

**Spring and Summer Chinook Salmon
Spawning Ground Surveys on the Entiat River, 1998**

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INTRODUCTION

Spring chinook salmon *Oncorhynchus tshawytscha* spawning has been monitored in the Entiat River since 1962 by Washington Department of Fish and Wildlife (WDFW) in a seven-mile index area that has been surveyed once annually after the peak of spawning. Summer chinook salmon surveys in the Entiat River have been limited to aerial surveys conducted from Ardenvoir to the mouth (River Mile (RM) 0 to 10.4), 1957 to 1991, by Chelan County Public Utility District (PUD). Starting in 1997, Mid-Columbia River Fishery Resource Office (MCRFRO), U.S. Fish and Wildlife Service (USFWS), has been conducting all surveys for spring and summer chinook salmon in the Entiat River. Fish counts at Rocky Reach and Wells dams are also used to monitor salmon runs in the Entiat River area.

This was the fifth year that MCRFRO expanded the spring chinook salmon spawning surveys to include an additional seven miles and conducted multiple summer chinook salmon surveys within a 13 mile section. Biologists also searched for sockeye salmon *O. nerka*, since they have been seen in the Entiat River in past years.

The purpose of the USFWS surveys are to:

1. Expand current Entiat River spring chinook salmon spawning surveys to assess spawning distribution over a larger area and more accurately estimate the spawning population.
2. Assess the spawning distribution and estimate the summer chinook salmon spawning population in the Entiat River.
3. Add to spawning and population trend analysis data for spring and summer chinook salmon in the Entiat River.
4. Check for possible straying of hatchery spring chinook salmon by retrieving coded-wire tag data from tagged fish.
5. Search for sockeye salmon and identify their spawning areas in the Entiat River.

STUDY AREA

The Entiat River enters the Columbia River approximately 484 miles and eight dams above the Pacific Ocean. The Entiat River is 52 miles long and begins as meltwater from glaciers and snow. Base flow is 385 ft³/s (Mullan et al. 1992), and its major tributaries are the North Fork and Mad rivers. Spawning surveys concentrated between Fox Creek Campground and McKenzie Diversion Dam (RM 28 to 16), because this reach contains most of the suitable spawning habitat (Figure 1). At RM 15 there is a terminal moraine formed by a valley glacier during the Pleistocene. Above the moraine, the valley is U-shaped and below it is V-shaped from stream cutting. Stream gradient below Box Canyon (RM 29 to 26) is steep and gravel is only found in small pockets. From RM 26 to 15 the gradient lessens and gravel is abundant. Between RMs 15 and 2 the river gradient steepens and substrate is mostly cobble and boulder. Below RM 2 the river gradient decreases. There are limited gravel areas around RM 1 and large deposits of silt and sand exist near the mouth. River miles and major landmarks are given in Appendix 1.

