

Review of bull trout redd observations in the Entiat River, 1994 – 2008¹

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Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the U. S. Fish and Wildlife Service.

Abstract

All known observations of bull trout *Salvelinus confluentus* redds in the main-stem Entiat River are reviewed. Reports of bull trout redds from bull trout spawning ground surveys, spring and summer Chinook salmon *Oncorhynchus tshawytscha* spawning ground surveys, and incidental observations are summarized and analyzed. Based on definitive observations of bull trout on redds, the furthest downstream known bull trout redd is at river mile 29 of the Entiat River. The multiple lines of evidence presented and analyzed in this review support the conclusion that there are no known bull trout redds observed downstream of river mile 29. Based on radio-telemetry information, stream temperatures, and the high probability that incomplete, abandoned, or small Chinook salmon redds or sockeye salmon *O. nerka* redds were misidentified as bull trout redds, none of the redds originally judged as bull trout during salmon spawning surveys in reaches 2, 3, 4, and 5 (river miles 16.2 – 26) are found to be credible. Five redds originally judged as bull trout during salmon spawning surveys in reach 1 (river miles 26 – 28.1) in the vicinity of river mile 27 have somewhat less uncertainty but are not known to be bull trout. Although stream temperatures are not as high in reach 1 during some years, the fact that both spring and summer Chinook salmon redds occur in this reach (as well as upstream), and coupled with the known misjudgment of incomplete Chinook salmon redds in the immediate vicinity as well as the history of misjudgments in the downstream reaches, none of these redds are found credible. Therefore, at this time and under current stream conditions, bull trout are not known to spawn in the reaches of the main-stem Entiat River downstream of Lake Creek (rm 29). Continued surveys with definitive confirmation of bull trout redds and stream temperature monitoring may assist in refining the downstream boundary of bull trout spawning in the main-stem Entiat River.

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Introduction

The principles and traditions of the scientific method obligate fish biologists to constantly evaluate data and hypotheses, to openly share findings and submit them to review, and to refine our understanding and knowledge of fish biology. This is necessary if we are to use sound science and the best available information to promote conservation and recovery of listed fishes. It is especially important for bull trout *Salvelinus confluentus*, where accurate measurements in redd counts are essential for the statistical power needed to detect changes during the monitoring of populations (Maxell 1999).

This review is an attempt to clearly define the spawning distribution of bull trout in the Entiat River. We summarize previous observations of bull trout redds from several different salmonid surveys and projects. We review U.S. Fish and Wildlife Service (USFWS) Mid Columbia River Fishery Resource Office (MCRFRO) and U.S. Forest Service (USFS) Entiat Ranger District reports which include observations from formal bull trout spawning ground surveys (river mile 29.2 – 33.8), opportunistic surveys for bull trout from Fox Creek to Box Canyon (rm 28.1 – 29.1), in Box Canyon (rm 29.1 – 29.2), and incidental observations of redds judged to be bull trout during spring and summer Chinook salmon *Oncorhynchus tshawytscha* spawning ground surveys (river mile 16.2 - 28.1). The locations of these reaches in the Entiat River are shown in Figure 1. When possible, field notes and maps or other documents related to the salmon surveys were also examined. Some of the salmon surveyors (D. Carie, M. Cooper, C. Hamstreet, B. Kelly-Ringel, R. Nelle, and M. Nelson) were informally interviewed about their recollections and methods of judging redds. Relevant stream temperature reports and radio-telemetry information were also examined. In the end, the analysis of multiple lines of evidence is used to reach conclusions regarding the likely downstream boundary of bull trout spawning in the main-stem of the Entiat River.

This review is not intended as a criticism of the many surveyors who put in long hours on the numerous spawning ground surveys that gather valuable information on the numbers and distribution of spawning salmonids in the Entiat River. Nor is it an evaluation of their skill in identifying salmonid redds. The authors are experienced redd surveyors who themselves participated in many of these spawning ground surveys and are well aware of the many pitfalls and second guessing that can develop over redd identifications. Indeed, there are many sources of error in redd counts no matter the species (Schwartzburg and Roger 1986, Dunham et al. 2001, Al-Chokhachy et al. 2005, Gallagher and Gallagher 2005, Muhlfeld et al. 2006, Holecek and Walters 2007).

