

Bull Trout Distribution, Movements and Habitat Use in the Walla Walla River Basin

2002-2003 Annual Progress Report

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Table of Contents

Table of Contents	2
List of Figures	3
List of Tables	5
Acknowledgements.....	6
Abstract	7
Introduction.....	8
Background.....	9
Study Area	11
Study Objectives	12
Methods.....	13
<i>Distribution</i>	13
<i>Movements</i>	14
<i>Habitat Suitability</i>	15
<i>Water Temperature</i>	18
Results and Discussion	20
<i>Distribution</i>	20
<i>Movements</i>	22
<i>Habitat Suitability</i>	25
<i>Water Temperature</i>	29
Plans for 2004	35
References.....	37

List of Figures

Figure 1.	Map of the Walla Walla Basin showing the Touchet River, Mill Creek, and Walla Walla River subbasins, and the Umatilla National Forest.	10
Figure 2.	Map of the 2002-2003 study area depicting 30 kilometers of the SFWWR and mainstem WWR. Stream segments that were sampled to determine bull trout distribution during 2003 are identified.	12
Figure 3.	Map of the South Fork Walla Walla River redd survey area showing reaches 1 through 7, Reser Creek, and Skiphorton Creek where surveys were conducted during 2002-2003.	15
Figure 4.	Geodimeter model 600 used to collect bathymetric data in a 200 meter stream segment of the South Fork Walla Walla River.	18
Figure 5.	Map showing the two river reaches surveyed during the TIR flight on 13 August 2003. The locations of instream sensors used to ground truth radiant temperatures derived from TIR images are also shown. The sensor locations are labeled by river mile (rm).	19
Figure 6.	Stream Segments in the SFWWR and mainstem WWR snorkeled during 2003 and locations of bull trout observed.....	21
Figure 7.	Relative frequency of habitat unit use by bull trout, and habitat unit availability in the South Fork Walla Walla River.....	22
Figure 8.	Number of bull trout captured and the corresponding number of days fished per month at the Day Road trap site from 13 August through 23 December 2003.	23
Figure 9.	Fork lengths and average number of Chinook salmon captured per day at the Day Road trap site by month from August through December 2003.	23
Figure 10.	Fork lengths and average number of O.mykiss captured per day at the Day Road trap site separated by month from August through December, 2003.	24
Figure 11.	Relative frequency of depths at bull trout redd locations and frequency of available depths in the SFWWR spawning area.	26
Figure 12.	Relative frequency of mean column velocities at bull trout redd locations and frequency of available mean column velocities in the SFWWR spawning area.	26
Figure 13.	Relative frequency of dominant substrate size classes at bull trout redd locations and frequency of available dominant substrate size classes in the SFWWR spawning area.	27

Figure 14. Relative frequency of percent fines at bull trout redd locations in the SFWWR spawning area.....	28
Figure 15. Distribution of dominant substrate size classes for a 200 m stream segment of the SFWWR.....	28
Figure 16. Median channel water temperatures versus river mile for the SFWWR. Surface water inflow sampled during the survey is labeled at rm 5.1.	30
Figure 17. TIR/color video image showing the SFWWR (13.0°C) at rm 5.1. An apparent inflow (12.0°C) was detected along the right bank (looking downstream).....	30
Figure 18. TIR/Color video image mosaic showing the confluence of the South Fork (15.0°C) and North Fork (20.0°C) Walla Walla rivers on 13 August 2003.	31
Figure 19. Median channel water temperatures versus river mile for the WWR, WA/OR along with the location of surface water inflows.....	32
Figure 20. TIR/color video image showing a relatively abrupt transition in radiant temperatures from $\approx 17.8^{\circ}\text{C}$ at location “A” to $\approx 16.6^{\circ}\text{C}$ at location “B”.....	33
Figure 21. TIR/color video image pair showing a cool water seep detected at rm 42.9. Seeps of this nature indicate the occurrence of shallow, sub-surface flow through the channel.	34
Figure 22. TIR/color video image pair showing an example of cool water (24.3°C) emerging from within the floodplain at river mile 28.0. The location of the cooler water at the downstream end of the gravel bar suggests shallow, sub-surface flow as its source..	35

List of Tables

Table 1.	Substrate types and particle sizes used to classify dominant and subdominant substrates at bull trout redd locations and adjacent non-use locations.	16
Table 2.	Percent fines codes and classification descriptions for conditions at bull trout redd locations and adjacent non-use locations.	16
Table 3.	Summary of the river reaches surveyed with TIR and color video on 13 August 2003.	20
Table 4.	Length and weight data collected from bull trout, Chinook salmon, and <i>O. mykiss</i> captured at the Day Road screw trap site on the Walla Walla River from 13 August through 23 December 2003. Length and weight ranges are in parentheses.	22
Table 5.	Tributary temperatures for the Walla Walla River, WA/OR.	33

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Abstract

A better understanding of bull trout *Salvelinus confluentus* life history strategies is necessary to identify corrective actions that will make progress toward recovery in the Walla Walla Basin. This report describes studies conducted by the U.S. Fish and Wildlife Service (FWS) from 2002 through 2003 on the lower South Fork Walla Walla River (SFWWR), and mainstem Walla Walla River (WWR) with the goal of obtaining detailed information on bull trout life history to assist with development and evaluation of recovery actions. These studies were designed to describe seasonal distribution and movements, and to determine the physical conditions that comprise suitable habitat for bull trout.

We conducted snorkel surveys in segments of the SFWWR and WWR during July to describe the summer distribution of bull trout. Bull trout were observed as far downstream as Nursery Bridge Dam. Stream habitat between Harris County Park (SFWWR) and the Oregon/Washington state line (WWR) was visually delineated into riffle, race, and pool habitat types. Bull trout distribution among the three habitat types were compared with habitat availability to determine if bull trout preferred a particular type of habitat so that future sampling could be stratified. Our observations suggested bull trout prefer pool habitat.

To better understand seasonal movements of bull trout, we operated a rotary screw trap to monitor dispersal into downstream areas. Results indicated that downstream movement occurred from October through December. A passive integrated transponder detection array was installed at the East Bank Nursery Bridge fish ladder to describe bull trout movement patterns into the impacted river segment downstream from the Little Walla Walla Irrigation Diversion. No bull trout were detected at the array.

Bull trout redd surveys were conducted in the SFWWR by the Oregon Department of Fish and Wildlife and the FWS to obtain an annual index of abundance, and to identify redd sites for development of a spawning habitat suitability model. The cumulative number of bull trout redds enumerated over six surveys during 2002 was 330. The cumulative number of bull trout redds enumerated over five surveys during 2003 was 362. We measured depth at 316 redd locations and mean column velocity, substrate composition, and percent fines at 319 redd locations to assess suitable bull trout spawning habitat. Bull trout selected slightly shallower depths, and slower velocities for redd sites relative to what was generally available. The greatest contrast between microhabitat use and availability was bull trout selection of smaller substrate sizes than were generally available. Bathymetric surveys were conducted on a 200 m reach of the SFWWR to create a two-dimensional flow model that could be used in the development of a spawning habitat suitability model. Elevation and substrate data were collected at 1,564 points for the model.

We contracted an airborne thermal infrared (TIR) remote sensing survey on the SFWWR and WWR to determine the presence and distribution of cold water refugia. TIR survey data were successfully collected along the entire length of the WWR, and on the lower 10 miles of the SFWWR. Cool water inflow from springs, seeps and tributaries was detected at several locations.

Introduction

Bull trout *Salvelinus confluentus* were officially listed as a Threatened Species under the Endangered Species Act (ESA) in 1998. The U.S. Fish and Wildlife Service (FWS) subsequently issued a Draft Recovery Plan for the Umatilla-Walla Walla Recovery Unit (U.S. Fish and Wildlife Service 2002, Chapter 10). The goal of bull trout recovery planning in the Umatilla-Walla Walla Recovery Unit is to describe courses of action necessary for the ultimate delisting of this species, and to ensure the long-term persistence of self-sustaining, complex interacting groups of bull trout distributed across the species' native range (U.S. Fish and Wildlife Service 2004, Chapter 10-revised). To meet this overall goal, the FWS has identified four recovery objectives which establish the basis for work conducted by the Columbia River Fisheries Program Office (CRFPO) in the Walla Walla Basin:

- Maintain current distribution of bull trout within the Core Areas and re-establish bull trout in previously occupied habitats,
- Maintain stable or increasing trends in abundance of bull trout,
- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and
- Conserve genetic diversity and provide the opportunity for genetic exchange.

Bull trout, which are native to the Walla Walla Basin, exhibit two different life history strategies. Fluvial (migratory) bull trout spawn in headwater streams and juveniles rear in these streams for one to four years before migrating downstream as subadults to larger mainstem areas, and possibly to the Columbia River where they grow and mature, returning to the tributary stream to spawn (Fraley and Shepard 1989). This pattern can also be observed in the adfluvial life history strategy with the primary difference being subadult migration to a lake rather than larger mainstem river areas. Downstream migration of subadults generally occurs during the spring, although it can occur throughout the year (Hemmingsen et al. 2002). These migratory forms occur in areas where conditions allow for movement from upper watershed spawning streams to larger downstream waters that contain greater foraging opportunities (Dunham and Rieman 1999). Stream-resident bull trout also occur in the Walla Walla Basin, and they complete their entire life cycle in the tributary streams where they spawn and rear. Resident and migratory forms of bull trout may be found living together for portions of their life cycle, however it is unknown if they can give rise to one another (Rieman and McIntyre 1993). Bull trout size is variable depending on life history strategy. Resident adult bull trout tend to be smaller than fluvial adult bull trout (Goetz 1989). Under appropriate conditions, bull trout regularly live to 10 years, and under exceptional circumstances, reach ages in excess of 20 years. They normally reach sexual maturity in four to seven years (Fraley and Shepard 1989; McPhail and Baxter 1996).

When compared to other North American salmonids, bull trout have more specific habitat requirements. The habitat components that shape bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing

substrates, and migratory corridors (U.S. Fish and Wildlife Service 1998). Throughout their lives, bull trout require complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989; Watson and Hillman 1997). Juveniles and adults frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). McPhail and Baxter (1996) reported that newly emerged fry are secretive and hide in gravel along stream edges and in side channels. They also reported that juveniles are found in pools, riffles, and runs where they maintain focal sites near the bottom, and that they are strongly associated with instream cover, particularly overhead cover. Bull trout have been observed overwintering in deep beaver ponds or pools containing large woody debris (Jakober 1995). Habitat degradation and fragmentation (Fraley and Shepard 1989), barriers to migration (Rieman and McIntyre 1995), and reduced instream flows have all contributed to the decline in bull trout populations in the Columbia Basin.

In summary, bull trout need adequate streamflows and the corresponding habitat for each of the different life history functions at specific times of the year in order to persist in the Walla Walla Basin. Instream flows and the associated habitat must be adequate to provide spawning opportunities, rearing opportunities, cover, forage, seasonal movement, migration opportunities, and overwintering refugia.

Background

The Walla Walla Basin in northeastern Oregon (OR) and southeastern Washington (WA) is a tributary of the Columbia River that drains an area of 4,553 km². 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, upper Mill Creek, and the North Fork, South Fork, and Wolf Fork of the Touchet River (Figure 1). The Walla Walla Basin historically supported a number of anadromous and resident native salmonid populations including spring and fall Chinook salmon (*Oncorhynchus tshawytscha*), chum salmon (*O. keta*), coho salmon (*O. kisutch*), redband trout (*O. mykiss* subpopulation), bull trout (*S. confluentus*), mountain whitefish (*Prosopium williamsoni*), and summer steelhead (*O. mykiss*) (Northwest Power and Conservation Council 2004). Currently, steelhead are the only remaining native anadromous salmonid population in the Walla Walla Basin. A supplementation program for spring Chinook salmon was initiated by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) in 2000 in the South Fork Walla Walla River (SFWWR) using outplanted adults to initiate spawning. The current plan is to continue supplementation using spring releases of spring Chinook hatchery smolts. Populations of native redband trout, bull trout, and mountain whitefish still persist in the Walla Walla Basin.