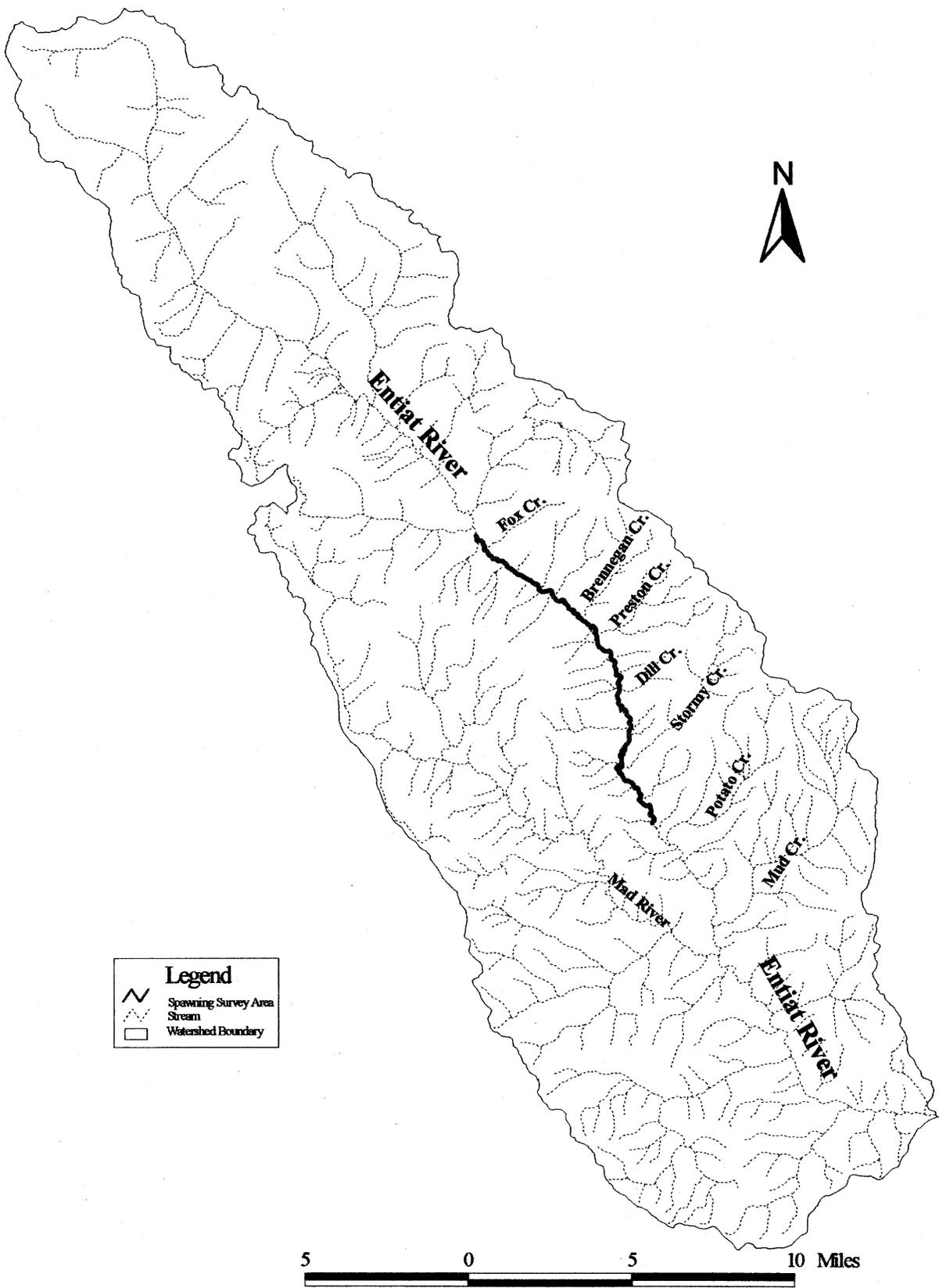


Figure 1. Overview of the Entiat River basin depicting the spawning survey area and landmark tributaries.

CHINOOK AND SOCKEYE SALMON POPULATIONS

The Entiat River historically supported excellent salmon runs that consisted of chinook (probably spring) and coho salmon (Craig and Suomela 1941). Construction of dams around the turn of the century near the mouth of the Entiat River blocked salmon from their spawning grounds, and salmon runs were essentially nonexistent by 1939 when Grand Coulee Dam was built (Craig and Suomela 1941). As part of the Grand Coulee Fish Maintenance Project mitigation effort, all ascending adult salmon from upriver stocks were trapped at Rock Island Dam from 1939 to 1943 and were relocated to upstream tributary streams below Grand Coulee Dam, including the Entiat River (mainly summer and fall chinook), and to hatcheries, including Leavenworth, Entiat, and Winthrop National Fish Hatcheries (NFH) (Fish and Hanavan 1948). The goal of these efforts was to rebuild salmon runs in the tributary streams and mitigate for lost production above Grand Coulee Dam.

Spring Chinook Salmon

In the initial years after Grand Coulee Dam was built, little effort was made to re-establish wild spring chinook salmon runs in the Entiat River. Entiat NFH released approximately 1 million sub-yearling and less than 50,000 yearling spring chinook salmon from 1942 to 1944 that were offspring of the upriver stocks collected at Rock Island Dam (Mullan 1987). No spring chinook salmon were released from Entiat NFH from 1945 to 1975. Aside from this, a wild spring chinook salmon run was observed as early as 1956 and 1957, spawning in the area above Stormy Creek (RM 18.4) (French and Wahle 1960). Since 1962 spring chinook salmon redds have been counted in an index section between RM 28 and 21, where a well established spring chinook salmon run has been documented (Figure 2 and Table 1). 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). Returning adults that voluntarily entered the hatchery were the primary broodstock in 1980 and from 1983 to 1998.

Summer Chinook Salmon

Although summer chinook salmon are not believed to be endemic to the Entiat River (Craig and Suomela 1941), several efforts were made to establish summer chinook salmon in the Entiat River 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). Entiat NFH reared and released juvenile summer chinook salmon into the Entiat River 1941-1964 and 1976 (Mullan 1987). Egg sources included the 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 Dam (1974). Summer chinook salmon spawning was monitored by aerial surveys in the lower 10.4 miles from 1957 to 1991. Visibility is usually poor, therefore aerial surveys likely underestimate actual redd numbers. Spawning numbers were never high, with a maximum of 55 redds in 1967. The number of redds declined following the adult return of the 1964 cohort. This cohort included the last group of fish returning from the summer chinook rearing program at Entiat NFH. For years 1972-1991 aerial redd counts averaged just under five per year.

Table 1. Spring chinook salmon redd counts from annual surveys in the **index area**, Fox Creek Campground to Dill Creek (RM 28 to 21), Entiat River, 1963-1998 (see Figure 2).