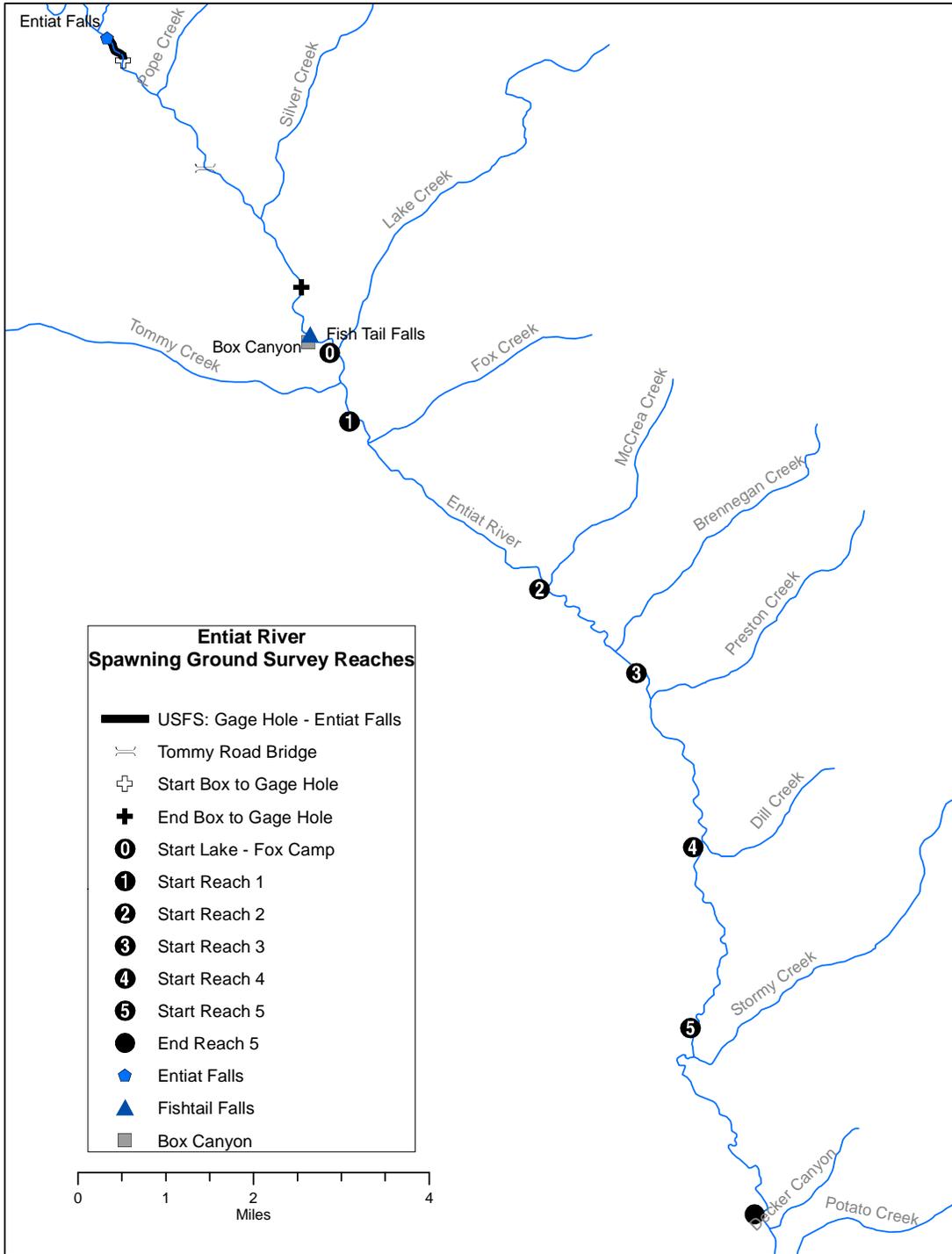


Figure 1. Map of all spawning ground survey reaches in the Entiat River.

Spawning Ground Survey Methods

Formal bull trout spawning ground surveys-

*Washington Department of Ecology (WDOE) gage station below Entiat Falls to Entiat Falls (rm 33.5 - 33.8)*²- During 1993 to 2002, incidental sightings of bull trout were recorded by USFS personnel at the WDOE gage station pool located just below Entiat Falls at river mile 33.5. Beginning in the autumn of 2002, USFS biologists conducted a short survey from the WDOE gage station pool below Entiat Falls to Entiat Falls (approx. 0.3 miles) and now survey this section every year using standard bull trout redd survey methods (Archibald and Johnson 2006).

Box Canyon to WDOE gage station below Entiat Falls (rm 29.2 - 33.5)- As part of an ongoing multiyear radio-telemetry study, the Entiat River from just upstream of Fishtail Falls at Box Canyon to the Entiat Falls gage station has been surveyed during the bull trout spawning season (mid-September to late October) since 2004 by MCRFRO. The survey was divided into two reaches, from the gage station down to the Tommy Road Bridge (Reach A) and from the bridge down to a location just upstream of Fishtail Falls and Box Canyon (Reach B). A team of 2 surveyors, with a least one member experienced in bull trout surveys, used standard bull trout spawning ground survey methods while surveying in a downstream direction. Each reach was surveyed on 3 dates during the bull trout spawning season, with surveys occurring approximately every 2 weeks. GPS coordinates of redd locations and notes regarding the location and characteristics were recorded. Dimensions of all redds encountered are recorded, and redds which are not identifiable to species were labeled as unknown (Nelson and Nelle 2007). Survey notes were recorded in rainproof field note books and archived at MCRFRO.

Opportunistic surveys for bull trout-

Lake Creek Campground to Box Canyon (rm 28.9 – 29.2)- In September and October of 2008, the first bull trout redd surveys in Box Canyon were conducted by MCRFRO. Surveyors wore dry suits and snorkeled to look for redds in deep areas and walked in other areas. Two surveys were conducted in a downstream direction, from the slot pool (2nd uppermost pool) to the downstream terminus of the canyon walls. The survey then continued to Lake Creek Campground. The number of bull trout redds, redd location, redd dimensions, number of bull trout observed on redds, and total number of bull trout observed were recorded.

Fox Creek Campground to Lake Creek Campground (rm 28.1 – 28.9)- In September and October of 2004, 2006, 2007 and 2008 MCRFRO conducted bull trout surveys from Fox Creek Campground to Lake Creek Campground. Depending on the year, surveys were conducted in either stream direction. This reach was also intermittently surveyed during salmon spawning ground surveys.

²River mile designations are dependent on the source map and are not necessarily uniform or exact so there may be slight variations between the reports of different agencies.

Incidental surveys for bull trout-

Spring and summer Chinook spawning ground surveys (rm 16.2 – 28.1)- The Entiat River from McKenzie Diversion (rm 16.2) to Fox Creek Campground (rm 28.1) has been surveyed by MCRFRO for spring and summer Chinook salmon redds since 1994 (Kelly 1995; Carie 1996, 1997, 1998, 1999, 2000; Carie and Hamstreet 2001, 2002, 2003, 2004; Hamstreet 2005, 2006, 2007, 2008). Incidental observations of bull trout, sockeye salmon *Oncorhynchus nerka* and coho salmon *O. kisutch* were recorded. Surveys were conducted in the downstream direction and the survey area was divided into 5 reaches: reach 1 (rm 28.1 - 25.8), reach 2 (rm 25.8 - 23.4), reach 3 (rm 23.4 - 21.3), reach 4 (rm 21.3 -18.7), and reach 5 (rm 18.7 - 16.2). Surveys were usually conducted from mid September to late October; the earliest survey was on September 4 and the latest on November 18. An estimated 50 different surveyors have participated in these surveys. In 1994, the ancillary objective of searching for sockeye salmon redds was stated, but no mention was made of bull trout (Kelly 1995). In 1999, the survey report included the ancillary objective “*to search for and note the presence of bull trout and/or redds and identify spawning distribution in the Entiat River*” (Carie 2000). In the 2001 report, the method section contained the first description of how other redds were distinguished - “*bull trout redds are generally smaller in size and utilize smaller substrate than SCS [spring Chinook salmon] and SUS [summer Chinook salmon] redds. Sockeye and coho salmon redds were identified ... through observation of fish on occupied redds*” (Carie and Hamstreet 2002). Prior to 2006, few dimensions of redds were recorded, and only minimal information related to redds judged to be bull trout is recorded in field notebooks. Many of the early notebooks may not have been preserved, and prior to 2000, the archival record is spotty. Since 2000, field forms, maps, and notes have been organized and archived in the files at MCRFRO.