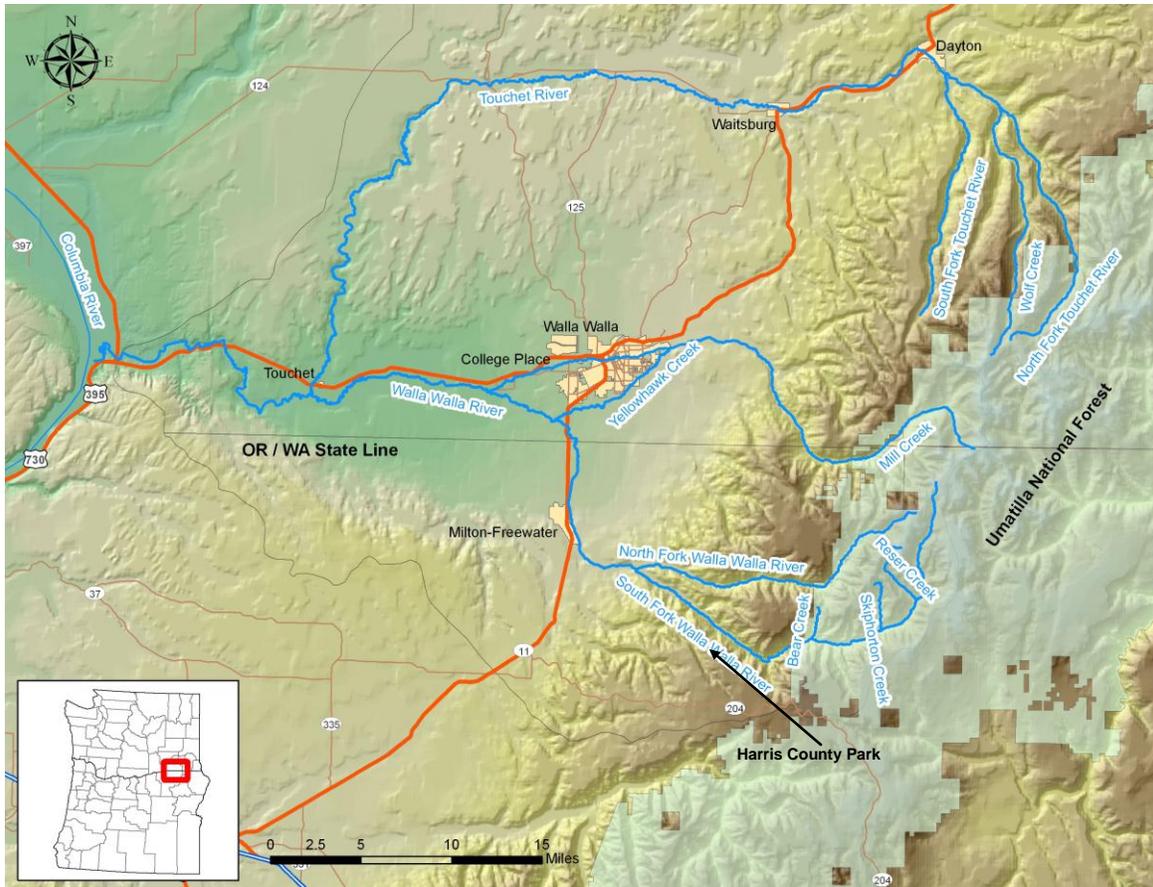


Figure 1. Map of the Walla Walla Basin showing the Touchet River, Mill Creek, and Walla Walla River subbasins, and the Umatilla National Forest.

CRFPO bull trout studies were focused on the Walla Walla River Subbasin in 2002-2003 with the goal of collecting and analyzing life history data to assist in assessing the relative merit of potential action strategies in making progress towards meeting the recovery goal outlined in the Draft Recovery Plan (U.S. Fish and Wildlife Service 2004) for the recovery and delisting of bull trout. Specifically CRFPO studies were designed to address the following Recovery Plan objectives:

- Restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and
- Conserve genetic diversity and provide opportunity for genetic exchange.

To make progress on the habitat objective, a number of steps may be required. A fundamental step should be to determine the physical conditions that comprise suitable bull trout habitat. A subsequent step should be application of these habitat “criteria” to current conditions in the Walla Walla Basin to determine whether suitable habitat conditions are present. Following this evaluation, potential changes in current conditions that may be needed, or actions

to improve bull trout habitat in the Basin should be identified. And finally, implementation of those changes and/or actions should be pursued on a prioritized basis.

The recovery objective that describes genetic diversity could be accomplished by maintaining physical connectivity among local populations of bull trout to facilitate gene flow and genetic exchange. As the Recovery Plan discusses, connectivity consists of maintaining the fluvial component of each local population which includes providing conditions that allow fluvial adults to effectively move between spawning and wintering areas, and ensuring that movement of both fluvial adult and subadult bull trout can occur, at least seasonally, between local populations within each Core Area in the Recovery Unit. This includes establishing the physical conditions necessary for up- and downstream fish passage, and providing a continuum of suitable physical habitat to ensure the persistence of fluvial lifestages and to provide the opportunity for genetic exchange.

The general approach CRFPO used to plan studies in the Walla Walla Basin consisted of the following three steps:

- Identify data needed to assess if criteria for recovery objectives are being achieved;
- To that end, design and implement studies to describe bull trout distribution, movement, and seasonal habitat use patterns;
- Use the data and analyses from these studies to assist in guiding actions that will make progress towards bull trout recovery.

Study Area

Our study area in 2002-2003 included the SFWWR from Harris County Park downstream to the mainstem WWR, and the mainstem WWR downstream to the OR/WA state line, a distance of approximately 30 river kilometers (Figure 2).

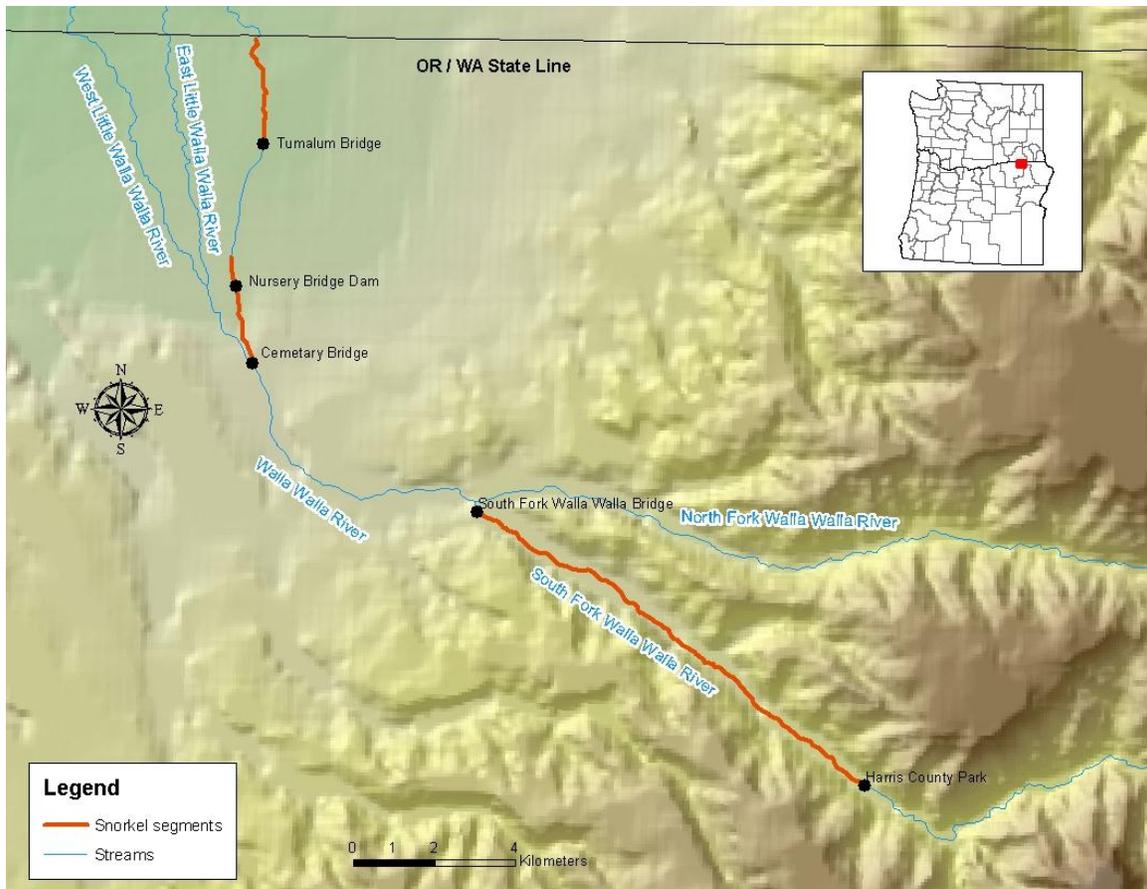


Figure 2. Map of the 2002-2003 study area depicting 30 kilometers of the SFWWR and mainstem WWR. Stream segments that were sampled to determine bull trout distribution during 2003 are identified.

Study Objectives

Recovery objectives and criteria from Chapter 10 of the revised Draft Recovery Plan (U.S. Fish and Wildlife Service 2004) were the basis for our specific study objectives in 2002-2003. Bull trout populations in the Walla Walla Basin consist of both resident and fluvial, or migratory life history strategies. Resident bull trout in the upper Walla Walla River local population are primarily located in the SFWWR upstream from Harris County Park where impacts are minimal. Thus, our study objectives were designed to address the fluvial portion of this population. In addition, it is the fluvial portion of the population that enables interaction between local populations to provide the opportunity for genetic exchange. This has been referred to as connectivity, or “connecting” local populations of bull trout within a Core Area, as well as metapopulations of bull trout among Core Areas. In order to make progress towards these recovery objectives, the temporal and spatial distribution of the two relevant life history stages (adult, subadult) for fluvial bull trout were required.

Temporal and spatial distribution data were required for bull trout to determine habitat use, migration patterns, and movement needs. In addition, identification of areas that limit fish passage were needed for determination of passage flows. The following specific study objectives were designed to obtain these data during 2002-2003:

- 1) Distribution – Determine the spatial and temporal distribution of adult and subadult bull trout in the SFWWR and WWR from Harris County Park to the OR/WA state line.
- 2) Movements – Describe bull trout movement patterns for adults between spawning and overwintering areas, and movement patterns for rearing subadults in the SFWWR and WWR.
- 3) Habitat suitability – Develop and validate habitat suitability models for spawning and rearing bull trout that can be used in the Walla Walla Basin and tested in other basins.
- 4) Water temperature – Collect water temperature data to correlate with bull trout distribution patterns and to determine the existence of cold water refugia.

Methods

Distribution

Snorkel Surveys

The extent that bull trout disperse or migrate downstream from the SFWWR spawning area to rear in impacted mainstem habitats during the summer irrigation months is unknown. Snorkel surveys were conducted at a reconnaissance level during summer flow and temperature conditions. These surveys were conducted from 15 July through 18 July 2003 to determine the spatial distribution of rearing fish. Surveys were conducted from Harris County Park to the South Fork Walla Walla Bridge (Figure 2) in the SFWWR (Segment 3). Surveys were also conducted in the mainstem WWR from Cemetery Bridge to just below Nursery Bridge (Segment 2) and from Tumalum Bridge to the OR/WA state line (Segment 1). Water temperature was recorded at locations where bull trout were observed.

Stream habitat in the three Segments was visually delineated into riffle, race and pool habitat units. GPS locations were recorded at the start and end of each habitat unit. Bull trout distribution among the three habitat unit types within each Segment were compared with habitat unit availability to determine if bull trout preferred a particular type of habitat unit.

Movements

Rotary Screw Trap

A five-foot (1.52 m) diameter rotary screw trap (E. G. Solutions Inc. Corvallis, OR) was fished from 13 August to 23 December 2003 to characterize the magnitude and timing of bull trout dispersal or downstream migration from the SFWWR spawning area. A suitable site to deploy the screw trap, and landowner permission for access were not accomplished in time to begin sampling during the spring of 2003, hence the summer start date. Rotary screw traps have been useful in monitoring salmonid migrations and have been used effectively to capture bull trout in Mill Creek (Hemmingsen et al. 2001).

