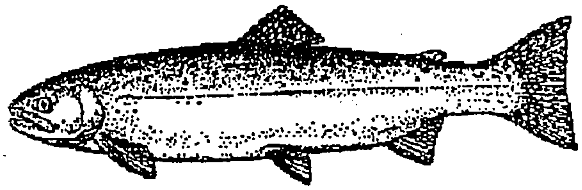
Progress Report

Warm Springs National Fish Hatchery Evaluation and Anadromous Fish Study on the Warm Springs Indian Reservation of Oregon



1975 - 1989

United States Department of Interior
U.S. Fish & Wildlife Service, Region 1
Lower Columbia River Fishery Resource Office
Vancouver, Washington

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

PROGRESS REPORT

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and

Anadromous Fish Study

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TABLE OF CONTENTS

LIST OF FIGURES ii
LIST OF TABLES iv
ACKNOWLEDGEMENTS vii
INTRODUCTIONS 1
STUDY AREA 2
METHODS 6
RESULTS AND DISCUSSIONS 6
- Wild Stocks 6
  - Summer Steelhead 6
  - Spring Chinook 14
    - Population Characteristics 14
    - Harvest 35
    - Predicting Returns 36
- Hatchery Program 36
  - History 36
  - Hatchery Facilities 38
  - Trout Program 38
  - Anadromous Fish Programs 39
    - Broodstock Collection 39
    - Broodstock Holding Procedures 41
    - Spawning Procedures and Incubation 42
    - Juvenile Rearing 44
    - Downstream Migration 45
    - Ocean Recoveries 49
    - Columbia River Harvest 49
    - Deschutes River Harvest 50
    - Disease Status 53
    - Evaluations 55
      - Spring Chinook Population(s) 56
      - Natural Reproduction of Hatchery Chinook 57
      - Run Timing Impacts 60
      - Hatchery Chinook Size Differentiation 65
      - Contribution of Fall Released Chinook 65
      - Predicting Hatchery Chinook Returns 69
      - Potential Impacts of Chinook Marking Program 71
      - Impacts of Hatchery Broodstock Collection 72
      - Hatchery Chinook Productivity 77

RECOMMENDATIONS 79
LITERATURE CITED 82
APPENDIX A 84

LIST OF FIGURES

Figure		Page
1	Map of the Warm Springs Indian Reservation, Oregon, and location of the Warm Springs National Fish Hatchery	3
2	Mean monthly discharge measured in the Warm Springs River below Kah-Nee-Ta (1972-1980)	4
3	Monthly minimum-maximum water temperatures at WSNFH, 1982-1984	5
4	Mean weekly run timing of wild summer steelhead at WSNFH, 1977-1981	8
5	Mean weekly run timing of wild summer steelhead at WSNFH, 1982-1986	8
6	Length frequency of wild summer steelhead arriving at WSNFH, 1982-1985	10
7	Size composition of wild downstream migrant juvenile steelhead/rainbow trout captured in the Warm Springs River scoop trap, 1976 and 1978-1980 (ODFW, unpublished)	11
8	Return of wild summer steelhead to WSNFH, 1977-1990	13
9	Five day mean run timing of wild and unmarked spring chinook to WSNFH, 1977-1986	15
10	Migration time of wild spring chinook in 1975 between Bonneville Dam and WSNFH (Diggs, 1976)	16
11	Length frequencies of wild spring chinook arriving at WSNFH, 1977-1981	22
12	Length-frequency distributions for juvenile spring chinook salmon captured in the Warm Springs River between Hebe and Schoolie, October 1977 to February 1978 (Lindsay, et.al., 1989)	25
13	Relationship between eggs deposited and survival to migrant for spring chinook salmon in the Warm Springs River, Oregon, 1975-1987 broods except 1982	26
14	Relationship between redds and spring migrants for spring chinook in the Warm Springs River, Oregon	27

LIST OF FIGURES

Figure		Page
15	Relationship between redds and total migrants for spring chinook in the Warm Springs River, Oregon	28
16	Number of migrants produced versus survival to adult rates for wild spring chinook in the Warm Springs River, Oregon	31
17	Spawner-recruitment curve for wild spring chinook salmon in the Warm Springs River, Oregon (1975-1984 broods)	33
18	Length and date of recapture of Warm Springs National Fish Hatchery chinook caught by beach seine at Jones Beach, Oregon in 1980	47
19	Length and date of recapture of Warm Springs National Fish Hatchery chinook caught by purse seine at Jones Beach, Oregon in 1981	48
20	Collection of spring chinook at Warm Springs NFH versus upstream escapement, 1978-1985	61
21	Average return timing of wild and hatchery spring chinook adults, 1982-1989	63
22	Cumulative arrival timing of wild spring chinook at Warm Springs NFH and subsequent upstream escapement in 1980	64
23	Lengths of jack spring chinook returning from fall and spring releases from WSNFH, 1983-1985 broods	68
24	Relationship between hatchery spring chinook jacks returning from fall and spring release groups and eventual total brood returns	70
25	Percent gain or loss of wild production resulting from withdrawals of 100 wild spring chinook from fish arriving at WSNFH	74
26	Percent gain or loss of wild production resulting from withdrawals of 200 and 400 wild spring chinook from fish arriving at WSNFH	75

LIST OF TABLES

Table		Page
1	Wild Summer steelhead returns to Warm Springs National Fish Hatchery, 1977-1990	7
2	Length frequency summary for wild steelhead passing Warm Springs National Fish Hatchery, 1977-1990	9
3	Returns of wild and stray steelhead to Warm Springs National Fish Hatchery	14
4	Returns and utilization of wild spring chinook to Warm Springs National Fish Hatchery	17
5	Spring chinook salmon released upstream of Warm Springs National Fish Hatchery and resulting redd counts, 1977-1989	18
6	Spring chinook redd counts in the Warm Springs River, Oregon	19
7	Percent distribution of spring chinook spawning effort in index areas of the Warm Springs River and tributaries	20
8	Estimated brood strengths and age composition of wild spring chinook entering the Deschutes River	23
9	Estimated prespawning mortalities of adult (age 4 and 5) spring chinook released above Warm Springs National Fish Hatchery	23
10	Population statistics for juvenile spring chinook in two tributaries of the Warm Springs River, August 17 to September 8, 1983	24
11	Egg-migrant survival of spring chinook in the Warm Springs River, Oregon	29
12	Survival of spring chinook migrants to adult return for wild spring chinook entering the Deschutes River, Oregon	30
13	Catch estimates for wild spring chinook in the sport and Indian fishery at Sheras Falls, 1974-1988	35
14	Chronological history of Warm Springs National Fish Hatchery	37
15	Evolution of proposed fish production programs at Warm Springs National Fish Hatchery	38
16	Adult spring chinook utilization at Warm Springs National Fish Hatchery	40

LIST OF TABLES

Table		Page
17	Prespawning mortalities of spring chinook adults held for broodstock at Warm Springs National Fish Hatchery	42
18	Spawning statistics of spring chinook at Warm Springs National Fish Hatchery	43
19	Spawning statistics of summer steelhead at Warm Springs National Fish Hatchery	44
20	Ocean recoveries of Warm Springs National Fish Hatchery spring chinook in the Columbia River	49
21	Recoveries of Warm Springs National Fish Hatchery spring chinook in the Columbia River	51
22	Estimated Deschutes River harvest and hatchery returns of Warm Springs National Fish Hatchery spring chinook	52
23	Age composition of Warm Springs National Fish Hatchery spring chinook returning to the Deschutes River, Oregon	52
24	Recoveries of Warm Springs National Fish Hatchery steelhead in the Deschutes and Warm Springs Rivers	53
25	Fish disease classification of Warm Springs National Fish Hatchery, 1978-1989	55
26	Fallback recoveries of jaw-tagged spring chinook released above Warm Springs National Fish Hatchery in 1983	57
27	Spawning ground recoveries of jaw-tagged spring chinook in the Warm Springs River, 1983	59
28	Mean fork lengths of four-year-old hatchery and wild spring chinook salmon returning to Warm Springs National Fish Hatchery, 1983-1985 broods	65
29	Estimated returns of fall and spring chinook released chinook to the Deschutes River after release from Warm Springs National Fish Hatchery	67
30	Return rates of hatchery spring chinook to the Deschutes River and Warm Springs National Fish Hatchery	72

LIST OF TABLES

Table		Page
31	Return of wild spring chinook to Warm Springs National Fish Hatchery and escapement of wild and hatchery adults upstream	76
32	Fish production compared to adults spawned for hatchery and wild spring chinook in the Warm Springs River	78

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INTRODUCTION

The U. S. Fish and Wildlife Service (USFWS) involvement with the anadromous fishery resources of the Warm Springs Indian Reservation began in the 1950's. The initial programs generally involved planting fish in reservation streams and technical assistance to tribal resource managers. From an early date there were Tribal requests for the establishment of a hatchery on the reservation. Warm Springs National Fish Hatchery (WSNFH) was eventually authorized by Congress in 1966 and ground breaking for the facility took place in 1972. During the planning process the hatchery was designed for the production of salmon, steelhead, and trout to complement natural populations already occurring. The intent was primarily to increase fishing opportunities in the Deschutes River and Reservation waters.

Throughout most the history of anadromous fish culture the main focus of hatchery operations has been to fill the hatchery every year and plant as many as possible to increase the number of fish that can be harvested. Often to suit man's needs or a hatchery's physical limitations fish culturalists and harvest managers have altered, sometimes unintentionally, the run timing, fish sizes, and even introduced fish from other geographical areas that exhibited sought after traits. Often such alterations did not produce the desired effects. After many trial and error experiences, biologists have come to realize that significant alterations of hatchery stocks from those present in natural environment may result in hatchery stocks that cannot adapt fully to life beyond the hatchery. While this may not mean that a hatchery is not successful, it can reduce the full usefulness and cost/benefit aspects of the station.

During the 1970's biologists became increasingly aware of some of the negative aspects of traditional hatchery practices. Some of the greatest concerns have involved the potential interactions between fish raised under traditional hatchery practices, and wild spawning populations. Prior to 1975 the proposed Warm Springs hatchery was thought of in a more "traditional" sense. As a new awareness of the importance of natural spawning populations became apparent, the Warm Springs program evolved away from a traditional fish culture facility and the hatchery evaluation needs expanded to encompass possible impacts to the wild spawning fish in the Warm Springs River. After numerous discussions between the USFWS, Oregon Department of Fish and Wildlife (ODFW), and Tribal authorities, a Hatchery Operational Plan was developed utilizing the available knowledge concerning minimizing hatchery induced changes in a fish population. The goals of the hatchery have become intertwined with those of the wild stocks. On one hand, the goal of the hatchery is to provide a significant number of hatchery spring chinook returning to the Deschutes River, and on the other hand it must insure that hatchery operations promote the preservation and enhancement of the wild stock.

In 1975 the USFWS began studies designed to define the biological characteristics of wild spring chinook (Oncorhynchus tshawytscha) and steelhead (O. mykiss) in the Warm Springs River. Additionally, research was initiated to document resident trout growth patterns and population status below the hatchery prior to hatchery releases. In response to ODFW concerns about potential hatchery impacts to wild trout and salmon in the Deschutes River the USFWS assigned a biologist to work cooperatively with an ODFW research crew studying fish ecology in the river. Studies were designed to identify potential impacts of the hatchery and to evaluate whether or not the operational plan was functioning as designed. From the onset it was recognized that as more became known about the hatchery's specific limitations and peculiarities the operational plan would be modified. Additionally, knowledge gained since 1975 about the wild stocks and research into fish genetics has produced changes, as have alternations of harvest and other management considerations. Many of these things could not be foreseen prior to the actual start-up of the hatchery.

This report is an attempt to condense the wealth of information learned through these studies and document the evolutionary sequence of events that has molded the hatchery and management programs since 1975. It is hoped that this document will give the reader insight as to how a fishery program evolves and may help future managers anticipate the changes that may occur in these types of programs.

A considerable amount of information is being presented, some of which is of considerable value now and some may show additional value in the future. The first portion of the report deals with a summary of the characteristics of the wild populations in the Warm Springs River and the remainder documents the evolution of the hatchery program.

STUDY AREA

The Warm Springs River is a major tributary of the Deschutes River in north central Oregon (Figure 1). It enters the Deschutes at River Kilometer (Rkm) 135 and has a mean annual flow of 440 cubic feet per second (cfs) and a dependable minimum flow of about 220 cfs. Mean monthly flows measured at Kah-Nee-Ta and temperatures noted at the hatchery are shown in Figures 2 and 3. Warm Springs NFH is located approximately sixteen kilometers (km) above the junction of the Warm Springs and Deschutes Rivers and is approximately 479 km from the Pacific Ocean. The climate of the reservation area is generally arid with little summer rain and hot temperatures. The headwaters of the Warm Springs River are near the crest of the Cascade Mountain Range where much of the precipitation is in the form of snowfall. The mainstem Warm springs River originates from numerous springs near its headwaters and does not fluctuate greatly above the confluence of Mill Creek. The tributaries appear to show more fluctuations. Approximately 111 km of stream habitat is available to anadromous fish above Warm Springs NFH if the tributaries of Mill and Beaver Creeks are taken into account.

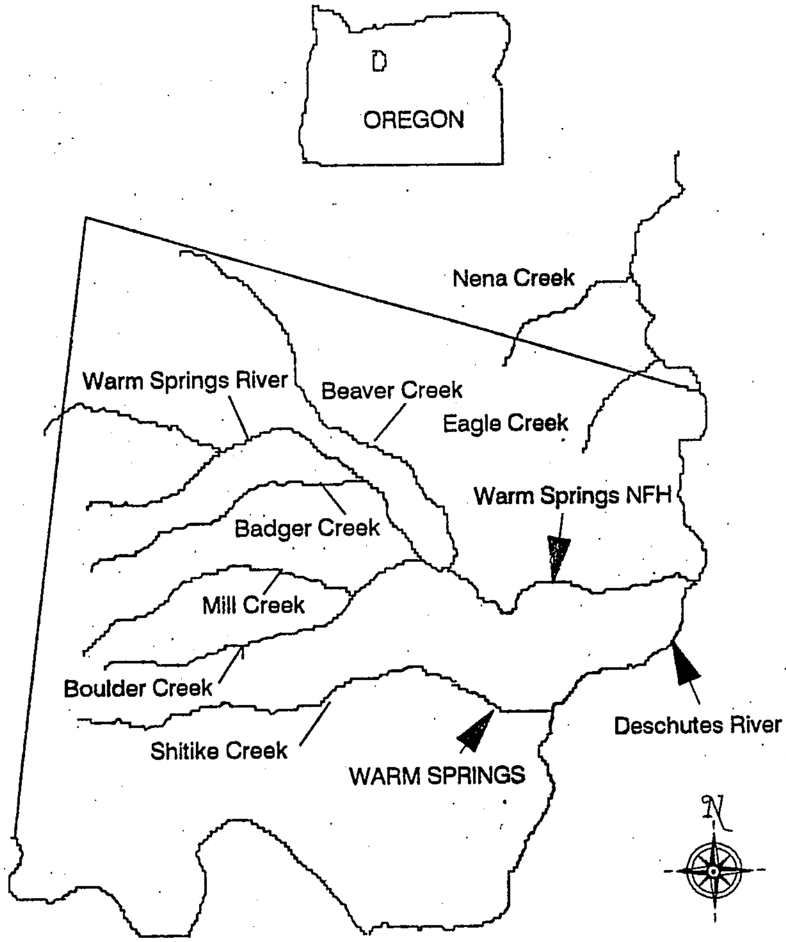

Figure 1. Map of the Warm Springs Indian Reservation, Oregon, and the location of Warm Springs National Fish Hatchery.

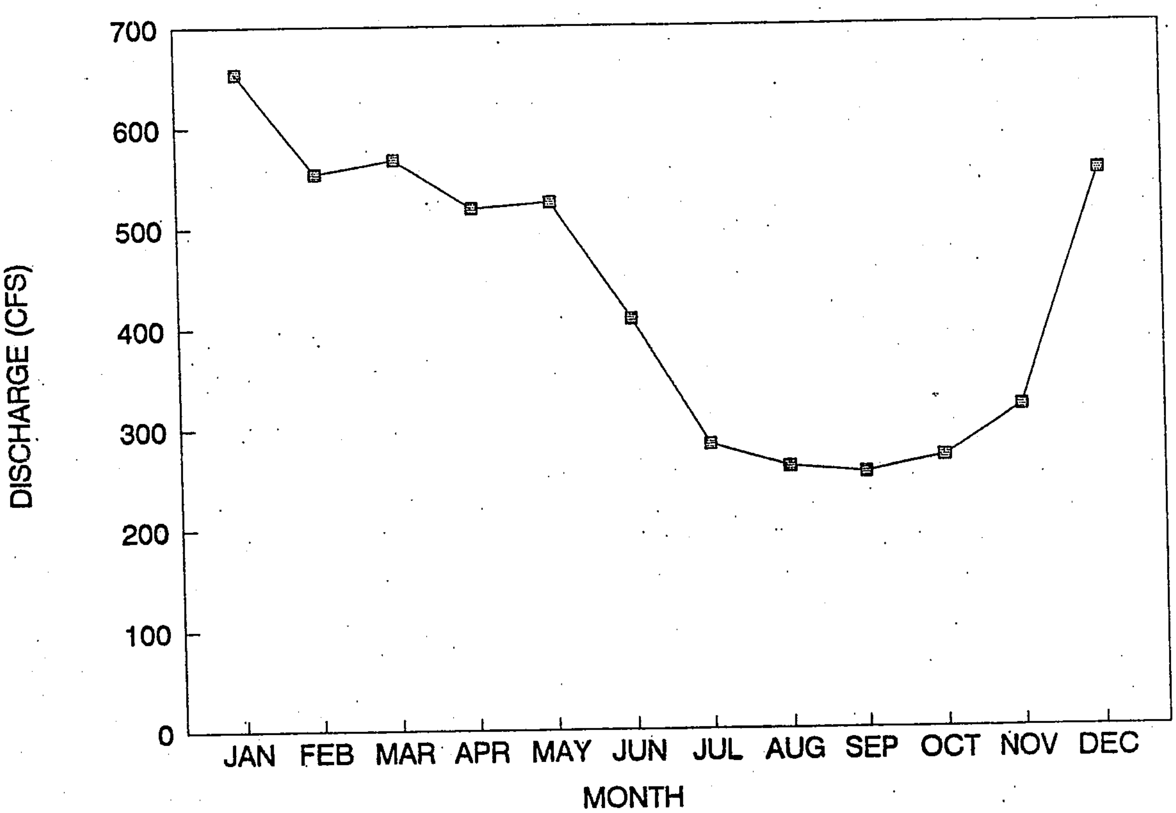

Figure 2. Mean monthly discharge measured in the Warm Springs River below Kah-Nee-Ta (1972-1980).

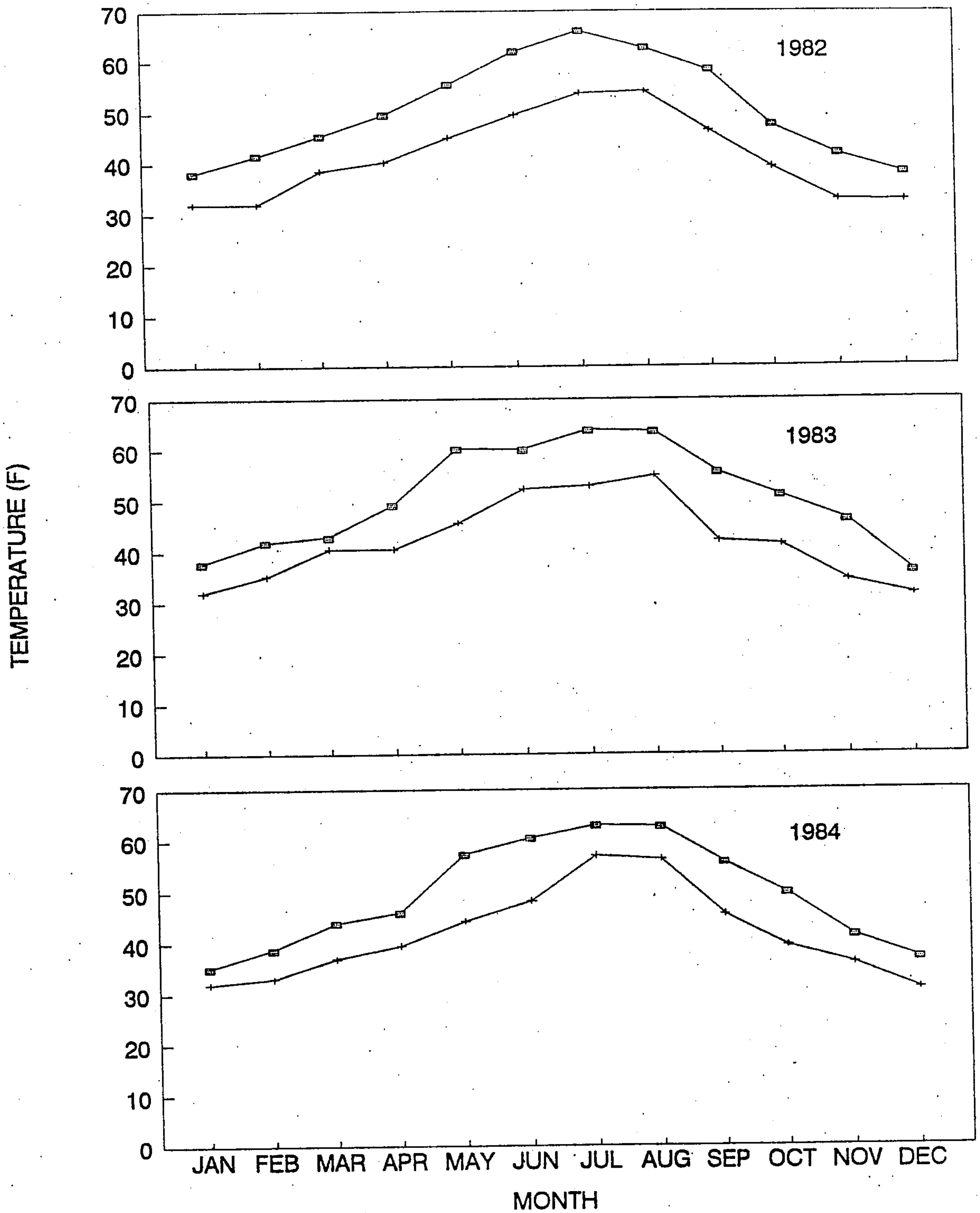

Figure 3. Monthly minimum-maximum water temperatures at Warm Springs National Fish Hatchery, 1982-1984.

METHODS

The fisheries data presented in this report has been collected and compiled through cooperative efforts of the USFWS, ODFW, and the Warm Springs Tribe. New data is continually being collected and added to the database by all three contributors. As a result of these continuous data inputs and revisions, it is difficult to always be current. This report attempts to give the most up-to-date figures, but experience dictates that corrections are inevitable. Adult data has been collected at Warm Springs NFH trapping facilities and through creel census and adult trapping at Sherars Falls on the Deschutes River. Most juvenile data was obtained at a floating scoop trap in the lower Warm Springs River as well as other similar traps that have been operated at times in the Deschutes River. Additional data was gathered via seining operations in the Deschutes River and electrofishing efforts in the upper Warm Spring River. Information documenting the specific sampling techniques is available in the various reports cited at the end of this paper.

RESULTS AND DISCUSSIONS

Wild Stocks

Salmonid fish present in the Warm Springs River include spring chinook salmon, coho salmon (O. kisutch), summer steelhead, mountain whitefish (Prosopium williamsoni), rainbow trout (O. mykiss), brown trout (Salmo trutta), bull trout (Salvelinus confluentus), and brook trout (S. fontinalis). Bull trout and brown trout are rarely found in the vicinity of the hatchery while brook trout are restricted to the upper reaches of the river and tributaries. Electrofishing by the USFWS has produced few adult resident rainbow trout below the hatchery (Cates, 1984); however, the river below the hatchery may be seasonally important to Deschutes River rainbow trout spawning in the spring. The trout fishery below the hatchery is sustained by a catchable trout program funded by the Tribe.

Spring chinook and summer steelhead return in significant numbers to spawning grounds primarily above Warm Springs NFH. Some coho are present but represent only a remnant run after a Tribal egg-box program was discontinued in 1965.

SUMMER STEELHEAD

Steelhead begin entering the Deschutes River as early as June. Tagging by ODFW at Sherars Falls and subsequent recoveries at Warm Springs NFH revealed that a lengthy period of time is spent in the Deschutes River before entering the Warm Springs river. This "layover" has averaged from 184 days to 233 days during the Warm Springs recovery years of 1978 to 1986. Migration timing of individual fish has ranged from a low of 133 days to as long as 208 days. It is important to note that steelhead arriving in the spring at Warm Springs NFH actually entered the Deschutes River during the previous summer. Thus the 1978 returns to Warm Spring NFH actually represent steelhead of the 1977 Deschutes River return year. Steelhead returns to Warm Springs NFH are summarized in Table 1.

Table 1. Wild summer steelhead returns to Warm Springs National Fish Hatchery, 1977-1990.

Deschutes Run Year	Warm Springs Return Year	Total	Males	Females	Percent Females	Female Upstream	Total Upstream
1976	1977	136	Unk.	Unk.	Unk.	Unk.	136
1977	1978	417	147	270	.65	189	336.*
1978	1979	378	86	292	.76	285	201.**
1979	1980	311	118	193	.62	134	232
1980	1981	397	128	269	.68	259	383
1981	1892	569	196	373	.66	373	569
1982	1983	255	56	199	.78	199	255
1983	1984	431	174	257	.60	257	431
1984	1985	577	200	377	.65	377	577
1985	1986	373	133	240	.64	240	373
1986	1987	822	234	588	.72	588	822
1987	1988	522	131	391	.75	391	522
1988	1989	385	123	262	.68	262	385
1989	1990	339	130	209	.62	209	339

* Unknown number of males spawned and released upstream
** 56 males spawned and released upstream

Steelhead begin arriving at Warm Springs NFH by mid-February with sporadic peaks throughout the migration period. Their migration is completed by the end of May. The peak period of returns is generally during the second or third week in April, although, this varies from year to year. The peaks and dips noted in any particular year appear to be related to the periodic warming trends, especially early in the return period. Cold spells tend to inhibit steelhead migrations into Warm Springs NFH. As the weather warms following these cold spells, fish activity increases. A comparison of five year average timing for wild steelhead prior to the first returns of hatchery steelhead and for the first five years after hatchery fish began returning is shown in Figures 4 and 5. The graphs indicate that the earliest portion of the wild run has increased during the

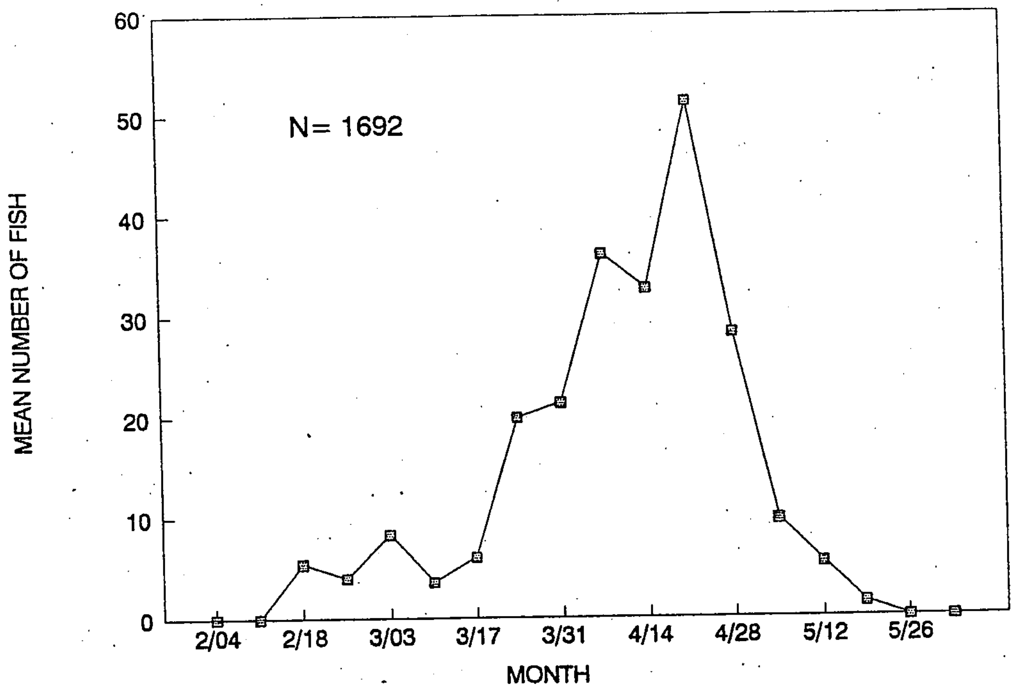

Figure 4. Mean weekly run timing of wild summer steelhead at Warm Springs National Fish Hatchery, 1977-1981.

