Integrated Status and Effectiveness Monitoring Program- Entiat River Intensively Monitored Watershed Study, 2011.

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Abstract

During 2011, the Mid-Columbia Fishery Resource Office operated a rotary screw trap, conducted two mark-recapture studies, 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 21,158 fish. The Entiat River mark-recapture study collected 6,109 juvenile fish species at 26 locations along the main stem Entiat and Mad Rivers. The off-channel habitat study resulted in the capture of 2,202 juvenile fish. In 2011, a total of 29,469 fish were captured and 20,287 wild salmonids were marked with Passive Integrated Transponder tags. Six main-stem Passive Integrated Transponder tag interrogation sites were operated throughout this reporting period resulting in a total of 2,394 unique detections. Four Passive Integrated Transponder tag antennas were used to monitor juvenile fish use of off-channel habitats and a total of 410 unique detections were recorded. Steelhead redd surveys were conducted from February 4 to May 12, 2011. The first redd was observed on March 2nd. A total of 205 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. This data is 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 of 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 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, Wydoski and Whitney 2003).

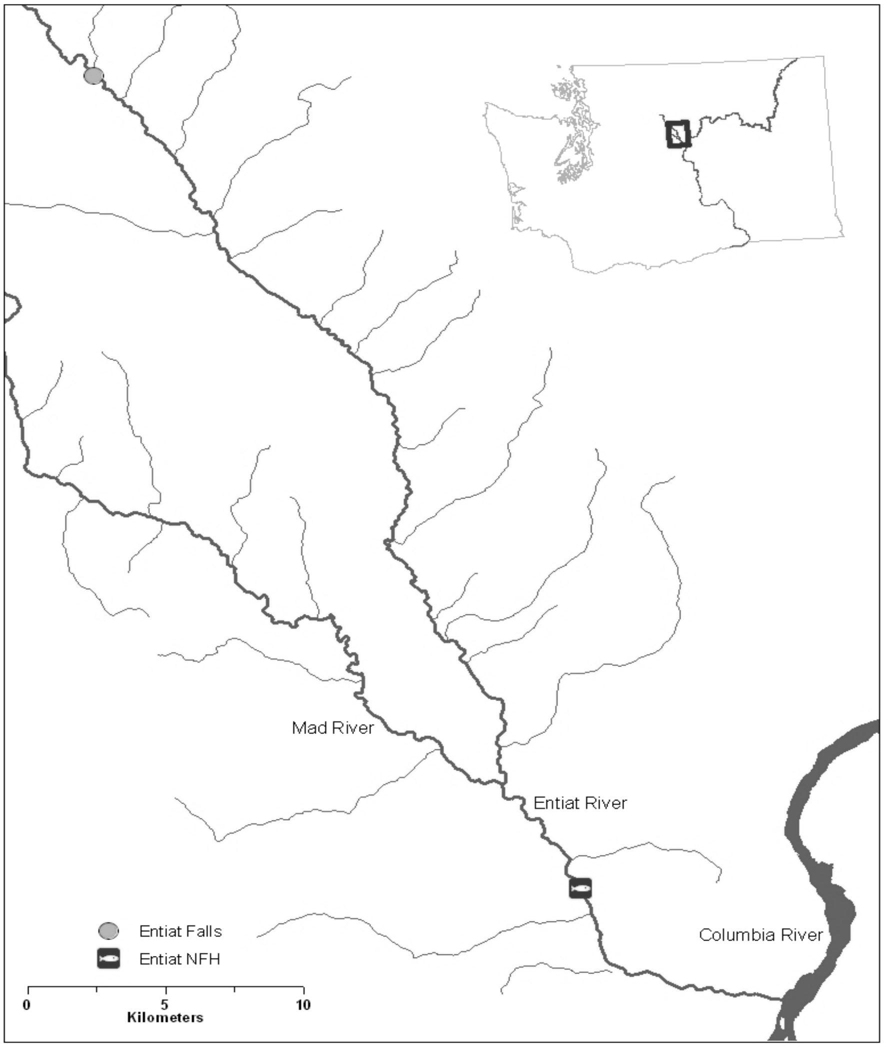

Figure 1. Map of the Entiat River from its mouth to Entiat Falls at river kilometer 54.

Methods-Rotary Screw Trap

Rotary screw trap locations

MCRFRO operated a rotary screw trap in the lower Entiat River at rkm 2 (Figure 2). This trap has been in operation since 2007. The rotary screw trap located near the Entiat National Fish Hatchery (ENFH) at rkm 11 was not operated in 2011.

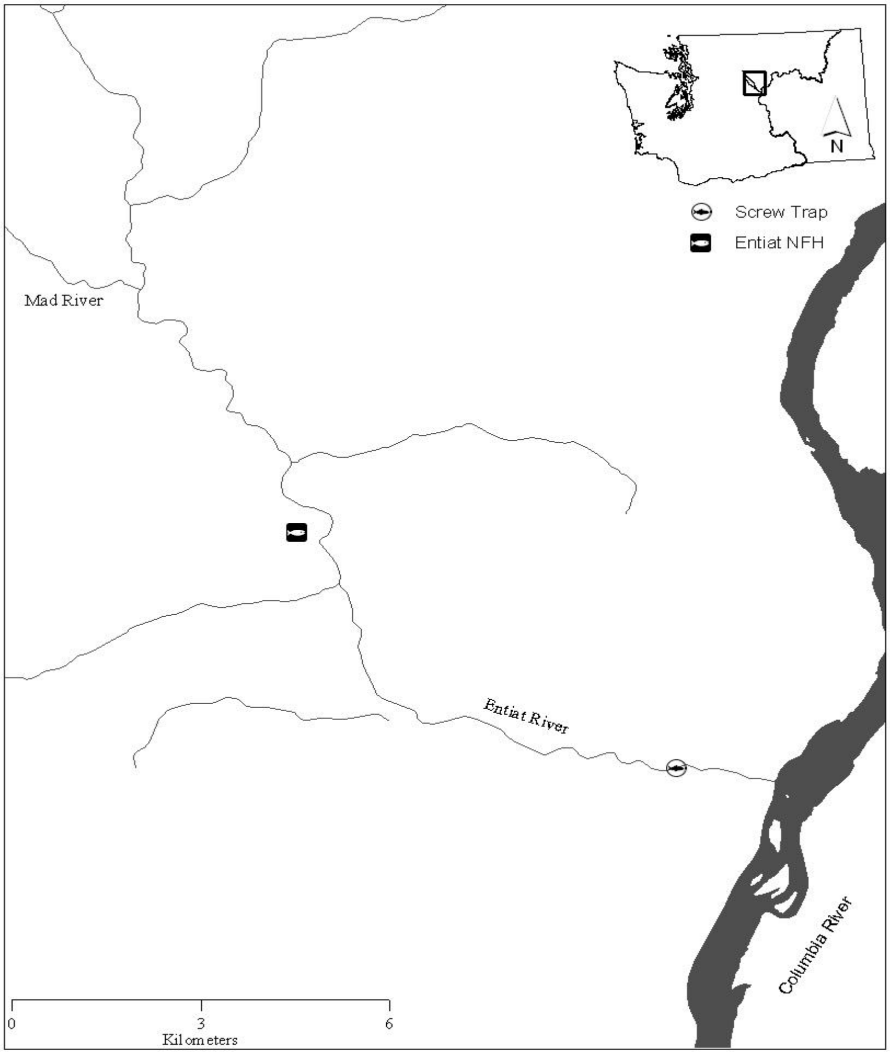

Figure 2. Map of the rotary screw trap location in the Entiat River, 2011.

Rotary screw trap operation

One modified 5 ft. diameter rotary screw trap (EG Solutions Inc.) was operated to capture downstream migrating salmonids. The trap was retrofitted with larger pontoons to increase floatation and safety during periods of higher flow. The trap was further modified to include an access door on the cone 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), Hydraulic Project Approval (control#106898-1, lower trap, dated November 21, 2006, expires November 22, 2011), and Land Use Permit (Control # 230107, dated January 15, 2008, expires November 22, 2011). The trap was hoisted into the river via boom truck, attached to ¼ inch aircraft cable, and anchored to large cottonwood trees (*Populus deltoids*) upstream. A cross cable suspended the anchor cable above the stream from the anchor point to the trap. A system of winches and pulleys was used to maintain the trap in a fixed position as flows changed throughout the trapping season. The trap was scheduled to operate seven days a week through mid-October and scheduled to run six days a week through November. If possible, the trap was operated 24 hours a day; however, during spring high flows and periods of increased debris loads the trap was operated from sunset to sunrise. The trap was removed from the river during periods of extreme flows to avoid damaging trapping equipment.

Fish handling

Fish handling procedures were conducted in accordance with WDFW Scientific Collection Permit #11-154 and #11-157 (annual permits - start date April 26, 2011, expires April 26, 2012); 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 ENFH and processed at the 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). 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 2011, Fish Passage Center provided limited PIT tags for spring Chinook salmon and steelhead as a part of the Comparative Survival Study, ISEMP supplied PIT tags for the remaining Chinook salmon and steelhead, 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 h. to monitor survival and tag retention. A maximum of 72 h. hold time was instituted on all tagged fish.

Data entry

All fish data were entered in the P3 program from PTAGIS. P3 is a data entry application program 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 the P3 program were then parsed into a custom 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, Chinook salmon, and steelhead juveniles were sampled for genetic and age analysis as suggested within the Upper Columbia Monitoring Strategy (Hillman 2006). A small clip of tissue was taken from either the ventral fin (steelhead, cutthroat trout & spring Chinook salmon) or caudal fin (bull trout). Scales were collected from steelhead only and were cataloged and stored on site for future analysis. Tissue samples from Chinook salmon, cutthroat trout, steelhead and bull trout were sent to the Region 1 USFWS genetics lab for archiving and 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 Bismark brown dye. Marked fish were placed in a live box for holding (<72 hrs.) prior to release. Marked fish were 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). Efficiency trials were limited to three days following release to minimize potential changes in river flow. Recaptured fish were re-measured, released, and not included in subsequent efficiency testing.

Calculating production estimates

Estimates of natural juvenile salmon production from the Entiat watershed were derived for wild yearling spring Chinook, wild subyearling spring Chinook and wild steelhead. Production estimates were calculated using two steps. First, daily trap efficiency was determined based on regression analysis of the relationship between trap efficiency (dependent variable) and flow (independent variable). The resulting regression formula was then used to estimate daily trap efficiency and juvenile production.
Trap efficiency was calculated using the following formula:

$$\text{Trap efficiency, } E_i = \frac{R_i}{M_i}$$

where E_i is the trap efficiency during time period i; M_i is the number of marked fish released during time period i; and R_i is the number of marked fish recaptured during time period i.

The number of fish captured was expanded by the estimated daily trap efficiency (e) to estimate the daily number of fish migrating past the trap (Ni) using the following formula:

$$\text{Estimated daily migration} = N_i = \frac{C_i}{e_i}$$

where N_i is the estimated number of fish passing the trap during time period i; C_i is the number of unmarked fish captured during time period i; and e_i is the estimated trap efficiency for time period i based on the regression equation. On days in which the trap was not operated (trap pulled) or only partially operated (incomplete), daily fish capture (N_i) was estimated through averaging known daily capture values from two days before and following the pulled or incomplete trapping day.

The variance for the total daily number of fish migrating past the trap was calculated using the following formulas:

$$\text{Variance of daily migration estimate} = \text{var}\left(N_i\right) = N_i^2 \frac{\text{MSE}\left(1 + \frac{1}{n} + \frac{\left(X_i - \overline{X}\right)^2}{(n-1)\, s_x^2}\right)}{e_i^2}$$

where X_i is the flow for time period i, and n is the sample size. If an adequate relationship between flow and trap efficiency was not present (i.e. $P < 0.05$; r^2 0.5) a pooled trap efficiency was used to estimate daily emigration:

$$\text{Pooled trap efficiency} = E_p = \frac{R}{M}$$

The daily emigration estimate was calculated using the formula:

$$\text{Daily emigration estimate} = N_i = \frac{C_i}{E_p}$$

The variance for the daily emigration estimates using the pooled trap efficiency was calculated using the following formula:

$$\text{Variance for daily emigration estimate} = \text{var}\ \ N_i\ \ = N_i^2\,\frac{E_p\ \ 1-E_p\ \ /\ \ \ M}{E_p^2}$$

The total emigration estimate and confidence interval was calculated using the following formulas:

$$\text{Total emigration estimate} = \quad N_i$$

$$95\%\ \text{confidence interval} = 1.96 \times \quad \overline{\ \text{var}\ }\ \ N_i$$

Egg deposition was calculated based on the number of redds counted in the Entiat River basin multiplied by an estimated fecundity. Spring Chinook fecundity estimates were calculated through regression analysis of the relationship between female fecundity and fork length using Leavenworth National Fish Hatchery (LNFH) spring Chinook brood stock collected between 2002 and 2008 ($n = 350$, $r^2 = 0.45$, $P = <0.01$). The resulting equation was applied to an average fork length of wild female spring Chinook carcasses recovered during Entiat River spawning ground surveys. Fecundity estimates for steelhead were generated from brood collection data within the Wenatchee River basin.

Steelhead age class distributions were derived from scale analysis of previously collected samples. Fork length to age class distributions from scale analysis were applied to steelhead fork lengths obtained within each capture year independently to obtain proportions of annual age class distributions. These resulting proportions were then applied to annual steelhead point estimates to bracket annual abundance estimates within age class.

Water temperature and flow

Water temperatures were measured daily at the trap location when the trap was in operation. Temperature measurements were recorded each morning prior to removing fish from the trap by submerging a hand held thermometer within the live box for a minimum of one minute. Flow was monitored by USGS station number 12452990, located at rkm 2.3.

Results-Rotary Screw Trap

Trap operation period
Rotary screw trap operation began on February 28th, 2011. The trap was operated on a seven day per week schedule through mid-October and then reduced to six days per week through November 19th, 2011. Of the 265 trapping days available within the season the lower trap operated 160 (60.38%) complete days (uninterrupted sampling from sunset to sunrise), 9 (3.40%) incomplete days (interrupted sampling from sunset to sunrise), and was not operated for 96 days (36.23%). Detailed daily operational summaries are included as Appendix Table 1.

Rotary screw trap target species capture summary
In 2011 a total of 21,158 fish were captured by the rotary screw trap (Table 1). Total juvenile fish capture consisted of 4,738 spring Chinook salmon (22.39%), 11,425 summer Chinook salmon (54.00%), 1,547 steelhead trout (7.31%), 112 coho salmon (0.53%), 776 sockeye salmon (3.67%), 10 cutthroat trout (0.05%), 25 bull trout (0.12%), and 2,525 non-target species (11.93%). A total of 13,641 wild salmonids were implanted with PIT tags. Total daily captures for yearling spring Chinook, subyearling spring Chinook, summer Chinook, and steelhead 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 the Entiat River rotary screw trap, 2011.

Species and Life Stage	Total number of Fish Caught	Total PIT Tagged
Wild sub-yearling spring Chinook salmon	3,949	3,755
Wild yearling spring Chinook salmon	789	729
Wild summer Chinook salmon	11,425	7,598
Wild coho salmon	112	85
Wild steelhead	1,547	1,425
Sockeye Salmon	776	15
Bull trout	25	22
Wild cutthroat trout	10	9
Non-target species	2,525	3
Grand total	**21,158**	**13,641**

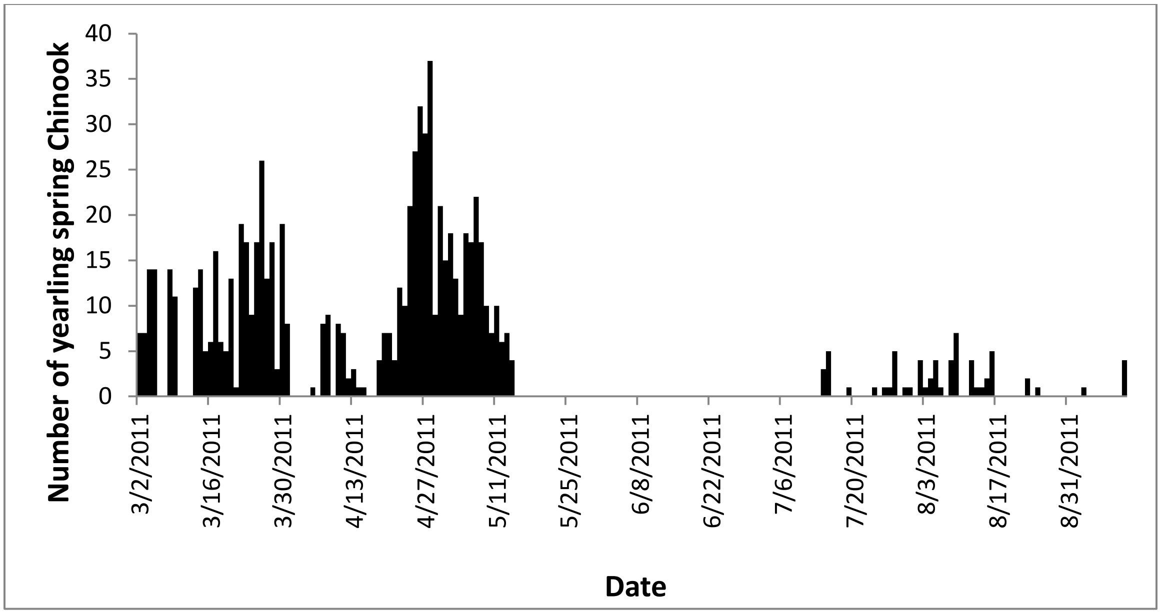

Figure 3. Total daily captures of yearling spring Chinook salmon at the Entiat River rotary screw trap, 2011.

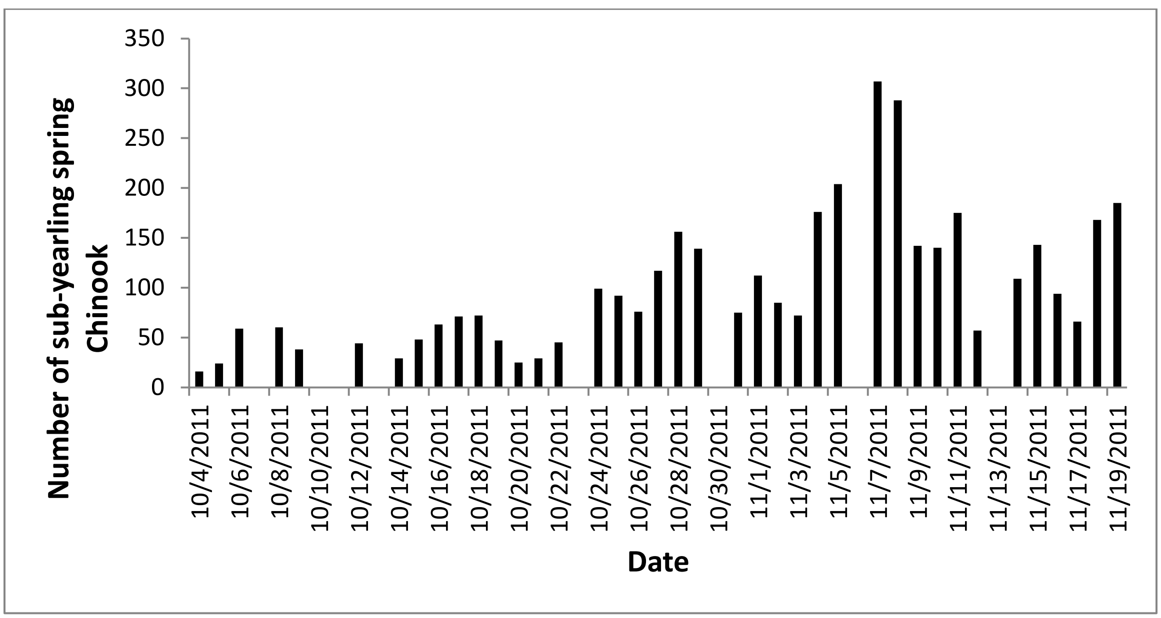

Figure 4. Total daily captures of sub-yearling spring Chinook salmon at the Entiat River rotary screw trap, 2011.

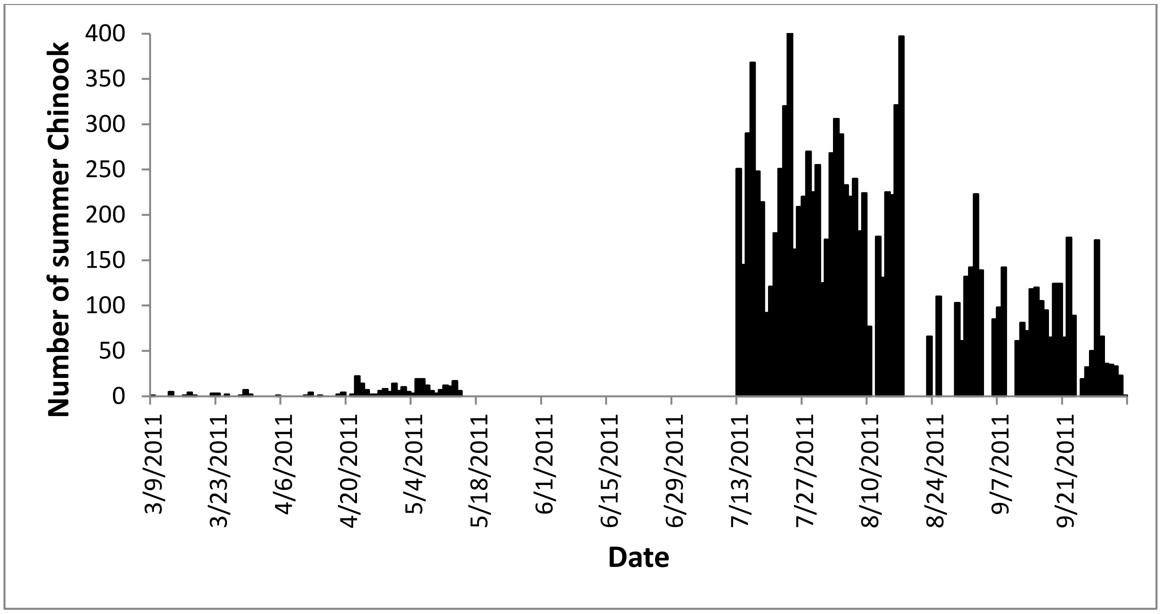

Figure 5. Total daily captures of summer Chinook salmon at the Entiat River rotary screw trap, 2011.

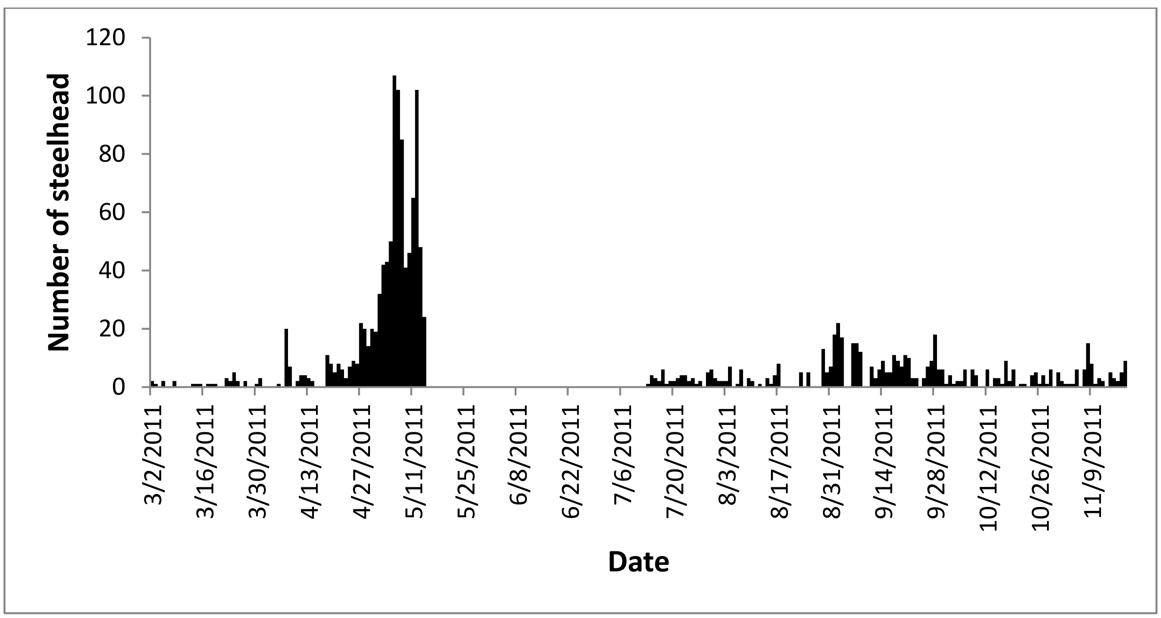

Figure 6. Total daily captures of steelhead at the Entiat River rotary screw trap, 2011.

Mean fork length (SD) of spring Chinook was 99.62 (11.67) mm and 86.80 (9.07) mm, for yearling and subyearling species respectively (Table 2). Summer Chinook had a mean fork length of 65.41 (13.58) mm and steelhead 165.32 (34.32) mm (Table 3).

Table 2. Mean fork lengths (mm), weights (g), and body condition factor for spring Chinook salmon captured at the Entiat River rotary screw trap, 2011.

	Yearling spring Chinook			Subyearling spring Chinook		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Fork Length	99.62	11.67	785	86.80	9.07	3,905
Weight	10.07	3.33	785	6.95	2.18	3,905
K factor	0.99	0.14	785	1.03	0.11	3,905

Table 3. Mean fork lengths (mm), weights (g), and body condition factor for summer Chinook salmon and steelhead captured at the Entiat River rotary screw trap, 2011.

	Summer Chinook			Steelhead		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Fork Length	65.41	13.58	8,380	165.32	34.32	1,495
Weight	3.20	2.49	8,380	46.39	21.35	1,495
K factor	0.99	0.16	8,380	0.94	0.12	1,495

Trap efficiencies

At the Entiat River rotary screw trap, 4 viable efficiency trials using PIT tags were conducted for yearling spring Chinook salmon, 7 trials were conducted for subyearling spring Chinook salmon, 11 trials were conducted for summer Chinook salmon, and 8 trials were conducted for steelhead. An additional four dye mark trials were conducted for summer Chinook salmon measuring less than 50mm. PIT tag trials for yearling spring Chinook salmon efficiency averaged 13.16% (Table 4), subyearling spring Chinook 37.03% (Table 5), summer Chinook 15.62% (Table 6) and steelhead 13.51% (Table 7). Summer Chinook dye mark trials averaged 10.17% (Table 8).

