Migratory Patterns, Structure, Abundance, and Status of Bull Trout Populations from Subbasins in the Columbia Plateau and Blue Mountain Provinces

2003 Annual Report

Prepared by:

Paul M. Sankovich
Steven J. Starcevich
Alan R. Hemmingsen
Stephanie L. Gunckel

Oregon Department of Fish and Wildlife
Salem, Oregon

and

Philip J. Howell

USDA Forest Service
Pacific Northwest Research Station
La Grande, OR

Prepared for:

U.S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

Project Number 199405400
Contract Number 4101

March 2004

Contents

Tables

Number Page

Figures

Appendix Tables

Appendix Figures

I. Fine-scale population structure of bull trout in the John Day and Grande Ronde River subbasins

Introduction

Metapopulation theory has been increasingly applied to salmonid management and research in general (Rieman and Dunham 2000) and specifically to bull trout *Salvelinus confluentus* (e.g., Rieman and McIntyre 1993). There is little empirical evidence to guide that application, however (Rieman and Dunham 2000). If or how bull trout populations are actually organized and function as metapopulations remain largely untested hypotheses. Empirical estimates of dispersal that may link local populations to a larger population are one of the fundamental needs for increasing our understanding of metapopulation dynamics in bull trout (Rieman and Dunham 2000). Currently, DNA microsatellite analysis is the best tool available to obtain such estimates.

We previously used DNA microsatellite analysis to describe the broad-scale structure of 65 bull trout populations in the Northwest (Bellerud et al. 1997; Spruell and Allendorf 1997; Spruell et al. 2003). That analysis included populations from the Deschutes, John Day, Umatilla, and Walla Walla river subbasins, as well as other populations from the Columbia and Klamath basins and coastal Washington. There was substantial genetic differentiation among populations but little within them. Three major regional groups of bull trout were identified: Coastal, Snake River, and Clark Fork River.

It is still not known how bull trout populations are structured within these regional groups. Given the results from our analysis, and telemetry data describing the extent of bull trout migrations, it is reasonable to suspect that metapopulation structure, if it exists, occurs at a smaller scale (i.e., within tributary basins). Our previous analysis was limited to the use of four DNA microsatellite loci that offered limited power to discriminate fine-scale population structuring within metapopulations. Recently, however, researchers have started to use new loci in their microsatellite analyses (Spruell et al. 1999). These loci have increased the levels of variation observed in the analysis and may be useful in providing increased resolution among bull trout populations (Spruell et al. 1999). Some preliminary, exploratory analysis of samples from the John Day and Grande Ronde river subbasins using additional loci developed since our earlier work suggests possible structuring of bull trout populations within those basins. Such structuring would have significant implications for management activities and recovery efforts.

The objective of this study is to evaluate the fine-scale population structure of bull trout in the John Day and Grande Ronde River subbasins. We collected genetic samples from bull trout in ten streams in the John Day River subbasin and eleven streams in the Grande Ronde River subbasin in 1995 as part of the previous analysis (Spruell et al. 2003). In 2002 and 2003, we collected additional samples in the two subbasins. Our aim was to increase the power of the analyses by sampling in additional streams and in streams where relatively small numbers of bull trout had been collected previously. We also wanted to sample bull trout in a portion of the streams sampled in 1995 to test for temporal variation in allele frequencies. Archived samples from 1995 will be re-analyzed using six new loci, and samples collected in 2002 and 2003 will be analyzed using all ten loci presently available. Information on our sampling activities in 2002 was presented in Sankovich et al. (2003). Here, we report on sampling activities in 2003 and summarize information on the genetic samples collected in 1995, 2002, and 2003. The genetic analyses will be completed subsequent to the publication of this report.

Methods

Our objective in the John Day River subbasin in 2003 was to increase sample sizes for Indian and South Fork Desolation creeks (Figure 1) to 25-30 individuals each. Other streams in the subbasin were sampled in 2002 (Table 1; Sankovich et al. 2003). In the Grande Ronde River subbasin, we wanted to sample 25-30 bull trout each from the North Fork Wenaha River and Lookingglass, Indiana, Lookout, and Crooked creeks (Figure 2), where bull trout had not been sampled previously. We also wanted to increase the sample size for Limber Jim Creek, previously sampled in 1995, to 25-30 bull trout. Hurricane Creek was re-sampled because results from the samples collected in 1995 were anomalous. Clear Creek and the Little Minam, Lostine, and South Fork Wenaha rivers (Figure 2) were re-sampled to test for temporal variation in allele frequencies.

We collected bull trout in July and August by electrofishing or angling. To reduce the likelihood of sampling related individuals, we sampled in multiple reaches and collected tissue samples from fish of different sizes (i.e., ages) in each stream. We anesthetized captured bull trout in tricaine methanesulfonate (MS-222), measured their fork length, and removed a portion of their caudal fin. Each caudal fin sample was divided between two uniquely numbered vials containing 95% ethanol and stored for subsequent analysis at the University of Montana's Wild Trout and Salmon Genetics Laboratory.

Results and Discussion

We met our objectives for all but two streams in 2003. We found no bull trout in Lookout and Crooked creeks, so we sampled bull trout in Deer Creek, a Wallowa River tributary, instead (Table 1). In all years combined, we collected genetic samples from bull trout in 12 streams in the John Day River subbasin and 15 streams in the Grande Ronde River subbasin (Table 1). Five streams each in the John Day and Grand River subbasins were sampled in more than one year to allow for testing of temporal variation in allele frequencies (Table 1).

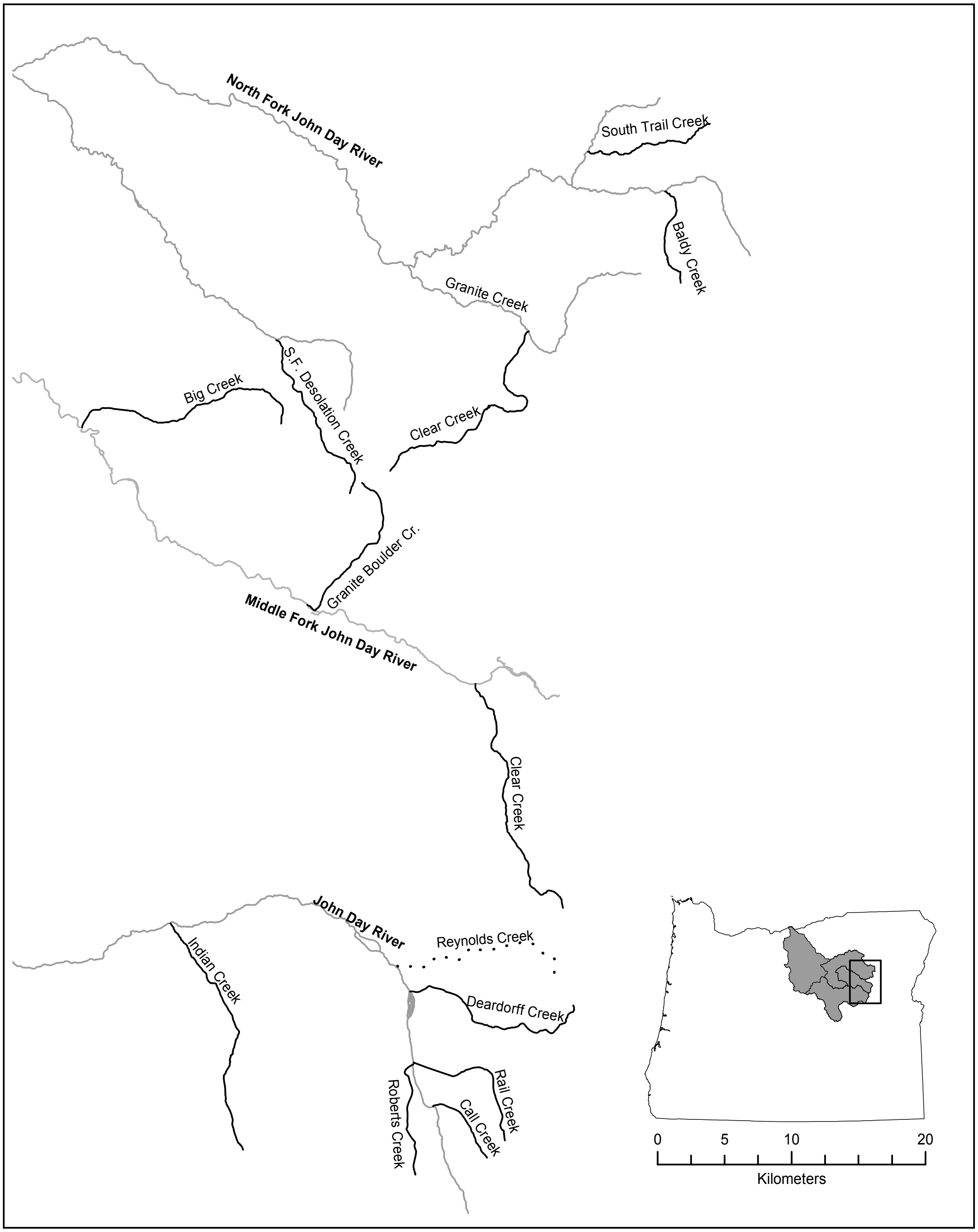


Figure 1. Map of the John Day River subbasin showing the location of streams where bull trout were sampled in 1995, 2002, and 2003 for genetic analyses (bold lines). Streams that were sampled but where no bull trout were found are also shown (dotted lines).

Table 1. Location, number, and fork length (FL) statistics of bull trout sampled in the John Day and Grande Ronde River subbasins in 1995, 2002, and 2003 for genetic analyses.

