Bull trout population assessment in northeastern Oregon: a template for recovery planning

Annual Progress Report for 2009

by

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24 September 2010

TABLE OF CONTENTS

Suggested citation:

Budy, P., T. Bowerman, and G.P. Thiede. 2010. Bull trout population assessment in northeastern Oregon: a template for recovery planning. 2009 Annual Progress Report to US Fish and Wildlife Service. UTCFWRU 2010(3):1-48

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

Page

LIST OF FIGURES

ACKNOWLEDGMENTS

Funding for this project was provided by the US Fish and Wildlife Service and the US Geological Survey, Utah Cooperative Fish and Wildlife Research Unit.

We would like to thank Howard Schaller for securing funding and providing guidance and support. Don Anglin, Darren Gallion, Courtney Newlon, Marshall Barrows, and Ryan Koch of the USFWS Columbia River Fisheries Program Office also contributed to the success of this project. Dave Crabtree (USFS), Jackie Dougan (BLM), Bob Bower and Brian Wolcott (WWBWC), and Phil Howell (USFS) provided information and support. We thank Bill Duke (ODFW), Paul Sankovich (USFWS), Brian Mahoney and Mike Lambert (CTUIR) for contributing information, data, support, and logistics. George Ehmer helped maintain the upper Bear Creek PIT-tag antenna array along with Courtney Newlon, Marshall Barrows, and Ryan Koch. George Ehmer and John Ehart provided assistance transporting gear to and from field sites. Thanks to our hard working 2009 summer field crew: Andy Hill, Brandon Simcox, and Sally Petre.

Scientific Take Permit (13738 M1) was obtained with assistance from Darren Gallion of the USFWS CRFPO, as well as Grant Canterbury with USFWS, Regional Office, Region 1. Special Use Permit (WAL0162) was obtained from the USFS with the assistance of Jeff Bloom. Research was conducted under Utah State University IACUC Protocol 1082 and US Fish and Wildlife Service Section 10 permit number TE-702631, sub-permit number CRFPO-5.

EXECUTIVE SUMMARY

There are critical gaps in information that potentially limit our ability to effectively manage bull trout and ensure their continued persistence (Porter and Marmorek 2005; Al-Chokhachy et al. 2008). These gaps include quantification of population abundance and trend for all but a few populations, estimates of larval and juvenile survival rates, estimates of dispersal rates between populations, and life-history-specific information, such as the contribution of migratory versus resident fish to overall population growth and persistence. Our research seeks to address some of these knowledge gaps through long-term monitoring of a relatively large bull trout population in the South Fork Walla Walla River (SFWW). We provide essential information on abundance, trend, vital rates, habitat needs, and information on the potential for improving survival at one or more life stages. In addition, we gather information related to population structure (e.g., age, life history, and genetic components). We provide a template against which different strategies for monitoring and evaluation can be evaluated in terms of accuracy, precision, cost/effort, and limiting factors. Our goal is to provide the data and conservation assessment tools to aid in the efforts of the US Fish and Wildlife Service, to determine the necessary courses of action and management actions for recovery of bull trout populations throughout this as well as other provinces. The project was initiated in 2002 and has continued through 2010, with plans to continue work through 2012 (10 years). To meet our goals, we have developed and implemented each year, a comprehensive mark- recapture program including two tag types, multiple capture techniques (both passive and active) and systematic sampling of two large study areas (SFWW and North Fork Umatilla rivers) with a high degree of effort. 2008 marked the fifth and final year of sampling and study in the North Fork Umatilla River.

The efforts of this project have been part of a completed PhD dissertation (Al-Chokhachy 2006) and Master's thesis (Homel 2007) and are currently part of an on-going PhD dissertation (Bowerman, *in preparation*; Appendix 2) conducted through Utah State University. Results and syntheses of different components of the project are available in previous annual reports (Budy et al 2003, 2004, 2005, 2006, 2007, 2008, and herein) as well as in the peer-reviewed manuscripts: Al-Chokhachy et al. 2005; Al-Chokhachy and Budy 2007; Homel and Budy 2008; Homel et al. 2008; Al- Chokhachy and Budy 2007; Al- Chokhachy and Budy 2008; and Al-Chokhachy et al. 2009; and Al-Chokhachy et al. 2010.

2009 Field Season

We sampled 22 reaches during the 2009 field season (late June to mid August) which accounted for approximately 26% of the study site. Over the summer, we handled 647 bull trout including 37 young-of-year (YOY; 55 – 78 mm TL, 0.5 – 2.9 g) bull trout. In 2009, the average bull trout captured was 150 mm (1 SE = 3.0) and 61.2 g (1 SE = 7.3). The smallest bull trout captured was 55 mm (0.5 g) and the largest bull trout caught was 619 mm TL (600 mm FL, 1.97 kg). Length-frequency distributions of captured bull trout in the SFWW have varied little from 2002 through 2009, with most captured fish in the 100 – 200 mm size range.

Of the 647 bull trout we handled in 2009, we tagged 610 with PIT tags and 126 of those were also tagged with T-bar, anchor tags. In 2009, as in all years since 2003, most bull trout were tagged upstream of Burnt Cabin Creek. As in 2008, we performed snorkeling surveys in 22 reaches in the SFWW in 2009; the total number of bull trout observed during snorkel counts in 2009 (1195 bull trout sighted) was higher than in 2007 and 2008.

In 2009, condition of juvenile (< 120 mm; K_{TL} ± 1 SE = 0.85 ± 0.008) and large adult (> 370 mm) bull trout (K_{TL} ± 1 SE = 0.85 ± 0.004) were below the 8-yr average, while condition of medium sized bull trout (120 – 370 mm TL) was higher in 2009 than in all previous years. Across years and sizes, condition in 2009 was the lowest observed ever in the SFWW (K_{TL} ± 1 SE = 0.85 ± 0.004).

The 2009 population estimate for bull trout > 120 mm was 12,748 (95% CI = 10,527 – 16,375), which was greater than any previous population estimate. Although observation suggests that the abundance of juvenile bull trout (80 - 170 mm) in the SFWW has increased in the past few years, several changes in methodology could have contributed to a positive bias of this estimate. In 2009, the estimated abundance of bull trout >370 mm was 817 (95% CI = 357 – 1,802) compared to 166 (95% CI = 100 – 835) in 2008. The population growth rate (lambda, λ) in the SFWW was relatively consistent among estimates obtained from each of the various approaches, all of which suggested a stable population trend (e.g., λ ~= 1).

We also summarized movement patterns of bull trout that were individually marked with PIT tags in the Walla Walla (WW) River system between 2002 and 2008 (Appendix 2, *this report*). Most fish were recaptured within 15 km of their tagging location, but a small percentage of both adults and juveniles migrated much larger distances, a few as far as 100 km. Combined monthly detections for the seven-year study period show a distinct pattern of upstream movement into the SFWW from June through August, and downstream movement during August through November. Adults (≥ 280 mm TL) exhibited distinct upstream movement during May through August, and downstream movement in September through November. In contrast, juveniles (< 280 mm TL) moved downstream past the WW1 passive in-stream antenna (PIA) throughout the year, with a peak in August. Very few juvenile fish made movements upstream past WW1. During the study, the majority of PIT-tagged fish we detected made a single spawning migration, although we also observed a number of fish spawning two, three, or four times. PIT-tagged fish in our study exhibited a range of migratory behavior, from individuals which did not appear to leave the upper SFWW system, to individuals that moved from the SFWW downstream past the PIA at Nursery Bridge dam and back upstream again past WW2; a number of fish repeated this pattern multiple times. Finally, we observed that most fish were initially resighted or recaptured within one year after being marked with a PIT tag. However, a small but significant percentage of fish were not observed until two to four years after initial tagging.

Stream temperatures in the SFWW were similar to previous years, with temperatures between September 2008 and 15 August 2009 ranging from 1 - 12.5 ^{o}C in the lower part of the study area near Harris Park. Air temperatures and precipitation were within the average range throughout the year, although the region experienced an unusual extended cold spell in December 2008, and a drier than usual late summer in 2009. Peak discharge occurred in the SFWW on 5 May 2009; this flow was only slightly greater than peak discharge in 2006 and 2007.

Monitoring and evaluation of bull trout populations in the South Fork Walla Walla River, Oregon

INTRODUCTION

Conservation of endangered species requires an understanding of key factors driving and limiting populations. Therefore, estimates of population abundance and trend are necessary to evaluate present and future population status (Soulé 1987). Additionally, because the health of a population is ultimately determined by the fitness of its individuals, estimates of vital rates such as survival and growth are important for identifying factors that potentially limit the population (Morris and Doak 2003). As such, quantification of these key demographic parameters can help inform decisions geared toward recovering and sustaining wild populations of imperiled organisms.

Populations of bull trout (*Salvelinus confluentus*) have experienced dramatic declines in both distribution and abundance across much of their range, and the species is listed as Threatened under the Endangered Species Act (USFWS 1999). Bull trout are primarily an inland species of char, native to Western North America. They were once distributed from Northern California northward to the headwaters of the Yukon River in Western Canada (Cavendar 1978). Today, however, bull trout have been extirpated from the southernmost extent of their historical range (Goetz 1989). Bull trout require cold, clean water, and are thought to prefer complex physical habitat (Fraley and Shepard 1989; Goetz 1989; Al-Chokhachy and Budy 2007). Numerous factors have contributed to the decline of bull trout populations including habitat degradation (Fraley and Shepard 1989), barriers to migration (Rieman and McIntyre 1995), competition with introduced species (McMahon et al. 2007), and active eradication (Parker et al. 2007). Bull trout populations may be further impacted by environmental changes such as climate warming (Rieman et al. 2007).

Bull trout exhibit complex life-history strategies, and are known to exhibit multiple life-history forms that can coexist within a single population (Rieman and McIntyre 1993; Al-Chokhachy and Budy 2008; Homel et al. 2008). Resident fish may spend their entire lives in a single stream system, while migratory bull trout may be fluvial, adfluvial, or anadromous (McPhail and Baxter 1996; Brenkman and Corbett 2005), moving between headwater spawning streams out into larger rivers, lakes, or the ocean, according to the respective life-history type. This diversity of life-history forms further highlights the need for large-scale, long-term studies that can evaluate populations that occupy a range of habitats throughout an entire large watershed (Watson and Hillman 1997).

The goal of bull trout recovery planning by the U.S. Fish and Wildlife Service (USFWS) is to describe courses of action necessary for the ultimate delisting of this species under the Endangered Species Act, and ensure the long-term persistence of self-sustaining, complex interacting groups of bull trout distributed across the species' native range (Lohr et al. 1999). To meet this goal, the USFWS has identified several objectives which require the type of information provided by this project: (1) maintain current distribution of bull trout within core areas in all recovery units and restore distribution where needed to encompass the essential elements for bull trout to persist, (2) maintain stable or increasing trends in abundance of bull trout in all recovery units, and (3) restore and maintain suitable habitat conditions for all bull trout life-history stages and strategies. The USFWS recovery-planning document emphasizes conserving core areas within conservation units to preserve genotypic and phenotypic diversity represented in different geographic locations, and to conserve bull trout populations across a range of habitats. The continued survival and recovery of individual core area populations is thought to be critical to the persistence of conservation units and in overall recovery of the Columbia River distinct population segment (Whitesel et al. 2004).

Recent research has contributed to our knowledge of bull trout populations in various parts of the species' range (e.g., Al-Chokhachy et al. 2010), as well as issues managers face in trying to recover bull trout populations (Al-Chokhachy et al. 2008). However, there are still critical gaps in information that potentially limit our ability to effectively manage bull trout and ensure their continued persistence (Porter and Marmorek 2005; Al-Chokhachy et al. 2008). These gaps include quantification of population abundance and trend for all but a few populations, estimates of larval and juvenile survival rates, estimates of dispersal rates between populations, and life-history-specific information, such as the contribution of migratory versus resident fish to overall population growth and persistence.

Our research seeks to address some of these knowledge gaps through long-term monitoring of a relatively large bull trout population in the South Fork Walla Walla River. Each year, we use mark-recapture/resight data to estimate population size and structure, population trend, vital rates, and movement patterns (Al-Chokhachy and Budy 2008; Homel and Budy 2008). Previous research on this population has allowed us to evaluate and compare different monitoring techniques (Al-Chokhachy et al. 2005; Al-Chokhachy et al. 2009), assess genetic differentiation between resident and migratory life-history types (Homel et al. 2008), and compare demographic parameters and habitat use among several distinct populations (Al-Chokhachy and Budy 2007; Budy et al. 2007). We provide a template against which different strategies for monitoring and evaluation can be assessed in terms of accuracy, precision, and cost per effort (Al-

Chokhachy et al. 2009) in addition to focused research on specific components of this greater project, which has included research on other populations (e.g., Wenaha, John Day, and Umatilla rivers). To date, our work includes eight years (2002 - 2009) of population monitoring data and vital-rate statistics from the SFWW. The data and conservation assessment tools provided by this project will ultimately help guide the USFWS in determining the necessary management actions for recovery of bull trout populations throughout this and other provinces. For example, preliminary data from 2002 - 2008 are currently being used by the USFWS Bull Trout Recovery, Monitoring, and Evaluation Technical Group (RMEG) in a draft monitoring and evaluation guidance document, which will eventually be used to help standardize sampling and monitoring protocols for bull trout.

In previous years, we have conducted research on several rivers, which allowed us to compare population abundance and distribution, as well as vital rate statistics and habitat use, between populations of bull trout in the John Day, Umatilla, and Walla Walla river systems. In 2009, our research focused solely on the South Fork Walla Walla River (SFWW), located in Northeastern Oregon (Figure 1). The SFWW was initially selected as the comprehensive study area for this research because it contains a relatively high abundance of both resident and migratory fish and a diversity of habitat types, which allows us to study differences in such metrics as movement and survival in relation to life-history strategy. In addition, this watershed is the focus of numerous complex water management issues associated with fish protection, and thus provides an opportunity to apply research to active management decisions. Long-term research in this watershed has allowed us to monitor the bull trout population in the SFWW for eight years, providing one of the most comprehensive continuous capture-recapture studies of fluvial bull trout in the region.

STUDY AREA

The South Fork Walla Walla River

The Walla Walla River in northeastern Oregon and southeastern Washington is a tributary of the Columbia River that drains an area of 4,553 km^2 (Walla Walla Subbasin Summary Draft 2001). The tributaries of the Walla Walla River originate in the Blue Mountains at elevations near 1800 m. Primary tributaries to the main stem Walla Walla River include the North and South Fork Walla Walla Rivers in Oregon, and Mill Creek and Touchet River, which enter the main stem after it flows northward into Washington state.

The Walla Walla River historically contained a number of anadromous and resident, native salmonid populations including: redband trout (*O. mykiss* subpopulation), bull trout, mountain whitefish (*Prosopium williamsoni*), and summer steelhead (*O. mykiss)*, spring and fall Chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*O. keta*), and coho salmon (*O. kisutch*), although the extent of fall Chinook, chum, and coho salmon within the system is not known; (Walla Walla Subbasin Summary Draft 2001). Today, steelhead represents the only native anadromous salmonid still present in the Walla Walla River system. However, since 2000 there has been annual supplementation of adult Chinook salmon in the SF Walla Walla River by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Populations of native redband trout, bull trout, mountain whitefish, sculpin (*Cottus* spp.), and dace (*Rhinichthys* spp.) still persist in the Walla Walla River, as well as introduced brown trout (*Salmo trutta*).

Little documentation exists on the historical distribution of bull trout in the Walla Walla Subbasin prior to 1990. Anecdotal evidence suggests that large fluvial bull trout were found to utilize the Columbia River. Telemetry studies in the mid-Columbia River region have shown bull trout to use both primary and secondary tributaries for spawning (FERC Project 2145 Draft 2002). Therefore, it is presumed that bull trout had access to the Columbia River and all of its tributaries prior to the impoundment of the Columbia River (Buchanan et al. 1997). Today, resident and fluvial forms of bull trout exist in the Walla Walla (Walla Walla Subbasin Summary Draft 2001), and both populations spawn in the tributaries and headwaters of the Walla Walla River. Recent data demonstrate that bull trout travel throughout the Walla Walla River system and into the Columbia River. Bull trout PIT tagged in Mill Creek and in the main stem Walla Walla have been detected at the PIA located at Oasis Road Bridge, only 10 kilometers upstream of the Columbia River. In 2009, three bull trout PIT tagged in the main stem Walla Walla River were detected at sites in the Columbia River, two at McNary Dam and one at Priest Rapids Dam. Within the Walla Walla River Basin, bull trout are arbitrarily divided into four populations based on geography: North Fork Walla Walla River, South Fork Walla Walla River (SFWW), Mill Creek, and the Touchet River (Buchanan et al. 1997). Ratliff and Howell (1992) described the population status of bull trout as “low risk” in the SFWW and Mill Creek, and “of special concern” in the North Fork Walla Walla River. Since that report, the status of the SFWW population has remained at low risk, but both the North Fork Walla Walla River and Mill Creek populations have been upgraded to “high risk” and “of special concern” respectively (Buchanan et al. 1997). Alterations to migratory corridors linking these populations have occurred, but the degree of genetic and geographical isolation is unknown.

