas, especially in the vicinity of irrigation diversion dams and canals.

We deployed acoustic and PIT tags in 15 bull trout in lower Basin areas during the year. In addition, we deployed 96 PIT tags in bull trout in middle Basin areas. No problems were encountered with surgical procedures, and all fish recovered and behaved normally during release. Despite establishing a maximum tag burden of 5% of the host fish weight, we found that the dimensions of the larger acoustic transmitters (IBT-96-6-I and IBT-96-9-I) were not conducive to the narrow body cavity of a bull trout when the ratio of transmitter to body weight exceeded approximately 4%. We recommend taking a conservative approach by using professional judgment and considering the physical attributes of an individual fish in addition to weight ratio when deploying acoustic transmitters. We did not observe any apparent evidence of mortality associated with complications following surgery or excessive tag burden, although it was not specifically evaluated. Six (40%) of the 15 acoustic-tagged bull trout were not subsequently detected following tagging and although the tagging process could have potentially contributed to this, these findings are similar to observations of strictly PIT-tagged bull trout in the Basin. The highly variable and complex movement patterns exhibited by migratory bull trout often expose fish to a myriad of threats including avian and mammalian predation, poaching and varying degrees of habitat degradation that contribute to low survival rates in the lower Basin. One unexpected observation was that three (23%) of the 13 acoustic-tagged bull trout released downstream of the CTUIR trap site were detected the following evening at the Garden City – Old Lowden #2 PIT detection array in the adult fish ladder. These detections indicate that a notable portion of the bull trout released initially moved back upstream shortly after tagging before continuing their downstream migration. This movement pattern may have been induced by tagging, or the fish possibly ascended the ladder in search of holding water or cover to recuperate following surgery.

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.

During FY2012, we attempted to address some of the acoustic tag limitations that we identified from the previous year of this study. During FY2011, data recorded on fixed hydrophones and observations from mobile tracking indicated that tags with 20 second ping intervals were likely too long, especially for fast-moving fish. Often, only a few and occasionally only one sequence of pings was recorded on the fixed hydrophones. In addition, during mobile tracking surveys, the 10 and 20 second ping 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. For FY2012, we attempted to address these limitations, by electing to tag at 5% of the host fish weight, enabling us to both tag more fish and a wider range of fish sizes while achieving shorter ping rate intervals and attaining longer tag lives. We also acquired IBT-96-6-I tags with five second intervals that were configured to maximize tag life (270 days). Unfortunately, a portion of the bull trout captured during November and December lacked the size to accommodate the larger IBT tags, prompting us to deploy PT-3 and PT-4 tags with 20 second intervals from the previous year until PT-4 transmitters with 10 second intervals could be procured. As a result, mobile tracking surveys required longer listening times at each location to ensure sufficient time was allotted for detecting multiple ping sequences of the 20 second interval tags, thus limiting the number of stations that could be monitored during each tracking survey.

Trapping location did not appear to notably influence the number of acoustic-tagged bull trout that were subsequently detected moving into the Columbia River. During FY2011 the percentage of acoustic-tagged bull trout from the Pierce’s RV trap site (rkm 8) and the Lowden trap site (rkm 51) that were detected moving into the Columbia River was similar (67%), thus the trapping location did not compromise our goal of monitoring bull trout movement in the Columbia River. During FY2012, neither of the two bull trout tagged at the Pierce’s RV trap site were subsequently detected moving into the Columbia River or during mobile tracking surveys compared to 6 of 13 (46%) captured via screw trap at the Lowden site. No reason for this disparity is readily apparent and may simply be an artifact of fewer tags being deployed at the

Pierce's RV trap site than at Lowden during FY2012. Considering the difficulties involved with operating the Pierce's RV Park screw trap, and the low numbers of bull trout tagged at the site during FY2011 and FY2012 (N = 5) when compared to the Lowden trap (N = 19), trapping at Pierce's RV Park may be discontinued in future years.

Only one of the three bull trout (33%) captured via angling at Lowden and subsequently tagged with an acoustic transmitter was detected moving into the Columbia River. One reason that a smaller percentage of angled fish moved to the Columbia River than screw trapped fish from the same location may be that the fish captured via the screw trap are actively moving downstream when captured. A portion of the bull trout sampled via angling may not be actively migrating and instead overwintering and foraging (i.e. winter station-keeping). Despite this possibility, angling helped to increase the number of acoustic transmitters available for subsequent detection in the lower Walla Walla River and in the mainstem Columbia River.

Acoustic Tag Monitoring

The fixed hydrophones in the lower Walla Walla River provided data on acoustic tagged bull trout as they migrated downstream toward the Columbia River. Not all fish that passed fixed in-river hydrophone locations were detected. Only one fish (#142) was detected on all four in-river SUR's during FY2012. There was a single bull trout (#247) that was not detected by any in-river SUR's en route to the Columbia River, but was relocated in the mainstem during mobile tracking surveys. The lack of consistent detections was likely associated with shallow and turbulent water that is known to compromise the effectiveness of acoustic telemetry (Cooke et al. 2013). In-river detections were also likely limited by relatively long ping rate configurations of some of the acoustic transmitters discussed previously. Despite the shortcomings, the additional data provided by the in-river SUR's allowed us to describe bull trout movement in the lower Walla Walla River with more detail than was possible in previous years.