YEAR	# OF REDDS	YEAR	# OF REDDS	YEAR	# OF REDDS
1963	145	1975	156	1987	64
1964	384	1976	47	1988	67
1965	104	1977	171	1989	37
1966	307	1978	326	1990	83
1967	252	1979	N/A	1991	32
1968	252	1980	107	1992	42
1969	83	1981	95	1993	100
1970	70	1982	107	1994	24
1971	136	1983	107	1995	1
1972	61	1984	84	1996	8
1973	229	1985	115	1997	20
1974	88	1986	105	1998	15

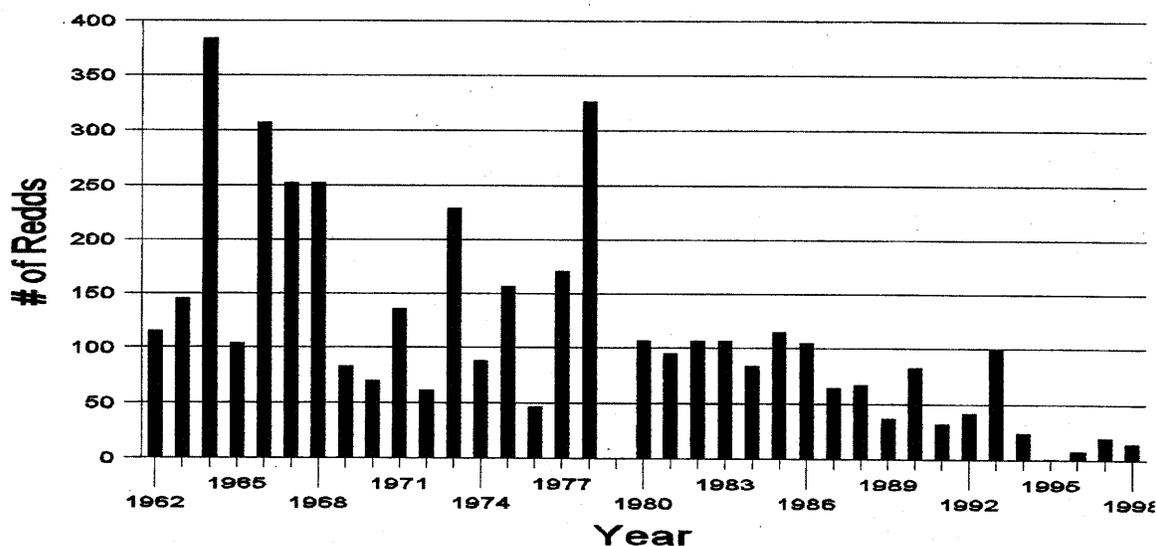


Figure 2. Spring chinook salmon redd counts from annual surveys in the **index area**, Fox Creek Campground to Dill Creek (RM 28 to 21), Entiat River, 1962-1998.

Sockeye Salmon

Sockeye salmon are not indigenous to the Entiat River (Craig and Suomela 1941) and have only been stocked on two occasions, in 1943 and 1944, from Lake Quinault and Lake Whatcom stocks (Mullan 1986). A small run of sockeye salmon became established in the Entiat River, and Entiat NFH collected sockeye salmon from 1944 to 1963 for planting elsewhere (Mullan 1986). Sockeye salmon were observed spawning in the Entiat River from 1945 to 1955, and 75-150 were counted in incidental counts between 1969 and 1981 (Mullan 1986).

METHODS

Spring Chinook Salmon

Methods for surveying spring chinook salmon were consistent with those used historically in the index area by WDFW. The survey area was divided into several reaches and single surveys of each reach were conducted after peak spawning in mid-September and early October by two persons walking downstream counting redds, live and dead fish (Figure 3). Only well established redds were counted. Dead fish were measured to the nearest centimeter (fork length), gender identified and scale samples taken when possible. All redd locations were marked with biodegradable flagging on nearby vegetation to distinguish them from summer chinook redds in subsequent surveys. Landowners were contacted by mail to notify them of the spring and summer chinook salmon spawning surveys and to seek permission to access their property as surveyors walked downstream.

The index area, from Fox Creek Campground to Dill Creek (RM 28 to 21), was surveyed on September 8-10, 1998, by USFWS for evidence of spring chinook salmon spawning. We surveyed from Dill Creek to McKenzie Diversion Dam (RM 21 to 16) on September 11, 1998 and from RM 28 to 16 on September 22-24.

We estimated the number of spring chinook salmon spawning in the Entiat River by expanding redd counts using two different estimators. The estimator of 2.4 chinook salmon adults per redd is widely used and generally accepted in the mid-Columbia basin. This estimator is used under the assumption that all redds were counted. Another estimator used by WDFW is 3.5 spring chinook salmon per redd. This estimator is used to determine the number of spawning spring chinook adults in the Entiat River given redd counts from only the index area (RM 28 to 21).

Summer Chinook Salmon

Methods were the same as for spring chinook salmon surveys with a few differences in area surveyed and survey frequency. The area from Fox Creek campground to McKenzie Diversion Dam (RM 28 to 16) was divided into several reaches and each was surveyed two to three times by two surveyors. Redd locations were marked with biodegradable flagging on nearby vegetation, and carcasses were cut in half to prevent recounting. The number of summer chinook salmon that spawned was estimated by expanding redd counts using the estimator of 2.4 chinook salmon per redd. Temperature probes were placed in the main spawning areas to help assess its affect on egg mortality (Appendix 2).

