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

Final Report
(April 15, 2005 – December 31, 2009)
Final

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Abstract

Little is known about use of the Columbia River by bull trout *Salvelinus confluentus* from the Walla Walla Basin. Mainstem Snake and Columbia River dams have the potential to impact both the connectivity between bull trout Core Areas (metapopulations), and the connectivity within migratory corridors. The need for research and monitoring of bull trout use of the Columbia and Snake rivers is identified in the U.S. Fish and Wildlife Service Biological Opinion. From April 2005 through December 2009, use of the Columbia River by Walla Walla Basin bull trout was investigated by operating a Passive Integrated Transponder (PIT) detection array at Oasis Road Bridge (ORB) near the mouth of the Walla Walla River to determine bull trout abundance and describe the migration timing between the Walla Walla and Columbia rivers. A quantitative estimate of the number of migratory Walla Walla Basin bull trout that moved into the Columbia River over the duration of this study was developed by utilizing empirical data consisting of monthly array detections in combination with physical detection efficiencies and annual estimates of the proportion of the population that was tagged based on hook and line sampling. Migration timing periodicity was described by examining detections at the ORB detection array, observations from a screw trap operated near the mouth of the Walla Walla River, and detections at mainstem dams. Migration timing was also examined for temporal patterns of activity, including peak migration periods, using abundance estimates. Data were insufficient to estimate migratory abundance during 2005 and 2006. We estimate a total of 192 bull trout emigrated from the Walla Walla Basin to the Columbia River from November 2007 through December 2009. Over the duration of the study, only one bull trout was detected returning to the Walla Walla River from the Columbia River. We did not attempt to make any estimates of the total number of returning adults for the single detection in June 2009. The timing of migratory bull trout emigration from the Walla Walla River to the Columbia River varied from year to year, but overall, occurred from October through May, peaking between November and February. Variation in streamflow patterns across migration seasons appears to influence emigration timing to a greater extent than changing water temperatures. The single detection of a returning bull trout in June was similar to upstream migration timing observations at other PIT detection arrays throughout the Walla Walla Basin, and other historic observations of upstream migrants. Four Walla Walla Basin bull trout were detected at mainstem Columbia River dams over the duration of this study. Detections in the juvenile bypass systems at John Day and McNary dams indicated two of these bull trout were moving downstream. Detections in the adult fish ladders at McNary and Priest Rapids dams indicated two of these bull trout were moving upstream. Walla Walla Basin connectivity with the mainstem Columbia River, and connectivity within the Columbia River migratory corridor is required to maintain genetic diversity of the Core Area metapopulations in the Columbia River Distinct Population Segment, and for re-colonization of areas where local populations have been extirpated by natural stochastic events or impacts from human-related activities. Future work should include monitoring efforts in the mainstem Columbia River to provide a more detailed understanding of the temporal and spatial aspects of mainstem habitat use and migration by Walla Walla Basin bull trout, and how they interact with the dams and reservoirs of the Federal Columbia River Power System.

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Introduction

A general decline in bull trout *Salvelinus confluentus* abundance across their range resulted in the listing of all populations in the Columbia River Distinct Population Segment (DPS) as threatened under the Endangered Species Act (ESA) in June of 1998 (63 FR 31647). The U.S. Fish and Wildlife Service (FWS) Draft Recovery Plan (USFWS 2002) identifies improving connectivity between populations of bull trout within the Columbia River DPS as a necessary action to help protect against local extinction events. Mainstem Snake and Columbia River dams have the potential to impact both the connectivity between bull trout Core Areas (metapopulations), and the connectivity within migratory corridors. The FWS Biological Opinion (Biop) on Effects to Listed Species from Operations of the Federal Columbia River Power System (USFWS 2000) cites the need for monitoring and research on bull trout use of the Columbia and Snake rivers. Specifically, Reasonable and Prudent Measure #1 for bull trout in the lower Columbia River (Section 10.A.2 of the Biop) states:

1. Determine the extent of bull trout use of the Lower Columbia River affected by the FCRPS. This would include the river reach from the Pacific Ocean to the upstream extent of the McNary Dam reservoir.

FWS-funded studies in the Walla Walla Basin on bull trout life history, population dynamics, and habitat requirements began in 2002 and are ongoing. The U.S. Army Corps of Engineers (COE) funded the FWS beginning in 2005 to evaluate use of the mainstem Columbia River by Walla Walla Basin bull trout.

The objectives of this project over the last five years were to:

1. Determine the number of PIT tagged bull trout from the Walla Walla Basin that enter the Columbia River.

2. Determine when PIT tagged bull trout from the Walla Walla Basin enter and return from the Columbia River.

This final report provides a description of the Walla Walla Basin, background information on the migratory life history of bull trout, the results of a previous effort to describe use of the Columbia River by Walla Walla Basin bull trout, and the approach taken by this project to describe use of the Columbia River by bull trout. This report summarizes our knowledge of Walla Walla Basin migratory bull trout abundance in the Columbia River and bull trout migration timing between the Walla Walla River and Columbia River from 2005 through 2009.

Background

Walla Walla Basin

The Walla Walla Basin in northeastern Oregon and southeastern Washington is a subbasin of the Columbia River that drains an area of 4,553 km^2 (NPCC 2004). The Walla Walla 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, Mill Creek, and the North Fork, South Fork, and Wolf Fork of the Touchet River (Figure 1).

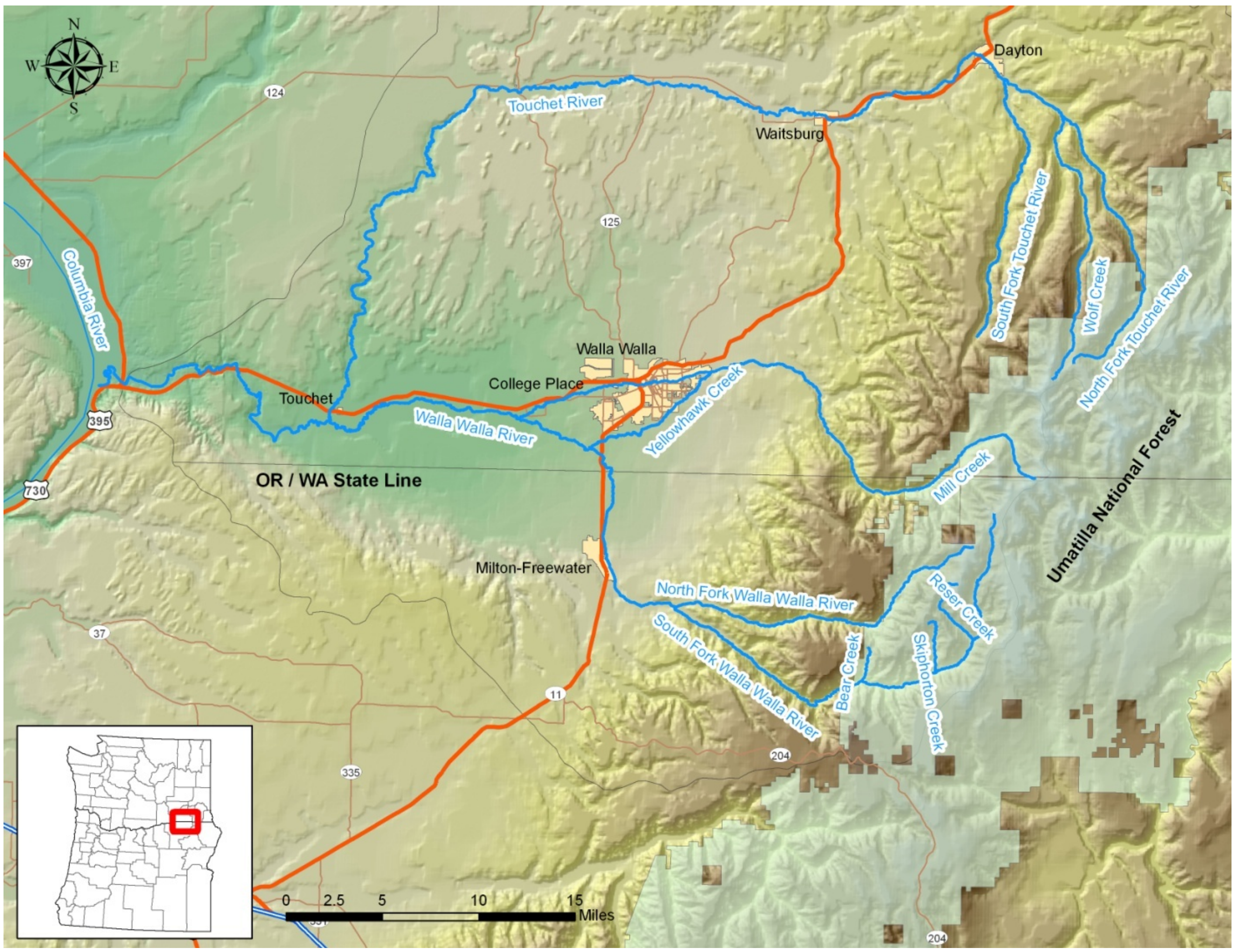

Figure 1. Walla Walla Basin depicting the Touchet River, Mill Creek, and Walla Walla River subbasins.