The screw trap was deployed at a site in the WWR near Day Road (rkm 80.5), approximately four rkm downstream from the forks, and was operated intermittently in coordination with CTUIR personnel. Operations were interrupted several times as a result of severe flow conditions, trap damage and repair, and limited personnel availability. The trap was checked daily when it was sampling to monitor streamflow and debris conditions, as well as to process any fish that were captured. During high flows, the cone was raised and the trap was secured to the bank to avoid damage from debris. The screw trap was fished at the head of a swift pool that offered little room for adjustment in high flow situations. However, the trap site was only accessible through private land which protected the equipment from vandalism.

Captured fish were removed from the screw trap live box with a dip net. Bull trout, Chinook salmon, and *O. mykiss* were anesthetized in a bath of 40mg/L MS-222 (tricaine methanesulfonate), scanned for passive integrated transponder (PIT) tags, and measured for weight and length. We planned to tag bull trout with 23 mm PIT tags if possible. The CTUIR tagged Chinook salmon and *O. mykiss* that were of sufficient size with 12 mm PIT tags when possible. We also planned to conduct sampling efficiency tests for bull trout in order to expand the samples to the estimated total number of individuals that may have passed the trap site.

PIT Tag Detection Arrays

During September/October 2003, we installed a full-duplex PIT tag interrogation system (Destron Fearing 1001) at the East Bank adult fish ladder at Nursery Bridge Dam. This site provided an additional downstream data collection point for bull trout PIT tagged in the SFWWR by other researchers. Ambient electrical noise was high at the site, so aluminum shields were installed around the screen cleaning motors in an attempt decrease noise interference with the PIT tag transceiver. Additionally, an EMI (electro-magnetic interference) noise filter was installed in November on the screen cleaning motor control panel. Data on the system and any PIT tag detections were logged to a desktop computer equipped with Minimon software (Pacific States Marine Fisheries Commission). The interrogation system computer was linked by phone to the internet allowing data to be automatically uploaded to PTAGIS, a regional online database website, every six hours. Routine inspection and maintenance was performed to ensure reliable data collection and system operation. Occasionally, informal PIT tag efficiency tests were conducted, which consisted of holding a PIT tag at varying distances away from the inside of the rectangular antenna frame to determine if there were any “holes” in the detection field.

Habitat Suitability

Redd Surveys

Multiple-pass spawning ground surveys were conducted by the Oregon Department of Fish and Wildlife (ODFW) and FWS biologists on the SFWWR, Reser Creek, and Skiphorton Creek (Figure 3) to obtain an annual index of abundance. Redd surveys were conducted from 19 August through 29 October 2002, and from 2 September through 29 October 2003. Surveyors began at either the upstream or downstream end of a reach and walked/waded through the reach enumerating redds, recording redd size, and recording estimated lengths of adults seen within the reach. Bull trout redds were categorized into small (<0.5m), medium (0.5-1.5m) or large (>1.5m) size classes in an attempt to identify resident and migratory redds. Bull trout redds were assigned a unique number and marked with flagging to avoid counting redds multiple times and to identify individual redd locations. These marked locations provided the opportunity to return later to measure habitat variables used by spawning bull trout.

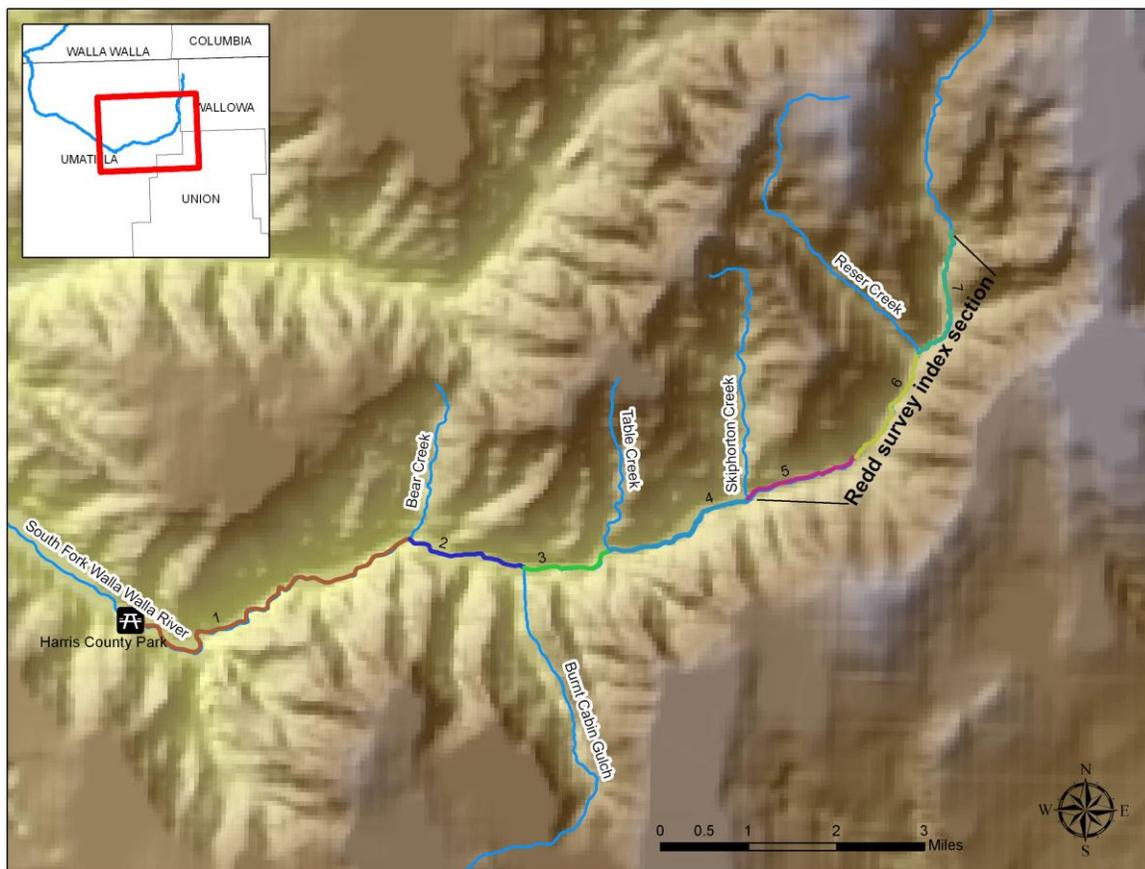


Figure 3. Map of the South Fork Walla Walla River redd survey area showing reaches 1 through 7, Reser Creek, and Skiphorton Creek where surveys were conducted during 2002-2003.

Spawning Habitat Suitability Model

During fall 2002 and 2003, we measured microhabitat variables at bull trout redds, and at nearby locations that were not used for spawning to obtain use and non-use data to develop a spawning habitat suitability model. Data were collected from 23 through 28 October 2002 and from 27 through 31 October 2003 at previously flagged redds in reaches 1 through 7 (Figure 3) of the SFWWR. Microhabitat variables determine the suitability of any particular location in the stream for a bull trout redd. Surrounding mesohabitat conditions may be important in some areas, but in the SFWWR where conditions are generally pristine, mesohabitat variables were continuous, uniform, and of good quality. As a result, we focused our data collection on microhabitat variables.

Surveyors measured the water depth and mean column velocity at the upstream edge of the redd pit with a top-set wading rod and a Marsh-McBirney Flo-Mate Model 2000 flow meter. When measuring water velocities in eddies, the flow meter sensor was pointed directly into the current, just as a fish would be oriented (Rantz 1982). Surveyors then classified dominant and subdominant substrate size and percent fines at the redd. Substrate was categorized into six classes by diameter (Table 1), and percent fines was categorized into four classes (Table 2).

Table 1. Substrate types and particle sizes used to classify dominant and subdominant substrates at bull trout redd locations and adjacent non-use locations.

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

Table 2. Percent fines codes and classification descriptions for conditions at bull trout redd locations and adjacent non-use locations.

Code	Description
1	0 to 25 percent of visible substrate <0.64 cm
2	26 to 50 percent of visible substrate <0.64 cm
3	51 to 75 percent of visible substrate <0.64 cm
4	76 to 100 percent of visible substrate <0.64 cm

During 2002, only use data were collected at bull trout redds. During 2003 non-use data were also collected. Following data collection at the redd location, a non-use point was determined by pacing a random distance (one to six steps upstream or downstream and one to six steps toward either stream bank) away from the redd, where data collection was repeated.

Analytical methods included an examination of bull trout preferences for depth, velocity, substrate, and percent fines. To determine bull trout preference for specific ranges of microhabitat variables, we compared empirical data on the ranges of the variables that were actually used at redd sites to the overall availability of the variables. Availability data were collected on transects within 15 stream reaches between Harris County Park and Reser Creek by Utah State University (Budy et al. 2005). We compared frequency distributions of the microhabitat variables at redd sites to frequency distributions for overall availability of the variables to determine if spawning bull trout were selecting specific conditions at frequencies that were different than the frequencies of overall availability.

Hydraulic Model

Bathymetric surveys were conducted on a 200-m reach of the SFWWR from 29 September through 31 October 2002. This stream segment is located approximately 0.4 km upstream of the SFWWR and Skiphorton Creek confluence (Figure 3). Bathymetric survey data will be required to create a two-dimensional flow model that will be used in the development of a habitat suitability model. Latitude, longitude and elevation were established at several benchmarks surrounding the study area using a Trimble RTK GPS receiver. A Geodimeter model 600 total station (Figure 4) was positioned over the benchmark and back-sighted to another benchmark to establish a location and direction for the instrument. Survey crews consisted of one instrument person operating the total station and one rod person holding a survey rod with a 360° prism. Individual bathymetric data points were then collected at approximately 1-m intervals across the width of the river and extended beyond the wetted width up the bank to approximately 1 m above the water surface elevation. In addition to location and elevation data, substrate and percent fines data were collected at each survey point. Surveyors classified dominant and subdominant substrate size and percent fines as previously described in Table 1 and Table 2.



Figure 4. Geodimeter model 600 used to collect bathymetric data in a 200 meter stream segment of the South Fork Walla Walla River.

Water Temperature

Water temperatures were measured with a field thermometer at bull trout locations during the snorkel surveys to correlate the pattern of temperatures with bull trout distribution between the SFWWR headwater area and the mainstem WWR near state line.

Thermal Infrared Remote Sensing Surveys

The FWS contracted with Watershed Sciences, LLC (WS) to conduct airborne thermal infrared (TIR) remote sensing surveys on the SFWWR and WWR to determine if cold water refugia were present as a result of either spring or groundwater interaction with the surface water, or hyporheic flow activity. Both TIR and color video imagery were collected in order to characterize the thermal regime of the surveyed area. The airborne surveys were conducted on 13 August 2003 (Figure 5, Table 3). Images were collected with TIR (8-12 μ) and visible-band cameras attached to a gyro-stabilized mount on the underside of a helicopter. The two sensors were aligned to represent the same ground area, and the helicopter was flown longitudinally along the stream channel with the sensors looking straight down. Thermal infrared images were recorded directly from the sensor to an on-board computer in a format in which each pixel contained a measured radiance value. The recorded images maintained the full 12-bit dynamic

range of the sensor. The individual images were referenced with time and position data provided by a global positioning system (GPS).

A consistent altitude above ground level was maintained in order to preserve the scale of the imagery throughout the survey. The ground width and spatial resolution represented by the TIR image vary based on the flight altitudes. The flight altitude is selected prior to the flight based on the channel width and morphology. During the flight, images were collected sequentially with approximately 40% vertical overlap. The flight was conducted in the mid-afternoon in order to capture heat-of-the-day conditions.