The long-term study site on the SFWW spans nearly 21 km in length. The upper boundary was set at the confluence with Reser Creek (117.7 km upstream of the Columbia River; Reach 103), and the lower boundary was set above Harris Park Bridge (97 kilometers upstream of the Columbia River; on public, county land; Budy et al. 2003, 2004, 2005). In order to account for spatial variation of the study area and the distribution of bull trout, the study site was divided into 102 reaches, each approximately 200 m in length, using Maptech mapping software (Figure 1).

An initial site was randomly selected from the list of reaches, and thereafter every fifth reach (an approximate 20% sample rate) was systematically designated for sampling in 2002. The UTM coordinates from the mapping software were used to locate the general location of the bottom of each reach, and the closest pool tail to the coordinates was set as the true reach boundary. The reach continued upstream for at least 200 m and the top was set at the first pool-tail above the 200-m mark. Total length was recorded for each reach. Location coordinates (UTM using GPS) were recorded at the boundaries of each reach.

METHODS

Size designations

Since the onset of the bull trout population assessment in northeastern Oregon in 2002 and in any bull trout publications and reports published by the USGS Utah Cooperative Fish and Wildlife Research Unit at Utah State University, the following size designations for bull trout have been used: Bull trout smaller than 220 mm represent juvenile, not sexually mature fish (Al-Chokhachy and Budy 2008, and bull trout 220 mm or larger represent both resident and migratory sexually mature fish (Al-Chokhachy et al. 2005; Al-Chokhachy and Budy 2007). The > 220 mm cutoff (here after termed adult) for sexually mature adults is a conservative estimate as we have found smaller adults in our study sites, and smaller resident adult bull trout have been found in other systems (WDFW 2000; Dunham et al. 2008). Additional size categories are used for population growth rate estimates and survival estimates where both Passive Integrated Transponder (PIT) and T-bar anchor (Floy-brand) tags are used for mark recapture events. Small bull trout are 120 - 220 mm, small adults are 220 - 370 mm, and large, likely migratory, adults are > 370 mm; based on percent migratory in Al-Chokhachy and Budy (2008) and others (Rieman et al.1993; Shephard 1989). We do know that not all bull trout > 370 mm are migratory (particularly in fluvial systems) but there is a presumption that larger fish are migratory, and observational movement data (*see* Appendix 2 in this report) support this presumption. The size categories > 220 mm and

> 370 mm are now considered the most important for trend and population analyses. The > 120-mm size cutoff was initially chosen as a safe size for inserting Floy tags and 23-mm PIT tags, although more recently, we have increased the minimum size of fish tagged with Floy tags to ≥ 170 mm. The development of smaller "super PIT tags" (8-mm and 12-mm) has made it safe and feasible to insert PIT tags into smaller (< 120 mm) bull trout. Since 2007 we have been tagging bull trout 70 - 120 mm with the 12-mm PIT tags. In 2005, age-at-length estimates were calculated from otolith analysis and are as follows; < 120 mm = age-1, 120 - 220 mm = age-2 and age-3, 220 - 370 mm = age-4 and age-5, and > 370 mm = ≥ age-6 (Budy et al. 2006).

<u>Fish sampling</u>

Capture.—We capture bull trout using multiple sampling techniques including angling and electroshocking downstream to a seine. All captured bull trout were weighed (nearest 0.1 g), measured (nearest mm total length, TL, and fork length, FL); we then used these measurements to calculate condition (Fulton's $K_{TL} = W / L^3 * 100{,}000$) and determine length-to-weight regressions. Scales were taken from a subsample of live fish prior to release. Gonads, otoliths, stomach contents, and tissue samples were taken from a small subsample of adults in order to estimate fecundity, sex ratio, and age, and to analyze diet and stable isotope ratios.

Marking.—In all study reaches, each bull trout > 70 mm TL captured was marked with a unique PIT tag as well as an external mark and subsequently recaptured using a combination of passive in-stream PIT-tag antennae (hereafter detector; *see* below) and snorkeling resights. We marked smaller bull trout (70 - 170mm TL) in the SFWW with unique 12-mm PIT tags and gave them an external mark by clipping the adipose fin; this fin clip was saved for later genetic analysis. We marked bull trout > 170 mm with 23-mm PIT tags and an external anchor (Floy) tag, unique to the year and stream, was inserted adjacent to the dorsal fin. Prior to tagging, bull trout were anesthetized until they exhibited little response to stimuli. A PIT tag was then placed into a small incision on the ventral side of the fish, anterior to the pelvic fins. After tag implant, scales were taken from the right side at the base of the dorsal fin for aging and growth information. All fish were placed in a flow-through recovery container within the channel, monitored until full equilibrium was restored, and returned to slow-water habitat near individual capture locations. We also tagged juvenile fish in Skiphorton Creek using the same methodology (*see* Appendix 3).

Resighting.—To resight tagged fish, we conducted daytime bull trout snorkel surveys in each of the study reaches (mean reach length = 244 m) of the SFWW. To avoid double-counting fish that were migrating upstream to the headwaters to spawn, we began snorkeling surveys at the highest reaches and worked downstream to the bottom of the study site, and conducted surveys on consecutive days until the sampling was complete. . This approach likely minimized the incidence of counting the same fish twice in different reaches. Water temperature and start and end times were recorded for each snorkeling session. All bull trout (tagged and untagged), *O. mykiss* spp., and mountain whitefish were enumerated and placed into 50-mm size classes, and all juvenile and adult Chinook salmon were. Accurate identification of fish species and size estimation was emphasized. In each channel unit snorkeled, two observers proceeded in an upstream direction while scanning for fish across their assigned lane, such that the entire channel was surveyed.

Recapture.—We recaptured previously tagged bull trout (2002 – current) using a combination of techniques including: electroshocking down to a seine (electroseining), snorkel herding, and angling, and passive fish detection using pass-through PIT-tag technology described below. All actively captured bull trout were passed over a handheld PIT-tag reader and checked for T-bar, anchor (Floy) tags from previous years. When recaptured, all bull trout were weighed and measured for estimates of annual growth, and we recorded information regarding location of recapture for movement analyses. Recapture events also provided critical information for estimates of bull trout survival, annual population estimates, and to parameterize the Pradel mark and recapture model.

Passive fish detection.—PIT-tag detectors were installed in-stream and continuously collect information on tagged bull trout from two locations within the SFWW study area. One detector is located at Harris Park Bridge (River km 97; UTM coordinates: 110408261 E, 5076370 N) at the bottom of the study site, and the second detector is located just above the confluence with Bear Creek (approximately 8 km upstream at river km 105.6; UTM coordinates: 110414281 E, 5077108 N). The Harris Park Bridge detector (WW1) has been running since mid-September 2002, and the Bear Creek detector (WW2) has been operational since mid-October 2002; however, there were periods of time in 2009 when both did not operate due to mechanical failure. Additional detectors are located downstream at Nursery Bridge, Burlingame Diversion, and Oasis Bridge on the Walla Walla River (*see* Appendix 2). Having more detectors further downstream on the SFWW and on other rivers allows us to monitor fish migrations and connectivity within the Walla Walla basin. All detectors are linked either through phone or satellite, and data is uploaded to the PTAGIS website (<*www.psmfc.org/pittag/Data_and_Reports/index.html* > under "*Small-scale Interrogation Site Detections -Query*").

Growth

Growth information was obtained from bull trout previously tagged in the SFWW (2002 - 2008) and recaptured during the 2009 summer field season. Length and weight gains were determined between initial tagging and subsequent recapture events. These length and weight gains were evaluated based on annual growth, and delineated by size class at initial tagging.

Population estimates

We used snorkeling and tagging data to parameterize mark-resight population estimates using a Lincoln-Petersen bias-adjusted estimator (Chapman 1951). We estimated the overall population size and 95% confidence intervals (Krebs 1999) for three size groupings of bull trout: > 120 mm, > 220 mm, and > 370 mm. In each of the 22 focal reaches, we initially marked fish with external anchor tags and then used snorkeling data to count unmarked and resight marked fish. Finally, we expanded these reach-based counts to estimate abundance for the subpopulation within the entire study area.

Population growth rate

Obtaining reliable estimates of population trend to determine whether the population is increasing or decreasing is a particularly challenging task that requires multiple years of data. For this report we estimated population trend using two different methods and three data types. Because each methodology has different sources of bias associated with it, comparison of different approaches can help improve confidence in the direction of the trend. First, we estimated trend via linear regression of log-transformed annual changes in population growth rate (λ) as a function of time step (Morris and Doak 2002; Budy et al. 2007) based on 1) SFWW redd count data (1994 - 2009) obtained from USFWS and ODFW and 2) population estimates from the SFWW mark-resight data (2002 - 2009). In a second approach, we estimated trend using a temporal symmetry model (Pradel 1996; Nichols and Hines 2002) based on capture-recapture data from 2002 - 2009. For both approaches, we estimated trend for fish > 220 mm because this size class corresponded to the adult population within the SFWW (Al-Chokhachy and Budy 2008) and directly corresponds to bull trout recovery goals. We also performed separate trend analyses using both approaches for large bull trout (> 370 mm) because this size class contains the greatest proportion of individuals exhibiting migratory patterns within the SFWW (Al-Chokhachy and Budy 2008).

Survival

Survival estimates will not be updated again until 2012. See the 2007 annual report (Budy et al. 2008) for survival estimates.

Temperature

We monitored temperature at four sites using temperature loggers set in stream and programmed to record temperatures at 90-minute intervals, generally year round.

RESULTS and DISCUSSION

Fish sampling

We sampled 22 reaches during the 2009 field season (late June to mid August) which accounted for approximately 26% of the study site. In the SFWW, we handled 647 bull trout including 37 young-of-year (YOY; 55 – 78 mm TL, 0.5 – 2.9 g) bull trout (Figure 2). In 2009, the average bull trout captured was 150 mm (1 SE = 3.0) and 61.2 g (1 SE = 7.3). The smallest bull trout captured was 55 mm (0.5 g) and the largest bull trout caught was 619 mm TL (600 mm FL, 1.97 kg). Length-frequency distributions of captured bull trout in the SFWW have varied little from 2002 through 2009, with most captured fish in the 100 – 200 mm size range (Figure 2).

Of the 647 bull trout we handled in 2009, we tagged 610 with PIT tags and 126 of those were also tagged with bicolored (blue-orange, green-yellow, or red-white) Floy, T-bar, anchor tags. In 2009, as in all years since 2003, most bull trout were tagged upstream of Burnt Cabin Creek (Figure 5). In reach 78, near Skiphorton, we tagged 106 bull trout, the most bull trout we ever tagged in one reach (Figure 3).

We weighed (to the nearest 0.1 g) and measured (TL and FL to the nearest mm) all captured bull trout from 2002 – 2009 in the SFWW and developed a strong relationship for weight-at-length (annually since 2002; Figure 4) and total length to fork length (in 2009; Figure 5).

Condition.—Condition (Fulton's K_{TL}) of bull trout captured from 2002 - 2009 varied by size class and year; in general, condition was lowest for juvenile (< 120 mm; 8-yr mean = 0.88) and small adult (120 - 370 mm; 8-yr mean = 0.89) bull trout and highest for large (> 370 mm) bull trout (8-yr mean = 0.94; Figure 6). These results make sense when compared to growth data over the same period, where larger fish put on more weight but less length resulting in higher condition values (Figures 6 and 11). In 2009, condition of juvenile (< 120 mm; K_{TL} ± 1 SE = 0.85 ± 0.008) and large adult (> 370 mm) bull trout (K_{TL} ± 1 SE = 0.85 ± 0.004) were below the 8-yr average, while condition of medium sized bull trout (120 – 370 mm TL) was higher in 2009 than in all previous years (Figure 6). Across years and sizes, condition in 2009 was the lowest observed ever in the SFWW (K_{TL} ± 1 SE = 0.85 ± 0.004; Figure 7). Condition in the SFWW population was similar to that observed in the nearby North Fork Umatilla River between 2003 and 2008 (Figure 7).

We then compared the relationship of Fulton's K_{TL} to the slope of the length-to-weight regression line (see equations on Figure 2) for 8 years of data and found Fulton's K_{TL} to be a reliable indicator of condition for bull trout (Figure 8).

Snorkel surveys.—As in 2008, we performed snorkeling surveys in 22 reaches in the SFWW in 2009. The distribution of observed bull trout in 2009 was similar to that of past years, with highest densities observed in reaches 78 and 58 and lowest densities in reaches 18 and 8 (Figure 9). The total number of bull trout observed during snorkel counts in 2009 (1195 bull trout sighted) was higher than in 2007 and 2008 (Figure 9). Observations were likely biased toward fish > 120 mm (80 %) due to the cryptic nature of small fishes (Figure 10; *see* Thurow 1997), and resights were likely biased toward marked fish >170 mm because the Floy tag was easier to see than the adipose fin clip, which were the external marks used to identify previously marked fish. In 2009, bull trout observed in the SFWW ranged from small juveniles < 70 mm up to 570 mm, and we resighted marked fish ranging from 70 – 520 mm TL (Figure 10).

<u>Growth of recaptured fish</u>

Since 2002 we have recaptured 106 bull trout in the SFWW for estimates of annual growth. We first began PIT tagging bull trout < 120 mm in 2007 and continued tagging these small fish in 2009. Average annual growth of tagged bull trout varied between subadults and adults: the smallest bull trout (70-120 mm, age -1) and age-2 and age-3 bull trout (120 - 219 mm in TL) exhibited similar annual growth in length, 66 mm/year (± 2 SE = 18.9 mm) and 65 mm/year (± 2 SE = 9.4 mm), respectively. These subadult fish exhibited higher annual growth in length than small adults (220 - 370 mm, age- 4 and -5), 41 mm/year (± 2 SE = 7.9 mm), and significantly larger growth in length than large adults (> 370 mm, ≥ age 6), 19 mm/year (± 2 SE = 6.0 mm; Figure 11).

In terms of body mass, the trend was opposite to that of length. Small (220 - 370 mm, age- 4 and -5) and large (>370 mm, ≥ age 6) adults exhibited higher growth rates, 120 g/year (± 2 SE = 33.7 g) and 167 g/year (± 84.5 g), respectively, than subadult bull trout:

120 - 220 mm (age- 2 and -3) at 93 g/year (± 21.2) and < 120 mm (age-1) at 29 g/year (± 9.0 g). However, variability was high and sample sizes were small (Figure 11).

Population estimates

Estimated abundance of bull trout in the SFWW varied among size groups. The 2009 population estimate for bull trout > 120 mm was 12,748 (95% CI = 10,527 – 16,375), which was greater than any previous population estimate (Figure 12). Although observation suggests that the abundance of juvenile bull trout (80 - 170 mm) in the SFWW has increased in the past few years, several changes in methodology could have contributed to a positive bias of this estimate. In 2009, we increased the minimum size of fish that were marked with an external anchor tag from 120 mm to 170 mm. All PIT-tagged fish < 170 mm were also marked by an adipose fin clip, but this latter marking was more difficult to observe during snorkel counts than the previously-used anchor tags. This change in methodology likely led us to undercount marked fish relative to unmarked fish in the small size class (120 – 170 mm), which would have resulted in higher population estimates. Second, for the past three years, we have been conducting additional research specific to juvenile life-stages, which may have inadvertently led to a heightened awareness of smaller fish (e.g., 120 – 170 mm) and an increased understanding of their behavior and habitat utilization. These factors may have contributed to an increase in the number of small size classes captured during standard surveys.

In 2009, the population estimates for larger size classes of bull trout was greater than in 2007 and 2008, and were similar to estimates from 2005 - 2006 (Figure 12). The 2009 estimated abundance of bull trout > 220 mm was 1,592 (95% CI = 1,095 – 2,947), compared to the previous year, which was the lowest estimate of the 8-year study period, 641 (95% CI = 451 – 1,269), although not as great as the 2002 estimate of 2,695 (95% CI = 2,244 – 3,456). In 2009, the estimated abundance of bull trout > 370 mm was 817 (95% CI = 357 – 1,802) compared to 166 (95% CI = 100 – 835) in 2008.

