Integrated Status and Effectiveness Monitoring Program- Entiat River Intensively Monitored Watershed Study, 2012.

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Prepared by:
Hayley Potter
Tom Desgroseillier
Cal Yonce
Jordan Sanford
RD Nelle

U.S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
7501 Icicle Rd.
Leavenworth, WA 98826

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Abstract

During 2012, the Mid-Columbia Fishery Resource Office operated two rotary screw traps, conducted two mark-recapture studies in the mainstem Entiat River, conducted three mark-recapture studies within off-channel habitats, operated and maintained six stream-width Passive Integrated Transponder tag interrogation sites and conducted steelhead redd surveys on the Entiat River as part of the Integrated Status and Effectiveness Monitoring Program's Entiat River Intensively Monitored Watershed study. Screw trap operations were conducted between March and November and caught a total of 19,295 fish. The Entiat River mark-recapture study collected 12,636 juvenile fish species at 26 locations along the main stem Entiat and Mad Rivers. The off-channel habitat study resulted in the capture of 6,795 juvenile fish. In 2012, a total of 38,754 fish were captured and 25,170 wild salmonids were marked with Passive Integrated Transponder tags. Six Passive Integrated Transponder tag interrogation sites were operated within the Entiat River throughout this reporting period resulting in a total of 2,510 unique detections. Six Passive Integrated Transponder tag antennas were used to monitor juvenile fish use in three off-channel habitats and a total of 1,238 unique detections were recorded. Steelhead redd surveys were conducted from February 4 to May 10, 2012. The first redd was observed on March 22, 2012. A total of 77 redds were observed in the lower 45 km of the river.

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Introduction

The Integrated Status and Effectiveness Monitoring Program (ISEMP – BPA project #2003-0017) was created as a cost effective means of developing protocols and new technologies, novel indicators, sample designs, analytical, data management and communication tools and skills, and restoration experiments. ISEMP activities support the development of region-wide Research, Monitoring and Evaluation (RME) programs to assess the status of anadromous salmonid populations, their tributary habitat and restoration and management actions.

The intent of the ISEMP project is to design monitoring programs that can efficiently collect information to address multiple management objectives over a broad range of scales. As well as status and trends monitoring, ISEMP is evaluating the benefits of habitat restoration actions to fish populations across the Columbia River Basin by implementing Intensively Monitored Watershed (IMW) studies. IMWs have been established in three pilot subbasins: Entiat River, WA; Bridge Creek, John Day River, OR; and Lemhi River, ID.

An IMW is a watershed-scale coordinated restoration effort with an associated effectiveness monitoring program (Bilby et al. 2004, PNAMP 2005) implemented in an experimental fashion to maximize the ability to detect fish responses to changes in their habitat (Bilby et al. 2005; Roni et al. 2005; Reeve et al. 2006). In addition, intensive monitoring is used to identify mechanisms by which habitat manipulations impact fish, so that these strategies can be extrapolated to other systems (Carpenter et al. 1995). An IMW is a powerful approach to answer cause-and-effect questions at the scale relevant to management (i.e., at the watershed or population scale). IMWs are designed to address key questions in a disciplined scientific manner, reduce the complications associated with effectiveness monitoring, increase the comprehensiveness of monitoring and increase efficiencies through shared responsibilities.

The restoration of the Entiat River subbasin under an IMW study design offers an opportunity to quantitatively evaluate the effectiveness of habitat restoration actions with regard to improving salmonid productivity in the Entiat River subbasin. This subbasin meets the prerequisites for an IMW, such as the feasibility of obtaining quantitative estimates of smolt production, the record of smolt monitoring, fish species present, and influence of hatchery-produced fish. In addition, the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) identifies the Entiat River subbasin as an IMW (RPA 57.1) and the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007) calls for effectiveness monitoring coupled with adaptive management to assess the effects of habitat actions and recover these listed species in the Entiat River subbasin.

The work presented in this report is a component of the overall ISEMP, and while it stands alone as an important contribution to the management of anadromous salmonids and their habitat, it also plays a key role within ISEMP. Each component of work within ISEMP is reported both individually and in annual summary reports that present the overall project components in their programmatic context and shows how the data and tools can be applied to the development of regionally consistent, efficient and effective RME.

Juvenile outmigration study

The primary goals of this study are to provide long-term monitoring information and to detect changes due to habitat restoration actions on the juvenile life history characteristics and

productivity of spring Chinook salmon *Oncorhynchus tshawytscha* and steelhead *O. mykiss gairdneri* in the Entiat River basin. The study uses rotary screw traps to capture juveniles in order to quantify abundance, measure physical characteristics, and tag individuals to assess migration timing and survival throughout the Entiat River and Columbia basin. These data are incorporated into a regional database that is utilized by area resource managers to compare attributes both within and between populations located in the Upper Columbia River basin. The ultimate goal of this study is to guide scientifically sound decisions regarding the future management of these species.

Entiat River IMW study
The primary goal of the Entiat IMW study is to identify and quantify the effects of habitat restoration upon response variables for ESA listed spring Chinook salmon and steelhead in the Entiat River basin. The measured response variables are productivity (emigrant per redd), emigrant age structure, egg-to-parr survival, parr-to-emigrant survival, annual and seasonal growth of parr, and alterations in site specific fish density or observed movement of tagged individuals. The study uses mark-recapture methodologies to quantify and assess each response variable. The Entiat River IMW study is structured upon previous studies in the subbasin conducted by the U.S. Fish and Wildlife Service's Mid-Columbia River Fishery Resource Office (MCRFRO) which included snorkel surveys and remote fish capture and tagging at the watershed scale.

Off-Channel Habitat study
The goal of the Entiat River off-channel habitat study is to provide quantitative evaluations of the effects of existing and proposed off-channel habitats for fish populations. Evaluations include seasonal assessments of species composition, abundance, site use patterns, species age composition, growth, and survival. The study utilizes mark-recapture methodologies and Passive Integrated Transponder (PIT) tag antenna monitoring to quantify the evaluations. Study findings will be made available to the habitat restoration community in order to increase current knowledge and better design future off-channel habitat projects within the Entiat watershed.

PIT Tag Interrogation Site monitoring
The goal of PIT tag interrogation site monitoring is to increase the amount of quantifiable data on PIT tagged adult and juvenile fish species within the Entiat subbasin. This is facilitated through remote detections, or resightings of PIT tagged fish at six independent interrogation sites within the Entiat subbasin. Interrogation site monitoring at these sites compliments a multitude of other projects occurring within the Upper Columbia basin as resighting data from these sites are made available to resource managers through a regional database. Interrogation data collected within the Entiat subbasin bolster estimates of juvenile survival and abundance while providing opportunities to verify key assumptions associated with mark-recapture methodologies.

Steelhead redd surveys
Steelhead redd surveys serve to track the annual spawning success of adults returning to the Entiat River. These surveys map the distribution of steelhead redds and allow evaluation of historic spawning areas and habitat restoration actions. Additionally, total redd counts play a vital role in calculating annual estimates of juvenile productivity.

Study Area

The Entiat River watershed originates from 11 glaciers and snowfields in the Cascade Mountains and flows southeast approximately 69 km to join the Columbia River at river kilometer (rkm) 778 (CCCD 2004, Mullan et al. 1992). The Entiat watershed is bordered by the Entiat Mountains to the southwest and the Chelan Mountains to the northeast and drains approximately 1,085 km^2. The topography is steep with unstable erodible soils and vegetation types varying from semi-arid shrub steppe near the confluence with the Columbia River to temperate forests and alpine meadows in the headwaters.

Past glacial activity has shaped the Entiat River valley by creating a U-shaped valley upstream of terminal moraine at rkm 26.1 and V shaped valley downstream (Mullan et al. 1992). The present upstream limit to anadromy is at Entiat Falls (rkm 54.4) (Figure 1).

The Entiat River watershed supports eight salmonid species including spring and summer Chinook salmon *Oncorhynchus tshawytscha*, steelhead and resident rainbow trout *O. mykiss gairdneri,* sockeye salmon *O. nerka*, westslope cutthroat trout *O. clarki lewisi,* coho salmon *O. kisutch,* mountain whitefish *Prosopium williamsoni,* bull trout *Salvelinus confluentus,* and introduced eastern brook trout *S. fontinalis*. Other fish species include, chiselmouth *Acrocheilus alutaceus,* northern pikeminnow *Ptychocheilus oregonensis,* largescale sucker *Catostomus macrocheilus,* bridgelip sucker *C. columbianus,* speckled dace *Rhinichthys osculus,* longnose dace *R. cataractae,* redside shiner *Richardsonius balteatus,* sculpin *Cottus spp*., three-spined stickleback *Gasterosteus aculeatus* and Pacific lamprey *Entosphenus tridentatus*. (Mullan et al 1992, CCCD 2004,).

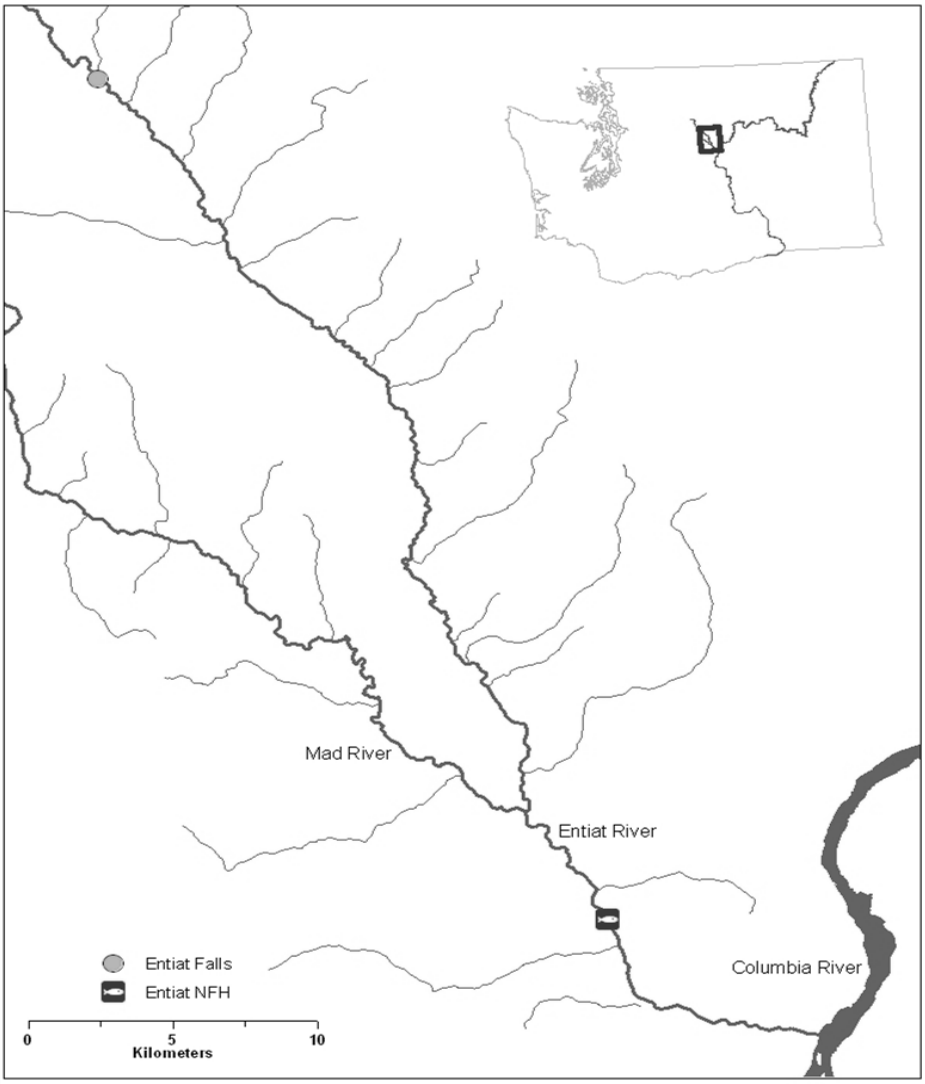

Figure 1. Map of the Entiat River from its mouth to Entiat Falls at river kilometer 54.

Methods-Rotary Screw Trap

Rotary screw trap locations

MCRFRO has been operating a rotary screw trap in the Entiat River at rkm 11 near the Entiat National Fish Hatchery (ENFH) since 2003. Juvenile fish have been captured at other sites within the Entiat subbasin for PIT tagging since 2005. In addition to these legacy collection sites, MCRFRO added another rotary screw trap at rkm 2 during the 2007 field season (Figure 2).

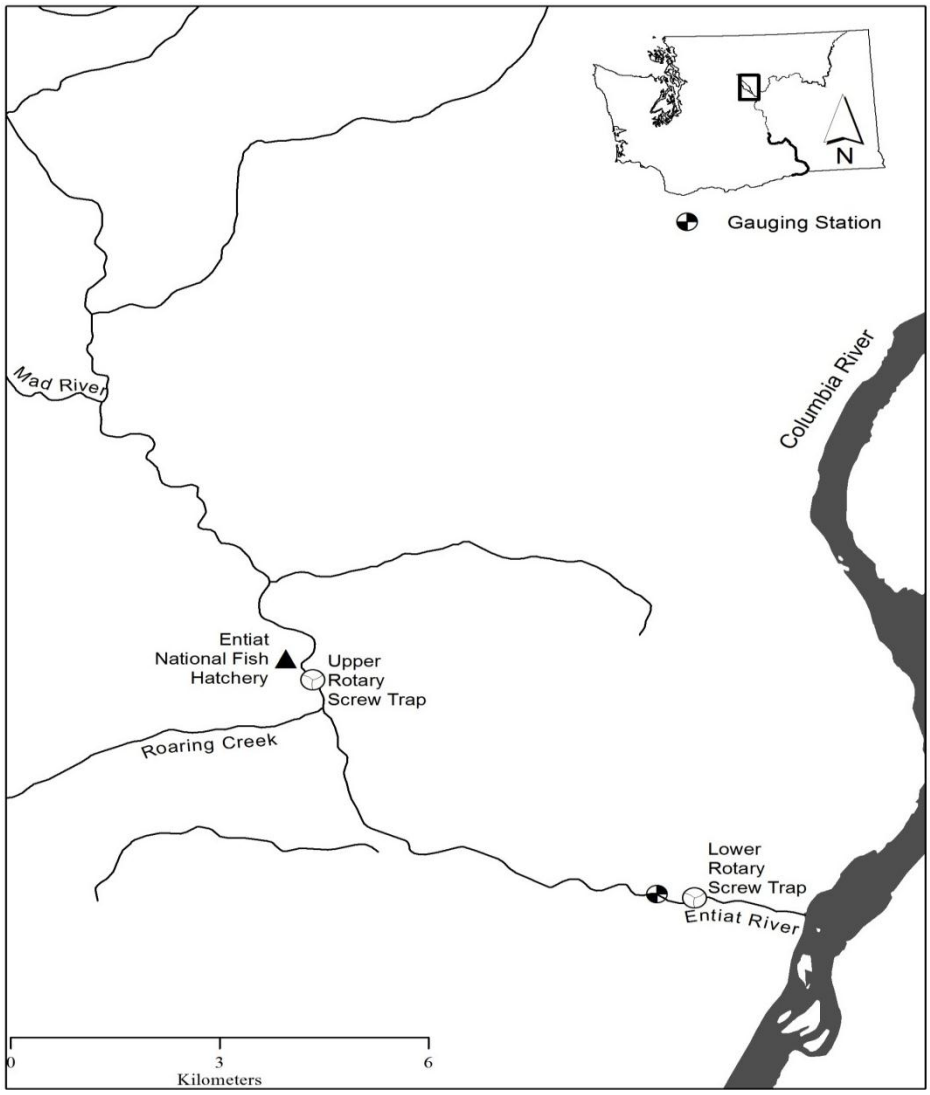

Figure 2. Map of the rotary screw trap locations in the Entiat River, 2012.

Rotary screw trap operation

Two modified 5 ft. diameter rotary screw traps (EG Solutions Inc.) were used to capture downstream migrating salmonids. The traps were retrofitted with pontoons from 8 ft. style screw traps to increase floatation and safety during higher flow. Traps were further modified to include an access door on the cone of each trap and a high pressure spray system to minimize algal accumulation upon the screen of the cone. Trap operations followed operational permit guidelines as per Chelan County Shoreline Management Act (file# SE 06-016 US Fish and Wildlife Service Fish Enhancement letter dated August 16, 2006), WDFW Temporary Use Permit (dated 11/27/07), and two Hydraulic Project Approval Permits (log#ST-F8213-01, upper trap dated 3/18/08 and control#125868-1, lower trap, dated February 06, 2012). Assembled traps were lowered into the river via a boom truck, attached to one quarter inch aircraft cable, and anchored upstream to the bases of large cottonwood trees. A concrete road bridge at the upper

trap site and a cross- river cable at the lower trap site suspended the anchor cable above the stream from the anchor point to the trap. A system of winches and pulleys were used to maintain the traps in fixed positions as flows changed throughout the trapping season. The traps were operated seven days a week from March through November with allowances for some events. If possible, traps were operated 24 hours a day; however, during spring high flows and periods of increased debris loads the traps were operated from sunset to sunrise.

Fish handling

Fish handling procedures were conducted in accordance with WDFW Scientific Collection Permit #12-117 and #12-178 (annual permits - start date April 3, 2012, expires April 3, 2013); NOAA Permit 1119 (dated April 10, 2008, expires December 31, 2012); and USFWS sub permit No. MCRFO-13 (dated Aug 5, 2010, expires December 31, 2013) under Regional Blanket Permit TE-702631.

At least once a day, juvenile fish were removed from the trap live box and transported within 5 gallon buckets for PIT tagging and biological sampling. The buckets were equipped with aerators and a light salt solution (1 tbs/gal.) was added to minimize stress during transport and holding. The fish were transported to Entiat National Fish Hatchery (ENFH) and processed at a permanent fish handling/tagging station.

Fish collected for biological sampling were anesthetized in a water bath with a measured amount of tricaine (MS-222) and buffered with sodium bicarbonate. Small groups of fish were anesthetized at any one time to reduce the chance of incidental mortality from anesthetic overdose. All fish were identified to species with the exception of sculpin, dace, and suckers. All salmonids were ascribed a life history stage as either fry (<60 mm), parr (>60 mm and distinctive parr marks), transitional (>60 mm silver sheen, faint parr marks) or smolt (>60 mm silver sheen with absent parr marks with possible black tipped caudal). For all other species, a daily minimum of 30 fish per species and life stage were measured to the nearest mm of fork length and weighed to the nearest tenth of a gram. All Chinook salmon, steelhead, coho salmon, sockeye salmon, bull trout, and cutthroat trout were measured to the nearest millimeter of fork length and weighed to the nearest tenth of a gram. Fulton-type condition factor was calculated for all Chinook and steelhead as described by Anderson and Gutreuter (1983) using the following calculation:

$$K = \frac{W}{L^3}$$

where K is the Fulton-type condition factor, W is the individual fish weight and L is the individual fish length.

After handling, all species were allowed to fully recover prior to release. Non-tagged individuals were released approximately 400 meters downstream from the trap of capture after a minimum of one hour recovery time.

PIT tagging of juvenile fish followed the procedures and file submission requirements outlined by Pacific State Marine Fisheries Commission PIT Tag Information System (PTAGIS). Fish were tagged using a disinfected hollow needle to insert the PIT tag into the abdominal cavity. Individuals measuring between 50 and 60 mm in fork length were tagged with a 9 mm PIT tag

(ISO tag model TX148511B operating at 134.2 kHz and weighing 0.065 g) and individuals greater than 60 mm were tagged with a 12.5 mm PIT tag (ISO tag model TX1411SST operating at 134.2 kHz and weighing 0.102 g). In 2012, Fish Passage Center provided limited PIT tags for spring Chinook salmon and steelhead as a part of the Comparative Survival Study. Tags for the remaining Chinook salmon and steelhead were supplied by ISEMP, while Chelan County PUD provided tags for bull trout, and USFWS supplied PIT tags for cutthroat trout and coho salmon. Any injuries or abnormalities were noted and juveniles were not PIT tagged if determined to have had a recent or substantial injury that could be aggravated by tagging. PIT tagged juveniles were generally held 24 hours to monitor survival and tag retention. A maximum of 72 hours hold time was instituted on all tagged fish.

Data entry

All fish data were entered into the P3 program from PTAGIS. P3 is a data entry application used to collect and submit information about marked or recaptured PIT tagged fish in the Columbia River Basin. USFWS used this program to enter all fish information whether or not the fish was marked with a PIT tag. P3 serves as a Microsoft Access™ overlay which allows communication with peripheral devices. USFWS peripheral devices included a Destron Fearing FS2001-ISO transceiver/antenna for reading PIT tags, a GTCO Calcomp DrawSlate VI digitizing board and a GSE 350 electronic balance for automating data entry into a laptop computer. Data files generated from P3 were parsed into a custom Microsoft Access™ database constructed by MCRFRO staff for the purpose of preparing data for analytical use and various reports. The original P3 file was left intact and subsequently uploaded to PTAGIS where it is available to researchers throughout the Columbia River Basin.

Genetic and scale sampling

Throughout the sampling period, a subset of captured bull trout, cutthroat trout, Chinook salmon, and steelhead juveniles were sampled for genetic and age analysis as suggested within the Upper Columbia Monitoring Strategy (Hillman 2006). Genetic material was collected by taking a small clip of tissue was taken from either the ventral fin (steelhead, cutthroat trout & Chinook salmon) or caudal fin (bull trout). Tissue samples from Chinook salmon, cutthroat trout, steelhead and bull trout were sent to the Region 1 USFWS genetics lab for archiving and analysis. Scales were only collected from steelhead and were cataloged and stored on site for future analysis.

Screw trap efficiency

A portion of the collected Chinook salmon and steelhead were used to estimate trap capture efficiency. Fish from several collection events were pooled and held for up-to 72 hours before release upstream of the capture location. All fish used for efficiency trials were either PIT tagged (>50 mm FL) or dye marked (<50 mm FL) with Bismarck Brown Y dye. All marked fish were placed in a live box for holding (<72 hrs.) prior to release. These fish were then transported to release sites using 5 gallon buckets with aerators to minimize stress. Juvenile fish used for efficiency trials were released after twilight upstream of the trap at rkm 2.3 (Keystone Ranch private bridge). Monitoring of the efficiency trials was limited to the three days following each release in order to minimize potential affects related to river flow. Recaptured fish were re-measured, released, and not included in subsequent efficiency testing.

Water temperature and flow
Hourly water temperature data was collected at the lower trapping site using HOBO U22 Water Temp Pro (version 2) data loggers (Onset Computer Corporation, Bourne, Massachusetts). Flow was monitored by USGS station number 12452990, located at rkm 2.3.

Results-Rotary Screw Trap

Trap operation period
Rotary screw trap operation at the lower and upper sites began on February 28th, 2012 and March 29th, 2012, respectively. The upper trap was operated intermittently and primarily during periods of low emigration to supplement the number of tagged individuals available for efficiency modeling at the lower trap location. The lower trap was operated on a seven day per week schedule through November 16th, 2012. Of the 265 trapping days available within the season, the lower trap operated 166 (62.6%) complete days (uninterrupted sampling from sunset to sunrise), 18 (6.8%) incomplete days (interrupted sampling from sunset to sunrise), and was not operated for 82 days (30.94%). Total daily capture numbers for Chinook salmon and steelhead are presented in Figures 3 through 6. Detailed operational summaries are included as Appendix Table 1.

Rotary screw trap target species capture summary
In 2012 a total of 19,295 fish were captured by the rotary screw traps (Table 1). Total juvenile fish capture consisted of 7,672 spring Chinook salmon (39.8%), 6,316 summer Chinook salmon (32.7%), 1,691 steelhead trout (8.8%), 99 coho salmon (0.5%), 69 sockeye salmon (0.4%), 32 cutthroat trout (0.2%), 95 bull trout (0.5%), and 3,321 non-target species (17.2%). A total of 12,460 wild salmonids were implanted with PIT tags. Total daily captures for yearling spring Chinook salmon, sub-yearling spring Chinook salmon, summer Chinook salmon, and steelhead at the lower trap location are presented in figures 3 through 6. Detailed capture summaries including adult species and total mortality are included as Appendix Table 2.

Table 1. Number of fish captured and PIT tagged at Entiat River rotary screw trap locations, 2012.