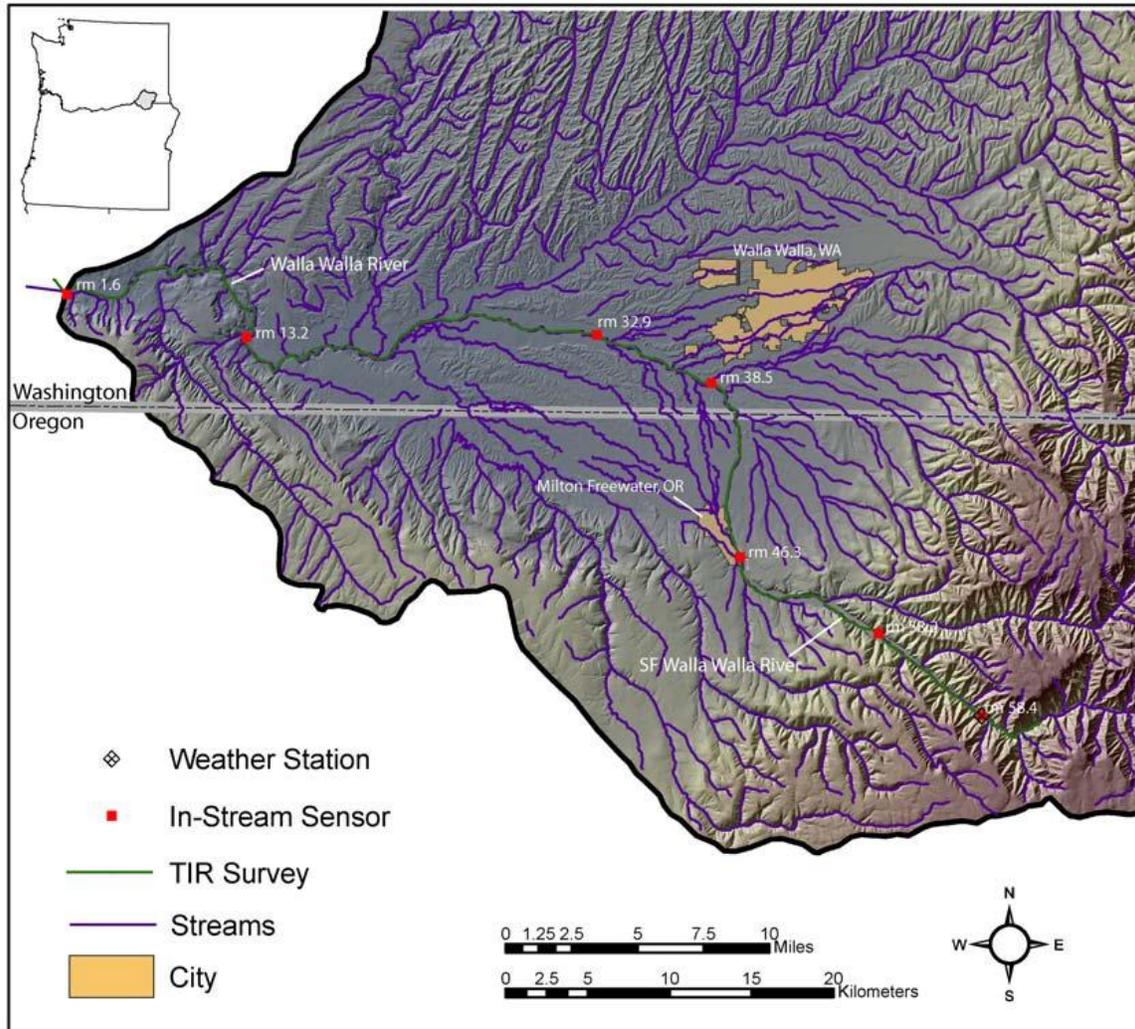


Figure 5. Map showing the two river reaches surveyed during the TIR flight on 13 August 2003. The locations of instream sensors used to ground truth radiant temperatures derived from TIR images are also shown. The sensor locations are labeled by river mile (rm).

Table 3. Summary of the river reaches surveyed with TIR and color video on 13 August 2003.

River Reach	Survey Date	Survey Time (24 hr)	Survey Extent	River Miles	Image Width Meter (ft)	TIR Image Pixel Size Meter (ft)
WWR	13 Aug	13:59-15:26	Mouth to SFWWR	49.8	193 (635)	0.61 (1.98)
SFWWR	13 Aug	15:26-15:45	SFWWR mouth to Elbow Creek	10.7	193 (635)	0.61 (1.98)

For each surveyed stream, WS deployed instream data loggers prior to the survey to ground truth (i.e. verify accuracy) the TIR data. The instream data loggers were located at intervals of 10 river miles or less over the survey route. The SFWWR was instrumented with two sensors; one in the upper reaches at Harris County Park and the other closer to its mouth. Five sensors were deployed in the WWR with relatively uniform distribution (as access allowed).

Meteorological data including air temperature and relative humidity were recorded using a portable weather station (Onset) located at Harris County Park. A detailed description of the methods used for data processing can be found in Faux (2003).

Results and Discussion

Distribution

Snorkel Surveys

A total of 67 bull trout were observed while conducting snorkel surveys to determine bull trout distribution (Figure 6). Nearly all of the observations (n=66) were within the lower SFWWR in Segment 3. One bull trout was observed in Segment 2 just below Nursery Bridge Dam. No bull trout were observed in the lower Segment 1.

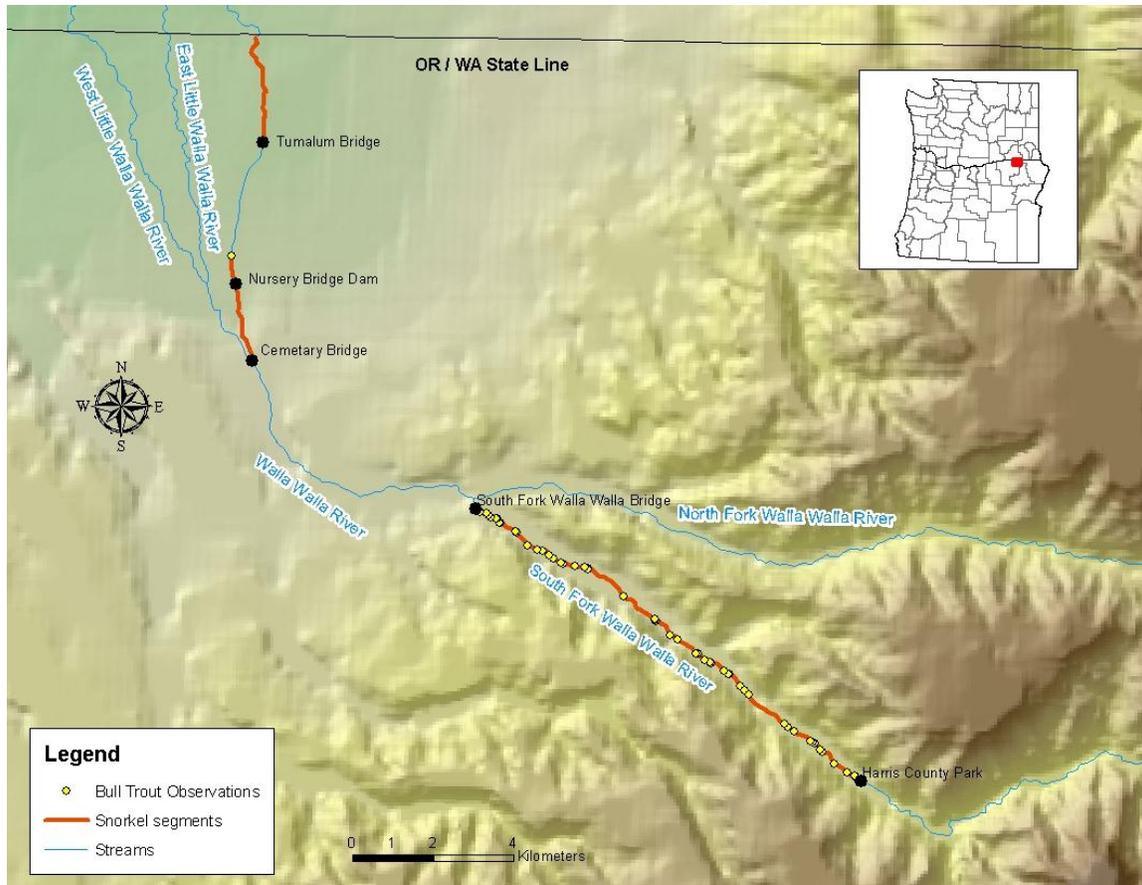


Figure 6. Stream Segments in the SFWWR and mainstem WWR snorkeled during 2003 and locations of bull trout observed.

Water temperature data collected at 39 bull trout observation locations in the SFWWR ranged from 10.6 to 20.0 °C with an average of 13.4 °C. The temperature at the single observation below Nursery Bridge Dam was 20.0 °C. The observation of only a single bull trout in the two downstream Segments was likely correlated with the pattern of increasing water temperatures in the downstream direction.

We compared habitat unit use with availability in the SFWWR where most of the observations occurred to determine if bull trout preferred one type of habitat unit (riffle, race or pool) over another. Of the bull trout that were observed, 27% were in riffles, 54% were in races, and 18% were in pools (Figure 7). Riffle, race, and pool habitat occurred at a frequency of 46%, 52%, and 2%, respectively. Pool habitat units were used more frequently than available suggesting bull trout selected for pool habitat. Riffle habitat units were used less frequently than available, possibly suggesting avoidance. Race habitat units were used at a frequency similar to their availability.

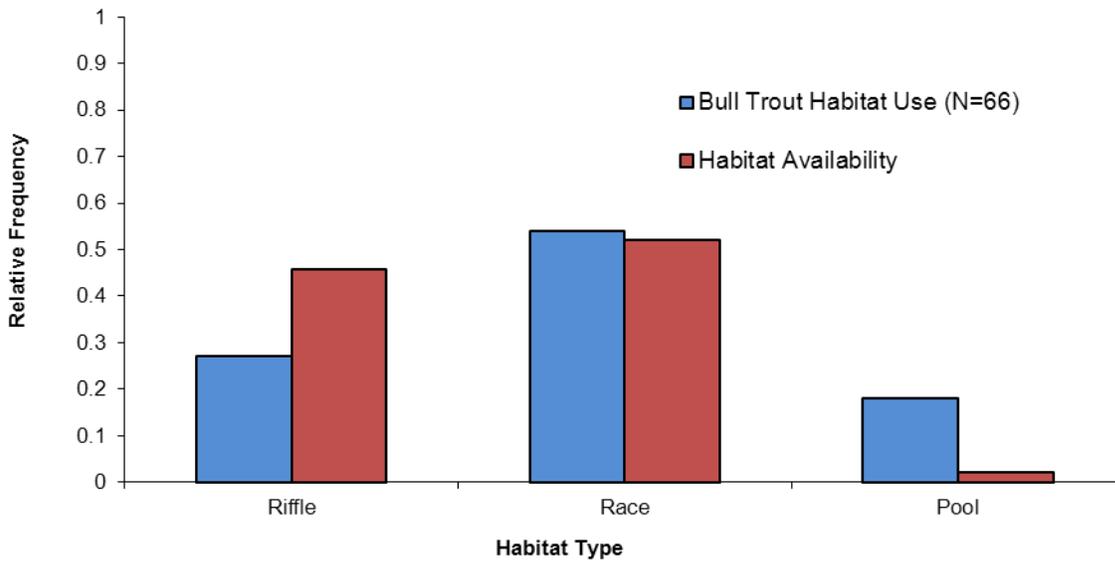


Figure 7. Relative frequency of habitat unit use by bull trout, and habitat unit availability in the South Fork Walla Walla River.

Movements

Rotary Screw Trap

We captured five bull trout, 3,135 Chinook salmon, and 1,371 *O. mykiss* in the rotary screw trap (Table 4). The trap sampled successfully for 63 of 130 days from 13 August to 23 December 2003. No previously PIT tagged bull trout were captured. Captures of previously PIT tagged Chinook salmon and *O. mykiss* totaled 595 and 98, respectively. No 23 mm PIT tags were available on the days that the bull trout were captured, thus none were PIT tagged. The CTUIR PIT tagged 2,205 Chinook salmon and 480 *O. mykiss* with 12 mm PIT tags during the sampling period. Sufficient numbers of bull trout were not captured to calculate a trap efficiency estimate.

Table 4. Length and weight data collected from bull trout, Chinook salmon, and *O. mykiss* captured at the Day Road screw trap site on the Walla Walla River from 13 August through 23 December 2003. Length and weight ranges are in parentheses.

Species	Mean length (mm)	Mean weight (g)	Total # captured
Bull trout	206.8 (123-375)	211.5 (18.0-659.0)	5
Chinook salmon	86.1 (48-118)	6.0 (1.4-46.0)	3135
<i>O. mykiss</i>	89.6 (40-233)	8.2 (0.4-139.0)	1371

Of the five bull trout captured, four were likely subadult fish (≤ 325 mm), and one was a larger adult fish (> 325 mm). The number of bull trout captured was not sufficient to establish a pattern of movement, although the sampling effort and catch during November suggested the possibility of more downstream movement activity during that month (Figure 8).

