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LOWER SNAKE RIVER COMPENSATION PLAN

SALMON HATCHERY EVALUATION PROGRAM

1989 ANNUAL REPORT

by

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ABSTRACT

This report provides a synopsis of activities from 1 April 1989 to 31 March 1990 by the Washington Department Fisheries' Lower Snake River Hatchery Evaluation Program. This work was completed with Fiscal Year 1989 funds provided by the U. S. Fish and Wildlife Service under the Lower Snake River Fish and Wildlife Compensation Plan (LSRCP). Specific programs studied are Lyons Ferry and Tucannon Fish Hatcheries (FH). Mandated adult return objectives for these hatcheries are 18,300 fall chinook salmon, Snake River stock, and 1,152 adult spring chinook salmon, Tucannon River stock, back to the Snake River Basin.

Fall chinook salmon escapement to Lyons Ferry FH in 1989 was 1,880 adults (age 4+) and 602 jacks. Fish were obtained from two sources, voluntary returns to the FH ladder, and fish trapped at Ice Harbor Dam and hauled to Lyons Ferry. We obtained 1,709 adults from trapping operations at Ice Harbor Dam, and 704 adults and 670 jacks (fish less than 71 cm fork length) through rack returns. All release groups from the 1983 through 1986 broods contributed to returns at Lyons Ferry FH. Preliminary coded-wire tag (CWT) recovery analysis indicates no consistent difference in returns to the LSRCP project area and fisheries' contribution between the on-station and transported release groups. This pertains to both the subyearling and yearling categories. To date, the yearling release groups have survived better than the subyearlings, regardless of release location.

The 1983 brood had 1.34 percent escapement to the LSRCP project area, and 5.67 percent contributed to high seas and Columbia River fisheries, for a total survival rate of 7.01 percent through age 6. Two treatment groups comprised the 1984 brood: 1) the subyearling (age 0) on-station release, which had 0.14 percent escapement to the Snake River and 0.62 percent total survival and contribution rate through age 5, and 2) the yearling on-station release: 0.11 percent escaped to the Snake River, with a 0.69 percent total survival rate through age 5. The 1985 brood had four treatment groups: 1) the subyearling on-station release, had 0.30 percent escapement to the Snake River and 0.16 percent total survival rate through age 4, 2) the subyearling transport (barge) release, had 0.01 percent escapement to the Snake River and 0.11 percent total survival through age 4, 3) the yearling on-station release, had 0.24 percent escapement to the Snake River and 1.52 percent total survival through age 4, and 4) the yearling transport release, had 0.14 percent escapement to the Snake River and 0.30 percent total survival through age 4. Return rates of the age 3 fish ranged from 0.02 to 0.14 percent. These survival rates are preliminary and will be updated in future reports. Analysis of coded-wire tags recovered from salmon spawned at Lyons Ferry FH indicated a 43 percent stray rate of other Upriver Bright fall chinook salmon stocks to Lyons Ferry FH. Salmon released from Umatilla River comprised the majority of the strays.

Fall chinook salmon were spawned at Lyons Ferry FH from 21 October to 16 December; eggtake was 3,518,107. Peak of spawning was 11 November. Lyons Ferry FH staff planted 413,017 yearling (1987 brood) fall chinook salmon in April 1989, and 1,765,433 subyearling (1988 brood) fall chinook salmon in June 1989. We differentially marked (CWT) representative groups of the yearling and subyearling groups for release on-station and for transport below Ice Harbor Dam for release. On-station releases were coordinated with spill at Lower Monumental Dam. Travel time of the yearling on-station release group from Lyons Ferry FH to McNary Dam ranged from 7.8 to 8.7 km/day. Travel time of the subyearling on-station release group over the same distance was 7.4 to 7.8 km/day. The middle 80 percent passage of branded Lyons Ferry yearlings at McNary Dam was about five days earlier than the basin-wide 80 percent passage window for yearling chinook salmon.

We monitored natural spawning in all streams upriver of Lower Granite Dam believed to be used by fall chinook salmon adults. Fall chinook salmon spawning ground counts in the Clearwater, Grande Ronde, Imnaha, and mainstem Snake Rivers in 1989 totaled 10, 0, 1, and 58 redds, respectively. Seven hundred six adults were counted pass Lower Granite Dam, providing an adult-to-redd ratio of about 10. We found 48 fall chinook salmon redds in the Lower Stratum of the Tucannon River. Coded-wire tags from nine marked carcasses were recovered; six were from on-station releases at Lyons Ferry, two were from transported releases, and one was a stray from the Umatilla River.

Spring chinook salmon escapement to the Tucannon River was 205 adults and 78 jacks; enumeration was by trapping adults adjacent to the hatchery, and by snorkel surveys downstream of the trap. We collected 92 adults and 76 jacks for broodstock at Tucannon FH. This is the first year of operations since 1985 that we did not meet eggtake requirements; eggtake was 106,321, design capacity is about 132,000. Peak of spawning was 5 September, which coincided well with natural spawners. Tucannon FH released 152,165 yearling (1987 brood) spring chinook smolts on a volitional basis from 11 to 13 April. The salmon had infestations of viral erythrocytic inclusion body syndrome in the acclimation pond. Modal travel time to the downstream migrant trap 38 km downstream of the hatchery was about four days.

Spring chinook salmon escapement to the Tucannon River spawning grounds was 113; 106 redds were dug. We initiated a radio telemetry study in the Tucannon River to provide information on adult holding and spawning behavior. We encountered difficulties in fish mortality and equipment failure during the study, but found some evidence of multiple redd construction by females.

We quantitatively electrofished 39 sites in three study strata in the upper Tucannon River, and found mean spring chinook salmon rearing densities ranged from 16.66 to 22.08 fish/100m2.

These data were used with extensive and intensive habitat surveys to estimate a late summer standing crop of 69,700 fry (1988 brood). We operated a downstream migrant trap from October 1988 through June 1989, and caught 9,573 natural and 6,233 hatchery spring chinook salmon smolts, at average efficiencies of 29.9 and 4.1 percent, respectively. We estimate 44,023 (with 95 percent confidence interval of 3,814) natural spring chinook salmon (1987 brood) outmigrated from the Tucannon River in the 1988/1989 season. The egg to fry survival rate for the natural-origin 1987 brood spring chinook salmon was 25.6 percent; fry to smolt survival for this same group was 55.6 percent. Overall egg to smolt survival for this group was 14.2 percent.

We provide information on quantitative snorkel surveys for estimates of parr production and overwinter survival in the Tucannon River. This method is compared with information gained through our electrofishing surveys. We studied summer growth rates of natural spring chinook salmon parr in the Wilderness and HMA Strata and found their instantaneous rates of growth were 1.54 and 1.30, respectively.

Six continuous reading thermographs placed in the four uppermost strata of the Tucannon River indicated heat loading occurred throughout the HMA and Hartsock Strata during summer and remained constant throughout the river continuum in winter. We quantified the upper Tucannon River invertebrate production (benthos and drift) and determined the food base for spring chinook salmon and steelhead parr in 1989. Additional studies initiated in FY 1989 include comparisons of Organosomatic indices, meristic counts, and gill ATP-ase levels between natural and hatchery-origin Tucannon spring chinook salmon.

We provide 22 recommendations to improve broodstock management, egg incubation, and smolt acclimation strategies at both Lyons Ferry and Tucannon Fish Hatcheries.

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LOWER SNAKE RIVER COMPENSATION PLAN

SALMON HATCHERY EVALUATION PROGRAM

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SECTION 1: INTRODUCTION

1.1: Compensation Objectives

Congress authorized the Lower Snake River Fish and Wildlife Compensation Plan (LSRCP) in 1976. As a result of that plan, Lyons Ferry and Tucannon Fish Hatcheries (FH) were designed and are currently under operation. The objective of these hatcheries is to compensate for the loss of 18,300 adult fall chinook salmon, Snake River stock, and 1,152 adult spring chinook salmon, Tucannon River stock (USACE 1975). An evaluation program was initiated in 1984 to monitor the success of these hatcheries in meeting the LSRCP compensation goals and to identify any production adjustments required to accomplish those objectives. The Washington Department of Fisheries (WDF) has identified two broad based goals in its evaluation program: 1) monitor hatchery practices at Lyons Ferry and Tucannon FH to ensure quality smolt releases, high downstream migrant survival, and sufficient contribution to fisheries with escapement to meet the LSRCP compensation goals, and 2) gather genetic information which will help maintain the integrity of Snake River Basin chinook salmon stocks (Bugert 1989). A specific list of the evaluation program's objectives is outlined in Appendix A.

This report summarizes all activities performed by the Washington Department of Fisheries' LSRCP Evaluation Program from the period 1 April 1989 through 31 March 1990. Section 2 of this report outlines the fall chinook salmon operation and evaluation progress. Section 3 outlines spring chinook salmon operation and evaluation progress. In Section 4 we provide recommendations to improve hatchery and natural production of the two stocks.

1.2: Description of Facilities

The Lyons Ferry facility is located at the confluence of the Palouse River with the lower Snake River at river kilometer (RK) 90 (Lower Monumental Pool, Figure 1). Design capacity is 101,800 pounds (9,162,000 subyearling smolts at 90 fish per pound) of fall chinook salmon and 8,800 pounds (132,000 yearling smolts at 15 fish per pound) of spring chinook salmon (Table 1).

Lyons Ferry FH has a single pass wellwater system through the incubators, two adult holding ponds, and 28 raceways. A satellite facility is maintained on the Tucannon River (RK 61; Figures 1, 2) for collection of spring chinook salmon adults and subsequent release of yearling progeny. It has an adult collection trap and one holding pond, which is used for both broodstock and yearlings. Returning adult spring chinook

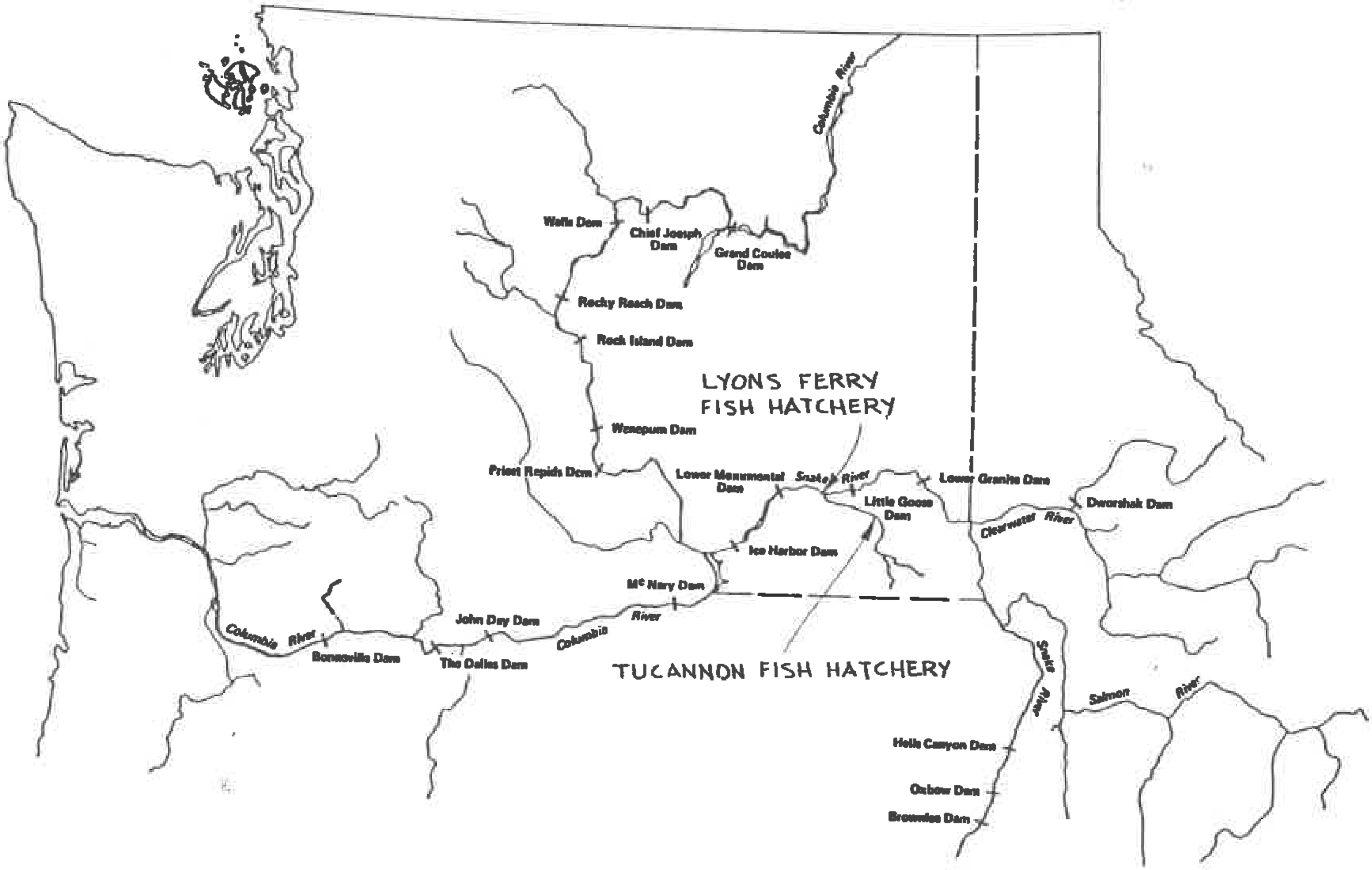

Figure 1. Location of Lyons Ferry and Tucannon Fish Hatcheries.

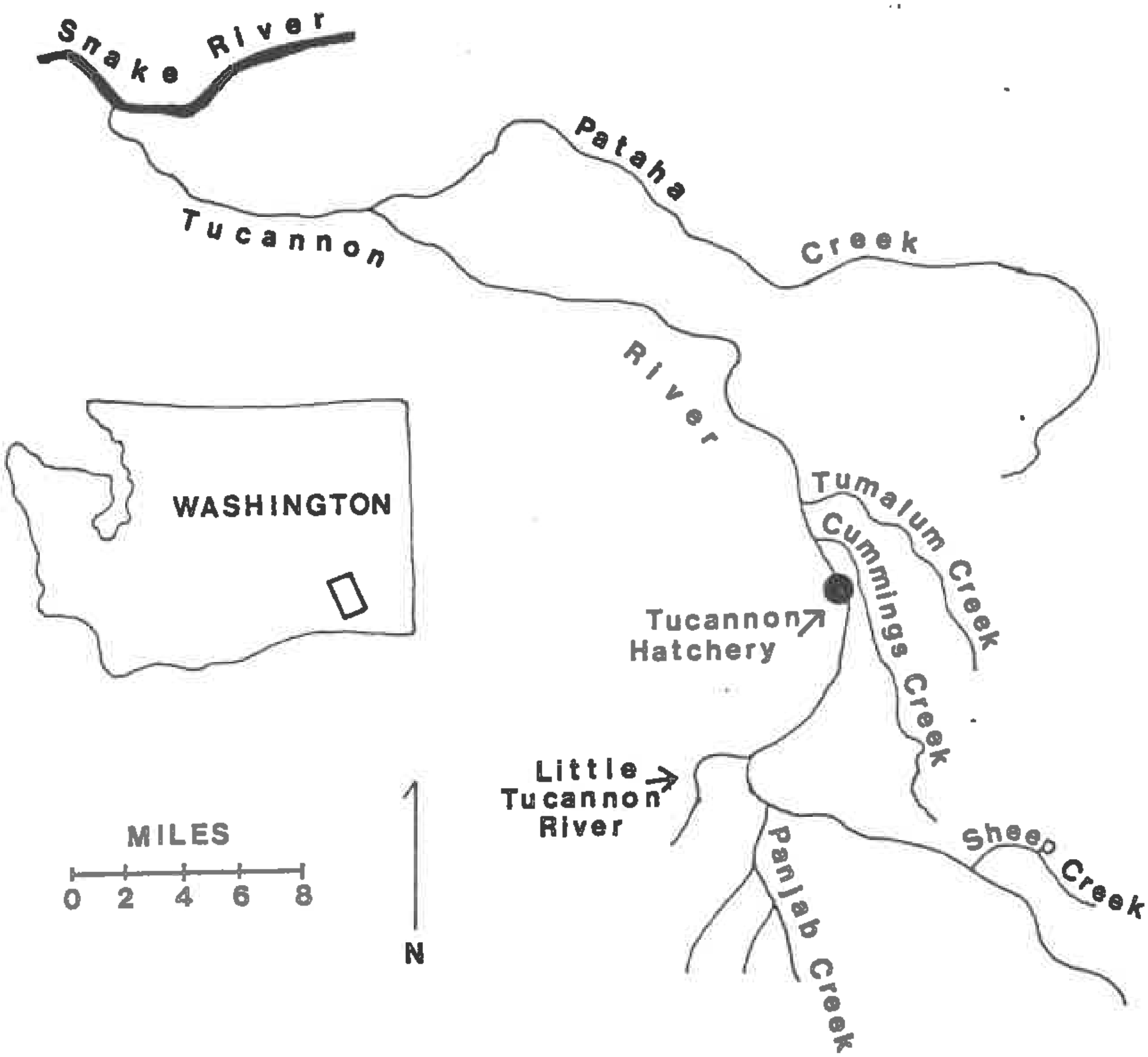

Figure 2. Tucannon River Basin, showing location of Tucannon Fish Hatchery.

salmon are trapped and spawned at Tucannon FH. Progeny are fertilized, incubated, and reared to parr size at the Lyons Ferry facility, then trucked back to the Tucannon satellite for acclimation to river water and release. The first spring chinook salmon smolt release from the Tucannon facility was in 1987. Fall chinook salmon are hatched and reared at Lyons Ferry FH and either released on-station or barged downstream of Ice Harbor Dam and released. Adult fall chinook salmon return to the fish ladder at Lyons Ferry FH, and, during these initial years of broodstock establishment, are trapped at Ice Harbor Dam and transported to Lyons Ferry FH to supplement the voluntary returns. The first year of adult (4+ year old) to the hatchery was 1987.

Table 1. Fall and spring chinook salmon production objectives for Lyons Ferry and Tucannon Fish Hatcheries.

Facility	Stock	Smolts produced	Pounds produced	Adult returns	Return rate (%)
Lyons Ferry	Fall	9,162,000	101,800	18,300	0.20
Tucannon	Spring	132,000	8,800	1,152	0.87

SECTION 2: FALL CHINOOK SALMON PROGRAM EVALUATION

2.1: Broodstock Establishment

The Lyons Ferry FH has been building its broodstock since the facility was completed in 1984. Snake River fall chinook salmon broodstock are currently obtained from two sources, returns to the Lyons Ferry FH ladder, and adults trapped at Ice Harbor Dam for transport to Lyons Ferry FH. The third source, transport of eyed eggs from Kalama Falls FH, done as part of the Snake River Egg Bank Program, was completed in 1986.

2.1.1: Returns to Lyons Ferry Fish Hatchery

Numbers of fall chinook salmon returning to the Lyons Ferry FH ladder are increasing each year because on-station releases underway since 1985 are returning as adults. A total of 704 adults and 670 jacks[a] returned to Lyons Ferry FH in 1989 (Table 2). First adult arrival to the rack was on 6 September; last arrival was on 4 December, compared to the period 5 September to 15 November in 1986, 18 September to 12 December in 1987, and 9 September to 5 December in 1988.

[a]*Throughout this report jacks collected in trapping operations and returns to the hatchery rack were distinguished by size, and in some cases our estimates were revised when coded-wire tag or scale data became available. The length criterion for jacks collected at Ice Harbor Dam and Lyons Ferry FH was 61 cm, the length criterion at Lower Granite Dam was 55 cm.*

2.1.2: Ice Harbor Dam trapping

Since 1977, returning adult fall chinook salmon have been trapped at Ice Harbor Dam and transported to Dworshak and Tucannon FH in conjunction with the Snake River Fall Chinook Egg Bank Program (Bugert and Hopley 1989). Since its completion in 1984, Lyons Ferry FH has been receiving the transported fall chinook salmon (Table 3). Over the 13 year period, numbers of fish transported have averaged 603 adults (range: 212- 1,613) and 52 jacks (range: 0- 150). In 1989, 1,179 adults were trapped and hauled to Lyons Ferry FH (Ringe and Bugert 1989), representing 25 percent of the total run of fall chinook salmon adults past Ice Harbor Dam for that year (Table 2). Actual trap efficiency for the period of operation, however, was 47 percent.

Table 2. Contribution of fall chinook salmon adult returns to Lyons Ferry Fish Hatchery (FH) from Ice Harbor Dam, Kalama Falls FH, to the Lyons Ferry FH ladder, and the total count past Ice Harbor Dam from 1984 to 1989.

Year	Collection point	Number collected		Ice Harbor Dam count	
		adults	jacks	adults	jacks
1984	Lyons Ferry FH	0	0	1,410	642[a]
	Ice Harbor Dam	663	97		
	Kalama Falls FH	220	10		
1985	Lyons Ferry FH	6	4,070[b]	2,046	7,119
	Ice Harbor Dam	589	90		
	Kalama Falls FH	952	0		
1986	Lyons Ferry FH	245	1,125	3,152	2,665
	Ice Harbor Dam	212	23		
	Kalama Falls FH	576	0[c]		
1987	Lyons Ferry FH	1,654	543	6,812	1,619
	Ice Harbor Dam	1,613	47		
1988	Lyons Ferry FH	327	1,053	3,847	2,035
	Ice Harbor Dam	1,076	6		
1989	Lyons Ferry FH	704	670	4,638	1,352
	Ice Harbor Dam	1,179	0		

[a] *Classification of adults and jacks is based upon size only.*

[b] *The first release from Lyons Ferry FH was in 1985 (1983 brood) therefore, first returns of hatchery-reared stock to Lyons Ferry FH were 2 year old jacks in 1985.*

[c] *The last year adults returned to Kalama Falls FH was 1986.*

Table 3. Numbers of fall chinook salmon trapped at Ice Harbor Dam and hauled to Lyons Ferry Fish Hatchery, duration of trapping, and peak day of trapping from 1984 through 1989.

Year	Number trapped		Duration of trapping	Peak trapping day	
	adults	jacks		date	number
1984	663	97	1 Sep - 5 Oct	11 Sep	57
1985	589	90	31 Aug - 30 Sep	9 Sep	68
1986	212	23	4 Sep - 3 Oct	18 Sep	24
1987	1,613	47	2 Sep - 11 Oct	26 Sep	97
1988	1,076	6	3 Sep - 11 Oct	15 Sep	67
1989	1,179	0	2 Sep - 11 Oct	26 Sep	78

2.2: Coded-Wire Tag Recoveries

2.2.1: Preliminary analysis of returns

In 1989, 14 out of a possible 15 separate treatment (release) groups returned to the Lyons Ferry FH rack:

1) 1983 brood yearling (age 1+) on-station release,
2) 1984 brood yearling on-station release,
3) 1984 brood subyearling (age 0) on-station release,
4) 1985 brood subyearling on-station release,
5) 1985 brood subyearling transport (below Ice Harbor Dam) release,
6) 1985 brood yearling on-station release,
7) 1985 brood yearling transport release,
8) 1986 brood subyearling on-station release,
9) 1986 brood subyearling transport release,
10) 1986 brood yearling on-station release,
11) 1986 brood yearling transport release,
12) 1987 brood subyearling on-station release,
13) 1987 brood yearling on-station release, and
14) 1987 brood yearling transport release.

The 1987 brood subyearling transport release group was not represented. Groups 2 through 11 contributed to the 1989 sport and commercial fisheries (Table 4). Each release group was differentially marked with coded-wire tags (CWT, Appendix B). The breakdown of CWT recoveries by release group is presented in Appendix C. Seidel and Bugert (1988) describe the experimental design for the fall chinook salmon release groups.

2.2.2: Lyons Ferry Hatchery returns

Representatives of all release groups from the 1983 through 1986 broods returned to Lyons Ferry FH in 1989 (Table 5). The 1985 and 1986 year classes comprised a majority of the returns; the numbers returned for those year classes were nearly equal (Figure 3, Table 6). Actual age distributions of returning fall chinook salmon to Lyons Ferry FH are based on scale impressions and verified with CWT recoveries.

Table 4. Preliminary coded-wire tag recoveries from contribution to various fisheries, returns to the hatchery rack, and fish trapped at Lower Granite Dam for 1983 through 1987 broods Lyons Ferry fall chinook salmon. Results are compared by type of release and year of recovery.

Brood year release group	Year recovered	Fishery contribution observed	Fishery contribution expanded	Hatchery returns	Lower Granite Dam
1983					
yearling on-station	1985	70	164	1,970	52
	1986	648	2,229	670	81
	1987	3,112	14,334	1,422	0[a]
	1988	562	2,253	275	0
	1989	0	0	1	- -[b]
	Total	4,392	18,980	4,338	133
1984					
subyearling on-station	1986	27	92	34	115
	1987	128	462	118	2
	1988	136	507	59	0
	1989	16	60	3	- -
	Total	387	1,121	214	117
yearling on-station	1986	2	6	49	8
	1987	47	195	91	6
	1988	266	936	98	0
	1989	106	385	20	- -
	Total	421	1,522	258	14
1985					
subyearling on-station	1987	3	14	18	32
	1988	17	52	20	0
	1989	60	248	5	- -
	Total	80	314	43	32
subyearling transport	1987	1	4	6	0
	1988	19	69	11	0
	1989	40	154	15	- -
	Total	60	227	32	0
yearling on-station	1987	6	28	129	28
	1988	74	217	116	15
	1989	448	1,708	71	- -
	Total	528	1,953	316	43
yearling transport	1987	8	32	112	4
	1988	92	304	117	4
	1989	439	1,630	75	- -
	Total	539	1,966	304	8

[a] Only jacks (less than 55 cm fork length) were collected at Lower Granite Dam, providing an accurate estimate for returns as two or three year olds only.

[b] Fall chinook salmon were not collected at Lower Granite Dam in 1989.

Table 4, continued.

Brood year release group	Year recovered	Fishery contribution observed	Fishery contribution expanded	Hatchery returns	Lower Granite Dam
1986					
subyearling on-station	1988	3	10	24	0
	1989	44	195	16	- -
	Total	47	205	40	0
subyearling transport	1988	16	55	129	13
	1989	93	337	38	- -
	Total	109	392	167	13
yearling on-station	1988	1	3	94	0
	1989	48	171	29	- -
	Total	49	174	123	0
yearling transport	1988	0	0	134	0
	1989	50	194	31	- -
	Total	50	194	165	0
1987					
subyearling on-station	1989	0	0	2	- -
subyearling transport	1989	0	0	0	- -
yearling on-station	1989	0	0	6	- -
yearling transport	1989	0	0	25	- -

Table 5. Number (and percent) of coded-wire tag recoveries by treatment (release) group and return year at Lyons Ferry Fish Hatchery.

Brood year	Release group	Number marked	Coded-wire tags recovered					Total
			1985	1986	1987	1988	1989	
1983	yearling on-station	334,442	1,970 (0.59)	670 (0.20)	1,422 (0.43)	275 (0.08)	1 (0.01)	4,338 (1.30)
1984	subyearling on-station	234,985	- -	34 (0.01)	118 (0.05)	59 (0.03)	3 (0.01)	214 (0.09)
	yearling on-station	258,355	- -	49 (0.02)	91 (0.04)	98 (0.04)	20 (0.01)	258 (0.10)
1985	subyearling on-station	246,625	- -	- -	18 (0.01)	20 (0.01)	5 (0.01)	43 (0.02)
	subyearling transport	245,561	- -	- -	6 (0.01)	11 (0.01)	15 (0.01)	32 (0.01)
	yearling on-station	152,479	- -	- -	129 (0.08)	116 (0.08)	71 (0.05)	316 (0.21)
	yearling transport	156,036	- -	- -	112 (0.07)	117 (0.07)	75 (0.05)	304 (0.19)
1986	subyearling on-station	251,646	- -	- -	- -	24 (0.01)	15 (0.01)	39 (0.02)
	subyearling transport	255,998	- -	- -	- -	129 (0.05)	38 (0.01)	167 (0.07)
	yearling on-station	117,705	- -	- -	- -	94 (0.08)	29 (0.02)	123 (0.10)
	yearling transport	120,804	- -	- -	- -	134 (0.11)	31 (0.03)	165 (0.14)
1987	subyearling on-station	248,739	- -	- -	- -	- -	2 (0.01)	2 (0.01)
	subyearling transport	245,749	- -	- -	- -	- -	0	0
	yearling on-station	115,350	- -	- -	- -	- -	6 (0.01)	6 (0.01)
	yearling transport	119,217	- -	- -	- -	- -	25 (0.02)	25 (0.02)

Table 6. Comparison of age composition (and percent of total) for fall chinook salmon broodstock since Lyons Ferry Fish Hatchery began operations. Numbers include both voluntary returns to the hatchery and fish trapped at Ice Harbor Dam.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Total
1984	0	278	401	67	-	746
	(0)	(37)	(54)	(9)		(100)
1985	4,147	71	442	95	-	4,755
	(87)	(2)	(9)	(2)		(100)
1986	157	1,344	63	41	-	1,605
	(10)	(83)	(4)	(3)		(100)
1987	563	453	2,823	18	-	3,857
	(15)	(12)	(72)	(1)		(100)
1988	781	444	647	583	-	2,455
	(32)	(18)	(26)	(24)		(100)
1989	277	982	957	248	18	2,482
	(11)	(39)	(39)	(10)	(1)	(100)

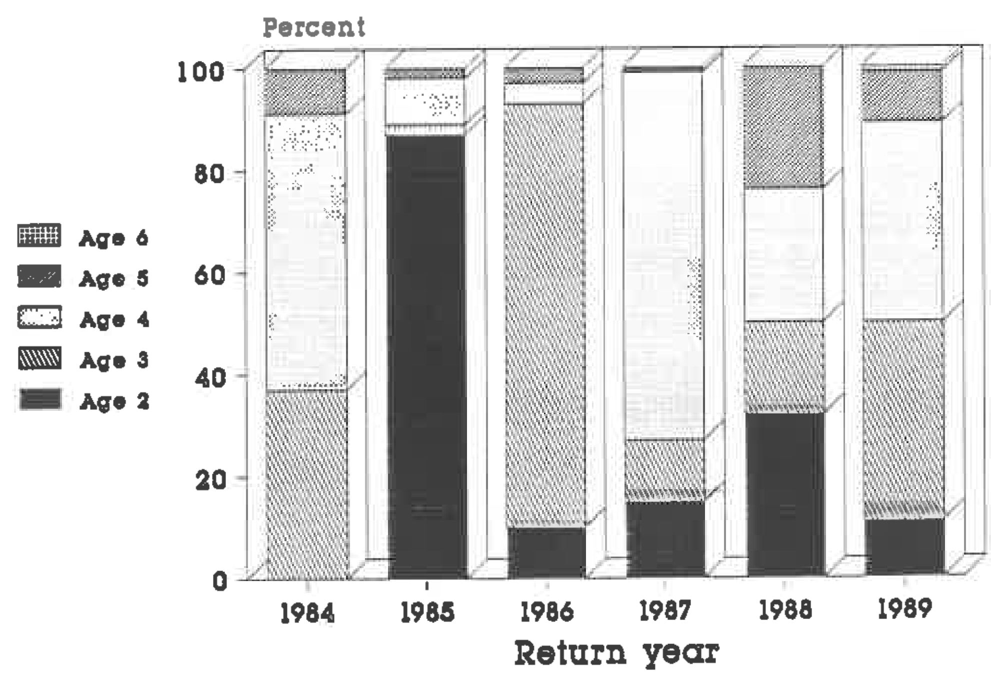

Figure 3. Comparison of fall chinook salmon age class contribution by year, 1984 to 1989, at Lyons Ferry FH.

2.2.3: Fishery contribution

To date, eleven release groups have contributed to catches in commercial and sport fisheries (release groups 1 through 11). These groups were represented in a wide geographic distribution, ranging from California to Alaska (Table 4 and Appendix C).

2.2.4: Snake River sport fishery

In 1987, WDF adopted a fall chinook salmon jack (less than 71 cm) sport fishery in the Snake River from Lower Monumental Dam upstream to the Palouse River confluence (adjacent to Lyons Ferry FH). The fishery regulations were changed in 1989: 1) the length restriction was changed to 61 cm to protect small age 4 females, and 2) the open area was extended downstream to the Snake River mouth, to increase angling opportunities. In the three years of this fishery, no coded-wire tags have been recovered. Based upon a 2.6 expansion of punch card data, we estimate 69 jacks were caught in 1987, and 14 jacks were caught in 1988 (Hoines, personal communication). Punch card data for 1989 were not available at time of this report. No creel surveys have been conducted on this fishery since it began in 1987.

2.2.5: Discussion

To date, we see no consistent difference in survival and contribution between the on-station and transported release groups within both the subyearling and yearling categories (Table 7). In general, yearling release groups have survived better than subyearling releases, regardless of release location. Actual numbers of adults produced, however, appear to be the same. For the 1984 brood year, based upon recoveries through age 5, Lyons Ferry FH was equally effective releasing 539,000 subyearlings at 67- 85 fish per pound (fpp) as releasing 482,000 yearlings at 8 fpp. The expanded contribution and survival rate for the subyearlings was 3,333 fish (1,452 CWT recoveries divided by 0.4356 CWT rate); the expanded value for the yearlings was 3,346 fish (1,794 CWT recoveries divided by 0.5361 CWT rate). For the 1984 brood year, more subyearlings were harvested as 2 and 3 year olds, whereas more yearlings were harvested as 4 and 5 year olds.

We see a large difference in survival between Snake River release years. The 1983 brood yearling and 1984 brood subyearling release groups outmigrated in 1985, and survived much better than release groups from the 1986 and 1987 runoff years (it should be noted, however, that all age classes from the latter releases have not returned, and this interpretation is preliminary). We see no obvious differences in flow, spill (both magnitude and duration), or both water temperature and turbidity in the Columbia and Snake Rivers between 1985 and other runoff years that would account for this large difference in survival.

The 1986 releases (which include the 1984 yearling and 1985 subyearling broods) have shown relatively poor survival. Compared to other release years, the subyearlings released in 1986 experienced higher flows, higher dissolved gas levels, and higher water turbidity (USACE 1986). Branded fish from this subyearling release group had a later peak passage date, and longer duration of passage at both Lower Monumental and McNary Dams (Fish Passage Center 1988).

Table 7. Percent returns to the LSRCP project area and overall survival (returns and fisheries contribution) of 1983 through 1987 broods fall chinook salmon released as subyearlings and yearlings at Lyons Ferry FH and transported below Ice Harbor Dam.

Brood year	Subyearling		Yearling	
Survival (%)	On-station	Transport	On-station	Transport
1983				
Project area	- -	- -	1.34	- -
Overall	- -	- -	7.01	- -
1984				
Project area	0.14	- -	0.11	- -
Overall	0.62	- -	0.69	- -
1985				
Project area	0.03	0.01	0.24	0.20
Overall	0.16	0.11	1.52	1.46
1986				
Project area	0.02	0.07	0.10	0.14
Overall	0.10	0.22	0.25	0.30
1987				
Project area	0.01	0.00	0.01	0.02
Overall	0.01	0.00	0.01	0.02

2.3: Fall Chinook Stock Profile Characteristics

2.3.1: Adult returns

From 6 September through 4 December 1989, 1,883 fall chinook salmon adults and 670 jacks (fish less than 61 cm fork length) were collected at Lyons Ferry FH. Duration of returns was similar to 1988 adult returns, and two weeks longer than in 1986 and 1987. Fish were spawned, and scales were sampled from 21 October to 22 November, with a total of 749 scale samples taken (29 percent; Figure 4). Predominant age classes in 1989 were 3 and 4 year olds; dominant ages have varied yearly depending upon year class strength (Figure 3).

Table 8. Age composition by sex of adult fall chinook salmon sampled at Lyons Ferry Fish Hatchery, 1989.

Sex	Age 2	3	4	5	6	Total
Male	277	835	397	70	3	1,582
Female	0	147	560	178	15	900
Total	277	982	957	248	18	2,482[a]

[a] *This information was extrapolated from a sample of 749 fish.*

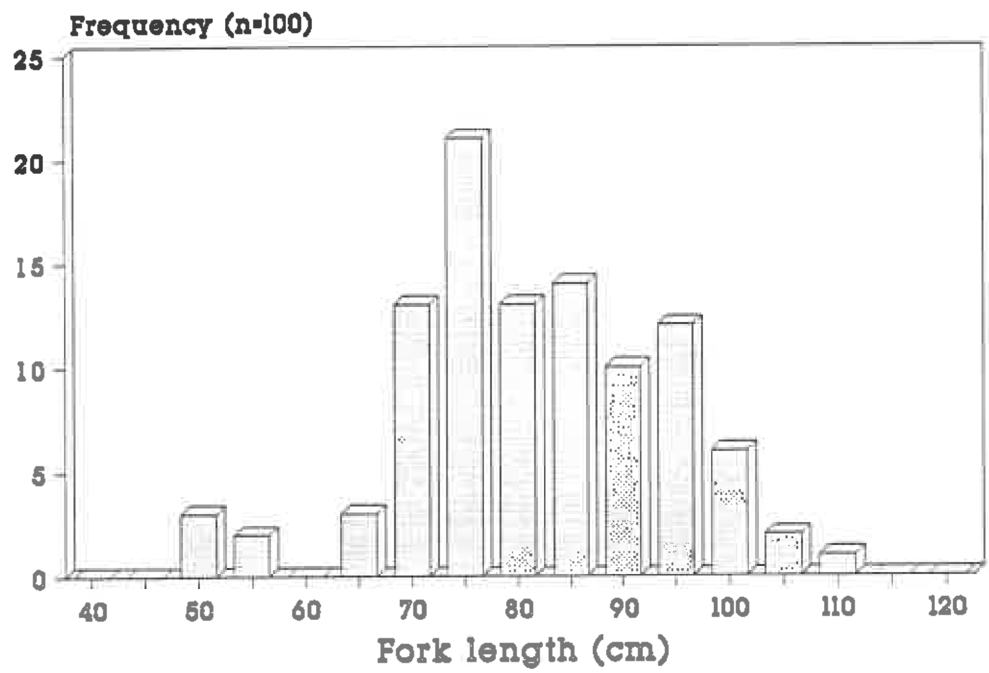

Figure 4. Length frequency distribution of fall chinook salmon sampled at Lyons Ferry Fish Hatchery in 1989.

The ratio of females to males for all age classes in 1989 was 0.57:1.00 (900:1,582). The 1988 ratio was 0.44:1.00 (749:1706). The average female:male ratio since 1977 is 1.03:1.00. Sex ratios vary yearly depending upon jack returns (Figure 5). Average fecundity and egg size for 1989 adult fall chinook salmon was 4,315 eggs/female and 1,574 eggs/pound (0.28 grams/egg), respectively. Average fecundity of Snake River stock fall chinook salmon since inception of the egg bank program in 1977 is 4,316. Fecundity values were determined by dividing the total number of eggs taken by the number of females spawned.

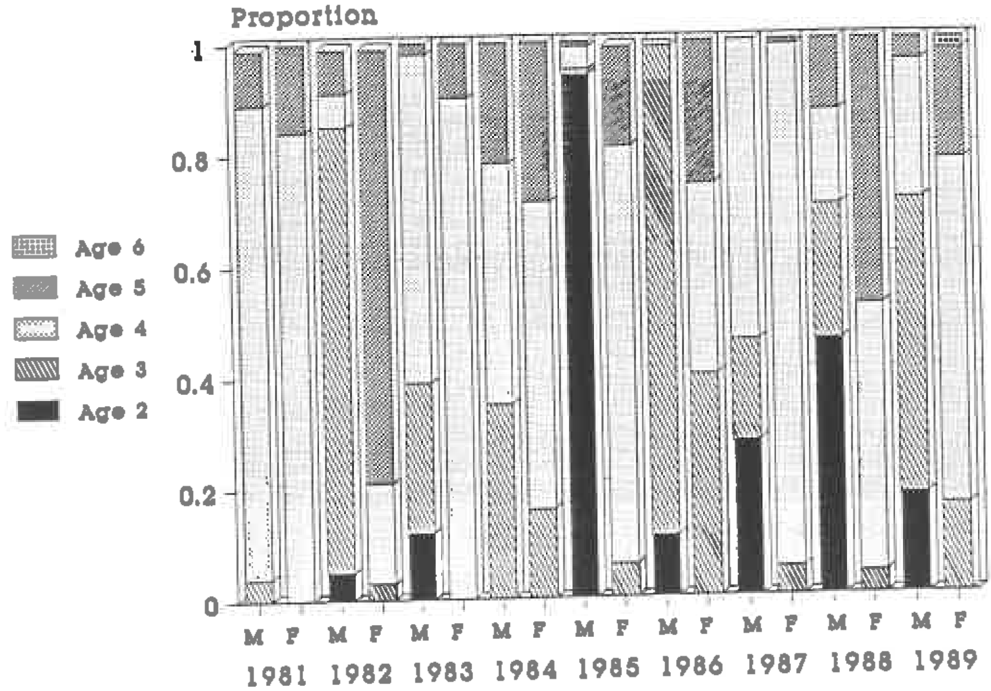

Figure 5. Relative composition of Snake River fall chinook salmon returns by age and sex since 1981.

