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TUCANNON RIVER SPRING CHINOOK SALMON HATCHERY EVALUATION PROGRAM

1992 ANNUAL REPORT

LOWER SNAKE RIVER
COMPENSATION PLAN
Hatchery Program

Washington Department of Fisheries
Salmon Culture Division

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TUCANNON RIVER SPRING CHINOOK SALMON HATCHERY EVALUATION PROGRAM

1992 ANNUAL REPORT

by

Glen Mendel
Joseph Bumgarner
Kristine Petersen
Robert Bugert
Lance Ross
Deborah Milks
Jerry Dedloff
James B. Shaklee
Curtis Knutson

Washington Department of Fisheries
P.O. Box 43154
Olympia, Washington 98504-3154

to

U.S. Fish and Wildlife Service
Lower Snake River Compensation Plan Office
4696 Overland Road, Room 560
Boise, Idaho 83702

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ABSTRACT

This report summarizes activities of the Washington Department of Fisheries' Lower Snake River Hatchery Evaluation Program from 1 April 1992 to 31 March 1993. This work was funded by the U. S. Fish and Wildlife Service under the Lower Snake River Fish and Wildlife Compensation Plan (LSRCP). In this report we describe the Spring Chinook Salmon Program at Lyons Ferry and Tucannon Fish Hatcheries (FH). Mandated adult return objective to the Snake River is 1,152 adult spring chinook salmon, Tucannon River stock.

Spring chinook salmon escapement to the Tucannon River weir, located at the Tucannon FH, was 547 salmon. We collected 50 hatchery and 47 wild salmon for broodstock at Tucannon FH. Prespawning mortalities of salmon collected for broodstock decreased substantially this year apparently because we held fish at Lyons Ferry FH prior to spawning. Only two hatchery males and four wild females died in the raceways at Lyons Ferry FH prior to spawning. Jaundice caused by toxic reaction to Erythromycin appears to the cause of death in three of the four females. Peak of spawning at Lyons Ferry FH was 8 September for both hatchery and wild fish which coincided well with natural spawning in the river. Forty-five females were spawned; 27 hatchery and 18 wild. Eggtake totaled 156,359 eggs; 86,983 from hatchery females, and 69,376 from wild females. Mortality prior to hatching was 2,765 eggs (1.8% of total) for a total of 153,594 fry that hatched. We continued to build a sperm bank using cryopreservation techniques. Semen from nine males were frozen for future use.

Tucannon FH released 85,797 yearling salmon (1990 Brood) to volitionally emigrate from the acclimation pond from 30 March to 10 April 1991. Mean fork length (with coefficient of variation) and total poundage of released smolts were 140.7 mm (8.5) and 7,798 lbs, respectively. Egg-to-smolt survival was 58.1% for the 1990 brood. Tucannon FH released 74,058 yearling salmon (1991 Brood) to volitionally emigrate from the acclimation pond from 6-12 April 1992. Egg-to-smolt survival was 81.1% for the 1991 brood.

Nine thermographs were stationed throughout the Tucannon River to measure daily minimum and maximum water temperatures. Periodic stream discharge measurements were taken at the smolt trap (RK 21) and at other locations within the Tucannon River basin.

Evaluation staff conducted salmon parr production surveys using snorkel and electrofishing techniques. We estimate there were 56,000 to 58,000 subyearling and 3,000 to 7,000 yearling chinook salmon in the Tucannon River in 1992. We operated a downstream migrant trap intermittently from 20 November 1991 to 4

June 1992. We trapped 3,837 wild and 974 hatchery spring chinook salmon smolts during this period. Based on mean monthly trap efficiency estimates, we estimate 49,481 wild juvenile spring chinook salmon emigrated from the Tucannon River during the 1991/1992 season. Trapping was limited to mid-winter during the 1992/1993 smolt trapping season because of a delay in receiving our Section 10 Permit. We therefore cannot make a population estimate on migrating smolts from the Tucannon River from 1992/1993.

Radio transmitters were inserted into 29 salmon (15 hatchery and 13 wild) collected and released upstream of the Tucannon FH weir. Fifteen of the 29 radio tagged salmon died prior to spawning. Five tags were regurgitated within a few days of tagging. Five tags apparently quit working during the season, and only four of the 29 radio tagged salmon were verified to have spawned. Circumstantial evidence indicates that seven radio tagged fish may have been poached. Radio tagged salmon generally held in pools or runs that had undercut banks or woody debris. We observed one radio tagged male spawning with multiple females. Evaluation staff also tracked 15 spring chinook that were radio tagged by the University of Idaho at Ice Harbor Dam. Seven of these tags were found without a carcass. Four of the 15 radio tagged salmon were confirmed prespawning mortalities. Three of the 15 salmon survived into the spawning season. One tag was located in a deep pool and never recovered.

Prespawning mortality in the river was substantially higher than we observed during previous years. Eighty one salmon carcasses were recovered prior to spawning season. Fifty-four of the 81 prespawning mortalities were hatchery salmon. Sixty-seven percent of the prespawning mortalities were females (50% of all prespawning mortalities were hatchery females).

Program staff surveyed spawning grounds from August to October. A total of 200 spring chinook salmon redds were counted in the Tucannon River in 1992. Forty-six hatchery and 82 wild salmon carcasses were recovered during spawning ground surveys. Spawning ground surveys were also conducted on Asotin Creek (tributary of the Snake River), and Butte Creek (tributary of the Wenaha River).

We calculated (or revised) our adult escapement estimates to the river for 1985-1992 to account for salmon spawning downstream of the weir. We estimate 784 salmon escaped to the Tucannon River in 1992. Four of 97 CWT were recovered from stray spring chinook salmon in 1992. Expanded smolt-to-adult survival of 1987 brood hatchery salmon is estimated to be 0.16%, with 0.38% survival estimated for wild salmon. This estimate does not include 1992 sport and commercial catch (data were not available for this report). Expanded smolt-to-adult survival of 1988 brood hatchery and wild salmon through age 4 is estimated at 0.36% and

0.77%, respectively. Smolt-to-adult survival estimates for 1987 and 1988 brood (incomplete) hatchery and wild salmon are below the LSRCP design objective of 0.87%. Survival rates from egg-to-fry, egg-to-smolt, and egg-to-returning adult is much higher for hatchery salmon than wild salmon.

Stock profile analyses of wild and hatchery spring chinook salmon was continued. Average fecundity of wild and hatchery females spawned for broodstock was 3,854 and 3,295 eggs, respectively. Sex ratio of wild and hatchery salmon in the Tucannon River was 0.82, and 1.8 females per male, respectively. Eighty-six percent of all fish sampled (wild and hatchery) were classified as age 4.

Tissue samples from collections were analyzed by the WDF Genetics Unit to investigate temporal patterns of allele frequencies, and determine if significant changes in gene frequency are occurring. As a group, allele frequencies for hatchery fish are basically similar to those of their wild counterparts.

Meristic analyses of samples collected in 1985-1989 are provided. No significant differences were detected in mean total counts of paired meristic traits for either wild or hatchery salmon. Differences in pectoral or pelvic fin counts in wild salmon were not detected. A significant difference in pectoral fin counts was detected among the 1986 to 1989 brood hatchery fish. Pelvic fin counts for hatchery salmon were not significant.

We provide nine recommendations to improve performance of the Tucannon chinook salmon hatchery and evaluation programs, and to improve natural production and survival of Tucannon River salmon. We recommended the following:

- establish a wild escapement goal
- continue to evaluate prespawning mortalities in the river
- reevaluate spawning use of Cummings, Panjab, and Asotin Creeks
- modify the trap and trapping procedures to reduce injuries and stress to salmon
- outplant adult and juvenile salmon to improve spawning distribution in the Wilderness Stratum
- increase sampling and monitoring of progeny from controlled matings study
- decrease morphometric and meristic sampling
- continue evaluation of snorkel techniques
- change dosage of Erythromycin injections to reduce drug related mortalities.

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SECTION 1: INTRODUCTION

1.1: Compensation Objectives

Congress authorized the Lower Snake River Fish and Wildlife Compensation Program (LSRCP) in 1976. As a result of that plan, Lyons Ferry and Tucannon Fish Hatcheries (FH) were designed, constructed and are currently under operation. A partial objective of these hatcheries is to compensate for loss of 1,152 adult spring chinook salmon[1], Tucannon River stock (USACE 1975). An evaluation program was initiated in 1984 to monitor the success of these hatcheries in meeting this goal, and to identify any production adjustments required to improve hatchery performance. 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 salmon stocks (WDF 1993). A list of the evaluation program's objectives is outlined in Appendix A.

This report summarizes all work performed by the WDF LSRCP Spring Chinook Salmon Evaluation Program for the period 1 April 1992 through 31 March 1993. A report on the fall chinook salmon evaluation program for the same period is presented separately.

1.2: Description of Facilities\Operations

Lyons Ferry FH is located at the confluence of the Palouse River and Snake River at river kilometer (RK) 90, and 5 km from the mouth of the Tucannon River (Figure 1). Lyons Ferry FH has a single pass well water system which flows through the incubators, two adult holding ponds (divided into four ponds in 1992), and 28 raceways. A satellite facility is maintained on the Tucannon River (RK 61; Figure 2) for adult salmon collection and subsequent release of yearling progeny. Tucannon FH has an adult collection trap and one holding pond, which has been used for both broodstock collection and yearling releases.

Returning adult salmon are trapped at Tucannon FH and hauled to Lyons Ferry FH for holding and spawning. Eggs are fertilized,

[1] Throughout this report, the term "salmon" refers to Tucannon River spring chinook salmon, unless otherwise noted in the text.

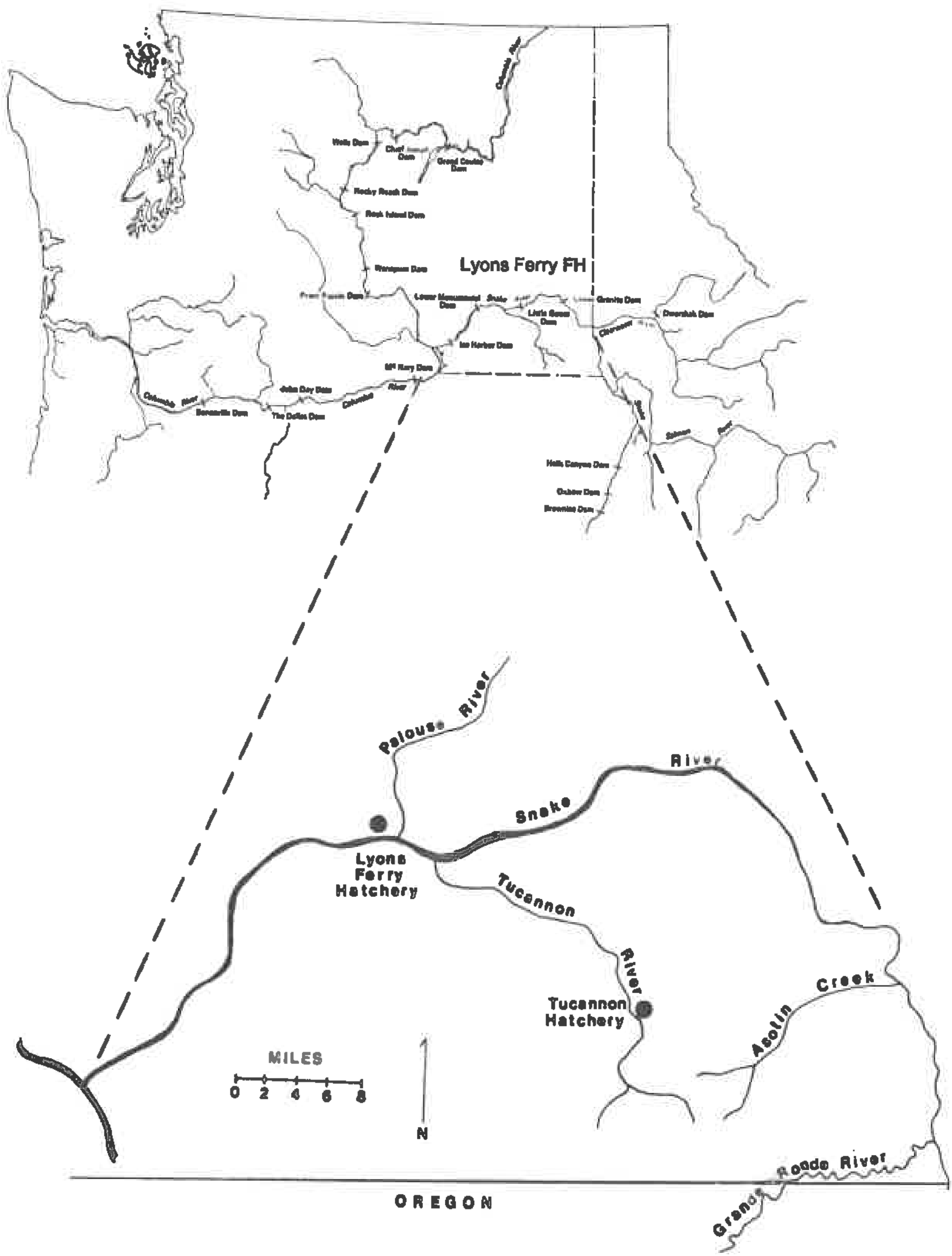

Figure 1. Location of Lyons Ferry and Tucannon Fish Hatcheries within the Lower Snake River Basin.

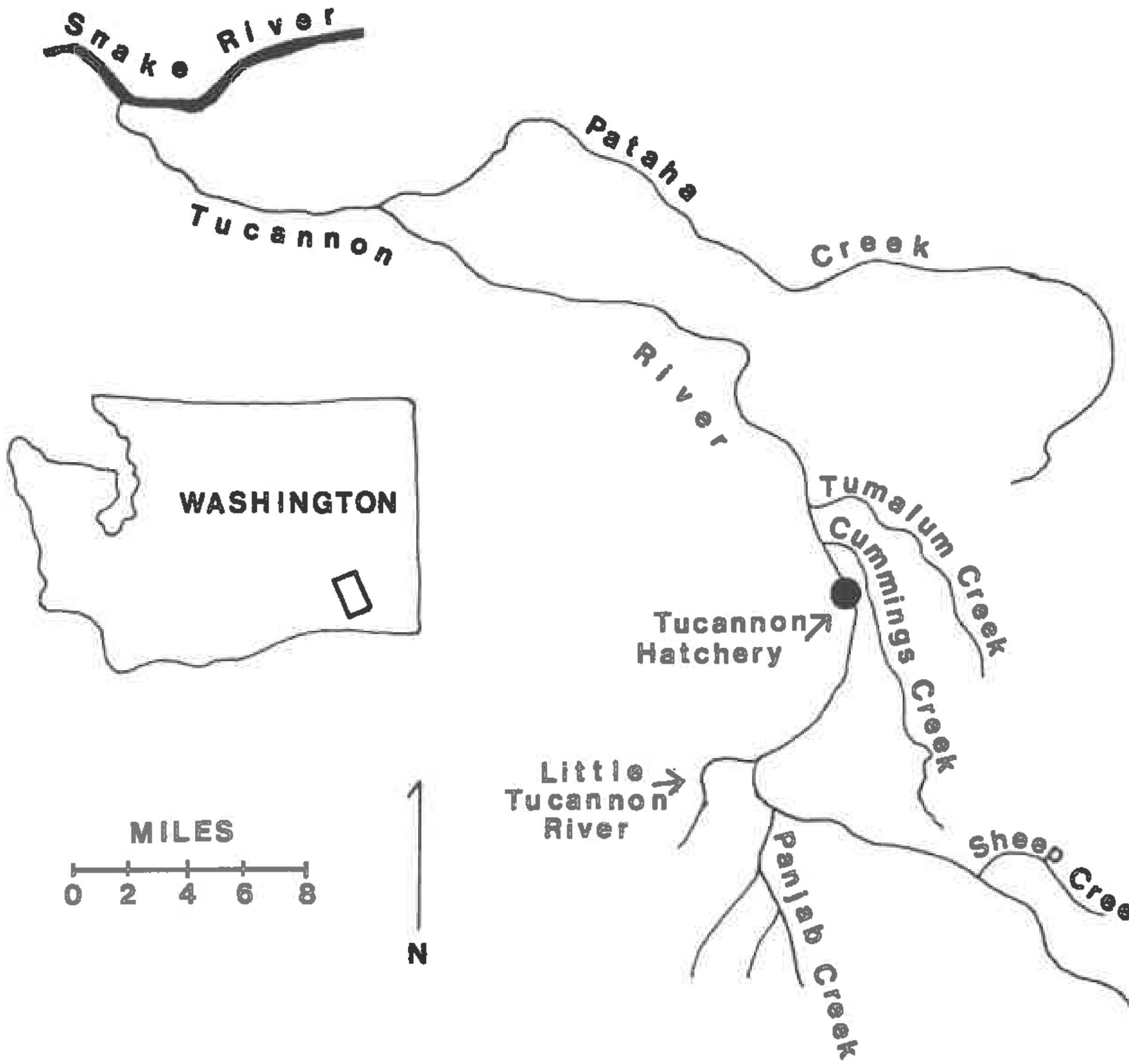

Figure 2. Location of Tucannon Fish Hatchery within the Tucannon River Basin.

incubated, and the fry reared to parr size at Lyons Ferry FH, then returned to Tucannon FH for acclimation and subsequent release in the Tucannon River. The 1992 Tucannon spring chinook salmon hatchery production goal was 88,000 fish for release as yearlings at 10 fish per pound (fpp; 8,800 lbs). This goal was primarily based on a density index at release of 0.18 $lbs/ft^3/in$ in the acclimation pond.

SECTION 2: HATCHERY PERFORMANCE

2.1: Broodstock Collection

Hatchery and evaluation personnel operated the permanent adult trap with a floating weir adjacent to the Tucannon FH to collect wild [1], and hatchery salmon for broodstock. The trap was operated daily from late April through mid-October. In general, one fish was collected for every four or five fish allowed to pass upstream of the weir for natural spawning. The objective was to collect 50 wild and 50 hatchery salmon for broodstock throughout the duration of the run (See Appendix B). This number was developed in 1991 using previous years broodstock survival, egg and fry loss, growth rate, feed conversion, and projected time and size at release. All hatchery salmon have adipose-fins removed and are coded-wire tagged (CWT), allowing their recognition as adults.

We collected 88 adults and nine jacks [2] (50 hatchery; 43 adults and seven jacks; and 45 wild adults, two jacks) for broodstock. Broodstock were captured between 5 May and 10 June, except one wild and one hatchery fish that were collected on 28 August. We passed 410 adults and 29 jacks upstream of the weir. Another 11 adults died in the trap. Total escapement to the weir was 509 adults and 38 jacks, of which 234 adults and eight jacks were hatchery and 275 adults and 30 jacks were wild (Table 1). Jacks were categorized by fork length (≤61 cm) when collected. Coded-wire tag and scale analyses have revealed that salmon categorized as jacks in the Tucannon River during all years were actually age 3 adults. We have no record of age 2 jacks returning to the Tucannon River since initiation of this project in 1984.

[1] Throughout this report, the term "wild salmon" refers to fish that have no hatchery parentage or to salmon which may be the progeny of either wild or hatchery fish that spawned in the river.

[2] This paragraph presents the data with some salmon as jacks (based on fork length, regardless of sex or age) to be consistent with hatchery records and preliminary data reports to other agencies. These fish are adults based on actual age (coded-wire tag or scale analyses).

Table 1. Escapement and collection of salmon to the Tucannon FH trap in 1992.

Week ending	Escaped to trap wild[a]	Escaped to trap hatchery[a]	Passed upstream wild	Passed upstream hatchery	Collected wild	Collected hatchery
09 May	18	25	9	15	9	10
16 May	38	34	30	24	8	10
23 May	66	54	56	46	10	8
30 May	32	59	24	49	8	10
06 Jun	21	57	14	50	7	7
13 Jun	10	34	6	30	4	4
20 Jun	1	5	1	5		
27 Jun	5	12	5	12		
04 Jul	1		1			
11 Jul						
18 Jul						
25 Jul		3		3		
01 Aug						
08 Aug		1		1		
15 Aug						
22 Aug	3	1	3	1		
29 Aug	10	4	9	3	1	1
05 Sep	13	5	13	5		
12 Sep	12	5	12	5		
19 Sep	11	4	11	4		
26 Sep	1	2	1	2		
Totals	242	305	195	255	47	50

[a] *Eleven fish died while entering the Tucannon FH trap. They are counted as fish passed upstream (includes eight wild males; one each on 2, 16, 18, and 21 September, and two each on 31 August and on 9 September, and three hatchery fish; one hatchery female on 26 May, and two hatchery males on 7 and 31 August.*

In 1992, a year of severe drought and warm water temperatures, the first salmon arrived at the trap on 4 May; the last fish arrived on 22 September. Peak of salmon arrival was 18-21 May. Salmon run timing was earlier than in 1991 (3-8 June) but similar to 1990. Peak arrival for hatchery salmon in 1992 was from 26-28 May while wild salmon returns peaked on 18-20 May. In 1991, peak arrival for hatchery salmon was 4 June; wild fish peaked on 11 June, compared to 23 May for hatchery fish and 22 May for wild fish in 1990.

In 1992 few fish arrived at the trap from late June to mid-August (Figure 3). This trapping lull is more pronounced than we observed in 1991, and earlier than in 1990. As in past years we observed a second peak of arrival at the trap just prior to, and during, spawning (21% of the wild fish, 7% of the hatchery fish).

Wild salmon consistently return to the trap near spawning time at a higher rate than hatchery salmon (38% of wild and 4% of hatchery in 1991, and 40% of the wild and 11% of hatchery in 1990).

Duration of salmon capture at the Tucannon FH trap was 142 days in 1992, compared to 110 days for wild fish and 90 for hatchery fish in 1991, and 111 days for both hatchery and wild fish in 1990. Prior to 1990, a temporary trap was used and removed in July each year so we do not have comparable run duration data for previous years.

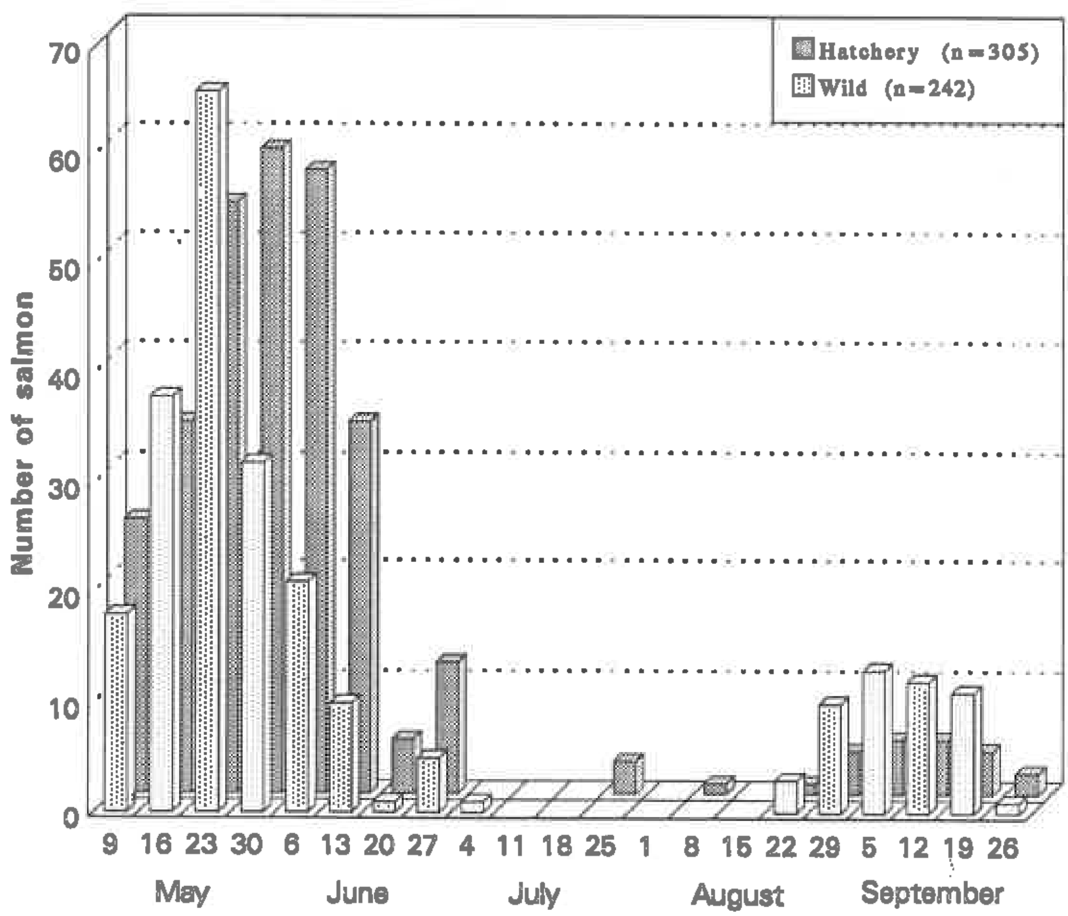

Figure 3. Weekly arrivals of wild and hatchery salmon to the Tucannon FH weir, 1992.

2.2: Lyons Ferry/Tucannon Hatchery Practices

2.2.1: Adult holding and spawning

In 1992 salmon captured for broodstock were hauled from the Tucannon FH trap to Lyons Ferry FH each day they were collected. This was the first year of transporting the fish immediately after capture to Lyons Ferry FH and holding them there until spawning. We made this operational change to hold salmon in cooler water than was available at the Tucannon FH in an effort to reduce prespawning mortalities.

Prespawning mortality of fish held in the hatchery decreased substantially from previous years to 6% (six fish) in 1992 (Table 2). This compares to a mean prespawning mortality for the previous seven years (1985 to 1991) of 34% (SD= 14.08, range 18-43%).

Two hatchery males and four wild females died in the pond prior to spawning in 1992 (Table 3). The mortality of females (8%), particularly hatchery females, was much lower than previous years. Jaundice caused by toxic reaction to Erythromycin appears to be the cause of death in three of the four wild female pond mortalities[1].

Table 2. Preliminary numbers of salmon collected and prespawning mortalities at either the Tucannon or Lyons Ferry FH, 1985-1992.

	Number Collected						Prespawning mortalities					
	hatchery			wild			hatchery			wild		
Year	male	female	jack	male	female	jack	male	female	jack	male	female	jack
1985	-	-	-	7	15	0	-	-	-	3	10	0
1986	-	-	-	58	58	0	-	-	-	15	9	0
1987	-	-	-	44	56	1	-	-	-	10	8	0
1988	3	0	6	46	70	9	3	-	6	7	22	0
1989	7	18	76	38	31	0	5	8	22	9	3	0
1990	24	44	6	32	27	1	14	22	3	12	6	1
1991	21	29	39	22	17	2	7	15	28	0	0	1
1992	16	28	6	23	22	2	2	0	0	0	4	0

[1] Tami Black, Washington Department of Fisheries, 610 N. Mission St., Suite B8, Wenatchee, WA 98801

All salmon were spawned at Lyons Ferry FH in 1992. Spawning occurred from 28 August to 22 September, with peak eggtake on 8 September (Table 3). Peak of spawning was the same for wild and hatchery salmon. Total eggtake was 156,359 eggs with 1.8% lost before eye up, for 153,594 eggs remaining (Section 2.2.4). Eggs and semen were bagged (oxygen added to semen), labelled, and kept cool until CWT were read from each of the parents. Spawning protocol was similar to that used in 1991 (Appendix B). Eggs from each female were mixed with semen from individual males (semen from a backup male was added 30 seconds later). All marked broodstock contained CWT from Lyons Ferry/Tucannon FH, therefore, all fertilized eggs were kept for hatchery production.

Table 3. Spawning and holding mortalities of hatchery and wild salmon at Lyons Ferry Hatchery in 1992.

Week	Hatchery Salmon				Wild Salmon			
	spawned		mortality		spawned		mortality	
Ending	male[a]	female	male	female	male[a]	female	male	female
23 May								2
20 Jun								
04 Jul								
11 Jul								
18 Jul								
25 Jul								
01 Aug								1
08 Aug								
15 Aug			1					
22 Aug								
29 Aug						1		
05 Sep		3				8		
12 Sep		13			13	9		1
19 Sep	17	9	1		12			
26 Sep	3	3						
Totals	20	28[b]	2	0	25	18	0	4

[a] *Males were live-spawned and tallied as spawned when they were killed, 5 wild males, 1 wild jack and 2 hatchery jacks were killed, but not spawned.*
[b] *Includes one hatchery female that had spawned in the raceway.*

2.2.2: Sperm cryopreservation and evaluation

In 1992 we continued to develop a sperm bank. These sperm will be used to fertilize ripe eggs when we have a shortage of semen from live males. Frozen semen also increases the number of males available as broodstock in the future and increases the available gene pool. Additionally, it enables us to genetically compare future broods with historical genotypes in our collection.

We selected nine males and froze semen (eight age 4, and one age 5) to preserve the wild genome. We evaluated sperm quality by observing motility of sperm from each fish. Cryoextender was mixed with sperm at a ratio of 3:1 (Wheeler and Thorgaard 1991). The mixture was then pulled into 4 ml straws and the ends were sealed. The straws were frozen on dry ice, then transferred into a liquid nitrogen tank. An inventory of cryopreserved semen for 1992 is listed in Appendix C. Cryopreservation procedures were as previously described (Bugert et. al, 1992 - Appendix C).

On 9 December, we performed an experiment to evaluate semen cryopreserved in previous years. Semen from two spring chinook salmon were included in this experiment. Results of the experiment will be included in our Lyons Ferry Fall Chinook Hatchery Evaluation Program Report for 1992-93.

2.2.3: Hatchery matings (controlled matings study)

We continued an experiment begun in 1990 to examine genotypic and phenotypic differences between separate matings of hatchery and wild salmon. Eggs from hatchery females were fertilized with hatchery males and eggs from wild females were fertilized with wild males. The objective of this study is to determine if measurable differences occur in early survival, growth, or rate of return, as a result of one generation of hatchery rearing. We used the spawning protocol (Appendix B) of dividing the eggs into two lots and using a separate primary male for each lot. Semen from a backup male was added 30 seconds later. Both lots of eggs from the same female were incubated separately, but constituted one "family". Data for individual matings are presented in Appendix D.

Forty-six females were spawned; 28 hatchery (one had spawned in the raceway) and 18 wild salmon. Hatchery staff shocked and counted the eggs (at eye up) from each family. A total of 86,983 eggs were collected from hatchery parents and 69,376 eggs from wild parents. Egg mortality was slightly higher in hatchery progeny (x=2.2%, SD= 2.34, range 0.5-13.0%) compared to progeny from wild salmon (x= 1.2%, SD= 0.62, range 0.3-2.6%). A total of 85,067 eggs from hatchery parents (97.8% of total) and 68,527 eggs from wild parents (98.8% of total) survived to eye up.

2.2.4: Incubation and rearing (controlled matings study)

A summary of the numbers of eggs incubated and fish reared at Lyons Ferry FH during 1985-1989 is presented for comparison with the 1990-1992 Controlled Matings Study data (Table 4). The 1988 and 1989 broods included hatchery parents, whereas the earlier broods were entirely from wild parents. Egg-to-smolt mortalities averaged 20% (SD = 4.84) from 1985-1989, with a general increase over the years (Figure 4, Table 5). Most of the mortality occurred during the early egg stage prior to eye-up.

Table 4. Numbers of salmon incubated and reared at Lyons Ferry/Tucannon FH during brood years 1985-1989.

	Brood Year				
	1985	1986	1987	1988	1989
Eggtake	14,843	187,958	196,573	182,438	133,521
Picking	13,633	184,165	168,287	152,743	106,321
Ponded	13,401	177,277	164,630	150,677 [a]	103,420
Tagged	13,244	159,188	156,981	153,900	99,839
Acclimation	13,000	156,526	156,138	152,817	99,433
Released	12,922	153,725	152,165	145,146	99,057

[a] *Apparently an underestimate occurred during ponding because an overage of 5,285 was reported after tagging in April.*

Table 5. Mean fecundities and percent mortalities between life stages for salmon at Lyons Ferry/Tucannon FH during brood years 1985-1989.

		Percent mortality				
Brood Year	Mean fecundity	Eggtake to picking	Egg to fry [a]	Fry to presmolt [b]	Presmolt to smolt [c]	Egg to smolt
1985	2,969 [d]	8.1	1.7	3.0	0.7	12.9
1986	3,916	2.0	3.7	11.7	1.8	18.2
1987	4,095	14.4	2.2	5.2	2.5	22.6
1988	3,882	16.3	- - [e]	- - [e]	5.0	20.4
1989	3,608	20.4	2.7	3.9	0.4	25.8

[a] *From egg picking at eyeup until ponding as fry.*
[b] *From time of ponding until acclimation at Tucannon FH.*
[c] *From eggtake (before picking) to release as smolts.*
[d] *Some females collected from broodstock on the spawning grounds. Two partially spawned females are included in the 1985 mean fecundity.*
[e] *No estimate was possible because of an error in the estimate of the number of fish ponded.*

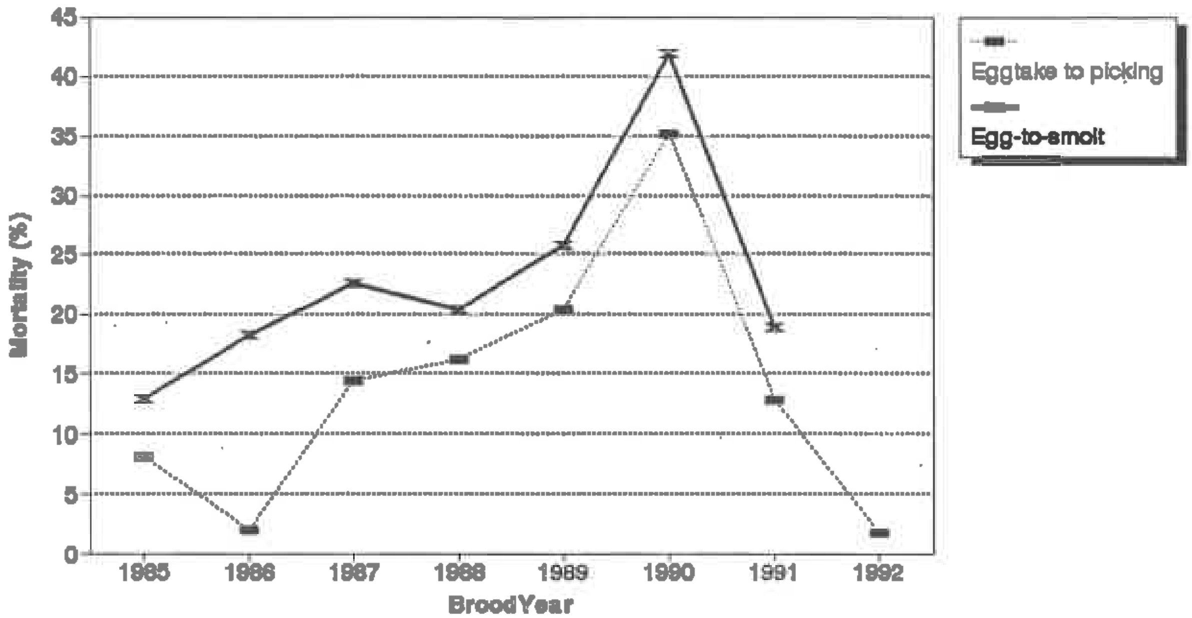

Figure 4. Percent mortality between life stages for salmon at Lyons Ferry FH, 1985-1989 broods.

<u>1990 brood:</u> Rearing information for this brood was presented previously (Bugert et al. 1992), but we have modified how the data is summarized (Table 6). We began using single pair matings in 1990 (without the use of back up males) to keep track of the success of various matings and to ensure that as many individual fish as possible contributed to the gene pool. If ripe mates of the same origin (eg. wild/wild) were not available on a particular spawning day, fish of mixed origin (hatchery/wild) were spawned together. These progeny were later uniquely marked to identify the group.

Fertilized eggs from each mated pair were incubated separately. Families were grouped together by origin during ponding. Each group received a unique CWT code for subsequent identification and tracking of survival. Hatchery and wild groups also received blank wire tags in the left or right cheeks for external identification.

<u>1991 brood:</u> In 1991 we fertilized eggs using semen from a second male 30 seconds after the semen from the first male was added to the eggs. This was an attempt to continue with single pair matings as in 1990, but it was also an attempt to reduce the possibility of egg loss caused by the use of infertile males.

Table 6. Estimated number of salmon from wild/wild, hatchery/hatchery, and mixed wild/hatchery crosses of 1990 brood.

	Hatchery	Wild	Mixed	Totals	Weight (lbs)
To river [a]	343	402	-	745	
To trap	214	251	-	465	
Collected	63	63	-	126	
Matings	19	19	6	44	
Eggtake	51,784	74,634	20,975	147,583 [b]	
Picking	25,962	53,988	15,656	95,684	
Ponded	22,151	52,275	14,079	89,519	66
Tagged	21,386	51,664	13,620	86,679	1,024
To Tucannon FH	21,161	51,208	13,548	85,919	3,089
Released	21,168	51,149	13,480	85,797	7,798

[a] *Estimated adult escapement, see section 3.3.4.*
[b] *Hatchery records listed these individual and total eggtakes. The listed total is assumed to be correct.*

As in 1990, progeny from individual matings were incubated in separate trays and families were combined by origin as they were ponded. Progeny from wild fish constituted the majority of this brood (Table 7). Fry were ponded from 17 December 1991 to 8 January 1992, and CWT from 15-22 September. All progeny were CWT with unique tag codes and externally marked with a red elastomer visual tag (VI) in the clear tissue behind the eye to designate their parental origin. Progeny from hatchery/hatchery crosses were VI tagged on the right side while progeny from wild crosses were VI tagged behind the left eye. The hatchery/hatchery progeny were handled immediately after tagging and had a 13.3% tag loss. Wild fish were tagged later and not handled immediately after tagging. Their tag loss was 1.8%. All fish were taken to the Tucannon FH acclimation pond on 7 December 1992. They were scheduled for a volitional release from 1 March to 10 April 1993. However, by the scheduled release date we did not have a Biological Opinion/Section 7 from National Marine Fisheries Service (NMFS). Release was delayed until 6-12 April.