In general, the timing of bull trout emigration from the Walla Walla Basin based on FY2012 hydrophone data was similar to observations from FY2011 and data from the ORB PIT detection array between 2007 and 2012 (Anglin et al. 2010a; Barrows et al. 2012a, 2012b). In FY2012, the ORB PIT array detected most of the downstream movement of PIT-tagged bull trout during November and December, while hydrophone data showed the majority of downstream movement into the mainstem Columbia River occurred during December and January. This difference in emigration timing may indicate that fish tagged with acoustic transmitters may not fully represent the migrating population. To examine this possibility, we compared detections from strictly PIT-tagged bull trout detected at the ORB PIT array with detections of bull trout that had received both an acoustic transmitter and a PIT tag (Figure 13). Bull trout hat were tagged with both acoustic and PIT tags migrated past the ORB detection array from December through the end of May, generally coinciding with detections of strictly PIT-tagged bull trout. For fish detected prior to December, there was an evident pulse of downstream migrating bull trout that included only PIT-tagged bull trout and no acoustic-tagged fish. This indicates that a notable portion of the bull trout that emigrated from the Walla Walla River in November and early December may be underrepresented or largely unrepresented in our study. One possible reason for this apparent underrepresentation may be due to our inability to effectively operate rotary screw traps in the lower Basin when streamflows are low in October and November. In addition, migratory bull trout have been observed moving downstream in the fall at a faster rate during periods of low streamflows, possibly to avoid the risk of predation (Monnot et al. 2008). Bull trout that move quickly through the lower Walla Walla River may be less susceptible to being captured via hook and line because they spend less time in the targeted sampling area. We examined the downstream movement rates of bull trout that were detected at both the Burlingame Dam PIT detection site (rkm 60) and subsequently at the ORB PIT array (rkm 10). The mean migration time for PIT tagged bull trout to move through this 50 km portion of the river prior to December (N = 6) was 12.8 days (95% confidence interval [CI] = 9.4-16.2 days) at a mean rate of 3.9 km/day while mean daily discharge and temperature averaged 129.1 ft^3/s and 10.1 °C, respectively. December fish (N = 12) averaged 27.8 days (95% CI = 19.86-35.81 days) to move through the lower river at a mean rate of 1.8 km/day while mean daily discharge and temperature averaged 248.5 ft^3/s and 6.5 °C, respectively. PIT tagged bull trout that migrated from Burlingame Dam to Oasis Rd. Bridge prior to December moved at over twice the rate of fish that migrated downstream through this portion of the river during December. In addition, fish that migrated prior to December did so when streamflow levels were approximately half of December levels, and at temperatures that averaged 3.6 °C warmer. Other researchers have observed positive correlations between migration distance and rate of migration (Starcevich et al. 2012; Monnot et al. 2008). This may suggest that bull trout that rapidly migrate through the lower Walla Walla River prior to December may also migrate the furthest once in the mainstem Columbia River, and may be more likely to encounter the mainstem hydroprojects. The aforementioned data and observations collectively suggest the importance of acoustic tagging bull trout that migrate through the lower Walla Walla River during October and November to more accurately represent the movements of migratory bull trout leaving the Walla Walla to enter the Columbia River.

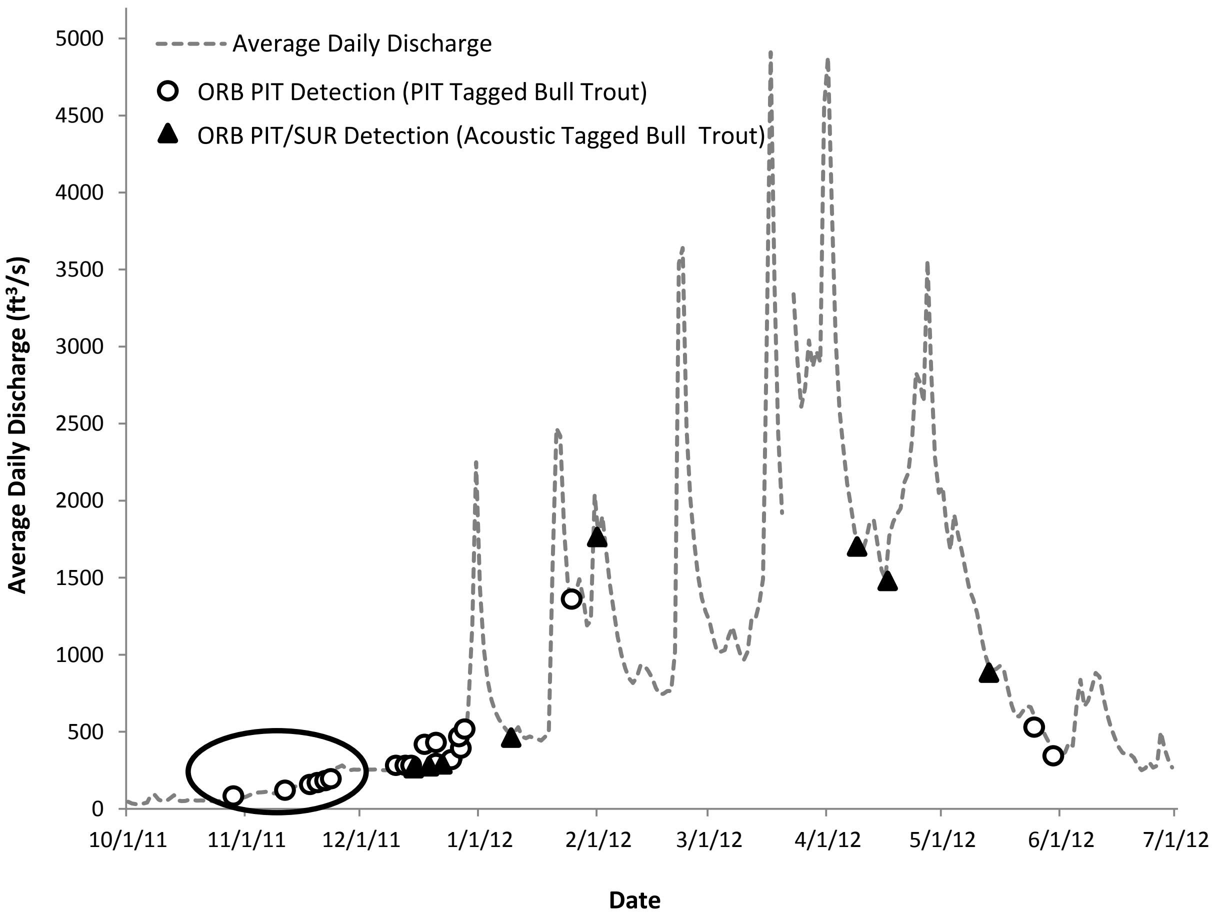

Figure 13. Detections of acoustic tagged bull trout and PIT tagged bull trout at the Oasis Road Bridge PIT detection site. The mean daily discharge from the USGS gage #14018500 near Touchet, WA for October 2011 through July 2012 is also shown. PIT-tagged bull trout detections prior to December are circled.

