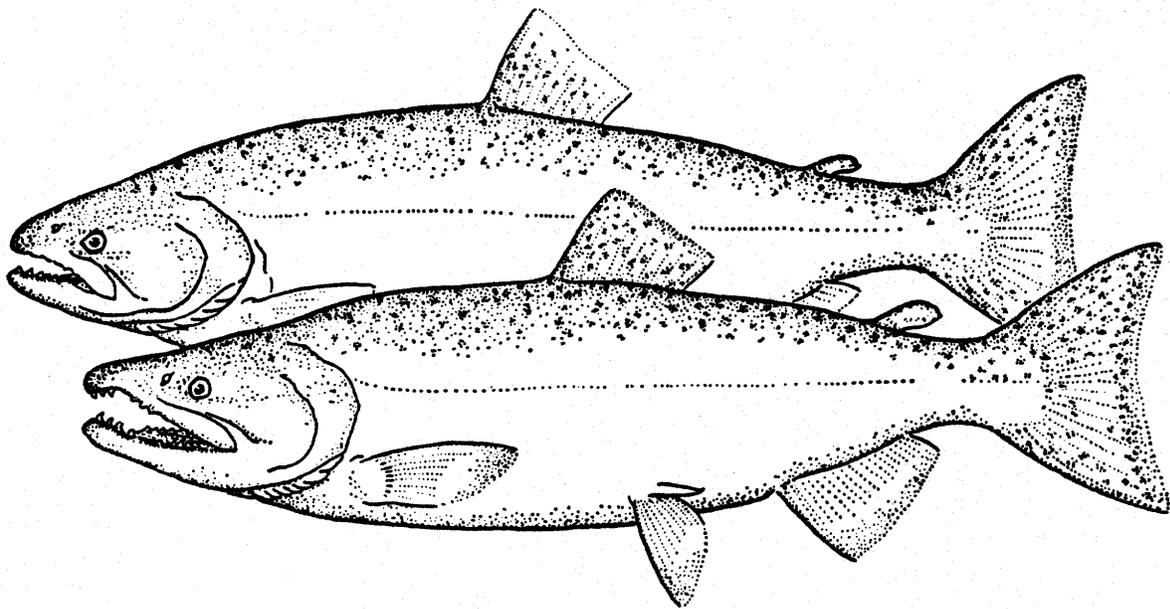


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December 1996

**SPRING AND SUMMER CHINOOK SALMON  
SPAWNING GROUND SURVEYS  
ON THE ENTIAT RIVER, 1996**



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

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Fisheries Research Board of Canada, Bulletin 184