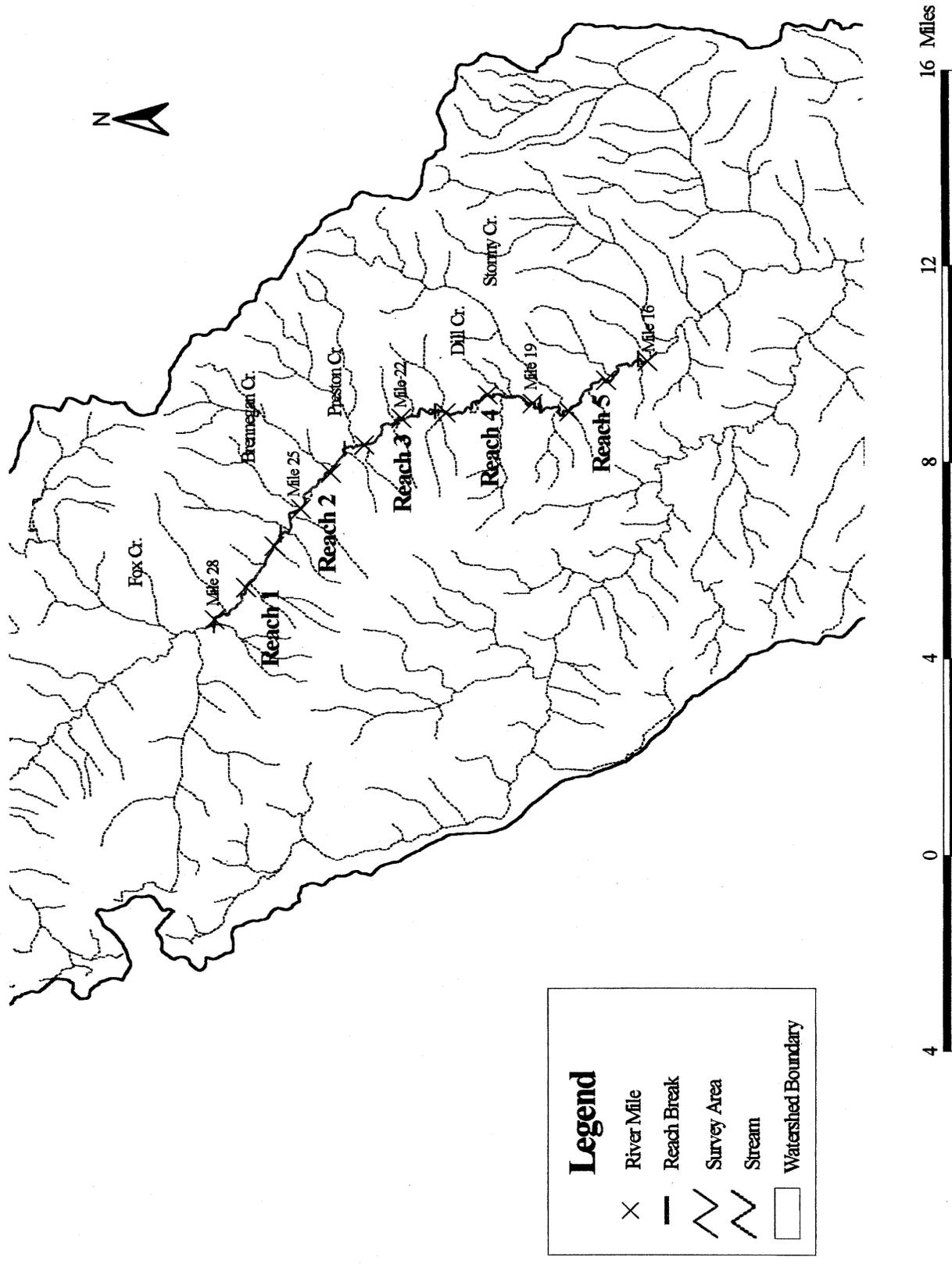


Figure 3. Survey area overview depicting reach breaks, USGS river miles, and landmark tributaries.

Sockeye Salmon

Sockeye salmon and/or redds were searched for on all surveys.

RESULTS

Spring Chinook Salmon

Fifteen spring chinook salmon redds were counted in the old "index" area (RM 28 to 21), (Table 1). Below the index area (RM 21 to 16), an additional 8 redds were found and one was located in Mad River. The complete survey identified a total of 24 redds and seven carcasses (Table 2, Figure 4, Figure 5 and Table 4). The index count was 63% of the total as compared to 54% in 1997, 40% in 1996 and 8% in 1995. The area from RM 28 to 16 probably included all or most of the spring chinook salmon spawning in the Entiat River since spring chinook are not known to spawn in the lower river. However, some spawning gravel (very little) exists in those areas not surveyed (RM 1 to 16), and it is possible that some spawning occurred in that area. For the 1998 "index" count, multiplication of the 15 redds by the estimator of 3.5 fish per redd yields an estimate of 53 spawners. Assuming all redds were counted, the total redd count of 24 multiplied by the estimator of 2.4 fish per redd gives an estimate of 58 adults escaping to spawn in the Entiat River. The peak of spawning appears to have occurred around the first week in September (Table 3). No marked or unmarked hatchery spring chinook were seen.