		No. of bull trout sampled				FL (mm)	
Drainage	Stream	1995	2002	2003	Total	Mean	SD
Upper John Day	Indian Cr.	16	0	9	25	161	40
Upper John Day	Call Cr.	32	30		62	147	44
Upper John Day	Deardorff Cr.		30		30	131	75
Upper John Day	Rail Cr.		30		30	134	71
Upper John Day	Roberts Cr.		30		30	94	29
Upper John Day	Reynolds Cr.		0		0	-	-
M. F. John Day	Granite Boulder Cr.	25	30		55	114	40
M. F. John Day	Big Cr.	30	30		60	136	33
M. F. John Day	Clear Cr.	25			25	123	36
N. F. John Day	S. F. Desolation Cr.	17	5	3	25	160	29
N. F. John Day	Clear Cr.	30			30	126	22
N. F. John Day	Baldy Cr.	30	30		60	147	52
N. F. John Day	S. F. Trail Cr.	26	30		56	157	89
Grande Ronde	Clear Cr.	31		30	61	119	24
Grande Ronde	Lookout Cr.			0	0	-	-
Grande Ronde	Indiana Cr.			26	26	125	15
Grande Ronde	Limber Jim Cr.	22		8	30	124	52
Grande Ronde	Indian Cr.	29			29	113	33
Grande Ronde	N. F. Catherine Cr.	26			26	155	61
Grande Ronde	Lookingglass Cr.			30	30	136	34
Wallowa	Lostine R.	25		26	51	122	37
Wallowa	Deer Cr.			25	25	109	23
Wallowa	Bear Cr.	30			30	154	84
Wallowa	Hurricane Cr.	30		25	55	184	60
Wenaha	S. F. Wenaha	30		25	55	110	33
Wenaha	Butte Cr.	26			26	119	58
Wenaha	N. F. Wenaha			30	30	139	29
Wenaha	Crooked Cr.	0		0	0	-	-
Minam	Little Minam R.	31		30	61	125	29
Minam	Elk Cr.	36			36	153	50

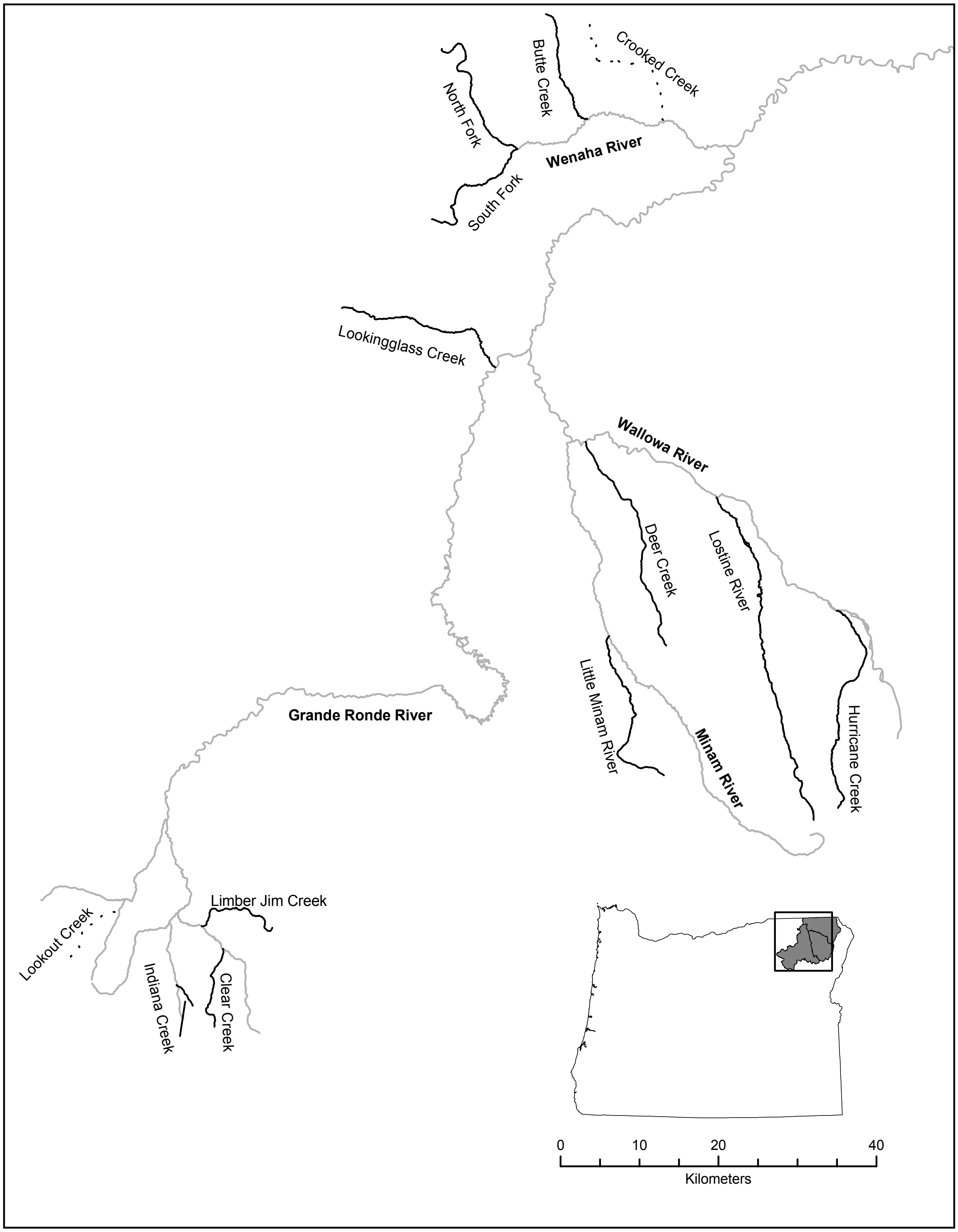


Figure 2. Map of the Grande Ronde River subbasin showing the location of streams where bull trout were sampled in 1995 and 2003 for genetic analyses (bold lines). Streams that were sampled but where no bull trout were found are also shown (dotted lines).

II. Migratory patterns of bull trout in the Umatilla and John Day River subbasins

Introduction

Bull trout populations are composed of resident or migratory individuals, and perhaps of both. Whether the two life history forms make up a single population or separate populations in systems where they occur together is not known (Rieman and McIntyre 1993). Resident bull trout remain in or near their natal tributary throughout life. Migratory bull trout rear in their natal tributary as juveniles, migrate to and rear in a larger river or lake as subadults, and return to their natal tributary as adults to spawn. Bull trout are capable of repeat spawning and may spawn every year or in alternate years (Fraley and Shepard 1989; Pratt 1992). Migratory fish that survive spawning subsequently return to a larger river or lake to feed and grow.

Timing of migration to and from the natal tributary and timing of spawning vary among migratory adults. Migratory adults generally ascend their natal tributary in spring or summer and spawn in late summer or early fall (as do resident adults). They leave their natal tributary shortly after spawning and spend winter in a larger water body. Bull trout that migrate within a stream system versus between a lake and stream system are termed fluvial and adfluvial, respectively. Fluvial adults that have spawned previously but are not reproductively mature in a given year may nevertheless migrate into headwater reaches along with mature adults in spring or summer potentially to avoid increasing water temperatures in areas downstream.

Determining the timing of seasonal movements of migratory bull trout, and the geographic extent of these movements, is critical to bull trout protection and recovery efforts. Migratory individuals are important to the persistence of local populations (Rieman and McIntyre 1993). Identifying migratory corridors and spawning and overwintering areas that migratory bull trout rely upon can help focus habitat protection and restoration efforts.

From 1998-2000 the Oregon Department of Fish and Wildlife (ODFW) studied the migratory behavior of fluvial adult-sized bull trout captured and radio-tagged in the upper Umatilla and North Fork Umatilla rivers (J. Germond, ODFW, personal communication), where most, if not all, of the fluvial fish in the subbasin originate. The study shed light on summer and fall movements of fluvial adults; however, most of the radio-tagged fish that had been observed migrating relatively far downstream after the fall spawning period were subsequently lost and never relocated. As a result, the migratory corridor and overwintering areas used by fluvial adults were not fully defined. The objective of this study, therefore, is to describe the seasonal distribution and movement of fluvial adult bull trout in the Umatilla River subbasin, with particular emphasis on identifying overwintering areas and the extent of the migratory corridor. This study was initiated in June 2002. Findings through February 2003 were presented in Sankovich et al. (2003). We report here on data collected from March through October 2003.

Methods

To monitor the movement of bull trout in the Umatilla subbasin, we surgically implanted radio transmitters in 15 fluvial adult-sized (>300 mm FL) fish in June and July 2002 (Sankovich et al. 2003). Eight of these fish died or lost their transmitters during the last reporting period. We continued to track the remaining fish during the present reporting period using methods described in Sankovich et al. (2003).

Results and Discussion

On 11 February 2003, during the final tracking event of the last reporting period, we located six of the seven radio-tagged bull trout that potentially remained alive. They were distributed between river kilometers (RKm) 120 and 144 on the Umatilla River (Figure 3, Appendix Figures A-1 and A-2, and Appendix Table A-1). The seventh bull trout had last been located on 17 December 2003 at RKm 126 (Figure 3 and Appendix Table A-1). Throughout the present reporting period, we could not locate three of the seven bull trout (tag frequencies 150.772, 151.071, and 151.753). These three fish, and one other (150.191), had migrated farthest downstream in the Umatilla River following the spawning period in 2002 (Appendix Figures A-1 and A-2 and Appendix Table A-1). The bull trout we were able to locate spent the remainder of the winter and early spring at or near the sites where they were observed in February 2003 (Appendix Table 1). One of these fish (150.752) initiated its upstream migration between 6 May and 6 June 2003. It was not possible to determine when the others began migrating upstream because the tracking data were limited. We reduced our tracking effort after May because few bull trout with operable radio tags remained at large and our primary objective—to determine where the tagged fish overwintered—had been met. By 31 October 2003, when we tracked for the last time, there appeared to be only one bull trout with an operable radio tag (150.243). It was found in the same location as it had been one year before, on 31 October 2002 (Appendix Table A-1).

