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Chinook Salmon Spawning Ground Surveys on the Entiat River, 2013

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Mid-Columbia River Fishery Resource Office
Leavenworth, WA 98826

***On the cover**: U.S. Fish and Wildlife Biological Science Technician, Josh Pieratt, sampling a summer Chinook salmon carcass on the banks of the Entiat River (October 28th, 2013). USFWS photograph by Robbette M. Schmit.*

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Abstract-This report summarizes the results of spring and summer Chinook salmon (*Oncorhynchus tshawytscha*) spawning ground surveys conducted in the Entiat River Basin in 2013. Data were collected on spawning location, spawn timing, redd characteristics, and superimposition. Salmon carcasses were recovered and analyzed for run, gender, age, rearing origin, and any research tags or marks they may have contained. The data were used to describe the population of returning adults from each run, using metrics including spawning run escapement size, natural- and hatchery-origin proportions, age class composition, and stray rates. Opportunistic data were also collected on sockeye salmon (*O. nerka*) and coho salmon (*O. kisutch*) spawning in the Entiat River Basin.

In 2013, a total of 99 spring Chinook salmon redds and 316 summer Chinook salmon redds were identified. A proportion (0.19) of spring Chinook salmon redds were superimposed upon by summer Chinook salmon , with 97% of this superimposition being conducted by natural-origin summer Chinook spawners. The spawning escapement was estimated to be 238 spring Chinook salmon and 758 summer Chinook salmon.

In 2013, carcass recoveries consisted of 22 spring Chinook salmon and 154 summer Chinook salmon, with carcass recovery rates for each run 0.09 and 0.20, respectively. Natural-origin fish accounted for 79% of the spring Chinook salmon spawning escapement, and 84% of the summer Chinook salmon spawning escapement. All spring Chinook salmon hatchery strays were from out-of-basin; Chiwawa Rearing Ponds (80%) and Chewuch Acclimation Site (20%). Summer Chinook salmon strays originated in-basin; Entiat NFH (24%), and out-of-basin; Dryden Acclimation Pond (41%), Turtle Rock Hatchery (29%), and Wells Hatchery (6%). The age class composition of spring Chinook salmon was made up of 37% age-3, 21% age-4, and 42% age-5 fish. For summer Chinook salmon, the age class composition was 9% age-3, 45% age-4, 45% age-5, and 1% age-6.

In 2013, 173 sockeye salmon and 10 coho salmon redds were identified.

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Introduction

Chinook salmon (*Oncorhynchus tshawytscha)* spawning ground surveys have been conducted on the Entiat River since 1962 for the spring run and since 1957 for the summer run. In the past two decades, surveys for spring and summer Chinook salmon in the Entiat River have become more rigorous in regards to effort and areas surveyed. Chinook salmon spawning ground surveys consist of both redd counts and carcass recovery, and are designed to be a complete census of the primary spawning areas in the Entiat River Basin. This report details the methods and results of spawning ground surveys for Chinook salmon in the Entiat River for the return year of 2013. This report also marks the 20th year that the United States Fish and Wildlife Service (USFWS) Mid-Columbia River Fisheries Resource Office (MCRFRO) has been conducting these surveys.

The objectives of the spawning ground surveys are to:

- Assess the distribution of redds and estimate the spawning population of spring and summer Chinook salmon within portions of the Entiat & Mad rivers.
- Evaluate straying of hatchery spring and summer Chinook salmon, which includes documenting superimposition of ESA listed spring Chinook salmon redds by summer Chinook salmon.
- Opportunistically document the occurrence of other spawning salmon species during Chinook salmon surveys, which may include sockeye salmon (*O. nerka)* and coho salmon (*O. kisutch).*

Study Area

The Entiat River Basin is located in Chelan County, in north-central Washington State (Figure 1). The river originates in a glaciated basin of the Cascade Mountains and flows southeasterly. Base flow is 385 cubic feet per second (Mullan et al. 1992) and the two major tributaries of the Entiat River are the North Fork (RM 34) and Mad River (RM 10.1). The upstream limit of anadromy is Entiat Falls (RM 33.8).

The Entiat River system drains an area of approximately 417 square miles. The watershed is nearly 42 miles in length and varies in width from 5 to 14 miles. The basin's highest elevation is the 9,249 foot summit of Mt. Fernow and its lowest is approximately 700 feet at the confluence with the Columbia River (USDA 1979). The Entiat River drains into the Columbia River at approximately river mile 484. Fish migrating to the Entiat River have to travel through eight mainstem Columbia River hydroelectric dams; Bonneville, The Dalles, John Day, McNary, Priest Rapids, Wanapum, Rock Island, and Rocky Reach.

Chinook salmon spawning ground surveys on the Entiat River include most of the known available spawning habitat. The two runs of Chinook salmon utilize overlapping habitat in some areas of the river and in other areas their spawning habitat is segregated. In the Upper River Section, Reaches 1 through 5 (rm 28.1 to 16.2), both spring and summer Chinook salmon spawning habitat is available. The Mad River Section (rm 3.5-1.5) includes only spring Chinook salmon spawning habitat. The Lower River Section, Reaches H and F (rm 6.8-0.3), includes only summer Chinook salmon spawning habitat. Refer to Appendix A for additional reach descriptions, survey stretches and surveyed miles.

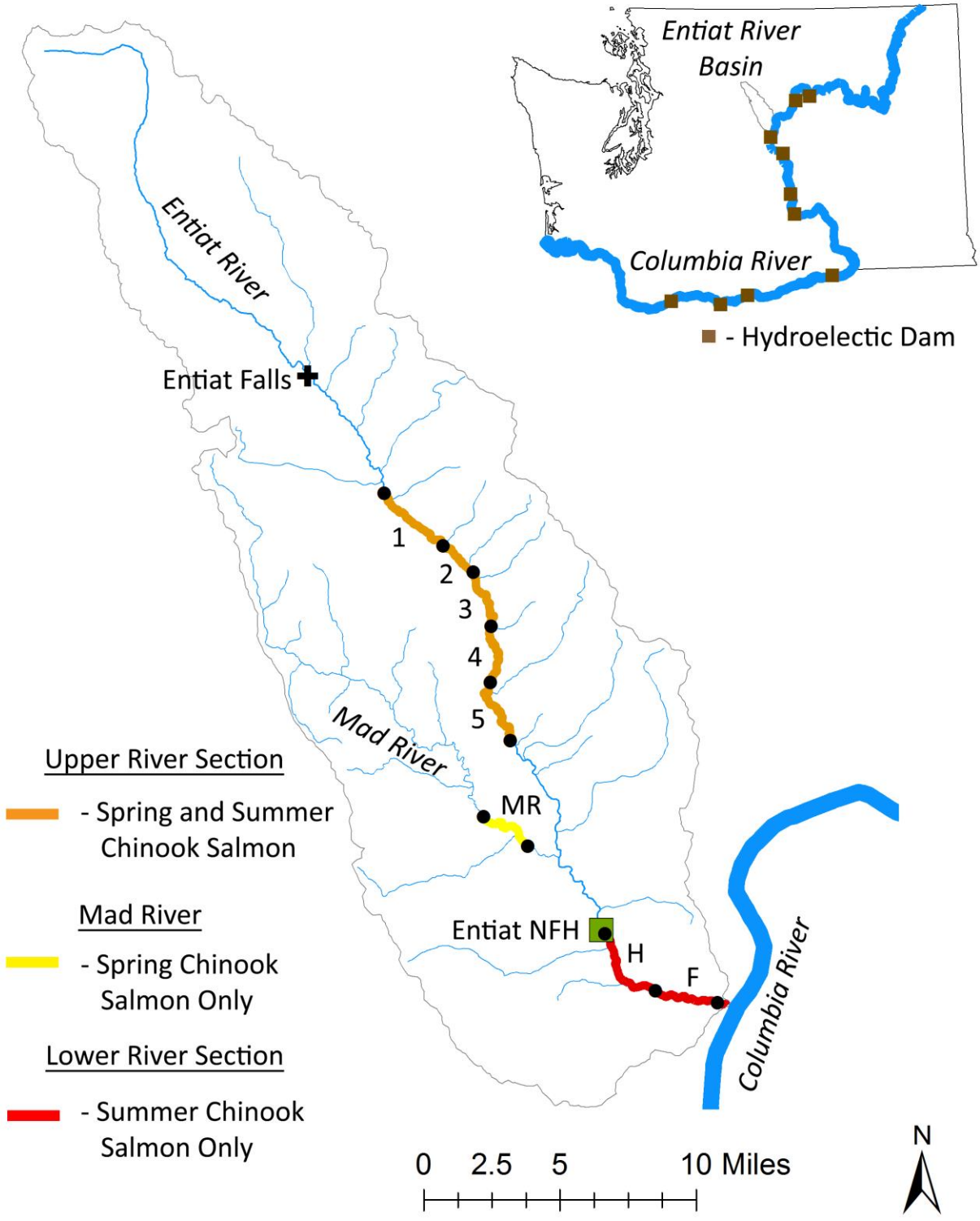

Figure 1. Overview of the Entiat River spawning ground survey areas.

Salmon Populations

The Entiat River has historically supported salmon runs consisting of Chinook and coho salmon (Craig and Suomela 1941). In the late 19th century the Entiat River began to be altered with the construction of numerous dams (from the mouth of the Entiat River to the town of Ardenvoir, rm 9.9) for milling and logging operations and to provide power for the towns of Entiat and Waterville (Long 2001). These dams blocked salmon from their spawning grounds and salmon runs were essentially nonexistent by 1939 when Grand Coulee Dam was built (Craig and Suomela 1941). Some mill dams on the Entiat River had fish ladders, but were ineffective in passing fish (USBF 1934/1935/1936). From 1939 to 1943, as part of the Grand Coulee Fish Maintenance Project, late returning adult salmon (mainly summer and fall Chinook salmon) were trapped at Rock Island Dam and relocated to tributaries below Grand Coulee Dam, including the Entiat River, and to hatcheries, including Leavenworth, Entiat, and Winthrop National Fish Hatcheries (Fish and Hanavan 1948). The goal of these efforts was to rebuild salmon runs in mid-Columbia tributaries and mitigate for lost production above Grand Coulee Dam. The last mill was closed in 1979 and with it the last channel spanning dam on the Entiat River.

Spring Chinook Salmon

In the initial years after Grand Coulee Dam was built (between 1939 to 1941), little effort was made to re-establish wild spring Chinook salmon runs in the Entiat River. From 1942 to 1944, the Entiat NFH released a total of 1.3 million sub-yearlings and ~50,000 yearling spring Chinook salmon that were offspring of the upriver stocks collected at Rock Island Dam (Mullan 1987). No spring Chinook salmon were reared at Entiat NFH from 1945 to 1973. The Entiat NFH resumed spring Chinook salmon production in 1974. Egg sources have included Cowlitz River (1974), Carson NFH (1975 to 1982), Little White Salmon NFH (1976, 1978, 1979, 1981), Leavenworth NFH (1979-1981, 1994), and Winthrop NFH (1988). Adults that voluntarily returned to the hatchery were the primary brood stock in 1980 and from 1983 to 2006. The last spring Chinook salmon juvenile release into the Entiat River was in 2007, after which the program was terminated. No Entiat NFH spring Chinook salmon have been observed since 2010 when the oldest age-class returned to the hatchery.

Natural-origin spring Chinook salmon were observed spawning in the Entiat River above rm 18.4 as early as 1956 (French and Wahle 1960). From 1962 to 1993, Washington Department of Fish and Wildlife (WDFW) annually walked the Entiat River after peak spawning between river miles 28.1 and 21.3 (Reaches 1 through 3, also referred to in past reports as the *index* area), to count spring Chinook salmon redds. In 1994, MCRFRO assumed responsibility for monitoring spring Chinook salmon redds in the Enitat River. At that time MCRFRO also expanded the survey area so that additional downstream reaches were included (below the *index* area), from RM 21.3 - 16.2 (referred to as the *expanded* section in prior reports) and a section on the Mad River, from RM 3.5 - 1.5.

Summer Chinook Salmon

Summer Chinook salmon are not believed to be endemic to the Entiat River (Craig and Suomela 1941) however, several efforts have been made to establish them following completion of Grand Coulee Dam. In 1939 and 1940, a total of 3,015 adult summer Chinook salmon, collected at Rock Island Dam from the commingled upriver stocks, were placed in upper Entiat River spawning areas, only an estimated 1,308 of these survived to spawn (Fish and Hanavan 1948). The Entiat NFH reared and released juvenile summer Chinook salmon into the Entiat River from 1941-1964, and in 1976 (Mullan 1987). After cessation of the

spring Chinook salmon program at Entiat NFH in 2007, a summer Chinook salmon program was reinitiated in 2009 with the first juvenile release occurring in 2011. The Entiat NFH summer Chinook salmon egg sources have included commingled upriver stocks intercepted at Rock Island Dam (1939-1943), Methow River (1944), Carson NFH (1944), Entiat River (1946-1964), Spring Creek NFH (1964), and Wells Hatchery (1974, 2009-2013).