<u>1992 brood:</u> Mating and rearing procedures were similar to those used for the 1991 brood. Most of the matings and progeny in 1992 were hatchery/hatchery (Table 8). There were no mixed matings. Fish were ponded from 22 to 28 December. These fish are scheduled to be marked in August 1993.

Table 7. Estimated number of salmon from wild/wild, hatchery/hatchery, and mixed wild/hatchery crosses of 1991 brood.

	Hatchery	Wild	Mixed	Totals	Weight (lbs)
To river [a]	350	189	-	539	
To trap	202	109	-	311	
Collected	91	42	-	133	
Matings [b]	11	17	-	28	
Eggtake	27,683	63,592	-	91,275	
Picking	19,130	60,466	-	79,596	
Ponded	18,377	58,848	-	77,232	53
Tagged	17,739	57,113	-	74,858	1,871
To Tucannon FH	17,635	56,899	-	74,534 [c]	2,381
Release	17,552	56,506	-	74,058	4,937

[a] *Estimated adult escapement, see section 3.3.4.*
[b] *Includes eggs from one freshly dead female (55% survival).*
[c] *We used numbers of fish at the hatchery at the end of November, one week prior to transfer to the acclimation site (12 fish less).*

Table 8. Estimated number of progeny of wild/wild, and hatchery/hatchery crosses of 1992 brood salmon.

	Hatchery	Wild	Mixed	Totals	Weight (lbs)
To river [a]	440	349	-	789	
To trap	305	242	-	547	
Collected	50	47	-	97	
Matings	27 [b]	18	-	45	
Eggtake	86,983	69,376	-	156,359	
Picking	85,067	68,527	-	153,594	
Ponded	83,907	67,820	-	151,727	106

[a] *Estimated adult escapement, see section 3.3.4.*
[b] *Does not include one female that was already spawned out in the pond, but it includes a partly spawned out female that contributed eggs.*

Comparison of broods for controlled matings study:
Hatchery/hatchery crosses consistently had lower fecundities and higher mortalities than progeny produced by wild/wild crosses (Table 9). We believe that mean fecundity for hatchery fish is lower than for wild fish primarily because of the difference in fish size and age (See section 4.1.1).

Survival from eggtake to smolt (at release) for progeny of hatchery, wild and mixed parent crosses was 40.9%, 68.5%, and 64.3%, respectively for the 1990 brood. Survival was substantially improved to 63.4% and 88.9% for progeny of hatchery and wild crosses for the 1991 brood. Egg handling techniques were improved in 1991, and again in 1992. Beginning in 1991, eggs and semen were placed in coolers with ice immediately after collection. Then in 1992, fish were spawned and eggs fertilized at Lyons Ferry FH instead of collecting gametes at the Tucannon FH and transporting them to Lyons Ferry FH where they were fertilized.

Table 9. Mean fecundities and mortalities between various life stages for the Controlled Matings Study, brood years 1990, 1991, and 1992.

Brood Year (origin)	Mean Fecundity [a]	Percent mortality: Eggtake to picking	Egg to fry [b]	Fry to presmolt [c]	Presmolt to smolt	Egg to smolt [d]
1990						
hatchery	2,725	49.9	10.8	7.6	1.0	59.1
wild	3,928	27.7	3.2	1.2	1.0	31.5
mixed	3,496	25.4	10.1	3.3	1.0	35.7
1991						
hatchery	2,517	30.9	3.9	3.5	1.0	36.6
wild	3,740	4.9	2.7	2.9	1.1	11.1
1992						
hatchery	3,226	2.2	1.4			
wild	3,854	1.2	1.0			

[a] *From actual individual egg counts, not estimates as in previous years.*
[b] *From egg picking at eyeup until ponding as fry.*
[c] *From time of initial ponding until acclimation at the Tucannon FH.*
[d] *From eggtake (before picking) to release as smolts.*

2.2.5: Disease incidence and treatments

The 1991 brood salmon were given two 21-day Gallimycin feedings during rearing: in March, and October 1992. These feedings were prophylactic treatments for Bacterial Kidney Disease (BKD).

The 1992 adult salmon were injected with 0.5 cc/4.5 kg (10 lbs) of both Erythromycin and Liquimycin when trapped, and twice again with erythromycin prior to spawning, to treat BKD and *Flexibacter columnaris*. Flush treatments of formalin (1:7,000 dilution rate for 2 hours) were applied to adults every other day to control fungus infection.

2.2.6: Acclimation

Lyons Ferry FH staff transported 74,522 yearling (1991 brood year) salmon to the adult holding pond at Tucannon FH on 7 December 1992. We continued to use river water mixed with 50% well water to maintain warmer water temperatures than the river. This strategy enables us to control disease and improve fish growth. In early February, well water was reduced over a period of several days until fish were entirely on river water. This was done to imprint fish to the Tucannon River instead of the hatchery water supply for a month prior to scheduled release. Cold water and ice on the pond in January and February reduced growth and feed conversion rates, but conversions increased in March when water temperatures moderated.

2.2.7: Smolt releases

<u>1990 brood:</u> Fish were allowed to volitionally migrate from 30 March to 10 April, 1992. An estimated 85,797 smolts (7,798 lbs; 11 fish/lb) were released. Mean fork length, standard deviation, coefficient of variation and condition factor of smolts at release were 140.7 mm, 12.0, 8.5, and 1.2, respectively (Figure 5). The pre-release sample exhibits a single modal distribution this year which is different than the bimodal distribution observed in previous pre-release samples. Overall feed conversion rate for these fish was 1.65 lbs of feed to 1.00 lb of weight gain. Mortality during acclimation was 0.1 % of the population. All releases of spring chinook salmon since the Lyons Ferry/Tucannon FH program began in 1985 are listed in Appendix E.

Many fish escaped the acclimation pond and were captured in March at the downstream migrant trap 40 km downstream of the hatchery (Section 3.2.5). We did not know when they left the pond so we could not monitor travel time to the trap. We caught escaping fish as early as 12 December. By 27 March, 75 hatchery migrants were captured at the downstream migrant trap. Hatchery fish numbers at the trap peaked on 12 April. Only one hatchery fish was caught after 7 May 1992. We captured 973 hatchery migrants (1.13% of total hatchery smolts released), although we made an effort to minimize our capture of hatchery salmon.

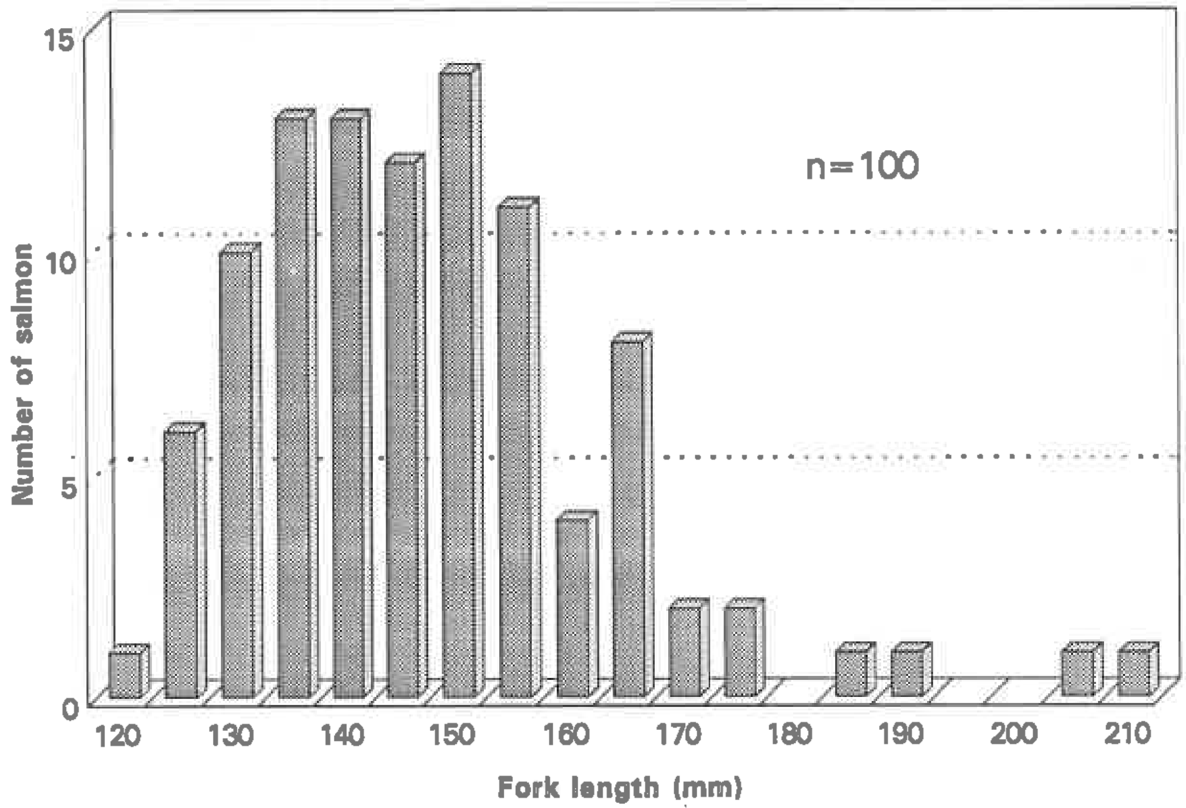

Figure 5. Length frequency distribution of 1990 brood salmon released from Tucannon FH in 1992.

1991 brood: We planned a one month volitional release period beginning the first part of March 1993. However, the release was delayed until 6-12 April when we received our Section 7 permit from NMFS. This early and extended release was meant to allow early migration. We had documented fish escaping the acclimation pond in 1992 that appeared to be very smolted and in good condition. Therefore, we wished to duplicate that type of release. Fish began circling the pond about a week prior to initiation of the release. Most of the fish moved out quickly after the volitional release began, but about one third of the fish were forced out of the pond on 12 April.

2.2.8: Harvest

Legal and reported harvest of Tucannon River hatchery spring chinook salmon has been consistently less than 5% of the observed CWT recoveries for the 1985-1988 broods (Appendix F). Most harvest occurs in the Columbia River in the test net or treaty fisheries, as reported by Oregon Department of Fisheries.

SECTION 3: RIVERINE EVALUATIONS

From 1985 to 1988, program staff collected biological information on wild salmon in the Tucannon River prior to hatchery enhancement. We are now collecting biological information from both hatchery and wild salmon. This information is part of a study to assess the short and long term effects of supplementation.

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 demographics (presented in Section 4), and 2) observation of the population dynamics of wild and hatchery salmon spawned in the Tucannon River. The following discussion pertains to research on the population dynamics aspects of this program.

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

Lower (RK 0.0 - RK 20.1),
Marengo (RK 20.1 - RK 39.9),
Hartsock (RK 39.9 - RK 55.5),
HMA (RK 55.5 - RK 74.5),
Wilderness (RK 74.5 - RK 86.3).

The Lower, Marengo, and Hartsock strata are within agricultural bottomland that receives limited water diversion for summer irrigation. Sections of the stream within these strata have a poorly defined or braided stream channel, stream banks are often unstable with limited riparian areas, and water temperatures often exceed the upper threshold of salmon tolerance. The upstream reach of 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 salmon at all stages of the life cycle. The Wilderness Stratum is in the Wenaha-Tucannon Wilderness Area, a part of 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.

3.1: Stream Temperature/Discharge Monitoring

Program staff deployed nine continuous-reading thermographs to record daily maximum and minimum water temperatures in the Tucannon River to monitor heat loading throughout the year. Locations of thermographs were as follows: 1) near the downstream outlet of Big 4 Lake (RK 65), 2) near the downstream outlet of Beaver-Watson Lakes (RK 62), 3) near the downstream outlet of Deer Lake (RK 60), 4) 100 m downstream of the Cummings Creek confluence (RK 56), 5) Bridge 14 (RK 52), 6) Bridge 12 (RK 47), 7) Marengo Bridge (RK 40), 8) WDF smolt trap (RK 20), and 9) Power's Bridge (RK 4). Miscellaneous river discharges (using a current meter and modified USGS techniques), and temperature data, are presented in Appendix G.

In 1992 river flows were low and water temperatures were high during the spring and summer. For example, mean maximum water temperatures were as much as 3-5 ^{o}C higher at Bridge 14 and Marengo in May and June 1992 than in 1991 (note: monthly maximum and minimum ranges were reported in Bugert et al. 1992, not mean maximums and minimums as indicated: the revised mean maximums and minimums for 1991 are presented in Appendix G). The Marengo thermograph recorded a high temperature of 28.9 ^{o}C on 23 June 1992. Temperatures of 20 ^{o}C or above were recorded regularly from 3 May to 22 September during 1992. Maximum water temperature at Powers Bridge reached 26.7 ^{o}C (80 ^{o}F) on 19 June and 29.4 ^{o}C (85 ^{o}F) on 23 June 1992: a period when salmon may still be entering the lower Tucannon River during some years.

In general, stream temperatures in June through September increased in varying increments from the furthest upstream location to the furthest downstream (Tables 10 and 11). Mean maximum temperatures increased consistently from Bridge 14 downstream to Powers Bridge, but temperatures did not consistently increase at each station from Big 4 Lake to Bridge 14.

Table 10. Mean monthly ranges (minimum to maximum) of water temperatures at four upper Tucannon River sampling locations from October 1991 to September 1992. Temperatures are listed in degrees Celsius.

Month	Big 4 Lake	Beaver Lake	Deer Lake	Cummings Creek
Oct 1991[a]	7.9- 9.9	7.5- 9.7	7.7-10.1	8.4-10.4
Nov 1991	6.1- 7.5	5.9- 7.2	6.0- 7.7	6.5- 7.7
Dec 1991	5.8- 6.7	5.2- 6.2	5.7- 6.7	6.1- 7.0
Jan 1992	4.9- 6.1	4.3- 5.5	4.6- 5.9	5.4- 6.4
Feb 1992	6.1- 7.7	5.3- 6.9	5.7- 7.4	6.3- 7.8
Mar 1992	6.4- 9.4	6.1- 9.4	6.7-10.0	6.0- 9.4
Apr 1992	7.3-10.5	7.5-11.1	8.2-11.8	8.4-11.4
May 1992	9.6-15.2	9.8-15.4	10.2-16.8	11.1-15.6
Jun 1992	12.7-18.3	12.6-15.9	13.6-20.1	14.2-18.3
Jul 1992	13.2-18.7	13.6-16.0	13.7-20.0	14.7-18.4
Aug 1992	12.8-18.7	13.1-16.0	13.7-20.2	14.6-18.4
Sep 1992[a]	11.1-15.3	9.8-13.3	11.2-16.3	12.2-14.8
Oct 1992	6.5- 8.7	7.6- 9.0	7.6-10.0	8.6-10.2
Nov 1992	3.4- 4.4	4.6- 5.3	2.8- 4.0	4.9- 5.7
Dec 1992	1.3- 2.3	2.8- 3.3	1.6- 2.4	2.6- 3.4
Jan 1993	0.3- 0.8[a]	2.0- 2.4	2.4- 3.2	1.9- 2.6
Feb 1993[a]	- -	3.3- 3.9	1.8- 2.6	7.1- 2.7

[a] *Data available for only part of the month.*

Table 11. Mean monthly ranges (minimum to maximum) of water temperatures at four lower Tucannon River sampling locations from October 1991 to February 1993. Temperatures are listed in degrees Celsius. [a]

Month	Bridge 14	Marengo Bridge	Smolt Trap	Powers Bridge
Oct 1991	- -	8.7-10.6[b]	- -	- -
Nov 1991	- -	6.4- 8.0	- -	- -
Dec 1991	- -	4.4- 5.4	- -	- -
Jan 1992	- -	4.3- 5.3	- -	- -
Feb 1992	- -	4.3- 5.8	7.3- 7.8[b]	- -
Mar 1992	5.9-10.8[b]	6.6-10.2	6.7-10.1	8.6-13.9[b]
Apr 1992	7.1-10.7	8.3-12.0	8.9-12.7	10.4-14.6
May 1992	9.3-14.3[b]	11.6-16.9	11.3-16.8[b]	12.6-20.3[b]
Jun 1992	13.6-19.0	15.2-20.4	15.9-21.8[b]	16.9-24.1[b]
Jul 1992	14.1-19.6	15.9-20.8	16.6-22.4	17.5-24.4
Aug 1992	13.7-19.6	15.6-20.2	15.9-20.2	16.6-23.5
Sep 1992	10.9-15.2	9.9-12.8[b]	12.6-16.6	13.6-18.3
Oct 1992	8.7-11.7	9.6- 9.8	9.8-12.4	10.8-13.9
Nov 1992	5.1- 6.6	5.4- 6.3	5.7- 7.1	7.5- 9.0
Dec 1992	2.5- 4.1	3.1- 4.3	2.2- 3.7	4.0- 5.4
Jan 1993	1.4- 3.2	1.2- 2.8	1.1- 2.1	2.8- 4.2
Feb 1993[b]	2.7- 7.1	3.3- 4.9	1.8- 3.0	3.5- 4.9

[a] *Bridge 12 Thermograph was used for only part of January 1991, mean minimum-maximum was 4.2-5.9.*

[b] *Data available for only part of the month.*

3.2: Juvenile Population Dynamics

We conducted parr production surveys at index sites to estimate salmon parr densities in the Tucannon River. We used both a modified line transect sampling method (Emlen 1971) and a total count snorkel method (Griffith 1981, Schill and Griffith 1984, Hillman et. al. 1992) for comparison of techniques. Snorkeling was conducted during mid day (1000 - 1600 hrs) on sunny days to take advantage of the best light conditions. Electrofishing was conducted at some of the same sites as the two snorkel methods, but on different days, to provide a comparison of the three juvenile density estimation methods. Summer snorkel and electrofishing surveys were conducted between 10 July and 26 August.

The modified line transect (LT) method consists of one snorkeler surveying along a diagonal transect. A lead line, or rope, was placed as a transect line diagonally across each site. Snorkeling started at the downstream end of the transect on the right bank. Fish were identified by species and age class and their estimated perpendicular distance from the transect line was recorded. The decimeter marks on the transect line provided a means to estimate distances. All index sites were snorkeled using the LT method on two or three separate occasions (by at least two different snorkelers to reduce bias) to estimate the average densities of salmon parr per site. Duration of the survey was noted, and snorkelers attempted to standardize the time taken to complete a survey. Sites were snorkeled no more than once per day. Most sites were snorkeled again within five days of the first snorkel survey.

We calculated the area surveyed by multiplying the mean greatest distance salmon parr could be detected (perpendicular distance from the transect in decimeters) by 2 (fish could be detected on both sides of the transect) by the mean transect length. We calculated rearing density by dividing the number of salmon observed by the area surveyed. A mean value (with standard error) was determined from two or three replicates. Population estimates were derived by multiplying the mean density of each habitat type by the total area of that habitat type (from the most recent habitat inventory) within each stratum.

The total count snorkel method (TC) consisted of one or two snorkelers counting all salmon observed as they moved upstream through a site. Total counts were conducted within a few days of the counts with the LT counts. Estimated area surveyed for each site was derived from the area calculated during electrofishing in the Wilderness and Hartsock strata. Inadvertently, widths were not measured at sites snorkeled with the TC method in the HMA Stratum. We therefore used area measurements for each site from electrofishing surveys in 1990 to calculate salmon parr densities in 1992.

Electrofishing surveys were conducted with a Smith-Root Type 12 backpack electrofisher. Block nets were erected at the upper and lower boundaries of each site prior to electrofishing. Each electrofishing pass consisted of methodically shocking and collecting stunned fish starting at the lower end of the site working upstream to the upper net and then back towards the bottom net. Two electrofishing passes were used at each site unless reductions of numbers of salmon captured were less than 60% between pass one and pass two. Up to four electrofishing passes were used per site. All salmon were anaesthetized with MS222 and measured (fork length), and a small sub-sample of fish were also weighed.

3.2.1: Wilderness Stratum parr production

Some of the index sites established in 1985 were selected at random for salmon parr production surveys in 1992. Sixteen sites, four sites of each habitat type (riffle, run, pool, side channel) were snorkel surveyed by program staff using the MLT method from 16 July to 30 July. Total area snorkeled in the Wilderness Stratum was 456 m^2.

Mean densities (fish/100 m^2) from snorkel surveys were highest in side channels and lowest in runs and riffles (Table 12). Mean density of salmon parr in pools was 10.84 fish/100 m^2, which was less than half the densities observed at the same sites in 1991 (Bugert et al. 1992). Only one of four pools contained salmon parr (Appendix H). In 1992 we conducted snorkel surveys in side channels within the Wilderness Stratum for the first time. Mean density was 37.79 fish/100 m^2 with the LT method, but salmon subyearlings were found in only one of three side channels surveyed. The one site that contained fish had an estimated 151.1 fish /100 m^2 with the LT method. Both the TC and electrofishing surveys produced lower density estimates. No salmon parr were observed in either riffles or runs in 1992 with any of the estimation methods. We estimate that approximately 2,700 subyearling parr reared in the Wilderness Stratum in 1992 by using either TC or electrofishing surveys. This estimate is higher than the estimate derived in 1991 from LT surveys (1,861 salmon) for this stratum, and much lower than the estimate in 1990 (6,578). The number of adult salmon spawning in this stratum in 1991 decreased dramatically from levels of previous years (Bugert et. al 1992). Adult salmon spawned only in the lower portion of this stratum in 1991 and in 1992 subyearlings were found in only the lower-most sites.

During 1992 surveys we frequently observed salmon yearlings in pools and side channels throughout the stratum (Table 13). Mean densities were 9.38 and 3.38/100 m^2, respectively. No yearlings were observed in riffles or runs. We estimate approximately 700 salmon yearlings reared in the Wilderness Stratum.

Total count surveys were conducted at 15 index sites. Four sites of three distinct habitat types (riffle, run, pool) plus three side channel sites were surveyed between 16 July and 28 July. Total area snorkeled was 606 m^2. Subyearling salmon parr were observed in pools and side channels, but not in riffles or runs. These results are identical to those obtained with the LT method.

We did electrofishing surveys at eight index sites from 21 to 28 July. Two sites of each habitat type (riffle, run, pool and side channel) were surveyed. Total area surveyed was 606 m^2. Subyearling and yearling salmon parr were captured in pools and side channels only, identical to both LT and TC surveys.

Table 12. Density (mean number of fish per 100 m2, number of sites) and population estimates for salmon subyearlings using various techniques (section 3.2) by habitat type in the Tucannon River, 1992.

Stratum Habitat type	Line Transect Density	 Population	Total Count Density	 Population	Electrofishing Density	 Population
Wilderness						
Riffle	0, 4	0	0, 4	0	0, 2	0
Run	0, 4	0	0, 4	0	0, 2	0
Pool	10.84, 4	288	29.25, 2	388	23.4, 2	620
Side Channel	37.79, 4	6,040	29.34, 2	2,345	11.41, 2	2,084
Total		6,328		2,733		2,704
HMA						
Riffle	1.51, 5	1,885	6.19, 4	7,728	-	-
Run	16.43, 6	13,243	12.44, 3	15,403	-	-
Pool	24.64, 5	1,378	26.84, 3	1,501	-	-
Boulder	3.89, 5	824	6.6, 2	1,398	-	-
Side Channel	68.38, 5	13,954	31.25, 3	6,377	-	-
Total		31,284		32,407		-
Hartstock						
Riffle	5.31, 3	5,971	6.96, 3	7,826	6.53, 3	7,346
Run	14.91, 4	11,685	17.57, 4	13,770	12.4, 4	8,542
Pool	10.89, 2	587	28.85, 2	1,554	3.47, 2	187
Total		18,242		23,150		16,075

3.2.2: HMA Stratum parr production

In 1992 we surveyed index sites which were randomly established in 1986. These index sites consisted of five distinct habitat types within the HMA Stratum: riffles, runs, pools, boulders, and side channels. We snorkeled five to six replicates of each habitat type for a total of 26 index sites. Surveys were conducted in this stratum from 10 July to 26 August. Total area snorkeled in the 26 index sites was 1,171 m^2. Mean densities (fish/100 m^2) were highest in side channels and pools (Table 12). We estimate that 31,284 salmon parr reared in this stratum in 1992 from the LT method. This is a 23% decrease in the rearing population estimate derived through LT snorkel surveys in 1991 (40,467 salmon).

Salmon yearlings were found in runs, pools and side channels (Table 13). Mean densities (fish/100 m^2) were 0.54, 3.17 and 4.68; respectively. No yearlings were found in boulder or riffle sites. We estimate 2,258 salmon yearlings reared in the HMA Stratum in 1992 from the LT method.

Total count snorkel surveys were conducted in the HMA Stratum from 13 July to 15 July. Fifteen index sites were surveyed, three of each habitat type (riffle, run, pool, boulder and side channel). Total area snorkeled in the fifteen sites was 2,143 m^2. Mean densities were highest in side channels and pools. We estimate 32,407 subyearling salmon parr reared in the HMA Stratum in 1992. Salmon yearlings were also found in runs, pools and side channels. Mean densities were 3.24, 15.03 and 5.43 fish/100 m^2 respectively. No yearlings were observed in boulder or riffle sites. We estimate 5,870 yearling salmon reared within the HMA Stratum during 1992. However, densities were calculated using 1990 area measurements. Thus, we believe the LT estimates are more credible. No electrofishing surveys were conducted in this stratum in 1992.

Table 13. Density and population estimates for salmon yearlings using various techniques by habitat type in the Tucannon River, 1992.

Stratum	Line Transect		Total Count		Electrofishing	
Habitat type	Density	Population	Density	Population	Density	Population
Wilderness						
Riffle	0, 4	0	0, 4	0	0, 2	0
Run	0, 4	0	0, 4	0	0, 2	0
Pool	9.38, 3	187	3.68, 4	44	3.61, 2	130
Side Channel	3.83, 4	611	1.09, 4	577	1.64, 2	174
Total		798		621		304
HMA						
Riffle	0, 5	0	0, 3	0	-	-
Run	0.54, 6	1,100	3.24, 3	3,921	-	-
Pool	3.17, 5	204	15.03, 3	841	-	-
Boulder	0, 5	0	0, 3	0	-	-
Side Channel	4.68, 5	954	5.43, 3	1,108	-	-
Total		2,258		5,870		-
Hartstock						
Riffle	0, 3	0	0, 3	0	0, 3	0
Run	0.13, 4	65	0.34, 4	529	0, 4	0
Pool	0, 2	0	0.79, 2	43	0, 2	0
Total		65		572		0

3.2.3: Hartsock Stratum parr production

Several previously established index sites were surveyed for parr production estimates. We snorkeled nine index sites (three riffles, four runs, and two pools) from 3 to 18 August. Total area snorkeled in this stratum was 291 m^2. Mean density was highest in runs (Table 12). We estimate that 18,242 subyearling salmon reared in the Hartsock Stratum during the summer of 1992 from the LT method. This estimate is 13% less than our 1991 estimate (21,024 salmon). Salmon yearlings were observed only in runs. Mean density was 0.13 fish/100 m^2, for an estimate of 65 yearling fish.

Total count snorkeling was conducted on 30 July. All nine index areas were surveyed for a total area of 1,401 m^2. We estimate 23,150 subyearling salmon parr reared in the Hartsock Stratum in 1992. Salmon yearlings were found in pools and runs. Mean densities for subyearlings and yearlings were highest in the pools. We estimate from TC that 572 salmon yearlings reared in the Hartsock Stratum in 1992. This estimate encompasses the largest area surveyed and therefore we assume it provides a better estimate than that derived from LT surveys.

Electrofishing surveys were conducted in the nine index sites from 8 to 13 August. Total area surveyed was 1,401 m^2. Mean densities were highest in runs. We estimate from electrofishing that 16,075 subyearling salmon parr reared in the Hartsock Stratum in 1992. No salmon yearlings were captured while electrofishing.

3.2.4: Marengo Stratum

We snorkeled six index sites (two riffles, two runs, two pools) in the Marengo Stratum from 29 July to 25 August 1992. Total area sampled was 100.7 m^2. Subyearling salmon were observed only at the uppermost site (riffle) for an estimated density of 2.5 fish/100 m^2. We estimate 47,964 m^2 of riffle habitat were available in this stratum, therefore we estimate the total standing crop at 120 subyearling salmon. No sites were electrofished in this stratum in 1992.

3.2.5: Downstream migrant trap operations

An important objective of our study is to estimate the magnitude, duration, periodicity, and peak of wild salmon emigration from the Tucannon River. To do this, we maintain a floating inclined plane downstream migrant trap at RK 20. We operated the trap intermittently from 20 November 1991 to 4 June 1992. The trap was operated three days in November, 15 in December, 19.5 in January, 19.5 in February, 22 in March, 21 in April, 18 in May, and two days in June. We stopped trapping in June because low discharge and velocity made trapping ineffective.

To calibrate trapping efficiency, we systematically marked (clipped the tip of a pelvic or caudal fin) wild smolts and transported them 10 km upstream of the trap for release. The percentage of marked fish re-captured was used as an estimate of trapping efficiency to estimate the total downstream migrants trapped. We used a modified form of the standard Peterson mark-recapture method described in Bugert et al. (1991). In 1992 we modified our trapping procedures by conducting intensive (24 hour/day) trapping for 10 day to two week blocks per month that were randomly selected. Our intent was to be able to obtain estimates of trapping efficiency from mark groups during each month. We supplemented our intensive trapping efforts with intermittent trapping intervals. These periods lasted several days to a week each month. This allowed us to determine the number of fish captured daily at the trap. Out of necessity, we assumed that estimated monthly trap efficiencies adequately reflected the average trap efficiencies for those respective months. We estimated the number of fish trapped per hour during our trapping efforts each month and applied the estimate to each time interval during that month that we did not trap.

We conducted one mark/recapture trial per month for January, and February, two each in December and May, three trials in April, and four in March to estimate trap efficiency. We caught 3,837 wild salmon (including 89 recaptures) and 974 hatchery salmon during the 1991/1992 season. Based upon the mean monthly trap efficiency estimates we estimate 49,481 wild salmon juveniles emigrated past the downstream migrant trap between 1 December 1991 and 4 June 1992 (Table 14). Too few fish were captured to estimate juvenile passage in November.

We classified 82.9% of 2,689 wild salmon caught as parr-smolt transitionals, while 16.5% were classified as smolts, and 0.6% were parr (Table 15). Condition factors were 1.78 (n=3), 1.14 (n=760), 1.30 (n=208), and 1.18 (n=971) for parr, transitional, smolt, and total fish, respectively. Virtually all salmon emigrants were assumed to be yearlings based on fork length (Figure 6). Scale analysis of some of the largest fish we collected indicated they were yearlings, not age 2 fish as we had assumed. Most parr were recently emerged fry in the 35-45 mm range. Most fish over 140 mm were classified as smolts.

In the seven month trapping period, 170 wild salmon (6.3%) were descaled, compared with 3% in 1990/91 and 10.2% in the 1989/1990 season. Salmon parr were not descaled, 5.5% of the 2,227 fish classified as transitional and 10.6% of the 445 smolts were descaled. Two mortalities were recovered in the trap during the seven month period of operation.

The major migration period was from late February through the end of May 1992. The peak of migration of wild salmon occurred in late April and a much smaller pulse of migrants were captured in December and early January (Figure 7). Most fish classified as smolts were observed in April and May (Figure 8).

Composition and numbers of incidental species caught in the downstream migrant trap in 1991/1992 changed little from previous years (Bugert et al. 1992).

Table 14. Estimated wild juvenile emigrants passing the downstream migrant trap in the Tucannon River from 1 December 1991 to 4 June 1992.

Month	Estimated number of migrants	Percent of total
December	8,543	17.3
January	683	1.4
February	1,606	3.2
March	13,116	26.5
April	14,940	30.2
May	10,547	21.3
June [a]	46	0.1
Total	49,481	100.0

[a] *Trap was operated only two days this month.*

Table 15. Mean lengths and weights for wild salmon weighed at the Tucannon River downstream migrant trap November 1991 through 4 June 1992.

Parr/smolt transformation	Mean length (mm) (SD)	Sample size	Mean weight (g) (SD)	Sample size
Parr	41.0 (11.4)	16	- -	3
Transitional	96.9 (11.8)	2,222	10.6 (4.1)	760
Smolt	107.6 (18.8)	445	15.3 (9.1)	196

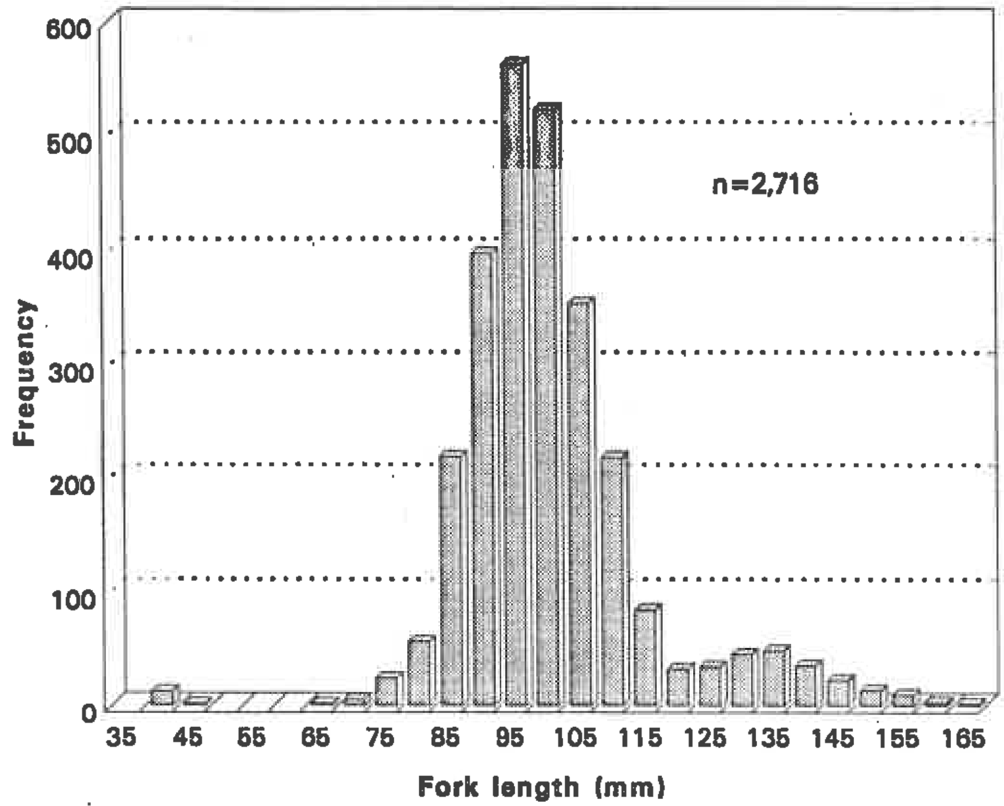

Figure 6. Length frequency distribution of wild salmon caught at the Tucannon River downstream migrant trap, 1991/1992 season.

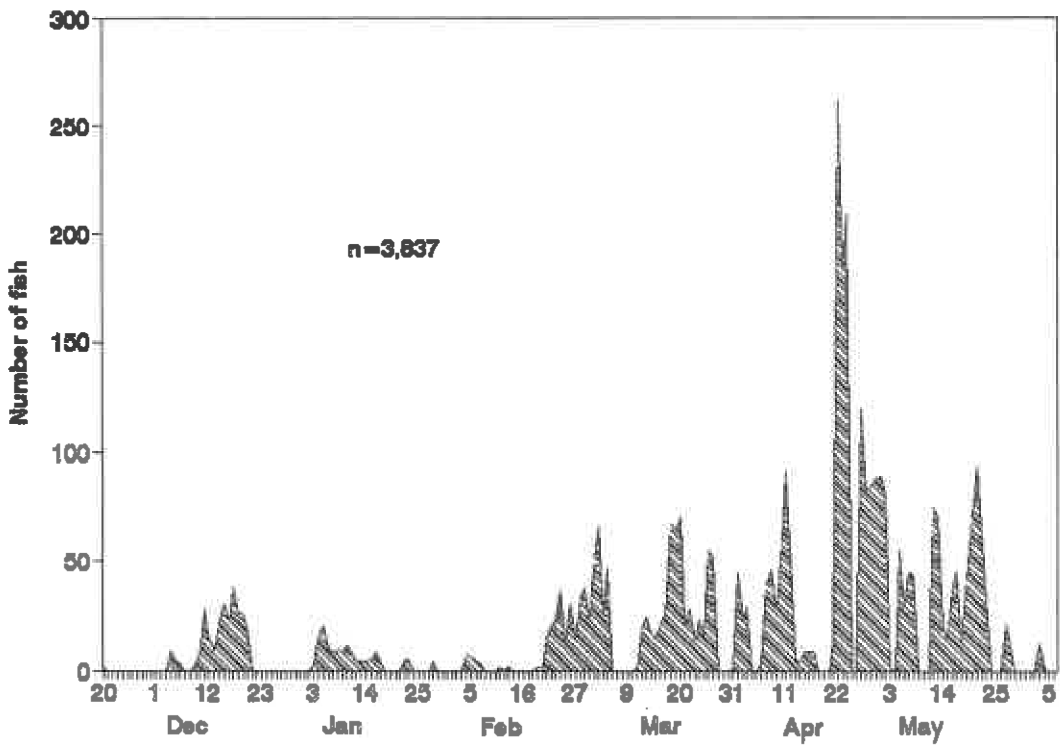

Figure 7. Trap collection timing of wild juvenile salmon in the Tucannon River, November 1991-June 1992.
(Note: dates where the number of salmon captured is zero indicates dates of no trapping).