Only one bull trout (#142) that was tagged with an acoustic transmitter and detected entering the Columbia River returned to the Walla Walla River and was detected on the hydrophone at the mouth. Another fish (#277) was detected entering the Columbia River, but was not detected when it returned to the Walla Walla River by the hydrophone at the mouth. It was detected passing upstream of the ORB PIT detection array on 8 May 2012 indicating that it had returned to ascend the Walla Walla River. Bull trout (#247), that had been relocated in the mainstem Columbia River during a mobile tracking survey on 3 April 2012, was not detected reentering the Walla Walla River, but was detected ascending the adult fish ladder at the Burlingame Dam PIT detection array (rkm 60) on 4 June 2012 indicating that it had returned to the Walla Walla River undetected by the in-river hydrophones and lower river PIT detection arrays. Missed detections at the mouth and at in-river hydrophones were likely influenced by the shallow and turbulent conditions resulting from relatively high streamflows occurring during the months that bull trout generally migrate. Shallow water environments commonly result in severe signal loss and interference at the receiving hydrophone (Niezgoda et al. 1998). The fate of bull trout that were detected on the hydrophones leaving the Basin, but not returning, could be the result of missed detections at in-river hydrophones, tag expiration/loss, mortality, avian predation, or emigration out of the study area.

As in FY2011, the timing of upstream migrating acoustic and PIT-tagged bull trout during FY2012 generally coincided with the upstream spawning migration of bull trout in the Basin (March through June). Of the six total acoustic and PIT tagged bull trout known to have passed downstream of the ORB PIT detection array or into the Columbia River and subsequently returned to ascend the Walla Walla River, only one (17%) eventually reached known spawning grounds in the upper Basin. 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. Instead of continuing to the spawning grounds, many bull trout in the Basin escape inhospitable conditions in the lower river and occupy habitat between rkm 74 and 97 that is more favorable for foraging and oversummering. Swanberg (1997) observed that a portion of bull trout that migrated upstream in the Blackfoot River drainage did not spawn but instead held in tributaries or upper river reaches short of spawning areas before returning downriver to overwinter. Of the five bull trout that did not reach the spawning grounds, two were only detected moving upstream of the ORB PIT detection array (rkm 10) and not subsequently detected, two fish moved upstream of Burlingame Dam (rkm 60) and were not subsequently detected and only one bull trout moved upstream of Nursery Bridge Dam (rkm 74). Bull trout that do not reach Nursery Bridge Dam likely do not survive due to detrimental habitat conditions, low flow passage barriers, avian and mammalian predation or poaching.

During FY2012, we did not conduct mobile tracking surveys to monitor the backwatered portion of the Walla Walla River. During FY2011, 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. The lack of detections suggested that 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. For this reason, we do not intend to actively track the backwatered portion of the lower Walla Walla River during the remaining years of this study unless new information suggests that it is needed to address study objectives.

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 during mobile surveys. Both fish were located upstream from the mouth of the Walla Walla River. This is in contrast with FY2011 tracking results where all fish were relocated downstream from the mouth of the Walla Walla River. Bull trout #112 was relocated during a mobile tracking survey on 7 February 2012 approximately four kilometers upstream from the mouth of the Walla Walla River and northwest of Crescent Island. Field staff again relocated this fish occupying the same location during a mobile tracking survey the following day (8 February 2012). There were no other relocations of this fish in the mainstem during mobile surveys or on the hydrophone arrays. Further, the fish was not subsequently detected in the Walla Walla River. This bull trout likely moved out of the study area, but other possible explanations for the lack of subsequent detections include avian predation and transmitter malfunction. Bull trout #247 was briefly relocated during a mainstem mobile tracking survey on 3 April 2012 approximately 13 km upstream from the mouth of the Walla Walla River near Foundation Island. The fish was only detected with acoustic equipment briefly so the locality of this relocation was approximate. This fish was not relocated in the vicinity during a survey two days later, and was not subsequently detected until it ascended the Burlingame Dam adult fish ladder (rkm 60) in the Walla Walla River on 4 June 2012. This fish was not detected leaving or reentering the Walla Walla River by the in-river hydrophones or the ORB PIT detection array, but since it was relocated and decoded via the mobile tracking equipment, the likelihood that the mainstem Columbia River relocation was erroneous is improbable. While in the mainstem, bull trout #247 may have moved into shallow water where severe signal loss commonly arises producing interference at the receiving hydrophone (Niezgoda et al. 1998) and where boat access is limited.

One (#22) of the six bull trout tagged with an acoustic transmitter that were known to have entered the Columbia River was detected at the Wallula Gap Array (#4) on 11 January 2012 after being detected while entering the Columbia River on 7 January 2012. No other fish were detected at fixed hydrophone stations located in the mainstem Columbia River during FY2012. Many factors limited the effectiveness of the fixed hydrophone stations in the mainstem. The most notable factor was the small acoustic tagged sample size of bull trout that actually entered the mainstem Columbia River. Our quantitative estimates of the number of bull trout emigrating from the Walla Walla River during FY2012 was low compared to FY2011 estimates. Another factor that influenced the effectiveness of the fixed hydrophone arrays was deployment timing. Due to procurement and deployment delays, the complete hydrophone network in the mainstem Columbia River was not fully deployed until 24 January 2012. Most of the acoustic tagged bull trout (80%) that were detected by hydrophones at the mouth of the Walla Walla while entering the mainstem Columbia River did so prior to 24 January 2012 and may have reached overwintering areas or moved through and out of the study area before the hydrophone network was fully installed. In addition, acoustic tagged bull trout may have passed fixed station arrays undetected if they moved through shallow water near the banks where transmitter signal loss commonly occurs. Further, a portion of the monitoring data was lost due to acoustic release failures that resulted in the inability to retrieve some of the fixed hydrophones in the mainstem. Overall, a network of fixed hydrophones in strategic locations within the mainstem Columbia River study area has the potential to be an effective tool to monitor acoustic tagged bull trout movements if the aforementioned challenges are addressed in future years.

