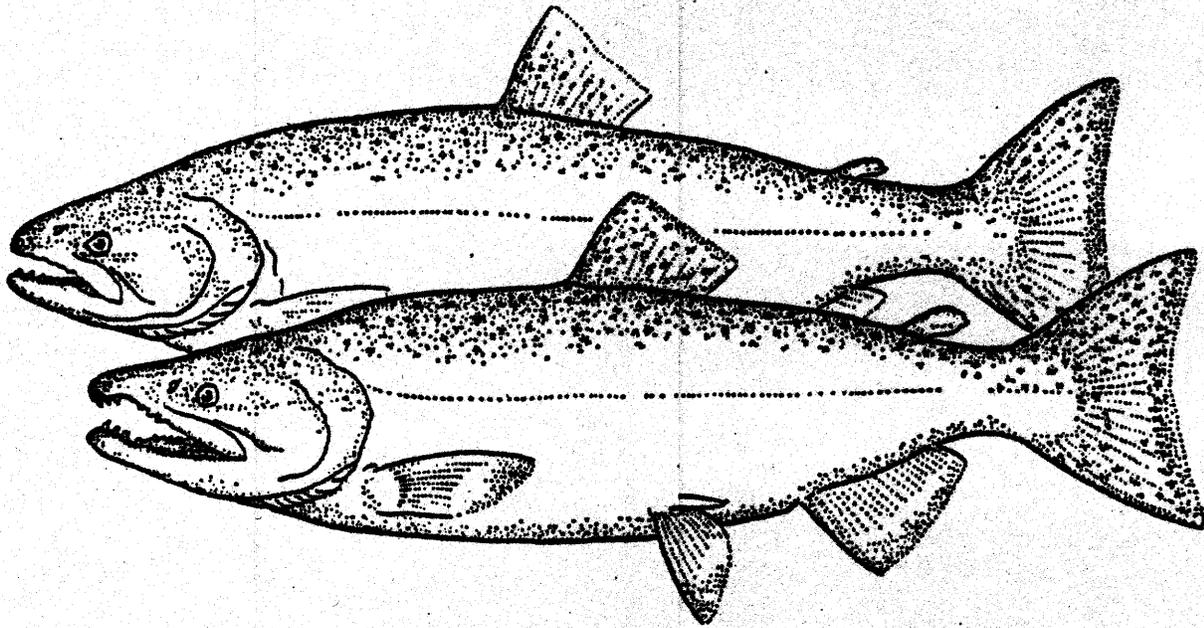

August 2000

**SPRING AND SUMMER CHINOOK SALMON
SPAWNING GROUND SURVEYS
ON THE ENTIAT RIVER, 1999**



**Fish and Wildlife Service
U.S. Department of the Interior**

**Spring and Summer Chinook Salmon
Spawning Ground Surveys on the Entiat River, 1999**

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August 2000

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INTRODUCTION

From 1962 to 1994, spring chinook salmon (SCS) *Oncorhynchus tshawytscha* spawning was monitored by the Washington Department of Fish and Wildlife (WDFW) in a seven-mile section (River Mile (RM) 21 to 28) of the Entiat River known as the "index area". From 1957 to 1991, the Chelan County Public Utility District (PUD) monitored summer chinook (SUS) spawning in the lower ten miles (RM 0 to 10.4) of the Entiat River. While informative, these monitoring efforts were later believed to be either deficient in scope (area surveyed) and/or methodology. In 1994, in recognition of the need to improve the spawning survey efforts, the U.S. Fish and Wildlife Service's (USFWS) Mid-Columbia River Fishery Resource Office (MCRFRO) began a more intensive spring and summer chinook spawning monitoring program on the Entiat River. Fish count data from Rocky Reach and Wells dams are also used to evaluate salmonid runs in the Entiat River area.

Efforts in 1999 mark the sixth year that MCRFRO has conducted the expanded spring and summer chinook spawning activities. Biologists also search for and note presence and/or redds of sockeye salmon *O. nerka* and bull trout *Salvelinus fontinalis* since observations of these fish have been made in previous years.

The purpose of the MCRFRO spawning surveys are to:

1. Continue to assess the distribution of spring and summer chinook salmon spawning throughout an expanded area of the Entiat River and provide accurate estimates of the respective spawning populations.
2. Supplement spawning and population trend analysis data for spring and summer chinook salmon in the Entiat River.
3. Evaluate possible straying of hatchery spring and summer chinook salmon.
4. Search for sockeye salmon and bull trout and identify spawning distribution in the Entiat River.