Species and Life Stage	Total Number of fish caught	Total PIT tagged
Wild sub-yearling spring Chinook salmon	5,212	4,900
Wild yearling spring Chinook salmon	2,456	2,239
Wild summer Chinook salmon	6,316	3,583
Wild coho salmon	104	95
Wild steelhead	1,691	1,525
Wild sockeye salmon	69	0
Bull trout	95	90
Wild cutthroat trout	32	28
Non-target species	3,321	0
Grand total	**19,295**	**12,460**

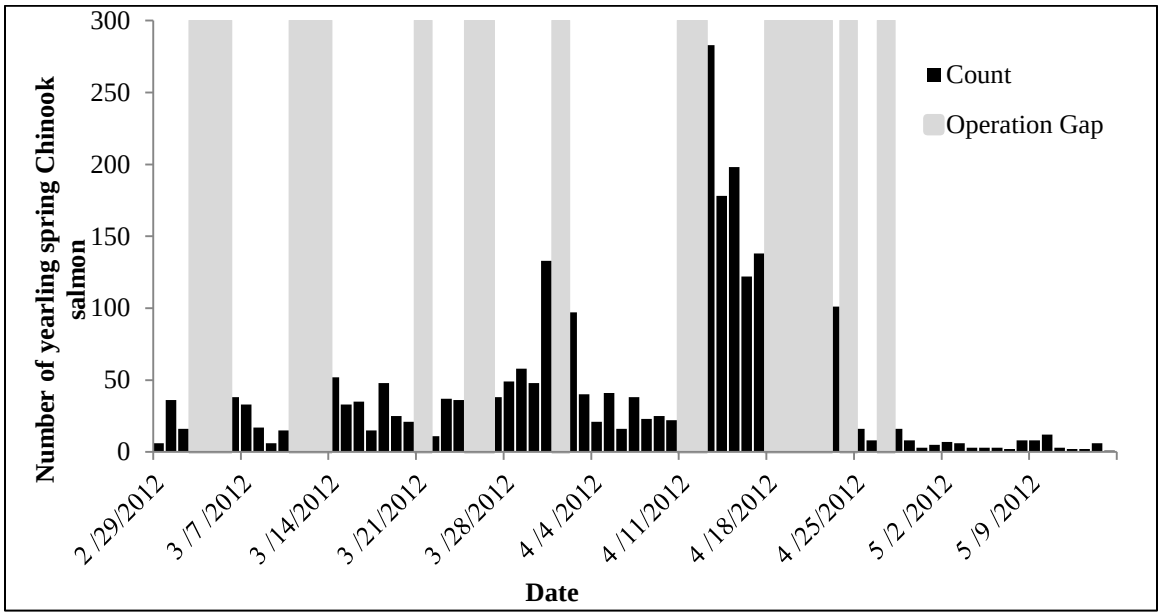

Figure 3. Total daily captures of yearling spring Chinook salmon at the lower Entiat River rotary screw trap, 2012.

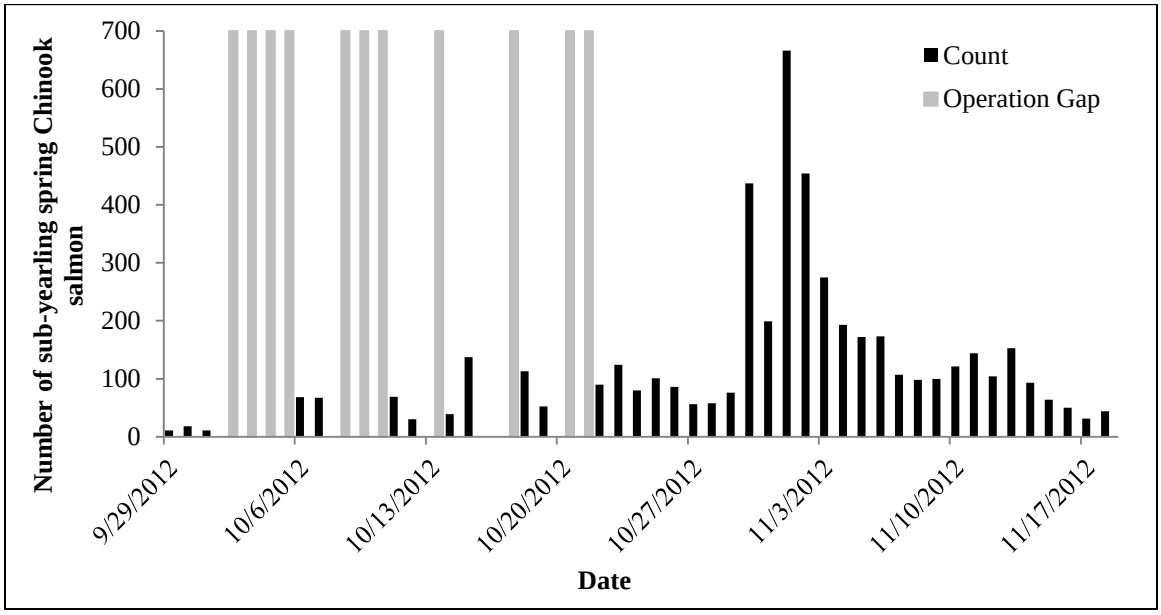

Figure 4. Total daily captures of sub-yearling spring Chinook salmon at the lower Entiat River rotary screw trap, 2012.

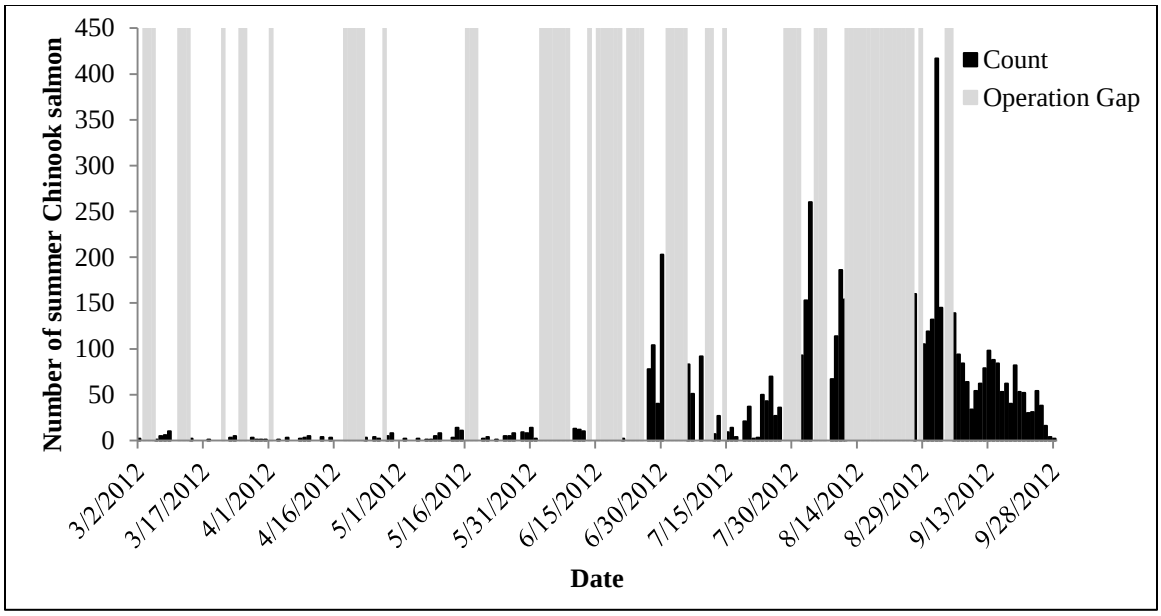

Figure 5. Total daily captures of summer Chinook salmon at lower Entiat River rotary screw trap, 2012.

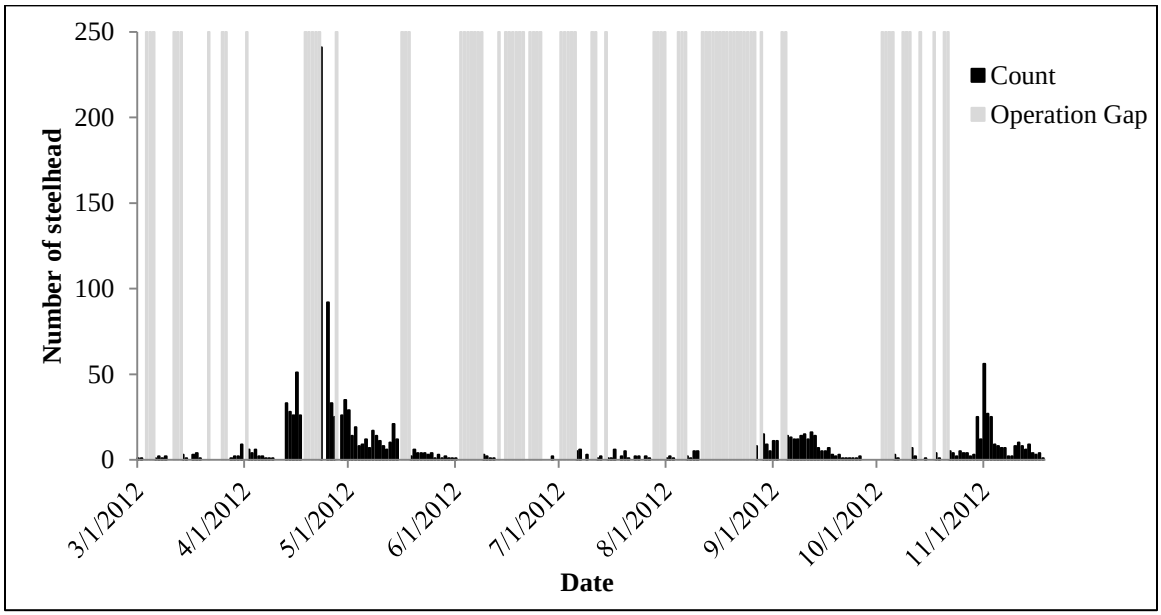

Figure 6. Total daily captures of steelhead at the lower Entiat River rotary screw trap, 2012.

Mean fork length (SD) of spring Chinook was 96.79 (8.11) mm and 83.20 (9.50) mm, for yearling and sub-yearling species respectively (Table 2). Summer Chinook had a mean fork length of 65.86 (13.31) mm and steelhead 143.98 (44.38) mm (Table 3).

Table 2. Mean fork lengths (mm), weights (g), and body condition factor (K) for spring Chinook salmon captured at the lower Entiat River rotary screw trap, 2012.

	Yearling spring Chinook			Sub-yearling spring Chinook		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Fork Length	96.79	8.11	2,446	83.20	9.50	5,319
Weight	9.55	2.92	2,440	6.41	2.57	5,322
K	1.03	0.07	2,440	1.07	0.12	5,315

Table 3. Mean fork lengths (mm), weights (g), and body condition factor (K) for summer Chinook salmon and steelhead captured at the lower Entiat River rotary screw trap, 2012.

	Summer Chinook			Steelhead		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Fork Length	65.86	13.31	4,218	143.98	44.38	1,538
Weight	3.45	2.28	4,183	36.79	25.74	1,531
K	1.04	0.15	4,218	0.98	0.11	1,531

Trap efficiencies

At the lower Entiat River rotary screw trap, 7 viable efficiency trials using PIT tags were conducted for yearling spring Chinook salmon, 10 trials for sub-yearling spring Chinook salmon, 8 trials for summer Chinook salmon and 9 trials for steelhead. An additional dye-mark trial was conducted for summer Chinook salmon measuring less than 50mm FL. PIT tag trials for yearling spring Chinook salmon efficiency averaged 29.91% (Table 4), sub-yearling spring Chinook 19.26% (Table 5), summer Chinook 22.39% (Table 6) and steelhead 13.34% (Table 7). The summer Chinook dye mark efficiency was 4.55% (Table 8).

Table 4. Estimated capture efficiency of PIT tagged yearling spring Chinook salmon at the lower Entiat River rotary screw trap with average (sunrise to sunset) flow from the USGS Keystone gauging station, 2012.

Trial Date	**Flow (m^3/s)**	**Release Size (n)**	**Efficiency**
03/08/2012	4.24	62	48.39%
03/15/2012	4.43	44	36.36%
03/29/2012	5.56	82	34.15%
04/03/2012	6.43	94	27.66%
04/14/2012	8.53	267	23.97%
04/23/2012	14.74	68	14.71%
05/01/2012	34.99	29	24.14%

Table 5. Estimated capture efficiency of PIT tagged sub-yearling spring Chinook salmon at the lower Entiat River rotary screw trap with average (sunrise to sunset) flow from the USGS Keystone gauging station, 2012.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency
10/12/2012	3.12	49	20.41%
10/23/2012	4.89	175	19.43%
10/30/2012	9.52	71	29.58%
11/01/2012	13.80	193	10.36%
11/03/2012	11.86	431	16.94%
11/05/2012	11.74	438	19.63%
11/06/2012	14.01	162	12.96%
11/08/2012	12.79	101	13.86%
11/11/2012	10.14	302	25.83%
11/15/2012	8.56	89	23.60%

Table 6. Estimated capture efficiency of PIT tagged summer Chinook salmon at the lower Entiat River rotary screw trap with average (sunrise to sunset) flow from the USGS Keystone gauging station, 2012.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency
07/09/2012	47.11	107	5.61%
08/03/2012	11.70	77	14.29%
08/09/2012	10.26	124	22.58%
08/10/2012	9.79	131	15.27%
08/31/2012	5.04	213	40.38%
09/07/2012	4.16	223	30.49%
09/12/2012	4.18	106	25.47%
09/19/2012	3.68	144	25.00%

Table 7. Estimated capture efficiency of PIT tagged steelhead at the lower Entiat River rotary screw trap with average (sunrise to sunset) flow from the USGS Keystone gauging station, 2012.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency
04/14/2012	8.53	32	12.50%
05/01/2012	34.99	100	4.00%
05/04/2012	28.33	51	11.76%
05/08/2012	24.36	36	13.89%
05/11/2012	31.64	47	8.51%
08/31/2012	5.04	22	18.18%
09/07/2012	4.16	27	18.52%
11/02/2012	13.41	86	17.44%
11/05/2012	11.74	59	15.25%

Table 8. Estimated capture efficiency of dye marked summer Chinook salmon at the lower Entiat River rotary screw trap with average (sunrise to sunset) flow from the USGS Keystone gauging station, 2012.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency
08/10/2012	9.79	88	4.55%

Water temperature and flow

Water temperature measurements averaged 9.66 ˚C throughout the study period. Water temperatures peaked at 21.03 ˚C on August 14th, and were lowest on February 28th when temperatures were 0.02˚C. Flow peaked in the spring on June 3rd, 2012 at 74.42 m^3/s. High water levels gradually declined through July, allowing rotary screw trap operations to resume (Figure 7).

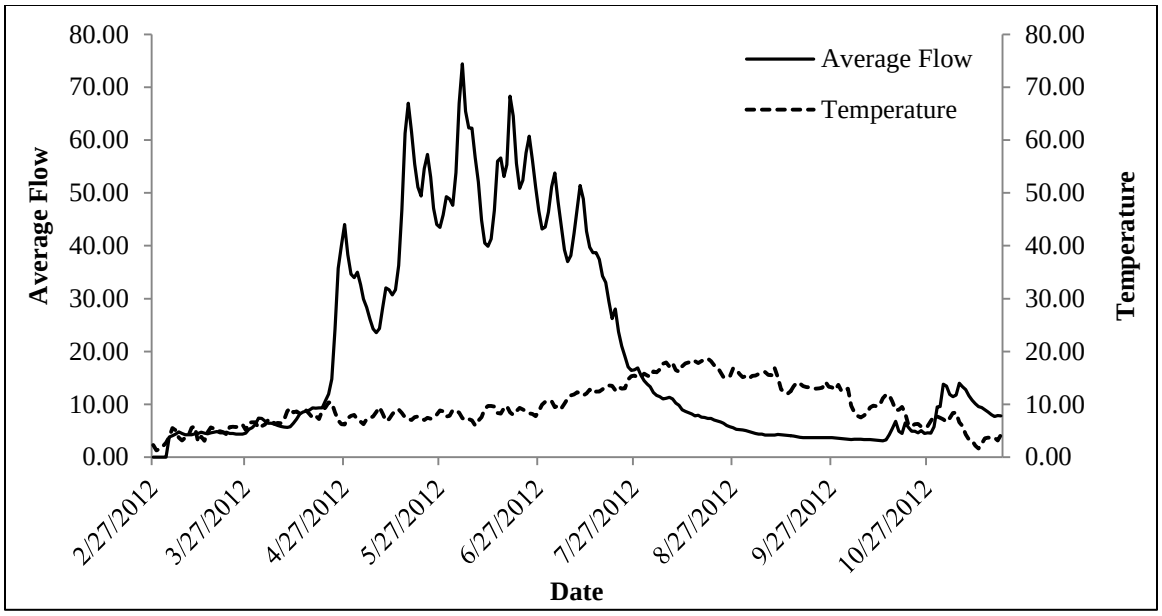

Figure 7. Average daily flow (m^3/s) and temperature (˚C) for the lower Entiat River rotary screw trap, 2012.

Data dissemination
All final data corrections were completed on December 19th, 2012 and submitted to PTAGIS. Electronic data was submitted to ISEMP (via Theo Burgoon) on December 20th, 2012.

Discussion-Rotary Screw Trap

Rotary screw trap operation
The day to day operation of rotary screw traps can be time consuming and difficult. Seasonally high discharge and weather events often increase the amount of debris present within the river leading to higher frequencies of missed trapping periods due to trap failure. These periods require more staff to maintain the traps in an operational condition. The high flows and debris can create a hazardous work environment for the crew, increase the trap related mortality of captured fish, and cause damage to equipment. To minimize these hazards, the trap was removed from operation when necessary. In 2012, the majority of non-operational days were due to snow melt resulting in a high spring flow event and wind storms inundating the trap with leaves and other debris in late October and November. To a lesser extent, the staffing requirements of mark-recapture sampling resulted in a reduction of rotary screw trap operation during the associated field sampling periods.

Summer vs. spring Chinook salmon
Both spring and summer Chinook salmon spawn in the Entiat basin. Early in the season, distinct morphological differences between summer sub-yearlings and spring Chinook salmon yearlings make identification easy: spring Chinook salmon yearlings are much larger in size (75-100 mm) than newly emergent summer Chinook fry (32-45 mm). Identification is more difficult during summer and early fall as both spring and summer Chinook sub-yearlings are similar sizes.

Currently there is no definitive method to apportion these two runs of sub-yearlings, so to determine if the difference in migration timing could be used to assign the proper run, total catch was monitored and plotted by day. When catch decreased and a relative nadir was reached in early October, all Chinook salmon captured onward were assigned a run based on any detectable break in fork length distributions. Annual dates of inclusion for spring Chinook are presented within Appendix Table 3. Undoubtedly, the run classification of some Chinook salmon is improperly assigned using this method. Utilizing the data from the Entiat River PIT tag interrogation sites and the emigration timing of PIT tagged Chinook salmon it is clear that delineation of the two runs of sub-yearling Chinook salmon used in previous years was inadequate.

The MCRFRO is attempting to address this issue through a combination of PIT tag monitoring and genetic analysis. In 2010, we began PIT tagging all Chinook species regardless of run designation. By monitoring the timing of juvenile outmigration and adult returns a better understanding of the accuracy and precision of the nadir-based identification method will be obtained. In 2011 genetic samples were collected from a proportion of all juvenile Chinook regardless of run designation throughout the trapping season. MCRFRO has secured funding and these samples will be analyzed by the USFWS Abernathy Genetics Lab in 2013. This will provide a definitive run classification for each sample when compared to base line genetic data.

Production estimates

Calculations of production estimates using rotary screw traps are standardized between monitoring agencies within the Upper Columbia basin to increase the consistency and usefulness of these annual estimates. A past common consensus among researchers in the Upper Columbia was that a fundamental problem existed with the equation used to estimate variance of point estimates. In 2012, these calculations were reviewed and corrected. MCRFRO is currently in the process of recalculating all production estimates and will include a comprehensive description of how the calculations have changed along with updated production estimates in the 2013 annual report.

Project goals

Project goals were met during the 2012 field season. In 2013, we will continue out-migrant monitoring at rotary screw trap locations to evaluate the success of wild steelhead and spring Chinook salmon recovery actions. This is especially relevant in order to monitor the effects of the discontinuation of the spring Chinook salmon program and the start of a summer Chinook program at the ENFH. In 2013, MCRFRO staff will continue efforts to review parameters and validate key assumptions associated with spring Chinook and steelhead productivity estimates.

Methods- Mark-Recapture Sampling

Sample site selection

The mark-recapture study was designed around a framework of a rotating panel of sites within defined geomorphic reaches of the Entiat River. Sample sites were selected at random from each reach. If a site was unavailable to be sampled, the next upstream site was then selected. A total of 14 sites are sampled annually in both the summer and winter months with new sample sites

selected following the winter sampling period. Sample site locations for winter and summer sample periods in 2012 are presented in Figures 8 and 9 respectively.

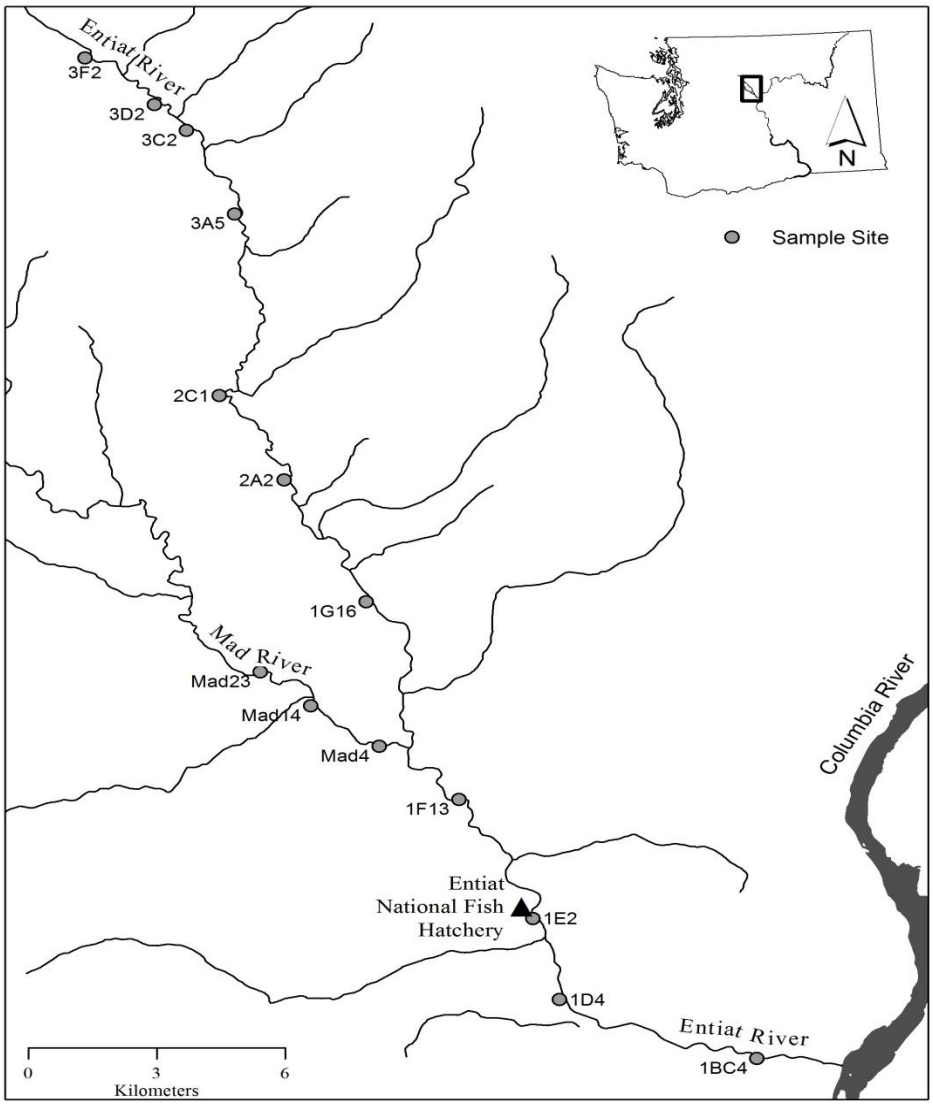

Figure 8. Map of the mark-recapture sites sampled during the winter period in the Entiat River, 2012.