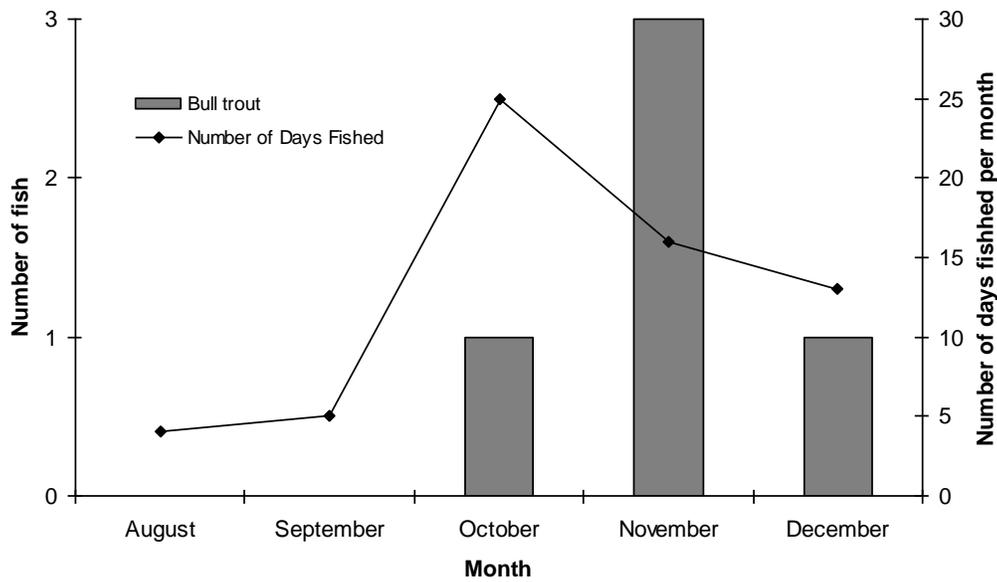


Figure 8. Number of bull trout captured and the corresponding number of days fished per month at the Day Road trap site from 13 August through 23 December 2003.

Chinook salmon and *O. mykiss* were caught throughout the trapping period at the Day Road trap site. Length-frequency distributions indicated the majority of Chinook salmon were in the 70 mm length interval in August and September (Figure 9). The highest frequency length group increased to 80 mm and was constant from October through December, although the samples were more evenly distributed among multiple length groups.

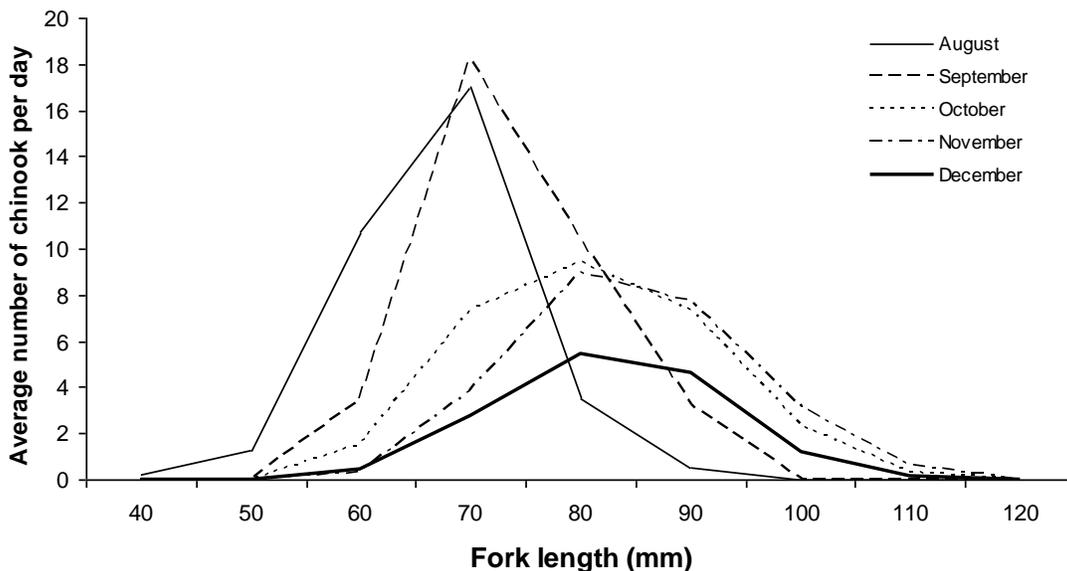


Figure 9. Fork lengths and average number of Chinook salmon captured per day at the Day Road trap site by month from August through December 2003.

Length frequency data for *O. mykiss* indicated movement of smaller fish, primarily in the 40 to 70 mm intervals, from August through October (Figure 10). These fish were likely young-of-year (YOY), or in the 0+ age category. In November and December, average fish size increased, and two higher frequency size groups were observed, possibly indicating movement of a second age group of 1+ fish along with the YOY fish.

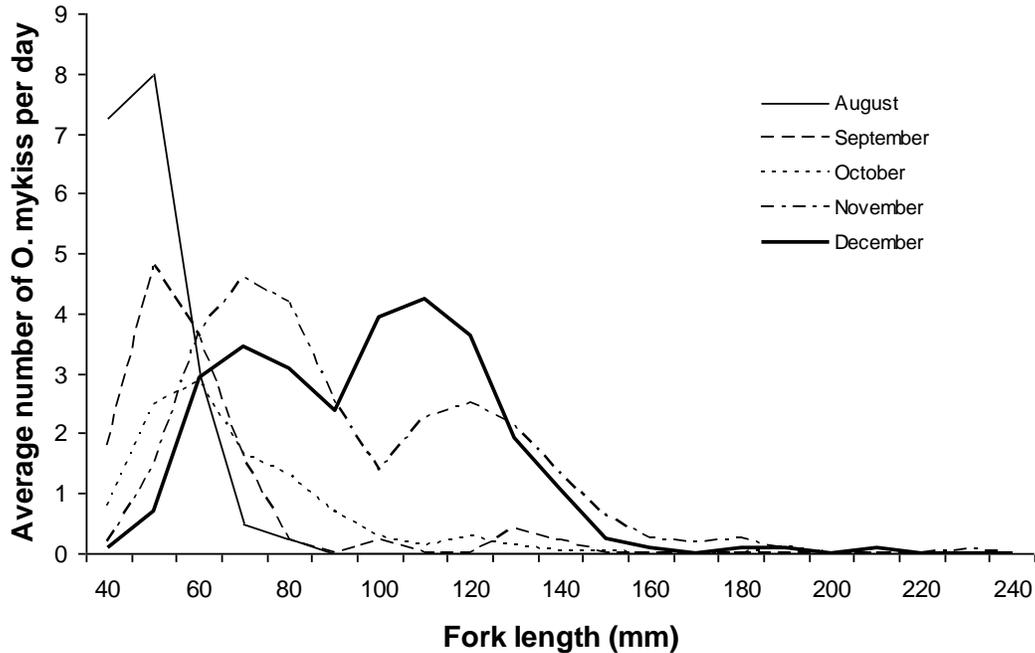


Figure 10. Fork lengths and average number of *O. mykiss* captured per day at the Day Road trap site separated by month from August through December, 2003.

The five-foot rotary screw trap allowed us to sample for bull trout in variable and difficult river conditions during the 2003 trapping season where other methods were not feasible, although the sampling efficiency of the effort was unknown. The Day Road trap site provided protection from vandalism, but offered limited adjustability to deal with high water velocities through the trap and the debris load, both of which caused equipment damage. Relatively few ($n=5$) bull trout were captured with the screw trap and no bull trout were recaptured. As such, data were insufficient to assess movement patterns past the Day Road trap site. It is unclear whether the screw trap deployment configuration reduced capture efficiency, or if the movement of bull trout past the trap site was small. Sub-adult bull trout behavior during downstream movement is largely unknown; however, rearing studies have indicated that older juveniles and adults are primarily bottom dwellers and often are associated with coarse substrates such as large cobbles and boulders (Fraley and Shepard 1989). The tendency of bull trout to be bottom-oriented may have contributed to low trap efficiency at the Day Road trap site.

Our goal is to monitor bull trout movement during all seasons to determine when time periods of “active migration” occur. Hemmingsen et al. (2002) found that downstream movement of smaller bull trout in Mill Creek occurred year-round, but they operated a screw trap much closer to the known spawning area. For the next screw trap deployment, we plan to

identify an alternative site that is more conducive to expanded screw trap operations throughout all seasons.

PIT Tag Detection Arrays

The East Bank fish ladder PIT detection array at Nursery Bridge Dam operated a total of 79 days between 3 October and 31 December 2003. No bull trout were detected during this time period. Fall bull trout movements are most likely downstream, with both subadults and adults moving into rearing and overwintering habitat that was too warm during the summer. Downstream migrant fish passing Nursery Bridge Dam can either pass over the spillway or through the ladders, and depending on discharge levels, spillway passage may be more likely. Upstream movements of bull trout in the spring documented by Bronson and Duke (2004) will be the most likely time period for detecting PIT tagged bull trout in the East Bank fish ladder at Nursery Bridge Dam. A total of 31 PIT tagged juvenile spring Chinook salmon were detected in the East Bank fish ladder during the sampling period.

Installation of the aluminum shields around the screen cleaning motors did not noticeably decrease ambient noise, but installation of the EMI filter did attenuate noise allowing consistent detections of 12 mm PIT tags. When efficiency tests were conducted, the East Bank fish ladder antenna was found to be 100% efficient when the screen cleaning motors were not operational, and slightly less when the motors were operational.

Habitat Suitability

Redd Surveys

Redd surveys conducted in the SFWWR and tributaries on six occasions resulted in a total of 330 bull trout redds during 2002. The cumulative number of bull trout redds enumerated over five surveys during 2003 was 362. These totals were not as high as the 2001 redd count (483), but they were higher than the 10-year average from 1994-2003 (287 redds).

Spawning Habitat Suitability Model

Depth measurements were collected at 316 bull trout redd locations identified during spawning ground surveys. Measurements of mean column velocity, substrate composition, and percent fines were collected at 319 redd locations. The availability of microhabitat variables was characterized at 1,433 individual points in the SFWWR spawning area by Utah State University researchers (Budy et al. 2005).

We found that 96% of the depths measured at bull trout redd sites ranged from 0.2 to 0.6 m, and the average depth was 0.28 m (Figure 11). Similarly, 90% of the depths measured for overall availability ranged from 0.2 to 0.6 m, but the average depth was 0.36 m (Figure 11). The primary difference between the two data sets was the higher frequency of redd sites in shallower depths compared to depths that were available.

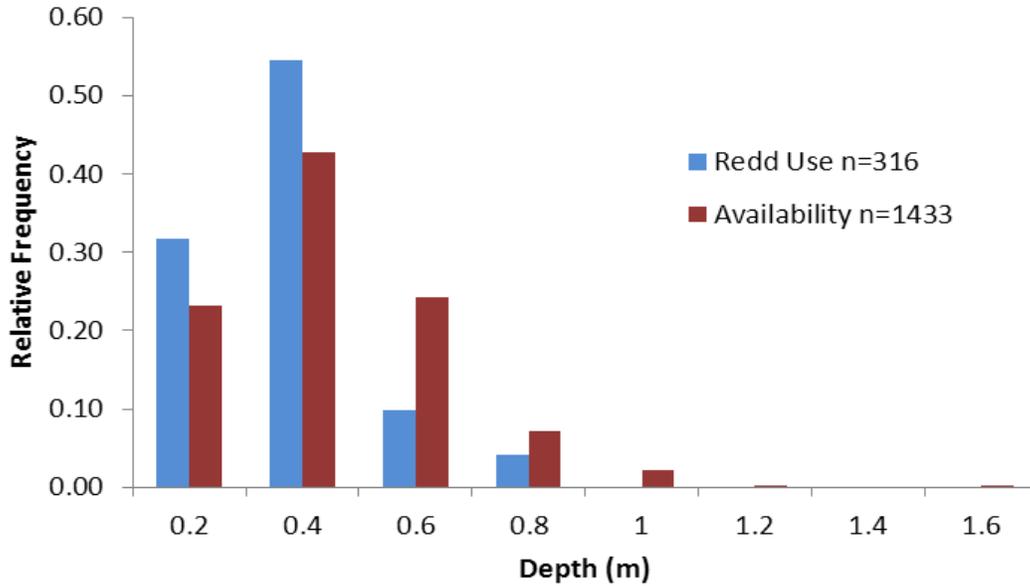


Figure 11. Relative frequency of depths at bull trout redd locations and frequency of available depths in the SFWWR spawning area.