Our results and those from a previous telemetry study in the Umatilla River drainage indicate fluvial adult bull trout overwinter primarily in the upper mainstem. We observed no bull trout below Rkm 120 during winter. In the previous study, one individual was observed at Rkm 110 in November, then lost for several months before being located at Rkm 63 in May (J. Germond, ODFW, personal communication). This fish remained at its May location through July, when it was located last. It presumably was dead in July (and perhaps earlier) given water temperatures in the Umatilla River at that time of year. In both studies, most of the fish that migrated farthest downstream in the Umatilla River were eventually lost during winter. Their tags may have failed prematurely, they may have been poached, or they may have moved to areas that were not tracked or could not be tracked effectively. Unless the missing fish in our study reached deep water in the Columbia River without being detected along the way, it is unlikely they were at large with functioning tags. We aerial tracked the entire Umatilla River, the Columbia River near the mouth of the Umatilla River, and in some unlikely locations (the South Fork Umatilla River and Meacham Creek) in winter. In the previous study, no aerial tracking was conducted and road access allowing effective tracking of the lower Umatilla River

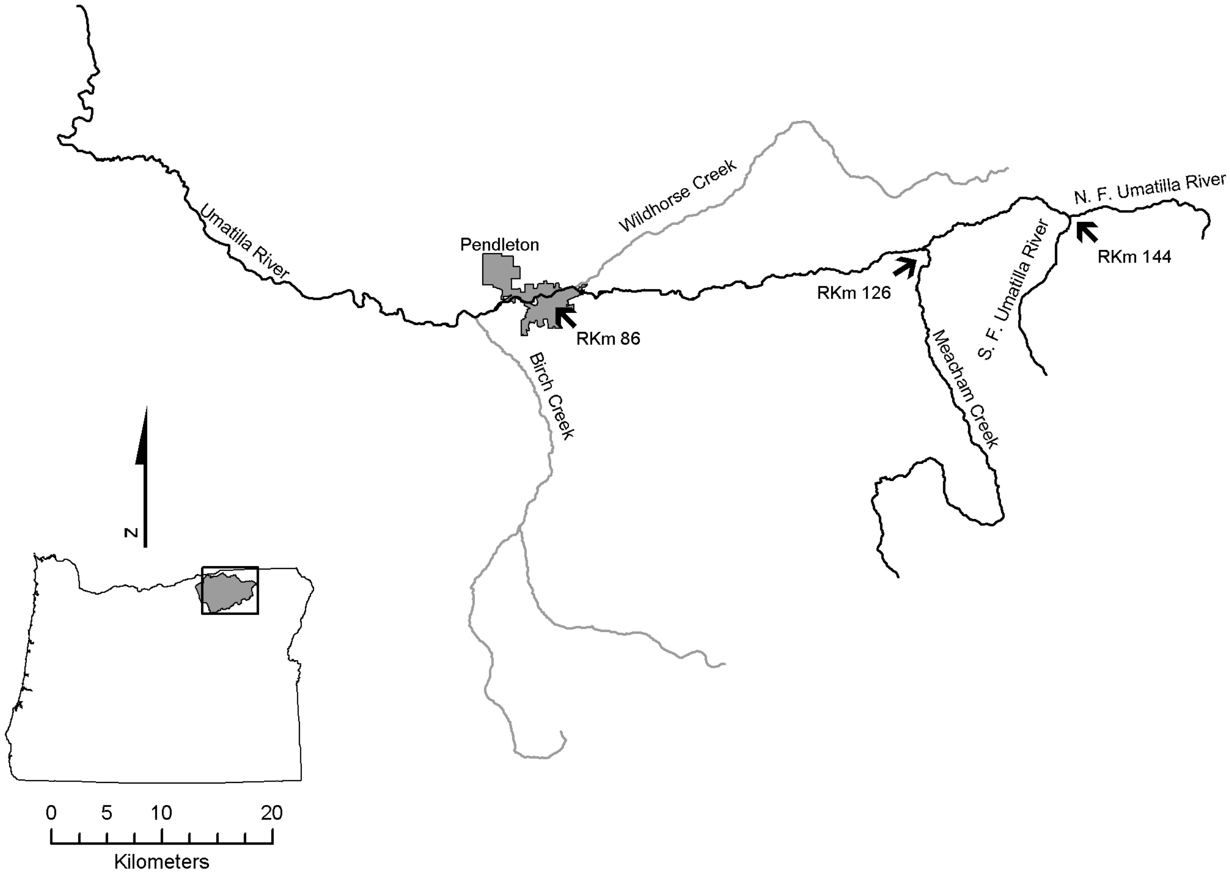


Figure 3. Map of the Umatilla River drainage showing landmarks and river kilometers (RKm) at selected locations.

was limited. Therefore, live fish with operable tags could have gone undetected.

Although the two studies provided no evidence fluvial bull trout utilize the lower Umatilla River, it is evident they do based on their capture at collection facilities and in fisheries between RKm 5 and RKm 98 (U.S. Fish and Wildlife Service 2002). This type of behavior appears to be expressed infrequently and, therefore, might not always be observed in a telemetry study like ours where a small portion of the population was radio-tagged and observed over a relatively short timeframe.

III. Comparing methods of estimating the abundance of adult bull trout

Introduction

Quantitative estimates of bull trout abundance are required to determine the status of populations, monitor changes in population size, and evaluate the effectiveness of conservation strategies. Little data are available on bull trout abundance and population trends (Rieman and McIntyre 1993). Obtaining such information has been identified as a critical research need (Rieman and McIntyre 1993; Buchanan et al. 1997). Redd counts typically have been used to monitor bull trout abundance and evaluate population trends (Rieman and Myers 1997). Counting redds is an attractive technique because it is relatively easy, inexpensive, and un-intrusive compared to other methods of monitoring, and is thought to provide an indirect measure of adult abundance (i.e., of breeding population size).

Despite their frequent use, redd counts may not be sufficient or appropriate to quantify bull trout abundance. Detecting changes in population size may not be possible using the most extensive sets of redd count data available (7-17 years) (Maxell 1999) and is unlikely for populations for which more limited data sets exist (Rieman and Myers 1997). Errors in redd identification not considered in these earlier analyses may further limit the utility of redd counts. Recent studies have shown substantial sampling error associated with counts of bull trout redds (Bonneau and LaBar 1997; Dunham et al. 2001; Hemmingsen et al. 2001b). In addition, we have found that redd counts may not relate well to the abundance of resident adult bull trout (Hemmingsen et al. 2001c), which build relatively small and inconspicuous redds compared to those of fluvial and adfluvial adults.

Standard, appropriate, and powerful methods to assess bull trout abundance across all ranges of habitats have not been established (see Bonar et al. 1997). Although data are beginning to accumulate on the validity of bull trout redd counts (Bonneau and LaBar 1997; Dunham et al. 2001; Hemmingsen et al. 2001b,c), more information is needed to fully evaluate this monitoring technique. The objective of this study is to compare redd counts to other measures of adult bull trout abundance in the Mill Creek drainage (Walla Walla River subbasin), which supports fluvial and resident fish. In 2003, our specific approach was to estimate the abundance of mature fluvial and resident females and subsequently count redds in the drainage in order to assess the relationship between the redd count and the number of mature females.

Methods

This study was conducted at and upstream from a dam and intake structure in Mill Creek that supplies water to the city of Walla Walla (Figure 4). A ladder on the dam allows passage for upstream migrants. We operated a trap, designed as described in Hemmingsen et al. (2001b), at the head of the dam's ladder from 1 May to 28 October 2003. The trap was usually checked daily, but sometimes as infrequently as every third day during periods when we expected few fish to be trapped based on past records. As in previous years, bull trout trapped at the ladder were anesthetized, measured, weighed, interrogated for a passive integrated transponder (PIT) tag, and, if no PIT tag was present, injected with one. Each fish was also inspected using

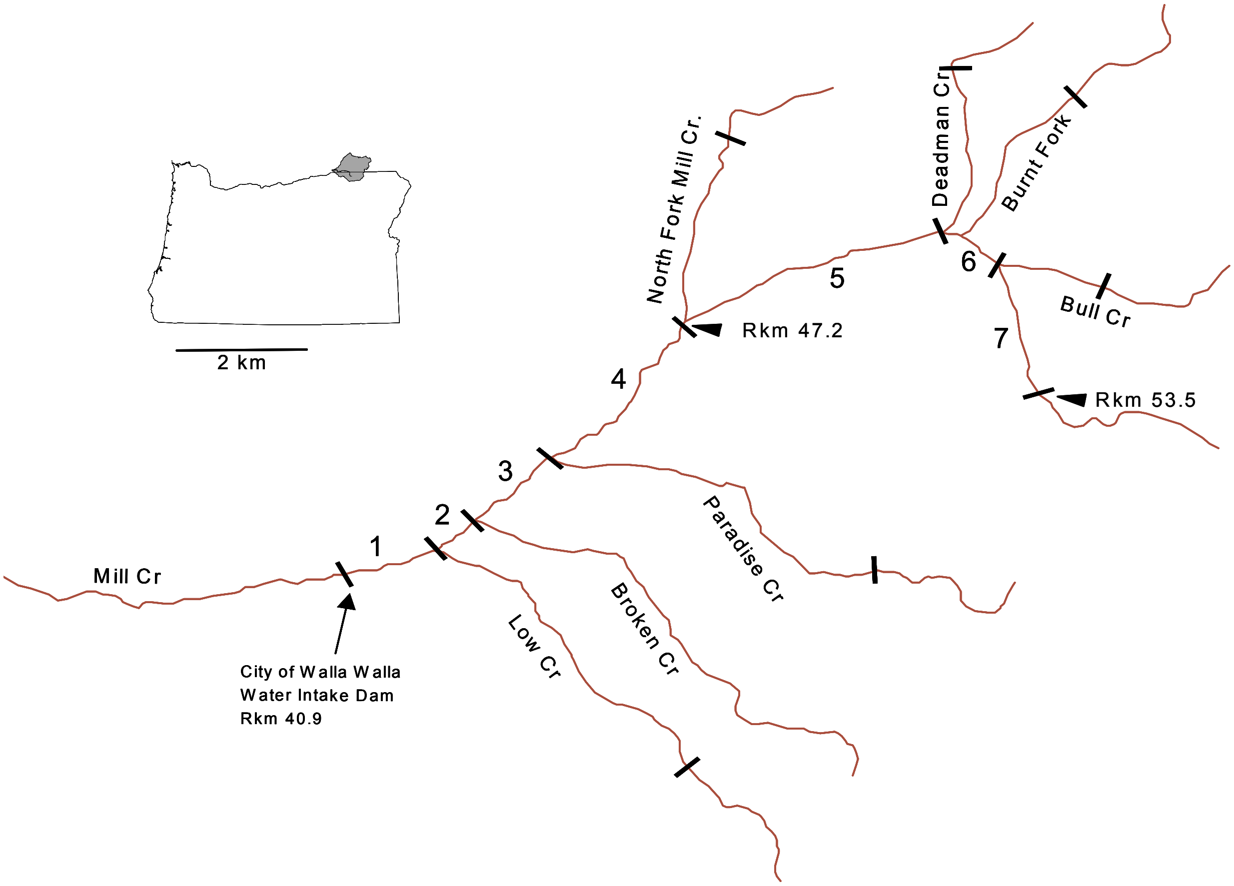


Figure 4. Map of the Mill Creek study area showing landmarks and units in which redds were counted during spawning ground surveys.

ultrasound to identify mature females, and marked by removing the adipose fin, unless that fin had been removed during trapping in 2002.