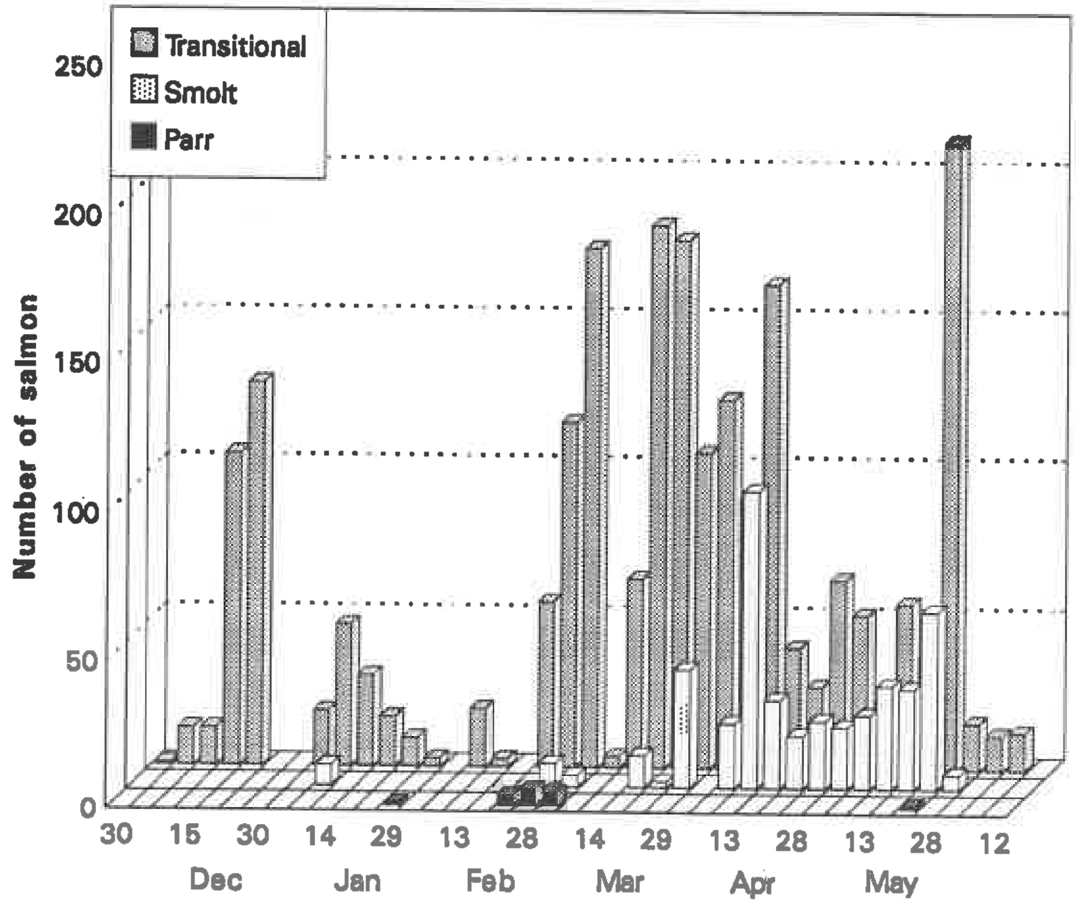

Figure 8. Migration timing of juvenile salmon by parr-smolt classification in the Tucannon River, November 1991-June 1992.

3.3: Adult Population Dynamics

We continued the study initiated in 1989 to evaluate movement, prespawning mortality, mate and habitat selection, and overall spawning success of adult salmon using a combination of upstream trapping, radio telemetry, snorkel surveys, and spawning ground surveys.

In 1992, as in 1991, the weir remained in the river and was checked on weekdays only from May through September. We did not conduct snorkel surveys to estimate the number of adults holding downstream of the weir because of the poor results we obtained in past years (Bugert et al 1992). We snorkeled downstream of the weir in June in an attempt to locate salmon carcasses and to obtain a relative index of salmon dying in the river. Several live adult salmon were observed, but no carcasses were observed or recovered.

3.3.1: Radio telemetry

Fish tagged at the Tucannon FH trap in 1992: Upon arrival to the Tucannon FH trap, we randomly anesthetized salmon with carbon dioxide and inserted radio tags into the esophagus prior to releasing them upstream. Twenty-nine salmon (15 hatchery, 13 wild, and one fish with unrecorded origin) were tagged between 8 May and 8 June, 1992 (Appendix I). We limited our tagging to the beginning of the migration period to minimize mortality that could be caused by increasing water temperatures or atrophy of the esophagus or stomach. Fork length, post-orbital to hypural plate length, general condition, and if possible, sex of each fish were recorded. Each radio transmitted a unique frequency code enabling us to track individual fish. Fish were tracked at approximately three-day intervals while they were least active, but intensified as spawning time approached. Tracking was conducted from vehicles on the road. Salmon holding for long periods of time in one location were precisely located in the river by snorkeling. This verified if the radio tag was still in the salmon or had been regurgitated. We attempted to determine: prespawning movements, spawning time, redd location, number of redds per female, and interactions with other salmon for each radio tagged fish. In August, after salmon kype development, we attempted to verify the sex of tagged fish by underwater observation. Sex was also verified when carcasses were recovered after spawning.

Two wild tagged salmon (tags 19 and 61 code 54b) and one hatchery tagged salmon (tag 20a) regurgitated their tags the same day they were implanted. We suspect one wild salmon (tag 60 code 60) and another salmon of unrecorded origin (tag 61 code 63) regurgitated their tags. These radios were recovered within 20 days after insertion. No carcasses were recovered with these transmitters.

Six wild salmon died 12 to 37 days after tagging (mean 25.2 days, SD=10.0), prior to spawning. Nine hatchery fish also died prior to spawning. They were recovered 17 to 112 days after tagging (mean 31.2 days, SD=33.0). Of all these prespawning mortalities, one fish was a verified tagging mortality (recovered 15 days after tagging), five had circumstantial evidence indicating they were poached (see below), and nine died of unknown causes.

Five fish and transmitters were never recovered: three wild tagged salmon and two hatchery tagged salmon. Of these, two had tag malfunctions (tags 11 and 25), two were possibly poached (tags 24 and 57 code 52), and we do not known what happened to the fifth fish (tag 13). It is possible that three of these salmon survived to spawn (tags 13, 57 code 52, and 11) because they were last located just prior to spawning and their transmitters may have failed (some indication of at least two of these transmitter signals fading and becoming erratic). Of the 29 fish tagged, only four were verified as having spawned: three wild and one hatchery fish.

Poaching on the Tucannon River: As in previous years, circumstantial evidence indicated possible poaching of radio tagged salmon from the Tucannon River. In 1992, seven salmon were suspected of being poached, four of them (tags 24, 61 code 74, 57 code 52, and 61 code 59) were last tracked, or their transmitters recovered, near a popular fishing hole associated with a campground. Up to 40 tagged and untagged salmon were observed holding in this pool from 22 May to 8 September. Fishing or snagging tackle was found in this area as well.

Four tagged salmon were suspected of being taken prior to spawning (one wild and three hatchery salmon). The spine and fin of a salmon were found 100 m below Rainbow Lake outlet prior to spawning season. One day later, a transmitter (tag 19) and part of a salmon fin was found 50 m up Rainbow Lake outlet (which drains into the Tucannon River) in an area not suited for salmon usage. This fish had been observed five days before in good condition. Another fish was found laying on a rip rap bank with it's transmitter (tag 61 code 74) five feet away on the shoreline, between the rocks in the water. Another tagged salmon (tag 60 code 69) was found dead with a hole through its back and a punctured kidney. Finally, the last tracked location of another tagged salmon (tag 24) was near a campground frequented by fishermen. The signal had been strong the day before it vanished prior to spawning season.

Three more tagged salmon could have been poached, although the evidence is less compelling (they could have died of other causes or had tag malfunctions). All of these fish were tracked to campgrounds frequented by fishermen. A wild tagged salmon (tag 57 code 52) was last located at a popular fishing hole (hatchery intake) six days before it disappeared. Two tagged hatchery fish were found dead, one of which was located at the shoreline with the transmitter (tag 12) laying beside it. The other hatchery fish (tag 61 code 59) had been dead a couple of weeks when it was recovered near the shore. This salmon was tagged just 20 days before its carcass was recovered however, which indicates it was a possible tagging mortality.

Salmon movements and spawning: The severe drought in 1992 caused lower river flows, higher water temperatures, and higher mortalities of tagged and untagged salmon than in previous years. Due to high prespawning mortalities, only nine tagged fish provided us with substantial tracking data. Some radio tagged wild salmon moved farther upstream in their initial movements (Figure 9 and 10) than tagged hatchery fish (Figures 11 and 12). All tagged salmon "staged", or "held" (remained relatively stationary for weeks or months with only relatively short movements between holding areas), during most of the summer. Two tagged wild fish moved upstream into the Wilderness Stratum (RK 74.5). Both salmon remained in this stratum until we recovered their carcasses (one salmon died prior to spawning). As in previous years no radio tagged hatchery salmon were observed in the Wilderness Stratum.

Tagged fish generally held in a pool or run associated with undercut banks, or woody debris, for up to 106 days (compared to a maximum of 101 days in 1991, 90 days in 1990, and 77 days in 1989). We were unable to compare hatchery and wild holding behavior in 1992 because of the small number of fish that survived until spawning season. We lost contact with a wild salmon (tag 57 code 52) that held for 106 days prior to spawning. Two of the tracked fish were observed using boulder sites (habitat improvements) for holding. A wild radio tagged female (tag 15) held for seven days in a boulder site prior to spawning. A hatchery female (tag 12) also used a boulder site for six days before moving to another holding location.

As in 1991, the influence area of a spring was used for salmon holding during the summer. A hatchery male salmon (tag 21) was observed holding (83 days) beneath an undercut bank in an area immediately downstream of the inflow of a spring. In 1991, a wild male held at the same location for 79 days. The spring continued flowing throughout the summer in 1991 and decreased river water temperatures by about 1.2°C (range of 0-3.3°C) where the fish held. In 1992, the spring started drying up in June and was completely dry by July 14.

Spawning: Spawning of radio tagged salmon occurred from 21 August to 8 September. Seven fish were tracked into the spawning season. This includes two wild males (tags 13 and 57 code 52) and one hatchery female (tag 11) that we lost contact with before we could confirm whether these fish spawned.

Spawning was confirmed for four radio tagged salmon; three wild females, and one hatchery male. We were unable to locate where one wild female (tag 18) spawned, because of a tag malfunction. Her spent carcass was recovered in the HMA Stratum (RK 73.9). Another wild tagged female (tag 15) spawned in the HMA Stratum (RK 70.9) and one wild tagged female (tag 23) spawned in the Wilderness Stratum (RK 77.8). We saw one hatchery male (tag 21) spawn several times at RK 59.6 and 61.6 in the HMA Stratum. We did not observe any radio tagged fish spawning with fish of different origin (hatchery/wild), although we did observe untagged salmon mating with fish of different origin as far upstream as Panjab Bridge (RK 74.5).

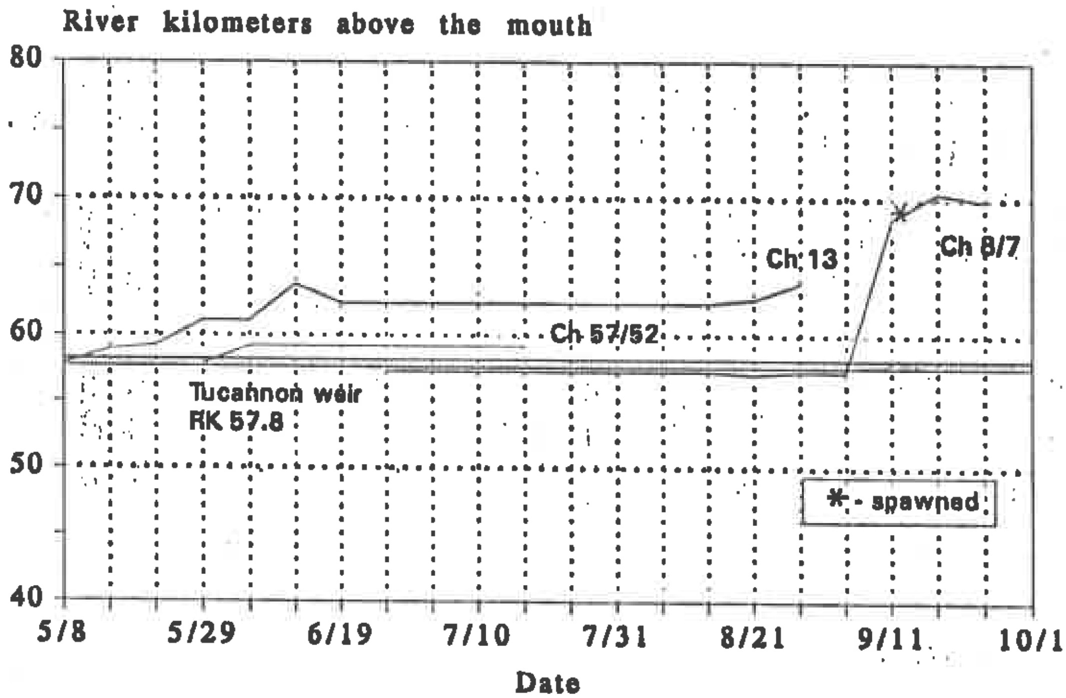

Figure 9. Movements of three radio tagged wild male spring chinook salmon (tags 13, 57 code 52, and 8 code 7) past the Tucannon FH in 1992. Channel 8 code 7 was radio tagged by the University of Idaho and released at Ice Harbor Dam.

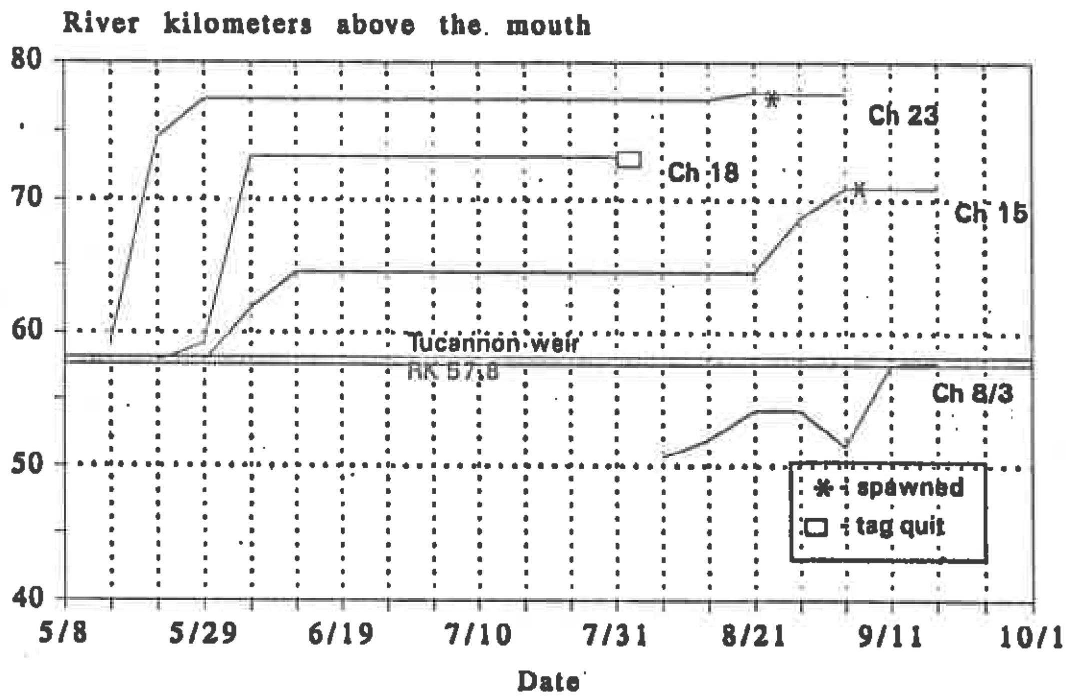

Figure 10. Movements of four radio tagged wild female spring chinook salmon (tags 23, 18, 15, and 8 code 3) in the Tucannon River in 1992. Channel 8 code 3 was radio tagged and released at Ice Harbor Dam by the University of Idaho.

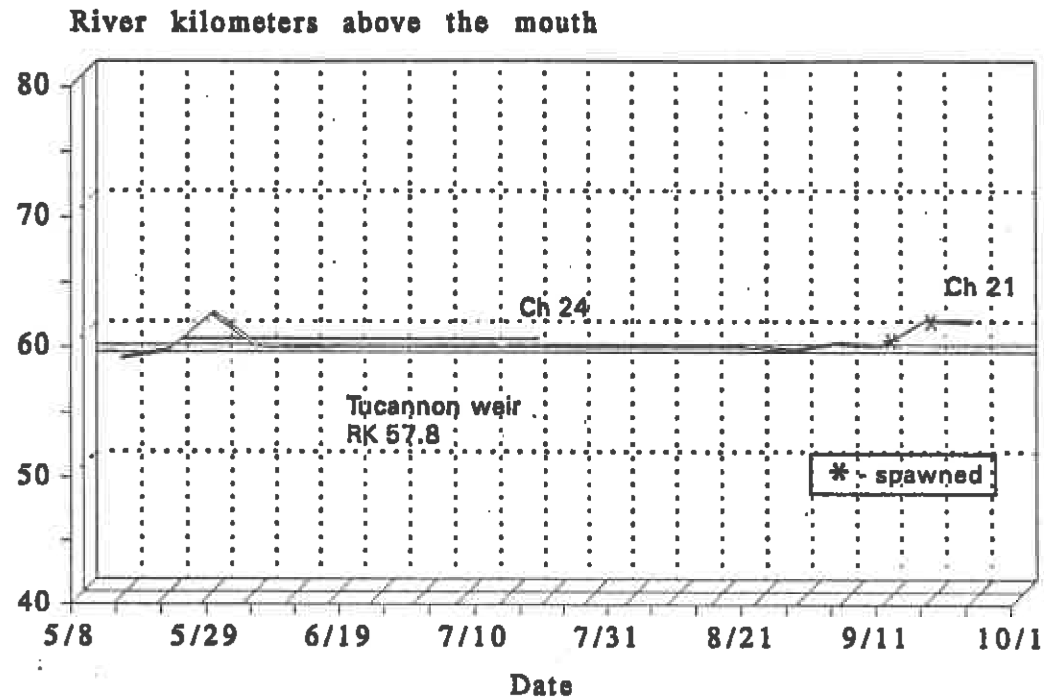

Figure 11. Movements of two radio tagged hatchery male spring chinook salmon (tags 21 and 24) past the Tucannon FH in 1992.

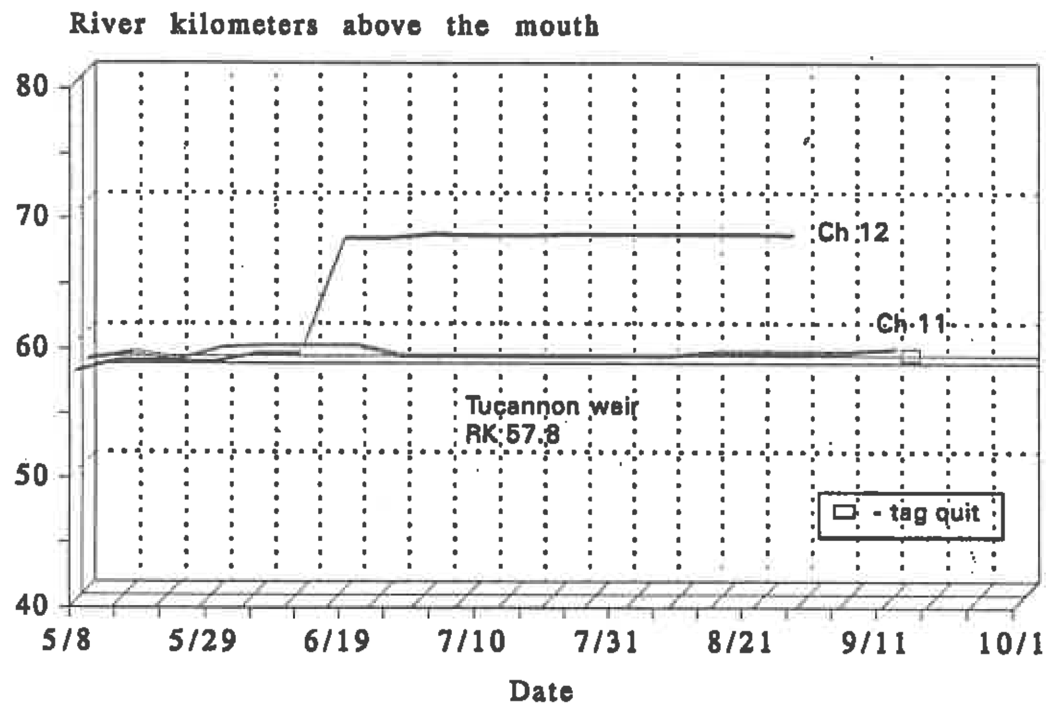

Figure 12. Movements of two radio tagged hatchery female spring chinook salmon (tags 12 and 11) past the Tucannon FH in 1992.

Discussion: This was our fourth year of radio telemetry, but only our third year of tracking hatchery fish. Tagged wild and hatchery salmon behaved as in past years (Bugert et al. 1992). Some regurgitation occurred (as much as 17.2%), as in previous years. Tagged hatchery fish had a higher overall mortality (9 fish, 31.0%) than tagged wild fish (6 fish, 20.7%). Generally fish reduced their movements and began to "stage" or "hold" in mid-May or early-June. Tagged fish limited their movements until mid-August or early September, often increasing the frequency of movement and noticeably changing their locations just prior to spawning. Wild and hatchery salmon usually selected pools and runs with undercut banks or overhanging logs and root wads to provide cover during holding. Boulder sites constructed in 1984 (Hallock and Mendel, 1985) were used for holding to a lesser degree; one wild and one hatchery salmon in 1992 (7 and 6 days), one wild fish in 1991 (20 days), two wild fish in 1990 (44 and 54 days), and one wild fish in 1989 (6 days).

Tagged wild females spawned in the Wilderness and HMA strata in 1992. No tagged hatchery females were observed spawning (due to the small sample size). The one radio tagged male (hatchery) we observed spawning was in the HMA Stratum (RK 59.6). We did not observe tagged females spawning over previously dug redds, as we did in 1990. However, redds were often found clumped together (possibly the result of multiple redd building). Observations of individual males spawning with several females were noted several times, a behavior observed in coho salmon by Gross (1984, 1985). Once spawning began females tended to stay in the vicinity of their redd (mean of 9.5 days), while males covered large areas seeking mates. Carcasses of females were usually found within 200 m of their respective redds.

University of Idaho radio tagged salmon: In 1992, we also tracked 15 spring chinook salmon that were radio tagged by the University of Idaho at Ice Harbor Dam. We collected few data regarding run timing for fish entering the Tucannon River because of an error in receiver programming. On 13 August, the receivers were modified to correctly monitor all University of Idaho tagged salmon.

We recovered seven tags without finding the carcasses. Quite often no movement was documented from the time we initially received signals from these tags until recovery. The tags could have been regurgitated or the fish taken from the river because many tags were recovered without any sign of a carcass. Two radios (tags 5 code 35 and 10 code 7) were recovered in the Lower Stratum (RK 4.5 and 5.0) and two radios (tag 10 code 12 and 10 code 28) were recovered in the Marengo Stratum (RK 24.1 and 22.9) prior to spawning. One transmitter (tag 8 code 19) was recovered in the Hartsock Stratum (RK 54.6) and another two tags (tags 8 code 8 and 2 code 1) were recovered in the HMA Stratum during spawning season, but we do not know if these fish spawned.

Pre-spawning mortality was confirmed for four salmon. Three of these carcasses were recovered in the Lower Stratum. Only bones were found of one tagged hatchery carcass (tag 5 code 39; RK 0.2) and two other recoveries (wild fish; tags 2 code 3 and 2 code 35) had substantial evidence indicating they were poached. The other hatchery salmon (tag 2 code 19) traveled into the HMA Stratum, past the Tucannon FH weir and died at RK 58.2 of unknown causes. Another tag was located in a deep pool but we were unable to recover it. No movement was documented during tracking and we do not know whether this fish spawned or regurgitated its tag.

Of the 15 fish tagged by the University of Idaho only three fish were verified alive during spawning. One wild tagged salmon (tag 9 code 3; sex unknown) was recovered in the Hartsock Stratum (RK 46.3) with redds present nearby. However, it is unknown if this fish spawned. One tagged wild female salmon (tag 8 code 3) spawned somewhere below the Tucannon FH weir and was recovered at (RK 57.6). The redd location of this fish is unknown although there were redds in the area where she was recovered. One wild tagged male (tag 8 code 7) passed the weir between 8-11 September and was observed on a redd at RK 68.9, in the HMA Stratum.

Due to problems with receiver programming, we obtained little tracking data from spring chinook salmon tagged by the University of Idaho. An extremely high percentage of tags were recovered without carcasses. Next year we will begin tracking earlier to document run timing of spring chinook into the Tucannon River and evaluate their migration timing and what happens to these salmon as they move through the lower river.

3.3.2: Pre-spawning mortality

All fresh salmon carcasses found were examined externally and internally to determine the cause of death. We collected blood, gills, hind gut and kidney samples from several fresh carcasses and sent them to WDF pathologists for examination. Generally, all efforts to determine the causes of death were inconclusive. Some samples were unusable and others did not indicate any parasites or disease organisms that may have caused mortalities. However, it was noted that gill samples from one fish collected on 9 June did contain two different bacteria (Epithelialcystis sp. and Tricidina sp.), but it is unknown if they caused the fish's death.

In 1992 we noted substantial pre-spawning mortality of salmon in the Tucannon River during May and early June. We often found dead or dying fish on the weir. By 1 June we had documented nine hatchery females and one wild female that were found dead on the weir. Most of these carcasses were healthy looking and did not show any internal or external signs of disease or injury that could have caused death. We did note that a day or so prior to death some fish upstream of the weir seemed weak and lethargic.

The number of carcasses we recovered from the weir in May and early June in 1992 was substantially higher than our observations during previous years. Few prespawning mortalities had been recovered from the weir or elsewhere in the river in past years. Therefore, in June 1992 we initiated surveys of portions of the river upstream and downstream of the weir to collect and document prespawning mortalities and to collect biological samples in an effort to determine the cause of death. Surveys were conducted upstream of the weir (RK 59.8 to the weir at RK 57.8) on 5 June and during our frequent radio tracking surveys. We surveyed from the weir downstream to Bridge 14 (RK 51.5) on 11, 17, and 30 June, and from Bridge 14 to Bridge 13 (RK 48.9) on 18 June. Two decomposed carcasses were located during the 11 June survey downstream of the weir, while no carcasses were found during other carcass surveys. The 17 June survey was conducted by snorkeling from the weir to Bridge 14. Approximately 50 live salmon were seen, but no dead fish. Additional salmon carcasses were located in the river during our radio tracking efforts. Many live salmon upstream of the weir were observed with fungus several days prior to their death and recovery on the weir. We believe that fungus may have been responsible for many deaths of salmon we recovered in late June and July, when flows were low and temperatures increased.

A total of 81 salmon carcasses were found prior to spawning season. By mid June we had recovered 25 hatchery fish (24 females and one male) and seven wild salmon carcasses (five females, one male and one of undetermined sex). By the end of June the numbers had increased to 37 hatchery fish (34 females) and 11 wild fish (nine females). Few carcasses of wild fish were recovered between the end of June and late August, but dead hatchery fish continued to be recovered throughout the summer. The high incidence of hatchery females dying prior to spawning was consistent with our observations of salmon held in the hatchery for broodstock in past years. A total of 54 hatchery salmon carcasses were found in the river prior to spawning in 1992 (41 females, 11 males, and two of unknown sex). Of these carcasses, 25 females, four males were found dead on the weir, one female and two males were found dead in the trap, 10 females and one male were recovered between the hatchery weir and the hatchery intake, three females and four males were recovered above the hatchery intake, one female was recovered below the weir, plus one female and two fish of unknown sex were found in the lower river. Nine of the fish that were recovered had been radio tagged, one of which died directly as a result of the tagging.

Twenty-seven wild salmon were found dead prior to spawning (13 females, nine males and five unknown sex). Of these 27 fish, six females and one male were recovered on the hatchery weir, eight males were found dead in the trap in late August and September, four females were recovered between the hatchery weir and the hatchery intake, two females and one male were recovered above the hatchery intake, one female and three unknown sex were recovered in the lower Tucannon, and one unknown sex and origin fish was found during a carcass survey below the weir. Ten of these carcasses had been radio tagged (four by University of Idaho and six by WDF).

3.3.3: Spawning ground surveys

Tucannon River: Program staff surveyed 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. Eight weekly spawning ground surveys were conducted over ten days; 19, 27 August, 2 and 3, 9, 16, 23 and 29 September, and 6 and 7 October.

We found 200 redds in the Tucannon River in 1992 (Table 16). The number of redds sighted this year increased from the previous five-year mean of 136 redds (Table 17). The Tucannon River tributaries were not surveyed in 1992 because we saw little evidence of spawning there in previous years.

We found carcasses from 46 hatchery and 82 wild salmon during spawning ground surveys (Table 16). We examined 37 wild female carcasses; 35 were completely spawned out, one was 98% spawned out and one was 70% spawned out. We examined 31 hatchery female carcasses; 24 were completely spawned out, three were found containing 100% of their eggs, and we were unable to determine the percentage of eggs retained for the remaining four fish (carcasses decomposed).

Most salmon spawned in the HMA and Hartsock strata as in 1991 (Tables 16 and 17). Redd densities increased in the Wilderness, HMA and Hartsock strata, but decreased in the Marengo Stratum (one survey only). Our surveys of the Marengo Stratum were limited to the upper six km as in previous years.

Table 16. Numbers of salmon redds observed and general locations of hatchery and wild carcasses recovered during spawning ground surveys on the Tucannon River 1992.

Stratum	River km[b]	Number of redds	Carcasses recovered[a] Hatchery male	Hatchery female	Hatchery jack	Wild male	Wild female
Wilderness	86-78	6					
	78-75	11					1
HMA	75-73[c]	15				2	1
	73-68[d]	36		6	1	9	8
	68-66	14	6	4		8	1
	66-62	19		3		2	6
	62-59	20	2	8		5	1
	59-58	9	4	7		7	2
	58-56	38	1	3		7	14
Hartsock	56-52	15					3
	52-47	9			1	2	2
	47-43	5					1
	43-40	2					
Marengo	40-34	1					
Totals		200	13	31	2	45	37

[a] Does not include carcasses recovered prior to spawning season or during radio tracking surveys.
[b] *Supplemental index area.*
[c] *Historical index area.*
[d] *Revised river distances (km) in 1992, area descriptions are in appendix J.*

Carcasses of wild salmon were recovered from every stratum except the Marengo Stratum; no hatchery carcasses were found in the Wilderness or Marengo strata during spawning ground surveys in 1992. However, live hatchery fish were observed in all strata.

Peak of salmon spawning varied among strata. Peak spawning activity in the Wilderness and HMA strata was approximately 9 September, but 16 September in the Hartsock Stratum. Two redds were observed in the Wilderness Stratum on 27 August and one new redd was dug in the Marengo Stratum on 7 October, indicating the duration of spawning to be at least 42 days, compared to 35 days in 1991, and 44 days in 1990.

Table 17. Comparison of Tucannon River salmon redd densities in redds/km, (redds/ha), and total redds by stratum and year [a].

Stratum	1985 redds/km (/ha) redds	1986 redds/km (/ha) redds	1987 redds/km (/ha) redds	1988 redds/km (/ha) redds	1989 redds/km (/ha) redds	1990 redds/km (/ha) redds	1991 redds/km (/ha) redds	1992 redds/km (/ha) redds
Wilderness	7.10 (9.45) 84	4.49 (5.96) 53	1.27 (1.69) 15	1.53 (2.02) 18	2.46 (3.26) 29	1.69 (2.25) 20	0.25 (0.34) 3	1.44 (1.91) 17
HMA	5.33 (4.78) 105	6.16 (5.32) 117	7.37 (6.37) 140	4.16 (3.59) 79	2.84 (2.46) 54	4.95 (4.28) 94	2.95 (2.55) 67	7.95 (6.87) 151
Hartsock	- -	1.86 (1.51) 29	1.92 (1.56) 30	1.28 (1.04) 20	1.47 (1.20) 23	4.10 (3.33) 64	1.86 (1.51) 18	1.99 (1.61) 31
Marengo	- -	0.00 0	- -	- -	- - (0.26)	0.34 (0.26) 2	0.34 (0.13) 2	0.17 1
Total redds	189	200 [b]	185	117	106	180	90	200

[a] *Distance measurements were modified in 1992, therefore the entire table is revised from previous reports.*
[b] *Includes one redd observed in Panjab Creek in 1986.*

<u>Historical Index:</u> Spawning surveys have been conducted in an index area (from Cow Camp Bridge downstream to Camp Wooten Bridge - RK 72.9-68.1) in the HMA Stratum since 1954 (See Appendix J for a description of the Historical Index Area and how the survey dates are currently selected). Thirty-six redds were observed in the historical Index Area in the HMA Stratum in 1992 (Figure 13).

A Supplemental Index area was established in 1980 which includes additional portions of the HMA Stratum from Panjab Bridge (RK 74.6) to Cow Camp Bridge (RK 72.9). Fifty-one redds were found in the combined Index and Supplemental Index areas in 1992.

The number of redds observed in the historical index area has declined substantially over the years, with a noticeable reduction since 1985. A similar reduction in redd counts is also obvious in the supplemental index area in the upper portion of the HMA Stratum, as well as throughout the Wilderness Stratum (Table 17, Figure 14). Additionally, the proportion of the total redds counted annually in the Tucannon River that were contained within these two index areas (during specific index survey dates) has declined. These reductions appear to be caused by a change in the spawning distribution of salmon in the Tucannon River. This is further documented by an increase in the proportion of

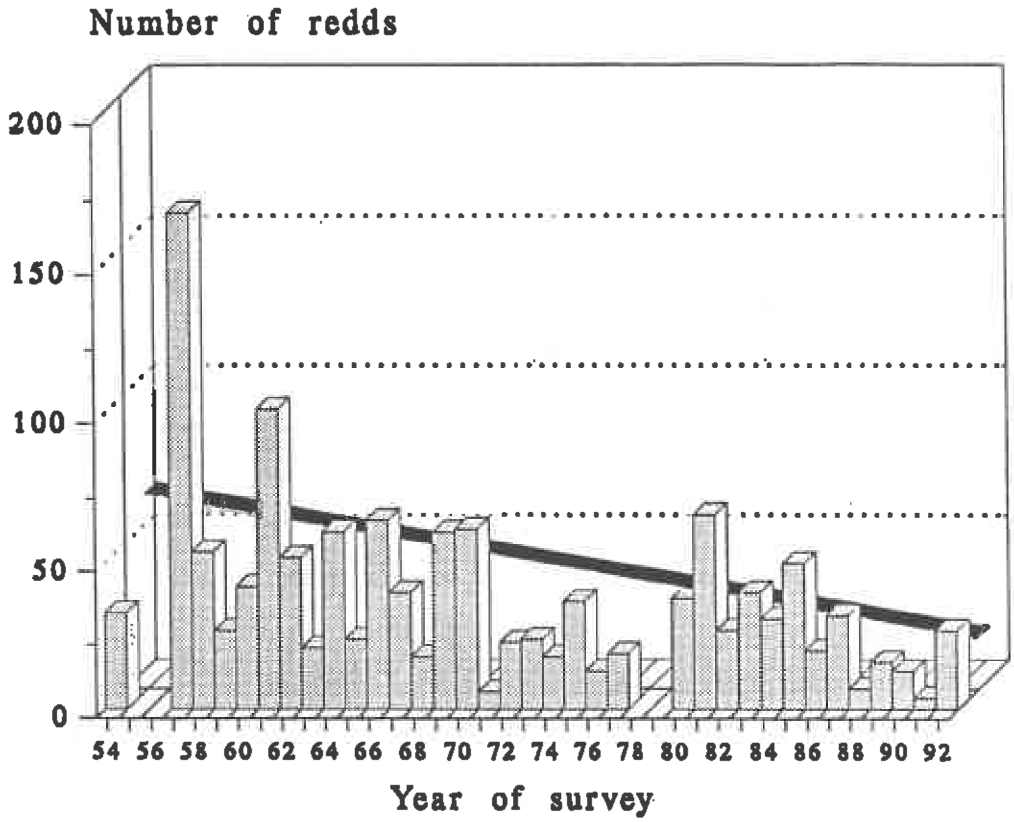

Figure 13. Revised salmon redd counts (one survey/year) within a 4 km index area (Cow Camp Bridge to Camp Wooten Bridge) 1954-1992 (Temporary adult trap was used in 1986-1989, permanent trap used for 1990-1992). Line shown is trend line.