The Walla Walla Basin is comprised of five bull trout local populations and two Core Areas; three local populations in the Touchet River Subbasin (Touchet River Core Area), and one local population each in the Mill Creek and Walla Walla subbasins (Walla Walla River Core Area). FWS research has been focused on the Mill Creek and Walla Walla River local populations.

Habitat quality for salmonids in the Walla Walla Basin ranges from poor to good. The highest quality stream habitat in the Basin occurs in areas with adequate riparian vegetation, sufficient streamflow, diverse habitat types, and good water quality. These areas are typically located in the upper portions of the Touchet, Mill Creek and Walla Walla watersheds (NPPC 2001). Migratory bull trout that use middle and lower Walla Walla Basin areas seasonally encounter some of the poorest habitat in the Basin. The Walla Walla Basin has an agriculture-based economy, and over 100 years of agricultural development have taken place. In addition, there are flood control projects in both Mill Creek and the Walla Walla River. Results of these activities have included impacts to stream channel geomorphology and the riparian zone, degraded water quality, and reduced instream flows. Consumptive water use for irrigation resulted in a dry river channel during the summer in some areas of the Basin for at least several decades. During this time period, migratory bull trout were seasonally relegated to upper Basin areas. Year round surface flows were restored in 2002, and migratory bull trout have expanded the temporal and spatial extent of their use of downstream areas since that time.

Migratory Bull Trout Life History

Much of the detailed data on migratory bull trout life history and distribution has been obtained from the extensive PIT tagging effort in the Basin (primarily headwaters) along with the instream PIT detection arrays deployed throughout the Basin. The detection array infrastructure has been developed gradually over the last seven years, including the addition of the COE-funded site in 2005 near the mouth of the Walla Walla River (rkm 10.1) at Oasis Road Bridge (ORB). Life history and distribution information has also been obtained from fish sampling efforts throughout the Basin.

Migratory subadult bull trout disperse during the spring and fall from headwater areas in Mill Creek and the South Fork Walla Walla River to rear to sexual maturity. PIT tag detections and fish sampling data indicate that fall-dispersing subadults use the mainstem Walla Walla River during fall, winter, and spring for rearing. Since conditions in the mainstem Walla Walla River during summer are severely degraded as a result of surface water diversions and stream channel modifications, it is likely that some of these rearing fish move to, and remain in the Columbia River during summer. Data from rotary screw trap sampling, radio telemetry, and PIT detection arrays in the headwaters indicate that there is also a spring dispersal of subadult bull trout. Distribution details for these spring migrants in the lower Walla Walla River are lacking, primarily because higher streamflows associated with the spring freshet reduce the detection probability at instream PIT detection arrays, and provide routes of passage around and over the arrays. In addition, many of the arrays are destroyed by high streamflows that occur during the freshet and must be replaced during early summer.

Migratory adult bull trout return from overwintering areas in the lower Walla Walla River and/or the Columbia River from March through June and migrate to upper Mill Creek and the upper South Fork Walla Walla River to spawn. When spawning is completed in October, these adults move back downstream to overwintering areas. Data from PIT detection arrays in the mainstem Walla Walla River including the ORB PIT detection array indicate that adult bull trout use both the lower Walla Walla River and Columbia River for overwintering.

The most significant gap in our knowledge of migratory bull trout life history is associated with use of the mainstem Columbia and Snake rivers. Numbers of bull trout using the mainstem are few compared to anadromous salmonids. Nearly all of the wild and hatchery produced salmon and steelhead smolts eventually migrate downstream in the mainstem, through the hydrosystem, and to the ocean. A much smaller proportion of the total number of bull trout produced in the Walla Walla Basin migrate into the mainstem, and very few, if any, are anadromous. Nonetheless, these migratory bull trout that use the mainstem corridors are essential for maintaining gene flow between Core Area metapopulations, and for re-colonizing areas where local populations have been extirpated by stochastic or human-caused events.

Radio telemetry studies have shown that migratory bull trout from the Wenatchee, Entiat, and Methow rivers overwintered in the Columbia River (Nelson and Nelle 2008), and bull trout from the Tucannon River have seasonally reared in the Snake River (Faler et al. 2008). Much of our current knowledge of the distribution of migratory bull trout in the mainstem Columbia and Snake rivers consists of observations at adult fish ladder counting stations and juvenile fish bypass facilities at the mainstem hydro projects, and more recently, PIT tag detections at some of these projects. Since 1999, there have been at least 175 confirmed bull trout observations in the adult ladders at mainstem hydro projects. At three of the four lower Snake River projects (Lower Monumental, Little Goose, Lower Granite), 169 bull trout have been observed in the ladders. The remaining six bull trout were observed at three of the four lower Columbia River projects (Bonneville, John Day, McNary). Over this same time period, there have been at least 120 confirmed observations of bull trout from the juvenile bypass systems of the lower Snake projects, and three observations from lower Columbia projects.

Walla Walla Basin Bull Trout Use of the Columbia River – Previous Effort

Brown and Newell (2004) operated a rotary screw trap near the mouth of the Walla Walla River to determine if migratory subadult bull trout were migrating out of the Walla Walla River into the Columbia River. The trap was operated from November 24 to the end of December 2003, and from March 17 to May 28, 2004. No bull trout were captured during either time period. Trapping efficiency for the entire season was 5% for Chinook salmon and 4.8% for steelhead. Although no bull trout were captured, they could not conclude that migratory Walla Walla Basin bull trout did not migrate into the Columbia River because trap efficiency was too low.

Walla Walla Basin Bull Trout Use of the Columbia River – Current Approach

The FWS proposed to use PIT technology as an alternative method to investigate use of the Columbia River by Walla Walla Basin bull trout. This approach required the installation of a PIT detection site, a monitoring protocol to determine the detection efficiency of the site for interpretation of detection data, PIT tagging migratory bull trout so sufficient numbers of bull trout were available for detection, and queries of the PTAGIS online database for detections and detection histories. In 2005, we were funded by the COE to install and operate a PIT detection array at a site near the mouth of the Walla Walla River. We began installation on April 15, 2005 and completed installation of the full stream width PIT detection array (Figure 2) on December 6, 2005. Detection efficiency for the array was determined based on physical factors (e.g. streamflow) and antenna performance. In general, detection efficiency was relatively high

(>80%) during the fall, followed by a decrease during the winter as streamflows exceeded the height of the array and/or antennas became damaged. When antennas were damaged during winter or spring high flows, detection efficiency remained relatively low until repairs could be made, which typically occurred in the late spring or summer.

Figure 2. Oasis Road Bridge (ORB) PIT detection array (rkm 10.1) near the confluence of the Walla Walla River and Columbia River.

Bull trout PIT tagging efforts by the U.S. Geological Survey-Utah Cooperative Fish and Wildlife Research Unit in the South Fork Walla Walla River, the Oregon Department of Fish and Wildlife and the U.S. Forest Service in Mill Creek, the Washington Department of Fish and Wildlife in the Touchet Basin, and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) at various locations around the Walla Walla Basin have been ongoing since at least 1998. Since bull trout PIT tagged in the headwater areas of Mill Creek (rkm 97-103) and the South Fork Walla Walla River (rkm 97-118) include both resident and migratory fish, the FWS began sampling and PIT tagging bull trout during 2006 in mid-Basin and lower-Basin areas. The goal was to capture migratory bull trout that were more likely to migrate downstream, through the Walla Walla Basin and into the Columbia River. Initially, FWS tagging success was limited, with only 22 bull trout PIT tagged from June 2006 through September 2007. Building on previous efforts and our increased knowledge of the spatial and temporal distribution of migratory bull trout, we were successful in tagging 441 bull trout from October 2007 through December 2009.

Movement of bull trout past the ORB PIT detection array prior to the fall of 2007 consisted of a single detection on January 31, 2007. Since that time, 25 additional bull trout have been detected at the array between October 2007 and December 2009. Detections of bull trout prior to the fall of 2007 were likely limited because relatively few migratory fish had been PIT tagged, and detection efficiencies were relatively low (47%-68%) during the winter and early spring of 2006 and 2007. Thus, the assessment of migration abundance and timing presented in this report, largely consists of detections that occurred from October 2007 through December 2009.