Summer Chinook Salmon

Forty-two summer chinook salmon redds were counted in the main survey section (RM 28 to 16), and these were all found below RM 24.8 (Table 2 and Figure 5). Three redds were located at RM 0.5 and one at RM 6.7. There was a total of 46 redds and eight carcasses found (Figure 4 and Table 4). The first summer chinook redd was discovered on the October 14th survey with the peak of spawning occurring the first or second week of October (Table 3). Multiplying the 46 redds by the estimator of 2.4 fish per redd yields an estimate of 110 summer chinook salmon adults escaping to spawn in Entiat River. This estimate should be considered a minimum since the lower 16 miles were not completely surveyed. One marked fish was found (radio transmitter). This fish was tagged at Bonneville Dam on June 28, 1998.

Sockeye Salmon

Nine adult sockeye salmon and three redds were observed at RM 24.3:

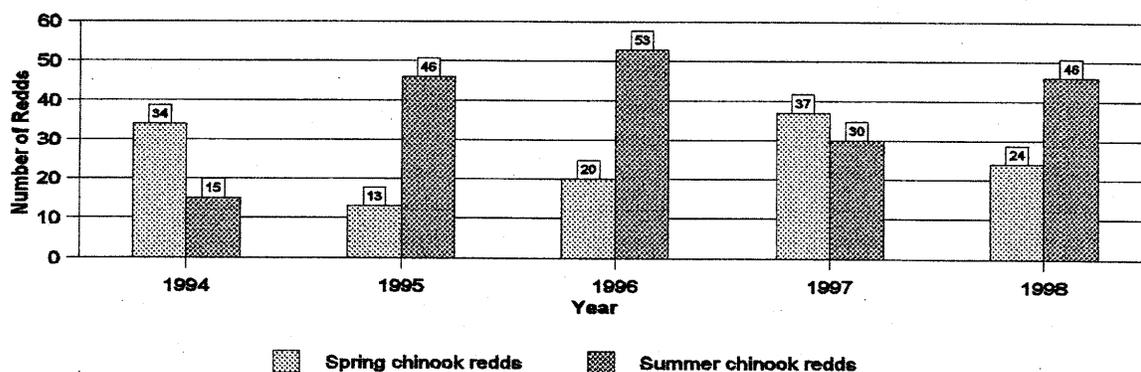


Figure 4. Total SCS and SUS redds - Entiat River, 1994 to 1998.