From 1957 to 1991, summer Chinook salmon spawning was monitored by aerial surveys in the lower 10.1 river miles by Chelan County Public Utility District (PUD). No summer Chinook salmon spawning surveys were conducted in the lower section in 1992 and 1993. In 1994, MCRFRO began conducting redd surveys by foot in the Upper River Section (RM 28.1 - 16.2) and portions of the lower river, which included spot checks at the Mad River mouth (RM 10.1) and various sections below the hatchery (< RM 6.8). In 2006, a continuous stretch of the lower river (the Lower River Section) began to be surveyed annually by raft, starting at the hatchery and concluding at the influence of the Columbia River (RM 6.8–0.3).

Natural-origin summer Chinook salmon can exhibit one of three distinct freshwater life histories; (age 0) ocean-reared juveniles which spend their first year wintering in the ocean, (age 1) stream-reared juveniles which spend their first year wintering in the stream, and (age 1) reservoir-reared juveniles which spend their first year winter in a reservoir (Healy 1991).

Sockeye and Coho Salmon

Sockeye salmon are not indigenous to the Entiat River (Craig and Suomela 1941), and have only been stocked on two occasions (1943 and 1944) from Lake Quinault and Lake Whatcom stocks (Mullan 1986). A small run of sockeye salmon became established in the Entiat River enabling the Entiat NFH to collect sockeye salmon from 1944 to 1963, and distribute juveniles outside of the Entiat River watershed (Mullan 1986). Presently, sockeye salmon returning to the Entiat River are natural-origin and out-of-basin hatchery strays.

Coho salmon runs had been largely extirpated in the mid-Columbia River basin prior to 1941 (Mullan 1983). Propagation of coho salmon at the federal mid-Columbia hatcheries began in the 1940s and extended into the early 1970s. Chelan and Douglas County PUD's, in cooperation with WDFW, started propagation of coho salmon in the 1970's and continued until 1994. In 1996, the Yakama Nation initiated the Mid-Columbia Coho Restoration Program, which is attempting to reintroduce the species into the Wenatchee and Methow sub-basins. Although no releases have occurred in the Entiat River, coho salmon have been observed in the Entiat River since 2001.

Methods

Spring and Summer Chinook Salmon Redd Surveys

Redd surveys consisted of surveying reaches by walking or rafting downstream on a weekly or bi-weekly basis throughout the spawning period. Areas of gravel disturbance and or spawning activity were determined to be a redd if there was a distinguishable pit and tailspill area, and the redd was larger than 1.5m long x 0.5 wide. Each redd was marked with colored flagging hung on nearby vegetation and redd

descriptions were recorded, including; length, width, presence of fish and GPS coordinates using a Garmin *Rino*™530.

Spawn timing and spatial distribution of redds was examined for both runs. Peak spawning was designated as the week in which the greatest number of new redds were excavated. Spatial distribution of redds was examined in the entirety of the surveyed sections, as well as on a reach by reach basis. Spawn timing and the spatial distribution of redds was compared to the 2006-2012 averages (7-yr average), as this was a period of consistent survey methods.

Spring and Summer Chinook Salmon Carcass Recoveries

Carcasses recovered during spawning ground surveys were utilized to describe the characteristics of the spawning population. Carcass recoveries consist of all mature adults, including age-2 (precocial or mini-jack) fish. While age-2 fish are sampled, their recovery rate is likely very low and their spawning contribution is unknown. For these reasons they are not included in any of the spawning run escapement calculations.

Field protocols for carcasses follow Crawford et.al (2007). When a carcass was found during a spawning ground survey, its gender was determined through abdominal dissection. Other physical carcass attributes include fork length and post-orbital hypural length to the nearest centimeter, and adipose fin condition (absent, intact, or partial). Scales were removed from carcasses to determine age, origin (natural or hatchery) and juvenile life history type. Tissue samples (fin clips) were taken and archived for future DNA analysis. Carcasses were also scanned for Passive Integrated Transponder (PIT) tags and Coded Wire Tags (CWT) with portable handheld detectors. If a CWT was present, the snout was removed for tag extraction. Detected PIT tags were recorded but not retained. Each carcass sampled had its caudal (tail) fin removed to indicate that it had been sampled and was then placed back in the stream.

Spawning success was categorized only for females by visually estimating the number of eggs retained within the body cavity (complete spawn success was <1% of eggs retained, incomplete spawn success was 2-99% eggs retained, and pre-spawn mortality was determined by total egg retention). This report does not further address pre-spawn mortality only documents its presence. This is largely because surveys often start the same week or the week prior to the beginning of spring Chinook salmon spawning and therefore mortality before spawning is not documented.

After the completion of the surveys, CWT's and scales were read and recorded. Data was entered into an archived database housed at the MCRFRO, and uploaded to regional databases including the Regional Mark Information System (www.rmpc.org), the PIT Tag Information System (www.ptagis.org), and StreamNet (www.streamnet.org).

Sockeye and Coho Salmon Redd Surveys

During Chinook salmon spawning ground surveys, sockeye and coho salmon spawning activities were documented, and carcasses sampled. Coho and sockeye redds were determined by the presence of live adults and/or redds of less than 1.5 m x 0.5m wide in substrate < 5 cm. diameter. All recovered sockeye and coho salmon carcasses were scanned for CWT and PIT tags. No scales, genetics, or spawn success data was collected for these species.

Estimating Salmon Spawning Escapement using Fish/Redd Ratio

Estimating the spawning run escapement (SRE) for both spring and summer Chinook salmon returning to the Entiat River was calculated as follows:

$$\text{SRE} = \#\ \text{redds} * 2.4\ \text{fish/redd}\ \ \text{(Mullan 1990)}$$

Scale Analysis and Age Determination

Scales were used to identify growth periods (freshwater age and saltwater age) and origin (hatchery or natural) using Gilbert (1912). Age descriptions are presented with the first numeral as the number of winters spent in freshwater (not including the winter of egg incubation), followed by a period, and then the second numeral as the number of winters spent in saltwater (Koo 1962). Total age, therefore, is equal to one plus the sum of the two numerals. For example, a five year old fish that emigrated to the marine environment as a sub-yearling and returned to the Entiat River would be classified as age 0.4.

Summer Chinook salmon scales were further examined to determine juvenile life history strategy and primary rearing location. These strategies include ocean type which enter the marine environment as a sub-yearling, reservoir type which spend their first winter in the Columbia River, and stream type which spend their first winter in their natal tributary. To document these rearing strategies we followed Gilbert (1912) classification of ocean and stream types and Connor et. al (2005) classification of reservoir type.

Carcass Recovery Rate

Estimating the carcass recovery rate (CRR) for both spring and summer Chinook salmon returning to the Entiat River to spawn was calculated as follows:

$$\text{CRR} = \frac{\text{Carcasses}}{\text{SRE}}$$

Where: Carcasses is the number of examined carcasses, and SRE is the estimated total spawning run escapement of adults to the river.

Estimating Natural-origin Spawners

(1) Calculate the proportion of natural-origin spawners (pNOS);

$$\text{pNOS} = \frac{\text{NOC}}{\text{TC}}$$

Where: NOC is the number of natural-origin carcasses recovered, and TC is the total number of known origin carcasses recovered.

(2) Calculate the number of natural-origin spawners (NOS);

$$\text{NOS} = \text{pNOS} * \text{SRE}$$

Natural Spawning Run Escapement

(1) Calculate the proportion of spawning run escapement (pSRE) by age class (*a*);

$$\mathrm{pSRE}_a = \frac{\mathrm{NOC}a}{\mathrm{TC}}$$

Where: NOC*a* is the natural-origin carcasses of an age class.

(2) Calculate the spawning run escapement (SRE) by age class (*a*);

$$\mathrm{SRE}_a = \mathrm{pSRE}_a * \mathrm{NOS}$$

Estimating Hatchery-origin Spawners

(1) Calculate the proportion of hatchery-origin spawners (pHOS);

$$\mathrm{pHOS} = \frac{\mathrm{HOC}}{\mathrm{TC}}$$

Where: HOC is the number of hatchery-origin carcasses recovered.

(2) Calculate the number of hatchery-origin spawners (HOS);

$$\mathrm{HOS} = \mathrm{pHOS} * \mathrm{SRE}$$

Hatchery Spawning Run Escapement

Hatchery-origin fish found on the spawning grounds may be from different facilities and thus need to be partitioned by tag code (*x)* to calculate spawning run escapement ($\mathrm{SRE}_{\mathrm{CWT}x}$). In order to estimate the potential total number of adults represented by a particular recovered CWT, we expand each CWT by using the following three-step process:

(1) Calculate the expanded CWT ($\mathrm{CWT}_{\mathrm{Expanded}}$) recoveries for each tag code (*x*) recovered;

$$\mathrm{CWT}_{\mathrm{Expanded}}{}^{x} = \frac{(\mathrm{CWT}_{\mathrm{Rcvrd}}{}^{x}/\mathrm{CWT}_{\mathrm{rate}}{}^{x})}{\mathrm{CRR}}$$

Where: $\mathrm{CWT}_{\mathrm{Rcvrd}}$ is the number of coded-wire tags recovered by each specific CWT code, $\mathrm{CWT}_{\mathrm{rate}}$ is tagging rate for each CWT code, and CRR is the calculated carcass recovery rate calculated in step 1.

.

(2) Calculate the proportion of CWT (pCWT) by tag code (*x*);

$$\mathrm{pCWT}_x = \frac{\mathrm{CWT}_{\mathrm{expanded}}{}^{x}}{\Sigma\mathrm{CWT}_{\mathrm{expanded}}}$$

(3) Calculate the spawning run escapement (SRE_{CWT}) by tag code (x);

$$SRE_{CWTx} = pCWT_x * HOS$$

Estimating Spring Chinook Salmon Superimposition Rates

We defined superimposition as the partial or complete disturbance of an earlier spawned spring Chinook salmon redd by a later spawning summer Chinook salmon. Superimposition rate is defined as the percent of spring Chinook salmon redds superimposed upon by summer Chinook salmon. We have assumed that superimposition occurs only within river miles 28.1 - 16.2, where both runs have been documented to overlap in spawning ground utilization.

Spring Chinook salmon redds were recorded with a GPS unit and visually described (i.e. near woody debris, angle of redd, distances from bank, etc.) to precisely identify location. Surveys of summer Chinook salmon redds immediately followed spring Chinook salmon surveys and superimposition was documented as present or absent for each spring Chinook salmon redd recorded earlier.

To estimate the proportion of superimposition on spring Chinook salmon redds (pSI) by summer Chinook salmon we used the following equation:

$$pSI = \frac{redds\_SCS_{SI}}{redds\_SCS}$$

Where: $redds\_SCS_{SI}$ equals the number of spring Chinook salmon redds superimposed upon by summer Chinook salmon redds, and redds_SCS equals the total number of spring Chinook salmon redds.

To estimate the extent of superimposition caused by natural- and hatchery-origin summer Chinook salmon. The following criteria were utilized: only female summer Chinook salmon carcasses of known origin were used, each summer Chinook salmon redd represented one summer Chinook salmon female, and superimposition is not related to origin.

To estimate summer Chinook salmon's superimposition impact on spring Chinook salmon redds the following steps were taken:

(1) Proportion hatchery-origin female summer Chinook salmon spawners (pHOS_SUS♀) was calculated using the following equation;

$$pHOS\_SUS_{♀} = \frac{HOC\_SUS_{♀}}{TC\_SUS_{♀}}$$

Where: $HOC\_SUS_{♀}$ equals the number of hatchery-origin female summer Chinook salmon carcasses, and $TC\_SUS_{♀}$ equals the total number of known origin female summer Chinook salmon carcasses.

(2) Proportion natural-origin female summer Chinook salmon spawners (pNOS_SUS♀) was calculated using the following equation;

$$\text{pNOS\_SUS}_{♀} = \frac{\text{NOC\_SUS}_{♀}}{\text{TC\_SUS}_{♀}}$$

Where: NOC_SUS♀ equals the number of natural-origin female summer Chinook salmon carcasses.

(3) Estimate the carcass recovery rate (CRR_SUS♀) for female summer Chinook salmon carcasses;

$$\text{CRR\_SUS}_{♀} = \frac{\text{TC\_SUS}_{♀}}{\text{redds\_SUS}}$$

Where: TC_SUS♀ is the total number of known origin female summer Chinook salmon carcasses, and redds_SUS equals the total number of summer Chinook salmon redds.

(4) Proportion of spring Chinook salmon redds superimposed by natural-origin female summer Chinook salmon (pSIN) was calculated with the following equation;

$$\text{pSI}_{\text{N}} = \text{pNOC\_SUS}_{♀} * \text{pSI}$$

(5) Proportion of spring Chinook salmon redds superimposed by hatchery-origin female summer Chinook salmon (pSIH) was calculated with the following equation;

$$\text{pSI}_{\text{H}} = \text{pHOC}_{\text{SUS}_{♀}} * \text{pSI}$$

(6) Proportion of spring Chinook salmon redds superimposed by hatchery (*x*) female summer Chinook salmon (pSI*x*) was calculated with the following equation;

$$\text{pSI}_{x} = \text{HOC\_SUS}_{♀x} * \text{pSI}_{\text{H}}$$

Where: HOC_SUS♀*x* equals the number of hatchery specific female summer Chinook salmon carcasses.