Population growth rate

The population growth rate (lambda, λ, or population trend) in the SFWW (time period: 2002 – 2009) was relatively consistent among estimates obtained from each of the various approaches, all of which suggested a stable population trend (Table 1). A λ value > 1 indicates positive population trend, a value of λ = 1 indicates no change in population growth rate, and a λ value < 1 indicates that the population is declining. Estimates based on the linear regression approach were slightly higher using redd count data from 1994 - 2009 (λ = 1.108, 95% CI = 0.891 – 1.378) than estimates using redd count data from only 2002 - 2009 (λ = 0.974, 95% CI = 0.803 – 1.183). These estimates were similar to those using population estimates for bull trout > 220 mm (λ = 1.068, 95% CI = 0.699 – 1.633). The small number of bull trout > 370 mm resulted in large confidence intervals around the growth rate using population estimates for this size group (λ = 1.337, 95% CI = 0.621 – 2.877). The confidence intervals for each of these estimates overlap 1, suggesting a stable population growth rate in the SFWW, regardless of which data set was used. However, because these values were estimated based on linear regression, a single value, such as the large increase in population abundance estimates between 2008 and 2009, can have a disproportionate influence on the resulting estimate of lambda. With only eight years of data, an estimate of the population growth rate may be skewed by a single particularly low or high year.

Using the temporal symmetry model, we obtained similar but slightly lower estimates of population growth rate for bull trout > 220 mm (λ = 0.931, 95% CI = 0.893 – 0.971) and > 370 mm (λ = 0.931, 95% CI = 0.878 – 0.996). While this approach is generally considered less biased than the regression-based approach, it can likewise be affected by sparse data (Hines and Nichols 2002). The precision of population growth rate estimates using the temporal symmetry model will improve with additional years of data collection.

Temperature and flow

Since the last report, we were able to collect temperature data at four sites from mid August 2008 to mid August 2009 using temperature loggers. We lost one logger in spring from the site below Reser Creek, therefore that data only runs through March 2009. Over this one-year period, stream temperatures were warmest at the Harris Bridge (range = 0.3 – 15.5 ^{o}C) and coldest at the site below Reser Creek (range = - 0.2 – 9.3 ^{o}C; Figure 13).

High flows occurred in the SFWW on four separate occasions during 2009. A high flow in January knocked out most of the passive in-stream antenna array (PIA) at Harris Park Bridge. One half of the unit was reinstalled, but subsequent high water events that occurred in mid-March, mid-April, and early May prohibited re-installation of the PIA. The high flow in May dislodged the remaining portion of the PIA; the entire unit was replaced on 17 June 2009 when discharge finally decreased. The high flow event in mid-April knocked out half of the PIA at Bear Creek, which remained inoperable until 31 July 2009.

Table 1. Population growth rate estimates with 95% confidence intervals (CI) in the South Fork Walla Walla River from 2002 - 2009, based on linear regression of the log-transformed annual changes in population growth using redd count data (Redds) and population abundance estimates for bull trout > 220 mm and > 370 (Pop Est), as well as the population growth estimates (± 95% CI) obtained using a temporal symmetry model (Pradel) based on mark-recapture data for bull trout > 220 mm and > 370 mm for the same time period.

Estimate source	Lambda	Lower 95% CI	Upper 95% CI
Redds 1994 – 2009	1.108	0.891	1.378
Redds 2002 – 2009	0.974	0.803	1.183
Pop Est > 220 mm, 2002 - 2009	1.068	0.699	1.633
Pop Est > 370 mm, 2002 - 2009	1.337	0.621	2.877
Pradel > 220 mm, 2002 - 2009	0.931	0.893	0.971
Pradel > 370 mm, 2002 - 2009	0.931	0.878	0.997

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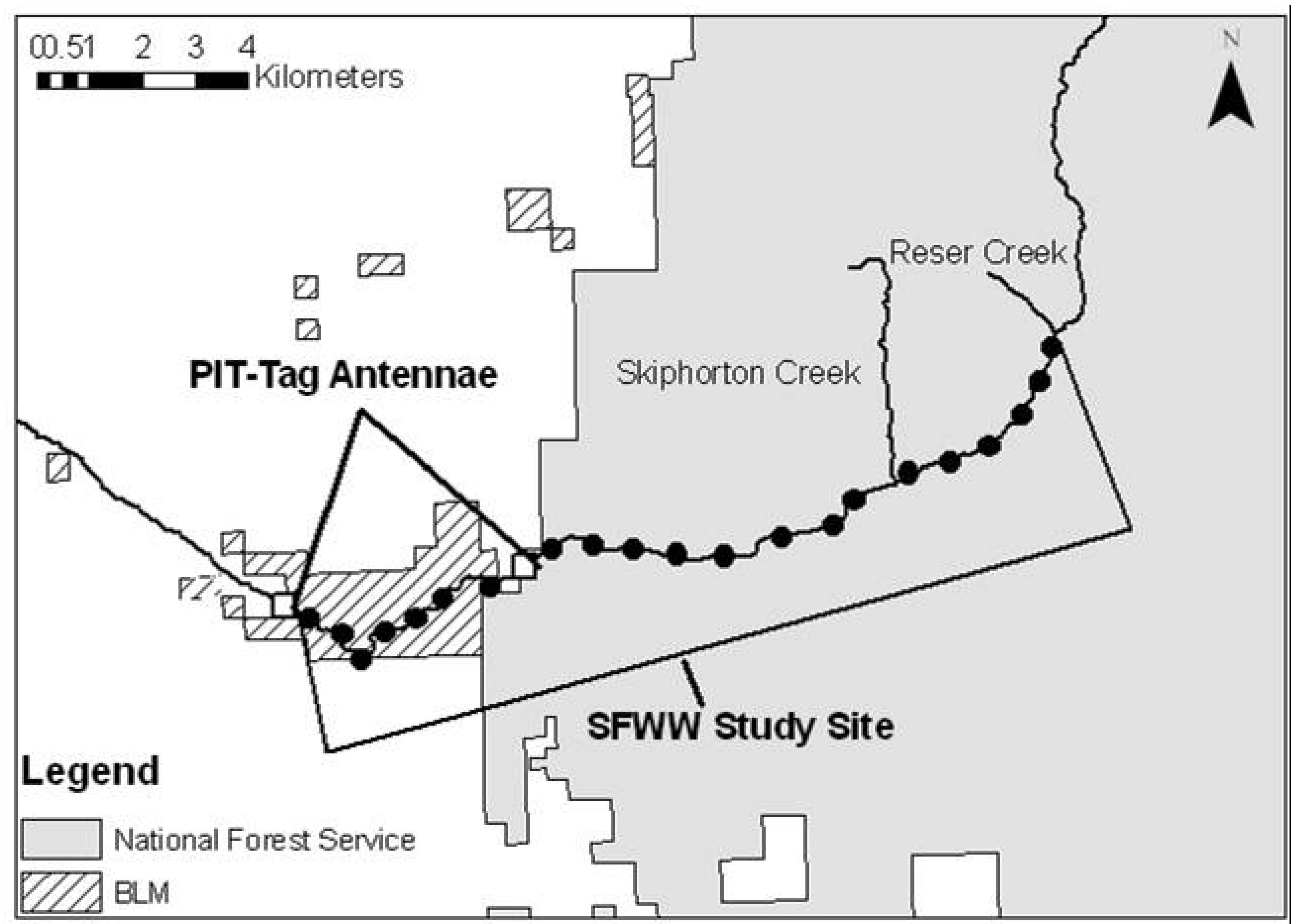

Figure 1. Map of the South Fork Walla Walla (SFWW) River, Oregon, showing original 22 study reaches (dark circles) and passive in-stream antenna (aka PIA or detectors) locations (white squares) within our primary study area.

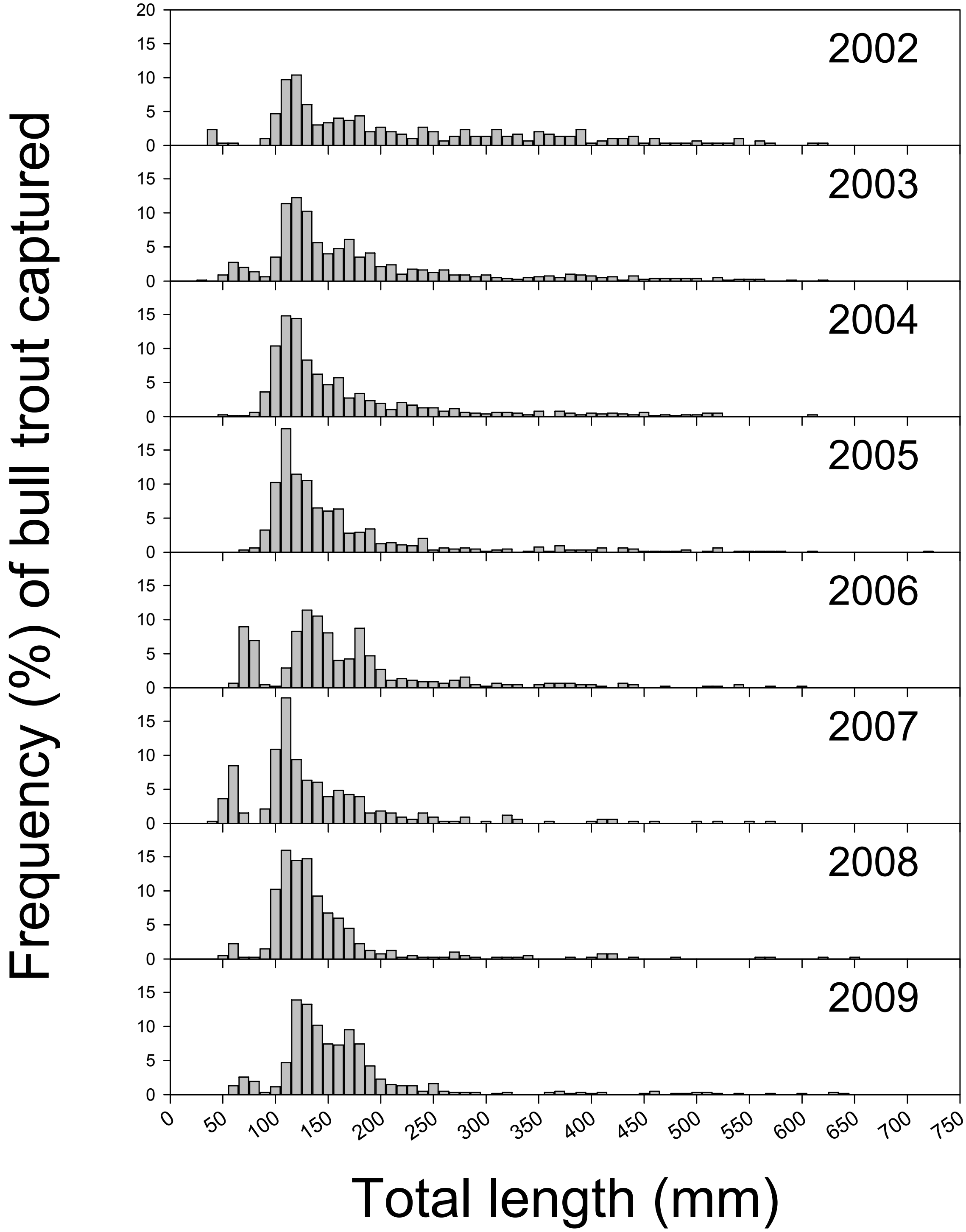

Figure 2. Length-frequency (% of total catch) distribution of bull trout captured and handled in the South Fork Walla Walla River, Oregon, 2002 – 2009.

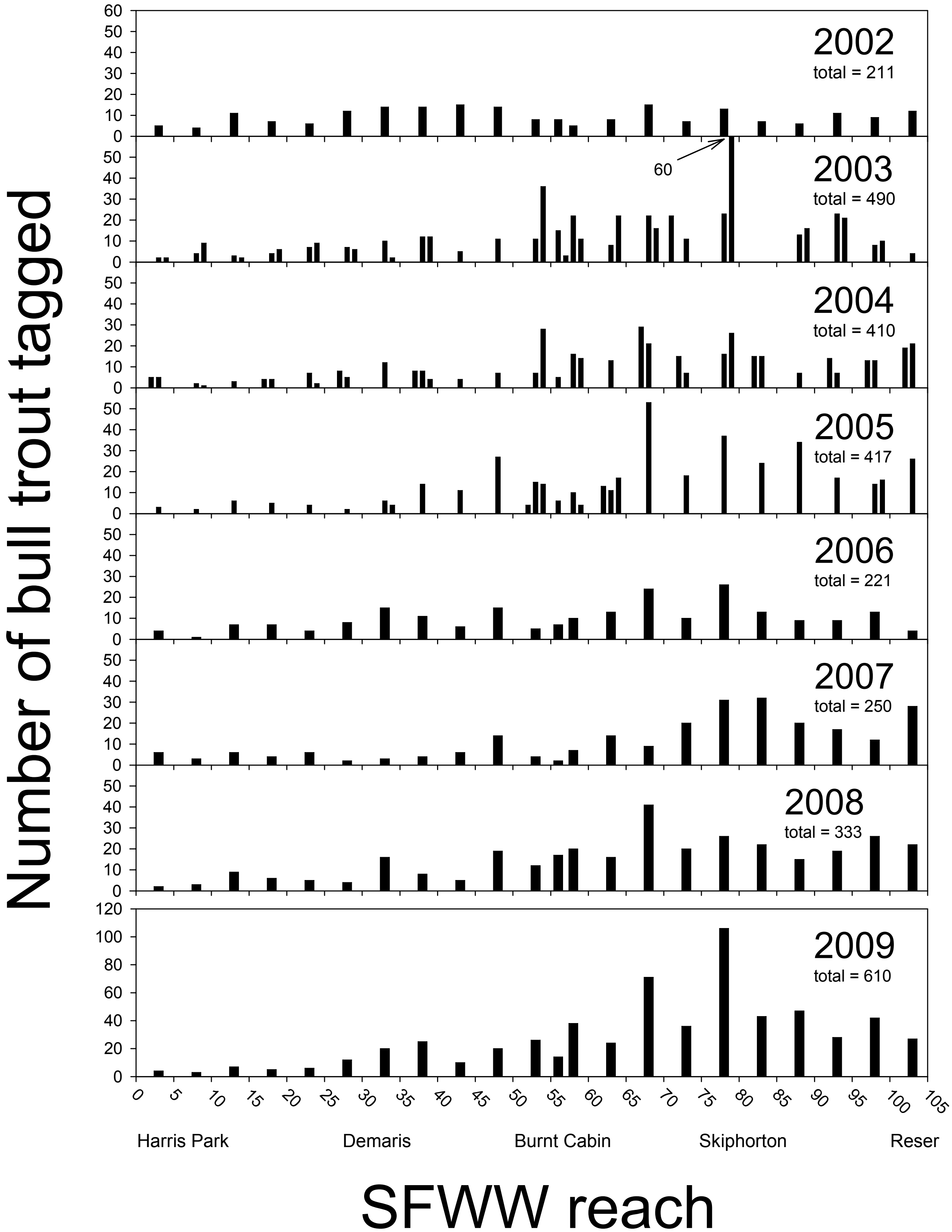

Figure 3. Number of bull trout tagged by reach in the South Fork Walla Walla River, Oregon, 2002 - 2009. Reaches are numbered from bottom (0) to top of the study site. Total numbers tagged are given below sample year. Note scale change in 2009 panel.