We found that 95% of the mean column velocities measured at bull trout redd sites ranged from 0.2 to 0.6 m/s, and the average mean column velocity was 0.20 m/s (Figure 12). In contrast, we found that only 49% of the velocities measured for overall availability ranged from 0.2 to 0.6 m/s, and the average available velocity was 0.64 m/s (Figure 12). Bull trout appear to be selecting for lower velocity areas for spawning compared to the overall distribution of velocities in the SFWWR spawning area.

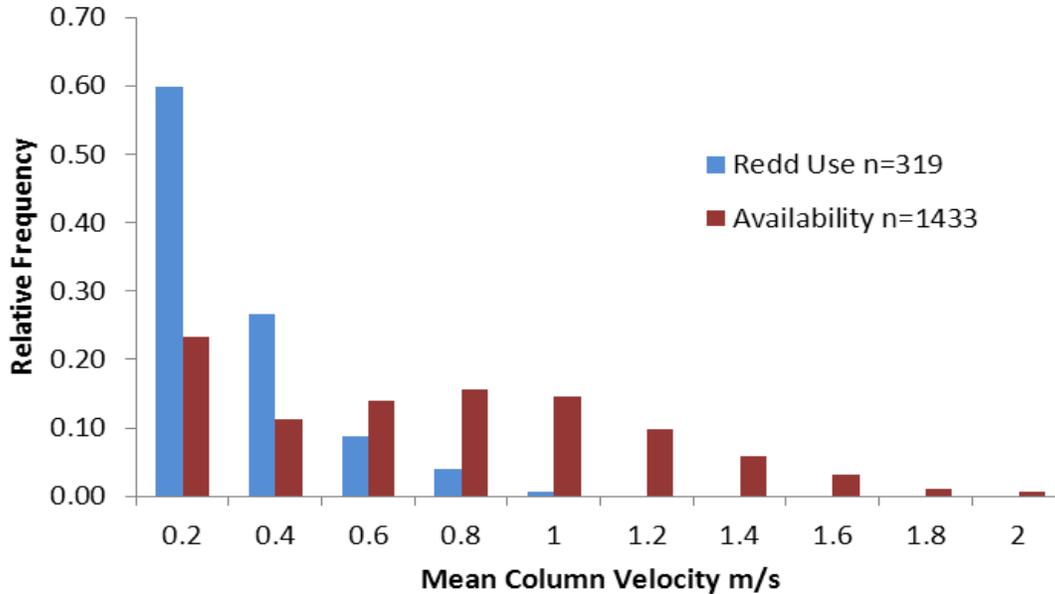


Figure 12. Relative frequency of mean column velocities at bull trout redd locations and frequency of available mean column velocities in the SFWWR spawning area.

We found that 84% of the dominant substrate sizes measured at bull trout redd sites were in the pebble and small gravel categories (Figure 13). In contrast, only 18% of the available dominant substrate sizes were in the pebble and small gravel categories (Figure 13). Bull trout appear to prefer smaller substrate sizes for redd construction and spawning, possibly because of the ease of excavation of smaller materials in the lower velocity conditions typical of bull trout redd sites.

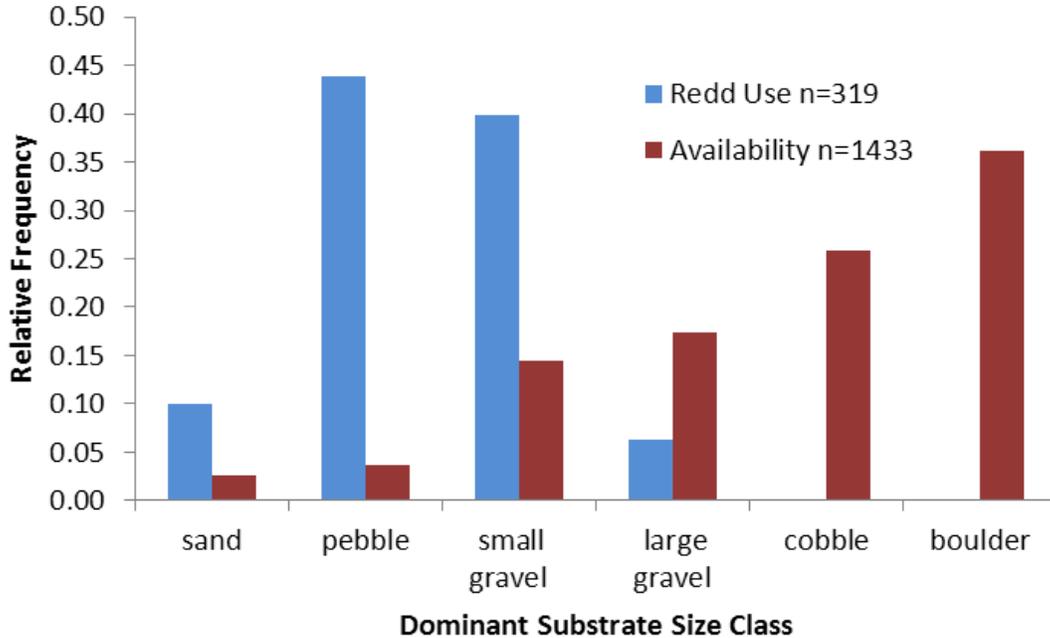


Figure 13. Relative frequency of dominant substrate size classes at bull trout redd locations and frequency of available dominant substrate size classes in the SFWWR spawning area.

Ninety-three percent of the percent fines values measured at bull trout redd sites fell within the 0-25% category (Figure 14). No percent fines availability information was collected for the SFWWR spawning area. This outcome was not surprising considering bull trout, like other salmonids, rely on good water circulation through the substrates in their redds for waste removal and oxygenation of incubating eggs.

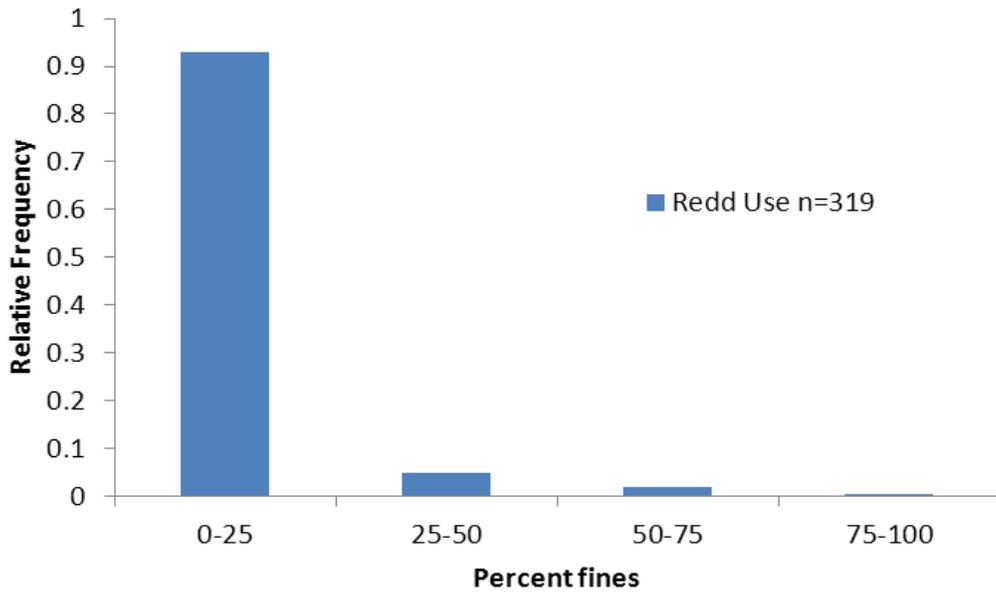


Figure 14. Relative frequency of percent fines at bull trout redd locations in the SFWWR spawning area.

Hydraulic Model

Location and elevation data, as well as substrate and percent fines data were collected at 1,564 points in the 200 m stream segment of the SFWWR selected for this modeling effort. Fifty-one percent of the dominant substrate sizes measured in the stream segment were in the cobble and boulder categories (Figure 15).

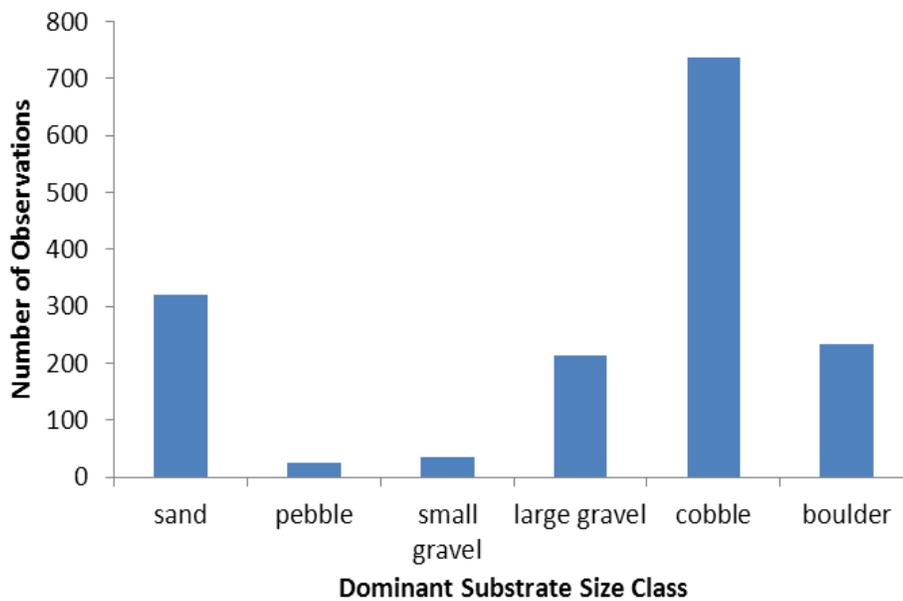


Figure 15. Distribution of dominant substrate size classes for a 200 m stream segment of the SFWWR.

These data will be used in the future to develop a 2-dimensional flow model for this section of the SFWWR spawning area, which in turn, will be used for development and evaluation of a spawning habitat suitability model, and spawning habitat simulations.

Water Temperature

Water temperature data were limited to field measurements during snorkel surveys, and generally showed an increasing pattern in the downstream direction. Temperatures in the SFWWR ranged from 10.6 to 20.0 °C with an average of 13.4 °C. More comprehensive, continuous data will be available in the future from a network of thermographs that we will install next year.

Thermal Infrared Remote Sensing Surveys

South Fork Walla Walla River

Median radiant water temperatures were plotted versus river mile (rm) for the SFWWR (Figure 16). The profile shows the location and temperature of the single surface water inflow sampled during the analysis.

At the upstream end of the survey (rm 10.8), radiant temperatures in the SFWWR were relatively cool at 11.8°C. Stream temperatures warmed slightly in the downstream direction reaching ≈13.6°C at river mile 8.4 and then appeared to cool again reaching ≈12.7°C at rm 7.7. The source of cooling was not apparent from the imagery. However, visual inspection of the temperature profile in relation to the 7.5' USGS topographic map shows a general transition from a canyon reach to a less confined, lower gradient valley reach. A change in morphology in relation to the apparent decrease in stream temperature suggests an area of ground water upwelling. Between rm 7.7 and 3.2, water temperatures in the SFWWR remained relatively constant at 13.2°C (±0.5°C). Local variations along the profile were within the noise level (±0.5°C) typical of TIR remote sensing and should not be used to draw conclusions on localized heating or cooling. An inflow source was detected and sampled within this reach at rm 5.1. Although the source was classified as a spring, the inflow occurs within a side channel and its source is difficult to identify (Figure 17). It was only slightly cooler (12.0°C) than the adjacent river temperature (13.0°C).