Program staff collected 100 electrophoretic samples of adult fall chinook salmon at Lyons Ferry FH in 1989. This represents the sixth year of stock profile analysis using electrophoresis. We also collected 100 1988 brood fall chinook salmon parr for morphometric analysis and 50 1988 brood fall chinook salmon parr for meristic analysis. We used the techniques for electrophoretic and morphometric research presented in our FY 1987 report. The meristic analysis is similar to Leary et al. (1985); this approach is outlined in Section 3.2 of this report. We also collected otoliths from 100 Lyons Ferry adults.

2.3.2: Stray stocks entering Lyons Ferry Hatchery

We have noticed a steady increase in the percentage of stray fall chinook salmon entering Lyons Ferry FH since 1987. Our analysis of CWT recovered at Lyons Ferry FH using standard expansion techniques shows that strays comprise 7.44 percent of the return in 1987, 16.01 percent in 1988, and 43.47 percent in 1989 (these percentages include all age classes). Umatilla River releases of Upriver Bright fall chinook salmon are the predominant strays to Lyons Ferry FH (Table 9). Low flows and high water temperatures in lower Umatilla River probably discourage the salmon from entering this stream; the Snake River is the next major left bank tributary to the Columbia River these salmon would encounter when migrating upstream. In 1989, Upriver Bright strays also included mid-Columbia (wild Hanford, Rock Creek, and Priest Rapids) and Yakima stocks (Appendix D). We do not know if stray salmon were trapped at Ice Harbor Dam at a different rate than voluntary returns to Lyons Ferry FH.

Table 9. Origin of fall chinook salmon Upriver Bright returns (all age groups) to Lyons Ferry Fish Hatchery in 1987, 1988, and 1989.

Return year	Lyons Ferry stock	Umatilla origin	Other stocks	Total
1987	3,570	217	70	3,857
1988	2,062	299	94	2,455
1989	1,403	799	280	2,482

2.4: Lyons Ferry Hatchery Practices

2.4.1: Spawning and rearing

Duration of 1989 fall chinook salmon spawning was from 21 October through 16 December (Table 10). Peak of spawning was 11 November. The egg take was 3,518,107, with an initial mortality rate of 5.75 percent (Table 11).

Table 10. Collection and spawning summary for 1989 fall chinook salmon broodstock at Lyons Ferry Fish Hatchery.

Week ending	Arrivals adult	Arrivals jacks	Mortality M	Mortality F	Mortality J	Spawned M	Spawned F	Estimated egg take
09 Sep	166	2						
16 Sep	245	2		1				
23 Sep	405	30						
30 Sep	358	71	4	6				
07 Oct	218	87	2	2				
14 Oct	91	67		1				
21 Oct	64	104	7	4	2		12	48,000
28 Oct	160	136	11	3	6		46	180,000
04 Nov	74	103	6	7		12	154	612,000
11 Nov	88	39	10	4	9	75	226	896,000
18 Nov	41	19	50	9	11	159	187	740,000
25 Nov	19	5	70	7	20	149	112	440,000
02 Dec	9	5	94	6	37	240	74	292,000
09 Dec	1		17	1	3	47	33	128,000
16 Dec			9	2	3	16	3	12,000
Totals	1,939[a]	670	280	53	89	700	847	3,348,000[b]

[a] *In-season escapement is estimated, and classification of adults and jacks at time of arrival was based on size only. Coded-wire tag and scale impression data revised escapement to 1,880 adults and 602 jacks.*

[b] *Corrected egg take after shocking was 3,518,107.*

Table 11. Duration and peak of spawning, egg take, and percent egg mortality at Lyons Ferry Fish Hatchery since it began operations.

Year	Spawning duration	Peak of spawning	Egg take	Percent egg loss
1984	8 Nov - 5 Dec	21 Nov	1,567,823	21.58
1985	2 Nov - 14 Dec	7 Nov	1,414,342	3.99
1986	22 Oct - 17 Dec	19 Nov	592,061	3.98
1987	20 Oct - 14 Dec	17 Nov	5,957,976	3.82
1988	18 Oct - 6 Dec	12 Nov	2,926,748	3.41
1989	21 Oct - 16 Dec	11 Nov	3,518,107	5.75

2.4.2: Disease incidence

The 1989 adult fall chinook salmon were given flush treatments of formalin (1:7,000) for fungus infection. Female adults were injected once with a broad-spectrum antibiotic to treat for bacterial kidney disease (BKD). In routine inspections of adults, WDF pathologist noted the presence of BKD in 3 of 23 salmon sampled, and 11 of 20 salmon sampled had infestations of *Ceratomyxa shasta*.

The 1988 brood fall chinook salmon had minor outbreaks of BKD and bacterial gill disease (BGD, Table 12). The 1988 brood yearlings had erythrocytic inclusion body syndrome (EIBS) from August through October 1989. Throughout the rearing period, WDF pathologists noted low to moderate anemia in these fish, often at times when EIBS virus was not present. The 1988 brood yearlings had Coldwater disease (CWD) in August, which was probably associated with EIBS incidence (Chapman, personal communication). The 1989 brood fall chinook salmon had no obvious pathological problems during the report period.

Monthly mortality rates for the 1988 and 1989 broods during this study period averaged 1.66 percent (range: 0.41 - 3.36, n = 12) and 0.21 percent (range: 0.10 - 0.33, n = 3), respectively. Overall (egg to smolt) mortality rates for the subyearling and yearling release groups have decreased since 1984 (Table 13).

Table 12. Incidence, date, location, and treatment of diseases for 1988 and 1989 broods fall chinook salmon contracted at Lyons Ferry Fish Hatchery.

Brood year	Date	Disease	Pond numbers	Treatment
1988	01/89	Fungus	Incubation room	Formalin
	03/89	BGD	3 to 12	Diquat
	04/89	BGD	3 to 12, 17, 18	Diquat
	05/88	BGD	11 to 26, 9	Diquat
	06/89	BKD	11 to 14	Gallimycin
	07/89	BKD	11 to 14	Gallimycin
	08/89	CWD	11 to 14	Terramycin
	12/89	BKD	13 to 28	Gallimycin
	01/90	BKD	13 to 28	Gallimycin
	02/90	BKD	13 and 14	Gallimycin
	03/90	BKD	13 and 14	Gallimycin
1989	10/89	Fungus	Incubation room	Formalin
	11/89	Fungus	Incubation room	Formalin
	12/89	Fungus	Incubation room	Formalin
	03/90	BKD	29	Gallimycin

Table 13. Lyons Ferry fall chinook salmon overall (egg to smolt) mortality rates, with monthly ranges, for the 1984 through 1988 brood years. Values are percentages with sample sizes (n).

Brood year	Subyearling (Monthly range, n)	Yearling (Monthly range, n)
1984	13.78	16.49
	(0.24 - 7.99, 4)	(0.03 - 7.99, 15)
1985	12.65	13.77
	(0.55 - 4.81, 4)	(0.11 - 4.81, 15)
1986	10.95	15.31
	(0.25 - 4.95, 4)	(0.23 - 4.95, 15)
1987	9.11	11.41
	(0.73 - 3.75, 4)	(0.17 - 3.75, 15)
1988	6.42	11.16
	(0.10 - 2.73, 4)	(0.41 - 3.36, 15)

2.5: Smolt Releases

Hatchery staff planted 413,017 yearling (1987 brood) fall chinook salmon in April 1989 and 1,765,433 subyearling (1988 brood) fall chinook salmon in June 1989 (Table 14). Of the yearling group, 293,202 fall chinook salmon were released from Lyons Ferry FH, and 119,815 were transported by barge for release below Ice Harbor Dam. Lyons Ferry FH staff released 1,095,602 subyearling fall chinook salmon on-station and transported 669,831 subyearlings below Ice Harbor Dam. Our experimental design for fall chinook salmon releases is a 2x2 factorial treatment of yearlings and subyearlings released both on-station and transported by barge to be released immediately downstream of Ice Harbor Dam (Seidel and Bugert 1988). In the first 3 years of operations at Lyons Ferry FH (1984 to 1986), we did not have sufficient eggtakes to meet minimum CWT sample size to perform all treatment groups (Appendix B). Since 1987, we had enough smolts on a yearly basis to perform all 4 treatments.

2.5.1: Yearling releases

On-station group Mean length and coefficient of variation for the yearling (1987 brood) fall chinook salmon released at Lyons Ferry FH were 145.0 mm and 14.2, respectively (Figure 6). The date of release (14 April) was coordinated with the Corps of Engineers for a controlled spill (70 percent of instantaneous discharge) at Lower Monumental Dam from 1800 to 0600 hours nightly beginning 16 April. Snake River water temperature at time of release was 8.3° C. Mean gill Na+K+ ATP-ase levels two weeks prior to release and at time of release were 25.4 and 28.3, respectively (n=20, Rondorf, personal communication).

Transport group Fish were loaded into the barge on 20 April and were released adjacent to the lower navigation wing wall at Ice Harbor Dam the following day. Water temperature was 11.1° C. during transport. Water was continuously pumped through the barge during the transport to aid fish in olfactory acclimation to the Snake River. Fish were not measured at time of release; mean length and coefficient of variation of these fish two weeks prior to release were 148.5 mm and 9.6, respectively (Figure 7).

2.5.2: Subyearling releases

On-station group Mean length and coefficient of variation for the subyearling (1988 brood) fall chinook salmon released from Lyons Ferry FH were 81.4 mm and 10.4, respectively (Figure 8). The date of release (8 June) was coordinated with the Corps of Engineers for a controlled spill (100 percent of instantaneous discharge) at Lower Monumental Dam. Snake River water temperature during release was 14.4° C. Mean gill Na+K+ ATP-ase levels one month, two weeks, and a few days prior to release were 10.1, 16.3, and 18.0, respectively (n=20, Rondorf, personal communication).

Transport group Fish were loaded into the barge on 14 June and were released adjacent to the lower navigation wing wall at Ice Harbor Dam the following day. Water temperature at Ice Harbor Dam at time of release was 15.6° C. Water was continuously pumped through the barge during the transport to aid fish in olfactory acclimation to the Snake River. Fish were measured two weeks prior to release; mean length and coefficient of variation were 81.2 mm and 10.46, respectively (Figure 9).

Table 14. Summary of 1987 and 1988 broods fall chinook salmon releases from Lyons Ferry Fish Hatchery in 1989. Data are summarized by release site, number and weight of fish planted, coded-wire tag (CWT) or freeze brand and marks, number of fish per pound (FPP), mean length (mm), coefficient of variation (CV), and condition factor (Kfactor) at time of release.

Age brood year	Release site	Number planted	Pounds planted	Marks and tag code	FPP	Length	CV	Kfactor
Subyearlings	On-station	113,193	1,257	Ad + CWT 6302/28 R6[a]	90	81	10.40	0.94
1988 brood	On-station	113,285	1,259	Ad + CWT 6302/26 R6	90	81	10.40	0.94
	On-station	4,151	46	Ad only	90	81	10.40	0.94
	On-station	36,488	406	Unmarked	90	81	10.40	0.94
	On-station	828,485	8,663	Unmarked	96[b]	- -	- -	- -
	On-station	39,991	580	Brand LA/U/1[c]	69	86	16.44	- -
	On-station	40,025	580	Brand LA/U/3	69	86	16.44	- -
subtotal		1,175,618	12,791					
	Ice Harbor	116,935	1,559	Ad + CWT 6352/07 R6	75	81	10.46	1.17[d]
	Ice Harbor	117,168	1,562	Ad + CWT 6352/04 R6	75	81	10.46	1.17
	Ice Harbor	6,249	84	Ad only	75	- -	- -	- -
	Ice Harbor	42,415	566	Unmarked	75	- -	- -	- -
	Ice Harbor	173,595	2,755	Unmarked	63	- -	- -	- -
	Ice Harbor	125,091	1,060	Unmarked	118	- -	- -	- -
	Ice Harbor	88,378	982	Unmarked	90	- -	- -	- -
subtotal		669,831	8,568					
Total 1988 brood		1,845,449	21,359					
Yearlings	On-station	57,756	5,776	Ad + CWT 6347/52 R6	10	145	14.20	1.24
1987 brood	On-station	57,594	5,759	Ad + CWT 6347/56 R6	10	145	14.20	1.24
	On-station	116	12	Ad only	10	145	14.20	1.24
	On-station	26,050	2,605	Brand LD/7U/1	10	145	14.20	1.24
	On-station	12,994	1,299	Brand LA/7U/3	10	145	14.20	1.24
	On-station	138,692	13,869	Unmarked	10	145	14.20	1.24
subtotal		293,202	29,320					
	Ice Harbor	59,608	5,961	Ad + CWT 6347/50 R6	10	148	9.55	1.16[d]
	Ice Harbor	59,609	5,961	Ad + CWT 6347/55 R6	10	148	9.55	1.16
	Ice Harbor	598	60	Ad only	10	148	9.55	1.16
subtotal		119,815	11,982					
Total 1987 brood		413,017	41,302					

[a] Six unique codes were given within this tag code to provide statistical replication.

[b] Six separate unmarked lots of subyearlings were released; sizes ranged from 68 to 122 fpp (mean; 96).

[c] Freeze branded fish were released on-station in conjunction with the Fish Passage Center to assess travel time through lower Snake and Columbia Rivers' sampling stations.

[d] Lengths of transported fish were taken two weeks prior to release.

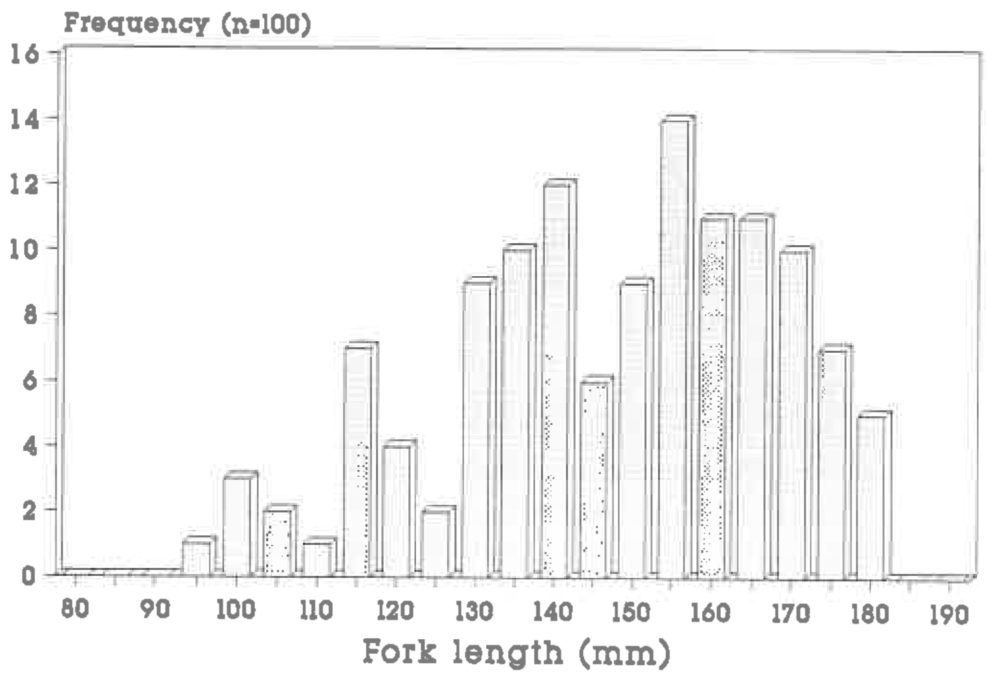

Figure 6. Length frequency distribution of yearling fall chinook salmon released at Lyons Ferry Fish Hatchery in April 1989.

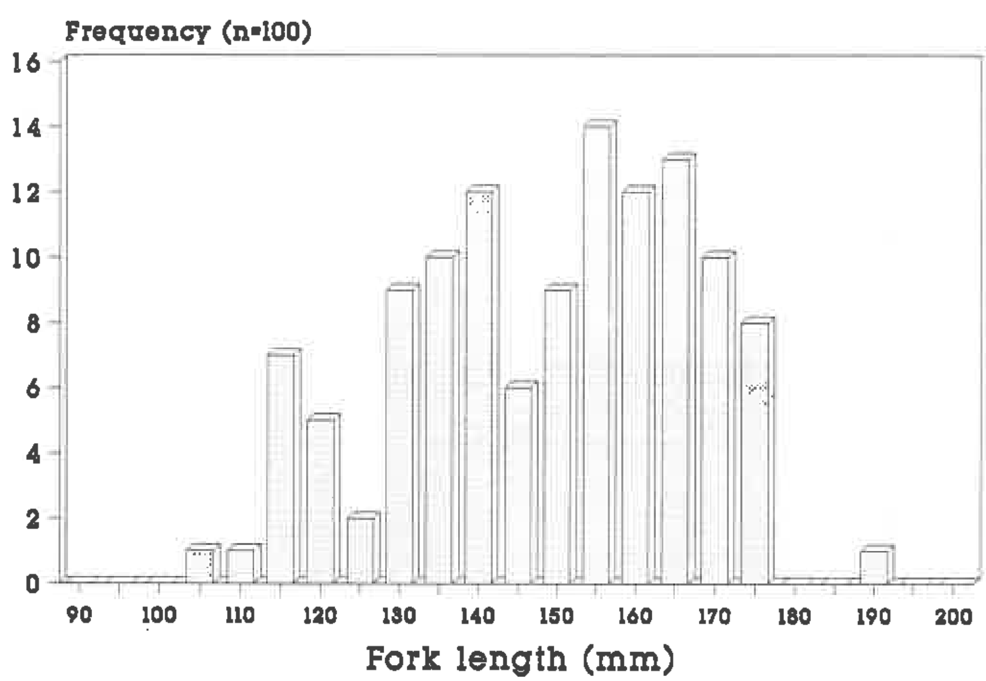

Figure 7. Length frequency distribution of yearling fall chinook salmon transported below Ice Harbor Dam in April 1989. Fish were measured two weeks prior to release.

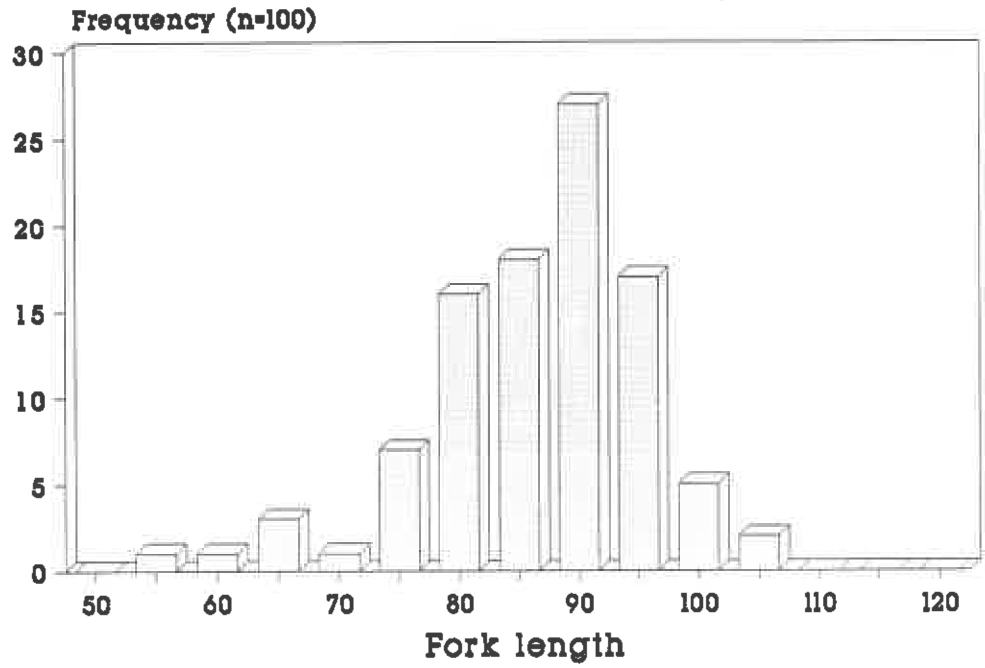

Figure 8. Length frequency distribution of subyearling fall chinook salmon released from Lyons Ferry Fish Hatchery in June 1989.

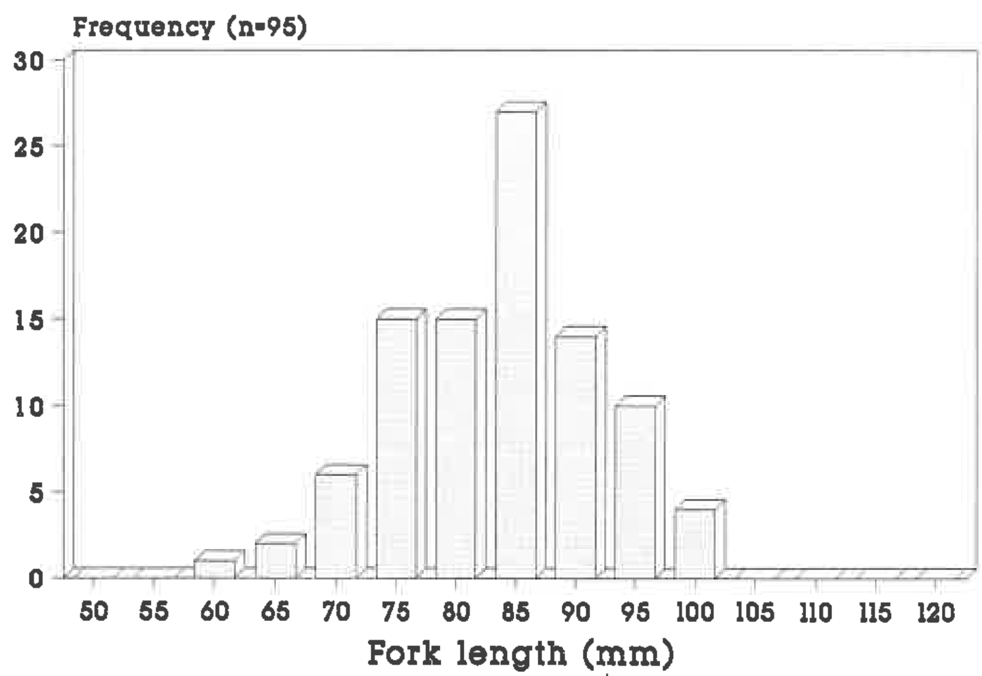

Figure 9. Length frequency distribution of subyearling fall chinook salmon transported below Ice Harbor Dam in June 1989. Fish were measured two weeks prior to release.

2.5.3: Fish passage

Yearling salmon Branded yearling fall chinook released from Lyons Ferry FH on 14 April began arriving at Lower Monumental Dam on 16 April. Controlled spill at Lower Monumental Dam was 70 percent of instantaneous discharge 12 hours/day from 16 April to 31 May (46 days). Controlled spill at Ice Harbor Dam was 25 percent of instantaneous discharge 12 hours/day from 20 April to 31 May (43 days).

Travel time of the branded yearling fall chinook from Lyons Ferry FH to McNary Dam ranged from 7.8 to 8.7 km/day. Flows on the Snake River during this period averaged 104.1 kcfs. The duration of the middle 80 percent passage of the branded release group at Lower Monumental Dam was 14 days (10 percent passage; 17 April, 90 percent passage; 30 April). Peak day of passage was 20 April. Duration of the middle 80 percent passage at McNary Dam was 16 days (10 percent passage; 25 April, 90 percent passage; 10 May). Peak day of passage was 1 May. The 80 percent passage period for branded yearling salmon from Lyons Ferry FH was about five days earlier, and a week shorter, than all yearling chinook salmon sampled at McNary Dam (Fish Passage Center 1990, Johnsen et al. 1990).

Subyearling salmon Branded subyearling fall chinook released from Lyons Ferry FH on 8 June began arriving at Lower Monumental Dam on 9 June. Controlled spill at Lower Monumental Dam was 70 percent of instantaneous discharge for 12 hours/day from 11 June through 1 July, and then 100 percent through 22 July. Spill at Ice Harbor Dam occurred from 13 June through 22 July at 25 percent of instantaneous discharge for 12 hours/day. Spill for both the yearling and subyearling groups terminated at the projected 90th percentile of spring and summer outmigrants, respectively.

Travel time of branded subyearling fall chinook from Lyons Ferry FH to McNary Dam ranged from 7.4 to 7.8 km/day. Snake River flow during this period averaged 81.6 kcfs. Travel time of the subyearlings between McNary and John Day Dams ranged from 12.3 to 17.6 km/day (Fish Passage Center 1990). The duration of the middle 80 percent passage of the branded release group at Lower Monumental Dam was 18 days (10 percent passage; 10 June, 90 percent passage; 28 June). Peak day of passage was 23 June. Duration of the middle 80 percent passage at McNary Dam was 22 days (10 percent passage; 20 June, 90 percent passage; 12 July). Peak day of passage was 28 June. The 80 percent passage period for branded subyearling salmon from Lyons Ferry FH was about 10 days shorter than, and within the 80 percent window for all subyearling chinook salmon sampled at McNary Dam (Fish Passage Center 1990, Johnsen et al. 1990).

2.6: Natural Production

In November 1989, the Nez Perce Tribe, Idaho Power Company, Oregon Department of Fish and Wildlife, and WDF cooperatively surveyed the Snake River from Asotin (RK 236) to Hells Canyon Dam (RK 400), and all its tributaries believed to be used by fall chinook salmon adults. Surveys were made with a Hiller 12E helicopter, except for Alpowa Creek, Tucannon River, and Palouse River, which were surveyed on foot.

Above Lower Granite Dam The mainstem Snake River was surveyed on 13 and 27 November 1989. The final tally for both counts was 58 redds and 27 adults (Table 15), compared to 57 redds and 19 adults in 1988, and 66 redds and 13 adults in 1987.

Table 15. Number and location of fall chinook salmon redds and adults seen on the mainstem Snake River in 1989.

River km	Proximal landmark	13 November count		27 November count	
		Redds	Adults	Redds	Adults
240.6	Tenmile Rapids			1	
245.5	Tenmile Canyon			1	1[a]
246.3	No proximal landmark	20	15	3	6
253.4	Couse Creek Range			1	
262.4	Captain John Creek	1			
266.8	Billy Creek	1		1	
274.2	Lewis Point	1			
284.4	*Washington/Oregon border*				
289.3	Big Cougar Creek	1			
312.4	Divide Creek	5			
320.9	Deep Creek	3	1		
336.1	Lookout Creek	1			1
345.0	Pleasant Valley Creek			2	
351.8	Durham Rapids	1			
359.9	Suicide Rock	4	3		
381.1	Hat Creek	3			
384.4	Saddle Creek	1	1		
385.4	Below Cache Creek	2			
388.6	Rock Bar	3			
393.3	Warm Springs	1			
395.3	Bush Creek	1			
Totals		49	20	9	8

[a] *carcass*

Conditions were excellent on the first flight, and good on the second flight. Virtually all redds seen on the first flight were not visible by the second flight, which necessitated two independent surveys. Discharge from Hells Canyon Dam for the day of the first survey was maintained at 9,132 cfs throughout the flight. Mean flow for the day of the second flight was 11,685 cfs, with a range of 8,920 - 18,020. Secchi disk readings were not taken this year.

The Grande Ronde River was surveyed from the mouth to the Wenaha River confluence on 27 November; no redds or fish were seen. We tried to survey the Grande Ronde on 13 November, but were unsuccessful because the river was turbid.

The Imnaha River was surveyed up to Cow Creek (about 10 km) on 13 November; 1 redd was seen. The second count was made up to Horse Creek (about 16 km) on 27 November; no spawning activity was seen.

The Clearwater River was surveyed from the mouth to the North Fork Clearwater confluence on 19 November 1989, and from the mouth to Harpster (on the south fork) on 2 December 1989. Eight redds were seen in the first flight, and two additional redds in the second flight, for a total of ten. All were in the mainstem Clearwater; conditions were good for both flights.

Asotin Creek was surveyed up to Headgate Park (11 km) on 27 November; no redds, live fish or carcasses were seen. Alpowa Creek was surveyed by foot from the mouth to Banner Ranch (1.5 km); no spawning activity was seen.

Fall chinook salmon counts at Lower Granite Dam were 706 adults and 276 jacks by 15 December, the last day of adult counts. The total redd count above Lower Granite Dam in 1989 was 69, resulting in a ratio of about 10 adults per sighted redd, compared to 8 in 1988.

Below Lower Granite Dam The Tucannon River was surveyed by foot weekly from 25 October to 29 November 1989. Most surveys were from the mouth to the 1.3 m high irrigation diversion dam (9.2 km); the 15 November survey extended to Highway 12 (23 km). A total of 48 redds were observed (Table 16). For the third successive year, all redds were downstream of the diversion dam, which appears to be an impediment. Spawning ground density was 5.2 redds/km, compared to 2.8 redds/km in 1988, and 1.7 redds/km in 1987.

We saw six redds on our initial survey of 25 October, one week earlier than the first redd seen in 1988, and observed seven new redds deposited by our last survey on 29 November. From this information, we inferred the duration of spawning to be at least 36 days, compared to 29 days in 1988. We estimate the peak of spawning to be 23 November, compared to 11 November at Lyons Ferry FH. For comparison, the peak spawning dates in 1988 were 16 November on the Tucannon River and 12 November at Lyons Ferry FH and 25 November on the Tucannon River and 17 November at Lyons Ferry FH in 1987.

We found 43 carcasses (26 females, 16 males, and 1 jack), nine of which were marked and recovered for CWT processing. Eight of the marked fish were from Lyons Ferry FH, the other fish was a Umatilla River stray. Fish from seven Lyons Ferry FH release groups comprised the recovered CWTs; six were from on-station releases and two were from transported releases. In 1988, four marked fish were recovered on the Tucannon River; all were released on-station at Lyons Ferry FH.

Table 16. Date, location, and number of fall chinook salmon redds observed, and carcasses recovered on the Tucannon River in 1989.

Survey date	River kilometer	Number of redds	Carcasses recovered females	males
25 Oct	15.6 - 11.6	0		
	11.6 - 6.1	6		
	6.1 - 0.0	1		0
1 Nov	9.4 - 6.1	1		1
	6.1 - 0.0	1		1
8 Nov	9.4 - 4.0	8	2	
	4.0 - 0.0	2		1
15 Nov	22.6 - 15.6	0	0	0
	15.6 - 9.4	0	0	0
	9.4 - 4.0	14	3	2
	4.0 - 0.0	9	3	2
21 Nov	9.4 - 4.0	9	8	4
	4.0 - 0.0	1	1	2
29 Nov	9.4 - 4.0	3	5	1
	4.0 - 0.0	4	4	3
Totals		59[a]	26	17

[a] *Livestock and fishers damaged the redd location markers during the surveys, subsequently, 11 redds were counted twice. We revised the number after the surveys to 48 redds.*

We surveyed the Palouse River from the falls downstream to its confluence with the Snake River on 27 November 1989. Two redds and 4 fish were seen. This is the first year we have documented fall chinook salmon spawning in this stream.

SECTION 3: SPRING CHINOOK SALMON PROGRAM EVALUATION

3.1: Broodstock Establishment

Evaluation and hatchery personnel operated an adult trap adjacent to the Tucannon FH to collect spring chinook salmon broodstock. On a random basis, we collected one fish for every one allowed to pass through the rack for natural spawning.

The first adult arrived at the rack on 15 May; the last adult arrived on 27 June. Peak day of adult arrival was 6 June (compared to 27 May in 1986, 15 May in 1987, and 24 May in 1988). We collected 92 adults and 76 jacks for broodstock, and passed 88 adults and 2 jacks upstream (Table 17). Total escapement to the rack was 180 adults and 78 jacks (compared to 247, 209, and 261 adults in 1986, 1987, and 1988 respectively). This is the first year since 1985 that we did not have sufficient broodstock to meet eggtake requirements. Prior to removal of the rack, we counted 25 adults by snorkel surveys 6.4 km immediately downstream of the rack (compared to 42 in 1987 and 38 in 1988). This adjusts the total Tucannon River spring chinook salmon escapement to 205 adults and 78 jacks.

In 1989, 23 age 4 hatchery fish returned from the program's initial release of 12,922 spring chinook salmon smolts from Tucannon FH (1985 brood year). In 1988, seven age 3 fish from this release group returned. Survival of this release group through age 4 is 0.23 percent. Seventy-two age 3 fish returned in 1989 from the second release of 153,725 smolts from Tucannon FH (1986 brood year). Survival of this release group through age 3 is 0.05 percent, the same as the 1985 brood year release group. No coded-wire tags from either brood years were recovered in commercial or sport fisheries in 1989.

3.2: Stock Profile Characteristics

3.2.1: Tucannon River natural stock

Twenty-eight natural-origin and nine hatchery-origin females were spawned at Tucannon FH in 1989. Average fecundity for the combined group was 3,608 (compared to 3,916 in 1986, 4,095 in 1987, and 3,882 in 1988). Fecundity was determined by dividing the total number of eggs taken by the number of females spawned. Average egg size for the 1989 adults was 1,870 eggs/pound, compared to 1,748 in 1987 and 1,793 in 1988.

We took scales from 78 natural-origin spring chinook salmon at Tucannon FH in 1989. They were mostly age 4 (57 of 78), with two years of their life in the ocean (4/2; Table 18). Mean fork length for all natural-origin fish was 72.7 cm (n = 78; Figure 10). We found the mean fork length for age 4 adults (69.0 cm) to be significantly less than age 5 adults (86.1 cm; unpaired t-test $p<0.05$). We have compared lengths of four year classes and found 80 cm to be a consistent breakoff between age 4 and 5 fish using one standard deviation (Table 19).

Table 17. Escapement, collection, and spawning summary for 1989 spring chinook salmon adults (age 4+) at Tucannon Fish Hatchery.

Week ending	Escapement to the rack	Number passed	Number collected	Mortality M	Mortality F	Spawned M	Spawned F
05/20	17	13	4				
05/27	33	23	10				
06/03	24	14	10				
06/10	60	23	37	1			
06/17	23	10	13		1		
06/24	6	3	3				
07/01	4	2	2				
07/08				1	2		
07/15					1		
07/22							
07/29					1		
08/05							
08/12							
08/19							
08/26					1		1
09/02					2		4
09/09				2	2		16
09/16				6	3	5	13
09/23				1		26	3
Totals	167[a]	88	79[a]	11	13	31	37

[a] *Weekly escapements were estimated; numbers were corrected at end of spawning. Actual numbers were 180 adults escaped to the rack, of which 92 were collected for broodstock.*

Table 18. Sex, mean fork length (cm), and age (from scale impressions) of natural-origin spring chinook salmon sampled at Tucannon Fish Hatchery, 1989 (s= standard deviation, n= sample size).

Sex	Fork length (s, n) at given age 3/2[a]	4/2	5/2	Totals
Female	- -	69.5 (2.9, 25)	83.9 (2.8, 11)	36
Male	46.6(- -, 2)	68.7 (5.1, 32)	89.1 (3.5, 8)	42
Totals	2	57	19	78
Percent	3	73	24	100

[a] *Age 3 with one year in the ocean.*

Table 19. Comparison of fork length (cm), by age of natural adult spring chinook salmon sampled at the Tucannon Fish Hatchery from 1985 through 1989. Values given are mean (x), standard deviation (s), and sample size (n).

Return year	Age 3 (x, s, n)	Age 4 (x, s, n)	Age 5 (x, s, n)
1985	- -	74.5, 5.7, 19	86.6, 2.9, 8
1986	63.0, - -, 2	72.3, 4.1, 89	86.9, 3.7, 13
1987	47.0, - -, 1	70.9, 4.7, 61	86.7, 5.6, 36
1988	52.8, 6.5, 6	71.7, 7.5, 57	85.1, 4.6, 47
1989	46.6, - -, 2	69.0, 4.2, 57	86.1, 4.0, 19

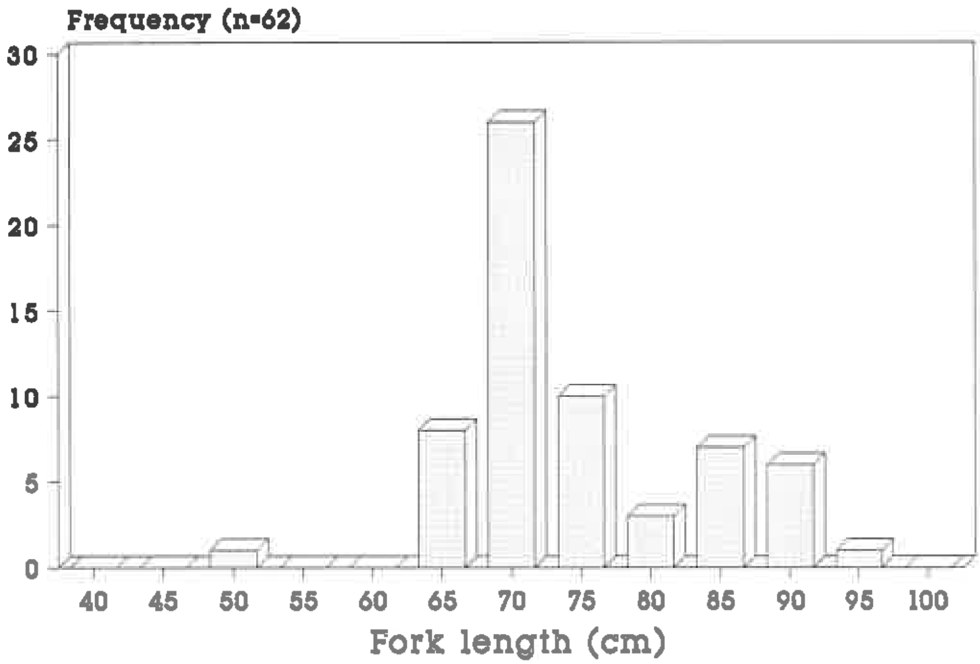

Figure 10. Length frequency distribution of natural-origin spring chinook salmon adults sampled at Tucannon Fish Hatchery in 1989.

3.2.2: Tucannon River hatchery stock

We took scales from 102 hatchery-origin spring chinook salmon that returned to the Tucannon FH in 1989. Age 3 fish, having spent one year of their life in the ocean, comprised the majority of these returns (77 out of 102). All age 3 fish were males. The remaining 25 hatchery-origin fish were age 4. Mean fork length in 1989 for age 3 hatchery-origin fish was 46.4 cm (Table 20), compared to 46.6 cm for natural stock. Mean fork length in 1989 for age 4 hatchery-origin fish was 69.0, the same as age 4 natural-origin fish.

Table 20. Sex, mean fork length (cm), and age (from coded-wire tag recoveries) of hatchery-origin spring chinook salmon sampled at Tucannon Fish Hatchery, 1989 (s= standard deviation, n= sample size).

Sex	Fork length (s, n) at given age 3/2	4/2	Totals
Female	- -	69.0 (5.1, 18)	18
Male	46.4(3.9, 77)	69.1 (3.4, 7)	84
Totals	77	25	102
Percent	75	25	100

3.2.3: Stock profile investigations

To monitor long-term trends in stock profile characteristics of Tucannon spring chinook salmon, we annually collect stock identification data in five separate methods; electrophoresis, adult body morphometry, juvenile body morphometry, meristics, and otoliths. We do not report this information on a yearly basis, rather, at points in time when we consider some information to be of significance.

Electrophoretic analysis Evaluation program staff collected 65 electrophoretic samples from 1989 natural-origin adults and 83 samples from 1989 hatchery-origin adults trapped at Tucannon FH. Techniques for electrophoretic analysis are presented in our FY 1987 report. In subsequent years, we will continue to collect separate samples of adults by origin. We will provide an initial comparison of these two groups in the FY 1990 report.

Morphometric analysis We collected body morphometry data on 64 natural-origin and 73 hatchery-origin spring chinook salmon adults at time of spawning at Tucannon FH. We measured 100 hatchery-reared 1988 brood spring chinook salmon and retained all mortalities of natural-origin juveniles (both 1987 and 1988 broods) incurred during electrofishing surveys and downstream migrant trap operations on the Tucannon River. Composite measurements of individual fish were then used for morphometric analysis (Taylor 1986). Techniques for morphometric analysis are presented in our FY 1987 report. We will provide a comparison of body morphometry by origin in the FY 1990 report.

Meristic analysis The objective of this study is to measure phenotypic similarity of the right and left sides of individual fish as an index of developmental stability. We counted bilateral meristic characteristics for 1985 through 1988 brood years Tucannon naturalorigin juvenile spring chinook salmon. We also made meristic counts for 1986 through 1988 brood years hatchery-origin juveniles to compare with natural-origin juveniles.

Methods used for the meristic counts are similar to Leary et al. (1985). We counted number of rakers on the upper and lower gill arches from the right and left sides, and number of fin rays in the pectoral and pelvic fin from both sides. The mean total count (left side plus right side) of each trait was compared between groups. We determined bilateral traits by computing the mean magnitude of asymmetry (absolute difference of right side and left side), and used this value in conjunction with the mean total count of bilateral traits (Table 21).

Table 21. Mean total counts (left plus right side, upper number) and mean magnitude of asymmetry (absolute value of left side minus right side, lower number) for 4 bilateral traits of natural and hatchery origin Tucannon spring chinook salmon juveniles. Sample size is 50 per group.