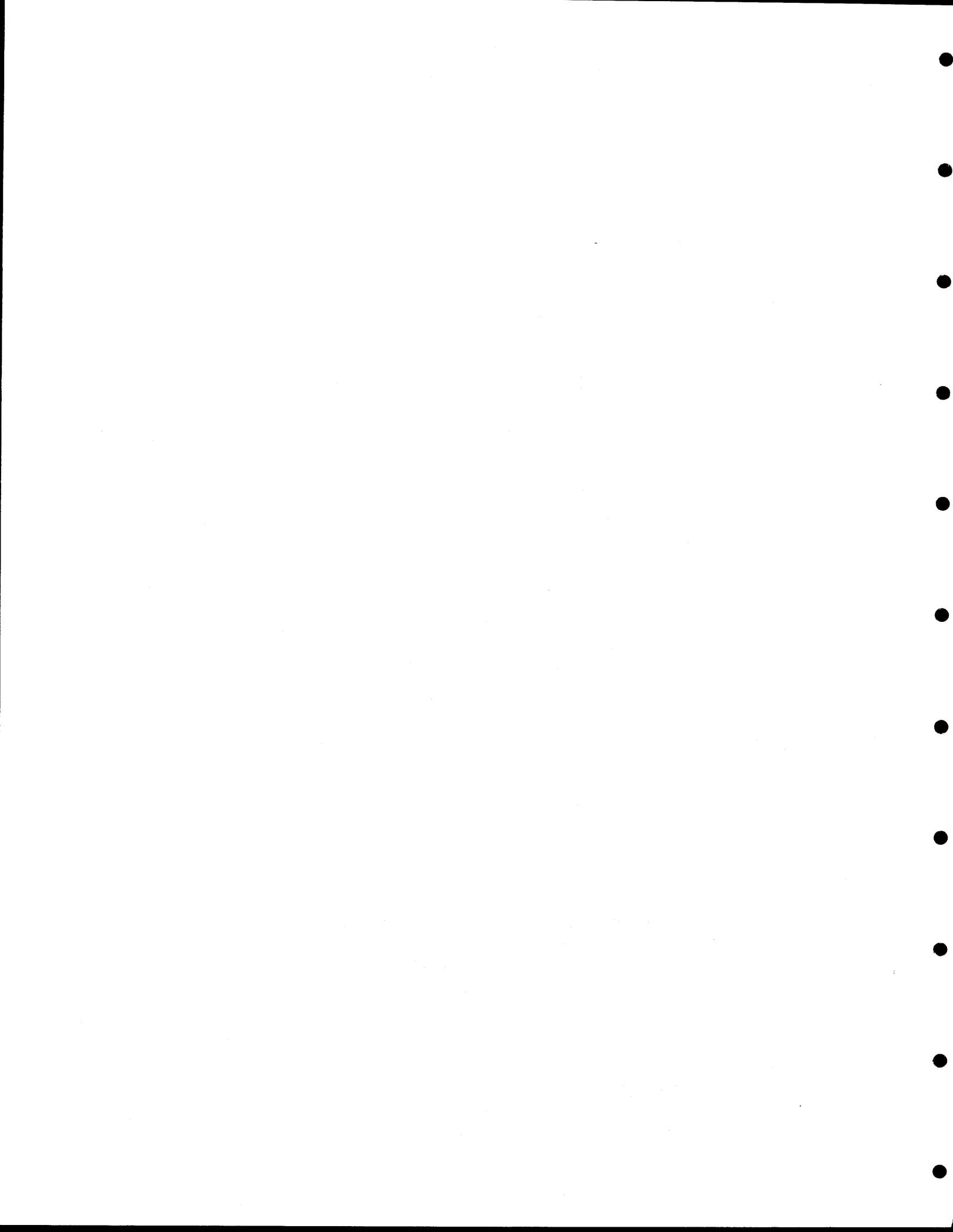
**Spring and Summer Chinook Salmon  
Spawning Ground Surveys on the Entiat River, 1996**

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December 1996

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## TABLE OF CONTENTS

LIST OF FIGURES, TABLES, AND APPENDICES .....	i
INTRODUCTION .....	1
STUDY AREA .....	1
CHINOOK AND SOCKEYE SALMON POPULATIONS .....	3
Spring Chinook Salmon .....	3
Summer Chinook Salmon .....	3
Sockeye Salmon .....	5
METHODS .....	5
Spring Chinook Salmon .....	5
Summer Chinook Salmon .....	5
Sockeye Salmon .....	6
RESULTS .....	6
Spring Chinook Salmon .....	6
Summer Chinook Salmon .....	6
Sockeye Salmon .....	6
Bull Trout .....	6
DISCUSSION .....	9
RECOMMENDATIONS .....	10
Spring Chinook Salmon .....	10
Summer Chinook Salmon .....	10
Sockeye Salmon .....	10
Temperature Monitoring .....	12
Genetics .....	12
Lower River Survey .....	12
REFERENCES .....	13
APPENDICES .....	14



## LIST OF FIGURES

	Page
1. Map of Entiat River . . . . .	2
2. Spring chinook salmon redd counts from annual surveys (index area) . . . . .	4
3. Map of Entiat River showing number of redds and their locations. . . . .	7

## LIST OF TABLES

1. Spring chinook salmon redd counts from annual surveys (index area) . . . . .	4
2. Number of redds and their locations. . . . .	8
3. Estimated escapement in 1996 of wild spring and summer chinook between Rocky Reach and Wells Dams. . . . .	8
4. Annual counts of spring and summer chinook, and sockeye salmon at Rocky Reach and Wells Dams. . . . .	11

## LIST OF APPENDICES

### Appendix

1. River mile index of the Entiat River from the mouth to Box Canyon. . . . .	15
2. Sex and fork lengths (cm) of dead spring and summer chinook salmon sampled in the Entiat River, 1996 . . . . .	16



## INTRODUCTION

Spring chinook salmon *Oncorhynchus tshawytscha* spawning has been monitored in the Entiat River since 1962 in a seven-mile index area that has been surveyed once annually after the peak of spawning by Washington Department of Fish and Wildlife (WDFW). Summer chinook salmon surveys in the Entiat River have been limited to aerial surveys conducted from Ardenvoir to the mouth (river mile (RM) 0-10.4), 1957-1991, by Chelan County Public Utility District (PUD). Dam counts at Rocky Reach and Wells dams are also used to monitor the salmon runs in the Entiat River area.