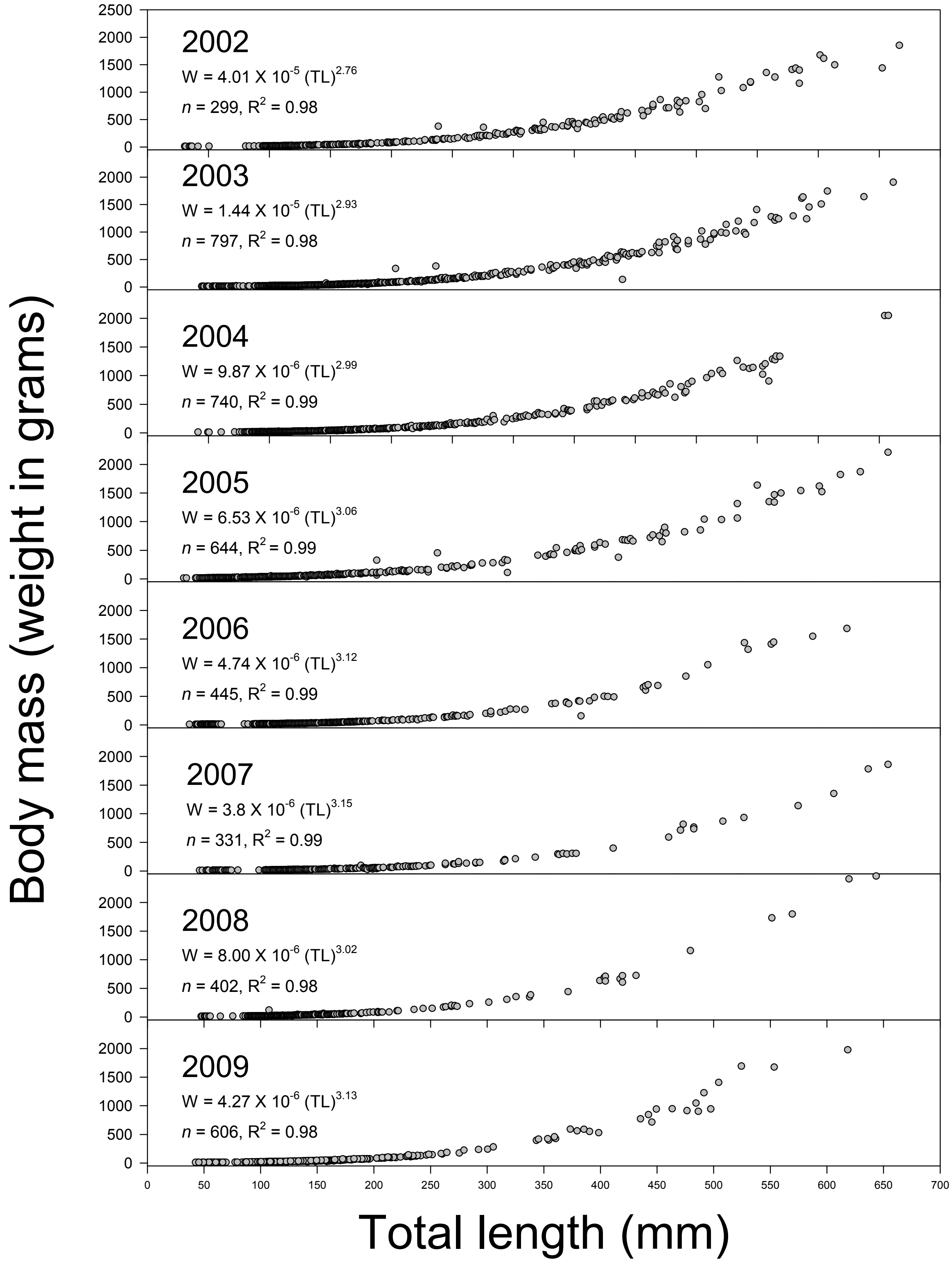

Figure 4. Length-weight regression for bull trout captured in the South Fork Walla Walla River, Oregon from 2002 – 2009. Regression equation, sample size (n), and R^2 values are given on each panel.

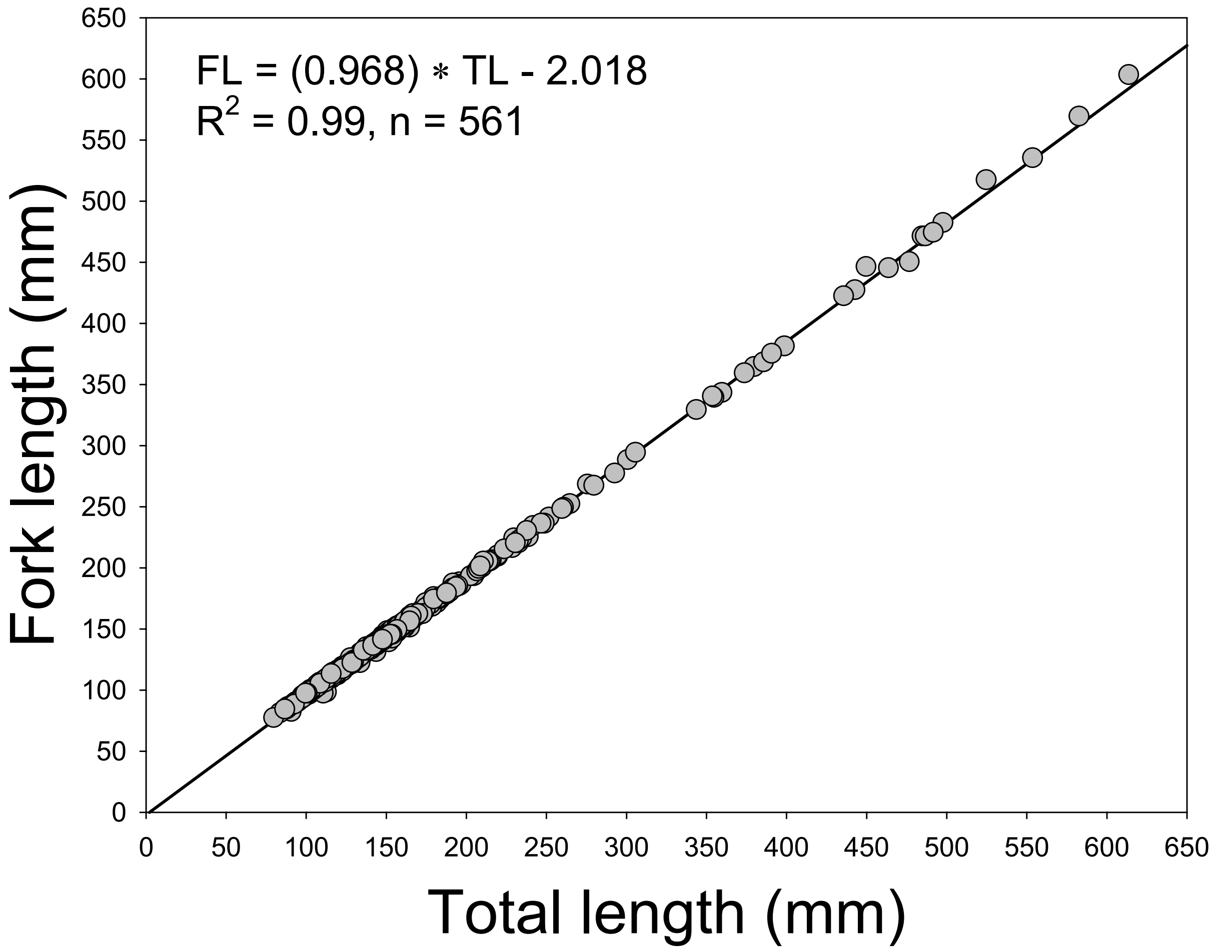

Figure 5. Relationship between total length (TL) and fork length (FL) for bull trout $\geq$ 80 mm TL tagged in the South Fork Walla Walla River, Oregon, 2009. Linear regression equation, R^2 value, and sample size (n) are given.

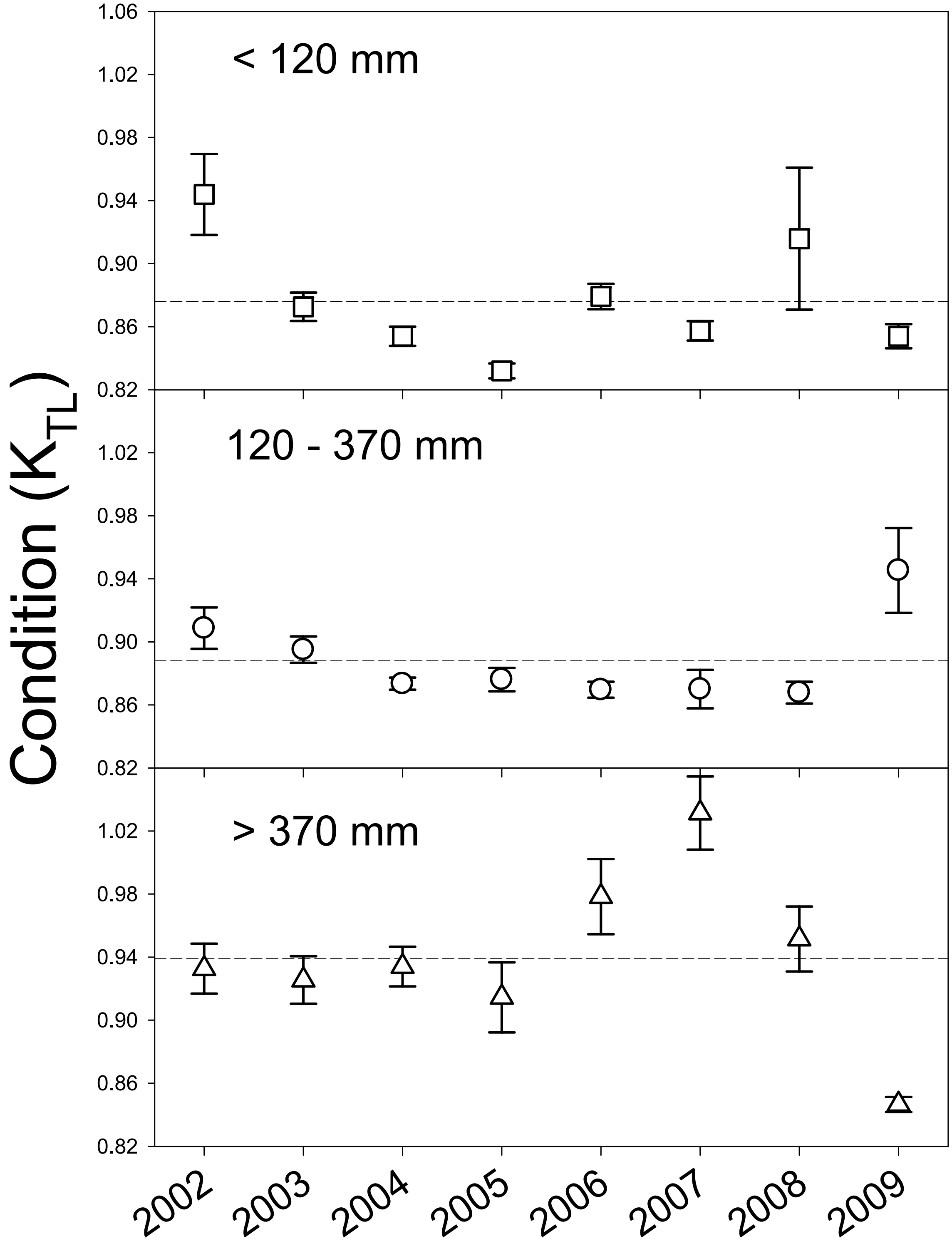

Figure 6. Condition (Fulton's $K_{TL} \pm$ 1 SE) of three different size classes of bull trout handled in the South Fork Walla Walla River, Oregon, 2002 - 2009. Dashed line represents size-specific, 8-year average K_{TL}.

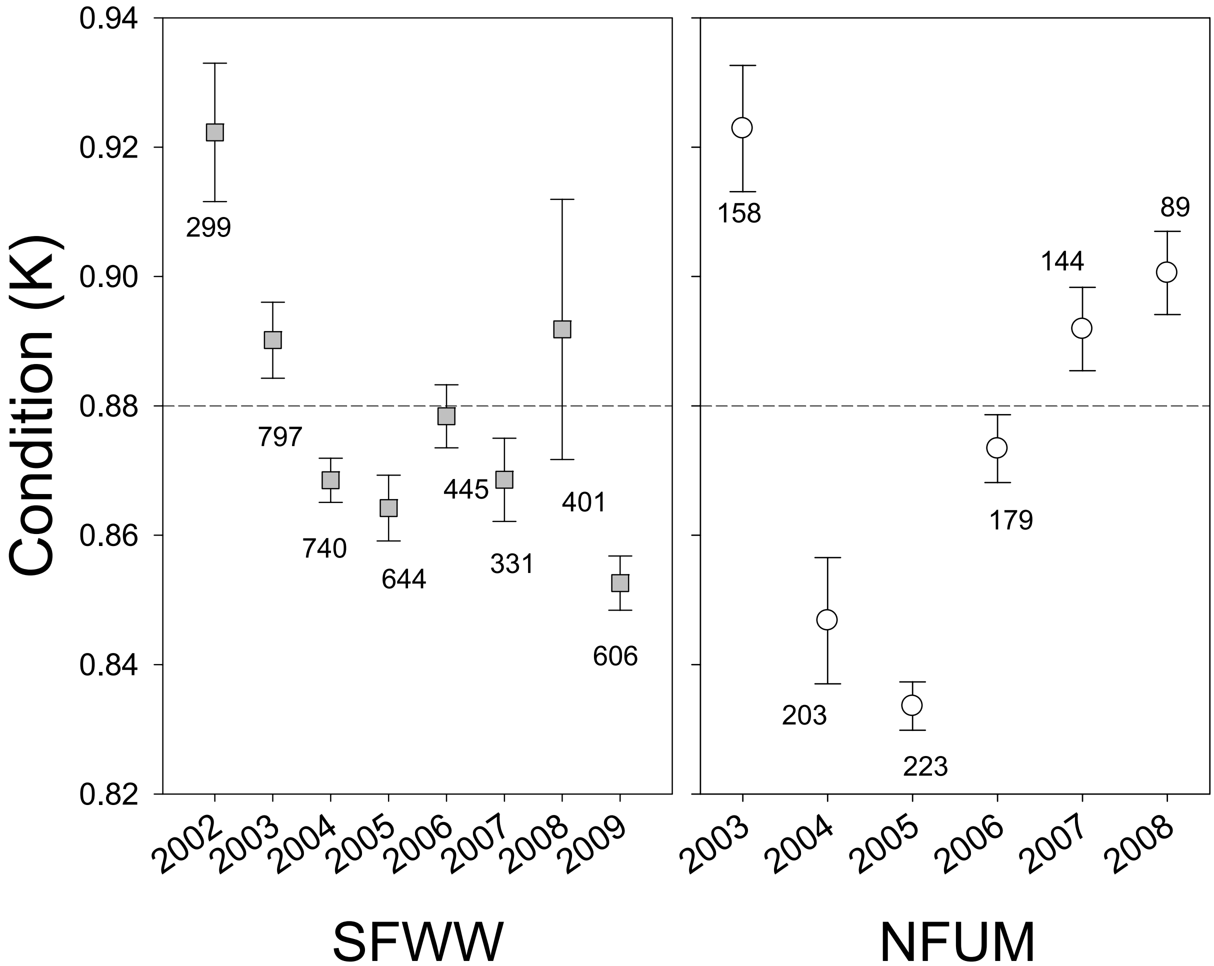

Figure 7. Average annual condition (Fulton's K_{TL} $\pm$ 1 SE) of bull trout (all sizes combined) sampled in the South Fork Walla Walla River, Oregon (2002 – 2009) and North Fork Umatilla River, Oregon (NFUM, 2003 – 2008). Sample size is given near error bars. Dashed line represents across-year average K_{TL}; 0.88 for both rivers.