Brood year	Origin	Lower gill rakers	Upper gill rakers	Pelvic rays	Pectoral rays
1985	natural	22.61 0.41	15.51 0.57	20.47 0.20	31.73 0.10
1986	natural	20.34 0.50	14.14 0.42	20.22 0.06	31.70 0.10
	hatchery	22.96 0.62	15.16 0.51	20.62 0.10	31.52 0.36
1987	natural	24.26 0.26	16.16 0.28	20.46 0.02	32.16 0.12
	hatchery	23.96 0.40	15.28 0.68	20.62 0.10	32.24 0.10
1988	natural	23.52 0.16	16.40 0.16	20.20 0.06	31.02 0.10
	hatchery	21.32[a] 0.24	15.96 0.24	20.43 0.08	32.27 0.12

[a] *Second gill arch used, n = 37.*

<u>Otoliths</u> We retained otoliths on all natural and hatchery-origin adults as a possible supplement in stock identification (Neilson et al. 1985). No analysis has been made on these samples.

3.3: Lyons Ferry/Tucannon Hatchery Practices

3.3.1: Spawning and rearing

Spring chinook salmon were spawned at Tucannon FH; unfertilized gametes were immediately transported to Lyons Ferry FH for fertilization, incubation, and rearing. Spawning went from 22 August to 19 September 1989, with peak eggtake on 5 September (compared to 17 September in 1986, 19 September in 1987, and 7 September in 1988; Table 17). Eggtake was 132,856 with 26,535 lost (19.97 percent) before eye up, for a total of 106,321.

3.3.2: Disease incidence

The 1989 adult spring chinook salmon were injected twice with Erythromycin prior to spawning to treat BKD. Flush treatments of formalin (1:5000) were applied to adults on a weekly basis for control of fungus infection. Department pathologists isolated the IHN virus in the 1989 brood; milt from 6 males spawned on 5 September 1989, and 2 males spawned on 12 September were found positive for IHNV (Table 22). The progeny of fish that were tested positive for IHNV were incubated and reared separately. The 1988 brood had a low incidence of BKD in spring 1989, and a high incidence of EIBS prior to release.

Table 22. Incidence, date, location, and treatment of diseases for 1988 and 1989 broods spring chinook salmon contracted at Lyons Ferry and Tucannon Fish Hatcheries.

Brood year	Date	Age (months)	Disease	Pond numbers	Treatment
1988	02/89	5	BKD	1, 2	Gallimycin
	03/89	6	BKD	1, 2	Gallimycin
	06/89	7	BKD	1 to 10	Gallimycin
	07/89	11	BKD	1 to 10	Gallimycin
	02/90	18	EIBS	Acclimation pond	- -
	03/90	19	EIBS	Acclimation pond	- -
1989	09/89	0	Fungus	Incubation room	Formalin
	10/89	0	Fungus	Incubation room	Formalin
	11/89	1	Fungus	Incubation room	Formalin
	11/89	2	IHN	Incubation room	Iodophor

Monthly mortality rate for the 1988 brood averaged 0.43 percent during the study period (range: 0.00 - 2.56, n = 12). Average monthly mortality rate for the 1989 brood was 0.29 percent (range: 0.00 - 0.68, n=4). Overall mortality rate (egg to smolt) for the 1987 brood spring chinook salmon was 22.59 percent, compared to 11.94 percent for the 1986 brood and 12.94 percent for the 1985 brood. The mortality rate for the 1987 brood includes destruction of eggs from three females which tested positive for IHNV. Excluding egg destruction, overall mortality rate for the 1987 brood was 17.43 percent.

3.3.3: Smolt releases

Lyons Ferry FH staff transported 156,138 yearling (1987 brood at 16.0 fpp) spring chinook salmon to the adult holding pond at Tucannon FH on 12 November 1988. Fish were acclimated to river water at least four months prior to release. Loss during acclimation was 3,973. We allowed a volitional release of 152,165 (1987 brood at 9.0 fpp) smolts from 11- 13 April. The release was 2- 5 days prior to spill at Lower Monumental Dam (the first dam on the Snake River downstream of Tucannon FH). Mean size and coefficient of variation of smolts at time of release were 165.4 mm and 12.1, respectively (Figure 11). Condition factors of these fish at release averaged 1.12. All were coded-wire tagged and adipose-fin clipped. The ratio of females to males at time of release was 0.92:1.00 (n = 60).

Program staff monitored travel time of the smolts from the hatchery to the downstream migrant trap located 38 km downstream (refer to section 3.4.11 for methods). Roughly four percent (6,233 of 152,165 released) of the hatchery-reared fish were collected at the trap; modal travel time for the hatchery-reared smolts was about four days for the 38 km distance. We analyzed 757 hatchery-origin fish and found 15 percent were descaled in two or more zones. In general, larger fish had higher levels of descaling, both prior to release, and during outmigration.

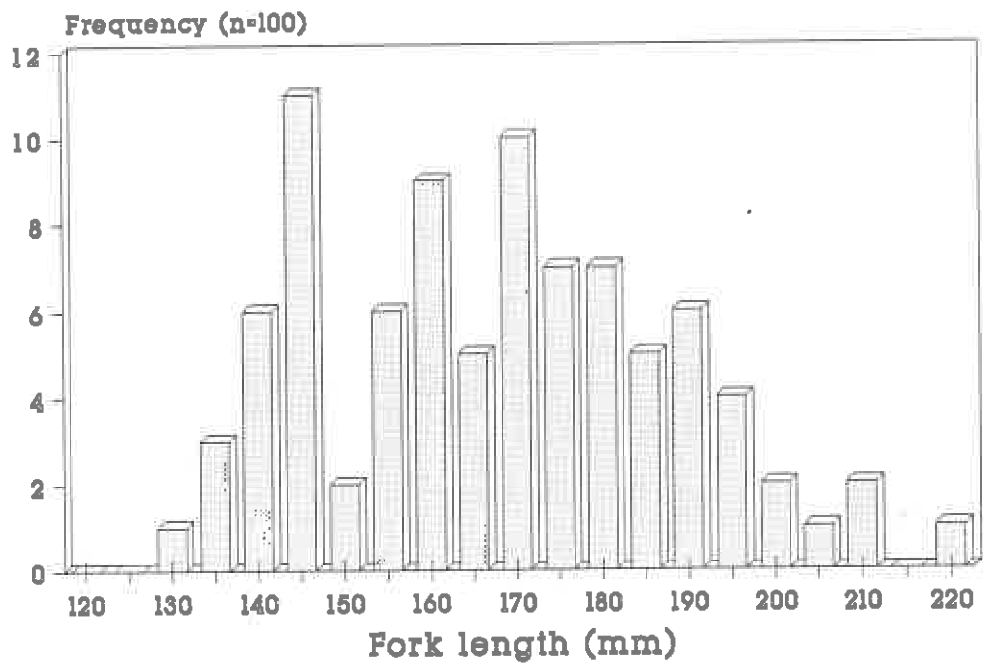

Figure 11. Length frequency distribution of 1987 brood spring chinook salmon released from Tucannon Fish Hatchery in April 1989.

3.3.4: Organosomatic indices

Program staff collected natural-origin 1987 brood Tucannon spring chinook salmon for standard Organosomatic analysis. The results were then compared with those of hatchery-origin fish. Sample sizes were 20 natural-origin and 60 hatchery-origin salmon. Samples were taken one month prior to release from Tucannon FH. Pathological results were as follows: 1) a prevalence of *Renibacterium salmoninarum* bacteria in three percent of the hatchery-origin salmon, and in 20 percent of the natural-origin salmon, but no clinical signs of BKD were present in the latter, 2) a prevalence of EIBS virus in 52 percent of the hatchery- origin salmon, and none in the natural-origin salmon, but blood samples from seven of the latter had small "inclusion-like" bodies (Michak, personal communication), and 3) no prevalence of IHNV, infectious pancreatic necrosis virus (IPNV), or viral hemorrhagic septicemia (VHS) in either group.

Mean fat level of natural-origin salmon was 0.3, compared to 1.7 in hatchery-origin salmon. Mean hematocrit (packed red blood cell count) was 44 in the natural-origin salmon and 37 in the hatcheryorigin salmon. Leucocrit (white blood cell count) and serum protein were normal in both groups (Appendix E).

3.3.5: Smolt indices

We collected samples of gill filaments from the 1987 brood spring chinook salmon to determine their ATP-ase enzyme activity levels. Samples were taken of both natural and hatchery-origin salmon in winter and spring. Enzyme activity levels of hatchery-origin fish were higher than natural-origin fish in winter, but less than natural-origin fish during spring outmigration. Enzyme levels of hatchery origin fish were less in spring than in winter, but is probably a function of smaller fish sampled during spring outmigration (Table 23).

Table 23. Gill ATP-ase levels and lengths of Tucannon natural and hatchery-origin spring chinook salmon sampled in January and April 1989. Sample size was 10 fish per group (x= mean, s= standard deviation).

Origin	Month	Gill ATP-ase level x	Gill ATP-ase level s	Fork length x	Fork length s
Hatchery	January	11.1	4.9	154.1	20.5
Hatchery	April	10.0	3.0	136.2	8.0
Natural	January	5.7	1.5	94.9	8.3
Natural	April	14.8	3.3	98.1	7.8

3.4: Natural Production

From 1985 through 1989, we have gathered biological information on spring chinook salmon in the Tucannon River prior to hatchery enhancement. This information is part of a study to assess the short and long term effects of supplementation on a wild stock of salmon (Appendix A). In 1990, significant numbers of hatchery-origin salmon will return to the Tucannon River for natural spawning. The information we have gathered to date will form a baseline to assess the effects of this interaction.

We are evaluating the effects of supplementation through two complementary strategies: 1) stock profile analysis, using a combination of electrophoresis, morphometrics, meristics, and quantifiable measures of fish behavior and productivity, and 2) observation of the population dynamics of natural and hatchery--origin salmon naturally producing in the Tucannon River. The following discussion pertains to research on the population dynamics aspect of this program.

Watershed description The Tucannon River is a third-order stream which flows through varied habitat conditions that restrict distribution of salmonids in the watershed. To compare differences in spring chinook production within the Tucannon River, we designated 5 strata, based upon the predominant land use adjacent to the stream:

Lower (RK 0.0 - RK 17.9),
Marengo (RK 18.0 - RK 42.1),
Hartsock (RK 42.2 - RK 54.8),
HMA (RK 54.9 - RK 75.1),
Wilderness (RK 75.2 - RK 85.3).

The Lower, Marengo, and Hartsock Strata are within agricultural bottomland which receives limited water diversion for summer irrigation. Sections of the stream within these strata have a poorly defined or braided stream channel. Banks are often unstable with limited riparian areas. Water temperatures often exceed the upper threshold of spring chinook salmon tolerance. The upper reach of the Hartsock Stratum has tolerable water temperatures for salmon during most of the summer rearing period. The HMA Stratum is within Washington Department of Wildlife (WDW) and U.S. Forest Service (USFS) owned and managed land that is forested, has relatively stable banks, and maintains water temperatures tolerable for spring chinook salmon at all stages in the life cycle. The Wilderness Stratum is in the Wenaha-Tucannon Wilderness Area, a part of the Umatilla National Forest.

Total watershed area is about 132,000 ha. Stream elevation rises from 150 m at the mouth to 1,640 m at the headwaters. Annual precipitation ranges from 25 cm in the lower reaches to 100 cm in the higher elevations.

In 1987, we evaluated Tucannon River spring chinook salmon spawning, incubation, and rearing conditions using the Habitat

Suitability Index (HSI) modeling procedure (Terrell et al. 1982, Raleigh and Miller 1985). Low percentage of pools and maximum summer water temperatures were the two factors deemed by this method to limit production (FY 1987 report). In 1985, we surveyed the Lower and Marengo Strata and found no evidence of spawning or rearing by spring chinook salmon in this reach (FY 1985 report). Our surveys for spawning and summer parr production since then have been in the upper three strata only.

3.4.1: Adult population dynamics

In 1989, we began a study to evaluate movement, prespawning mortality, mate and habitat selection, and overall spawning success of spring chinook salmon adults using a combination of upstream trapping, radio telemetry, snorkel surveys, and spawning ground surveys (Section 3.4.11 has a discussion of the latter).

Snorkel surveys On a weekly basis in June and July, we surveyed adults holding downstream of the rack by snorkeling. We had two objectives in these surveys: 1) refine our estimate of total escapement to the river (upstream and downstream of the rack), and 2) assess in-river movements prior to spawning. Typically, we see about 40 adults (15 percent of total) holding below the rack. After the Tucannon FH rack is removed in early August, we find an average of 11 adults in the same survey area. We believe these adults move upstream into cooler waters after the barrier is removed, and return to this lower reach in September, when the river cools.

Radio telemetry During their migration period, adults were trapped at the Tucannon FH rack and passed upstream daily (Section 3.1). At that time, we collected adults on a random basis, anesthetized them with carbon dioxide, and placed radio tags in their stomachs. We measured (fork length and post-orbital to hypural plate length) and assessed condition of the fish prior to release. Each radio transmitter had a unique frequency to allow us to recognize individual fish. Every three days (or more often if the need arose), we located the study fish. General searches for adults were done by vehicle. Average distance between the road and river is 100 m (maximum is about 500 m), allowing good radio reception. If a radio signal remained in a fixed location for an extended period, we searched for its specific location by foot to determine its status (mortality, transmitter regurgitation, or microhabitat use).

When adults developed sexual dimorphism we identified the sex of tagged fish (we usually could distinguish sexes through underwater visual observation by mid-August). We used this information during spawning to monitor site selection, movement, and multiple redd construction of females. Identification of males with radio tags allowed us to study mate selection and movement. We have enough background data available to distinguish age classes by post-orbital to hypural plate length. By measuring adults when we tag them, we can assess differences in habitat use, river distribution, and mate selection by age.

Results We inserted radio tags in 16 natural-origin adult salmon from the period 17 May 1989 to 29 June 1989. Three of 16 fish regurgitated the tags one to 26 days after insertion, eight fish died 12 to 31 days after tag insertion, tags from two fish provided information through to spawning (86 and 116 days), and tags from three fish became undetectable 37 to 63 days after insertion.

We performed necropsies on the eight recovered salmon carcasses, and determined the cause of mortality in two fish was the result of a ruptured stomach wall. We could not determine the cause of death in the remaining six fish. We were unable to locate the three tags that we lost detection of. We assume these tags either malfunctioned and failed to transmit a signal, or the tags were removed from the study area, as would occur if the fish were poached.

We collected information on two fish whose tags performed adequately during the study period. One fish was an age 4 female, tagged on 23 May. It moved upstream 5.79 km in a period of 28 days, and remained below an undercut bank 73 days, until it moved 3.05 km upstream in five days an began spawning for a period of 14 days over a distance of 400 m. We observed the female in three separate locations during spawning, and inferred that the female constructed two redds. The second fish was an age 5 male, tagged on 26 June. It moved upstream 5.80 km in three days and remained three days more; it then moved downstream 1.45 km the next two days and returned upstream to its prior position. It then held in a pool 42 days before spawning. It spawned with at least two females over a distance of 6.87 km in a period of 20 days.

We encountered several difficulties in operation of radio receivers and data loggers, which limited the collection of data at important times and locations.

3.4.2: Juvenile population dynamics

We conducted electrofishing surveys in the Wilderness, HMA, and Hartsock Strata from 17 July through 21 September. We sample several index sites within each stratum yearly to determine trends in juvenile salmonid production. Refer to our FY 1988 report for a description of site locations. Sampling design and methods for these surveys are presented in our FY 1986 report.

We used the depletion method for population estimation of all salmonids (Zippin 1958) and analyzed data using the Burnham Maximum Likelihood method (Van Deventer and Platts 1983). We did snorkel surveys in the HMA Stratum index sites in summer to provide complementary information to the electrofishing data (Section 3.4.7) and in winter to gain information on overwinter survival and habitat use (Section 3.4.8).

We used the habitat terminology suggested by Helm (1985), and evaluated habitat quality within each electrofishing index area using a modified version of the rating system suggested by Platts et al. (1983, Appendix F). The habitat rating system applied to the index sites is the same used in the habitat inventory and is described in the FY 1987 report.

3.4.3: Wilderness Stratum parr production

Methods We used a stratified random sampling design to identify and survey three distinct habitat types within the Wilderness Stratum: riffles, runs, and pools. Twenty-three index sites have been established in this stratum; some or all of these sites are sampled yearly to serve as indicators of relative parr abundance.

Results In 1989 we sampled five index sites in the Wilderness Stratum (0.65 percent of stream area). Mean density and biomass of spring chinook salmon parr were 16.24 fish/100m² and 64.44 grams/100m², respectively (Table 24). Salmon densities averaged 25.82 fish/100m² in the pools (n=3), 3.77 fish/100m² in the runs (n=1), and 0.0 fish/100m² in the riffles (n=1, Table 25). Spring chinook salmon parr mean densities were lower in each habitat type in 1989 compared to the previous four-year average (Table 26). Given these densities, we estimate 4,600 subyearling (1988 brood) spring chinook reared in the Wilderness Stratum in summer 1989. This estimate is based upon the habitat inventory conducted in 1985 (refer to our FY 1985 report), and weighted by habitat quality (Appendix F).

Table 24. Comparison of spring chinook salmon rearing densities and biomass by stratum in the Tucannon River, Washington, 1989 (x= mean, and s= standard deviation).

Stratum	Sample size	Density (fish/100m²) x	Density (fish/100m²) s	Biomass (grams/100m²) x	Biomass (grams/100m²) s
Wilderness	5	16.24	23.72	64.44	82.57
HMA	30	22.08	21.41	85.89	74.69
Hartsock	4	13.66	20.54	72.15	118.91

Table 25. Spring chinook salmon rearing densities and biomass within the Wilderness Stratum, Tucannon River, Washington, 1989.

Habitat type	Site	1989 density (fish/100m²)	1989 biomass (grams/100m²)
Riffle	Wild 12	0.00	0.00
Run	Wild 10	3.77	9.62
Pool	Wild 3	57.88	204.83
	Wild 7	7.07	44.38
	Wild 11	12.50	63.36

Table 26. Comparison of 1985- 1989 spring chinook salmon rearing densities in selected index sites in the Wilderness Stratum, Tucannon River, Washington.

Habitat type	Site	Density (fish/100m²) by year				
		1985	1986	1987	1988	1989
Riffle	Wild 12	- -	- -	7.64	- -	0.00
Run	Wild 10	12.92	37.48	15.65	4.41	3.77
Pool	Wild 3	34.51	96.65	40.60	39.42	57.88
	Wild 5	45.01	41.22	79.06	53.90	- -
	Wild 7	- -	- -	- -	- -	7.07
	Wild 11	47.39	80.72	46.76	23.57	12.50

3.4.4: HMA Stratum parr production

Methods We used a random systematic sampling design to identify and electrofish five distinct habitat types within the HMA Stratum: riffles, runs, pools, side channels, and boulder sites. We sampled six replicates of each habitat type for a total of 30 index sites. All of these sites are sampled yearly.

Results We sampled 1.68 percent of the stream within the HMA Stratum (30 sites total). Mean density and biomass were 22.08 fish/100m² and 85.89 grams/100m², respectively (Table 24). Stratum densities decreased yearly from 1986 to 1989 (Figure 12 and Appendix G). Densities differed significantly between habitat types within the HMA Stratum (Friedman's two-way ANOVA $p<0.05$, Daniel 1978). Boulder sites differed significantly from all other habitat types (Wilcoxon sign-rank pairwise comparisons $p<0.05$; Zar 1974). Density and biomass were highest in side channels, and lowest in boulder sites (Table 27). Given these densities, we estimate 44,900 subyearling (1988 brood) spring chinook reared in the HMA Stratum in summer 1989. This estimate is based on the habitat inventory conducted in 1987 (refer to our FY 1987 report), and weighted by habitat quality (Appendix F).

Table 27. Spring chinook salmon parr density and biomass by habitat type in the HMA Stratum, Tucannon River, Washington, 1989. Sample size was 6 sites per habitat type.

Habitat type	Mean density (fish/100m²)	Mean biomass (grams/100m²)
Riffle	11.99	52.31
Run	28.41	112.67
Pool	27.03	111.83
Boulder	5.24	26.45
Side channel	37.73	126.19

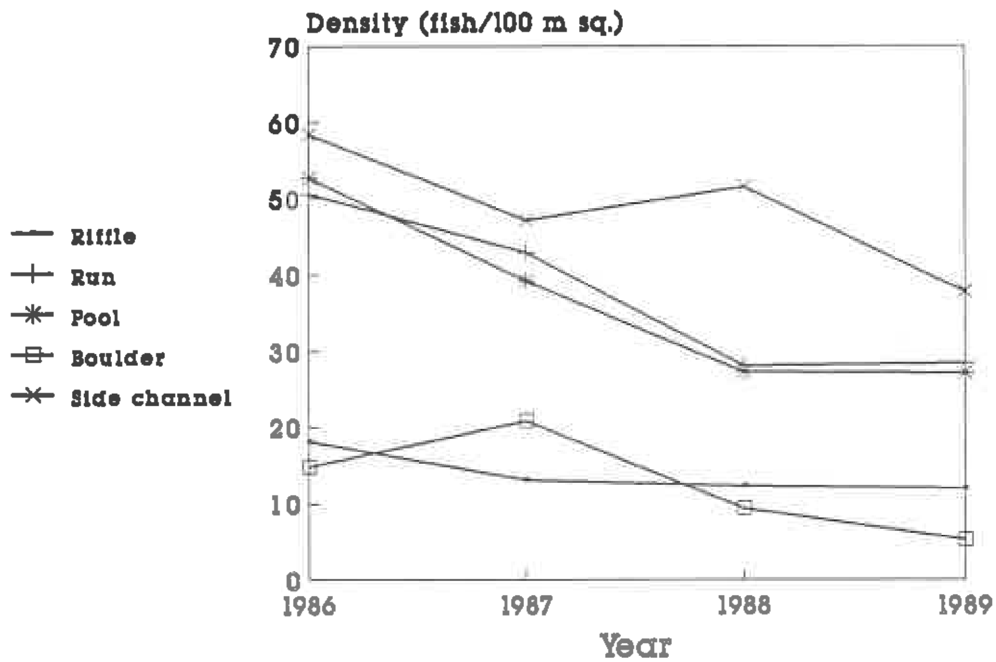

Figure 12. Comparison of spring chinook salmon rearing densities in the HMA Stratum from 1986 to 1989.

3.4.5: Hartsock Stratum parr production

Methods We used a stratified random sampling design to identify and survey riffles, runs, and pools. We established nine index sites; some or all of these index sites are surveyed annually.

Results We sampled 4 sites (0.36 percent of the stream) in the Hartsock Stratum in 1989. Mean spring chinook salmon density and biomass for the Hartsock Stratum were 13.66 fish/100m² and 72.15 grams/100m², respectively, (Table 24). Salmon densities averaged 2.95 fish/100m² in riffles (n=2) and 24.37 fish/100m² in runs (n=2, Table 28). In general, salmon densities have decreased from 1985 to 1989 (Table 29). Given these densities, we estimate 20,200 subyearling (1988 brood) spring chinook reared in the Hartsock Stratum in summer 1989. This estimate is based upon the habitat inventory conducted in 1987 (refer to our FY 1987 report), and weighted by habitat quality (Appendix F).

Table 28. Spring chinook salmon rearing densities and biomass in the Hartsock Stratum, Tucannon River, Washington, 1989.

Habitat type	Site	1989 density (fish/100m²)	1989 biomass (grams/100m²)
Riffle	Hart 5	1.43	4.77
	Hart 8	4.47	16.58
Run	Hart 2	44.40	250.32
	Hart 6	4.34	16.93

Table 29. Comparison of spring chinook salmon rearing densities in selected index sites in the Hartsock Stratum, Tucannon River, Washington from 1985 to 1989.

Habitat type	Site	Density fish/100m²)				
		1985	1986	1987	1988	1989
Riffle	Hart 3	- -	- -	21.95	- -	- -
	Hart 5	- -	13.91	10.67	5.04	1.43
	Hart 8	- -	9.13	21.16	17.66	4.47
	Hart 9	- -	- -	17.80	10.12	- -
Run	Hart 1	- -	- -	24.63	1.92	- -
	Hart 2	3.48	12.56	34.83	- -	44.40
	Hart 6	10.30	21.48	16.41	6.46	4.34
Pool	Hart 4	- -	- -	4.26	- -	- -
	Hart 7	- -	- -	52.49	55.16	- -

Spring chinook salmon rearing densities have decreased since 1986. The first year we collected wild adults for Tucannon FH broodstock was 1986, thereby reducing natural escapement by roughly one half. Rearing density decreases would be manifested in 1987. In general, yearly parr production corresponds with the number of redds in the Wilderness and HMA Strata in the preceding years (189 redds in 1985, 171 redds in 1986, 155 redds in 1987, and 97 redds in 1988). The Hartsock Stratum was not surveyed in 1985, hence we cannot correlate total redd deposition with parr production. Average length of salmon parr during these surveys has remained somewhat constant (63.6 mm in 1986, 67.9 mm in 1987, 66.9 mm in 1988, and 65.9 mm in 1989), suggesting that growth rates did not change in response to lower densities.

3.4.6: Rate of growth

Program staff calculated summer growth rates based upon both weight and length for the 1988 brood year spring chinook salmon parr in the Wilderness and HMA Strata. Duration of the growth study was 16 June to 26 October. We sampled about twenty fish per stratum once a month during this period. A mean condition factor (kfactor) was calculated for each group sampled.

Mean kfactor of fish in the Wilderness Stratum was consistently higher than the HMA Stratum during the study. The salmon parr mean length and mean weight were smaller in the Wilderness Stratum in June, but they grew faster during the summer. On the last sample date, 26 October, parr in the Wilderness Stratum were no different in length or weight from the HMA Stratum parr (unpaired t-test, $p<0.05$). The instantaneous growth rate (Ricker 1975) for salmon weight in the Wilderness Stratum for 132 days was 1.54 (Table 30). The HMA Stratum instantaneous growth rate for salmon weight during the same period was 1.30. Relative growth rates for salmon weight were 353 percent and 267 percent for the Wilderness and HMA Strata respectively.

The length frequency distribution of the 837 salmon captured and measured during the 1989 electrofishing surveys indicated a predominant age class of subyearlings (Figure 13). Mean length and coefficient of variation of parr collected were 65.9 mm and 15.5, respectively. We took scales from six fish within the 90th percentile of fork lengths and determined them to be yearlings.

Table 30. Growth rates for spring chinook salmon parr from 16 June to 26 October 1989, Tucannon River, Washington.

Location	Date	Sample size	Mean weight (gm)	Mean length (mm)
Wilderness Stratum	16 Jun	20	1.5	47.8
	13 Jul	17	2.3	53.4
	15 Aug	19	4.0	65.8
	27 Sep	20	6.1	77.0
	26 Oct	20	6.8	78.2
Total growth rate		Instantaneous	1.54	0.49
		Relative (%)	353.3	63.6
HMA Stratum	16 Jun	19	1.8	52.0
	13 Jul	20	3.0	61.1
	15 Aug	20	5.0	70.0
	12 Sep	13	5.3	75.0
	26 Oct	20	6.6	80.3
Total growth rate		Instantaneous	1.30	0.43
		Relative (%)	266.7	54.4

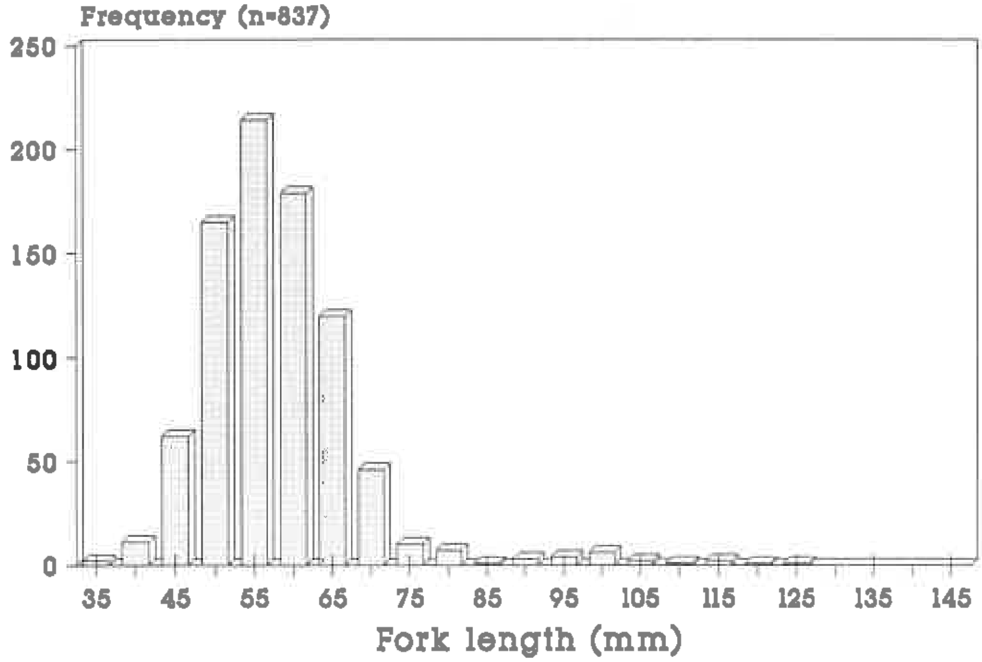

Figure 13. Length frequency distribution of Tucannon spring chinook salmon measured in electrofishing surveys, 1989.

3.4.7: Summer snorkel surveys

Methods We used a modified line transect sampling method (Emlen 1971) to estimate juvenile salmonid abundance during summer and winter in the Tucannon River. Summer snorkeling surveys were done between 19 July and 12 September, within the electrofishing time frame, enabling us to compare these two techniques for population estimation. All HMA electrofishing index sites were snorkeled three times (each time by a different person to reduce bias) to estimate densities of spring chinook salmon parr.

A lead line marked in decimeters was placed diagonally across each site. Snorkeling always started at the downstream end of the transect on the right bank. Fish were identified by species and age class and their perpendicular distance from the transect was recorded. The decimeter marks on the transect provided a means to estimate distances. Duration of the survey was noted, and snorkelers attempted to standardize survey times. Each site was not snorkeled more than once a day. We waited at least two days after a site was electrofished before we snorkeled.

We calculated the area surveyed by multiplying the mean transect length (measured to the nearest decimeter) by the furthest distance spring chinook salmon parr could be detected (perpendicular distance from the transect in decimeters) by 2 (fish could be detected on both sides of the transect). We calculated rearing density by dividing the number of spring chinook salmon by the area surveyed. A mean value (with standard error) was determined from the three replicates.

Results Densities differed significantly between habitat types within the HMA Stratum (Friedman's two way ANOVA, $p<0.05$). Riffle and boulder densities differed significantly from those found in pools and side channels (Wilcoxon sign-rank pairwise comparisons: Zar 1974). Estimates of mean density derived through line transect snorkel surveys were higher than multiple-pass depletion electrofishing surveys in runs, pools, boulder placements, and side channels (Appendix G). Density estimates for riffles were higher by electrofishing, probably because of difficulty in snorkeling this habitat type. Our late summer population estimate in the HMA using snorkel data was 0.1 percent more than derived from electrofishing data (Table 31). Total area snorkeled in the 30 sites was 1,112 m^2; the area electrofished was 4,246 m^2. Time spent on the HMA Stratum electrofishing surveys was 48 person-days, compared to 24 person-days on the HMA Stratum summer snorkel surveys.

3.4.8: Winter snorkel surveys

We surveyed the 30 index sites (3 replicates of each) in the HMA Stratum from 11 December 1989 to 23 February 1990. Winter methods were the same as summer methods. We also did random snorkel surveys in the Wilderness, Hartsock, Marengo, and Lower Strata. We also did winter snorkel surveys in FY 1988 which were not presented in that year's report. Duration of these surveys was 2 November 1988 to 16 March 1989. Results of that work are included here.

Table 31. Estimates of spring chinook salmon parr mean density and population size by habitat type within the HMA Stratum, Tucannon River, Washington, 1989. Estimates are based upon snorkeling and electrofishing surveys; sample size was 6 sites per habitat type.

Habitat type	Snorkeling		Electrofishing	
	density (fish/100m²)	population estimate	density (fish/100m²)	population estimate
Riffle	5.92	6,000	11.99	16,340
Run	36.00	20,179	28.41	17,212
Pool	58.68	3,479	27.03	2,015
Boulder	7.92	1,313	5.24	851
Side channel	69.47	13,982	37.73	8,500
Total		44,953		44,918

Spring chinook salmon densities were considerably less in winter than in summer (Table 32 and Appendix G). Mean densities decreased from summer to winter in all habitats except side channels. We found evidence of overwinter use in all strata; summer use is restricted to the Wilderness, HMA, and upper Hartsock Strata because of intolerable water temperatures. Although overall densities decrease from summer to winter, more stream area is available for use. Thirty-two percent of the mainstem stream surface area is used in summer (41 out of 128 ha); up to 85 percent is used in winter (109 ha).

We found snorkeling to be an effective means to assess changes in distribution of salmonids from summer to winter, both in terms of habitat use and location within the river continuum. For late summer rearing salmonid estimates, we believe line transect sampling is reliable when estimating the size of single age class populations (such as spring chinook salmon), but may not be as effective when used on multiple aged populations (such as steelhead).

Table 32. Comparison of mean snorkel density estimates (fish/100m^2) for riffles, runs, pools, boulder sites, and side channels between summer and winter in the HMA Stratum, Tucannon River, 1988 and 1989.

Habitat type	Summer 1988	Winter 88/89	Summer 1989	Winter 89/90
Riffle	15.39	2.02	5.92	0.19
Run	48.75	3.25	36.00	16.39
Pool	52.85	24.24	58.68	40.75
Boulder	22.39	3.19	7.92	0.33
Side channel	68.50	32.00	69.47	64.77

3.4.9: Stream temperature studies

Program staff deployed five continuous-reading thermographs in the Tucannon River to monitor heat loading throughout the year. The thermographs recorded daily maximum and minimum water temperatures from 2 November 1988 through 30 September 1989. Locations of thermographs were as follows: 1) 300 m downstream of the Panjab Creek confluence (RK 76), 2) near the downstream outlet of Big 4 Lake (RK 66), 3) near the downstream outlet of Beaver-Watson Lakes (RK 64), 4) near the downstream outlet of Deer Lake (RK 62), and 5) 100 m downstream of the Cummings Creek confluence (RK 58, Figure 17).

In general, summer (April through September) stream temperatures increased in varying increments from the furthest upstream location to the furthest downstream (Table 33). Minimum water temperatures decreased between the Panjab Creek and Big 4 Lake thermographs, in contrast to what we had observed in 1987 and 1988, when both maximum and minimum temperatures increased the most between these two stations. Stream temperatures remained essentially the same between the Beaver-Watson Lakes complex and Deer Lake. Daily maximum stream temperatures were higher at the Cummings Creek sampling location than at the Deer Lake location, five km upstream. This phenomenon also contrasts with our results in 1987 and 1988. We placed a thermograph at Marengo Bridge (RK 41) during the period 28 July to 20 September. Late summer water temperatures at this location reached a high of 24°C.

Winter (November through March) stream temperatures remained fairly constant from the Panjab Creek confluence to the Cummings Creek confluence. Water temperatures decreased about 2°C. between Big 4 Lake outlet and Beaver Lake outlet in winter. Daily record for the six thermographs is presented in Appendix H.

Table 33. Mean monthly ranges (minimum to maximum) water temperatures at five Tucannon River sampling locations from November 1988 to September 1989. Data are listed in degrees Celsius.

Month	Panjab Creek	Big 4 Lake	Beaver Lake	Deer Lake	Cummings Creek
Nov 1988	5.6- 6.7	6.5- 7.8	4.6- 6.2	3.6- 4.9	4.5- 5.6
Dec 1988	4.1- 5.2	4.6- 5.7	3.1- 3.9	1.7- 2.8	2.1- 3.1
Jan 1989	4.7- 5.6	5.0- 6.4	2.9- 3.6	2.1- 3.1	2.6- 3.6
Feb 1989	3.4- 4.4	3.8- 5.2	2.8- 4.4	0.9- 2.2	1.2- 2.1
Mar 1989	4.7- 6.2	5.9- 7.6	5.0- 6.1	2.8- 5.3	3.4- 5.3
Apr 1989	6.4- 8.6	4.6- 7.8	4.5- 7.9	3.8- 7.9	7.4-10.4
May 1989	7.3- 9.8	4.2- 7.7	5.3- 8.9	4.8- 8.7	8.7-11.9
Jun 1989	10.8-14.0	7.6-11.9	7.9-13.2	8.3-13.7	12.8-16.8
Jul 1989	12.5-16.8	9.6-15.8	8.2-14.8	11.0-17.7	15.3-19.4
Aug 1989	11.9-14.8	- -	6.5-10.6	11.0-15.7	14.9-18.1
Sep 1989	10.2-12.6	- -	3.3- 7.8	8.1-13.1	12.4-15.4

3.4.10: Spawning ground surveys

Tucannon River Program staff surveyed spring chinook salmon spawning grounds on the upper Tucannon River to determine the temporal and spatial distribution of spawning and to assess the abundance and density of spawners. Spawning grounds were surveyed on 23 and 30 August, 6, 13, 20, 21, and 27 September. Person-days required for the surveys were 2, 6, 5, 6, 4, 2, and 4 respectively. The 13, 20, and 21 September surveys encompassed all known spring chinook salmon spawning areas within the Tucannon River.

Total number of redds observed in the Tucannon River in 1989 was 106 (Table 34). The number of redds sighted in the Tucannon River decreased from the estimated previous five year mean of 159 redds (Table 35), and 20 year mean of 127 redds. The Tucannon River tributaries were not surveyed because we saw little evidence of spawning activity in the previous four years.

Table 34. Number of spring chinook salmon redds observed and carcasses recovered in Tucannon River spawning ground surveys, 1989.

Stratum	River kilometer	Number of redds	Carcasses recovered females	males	jacks
Wilderness	85-75	29	3	5	0
HMA	75-69	22	10	3	0
	69-64	19	5	15	0
	64-55	13	4	11	1
Hartsock	55-48	14	7	7	1[a]
	48-43	9	6	3	0
Totals		106	35	44	2

[a] *Hatchery-origin, 1986 brood.*

Twenty-nine redds were observed in the Wilderness Stratum of the Tucannon River, which is 10.1 km long, resulting in a density of 2.87 redds/km (3.50 redds/ha). This density is higher than in 1987 and 1988, but considerably lower than in 1985 and 1986 (Table 35). We observed 54 redds in the 20.2 km HMA Stratum, resulting in a density of 2.67 redds/km (2.29 redds/ha). This density is considerably lower than in the previous four years. In the 12.7 km long Hartsock Stratum we observed 23 redds for a density of 1.81 redds/km (1.45 redds/ha), which is slightly higher than in 1988 but lower than 1986 and 1987.

From the seven counts on the Tucannon River, we concluded that the peak of spawning for spring chinook salmon varied with each stratum. Peak of spawning in the Wilderness Stratum was 6 September, 13 September for the HMA Stratum, and 20 September for the Hartsock Stratum. Two redds were deposited in the Wilderness Stratum on 23 August and two new redds were deposited in the Hartsock Stratum on 27 September, indicating that the duration of spawning to be at least 36 days.

<u>Asotin Creek</u> On 18 September and 12 October, we surveyed the North Fork of Asotin Creek downstream to its confluence with the South Fork of Asotin Creek. There were no redds observed in the 7.2 km section. One redd was observed in this section in 1988, 3 redds in 1987, and 1 redd in 1986.

Table 35. Comparison of spring chinook salmon redd densities (redds/km and redds/ha) by stratum and year, Tucannon River, Washington.

Stratum	1985 km (ha)	1986 km (ha)	1987 km (ha)	1988 km (ha)	1989 km (ha)
Wilderness	8.32 (10.14)	5.25 (6.04)	1.49 (1.81)	1.78 (2.17)	2.87 (3.50)
HMA	5.33 (4.46)	5.79 (4.97)	6.93 (5.95)	3.91 (3.36)	2.67 (2.29)
Hartsock	- -[a] (- -)	2.28 (1.84)	2.36 (1.90)	1.57 (1.27)	1.81 (1.45)

[a] *Hartsock Stratum was not surveyed in 1985.*

Butte Creek This tributary to the Wenaha River was surveyed on 31 August. One redd was observed in 4 km surveyed downstream of the East Fork and West Fork confluence, resulting in a density of 0.25 redds/km. In 1988 we observed ten redds in 6.4 km for a density of 1.56 redds/km and in 1987 we observed eight redds in 3.2 km for a density of 2.50 redds/km.

North Fork Wenaha River This stream was surveyed on 10 September from the Oregon/Washington border upstream 2.4 km. No redds were sighted.

3.4.11: Downstream migrant trap operations

An important objective of our study is to estimate the magnitude, duration, periodicity, and peak of spring chinook salmon outmigration from the Tucannon River. To do this, we maintain a floating inclinedplane downstream migrant trap at RK 21. We operated the trap intermittently from 25 October 1988 to 27 February 1989, and then trapped continuously until 30 June 1989. A detailed description of our trapping operations is given in our FY 1986 and 1987 reports.