This was the third year that the U.S. Fish and Wildlife Service (USFWS) Mid-Columbia River Fisheries Resource Office 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. Surveyors also covered approximately 70% of the lower 16 miles in search of summer chinook redds. Biologists searched for sockeye salmon *O. nerka*, since they have been seen in the Entiat River in recent years.

The purposes of the USFWS surveys were 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.
6. Determine adequacy of using index area counts for measuring status of spring and summer chinook populations.

## STUDY AREA

The Entiat River enters the Columbia River approximately 484 miles and 8 dams above the Pacific Ocean. The Entiat River is 52 miles long and begins as meltwater from glaciers and snow (Figure 1). Base flow is 385 ft<sup>3</sup>/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 28-16), because this reach contains most of the suitable spawning habitat. 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 RM 26 is steep and gravel is only found in small pockets. From RM 26 to RM 15, the gradient lessens and gravel is abundant. Between RM 15 and RM 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.

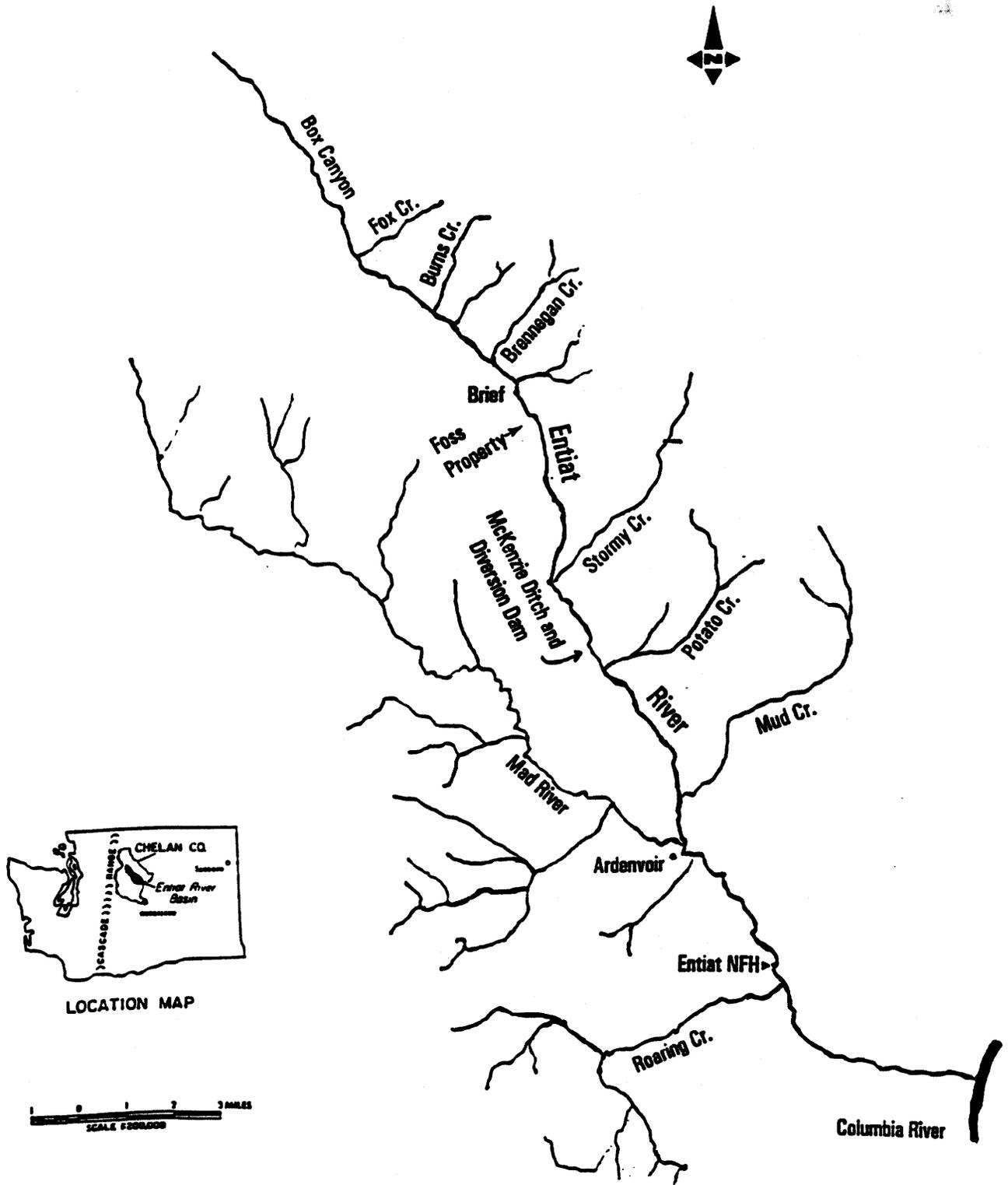


Figure 1. Map of Entiat River (see Appendix 1 for River Mile Index)