The lack of subsequent detections of acoustic tagged bull trout following their initial relocation in the mainstem Columbia River during mobile tracking surveys and at fixed hydrophone arrays may indicate that 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. Also, acoustic tagged bull trout may move into shallow areas within the mainstem where boat access is limited and the effectiveness of acoustic telemetry is severely compromised. Despite limited relocations, the timing and extent of their movements suggests Walla Walla Basin bull trout 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 six of the acoustic-tagged bull trout enabled us to further describe their movements. The array remained intact and functional during all months of the year and detected 24 individual PIT tagged bull trout.

Considering the relatively high numbers of PIT-tagged bull trout that emigrated from the Walla Walla Basin in migration year 2011/12, we hypothesized that there would also be bull trout PIT detections at one or more mainstem dams. Only one PIT-tagged bull trout from the Walla Walla Basin was detected ascending the adult ladder at McNary Dam. This fish moved past the ORB PIT detection array on 10 November 2011 as part of the early group of outmigrating bull trout that was discussed earlier. Due to its relatively rapid rate of movement through the lower Walla Walla River, the fish most likely moved downstream of McNary Dam during fall or early winter. The most likely downstream route of passage for this bull trout was through the turbines at McNary Dam which are not equipped with PIT detection capabilities. While attempting to return upstream, this bull trout first entered the McNary Dam adult ladder (Oregon) on 26 June 2012, was last detected in the ladder on 29 June 2012 and was not subsequently detected. Similarly, in 2009 a PIT tagged bull trout from the Walla Walla Basin spent multiple days attempting to navigate the adult fish ladder at McNary Dam before finally passing upstream in late June (Anglin et al. 2010a). This fish was also not subsequently detected. Considering almost all bull trout reenter and ascend the lower Walla Walla River prior to June (Anglin et al. 2010a; Barrows et al. 2012a, 2012b), the fact that these fish were detected at McNary Dam at the end of June and took multiple days to pass upstream through the fish ladder suggests that bull trout may experience a delay while finding and navigating the fish ladder when attempting to pass upstream of the dam. Other studies have documented bull trout passage delays at Columbia River dams (BioAnalysts, Inc. 2004; Stevenson et al. 2009). BioAnalysts, Inc. (2004) reported that once a bull trout entered the tailrace of a mainstem hydroproject (300 meters downstream), passage delays of up to 24.87 days for fish that eventually passed upstream were observed. Stevenson et al. (2009) also observed bull trout upstream migration delays varying from 0.93 to 17.20 days at Rocky Reach Dam and from 0.29 to 19.93 days at the Rock Island project. In both examples, it was concluded that despite passage delays at the dams, bull trout appear to have adequate time to find spawning tributaries and appear to reach spawning grounds in a timely manner. This may not hold true in the Walla Walla Basin. Due primarily to irrigation diversions, low flow barriers to upstream bull trout passage develop during the late spring and early summer months in middle Basin areas within the mainstem Walla Walla River. Instream passage barriers develop between rkm 60 and rkm 65 when streamflows measure below 42.3 ft^3/s at the Pepper Bridge stream flow monitoring station and become increasingly prevalent as flows diminish (unpublished data, USFWS). These conditions usually develop by late June. Even a short passage delay at McNary Dam may critically affect the ability of a bull trout to migrate the 40 km to the mouth of the Walla Walla River and the additional 66 km to traverse the low flow barriers in the Walla Walla River before the window of passage opportunity closes.

During 2012, conditions resulting in low flow passage barriers developed after 2 July 2012 (Figure 14). If the PIT-tagged bull trout detected in the fish ladder at McNary Dam were to successfully ascend the Walla Walla River, it would have needed to migrate 40 rkm to the mouth of the Walla Walla River and an additional 66 rkm to pass upstream of the barrier section, a total of 106 rkm in less than four days (approximately 26.5 rkm/day).