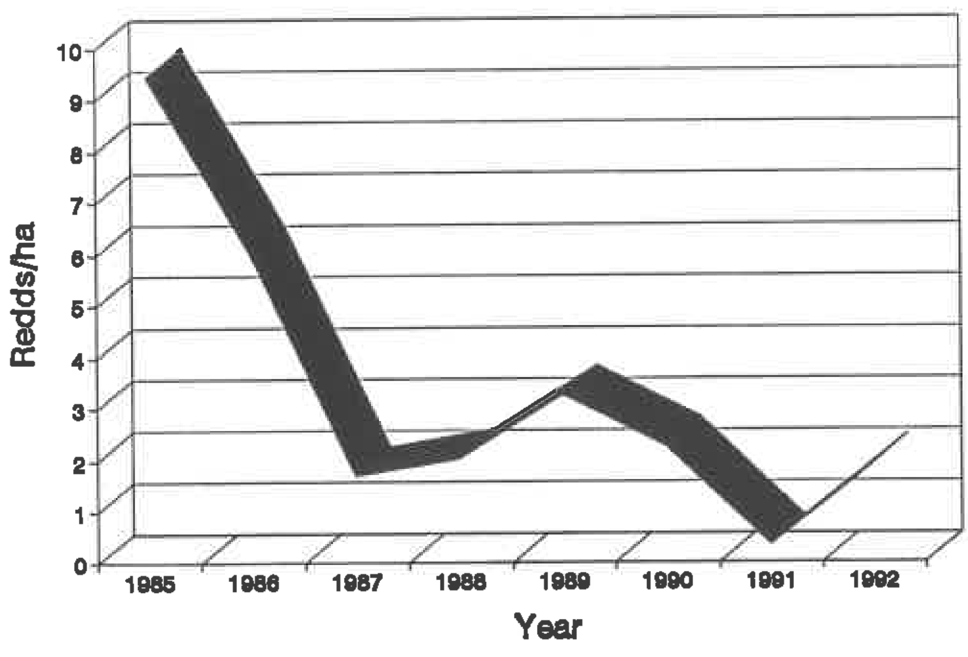

Figure 14. Redd densities in the Wilderness Stratum of the Tucannon River, 1985-1992.

the total redds that occurred downstream of the weir since 1986 (Table 18, Figure 15). Redd counts below the weir have increased every year since 1986, except in 1992. One hundred-thirty redds were documented above the Tucannon Hatchery weir in 1992, while 70 redds were found below the weir. However, the noticeable reduction in redds in the index area can be partially explained because a significant number of fish were collected at the trap for broodstock each year since 1986. The shift in proportions of redds upstream and downstream of the weir can also be partially explained by trapping broodstock and increased surveys downstream of the weir since 1986.

Table 18. Redd distribution in relation to the hatchery weir, 1986-1992 (not surveyed below the weir site in 1985).

Year	Redds above weir	Redds below weir	Total redds	Percent of total below weir
1986	163	37	200	18.5
1987	149	36	185	19.5
1988	90	27	117	23.1
1989	74	32	106	30.2
1990	96	84	180	46.7
1991	40	50	90	55.6
1992	130	70	200	35.0

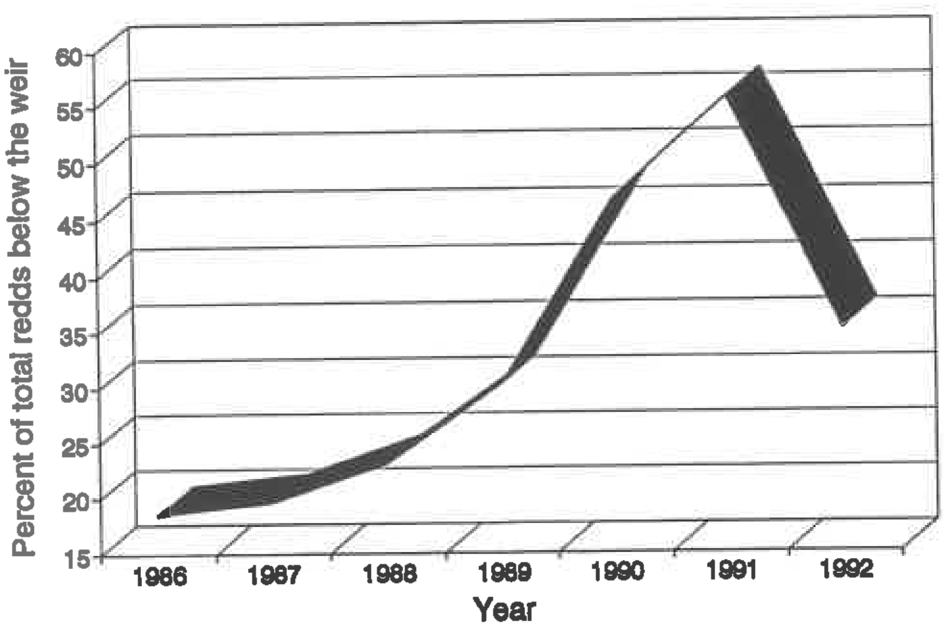

Figure 15. Percentage of the annual total of salmon redds found below the Tucannon FH weir, 1986-1992.

Asotin Creek: On 17 September we surveyed the North Fork of Asotin Creek from 0.8 km above Lick Creek upstream 5.6 km, for spring chinook salmon redds. No redds were found in 1992, or in 1991. Two redds were observed in 1990, none in 1989, one in 1988, three in 1987, one redd in 1986, and eight redds in 1985.

Wenaha tributaries: Tributaries of the Wenaha River that extend into Washington State and contain spring chinook salmon are the North Fork Wenaha River and Butte Creek. No survey was conducted on the North Fork Wenaha River in 1992. We surveyed Butte Creek from the confluences of Dickinson Creek and West Fork Butte Creek downstream to the Oregon/Washington border on 13 and 14 September. Fourteen redds were observed in approximately 6.4 km for a density of 2.2 redds/km. Two live females were observed and one dead hatchery female was recovered. The CWT from the carcass indicated the fish was a stray from Lookinglass FH.

3.3.4: Adult escapement

In general, redd counts are directly related to escapement to the Tucannon FH weir (Bugert et al. 1991). We estimated the total escapement to the Tucannon River (salmon known upstream of trap/weir, plus salmon estimated downstream) for 1985-1992 (Table 19). These estimates are an expansion and revision of the escapement estimates contained in previous reports.

The number of females above the weir is based on the female-to-male ratio of broodstock and carcasses collected and the number of salmon released upstream of the weir. We then used the number of females estimated to be above the trap and redds counted above the weir to estimate female-to-redd ratios upstream of the trap. This value, multiplied by the number of redds counted downstream of the trap, yields the estimated number of females downstream. Based on the female-to-male ratio of broodstock and carcasses we can extrapolate the number of males downstream of the trap as well. Total estimated escapement is the sum estimated number of males and females above and below the weir, and the fish collected for broodstock. The estimated escapement is separated into hatchery or wild origin based on the annual proportion of hatchery-to-wild salmon escaping to the trap.

Revised escapement estimates for 1989-1991 are substantially higher than estimates given in previous reports. We now account for escapement downstream of the weir as well as those fish that passed the trap site after the temporary weir had been removed prior to 1990.

Table 19. Estimated adult salmon escapement to the Tucannon River from 1985 through 1992.

Year	Female /male ratio[a] (A)	Total number of redds (B)	Female /redd ratio[b] (C)	Estimated salmon in river[c]	Salmon collected (broodstock)	Estimated total escapement	Percent wild[d]
1985	1.1	189[e]	1.80	649	15	664	100.0
1986	1.1	200	1.80	687	116	803	100.0
1987	1.2	185	1.80	611	101	712	100.0
1988	1.8	117	1.80	328	119	447	97.3
1989	0.8[f]	105	1.80	425	92	517	47.2
1990	1.0	181	1.73	626	126	752	54.0
1991	0.7	90	1.87	408	130	538	35.0
1992	1.1[g]	200	1.80	687	97	784	44.2

[a] *Female/male ratio calculated from broodstock and carcass collections.*
[b] *1985-1989 female/redd ratio based on 1990-1992 average because during these years the weir was removed while fish were still arriving and numbers above the weir would be an underestimate.*
[c] *Calculated as (BxC)/A equals number of males, plus BxC (number of females).*
[d] *Percent wild fish returns calculated from fish counted at the trap.*
[e] *1985 redd counts are from Wilderness and HMA strata only.*
[f] *1989 female/male ratio based on wild salmon only. Inclusion of hatchery fish would have biased the data since all hatchery fish were collected.*
[g] *Female/male ratio calculated from broodstock collection and carcasses from spawning ground surveys. Prespawning mortality in 1992 was high, and contained a high proportion of females which would bias the female/male ratio.*

3.3.5: Stray returns

We extracted and read CWT prior to fertilizing the eggs to prevent inclusion of genetic material from stray stocks into the Tucannon River stock. Forty-five CWT were read; no tags from stray fish were recovered from broodstock collected in 1992.

Four of 97 CWT were recovered from stray spring chinook salmon in the Tucannon River in 1992. Two 1989 brood year (BY) from Meacham Creek (7-51-11, 7-50-63) and two (1989 BY) from Bonifer Ponds (7-51-7), tributary to the Umatilla River. These recoveries expand (based on mark rate) to six marked fish from each release location (12 total) expected to have escaped to the Tucannon River in 1992. No stray tags were recovered in the Tucannon River or at the hatchery in 1991, but in 1990 we recovered CWT from two fish from Meacham Creek, Umatilla River, two NMFS McNary release groups, and one CWT from Lookingglass FH, Grande Ronde River. No other stray fish with CWT have been recovered from the Tucannon River since the inception of this program.

3.4: Survival Rates

Smolt-to-adult survival estimates prior to 1991 were based only on actual salmon counts at the Tucannon FH weir. Redd counts conducted since 1990 show a high number of salmon spawning downstream of the permanent weir. We believe few adult salmon move downstream over the weir. Therefore, trap counts do not accurately reflect the total number of salmon escaping to the Tucannon River because salmon remaining downstream of the weir are not included. Similar to last year's report we have revised our escapement estimates to include all known salmon in the Tucannon River (Section 3.3.4). Total annual estimated escapement is then separated into wild or hatchery based on the proportion of hatchery-to-wild salmon that escaped to the weir for that year.

Using our revised escapement estimates and proportions of hatchery and wild returns each return year, we are able to calculate smolt-to-adult and egg-to-adult survival for hatchery and wild salmon. Comparisons of survival rates between salmon produced naturally in the river and the hatchery are now possible.

3.4.1: Hatchery salmon

Survivals to various life stages were calculated (Table 20) from data presented in Section 2.2. Mean survival from egg-to-fry (parr) for 1985-91 broods is 79.1% (SD=10.0). Mean survival from fry-to-smolt and egg-to-smolt is 97.5% (SD=1.8) and 77.0% (SD=9.2), respectively. Estimates of survival from smolts to returning adults can be calculated by using CWT recoveries.

Hatchery salmon have been returning to the Tucannon River since 1988. Known returns from the 1989 release (1987 brood) through age 5 is 87 fish (0.05%). Returns for 1990 and 1991 releases are not complete (Table 21). Appendix F lists specific CWT recoveries for all release years.

Table 20. Summary of survival rates by brood year for Tucannon River spring chinook salmon spawned and reared at the Tucannon/Lyons Ferry FH.

Brood year	Percent egg to fry	Percent fry to smolt	Percent egg to smolt
1985	89.2	97.6	87.1
1986	84.7	96.6	81.8
1987	79.9	96.9	77.4
1988	84.4	94.3	79.6
1989	74.8	99.2	74.2
1990	58.7	99.0	58.1
1991	82.0	98.9	81.1

Table 21. Known and expanded returns (based on escapement estimates and age composition) of hatchery salmon to the Tucannon River for brood years 1985-1989. Ages are from coded-wire tag recoveries and fitted ages by length or scale analysis through 1992.

Year released (brood)	Number of smolts released	Escapement			Percent returns (expanded)
		Age 3	Age 4	Age 5	
1987 (1985)	12,922	9 (12)	24 (64)	0 (0)	0.26 (0.59)
1988 (1986)	153,725	79 (209)	104 (321)	8 (22)	0.12 (0.36)
1989 (1987)	152,165	8 (25)	72 (200)	8 (22)	0.06 (0.16)
1990 (1988)	146,239	46 (129)	139 (397)	- -	0.13 (0.36)
1991 (1989)	99,057	7 (20)	- -	- -	0.01 (- -)

3.4.2: Wild salmon

We have estimated salmon populations in the river at various life stages since the 1985 brood (Table 22). From these population estimates we calculated survival rates from egg-to-smolt (Table 23) to compare between salmon produced in the hatchery in the river. All escapements and survival estimates reported here are revisions of estimates reported previously. Mean egg-to-fry survivals for 1985-1991 broods is 7.6% (SD=1.7), while mean survival rates for fry-to-smolt and egg-to-smolt for 1985-1990 broods are 54.5% (SD=13.1) and 3.8% (SD=0.8), respectively. These mean survival rates are approximately 10-56% of the mean survival rates documented for salmon spawned and reared at either Lyons Ferry or Tucannon FH.

Table 22. Estimates of wild Tucannon spring chinook salmon abundance by life stage for 1985 through 1992 broods.

Brood year	Number of redds	Females in river[b]	Mean fecundity	Number of eggs[d]	Number of fry[e]	Number of smolts[f]
1985	189[a]	340	4,006[c]	1,362,040	90,200	35,600
1986	200	360	3,916	1,409,760	102,600	58,200
1987	185	333	4,095	1,363,635	79,100	44,000
1988	117	211	3,882	819,100	69,700	37,500
1989	105	189	3,608	681,910	58,600	25,900
1990	181	313[g]	3,507	1,076,650	64,100	49,500
1991	90	168[g]	3,260	524,860	54,800	- -
1992	200	360[g]	3,524	1,078,340	- -	- -

[a] *Wilderness and HMA redd counts only (does not include Hartstock or Marengo)*
[b] *Adult estimates from 1985-1989 based on a female/redd ratio of 1.8 (average of 1990-1992), and expansions from that ratio with total redd counts. Adult estimates for 1990-92 based on annual female/redd ratios and total redd counts.*
[c] *Average of 1986 and 1987 fecundities because of small sample of females in 1985.*
[d] *Number of females (from female/male ratio in Table 19) multiplied by mean fecundity.*
[e] *Number of fry (parr) estimated from electrofishing and snorkel surveys.*
[f] *Number of smolts estimated from smolt trapping.*
[g] *Minus female prespawning mortalities (6 in 1990, 7 in 1991, and 54 in 1992). Prior to 1990 prespawning mortalities observed in the river was negligible.*

Table 23. Summary of survival rates by brood year for wild salmon in the Tucannon River.

Brood year	Percent egg to fry	Percent fry to smolt	Percent egg to smolt
1985	6.6	39.5	2.6
1986	7.3	56.7	4.1
1987	5.8	55.6	3.2
1988	8.5	53.8	4.6
1989	8.6	44.2	3.8
1990	6.0	77.2	4.6
1991	10.4	- -	- -

Smolt-to-adult survival estimates are based on annual estimated escapements for wild fish and estimated age structure (Table 24). Age structure was estimated from annual broodstock collections and carcass recoveries. Known recoveries from all age groups for a particular return year were multiplied by the estimated wild salmon escapement to the river for that year.

Expanded smolt-to-adult survival for 1987 brood salmon produced in the Tucannon River was 0.38% (169 salmon) through age 5 (Table 24). This survival rate is 138% higher than for salmon produced in the hatchery (0.16%, 1987 BY). Smolt-to-adult survival of salmon produced in the river is double the survival of hatchery salmon so far for the 1988 brood as well (incomplete returns).

Table 24. Known and expanded returns (based on escapement estimates and age composition) of wild (and natural-1988 and 1989 broods) salmon to the Tucannon River for brood years 1985-1989. Ages are fitted by fork lengths based on scale impressions.

Percent Brood year	Number of smolts emigrating [a]	Escapement				returns (expanded)
		Age 3	Age 4	Age 5	Age 6	
1985	35,600	9 (22)	110 (185)	36 (96)	- -	0.44 (0.85)
1986	58,200	1 (2)	116 (310)	28 (65)	1 (2)	0.25 (0.65)
1987	44,000	0 (0)	52 (121)	21 (48)	- -	0.17 (0.38)
1988	37,500	1 (2)	126 (287)	- -	- -	0.34 (0.77)
1989	25,900	5 (11)	- -	- -	- -	0.02 (- -)

[a] *Refer to Section 3.2.5 for smolt yield estimation.*

Overall, survival from smolt-to-adult is substantially higher for wild salmon than for hatchery salmon for each brood year. However, survival from egg-to-returning adult ranges from 0.01-0.03% (1985-1987 BY) for salmon produced in the river and 0.13-0.52% for salmon produced in the hatchery (1985-1987 BY).

3.4.3: Compensation progress

We estimate 784 salmon returned to the Tucannon River in 1992. This value reflects expanded escapements of both wild and hatchery salmon. Our preliminary estimates show a hatchery smolt-to-adult survival rate (0.16-0.59%) substantially below the design objective of 0.87%. It appears, based on CWT recoveries, that few salmon contribute to fisheries, or are recovered elsewhere outside the Tucannon River Basin.

We have identified several other concerns with this program beyond the total returns and return rates:

1) High annual prespawning mortalities either in the hatchery or in the river during any given year.
2) High annual mortalities from eggtake to eyeup and from egg-to-smolt within the hatchery, until 1992.
3) Adult returns that now differ in regards to spawning distribution and age composition of spawners since initiation of the hatchery program. Also, hatchery salmon appear to be generally smaller at a given age than wild salmon and are not well distributed in the upper Tucannon River.

Over the years we have made several changes in an effort to improve the hatchery program. The data suggest that survivals of adults and eggs in the hatchery were dramatically improved by transporting, holding, and spawning adult salmon at Lyons Ferry Hatchery instead of at the Tucannon FH in 1992. Another major change was to reduce the program from 132,000 yearlings to 88,000 yearlings, and to incubate the fish on chilled water.

SECTION 4: STOCK PROFILE ANALYSIS

To monitor long-term trends in stock profile characteristics of Tucannon spring chinook salmon, we collect stock identification data for genotypic analysis using electrophoresis, and various quantifiable measures of phenotypic expression such as run timing, fecundity, age structure and growth (scales, CWTs, and otoliths), adult body morphometry, juvenile body morphometry, and meristics.

4.1: Population Structure

4.1.1: Fecundity and egg size

Eighteen wild and 27 hatchery females were spawned at Lyons Ferry FH in 1992 (Table 3). Average fecundity and egg size (number/pound) were 3,475 eggs and 2,063, respectively (n=45). This estimate includes one female that had partially spawned in the raceway. Mean fecundity for females completely spawned during eggtake (n=44) was 3,524 (SD=700.0). Eggs/female was determined by dividing the total number of eggs taken by the number of females spawned. Mean fecundity based on incubation room counts for individual hatchery females (n=26)[1] was 3,295 eggs (SD=634), and for wild females (n=18) 3,854 eggs (SD=694). Fecundity is higher for wild females because they are generally older and larger than hatchery females and fecundity increases with size (Figure 16, Bugert et al. 1992). Wild females spawned in 1992 consisted of 16 age 4 fish and two age 5 fish. Hatchery females spawned consisted of 26 age 4 fish and one age 5 fish.

y = -4382.42 + 109.463x
n = 44
r = 0.5821

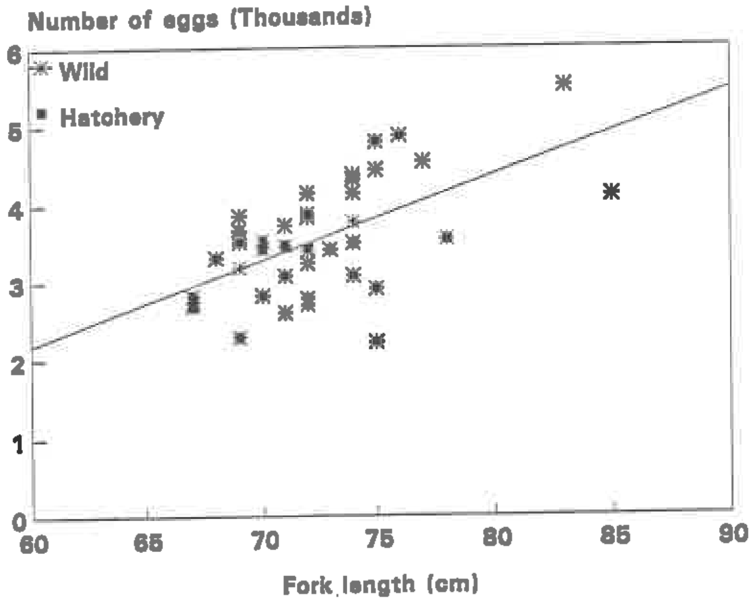

Figure 16. Relationship of fork length to mean fecundity of Tucannon River spring chinook salmon broodstock, 1992.

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[1] One female that had partially spawned and one that had completely spawned in the raceway are not included in this estimate (28 total).

4.1.2: Sex and age structure

Wild salmon: The sex ratio for all wild salmon that returned to the Tucannon River in 1992 was 0.9 females per male; this includes all age classes recovered from the river, or as broodstock at the hatchery (n=152 fish). The sex ratio for wild salmon sampled in the river or at Lyons Ferry FH was 0.91 and 0.88 females/male, respectively. Based upon scale analysis and

salmon fitted by fork length, 3.3% of the recovered salmon were age $3/_2$ (total age/years in freshwater), 82.2% were age $4/_2$, 13.8% were age $5/_2$, and 0.7% were age 6/2 in 1992 (Table 25). Salmon returning in 1992 at age 3 comprise the second year of returns of adult salmon that may be progeny of hatchery parents (hatchery/hatchery or hatchery/wild) that spawned in the river. Age classification from 1985-1991 is 1.3% age $3/_2$, 67.4% age $4/_2$, and 31.3% age $5/_2$ (n=527, Bugert et al. 1992).

Table 25. Sex, mean fork length (cm), and age (from scale impressions or fitted by fork length) for all wild salmon sampled in the Tucannon River and Lyons Ferry FH, or just at Lyons Ferry FH, 1992 (s=standard deviation, n=sample size).

	Mean length (s, n) at given age				
Sex	$3/_2$	$4/_2$	$5/_2$	$6/_2$	Totals
All Salmon					
Female	54 (-, 1)	69.2 (3.6, 58)	81.3 (5.2, 12)	88 (-, 1)	72
Male	52.7 (7.4, 4)	68.9 (4.9, 67)	84.0 (2.6, 9)	- -	80
Totals	5	125	21	1	152
Salmon at Lyons Ferry FH					
Female	- -	71.6 (2.8, 17)	85.3 (1.6, 4)	88 (-, 1)	22
Male	51.0 (-, 1)	70.6 (5.2, 22)	87.0 (1.4, 2)	- -	25
Totals	1	39	6	1	47

Wild fish collected as broodstock were quite similar in age to all wild fish sampled (Table 25). Age distribution for wild fish collected as broodstock was 2.1% age 3/2, 83.0% age 4/2, 12.7% age 5/2, and 2.1% age 6/2. Based on fork length, wild salmon collected for broodstock were less similar to wild salmon recovered from the river (Figure 17).

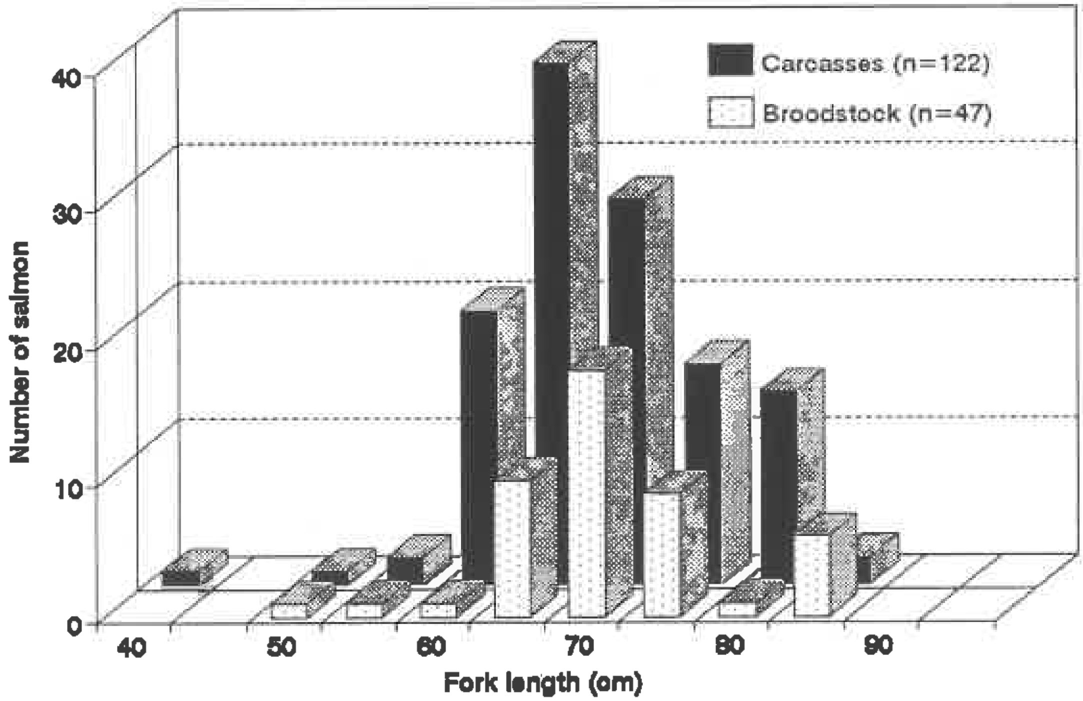


Figure 17. Length frequency distribution of wild salmon adults sampled as carcasses in the Tucannon River or at Lyons Ferry FH, 1992.

<u>Hatchery salmon:</u> Sex ratio of all hatchery salmon that returned to the Tucannon River in 1992 was 1.94 females per male; this includes all age classes (n= 147 fish) as well as fish recovered from the river, or as broodstock at the hatchery. The sex ratio for hatchery salmon sampled in the river or at Lyons Ferry FH was 2.4 and 1.3 females/male, respectively. We recovered 41 hatchery female prespawning mortalities in the river in 1992 which greatly affects the female/male ratios calculated. Also, carcasses of females probably have higher likelihood to be found than males during spawning surveys. Based upon CWT and scale analyses, 4.8% of the salmon recovered in 1992 were age $3/_2$, 89.8% were age $4/_2$, and 5.4% were age $5/_2$ (Table 26). Cumulative age structure for hatchery salmon from the Tucannon River (1988-1991) is 49.3% age $3/_2$, 49.6% age $4/_2$, and 1.1% age $5/_2$ (Bugert et al. 1992).

Returns of age 5 fish are limited to the 1991 and 1992 return years (1985, 1986, and 1987 broods), therefore the cumulative age structure is not comparable to cumulative returns of wild salmon.

Table 26. Sex, mean fork length (cm), and age (from code-wire tags and scale analysis) of all hatchery salmon sampled from the Tucannon River and Lyons Ferry FH, or just at Lyons Ferry FH, 1992 (s=standard deviation, n=sample size).

Sex	Mean length (s, n) at given age			Totals
	3/2	4/2	5/2	
All Salmon				
Female	- -	68.9 (3.8, 92)	77.4 (3.6, 5)	97
Male	49.7 (4.4, 7)	70.1 (4.1, 40)	82.0 (11.3, 3)	50
Totals	7	132	8	147
Salmon at Lyons Ferry FH				
Female	- -	71.1 (2.74, 26)	79.0 (1.4, 2)	28
Male	50.4 (5.2, 5)	69.7 (4.5, 15)	76.0 (-, 1)	21
Totals	5	41	3	49 [a]

[a] *Plus one male (63 cm) of unknown age; no readable scales or CWT; should be age 4 based on fork length.*

Hatchery fish collected as broodstock were slightly different in age compared to all hatchery fish sampled in 1992 (Table 26). Age distribution for hatchery fish collected as broodstock was 10.2% age 3/2, 83.7% age 4/2, and 6.1% age 5/2. Based on fork length, hatchery fish collected as broodstock differed from the hatchery fish recovered from the river (Figure 18). We had attempted to collect fish at random from the trap to eliminate any selection of broodstock. Age structure of all 1992 hatchery salmon recovered shows an increase (Figure 19) in the proportion of fish age 5 compared with 1991, and more closely approximates the proportions of wild returns (Bugert et al. 1992).

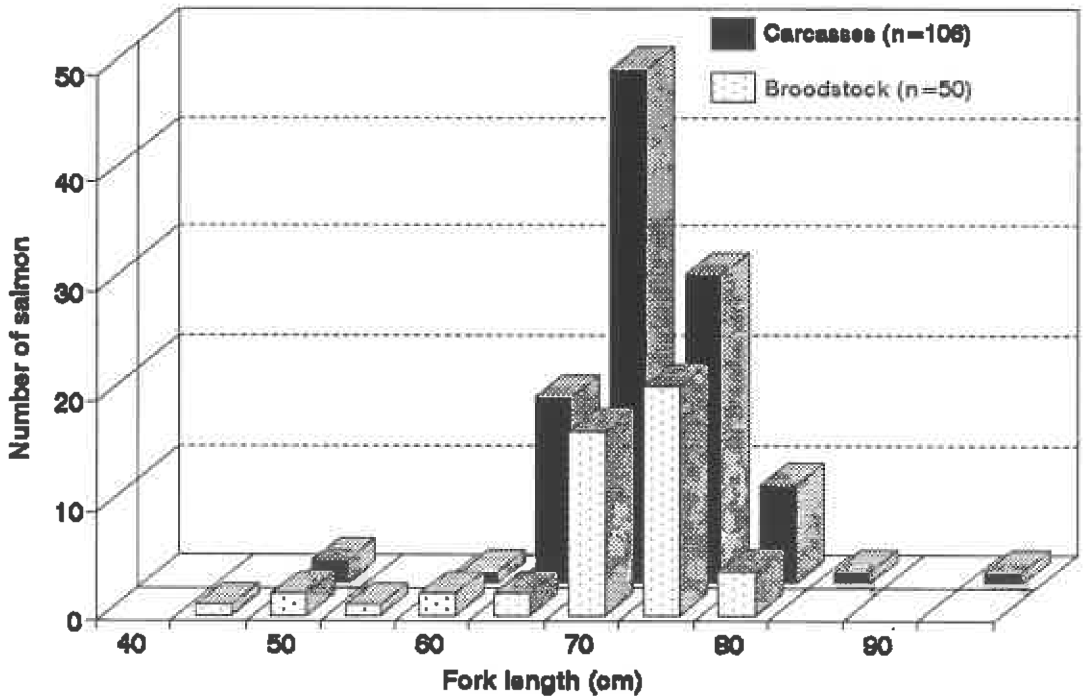


Figure 18. Length frequency distribution of adult hatchery salmon sampled in the Tucannon River or at Lyons Ferry FH, 1992.

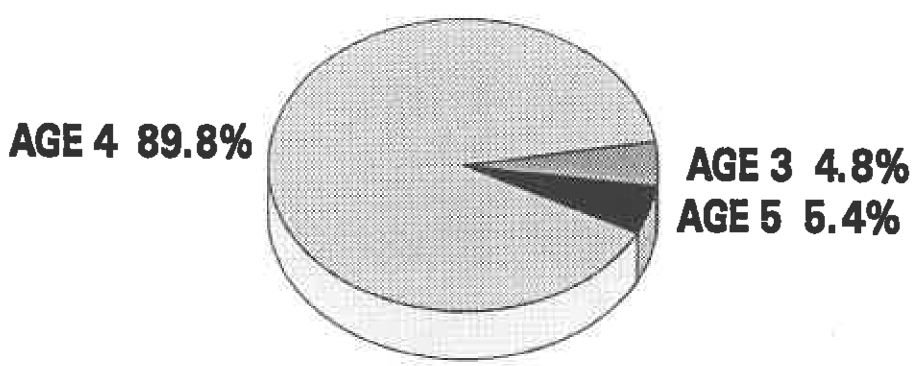


Figure 19. Age structure of hatchery fish (based on CWT or scales-for lost CWTs) from recoveries along the Tucannon River or at Lyons Ferry FH, 1992 (n=147 fish).

4.2: Electrophoretic Analysis

In 1992, evaluation program staff collected 100 electrophoretic samples each from 1991 brood hatchery chinook salmon of hatchery/hatchery parentage and wild/wild parentage prior to release. We also collected samples from 43 wild and 47 hatchery adult salmon collected for broodstock.

Tissue samples came from four 1991 collections: a) 101 1989 Brood juveniles produced in the hatchery ("BY-89 Hatchery"), b) 101 1989 Brood juveniles produced by natural spawning in the river ("BY-89 Wild"), c) 51 marked adults (from previous hatchery spawnings) that returned to the hatchery ("1991 Hatchery"), and d) 40 unmarked adults (from previous natural spawning in the river) that were brought into the hatchery for spawning in 1991 ("1991 Wild"). Two collections of juveniles from 1990 ("BY-88 Hatchery" and "BY-88 Wild) were also analyzed in 1992 by the WDF Genetics Unit using horizontal starch-gel electrophoresis and standard procedures for chinook salmon (appendixes 3-5 in Marshall et al., 1991). Locus and allele designations follow the system of Shaklee et al. (1990) and are consistent with those used in our 1990 progress report, with the exception that the enzyme previously identified as hydroxyacylglutathione hydrolase ("HAGH"; 3.1.2.6) is now recognized as formaldehyde dehydrogenase (glutathione) -("FDHG"; 1.2.1.1). Allele frequencies at the 24 loci exhibiting variation in one or more of these six collections are presented in Appendix K.

As in past years, the Tucannon spring chinook stock was monomorphic for many of the loci screened in these six collections. The invariant loci in all six collections were: sAAT-3*; ADA-2*; mAH-3*; GAPDH-2*; GPI-A*; GPI-B1*; GPIr*; GR*; mIDHP-1*; mIDHP-2*; sIDHP-2*; LDH-B1*; mMDH-3*; sMDH-A1,2*; sMEP-2*; PEPD-2*; PGDH*; PGM-1*; PGM-2*; TPI-1*; TPI-2*; and TPI-3*. Two additional loci (CK-A1* and CK-A2*) were monomorphic in the juvenile collections but were not screened in the adult collections. Similarly, two loci (G3PDH-3* and G3PDH-4*) were monomorphic in the adult collections but were not screened in the juvenile collections. Eighteen of the 24 loci in Appendix K have consistently exhibited variation in collections of Tucannon spring chinook salmon. However, six loci (sAAT-1,2*; LDH-B2*; sMDH-B1,2*; and PEP-LT*) that have frequently displayed little or no variation in past Tucannon collections exhibited rare variation in one or more of the six recent collections.

Tests of genotype counts against Hardy-Weinberg equilibrium expectations in all six collections yielded only three statistically significant deviations (for loci where the observed values of each genotype were three or greater): TPI-4* in both 1991 collections of juveniles (hatchery and wild) and sSOD-1* in the 1991 collection of wild juveniles. Because at least this number of significant deviations would have been expected by chance, given an alpha level of 0.05 and over 100 tests, we conclude that the genotype distributions seen in these six collections are consistent with Hardy-Weinberg expectations.

One of the primary purposes for the ongoing electrophoretic monitoring of Tucannon spring chinook salmon is to investigate temporal patterns of allele frequencies in this stock and to determine if significant changes in frequency are occurring at any of the specific gene loci being screened. The primary concern here is whether or not the hatchery program is altering the genetic characteristics of the original, wild stock. We have now accumulated enough collections over a long enough time span, both pre- and post-facility start-up, to begin addressing this question. Figure 20 shows plots of allele frequency trajectories at 12 of the most variable loci in this stock. We have used this descriptive, graphical approach to investigate the magnitude and directionality of allele frequency variation. We believe that the results depicted in this figure indicate five important genetic features of these collections and this stock:

1) Allele frequencies are not identical among all collections. Rather, frequencies vary among years, among life history stages, and among environments (hatchery vs. natural).

2) Despite the variation noted above, allele frequencies in collections from different years are usually quite similar, but can vary by as much as 0.25 in successive years (e.g., MPI* in the BY-85 and BY-86 juvenile collections).

3) In general, the juvenile collections exhibit similar allele frequencies to the adult collections.