STUDY AREA

The Entiat River Basin is located in Chelan County, north-central Washington State. The river heads in a glaciated basin near the crest of the Cascade Mountains and flows southeasterly. Base flow is 385 cubic feet/second (Mullan et al. 1992) and its major tributaries are the North Fork (RM 34) and Mad River (RM 10.5). The upstream limit of anadromy is Entiat Falls (RM 29.2).

The Entiat System drains an area of about 416.5 square miles. The Watershed is nearly 42 miles in length and varies in width from 5 to 14 miles. The basins highest elevation is the 9,249 foot summit of Mt. Fernow and its lowest is about 700 feet at the confluence with the Columbia River (USDA 1979). The Entiat River enters the Columbia River approximately 484 RM's and eight mainstem hydroelectric dams above the Pacific Ocean.

Spawning ground 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).

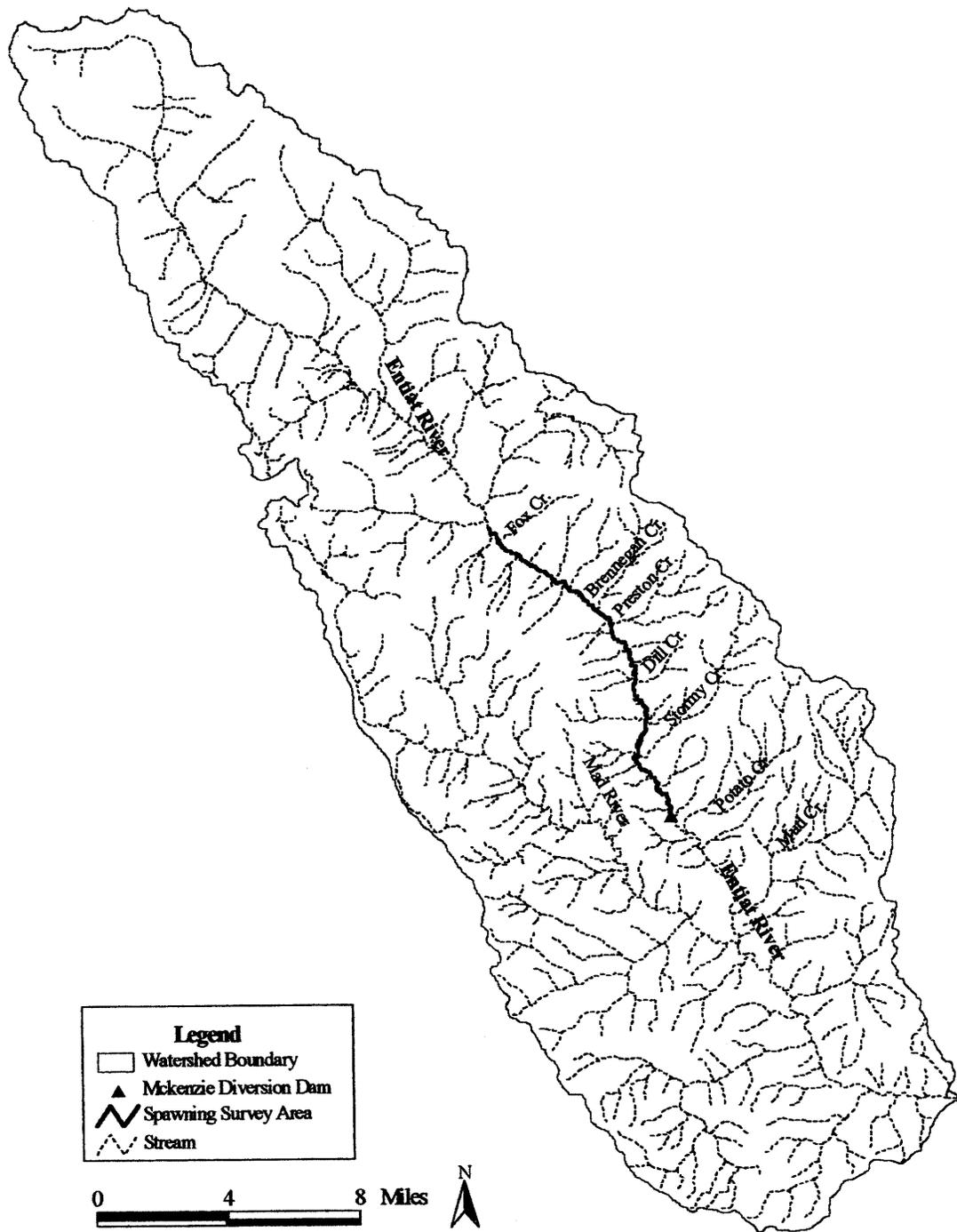


Figure 1. Overview of the Entiat River basin depicting the spawning survey area and landmark tributaries.

CHINOOK AND SOCKEYE SALMON POPULATIONS

The Entiat River historically supported excellent salmon runs that consisted of chinook (probably spring chinook) 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 one 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. 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 an 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 1999.