## CHINOOK AND SOCKEYE SALMON POPULATIONS

The Entiat River historically supported excellent salmon runs that consisted of chinook (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 reestablish 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. Despite 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 28-21, where a well established spring chinook salmon run has been documented (Figure 2, Table 1). Entiat NFH resumed spring chinook salmon production in 1974. Egg sources have included Cowlitz River (1974), Carson NFH (1975-1982), 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 1996.

### *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 in the lower 10.4 miles by aerial surveys 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 Foss property (RM 28-21), Entiat River, 1962-1996 (see Figure 2).

YEAR	# OF REDDS	YEAR	# OF REDDS
1962	115	1979	N/A
1963	145	1980	107
1964	384	1981	95
1965	104	1982	107
1966	307	1983	107
1967	252	1984	84
1968	252	1985	115
1969	83	1986	105
1970	70	1987	64
1971	136	1988	67
1972	61	1989	37
1973	229	1990	83
1974	88	1991	32
1975	156	1992	42
1976	47	1993	100
1977	171	1994	24
1978	326	1995	1
		1996	8

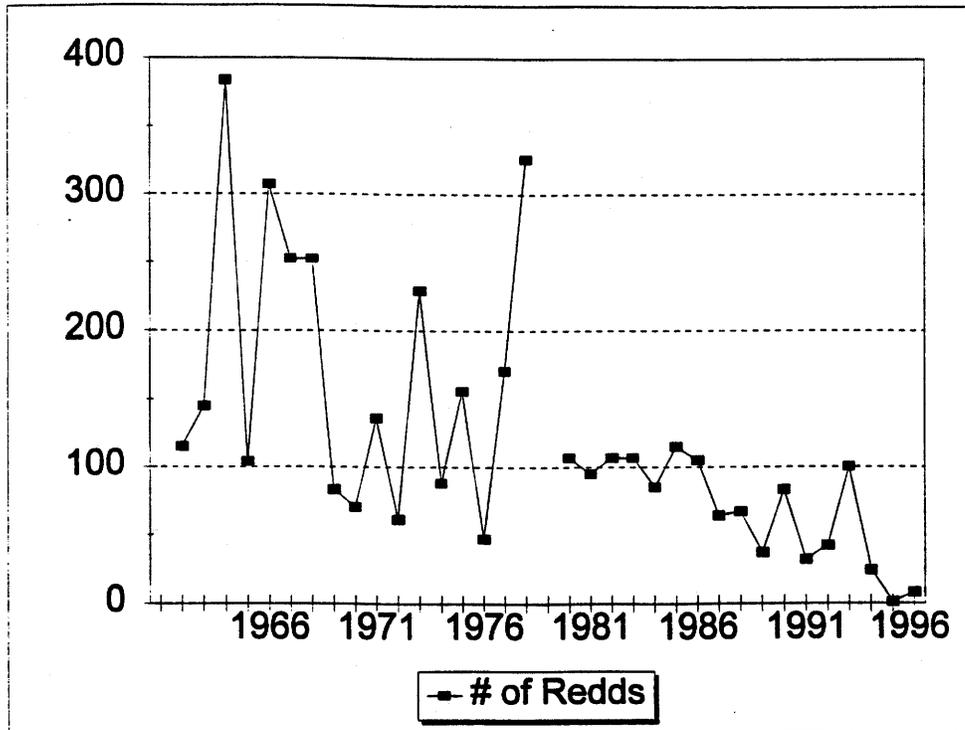


Figure 2. Spring chinook salmon redd counts from annual surveys in the index area, Fox Creek Campground to Foss property (RM 28-21), Entiat River, 1962-1996.