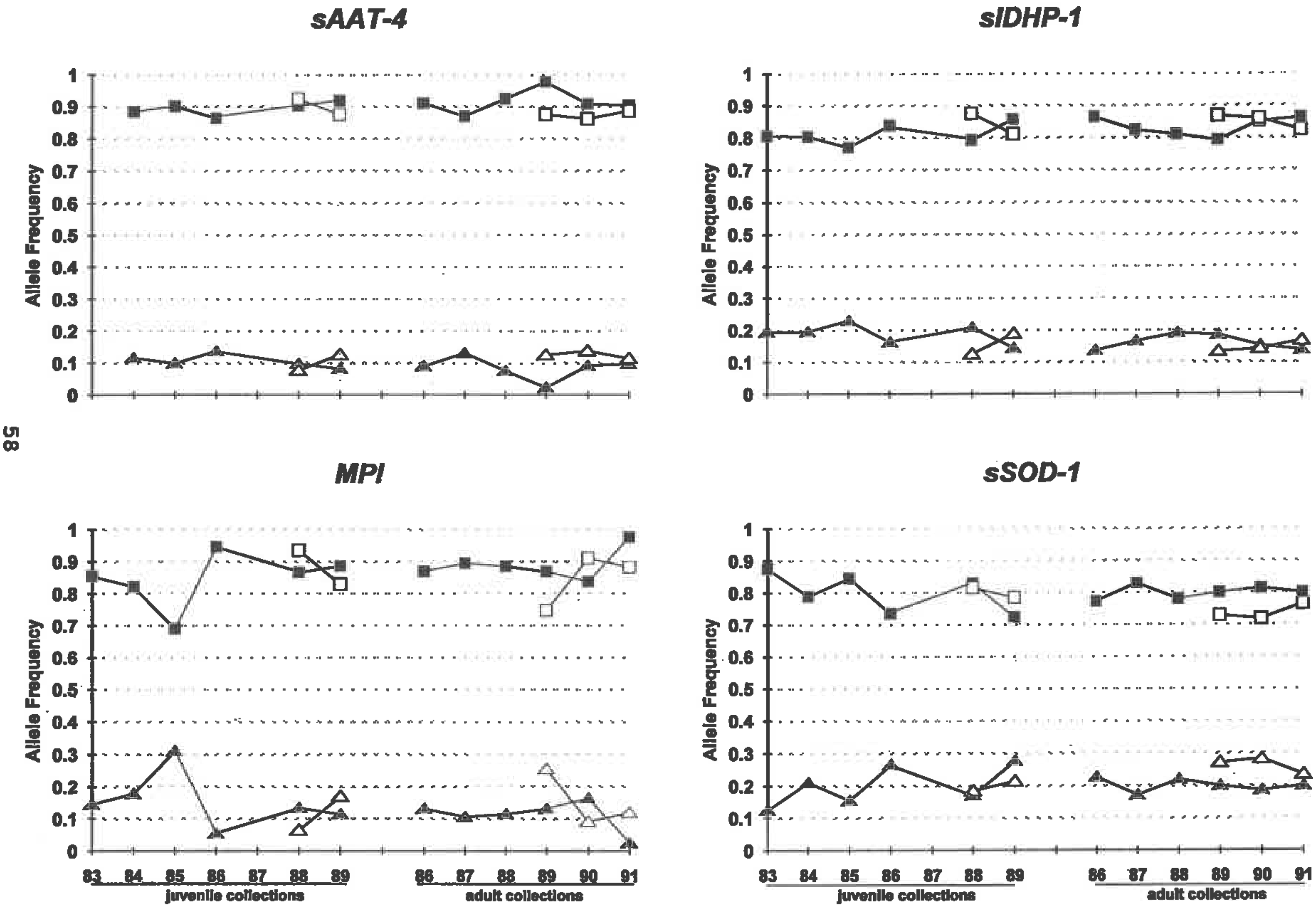
4) Allele frequencies at a few loci seem to be somewhat more variable among juvenile collections than among adult collections (e.g., MPI*; sSOD-1*; and mSOD*).

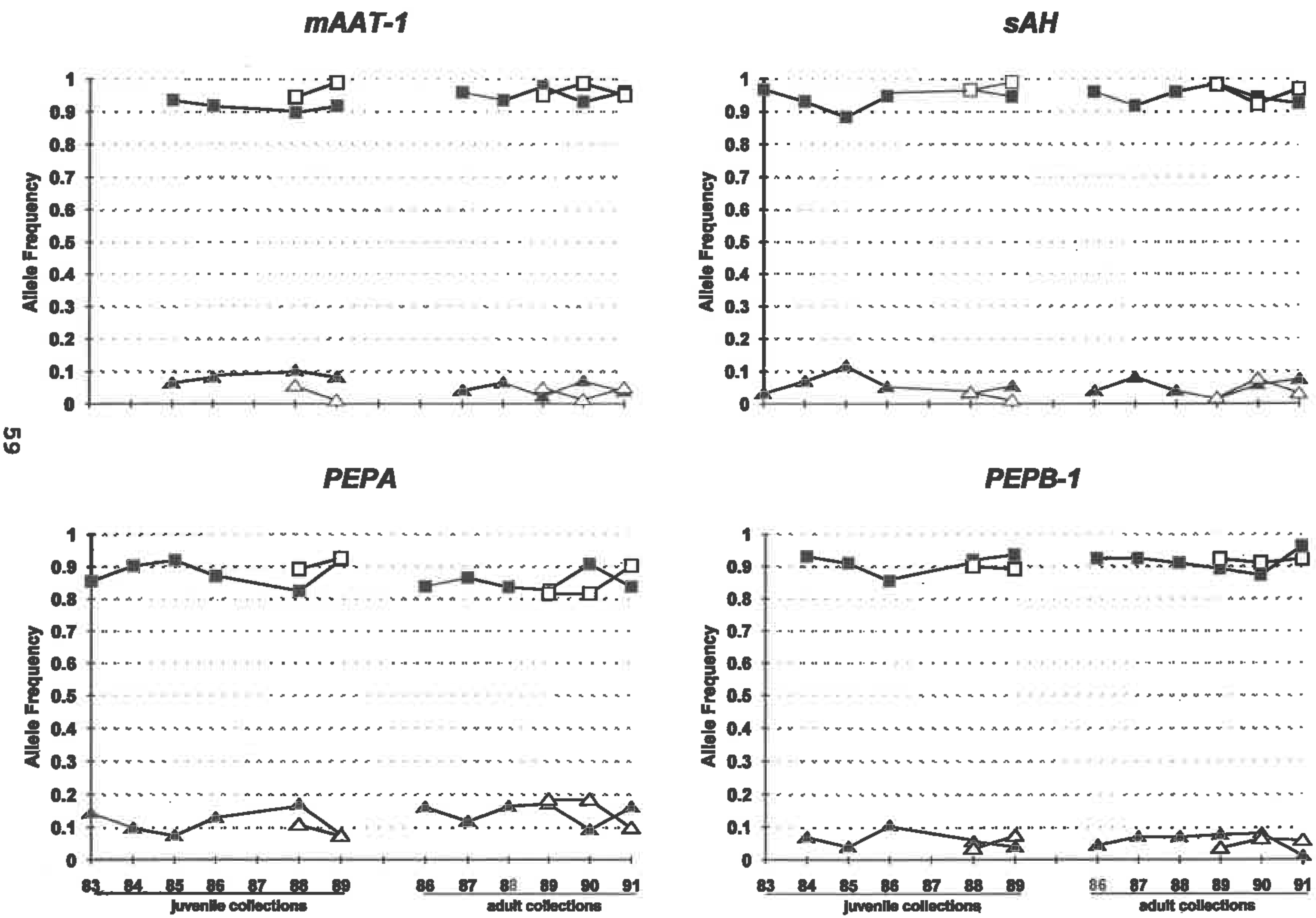
5) As a group, allele frequencies for the hatchery origin fish are basically similar to those of their "wild" counterparts [solid vs. open symbols in Fig. 20], although there are a few notable differences for individual loci in certain years.

The among-collection variation in allele frequencies noted in #1 above is not unexpected and is derived from two primary sources. First, sampling error when the collections are made undoubtedly contributes some of the variation. This variation, however, is not a characteristic of the population but rather a consequence of our inability to sample the population perfectly. The other source of the among-collection variation is presumably attributable to real genetic changes in the population that occur due to some combination of selection, immigration and/or emigration, and drift. Of these three possible causes, we believe that genetic drift, caused by small effective population size, is most likely the major contributor to the observed variation among samples. The relatively small size of this population (average adult escapement from 1985-1992 was 647 fish, see Table 19) is consistent with this explanation.

Support for the hypothesis that the small effective population size of the Tucannon spring chinook stock is driving much of the allele frequency variation documented by our monitoring is provided by the theoretical considerations summarized by Figure 21. This figure shows the expected range of allele frequencies observed in populations derived from different numbers of effective spawners (N_b). It is important to emphasize that this analysis considers the effects of genetic drift only and does not include the additional variability expected due to sampling error. The graph depicts the expected 95% confidence intervals of observed allele frequencies for three different values of N_b: 25, 50, and 100. At allele frequencies from about 0.05 to 0.45, a population having N_b equal to 25 would be expected to exhibit 30-50% more genetic drift (variation in allele frequencies) than one with N_b equal to 100. Given the small escapement of the Tucannon spring chinook stock in recent years, the range of values of N_b used to generate Figure 21 would seem to be appropriate for modeling the Tucannon population. Thus, because the allele frequency variation observed in the Tucannon stock (Figure 20) is included within the confidence limits predicted based on small numbers of breeders each year (Figure 21), it appears that genetic drift is both a likely and an adequate explanation for the observed values.

Figure 20. (following three pages) Allele frequency trajectories at 12 variable loci in the Tucannon River spring chinook stock. Dates across the bottom of each panel indicate the brood year (year fish were produced) for the juvenile collections whereas they indicate the year of collection for the adult collections. Solid symbols indicate naturally spawning ("wild") fish (adult collections) and the progeny of naturally spawning ("wild") fish (juvenile collections) whereas open symbols indicate fish produced by hatchery spawning. For each locus, squares indicate the frequency of the most common allele (*100 or *-100; depending on the locus) whereas the triangles indicate the frequency of the second most common allele. Note that the 1989 adult collection indicated by the open symbols consisted primarily of jacks (3-yr. old male fish).


sAAT-4
sIDHP-1
MPI
sSOD-1
Allele Frequency
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
83
84
85
86
87
88
89
86
87
88
89
90
91
juvenile collections
adult collections


mAAT-1
sAH
PEPA
PEPB-1
Allele Frequency
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
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0
83
84
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88
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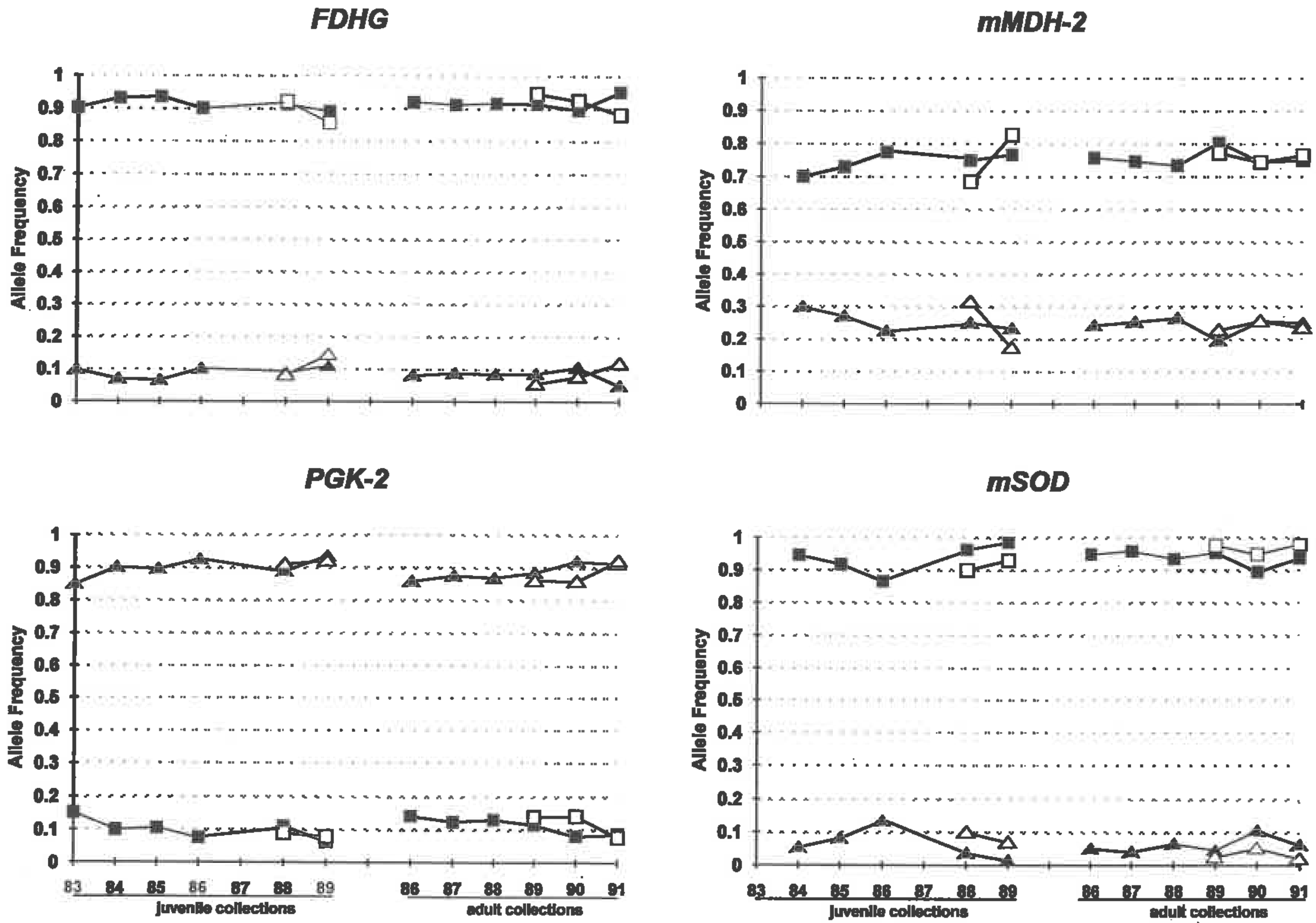
juvenile collections
adult collections


FDHG
mMDH-2
PGK-2
mSOD
Allele Frequency
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
83 84 85 86 87 88 89
juvenile collections
86 87 88 89 90 91
adult collections

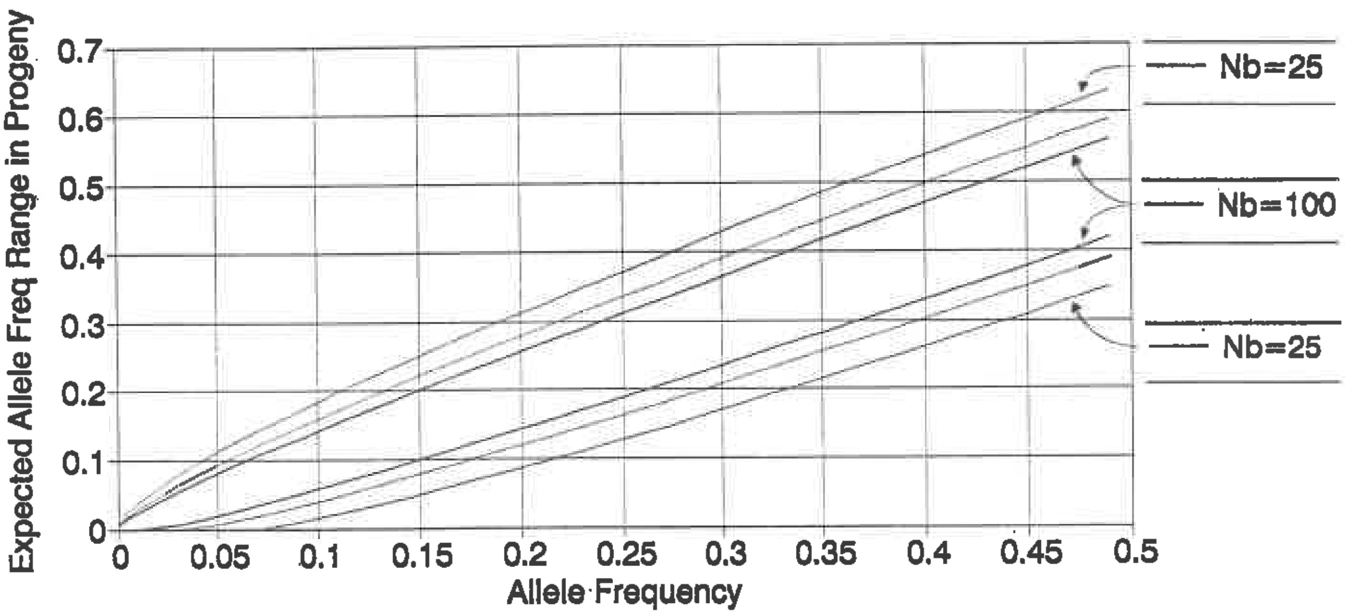


Figure 21. Theoretical expectations for allele frequency variation in a single generation as a function of the effective number of breeders (N_b) in the population. The three pairs of lines delineate the 95% confidence limits of expected allele frequencies in the next generation for N_b = 25, 50, and 100.

4.3: Organosomatics

We collected 20 organosomatic (Goede and Barton 1990) samples each from 1990 brood and 1991 brood salmon prior to release from the hatchery and from wild salmon collected at our smolt trap in 1992. We will present data for these fish in subsequent reports.

4.4: Morphometric Analysis

In 1992, evaluation program staff collected 100 morphometric samples each from 1990 brood hatchery salmon prior to release and wild fish collected at our smolt trap (same fish as were used in electrophoretic sampling). We will present results for these fish in subsequent reports.

4.5: Meristic Analysis

The objective of this study was to measure phenotypic similarities of the right and left sides of individual fish as an indicator of developmental stability (Van Valen 1962, Brückner 1976, Leary et al. 1984). We counted bilateral meristic characteristics of wild juvenile salmon prior to significant returns of hatchery salmon (the 1985 through 1989 brood years). We made corresponding counts on hatchery reared juvenile salmon from the 1986 through 1989 brood years. These initial analyses provide a baseline to compare with when counts are done for salmon after several generations of hatchery supplementation.

Methods:

Techniques used for the meristic counts are similar to those developed by Leary et al. (1985). We counted numbers of gill rakers on the upper and lower parts of the first two gill arches from the right and left sides, and numbers of fin rays in the pectoral and pelvic fins 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.

Total counts: We summarized the total counts of paired body parts two ways: 1) comparison of means between the treatment groups (hatchery versus wild), and 2) analysis of trends between brood years within a given treatment group.

Magnitude of asymmetry: In our initial analysis of these data, we statistically compared the mean magnitude of asymmetry of only the pelvic and pectoral fin counts. These variables contained the most continuous data. All other variables will be analyzed in subsequent years, when a larger data base is established.

Three separate analyses were performed: 1) variation between brood years within all hatchery salmon, 2) variation between brood years within all wild salmon, and 3) variation between wild and hatchery salmon across all brood years. Data were analyzed using Kruskal-Wallis (KW) one-way analysis of variance by ranks (Daniel 1978) with the BMDP statistical program. The data were transformed (square root of the sum of value plus 0.5) to approximate a normal distribution more closely.

Results:

Total counts: There appears to be little or no change in mean total counts of paired meristic traits for either the wild or hatchery origin salmon since Tucannon FH began production (Table 27, Figure 22). No differences between the two treatment groups within a given year were detectable either.

Magnitude of asymmetry: No difference was detected among the 1985 to 1989 broods wild salmon for the pectoral fin counts (KW test statistic = 6.91, $\alpha = 0.14$) or the pelvic fin counts (KW test statistic = 6.55, $\alpha = 0.16$). Nor did We detect any differences between individual brood years by multiple contrasts ($\alpha = 0.10$).

Table 27. 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 four bilateral traits of salmon juveniles. Sample size is 50 per group (wild and hatchery origin).

		First Arch		Second Arch			
Brood Year	Origin	Lower gill rakers	Upper gill rakers	Lower gill rakers	Upper gill rakers	Pelvic rays	Pectoral rays
1985	wild	22.61 (0.41)	15.36 (0.58)	- - - -	- - - -	20.46 (0.14)	31.88 (0.28)
1986	wild	20.34 (0.50)	14.14 (0.42)	- - - -	- - - -	20.22 (0.06)	31.70 (0.10)
	hatchery	22.96 (0.48)	15.16 (0.51)	- - - -	- - - -	20.62 (0.10)	31.52 (0.36[a])
1987	wild	24.26 (0.26)	16.16 (0.28)	- - - -	- - - -	20.50 (0.02)	32.16 (0.12)
	hatchery	23.96 (0.40)	14.88 (0.68)	- - - -	- - - -	20.62 (0.10)	32.18 (0.10)
1988	wild	- - - -	- - - -	23.52 (0.16)	16.40 (0.16)	20.20 (0.06)	31.02 (0.08)
	hatchery	- - - -	- - - -	21.32 (0.24)	15.81 (0.14)	20.19 (0.08)	32.16 (0.11)
1989	wild	25.36 (0.46)	16.92 (0.52)	24.50 (0.36)	15.84 (0.24)	20.40 (0.08)	31.56 (0.16)
	hatchery	20.04 (0.88)	13.44 (0.40)	19.64 (0.48)	13.74 (0.54)	20.56 (0.12)	32.06 (0.38[a])

[a] *Significantly different from 1987 and 1988 broods hatchery origin and pooled wild origin ($\alpha = 0.0004$).*

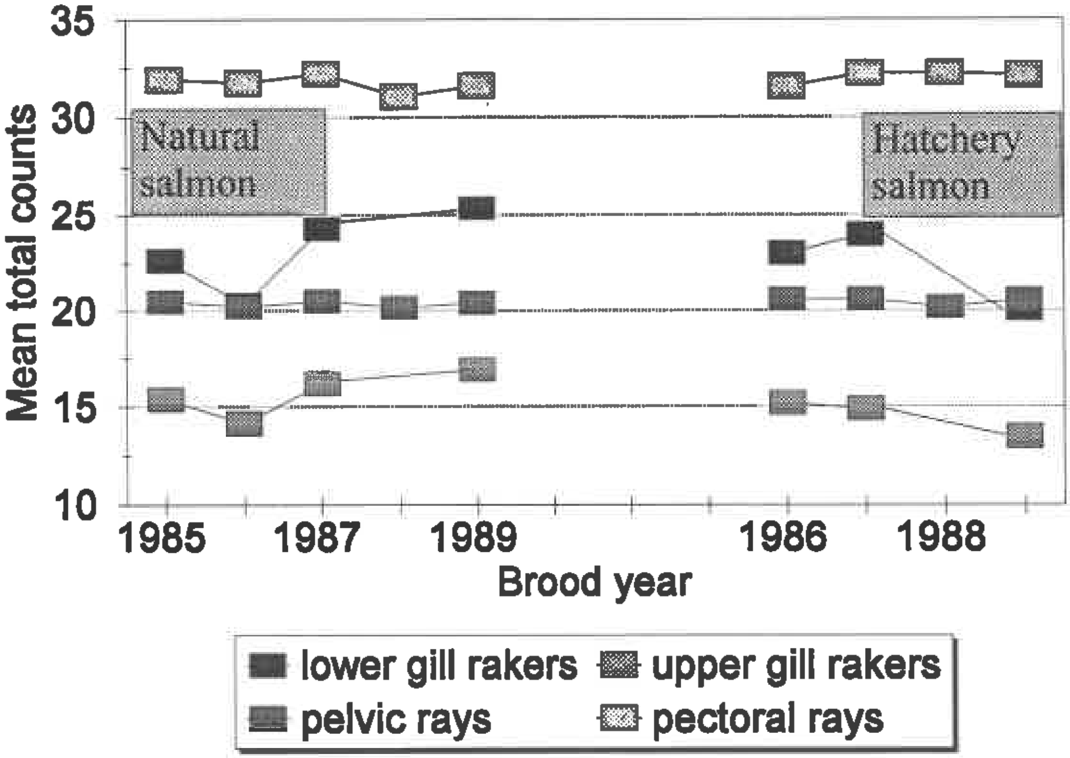


Figure 22. Comparison of total counts of four bilateral meristic traits of natural and hatchery salmon through time.

We detected a significant overall difference in pectoral fin counts among the 1986 to 1989 broods hatchery salmon (KW test statistic = 18.19, α = 0.0004). Based upon multiple comparison tests, the 1986 and 1989 broods differed from the 1987 and 1988 broods (α = 0.05, Figure 22). For the 1986 brood, one of 50 fish measured had a difference of two rays between the right and left pectoral fin counts, 18 had a difference of one fin ray between the left and right, the remaining 31 fish had no difference between the left and right pectoral fin counts. For the 1989 brood, two of 50 fish measured had a difference of two rays between the right and left pectoral fin counts, 15 had a difference of one fin ray between the left and right, and 33 fish had no difference between the left and right pectoral fin counts. No overall difference was found among pelvic fin counts for hatchery salmon (KW test statistic = 0.29, α = 0.96).

To analyze the effect of origin on mean magnitude of asymmetry, five brood years of wild salmon were combined together, and compared with individual brood years of hatchery salmon (1986-1989 Broods). We found a significant overall difference in pectoral counts among the treatment groups (KW test statistic = 26.34, α = 0.0000). Based upon multiple comparisons, the 1986 and 1989 hatchery salmon differed from the 1987 and 1988 brood hatchery salmon and the pooled wild salmon (α = 0.05, Figure 23).

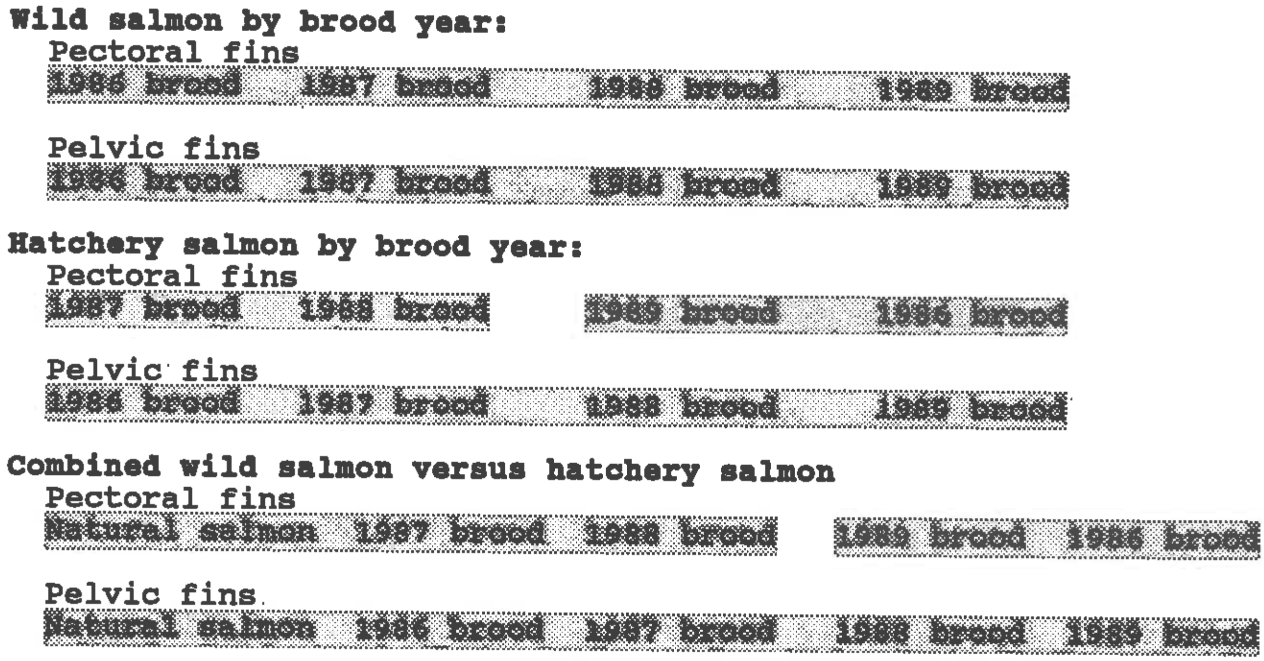


Figure 23 . Results of multiple comparisons between treatment groups for bilateral asymmetry indices. A discontinuity in shaded areas indicates a significant difference (α = 0.05).

<u>Discussion:</u>

No differences were detected in pectoral or pelvic fin ray counts for the 1985 through 1989 brood years of wild salmon. This consistent data base may provide an appropriate baseline for future analyses of the long-term effects of hatchery supplementation on a wild population.

We believe the statistically detected difference within the hatchery salmon was not a result of sampling bias. There was no relation between individuals making the counts and variations in data collection. Moreover, total counts for these brood years did not differ from other years, and the pectoral fin count is fairly straightforward relative to the other counts. We should be able to determine if these results are spurious when complete analyses of all bilateral characters are made in the future.

Environmental stressors may affect developmental stability of the pectoral fin rays in fishes (Valentine et al. 1973, Valentine and Soule 1973). To investigate this possibility, we compared mortality rates between all brood years, yet saw no obvious trends in environmental stress during their development. The 1986 brood had relatively low mortality in the early stages of development, while the 1989 brood had high loss in early development (Table 5). No significant changes in fish husbandry or disease prophylaxis occurred during this period.

SECTION 5: RECOMMENDATIONS

We recommend the following actions to improve performance of the Tucannon salmon hatchery and evaluation program. Some additional recommendations provided in the FY 1991 report will be implemented in 1992 also.

1) Establish a wild salmon escapement goal based on an estimate of effective breeders (from our genetic analyses) to ensure the wild salmon population is not replaced by hatchery salmon.

2) Continue to evaluate prespawning mortality at weir and for radio tagged fish (tagged by University of Idaho) in the lower Tucannon River. Determine source of losses, if possible. Continue and expand monitoring of radio tagged spring chinook salmon that enter the lower Tucannon River from the University of Idaho radio telemetry study of the Snake and Columbia rivers.

3) Reevaluate spawning use of Cummings Creek because of increased spawning below the weir. Also reevaluate spawning use of lower Panjab Creek and Asotin Creek. Determine whether spring chinook salmon still exist in Asotin Creek.

4) Improvements at the adult trap should be made to reduce handling and trapping injuries and stress to adult salmon. Salmon enumeration at the trap should be modified to reduce handling by counting salmon passing the trap with a camera and video tape system. A sprinkler system should be installed at the trap to reduce fish jumping in the trap and to minimize injuries. Picket spacing in the weir and trap entrance should be reduced to prevent gilling. Change the attraction water for the trap for fish wanting to go upstream. Provide a larger pool or a series of pools above the weir to reduce the chance of salmon being washed and trapped against the weir. Have hatchery or evaluation personnel monitor the weir during all daylight hours to assist any salmon trapped on the weir.

5) Outplant adults and juveniles to improve spawning distribution in the Wilderness Stratum. Limit releases from the acclimation pond to 8,800 lbs and outplant all excess juveniles in the upper Tucannon River during the fall.

6) Increase sampling and monitoring of hatchery/hatchery and wild/wild progeny in the hatchery to maintain similar incubation and rearing conditions and to compare their survival and growth.

7) Temporarily decrease morphometric and meristic sampling. Reinitiate sampling for two or three year intervals every three years to determine long term trends.

8) Continue to evaluate total snorkel count and modified line transect count methods for estimating parr densities.

9) Change the dosage of Erythromycin injection to 0.5cc/4.5kg (10 lbs) fish weight to reduce drug related mortalities.

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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 weirs 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 movement 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.** 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 collected. 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) **Maintain genetic integrity of indigenous Snake River salmon stocks.** Utilization and maintenance of native stocks is an important goal of the LSRCP. We plan to protect these stocks through two strategies: a) identify stray adults at Lyons Ferry and Tucannon FH for removal from the broodstock, and b) mark all hatchery raised smolts prior to release for their proper identification upon return.

7) 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.

8) 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 refinement 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 Objectives 5 and 6, and in accordance with tribal agreements.
>
> **C. Loading densities, feeding regimes, disease investigations, or other special treatments** on experimental hatchery practices often require mark-release-return groups to facilitate evaluation. Program staff will develop the experimental designs, direct the marking, and analyze the results.

9) 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.

10) 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.

LYONS FERRY HATCHERY
TUCANNON SPRING CHINOOK PROGRAM
BROODSTOCK COLLECTION PROTOCOL

Background

Production goal The current smolt production goal for Tucannon Fish Hatchery (FH) is 88,000 fish for release as yearlings at 10 fish per pound (fpp; 8,800 pounds). This goal is primarily based upon a density index at release of 0.18 pounds/cubic feet/inch. This goal will be modified in subsequent years as a result of several factors. The purpose of this document is to identify those factors which affect the smolt production goal, and to provide guidelines for broodstock collection and spawning in 1992. This protocol is intended for the 1992 season but may be applied in 1993.

Two major operational changes at Lyons Ferry FH may affect changes in Tucannon spring chinook production goals:

1) Water chiller at Lyons Ferry FH. Fish are incubated and reared in constant temperatures at Lyons Ferry FH, which accelerates growth rates. For the first six years of production (1985 through 1990 broods), smolts were released at about 10 fpp. To reduce excessive growth rates, hatchery staff feed these fish at, or near maintenance ration. In October 1991, a water chiller was installed in the Lyons Ferry incubation system to rectify this problem. The 1991 brood received partial benefit, and were delayed in ponding by several weeks. The long-term goal for the program is to transfer fish to the acclimation pond in November at 35 fpp (instead of 18 fpp), with an eventual release in late March through mid-April at 15 fpp.

2) Adult holding at Lyons Ferry FH. Beginning 1992, adults will be held at Lyons Ferry FH in lieu of the Tucannon smolt acclimation pond. Adults will be transported in a 1,135 L tank aerated tank truck the day they are collected at the weir. This plan was developed to mitigate prespawning and incubation mortality. Adult holding water temperatures are about 2°C cooler at Lyons Ferry than Tucannon FH, and gametes can be fertilized and water hardened with no transport delays.

Both of these factors will affect production: the former will reduce poundage at release, the latter will conceivably increase poundage, because of higher spawner and egg survival. One cannot presently quantify these effects. It is therefore prudent to program production at a low level to ensure that the density index upon release is within acceptable limits, regardless of final number at release.

Eggtake requirements To meet the current goal (produce 88,000 smolts at 10 fpp), 74 spawning adults are required, based upon the following assumptions:

average fecundity of 3,700,
average sex ratio of 1.0:1.0,
average prespawning survival of females of 74%,
average egg to smolt loss of 35%.

Given this information, 135,385 eggs are needed to produce 88,000 smolts. This eggtake would require spawning of 37 females, which requires the collection of 100 adults, based upon the prespawning survival rate. Therefore, in this document, the collection goal is 100 salmon (adults and jacks), which is required for the production goal of 74 salmon.

Run size projections Broodstock goals will be adjusted downward if the Snake River spring chinook runsize is projected to be less than 60% of the recent ten-year average as measured at Ice Harbor Dam. The collection goal will remain unchanged if the Snake River run size exceeds 60% of the ten-year average. Based on counts in 1982-1991, downward adjustments would occur 10% of the years. Reductions in the goal, if necessary, will be proportionate to the reduction in the overall Snake River run. For 1992, a Snake River run projection and a decision on the broodstock goal will be made on May 15. This date is the average 70% cumulative passage point during 1982-91. May 15 is late enough into the run for a reliable projection and is early in the Tucannon trapping period.

Collection methods On an annual basis, natural and hatchery-origin spring chinook adults are collected for broodstock at a floating weir, which is located adjacent to Tucannon FH at river kilometer 61. This weir has a high trapping efficiency. An undetermined number of salmon however, remain downstream of the weir. All hatchery smolts are marked with coded-wire tag and adipose clip, enabling one to distinguish hatchery vs wild production upon recovery at the weir.

Controlled matings research In 1990, Washington Department of Fisheries began an experiment to examine genotypic and phenotypic differences between inter se matings of hatchery-origin and wild-origin salmon at Tucannon FH. This study is to continue through the 1993 eggtake. The objective is to determine if measurable genetic differences occur in early survival, growth, or rate of return as a result of one generation of hatchery rearing.

Specifically, wild-origin parents are mated individually, and their progeny are incubated in discrete family units. These juveniles are given a unique mark, allowing their recognition in fisheries and as returning adults. The same protocol is then applied for hatchery-origin salmon. In consultation with tribal co-managers, several conditions were applied to this study. Two conditions which affect broodstock collection procedures are:

1) The number of salmon available for harvest and natural production opportunities above the weir will not be affected.

2) Progeny of these experimental crosses will be externally marked. All of these fish will be passed upstream for natural spawning when they return as adults.

Biological Information

Available habitat Current estimates of natural production of salmon in Tucannon River suggest that escapement of 400 salmon upstream of the weir approaches full seeding. Combined upstream escapement was 82% of full seeding in 1990 and 42% in 1991.

Run timing In spring, natural and hatchery-origin salmon arrive at the Tucannon weir roughly the same time. Peak of arrival at the weir is typically 20 May to 5 June; first migrants arrive in early May. A significant number of salmon also arrive at the weir in late August and September after a temporary lull in July. Most of these late arrivals are sexually mature males. We assume this late movement is a natural phenomenon.

Weir escapement For the period 1986- 1991, the average wild salmon escapement to the Tucannon FH weir was 206 (range: 109-261). Of this, an average of 120 wild salmon (range 67- 184) have been passed upstream. In 1990 and 1991, 145 and 101 hatchery salmon were passed upstream, which accounted for 70% and 50% of trapped fish, for those respective years. Sixty-two percent of those fish passed upstream in 1991 were hatchery origin and 44% in 1990.

Prespawning mortality In 1990 and 1991, prespawning mortality of hatchery-origin salmon held for broodstock has been significantly higher than wild salmon. Adults from both groups were handled the same and would have been expected to experience similar prespawning mortality rates. The reason for this disparity is presently unknown. Relative prespawning mortality rates of hatchery and wild salmon released above the weir is unknown.