Survey Results

WDOE gage station to Entiat Falls (rm 33.5 - 33.8)- From 1 to 16 bull trout redds have been counted during USFS bull trout spawning ground surveys from the tail-out of the gage station pool to Entiat Falls (Table 1) (Archibald and Johnson 2006, P. Archibald pers. comm.). Paired bull trout were occasionally observed on redds during or prior to these surveys. No Chinook or sockeye salmon redds have been observed in this reach.

Box Canyon to WDOE gage station (rm 29.2 - 33.5)- Formal bull trout redd surveys were first conducted by MCRFRO in this reach in 2004. From 2004 to 2008, 7 to 40 bull trout redds have been counted from Box Canyon to the gage station (Table 2, Figure 2)). Bull trout are occasionally seen on redds, including digging females. Most of the fluvial bull trout redds in the Entiat River were counted in this reach. In 2005, a total of 8 spring Chinook salmon redds and 1 spawned out female Chinook carcass were recorded (Table 2). These were the first documented spring Chinook salmon redds located above Box Canyon, and prior to these observations, Fishtail Falls at Box Canyon was generally considered the upper limit to anadromous salmon migrations (see Nelson and Nelle 2007). Five “redds” could not be identified to species and were recorded as unknown. In 2006, radio-telemetry monitoring of tagged bull trout documented that obstructions in

Box Canyon impeded the upstream migrations of fluvial bull trout. Prior to 2006, an average of 67 % of tagged bull trout passed Box Canyon, but from 2006 to 2008, the percentage declined from 25 to 0 % (Nelson 2008, MCRFRO data in files).

Correspondingly, the number of redds observed upstream on the optimal spawning grounds declined each year (Table 2).

Table 1. Number of bull trout redds observed during USFS incidental spot check surveys and formal spawning surveys from river mile 33.5 – 33.8 of the Entiat River, 1994 – 2008.

Year	n redds SCS	n redds SUS	n redds SOS	n redds judged BT	n redds w/ BT	n bull trout obs	River mile of redds judged BT
1994	0	0	0	3	0	0	33.5
1995	0	0	0	3	1 ^a	2	33.5
1996	0	0	0	0	0	0	-
1997	0	0	0	0	0	0	-
1998	0	0	0	1	0	0	33.5
1999	0	0	0	0	0	0	-
2000	0	0	0	1	0	0	33.5
2001	0	0	0	3	1 ^b	2	33.5
2002	0	0	0	7	0	0	33.5 – 33.8
2003	0	0	0	5	3	5	33.5 – 33.8
2004	0	0	0	6	0	1	33.5 – 33.8
2005	0	0	0	16	0	0	33.5 – 33.8
2006	0	0	0	3	0	3	33.5 – 33.8
2007	0	0	0	4	0	0	33.5 – 33.8
2008	0	0	0	2	0	0	33.5
totals	0	0	0	54	5	13	33.5 – 33.8

Note: a = pair observed on redd, b = pair videotaped on redd, SCS = spring Chinook salmon, SUS = summer Chinook salmon, SOS = sockeye salmon, BT = bull trout.

Table 2. Number of bull trout redds observed during formal spawning ground surveys from river mile 29.2 – 33.5 in the Entiat River, 2004 – 2008.

Year	n redds SCS	n redds SUS	n redds unk	n redds judged BT	n redds w/ BT	n bull trout obs	River mile of redds judged BT
2004	0	0	0	40	2	6	30.3 – 32.6
2005	8	0	5	34	3	14	30.4 – 32.6
2006	0	0	0	18	0	5	30.9 – 33.3
2007	0	0	0	8	0	0	31.2 – 32.5
2008	0	0	0	7	0	0	31.0 – 32.5
totals	8	0	5	97	5	25	30.3 – 33.3

Note: Reach not surveyed prior to 2004. SCS = spring Chinook salmon, SUS = summer Chinook salmon, BT = bull trout.

Lake Creek Campground to slot pool in Box Canyon (rm 28.9 – 29.2)- On September 16, 2008, a female fluvial bull trout attended by a fluvial male was observed and photographed digging a redd just downstream of the vista on the canyon rim at river mile 29.15. This observation prompted the first survey to be conducted within Box Canyon. On September 26, 2008 a total of 13 bull trout redds were found in this reach from river mile 28.9 – 29.2 (Table 3). Twelve redds were located within Box Canyon and 1 redd was a short distance downstream of the canyon walls at river mile 29.0. Adult fluvial bull trout were observed on 4 redds. A pair of spring Chinook salmon on a redd was also observed in this reach (Table 3). No new redds were observed on the follow up survey.

Table 3. Number of bull trout redds observed during bull trout spawning ground surveys from river mile 28.9 - 29.2 of the Entiat River, 2008.

Year	n redds SCS	n redds SUS	n redds SOS	n redds judged BT	n redds w/ BT	n bull trout obs	River mile of redds judged BT
2008	1	0	0	13	4	9	29.0 – 29.15
totals	1	0	0	13	4	9	29.0 – 29.15

Note: Reach not surveyed prior to 2008. SCS = spring Chinook salmon, SUS = summer Chinook salmon, SOS = sockeye salmon, BT = bull trout.

Fox Creek Campground to Lake Creek Campground (rm 28.2 – 28.9)- This reach has been surveyed in 6 years since 1994, both as an extension of spring Chinook salmon spawning ground surveys and as an extension of bull trout spawning ground surveys. No bull trout redds were found during any of the surveys from Fox Creek Campground to Lake Creek Campground. A total of 5 spring Chinook salmon redds have been counted in this reach since 1994 (Table 4).

Table 4. Number of bull trout redds observed during spawning ground surveys from river mile 28.2 - 28.9 of the Entiat River, 1994 - 2008.

Year	n redds SCS	n redds SUS	n redds SOS	n redds judged BT	n redds w/ BT	n bull trout obs	River mile of redds judged BT
1994	2	0	0	0	0	0	
95-99	-	-	-	-	-	-	
2000	-	-	-	-	-	-	
2001	1	0	0	0	0	0	
02-03	-	-	-	-	-	-	
2004	2	0	0	0	0	0	
2005	-	-	-	-	-	-	
2006	0	0	0	0	0	0	
2007	0	0	0	0	0	1	
2008	0	0	0	0	0	1	
totals	5	0	0	0	0	2	

Notes: Hyphen (-) indicates the reach was not surveyed in that year, SCS = spring Chinook salmon, SUS = summer Chinook salmon, SOS = sockeye salmon, BT = bull trout.