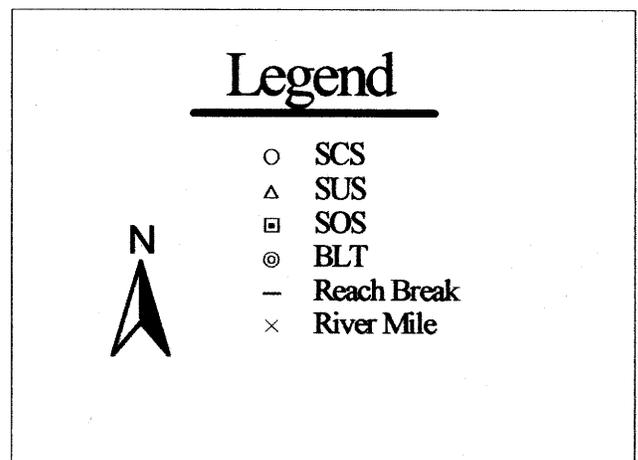
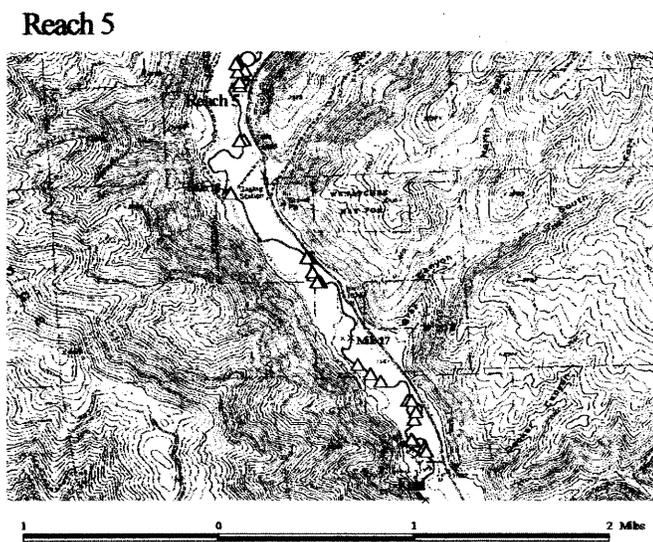
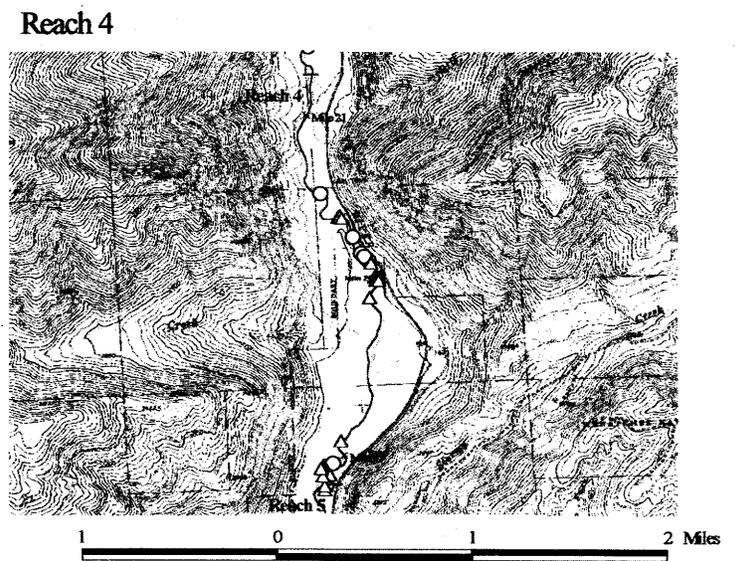
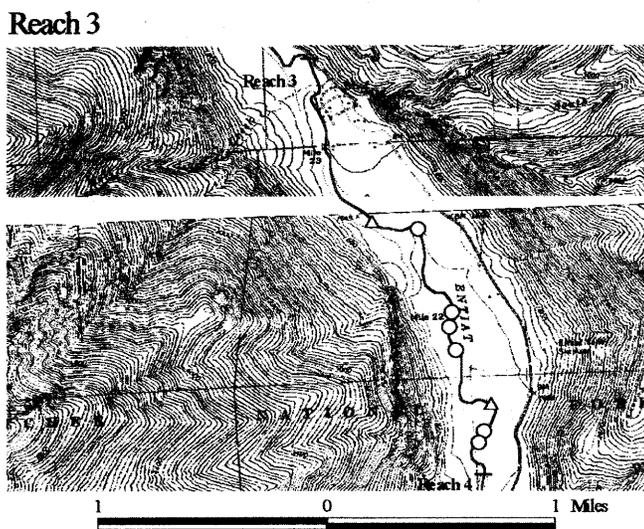
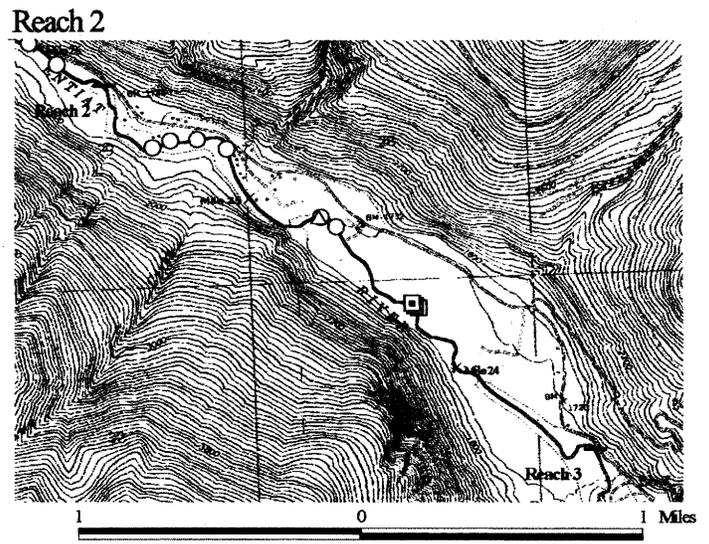
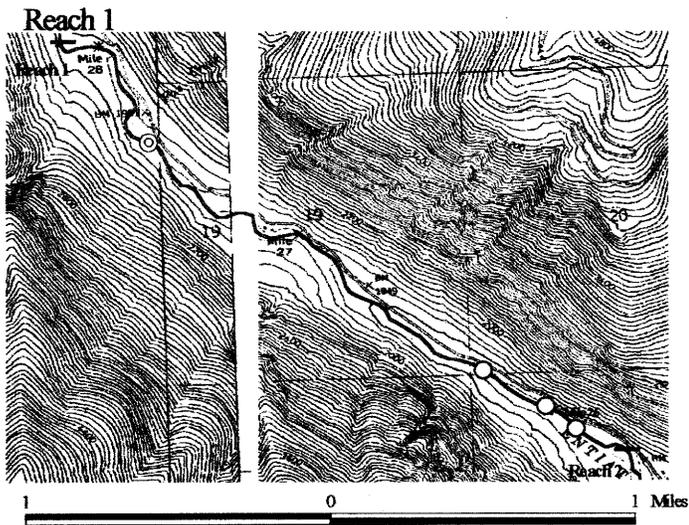


Figure 5. Redds displayed by reach.

Table 2. Number of redds and their locations on Entiat River, 1998.