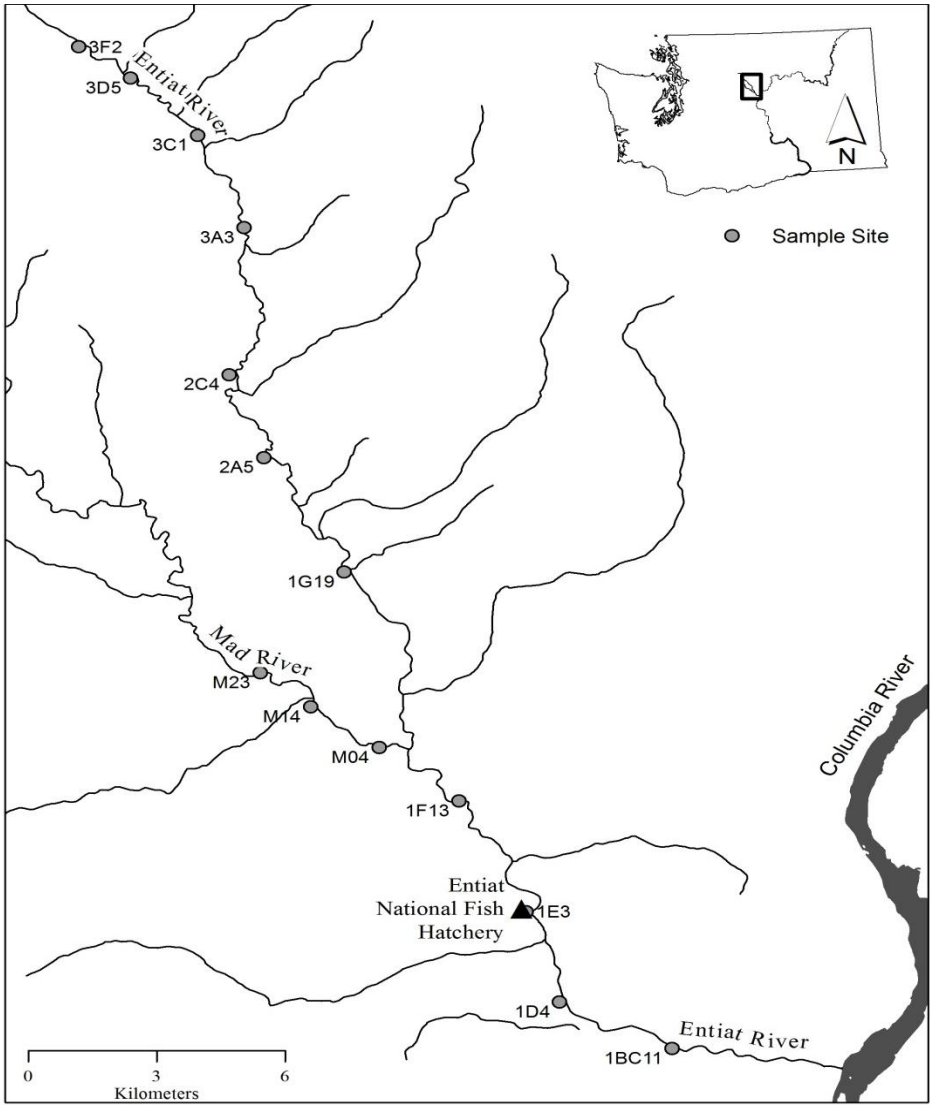

Figure 9. Map of the mark-recapture sites sampled during the summer period in the Entiat River, 2012.

Sample periods

Mark-recapture sampling was conducted twice annually. Winter surveys were conducted within the Entiat and Mad Rivers during March of 2012, prior to the beginning of the spring emigration period. Summer surveys were conducted during August and September when river discharge fell below 9.9 m^3/s.

Fish collection

Mark-recapture methods were used to estimate capture probability and population size for Chinook salmon and steelhead at discrete sites within the Entiat subbasin. Fish were captured using backpack electrofishing, snorkel-herding, hand-netting, beach seining, and angling.

Sampling methods were based upon specific sampling conditions within each site and were often used in combination. All methods relied on the assumption that a population within a site can be treated as effectively closed and that immigration, emigration, or mortality during the sampling period was zero or negligible.

Sampling was conducted at each site over a period of two consecutive days. During the winter period all sites were sampled following sunset to maximize fish capture numbers. During the summer period daytime effort provided adequate captures but in order to avoid high afternoon water temperatures, all sampling began no later than 7:00 am and usually was complete by 2:00 pm. One to three capture crews, each consisting of a minimum of six personnel, sampled sites independently of one another. Within each crew, four personnel were assigned to fish capture and the remaining two to fish handling and PIT tagging. Prior to sampling, all sites were surveyed to determine a primary sampling method. Pre-sampling surveys included recording visual observations of available habitats and when necessary incorporated snorkeling observations at sites where age and species composition was unknown. A primary sampling method of either backpack electrofishing or snorkel-seining was chosen based upon site specific conditions such as water depth, expected flow at time of sampling, the expected age and species composition, and the overall complexity of habitat types present. All sampling was conducted in an upstream direction with crews beginning at the lowermost point and methodically working upstream until the site was completely sampled. In some cases the site or specific habitat was sampled a second time using an alternative method if it was deemed more suitable to the specific conditions. Electrofishing was conducted with either a Smith-Root model 12 or LR-24 backpack electrofisher. Electrofisher operation followed the guidelines of the manufacturer and the National Marine Fisheries Service (NOAA 2000).

Fish handling

Fish were handled in accordance with WDFW Scientific Collection Permit #11-154 and #11-157 (annual permits - start date April 3, 2012, expires April 3, 2013), NOAA Permit 1119 (dated April 10, 2008, expires December 31, 2012) and USFWS Sub permit No. MCRFO-13 (dated Aug 5, 2010, expires December 31, 2013) under Regional Blanket Permit TE-702631.

Fish were transported within 5 gallon aerated buckets from the point of capture to 25 gallon plastic live boxes located on the river margins within the site. Water temperatures and fish condition were closely monitored during transportation and holding. All individuals that exhibited signs of injury or excessive stress were scanned for a pre-existing PIT tag and released. Fish were periodically transported from live boxes to a stationary fish handling and tagging station.

Collected species were anesthetized in a water bath with a measured amount of tricaine (MS-222) buffered with sodium bicarbonate. Small groups of fish were anesthetized at any one time during daily handling to reduce the chance of incidental mortality from anesthetic overdose. Fish were identified to species with the exception of sculpin, dace and suckers. Chinook salmon run designation was classified as unknown when captured during the summer period due to the inability to distinguish between spring and summer run characteristics. All salmonids were ascribed to a life history stage as either fry (<60 mm), parr (>60mm and distinctive parr marks),

transitional (>60 mm silver sheen, faint parr marks, and deciduous scales) or smolt (>60 mm silver sheen, absent parr marks, deciduous scales, and with possible black tipped caudal fins).

All Chinook salmon, steelhead, coho salmon, sockeye salmon, bull trout, and cutthroat trout were measured to the nearest millimeter of fork length and weighed to the nearest tenth of a gram. Fulton-type condition factor was calculated for all Chinook and steelhead as described previously. Non-target species were either measured or counted and released within the site dependent upon time restrictions. All individuals were allowed full recovery prior to release. Non-marked individuals were released within the site in close proximity to their point of capture.

PIT tagging of juvenile Chinook salmon, steelhead, coho salmon, and bull trout followed the procedures outlined under rotary screw trap operations. ISEMP supplied PIT tags for Chinook salmon and steelhead, Chelan County PUD provided tags for bull trout and USFWS supplied PIT tags for cutthroat trout, coho and sockeye salmon. Any injuries or abnormalities were noted and juveniles were not PIT tagged if determined it had a recent or substantial injury that could be aggravated by tagging. Marked juveniles were held for a minimum of one hour to ensure full recovery prior to being released in close proximity to their capture origin.

Mortality rates were tracked for Chinook salmon and steelhead during mark-recapture sampling and categorized as the result of capture, handling, or PIT. In 2013, tagged individuals were not held to assess delayed mortality or tag shed rates.

Site level point estimates

Point estimates of abundance and 95% confidence intervals were generated for wild Chinook salmon and steelhead at each of the sample sites for winter and summer periods. Estimates were generated using the Chapman modification of the Peterson equation as presented in Van Den Avyle and Hayward (1999). All estimates were further tested and considered valid when the data met the validity test conditions proposed by Robson and Regier (1964). The Chapman modification of the Peterson equation is as follows:

$$N = \frac{(M+1)(C+1)}{R+1} - 1$$

with variance:

$$V(N) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2\,(R+2)}$$

where *N* is the population estimate; *M* is the number of fish captured, marked, and released in the first sample; *C* is the total number of fish caught in the second sample including recaptures; and *R* is the number of recaptures caught in the second sampling event.

The Robson and Regier equation to test the amount of bias present within the estimate is as follows:

$$\text{Negligible bias if } N \times C \; < N \times 4$$

Growth per day estimates
Estimates of specific growth rate (SGR) were obtained through the recapture of PIT tagged Chinook salmon and steelhead for winter, summer, and annual periods. SGR estimates were calculated by determining the temporal change in mean fork-length between mark-recapture sampling periods. Total growth rate was determined for each recaptured fish and was then applied to the date intermediate between sampling periods to achieve SGR in growth per day. Estimates were limited to recaptures of fish occurring within the sample site they were originally tagged in. Recaptures were further limited to exclude fish that were PIT tagged within 20 days of the recapture event to avoid the negative short-term effect of PIT tagging on growth rates (Bateman and Gresswell 2006).

Data entry
During the 2012 winter sampling period data entry utilized the P3 program from PTAGIS. These data files generated from the P3 program were then parsed into a database maintained by MCRFRO staff. The summer sampling period utilized an Allegro MX field computer (Juniper Systems) and a new program developed by Quantitative Consultants, Inc. This program, QC_PIT Tagging, is designed for fish capture and PIT tagging in remote settings. Data files created by QC_PIT Tagging were then entered into a custom MS Access® database also developed by Quantitative Consultants, Inc., where a quality check was performed and a P3 file is created. All data files were provided to ISEMP and the original P3 file uploaded to PTAGIS where it is available to researchers throughout the Columbia River Basin.

Genetic sampling
Throughout the summer sampling period genetic samples were taken from a subset of PIT tagged Chinook salmon. Tissue was obtained from a small portion of the ventral fin, preserved in alcohol and sent to the Region 1 USFWS genetics lab for storage.

Scale sampling
Throughout the sampling period, scales were taken from a subset of juvenile steelhead and archived for future age analysis.

Results – Mark-Recapture Sampling

Winter sampling period fish capture summary
Fish sampling began on March 5, 2012 when river surface ice had receded allowing safe access to sample sites. All sampling activities were completed on March 16. Average daily flow (m^3/s) during the sampling period is summarized in Figure 10. Detailed locations and sampling notes are presented as Appendix Table 4.

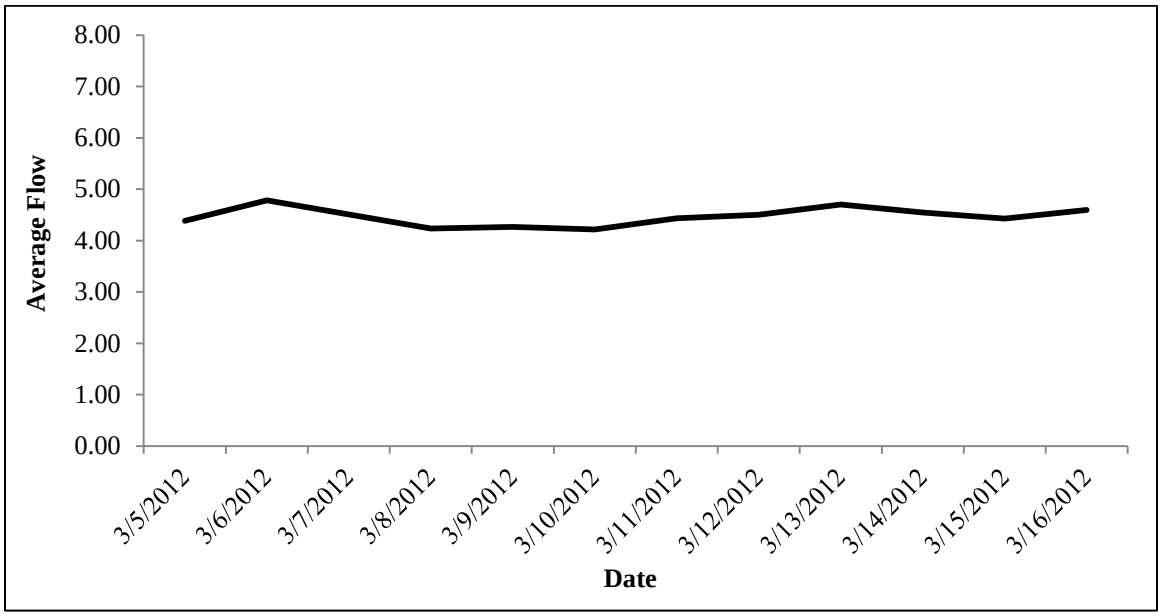

Figure 10. Entiat River average daily flow (m^3/s) during winter period mark-recapture sampling, 2012.

A total of 2,863 fish were captured at 14 sites throughout the Entiat and Mad rivers during the 2012 winter sampling period (Table 9). Species composition included 863 wild spring Chinook salmon (30.1%), 1,978 wild steelhead (69.1%), 11 wild Coho salmon, (0.4%), and two bull trout (0.1%). A total of 2,810 wild salmonids (98.2%) were implanted with PIT tags. Detailed capture summaries are included as Appendix Table 5. Mean fork length (SD) of juvenile spring Chinook and steelhead was 90.37 (8.03) mm and 106.36 (42.33) mm, respectively (Table 10).

Table 9. Number of fish captured and PIT tagged from the winter mark-recapture sample period, 2012.

Species and Life Stage	Total number of Fish Caught	Total PIT Tagged
Wild spring Chinook salmon	863	853
Wild steelhead	1,978	1,944
Wild Coho salmon	11	11
Bull trout	2	2
Grand total	**2,863**	**2,810**

Table 10. Mean fork lengths (mm), weights (g), and body condition factor (K) for spring Chinook salmon and steelhead captured in the winter mark-recapture sample period, 2012.

	Spring Chinook			Steelhead		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Fork Length	90.37	8.03	854	106.36	42.33	1973
Weight	7.52	1.99	854	17.73	22.41	1973
K	1.0	0.09	854	0.97	0.21	1973

During the 2012 winter sample period, instantaneous mortality was attributed to a total of one Chinook salmon (< 0.01%) as a result of PIT tagging. Capture related mortality was limited to three cases for Chinook salmon (< 0.01%) as a result of predation. A total of 25 wild Chinook salmon and 123 steelhead were retained from a total of two sample sites throughout the Entiat and Mad Rivers for assessing delayed mortality and shed rates. There were no cases of delayed tagging mortality for Chinook salmon and steelhead. Shed tag recoveries were limited to one steelhead (< 0.01% shed rate).

Summer period fish capture summary

Fish sampling began on August 13, 2012 when flows within the Entiat River had dropped below 8.5 m^3/s. Above average snow accumulation coupled with a cool spring temperatures resulted in an extended period of high flow conditions within the Entiat River and forced the delay of sampling. Daily average flow (m^3/s) during the sampling period is summarized in Figure 11. Initial sampling efforts focused on the uppermost Entiat River sites in attempt to complete sampling before the peak of spring Chinook spawning activity. All sampling activities were completed on August 24, 2012. Detailed locations and sampling notes are presented as Appendix Table 6.

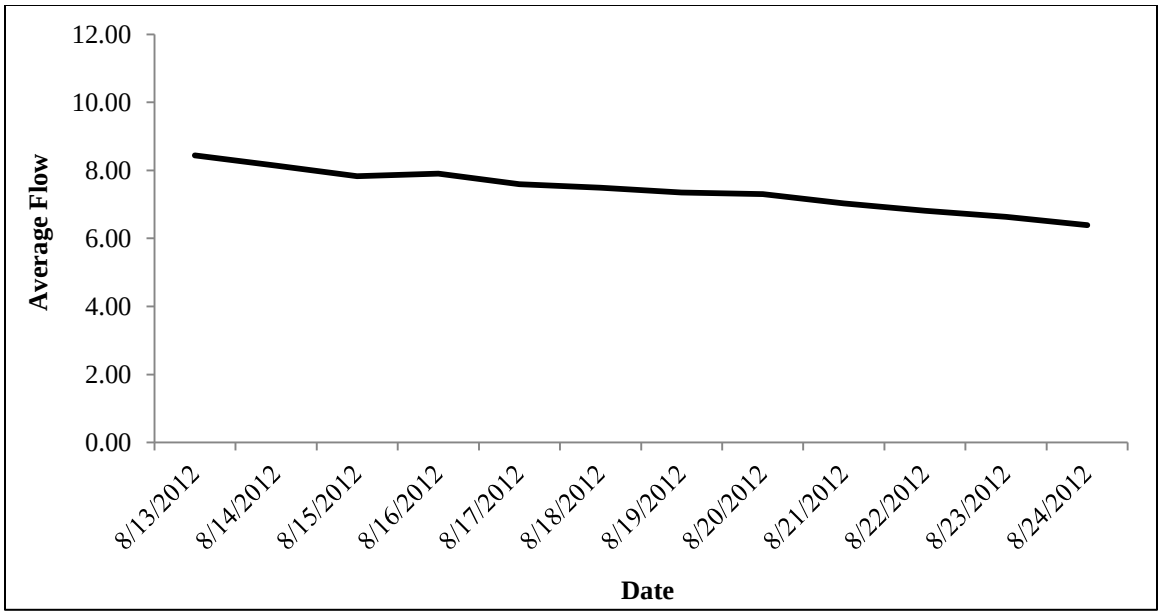

Figure 11. Entiat River average daily flow (m^3/s) during summer period mark-recapture sampling, 2012.

A total of 9,773 fish were captured at 14 sites throughout the Entiat and Mad rivers during the 2012 summer sampling period (Table 11). Species composition included 3,532 wild Chinook salmon (36.1%), 2,727 wild steelhead (27.9%), 125 wild coho salmon (1.3%), 13 bull trout (0.1%), 15 cutthroat trout (0.2%), and 3,361 non-target species (34.4%). A total of 4,751 wild salmonids (48.6%) were implanted with PIT tags. Detailed capture summaries are included as Appendix Table 7. Mean fork length (SD) of Chinook salmon and steelhead was 68.51 (11.38) mm and 84.01 (42.01) mm respectively (Table 12).

Table 11. Number of fish captured and PIT tagged from the summer mark-recapture sample period, 2012.

Species and Life Stage	Total number of Fish Caught	Total PIT Tagged
Chinook salmon	3,532	2,984
Wild steelhead	2,727	1,618
Coho salmon	125	123
Bull trout	13	12
Wild cutthroat trout	15	14
Non-target species	3,361	0
Grand total	**9,773**	**4,751**

Table 12. Mean fork lengths (mm), weights (g), and body condition factor (K) for Chinook salmon (unknown run) and steelhead captured in the summer mark-recapture sample period, 2012.

	Chinook (unknown run)			Steelhead		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Fork Length	68.51	11.38	3,202	84.01	42.01	1,882
Weight	4.00	2.25	3,202	12.10	21.24	1,882
K	1.13	0.12	3,202	1.05	0.11	1,882

During the 2012 summer sample period, instantaneous mortality was attributed to a total of one Chinook salmon (< 0.01%) as a result of PIT tagging. Capture related activities attributed to a total of 122 Chinook salmon (3.5%), 46 steelhead (1.7%), and one coho salmon (0.01%). Of the 169 mortalities, 76 (46.75%) were the result of overcrowding holding buckets.

Site level point estimates

Point estimates of abundance and 95% confidence intervals were generated for wild Chinook and steelhead at each of the sample sites for winter (Table 13) and summer (Table 14) periods. Winter mark-recapture sampling produced a total of 10 valid point estimates of Chinook and 14 for steelhead of the 14 possible for each species. Of the 14 possible point estimates in the summer period 10 were valid for Chinook and five were valid for steelhead.

Table 13. Point estimates of abundance for Chinook salmon and steelhead captured at mark-recapture sites sampled during the winter period, 2012.

Site	Species	New Cptrs	Total Marked	Total Recaps	Recap prob.	Pop. Est.	Lower 95% C.I.	Upper 95% C.I.	Stdrd Error
1BC4	Wild Spring Chinook	29	35	6	0.17	153	69	237	42.87
	Wild steelhead	74	49	6	0.12	535	207	863	167.25
1D4	Wild Spring Chinook	54	62	14	0.23	230	146	314	42.99
	Wild steelhead	214	197	66	0.34	634	532	736	52.00
1E2	Wild Spring Chinook	34	50	10	0.20	161	94	229	34.35
	Wild steelhead	210	174	59	0.34	614	509	720	54.04
1F13	Wild Spring Chinook	2	3	0	0.00	INV	--	--	--
	Wild steelhead	71	72	12	0.17	403	229	577	88.68
1G16	Wild Spring Chinook	11	20	4	0.20	49	23	76	13.72
	Wild steelhead	136	111	41	0.37	364	292	436	36.68
2A5	Wild Spring Chinook	10	11	1	0.09	INV	--	--	--
	Wild steelhead	31	39	6	0.15	182	80	284	51.90
2C1	Wild Spring Chinook	155	88	34	0.39	396	307	485	45.36
	Wild steelhead	55	54	16	0.30	180	122	238	29.62
3A5	Wild Spring Chinook	9	32	6	0.19	46	30	62	8.10
	Wild steelhead	26	50	17	0.34	76	60	91	8.15
3C2	Wild Spring Chinook	81	80	15	0.19	414	256	573	80.92
	Wild steelhead	16	16	4	0.25	57	24	89	16.66
3D2	Wild Spring Chinook	46	55	19	0.35	131	96	165	17.45
	Wild steelhead	32	57	8	0.14	212	108	315	52.71
3F2	Wild Spring Chinook	36	39	18	0.46	77	60	94	8.80
	Wild steelhead	19	19	4	0.21	79	31	127	24.49
M04	Wild Spring Chinook	2	14	0	0.00	INV	--	--	--
	Wild steelhead	92	83	24	0.29	311	225	398	43.92
M14	Wild Spring Chinook	2	0	0	0.00	INV	--	--	--
	Wild steelhead	76	57	16	0.28	262	172	352	45.96
M23	Wild Spring Chinook	7	18	5	0.28	24	17	32	3.96
	Wild steelhead	129	123	59	0.48	268	232	303	18.13

Note: Estimates that did not pass validity criteria (Robson and Reiger calculation) are identified by INV.

Table 14. Point estimates of abundance for Chinook salmon and steelhead captured at mark-recapture sites sampled during the summer period, 2012.

Site	Species	New Cptrs	Total Marked	Total Recaps	Recap prob.	Pop. Est.	Lower 95% C.I.	Upper 95% C.I.	Stdrd Error
1BC11	Wild Chinook	85	128	4	0.03	INV	--	--	--
	Wild steelhead	44	60	3	0.05	INV	--	--	--
1D4	Wild Chinook	568	415	62	0.15	3,756	2,957	4,556	407.98
	Wild steelhead	195	222	36	0.16	1,180	871	1,489	157.63
1E3	Wild Chinook	157	169	23	0.14	1,118	744	1,493	191.03
	Wild steelhead	231	209	40	0.19	1,187	895	1,480	149.25
1F13	Wild Chinook	45	50	8	0.16	260	128	391	67.09
	Wild steelhead	31	33	3	0.09	INV	--	--	--
1G19	Wild Chinook	55	75	2	0.03	INV	--	--	--
	Wild steelhead	68	29	2	0.07	INV	--	--	--
2A5	Wild Chinook	165	67	6	0.09	1,612	576	2,647	528.48
	Wild steelhead	6	12	0	0.00	INV	--	--	--
2C4	Wild Chinook	111	102	21	0.21	523	353	694	86.92
	Wild steelhead	9	11	0	0.00	INV	--	--	--
3A3	Wild Chinook	102	122	17	0.14	703	437	968	135.53
	Wild steelhead	8	8	0	0.00	INV	--	--	--
3C1	Wild Chinook	229	180	67	0.37	611	515	707	48.87
	Wild steelhead	8	19	1	0.05	INV	--	--	--
3D5	Wild Chinook	54	68	19	0.28	189	134	243	27.84
	Wild steelhead	3	19	1	0.05	INV	--	--	--
3F2	Wild Chinook	104	96	35	0.36	282	223	341	29.90
	Wild steelhead	4	2	0	0.00	INV	--	--	--
M04	Wild Chinook	26	58	25	0.43	60	57	64	1.70
	Wild steelhead	116	110	28	0.25	447	327	566	60.95
M14	Wild Chinook	5	3	0	0.00	INV	--	--	--
	Wild steelhead	51	72	11	0.15	317	178	456	70.81
M23	Wild Chinook	12	13	3	0.23	INV	--	--	--
	Wild steelhead	91	103	37	0.36	251	203	299	24.61

Note: Estimates that did not pass validity criteria (Robson and Reiger calculation) are identified by INV.

Growth per day estimates

In 2012, a total of 286 recaptures were used to generate SGR estimates. These recaptures consisted of 50 Chinook salmon (17.5%) and 236 steelhead (82.5%). The majority of recaptures occurred during the summer sampling period of 2012. Estimates of SGR for steelhead varied between growth period and river location. Fish from the Mad River exhibited lower growth rates than fish from the Entiat River (Table 15).

Table 15. Estimated specific growth rates (mm/day) and SD for juvenile Chinook salmon and steelhead captured during mark-recapture sampling per residence river and growth period, 2012.

				Total Growth (mm)		Days to Recapture		Specific Growth Rate (mm/day)	
River	**Species**	**Growth Period**	**n**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Entiat	Chinook	Winter	46	16.8	6.0	194.5	5.0	0.09	0.03
Entiat	Steelhead	Winter	99	13.5	8.3	192.8	7.9	0.07	0.04
Mad	Chinook	Winter	4	17.5	2.5	204.8	5.2	0.08	0.01
Mad	Steelhead	Winter	68	9.9	4.6	202.0	4.9	0.05	0.02
Entiat	Steelhead	Summer	5	57.4	5.98	160.6	0.55	0.36	0.04
Mad	Steelhead	Summer	22	41.0	10.2	160.2	4.5	0.25	0.06
Entiat	Steelhead	Annual	11	76.9	16.0	363.5	15.0	0.21	0.04
Mad	Steelhead	Annual	31	49.2	11.5	366.0	3.7	0.13	0.03

Data dissemination

Data obtained during the winter sampling period was entered into the P3 program from PTAGIS. Once data quality checks were complete, this data was then uploaded to PTAGIS and the MCRFRO database. Fall data was uploaded into the newly developed ISEMP database on a daily basis where built in measures verified data quality. Once all data underwent quality testing it was then uploaded to the PTAGIS, and the MCRFRO databases. Data was also transferred to the Upper Columbia Data Steward on December 20, 2012.

