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Abstract

During 2013, the Mid-Columbia River Fishery Resource Office conducted several projects as part of the Integrated Status and Effectiveness Monitoring Program’s Entiat River Intensively Monitored Watershed study. In addition to operating a rotary screw trap and conducting steelhead redd surveys it also directed mark-recapture studies and operated Passive Integrated Transponder (PIT) tag antennas in both the mainstem Entiat River and off-channel habitats. Screw trap operation was conducted between March and November and caught a total of 55,351 fish. The Entiat River mark-recapture study collected 12,692 juvenile fish species at 20 locations along the mainstem Entiat and Mad Rivers. The off-channel habitat study resulted in the capture of 6,785 juvenile fish. Through all studies combined, a total of 74,828 fish were captured and 32,307 wild salmonids were marked with PIT tags. Six PIT tag interrogation sites were operated within the mainstem Entiat River throughout this reporting period. Sixteen additional PIT tag antennas were used to monitor juvenile fish use in six off-channel habitats. Steelhead redd surveys were conducted from February 4 to May 10, 2012. A total of 141 redds were observed in the lower 45 km of the river. The first redd was observed on March 19 with a peak of 45 new redds being observed occurring during the last full week of April.
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Introduction

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

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

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

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

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

Juvenile outmigration study

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

*Entiat River IMW study*

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

*Off-Channel Habitat study*

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

*PIT Tag Interrogation Site monitoring*

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

*Steelhead redd surveys*

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

**Study Area**

The Entiat River watershed originates from 11 glaciers and snowfields in the Cascade Mountains and flows southeast approximately 69 km to join the Columbia River at river kilometer (rkm) 778 (CCCD 2004, Mullan et al. 1992). The Entiat watershed is bordered by the Entiat Mountains to the southwest and the Chelan Mountains to the northeast and drains approximately 1,085 km². 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,).
Methods-Rotary Screw Trap

Rotary screw trap operation

The Mid-Columbia River Fishery Resource Office (MCRFRO) has been operating a rotary screw trap in the Entiat River at rkm 2 since 2007 (Figure 2). One modified 5 ft. diameter rotary screw traps (EG Solutions Inc.) was used to capture downstream migrating salmonids. The trap was retrofitted with pontoons from 8 ft. style screw traps to increase floatation and safety during higher flow. It was further modified to include a high pressure spray system to minimize algal accumulation upon the screen of the cone. Trap operations followed operational permit
guidelines as per Chelan County Shoreline Management Act (file# SE 06-016 US Fish and Wildlife Service Fish Enhancement letter dated August 16, 2006), WDFW Temporary Use Permit (dated 11/27/07), and Hydraulic Project Approval Permit (control#125868-1, dated February 06, 2012). The trap was operated seven days a week from March through November with allowances for some events. If possible, the trap was operated 24 hours a day; however, during spring high flows and periods of increased debris loads it was operated from sunset to sunrise.

Figure 2. Map of the rotary screw trap location in the Entiat River, 2013.
Fish handling procedures were conducted in accordance with WDFW Scientific Collection Permit #13-107 and #13-107a (annual permits - start date April 9, 2013, expires April 9, 2014); NOAA Permit 1119 (dated April 10, 2008, expires December 31, 2013); and USFWS sub permit No. MCRFO-14 (dated April 15, 2013, expires December 31, 2016) under Regional Blanket Permit TE-702631.

At least once a day, juvenile fish were removed from the trap live box for PIT tagging and biological sampling. Fish were anesthetized prior to any biological sampling. All fish were identified to species with the exception of sculpin, dace, and suckers. All salmonids were ascribed a life history stage as either fry (<60 mm), parr (>60 mm and distinctive parr marks), transitional (>60 mm silver sheen, faint parr marks) or smolt (>60 mm silver sheen with absent parr marks with possible black tipped caudal). For all other species, a daily minimum of 30 fish per species and life stage were measured to the nearest mm of fork length and weighed to the nearest tenth of a gram. All Chinook salmon, steelhead, coho salmon, sockeye salmon, bull trout, and cutthroat trout were measured to the nearest millimeter of fork length and weighed to the nearest tenth of a gram.