Results

Environmental Conditions

In 2013, the Entiat River had an above average discharge regime during all of spring Chinook salmon spawning and the beginning of the summer Chinook salmon spawning period (Figure 2). Specifically, peaks in discharge occurred after rain events that may have hindered visibility due to increased turbidity. As a result of these rain events, surveys were shifted to different days of the week when visibility improved.

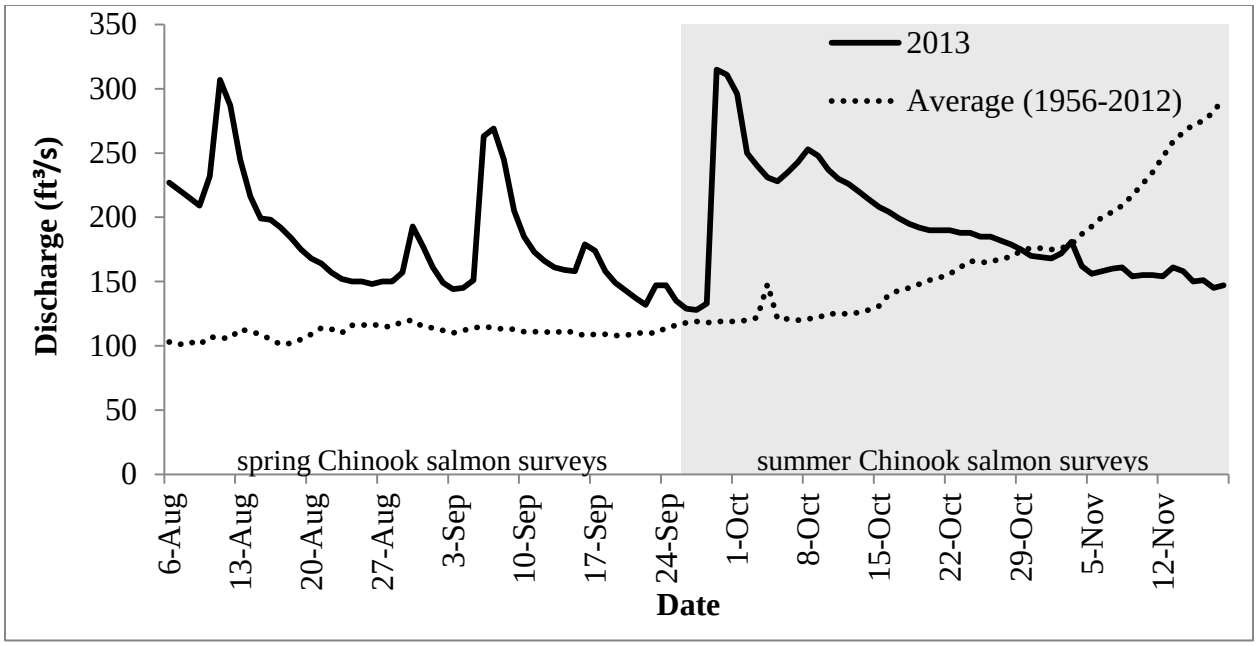

Figure 2. Entiat River 2013 hydrograph (solid line) for Chinook salmon spawning period (unshaded portion is the spring Chinook salmon and shaded portion is the summer Chinook salmon) and average daily discharge (dotted line) based on 56 years of record. USGS 12452800 gage, Entiat River near Ardenvoir, WA.

Spring Chinook Salmon

Spring Chinook salmon spawning ground surveys began on August 6th and concluded on September 26th (Appendix B describes dates and reaches surveyed). Peak spawning occurred during the second week in September, which was the same as the 7-yr average (Figure 3).

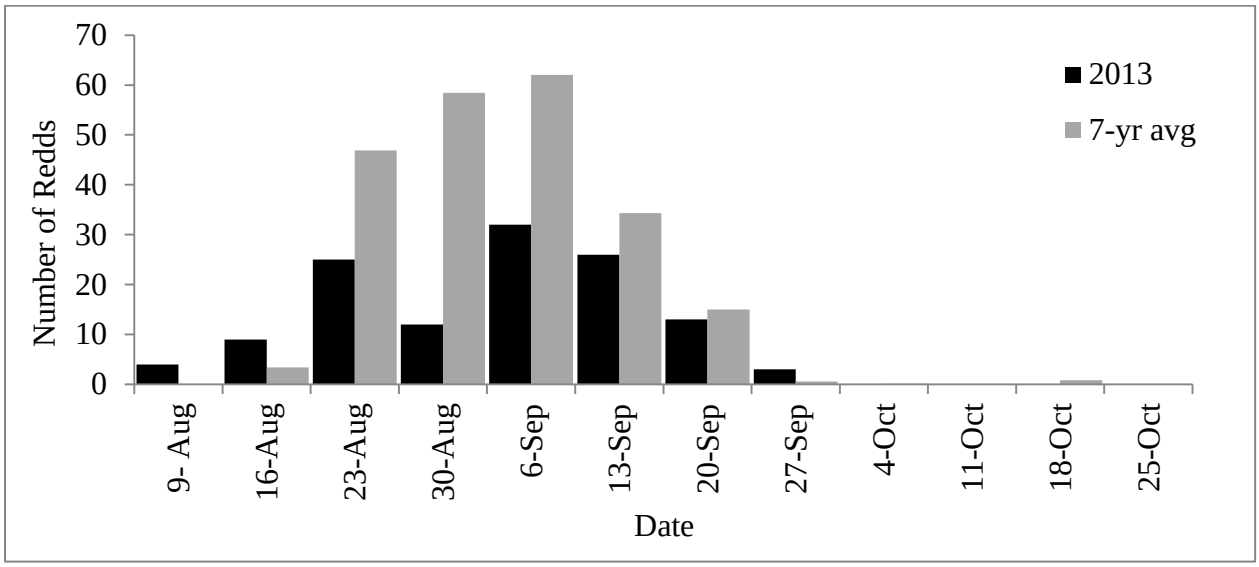

Figure 3. Number of spring Chinook salmon redds excavated in the Entiat River per week in 2013 and the 7-yr average (2006-2012).

In 2013, a total of 99 spring Chinook salmon redds were identified throughout the surveyed portions of the Entiat River. This was 66% of the 7-year average of 150 redds/year. In 2013, the number of spring Chinook salmon redds was lower than the previous twelve years, and no redds were found in the Mad River Section (Figure 4). Redd distributions decreased linearly from Reach 1 downstream to Reach 5, which was different than the 7-year average in which redds were the greatest in reach 2 and decreased upstream and downstream (Figure 5).

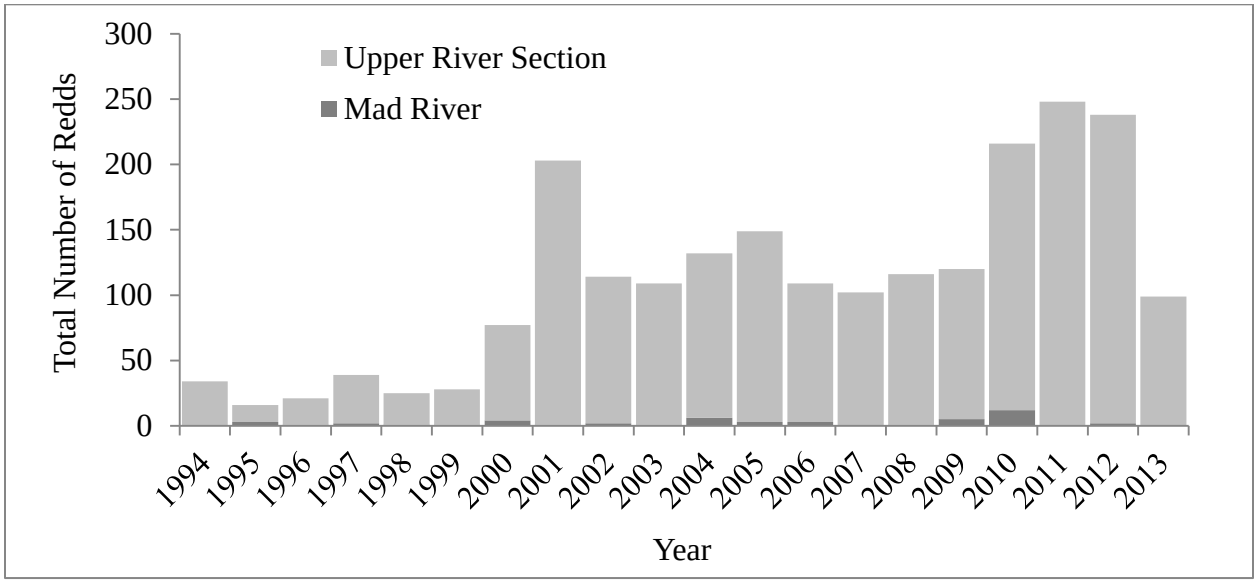

Figure 4. Annual Entiat River spring Chinook salmon redd counts in the Upper River Section (light grey) and the Mad River Section (dark grey).

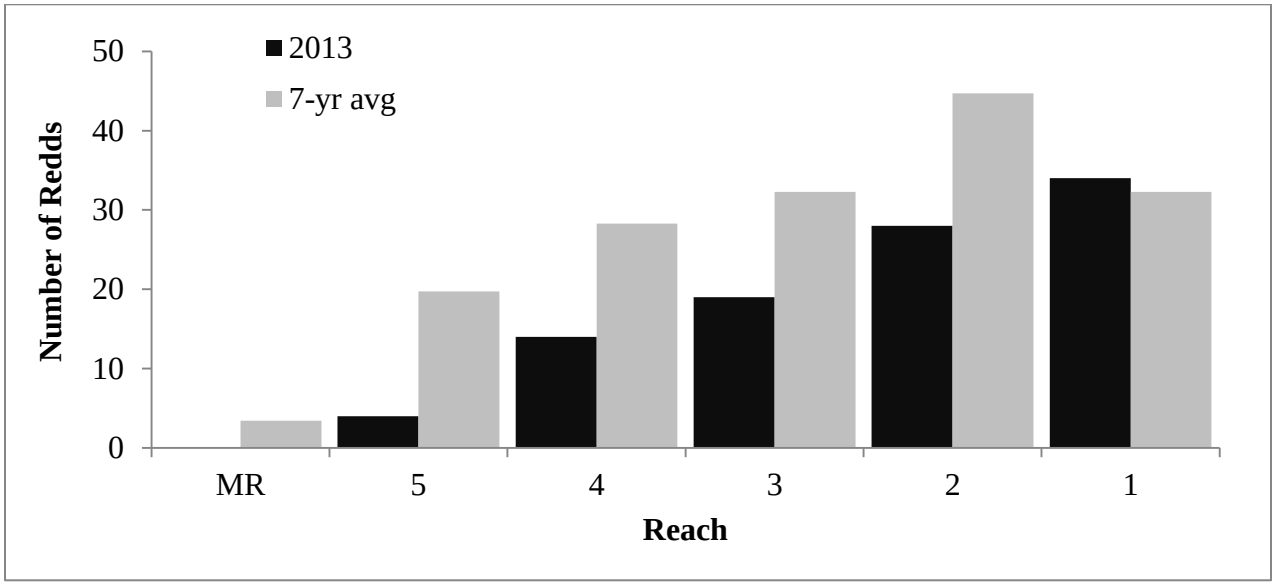

Figure 5. Entiat River spring Chinook salmon redd counts for Reaches 1-5 and Mad River for year 2013 and 7-year average (2006-2012). *For river kilometers and locations of reaches refer to Appendix A and Figure 1.*

Adult SRE in 2013 for spring Chinook salmon in the Entiat River was estimated to be 238 fish (Table 1). Twenty-two spring Chinook salmon carcasses were recovered, which was a CRR of 0.09. This low CRR was probably due in part to the atypical discharge regime seen during the spawning ground survey period. Half of the recovered carcasses were female and the other half were male. All 11 female carcasses were examined for spawning success; 8 (73%) were complete and 3 (27%) could not be determined because of poor carcass condition.

Table 1. Surveyed number of redds and carcasses with calculated SRE and CRR for spring Chinook salmon in the Entiat River basin from 2006-2013.

Year	Redds	SRE	Carcasses	CRR
2006	106	254	75	0.30
2007	102	245	41	0.17
2008	115	276	80	0.29
2009	115	276	79	0.29
2010	204	490	93	0.19
2011	248	595	173	0.29
2012	236	566	125	0.22
2013	99	238	22	0.09

Of the 22 spring Chinook salmon carcasses recovered in 2013, age and origin were determined for 19. The pNOS was 0.79 (n=15), resulting in an estimated NOS escapement of 188 fish. The pHOS was 0.21 (n=4) in 2013, resulting in an estimated HOS escapement of 50 fish. Hatchery and natural-origin spawner proportions have differed from year to year since 1996 (Figure 6), but since the conclusion of the Entiat NFH spring Chinook salmon program in 2007 pNOS has increased on the spawning grounds. The age composition of recovered carcasses varied for both natural- and hatchery-origin fish. Hatchery-origin fish were represented exclusively by male age-2 and male age-3 while the natural-origin fish had various ages and genders (Table 2). The spawning run escapement at large was represented by 37% age-3, 21% age-4, and 42% age-5 fish.