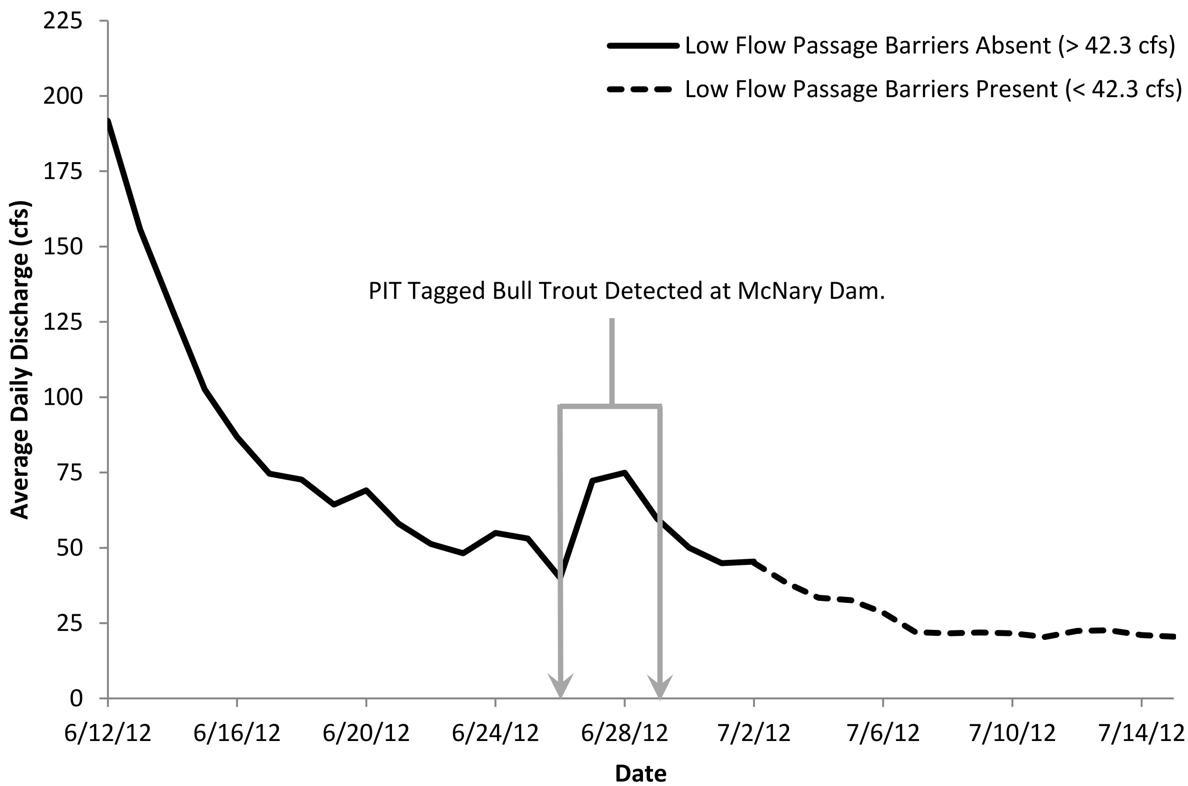

Figure 14. Mean daily discharge of the Walla Walla River from the WDOE water monitoring gage at Pepper Bridge for 12 June 2012 to 14 July 2012. The onset of flows where low flow passage barriers develop are depicted by the dashed line. Detection dates of the PIT tagged bull trout at McNary Dam are also shown.

In addition to mainstem detections, one bull trout PIT-tagged in the Walla Walla River as part of this project, was subsequently recaptured while ascending the adult fish ladder at Three Mile Falls Dam in the Umatilla River. The fish was PIT tagged on 17 November 2011 at Nursery Bridge Dam in the Walla Walla River (rkm 74), was detected at the ORB PIT detection array (rkm 10) on 28 December 2011 and was recaptured at Three Mile Falls Dam on 10 May 2012. The detection history of this fish suggests that it successfully passed downstream of McNary Dam during the winter, likely through the turbines. This recapture prompted the Service to fund a genetic analysis of all bull trout trapped at the Three Mile Falls Dam in the Umatilla River since 2007. Unexpectedly, genetic assignments indicated that all eight of the bull trout captured originated from outside the Umatilla Basin. Most (N = 7) originated in the South Fork Walla Walla River, and one was from the Tucannon River (Small et al. 2012). Radio telemetry work conducted by FWS staff demonstrated that at least one of these fish successfully ascended the Umatilla River and reached known spawning grounds in the North Fork Umatilla River during the bull trout spawning season (Small et al. 2012). In addition, a relatively close genetic relationship between the Walla Walla and Umatilla river bull trout populations suggests that bull trout from the Walla Walla River do occasionally spawn with Umatilla River bull trout (Small et al. 2012). Following a metapopulation model, connectivity between bull trout populations relies upon unimpeded migratory corridors that allow occasional gene flow as fish from one population disperse downstream and subsequently ascend non-natal streams for spawning (USFWS 2002; Small et al. 2012; Barrows et al. 2012a, 2012b). The recaptures in the Umatilla River indicate that at least a portion of the bull trout that encounter Lower Monumental, Ice Harbor and McNary dams survive, but it is currently unknown to what extent bull trout attempt to pass the dams and fail or if fish are fatally injured while attempting to pass. It is also unknown if the aforementioned connectivity with the Umatilla River was intrinsic, or induced by the presence of McNary Dam (i.e. fish unable to locate fish ladder entrances or otherwise pass back upstream via the fish ladders to return to their natal river system). Conclusions from a report prepared by BioAnalysts, Inc. (2004) on research (jointly funded by Chelan, Douglas and Grant County Public Utility Districts) that monitored movements of adult bull trout within the Mid-Columbia River support this possibility. They concluded that when bull trout were captured while moving upstream of Rocky Reach Dam and subsequently released downstream following tagging, they often did not successfully pass upstream of the dam and instead entered a downstream tributary (e.g. Wenatchee River). If McNary Dam does not allow for unimpeded upstream bull trout passage, the rate of dispersal of Walla Walla Basin bull trout to the North Fork Umatilla local population may be artificially high. Normally, this may not pose management implications, but the exceptionally depressed numbers of the imperiled Umatilla Basin bull trout population paired with a possibly unnaturally high influx of Walla Walla Basin bull trout may compromise the genetic integrity (i.e. genetic drift) of the Umatilla Basin bull trout population. Such an occurrence would affect bull trout recovery efforts and further underscores the importance and urgency of understanding bull trout use of the mainstem Columbia River and both upstream and downstream passage at McNary Dam.

In recent years, the recovery of bull trout PIT tags on Foundation, Badger and Crescent Islands has been noteworthy given their relative abundance. During FY2012, recoveries were notably less abundant than FY2011. Only two additional PIT tags from Walla Walla Basin bull trout were recovered, but neither were from migratory bull trout tagged during FY2012. The number of PIT tag recoveries of Walla Walla Basin bull trout from avian colonies may correlate with the abundance of PIT tagged bull trout emigrating from the Walla Walla River, but this was not specifically evaluated.