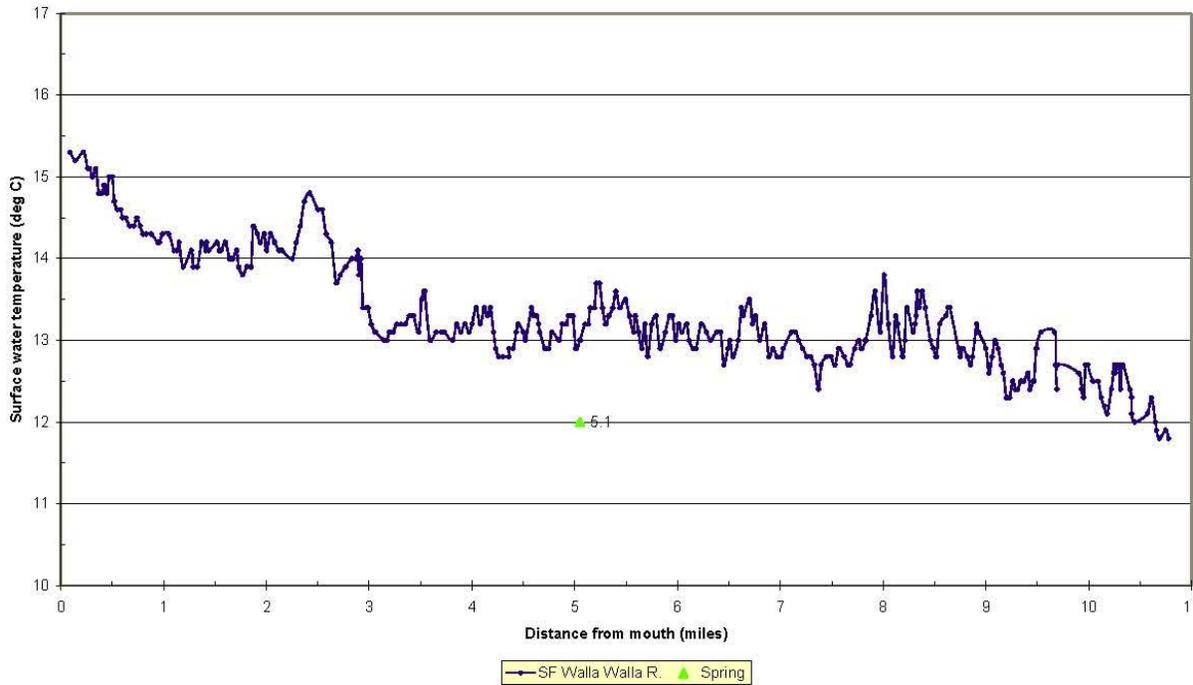


Figure 16. Median channel water temperatures versus river mile for the SFWWR. Surface water inflow sampled during the survey is labeled at rm 5.1.

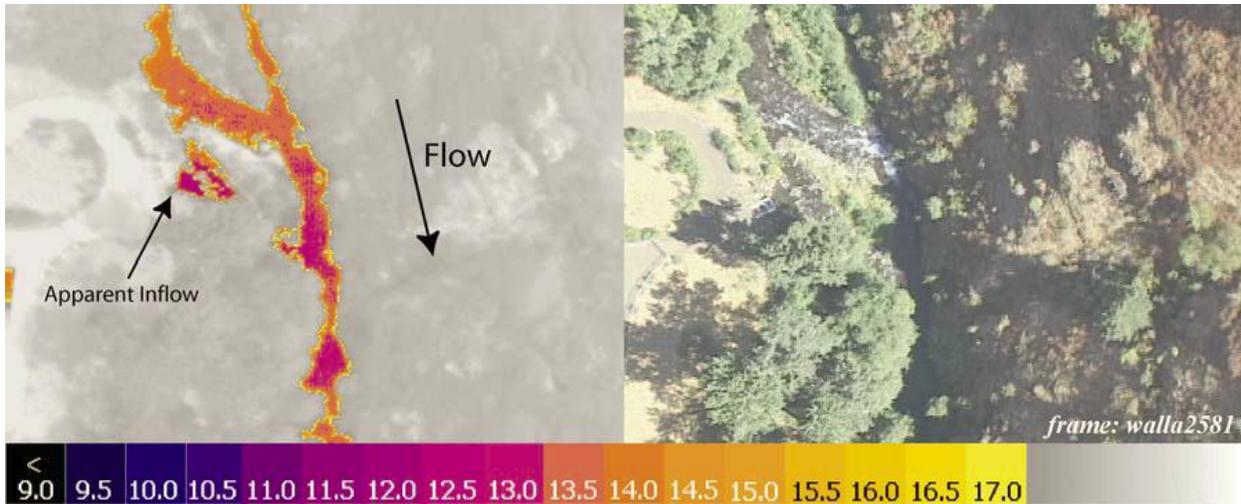


Figure 17. TIR/color video image showing the SFWWR (13.0°C) at rm 5.1. An apparent inflow (12.0°C) was detected along the right bank (looking downstream).

Water temperatures in the SFWWR exhibited a general warming trend between rm 3.2 and the North Fork confluence. Overall, stream temperatures along this reach had a net increase of $\approx 2.1^{\circ}\text{C}$ (13.2°C to 15.3°C). Within this reach, longitudinal heating was observed between rm 3.2 and 2.5, and again between rm 1.2 and the NF confluence. A local maximum of $\approx 14.7^{\circ}\text{C}$ was observed at rm 2.5. However, an instream data logger at river mile 2.5 recorded

temperatures of 14.3°C at the time of the survey. The small spike in the profile is within characteristic noise levels and most likely represents an artifact of the remote sensing rather than an actual maximum. At the confluence, the North Fork was ≈5.0°C warmer than the South Fork (Figure 18).

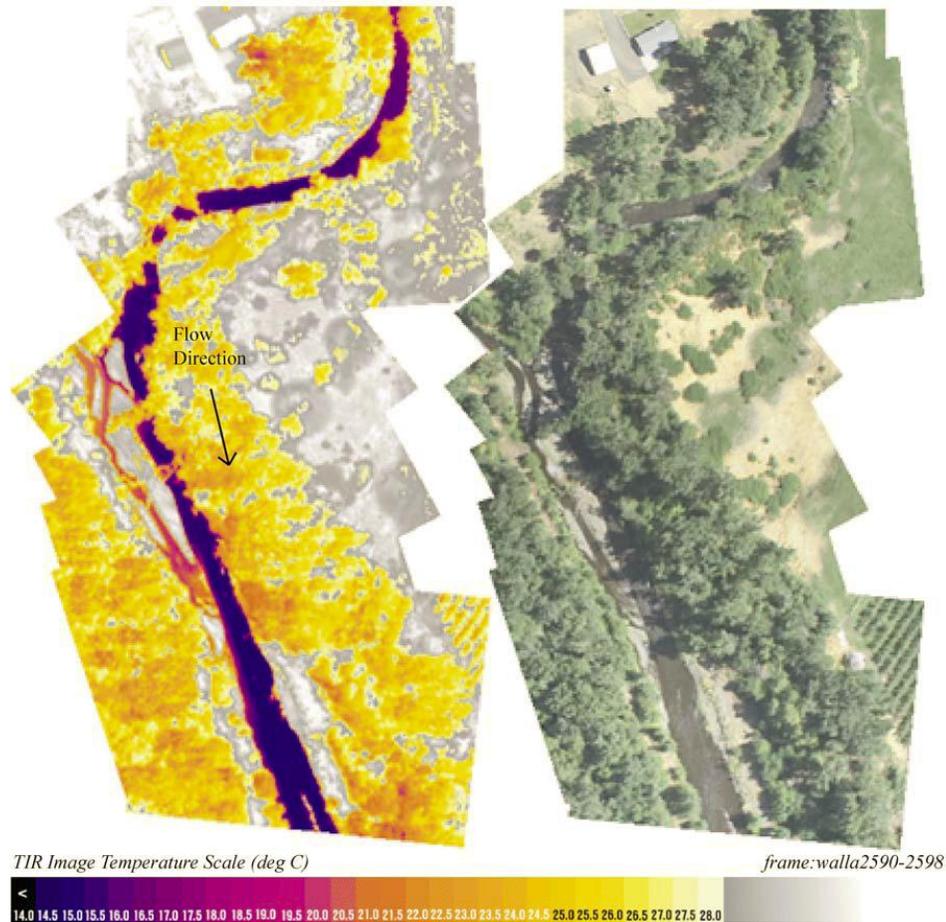


Figure 18. TIR/Color video image mosaic showing the confluence of the South Fork (15.0°C) and North Fork (20.0°C) Walla Walla rivers on 13 August 2003.

Walla Walla River

Median radiant stream water temperatures of the WWR were plotted versus river mile (Figure 19). The location of sampled surface water inflows (i.e. tributaries, springs, and side channels) are illustrated on the plot by river mile, and are listed in Table 5 by river mile and name.

Downstream of the North and South Fork confluence, water temperatures increased from ≈15.1°C at the confluence (rm 50.7) to ≈18.0°C at rm 49.6. The rapid longitudinal heating (≈2.6°C/mile) through this reach may at least partially reflect the downstream mixing of flows from the forks. At rm 49.2, stream temperatures decreased to 16.6°C. The imagery at this location showed a relatively abrupt transition in temperature just downstream of county road 525

crossing (at Joe West Bridge), however, the source of cooling was not apparent from the imagery (Figure 20). The magnitude of the decrease ($>1.0^{\circ}\text{C}$) suggests that the decrease at this location is valid.

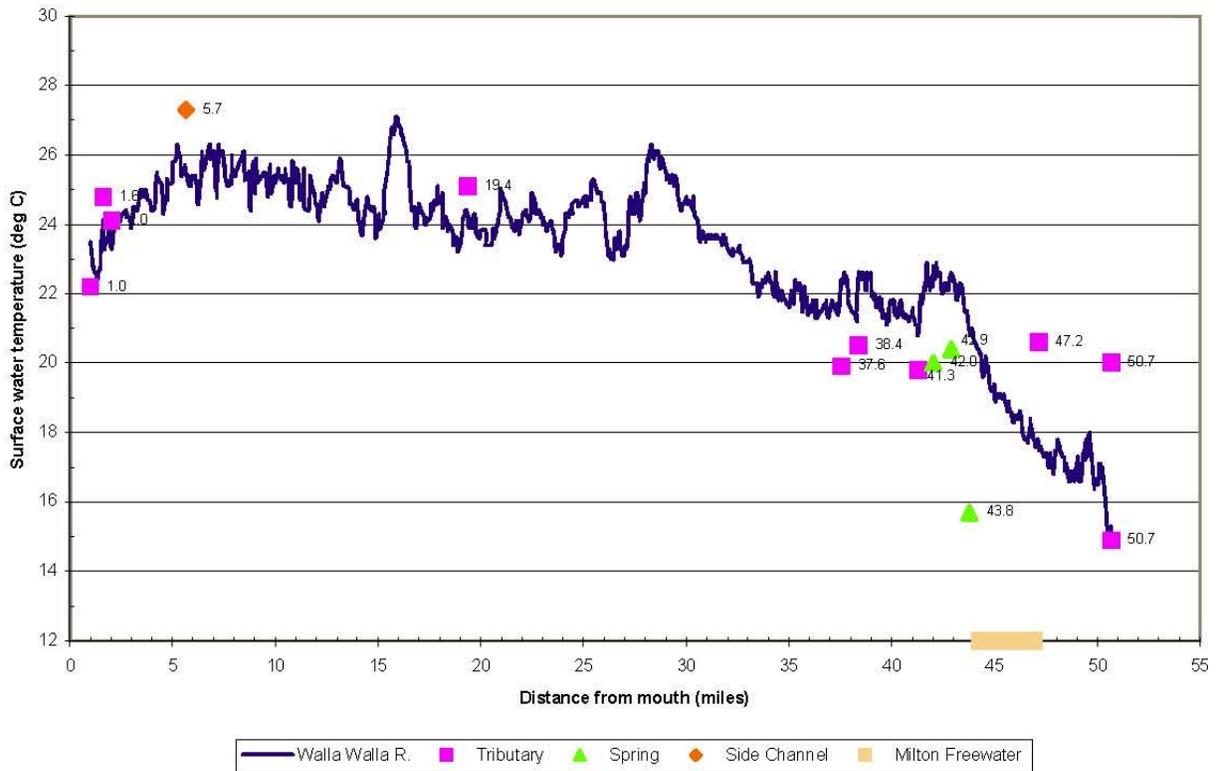


Figure 19. Median channel water temperatures versus river mile for the WWR, WA/OR along with the location of surface water inflows.