Spring and summer Chinook spawning ground surveys (rm 16.2 – 28.1)- The first redds judged as bull trout during salmon spawning ground surveys were noted in the 1996 survey. From 1996 to 2008 surveyors have judged that 20 redds belong to bull trout in this area of the Entiat River (Table 5). Redds were judged as bull trout in 7 of 15 years. Seventy percent of all redds judged as bull trout occurred in 2 years: 6 redds in 1999 and 8 in 2006. Only one redd with a live bull trout near it (not on it and distance or location not recorded) has been reported (in 1996 at river mile 18.7). Redds were judged as bull trout in all reaches (Figure 2). The furthest upstream redd was at river mile 27.4, downstream of Fox Creek near the spawning channel. The furthest downstream locations were between river mile 16.5 - 17.0 in 1999, and near river mile 16.3 in 2006. Sixteen adult bull trout have been observed during the surveys.

Table 5. Numbers of spring and summer Chinook salmon redds, sockeye salmon redds, and judged bull trout redds observed during salmon spawning ground surveys from river mile 16.2 - 28.2 of the Entiat River, 1994 - 2008.

Year	n redds SCS	n redds SUS	n redds SOS	n redds judged BT	n redds w/ BT	n bull trout obs	River mile of redds judged BT
1994 ^a	34	30	0	0	0	0	
1995 ^a	10	40	0	0	0	0	
1996 ^a	20	53	0	2	0	1	18.7, 19.7
1997 ^a	37	25	0	0	0	0	
1998 ^a	23	42	3	1	0	1	27.4
1999	26	41	0	6	0	0	16.5 – 17, 19, 27
2000	69	72	2	0	0	0	
2001	200	23	10	1	0	3	21.4
2002	110	136	139	0	0	1	
2003	106	73	15	0	0	4	
2004	118	65	39	1	0	0	24
2005	137	79	42	0	0	2	
2006	104	152	9	8	0	3	16.3, 20.4, 22, 25, 27.3
2007	102	35	1	0	0	1	
2008	113	49	16	1	0	0	20.7
totals	1209	915	276	20	0	16	16.3 – 27.4

Notes: a = surveying for bull trout not an objective in these years, SCS = spring Chinook salmon, SUS = summer Chinook salmon, SOS = sockeye salmon, BT = bull trout.

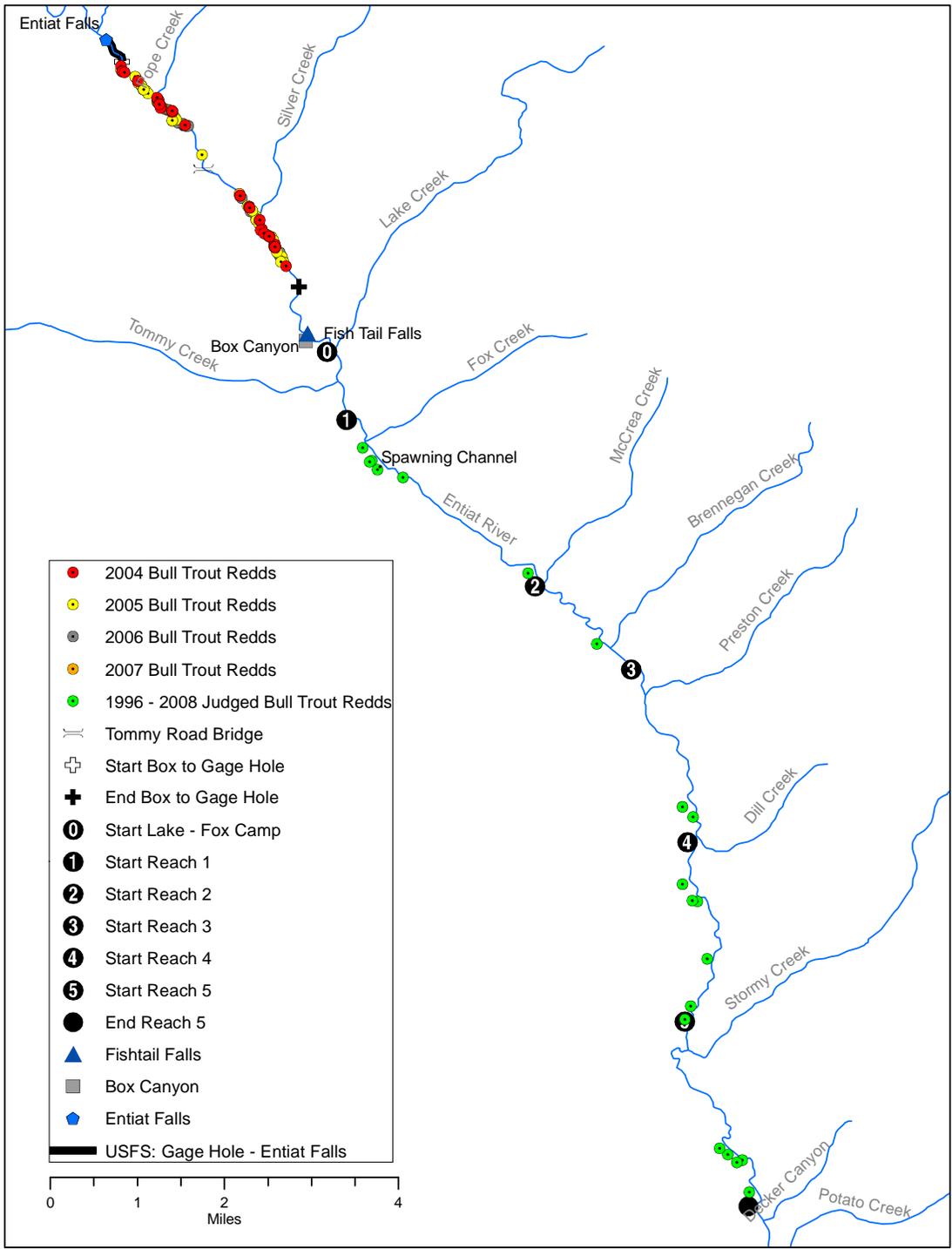


Figure 2. Map of locations of redds judged to be bull trout during salmon spawning ground surveys 1996 - 2008. The locations of known bull trout redds recorded during the Box Canyon to Gage Hole bull trout surveys during 2004 - 2007 are also shown.