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 2013, Fish Passage Center provided limited PIT tags for spring Chinook salmon and steelhead as a part of the Comparative Survival Study. Tags for the remaining Chinook salmon and steelhead were supplied by ISEMP, while Chelan County PUD provided tags for bull trout, and USFWS supplied PIT tags for cutthroat trout and coho salmon. Any injuries or abnormalities were noted and juveniles were not PIT tagged if determined to have had a recent or substantial injury that could be aggravated by tagging. After handling, all species were allowed to fully recover prior to release. PIT tagged juveniles were generally held 24 hours to monitor survival and tag retention. A maximum of 72 hours hold time was instituted on all tagged fish. Non-tagged individuals were released approximately 400 meters downstream from the trap after a minimum of one hour recovery time.

Data entry
All fish data were entered into the P3 program from PTAGIS. P3 is a data entry application used to collect and submit information about marked or recaptured PIT tagged fish in the Columbia River Basin. USFWS used this program to enter all fish information whether or not the fish was marked with a PIT tag. Data files generated from P3 were parsed into a custom Microsoft Access™ database constructed by MCRFRO staff for the purpose of preparing data for analytical use and various reports. The original P3 file was left intact and subsequently uploaded to PTAGIS where it is available to researchers throughout the Columbia River Basin.
**Genetic and scale sampling**

Throughout the sampling period, a subset of captured bull trout, cutthroat trout, Chinook salmon, and steelhead juveniles were sampled for genetic and age analysis as suggested within the Upper Columbia Monitoring Strategy (Hillman 2006). Genetic material was collected by taking a small clip of tissue from either the ventral fin (steelhead, cutthroat trout & Chinook salmon) or caudal fin (bull trout). All tissue samples along with scale samples taken from steelhead were sent to the Region 1 USFWS genetics lab for archiving and 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 rotary screw trap. All fish used for efficiency trials were either PIT tagged (>50 mm FL) or dye marked (<50 mm FL) with Bismarck Brown Y dye. All marked fish were placed in a live box for holding (<72 hrs.) prior to release. Juvenile fish used for efficiency trials were released after twilight upstream of the trap at rkm 2.3 (Keystone Ranch private bridge). Monitoring of the efficiency trials was limited to the three days following each release in order to minimize potential affects related to river flow. Recaptured fish were re-measured, released, and not included in subsequent efficiency testing.

**Water temperature and flow**

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

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**Discussion- Rotary Screw Trap**

**Fish collection**

A total of 55,310 fish were caught by the rotary screw trap during 2013. Of these, Total juvenile fish capture consisted of 6,671 spring Chinook salmon (12.05%), 39,727 summer Chinook salmon (71.77%), 2,260 steelhead trout (4.08%), 55 coho salmon (0.10%), 320 sockeye salmon (0.58%), 47 bull trout (0.08%), 32 cutthroat trout (0.06%), 3,076 lamprey (5.56%), and 3,122 non-target species (5.71%). A total of 24,712 wild salmonids were implanted with PIT tags.

**Rotary screw trap operation**

The trapping season began on March 5th and ended on November 20th. Of the 261 days available, the rotary screw trap operated for 193 (73.9%) days of sunset to sunrise sampling. The day to day operation of rotary screw traps can be time consuming and difficult. Seasonally high discharge and weather events often increase the amount of debris present within the river leading to higher frequencies of missed trapping periods due to trap failure. These periods require more staff to maintain the traps in an operational condition. The high flows and debris can create a hazardous work environment for the crew, increase the trap related mortality of captured fish, and cause damage to equipment. To minimize these hazards, the trap was removed from operation when necessary. The majority of non-operational days were due to snow melt resulting
in a high spring flow. 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.