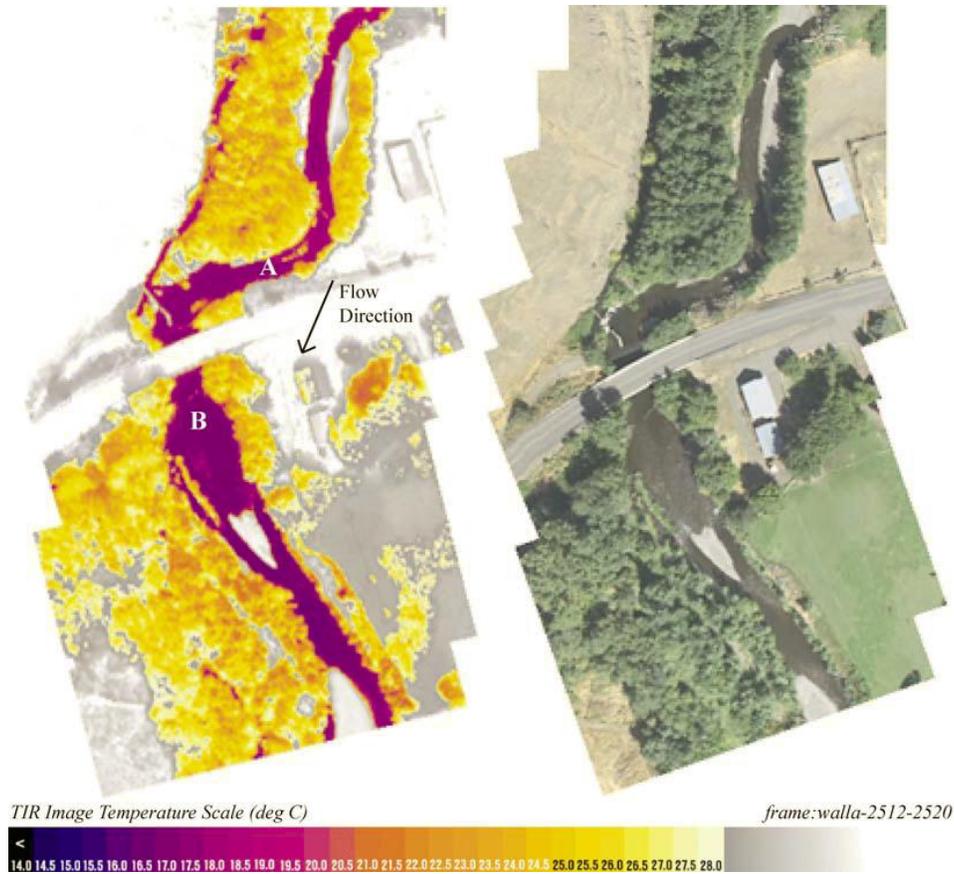


Figure 20. TIR/color video image showing a relatively abrupt transition in radiant temperatures from $\approx 17.8^{\circ}\text{C}$ at location “A” to $\approx 16.6^{\circ}\text{C}$ at location “B”.

Table 5. Tributary temperatures for the Walla Walla River, WA/OR.

Tributary Name	km	Mile	Tributary $^{\circ}\text{C}$	Walla Walla River $^{\circ}\text{C}$	Difference $^{\circ}\text{C}$
Lake Wallula (RB)	1.5	0.9	22.2	23.5	-1.3
Unnamed Tributary (LB)	2.6	1.6	24.8	24.1	0.7
Smiths Harbor Inlet (RB)	3.2	2.0	24.1	23.3	0.8
Side Channel (LB)	9.1	5.6	27.3	25.4	1.9
Touchet River (RB)	31.2	19.4	25.1	24.1	1.0
East Little Walla Walla River (LB)	60.3	37.5	19.9	22.4	-2.5
Yellowhawk Creek (RB)	61.6	38.3	20.5	22.6	-2.1
Spring (LB)	67.5	42.0	20.0	22.8	-2.8
Spring (LB)	68.9	42.8	20.4	22.6	-2.2
Spring (LB)	70.4	43.7	15.7	20.8	-5.1
Couse Creek (LB)	75.8	47.1	20.6	17.5	3.10
South Fork Walla Walla River (LB)	81.4	50.6	14.9	15.1	-0.20

Stream temperatures increased by $\approx 5.9^{\circ}\text{C}$ between rm 49.2 and 43.0. The reach, which included the town of Milton-Freewater, exhibited an average downstream heating rate of $\approx 1.0^{\circ}\text{C}/\text{mile}$ and represented one of two reaches where sustained longitudinal heating was observed. A second warming reach was observed between rm 34.3 and 28.3 where stream temperatures increased from $\approx 21.9^{\circ}\text{C}$ to $\approx 26.3^{\circ}\text{C}$, an average rate of $0.7^{\circ}\text{C}/\text{mile}$.

Between the two warming reaches (river miles 43.0 and 34.3), water temperatures in the WWR remained relatively constant at 21.9°C ($\pm 1.0^{\circ}\text{C}$) with areas of localized warming and cooling. Three tributary inflows contributed to the localized cooling observed at river miles 41.3, 38.4, and 37.6. In addition, two spring inflows were sampled within this reach and, although labeled as springs, they more accurately represent cool water seeps that emerge from the channel substrate. These inflows more importantly signify the occurrence of hyporheic flow, which likely buffers heating within this reach (Figure 21).

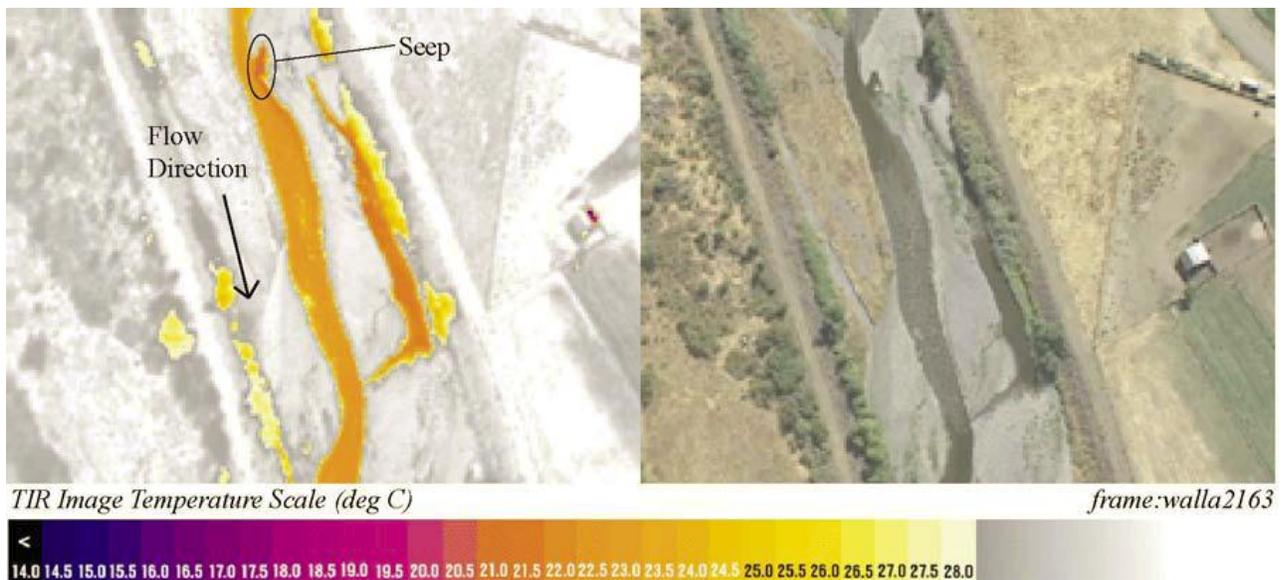


Figure 21. TIR/color video image pair showing a cool water seep detected at rm 42.9. Seeps of this nature indicate the occurrence of shallow, sub-surface flow through the channel.

Between rm 28.3 and 5.2, water temperatures in the WWR remained above $\approx 23.0^{\circ}\text{C}$ with localized areas of heating and cooling. The Touchet River was the only surface water inflow detected through this reach and it contributed water that was warmer than the mainstem. In streams with warm temperatures and relatively low flows, sub-surface inputs can result in a high degree of local variability along the profile. The TIR images showed areas of cool water within the channel floodplain, and interpretation of these images suggests that much of the spatial temperature variability in the lower 28 miles of the WWR was the result of localized sub-surface inflows followed by longitudinal heating of the surface water (Figure 22).

A general cooling trend was observed between river mile 5.2 and the river mouth at Lake Wallula. The processes driving this cooling trend were not apparent from the imagery.

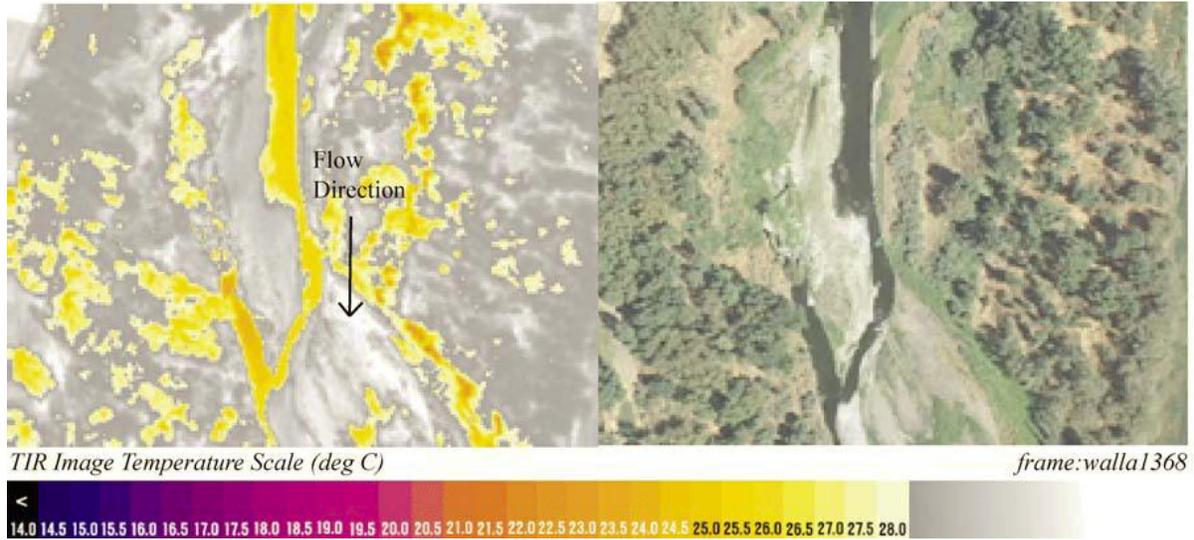


Figure 22. TIR/color video image pair showing an example of cool water (24.3°C) emerging from within the floodplain at river mile 28.0. The location of the cooler water at the downstream end of the gravel bar suggests shallow, sub-surface flow as its source.

Plans for 2004

We intend to further investigate the spatial and temporal distribution of bull trout in relation to water temperatures. We plan to conduct more thorough snorkel surveys throughout the summer and fall to gain a better understanding of distribution as water temperatures change. Thermographs will be deployed to monitor stream temperatures throughout the year and we plan to investigate the importance of cold water inflows identified from TIR data.

To remedy screw trapping difficulties associated with elevated flows and debris loads at the Day Road site, an alternative sampling site will be investigated. Limited data about bull trout movements was obtained by operating the screw trap at the Day Road trap site from August to December. We will attempt to operate the screw trap from January to July depending on personnel availability.

In addition to the existing PIT detection array at the East Bank fish ladder at Nursery Bridge Dam, we will investigate installation of an additional array at the West Bank ladder. Monitoring of both ladders would likely detect most upstream migrants that are PIT tagged. Video monitoring of the East Bank ladder is conducted by the CTUIR. We will also investigate installation of a video system in the West Bank ladder to monitor movements of fish that are not PIT tagged.

We will continue conducting redd surveys and collecting spawning habitat suitability data. We may also begin collecting rearing habitat suitability data at observed bull trout locations while conducting snorkel surveys.

Lastly, we will install a stream gage at Harris County Park. Monitoring river stage will assure that spawning habitat suitability data will be collected under the same conditions that were present when the redds were constructed.

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