RIVER MILE	# OF SPRING CHINOOK REDDS	# OF SUMMER CHINOOK REDDS
27 - 28	0	0
26 - 27	2	0
25 - 26	5	0
24 - 25	2	1
23 - 24	0	0
22 - 23	3	1
21 - 22	3	1
20 - 21	5	9
19 - 20	0	2
18 - 19	1	10
17 - 18	0	7
16 - 17	2	11
6 - 7	0	1
0 - 1	0	3
Mad River	1	0
TOTAL	24	46

Table 3. Survey dates and number of new redds found, 1998

SURVEY DATES	SPRING CHINOOK REDDS	SUMMER CHINOOK REDDS
September 8 - 11	17	0
September 22 - 24	6	0
October 14, 15	1	30
October 27, 28	0	15
November 9th	0	1
TOTAL	24	46

Table 4. Sex, age, and fork lengths of spring and summer chinook salmon carcasses sampled in the Entiat River, 1998.

Fish #	Sex	Length (cm)	Species	Age	Spawned
1.	Female	82	Spring Chinook	4	yes
2.	Female	85	"	4	yes
3.	Male	97	"	5	
4.	Male	72	"	4	
5.	Male	100	"	5	
6.	Male	94	"	5	
7.	Male	94	"	5	
8.	Male	46	Summer Chinook	3	
9.	Male	85	"	4	
10.	Male	67	"	4	
11.	Male	79	"	4	
12.	Male	104	"	5	
13.	Male	99	"	unk	
14.	Female	91	"	5	yes
15.	Female	50	" (hatchery origin)"	3	unk
16.	Female	55	Sockeye Salmon	4	yes

Unk = Unknown

Table 5. Estimated escapement in 1998 of wild spring and summer chinook between Rocky Reach and Wells dams using the difference between dam counts reduced by the number of salmon taken at state and federal fish hatcheries (includes jacks).

Count	Spring chinook	Summer chinook
Rocky Reach Dam ¹	867	8524
Wells Dam ²	<u>531</u>	<u>4108</u>
Difference	336	4416
Entiat NFH-# Fish Taken	216	0
Wells SFH-# Fish Taken	0	1678
Chelan River Spawners ¹	<u>0</u>	<u>65³</u>
Potential Entiat R. natural spawners	120	2673

¹ Chuck Peven, Chelan County Public Utility District, pers comm. 1999.

² Rick Klinge, Douglas County Public Utility District, pers comm. 1999.

³ Twenty-seven redds multiplied by 2.4 fish/redd

DISCUSSION

Wild spring chinook salmon adult returns to Entiat River in 1998 were again at low levels. The index count of 15 redds is the third lowest on record and 12.7 percent of the 1962 to 1997 average of 118. Since 1987, redd counts have been depressed. Index counts have averaged only 41 redds for years 1987 to 1998, and only 14 since 1994. Spring chinook salmon counts at Rocky Reach and Wells dams were also low this year (Table 6). Counts at Rocky Reach Dam were 28 percent of the previous 15 year (1983 to 1997) average of 3,090 and 27 percent of the same 15 year average at Wells Dam of 1,948 spring chinook salmon. Potential adult spring chinook salmon escapement (after deducting hatchery returns) between the two dams is estimated at 120 (Table 5) compared to the number generated by redd expansions of 58. Both methods of estimating the size of the wild salmon spawning population have inherent assumptions that influence their results. Dam counts suffer from possible multiple counts due to fall back and failure to account for pre-spawning mortality. The date for separating the chinook run into spring and summer components is founded on historical dam counts. It does not allow for overlap of run timing between stocks nor annual variability in run timing for each stock. On the other hand, the accuracy of redd counts can be influenced by salmon spawning outside of the survey area, observer error, and/or the use of an incorrect expansion factor to estimate the number of spawners from redd counts. Given the inherent problems with each estimation method, we believe that the expanded redd counts provide a better monitoring tool, compared to dam counts, for determining trends in the Entiat River. We do not believe that the actual number of spring chinook spawning in the Entiat River differs significantly from our estimate of 58 fish.

In 1998 we conducted three full summer chinook surveys (Table 3). The four redds found in the lower river was similar to counts noted from aerial surveys from 1977 to 1991. In 1994 USFWS conducted the first summer chinook redd survey in the Entiat River when eleven redds were found. In 1995 surveyors located 40 summer chinook redds in the same area (RM 28 to 16), 45 were found in 1996, and 30 in 1997. Counts at Rocky Reach Dam of 8524 summer chinook exceeded the 15 year average (1983 to 1997) of 4911 (Table 6). The difference in counts (after subtracting hatchery brood takes) between Rocky Reach and Wells dams was 2673 fish (Table 5), which greatly exceeds the estimate from the Entiat River redd expansion of 110 (2.4/redd) summer chinook. Had the entire lower river been surveyed (ground or aerial) some additional redds may have been found, although suitable spawning gravels are lacking in this area. Again, inherent problems with dam counts cause us to prefer using redd counts to better quantify the number of summer chinook actually spawning in the Entiat River.

Nine adult sockeye salmon were observed at RM 24.3 near three active redds. One sockeye carcass was also found.

Although the focus of our surveys is not directed at bull trout, any redd found will be identified to species origin if possible. One bull trout redd was observed at the entrance of the old spawning channel near RM 27.