**Project goals**

Project goals were met during the 2013 field season. In 2014, we will continue out-migrant monitoring using the rotary screw trap to evaluate the success of wild steelhead and spring Chinook salmon recovery actions. This is especially relevant in order to monitor the effects of the discontinuation of the spring Chinook salmon program and the start of a summer Chinook program at the ENFH. In 2014, MCRFRO staff will continue efforts to review parameters and validate key assumptions associated with spring Chinook and steelhead productivity estimates.

**Methods- Mark-Recapture Sampling**

**Sample site selection**

The mark-recapture study was designed around a framework of a rotating panel of sites within defined geomorphic reaches of the Entiat River. Sample sites were selected at random from each reach. If a site was unavailable to be sampled, the next upstream site was then selected. A total of 14 sites were sampled during the winter period which were the same sites sampled the previous summer. New sites were selected for the summer 2013 sampling period. A total of 20 sites were selected for the summer period. Eight sites were identified as mark-recapture sites and 12 were sampled as single pass or only mark sites. The 20 summer sites will be sampled again in the winter of 2014. Sample site locations for winter and summer sample periods in 2013 are presented in Figures 3 and 4 respectively.
Figure 3. Map of the mark-recapture sites sampled during the winter period in the Entiat River, 2013.
Figure 4. Map of the mark-recapture sites sampled during the summer period in the Entiat River, 2013.

Sample periods
Mark-recapture sampling was conducted twice annually. Winter surveys were conducted within the Entiat and Mad Rivers during March of 2013, prior to the beginning of the spring emigration period. Summer surveys were conducted during August when river discharge fell below 9.9 m$^3$/s.

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

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

Fish handling

Fish were handled in accordance with WDFW Scientific Collection Permit #13-107 and #11-157 (annual permits - start date April 9, 2013, expires April 9, 2014), NOAA Permit 1119 (dated April 10, 2008, expires December 31, 2013) and USFWS Sub permit No. MCRFO-14 (dated April 15, 2013, expires December 31, 2016) under Regional Blanket Permit TE-702631.

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

Collected species were anesthetized in a water bath with a measured amount of tricaine (MS-222) buffered with sodium bicarbonate. Small groups of fish were anesthetized at any one time during daily handling to reduce the chance of incidental mortality from anesthetic overdose. Fish were identified to species with the exception of sculpin, dace and suckers. Chinook salmon run designation was classified as unknown when captured during the summer period due to the inability to distinguish between spring and summer run characteristics. All salmonids were ascribed to a life history stage as either fry (<60 mm), parr (>60mm and distinctive parr marks), transitional (>60 mm silver sheen, faint parr marks, and deciduous scales) or smolt (>60 mm silver sheen, absent parr marks, deciduous scales, and with possible black tipped caudal fins).
All Chinook salmon, steelhead, coho salmon, sockeye salmon, bull trout, and cutthroat trout were measured to the nearest millimeter of fork length and weighed to the nearest tenth of a gram. Fulton-type condition factor was calculated for all Chinook and steelhead as described previously. Non-target species were either measured or counted and released within the site dependent upon time restrictions. All individuals were allowed full recovery prior to release. Non-marked individuals were released within the site in close proximity to their point of capture.

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

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

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

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

Discussion- Mark-Recapture Sampling

Fish sampling
Warmer winter temperatures and lower snow accumulations minimized shelf ice buildup and allowed easier access to the sample sites during the winter sample period. These climate factors allowed for better capture conditions for the winter period and lower flows during the summer period. The winter sample period occurred from March 4-15th prior to the expected onset of Chinook salmon and steelhead emigration. Hand netting was used during the winter period.
because electrofishing and angling are not suitable methods for sampling at night. A total of 771 Chinook and 2,237 steelhead were PIT tagged during the winter period.

The summer sample period targeted a maximum flow of 8.5\(\text{m}^3/\text{s}\) for the onset of fish sampling. Sampling began on August 2\(^{nd}\) and was completed on August 15\(^{th}\). Electrofishing, snorkel-seining, beach seining and angling allowed for 2,991 Chinook and 1,409 steelhead to be PIT tagged. 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 was used prior to electrofishing at sites where either method was possible. Delayed mortality and PIT tag shed rates were not assessed during the 2013 mark-recapture sampling. This was due to extensive evaluations during prior sampling occasions and daily assessments of tagged fish from the rotary screw trap.