Radio-telemetry dates of bull trout movements- During radio-telemetry studies of adult fluvial bull trout conducted by MCRFRO in the Entiat River from 2003 - 2006, fixed telemetry stations recorded the movement dates of tagged bull trout (Nelson 2008). Fixed stations were located upstream of Box Canyon (BC), downstream of Box Canyon (DB), at Shorty Long's (SH) property near McKenzie Diversion, at the mouth of the Mad River (MD), and at Bob Whitehall's property (ER) at river mile 3.2 (Table 6). As recorded at the BC station (rm 29.2), the date that post-spawning tagged bull trout first migrated downstream from the upper bull trout spawning grounds was September 13 in 2005, September 25 in 2006, and September 27 in 2004 (Table 6). Tagged bull trout were first detected at the SH station (rm 16.2) on September 23 in 2004 and September 25 in 2005 (Table 6). Post-spawning bull trout from the upper bull trout spawning grounds were also monitored by foot and truck tracking while they were present in the salmon spawning reaches, and no tagged bull trout were tracked to or located on redds (Nelson 2008).

Table 6. Dates that radio-tagged bull trout moved downstream past fixed telemetry stations during post-spawning migrations in the Entiat River, 2003 - 2006.

Station:	BC	DB	SH	MD	ER
Year	(rm 29.2)	(rm 29)	(rm 16.2)	(rm 10.3)	(rm 3.2)
2003	not monitored	not monitored	not monitored	3-Oct to 8-Nov	6-Oct to 23-Nov
2004	27-Sep to 26-Oct	not monitored	23-Sep to 19-Oct	23-Sep to 19-Oct	25-Sep to 21-Nov
2005	13-Sep to 8-Oct	17-Sep to 8-Oct	25-Sep to 31-Oct	25-Sep to 1-Nov	27-Sep to 11-Dec
2006	25-Sept to 8-Oct	not monitored	not monitored	20-Sep to 5-Nov	28-Sep to 20-Oct ¹

Table from Nelson (2008). Notes: 1 = Station not recording after 20-October, BC = station upstream of Box Canyon, DB = station downstream of Box Canyon, SH = station at Shorty Long's near McKenzie Diversion, MD = station at mouth of Mad River, ER = station at Bob Whitehall's property upstream of mouth of Entiat River.

Stream temperature data- In the bull trout spawning and rearing reaches upstream of Box Canyon (rm 29.2 – 33.8) maximum weekly maximum temperatures (MWMT) ranged from 13.5 – 16.4 °C during 2003 to 2006. Downstream of Box Canyon at the Forest Boundary (rm 26), MWMT ranged from 15.1 – 18.7°C during 2000 to 2005 (Table 7). Near Stormy Creek (rm 18) MWMT ranged from 17.4 – 20.2°C during 2000 to 2004 (Table 7). Thermal infrared remote sensing (TIR) data collected on August 11, 2001 recorded stream temperatures of 17.5 – 20.2°C in the reaches from river miles 16 to 28 (Figure 3, Watershed Sciences 2002).

Table 7. Stream maximum weekly maximum temperatures (MWMT) at monitoring stations in the Entiat River, 2000 - 2006.

Year	@ Stormy Cr (rm 18)	@ Forest bndry (rm 26)	@ Silver Cr (rm 32)	@ EF gage (rm 33.5)
2000	17.4	15.1	-	-
2001	20.1	17.9	-	-
2002	17.6	15.6	-	-
2003	19.6	17.2	14.7	14.1
2004	20.2	18.5	16.4	15.7
2005	-	18.7	16.3	16.1
2006	-	-	-	13.5

Table from USFS data in Nelson (2008). Notes: Hyphen (-) indicates data not currently available.

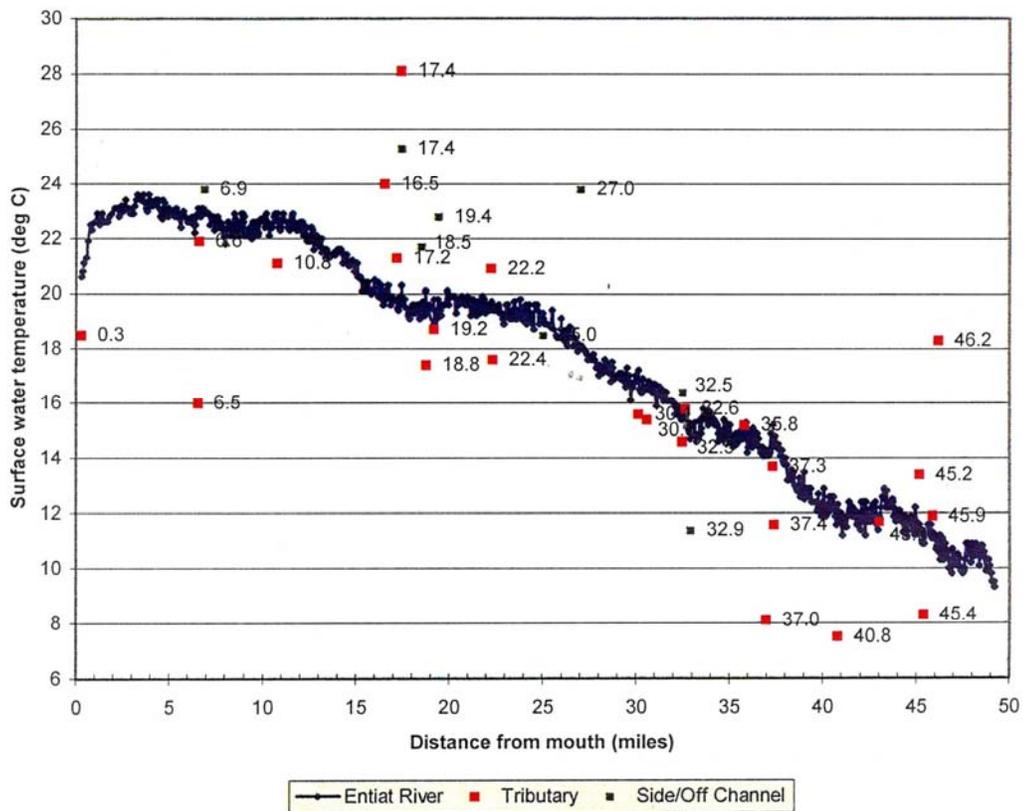


Figure 3. Surface water temperature profile of the Entiat River as recorded during the Thermal Infrared remote sensing flight conducted on August 11, 2001. The numbers in the body of the chart refer to the river mile location. Chart from Watershed Sciences (2002).