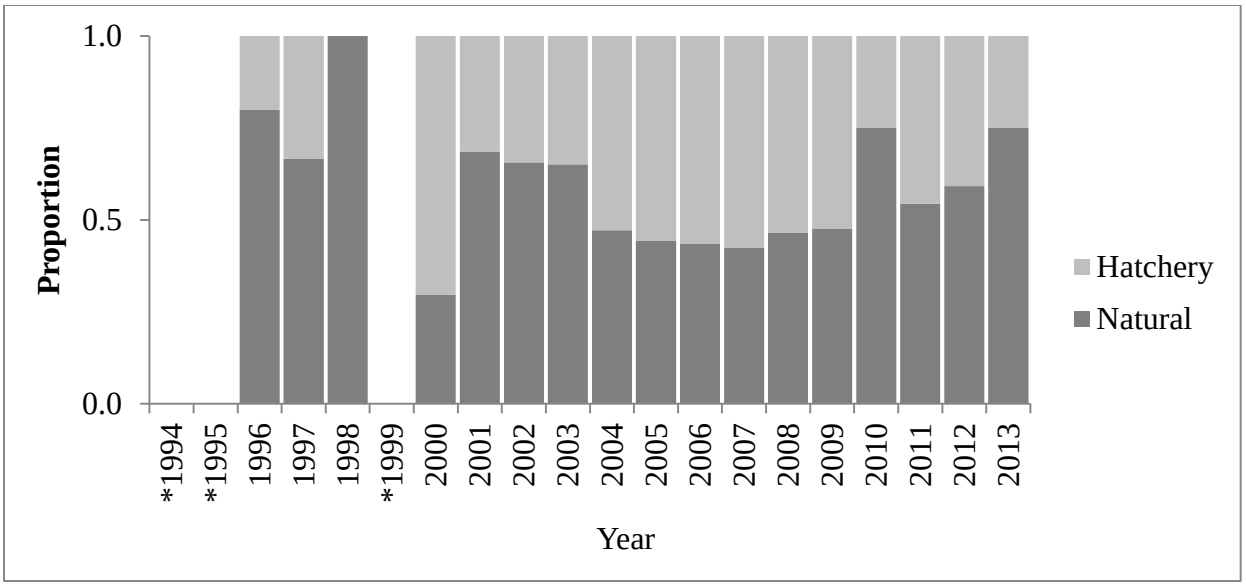

Figure 6. The proportion of hatchery- and natural-origin spring Chinook salmon spawning run escapement into the Entiat River (**no carcasses were recovered*).

Table 2. Age composition for spring Chinook salmon sampled from the Entiat River in 2013.

Origin	Age description	Total Age	Male (N)	Female (N)	Total (N)	pSRE	SRE
Natural	0.2	3	1	0	1	0.05	12
	1.1	3	2	0	2	0.11	26
	1.2	4	1	3	4	0.21	50
	1.3	5	1	7	8	0.42	100
Natural Total			5	10	15	0.79	188
Hatchery	1.0*	2	1	0	-	-	-
	1.1	3	4	0	4	0.21	50
Hatchery Total			5	0	5	0.21	50
Total*			**9**	**10**	**19**		**238**

*Age-2 recoveries that did not spend at least one year in salt water were not included in SRE estimates.

All 22 recovered carcasses were checked for adipose fin condition and scanned for CWT's. Recovered CWT's revealed that four carcasses originated from Chiwawa Rearing Ponds in the Wenatchee River Basin and one carcass originated from the Chewuch Acclimation Ponds in the Methow River Basin. The pCWT for Chiwawa Rearing Ponds made up the entirety of the HOS as the Chewuch Acclimation Pond fish was an age-2 and not included in the SRE_{CWT} estimates (Table 3).

Table 3. Coded wire tag (CWT) recoveries collected from spring Chinook salmon carcasses on the Entiat River in 2013.

CWT	Brood Year	Release Agency	Hatchery	# of Carcasses Recovered	Tagging Rate	$CWT_{Expanded}$	pCWT	SRE_{CWT}
635969	2010	WDFW	Chiwawa R. Ponds	4	99%	44	1.0	50
635664	2011	WDFW	Chewuch Acc. Pond	1	98%	11	*	*
Hatchery Total				**5**		**55**		**50**

*Age-2 recoveries that did not spend at least one year in salt water were not included in spawning run escapement estimates.

Of the 22 recovered carcasses from the Entiat River, all were scanned with a portable receiver for PIT tags, and no PIT tags were identified.

Summer Chinook Salmon

Summer Chinook salmon spawning ground surveys began September 25th and concluded on November 15th (Appendix B). Peak spawning occurred during the second week of October, which was a week prior to the 7-year average (Figure 7).

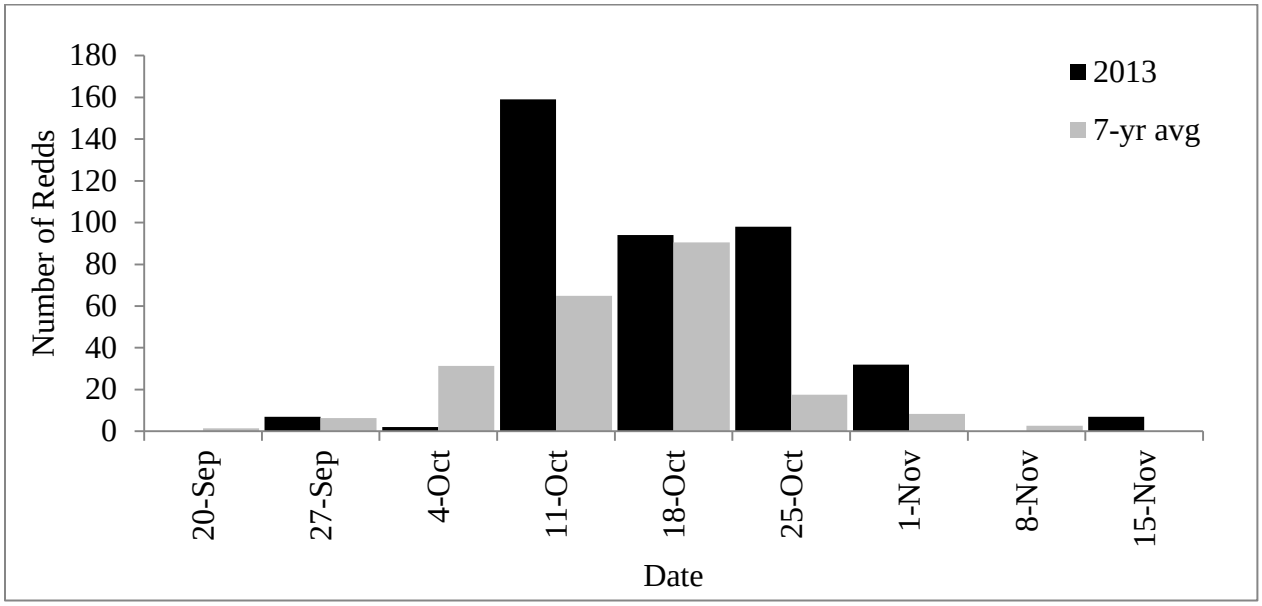

Figure 7. Number of new summer Chinook salmon redds excavated in the Entiat River per week in 2013 and for the 7-yr average (2006-2012).

In 2013, a total of 316 summer Chinook salmon redds were identified during spawning ground surveys. This was 169% of the 7-year average of 187 redds. Most spawning occurred in the Upper River Section (92%), which is consistent with prior years (Figure 8). Spawning distribution in the Upper and Lower River Sections increased in a downstream direction, with more redds in the bottom reaches than in the top reaches (Figure 9 and 10) which is very similar to the 7-year average.

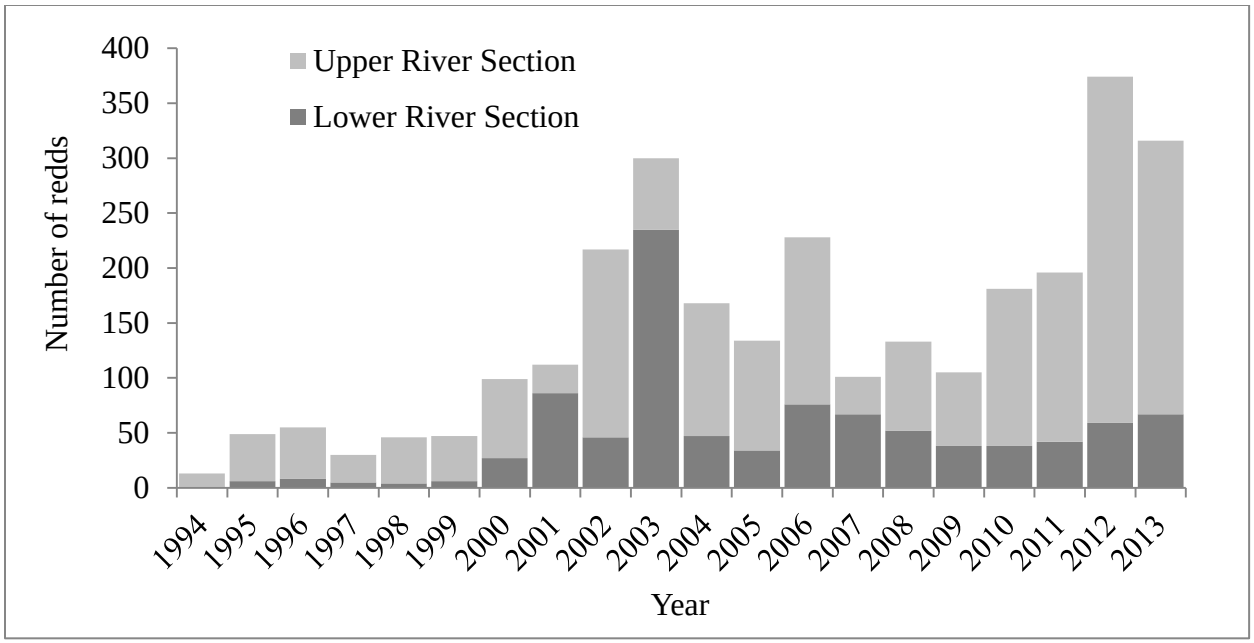

Figure 8. Annual Entiat River summer Chinook salmon redd counts in the Lower River Section (dark grey) and the Upper River Section (light grey).

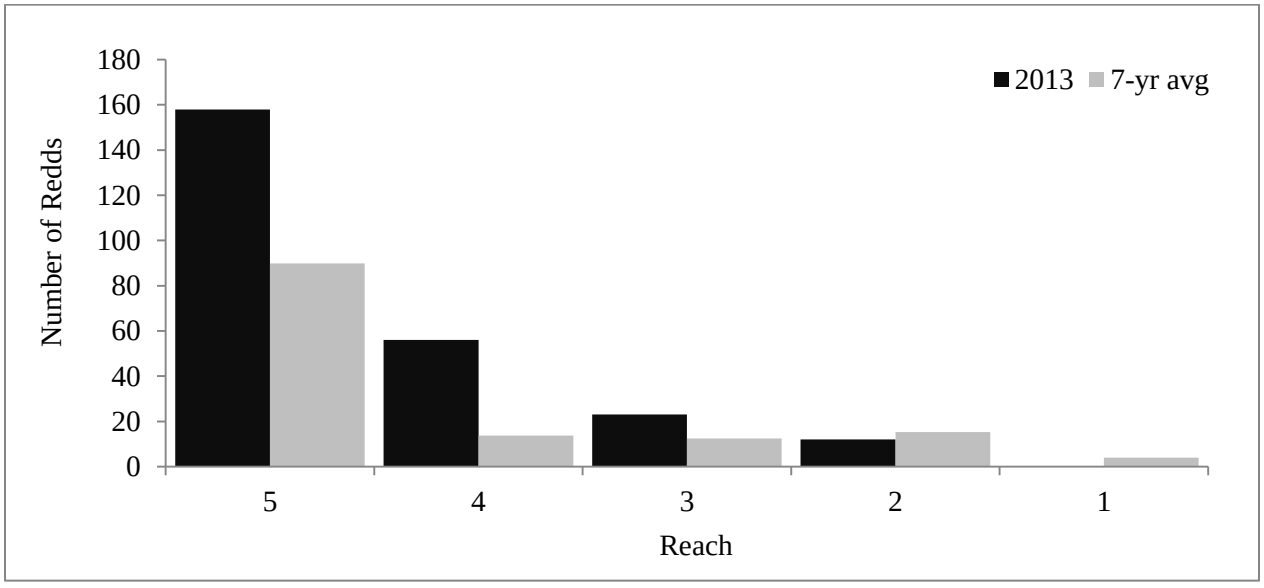

Figure 9. Entiat River summer Chinook salmon redd counts for the Upper River Section in 2013 and the 7-year average (2006-2012). *For river kilometers and locations of reaches refer to Appendix A and Figure 1.*