Most fluvial adult bull trout in a previous telemetry study in the Mill Creek drainage overwintered downstream from the dam (Hemmingsen et al. 2001a,b,c,d; 2002) and used the ladder when returning upstream in late spring or summer. A small number, however, overwintered upstream from the dam or jumped it upon their return. To eliminate the possibility of fish jumping the dam and entering the study area without being trapped, we installed a net across the stream near the base of the dam. The net was made of 3.8 cm square, nylon mesh and was positioned vertically like a tennis net. Two parallel cables supported the net's top and bottom ends approximately 3 m and 0.75 m, respectively, above the water's surface. We hung sections of rubber matting (approximately 1.5 m long x 0.75 m high) from the bottom cable across the full width of the stream to close the gap between the bottom of the net and the stream, yet allow large debris to pass without damaging the net. Each section of matting had grommets in its upper corners and was attached to the bottom cable with carabiners. Once erected, the net and matting formed an aerial barrier between the dam's shallow, concrete-bottomed spill basin and the deep pool immediately downstream.

To account for any fluvial females that might have overwintered upstream from the dam, we snorkeled the study area from 2-4 September 2003. A single diver snorkeled all the pools and a portion of the other habitats capable of holding fluvial adult-sized fish. The diver recorded the number of marked (adipose fin-clipped) and unmarked bull trout $\geq$ 300 mm FL that were observed. Bull trout $\geq$ 300 mm FL were considered fluvial adults for two reasons: 1) few fluvial fish <300 mm FL have been trapped at the ladder since 1997 (Hemmingsen et al. 2001a,b,c; 2002; Sankovich et al. 2003), and 2) we have not observed bull trout $\geq$ 300 mm FL in other streams in northeast Oregon supporting only resident bull trout. The diver's efficiency at locating fluvial adults was estimated by comparing the number of marked bull trout observed to the number released at the trap as of 2 September 2003. This approach assumed all surviving bull trout marked in 2002 had overwintered downstream from the dam and been counted at the trap in 2003. If some bull trout marked in 2002 overwintered upstream from the dam and were observed by the diver, the diver's efficiency would have been overestimated to an unknown extent. We used the efficiency estimate to expand the snorkel count of unmarked fish and estimate the total number of unmarked fluvial adults in the study area. We estimated how many of these fish were mature females by assuming females were as prevalent among the unmarked fish as they were among the fish inspected at the trap. The overall estimate for mature fluvial females in the study area, then, was calculated as

$$N = T + (U \times R \times T)/(M \times I),$$

where N = the total number of mature fluvial females, T = the number of mature fluvial females trapped, U = the snorkel count of unmarked fish $\geq$ 300 mm FL, R = the number of marked fish released at the trap as of 2 September 2003, M = the snorkel count of marked fish, and I = the number of fish inspected for maturity at the trap.

To estimate the abundance of mature resident females in the drainage upstream from the dam, we focused our sampling effort in Low Creek. Our observations of small (< 300 mm FL) fish occupying small redds have occurred almost entirely in that stream each year since 1996. In 2002, we found no mature resident females in Low Creek or elsewhere in the Mill Creek drainage while examining resident-sized fish for maturity (Sankovich et al. 2003); however, we subsequently observed resident-sized fish on redds in Low Creek. This suggested our sampling intensity for enumerating mature resident females might have been too low, particularly if the population size was small. In 2003, we sampled more intensively in Low Creek. In early August, we block-netted and electrofished every third pool and riffle to obtain removal estimates of mature resident females. These estimates were expanded across the available habitat area using methods described by Hankin (1986) to obtain an abundance estimate for mature resident females. Habitat unit areas were measured in 2002-2003, with habitat units being classified as pools or riffles. A sample of the fish collected while conducting the removal estimates was inspected using an endoscope to identify mature females. Similar work we conducted previously in Silver Creek (Powder River drainage) indicated resident females might not mature until they are about 140 mm FL or longer (Hemmingsen et al. 2001c). Therefore, to be conservative, we inspected every fish captured that was $\geq$ 130 mm FL. These fish were first anesthetized in aerated bath containing MS-222. We then made a small incision anterior to the pelvic fin, injected saline solution into the abdominal cavity, and inserted the endoscope to inspect the reproductive organs. The incision was closed with a suture and surgical glue, and the fish were allowed to recover fully from anesthesia before being released into the habitat unit from which they came. We also removed a sample of caudal fin tissue from 31 fish from Low Creek for DNA microsatellite analysis. These samples will be compared to samples collected from fish from the mainstem of Mill Creek in 1995 to determine if there is evidence of reproductive isolation of the suspected resident population in Low Creek and fluvial population in Mill Creek.

Redd counts in the study area were conducted three times between mid-September and late October, throughout all spawning areas. During each survey, we flagged newly observed redds, identified them with a unique number, measured their length (from the beginning of the pit to end of the pillow) and width (at the widest part of the pillow), and noted all fish observed.

Results and Discussion

We captured 160 bull trout in the upstream trap, 80 of which were identified as mature females (Table 2). Three of the bull trout were less than 300 mm FL (171, 252, and 271 mm FL). None of the three was a mature female.

Table 2. Number, sex, and maturity status of bull trout captured in an upstream migrant trap in Mill Creek in 2003. Mature females were identified using ultrasound. Trapping data for rainbow trout *Oncorhynchus mykiss* and mountain whitefish *Prosopium williamsoni* are also included.

Species	Mature females	Mature males and immature males and females	Total
bull trout	80	80[a]	160
rainbow trout			5
mountain whitefish			11

[a] Three of these bull trout were less than 300 mm FL.

One hundred and thirty-five marked bull trout were released at the trap before the study area was snorkeled. The diver located 41 marked fish for an estimated efficiency of 0.30. Ten unmarked bull trout $\geq$ 300 mm FL were also observed; thus, we estimated there were 33 (10/0.30) unmarked fluvial adults. Seventeen of these fish were assumed to be mature females based on the maturity data collected at the trap. Combining these females with the 80 released at the trap yielded an estimate of 97 mature fluvial females in the study area.

While electrofishing in Low Creek to obtain removal estimates, we sampled 28 bull trout for maturity. Eight were identified as mature females (Table 3). Expanding estimated mean densities of mature females in pools and riffles across the available habitat areas yielded an abundance estimate of 51 (95% C.I.: 36-66) mature resident females.

We counted 141 redds in the study area, 28 in Low Creek and 113 in Mill Creek and its remaining tributaries (Table 4). The total redd count closely approximated the abundance

Table 3. Length, maturity status, and sex of bull trout sampled in Low Creek in 2003. Maturity status and sex were determined via endoscopic examination of reproductive organs. The sex of immature fish could not be determined.

		Mature	
Fork Length	Immature	Female	Male
130-139	5		
140-149	4	1	
150-159	2	1	3
160-169	0	2	1
170-179	0	1	3
180-189	0	2	1
190-199		1	1
Total	11	8	9

estimate for mature fluvial and resident females (148). The redd count in Low Creek, however, was only 55% of the abundance estimate for mature resident females in that stream, suggesting we failed to identify a substantial portion of the resident redds. If some redds recorded in Low Creek were produced by fluvial females or by resident females that were not accounted for, our ability to identify resident redds would have been even poorer than the results showed. However, we believe few, if any, fluvial females spawned in Low Creek. We observed no fluvial adult-sized bull trout when electrofishing and conducting spawning surveys there, and all but two redds appeared, based on size, to be made by resident females. We do not know whether any resident females might have immigrated into Low Creek to spawn after we completed the removal estimates. The likelihood of this having occurred was perhaps small given that no redds or spawners were observed in the lower 2 km of Low Creek.

The redd count in Mill Creek and its tributaries other than Low Creek was 17% greater than the abundance estimate for mature fluvial females. This could indicate we were more likely to “invent” fluvial redds than fail to identify them, assuming no or few resident female were responsible for the redds identified. Based on the size of the redds and spawners we observed in areas other than Low Creek, we believe this is a valid assumption.

Table 4. Redd counts in the Mill Creek drainage in 2003. The locations of survey sections are shown in Figure 4.

Survey section	No. of redds
1	0
2	0
3	6
4	18
5	53
6	12
7	9
Low Cr	28
Paradise Cr	1
N.F. Mill Cr	8
Deadman Cr	0
Burnt Fork Cr	1
Bull Cr	5
All	141

IV. Monitoring the abundance of adult bull trout in the Walla Walla, Umatilla, John Day, and Deschutes River subbasins using the Environmental Monitoring and Assessment Program (EMAP) protocol

Introduction

The ability to accurately assess bull trout population status, trend, and distribution is central to conservation efforts for the species. A coordinated approach to conducting such assessments is needed to support restoration efforts. Currently, most monitoring activities are not part of an overall framework for coordinating effort and synthesizing and interpreting results. The Environmental Protection Agency (EPA) has developed the Environmental Monitoring and Assessment Program (EMAP) to evaluate the status of natural resources at regional and national scales. The goal of EMAP is to provide a scientific basis for monitoring programs that measure current and changing resource status.