Table 4. Estimated capture efficiency of PIT tagged yearling spring Chinook salmon at the Entiat River rotary screw trap with average (sunrise to sunset) flow from the USGS Keystone gauging station, 2011.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency
03/25/2011	7.28	43	18.60%
04/26/2011	11.92	53	13.21%
05/01/2011	12.35	60	8.33%
05/07/2011	18.90	40	12.50%

Table 5. Estimated capture efficiency of PIT tagged subyearling spring Chinook salmon at the Entiat River rotary screw trap with average (sunrise to sunset) flow from the USGS Keystone gauging station, 2011.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency
09/14/2011	5.59	205	37.07%
10/19/2011	4.59	69	28.99%
10/26/2011	4.43	184	42.93%
11/02/2011	4.27	180	33.89%
11/09/2011	4.21	279	36.56%
11/15/2011	3.91	104	41.35%
11/17/2011	3.37	229	38.43%

Table 6. Estimated capture efficiency of PIT tagged summer Chinook salmon at the Entiat River rotary screw trap with average (sunrise to sunset) flow from the USGS Keystone gauging station, 2011.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency
07/15/2011	39.33	245	4.08%
07/17/2011	37.44	318	9.75%
07/19/2011	37.46	228	3.95%
07/22/2011	32.33	232	7.33%
07/24/2011	28.10	261	8.05%
07/31/2011	23.71	118	21.19%
08/03/2011	20.10	267	16.85%
08/05/2011	18.39	340	16.47%
08/09/2011	15.83	432	22.45%
08/15/2011	12.39	407	22.85%
09/07/2011	5.80	85	38.82%

Table 7. Estimated capture efficiency of PIT tagged steelhead at the Entiat River rotary screw trap with average (sunrise to sunset) flow from the USGS Keystone gauging station, 2011.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency
04/26/2011	11.92	18	22.22%
04/29/2011	12.39	29	17.24%
05/04/2011	14.36	92	5.43%
05/07/2011	18.90	183	9.84%
05/09/2011	20.59	188	13.83%
05/12/2011	24.75	149	8.05%
05/14/2011	35.19	143	7.69%
11/09/2011	4.21	21	23.81%

Table 8. Estimated capture efficiency of dye marked summer Chinook salmon at the Entiat River rotary screw trap with average (sunrise to sunset) flow from the USGS Keystone gauging station, 2011.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency
07/18/2011	36.46	192	5.21%
07/25/2011	28.10	370	8.38%
08/05/2011	18.39	231	8.66%
08/09/2011	15.83	117	15.38%
08/15/2011	12.39	106	13.21%

Production estimates

Estimates for yearling spring Chinook and steelhead were independently derived from regression analysis ($r^2 = 0.60, P < 0.01; r^2 = 0.81, P = < 0.01$). Subyearling spring Chinook abundance could not be estimated by regression analysis ($r^2 = < 0.50$) and was calculated by pooling the trap efficiency during the emigration period (average efficiency = 37.02%). The point estimate of emigrant abundance (95% C.I.) for yearling and subyearling spring Chinook was 6,087 (± 381) and 12,875 (± 179), respectively (Appendix Table 3 and 4). Wild summer steelhead was estimated at 15,691 (± 3,009) (Appendix Table 5).

Total egg deposition spring Chinook was estimated at 472,069 eggs. Deposition was based on 115 redds counted within the Entiat River basin (Hamstreet, 2011) multiplied by an estimated fecundity of 4,105 eggs. Average fork length of spring Chinook carcasses recovered during 2009 spawning ground surveys was 761 mm (n = 14). Egg-to-emigrant survival rate and emigrant-per-redd estimates were calculated at 4.05% and 166 fish, respectively for 2009 brood year spring Chinook (Table 9).

Abundance estimates for steelhead in 2011 allowed for the completion of 2008 brood year production estimates. Annual fecundity estimates for brood years 2006, 2007, and 2008 were generated from wild steelhead brood collection within the Wenatchee River basin (T. Miller, WDFW, personal communication) and were estimated at 5,480, 5,660, and 5,422 eggs, respectively. Steelhead egg-to-emigrant survival rate for Brood year 2008 was calculated at 1.29% and emigrant per redd was 70 fish (Table 10). Annual point estimates for spring Chinook and steelhead and associated confidence intervals are presented within Appendix Table 6.

Table 9. Estimated egg deposition (# of redds × estimated female fecundity), egg-to-emigrant survival rates, and emigrant per redd estimates for Entiat River wild spring Chinook salmon juveniles, brood years 2002 to 2009.

Brood Year	Number of Redds	Estimated Egg Deposition	Estimated Number			Egg-to-Emigrant Survival (%)	Emigrant per Redd
			Subyearling	Yearling	Total		
2002	112	488,979	10,437	4,363	14,800	3.03[a]	132[a]
2003	108	574,172	8,896	5,916	14,812	2.58[a]	137[a]
2004	126	510,179	15,185	9,689	24,874	4.88[a]	197[a]
2005	148	608,912	12,998	9,693	22,690	3.73[b]	153[b]
2006	107	420,284	10,464	15,652	26,116	6.21	244
2007	102	423,458	14,234	7,479	21,713	5.12	213
2008	116	483,741	11,354	15,230	26,584	5.50	229
2009	115	472,069	13,021	6,087	19,108	4.05	166

[a] Derived from upper trap estimates.
[b] Derived from upper trap subyearling and lower trap yearling estimates.

Table 10. Estimated egg deposition (# of redds × average annual fecundity), egg-to-emigrant survival rates, and emigrant per redd estimates for Entiat River wild steelhead juveniles, brood years 2002 to 2008.

Brood Year	Number of Redds	Estimated Egg Deposition	Estimated Number					Egg-to-Emigrant Survival (%)	Emigrant per Redd
			Age 0	Age 1	Age 2	Age 3+	Total		
2002[a b]	--	--	--	--	--	1,497	--	--	--
2003[a b]	--	--	--	--	2,370	1,554	--	--	--
2004[a b]	--	--	--	2,112	3,945	1,605	--	--	--
2005[a]	--	--	3,970	3,945	2,376	4,485	14,774	--	--
2006	98	537,040	1,624	1,954	5,043	1,620	10,241	1.91[d]	104[d]
2007[c]	33	186,780	638	3,946	5,014	982	10,580	7.84	445
2008	298	1,619,034	3,202	3,872	15,249	5,410	27,733	1.29	70

[a] No redd counts.
[b] Incomplete brood year.
[c] Partial basin redd count.
[d] Derived from upper trap estimates.

Water temperature and flow
Water temperature measurements averaged 8.09 ˚C throughout the study period. Water temperatures peaked at 15 ˚C on August 25th, and were lowest on November 11th when temperatures were 0.0 ˚C. Flow peaked in the spring on June 12th, 2011 at 81.25 m^3/s. High water levels gradually declined through July, allowing rotary screw trap operations to resume (Figure 7).

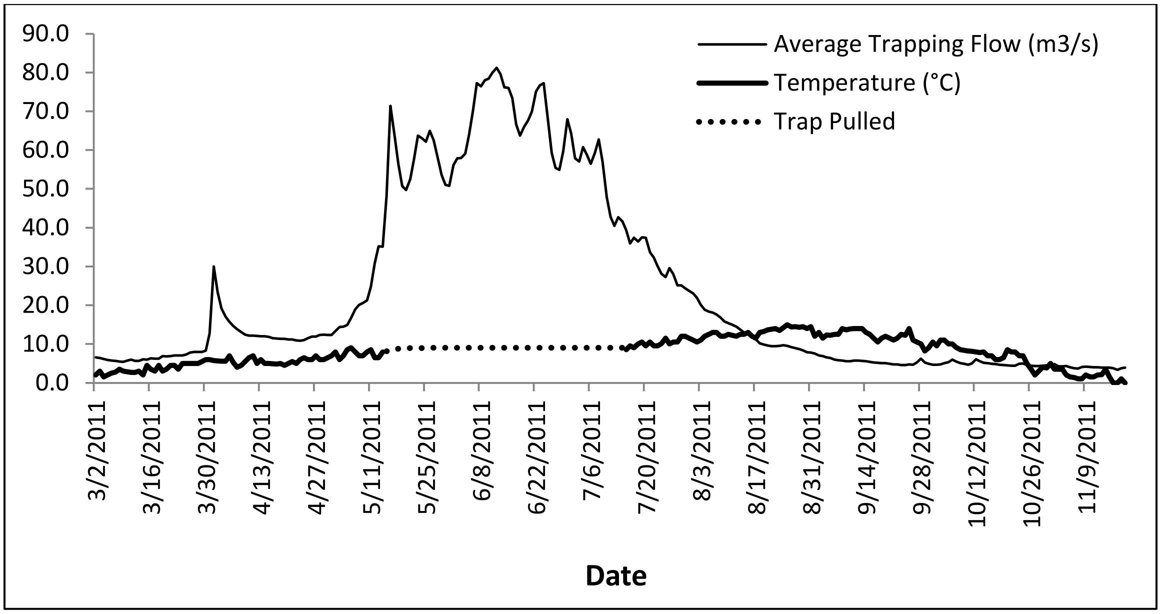

Figure 7. Average daily flow (m^3/s) and temperature (˚C) for the lower Entiat River rotary screw trap, 2011.

Data dissemination
All final data corrections were completed on December 7th, 2011. Electronic data was submitted to ISEMP (via James White) on January 4th, 2012.

Discussion-Rotary Screw Trap

Rotary screw trap operation
The day to day operation of rotary screw traps are time consuming and difficult. Seasonal high river flow 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 pulled when necessary. In 2011 the majority of nonoperational 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. During the fall period,

trap operation was reduced from the normal seven day per week to a six day per week operational schedule as a cost savings measure.

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 7. 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. This will provide a definitive run classification for each sample when compared to base line genetic data.

Production estimates

In 2011, low capture numbers of yearling spring Chinook limited the number of efficiency trials that could be conducted at various levels of river discharge. Regression analysis including only 2011 efficiency trials did not meet the required criteria ($r^2 > 0.50$); therefore, trials from 2009 and 2010 were used to increase the sample size of the model. The inclusion of efficiency trial data from previous years is suitable when trap operations were consistent between years and the physical dynamics of the trapping location remained static (river depth, width, flow, etc.). Data used to generate spring Chinook point estimates in 2011 are presented in Appendix Table 8. To lessen future impacts of low capture years on production estimates, a second rotary screw trap will be operated as needed at the location below the ENFH (rkm 11) to supplement the number of fish available for efficiency trials at the lower trap location.

Currently, steelhead age determination is based on two years of scale analysis (capture years 2008 and 2009) and is limited to migrants during the spring emigration period

(March through July). The use of this analysis to determine the distribution of age classes outside of the analytical years required assuming that variation in the relationship between fork length and age class was negligible both between and within years. MCRFRO plans to test these assumptions in 2012 with the addition of scale analysis from capture years 2010 and 2011. If the relationship is not valid, estimates of steelhead production will be recalculated. In the case of spring Chinook production estimates, genetic analysis should prove useful in differentiating between spring and summer run subyearlings. If this analysis does not support our current method of the relative catch nadir, production estimates for subyearling spring Chinook will require recalculation.

Annual point estimates from brood years 2002 to 2009 indicate that an average 43.42% of spring Chinook emigrated from the Entiat River as subyearlings. This contrasts emigration from the Wenatchee River where all spring Chinook emigrate from the watershed as yearlings (T. Miller, WDFW, personal communication). Currently, juvenile fish monitoring and collection facilities within the Columbia River lack the ability to adequately monitor over winter movements of juvenile fish. This has limited our efforts to determine the overall survival rates and age of ocean entry for this component of the spring Chinook population.

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 common consensus among researchers in the Upper Columbia is that a fundamental problem exists with the equation used to estimate variance of point estimates. Our current calculations may not adequately account for all variables that influence the confidence intervals associated with our estimates. Although we feel our estimates are accurate and applicable to resource management needs we will continue to proactively review the parameters included in these calculations in order to improve methodology.

Project goals
Project goals were met during the 2011 field season. Continued out-migrant monitoring is required at the rotary screw trap and elsewhere within the basin 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 at the ENFH. In 2012, 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 is designed as a rotating panel of sample sites chosen annually. Sample sites were selected within defined geomorphic reaches. Start locations were randomly drawn then the resulting sites were generated systematically based on the number of sites needed per 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 2011 are presented in Figures 8 and 9 respectively.

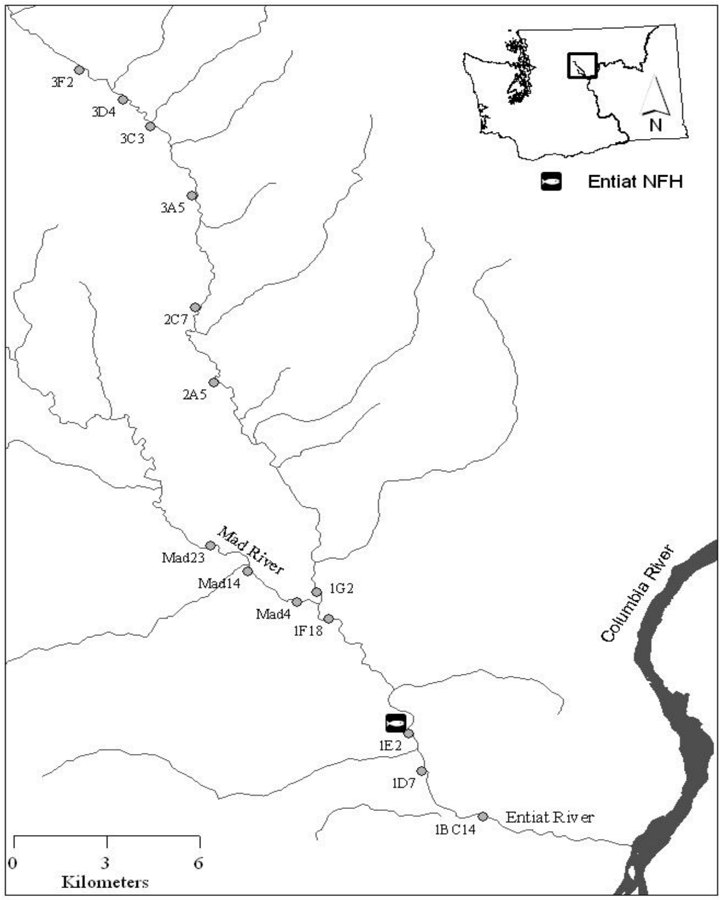

Figure 8. Map of the mark-recapture sites sampled during the winter period in the Entiat River, 2011.

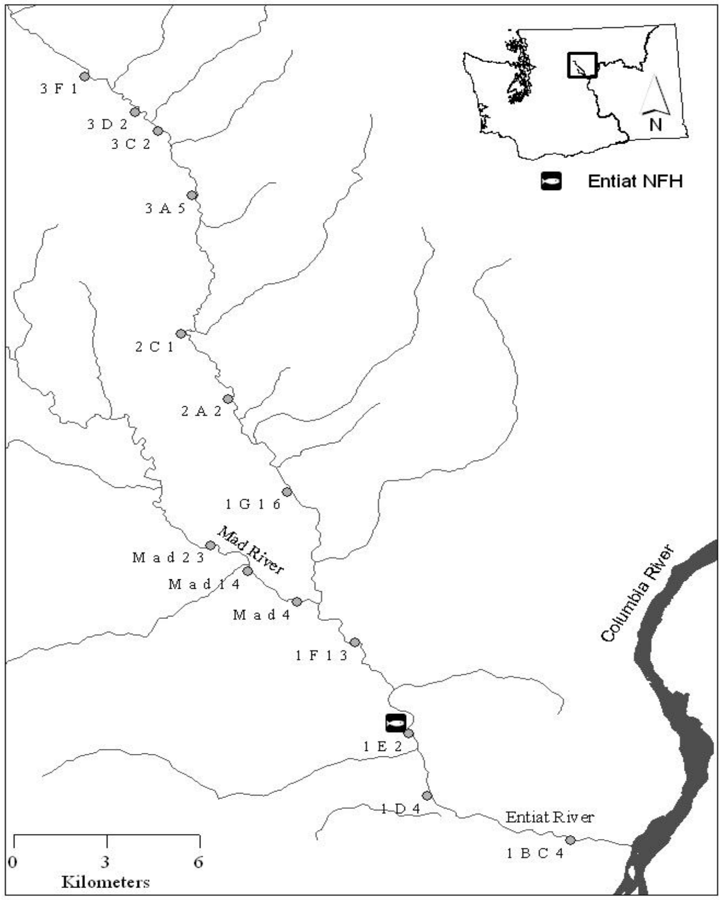

Figure 9. Map of the mark-recapture sites sampled during the summer period in the Entiat River, 2011.

Sample periods

Mark-recapture sampling was conducted twice annually. Winter period fish sampling was conducted within the Entiat and Mad Rivers during February and March of 2011, prior to the beginning of the spring emigration period. Summer period fish sampling was conducted during August and September when river flow 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.

Fish sampling was conducted at each site over a period of two consecutive days. During the winter sampling period all sites were sampled following sunset to maximize fish capture numbers. During the summer period daytime sampling 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, 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 the sampling period, all sites were surveyed to determine a primary sampling method. Pre-sampling surveys included recording visual observations of available habitats and often 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 26, 2011, expires April 26, 2012), 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 interrogated 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 either instantaneous or delayed. Instantaneous mortality was the result of capture, handling, or PIT tagging while delayed mortality was assumed to be due to PIT tagging alone. Delayed mortality and shed rates were assessed at a subset of sites by holding newly PIT tagged fish following day two of recapture sampling.

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

All individual fish data entry utilized the P3 program from PTAGIS. Data files generated from the P3 program were then parsed into a database maintained by MCRFRO staff. 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.

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 February 28, 2011 when river surface ice had receded allowing safe access to sample sites. All sampling activities were completed on March 11. Daily average flow (m^3/s) during the sampling period is summarized in Figure 10. Snow depth upon an unmaintained road caused one site to remain inaccessible for sampling during this period. Detailed locations and sampling notes are presented as Appendix Table 9.

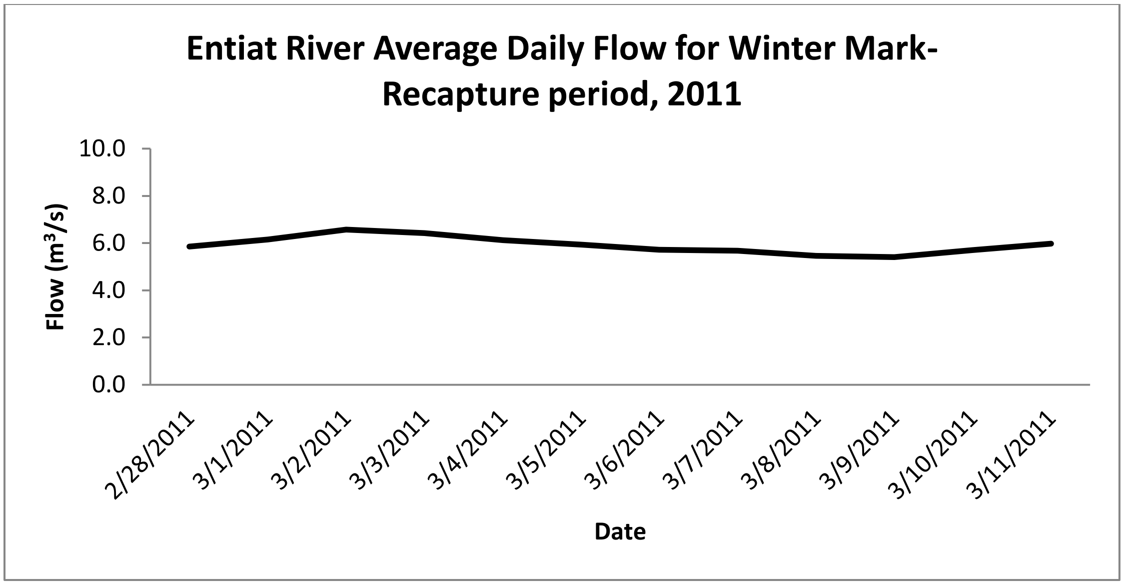

Figure 10. Entiat River average daily flow (m^3/s) during winter period mark-recapture sampling, 2011.

A total of 1,650 fish were captured at 13 sites throughout the Entiat and Mad rivers during the 2011 winter sampling period (Table 11). Species composition included 329 wild spring Chinook salmon (19.9%), 1,315 wild steelhead (79.7%), 5 bull trout (0.3%) and 1 cutthroat trout (0.1%). A total of 1,528 wild salmonids (92.6%) were implanted with PIT tags. Detailed capture summaries including those from training events are included as Appendix Table 10. Mean fork length (SD) of juvenile spring Chinook and steelhead was 91.59 (8.00) mm and 104.15 (40.54) mm, respectively (Table 12).

Table 11. Number of fish captured and PIT tagged from the winter mark-recapture sample period, 2011.

Species and Life Stage	Total number of Fish Caught	Total PIT Tagged
Wild spring Chinook salmon	329	309
Wild steelhead	1,315	1,213
Bull trout	5	5
Wild cutthroat trout	1	1
Grand total	**1,650**	**1,528**

Table 12. 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, 2011.

	Spring Chinook			**Steelhead**		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Fork Length	91.59	8.0	295	104.15	40.54	1,222
Weight	8.00	2.19	295	16.79	22.52	1,222
K	1.01	0.09	295	1.01	0.15	1,222

During the 2011 winter sample period, instantaneous mortality was attributed to a total of one Chinook salmon (0.1%) as a result of PIT tagging. There were no cases of capture related mortality recorded. A total of 82 wild Chinook salmon and 256 steelhead were retained from a total of six 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 (0.4% shed rate).

Summer period fish capture summary

Fish sampling began on August 18, 2011 when flows within the Entiat River had dropped below 9.9 m^3/s. Above average snow accumulation caused 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. Sampling efforts focused first on Mad River sites where flows were lower than in the Entiat River. Following the completion of the Mad River sited, efforts focused on the uppermost Entiat River sites in attempt to complete sampling before the peak of spring Chinook spawning activity. One Entiat River site was not sampled due to the number of spring Chinook redds present within the site. All sampling activities were completed on September 10, 2011. Detailed locations and sampling notes are presented as Appendix Table 11.

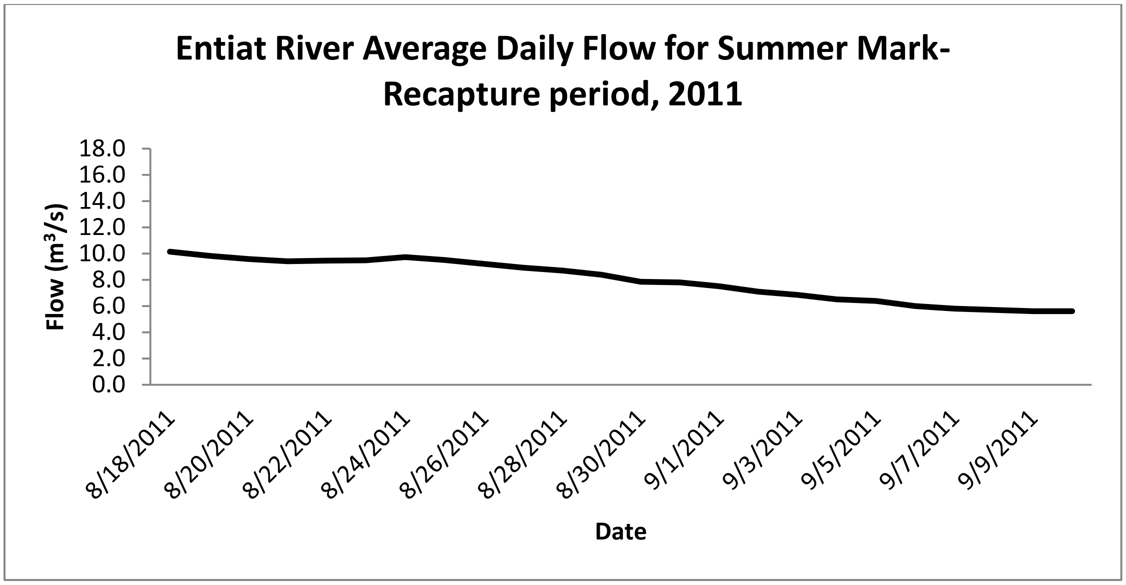

Figure 11. Entiat River average daily flow (m^3/s) during summer period mark-recapture sampling, 2011.

A total of 4,459 fish were captured at 13 sites throughout the Entiat and Mad rivers during the 2011 summer sampling period (Table 13). Species composition included 1,751 wild Chinook salmon (39.3%), 1,673 wild steelhead (37.5%), 26 wild coho salmon (0.6%), 10 bull trout (0.2%), 4 cutthroat trout (0.1%), and 995 non-target species (22.3%). A total of 2,973 wild salmonids (66.7%) were implanted with PIT tags. Detailed capture summaries including those from training events are included as Appendix Table 12. Mean fork length (SD) of Chinook salmon and steelhead was 78.33 (12.51) mm and 110.19 (45.33) mm respectively (Table 14).

Table 13. Number of fish captured and PIT tagged from the summer mark-recapture sample period, 2011.

Species and Life Stage	Total number of Fish Caught	Total PIT Tagged
Chinook salmon	1,751	1,661
Wild steelhead	1,673	1,276
Coho salmon	26	24
Bull trout	10	8
Wild cutthroat trout	4	4
Non-target species	995	0
Total	**4,459**	**2,973**

Table 14. Mean fork lengths (mm), weights (g), and body condition factor for Chinook salmon (unknown run) and steelhead captured in the summer mark-recapture sample period, 2011.

	Chinook (unknown run)			**Steelhead**		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Fork Length	78.33	12.51	1,697	110.19	45.33	1,357
Weight	5.59	2.83	1,679	21.67	26.32	1,357
K	1.10	0.18	1,679	1.05	0.14	1,357

During the 2011 summer sample period, instantaneous mortality was attributed to a total of 64 Chinook salmon (3.7%) and 30 steelhead (1.8%) as a result of capture activities. There were no cases of tagging related instantaneous mortality recorded. A total of 168 wild Chinook salmon and 125 steelhead were retained from a total of 4 sample sites throughout the Entiat and Mad rivers for assessing post tagging mortality and shed rates. In total, delayed tagging mortality was attributed to 3 Chinook salmon (1.8%). There were no cases of delayed tagging mortality associated with steelhead. Shed tag recoveries were limited to one Chinook salmon (0.6% shed rate) and steelhead (0.8% shed rate).