### ***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). Sockeye salmon were most recently observed in the Entiat River in 1995 when one was discovered in the lower river.

## **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 and counting redds, live and dead fish. 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 the Foss property bridge (RM 28-21), was surveyed on September 11, 1996 by WDFW with assistance from USFWS for evidence of spring chinook salmon spawning. USFWS surveyed from Foss property bridge to McKenzie Diversion Dam (RM 21-16) on September 17-18, 1996, and from RM 28-16 on October 15-16, which was also the first summer chinook survey.

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 28-21).

### ***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 28-16) was divided into several reaches and each was surveyed one 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. Since permission for access to the entire area downstream of RM 16 was not granted from landowners, surveys were limited to observing stream substrate from the road, walking some areas where permission was granted, and walking

the area around RM 1. The number of summer chinook salmon that spawned was estimated by expanding redd counts using the estimator of 2.4 chinook salmon per redd.

### ***Sockeye Salmon***

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

## **RESULTS**

### ***Spring Chinook Salmon***

Eight spring chinook salmon redds, two live and three dead spring chinook salmon were counted in the index area (RM 28-21). Below the index area, down to RM 19, eleven spring chinook salmon redds were found and one spring chinook salmon redd was counted in the Mad River. The complete survey identified a total of 20 redds, two live and six dead fish (length and gender data is given in Appendix 2). The index redd count was 40% of the total redd count as compared to 1995 when it was 8% of the total. The area from RM 28 to 16 probably included most of the spring chinook spawning in the Entiat River, since spring chinook salmon are not known to spawn in the lower river. However, some spawning gravel exists in those areas which were not surveyed. The Mad River redd was found by USFS personnel conducting a Bull trout *Salvelinus confluentus* survey. For the 1996 redd count, multiplication of the eight redds (index area) by the estimator of 3.5 salmon per redd yields an estimate of 28 spring chinook salmon. Assuming all spawning areas were surveyed, the total redd count of 20 (Table 2, Figure 3) multiplied by 2.4 chinook per redd gives an estimate of 48 spring chinook salmon. One marked hatchery fish was recovered, but did not contain an identification tag.