Table 6. Annual fish counts of spring and summer chinook and sockeye salmon at Rocky Reach Dam, 1962-1998, and Wells Dam, 1967-1998.

Year	<u>Spring Chinook</u>		<u>Summer Chinook</u>		<u>Sockeye Salmon</u>	
	Rocky Reach	Wells	Rocky Reach	Wells	Rocky Reach	Wells
1962	3,697		9,295		9,870	
1963	4,644		5,776		37,046	
1964	6,536		10,752		32,159	
1965	2,755		15,975		31,735	
1966	6,962		19,445		129,557	
1967	5,560	1,157	15,558	12,504	109,434	113,232
1968	6,422	4,931	14,721	8,922	91,376	81,530
1969	4,400	3,599	12,996	6,846	20,374	17,352
1970	4,375	2,670	11,822	8,003	57,251	50,677
1971	4,132	3,168	10,031	5,988	49,838	48,172
1972	3,894	3,616	5,577	4,141	26,978	33,398
1973	4,344	2,937	9,683	5,052	48,856	37,178
1974	4,263	3,420	8,274	4,567	20,976	16,716
1975	3,353	2,225	15,367	8,522	26,925	22,286
1976	1,892	2,759	7,771	7,901	27,205	27,619
1977	5,948	4,211	10,593	7,527	25,648	21,973
1978	7,396	3,625	8,095	6,419	8,157	7,458
1979	2,203	1,103	8,577	10,080	28,747	22,655
1980	1,866	1,182	5,367	4,892	29,906	26,573
1981	3,529	1,935	4,668	4,276	30,649	28,234
1982	2,815	2,401	2,705	3,349	17,379	19,005
1983	3,406	2,869	2,777	2,821	26,069	27,925
1984	4,171	3,280	5,875	5,941	73,290	81,054
1985	8,910	5,257	5,937	4,456	54,077	53,170
1986	4,300	3,150	5,554	4,178	32,912	34,876
1987	3,586	2,344	4,078	3,142	41,115	39,948
1988	4,959	3,036	3,683	2,775	34,090	33,980
1989	3,316	1,740	5,654	3,333	16,176	15,895
1990	1,951	981	4,297	3,354	9,296	7,597
1991	1,401	779	3,158	2,028	27,439	27,492
1992	2,774	1,623	2,257	1,967	41,804	41,844
1993	4,256	2,444	4,980	3,603	28,318	23,038
1994	388	257	7,293	4,891	1,680	1,662
1995	290	103	5,638	5,043	4,985	4,892
1996	628	387	5,737	4,479	21,741	17,701
1997	2,014	971	6,750	3,902	30,485	25,304
1998	867	531	8,524	4,108	5,653	4,669

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APPENDICES

Appendix 1. River mile index of the Entiat River from the mouth to Box Canyon.

River-mile	Description
0.0	Mouth of <u>Entiat River</u> at river-mile 483.7 on Columbia River
0.3	Head of Pool from Rocky Reach Dam
3.1	Entiat River Road Bridge
4.5	Entiat River Road Bridge
7	Entiat National Fish Hatchery
10.4	Ardenvoir Road Bridge at Ardenvoir
10.6	Mad River
15.2	Potato Creek
16	McKenzie Ditch and Diversion Dam
18.4	Stormy Creek
18.9	"Watch for Ice" sign on Highway
21.2	Dill Creek
23.1	Preston Creek
23.4	Brief bridge
23.9	Brennegan Creek
25	McCrea Creek
25.5	Burns Creek
27.7	Fox Creek
28	Fox Creek Campground
28.6	Tommy Creek
28.9	Lake Creek Campground
29.2	Box Canyon

mileage may not be exact

Appendix 2. Temperature monitoring on Entiat River, 1998

Temperature Monitoring

It has been demonstrated that if chinook salmon eggs are initially exposed to water temperatures less than 42.5°F significant mortality will likely occur (Combs 1965). If water temperature is 42.5°F to 56°F for the first 72 hours after deposition, a subsequent drop in temperature below this threshold will not cause abnormal mortality. At the time summer chinook salmon are spawning in the Entiat River, water temperatures are very close to, and sometimes below, this lower threshold.

To help determine the potential impact on summer chinook populations in the Entiat River caused by this temperature variance, USFWS installed temperature recording devices in the spawning areas. Three "Optic StowAway" temperature probes (Onset Computer Corp.) were placed at rms 27, 21 and 17. Data indicates that during peak spawning of summer chinook salmon in 1998, temperatures remained above this lower threshold although dropped below 42.5°F from 10/19 to 10/25. How this may affect smolt production is unknown. River temperature data obtained from Entiat NFH (ENFH) showed on average a 2.5° increase over our recorders (ENFH is about twelve miles downstream of survey area).

USFWS is currently attempting to gather information on out-migrating spring and summer chinook salmon in Entiat River using an eight-foot rotary screw-trap. In 1997 we captured summer chinook fry during the trapping period from April to early June so some summer chinook are likely produced by fish spawning in the Entiat River. The trap was not operating in 1998 because our ESA permit had not been completed.