Age composition The natural and hatchery-origin salmon returning to Tucannon River have different age structures. From 1985-1991, average ages of natural salmon are 2% age 3, 69% age 4, and 29% age 5. These fish can be recognized by fork length at the weir with a high level of accuracy. In 1990 and 1991, about 200 hatchery-origin salmon escaped to the weir; roughly a quarter of these would be considered age 3, based upon size. The remainder of the hatchery run is predominantly age 4. Age discrimination of hatchery fish by fork length is not as reliable, however.

Stray salmon An undetermined, but potentially significant number of salmon released from non-local hatcheries stray as adults into Tucannon River. This evidence was derived from coded-wire tags in carcasses recovered at Tucannon FH. Starting with the 1990 brood, all Tucannon stock smolts have a blank-wire tag placed in specified locations. This will allow hatchery staff to distinguish them from non-local hatchery stocks.

Broodstock Collection Guidelines

Broodstock collection should be conducted to achieve the following broad objectives:

1) No more than 50 natural salmon and 50 hatchery-origin salmon will be retained for broodstock. (The exact goal will be set about May 15 when Snake River runsize projections are made).

2) Throughout the trapping season, a minimum of 60% of cumulative escapement to the weir (salmon of combined origins) will be passed upstream.

3) Broodstock collected and, likewise, those passed upstream are a representative sample of the size, age, sex, and run timing of the overall population of hatchery or wild salmon arriving at the weir. Jacks (fork length less than 26 inches) should be retained in proportion to their overall abundance in the hatchery or wild run.

These objectives are similar to those guiding operations in 1990 and 1991. Based upon genetic and biological concerns, it may be necessary in subsequent years to set a maximum allowable percentage of hatchery salmon in the spawning grounds.

Time frame The programmed number of broodstock (100 salmon) will be collected until 1 August. Thereafter, salmon that enter the trap will be allowed to pass upstream, unless one of three conditions is met:

1) the ceiling percentage (60%) of hatchery-origin salmon relative to natural salmon passed upstream is exceeded. In this case, hatchery-origin salmon should be retained.

2) if at least 60% of all salmon are upstream, and prespawning mortality in the hatchery has reduced the number of spawners below the production goal (74 spawners).

3) if more than 10 salmon of a given origin arrive after 1 August, one fish will be retained for every five passed.

Stray salmon In 1993, jack-size salmon collected at the Tucannon weir that have an adipose clip, but no blank-wire tag, will be retained for stock and age verification. In 1993 all salmon from the 1990 brood experimental crossings will be passed upstream. These will be identified by having adipose clips, blank-wire tags, and coded-wire tags. During the 1992 and 1993 eggtake, all hatchery salmon will have their coded-wire tags read prior to fertilization. Only known Tucannon stock will be used for production. Gametes from stray fish will be destroyed, or transferred to the hatchery of origin, if possible.

To ensure that broodstock collection is random, the hatchery crew will determine before a given day whether the salmon trapped would be collected or passed upstream. Collections will occur on a systematic schedule, although some in-season adjustments may be necessary. Hatchery evaluations staff will routinely notify tribal co-managers of in-season escapement and broodstock collection progress.

Spawning Guidelines

The following spawning plan was developed to meet three criteria: 1) increased genetic contribution from all parents, 2) high fertilization and survival rate, and 3) fitting the experimental design of the hatchery matings study. This plan will be implemented through 1993. These methods will be used regardless of number of fish collected for broodstock.

Fertilization methods When enough males and females are ripe on a given day, eggs from females will be split approximately in half, and sperm from males will be split in half. Matings will follow a crossover format demonstrated below:

	FEMALE A	FEMALE B
MALE 1	A/1 cross first A/2 cross second	B/1 cross first B/2 cross second
MALE 2	A/2 cross first A/1 cross second	B/2 cross first B/1 cross second

In the upper left hand cell of the above box, eggs from female A will get fertilized by sperm from male 1 first, then from male 2 second. In the lower left hand cell, the other half of eggs from female A will get fertilized from male 2 first, then by male 1. The hatchery crew will wait 30 seconds between adding sperm from the first and second male, and then stir the egg/sperm mixture thoroughly during that period. The same scenario would occur for female B.

If there are insufficient ripe females of a given origin in a number that's not a multiple of 2, perform the cross mating first, then mate the remainder to a male that's the same origin (wild or hatchery) and hasn't been used yet. If that cannot be done, mate it with a male of different origin that hasn't been used. If that cannot be done, use a male that has been used. In all cases back up the first male with a second one, preferably one that hasn't been used.

Gametes from age 3 and age 2 salmon will be used in proportion to the population of their origin. Ages of hatchery-origin fish will be known at spawning by CWT analysis. All males should be live-spawned, and given unique marks after their use. The priority in male selection is a fish that hasn't contributed yet; choosing a fish of same origin (wild or hatchery) comes second. For those groups not ending up in the study because of logistical reasons, splitting, fertilizing, backup fertilizing, then recombining of eggs would be the ideal.

APPENDIX C

Summary of Tucannon River spring chinook salmon semen cryopreservation in 1992.

Date Frozen	Tag number	Fork length (cm)	Brood year[a]	Sperm motility (%)	Number straws frozen
9/15 [b]	22	67	88	80	10
9/22	56	86	87	90	5
9/15	58	76	88	75	5
9/22	59	75	88	75	5
9/15 [c]	63	75	88	75	10
9/22	93	69	88	75	5
9/15	173	70	88	90	5
9/22	716	68	88	70	5
9/22	718	70	88	70	2

[a] Brood year based on fork length verified using scale data.

[b] Five of these straws were frozen on Sep. 22. Motility was the same.

[c] Five of these straws were frozen on Sep. 22. Motility had decreased to 80 percent by then.

APPENDIX D

Table 1. Tucannon spring chinook salmon spawning crosses at Lyons Ferry FH, 1992

		FEMALE			#1 MALE			#2 MALE			DEAD	LIVE	TOTAL	EGG
DATE	ORIGIN	NUMBE	GENETIC	AGE	NUMBER	GENETIC	AGE	NUMBER	GENETIC	AG	EGGS	EGGS	EGGS	WT
8-25	wild	1001	92EJ01	4	56	92EJ36	5	63	92EJ37	4	28	2,565	2,593	
9-01	hatch	1002	92EK01	5	135	92EK29	4	197	92EK26	4	58	1,618	1,676	0.88
9-01	hatch	1002	92EK01	5	197	92EK26	4	135	92EK29	4	31	1,838	1,869	0.94
9-01	hatch	1003	92EK02	4	135	92EK29	4	197	92EK26	4	189	1,324	1,513	0.73
9-01	hatch	1003	92EK02	4	197	92EK26	4	135	92EK29	4	253	1,645	1,898	0.94
9-01	hatch	1004	92EK03	4	101	92EK30	4	198	92EK31	4	22	1,030	1,052	0.60
9-01	hatch	1004	92EK03	4	198	92EK31	4	101	92EK30	4	24	1,132	1,156	0.68
9-08	wild	1005	92EJ02	4	58	92EJ34	4	63	92EJ33	4	16	1,974	1,990	1.04
9-08	wild	1005	92EJ02	4	63	92EJ33	4	58	92EJ34	4	13	1,231	1,244	0.64
9-08	wild	1006	92EJ03	4	22	92EJ43	4	59	92EJ35	4	69	1,703	1,772	0.92
9-08	wild	1006	92EJ03	4	59	92EJ35	4	22	92EJ43	4	20	1,597	1,617	0.88
9-08	wild	1007	92EJ04	4	22	92EJ43	4	59	92EJ35	4	18	2,623	2,641	1.14
9-08	wild	1007	92EJ04	4	59	92EJ35	4	22	92EJ43	4	12	1,709	1,721	0.77
9-08	hatchery	1008	92EK15	4	5	92EK33	4	148	92EK40	3	10	2,283	2,293	1.14
9-08	hatchery	1008	92EK15	4	148	92EK40	3	5	92EK33	4	21	2,550	2,571	1.19
9-08	hatchery	1009	92EK08	4	2	92EK34	4	121	92EK44	4	27	1,813	1,840	0.98
9-08	hatchery	1009	92EK08	4	121	92EK44	4	2	92EK34	4	18	1,679	1,697	0.88
9-08	hatchery	1010	92EK14	4	66	92EK43	4	171	92EK32	4	16	1,461	1,477	0.69
9-08	hatchery	1010	92EK14	4	171	92EK32	4	66	92EK43	4	21	2,015	2,036	0.95
9-08	hatchery	1011	92EK12	4	137	92EK39	3	177	-	3	33	1,174	1,207	0.62
9-08	hatchery	1011	92EK12	4	177	-	3	44	92EK35	4	24	1,054	1,078	0.59
9-08	hatchery	1012	92EK07	4	35	92EK28	4	98	92EK37	4	23	1,606	1;629	0.81
9-08	hatchery	1012	92EK07	4	98	92EK37	4	35	92EK28	4	26	2,222	2,248	1.18
9-08	hatchery	1013	92EK09	4	66	92EK43	4	171	92EK32	4	64	2,247	2,311	1.02
9-08	hatchery	1013	92EK09	4	171	92EK32	4	66	92EK43	4	39	1,317	1,356	0.51
9-08	hatchery	1014	92EK06	4	7	92EK27	4	35	92EK28	4	34	1,539	1,573	0.95
9-08	hatchery	1014	92EK06	4	35	92EK28	4	7	92EK27	4	18	1,106	1,124	0.65
9-08	hatchery	1015	92EK05	4	2	92EK34	4	121	92EK44	4	34	1,399	1,433	0.67
9-08	hatchery	1015	92EK05	4	121	92EK44	4	2	92EK34	4	43	1,947	1,990	0.93
9-08	wild	1016	92EJ05	4	58	92EJ34	4	63	92EJ33	4	32	1,548	1,580	0.82
9-08	wild	1016	92EJ05	4	63	92EJ33	4	58	92EJ34	4	38	1,567	1,605	0.84
9-08	hatchery	1017	92EK13	4	35	92EK28	4	98	92EK37	4	68	1,312	1,380	0.68
9-08	hatchery	1017	92EK13	4	98	92EK37	4	35	92EK28	4	114	2,363	2,477	1.31
9-08	hatchery	1018	92EK04	4	44	92EK35	4	54	92EK36	4	31	1,085	1,116	0.57
9-08	hatchery	1018	92EK04	4	54	92EK36	4	44	92EK35	4	51	1,562	1,613	0.83
9-08	wild	1019	92EJ06	4	12	92EJ36	4	131	92EJ30	4	20	2,187	2,207	1.03
9-08	wild	1019	92EJ06	4	131	92EJ30	4	12	92EJ36	4	32	2,072	2,104	1.01
9-08	wild	1020	92EJ07	4	84	92EJ31	3	173	92EJ32	4	75	2,366	2,441	1.15
9-08	wild	1020	92EJ07	4	173	92EJ32	4	84	92EJ31	3	36	2,050	2,086	0.96
9-08	wild	1021	92EJ08	4	12	92EJ36	4	131	92EJ30	4	15	2,180	2,195	0.98
9-08	wild	1021	92EJ08	4	131	92EJ30	4	12	92EJ36	4	16	1,351	1,367	0.61
9-08	wild	1022	92EJ09	4	84	92EJ31	3	173	92EJ32	4	21	2,076	2,097	0.89
9-08	wild	1022	92EJ09	4	173	92EJ32	4	84	92EJ31	3	28	1,726	1,754	0.77
9-08	hatchery	1023	92EK11	4	44	92EK35	4	54	92EK36	4	19	1,832	1,851	0.89
9-08	hatchery	1023	92EK11	4	54	92EK36	4	44	92EK35	4	18	1,551	1,569	0.76
9-08	hatchery	1024	92EK10	4	5	92EK33	4	148	92EK40	3	16	1,900	1;916	0.80
9-08	hatchery	1024	92EK10	4	148	92EK40	3	5	92EK33	4	11	1,385	1,396	0.58
9-08	hatchery	1025	92EK16	4	137	92EK39	3	177	-	3	35	1,887	1,922	1.10
9-08	hatchery	1025	92EK16	4	177	-	3	44	92EK35	4	26	868	894	0.52
9-15	hatchery	1026	92EK24	4	101	92EK30	4	197	92EK26	4	13	1,219	1,232	0.73
9-15	hatchery	1026	92EK24	4	197	92EK26	4	101	92EK30	4	21	1,645	1,666	0.95
9-15	hatchery	1027	92EK22	4	7	92EK27	4	35	92EK28	4	25	1,628	1,653	0.94
9-15	hatchery	1027	92EK22	4	35	92EK28	4	197	92EK26	4	15	1,402	1,417	0.77
9-15	wild	1028	92EJ11	4	701	92EJ22	4	704	92EJ24	4	16	1,207	1,223	0.57
9-15	wild	1028	92EJ11	4	704	92EJ24	4	701	92EJ22	4	20	1,489	1,509	0.77
9-15	hatchery	1029	92EK21	4	135	92EK29	4	198	92EK31	4	21	1,858	1,879	0.88

Appendix D

Table 1. continued.

9-15	hatchery	1029	92EK21	4	198	92EK31	4	135	92EK29	4	18	1,602	1,620	0.78
9-15	wild	1031	92EJ17	5	701	92EJ22	4	704	92EJ24	4	52	2,776	2,828	1.39
9-15	wild	1031	92EJ17	5	704	92EJ24	4	701	92EJ22	4	41	2,633	2,674	1.28
9-15	hatchery	1032	92EK20	4	7	92EK27	4	35	92EK28	4	27	1,389	1,416	0.70
9-15	hatchery	1032	92EK20	4	35	92EK28	4	197	92EK26	4	25	1,237	1,262	0.69
9-15	wild	1033	92EJ15	4	706	92EJ26	4	709	92EJ27	4	6	2,252	2,258	1.00
9-15	wild	1033	92EJ15	4	709	92EJ27	4	706	92EJ26	4	7	1,873	1,880	0.79
9-15	hatchery	1034	92EK25	4	135	92EK29	4	198	92EK31	4	10	1,314	1,324	0.66
9-15	hatchery	1034	92EK25	4	198	92EK31	4	135	92EK29	4	16	1,473	1,489	0.69
9-15	hatchery	1035	92EK17	4	101	92EK30	4	197	92EK26	4	40	1,685	1,725	1.15
9-15	hatchery	1035	92EK17	4	197	92EK26	4	101	92EK30	4	27	1,016	1,043	0.70
9-15	hatchery	1036	92EK18	4	2	92EK34	4	5	92EK33	4	12	551	563	0.27
9-15	hatchery	1036	92EK18	4	5	92EK33	4	2	92EK34	4	37	711	748	0.34
9-15	wild	1037	92EJ10	5	12	92EJ36	4	708	92EJ19	4	9	1,827	1,836	1.32
9-15	wild	1037	92EJ10	5	708	92EJ19	4	12	92EJ36	4	30	2,232	2,262	1.55
9-15	wild	1038	92EJ16	4	705	92EJ20	4	707	92EJ25	4	9	1,574	1,583	0.65
9-15	wild	1038	92EJ16	4	707	92EJ25	4	705	92EJ20	4	18	2,125	2,143	0.85
9-15	wild	1039	92EJ13	4	706	92EJ26	4	709	92EJ27	4	13	2,328	2,341	1.01
9-15	wild	1039	92EJ13	4	709	92EJ27	4	706	92EJ26	4	9	1,423	1,432	0.64
9-15	wild	1040	92EJ18	4	702	92EJ23	4	703	92EJ21	5	26	2,347	2,373	1.26
9-15	wild	1040	92EJ18	4	703	92EJ21	5	702	92EJ23	4	22	1,434	1,456	0.80
9-15	wild	1041	92EJ12	4	702	92EJ23	4	703	92EJ21	5	11	1,970	1,981	1.02
9-15	wild	1041	92EJ12	4	703	92EJ21	5	702	92EJ23	4	30	2,127	2,157	1.17
9-15	wild	1042	92EJ14	4	705	92EJ20	4	707	92EJ25	4	21	1,775	1,796	0.82
9-15	wild	1042	92EJ14	4	707	92EJ25	4	705	92EJ20	4	20	2,610	2,630	1.16
9-15	hatchery	1050	92EK19	4	2	92EK34	4	5	92EK33	4	33	1,367	1,400	0.62
9-15	hatchery	1050	92EK19	4	5	92EK33	4	2	92EK34	4	59	2,001	2,060	0.96
9-22	hatchery	1046	92EK46	4	121	92EK44	4	714	92EK45	4	31	2,792	2,823	1.15
9-22	hatchery	1046	92EK46	4	714	92EK45	4	66	92EK43	4	17	1,945	1,962	0.85
9-22	hatchery	1047	92EK47	4	66	92EK43	4	121	92EK44	4	15	3,056	3,071	1.54
9-22	hatchery	1048	92EK48	4	121	92EK44	4	714	92EK45	4	13	1,624	1,637	0.66
9-22	hatchery	1048	92EK48	4	714	92EK45	4	66	92EK43	4	24	1,808	1,832	0.70
											2,765	153,594	156,359	75.8

Appendix D

Table 2. Tucannon spring chinook salmon spawning crosses at Lyons Ferry FH, 1991

DATE	ORIGIN	FEMALE	AGE	#1 MALE	AGE	#2 MALE	AGE	DEAD EGGS	LIVE EGGS	TOTAL EGGS	Hatch code
09/10/91	wild	91DF12	5	91DF35	4	91DF27	4	15	1,815	1,830	7AX7,8
09/10/91	wild	91DF13	5	91DF37	4	91DF25	4	154	1,902	2,056	6BX6,5
09/10/91	wild	91DF11	5	91DF35	4	91DF27	4	182	2,046	2,228	8BX7,8
09/10/91	wild	91DF12	5	91DF27	4	91DF35	4	27	2,001	2,028	7AX8,7
09/10/91	wild	91DF13	5	91DF25	4	91DF37	4	201	2,829	3,030	6BX5,6
09/10/91	wild	91DF08	4	91DF32	4	91DF14	4	32	393	425	4BX4,3
09/10/91	wild	91DF08	4	91DF14	4	91DF32	4	71	624	695	4BX3,4
09/10/91	wild	91DF07	4	91DF37	4	91DF25	4	161	1,124	1,285	5AX6,5
09/10/91	wild	91DF07	4	91DF25	4	91DF37	4	75	1,215	1,290	5AX5,6
09/17/91	wild	91DF20	4	91DF16	4	91DF19	-	24	1,311	1,335	3AX4,3
09/17/91	wild	91DF20	4	91DF19	-	91DF16	4	37	1,957	1,994	3AX3,4
09/17/91	wild	91DF22	5	91DF16	4	91DF19	-	176	1,309	1,485	4BX4,3
09/17/91	wild	91DF22	5	91DF19	-	91DF16	4	316	2,272	2,588	4BX3,4
09/17/91	wild	91DF21	4	91DF15	4	91DF18	4	153	1,280	1,433	2BX2,1
09/17/91	wild	91DF23	5	91DF18	4	91DF15	4	25	2,198	2,223	1AX1,2
09/10/91	wild	91DF11	5	91DF27	4	91DF35	4	93	1,171	1,264	8BX8,7
09/17/91	wild	91DF21	4	91DF18	4	91DF15	4	200	1,350	1,550	2BX1,2
09/17/91	wild	91DF23	5	91DF15	4	91DF18	4	26	1,618	1,644	1AX2,1
09/10/91	wild	91DF09	4	91DF32	4	91DF14	4	39	1,386	1,425	3AX4,3
09/03/91	wild	91DF02	5	91DF29	4	--	-	58	1,898	1,956	AXD
09/03/91	wild	91DF03	5	91DF30	5	--	-	71	2,794	2,865	BXC
09/03/91	wild	91DF02	5	91DF30	5	--	-	68	2,049	2,117	AXC
09/03/91	wild	91DF05	5	91DF17	4	91DF26	4	21	1,783	1,804	BXDC
09/03/91	wild	91DF04	5	91DF17	4	91DF26	4	95	1,988	2,083	AXDC
09/03/91	wild	91DF05	5	91DF26	4	91DF17	4	34	2,745	2,779	BXCD
09/03/91	wild	91DF03	5	91DF29	4	--	-	90	2,792	2,882	BXD
09/03/91	wild	91DF04	5	91DF26	4	91DF17	4	83	1,995	2,078	AXCD
09/10/91	wild	91DF10	5	91DF39	4	91DF36	4	40	2,165	2,205	2BX1,2
09/10/91	wild	91DF06	5	91DF36	4	91DF39	4	86	1,214	1,300	1AX2,1
09/10/91	wild	91DF09	4	91DF14	4	91DF32	4	36	1,886	1,922	3AX3,4
09/10/91	wild	91DF10	5	91DF36	4	91DF39	4	50	2,611	2,661	2BX2,1
08/27/91	wild	91DF01	4	91DF38	5	--	-	361	3,104	3,465	WXW
09/10/91	wild	91DF06	5	91DF39	4	91DF36	4	26	1,641	1,667	1AX1,2
09/10/91	hatchery	91DE27	4	91DE33	4	91DE34	4	50	497	547	7AX9,8
09/10/91	hatchery	91DE26	4	91DE31	3	91DE30	4	370	507	877	6BX6,5
09/10/91	hatchery	91DE27	4	91DE34	4	91DE33	4	65	1,116	1,181	7AX8,9
09/10/91	hatchery	91DE28	4	91DE34	4	91DE33	4	343	197	540	8BX8,9
09/24/91	hatchery	91DE47	4	91DE46	3	91DE45	4	9	1,772	1,781	1AX2,1
09/24/91	hatchery	91DE47	4	91DE45	4	91DE46	3	20	1,942	1,962	1AX1,2
09/10/91	hatchery	91DE28	4	91DE33	4	91DE34	4	215	36	251	8BX9,8
09/10/91	hatchery	91DE21	4	91DE36	4	91DE37	4	233	1,388	1,621	1AX1,2
09/10/91	hatchery	91DE21	4	91DE37	4	91DE36	4	156	783	939	1AX2,1
09/10/91	hatchery	91DE22	4	91DE36	4	91DE37	4	1,110	284	1,394	2BX1,2
09/03/91	hatchery	91DE08	4	91DE06	4	--	-	278	1,420	1,698	AXC
09/03/91	hatchery	91DE04	4	91DE07	4	--	-	963	0	963	BXD
09/03/91	hatchery	91DE04	4	91DE06	4	--	-	190	1,213	1,403	BXC
09/03/91	hatchery	91DE08	4	91DE07	4	--	-	1,369	0	1,369	AXD
09/10/91	hatchery	91DE22	4	91DE37	4	91DE36	4	734	186	920	2BX2,1

Appendix D

Table 2. continued.

09/10/91	hatchery	91DE25	4	91DE30	4	91DE31	3	79	1,843	1,922	5AX5,6
09/10/91	hatchery	91DE25	4	91DE31	3	91DE30	4	67	1,147	1,214	5AX6,5
09/10/91	hatchery	91DE26	4	91DE30	4	91DE31	3	609	693	1,302	6BX5,6
09/10/91	hatchery	91DE24	5	91DE32	4	91DE35	4	433	967	1,400	4BX4,3
09/10/91	hatchery	91DE23	4	91DE35	4	91DE32	4	609	1,463	2,072	3AX3,4
09/10/91	hatchery	91DE23	4	91DE32	4	91DE35	4	204	471	675	3AX4,3
09/10/91	hatchery	91DE24	5	91DE35	4	91DE32	4	447	1,205	1,652	4BX3,4
								11,679	79,596	91,275	

Appendix D

Table 3. Tucannon spring chinook salmon spawning crosses at Lyons Ferry FH, 1990.

		FEMALE			MALE							
DATE	TAKE	ORIGIN	GSI	AGE	ORIGIN	GSI	AGE	EXPER. GROUP	LIVE EGGS	DEAD EGGS	TOTAL EGGS	NUMBER PONDED
04-Sep	2	Hat.	90AM04	4	Hat.	90AM19		Hat.	1	2,506	2,507	1
04-Sep	1	Hat.	90AM03	4	Hat.	90AM17	4	Hat.	2,293	697	2,990	2,189
04-Sep	5	Hat.	90AM07	4	Hat.	90AM18	4	Hat.	1,406	1,848	3,254	1,338
04-Sep	7	Hat.	90AM08	4	Hat.	--		Hat.	4	3,097	3,101	3
04-Sep	3	Hat.	90AM05	4	Hat.	90AM27	4	Hat.	81	1,311	1,392	55
04-Sep	4	Hat.	90AM06	4	Hat.	90AM26	4	Hat.	325	2,399	2,724	280
11-Sep	2	Hat.	90AM10	4	Hat.	--		Hat.	475	1,262	1,737	262
11-Sep	3	Hat.	90AM11	4	Hat.	90AM34	4	Hat.	2	1,919	1,921	2
11-Sep	8	Hat.	90AM16	4	Hat.	--		Hat.	833	1,248	2,081	756
11-Sep	4	Hat.	90AM12	4	Hat.	90AM35		Hat.	1,022	1,340	2,362	734
11-Sep	7	Hat.	90AM15	4	Hat.	90AM39	4	Hat.	2,201	131	2,332	2,115
11-Sep	1	Hat.	90AM09	4	Hat.	90AM28	4	Hat.	1,105	958	2,063	1,033
11-Sep	6	Hat.	90AM14	4	Hat.	90AM25	4	Hat.	2,465	872	3,337	1,891
11-Sep	5	Hat.	90AM13	4	Hat.	--		Hat.	2,282	2,271	4,553	1,961
18-Sep	4	Hat.	90AM23	4	Hat.	90AM32	4	Hat.	3,491	125	3,616	3,602
18-Sep	5	Hat.	90AM24	4	Hat.	90AM33	3	Hat.	863	1,518	2,381	409
18-Sep	3	Hat.	90AM22	4	Hat.	90AM31	4	Hat.	2,661	93	2,754	2,570
18-Sep	1	Hat.	90AM20	4	Hat.	90AM29	4	Hat.	1,068	2,118	3,186	740
18-Sep	2	Hat.	90AM21	4	Hat.	90AM30	3	Hat.	3,384	109	3,493	3,210
21-Aug	1	Hat.	90AM02	4 S	Mixed	--		Mixed	1,638	1,927	3,565	1,577
28-Aug	1	Wild	90AL01	4	3 Wild	--		Mixed	4,636	327	4,963	4,629
04-Sep	6	Wild	90AL02	4	Hat.	--		Mixed	2,365	1,094	3,459	2,006
25-Sep	1		90AM38	4	Mixed	--		Mixed				
25-Sep	1		90AM36	4	Mixed	90AM39	4	Mixed				
25-Sep	1	3 Hat	90AM37	4	Mixed	90AL43	4	Mixed	7,017	1,971	8,988	5,867
04-Sep	17	Wild	90AL09	5	Wild	90AL28	4	Wild	5,408	219	5,627	4,927
04-Sep	11	Wild	90AL03	4	Wild	90AL14	-	Wild	3,009	158	3,167	2,748
04-Sep	18	Wild	90AL10	5	Wild	90AL30	-	Wild	3,749	485	4,234	3,587
04-Sep	14	Wild	90AL06	4	Wild	90AL32	4	Wild	0	4,466	4,466	0
04-Sep	21	Wild	90AL13	4	Wild	90AL24	4	Wild	2,077	1,259	3,336	1,980
04-Sep	16	Wild	90AL08	4	Wild	--		Wild	2,813	465	3,278	2,800
04-Sep	13	Wild	90AL05	5	Wild	90AL26	5	Wild	2,800	1,332	4,132	2,333
04-Sep	19	Wild	90AL11	4	Wild	90AL43	4	Wild	2,429	457	2,886	2,256
04-Sep	15	Wild	90AL07	5	Wild	--		Wild	3,365	542	3,907	3,252
04-Sep	20	Wild	90AL12	5	Wild	--		Wild	692	4,267	4,959	581
04-Sep	12	Wild	90AL04	5	Wild	90AL25	-	Wild	3,843	1,267	5,110	3,443
11-Sep	23	Wild	90AL19	5	Wild	90AL29	4	Wild	3,490	641	4,131	3,323
11-Sep	24	Wild	90AL20	5	Wild	--		Wild	3,632	104	3,736	3,554
11-Sep	20	Wild	90AL16	5	Wild	--		Wild	3,126	238	3,364	3,094
11-Sep	25	Wild	90AL21	4	Wild	--		Wild	87	3,393	3,480	87
11-Sep	27	Wild	90AL23	4	Wild	90AL31	-	Wild	3,691	151	3,842	3,521
11-Sep	26	Wild	90AL22	4	Wild	--		Wild	2,961	302	3,263	4,157
11-Sep	21	Wild	90AL17	4	Wild	90AL15	5	Wild	3,206	595	3,801	3,202
11-Sep	22	Wild	90AL18	4	Wild	90AL27	4	Wild	3,610	305	3,915	3,430
									95,606	51,787	147,393	89,505

APPENDIX E

Table 1. Summary of salmon yearling releases for the Tucannon River, 1985-1991 brood years [a].

Brood year	Parents male	Parents female	Release dates mon/day	Release dates Yr.	Number Released	No. lbs.	Fish/ pound	CWT code
1985	4	5	4/6-10	87	12,922	2,172	6	63-34-42
1986	43	49	3/7	88	13,328	1,333		63-33-25
					512	51		ad only
					12,095	1,209		63-41-46
					465	47		ad only
					13,097	1,310		63-41-48
					503	50		ad only
			4/13	88	37,893	3,789		63-33-25
					1,456	146		ad only
					34,389	3,439		63-41-46
					1,321	132		ad only
					37,235	3,723		63-41-48
					1,431	144		ad only
					153,725	15,373	10	
1987	35	48	4/11-13	89	151,100	16,789		63-49-50R6
					1,065	118		ad only
					152,165	16,907	9	
1988	[b] 41	49	3/30-4/10	90	68,591	6,236		63-55-01R3
					3,007	273		ad only
					70,459	6,405		63-01-42R3
					3,089	281		ad only
					146,239	13,295	11	
1989	[b] 31	37	4/1-12	91	75,661	8,407		63-14-61R3
					989	110		ad only
					22,118	2,458		63-01-31R6
					289	32		ad only
					99,057	11,007	9	
1990	[c] 33	19	3/30-4/10	92	51,149	4,649		63-40-21 [d]
		19			21,108	1,924		63-43-11 [e]
		6			13,480	1,225		63-37-25
					85,797	7,798	11	

Appendix E. Table 1. (Continued).

Brood year	Parents male	Parents female	Release dates mon/day	Release dates Yr.	Number Released	No. lbs.	Fish/ pound	CWT code
1991	11	11	4/6-4/12	93	16,745	1,116		63-46-47 [f]
					807	54		ad only
	17	17			55,716	3,714		63-46-25 [g]
					790	53	15	ad only
					74,058	4,937		

[a] *Some numbers of fish released have been corrected from those reported in Bugert et al. 1992.*

[b] *Includes hatchery and wild adults in the spawning; gametes were pooled.*

[c] *Began the controlled matings study, some males were used more than once but matings were kept separate by origin of fish, except in the mixed group.*

[d] *Wild cross progeny have blank-wire tags in right cheek.*

[e] *Hatchery cross progeny have blank-wire tags in left cheek.*

[f] *Hatchery cross progeny have red elastomere tags behind right eye.*

[g] *Wild cross progeny have red elastomere tags behind left eye.*

APPENDIX F

Contribution of 1986-1989 broods Tucannon spring chinook salmon to various fisheries and returns to the hatchery weir. Returns for 1991 and 1992 fisheries were not available at time of printing and will be updated in subsequent annual reports.

Table 1. Recoveries of 1985 brood salmon released from Tucannon FH on 6 to 10 April 1987. Tagcode was 633442. Mark rate was 100% (12,922 total released). Size of fish at release was 9 fpp.

<u>Year</u> Recovery location and agency	Observed recoveries
<u>1988</u>	
Tucannon FH, WDF	9
Tucannon spawning grounds, WDF	0
<u>1989</u>	
Test Fishery Net - ODFW	1
Tucannon FH, WDF	23
Tucannon spawning grounds, WDF	0
Totals for tagcode 633442:	33

Table 2. Recoveries of 1986 brood salmon released from Tucannon FH on 7 March and 11 to 13 April 1988. Tagcode was 634146. Mark rate was 96.30% (46,484 out of 48,270 total released). Size of fish at release was 10 fpp.

<u>Year</u> Recovery location and agency	Observed recoveries
<u>1989</u>	
Tucannon FH, WDF	20
Tucannon spawning grounds, WDF	0
<u>1990</u>	
Test fishery net, ODFW	1
Treaty ceremonial, ODFW	1
Tucannon FH, WDF	19
Tucannon spawning Grounds, WDF	5
<u>1991</u>	
Tucannon FH, WDF	1
Tucannon spawning Grounds, WDF	2
Totals for tagcode 634146:	49

Appendix F, continued.

Table 3. Recoveries of 1986 brood salmon released from Tucannon FH on 7 March and 11 to 13 April 1988. Tagcode was 634148. Mark rate was 96.30% (50,332 out of 52,266 total released). Size of fish at release was 10 fpp.

Year Recovery location and agency	Observed recoveries
1989	
Tucannon FH, WDF	33
Tucannon spawning grounds, WDF	1
1990	
Freshwater Sport-Kalama R.(May 2),WDF 1	
Treaty ceremonial, ODFW	1
Ocean Troll (Non-treaty), CDFO	1
Tucannon FH, WDF	17
Tucannon spawning grounds, WDF	11
1991	
Tucannon FH, WDF	2
Tucannon spawning grounds, WDF	1
Totals for tagcode 634148:	67

Table 4. Recoveries of 1986 brood salmon released from Tucannon FH on 7 March and 11 to 13 April 1988. Tagcode was 633325. Mark rate was 96.30% (51,221 out of 53,189 total released). Size of fish at release was 10 fpp.

Year Recovery location and agency	Observed recoveries
1989	
Treaty Troll-AREA 4B(Nov. 28), WDF	1
Tucannon FH, WDF	21
Tucannon spawning grounds	0
1990	
Tucannon FH, WDF	22
Tucannon spawning Grounds, WDF	10
1991	
Tucannon FH, WDF	1
Tucannon spawning grounds	0
Totals for tagcode 633325:	55

Appendix F, continued.

Table 5. Recoveries of 1987 brood salmon released from Tucannon FH from 11 to 13 April 1989. Tagcode was 634950. Mark rate was 96.30% (146,535 out of 152,165 total released). Size of fish at release was 9 fpp.

Year Recovery location and agency	Observed recoveries
1990	
Tucannon FH, WDF	5
Tucannon spawning grounds	3
1991	
Tucannon FH, WDF	45
Tucannon spawning grounds, WDF	20
1992	
Treaty Ceremonial, ODFW	1
Tucannon FH, WDF	3
Tucannon spawning grounds, WDF	5
Totals for tagcode 634950:	79

Table 6. Recoveries of 1988 brood salmon released from Tucannon FH from 3 March to 10 April 1990. Tagcode was 630142. Mark rate was 95.80% (70,459 out of 73,548 total released). Size of fish at release was 11 fpp.

Year Recovery location and agency	Observed recoveries
1990	
Fish Trap-Snake River (Aug. 31), WDF	1
1991	
Tucannon FH, WDF	25
Tucannon spawning grounds, WDF	4
1992	
Test Fishery Net, ODFW	1
Treaty Ceremonial, ODFW	3
Tucannon FH, WDF	19
Tucannon spawning grounds, WDF	47
Totals for tagcode 630142:	100

Appendix F, continued.

Table 7. Recoveries of 1988 brood salmon released from Tucannon FH from 3 March to 10 April 1990. Tagcode was 635501. Mark rate was 95.80% (68,591 out of 71,598 total released). Size of fish at release was 11 fpp.

Year Recovery location and agency	Observed recoveries
1990	
Hatchery, IDFG	1
1991	
Tucannon FH, WDF	12
Tucannon spawning grounds, WDF	0
1992	
Test Fishery Net, ODFW	1
Treaty Commercial, ODFW	2
Tucannon FH, WDF	19
Tucannon spawning grounds, WDF	39
Totals for tagcode 635501:	74

Table 8. Recoveries of 1989 brood salmon released from Tucannon FH from 1 to 12 April 1991. Tagcode was 631461. Mark rate was 98.71% (75,661 out of 76,650 total released). Size of fish at release was 9 fpp.

Year Recovery location and agency	Observed recoveries
1992	
Tucannon FH, WDF	4
Tucannon spawning grounds, WDF	2
Totals for tagcode 631461:	6

Table 9. Recoveries of 1989 brood salmon released from Tucannon FH from 1 to 12 April 1991. Tagcode was 630131. Mark rate was 98.71% (22,118 out of 22,407 total released). Size of fish at release was 9 fpp.

Year Recovery location and agency	Observed recoveries
1992	
Totals for tagcode 630131:	0

APPENDIX G

Table 1. Comparison of daily minimum and maximum stream temperatures in the Tucannon River near the confluence of Cummings Creek, outlets of Big Four, Beaver/Watson and Deer Lake and at Bridge 14 from 8 October, 1991 to 24 February, 1993. Temperatures are in degrees Fahrenheit.