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 15) and summer (Table 16) periods. Winter mark-recapture sampling produced a total of five valid point estimates of Chinook and 10 for steelhead of the 13 possible for each species. Of the 13 possible point estimates in the summer period 10 were valid for Chinook and nine were valid for steelhead. Appendix Table 13 presents point estimates from past mark-recapture sampling periods.

Table 15. Point estimates of abundance for Chinook salmon and steelhead captured at mark-recapture sites sampled during the winter period, 2011.

Site	Species	New Cptrs	Total Marked	Total Recaps	Recap prob.	Pop. Est.	Lower 95% C.I.	Upper 95% C.I.	Stdrd Error
1BC14	Wild Chinook	0	1	0	0.00	INV	--	--	--
	Wild steelhead	117	98	26	0.26	432	312	552	61.24
1D7	Wild Chinook	1	0	0	0.00	INV	--	--	--
	Wild steelhead	90	46	11	0.24	355	200	511	79.48
1E2	Wild Chinook	0	2	0	0.00	INV	--	--	--
	Wild steelhead	85	84	19	0.23	365	245	484	61.10
1F18	Wild Chinook	4	8	2	0.25	INV	--	--	--
	Wild steelhead	85	132	32	0.24	346	266	425	40.46
1G2	Wild Chinook	8	7	3	0.43	INV	--	--	--
	Wild steelhead	71	90	23	0.26	272	197	347	38.25
2A5	Wild Chinook	44	32	5	0.16	247	92	401	78.77
	Wild steelhead	61	56	18	0.32	185	130	240	28.28
2C7	Wild Chinook	34	20	4	0.20	146	51	241	48.50
	Wild steelhead	41	35	3	0.09	INV	--	--	--
3A5	Wild Chinook	20	13	1	0.08	INV	--	--	--
	Wild steelhead	31	19	1	0.06	INV	--	--	--
3C3	Wild Chinook	38	24	8	0.33	107	60	154	24.04
	Wild steelhead	6	4	2	0.50	INV	--	--	--
3D4	Wild Chinook	13	31	8	0.26	49	33	64	7.98
	Wild steelhead	17	30	8	0.27	61	38	84	11.68
3F2	Wild Chinook	30	51	24	0.47	63	56	71	4.01
	Wild steelhead	31	33	9	0.27	108	63	153	22.85
M04	Wild Chinook	0	1	0	0.00	INV	--	--	--
	Wild steelhead	79	63	31	0.49	159	129	189	15.26
M14	Wild Chinook	0	0	0	0.00	INV	--	--	--
	Wild steelhead	49	40	11	0.28	170	102	238	34.74
M23	Wild Chinook	--	--	--	--	--	--	--	--
	Wild steelhead	--	--	--	--	--	--	--	--

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

Table 16. Point estimates of abundance for Chinook salmon and steelhead captured at mark-recapture sites sampled during the summer period, 2011.

Site	Species	New Cptrs	Total Marked	Total Recaps	Recap prob.	Pop. Est.	Lower 95% C.I.	Upper 95% C.I.	Stdrd Error
1BC4	Wild Chinook	108	117	21	0.18	548	391	776	98.23
	Wild steelhead	55	74	8	0.10	466	217	714	126.82
1D4	Wild Chinook	178	210	18	0.09	1,987	1,201	2,773	400.88
	Wild steelhead	143	254	41	0.16	873	672	1,074	102.56
1E2	Wild Chinook	76	94	13	0.14	522	301	742	112.68
	Wild steelhead	82	78	6	0.08	936	343	1,529	302.54
1F13	Wild Chinook	81	100	15	0.15	517	314	719	103.32
	Wild steelhead	48	52	8	0.15	288	140	435	75.12
1G16	Wild Chinook	35	36	1	0.03	INV	--	--	--
	Wild steelhead	44	88	4	0.04	800	213	1,387	299.52
2A2	Wild Chinook	71	100	4	0.04	1,453	359	2,548	558.41
	Wild steelhead	15	18	4	0.22	60	25	94	17.67
2C1	Wild Chinook	41	23	2	0.09	INV	--	--	--
	Wild steelhead	11	13	1	0.08	INV	--	--	--
3A5	Wild Chinook	52	19	1	0.05	INV	--	--	--
	Wild steelhead	7	2	0	0.00	INV	--	--	--
3C2	Wild Chinook	64	53	8	0.15	389	184	594	104.50
	Wild steelhead	4	4	0	0.00	INV	--	--	--
3D2	Wild Chinook	92	88	18	0.20	435	284	586	77.06
	Wild steelhead	5	8	1	0.12	INV	--	--	--
3F1	Wild Chinook	--	--	--	--	--	--	--	--
	Wild steelhead	--	--	--	--	--	--	--	--
M04	Wild Chinook	68	49	26	0.47	143	110	176	16.74
	Wild steelhead	43	61	6	0.10	389	155	622	119.00
M14	Wild Chinook	12	6	4	0.67	17	11	23	3.12
	Wild steelhead	63	63	20	0.32	194	139	249	27.94
M23	Wild Chinook	20	12	5	0.42	45	24	65	10.67
	Wild steelhead	81	72	27	0.37	213	163	262	25.29

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

Growth per day estimates

In 2011, a total of 124 recaptures were used to generate SGR estimates. These recaptures consisted of 17 Chinook salmon (13.7%) and 107 steelhead (86.3%). The majority of recaptures occurred during the spring sampling period of 2011. 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 17).

Table 17. 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, 2011.

				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	17	24.06	4.29	203.35	6.09	0.12	0.02
Entiat	Steelhead	Winter	41	24.29	13.77	199.27	3.83	0.12	0.07
Mad	Steelhead	Winter	27	15.81	9.42	206.81	11.68	0.07	0.05
Entiat	Steelhead	Summer	6	69.17	12.19	175.17	1.17	0.40	0.07
Mad	Steelhead	Summer	10	43.10	10.84	171.80	2.44	0.25	0.06
Entiat	Steelhead	Annual	2	--	--	--	--	--	--
Mad	Steelhead	Annual	21	55.81	14.84	381.38	7.24	0.15	0.04

Data dissemination
All data was uploaded into the PTAGIS database and the MCRFRO database on a weekly basis. Due to programming issues, data was not entered into an ATM but instead was transferred to the Upper Columbia Data Steward on January 4, 2011.

Discussion- Mark-Recapture Sampling

Fish sampling
Full implementation of fish capture efforts within the IMW design were completed with the addition of the winter sample period in 2011. Sampling within the winter period presented new challenges to crews conducting fish capture. Whereas high water temperatures and river discharge limited sampling crews ability to fully sample sites during the summer of 2010, fish behavior and sample site accessibility proved challenging during the winter of 2011. Previous experience gained by MCRFRO staff conducting snorkel surveys within the Entiat River during winter months suggested that fish become more active at night during the winter than in the summer. However, as greater effort and better suited equipment would be required for fish sampling to occur at night, we conducted a test of capture rates between sampling regimes. At the beginning of the sample period one crew was scheduled to sample at night while the remaining two were scheduled during the day. Because more fish were captured during the night the two daytime crews were rescheduled and all sampling occurred at night.

In 2011, the winter sample period was scheduled to begin in late February prior to the expected onset of Chinook and steelhead emigration while the summer sample period targeted a maximum flow of 9.9m^3/s for the onset of fish sampling. This maximum flow target was reduced from the 2010 target of 11.3m^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. However, capture related mortality was observed to be higher during the summer period. This may be attributed to the exclusion of electrofishing and lower water temperatures during the winter 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.

Length-frequency analysis of data collected in 2010 appeared to support a size bias toward the capture of smaller steelhead within the main stem Entiat River. Snorkel observations at a number of sites supported the apparent size bias as a considerable number of larger steelhead were observed but were not represented within the total capture. As the Entiat IMW study design seeks to define steelhead abundance within multiple age classes it is imperative that these larger steelhead be represented in future sampling efforts. Past sampling conducted by MCRFRO in the Entiat watershed suggests that angling is biased toward larger, older age class juvenile steelhead. During the summer sampling period of 2011 angling was introduced in attempt to better represent older age classes of juvenile steelhead.

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 seeking to analyze a subset of these samples in order to determine if a break between run types can be established.

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.

Given the physical river conditions of the study sites, block netting is not a feasible method to use during either sampling period. To be effective within larger rivers such as the Entiat, block netting requires periodic inspection and maintenance between marking and recapture. Given the additional staff this would require, block netting was not achievable. By leaving the sample population physically open to immigration and emigration during the study period, we were not able to meet the assumption of a closed population, nor did we have the means to determine if these rates were substantial enough to introduce bias to the abundance estimates. ISEMP has experimented with the use of portable antennas in place of block netting to monitor the movements of PIT tagged fish from study sites in other areas. We suggest the use of portable antennas at Entiat River IMW sampling sites would allow the rate of emigration of marked fish from the study site to be calculated. Although the rate of immigration of marked or unmarked fish could not be determined, data on how many marked individuals moved into a study site would be beneficial. Since the use of these portable antenna systems would require a substantial increase in staff it is doubtful that all sample sites could be monitored; however, if a subset of sites were monitored that data may then be applied to the project as a whole.

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 18 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.

Growth per day estimates

A comparison of specific growth estimates between steelhead in the lower Entiat (valley segment 1) and the Mad Rivers was possible in 2011 and a higher growth rate within the lower 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. Growth estimates for the middle and upper Entiat River (valley segment 2 and 3) were not possible due to inadequate recapture data. Greater numbers of captures in the middle and upper portions of the study area are needed in order to compare growth rates through the Entiat watershed.

Project goals

Project goals were met during 2011. This first year of fully implemented fish sampling under the Entiat IMW study design provided estimates of abundance for juvenile Chinook salmon and steelhead at most sites. This season provided lessons that will improve future abundance and survival estimates. 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 2012, MCRFRO staff will begin to assess juvenile survival at various spatial and temporal scales within the IMW study area.

Methods- PIT Tag Interrogation Site Monitoring

Interrogation site locations

MCRFRO operated six PIT tag interrogation sites within the Entiat watershed in 2011. 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 12.

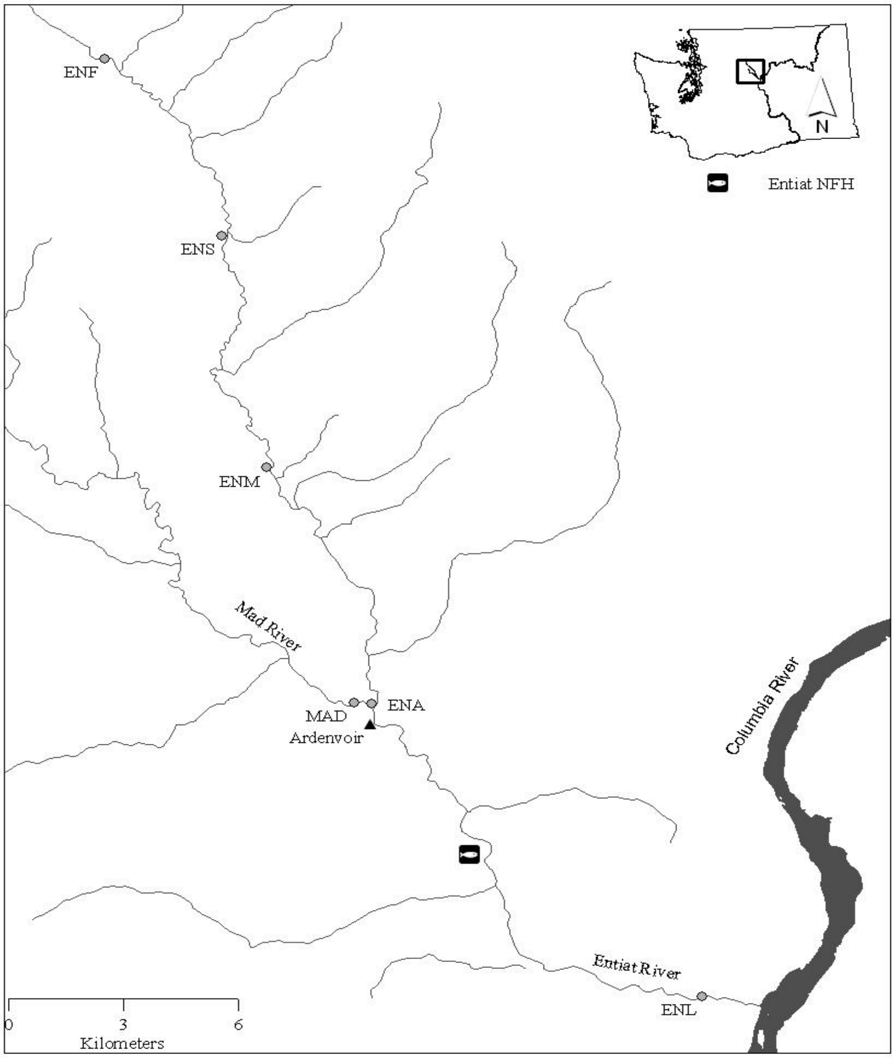

Figure 12. Map of the locations of PIT tag interrogation sites in the Entiat River, 2011.

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. Antennas were anchored to the substrate in one of two configurations. The flat plate or pass-over configuration involved anchoring both the upstream and the downstream sides of each antenna to hold it firmly to the substrate. The hybrid configuration required only that the upstream side be anchored allowing the downstream side to float freely.

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 2011. 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.

Interrogation site detection efficiency

Detection efficiency was measured for wild spring Chinook and steelhead at the ENL interrogation site. The ENL site was located below the rotary screw trap operated in the lower Entiat River. The operation of the rotary screw trap required regular releases of PIT tagged juvenile fish to estimate trap capture efficiencies during specific time periods. A modification to the calculation used to determine trap efficiency allowed the detection efficiency of the interrogation site to be determined.

Detection efficiency was calculated using the following formula:

$$\text{Detection efficiency, } E_i = \frac{D_i}{TM_i - TR_i}$$

where E_i is the detection efficiency during time period i; TM_i is the number of marked fish released for a trap efficiency trial during time period i; TR_i is the number of marked recaptures at the trap during time period i, and D_i is the number of marked fish detected at the interrogation site during time period i.

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 365 day monitoring period, the ENL site operated for 248 days (67.9%), ENM for 342 days (93.6%), ENF for 313 days (85.8%) and the MAD site operated 284 days (77.8%). The ENA site was installed on April 16, 2011 and out of the 260 possible days, operated 219 (84.2%). The ENS site was installed on May 6, 2011 and operated 230 days out of the possible 240 (95.8%). Specific details pertaining to site inactivity or failure are outlined in Appendices 14 through 19.

Detection summary
In 2011, a combined total of 2,394 unique PIT tag detections were recorded between all sites (Table 18). 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 2,003 (83.7%) of all unique detections, adult detections accounted for 350 (14.6%), and the remaining 41 (1.7%) detections were attributed to unknown fish that were not registered on the PTAGIS database. Of the juvenile detections a total of 1,753 (87.5%) were determined to be of Entiat River origin and 252 (12.5%) were apparent strays (Table 19). A total of 130 (37.1%) adults were of Entiat River origin, 44 (12.6%) were apparent strays, and 176 (50.3%) were of unknown origin (Table 20). In general, adults of an unknown origin were tagged as adults at collection facilities within the Columbia hydro system. Unique detections were further determined for each individual interrogation site and are presented in Appendices 20 through 25.

Table 18. Combined unique detections from all interrogation sites within the Entiat watershed, 2011. 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	6	33	39
Wild spring Chinook salmon	677	47	724
Hatchery summer Chinook salmon	230	10	240
Wild summer Chinook salmon	103	1	104
Hatchery fall Chinook salmon	0	1	1
Wild fall Chinook salmon	0	1	1
Chinook salmon (unknown run and rear type)	0	18	18
Wild Chinook salmon (unknown run)	519	33	552
Hatchery coho salmon (unknown run)	4	3	7
Wild coho salmon (unknown run)	11	1	12
Hatchery summer steelhead	1	32	33
Summer steelhead (unknown rear type)	0	2	2
Wild summer steelhead	440	130	570
Hatchery summer sockeye salmon	1	3	4
Hatchery sockeye salmon (unknown run)	0	4	4
Sockeye salmon (unknown run and rear type)	0	4	4
Bull trout	8	25	33
Wild resident cutthroat trout	3	1	4
Mountain whitefish	0	1	1
Unknown species run and rear	--	--	41
Grand totals	2,003[a]	350[a]	2,394

[a] Unknown fish are not assigned a life stage and are not included in totals for adults and juveniles.

Table 19. Origin of juvenile fish detected at interrogation sites within the Entiat River, 2011. 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	6	6
Wild spring Chinook salmon	677	0	677
Hatchery summer Chinook salmon	209	21	230
Wild summer Chinook salmon	103	0	103
Wild Chinook salmon (unknown run)	519	0	519
Hatchery coho salmon (unknown run)	0	4	4
Wild coho salmon (unknown run)	11	0	11
Hatchery summer steelhead	0	1	1
Wild summer steelhead	439	1	440
Hatchery sockeye salmon (unknown run)	1	0	1
Bull trout	8	0	8
Wild resident cutthroat trout	3	0	3
Grand totals	1,969	34	2,003

Table 20. Origin of adult fish detected at interrogation sites within the Entiat River, 2011. PTAGIS naming convention used to indicate species, run and rear type.

Species (indicating rear and run type)	Entiat Origin	Stray	Unknown Origin	Adult
Hatchery spring Chinook salmon	0	7	26	33
Wild spring Chinook salmon	41	1	5	47
Hatchery summer Chinook salmon	0	10	0	10
Wild summer Chinook salmon	1	0	0	1
Hatchery fall Chinook salmon	0	1	0	1
Wild fall Chinook salmon	0	0	1	1
Chinook salmon (unknown run and rear type)	0	1	17	18
Wild Chinook salmon (unknown run)	13	1	19	33
Hatchery coho salmon (unknown run)	0	3	0	3
Wild coho salmon (unknown run)	1	0	0	1
Hatchery summer steelhead	0	9	23	32
Summer steelhead (unknown rear type)	0	0	2	2
Wild summer steelhead (*2011 spawners*)	39	1	57	97
Wild summer steelhead (*2012 spawners*)	9	0	24	33
Hatchery summer sockeye salmon	0	3	0	3
Hatchery sockeye salmon (unknown run)	0	4	0	4
Sockeye salmon (unknown run and rear type)	0	2	2	4
Bull trout	24	0	0	25
Wild resident cutthroat trout	1	0	0	1
Mountain whitefish	0	1	0	1
Grand totals	130	44	176	350

Interrogation site detection efficiency

At the ENL interrogation site, a total of 12 trials were conducted for yearling spring Chinook salmon, 6 for subyearling spring Chinook salmon, 12 for summer Chinook salmon, and 16 for steelhead. Detection efficiency for yearling spring Chinook salmon averaged 1.0% (Table 21), 86.1% for subyearling spring Chinook (Table 22), 8.6% for summer Chinook salmon (Table 23), and 10.6% for steelhead (Table 24).

Table 21. Estimated detection efficiency of yearling spring Chinook at the ENL interrogation site, 2011.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency (%)
03/24/2011	7.08	35	5.7
04/08/2011	13.1	17	5.9
04/12/2011	12.1	17	0.0
04/25/2011	11.9	46	0.0
04/28/2011	12.4	54	0.0
05/03/2011	14.4	40	0.0
05/08/2011	20.6	33	0.0
05/11/2011	24.8	23	0.0
5/13/2011	35.2	13	0.0

Table 22. Estimated detection efficiency of subyearling spring Chinook at the ENL interrogation site, 2011.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency (%)
10/18/2011	4.6	49	77.6
10/25/2011	4.4	105	89.5
11/01/2011	4.3	118	86.4
11/8/2011	4.2	141	81.6
11/14/2011	3.9	59	93.2
11/16/2011	3.4	135	88.2

Table 23. Estimated detection efficiency of juvenile summer Chinook at the ENL interrogation site, 2011.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency (%)
07/14/2011	39.4	233	0.0
07/16/2011	37.5	285	0.0
07/21/2011	32.3	214	0.0
07/23/2011	28.1	240	0.0
07/30/2011	23.7	92	1.1
08/02/2011	20.1	222	0.9
08/04/2011	18.4	284	1.4
08/08/2011	15.8	335	1.2
08/14/2011	12.4	311	1.0
09/06/2011	5.8	45	31.1
09/21/2011	4.7	49	44.9

Table 24. Estimated detection efficiency of juvenile steelhead at the ENL interrogation site, 2011.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency (%)
03/24/2011	7.1	8	12.5
04/09/2011	13.4	26	23.1
04/12/2011	12.1	8	12.5
04/25/2011	11.9	14	0.0
04/28/2011	12.4	24	0.0
04/30/2011	12.4	49	2.0
05/03/2011	14.4	87	2.3
05/06/2011	18.9	167	0.6
05/08/2011	20.6	162	1.2
05/11/2011	24.8	137	0.7
05/13/2011	35.2	133	0.8
07/14/2011	39.4	5	0.0
07/21/2011	32.3	6	0.0
11/01/2011	4.3	5	60.0
11/08/2011	4.2	7	53.8

Detection efficiency at the lower Entiat River interrogation site (ENL) in 2011 was similar to detection efficiencies for 2010. In both 2010 and 2011 antennas were anchored in the pass-over configuration. However, in the two years prior, 2008 and 2009, antennas were anchored in the hybrid configuration. A comparison of the detection efficiencies between the pass-over and hybrid configurations shows a considerable difference. This difference is illustrated for Chinook in Figures 13 and 14 and again for steelhead in Figures 15 and 16.

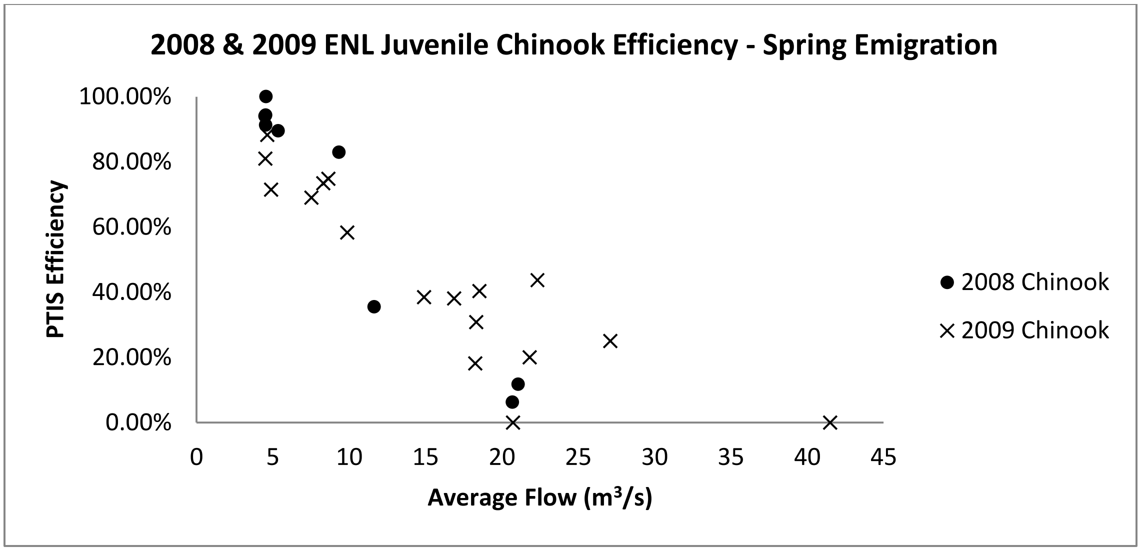

Figure 13. Graphical relationship between flow and juvenile spring Chinook detection efficiency for the Lower Entiat River interrogation site while in the hybrid antenna configuration, spring 2008 and 2009.

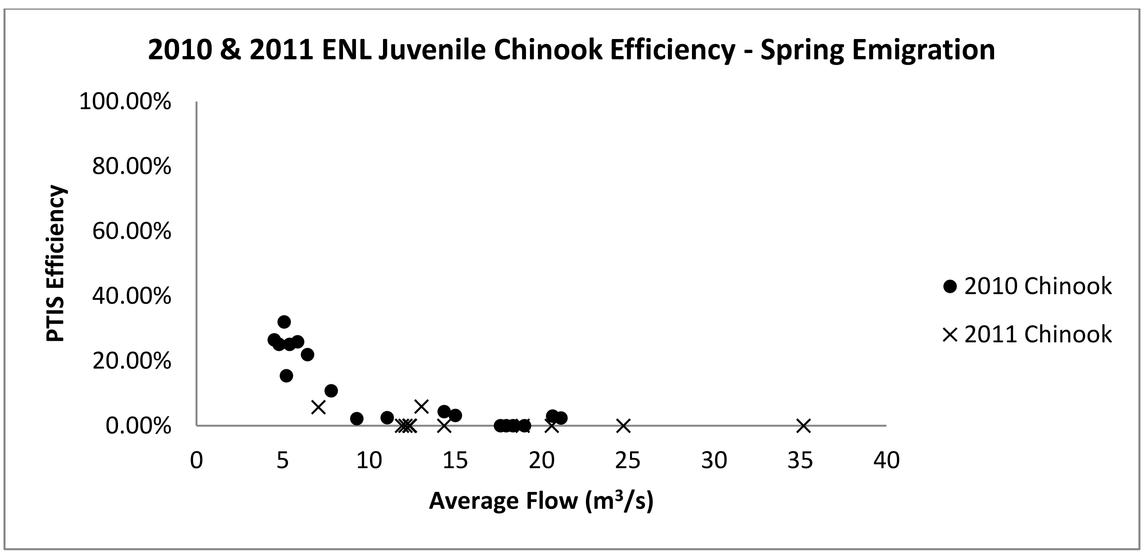

Figure 14. Graphical relationship between flow and juvenile spring Chinook detection efficiency for the Lower Entiat River interrogation site while in the flat-plate antenna configuration, spring 2010 and 2011.