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 RM's from 1957 to 1991. Positive redd identification from the air is difficult at best, therefore aerial surveys likely underestimate actual redd numbers. Spawning numbers were never high, with a maximum of 55 redds in 1967. For years 1972-1991 aerial redd counts averaged just under five fish 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, 1964-1994 (WDFW) and 1995 - 1999 (USFWS) (see Figure 2).

YEAR	# OF REDDS	YEAR	# OF REDDS	YEAR	# OF REDDS
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
1975	156	1987	64	1999	6

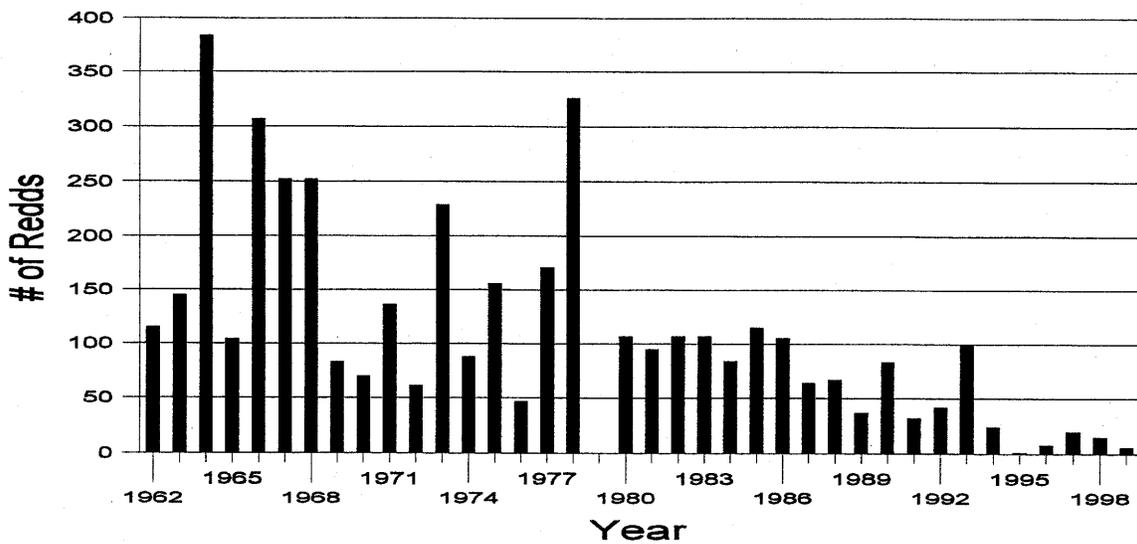


Figure 2. Spring chinook salmon redd counts from annual surveys in the *index area*, Fox Creek Campground to Dill Creek (RM 28 to 21), Entiat River, 1962-1999.

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. Scales are viewed under a microscope where age and origin (wild or hatchery) can be determined. Snouts were removed from marked hatchery fish for later retrieval and de-coding of coded-wire tag (CWT). 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 7- 9, 1999, by USFWS for evidence of spring chinook salmon spawning. We surveyed from Dill Creek to McKenzie Diversion Dam (RM 21 to 16) on September 10, 1999 and again from RM 28 to 16 on September 21 - 23. The entire area (RM 28 to 16) was therefore surveyed twice.

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, survey frequency and timing. 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.