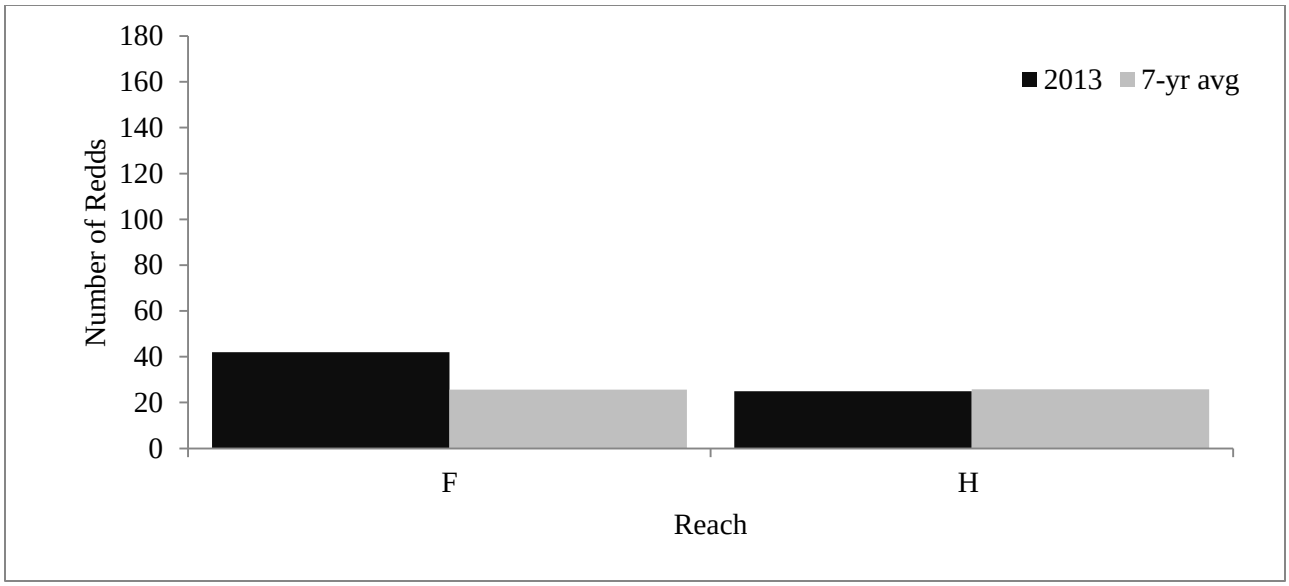

Figure 10. Entiat River summer Chinook salmon redd counts for the Lower River Section in 2013 and the 7-year average (2006-2012). *For river kilometers and locations of reaches refer to Appendix A and Figure 1.*

In 2013, the summer Chinook salmon SRE for the Entiat River was estimated to be 758 fish (Table 4). During the surveys 154 summer Chinook salmon carcasses were recovered, which was a CRR = 0.20. Carcasses recovered were 67% female and 33% male. All 103 female carcasses were examined for spawning success; 85 (83%) were complete, 3 (3%) were incomplete, 3 (3%) were pre-spawn mortalities, and 12 (11%) could not be determined because of poor carcass condition.

Table 4. Surveyed number of redds and carcasses with calculated SRE and CRR for summer Chinook salmon in the Entiat River basin from 2006-2013.

Year	Redds	SRE	Carcasses	CRR
2006	228	547	180	0.33
2007	101	242	88	0.36
2008	133	319	82	0.26
2009	105	252	83	0.33
2010	181	434	96	0.22
2011	196	470	137	0.29
2012	374	898	207	0.23
2013	316	758	154	0.20

Of the 154 summer Chinook salmon carcasses recovered in 2013, age and origin were determined for 147. The pNOS was 0.85 (n=125), resulting in an estimated NOS escapement of 645 fish. The pHOS was 0.15 (n=22) in 2013, resulting in an estimated HOS escapement of 113 fish. Coded wire tag and scale analysis indicated various hatchery and natural-origin summer Chinook salmon age-classes returned to the Entiat River (Table 5). The spawning run escapement was represented by 9% age-3, 45% age-4, 45% age-5 fish, and 1% age-6 fish. Hatchery and natural-origin spawner proportions have differed from year to year since 1996 (Figure 11). Based on recovered summer Chinook salmon carcasses in 2013,

hatchery fish have a greater presence in the lower portions of the river compared to the upper portions of the river (Figure 12).

Table 5. Age composition for summer Chinook salmon sampled from the Entiat River in 2013.

Origin	Age description	Total Age	Male (N)	Female (N)	Total (N)	pSRE	SRE
Natural	0.2	3	8	1	9	0.06	45
	0.3	4	7	36	43	0.29	220
	0.4	5	12	25	37	0.25	190
	1.1	3	2	0	2	0.01	7
	1.2	4	6	8	14	0.1	76
	1.3	5	7	12	19	0.13	99
	1.4	6	1	0	1	0.01	7
Natural Total			43	82	125	0.85	637
Hatchery	0.2	3	0	1	1	0.01	7
	0.3	4	0	1	1	0.01	7
	1.0*	2	1	0	-	-	-
	1.1	3	1	0	1	0.01	7
	1.2	4	0	8	8	0.05	40
	1.3	5	3	8	11	0.07	53
Hatchery Total			4	18	22	0.15	121
Total*			**48**	**100**	**147**		**758**

*Age-2 recoveries that did not spend at least one year in salt water were not included in spawning escapement estimates.

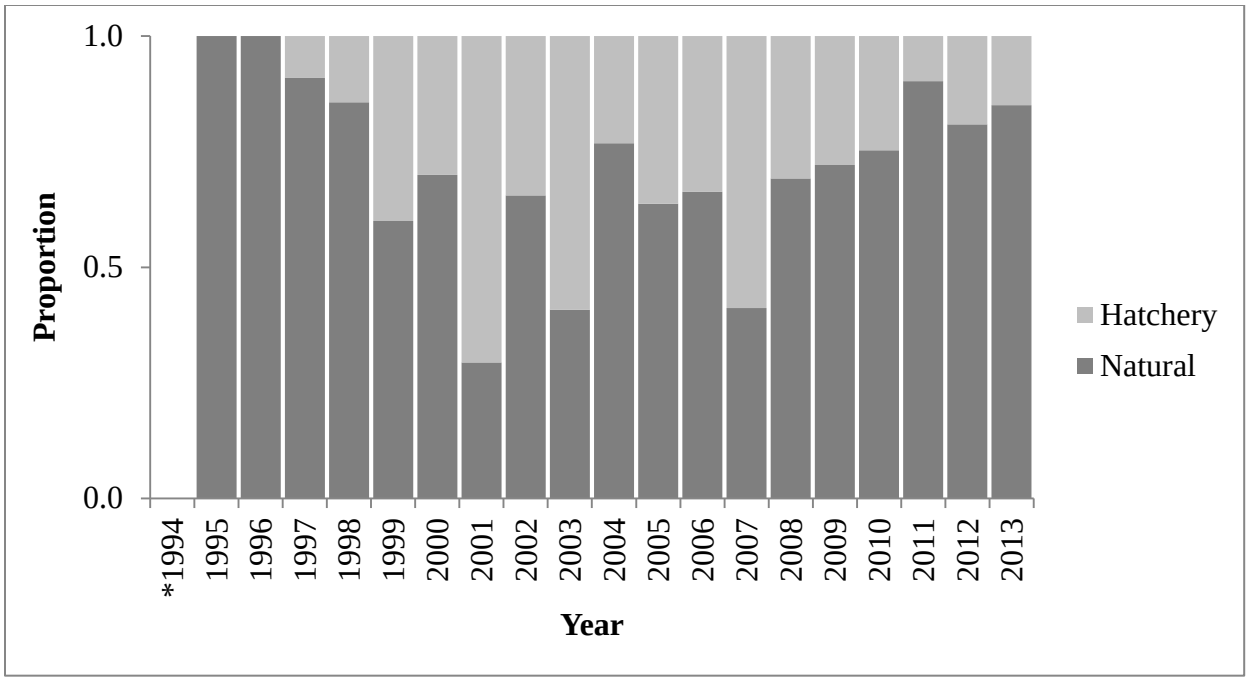

Figure 11. The proportion of hatchery- and natural-origin summer Chinook salmon spawning run escapement into the Entiat River (**no carcasses were recovered*).

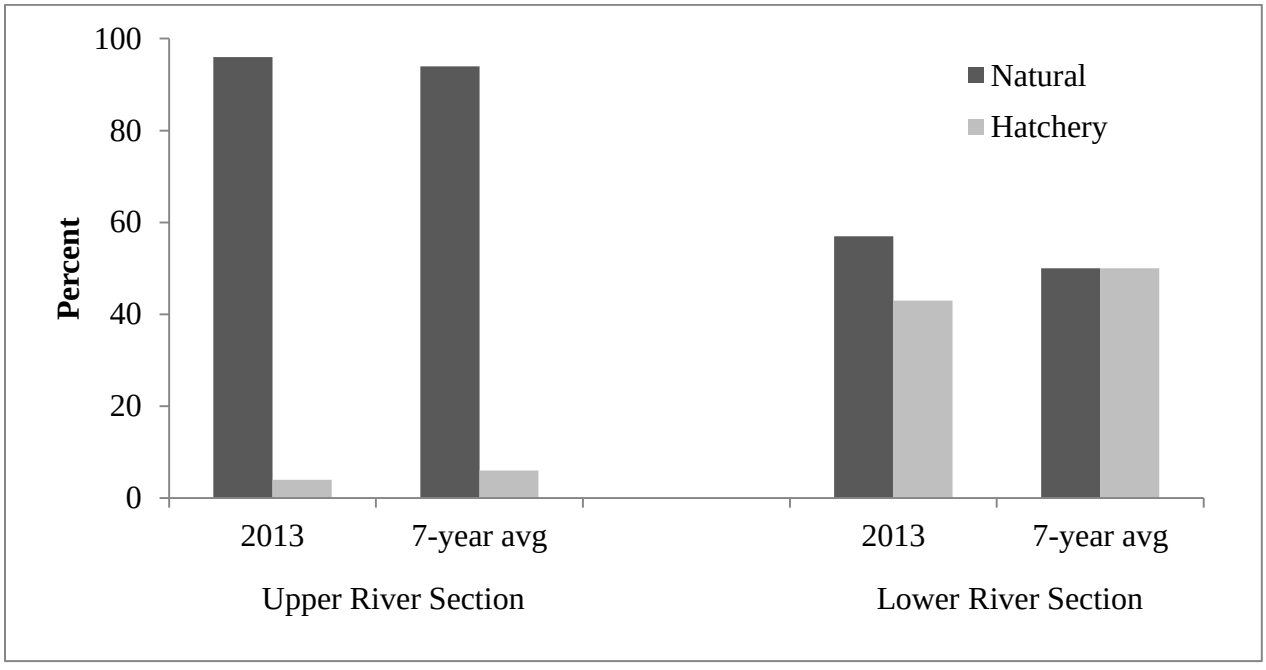

Figure 12. Estimated percent composition of hatchery and wild summer Chinook salmon spawning in the Upper River Section compared to the Lower River Section in 2013 and the 7-year average. *For river kilometers and locations of reaches refer to Appendix A and Figure 1.*

Two juvenile life history types were identified for returning natural-origin summer Chinook salmon in 2013; 71% migrated to saltwater at age 0 and 29% over wintered (age 1) in a reservoir. None were identified as over wintering in their natal stream. Juvenile life history numbers and percentages for years 2006-2013 are found in Table 6.

Table 6. Juvenile life history types and percentages for summer Chinook salmon sampled from the Entiat River in years 2006-2013.

Year	Ocean (N)	%	Reservoir (N)	%	Stream (N)	%	Total (N)
2006	84	73%	27	23%	4	4%	115
2007	25	74%	9	26%	0	0%	34
2008	42	84%	8	16%	0	0%	50
2009	51	89%	6	11%	0	0%	57
2010	49	72%	19	28%	0	0%	68
2011	88	76%	27	23%	1	1%	116
2012	124	74%	44	26%	0	0%	168
2013	89	71%	36	29%	0	0%	125
Avg		76%		23%		1%	

Of the 154 recovered summer Chinook salmon carcasses from the Entiat River 17 contained a CWT. Recovered CWT's revealed that a variety of hatchery fish returned to spawn in the Enitat River, including hatchery fish from Enitat NFH (pCWT=0.26, SRE_{CWT}=30), Turtle Rock (pCWT=0.34, SRE_{CWT}=38), Dryden Acclimation ponds (pCWT=0.33, SRE_{CWT}=38), and Wells Hatchery (pCWT=0.07, SRE_{CWT}=7) (Table 7). Out-of basin strays accounted for 75% of the hatchery influence on the spawning grounds.

Table 7. Coded-wire tag recoveries collected from summer Chinook salmon carcasses on the Entiat River in 2013.