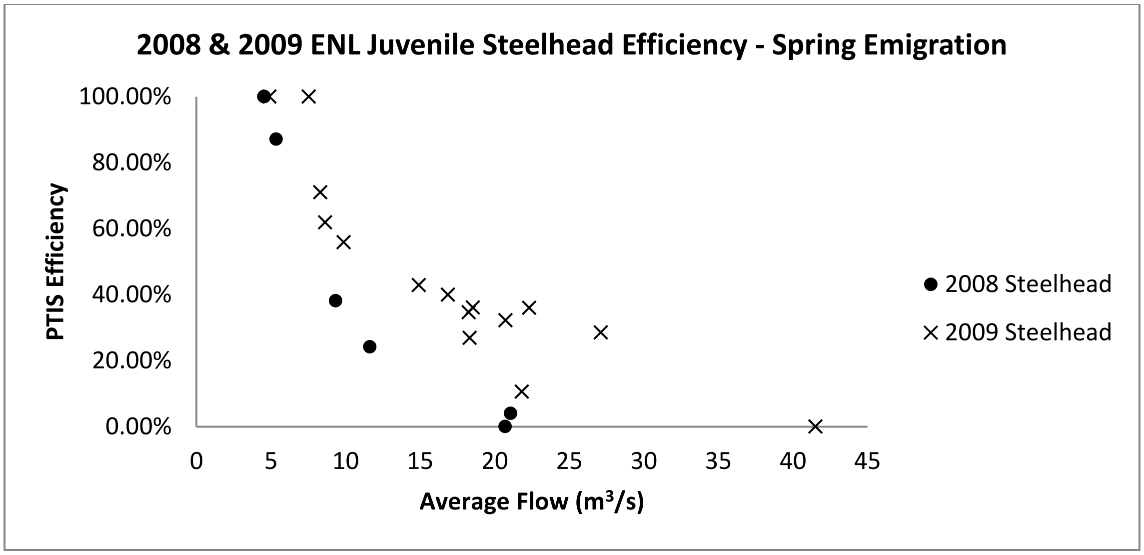

Figure 15. Graphical relationship between flow and juvenile steelhead detection efficiency for the Lower Entiat River interrogation site while in the hybrid antenna configuration, spring 2008 and 2009.

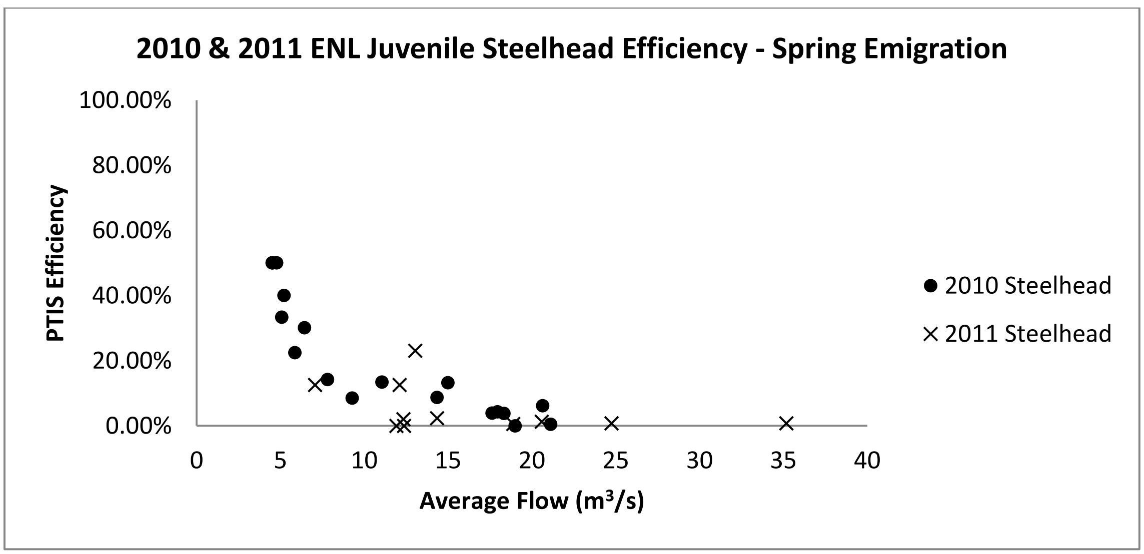

Figure 16. Graphical relationship between flow and juvenile steelhead detection efficiency for the Lower Entiat River interrogation site while in the flat-plate antenna configuration, spring 2010 and 2011.

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 2011, repairs to interrogation sites were further delayed due to the prolonged peak of river discharge.

All antennas were configured in the flat-plate or pass-over configuration in attempt to minimize breakage due to high flow and debris. The ENL interrogation site was the exception as it was placed in the hybrid configuration on September 13, 2011. This decision was based on the comparison of differences in ENL detection efficiencies between the two configurations between 2008 and 2011. This indicated that higher detection efficiency was achieved when the site was operated in the hybrid configuration; however, when in this position there was a greater likelihood of damage due to debris catching on the antennas during high flow periods. To maximize detection efficiency while attempting to minimize antenna damage, MCRFRO will begin placing antennas at the ENL site in the hybrid configuration at flows below 11.3 m^3/s. At flows above 11.3 m^3/s and during the winter months when ice formation on antennas would be problematic the site will be placed in the pass-over configuration.

The classification of adult steelhead into either 2011 or 2012 spawning populations was made by examining the date of first and last detections (assuming multiple detections) throughout the year. With few exceptions, detections of adult steelhead within the Entiat basin is bimodal with peaks occurring prior to the peak of spawning activity in the spring and again in the fall as adults move into the Entiat River to over winter. This pattern was again evident in 2011 with steelhead spawners attributing to the 2011 population detected in the spring and those that will attribute to 2012 in the fall.

Interrogation site detection efficiencies

Calculating detection efficiencies for the ENL interrogation site was possible due to the location of the antennas directly below the rotary screw trap where the release numbers of PIT tagged juvenile fish are known. Currently, ENL is the only interrogation site where this method may be used. MCRFRO is currently working with staff from NOAA, Quantitative Consulting Inc., and WDFW to install temperature loggers and pressure transducers at all interrogation sites. ISEMP is exploring a model incorporating this data to determine detection efficiencies within specific time intervals. If successful, this model will allow detection efficiencies to be calculated for all interrogation sites and strengthen both juvenile and adult production estimates within the Entiat watershed.

Project goals

Project goals were met during 2011. In the coming year we will upgrade the capacity of interrogation site monitoring. ISEMP currently plans on updating sites with satellite modems enabling consistent data transmission and less loss of data due to equipment malfunction. 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 conditions.

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 2011, two sample sites were selected based upon these criteria (Figure 17).

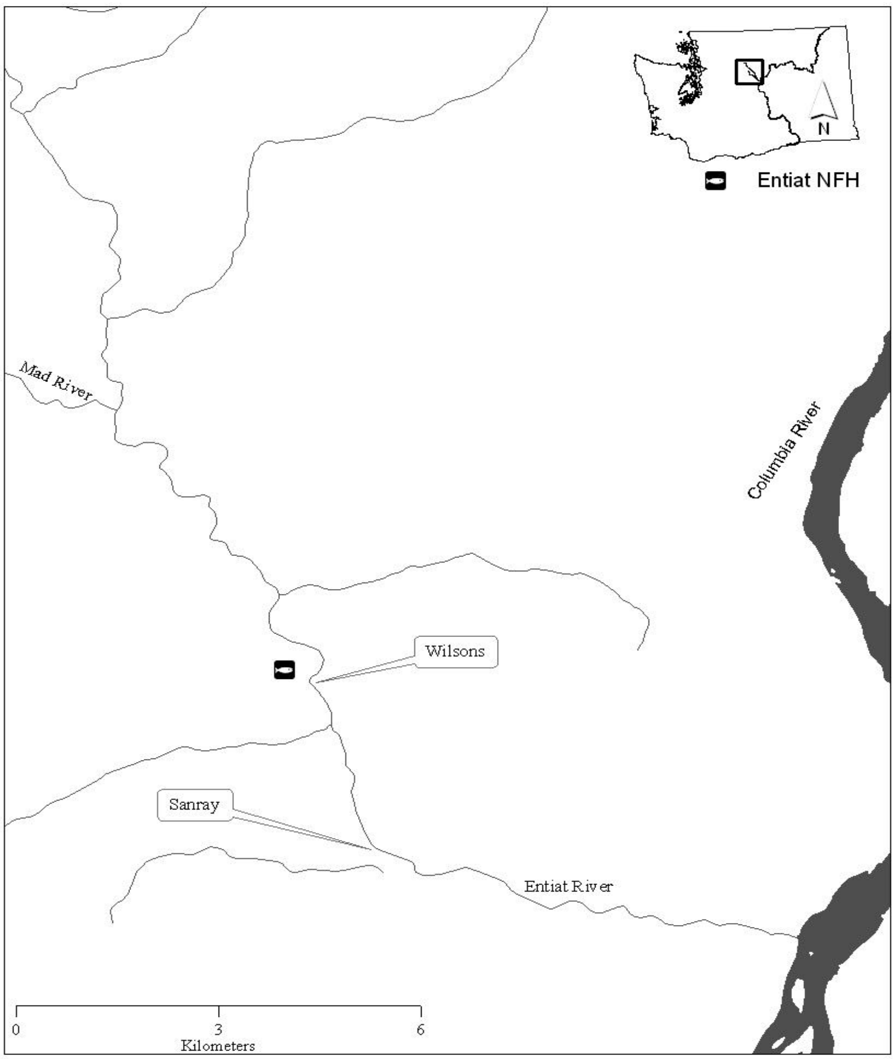

Figure 17. Map of the Entiat River watershed defining locations of the off-channel study sites sampled, 2011.

Sampling period

Fish sampling was conducted in 2011 during early October when peak daily water temperatures within study sites averaged below 18.0˚C.

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. Block nets were used at the top and bottom of each site and maintained for the duration of the mark-recapture period. Fish sampling was conducted at each site over two consecutive days. One capture crew consisting of six personnel sampled each site. Four personnel were assigned fish capture responsibilities and two to fish handling 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
All individual fish data entry utilized the P3 program from PTAGIS. Data files generated from the P3 program were then parsed into a MCRFRO database and the original P3 files were uploaded to the PTAGIS database where it is available to researchers throughout the Columbia River Basin.

PIT tag antenna monitoring
PIT tag antennas were used to monitor the passage of tagged fish into and out of the study sites. At locations where the off-channel habitat reconnected with the river a single channel spanning antenna was used at the upstream and downstream most sections of the off-channel habitat. 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. Antennas were 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 antenna 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 brief 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 each antenna location throughout the study period. Temperature was recorded hourly using Onset temperature loggers (HOBO Water Temp

Pro V2 U22-001). Temperature loggers were downloaded to a laptop computer at two week intervals using the software provided by the manufacturer.

Results- Off-Channel Habitat Study

Sample site selection

Two sample sites were chosen for sampling during the fall of 2011. The Sanray site, 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. A second sample site was chosen at rkm 11.0 near the ENFH. The Wilson's site consists of a 286 m long reconnecting perennial side-channel. Habitat within the side-channel is composed primarily of a series of connected pools. Channel complexity is provided by a number of wood and boulder structures throughout the site.

Sampling period

Fish sampling began on October 6, and was completed on October 12, 2011 when average maximum daily water temperatures were below 18.0˚C. Daily average flow (m^3/s) during the study period is summarized in Figure 18.

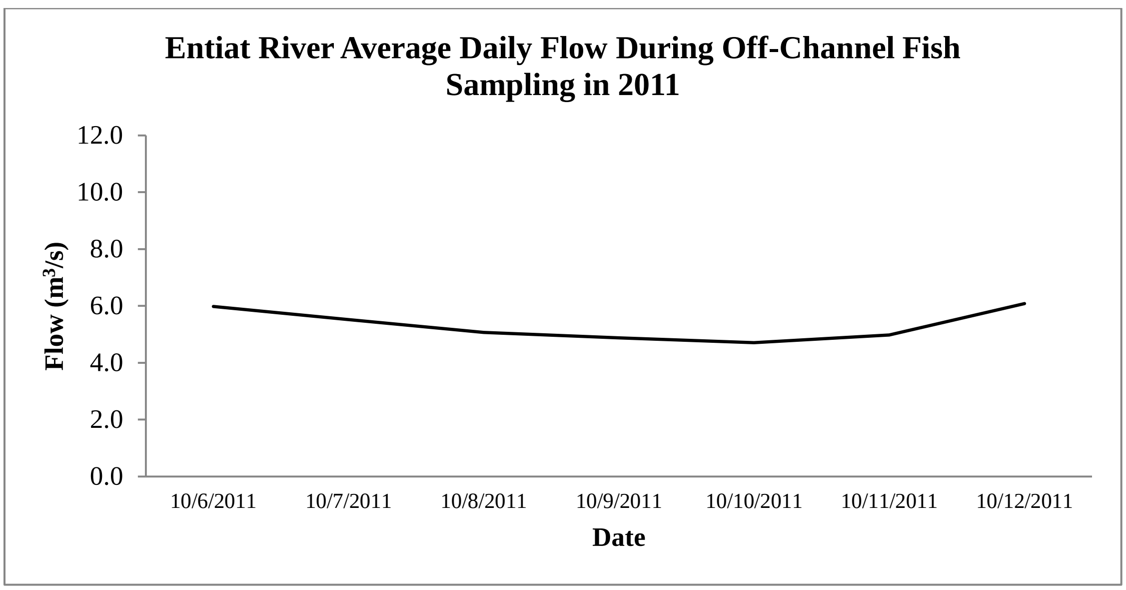

Figure 18. Entiat River average daily flow (m^3/s) during off-channel mark-recapture sampling, 2011.

Fish capture summary

A total of 2,202 fish were captured at two off-channel sites in 2011 (Table 25). Total capture species composition included; 1,813 Chinook salmon (82.3%), 307 steelhead (13.9%), 50 coho salmon (2.3%), 26 sockeye salmon (1.2%), and 6 pacific lamprey (0.3%). A total of 2,045 wild salmonids (92.9%) were implanted with PIT tags.

Table 25. Number of fish captured and PIT tagged within the Entiat River during the fall off-channel mark-recapture sample period, 2011.

Species and Life Stage	Total number of Fish Caught	Total PIT Tagged
Chinook salmon	1,813	1,688
Wild steelhead	307	289
Coho salmon	50	49
Sockeye salmon	26	19
Pacific lamprey	6	0
Total	**2,202**	**2,045**

Total capture numbers and species composition differed between sites. At the Sanray site a total of 270 fish were captured consisting of; 93 Chinook salmon (34.4%), 162 steelhead (60.0%), and 15 coho salmon (5.6%). At the Wilson site a total of 1,932 fish were captured consisting of; 1,720 Chinook salmon (89.0%), 145 steelhead (7.5%), 35 coho salmon (1.8%), 26 sockeye salmon (1.3%), and 6 pacific lamprey (0.3%).

At the Sanray site mean fork length (SD) of Chinook salmon and steelhead was 79.58 (7.97) mm and 80.75 (23.30) mm, respectively (Table 26). At the Wilson site mean fork length for Chinook salmon was 70.07 (10.23) mm and steelhead measured 86.56 (36.72) mm (Table 27).

Table 26. Mean fork lengths (mm), weights (g), and body condition factor (K) for Chinook salmon (unknown run) and steelhead captured at the Sanray off-channel study site, 2011.

	Chinook (unknown run)			Steelhead		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Fork Length	79.58	7.97	91	80.75	23.30	156
Weight	5.72	1.94	91	7.20	7.86	156
K factor	1.10	0.13	91	1.10	0.16	156

Table 27. Mean fork lengths (mm), weights (g), and body condition factor (K) for Chinook salmon (unknown run) and steelhead captured at the Wilson off-channel study site, 2011.

	Chinook (unknown run)			Steelhead		
	Mean	**SD**	**N**	**Mean**	**SD**	**N**
Fork Length	70.07	10.23	1,700	86.56	36.72	142
Weight	3.76	1.89	1,700	10.55	14.30	142
K factor	1.02	0.14	1,700	1.04	0.12	142

Mortality rates were tracked for Chinook salmon and steelhead throughout the study and categorized as either instantaneous or delayed. Instantaneous mortality was the result of capture, handling or PIT tagging while delayed mortality was assumed to be due to PIT tagging alone. In the fall of 2011 sampling event, instantaneous mortality was attributed to a total of 49 Chinook salmon (2.7%) and 3 steelhead (1.0%). Capture related mortality accounted for 48 Chinook salmon and 3 steelhead (98% and 100% of total instantaneous capture mortality respectively) while tagging related mortality accounted for 1 Chinook salmon (2.0% of total instantaneous capture mortality). Delayed mortality and tag shed rates were assessed at the Sanray site by holding newly PIT tagged and recaptured fish overnight following day two recapture sampling. A total of 56 wild Chinook salmon and 104 steelhead were retained for assessing post tagging mortality and shed-tag rates. There were no fish associated with post tagging mortality or shed tags recovered within this group.

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 28). Estimates were generated and validated following the methods outlined for the Entiat River mark-recapture study.

Table 28. Point estimates of abundance for Chinook salmon and steelhead captured at Entiat River off-channel sample locations, 2011.

Site	Species	New Cptrs	Total Marked	Total Recap	Recap prob.	Pop. Est.	Lower 95% C.I.	Upper 95% C.I.	Stdrd Error
Sanray	Wild Chinook	60	57	26	0.42	130	104	157	13.52
	Wild steelhead	107	84	34	0.40	261	207	315	27.56
Wilson	Wild Chinook	953	1,043	347	0.33	2,861	2,666	3,056	99.70
	Wild steelhead	69	86	13	0.15	434	254	614	92.02

Data dissemination

All fish capture data was uploaded to the PTAGIS database upon completion of sampling and subsequently the MCRFRO database. Interrogation data was uploaded to the MCRFRO database weekly.

PIT tag antenna monitoring

Operation of PIT tag antennas at the upper and lower end of each site yielded a total of 410 unique detections in 2011 (Table 29). Total species composition included 273 wild Chinook (unknown run) (66.6%), one wild spring Chinook (0.2%), 122 wild summer steelhead (29.8%), 12 wild coho (2.9%), and two wild sockeye (0.5%).

Table 29. Totals of unique detections by species and antenna location at Entiat River off-channel study sites, 2011.

	Sanray Antennas			Wilson Antennas		
Species	**Lower**	**Upper**	**Total**	**Lower**	**Upper**	**Total**
Wild Chinook (unknown run)	62	14	76	55	142	197
Wild spring Chinook	1	0	1	0	0	0
Wild summer steelhead	47	49	96	2	24	26
Wild coho	5	4	9	0	3	3
Wild Sockeye	0	0	0	0	2	2

Temperature monitoring

Daily water temperatures throughout the fall study period (October through December) averaged 2.9 ˚C at the Sanray lower antenna site (Figure 19), 3.0 ˚C at the Sanray upper antenna site (Figure 20), and 2.8 ˚C at the Wilson lower antenna site (Figure 21). Water temperatures for the Wilson upper antenna site are not available due to the temperature logger breaking as a result of ice accumulation.

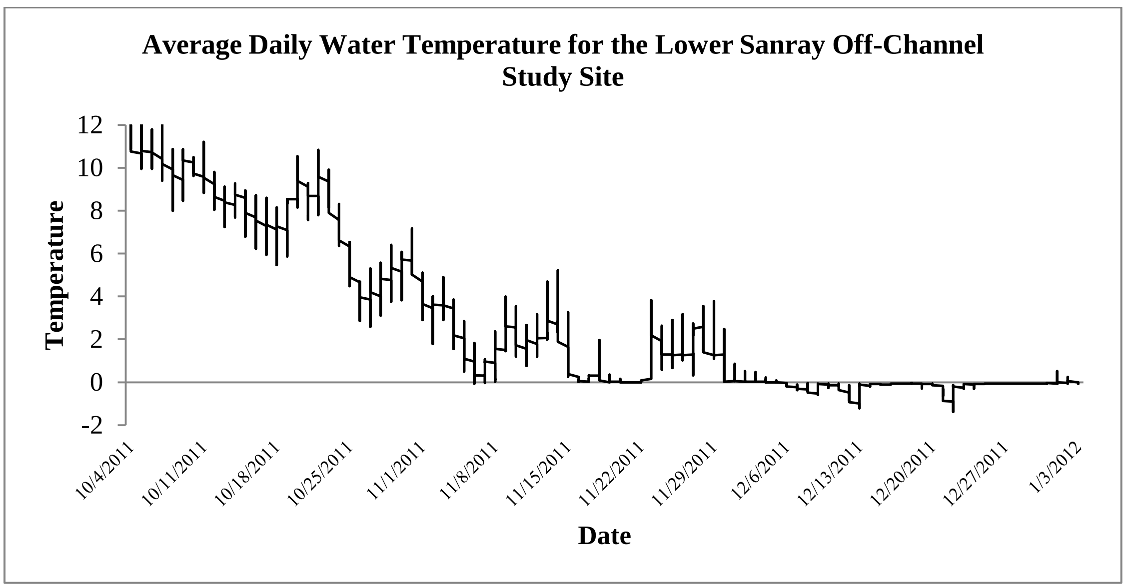

Figure 19. Daily average, minimum, and maximum water temperature (˚C) at the lower Sanray off-channel study site, 2011. Periods of sustained zero temperature indicate ice formation on temperature probe.

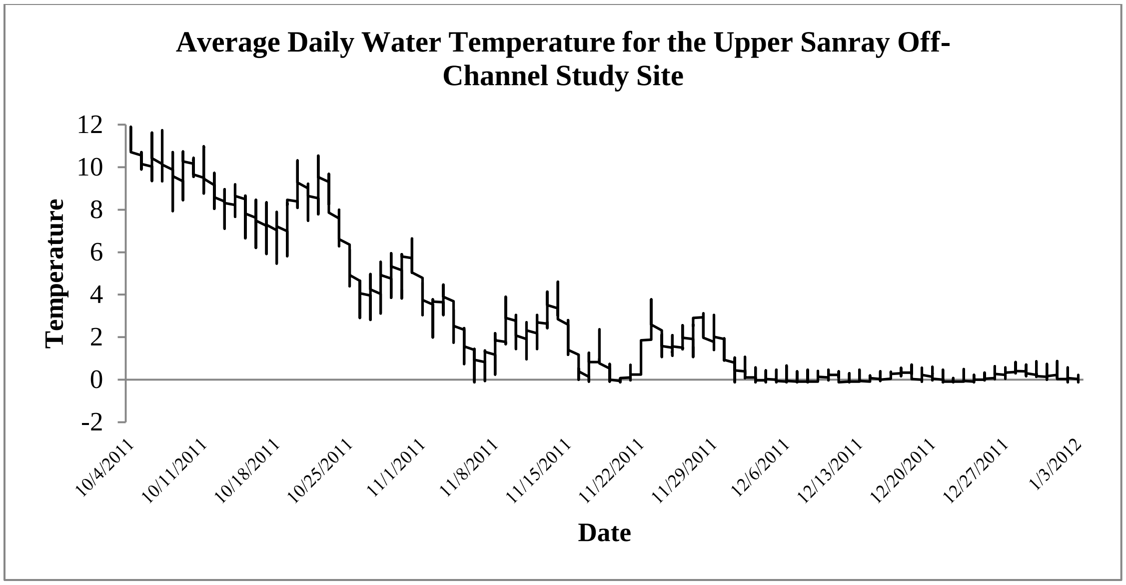

Figure 20. Daily average, minimum, and maximum water temperature (˚C) at the upper Sanray off-channel study site, 2011.

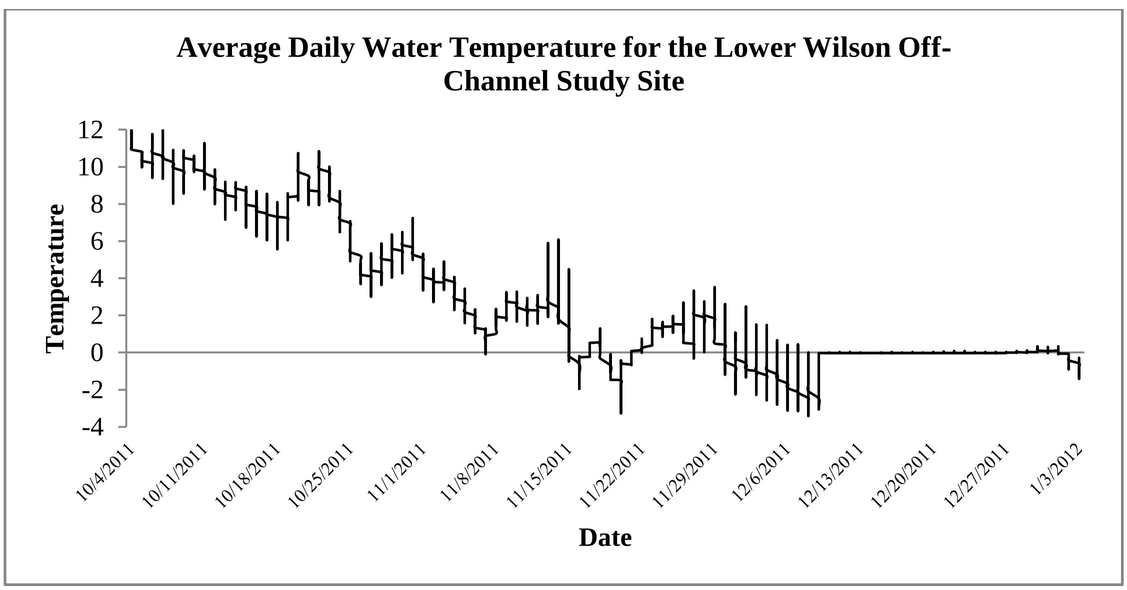

Figure 21. Daily average, minimum, and maximum water temperature (˚C) at the lower Wilson study site, 2011. Periods of sustained zero temperature indicate ice formation on temperature probe.

Discussion- Off-Channel Habitat Study

Fish sampling

In 2011, the first year of the Entiat River off-channel study, fish capture efforts were expanded to include habitats where information on the distribution and abundance of juvenile salmonids was relatively unknown. Mark-recapture sampling during the fall sample period provided data for abundance calculations and species compositions within each site. The off-channel fish capture methods used electrofishing as a primary capture method. In other studies within the Entiat River, electrofishing has resulted in higher numbers of capture related mortalities when compared to other methods. Low water depth and high turbidity prohibited the use of hand-netting and snorkel-seining during the fall period. These methods are preferable due to the lower occurrence of capture related mortality and will be utilized in the future as site conditions allow.

Higher than anticipated capture numbers at the Wilson site required a larger time input than expected. Tagging crews worked into the night to ensure that all fish were marked and released appropriately prior to recapture sampling. Although this had no negative impact on the quality of data collected, staff will be better prepared for potentially longer hours during future sampling efforts.