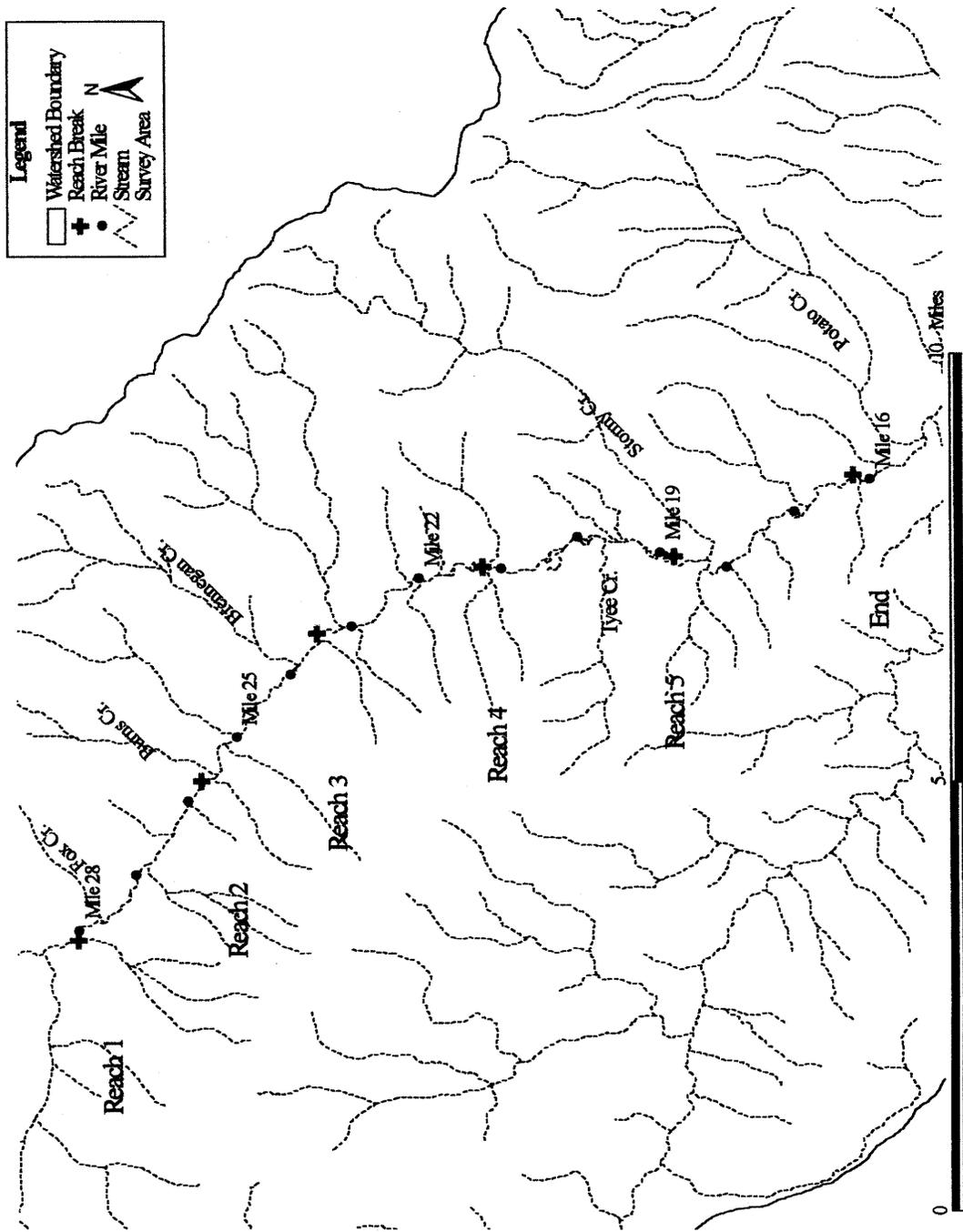


Figure 3. Survey area overview depicting reach breaks, USGS river miles, and landmark tributaries.

Sockeye Salmon

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

RESULTS

Spring Chinook Salmon

Six spring chinook salmon redds were counted in the "index" area (RM 28 to 21). An additional 20 redds were found below the index area and one was found in Mad River (Table 1). The complete survey identified a total of 27 redds and four carcasses (Figure 4, Table 2 and Table 4). The index area count was 22% of the total count as compared to 63% in 1998, 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 1999 "index" count, multiplication of the 6 redds by the estimator of 3.5 fish per redd yields an estimate of 21 spawners. Assuming all redds were counted, the total redd count of 27 multiplied by the estimator of 2.4 fish per redd gives an estimate of 65 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 found.