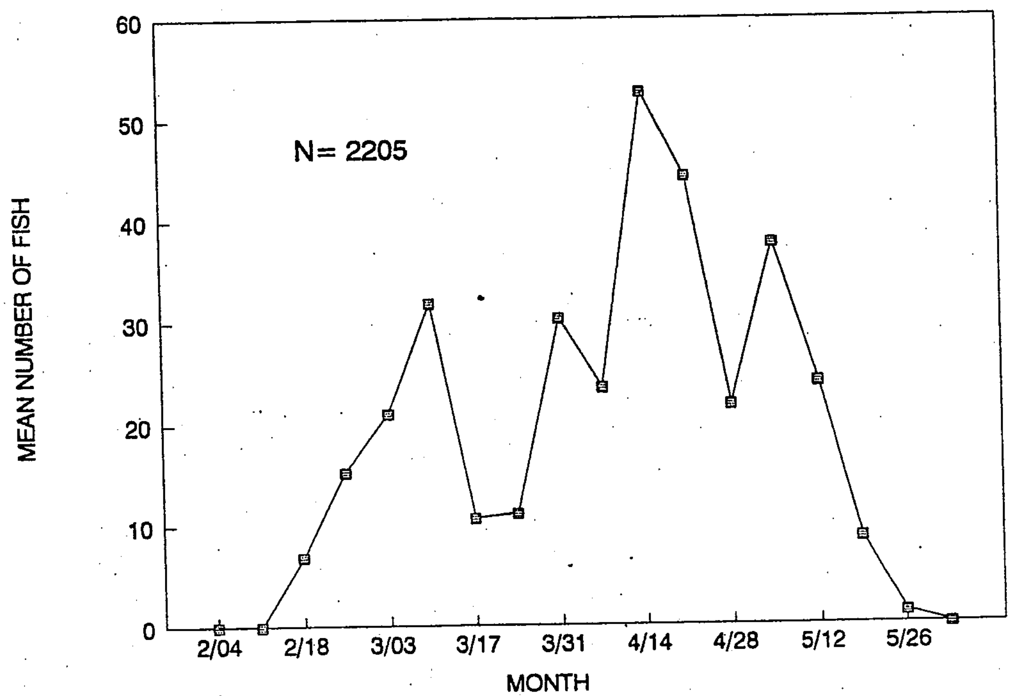

Figure 5. Mean weekly run timing of wild summer steelhead at Warm Springs National Fish Hatchery, 1982-1986.

second five years we examined. This is at least partially due to the fact that the trap at Warm Springs NFH was not operating during this early period in 1977 and 1978.

Steelhead arrive at Warm Springs NFH in spawning condition throughout most of the migration period. Due to the reabsorption of scales during their extensive period in the Deschutes River, age analysis is difficult when they arrive at the hatchery. Samples taken at Sherar's Falls from fish that eventually returned to Warm Springs NFH and a few readable scales taken at Warm Springs NFH indicate that most fish spend one or two years in the ocean. Those fish spending only one year in the ocean return at a relatively small size, generally three to five pounds. Even those fish spending longer periods in the ocean do not seem to reach sizes seen with other stocks. It is unusual to see wild fish much over twelve pounds with the average weight of fish for the entire run usually averaging five to six pounds. Length-frequency data collected for wild steelhead at Warm Springs NFH is summarized in Table 2 and Figure 6.

Juvenile steelhead migrate from the Warm Springs River in the spring after spending one or two years in the river. Smolt outmigration generally occurs in early May (Diggs, 1979). Some movement of juvenile rainbow/steelhead trout coincides with the fall outmigration of spring chinook juvenile; however, these fish are small and not smolted. It is not known if these fall migrants are steelhead or represent an outmigration of progeny from Deschutes River rainbow trout spawning in the lower Warm Springs River. Length frequencies of rainbow/steelhead migrants observed in the Warm Springs River scoop trap in 1977 to 1980 are shown in Figure 7.

Table 2. Length frequency summary for wild steelhead passing Warm Springs National Fish Hatchery, 1977-1990.

WSNFH Year	Number Sampled	Mean Fork Length (cm)	Standard Deviation	Range
1977	20	61.0	10.11	44-84
1978	90	64.3	7.52	29-77
1979	52	66.4	6.14	54-77
1980	125	63.0	8.73	54-84
1981	18	62.2	5.49	56-72
1982	68	64.9	6.26	54-78
1983	15	67.1	4.81	59-73
1984	53	61.5	5.84	48-81
1985	131	65.7	8.94	52-81
1986	29	63.0	6.15	53-81
1987	150	68.7	3.50	54-84
1988	38	68.0	5.13	57-86
1989	42	66.7	5.37	56-77
1990	51	65.3	6.19	53-77

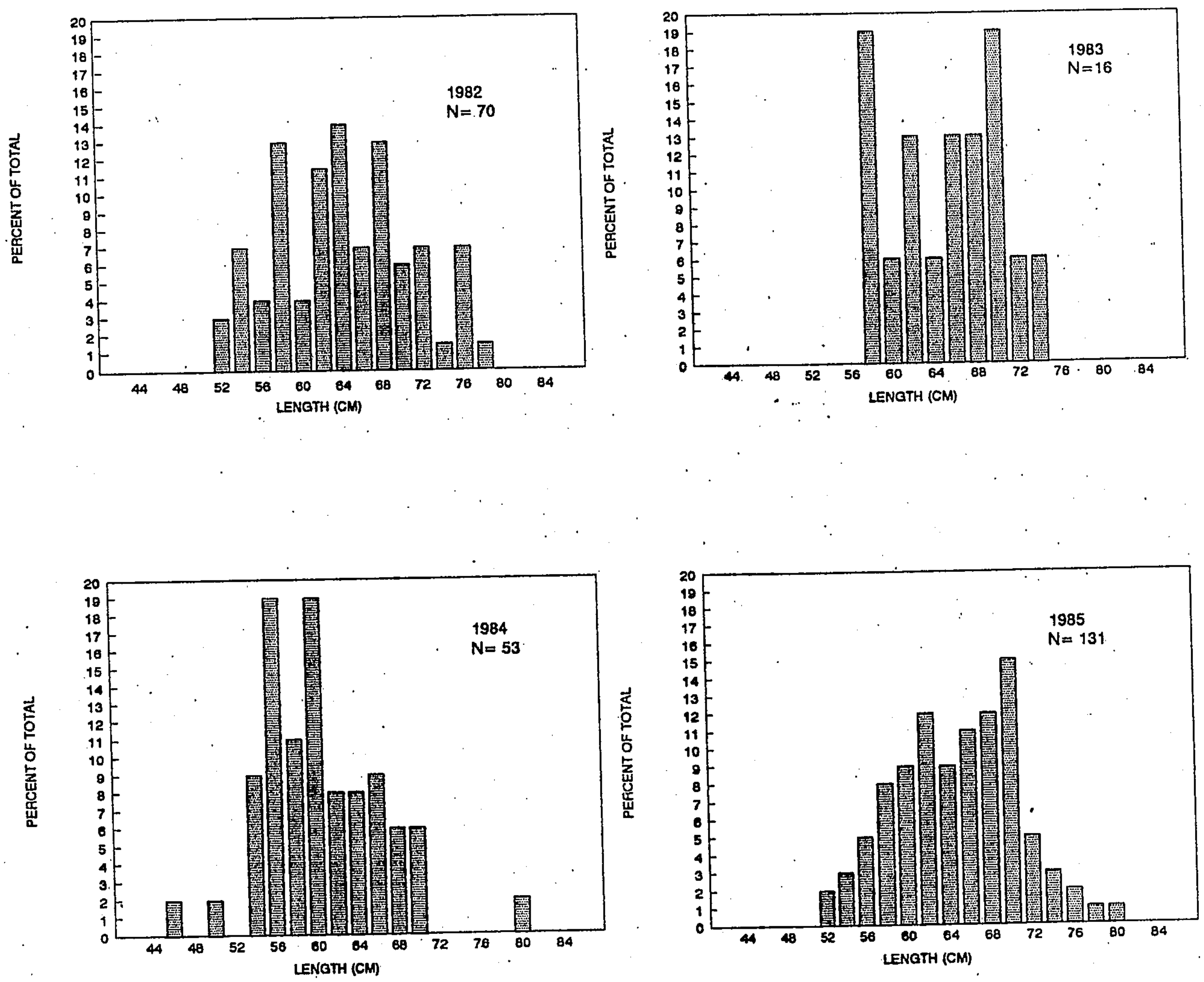

Figure 6. Length frequency of wild summer steelhead arriving at Warm Springs National Fish Hatchery, 1982-1985.

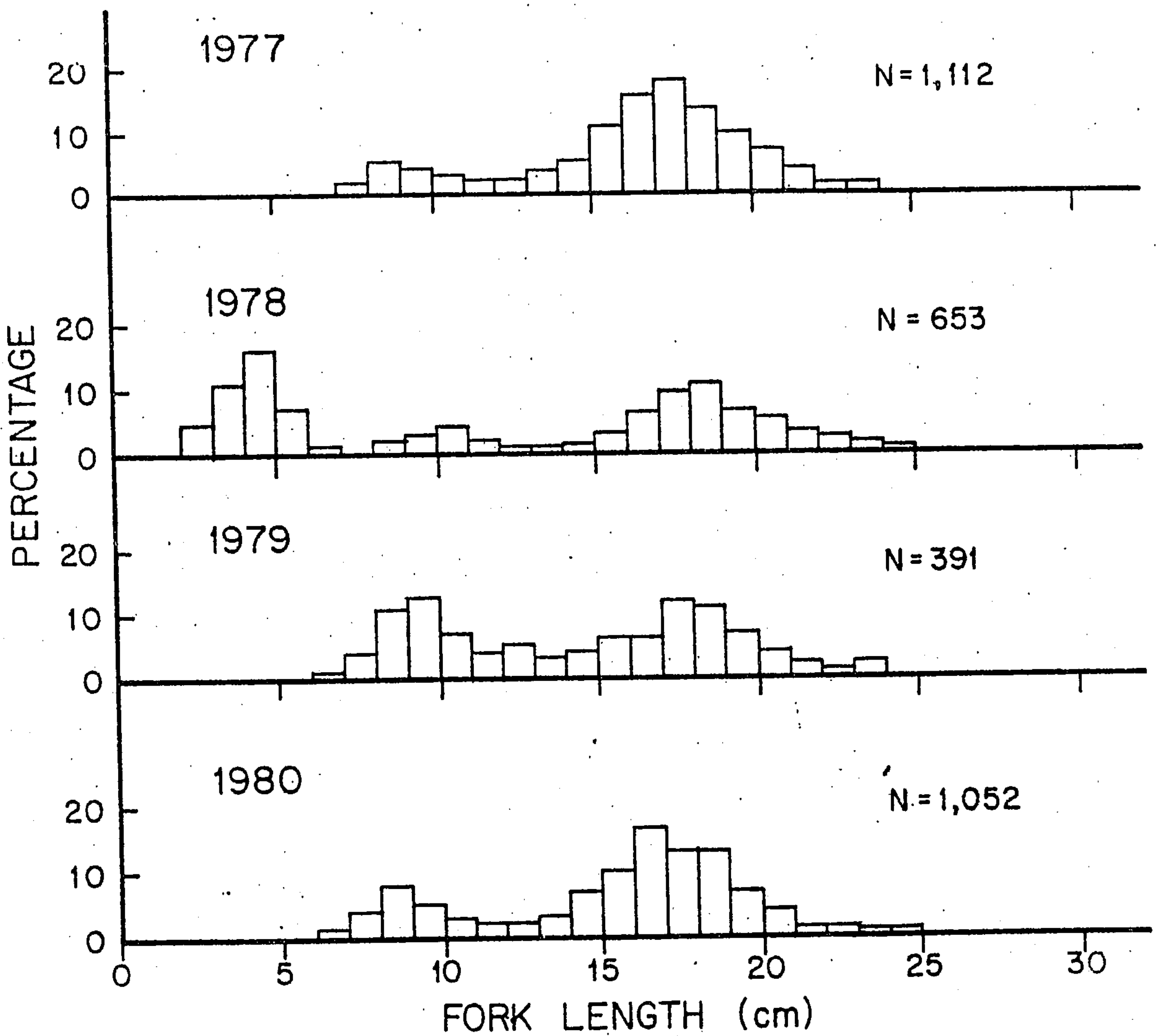

Figure 7. Size composition of wild downstream migrant juvenile steelhead/rainbow trout captured in the Warm Springs River scoup trap, 1976 and 1978-1980 (ODFW, unpublished).

The Deschutes River is one of Oregon's premier steelhead fishing streams. Harvest rates of wild steelhead have been negligible since 1979 when sport fishing regulations began to fully protect wild steelhead. Since that time it has been illegal to harvest wild steelhead in the sport fishery although Indian dipnetters continue to harvest some in their subsistence fishery at Sherars Falls. During the period 1977, 1980-1983 the exploitation rate of hatchery steelhead has ranged from 23% to 33% (Johnson and Lindsay, 1983). The return numbers of wild steelhead to Warm Springs NFH since this closure probably reflects a reduction in harvest rates; however, with the exception of 1987 no dramatic trend of increases in the numbers of wild steelhead have been observed at the hatchery beyond a gain of fish that would likely have been harvested (Figure 8). If this trend continues, it may indicate that the harvest restrictions are not greatly influencing production of wild steelhead in the Warm Springs River. This could be due to a number of factors including hook and release mortalities, possible increased harvest in the mainstem Columbia River, and rearing capacity limitations in the Warm Springs River. A considerable increase in the number of stray steelhead returning to the trap at Warm Springs NFH has occurred since 1987. More than 1,500 steelhead returned in 1987 (Table 3) including 692 stray hatchery fish. Hatchery fish were identified by fin marks or the presence of eroded dorsal fins. Most strays appear to be coming from the upper Columbia River, primarily Snake River tributaries. Large numbers of these fish are apparently entering the Deschutes River, and judging from the number of strays at Warm Springs NFH and Round Butte State Fish Hatchery (SFH) are probably entering many of the spawning streams. The impact of these fish on the native Deschutes summer steelhead stocks are unknown. It is possible that some of the "wild" steelhead returning to Warm Springs NFH may also be stray fish. Straying fish, both hatchery and wild complicates any analysis of the status of wild steelhead in this system.

Because of the extended nature of steelhead spawning above Warm Springs NFH and the high water conditions occurring at that time little comprehensive data is available concerning the spawning distribution of steelhead. During 1982 Tribal and USFWS biologists did document 38 steelhead redds in the upper Warm Springs River. Approximately 373 females were released above the hatchery in 1982 and others (five redds) were present below the hatchery. The primary areas containing redds were the Warm Springs River between Hehe and Bunchgrass Creek, Robinson Park down to the canyon on Beaver Creek, and Mill Creek from Strawberry Falls to Boulder Creek. In 1985 and 1986 steelhead were observed spawning in Mill Creek above Strawberry Falls following passage improvements. Steelhead spawning has also been observed in Boulder and Badger Creeks. Other small tributaries are also likely to be producing steelhead. Wild steelhead are also known to spawn in Eagle Creek and Nena Creek which are intermittent streams draining directly into the Deschutes River.

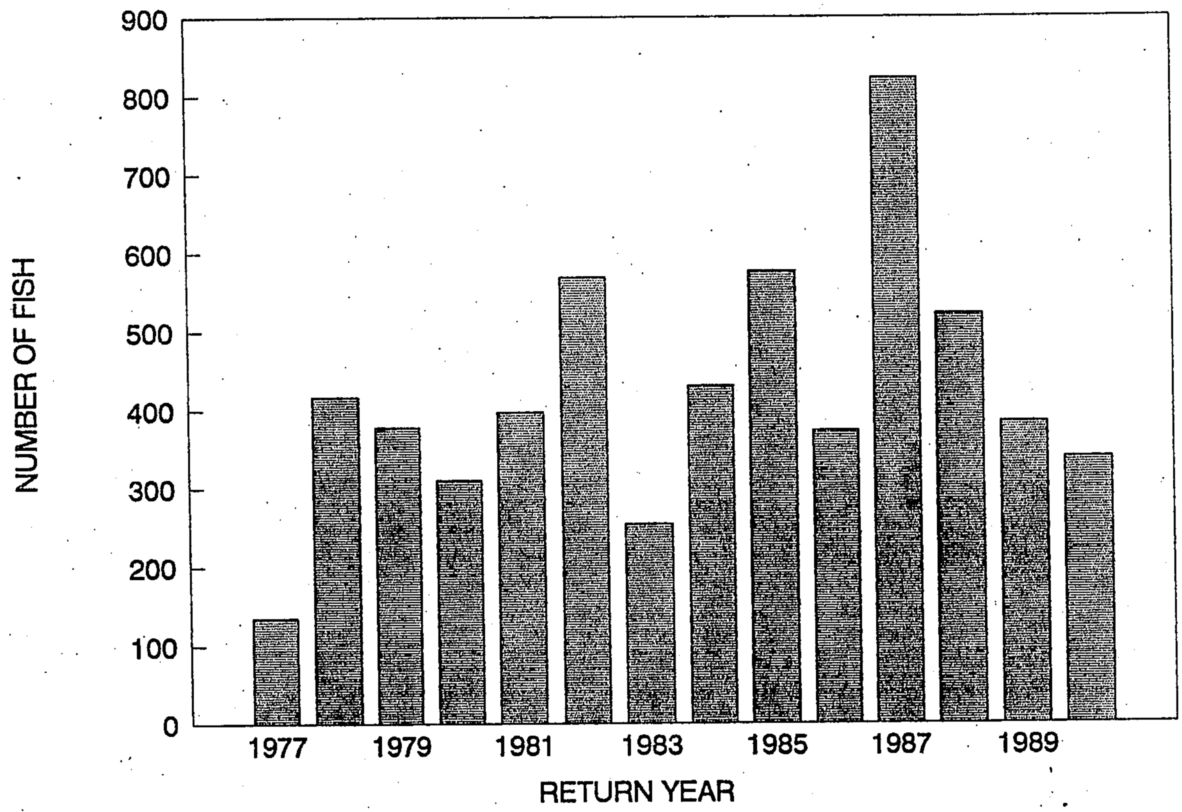

Figure 8. Returns of wild summer steelhead to Warm Springs National Fish Hatchery, 1977-1990.

Table 3. Returns of wild and stray steelhead to Warm Springs National Fish Hatchery.

Deschutes

Run Year	Return Year	Wild	Adipose Stray	Other Marks	Total Stray	Total Run	Percent Strays
1979	1980	311	18	24	42	353	0.119
1980	1981	397	16	39	55	452	0.122
1981	1982	569	31	9	40	609	0.066
1982	1983	255	16	19	35	290	0.121
1983	1984	431	22	107	129	560	0.230
1984	1985	577	15	74	89	666	0.134
1985	1986	373	4	52	56	429	0.131
1986	1987	822	200	492	692	1514	0.457
1987	1988	522	179	520	699	1221	0.572
1988	1989	385	66	139	205	590	0.347
1989	1990	339	100	82	182	521	0.349

SPRING CHINOOK

Population Characteristics

Spring chinook salmon begin returning to the Warm Springs River during late April or early May and peak by the first of June. The first arrivals generally occur once water temperatures exceed 50° F. Few fish return from late June to mid-August then a second peak of returns is noted and lasts until about the second week in September (Figure 9). Peaks and dips during the May period of return appear to be related to weather conditions. Returns generally drop when cooler weather prevails. A further discussion of wild run timing since the hatchery began production is included in the hatchery evaluation portion of this report. Wild spring chinook counts observed at Warm Springs NFH since 1979 are summarized in Table 4. The last fish passes Warm Springs NFH by mid-September. Travel time (Figure 10) between Bonneville Dam and Warm Springs NFH was estimated to average nearly 38 days in 1975 (Diggs, 1977). Tagging at Sherars Falls on the Deschutes River by ODFW and subsequent recaptures at Warm Springs NFH averaged 24 days for the years 1977 through 1980. A yearly average range of 12-40 days has been observed with the longest travel time occurring during the drought year of 1977. Natural spawning primarily occurs above Warm Springs NFH. Some spawning occurs below the hatchery but is generally insignificant except for the 1977 drought year when more than 28% of the redds were located below Warm Springs NFH.

It was once thought that the late arriving fish might represent a separate population of spring chinook. This speculation has largely been rejected as will be discussed in the hatchery evaluation portion of this report.

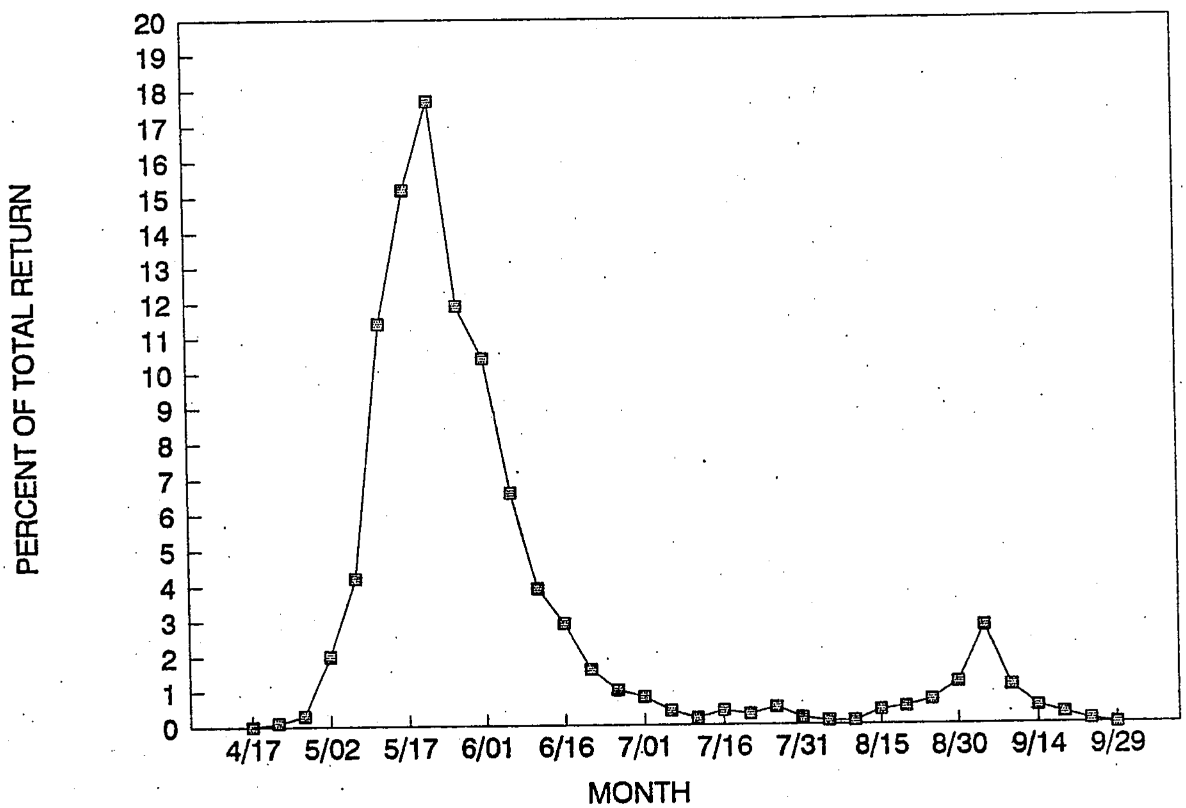

Figure 9. Five day mean run timing of wild and unmarked spring chinook to Warm Springs National Fish Hatchery, 1977-1986.

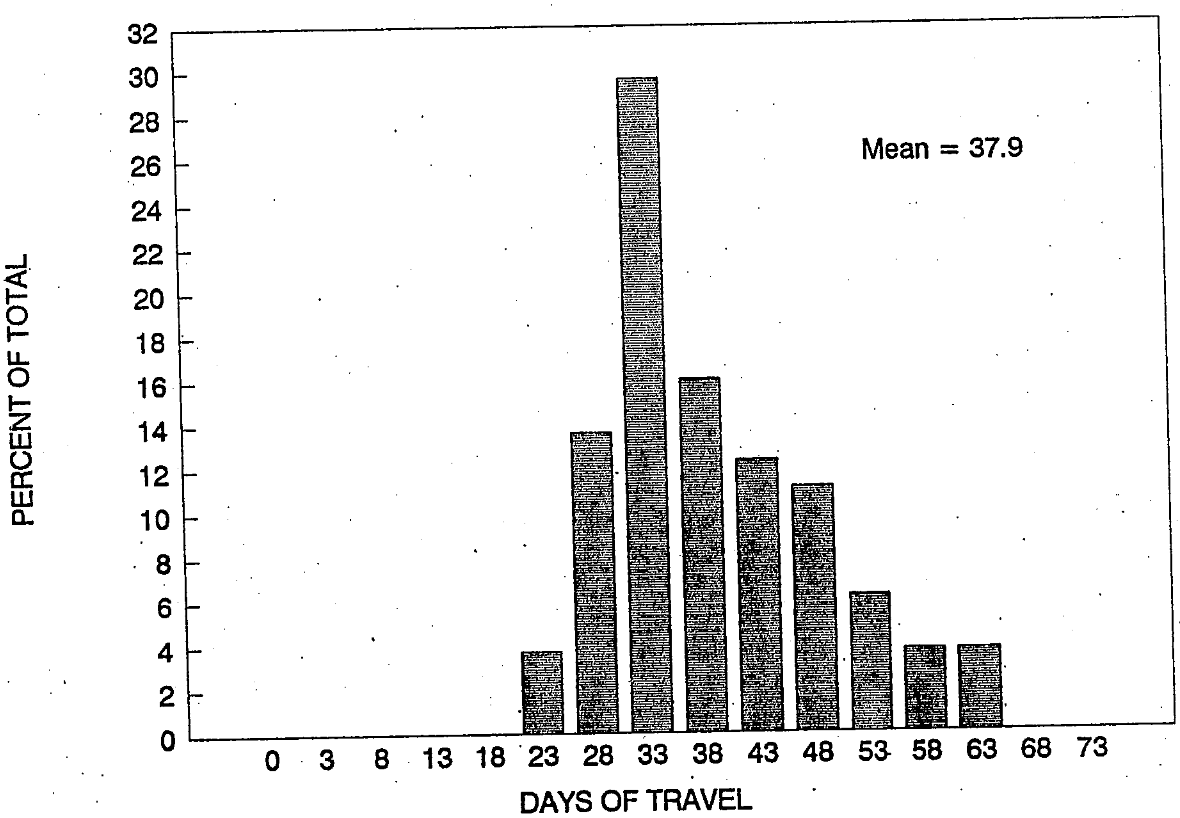

Figure 10. Migration time of wild spring chinook in 1975 between Bonneville Dam and Warm Springs National Fish Hatchery (Diggs, 1976).