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 fall sampling period 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

Calculations of site level abundance followed those outlined for the Entiat River mark-recapture study. Subsequent bias measurements indicated that bias present in the abundance estimates were negligible. The physical conditions present in the study areas allowed for the use of block netting during the mark-recapture period. This allowed greater assurance that the closed population assumption was met. Although capture mortality resulted in high rates of instantaneous mortality, post tagging assessments of mortality and shed rates indicated that these effects were negligible between marking and recapture events.

The difference in abundance estimates between the Sanray and Wilson sites has raised concern. Habitat complexity may explain the differences in species composition; however, high abundance of juvenile salmonids within Wilson’s side-channel is troubling. MCRFRO is closely monitoring over winter conditions within the Wilson side-channel and is hopeful that survival and growth estimates will be possible in 2012. Modifications were made to the 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. 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

Antenna monitoring techniques utilizing Allflex equipment is a fairly recent tool used in fisheries research. This technology has provided a low cost alternative to antenna monitoring at smaller sites. As this is the first project utilizing this technology by MCRFRO there have been a few challenges and technical difficulties resulting in some data loss in the monitoring period. Currently we are unable to address the impact of this data loss on determining site level movement patterns and estimates of seasonal survival. Having gained experience from these difficulties it is doubtful that significant data loss will occur due to these same reasons in the future.

Habitat monitoring

In 2011, 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. MCRFRO staff will continue to monitor water temperature within the study sites and will begin to monitor dissolved oxygen levels in 2012. Dissolved oxygen measurements are of interests from our over winter observations of low flow and ice formation within the Wilson off-channel study site.

Project goals

MCRFRO plans to add an additional four sites for a total of six study sites by the end of 2012. Study sites will include existing naturally occurring off-channel habitats as well as past and present restoration projects. 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 and prolonged maintenance considerations for future off-channel habitat projects.

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 at rkm 45 to the Entiat information kiosk at rkm (Figure 22). The survey area was divided into four reaches based on river access points and distances that could be surveyed in a work day (Table 30). A two person crew, floating on catarafts, recorded all redds observed. Surveyors walked and waded areas that were inaccessible or unsafe to raft. All four reaches were surveyed on a weekly basis as weather and stream conditions permitted.

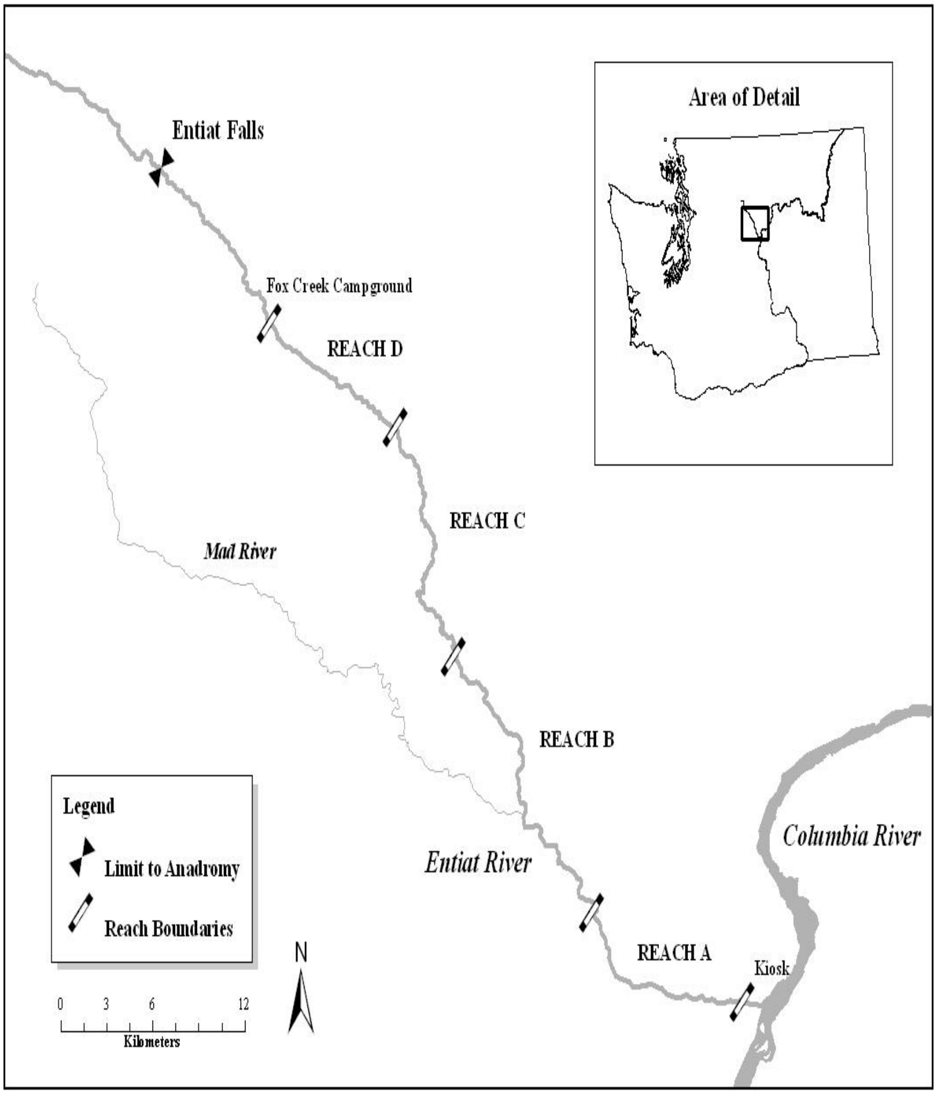

Figure 22. Map of the Entiat River watershed defining reach locations of steelhead redd surveys, 2011.

Table 30. Descriptions of steelhead spawning ground reach locations on the Entiat River, 2011.

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

In 2011 a more accurate method of calculating lateral water visibility in relation to surveyor line of sight was developed. This new technique used a weighted Secchi disk attached to a 1.5 meter cord and a fifty meter measuring tape. One surveyor suspended the Secchi disk within the river at 0.5 meter depth with the face oriented upstream. The second surveyor then waded upstream until the disk's color patterns were no longer discernible. A distance measurement was then taken and recorded. For comparison to the methods used previously, water clarity was categorized by visual estimation and recorded as 1, 2, or 3 by the observers; a category 3 precluded the survey for the day. Water samples were taken to measure stream turbidity associated with that particular day. In the office samples were transferred into clear glass vials, placed in a Hach 2100P Portable Turbidity meter, and Nephelometric Turbidity Units (NTU) were recorded. These water visibility measurements were recorded at the start and end of each survey reach.

Results- Steelhead Redd Surveys

Steelhead redd surveys began on February 4, 2011 and continued through May 12, 2011, when high stream flows prevented additional surveys. During the survey season water temperatures ranged from 0.5 at the beginning to 10.5° C at the end. Turbidity averaged 1.46 NTU, lateral Secchi disk visibility readings averaged 26.7 meters, water clarity averaged 1 (Table 31). Average turbidity was greater 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 31. Ranges and means of temperature (°C), Secchi disk lateral visibility (m), turbidity (NTU), and water clarity of the Entiat River during steelhead redd surveys, 2011.

	Ranges (mean)			
Reach	**Temp °C**	**Secchi Disk (m)**	**Turbidity (NTU)**	**Water Clarity**
A	1.0 - 8.5 (5.3)	13.0 - 48.3 (27.9)	0.7 - 3.0 (1.69)	1 – 2 (1)
B	0.5 - 10.5 (5.3)	18.0 - 34.6 (23.0)	0.4 - 3.4 (1.34)	1 – 2 (1)
C	2.5 - 9.0 (5.2)	11.9 - 41.8 (26.0)	0.3 - 6.0 (1.46)	1 - 2 (1)
D	3.5 - 8.5 (5.9)	12.0 - 36.1 (29.8)	0.3 - 4.7 (1.32)	1 - 2 (1)
All Reaches	0.5 - 10.5 (5.4)	12.0 - 48.3 (26.7)	0.3 - 6.0 (1.46)	1 – 2 (1)

A total of 205 redds were counted during 2011 (Table 32). No redds were observed during the first survey of each reach with the exception of Reach C. The first redd was observed on March 3 in Reach A when mean temperature was 3.0 °C. New redds were found in at least one reach during every survey week from March 16 to May 11. A total of 177 steelhead redds (86.3%) were constructed in April, with a peak of 81 redds observed the week of April 20. The mean temperature during this peak spawning week was 5.8 °C. Similar to previous years, the majority of new redds (98% in 2011) were observed during April and May (Fig 23).

Table 32. The numbers of new steelhead redds counted each week and cumulative totals in the survey reaches on the Entiat River, 2011.

Midweek Date	Reach A		Reach B		Reach C		Reach D		All Reaches	
	New	Total	New	Total	New	Total	New	Total	New	Total
02/02/2011	0	0							0	0
02/09/2011	0	0							0	0
02/16/2011	0	0							0	0
02/23/2011	0	0	0	0					0	0
03/02/2011	1	1	0	0					1	1
03/09/2011	0	1	0	0					0	1
03/16/2011	0	1	0	0	1	1			1	2
03/23/2011	1	2	0	0	0	1			1	3
03/30/2011	2	4	0	0	0	1			2	5
04/06/2011	0	4	10	10	1	2			11	16
04/13/2011	11	15	19	29	1	3	0	0	31	47
04/20/2011	13	28	29	58	30	33	9	9	81	128
04/27/2011	16	44	12	70	13	46	13	22	54	182
05/04/2011	8	52	2	72	5	51	4	26	19	201
05/11/2011	3	55	1	73	0	51	0	26	4	205

Note: Blank cells indicate a survey was not conducted in that reach during the survey week.

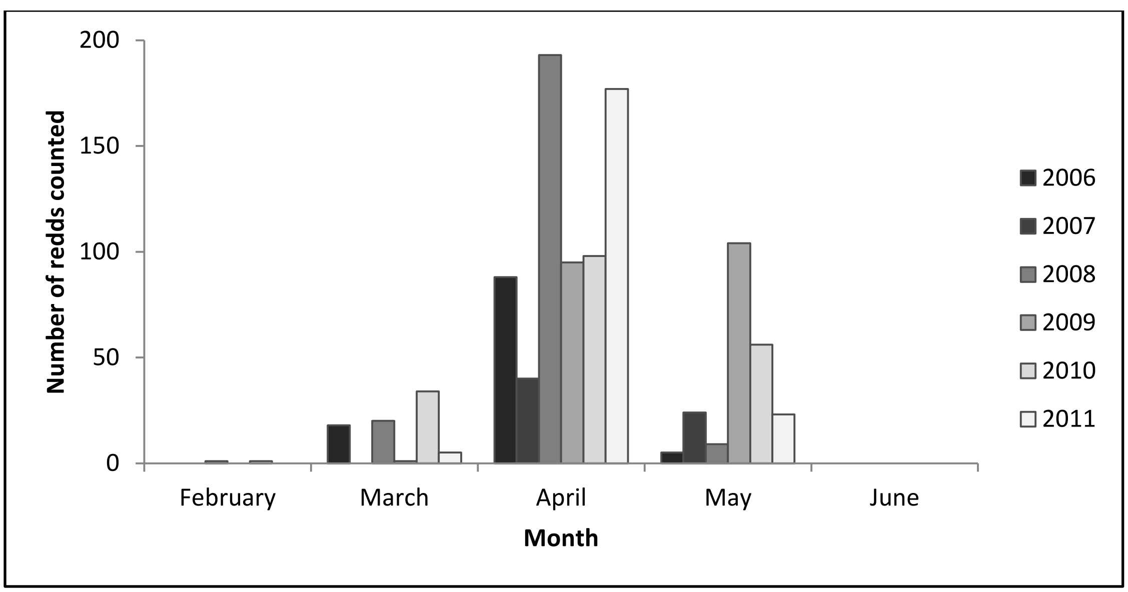

Figure 23. Numbers of steelhead redds observed by month in the Entiat River, 2006 to 2011.

The number of steelhead redds counted in each reach between 2006 and 2011 are presented in Table 33. In 2011, 27% of the steelhead redds were found in Reach A, 36% in Reach B, 25% in Reach C and 13% in Reach D. More redds were found in the upper reaches in 2011 than in previous years. This year Reach D had the highest number of redds recorded to date in that section while Reach A had its lowest counts since survey methods were standardized in 2008. The location of individual redds within the survey reaches are shown in Figures 24 – 27.

Table 33. The total number of steelhead redds by reach on the Entiat River, 2006 to 2011.

Year	Reach A	Reach B	Reach C	Reach 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

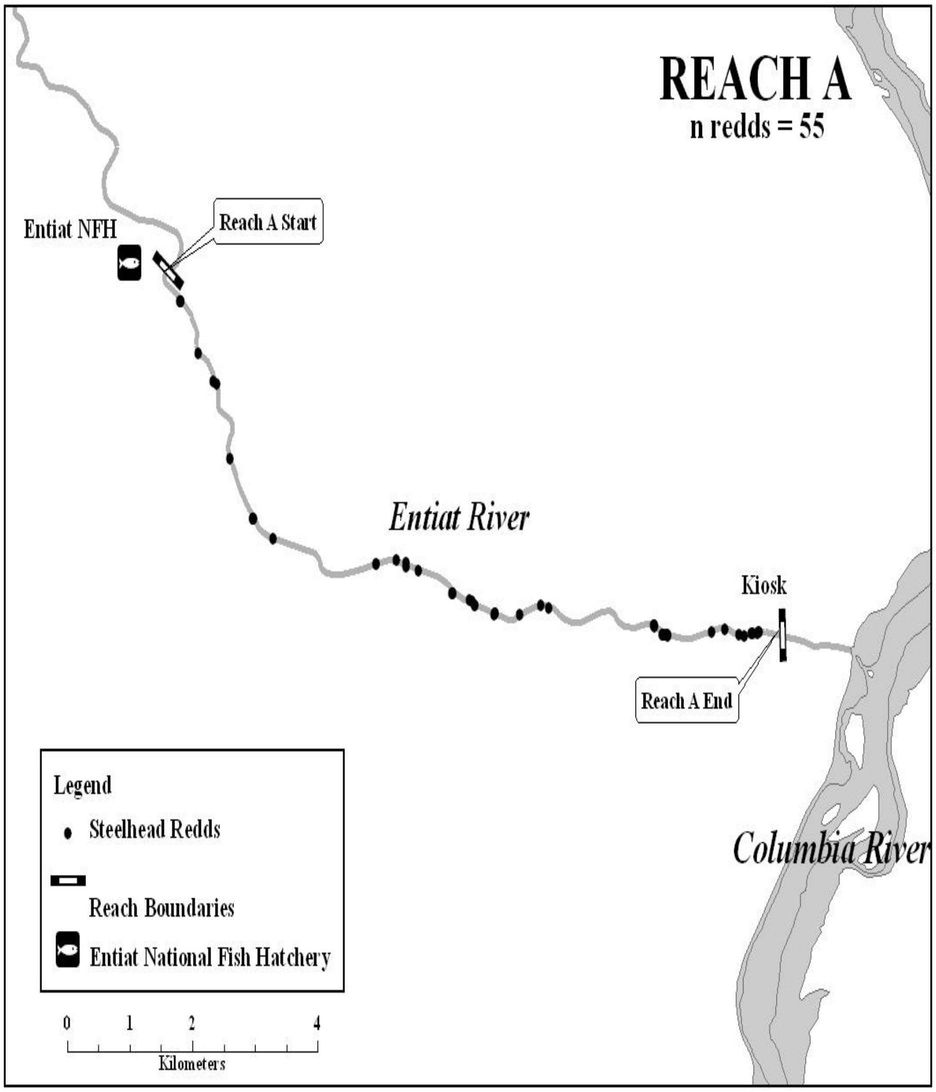

Figure 24. Locations of steelhead redds observed in Reach A during surveys conducted by USFWS on the Entiat River, 2011.

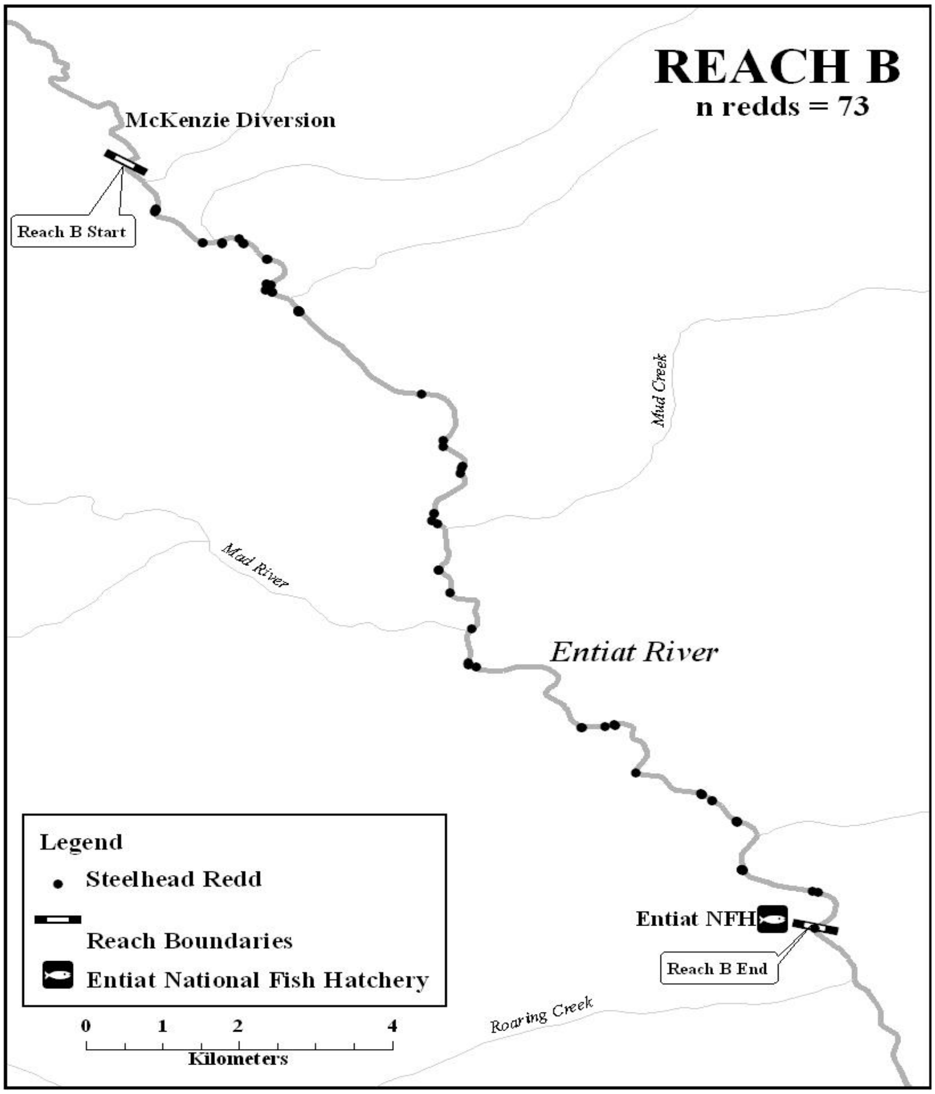

Figure 25. Locations of steelhead redds observed in Reach B during surveys conducted by the USFWS on the Entiat River, 2011.

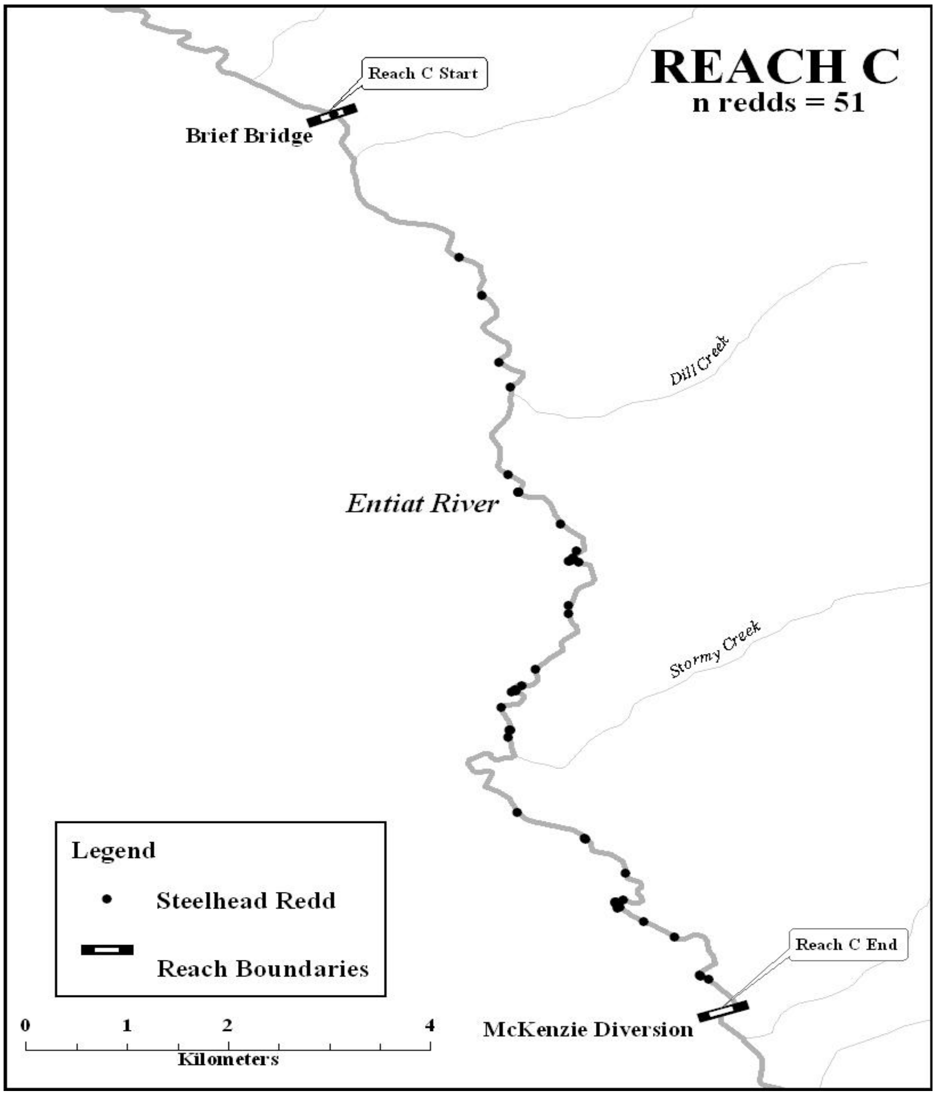

Figure 26. Locations of steelhead redds observed in Reach C during surveys conducted by the USFWS on the Entiat River, 2011.

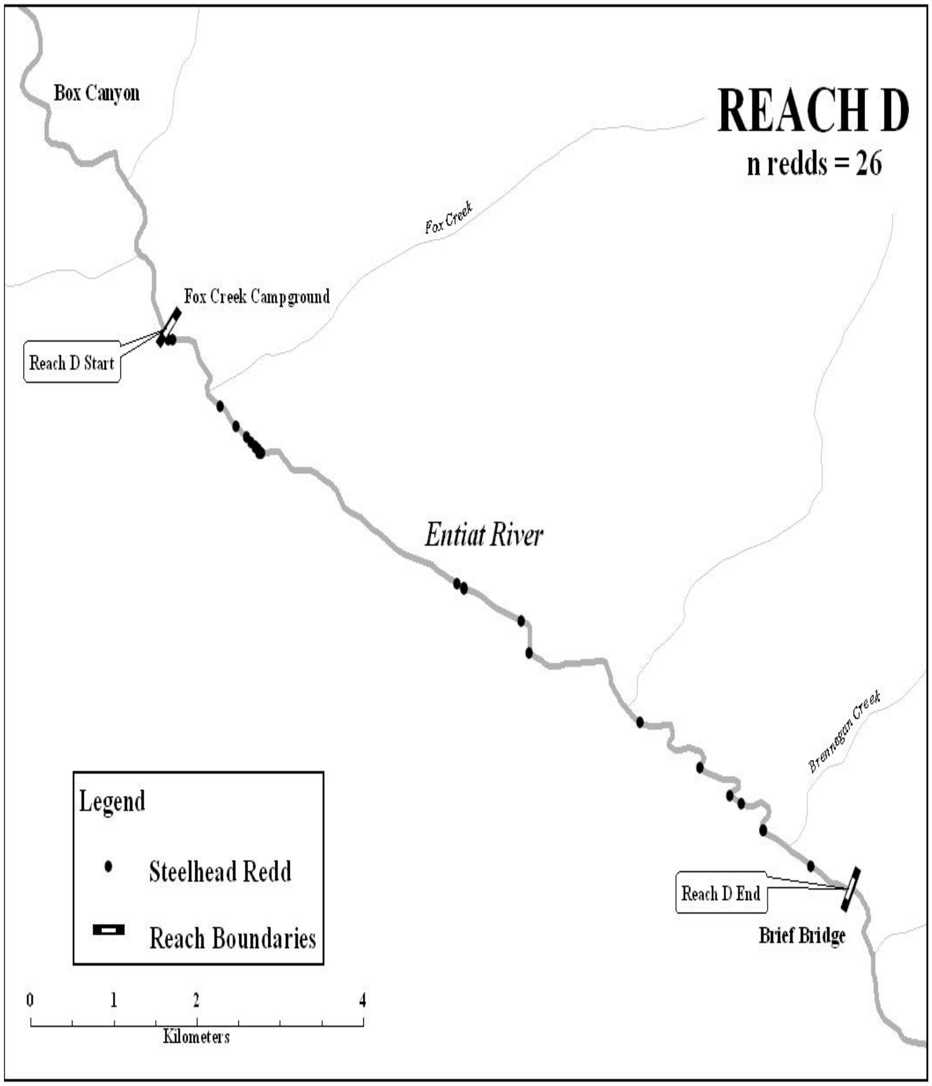

Figure 27. Locations of steelhead redds observed in Reach D during surveys conducted by the USFWS on the Entiat River, 2011.

Within reach A, 20 redds (36.4% of reach total) were associated with restoration sites. The 2011 total is lower than counts in 2010 (39.1% of reach total) although higher than 2009 (28.9% of total). Older restoration sites had fewer associated redds than those that were recently constructed (Table 34). The Hanan-Detwiler irrigation diversion located at rkm five was not opened this year. In previous years this diversion was used for redd construction, on a very limited basis. Redds were still constructed at the upstream side of the head gate of this diversion. The overall numbers seen in this diversion in previous years suggests that the gate being closed only minimally effects total redd counts throughout Reach A.