Methods To calibrate trapping efficiency, we marked (clipped the tip of the pelvic fin) captured smolts and transported them 10 km upstream of the trap for release. Only natural-origin smolts were used. The percentage of marked fish captured was used to estimate percent total downstream migrants trapped. With these data, we used a modified form of the standard Peterson mark-recapture method (Chapman 1948, Steinhorst personal communication) to estimate spring chinook salmon and steelhead outmigrants from the Tucannon River. We estimated the number of outmigrants using the equation:

$$P = \frac{1}{M} \sum_{i=1}^{M} \frac{y_i}{n_i}$$

$$SE(P) = \sqrt{\frac{1}{M^2} \sum_{i=1}^{M} \frac{p_i q_i}{n_i}}$$

where:

m = number of days fish were marked

p_i =proportion of fish caught that were marked on day i

y_i =number of recaptured fish on day i

n_i =number of fish that were marked on day i

Salmon released from Tucannon FH were also collected in the trap; we determined travel times of these fish. We also marked four separate groups of natural-origin smolts (clipped the tip of the caudal fin) and released them adjacent to Tucannon FH, 38 km upstream of the trap. Our objectives were: 1) to compare travel time of natural and hatchery smolts, and 2) use information from both groups to estimate the appropriate release date for the hatchery smolts to arrive at Lower Monumental Dam during spill conditions.

On most spring chinook salmon collected, we assessed the amount of descaling (Achord et al. no date), fin erosion, and the degree of smoltification. We measured fork lengths of virtually all fish collected (9,044) and weighed 1,738 (19 percent) of the fish on a random basis. Water temperature, flow, velocity, clarity (determined with a 25 cm Secchi disk), and photoperiod were recorded daily to be used as covariates in explaining variability in smolt migrations.

<u>Results</u> During the period 25 October 1988 to 30 June 1989, we caught and processed 9,573 natural and 6,233 hatchery spring chinook salmon smolts. Peak of outmigration was the period 27 April to 1 May (Figure 14), coinciding well with the peak flow (least squares $p<0.05$), and similar in timing to the peak outmigration during the 1987/88 season. Mains and Smith (1955) found peaks of outmigration from the Tucannon River in November, April, and May. Major and Mighell (1969) trapped spring chinook salmon outmigrants in the Yakima River from 1959 to 1963 and found the peak of outmigration to be 14 April to 19 May.

During the 1988/1989 season, average trap efficiency was 29.9 percent (524 of 1,753), an increase of 6 percent from the 1987/88 season, for the 10 km release test fish. Average trap efficiency for 38 km release test fish was 33.0 percent (66 of 200), an increase of nearly 5 percent from the 1987/88 trapping season (Appendix I). We observed an increase in overall trap efficiency during the 1988/1989 season to 30.2 percent (590 of 1,953) from 24.3 percent during 1987/88 season and 21.6 percent in the 1986/1987 season. We estimate 44,023 (95 percent confidence interval of 3,814) natural-origin spring chinook salmon smolts outmigrated in the 1988/1989 season, compared to 58,236 (95 percent confidence interval of 1,401) in the 1987/88 season, and 35,559 (95 percent confidence interval of 2,485) in the 1986/1987 season.

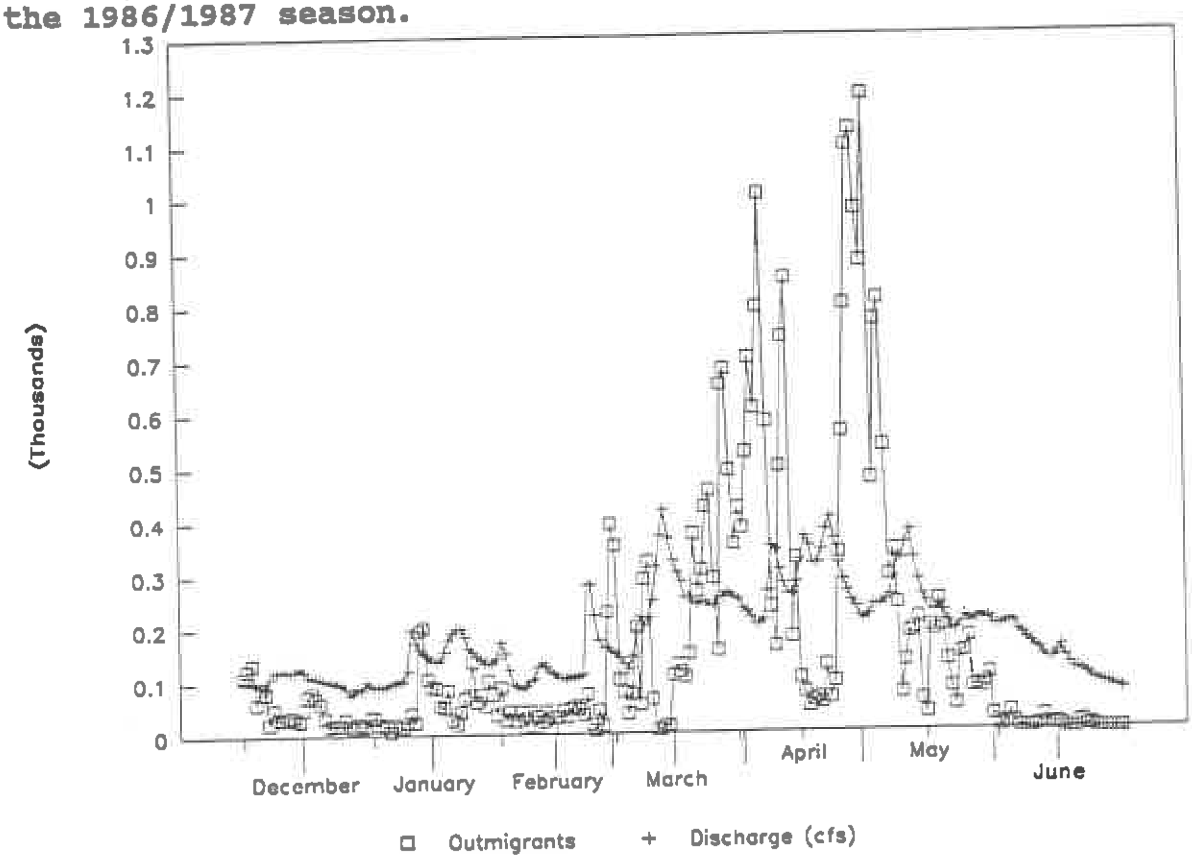

Figure 14. Comparison of daily numbers of spring chinook salmon outmigrants with average Tucannon River daily flow.

Dates of the 5, 25, 50, 75, and 95 percentiles of cumulative outmigrants caught occurred on 13 January, 27 March, 11 April, 30 April, and 17 May, respectively. We compared Julian date, photoperiod, water temperature, flow, and clarity for the period 1 March to 30 June 1989 with a logit transformation of the cumulative catch. Julian date and photoperiod correlated well with the cumulative number of outmigrants caught (least squares $p<0.05$). We caught 79 percent of the outmigrants between 2201 and 0700 hours, 19 percent were caught between 0701 and 1500 hours, and 2 percent were caught between 1501 and 2200 hours.

Travel time for natural-origin spring chinook salmon from the 38 km release fish varied from one to more than 32 days. Travel time depended on the date the trial occurred, and was fastest at peak of outmigration (Table 36). Median and mean travel times were 8 and 10.2 days (4.8 and 3.7 km/day) respectively, compared to 6.2 and 8 days in the 1987/88 season.

Table 36. Comparison of travel times for natural spring chinook salmon smolts traveling 38 km, Tucannon River, 1989.

Release date	Number released	Number recaptured	Travel time in days			
			Mode	Median	Mean	Range
23 March	50	11	8	12	13	5 to 32
6 April	50	26	5	12	14	1 to 26
27 April	50	16	3	3	6	1 to 22
4 May	50	12	2	5	7	1 to 20

Mean length of the 9,044 natural-origin spring chinook salmon measured was 97.23 mm (Figure 16), compared to 99.79 mm during the 1987/88 season and 89.57 mm during the 1986/87 season. We found the salmons' mean length increased as the outmigration season progressed. Mains and Smith (1955) and Major and Mighell (1969) also saw this relationship. Condition factors were calculated on 1,738 fish during the 1988/1989 outmigration. Mean condition factor increased as the season progressed: October through February, 1.05; March, 1.05; April, 1.08; May, 1.13; and June, 1.25. We saw this same phenomenon in the 1987/1988 outmigrants. Mean condition factors for parr, transitional smolts, and full smolts were 1.17 (n=15), 1.08 (n=1,390), and 1.08 (n=330), respectively.

We assessed the degree of smoltification on 8,960 natural spring chinook salmon; 20 percent (1,817) were classified as full smolts, 79 percent (7,063) were considered transitional smolts, and one percent (80) were assessed as parr. Virtually all of the outmigrants were yearlings (Figure 15). Most parr were recently- emerged fry collected in May and June.

We found an overall 1.6 percent descaling rate (two or more zones each with 40 percent scale loss), compared to 2.2 percent in the 1987/88 season and 6.9 percent in the 1986/1987 season. We saw no difference in descaling between fish captured once and those captured and handled twice (recaptured marked fish). Overall, 22 natural- origin (0.22 percent) and 38 (0.61 percent) hatchery-origin spring chinook salmon died in the trap during the eight month season.

Steelhead were trapped at a lower overall efficiency than salmon, but were caught over a longer period of time. Peak of steelhead outmigration occurred at roughly the same time as spring chinook salmon. We also collected large numbers of non-gamefish; Appendix J lists species caught, and their relative abundance.

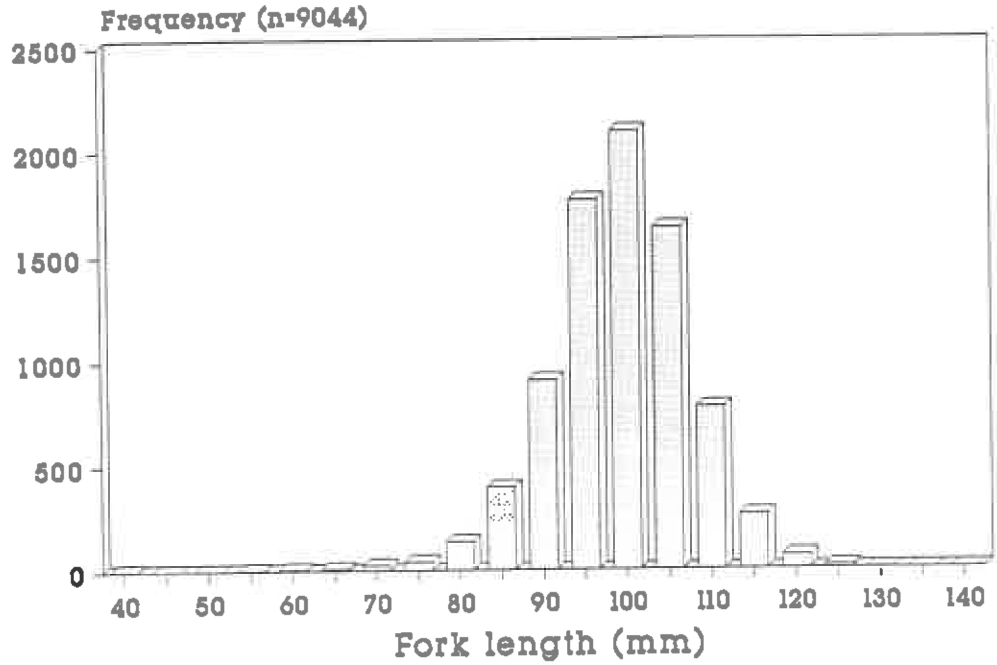

Figure 15. Length frequency distribution of natural spring chinook salmon caught at the Tucannon River downstream migrant trap, 1988/1989 season.

3.4.12: Standing crop

Natural spring chinook salmon population estimates have been derived for several brood years at the egg deposition, late summer rearing fry, and yearling outmigrant stages of life history. Currently, we have estimates for the 1985, 1986, and 1987 broods at all juvenile life stages. All estimates are preliminary and are periodically revised as we obtain additional information from ongoing studies.

We estimate the number of eggs deposited by calculating the product of 1) number of adults allowed to pass the hatchery rack for natural spawning (refer to Sections 3.1 and 3.4.10), and 2) the mean fecundity of those fish collected at the rack for spawning in the hatchery (Section 3.2.1). We have four years' data to date (1986 through 1989 broods), and are able to extrapolate these data to the 1985 brood.

The rearing fry population estimate is the product of 1) parr production density estimates (Sections 3.4.3 to 3.4.5), and 2) areal measurements of the stream derived from previous habitat surveys (FY 1987 report). Both estimators are stratified by stream reach, habitat type, and habitat quality. We have four years' data to date (1985 through 1988 broods).

We have estimates of smolt yield for three brood years (1985, 1986, and 1987; Section 3.4.11), and can calculate egg-to-smolt survival by comparing population estimates by life stage (Figure 16, Table 37, Bugert and Seidel 1988).

Table 37. Estimates of Tucannon River spring chinook salmon abundance by life stage for 1985 through 1989 broods.

Brood year	Redds	Adults	Eggs	Parr	Smolts
1985	189[a]	138[b]	276,300[c]	90,200	36,600
1986	200	131	256,500	102,600	58,200
1987	185	151	309,200	79,100	44,000
1988	117	180	475,800	69,700	--
1989	106	88	136,500	--	

a *Number of adults in 1985 was extrapolated from average adult to redd ratio (1.37:1.00) from 1986 and 1987.*

b *The female to male ratio of adults trapped for broodstock was 1:1 in 1986 and 1987. The ratio was 1.36 females per male in 1988, and 0.86 females per male in 1989. We assume the 1985 value was 1:1.*

c *Average fecundity was 3,916 in 1986, 4,095 in 1987, 3,882 in 1988, and 3,608 in 1989. We assume the 1985 value to be the average of 1986 and 1987 (4,006).*

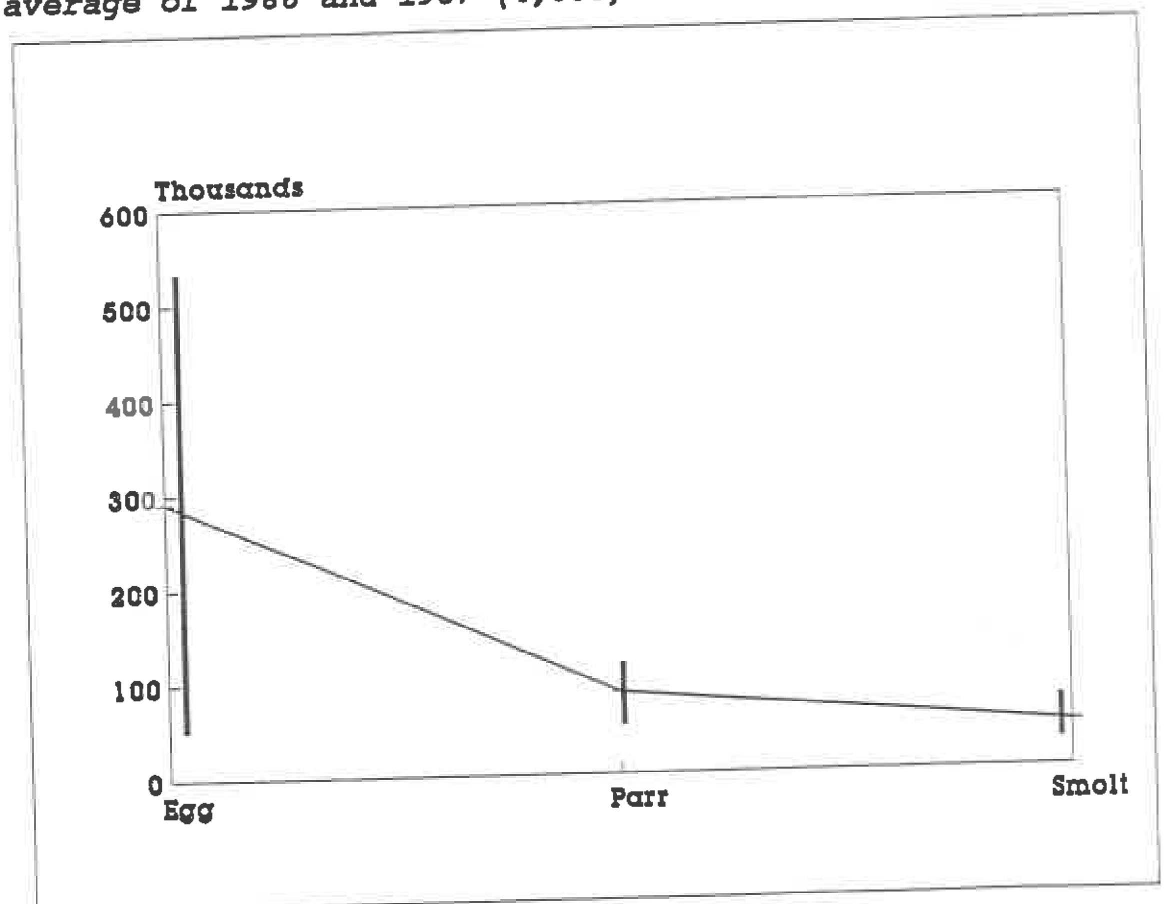

Figure 16. Tucannon River spring chinook salmon freshwater survival rates for 1985- 1988 brood years.

3.5: Invertebrate Production

An important objective of our Tucannon FH evaluation is to determine an appropriate escapement level of spring chinook salmon to provide full seeding of habitat (Appendix A). Seeding levels may be limited by available food. The objective of the invertebrate production study was to: 1) assess invertebrate (benthic and drift) density and diversity, 2) determine which invertebrates serve as the food base for spring chinook salmon and steelhead, and 3) provide an insight on the level of seeding in which food will limit salmon production on the Tucannon river. Kelly and Associates (1982) studied invertebrate production in the Tucannon River in 1980; results of that analysis demonstrated to us that factors other than food base will limit salmonid production in this stream. The following exercise is a supplement to existing information on Tucannon River invertebrate production and food use, yet provides it in a context that is germane to our study of spring chinook population dynamics.

Steelhead are managed as a supplemented natural stock in the Tucannon River. Our estimates of 1989 steelhead parr production in the Wilderness, HMA, and Hartsock Strata are 7,400, 90,400, and 17,800, respectively (unpublished WDF files). We included an analysis of the steelhead food base to determine food overlap, and to incorporate this into our estimate of the available food resource. Some inferences on steelhead seeding levels could be made from these results.

To evaluate food as a limiting factor to freshwater production, we made four assumptions:

1) We assumed that the number of resident fish is negligible compared to the salmon and steelhead parr populations, and are therefore not included in the analysis and presentation. Resident fish include mountain whitefish, bull trout, numerous non-game fish (Appendix J), and rainbow trout larger than 125 mm fork length. The 1989 standing crop estimates of age 2+ rainbow trout in the Wilderness and HMA Strata are 465 and 1,959, respectively. The salmon we sampled were subyearlings (Section 3.4.6), and steelhead were age 1 or 2 (Schuck, personal communication) and hence include juvenile resident rainbow trout.

2) We determined the number of days required for the current salmon and steelhead populations to eliminate the standing crop of invertebrates, and assumed this could be used as a gross indicator of the potential for food to be a limiting factor to outplanted salmon and steelhead.

3) Yearly variations in invertebrate production are not considered, because of the short duration of this study.

4) We found few allochthonous invertebrates in the drift and the stomachs of steelhead and salmon, therefore, we assume they are a negligible part of the diet.

3.5.1: Field methods

Eight sites were selected throughout the Wilderness, HMA, and Hartsock Strata. We did not sample the Marengo and Lower Strata because a negligible number of spring chinook salmon rear there in summer (FY 1985 report). The eight sites were distributed evenly in the upper three strata to ensure all variability in invertebrate production would be quantified. Benthic and drift invertebrates were collected at all sites. We recorded stream depth, water velocity and temperature, substrate size, and time of day when sampled at each site. We collected fish directly downstream of every other site (four sites total, Figure 17).

Nine spring chinook salmon and steelhead each were collected monthly from June through September 1989 using a concussion gun and backpack electrofisher. The nine stomachs for each species of fish were grouped into one allotment for analysis due to the relatively few organisms seen in each individual stomach. Samples were collected within 1 hour of sunrise. Fish stomachs were excised from the pyloric sphincter to the anterior portion of the esophagus and placed in a fixative of 10 percent formalin; we recorded length and weight of all collected fish.

Benthic invertebrates were collected using a modified Hess-Waters sampler (Hess 1941, Waters and Knapp 1961) with an aperture area of $0.1 m^2$ and 390 μm mesh size. We collected samples by pushing the sampler 10 cm into the substrate and disturbing the area within the sampler to a depth of 8- 10 cm (Hynes 1970, Williams and Hynes 1974). Organisms were displaced from rocks with a brush; the rocks were then removed from the sampler. Samples were collected in riffles since they contain higher invertebrate densities and diversities than pools and runs (Egglishaw and Mackay 1967, Armitage et al. 1974, Scullin et al. 1982, O'Laughlin et al. 1988). Two benthic samples were collected twice a month at each site.

One drift sample was collected simultaneous to benthic collection, at each site using a $1/10 m^2$ modified Surber Sampler. Water depth and velocity were taken at the drift net aperture to determine volume of water sampled during a 30 minute period, within 2 hours of sunrise.

Benthic and drift organisms were preserved in 10 percent formalin and later transferred to 70 percent alcohol. Each sample was divided into eight equal portions using a sub-sampler. The organisms were sorted and identified to family using keys set by Merritt and Cummins (1984). Counts of the stomach contents of each species of fish were determined through frequency of occurrence and percent composition by number and weight methods (Windell 1971; Bowen 1983). Each family sample was dried in an oven at 105°C. for 24 hours then weighed to 0.0001 grams, using a Mettler H-8 balance, to obtain dry weight (Weber 1973).

3.5.2: Data analysis

<u>Frequency of occurrence, weight and number</u> Procedures designed to show the relative contribution of each food item to the fish's diet (George and Hadley 1979; Bowen 1983) were used to analyze the gut contents. We determined the mean number and weight of prey organisms, with respective standard deviation. Frequency of occurrence (presence of a particular prey item in the stomach), numerical percent and weight percent were calculated.

<u>Index of relative importance</u> We used the index of relative importance (IRI; George and Hadley 1979), to indicate the relative contribution of each taxon of prey to fish and to identify prey items important to fish. This formula synthesizes occurrence, numerical frequencies, and weight frequencies into one number in order to compensate for the perceived biases of the individual indices. The IRI was calculated using the formula:

$$RI_a = \frac{100\ AI_a}{\sum_{a=1}^{n} AI_a}$$

Where: RI_a = relative importance of food item a
AI_a = absolute importance of food item a (frequency of occurrence + weight frequency of food item a)
n = number of different taxa

<u>Electivity index</u> Areal benthic invertebrate density was the product of the number of organisms collected and the area sampled. Volumetric drift invertebrate density was calculated as the product of 1) organisms collected per volume sampled, and 2) stream flows. After we determined invertebrate density, we calculated the relative proportion of each invertebrate available as a prey base. These data were combined with the numerical percentage obtained from the stomach analyses to determine a linear index of invertebrate food selection (Strauss 1979):

$$L = R_I - P_I$$

Where: L = the measure of food selection
R_I = the relative abundance of prey (i) in thegut
P_I = the relative abundance of the same prey (i) in the environment

Food selection values range from -1 to +1. Values near zero indicate the fish is selecting prey proportional to its abundance. Positive values indicate the fish is actively selecting the food item from the environment, while negative numbers indicate either that the fish avoids the food item or the food item is inaccessible to the fish. We used this index to determine if salmon and steelhead selectively prey on particular taxa of invertebrates.

Index of diet overlap Diet overlap indices (Keast 1978a) were calculated to determine if spring chinook salmon and steelhead compete for food items. A diet overlap may indicate competition if the food resources shared by the two species are limited (MacArthur 1968). However, high diet overlap values could indicate a surfeit of food, and that it is not limiting. Therefore, available food resources were determined before we assessed competition for food between spring chinook salmon and steelhead. Horn's (1966) index for diet overlap for steelhead and spring chinook salmon was used with the estimate of standing crop of prey to determine if a potential for competition exist.

Fish diet overlap values (Morisita 1959, Horn 1966) were based upon the IRI calculations. The overlap index is expressed in the equation:

$$C_x = \frac{2\sum_{i=1}^{n}(P_{Xi} \times P_{Yi})}{\sum_{i=1}^{n} P_{Xi}^2 + \sum_{i=1}^{n} P_{Yi}^2}$$

Where: Cx = the overlap coefficient
Px_i = the proportion of food category (i) in the diet of species x
Py_i = the proportion of food category (i) in the diet of species y
n = the number of food categories

Overlap values range from 0 (no overlap) to 1 (complete overlap). Values of less than 0.3 are usually considered low and values greater than 0.7 indicate significant overlap (Peterson and Martin-Robichaud 1982).

Food use The four most numerous invertebrate families were chosen as the preferred invertebrate prey; these families were determined by frequency of occurrence, percent composition by number, percent composition by weight, and electivity index. Each prey item was allotted 3 points for scoring highest in a category, 2 points for second and 1 point for third. Points were totaled and prey items were ranked accordingly. We compared only the predominant organisms consumed by both species (Geist et al. 1988).

3.5.3: Results

The principal foods of spring chinook salmon and steelhead differed greatly. The following text provides a comparison of food use (frequency of occurrence, number, weight, relative importance, and diet overlap) by both salmon and steelhead within each stratum.

Wilderness Stratum Frequencies of occurrence were as follows: Elmidae pupa were found in 90.1 percent of the spring chinook salmon stomachs, while Perlodidae were found in 33.3 percent, and Baetidae in 8.5 percent of the stomachs. For steelhead, Baetidae were found in 76.1 percent of the stomachs, followed by Chironomidae pupa at 33.3 percent, and Nematoda at 19.4 percent (Appendix K, Table 1).

In spring chinook salmon, Elmidae pupa had the highest numerical percentage at 46.1 percent, followed by Ephemerellidae at 19.2 percent, and Perlodidae at 8.5 percent. For steelhead, Baetidae had the highest numerical percentage at 54.8, followed by Chironomidae at 11.5 percent, and Nematoda at 6.7 percent.

Elmidae pupa had the highest mean dry weight for spring chinook salmon with an average of 4.3 mg, followed by Ephemerellidae at 4.1 mg, and Perlodidae at 1.3 mg. For steelhead, Baetidae had the highest mean dry weight with an average of 2.8 mg, followed by Simulidae at 1.0 mg, and Ephemerellidae and Glossosomatidae, both at 0.4 mg.

Elmidae pupa formed the highest percentage by weight at 27.5 percent for spring chinook salmon, followed by Ephemerellidae at 25.5 percent, and Perlodidae at 7.9 percent. For steelhead, Baetidae had the highest percent composition by weight at 42.3 percent, followed by Simulidae at 15.8 percent, and Ephemerellidae and Glossosomatidae both at 6.0 percent.

For spring chinook salmon, Elmidae pupa had the highest index of relative importance at 50.1, followed by Perlodidae at 9.8, and Ephemerellidae at 9.0. For steelhead, Baetidae had the highest relative importance at 52.9 followed by Chironomidae at 9.6, and Nematoda at 6.0 (Figure 18). Diet overlap index for spring chinook salmon and steelhead was 0.16 (Appendix K, Table 2) in the Wilderness Stratum; from this we inferred little competition for food between the two species at existing levels of seeding.

HMA Stratum Frequencies of occurrence were as follows: Lumbriculidae were found in 54.0 percent of the spring chinook salmon stomachs, while Simulidae were found in 40.5 percent, and Hydropsychidae in 29.7 percent of the stomachs. For steelhead, Elmidae pupa were found in 98.0 percent of the stomachs, followed by Limnephilidae at 52.9 percent, and Ephemerellidae at 44.1 percent (Appendix K, Table 3).

Lumbriculidae had the highest numerical percentage for spring chinook salmon at 40.8 percent, followed by Simulidae at 15.3 percent, and Hydropsychidae at 11.2 percent. For steelhead, Elmidae pupa had the highest numerical percentage at 48.9 percent, followed by Limnephilidae at 10.0 percent, and Ephemerellidae at 8.3 percent.

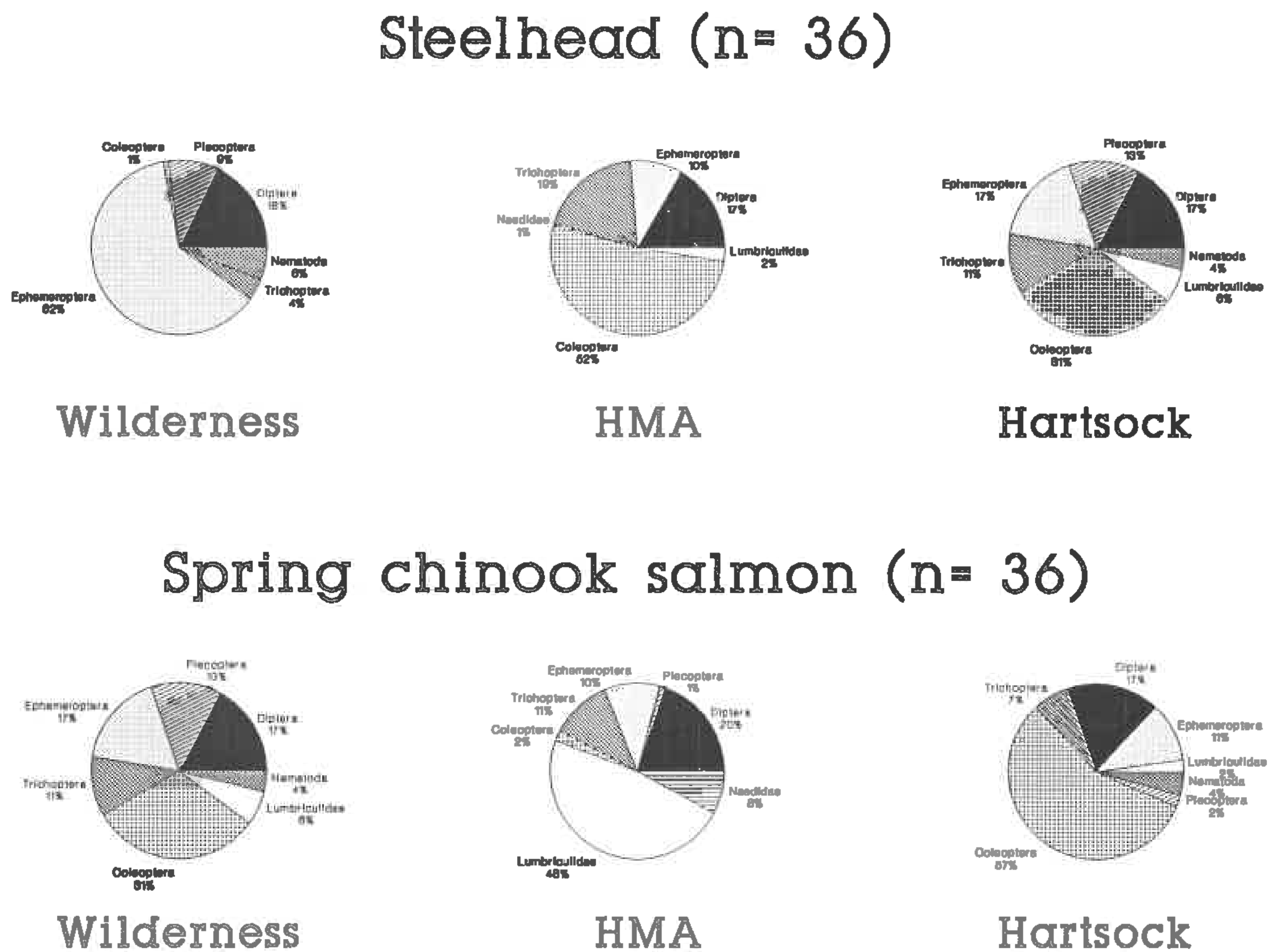

Figure 18. Comparison of food items of spring chinook salmon and steelhead in three study strata of the Tucannon river.

For spring chinook salmon, Lumbriculidae had the highest mean dry weight with an average of 20.4 mg, followed by Ephemerellidae at 2.0 mg, and Naedidae at 1.4 mg. Elmidae pupa had the highest mean dry weight for steelhead with and average of 21.1 mg, followed by Lumbriculidae at 5.4 mg, and Rhyacophilidae at 3.8 mg.

Lumbriculidae had the highest percentage by weight for spring chinook salmon at 50.9 percent, followed by Ephemerellidae at 5 percent, and Naedidae at 3.5 percent. For steelhead, Elmidae pupa had the highest percent composition by weight at 48.6 percent, followed by Lumbriculidae at 9.0 percent, and Simulidae at 3.5 percent.

Lumbriculidae had the highest relative importance for spring chinook salmon at 47.7, followed by Ephemerellidae at 10.3, and Simulidae at 10.2. For steelhead, Elmidae pupa had the highest relative importance at 50.4, followed by Limnephilidae at 9.5, and Ephemerellidae at 8.0 (Figure 18). Diet overlap index for spring chinook salmon and steelhead trout was 0.11 (Appendix K, Table 4) in the HMA Stratum, suggesting limited competition.

Hartsock Stratum Chironomidae pupa were found in 81.0 percent of the spring chinook salmon stomachs, while Elmidae pupa were found in 63.9 percent, and Lumbriculidae in 61.1 percent of the stomachs. For steelhead, Elmidae pupa were found in 80.6 percent of the stomachs, followed by Chironomidae pupa at 33.3 percent, and Ephemerellidae pupa at 25.0 percent (Appendix K, Table 5).

In spring chinook salmon, Chironomidae had the highest numerical percentage at 17.1 percent, followed by Nematoda at 12.4 percent, and Elmidae pupa at 10.6 percent. For steelhead, Elmidae pupa had the highest numerical percentage at 35.8 percent, followed by Chironomidae pupa at 14.8 percent, and Ephemerellidae pupa at 11.1 percent.

Lumbriculidae had the highest mean dry weight in spring chinook salmon with and average of 9.80 mg, followed by Elmidae pupa at 1.06 mg, and Chloroperlodidae at 1.03 mg. For steelhead, Ephemerellidae adults had the highest mean dry weight with an average of 1.19 mg, followed by Elmidae pupa at 1.06 mg, and Chloroperlodidae at 1.03 mg.

Lumbriculidae had the highest percentage by weight at 42.7 percent for spring chinook salmon, followed by Ephemeriidae at 8.2 percent, and Naedidae at 6.4 percent. For steelhead, Ephemerellidae adults had the highest percent composition by weight at 14.5 percent, followed by Elmidae pupa at 12.8 percent, and Chloroperlodidae at 12.5 percent.

For spring chinook salmon, Chironomidae had the highest relative importance at 17.3, followed by Lumbriculidae at 15.8, and Elmidae pupa at 11.0. For steelhead, Elmidae pupa had the highest relative importance at 31.9, followed by Chironomidae at 12.1, and Ephemerellidae pupa at 10.0 (Figure 18). Diet overlap index between spring chinook salmon and steelhead was 0.52 (Appendix K, Table 6) in the Hartsock Stratum. Diet overlap for the two species of fish in this stratum shows moderate competition for food resources is occurring.

3.5.4: Electivity index

We used the electivity index (Strauss 1979) to compare the diet selected by fish to available benthic and drift invertebrates (Bowen 1983). The index value indicated how the selected diet differed from a diet selected at random. The percent composition by number, for a prey item in the gut, was compared to the percent composition by number for the same prey item in the environment (Appendix K, Tables 7, 8, 9, 10).

<u>Wilderness Stratum</u> The highest positive index for spring chinook salmon was 0.34 for Chironomidae pupa, followed by Ephemerellidae at 0.15. The highest negative electivity was -0.05 for Elmidae pupa, followed by -0.03 for Perlodidae. The highest positive index for steelhead was .49 for Baetidae, followed by Nematoda at 0.03. The highest negative value was -0.09 for Perlodidae, followed by Elmidae pupa at -0.08 (Table 38).

<u>HMA Stratum</u> The highest positive index for spring chinook salmon was 0.39 for Lumbriculidae, followed by Simulidae at 0.11. The highest negative electivity was -0.14 for Chironomidae pupa, followed by Brachycentridae at -0.12. The highest positive index for steelhead was 0.9 for Limnephilidae, followed by 0.32 for Elmidae pupa. The highest negative index was -0.21 for Chironomidae, followed by Brachycentridae at -0.1 (Table 39).

<u>Hartsock Stratum</u> The highest positive index for spring chinook salmon was 0.1 for Nematoda, followed by Chironomidae pupa at 0.07. The highest negative electivity was -0.06 for Chironomidae followed by Heptageniidae, Elmidae pupa, and Naedidae at -0.04. The highest positive index for steelhead was 0.22 for Elmidae pupa, followed by Ephemerellidae pupa at 0.7. The highest negative value for steelhead was -0.08 for Chironomidae (Table 40). There were no other negative values.

Table 38. Wilderness Stratum electivity indices. Benthic macroinvertebrate densities were quantified in the gut and the environment and converted into percentages.

Organism	Environment	Salmon stomach	Electivity index	Steelhead stomach	Electivity index
Chironomidae	0.144	0.049	0.34	0.115	-0.03
Chironomidae pupa	-	0.710	-	0.019	-
Ceratopogonidae	-	-	-	-	-
Tipulidae	-	-	-	-	-
Simulidae	0.002	0.036	0.03	0.029	0.03
Empidae	-	-	-	-	-
Tabanidae	-	-	-	-	-
Sciomyzidae	0.002	-	-	-	-
Glossosomatidae	0.013	0.007	-0.01	-	-
Glossosomatidae pupa	-	-0.010	-	0.001	-
Brachycentridae	0.061	-	-	-	-
Hydropsychidae	0.011	-	-	0.019	0.01
Limnephilidae	0.002	0.010	-	-	-
Rhyacophilidae	0.008	-	-	-	-
Lepidostomatidae	-	-	-	-	-
Helicopsychidae	-	0.007	-	-	-
Chloroperlidae	0.044	0.014	-0.03	0.058	0.01
Perlodidae	0.112	0.085	-0.03	0.019	-0.09
Heptageniidae	0.082	-	-	0.048	-0.03
Ephemerellidae	0.037	0.192	0.15	0.048	0.01
Baetidae	0.063	0.057	-0.01	0.548	0.49
Elmidae adult	0.008	0.104	0.01	-	-
Elmidae pupa	0.093	0.046	-0.05	0.001	-0.08
Hydracarina	0.002	-	-	-	-
Lumbriculidae	0.032	0.007	-0.02	-	-
Naedidae	0.025	-	-	-	-
Nematoda	0.004	0.036	0.03	0.067	0.06
Spheridae	0.028	-	-	-	-

Table 39. HMA Stratum electivity indices. Benthic macroinvertebrate densities were quantified in the gut and the environment and converted into percentages.

Organsim	Environment	Salmon stomach	Electivity index	Steelhead stomach	Electivity index
Chironomidae	0.215	0.071	-0.14	0.001	-0.21
Chironomidae pupa	0.001	-	-	-	-
Ceratopogonidae	0.002	-	-	-	-
Tipulidae	0.005	0.010	0.01	0.006	0.00
Simulidae	0.042	0.153	0.11	0.056	0.01
Empidae	0.001	-	-	-	-
Tabanidae	0.0002	-	-	-	-
Sciomyzidae	0.008	-	-	-	-
Glossosomatidae	0.013	-	-	0.006	-0.01
Glossosomatidae pupa	0.006	-	-	-	-
Brachycentridae	0.126	0.010	-0.12	0.028	-0.10
Hydropsychidae	0.020	0.112	0.09	-	-
Limnephilidae	0.007	0.010	0.00	0.100	0.90
Rhyacophilidae	0.001	-	-	0.078	0.08
Lepidostomatidae	0.006	-	-	0.022	0.02
Helicopsychidae	0.001	-	-	0.006	0.00
Chloroperlidae	0.010	-	-	-	-
Perlodidae	0.029	0.010	-0.02	-	-
Heptageniidae	0.034	-	-	-	-
Ephemerellidae	0.016	0.102	0.09	0.083	0.07
Baetidae	0.037	0.010	-0.04	-	-
Elmidae adult	-	0.020	-	0.022	-
Elmidae pupa	0.167	-	-	0.489	0.32
Hydracarina	0.045	-	-	-	-
Lumbriculidae	0.030	0.408	0.39	0.028	0.00
Naedidae	0.041	0.082	0.04	0.017	-0.02
Nematoda	0.025	-	-	0.006	-0.02
Spheridae	-	-	-	-	-

Table 40. Hartsock Stratum electivity indices. Benthic macroinvertebrate densities were quantified in the gut and the environment and converted into percentages.

Organism	Environment	Salmon stomach	Electivity index	Steelhead stomach	Electivity index
Chironomidae	0.23	0.171	-0.06	0.148	-0.08
Chironomidaepupa	0.01	0.074	0.07	0.037	0.04
Simulidae	0.03	0.069	0.04	0.000	-
Tabanidae	0.01	0.023	0.02	0.000	-
Sciomyzidae	0.02	0.042	0.02	0.025	0.01
Glossosomatidae	0.50	0.009	0.01	0.037	0.03
Glossosomatidae pupa	0.02	0.005	0.01	0.000	-
Hydropsychidae	0.50	0.051	0.05	0.049	0.04
Lepidostomatidae	0.25	0.000	-	0.062	0.06
Helicopsychidae	0.01	0.000	-	0.012	0.01
Chloroperlidae	0.75	0.014	0.01	0.012	0.01
Perlodidae	0.03	0.000	-	0.025	-0.01
Heptageniidae	0.05	0.005	-0.04	0.000	-
Ephemeriidae	0.01	0.032	0.03	0.000	-
Ephemerellidae pupa	0.04	0.088	0.05	0.111	0.07
Ephemerellidae	0.01	0.000	-	0.012	0.01
Elmidae pupa	0.14	0.106	-0.04	0.358	0.22
Lumbriculidae	0.06	0.101	0.05	0.062	0.01
Naedidae	0.13	0.088	-0.04	0.000	-
Nematoda	0.02	0.124	0.10	0.049	0.03

3.5.5: Food as a limiting factor

To determine if available food resources were limiting fish production in the Tucannon River, food consumption of spring chinook salmon and steelhead populations were compared to invertebrate production. We also determined the number of days the standing crop of invertebrates could support the salmon and steelhead population. This estimate could provide insight on potential limitations to anadromous fish production in the Tucannon River. Food use of resident fish (mountain whitefish, bull trout, and rainbow trout) were not considered in this analysis.