In addition to the ORB PIT detection array, 10 other PIT detection arrays have been installed in the Walla Walla Basin since 2002. As described previously, detections at these sites provide much of the detailed data on migratory bull trout life history and distribution within the Basin. Detections at these sites also provide context for detections at the ORB PIT detection array, and allow us to infer direction of movement and determine whether the fish are dispersing to rear/overwinter, or are returning to spawn. Detections at the ORB PIT detection array of dispersing/overwintering bull trout provide the starting point for Columbia River use, and those fish are also available for detection at mainstem Columbia and/or Snake River dams.

Detailed information regarding operation and detection efficiency of the ORB PIT detection array, bull trout PIT tagging efforts and results, PIT tag detection histories, and mainstem dam detections can be found in four previous annual reports on this project (Gallion and Anglin 2009; Anglin et al. 2009a; Anglin et al. 2009b; Anglin et al. 2010). Those reports present results for this project through September 2009. The project continued through December 31, 2009 and results for the final three months are presented in Appendices A-E in this report.

Methods

Monthly detections of PIT tagged bull trout at the ORB PIT detection array were summarized by migration season. We use the term "migration season" to describe the time period when migratory bull trout are moving into, or out of the Walla Walla River. The migration season begins in the fall and is generally associated with increasing streamflow and decreasing water temperature. During the early part of the season, subadult bull trout (<300 mm) are dispersing from headwater and upper Basin areas to the lower mainstem Walla Walla and Columbia rivers to rear, and adult bull trout (≥300 mm) are moving downstream to overwintering areas following the completion of the spawning season in October. The migration season ends in late spring or early summer when streamflows decline abruptly with the onset of the irrigation season and increasing water temperatures. During the later part of the season, subadult bull trout are also dispersing from headwater and upper Basin areas to rear, but adult bull trout are returning from overwintering locations in the lower Walla Walla and Columbia rivers to the spawning grounds in the headwaters. Detections by month and migration season comprised the raw data that was used to estimate migratory bull trout abundance and migration timing.

Migratory Bull Trout Abundance

The first objective of this project was to develop a quantitative estimate of the number of migratory Walla Walla Basin bull trout that are using the Columbia River. When the project began in 2005, we anticipated this estimate being limited to PIT tagged bull trout only. These methods describe the process we used to extend this estimate to the total number of migratory bull trout that may be using the Columbia River.

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 annual estimates of the proportion of the population that was tagged based on supplemental hook and line sampling. This sampling was conducted near the Burlingame Diversion facility which was our lower-most, relatively successful sampling site in the Walla Walla Basin, approximately 52 rkm upstream from the ORB PIT detection array. The hook and line sampling provided annual estimates of the proportion of the assumed outmigrant population that had previously been PIT tagged. We treated these proportions as estimates of the detection probability for the outmigrant populations in each year. 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 hook and line samples with PIT tags divided by the total number sampled each year (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 for each migration season. The variance of the annual total number of estimated outmigrants was the sum of the monthly variance estimates, with confidence limits calculated as ±1.96·SE.

We also developed an estimate of $\hat{p}$ from a rotary screw trap sampling effort to enumerate outmigrant Chinook and steelhead conducted by the CTUIR at rkm 9 near the ORB PIT detection array. Bull trout were only captured by this effort during the 2008 migration season (2008/2009). We only used this estimate of $\hat{p}$ to lend perspective to the value developed near Burlingame using hook and line sampling for the 2008 migration season.

Migration Timing

We compiled data from several different sources to accomplish the second objective of this project which was to describe Walla Walla Basin bull trout migration timing into the Columbia River. First, we summarized detections of migratory bull trout at the ORB PIT detection array by month for migration seasons 2006/07 through 2009/10. Second, we obtained sampling results for bull trout collected with an eight-foot rotary screw trap operated by the CTUIR near the mouth of the Walla Walla River during the 2008/09 migration season. Lastly, we queried the PTAGIS online database for detections of migratory bull trout at mainstem Columbia River dams. These data sources were used to describe the migration timing of bull trout that were both dispersing downstream in the Walla Walla River to the Columbia River, and returning from the Columbia River to the Walla Walla River. Detection histories for PIT tagged bull trout were examined to determine whether they were upstream or downstream migrants.

We also examined monthly abundance estimates derived from PIT detections at the ORB PIT detection array for migration seasons 2007/08 through 2009/10 to determine if there were temporal patterns, including peak migration periods, associated with bull trout migration timing. We did not use data from the 2006/07 migration season for this analysis because there was only a single detection. Similarly, we were not able to determine if there was a temporal pattern or peak migration period for upstream migrants because only a single upstream migrant detection was documented.

Columbia River PIT Detections

The PTAGIS database was queried regularly over the duration of this project for detections of Walla Walla Basin 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 at those facilities would be detected.

Results and Discussion

Over the duration of this study (2005-2009), 26 PIT tagged bull trout were detected at the ORB PIT detection array (Table 1). Only one of these bull trout was determined to be returning from the Columbia River. Twenty two of the 26 total bull trout detected at the ORB array were tagged near Milton-Freewater and downstream, indicating the importance of focusing on longer range, lower river migrants to evaluate use of the Columbia River. Prior to initiating our lower river tagging efforts, no bull trout were detected at the ORB array. Four of the 26 bull trout detected at ORB over the duration of the study were from upper Basin areas. Two of these bull trout were tagged in upper Mill Creek, one was tagged in the South Fork Walla Walla River, and one was tagged near the confluence of the North and South Fork Walla Walla rivers.

Table 1. Migratory bull trout detected at the Oasis Road Bridge (ORB) PIT detection array (rkm 10.1). The 2009/10 migration season data included only October through December, 2009 due to completion of the project.

Month	**2006/07 Migration Season**		**2007/08 Migration Season**		**2008/09 Migration Season**		**2009/10 Migration Season**	
	US	DS	US	DS	US	DS	US	DS
October								1
November				2		7		2
December				3		1		3
January		1		1		1		
February						3		
March								
April								
May								
June					1			
Total	0	1	0	6	1	12	0	6

Migratory Bull Trout Abundance

Hook and line sampling that was conducted to develop annual estimates of the proportion of the assumed outmigrant population that had previously been PIT tagged ($\hat{p}$), collected 32, 46, and 7 bull trout during the 2007/08, 2008/09, and 2009/10 migration seasons, respectively (Table 2). Of those bull trout in the samples, four, eight and two of the fish, respectively, were PIT tagged, resulting in estimates of the proportion tagged of 0.125 in 2007/08, 0.174 in 2008/09, and 0.286 in 2009/10 (Table 2).

Table 2. Fish and Wildlife Service hook and line mark/recapture samples at the Burlingame Diversion Facility (rkm 61) during three migration seasons including the proportion tagged ($\hat{\boldsymbol{p}}$), and the variance of $\hat{\boldsymbol{p}}$.

Migration Season	**Year (Sample period)**	**Total Bull Trout Captured**	**Number of Recaps**	$\hat{\boldsymbol{p}}$	$\boldsymbol{var}(\hat{\boldsymbol{p}})$
2007/08	2007 (Nov-Dec)	32	4	0.125	0.003
2008/09	2008 (Oct-Dec)	46	8	0.174	0.003
2009/10	2009 (Nov)	7	2	0.286	0.029

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 49 outmigrant bull trout during the 2007/08 migration season (Table 3), with a 95% confidence interval of (3, 96). Because the number of detections in 2007/08 (6) was greater than the lower 95% confidence level (3), we replaced the lower confidence level with the number of observed detections, resulting in a 95% confidence interval of (6, 96).

Table 3. 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, monthly estimates of PDE, and monthly estimates of the total population of outmigrants adjusted for PDE (1/PDE*$\hat{\tau}$) and their variance for the 2007/08 migration season.

Month/year	**Detections**	$\hat{p}$	$\hat{\tau}$	**var($\hat{\tau}$)**	**PDE**	**1/PDE*$\hat{\tau}$**	**var(1/PDE*$\hat{\tau}$)**
November-07	2	0.125	16.0	168.0	0.99	16.2	171.4
December-07	3	0.125	24.0	294.0	0.97	24.7	312.5
January-08	1	0.125	8.0	70.0	0.95	8.4	77.6
Total	**6**		**48**			**49.3**	

For the 2008/09 migration season, after incorporating the proportion of the outmigrant population that was PIT tagged, and adjusting for monthly variation in PDE at the ORB PIT detection array, we estimated that there were 120 outmigrant bull trout (Table 4), with a 95% confidence interval of (38, 203).

Table 4. 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, monthly estimates of PDE, and monthly estimates of the total population of outmigrants adjusted for PDE (1/PDE*$\hat{\tau}$) and their variance for the 2008/09 migration season.