Discussion- Mark-Recapture Sampling

Fish sampling

Warmer winter temperatures and lower snow accumulations minimized shelf ice buildup and allowed easier access to the sample sites during the winter sample period. These climate factors allowed for better capture conditions for the winter period and lower flows during the summer period.

The winter sample period was scheduled to begin in early March prior to the expected onset of Chinook salmon and steelhead emigration while the summer sample period targeted a maximum flow of 8.5m^3/s for the onset of fish sampling. This maximum flow target was reduced from the 2011 target of 9.9m^3/s and proved better suited for maximizing fish capture. Hand netting and snorkel-seining were used during the winter period because electrofishing and angling are not suitable methods for sampling at night. Electrofishing, snorkel-seining, beach seining and angling produced sufficient capture numbers of Chinook salmon and steelhead during the summer sampling period. Our experience indicates electrofishing results in a higher mortality rate than for the other methods. This difference is most likely due to low conductivity which diminishes the size of the electrical field and requires higher voltage settings to stun and capture fish. The resulting mortality was observed predominantly when smaller juveniles were encountered (< 60mm fork-length). To reduce mortality, snorkel-seining will be used prior to electrofishing at sites where either method is possible. Delayed mortality and PIT tag shed rates

were not assessed during the 2012 mark-recapture sampling. This was primarily due to extensive evaluations during prior sampling rounds as well as daily assessments of tagged fish from the rotary screw trap.

Summer vs. spring Chinook salmon
The Entiat watershed supports populations of both spring and summer run Chinook salmon. Late summer identification of juvenile Chinook salmon at the rotary screw trap located in the lower Entiat River is hindered by the inability to visually distinguish between spring and summer run Chinook. A relative nadir (based on catch frequency) has been used at rotary screw trap locations to differentiate between Chinook run types. The summer sampling period for the Entiat IMW currently lacks such a method to differentiate between run types of Chinook and as a result all Chinook were classified as 'wild Chinook (unknown run).' Through continued monitoring of the emigration timing of juvenile PIT tagged Chinook we hope to detect trends that will enable classification of run type at time of capture. USFWS collects and archives genetic samples from juvenile Chinook salmon throughout their emigration period. Currently the MCRFRO is analyzing a subset of these samples. The results from this analysis will be used to better partition Chinook run in future sampling efforts.

Site level point estimates
Estimates of site level abundance were calculated for all sample sites using the Chapman modification of the Petersen estimate. Several assumptions were made concerning the validity of these estimates: 1) the sample population remained closed to immigration and emigration during the study or rates were negligible; 2) marked and unmarked fish had the same mortality rates; 3) marked and unmarked fish were equally available for capture; 4) all marks were retained during the sample period and all marks on recaptured fish were recognized; 5) marked fish randomly mixed with the unmarked population following release. We are confident that our current study design accounts for these assumptions with exception to ensuring a closed sample population.

Due to the high discharge and width of the Entiat and Mad rivers block netting is not feasible. By leaving the sample populations physically open to immigration and emigration during the study period, we were not able to meet the assumption of a closed population. The MCRFRO staff tested the assumption of population closure at three fish capture sites using portable antennas during the summer 2012 sample period. These data show a violation of population closure and indicate that current estimates of abundance likely overestimate the actual populations. MCRFRO will replicate this effort during the winter 2013 sample period to better determine the validity of abundance estimates generated during winter sampling periods. MCRFRO is currently working with the ISEMP on potential solutions to this issue.

The effects of PIT tagging, specific to tag related mortality and shed rates, have recently been brought to question in a publication by Knudsen et. al. (2009). The authors suggest that delayed mortality and shed rates for hatchery reared spring Chinook in the upper Yakima River can exceed previous estimates. Assuming that these finding are applicable to wild populations of Chinook and steelhead in the Entiat watershed a number of problems arise in consideration to the goals of the Entiat River IMW study. We will continue to monitor rates of mortality and mark retention in order to limit bias in juvenile abundance estimates; however, we are currently unable

to account for long-term tag related mortality and retention rates that could bias estimates of seasonal survival and adult recruitment.

Theoretical bias within the Petersen estimator of population abundance has been well documented (Baily, 1951; Chapman, 1948). According to Robson and Regier (1964), bias in abundance estimates produced by the Chapman modification of the Petersen estimate are negligible (less than 2%) when the product of marked fish (*M*) and the total number of fish examined for marks (*C*) exceeds the population size (*N*) by a factor of 4 ($M \times C > N \times 4$). Of the 52 abundance estimates generated, all but 16 were determined to be valid estimates. The bias within these estimates is most likely attributed to low fish densities leading to insufficient numbers of marked fish available for recapture.

Invalid point estimates for both wild Chinook salmon and steelhead at site 1BC11 was a result of a failure to release all marked fish between mark and recapture sampling. Fish were subsequently released and allowed to recover for three hours before sampling commenced. Although it is suggested a recovery time of three hours is adequate for mark-recapture sampling (Temple and Pearsons, 2006) the recapture rates associated with these estimates indicated that this shortened recovery time was inadequate.

Growth per day estimates
A comparison of specific growth estimates between steelhead Entiat and the Mad Rivers was possible in 2012 and a higher growth rate within the Entiat River was observed. This difference may be attributed to a number of factors such as temperature and habitat functions. In order to adequately address this difference future analysis incorporating these variables is needed.

Project goals
Project goals were met during 2012. Fish sampling through the Entiat IMW study provides additional data on non-target species and this information is needed for the long-term monitoring of species native to the Entiat watershed. In 2013, MCRFRO staff will further test the assumption of population closure and work towards a solution to the violation of this assumption. Efforts to model juvenile growth and survival estimates for the IMW study area will continue in 2013.

Methods- Off-Channel Habitat Study

Sample site selection
Sample sites considered for the off-channel habitat study were limited to habitats distinctly separate from the main river channel where flow was perennial, the site was accessible year round, and physical site conditions supported the PIT tag antenna monitoring requirements of the study. In addition to the two sites sampled in 2011, a third site was included in monitoring efforts for 2012 (Figure 12).

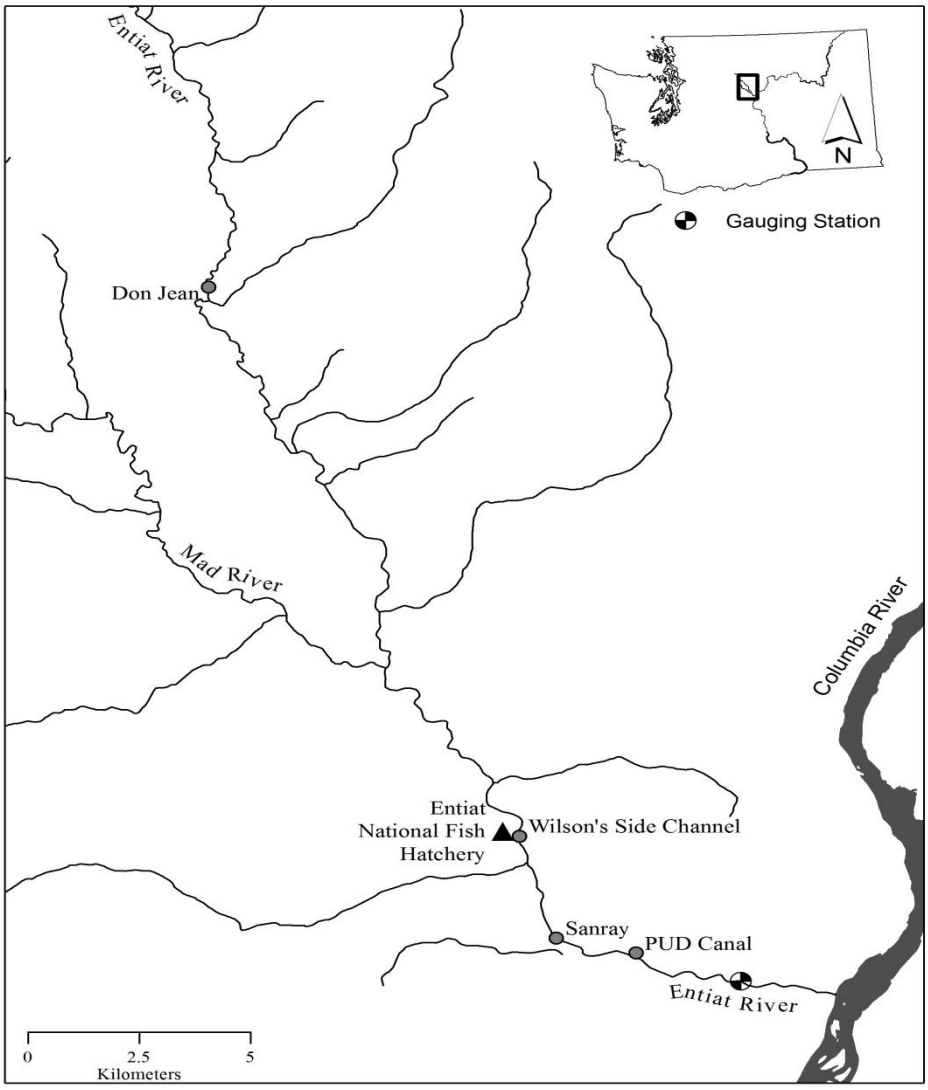

Figure 12. Map of the Entiat River watershed defining locations of the three off-channel study sites sampled, 2012.

Site Descriptions

The Public Utility District (PUD) canal site is located at rkm 5.0 and consists of a 230m long reconnecting perennial channel that includes both a man-made, concrete-lined canal and a naturalized riffle-run habitat. The lower portion of the canal is deep (>1m) and has sparse in-stream habitat, whereas the upper section is complex, with habitat including undercut banks, riprap, log structures, and large boulders.

The SanRay side-channel (SAN), located at rkm 7.0, consists of a 117 m long perennial side-channel that reconnects to the main river. The side-channel is composed primarily of riffle-run habitat with few pools and complex wood structure.

The Wilson side-channel (WLS), at rkm 11.0 near the ENFH, consists of a 286 m long reconnecting perennial side-channel. Habitat within the side-channel is complex. The lower

portion of the site is comprised of downed trees and a series of beaver dams and pools. Where-as the upper portion is a cobble riffle with thick riparian cover.

Sampling periods
Fish sampling was conducted at two sites in the winter and three sites in the summer and fall.

SanRay and Wilson side-channels were sampled three times in 2012. Sampling occurred on March 26-29 (winter sampling period), July 30-31 (summer sampling period), and October 2-5 (fall sampling period). In April 2012 the PUD canal was added and sampling occurred on August 7-8 (summer sampling period), and October 9-10 (fall sampling period).

Fish Collection
Fish collection utilized mark-recapture methods similar to the Entiat River mark-recapture study. Fish sampling methods included backpack electrofishing, seining and hand-netting. Since fish capture during daytime hours provided sufficient numbers of fish for marking and recapture, a night sampling period was not necessary. Fish sampling was conducted at each site over two consecutive days. Block nets were utilized at the top and bottom of each site and maintained for the duration of the mark-recapture period. One capture crew consisting of six personnel sampled each site. Four personnel were assigned fish capture responsibilities and two to data recording and PIT tagging. Sampling was conducted in an upstream direction with crews beginning at the lowermost point and methodically working upstream until the site was completely sampled. Electrofishing was conducted with a Smith-Root model LR-24 backpack electrofishing unit. Electrofishing operations followed the guidelines of the manufacturer and the National Marine Fisheries Service (NOAA 2000). Fish handling and marking methods followed those outlined in the Entiat River mark-recapture study.

Data Entry
Data entry during the winter period utilized the P3 program from PTAGIS. Files were parsed into a database maintained by MCRFRO staff. The summer and fall sampling periods utilized a new program developed by Quantitative Consultants, Inc. This program, QC_PIT Tagging, was designed for fish capture and PIT tagging in remote settings. Data files created by QC_PIT Tagging were then entered into a custom MS Access® database also developed by Quantitative Consultants, Inc., where a quality check was performed and a P3 file is created. All data files were provided to ISEMP and the original P3 file uploaded to PTAGIS where they are available to researchers throughout the Columbia River Basin.

PIT tag antenna monitoring
A single channel spanning antenna was used at the inlet and outlet of each off-channel study site. Antennas were configured in a pass-through orientation and were anchored to the stream bed using steel fence posts. Antenna systems were comprised of an antenna, transceiver, data logger and a power source. Individual antennas were constructed of multiple coils of 20 gauge solid core copper wire sealed within schedule 80 PVC pipe and connected to an Allflex transceiver (RM310 Reader Module) capable of decoding both full and half duplex PIT tags. Individual tag detections were recorded with an Acumen Data Bridge (SDR2-CF) serial data logger which stored tag data on a removable 2 GB compact flash card. The system was powered by two six volt sealed lead-acid DC batteries stored in a waterproof locking worksite storage box.

PIT tag antennas were operated continuously throughout the study period with exception to periods of equipment failure. Interrogation files were downloaded onto a laptop computer weekly or as necessary based on river conditions or expected periods of high fish movement. Records of operational status were taken during each site visit. Routine maintenance was conducted and included battery changing, replacement of anchor straps, and debris removal.

Water temperature monitoring
Water temperature was monitored at the top and bottom of each site throughout the study period. Hourly data was recorded using Onset temperature loggers (HOBO Water Temp Pro V2 U22-001). Loggers were downloaded to a laptop computer at two week intervals using the software provided by the manufacturer.

Dissolved Oxygen monitoring
Dissolved oxygen (DO) was monitored at all off-channel sites using a dissolved oxygen probe (YSI Incorporated, Model 55). Readings were taken once a week and recorded in a spreadsheet for further analysis.

Results- Off-Channel Habitat Study

Fish capture summary
A total of 6,785 fish were captured at three off-channel sites in 2012 (Table 16). Total capture species composition included: 4,937 wild Chinook salmon (71.9%), 1,297 wild steelhead (19.1%), 157 wild coho salmon (2.3%), seven wild sockeye salmon (0.1%), four bull trout (0.1%), 67 Pacific lamprey (1.0%), and 383 non-target species (4.7%). A total of 4,571 wild salmonids (67.4%) were implanted with PIT tags.

Table 16. Total number of fish captured at PUD canal (PUD), SanRay (SAN) and Wilson Side Channel (WLS), 2012.

	Winter 2012			Summer 2012			Fall 2012		
Species	**PUD[a]**	**SAN**	**WLS**	**PUD**	**SAN**	**WLS**	**PUD**	**SAN**	**WLS**
Wild spring Chinook salmon	--	4	54	0	0	0	0	0	0
Wild Chinook (unknown run)	--	0	0	1,285	177	1,594	385	20	1,418
Wild coho salmon	--	10	4	11	33	13	28	28	30
Wild summer steelhead	--	66	46	35	130	123	353	297	247
Bull Trout	--	0	0	2	0	2	0	0	0
Wild sockeye salmon (unknown run)	--	0	3	0	0	0	1	0	3
Pacific lamprey ammocoete	--	0	0	1	3	0	26	7	30
Non-target	--	0	0	95	28	57	12	22	103

[a] PUD canal not sampled during winter period.

Mean fork length (SD) for juvenile Chinook salmon during the winter, summer and fall survey periods in 2012 were 72.93 (10.39) mm (n=57), 60.72 (9.71) mm (n=1,643) and 69.39 (10.77)

mm (n=1,813), respectively. Mean fork lengths (SD) for steelhead during the same sampling periods were 72.22 (11.38) mm (n=88), 60.22 (24.03) mm (n=81) and 66.42 (12.04) mm (n=768), respectively. Mean fork lengths for juvenile Chinook and steelhead are presented by site and sample period in Figure 13. Mean condition factor (K) for all sampling periods for Chinook salmon and steelhead was 1.07 and 1.08, respectively. Figure 14 displays mean condition factors of juvenile Chinook and steelhead by site and sample period.

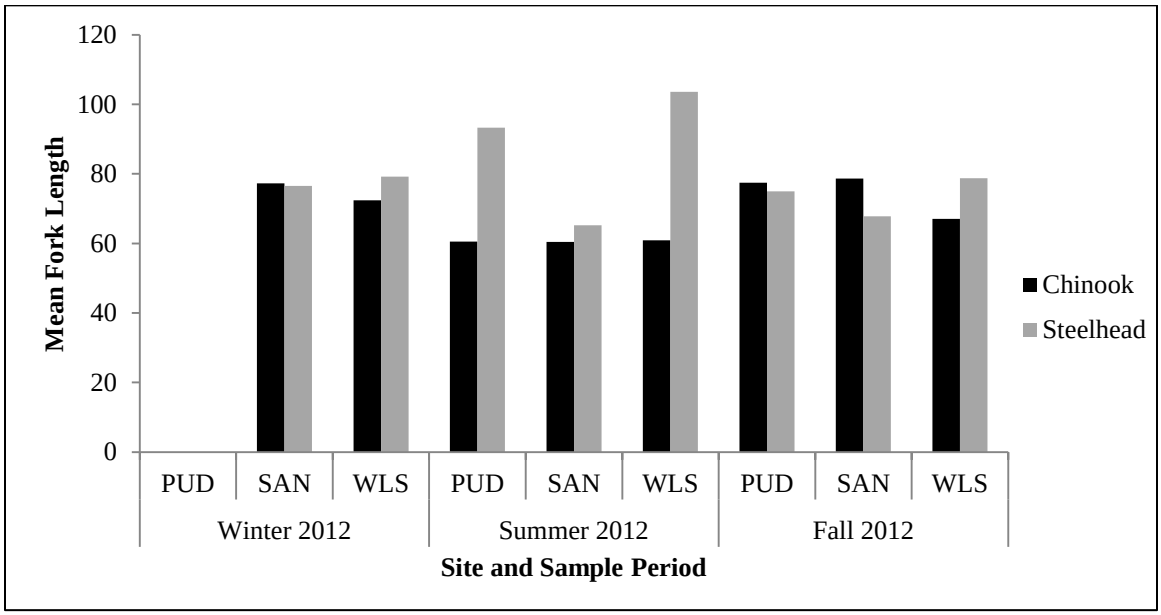

Figure 13. Mean fork lengths (mm) for Chinook salmon and steelhead at PUD canal (PUD), SanRay (SAN) and Wilson Side Channel (WLS), 2012. Note: PUD canal was not sampled during the winter survey.

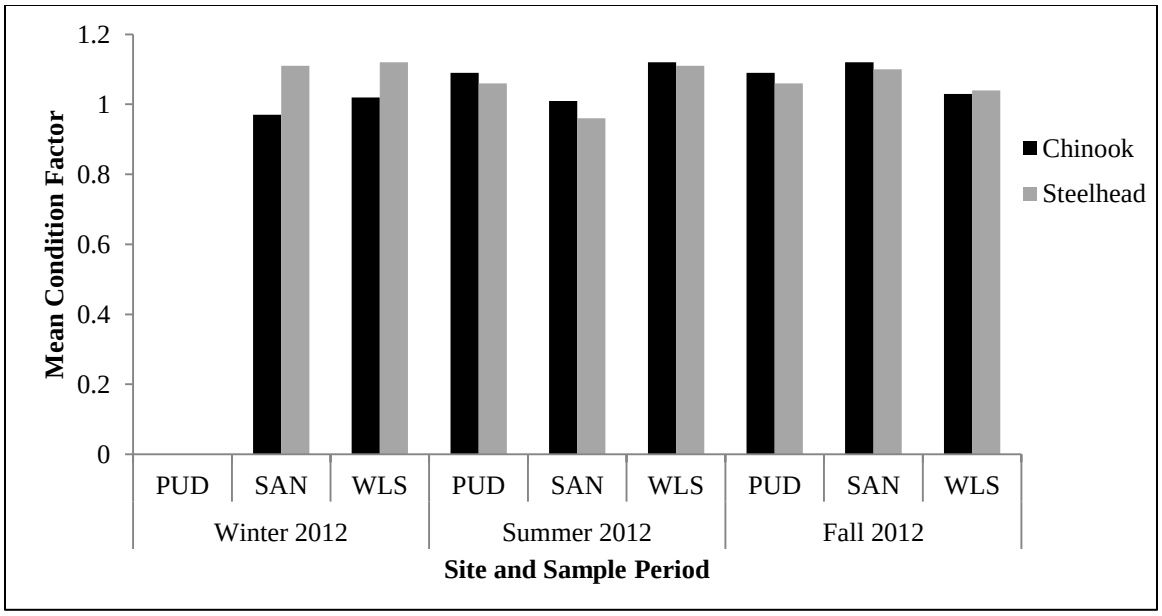

Figure 14. Mean condition factor (K) for Chinook salmon and steelhead at PUD canal (PUD), SanRay (SAN) and Wilson Side Channel (WLS), 2012. Note: PUD canal was not sampled during the winter survey.

Mortality rates were tracked for all species throughout the study.
Capture related mortality in 2012 accounted for a total of 169 fish. This included 123 wild Chinook salmon (71.0%), 28 steelhead (16.6%), 15 mountain whitefish (8.9%), two unknown dace species (1.2%) and one Pacific lamprey (0.6%) (Table 17). Tagging-related mortality totaled five fish. This included four wild Chinook (80%) and one wild coho salmon (20%) (Table. 18).

Table 17. Capture related mortality during the off-channel study at PUD canal (PUD), SanRay (SAN) and Wilson Side Channel (WLS), 2012.

Species	Winter 2012			Summer 2012			Fall 2012		
	PUD[a]	SAN	WLS	PUD	SAN	WLS	PUD	SAN	WLS
Wild spring Chinook salmon	--	0	3	0	0	0	0	0	0
Wild Chinook salmon (unknown run)	--	0	0	12	7	37	10	0	54
Wild coho salmon	--	0	0	0	0	0	0	0	0
Wild summer steelhead	--	4	0	0	2	4	9	3	6
Pacific lamprey ammocoete	--	0	0	0	0	0	0	0	1
Non-target species	--	0	0	6	0	9	0	1	2

[a] PUD canal not sampled

Table 18. PIT tagging mortality at PUD canal (PUD), SanRay (SAN) and Wilson Side Channel (WLS), 2012

Species	Winter 2012			Summer 2012			Fall 2012		
	PUD[a]	SAN	WLS	PUD	SAN	WLS	PUD	SAN	WLS
Wild spring Chinook salmon	--	0	2	0	0	0	0	0	0
Wild Chinook salmon (unknown run)	--	0	0	0	1	0	0	0	1
Wild coho salmon	--	0	0	0	0	1	0	0	0

[a] PUD canal not sampled

Site Level Point Estimates

Point estimates of abundance and 95% confidence intervals were generated for wild Chinook and steelhead at each of the sample sites (Table 19). Winter sampling produced a total of one valid point estimate for Chinook salmon and two for steelhead of the two possible for each species. Summer and fall sampling produced a total of 5 valid point estimates of Chinook and 5 for steelhead of the 6 possible for each species.

Table 19. Point estimates of abundance for wild Chinook salmon and steelhead captured in PUD canal (PUD), SanRay (SAN) and Wilson Side Channel (WLS), 2012.

Site	Sample Period	Species	New Cptrs	Total Marked	Total Recap	Recap prob.	Pop. Est.	Lower 95% C.I.	Upper 95% C.I.	Stdrd Error
PUD	Summer	Chinook	428	265	36	0.14	3,083	2,213	3,953	443.75
		Steelhead	19	3	2	0.67	INV	--	--	--
	Fall	Chinook	223	287	133	0.46	480	443	518	19.21
		Steelhead	229	198	95	0.48	476	424	528	26.58
SAN	Winter	Chinook	3	4	3	0.75	INV	--	--	--
		Steelhead	42	53	30	0.57	74	65	83	4.57
	Summer	Chinook	35	69	7	0.10	314	143	485	87.15
		Steelhead	23	32	9	0.28	78	48	108	15.23
	Fall	Chinook	5	18	3	0.17	INV	--	--	--
		Steelhead	196	202	115	0.57	344	318	370	13.38
WLS	Winter	Chinook	39	25	13	0.52	73	53	94	10.51
		Steelhead	26	27	7	0.26	94	50	137	22.33
	Summer	Chinook	437	387	81	0.21	2,071	1,715	2,428	182.13
		Steelhead	48	36	4	0.11	362	106	617	130.45
	Fall	Chinook	1,020	933	617	0.66	1,542	1,498	1,586	22.66
		Steelhead	169	149	80	0.54	314	280	347	17.06

Note: Estimates that did not pass validity criteria (Robson and Reiger calculation) are identified by INV. PUD not sampled during winter period of 2012.

PIT tag antenna monitoring

Operation of PIT tag antennas at the upper and lower end of the PUD canal yielded a total of 1,238 unique detections in 2012 (Table 20). Species composition included 15 wild spring Chinook (1.2%), two wild summer Chinook (0.2%),515 wild Chinook (unknown run) (41.6%),

150 wild summer steelhead (12.1%), 14 wild coho (1.1%),one wild cutthroat trout (0.1%) and 541 hatchery or unknown species (43.7%).