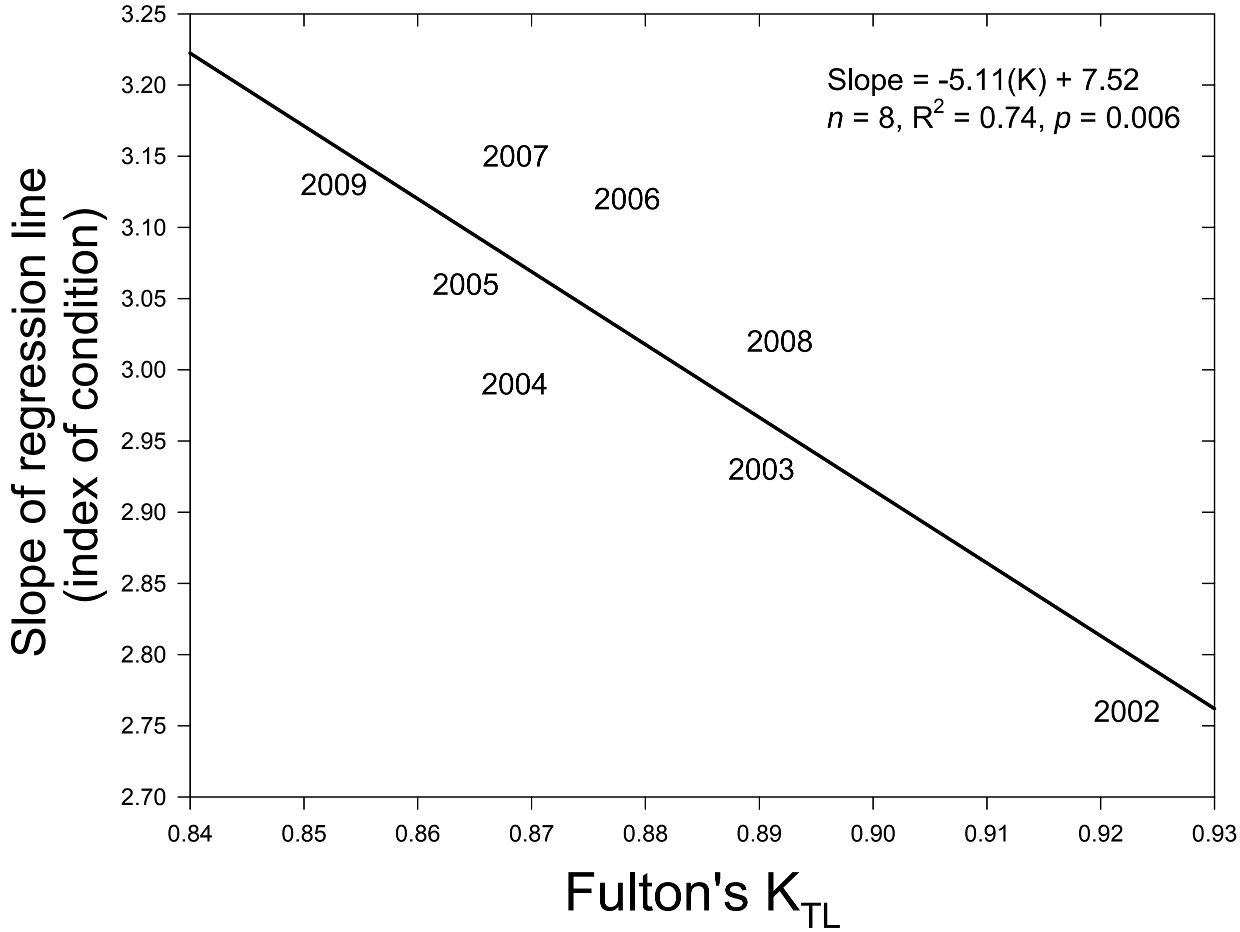

Figure 8. Relationship between two annual measures of condition: Fulton's K_{TL} and slope (of the length-to-weight regression line [*see* Figure 2]; years are symbols) for bull trout captured in the South Fork Walla Walla River, Oregon, 2002 – 2009. Regression equation, sample size (n), and R^2 value are given on panel.

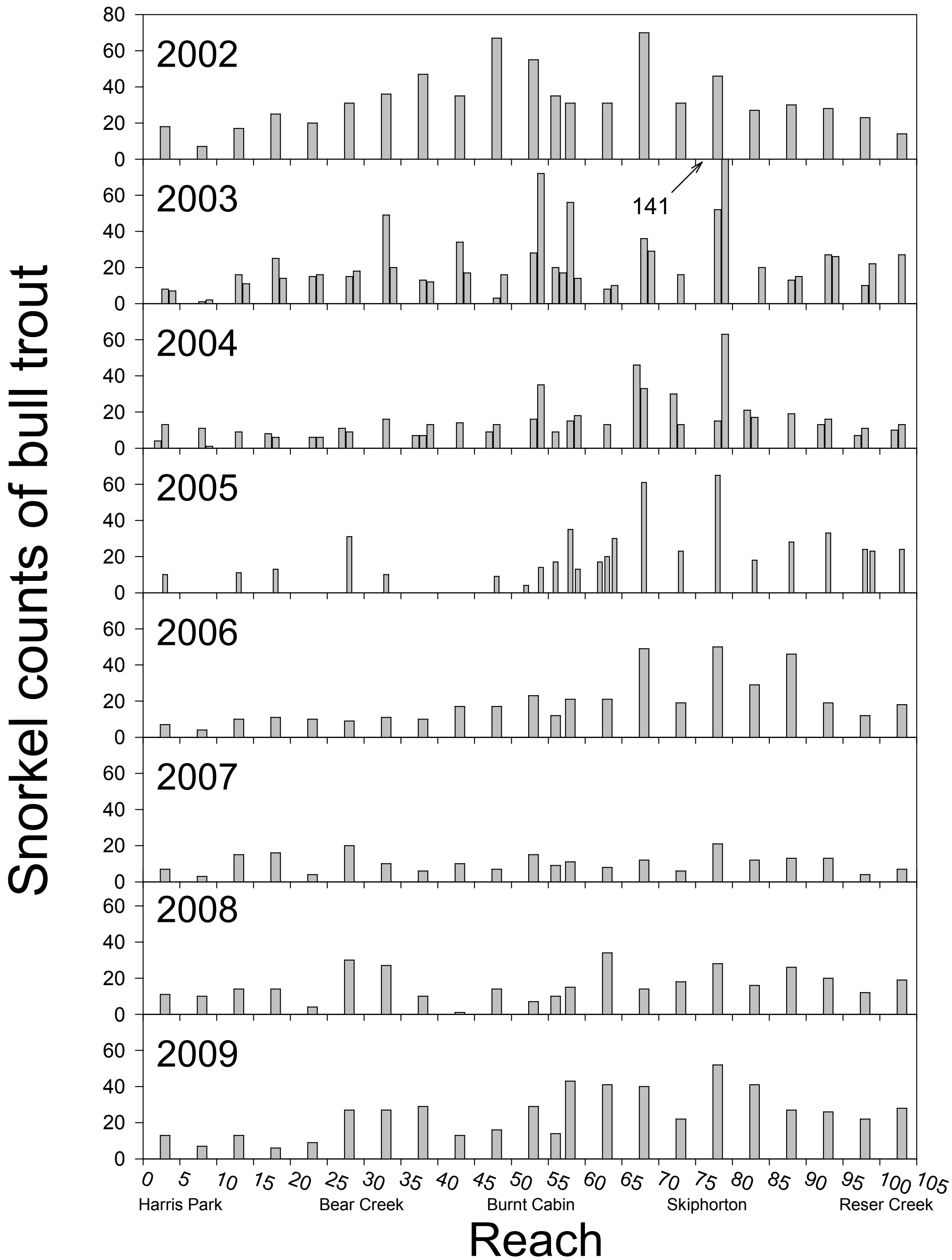

Figure 9. Number of bull trout counted during snorkel surveys in sample reaches of the South Fork Walla Walla River, Oregon, 2002 - 2009. Reaches are numbered from bottom (0 at Harris Park) to top of the study site. No bar implies that no sampling was conducted in a particular reach. Percentage of stream sampled in 2003 and 2004 and 2005 changed to approximately 47%, 47% and 30% of study area, respectively.

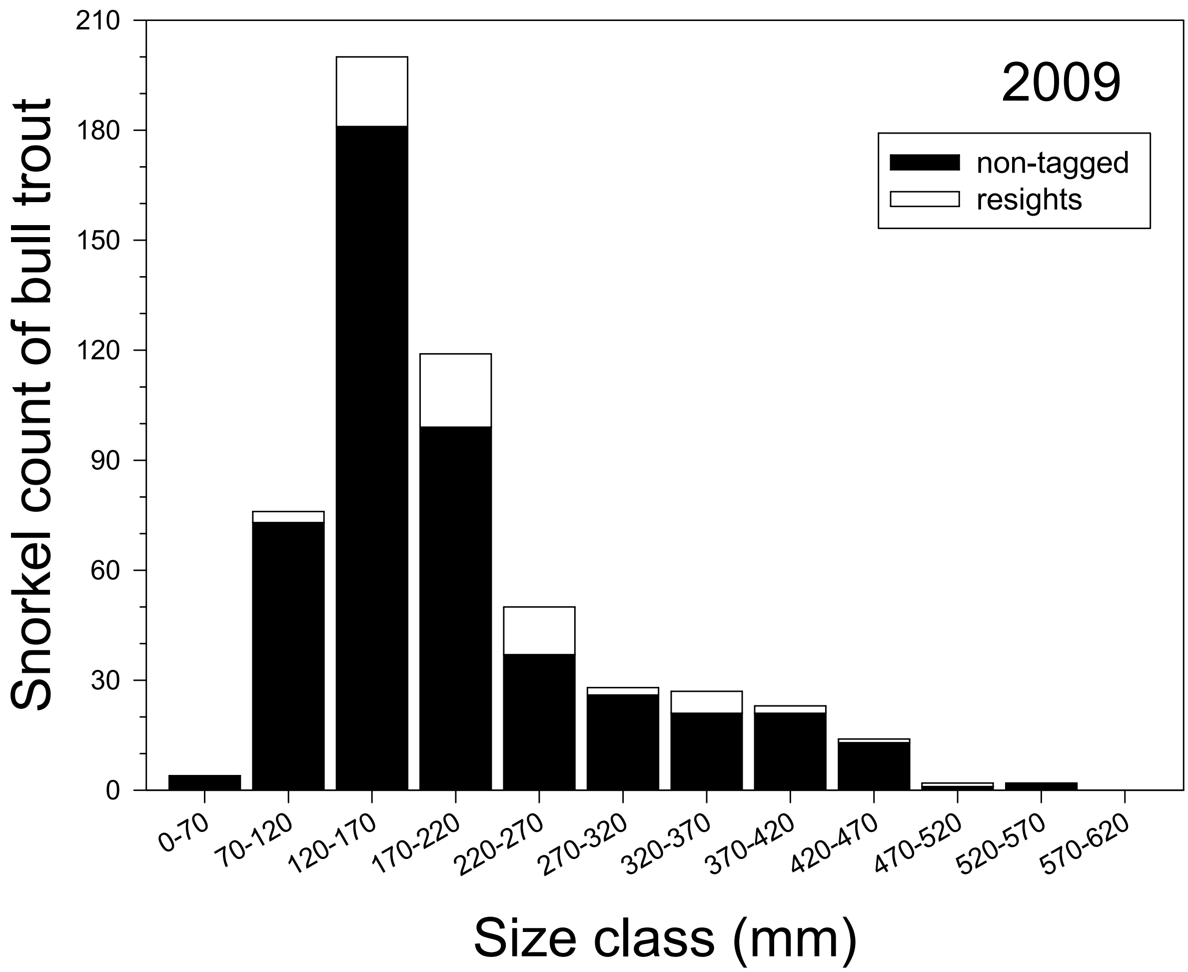

Figure 10. Number of bull trout in 50-mm size bins observed during snorkel-count surveys in the South Fork Walla Walla River, Oregon in 2009: black bars are newly sighted fish and white bars are resighted (previously marked) fish.

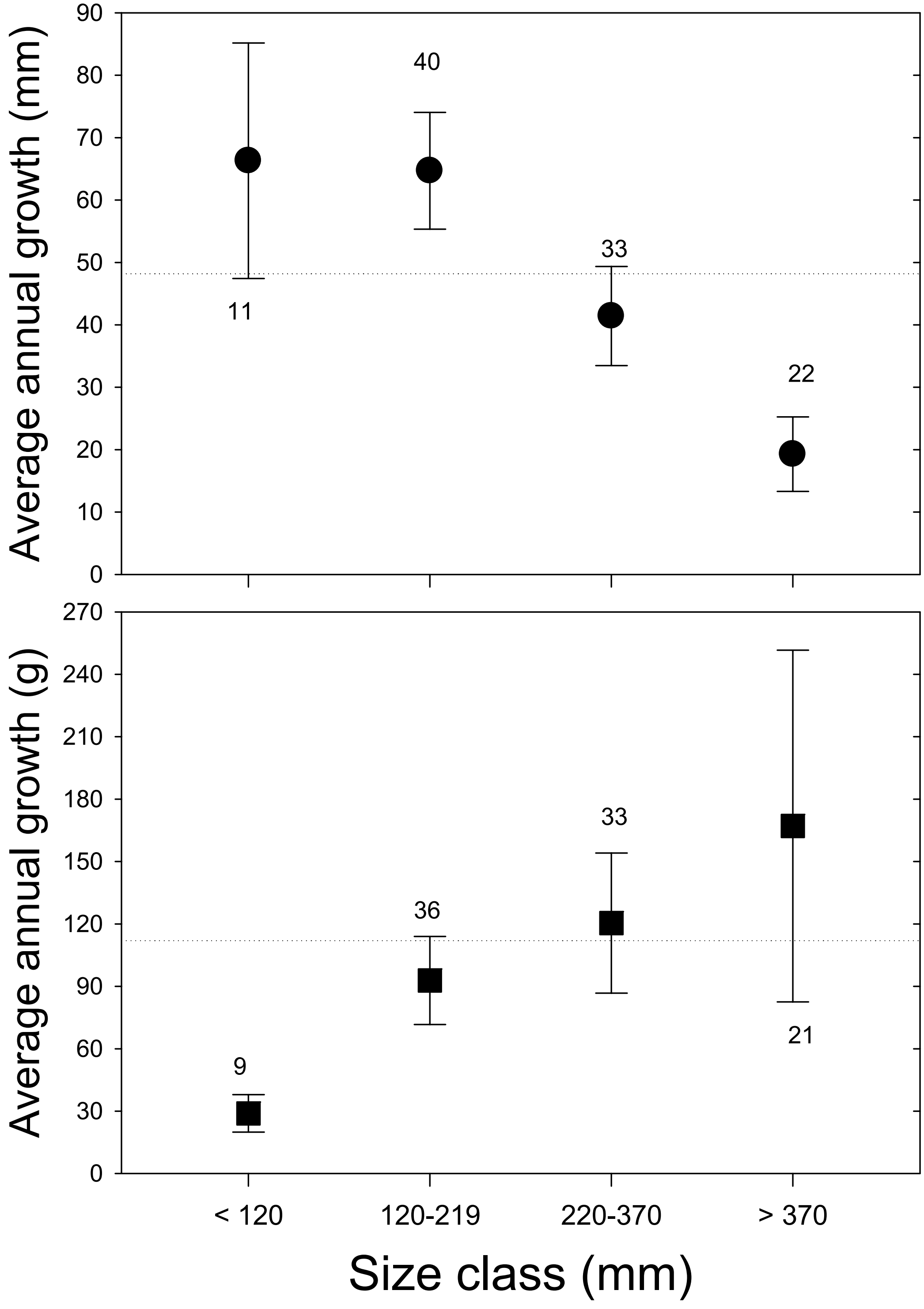

Figure 11. Average annual growth (± 2 SE) in length (mm, top panel) and mass (g, bottom panel) for four size classes of tagged and recaptured bull trout in the South Fork Walla Walla River, Oregon, 2002 – 2009. Sample sizes are given by error bars. Light dashed lines indicate mean across all size classes.

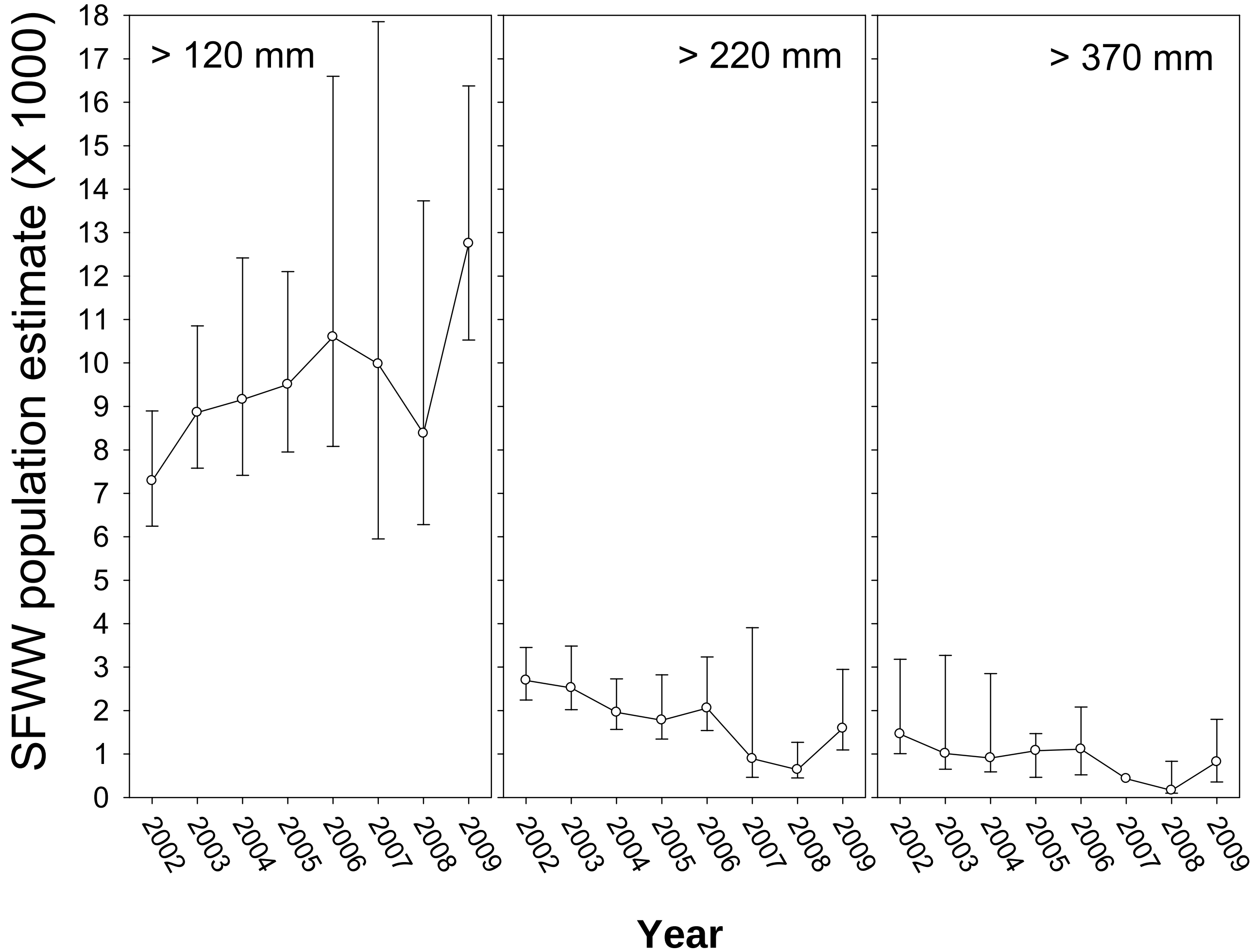

Figure 12. Annual population estimates (± 95% CI) for three size groupings of bull trout in the South Fork Walla Walla River study area, Oregon, 2002 - 2009. Due to low sample size, no confidence intervals were obtainable for the bull trout population component > 370 mm TL in 2007. Study area encompasses the zone from Harris Park bridge upstream to Reser Creek.