Summer Chinook Salmon

Forty-one summer chinook salmon redds were counted in the main survey section (RM 28 to 16), and these were all found below RM 24.4 (Table 2). Five redds were located at RM 0.5 and one at RM 3.4. There was a total of 47 redds and eight carcasses found (Figure 4 and Table 4). The first summer chinook redd was discovered on the October 6th survey with the peak of spawning occurring the first or second week of October (Table 3). Multiplying the 47 redds by the estimator of 2.4 fish per redd yields an estimate of 113 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. Two marked fish were found, a 5 year-old female released from Turtle Rock Hatchery and the other, a 4 year-old female released from Dryden Pond, both WDFW facilities.

Sockeye Salmon

No sockeye salmon were found in 1999.

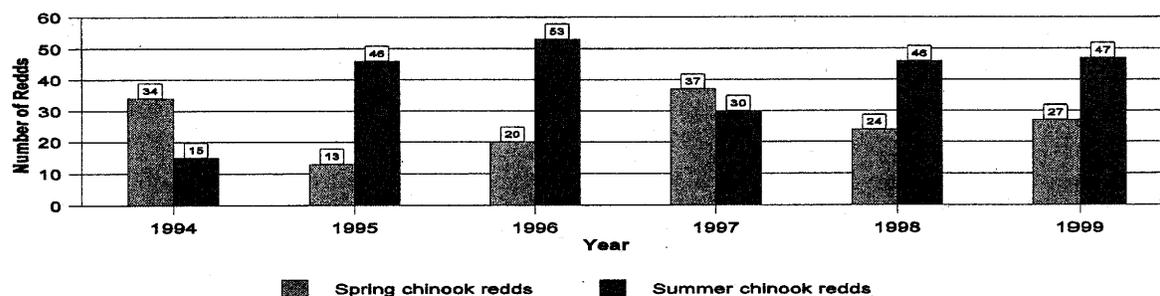


Figure 4. Total SCS and SUS redds - Entiat River, 1994 to 1999.

Table 2. Number of redds and their locations on Entiat River, 1999.

RIVER MILE	# OF SPRING CHINOOK REDDS	# OF SUMMER CHINOOK REDDS
27 - 28	1	0
26 - 27	0	0
25 - 26	0	0
24 - 25	0	1
23 - 24	1	0
22 - 23	3	0
21 - 22	1	2
20 - 21	3	2
19 - 20	4	8
18 - 19	4	11
17 - 18	4	8
16 - 17	4	9
6 - 7	1	0
0 - 4	0	6
Mad River	1	0
TOTAL	27	47

Table 3. Survey dates and number of new redds found, 1999

SURVEY DATES	SPRING CHINOOK REDDS	SUMMER CHINOOK REDDS
September 7 - 10	15	-
September 21 - 23	10	-
October 6, 7	2	24
October 21, 22	-	20
November 9th	-	3
TOTAL	27	47

Table 4. Sex, age, and fork lengths of spring and summer chinook salmon carcasses sampled in the Entiat River, 1999.

Fish #	Sex	Length (cm)	Species	Age	Spawned
1.	Male	86	Spring Chinook	4	-
2.	Male	71	"	4	-
3.	Male	71	"	4	-
4.	Male	76	"	4	-
5.	Male	79	Summer Chinook	4	-
6.	Male	89	"	4	-
7.	Male	71	"	4	-
8.	Male	91	"	unk	-
9.	Female	73	"	unk	unk
10.	Female	91	(hatchery origin ¹)	5	yes
11.	Female	84	(hatchery origin ²)	4	yes
12.	Female	91	"	5	yes