<u>Standing crop</u> Food availability was estimated as the product of invertebrate density (Tables 41,42,43) and invertebrate habitat. We estimated the latter by calculating the area of riffle habitat throughout the study area (Bugert and Seidel 1988). Since more than 80 percent of invertebrate production occurs in the riffle areas of the stream (Hynes 1970; Leathe and Nelson 1986), we assumed that riffle habitat produced essentially all autochthonous food available to the fish. We evaluated benthic organisms only to determine standing crop; drift organisms comprised less than one percent of the sampled invertebrates. We calculated the standing crop of each prey organism (the total number of invertebrates in riffle areas at any point in time which were potentially available to fish). Total riffle area at mean base (summer) flow in the Wilderness Stratum is 61,595 m^2; riffle area in the HMA Stratum is 124,865 m^2; riffle area in the upper Hartsock Stratum (that reach used by spring chinook salmon in summer) is 23,247 m^2 (Bugert and Seidel 1988). Riffle area was then multiplied by the invertebrate density in that stratum to obtain a mean stream abundance of that evaluation organism (Appendix K, Table 11).

To determine the biomass of the preferred prey standing crop, the total number of each preferred prey was multiplied by that individual prey's weight. Individual weights were estimated by dividing the prey's accumulated dry weight by the total number of that prey found in the stomach contents of fish. This value was then multiplied by the spring chinook salmon population to achieve a consumption value (mg) for both the spring chinook salmon and steelhead populations in each stratum.

Food consumption for the entire salmon and steelhead populations was based upon: 1) the amount of preferred prey items found in the stomachs, and 2) the digestive rates of each of the preferred prey. The average number of organisms found in the stomach of each species was multiplied by the entire population of that species to give a consumption value for that population. This consumption value is an instantaneous value; it does not indicate the daily meal (the amount of food the fish may have eaten over a period of time).

Table 41. Benthic invertebrate densities per square meter (with standard deviation) by month in the Wilderness Stratum.

Organism	June	July	August	September
Chironomidae	760(56)	1560(1301)	240 (113)	160 (113)
Simulidae	0	40 (56)	0	0
Sciomyzidae	0	40 (56)	0	0
Limnephilidae	0	0	40 (56)	0
Hydropsychidae	120 (169)	0	0	80 (0)
Brachycentridae	0	1040 (1470)	120 (169)	0
Glossosomatidae	80 (113)	0	0	160 (226)
Rhyacophilidae	0	80 (113)	80 (113)	0
Perlodidae	600 (169)	630 (127)	680 (56)	200 (56)
Chloroperlidae	40 (56)	80 (113)	160 (226)	560 (452)
Baetidae	840 (282)	310 (325)	40 (56)	0
Ephemerellidae	200 (56)	80 (113)	240 (339)	120 (56)
Heptageniidae	280 (169)	670 (70)	160 (113)	440 (282)
Leptophlebiidae	0	0	0	80 (113)
Elmidae pupa	440 (509)	840 (169)	360 (509)	120 (56)
Elmidae adult	40 (56)	0	0	120 (169)
Lumbriculidae	0	0	120 (56)	480 (565)
Naedidae	120 (169)	360 (369)	0	0
Hydracarina	0	40 (56)	0	0
Nematoda	0	80 (0)	0	0
Planaria	0	120 (169)	360 (56)	0
Spheridae	0	160 (226)	360 (56)	0

Table 42. Benthic invertebrate densities per square meter (with standard deviation) by month in the HMA Stratum.

Organism	June	July	August	September
Chironomidae	1520 (792)	2520 (282)	1560(396)	1560 (169)
Chironomidae pupa	0	0	200 (169)	0
Tipulidae	80 (0)	80 (113)	1160 (1414)	40 (56)
Ceratopogonidae	40 (56)	40 (56)	0	0
Empidae	40 (56)	0	0	0
Sciomyzidae	0	0	280 (169)	0
Limnephilidae	0	80 (113)	0	0
Hydropsychidae	160 (0)	0	120 (169)	400 (452)
Brachycentridae	1000 (735)	1230 (155)	1040 (1018)	960 (452)
Glossosomatidae	200 (56)	40 (56)	240 (226)	0
Glossosomatidae pupa	120 (169)	0	0	40 (56)
Leptostomatidae	0	0	0	200 (56)
Rhyacophilidae	0	0	0	40 (56)
Hydroptilidae	0	0	40 (56)	0
Helicopsychidae	0	0	0	40 (56)
Pteronarcydae	0	80 (113)	80 (113)	120 (56)
Perlodidae	40 (56)	400 (113)	320 (113)	200 (169)
Chloroperlidae	0	80 (113)	80 (113)	200 (56)
Baetidae	280 (282)	600 (509)	360 (509)	0
Ephemerellidae	120 (56)	40 (56)	160 (226)	200 (56)
Heptageniidae	280 (282)	40 (56)	200 (169)	600 (169)
Elmidae pupa	1670 (1117)	2160 (565)	1600 (1130)	80 (0)
Elmidae adult	320 (113)	390 (212)	240 (113)	0
Lumbriculidae	160 (226)	0	280 (396)	560 (226)
Naedidae	280 (169)	800 (113)	280 (369)	0
Hydracarina	360 (56)	280 (169)	720 (113)	160 (226)
Nematoda	40 (56)	400 (565)	40 (56)	80 (113)
Planaria	120 (169)	440 (282)	280 (56)	240 (339)
Spheridae	160 (113)	350 (268)	280 (56)	40 (56)

Table 43. Benthic invertebrate densities per square meter (with standard deviation) by month in the Hartsock Stratum.

Organism	June	July	August	September
Chironomidae	1000 (396)	600 (396)	680 (169)	2960 (1244)
Tipulidae	200 (282)	0	0	80 (0)
Simulidae	0	160 (0)	160 (226)	200 (56)
Stratiomyidae	40 (56)	0	0	0
Sciomyzidae	0	0	200(169)	200 (169)
Limnephilidae	0	40 (56)	0	80 (0)
Hydropsychidae	600 (735)	0	0	120 (56)
Brachycentridae	1000 (1074)	160 (113)	80 (0)	80 (113)
Glossosomatidae	160 (113)	200 (169)	40 (56)	0
Glossosomatidae pupa	120 (169)	0	0	0
Leptostomatidae	0	0	0	40 (56)
Rhyacophilidae	0	0	0	40 (56)
Pteronarcyidae	0	0	40 (56)	120 (56)
Perlodidae	120 (56)	40 (56)	120 (56)	160 (113)
Chloroperlidae	0	0	0	160 (113)
Baetidae	520 (282)	160 (113)	240(113)	120 (169)
Ephemerellidae	160 (113)	240 (0)	120 (56)	400 (226)
Heptageniidae	400 (0)	120 (56)	120 (169)	480 (113)
Leptophlebiidae	0	0	0	80 (0)
Elmidae pupa	1840 (1010)	880 (0)	560 (452)	80 (0)
Elmidae adult	80 (113)	0	0	40 (56)
Lumbriculidae	280 (169)	640 (0)	120 (56)	200 (169)
Naedidae	240 (0)	1440 (452)	600 (848)	280 (282)
Hydracarina	160 (0)	0	120 (56)	40 (56)
Nematoda	200 (282)	40 (56)	160 (113)	0
Planaria	0	0	120 (169)	80 (113)
Spheridae	280 (282)	1040 (1470)	120 (169)	80 (113)
Daphnia	520 (735)	0	0	0
Unknown	0	0	0	120 (169)

<u>Daily meal</u> To estimate the daily meal, the average instantaneous consumption rate of each of the preferred prey was calculated for salmon and steelhead (Appendix K, Tables 12, 13). The daily meal for individual fish was estimated from actual measurements of stomach contents and corrected by applying a formula that calculated a temperature-dependent rate of stomach evacuation. The correction was applied because the stomach contents did not reflect the total amount of preferred prey eaten per fish per day. By factoring in the rate of gastric evacuation, the daily meal could be estimated.

The daily meal was calculated using the formula (Stauffer 1973; Dobble and Eggers 1978):

$$DM = A \times 24/N_p$$

Where: DM = the daily meal in mg dry weight of the preferred prey
A = the average mg dry weight of the preferred prey found in the stomach
N_p = gastric evacuation rate

The rates of gastric evacuation,hours required to evacuate 99 percent of the stomach contents, for the invertebrates were set by Elliot (1972), who determined constants for each food item to account for the different digestive rates. The formula is:

$$N_p = A_p \times E^{-BT}$$

Where: N_p = hours required to evacuate 99 percent of the stomach contents.
A_p and B = digestion rates constants for particular food items
T = water temperature (degrees C.)
E = natural antilog (2.713)

Rates of gastric evacuation and resultant daily meals for spring chinook salmon and steelhead trout are presented in Appendix K, Tables 12 and 13, respectively. Once the daily meal of a single fish was known, total consumption of each preferred prey by the entire salmon population was calculated with the formula:

$$TCON = DM \times POP$$

Where: TCON = total consumption of the preferred prey by all fish per day
DM = the average daily meal per fish
POP = estimated fish population.

TCON was calculated in both mass (mg) and total number of organisms consumed (Table 44).

Table 44. The estimated consumption of the preferred food items by the entire salmon and steelhead population in comparison to the total available food resources.

Prey item	Standing Crop (number)	Individual weight (mg)	Standing crop (g)	Daily meal (g)	Elimination (days)
Elmidae pupa	59,400,000	1.41	83,160,000	271,264	304
Ephemerellidae	46,900,000	0.41	18,872,907	147,100	128
Perlodidae	80,170,350	0.42	34,230,000	8,915	3,840
Chironomidae	605,016,700	0.80	484,013,360	200,200	2,417
Limnephilidae	39,475,450	15.00	592,131,750	225,900	2,621
Lumbriculidae	80,239,250	1.90	150,849,790	307,894	490
Simulidae	5,015,950	0.85	4,263,558	13,700	311
Hydropsychidae	46,555,450	3.10	144,321,895	8,590	16,800
Nematoda	38,000,000	0.13	4,940,000	12,192	405
Rhyacophilidae	243,500,000	0.90	219,500,000	361,400	607
Ephemerellidae adult	2,800	1.20	3,360	11,550	291

The principle foods of the salmon and steelhead differed considerably (diet overlap values ranged from 0.11 to 0.52; Appendix K, Tables 2, 4, 6). Elmidae pupa, Ephemerellidae, Perlodidae, Chironomidae, Limnephilidae, Lumbriculidae, Simulidae, Hydropsychidae, Nematoda, Rhyacophilidae, and Ephemerellidae adults were consistently among the most prevalent three families selected by both salmon and steelhead in the three strata that were sampled (Appendix K, Table 14). We chose these taxa as the principle foods based upon these data. These data were then compared to invertebrate availability to determine how many days the present food resource base could support the entire salmon and trout population (Table 44).

3.5.6: Discussion

We estimated invertebrate production separately for each of the Wilderness, HMA, and Hartsock Strata (that reach of the Tucannon River which support salmonids at all stages of their freshwater life cycle). For simplicity of analysis and discussion, the estimate of standing crop and the days required for the entire fish population to consume the standing crop is reported on an entire reach basis, while all other data is reported on a per-stratum basis.

Selection of evaluation organisms Key invertebrates were identified by ranking each one using a combination of methods including frequency of occurrence, percent composition by number and weight, and the electivity index for each food item found in the gut of both species (Appendix K, Table 20). The top four invertebrate species for each stratum based on the relative ranking were chosen as evaluation organisms for the study. If an organism ranked in the top four for either species of fish it was included in the study. If there was no species overlap, a total of eight families of invertebrates could be evaluated in a stratum. Seven invertebrate families were studied in the Wilderness Stratum, eight families were studied in the HMA Stratum, and five families in the Hartsock Stratum. Selecting a limited number of invertebrates from the many identified in the diets allowed a more detailed study of the important prey items to both the salmon and steelhead populations.

Potential competitive interactions Results of the diet analysis between spring chinook salmon and steelhead in the Tucannon River indicated a low diet overlap index. Values obtained from overlap indices have been used by investigators as competition coefficients when studying the potential for competition and ecological relationships within fish communities (George and Hadley 1979). An overlap is considered high if it exceeds 0.70 (Peterson and Martin-Robichaud 1982). The overlap value of 0.52 for the Hartsock Stratum, 0.11 for the HMA Stratum, and 0.16 for the Wilderness Stratum between the diets of spring chinook salmon and steelhead in this study suggest that moderate to little competition was occurring between these species during the sampling.

Spring chinook salmon and steelhead consumed few similar food items, however those organisms that overlapped in their diets were consumed frequently. As expected, neither species of fish showed picsivorous habits; the length of fish sampled did not exceed 127 mm.

Keast (1965) reported that when food availability is high there is a corresponding high degree of overlap between two similar species. However, as food availability decreased, overlap indices decreased as each species began to specialize by selectively preying on certain food items. Typically, when food resources are scarce one species will shift its diet so that the competing species partition the limited resources; reducing competition.

Based upon the low index of diet overlap between salmon and steelhead in the Tucannon River, our interpretation could be that food resources are limited in this system. However, these two species of fish are ecologically distinct (Chapman and Bjornn 1969) and use different portions of the food resource base. This statement appears valid for the Tucannon if we refer to the electivity indices. The fact that electivity indices were clustered near zero for both species (ie., prey selection was random and relative to availability) they are opportunistic and not preying on similar food items. Geist et al. (1988) and O'Laughlin et al. (1988) found similar results in Chamokane Creek, Washington.

Food production is not a limiting factor to the current standing crop of both salmon and steelhead parr, and will probably not be when the LSRCP compensation escapement levels are approached. It must be kept in mind, however, that resident trout and whitefish populations occur in the Tucannon River and these fish are also preying upon the invertebrate community. This additional predation will decrease the ratio of food availability to consumption. We estimate that it would take 128 days to eliminate the most limiting invertebrate population, assuming that the fish and invertebrate population did not change.

SECTION 4: RECOMMENDATIONS

The following recommendations to improve the production and survival of chinook salmon at Lyons Ferry and Tucannon FH are based upon our analysis of broodstock collection strategies, spawning practices, smolt releases, and downstream migrant survival. At this time, we do not have sufficient information on adult contribution and return rates to provide recommendations on appropriate release strategies.

4.1: Fall Chinook Salmon

1) The adult trapping operations at Ice Harbor Dam continues to be an important element of broodstock collection for Lyons Ferry FH, particularly since the hatchery is operating below design capacity. To ensure adequate broodstock, we recommend that trap operations continue, but at a reduced level. The strategy should be to trap only during the last 3 weeks of September, or to collect 1,000 fish, if this occurs first. Operating costs for the trapping project would be reduced about forty percent.

2) Fall chinook salmon released from Lyons Ferry FH as yearlings have shown higher rates of ocean contribution and returns to the project area than do the salmon released as subyearlings. Lyons Ferry FH should rear as many fish for yearling releases as possible, given existing poundage capacity.

3) A pond should be constructed at Lyons Ferry FH to continue the yearling program. Health of the yearlings would improve because of reduced handling and reduced loading densities.

4) The middle 80 percent passage period of branded yearling salmon released on-station occurs at McNary Dam earlier than the Columbia River yearling chinook salmon passage window. Lyons Ferry FH should release fish on-station no earlier than 15 April, to best utilize potential spill at the Lower Columbia River Dams.

5) Our release strategy for fall chinook salmon is a factorial comparison of subyearling versus yearling releases combined with a comparison of on-station release versus off-station (transported below Ice Harbor Dam). Fiscal year 1990 will be the sixth year of this study to develop an optimum release strategy and to obtain baseline adult return and fisheries contribution data. We feel these 2 objectives (release strategy and fisheries contribution) are compatible and of equal importance in evaluating the success of the fall chinook salmon program at Lyons Ferry FH.

We recommend this study continue at least through FY 1992. Thereafter, we will initiate an experiment to refine our information gained from release strategies. The study design will be based upon: 1) results of coded-wire tag recoveries of the current study, 2) rearing space available for yearlings, and 3) results of loading density studies currently carried out by other LSRCP evaluation programs.

6) Partitions are needed in the adult holding ponds at Lyons Ferry FH. The salmon do not move into the fall back channel when ripe, requiring hatchery staff to manually crowd all fish (ripe and unripe) into the channel for sorting during weekly eggtakes. As escapement to Lyons Ferry FH increases, the hatchery crew will be required to crowd a large number of adults into the fall back channel, placing undue stress upon the adults. Partitions in the holding ponds would allow the crew to crowd half the number of adults into the fall back channel at a time, mitigating the stress upon the salmon.

7) Subyearlings reared in baffled ponds appeared to have higher condition factors than those reared in regular ponds (Chapman, personal communication), despite difficulties in feeding fish in the former. More effort should be made to determine the feasibility of using pond baffles in the subyearling program.

8) An increasing number of Upriver bright fall chinook salmon released from the Umatilla River are straying to Lyons Ferry FH. Genetic dilution of a discrete, important stock of fish is inevitable unless efforts are made to reduce this straying problem. Our interim management recommendation is to determine if adults trapped at Ice Harbor Dam are contributing a disproportionate number of strays to the broodstock. A long-term solution to this problem is currently being established by WDF administration.

9) The amount of suspended particulate manganese in the raceways, and the incidence of gill hyperplasia in subyearling fall chinook salmon at Lyons Ferry FH seem to be reduced when pump #4 is not used. All efforts should be made to operate the fall chinook salmon program without wellwater derived from this source. An investigation should be made to determine if this well is the source of the manganese particles.

4.2: Spring Chinook Salmon

1) There is a high likelihood that salmon are released from Tucannon FH too late to meet the scheduled spill periods at Lower Monumental Dam. We base this upon our estimates of hatchery- reared salmon travel time in both the Tucannon and Snake Rivers. Smolt releases at Tucannon FH should occur 14 to 16 days prior to spill at the dam.

2) The designed operation of the spring chinook salmon program is to rear 132,000 yearling smolts for release into the Tucannon River at 15 fish per pound (8,800 pounds). Hatchery staff rear these salmon at Lyons Ferry FH and acclimate them to river water at Tucannon FH prior to release.

In the three years of operation, we have consistently exceeded the designed rearing densities of the acclimation pond, yet stayed within acceptable standards for hatchery rearing densities. Given existing rearing conditions at Lyons Ferry FH, hatchery staff have been unable to rear smolts smaller than 10 fish per pound for release, because of constant water temperatures during rearing. To retard their growth, hatchery staff feed these fish at, or near maintenance ration.

To meet the LSRCP compensation levels, we may be required in the future to increase our eggtake and resultant smolt production, but at present we are constrained by this limitation. We foresee the most cost effective means to rectify this problem will be to use water chillers during incubation.

3) Broodstock collection at Tucannon FH should be done to provide maximum survival of the natural stock. Selection of broodstock will become increasingly complex within the next three years when progeny of wild, natural, and hatchery-origin salmon return as adults. We recommend two strategies to meet this need:

a. To the maximum extent possible, the age ratios of adults passed upstream to spawn naturally should be the same as the ratios prior to the return of hatchery-origin fish. The proportions of age 3, 4, and 5 salmon passed upstream to spawn naturally should be 0.05, 0.65, and 0.35, respectively.

b. To the maximum extent possible, the ratio of hatchery to natural-origin fish passed upstream to spawn naturally should be 1:1. This practice should continue for several years, until we have sufficient genetic information to assess the results of this interaction.

4) Given the small number of parents used for spawning at Tucannon FH, additional efforts should be made to increase the effective population size for both males and females, and to decrease the possibility of directional selection. We recommend three strategies:

a. Sperm from a given male may have a higher motility rate than another, and hence would have a disproportionately higher likelihood of fertilization if milt from several males is added to the eggs simultaneously. Males and females should be mated on a one-to-one basis, unless pathological needs preclude this action.

b. Cryopreserve milt from 20 males each year. In subsequent years, add sperm from 10 males to the breeding population. Evaluate sperm viability on a random basis yearly. This action should only be done as an ancillary means to increase genetic diversity.

c. Fewer gametes should be taken from individual parents, and more parents should be used in spawning. The feasibility of this strategy depends upon relative proportions of wild and hatchery-origin salmon.

5) Salmon held in the Tucannon FH acclimation pond have chronic infestations of viral EIBS. During this acclimation period, water temperatures generally range from 2 to 6 degrees C. Through routine necropsies, WDF pathologists have noted the presence of the EIBS virus throughout the rearing period, and up to the day of release. To speed up the progress of the epizootic, we recommend the addition of well water to the river water immediately upon diagnosis.

6) Based upon our analysis of freshwater survival rates of natural spring chinook salmon in the Tucannon River, escapement for natural spawning should be 400 salmon. This includes fish upstream and downstream of the Tucannon FH rack. Consistent with recommendation 3, protection of natural-origin salmon should be the highest priority in setting escapement levels.

7) We recommend the initiation of an accelerated smolt program for spring chinook salmon to supplement the yearling program. If the run is strong enough to meet our natural escapement objectives, the hatchery crew should double their eggtake at Tucannon FH to 300,000 eggs. Half of these fish would under an accelerated rearing program at 7 months of age; the remainder would be released at our normal strategy of 19 months. At a 1.3 food conversion, hatchery staff could feed the juveniles at a 2.8 percent body weight regimen to grow the fish to 20 fpp by 1 May. This includes a 3 week hiatus in feeding to allow for tagging operations. The subyearlings would be acclimated to river water for 3 to 4 weeks prior to release in early May.

An accelerated smolt program is highly contingent upon sufficient escapement to allow increased broodstock collection on a continuous basis. This plan should not be used to supplant the yearling program.

4.3: General Hatchery Practices

1) To the maximum extent possible, general hatchery records of feeding regimes, loading densities, mortality rates, and water temperature should be maintained on computer. Records should be maintained on the smallest rearing unit feasible. This would allow us a means to assess long-term trends in hatchery effectiveness.

2) Substrate should be installed in the incubation trays. Benefits would include: 1) increased yolk absorption and resultant emergent fry size, and 2) reduced incidence of coagulated yolk disease and coldwater disease (Fuss, personal communication).

3) All efforts should be made to isolate incubation stacks to prevent cross contamination of viral diseases. Impermeable barriers should be placed between individual incubation stacks, splash protectors should be installed at all effluents, and curtains should be installed between incubator rows. Footbaths of iodophor should be placed at the entrance to each "curtained-off" set of isolation units.

4) More effort should be made to adjust the amount of antibiotic injected into adults according to body size during routine BKD prophylactic treatments.

5) Additional virology samples should be taken during spawning. Those samples that are not needed on an immediate basis should be labeled and stored in the evaluation program's ultra-low freezer.

6) The feasibility of using fry starting troughs should be investigated. Benefits include a reduction in dropout problems.

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APPENDIX A

Washington Department of Fisheries' objectives for the LSRCP Hatchery Evaluation Program. These objectives are interrelated in scope, and are not set in priority.

1) **Document juvenile fish output for Lyons Ferry and Tucannon FH.** Records will be compiled and summarized by numbers of fish produced at each facility and categorized by stock, size, weight, and planting location. Fish condition and survival rates to planting will be noted.

2) **Maintain records of adult returns to the Snake River Basin for each rearing program, categorized by stock and brood year.** Data are collected at hatchery racks and spawning grounds by program staff, and compared with escapement to other hatcheries and streams throughout the Columbia River Basin.

3) **Document contributions of each rearing program to the various fisheries through coded-wire tag returns.** Pacific Coast states, Federal, and Canadian agencies cooperate in returning tags and catch data to the agency of origin. We will attempt to tag sufficient fish to represent each rearing program, and to avoid duplication with contribution studies from other hatcheries.

4) **Document downstream survival to Fish Passage Center and National Marine Fisheries Service sampling points on the Snake River and/or lower Columbia River for each rearing program.** Program staff will retrieve and summarize data for the Lyons Ferry/Tucannon facilities. Survival rate comparisons for each rearing program will be made. We will use these data to modify hatchery releases to improve downstream migrant survival.

5) **Quantify genetic variables that might be subject to alteration under hatchery production strategies.** Utilization and maintenance of native stocks is an important goal of the LSRCP. We plan to identify and quantify as many genetic variables as possible in all available Snake River chinook salmon populations. Similar data for other populations which may overlap with Snake River chinook salmon in the lower Columbia River are being developed. These data include qualitative loci analysis through electrophoresis, and quantitative analysis of such factors as meristics, adult and juvenile body morphometry, adult size, run timing, and disease susceptibility.

6) **Determine the success of any off-station enhancement projects, and determine the impact of hatchery fish on wild stock.** Our emphasis will be to evaluate changes in natural production in response to hatchery enhancement, and to develop escapement goals based upon optimum natural and hatchery production. We will study interactions at both the juvenile and adult life stages.

We may use information obtained from Objective 5 to develop genetic marks (qualitative or quantitative) which could provide techniques for evaluating interactions of wild and hatchery fish in the Tucannon River system.

7) **Evaluate and provide management recommendations for major hatchery operational practices**, including:

A. **Optimum size and time-of-release strategies will be determined for both spring and fall chinook salmon.** Existing size, time and return data for other Columbia River Basin programs will be reviewed to determine the release strategies which would have the most likelihood of success. Continual experimentation may be necessary in some cases.

B. **Selection and maintenance of broodstock will be done in conformance with LSRCP goals.** Criteria will be developed to program genetic management as determined by Objective 5, and in accordance with tribal agreements.

C. **Rearing densities, feeding regimes, disease investigations, or other special treatments** on experimental hatchery practices often require mark-release-return groups to facilitate evaluation. Program staff develop the experimental designs, direct the marking, and analyze results.

8) **Evaluate and provide management recommendations for Snake River salmon distribution programs basin-wide.** As Lyons Ferry FH and Tucannon FH goals are reached, eggtake needs to supplement natural production in other streams will be specified. We will set priorities for off-site distribution, based upon current escapement levels, habitat quality, and agreements with co-managing agencies and tribes. Evaluation and improvement of the distribution plan will be an on-going process.

9) **Coordinate research and management programs with hatchery capabilities.** Advance notice to the hatcheries for specific study groups of marking programs will allow a more efficient use of hatchery facilities and reduce handling and stress on the fish. Research and management programs will be reviewed to determine if the hatcheries will have the capabilities to meet program goals.

APPENDIX B

Numbers released and proportion marked (coded-wire tag) for Lyons Ferry fall chinook salmon, for each brood year and release group.

Brood year release group	Number marked	Number unmarked	Mark rate	Total released
1983				
yearling on-station	334,442	315,858	0.5143	650,300
1984				
subyearling on-station	234,985	304,407	0.4356	539,392
yearling on-station	258,355	223,595	0.5361	481,950
1985				
subyearling on-station	246,625	1,295,543	0.1904	1,542,168
subyearling transport	245,561	1,831	0.9926	247,392
yearling on-station	152,479	77,934	0.6618	230,413
yearling transport	156,036	470	0.9970	156,506
1986				
subyearling on-station	251,646	86,139	0.7450	337,785
subyearling transport	255,998	80,264	0.7613	336,262
yearling on-station	117,705	168,906	0.4107	286,611
yearling transport	120,804	425	0.9965	121,229
1987				
subyearling on-station	248,739	1,760,409	0.1238	2,009,148
subyearling transport	245,749	2,318,550	0.0958	2,564,299
yearling on-station	115,350	177,852	0.3934	293,202
yearling transport	119,217	598	0.9950	119,815
1988				
subyearling on-station	226,478	869,124	0.2067	1,095,602
subyearling transport	234,103	435,728	0.3495	669,831

APPENDIX C

Contribution of 1984, 1985, and 1986 broods Lyons Ferry fall chinook salmon to commercial, Indian, and sport fisheries, escapement to the hatchery rack and Lower Granite Dam. Data are based on coded-wire tag recoveries in 1986, 1987, 1988, and 1989.

Table 1. Recoveries of 1984 brood fall chinook salmon subyearlings released on-station in June 1985. Tagcode was 633226. Mark rate was 43.55 percent (78,417 out of 180,053). Size of fish at release was 67.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1986			
Mixed Net and Seine - CDFO	8	22	430
Columbia River Gillnet - ODFW	3	11	453
Sport (Private) - WDF	1	3	470
Lyons Ferry hatchery rack	13	13	464
Lower Granite Dam trap	24	49	462
1986 totals:	49	98	458
1987			
Ocean Troll (Non-treaty) - CDFO	12	65	688
Ocean Sport - CDFO	3	12	
Columbia River Gillnet - ODFW	14	58	666
Ocean Sport - ODFW	2	5	640
Ocean Troll (Non-treaty) - ODFW	10	23	683
Estuary Sport - ODFW	1	3	640
Ocean Troll (Non-treaty) - ADFG	1	2	740
Ocean Gillnet (non-treaty) - ADFG	1	1	590
Treaty Troll - WDF	1	6	490
Ocean Troll (Non-treaty) - WDF	1	2	670
Sport (Charter) - WDF	3	7	670
Sport (Private) - WDF	2	8	735
Lyons Ferry hatchery rack	37	37	670
1987 totals:	88	229	671
1988			
Ocean Troll (Non-treaty) - CDFO	17	62	804
Ocean Troll (Non-treaty) - ODFW	2	7	827
Test Fishery Net - ODFW	1	1	980
Columbia River Gillnet - ODFW	17	66	826
Ocean Troll (Non-treaty) - WDF	2	8	715
Treaty Troll - WDF	1	2	500
Lyons Ferry Hatchery rack	19	19	
1988 totals:	59	165	807

Appendix C, Table 1, continued.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1989			
Columbia River Gillnet - ODFW	4	20	910
Ocean Troll (Non-treaty) - ADFG	1	1	
1989 totals:	5	21	910
Totals for tagcode 633226:	201	513	649

Appendix C, continued.

Table 2. Recoveries of 1984 brood fall chinook salmon subyearlings released on-station in June 1985. Tagcode was 633227. Mark rate was 43.56 percent (78,064 out of 179,199). Size of fish at release was 67.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1986			
Mixed Net and Seine - CDFO	4	13	445
Columbia River Gillnet - ODFW	3	14	480
Lyons Ferry hatchery rack	12	12	458
Lower Granite Dam trap	13	27	454
1986 totals:	32	66	457
1987			
Ocean Troll (Non-treaty) - CDFO	10	36	664
Mixed Net and Seine - CDFO	1	4	564
Ocean Sport - CDFO	1	4	
Columbia River Gillnet - ODFW	1	49	670
Ocean Sport - ODFW	2	4	725
Ocean Troll (Non-treaty) - ODFW	7	25	669
Estuary Sport - ODFW	1	3	752
Ocean Troll (Non-treaty) - ADFG	1	2	630
Sport (Private) - WDF	1	3	710
Sport (Charter) - WDF	1	2	710
Ocean Troll (Non-treaty) - WDF	1	3	700
Lyons Ferry hatchery rack	36	36	659
1987 totals:	73	171	666
1988			
Ocean Troll (Non-treaty) - CDFO	15	61	793
Ocean Troll (Non-treaty) - CDFO	1	13	855
Columbia River Gillnet - ODFW	24	91	821
Ocean Troll (Non-treaty) - ODFW	3	7	846
Ocean Troll (Non-treaty) - ADFG	4	9	820
Treaty Troll - WDF	1	1	610
Ocean Troll (Non-treaty) - WDF	6	21	788
Sport (Private) - WDF	2	11	785
Lyons Ferry hatchery rack	19	19	
1988 totals:	75	233	807
1989			
Ocean Troll (Non-treaty) - CDFO	1	4	1,022
Columbia River Gillnet - ODFW	3	13	877
Lyons Ferry hatchery rack	1	1	
1989 totals:	5	18	914
Totals for tagcode 633227:	185	487	681

Appendix C, continued.

Table 3. Recoveries of 1984 brood fall chinook salmon subyearlings released on-station in June 1985. Tagcode was 633228. Mark rate was 43.58 percent (78,504 out of 180,140). Size of fish at release was 67.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1986			
Mixed Net and Seine - CDFO	5	19	419
Columbia River Gillnet - ODFW	3	10	516
Lyons Ferry hatchery rack	9	9	432
Lower Granite Dam trap	19	39	456
1986 totals:	36	77	451
1987			
Ocean Troll (Non-treaty) - CDFO	12	57	687
Ocean Sport - CDFO	1	4	
Columbia River Gillnet - ODFW	6	26	698
Ocean Troll (Non-treaty) - ODFW	11	22	685
Ocean Troll (Non-treaty) - ADFG	3	5	698
Ocean Sport - ADFG	1	1	527
Ocean Troll (Non-treaty) - WDF	4	16	678
Sport (Private) - WDF	1	2	720
Lyons Ferry hatchery rack	45	45	656
Lower Granite Dam trap	1	2	530
1987 totals:	85	182	667
1988			
Ocean Troll (Non-treaty) - CDFO	12	52	754
Columbia River Sport - ODFW	1	8	800
Estuary Sport - ODFW	2	7	773
Columbia River Gillnet - ODFW	16	57	812
Ocean Troll (Non-treaty) - ODFW	1	2	690
Ocean Troll (Non-treaty) - ADFG	3	6	740
Treaty Troll - WDF	3	10	663
Ocean Troll (Non-treaty) - WDF	2	5	695
Lyons Ferry hatchery rack	21	21	
1988 totals:	61	168	767
1989			
Ocean Troll (Non-treaty) - CDFO	3	10	873
Columbia River Gillnet - ODFW	3	9	840
Ocean Troll (Non-treaty) - ADFG	1	2	950
Ocean Sport - ADFG	1	1	838
Lyons Ferry hatchery rack	2	2	
1989 totals:	10	24	866
Totals for tagcode 633228:	171	451	656

Appendix C, continued.

Table 4. Recoveries of 1984 brood fall chinook salmon yearlings released on station in April 1986. Tagcode was 632841. Mark rate was 58.49 percent (258,355 out of 441,676). Size of fish at release was 8.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1986			
Mixed Net and Seine - CDFO	1	2	
Columbia River Gillnet - ODFW	1	4	378
Lyons Ferry hatchery rack	49	49	362
Lower Granite Dam trap	4	8	333
1986 totals:	55	63	360
1987			
Ocean Troll (Non-treaty) - CDFO	5	40	507
Mixed Net and Seine - CDFO	12	37	486
Ocean Sport - CDFO	7	28	
Columbia River Gillnet - ODFW	9	43	546
Ocean Sport - ODFW	3	8	546
Ocean Troll (Non-treaty) - ODFW	1	3	530
Treaty Troll - WDF	1	5	530
Sport (Private) - WDF	4	12	563
Estuary Sport - WDF	3	12	
Mixed Net and Seine - WDF	1	5	550
Sport (Charter) - WDF	1	2	530
Lyons Ferry hatchery rack	90	91	537
Lower Granite Dam trap	3	6	507
1987 totals:	140	292	525
1988			
Ocean Troll (Non-treaty) - CDFO	94	378	704
Mixed Net and Seine - CDFO	1	2	744
Ocean Sport - CDFO	2	8	
Ocean Troll (Non-treaty) - CDFG	1	4	740
Ocean Troll (Non-treaty) - ODFW	58	194	703
Columbia River Gillnet - ODFW	41	156	727
Ocean Sport - ODFW	3	6	740
Ocean Troll (Non-treaty) - ADFG	2	2	718
Treaty Troll - WDF	18	51	595
Coastal Gillnet - WDF	1	2	910
Ocean Troll (Non-treaty) - WDF	28	83	689
Sport (Private) - WDF	7	27	683
Sport (Charter) - WDF	9	18	679
Estuary Sport - WDF	1	5	
Lyons Ferry hatchery rack	98	98	
1988 totals:	364	1,034	696

Appendix C, Table 4, continued.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1989			
Ocean Troll (Non-treaty) - CDFO	25	105	811
Ocean Sport - CDFG	2	14	854
Ocean Troll (Non-treaty) - CDFG	1	3	850
Estuary Sport - ODFW	1	3	980
Columbia River Gillnet - ODFW	45	165	835
Ocean Troll (Non-treaty) - ODFW	8	35	787
Ocean Troll (Non-treaty) - ADFG	1	2	888
Treaty Troll - WDF	5	9	676
Ocean Troll (Non-treaty) - WDF	11	26	760
Sport (Private) - WDF	5	19	790
Sport (Charter) - WDF	2	4	
Lyons Ferry hatchery rack	20	20	
1989 totals:	126	405	810
Totals for tagcode 632841:	685	1,794	644

Table 5. Recoveries of 1985 brood fall chinook salmon subyearlings transported below Ice Harbor Dam in June 1986. Tagcode was 633633. Mark rate was 99.26 percent (49,112 out of 49,478). Size of fish at release was 55.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Lyons Ferry hatchery rack	1	1	500
1987 total:	1	1	500
1988			
Ocean Troll (Non-treaty) - CDFO	2	9	682
Columbia River Gillnet - ODFW	1	4	675
1988 totals:	3	13	679
1989			
Ocean Troll (Non-treaty) - CDFO	6	30	786
Columbia River Gillnet - ODFW	4	12	848
Ocean Troll (Non-treaty) - ADFG	2	7	833
Lyons Ferry hatchery rack	2	2	
1989 totals:	14	51	817
Totals for tagcode 633633:	18	65	768

Appendix C, continued.

Table 6. Recoveries of 1985 brood fall chinook salmon subyearlings transported below Ice Harbor Dam in June 1986. Tagcode was 633634. Mark rate was 99.26 percent (49,112 out of 49,478). Size of fish at release was 55.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Lyons Ferry hatchery rack	1	1	440
1987 totals:	1	1	440
1988			
Ocean Troll (Non-treaty) - CDFO	1	3	
Ocean Troll (Non-treaty) - ODFW	1	4	620
Columbia River Gillnet - ODFW	2	8	654
Mixed Net and Seine - WDF	1	3	640
Lyons Ferry hatchery rack	3	3	
1988 totals:	8	21	642
1989			
Ocean Troll (Non-treaty) - CDFO	3	16	787
Columbia River Gillnet - ODFW	3	13	856
Ocean Troll (Non-treaty) - ADFG	1	3	931
Ocean Troll (Non-treaty) - WDF	1	2	850
Lyons Ferry hatchery rack	3	3	
1989 totals:	11	37	839
Totals for tagcode 633634:	20	59	748

Appendix C, continued.

Table 7. Recoveries of 1985 brood fall chinook salmon subyearlings transported below Ice Harbor Dam in June 1986. Tagcode was 633635. Mark rate was 99.26 percent (49,112 out of 49,478). Size of fish at release was 55.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1988			
Ocean Troll (Non-treaty) - CDFO	2	9	663
Columbia River Gillnet - ODFW	1	4	662
Treaty Troll - WDF	1	2	510
Lyons Ferry hatchery rack	2	2	
1988 totals:	6	17	624
1989			
Ocean Troll (Non-treaty) - CDFO	2	7	869
Columbia River Gillnet - ODFW	3	11	812
Ocean Troll (Non-treaty) - ADFG	1	3	785
Lyons Ferry hatchery rack	3	3	
1989 totals:	9	24	826
Totals for tagcode 633635:	15	41	745

Appendix C, continued.

Table 8. Recoveries of 1985 brood fall chinook salmon subyearlings transported below Ice Harbor Dam in June 1986. Tagcode was 633636. Mark rate was 99.26 percent (49,113 out of 49,480). Size of fish at release was 55.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Lyons Ferry hatchery rack	1	1	460
1987 totals:	1	1	460
1988			
Ocean Troll (Non-treaty) - CDFO	1	5	720
Columbia River Gillnet - ODFW	1	5	651
Treaty Troll - WDF	1	1	570
Sport (Charter) - WDF	1	2	620
Lyons Ferry hatchery rack	1	1	
1988 totals:	5	15	640
1989			
Columbia River Gillnet - ODFW	3	12	865
Ocean Troll (Non-treaty) - ODFW	1	4	790
Ocean Troll (Non-treaty) - ADFG	1	3	875
Lyons Ferry hatchery rack	4	4	
1989 totals:	9	23	852
Totals for tagcode 633636:	15	39	728

Appendix C, continued.

Table 9. Recoveries of 1985 brood fall chinook salmon subyearlings transported below Ice Harbor Dam in June 1986. Tagcode was 633637. Mark rate was 99.26 percent (49,112 out of 49,478). Size of fish at release was 55.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Mixed Net and Seine - CDFO	1	4	
Lyons Ferry hatchery rack	3	3	460
1987 totals:	4	7	460
1988			
Ocean Troll (Non-treaty) - CDFO	1	5	663
Columbia River Gillnet - ODFW	1	3	623
Treaty Troll - WDF	1	2	510
Lyons Ferry hatchery rack	5	5	
1988 totals:	8	15	599
1989			
Ocean Troll (Non-treaty) - CDFO	2	10	781
Columbia River Gillnet - ODFW	3	13	820
Ocean Troll (Non-treaty) - ADFG	4	8	815
Lyons Ferry hatchery rack	3	3	
1989 totals:	12	34	813
Totals for tagcode 633637:	24	56	691

Appendix C, continued.