EMAP employs a probabilistic sampling design that allows resource assessment over large areas based on data from representative sample locations. The design involves a spatially balanced random sampling strategy that distributes sample locations evenly throughout the area of assessment. Trends in status are best assessed by visiting randomly selected sampling sites on annual and multi-year cycles. The EMAP sampling design allows evaluation of status, trend, and distribution at multiple scales with statistical rigor.

In 2003, we implemented the EMAP protocol to monitor the abundance of adult bull trout in the Deschutes, John Day, Umatilla, and Walla Walla River subbasins. We used redd counts to assess adult abundance. Counting redds is the easiest and often the least costly way to estimate adult abundance. Although there can be substantial error associated with the enumeration of redds (Bonneau and LaBar 1997; Dunham et al. 2001; Hemmingsen et al. 2001b), research has shown that redd counts are strongly correlated with estimates of adult escapement (Dunham et al. 2001).

Methods

The sampling frames in the four subbasins consisted of all wadable stream reaches that contain current and potential bull trout spawning habitat. The identification of these reaches was based on ODFW maps of current distribution (derived from the EPA's 1:100k river reach data set), input from ODFW and Washington Department of Fish and Wildlife (WDFW) district biologists, and input from other fishery managers via Streamnet's (http://www.streamnet.org) 1:24K mapping effort. We included only wadable stream reaches because redds can be difficult to count effectively in unwadable areas. The sampling frame was the pool of possible locations from which sample sites were selected and represents our scope of inference.

Site selection was conducted by the EPA Research Lab in Corvallis, Oregon. The site selection process is based on a spatial grid design with hexagonal areas centered at grid points (Stevens and Olsen 1999). Points along all streams in the sampling frame were plotted sequentially by computer and then randomly selected. The randomly selected points were then re-plotted on maps for survey site location.

The number of sample sites within subbasins was based on the minimum number of sites necessary to quantify status and detect trends over time. Our target measure of precision for the estimated number of redds was ± 45% at the subbasins scale and ± 25% at the provincial (all subasins combined) scale. The spawning distributions in the Walla Walla and Umatilla subbasins were limited, so they were combined and the two subbasins were treated as an aggregate when selecting sites. The site selection process produced 50 spatially balanced sites in each of the Deschutes, John Day, and combined Walla Walla–Umatilla subbasins. We thought 50 sites would be the maximum number a crew of two surveyors could effectively survey multiple times throughout the spawning period. We determined that a minimum of 30 sites should be surveyed per subbasin. Fifty additional sites were selected in each subbasin for use as replacements in the event some sites were unsuitable (e.g., located in a dry stream channel) or on private property we could not get permission to access.

During August, field crews located each sample point using Universal Transverse Mercator (UTM) coordinates, maps, and a GPS receiver. The suitability of each site was judged by the presence of adequate spawning habitat and the absence of barriers to bull trout migration, unless bull trout were known to exist upstream from a barrier. Each sample point served as the mid-point of a 1.6 km spawning survey section. End-points were determined by measuring 0.8 km upstream and downstream from the mid-point. Survey end-points were flagged with surveyor's tape, and plastic identification signs were fixed to a nearby tree on the stream bank. UTM coordinates of survey section end-points were recorded with GPS receivers and marked on a map.

From early September through early November, all sites in each subbasin were surveyed three to five times. Four survey crews of two individuals each conducted the surveys. The four crews were separately responsible for surveys in the Deschutes subbasin, Middle Fork and upper John Day River drainages, North Fork John Day River drainage, and Walla Walla–Umatilla subbasin. Crews were trained in the identification of bull trout redds prior to conducting the surveys. During the surveys, each newly observed redd was recorded and flagged with surveyors tape. In streams where the presence of sympatric fall-spawning species made bull trout redd identification difficult, redds were attributed to bull trout only if bull trout were observed on them.

Bull trout population status was assessed based on cumulative redd counts. These counts were analyzed using analytical algorithms developed by the EMAP (Stevens 2002). To assess the accuracy of the EMAP estimates, we also surveyed the entire sampling frame (full census) in the Walla Walla-Umatilla subbasin. The census surveys were conducted multiple times throughout the spawning period, as for the EMAP surveys. The total redd count within the sampling frame was compared to the estimated number of redds obtained using the EMAP protocol.

Results and Discussion

Using the EMAP sampling strategy, we estimated there were 193 (±60) bull trout redds in the John Day River subbasin, 684 (±105) in the Walla Walla-Umatilla River subbasin, and 877 (±121) redds in the two subbasins combined in 2003 (Table 5). Sampling in the Deschutes River subbasin was cancelled because of the Booth and Bear Butte forest fires. Over 20 EMAP survey sections had been set up by August 19, when the U.S. Forest Service closed access to areas where we intended to establish sampling sites. Those areas were re-opened on September 26, but insufficient time remained to complete site set-up and conduct surveys.

Table 5. Bull trout redds counted in survey sections (n) and estimated to be within two subbasins in 2003.

Subbasin	n	Estimated no. of redds	C.I. (%) [a]
John Day	48	193	31
Walla Walla-Umatilla	48	684	15
Combined	96	877	14

[a] ± 95% confidence interval.

The precision of the estimates for the individual and combined subbasins was well within our target of ± 45% and ± 25 %, respectively (Table 5). The estimates were more precise in 2003 than in 2002, the first year of this pilot study. Precision improved from ± 23% in 2002 to ±15% in 2003 for the Walla Walla-Umatilla River subbasin estimate, and from ± 39% to ±31% for the John Day River subbasin estimate. The precision of the estimate for the combined subbasins improved from ± 19% in 2002 to ±14% in 2003, but no data for the Deschutes River subbasin were available for inclusion in the analysis in 2003.

We expected the estimates to be more precise in 2003 because we monitored 17% more survey sections in the Walla Walla-Umatilla and John Day River subbasins. We also refined the sampling frame for the Walla Walla-Umatilla River subbasin by removing 3.9 km (3%) of stream from it so that it matched the census survey area. We monitored 48 survey sections in each subbasin, coming closer to our goal of 50. Two survey sections were dropped because they were located outside the modified sampling frame, another because the channel was dry, and one because the surveyors never saw the boundary signs (Figures 5 and 6). In 2002, 40 sections were surveyed in the Walla Walla-Umatilla River subbasin, and 42 were surveyed in the John Day River subbasin.

In 2003, as in 2002, the EMAP estimate for the John Day River subbasin was more imprecise than the estimate for the Walla Walla-Umatilla River subbasin. This was due partly to our having surveyed only 26% of the relatively large sampling frame in John Day River subbasin, compared to 55% of the sampling frame in the Walla Walla-Umatilla River subbasin.

It was also due to the relatively low site occupancy rate (proportion of survey sections in which redds were identified) in the John Day River subbasin. Redds were recorded in only 42% of the survey sections in the John Day River subbasin compared to 60% of the survey sections in the Walla Walla-Umatilla River subbasin. Under the EMAP protocol, it is expected that some sites will be unoccupied and that changes in fish distribution through time will be reflected by changes in site occupancy and the distribution of occupied sites. However, the site occupancy rate in the John Day River subbasin may have been artificially low. In some drainages within the subbasin, current and potential spawning distributions were based largely on professional judgment rather than existing data, and we may have surveyed some stream reaches that should have been excluded from the sampling frames. In addition, in areas where fall-spawning species other than bull trout were present, we recorded only redds occupied by bull trout. As a result, we may have recorded no bull trout redds in survey sections that actually contained them.

The EMAP estimate of the number of redds in the Walla Walla-Umatilla River subbasin appeared to be accurate, differing from the census redd count by less than 1% (Table 6). A similar result was obtained in 2002, when the EMAP estimate differed from the census count by 2% (Sankovich et al. 2003). The EMAP surveys covered 51% and 55% of the stream kilometers encompassed in the census surveys in 2002 and 2003, respectively. In the relatively small Walla Walla-Umatilla River subbasin, the EMAP surveys (including site set up) and census surveys required about the same effort to complete. In the larger subbasins, the effort required to obtain reasonably precise EMAP estimates was considerably less than what would be needed to conduct census surveys.

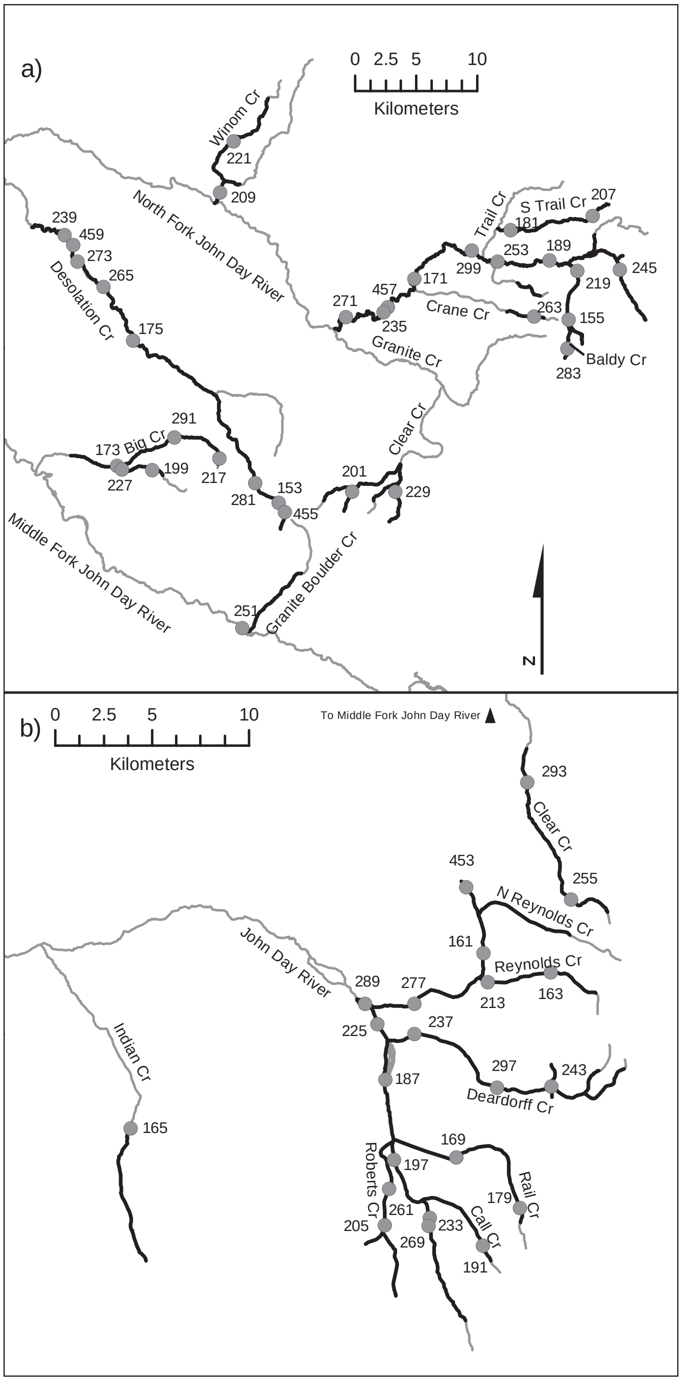
Table 6. Comparison of two strategies used to count bull trout redds in the Walla Walla-Umatilla subbasin in 2003.