Table 20. Totals of unique PIT tag detections by species for the PUD side-channel, 2012**.**

Species	Lower	Upper	Total
Wild spring Chinook salmon	3	12	15
Wild summer Chinook salmon	1	1	2
Wild Chinook salmon (unknown run)	321	194	515
Hatchery summer Chinook salmon	29	487	516
Wild summer steelhead	51	99	150
Hatchery summer steelhead	1	5	6
Wild coho salmon	6	8	14
Hatchery coho salmon	2	0	2
Hatchery summer sockeye salmon	1	0	1
Wild cutthroat trout	1	0	1
Unknown Species and Rear	5	11	16

Operation of PIT tag antennas at the upper and lower end of SanRay side-channel yielded a total of 606 unique detections in 2012 (Table 21). Species composition included four wild spring Chinook (0.7%), two wild summer Chinook (0.3%), 183 wild Chinook (unknown run) (30.2%), 333 wild summer steelhead (55.0%), 62 wild coho (10.2%) and 22 hatchery or unknown species (3.6%).

Table 21. Totals of unique PIT tag detections by species for the SanRay side-channel, 2012.

Species	Lower	Upper	Total
Wild spring Chinook salmon	2	2	4
Wild summer Chinook salmon	2	0	2
Wild Chinook salmon (unknown run)	152	31	183
Hatchery spring Chinook salmon	0	1	1
Hatchery Chinook salmon (unknown run)	0	1	1
Wild summer steelhead	197	136	333
Hatchery summer steelhead	1	2	3
Wild coho salmon	42	20	62
Unknown Species and Rear	7	10	17

Operation of PIT tag antennas at the upper and lower end of Wilson side-channel yielded a total of 674 unique detections in 2012 (Table 22). Species composition included eight wild spring Chinook (1.2%), three wild summer Chinook (0.4%), 506 wild Chinook (unknown run) (75.1 104 wild summer steelhead (15.4%), 10 wild coho (1.5%), one wild sockeye (0.2%), three bull trout (0.5%), one cutthroat trout (0.1%) and 38 hatchery or unknown species (5.6%).

Table 22. Totals of unique PIT tag detections by species for Wilson side-channel, 2012.

Species	Lower	Upper	Total
Wild spring Chinook salmon	7	1	8
Wild summer Chinook salmon	3	0	3
Wild Chinook salmon (unknown run)	383	123	506
Hatchery summer Chinook salmon	0	1	1
Wild summer steelhead	30	74	104
Wild coho salmon	7	3	10
Wild sockeye salmon	1	0	1
Bull trout	0	3	3
Cutthroat trout	0	1	1
Unknown species and rear	24	13	37

Temperature and dissolved oxygen monitoring

Average daily temperature for 2012 in the PUD canal was 9.02^{o}C. Temperatures peaked on August 19 at 18.40^{o}C and were lowest on December 21 at 0.03^{o}C. A data gap of 15 days is attributable to the loss of the lower logger in high flows and a corrupt file on the upper logger. Dissolved oxygen (DO) averaged 11.50 mg/L throughout the sampling period. Levels peaked at 16.88 mg/L on December 13 and were lowest on August 18 at 8.8mg/L (Figure 15).

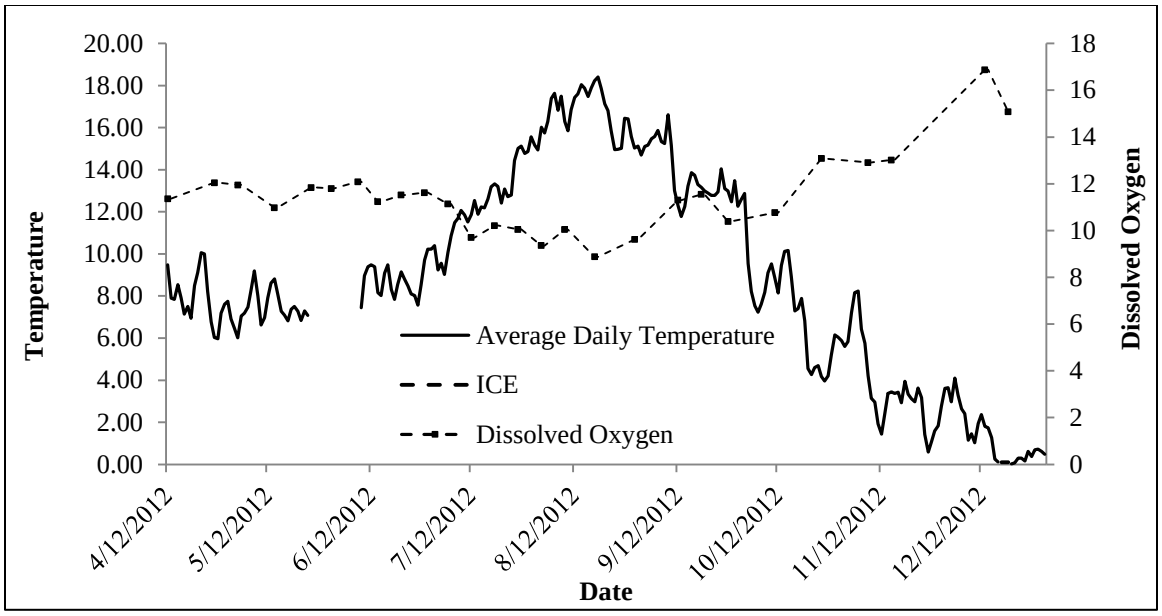

Figure 15. Temperature (^{o}C) and dissolved oxygen (mg/L) in the PUD side channel, 2012.

Average daily temperature for 2012 in the SanRay side-channel was 7.79^{o}C. Temperatures peaked on August 19 at 18.0^{o}C and were lowest in January and February at 0.0^{o}C. Dissolved oxygen (DO) average was 10.48mg/L throughout the sampling period. Levels peaked at 12.18mg/L on January 19 and were lowest on August 9 at 8.8mg/L (Figure 16).

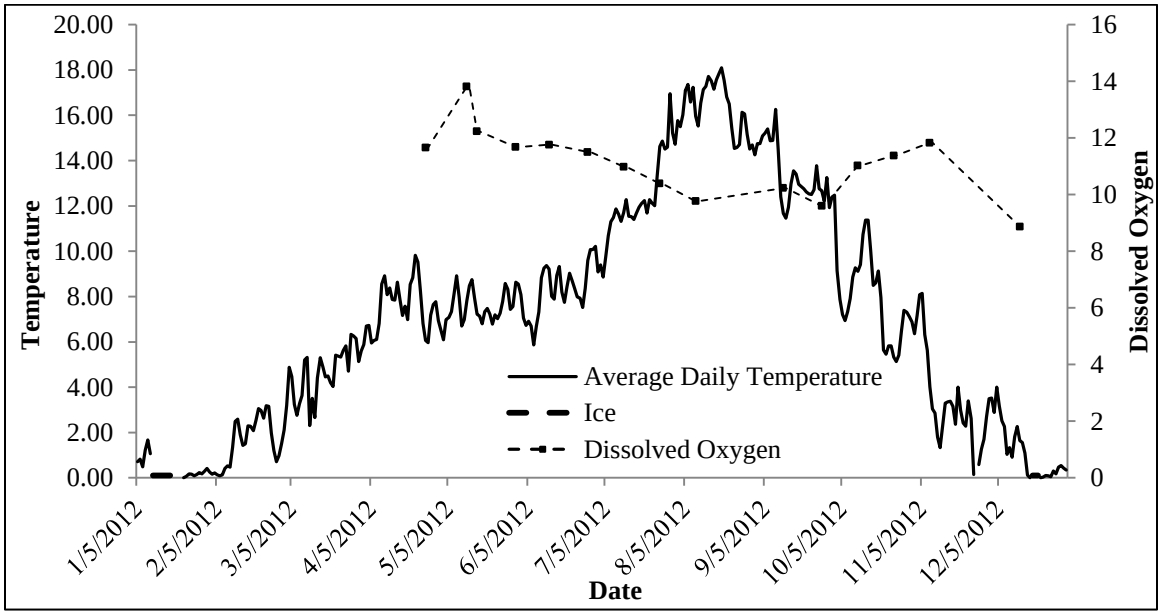

Figure 16. Temperature (^{o}C) and dissolved oxygen (mg/L) in the SanRay side channel, 2012.

Average daily temperature for 2012 in Wilson side-channel was 7.79°C. Temperatures peaked on August 19 at 18.0°C and were lowest in January and February at 0.0°C. Dissolved oxygen (DO) average was 10.48mg/L throughout the sampling period. Levels peaked at 12.18mg/L on January 19 and were lowest on August 9 at 8.8mg/L (Figure 17).

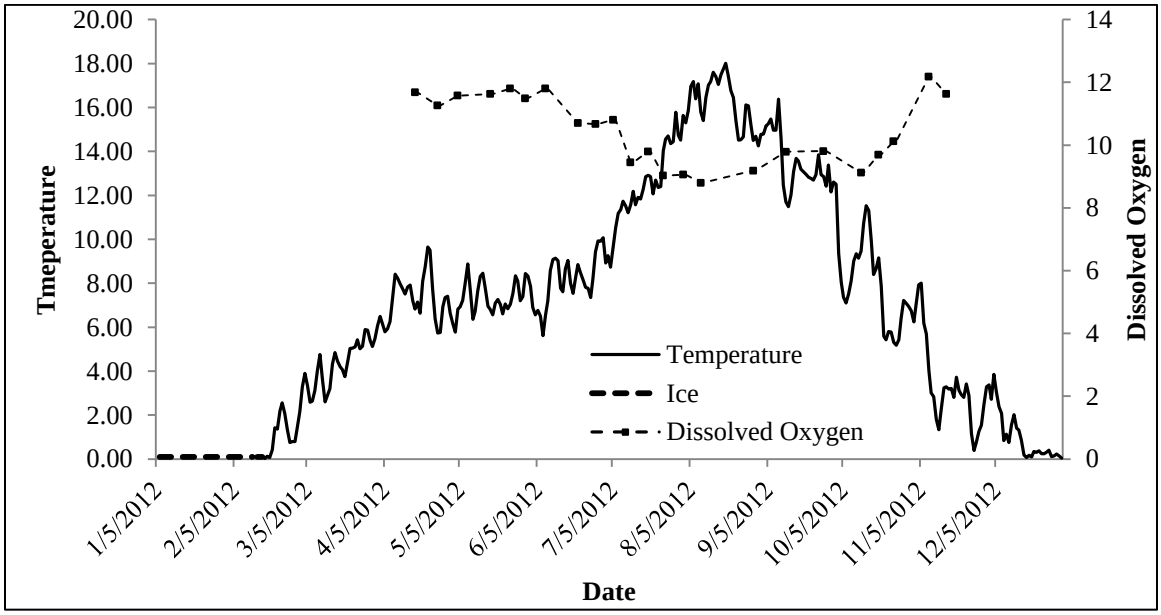

Figure 17. Temperature (°C) and dissolved oxygen (mg/L) in Wilson side channel, 2012.

Data dissemination

Data obtained during the winter and summer sampling periods was entered into the P3 program from PTAGIS. Once data quality checks were complete, this data was then uploaded to PTAGIS and the MCRFRO database. During the fall sampling period MCRFRO staff collected data on a handheld data logger using the QC_PIT Tagging program. Fall data was uploaded into the newly developed ISEMP database on a daily basis where built in measures verified data quality. Once all data underwent quality testing it was then uploaded to the PTAGIS, and the MCRFRO databases. Data was also transferred to the Upper Columbia Data Steward on December 20, 2012.

Discussion- Off-Channel Habitat Study

Fish sampling

Although full implementation of fish capture efforts within the off-channel study will not be completed until 2013, with the addition of more sites, 2012 was the first year SanRay and Wilson side-channels were sampled in the winter and summer periods. Off-channel fish capture methods used electrofishing as a primary capture method with the exception of the concrete lined portion of the PUD canal. In this section, depth is a limiting factor for effective electrofishing and therefore crews used snorkel-herding methods for fish capture. In our experience, electrofishing has resulted in higher numbers of capture related mortalities when compared to other methods.

Low water depth and high turbidity inhibits the use of hand-netting and snorkel-seining as a capture method at most of the off-channel sites. These methods are preferable due to the lower occurrence of capture related mortality and will be utilized in the future as site conditions allow. Delayed mortality and tag shed rates were not assessed during off-channel sampling as these rates have been well documented in past mark-recapture efforts.
The MCRFRO attempted to sample a fourth off-channel site, the Don Jean side-channel (rkm 30.6), during the spring and summer sampling periods. Although this area appeared to have adequate habitat for salmonids, relatively few were found within the site. In addition, high water velocities limited the extent of monitoring that could be performed throughout much of the year. As it appears that salmonids currently do not utilize this habitat MCRFRO opted to focus efforts on the PUD irrigation canal although periodic sampling at the Don Jean site will occur in the future.

Summer vs. spring Chinook salmon
The problem of accurately assigning a run designation to Chinook salmon encountered in the late summer months was managed using the same criteria as was applied in the Entiat River mark-recapture study. Juvenile Chinook salmon encountered in the summer and fall sampling periods were classified as 'wild Chinook (unknown run)'. In future sampling, the fall and summer periods will be the only times this classification will be applied as run classification of Chinook encountered during spring period is known.

Site level point estimates
The difference in abundance estimates between the off-channel sites during the fall period has raised concern. Habitat complexity may explain the differences in species composition; however, high abundance of juvenile salmonids within Wilson's side-channel during the fall sampling period is concerning. MCRFRO is closely monitoring over winter conditions within the Wilson side-channel and expects that survival and growth estimates will be completed in 2013. Modifications were made to Wilson's side-channel through a project sponsored by Trout Unlimited in 2004 and included an inlet pipe, the placement of wood and boulders within the channel, and riparian plantings. Since the completion of this project the side-channel has been impounded through beaver activity which has increased annually. Currently the site exists as a series of ponds which may act as a barrier to passage during normal fall and winter flow conditions resulting in the overwinter stranding of juveniles. Furthermore, the site experiences significant ice cover during the winter months. Through continued monitoring of this and other sites, MCRFRO is hopeful that the information obtained may be used to better maintain current off-channel habitats and be insightful for improving designs and maintenance considerations of future sites.

Antenna monitoring
Incorporating PIT tag antenna monitoring into the Off-Channel Habitat Study will provide significant insight into when these habitats are being utilized by wild Chinook and steelhead. Furthermore, data generated from PIT tag antennas will serve to bolster future estimates of survival within these habitats. In 2012, a number of operational issues arose early in the monitoring year which resulted in numerous data gaps. Most of these issues were resulting from equipment failure although staff inexperience with operating and maintaining the monitoring equipment played a role to a lesser extent. Spring time high river flow further limited our ability

to adequately monitor at a number of locations. New operational procedures, staff training and equipment modifications greatly decreased the periods of downtime later in the monitoring period.

Habitat monitoring
In 2012, physical habitat measurements were recorded by staff from Terraqua Inc. As this work was not conducted within the contractual scope of MCRFRO it is not included within this report.

Project goals
MCRFRO will be adding two new sites during the winter/spring of 2013. By adding these sites we will be able to continue monitoring various habitat types at different locations. As more data is acquired, a quantitative assessment of the biological importance of these habitats to juvenile spring Chinook and steelhead will be accomplished. MCRFRO is hopeful that this study will provide valuable insight into the design of future off-channel habitat restoration projects.

Additionally, we will per sue upgrading antenna monitoring equipment to include solar battery charging capabilities. This upgrade would further limit data loss by ensuring a steady supply of power with less physical maintenance requirements.

Methods- PIT Tag Interrogation Site Monitoring

Interrogation site locations
MCRFRO operated six PIT tag interrogation sites within the Entiat watershed in 2012. The lower Entiat River interrogation site (ENL) has been operational since 2007 and is located below the rotary screw trap at rkm 2. The interrogation site near the town of Ardenvoir (ENA) was installed in May of 2011 and is located at rkm 17.1. The middle Entiat River interrogation site (ENM) has been operational since 2008 and is located below the McKenzie diversion dam at rkm 26. The interrogation site near Stormy Creek (ENS) was installed in April of 2011 and is located at rkm 35.7. The Entiat River Forest Service boundary (ENF) site became operational in 2010 and is located at rkm 40.6. The Mad River (MAD) site has been operational since 2008 and is located on the Mad River at rkm 1. Locations of current interrogation sites within the Entiat watershed are shown in Figure 18.

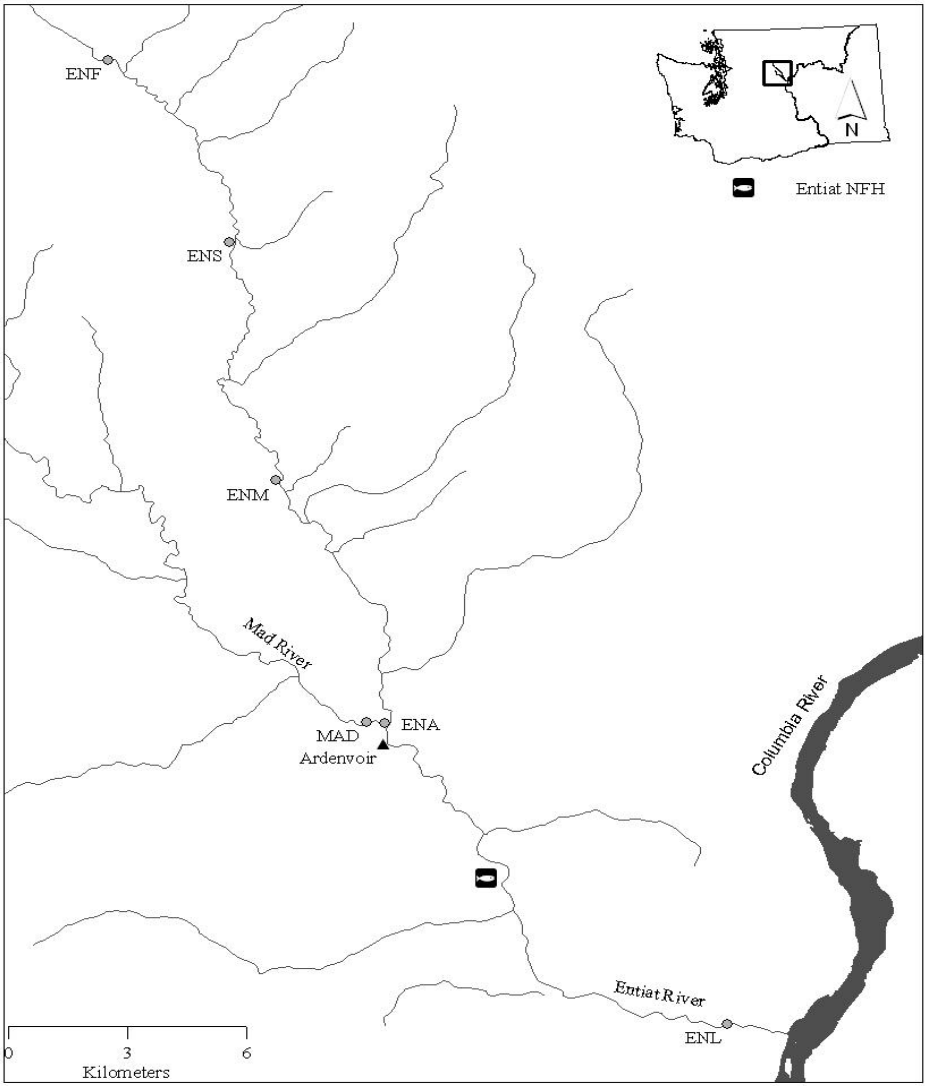

Figure 18. Map of the locations of PIT tag interrogation sites in the Entiat River, 2012.

Interrogation site operation

Interrogation sites were equipped with a multiplexing transceiver (Destron-Fearing Digital Angel model # FS1001M) capable of reading full duplex PIT tags (134.2 kHz). Six antennas, each ranging from 3.0 to 6.1 m, spanned the width of the river at each site. Antenna power and communication was provided by a coax cable connected to the transceiver. External AC power was used to charge DC batteries in a weatherproof housing.

Antenna size was dependent upon the width of the river and thus varied between individual sites. Antennas were configured within the river in rows to determine the direction of fish movement and increase site efficiency through redundancy. At main-stem Entiat River interrogation sites (ENL, ENA, ENM, ENS and ENF) antennas were configured as two rows of three while at the Mad River interrogation site (MAD) three rows of two antennas were used.

Interrogation sites were operated continuously throughout the year with exception to brief periods of equipment failure. All sites were downloaded weekly or as necessary based on river conditions or expected periods of high fish movement. Records of operational status were taken during each site visit. Transceiver data files were either transmitted via a cellular modem located at the site or by manually downloading the file onto a laptop computer. Site operational status and data files were uploaded to the PTAGIS website on a weekly basis.

Proportions of Entiat River origin, stray, and unknown origin fish were calculated using PTAGIS based web queries of all detections logged within the Entiat basin. Data generated from web queries was validated through the MCRFRO database to ensure its completeness. Juvenile versus adult classification was based on a combination of comments made by tagging agencies at time of initial capture and the time period between the initial tagging date and last interrogation date.

Interrogation site maintenance
Routine maintenance was conducted by MCRFRO and included cable reconnection, replacement of anchor straps, debris removal, and antenna tuning. Repairs in the event of equipment failure were beyond the contractual scope of work for MCRFRO as defined in 2012. In these events the Upper Columbia ISEMP coordinator (Pamela Nelle) and subsequently Washington Department of Fish and Wildlife (WDFW) staff were contacted to schedule repairs.

Results- PIT Tag Interrogation Site Monitoring

Monitoring periods
PIT tag interrogation sites were considered fully operational if all antennas were functioning properly and the site was logging data as expected. During the 366 day monitoring period, the ENL site operated for 366 days (100%), ENM for 363 days (99.05%), ENF for 354 days (96.86), MAD for 366 days (100%), ENA for 305 (83.42%), and the ENS site operated 241 (65.85%). Specific details pertaining to site inactivity or failure are outlined in Appendices 8 through 13.

Detection summary
In 2012, a combined total of 2,510 unique PIT tag detections were recorded between all sites (Table 23). Unique detections were determined by pooling detections from all sites during the monitoring period and removing any duplicate values. Juvenile fish accounted for a total of 2,168 (86.4%) of all unique detections, adult detections accounted for 342 (13.6%). Of the juvenile detections a total of 2,161 (99.7%) were determined to be of Entiat River origin and 7 (0.3%) were apparent strays (Table 24). A total of 118 (34.5%) adults were of Entiat River origin, 197 (57.6%) were apparent strays, and 27 (7.9%) were of unknown origin (Table 25). In general, adults of an unknown origin were tagged as adults at collection facilities within the Columbia hydro system.

Table 23. Combined unique detections from all interrogation sites within the Entiat watershed, 2012. PTAGIS naming convention used to indicate species, run and rear type.

Species (indicating rear and run type)	Juvenile	Adult	Total Detected
Hatchery spring Chinook salmon	1	11	12
Wild spring Chinook salmon	487	44	531
Spring Chinook salmon (unknown rear type)	0	1	1
Hatchery summer Chinook salmon	110	24	134
Wild summer Chinook salmon	301	15	316
Hatchery fall Chinook salmon	0	3	3
Fall Chinook salmon (unknown rear type)	0	4	4
Chinook salmon (unknown run and rear type)	0	13	13
Hatchery Chinook salmon (unknown rear type)	0	8	8
Wild Chinook salmon (unknown run)	633	6	639
Hatchery coho salmon (unknown run)	1	4	5
Wild coho salmon (unknown run)	11	0	11
Hatchery summer steelhead	4	32	36
Summer steelhead (unknown rear type)	0	4	4
Wild summer steelhead	588	131	601
Hatchery summer sockeye salmon	0	5	5
Wild sockeye salmon (unknown run)	0	1	1
Hatchery sockeye salmon (unknown run)	0	3	3
Sockeye salmon (unknown run and rear type)	0	3	3
Bull trout	15	28	43
Wild resident cutthroat trout	17	2	19
Mountain whitefish	0	1	1
Grand totals	2,168	342	2,510

Table 24. Origin of juvenile fish detected at interrogation sites within the Entiat River, 2012. PTAGIS naming convention used to indicate species, run and rear type.

Species (indicating rear and run type)	Entiat Origin	Stray	Total
Hatchery spring Chinook salmon	0	1	1
Wild spring Chinook salmon	487	0	487
Hatchery summer Chinook salmon	110	0	110
Wild summer Chinook salmon	301	0	301
Wild Chinook salmon (unknown run)	0	0	0
Hatchery coho salmon (unknown run)	0	1	1
Wild coho salmon (unknown run)	11	0	11
Hatchery summer steelhead	0	4	4
Wild summer steelhead	587	1	588
Hatchery sockeye salmon (unknown run)	0	0	0
Bull trout	15	0	15
Wild resident cutthroat trout	17	0	17
Grand totals	2,161	7	2,168

Table 25. Origin of adult fish detected at interrogation sites within the Entiat River, 2012. PTAGIS naming convention used to indicate species, run and rear type.