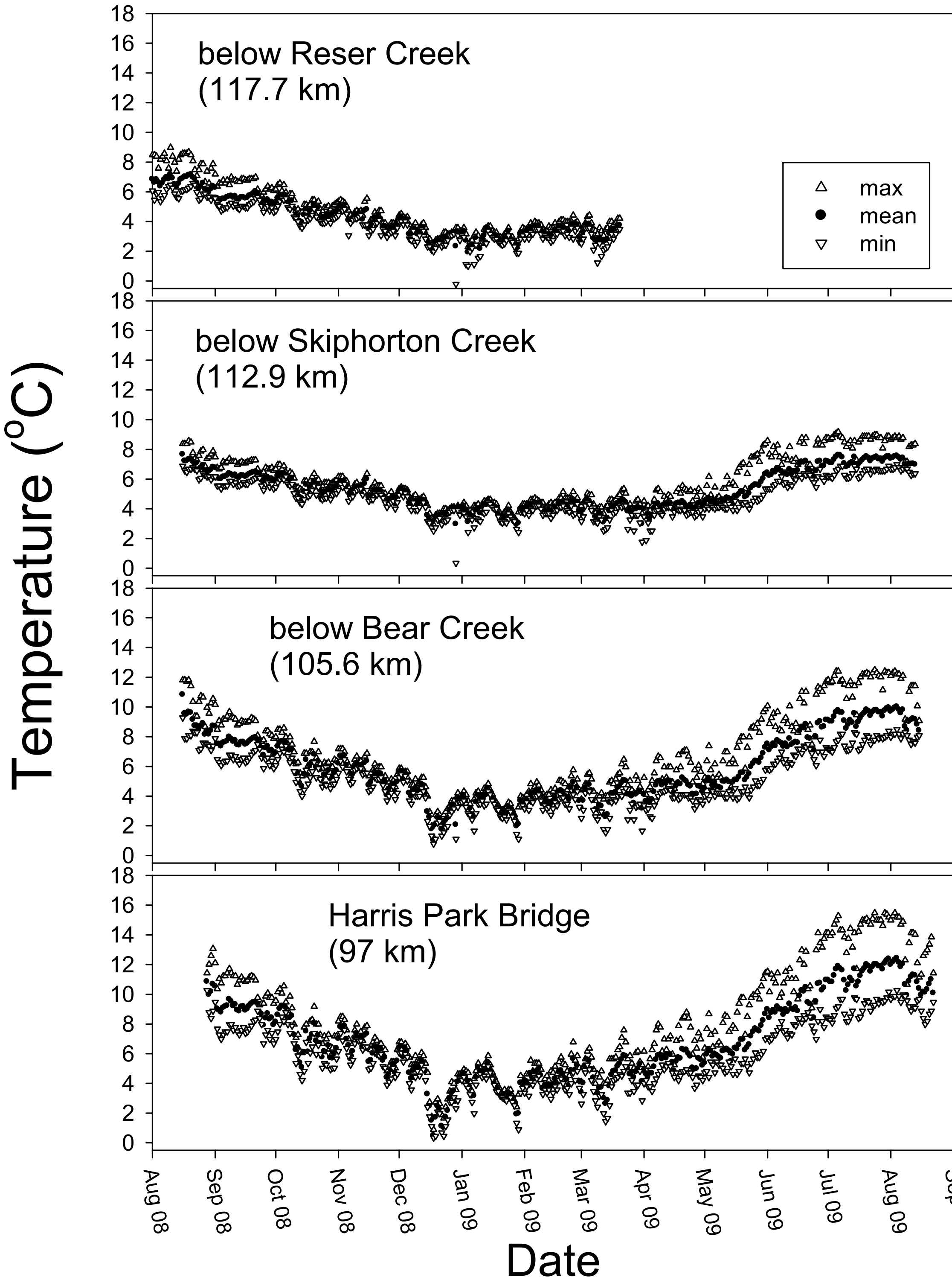

Figure 13. Daily temperatures (maximum, mean, minimum) recorded at four locations in the South Fork Walla Walla River, Oregon, from August 2008 through August 2009. River kilometers describe the distance of the location upstream from the confluence of the Walla Walla and Columbia rivers. Our study area is located between river kilometers 97 and 117.7.

APPENDIX 1

Original objectives and tasks specified to meet the overall 5-year project goals.

Objective 1. Comprehensive bull trout population assessment and monitoring.

Task 1.1 Marking.
Task 1.2 Recapture.
Task 1.3 Snorkel surveys for juvenile densities.
Task 1.4 Adult and egg information, egg-to-parr survival.

Objective 2. Comprehensive stream and riparian habitat assessment and monitoring.

Task 2.1 Habitat assessment.

Objective 3. Innovative pass-through PIT-tag monitoring system.

Task 3.1 Tagging, detection, and fish movement.

Objective 4. Data analysis.

Task 4.1 Analysis of mark-recapture data: population estimates and movement.
Task 4.2 Analysis of snorkel data: parr density and habitat use.
Task 4.3 Analysis of adult and egg data: egg-to-parr survival.
Task 4.4 Analysis of habitat attributes in relation to fish survival and density.

Objective 5. Summarizing available information into a simple population model.

Task 5.1 Assemble and summarize all existing bull trout population and life-history data for the selected tributaries of the Walla Walla Subbasin.
Task 5.2 Building the population life-cycle model.

Objective 6. Describe current habitat conditions and land use patterns as they relate to bull trout survival and growth.

Task 6.1 Summarize and quantify all available habitat data.
Task 6.2 Exploring the relationship between habitat and bull trout population status indicators.
Task 6.3 Model calibration and validation.

APPENDIX 2

Patterns of bull trout movement and life-history expression learned from multiple recaptures of individually marked fish in the Walla Walla River, Oregon

Bull trout (*Salvelinus confluentus*) are a species of inland char, native to the Pacific Northwest, which are known to exhibit diverse movement patterns. Throughout their range, bull trout can co-occur as resident and migratory life-history forms (Rieman and Dunham 2000). Migratory bull trout move downstream into larger river systems or lakes as juveniles, and return to natal streams to spawn as adults; in contrast, fish are considered resident if they complete their entire life cycle in small headwater streams. Coexisting or adaptable life-history forms within a single population can help disperse risks associated with environmental stochasticity, as individuals occupy a variety of habitats within the landscape (Gross 1991). Additionally, long-distance migrations can result in individuals dispersing into new populations or habitats, increasing genetic exchange between populations (Cooper and Mangel 1999).

Bull trout movement patterns vary both spatially and temporally (DuPont et al. 2007; Homel and Budy 2008); bull trout have been known to move between two and 250 km (Fraley and Shepard 1989), and movement patterns often differ between fish of different size classes and between fish exhibiting different life-history strategies (Watry and Scarnecchia 2008; Johnston and Post 2009) . Because movement distances and timing can vary considerably between bull trout within the same river system (Monnot et al. 2008), or even between years for an individual fish, it is important for managers to understand the range of movement patterns that a population can exhibit within a single river system.

We summarized movement patterns of bull trout that were individually marked with PIT-tags in the Walla Walla (WW) River system between 2002 and 2008. Both resident and migratory life-history forms occur within the WW and a genetic assessment of this population demonstrated interbreeding between the two (Homel et al. 2008). The two forms are morphologically indistinguishable, although migratory adults tend to be larger than resident fish. Therefore, we did not differentiate between the two life-history forms in this study, but instead sought to describe the variation in movement exhibited by individuals within the entire WW system. To assess the timing, frequency, and distance of fish movement, we combined information from active recaptures with detections at passive in-stream PIT-detection arrays (PIA; Figure A1). We use the term “recapture” to refer to both active captures and passive detections of previously marked fish.

Here, we report only information from fish that were tagged and subsequently recaptured at least once (1,015 fish out of a total 4,259 tagged in entire WW system) during the seven-year study period. A PIT-tagged fish that was never recaptured may be subject to a number of different fates, including: 1) the tag was shed before the fish was detected, 2) the fish died before it was detected, 3) the tagged fish remained alive but was not physically recaptured in the WW system and never moved past a PIA, or 4) the tagged fish remained alive and migrated past PIA without PIT-tag detection. This last fate was possible because PIAs in the system did not have 100% detection efficiency, and several were broken or failed at numerous occasions throughout the study period. However, the probability of a PIT-tagged fish passing a PIA without being detected was increasingly less likely the farther a fish moved in the system, because larger movements would have increased the likelihood of a fish to pass through more PIAs. There were undoubtedly fish in the WW that were PIT tagged, remained alive, but were never recaptured (fate 3). Because considerably more recaptures occurred at PIA than by active recapture (918 individual fish detected at least once at PIA vs. 218 fish recaptured at least once by physical sampling), the farther an individual fish moved in the system, the more likely it was to be detected. Therefore, by default, our summary includes more observations of migratory fish than those that are less mobile.

The majority of the fish observed in this study were caught and tagged or recaptured in the South Fork Walla Walla (SFWW; Figure A1). A minimum of 20% of this study area was sampled annually by Utah State University using angling and low-voltage electroshocking downstream to a seine (electroseining). This summary also included data from fish caught and tagged or recaptured in the lower South Fork Walla Walla and main stem Walla Walla River by U.S. Fish and Wildlife Service, Confederated Tribes of the Umatilla Indian Reservation, and the U.S. Forest Service using angling and in screw traps (Figure A1). Based on gametes collected from mortalities, we considered fish juveniles if they were < 280 mm total length (TL), and adults if they were ≥ 280 mm TL (Al-Chokhachy and Budy 2008). We recognize that this is an arbitrary criterion, but one that is at least supported by observations, as more than 95% of the fish that demonstrated upstream migratory behavior for the first time (presumably related to spawning) were > 280 mm long.

We summarized detections at five PIAs in the Walla Walla River system located at Oasis Road Bridge (ORB), Burlingame diversion (BGM), Nursery Bridge dam (NBA), Harris Park Bridge (WW1), and at the confluence of Bear Creek with the SFWW (WW2), located at 10.1, 61, 74.3, 97, and 105.6 river kilometers, respectively (Figure A1). The largest number of detections of individual fish occurred at WW2, and the number of detections declined at each downstream PIA (Figure A2). Most fish were recaptured within 15 km of their tagging location, but a small percentage of both adults and juveniles migrated much larger distances, a few as far as 100 km (Figure A3). Combined monthly detections for the seven-year study period show a distinct pattern of upstream movement into the SFWW from June through August, and downstream movement during August through November (Figure A4). In August and September, no individuals were detected moving past Burlingame (BGM) or Nursery Bridge (NBA), both located in the main stem Walla Walla River.

A seasonal migration pattern is apparent from observations of fish passing the PIA at WW1, which is located below the primary spawning habitat in the SFWW. Adults (≥ 280 mm TL) exhibited distinct upstream movement during May through August, and downstream movement in September through November. In contrast, juveniles (< 280 mm TL) moved downstream past WW1 throughout the year, with a peak in August (Figure A5). Very few juvenile fish made movements upstream past WW1.

We characterized discrete movements upstream in the summer and downstream in the fall as spawning migrations, although we could not verify if a fish that exhibited this movement pattern actually spawned. During the study, the majority of PIT-tagged fish we detected made a single spawning migration, although we also observed a number of fish spawning two, three, or four times (Figure A6). All of the bull trout that we detected moving upstream during spawning season more than once did so on consecutive years, except for one fish, which skipped a year between spawning migrations.

PIT-tagged fish in our study exhibited a range of migratory behavior, from individuals which did not appear to leave the upper SFWW system, to individuals that moved from the SFWW downstream past the PIA at Nursery Bridge dam and back upstream again past WW2; a number of fish repeated this pattern multiple times. We classified individuals as *resident*, *migratory*, or *combination* according to observed movement patterns based on recaptures. Individuals were considered *migratory* if they were tagged in the SFWW and later observed moving downstream past Harris Park Bridge (WW1), or were tagged in the main stem WW and observed moving upstream past WW1. Individuals were considered *resident* if they were tagged in the SFWW and never observed at WW1 or further downstream, but were detected at WW2 or recaptured upstream of WW1. Individuals that remained above WW1 for more than one full year, but also migrated past WW1 at some point in their life cycle exhibited what we termed *combination* behavior. More medium-sized fish (280 - 400 mm TL) demonstrated resident behavior, whereas larger fish (> 400 mm) were predominantly migratory, and fish > 500 mm were almost all migratory (Figure A7). A small number of fish in almost every size class exhibited *combination* behavior. Of adults exhibiting *combination* behavior, most stayed in the upper SFWW between 2 - 4 years before migrating to the lower main stem WW; a few *combination* fish first exhibited migratory behavior prior to holding over in the upper SFWW for more than one year.

Finally, we observed that most fish were initially resighted or recaptured within one year after being marked with a PIT tag. However, a small but significant percentage of fish were not observed until two to four years after initial tagging (Figure A8). This suggests that in open systems such as the WW, studies of migratory marked fish based on recapture data are likely to underestimate survival and movement because marked individuals can exist in the system for numerous years without being observed.

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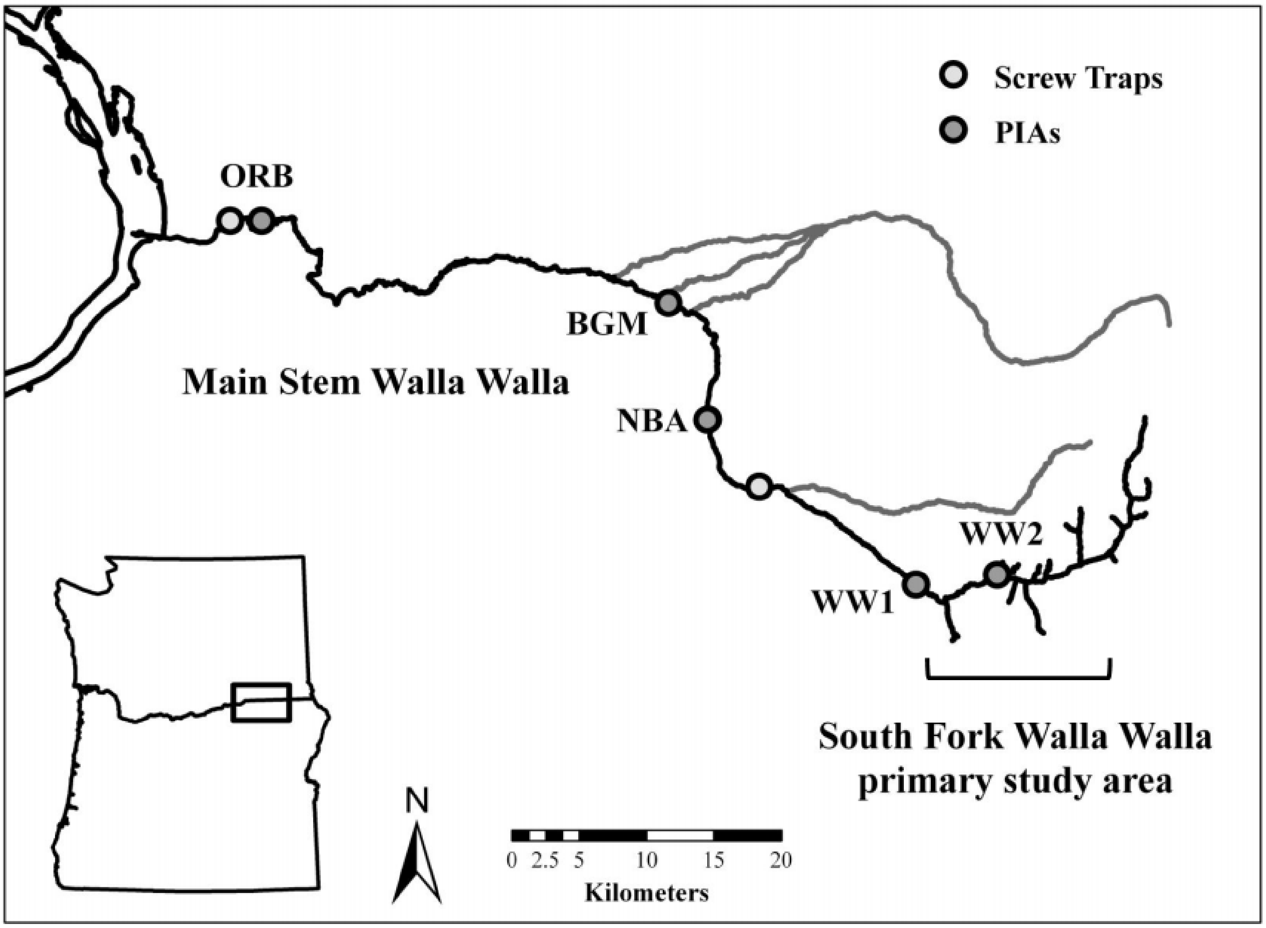

Figure A1. Map of the Walla Walla River, Oregon, showing the primary study area on the South Fork Walla Walla River, as well as the location of five passive in-stream PIT-tag antenna arrays (PIA) and two screw trap locations.