	Census	EMAP
Number of redds	682	684
Stream km surveyed	114	62

The accuracy of the estimate for the Walla Walla-Umatilla River subbasin might not reflect that of the estimate for the John Day River subbasin. In the John Day River subbasin, it was more difficult to train crew members to identify redds because there were few redds available to observe. Also, during the surveys, we might have failed to record some bull trout redds in areas where brook trout were present because we counted only redds occupied by bull trout in those areas. Finally, because the sample frame in the John Day River subbasin was less refined, we may have surveyed some stream reaches that were outside the bull trout spawning distribution.

In 2004, the final year of this pilot study, we will continue to take steps to improve the precision and accuracy of our estimates. We will continue conducting surveys more frequently in reaches with sympatric fall-spawning species to increase the probability of observing bull trout on redds. We will also train the two crews in John Day River subbasin in redd identification in the Deschutes River subbasin, where bull trout spawning begins relatively early and ample redds are available for trainees to observe. Finally, we will randomly select 50 new sites per subbasin. This sampling design will allow us to further refine known bull trout spawning distributions and sampling frames for future EMAP efforts.

Figure 5. Location, status, and number of bull trout redds/km for sample sites in a) North and Middle Forks and b) Mainstem John Day River subbasins, OR.



Site	Stream	Status	Redds/Km
153	South Fork Desolation Creek	Surveyed	0.6
155	Baldy Creek	Surveyed	0.0
161	North Reynolds Creek	Surveyed	1.3
163	Reynolds Creek	Surveyed	1.9
165	Indian Creek	Surveyed	0.0
169	Rail Creek	Surveyed	0.0
171	North Fork John Day River	Surveyed	0.0
173	Big Creek	Surveyed	0.0
175	Desolation Creek	Surveyed	0.0
179	Rail Creek	Surveyed	3.1
181	South Trail Creek	Surveyed	0.6
187	John Day River	Denied Permission	--
189	North Fork John Day River	Surveyed	0.0
191	Call Creek	Surveyed	1.3
197	John Day River	Surveyed	1.3
199	Deadwood Creek	Surveyed	3.8
201	East Fork Clear Creek	Surveyed	0.0
205	Roberts Creek	Surveyed	2.5
207	South Trail Creek	Surveyed	0.0
209	Big Creek	Surveyed	0.0
213	Reynolds Creek	Surveyed	0.6
217	Big Creek	Surveyed	0.0
219	Baldy Creek	Surveyed	0.6
221	Winom Creek	Out of Target Area	--
225	John Day River	Denied Permission	--
227	Deadwood Creek	Surveyed	0.0
229	Lightning Creek	Surveyed	0.0
233	John Day River	Surveyed	3.1
235	North Fork John Day River	Surveyed	0.0
237	Deardorff Creek	Surveyed	0.6
239	Desolation Creek	Surveyed	0.0
243	Little Baldy Creek	Surveyed	0.0
245	North Fork John Day River	Surveyed	1.9
251	Granite Boulder Creek	Surveyed	0.0
253	North Fork John Day River	Surveyed	0.0
255	Clear Creek	Dry Channel	--
261	Roberts Creek	Surveyed	0.0
263	Crane Creek	Surveyed	1.9
265	Desolation Creek	Surveyed	0.0
269	John Day River	Surveyed	0.6
271	North Fork John Day River	Surveyed	0.0
273	Desolation Creek	Surveyed	0.0
277	Reynolds Creek	Denied Permission	--
281	South Fork Desolation Creek	Surveyed	0.6
283	Baldy Creek Trib	Surveyed	0.0
289	John Day River	Denied Permission	--
291	Big Creek	Surveyed	0.0
293	Clear Creek	Surveyed	5.0
297	Deardorff Creek	Surveyed	0.0
299	North Fork John Day River	Surveyed	0.0
453	Mossy Gulch	Surveyed	1.9
455	South Fork Desolation Creek	Surveyed	0.6
457	North Fork John Day River	Surveyed	0.0
459	Desolation Creek	Surveyed	0.0

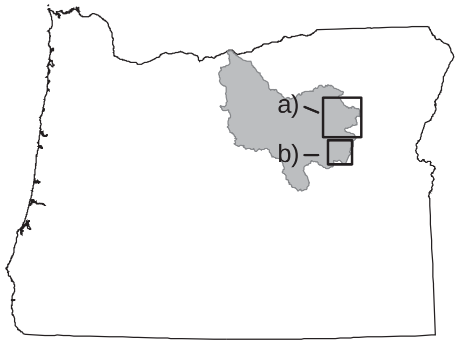
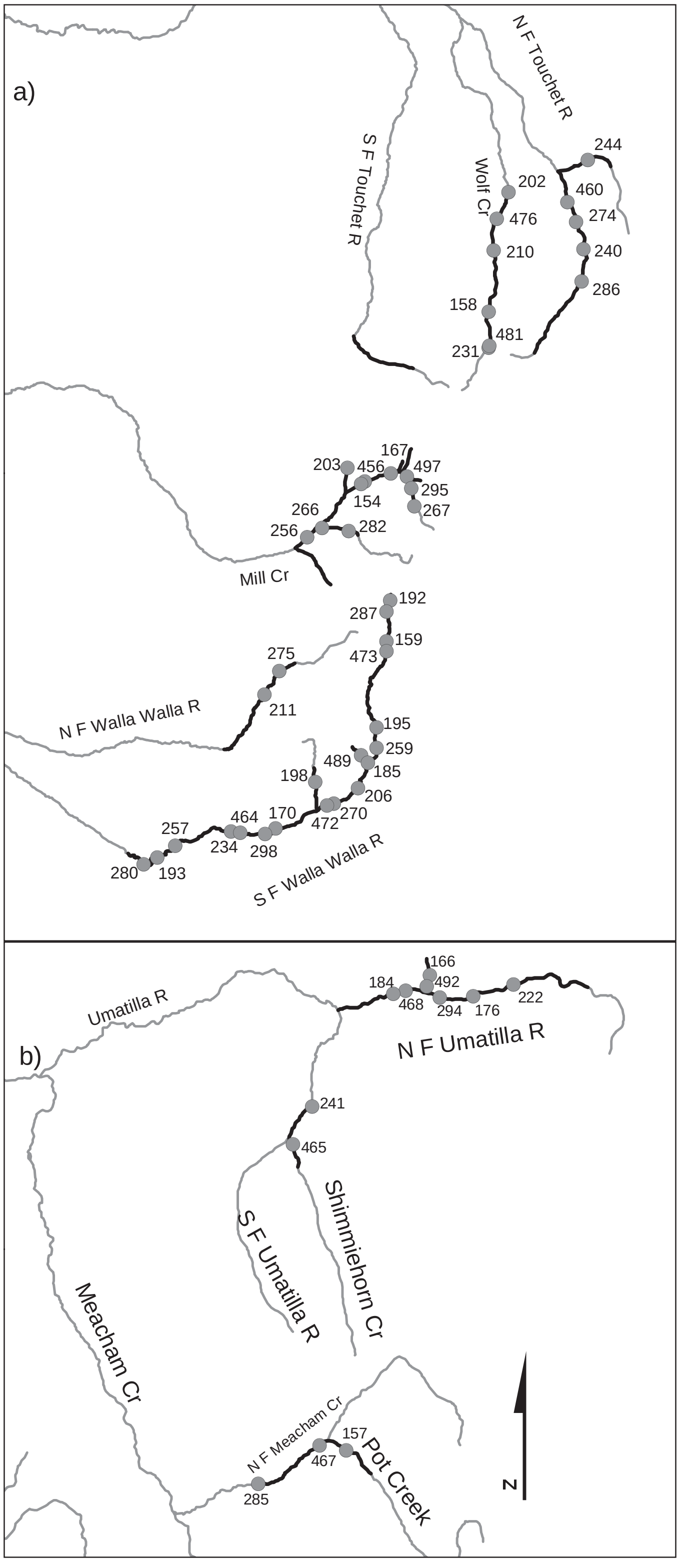
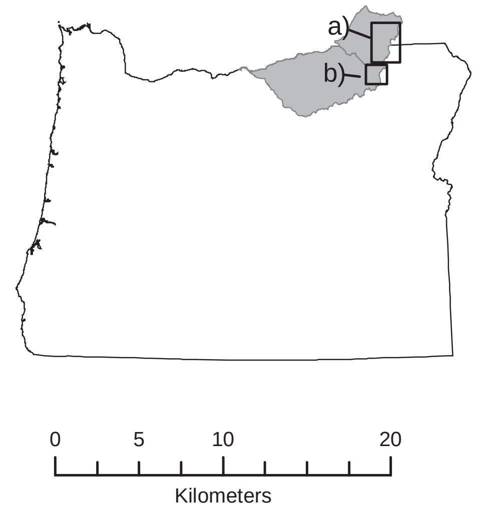


Figure 6. Location, status and number of bull trout redds/km for sample sites in a) Walla Walla River and b) Umatilla River subbasins, OR.