Quantitative Emigration Abundance Estimates

Our quantitative estimate of the number of Walla Walla Basin bull trout that may have used the Columbia River during the 2011/12 migration season was 41 (95% CI 21-87). Movement past the ORB array into the mainstem Columbia River occurred from October 2011 through January 2012, peaking during December. This estimate is much less than the annual estimate of 263 (95% CI 59-466) for migration year 2010/11 (Barrows et al. 2012b) and second lowest of the five years that Walla Walla River emigration abundance has been estimated (Anglin et al. 2010a; Barrows et al. 2012a). Only the annual estimate of 23 (95% CI 6-46) for the 2009/10 migration season was lower. It is interesting to note that migratory bull trout emigrating from the Walla Walla River seem to exhibit a two-year cyclic pattern of abundance. This pattern may be coincidental, but others have observed possible cyclic patterns of bull trout abundance as well (Paul et al. 2000). A multitude of factors likely influence the abundance of bull trout emigrating from the Walla Walla River. 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. Moderate rain events and a decreasing demand for consumptive water use for irrigation during October resulted in a steady increase from summer base flows through December, gradually eliminating low-flow passage barriers in middle and lower Basin areas. 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 ($R^2 = 0.99996$) during the initial portion of the migration season from October through December (Figure 15). These 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). Following December, higher flows do not coincide with higher estimated numbers of bull trout emigrating from the Walla Walla River, indicating that there may be a streamflow threshold that once reached, negatively influences emigration. This pattern is more similar to findings by Monnot et al. (2008) where bull trout migrated downstream at a slower rate when stream discharge was greater. In addition, positive correlations have been observed between migration distance and rate of migration (Sankovich et al. 2012). To this end, bull trout that move downstream through lower Basin migratory corridors and into the mainstem Columbia River following an increase from summer base flows, but prior to elevated winter flows may migrate faster and possibly further than cohorts that migrate downstream later in the migration season (January through February).

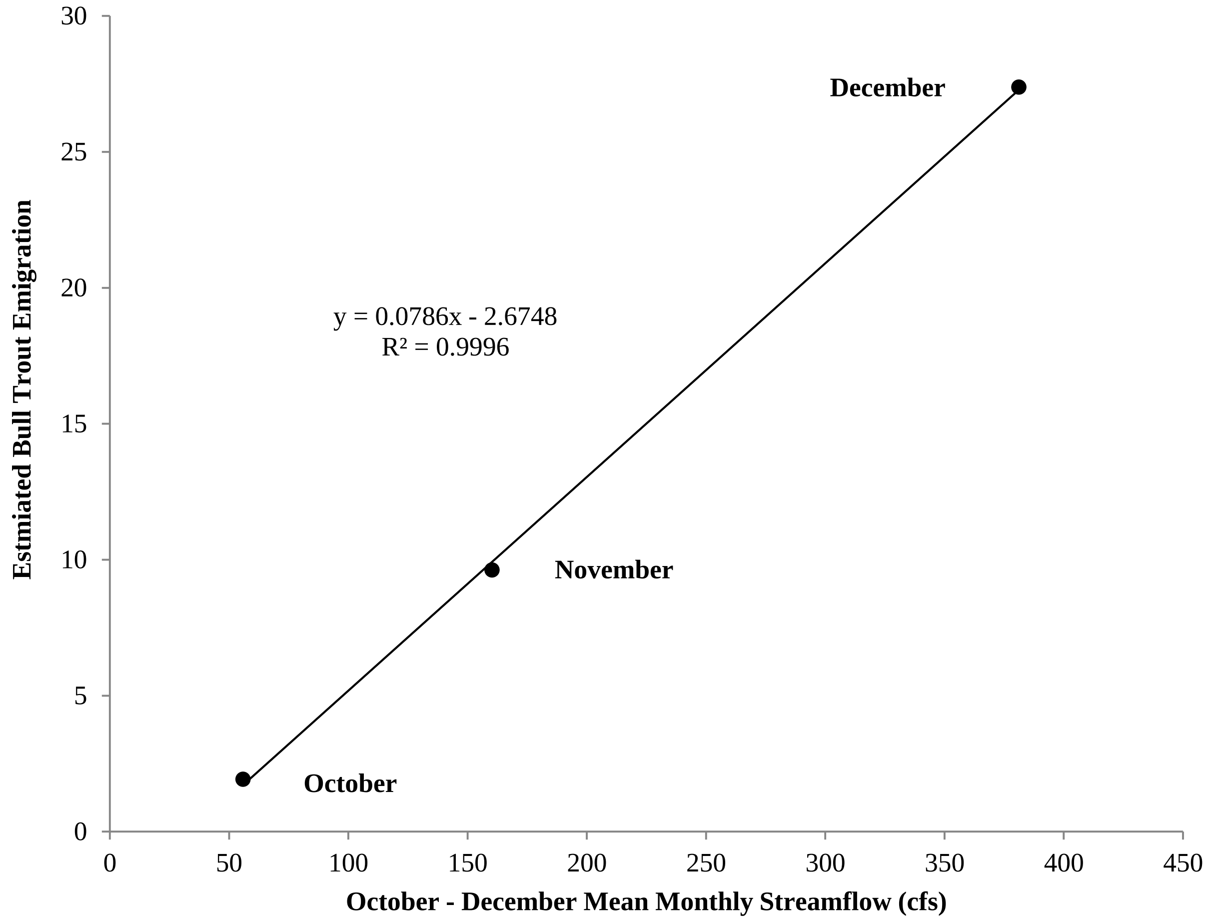

Figure 15. Correlation between estimated monthly bull trout emigration at the Oasis Road Bridge PIT detection array and the mean monthly discharge from the USGS gage #14018500 near Touchet, WA for October through December 2011.