Table 4. Returns and utilizations of wild spring chinook to Warm Springs National Fish Hatchery.

	Wild Returns		Wild Adult Utilization at Warm Springs NFH	
Run Year	Adult	Jack	Kept	Upstream
1977	1,505	101	---	1,505
1978	2,584	76	569	2,015
1979	1,322	73	416	906
1980	968	34	317	651
1981	1,525	50	511	1,014
1982[1]	1,408	46	91	1,317
1983[1]	1,523	18	442	1,081
1984[1]	1,192	98	389	803
1985[1]	1,099	56	322	777
1986[1]	1,656	55	470	1186
1987	1,697	86	147	1,550
1988	1,578	69	319	1,259
1989	1,344	65	90	1,254

1 Adult upstream escapement was supplemented by 270, 170, 519, 487, and 25 adult hatchery fish from 1982-1986 respectively.

Limited Tribal monitoring of adults released above Warm Springs NFH via radio tagging indicates that most fish stay in the canyon in the first few miles above the hatchery until spawning time approaches. Sometime in August most fish begin entering the actual spawning areas. Historically spawning has begun in the last week of August and been nearly completed by the second week of September. Since complete counts of adults began with the completion of Warm Springs NFH the relationship of adults passed above the hatchery to redds observed has been documented (Table 5). Normally it appears that for every three adults passed above the hatchery, one redd will be found within the spawning index areas. This indicates that considerable prespawning mortality is occurring and will be discussed in detail later in this report. The index areas contain all of the significant spawning areas existing above Warm Springs NFH. Some scattered spawning exists outside of the areas but it is estimated that the index counts represent more than 90% of the total redds in the system.

Table 5. Spring chinook salmon released upstream of Warm Springs National Fish Hatchery and resulting redd counts, 1977-1989.

Year	Adults Upstream Wild	Adults Upstream Hatchery	Total	Redds	Adults/Redds
1977	1,505	0	1,505	498	3.0
1978	2,015	0	2,015	788	2.6
1979	906	0	906	357	2.5
1980	651	0	651	114	5.7
1981	1,014	0	1,014	147	6.9
1982[1]	1,317	270	1,587	421	3.8
1983[1]	1,081	170	1,251	433	2.9
1984[1]	803	519	1,322	415	3.2
1985[1]	777	487	1,264	377	3.4
1986	1,186	25	1,211	417	2.9
1987	1,550	0	1,550	478	3.2
1988	1,259	0	1,259	396	3.2
1989	1,254	0	1,254	407	3.1

1 Outplant redds and fish included.

Redd counts in the system have occurred since 1969. Redd totals for the Warm Springs River, Beaver Creek, and Mill Creek are listed in Table 6. Prior to 1975 redd counts were done exclusively by the Warm Springs Tribe. Those counts apparently covered slightly more area than the 1975 and later counts, although only the unproductive areas were dropped to establish the 1975 index areas. Since 1982, some new areas have been included, especially in Mill Creek. The addition of these areas reflect the opening of new habitat due to barrier removal projects. At times additional areas have been examined for various reasons. This included the area in upper Mill Creek where adults have been outplanted to bring unutilized habitat into production. These "outplanted redds" are not included in the index area counts to facilitate comparisons with past years. On the average more than 77% of the spring chinook redds are located in the Warm Springs River primarily between Bunchgrass Creek and Hehe. Beaver Creek averages about 18% and Mill Creek 5% (Table 7). The historical percentage breakdown for the distribution of spawning effort between streams appears to be maintaining itself. More variation occurs in the redd distribution within Mill Creek and Beaver Creek. Within Mill Creek the primary spawning effort in some years has shifted to the area above Potters Pond Bridge. This is probably due to the scouring and loss of spawning gravel below and the improved passage at Potters Pond and Strawberry Falls. Due to the apparent destruction of several beaver dams in Beaver Creek, salmon are now increasingly utilizing the area between the upper end of the Dahl Pine Area to Robinson Park. This appears to explain the "reduction" of effort in the Dahl Pine area. No significant spawning shifts appear to be occurring in the mainstem Warm Springs River although a considerable anomaly appears to have occurred in 1977. At that Time 201 redds were counted below Warm Springs NFH primarily between the

Table 6. Spring chinook redd counts in the Warm Springs River, Oregon.

Year	Warm Springs River Below WSNFH	Warm Springs River Above WSNFH	Beaver Creek	Mill Creek	Total	Total Above WSNFH
1969	No Survey	205	39	20	264	264
1970	No Survey	119	41	12	172	172
1971	No Survey	152	15	6	173	173
1972	No Survey	75	12	0	87	87
1973	No Survey	396	154	34	584	584
1974	No Survey	172	31	13	216	216
1975	No Survey	560	162	86	808	808
1976	No survey	834	161	71	1,066	1,066
1977	201	390	73	35	699	498
1978	8	620	119	49	796	788
1979	2	253	97	7	359	357
1980	3	86	22	6	117	114
1981	10	131	9	7	157	147
1982	12	309	72	25 (15)	418 (15)	406 (15)
1983	5	287 (17)	104	22 (3)	418 (20)	413 (20)
1984	14	211 (28)	128 (18)	14 (16)	367 (62)	353 (62)
1985	21	236 (14)	81 (13)	15 (18)	353 (45)	332 (45)
1986	11	292	66 (27)	25 (7)	394 (34)	383 (34)
1987	6	325 (29)	87 (14)	21 (2)	441 (43)	435 (43)
1988	5	266 (18)	74 (9)	26 (3)	37 (30)	366 (30)
1989	8	259 (21)	97 (3)	27	391 (24)	383 (24)

Redds from outplants or from survey of supplemental areas are in parentheses and are not included in index counts.

Table 7. Percent distribution of spring chinook spawning effort in index areas of the Warm Springs River and tributaries.[1]

Year	Warm Springs River Below WSNFH	Warm Springs River Above WSNFH	Beaver Creek	Mill Creek	Total Number of Redds
1969	----	.777	.148	.076	264
1970	----	.692	.238	.070	172
1971	----	.879	.087	.035	173
1972	----	.862	.138	.000	87
1973	----	.678	.264	.058	584
1974	----	.796	.144	.060	216
1975	----	.693	.200	.106	808
1976	----	.782	.151	.067	1,066
1977	.288	.558	.104	.050	699
1978	.010	.779	.149	.062	796
1979	.006	.705	.270	.019	359
1980	.026	.735	.188	.051	117
1981	.064	.834	.057	.045	157
1982	.029	.739	.172	.060	418
1983	.012	.687	.249	.053	418
1984	.038	.575	.349	.038	367
1985	.059	.667	.229	.045	354
1986	.027	.726	.167	.808	402
1987	.014	.737	.197	.052	441
1988	.013	.704	.206	.077	378
1989	.020	.683	.248	.069	391

[1] Redds from outplanted adults not included. No survey done below Warm Springs NFH prior to 1977; areas previously accessible but not surveyed are not included, newly accessible areas are.

hatchery and Kah-Nee-Ta Village. The magnitude of spawning within this area greatly exceeds those noted in all the years counts have been made and appears to be related to severe drought conditions and/or early fish trapping efforts at Warm Springs NFH.

Warm Springs River spring chinook are not large compared to other spring chinook stocks. This is at least partially due to their tendency to return as four year olds (Table 8). Most fish return as four year old adults, jacks are not usually abundant, and five year olds generally average 17% of the total brood return. Most fish average between nine and ten pounds at return. The largest five year olds are usually under twenty pounds. Length frequencies observed for the three age classes of wild fish arriving at Warm Springs NFH from 1977-1981 are shown in Figure 11.

Wild spring chinook generally exhibit scale patterns indicating that most fish migrated as smolts to the ocean during their second spring. A large number of juvenile fish migrate from the Warm Springs River as zero age fish in the fall primarily in November and December. The fall migrants have been trapped and tagged at times by ODFW. Return data indicates that these fish contribute to adult returns but it appears that they do not often migrate directly to the ocean in the fall. Work by ODFW (Lindsay, et.al., 1980) indicates that many of these fall migrants overwinter in the Deschutes River and complete their migration the following spring.

Judging from past male/female ratios and redds located above the hatchery (Table 9), it appears that significant prespawning mortality has occurred above the Warm Springs NFH site and approximates that seen at the hatchery before holding conditions were improved and the adults inoculated for Bacterial Kidney Disease (BKD). The almost doubling of mortalities in 1981 and 1985 (Table 9) has been attributed to increased BKD levels. The exact levels of natural prespawning mortality shown may be somewhat overestimated because we do not count every redd in the system and some illegal poaching could be occurring above Warm Springs NFH. However, it is safe to assume that significant numbers of spring chinook adults are released above Warm Springs NFH that never survive to spawn. This loss has averaged 44% with the exception of 1980 and 1981.

Little is known about the presmolt life history of spring chinook in the Warm Springs River system. Seining done in Beaver Creek near Dahl Pine by ODFW in July and August of 1979 resulted in 2,775 being captured and coded wire tagged. The mean length of these fish was 59.2 mm (Lindsay, et.al., 1980). Data on juvenile chinook captured during electrofishing by the USFWS in the summer of 1983 is summarized in Table 10. The sampling sites noted in this table occur within or very near to spawning index stretches on Mill and Beaver Creeks. Samples were taken from the last week of August to the first week of September 1983. Other areas were sampled which generally contained fewer fish or reliable population estimates were not obtained. Areas with an abundance of boulders and other cover often had the highest densities of juvenile chinook.

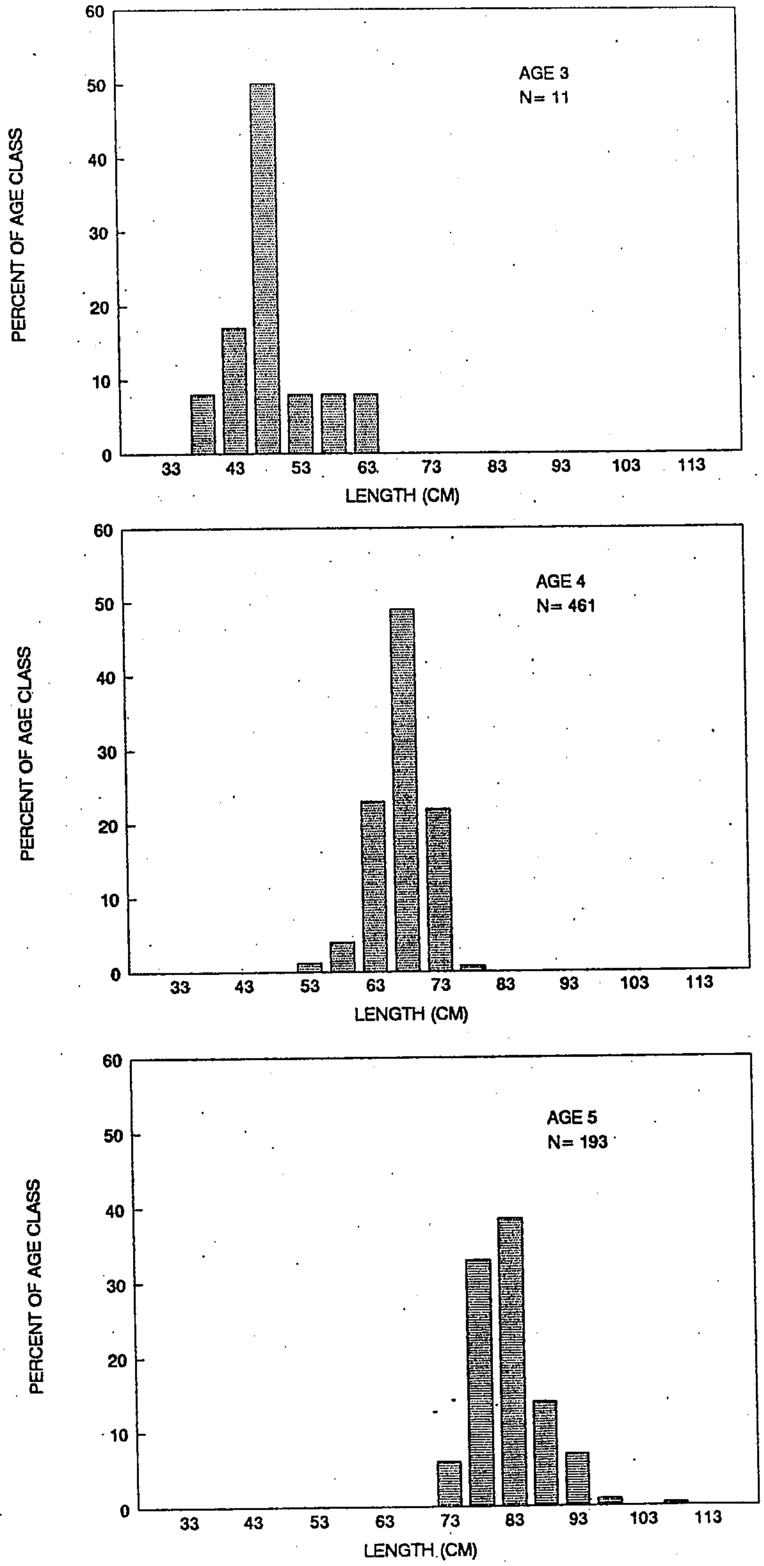

Figure 11. Length frequencies of wild spring chinook arriving at Warm Springs National Fish Hatchery, 1977-1981.

Table 8. Estimated brood strengths and age composition of wild spring chinook entering the Deschutes River.

Brood	AGE COMPOSITION					
	Jacks		Fours		Fives	
	Number	Percent	Number	Percent	Number	Percent
1974	248	(.09)	2,218	(.76)	440	(.15)
1975	85	(.04)	1,474	(.78)	332	(.18)
1976	114	(.07)	1,107	(.72)	326	(.21)
1977	73	(.04)	1,205	(.71)	413	(.25)
1978	50	(.02)	1,650	(.82)	309	(.15)
1979	107	(.05)	1,715	(.83)	255	(.12)
1980	45	(.04)	937	(.81)	180	(.15)
1981	98	(.05)	1,503	(.83)	206	(.11)
1982	114	(.04)	2,160	(.78)	496	(.18)
1983	79	(.03)	2,064	(.75)	600	(.22)
1984	132	(.06)	1,772	(.75)	440	(.19)

Table 9. Estimated prespawning mortalities of adult (age 4 and 5) spring chinook released above Warm Springs National Fish Hatchery.

Year	Adults Released	Redds	Adults Per Redd	Percent Females	Estimated Females	Percent Prespawning Mortality
1977	1,505	498	3.0	.62	872	.43
1978	2,015	788	2.6	.63	1,269	.38
1979	906	357	2.5	.62	562	.36
1980	651	114	5.7	.65	423	.73
1981	1,014	147	6.9	.58	588	.75
1982[ABC]	1,540	406	3.8	.65	1,001	.59
1983[ABC]	1,241	430	2.9	.59	732	.41
1984[ABC]	1,282	399	3.2	.61	782	.49
1985[ABC]	1,222	360	3.4	.61	745	.52
1986[ABC]	1,211	417	2.9	.52	630	.34
1987[B]	1,550	478	3.2	.57	884	.46
1988[B]	1,259	396	3.2	.58	730	.46
1989[B]	1,254	407	3.1	.60	757	.46

A Fish and Redds from adult outplants not included
B All adults inoculated for BKD
C Adult totals include hatchery fish released upstream

Table 10. Population statistics for juvenile spring chinook in two tributaries of the Warm Springs River, August 17 to September 8, 1983. The ± 95% confidence limit for estimated abundance is in parentheses (from Lindsay, et.al., 1989).

Stream Location	Estimated Abundance	Density (Fish/ Sq M)	Fork Length (mm) Mean	Fork Length (mm) Range	Weight (g) Mean	Weight (g) Range	Biomass (g/sq m)
Mill Creek:							
Lower Canyon	28 (7)	0.047	80.7	57-108	7.11	2.6-16.3	0.34
Just Below Potters Pond	53 (4)	0.097	72.5	62- 89	5.13	2.5- 9.0	0.50
Potters Pond Area	50 (16)	0.067	70.5	59- 80	4.40	1.4- 7.4	0.29
Above Potters Pond	56 (2)	0.079	78.7	69-109	7.71	5.1-17.0	0.61
Beaver Creek:							
Canyon Above Simnasho Branch	72 (8)	0.074	82.5	69-100	6.95	2.8-14.3	0.52
Dahl Pine	25[a]	---	70.7	64- 78	4.25	2.6- 5.9	---

[a] Number captured; no population estimate.

Based on the information gathered in the tributary streams it appears that most of the stream habitat within the Warm Springs River canyon is similar to tributary areas that contained the highest densities of larger juvenile chinook and may be very important.

Some additional limited sampling done in the fall and winter of 1977-1978 by the USFWS indicates that some chinook juveniles overwinter in the Warm Springs River between Hehe and Schoolie (Figure 12).

The survival of spring chinook from eggs deposited to outmigrating juveniles has been estimated since 1976 through the cooperative efforts of the USFWS, ODFW, and the Tribe. Biological data collected at Warm Springs NFH, redd counts, and juvenile outmigration estimates are combined to estimate system wide survival. Table 11 lists the egg/migrant survival data collected for the 1975-1987 broods.

A significant ($P < .01$) correlation exist between the number of eggs deposited and survival to outmigration (Figure 13). High egg depositions appear to result in much lower survival to migrant rates whereas low egg depositions appear to result in much higher survival to migrant rates. A density-dependent relationship seems to be indicated by this data. Such a relationship would help to explain how spring chinook in the Warm Springs River compensate for low spawner escapements and still produce harvestable surpluses of returning adults. This same type of compensation can be seen in comparing the numbers of migrants produced per redd at varying redd counts (Figures 14 and 15).

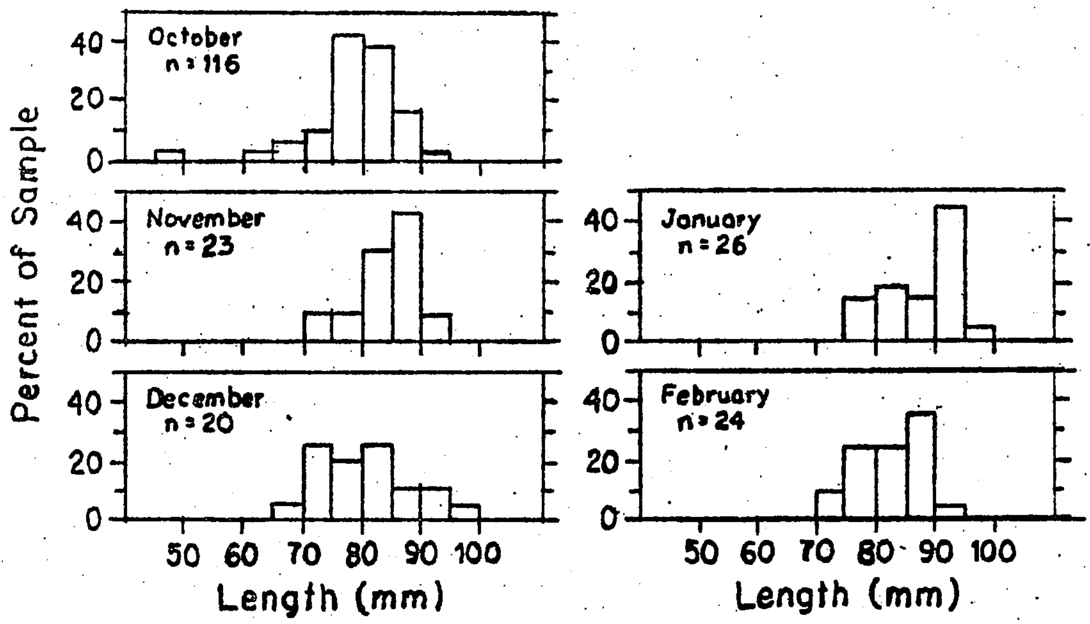

Figure 12. Length-frequency distributions for juvenile spring chinook salmon captured in the Warm Springs River between Hehe and Schoolie, October 1977 to February 1978 (Lindsey, et.al., 1989).

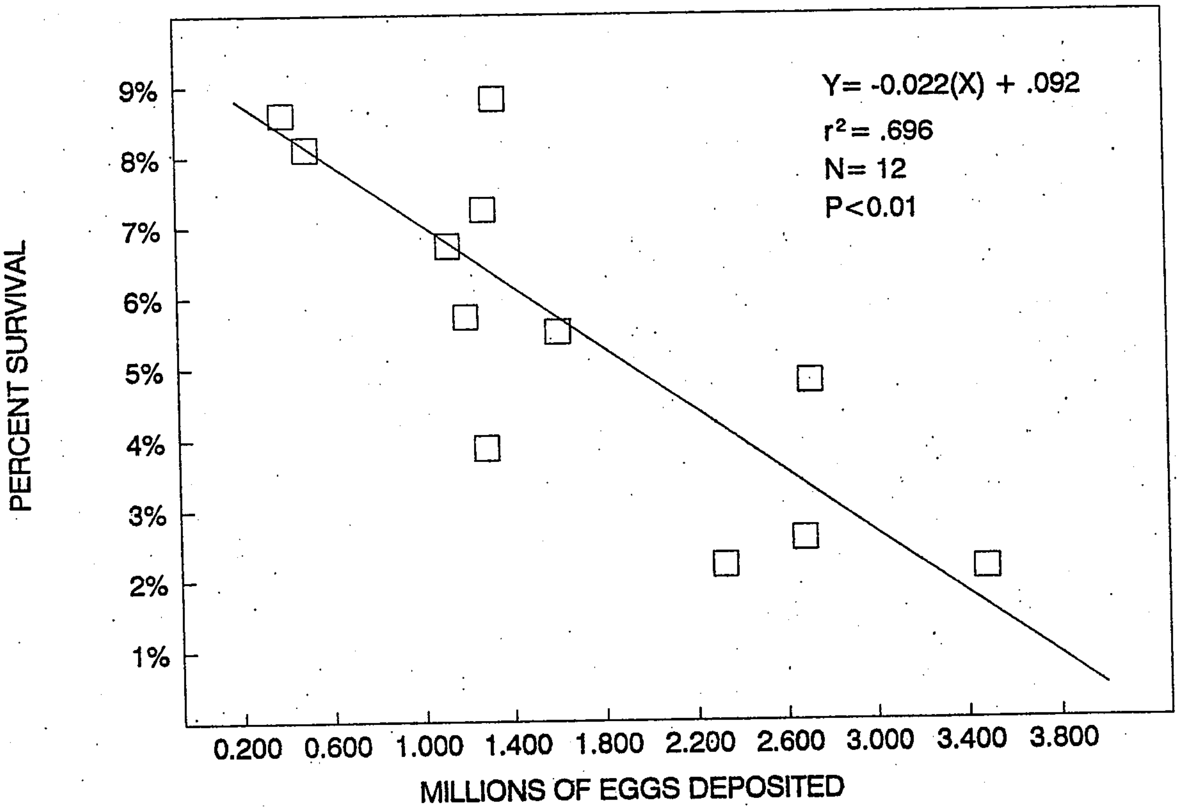

Figure 13. Relationship between eggs deposited and survival to migrant for spring chinook in the Warm Springs River, Oregon, 1975-1987 broods except 1982.

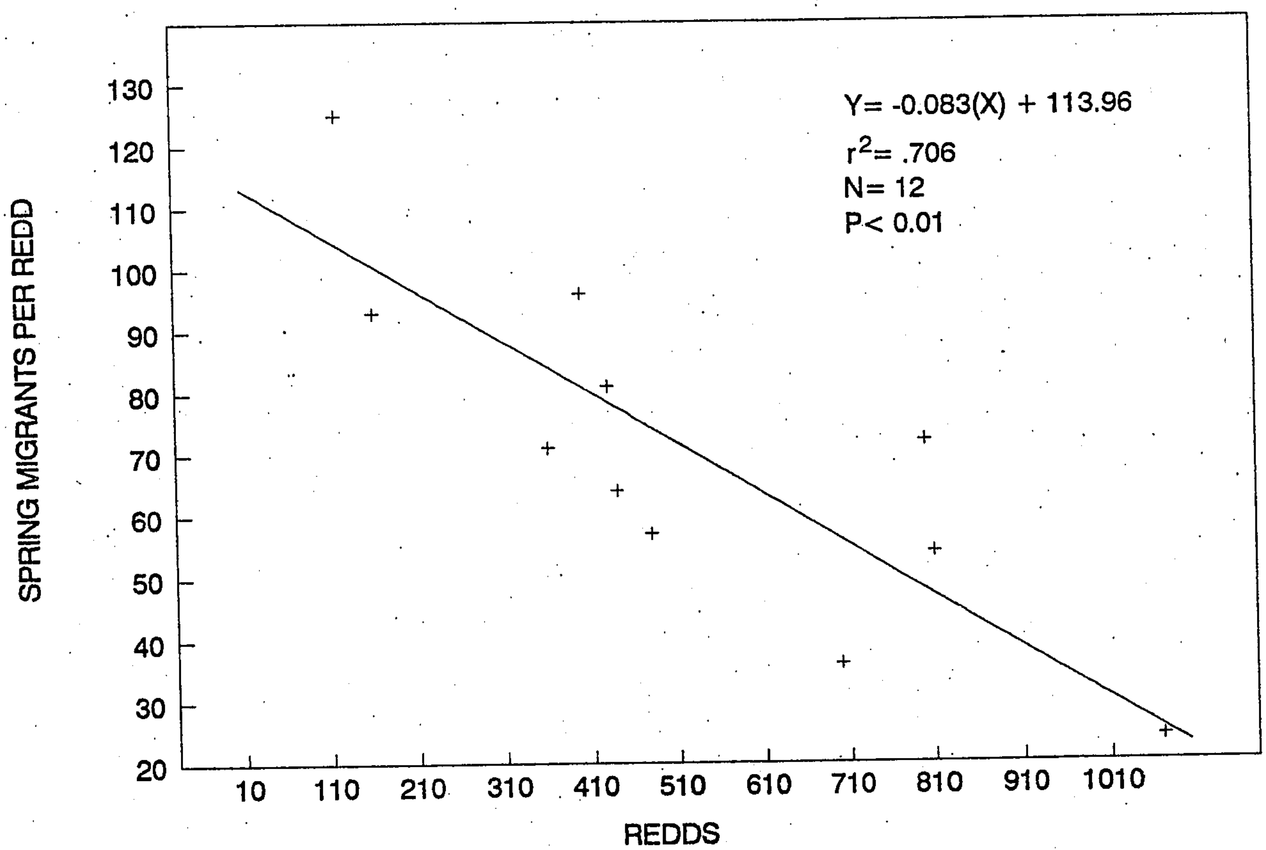

Figure 14. Relationship between redds and spring migrants for spring chinook in the Warm Springs River, Oregon.