Site	Stream	Status	Redds/Km
154	Mill Creek	Surveyed	10.6
157	Pot Creek	Surveyed	0.0
158	Wolf Creek	Surveyed	7.5
159	South Fork Walla Walla River	Surveyed	1.3
166	Coyote Creek	Surveyed	0.0
167	Mill Creek	Surveyed	6.3
170	South Fork Walla Walla River	Surveyed	11.3
176	North Fork Umatilla River	Surveyed	6.3
184	North Fork Umatilla River	Surveyed	0.0
185	Reser Creek	Surveyed	23.8
192	South Fork Walla Walla River	Out of Target Area	--
193	South Fork Walla Walla River	Surveyed	0.0
195	South Fork Walla Walla River	Surveyed	5.0
198	Skiphorton Creek	Surveyed	0.0
202	Wolf Creek	Surveyed	1.3
203	North Fork Mill Creek	Out of Target Area	--
206	South Fork Walla Walla River	Surveyed	23.1
210	Wolf Creek	Surveyed	17.5
211	North Fork Walla Walla River	Surveyed	0.0
222	North Fork Umatilla River	Surveyed	16.3
231	Wolf Creek	Surveyed	7.4
234	South Fork Walla Walla River	Surveyed	0.6
240	North Fork Touchet River	Surveyed	0.0
241	South Fork Umatilla River	Surveyed	0.0
244	Lewis Creek	Surveyed	0.0
256	Mill Creek	Surveyed	3.1
257	South Fork Walla Walla River	Surveyed	0.0
259	South Fork Walla Walla River	Surveyed	26.3
266	Paradise Creek	Surveyed	1.0
267	Mill Creek	Out of Target Area	--
270	South Fork Walla Walla River	Surveyed	21.9
274	North Fork Touchet River	Surveyed	0.0
275	North Fork Walla Walla River	Surveyed	0.0
280	South Fork Walla Walla River	Surveyed	0.0
282	Paradise Creek	Surveyed	0.0
285	North Fork Meacham Creek	Surveyed	0.0
286	North Fork Touchet River	Did Not Survey	--
287	South Fork Walla Walla River	Out of Target Area	--
294	North Fork Umatilla River	Surveyed	3.1
295	Mill Creek	Surveyed	11.9
298	South Fork Walla Walla River	Surveyed	5.6
456	Mill Creek	Surveyed	9.4
460	North Fork Touchet River	Surveyed	0.0
464	South Fork Walla Walla River	Surveyed	3.8
465	Shimmiehorn Creek	Surveyed	0.0
467	North Fork Meacham Creek	Surveyed	0.0
468	North Fork Umatilla River	Surveyed	3.8
472	South Fork Walla Walla River	Surveyed	26.3
473	South Fork Walla Walla River	Surveyed	3.1
476	Wolf Creek	Surveyed	2.5
481	Wolf Creek	Surveyed	6.4
489	Reser Creek	Surveyed	23.2
492	Coyote Creek	Surveyed	0.0
497	Green Fork Mill Creek	Out of Target Area	0.0



Acknowledgements

We are grateful to the following individuals for their assistance in the field: Alex Higgins, Lesley Jones, Matthew Weeber, Tracy Wilson, Karen Lashenske, Edward Imholt, Tatnai Burnett, Christopher Uraneck, Robert Torell, Tim Plawman, and Christopher Wold of ODFW; Marshall Barrows, Tad Kisaka, and Darren Gallion of the USFWS; Jeremy Trump, Mike Gembala, Chris Fulton, Justin Steinhoff, Derek Gloyn, Joe Zelinski, and Rob Martin of the WDFW; and Troy Baker. We thank Tim Bailey, Tim Unterwegner, and Jeff Neil of ODFW for their cooperation and assistance in the field; Tim Whitesel of the USFWS for recruiting and organizing volunteers; Glen Mendel of WDFW for his cooperation and for supervising and coordinating work on the Touchet River, Washington; Ralph Hartman and Craig Smith-Dixon of the North Fork John Day Ranger District for permission to locate a crew at the Fremont Powerhouse and Joe Batty for his hospitality; Mark Kersh of ODFW for assistance with pack horses; Michael Leake of Union Pacific Railroad for permission to survey in NF Meacham Creek; Dan Bishop of Prairie Wood Products for cooperation and permission to access private land; and many other landowners for permission to access their private land. Senior Trooper Ken West of the Oregon State Police piloted the aircraft we used for telemetry flights.

References

Bonar, S.A., M. Divens, and B. Bolding. 1997. Methods for sampling the distribution and abundance of bull trout and Dolly Varden. Washington Department of Fish and Wildlife, Olympia, WA.

Bonneau, J., and LaBar. 1997. Interobserver and temporal bull trout redd count variability in tributaries to of Lake Pend Oreille, Idaho: Completion Report. Department of Fisheries and Wildlife, University of Idaho, Moscow.

Buchanan, D.V., M. Hanson, and B. Hooton. 1997. Bull trout status report for Oregon. Oregon Department of Fish and Wildlife. Portland, OR.

Dunham, J., B. Rieman, and K. Davis. 2001. Sources and magnitude of sampling error in redd counts for bull trout *Salvelinus confluentus*. North American Journal of Fisheries Management 21: 343-352.

Fraley, J. J., and B. B. Shepard. 1989. Life history, ecology, and population status of migratory bull trout (*Salvelinus confluentus*) in the Flathead Lake river system, Montana. Northwest Science 63 (4): 133-143.

Hankin, D.G. 1986. Sampling designs for estimating the total number of fish in small streams. Research Paper PNW-360. USDA Forest Service, Pacific Northwest Research Station. Portland, OR.

Hemmingsen, A.R., S.L. Gunckel, P.M. Sankovich, and P.J. Howell. 2001a. Bull trout life history, genetics, habitat needs, and limiting factors in central and northeast Oregon. 2000 Annual Report. Project 199405400, Bonneville Power Administration. Portland, OR.

Hemmingsen, A.R., B.L. Bellerud, and S.L. Gunckel. 2001b. Bull trout life history, genetics, habitat needs, and limiting factors in central and northeast Oregon. 1998 Annual Report. Project 199405400, Bonneville Power Administration. Portland, OR.

Hemmingsen, A.R., S.L. Gunckel, and P.J. Howell. 2001c. Bull trout life history, genetics, habitat needs, and limiting factors in central and northeast Oregon. 1999 Annual Report. Project 199405400, Bonneville Power Administration. Portland, OR.

Hemmingsen, A.R., S.L. Gunckel, J.S. Shappart, B.L. Bellerud, D.V. Buchanan, and P.J. Howell. 2001d. Bull trout life history, genetics, habitat needs, and limiting factors in central and northeast Oregon. 1997 Annual Report. Project 199405400, Bonneville Power Administration. Portland, OR.

Hemmingsen, A.R., S.L. Gunckel, P.M. Sankovich, and P.J. Howell. 2002. Bull trout life history, genetics, habitat needs, and limiting factors in central and northeast Oregon. 2001 Annual Report. Project 199405400, Bonneville Power Administration. Portland, OR.

Maxell, B. A. 1999. A prospective power analysis on the monitoring of bull trout stocks using redd counts. North American Journal of Fisheries Management 19:860-866.

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

Rieman, B.E., and J.B. Dunham. 2000. Metapopulations and salmonids: a synthesis of life history patterns and empirical observations. Ecology of Freshwater Fish 9:51-64.

Rieman, B.E., and J.D. McIntyre. 1993. Demographic and habitat requirements for conservation of bull trout. General Technical Report INT-302, Intermountain Research Station, Ogden, UT.

Rieman, B.E., and D.L. Myers. 1997. Use of redd counts to detect trends in bull trout (Salvelinus confluentus) populations. Conservation Biology 11(4): 1015-1018.

Sankovich, P.M., S.L. Gunckel, A.R. Hemmingsen, I.A. Tattam, and P.J. Howell. 2003. Migratory patterns, structure, abundance, and status of bull trout populations from subbasins in the Columbia Plateau. 2002 Annual Report. Project 199405400. Bonneville Power Administration, Portland, OR.

Spruell, P., and F.W. Allendorff. 1997. Nuclear DNA analysis of Oregon bull trout, Report 97/5. Oregon Department of Fish and Wildlife. Portland, OR.

Spruell, P, A.R. Hemmingsen, P.J. Howell, N. Kanda, and F.W. Allendorf. 2003. Conservation genetics of bull trout: geographic distribution of variation at microsatellite loci. Conservation Genetics 4: 17-29.