Discussion

When spawning ground surveyors observe disturbed or dug gravel and redds, they note “a fish did something here.” Absent a digging fish, the decision as to what species did it, and whether it was a completed redd is subjective. Familiarity with the different salmonid redd dimensions and characteristics can help with redd judgments. Repeating surveys to evaluate timing and changes in redds, or observing fish on redds can also help, but even experienced surveyors can have difficulty in differentiating redds of different species. In particular, the salmon spawning ground index reaches of the Entiat River are much more difficult to survey due to concurrent spawning of spring and summer Chinook salmon, sockeye salmon, and possibly coho salmon and bull trout.

It is clear from radio-telemetry observations, formal bull trout redd surveys, and temperature data that the optimal fluvial bull trout spawning habitat in the Entiat River is upstream of Box Canyon (29.2) and extends to Entiat Falls (rm 33.8)³. Radio-telemetry movement data and observations of adult bull trout digging or paired on redds confirm that most redds in that reach belong to bull trout (Archibald and Johnson 2006, Nelson and Nelle 2007, Nelson 2008). Bull trout have been observed and photographed digging in Box Canyon just below the public viewing vista and bull trout on redds have also been observed in the canyon just downstream so those redds are also beyond doubt. The furthest downstream redd with a bull trout observed on it was at river mile 29, a short distance downstream of the Box Canyon walls. Therefore, these redds are known bull trout and will not be evaluated further. Conversely, no bull trout redds have been detected between Lake Creek and Fox Creek campgrounds, so there is no basis for evaluation there.

Redds with the highest degree of uncertainty are those judged to be bull trout during Chinook salmon surveys between river miles 16.2 – 28.1. It is evident from migration patterns that adult bull trout move upstream past the salmon reaches as they attempt to seek the coldest stream temperatures for spawning upstream of Box Canyon. All radio-tagged bull trout entered Box Canyon and were present there until declining stream discharge allowed passage upstream to the spawning grounds (Nelson 2008). The tagged bull trout unable to continue moving upstream were the smallest fish and presumably non-spawning, but even those fish did not move downstream past Lake Creek. In 2006, when conditions changed and the majority of bull trout were blocked from the optimal spawning grounds, no tagged fish moved back downstream onto the salmon reaches prior to the peak of the bull trout spawning season (Nelson 2008).

Entiat River temperatures add to the uncertainty of redds judged as bull trout between river miles 16.2 – 28.1. Stream temperatures are strongly associated with the distribution of bull trout, and the probability of occurrence of small bull trout is relatively low (< 0.50) at temperatures above 16 °C (Dunham et al. 2003). Maximum weekly maximum temperatures (MWMT) of 13 °C during June, July, and August are considered necessary to be fully protective of juvenile bull trout rearing (Essig et al. 2003), and 13.2 °C is the

³ Entiat Falls is a barrier to all migratory fish so the coldest water in the upper Entiat River is unavailable to fluvial bull trout.

optimal temperature for juvenile growth (Selong et al. 2001). MWMT of 16 °C are routinely exceeded for weeks at a time in most of the salmon spawning reaches (Archibald and Johnson 2003) and MWMT can be as high as 20.2 °C at river mile 18 (Table 7). The stream temperature in August is uniformly high from river mile 26 downstream to river mile 16 (Figure 3; Watershed Sciences 2002). All temperature measurements indicate that in most years it is likely that little if any juvenile rearing of bull trout occurs in the majority of the salmon spawning reaches. For recovery planning purposes, bull trout rearing habitat is the same area as spawning habitat (USFWS 2002).

No bull trout were observed on any of the redds judged as bull trout between river miles 16.2 to 28.1, but by salmon survey protocols all redds were identified to species if possible (Carie 2000). In the salmon spawning reports, all “well established” redds were assigned a species, and while the process of assigning a species to unknown redds was refined and changed over time (C. Hamstreet pers. comm.), no redds were ever designated as an unknown species. In the earlier surveys, the general methods as described in Carie (2001) were if a surveyor decided the disturbance was not a test dig and the redd was too small or in small substrate, the surveyor ruled out Chinook salmon. If the small redd was occupied (or perhaps a carcass in the vicinity), the surveyor designated the redd accordingly. If unoccupied and the surveyor felt it was not a sockeye redd, then generally that redd was recorded as bull trout, either in the field or later in the office. In more recent surveys, individual surveyors had varying degrees of experience and might have subjectively compared the characteristics of the unknown redd to bull trout or sockeye salmon redds they had observed elsewhere, including size, shape, pit depth, substrate, or redd location. Because no bull trout were ever observed on these redds, ultimately all assignments were judgment calls.

Examination of field notes and interviews with surveyors indicated there was more uncertainty about the judgments of bull trout redds than is apparent in the final reports. In many of the entries or on field maps of possible bull trout redds uncertainty is illustrated by this typical entry or map label: “*BT redd?*”. In 1999 this uncertainty was expressed in an MCRFRO memorandum, as this excerpt shows:

“Note: an additional six redds of unknown origin were also found. These appeared to be complete redds, but were small and located in smaller substrate. One of these was located in the old spawning channel, one at RM 19 and four between RM 16.5 to 17. The lower five appeared to be consistent with the sockeye redds found last year, but no live or dead sockeye were seen in 1999. The upper redd may have been created by a bull trout, or all six may have been. Without any other species visible, we can’t be certain.” (Carie 1999b)

In the field notes summary, these are called mystery redds (MCRFRO 1999 field notes). In the final published report, these redds “appeared to be from bull trout” (Carie 2000), evidently only because no sockeye salmon were observed (even though 5 of these redds were consistent with location and observation of sockeye salmon redds the previous year). This memorandum illustrates that the methodology itself resulted in the final

judgment of these redds as bull trout, which occurred in the office after the survey was completed.

When interviewed, all surveyors were confident in their assessment of completed Chinook salmon redds (the main focus of the surveys) but expressed varying amounts of uncertainty about their judgment of bull trout redds. One surveyor felt where he sometimes judged redds as bull trout redds there was a difference in the look and size of the redd compared to a Chinook salmon redd and that sockeye salmon redds were usually less defined and almost always found in a commingled group of several tail spills with several egg pockets and pits. Thus, if he observed a single small redd in small substrate with a defined pit it was more likely to be judged as a bull trout. Using this methodology in years where few sockeye salmon were present or observed could result in single sockeye salmon redds being more likely to be judged as bull trout, and this is supported by the data in the reports. The years with the highest number of judged bull trout redds are years when no or few sockeye redds were reported (Table 5). Note also that size is not a reliable criteria to distinguish redds of the two species- the mean area of a sockeye redd is 1.75 m² (Burner 1951) and bull trout redds measured upstream of Box Canyon ranged from 0.5 – 3.45 m² (Nelson and Nelle 2007).