Habitat Use of Acoustic Tagged Bull Trout

The limited data that we collected from relocation sites during FY2011 and FY2012 indicates that deep, slow water habitat is utilized by bull trout in the mainstem Columbia River. However, this does not necessarily suggest that near-shore, shallow water habitat is not used. Limited boat access in addition to the severe acoustic signal loss that commonly occurs in shallow water, compromised our ability to detect tagged bull trout that may be using such habitats. In addition, overwintering bull trout often establish winter station-keeping ranges. These ranges are relatively small, and bull trout exhibit meandering and repetitive movements within them compared to other migratory movements in the mainstem Columbia River and lower Walla Walla River. Within the Walla Walla Basin, winter station-keeping movement patterns have commonly been observed (Starcevich et al. 2012; Mahoney et al. 2008). During FY2011 and FY2012, when we relocated an acoustic-tagged bull trout within the mainstem Columbia River, they were not usually relocated multiple times within the same area during subsequent surveys. This suggests that they may not commonly establish a winter station-keeping range, but instead continuously move throughout the corridor, possibly using multiple habitat types with varying attributes.

Summary of Conclusions and Observations

This project was proposed for implementation over a six-year time period beginning in FY2010. Conclusions should be considered preliminary until completion of the project. Based upon the data collected during FY2012, we offer the following conclusions and observations:

1. During the 2012 study period, we were able to capture and implant acoustic tags into 15 bull trout in the lower Walla Walla River.

2. Based on detection histories, six acoustic-tagged bull trout emigrated to the Columbia River. Emigration occurred between 19 December 2011 and 31 January 2012.

3. Only two of the six bull trout were relocated during mobile tracking surveys. These fish were located no further than 13 rkm upstream from the mouth of the Walla Walla River. One additional bull trout was detected on the Wallula Gap fixed hydrophone array approximately four rkm downstream from the mouth of the Walla Walla River possibly heading toward McNary Dam.

4. Three of the six acoustic-tagged bull trout that entered the mainstem Columbia River subsequently returned to the Walla Walla River. The fate of the other three bull trout is currently unknown.

5. During the 2012 study period, 96 of the 139 total migratory bull trout captured in middle Basin areas were subsequently PIT-tagged. Emigration of PIT-tagged bull trout toward the Columbia River occurred between 31 October 2011 and 30 January 2012. Our quantitative estimate of the number of Walla Walla Basin bull trout that may have used the Columbia River during the 2011/12 migration season was 41 (95% CI 21-87).

6. Of the 21 total PIT-tagged bull trout that were detected moving downstream past the Oasis Road Bridge PIT detection array toward the Columbia River, only 3 (15%) subsequently returned to the Walla Walla River. Immigration of PIT tagged bull trout occurred between 10 April 2012 and 29 May 2012.

7. One PIT-tagged bull trout that likely migrated downstream past McNary Dam during the fall or early winter, was detected while ascending the adult ladder at McNary Dam from 26 June 2012 to 29 June 2012. Similarly, in 2009, a PIT-tagged bull trout from the Walla Walla Basin spent multiple days attempting to navigate the adult fish ladder at McNary Dam before finally passing upstream in late June (Anglin et al. 2010a). Neither fish was subsequently detected. Considering almost all bull trout reenter and ascend the lower Walla Walla River prior to June (Anglin et al. 2010a; Barrows et al. 2012a, 2012b), the fact that these fish were detected at the end of June at McNary Dam, and took multiple

days to pass upstream through the fish ladder may suggest that bull trout experience a delay while finding and navigating the fish ladder when attempting to pass upstream of the dam.

8. One bull trout PIT-tagged in the Walla Walla River as part of this project, was subsequently recaptured while ascending the adult fish ladder at Three Mile Falls Dam in the Umatilla River. This detection, in addition to the genetic assignment of seven other bull trout captured at this location since 2007 (Small et al. 2012), indicated that connectivity between Walla Walla Basin and Umatilla Basin bull trout populations is likely. It is unknown if this degree of connectivity is intrinsic, or influenced by the presence of McNary Dam.

9. No PIT tags from bull trout tagged in the Walla Walla River during FY2012 were subsequently recovered from avian colonies.

Future Plans

Contingent upon future funding levels, we plan to build upon past successes and continue to conduct the final three years of this proposed six year study to better understand the movements and disposition of bull trout that enter the Columbia River and how they are influenced by mainstem hydroprojects and their associated reservoirs. Details regarding movements around, or passage through the mainstem hydropower projects are largely unknown. As funding levels allow, we plan to expand the project to include both Walla Walla River and Tucannon River Basin bull trout. This project was proposed for implementation over a six-year time period (beginning in FY2010) primarily to provide for multiple years of fish sampling and the associated monitoring for the life of the acoustic tags. In addition, spreading the tagging effort over multiple years reduces the potential to negatively impact the population health or status of bull trout.

We plan to continue the migratory bull trout sampling and tagging program during all months of the migration season (October through March) in the Walla Walla Basin and begin sampling fish in the lower Tucannon River. We will continue to implant acoustic transmitters into bull trout captured in the lower Walla Walla Basin and initiate tagging in the Tucannon Basin as well. Project staff will continue to develop and improve upon fish sampling techniques and strategies that will efficiently and effectively capture migratory bull trout in lower Basin areas. Although we have made progress by increasing the number of acoustic transmitters deployed each year, the success of the first three years of this study has been limited by a small acoustic-tagged population available for subsequent tracking in the Columbia River. One such method is to trap and selectively tag fish upstream from previous efforts. A review of past PIT tag detection data indicates that a relatively high percentage (approximately 40%) of PIT-tagged, migratory bull trout that pass downstream through the Burlingame Dam fish bypass canal (rkm 61) in October and November, and have fork lengths < 350 mm are subsequently detected at the Oasis Road Bridge PIT detection array as they enter the Columbia River. We anticipate that trapping bull trout that use this canal in October and November and only tagging fish that meet the targeted size criteria could be an effective and efficient method to increase the number of acoustic tagged bull trout available for subsequent tracking in the Columbia River. Further, we had increased success capturing bull trout in the lower river via angling during FY2012 and intend to build upon that success. We also plan to deploy acoustic tags into bull trout captured at the Washington Department of Fish and Wildlife rotary screw trap site in the lower Tucannon River. In addition, migratory bull trout collected incidentally at Lower Granite, Little Goose, Lower Monumental, and McNary juvenile bypass facilities will be acoustically tagged and PIT-tagged.