Species (indicating rear and run type)	Entiat Origin	Stray	Unknown Origin	Total
Hatchery spring Chinook salmon	0	11	0	11
Spring Chinook (unknown run)	0	0	1	1
Wild spring Chinook salmon	41	0	3	44
Hatchery summer Chinook salmon	0	24	0	24
Wild summer Chinook salmon	1	14	0	15
Hatchery fall Chinook salmon	0	3	0	3
Fall Chinook salmon (unknown rear type)	0	0	4	4
Chinook salmon (unknown run and rear type)	0	0	13	13
Hatchery Chinook Salmon (unknown run)	0	8	0	8
Wild Chinook salmon (unknown run)	6	0	0	6
Hatchery coho salmon (unknown run)	0	4	0	4
Wild coho salmon (unknown run)	0	0	0	0
Hatchery summer steelhead	0	32	0	32
Summer steelhead (unknown rear type)	0	0	4	4
Wild summer steelhead	42	89	0	131
Hatchery summer sockeye salmon	0	5	0	5
Hatchery sockeye salmon (unknown run)	0	3	0	3
Sockeye salmon (unknown run and rear type)	0	0	2	2
Wild sockeye salmon (unknown run)	0	1	0	1
Bull trout	26	2	0	28
Wild resident cutthroat trout	2	0	0	2
Mountain whitefish	0	1	0	1
Grand totals	118	197	27	342

Discussion- PIT Tag Interrogation Site Monitoring

Interrogation site operation

Instream interrogation sites are often subjected to a multitude of harsh conditions that can result in equipment loss or damage. As this typically occurs during high water events, there are periods of time in which they cannot be safely accessed for repair. This occurs most frequently at the ENL site due to its location within the drainage and the higher flow associated with it. In 2012, only minor repairs were required following peak spring river flow.

Project goals
Project goals were met during 2012. In the coming year we will upgrade the capacity of interrogation site monitoring. We will continue to explore various methods to determine site detection efficiency. We will also explore new anchoring techniques and materials in attempt to maintain interrogation sites in an operable status through normal high river discharge condition

Methods- Steelhead Redd Surveys

Surveys to count steelhead redds were conducted using methods described in Nelle and Moberg (2008). The main-stem Entiat River was surveyed from Fox Creek Campground (river kilometer (rkm) 45) to the Entiat information kiosk (rkm 1.1). The survey area was divided into four reaches based on river access points and distances that could be surveyed in a work day (Figure 19, Table 26). A two person crew each using a 10' cataraft, conducted redd surveys in a downstream manner. Surveyors walked areas that were inaccessible or unsafe to raft. All four reaches were surveyed on a weekly basis as long as the weather and stream conditions permitted.

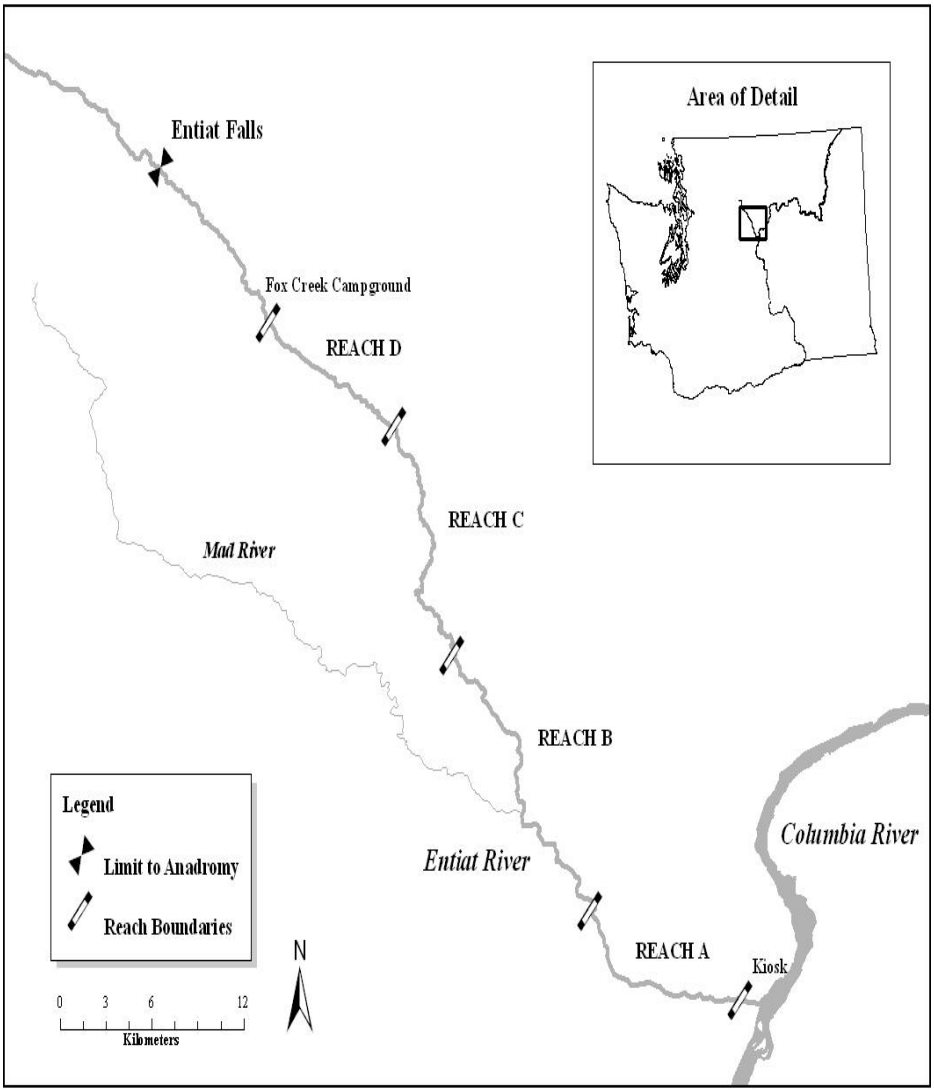

Figure 19. The four reaches of steelhead redd surveys on the Entiat River, 2012.

Table 26. Steelhead spawning ground reaches on the Entiat River in 2012.

Reach	Start (Landmark)	End	Length (km)
D	rkm 45.0 (Fox Cr. Campground)	rkm 37.7	7.3
C	rkm 37.7 (Brief Bridge)	rkm 25.9	11.8
B	rkm 25.9 (McKenzie Diversion)	rkm 10.6	15.3
A	rkm 10.6 (Entiat NFH)	rkm 1.1	9.5

Three separate methods were used to describe water clarity. First, a Secchi disk method of calculating lateral water visibility that we first used in 2011 was further developed. This

technique used a weighted Secchi disk attached to a cord 1.5m in length and a fifty meter measuring tape. The downstream surveyor rested the Secchi disk on the bottom at a depth of 0.5meters with the face oriented parallel to the water surface. A second observer waded upstream unreeling the measuring tape until the disk's color patterns are no longer discernible. The distance was recorded (Figure 20). The second method categorized water clarity by visual estimation. Water clarity was recorded as 1 (very clear), 2 (somewhat turbid), or 3 (too turbid to see through) by the observers; a category 3 precludes the survey for the day. Finally, water samples were taken to measure stream turbidity by light scatter due to suspended particles. In the office samples were transferred into clear glass vials, placed in a Hach 2100P Portable Turbid meter, and NTUs were recorded. All three water visibility measurements were recorded at the start and end of each survey reach.

Weather conditions were recorded at the beginning of each survey. Changes in weather conditions taking place throughout the duration of the survey were recorded.

Water temperatures were recorded at the beginning and end of each survey reach. Temperatures (°C) were taken with calibrated thermometers accurate to +/- 0.04 - 0.07°.

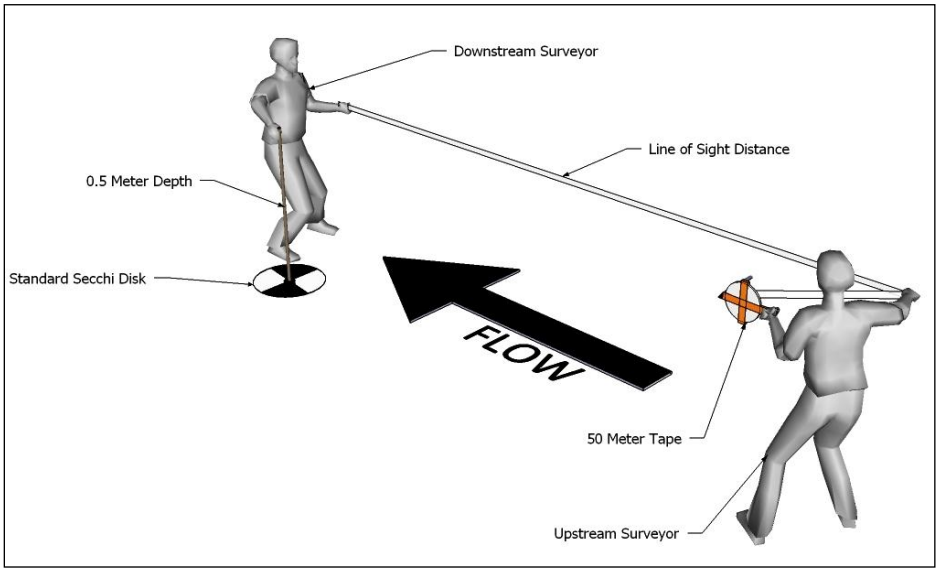

Figure 20. Diagram showing Lateral Secchi Disk visibility measurement.

Results- Steelhead Redd Surveys

Steelhead redd surveys began on February 14, 2012 and continued through May 10, 2012. During the week of April 25, we were unable to complete any surveys due to high discharge and low water clarity. One additional survey was done on reach A, B and C the week of June 13. These final surveys were done to remove flagging and to determine if spawning had continued throughout the high flow period. During the survey season water temperatures ranged from 0.0°C at the beginning to 9.5° C at the end. Turbidity averaged 0.97 NTU, lateral Secchi disk

visibility readings averaged 23.9 meters, water clarity averaged 1 (Table 27). Average turbidity was greatest in Reach A, but the highest turbidity was recorded in the upper Entiat River during increased stream flow time periods. There was minimal difference in lateral Secchi disk readings based on location alone (Table 27).

A total of 77 redds were counted during 2012 (Table 28). No redds were observed during the first survey of each reach. The first redd was observed on March 26 in Reach A when mean temperature was 5.3 °C. Eighty-one percent (68/77) of the steelhead redds were constructed in April, with a peak of 29 new redds observed the week of April 18. The mean temperature during this peak spawning week was 6.1 °C.

Table 27. Ranges and means of temperature (°C), Secchi disk lateral visibility (m), turbidity (NTU), and water clarity of the Entiat River during steelhead redd surveys, 2012.

	Range (mean)			
Reach	**Temp °C**	**Secchi Disk (m)**	**Turbidity (NTU)**	**Water Clarity**
A	1.5 – 9.5 (4.8)	13.0 – 34.1 (23.6)	0.6 – 2.11 (1.09)	1 – 2 (1.2)
B	0.0 - 8.5 (5.2)	7.0 – 35.8 (22.2)	0.4 – 1.76 (0.97)	1 – 2 (1.1)
C	0.0 – 7.5 (4.1)	17.0 – 28.5 (24.8)	0.3 - 2.46 (0.89)	1 - 2 (1.0)
D	3.5 - 7.5 (5.4)	17.7 – 42.3 (31.3)	0.5 – 0.92 (0.67)	1 - 2 (1.0)
All Reaches	0.0 – 9.5 (4.9)	7.0 – 42.3 (25.4)	0.3 - 6.0 (0.90)	1 – 2 (1.2)

Table 28. The numbers of new steelhead redds counted each week and cumulative totals in the survey reaches on the Entiat River, 2012.

Midweek Date	Number of steelhead redds									
	A		B		C		D		All Reaches	
	New	Total	New	Total	New	Total	New	Total	New	Total
02/15/12	0	0	--	--	--	--	--	--	0	0
02/22/12	0	0	0	0	--	--	--	--	0	0
02/29/12	0	0	0	0	0	0	--	--	0	0
03/07/12	0	0	0	0	0	0	--	--	0	0
03/14/12	0	0	0	0	0	0	--	--	0	0
03/21/12	0	0	0	0	0	0	--	--	0	0
03/28/12	1	1	0	0	0	0	--	--	1	1
04/04/12	4	5	1	1	2	2	--	--	7	8
04/11/12	9	14	9	10	9	11	--	--	27	35
04/18/12	7	21	9	19	13	24	0	0	29	64
04/25/12	--	21	--	19	--	24	--	0		64
05/02/12	3	24	1	20	3	27	--	0	7	71
05/09/12	5	29	0	20	1	28	0	0	6	77
5/16/2012	--	29	--	20	--	28	--	--	0	77
5/23/2012	--	29	--	20	--	28	--	--	0	77
5/30/2012	--	29	--	20	--	28	--	--	0	77
6/6/2012	--	29	--	20	--	28	--	--	0	77
6/13/2012	0	29	0	20	0	28	--	--	0	77

Note: Cells containing -- indicate a survey was not conducted in that reach during the survey week. Midweek dates appearing in italics denote that no surveys were attempted due to stream conditions.

The number of steelhead redds counted in each reach during 2006 to 2012 are shown in Table 29. Figure 21 shows the number of redds by month from 2006 to 2012. The location of individual redds within the survey reaches are shown in Figures 22 through 25. In 2012, 38% of the steelhead redds were found in Reach A, 26% in Reach B, 36% in Reach C and 0% in Reach D. We documented the onset of spawning in all reaches except D, where surveys started as scheduled on April 18, but stream flows did not allow for the next survey until May 9. At this time no redds were observed in reach D and no additional surveys were attempted due to stream conditions. This resulted in a count of zero for reach D. This year Reach A had the lowest number of redds recorded to date.

Table 29. The total number of steelhead redds by reach on the Entiat River from 2006 to 2012.

	Reach				
Year	**A**	**B**	**C**	**D**	**Total**
2006	38	26	34	13	111
2007	40	7	14	3	64
2008	93	84	31	14	222
2009	128	37	27	8	200
2010	87	33	52	17	189
2011	55	73	51	26	205
2012	29	20	28	0	77

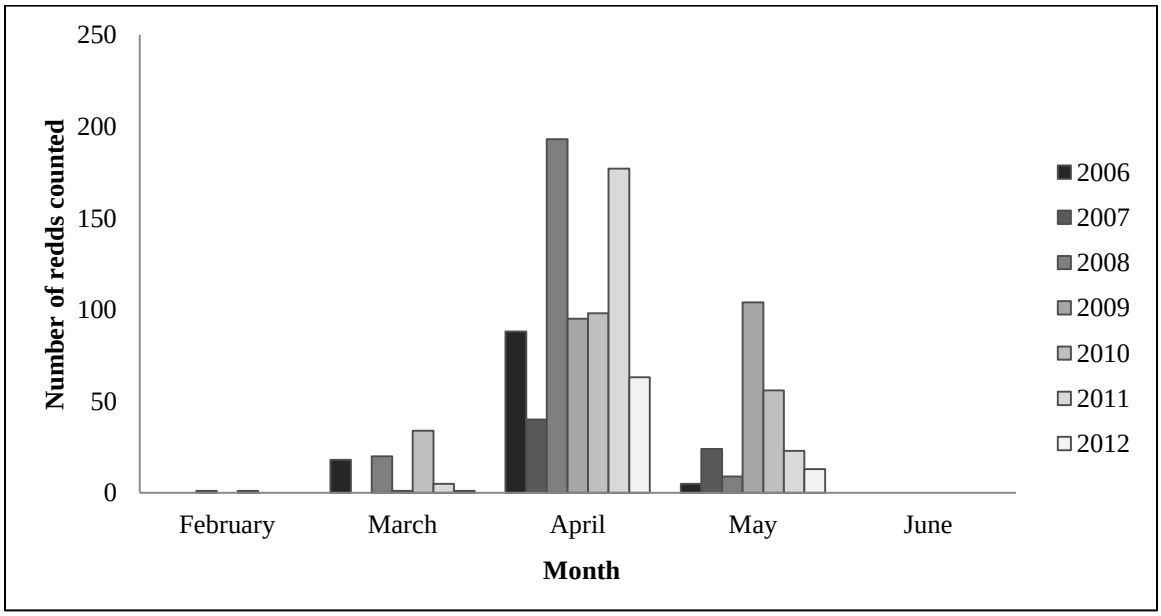

Figure 21. The numbers of steelhead redds observed by month in the Entiat River from 2006 to 2012.

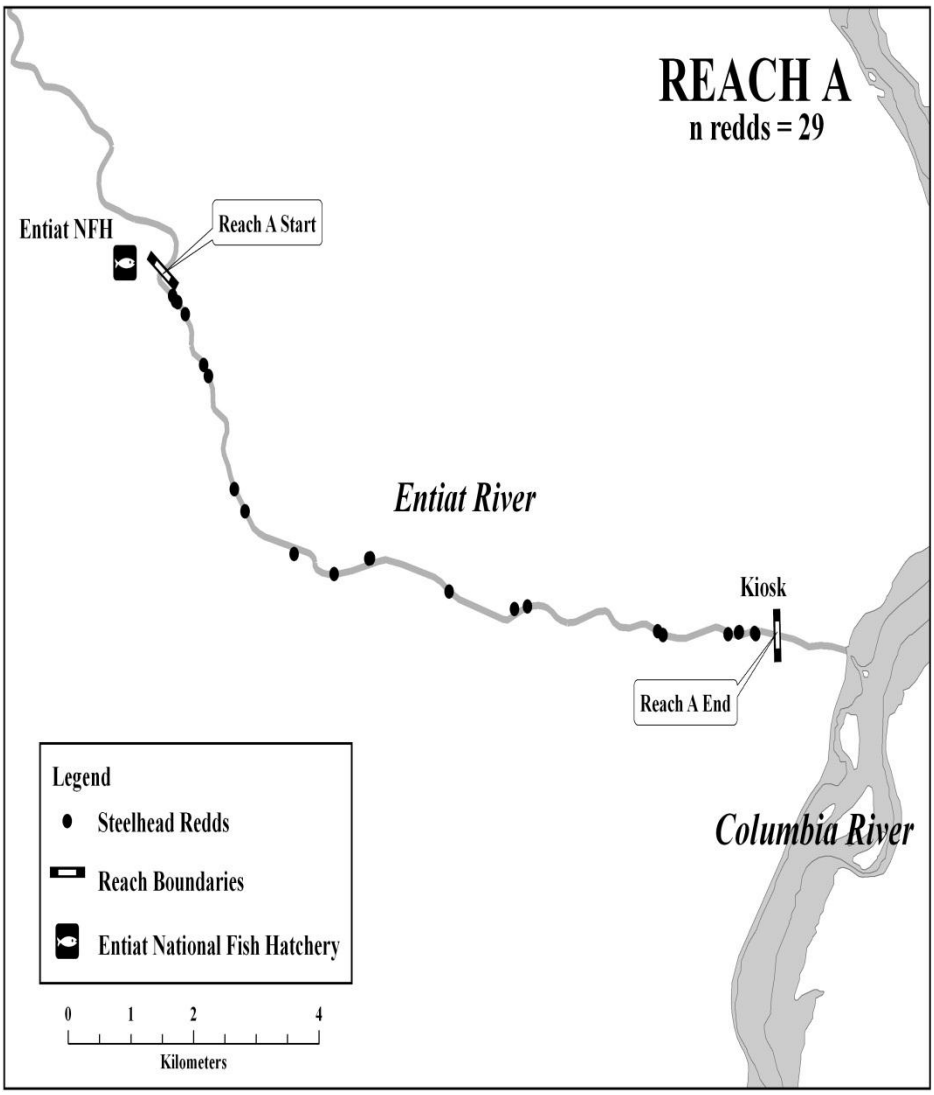

Figure 22. Locations of steelhead redds observed in Reach A during surveys conducted by USFWS on the Entiat River, 2012.

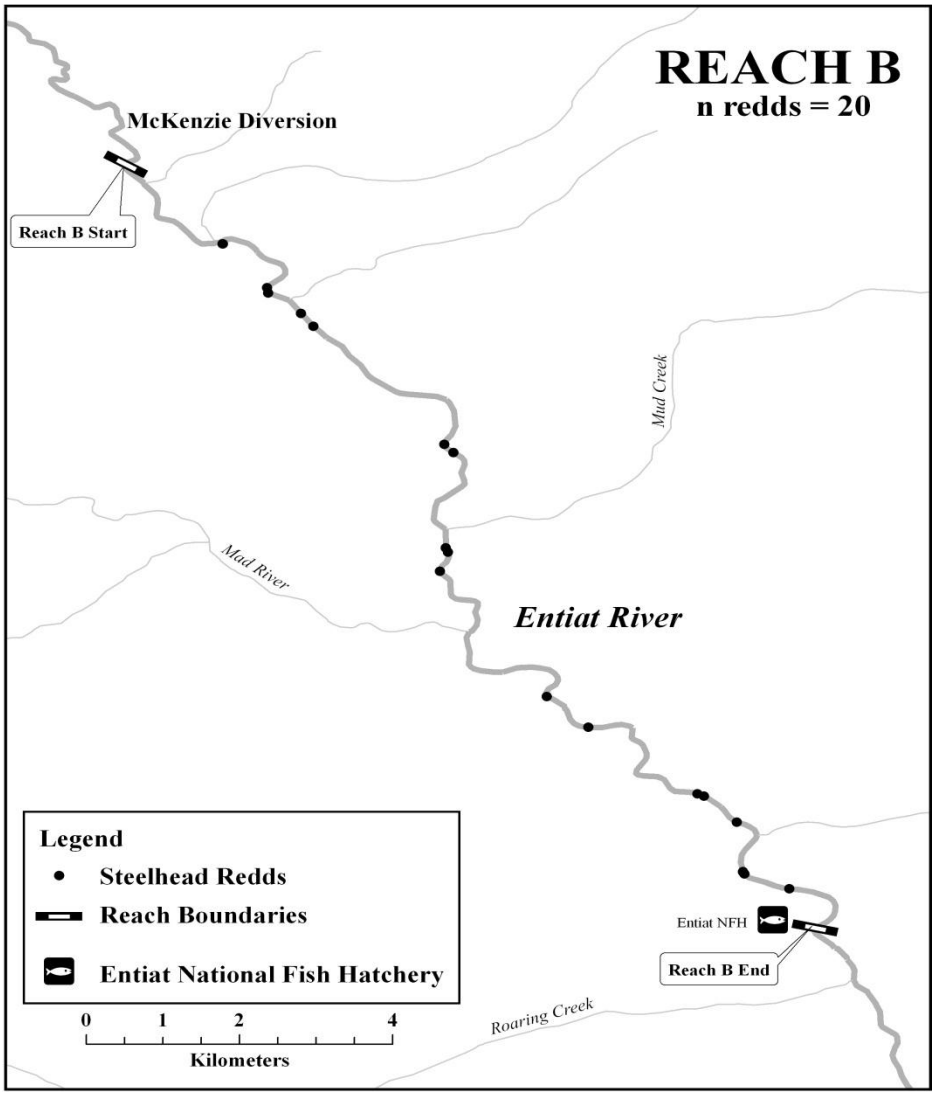

Figure 23. Locations of steelhead redds observed in Reach B during surveys conducted by the USFWS on the Entiat River, 2012.

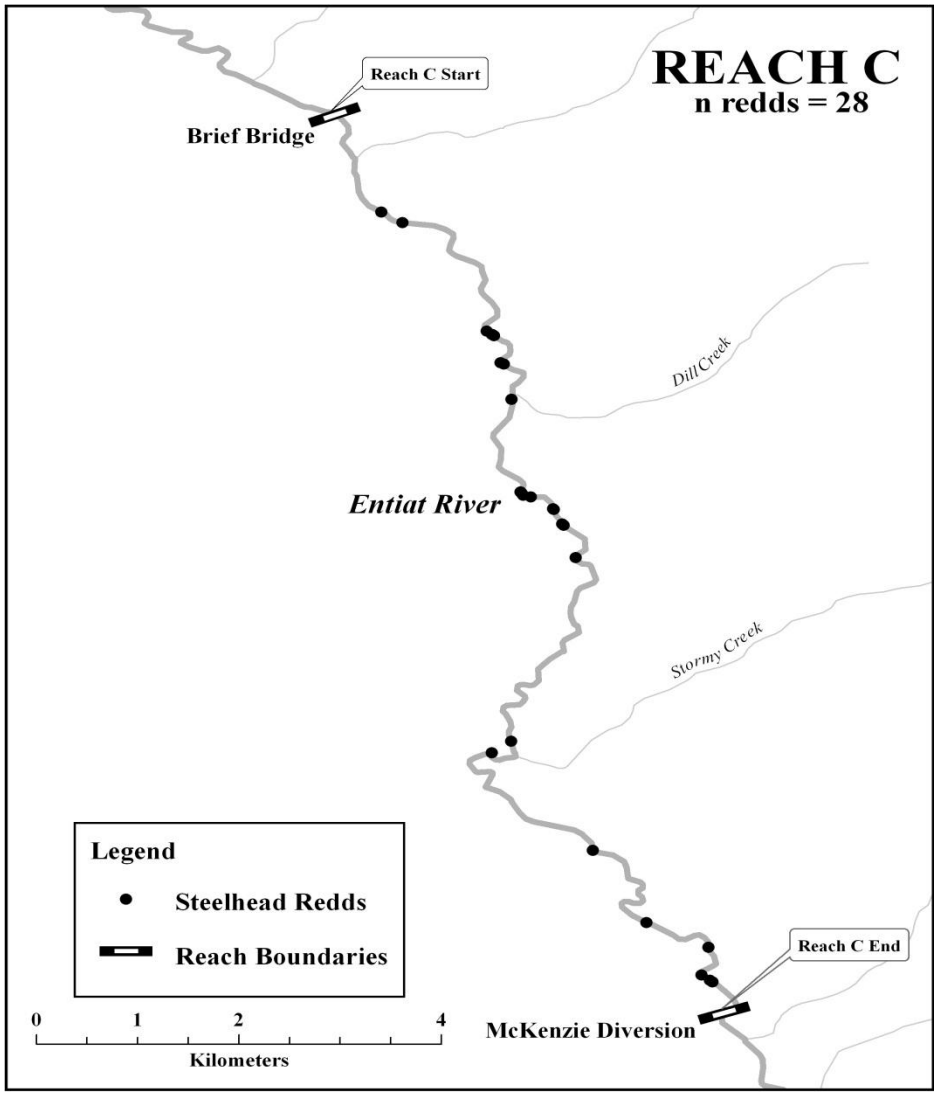

Figure 24. Locations of steelhead redds observed in Reach C during surveys conducted by the USFWS on the Entiat River, 2012.