Sockeye salmon are not indigenous to the Entiat River (Craig and Sumoela 1941 *cited in* Kelly 1995) but were planted in the 1940s and collected at Entiat National Fish Hatchery until 1963 (Mullan 1986 *cited in* Kelly 1995). In 1993 (perhaps the first time since 1981) sockeye salmon were observed spawning in the Entiat River (Archibald 1993). From September 13 to October 26, 1993, USFS biologist Phil Archibald documented sockeye salmon spawning activity between river miles 17 and 22, including observations of fish on several redds. This is the area where 13 of the 20 redds judged as bull trout were located over the years, and it appears the methodology and subjective surveyor experience may have played a role in the judgment of unknown redds. On October 11, 2001, a small single redd was judged a bull trout redd at river mile 21.4; no sockeye salmon redds or fish were recorded, but during the next survey on October 24, 6 – 8 sockeye salmon redds were counted just downstream at river mile 21 (MCRFRO 2001 field notes and maps). Sockeye salmon redds with live fish were recorded as far upstream as river mile 24.3 in 1998 (MCRFRO 1998 field notes). Sockeye salmon redds have been recorded in reaches 2, 3, 4, and 5. These are also the reaches where many of the redds judged as bull trout were counted.

A Chinook salmon redd is constructed over several days and the redd changes in size and shape as it develops (Figure 4). Even though the size and shape of the initial stages of the developing salmon redd are similar to a completed bull trout redd (Figure 4), most salmon surveyors when interviewed were confident in their ability to distinguish incomplete salmon redds. However, some redds initially judged as bull trout were actually incomplete salmon redds as they were later noted as obviously much larger and reclassified as Chinook salmon on the following survey (MCRFRO field notes). This occurred most notably in 2006 near river mile 27, when a survey team initially judged two redds as bull trout because the recorded measurements were within the observed range of bull trout redds, but two weeks later, the new dimensions and shape were

obvious summer Chinook salmon redds (MCRFRO 2006 field notes). One member of this team had the most bull trout experience of all the 2006 salmon redd surveyors. If the initial judgments had not been checked and reclassified on the follow up survey, these would have been recorded as bull trout redds.

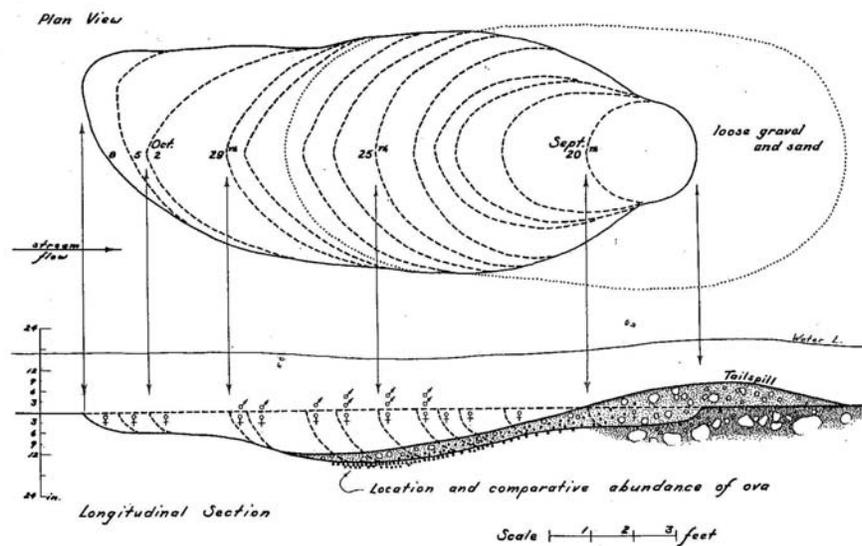


Figure 4. Diagrammatic views of a fall Chinook salmon redd measured daily (Burner 1951). The dashed outlines chart the daily change in size and shape of the redd as it was constructed.

In 1996 the judgment and reporting of an incomplete summer Chinook redd as a bull trout redd apparently occurred due to a combination of several factors. On the October 16, 1996 survey, 2 redds were judged as bull trout redds because “*these redds were much smaller in size than a Chinook redd and a large adult Bull trout was spotted near the lower redd*” (Carie 1997). However, examination of the field notes and maps revealed that the initial field judgment of these redds were summer Chinook salmon, and that during a follow-up survey conducted November 1 by a different team, notes made at the ‘lower redd’, indicated that the redd had changed and stated that “it looks like 2 redds” so they added another summer Chinook redd at that spot (MCRFRO 1996 field notes). There are no notes made on the other judged bull trout redd and it seems reasonable that the second team saw and accepted it was also a complete summer Chinook salmon redd. It appears that when the report was written after the field season, the November 1 survey

notes were missed and the incomplete summer Chinook salmon redds were judged afterwards to be bull trout redds, most likely due to the bull trout that was seen nearby.

The last salmon spawning survey was often made before the conclusion of either of the Chinook salmon spawning seasons, and this may have inadvertently resulted in incomplete redds incorrectly judged as bull trout redds. With no additional surveys to verify if these redds remained unchanged, they may have been called bull trout redds only because as incomplete redds they were smaller than typical Chinook salmon redds. This may have occurred in 1998, 1999, and 2008. In 1998 and 1999 redds were judged bull trout in reach 1 near river mile 27 on the last spring Chinook survey date (MCRFRO 1998 and 1999 field notes). On October 16, 2008 a redd was judged bull trout on the last survey of reach 4 (MCRFRO 2008 field notes).

Redds of spring Chinook salmon (2.4 – 4.1 m²) are smaller than redds of summer Chinook salmon (3.9 – 6.5 m²) and the size can vary depending on the stream, location, and substrate (Burner 1951). Some of the redds attributed to bull trout near river mile 27 could have been spring Chinook salmon redds, as indicated by an observation of a radio-tagged spring Chinook salmon that was recorded by the National Marine Fisheries Service at river mile 27.5:

“Fish ID 12060. Run Sp. Date 9/01/93. Rmile 27.5 Large male with female - Tiny gravel patch & redd amid bedrock and boulders- Odd spot” (NMFS 1994).