Month/year	**Detections**	$\hat{p}$	$\hat{\tau}$	**var($\hat{\tau}$)**	**PDE**	**1/PDE*$\hat{\tau}$**	**var(1/PDE*$\hat{\tau}$)**
November-08	7	0.174	40.3	358.5	0.93	43.3	414.5
December-08	1	0.174	5.8	30.7	0.80	7.2	48.0
January-09	1	0.174	5.8	30.7	0.28	20.5	391.9
February-09	3	0.174	17.3	112.7	0.35	49.3	919.7
Total	**12**		**69.2**			**120.3**	

For the 2009/2010 migration season, after incorporating the proportion of the outmigrant population that was PIT tagged, and adjusting for monthly variation in PDE at the ORB PIT detection array, we estimated that there were 23 outmigrant bull trout (Table 5), with a 95% confidence interval of (0, 46). Again, because the number of detections in 2009/2010 (6) was greater than the lower 95% confidence level (0), we replaced the lower confidence level with the number of observed detections, resulting in a 95% confidence interval of (6, 46).

Table 5. 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, monthly estimates of PDE, and monthly estimates of the total population of outmigrants adjusted for PDE (1/PDE*$\hat{\tau}$), and their variance for the 2009/2010 migration season.

Month/year	Detections	$\hat{p}$	$\hat{\tau}$	var($\hat{\tau}$)	PDE	1/PDE*$\hat{\tau}$	var(1/PDE*$\hat{\tau}$)
October-09	1	0.286	3.5	13.1	0.75	4.7	23.3
November-09	2	0.286	7.0	35.0	0.96	7.3	38.0
December-09	3	0.286	10.5	65.6	0.94	11.2	74.3
Total	**6**		**21.0**			**23.2**	

Based on the actual detections of 24 PIT tagged bull trout from November 2007 through December 2009, the overall estimated total number of bull trout emigrating to the Columbia River from the Walla Walla Basin was approximately 192 over the duration of this study, with a 95% confidence interval of (50, 345). The 2008/09 migration season was the most active with an estimated 120 emigrants. We did not attempt to make any estimates of the total number of outmigrant bull trout for the single PIT detection in January 2007, or of returning adults for the single detection in June 2009.

In addition to the estimates of $\hat{p}$ from our own hook and line sampling data, we also calculated an estimate of $\hat{p}$ for emigrating bull trout captured by the CTUIR in their rotary screw trap during the 2008/09 migration season. The resulting estimate was 0.214 (Table 6), which was similar to the mark ratio calculated from our sampling efforts (0.174).

Table 6. Confederated Tribes of the Umatilla Indian Reservation rotary screw trap samples (rkm 9) downstream from Oasis Road Bridge (ORB) PIT detection array for the 2008/09 migration season, including the proportion tagged ($\hat{p}$).

Migration Season	Year (Sample period)	Number of Samples	Total Bull Trout Captured	Number of Recaps	$\hat{p}$
2008/09	2009 (Jan-May)	11	14	3	0.214

Migration Timing

Detections of 26 PIT tagged bull trout at the ORB PIT detection array for migration seasons 2006/07 through 2009/10 (Table 1) were used to describe migration timing. CTUIR screw trap sampling near the mouth of the Walla Walla River resulted in the capture of 14 downstream migrant bull trout during the 2008/09 migration season (Figure 3), which were also used to describe migration timing. Queries of the PTAGIS database revealed four PIT tagged bull trout detections at mainstem Columbia River dams from migration seasons 2007/08 through 2008/09, but only one of the fish had a detection history that allowed us to identify migration timing at the mouth of the Walla Walla River (Table 7). However, all four bull trout may suggest a pattern in migration timing in the Columbia River itself.

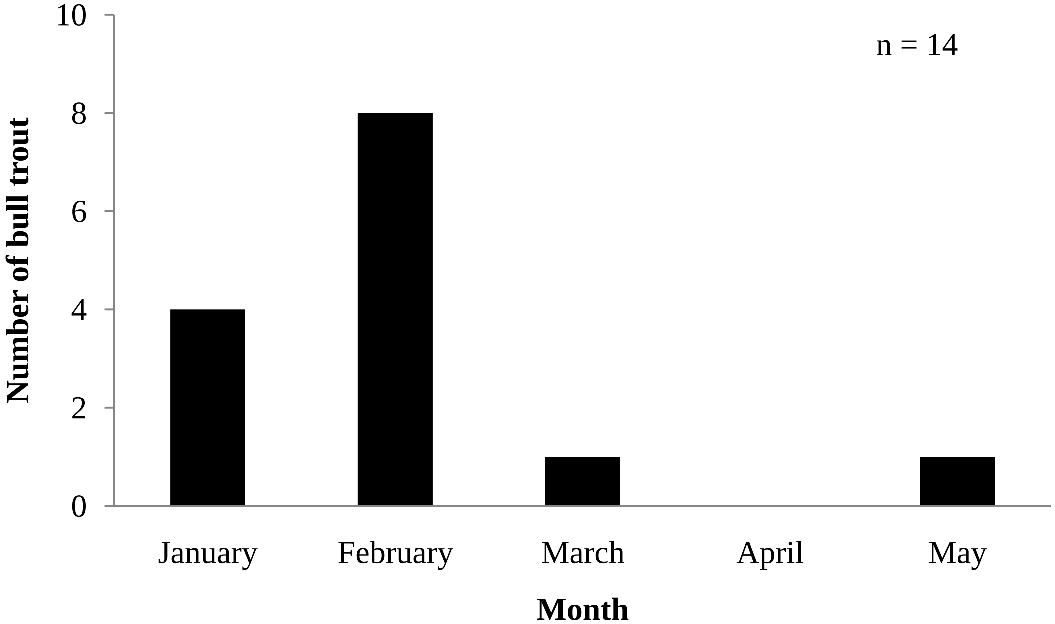

Figure 3. Bull trout captures at the rotary screw trap (rkm 9) operated by the Confederated Tribes of the Umatilla Indian Reservation near the mouth of the Walla Walla River during the 2008/09 migration season (October 2008 through June 2009).

Table 7. Migration timing for a PIT tagged bull trout detected in the John Day Dam juvenile bypass system.

Bull Trout # (length at tagging)	Date Tagged (*) / Detected	Elapsed Time (days)	Location Tagged (*) / Detected
Bull trout #1	04-24-08*	N/A	Touchet River – Dayton Pond (rkm 87)*
(155 mm)	05-12-08	18	John Day Dam Juvenile Bypass (rkm 347)

Migration Timing Periodicity – Downstream Migrants

Downstream migrating or dispersing bull trout were documented leaving the Walla Walla River and entering the Columbia River in a single month (January) during the 2006/07 migration season (Figure 4). The single detection may have been a function of our relatively low success rate for capturing and PIT tagging bull trout in lower Basin areas during 2006 (Gallion and Anglin 2009, Anglin et al. 2009a). In addition, PDE at the ORB array was relatively low during the December through March portion of the 2006/07 migration season, ranging from 47% to 68%.

Bull trout were detected leaving the Walla Walla River in November, December, and January during the 2007/08 migration season (Figure 4). This may have been associated with the first relatively successful year of sampling and PIT tagging bull trout in lower Basin areas (Anglin et al. 2009b). It may also have been a function of higher PDE during the 2007/08 migration season, which ranged between 81% and 99%. In addition, the Touchet River bull trout shown in Table 7, emigrated from the Walla Walla River in April or May, although it was not detected at the ORB PIT detection array, and it is not shown in Figure 4. The only other documented bull trout emigrant during these two months was from a screw trap capture. These results may reflect the effect on our PIT detection array of higher flows associated with the spring freshet during these months.

Migratory bull trout moved out of the Walla Walla River during the 2008/09 migration season over the longest time span we observed during this study (Figure 4). Our ability to document this longer time span was partially a function of data that was available from the CTUIR screw trapping effort. Movement in November and December was comprised of ORB PIT detections, movement in January and February was comprised of both ORB PIT detections and screw trap captures, and movement in March and May was comprised of only screw trap captures. PIT tagged bull trout were detected at the ORB PIT detection array during January and February despite a PDE that ranged between 28% and 35%. Our bull trout sampling and PIT tagging efficiency in lower Basin areas increased again during the early part of the 2008/09 migration season (Anglin et al. 2010), and may have contributed to detections over a longer time span at the ORB PIT detection array.

Bull trout were detected migrating out to the Columbia River from October through December during the 2009/10 migration season (Figure 4). Movement in October was the earliest observed at the ORB PIT detection array during all migration seasons. During the 2009/10 migration season, streamflows increased (~112 cfs) from base flow in October, which was earlier than during the 2007/08 (October flow ~27 cfs) and 2008/09 (October flow ~46 cfs) migration seasons (Figure 5), and may have facilitated earlier downstream migration through the lower Walla Walla River to the Columbia River.