**Project goals**

Project goals were met during 2013. 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 2014, MCRFRO staff will further test the assumption of population closure and work towards a solution to the violation of this assumption. Efforts to model juvenile growth and survival estimates for the IMW study area will continue in 2014.

**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. Six sites were selected and sampled during the 2013 season (Figure 5).
Figure 5. Map of the Entiat River watershed defining locations of the five off-channel study sites, 2013.

Site Descriptions

The Harrison side-channel (HAR) is located at rkm 6.0. In 2008 it was reconnected to the main-channel by partial removal of a levee. It is a 515 m long channel that has both a high flow and low flow connection to the main channel. The low flow branch consists mainly of beaver dams and sand. The high flow branch and lower channel below the confluence are comprised of low gradient large cobble riffle habitat and pools.

The SanRay side-channel (SAN), located at rkm 7.0, consists of a 117 m long naturally occurring perennial side-channel that reconnects to the main river. A now defunct irrigation canal historically entered the channel near its upstream end. The side-channel is composed primarily of riffle-run habitat with few pools and complex wood structure.
The Wilson side-channel (WLS), at rkm 11.0 near the ENFH, consists of a 286 m long reconnecting perennial side-channel. Habitat within the side-channel is complex and has changed considerably since its construction in 2006. The lower portion of the site is comprised of downed trees and a series of beaver dams and pools, whereas the upper portion is a cobble riffle with thick riparian cover.

The Tyee side-channel (TYE) is located at approximately rkm 38.0. The site was completed as part of the 2012 round of habitat implementation under the Entiat IMW. An existing beaver pond was deepened and enhanced with large wood in what is now the lower portion of the side-channel. Flow is maintained within the side-channel through connections made above and below the beaver pond. Upstream connections utilize a main, low flow channel as well as a reconnected high flow channel. The side-channel is 304 m in length and is largely a glide habitat with substrates including silt, sand, gravel, and cobble.

The 3D site is located at rkm 42.7. The site was completed as part of the 2012 round of habitat implementation under the Entiat IMW. The side-channel utilizes the lower portion of Brennegan Creek as it connects to the Entiat River. Additional channel was constructed making an upstream connection between the creek and the Entiat River and large wood was added to both sections. The total length of the side-channel is 402 m in length. The reconstruction of an existing beaver dam at the base of Brennegan Creek has resulted in added depth and reduced velocity within the lower portion of the side-channel.

Sampling periods
Sampling occurred at 4 sites (Tyee was not sampled) during the winter period from March 19 to March 29. Summer sampling occurred between August 20 and September 6 at all 5 sites. All 5 were also sampled during the fall period which occurred from October 1-11.

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

All sampling periods utilized the QC_PIT Tagging program developed by Quantitative Consultants, Inc. Data files created by QC_PIT Tagging were then entered into a custom MS Access® database also developed by Quantitative Consultants, Inc., where a quality check was performed and a P3 file is created. All data files were provided to ISEMP and the original P3 file uploaded to PTAGIS where they are available to researchers throughout the Columbia River Basin.

**PIT tag antenna monitoring**

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

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

**Water temperature monitoring**

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

**Dissolved Oxygen monitoring**

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

**Discussion- Off Channel Habitat Study**

**Fish sampling**

The winter sampling period produced 172 Chinook and 246 steelhead PIT tagged individuals. During the summer period new PIT tags were placed in 1,806 Chinook and 280 steelhead. Totals of 487 Chinook and 219 steelhead were PIT tagged during the fall period. In our experience, electrofishing has resulted in higher numbers of capture related mortalities when compared to
other methods. Low water depth and high turbidity inhibits the use of hand-netting and snorkel-seining as a capture method at most of the off-channel sites. These methods are preferable due to the lower occurrence of capture related mortality and will be utilized in the future as site conditions allow. Delayed mortality and tag shed rates were not assessed during off-channel sampling as these rates have been well documented in past mark-recapture efforts.