The description of this redd on a tiny gravel patch and amid bedrock and boulders in an odd spot matches that of the known bull trout redds observed in Box Canyon during 2008. Without the presence of spring Chinook salmon, even an experienced bull trout surveyor could easily misjudge a similar redd.

In addition to incomplete or small salmon redds being misjudged, partially constructed and then abandoned Chinook salmon redds could also be misidentified as bull trout. Studies of the reproductive behavior of captive reared Chinook salmon documented that female egg deposition was much lower than wild females, females dug an average of 2.2 nests and abandoned 40 % of the nests, females moved upstream a short distance before digging again, and males were often absent during nest construction (Berejikian and Tezak 2001). Summer Chinook salmon spawning success in the Entiat River is significantly lower for hatchery versus wild females (Carie and Hamstreet 2002, 2003, 2004; Hamstreet 2005, 2006, 2007). In 2006, as described above, 2 judged bull trout redds near river mile 27 were later found to be complete summer Chinook redds. Three other redds (judged as bull trout based on size) were observed in the immediate vicinity but were unchanged on the following survey, which is consistent with multiple redds and abandonment by hatchery salmon. Also, some of the small redds judged as bull trout in reaches 4 and 5 were noted just downstream of large or active summer Chinook salmon redds (MCRFRO field notes). Several “bucket” digs with circular shaped tail spills and in large and moderate size gravels were initially noted as possible bull trout redds in reach 4 during 2001 (MCRFRO 2001 field notes). These were not recorded as bull trout as the surveyor evidently later decided they were tests by summer Chinook salmon. These

observations support the possibility that some redds attributed to bull trout were dug and then abandoned by hatchery origin summer Chinook salmon.

When biologists collect scientific data, there is always a risk that unconscious bias may influence the interpretation of observations. For instance, in 1996 the judgment of the 2 incomplete summer Chinook redds as bull trout was likely biased by the observation of a single large bull trout “near” one redd, but not digging or on the redd itself. The dates that radio-tagged post-spawning bull trout leave the optimal bull trout spawning reaches and move downstream through the salmon reaches (Table 6) coincide with both spring and summer Chinook salmon spawning surveys. Bull trout are known for shadowing salmon redds, so the observation of a bull trout near a redd is not a confirmation. In an area where bull trout would not be expected to spawn, a bull trout must be definitively associated with the redd, and reproductive activities such as pairing, digging, spawning, guarding, sweeping, or undulating documented.

Confirmation bias occurs when we look for and find evidence of what we already believe and ignore evidence to the contrary. A confirmation bias probably occurred during the 1999 and 2006 surveys. In 1999, bull trout had recently been listed as a threatened species and the delineation of bull trout spawning was added as an objective for the salmon spawning ground surveys. At that time little was known about bull trout in the Entiat River and while it is commendable that fish biologists wanted to document bull trout, it probably added an unconscious bias into judgments. The redds misjudged as bull trout in 1996 provided the belief that bull trout were spawning in the downstream salmon reaches (even though at the time the only known definitive bull trout redds were 15 miles upstream near Entiat Falls), and in 1999, that may have reinforced the judgment of bull trout redds when they were most likely sockeye salmon or incomplete Chinook salmon redds. From that point on, biologists surveyed the salmon reaches with the mindset that bull trout redds had been confirmed and continued to misjudge redds. In 2006, when it became apparent during the radio-telemetry study that obstacles in Box Canyon prevented the majority of fluvial bull trout from reaching the optimal spawning grounds, a request was explicitly made for salmon surveyors to look specifically for bull trout redds in reaches 1 – 5. In retrospect, this most likely added bias to the surveyors’ judgments of unknown redds.

When MCRFRO began salmon surveys in 1994, little was known about the temperature profile of the Entiat River in the survey reaches. Reports from 1994 to 1997 mention the need for temperature information, primarily to assess whether low water temperatures could affect salmon egg survival. Many of the studies on the influence of temperature on the distribution and survival of bull trout were not published until well after the initial judgment of redds as bull trout in the salmon reaches of the Entiat River. However, even after it was known that most bull trout do not start spawning until stream temperatures decline to 9 °C, the belief that bull trout were spawning in the downstream reaches outweighed that evidence in the judgment of redds. On September 4, 2007 in reach 4 a small redd was initially noted as a possible bull trout redd even though the stream temperature during the survey was 12 – 16 °C (MCRFRO 2007 field notes). This small

redd was actually an incomplete salmon redd as it was recorded on the next survey as a complete spring Chinook salmon redd (MCRFRO 2007 field notes).

Based on definitive observations of bull trout, the furthest downstream known bull trout redd is at river mile 29 of the Entiat River. The multiple lines of evidence presented and analyzed in this review support the conclusion that there are no known bull trout redds downstream of river mile 29. Based on radio-telemetry information, warm stream temperatures, and the high probability of the misidentification of sockeye redds and incomplete, abandoned, or small Chinook salmon redds, none of the redds originally judged as bull trout during salmon spawning surveys in reaches 2, 3, 4, and 5 (river miles 16.2 – 26) are found to be credible. Five redds originally judged as bull trout during salmon spawning surveys in reach 1 (river miles 26 – 28.1) in the vicinity of river mile 27 have somewhat less uncertainty but are not known to be bull trout. Although stream temperatures are not as high in reach 1 during some years, the fact that both spring and summer Chinook salmon redds occur in this reach (as well as upstream), coupled with the known misjudgment of incomplete Chinook salmon redds in the immediate vicinity and the history of misjudgments in the downstream reaches, none of these redds are found credible. Therefore, at this time and under current stream conditions, bull trout are not known to spawn in the reaches of the main-stem Entiat River downstream of Lake Creek (rm 29). Continued surveys with definitive confirmation of bull trout redds and stream temperature monitoring may assist in refining the downstream boundary of bull trout spawning in the main-stem Entiat River.

It is recommended that all USFWS reports and tables that track yearly bull trout redd numbers be modified with the corrections noted in this review. It is recommended that the ancillary objectives of the MCRFRO salmon spawning ground surveys be modified to “locate and definitively document redds with bull trout spawning on them” in order to eliminate the bias to label unknown or incomplete redds as bull trout. It is recommended that an “Unknown Species” category of redd be added to the methodology of all spawning ground surveys. It is also recommended that a correction regarding the past misidentification of redds be placed in future reports of the USFWS MCRFRO *Spring and Summer Chinook Salmon Spawning Ground Surveys on the Entiat River*.

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