Table 10. Recoveries of 1985 brood fall chinook salmon subyearlings released on-station in June 1986. Tagcode was 633638. Mark rate was 99.06 percent (49,325 out of 49,793). Size of fish at release was 58.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Mixed Net and Seine - CDFO	1	5	401
Lower Granite Dam trap	3	6	403
Lyons Ferry hatchery rack	4	4	423
1987 totals:	8	15	413
1988			
Mixed Net and Seine - CDFO	1	2	524
Ocean Troll (Non-treaty) - ODFW	1	6	685
Sport (Charter) - WDF	1	2	560
Lyons Ferry hatchery rack	2	2	
1988 totals:	5	12	590
1989			
Ocean Troll (Non-treaty) - CDFO	6	32	770
Columbia River Gillnet - ODFW	5	20	760
Ocean Troll (Non-treaty) - ODFW	1	30	860
Ocean Troll (Non-treaty) - ADFG	1	3	780
Lyons Ferry hatchery rack	3	3	
1989 totals:	16	88	774
Totals for tagcode 633638:	29	115	624

Appendix C, continued.

Table 11. Recoveries of 1985 brood fall chinook salmon subyearlings released on-station in June 1986. Tagcode was 633639. Mark rate was 99.06 percent (49,325 out of 49,793). Size of fish at release was 58.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Mixed Net and Seine - CDFO	1	5	345
Lower Granite Dam trap	5	10	428
Lyons Ferry hatchery rack	1	1	430
1987 totals:	7	16	416
1988			
Ocean Troll (Non-treaty) - CDFO	1	2	617
Mixed Net and Seine - CDFO	1	3	621
Columbia River Gillnet - ODFW	1	4	663
Lyons Ferry hatchery rack	7	7	
1988 totals:	10	16	634
1989			
Ocean Troll (Non-treaty) - CDFO	4	16	827
Columbia River Gillnet - ODFW	6	19	800
Ocean Troll (Non-treaty) - ODFW	1	1	820
Ocean Troll (Non-treaty) - ADFG	3	9	807
Sport (Charter) - WDF	1	2	850
Lyons Ferry hatchery rack	2	2	
1989 totals:	17	49	814
Totals for tagcode 633639:	34	81	675

Appendix C, continued.

Table 12. Recoveries of 1985 brood fall chinook salmon subyearlings released on-station in June 1986. Tagcode was 633640. Mark rate was 99.06 percent (49,325 out of 49,793). Size of fish at release was 58.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Lower Granite Dam trap	4	8	455
Lyons Ferry hatchery rack	3	3	437
1987 totals:	7	11	447
1988			
Ocean Troll (Non-treaty) - CDFO	1	6	595
Columbia River Gillnet - ODFW	2	7	833
Sport (Charter) - WDF	1	1	600
Lyons Ferry hatchery rack	2	2	
1988 totals:	6	17	715
1989			
Ocean Troll (Non-treaty) - CDFO	2	7	882
Ocean Sport - ODFW	1	1	830
Columbia River Gillnet - ODFW	6	28	792
1989 totals:	9	36	816
Totals for tagcode 633640:	22	64	667

Appendix C, continued.

Table 13. Recoveries of 1985 brood fall chinook salmon subyearlings released on-station in June 1986. Tagcode was 633641. Mark rate was 99.06 percent (49,325 out of 49,793). Size of fish at release was 58.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Lyons Ferry hatchery rack	7	7	449
Lower Granite Dam trap	1	2	460
1987 totals:	8	9	450
1988			
Ocean Troll (Non-treaty) - CDFO	1	3	826
Treaty Troll - WDF	1	2	500
Lyons Ferry hatchery rack	3	3	
1988 totals:	5	8	663
1989			
Ocean Troll (Non-treaty) - CDFO	2	10	780
Columbia River Gillnet - ODFW	8	26	814
Ocean Troll (Non-treaty) - ADFG	1	3	805
Ocean Troll (Non-treaty) - WDF	1	2	790
1989 totals:	12	41	805
Totals for tagcode 633641:	25	58	663

Appendix C, continued.

Table 14. Recoveries of 1985 brood fall chinook salmon subyearlings released on-station in June 1986. Tagcode was 633642. Mark rate was 99.06 percent (49,325 out of 49,793). Size of fish at release was 58.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Columbia River Gillnet - ODFW	1	4	655
Lyons Ferry hatchery rack	3	3	437
Lower Granite Dam trap	3	6	440
1987 totals:	7	13	469
1988			
Mixed Net and Seine - CDFO	1	2	610
Columbia River Gillnet - ODFW	1	4	514
Ocean Troll (Non-treaty) - ODFW	2	6	666
Sport (Charter) - WDF	1	2	650
Lyons Ferry hatchery rack	6	6	
1988 totals:	11	20	621
1989			
Ocean Troll (Non-treaty) - CDFO	3	12	769
Columbia River Gillnet - ODFW	5	19	786
Ocean Troll (Non-treaty) - ADFG	1	2	720
Sport (Private) - WDF	1	4	830
Ocean Troll (Non-treaty) - WDF	1	2	740
1989 totals:	11	39	775
Totals for tagcode 633642:	29	72	649

Appendix C, continued.

Table 15. Recoveries of 1985 brood fall chinook salmon yearlings released on-station in April 1987. Tagcode was 634156. Mark rate was 99.30 percent (152,479 out of 153,554). Size of fish at release was 6.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Mixed Net and Seine - CDFO	3	16	297
Columbia River Gillnet - ODFW	2	10	343
Ocean Sport - ODFW	1	2	380
Lyons Ferry hatchery rack	129	129	366
Lower Granite Dam trap	15	28	353
1987 totals:	150	185	363
1988			
Ocean Troll (Non-treaty) - CDFO	2	8	521
Mixed Net and Seine - CDFO	27	53	495
Ocean Sport - CDFO	1	4	
Estuary Sport - ODFW	7	23	585
Ocean Troll (Non-treaty) - ODFW	4	17	630
Ocean Sport - ODFW	2	4	586
Columbia River Gillnet - ODFW	15	63	531
Commercial Seine - ADFG	2	2	518
Ocean Sport - ADFG	1	1	430
Mixed Net and Seine - WDF	3	6	570
Sport (Private) - WDF	6	23	573
Sport (Charter) - WDF	3	6	577
Treaty Troll - WDF	1	7	640
Lyons Ferry hatchery rack	116	116	
1988 totals:	190	333	537
1989			
Ocean Troll (Non-treaty) - CDFO	98	454	717
Mixed Net and Seine - CDFO	2	8	600
Ocean Sport - CDFO	6	27	
Ocean Sport - CDFG	1	4	720
Ocean Troll (Non-treaty) - CDFG	2	7	742
Estuary Sport - ODFW	2	6	790
Ocean Troll (Non-treaty) - ODFW	79	388	710
Columbia River Gillnet - ODFW	91	363	756
Ocean Sport - ODFW	12	27	752
Freshwater Sport - ODFW	1		
Ocean Troll (Non-treaty) - ADFG	6	9	720
Ocean Sport - ADFG	1		760
Estuary Sport - WDF	2	7	720
Sport (Private) - WDF	15	58	743

Appendix C, Table 15, continued.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1989			
Treaty Troll - WDF	24	97	648
Ocean Troll (Non-treaty) - WDF	68	170	694
Sport (Charter) - WDF	38	81	719
Lyons Ferry hatchery rack	71	71	
1989 totals:	519	1,779	719
Totals for tagcode 634156:	859	2,297	616

Appendix C, continued.

Table 16. Recoveries of 1985 brood fall chinook salmon yearlings transported below Ice Harbor Dam in April 1987. Tagcode was 634159. Mark rate was 99.70 percent (156,036 out of 156,506). Size of fish at release was 6.9 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1987			
Mixed Net and Seine - CDFO	2	8	310
Columbia River Gillnet - ODFW	1	4	396
Ocean Sport - ODFW	1	2	380
Ocean Sport - ADFG	1	1	368
Mixed Net and Seine - WDF	2	13	430
Estuary Sport - WDF	1	4	55
Lyons Ferry hatchery rack	112	112	358
Lower Granite Dam trap	2	4	330
1987 totals:	122	148	356
1988			
Ocean Troll (Non-treaty) - CDFO	2	5	475
Mixed Net and Seine - CDFO	26	64	476
Ocean Sport - CDFO	2	9	
Ocean Troll (Non-treaty) - ODFW	2	6	725
Ocean Sport - ODFW	5	13	577
Estuary Sport - ODFW	8	25	591
Columbia River Gillnet - ODFW	22	90	544
Estuary Sport - WDF	9	40	236
Mixed Net and Seine - WDF	4	17	540
Sport (Private) - WDF	3	8	557
Sport (Charter) - WDF	6	13	563
Treaty Troll - WDF	2	10	525
Sport (Jetty) - WDF	1	4	580
Lyons Ferry hatchery rack	117	117	
1988 totals:	209	421	504
1989			
Ocean Troll (Non-treaty) - CDFO	93	423	729
Mixed Net and Seine - CDFO	3	9	696
Ocean Sport - CDFO	1	4	
Ocean Troll (Non-treaty) - CDFG	5	36	747
Ocean Sport - CDFG	1	5	713
Estuary Sport - ODFW	3	10	747
Ocean Troll (Non-treaty) - ODFW	67	324	708
Columbia River Gillnet - ODFW	126	466	763
Ocean Sport - ODFW	5	14	731
Freshwater Sport - ODFW	1		870
Ocean Troll (Non-treaty) - ADFG	20	39	718
Ocean Gillnet (non-treaty) - ADFG	1	4	735

Appendix C, Table 16, continued.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1989			
Sport (Private) - WDF	16	58	721
Treaty Troll - WDF	14	41	631
Estuary Sport - WDF	2	10	
Ocean Troll (Non-treaty) - WDF	48	115	693
Sport (Charter) - WDF	33	71	720
Lyons Ferry hatchery rack	75	75	
1989 totals:	514	1,705	727
Totals for tagcode 634159:	653	2,081	625

Table 17. Recoveries of 1986 brood fall chinook salmon subyearlings transported below Ice Harbor Dam in June 1987. Tagcode was 634262. Mark rate was 99.20 percent (127,715 out of 128,745). Size of fish at release was 71.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1988			
Mixed Net and Seine - CDFO	2	5	429
Columbia River Gillnet - ODFW	3	9	448
Commercial Seine - ADFG	1	9	447
Lyons Ferry hatchery rack	63	63	
1988 totals:	69	86	442
1989			
Ocean Troll (Non-treaty) - CDFO	17	74	694
Ocean Sport - CDFO	2	11	
Columbia River Gillnet - ODFW	14	52	712
Ocean Troll (Non-treaty) - ODFW	6	29	688
Ocean Sport - ADFG	1	1	
Estuary Sport - WDF	1	5	
Sport (Private) - WDF	2	8	705
Ocean Troll (Non-treaty) - WDF	2	5	710
Sport (Charter) - WDF	6	13	690
Lyons Ferry hatchery rack	17	17	
1989 totals:	68	215	699
Totals for tagcode 634262:	137	301	670

Appendix C, continued.

Table 18. Recoveries of 1986 brood fall chinook salmon subyearlings transported below Ice Harbor Dam in June 1987. Tagcode was 634401. Mark rate was 99.42 percent (128,283 out of 128,745). Size of fish at release was 71.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1988			
Mixed Net and Seine - CDFO	3	7	369
Columbia River Gillnet - ODFW	6	24	469
Commercial Seine - ADFG	1	1	380
Lyons Ferry hatchery rack	66	66	
1988 totals:	76	98	430
1989			
Ocean Troll (Non-treaty) - CDFO	12	44	679
Ocean Sport - CDFO	1	4	
Columbia River Gillnet - ODFW	14	57	709
Ocean Troll (Non-treaty) - ODFW	4	13	721
Ocean Sport - ODFW	1	2	675
Ocean Troll (Non-treaty) - ADFG	3	2	685
Treaty Troll - WDF	3	7	530
Sport (Private) - WDF	1	5	760
Sport (Charter) - WDF	3	5	623
Lyons Ferry hatchery rack	21	21	
1989 totals:	63	160	681
Totals for tagcode 634401:	139	258	628

Appendix C, continued.

Table 19. Recoveries of 1986 brood fall chinook salmon yearlings transported below Ice Harbor Dam in April 1988. Tagcode was 634407. Mark rate was 99.60 percent (60,523 out of 60,766). Size of fish at release was 8.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1988			
Lyons Ferry hatchery rack	62	62	
1988 totals:	62	62	
1989			
Ocean Troll (Non-treaty) - CDFO	1	4	505
Mixed Net and Seine - CDFO	6	16	508
Ocean Sport - CDFO	1	4	
Estuary Sport - ODFW	2	7	565
Columbia River Gillnet - ODFW	3	9	562
Ocean Troll (Non-treaty) - ODFW	3	16	568
Commercial Seine - ADFG	1	1	480
Mixed Net and Seine - WDF	2	5	555
Estuary Sport - WDF	3	14	550
Treaty Troll - WDF	2	41	525
Sport (Private) - WDF	1	3	530
Sport (Charter) - WDF	1	2	550
Lyons Ferry hatchery rack	9	9	
1989 totals:	35	131	539
Totals for tagcode 634407:	97	193	539

Appendix C, continued.

Table 20. Recoveries of 1986 brood fall chinook salmon yearlings transported below Ice Harbor Dam in April 1988. Tagcode was 634408. Mark rate was 99.60 percent (60,281 out of 60,523). Size of fish at release was 8.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1988			
Lyons Ferry hatchery rack	72	72	
1988 totals:	72	72	
1989			
Mixed Net and Seine - CDFO	4	9	516
Ocean Sport - CDFO	3	12	
Estuary Sport - ODFW	1	3	580
Columbia River Gillnet - ODFW	5	17	598
Ocean Troll (Non-treaty) - ODFW	1	6	570
Ocean Sport - ODFW	2	5	545
Commercial Seine - ADFG	1	1	487
Treaty Troll - WDF	1	1	540
Estuary Sport - WDF	3	10	610
Sport (Private) - WDF	1	4	580
Sport (Charter) - WDF	2	4	555
Lyons Ferry hatchery rack	22	22	
1989 totals:	46	94	559
Totals for tagcode 634408:	118	166	559

Appendix C, continued.

Table 21. Recoveries of 1986 brood fall chinook salmon yearlings released on-station in April 1988. Tagcode was 634411. Mark rate was 47.72 percent (58,735 out of 123,083). Size of fish at release was 8.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1988			
Lyons Ferry hatchery rack	44	44	
1988 totals:	44	44	
1989			
Mixed Net and Seine - CDFO	7	27	506
Ocean Sport - CDFO	2	8	
Columbia River Gillnet - ODFW	6	18	578
Ocean Troll (Non-treaty) - ODFW	1	10	615
Mixed Net and Seine - WDF	1	2	530
Sport (Private) - WDF	2	8	530
Sport (Charter) - WDF	1	2	590
Lyons Ferry hatchery rack	19	19	
1989 totals:	39	94	545
Totals for tagcode 634411:	83	138	545

Appendix C, continued.

Table 22. Recoveries of 1986 brood fall chinook salmon yearlings released on-station in April 1988. Tagcode was 634413. Mark rate was 47.72 percent (58,970 out of 123,576). Size of fish at release was 8.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1988			
Mixed Net and Seine - CDFO	1	3	318
Lyons Ferry hatchery rack	50	50	
1988 Totals:	51	53	318
1989			
Mixed Net and Seine - CDFO	5	20	500
Ocean Sport - CDFO	2	8	
Estuary Sport - ODFW	2	3	590
Columbia River Gillnet - ODFW	11	37	547
Ocean Sport - ODFW	2	4	588
Mixed Net and Seine - WDF	1	4	510
Treaty Troll - WDF	2	14	585
Sport (Charter) - WDF	2	4	570
Sport (Private) - WDF	1	2	640
Lyons Ferry hatchery rack	10	10	
1989 Totals:	38	106	553
Totals for tagcode 634413:	89	159	544

Appendix C, continued.

Table 23. Recoveries of 1986 brood fall chinook salmon subyearlings released on-station in June 1987. Tagcode was 634259. Mark rate was 97.80 percent (126,076 out of 128,912). Size of fish at release was 48.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1988			
Mixed Net and Seine - CDFO	1	3	446
Columbia River Gillnet - ODFW	1	3	435
Lyons Ferry hatchery rack	7	7	
1988 totals:	9	13	441
1989			
Ocean Troll (Non-treaty) - CDFO	7	36	680
Mixed Net and Seine - CDFO	2	6	589
Ocean Sport - CDFO	1	4	
Estuary Sport - ODFW	1	3	720
Columbia River Gillnet - ODFW	3	11	575
Ocean Troll (Non-treaty) - ODFW	2	8	710
Ocean Troll (Non-treaty) - ADFG	1	1	660
Treaty Troll - WDF	1	21	600
Sport (Charter) - WDF	1	2	640
Lyons Ferry hatchery rack	12	12	
1989 totals:	31	104	650
Totals for tagcode 634259:	40	117	629

Appendix C, continued.

Table 24. Recoveries of 1986 brood fall chinook salmon subyearlings released on-station in June 1987. Tagcode was 634261. Mark rate was 97.80 percent (125,570 out of 128,395). Size of fish at release was 48.0 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries	Average length (mm)
1988			
Columbia River Gillnet - ODFW	1	4	577
Lyons Ferry hatchery rack	17	17	
1988 totals:	18	21	577
1989			
Ocean Troll (Non-treaty) - CDFO	7	31	683
Mixed Net and Seine - CDFO	2	6	584
Ocean Sport - CDFG	2	17	675
Ocean Troll (Non-treaty) - ODFW	5	21	692
Columbia River Gillnet - ODFW	5	19	733
Treaty Troll - WDF	1	3	540
Ocean Troll (Non-treaty) - WDF	1	2	700
Sport (Charter) - WDF	2	4	620
Lyons Ferry hatchery rack	3	3	
1989 totals:	28	106	676
Totals for tagcode 634261:	44	127	672

APPENDIX D

Origin of coded wire tags recovered at Lyons Ferry Fish Hatchery in 1989 that are not Snake River stock.

Tag code	Number recovered	Tag origin	Agency/Tribe
07/50/07	4	1987 Irrigon	Umatilla
23/25/02	1	1987 Bonneville	NMFS
23/25/47	1	1987 Bonneville	NMFS
05/19/16	1	1986 Spring Creek	Yakima
05/19/18	1	1986 Spring Creek	Yakima
05/19/21	1	1986 Spring Creek	Yakima
63/41/28	1	1986 Priest Rapids	WDF
23/19/60	1	1986 Wild Upriver bright	
23/20/63	1	1986 Bonneville	NMFS
23/21/10	1	1986 Bonneville	NMFS
23/21/11	1	1986 Bonneville	NMFS
23/21/12	1	1986 Bonneville	NMFS
23/21/17	1	1986 Bonneville	NMFS
23/21/20	1	1986 Bonneville	NMFS
23/21/38	1	1986 Bonneville	NMFS
23/21/39	1	1986 Bonneville	NMFS
23/21/40	1	1986 Bonneville	NMFS
23/21/44	1	1986 Bonneville	NMFS
23/21/51	1	1986 Bonneville	NMFS
23/21/52	1	1986 Bonneville	NMFS
23/22/09	3	1986 Bonneville	NMFS
23/22/22	1	1986 Bonneville	NMFS
07/39/12	11	1986 Irrigon	Umatilla
07/39/13	7	1986 Irrigon	Umatilla
07/39/14	11	1986 Irrigon	Umatilla
07/40/35	1	1986 Irrigon	Umatilla
07/40/37	1	1986 Umatilla	Umatilla
07/40/39	1	1986 Umatilla	Umatilla
07/38/23	1	1985 Minthorn	Umatilla
07/38/24	1	1985 Minthorn	Umatilla
07/38/25	1	1985 Minthorn	Umatilla
07/38/26	1	1985 Minthorn	Umatilla
07/38/27	1	1985 Minthorn	Umatilla
07/38/29	2	1985 Bonifer	Umatilla
07/38/30	4	1985 Bonifer	Umatilla
07/38/31	5	1985 Bonifer	Umatilla
07/38/32	1	1985 Bonifer	Umatilla
07/38/33	2	1985 Lower Umatilla	Umatilla
07/38/35	3	1985 Lower Umatilla	Umatilla
07/38/36	4	1985 Lower Umatilla	Umatilla
07/38/37	1	1985 Lower Umatilla	Umatilla
07/38/38	2	1985 Lower Umatilla	Umatilla

Appendix D, continued.

Tag code	Number recovered	Tag origin	Agency/Tribe
07/38/39	1	1985 Lower Umatilla	Umatilla
07/38/40	4	1985 Lower Umatilla	Umatilla
07/38/41	3	1985 Lower Umatilla	Umatilla
07/38/42	4	1985 Lower Umatilla	Umatilla
B5/02/15	1	1985 Rock Creek	
B5/03/09	1	1985 Rock Creek	
06/61/44	1	1985 Trinity	CDFG
63/23/30	1	1984 Priest Rapids	WDF
07/31/62	7	1984 Bonifer	Umatilla
07/33/26	4	1984 Lower Umatilla	Umatilla
07/33/27	19	1984 Irrigon	Umatilla
H5/07/01	1	1984 Rock Creek	
H5/07/02	1	1984 Rock Creek	
H5/07/03	2	1984 Rock Creek	
07/31/24	1	1983 Lower Umatilla	Umatilla

APPENDIX E

Organosomatic analysis of 1987 brood natural and hatchery-origin Tucannon spring chinook salmon smolts collected in March 1989.

Sample	Length	Weight	Ktl	Eye	Gill	Pseudo-branch	Thymus	Fat levels	Spleen	Gut	Kidney	Liver	Bile	Sex	Hematocrit	Leucocrit	SPR
Hatchery Origin																	
1	125	18.6	1.0	N	N	N	0	1	R	0	N	B	2	M	32	0.0	3.7
2	158	34.4	0.9	N	N	N	0	2	R	0	N	B	0	F	42	0.0	4.5
3	132	22.3	1.0	N	P	OT	0	3	R	0	N	C	0	M	18	0.0	4.1
4	196	69.3	0.9	N	N	L	0	1	R	0	N	B	1	F	43	1.0	5.9
5	144	28.3	0.9	N	N	N	0	2	R	0	N	B	0	F	35	1.0	5.2
6	184	58.7	0.9	N	N	N	0	1	R	0	N	B	1	M	36	0.0	4.5
7	135	21.4	0.9	E1	N	N	0	1	R	0	N	B	2	M	36	0.5	3.8
8	147	31.0	1.0	N	N	N	0	2	R	0	N	B	2	F	39	1.0	6.0
9	147	30.5	1.0	N	N	N	0	2	R	0	N	B	2	M	33	1.0	3.4
10	161	39.7	1.0	N	N	N	0	2	R	0	N	B	2	M	40	1.0	6.8
11	140	25.4	0.9	N	N	N	0	2	R	0	N	B	0	F	37	1.0	5.2
12	187	58.0	0.9	N	N	S,L	0	2	R	0	N	C	2	M	28	0.5	3.8
13	154	33.0	0.9	N	N	N	0	3	R	0	N	B	1	F	37	0.0	5.7
14	148	30.4	0.9	N	N	S	0	2	R	0	N	B	1	F	40	1.0	6.0
15	153	34.1	1.0	N	N	N	0	2	R	0	N	B	1	M	42	0.5	5.5
16	131	20.6	0.9	N	N	N	0	2	R	0	N	B	1	M	41	1.0	3.2
17	193	66.9	0.9	N	N	N	0	1	R	0	N	B	2	F	35	0.5	2.7
18	150	31.7	0.9	N	N	N	0	2	R	0	N	B	0	F	36	1.0	4.9
19	157	34.2	0.9	N	N	N	0	1	R	0	N	B	1	M	34	0.5	2.5
20	132	19.0	0.8	N	N	N	0	1	R	0	N	B	1	F	43	1.0	5.0
21	164	36.6	0.8	N	N	N	0	0	E	0	N	B	1	M	37	1.0	1.6
22	181	52.8	0.9	N	N	N	0	1	R	0	N	B	0	M	41	0.5	6.2
23	146	30.3	1.0	N	N	N	0	3	R	0	N	B	1	F	38	1.0	6.6
24	137	25.8	1.0	N	N	S	0	2	R	0	N	B	1	F	36	1.0	4.1
25	158	33.4	0.8	N	N	N	0	2	R	0	N	B	0	F	41	1.0	6.3
26	144	27.0	0.9	N	N	N	0	2	R	0	N	B	1	M	37	0.0	3.7
27	179	49.4	0.9	N	N	N	0	1	R	0	N	B	1	M	38	0.5	2.5
28	200	69.9	0.9	N	N	N	0	1	R	0	N	B	1	M	43	0.5	5.4
29	139	24.3	0.9	N	N	N	0	3	R	0	N	B	1	F	38	0.5	4.8
30	132	20.4	0.9	N	N	S	0	1	R	0	N	B	0	F	34	1.0	3.0
31	172	50.4	1.0	N	N	N	0	1	R	0	N	B	1	M	36	0.0	4.3
32	143	28.8	1.0	N	N	N	0	2	R	0	N	B	1	F	41	1.0	4.3
33	148	30.2	0.9	N	N	N	0	2	R	0	N	C	1	F	38	1.0	5.7
34	147	30.6	1.0	N	N	N	0	2	R	0	N	B	1	F	37	0.5	6.8
35	183	55.4	0.9	N	N	N	0	1	R	0	N	B	2	M	32	0.0	4.8
36	147	31.1	1.0	N	N	N	0	2	R	0	N	B	1	F	35	2.0	4.9
37	211	84.3	0.9	N	N	N	0	1	R	0	N	B	1	M	- -	- -	2.0
38	144	27.4	0.9	N	N	N	0	2	R	0	N	B	0	F	38	1.0	5.2
39	137	24.5	1.0	N	N	N	0	2	R	0	N	B	1	M	39	0.5	5.0
40	129	19.4	0.9	N	N	N	0	2	R	0	N	B	1	F	40	1.0	6.4
41	146	27.7	0.9	N	N	N	0	2	R	0	N	B	1	F	40	1.0	6.4
42	191	59.4	0.9	N	N	N	0	1	R	0	N	B	0	M	33	0.0	3.1
43	189	59.8	0.9	N	N	N	0	1	R	0	N	B	1	M	37	0.0	2.0
44	170	41.6	0.8	N	N	N	0	1	R	0	N	B	2	F	34	0.0	3.7
45	179	49.1	0.9	N	N	N	0	2	R	0	N	B	2	F	32	0.0	4.4
46	152	30.3	0.9	N	N	N	0	2	R	0	N	B	1	F	36	1.0	8.8

APPENDIX E, continued.

Sample	Length	Weight	Ktl	Eye	Gill	Pseudo-branch	Thymus	Fat levels	Spleen	Gut	Kidney	Liver	Bile	Sex	Hematocrit	Leucocrit	SPR
Hatchery Origin																	
47	173	44.2	0.9	N	N	N	0	1	R	0	N	B	1	M	38	1.0	3.0
48	146	28.6	0.9	N	N	N	0	1	R	0	N	B	1	F	38	1.0	6.0
49	143	25.7	0.9	N	N	N	0	2	R	0	N	B	1	M	38	1.0	4.7
50	143	28.1	1.0	N	P	L	0	2	R	0	N	B	1	M	33	0.5	4.8
51	173	49.0	0.9	N	N	N	0	2	R	0	N	B	1	M	40	1.0	4.2
52	136	22.9	0.9	N	N	N	0	2	R	0	N	B	2	F	38	1.0	5.5
53	158	33.3	0.8	N	N	N	0	1	R	0	N	B	1	F	- -	- -	- -
54	169	46.6	1.0	N	N	N	0	2	R	0	N	B	2	M	40	1.0	6.2
55	137	24.1	0.9	N	N	N	0	2	R	0	N	B	1	M	44	1.0	6.0
56	186	54.6	0.8	N	N	N	0	0	R	0	N	B	1	M	36	0.0	2.5
57	185	56.2	0.9	N	N	N	0	1	R	0	N	B	1	F	44	0.5	4.7
58	127	18.3	0.9	E1	P	S,L	0	2	R	0	N	F	3	F	13	3.0	3.8
59	132	21.6	0.9	N	N	N	0	2	E	0	N	B	1	M	38	1.0	3.8
60	131	19.5	0.9	N	N	N	0	2	R	0	N	B	2	F	28	1.5	3.5
Natural origin																	
1	83	4.2	0.7	N	N	N	0	0	R	0	N	A	1	F	- -	- -	2.8
2	89	5.3	0.8	N	N	N	0	0	R	0	N	A	0	M	37	0.5	3.0
3	120	12.9	0.7	N	N	N	0	1	R	0	N	A	1	F	44	1.0	4.7
4	106	8.8	0.7	N	N	N	0	0	R	0	N	A	0	M	45	1.0	3.6
5	107	9.2	0.8	N	N	N	0	0	R	0	N	A	1	M	45	0.5	4.5
6	101	8	0.8	N	N	N	0	0	R	0	N	A	1	F	43	0.5	4.7
7	101	7.5	0.7	N	N	N	0	0	R	0	N	A	1	U	40	1.0	4.4
8	102	7.7	0.7	N	N	N	0	1	R	0	N	A	1	F	43	0.5	2.9
9	98	6.7	0.7	N	N	N	0	1	R	0	N	B	1	F	46	1.0	3.9
10	94	6	0.7	N	N	N	0	1	R	0	N	A	1	M	43	0.5	3.8
11	123	13.5	0.7	N	N	N	0	0	R	0	N	A	1	F	41	0.0	5.1
12	100	7.6	0.8	N	N	N	0	0	R	0	N	A	1	F	43	1.0	4.8
13	101	7	0.7	N	N	N	0	0	R	0	N	B	1	M	43	0.5	4.0
14	123	14	0.8	N	N	N	2	2	R	0	N	A	1	F	46	1.0	5.9
15	108	8.9	0.7	N	N	N	0	0	R	0	N	A	1	F	45	1.0	3.8
16	111	9.7	0.7	N	N	N	0	0	R	0	N	A	1	M	50	0.5	4.9
17	109	9.4	0.7	N	N	N	0	0	R	0	N	A	1	F	47	0.5	4.1
18	103	8.3	0.8	N	OT	N	0	0	R	0	N	A	1	F	47	1.0	4.8
19	96	6.4	0.7	N	N	N	0	0	R	0	N	A	1	M	41	0.5	3.9
20	90	5.3	0.7	N	N	N	0	0	R	0	N	A	1	U	43	0.5	2.0

APPENDIX F

Rearing habitat quality rating used for Tucannon River spring chinook salmon population assessment. The sum of point ratings from each of the four categories is used. Modified from Platts et al. (1983).

Factor	Description	Points
Depth (D)	Thalweg depth at the transect is greater than 90 cm in the main channel, and 60 cm in the side channel.	3
	Thalweg depth at the transect is greater than 60 cm in the main channel, and 30 cm in the side channel.	2
	Thalweg depth at the transect is less than 60 cm in the main channel, and 30 cm in the side channel.	1
Riparian Cover (R)	Abundant cover, 65 to 100% of the rearing area is protected.	3
	Partial cover, 35 to 65% of the rearing area is protected.	2
	Exposed, less than 35% of the rearing area is protected.	1
Woody Debris (W)	Abundant, complex debris in the main rearing area.	3
	Partial debris build-up in the main rearing area.	2
	No debris.	1
Boulder Cover (B)	High diversity, with at least one boulder larger than 60 cm at maximum diameter.	3
	Moderate diversity, some interstices available for cover.	2
	Flat uniform cobble, no interstices.	1

APPENDIX G

Table 1. Comparison of 1986, 1987, 1988, and 1989 spring chinook salmon rearing density estimates for riffles, runs, pools, boulder sites, and side channels within the HMA Stratum, Tucannon River, Washington.

Habitat type	Site[a]	Density (fish/100m²) by year 1986	1987	1988	1989
Riffle	HMA 1	23.37	19.77	20.86	12.55
	HMA 5	24.10	12.79	26.66	20.19
	HMA 9	11.77	10.33	7.10	4.41
	HMA 13	17.35	9.74	8.87	11.94
	HMA 18	13.87	7.91	8.66	14.23
	HMA 20	18.37	18.19	1.93	8.62
Run	HMA 3	24.75	45.09	44.16	13.02
	HMA 6	19.91	6.78	2.31	4.86
	HMA 10	20.72	65.54	24.04	41.42
	HMA 14	96.68	56.43	29.03	31.04
	HMA 19	48.94	37.43	33.44	18.88
	HMA 24	92.45	45.48	35.33	61.24
Pool	HMA 4	12.14	4.43	9.00	20.98
	HMA 8	10.53	47.53	31.73	9.48
	HMA 12	38.73	33.04	14.51	4.76
	HMA 16	67.43	46.80	34.63	20.27
	HMA 21	60.89	31.40	34.57	41.12
	HMA 22	126.26	71.64	38.77	65.55
Boulder	HMA 2	8.95	7.48	14.82	6.42
	HMA 7	13.68	37.48	13.57	3.73
	HMA 11	12.99	9.00	7.72	3.50
	HMA 15	12.79	34.87	11.68	4.33
	HMA 17	22.96	20.53	6.87	8.89
	HMA 23	17.73	15.39	1.46	4.57
Side channel	HMAS-1	75.44	36.89	38.19	17.95
	HMAS-2	23.79	123.60	113.33	86.05
	HMAS-3	41.22	49.07	13.34	32.89
	HMAS-4	35.23	23.33	27.09	4.54
	HMAS-5	122.11	19.41	82.81	55.90
	HMAS-6	53.20	30.21	33.86	29.06

[a] *Refer to our FY 1988 report for site descriptions.*

APPENDIX G, continued.

Table 2. Comparison of density estimates from summer snorkeling and electrofishing surveys by habitat type and site, for spring chinook salmon parr in HMA Stratum, Tucannon River, Washington, 1989.

Habitat type	Site[a]	Density ($fish/100m^2$)	
		Snorkeling	Electrofishing
Riffle	HMA 1	0.97	12.55
	HMA 5	4.25	20.19
	HMA 9	9.08	4.41
	HMA 13	7.13	11.94
	HMA 18	3.68	14.23
	HMA 20	10.40	8.62
Run	HMA 3	6.31	13.02
	HMA 6	1.31	4.86
	HMA 10	29.25	41.42
	HMA 14	105.40	31.04
	HMA 19	23.98	18.88
	HMA 24	49.74	61.24
Pool	HMA 4	75.28	20.98
	HMA 8	58.91	9.48
	HMA 12	12.94	4.76
	HMA 16	74.13	20.27
	HMA 21	43.99	41.12
	HMA 22	86.82	65.55
Boulder	HMA 2	5.09	6.42
	HMA 7	5.10	3.73
	HMA 11	5.45	3.50
	HMA 15	1.25	4.33
	HMA 17	10.59	8.89
	HMA 23	20.03	4.57
Side channel	HMAS-1	79.00	17.95
	HMAS-2	148.69	86.05
	HMAS-3	20.81	32.89
	HMAS-4	32.72	4.54
	HMAS-5	37.62	55.90
	HMAS-6	97.98	29.06

[a] *Refer to our FY 1988 report for site descriptions.*

APPENDIX G, continued.

Table 3. Comparison of mean snorkel density estimates for riffles, runs, pools, boulder sites, and side channels between summer and winter in the HMA Stratum, Tucannon River, 1988 to 1990.

Habitat type	Site[a]	Summer 1988 (fish/100m²)	Winter 1988/89 (fish/100m²)	Summer 1989 (fish/100m²)	Winter 1989/90 (fish/100m²)
Riffle	HMA 1	21.04	0.97	0.97	0.00
	HMA 5	21.05	0.66	4.25	0.00
	HMA 9	19.62	8.33	9.10	0.58
	HMA 13	13.37	1.42	7.14	0.58
	HMA 18	10.31	0.00	3.67	0.00
	HMA 20	6.95	0.75	10.39	0.00
Run	HMA 3	62.52	6.10	6.32	1.93
	HMA 6	6.71	0.00	1.29	2.70
	HMA 10	71.09	7.74	29.25	2.96
	HMA 14	62.22	0.00	105.40	73.01
	HMA 19	55.85	0.00	23.98	6.71
	HMA 24	34.11	5.66	49.73	11.02
Pool	HMA 4	60.34	69.23	75.28	161.29
	HMA 8	48.30	0.81	58.91	35.78
	HMA 12	21.64	3.03	12.93	0.90
	HMA 16	79.62	36.63	74.14	1.05
	HMA 21	56.25	0.00	44.00	10.93
	HMA 22	50.92	35.71	86.82	34.54
Boulder	HMA 2	32.47	14.03	5.08	0.00
	HMA 7	39.59	3.22	5.09	0.58
	HMA 11	31.06	0.00	5.44	0.00
	HMA 15	7.87	0.00	0.24	0.00
	HMA 17	12.50	0.99	10.59	0.00
	HMA 23	10.85	0.90	20.03	1.40
Side channel	HMAS-1	47.05	52.49	79.07	6.40
	HMAS-2	133.61	102.64	148.70	234.35
	HMAS-3	29.22	0.00	20.80	0.00
	HMAS-4	77.94	31.57	32.71	79.20
	HMAS-5	98.57	5.29	37.62	64.57
	HMAS-6	24.58	0.00	97.98	4.08

[a] Refer to our FY 1988 report for site descriptions.

APPENDIX M

Comparison of minimum and maximum stream temperatures in the Tucannon River near confluences of Sheep, Panjab, and Cummings Creeks, outlets of Big 4, Deer, and Beaver Lakes, and Marengo Bridge (River km 41) from November 1988 to September 1989. Temperatures are in degrees F.

Date	Sheep Creek Min	Sheep Creek Max	Panjab Creek Min	Panjab Creek Max	Big 4 Lake Min	Big 4 Lake Max	Deer Lake Min	Deer Lake Max	Cummings Creek Min	Cummings Creek Max	Beaver Lake Min	Beaver Lake Max	Marengo bridge Min	Marengo bridge Max
02 Nov	-	-	46	50	46	52	45	46	46	50	48	48	-	-
03 Nov	-	-	46	48	48	50	43	46	45	46	46	48	-	-
04 Nov	-	-	45	46	48	50	43	46	45	46	46	48	-	-
05 Nov	-	-	45	48	48	52	43	46	45	46	45	50	-	-
06 Nov	-	-	46	48	46	50	41	43	43	46	43	50	-	-
07 Nov	-	-	43	45	45	48	39	43	41	43	43	45	-	-
08 Nov	-	-	43	45	45	50	39	43	41	43	37	45	-	-
09 Nov	-	-	43	45	45	46	39	43	41	43	40	43	-	-
10 Nov	-	-	43	45	46	48	41	43	43	45	43	41	-	-
11 Nov	-	-	43	45	45	46	39	41	41	43	39	45	-	-
12 Nov	-	-	43	45	45	46	39	41	41	43	40	41	-	-
13 Nov	-	-	41	43	43	45	37	41	39	41	39	41	-	-
14 Nov	31	31	39	41	41	45	36	39	37	39	37	41	-	-
15 Nov	31	31	39	43	41	45	36	39	37	39	37	41	-	-
16 Nov	31	32	41	45	43	46	39	41	39	41	41	43	-	-
17 Nov	32	32	43	43	44	45	39	40	41	41	39	45	-	-
18 Nov	32	32	43	44	43	45	37	39	40	41	37	41	-	-
19 Nov	31	31	41	43	43	45	37	39	39	41	39	41	-	-
20 Nov	31	31	41	43	43	45	37	39	39	41	37	41	-	-
21 Nov	31	31	41	43	43	45	37	39	39	41	39	41	-	-
22 Nov	30	31	43	45	45	46	39	43	41	43	41	42	-	-
23 Nov	31	31	41	43	42	43	37	41	39	39	39	41	-	-
24 Nov	30	30	41	42	41	43	36	37	37	39	37	41	-	-
25 Nov	30	30	41	42	42	43	37	38	37	39	39	43	-	-
26 Nov	30	31	39	41	41	43	36	37	37	39	39	41	-	-
27 Nov	31	31	39	41	39	43	34	37	36	39	37	39	-	-
28 Nov	30	31	41	43	43	45	37	39	39	40	37	41	-	-
29 Nov	30	31	41	43	43	45	37	40	37	41	41	43	-	-
30 Nov	30	31	39	40	41	43	36	37	37	39	41	43	-	-
01 Dec	31	31	39	41	41	43	36	37	36	37	39	41	-	-
02 Dec	31	31	41	43	43	45	37	39	37	39	42	43	-	-
03 Dec	30	31	41	42	43	44	37	39	37	39	39	43	-	-
04 Dec	30	31	41	41	41	43	36	37	36	37	41	43	-	-
05 Dec	31	32	40	43	39	45	34	38	36	39	43	45	-	-
06 Dec	31	32	43	45	45	46	37	41	37	41	43	45	-	-
07 Dec	32	32	43	43	43	45	39	41	39	41	39	41	-	-
08 Dec	32	32	41	43	43	45	37	39	37	39	36	39	-	-
09 Dec	32	32	42	43	45	46	39	41	39	41	36	37	-	-
10 Dec	31	32	41	43	43	45	37	39	39	40	36	37	-	-
11 Dec	32	32	41	43	43	45	39	40	39	41	36	37	-	-
12 Dec	31	32	42	45	45	46	40	43	41	43	37	39	-	-
13 Dec	30	31	43	44	43	46	39	43	39	43	39	40	-	-
14 Dec	30	30	41	43	41	43	36	37	36	39	39	40	-	-
15 Dec	30	30	37	39	39	40	34	35	34	35	39	40	-	-
16 Dec	31	31	37	39	39	40	34	36	33	34	37	39	-	-
17 Dec	31	31	37	39	37	39	32	34	34	36	36	37	-	-
18 Dec	31	31	37	39	37	39	34	36	32	34	34	36	-	-
19 Dec	31	31	39	41	40	43	34	37	36	37	34	36	-	-
20 Dec	30	30	40	41	41	43	36	37	36	37	34	36	-	-
21 Dec	30	30	41	41	41	43	36	37	36	37	34	34	-	-
22 Dec	30	30	40	41	41	43	36	37	36	37	34	37	-	-
23 Dec	30	30	39	41	39	41	34	36	36	37	37	34	-	-
24 Dec	30	30	37	39	39	41	32	34	34	36	37	39	-	-
25 Dec	30	30	36	39	37	39	30	32	32	33	37	39	-	-
26 Dec	30	30	36	41	36	37	31	32	32	34	37	39	-	-
27 Dec	30	30	36	39	36	37	30	32	32	33	39	43	-	-
28 Dec	30	30	36	37	36	37	31	32	32	33	39	41	-	-
29 Dec	30	30	36	39	36	41	32	34	32	36	39	39	-	-
30 Dec	30	30	39	41	39	41	34	36	35	36	37	37	-	-

Appendix H, continued.