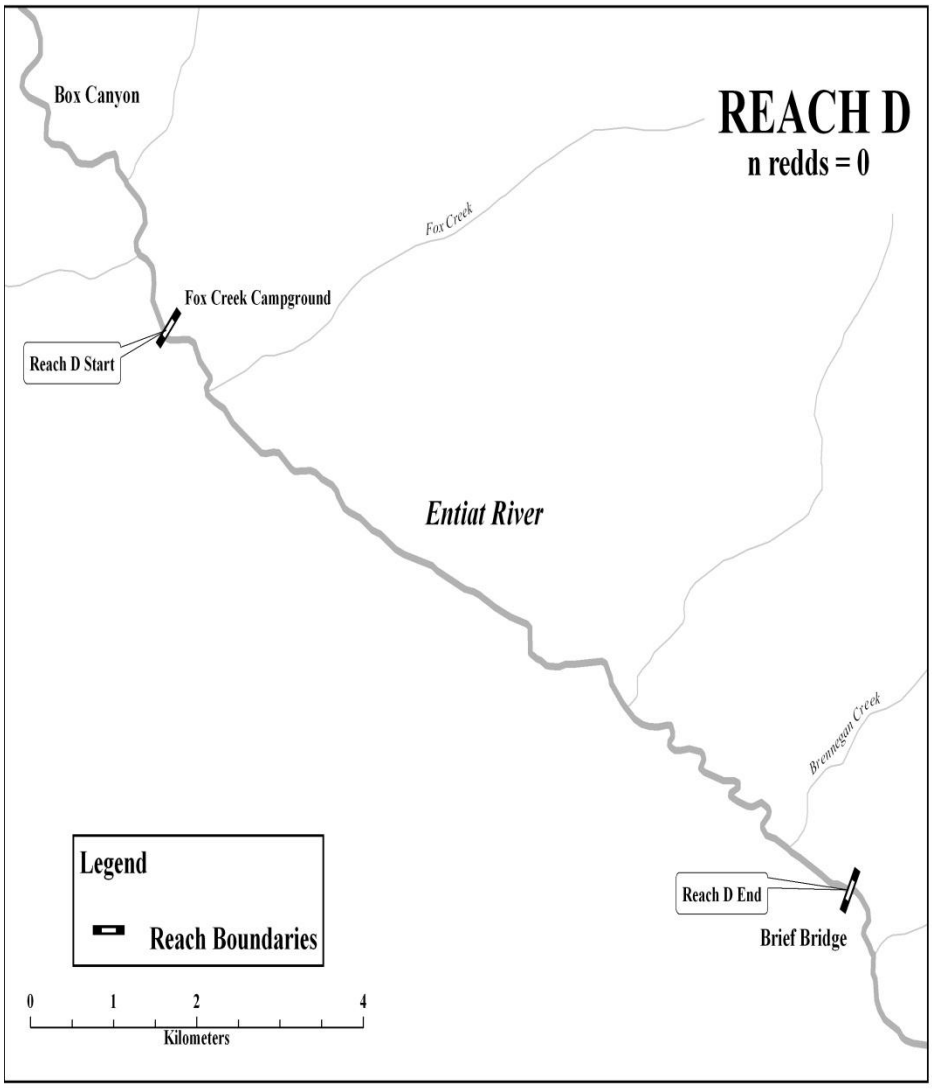

Figure 25. No steelhead redds were observed in Reach D during surveys conducted by the USFWS on the Entiat River, 2012.

Four redds in reach A (14% of reach total) were associated with restoration sites. This is lower than last years' count (20 redds or 36% of the reach A total) and is the fewest redds counted within restoration areas since 2007. All restoration sites have seen a gradual decline in redd construction over the past seven seasons (Table 30).

Table 30. Number of redds observed in close proximity to restoration sites in reach A of the Entiat River, 2006 through 2012.

Survey Year	2012	2011	2010	2009	2008	2007	2006
Total Redds Observed	77	205	189	200	222	64	111
Redds above reach A	48	150	102	72	129	24	73
Redds in reach A	29	55	87	128	93	40	38
Hatchery to Dinkelman Canyon Rd.							
John Small Barbs (pre 2006)	0	0	0	0	0	0	0
Hanan/Detwiler Cross Vane (2007)	0	0	1	5	9	9	2
Rest of the Section	14	14	23	32	31	18	5
Total Redds	14	14	24	37	40	27	7
Dinkelman Canyon Rd. to Fire Station							
Dinkelman Canyon. Rd. Cross Vane (2001)	0	1	1	2	3	0	0
PUD Irrigation Ditch	0	0	6	2	4	0	7
Whitehall Cross Vane (2006)	0	1	7	1	4	0	1
Rest of the Section	4	5	10	17	6	0	6
Total Redds	4	7	24	22	17	0	14
Fire Station to U.S.G.S.							
Fire Station Cross Vanes (2001)	1	3	2	6	1	0	
Milne Irrigation Diversion (2007)	0	8	6	15	24	3	4
Rest of the Section	2	3	0	10	2	4	2
Total Redds	3	14	8	31	27	7	6
U.S.G.S. to Columbia River Confluence							
Keystone (2009)	3	7	11	6	0	0	1
Rest of the Section	5	13	20	33	9	6	10
Total Redds	8	20	31	39	9	6	11

Discussion- Steelhead Redd Surveys

Steelhead spawning ground surveys on the Entiat River were conducted within the required time frame. Surveys were initiated in mid-February to provide zero counts and to avoid missing the initiation of spawning activity. Conditions did not allow for surveys during the week of April 25 which most likely affected the total numbers of redds. In previous years on the Entiat River,

surveyors observed more redds during April than any other month and particularly in late April. We were able to determine the onset of the spawning season this year, but the end of spawning was not well defined. In order to better determine when spawning season ceases surveyors attempted to do several surveys after high water had begun to recede. No redds were found during this final week of surveys. We documented the onset of spawning in all reaches except D. Only two surveys were attempted in this reach due to unexpected increases in discharge. This resulted in a count of zero for reach D. Reach D has generally contributed to the total redd count in previous years, (8% from 2006-2012). Similar to previous years, the majority of new redds (99% in 2012) were observed during April and May.

The new method for estimating redd visibility in relation to line of sight has proved difficult to reliably replicate. Many factors affect the measurement, including the amount of sunlight in the sky, the water surface (glassy versus rippled), shadows over the water's surface and the subjectivity of the individual estimating the point at which the Secchi disk is no longer visible. However, this method seems to be a better estimator of real world survey conditions despite the environmental factors taken into account.

The Hanan-Detwiler irrigation diversion located at rkm 5 was not opened this year. In previous years this diversion was used for construction of a few redds. In 2011 the Hanan-Detwiler irrigation diversion was mechanically plugged with soil and large boulders at the location of the existing diversion head gate and has since been abandoned (BOR, 2012). The fish return channel was dry and prevented any spawning from occurring in the channel during 2012. However, the channel has never produced a large number of redds and the lack of water has little impact on the total number of redds in reach A.

The primary purpose of the surveys is to monitor the spawning steelhead population in the Entiat River. Annually surveying areas where habitat restoration projects have been implemented may make it possible to determine if these sites have a long term effect on the numbers and distribution of spawning steelhead. Existing restoration projects were intended to improve limiting factors for ESA listed species populations within the Entiat River system (BOR, 2012). The idea was to introduce more diverse habitat to the lower river, which was lacking heterogeneity (BOR, 2012). Although the original addition of several restoration sites was not intended to enhance spawning habitat, some side effects have been noted throughout annual monitoring. Generally during the first year of construction at a given restoration site, heavy equipment is used to place large structures in the stream and the adjacent bank. During this construction many different sizes of substrate are uncovered and disturbed from their original location in the stream bed. This causes much of this newly exposed spawning sized gravel, which was previously embedded in finer sediments and sand, to be more readily available to spawning steelhead. After the initial construction year we have observed redds in the proximity to almost all restoration sites. This effect varies at each site due to water depth, velocities, and likelihood that fish would find the area suitable for spawning. Our redd surveys document a decline in redd construction around the initial restoration sites in subsequent years. This could be due to increased fine sediment deposition over top of substrate which was previously disturbed.

One example of substrate deposition has occurred at the Milne restoration project. Large woody debris, boulder groupings, and a rock barb were placed at this site during 2006 and 2007 (BOR, 2012). We saw a dramatic increase in redd construction in 2008 (Table 5). Fewer redd numbers were seen in this section after 2008, probably due to the continual deposition of fine sediments.

Even with the decline of redd productivity the area still seems to attract more spawning than during pre-restoration. Perhaps the restoration additions that were meant to promote deposition of spawning gravels have functioned, thus we are still seeing higher redd productivity at these sites. In 2009, construction of the Keystone Canyon restoration site exposed and loosened previously embedded gravel substrate. This created spawning habitat and increased the number of redds at this site. Large woody debris and boulders were also placed at this site. It appears that an increase in spawning depends upon the type of structure and where it is located i.e. pool, riffle, or run. Restoration sites that are intended to create pool habitat have had a much shorter longevity for increasing redd productivity. This is thought to be due to the fact that a flood event large enough to mobilize bed material at these sites has not occurred since construction (BOR, 2012). Whereas restoration sites such as Milne and Keystone Canyon that utilize instream habitat enhancements to promote spawning gravel deposition still produce more redds. These sites may also allow hydrological processes to continually remove fine sediments and sand during peak flow events better than the pool habitat enhancements. Thus, it appears that an increase in spawning activity could be attributed to large woody debris and boulder groupings like those placed at the Milne and Keystone sites. However this remains to be seen. Although not mentioned in previous reports the Knapp-Wham irrigation diversion has undergone maintenance construction annually. The diversion consistently has redds located directly in the canal above the head gate in proximity to this construction. Long term monitoring will be needed to further analyze these complex habitat enhancements and their value to spawning steelhead.

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Appendix

Appendix Table 1. Summary of nonoperational days for the lower Entiat River rotary screw trap, 2012.

Date	Status	Flow (m^3/s)	Comments
3/3/2012	Not Operated	4.00	Trap pulled due to IMW staffing needs
3/4/2012	Not Operated	4.20	Trap pulled due to IMW staffing needs
3/5/2012	Not Operated	4.59	Trap pulled due to IMW staffing needs
3/11/2012	Not Operated	4.50	Trap pulled due to IMW staffing needs
3/12/2012	Not Operated	4.65	Trap pulled due to IMW staffing needs
3/13/2012	Not Operated	4.64	Trap pulled due to IMW staffing needs
3/21/2012	Not Operated	4.70	Trap pulled for CPR training
3/25/2012	Not Operated	4.33	Trap pulled
3/26/2012	Not Operated	4.37	Trap pulled due to IMW staffing needs
3/30/2012	Incomplete	6.18	Branch stopped cone
4/1/2012	Not Operated	7.30	Trap pulled
4/11/2012	Incomplete	6.44	Branch stopped cone
4/12/2012	Incomplete	7.19	Branch stopped cone
4/18/2012	Not Operated	9.26	Trap pulled due to hatchery release
4/19/2012	Not Operated	9.23	Trap pulled due to hatchery release
4/20/2012	Not Operated	9.32	Trap pulled due to hatchery release
4/21/2012	Not Operated	10.64	Trap pulled - short handed
4/22/2012	Not Operated	11.91	Trap pulled - short handed
4/23/2012	Incomplete		Branch stopped cone
4/24/2012	Incomplete	24.14	Trap sunk
4/25/2012	Incomplete	35.71	Trap sunk
4/26/2012	Incomplete	40.00	Trap sunk
4/27/2012	Not Operated	44.03	Trap pulled due to cone damage
4/30/2012	Incomplete	33.95	Branch stopped cone
5/15/2012	Incomplete	46.80	Trap sunk
5/16/2012	Not Operated	61.26	Trap pulled
5/17/2012	Not Operated	66.95	Trap pulled due to high flow
5/18/2012	Not Operated	61.61	Trap pulled due to high flow
5/19/2012	Incomplete	55.46	Trap sunk
5/28/2012	Incomplete	45.82	Trap sunk
6/1/2012	Incomplete	53.83	Trap pulled due to high flow
6/2/2012	Not Operated	66.94	Trap pulled due to high flow
6/3/2012	Not Operated	74.42	Trap pulled due to high flow
6/4/2012	Not Operated	65.45	Trap pulled due to high flow
6/5/2012	Not Operated	62.33	Trap pulled due to high flow
6/6/2012	Not Operated	62.22	Trap pulled due to high flow
6/7/2012	Not Operated	56.71	Trap pulled due to high flow

Appendix Table 1. Continued

Date	Status	Flow (m^3/s)	Comments
6/8/2012	Not Operated	52.09	Trap pulled due to high flow
6/13/2012	Not Operated	46.68	Trap pulled
6/14/2012	Incomplete	56.02	Trap sunk
6/15/2012	Not Operated	56.64	Trap pulled due to high flow
6/16/2012	Not Operated	53.08	Trap pulled due to high flow
6/17/2012	Not Operated	55.33	Trap pulled due to high flow
6/18/2012	Not Operated	68.31	Trap pulled due to high flow
6/19/2012	Not Operated	64.52	Trap pulled due to high flow
6/20/2012	Not Operated	55.57	Trap pulled due to high flow
6/22/2012	Not Operated	52.36	Trap pulled due to high flow
6/23/2012	Not Operated	57.56	Trap pulled due to high flow
6/24/2012	Not Operated	60.71	Trap pulled due to high flow
6/25/2012	Not Operated	56.21	Trap pulled due to high flow
6/26/2012	Incomplete	51.08	Trap sunk
7/1/2012	Not Operated	51.15	Trap pulled due to high flow
7/2/2012	Not Operated	53.74	Trap pulled due to high flow
7/3/2012	Not Operated	48.38	Trap pulled due to high flow
7/4/2012	Not Operated	43.76	Trap pulled for holiday
7/5/2012	Not Operated	39.21	Trap pulled for holiday
7/8/2012	Incomplete	42.32	Trap sunk
7/10/2012	Not Operated	51.40	Trap pulled due to high flow
7/11/2012	Not Operated	48.89	Trap pulled due to high flow
7/14/2012	Not Operated	38.66	Trap pulled - short handed
7/18/2012	Incomplete	33.04	Trap sunk
7/23/2012	Incomplete	21.00	Branch stopped cone
7/28/2012	Not Operated	16.89	Trap pulled due to IMW staffing needs
7/29/2012	Not Operated	15.49	Trap pulled due to IMW staffing needs
7/30/2012	Not Operated	14.48	Trap pulled due to IMW staffing needs
7/31/2012	Not Operated	13.80	Trap pulled due to IMW staffing needs
8/4/2012	Not Operated	11.47	Trap pulled due to IMW staffing needs
8/5/2012	Not Operated	11.03	Trap pulled due to IMW staffing needs
8/6/2012	Not Operated	11.13	Trap pulled due to IMW staffing needs
8/11/2012	Not Operated	8.95	Trap pulled due to IMW staffing needs
8/12/2012	Not Operated	8.63	Trap pulled due to IMW staffing needs
8/13/2012	Not Operated	8.44	Trap pulled due to IMW staffing needs
8/14/2012	Not Operated	8.14	Trap pulled due to IMW staffing needs
8/15/2012	Not Operated	7.83	Trap pulled due to IMW staffing needs
8/16/2012	Not Operated	7.91	Trap pulled due to IMW staffing needs
8/17/2012	Incomplete	7.59	Trap pulled due to IMW staffing needs
8/18/2012	Not Operated	7.49	Trap pulled due to IMW staffing needs
8/19/2012	Not Operated	7.35	Trap pulled due to IMW staffing needs

Appendix Table 1. continued

Date	Status	Flow (m^3/s)	Comments
8/20/2012	Not Operated	7.31	Trap pulled due to IMW staffing needs
8/21/2012	Not Operated	7.03	Trap pulled due to IMW staffing needs
8/22/2012	Not Operated	6.82	Trap pulled due to IMW staffing needs
8/23/2012	Not Operated	6.64	Trap pulled due to IMW staffing needs
8/24/2012	Not Operated	6.39	Trap pulled due to IMW staffing needs
8/25/2012	Not Operated	6.01	Trap pulled due to IMW staffing needs
8/26/2012	Not Operated	5.75	Trap pulled due to IMW staffing needs
8/28/2012	Not Operated	5.24	Trap pulled due to IMW staffing needs
9/3/2012	Not Operated	4.50	Trap pulled for holiday
9/4/2012	Not Operated	4.33	Trap pulled for holiday
10/2/2012	Not Operated	3.41	Trap pulled due to IMW staffing needs
10/3/2012	Not Operated	3.31	Trap pulled due to IMW staffing needs
10/4/2012	Not Operated	3.40	Trap pulled due to IMW staffing needs
10/5/2012	Not Operated	3.42	Trap pulled due to IMW staffing needs
10/8/2012	Not Operated	3.35	Trap pulled for holiday
10/9/2012	Not Operated	3.31	Trap pulled due to IMW staffing needs
10/10/2012	Not Operated	3.26	Trap pulled due to IMW staffing needs
10/13/2012	Not Operated	3.11	Trap pulled due to leaf debris
10/16/2012	Incomplete	5.42	Trap pulled due to leaf debris
10/17/2012	Not Operated	6.80	Trap Pulled
10/20/2012	Not Operated	6.50	Trap pulled to prepare for night shifts
10/21/2012	Not Operated	5.64	Trap pulled to prepare for night shifts

Appendix Table 2. Summary of fish species captured in the Entiat River rotary screw trap, 2012.

Species and Life Stage	Total Capture	Capture Mortality
Wild spring Chinook salmon precocial	4	--
Wild spring Chinook salmon juvenile	7,668	72
Hatchery summer Chinook salmon juvenile	202	--
Wild summer Chinook salmon precocial	3	--
Wild summer Chinook salmon juvenile	6,313	285
Hatchery Chinook salmon (unknown r/t) adult	11	6
Hatchery Chinook salmon (unknown r/t) jack	4	--
Hatchery Chinook salmon (unknown r/t) precocial	1	--
Hatchery Chinook salmon (unknown r/t) juvenile	2	--
Wild Chinook salmon (unknown r/t) adult	2	--
Wild Chinook salmon (unknown r/t) jack	3	1
Wild coho salmon juvenile	99	--
Hatchery summer steelhead adult	2	--
Wild summer steelhead adult	1	--
Wild steelhead juvenile	1,690	4
Bull trout adult	13	--
Bull trout juvenile	82	1
Wild cutthroat trout juvenile	32	--
Wild sockeye salmon (unknown run) adult	1	--
Wild sockeye salmon (unknown run) juvenile	68	--
Other (unknown fish)	26	--
Pacific lamprey ammocoete	1,524	3
Northern pikeminnow adult	5	1
Northern pikeminnow juvenile	4	--
Mountain whitefish adult	7	--
Mountain whitefish juvenile	510	14
Unknown sucker adult	34	--
Unknown sucker juvenile	102	1
Unknown dace	639	19
Chiselmouth adult	9	--
Chiselmouth juvenile	28	--
Unknown sculpin	52	15
Red side shiner	153	1
Three-spine stickleback	1	--
Total	**19,295**	**423**

Appendix Table 3. Annual dates of inclusion for yearling and sub-yearling Chinook species used in rotary screw trap based Entiat River production estimates, capture years 2003 to 2012.

Migration Year	Life stage	Upper Trap		Lower Trap	
		Start	End	Start	End
2003	Yearling	--	--	--	--
	Sub-yearling	9/1/2003	11/24/2003	--	--
2004	Yearling	3/8/2004	5/26/2004	--	--
	Sub-yearling	8/31/2004	11/21/2004	--	--
2005	Yearling	3/2/2005	5/9/2009	--	--
	Sub-yearling	8/24/2005	11/27/2005	--	--
2006	Yearling	3/3/2006	5/15/2006	--	--
	Sub-yearling	9/1/2006	11/27/2006	--	--
2007	Yearling	2/28/2007	5/18/2007	3/23/2007	5/9/2007
	Sub-yearling	9/8/2007	11/20/2007	9/8/2007	11/19/2007
2008	Yearling	3/3/2008	5/15/2008	3/3/2008	5/14/2008
	Sub-yearling	9/8/2008	11/20/2008	9/8/2008	11/19/2008
2009	Yearling	2/26/2009	5/14/2009	3/18/2009	5/22/2009
	Sub-yearling	9/4/2009	11/20/2009	9/4/2009	11/20/2009
2010	Yearling	--	--	3/1/2010	5/27/2010
	Sub-yearling	--	--	9/18/2010	11/19/2010
2011	Yearling	--	--	3/1/2011	5/14/2011
	Sub-yearling	--	--	10/4/2011	11/19/2011
2012	Yearling	3/30/2012	5/10/2012	2/29/2012	5/25/2012
	Sub-yearling	9/29/2012	10/22/2012	9/29/2012	11/18/2012

Appendix Table 4. Mark-recapture site locations, dates sampled, average flow (m^3/s), maximum water temperature (˚C) and sampling notes during the winter 2012 sampling period.

Site Code	River	Site Length (m)	RKM	Avg. (m^3/s)	Mark Date	Recap Date	Max Water Temp (˚C)	Sample Comments
1BC4	Entiat	330	1.88	4.63	03/05	03/06	6.0	Site fully sampled.
1D4	Entiat	330	7.42	4.56	03/13	03/14	5.0	Site fully sampled.
1E2	Entiat	330	9.93	4.56	03/13	03/14	4.0	Site fully sampled.
1F13	Entiat	330	14.66	4.63	03/05	03/06	5.5	Site fully sampled.
1G16	Entiat	330	22.45	4.51	03/15	03/16	5.0	Site fully sampled.
2A2	Entiat	330	27.12	4.63	03/05	03/06	4.0	Site fully sampled.
2C1	Entiat	330	30.58	4.32	03/07	03/08	4.0	Site fully sampled.
3A5	Entiat	330	37.35	4.26	03/09	03/10	4.0	Site fully sampled.
3C2	Entiat	330	40.55	4.29	03/09	03/10	3.5	Site fully sampled.
3D2	Entiat	330	41.75	4.56	03/13	03/14	3.0	Site fully sampled.
3F2	Entiat	330	44.59	4.26	03/09	03/10	3.0	Site fully sampled.
M04	Mad	220	0.65	4.32	03/07	03/08	3.0	Site fully sampled.
M14	Mad	220	2.85	4.32	03/07	03/08	2.0	Site fully sampled.
M23	Mad	220	4.83	4.51	03/15	03/16	2.0	Site fully sampled.

Appendix Table 5. Number of fish captured and mortalities during the winter 2012 mark recapture study in the Entiat and Mad rivers.

Species and Life Stage	Total Capture	Capture Mortality
Wild spring Chinook salmon juvenile	863	2
Wild summer Chinook salmon juvenile	9	1
Wild coho salmon juvenile	11	0
Wild steelhead juvenile	1,975	0
Wild steelhead precocial	3	0
Bull trout juvenile	2	0
Mountain whitefish juvenile	13	0
Unknown sculpin juvenile	3	0
Total	**2,879**	**3**

Appendix Table 6. Mark-recapture site locations, dates sampled, average flow (m^3/s), maximum water temperature (˚C) and sampling notes during the summer 2012 sampling period.

Site Code	River	Site Length (m)	RKM	Avg. (m^3/s)	Mark Date	Recap Date	Max Water Temp (˚C)	Sample Comments
1BC11	Entiat	330	4.19	6.51	08/23	08/24	17.0	Site fully sampled.
1D4	Entiat	330	7.43	6.92	08/21	08/22	18.0	Site fully sampled.
1E3	Entiat	330	10.25	6.51	08/23	08/24	15.5	Site fully sampled.
1F13	Entiat	330	14.66	7.30	08/15	08/16	17.5	Site fully sampled.
1G19	Entiat	330	23.44	8.29	08/13	08/14	17.5	Site fully sampled.
2A5	Entiat	330	28.18	8.29	08/13	08/14	15.0	Site fully sampled.
2C4	Entiat	330	31.55	6.92	08/21	08/22	16.0	Site fully sampled.
3A3	Entiat	330	36.69	7.87	08/15	08/16	16.5	Site fully sampled.
3C1	Entiat	330	40.24	7.54	08/17	08/18	16.5	Site fully sampled.
3D5	Entiat	330	42.73	7.87	08/15	08/16	15	Site fully sampled.
3F2	Entiat	330	44.58	8.29	08/13	08/14	15.5	Site fully sampled.
M04	Mad	220	0.65	6.92	08/21	08/22	15.5	Site fully sampled.
M14	Mad	220	2.85	7.54	08/17	08/18	16.5	Site fully sampled.
M23	Mad	220	4.83	7.54	08/17	08/18	14.0	Site fully sampled.