Table 34. Number of redds observed in close proximity to restoration sites in reach A of the Entiat River, 2006 to 2011.

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

Discussion- Steelhead Redd Surveys

Steelhead spawning ground surveys on the Entiat River were conducted on time and within the required time frame for 2011. Surveys were initiated one week early, at the beginning of February, to avoid missing spawning activity. We were able to document the onset of spawning in all reaches except for C, where surveys started two weeks later than planned due to project schedule conflicts. Surveys ended three weeks earlier than in 2010 due to high stream discharge that created hazardous rafting conditions and reduce water clarity. Because in previous years only a few redds were found past mid-May, ending surveys earlier probably had minimal impact on the total redd count.
The primary purpose of the surveys is to monitor the steelhead spawning population in the Entiat River. However, 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. In 2009, for example, construction of the Keystone Canyon restoration site exposed and loosened previously embedded gravel substrate. This apparently created spawning habitat and increased the number of redds at this site. Large woody debris and boulders were also added here and continued monitoring will help determine if this type of structure has a long term effect on steelhead spawning. It appears that an increase in spawning depends upon the type of structure and where it is located. For example the John Small barbs restoration site is located in a pool area that has almost no spawning sized gravels and no redds have been counted here. Thus, it appears that an increase in spawning activity in areas that previously had little is a direct influence of the exposed substrate caused by construction but whether the new habitat created by the restoration site has an effect remains to be seen. Continued monitoring is needed before any conclusions should be drawn.

A new stream bank revetment restoration site was constructed in the Stillwater section in Reach C of the Entiat River in the summer of 2010. Although this site did create possible rearing habitat for steelhead it is not expected to improve spawning habitat in the area. A majority of the habitat associated with this site is too deep for spawning activity but could possibly move clean gravel downstream into areas more suitable for redd construction. Annual monitoring of this area will show if this type of habitat restoration could create new spawning habitat.

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References

Anderson, R.O, S.J. Gutreuter. 1983. Length, Weight, and Associated Structural Indices. In: *Fisheries Techniques.* (eds. L. A. Nielsen and D. L. Johnson), pp. 283-300. Bethesda MD: American Fisheries Society.

Bilby, R.E., W.J. Ehinger, C. Jordan, K. Krueger, M. McHenry, T. Quinn, G. Pess, D. Poon, D. Seiler, G. Volkhardt. 2004. Evaluating watershed response to land management and restoration actions: Intensively monitored watersheds (IMW) progress report. Submitted to Washington Salmon Recovery Funding Board.

Bilby, R.E., W. Ehinger, T. Quinn, G. Volkhardt, K. Krueger, D. Seiler, G. Pess, C. Jordan, M. McHenry, D. Poon. 2005. Study evaluates fish response to management actions. Western Forester 50(2):14-15.

Bateman, D.S., R.E. Gresswell. 2006. Survival and Growth of Age-0 Steelhead after Surgical Implantation of 23-mm Passive Integrated Transponders. North American Journal of Fisheries Management 26:545-550.

Bailey, N. J. 1951. On estimating the population size of mobile populations from recapture data. Biometrica, 38:293-306.

Carpenter, S.R., S.W. Chisholm, C.J. Krebs, D.W. Schindler, R.F. Wright. 1995. Ecosystem experiments. Science 269(5222):324-327.

Chapman, D. G. 1948. A mathematical study of confidence limits of salmon populations calculated from sample tag ratios. Internat. Pacific Salmon Fisheries Comm. Bull., 2:69-85.

Chelan County Conservation District. 2004. Entiat Water Resource Inventory (WRIA) 46 Management Plan. October 2004. Prepared for the Entiat Watershed Planning Unit by the Chelan County Conservation District. Wenatchee, Washington.

Hamstreet, C.O. 2012. Spring and Summer Chinook Salmon Spawning Ground Surveys on the Entiat River, 2010. United States Fish and Wildlife Service, Leavenworth Washington.

Hamstreet, C.O. 2012. United States Fish and Wildlife Service, personal communication.

Hillman, T.W. 2006. Monitoring strategy for the Upper Columbia Basin. Bioanalysts, Inc. Second draft report to the Upper Columbia Regional Technical Team, Upper Columbia Salmon Recovery Board, Wenatchee, Washington. Available: http://www.ucsrb.com/resources.asp. (December 2010).

Knudsen, C.M., M.V. Johnston, S.L. Schroder, W.J. Bosch, D.E. Fast, C.R. Strom. 2009. Effects of Passive Integrated Transponder Tags on Smolt-to-Adult Recruit Survival, Growth, and Behavior of Hatchery Spring Chinook Salmon. North American Journal of Fisheries Management 29:658-669.

Miller, T. L. 2012. Washington Department of Fish and Wildlife, personal communication.

Mullan J. W., K. R. Williams, G. Rhodus, T. W. Hillman, J. McIntyre. 1992.   Production and habitat of salmonids in the mid-Columbia River tributary streams. U.S. Fish and Wildlife Service Monograph I.

National Oceanic and Atmospheric Administration, National Marine Fisheries Service. 2000. Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act. Available: http://www.nwr.noaa.gov/ESA-Salmon-Regulations-Permits/4d-Rules/upload/electro2000.pdf. (December, 2010).

Nelle, R.D. and J. Moberg 2008. A Field Manual of Scientific Protocols for Steelhead Redd Surveys within the Upper Columbia Monitoring Strategy. Terraqua, Inc.

PNAMP. 2005. Establishing a network of intensively monitored watersheds in the Pacific Northwest. http://www.pnamp.org/node/1061.

Reeve, T., J. Lichatowich, W. Towey, A. Duncan. 2006. Building sciences and accountability into community-based restoration: can a new funding approach facilitate effective and accountable restoration? Fisheries 31(1):17-24.

Robson, D.S. and H.A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Transactions of the American Fisheries Society 93:215-226.

Roni, P., M.C. Liermann, C. Jordan, E.A. Steel. 2005 in P. Roni, editor. Monitoring stream and watershed restoration. American Fisheries Society, Bethesda, Maryland.

USCRB. 2007. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. Upper Columbia Salmon Recovery Board.
http://www.ucsrb.com/UCSRP%20Final%209-13-2007.pdf

Van Den Avyle M.J. and R.S. Hayward. 1999. Dynamics of Exploited Fish Populations. In: *Inland Fisheries Management in North America Second Edition.* (eds. C.C. Kohler and W.A. Hulbert), pp. 127-165. Bethesda MD: American Fisheries Society.

Appendix

Appendix Table 1. Summary of nonoperational days for the Entiat River rotary screw trap, 2011.

Date	Status	Flow (m^3/s)	Comments
3/1/2011	Not operated	6.10	Trap pulled due to IMW staffing needs
3 /6 /2011	Not operated	5.72	Trap pulled due to IMW staffing needs
3 /7 /2011	Not operated	5.68	Trap pulled due to IMW staffing needs
3 /10/2011	Not operated	5.72	Trap pulled due to IMW staffing needs
3 /11/2011	Not operated	5.98	Trap pulled due to IMW staffing needs
3 /12/2011	Not operated	5.69	Trap pulled due to IMW staffing needs
3 /27/2011	Incomplete	8.00	Maintenance
3 /29/2011	Incomplete	7.93	Maintenance
3 /31/2011	Incomplete	12.73	Maintenance
4 /1 /2011	Not operated	29.96	Trap pulled due to high flows
4 /2 /2011	Not operated	23.37	Trap pulled due to damaged debris wheel
4 /3 /2011	Not operated	19.20	Trap pulled due to damaged debris wheel
4 /4 /2011	Not operated	17.08	Trap pulled due to damaged debris wheel
4 /5 /2011	Incomplete	15.72	Trap pulled due to damaged debris wheel
4 /6 /2011	Not operated	14.64	Replaced trap
4 /9 /2011	Not operated	12.40	Trap pulled - short handed
4 /16/2011	Not operated	11.50	Trap pulled for hatchery release
4 /17/2011	Not operated	11.47	Trap pulled for hatchery release
5 /29/2011	Not operated	53.58	Trap pulled due to high flows
5 /12/2011	Incomplete	30.82	Log in cone
5 /15/2011	Not operated	48.22	Trap pulled due to high flows
5 /16/2011	Not operated	71.41	Trap pulled due to high flows
5 /17/2011	Not operated	63.72	Trap pulled due to high flows
5 /18/2011	Not operated	56.33	Trap pulled due to high flows
5 /19/2011	Not operated	50.66	Trap pulled due to high flows
5 /20/2011	Not operated	49.71	Trap pulled due to high flows
5 /21/2011	Not operated	52.49	Trap pulled due to high flows
5 /22/2011	Not operated	57.79	Trap pulled due to high flows
5 /23/2011	Not operated	63.71	Trap pulled due to high flows
5 /24/2011	Not operated	63.04	Trap pulled due to high flows
5 /25/2011	Not operated	62.16	Trap pulled due to high flows
5 /26/2011	Not operated	64.99	Trap pulled due to high flows
5 /27/2011	Not operated	62.54	Trap pulled due to high flows
5 /28/2011	Not operated	57.96	Trap pulled due to high flows
05/29/2011	Not operated	53.85	Trap pulled due to high flows
5 /30/2011	Not operated	51.03	Trap pulled due to high flows

Appendix Table 1. Continued

Date	Status	Flow (m^3/s)	Comments
5 /31/2011	Not operated	50.77	Trap pulled due to high flows
6 /1 /2011	Not operated	56.14	Trap pulled due to high flows
6 /2 /2011	Not operated	57.87	Trap pulled due to high flows
6 /3 /2011	Not operated	57.94	Trap pulled due to high flows
6 /4 /2011	Not operated	59.14	Trap pulled due to high flows
6 /5 /2011	Not operated	64.06	Trap pulled due to high flows
6 /6 /2011	Not operated	70.14	Trap pulled due to high flows
6 /7 /2011	Not operated	77.24	Trap pulled due to high flows
6 /8 /2011	Not operated	76.46	Trap pulled due to high flows
6 /9 /2011	Not operated	78.03	Trap pulled due to high flows
6 /10/2011	Not operated	78.45	Trap pulled due to high flows
6 /11/2011	Not operated	80.00	Trap pulled due to high flows
6 /12/2011	Not operated	81.25	Trap pulled due to high flows
6 /13/2011	Not operated	79.59	Trap pulled due to high flows
6 /14/2011	Not operated	76.20	Trap pulled due to high flows
6 /15/2011	Not operated	75.99	Trap pulled due to high flows
6 /16/2011	Not operated	73.43	Trap pulled due to high flows
6 /17/2011	Not operated	66.61	Trap pulled due to high flows
6 /18/2011	Not operated	63.77	Trap pulled due to high flows
6 /19/2011	Not operated	66.02	Trap pulled due to high flows
6 /20/2011	Not operated	67.58	Trap pulled due to high flows
6 /21/2011	Not operated	69.95	Trap pulled due to high flows
6 /22/2011	Not operated	75.09	Trap pulled due to high flows
6 /23/2011	Not operated	76.65	Trap pulled due to high flows
6 /24/2011	Not operated	77.31	Trap pulled due to high flows
6 /25/2011	Not operated	68.71	Trap pulled due to high flows
6 /26/2011	Not operated	59.24	Trap pulled due to high flows
6 /27/2011	Not operated	55.42	Trap pulled due to high flows
6 /28/2011	Not operated	54.92	Trap pulled due to high flows
6 /29/2011	Not operated	59.68	Trap pulled due to high flows
6 /30/2011	Not operated	67.93	Trap pulled due to high flows
7 /1 /2011	Not operated	64.24	Trap pulled due to high flows
7 /2 /2011	Not operated	57.89	Trap pulled due to high flows
7 /3 /2011	Not operated	57.06	Trap pulled due to high flows
7 /4 /2011	Not operated	60.74	Trap pulled due to high flows
7 /5 /2011	Not operated	58.76	Trap pulled due to high flows
7 /6 /2011	Not operated	56.46	Trap pulled due to high flows
7/7/2011	Not operated	59.26	Trap pulled due to high flows
7 /8 /2011	Not operated	62.78	Trap pulled due to high flows
7 /9 /2011	Not operated	56.93	Trap pulled due to high flows
7 /10/2011	Not operated	47.88	Trap pulled due to high flows

Appendix Table 1. continued

Date	Status	Flow (m^3/s)	Comments
7 /11/2011	Not operated	42.76	Trap pulled due to high flows
7 /12/2011	Not operated	40.50	Trap pulled due to high flows
8 /1 /2011	Incomplete	23.10	Trap pulled due to high flows
8 /10/2011	Incomplete	15.41	Log in cone
8 /11/2011	Not operated	14.97	Trap pulled due to IMW staffing needs
8 /18/2011	Not operated	10.16	Trap pulled due to IMW staffing needs
8 /19/2011	Not operated	9.84	Trap pulled due to IMW staffing needs
8 /20/2011	Not operated	9.59	Trap pulled due to IMW staffing needs
8 /21/2011	Not operated	9.42	Trap pulled due to IMW staffing needs
8 /22/2011	Not operated	9.46	Trap pulled due to IMW staffing needs
8 /24/2011	Not operated	9.73	Trap pulled due to IMW staffing needs
8 /26/2011	Not operated	9.23	Trap pulled due to IMW staffing needs
8 /27/2011	Not operated	8.92	Trap pulled due to IMW staffing needs
8 /28/2011	Not operated	8.69	Trap pulled due to IMW staffing needs
9 /4 /2011	Not operated	6.54	Trap pulled for holiday
9 /5 /2011	Not operated	6.40	Trap pulled for holiday
9 /9 /2011	Not operated	5.61	Trap pulled due to IMW staffing needs
9 /10/2011	Not operated	5.61	Trap pulled due to IMW staffing needs
9 /24/2011	Not operated	4.61	Trap pulled due to staffing needs
10/7 /2011	Not operated	5.52	Trap pulled for off-channel research
10/10/2011	Not operated	4.70	Trap pulled for holiday
10/11/2011	Not operated	4.97	Trap pulled for off-channel research
10/13/2011	Incomplete	5.60	Trap pulled for off-channel research
10/23/2011	Not operated	4.90	Trap pulled due to high leaf debris
10/30/2011	Not operated	4.53	Trap pulled due to high leaf debris
11/6 /2011	Not operated	3.74	Trap pulled due to high leaf debris
11/12/2011	Incomplete	3.99	Maintenance
11/13/2011	Not operated	3.89	Trap pulled due to high leaf debris

Appendix Table 2. Summary of fish species captured in the Entiat River rotary screw trap, 2011.

Species and Life Stage	Total Capture	Capture Mortality
Wild spring Chinook salmon jack	2	0
Wild spring Chinook salmon precocial	2	0
Wild spring Chinook salmon juvenile	4,738	22
Hatchery summer Chinook salmon jack	6	0
Hatchery summer Chinook salmon juvenile	223	0
Wild summer Chinook salmon adult	1	0
Wild summer Chinook salmon jack	3	0
Wild summer Chinook salmon juvenile	11,425	127
Hatchery Chinook salmon (unknown r/t) adult	4	0
Hatchery Chinook salmon (unknown r/t) jack	2	0
Wild Chinook salmon (unknown r/t) jack	1	0
Wild Chinook salmon (unknown r/t) precocial	17	0
Wild coho salmon adult	1	0
Wild coho salmon juvenile	112	0
Hatchery summer steelhead adult	1	0
Wild summer steelhead adult	2	0
Wild steelhead juvenile	1,547	2
Bull trout adult	11	0
Bull trout juvenile	14	0
Wild cutthroat trout adult	1	0
Wild cutthroat trout juvenile	9	0
Hatchery sockeye (unknown run) adult	1	0
Wild sockeye (unknown run) salmon juvenile	776	0
Other (unknown salmonid)	3	0
Pacific lamprey ammocete	1,070	5
Northern pikeminnow adult	17	3
Northern pikeminnow juvenile	20	2
Mountain whitefish adult	10	0
Mountain whitefish juvenile	805	31
Unknown sucker adult	39	1
Unknown sucker juvenile	86	0
Unknown dace juvenile	78	4
Chiselmouth adult	29	0
Chiselmouth juvenile	9	0
Unknown sculpin	30	0
Red side shiner	57	0
Three-spine stickleback	6	0
Total	**21,158**	**196**

Appendix Table 3. Emigration estimates for wild yearling spring Chinook salmon at the lower Entiat River rotary screw trap including actual daily and estimated captures, 2011.

Date	Average Trapping Flow (m^3/s)	Daily Catch		Yearling spring Chinook Migration Estimate
		Actual	Estimated	
3/2/2011	6.6	7	--	31
3/3/2011	6.4	7	--	31
3/4/2011	6.1	14	--	62
3/5/2011	5.9	14	--	62
3/6/2011	5.7	--	13	58
3/7/2011	5.7	--	13	57
3/8/2011	5.5	14	--	61
3/9/2011	5.4	11	--	48
3/10/2011	5.7	--	13	56
3/11/2011	6.0	--	12	55
3/12/2011	5.7	--	13	56
3/13/2011	5.7	12	--	52
3/14/2011	6.1	14	--	62
3/15/2011	6.0	5	--	22
3/16/2011	6.3	6	--	27
3/17/2011	6.3	16	--	71
3/18/2011	6.2	6	--	27
3/19/2011	6.9	5	--	23
3/20/2011	6.8	13	--	59
3/21/2011	6.9	1	--	5
3/22/2011	7.0	19	--	87
3/23/2011	7.1	17	--	78
3/24/2011	7.1	9	--	41
3/25/2011	7.3	17	--	78
3/26/2011	7.8	26	--	121
3/27/2011	8.0	--	20	93
3/28/2011	8.0	17	--	80
3/29/2011	7.9	--	16	75
3/30/2011	8.3	19	--	90
3/31/2011	12.7	--	13	72
4/1/2011	30.0	--	12	99
4/2/2011	23.4	--	11	85
4/3/2011	19.2	--	10	70
4/4/2011	17.1	--	9	61
4/5/2011	15.7	--	9	56
4/6/2011	14.6	--	9	52
4/7/2011	13.8	8	--	46
4/8/2011	13.0	9	--	50

Appendix Table 3. continued.

4/9/2011	12.4	--	8	44
4/10/2011	12.2	8	--	43
4/11/2011	12.2	7	--	38
4/12/2011	12.1	2	--	11
4/13/2011	12.0	3	--	16
4/14/2011	12.0	1	--	5
4/15/2011	11.8	1	--	5
4/16/2011	11.5	--	3	17
4/17/2011	11.5	--	4	20
4/18/2011	11.4	4	--	21
4/19/2011	11.4	7	--	37
4/20/2011	11.2	7	--	37
4/21/2011	11.2	4	--	21
4/22/2011	10.9	12	--	62
4/23/2011	10.8	10	--	52
4/24/2011	11.0	21	--	109
4/25/2011	11.5	27	--	143
4/26/2011	11.9	32	--	172
4/27/2011	11.9	29	--	156
4/28/2011	12.3	37	--	202
4/29/2011	12.4	9	--	49
4/30/2011	12.4	21	--	114
5/1/2011	12.3	15	--	82
5/2/2011	13.3	18	--	102
5/3/2011	14.4	13	--	76
5/4/2011	14.5	9	--	53
5/5/2011	14.9	18	--	108
5/6/2011	16.7	17	--	109
5/7/2011	18.9	22	--	154
5/8/2011	20.1	17	--	125
5/9/2011	20.6	10	--	75
5/10/2011	21.3	7	--	54
5/11/2011	24.8	10	--	81
5/12/2011	30.8	--	7	57
5/13/2011	35.2	7	--	57
5/14/2011	35.1	4	--	32
5/15/2011	48.2	--	4	28
5/16/2011	71.4	--	3	21
5/17/2011	63.7	--	2	18
5/18/2011	56.3	--	2	16
5/19/2011	50.7	--	2	15
5/20/2011	49.7	--	2	14

Appendix Table 3. continued.

5/21/2011	52.5	--	2	13
5/22/2011	57.8	--	2	13
5/23/2011	63.7	--	2	13
5/24/2011	63.0	--	2	12
5/25/2011	62.2	--	2	12
5/26/2011	65.0	--	2	12
5/27/2011	62.5	--	2	12
5/28/2011	58.0	--	2	12
5/29/2011	53.6	--	2	12
5/30/2011	51.0	--	2	12
5/31/2011	50.8	--	2	12
6/1/2011	56.1	--	2	12
6/2/2011	57.9	--	2	12
6/3/2011	57.9	--	2	12
6/4/2011	59.1	--	2	12
6/5/2011	64.1	--	2	12
6/6/2011	70.1	--	2	12
6/7/2011	77.2	--	2	12
6/8/2011	76.4	--	2	12
6/9/2011	78.0	--	2	12
6/10/2011	78.4	--	2	12
6/11/2011	80.0	--	2	12
6/12/2011	81.2	--	2	12
6/13/2011	79.6	--	2	12
6/14/2011	76.2	--	2	12
6/15/2011	76.0	--	2	12
6/16/2011	73.4	--	2	12
6/17/2011	66.6	--	2	12
6/18/2011	63.8	--	2	12
6/19/2011	66.0	--	2	12
6/20/2011	67.6	--	2	12
6/21/2011	69.9	--	2	12
6/22/2011	75.1	--	2	12
6/23/2011	76.6	--	2	12
6/24/2011	77.3	--	2	12
6/25/2011	68.7	--	2	12
6/26/2011	59.2	--	2	12
6/27/2011	55.4	--	2	12
6/28/2011	54.9	--	2	12
6/29/2011	59.7	--	2	12
6/30/2011	67.9	--	2	12
7/1/2011	64.2	--	2	12
7/2/2011	57.9	--	2	12

Appendix 3. continued.

7/3/2011	57.1	--	2	12
7/4/2011	60.7	--	2	12
7/5/2011	58.7	--	2	12
7/6/2011	56.5	--	2	12
7/7/2011	59.2	--	2	12
7/8/2011	62.8	--	2	12
7/9/2011	56.9	--	2	12
7/10/2011	47.9	--	2	12
7/11/2011	42.8	--	2	12
7/12/2011	40.5	--	2	12
7/13/2011	42.7	--	0	0
7/14/2011	41.6	3	--	24
7/15/2011	39.3	5	--	40
7/16/2011	35.9	--	0	0
7/17/2011	37.4	--	0	0
7/18/2011	36.5	--	0	0
7/19/2011	37.5	1	--	8
7/20/2011	37.4	--	0	0
7/21/2011	33.7	--	0	0
7/22/2011	32.3	--	0	0
7/23/2011	30.0	--	0	0
7/24/2011	28.1	1	--	8
7/25/2011	27.3	--	0	0
7/26/2011	29.6	1	--	8
7/27/2011	28.0	1	--	8
7/28/2011	25.1	5	--	40
7/29/2011	25.1	--	0	0
7/30/2011	24.4	1	--	8
7/31/2011	23.7	1	--	8
8/1/2011	23.1	--	0	0
8/2/2011	21.9	4	--	32
8/3/2011	20.1	1	--	7
8/4/2011	18.9	2	--	14
8/5/2011	18.4	4	--	27
8/6/2011	18.1	1	--	7
8/7/2011	17.6	--	0	0
8/8/2011	16.8	4	--	26
8/9/2011	15.8	7	--	43
8/10/2011	15.4	--	4	24
8/11/2011	15.0	--	4	24
8/12/2011	14.5	4	--	24
8/13/2011	13.8	1	--	6

Appendix Table 3. continued

8/14/2011	13.0	1	--	6
8/15/2011	12.4	2	--	11
8/16/2011	11.8	5	--	27
8/17/2011	11.2	--	0	0
8/18/2011	10.2	--	2	10
8/19/2011	9.8	--	1	6
8/20/2011	9.6	--	2	8
8/21/2011	9.4	--	1	7
8/22/2011	9.5	--	2	7
8/23/2011	9.5	2	--	10
8/24/2011	9.7	--	1	6
8/25/2011	9.5	1	--	5
8/26/2011	9.2	--	1	3
8/27/2011	8.9	--	0	2
8/28/2011	8.7	--	0	1
8/29/2011	8.4	--	0	0
8/30/2011	7.9	--	0	0
8/31/2011	7.8	--	0	0
9/1/2011	7.5	--	0	0
9/2/2011	7.1	--	0	0
9/3/2011	6.9	1	--	5
9/4/2011	6.5	--	0	1
9/5/2011	6.4	--	0	1
9/6/2011	6.0	--	0	0
9/7/2011	5.8	--	0	0
9/8/2011	5.7	--	0	0
9/9/2011	5.6	--	1	4
9/10/2011	5.6	--	1	5
9/11/2011	5.7	4	--	18

Appendix Table 4. Emigration estimates for wild subyearling yearling spring Chinook salmon at the lower Entiat River rotary screw trap including actual daily and estimated captures, 2011.

Date	Average Trapping Flow (m^3/s)	Daily Catch		Subyearling spring Chinook Migration Estimate
		Actual	Estimated	
10/4/2011	5.0	16	--	43
10/5/2011	5.4	24	--	65
10/6/2011	6.0	59	--	159
10/7/2011	5.5	--	41	111
10/8/2011	5.1	60	--	162
10/9/2011	4.9	38	--	103
10/10/2011	4.7	--	43	115
10/11/2011	5.0	--	38	104
10/12/2011	6.1	44	--	119
10/13/2011	5.6	--	40	108
10/14/2011	5.2	29	--	78
10/15/2011	5.0	48	--	130
10/16/2011	4.9	63	--	170
10/17/2011	4.8	71	--	192
10/18/2011	4.6	72	--	194
10/19/2011	4.6	47	--	127
10/20/2011	4.5	25	--	68
10/21/2011	4.5	29	--	78
10/22/2011	4.4	45	--	122
10/23/2011	4.9	--	66	179
10/24/2011	5.0	99	--	267
10/25/2011	4.6	92	--	248
10/26/2011	4.4	76	--	205
10/27/2011	4.4	117	--	316
10/28/2011	4.4	156	--	421
10/29/2011	4.4	139	--	375
10/30/2011	4.5	--	121	325
10/31/2011	4.4	75	--	203
11/1/2011	4.8	112	--	303
11/2/2011	4.3	85	--	230
11/3/2011	4.2	72	--	194
11/4/2011	4.3	176	--	475
11/5/2011	4.0	204	--	551
11/6/2011	3.7	--	244	658
11/7/2011	3.7	307	--	829
11/8/2011	4.1	288	--	778
11/9/2011	4.2	142	--	384

Appendix Table 4. Continued

11/10/2011	4.1	140	--	378
11/11/2011	4.0	175	--	473
11/12/2011	4.0	--	142	383
11/13/2011	3.9	--	142	384
11/14/2011	4.0	109	--	294
11/15/2011	3.9	143	--	386
11/16/2011	3.8	94	--	254
11/17/2011	3.4	66	--	178
11/18/2011	3.8	168	--	454
11/19/2011	3.9	185	--	500

Appendix Table 5. Emigration estimates for wild steelhead at the lower Entiat River rotary screw trap including actual daily and estimated captures, 2011.