Antenna monitoring

Antennas were added to three side channels in 2013: Harrison, 3D, and Tyee. Solar power was added to nearly all the off channel antennas in 2013. This greatly reduced the amount of time and effort required to maintain each site. Sites were operated continually with the exception of the occasional couple weeks due to power loss, equipment failure, or destruction by high flow. Some antennas, such as the upstream ends of the Harrison and Tyee channels are dry for most of the year and so while the antennas are working correctly, they are not detecting any fish due to the absence of water. The antennas monitoring the PUD canal were in operation for the first half of the year but were removed due to conflicts with monitoring and the operations schedule of the canal. It was noted that some of the antennas are beginning to attract fish as habitat which causes a significant increase in the number of detections. In 2014 we will examine the possibility of filling in areas near the antennas with larger rocks and/or sand may reduce the quality of this habitat and therefore reduce the number of detections to a more manageable level.

Project goals

MCRFRO added three new sites during 2013. By adding these sites we are able to continue monitoring various habitat types at different locations. Two sites sampled in years past were not sampled in 2013. This was due to several factors. Sampling in the Don Jean side-channel has historically yielded very few fish. This may be in part to the available habitat. It was decided that focusing our sampling efforts in other side-channels at this time might be more productive. We plan on periodically sampling the Don Jean side-channel to look for changes in fish abundance. The PUD side-channel was also not included in this year’s sampling schedule. The assumptions that are used by this study regarding fish movement are not being met by the way the PUD side-channel is currently being operated. It is hoped that these differences can be addressed and allow for sampling in this channel once again in the future. As more data is acquired, a quantitative assessment of the biological importance of these habitats to juvenile spring Chinook and steelhead will be accomplished. MCRFRO is hopeful that this study will provide valuable insight into the design of future off-channel habitat restoration projects.

Methods- PIT Tag Interrogation Site Monitoring

Interrogation site locations

MCRFRO operated six PIT tag interrogation sites within the Entiat watershed in 2013. 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 6.

Figure 6. Map of the locations of PIT tag interrogation sites in the Entiat River, 2013.

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. Modems allowed data to be downloaded via a wireless connection. Site operations were checked through a website designed by QCI. Emails were automatically sent to inform us when an operations issue occurred at a site.

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

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

**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 2013. 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.

**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. During the late spring/early summer ENL, ENA, and ENM all had a period of down time associated with high flow damage. The ENF site experienced intermittent power failures during the summer and fall due to equipment failure but was ultimately fixed.

**Project goals**

Project goals were met during 2013. In the coming year we will upgrade the capacity of interrogation site monitoring. Installation of wireless modems and use of the QCI website greatly reduced the amount of time spent downloading and checking on the status of each site. We will continue to explore various methods to determine site detection efficiency. We will also explore new anchoring techniques and materials in attempt to maintain interrogation sites in an operable status through normal high river discharge condition.
Methods – Steelhead 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 to the Entiat information kiosk, rkm 45 and 1.1 respectively (Figure 1). The survey area was divided into four reaches based on river access points and distances that could be surveyed in a single day. A two person crew, each using a 10’cataraft, conducted redd surveys in a downstream manner. Surveyors walked areas that were inaccessible or unsafe to raft. All four reaches were surveyed on a weekly basis as weather and stream conditions permitted.

![Map of Entiat River with survey reaches](image)

**Figure 7**. The four reaches of steelhead redd surveys on the Entiat River, 2013.

Discussion- Steelhead Surveys

Steelhead spawning ground surveys on the Entiat River were conducted within the required time frame. Surveys began on February 14, 2013 and continued through June 18, 2013. No surveys
were conducted between May 6 and 24 due to high water conditions. A total of 141 redds were counted throughout the survey season with the first observed on March 19. Redd counts peaked with 47 new redds added during the week of April 22-26.
References