### ***Summer Chinook Salmon***

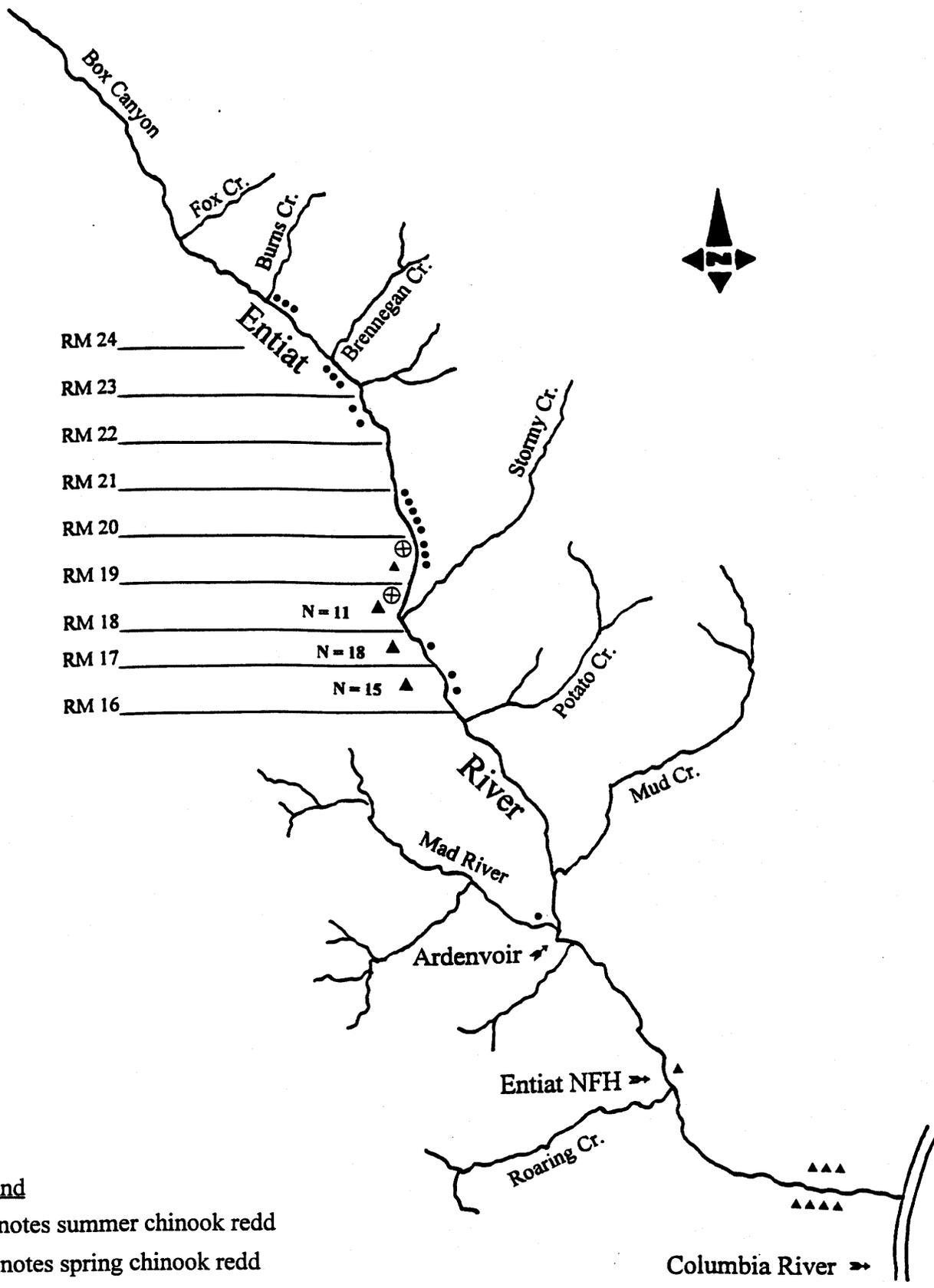
Forty-five summer chinook salmon redds were counted in the survey section (RM 28-16), and these were all below RM 19 (Table 2, Figure 3). Eight summer chinook salmon redds were located below RM 16 (seven near RM 1, and one near Entiat NFH). There was a total of 23 live and 16 dead (9 were retrieved) summer chinook salmon. The first summer chinook redd was discovered on the October 15 survey with peak spawning occurring the second week in October. Length and gender data for the nine carcasses is given in Appendix 2. As in 1995, all retrieved carcasses were five years of age, of which two were spent in fresh water and one of those in a reservoir environment, possibly Rocky Reach pool. The total count of summer chinook salmon redds was 53. Multiplying this total count by the estimator of 2.4 salmon per redd gives an estimate of 127 summer chinook salmon. This estimate should be considered a minimum, since the river was not completely surveyed below RM 16. No marked fish were found.

### ***Sockeye Salmon***

No sockeye salmon were observed during any of the surveys.

### ***Bull Trout***

Although we were not looking for Bull trout redds during this survey, we did locate and mark two redds. These redds were much smaller in size than a chinook redd and a large adult Bull trout was spotted near the lower redd (see Figure 3 for locations).



**Legend**

- ▲ denotes summer chinook redd
- denotes spring chinook redd
- ⊕ denotes Bull trout redd

Figure 3. Map of Entiat River showing redds and their locations.

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

Species	River Mile	# found
Spring Chinook Salmon	24-25	3
	23-24	3
	22-23	2
	20-21	5
	19-20	3
	17-18	1
	16-17	2
Found in Mad River		1
<b>Total</b>		<b>20</b>

Summer Chinook Salmon	19-20	1
	18-19	11
	17-18	18
	16-17	15
	6-7	1
	0-1	7
<b>Total</b>		<b>53</b>

Table 3. Estimated escapement in 1996 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.