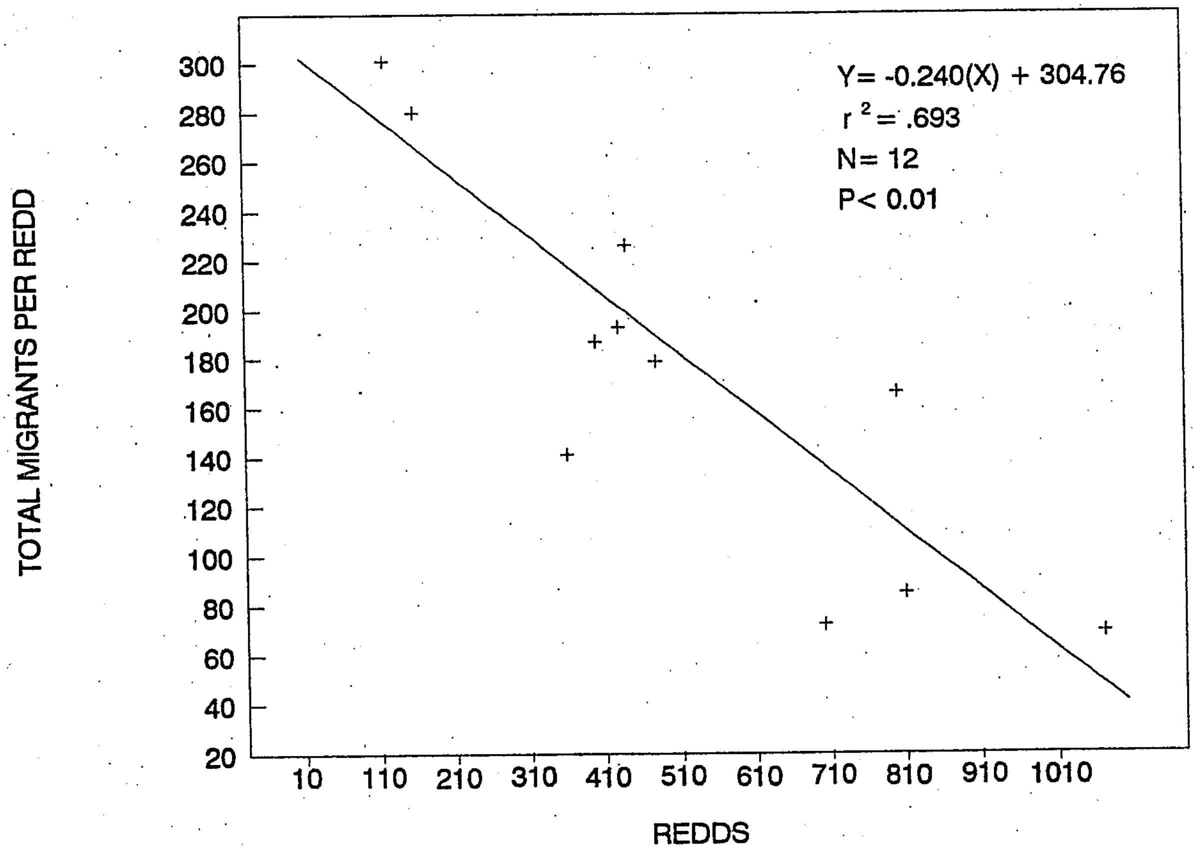

Figure 15. Relationship between redds and total migrants for spring chinook in the Warm Springs River, Oregon.

Table 11. Egg-migrant survival of spring chinook in the Warm Springs River, Oregon.

Brood	Redds	Eggs Per Females	Eggs Deposited (Millions)	Fall Migrants	Spring Migrants	Total	Egg-Migrant Survival Rate
1975	808	3,303	2.699	25,795	43,250	69,045	.026
1976	1,066	3,303	3.521	47,041	26,043	73,084	.021
1977	699	3,303	2.309	25,125	25,304	50,329	.022
1978	796	3,355	2.671	74,727	57,216	131,943	.049
1979	359	3,647	1.309	24,930	25,628	50,558	.039
1980	117	3,443	.403	20,579	14,656	35,2358	.087
1981	157	3,435	.539	29,238	14,547	43,885	.081
1982[1]	433	3,303	1.430	67,719	30,594	98,313	.069
1983	438	3,089	1.353	89,396	31,101	120,497	.089
1984	429	3,124	1.340	61,970	34,827	96,797	.072
1985	398	3,303	1.315	35,991	38,335	74,326	.057
1986	428	2,850	1.220	47,125	35,651	82,776	.068
1987	484	3,303	1.599	59,195	27,508	86,703	.054

Average eggs/female for 1978-1981, 1983-1981, 1983-1985 (3,303) used when no estimate of natural spawner fecundity was available. Fecundities in 1983 and 1984 were 3,089 and 3,124 respectively.

[1] 1982 brood data has not been used in egg-migrant survival relationships due to questions about fish misidentification and trap operational irregularities.

Some questions exist concerning the effects of the 1976-1977 drought on survival of the 1975-1977 broods. These broods resulted from high egg depositions and coincided at least partly with drought conditions and in the case of 1977 with a significant alteration in spawning distribution. Exactly what effect this had on eventual production is not known, but it may have reduced survival. High egg deposition in "normal" water years might result in better survival than in drought years.

Although droughts have the potential to impact the rearing environment of fish, the relative stability of the Deschutes River and the Warm Springs River probably reduces its severity to fish populations. Because of the influence of large springs at its headwaters, the water levels in the mainstem Warm Springs River do not fluctuate greatly, although certain tributaries such as Beaver Creek may be at greater risk. Data collected during "normal" water years since 1977 continue to indicate significant lessening of survival as egg depositions increase. It appears that the dampening effect of excess escapement on production may be the primary factor determining ultimate adult returns given current rearing capacities. Drought conditions may also contribute to lower survival.

A further illustration of the possible effect of high egg deposition appears to be an association between the number of migrants produced and percent survival to adult return (Table 12). As shown in Figure 16, migrants resulting from large migrations appear to have a lessening chance of survival to adult return. The returns of later broods should determine its further usefulness.

Table 12. Survival of spring chinook migrants to adult return for wild spring chinook entering the Deschutes River, Oregon.

Brood	Migrant	Adult Returns	Survival Rate
1975	69,045	1,891	.027
1976	73,084	1,547	.021
1977	50,329	1,691	.034
1978	131,943	2,009	.015
1979	50,558	2,077	.041
1980	35,235	1,162	.033
1981	43,885	1,802	.041
1982[1]	98,313	2,790	.028
1983	120,497	2,743	.023
1984	96,797	2,344	.024

[1] Estimates for the 1982 Brood outmigration are considered unreliable and are not utilized in making survival estimates.

When comparing migrant/adult return rates between broods of wild Warm Springs River spring chinook it is assumed that environmental conditions, harvest levels, and other factors occurring in the ocean and Columbia River were not different enough from year to year to significantly effect returns. We believe this is a reasonable assumption for this stock of spring chinook.

One of the primary goals of the USFWS studies on the Warm Springs Indian Reservation is to determine the number of spring chinook needed for spawning above Warm Springs NFH. Once this relationship is understood we may estimate what effect the utilization of wild chinook in the hatchery broodstock may have had on natural production and more importantly it will allow us to pinpoint escapement goals needed to meet management objectives. Data collected concerning juvenile and adult production in the Warm Springs River has led to the creation of a spawner-recruitment (S/R) curve for spring chinook (Figure 17). This curve is based on the spawner versus eventual returning adult data generated through harvest estimates, enumeration at Warm Springs NFH, and redd counts.

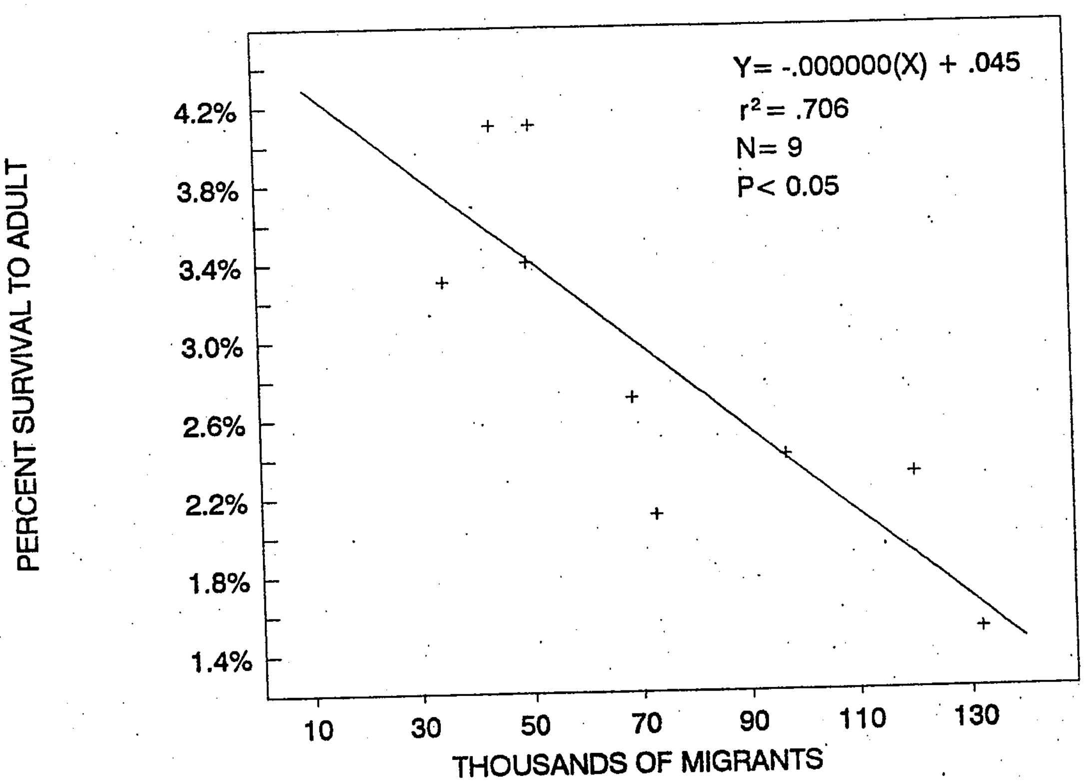

Figure 16. Number of migrants produced versus survival to adult rates for wild spring chinook in the Warm Springs River, Oregon.

The S/R curve noted in Figure 17 illustrates that actual number of spawning females and males as related to eventual brood returns. The curve is of the type described by Ricker (1975) which can be written in the following way:

$$R = \alpha P e^{-BP}$$

where:

R equals the number of recruits
P equals the size of parental stocks
α equals a dimensionless parameter, and
B equals parameter with dimensions of 1/P.

The relationship demonstrated through this regression reflects highly compensatory abilities of spring chinook in the Warm Springs River as seen in the egg/migrant and migrant/adult relationships previously noted. This stock would be considered among the more productive stocks if compared to those examined by Reisenbichler (1987).

An examination of the S/R curve allows us to pinpoint key areas relating to spawner numbers and eventual adult production. Three key points are illustrated on the curve. Maximum production occurs at the apex of the curve. This corresponds with the production of 2,415 adult progeny from 771 spawners. Based on the average prespawning mortalities observed above Warm Springs NFH approximately 1,377 adults should be passed above the hatchery for maximum production. The point where the maximum number of fish (2,326) are available for sustainable harvest (MSY) occurs from the production of 579 spawners. Approximately 1,034 adults would need to be passed above Warm Springs NFH to achieve this. Considerable harvest potentials exist below MSY. The average 30% harvest rate at Sherars can be maintained at spawner levels below the lowest observed to data (180 in 1980); however, it seems prudent to avoid such low escapements.

The replacement level is the point where the number of spawners will just replace itself and not provide a harvest if it also was the escapement goal. This occurs at a level of 1,651 spawners or about 2,948 fish above Warm Springs NFH.

Examining Figure 17 indicates that considerable fish in excess to harvest and replacement needs are generally available at escapements to Warm Springs NFH of substantially less than 1,000 fish. Up to the present time we have observed the production of only two broods resulting from less than 300 spawners. We do not know at what level production may drastically decline in this range, so caution is advisable. Additionally, we cannot predict when higher than average prespawning mortalities may occur above Warm Springs NFH. With that in mind we suggest that a minimum escapement goal of 800 adults above Warm Springs NFH be established before harvests are restricted. This would allow for the highest prespawning mortalities yet observed (75%) and still allow 200 adults to spawn. We have already seen that 200 spawners should produce 1,314 adult returns. This

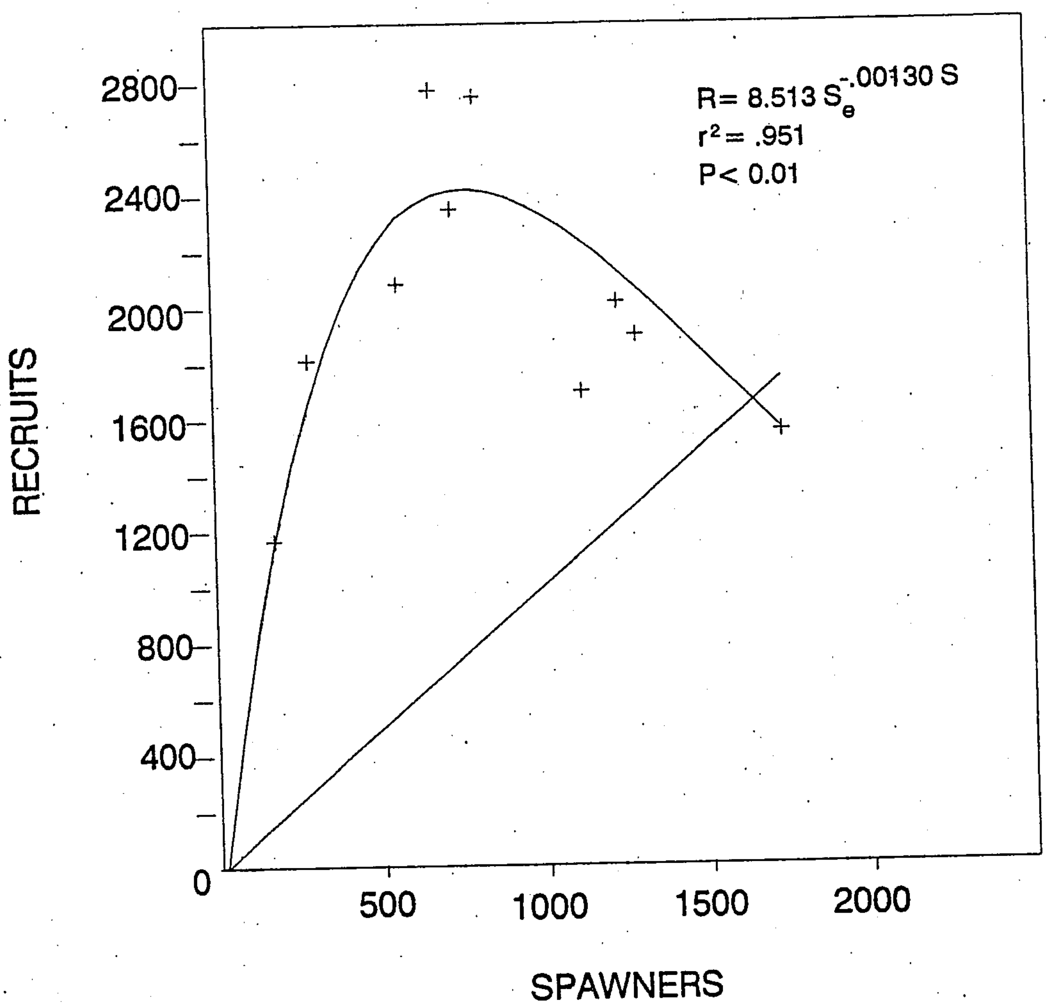

Figure 17. Spawner-recruitment curve for wild spring chinook salmon in the Warm Springs River, Oregon (1975-1984 broods).

would maintain average Sherars harvest rates and provide adequate escapement. If prespawning mortalities on the 800 adults are "normal" then 440 spawners would result. They would be expected to produce nearly 2,117 recruits or about 88% of maximum production.

It seems reasonable to establish, for hatchery operational objectives a goal of 1,000 fish above Warm Springs NFH. Below this number wild fish would not be retained at the hatchery. If more than 1,250 wild fish are expected, then the hatchery may take the full complement of 90 adults. These are conservative goals that will provide for substantial wild production and greatly reduce the possibility of restricting harvests.

A general goal for wild production would be a level that produces the maximum number of adult recruits while still resulting in an excess returning to Warm Springs NFH after normal harvest.

At this time the data suggests that 1,377 fish above the hatchery should generate full recruit production. Using this as a goal would not allow management flexibility the productivity offers. We estimate greater than 88% of the total production potential can normally be achieved by any escapement above Warm Springs NFH from 800 to 2,100. It certainly makes sense from a potential harvest standpoint to operate on the mid to lower end of this range.

In order to avoid the possibility of a significant exceedance of the rearing capacity of the system above Warm Springs NFH we should establish a maximum escapement level. This should be conservative to account for drought years when production capacity may be reduced. We suggest that managers should be cautious about allowing more than 2,200 and certainly more than 2,700 fish above Warm Springs NFH. Based on the spawner recruitment data, it appears that production from escapements above 2,700 may not sustain a 30% harvest and allow 1,250 fish back to Warm Springs NFH.

The significant prespawning mortalities that occur above Warm Springs NFH greatly influence the number of fish needed for escapement above the hatchery. The cause(s) of this mortality should be investigated. As a preventative measure the injection of erythromycin should be continued if BKD continues to be a problem in the system. At a minimum it should be continued in years when escapements are low (< 1,000) and whenever BKD is known to be prevalent.

Harvest

A significant sport and Indian fishery for spring chinook exists in the Deschutes River at Sherars Falls (Rkm 71). Sport anglers generally harvest the majority of the fish in the stream areas open to this fishery. The Indian subsistence fishery generally utilizes dip nets to capture fish although they sometimes employ hook and line. Recently snagging methods to capture fish have been utilized by some Indian fisheries. Catches of wild and hatchery spring chinook at Sherars Falls since 1974 (Lindsay, et.al., 1989) are shown in Table 13. Several years of additional harvest estimates made by ODFW were added to make it current. The mean harvest rate for wild and hatchery fish is approximately 30% based on past creel surveys. Harvest rates of wild fish from 1987 to 1989 were 34%, 35%, and 36% respectively. Whether or not this is indicative of a trend of rising harvest rates is unknown. Catches of hatchery spring chinook from Round Butte SFH and Warm Springs NFH have been increasing at Sherars Falls and accounted for 55%, 64% and 73% of the total harvest in 1989. It has already been noted by Lindsay, et.al., 1989, that the numerical harvest of wild fish has been increasing in conjunction with that of the hatchery fish. It appears, however, that wild harvest rates may be only slightly increasing despite the presence of increasing numbers of hatchery chinook. The limited bait fishing areas at Sherars Falls may effectively limit the harvest rates of this stock. The addition of significant numbers of hatchery fish to the fishery has primarily increased the catch per unit of effort while the harvest rates have changed little.

Table 13. Catch Estimates for Wild Spring Chinook From the Sport and Indian Fishery at Sherars Falls, 1974-1988.

	Wild Harvest		Total	
Year	Sport	Indian	Sport	Hatchery
1974	358	1,133	1,491	0
1975[ac]	0	unk	unk	unk
1976[a]	0	1,162	1,162	0
1977	1,107	391	1,498	7
1978	512	173	685	0
1979	345	199	544	0
1980	337	113	450	60
1981[ab]	0	0	0	0
1982	515	201	716	660
1983	338	190	528	435
1984[ab]	0	0	0	0
1985[c]	453	unk	unk	unk
1986[cd]	unk	unk	unk	unk
1987	501	408	909	1,130
1988	629	241	870	1,656
1989	519	265	784	2,085

[a] Closed to sport fishing
[b] Closed to Indian fishing
[c] No Indian Creel survey
[d] No sport creel survey

Predicting Returns

A pre-return estimate of wild brood strength can be made by utilizing the number of redds documented for a particular year to determine number of males and females that spawned. The total number of fish spawning can then be utilized in the Spawner-Recruitment curve to estimate the expected "average" brood strength. It must be stressed that this predicted number was based on a mix of environment factors that influenced the return of ten previous broods. The factors influencing brood strength can be expected to vary from year to year, however, the apparent importance of fresh water density-dependence on the future brood strength of this stock appears to make predictions useful for managing this fishery.

The number of fish returning each run year depends on the strengths of three brood years, although the contribution of jacks is minor. As noted in Table 8, the relative contribution of each year class in a brood varies somewhat between broods but four-year-olds have always dominated the return. The average contribution rate of four year olds to a brood is 78%, and has ranged from 71% to 83%. For prediction purposes the average percent contribution rate of each year class 0.05 (jacks), 0.78 (fours), and 0.17 (fives) are utilized.

Since each run year is composed of representative year classes from three broods an estimate of the brood strength for each of the return broods is needed. The final step is to determine what years and in what numbers they can be expected to return. For example, the return in 1990 will consist of jacks from the 1987 brood, fours from the 1986 brood, and fives from the 1985 brood. Utilizing the average return rates for jacks, 4's and 5's observed for past broods and estimating total expected numbers of fish expected from the 1985, 1986, and 1987 broods will allow a run estimate for 1990.

Hatchery Program

HISTORY

A chronological history of the establishment of Warm Springs NFH is given in Table 14. Some important aspects to remember while reviewing the operational, management, and actual structural changes that have occurred at Warm Springs NFH include the changing priorities and desires of the USFWS and the Tribe.

The initial fish production program envisioned for Warm Springs NFH in 1964 is greatly different from that existing in 1989 (Table 15). The reasons for these changes result from the changing management philosophies of the state, federal, and Tribal governments, disease considerations, and the physical limitations of the facility. Since the hatchery became operational in 1978, the original 1977 operational plan has been significantly revised on three occasions. In 1981 the steelhead program was discontinued primarily due to disease problems and the apparent physical limitations of the facility in rearing two year old steelhead smolts. As a result, excess ponds were available to initiate an expanded spring

Table 14. Chronological history of Warm Springs National Fish Hatchery.

Year	Event
1958	Pilot hatchery at Schoolie
1963	Warm Springs Tribal Council requests Bureau of Sport Fisheries and Wildlife (BSFW) to determine feasibility of a permanent fish hatchery on the reservation.
1963	Fish counting weir established near Kah-Nee-Ta.
1966	Hatchery authorized (Federal Statute 184, May 31, 1966).
1967	Tribe leases hatchery site to BSFW.
1971	Hatchery Master Plan developed.
1972	Environmental Impact Plan issued. Hatchery ground breaking.
1975	Anadromous fish studies begin (USFWS).
1977	Trout production testing at Warm Springs NFH. Original Operational Plan developed.
1978	Hatchery dedicated. Production begins for spring chinook and steelhead.
1979	First steelhead released.
1980	First chinook released.
1981	First hatchery fish return.
1985	Operational Plan signed revised.
1988	Operational Plan revised.

chinook program. The changes in 1985 primarily dealt with altering hatchery procedures to accommodate a separation of the hatchery and wild stocks under Tribal management objectives. That plan was revised in 1988. The 1988-1991 operations plan is included in Appendix A.

Table 15. Evolution of proposed fish production programs at Warm Springs National Fish Hatchery.

Species	1964	1967	1970	1971	1972	1977*	1981
Spring Chinook	500,000	1,000,000	400,000	400,000	400,000	400,000	1,200,000
Fall Chinook	1,000,000	-------	------	------	------	------	-------
Coho	500,000	200,000	300,000	------	------	------	-------
Steelhead	150,000	-------	------	140,000	250,000	140,000	-------
Rainbow Trout	435,000	875,000	875,000	875,000	280,000	154,000	13,500
Brook Trout	20,000	-------	------	------	------	------	-------

* initial Operational Plan

HATCHERY FACILITIES

When the hatchery became operational in 1978 the primary rearing area consisted of three groups of ten Burrows 17" x 75" ponds. Within the hatchery building 24 circular tanks were used to initially start fish once they were ready to leave the Heath incubators. The hatchery is equipped with an ultraviolet sterilization systems, and filters, and the ability to heat or cool the incubators, adult holding ponds, and inside tanks. The adult holding area consisted of four 8' x 28' concrete ponds.

TROUT PROGRAM

Originally Warm Springs NFH was expected to provide trout for all programs on the Warm Springs Indian Reservation including Lake Simtustus, and also provide trout for the Umatilla Indian Reservation. Due to fish disease considerations and changing Service priorities the trout program has been reduced to a small program, partially funded by the Warm Springs Tribe.

The trout program at Warm Springs NFH is currently producing about 13,500 catchable trout, primarily for the lower Warm Springs River. The fish are <u>Ceratomyxa shasta</u> susceptible fish obtained as eggs from Roaring River SFH (Oregon). <u>Ceratomyxa</u> susceptible fish are utilized in the Warm Springs River program to ensure that hatchery trout do not impact the wild trout populations of the Deschutes River where <u>Ceratomyxa</u> is present. It is expected that the hatchery trout would die if they migrate out of the Warm Springs River into the Deschutes River which is managed for wild trout.

After several seasons of use some modifications of hatchery structures occurred. The first significant change occurred when the juvenile rearing tanks within the hatchery building were discarded in favor of large troughs. This was due to the disease problems with the circular tanks. A major modification was deemed necessary to improve adult holding capabilities. During the first several years, spring chinook adults being held spent considerable effort jumping at the steepsided walls of the holding ponds. Additionally, the roughness of the concrete walls of these ponds caused extensive, abrasive damage to the fish. This contributed to unacceptability high prespawning mortalities. Two new adult holding ponds (20' x 60') were built in 1980. These ponds feature smooth, gently sloped sides which greatly reduced the amount of jumping and subsequent abrasion related mortalities. The third major modification to the hatchery consisted of modifying some Burrows Ponds into raceways. Since 1984 five Burrows Ponds have been converted into ten raceways. This transition was initiated in an effort to reduce the considerable disease load of fish reared at the facility.

ANADROMOUS FISH PROGRAMS

Broodstock Collection

During the start-up phase of hatchery operations, it was necessary to collect all broodstock from the existing wild runs of spring chinook and steelhead. A limitation of 1/3 of the run or about a 400 fish brood take was originally established for spring chinook. The 1/3 rule also held for steelhead although the total needs were less.

Wild spring chinook were exclusively utilized for broodstock from 1978 until 1982 when the first hatchery adults began returning. Starting in 1982 the number of wild fish utilized in the hatchery program has ranged from 10% to 79% of the total broodstock held (Table 16). The primary need for continuing the use of wild fish in the hatchery broodstock is for the annual injection of 10% wild genes into the hatchery stock, however, shortages of returning hatchery fish and other factors have occasionally resulted in a higher use of wild fish. The expansion of the smolt program beginning with the 1982 brood required adults in excess to hatchery fish returns from the previous small scale releases. Additionally, unmarked hatchery fish were released from the 1980 and 1981 broods which could not externally be identified from wild adults upon return. Thus we utilized more wild fish than the 10% even though there were usually enough hatchery fish to support the expanded program had we used hatchery fish alone.