Date	Sheep Creek Min	Sheep Creek Max	Panjab Creek Min	Panjab Creek Max	Big 4 Lake Min	Big 4 Lake Max	Deer Lake Min	Deer Lake Max	Cummings Creek Min	Cummings Creek Max	Beaver Lake Min	Beaver Lake Max	Marengo bridge Min	Marengo bridge Max
31 Dec	30	30	39	41	39	41	34	36	36	37	36	37	-	-
01 Jan	30	30	40	41	41	43	36	36	36	37	34	36	-	-
02 Jan	30	30	41	43	41	43	36	37	36	39	37	37	-	-
03 Jan	30	30	41	43	43	45	37	39	39	41	36	39	-	-
04 Jan	30	30	41	43	43	45	36	39	37	39	39	41	-	-
05 Jan	30	30	40	41	41	43	36	37	37	38	39	41	-	-
06 Jan	30	30	39	41	41	43	34	36	36	37	39	40	-	-
07 Jan	30	30	37	39	36	41	32	34	34	35	37	39	-	-
08 Jan	30	30	37	39	37	39	32	34	33	34	37	39	-	-
09 Jan	30	30	37	39	37	41	32	36	34	37	39	42	-	-
10 Jan	30	30	39	41	41	43	36	37	36	37	41	42	-	-
11 Jan	30	30	40	41	41	43	36	37	37	39	41	43	-	-
12 Jan	30	30	41	41	41	43	36	37	37	39	41	42	-	-
13 Jan	30	30	41	41	40	41	36	37	37	38	41	43	-	-
14 Jan	30	30	39	41	41	43	36	36	36	37	41	43	-	-
15 Jan	30	30	41	41	41	43	36	37	37	38	37	41	-	-
16 Jan	30	30	41	42	43	45	37	39	38	39	37	39	-	-
17 Jan	30	30	41	43	43	45	39	39	39	41	37	39	-	-
18 Jan	30	30	42	45	45	46	39	41	38	41	36	37	-	-
19 Jan	30	30	43	43	43	45	37	39	38	39	41	45	-	-
20 Jan	-	-	43	45	43	46	37	41	39	41	39	43	-	-
21 Jan	-	-	43	45	44	45	39	39	39	41	37	37	-	-
22 Jan	-	-	42	43	43	45	37	39	38	39	34	34	-	-
23 Jan	-	-	41	43	41	43	36	37	36	37	34	34	-	-
24 Jan	-	-	38	41	39	41	34	36	34	36	34	34	-	-
25 Jan	-	-	40	41	41	43	36	37	36	37	34	34	-	-
26 Jan	-	-	39	41	39	43	34	36	36	37	34	34	-	-
27 Jan	-	-	41	43	39	43	34	37	36	37	34	34	-	-
28 Jan	-	-	39	43	39	43	34	37	36	37	34	34	-	-
29 Jan	-	-	41	43	41	45	36	39	36	38	34	34	-	-
30 Jan	-	-	43	45	43	46	37	41	39	43	37	37	-	-
31 Jan	-	-	41	43	41	45	37	39	37	41	37	37	-	-
01 Feb	-	-	39	41	39	41	36	37	34	36	36	39	-	-
02 Feb	-	-	36	37	36	37	30	34	31	32	36	36	-	-
03 Feb	-	-	36	36	37	37	30	30	31	32	36	37	-	-
04 Feb	-	-	36	37	36	37	31	31	32	32	34	34	-	-
05 Feb	-	-	36	36	36	36	31	31	32	32	36	37	-	-
06 Feb	-	-	36	36	36	36	31	31	32	32	37	37	-	-
07 Feb	-	-	36	39	36	36	31	31	32	32	37	39	-	-
08 Feb	-	-	36	37	36	36	30	31	32	32	36	39	-	-
09 Feb	-	-	36	37	36	37	31	31	32	32	39	41	-	-
10 Feb	-	-	37	39	37	41	31	34	32	34	37	41	-	-
11 Feb	-	-	39	41	39	43	34	36	34	36	39	43	-	-
12 Feb	-	-	39	41	39	41	34	37	34	36	37	43	-	-
13 Feb	-	-	39	40	39	41	34	36	34	36	37	41	-	-
14 Feb	-	-	37	39	39	41	34	36	34	36	36	41	-	-
15 Feb	-	-	36	39	36	41	30	36	32	34	37	41	-	-
16 Feb	-	-	37	41	39	41	34	36	34	36	37	41	-	-
17 Feb	-	-	39	41	41	43	36	37	36	37	39	41	-	-
18 Feb	-	-	40	41	41	43	36	37	36	37	37	41	-	-
19 Feb	-	-	39	41	39	43	34	37	34	37	34	37	-	-
20 Feb	-	-	41	43	41	45	36	39	36	39	34	37	-	-
21 Feb	-	-	41	43	41	45	36	39	37	39	34	37	-	-
22 Feb	-	-	41	43	43	46	37	41	37	40	37	37	-	-
23 Feb	-	-	39	41	41	45	36	41	37	39	39	41	-	-
24 Feb	-	-	39	43	41	45	36	39	37	39	39	43	-	-
25 Feb	-	-	39	41	39	45	34	39	36	39	39	43	-	-
26 Feb	-	-	39	41	41	45	36	39	36	37	39	43	-	-
27 Feb	-	-	39	43	41	45	36	39	37	39	41	45	-	-
28 Feb	-	-	40	41	43	45	37	39	37	39	41	43	-	-
01 Mar	-	-	37	41	39	43	34	37	34	39	41	43	-	-
02 Mar	-	-	37	39	39	41	32	36	33	36	-	-	-	-

Appendix H, continued.

Date	Sheep Creek Min	Sheep Creek Max	Penjab Creek Min	Penjab Creek Max	Big 4 Lake Min	Big 4 Lake Max	Deer Lake Min	Deer Lake Max	Cummings Creek Min	Cummings Creek Max	Beaver Lake Min	Beaver Lake Max	Marengo bridge Min	Marengo bridge Max
03 Mar	-	-	36	37	37	41	32	36	32	36	-	-	-	-
04 Mar	-	-	36	39	36	41	30	36	32	36	-	-	-	-
05 Mar	-	-	39	43	41	43	36	39	36	39	-	-	-	-
06 Mar	-	-	41	43	43	46	37	41	39	41	-	-	-	-
07 Mar	-	-	41	43	43	46	37	41	39	41	-	-	-	-
08 Mar	-	-	41	45	43	46	37	41	37	41	-	-	-	-
09 Mar	-	-	41	43	43	48	39	43	39	45	-	-	-	-
10 Mar	-	-	41	43	43	46	39	43	39	43	-	-	-	-
11 Mar	-	-	41	43	43	46	39	43	41	43	-	-	-	-
12 Mar	-	-	41	43	43	46	39	41	39	43	-	-	-	-
13 Mar	-	-	41	43	44	45	39	41	41	41	-	-	-	-
14 Mar	-	-	41	43	43	45	37	41	37	41	-	-	-	-
15 Mar	-	-	40	43	43	45	37	41	37	41	-	-	-	-
16 Mar	-	-	41	43	43	46	39	41	39	41	-	-	-	-
17 Mar	-	-	41	43	43	48	37	43	39	43	-	-	-	-
18 Mar	-	-	41	45	43	46	37	43	39	43	-	-	-	-
19 Mar	-	-	41	43	43	46	37	43	39	43	-	-	-	-
20 Mar	-	-	40	43	43	48	37	45	37	43	-	-	-	-
21 Mar	-	-	43	45	45	46	39	43	41	43	-	-	-	-
22 Mar	-	-	41	43	43	46	37	41	39	41	-	-	-	-
23 Mar	-	-	41	45	43	46	37	43	39	43	-	-	-	-
24 Mar	-	-	41	45	43	46	37	41	37	42	-	-	-	-
25 Mar	-	-	43	45	45	48	39	43	41	43	-	-	-	-
26 Mar	-	-	41	45	43	48	37	45	39	45	-	-	-	-
27 Mar	-	-	43	45	45	46	39	43	41	43	-	-	-	-
28 Mar	-	-	43	45	45	48	39	45	41	45	-	-	-	-
29 Mar	-	-	41	45	45	46	39	40	39	41	-	-	-	-
30 Mar	-	-	39	43	41	46	37	43	37	43	-	-	-	-
31 Mar	-	-	43	43	45	46	39	43	41	43	-	-	-	-
01 Apr	-	-	41	43	43	46	37	41	37	43	-	-	-	-
02 Apr	-	-	40	45	43	48	37	43	41	43	-	-	-	-
03 Apr	-	-	41	45	43	48	37	45	-	-	-	-	-	-
04 Apr	-	-	41	45	43	46	37	43	-	-	-	-	-	-
05 Apr	-	-	43	46	45	50	39	46	-	-	-	-	-	-
06 Apr	-	-	43	46	46	52	41	46	-	-	-	-	-	-
07 Apr	-	-	43	45	46	50	41	46	-	-	-	-	-	-
08 Apr	-	-	41	45	43	48	37	45	-	-	-	-	-	-
09 Apr	-	-	41	45	43	48	37	45	-	-	-	-	-	-
10 Apr	-	-	44	48	43	50	40	45	41	50	-	-	-	-
11 Apr	-	-	43	48	37	45	37	46	43	52	-	-	-	-
12 Apr	-	-	43	48	37	46	39	48	45	52	-	-	-	-
13 Apr	-	-	43	50	39	46	39	50	45	54	-	-	-	-
14 Apr	-	-	43	48	39	45	39	55	46	52	-	-	-	-
15 Apr	-	-	45	48	39	45	41	46	46	52	-	-	-	-
16 Apr	-	-	45	48	39	45	39	45	45	50	-	-	-	-
17 Apr	-	-	45	48	39	45	41	46	46	52	-	-	-	-
18 Apr	-	-	43	50	37	46	37	48	45	54	43	48	-	-
19 Apr	-	-	45	48	39	45	41	48	46	52	41	48	-	-
20 Apr	-	-	45	50	39	46	39	48	46	54	39	48	-	-
21 Apr	-	-	45	46	39	41	41	43	46	48	41	43	-	-
22 Apr	-	-	45	46	39	43	39	45	46	50	39	45	-	-
23 Apr	-	-	45	48	39	45	39	46	45	51	39	46	-	-
24 Apr	-	-	43	48	37	39	37	45	45	50	39	43	-	-
25 Apr	-	-	45	48	39	43	39	45	46	50	39	45	-	-
26 Apr	-	-	45	48	39	45	41	46	46	50	41	46	-	-
27 Apr	-	-	45	48	39	43	39	43	46	50	41	43	-	-
28 Apr	-	-	45	48	39	45	39	45	46	50	41	45	-	-
29 Apr	-	-	43	50	37	48	37	50	45	54	39	50	-	-
30 Apr	-	-	46	52	39	50	39	52	45	55	39	52	-	-
01 May	-	-	45	48	41	45	41	46	48	52	41	45	-	-
02 May	-	-	45	48	41	45	41	46	48	52	41	46	-	-
03 May	-	-	45	52	39	48	39	50	46	55	41	50	-	-

Appendix H, continued.

Date	Sheep Creek Min	Sheep Creek Max	Panjab Creek Min	Panjab Creek Max	Big 4 Lake Min	Big 4 Lake Max	Deer Lake Min	Deer Lake Max	Cummings Creek Min	Cummings Creek Max	Beaver Lake Min	Beaver Lake Max	Marengo bridge Min	Marengo bridge Max
04 May	-	-	45	52	39	49	41	52	46	55	41	52	-	-
05 May	-	-	45	50	39	46	41	48	46	54	41	50	-	-
06 May	-	-	46	52	41	48	41	50	48	55	43	50	-	-
07 May	-	-	46	50	41	48	43	50	50	55	43	50	-	-
08 May	-	-	45	50	39	46	41	48	48	54	41	48	-	-
09 May	-	-	46	50	39	46	41	48	48	54	41	48	-	-
10 May	-	-	45	46	41	43	43	45	48	49	43	44	-	-
11 May	-	-	45	48	39	45	39	46	46	52	41	46	-	-
12 May	-	-	43	46	37	41	39	45	45	50	39	43	-	-
13 May	-	-	43	48	37	43	37	46	45	52	39	46	-	-
14 May	-	-	45	48	39	45	39	46	46	52	41	46	-	-
15 May	-	-	45	52	39	48	41	50	46	55	41	51	-	-
16 May	-	-	45	50	39	48	41	50	48	55	41	50	-	-
17 May	-	-	46	52	41	46	41	48	50	55	43	50	-	-
18 May	-	-	45	48	39	45	41	45	48	52	41	46	-	-
19 May	-	-	45	48	39	45	39	46	46	54	41	48	-	-
20 May	-	-	43	52	37	48	39	52	46	55	39	52	-	-
21 May	-	-	45	50	39	46	41	48	48	55	41	49	-	-
22 May	-	-	46	52	41	48	43	52	50	55	43	52	-	-
23 May	-	-	46	48	43	46	43	45	50	52	43	46	-	-
24 May	-	-	45	48	39	45	41	45	48	52	41	46	-	-
25 May	-	-	45	52	39	46	41	50	48	55	41	50	-	-
26 May	-	-	45	50	39	45	41	46	48	52	41	46	-	-
27 May	-	-	46	48	41	45	43	45	50	52	45	46	-	-
28 May	-	-	46	48	41	43	41	45	48	52	43	46	-	-
29 May	-	-	46	48	41	43	41	43	50	51	43	45	-	-
30 May	-	-	45	50	39	46	39	50	46	55	41	50	-	-
31 May	-	-	46	54	41	52	41	54	50	59	43	54	-	-
01 Jun	-	-	48	55	43	54	43	55	52	63	45	57	-	-
02 Jun	-	-	48	54	45	52	45	54	54	61	46	55	-	-
03 Jun	-	-	48	55	45	52	45	55	54	61	46	55	-	-
04 Jun	-	-	48	55	43	54	45	55	54	63	46	57	-	-
05 Jun	-	-	48	58	45	54	46	57	54	64	46	57	-	-
06 Jun	-	-	50	58	45	54	46	57	55	64	46	57	-	-
07 Jun	-	-	48	55	45	54	45	57	54	63	46	57	-	-
08 Jun	-	-	48	57	45	55	46	57	54	64	46	57	-	-
09 Jun	-	-	50	55	45	54	46	57	55	63	46	57	-	-
10 Jun	-	-	50	54	45	50	46	54	54	59	46	54	-	-
11 Jun	-	-	48	55	45	54	45	57	54	64	46	57	-	-
12 Jun	-	-	50	59	46	57	48	61	55	66	48	61	-	-
13 Jun	-	-	52	55	48	50	50	54	57	61	50	54	-	-
14 Jun	-	-	54	55	48	52	50	55	57	63	50	55	-	-
15 Jun	-	-	53	54	48	49	50	52	58	59	50	52	-	-
16 Jun	-	-	50	54	45	52	46	55	54	61	46	55	-	-
17 Jun	-	-	50	54	43	50	45	52	54	59	45	51	-	-
18 Jun	-	-	50	57	45	55	46	59	54	63	45	57	-	-
19 Jun	-	-	54	55	46	52	48	54	55	61	46	52	-	-
20 Jun	-	-	52	55	45	52	46	55	54	61	45	54	-	-
21 Jun	-	-	50	57	43	55	45	59	52	63	43	55	-	-
22 Jun	-	-	54	57	46	52	48	54	57	59	46	52	-	-
23 Jun	-	-	54	61	45	48	46	61	57	63	45	59	-	-
24 Jun	-	-	55	63	46	59	48	63	55	64	46	59	-	-
25 Jun	-	-	55	63	46	57	48	61	55	63	46	57	-	-
26 Jun	-	-	57	63	48	57	50	61	57	64	48	59	-	-
27 Jun	-	-	55	59	46	55	48	57	55	61	46	55	-	-
28 Jun	-	-	54	61	46	55	48	57	55	63	45	54	-	-
29 Jun	-	-	55	63	48	57	50	61	57	64	46	57	-	-
30 Jun	-	-	55	59	48	54	50	55	57	63	48	54	-	-
01 Jul	-	-	55	57	46	52	48	54	55	59	46	50	-	-
02 Jul	-	-	54	63	48	59	48	63	55	64	46	59	-	-
03 Jul	-	-	55	64	48	61	50	64	57	66	46	61	-	-
04 Jul	-	-	55	63	48	61	50	63	57	64	46	59	-	-

Appendix H, continued.

Date	Sheep Creek Min	Sheep Creek Max	Panjab Creek Min	Panjab Creek Max	Big 4 Lake Min	Big 4 Lake Max	Deer Lake Min	Deer Lake Max	Cummings Creek Min	Cummings Creek Max	Beaver Lake Min	Beaver Lake Max	Marengo bridge Min	Marengo bridge Max
05 Jul	-	-	55	63	50	61	50	63	57	66	46	59	-	-
06 Jul	-	-	55	64	48	63	50	64	57	68	46	61	-	-
07 Jul	-	-	57	64	50	63	52	64	59	68	48	61	-	-
08 Jul	-	-	55	63	48	61	50	63	59	66	46	59	-	-
09 Jul	-	-	54	61	48	61	48	63	57	66	45	59	-	-
10 Jul	-	-	54	59	48	59	50	61	57	64	46	57	-	-
11 Jul	-	-	52	63	48	63	50	66	57	68	46	61	-	-
12 Jul	-	-	55	59	52	57	54	59	61	64	50	54	-	-
13 Jul	-	-	55	64	51	64	52	68	61	69	48	63	-	-
14 Jul	-	-	55	64	52	64	55	68	63	72	50	63	-	-
15 Jul	-	-	57	61	54	59	55	63	63	66	50	57	-	-
16 Jul	-	-	54	57	-	-	52	57	59	63	46	52	-	-
17 Jul	-	-	54	59	-	-	52	64	59	66	48	59	-	-
18 Jul	-	-	54	63	-	-	54	66	61	68	48	61	-	-
19 Jul	-	-	55	64	-	-	54	68	63	69	48	63	-	-
20 Jul	-	-	57	64	-	-	57	68	64	69	50	61	-	-
21 Jul	-	-	54	61	-	-	52	64	59	68	46	57	-	-
22 Jul	-	-	52	63	-	-	50	64	59	68	46	57	-	-
23 Jul	-	-	54	63	-	-	52	66	61	69	46	61	-	-
24 Jul	-	-	55	63	-	-	54	66	63	69	48	61	-	-
25 Jul	-	-	54	64	-	-	52	66	61	69	46	59	-	-
26 Jul	-	-	54	59	-	-	54	61	61	66	46	54	-	-
27 Jul	-	-	54	63	-	-	52	66	59	68	46	59	-	-
28 Jul	-	-	52	63	-	-	50	64	59	68	45	59	61	72
29 Jul	-	-	54	63	-	-	52	66	59	68	46	59	59	73
30 Jul	-	-	54	63	-	-	52	66	61	68	46	59	61	72
31 Jul	-	-	55	63	-	-	54	64	61	68	46	57	61	72
01 Aug	-	-	54	59	-	-	52	59	61	64	46	52	59	72
02 Aug	-	-	54	59	-	-	52	63	59	66	46	54	59	68
03 Aug	-	-	54	57	-	-	52	57	59	63	45	50	59	64
04 Aug	-	-	52	61	-	-	50	64	57	66	43	55	57	70
05 Aug	-	-	54	61	-	-	52	64	59	68	45	57	59	73
06 Aug	-	-	54	63	-	-	52	66	61	70	45	59	61	75
07 Aug	-	-	55	63	-	-	55	66	63	70	46	57	64	75
08 Aug	-	-	55	61	-	-	57	64	64	70	48	57	64	72
09 Aug	-	-	57	63	-	-	57	66	64	70	48	57	64	73
10 Aug	-	-	55	63	-	-	54	64	61	68	45	55	61	72
11 Aug	-	-	55	63	-	-	54	64	61	68	45	55	61	72
12 Aug	-	-	54	61	-	-	54	60	61	66	45	52	61	66
13 Aug	-	-	54	61	-	-	52	64	61	65	45	55	61	72
14 Aug	-	-	54	59	-	-	52	61	59	65	54	52	59	66
15 Aug	-	-	54	59	-	-	50	59	59	64	43	50	59	66
16 Aug	-	-	52	57	-	-	48	57	57	63	41	48	57	66
17 Aug	-	-	52	59	-	-	50	63	57	64	41	52	61	68
18 Aug	-	-	52	59	-	-	50	63	57	65	41	54	59	70
19 Aug	-	-	52	57	-	-	52	58	59	63	43	50	59	64
20 Aug	-	-	54	59	-	-	54	61	61	66	45	52	61	70
21 Aug	-	-	55	59	-	-	54	61	61	66	45	50	61	68
22 Aug	-	-	55	57	-	-	54	55	61	63	45	46	61	64
23 Aug	-	-	53	54	-	-	52	54	57	59	43	44	57	61
24 Aug	-	-	52	54	-	-	50	52	55	57	41	43	55	57
25 Aug	-	-	52	55	-	-	50	54	55	59	41	45	55	59
26 Aug	-	-	51	55	-	-	48	57	55	61	39	46	55	64
27 Aug	-	-	52	57	-	-	50	57	57	61	40	48	57	64
28 Aug	-	-	52	55	-	-	50	57	57	61	39	46	57	66
29 Aug	-	-	52	57	-	-	50	59	57	63	39	48	57	64
30 Aug	-	-	54	55	-	-	50	57	57	61	43	46	59	64
31 Aug	-	-	52	55	-	-	48	59	55	63	39	48	57	64
01 Sep	-	-	52	55	-	-	48	55	55	59	39	45	57	61
02 Sep	-	-	52	55	-	-	48	57	57	61	39	46	55	63
03 Sep	-	-	52	55	-	-	46	57	55	61	37	48	55	64
04 Sep	-	-	52	55	-	-	48	57	55	61	39	48	55	64

APPENDIX I

Tucannon River 1988/1989 spring chinook salmon downstream migrant trapping data. Columns 3 through 15 are as follows: 3) fish marked (left partial ventral clip) and transported 10 km with 4) subsequent recaptures, 5) fish marked (right partial ventral clip) and transported 10 km with 6) subsequent recaptures, 7) fish marked (top caudal clip) and transported 40 km with 8) recaptures, 9) fish marked (bottom caudal clip) with 10) subsequent recaptures, 11) fish that were not marked and released downstream of trap, 12) fish sampled for electrophoresis, morphometrics, or ATP-ase activity, 13) mortalities incurred at the trap (Some recaptured fish died and therefore are counted both as recaptures and mortalities, causing a disparity in the total count), 14) the sum of columns 3 through 13 for that row, 15) spring chinook salmon released from Tucannon Fish Hatchery and caught at the trap, and 16) the sum of columns 14 and 15 for that row.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Mark	Recapture	Mark	Recapture	Mark	Recapture	Mark	Recapture	No			Total	Total	Total
Date	Time	LPV	LPV	RPV	RPV	TC	TC	BC	BC	marks	Sampled	Morts	wild	hatchery	fish
25-Oct-88	700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26-Oct-88	700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27-Oct-88	730	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Oct-88	700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-Oct-88	630	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01-Nov-88	645	0	0	0	0	0	0	0	0	0	0	0	1	0	1
07-Nov-88	645	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-Nov-88	630	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15-Nov-88	630	0	0	0	0	0	0	0	0	0	0	0	1	0	1
21-Nov-88	630	0	0	0	0	0	0	0	0	0	0	0	1	0	1
29-Nov-88	730	0	0	15	0	0	0	0	0	0	0	0	15	0	15
29-Nov-88	1500	0	0	0	0	0	0	0	0	0	0	0	3	0	3
30-Nov-88	700	26	0	0	4	0	0	0	0	1	0	0	31	1	32
30-Nov-88	1600	0	0	0	0	0	0	0	0	3	0	0	3	0	3
01-Dec-88	730	0	2	28	0	0	0	0	0	2	0	1	33	1	34
02-Dec-88	700	35	0	0	1	0	0	0	0	1	0	0	37	3	40
03-Dec-88	730	0	17	0	1	0	0	0	0	22	0	0	40	2	42
04-Dec-88	730	14	0	0	1	0	0	0	0	3	0	0	18	1	19
05-Dec-88	730	0	8	17	2	0	0	0	0	0	0	0	27	4	31
07-Dec-88	700	4	0	0	3	0	0	0	0	0	0	0	7	1	8
08-Dec-88	730	0	2	11	0	0	0	0	0	2	0	0	15	1	16
09-Dec-88	700	7	0	0	3	0	0	0	0	0	0	0	10	0	10
12-Dec-88	700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-Dec-88	1600	0	0	0	0	0	0	0	0	0	0	0	0	1	1
13-Dec-88	730	0	0	9	0	0	0	0	0	0	0	0	9	1	10
14-Dec-88	730	5	0	0	3	0	0	0	0	0	0	0	8	1	9
15-Dec-88	730	0	0	14	1	0	0	0	0	0	0	0	15	1	16
16-Dec-88	800	12	1	0	7	0	0	0	0	2	0	0	22	0	22
17-Dec-88	1200	0	1	0	1	0	0	0	0	22	0	0	24	3	27
19-Dec-88	730	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20-Dec-88	730	9	0	0	1	0	0	0	0	0	0	0	10	2	12
21-Dec-88	730	0	0	5	0	0	0	0	0	0	0	0	5	0	5
22-Dec-88	730	3	1	0	1	0	0	0	0	1	0	0	6	0	6
23-Dec-88	1000	0	0	0	0	0	0	0	0	0	0	0	0	1	1
04-Jan-89	730	5	0	0	0	0	0	0	0	1	0	0	6	0	6
05-Jan-89	730	0	0	0	0	0	0	0	0	2	0	0	2	0	2
06-Jan-89	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-Jan-89	730	0	0	11	1	0	0	0	0	0	0	0	12	0	12
11-Jan-89	730	7	0	0	0	0	0	0	0	0	0	0	7	0	7

Appendix I, continued.

1 Date	2 Time	3 Mark LPV	4 Recapture LPV	5 Mark RPV	6 Recapture RPV	7 Mark TC	8 Recapture TC	9 Mark BC	10 Recapture BC	11 No marks	12 Sampled	13 Morts	14 Total wild	15 Total hatchery	16 Total fish
12-Jan-89	930	0	1	50	2	0	0	0	0	4	0	1	58	0	58
13-Jan-89	730	32	1	0	14	0	0	0	0	2	10	2	60	6	66
14-Jan-89	930	0	6	0	1	0	0	0	0	24	0	0	31	3	34
18-Jan-89	730	0	0	14	0	0	0	0	0	1	0	0	15	1	16
19-Jan-89	730	17	0	0	5	0	0	0	0	3	0	0	25	0	25
20-Jan-89	800	0	0	7	0	0	0	0	0	0	0	1	8	0	8
21-Jan-89	830	0	0	0	0	0	0	0	0	6	0	0	6	0	6
24-Jan-89	800	0	0	16	2	0	0	0	0	4	0	0	22	1	23
25-Jan-89	800	31	3	0	2	0	0	0	0	4	0	0	40	0	40
26-Jan-89	730	0	3	13	1	0	0	0	0	1	0	0	18	1	19
27-Jan-89	815	0	2	0	1	0	0	0	0	19	0	0	22	0	22
31-Jan-89	730	5	2	0	1	0	0	0	0	3	0	0	11	0	11
01-Feb-89	730	0	2	22	1	0	0	0	0	1	0	0	26	1	27
02-Feb-89	730	0	0	0	0	0	0	0	0	8	0	0	8	0	8
15-Feb-89	730	0	0	0	0	0	0	0	0	0	7	3	7	0	7
15-Feb-89	1400	0	1	0	1	0	0	0	0	0	0	0	2	0	2
16-Feb-89	1200	0	0	0	0	0	0	0	0	3	10	0	13	0	13
17-Feb-89	730	0	0	8	0	0	0	0	0	1	0	1	10	0	10
18-Feb-89	730	0	1	0	0	0	0	0	0	13	0	0	14	1	15
21-Feb-89	745	2	0	0	0	0	0	0	0	0	0	0	2	0	2
22-Feb-89	745	0	0	20	1	0	0	0	0	0	0	1	22	2	24
23-Feb-89	745	3	2	0	0	0	0	0	0	0	0	0	5	0	5
24-Feb-89	730	0	0	2	0	0	0	0	0	0	0	0	2	0	2
25-Feb-89	745	12	0	0	1	0	0	0	0	0	0	0	13	0	13
27-Feb-89	730	50	1	0	1	0	0	0	0	16	0	0	68	12	80
28-Feb-89	730	50	9	0	1	0	0	0	0	56	0	1	117	4	121
01-Mar-89	715	50	11	0	0	0	0	0	0	26	20	1	105	5	110
02-Mar-89	800	0	3	19	2	0	0	0	0	6	0	0	30	2	32
03-Mar-89	700	0	2	4	2	0	0	0	0	15	0	0	23	0	23
04-Mar-89	800	0	0	9	0	0	0	0	0	1	0	1	11	0	11
05-Mar-89	730	0	2	20	0	0	0	0	0	0	0	0	22	0	22
06-Mar-89	730	45	3	0	3	0	0	0	0	7	0	1	59	4	63
07-Mar-89	730	12	2	0	2	0	0	0	0	0	0	0	16	0	16
08-Mar-89	730	50	1	0	2	0	0	0	0	33	0	0	86	2	88
09-Mar-89	730	0	11	50	2	0	0	0	0	33	0	0	96	1	97
10-Mar-89	800	0	1	11	3	0	0	0	0	0	0	0	15	0	15
10-Mar-89	1600	0	0	0	0	0	0	0	0	0	0	0	4	0	4
11-Mar-89	800	0	0	0	1	0	0	0	0	1	0	0	2	0	2
12-Mar-89	730	2	0	0	0	0	0	0	0	0	0	0	2	0	2
13-Mar-89	730	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-Mar-89	1600	0	0	0	0	0	0	0	0	4	0	0	4	0	4
15-Mar-89	700	0	0	3	0	0	0	0	0	1	0	0	4	0	4
15-Mar-89	1500	0	0	0	1	0	0	0	0	27	0	0	28	0	28
16-Mar-89	700	0	0	16	1	0	0	0	0	2	0	0	19	6	25
16-Mar-89	1600	0	0	0	0	0	0	0	0	19	0	0	19	1	20
17-Mar-89	730	0	0	25	0	0	0	0	0	4	0	0	29	13	42
17-Mar-89	1630	0	0	0	0	0	0	0	0	5	0	0	5	0	5
18-Mar-89	800	28	0	0	0	0	0	0	0	3	0	0	31	3	34

Appendix I, continued.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Date	Time	Mark LPV	Recapture LPV	Mark RPV	Recapture RPV	Mark TC	Recapture TC	Mark BC	Recapture BC	No marks	Sampled	Morts	Total wild	Total hatchery	Total fish
19-Mar-89	700	40	4	0	0	0	0	0	0	0	0	0	44	7	51
20-Mar-89	630	50	12	0	3	0	0	0	0	38	0	0	103	15	118
20-Mar-89	110	0	0	0	0	0	0	0	0	2	0	0	2	0	2
20-Mar-89	1100	0	1	0	0	0	0	0	0	5	0	0	6	0	6
21-Mar-89	30	0	4	0	2	0	0	0	0	25	0	0	31	2	33
21-Mar-89	630	0	8	32	1	0	0	0	0	2	0	0	43	5	48
21-Mar-89	1100	0	1	0	0	0	0	0	0	4	0	0	5	0	5
22-Mar-89	30	0	4	41	3	0	0	0	0	3	0	0	51	6	57
22-Mar-89	630	0	3	9	3	0	0	0	0	25	0	0	40	4	44
23-Mar-89	30	0	4	0	14	0	0	50	0	9	0	0	77	7	84
23-Mar-89	630	0	1	0	5	0	0	0	0	43	0	0	49	5	54
24-Mar-89	30	0	1	0	2	0	0	0	0	101	1	0	106	18	124
24-Mar-89	900	0	0	0	2	0	0	0	0	27	0	0	29	2	31
25-Mar-89	100	0	3	0	0	0	0	0	0	64	0	0	67	14	81
25-Mar-89	900	0	0	0	0	0	0	0	0	19	0	0	19	6	25
26-Mar-89	30	0	1	0	0	0	0	0	0	20	0	1	22	2	24
26-Mar-89	1030	0	0	0	0	0	0	0	0	24	0	0	24	0	24
27-Mar-89	100	50	1	0	4	0	0	0	0	63	0	0	118	17	135
27-Mar-89	800	0	0	0	0	0	0	0	0	55	0	0	55	4	59
27-Mar-89	1600	0	1	0	0	0	0	0	0	20	0	0	21	0	21
28-Mar-89	100	0	18	0	1	0	0	0	2	104	0	0	125	8	133
28-Mar-89	800	0	5	0	0	0	0	0	0	62	0	0	67	3	70
28-Mar-89	1600	0	0	0	0	0	0	0	0	0	0	0	11	0	11
29-Mar-89	100	0	3	0	2	0	0	0	1	85	0	0	91	15	106
29-Mar-89	615	0	3	0	0	0	1	0	0	51	0	0	55	4	59
30-Mar-89	100	0	1	49	2	0	0	0	0	17	0	1	70	10	80
30-Mar-89	630	0	0	0	0	0	0	0	0	35	0	0	35	2	37
31-Mar-89	100	0	2	50	6	0	0	0	1	27	0	1	87	8	95
31-Mar-89	630	0	0	0	2	0	0	0	1	35	0	0	38	3	41
01-Apr-89	100	0	1	50	6	0	0	0	0	13	0	0	70	10	80
01-Apr-89	630	0	0	0	6	0	0	0	0	48	0	0	54	1	55
02-Apr-89	100	50	1	0	10	0	0	0	0	10	0	0	71	10	81
02-Apr-89	700	0	0	0	9	0	0	0	0	76	0	0	85	9	94
03-Apr-89	100	0	15	0	11	0	0	0	0	103	0	0	129	11	140
03-Apr-89	600	0	2	0	2	0	0	0	0	76	0	0	80	8	88
04-Apr-89	100	0	8	0	2	0	0	0	1	92	0	0	103	5	108
04-Apr-89	600	0	0	0	1	0	0	0	0	77	0	0	78	3	81
05-Apr-89	100	0	3	0	0	0	0	0	1	110	0	0	114	7	121
05-Apr-89	600	0	2	0	1	0	0	0	0	119	0	1	123	7	130
06-Apr-89	115	0	2	0	6	0	0	0	0	139	0	0	147	9	156
06-Apr-89	700	0	0	0	2	50	0	0	0	101	0	0	153	7	160
07-Apr-89	100	0	0	0	0	0	0	0	0	46	0	0	46	7	53
07-Apr-89	700	0	1	0	0	0	1	0	2	123	0	0	127	7	134
08-Apr-89	30	0	0	0	1	0	0	0	0	55	0	0	56	4	60
08-Apr-89	630	0	0	0	0	0	0	0	0	14	0	0	14	4	18
09-Apr-89	100	0	0	0	0	0	1	0	0	29	0	0	30	8	38
09-Apr-89	630	0	1	0	0	0	0	0	0	17	0	0	18	5	23
10-Apr-89	100	0	3	50	4	0	2	0	0	34	0	0	93	26	119

Appendix I, continued.