Date	Average Trapping Flow (m^3/s)	Daily Catch Actual	Daily Catch Estimated	Steelhead Migration Estimate
3/2/2011	6.6	2	--	9
3/3/2011	6.4	1	--	5
3/4/2011	6.1	--	0	0
3/5/2011	5.9	2	--	9
3/6/2011	5.7	--	1	4
3/7/2011	5.7	--	1	6
3/8/2011	5.5	2	--	9
3/9/2011	5.4	--	0	0
3/10/2011	5.7	--	1	4
3/11/2011	6.0	--	1	3
3/12/2011	5.7	--	1	4
3/13/2011	5.7	1	--	4
3/14/2011	6.1	1	--	5
3/15/2011	6.0	1	--	5
3/16/2011	6.3	--	0	0
3/17/2011	6.3	1	--	5
3/18/2011	6.2	1	--	5
3/19/2011	6.9	1	--	5
3/20/2011	6.8	--	0	0
3/21/2011	6.9	--	0	0
3/22/2011	7.0	3	--	14
3/23/2011	7.1	2	--	9
3/24/2011	7.1	5	--	23
3/25/2011	7.3	2	--	9
3/26/2011	7.8	--	0	0
3/27/2011	8.0	2	--	10
3/28/2011	8.0	--	0	0
3/29/2011	7.9	--	2	7
3/30/2011	8.3	1	--	5
3/31/2011	12.7	3	--	17
4/1/2011	30.0	--	6	78
4/2/2011	23.4	--	8	67
4/3/2011	19.2	--	9	64
4/4/2011	17.1	--	9	63
4/5/2011	15.7	1	--	6
4/6/2011	14.6	--	9	57
4/7/2011	13.8	20	--	118
4/8/2011	13.0	7	--	40
4/9/2011	12.4	--	8	46

Appendix Table 5. continued.

4/10/2011	12.2	2	--	11
4/11/2011	12.2	4	--	22
4/12/2011	12.1	4	--	22
4/13/2011	12.0	3	--	17
4/14/2011	12.0	2	--	11
4/15/2011	11.8	--	0	0
4/16/2011	11.5	--	5	29
4/17/2011	11.5	--	6	33
4/18/2011	11.4	11	--	60
4/19/2011	11.4	8	--	43
4/20/2011	11.2	5	--	27
4/21/2011	11.2	8	--	43
4/22/2011	10.9	6	--	32
4/23/2011	10.8	3	--	16
4/24/2011	11.0	7	--	37
4/25/2011	11.5	9	--	49
4/26/2011	11.9	8	--	44
4/27/2011	11.9	22	--	122
4/28/2011	12.3	20	--	112
4/29/2011	12.4	14	--	79
4/30/2011	12.4	20	--	112
5/1/2011	12.3	19	--	107
5/2/2011	13.3	32	--	186
5/3/2011	14.4	42	--	254
5/4/2011	14.5	43	--	261
5/5/2011	14.9	50	--	308
5/6/2011	16.7	107	--	709
5/7/2011	18.9	102	--	740
5/8/2011	20.1	85	--	649
5/9/2011	20.6	41	--	320
5/10/2011	21.3	46	--	370
5/11/2011	24.8	65	--	615
5/12/2011	30.8	102	--	1,337
5/13/2011	35.2	48	--	829
5/14/2011	35.1	24	--	414
5/15/2011	48.2	--	19	332
5/16/2011	71.4	--	12	208
5/17/2011	63.7	--	9	157
5/18/2011	56.3	--	7	113

Appendix Table 5. continued

5/19/2011	50.7	--	5	89
5/20/2011	49.7	--	4	72
5/21/2011	52.5	--	4	62
5/22/2011	57.8	--	3	55
5/23/2011	63.7	--	3	51
5/24/2011	63.0	--	3	48
5/25/2011	62.2	--	3	46
5/26/2011	65.0	--	3	45
5/27/2011	62.5	--	3	44
5/28/2011	58.0	--	3	44
5/29/2011	53.6	--	3	44
5/30/2011	51.0	--	3	44
5/31/2011	50.8	--	3	43
6/1/2011	56.1	--	3	43
6/2/2011	57.9	--	3	43
6/3/2011	57.9	--	3	43
6/4/2011	59.1	--	3	43
6/5/2011	64.1	--	3	43
6/6/2011	70.1	--	3	43
6/7/2011	77.2	--	3	43
6/8/2011	76.4	--	3	43
6/9/2011	78.0	--	3	43
6/10/2011	78.4	--	3	43
6/11/2011	80.0	--	3	43
6/12/2011	81.2	--	3	43
6/13/2011	79.6	--	3	43
6/14/2011	76.2	--	3	43
6/15/2011	76.0	--	3	43
6/16/2011	73.4	--	3	43
6/17/2011	66.6	--	3	43
6/18/2011	63.8	--	3	43
6/19/2011	66.0	--	3	43
6/20/2011	67.6	--	3	43
6/21/2011	69.9	--	3	43
6/22/2011	75.1	--	3	43
6/23/2011	76.6	--	3	43
6/24/2011	77.3	--	3	43
6/25/2011	68.7	--	3	43
6/26/2011	59.2	--	3	43
6/27/2011	55.4	--	3	43
6/28/2011	54.9	--	3	43
6/29/2011	59.7	--	3	43

Appendix Table 5. continued.

6/30/2011	67.9	--	3	43
7/1/2011	64.2	--	3	43
7/2/2011	57.9	--	3	43
7/3/2011	57.1	--	3	43
7/4/2011	60.7	--	3	43
7/5/2011	58.7	--	3	43
7/6/2011	56.5	--	3	43
7/7/2011	59.2	--	3	43
7/8/2011	62.8	--	3	43
7/9/2011	56.9	--	3	43
7/10/2011	47.9	--	3	43
7/11/2011	42.8	--	3	43
7/12/2011	40.5	--	3	43
7/13/2011	42.7	1	--	17
7/14/2011	41.6	4	--	69
7/15/2011	39.3	3	--	52
7/16/2011	35.9	2	--	35
7/17/2011	37.4	6	--	104
7/18/2011	36.5	1	--	17
7/19/2011	37.5	2	--	35
7/20/2011	37.4	2	--	35
7/21/2011	33.7	3	--	47
7/22/2011	32.3	4	--	57
7/23/2011	30.0	4	--	50
7/24/2011	28.1	2	--	22
7/25/2011	27.3	3	--	32
7/26/2011	29.6	1	--	12
7/27/2011	28.0	2	--	22
7/28/2011	25.1	--	0	0
7/29/2011	25.1	5	--	48
7/30/2011	24.4	6	--	56
7/31/2011	23.7	3	--	27
8/1/2011	23.1	--	3	28
8/2/2011	21.9	2	--	17
8/3/2011	20.1	2	--	15
8/4/2011	18.9	7	--	51
8/5/2011	18.4	--	0	0
8/6/2011	18.1	1	--	7
8/7/2011	17.6	6	--	41
8/8/2011	16.8	--	0	0
8/9/2011	15.8	3	--	19
8/10/2011	15.4	2	--	13

Appendix Table 5. continued.

8/11/2011	15.0	--	2	9
8/12/2011	14.5	1	--	6
8/13/2011	13.8	--	0	0
8/14/2011	13.0	3	--	17
8/15/2011	12.4	1	--	6
8/16/2011	11.8	4	--	22
8/17/2011	11.2	8	--	43
8/18/2011	10.2	--	6	29
8/19/2011	9.8	--	6	30
8/20/2011	9.6	--	5	27
8/21/2011	9.4	--	5	27
8/22/2011	9.5	--	5	26
8/23/2011	9.5	5	--	25
8/24/2011	9.7	--	7	36
8/25/2011	9.5	5	--	25
8/26/2011	9.2	--	8	38
8/27/2011	8.9	--	8	38
8/28/2011	8.7	--	8	41
8/29/2011	8.4	13	--	64
8/30/2011	7.9	5	--	24
8/31/2011	7.8	7	--	34
9/1/2011	7.5	18	--	86
9/2/2011	7.1	22	--	103
9/3/2011	6.9	17	--	79
9/4/2011	6.5	--	17	79
9/5/2011	6.4	--	16	74
9/6/2011	6.0	15	--	68
9/7/2011	5.8	15	--	67
9/8/2011	5.7	12	--	54
9/9/2011	5.6	--	9	41
9/10/2011	5.6	--	8	35
9/11/2011	5.7	7	--	31
9/12/2011	5.7	3	--	13
9/13/2011	5.6	6	--	27
9/14/2011	5.6	9	--	40
9/15/2011	5.4	5	--	22
9/16/2011	5.2	5	--	22
9/17/2011	5.2	11	--	48
9/18/2011	5.0	9	--	40
9/19/2011	5.0	7	--	31
9/20/2011	4.9	11	--	48
9/21/2011	4.8	10	--	44

Appendix Table 5. continued.

9/22/2011	4.7	3	--	13
9/23/2011	4.6	3	--	13
9/24/2011	4.6	--	4	17
9/25/2011	4.8	3	--	13
9/26/2011	4.7	7	--	30
9/27/2011	5.3	9	--	40
9/28/2011	6.2	18	--	82
9/29/2011	5.3	6	--	27
9/30/2011	4.9	6	--	26
10/1/2011	4.7	1	--	4
10/2/2011	4.7	4	--	17
10/3/2011	4.7	1	--	4
10/4/2011	5.0	2	--	9
10/5/2011	5.4	2	--	9
10/6/2011	6.0	6	--	27
10/7/2011	5.5	--	5	20
10/8/2011	5.1	6	--	26
10/9/2011	4.9	4	--	17
10/10/2011	4.7	--	5	21
10/11/2011	5.0	--	4	19
10/12/2011	6.1	6	--	27
10/13/2011	5.6	--	4	18
10/14/2011	5.2	3	--	13
10/15/2011	5.0	3	--	13
10/16/2011	4.9	1	--	4
10/17/2011	4.8	9	--	39
10/18/2011	4.6	2	--	9
10/19/2011	4.6	6	--	26
10/20/2011	4.5	--	0	0
10/21/2011	4.5	1	--	4
10/22/2011	4.4	1	--	4
10/23/2011	4.9	--	3	12
10/24/2011	5.0	4	--	18
10/25/2011	4.6	5	--	22
10/26/2011	4.4	1	--	4
10/27/2011	4.4	4	--	17
10/28/2011	4.4	1	--	4
10/29/2011	4.4	6	--	26
10/30/2011	4.5	--	4	15
10/31/2011	4.4	5	--	22
11/1/2011	4.8	2	--	9
11/2/2011	4.3	1	--	4

Appendix Table 5. continued.

11/3/2011	4.2	1	--	4
11/4/2011	4.3	1	--	4
11/5/2011	4.0	6	--	26
11/6/2011	3.7	--	7	30
11/7/2011	3.7	6	--	26
11/8/2011	4.1	15	--	64
11/9/2011	4.2	8	--	34
11/10/2011	4.1	1	--	4
11/11/2011	4.0	3	--	13
11/12/2011	4.0	2	--	9
11/13/2011	3.9	--	3	14
11/14/2011	4.0	5	--	21
11/15/2011	3.9	3	--	13
11/16/2011	3.8	2	--	9
11/17/2011	3.4	5	--	21
11/18/2011	3.8	9	--	39
11/19/2011	3.9	4	--	17

Appendix Table 6. Annual point estimates of abundance and 95% confidence intervals derived from Entiat River rotary screw trap capture data, capture years 2003 to 2011.

Species	Lower Trap		Upper Trap	
	Point Estimate	**95% C.I.**	**Point Estimate**	**95% C.I.**
	2003			
Yearling Spring Chinook	--	--	--	--
Subyearling Spring Chinook	--	--	10,437	181
Steelhead	--	--	--	--
Age 0	--	--	--	--
Age 1	--	--	--	--
Age 2	--	--	--	--
Age 3+	--	--	--	--
	2004			
Yearling Spring Chinook	--	--	4,363	141
Subyearling Spring Chinook	--	--	8,886	106
Steelhead	--	--	--	--
Age 0	--	--	--	--
Age 1	--	--	--	--
Age 2	--	--	--	--
Age 3+	--	--	--	--
	2005			
Yearling Spring Chinook	--	--	5,916	58
Subyearling Spring Chinook	--	--	15,185	303
Steelhead	--	--	9,948	258
Age 0	--	--	9,948	258
Age 1	--	--	3,970	103
Age 2	--	--	2,370	61
Age 3+	--	--	1,497	39
	2006			
Yearling Spring Chinook	--	--	9,689	164
Subyearling Spring Chinook	--	--	12,998	122
Steelhead	--	--	10,999	219
Age 0	--	--	1,624	103
Age 1	--	--	3,945	55
Age 2	--	--	2,976	61
Age 3+	--	--	1,554	39

Appendix Table 6. continued.

		2007		
Yearling Spring Chinook	9,693	222	--	--
Subyearling Spring Chinook	10,464	217	7,084	104
Steelhead	8,023	393	6,320	295
Age 0	638	31	385	18
Age 1	2,140	105	1,954	91
Age 2	2,866	140	2,376	111
Age 3+	2,378	116	1,605	75
		2008		
Yearling Spring Chinook	15,652	314	13,922	553
Subyearling Spring Chinook	14,234	195	10,442	142
Steelhead	16,724	1,511	14,094	3,367
Age 0	3,202	289	1,658	396
Age 1	3,946	357	2,908	695
Age 2	4,294	388	5,043	1,205
Age 3+	5,281	477	4,485	1,072
		2009		
Yearling Spring Chinook	7,479	921	3,956	722
Subyearling Spring Chinook	11,354	128	17,003	229
Steelhead	15,707	3,345	6,831	1,180
Age 0	3,758	800	997	172
Age 1	3,872	825	1,768	305
Age 2	5,014	1,068	2,446	423
Age 3+	3,062	652	1,620	280
		2010		
Yearling Spring Chinook	15,230	713	--	--
Subyearling Spring Chinook	13,021	166	--	--
Steelhead	30,318	5,593	--	--
Age 0	9,680	5,593	--	--
Age 1	7,130	1,315	--	--

Appendix Table 6. continued.

		2011		
Yearling Spring Chinook	6,087	381	--	--
Subyearling Spring Chinook	12,875	179	--	--
Steelhead	15,691	3,009	--	--
Age 0	1,758	337	--	--
Age 1	2,803	537	--	--
Age 2	5,720	1,097	--	--
Age 3+	5,410	1,037	--	--

Appendix Table 7. Annual dates of inclusion for yearling and subyearling Chinook species used in rotary screw trap based Entiat River production estimates, capture years 2003 to 2011.

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

Appendix Table 8. 2009 and 2010 trap efficiency data used in 2011 yearling spring Chinook point estimate.

Trial Date	Flow (m^3/s)	Release Size (n)	Efficiency (%)
3/6/2010	184.67	85	12.5
3/8/2010	179.71	100	23.53
3/11/2010	169.06	91	29.67
3/17/2010	159.8	71	22.54
4/1/2010	190.78	81	25.93
4/17/2010	227.66	240	25.83
4/18/2010	276.2	154	21.43
4/19/2010	328.2	248	22.98
4/20/2010	390.85	204	20.59
4/23/2010	746.32	51	15.69
4/25/2010	671.56	53	16.98
4/27/2010	622.8	24	20.83
5/4/2010	648.0	43	11.43
4/6/2009	172.93	28	25.0
4/10/2009	266.32	35	17.14
4/13/2009	304.88	130	14.62
4/16/2009	293.44	140	22.14
4/22/2009	788.41	208	8.65
4/25/2009	654.49	75	17.33

Appendix Table 9. Mark-recapture site locations, dates sampled, average flow (m^3/s), maximum water temperature (˚C) and sampling notes during the winter 2011 sampling period.

Site Code	River	Site Length (m)	RKM	Avg. (m^3/s)	Mark Date	Recap Date	Max Water Temp (˚C)	Sample Comments
1BC14	Entiat	330	5.19	5.75	03/04	03/05	3.5	Site fully sampled.
1D7	Entiat	330	8.42	5.86	02/28	03/01	2.0	Site fully sampled.
1E2	Entiat	330	9.93	6.34	03/01	03/02	2.0	Site fully sampled.
1F18	Entiat	330	16.31	6.48	03/02	03/03	2.0	Final 150 meters on left bank not sampled. Freezing temperatures impacting fish health.
1G2	Entiat	330	17.84	6.12	03/04	03/05	2.5	Site fully sampled.
2A5	Entiat	330	28.12	5.95	03/10	03/11	4.5	Site fully sampled.
2C7	Entiat	330	32.55	5.44	03/08	03/09	2.5	Site fully sampled.
3A5	Entiat	330	37.35	5.47	03/09	03/10	3.0	Site fully sampled.
3C3	Entiat	330	40.89	5.86	03/04	03/05	0.5	Site fully sampled.
3D4	Entiat	330	42.41	5.95	03/10	03/11	3.0	Site fully sampled.
3F2	Entiat	330	44.59	5.44	03/08	03/09	1.0	Site fully sampled.
M04	Mad	220	0.65	6.48	03/02	03/03	1.0	Site fully sampled.
M14	Mad	220	2.85	5.52	03/07	03/08	2.0	Site fully sampled.
M23	Mad	220	4.83	--	--	--	--	Site inaccessible due to road conditions. Unable to sample.

Appendix Table 10. Number of fish captured and mortalities during the winter 2011 mark recapture study in the Entiat and Mad rivers.

Species and Life Stage	Total Capture	Capture Mortality
Wild spring Chinook salmon juvenile	329	0
Wild steelhead juvenile	1,314	1
Wild steelhead precocial	1	0
Bull trout juvenile	5	0
Wild resident cutthroat trout juvenile	1	0
Total	1,650	1

Appendix Table 11. Mark-recapture site locations, dates sampled, average flow (m^3/s), maximum water temperature (˚C) and sampling notes during the summer 2011 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	5.90	09/06	09/07	16.5	Site fully sampled.
1D4	Entiat	330	7.43	5.65	09/08	09/09	16.5	Site not fully sampled due to probability of reaching upper temperature limit of sampling.
1E2	Entiat	330	9.93	9.63	08/24	08/25	16.0	Site fully sampled.
1F13	Entiat	330	14.67	7.30	09/01	09/02	13.0	Site fully sampled.
1G16	Entiat	330	22.45	9.08	08/26	08/27	14.0	Water velocity within thawleg prevented sampling throughout site. Sampling concentrated on river margins.
2A2	Entiat	330	27.13	7.82	08/30	08/31	14.0	Site fully sampled.
2C1	Entiat	330	30.58	7.82	08/30	08/31	13.0	Site not fully sampled due to spring Chinook redd activity and adult presence.
3A5	Entiat	330	37.35	9.08	08/26	08/27	13.0	Site not fully sampled due to spring Chinook redd activity and adult presence.
3C2	Entiat	330	40.56	9.63	08/24	08/25	12.0	100 meters on right bank not sampled due to spring Chinook spawning activity.

Appendix Table 11. continued

Site Code	River	Site Length (m)	RKM	Avg. (m^3/s)	Mark Date	Recap Date	Max Water Temp (˚C)	Sample Comments
3D2	Entiat	330	41.75	7.30	09/01	09/02	10.0	Site fully sampled.
3F1	Entiat	330	44.27	--	--	--	--	Site not sampled due to excessive spring Chinook spawning activity.
M04	Mad	220	0.65	9.48	08/22	08/23	16.0	Site fully sampled.
M14	Mad	220	2.85	9.48	08/22	08/23	14.0	30 meters within site not sampled due to adult salmonid presence.
M23	Mad	220	4.83	10.0	08/18	08/19	12.5	Site fully sampled.

Appendix Table 12. Number of fish captured and mortalities during the summer 2011 mark recapture study in the Entiat and Mad rivers.

Species and Life Stage	Total Capture	Capture Mortality
Wild Chinook (unknown run) salmon juvenile	1,751	67
Wild Chinook (unknown run) salmon precocial	4	0
Hatchery summer Chinook salmon juvenile	1	0
Wild coho salmon juvenile	26	0
Wild steelhead juvenile	1,742	30
Wild steelhead precocial	1	0
Bull trout juvenile	10	0
Wild resident cutthroat trout juvenile	3	0
Wild resident cutthroat trout adult	1	0
Pacific lamprey ammocete	97	0
Mountain whitefish juvenile	24	0
Unknown sucker juvenile	2	0
Unknown dace juvenile	72	0
Unknown sculpin juvenile	799	0
Total	4,533	97

Appendix Table 13. Point estimates of abundance for Chinook salmon and steelhead captured at mark-recapture sites sampled during the summer period of 2010.

Site	Species	New Cptrs	Total Marked	Total Recaps	Recap prob.	Pop. Est.	Lower 95% C.I.	Upper 95% C.I.	Stdrd Error
1BC14	Wild Chinook	71	43	4	0.09	633	172	1,093	234.92
	Wild steelhead	143	101	9	0.09	1,468	673	2,263	405.72
1D7	Wild Chinook	65	53	5	0.09	593	197	989	201.82
	Wild steelhead	229	120	19	0.16	1,391	871	1,910	265.09
1E2	Wild Chinook	107	70	17	0.24	425	274	576	77.08
	Wild steelhead	93	76	6	0.08	1,033	376	1,690	335.33
1F18	Wild Chinook	141	61	15	0.25	549	337	761	108.28
	Wild steelhead	34	47	4	0.09	335	99	571	120.20
1G2	Wild Chinook	65	47	9	0.19	316	162	469	78.29
	Wild steelhead	55	36	4	0.11	413	119	708	150.14
2A5	Wild Chinook	19	23	0	0.0	INV	--	--	--
	Wild steelhead	4	1	0	0.0	INV	--	--	--
2C7	Wild Chinook	91	16	1	0.06	INV	--	--	--
	Wild steelhead	50	7	2	0.28	INV	--	--	--
3A5	Wild Chinook	185	41	9	0.22	780	388	1,172	199.99
	Wild steelhead	9	1	0	0.0	INV	--	--	--
3C3	Wild Chinook	57	36	4	0.11	428	123	734	155.77
	Wild steelhead	14	3	1	0.33	INV	--	--	--
3D4	Wild Chinook	11	9	1	0.11	INV	--	--	--
	Wild steelhead	13	2	0	0.0	INV	--	--	--
3F2	Wild Chinook	134	57	13	0.23	558	325	792	119.08
	Wild steelhead	13	2	0	0.0	INV	--	--	--
M04	Wild Chinook	43	26	13	0.5	84	59	108	12.55
	Wild steelhead	140	105	23	0.22	622	426	817	99.79
M14	Wild Chinook	20	8	4	0.5	37	19	54	8.98
	Wild steelhead	128	74	18	0.24	508	330	686	90.85
M23	Wild Chinook	29	11	4	0.36	71	31	111	20.49
	Wild steelhead	156	93	33	0.35	433	331	535	51.88

Appendix Table 14. Site operational summary for the lower Entiat River interrogation site (ENL) during the 2011 monitoring period. Site event logs as submitted to the PTAGIS website.

Date	Operational Comments
12/21/2011	Antenna 2 high noise ~22%; antenna 3 high noise ~22%; antenna 4 high noise ~20%; antenna 6 high noise ~20. 255 new records downloaded.
12/16/2011	Antenna 1 high noise ~30%; antenna 2 high noise ~26%; antenna 6 ~21%. 379 new records downloaded.
12/14/2011	Site connected to satellite modem.
12/06/2011	Changed antennas from hybrid to flat plate configuration. Installed new ratchet straps. Cable was repaired on antenna 1. Rocks were piled to shield antennas.
11/14/2011	Leaves and debris removed from all antennas.
10/27/2011	Antenna 1 lost power, connection is good. Assuming that antenna is cracked or broken. Washington Department Fish and Wildlife notified. No data collected between 10/25 and 10/27 approximately 0730.
10/22/2011	Antenna 1 high noise.
10/16/2011	Debris removed from all antennas.
10/11/2011	Antennas operational now, battery charger and fuses replaced.
10/5/2011	Antennas are not operating; no current. Checked batteries voltage, all show 6.9V or less. Turned off MUX power.
9/13/2011	Antennas all changed into hybrid position.
9/1/2011	Antennas 3, 5, 6 replaced.
6/13/2011	Antenna 3 current lost; antenna 5 & 6 no current.
6/7/2011	Modem now working antennas 3 and 6 still not working and show no current so likely unplugged. Will reconnect when flows drop later in the season.
6/2/2011	Cellular modem not sending data. Reset modem.
5/23/2011	Antennas 3 and 6 have no current; 2 is not reading tags due to high noise.
5/18/2011	Wrong file close date on ENL11137.ALL. The correct date is on the file open date of the next file ENL11139.ALL
5/13/2011	Antenna 3 has no current; probably unplugged, discharge too high to reconnect at this time. Antenna 2 has high noise and is not reading any timer tags.
5/10/2011	High noise on antennas 2 and 3, still reading timer tags but not consistently.
3/31/2011	Antenna 3 and 5 has high noise and are not consistently detecting tags.
2/10/2011	Antennas 3, 5 and 6 have been replaced. All antennas operational now. Noise is reduced on 1, 2 and 4.
1/27/2011	Antennas 1, 2 and 4 all have high noise and are not reading tags. Verified antennas 3, 5 and 6 were damaged by a large log in the river and require replacement. Washington Department Fish and Wildlife was notified in order to replace.
1/19/2011	Antennas 3, 5 and 6 have no power. Antennas 2 and 4 have high noise (>30%). Antenna 1 has intermittent high noise and is not reading tags most of the time
1/11/2011	Tag code 3D9.1C2D4C4556 originally implanted in 15W in August 2010 is being read repeatedly; possibly mort or loose bare tag.

Appendix Table 15. Site operational summary for the Entiat River interrogation site at Ardenvoir (ENA) during the 2011 monitoring period. Site event logs as submitted to the PTAGIS website.