CWT	Brood Year	Release Agency	Hatchery	# of Carcasses Recovered	Tagging Rate	$CWT_{Expanded}$	pCWT	SRE_{CWT}
053568	2009	USFWS	Entiat NFH	1	99%	5	0.07	7
053569	2010	USFWS	Entiat NFH	1	100%	5	0.07	7
053619	2009	USFWS	Entiat NFH	2	99%	10	0.13	15
635097	2008	WDFW	Dryden Pond	3	94%	16	0.21	24
635098	2008	WDFW	Dryden Pond	2	100%	10	0.13	15
636177	2011*	WDFW	Dryden Pond	1	99%	5	*	*
634778	2008	WDFW	Turtle Rock	1	97%	5	0.07	8
635164	2008	WDFW	Turtle Rock	1	99%	5	0.07	7
635179	2008	WDFW	Turtle Rock	1	99%	5	0.07	7
635577	2009	WDFW	Turtle Rock	2	97%	10	0.13	15
635775	2010	WDFW	Wells	1	99%	5	0.07	7
				17		81		114

*Age-2 recoveries that did not spend at least one year in salt water were not included in spawning run escapement estimates.

Of the 154 recovered carcasses from the Entiat River, one was identified as containing a PIT tag (Appendix D). Utilizing PTAGIS, the recovered female carcass was tagged on its upstream migration from the ocean at Bonneville Dam on June 20th. Travel time in the mainstem from Bonneville to the Entiat River took 16 days. The first detection in the Entiat River was on July 5th and the carcass was recovered on October 24th, indicating that the fish was in the river for up to 111 days before spawning.

Superimposition by female summer Chinook salmon was evaluated from rm 25.8 to rm 16.2. A total of 19 out of the 99 (pSI = 0.192) spring Chinook salmon redds were superimposed upon by summer Chinook salmon. The pNOS_SUS♀ was 0.97 and the pHOS_SUS♀ was 0.03, with a CRR♀ 0.22 (n=69). Two HOS_SUS♀ were recovered and originated from Entiat NFH and Dryden Acclimation Pond. The pSI_N was 0.186 and the pSI_H was 0.006 (Table 8).

Table 8. Proportions of superimposition by natural (pSI_N), Entiat NFH (pSI_{ENFH}) and out-of-basin hatchery strays (pSI_{OBH}).

	pSI_N	pSI_{ENFH}	pSI_{OBH}
2013	0.186	0.003	0.003

Sockeye and Coho Salmon

In 2013, 180 sockeye salmon redds and 406 live adults were observed. A total of 20 sockeye salmon carcasses were recovered of which five contained a coded-wire tag (Table 8) and none contained a PIT tag.

Table 9. Coded-wire tag recoveries from sockeye salmon carcasses on the Entiat River in 2013.

Species	Tag Code	Brood Year	Release Agency	Hatchery	Recovered
Sockeye	635265	09	WDFW	Lk Wenatchee	3
Sockeye	635277	09	WDFW	Lk Wenatchee	1
Sockeye	634389	08	WDFW	Lk Wenatchee	1
Total					5

In 2013, 10 coho salmon redds and nine live adults were observed. No coho salmon carcasses were recovered.

Summary

The total number of spring Chinook salmon redds counted during the 2013 spawning ground surveys was 99, with an estimated adult spawning run escapement of 238 fish to the Entiat River. A total of 22 carcasses were recovered; females and males each comprised 50%. Female carcasses spawn success were 100% complete. Recovered carcasses indicate that natural-origin fish comprised 75% of the adult return escapement to the Entiat River and the remaining were of hatchery-origin. Based on the CWT recoveries hatchery spring Chinook salmon carcasses were from the Chiwawa Rearing Ponds (80%) and the

Chewuch Acclimation Site (20%). Spring Chinook salmon redds were superimposed upon at a rate of 19%, with natural-origin summer Chinook salmon being the largest (95%) source of this impact at and the remaining impact attributed to hatchery-origin fish.

In 2013, 316 summer Chinook salmon redds were counted during spawning ground surveys, with an estimated adult spawning run escapement of 758 fish to the Entiat River. A total of 154 carcasses were recovered; females comprised 67% and males 33%. Female carcasses had various degree of spawn success: 83% were complete, 3% were incomplete, 3% were pre-spawn mortalities, and 11% could not be determined because of carcass decomposition. Recovered carcasses indicated that natural-origin fish compromised 84% of the adult spawning escapement to the Entiat River and the remaining were of hatchery-origin. Scale analysis revealed natural-origin summer Chinook salmon had two distinctive freshwater life histories; 71% were ocean-type juvenile migrants and 29% were reservoir-type juvenile migrants. A total of 17 CWT's were recovered from carcasses. Based on the CWT recoveries hatchery summer Chinook salmon carcasses were from Entiat NFH (24%), Dryden Acclamation Pond (41%), Turtle Rock Hatchery (29%), and Wells Hatchery (6%).

During the spring and summer Chinook salmon spawning ground surveys, surveyors counted 173 sockeye salmon redds, 406 live adults, and recovered 20 carcasses. Ten coho salmon redds, nine live adults were counted, and no carcasses were recovered.

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References

Connor, W.P., J.G. Sneva, K.F. Tiffan, R.K. Steinhorst, and D. Ross. 2005. Two alternative juvenile life history types for fall Chinook salmon in the Snake River. Transactions of the American Fisheries Society 134:291-304.

Craig, J.A. and A.J. Suomela. 1941. Time of appearance of the runs of salmon and steelhead trout native to the Wenatchee, Entiat, Methow, and Okanogan rivers. USFWS Unpublished Manuscript

Crawford, B., T.R. Mossey, and D.H. Johnson 2007. Carcass Counts. Pages 59-94 *in* D.H. Johnson, Shrier B.M., J.S. O'Neal, J.A. Knutzen, Augerot X., T.A. O'Neal, and T.N. Pearsons, editors. Salmonid Field Protocoals Handbook:Techniques for assessing status and trends in slamon and trout populations. American Fisheries Society, Bethseda, Maryland.

Fish, F.F. and M.G. Hanavan. 1948. A report on the Grand Coulee Fish Management Project 1939-1947. USFWS Special Scientific Report 55

French, R.R. and R.J. Wahle. 1960. Salmon runs- upper Columbia River, 1956-1957. USFWS Special Scientific Report 364

Gilbert, C.H. 1912. Age at maturity of the pacific coast salomon of the the genus Oncorhynchus. Bulletin of the Bureau of Fisheries 32:1-22.

Healy, M.C. 1991. Life history of Chinook salmon (Oncorhyncus tshawytscha). Pages 312-393 *in* C. Groot and L. Margolis, editors. Pacific salmon life histories. UBC Press, Vanouver, Canada.

Koo, T.S.Y. 1962. Age designation in salmon. Pages 37-48 *in* T.S.Y. Koo, editors. Studies of Alaskan red salmon. University of Washington Press, Seattle, Washington.

Long, A. 2001. Under the Guard of the Ole Tyee. Wenatchee, WA.

Mullan, J.W. 1983. Overview of artificial and natural propogation of coho salmon on the mid-Columbia River. USFWS Report No. FRI/FAO-84-4

Mullan, J.W. 1986. Determinants of sockeye salmon abundance in the Columbia River, 1880s-1982: A reiew and synthesis. USFWS USFWS Biological Report 86(12)

Mullan, J.W. 1987. Status and propogation of Chinook salmon in the Mid-Columbia River through 1985. USFWS Biological Report 89(3)

Mullan, J.W. 1990. Status of Chinook salmon stocks in the mid-Columbia. Pages 45-55 *in* D.L. Park, editors. Status and future of spring Chinook salmon in the Columbia River Basin-conservation and enhancement. US Dept. Commerce, NOAA Tech. Memo. NMFS F/NWC-187.

Mullan, J.W., K.R. Williams, G. Rhodus, T.W. Hillman, and J.D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. USFWS Monograph.

USBF. 1934/1935/1936. Entiat River physical stream survey report. US Bureau of Fisheries

USDA. 1979. Enitat: cooperative river basin study. US Department of Agriculture

APPENDIX A- Entiat River Survey Reach Descriptions

Reach	River Mile	Surveyed miles	Description
1	25.8-28.1	2.3	Forest Service boundary to Fox Creek camp ground
2	23.4-25.8	2.4	Fox Creek camp ground to Brief Bridge
3	21.3-23.4	2.1	Brief Bridge to Kelsey Lane Bridge
4	18.7-21.3	2.6	Kelsey Lane Bridge to Stormy Creek preserve
5	16.2-18.7	2.5	Stormy Creek Preserve to McKenzie Diversion
H	6.8-3.1	3.7	Entiat NFH to Fire Station
F	3.1-0.3	2.8	Fire Station to Columbia River influence
MR	3.5-1.5	2.0	Mad River, Pine Flats Campground to road sign

mileage may not be exact

*Kelsey Lane Bridge referred to as Foss Bridge in prior reports.

APPENDIX B- Spring and Summer Chinook Salmon Spawning Ground Data

Spring Chinook salmon spawning ground survey results on the Entiat and Mad Rivers in 2013.

Reach	River Mile	Date	Redds	Live Fish	Carcasses
Upper River Section (part of *index* area)					
1	28.1-25.8	08/06/13	2	5	0
		08/13/13	0	1	0
		08/19/13	4	3	0
		08/26/13	15	17	1
		09/03/13	10	1	0
		09/10/13	1	2	0
		09/19/13	2	1	1
		09/23/13	0	0	3
		Total Count	34	30	5
2	25.8-23.4	08/07/13	1	0	0
		08/15/13	2	4	0
		08/22/13	6	9	1
		08/27/13	5	6	0
		09/05/13	12	7	4
		09/12/13	1	0	3
		09/20/13	1	0	3
		09/24/13	0	0	0
		Total Count	28	26	11
3	23.4-21.3	08/08/13	0	0	0
		08/15/13	0	0	0
		08/23/13	2	1	0
		08/30/13	4	8	0
		09/13/13	10	3	0
		09/20/13	3	0	0
		09/26/13	0	0	0
		Total Count	19	12	0
***Index* Area Total**			**81**	**68**	**16**

Cont'd- Spring Chinook salmon spawning ground survey results on the Entiat and Mad Rivers in 2013.

Reach	River Mile	Date	Redds	Live Fish	Carcasses
Upper River Section (part of *expanded* area)					
4	21.3-18.7	08/13/13	0	0	0
		08/20/13	0	0	0
		08/26/13	2	12	0
		09/04/13	3	9	0
		09/11/13	5	4	2
		09/18/13	2	0	0
		09/24/13	2	0	2
		Total Count	14	25	4
5	18.7-16.2	08/14/13	0	0	0
		08/22/13	0	0	0
		08/29/13	0	0	0
		09/05/13	2	3	1
		09/13/13	0	0	0
		09/19/13	2	0	0
		09/25/13	0	0	1
		Total Count	4	3	2
***Expanded* Area Total**			**18**	**28**	**6**
Mad River Section (part of *expanded* area)					
MR	3.5-1.5	08/30/13	0	0	0
		10/04/13	0	0	0
		Total Count	0	0	0
Mad River Section Total			**0**	**0**	**0**
Upper River Section Total			**99**	**96**	**22**

Summer Chinook salmon spawning ground survey results on the Entiat River in 2013.

Reach	River Mile	Date	Redds	Live Fish	Carcasses
1	28.1-25.8	10/16/2013	0	0	0
		10/28/2013	0	0	0
		Total Count	0	0	0
2	25.8-23.4	10/17/2013	12	3	0
		11/1/2013	0	0	0
		Total Count	12	3	0
3	23.4-21.3	9/26/2013	1	1	0
		10/15/2013	17	10	0
		10/29/2013	5	3	0
		11/13/2013	0	0	1
		Total Count	23	14	1
4	21.3-18.7	10/9/2013	33	50	0
		10/15/2013	4	14	2
		10/25/2013	18	9	7
		10/31/2013	1	3	5
		11/5/2013	0	0	4
		Total Count	56	76	18
5	18.7-16.2	8/22/2013*	--	--	1
		8/29/2013*	--	--	1
		9/25/2013	3	80	0
		10/11/2013	111	163	3
		10/18/2013	22	101	16
		10/24/2013	12	49	36
		10/30/2013	10	10	26
		11/6/2013	0	1	5
		Total Count	158	404	88
Upper River Section Total			**249**	**497**	**107**

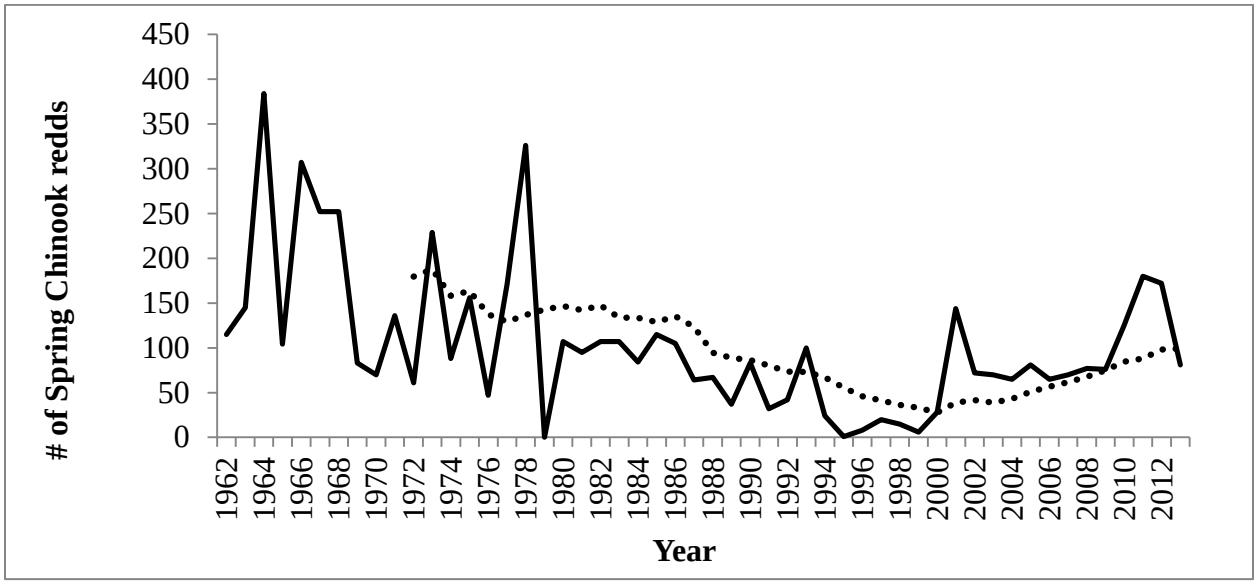
Cont'd- Summer Chinook salmon spawning ground survey results on the Entiat River in 2013.