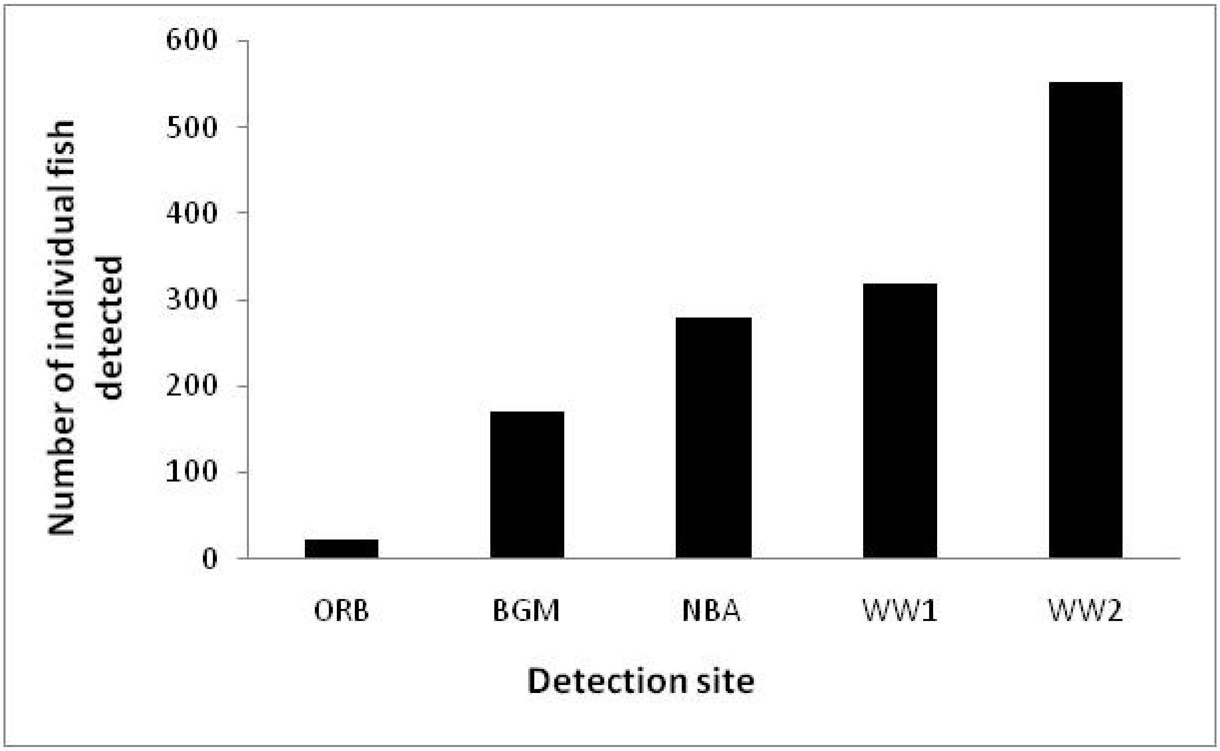

Figure A2. Total number of individual PIT-tagged bull trout detected each passive in-stream antenna (PIA) in the South Fork Walla Walla and main stem Walla Walla rivers, Oregon, between 2002 and 2008. Counts of individual fish were reduced to one observation per PIA per month.

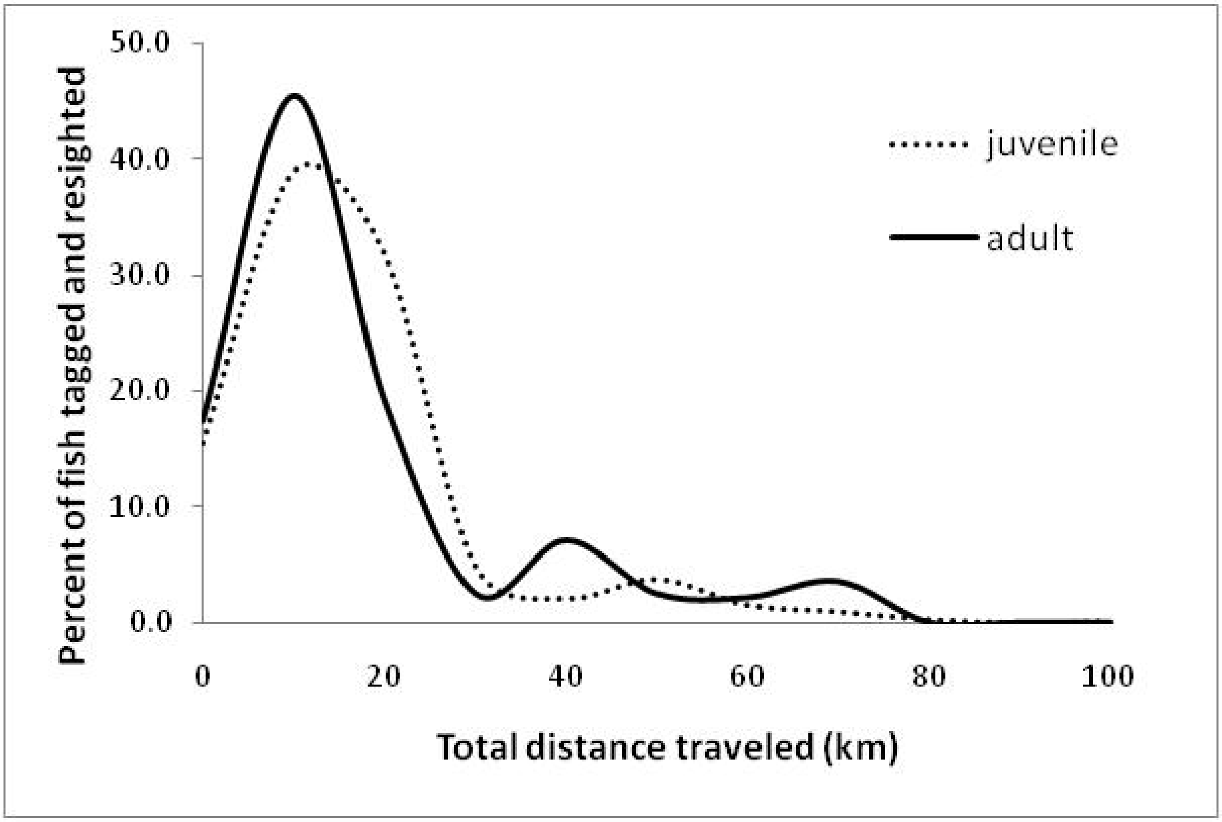

Figure A3. Maximum distance traveled over the course of the study by percentage of juvenile (n = 751) and adult (n = 264) bull trout tagged and later resighted, either by active recapture or detected at passive in-stream antenna (PIA) in the Walla Walla River system, Oregon.

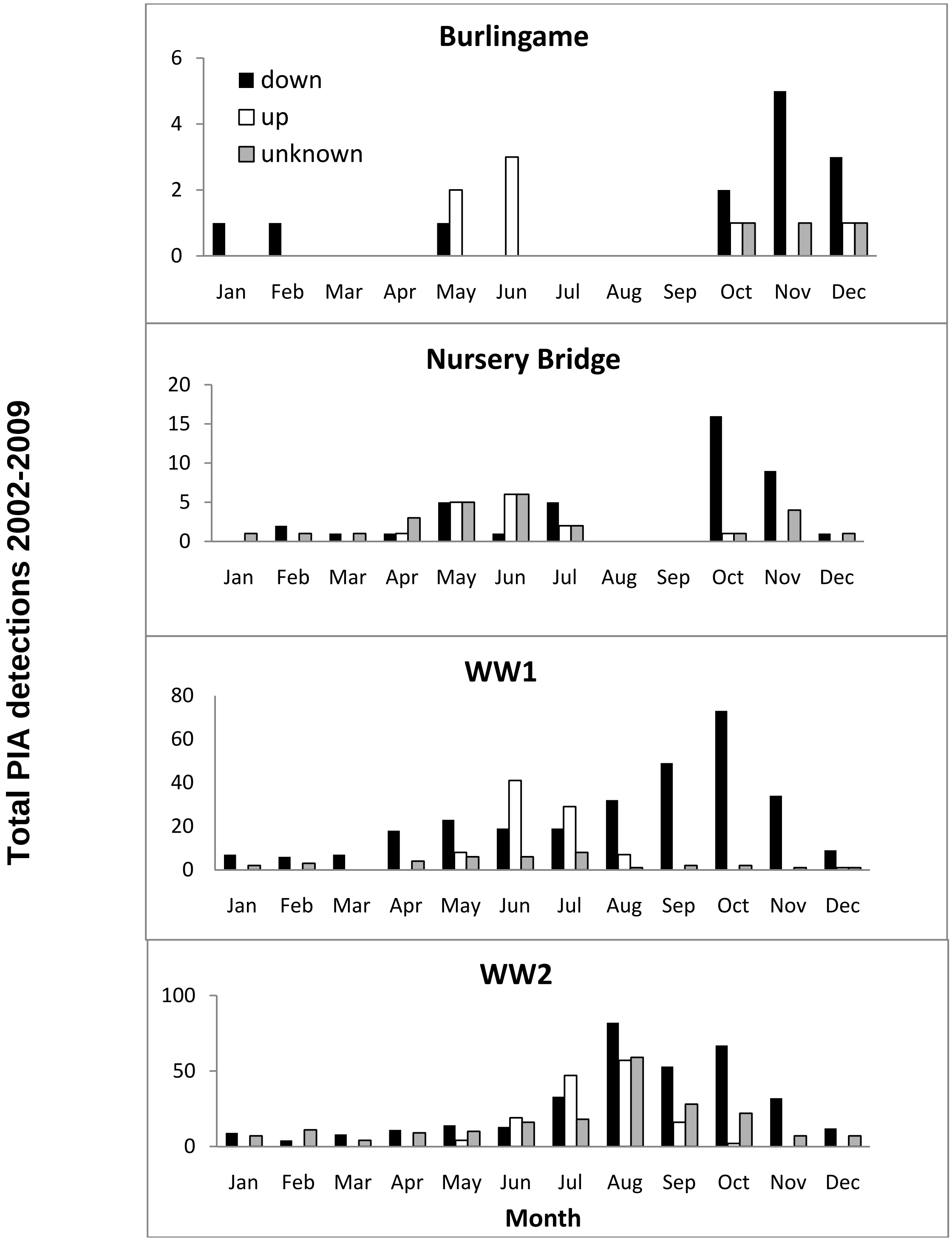

Figure A4. Number of unique PIT-tagged bull trout detected at each passive in-stream antenna (PIA) per month for all years (2002 - 2009) combined. Black bars show downstream movement, white bars depict upstream movement, and grey bars were used when movement direction could not be determined.

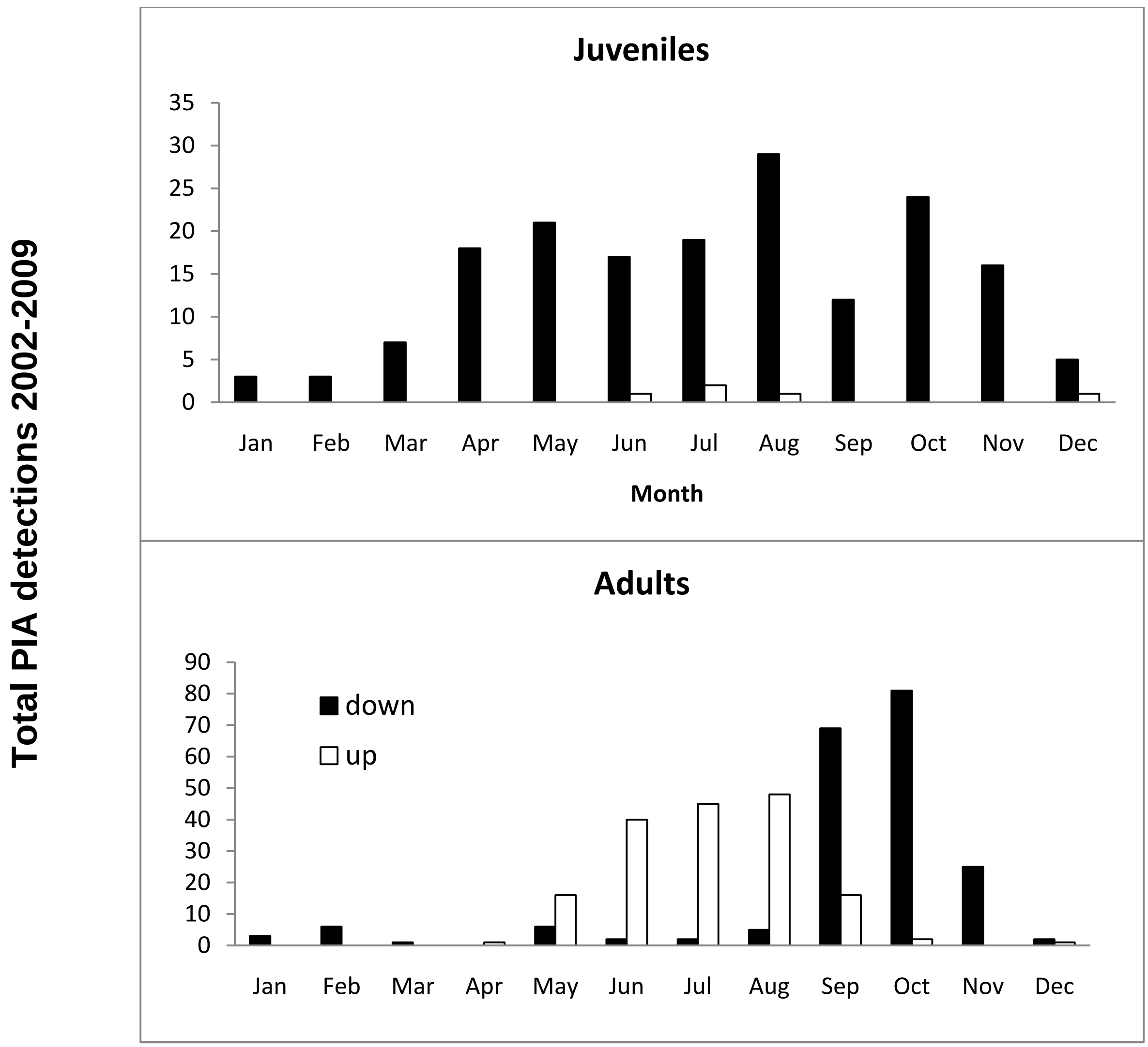

Figure A5. Total number of individual PIT-tagged bull trout detected moving past WW1 during all years of the study combined (2002 - 2009). We used an age-to-length relationship to estimate fish age at tagging. During subsequent observations of PIT-tagged fish, we added the number of years elapsed since tagging to their initial age estimate in order to keep track of individual cohorts and monitor juvenile vs. adult behavior as fish aged over the course of the study (i.e., age at recapture = age at tagging + years since tagging). Fish recaptured at age-5 and greater were considered adults (lower panel) and age-1 to age-4 fish were considered juveniles (top panel). Black bars represent downstream movement and white bars, upstream.