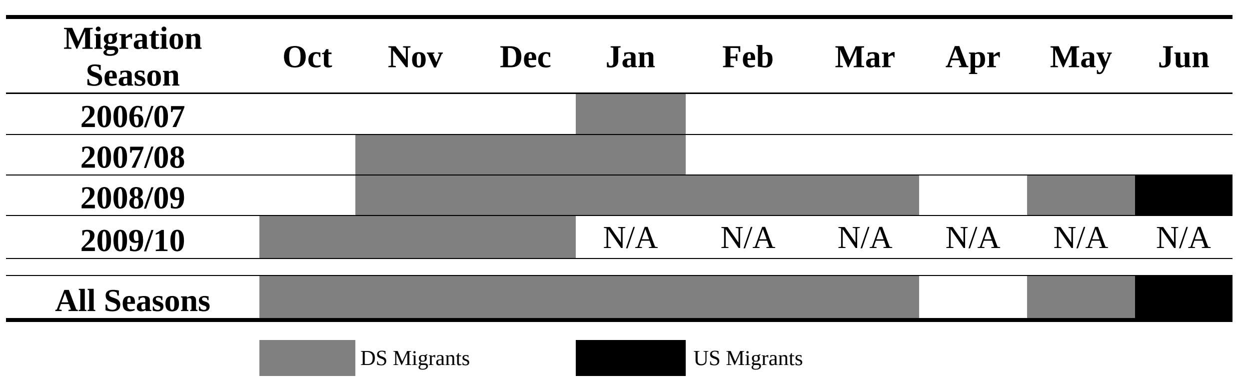

Figure 4. Migration timing periodicity for downstream (DS) and upstream (US) migrant bull trout detected at the Oasis Road Bridge (ORB) PIT detection array for migration seasons 2006/07 through 2009/10. Migration season 2008/09 also includes rotary screw trap data.

The migration timing periodicity of emigrating bull trout varied across migration seasons. Variable success rates for capturing and PIT tagging bull trout in the lower Basin in addition to widely variable monthly PDE at the ORB PIT detection array likely contributed to the observed differences in migration timing between migration seasons. How water temperature specifically affects bull trout migration patterns is largely unknown, but changing temperatures may stimulate downstream migration (Jakober et al. 1998), contribute to the cessation of downstream migratory activity as temperatures approach freezing conditions (Monnot et al. 2008), or incur variable and unpredictable responses (Howell et al. 2009; Homel and Budy 2008). Similarly, downstream bull trout migration has been commonly associated with changes in streamflow (e.g., Fraley and Shepard 1989; Monnot et al. 2008; Anglin et al. 2009b). Downstream movement of PIT tagged bull trout past the ORB PIT detection array commenced during each migration season following an increase in discharge from base flows (Figure 5). We could not determine whether the increase in discharge itself, was the primary catalyst for movement, or if the increase improved physical passage conditions, allowing movement to occur. Our previous work in the Basin has demonstrated that irrigation withdrawals in mid- and lower-Basin areas may severely impair fish passage at base flows and affect emigration timing.

Considering the various factors that may affect migration timing during any given migration season, the most comprehensive representation of migration timing periodicity for bull trout emigrating from the Walla Walla River to the Columbia River results from combining the data for all migration seasons. The combined data indicate downstream migrating or dispersing bull trout emigrated from the Walla Walla Basin and entered the Columbia River from October through May over the duration of this project (Figure 4).

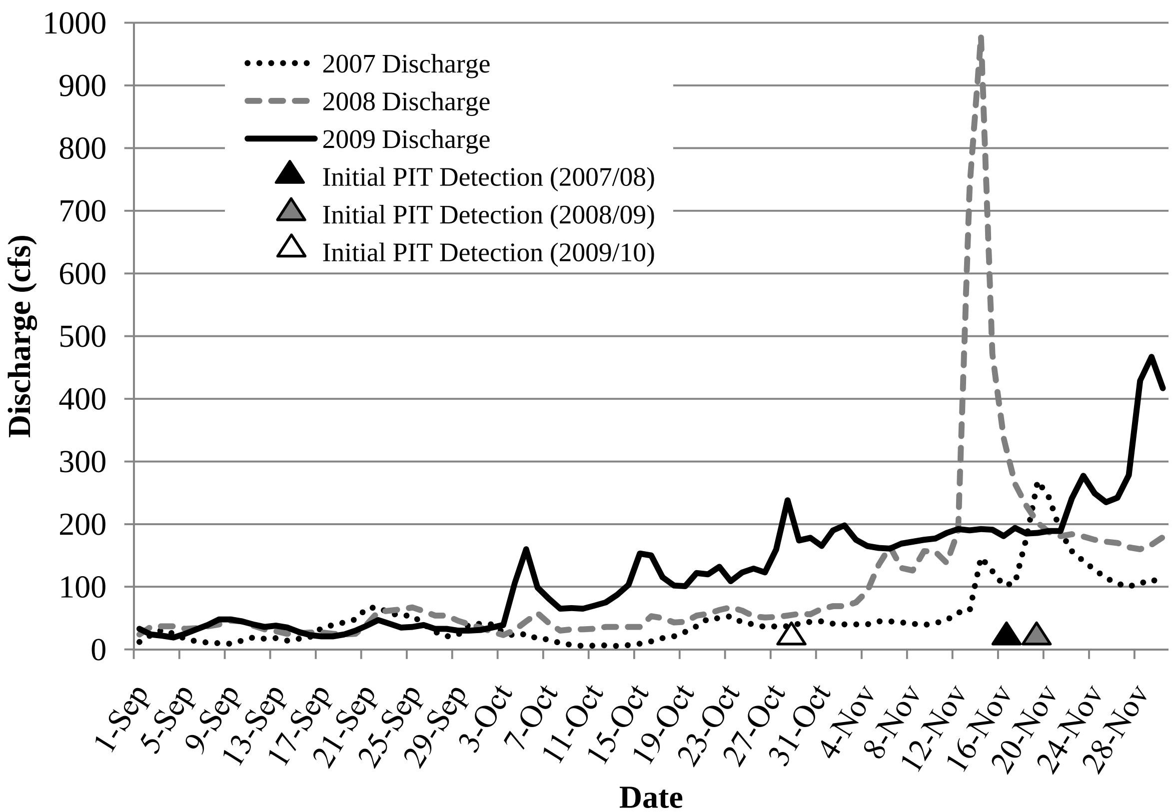

Figure 5. Walla Walla River average daily discharge from USGS gage #14018500 near Touchet, WA, and the initial Oasis Road Bridge (ORB) PIT detections for migration seasons 2007/08 through 2009/10.

Migration Timing Periodicity – Upstream Migrants

No upstream migrating bull trout were documented returning from the Columbia River to the Walla Walla River during the 2006/07 migration season. Since PDE at the ORB PIT detection array was relatively high during months where upstream movement would be likely (March through June), ranging from 56% to 99% with an average of 82%, the lack of detections may have been attributed to our low success rate for capturing bull trout in the lower Basin areas during 2006 (Gallion and Anglin 2009, Anglin et al. 2009a).

No bull trout were detected entering the Walla Walla River during the 2007/08 migration season. Neither the relatively successful year of sampling and PIT tagging bull trout in the lower Basin areas during 2007 (Anglin et al. 2009b), nor the high PDE, ranging from 77% to 89% with an average of 83%, resulted in detections of upstream migrating fish during the 2007/08 migration season.

Finally, during the 2008/09 migration season, a bull trout was documented returning to the Walla Walla River from the Columbia River. Despite relatively low PDE, ranging from 16% to 28% from March through June, and averaging just 22%, a bull trout was detected in June and was subsequently documented moving rapidly past three additional PIT detection arrays in the Walla Walla River upstream from the ORB PIT detection array. This detection may have been partially a result of our relatively successful sampling and PIT tagging of bull trout in the lower Basin areas during 2008 (Anglin et al. 2009b, Anglin et al. 2010).

The migration timing periodicity of upstream migrating bull trout cannot be described based on a single detection. Variable success rates for capturing and PIT tagging bull trout in the lower Basin, in addition to variable monthly PDE could have contributed to the limited number of upstream migrating bull trout detected at the ORB PIT detection array. Irrigation diversions during spring and early summer months contribute to the rapid onset of artificially low base flows and elevated water temperatures, possibly impairing the ability of bull trout to return from the Columbia River and ascend the Walla Walla River. In addition, the detection of a Walla Walla Basin bull trout ascending the fish ladder at Priest Rapids Dam in July of 2009 (Table 8) suggests that some portion of the migratory bull trout that emigrated to the Columbia River have continued their migration upstream, past one or more mainstem Columbia River hydro projects rather than returning to the Walla Walla Basin. Similarly, Walla Walla Basin bull trout detected migrating downstream through juvenile bypass systems at McNary Dam (April 2009) and John Day Dam (May 2008) (Table 8) may suggest that some portion of the migratory bull trout that emigrated to the Columbia River have continued their migration downstream, past one or more mainstem Columbia River hydro projects rather than returning to the Walla Walla Basin. Lastly, natural mortality in addition to avian, mammalian and piscivorous predation could be factors contributing to the apparent lack of bull trout returning to the Walla Walla Basin from the Columbia River.