	BIG FOUR		BEAVER WATSON		DEER LAKE		CUMMINGS CREEK		BRIDGE 14	
DATE	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
08-Oct	-	53	-	52	-	53	-	55	-	-
09-Oct	47	53	47	52	47	53	48	53	-	-
10-Oct	48	54	48	53	48	55	50	55	-	-
11-Oct	49	55	49	54	49	56	51	55	-	-
12-Oct	50	55	49	54	50	56	51	55	-	-
13-Oct	48	53	47	52	48	53	51	53	-	-
14-Oct	48	53	47	53	47	53	49	53	-	-
15-Oct	49	55	48	54	48	55	50	55	-	-
16-Oct	51	54	50	53	50	55	52	55	-	-
17-Oct	46	51	46	51	48	51	48	53	-	-
18-Oct	44	49	44	49	44	50	46	50	-	-
19-Oct	47	51	47	51	47	52	49	52	-	-
20-Oct	46	51	46	51	46	52	47	52	-	-
21-Oct	49	53	48	52	48	53	50	54	-	-
22-Oct	45	49	44	46	44	46	46	49	-	-
23-Oct	46	47	45	49	46	50	46	49	-	-
24-Oct	46	47	45	47	46	48	47	49	-	-
25-Oct	46	46	45	48	46	48	47	49	-	-
26-Oct	47	48	46	48	46	48	47	49	-	-
27-Oct	44	46	43	48	44	46	45	47	-	-
28-Oct	43	45	43	44	43	45	43	45	-	-
29-Oct	42	44	41	43	42	44	43	44	-	-
30-Oct	39	42	39	42	38	42	39	42	-	-
31-Oct	41	42	40	42	41	42	41	42	-	-
01-Nov	42	45	41	44	41	44	42	44	-	-
02-Nov	38	42	39	41	37	42	39	41	-	-
03-Nov	39	43	39	42	38	42	39	42	-	-
04-Nov	42	46	42	46	42	47	42	46	-	-
05-Nov	45	47	45	46	46	48	46	48	-	-
06-Nov	45	47	44	46	44	47	46	48	-	-
07-Nov	43	47	42	46	43	47	44	47	-	-
08-Nov	46	49	45	46	46	49	46	49	-	-
09-Nov	46	48	46	48	46	49	47	49	-	-
10-Nov	45	48	45	48	45	48	46	49	-	-
11-Nov	45	46	44	48	44	49	46	49	-	-
12-Nov	46	47	46	47	49	50	49	47	-	-
13-Nov	45	48	44	48	44	49	46	49	-	-
14-Nov	44	46	44	45	44	46	45	47	-	-
15-Nov	45	45	40	44	41	44	42	45	-	-

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
16-Nov	40	44	39	43	39	44	41	44	-	-
17-Nov	44	46	43	45	44	46	44	46	-	-
18-Nov	43	45	43	45	43	45	44	46	-	-
19-Nov	43	45	42	45	42	46	43	46	-	-
20-Nov	44	46	45	46	45	46	46	47	-	-
21-Nov	43	44	42	44	43	45	43	45	-	-
22-Nov	41	43	40	42	41	43	42	43	-	-
23-Nov	41	43	39	42	40	43	41	44	-	-
24-Nov	43	45	42	44	43	45	43	46	-	-
25-Nov	44	46	46	47	45	46	45	46	-	-
26-Nov	44	45	46	46	44	45	44	46	-	-
27-Nov	42	44	42	44	42	45	43	46	-	-
28-Nov	43	44	42	44	43	44	43	45	-	-
29-Nov	42	43	41	42	41	43	42	43	-	-
30-Nov	40	42	39	42	40	42	41	43	-	-
01-Dec	42	44	41	44	42	44	42	45	-	-
02-Dec	44	44	43	44	44	45	44	45	-	-
03-Dec	43	46	43	45	43	46	44	46	-	-
04-Dec	44	46	44	45	44	46	45	46	-	-
05-Dec	44	46	44	46	44	46	46	47	-	-
06-Dec	45	45	45	46	46	46	46	47	-	-
07-Dec	45	45	43	44	44	46	45	46	-	-
08-Dec	45	46	44	45	45	46	45	46	-	-
09-Dec	45	47	44	46	45	47	45	48	-	-
10-Dec	44	45	42	44	43	46	44	46	-	-
11-Dec	44	46	42	44	43	46	44	46	-	-
12-Dec	44	46	43	44	44	45	45	46	-	-
13-Dec	43	46	42	43	42	44	43	45	-	-
14-Dec	42	43	41	42	41	42	42	43	-	-
15-Dec	41	42	39	41	40	42	41	42	-	-
16-Dec	41	42	40	41	40	42	41	44	-	-
17-Dec	41	42	39	40	40	41	41	42	-	-
18-Dec	41	44	40	43	41	44	42	44	-	-
19-Dec	41	43	40	42	41	43	42	44	-	-
20-Dec	39	41	38	40	39	41	40	42	-	-
21-Dec	40	43	37	42	40	42	41	44	-	-
22-Dec	42	45	42	43	42	44	43	44	-	-
23-Dec	43	44	42	42	42	44	44	44	-	-
24-Dec	42	44	41	42	42	43	43	44	-	-
25-Dec	42	43	41	42	42	42	43	43	-	-
26-Dec	42	44	41	43	41	43	42	44	-	-
27-Dec	43	44	42	43	42	44	43	45	-	-
28-Dec	42	43	41	42	42	43	43	44	-	-
29-Dec	41	43	40	42	41	42	42	43	-	-
30-Dec	42	44	42	43	42	44	43	45	-	-

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
31-Dec	41	43	39	42	40	43	41	44	-	-
01-Jan	40	42	38	40	39	42	40	42	-	-
02-Jan	45	43	40	42	41	43	42	44	-	-
03-Jan	40	43	39	41	39	42	41	43	-	-
04-Jan	41	44	40	42	41	43	42	44	-	-
05-Jan	41	43	40	42	41	42	42	44	-	-
06-Jan	41	43	40	42	41	42	42	43	-	-
07-Jan	40	42	39	40	39	41	41	42	-	-
08-Jan	38	40	37	39	37	39	39	41	-	-
09-Jan	39	42	38	40	39	41	40	42	-	-
10-Jan	41	43	39	41	40	42	40	43	-	-
11-Jan	41	42	40	41	41	42	42	43	-	-
12-Jan	41	42	39	41	40	42	41	42	-	-
13-Jan	41	43	39	41	40	42	41	43	-	-
14-Jan	41	43	39	42	39	43	41	44	-	-
15-Jan	41	43	39	42	39	42	41	43	-	-
16-Jan	42	44	42	43	42	44	43	44	-	-
17-Jan	40	42	37	42	39	43	41	44	-	-
18-Jan	39	40	37	37	39	40	40	42	-	-
19-Jan	38	40	37	39	38	39	40	41	-	-
20-Jan	38	39	37	38	37	39	39	40	-	-
21-Jan	38	41	36	41	37	41	39	41	-	-
22-Jan	39	42	37	40	38	41	39	42	-	-
23-Jan	42	45	40	44	42	45	42	46	-	-
24-Jan	44	46	43	45	44	46	45	47	-	-
25-Jan	43	45	42	44	43	45	44	46	-	-
26-Jan	41	44	39	42	40	43	42	44	-	-
27-Jan	42	44	41	43	42	44	43	45	-	-
28-Jan	43	45	42	44	43	45	44	46	-	-
29-Jan	43	46	42	46	43	46	44	46	-	-
30-Jan	44	46	43	45	43	46	45	47	-	-
31-Jan	45	46	46	47	42	46	46	47	-	-
01-Feb	44	46	43	45	43	46	44	47	-	-
02-Feb	42	45	41	44	42	45	43	46	-	-
03-Feb	42	44	40	42	41	44	42	44	-	-
04-Feb	41	44	39	42	39	43	41	44	-	-
05-Feb	41	44	39	42	40	43	41	44	-	-
06-Feb	41	45	39	42	40	43	41	44	-	-
07-Feb	42	44	39	42	41	43	41	44	-	-
08-Feb	42	45	41	43	42	44	42	44	-	-
09-Feb	43	46	42	45	42	46	42	46	-	-
10-Feb	42	46	41	44	41	45	42	46	-	-
11-Feb	44	47	42	46	43	46	44	47	-	-
12-Feb	43	46	42	45	42	46	43	46	-	-
13-Feb	44	47	43	46	43	46	44	48	-	-

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
14-Feb	44	47	42	46	43	47	44	48	-	-
15-Feb	44	45	42	43	43	44	44	45	-	-
16-Feb	41	45	40	43	40	44	41	44	-	-
17-Feb	41	45	40	44	40	44	41	45	-	-
18-Feb	42	44	41	42	41	44	42	45	-	-
19-Feb	44	48	42	46	44	47	44	47	-	-
20-Feb	45	46	44	45	45	46	46	47	-	-
21-Feb	44	46	42	45	43	46	44	47	-	-
22-Feb	44	46	43	45	44	46	45	47	-	-
23-Feb	42	46	41	45	42	46	43	46	-	-
24-Feb	44	48	44	46	44	48	45	48	-	-
25-Feb	45	48	44	46	44	47	46	48	-	-
26-Feb	43	47	42	46	43	47	44	47	-	-
27-Feb	43	47	42	46	43	48	44	48	-	-
28-Feb	44	47	43	46	44	47	45	47	-	-
29-Feb	44	47	44	46	44	47	45	47	-	-
01-Mar	44	46	43	45	44	46	45	47	-	-
02-Mar	43	47	42	46	43	48	44	48	-	-
03-Mar	45	46	44	46	45	46	46	47	-	-
04-Mar	43	47	42	47	43	48	44	48	-	-
05-Mar	43	48	42	48	43	48	44	49	-	-
06-Mar	44	48	42	47	43	49	44	49	-	-
07-Mar	46	47	45	46	46	48	46	48	-	-
08-Mar	43	48	42	48	43	49	44	48	-	-
09-Mar	42	48	41	46	42	48	43	48	-	-
10-Mar	42	48	41	47	42	48	43	48	-	-
11-Mar	42	49	41	48	42	49	43	49	-	-
12-Mar	43	50	42	50	43	51	43	48	-	-
13-Mar	44	51	43	51	44	52	43	49	-	-
14-Mar	44	51	44	51	45	52	44	50	-	-
15-Mar	46	50	46	49	47	51	46	49	-	-
16-Mar	45	48	44	48	46	47	44	47	-	-
17-Mar	46	48	45	48	46	49	44	47	-	-
18-Mar	44	48	43	48	44	49	43	47	-	-
19-Mar	42	48	42	48	42	49	41	47	-	-
20-Mar	42	49	42	49	43	50	41	48	-	-
21-Mar	42	49	41	48	42	50	40	47	-	-
22-Mar	45	49	45	52	46	53	46	50	42	50
23-Mar	42	50	43	51	43	51	44	50	42	51
24-Mar	43	51	43	52	44	53	44	51	43	52
25-Mar	43	53	43	52	44	53	44	52	44	51
26-Mar	44	49	44	50	45	51	46	51	44	50
27-Mar	46	49	46	50	46	50	46	51	40	49
28-Mar	42	49	42	50	42	51	42	49	41	48
29-Mar	42	49	42	50	42	51	43	49	43	53

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
30-Mar	43	52	44	53	44	54	45	52	44	54
31-Mar	44	53	45	53	46	55	46	54	45	55
01-Apr	45	54	46	53	46	55	46	55	46	56
02-Apr	46	55	46	55	48	58	48	56	47	53
03-Apr	46	52	47	53	48	54	49	53	46	52
04-Apr	46	50	46	53	47	53	47	52	42	49
05-Apr	43	49	44	50	44	50	44	50	42	48
06-Apr	42	48	42	48	43	49	44	49	40	46
07-Apr	41	46	41	46	42	47	42	47	40	45
08-Apr	41	44	41	45	42	46	42	46	44	47
09-Apr	44	46	44	48	45	48	46	49	44	47
10-Apr	45	48	45	48	47	50	47	49	42	49
11-Apr	43	48	44	49	44	50	45	50	45	49
12-Apr	46	49	46	49	48	51	48	50	45	52
13-Apr	46	52	46	53	48	54	48	53	44	52
14-Apr	45	50	45	51	46	54	46	53	44	51
15-Apr	45	51	45	51	46	53	46	52	47	51
16-Apr	47	51	48	52	49	53	49	53	46	50
17-Apr	47	49	47	50	48	55	48	51	45	51
18-Apr	46	51	46	53	47	53	48	53	43	52
19-Apr	44	52	44	53	46	54	46	53	45	52
20-Apr	46	53	46	54	47	54	48	54	45	49
21-Apr	46	49	46	49	49	55	48	53	43	51
22-Apr	44	50	44	51	46	53	46	51	41	49
23-Apr	42	48	42	51	44	53	44	51	42	52
24-Apr	43	53	43	54	44	52	45	53	46	56
25-Apr	46	56	46	58	48	55	48	57	47	56
26-Apr	47	57	48	58	49	59	50	58	49	56
27-Apr	48	55	49	57	50	59	51	57	49	56
28-Apr	48	55	49	57	50	58	51	57	49	55
29-Apr	49	54	49	55	50	58	52	57	49	54
30-Apr	48	53	48	55	51	57	50	55	45	53
01-May	45	53	45	55	47	56	48	55	45	55
02-May	45	55	45	57	47	56	48	57	47	57
03-May	46	57	47	60	48	58	49	59	48	58
04-May	47	59	48	61	48	60	50	60	49	59
05-May	48	59	49	61	49	61	51	60	50	60
06-May	48	60	50	62	48	62	52	62	51	61
07-May	50	61	51	63	51	63	53	63	51	55
08-May	50	54	50	55	52	64	53	56	48	55
09-May	48	54	48	56	50	56	51	55	49	56
10-May	49	55	49	57	50	57	51	57	46	54
11-May	46	55	46	57	48	58	48	55	44	53
12-May	44	53	44	55	46	57	46	54	46	56
13-May	47	57	47	48	46	56	49	57	48	59

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
14-May	48	60	48	60	49	59	50	60	50	59
15-May	50	59	50	59	49	62	52	59	48	59
16-May	47	59	48	60	49	62	50	59	49	58
17-May	46	57	48	59	49	62	51	59	52	63
18-May	51	62	52	60	50	61	55	63	53	60
19-May	52	59	53	59	54	65	55	61	53	60
20-May	53	60	51	60	54	62	53	60	-	-
21-May	47	58	48	59	49	62	50	58	-	-
22-May	48	60	48	60	59	61	50	60	-	-
23-May	51	63	52	59	50	63	53	63	-	-
24-May	52	65	53	63	53	66	55	65	-	-
25-May	53	66	53	64	55	68	56	66	-	-
26-May	56	63	54	62	55	69	58	64	-	-
27-May	52	64	51	62	53	66	54	63	-	-
28-May	52	61	51	61	53	66	55	62	-	-
29-May	53	64	53	64	54	64	56	64	-	-
30-May	52	64	51	63	54	66	55	63	-	-
31-May	54	66	52	64	55	67	55	65	-	-
01-Jun	52	65	53	63	55	69	57	66	61	72
02-Jun	55	66	55	64	56	69	59	65	53	61
03-Jun	52	61	51	60	53	69	54	61	52	62
04-Jun	51	62	50	61	53	64	53	62	54	65
05-Jun	53	64	52	62	53	66	56	64	53	65
06-Jun	52	63	51	62	54	67	55	64	54	66
07-Jun	53	64	52	61	55	68	55	64	54	67
08-Jun	53	66	52	62	54	67	55	66	55	66
09-Jun	54	66	53	61	55	70	57	65	55	66
10-Jun	54	65	54	61	55	69	57	65	58	63
11-Jun	57	63	56	60	56	68	59	63	54	60
12-Jun	53	59	53	59	58	66	55	61	52	59
13-Jun	53	58	51	58	54	58	54	59	51	55
14-Jun	51	53	50	53	52	62	52	55	51	55
15-Jun	51	54	50	53	52	56	53	55	53	60
16-Jun	53	59	52	57	53	56	54	59	53	65
17-Jun	52	66	52	62	53	61	54	64	55	68
18-Jun	54	68	55	58	54	69	57	66	57	69
19-Jun	55	69	55	59	57	71	58	67	58	69
20-Jun	56	68	56	59	58	72	59	67	58	71
21-Jun	57	70	57	60	58	71	59	68	60	72
22-Jun	58	71	58	62	59	73	60	71	60	73
23-Jun	59	73	59	63	60	75	61	72	61	73
24-Jun	59	73	60	63	61	76	62	72	62	73
25-Jun	60	70	60	62	62	77	63	71	62	74
26-Jun	60	69	60	63	62	74	63	70	61	73
27-Jun	59	72	59	62	61	73	62	71	62	67

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
28-Jun	59	64	60	62	61	76	64	66	60	67
29-Jun	59	66	59	64	60	68	60	66	57	67
30-Jun	56	65	56	63	58	69	59	65	58	62
01-Jul	57	60	56	59	58	67	60	61	57	66
02-Jul	56	66	56	62	57	62	58	65	58	65
03-Jul	56	64	57	62	57	69	59	64	58	64
04-Jul	57	62	57	62	58	68	59	64	56	66
05-Jul	55	64	56	61	57	66	58	64	56	67
06-Jul	54	65	55	61	56	66	57	63	56	62
07-Jul	55	62	55	60	56	66	57	62	56	66
08-Jul	55	67	55	61	56	64	57	64	56	68
09-Jul	55	66	55	61	56	68	57	66	56	64
10-Jul	55	59	55	60	56	66	57	62	57	63
11-Jul	56	60	56	59	56	63	58	61	55	65
12-Jul	54	65	54	60	55	62	56	64	57	67
13-Jul	55	66	56	60	56	67	58	65	57	69
14-Jul	55	69	56	60	55	69	59	66	56	69
15-Jul	54	68	55	60	56	71	57	66	56	69
16-Jul	54	69	55	61	56	71	57	67	58	72
17-Jul	56	71	57	61	56	72	59	69	59	70
18-Jul	57	69	59	61	58	74	60	68	62	71
19-Jul	59	66	60	63	60	72	63	68	59	66
20-Jul	57	62	58	61	59	71	60	65	59	71
21-Jul	57	68	58	62	59	66	60	66	59	63
22-Jul	57	60	58	62	59	70	60	63	56	59
23-Jul	56	58	56	58	58	63	57	60	55	64
24-Jul	56	61	55	60	57	59	57	62	55	68
25-Jul	55	68	55	61	56	64	58	66	57	70
26-Jul	56	70	57	61	56	71	59	68	57	70
27-Jul	55	69	57	61	56	73	59	58	57	69
28-Jul	55	68	57	61	55	72	58	66	54	71
29-Jul	56	70	57	61	55	71	59	68	58	72
30-Jul	57	71	58	61	58	73	59	68	60	72
31-Jul	57	71	59	61	59	73	60	70	61	72
01-Aug	59	71	60	62	60	74	62	70	59	71
02-Aug	57	71	59	62	60	74	60	69	58	70
03-Aug	56	69	58	62	58	73	58	66	57	69
04-Aug	55	68	57	62	57	71	57	64	56	66
05-Aug	55	66	57	62	57	71	57	62	56	63
06-Aug	55	62	57	60	57	70	57	65	56	68
07-Aug	56	66	57	62	57	64	57	64	56	66
08-Aug	55	66	57	62	56	69	56	64	55	67
09-Aug	54	66	55	61	55	68	56	66	55	69
10-Aug	54	68	56	61	55	69	58	67	57	71
11-Aug	56	69	57	61	56	70	60	69	59	71

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
12-Aug	57	70	59	61	58	72	63	71	62	73
13-Aug	60	71	61	62	59	73	62	71	60	79
14-Aug	59	71	60	62	61	75	65	70	65	75
15-Aug	60	69	60	62	62	75	63	70	62	70
16-Aug	58	67	58	62	61	72	63	67	60	71
17-Aug	58	66	58	62	60	71	62	70	60	68
18-Aug	57	69	57	62	60	68	62	68	59	71
19-Aug	57	67	57	62	60	71	61	68	59	69
20-Aug	57	68	57	62	59	70	61	64	58	69
21-Aug	57	64	57	62	59	70	57	62	59	63
22-Aug	54	59	52	58	58	66	54	59	54	59
23-Aug	52	58	51	57	53	58	52	59	51	60
24-Aug	49	60	47	59	50	60	52	60	50	60
25-Aug	49	61	48	60	50	62	54	62	50	61
26-Aug	50	63	49	60	51	62	56	62	51	64
27-Aug	52	63	51	59	52	65	57	63	53	64
28-Aug	53	63	53	60	54	65	55	62	55	64
29-Aug	52	62	51	59	53	65	56	62	53	63
30-Aug	52	62	51	59	53	64	57	62	54	63
31-Aug	53	62	52	59	55	64	57	64	54	64
01-Sep	53	64	52	59	55	63	57	64	54	65
02-Sep	-	-	53	59	55	66	56	63	55	65
03-Sep	-	-	51	59	54	66	58	62	54	64
04-Sep	-	-	54	58	54	64	55	60	56	63
05-Sep	-	-	51	58	53	63	52	57	53	60
06-Sep	-	-	48	55	51	61	59	57	50	58
07-Sep	-	-	46	55	48	58	54	60	48	58
08-Sep	-	-	50	57	48	58	53	59	52	60
09-Sep	-	-	49	57	52	62	54	60	51	61
10-Sep	-	-	50	57	52	62	56	62	52	61
11-Sep	-	-	52	57	52	62	55	59	54	63
12-Sep	-	-	51	55	54	65	51	55	53	59
13-Sep	-	-	48	54	51	59	50	55	50	56
14-Sep	-	-	46	53	48	57	53	54	48	55
15-Sep	-	-	50	52	48	56	51	57	51	53
16-Sep	-	-	48	55	50	55	52	57	50	58
17-Sep	-	-	49	55	50	60	52	57	51	58
18-Sep	-	-	46	54	48	59	54	59	48	57
19-Sep	-	-	48	55	48	57	-	-	50	58
20-Sep	-	-	-	-	53	59	-	-	52	60
21-Sep	-	-	-	-	54	62	-	-	53	62
22-Sep	-	-	-	-	55	64	-	-	54	63
23-Sep	-	-	-	-	59	68	-	-	55	62
24-Sep	-	-	-	-	59	68	-	-	52	57
25-Sep	-	-	-	-	-	-	-	-	51	56

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
26-Sep	-	-	-	-	-	-	-	-	50	56
27-Sep	-	-	-	-	-	-	-	-	51	57
28-Sep	-	-	-	-	-	-	-	-	49	57
29-Sep	-	-	-	-	-	-	-	-	50	59
30-Sep	51	55	52	53	-	58	54	57	52	60
01-Oct	49	55	50	53	51	58	53	58	54	61
02-Oct	49	54	50	53	51	57	53	57	54	60
03-Oct	50	51	51	52	.52	55	54	55	54	56
04-Oct	47	51	48	51	49	53	51	54	51	56
05-Oct	44	49	46	49	46	51	49	53	49	55
06-Oct	43	48	45	48	45	50	48	51	47	54
07-Oct	41	47	43	47	43	49	46	50	45	53
08-Oct	45	49	46	49	47	52	49	52	48	54
09-Oct	44	49	46	49	46	51	49	52	47	54
10-Oct	43	49	45	49	44	51	48	52	47	55
11-Oct	44	50	46	50	47	53	49	53	49	56
12-Oct	44	48	46	49	46	51	49	53	49	55
13-Oct	45	49	47	48	48	51	49	53	50	55
14-Oct	42	45	45	48	44	48	46	49	46	51
15-Oct	40	43	42	45	41	46	43	47	44	48
16-Oct	40	44	42	45	41	46	43	46	44	48
17-Oct	43	48	45	48	45	50	46	49	47	52
18-Oct	44	48	46	49	46	50	43	50	48	52
19-Oct	46	49	48	49	48	52	49	51	50	54
20-Oct	44	48	46	49	46	51	48	51	48	54
21-Oct	45	47	47	48	47	49	48	50	49	52
22-Oct	44	47	46	48	46	49	47	50	47	53
23-Oct	44	48	47	48	46	50	47	50	48	54
24-Oct	43	47	45	48	45	49	46	49	46	53
25-Oct	43	47	45	47	45	49	46	49	47	53
26-Oct	43	47	45	47	44	49	46	48	46	51
27-Oct	41	44	43	46	42	46	44	47	44	50
28-Oct	41	44	43	45	42	45	44	46	44	48
29-Oct	43	45	45	46	45	47	45	47	46	49
30-Oct	42	44	44	46	44	46	45	47	46	49
31-Oct	42	44	44	45	44	46	44	46	45	49
01-Nov	43	45	45	46	45	46	46	47	47	49
02-Nov	41	43	43	45	44	46	45	46	45	48
03-Nov	40	41	41	43	41	44	42	45	43	46
04-Nov	39	42	41	45	41	43	42	44	43	46
05-Nov	42	43	43	44	43	45	44	46	44	47
06-Nov	40	43	42	44	42	44	43	45	43	47
07-Nov	42	43	44	44	42	45	45	46	45	48
08-Nov	41	42	43	44	40	43	44	45	44	46
09-Nov	40	41	41	43	39	43	42	44	42	44

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
10-Nov	37	40	39	41	39	40	40	42	40	43
11-Nov	38	40	39	41	36	40	40	42	40	44
12-Nov	40	42	41	43	34	36	42	44	44	45
13-Nov	40	42	42	43	34	35	43	44	44	47
14-Nov	40	41	42	42	33	35	43	44	44	46
15-Nov	40	41	41	42	35	38	42	44	43	46
16-Nov	39	40	41	42	37	39	42	43	43	44
17-Nov	40	42	41	42	35	37	42	44	43	45
18-Nov	39	42	41	43	37	39	42	44	42	46
19-Nov	39	40	40	41	36	38	41	42	42	44
20-Nov	38	40	40	41	36	39	40	42	40	44
21-Nov	37	38	39	40	33	36	40	40	40	41
22-Nov	37	39	39	40	33	33	40	41	40	43
23-Nov	36	39	38	40	33	33	39	41	39	42
24-Nov	33	36	37	38	33	33	36	39	36	39
25-Nov	33	34	37	38	33	35	35	36	35	38
26-Nov	32	34	37	38	35	37	34	35	33	37
27-Nov	34	37	37	38	37	38	35	38	36	39
28-Nov	36	38	38	38	37	39	38	39	39	41
29-Nov	34	36	37	38	36	38	37	39	36	39
30-Nov	36	38	38	38	37	38	37	40	38	42
01-Dec	35	37	37	38	35	37	37	39	37	40
02-Dec	36	38	38	38	37	40	38	39	38	40
03-Dec	32	36	38	38	36	38	35	38	35	38
04-Dec	32	33	38	39	35	36	35	35	33	37
05-Dec	32	32	38	39	35	37	35	35	33	37
06-Dec	32	32	38	39	33	36	35	35	33	36
07-Dec	32	36	37	38	33	36	35	35	35	37
08-Dec	35	36	37	37	35	37	33	37	36	39
09-Dec	36	36	37	38	37	38	37	38	38	40
10-Dec	36	38	37	38	38	39	38	40	39	42
11-Dec	35	37	37	38	38	40	37	39	37	39
12-Dec	35	37	37	38	36	39	37	38	38	40
13-Dec	33	36	37	38	35	37	36	38	36	39
14-Dec	36	39	37	39	37	40	37	40	39	43
15-Dec	36	37	37	38	39	39	38	39	38	40
16-Dec	34	36	37	38	38	40	36	38	36	38
17-Dec	34	35	37	37	35	38	36	37	36	39
18-Dec	32	35	37	37	35	37	35	37	34	37
19-Dec	32	35	37	37	35	37	35	37	34	38
20-Dec	34	36	36	37	33	36	36	38	36	39
21-Dec	36	37	37	38	33	35	38	39	39	41
22-Dec	37	38	38	38	33	35	39	40	39	42
23-Dec	37	38	38	39	34	35	39	40	40	42
24-Dec	36	37	37	38	33	34	38	40	38	42

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
25-Dec	34	36	37	37	33	33	37	38	36	39
26-Dec	35	38	37	38	33	33	37	40	38	42
27-Dec	37	38	38	38	33	33	39	40	40	41
28-Dec	37	38	38	39	33	33	39	41	40	42
29-Dec	34	37	37	38	33	33	35	40	35	39
30-Dec	35	36	36	37	33	33	36	37	36	38
31-Dec	34	36	36	36	33	33	35	37	35	39
01-Jan	33	35	36	36	33	33	34	37	34	36
02-Jan	32	34	36	37	33	33	34	35	33	36
03-Jan	32	34	36	37	33	33	34	35	33	37
04-Jan	33	34	36	36	33	33	35	36	34	37
05-Jan	32	34	36	36	33	34	34	35	33	36
06-Jan	32	32	37	37	34	34	34	35	33	36
07-Jan	32	32	37	37	33	37	34	35	32	35
08-Jan	32	32	36	37	37	38	34	35	32	35
09-Jan	32	32	36	36	37	38	34	34	32	35
10-Jan	32	32	36	36	34	38	34	34	32	35
11-Jan	32	32	34	36	33	36	34	35	32	36
12-Jan	32	32	34	34	36	38	33	34	32	34
13-Jan	32	32	34	34	38	41	34	35	32	35
14-Jan	32	34	33	34	38	40	34	35	34	35
15-Jan	32	34	33	33	38	39	34	35	33	36
16-Jan	32	33	33	34	39	40	34	35	32	35
17-Jan	33	34	34	34	37	40	35	35	33	36
18-Jan	32	32	34	34	36	38	34	35	33	36
19-Jan	33	36	34	35	38	38	35	37	34	38
20-Jan	36	37	35	36	37	38	37	38	38	40
21-Jan	36	37	36	37	36	37	37	39	37	40
22-Jan	35	37	35	37	37	37	36	39	35	39
23-Jan	-	-	35	36	36	38	35	37	34	38
24-Jan	-	-	35	37	37	39	37	39	37	40
25-Jan	-	-	37	39	38	41	39	41	41	44
26-Jan	-	-	38	39	38	40	40	41	39	43
27-Jan	-	-	38	39	37	40	38	40	38	42
28-Jan	-	-	38	39	40	40	39	41	39	42
29-Jan	-	-	38	39	40	41	39	41	40	42
30-Jan	-	-	37	39	39	40	37	40	37	40
31-Jan	-	-	38	38	40	41	39	39	39	40
01-Feb	-	-	38	38	40	41	39	39	38	40
02-Feb	-	-	37	38	38	40	38	39	38	40
03-Feb	-	-	37	37	34	38	38	39	38	40
04-Feb	-	-	37	38	34	34	37	39	37	42
05-Feb	-	-	37	38	34	34	37	39	37	42
06-Feb	-	-	38	39	34	34	38	42	38	44
07-Feb	-	-	38	39	34	35	39	41	38	43

Appendix G, continued.

DATE	BIG FOUR MIN	BIG FOUR MAX	BEAVER WATSON MIN	BEAVER WATSON MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	BRIDGE 14 MIN	BRIDGE 14 MAX
08-Feb	-	-	38	39	35	37	38	41	32	43
09-Feb	-	-	39	40	35	37	41	42	-	-
10-Feb	-	-	40	40	35	37	41	42	-	-
11-Feb	-	-	39	40	35	36	39	41	-	-
12-Feb	-	-	39	40	35	-	41	42	-	-
13-Feb	-	-	40	40	-	-	41	42	-	-
14-Feb	-	-	39	40	-	-	39	42	-	-
15-Feb	-	-	-	-	-	-	35	40	-	-
16-Feb	-	-	-	-	-	-	34	35	-	-
17-Feb	-	-	-	-	-	-	34	35	-	-
18-Feb	-	-	-	-	-	-	34	34	-	-
19-Feb	-	-	-	-	-	-	34	35	-	-
20-Feb	-	-	-	-	-	-	35	37	-	-
21-Feb	-	-	-	-	-	-	35	37	-	-
22-Feb	-	-	-	-	-	-	35	38	-	-
23-Feb	-	-	-	-	-	-	35	37	-	-
24-Feb	-	-	-	-	-	-	35	-	-	-

Appendix G, continued.

Table 2. Comparison of daily minimum and maximum stream temperatures in the Tucannon River at Bridge 12, Marengo Bridge, WDF smolt trap and at Powers Bridge from 8 October, 1991 to 24 February, 1993. Temperatures are in degrees Fahrenheit.