Although spring chinook releases have increased to the 700,000 to 1,000,000 range funding has not been sufficient to mark and rear capacity numbers of fish. Beginning with the 1990 brood a series of density studies will be initiated to determine the most appropriate smolt production levels for this facility based on the environment and other conditions unique to this rearing program. It is expected that this will lead to a lower production level of smolts but a higher, more stable return rate of hatchery adults.

In order to maintain the run timing and other biological characteristics inherent in the wild run, the original operational plan identified that wild broodstock should be collected throughout the run without bias to any particular time period and broodstock should be randomly collected without size or age preference. Initially it was felt that we could collect the number of broodstock needed by keeping approximately every third fish each day. Problems were quickly evident with this approach. As seen in the earlier sections of this report natural run timing and run size vary from year to year. If the hatchery broodstock need was 400 fish and we generally expected 60% by June 1, then an early arriving run may be interpreted as being larger than expected, rather than early. In such a case we would probably irreplaceably pass fish upstream counting on a larger run and be caught short on hatchery needs or have to take a much larger proportion of later arriving fish. Either case is undesirable if we are to maintain the natural timing and make the best use of this facility.

While we are trying to collect fish from throughout the run, we also are trying to avoid size bias. Taking every third fish resulted in a size selection bias towards larger fish during 1978. As a result of this bias, the selection procedure was changed. It was found that the size bias could be eliminated by taking all the fish about every third day and releasing all fish on other days. After studying spring chinook run timing since 1975, it became clear that if we are to approximate natural run timing and still meet our capacity egg needs, it would on average be necessary to have 70% of our broodstock collected by June 1 and 90% by July 1. With these general guidelines in mind we have found it best to allow the hatchery manager to decide how often to collect broodstock based on his "intuition" concerning the stage and strength of the run. Combined with our best estimates of how strong a brood will return this method should prove satisfactory.

Table 16. Adult spring chinook utilization at Warm Springs National Fish Hatchery.

Year	Wild Kept	Wild Upstream	Hatchery Kept	Hatchery Upstream	Total
1977	0	1,505	0	0	1,505
1978	569	2,015	0	0	2,584
1979	416	906	0	0	1,322
1980	317	651	0	0	968
1981	511	1,014	0	0	1,525
1982	91	1,317	625	270	2,303
1983	442	1,081	185	170	1,878
1984	389	803	270	519	1,981
1985	322	777	586	487	2,172
1986	470	1,186	127	25	1,808
1987	147	1,550	484	0	2,181
1988	319	1,259	431	0	2,009
1989	90	1,254	2,362	0	3,706

Strays are not included.

Under the current operational plan the hatchery collects all returning hatchery fish. If they return in excess to capacity, periodic decisions will have to be made to estimate the total hatchery run and the apparent excess. Since our holding ponds can safely hold about 1,000 total fish, the "excess" will be given to the Tribe. It is likely that it will be necessary to dispose of these potential "excess" fish <u>before</u> the broodstock capacity is reached, if we are to maintain the natural run timing characteristics. Our collection of wild adults (10%) to be maintained within the hatchery broodstock is to be taken proportionally throughout the run as judged by the hatchery manager each year.

Broodstock Holding Procedures

Spring chinook are held for an extended period of time prior to spawning at Warm Springs NFH. Fish are held beginning in early May and are not ready to spawn until late August or early September. During this period water temperatures in the Warm Springs River increase above 55° F. As a result the stations chillers must cool water in the holding ponds to a range of 47°-50° F. To do this a portion of the water is recycled through the chillers and filtered. These procedures are necessary to minimize disease and other problems inherent with holding large numbers of fish. Problems with BKD and fungus can be anticipated on a yearly basis in such conditions and are treated accordingly.

Beginning in 1982 all spring chinook being held for broodstock were injected with erythromycin to curtail prespawning mortalities attributable to BKD. A second injection is given approximately thirty days after the first. Fish are also dipped in malachite green just prior to entering the holding pond and are periodically treated with malachite or formalin to control fungus problems.

The injections and the new holding ponds have significantly reduced annual prespawning losses attributable to BKD and abrasion related maladies. Losses associated with the injections appear to be responsible for the remaining BKD related prespawning mortality. Fish reacting negatively to the injection turn yellow before death and are easily recognized.

Although BKD related mortalities have declined since the injections began, the hatchery has had losses of fish due to other causes. In 1987 the broodstock suffered losses due to Ichthyophthirus ("Ich"). "Ich" had not previously been noted in adult salmon at Warm Springs NFH. During the 1988 run year large numbers of copepods were noted in many of hatchery and wild salmon arriving at Warm Springs NFH. Many of the highly infected individuals succumbed to the stress produced by this untreatable infestation. These type of maladies which normally do not cause problems with adult fish are difficult to foresee and are likely due to unique combinations of a susceptible host, a virulent pathogen, and a favorable environment that may occur only rarely.

Prespawning mortalities of spring chinook observed at Warm Springs NFH are shown in Table 17.

Table 17. Prespawning mortalities of adults held for broodstock at Warm Springs National Fish Hatchery.[1]

Year	Adults Held	Mortality	Mortality	Adults Spawned
1978	546	221	0.41	325
1979	416	117	0.28	299
1980	317	151	0.48	166
1981	517	253	0.49	264
1982	645	109	0.17	536
1983	604	97	0.16	507
1984	659	107	0.16	552
1985	835	116	0.14	719
1986	634	95	0.15	539
1987	684	220	0.32	464
1988	754	167	0.22	587
1989	924	102	0.11	822

1 Totals do not account for adults held but not spawned because of high BKD levels, poachers, given to the Tribe, and unaccounted losses. Excessive losses in 1987 were due to "ich" and in 1988 to copepods.

Spawning Procedures and Incubation

Shortly after mid-August the first spring chinook become ripe for spawning. The hatchery crew sorts through the ponds once or twice a week between mid-August and the second week of September and spawn the ripe fish. Adults are spawned on a one-to-one basis, one female to one male. The average sex ratio of adults is normally 62% female, 38% male; thus in order to accomplish the desired mating ratios, some males are used several times with different females.

Problems associated with BKD and the potential for virus infection make these type of spawning procedures a useful tool in reducing future rearing losses. Testing of the parents in these matings allows the culling of highly infected individuals from the production lots and, hopefully, reduces the overall incidence rates of these diseases.

Adults arriving after July cannot be inoculated with erthyromycin due to the needed 30 days period between the last inoculation and spawning. In order to maintain this portion of the run in our broodstock and still reduce the incidence of BKD we do not spawn any individuals that exhibit gross symptoms of the disease. These procedures have been in place beginning with the 1983 brood, although culling of adults with gross BKD began in 1982.

From 1978 to 1982 the fertilized eggs were water hardened and disinfected in Wescodyne, then placed in Heath incubators. Incubation water is passed through sand filters, an electric grid, exposed to ultraviolet light, and may be chilled. Currently eggs from each female are placed in individual incubation units to water harden in a 75 ppm iodophor solution for 30 minutes. Eggs are then incubated in chilled water until regular hatchery (river) water drops to 52° F. The eggs are then incubated in water at river temperatures (33°-52° F.). After the eggs have eyed (about six weeks) they are shocked, sorted to remove dead eggs and counted. They are then placed into Heath incubators with about 6,500 eggs to a tray. Eggs hatch in November and the fry are moved to inside hatchery troughs by late December or early January.

Problems during the incubation period have impacted the production of the 1978, 1980, and 1985 spring chinook broods. Problems with back-washing the sand filters caused the loss of much of the early egg takes of the 1978 brood. The 1985 brood suffered losses on two occasions due to the malfunction and blockage to the incubation trays and losses attributable to lack of sperm viability after a delayed fertilization (due to disease testing).

Steelhead adults and eggs were taken primarily in 1978-1980. Steelhead begin arriving in February and ripe adults can be taken throughout most of the run although spawning peaks in April. Adults were usually spawned immediately after arriving. Tables 18 and 19 provide information on the number of salmon and steelhead spawned and eggs obtained since 1978. Steelhead were raised for one or two years, then released. More information on the discontinued steelhead program is available in previous progress reports (Cates 1981)(Cates 1984).

Table 18. Spawning statistics of spring chinook at Warm Springs National Fish Hatchery.

Brood Year	Adults Spawned: Males	Adults Spawned: Females	Eggs Per Female	Green Eggs	Eyed Eggs	Percent Eyed Up
1978	119	206	3,355	691,035	623,050	90 %
1979	112	187	3,647	681,929	631,618	93 %
1980	54	112	3,443	385,622	264,104	68 %[1]
1981	102	162	3,435	556,500	508,100	91 %
1982	178	358	2,680[2]	959,289	927,050	97 %
1983	206	301	3,089	929,695	883,000	95 %
1984	213	339	3,124	1,059,000	909,200	86 %
1985	289[3]	430	3,028	1,301,989	932,500	72 %[4]
1986	257	282	2,850	803,612	767,431	95 %
1987	223	266	2,724	724,613	691,750	95 %
1988	246	316	2,663	841,440	765,500	91 %
1989	275	422	2,730	1,152,456	1,107,639	96 %

[1] Incubation difficulties
[2] Four year olds only
[3] Unknown percentage not used
[4] Poor eye up due to delayed fertilization

Table 19. Spawning statistics of summer steelhead at Warm Springs National Fish Hatchery

Brood Year	Adults Spawned Male	Adults Spawned Female	Eggs/Female	Green Eggs
1978	?	81	2,926	237,000
1979	56	91	3,495	318,000
1980	20	59	3,500	206,500
1981	4	10	3,000	30,000
1982	22	46	3,500	161,000
1983	15	32	3,500	112,000
1984	16	33	3,030	100,000
1985	0	0	0	0

? Unknown number of males used and then released upstream

Juvenile Rearing

Beginning with the 1982 brood the Tribal fin-clipping program has ventrally marked all spring chinook released from the station. Marking takes place when the fish reach a sufficient size. This generally occurs in late April or early May. Due to concerns about the potential impact of ventral fin marking on returns of hatchery fish, the use of ventral marks was reduced to a portion of the production beginning with the 1987 brood. All other fish are being adipose clipped and coded wire tagged until an alternative marking program can be agreed upon. The marking program at Warm Springs NFH will be discussed later in this report.

When the juveniles leave the hatchery building approximately 150,000 fish are placed in a pond. By June the fish are split into ponds of about 50,000 each and raceways of 25,000 each.

By late summer, from 10% to 55% of the juveniles are considerably larger than their counterparts and begin showing smolting characteristics. Mortality of these fish has been high when they are held until spring. In response to this phenomenon these large fish are separated from the others by use of a grading device in a fish loading pump. This grading occurs in late summer as temperatures decrease. Passive in-pond graders were used for this program beginning in 1988.

The large fish are released in early October at 9 to 10 fish per pound after being treated with oxytetracycline (OTC) antibiotics. In recent broods the spring fish were marked with OTC. These fish can later be identified by the OTC fluorescence in their vertebra when they return as adults. The remaining smaller fish are reared over-winter until release in mid April at 15 - 20 fish per pound. Spring chinook salmon have generally been released from the hatchery by being forced from the ponds and leave the hatchery by an exit pipe adjacent to the fish ladder. A volitional release from the hatchery in 1981 is described by Cates (1984). The success of the volitional release in terms of adult returns is not known. Pond densities at Warm Springs NFH are not extreme, averaging about 1.5-2.0 ponds of fish per cubic foot of rearing space at release since 1978. The average loading at Warm Springs NFH is 5.7 pounds of fish per gallon per minute at release.

As previously noted in Figure 3 water temperatures at Warm Springs NFH are less than ideal for raising salmon. Maximum summer temperatures often hit 60° F. or higher from June through August. In winter the daily maximums are often slightly over freezing. Slush ice is evident most winters and has at times had the potential for causing serious difficulties at the hatchery. Little fish growth occurs over-winter in these conditions.

Downstream Migration

The characteristics of the downstream migration of hatchery spring chinook has been assembled through a combination of sampling techniques. The primary sources of information have come from the operation of juvenile migrant traps in the Warm Springs and Deschutes Rivers, juvenile seining, sampling at Columbia River dams, and Columbia River estuary sampling by the National Marine Fisheries Service (NMFS).

A general description of hatchery fish outmigration will be presented rather than a year by year account. This approach is taken because the level and types of downstream sampling have varied each year and Warm Springs NFH fish have not always been marked.

Release dates have been established at Warm Springs NFH primarily to reflect the perceived migration readiness of the fish, historical natural migration timing, and more favorable passage conditions at Columbia River dams. The fall release was established because it has shown favorable results in other systems and it may help alleviate the winter holding mortalities at the hatchery associated between BKD and previously smolted, large juvenile chinook. From an economic standpoint the fall release offers savings associated with pond water pumping and the reduced rearing needs. It also avoids the possible catastrophic winter losses associated with winter ice problems.

Most fish released from Warm Springs NFH appear to move quickly out of the Warm Springs River. Most fish apparently travel the ten miles to the Warm Springs migrant trap within several days. The rapid movement by these fish makes it necessary to quit trapping for a few days to avoid large losses in the trap.

Chinook released in mid-April generally show peak numbers at the trap rather quickly, however, a few smaller hatchery fish may be seen as late as early June. Apparently large hatchery fish migrate quickly while smaller fish may linger. An example of this occurred in the spring of 1982. Fish were released at Warm Springs NFH on April 23. At that time approximately 46% of the fish were greater than 120 mm in length. Recaptures at the migrant trap between April 26 and June 5 revealed only 12% of the Warm Springs NFH fish were larger than 120 mm. Trap bias could account for some of this difference, however, no significant trap catchability bias for chinook this size has been previously noted.

Fall released fish migrate from the Warm Springs River in large numbers for about two to three weeks. Some fish linger until December, but size differentiation throughout the fall period is not recognizable. A few fall release fish have been recovered the following spring in the migrant trap. This indicates that either few hatchery chinook overwinter in the Warm Springs River or they do not survive until spring. Additionally, no spring released hatchery fish have been seen during the following fall outmigration, although this is hard to confirm. Seining between the hatchery and the migrant trap during the summer and early fall in 1980 and 1981 revealed few hatchery chinook to be present.

The destination of hatchery fall release fish once they leave the Warm Springs River is unclear. Limited recaptures of wild Warm Springs River fall migrants in the Deschutes River (Lindsay, et. al., 1980) indicates that overwintering is occurring in the Deschutes River. Evidence from the first fall release of WSNFH chinook indicates that some enter the Columbia River. On November 6, 1980, 55,668 spring chinook were released from Warm Springs NFH. On November 7 during test sampling of collection equipment at The Dalles Dam sluiceway six Warm Springs NFH Ad-cwt fish were captured and decoded. Brief sampling for several days in early November and again in mid-December continued to capture some Ad-cwt chinook. All of the Warm Springs fish captured were 163 m or larger. The tagged sample at the collection facilities represented only a small portion of the tagged fish migrating through the sluiceway. Marked Warm Springs NFH fish from other fall releases have also been observed at Bonneville Dam.

One may surmise that these fish continued on to enter the ocean. Dawley et. al. (1984), noted that some fall release groups primarily move past Jones Beach (Columbia River, Rkm 75) before December 14. Other groups, primarily smaller fish, may over winter and pass Jones Beach in late February through April. Several Warm Springs NFH fall release fish were captured at Jones Beach sampling sites in the Estuary during the spring of 1981. They were probably fish that held over in the Deschutes River or the Columbia River until spring migration. Evidence from fall releases at Round Butte SFH indicates that at least 42% of the fish released in the fall moved into the ocean prior to spring (Lindsay, et. al., 1989). It is not known what percent of Warm Springs fall releases have held over in freshwater until Spring.

Spring releases take place during the first two weeks of April. The fish released in 1980 (1978 brood) began arriving at The Dalles Dam by April 17; however, peak numbers occurred in the collection facilities from May 5 through 10. A few stragglers continued to arrive until about mid-June. The recovery dates of Warm Springs NFH fish seen at Jones Beach in 1980 and 1981 are illustrated according to fish length in Figures 18 and 19. Peak catches of Warm Springs NFH fish occur at Jones Beach in late April to mid-May but some larger fish have arrived in the estuary within nine days of release. Few Warm Springs NFH fish smaller than 120 mm were seen at Jones Beach although a large percentage of fish 120 mm and smaller were released. Unless a significant amount of growth occurred after release or some sort of sampling bias occurs at Jones Beach these small fish may not be surviving.

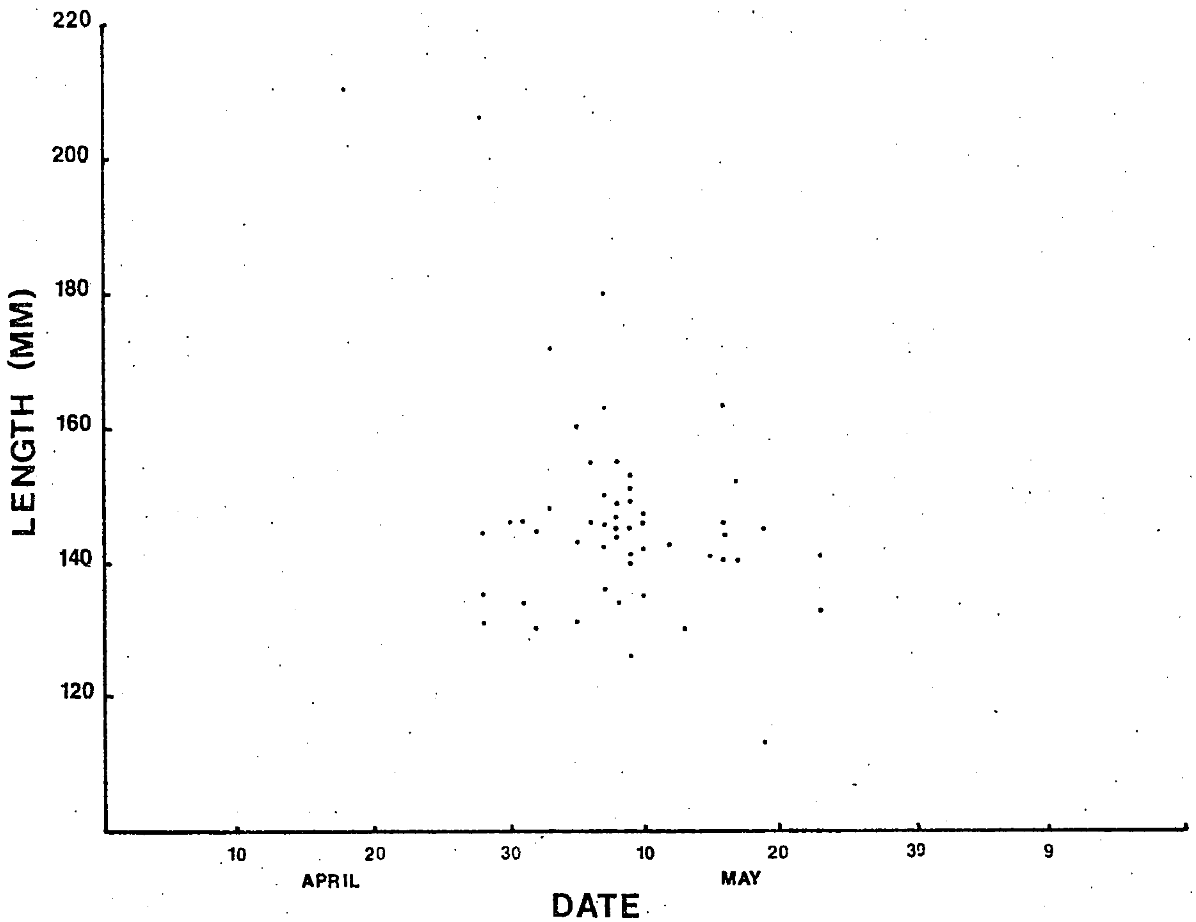

Figure 18. Length and date of recapture of Warm Springs National Fish Hatchery chinook caught by beach seine at Jones Beach, Oregon in 1980.

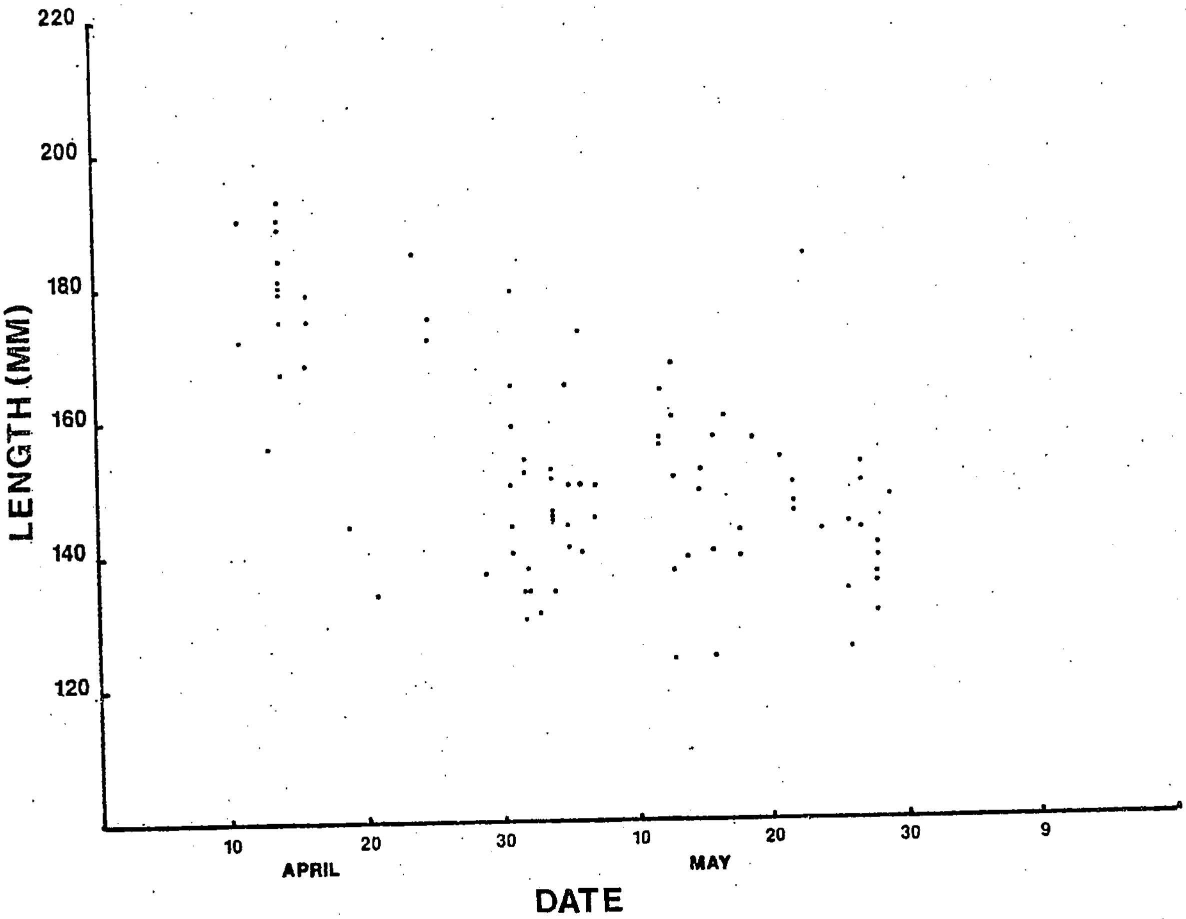

Figure 19. Length and date of recapture of Warm Springs National Fish Hatchery chinook caught by purse seine at Jones Beach, Oregon in 1981.

Ocean Recoveries

There is some evidence to help determine which direction Warm Springs NFH spring chinook travel once they leave the Columbia River. While a juvenile Warm Springs NFH fish has been captured off the south jetty at the mouth of the Columbia River, the only known ocean recoveries of jacks and adult fish have occurred off the northern Washington and British Columbia coasts. Known recoveries resulted from the capture of Ad-cwt chinook representing the 1978 and 1979 broods. Known ocean recoveries of Ad-cwt chinook from Warm Springs NFH are shown in Table 20. Spring chinook in the Columbia River do not appear to contribute greatly to ocean fisheries and Warm Springs hatchery fish are no exception.

Table 20. Ocean recoveries of Warm Springs National Fish Hatchery spring chinook.

Tag Code	Brood	Date Recovered	Recovery Gear	Area Recovered	Fork Length (cm)
5-6/27	1978	06-23-81	Sport	West Port, WA	55
5-6/27	1978	04-16-82	Ind Troll	Washington	68
5-6/27	1978	04-26-83	Commercial	Prince Rupert, BC	76.4
5-6/27	1978	04-28-83	Commercial	Vancouver, BC	83.5
5-8/23	1979	04-25-83	Commercial	Vancouver, BC	69
5-8/21	1979	1984	Commercial	Vancouver, BC	60.5

To date all Warm Springs hatchery chinook ocean recoveries have occurred north of the Columbia River with most being taken off the coast of British Columbia, Canada. More extensive data available for wild spring chinook and Round Butte SFH fish indicated that 39% of the wild and 43% of the hatchery fish were caught south of the Columbia River (Lindsay, et. al., 1981).

Coded wire tagging of the 1987 and later broods at Warm Springs NFH should yield additional information concerning ocean harvests and distribution of the Warm Springs stock.

Columbia River Harvest

Warm Springs hatchery chinook are subject to angler harvest during the March-May sport season in the lower Columbia River. Because of the poor upriver spring chinook runs in recent years, this season has been restricted to March or a portion of March since 1977. The fishery is primarily aimed at the earlier arriving more abundant Willamette and Cowlitz Rivers stock. In 1982 approximately 550 upriver fish were harvested (ODFW, unpublished). Two were tagged Warm Springs NFH fish. Expansion of this data indicate that approximately 13 Warm Springs NFH were harvested. One fish was captured March 18 and the other on March 30. It is interesting to note that only nine upriver spring chinook Ad-cwt fish were captured in this fishery. Three of these were of Warm Springs NFH and Warm Springs River stocks and another tagged in the Deschutes was probably Warm Springs River wild stock origin.

When run sizes are sufficient a commercial gillnet season is allowed in the lower Columbia River. The season generally occurs in late February and early March. The season is usually designed to capture the more abundant lower river spring chinook stocks. However, some upriver stocks are usually taken but they make up only a small portion catch.

No Warm Springs NFH tags were recovered from this fishery in 1982; however, during 1983 a total of three 5-6/27 tagged fish were identified in the catch during the last week in February and the first week in March. In 1984 three fish with Warm Springs NFH tags were caught in this fishery.

Additional recoveries of adult Warm Springs NFH fish in the Columbia River have primarily come from two other sources, agency test fishing and Indian commercial fishing. These and other miscellaneous recoveries are listed in Table 21. Despite restricted fishing opportunities in the Columbia River, Warm Springs fish (wild and hatchery) appear to contribute with surprising regularity in the fishery. This harvest has been documented despite the fact that relatively few coded-wire tagged Warm Springs fish have been available. Fin clipped fish from other broods have undoubtedly been captured in these fisheries but since other hatcheries have occasionally employed ventral fin clips, the catch rate of Warm Springs NFH fish could not be determined.