Temporal Patterns

Of an estimated 49 bull trout emigrating or dispersing from the Walla Walla River to the Columbia River during the 2007/08 migration season (Table 3), fish were detected from November through January, and peak emigration (50%) occurred during December (Figure 6). Discharge in the mainstem Walla Walla River was at base flow in early November, followed by an increase to about 150 cfs in mid-November. Fish passage in the Walla Walla River is severely impaired at base flow, and most of the downstream movement of bull trout occurred after the increase in discharge and peaked when flows were highest in December (Anglin et al. 2009b).

During migration season 2008/09, an estimated 120 bull trout emigrated from the Walla Walla River and entered the Columbia River from November through February (Table 4), peaking in February (41%). Another notable period of emigration during this migration season occurred in November, when approximately 36% of the bull trout emigrated (Figure 6). As in the 2007/08 migration season, bull trout were first detected migrating to the Columbia River from the Walla Walla River following an increase in discharge in mid-November. The peak emigration observed during February may have been associated with the period of higher flows during December and January (Anglin et al. 2010).

An estimated 23 migratory bull trout entered the Columbia River from the Walla Walla River in October, November, and December during the 2009/10 migration season (Table 5). The peak emigration (48%) occurred during December (Figure 6). Unlike the two previous migration seasons, discharge in the mainstem Walla Walla River increased from base flows during October, and bull trout were first detected migrating downstream in late October (Appendix D). Similar to the 2007/08 migration season, peak emigration during the 2009/10 migration season occurred following a period of higher streamflow in December.

When comparing patterns for the three migration seasons, there did not appear to be a consistent, definitive temporal pattern or peak migration period (Figure 6). The apparent variability in emigration timing at the beginning of the migration season appears to be partly associated with the time period when streamflows in the Walla Walla River first exceed base flow during the fall. Similarly, peak migration may be associated with higher streamflows during winter months.

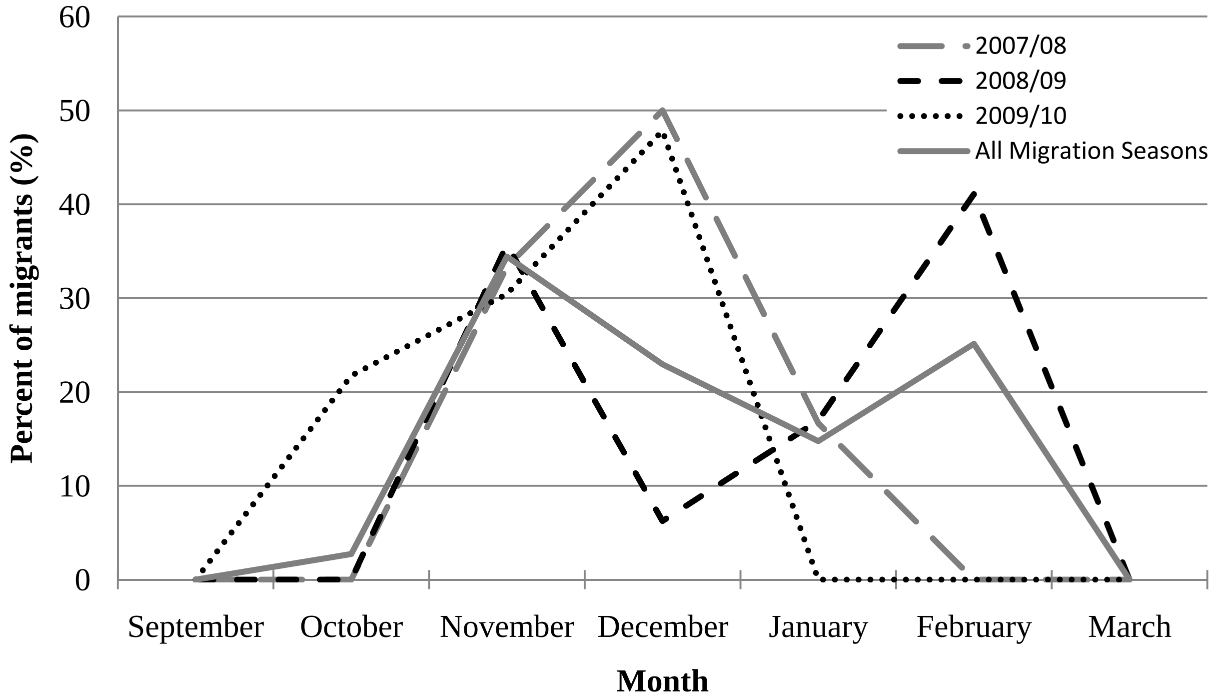

Figure 6. Relative monthly migration timing of bull trout passing the Oasis Road Bridge (ORB) PIT detection array from September through March during migration seasons 2007/08, 2008/09, and 2009/10.

Columbia River PIT Detections

A total of four Walla Walla Basin PIT tagged bull trout were detected at mainstem Columbia River dams between the months of April and July in 2008 and 2009 (Table 8). In May 2008 and April 2009, bull trout were detected moving downstream through the juvenile bypass systems at John Day and McNary dams, respectively (Table 8) (Anglin et al. 2009b). In June and July 2009, bull trout were detected in the adult ladder at McNary Dam, and moving upstream in the adult ladder at Priest Rapids Dam, respectively (Table 8) (Anglin et al. 2010). There were no additional Walla Walla bull trout detections at mainstem dams between October 1 and December 31, 2009.

Table 8. Tagging and detection history details for Walla Walla Basin PIT tagged bull trout detected at mainstem Columbia River dams from 2005-2009.

Bull Trout # (fork length at tagging)	Date Tagged (*) / Detected	Elapsed Time (days)	Location Tagged (*) / Detected
Bull trout 1 (155 mm)	04-24-08*	N/A	Touchet River – Dayton Pond (rkm 87)*
	05-12-08	18	John Day Dam Juvenile Bypass (rkm 347)
Bull trout 2 (249 mm)	07-30-08*	N/A	Little Walla Walla Diversion (rkm 76)*
	12-06-08	129	Nursery Bridge (rkm 74)
	12-22-08	16	Burlingame Diversion (rkm 60)
	12-23-08	1	Burlingame Diversion (rkm 60)
	04-15-09	113	McNary Dam Juvenile Bypass (rkm 470)
Bull trout 3 (269 mm)	10-23-08*	N/A	Nursery Bridge (rkm 74)*
	11-08-08	16	Nursery Bridge (rkm 74)
	11-09-08	1	Nursery Bridge (rkm 74)
	11-14-08	5	Burlingame Diversion (rkm 60)
	12-28-08	44	Burlingame Diversion (rkm 60)
(recaptured at 298 mm)	02-11-09	45	Pierce's RV Park (rkm 9)
	05-25-09	103	McNary Dam Adult Ladder (rkm 470)
	06-19-09	25	McNary Dam Adult Ladder (rkm 470)
	06-20-09	1	McNary Dam Adult Ladder (rkm 470)
Bull trout 4 (272 mm)	01-28-09*	N/A	Pierce's RV Park (rkm 9)*
	07-05-09	158	Priest Rapids Dam Adult Ladder (rkm 639)

These results indicate that both overwintering adult and rearing subadult bull trout from the Walla Walla Basin use upstream and downstream habitats in the mainstem Columbia River. Detections at John Day, McNary, and Priest Rapids dams show these fish moved at least 159 rkm, 36 rkm, and 133 rkm, respectively, in the mainstem from the mouth of the Walla Walla River. Because not all routes of passage on the mainstem dams are monitored, these detections should be considered a minimum. PIT tagged bull trout that move upstream through a mainstem dam will likely be detected by ladder antennas. However, bull trout moving downstream have three possible routes of passage when navigating a dam; the juvenile bypass system, the turbines, and the spillway. Of these passage routes, only the bypass facilities have PIT tag detection capability. The bypass systems at John Day and McNary dams are operational from April 1 through December 15 each year. Considering bull trout emigrated out of the Walla Walla River and into the Columbia River from October through May over the duration of this study, access to juvenile bypass routes of passage would not have been available for approximately 3.5 months during this migration period. In addition, water is not typically spilled at the mainstem dams until approximately April 10 each year, thus spillway passage would not be possible during part of the bull trout migration period. The only remaining passage route would be through the turbines, and any PIT tagged bull trout would not be detected. After April 10, spillway passage would be possible, however, PIT tagged bull trout would also not be detected using this route of passage. Bull trout #1 in Table 8 may be an example of this situation. It was tagged in the Touchet River on April 24, after spring spill had started in the mainstem Columbia. It was next detected at the John Day juvenile bypass facility, likely having passed McNary Dam via the turbines or the spillway.