Section	River Mile	Date	Redds	Live Fish	Carcasses
H	6.8-3.1	10/7/2013	2	61	0
		10/22/2013	19	33	2
		11/4/2013	4	2	14
		Total Count	25	96	16
F	3.1-0.3	10/10/2013	12	38	1
		10/23/2013	24	52	7
		11/15/2013	6	7	23
		Total Count	42	97	31
Lower River Section Total			**18**	**28**	**6**
Entiat River Total			**316**	**690**	**154**

APPENDIX C- Chinook Salmon Redd Historical Data

Entiat River spring Chinook salmon redd counts from annual surveys in old *index* area, Fox Creek C. G. to Dill Creek (RM 28.1 to 21.3, Reaches 1 through 3), 1962-1993 (WDFW) and 1994-2013 (USFWS).

Year	# of Redds	Year	# of Redds	Year	# of Redds	Year	# of Redds
1962	115	1975	156	1988	67	2001	144
1963	145	1976	47	1989	37	2002	72
1964	384	1977	171	1990	83	2003	70
1965	104	1978	326	1991	32	2004	65
1966	307	1979	NA	1992	42	2005	81
1967	252	1980	107	1993	100	2006	65
1968	252	1981	95	1994	24	2007	70
1969	83	1982	107	1995	1	2008	77
1970	70	1983	107	1996	8	2009	76
1971	136	1984	84	1997	20	2010	125
1972	61	1985	115	1998	15	2011	180
1973	229	1986	105	1999	6	2012	172
1974	88	1987	64	2000	28	2013	81

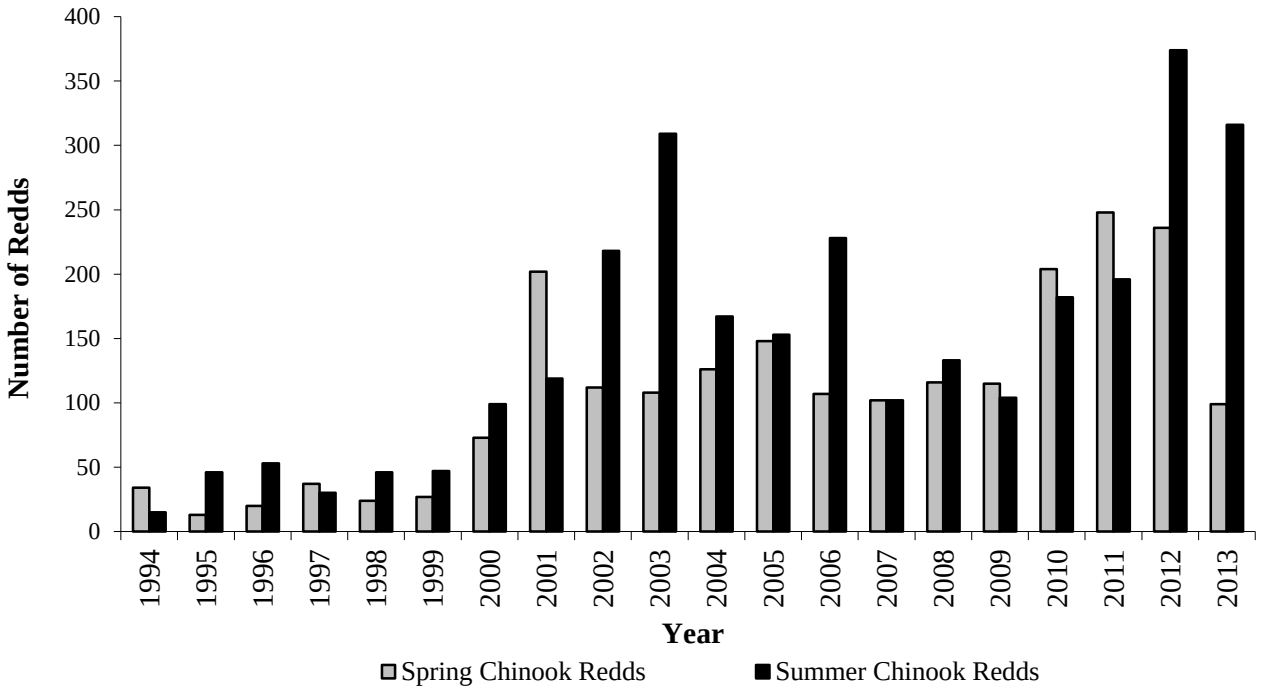


Entiat River spring Chinook salmon redd counts in the *index* area, RM 21.3 – 28.1 (Reaches 1 through 3), solid line is number of redds each year and dotted line is 10-year moving average.

Entiat River spring and summer Chinook salmon redd counts from the summation of redd surveys observed on Fox Creek C. G. to Mckenzie Diversion (RM 28.1 to 16.2), Enitat National Fish Hatchery to Columbia River Influence (RM 6.8 to 0.3) and the Mad River, 1994 – 2013.

Year	Spring Chinook Salmon	Summer Chinook Salmon
1994	34	15
1995	13	49*
1996	20	55*
1997	37	30
1998	24	46
1999	27	47
2000	73	99
2001	202	112*
2002	112	217
2003	108	300*
2004	126	168*
2005	146*	155*
2006	106*	228
2007	102	101*
2008	115*	133
2009	115	105*
2010	204	181*
2011	248	196
2012	236	374
2013	99	316

* redd numbers may be more or less than those numbers published in past reports due to validation of data through a new database and original data.



Spring and summer Chinook salmon redd counts for the Entiat River, 1994-2013.

APPENDIX D- PIT Tag Recoveries

Passive Integrated Transponder tag interrogations from spring Chinook salmon carcasses on the Entiat River in 2013.

PIT Tag Code	Gender	Release Site	Release Date	Last Detection Site	Last Detection Date
No PIT tags were detected in spring Chinook salmon carcasses for 2013.					

Passive Integrated Transponder tag interrogations from summer Chinook salmon carcasses on the Entiat River in 2013.

PIT Tag Code	Gender	Release Site	Release Date	Last Detection Site	Last Detection Date
3D9.1C2E040908	F	Bonneville Dam	6/20/2013	Entiat R. ENA	7/09/2013

Complete Tag History for PIT tagged summer Chinook salmon carcass (3D9.1C2E040908) found in the Upper River Section (Reach 5) in 2013.

Date	Event Type	Site Name	Site Type	Site RKM
6/20/13	Obs	Bonneville WA Ladder	Adult Fishway	234
6/22/13	Obs	The Dalles East Fish Ladder	Adult Fishway	308
6/26/13	Obs	McNary Washington Shore Ladder	Adult Fishway	470
6/29/13	Obs	Priest Rapids Adult Ladder	Adult Fishway	639
7/1/13	Obs	Rock Island Adult Ladder	Adult Fishway	730
7/3/13	Obs	Rocky Reach Adult Fishway	Adult Fishway	763
7/5/13	Obs	Lower Entiat River Array	Instream Remote Detection System	778.002
7/9/13	Obs	Upper Entiat River Array	Instream Remote Detection System	778.017
10/24/13	Mort	Entiat River Reach 5 Spawning Ground Recovery	River	778.026

Passive Integrated Transponder tag interrogations from sockeye salmon carcasses on the Entiat River in 2013.

PIT Tag Code	Gender	Release Site	Release Date	Last Detection Site	Last Detection Date
No PIT tags were detected in sockeye salmon carcasses for 2013.					

Passive Integrated Transponder tag interrogations from coho salmon carcasses on the Entiat River in 2013.

PIT Tag Code	Gender	Release Site	Release Date	Last Detection Site	Last Detection Date
No PIT tags were detected in coho salmon carcasses for 2013.					

APPENDIX E- Sockeye and Coho Historical Redd Data

	Sockeye salmon	Coho salmon
1994	0	-
1995	0	-
1996	0	-
1997	0	-
1998	3	-
1999	0	-
2000	2	-
2001	10	12
2002	139	0
2003	15	0
2004	39	5
2005	42	2
2006	9	1
2007	1	6
2008	16	6
2009	23	0
2010	138	0
2011	35	10
2012	52	0
2013	180	10

APPENDIX F- Spring and Summer Chinook Salmon Redd GPS coordinates

2013 spring Chinook salmon redd coordinates.

Reach	Redd #	Latitude	Longitude	Reach	Redd #	Latitude	Longitude
R1	001	47.91636	-120.50178	R2	001	47.89756	-120.45829
R1	002	47.91673	-120.50019	R2	002	47.90635	-120.47872
R1	003	47.91699	-120.50153	R2	003	47.90268	-120.47323
R1	004	47.91685	-120.50078	R2	004	47.90635	-120.47861
R1	005	47.90867	-120.48405	R2	005	47.90613	-120.47823
R1	006	47.90639	-120.47881	R2	006	47.90501	-120.47509
R1	007	47.92307	-120.50939	R2	007	47.90285	-120.47317
R1	008	47.91750	-120.50405	R2	008	47.90173	-120.47200
R1	009	47.91745	-120.50370	R2	009	47.89673	-120.45632
R1	010	47.91696	-120.50339	R2	010	47.90628	-120.47869
R1	011	47.91672	-120.50323	R2	011	47.90632	-120.47868
R1	012	47.91663	-120.50315	R2	012	47.90486	-120.47655
R1	013	47.91685	-120.50101	R2	013	47.89195	-120.45061
R1	014	47.91703	-120.50161	R2	014	47.88630	-120.44172
R1	015	47.91704	-120.50198	R2	015	47.90533	-120.47742
R1	016	47.91709	-120.50239	R2	016	47.90498	-120.47657
R1	017	47.91683	-120.50075	R2	017	47.90227	-120.47343
R1	018	47.91689	-120.50060	R2	018	47.90173	-120.46623
R1	019	47.91680	-120.50053	R2	019	47.89714	-120.45705
R1	020	47.91636	-120.50014	R2	020	47.89466	-120.45426
R1	021	47.91049	-120.48865	R2	021	47.89360	-120.45400
R1	022			R2	022	47.89286	-120.45250
R1	023	47.91667	-120.50320	R2	023	47.89280	-120.45206
R1	024	47.91690	-120.50090	R2	024	47.89255	-120.45077
R1	025	47.91055	-120.48854	R2	025	47.88785	-120.44505
R1	026	47.90960	-120.48820	R2	026	47.88574	-120.44116
R1	027	47.90593	-120.48070	R2	027	47.90513	-120.47524
R1	028	47.90669	-120.47971	R2	028	47.89733	-120.45741
R1	029	47.90669	-120.47962				
R1	030	47.90627	-120.47906	R3	001	47.88394	-120.43707
R1	031	47.90625	-120.47904	R3	002	47.88331	-120.43671
R1	032	47.91678	-120.50054	R3	003	47.86951	-120.42561
R1	033	47.91760	-120.50416	R3	004	47.86255	-120.42312
R1	034	47.91741	-120.50372	R3	005	47.86247	-120.42301

Reach	Redd #	Latitude	Longitude
R3	006	47.85923	-120.42343
R3	007	47.87137	-120.42726
R3	008	47.87029	-120.42722
R3	013	47.86069	-120.42244
R3	014	47.85850	-120.42283
R3	015	47.85776	-120.42211
R3	016	47.87019	-120.42721
R3	017	47.86772	-120.42478
R3	018	47.85775	-120.42213
R3	019	47.86805	-120.42379
R4	001	47.84865	-120.42163
R4	002	47.84780	-120.42088
R4	003	47.84893	-120.42218
R4	004	47.84423	-120.41760
R4	005	47.84146	-120.41574
R4	006	47.84886	-120.42219
R4	007	47.84901	-120.42254
R4	008	47.84071	-120.41585
R4	009	47.83031	-120.41904
R4	010	47.83038	-120.42024
R4	011	47.84999	-120.42329
R4	012	47.84405	-120.41804
R4	013	47.84171	-120.41553
R4	014	47.84249	-120.41531
R5	001	47.81571	-120.42132
R5	002	47.81492	-120.41892
R5	003	47.81579	-120.42134
R5	004	47.81492	-120.41892

2013 summer Chinook salmon redd coordinates.