Count	Spring chinook	Summer chinook
Rocky Reach Dam <sup>1</sup>	628*	5737*
Wells Dam <sup>2</sup>	<u>387*</u>	<u>2709*</u>
Difference	241	3028
Entiat NFH-# Fish Taken	175	0
Wells SFH-# Fish Taken	<u>0</u>	<u>1770</u>
<b>Potential Entiat R. natural spawners</b>	<b>66</b>	<b>1258</b>

<sup>1</sup> Chuck Peven, Chelan County Public Utility District, pers comm. 1996.

<sup>2</sup> Rick Klinge, Douglas County Public Utility District, pers comm. 1996.

\*Represents number of fish passed above dam.

## DISCUSSION

Wild spring chinook salmon adult returns to the Entiat River in 1996 were at low levels. The index count of eight redds is the second lowest on record and 6.5% of the 1962-1995 average count of 124. Since 1980, redd counts have been depressed. Counts have averaged only 50 redds for 1987-1995. Spring chinook salmon runs throughout the Columbia River basin were severely depressed in 1996, indicating possibly poor conditions in their natal streams, migration corridor and ocean.

Dam counts at Rocky Reach and Wells dams for spring chinook salmon were also at critical lows in 1996. Averaged counts at both dams were 18.6% of the 15 year average (1981-1995). Potential wild spring chinook salmon escapement (after deducting hatchery returns) between Rocky Reach and Wells Dam is estimated at 66 (Table 3) compared to the number estimated by redd expansions of 48. 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. As in 1995, the importance of the extended survey (RM 21-16) is highlighted by the fact that only eight redds were found in the index area (RM 28-21). Using the index area estimator of 3.5 fish/redd yields an estimate of only 28 fish, when in fact the actual number was probably closer to 50. This discrepancy increases the value of the extended survey as the number of spawning fish would have been significantly underestimated using the index area expansions.

The number of summer chinook salmon spawning in the Entiat River in 1996 was higher than expected. The eight redds found in the lower river was similar to counts noted from aerial surveys from 1977-1991. In 1994, USFWS surveyed the index area down to the McKenzie Diversion Dam. That survey represented the first known in-river summer chinook spawning survey done on this section (RM 28-16) when 11 redds were found. In 1995, surveyors located 40 summer chinook salmon redds in the same area and 1996 yielded 45 redds. It is unknown if the summer chinook salmon observed are an established wild run or if they are strays from other areas. Counts at Rocky Reach Dam of 5,737 summer chinook exceeded the 15 year average (1981-1995) of 4,510 (Table 4). The difference in counts (after subtracting hatchery brood takes) between Rocky Reach and Wells dams was 1258 fish (Table 3), which greatly exceeds the estimate from the Entiat River redd expansion of 127 (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. Inherent problems with dam counts causes us to prefer using redd counts for better estimating the number of summer chinook actually spawning in the Entiat River.

No sockeye salmon were seen during these surveys, though it is possible that some ascended the Entiat River but were not detected during these surveys. It is not known if there is an established run of sockeye salmon in the Entiat River or if the individuals that have been

observed in past years were strays. The numbers of sockeye salmon counted at Rocky Reach and Wells dams in 1996 were four times the 1995 count but only 65% of the 1976-1995 average (Table 4).

In 1995, and again in 1996, letters were sent out to all known private landowners bordering the Entiat River seeking permission to access their river property. Although most granted us permission to walk through their property, many gaps remained where either no response was returned or permission was not granted. Therefore, not all of the lower 16 miles was actually walked impacting the accuracy of our survey. We would like to acknowledge the help of those landowners who granted us permission to pass through their property in 1996.

## RECOMMENDATIONS

### ***Spring Chinook Salmon***

The annual one-day index area should be split into reaches and become a segment of the complete survey (RM29-16). This "new index" area should be surveyed at least twice for evidence of spring chinook spawning. Multiple surveys allows us to better determine peak spawning time, actual spawning numbers, and gives us the chance to collect more carcasses for biological data.