We will make significant improvements to our acoustic tracking approach by ensuring that our network of fixed mainstem hydrophone arrays for passive monitoring of bull trout movements are fully deployed and robust prior to the migration season. This will also include working with the COE to ensure project funding is available for equipment procurement and for preparatory field work prior to project implementation beginning in October. In addition, we plan to acquire acoustic transmitters with reduced intervals between ping sequences. This should provide more comprehensive and verifiable data on the fixed hydrophones, and mobile tracking should be more efficient.

As with previous years, we intend to review equipment options 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. In addition, we may consider employing radio telemetry despite the obvious limitations associated with tracking in mainstem environments (e.g. signal loss in deep water). By using radio telemetry, we may be able to determine if bull trout are using the largely inaccessible, shallow environments where acoustic signals fail in the mainstem Columbia River. Radio telemetry may also be used to better assess upstream and downstream passage at McNary Dam.

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 also plan to establish or improve upon a PIT detection site near the mouth of the Tucannon River. We will query the PTAGIS database regularly for Walla Walla and Tucannon 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, Lower Monumental, Little Goose and Lower Granite dams 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.

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. Barbara Pierce provided access to the lower Walla Walla River for rotary screw trap sampling. We would also like to thank Walla Walla University students Alexandra Buell, Amy Tan, Dan Sinkbeil, Kevin House, Rebecca Bullard, Robyn Reeves and Rodney Smith for their participation in the Student Temporary Employment Program (STEP) and their contributions to this project. Professor Dave Cowles (Walla Walla University) was instrumental in developing and fostering the educational and work experience for the STEP students. In addition, we would like to thank Terry McCall, Mike Berger and Carla Hurlbert (U.S. Army Corps of Engineers) for their contributions to the project. We would also like to acknowledge Paul Sankovich and Courtney Newlon (U.S. Fish and Wildlife Service) for their contributions to the project. Project funding for FY2012 was provided by the U.S. Army Corp of Engineers-Walla Walla District. Dean Holecek provided technical and administrative support for the Corps of Engineers.

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Appendix A

Non-salmonids Captured in Fyke Nets and the Pierce's RV Park Screw Trap, October 2011-February 2012

Table A1. 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 15 November 2011 through 21 February 2012.

Month/Year	Northern Pikeminnow	*Lepomis* spp.	Smallmouth Bass	Largemouth Bass	Sucker	Bullhead Catfish	Channel Catfish	Chiselmouth	Peamouth	Carp	Dace	Yellow Perch
November/2011	0	2	47	4	43	8	0	4	0	1	0	0
December/2011	3	0	28	2	65	1	0	74	1	0	1	1
January/2012	1	1	14	0	398	6	1	24	0	4	12	0
February/2012	3	0	13	1	101	7	0	14	0	1	1	0
Total	7	3	202	7	607	22	1	116	1	6	14	1

Table A2. Monthly summary of fish captured in the lower Walla Walla River using a fyke net and rigid leads at the Lowden Diversion site. Sampling was conducted from 25 October through 27 November 2011.

Month/Year	Northern Pikeminnow	Redside Shiner	Dace	Smallmouth Bass	Sculpin	Sucker	Bullhead Catfish	Chiselmouth
October/2011	6	9	43	2	2	69	1	7
November/2011	22	23	27	2	1	51	0	18
Total	**28**	**32**	**70**	**4**	**3**	**120**	**1**	**25**

Appendix B

Estimated tag life and expected Expiration dates for acoustic tags deployed during FY2012.

During FY2012, eight of the newly purchased miniature IBT-96-6-I tags and two PT-4 sub-miniature Pico Tags were deployed. Estimated tag lives for these tags were 270 and 170 days, respectively. We also deployed one miniature IBT-96-9-I tag, two PT-4 sub-miniature Pico Tags and two sub-miniature PT-3 Pico Tags that were purchased during FY2010. Sonotronics Inc. estimated that the IBT-96-9-I tags may lose approximately 4% of their battery life after two years and the Pico Tags may lose up to 18% over the same timeframe. We used the estimated tag life and battery loss estimates to derive an approximate tag expiration date for each deployed tag (Table B1).

Table B1. Estimated tag life and expected expiration dates for each acoustic tag deployed during FY2012.

Tag Code #	Tag Type	Year Purchased	Ping Rate (Seconds)	Estimated Tag Life (Days)	Start Date	Expected Expiration Date
142	IBT-96-9-I	FY2010	3	259	11/16/2011	8/1/2012
247	IBT-96-6-I	FY2012	5	270	11/18/2011	8/14/2012
67	IBT-96-6-I	FY2012	5	270	11/22/2011	8/18/2012
52	PT-4	FY2010	10	246	11/28/2011	7/30/2012
98W	IBT-96-6-I	FY2012	5	270	11/30/2011	8/26/2012
232	IBT-96-6-I	FY2012	5	270	12/12/2011	9/7/2012
277	PT-4	FY2010	20	221	12/15/2011	7/23/2012
37	PT-3	FY2010	20	49	12/17/2011	2/4/2012
22	PT-3	FY2010	20	49	12/17/2011	2/4/2012
113W	IBT-96-6-I	FY2012	5	270	12/21/2011	9/16/2012
217	IBT-96-6-I	FY2012	5	270	12/27/2011	9/22/2012
262	IBT-96-6-I	FY2012	5	270	12/27/2011	9/22/2012
202	IBT-96-6-I	FY2012	5	270	12/28/2011	9/23/2012
112	PT-4	FY2012	10	170	1/24/2012	7/12/2012
21W	PT-4	FY2012	10	170	2/9/2012	7/28/2012

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May 2014
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