Reach	Redd #	Latitude	Longitude	Reach	Redd #	Latitude	Longitude
R2	1	47.90621	-120.47825	R4	4	47.84779	-120.42074
R2	2	47.90615	-120.47822	R4	5	47.84668	-120.42126
R2	3	47.90293	-120.47313	R4	6	47.84656	-120.42028
R2	4			R4	7	47.84700	-120.42011
R2	5	47.90221	-120.47345	R4	8	47.84580	-120.41842
R2	6	47.90178	-120.47212	R4	9	47.84576	-120.41852
R2	7	47.89758	-120.45828	R4	10	47.84173	-120.41550
R2	8	47.89266	-120.45091	R4	11	47.84071	-120.41669
R2	9	47.89191	-120.45067	R4	12	47.84073	-120.41648
R2	10	47.88914	-120.44715	R4	13	47.84073	-120.41648
R2	11	47.88918	-120.44703	R4	14	47.87137	-120.42726
R2	12	47.88549	-120.43917	R4	15	47.83829	-120.41638
				R4	16	47.83828	-120.41636
R3	1	47.88326	-120.43659	R4	17	47.83818	-120.41641
R3	2	47.88326	-120.43681	R4	18	47.83809	-120.41646
R3	3	47.87137	-120.42726	R4	19	47.83812	-120.41649
R3	4	47.86818	-120.42386	R4	20	47.83718	-120.41738
R3	5	47.86818	-120.42386	R4	21	47.83718	-120.41738
R3	6	47.86818	-120.42386	R4	22	47.83229	-120.41763
R3	7	47.86818	-120.42386	R4	23	47.83229	-120.41754
R3	8	47.86554	-120.42407	R4	24	47.83225	-120.41763
R3	9	47.86255	-120.42310	R4	25	47.82160	-120.41525
R3	10	47.86255	-120.42310	R4	26	47.80184	-120.39358
R3	11	47.86251	-120.42282	R4	27	47.83100	-120.41906
R3	12	47.86164	-120.42065	R4	28	47.82875	-120.42165
R3	13	47.86164	-120.42065	R4	29	47.82872	-120.42159
R3	14	47.86069	-120.42234	R4	30	47.82857	-120.42261
R3	15	47.86069	-120.42234	R4	31	47.82712	-120.42222
R3	16	47.85909	-120.42325	R4	32	47.82723	-120.42225
R3	17	47.85909	-120.42325	R4	33	47.82722	-120.42234
R3	18	47.85854	-120.42273	R4	34	47.84891	-120.42216
R3	19	47.86822	-120.42381	R4	35	47.84075	-120.41664
R3	20	47.86589	-120.42474	R4	36	47.82899	-120.42163
R3	21	47.86567	-120.42446	R4	37	47.82772	-120.42224
R3	22	47.86249	-120.42322	R4	38	47.85002	-120.42325
R3	23	47.86249	-120.42322	R4	39	47.84892	-120.42219
				R4	40	47.84892	-120.42219
R4	1	47.85002	-120.42325	R4	41	47.84656	-120.42028
R4	2	47.84897	-120.42222	R4	42	47.84700	-120.42011
R4	3	47.84892	-120.42219	R4	43	47.84475	-120.41838

Reach	Redd #	Latitude	Longitude	Reach	Redd #	Latitude	Longitude
R4	44	47.84374	-120.41604	R5	29	47.81528	-120.42077
R4	45	47.84125	-120.41637	R5	30	47.81501	-120.42014
R4	46	47.84125	-120.41637	R5	31	47.81507	-120.41974
R4	47	47.84045	-120.41686	R5	32	47.81507	-120.41974
R4	49	47.84040	-120.41611	R5	33	47.81528	-120.41909
R4	50	47.84040	-120.41611	R5	34	47.81531	-120.41903
R4	51	47.83825	-120.41637	R5	35	47.81531	-120.41903
R4	52	47.83825	-120.41637	R5	36	47.81518	-120.41863
R4	53	47.83825	-120.41637	R5	37	47.81518	-120.41863
R4	54	47.83825	-120.41637	R5	38	47.81518	-120.41863
R4	55	47.82922	-120.42239	R5	39	47.81518	-120.41863
R4	56	47.82776	-120.42232	R5	40	47.81518	-120.41863
R4	57	47.84040	-120.41611	R5	41	47.81518	-120.41863
				R5	42	47.81518	-120.41863
R5	1	47.82676	-120.42353	R5	43	47.81485	-120.41786
R5	2	47.80601	-120.41130	R5	44	47.81437	-120.41616
R5	3	47.80047	-120.40510	R5	45	47.81437	-120.41616
R5	4	47.82678	-120.42346	R5	46	47.81383	-120.41512
R5	5	47.82678	-120.42346	R5	47	47.81383	-120.41512
R5	6	47.82678	-120.42346	R5	48	47.81267	-120.41494
R5	7	47.82678	-120.42346	R5	49	47.81212	-120.41484
R5	8	47.82678	-120.42346	R5	50	47.81212	-120.41484
R5	9	47.82618	-120.42232	R5	51	47.81212	-120.41484
R5	10	47.82466	-120.42209	R5	52	47.81180	-120.41427
R5	11	47.82398	-120.42258	R5	53	47.81188	-120.41290
R5	12	47.82277	-120.42231	R5	54	47.81112	-120.41231
R5	13	47.82067	-120.42583	R5	55	47.81112	-120.41231
R5	14	47.82070	-120.42580	R5	56	47.81095	-120.41243
R5	15	47.82014	-120.42517	R5	57	47.81036	-120.41197
R5	16	47.81995	-120.42486	R5	58	47.81036	-120.41197
R5	17	47.81995	-120.42486	R5	59	47.81006	-120.41195
R5	18	47.81734	-120.42229	R5	60	47.81006	-120.41195
R5	19	47.81572	-120.42135	R5	61	47.80981	-120.41176
R5	20	47.81572	-120.42135	R5	62	47.80956	-120.41174
R5	21	47.81572	-120.42135	R5	63	47.80945	-120.41164
R5	22	47.81557	-120.42127	R5	64	47.80945	-120.41164
R5	23	47.81553	-120.42119	R5	65	47.80921	-120.41156
R5	24	47.81553	-120.42119	R5	66	47.80799	-120.41107
R5	25	47.81553	-120.42119	R5	67	47.80679	-120.41167
R5	26	47.81548	-120.42100	R5	68	47.80503	-120.40937
R5	27	47.81545	-120.42075	R5	69	47.80503	-120.40937
R5	28	47.81528	-120.42077	R5	70	47.80495	-120.40910

Reach	Redd #	Latitude	Longitude	Reach	Redd #	Latitude	Longitude
R5	71	47.80495	-120.40910	R5	114	47.79697	-120.40279
R5	72	47.80429	-120.40813	R5	115	47.82618	-120.42232
R5	73	47.80288	-120.40498	R5	116	47.82618	-120.42232
R5	74	47.80288	-120.40498	R5	117	47.82466	-120.42209
R5	75	47.80288	-120.40498	R5	118	47.82398	-120.42258
R5	76	47.80288	-120.40498	R5	119	47.82277	-120.42231
R5	77	47.80288	-120.40498	R5	120	47.82144	-120.42329
R5	78	47.80207	-120.40445	R5	121	47.81861	-120.42432
R5	79	47.80207	-120.40445	R5	122	47.81748	-120.42252
R5	80	47.80207	-120.40445	R5	123	47.81572	-120.42137
R5	81	47.80207	-120.40445	R5	124	47.81572	-120.42137
R5	82	47.80188	-120.40445	R5	125	47.81553	-120.42119
R5	83	47.80188	-120.40445	R5	126	47.81528	-120.41909
R5	84	47.80175	-120.40421	R5	127	47.81182	-120.41387
R5	85	47.80114	-120.40410	R5	128	47.81064	-120.41220
R5	86	47.80114	-120.40410	R5	129	47.81064	-120.41220
R5	87	47.80114	-120.40410	R5	130	47.81064	-120.41220
R5	88	47.80114	-120.40410	R5	131	47.80981	-120.41176
R5	89	47.80089	-120.40442	R5	132	47.80503	-120.40937
R5	90	47.80039	-120.40510	R5	133	47.80503	-120.40937
R5	91	47.79969	-120.40496	R5	134	47.80503	-120.40937
R5	92	47.79969	-120.40496	R5	135	47.80442	-120.40701
R5	93	47.79955	-120.40410	R5	136	47.79754	-120.40244
R5	94	47.79955	-120.40410	R5	137	47.80218	-120.40489
R5	95	47.79955	-120.40410	R5	138	47.81572	-120.42137
R5	96	47.79955	-120.40410	R5	139	47.81507	-120.41974
R5	97	47.79955	-120.40410	R5	140	47.81518	-120.41863
R5	98	47.79955	-120.40410	R5	141	47.81383	-120.41512
R5	99	47.79955	-120.40410	R5	142	47.81112	-120.41231
R5	100	47.79955	-120.40410	R5	143	47.80956	-120.41174
R5	101	47.79937	-120.40355	R5	144	47.80288	-120.40498
R5	102	47.79908	-120.40345	R5	145	47.80288	-120.40498
R5	103	47.79908	-120.40345	R5	146	47.80089	-120.40442
R5	104	47.79908	-120.40345	R5	147	47.80089	-120.40442
R5	105	47.79908	-120.40345	R5	148	47.80089	-120.40442
R5	106	47.79908	-120.40345	R5	149	47.81997	-120.42485
R5	107	47.79908	-120.40345	R5	150	47.81507	-120.41974
R5	108	47.79908	-120.40345	R5	151	47.81218	-120.41459
R5	109	47.79908	-120.40345	R5	152	47.82034	-120.42551
R5	110	47.79879	-120.40327	R5	153	47.81195	-120.41414
R5	111	47.79867	-120.40305	R5	154	47.80288	-120.40498
R5	112	47.79867	-120.40305	R5	155	47.80014	-120.40502
R5	113	47.79862	-120.40287	R5	156	47.79955	-120.40410

Reach	Redd #	Latitude	Longitude
R5	157	47.79955	-120.40410
R5	158	47.79937	-120.40355
F	1	47.66665	-120.27969
F	2	47.66318	-120.25085
F	3	47.66356	-120.25088
F	4	47.66313	-120.25065
F	5	47.66316	-120.25046
F	6	47.66283	-120.24989
F	7	47.66283	-120.24958
F	8	47.66321	-120.24053
F	9	47.66360	-120.23776
F	9A	47.66559	-120.27647
F	10	47.66347	-120.23601
F	11	47.66357	-120.23604
F	12	47.66686	-120.28044
F	13	47.66686	-120.28044
F	14	47.66341	-120.25100
F	15	47.66321	-120.25072
F	16	47.66321	-120.25072
F	18	47.66283	-120.24958
F	19	47.66366	-120.23551
F	20	47.66295	-120.24054
F	21	47.66295	-120.24054
F	22	47.66295	-120.24054
F	23	47.66342	-120.23916
F	24	47.66342	-120.23916
F	25	47.66351	-120.23793
F	26	47.66349	-120.23588
F	27	47.66349	-120.23588
F	28	47.66349	-120.23588
F	29	47.66349	-120.23588
F	30	47.66349	-120.23588
F	31	47.66349	-120.23588
F	32	47.66349	-120.23588
F	33	47.66349	-120.23588
F	34	47.66349	-120.23588
F	35	47.66349	-120.23588
F	36	47.66349	-120.23588
F	37	47.66686	-120.28044
F	38	47.66686	-120.28044
F	39	47.66356	-120.25088
F	40	47.66356	-120.25088
F	41	47.66318	-120.25088
F	42	47.6636	-120.23776
H	1	47.69378	-120.31952
H	2	47.69377	-120.61949
H	3	47.69454	-120.32038
H	4	47.69378	-120.31952
H	5	47.69378	-120.31952
H	6	47.68665	-120.31549
H	7	47.68665	-120.31549
H	8	47.68665	-120.31549
H	9	47.67675	-120.31533
H	10	47.67850	-120.31255
H	11	47.67850	-120.31255
H	12	47.67850	-120.31255
H	13	47.67714	-120.31177
H	14	47.67561	-120.31088
H	15	47.67516	-120.31091
H	16	47.67406	-120.31017
H	17	47.67237	-120.30785
H	18	47.67098	-120.30155
H	19	47.66918	-120.28464
H	20	47.66918	-120.28464
H	21	47.66918	-120.28464
H	22	47.69345	-120.31895
H	23	47.67892	-120.31311
H	24	47.67369	-120.30922
H	25	47.67202	-120.30567

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

May 2014