### ***Summer Chinook Salmon***

Valuable information about run size and spawning distribution of summer chinook salmon was gained by this survey, but questions remain about actual population levels. Summer chinook salmon spawning should continue to be monitored annually in RM 28-16 and around RM 1 to identify trends and the effect of the 1994 forest fire on spawning numbers and distribution. The entire reach should be surveyed at least once in mid-October and early November, after most spawning is completed. This would allow data collection on timing of spawning, increase counting and sampling of live and dead salmon, and would also reduce the chance of not observing older redds. To complete one survey from RM 28-16 takes 3 days.

As in 1995, the area below RM 16 was not surveyed completely in 1996, due to the lack of owner approved access, even though summer chinook salmon were found to spawn in this section in previous aerial surveys (1957-1991). It is possible that some salmon still spawned in this reach.

### ***Sockeye Salmon***

Chinook salmon surveys should continue to include possible observations of sockeye salmon and their spawning areas.

Table 4. Annual fish counts of spring and summer chinook and sockeye salmon at Rocky Reach Dam, 1962-1996, and Wells Dam, 1967-1996.

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	3,934	3,280	5,875	5,941	73,290	81,054
1985	8,718	5,257	5,937	4,456	54,077	53,170
1986	4,206	3,150	5,554	4,178	32,912	34,876
1987	3,496	2,344	4,078	3,142	41,115	39,948
1988	4,777	3,036	3,683	2,775	34,090	33,980
1989	3,229	1,740	5,654	3,333	16,176	15,895
1990	1,916	981	4,297	3,354	9,296	7,597
1991	1,303	779	3,158	2,028	27,439	27,492
1992	2,741	1,623	2,257	1,967	41,804	41,844
1993	4,249	2,444	4,980	3,603	28,318	23,038
1994	378	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

### ***Temperature Monitoring***

It has been shown that if chinook salmon eggs are initially exposed to temperatures less than 5.8°C, significant mortality will likely occur (Combs 1965). If water temperatures are between 5.8 and 15.5°C for the first 72 hours after deposition, a subsequent drop in temperature below 5.8°C will not cause this abnormal mortality. At the time summer chinook salmon are spawning in the Entiat River, water temperatures are very close to this lower threshold and sometimes below (Entiat NFH records). In some years this might be a limiting factor in the survival of summer chinook eggs. Starting in 1997, we plan to install a temperature recording device(s) in the area(s) where most spawning is occurring.

### ***Genetics***

Genetic analysis of wild and hatchery spring chinook salmon and of wild summer chinook salmon in the Entiat River would be useful to identify their relationship with other stocks in the mid-Columbia River basin. This could help answer some questions about stock origins and provide management guidance.

### ***Lower River survey (RM 1-16)***

The area below RM 16 was not completely surveyed in 1996 due to the lack of owner approved access. In the spring of 1996, the National Resource Conservation Service (NRCS) conducted a habitat survey on the lower 16 miles. Their data has shown that suitable spawning substrate exists at only a few select sites. Starting with the 1997 redd surveys, we may only pursue access to these select sites where adequate substrate has been identified.

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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 Valley Highway Bridge
4.5	Entiat Valley Highway 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
18.1	large hole on Bockoven's property
18.4	Stormy Creek
18.9	"Watch for Ice" sign on Highway
21.2	Foss property
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 and Campground
29.2	Box Canyon

mileage may not be exact

Appendix 2. Sex, age, and fork lengths of spring and summer chinook salmon carcasses sampled in the Entiat River, 1996.

Fish #	Sex	Length (cm)	Species	Age	Spawned
1.	Female	70	Spring Chinook	4	yes
2.	Female	76	"	4	UNK
3.	Male	70	"	UNK	
4.	Male	UNK	Jack, clipped-no tag	3	
5.	Male	75	"	4	
6.	Male	49	couldn't verify race	4	
7.	Female	87	Summer Chinook	5	yes
8.	Female	98	"	5	yes
9.	Female	91	"	5	UNK
10.	Female	94	"	5	UNK
11.	Female	91	"	5	UNK
12.	Male	92	"	5	
13.	Male	104	"	5	
14.	Male	88	"	5	
15.	UNK	85	"	5	

When possible, scales were taken from mortalities and ages determined by microscopic examination. All recovered carcasses were of wild origin with the exception of number 4. All recovered summer chinook were five years of age. The growth pattern on the scale indicates the first two years were spent in fresh water with the second being a reservoir type environment (Chuck Hamstreet, pers. Comm.).

UNK = Unknown