Marked steelhead from the 1978 brood released from Warm Springs NFH have been recovered in the Columbia River Indian net fishery. The 1978 brood began returning in 1981. Two fish with tag code 5-4/39 were caught in the Indian net fishery above Bonneville Dam in September 1981. During September 1982, this same fishery recovered three 5-4/39 tagged fish. An additional 5-4/39 fish was captured by an angler in the Big White Salmon River on August 19, 1982. These recoveries represent only a partial accounting of Warm Springs NFH steelhead harvest in the Columbia River. These figures do not represent data expansions to account for unsampled days, hours, other fisheries, etc.

<u>Deschutes River Harvest</u>

The primary harvest areas for steelhead and salmon produced in the Warm Springs system occur in the Deschutes River. Steelhead may be harvested throughout the river but chinook are almost exclusively captured in the area just below Sherars Falls. The harvest of steelhead primarily occurs from July through October while spring chinook are taken in the April to early June period. The fishery at Sherars Falls is a combination of sport angling and Indian subsistence dipnet methods. At times the Indian fishermen may also utilize hook and line and/or snagging.

Sport fishermen annually take significantly more spring chinook than the subsistence fishery except during years when sport angling has been curtailed or closed to protect wild fish. While steelhead are taken in the subsistence fishery most steelhead are harvested by sport fisheries below the Sherars Falls fishing areas.

Table 21. Recoveries of Warm Springs National Fish Hatchery spring chinook in the Columbia River.

Tag Code	Brood	Date Recovered	Fishery	Length
5-6/27	1978	03-18-82	Columbia Sport	68.0
	1978	03-30-82	Columbia Sport	64.0
	1978	04-14-82	Test Woody Island	68.0
	1978	04-24-82	Test Zone 4	77.0
	1978	04-26-82	Test Zone 4	69.0
	1978	04-30-82	Test Zone 4	69.0
	1978	06-01-82	Commercial Shad	--
	1978	06-01-82	Commercial Shad	--
	1978	05-01-82	Indian Ceremonial	65.3
	1978	04-05-82	Indian Ceremonial	--
	1978	04-20-83	Indian Ceremonial	77.0
	1978	02-28-83	Columbia Net Zone 1	74.8
	1978	03-03-83	Columbia Net Zone 1	78.6
	1978	03-03-83	Columbia Net Zone 1	79.6
	1978	03-29-83	Columbia Sport	82.0
5-6/28	1978	04-12-82	Test Woody Island	71.0
	1978	04-26-82	Test Zone 4	71.0
5-8/20	1979	03-05-84	Columbia Net Zone 1	84.4
5-8/23	1979	04-08-83	Test Woody Island	70.0
	1979	04-20-83	Indian Ceremonial	69.2
	1979	05-05-83	Indian Ceremonial	73.3
	1979	03-05-84	Columbia Net Zone 2	81.5
	1979	03-06-84	Columbia Net Zone 2	80.5

* These are known recoveries and are not expanded number.

** An additional nine 5-6/27 fish were found by Washington Department of Fish on fish obtained by fish buyers in the fall of 1983. Two known wild Warm Springs River fish were also noted at that time.

The Deschutes River harvest rates of Warm Springs NFH spring chinook from the 1978-1981 broods is shown in Table 22 and is comparable to wild harvest rates.

Table 22. Estimated Deschutes River harvest and hatchery returns of Warm Springs National Fish Hatchery spring chinook.

Brood	Run Size	Deschutes Harvest	Warm Springs NFH Escapement	Harvest
1978	1,510	433	1,067	29 %
1979	371	70	301	19 %
1980	874	38	836	4 %
1981	1,782	507	1,275	28 %
1982	196	67	129	34 %
1983	1,031	319	712	31 %
1984	912	260	652	29 %

Hatchery fish have tended to return more strongly as four year olds than wild fish. The bulk of this change has apparently been at the expense of the five year old return. A breakdown of hatchery spring chinook returns by age are noted in Table 23. The percentage of jacks in the hatchery return has been somewhat more than that normally observed in the wild population. This is more apparent with fall release fish than those from the spring release.

Table 23. Age composition of Warm Springs National Fish Hatchery spring chinook returning to the Deschutes River, Oregon.

Brood	Jacks	Percent Jacks	Fours	Percent Fours	Fives	Percent Fives	Total
1978	95	0.06	1,300	0.86	115	0.08	1,510
1979	25	0.07	326	0.88	20	0.05	371
1980	34	0.04	767	0.88	73	0.08	874
1981	203	0.11	1,508	0.85	71	0.04	1,782
1982	9	0.05	146	0.74	41	0.21	196
1983	264	0.25	678	0.66	89	0.09	1,031
1984	303	0.33	520	0.57	89	0.10	912
1985	449		3,254				
1986	203						

Some Warm Springs NFH spring chinook have been allowed to spawn naturally above the hatchery. This has been done for three reasons: (1) to determine if and where hatchery fish would spawn naturally, (2) to determine if adult outplanting would seed unutilized habitat, and (3) because some hatchery fish were unmarked and not distinguishable from wild fish. Since 1982 numbers of hatchery fish knowingly released upstream has ranged from 0 to 519.

Hatchery steelhead returns to Warm Springs NFH have occurred from releases at the hatchery as well as the tributary outplants in 1981. Table 24 summarizes known Deschutes River and Warm Springs NFH recoveries of Warm Springs NFH steelhead. Recovery data is incomplete but does indicate some harvest in the Deschutes River as well as returns to Pelton Trap from gradeouts released in Lake Simtustus. The majority of the fish apparently returned after one year in the ocean. There is some indication that a portion of the 1978 brood remained in fresh water an additional year after release.

Table 24. Recoveries of Warm Springs National Fish Hatchery steelhead in the Deschutes and Warm Springs Rivers.

Tag Code	Brood	Recovery Area	Number Recoveries[1]
5-4/39	1978	Deschutes River	20
		Pelton Dam[2]	41
		Warm Springs NFH	175
5-7/29	1980	Deschutes River	2
		Warm Springs NFH	10

1 Recovery Numbers are incomplete
2 Pelton Dam recoveries probably result from gradeouts planted in Lake Simtustus.

Disease Status

During the first year of operations it became apparent that Warm Springs NFH, like many hatcheries, would be faced with considerable disease problems. The programs originally envisioned for the hatchery had to be altered to accommodate disease impacts. Up to the present time only the trout and steelhead programs have been drastically affected, but disease, especially BKD, is also a limiting factor in chinook survival.

The greatest impacts to the trout and steelhead programs at Warm Springs NFH has been due to IPN and Glochidia. IPN was first detected at Warm Springs NFH in steelhead adults during 1978. The entire 1979 brood steelhead were destroyed as juveniles due to IPN. Sampling in the Warm Springs river drainage above Warm Springs NFH revealed IPN to be present in Eastern Brook Trout residing in several high mountain lakes. IPN was again detected in hatchery rainbow trout in 1989, and all were destroyed.

Glochidia are the juvenile stage of the freshwater mussel and are temporarily parasitic on juvenile salmonids. Mussels occur naturally in the Warm Springs River and the glochidia do not normally become a problem until late spring. During late spring they can accumulate in large numbers on the gills of trout and steelhead. Considerable losses have been attributed to glochidia when they break away from the gills. They have been a major limiting factor in trout and steelhead production at Warm Springs NFH. Chinook appear to be considerably less vulnerable than trout. Because of the apparent abundance of Glochidia in the Warm Springs River it could potentially be a limiting factor to natural trout and steelhead production. Studies done by Moles (1983) indicated that glochidia reduced the growth of coho fry regardless of the number of parasites on the fish. Thus high densities of glochidia may not be necessary to effect wild fish growth and production.

Many other disease agents have been identified at Warm Springs NFH. Probably the one causing most concern is Infectious Hematopoietic Necrosis (IHN). This virus has been isolated in adult steelhead reaching Warm Springs NFH and was most recently seen in adult chinook and trout in 1989. Extreme losses to steelhead from IHN have occurred in steelhead at the nearby Round Butte SFH. Every year a variable number of stray Round Butte steelhead enter the Warm Springs NFH trap. At the present time all of these fish are destroyed; however, they are at times in contact with wild fish destined to spawn upstream of Warm Springs NFH. A USFWS pathologist has examined stray steelhead at Warm Springs NFH and found that Round Butte fish generally do not contain IHN virus. The exception to this are excess adults that have previously returned to the Round Butte trapping facilities at Pelton and then are transported down stream to re-enter the fishery and/or spawn naturally. These fish have exhibited a high incidence of IHN when they arrive at Warm Springs NFH.

Recent and past disease classifications of Warm Springs NFH are shown in Table 25. Enteric redmouth (ERM) has been parenthetical because we import trout eggs from Roaring River SFH which has the disease. In 1984 ERM was found in juvenile chinook. Other disease agents that have been seen at the hatchery include: Colummaris, Costia, Ichthyophthieius, Sanguinicula, etc. Many of these agents will always be present in the system but are not usually the sole causative factors in fish losses.

BKD is a major limiting factor reducing the effectiveness of the spring chinook program. Significant mortalities have been noted in holding adults and rearing juveniles. Prespawning mortalities of nearly 50% have been primarily attributed to BKD. These mortalities have been reduced since 1981 to an average of approximately 15% with a 11 ml/kg body weight injection of erythromycin.

The greatest mortalities in juvenile chinook generally occur in June, July, and August; however, considerable losses may also occur just prior to spring release. Beginning in 1982 brood adults were separated into two groups based on BKD incidence. The groups were spawned and reared separately. During the rearing period mortalities in the non-BKD parent group were considerably less than that of the other. During the spawning of the 1984 brood year each parent was tested for BKD utilizing FAT techniques. Additionally females were tested utilizing ELISA methods. Grossly positive fish were culled from the broodstock. Spawning combinations resulting in fertilized eggs representing low, medium, and high incidence levels of BKD were incubated and reared separately. This was repeated with the 1985 through 1988 broods. Differential fin clips were assigned to each group (medium and high groups combined). Detailed description of these procedures are available (Leek, 1984).

Table 25. Fish disease classification of Warm Springs National Fish Hatchery, 1978-1989.

Date	Code
02-21-78	C-VE-VP-VH-BR-SW-B-BK-SL
04-08-80	B-BK-BF-VH-VP-SL-(BR)
01-29-81	B-BK-SC (VH-VP-BR-BF)
03-30-82	B-BK-SL (VH-BR)
06-13-83	B-BK-SC (VH)
06-24-84	C-BK-BR [Partial inspection]
09-24-85	C-BK-BR-BF [Partial inspection]
11-10-86	C-BK-BR-BF
10-05-87	C-VH-BK-BF-BR
10-26-88	C-VH-BK-BF-BR
12-18-89	C-VH-VP-BK-BR

B- Class "B" denotes certifiable diseases have occurred within the last two years.
C- Class "C" designation denotes lack of information (unknown disease history)
BF- Furunculosis
BR- Enteric Redmouth Hatcherium
BK- Salmonid Kidney Disease Bacterium
SC- _Ceratomyxa shasta_
SW- _Myxosoma cerebralis_
VE- Viral Hemorrhagic Septicemia Virus
VH- Infectious Hermatopoetic Necrosis Virus
VP- Infectious Pancreatic Nerosis Virus
( )- Parenthetical classification demotes past occurrence but not recently found.

Evaluations

Since studies began on the Warm Springs River a number of projects and data collection efforts have been implemented to help answer various questions pertaining to characteristics of anadromous fish runs, and/or impacts of hatchery practices and operations on the resource as it existed prior to the establishment of Warm Springs NFH. Investigations since 1975 have helped to provide a clearer perception of past observations and answered some basic questions that have arisen since that time. Although some of these observations represent "one time only" efforts, they increase our knowledge concerning this stock of spring chinook. In certain cases the studies could not continue due to the strict regulations concerning the release of hatchery fish above Warm Springs NFH.

<u>Do the two peaks in arrival timing of spring chinook at Warm Springs NFH represent two separate populations?</u>

This question originated from early Tribal counts at their weir in the lower Warm Springs River. There appeared to be one major peak of migration in the April-May period and a later arriving August-September pear. More complete counts at Warm Springs NFH, tag recoveries of adults released above the hatchery, and returns of hatchery fish indicate that there is likely only one population of chinook, some of which don't arrive at Warm Springs NFH until just prior to spawning.

The key factors influencing this conclusion are:

1. In 1975, 1977, and again in 1983 adults were trapped in the lower Warm Springs River, jawed tagged and released to spawn naturally upstream. All fish spawned within the same limited time frame and in the same areas regardless of arriving in May or August.

2. Spawning times for early as well as late arriving adults at Warm Springs NFH are not different.

3. The date fish are tagged at Sherars Falls and subsequently recaptured at Warm Springs NFH is positively correlated (Lindsay et.al., 1989); however, fish arriving at Warm Springs NFH in late summer do not necessarily arrive at Sherars Falls during any specific period.

4. Progeny of early and late group adults (1978) showed significant intermixing of arrival timing upon return as adults in 1982. From 30% to 41% of each group returned during the "wrong" time frame.

5. No morphological (size, coloration, etc.) differences are obvious between fish of each group.

6. Adult run timing since 1977 indicates one primary migration period peaking in late May with a much smaller peak observed just prior to spawning in late August and early September.

At this time there is no supporting evidence that more than one population of spring chinook is utilizing the Warm Springs River.

Will hatchery chinook released above Warm Springs NFH enter the historical spawning areas and will they spawn successfully?

The operational guidelines developed for Warm Springs NFH were designed to allow hatchery fish to remain as similar to naturally produced wild stock as possible, given the realities of the hatchery environment. Such a similarity should help to insure the success of the hatchery product outside of the hatchery ponds. At the same time it broadens the potential uses of the hatchery stock while lessening its potential impacts on wild stocks. Until the Tribe decided (1983) to completely separate wild and hatchery fish in the Warm Springs River, it was anticipated that Warm Springs NFH would utilize fish excess to hatchery needs to supplement natural production. Even though hatchery fish are not now intended for supplementation, reasonable efforts are still taken to minimize genetic or other impacts hatchery fish may have should they come into contact with wild fish.

In order to determine the feasibility of releasing hatchery adults directly upstream to spawn naturally, marked fish were jaw tagged and released upstream in 1983. The first fish were tagged on May 30 and the last fish were released upstream on August 31. A total of 192 were jaw tagged and initially released upstream. Fall back was observed 19 times. Tag analysis revealed that these recaptures represented 14 individual fish. Table 26 summarizes the recaptures at Warm Springs NFH.

Table 26. Fallback recoveries of jaw tagged spring chinook released above Warm Springs National Fish Hatchery in 1983.

Jaw Tag Number	Coded Wire Tag Number	Number Recaptures	Date Tagged	Last Return	Disposition
N 7204	5-8/23	3	May 30	Sept 12	Spawned
N 3997	------	2	June 22	Aug 22	Released
N 4002	5-8/23	2	June 22	Aug 22	Released[1]
N 4004	------	2	June 24	Aug 29	Released
N 3947	------	1	June 3	Aug 29	Released
N 3915	------	1	May 30	Aug 29	Released
N 3954	------	1	June 6	Aug 29	Released
N 3935	------	1	May 30	Aug 29	Released
K 7139	5-6/27	1	Aug 29	Sept 2	Spawned
N 4034	5-6/28	1	Aug 31	Sept 12	Spawned
K 7126	5-6/28	1	July 1	Sept 12	Spawned
K 7111	5-8/23	1	June 10	Sept 7	Spawned
T 827	7-21/52	1	June 10	Sept 7	Spawned
N 3985	------	1	June 15	July 18	Released

[1] Spawned out carcass found in Beaver Creek above Dahl Pine 9-6-83.

The recaptures indicated a 7.3% fall back rate for individual adipose clipped-jaw tagged fish in 1983. Fall back to the hatchery was not unexpected; since occasional fall back of wild fish has been suspected since counts were started in 1977. Tag number T-827 confirms this since it contained a coded wire tag identifying it as a wild fish tagged by ODFW in the Deschutes River as a smolt in 1980. Once we started noting fallback of these marked fish at the hatchery we started keeping returnees, if they were determined to be ripe. This practice began in September with the justification that at this late date they would continue to return unspawned since most suitable spawning gravel occurs many miles above the hatchery. It was thought that these fish might not leave the hatchery area, however, evidence exists (Tag # N-4002) that a hatchery fish returning a multiple of times and as late as August 22 continued upstream and eventually spawned in the very upper areas of the traditional spawning areas.

Since the hatchery ended up recapturing and spawning six jaw tagged fish the total number of jaw tagged fish available for recovery on the spawning grounds numbered 186, excluding any mortality or tag loss.

Despite the differential treatment given the tagged fish, tag loss, etc., the recovery rate (6.5%) for jaw tagged carcasses was similar to expectations, based on normal carcass recoveries noted in other years.

The overall distribution of redds within the system in 1983 was within the historical variations seen for the wild runs, i.e., 70% WSR, 25% Beaver Creek, and 5% Mill Creek.

The location of jaw tag recoveries on the spawning grounds is shown in Table 27.

Tag recoveries were made in every index area except the WSR from Bunchgrass to Schoolie (Table 27). This is not surprising since we rarely find many carcasses in this area (15 in 1983) even though many redds (112 in 1983) are found here.

Sampling of Ad-CWT fish at Warm Springs NFH revealed that wild fish should have made up about 8.4% of the fish jaw tagged. They comprised 9% of the jaw tag recoveries.

All tagged fish recovered on the spawning grounds had spawned. Although the sample size is small there is no data to indicate abnormal mortalities prior to spawning nor any significant distribution deviation from wild fish.

Beginning in 1982, Warm Springs NFH at the request of Tribal resource managers, began transporting ripe adults arriving at the hatchery into upper Mill Creek. This area was above an impassible barrier that was finally removed in 1985. A total of 47 fish were transported into the area in 1982. Nine of these fish were wild including five females. A total of fifteen redds were observed in the area and no unspawned fish were found. Some follow-up electrofishing and visual observation the following summer revealed considerable numbers of juvenile chinook rearing upstream and downstream of the release site. Chinook juveniles were found 2.4 km above the release site as well as 5.6 km below. At least five miles of stream appears to have been successfully seeded from this outplant.

Table 27. Spawning ground recoveries of jaw-tagged spring chinook in the Warm Springs River, 1983.

Jaw Tag Number	Date	Coded Wire Tag Number	Location Released	Recovery Stream	Location	Date
N 3940	6-3	5-8/23	WSNFH (1981 brood)		Beaver Creek Above Dahl Pine	9-6
N 4002	6-22	5-8/23	WSNFH (1981 brood)		Beaver Creek Above Dahl Pine	9-6
N 3969	9-10	5-8/23	WSNFH (1981 brood)		Beaver Creek Above Canyon	9-6
N 3913	5-30	5-8/23	WSNFH (1981 brood)		Beaver Creek Above Mouth	9-19
N 3998	6-22	Negative	----------	Beaver Creek	Above Mouth	9-6
Ad Clip	----	5-8/23	WSNFH (1981 brood)		Beaver Creek Above Dahl Pine	9-6
N 2995	6-22	7-20/29	Wild Beaver Cr. (1979)	Mill Creek	Just above Boulder Creek	9-8
N 3926	5-30	10-21/14	Rapid River (1980)	Mill Creek	Above Potter Pond	9-8
N 3934	5-30	7-23/9	Round Butte (1981)	WSR	Above Hehe	9-14
N 3944	6-3	5-6/27	WSNFH (1980 brood)	WSR	Above McKinley-Arthur	9-19
K 7144	8-13	5-6/27	WSNFH (1980 brood)	WSR	Above McKinley-Arthur	9-19
N 4021	8-22	5-8/25	WSNFH (1981 brood)	WSR	Below McKinley-Arthur	9-19
T 836	6-15	5-6/2	WSNFH (1980 brood)	WSR	Above Hehe	9-7
Ad Clip	----	5-6/27	WSNFH (1980 brood)	WSR	Above Badger Cr.	9-15

The preceding information suggests that hatchery fish released above Warm Springs NFH will migrate upstream and spawn successfully. While some fish may linger in the vicinity of the hatchery most will eventually enter the historical spawning areas.

<u>Is run timing being impacted by hatchery operations?</u>

Run timing of spring chinook salmon has been closely monitored at Warm Springs NFH since the hatchery weir became operational in 1977. Once hatchery fish began returning in 1981 their timing has been compared to that of wild fish. One of the goals of the hatchery operational plan is to maintain the natural timing of the wild run and to create a hatchery run with similar timing. The method to accomplish this goal would be through collecting broodstock throughout the run in proportion to the wild returns. Based on information collected on wild fish in the Warm Springs River some general guideline were established to aid in this goal and meet other goals of the program. It was expected that wild fish would return to the hatchery weir between late April and early September. Most fish return the last two weeks of May. In order to protect wild productivity it was decided that the hatchery could take no more than 1/3 of the run during the founding years of the hatchery. Once hatchery adults became available they would become the primary source of broodstock with an annual 10% injection of wild adults.

Our early goals for hatchery brood collection indicated that we should have 60% of our needs by June 1. Our initial broodstock holding requirements were based on an expected low level of prespawning mortality and limited by our restriction on the percentage of the wild run that could be taken. Until recent years we had no reliable way of predicting the expected size of the wild run and thus the number of fish we could safely utilize at the hatchery. As a result we never knew exactly how many fish we would be taking, but that we would need 60% of them by June 1.

It was difficult to take fish proportionally through the run when we could not predict (1) how large the run would be, (2) if the run was early or late, and (3) what our initial broodstock take would be. We could not plan on our capacity broodstock needs unless the wild run was large.

As a result in nearly all years the take of broodstock for the hatchery lagged behind the proportional return of wild fish. We judged that a conservative approach to taking wild fish into the hatchery would be preferable to impacting wild production by "over harvest" at the hatchery. As a result the early proportion of the wild run was under represented in the hatchery broodstock. As the run progressed and we got a better handle on the total expected return, the hatchery took more fish. An increase in the proportional take often occurred in the last week of May and early June. In some years later arriving fish were utilized to replace the unexpected high losses of fish held at the hatchery. The average broodstock take from 1978-1985 is shown in Figure 20. The lag time between hatchery take and upstream escapement is best illustrated by the fact that slightly more than 20% of the wild run was upstream by May 14 while only about 9% of the hatchery brood had been taken. By May 29 the hatchery take had increased and was about 67% of the total versus 74% for wild passage upstream.

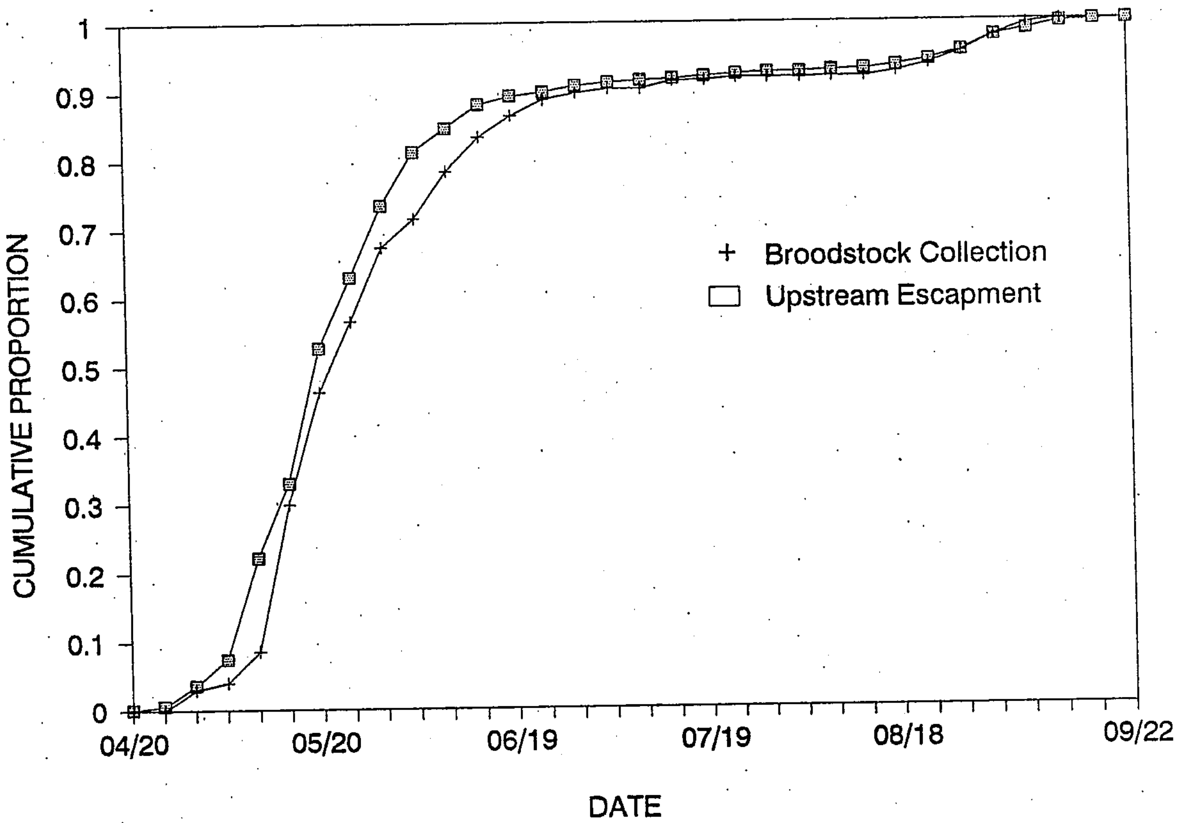

Figure 20. Collection of spring chinook for broodstock at Warm Springs National Fish Hatchery versus upstream escapement, 1978-1985.

The impact of this difference on return timing appears to be more prominent in the return of hatchery fish than on wild return timing. We would expect that progeny from these hatchery fish would return somewhat later than their wild counter parts and in more abundance during the late May early June period. Although it is difficult to determine the exact timing of a brood given the overlapping generations, we would expect to best observe a difference in run timing when the four year olds return. This is due to the dominance of this age class in this stock.

The average return time for hatchery and wild stock returning from 1982-1989 gives our best clue as to whether the adult broodstock take has resulted in a similar pattern of adult returns (Figure 21). Timing of wild and hatchery returns for these years and indicates that a lag in hatchery returns is occurring and is similar to that expected from the timing of their parents.

Other factors are also influencing this difference. During some years many hatchery fish called adults at arrival time (based on size) were later found to be jacks from fall releases that reached a larger size and matured early. Both hatchery and wild jacks tend to return later than adults, predominately at the end of May and later. In several of the earlier broods of hatchery fish prespawning mortality of early arriving adults and losses of eggs and progeny from early arriving adults resulted in a greater percentage return of late fish than their collection timing would indicate.

It is possible that the wild run is arriving earlier than it once did but our pre-hatchery data is limited. It does appear that based on many years of data a higher percentage of wild fish return prior to June 1 than the 60% we earlier estimated. The collection of wild fish disproportionately from the wild run could potentially influence wild fish to return earlier; however, this seems less likely to influence wild timing than the return of hatchery fish based on the number of fish involved.

A typical year (1980) comparing the arrival timing of wild adults and jacks versus their upstream passage after brood take at the hatchery is shown in Figure 22. Although the cumulative passage upstream generally was ahead of the original cumulative arrival time the difference never exceeded 8% and was usually within 3%.

Although the differential between return timing of hatchery and wild fish may be due to more than one factor, it is apparent that we could do a better job in collection harmony between the stocks. If it is our intent to "match" timing of the wild stock it will be necessary to change tactics. We currently can reasonably predict wild run strengths prior to the season. Knowing this, we can collect hatchery fish broodstock proportionally to wild abundance without regard to having an arbitrary number or percentage by June 1. This should allow a better tracking of the peaks and valleys of wild run timing as it varies from year to year. We will be limited for some time by the late tendencies that have already developed but over time we should be able to better maintain a more comparative timing structure. This should increase the numbers of hatchery fish returning during the early to mid May period.