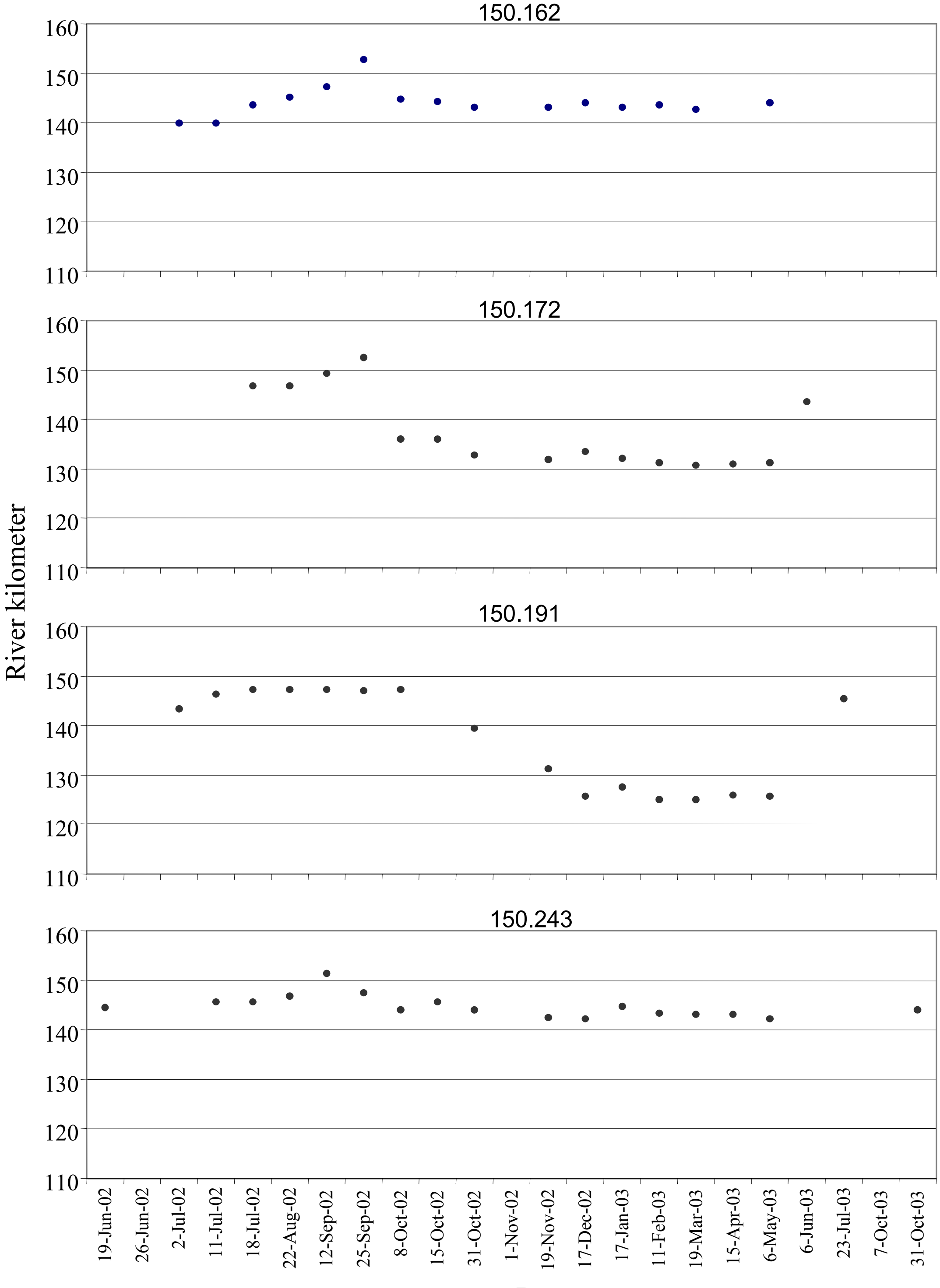
Spruell P., B.E. Rieman, K.L. Knudsen, F. M. Utter, and F.M. Allendorf. 1999. Genetic population structure within streams: microsatellite analysis of bull trout populations. Ecology of Freshwater Fish 8: 114-121.

Stevens, D.L., Jr. 2002. Sampling design and statistical analysis methods for integrated biological and physical monitoring of Oregon streams. OPSW-ODFW-2002-07, Oregon Department of Fish and Wildlife, Portland, Oregon.

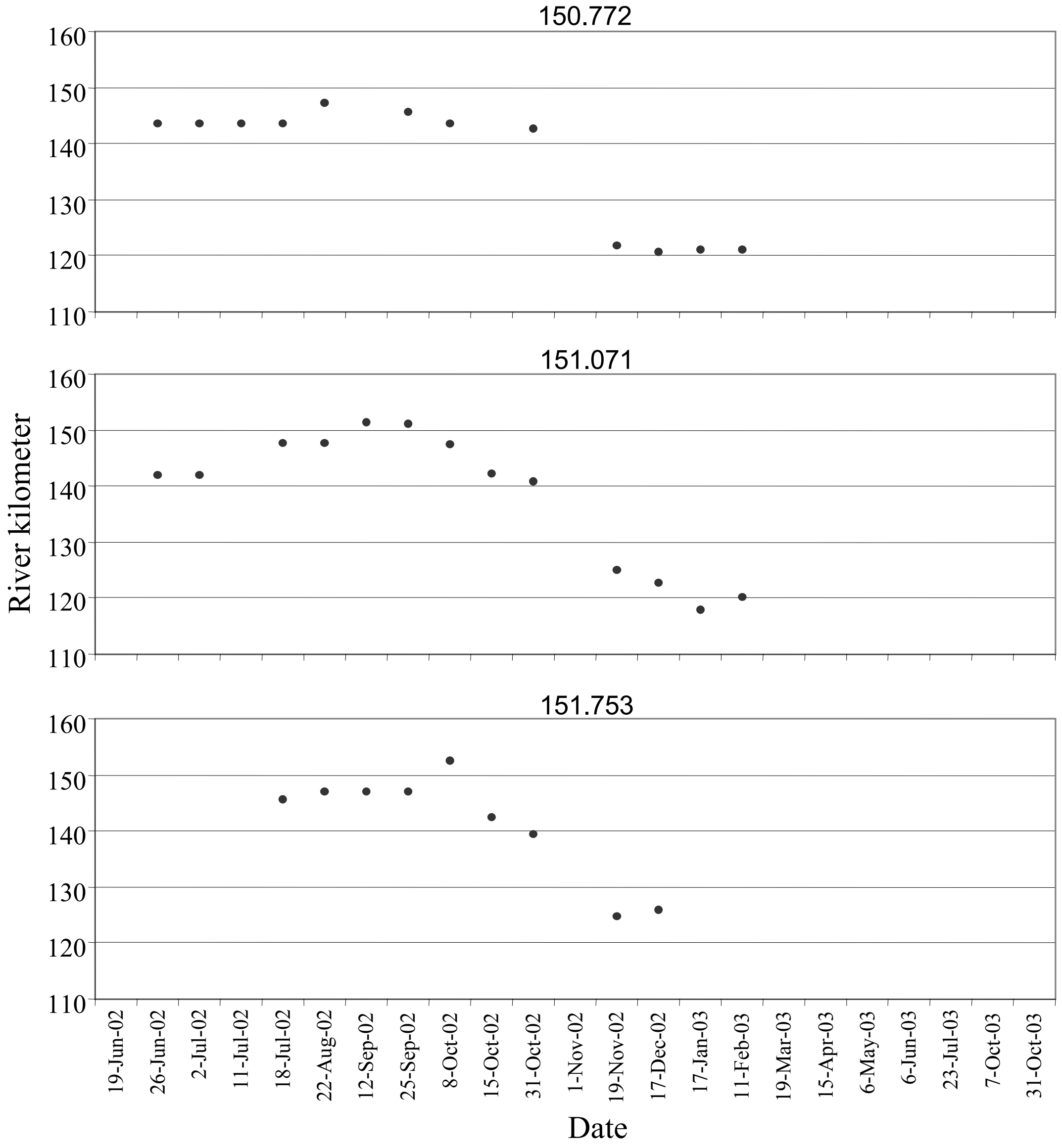
Stevens, D.L., Jr., and A.R. Olsen. 1999. Spatially restricted surveys over time for aquatic resources. Journal of Agriculture, Biological, and Environmental Statistics 4: 415-428.

U.S. Fish and Wildlife Service. 2002. Chapter 11, Umatilla-Walla Walla Recovery Unit, Oregon and Washinton. 153 p. *In*: U.S. Fish and Wildlife Service. Bull Trout (*Salvelinus confluentus*) Draft Recovery Plan. Portland, Oregon.

Appendix A. Movements of radio-tagged bull trout in the Umatilla River subbasin



Appendix Figure A-1. Locations of bull trout with radio tag freqencies 150.162, 150.172, 150.191, and 150.243 during tracking events from June 2002 through October 2003. River kilometers are continuous from the mouth of the Umatilla River into the North Fork Umatilla River. The North Fork Umatilla River enters the Umatilla River at river kilometer 144.



Appendix Figure A-2. Locations of bull trout with radio tag freqencies 150.772, 151.071, and 151.753 during tracking events from June 2002 through October 2003. River kilometers are continuous from the mouth of the Umatilla River into the North Fork Umatilla River. The North Fork Umatilla River enters the Umatilla River at river kilometer 144.

Appendix Table A-1. Locations of radio-tagged bull trout in the Umatilla and North Fork Umatilla rivers during tracking events from June 2002 to October 2003. River kilometers are continuous from the mouth of the Umatilla River into the North Fork Umatilla River. The North Fork Umatilla River enters the Umatilla River at river kilometer144. River kilometers in italics indicate tag recoveries (i.e., the fish was dead or had rejected its tag).

Date	Radio tag frequency														
	150.162	150.172	150.182	150.191	150.212	150.223	150.232	150.243	150.252	150.752	150.772	150.792	151.071	151.291	151.753
6/19/02			137.6				137.6	144.4		143.6		142.3		138.3	
6/26/02							137.6		137.6	143.6	143.6	142.3	142.0	138.7	
7/2/02	139.9			143.2			143.2		141.8	143.6	143.6	143.6	141.8	138.4	
7/11/02	139.9			146.3		145.5	143.6	145.5	145.5	144.0	143.6			139.9	
7/18/02	143.6	146.6		147.2	146.8	145.3	147.4	145.6	150.0	145.8	143.6	147.6	147.7	138.4	145.5
8/22/02	145.0	146.8	151.9	147.1	147.2	146.4	151.6	146.8	150.1	150.0	147.1	149.7	147.6	143.6	146.9
9/12/02	147.1	149.2	152.1	147.1	150.0	146.1	151.6	151.3	150.0	149.8		149.5	151.3	147.2	146.9
9/25/02	152.7	152.4		146.9	152.2	151.7	151.3	147.4	150.0	149.8	145.5	149.5	151.1	152.5	146.9
10/8/02	144.5	135.9		147.1	152.1	153.0	151.4	143.9	152.7	147.4	143.6	149.7	147.4	152.7	152.5
10/15/02	144.2	135.9						145.6					142.1		142.3
10/31/02	143.1	132.8	*152.9*	139.4	151.3	153.0	*151.4*	144.0		147.7	142.6		140.7	*152.7*	139.4
11/1/02					*151.4*	*153.0*			*152.7*	*147.4*		*149.7*			
11/19/02	143.1	131.8		131.2				142.4			121.7		125.0		124.6
12/17/02	144.0	133.3		125.6				142.1			120.5		122.5		125.9
1/17/03	142.9	132.0		127.5				144.7			121.1		117.9		
2/11/03	143.4	131.2		125.0				143.2			120.9		120.0		
3/19/03	142.6	130.6		125.0				142.9							
4/15/03		130.9		125.9				142.9							
5/6/03	143.9	131.0		125.6				142.1							
6/6/03		143.6													
7/23/03				145.4											
10/7/03															
10/31/03								144.0							