Migration timing for Walla Walla Basin bull trout in the Columbia River itself, occurred during the winter, spring, and early summer (Table 8). Bull trout #1 moved through the Columbia River to Priest Rapids Dam during the spring, in April and May. Bull trout #2 was at large for four months during winter and spring, although, since it was not detected at the ORB detection array, the portion of the four months that it was moving through the Columbia River to McNary Dam is unknown. Bull trout #3 emigrated from the Walla Walla River during the winter, and arrived at McNary Dam in May, a span of three and a half months. And bull trout #4 emigrated from the Walla Walla River during the winter, and arrived at Priest Rapids Dam in July, a span of over five months. These patterns of movement indicate that Walla Walla Basin bull trout are using the Columbia River migratory corridor from late winter through spring, and into the early summer.

These mainstem detections, coupled with data from the ORB PIT detection array (Table 1) and CTUIR screw trap sampling data (Figure 3), further indicate that more bull trout are using the Columbia River than dam detections alone suggest. It is possible that many of the bull trout detected at the ORB array leaving the Walla Walla River are utilizing the McNary Pool, the Hanford Reach, or the lower Snake River without moving far enough to encounter a mainstem dam, or passing downstream through the dams via the turbines or the spillway.

Expression of a migratory life history by bull trout that includes use of mainstem habitats is not an uncommon strategy. This behavior has been documented in the Wenatchee River, Washington (Ringel and DeLaVergne, 2000 and 2001), the Tucannon River, Washington (Faler et al. 2004), the Flathead River, Montana (Fraley and Shepard 1989), and the Metolius River, Oregon (Theisfeld et al. 1996). Migratory bull trout between the sizes of 140mm – 360mm have been observed migrating from smaller tributaries to large river systems (Fraley and Shepard 1989). The four bull trout tagged in the Walla Walla Basin and detected at the mainstem dams fell within this range (Table 8). Like other species, bull trout may express a migratory life history because food is more abundant in larger river systems (Swanberg 1997), to rear (Fraley and Shepard 1989), to overwinter (Brown and Mackay 1995), or purely as an innate behavior associated with a migratory life history (McPhail and Baxter 1996). Gross (1991) believes the evolution of a migratory bull trout life history may have occurred because larger river systems offered higher growth, survival, and gamete production which further increased their reproductive potential. It is also possible that as fall and winter temperatures decline salmonids make substantial movements from smaller to larger river systems where overwintering habitat maybe more stable (Bjornn and Mallet 1964; Brown and Mackay 1995; Howell et al. 2009).

Conclusions

Migratory Bull Trout Abundance

We developed a quantitative estimate of the number of migratory Walla Walla Basin bull trout that may be using the Columbia River (192; 95% CI 50, 345) by utilizing the empirical data consisting of monthly array detections in combination with physical detection efficiency (PDE) and annual estimates of the proportion of the population that was tagged based on supplemental hook and line sampling. Since only one returning PIT tagged bull trout was detected at ORB, we were unable to quantify the total number of bull trout that may have returned to the Walla Walla Basin from the Columbia River. Adult bull trout generally return from overwintering locations to the spawning grounds in upper Mill Creek and the South Fork Walla Walla River from March through June. The average seasonal PDE for this time period at ORB was 31% in 2005, 8% in 2006, 82% in 2007, 83% in 2008, and 22% in 2009. Thus, the challenging spring hydrologic conditions that contribute to low PDE at the ORB detection array during this time period may have affected our ability to describe return timing patterns and abundance of immigrating bull trout.

Migration Timing

The timing of migratory bull trout movement from the Walla Walla River to the Columbia River varies from year to year, but generally occurs between October and May, peaking between December and February. Differences in streamflow patterns across migration seasons appear to influence migration timing to a greater extent than changing water temperatures.

Of the estimated 36 PIT tagged bull trout that entered the Columbia River from the Walla Walla River, only one was detected returning. This may indicate that bull trout returning from the Columbia River to the Walla Walla River is infrequent. The single, confirmed upstream detection suggests that bull trout returning to the Walla Walla River may migrate during late spring and early summer, which coincides with upstream migration timing observed at other PIT detection arrays throughout the Walla Walla Basin, and other historic observations of upstream migrants. Predation, natural mortality, life history patterns (e.g. interactions with adjacent Core Areas), and other factors may influence the migration timing and return rates of Walla Walla Basin bull trout.

Columbia River PIT Detections

Our data indicate that bull trout dispersed into the mainstem Columbia River from the Walla Walla Basin, and at times, this dispersal included a relatively long migration. As an example, one bull trout moved 130 rkm upstream and was detected at Priest Rapids Dam, and another moved 162 rkm downstream to John Day Dam (Anglin et al. 2009b). At the time of development of this report, there was only one documented bull trout that returned from the Columbia River to the Walla Walla River. However, two additional bull trout were detected returning to the Walla Walla from the Columbia River in mid-April 2010.

Based on detection histories of Walla Walla bull trout at the Columbia River mainstem dams, use of the Columbia River migratory corridor occurred from late winter through early summer.

Summary

Results from this project have documented the use of the Columbia River by migratory bull trout from the Walla Walla Basin over multiple seasons. Bull trout that express this "long range" migratory life history serve an important role in maintaining the long term productivity, stability, and distribution across all of the Core Area metapopulations in the Columbia River DPS. Our data show the importance of maintaining the connectivity of subbasin spawning, rearing, and overwintering habitats with mainstem Columbia River rearing and overwintering habitats, as well as connectivity within the Columbia River migratory corridor in an effort to conserve the full expression of migratory bull trout life history traits. Bull trout that use the mainstem migratory corridors are essential for maintaining gene flow between Core Area metapopulations, and for re-colonizing areas where local populations have been extirpated by stochastic natural or man-made events. Specifically, the draft bull trout Recovery Plan for the Umatilla-Walla Walla Recovery Unit discusses objectives pertaining to suitable habitat conditions for all bull trout life histories, and connectivity between local populations and Core Areas to provide the opportunity for genetic exchange (USFWS 2002). The Recovery Plan also identifies the Columbia River as essential rearing, overwintering, and migration habitat for the migratory portion of the Walla Walla River, Umatilla River, and Touchet River Core Area populations. Future work should include monitoring efforts in the mainstem Columbia River to provide a more detailed understanding of the temporal and spatial aspects of mainstem habitat use and migration by bull trout, and how they interact with the dams and reservoirs of the Federal Columbia River Power System.

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Appendix A – Monthly Physical Detection Efficiency, October – December 2009

Table A1**.** Percent area monitored for individual antennas and average monthly percent physical detection efficiency (PDE) at the Oasis Road Bridge (ORB) PIT detection array from October 1 to December 31, 2009.

	Antenna						Detection Efficiency
Month	1	2	3	4	5	6	(%)
October 2009	100	100	100	100	100	100	75
November 2009#	100	100	100	100	100	100	96
December 2009#	100	100	100	100	100	100	94

#Stream stage height exceeded the monitoring height of the bank antennas at times.

Stream stage height exceeded the monitoring height of the array's bank antennas for a short period of time during November and December, thus slightly affecting overall PDE during those months. Maintenance work on antennas and antenna cable repair occurred during October. The result was three antennas were not functional for nine days and three were not functional for five days, thus reducing overall PDE for October to 75%.

Based on repetitive measurements conducted from 2005-2007, individual antenna performance was assumed to be 100% when the system was operating normally. Overall array PDE based on site functionality, streamflow magnitude, and antenna efficiency ranged from 75% to 96% from October through December 2009. PDE never reached 100% because there is a small space between antennas where fish can pass undetected. PDE was less than 99% when antennas were damaged and/or stream stage exceeded the monitoring height of the array or the array's bank antennas. When detection efficiency was less than 99%, it is possible that additional PIT tagged bull trout passed the ORB PIT detection array without being detected.

Appendix B – Bull Trout Captured and PIT Tagged, October – December 2009

Table B1. Bull trout captured and PIT tagged by the FWS at various locations in the Walla Walla Basin from October 1 to December 31, 2009.