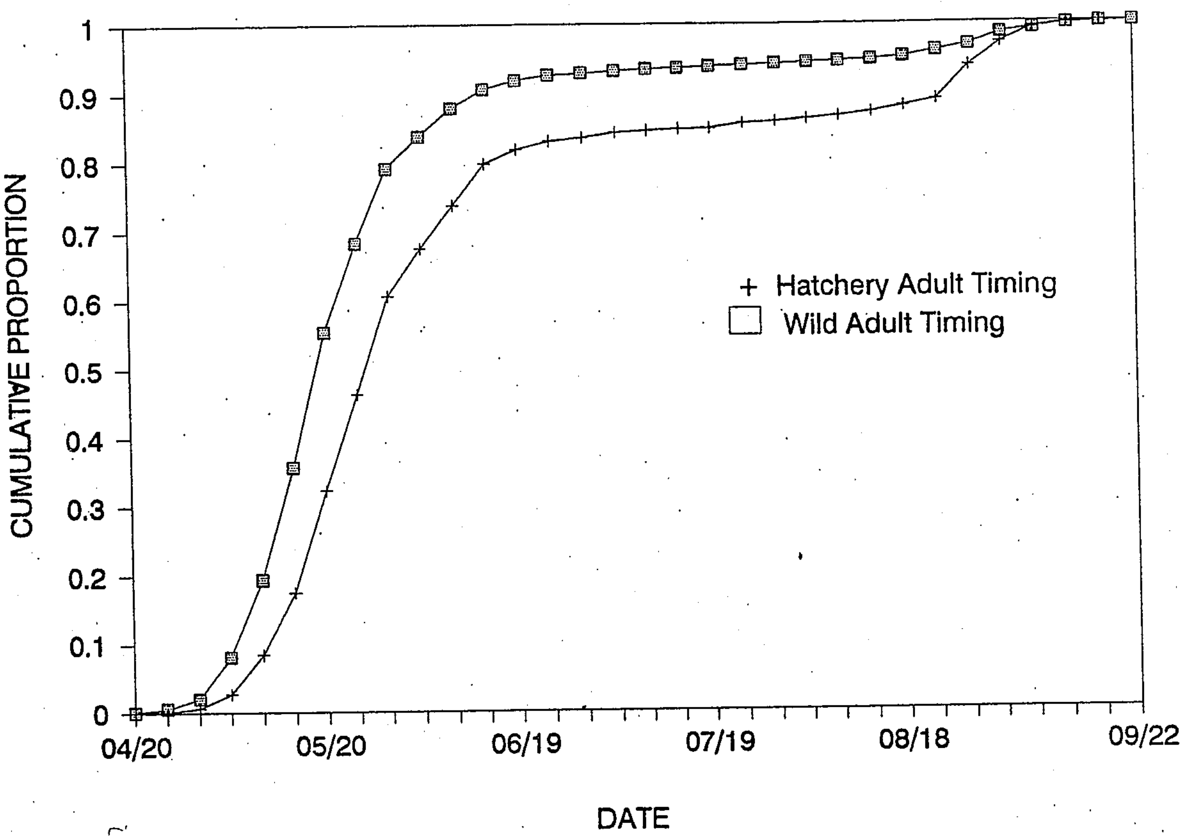

Figure 21. Average return timing of wild and hatchery spring chinook adults, 1982-1989.

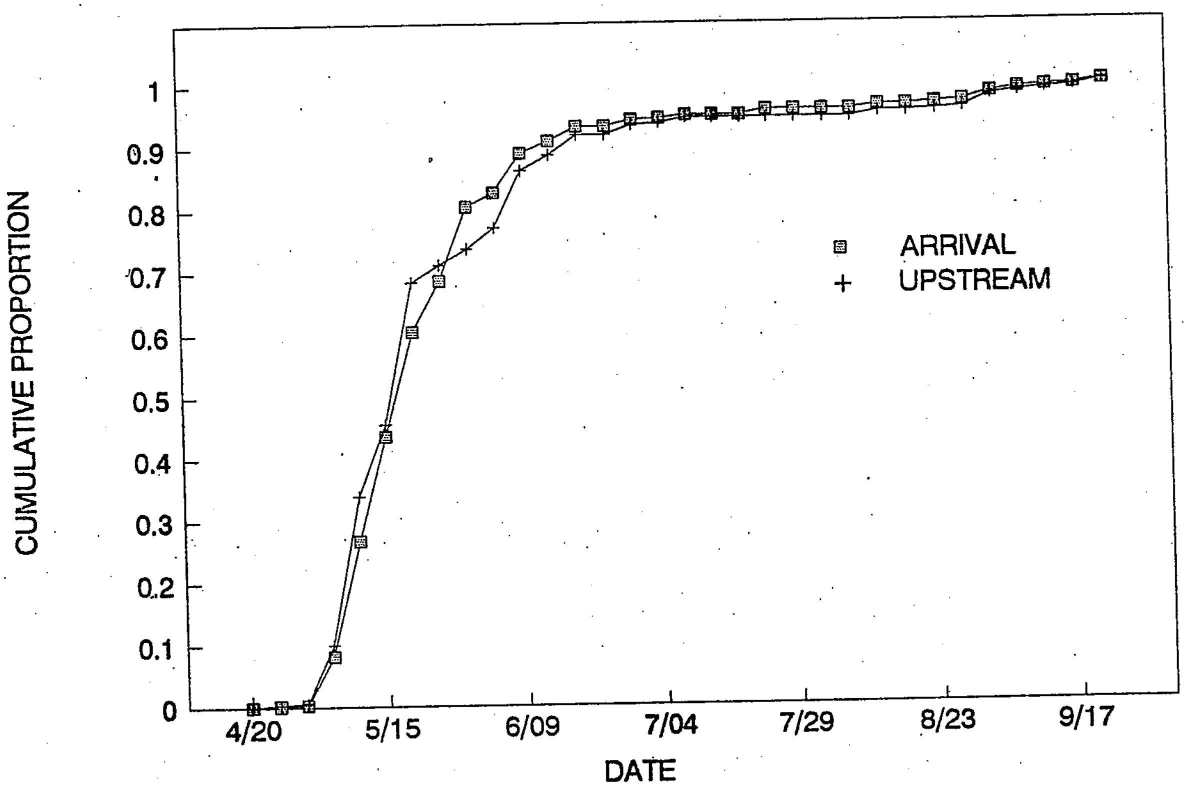

Figure 22. Cumulative arrival timing of wild spring chinook arriving at Warm Springs National Fish Hatchery and subsequent upstream escapement in 1980.

Judging from our experiences at Warm Springs NFH it appears that this stock of spring chinook would be susceptible to altering run timing through hatchery practices. Although hatchery fish have demonstrated some changes relative to wild fish during their migrating period to Warm Springs NFH little change in spawning time has been noted either at the hatchery or in the wild since broodstock collections began.

<u>Can the size of returning hatchery fish be maintained similar to that of similar aged wild fish?</u>

Great care has been taken to avoid size selection bias in the collection of broodstock for the hatchery. Despite this effort some differences have occasionally been noted between hatchery and wild fish in recent broods. Adult hatchery fish returning from the 1982 and later broods appear to average slightly smaller than wild fish of the same ages and broods. This difference is illustrated with four-year-old fish as noted in Table 28. In some broods ventrally clipped hatchery fish are averaging about one centimeter smaller than unmarked fish. The cause of this is unknown, but could be related to the influence of the fin clip on feeding and survival.

We intend to continue monitoring fish sizes at Warm Springs NFH to see if true differences exist. During the next few years we should be able to compare fish returning with Ad-cwt marks with those having ventral clips. This may shed some light on the differences now being noted; however, conclusions about possible hatchery induced changes on fish size are suspect unless wild fish are marked identically.

Table 28. Mean fork lengths of four year old hatchery and wild spring chinook salmon returning to Warm Springs National Fish Hatchery, 1983-1985 broods.

	Hatchery		Wild	
Brood	Male	Female	Male	Female
1983	69.0	67.9	70.3	68.7
1984	70.2	69.9	69.2	68.5
1985	70.3	68.4	71.2	69.4

<u>Do fall migrants contribute to adult returns?</u>

Data obtained from ODFW marking of wild juvenile spring chinook migrating from the Warm Springs River in the fall indicates that most of these fish are rearing over winter in the Deschutes or Columbia Rivers until spring. Based on scale analysis only about 1% of the returning adults had migrated to the ocean at age 0 (Lindsay, et.al., 1989). They also noted that tagged fall migrants returned at about half the rate as tagged spring migrants.

Fall releases of Warm Springs NFH hatchery fish began with the 1979 brood. This brood was marked with coded-wire tags and subsequent broods (exception 1980 and 1986) utilized OTC marks to identify fall release fish. Fall release fish are identified by the presence or absence of the OTC ring(s) in their vertebrae. Proper feeding of oxytetracycline supplemented feed has been demonstrated to effectively mark nearly 100% of the fish without affecting growth or survival (Weber and Ridgeway, 1967) (Weber and Wahle, 1969). The fish are fed OTC supplemental food for 14 days shortly after grading, usually in early September. The amount of OTC utilized is four grams of active ingredient per 100 pounds of fish per day. They are usually released in early October. The fall release was initiated beginning with the 1979 brood after observing that the larger, faster growing fish (1978 brood) were smolting in the fall and subsequently suffered considerable losses when held until spring. The 1979 brood, large fish were separated into four groups, two released in the fall and two released in the spring. Unfortunately due to poor fish health and lack of funding this tag study was not continued in other broods. The OTC marking program was initiated in 1981 to provide limited data on the contribution of the large fish released in the fall. No further attempts to hold large fish through spring occurred again until Broodyear 1987 when coded-wire tags in conjunction with OTC marking were used to distinguish between large fish released in the fall versus large fish held for spring release. It is planned that this evaluation will continue for three or more broods.

The return rates for large fish released in the spring were considerably less than those noted for fall fish in the 1979 brood, however, overall return rates were poor (Table 29). Analyzing this difference is difficult due to only one year of coded-wire tag data, differing fish health between tag groups, and staggered release times in the spring.

Return rates for fall and spring release fish of the 1981 brood were much improved. The large fish released in the fall appeared to return at a higher rate than smaller fish released in the spring. The number of fish estimated to have returned from each release for this brood should be judged with some skepticism due to problems associated with interpreting the OTC ring count on these fish. Fall fish received one OTC ring while spring fish received two rings. Artifact rings have since been observed in fish from other broods where OTC was fed to one release and only one time. Dual rings should not have been noted in these later broods. Fish returning from the 1982-1985 and later broods generally received only OTC marks for the fall release group. The return numbers of fall released fish for these broods represents an estimated minimum number and does not take into account fish that did not retain an OTC mark. We consider the presence of the OTC mark as an index value and it probably underestimates actual fall release returns.

Although the data is limited it appears that fall releases are providing a mixed bag of returns, as are the smaller fish released in the spring.

Fall releases are providing a higher percentage of jacks relative to adult returns than spring releases. The jack percentage of fall release group returns has ranged from 14% to 46% and averaged 28%. Jack return percentages of spring release fish have ranged from 3% to 16% and averaged 8% (1980 brood not included).

TABLE 29. Estimated returns of fall and spring released chinook salmon to the Deschutes River after release from Warm Springs National Fish Hatchery.

Brood	Number Released	Date	Size	Returns Jack	Returns Fours	Returns Fives	Total	Return Rate
1979	54,668	11-06-80	9/lb	10	33	1	44	.0008
	99,000	04-02-81	8/lb	2	13	0	15	.0002
	259,137	04-09-81	19/lb	13	280	19	312	.0012
1981	108,328	10-05-82	10/lb	135	527	33	695	.0064
	209,856	04-12-83	15/lb	68	981	38	1,087	.0052
1982	61,864	10-24-83	9/lb	5	32	0	37	.0006
	625,995	04-13-84	18/lb	4	114	41	159	.0003
1983	423,481	10-16-84	9/lb	167	241	4	412	.0010
	382,844	04-09-85	19/lb	97	437	85	619	.0016
1984	325,823	10-01-85	9/lb	269	284	29	582	.0018
	420,364	04-09-86	17/lb	34	236	60	330	.0008
1985	160,188	10-01-86	9/lb	54	107	----	---	
	560,140	04-09-87	17/lb	395	3,147	----	---	

Although we have not specifically investigated the reasons for the difference in jack rates between the releases, we feel that the difference is due to a combination of factors. Fall release juveniles are the larger, faster growing individuals that may be more inclined to return as jacks. Round Butte SFH which raises large smolts and releases them in the spring has a jack rate comparable to Warm Springs NFH fall releases (Lindsay, et.al., 1988). We have also observed that fall release jacks tend to be larger than spring release jacks. Many of the fall release jacks are the size of small four year old and have included females (Figure 23).

Most jacks returning from fall releases tend to be 55 cm or larger while jacks from spring releases are generally under 55 cm. This size differential between releases has not been noted in four and five year old adults. The larger size noted for fall release jacks may also be related to the increased period of ocean residence gained by fish that migrate to the ocean prior to the normal spring release period. This is consistent with observations made at Little White NFH for zero-age releases of spring chinook (Roth, USFWS, unpublished data).

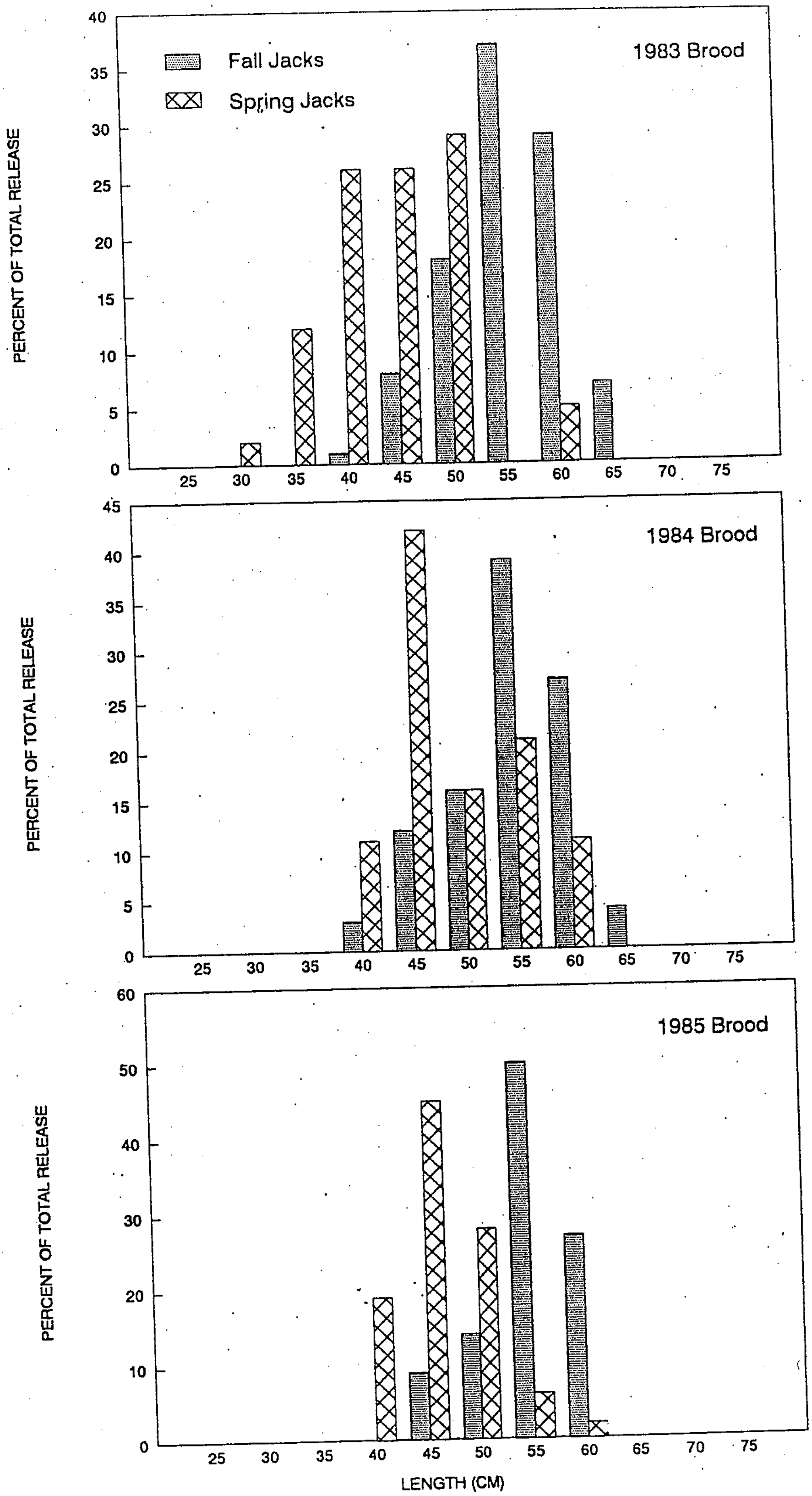

Figure 23. Lengths of jack spring chinook returning from fall and spring releases from Warm Springs National Fish Hatchery, 1983-1985 broods.

Although other factors, ie. genetics, harvest, etc., may be influencing jack/adult ratios for hatchery fish, it seems plausible that the current jack rates are likely primarily due to the size of fish at release and the length of time between release and return. In evaluating the effectiveness of the fall release it will be necessary to determine if fall releases actually increase the return rate of large smolts, if this benefit is of the type we desire (jack vs. adult), and balance the results against the costs and risks associated with relying solely on the full term spring release program.

Predicting Returns

Can we predict the return of hatchery fish?

When planning for an upcoming return year it is important to have the ability to accurately predict how many fish can be expected to return. Relating adult returns to numbers of fish released does not take into account factors such as fish health and ocean conditions during the first year after release. This period is likely critical in determining eventual returns especially for hatchery fish which appear to have a more variable range of survival than wild fish. For example, the survival of wild outmigrants to adult returns has ranged from .015 to .044, a three fold difference. The survival of hatchery migrants has ranged from .0003 to .0084, a twenty-eight fold difference. This wide variability must be reduced to adequately predict returns.

Utilizing jack returns to estimate eventual adult returns has been employed with some success at other hatcheries. The number of jacks returning is usually expanded to include the average age composition of the stock as noted from past broods. The Warm Springs hatchery stock is amendable to this because four year old returns are highly dominate followed by jacks.

The relationship between jacks returning from fall and spring releases is compared to eventual brood returns of those releases in Figure 24. The relationships noted are based on few data points which limits their usefulness. Further data collection is necessary to better define their relationship. The higher ratio of fall jacks to adult return is quite evident in this figure. When predicting future adult returns it will be important to delineate between fall and spring release jacks, either by the presence of an OTC mark or perhaps through length frequency analysis. Once the total brood return is estimated, the number of jacks actually seen can be subtracted to reveal the number of adults expected. The number of four-year olds and five-year olds can then be roughly estimated at 95% and 5%, respectively. This process should provide a reasonable estimate of potential adult returns and hopefully more data will improve its reliability.

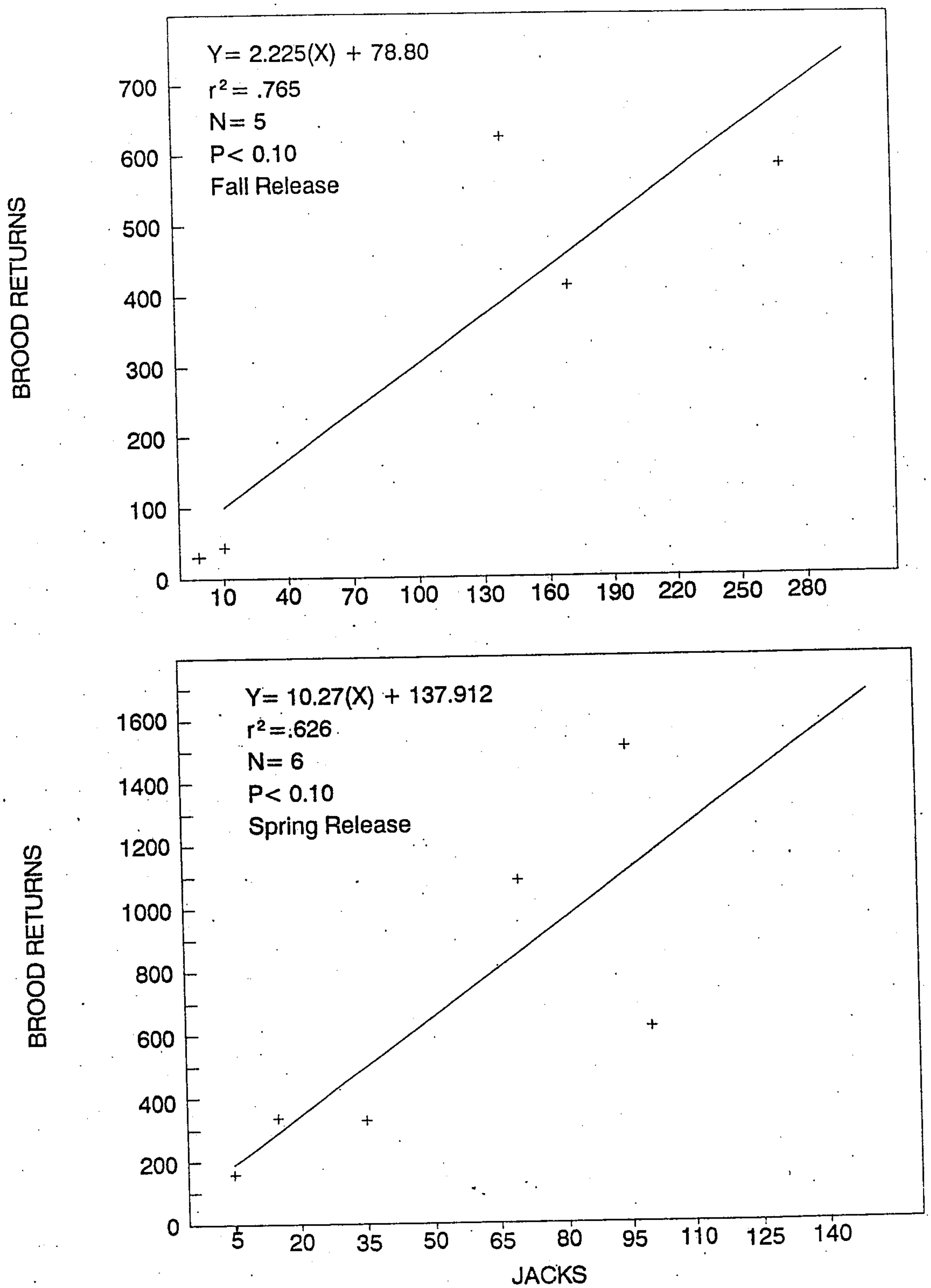

Figure 24. Relationship between hatchery spring chinook jacks returning from fall and spring release groups and eventual total group returns.

Is the marking program at Warm Springs NFH impacting the return of hatchery fish?

The current tribal management policy for spring chinook in the Warm Springs River is premised upon preserving the genetic integrity and productivity of the wild fish spawning above the hatchery. The tribal interpretation of this policy requires stringent controls on the hatchery program. Hatchery brood stock collection and spawning procedures have been designed to accommodate these goals.

A key ingredient to the Tribe's approach to wild fish management requires that hatchery fish do not spawn naturally above the hatchery. At the present level of technology, this requires that each juvenile hatchery fish be marked so that it can be separated from wild fish upon return. Currently this requires that fin clipping and/or coded wire tagging are required to mark hatchery fish. The 1982-1986 broods at Warm Springs NFH were 100% ventral fin clipped by the Tribe to meet their wild fish management objectives. The cost of this marking was paid by the Tribe through its BPA funded studies on wild fish in the Warm Springs River. The use of the ventral clip was based on the funding available and the belief by Tribal biologists that the mark would not be detrimental to hatchery spring chinook returns. The USFWS responded to the Tribal desires by providing the fish and assistance during the marking operations as well as documenting returns and passing wild fish upstream. The Service also began searching fisheries literature to ascertain if ventral fin marking could be expected to significantly impact spring chinook returns. Due to the fact that releasing unmarked hatchery fish is currently unacceptable at Warm Springs NFH and funding was not available to establish coded wire tag studies no direct comparisons between types of marking could be made. However, nearby Round Butte SFH which was also required to mark all hatchery fish for the wild fish policy did mark three broods of spring chinook with various fin marks. They utilized ventral, maxillary, and pectoral clips as potential alternates to more expensive coded wire tagging procedures. These broods began returning in 1986 and once the final return occur a true picture of the impact of fin clipping versus coded wire tagging should be more apparent.

It has been well established in fisheries literature that removing fins and the marking of fish can cause significant, if variable, impacts on their survival (Wahle et.al., 1972; Phinney and Mathews, 1969; Means and Hatch, 1976; and Weber and Wahle, 1969). The level of mark induced mortalities probably depends on the fin clip used, fish health, competitions, and environmental conditions. Although the returns are not yet complete, the initial returns of fin clipped spring chinook in the Round Butte SFH study indicate that return rates of fish containing coded-wire tags and having an adipose clip appear to be significantly better than fish having other fin clips (Don Ratliff (PGE), personal communication).

With the exception of the 1985 brood return rates of hatchery fish to Warm Springs NFH since 100% ventral fin clipping began (1982 brood) have averaged below earlier return rates (Table 30). It is suspected that at least part of this drop in return rates could be due to the ventral marking program. Beginning with the 1987 brood, funding was found to coded-wire tag most fish released from Warm Springs NFH until the impact on returns due to ventral clipping fish can be ascertained. Results from studies at Round Butte SFH and Warm Springs NFH should help to determine the least damaging mark that is acceptable in separating hatchery from wild spring chinook. This type of information is critical if we are to maximize the harvest and returns of hatchery adults.

Table 30. Return rates of hatchery spring chinook salmon returning to the Deschutes River and Warm Springs National Fish Hatchery.

Brood Year	Number Released	Number to Deschutes	Rate to Deschutes	Number to WSNFH	Rate to WSNFH
1978	178,890	1,510	0.84	1,057	0.59
1979	412,805	371	0.09	301	0.07
1980	208,187	874	0.42	836	0.40
1981	318,184	1,782	0.56	1,275	0.40
1982	685,859	196	0.03	125	0.02
1983	806,325	1,031	0.13	712	0.09
1984	746,187	912	0.12	652	0.09
1985*	720,328	3,703	0.51	2,661	0.37

* Does not include five-year olds.

<u>Has wild adult usage at Warm Springs NFH impacted wild production above Warm Springs NFH?</u>

From 1978-1981 Warm Springs NFH was fully dependent on wild spring chinook salmon from the Warm Springs River for its broodstock, although in 1981 some eggs were accepted from Round Butte SFH. This was primarily done to lessen the impact of the hatchery brood take on the wild stock in 1981, a year the fishery was closed to protect a projected poor return of wild fish.