1 Date	2 Time	3 Mark LPV	4 Recapture LPV	5 Mark RPV	6 Recapture RPV	7 Mark TC	8 Recapture TC	9 Mark BC	10 Recapture BC	11 No marks	12 Sampled	13 Morts	14 Total wild	15 Total hatchery	16 Total fish
11-Apr-89	2000	0	0	0	1	0	0	0	0	27	0	0	28	2	30
10-Apr-89	630	0	1	0	0	0	0	0	0	54	0	0	55	7	62
11-Apr-89	100	0	0	0	5	0	2	0	0	96	0	0	103	16	119
11-Apr-89	630	0	0	0	8	0	2	0	0	79	0	0	89	25	114
12-Apr-89	100	0	0	0	5	0	2	0	0	82	0	0	89	37	126
12-Apr-89	630	0	1	0	2	0	0	0	0	105	0	0	108	141	249
12-Apr-89	1100	0	0	0	0	0	0	0	0	13	0	0	13	8	21
12-Apr-89	2200	0	0	0	2	0	0	0	0	41	0	0	43	66	109
13-Apr-89	30	0	0	0	1	0	0	0	0	38	0	0	39	121	160
13-Apr-89	800	0	0	0	0	0	0	0	0	0	0	0	0	7	7
13-Apr-89	1200	0	0	0	0	0	0	0	0	3	0	0	3	0	3
13-Apr-89	2330	42	1	0	0	0	0	0	0	6	0	0	50	199	249
14-Apr-89	200	7	1	0	1	0	1	0	0	39	0	0	49	279	328
14-Apr-89	1400	0	1	0	0	0	1	0	0	18	0	0	20	16	36
14-Apr-89	2100	0	3	0	1	0	0	0	0	24	0	0	28	206	234
15-Apr-89	300	0	1	0	0	0	0	0	0	11	0	0	12	310	322
15-Apr-89	730	0	0	0	0	0	0	0	0	5	0	0	5	17	22
15-Apr-89	1600	0	0	0	0	0	0	0	0	6	0	0	6	10	16
15-Apr-89	2100	0	1	0	0	0	0	0	0	6	0	0	7	93	100
16-Apr-89	300	0	0	0	0	0	0	0	0	5	0	0	5	273	278
16-Apr-89	745	0	0	0	0	0	0	0	0	3	0	0	3	23	26
16-Apr-89	1430	0	1	0	1	0	0	0	0	10	0	0	12	8	20
16-Apr-89	2030	0	0	0	0	0	0	0	0	0	0	0	2	11	13
17-Apr-89	200	0	0	0	0	0	0	0	0	0	0	0	0	419	419
17-Apr-89	745	0	0	0	0	0	0	0	0	2	0	0	2	14	16
17-Apr-89	1530	0	0	0	0	0	0	0	0	2	0	0	2	2	4
17-Apr-89	2200	0	0	0	0	0	0	0	0	10	0	0	10	105	115
18-Apr-89	100	0	0	0	0	0	0	0	1	8	0	0	9	78	87
18-Apr-89	930	0	0	0	0	0	0	0	0	3	0	0	3	12	15
18-Apr-89	1530	0	0	0	0	0	1	0	0	2	0	0	3	4	7
18-Apr-89	2300	0	0	0	0	0	0	0	0	2	0	0	2	35	37
19-Apr-89	100	0	0	0	0	0	0	0	0	3	0	0	3	1	4
19-Apr-89	400	0	0	0	0	0	0	0	0	10	0	0	10	105	115
19-Apr-89	1630	0	1	0	0	0	0	0	0	2	0	0	3	1	4
19-Apr-89	2200	0	0	0	0	0	0	0	0	3	0	0	3	18	21
20-Apr-89	100	0	0	0	0	0	0	0	0	10	0	0	10	40	50
20-Apr-89	700	0	0	0	0	0	0	0	0	0	5	0	5	8	13
20-Apr-89	1530	0	0	0	0	0	0	0	0	1	0	0	1	3	4
21-Apr-89	100	0	0	0	0	0	0	0	0	9	0	0	9	42	51
21-Apr-89	715	0	0	0	1	0	0	0	0	11	0	0	12	19	31
21-Apr-89	1300	0	0	0	0	0	0	0	0	6	0	0	6	14	20
21-Apr-89	2200	0	0	0	1	0	0	0	0	4	0	0	5	115	120
21-Apr-89	2345	0	0	0	0	0	0	0	0	5	0	0	5	127	132
22-Apr-89	200	0	0	0	0	0	0	0	0	4	0	0	4	89	93
22-Apr-89	700	0	0	0	0	0	0	0	0	1	0	0	1	9	10
22-Apr-89	1000	0	0	0	0	0	0	0	0	0	0	0	0	1	1
22-Apr-89	1300	0	0	0	0	0	0	0	0	2	0	0	2	1	3
22-Apr-89	2345	0	1	0	0	0	0	0	0	11	0	0	12	85	97

Appendix I, continued.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Date	Time	Mark LPV	Recapture LPV	Mark RPV	Recapture RPV	Mark TC	Recapture TC	Mark BC	Recapture BC	No marks	Sampled	Morts	Total wild	Total hatchery	Total fish
24-Apr-89	300	0	0	0	0	0	1	0	0	18	0	0	19	92	111
23-Apr-89	300	0	0	0	0	0	0	0	0	9	0	0	9	38	47
23-Apr-89	900	0	0	0	0	0	0	0	0	2	0	0	2	2	4
23-Apr-89	1600	0	0	0	1	0	0	0	0	13	0	0	14	3	17
23-Apr-89	2100	0	0	0	0	0	0	0	0	3	0	0	3	6	9
24-Apr-89	10	0	0	0	0	0	0	0	0	25	0	1	25	74	99
24-Apr-89	600	17	0	0	0	0	0	0	0	7	0	0	24	75	99
24-Apr-89	1530	0	0	0	0	0	0	0	0	11	0	2	11	2	13
24-Apr-89	2300	0	0	0	0	0	0	0	1	19	0	9	21	215	236
25-Apr-89	300	0	2	0	0	0	1	0	0	45	0	2	48	121	169
25-Apr-89	600	0	1	0	0	0	0	0	0	25	18	2	35	59	94
25-Apr-89	2300	0	0	0	1	0	0	0	0	79	2	4	84	141	225
26-Apr-89	300	0	0	0	0	0	1	0	0	72	6	1	79	113	192
26-Apr-89	615	0	0	0	0	0	0	0	0	39	2	0	39	47	86
26-Apr-89	2300	0	0	0	0	0	1	0	0	119	0	2	120	88	208
27-Apr-89	300	0	0	0	0	0	0	50	0	62	9	1	122	86	208
27-Apr-89	630	0	0	0	0	0	0	0	0	74	0	0	74	61	135
27-Apr-89	1100	0	0	0	0	0	0	0	0	0	2	0	2	0	2
27-Apr-89	1400	0	0	0	0	0	0	0	0	3	1	2	4	7	11
27-Apr-89	2330	0	0	0	0	0	1	0	0	112	12	5	125	124	249
28-Apr-89	300	0	0	0	0	0	1	0	1	107	0	0	109	88	197
28-Apr-89	630	0	0	0	1	0	0	0	0	56	14	1	72	37	109
28-Apr-89	1230	0	0	0	0	0	0	0	0	2	0	0	2	2	4
28-Apr-89	1530	0	0	0	0	0	0	0	0	1	0	0	1	1	2
28-Apr-89	2330	0	1	0	0	0	1	0	2	148	0	6	152	154	306
29-Apr-89	300	0	0	0	0	0	0	0	0	152	0	0	152	121	273
29-Apr-89	630	0	0	0	0	0	0	0	0	70	0	0	70	41	111
29-Apr-89	1500	0	0	0	0	0	0	0	0	5	0	1	5	2	7
29-Apr-89	2330	0	0	0	0	0	0	0	2	62	0	0	64	60	124
30-Apr-89	300	0	0	0	0	0	1	0	1	145	0	0	147	66	213
30-Apr-89	600	0	0	0	0	0	0	0	2	85	17	0	104	63	167
30-Apr-89	1100	0	0	0	0	0	0	0	0	3	0	0	3	0	3
30-Apr-89	1430	0	0	0	0	0	0	0	1	5	0	1	6	1	7
30-Apr-89	2130	0	0	0	1	0	0	0	0	0	2	0	2	2	4
01-May-89	30	0	0	0	1	0	0	0	0	95	16	0	112	67	179
01-May-89	300	0	0	0	0	0	1	0	0	88	0	0	89	54	143
01-May-89	600	50	0	0	0	0	2	0	0	35	0	0	87	28	115
01-May-89	1430	0	0	0	0	0	0	0	0	2	0	0	2	1	3
01-May-89	2330	0	1	0	0	0	0	0	0	54	0	0	65	35	100
02-May-89	600	0	0	0	0	0	1	0	0	118	0	0	119	38	157
02-May-89	2130	0	0	0	0	0	1	0	0	21	0	0	22	13	35
03-May-89	200	0	0	0	0	0	0	0	1	156	0	0	157	38	195
03-May-89	600	0	0	0	0	0	0	0	1	53	0	0	54	11	65
03-May-89	2300	0	0	0	1	0	0	0	0	17	0	0	18	3	21
04-May-89	100	0	0	0	0	0	0	0	0	75	0	0	75	17	92
04-May-89	630	0	0	0	0	50	0	0	1	88	0	0	139	30	169
04-May-89	2330	0	0	0	0	0	0	0	0	27	0	0	27	15	42
05-May-89	300	0	0	0	0	0	0	0	0	50	0	0	73	45	118

Appendix I, continued.

1 Date	2 Time	3 Mark LPV	4 Recapture LPV	5 Mark RPV	6 Recapture RPV	7 Mark TC	8 Recapture TC	9 Mark BC	10 Recapture BC	11 No marks	12 Sampled	13 Morts	14 Total wild	15 Total hatchery	16 Total fish
05-May-89	630	0	0	0	0	0	0	0	0	65	0	0	65	5	70
05-May-89	2330	0	0	0	0	0	2	0	0	19	0	0	21	9	30
06-May-89	300	0	0	0	0	0	1	0	0	71	0	0	72	16	88
06-May-89	600	0	0	0	0	0	2	0	0	81	0	0	83	25	108
08-May-89	730	0	0	0	1	0	0	0	1	52	0	0	54	35	89
08-May-89	2300	0	1	0	0	0	0	0	0	31	0	0	33	13	46
09-May-89	200	0	0	0	0	0	0	0	0	34	0	0	34	13	47
09-May-89	630	0	0	0	0	0	0	0	1	33	0	0	34	6	40
09-May-89	2300	0	0	32	0	0	1	0	0	0	0	0	33	4	37
10-May-89	300	0	0	17	0	0	1	0	0	15	0	0	34	6	40
10-May-89	630	0	0	0	0	0	0	0	0	22	0	0	22	5	27
10-May-89	1830	0	0	0	0	0	0	0	0	9	0	0	9	7	16
10-May-89	2330	0	0	0	0	0	0	0	0	6	0	0	6	3	9
11-May-89	130	0	0	0	0	0	0	0	0	1	0	0	1	0	1
11-May-89	300	0	0	0	0	0	0	0	0	1	0	0	1	1	2
11-May-89	630	0	0	0	0	0	0	0	0	1	0	0	1	3	4
11-May-89	1100	0	0	0	1	0	0	0	0	3	0	0	4	0	4
11-May-89	2330	0	0	0	3	0	0	0	0	11	0	1	14	6	20
12-May-89	300	0	0	0	0	0	0	0	0	8	0	0	8	3	11
12-May-89	630	0	0	0	1	0	1	0	0	8	0	0	10	4	14
12-May-89	2330	0	0	0	0	0	0	0	0	21	0	0	21	15	36
13-May-89	300	0	0	0	0	0	1	0	0	30	0	0	31	1	32
13-May-89	630	0	0	0	0	0	0	0	0	24	0	0	24	4	28
15-May-89	2330	0	0	0	0	0	0	0	0	10	0	0	10	2	12
16-May-89	300	0	0	0	0	0	0	0	0	13	0	0	13	0	13
16-May-89	700	33	0	0	0	0	0	0	0	1	0	0	34	4	38
16-May-89	2330	0	0	0	0	0	0	0	0	11	0	0	11	1	12
17-May-89	230	0	1	0	0	0	0	0	0	13	0	0	14	3	17
17-May-89	630	0	2	0	0	0	1	0	0	30	0	0	33	4	37
17-May-89	2330	0	0	7	0	0	0	0	1	1	0	0	9	1	10
18-May-89	300	0	2	23	0	0	0	0	0	2	0	0	28	2	30
18-May-89	645	0	1	25	0	0	1	0	0	11	0	0	33	1	34
18-May-89	2330	9	0	0	2	0	0	0	0	1	0	0	12	1	13
19-May-89	300	24	0	0	4	0	0	0	1	2	0	0	31	0	31
19-May-89	630	13	0	0	2	0	0	0	0	3	0	0	18	1	19
19-May-89	2330	0	0	0	0	0	0	0	0	9	0	0	9	1	10
20-May-89	300	0	0	0	0	0	0	0	0	11	0	0	11	2	13
20-May-89	700	0	2	0	1	0	0	0	0	15	0	0	18	2	20
20-May-89	2330	0	0	0	0	0	0	0	0	10	0	0	10	2	12
21-May-89	300	0	1	0	0	0	0	0	0	6	0	0	7	1	8
21-May-89	730	0	0	0	0	0	0	0	0	12	0	0	12	2	14
21-May-89	2100	0	0	0	0	0	0	0	0	5	0	0	5	0	5
22-May-89	700	13	1	0	0	0	0	0	0	0	0	0	14	0	14
23-May-89	300	0	0	0	2	0	0	0	0	19	0	0	21	1	22
23-May-89	600	0	0	0	0	0	0	0	0	5	0	0	5	0	5
23-May-89	2330	17	0	0	0	0	0	0	0	0	0	0	17	0	17
24-May-89	600	18	0	0	0	0	1	0	0	4	0	0	38	1	39
24-May-89	2330	0	2	0	0	0	0	0	0	4	0	0	6	0	6

Appendix 1, continued.

1 Date	2 Time	3 Mark LPV	4 Recapture LPV	5 Mark RPV	6 Recapture RPV	7 Mark TC	8 Recapture TC	9 Mark BC	10 Recapture BC	11 No marks	12 Sampled	13 Morts	14 Total wild	15 Total hatchery	16 Total fish
25-May-89	600	0	16	0	1	0	0	0	0	34	0	0	51	0	51
25-May-89	2300	0	0	0	0	0	0	0	0	1	0	0	1	0	1
26-May-89	600	0	2	0	1	0	0	0	0	17	0	0	20	0	20
26-May-89	2330	0	0	0	0	0	0	0	0	4	0	0	4	0	4
27-May-89	630	0	2	0	0	0	0	0	0	22	0	0	24	0	24
27-May-89	2200	0	0	0	0	0	0	0	0	1	0	0	1	0	1
30-May-89	630	0	0	0	0	0	0	0	0	31	0	0	31	0	31
31-May-89	630	0	0	0	0	0	0	0	0	8	0	0	8	0	8
01-Jun-89	630	0	0	0	0	0	0	0	0	4	0	0	4	0	4
02-Jun-89	600	0	0	0	0	0	0	0	0	2	0	0	2	0	2
03-Jun-89	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04-Jun-89	630	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05-Jun-89	630	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06-Jun-89	630	0	0	0	0	0	0	0	0	1	0	0	1	0	1
07-Jun-89	600	0	0	0	0	0	0	0	0	1	0	0	1	0	1
08-Jun-89	630	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09-Jun-89	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-Jun-89	700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-Jun-89	730	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-Jun-89	630	0	0	0	0	0	0	0	0	7	0	0	7	0	7
13-Jun-89	600	0	0	0	0	0	0	0	0	2	0	1	3	0	3
14-Jun-89	630	0	0	0	0	0	0	0	0	2	0	0	2	0	2
15-Jun-89	600	0	0	0	0	0	0	0	0	3	0	0	3	0	3
16-Jun-89	800	0	0	0	0	0	0	0	0	2	0	0	2	0	2
20-Jun-89	600	0	0	0	0	0	0	0	0	3	0	0	3	0	3
21-Jun-89	600	0	0	0	0	0	0	0	0	4	0	0	4	0	4
22-Jun-89	600	0	0	0	0	0	0	0	0	1	0	0	1	0	1
23-Jun-89	600	0	0	0	0	0	0	0	0	2	0	0	2	0	2
27-Jun-89	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Jun-89	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29-Jun-89	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30-Jun-89	630	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totals		949	273	804	251	100	39	100	27	6800	154	60	9573	6233	15806

APPENDIX J

Incidental species caught in the Tucannon River downstream migrant trap during 1988/1989 season, with an indication of relative abundance.

Species	Oct- Nov	Dec- Feb	Mar- Jun
River lamprey *(Lampetra richardsoni)*	rare	common	rare
Bull trout *(Salvelinus confluentus)*	none	none	none
Longnose dace *(Rhinichthys cataractae)*	common	common	common
Speckled dace *(Rhinichthys osculus)*	rare	common	common
Redside shiner *(Richardsonius balteatus)*	common	common	common
Northern squawfish *(Ptychocheilus oregonensis)*	rare	rare	rare
Peamouth *(Mylocheilus caurinus)*	rare	rare	rare
Bridgelip sucker *(Catostomus columbianus)*	rare	rare	rare
Pumpkinseed *(Lepomis gibbosus)*	none	none	none
Smallmouth bass *(Micropterus dolomieui)*	none	none	none
Margined sculpin *(Cottus marginatus)*	none	none	rare

APPENDIX K

Table 1. Relative contribution of each food item to the fish's diet in the Wilderness Stratum.

Organism	Mean Number	% by Number	Weight (mg)	% by Number	Frequency of Occurs.	IRI
<u>Spring chinook salmon</u>						
Elmidae pupa	65	46.1	16.1	27.5	90.1	50.1
Ephemerellidae	27	19.2	14.9	25.5	75.0	9.0
Perlodidae	12	8.5	4.6	7.9	33.3	9.8
Chironomidae	7	5.0	0.7	1.2	19.4	6.0
Baetidae	8	5.7	0.6	1.0	22.2	5.7
Simulidae	5	3.6	0.3	0.5	13.9	3.5
Nematoda	5	3.6	0.9	1.5	13.9	3.7
Elmidae adult	2	1.4	0.4	0.7	5.6	1.5
Glossosomatidae adult	2	1.4	2.9	5.0	5.6	2.4
Chloroperlidae	2	1.4	0.1	0.2	5.6	1.4
Helicopsychidae	1	0.7	3.0	5.1	2.8	1.7
Hydroptilidae	1	0.7	2.2	3.8	2.8	0.5
Limnephilidae	1	0.7	0.3	0.5	2.8	0.8
Glossosomatidae pupa	1	0.7	1.4	2.4	2.8	1.2
Chironomidae adult	1	0.7	0.1	0.2	2.8	0.7
Lumbriculidae	1	0.7	3.7	6.3	2.8	1.9
Other			6.3	10.8		
<u>Steelhead</u>						
Baetidae	57	54.8	9.9	42.3	76.1	52.9
Chironomidae	12	11.5	0.4	1.7	33.3	9.6
Nematoda	7	6.7	0.6	2.6	19.4	6.0
Simulidae	3	2.9	3.7	15.8	8.3	5.6
Chloroperlidae	6	5.8	1.2	5.1	16.7	5.7
Ephemerellidae	5	4.8	1.4	6.0	13.9	5.0
Heptageniidae	5	4.8	0.3	1.3	13.9	4.0
Perlodidae	2	1.9	1.3	5.6	5.6	2.7
Chironomidae pupa	2	1.9	1.0	4.3	5.6	2.4
Hydropsychidae	2	1.9	0.3	1.3	5.6	2.2
Glossosomatidae pupa	1	1.0	1.4	6.0	2.8	2.0
Elmidae pupa	1	1.0	0.2	0.9	2.8	1.0
Pteronarcyidae	1	1.0	0.2	0.9	2.8	1.0

Appendix K, continued.

Table 2. Procedures and data used in the computation of the diet overlap between spring chinook salmon and steelhead: Wilderness Stratum.

Prey item	Chinook salmon		Steelhead		
	(Px_i)	$(Px_i)^2$	(Py_i)	$(Py_i)^2$	$Px_i \times Py_i$
Chironomidae	0.115	0.0132	0.050	0.0025	0.0058
Chironomidae pupa	0.019	0.0004	0.007	0.0000	0.0001
Simulidae	0.029	0.0008	0.035	0.0120	0.0010
Glossosomatidae	0.010	0.0001	0.007	0.0000	0.0000
Glossosomatidae pupa	0.000	0.0000	0.014	0.0002	0.0001
Hydropsychidae	0.019	0.0004	0.000	0.0000	0.0000
Limnephilidae	0.000	0.0000	0.007	0.0000	0.0000
Helicopsychidae	0.000	0.0000	0.007	0.0000	0.0000
Chloroperlidae	0.058	0.0034	0.014	0.0002	0.0008
Perlodidae	0.019	0.0004	0.085	0.0072	0.0016
Pteronarcydae	0.010	0.0001	0.000	0.0000	0.0000
Heptageniidae	0.048	0.0023	0.000	0.0000	0.0000
Baetidae	0.548	0.3003	0.057	0.0032	0.0312
Elmidae pupa	0.000	0.0000	0.461	0.2125	0.0000
Elmidae adult	0.010	0.0001	0.014	0.0002	0.0001
Lumbriculidae	0.000	0.0000	0.007	0.0001	0.0000
Nematoda	0.067	0.0045	0.035	0.0012	0.0024
Totals:		0.3259		0.2288	0.0432

$$C_x = \frac{2 \times 0.0432}{0.3259 + 0.2288}$$

$$C_x = 0.1557$$

Appendix K, continued.

Table 3. Relative contribution of each food item to the fish's diet for the HMA Stratum.

Organism	Mean number	% by number	Weight (mg)	% by weight	Frequency of occurrence	IRI
Spring chinook salmon						
Lumbriculidae	40	40.8	75.6	50.9	54.0	47.7
Simulidae	15	15.3	1.1	0.7	40.5	10.2
Hydropsychidae	11	11.2	1.7	1.7	1.1	10.0
Ephemerellidae	10	10.2	7.4	5.0	27.0	10.3
Chironomidae	7	7.1	0.3	0.2	18.9	8.0
Naedidae	8	40.8	5.2	3.5	21.6	7.9
Elmidae adult	2	2.0	0.6	0.4	5.4	1.9
Tipulidae	1	1.0	0.1	0.1	2.7	0.9
Limnephilidae	1	1.0	0.1	0.1	2.7	0.9
Perlodidae	1	1.0	0.1	0.1	2.7	0.9
Baetidae	1	1.0	0.1	0.1	2.7	0.9
Brachycentridae	1	1.0	0.3	0.2	2.7	0.4
Steelhead						
Elmidae pupa	88	48.9	99.0	48.6	98.0	50.4
Limnephilidae	18	10.0	6.2	3.0	52.9	9.5
Ephemerellidae	15	8.3	5.8	2.8	44.1	8.0
Rhyacophilidae	14	7.8	13.0	0.7	41.2	7.2
Lumbriculidae	5	2.8	18.4	9.0	14.7	3.8
Simulidae	10	5.6	7.1	3.5	29.4	5.6
Chironomidae	9	0.1	5.0	0.3	26.5	3.9
Lepdiostomatidae	4	2.2	6.8	3.3	11.8	2.5
Brachycentridae	5	2.8	0.2	0.1	14.7	2.5
Elmidae adult	4	2.2	1.3	0.6	11.8	2.1
Naedidae	3	1.7	1.9	0.9	8.8	1.7
Helicopsychidae	1	0.6	2.5	1.3	2.9	0.7
Nematoda	1	0.6	0.1	0.1	2.9	0.5
Glossosomatidae	1	0.6	0.3	0.2	2.9	0.5
Tipulidae	1	0.6	0.1	0.1	2.9	0.5
Leptoceridae	1	0.6	0.1	0.1	2.9	0.5
Other			52.3	25.7		

Appendix K, continued.

Table 4. Procedures and data used in the computation of the diet overlap between spring chinook salmon and steelhead: HMA Stratum.

Prey Item	Chinook Salmon (Px_i)	Chinook Salmon $(Px_i)^2$	Steelhead (Py_i)	Steelhead $(Py_i)^2$	$Px_i \times Py_i$
Chironomidae	0.071	0.0050	0.050	0.0025	0.0036
Tipulidae	0.010	0.0001	0.006	0.0001	0.0001
Simulidae	0.153	0.0234	0.056	0.0031	0.0086
Glossosomatidae	0.000	0.0000	0.006	0.0001	0.0000
Brachycentridae	0.010	0.0001	0.028	0.0008	0.0003
Hydropsychidae	0.112	0.0125	0.000	0.0000	0.0000
Limnephilidae	0.001	0.0000	0.100	0.0100	0.0000
Rhyacophilidae	0.000	0.0000	0.078	0.0061	0.0001
Lepidostomatidae	0.000	0.0000	0.022	0.0005	0.0000
Helicopsychidae	0.000	0.0000	0.006	0.0001	0.0000
Perlodidae	0.010	0.0001	0.000	0.0000	0.0008
Ephemerellidae	0.010	0.0001	0.083	0.0069	0.0000
Baetidae	0.010	0.0001	0.000	0.0000	0.0000
Leptoceridae	0.000	0.0000	0.006	0.0001	0.0000
Elmidae pupa	0.000	0.0000	0.489	0.2391	0.0000
Elmidae adult	0.020	0.0004	0.022	0.0005	0.0004
Lumbriculidae	0.408	0.1665	0.028	0.0008	0.0114
Naedidae	0.082	0.0067	0.017	0.0003	0.0014
Nematoda	0.000	0.0000	0.006	0.0000	0.0000
TOTALS:		0.2151		0.2707	0.0266

$$C_x = \frac{2 \times 0.0266}{0.2151 + 0.2707}$$

$$C_x = 0.1097$$

Appendix K, continued.

Table 5. Relative contribution of each food item to the fish's diet for the Hartsock Stratum.

Organism	Mean number	% by number	Weight (mg)	% by weight	Frequency of occurrence	IRI
<u>Spring chinook salmon</u>						
Nematoda	27	12.4	0.9	1.1	75.0	2.0
Lumbriculidae	22	10.1	35.1	42.7	61.1	9.4
Chironomidae	37	17.1	3.9	4.8	81.0	17.9
Ephemerellidae	19	8.8	5.9	0.6	52.8	8.6
Elmidae pupa	23	10.6	4.0	4.9	63.9	11.0
Naedidae	19	8.8	5.3	6.5	52.8	9.4
Chironomidae pupa	37	17.1	3.9	4.8	81.0	17.9
Simulidae	15	6.9	4.8	5.8	41.7	7.5
Hydropsychidae	11	5.1	0.8	1.0	30.6	5.1
Sciomyzidae	9	4.2	1.9	2.3	25.0	4.9
Ephemeriidae	19	8.8	5.9	0.6	52.8	8.6
Tabanidae	5	2.3	1.2	1.5	13.9	2.5
Chloroperlidae	3	1.4	1.6	2.0	8.3	1.6
Glossosomatidae adult	2	0.9	3.0	3.7	56.0	1.4
Glossosomatidae pupa	1	0.5	1.7	2.1	2.8	0.7
Heptageniidae	1	0.5	0.1	0.1	2.8	0.5
<u>Steelhead</u>						
Elmidae	29	35.8	3.8	12.8	80.6	31.9
Chironomidae	12	14.8	0.2	0.7	33.3	12.1
Ephemerellidae	9	11.1	1.3	4.4	25.0	10.0
Ephemerellidae adult	1	1.2	4.3	14.5	2.8	4.6
Lepidostomatidae	5	6.2	2.7	9.1	13.9	7.2
Lumbriculidae	5	6.2	2.1	7.1	13.9	6.7
Hydropsychidae	4	4.9	1.8	6.1	11.1	5.5
Chloroperlodidae	1	1.2	3.7	12.5	2.8	4.1
Nematoda	4	5.0	0.1	0.4	11.1	4.1
Glossosomatidae pupa	3	3.7	2.6	8.8	8.3	5.1
Chironomidae pupa	3	3.7	0.7	2.4	8.3	3.6
Perlodidae adult	2	2.5	0.1	0.4	5.6	2.1
Sciomyzidae	2	2.5	0.1	0.4	5.6	2.1
Helicopsychidae	1	1.2	1.5	0.4	2.8	1.1

Appendix K, continued.

Table 6. Procedures and data used in the computation of the diet overlap between spring chinook salmon and steelhead: Hartsock Stratum.

Prey item	Chinook salmon (Px_i)	Chinook salmon $(Px_i)^2$	Steelhead (Py_i)	Steelhead $(Py_i)^2$	$Px_i \times Py_i$
Chironomidae	0.171	0.0292	0.118	0.0139	0.0202
Simulidae	0.069	0.0048	0.000	0.0000	0.0000
Tabanidae	0.023	0.0005	0.000	0.0000	0.0000
Sciomyzidae	0.041	0.0017	0.000	0.0000	0.0000
Glossosomatidae	0.009	0.0001	0.000	0.0000	0.0000
Glossosomatidae pupa	0.005	0.0001	0.000	0.0000	0.0000
Hydropsychidae	0.051	0.0026	0.118	0.0139	0.0060
Leptostomatidae	0.000	0.0000	0.156	0.0243	0.0000
Chloroperlidae	0.014	0.0002	0.000	0.0000	0.0000
Heptageniidae	0.005	0.0001	0.000	0.0000	0.0000
Ephemeriidae	0.032	0.0010	0.000	0.0000	0.0000
Ephemerellidae	0.088	0.0077	0.250	0.0625	0.0220
Elmidae pupa	0.106	0.0112	0.375	0.1406	0.0398
Lumbriculidae	0.101	0.0102	0.031	0.0010	0.0031
Naedidae	0.088	0.0077	0.000	0.0000	0.0000
Nematoda	0.124	0.0154	0.000	0.0000	0.0000
TOTALS:		0.0925		0.2563	0.0911

$$C_x = \frac{2 \times 0.0911}{0.0925 + 0.2563}$$

$$C_x = 0.5522$$

Appendix K, continued.

Table 7. June drift invertebrate densities reported in 100 square meter area and percent composition in the environment.

Organism	Total	100 m^2	Percent composition	Weight (mg)	% by weight
Lower Hartsock Stratum					
Simulidae	2	3.3	28	0.1	2.0
Glossosomatidae pupa	1	1.7	15	4.6	77.0
Baetidae	1	1.7	15	1.0	17.0
Ephemerellidae	2	3.3	28	0.1	2.0
Spheridae	1	1.7	15	0.1	2.0
Hartsock Stratum					
Simulidae	8	10.7	47	0.9	45.0
Glossosomatidae pupa	1	1.3	4	0.7	35.0
Perlodidae	1	1.3	4	0.1	5.0
Baetidae	1	1.3	4	0.1	5.0
Elmidae pupa	5	6.7	30	0.1	5.0
Naedidae	1	1.3	4	0.1	5.0
HMA Stratum					
Simulidae	1	0.7	2	0.1	0.4
Brachycentridae	3	2	6	1.9	8.0
Glossosomatidae pupa	1	0.7	2	1.1	5.0
Glossosomatidae	1	0.7	2	0.1	0.4
Baetidae	3	2	6	0.1	0.4
Ephemerellidae	2	1.3	4	0.1	0.4
Elmidae pupa	41	27.0	76	9.4	40.0
Elmidae adult	1	0.7	2	0.1	0.4
Lumbriculidae	1	0.7	2	10.5	45.0
Wilderness Stratum					
Chironomidae	4	4.7	17	0.1	12.5
Simulidae	1	1.2	4	0.1	12.5
Brachycentridae	2	2.3	8	0.1	12.5
Perlodidae	2	2.3	8	0.1	12.5
Baetidae	12	14.0	50	0.1	12.5
Ephemerellidae	1	1.2	4	0.1	12.5
Elmidae adult	1	1.2	4	0.1	12.5
Hydracarina	1	1.2	4	0.1	12.5

Appendix K, continued.

Table 8. July drift invertebrate densities reported in 100 square meters and percent composition in the environment.

Organism	Total	100m²	Percent composition	Weight (mg)	% by weight
<u>Lower Hartsock Stratum</u>					
Chironomidae	2	2.2	22	0.6	19.0
Simulidae	1	1.1	11	0.7	22.0
Perlodidae	1	1.1	11	0.1	3.0
Baetidae	1	1.1	11	0.1	3.0
Elmidae pupa	1	1.1	11	0.1	3.0
Elmidae adult	1	1.1	11	1.2	39.0
Hydracarina	2	2.2	22	0.3	10.0
<u>Hartsock Stratum</u>					
Chironomidae	4	4.8	24	0.6	43.0
Tipulidae	1	1.2	6	0.5	36.0
Simulidae	5	6.0	29	0.1	7.0
Perlodidae	5	6.0	29	0.1	7.0
Heptageniidae	2	2.4	12	0.1	7.0
<u>HMA Stratum</u>					
Chironomidae	2	2.7	66	0.2	66.0
Baetidae	1	1.4	33	0.1	33.0
<u>Wilderness Stratum</u>					
Chironomidae	2	0.02	3	0.1	0.5
Tipulidae	4	0.04	7	0.8	4.0
Simulidae	3	0.03	5	0.1	4.0
Sciomyzidae	4	0.04	7	0.8	4.0
Brachycentridae	3	0.03	5	4.1	21.0
Glossosomatidae pupa	1	0.01	2	2.1	11.0
Pteronarcydae	2	0.02	3	5.7	30.0
Perlodidae	3	0.03	5	0.4	2.0
Chloroperlidae	1	0.01	2	0.1	0.5
Baetidae	18	0.18	30	2.6	14.0
Ephemerellidae	2	0.02	3	2.2	12.0
Heptageniidae	8	0.08	13	0.1	0.5
Elmidae pupa	7	0.07	11	0.1	0.5
Naedidae	1	0.01	2	0.4	2.0
Nematoda	2	0.02	3	0.1	0.5

Appendix K, continued.

Table 9. August drift invertebrate densities reported in 100 square meters along with percent composition.

Organism	Total	100 m^2	Percent composition	Weight (mg)	% by weight
Lower Hartsock Stratum					
Simulidae	3	2.5	20	0.4	14.0
Hydropsychidae	1	0.8	7	0.1	4.0
Brachycentridae	1	0.8	7	1.8	66.0
Perlodidae	1	0.8	7	0.1	4.0
Ephemerellidae	1	0.8	7	0.1	4.0
Hydracarina	5	4.1	33	0.1	4.0
Spheridae	3	2.5	20	0.1	4.0
Hartsock Stratum					
Chironomidae pupa	1	1	4	0.1	1.0
Simulidae	5	5.2	23	0.1	1.0
Sciomyzidae	1	1	4	0.6	8.0
Brachycentridae	3	3	13	0.1	1.0
Glossosomatidae	1	1	4	0.1	1.0
Elmidae pupa	3	3	13	0.1	1.0
Elmidae adult	1	1	4	0.2	3.0
Hydracarina	5	5.2	23	6.2	82.0
Spheridae	2	2.1	10	0.1	1.0
HMA Stratum					
Chironomidae	1	10	10	0.1	3.0
Simulidae	3	30	30	0.4	11.0
Brachycentridae	2	20	20	0.1	3.0
Glossosomatidae	1	10	10	0.1	3.0
Baetidae	1	10	10	1.9	50.0
Elmidae pupa	1	10	10	1.1	29.0
Hydracarina	1	10	10	0.1	3.0
Wilderness Stratum					
Chironomidae	4	4.9	24	0.3	5.0
Brachycentridae	1	1.2	6	0.1	2.0
Perlodidae	10	12.2	59	2.6	46.0
Elmidae adult	2	2.4	12	2.7	47.0

Appendix K, continued.

Table 10. September drift invertebrate densities reported in 100 square meters and percent composition.

Organism	Total	100 m²	Percent composition	Weight (mg)	% by weight
Lower Hartsock Stratum					
Simulidae	3	2.5	20	0.4	14.0
Hydropsychidae	1	0.8	7	0.1	4.0
Brachycentridae	1	0.8	7	1.8	66.0
Perlodidae	1	0.8	7	0.1	4.0
Ephemerellidae	1	0.8	7	0.1	4.0
Hydracarina	5	4.1	33	0.1	4.0
Spheridae	3	2.5	20	0.1	4.0
Hartsock Stratum					
Chironomidae pupa	1	1	4	0.1	1.0
Simulidae	5	5.2	23	0.1	1.0
Sciomyzidae	1	1	4	0.6	8.0
Brachycentridae	3	3	13	0.1	1.0
Glossosomatidae	1	1	4	0.1	1.0
Elmidae pupa	3	3	13	0.1	1.0
Elmidae adult	1	1	4	0.2	3.0
Hydracarina	5	5.2	23	6.2	82.0
Spheridae	2	2.1	10	0.1	1.0
HMA Stratum					
Chironomidae	1	10	10	0.1	3.0
Simulidae	3	30	30	0.4	11.0
Brachycentridae	2	20	20	0.1	3.0
Glossosomatidae	1	10	10	0.1	3.0
Baetidae	1	10	10	1.9	50.0
Elmidae pupa	1	10	10	1.1	29.0
Hydracarina	1	10	10	0.1	3.0
Wilderness Stratum					
Chironomidae	4	4.9	24	0.3	5.0
Brachycentridae	1	1.2	6	0.1	2.0
Perlodidae	10	12.2	59	2.6	46.0
Elmidae adult	2	2.4	12	2.7	47.0

Appendix K, continued.

Table 11. Invertebrate abundance in the Wilderness, HMA, and Hartsock Strata, Tucannon River, Washington in summer 1989.

Stratum Preferred prey	Invertebrate/m² (stan. dev)	Riffle habitat (m²)	Mean stratum abundance
Wilderness Stratum			
Elmidae	88 (31)	61,595	5,400,000
Ephemerellidae	32 (14)		1,900,000
Perlodidae	106 (11)		6,500,000
Baetidae	298 (166)		18,000,000
Chironomidae	680 (368)		42,000,000
Nematoda	80 (0)		4,900,000
Simulidae	40 (56)		2,500,000
HMA Stratum			
Elmidae pupa	278 (71)	249,730	34,000,000
Limnephilidae	12 (11)		1,400,000
Rhyacophilidae	2 (2)		240,000
Lumbriculidae	250 (212)		31,000,000
Simulidae	35 (41)		4,400,000
Hydropsychidae	170 (155)		21,000,000
Ephemerellidae	130 (99)		16,000,000
Hartsock Stratum			
Elmidae pupa	168 (33)	124,865	20,000,000
Nematoda	133 (150)		16,000,000
Lumbriculidae	347 (75)		45,000,000
Chironomidae	1310 (551)		116,000,000
Ephemerellidae	230 (99)		29,000,000
Ephemerellidae adult	23 (16)		2,800,000

Appendix K, continued.

Table 12. Digestive rates and daily meal of preferred prey and the estimated daily consumption of spring chinook salmon population.

Part 1. Digestive rates of predominant prey items (Elliot 1972).

Food Item	7.7°C	10.6°C	11.8°C
Mayflies and Midges	35 Hrs.	30 Hrs.	24 Hrs.
Caddisflies	45 Hrs.	35 Hrs.	30 Hrs.
Lumbriculidae/Nematoda	24 Hrs.	15 Hrs.	10 Hrs.

Part 2. Daily meal and total consumption by the salmon population.

Stratum Prey item	Daily meal	Salmon population	Invertebrate consumption
Wilderness Stratum			
Elmidae pupa	13.2	4,600	60,700
Ephemerellidae	0.5		2,300
Perlodidae	0.1		500
Chironomidae	1.5		6,900
HMA Stratum			
Lumbriculidae	118.0	44,900	5,200,000
Chironomidae	2.0		89,000
Ephemerellidae	3.2		114,000
Simulidae	0.7		3,300
Hydropsychidae	0.4		1,900
Hartsock Stratum			
Nematoda	0.3	20,200	6,100
Lumbriculidae	6.0		121,200
Chironomidae	1.2		24,200
Ephemerellidae	0.1		2,000

Table 13. Daily meal of preferred prey and the estimated total consumption of steelhead population.

Stratum Prey item	Daily meal	Steelhead population	Invertebrate consumption
Wilderness Stratum			
Baetidae	10.7	7,400	79,200
Chironomidae	0.1		700
Nematoda	0.1		700
Simulidae	1.4		10,400
HMA Stratum			
Rhyacophilidae	4.0	90,300	361,400
Elmidae pupa	84.0		7,589,400
Chironomidae	0.8		72,300
Ephemerellidae	1.0		90,400
Limnephilidae	2.5		225,900
Hartsock Stratum			
Elmidae pupa	4.9	17,800	87,400
Chironomidae	0.4		7,100
Ephemerellidae	2.3		41,000
Ephemerellidae adult	0.1		1,800

Appendix K, continued.

Table 14. Ranking of preferred food items for spring chinook salmon and steelhead. The prey items were ranked for each method used and given 3 points for first, 2 points for second, and 1 point for third.

Spring Chinook Salmon

Wilderness Stratum

Rank	% Occurrence	% Number	% Weight	Electivity Index
1	Elmidae pupa	Elmidae pupa	Elmidae pupa	Chironomidae
2	Ephemerellidae	Ephemerellidae	Ephemerellidae	Ephemerellidae
3	Perlodidae	Perlodidae	Perlodidae	Simulidae
				(tie) Nematoda

Food Items	Points	Rank
Elmidae pupa	9	1
Ephemerellidae	7	2
Perlodidae	5	3
Chironomidae	3	4

HMA Stratum

Rank	% Occurrence	% Number	% Weight	Electivity Index
1	Lumbriculidae	Lumbriculidae	Lumbriculidae	Lumbriculidae
2	Simulidae	Simulidae	Ephemerellidae	Simulidae
3	Hydropsychidae	Hydropsychidae	Hydropsychidae	Hydropsychidae (tie) Ephemerellidae

Food Items	Points	Rank
Lumbriculidae	12	1
Simulidae	6	2
Hydropsychidae	4	3.
Ephemerellidae	3	4

Hartsock Stratum

Rank	% Occurrence	% Number	% Weight	Electivity Index
1	Nematoda	Chironomidae	Lumbriculidae	Nematoda
2	Elmidae pupa	Nematoda	Ephemerellidae	Chironomidae
3	Lumbriculidae	Lumbriculidae	Naedidae	Ephemerellidae
				(tie) Lumbriculidae
				(tie) Hydropsychidae

Food items	Points	Rank
Nematoda	8	1
Lumbriculidae	6	2
Chironomidae	5	3
Ephemerellidae	3	4

Appendix K, Table 14, continued.

Steelhead

Wilderness Stratum

Rank	% Occurrence	% Number	% Weight	Electivity Index
1	Baetidae	Baetidae	Baetidae	Baetidae
2	Chironomidae	Chironomidae	Simulidae	Nematoda
3	Nematoda	Nematoda	Ephemerellidae (tie) Glossosomatidae adult	Simulidae

Food Item	Points	Rank
Baetidae	11	1
Chironomidae	4	2 (tie)
Nematoda	4	2 (tie)
Simulidae	3	3

HMA Stratum

Rank	% Occurrence	% Number	% Weight	Electivity Index
1	Elmidae pupa	Elmidae pupa	Elmidaepupa	Limnephilidae
2	Limnephilidae	Ephemerellidae	Lumbriculidae	Elmidae pupa
3	Ephemerellidae	Rhyacophilidae	Simulidae	Rhyacophilidae

Food Item	Points	Rank
Elmidae pupa	11	1
Limnephilidae	5	2
Ephemerellidae	3	3
Rhyacophilidae	2	4 (tie)
Lumbriculidae	2	4 (tie)

Hartsock Stratum

Rank	% Occurrence	% Number	% Weight	Electivity Index
1	Elmidae pupa	Elmidae pupa	Ephemerellidae adult	Elmidae pupa
2	Chironomidae	Chironomidae	Elmidae pupa	Ephemerellidae
3	Ephemerellidae	Ephemerellidae	Chloroperlidae	Lepidostomatidae

Food Items	Points	Rank
Elmidae pupa	11	1
Chironomidae	4	2 (tie)
Ephemerellidae	4	3 (tie)
Ephemerellidae adult	3	4

Appendix K, continued.

Table 15. Instantaneous consumption values for spring chinook salmon in the Tucannon River, Washington in summer 1989.

Stratum Organism	Mean number	Salmon population	Invertebrate consumption
Wilderness Stratum			
Elmidae pupa	1.81	4,600	8,326
Ephemerellidae	0.75		3,450
Perlodidae	0.33		1,533
Chironomidae	0.19		894
HMA Stratum			
Lumbriculidae	1.11	44,900	49,889
Chironomidae	0.19		8,531
Ephemerellidae	0.28		13,611
Simulidae	0.45		20,205
Hydropsychidae	0.31		13,719
Hartsock Stratum			
Nematode	0.75	20,200	15,150
Lumbriculidae	0.61		12,322
Chironomidae	1.03		20,806
Ephemerellidae	0.53		10,706

Table 16. Instantaneous consumption values for steelhead in the Tucannon River, Washington in summer 1989.

Stratum Organism	Mean number	Steelhead population	Invertebrate consumption
Wilderness Stratum			
Elmidae	0.03	7,400	222
Chironomidae	0.33		2,442
Ephemerellidae	0.14		1,036
HMA stratum			
Rhyacophilidae	0.39	90,350	35,236
Elmidae pupa	2.44		220,454
Chironomidae	0.25		22,588
Ephemerellidae	0.42		37,947
Limnephilidae	0.50		45,175
Hartsock Stratum			
Elmidae pupa	0.81	17,828	14,441
Chironomidae	0.33		5,883
Ephemerellidae	0.25		4,457
Ephemerellidae adult	0.03		495