	Burlingame Diversion	Nursery Bridge Dam	Little Walla Walla Diversion	Joe West Bridge	Total Bull Trout
October 2009	0	18	33	4	55
November 2009	5	3	10	0	18
December 2009	0	0	0	0	0
Total	5	21	43	4	73

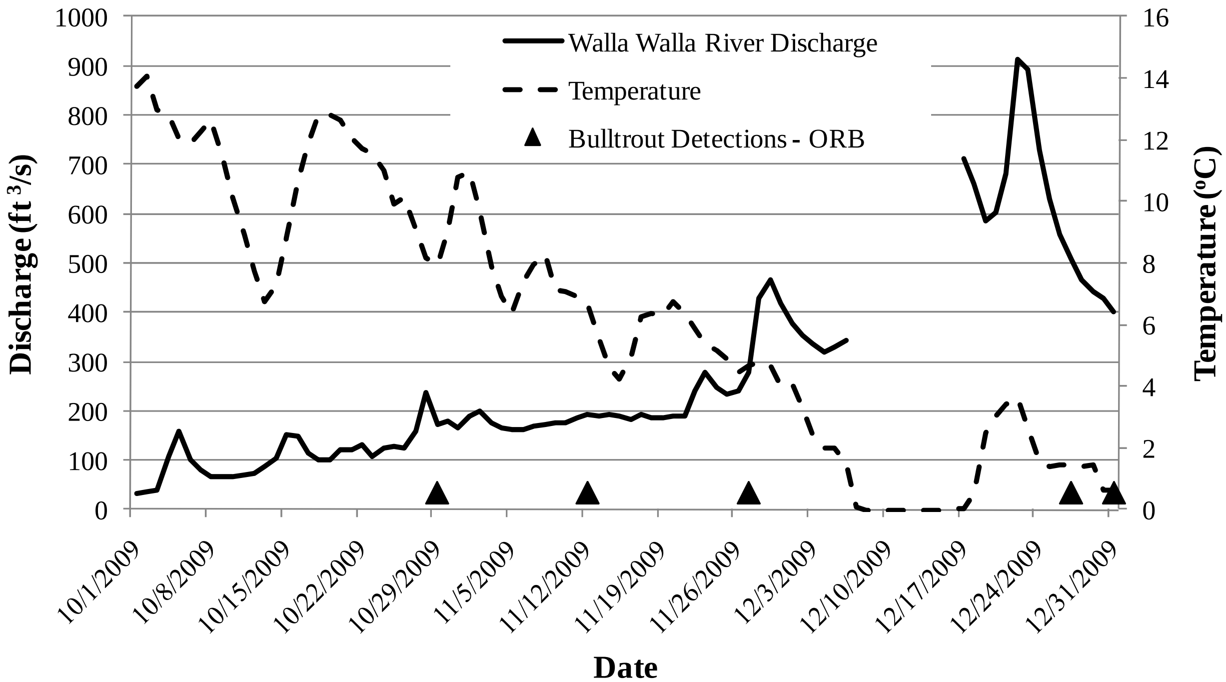
Appendix C – Oasis Road Bridge PIT Detections, October – December 2009

Table C1. Tagging and detection history details for PIT tagged bull trout detected at the Oasis Road Bridge (ORB) PIT detection array from October 1 through December 31, 2009.

Bull Trout # (fork length at tagging)	Date Tagged (*) / Detected	Elapsed Time (days)	Location Tagged (*) / Detected
Bull trout 1 (333 mm)	10/22/2009*	N/A	Nursery Bridge (rkm 74)*
	10/24/2009	2	Burlingame Diversion (rkm 60)
	10/25/2009	1	Lowden Diversion (rkm 51)
	10/29/2009	4	Oasis Road Bridge (rkm 10)
Bull trout 2 (280 mm)	9/22/2009*	N/A	Nursery Bridge (rkm 74)*
	10/26/2009	34	Nursery Bridge (rkm 74)
	10/28/2009	2	Burlingame Diversion (rkm 60)
	11/12/2009	15	Oasis Road Bridge (rkm 10)
Bull trout 3 (287 mm)	11/17/2009*	N/A	Burlingame Diversion (rkm 60)*
	11/27/2009	10	Oasis Road Bridge (rkm 10)
Bull trout 4 (304 mm)	9/23/2009*	N/A	Nursery Bridge (rkm 74)*
	11/29/2009	67	Burlingame Diversion (rkm 60)
	12/27/2009	28	Oasis Road Bridge (rkm 10)
Bull trout 5 (241 mm)	10/8/2009*	N/A	Little Walla Walla Diversion (rkm 76)*
	10/23/2009	15	Nursery Bridge (rkm 74)
	11/12/2009	20	Burlingame Diversion (rkm 60)
	12/31/2009	49	Oasis Road Bridge (rkm 10)
Bull trout 6 (150 mm)	9/26/2008*	N/A	Upper Mill Creek Screw Trap (rkm 41)*
	11/10/2009	410	Bennington Diversion Dam Mill Creek (rkm 19)
	11/10/2009	0	Upper Yellowhawk Creek (rkm 14)
	11/10/2009	0	Middle Yellowhawk Creek #2 (rkm 8)
	11/11/2009	1	Burlingame Diversion (rkm 60)
	12/31/2009	50	Oasis Road Bridge (rkm 10)

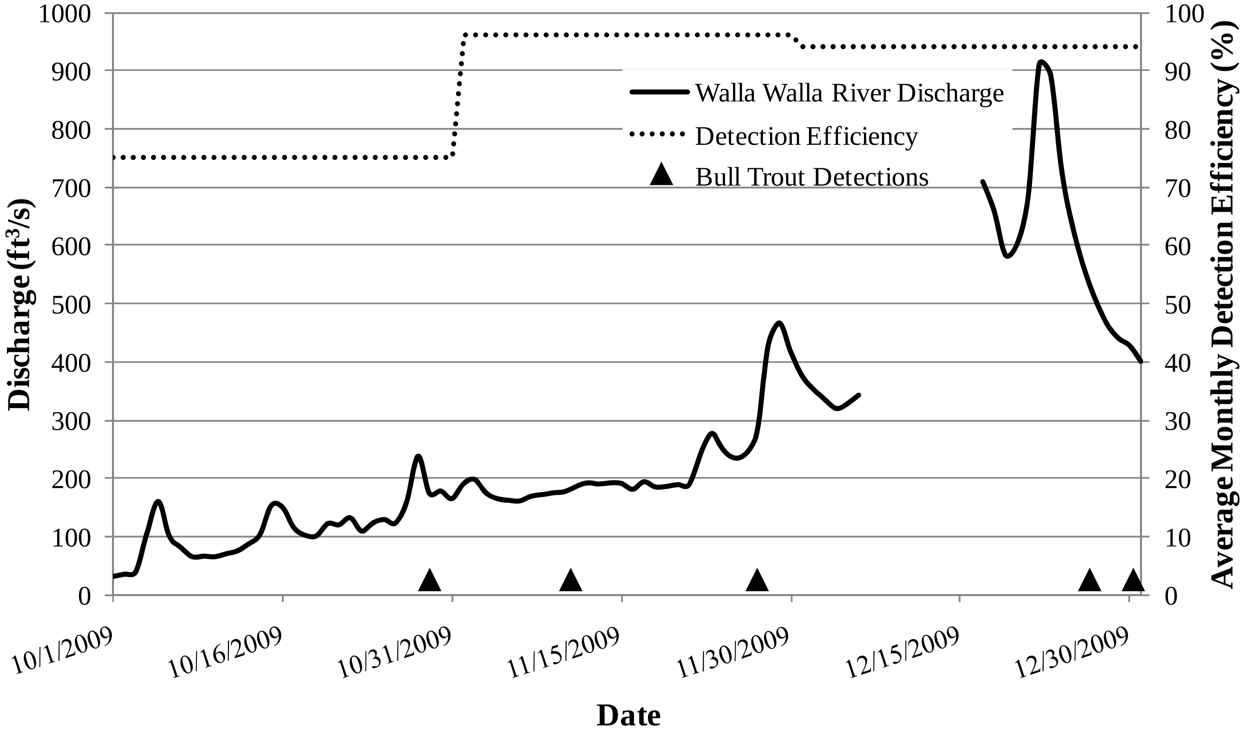
Appendix D – Streamflow, Water Temperature and Oasis Road Bridge PIT Detections, October–December 2009

Figure D1. Walla Walla River discharge from USGS gage #14018500 near Touchet, WA, bull trout PIT detections and average daily water temperature from the FWS thermograph at the Oasis Road Bridge (ORB) PIT detection array from October 1 through December 31, 2009.



Each marker represents a single bull trout detection with the exception of the marker for 12/31/2009, which consisted of two bull trout detections.

Figure D2. Walla Walla River discharge from USGS gage #14018500 near Touchet, WA, bull trout PIT detections at the Oasis Road Bridge (ORB) PIT detection array, and average monthly physical detection efficiency from October 1 through December 31, 2009.



Each marker represents a single bull trout detection with the exception of the marker for 12/31/2009, which consisted of two bull trout detections.

Appendix E – Mainstem Columbia and Snake River Dam PIT Detections, October–December 2009

No PIT tagged Walla Walla Basin bull trout were detected at mainstem Columbia or Snake River dams from October 1 to December 31, 2009.