Unk = Unknown

1- BY 94, released from Dryden Pond

2- BY 95 released from Turtle Rock

DISCUSSION

Wild spring chinook salmon adult returns to Entiat River in 1999 were again at low levels. The index count of 6 redds is the second lowest on record and 5.2 percent of the 1963 to 1998 average of 115. Since 1987, redd counts have been depressed. Index counts have averaged only 38 redds for years 1987 to 1999, and only 12 per year since 1994. Spring chinook salmon counts at Rocky Reach and Wells dams were also low this year (Table 5 and Table 6). Counts at Rocky Reach Dam were 58 percent of the previous 15 year (1984 to 1998) average of 2,920 and 36 percent of the same 15 year average at Wells Dam of 1,792 spring chinook salmon. Potential adult spring chinook salmon escapement (after deducting hatchery returns) between the two dams is estimated at 315 (Table 5) compared to the number generated by redd expansions of 65. 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 65 fish. In 1999 we conducted three full summer chinook surveys (Table 3). The six 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, 30 in 1997 and 46 in 1998. Counts at Rocky Reach Dam of 14,752 summer chinook exceeded the 15 year average (1984 to 1998) of 5,294 (Table 6). The difference in counts (after subtracting hatchery brood takes) between Rocky Reach and Wells dams was 3,403 fish (Table 5), which greatly exceeds the estimate from the Entiat River redd expansion of 113 (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.

No sockeye salmon were observed in 1999.

Although the focus of our surveys is not directed at bull trout, any redd found was identified to species origin if possible. In 1999, we identified 6 redds, completed in smaller substrate, that appeared to be from bull trout. One was located near RM 27, one at RM 19 and the other four were between RMs 16.5 and 17. These were found during the September surveys.

Table 5. Estimated escapement in 1999 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	1,688	14,752
Wells Dam	<u>649</u>	<u>9,033</u> ²
Difference	1,039	5,719
Entiat NFH-# Fish Taken	724	0
Wells SFH-# Fish Taken	0	1,246 ²
Chelan River Spawners	<u>0</u>	70 ³
Columbia River Spawners ²		<u>1,000</u>
Potential Entiat R. natural spawners	315	3,403

¹ Mosey T. R. and K. G. Murdoch, 2000.

² Rick Klinge, Douglas County Public Utility District, pers comm. 2000.

³ Twenty-nine redds multiplied by 2.4 fish/redd (redd count, Chelan Co. PUD, pers comm. 2000)=70 estimated adult spawners in river below Wells Dam.

Table 6. Annual fish counts of spring and summer chinook and sockeye salmon at Rocky Reach Dam, 1962-1999, and Wells Dam, 1967-1999.

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
1999	1,688	649	14,752	9,033	14,118	12,388

REFERENCES

- 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. Unpublished MS, USFWS. 35 pp. plus 18 affidavits and accompanying letters of corroboration. *in* Mullan et. al. 1992, Appendix J.
- Fish, F.F., and M.G. Hanavan. 1948. A report on the Grand Coulee Fish Maintenance Project 1939-1947. USFWS, Special Scientific Report 55. 63 pp.
- French, R.R., and R.J. Wahle. 1960. Salmon runs - upper Columbia River, 1956-57. USFWS, Special Scientific Report 364.
- Klinge, R., Douglas County Public Utility District, pers. comm., 2000
- Mosey, T.R., and K.G. Murdoch. 2000. Spring and Summer Chinook Spawning Ground Surveys on the Wenatchee River Basin, 1999.
- Mullan, J.W. 1986. Determinants of sockeye salmon abundance in the Columbia River, 1880s-1982: A review and synthesis. USFWS Biological Report 86(12). Leavenworth, WA. 136 pp.
- Mullan, J.W. 1987. Status and propagation of chinook salmon in the mid-Columbia River through 1985. USFWS Biological Report 89(3). Leavenworth, WA. 111 pp.
- Mullan, J.W., K.R. Williams, G. Rhodus, T.W. Hillman, J.D. McIntyre. 1992. Production and habitat of salmonids in Mid-Columbia River tributary streams. USFWS Monograph I. Leavenworth, WA. 489 pp.
- USDA. U.S. Department of Agriculture (USFS and SCS), 1979. Entiat: Cooperative River Basin Study.

APPENDIX

Appendix A. 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
7.0	Entiat National Fish Hatchery
10.4	Ardenvoir Road Bridge at Ardenvoir
10.6	Mad River
15.2	Potato Creek
16.0	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
25.0	McCrea Creek
25.5	Burns Creek
27.7	Fox Creek
28.0	Fox Creek Campground
28.6	Tommy Creek
28.9	Lake Creek Campground
29.2	Box Canyon

mileage may not be exact