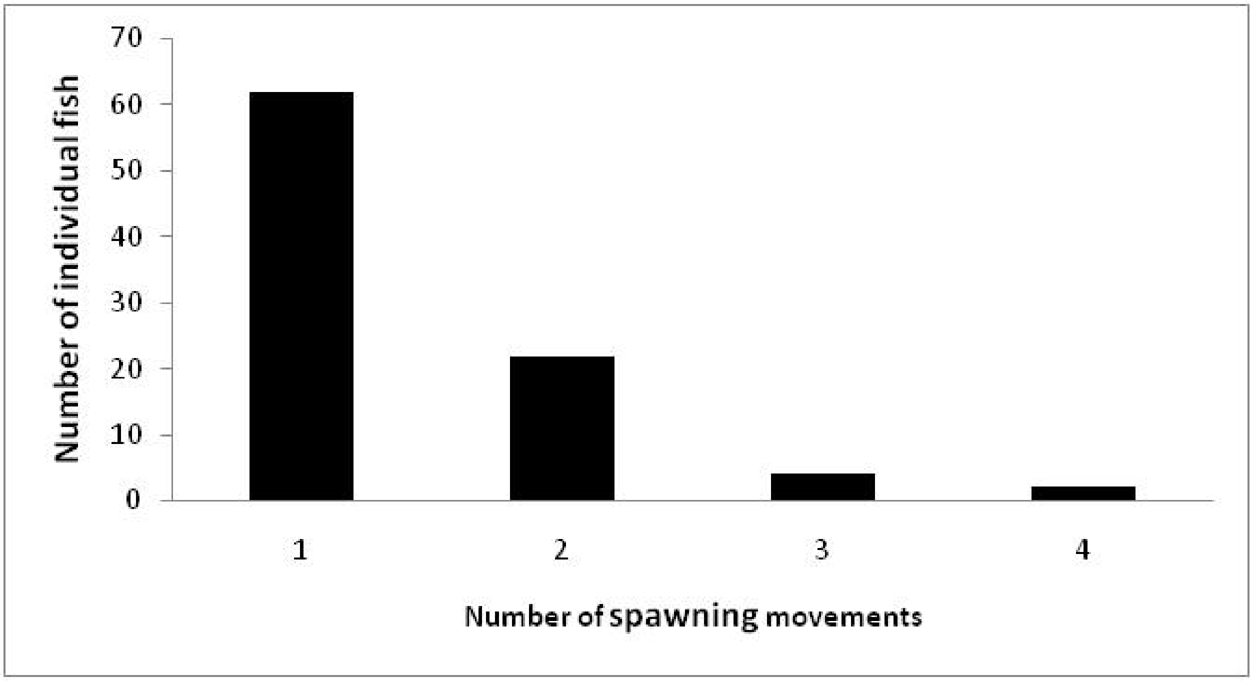

Figure A6. Number of seasonal spawning movements (characterized by upstream movement in summer/early autumn and downstream movement in the late autumn) made by individual PIT-tagged bull trout past the WW1 PIA over the course of the study (2002 - 2009). All repeated spawning movements were on consecutive years except one.

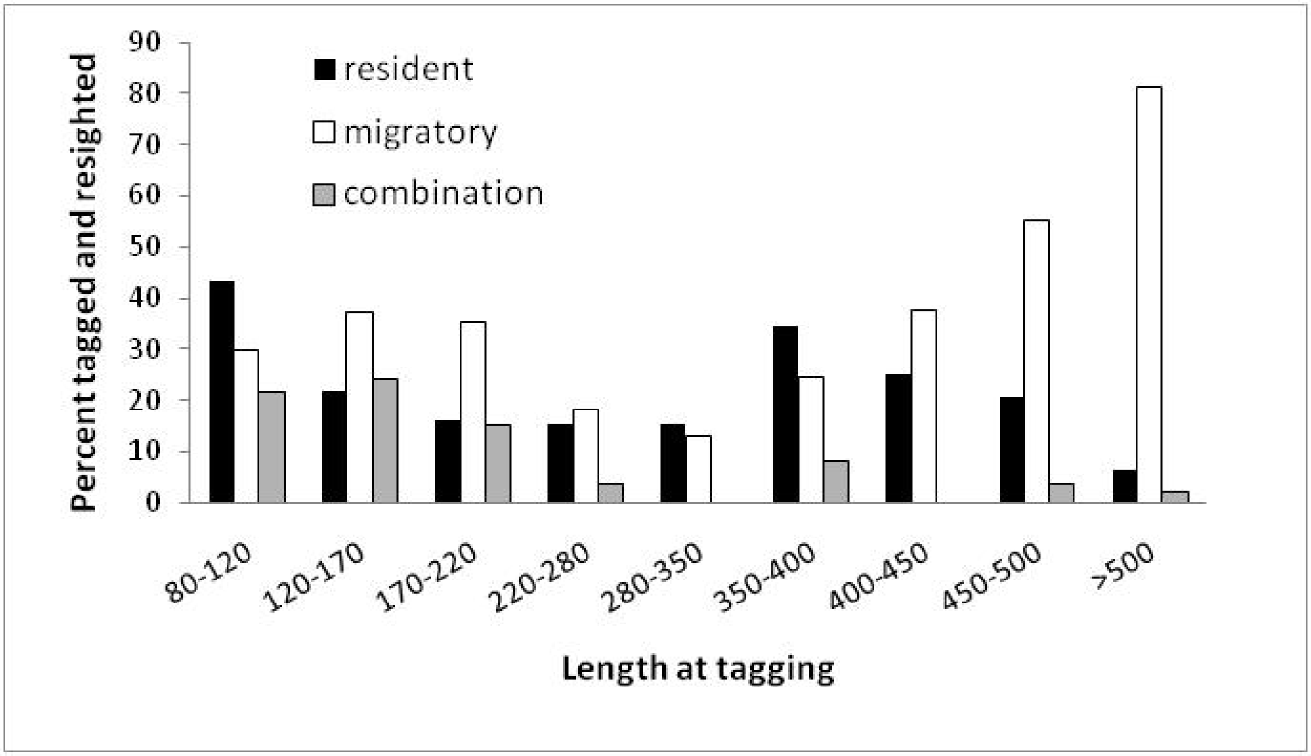

Figure A7. Movement behavior exhibited by various size classes of bull trout based on combined data from active recaptures and detections at PIA. Fish that moved past WW1 were considered *migratory* (n = 322), fish that were recaptured at least once after tagging but never detected outside of the SFWW study area (below WW1) were considered *resident* (n = 208), and fish that remained in the SFWW system for more than one year, but at some point migrated past WW1 exhibited "*combination*" behavior (n = 124).

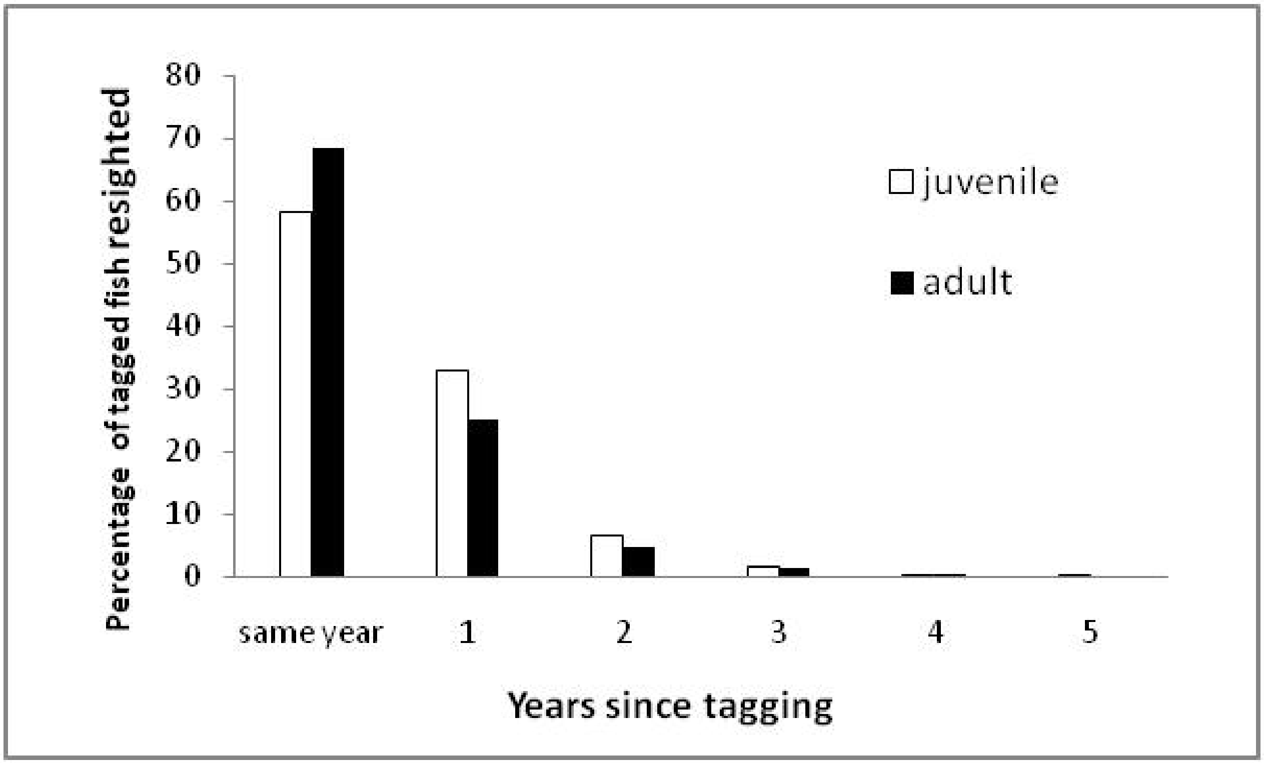

Figure A8. Number of years that elapsed between initial tagging and the first time an individual bull trout, tagged as a juvenile (< 280 mm; n = 720) or an adult (≥ 280 mm; n = 295), was detected at a PIA in the Walla Walla River system, Oregon.

APPENDIX 3

Juvenile bull trout mark and recapture in Skiphorton Creek

In 2009, we marked and recaptured juvenile bull trout (*Salvelinus confluentus*) in Skiphorton Creek as part of a three year (2007 - 2009) study on juvenile survival. The overall goal of this research is to develop empirical estimates of survival for age-1 and age-2 bull trout. Skiphorton Creek originates in the foothills of the Blue Mountains of northeastern Oregon and enters the South Fork Walla Walla River (SFWW) approximately 30 km upstream from the confluence of the SFWW and mainstem Walla Walla rivers. We captured juvenile bull throughout approximately 600 m of Skiphorton Creek directly upstream of the confluence with the SFWW; this section was divided into 10 contiguous reaches of approximately 50 m in length, and we censused the entire area during each sampling event. In 2009, we caught juvenile bull trout on two discrete occasions using electroseining (i.e., using low-voltage electroshocking down to a seine); we anaesthetized and PIT-tagged fish in the same manner described above (*see* Chapter 1). We also recaptured marked individuals using a portable PIT-tag detector on five discrete occasions, one which was conducted during the day, and four which were conducted at night, so that the observer moved through the stream in the dark. We also recaptured fish on a continual basis between June and October using a temporary passive in-stream PIT-tag antenna (PIA), located at the lowest end of the study area, just upstream of the SFWW confluence. This combination of data will enable us to estimate juvenile survival using a Barker model, which utilizes both discrete and ongoing capture events and can lead to substantial gains in precision on survival probability estimates compared to other estimation methods.

During the two electroseining sampling periods, we captured and marked 253 individual fish ranging from 72 to 229 mm TL. We recaptured 20 fish that had been marked in 2008, and 25 fish in the second marking occasion that had been marked in the first capture occasion in 2009 (Figure A9). We did not physically recapture any individuals that had been PIT tagged in 2007. Using the portable PIT-tag detector, we were able to detect 166 individuals that were alive and had been previously tagged in 2009. We also detected 50 individuals that had been previously tagged in 2007 and 2008 that were still alive and in the study area. Two of the fish tagged in 2009 were determined to be dead because tags were repeatedly detected in the same location using the portable detector, and did not move when the substrate near them was disturbed. The single recapture period conducted during daylight hours resulted in significantly fewer recapture observations of marked fish than did any of the four recapture sampling events that were conducted at night (Figure A9). During the time the PIA was installed in Skiphorton Creek, we detected 57 individuals; 6 of these had been tagged in 2008 and 51 were tagged in 2009.

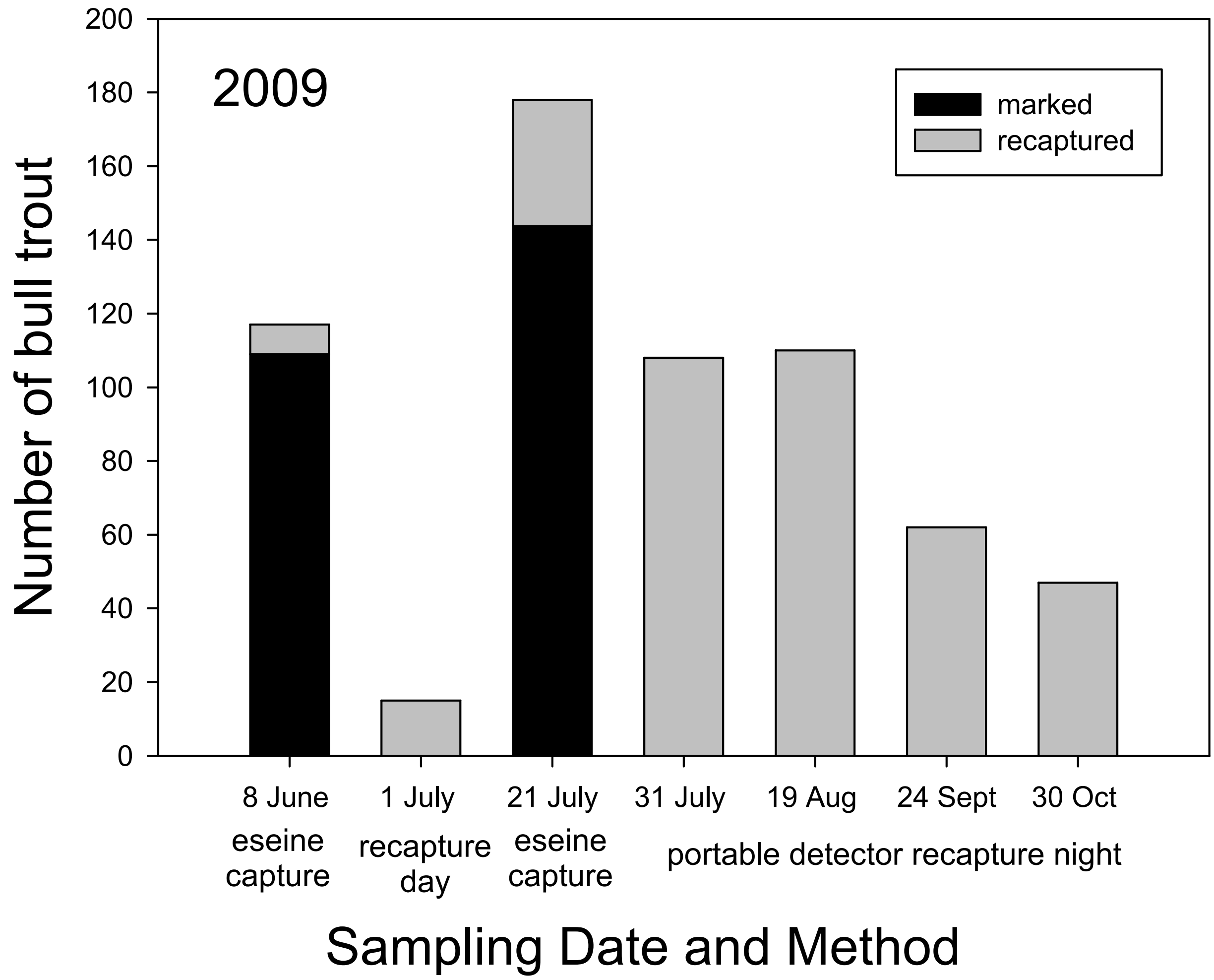

Figure A9. The number of bull trout captured during active mark-recapture sampling (8 June and 21 July), and during recapture sampling, using a portable PIT-tag detector in 2009. Black bars depict the number of fish marked and grey bars show the number of fish recaptured during each of the sampling periods.