Appendix Table 7. Number of fish captured and mortalities during the summer 2012 mark recapture study in the Entiat and Mad rivers.

Species and Life Stage	Total Capture	Capture Mortality
Wild Chinook (unknown run) salmon juvenile	3,529	92
Wild Chinook (unknown run) salmon precocial	3	0
Hatchery summer Chinook salmon juvenile	1	0
Hatchery summer Chinook salmon precocial	1	0
Wild coho salmon juvenile	125	1
Wild steelhead juvenile	2,727	37
Bull trout juvenile	13	0
Wild resident cutthroat trout juvenile	15	0
Pacific lamprey ammocoete	126	0
Mountain whitefish juvenile	52	7
Unknown sucker juvenile	14	0
Unknown dace juvenile	808	1
Unknown sculpin juvenile	2,355	11
Total	**9,769**	**149**

Appendix Table 8. Site operational summary for the lower Entiat River interrogation site (ENL) during the 2012 monitoring period.

Date	Operational Comments
12/6/2012	Antenna checked all good. Removed debris by antenna.
10/16/2012	Antennas checked all good.
8/22/2012	Automated modem uploads discontinued.
6/18/2012	Possible shed tag with multiple detections at site. Originally implanted in 15W in 2003- tag code is 3D9.1BF1637723
6/6/2012	Antenna #2 high noise ~36%; antenna #3 high noise ~47%; antenna #5 high noise ~ 27%, antenna #6 high noise ~43%.
5/30/2012	Antenna #2 high noise ~32%; antenna #3 high noise ~35%; antenna #5 high noise ~23%; antenna #6 high noise ~34%. 5315 records. Alarm reads, "memory full."
2/9/2012	Antenna #1 high noise ~25%, antenna #2 high noise ~39%, antenna #3 high noise ~40%, antenna #4 high noise ~23%, antenna #5 high noise ~21%, antenna #6 high noise ~36%.
1/19/2012	Antenna #2 high noise ~28%; antenna #3 high noise ~31%; antenna #5 high noise ~25%; antenna #6 ~28%. Alarm reads, "Test Tag Failed." Changed Lithium battery. Changed MUX time from 11:55 to 11:49 to match the laptop time. Alarm reads, "Lithium Low," after battery was changed.
1/3/2012	Antenna 2 high noise ~31%; antenna 3 high noise ~34%; antenna 4 high noise ~20%; antenna 6 high noise ~24%. 861 new records downloaded.

Appendix Table 9. Site operational summary for the Entiat River interrogation site at Ardenvoir (ENA) during the 2012 monitoring period.

Date	Operational Comments
12/11/2012	Site set up for wireless downloads.
12/06/2012	Antennas checked and straps checked. Looks good removed debris near Antennas.
11/28/2012	Antenna #1 Noise = 28%, #4 = 58%, 1701 new records. File looks good.
11/07/2012	Antenna #4 High noise = 30%, 1758 New Records. File looks good.
10/18/2012	No Alarms, File looks good. 648 New records.
10/11/2012	Antenna #2 high noise= 20%, #4=36%. 1043 new records File looks good.
9/26/2012	Test Tag Failed, 1968 new records. File looks good
8/29/2012	Antenna #1 high noise= 34%, #4= 46%. No alarm, 2004 new records. File looks good
8/9/2012	No Alarms, 2104 new records. File looks good.
8/3/2012	Couldn't get in to do downloads. Spraying trees in orchard.
7/26/2012	Couldn't get in to do downloads. Sprinklers on in orchard.
7/18/2012	Antenna #3 high noise ~26%. 469 new records downloaded. It seems that the data has been fixed starting on 7/13/2012.
7/11/2012	No alarms. Antennas all look good. No test tags show up on data except for one on 7/7/2012 at 00:20. 5 new records downloaded.
7/3/2012	Antenna #3 high noise ~26%. 17 new records downloaded.
6/27/2012	Antenna #3 high noise ~21%. 13 new records downloaded.
6/20/2012	Alarm reads, "Test Tag Failed." Last time tag read at 6/15/12, 3:18. No tags recorded after 6/17/12, 5:48.
6/15/2012	Antenna #4 high noise ~29%. Alarm reads, "test tag failed." MUX stopped recording on 6/14/12 after 17:40. 70 new records downloaded. Data lost from 6/5/12, 17:32
6/7/2012	GFCI breaker was tripped again. MUX left off to charge batteries. Unable to turn MUX on. Number of records unknown. 0 records new downloaded. WDFW notified about the GFCI breaker.
5/31/2012	WDFW replaced the GFCI breaker. Waiting to see if that fixes the problem. If not WDFW says an election will need to be brought in. Data lost from 5/25/12, 3:31 – 5/31/12, 13:31.
5/30/2012	No power to MUX. GFI breaker tripped. Left MUX off to charge batteries. 0 records downloaded.
5/17/2012	Started MUX; Both battery banks are charged. MUX was off on arrival. Charger flashing green on ready light.
5/16/2012	Could not communicate with MUX and the display very dim, found the GFCI breaker tripped. Turned off MUX and reset the breaker. Couldn't tell how long power was off. No records downloaded.
4/23/2012	Antennas all good. Reset circuit breaker. Turned on MUX; the MUX was off to change batteries. 267 new records downloaded. No data from 4/09/12, 14:04:39 – 4/23/2012, 14:47:50.
4/20/2012	The MUX was off and there was no power to the MUX. The "on" light on the MUX was not lit up. The GFCI was tripped approx. on 4/9 at 14:04 and then turned on at 4/23 at 14:47.
4/4/2012	Changed end times on files due to day light savings time.
4/2/2012	Antennas all good. 376 new records downloaded.
3/22/2012	When the communication cord to Loggernet data logger is unplugged from MUX the amps jump from 0 to 3.96amps; and the slope flashes from -7 to 217 on all antennas. When the communication cord was plugged back in the amps and slope went back to normal.
3/16/2012	Current flashing between 4.45 and 0 on antennas 1,4,5,6. Problem with current stopped when I unplugged computer and removed it from box.
3/1/2012	Antenna #1 high noise ~29%. Antenna #3 high noise ~26%, antenna #4 high noise ~32%, antenna #5 high noise ~32%. 152 new records downloaded.
2/24/2012	Antenna #1 high noise ~50%, antenna #4 high noise ~32%, antenna #6 high noise ~29%. 217 new records.
2/15/2012	Antenna #1 high noise ~42%, antenna #4 high noise ~32%, antenna #6 high noise ~ 25%. 159 new records.
2/9/2012	Antenna #4 high noise ~32%, antenna #6 high noise ~ 23%. 67 new records.
2/1/2012	Antenna # 4 high noise ~39%, antenna #6 high noise ~22%. Alarm reads test tag failed. 144 new records downloaded.

Appendix Table 9. Continued

Date	Operational Comments
1/26/2012	Antennas all good. 204 new records. Alarm reads, "lithium low." Reset MUX, "lithium low," alarm went off.
1/19/2012	Antenna #4 high noise ~59%; alarm reads "Test Tag Failed." Changed lithium battery. Changed MUX time from 11:09 to 11:08 to match laptop time. Alarm reads "Lithium Low," after battery was changed.
1/10/2012	Antennas all good. 206 new records downloaded
1/3/2012	Changed the time on MUX to match the laptop time. Antennas all good; 336 new records downloaded.

Appendix Table 10. Site operational summary for the middle Entiat River interrogation site (ENM) during the 2012 monitoring period.

Date	Operational Comments
12/11/2012	Wireless Download set up.
12/06/2012	Checked antennas and straps all good. Removed debris from around antennas.
11/28/2012	Antenna # 1 high amps = 5.00A High noise Antenna #2 = 60%, #3 = 26%. 454 New Records File Good.
10/18/2012	Antenna #1 high noise= 68%, #3= 27%, 211 new records. File looks good.
10/11/2012	Antenna #3 high noise= 28%, #5 = 60%, #6 = 22%, 496 new records file looks good.
9/26/2012	Antenna #3 high noise= 29%, Antenna #5 high noise= 40%, 839 new records, File looks good.
8/29/2012	Antenna #3 high noise= 26%, No Alarms. 600 new records, File looks good.
8/8/2012	High noise on Antenna #1= 30%, #2=40%, #3= 24%, #4= 29%, #5= 21%. 113 New records. File looked good.
8/3/2012	High noise on Antenna #1= 22%, #3= 27%, #4= 49%, #5=20% 183 New Records. File looked good.
7/26/2012	Antenna #1 High noise= 25%, #2 high noise= 25%, #3 high noise= 26%, #4 high noise= 27%, #5 high noise= 21%, 181 New records. MUX was fast by about 18 minutes. Changed time to 13:08:00 Laptop is fast by 1 hour.
7/18/2012	Antenna #1 high noise ~26%; antenna #2 high noise ~20%; antenna #3 high noise ~30%; antenna #4 high noise ~89%; antenna #5 high noise ~21%, antenna #6 high noise ~23%.
7/11/2012	Antenna #1 high noise ~24%; antenna #3 high noise ~31%; antenna #4 high noise~ 93%; antenna #5 high noise ~ ~22%. 157 new records downloaded.
7/3/2012	Antenna #1 high noise ~34%; antenna #2 high noise ~24%; antenna #3 high noise ~26%; antenna #4 high noise ~25%; antenna #5 high noise ~21%; antenna #6 high noise ~28%. 116 new records downloaded.
6/27/2012	Antenna #1 high noise ~36%; antenna #2 high noise ~75%; antenna #3 high noise ~28%; antenna #4 high noise ~31%; antenna #5 high noise ~22%; antenna #6 high noise ~20%. 129 new records downloaded.
6/20/2012	Antenna #1 high noise ~27%; antenna #2 high noise ~49%; antenna # high noise ~31%; antenna; antenna #4 high noise ~36%; antenna #5 high noise ~20%. 78 new records.
6/15/2012	Antenna #1 high noise ~26%; antenna #2 high noise ~43%; antenna #3 high noise 30%; antenna #4 high noise 28%; antenna #5 high noise ~21%. 121 new records downloaded.
6/6/2012	Antenna #1 high noise ~22%; antenna #3 high noise ~45%; antenna #4 high noise ~29%. 100 new records downloaded.
5/30/2012	Antenna #3 high noise ~22%. 62 new records downloaded.
5/23/2012	Antenna #3 high noise ~20%; antenna #4 high noise ~22%. 92 new records downloaded.
5/16/2012	Antenna #1 high noise ~24%. 116 new records downloaded.
5/9/2012	Antenna #2 high noise ~49%. 110 new records downloaded.
5/2/2012	Antenna #1 high noise ~37%. 90 new records downloaded. On 4/26, only antennas 1,5, and 6 fired one test tag at 11:24; no other data for 4/26, unknown reason why.
4/25/2012	Antenna #3 high noise ~20%; antenna #5 high noise ~41%. 147 new records downloaded.
4/20/2012	Antenna #1 high noise ~22%; antenna #2 high noise ~32%; antenna #4 high noise ~36%; antenna #5 high noise ~35%. 150 new records downloaded.

Appendix Table 10. Continued

Date	Operational Comments
4/15/2012	Antenna #2 high noise ~21%. 165 new records downloaded.
4/11/2012	Antenna #2 high noise ~72%. 136 new records downloaded. Checked all antennas straps; they all looked good.
4/7/2012	142 new records. Antenna #1 high noise ~20%. Change time on MUX from 09:37 to 09:30 to match the time on the laptop.
4/4/2012	Changed end times on files ENM12076.ALL, ENM12082.ALL, and ENM12093.ALL to 1 hour earlier than what they were originally due to they were downloaded with a lap top that was on day light savings time. Also changed start times on files ENM12082.ALL and ENM12093.ALL due to the same reason
4/3/2012	Cleared debris off of all antennas.
4/2/2012	Antenna #3 high noise ~23%. 349 new records downloaded.
3/22/2012	Antenna #3 high noise ~22%. 184 new records.
3/1/2012	Antenna #1 high noise ~34%. 208 new records.
2/24/2012	Antenna #1 high noise ~31%. 269 new records.
1/26/2012	Antenna #2 high noise ~31%. Changed lithium battery. Changed MUX time from 11:37 to 11:22 to match the time on the laptop. 662 new records downloaded. After battery changed, alarm reads, "lithium low." Reset MUX, "lithium low," alarm went off.
1/10/2012	Antenna #1 high noise ~48%. Time on MUX reads 11:08, time on laptop reads 10:54; MUX is 14 minutes faster than the time on the laptop. On 11/8/2011 the time on MUX was changed to match the laptop time. 224 new records downloaded.
1/3/2012	Antenna 1 high nose ~55%; Antenna 2 high noise ~22%. Could not connect to MUX again; reset MUX, and was able to download all records. 538 new records downloaded.

Appendix Table 11. Site operational summary for the Entiat River interrogation site near Stormy Creek (ENS) during the 2012 monitoring period

Date	*Operational Date*
12/11/2012	Wireless downloads set up.
12/06/2012	Checked all Straps and antennas all good. Removed debris around antennas.
11/28/2012	Low amps on #2= 2.84, Reset MUX 6 New Records. Only 1 day of data 11/14
11/14/2012	Low Amps on #2 = 2.97, 9 New Records, Missing Test Tag. File looks good otherwise.
11/07/2012	Low Amps on Antenna #2= 2.97, No test tag on file. File good otherwise. 21 New Records.
10/18/2012	24 New records. Low amps on #2= 2.77 No Alarms
10/11/2012	No Alarms Low amps on #2 = 2.85. 23 New records.
10/1/2012	Low amps on Antenna #2 = 2.81. Missing days of info on file. 14 New records.
9/26/2012	Low Amps on Antenna #2 = 2.81. Missing days of info on file could be due to missing timer tags. 102 New records.
8/29/2012	Timer tags recording. File looks good. 145 new records. No Alarms. Antennas look good.
8/18/2012	Not recording timer tags.
8/8/2012	Antenna #4 high noise ~20%. Could not communicate with MUX; reset MUX and then was able to download. 48 new records downloaded.
8/2/2012	Antenna #2 low amps ~2.8. 39 new records downloaded.
7/26/2012	Antenna #4 high noise ~22%. 47 new records downloaded.
7/18/2012	Antenna #2 low amps 2.85 amps. 50 new records downloaded.
7/11/2012	Antenna #2 low amps 2.95 amps. 38 new records downloaded.
7/3/2012	Antenna #2 low amps 2.91. No test tag stored 6/27-7/3. No data stored from 7/1-7/3. Unknown reason why.
6/27/2012	Antenna #2 low amps 2.94. Diagnostic readout was there. No test tag stored from 6/21-6/27, no data stored from 6/22, 6/23, 6/26. Unknown reason why. 12 new records downloaded.
6/20/2012	Antenna #2 low amps at 2.83amps. Could not communicate at first with MUX, had to reset MUX; then could communicate with MUX. 219 new records downloaded.
6/18/2012	Downloaded 290 new files. Antennas all good
6/15/2012	Antenna #1 high noise ~25%; antenna #4 high noise ~26%. Initially couldn't communicate with MUX. Reset MUX then downloaded. 142 new records downloaded. WDFW Replaced the MUX later in the day after site had been downloaded.
6/6/2012	Antenna #4 high noise ~20%. Could not communicate with MUX; reset MUX; after resetting MUX was able to then communicate. Lost 0 records from resetting. MUX stopped recording "test tags", or any tags after 5/31/12, 6:44; no unique tags were recorded. 47 new records downloaded.
5/31/2012	WDFW went through all of the settings and everything looked to be running good.
5/30/2012	Antenna #1 high noise ~24%; antenna #4 high noise ~23%. Connected to MUX and ran test tag diagnosis. MUX read and saved tags. Set timer tag to 180 minutes. 0 records downloaded.
5/23/2012	Antenna #1 high noise ~21%; antenna #4 high noise ~38%. Data lost from 5/14/12, 11:53- 5/17/12, 14:50. File stopped on 5/19/12. 316 new files downloaded.
5/9/2012	MUX screen was black. 342 new records downloaded.
4/11/2012	237 new records downloaded. Antennas all good. Checked all antennas straps; they all looked good.
4/7/2012	Antenna #4 high noise ~20%. Changed time on MUX from 09:52 to 09:45 to match the laptop time. 182 new records downloaded.
4/4/2012	Changed end times on to 1 hour earlier than what they were originally due to they were downloaded with a lap top that was on day light savings time.
1/26/2012	Antennas all good. Alarm reads, "lithium low." MUX time matches the time on the laptop. Reset MUX, "lithium low," alarm went off. 296 new records downloaded.
1/19/2012	Antennas all good. Changed lithium battery. Changed MUX time from 10:24 to 10:16 to match the laptop time. 83 new records downloaded.
1/17/2012	Antennas all good. MUX is 8 minutes faster than laptop time. 315 new records downloaded.
1/10/2012	Antennas all good. Mux time reads 10:45; the time on the laptop reads 10:38. Mux is 7 minutes fast from the time on the laptop. On 11/08/11 the time on MUX was changed to match the time on the laptop. 301 new records downloaded.

Appendix Table 12. Site operational summary for the Entiat River Forest Service boundary interrogation site (ENF) during the 2012 monitoring period.

Date	Operational Comments
12/11/2012	Wireless download set up.
12/06/2012	Antennas checked all straps good. Removed debris.
11/28/2012	Antenna #2 noise = 24%, #6 = 62%. 1030 New Records. File looks good. "Test Tag Failed"
11/07/2012	Antennas look good. 1435 New records. File looks good.
10/18/2012	Antenna #5 high noise-31%, Test Tag Failed, 490 new records.
10/11/2012	Antenna #1 high noise-38%, Antenna #2 high noise-25%, Antenna #4 high noise- 27%, Antenna #5 high noise-32%, 606 new records, Had to reset MUX in order for download to work.
10/01/2012	Antenna #1 high noise-55%, Antenna #5 high niose-33%, 335 new records,
9/26/2012	Test Tag Failed. 1816 new records. File looked good.
8/29/2012	Antenna #5 high noise ~44%. File looks good. 954 new records downloaded.
8/8/2012	Antenna #6 high noise ~44%; alarm reads test tag failed. 493 new records.
8/2/2012	Antenna #6 high noise ~38%. 501 new records downloaded.
7/26/2012	Antenna #4 slope is fluctuating very fast between -3 to 6. Antenna #6 high noise ~40%. 531 new records downloaded.
7/18/2012	Antenna #5 high noise ~35%; antenna #6 high noise ~71%. 301 new records downloaded.
7/11/2012	Alarm reads, "test tag failed." Antenna #4 high noise ~447%. 562 new records downloaded.
7/3/2012	Antenna #6 high noise ~72%. 456 new records were thought to have been downloaded, but were not. The buffer was also erased. The 456 records were lost.
6/27/2012	Alarm reads, "test tag failed." 504 new records downloaded.
6/20/2012	Alarm reads, "test tag failed." 365 new records downloaded.
6/15/2012	Alarm reads, "test tag failed." 668 new records downloaded.
6/6/2012	Antenna #3 high noise ~49%. 503 new records downloaded.
5/30/2012	Antenna #6 high noise ~23%; 479 new records downloaded.
5/23/2012	Antenna #3 high noise ~23%; antenna #6 high noise ~29%. Alarm reads "test tag failed." 557 new records downloaded.
5/16/2012	Antenna #3 high noise ~26%; antenna #6 high noise ~22%. 497 new records downloaded.
5/9/2012	Alarm reads "test tag failed." Antennas all good. 167 new records downloaded.
5/7/2012	Alarm reads "test tag failed." Reset MUX.
5/2/2012	Test tag stopped working on all antennas. MUX seemed locked up. Reset MUX 14 new records downloaded.
4/25/2012	Antenna #3 high noise ~22%. Alarm reads "test tag failed." 140 new records downloaded.
4/20/2012	Other than the alarm reading "test tag failed" , the antennas are all good. 131 new records downloaded.
4/15/2012	Antenna #1 high noise ~84%, antenna #4 high noise ~63%. 159 new records.
4/11/2012	Antenna #1 high noise ~85%. 149 new records downloaded. Antennas #1 and #4 have disconnected middle braces. Data lost from 4/7/2012, 12:15 – 4/11/12, 10:05, unknown reason
4/7/2012	Could not connect to the MUX with the laptop. Was able to connect to MUX after resetting it. Antennas all good. 103 new records downloaded.
4/4/2012	Changed end times on files due to day light savings time.
3/14/2012	Antenna #3 replaced by the state because of low amps.
3/1/2012	Antenna #3 low amps 0.76. 260 new records downloaded.
2/24/2012	Antenna #3 low current 0.86. Examined antenna from the bank, could not see anything wrong with it. All other antennas are good. 388 new records.
2/6/2012	Antenna #4 slope fluctuating fast from -2 to 2. 210 new records downloaded.
2/1/2012	Alarm reads lithium low. Antennas all good. Reset MUX, 248 records downloaded.
1/26/2012	Antennas all good. 295 new records downloaded.
1/19/2012	Changed lithium battery. Changed MUX time from 9:55 to 9:47 to match the time on the lap top. 82 new records downloaded.
1/17/2012	Antenna #4 high noise ~28%, antenna #5 high noise ~22%. Alarm reads, "Test tag failed." 260 new records downloaded.
1/10/2012	Alarm reads "test tag failed." Antennas all good; 278 new records downloaded.

Appendix Table 13. Site operational summary for the Mad River interrogation site (MAD) during the 2012 monitoring period.

Date	Operational Comments
12/11/2012	Wireless Downloads set up
12/06/2012	Checked all straps and antennas all good.
11/29/2012	Checked batteries and called state to come investigate site
11/28/2012	No Amps to antennas upon arrival. Switched the battery banks and Amps went up. 392 New records
11/14/2012	Antenna #3 high noise + 60%, 203 New Records. File looks good.
11/07/2012	Antennas look good. 483 new records. No diagnostic report. File looks good.
10/18/2012	No alarms. 203 records
10/11/2012	All antennas show 0 amps again, after pushing reset all show not present. 463 records
9/26/2012	All antennas show 0 amps, after pushing reset all back to normal amperage. 1596 records
8/29/2012	1160 records, all good at site
8/9/2012	Screen blacked out at arrival to site. Reset the MUX and it started to work. 293 records
8/3/2012	Mux Digital Read Screen was blacked out. Download still worked and file looked good. 382 new records.
7/26/2012	Screen on MUX was blacked out from being too hot. Download 390 new records.
7/18/2012	Antenna #2 high noise= 28%, #3= 21%, #5 = 26%. No Alarms, 302 New records. File looks good
7/11/2012	No Alarms, File looks good. 347 new records.
6/20/2012	Antenna #6 high noise ~74%. 249 new records downloaded.
6/15/2012	Antenna #4 high noise ~93%; antenna #6 high noise ~37%. Time on MUX incorrect, was fast by 15 minutes; changed to 10:09. 715 new records downloaded.
6/6/2012	Antenna #5 high noise ~ 60%. 480 new records downloaded.
5/30/2012	Antenna #3 high noise ~54%. 324 new records downloaded.
5/23/2012	High noise ~43%, antenna #6 high noise ~23%. 331 new records downloaded.
4/11/2012	425 new records downloaded. All antennas good.
4/7/2012	Antenna #6 high noise ~43%. 541 new records downloaded
4/4/2012	Changed end times on files due to day light savings time.
4/2/2012	Turned timer button "ON." Antenna #1 high noise ~41%; antenna #5 high noise ~45%; antenna #6 high noise ~37%. 793 new records downloaded.
3/22/2012	The amps jump from 0 to 3.96 amps; and the slope flashes from -7 to 217 on all antennas.
3/16/2012	Antenna #5 high noise ~25%. 421 new records downloaded.
3/1/2012	Antenna #1 high noise ~48%, antenna #5 high noise ~53%. 202 new records downloaded.
2/24/2012	Antenna #1 high noise ~32%, antenna #3 high noise ~21%. 390 new records downloaded.
2/15/2012	Antenna #5 high noise ~23%. 283 new records downloaded.
2/9/2012	Antenna #5 high noise ~21%. 149 new records downloaded.
1/26/2012	Antenna #5 slope is fluctuating fast from -10 to 10. Alarm reads, "Lithium low." Reset MUX, "lithium low," alarm went off. 292 new records downloaded.
1/19/2012	Antennas all good. Changed lithium battery
1/10/2012	Antennas all good. 312 new records downloaded.
1/5/2012	All debris removed from all antennas.
1/3/2012	Antennas all good. Antenna 5 center brace is separated from the upstream part of the antenna. Lost data from 12/22-12/28. This was not realized until after the buffer was erased.