Date	Operational Comments
12/08/2011	Antenna 1 high noise ~31%; antenna 3 high noise ~19%; antenna 4 high noise ~28%; antenna 6 high noise ~30%. No communication errors.
12/02/2011	Antenna 6 high noise ~24%. MUX reset. 178 new records downloaded.
12/01/2011	Antenna 4 high noise ~50%. 157 new records, no records downloaded due to bad connection between MUX and laptop.
11/22/2011	Antenna 1 high noise ~48%; antenna 3 high noise ~27%; antenna 5 high noise ~32%.
11/18/2011	Antenna 1 high noise ~53%; antenna 4 high noise ~30%; antenna 6 high noise ~33%.
11/14/2011	Antenna's 1, 3, & 5 high noise; 107 new records downloaded.
11/8/2011	Antenna 1 high noise ~26%; antenna 3 high noise ~30%; antenna 5 high noise ~43%. Changed MUX time to match the laptop time; 75 new records downloaded.
11/4/2011	Antenna 1 high noise ~49%; Antenna 3 high noise ~25%; Antenna 4 high noise ~32%; Antenna 6 high noise ~25%.
10/24/2011	Antenna 1 high noise ~23%; antenna 4 high noise ~23%; antenna 5 high noise ~20%. Time changed from 11:36:00 to 12:17:00. 111 new records downloaded.
10/19/2011	Antenna 3 high noise ~22%; antenna 5 high noise ~27%. 68 new records downloaded.
10/16/2011	Antenna 1 high noise ~45%; antenna 4 high noise about 36%, antenna 6 high noise ~26%. 249 new records downloaded.
10/4/2011	Antenna 1 high noise ~22%; antenna 4 high noise ~29%. 155 new records downloaded.
9/28/2011	Antenna 5 high noise ~24%; 80 new records downloaded.
9/25/2011	Antenna 4 high noise ~ 20%; 124 new records downloaded.
9/20/2011	Antenna 4 high noise ~30%. Test tag failed. All straps inspected and debris removed; 59 new records downloaded.
9/18/2011	Antenna 1 high noise ~24%; antenna 5 high noise ~23%. Alarm reads, "Test tag failed." 77 new records downloaded.
9/15/2011	Antenna 4 high noise ~20%; 6 high noise ~23%. 117 new records downloaded.
9/11/2011	Antenna 5 high noise ~20%; 599 new records downloaded.
9/2/2011	One 20' antenna replaced (antenna 3).
8/14/2011	Antenna 3 not present; 213 new records downloaded.
8/4/2011	Antenna 3 unplugged; antenna 5 high noise; 67 new records downloaded.
7/31/2011	Antenna 3 zero amps; antenna 5 high noise ~26%; antenna 6 high nose ~20%.
7/28/2011	Antenna 1 high noise ~23%; antenna 3 zero amps; antenna 4 high noise ~27%; 205 new records downloaded.
7/14/2011	Antenna 1 high noise ~19%; antenna 3 zero current; 5 high noise ~24%. 68 new records downloaded.
7/11/2011	Antenna 3 zero current; antenna 6 high noise ~28%. 437 new records downloaded.
7/1/2011	Antenna 2 high noise ~41%; antenna 4 high noise ~20%; antenna 6 high noise ~30%. No records downloaded due to problems with MiniMon.
6/21/2011	Antenna 2 high noise ~50%; 98 new records downloaded.

Appendix Table 15. continued.

6/17/2011	*Antenna 2 high noise 21%; antenna 6 high noise 23%. 106 new records downloaded.*
6/13/2011	Antenna 2 high noise at about 19%; 280 records downloaded.
6/6/2011	Battery charger at site was replaced today. MUX now powered and operational.
6/3/2011	Returned to check batteries they are still not charging. Charger shows 1-2 A. MUX not working MUX power kept turning off.
6/1/2011	No power; GFCI was tripped, but batteries are dead so MUX is turned off. Will return to turn power back on once batteries have charged.
5/20/2011	Antennas all good; changed time to PST from DST.
5/13/2011	Antennas all good; 273 records.
5/6/2011	Time was set on DST changed back to PST; 392 records.
4/6/2011	Site up and running.

Appendix Table 16. Site operational summary for the middle Entiat River interrogation site (ENM) during the 2011 monitoring period. Site event logs as submitted to the PTAGIS website.

Date	Operational Comments
12/29/2011	370 new records. Communication problem between laptop and MUX. Also the white cable was not connected when arrived to the site. Was unable to download records; buffer contains 370 records.
12/13/2011	Washington Department Fish and Wildlife left a note saying "MUX was off when arrived, started it at approximately 11:00. Reset parameters and there were no tags on the reader. There was a blown fuse. It was replaced and reader started."
12/02/2011	Virtual Timer Tag set to 20 for all 6 antennas. Unique mode set to "off." Test tag now successfully storing on the buffer.
12/1/2011	13 new records downloaded; Antenna 3 high noise ~22%.
11/22/2011	8 new records downloaded. Antenna 3 high noise ~20%; antenna 5 high noise ~55%. Virtual test tag delay set to 180 minutes. Set VTT to 20 for ANT 1 was unable to set VTT for any of the other antennas due to an error on the hyper terminal screen reading, " unexpected or missing argument," Turned "on" store test tag (DS1). It was firing and showing up in Miniterm but not storing it in the MUX.
11/8/2011	Antenna's all good. Changed MUX time to match laptop time; 4 new records downloaded.
10/24/2011	Antenna's all good. Time changed from 11:11:00 to 11:56:00; 10 new records downloaded.
10/19/2011	Antenna 3 high noise ~19%; 10 new records downloaded.
10/16/2011	Antenna 3 high noise ~20%; 33 new records downloaded.
10/4/2011	Antennas all good. Storing of virtual test tag is not working; 19 new records downloaded.
9/28/2011	"Store test tag" was turned on; 31 new records downloaded.
9/22/2011	Set virtual timer tag to every 2 hours. Antenna 4 high noise ~93%; 8 new records downloaded.
9/20/2011	3 new records downloaded. Antennas all operating well. Date and time correct. All antennas inspected, antenna 3 brace is broken in the middle of antenna and there is a big groove in the antenna's PVC. All debris was removed from antennas.
9/18/2011	7 new records downloaded. Antennas all operating as expected. Date/time checked.
9/15/2011	7 new records downloaded. MUX reads 11-12-2011, 2011, 20:31. Date and time corrected to laptop time. Antennas are all good.
9/12/2011	Files downloaded, but the dates were showing 1996, somehow lost power? Reset? Date was changed to reflect current date and time.
9/2/2011	Antenna 6 was replaced today.
9/1/2011	Antenna 6 not present; 261 new records.
8/14/2011	Antenna 6 not present; 178 new records downloaded.
8/12/2011	Checked antenna 6 confirmed broken.
8/9/2011	State downloaded and updated MUX firmware
8/4/2011	Antenna 6 zero amps; 217 new records.
7/31/2011	Antenna 6 zero amps; 156 new records downloaded.
7/28/2011	Antenna 3 high noise ~21%; antenna 6 zero amps.
7/19/2011	Antenna 6 zero amps; 260 new records downloaded.
7/14/2011	Antenna 5 high noise ~31%; 162 new records downloaded.
7/11/2011	Antenna 3 high noise; 1058 new records downloaded.

Appendix Table 16. continued.

7/1/2011	*All antennas operating well. No records downloaded due to problems with MiniMon.*
6/21/2011	Antenna 3 high noise ~33%, antenna 6 zero amps. 208 new records downloaded.
6/17/2011	Antenna 6 zero amps. 193 records new records downloaded.
6/13/2011	Antenna 2 high noise about 43%; antenna 6 zero amps; antenna 3 slope bouncing up to 30
6/1/2011	All good except antenna 4 high noise; 723 records.
5/20/2011	418 records; all antennas operating well.
5/6/2011	Antenna 4 has elevated noise ~23%
4/22/2011	Antenna 3 has elevated noise ~22%; all others good.
2/23/2011	High noise on antenna 3.

Appendix Table 17. Site operational summary for the Entiat River interrogation site near Stormy Creek (ENS) during the 2011 monitoring period. Site event logs as submitted to the PTAGIS website.

Date	Operational Date
12/21/2011	Antennas all good. 1276 new records downloaded. Set test tag to 180 minutes (HyperTerminal- coded DTD).
12/16/2011	All antennas noise levels back down to low levels. 455 new records downloaded.
12/13/2011	Antenna 1 high noise ~89%; antenna 2 high noise ~85%; antenna 3 high noise ~79%, antenna 4 high noise ~87%; antenna 6 high noise ~77%. State was notified of the high noise levels; 231 new records not downloaded.
12/02/2011	Set Virtual Timer Tag to 20 on all 6 antennas. Turned “off” unique mode. Test tag is now storing.
11/22/2011	No new records to download. Antennas were all good. Test tag timer set to 180 minutes. Set Virtual Timer Tag to 20 for Antenna 1 was unable to set Virtual Timer Tag for any of the other antennas due to an error on the hyper terminal screen reading “unexpected or missing argument” Turned “on” store test tag on hyper terminal screen. Unable to get the Virtual Timer Tag to store on MUX. It was firing and reading, on the hyper terminal screen, and on the MUX, it was just not storing it in the MUX.
11/08/2011	Antennas all good. Changed time on MUX to match the lap top time. 18 new records downloaded.
10/24/2011	Antennas all good. Time changed from 10:48:00 to 11:36:00. 11 new records downloaded.
10/4/2011	Antennas all good; 12 new records downloaded. Store test tag is not working.
9/28/2011	MUX reads 03-01-1996, 19:51. Date and time corrected. HEX ID set, also turned “store test tag on.” 18 new records downloaded.
9/26/2011	Reset MUX, attempted to set timer tags. Date and time is incorrect; MUX reads Jan 1996; not able to correct the date; 9 new records downloaded.
9/25/2011	Changed lithium battery back to the old battery. MUX still reads “lithium low”. Antennas were all good. O new records downloaded.
9/22/2011	Lithium battery changed. MUX reads 22-09-2011, 09:42. Timer tag set to every hour. Changed battery, when new battery was installed MUX read “lithium low”. Antennas were all good. 14 new records downloaded.
9/20/2011	4 new records. Antennas were all good. Date and time correct. All antennas plus straps inspected all look good, and debris removed from them.
9/18/2011	27 new records. MUX reads 07-01-1996, 23:14. Time changed to lap top time. Antennas were all good. Files downloaded buffer not erased.
9/15/2011	1996, 21:01:19. Antennas were all good. Files downloaded buffer not erased.
9/11/2011	All good; 570 new records; 569 new records downloaded; connection timed out. Buffer not erased.
8/25/2011	Wouldn’t download, then reset MUX; downloaded records, changed MUX ID; HEX ID?
8/14/2011	Could not read screen on MUX it was completely black from being too hot. 359 new records downloaded.
8/9/2011	Reader stuck in startup mode; boot manager restarted multiple times to start MUX record count 0. Resend parameters; tuned ANTS. Needs Reader HEX ID* MUX.
8/4/2011	Could not read screen on MUX it was completely black from being too hot. 586 new records downloaded.

Appendix Table 17. continued.

7/31/2011	*Could not read screen on MUX it was completely black from being too hot. 448 new records downloaded.*
7/28/2011	Could not read screen on MUX it was completely black from being too hot. 1348 new records downloaded.
7/1/2011	No records downloaded because of problems with Minimon. All antennas were operating well.
6/21/2011	Display window on MUX cannot be read; still able to download records successfully. 579 records downloaded.
5/20/2011	After MUX reset, time was set incorrectly to DST. (Washington State Fish and Wildlife had reset the MUX and were likely unaware that the time was supposed to be set to PST). Changed back to PST.
5/16/2011	Site is now operational and collecting data
5/13/2011	Found MUX to be continually running through self-test mode. Washington State Fish and Wildlife contacted.
5/6/2011	MUX was stuck in test mode (audible alarm) had to reset and was unable to recover any data; time and date reset. Washington State Fish and Wildlife contacted and problem reportedly fixed.

Appendix Table 18. Site operational summary for the Entiat River Forest Service boundary interrogation site (ENF) during the 2011 monitoring period. Site event logs as submitted to the PTAGIS website.

Date	Operational Comments
11/8/11	Antennas all good. Changed laptop time and MUX time to the correct time.
10/24/2011	Antennas all good. Time changed to 10:00:00 from 09:18:00. 225 new records downloaded.
10/16/2011	Antenna 6 has high noise ~47%; 539 new records downloaded.
10/4/2011	Antennas all good; 252 new records downloaded.
9/28/2011	Antenna 6 high noise ~23%; 128 new records downloaded.
9/25/2011	Antenna 6 high noise ~23%; 213 new records downloaded.
9/20/2011	Antenna 2 is fluctuating between 5 and 6. All antennas and their straps were inspected and all was debris removed. All antennas looked good; 77 new records downloaded.
9/18/2011	Antenna 6 high noise ~20%; 127 new records downloaded.
9/15/2011	Antenna 6 high noise ~29%; 173 new records downloaded.
9/11/2011	Antenna 6 high noise; 471 new records downloaded.
9/1/2011	Antenna 6 high noise; 347 records downloaded.
8/9/2011	Updated MUX firmware from 1.90 to 2.1.
7/28/2011	Antenna 6 high nose 40%. 397 new records downloaded.
7/19/2011	Antenna 3 high noise ~53%; antenna 6 high noise ~31%. 212 new records downloaded.
7/14/2011	Antenna 6 high noise ~52%; 126 new records downloaded.
7/11/2011	Antenna 3 high noise and 6 high noise; 827 new records downloaded.
7/1/2011	All antennas good. No records were downloaded due to problems with MiniMon.
6/21/2011	Antenna 3 high noise ~ 38%; 164 records downloaded.
6/17/2011	Antenna 3 high noise ~ 27%; 165 records downloaded.
6/13/2011	Antenna 3 high noise ~ 43%; 670 records downloaded.
5/20/2011	High noise on antenna 3; all other antennas good.
4/7/2011	All antennas operating with no problem; 370 records downloaded.
3/23/2011	Problems with communication between lap top and mux. Attempted download through Hyperterminal and reset of mux resulted in data loss between the dates 2/17/2011 and 3/23/2011.
3/16/2011	All antennas operating well. Unable to connect to MUX
2/28/2011	Cable on antenna 6 replaced and all are operational again
2/23/2011	Antenna 6 still not operating; all others are good. No download occurred; unable to connect to mux. Buffer contains 220 records.
2/17/2011	Antenna 6 cable disconnected again. Cable reconnected but showing low amps and high noise. Washington Department of Fish and Wildlife contacted and will replace cable as soon as possible.
2/7/2011	Antenna 6 down again and river iced over; 478 records downloaded.
1/25/2011	Antenna 6 cable came unplugged and has no power. Cable reconnected.
1/14/2011	Antenna 6 has no power; unable to access to check cable connection due to ice. 302 records were downloaded.
1/5/2011	Antenna 6 appears to be unplugged, river iced over and not accessible at this time. Tag file contents from 12/29/2010-1/5/2011 mistakenly overwritten with ENM file tag contents. Only virtual timer tag codes were observed during download.

Appendix Table 19. Site operational summary for the Mad River interrogation site (MAD) during the 2011 monitoring period. Site event logs as submitted to the PTAGIS website.

Date	Operational Comments
12/01/2011	Antenna 5 high noise 23%; 395 new records downloaded.
11/22/2011	Antenna 1 high noise ~25%; antenna 5 high noise ~28%; 167 new records downloaded.
11/18/2011	Antenna 1 high noise ~53%; antenna 5 high noise ~22%; 160 new records downloaded.
11/8/2011	Antenna 5 high noise ~43%; MUX time changed to match the laptop time; 152 new records downloaded.
11/4/2011	Antenna 5 high noise ~34%. 516 new records downloaded.
10/24/2011	Antenna's all good. Time changed from 11:46:00 to 12:30:00. 283 new records downloaded.
10/19/2011	Antenna 5 high noise 25%; 125 new records downloaded.
10/16/2011	Antenna 5 high noise ~ 32%; 92 new records downloaded.
10/14/2011	Antennas 1,3,5,6 have high noise levels; 474 new records downloaded.
10/4/2011	Antenna 5 high noise ~25%; antenna 6 high noise ~20%; 278 new records downloaded.
9/28/2011	Antenna 5 high noise ~31%; 340 new records downloaded.
9/22/2011	Antennas all good; 116 new records downloaded.
9/20/2011	Site needs new locks on box. 119 new records downloaded. Antenna 5 noise ~50%. All antennas and straps inspected, all debris removed.
9/18/2011	Antenna 5 high noise ~37%; 176 new records downloaded.
9/15/2011	Antenna 5 high noise ~31%; 876 new records downloaded; buffer erased.
9/11/2011	Antenna 5 high noise ~53%; 634 new records; 633 records downloaded unknown reason why, buffer not erased.
9/2/2011	Antennas numbers 1 and 4 had damaged COAX cables, fixed and operating now.
9/1/2011	Antenna 3 high noise ~32%, antenna 4 not present; antenna 5 high noise ~46%. 576 new records downloaded.
8/22/2011	Antenna 4 not present; antenna 5 high noise; 359 new records downloaded.
8/14/2011	Antenna 3 high noise; antenna 4 not present; antenna 5 high noise; antenna 6 high noise. 4 tags downloaded date from 1/1/1996. 217 new records downloaded.
8/9/2011	Antenna 4 down low amps; high noise; updated firmware to 2.1; downloaded tuned amps; reset parameters.
8/4/2011	Antenna 1 not present; it got plugged back in but still not working; antenna 3 high noise, antenna 4 not present. 105 new records downloaded.
7/28/2011	Antenna 1 not present; antenna 3 high noise ~32%; antenna 4 not present. 80 new records downloaded.
7/19/2011	Antenna 1 not present; antenna 3 high noise ~72%; antenna 4 not present. 249 new records downloaded.
7/14/2011	Antenna 1 not present; antenna 4 not present; 81 new records downloaded.
7/11/2011	Antenna 1 not present; antenna 3 high noise; antenna 4 not present; antenna 5 high noise; antenna 6 high noise. 405 new records downloaded.
7/1/2011	Antenna 1 zero amps; antenna 3 high noise ~44%; antenna 4 not present; antenna 6 high noise ~ 20%. No records downloaded; due to issues with Minimon.
6/21/2011	Antenna 1 zero amps, antenna 3 high noise ~44%, antenna 4 not present antenna 6 high noise ~ 20%. 78 new records downloaded.
6/17/2011	Antenna 1 zero amps, antenna 3 high noise 40%, antenna 4 not present. 80 new records downloaded.
6/13/2011	Antenna 1 zero amps, antenna 2 high noise ~ 43%, antenna 3 high noise ~ 43%, antenna 4 not present, antenna 5 high noise ~ 22%, antenna 6 high noise at 43%. 285 records downloaded.
6/1/2011	Antenna 1 zero current, antenna 4 not present, antenna 3 has high noise, other antennas good.
5/20/2011	Antenna 1 zero current; antenna 4 not present; all antennas have high noise.
5/13/2011	Antennas 1 and 4 have no current, unable to check to see if unplugged due to high flows. Will check when flows drop down.
5/9/2011	Washington Department Fish and Wildlife repaired Mux. Site is up and running again. Data gap as a result between 4/28 and 5/9

Appendix Table 19. continued.

5/6/2011	Mux had no power. Washington Department Fish and Wildlife contacted.
4/28/2011	Antenna 4 has low current.
4/22/2011	Antennas 2, 4, and 6 not operating. Antennas 2 and 4 to be replaced by Washington Department Fish and Wildlife
4/7/2011	Antennas 1, 2, 4 and 6 have no current. 1, 2, and 4 plugged back in. 2 and 4 need replaced. Was unable to access antenna 6 today with the elevated discharge.
3/28/2011	Cable to antenna 4 installed today.
3/22/2011	No power on antennas 3, 4, 5 and 6. Was able to plug back in cables on 3, 5, and 6 but 4 has a damaged cable. Washington Department Fish and Wildlife notified
2/17/2011	High noise on antenna 1. All others are good.
2/7/2011	High noise on antenna 4. All others are operating well.
1/26/2011	Antennas 1and 4 were reconnected and straps were added to cabling. High noise levels on antennas 1, 5 and 6.
1/25/2011	Antennas 1and 4 have no power; 451 records downloaded
1/14/2011	All antennas operating well. Alarm shows test tag not firing on 6; 877 records downloaded.
1/5/2011	All antennas operating with minimal noise.

Appendix Table 20. Summary of unique detection from the lower Entiat River interrogation site (ENL) during the 2011 monitoring period. PTAGIS naming convention used to indicate run and rear type.

Species (indicating rear and run type)	Total Juvenile	Total Adult	Total Detected
Hatchery spring Chinook salmon	2	4	6
Wild spring Chinook salmon	570	10	580
Hatchery summer Chinook salmon	227	10	237
Wild summer Chinook salmon	101	1	102
Wild Fall Chinook salmon	0	1	1
Hatchery Chinook Salmon (unknown run)	0	0	0
Chinook salmon (unknown run and rear type)	0	7	0
Wild Chinook salmon (unknown run)	329	16	345
Hatchery coho salmon	0	3	3
Wild coho salmon	10	1	11
Hatchery summer steelhead	0	31	31
Summer steelhead (unknown rear type)	0	2	2
Wild summer steelhead	191	108	299
Hatchery summer sockeye salmon	0	1	1
Hatchery sockeye salmon (unknown run)	0	3	3
Sockeye salmon (unknown run and rear type)	0	4	4
Bull trout	4	15	19
Wild resident cutthroat trout	2	1	3
Unknown species run and rear	--	--	7
Grand totals	1436[a]	218[a]	1662

[a] Unknown fish are not assigned a life stage so are not included in totals for adults and juveniles.

Appendix Table 21. Summary of unique detection from the Entiat River at Ardenvoir interrogation site (ENA) during the 2011 monitoring period. PTAGIS naming convention used to indicate run and rear type.

Species (indicating rear and run type)	Total Juvenile	Total Adult	Total Detected
Hatchery spring Chinook salmon	4	20	24
Wild spring Chinook salmon	27	28	55
Hatchery summer Chinook salmon	12	0	12
Wild summer Chinook salmon	0	1	1
Chinook salmon (unknown run and rear type)	0	12	12
Wild Chinook salmon (unknown run)	50	15	65
Hatchery fall Chinook salmon	0	1	1
Hatchery coho salmon (unknown run)	3	0	3
Hatchery summer steelhead	1	5	6
Summer steelhead (unknown rear type)	0	1	1
Wild summer steelhead	67	35	102
Hatchery sockeye salmon (unknown run)	0	1	1
Sockeye salmon (unknown run and rear type)	0	1	1
Hatchery summer sockeye salmon	1	1	2
Bull trout	2	10	12
Unknown species run and rear	--	--	13
Grand totals	167[a]	131[a]	311[a]

[a] Unknown fish are not assigned a life stage so are not included in totals for adults and juveniles

Appendix Table 22. Summary of unique detection from the middle Entiat River interrogation site (ENM) during the 2011 monitoring period. PTAGIS naming convention used to indicate run and rear type.

Species (indicating rear and run type)	Total Juvenile	Total Adult	Total Detected
Hatchery spring Chinook salmon	2	15	17
Wild spring Chinook salmon	78	21	99
Hatchery summer Chinook salmon	8	0	8
Wild summer Chinook salmon	0	1	1
Chinook salmon (unknown run and rear type)	0	9	9
Wild Chinook salmon (unknown run)	106	15	121
Hatchery summer steelhead	0	2	2
Summer steelhead (unknown rear type)	0	2	2
Wild summer steelhead	42	43	85
Hatchery sockeye salmon (unknown run)	0	2	2
Hatchery summer sockeye salmon	0	2	2
Bull trout	0	6	6
Unknown species run and rear	--	--	1
Grand totals	236[a]	118[a]	355

[a] Unknown fish are not assigned a life stage so are not included in totals for adults and juveniles.

Appendix Table 23. Summary of unique detection from the Entiat River at Stormy interrogation site (ENS) during the 2011 monitoring period. PTAGIS naming convention used to indicate run and rear type.

Species (indicating rear and run type)	Total Juvenile	Total Adult	Total Detected
Hatchery spring Chinook salmon	1	25	26
Wild spring Chinook salmon	9	41	50
Wild summer Chinook salmon	0	1	1
Chinook salmon (unknown run and rear type)	0	12	12
Wild Chinook salmon (unknown run)	52	16	68
Wild summer steelhead	11	5	16
Bull trout	3	10	13
Wild resident cutthroat trout	1	0	1
Unknown species run and rear			1[a]
Grand totals	77[a]	110[a]	188[a]

[a] Unknown fish are not assigned a life stage so are not included in totals for adults and juveniles.

Appendix Table 24. Summary of unique detection from the middle Entiat River Forest Service boundary interrogation site (ENF) during the 2011 monitoring period. PTAGIS naming convention used to indicate run and rear type.

Species (indicating rear and run type)	Total Juvenile	Total Adult	Total Detected
Hatchery spring Chinook salmon	2	23	25
Wild spring Chinook salmon	15	30	45
Chinook salmon (unknown run and rear type)	0	9	9
Wild Chinook salmon (unknown run)	11	8	19
Wild summer steelhead	9	12	21
Hatchery coho salmon (unknown run)	1	0	1
Summer steelhead (unknown rear type)	0	1	1
Bull trout	1	7	8
Unknown species run and rear	--	--	1
Grand totals	39[a]	90[a]	130

[a] Unknown fish are not assigned a life stage so are not included in totals for adults and juveniles.

Appendix Table 25. Summary of unique detections from the Mad River interrogation site (MAD) during the 2011 monitoring period. PTAGIS naming convention used to indicate run and rear type.

Species (indicating rear and run type)	Total Juvenile	Total Adult	Total Detected
Hatchery spring Chinook salmon	0	4	4
Wild spring Chinook salmon	1	1	2
Wild summer Chinook salmon	2	0	2
Chinook salmon (unknown run and rear)	0	1	1
Wild Chinook salmon (unknown run)	54	1	55
Hatchery summer Chinook salmon	1	0	1
Wild coho salmon (unknown run)	1	0	1
Hatchery summer steelhead	0	3	3
Wild summer steelhead	158	20	178
Bull trout	4	3	7
Unknown species run and rear	--	--	24
Grand totals			

[a] Unknown fish are not assigned a life stage so are not included in totals for adults and juveniles.