The adult progeny from our first egg takes began supplying most of our broodstock beginning in 1982. In 1982 the wild portion of the hatchery brood take consisted entirely of wild fish previously marked as juveniles by ODFW. Although it has varied yearly, the majority of the broodstock is now of hatchery origin. The use of wild fish in the present program continues for several reasons: (1) we desire to retain the genetic characteristics of the wild fish in the hatchery stock, and (2) short falls in the brood take needs of hatchery fish can be alleviated by the use of wild fish returning in "excess" of the number we estimate are needed for maximum wild production. "Excess" adult returns are estimated using spawner-recruitment data collected for this stock adjusted for average prespawning mortalities seen above the hatchery. As noted earlier in this report a significant correlation has been observed between the number of wild adults spawning and the eventual returns of their progeny. While this relationship is strong, it will require more years of data to fully substantiate its validity, yet it does offer an opportunity to examine how the hatchery use of wild broodstock may have impacted eventual wild production.

When fish are taken from the run at Warm Springs NFH or at any other point prior to spawning, the eventual number of wild spawners is reduced. The impact to the succeeding generations of adult recruits depends greatly on the number of remaining spawners as illustrated by the S/R curve. The reduction in the number of wild spawners by their inclusion in the hatchery broodstock results in fewer natural spawners above Warm Springs NFH. This reduction, if examined on the S/R curve moves the number of spawners to areas of the curve where each spawner is more productive. The ultimate effect of the change depends upon where the point lies on the curve. Potentially significant benefits are possible if very large escapements are reduced. On the other hand, if the initial run size is low, any further reductions may significantly reduce potential wild returns since these would represent losses of potentially highly productive spawners. Wild production may be impacted by the take of wild fish for inclusion into hatchery broodstock (Figures 25 and 26). The estimated impact is based on the relationship between spawners and recruits as described by the S/R curve generated for wild fish. These tables illustrate the estimated impact to wild recruit production after wild adult withdrawals at Warm Springs NFH. Each figure compares the baseline recruit production from a wide range of returns to that expected if a certain number of fish (100, 200, etc.) were utilized at the hatchery. The number of fish allowed to pass Warm Springs NFH is adjusted by the average 44% prespawning mortality to arrive at the number of fish expected to spawn, their potential adult progeny is calculated with the S/R equation. Gain or losses in recruit production are measured against recruit production expected if no fish had been taken for the hatchery. For example, if 700 adults arrived at Warm Springs NFH and 100 of these were kept at the hatchery, the remaining 600 fish passing the facility would have been expected to produce 92% as many adult recruits as the full baseline escapement of 700 adults. Conversely, if 2000 adults arrived at Warm Springs NFH and 100 were taken by the hatchery the remaining 1900 would be expected to produce 2% more adult recruits than the original number of adults arriving. This increase is explained by the higher productivity of lower numbers of spawners as indicated by the S/R curve and is at least partially related to the postulated density-dependent mortality of juveniles previously noted.

If one examines these calculations a number of factors appear to be recognizable for this stock. Once wild escapement at Warm Springs NFH reaches about 1,500 fish the expected production impact of withdrawing even up to 500 fish is minimal (<4%) under "normal" circumstances. Secondly, at the range of wild adult escapements thus far noted at Warm Springs NFH (968-2,584) the impact of utilizing 100 fish annually in the hatchery broodstock is minimal and not likely to impact eventual production more than 5% in either direction. Once natural escapements above the hatchery reach beyond 1,400 the expected production impact is neutral or positive. The average return rate of wild adults to Warm Springs NFH since 1978 has been 1,491 fish while the average use of wild fish in the hatchery has been 341 (Table 31). The impact of the hatchery take was probably greatest in 1980 and 1981 when unusual prespawning mortalities occurred above Warm Springs NFH. In other years the number of wild fish, sometimes

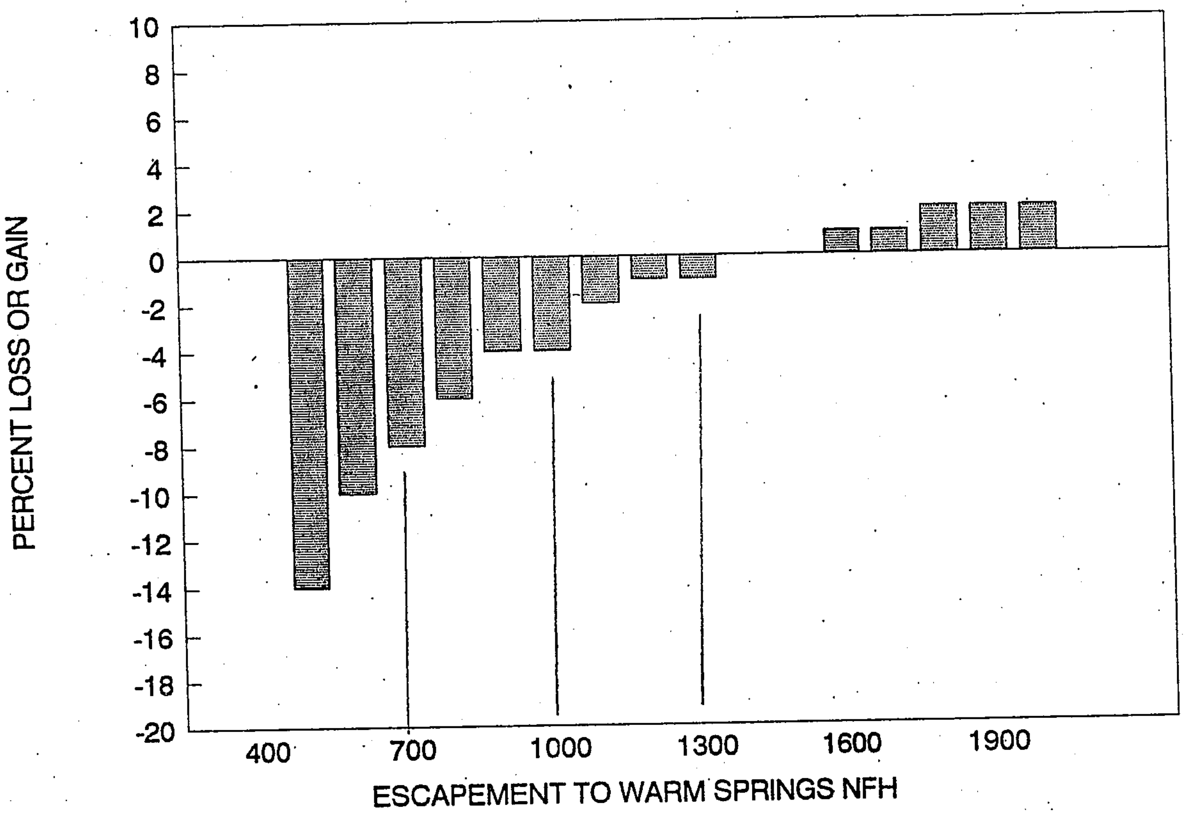

Figure 25. Percent gain or loss of wild production resulting from withdrawals of 100 wild spring chinook from fish arriving at Warm Springs National Fish Hatchery.

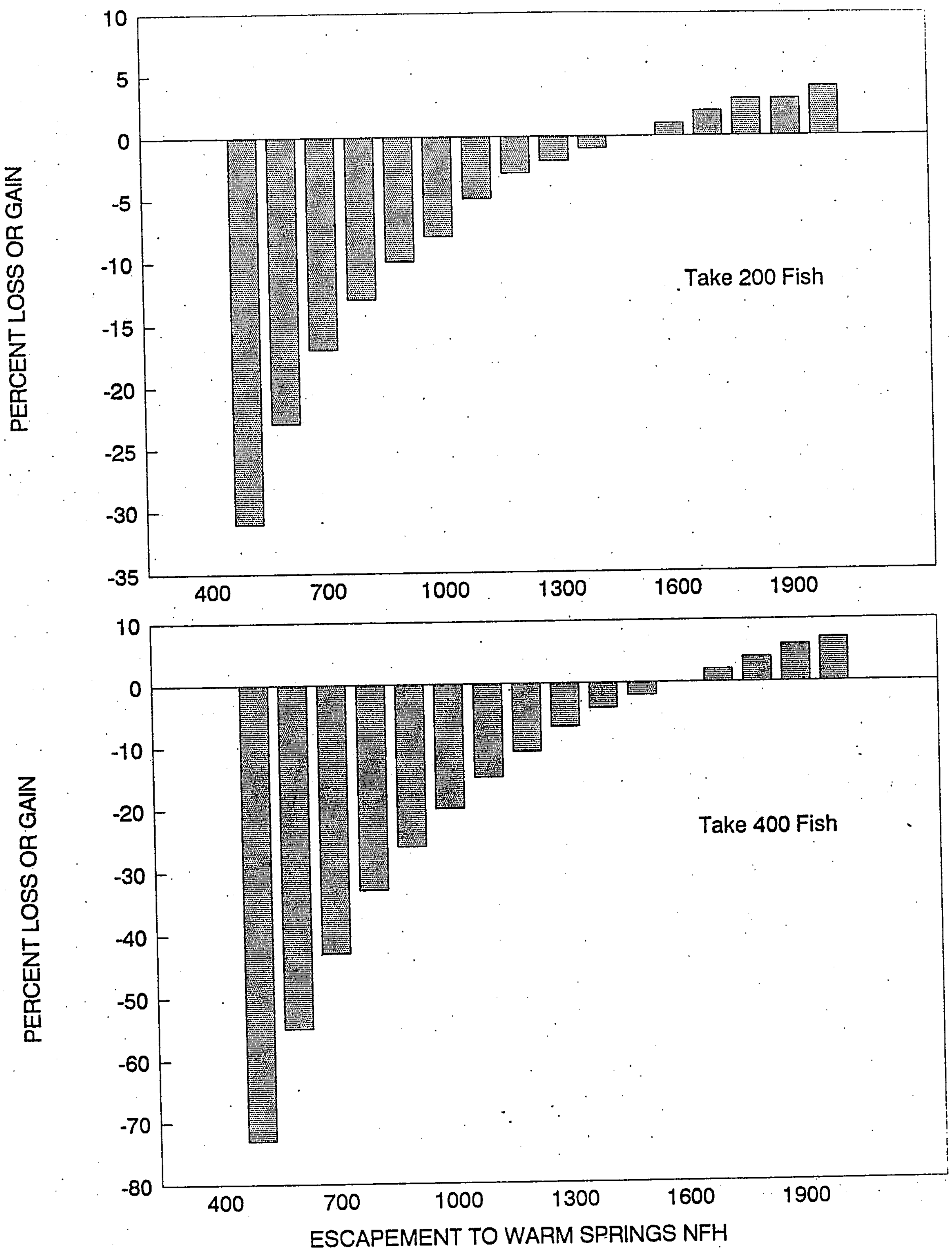

Figure 26. Percent gain or loss of wild production resulting from withdrawals of 200 and 400 wild spring chinook from fish arriving at Warm Springs National Fish Hatchery.

supplemented by hatchery fish (1982-1985) was great enough that we expect little reduction of potential recruits has resulted. Since 1982 the average escapement above Warm Springs NFH has been 1,337 adults.

Table 31. Return of wild spring chinook to Warm Springs National Fish Hatchery and escapement of wild and hatchery adults upstream.

	Total Wild Adults to Warm Springs NFH	Total Hatchery Take	Total Hatchery Adults Upstream	Net Hatchery/Wild Escapement Upstream
1977	1,505	0	0	1,505
1978	2,584	569	0	2,015
1979	1,322	416	0	906
1980	968	317	0	651
1981	1,525	511	0	1,014
1982	1,408	91	270	1,587
1983	1,523	442	170	1,251
1984	1,192	389	519	1,322
1985	1,099	322	487	1,264
1986	1,656	470	25	1,211
1987	1,697	147	0	1,550
1988	1,578	319	0	1,259
1989	1,344	90	0	1,254

Although we cannot "truly" predict what would have happened in any particular year if the hatchery had not taken wild fish from the run, the performance of this stock as observed above the hatchery over the last 13 years indicates that the use of wild fish in the hatchery has probably had little impact on eventual wild production.

It appears that the take of wild fish to establish the hatchery program probably had little impact on eventual wild returns and harvest, however it is readily apparent that hatchery fish have contributed significantly to harvest and escapement. In years when Warm Springs NFH jacks and adults have been present and harvests have taken place their estimated harvest has ranged from 120 to 1,020 per year. Creel census efforts at Sherars Falls in 1987, 1988, and 1989 indicated that the catch of hatchery fish (Round Butte and Warm Springs NFH) has surpassed that of wild fish. In 1988 and 1989 the harvest of hatchery fish was nearly twice that of wild fish even though the wild run numbers and harvest was at a high level. Clearly, the careful utilization of the wild stock to establish both hatchery stocks has been successful and is currently yielding significant benefits to sport and Indian fishermen alike.

Are hatchery fish as productive as wild fish?

There is a tendency among biologists and others to consider hatchery fish as being less productive than wild fish and, therefore of inferior quality. This belief is at least partially based on the fact that wild smolts survive at a much higher rate to adult than hatchery releases. Data collected at Warm Springs NFH offers a clear comparison between the survival of wild smolts compared to that of hatchery fish. Wild spring chinook migrant to adult survival in the Warm Springs River has ranged from 1.5% to 4.1% while averaging about 2.9%. The survival of hatchery smolts has ranged from 0.03% to 0.84% and averaged about 0.31%. Clearly the survival of wild smolts is much superior to that seen for hatchery fish at Warm Springs NFH. The return rates for spring chinook from Warm Springs NFH are fairly typical for fish released from Columbia River Basin hatcheries, although returns to some stations, i.e. Round Butte SFH indicate that unusual rearing practices like that used in their fish ladder rearing program can consistently produce hatchery smolt survival of more than 1%. This indicates that most hatcheries including Warm Springs NFH are not taking advantage of the full potential of these fish.

Although this comparison is useful in identifying potential areas of smolt survival improvement possible for hatchery fish one should not compare wild and hatchery productivity based on one lifestage. As an example, survival from the egg to smolt for hatcheries is much higher than occurs for fish spawning naturally. Probably the best way to truly compare the productivity of hatchery fish versus wild is from adult to adult. This comparison would begin with the adults that spawned and end with the number of adult recruits entering the Deschutes River.

A comparison based on such data illustrates that the hatchery productivity can be very comparable to wild productivity (Table 32). Although comparing hatchery and wild production for any one year is full of pitfalls examining the range of recruits per spawning adult for each stock indicates that hatchery fish are responding within a similar range but with more variation. Hatchery adult recruits have averaged .37 to 6.75 per spawner and averaged 3.1. Wild recruits have ranged from .90 to 6.67 per spawner and averaged 3.3.

Wild fish appear to be more productive at lower spawning densities while fluctuations in the return of hatchery fish may relate more to disease status or other factors. Hatchery return rates of about 0.3% would produce spawner/recruit ratios similar to that observed for wild fish at what we estimate as maximum recruitment. It certainly appears that there is considerable potential for hatchery fish to exceed wild fish spawner/recruit ratios even if their smolt to adult survival rate remains lower than that for wild fish. The ladder rearing program at Round Butte SFH clearly illustrates this.

Table 32. Fish production compared to adults spawned for hatchery and wild spring chinook in the Warm Springs River.

Stock	Brood Year	Adults Spawned	Adult Recruits	Recruits/ Adult
WILD	1975	1,247	1,891	1.40
	1976	1,719	1,547	.90
	1977	1,127	1,691	1.50
	1978	1,263	2,009	1.59
	1979	579	2,077	3.59
	1980	180	1,162	6.46
	1981	271	1,807	6.67
	1982	666	2,770	4.16
	1983	742	2,743	3.70
	1984	703	2,344	3.33
HATCHERY	1978	325	1,510	4.65
	1979	299	371	1.24
	1980	166	874	5.27
	1981	564	1,782	6.75
	1982	536	196	.37
	1983	507	1,031	2.03
	1984	552	912	1.65

RECOMMENDATIONS

The management needs of spring chinook in the Warm Springs River require further collection of data to strengthen the database for decision making. The following five recommendations are made concerning the wild stock.

1. The validation of the spawner-recruitment curve for wild spring chinook requires that estimates of spawners and resulting brood strengths be continued. This relationship is critical for setting escapement goals above the hatchery and judging the impact of harvests. Continued monitoring of outmigrants would also aid in this goal.

2. The fate of wild fall outmigrants needs to be quantified and their relative importance determined. Little is known about the presmolt life history of spring chinook in the Warm Springs River system.

3. Prespawning mortalities of adult spring chinook above Warm Springs NFH are high and significantly impact the harvestable surpluses of this stock. A study should be designed to identify the cause(s) of these losses and, if possible, provide ways in which they might be reduced. Preventative efforts to reduce mortality should be compatible with the Tribe's wild fish policy.

4. Run timing and other biological characteristics of the wild and hatchery stocks should continue to be taken at Warm Springs NFH. These characteristics need to be monitored to evaluate the long term interplay between stocks in this system.

5. At the present time wild spring chinook are returning in excess to the numbers needed to sustain the present fishery and escapement needs. This should continue under the present escapement goals enacted above Warm Springs NFH. Thought should be given to establishing another wild run of this stock in the Deschutes Basin utilizing some of this excess. Opportunities exist in Shitike Creek and possibly White River for introducing this stock to rapidly increase or start wild spring chinook production. Such a policy would provide a measure of safety for this stock if a catastrophic event impacted the Warm Springs River. The 1980 event at Mt. Saint Helens should be a reminder that this is a possibility.

We also recommend that studies be done in the Warm Springs River to more fully describe the life history, biological characteristics, and escapement needs of wild summer steelhead.

We recommend that the future direction of the hatchery program be followed according to the following guidelines.

1. Eliminate or greatly reduce the future use of ventral fin marks. If ventral or any other marks can be shown to not significantly impact returns of spring chinook, they may be reinstated to meet Tribal management goals.

Since 100% ventral fin clipping began with the 1982 brood, the average return rate to Warm Springs NFH has dropped from 0.48% to 0.09%. While other factors may also be influencing this decline, a considerable amount of experience with fin clipping of anadromous fish at other facilities suggests that a significant portion of this reduction could be attributable to mark mortality. Given the levels of marking mortality noted at other stations, it is probable that discontinuing this mark alone should result in returns that meet historical harvest rates and on average generate a large increase in adult production from the current production levels at Warm Springs NFH.

Given the current level of technology we recommend utilizing the Adipose-coded wire tag and/or the presence of blank wire tags to separate hatchery from wild fish at Warm Springs NFH. If adipose fin clipping only is approved for other hatchery stocks, it should also be used at Warm Springs NFH.

2. Continue to improve the quality of smolt production through disease control and suppression; especially BKD. This could be accomplished through improved diets, adult culling, other modified spawning procedures, reduced stress, and improving water quality. Studies should be designed to reveal statistically significant differences and not limited to performance in the hatchery environment. The complete adult to adult cycle should be investigated.

3. Fall releases should continue but more precise accounting via Ad-cwt marking should be employed. Replicate groups of large fish should be released in the fall and spring. Until the contribution of these large fish released in the fall and spring can be ascertained, the fall release should represent only a portion of the large fish available.

4. Studies should continue to determine the best rearing strategies to be employed at Warm Springs NFH. These studies should relate to densities at all life stages and differing release strategies. Improving return rates would do much to stabilize production levels, harvest, and would reduce the hatchery's need to use wild broodstock in excess of the normal 10% infusion.

5. The biological characteristics and run timing of hatchery fish should continue to be monitored at Warm Springs NFH to evaluate the success of the hatchery operational plan in maintaining historical patterns.

6. We believe that general guidelines should be established by the USFWS, Tribe, and ODFW to balance the needs of the hatchery program and the goal of protecting the wildstock above the hatchery. An effort should be undertaken to reconcile the expectations of each entity for the

hatchery programs, the level or protection needed to maintain the wild stock, and the type of management program required to maintain Warm Springs NFH, Round Butte SFH, and wild stocks in the Deschutes River. Until such guidelines are available, the interactions of hatchery and wild production of spring chinook in the Deschutes River will create management difficulties should conditions change for any of the stocks. Contingencies to deal with shortages or excesses of each stock should be developed relating to harvest alternatives and brood stock requirements.

We also recommend that a comprehensive report on the status of the hatchery and wild programs in the Warm Springs River be done every five years. In addition, a yearly update of returns, releases, etc. should be distributed to interested parties.

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APPENDIX A

Operational Plan for Warm Springs National Fish Hatchery

Warm Springs National Fish Hatchery
Operational Plan
1988 - 1991

Introduction

Warm Springs National Fish Hatchery (Warm Springs NFH) was authorized by Federal Statue 184, on May 31, 1966 to stock the waters of the Warm Springs Indian Reservation with salmon and trout. The hatchery is operated by the U.S. Fish and Wildlife Service (USFWS) on lands leased from the Confederated Tribes of the Warm Springs Indian Reservation.

Warm Springs NFH began fish production in 1978 with eggs from spring chinook salmon and steelhead trout captured from the existing natural runs passing the hatchery site. Catchable trout are also raised at the hatchery for planting in reservation waters. Eggs for the trout program are obtained yearly from the Oregon Department of Fish and Wildlife (ODFW).

The spring chinook program at the hatchery originally had a broodstock requirement of 400 adult fish. When the steelhead smolt program was abandoned in 1981, the chinook program was expanded, with Tribal concurrence, to fully utilize hatchery production potential. The hatchery now has the capacity to produce 1.2 million spring chinook smolts resulting in a broodstock requirement of about 900 adults.

Although good returns have resulted from early production levels returns for more recent broods (1982 and 1983), have not been as good, and the hatchery is experiencing difficulty building toward full production.

At the present time the hatchery is operating at about 60% of capacity. The current production levels and operational procedures do not appear to be capable of returning of a regular basis, enough fish to satisfy both harvest and full production needs.

The USFWS recognizes that the Tribe has the sole management responsibility for fishery resources on the Warm Springs Indian Reservation. After careful analysis of the available data, it is recommended that some basic modifications be made to the existing operational plan to improve the contribution of hatchery fish. These modifications would still provide for maintaining the wild/hatchery fish separation desired by the Tribe. The steps necessary to meet this goal are outlined in the following portions of this plan. It is anticipated that the USFWS and the Tribe should again formally review the progress of the program after four years (October 1991).

Fish Program

Except for a relatively small trout program, production of fish at Warm Springs NFH shall be restricted to spring chinook salmon taken from the Warm Springs

River. A systematic approach to the selection and spawning of spring chinook broodstock will be used to preserve the natural characteristics inherent to the native run. The total broodstock requirement will normally be between 900 and 1,000 adults depending on fish size, sex ratios, etc.

The desired escapement goal for wild fish above Warm Springs NFH shall be 1,250 adults. This is the number of fish we estimate will be needed to maintain maximum wild production. In order to help promote the retention of wild genetic traits in the hatchery broodstock, a minimum of 10% of the broodstock will be of wild origin. A minimum of 1,000 wild adults are required to be released above the hatchery to spawn naturally. In the event that less than 1,000 wild adults are anticipated at Warm Springs NFH, the USFWS, ODFW, and the Tribe will consult on possible alternatives.

At capacity, the hatchery will release approximately 1.2 million smolts. Because of the relatively small size of prior hatchery releases, it is likely that additional wild fish beyond the 10% minimum will be needed for the hatchery if it is to reach capacity. This need will continue until about 1991.

Procedures to be followed in the selection, spawning, and rearing of spring chinook are listed below:

1. Spring chinook from the Warm Springs River will be the stock of choice to be used at the hatchery.

2. Beginning in 1988 and continuing until 1991 the hatchery production will be maintained as close to capacity as possible, depending upon funding levels. It is expected that wild fish in excess of the 10% minimum requirement will probably be needed for broodstock.

Based upon analysis of return data and redd counts since 1975, it is anticipated that the escapement of wild fish to Warm Springs NFH during this period will significantly exceed current harvest and replacement seeding needs. It shall be policy that at least 1,000 wild adults be released above the hatchery, but that fish in excess of "1,250" may be utilized to bring the hatchery up to capacity production. All others will be released upstream unless the Tribe desires otherwise. It can be expected that the total number of wild fish needed at the hatchery for genetic introduction and to reach capacity will number from 90 to 400 during the years of this agreement. Such a policy should not only help the hatchery obtain full production but also be of benefit in maintaining the characteristics of the wild run in hatchery fish. If hatchery fish return in numbers excess to broodstock needs, they will be reserved to meet other Warm Springs Reservation needs as identified by the Tribe.

3. Retrieval of adults for hatchery broodstock should be random and occur throughout the run.

4. Adults handled through the hatchery will be injected with erythromycin to curtail mortalities caused by Bacterial Kidney Disease (BKD). All wild fish more than 30 days from spawning will be inoculated before they are released upstream as permitted by federal regulations.

Spawners retained at the hatchery will receive a second inoculation approximately 30 days after the first.

5. Spawning will be random; that is, as the fish reach spawning maturity they will be spawned. Since returning females normally outnumber males, all males are used for spawning purposes. Spawning is conducted on a one to one basis; however, some males have to be used more than once.

6. A monitoring program for IHN and IPN virus will be established for all eggs taken. If virus incidence is present, virus/non-virus groups will be raised separately to minimize horizontal transmission to non-infected fish.

Fish used for spawning will be examined for the presence of BKD before fertilization. Those exhibiting gross symptoms of BKD infection will be discarded.

7. In order to meet Tribal and Oregon Department of Fish and Wildlife (ODFW) management objectives all juvenile spring chinook released from the hatchery will be marked to differentiate them from wild fish on return.

The 1987 Brood spring chinook will be marked Ad-cwt in response to Tribal and ODFW management needs. The Tribe and the USFWS will share equally in the associated cost of marking the 1987 Brood.

Because marking will be a yearly expenditure under the wild fish management plan, funding must be assured. If additional funding is not secured, the marking costs will be absorbed at the expense of fish production. Unless additional funding for marking can be obtained, it is accepted that the hatchery will operate at less than full capacity. An annual funding base for the marking program must be secured prior to egg take in any given year.

Other marking may occur to evaluate specific fish cultural practices or hatchery contribution studies. Such studies may be implemented by the USFWS at no expense to the Tribe, but only after discussions with the Tribal Natural Resources Department.

8. Size at time of release for spring chinook is variable from station to station; consequently, size at release is being monitored to determine which sizes survive best. At the present time Warm Springs NFH employs two release periods, fall and spring. The fall release group consists of the faster growing large fish, usually greater than 140 mm, that smolt in the fall of their first year. This release takes place in early October. The size of the release depends on the number of fish reaching the 140 mm threshold. The remainder of the fish are kept until they are yearlings and released in mid-April.

During the four year period of this plan the USFWS expects to investigate the potential value of a volitional release program and initiate the use of passive fish graders for separating fall and spring release fish. Additionally, a further examination of the fall release strategy is anticipated.

9. All juvenile releases will be at the hatchery except to meet a Tribal request for establishing a run or supplementing natural production in other Reservation waters.

Trout

The trout program at Warm Springs NFH is currently limited to the production of approximately 15,000 catchable rainbow trout. Eggs are obtained from the ODFW. A Memorandum of Understanding has been entered into between the USFWS and the Tribe. Under this agreement the Tribe purchases the necessary fish food for the program while the USFWS provides other rearing and transportation costs.

Trout utilized in this program are limited to a Ceratomyza susceptible strain in an effort to minimize possible impacts to native resistant populations. They primarily are planted in the lower Warm Springs River and Shitike Creek.

This operational plan shall be in effect from the time of signing until October 1991. At that time a new agreement will be established for future years. Alterations of a technical nature to this plan shall have the mutual agreement of both parties as represented by the technical staff of the USFWS and the Tribal Natural Resources Department.