	BRIDGE 12		MARENGO BRIDGE		SMOLT TRAP		POWERS BRIDGE	
DATE	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
08-Oct	-	-	-	58	-	-	-	-
09-Oct	-	-	51	57	-	-	-	-
10-Oct	-	-	52	58	-	-	-	-
11-Oct	-	-	53	58	-	-	-	-
12-Oct	-	-	54	59	-	-	-	-
13-Oct	-	-	52	57	-	-	-	-
14-Oct	-	-	52	57	-	-	-	-
15-Oct	-	-	53	58	-	-	-	-
16-Oct	-	-	55	57	-	-	-	-
17-Oct	-	-	50	54	-	-	-	-
18-Oct	-	-	48	52	-	-	-	-
19-Oct	-	-	53	54	-	-	-	-
20-Oct	-	-	50	55	-	-	-	-
21-Oct	-	-	55	60	-	-	-	-
22-Oct	-	-	52	55	-	-	-	-
23-Oct	-	-	51	53	-	-	-	-
24-Oct	-	-	52	54	-	-	-	-
25-Oct	-	-	51	54	-	-	-	-
26-Oct	-	-	51	53	-	-	-	-
27-Oct	-	-	50	51	-	-	-	-
28-Oct	-	-	47	49	-	-	-	-
29-Oct	-	-	46	48	-	-	-	-
30-Oct	-	-	43	46	-	-	-	-
31-Oct	-	-	45	46	-	-	-	-
01-Nov	-	-	45	48	-	-	-	-
02-Nov	-	-	42	45	-	-	-	-
03-Nov	-	-	42	46	-	-	-	-
04-Nov	-	-	46	50	-	-	-	-
05-Nov	-	-	50	55	-	-	-	-
06-Nov	-	-	51	54	-	-	-	-
07-Nov	-	-	48	51	-	-	-	-
08-Nov	-	-	50	53	-	-	-	-
09-Nov	-	-	52	53	-	-	-	-
10-Nov	-	-	51	54	-	-	-	-
11-Nov	-	-	50	53	-	-	-	-
12-Nov	-	-	53	56	-	-	-	-
13-Nov	-	-	49	55	-	-	-	-
14-Nov	-	-	48	51	-	-	-	-
15-Nov	-	-	44	48	-	-	-	-
16-Nov	-	-	42	48	-	-	-	-
17-Nov	-	-	46	47	-	-	-	-

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
18-Nov	-	-	47	50	-	-	-	-
19-Nov	-	-	46	49	-	-	-	-
20-Nov	-	-	48	51	-	-	-	-
21-Nov	-	-	46	48	-	-	-	-
22-Nov	-	-	43	46	-	-	-	-
23-Nov	-	-	43	46	-	-	-	-
24-Nov	-	-	46	48	-	-	-	-
25-Nov	-	-	48	51	-	-	-	-
26-Nov	-	-	48	48	-	-	-	-
27-Nov	-	-	46	48	-	-	-	-
28-Nov	-	-	45	46	-	-	-	-
29-Nov	-	-	44	46	-	-	-	-
30-Nov	-	-	42	44	-	-	-	-
01-Dec	-	-	44	47	-	-	-	-
02-Dec	-	-	47	48	-	-	-	-
03-Dec	-	-	46	48	-	-	-	-
04-Dec	-	-	46	49	-	-	-	-
05-Dec	-	-	48	50	-	-	-	-
06-Dec	-	-	48	50	-	-	-	-
07-Dec	-	-	45	47	-	-	-	-
08-Dec	-	-	45	47	-	-	-	-
09-Dec	-	-	45	47	-	-	-	-
10-Dec	-	-	44	46	-	-	-	-
11-Dec	-	-	44	46	-	-	-	-
12-Dec	-	-	44	47	-	-	-	-
13-Dec	-	-	43	44	-	-	-	-
14-Dec	-	-	41	43	-	-	-	-
15-Dec	-	-	40	42	-	-	-	-
16-Dec	-	-	41	42	-	-	-	-
17-Dec	-	-	41	41	-	-	-	-
18-Dec	-	-	41	43	-	-	-	-
19-Dec	-	-	41	43	-	-	-	-
20-Dec	-	-	40	44	-	-	-	-
21-Dec	-	-	41	43	-	-	-	-
22-Dec	-	-	43	44	-	-	-	-
23-Dec	-	-	44	44	-	-	-	-
24-Dec	-	-	43	44	-	-	-	-
25-Dec	-	-	43	43	-	-	-	-
26-Dec	-	-	42	43	-	-	-	-
27-Dec	-	-	42	44	-	-	-	-
28-Dec	-	-	42	43	-	-	-	-
29-Dec	-	-	42	43	-	-	-	-
30-Dec	-	-	43	45	-	-	-	-
31-Dec	-	-	43	44	-	-	-	-

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
01-Jan	-	-	42	43	-	-	-	-
02-Jan	-	-	42	45	-	-	-	-
03-Jan	-	-	42	44	-	-	-	-
04-Jan	-	-	44	45	-	-	-	-
05-Jan	-	-	43	44	-	-	-	-
06-Jan	-	-	43	44	-	-	-	-
07-Jan	-	-	41	43	-	-	-	-
08-Jan	-	-	40	42	-	-	-	-
09-Jan	-	-	40	42	-	-	-	-
10-Jan	-	-	40	43	-	-	-	-
11-Jan	-	-	43	44	-	-	-	-
12-Jan	-	-	42	44	-	-	-	-
13-Jan	-	-	42	44	-	-	-	-
14-Jan	40	43	43	44	-	-	-	-
15-Jan	39	42	42	44	-	-	-	-
16-Jan	42	43	44	45	-	-	-	-
17-Jan	38	41	42	45	-	-	-	-
18-Jan	38	40	42	42	-	-	-	-
19-Jan	38	39	42	42	-	-	-	-
20-Jan	37	38	41	42	-	-	-	-
21-Jan	36	40	41	43	-	-	-	-
22-Jan	36	42	42	44	-	-	-	-
23-Jan	41	45	44	48	-	-	-	-
24-Jan	43	46	47	49	-	-	-	-
25-Jan	42	45	46	48	-	-	-	-
26-Jan	39	44	43	46	-	-	-	-
27-Jan	41	44	45	47	-	-	-	-
28-Jan	42	45	46	48	-	-	-	-
29-Jan	42	45	46	48	-	-	-	-
30-Jan	43	43	47	48	-	-	-	-
31-Jan	-	-	47	48	-	-	-	-
01-Feb	-	-	46	48	-	-	-	-
02-Feb	-	-	44	47	-	-	-	-
03-Feb	-	-	43	46	-	-	-	-
04-Feb	-	-	41	45	-	-	-	-
05-Feb	-	-	41	45	-	-	-	-
06-Feb	-	-	42	44	-	-	-	-
07-Feb	-	-	43	44	-	-	-	-
08-Feb	-	-	44	45	-	-	-	-
09-Feb	-	-	44	47	-	-	-	-
10-Feb	-	-	43	47	-	-	-	-
11-Feb	-	-	46	50	-	-	-	-
12-Feb	-	-	44	49	-	-	-	-
13-Feb	-	-	46	49	-	-	-	-
14-Feb	-	-	46	50	-	-	-	-

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
15-Feb	-	-	46	47	-	-	-	-
16-Feb	-	-	42	47	-	-	-	-
17-Feb	-	-	43	46	-	-	-	-
18-Feb	-	-	44	46	-	-	-	-
19-Feb	-	-	46	48	-	-	-	-
20-Feb	-	-	47	49	-	-	-	-
21-Feb	-	-	46	50	-	-	-	-
22-Feb	-	-	46	50	-	-	-	-
23-Feb	-	-	44	46	-	-	-	-
24-Feb	-	-	47	49	-	-	-	-
25-Feb	-	-	48	49	-	-	-	-
26-Feb	-	-	47	49	-	-	-	-
27-Feb	-	-	47	49	-	-	-	-
28-Feb	-	-	47	48	46	46	-	-
29-Feb	-	-	47	48	45	46	-	-
01-Mar	-	-	46	48	44	46	-	-
02-Mar	-	-	46	50	44	47	-	-
03-Mar	-	-	48	48	45	47	-	-
04-Mar	-	-	46	51	43	49	-	-
05-Mar	-	-	45	51	42	49	-	-
06-Mar	-	-	46	52	44	49	-	-
07-Mar	-	-	48	51	47	51	-	-
08-Mar	-	-	46	52	42	49	-	-
09-Mar	-	-	44	52	42	49	-	-
10-Mar	-	-	44	52	42	49	-	-
11-Mar	-	-	45	53	42	51	-	-
12-Mar	-	-	46	55	43	51	-	-
13-Mar	-	-	47	56	44	53	-	-
14-Mar	-	-	48	57	46	54	-	-
15-Mar	-	-	51	55	50	54	-	-
16-Mar	-	-	50	53	48	53	-	-
17-Mar	-	-	48	52	46	51	-	-
18-Mar	-	-	48	53	45	51	-	-
19-Mar	-	-	46	52	42	51	-	-
20-Mar	-	-	46	54	42	52	-	-
21-Mar	-	-	44	53	41	51	-	-
22-Mar	-	-	51	56	43	52	50	64
23-Mar	-	-	47	55	44	53	46	56
24-Mar	-	-	48	57	44	54	47	57
25-Mar	-	-	48	57	45	55	47	57
26-Mar	-	-	49	55	47	52	50	55
27-Mar	-	-	50	54	47	52	50	56
28-Mar	-	-	46	54	41	51	44	54
29-Mar	-	-	46	54	42	51	44	54
30-Mar	-	-	44	55	44	55	47	58

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
31-Mar	-	-	48	60	47	57	50	61
01-Apr	-	-	51	61	48	59	51	62
02-Apr	-	-	52	62	49	60	51	64
03-Apr	-	-	53	58	52	57	55	61
04-Apr	-	-	51	57	48	54	51	58
05-Apr	-	-	48	55	44	52	47	55
06-Apr	-	-	47	53	43	51	46	54
07-Apr	-	-	46	50	42	47	45	51
08-Apr	-	-	45	50	40	48	44	52
09-Apr	-	-	48	51	46	48	49	51
10-Apr	-	-	50	53	47	52	50	56
11-Apr	-	-	48	53	45	51	48	53
12-Apr	-	-	50	53	48	51	51	54
13-Apr	-	-	51	58	49	56	52	61
14-Apr	-	-	50	59	47	57	51	61
15-Apr	-	-	50	60	48	58	51	61
16-Apr	-	-	52	56	51	55	55	59
17-Apr	-	-	51	55	50	55	52	58
18-Apr	-	-	50	55	47	53	50	57
19-Apr	-	-	49	57	47	56	50	60
20-Apr	-	-	51	57	49	56	51	59
21-Apr	-	-	51	54	49	53	52	56
22-Apr	-	-	48	55	45	51	48	55
23-Apr	-	-	47	56	45	54	47	57
24-Apr	-	-	48	58	45	55	48	58
25-Apr	-	-	51	62	49	60	51	63
26-Apr	-	-	53	62	52	60	55	64
27-Apr	-	-	55	62	53	61	56	65
28-Apr	-	-	55	62	54	61	57	66
29-Apr	-	-	55	60	54	58	56	61
30-Apr	-	-	54	60	53	58	55	61
01-May	-	-	50	59	48	57	51	61
02-May	-	-	51	61	49	58	51	62
03-May	-	-	53	64	51	62	53	66
04-May	-	-	54	65	52	63	54	67
05-May	-	-	55	66	53	64	55	68
06-May	-	-	56	67	54	65	56	70
07-May	-	-	58	68	57	67	59	71
08-May	-	-	57	62	54	60	56	62
09-May	-	-	53	59	51	57	53	60
10-May	-	-	54	61	52	60	54	63
11-May	-	-	51	59	49	57	52	60
12-May	-	-	50	47	48	56	50	60
13-May	-	-	52	62	49	60	51	64
14-May	-	-	54	65	52	64	54	67

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
15-May	-	-	57	64	55	64	57	68
16-May	-	-	54	65	51	64	54	68
17-May	-	-	55	65	51	64	54	67
18-May	-	-	59	69	57	68	60	71
19-May	-	-	60	67	58	66	60	69
20-May	-	-	58	64	56	71	58	71
21-May	-	-	53	64	-	-	-	-
22-May	-	-	54	66	-	-	-	-
23-May	-	-	57	69	-	-	-	-
24-May	-	-	59	72	-	-	-	-
25-May	-	-	61	73	-	-	-	-
26-May	-	-	63	71	-	-	-	-
27-May	-	-	59	69	-	-	-	-
28-May	-	-	59	69	-	-	-	-
29-May	-	-	61	70	-	-	-	-
30-May	-	-	60	70	-	-	-	-
31-May	-	-	60	72	-	-	-	-
01-Jun	-	-	61	72	-	-	-	-
02-Jun	-	-	62	71	66	72	68	74
03-Jun	-	-	59	67	56	67	57	71
04-Jun	-	-	58	66	55	66	57	69
05-Jun	-	-	60	69	57	68	60	72
06-Jun	-	-	59	72	56	71	58	75
07-Jun	-	-	60	71	59	70	60	75
08-Jun	-	-	61	73	59	72	61	77
09-Jun	-	-	62	72	59	70	61	75
10-Jun	-	-	61	72	59	71	61	76
11-Jun	-	-	64	69	62	68	63	72
12-Jun	-	-	59	66	56	66	58	68
13-Jun	-	-	57	64	54	62	56	65
14-Jun	-	-	57	60	54	59	56	63
15-Jun	-	-	57	60	55	60	57	64
16-Jun	-	-	58	64	56	66	58	69
17-Jun	-	-	59	71	56	69	58	74
18-Jun	-	-	62	74	60	73	62	78
19-Jun	-	-	63	76	61	75	63	80
20-Jun	-	-	64	75	63	74	65	79
21-Jun	-	-	65	77	63	77	65	81
22-Jun	-	-	66	79	64	80	66	84
23-Jun	-	-	67	80	65	80	67	85
24-Jun	-	-	68	80	66	80	67	84
25-Jun	-	-	69	80	67	79	69	83
26-Jun	-	-	69	79	68	78	69	82
27-Jun	-	-	68	80	66	80	67	84
28-Jun	-	-	69	74	68	73	69	76

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
29-Jun	-	-	66	72	65	71	66	74
30-Jun	-	-	64	73	62	72	64	76
01-Jul	-	-	64	68	62	67	64	71
02-Jul	-	-	63	73	61	72	64	76
03-Jul	-	-	65	72	63	73	64	78
04-Jul	-	-	64	69	63	68	65	73
05-Jul	-	-	63	70	60	69	61	72
06-Jul	-	-	63	72	60	71	62	73
07-Jul	-	-	63	68	61	68	62	72
08-Jul	-	-	62	71	60	69	62	74
09-Jul	-	-	63	73	60	72	62	76
10-Jul	-	-	63	69	60	68	62	71
11-Jul	-	-	64	70	62	70	63	73
12-Jul	-	-	62	72	60	72	63	75
13-Jul	-	-	64	72	63	72	64	75
14-Jul	-	-	63	73	61	72	62	76
15-Jul	-	-	62	74	59	73	61	77
16-Jul	-	-	62	75	60	75	62	78
17-Jul	-	-	64	78	62	78	64	82
18-Jul	-	-	66	76	64	76	65	79
19-Jul	-	-	68	76	67	78	69	82
20-Jul	-	-	66	71	66	73	68	76
21-Jul	-	-	66	76	64	76	66	79
22-Jul	-	-	65	70	64	71	66	74
23-Jul	-	-	62	65	61	64	62	66
24-Jul	-	-	62	69	59	68	61	72
25-Jul	-	-	62	74	59	73	61	76
26-Jul	-	-	64	75	62	75	64	78
27-Jul	-	-	64	75	63	74	64	79
28-Jul	-	-	64	74	61	74	62	78
29-Jul	-	-	64	76	63	76	64	81
30-Jul	-	-	65	77	62	77	64	82
31-Jul	-	-	66	78	64	78	65	82
01-Aug	-	-	68	77	67	77	68	80
02-Aug	-	-	66	75	64	74	64	78
03-Aug	-	-	65	75	63	75	64	79
04-Aug	-	-	64	73	62	73	63	76
05-Aug	-	-	63	70	60	70	62	73
06-Aug	-	-	63	68	61	67	62	69
07-Aug	-	-	64	73	62	71	64	73
08-Aug	-	-	62	70	60	70	61	73
09-Aug	-	-	62	71	59	71	60	75
10-Aug	-	-	62	73	58	73	60	77
11-Aug	-	-	64	75	61	75	62	79
12-Aug	-	-	65	76	63	77	64	79

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
13-Aug	-	-	69	78	68	79	69	83
14-Aug	-	-	68	78	66	76	66	79
15-Aug	-	-	69	75	68	77	68	80
16-Aug	-	-	67	75	65	75	66	79
17-Aug	-	-	67	75	64	74	65	76
18-Aug	-	-	67	76	63	76	64	80
19-Aug	-	-	66	73	64	72	64	77
20-Aug	-	-	66	73	63	73	64	77
21-Aug	-	-	65	69	62	67	63	69
22-Aug	-	-	60	66	58	62	60	64
23-Aug	-	-	57	64	53	62	55	65
24-Aug	-	-	56	65	52	63	54	67
25-Aug	-	-	57	66	53	65	56	69
26-Aug	-	-	58	68	55	67	56	71
27-Aug	-	-	60	69	57	68	59	71
28-Aug	-	-	62	69	60	68	61	72
29-Aug	-	-	59	68	57	67	59	71
30-Aug	-	-	60	66	56	65	58	69
31-Aug	-	-	61	68	59	68	61	71
01-Sep	-	-	61	69	60	69	62	72
02-Sep	-	-	62	69	60	68	62	72
03-Sep	-	-	61	67	59	68	61	72
04-Sep	-	-	62	66	59	65	60	67
05-Sep	-	-	59	64	55	62	57	66
06-Sep	-	-	56	61	53	59	54	63
07-Sep	-	-	55	62	50	60	52	63
08-Sep	-	-	57	64	55	61	56	65
09-Sep	-	-	58	64	55	64	56	68
10-Sep	-	-	58	66	54	63	56	66
11-Sep	-	-	60	67	58	66	59	69
12-Sep	-	-	58	64	55	61	57	65
13-Sep	-	-	55	60	51	57	53	62
14-Sep	-	-	54	60	50	57	52	60
15-Sep	-	-	57	58	54	56	56	59
16-Sep	-	-	57	63	53	61	56	63
17-Sep	-	-	58	64	55	61	56	65
18-Sep	-	-	56	62	50	59	52	62
19-Sep	-	-	57	62	53	60	56	64
20-Sep	-	-	59	65	56	63	58	67
21-Sep	-	-	61	66	59	66	60	69
22-Sep	-	-	60	67	56	65	58	68
23-Sep	-	-	-	-	60	66	61	68
24-Sep	-	-	-	-	56	61	57	63
25-Sep	-	-	-	-	54	58	56	61
26-Sep	-	-	-	-	53	60	56	62

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
27-Sep	-	-	-	-	53	59	54	62
28-Sep	-	-	-	-	51	58	53	61
29-Sep	-	-	-	-	52	60	53	62
30-Sep	-	-	54	60	55	62	56	65
01-Oct	-	-	55	61	55	62	57	65
02-Oct	-	-	57	60	58	63	60	65
03-Oct	-	-	55	57	56	59	58	61
04-Oct	-	-	52	56	53	58	55	61
05-Oct	-	-	50	55	50	56	51	59
06-Oct	-	-	49	53	50	55	51	58
07-Oct	-	-	47	52	47	53	48	56
08-Oct	-	-	49	53	50	55	52	58
09-Oct	-	-	50	53	50	55	52	58
10-Oct	-	-	49	55	49	56	51	58
11-Oct	-	-	50	55	51	58	52	60
12-Oct	-	-	51	55	51	57	53	59
13-Oct	-	-	51	55	52	56	54	60
14-Oct	-	-	48	51	49	52	50	55
15-Oct	-	-	45	48	44	49	47	52
16-Oct	-	-	45	48	44	49	47	52
17-Oct	-	-	48	52	48	53	50	55
18-Oct	-	-	49	53	49	53	51	56
19-Oct	-	-	52	54	53	57	55	60
20-Oct	-	-	50	54	49	55	51	58
21-Oct	-	-	51	53	52	54	54	57
22-Oct	-	-	49	53	51	55	53	58
23-Oct	-	-	50	54	50	55	51	57
24-Oct	-	-	48	52	48	53	50	56
25-Oct	-	-	48	52	48	53	51	56
26-Oct	-	-	48	52	49	53	50	56
27-Oct	-	-	46	51	45	50	47	53
28-Oct	-	-	46	48	45	48	47	51
29-Oct	-	-	47	50	46	50	49	53
30-Oct	-	-	47	49	47	50	49	53
31-Oct	-	-	47	49	47	51	50	54
01-Nov	-	-	48	50	50	52	52	54
02-Nov	-	-	47	48	47	49	49	53
03-Nov	-	-	45	47	44	47	47	50
04-Nov	-	-	45	47	44	47	47	51
05-Nov	-	-	46	48	46	49	48	52
06-Nov	-	-	45	47	45	48	48	51
07-Nov	-	-	47	48	47	49	50	52
08-Nov	-	-	45	47	45	47	48	50
09-Nov	-	-	44	45	43	45	46	48
10-Nov	-	-	42	44	42	44	44	47

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
11-Nov	-	-	42	44	42	45	45	48
12-Nov	-	-	44	46	45	46	48	49
13-Nov	-	-	45	47	45	47	48	51
14-Nov	-	-	46	47	46	47	48	51
15-Nov	-	-	45	46	46	47	49	51
16-Nov	-	-	45	45	46	47	49	51
17-Nov	-	-	45	46	45	47	49	51
18-Nov	-	-	44	46	44	48	47	51
19-Nov	-	-	43	44	42	45	45	48
20-Nov	-	-	42	43	41	43	44	47
21-Nov	-	-	41	43	41	44	44	47
22-Nov	-	-	42	44	43	44	46	47
23-Nov	-	-	41	43	39	43	42	46
24-Nov	-	-	37	41	36	38	40	42
25-Nov	-	-	36	38	35	37	40	42
26-Nov	-	-	35	37	35	37	40	41
27-Nov	-	-	37	39	35	38	39	42
28-Nov	-	-	39	41	37	40	41	43
29-Nov	-	-	38	40	38	40	42	43
30-Nov	-	-	39	42	38	42	42	45
01-Dec	-	-	38	41	37	40	40	42
02-Dec	-	-	39	41	37	40	40	44
03-Dec	-	-	36	39	34	36	37	40
04-Dec	-	-	34	36	32	33	36	38
05-Dec	-	-	34	36	32	33	37	38
06-Dec	-	-	34	35	32	33	36	38
07-Dec	-	-	35	37	32	34	37	38
08-Dec	-	-	36	40	33	39	35	41
09-Dec	-	-	39	40	38	39	40	43
10-Dec	-	-	39	42	38	41	41	44
11-Dec	-	-	39	41	37	39	39	42
12-Dec	-	-	39	40	37	39	40	43
13-Dec	-	-	38	39	37	39	39	42
14-Dec	-	-	37	43	38	43	41	46
15-Dec	-	-	39	41	38	40	40	43
16-Dec	-	-	37	39	36	38	38	41
17-Dec	-	-	38	39	36	38	38	41
18-Dec	-	-	35	38	32	35	36	38
19-Dec	-	-	35	39	32	37	36	39
20-Dec	-	-	38	39	37	40	40	42
21-Dec	-	-	39	41	39	41	41	44
22-Dec	-	-	40	42	39	42	42	45
23-Dec	-	-	41	43	41	43	44	46
24-Dec	-	-	40	42	38	42	42	45
25-Dec	-	-	38	40	36	38	39	42

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
26-Dec	-	-	39	42	37	42	40	44
27-Dec	-	-	41	41	40	41	43	44
28-Dec	-	-	40	42	39	42	42	44
29-Dec	-	-	36	40	36	39	40	42
30-Dec	-	-	36	38	34	36	38	39
31-Dec	-	-	36	38	34	36	37	40
01-Jan	-	-	35	37	32	35	37	38
02-Jan	-	-	35	37	32	35	36	38
03-Jan	-	-	34	37	32	36	36	39
04-Jan	-	-	36	37	33	36	38	40
05-Jan	-	-	34	36	32	34	36	38
06-Jan	-	-	34	34	32	32	36	37
07-Jan	-	-	34	34	32	32	36	38
08-Jan	-	-	34	34	32	32	36	37
09-Jan	-	-	34	34	32	32	34	36
10-Jan	-	-	34	34	31	32	34	36
11-Jan	-	-	34	34	32	32	36	38
12-Jan	-	-	34	34	32	32	34	36
13-Jan	-	-	34	34	32	32	33	36
14-Jan	-	-	34	34	32	32	36	38
15-Jan	-	-	34	34	32	32	36	37
16-Jan	-	-	34	34	32	32	36	38
17-Jan	-	-	34	34	32	32	37	39
18-Jan	-	-	34	35	31	32	38	39
19-Jan	-	-	35	38	31	32	38	40
20-Jan	-	-	38	40	32	32	34	40
21-Jan	-	-	38	41	35	40	33	40
22-Jan	-	-	37	40	35	39	37	41
23-Jan	-	-	35	39	33	37	36	40
24-Jan	-	-	38	42	36	41	39	43
25-Jan	-	-	42	45	41	46	41	43
26-Jan	-	-	41	44	41	44	40	44
27-Jan	-	-	39	43	38	42	40	43
28-Jan	-	-	40	43	39	42	41	44
29-Jan	-	-	39	42	41	42	44	45
30-Jan	-	-	39	41	38	40	42	44
31-Jan	-	-	40	40	38	40	41	43

Appendix G, continued.

DATE	BRIDGE 12 MIN	BRIDGE 12 MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX	SMOLT TRAP MIN	SMOLT TRAP MAX	POWERS BRIDGE MIN	POWERS BRIDGE MAX
01-Feb	-	-	40	40	39	40	42	42
02-Feb	-	-	39	41	38	40	42	43
03-Feb	-	-	39	40	38	40	42	43
04-Feb	-	-	38	41	36	39	39	42
05-Feb	-	-	37	42	35	39	39	42
06-Feb	-	-	39	43	38	42	40	44
07-Feb	-	-	39	43	37	41	40	44
08-Feb	-	-	39	43	37	38	40	42
09-Feb	-	-	42	43	-	-	-	-
10-Feb	-	-	43	44	-	-	-	-
11-Feb	-	-	41	43	-	-	-	-
12-Feb	-	-	42	43	-	-	-	-
13-Feb	-	-	42	44	-	-	-	-
14-Feb	-	-	40	43	-	-	-	-
15-Feb	-	-	36	41	-	-	-	-
16-Feb	-	-	34	36	-	-	-	-
17-Feb	-	-	34	36	-	-	-	-
18-Feb	-	-	34	36	-	-	-	-
19-Feb	-	-	34	38	-	-	-	-
20-Feb	-	-	35	40	-	-	-	-
21-Feb	-	-	37	40	-	-	-	-
22-Feb	-	-	36	40	-	-	-	-
23-Feb	-	-	36	39	-	-	-	-
24-Feb	-	-	35	-	-	-	-	-

Appendix G, continued.

Table 3. Discharge measurements of Tucannon River at selected sites and tributaries in 1992. Measurements made using modified U.S. Geological Survey techniques (Platts et al. 1983).

Location (RK)	Date	Discharge (m^3/sec)
Tucannon River smolt trap [a]	19 Mar	3.156
	24 Mar	2.716
	9 Apr	2.913
	13 Apr	4.055
	22 Apr	4.259
	28 Apr	3.628
	30 Apr	4.265
	5 May	3.317
	14 May	2.493
	19 May	2.085
	28 May	1.694
	2 Jun	1.553
	10 Jun	1.213
	16 Jun	1.569
	25 Jun	1.206
	1 Jul	1.224
	7 Jul	1.195
	15 Jul	1.033
	31 Jul	0.838
	7 Aug	0.735
	18 Aug	0.685
	26 Aug	1.222
	1 Sep	0.994
	16 Sep	1.138
	14 Oct	1.449
	16 Nov	1.828
Tucannon FH bridge [b]	25 Jun	1.258
	7 Jul	1.091
	15 Jul	1.051
	7 Aug	0.970
	18 Aug	0.999
	2 Sep	1.044
	16 Sep	0.872
	14 Oct	1.051
	16 Nov	1.343

Appendix G Table 3, continued

Location (RK)	Date	Discharge (m^3/sec)
Smith Hollow Bridge [c]	16 Jun	1.938
	25 Jun	1.296
	7 Jul	1.436
	15 Jul	1.201
	7 Aug	0.936
	18 Aug	1.993
	1 Sep	1.230
	16 Sep	1.335
	14 Oct	1.722
	16 Nov	2.189

[a] *75 m above smolt trap.*

[b] *5 m above Tucannon FH bridge.*

[c] *30 m below Smith Hollow bridge.*

Table 4. Revised mean monthly range (minimum to maximum) water temperatures at five upper Tucannon River sampling locations, April 1991 to October 1991. Temperatures are listed in degrees Celsius.

Month	Panjab 14	Big 4 Lake	Beaver Lake	Deer Lake	Cummings Creek
Apr 1991[a]	6.9-9.6	8.6-12.7	6.1-12.3	9.2-13.2	8.8-12.2
May 1991	8.6-10.8	- -	10.0-13.8	10.5-14.4	10.4-13.3
Jun 1991	10.5-13.1	- -	12.6-16.9	12.9-18.0	13.1-16.1
Jul 1991	12.9-17.0	- -	16.1-19.0	15.8-22.6	16.4-20.7
Aug 1991	13.6-17.2[a]	- -	16.8-20.7	16.8-22.9	17.6-21.2
Sep 1991	- -	- -	13.8-17.5	14.1-18.9	14.8-17.8
Oct 1991[a]	- -	- -	11.2-14.1	11.7-15.8	12.3-14.9

[a] Data available for only part of the month.

Appendix G, continued.

Table 5. Revised mean monthly range (minimum to maximum) water temperatures at four lower Tucannon River sampling locations, April 1991 to January 1992. Temperatures are listed in degrees Celsius.

Month	Bridge 14	Bridge 12	Marengo	Smolt Trap
Apr 1991	5.8-10.3	6.3-11.0	7.0-11.9[a]	- -
May 1991	7.1-11.1	7.7-11.7	8.4-12.2	- -
Jun 1991	9.8-14.1	10.2-13.8	11.1-15.3	13.4-18.2[a]
Jul 1991	13.3-19.3	13.7-18.0	15.1-18.3	16.1-22.0
Aug 1991	14.2-19.9	14.5-20.6	16.1-20.8	16.8-22.6
Sep 1991	11.3-16.3	11.9-15.7	12.8-16.6	12.8-17.8
Oct 1991	7.6-10.8	7.9-11.2	10.8-13.3[a]	8.4-11.4
Nov 1991	5.4-7.6[a]	5.7-7.9[a]		4.5-8.0
Dec 1991	- -			4.5-5.7
Jan 1992	- -			-0.3-0.1[a]

[a] Data available for only part of the month.

APPENDIX H

Table 1. Juvenile salmon counted (with density estimates in fish/100 m^2) from parr production surveys using various techniques for sites within the Wilderness Stratum, 1992.

Site	Habitat type	Line transect			Total count		Electrofishing		
		Age 0	Age 1+	Area (m^2)	Age 0	Age 1+	Age 0	Age 1+	Area (m^2)
3	Pool	15.5 (43.4)	2 (5.6)	35.75	35 (58.5)	4 (6.7)	28 (46.8)	1 (1.7)	59.84
11	Pool	0	8 (10.0)	80.10	0	10 (8.0)	0	2 (1.6)	124.42
17	Pool	0	4.5 (12.6)	35.85	-	-	-	-	-
19	Pool	0	0	14.06	-	-	-	-	-
1	Side Channel	36.5 (151.1)	2.5 (10.4)	24.15	36 (58.7)	2 (3.3)	14 (46.8)	3 (4.9)	61.35
2	Side Channel	0	0	17.10	-	-	0	1 (2.3)	42.9
4	Side Channel	0	1 (4.9)	20.2	0	2[a]	-	-	

[a] No areas calculated because electrofishing not done at those sites.

Table 2. Juvenile salmon counted (with density estimates in fish/100 m^2) from parr production surveys using various techniques for sites within the HMA Stratum, 1992.

Site	Habitat type	Line transect			Total count		Electrofishing		
		Age 0	Age 1+	Area (m^2)	Age 0	Age 1+	Age 0	Age 1+	Area (m^2)
5	Riffle	0.67 (1.4)	0	47.74	16 (7.8)	1 (0.5)			205.3
9	Riffle	1.33 (2.9)	0	46.33	9 (3.7)	0			
13	Riffle	0.5 (0.9)	0	57.65	-	-			-
18	Riffle	0	0	36.36	-	-			-
3	Run	0.5 (1.2)	0	41.04	-	-			-
6	Run	0	0	34.60	-	-			-

Appendix H, Table 2, continued.

Site	Habitat type	Line transect Age 0	Line transect Age 1+	Line transect Area (m^2)	Total count Age 0	Total count Age 1+	Electrofishing Age 0	Electrofishing Age 1+	Electrofishing Area (m^2)
10	Run	17 (25.4)	0	66.88	30 (19.6)	1 (0.7)			152.90
14	Run	23.5 (48.4)	1 (2.1)	48.50	-	-			-
19	Run	8.67 (13.4)	1 (1.6)	64.50	24 (16.0)	0			150.45
24	Run	3.67 (10.1)	1.67 (4.6)	36.44	24 (21.8)	3 (2.7)			110.29
4	Pool	4.5 (13.9)	0	32.23	-	-			-
12	Pool	8.5 (16.2)	1.5 (2.9)	52.50	-	-			-
16	Pool	24 (37.3)	4.33 (6.7)	64.43	48 (25.6)	5 (2.7)			187.68
21	Pool	6.67 (10.6)	1.67 (2.7)	62.7	22 (27.2)	0			80.00
22	Pool	27.67 (45.2)	3.67 (6.0)	61.26	36 (27.8)	0			129.53
2	Boulder	4.33 (6.8)	0	63.75	28 (12.6)	0			222.01
11	Boulder	0	0	53.50	-	-			-
15	Boulder	0	0	34.30	-	-			-
17	Boulder	7.67 (12.7)	0	60.60	12 (6.6)	0			181.28
23	Boulder	0	0	52.95	1 (0.6)	0			169.93
2	Side Channel	18 (86.8)	1 (4.8)	20.74	-	-			-
3	Side Channel	0.33 (1.2)	0	28.29	2 (5.0)	0			39.90
4	Side Channel	14.33 (48.4)	3.67 (12.4)	29.64	27 (34.1)	0			79.20
5	Side Channel	15.67 (96.9)	1 (6.2)	16.17	31 (54.6)	0			56.73

Areas used to estimated total count and electrofishing populations are from 1990 electrofishing surveys.

Appendix H.

Table 4. Juvenile salmon counted (with density estimates in fish/100 m^2) from parr production surveys using various techniques for sites within the Hartstock and Marengo Stratum, 1992.

Site	Habitat type	Line transect			Total count		Electrofishing		
		Age 0	Age 1+	Area (m^2)	Age 0	Age 1+	Age 0	Age 1+	Area (m^2)
6	Side Channel	2.5 (108.7)	0	2.3	-	-			-
4	Pool	3.5 (10.4)	0	33.53	46 (41.1)	1 (.8)	3 (2.5)	0	119.29
7	Pool	3 (11.3)	0	26.48	26 (19.1)	1 (.7)	6 (4.4)	0	135.83
1	Run	4.5 (13.6)	0	33.0	13 (8.9)	0	4 (2.7)	2 (1.4)	146.51
2	Run	3 (8.7)	0	34.47	37 (22.7)	0	42 (26.0)	0	161.76
5	Run	6 (17.0)	.5 (1.4)	35.28	22 (14.7)	1 (.7)	6 (4.0)	0	149.57
6	Run	6 (20.3)	0	29.6	31 (23.8)	0	22 (16.9)	0	130.21
3	Riffle	2.5 (7.1)	0	35.01	20 (13.4)	0	21 (14.1)	0	149.24
8	Riffle	.5 (1.4)	0	36.45	8 (3.3)	0	9 (3.8)	0	239.36
9	Riffle	2 (7.4)	0	27.0	7 (4.1)	0	3 (1.8)	0	169.47
Marengo									
6	Riffle	0.5 (2.5)	0	20.02	3[a]	0	-	-	-

[a] No areas calculated because electrofishing not done at those sites.

APPENDIX I

Table 1. Summary of salmon radio tagged and released upstream of the Tucannon FH weir, 1992.

Tag no. (code)	Date tagged	Sex[a]	Fork length (cm)[b]	Age[c]	Days tracked	Recovery Date[d]	Recovery Locale (RK)[d]	Recovery Carcass recovered	Comments
WILD SALMON									
19	6/02	F	72	4	1	6/02	57.8	no	regurgitated tag
61 (54b)	6/08	F	74	4	1	6/08	57.8	no	regurgitated tag
60 (60)	5/27	F	73	4	16	6/11	58.2	no	recovered tag
16	5/14	F	71	4	37	6/19	77.2	yes	prespawning mort
17	6/04	F	70	5	12	6/15	57.8	yes	prespawning mort
57 (69)	5/13	F	73	4	24	6/05	58.6	yes	prespawning mort
60 (56)	6/02	F	73	4	16	6/17	59.6	yes	prespawning mort
61 (54)	5/08	M	80	4	27	6/03	67.2	yes	prespawning mort
61 (74)	5/19	F	83	-	35	6/22	59.2	yes	prespawning mort[f]
13	5/08	M	63	4	113	8/28	63.9	no	no tag or fish
25	5/20	F	73	4	56	7/14	73.2	no	no tag or fish[e]
57 (52)	5/28	M	86	5	111	9/15	59.2	no	no tag or fish[f]
15	5/26	F	66	4	114	9/16	70.7	yes	spawned
18	5/19	F	70	4	127	9/23	73.9	yes	spawned[e]
23	5/13	F	69	4	113	9/02	77.7	yes	spawned
HATCHERY SALMON									
20a	5/28	M	74	4	1	5/28	57.8	no	regurgitated tag
12	5/08	F	75	4	112	8/27	68.2	yes	prespawning mort[f]
14	5/26	F	69	4	17	6/11	59.2	yes	prespawning mort
17	5/19	F	68	4	15	6/02	59.3	yes	tagging mort
20b	6/02	M	74	4	49	7/20	61.6	yes	prespawning mort
22	5/14	M	74	4	27	6/09	57.9	yes	prespawning mort
60 (69)	5/14	F	73	4	28	6/10	57.8	yes	prespawning mort[f]
61 (59)	5/27	F	74	4	20	6/15	59.2	yes	prespawning mort[f]
61 (71)	5/19	M	78	-	49	7/06	59.9	yes	prespawning mort
19	6/03	F	73	4	14	6/16	58.6	no	recovered tag[f]
11	5/08	F	67	-	124	9/08	58.5	no	no tag or fish[e]
24	5/20	M	72	4	62	7/20	59.2	no	no tag or fish[f]
21	5/13	M	64	4	133	9/22	61.5	yes	spawned
UNKNOWN ORIGIN/NO DATA									
61 (63)	5/28	-	-	-	21	6/16	58.6	no	recovered tag

[a] Initially determined at tagging, verified by underwater observations and/or when carcass recovered, if possible.

[b] Measured at tagging.

[c] Estimated age based on fitted fork length-at-age, scale or CWT analysis.

[d] Refers to recovery or last day tracked. Mouth of Tucannon River is at RK 0.0.

[e] Possible tag malfunction, thus loss of data from this fish.

[f] This fish was either poached, died naturally, or had a tag malfunction.

APPENDIX I, continued.

Table 2. Summary of salmon radio tagged by the University of Idaho and released near Ice Harbor Dam on the Snake River, 1992.

Tag no. (code)	Date tagged	Sex[a]	Fork length (cm)[a]	Age[b]	Days tracked[c]	Recovery Date[d]	Recovery Locale (RK)[d]	Recovery Carcass recovered	Comments
WILD SALMON									
2 (35)	6/04	F	82	-	8	6/23	9.2	no	prespawning mort[e]
9 (3)	5/09	-	71	4	43	9/24	46.3	yes	spawned
8 (7)	4/20	M	70	4	93	9/22	69.9	yes	spawned
2 (3)	4/21	-	71	4	13	5/27	9.2	no	prespawning mort[e]
8 (3)	5/03	F	74	4	47	9/21	57.6	yes	spawned
10 (12)	5/09	-	77	-	76	8/11	24.1	no	tag recovered
10 (28)	5/02	-	71	4	6	8/11	22.9	no	tag recovered
8 (19)	5/11	-	67	4	52	9/24	54.6	no	tag recovered
2 (1)	6/05	-	68	4	49	9/21	57.5	no	tag recovered
HATCHERY SALMON									
2 (19)	5/02	F	70	4	16	6/05	58.2	yes	prespawning mort
5 (39)	5/30	-	79	5	1	8/13	0.2	yes	prespawning mort
5 (35)	5/31	-	72	5	13	8/25	4.5	no	tag recovered
10 (7)	5/07	-	71	5	20	8/26	5.0	no	tag recovered
8 (6)	5/11	-	66	-	42	9/17	4.3	no	tag not recovered
UNKNOWN ORIGIN/NO DATA									
8 (8)	4/20	-	69	-	98	9/29	53.4	no	tag recovered

[a] Determined at tagging or recovery.

[b] Estimated age based on fitted fork length-at-age, scale or CWT analysis.

[c] Days tracked on the Tucannon River.

[d] Refers to recovery or last day tracked. Mouth of Tucannon River is at RK 0.0.

[e] Strong evidence indicating this fish was poached.

APPENDIX J

Tucannon River Spring Chinook Spawning Ground Survey Historical Index Area 1954 - 1992

From 1954 to 1977 the Historical Index Area was from Cow Camp Bridge to Camp Wooten Bridge (approx. 2.4 miles). In 1980 a supplemental index area was added to now include from Panjab Campground Bridge to Cow Camp Bridge (approx. 1.2 miles). Between 1954 and 1983 all data were collected from one day of spawning ground survey between 26 August to 28 September. Seventy-seven percent of the surveys were between 8 September and 15 September. WDF personnel began monitoring spawning activity more closely in 1985, with more surveys being conducted throughout each spawning season. One survey day was chosen from the many days of surveys during the season for use as the historical index. With 77% of the previous years surveys conducted between 8 and 15 September, we selected one survey annually within those dates from 1985 to present to be used as the historical index. A survey was chosen at random if two or more surveys were conducted between 8 and 15 September during a particular year. If no surveys were conducted during this time period during a particular year, the survey date closest to these dates was chosen as the index survey.

Table 1. Spawning survey data for Tucannon River Historical Index Areas (Cow Camp Bridge to Camp Wooten Bridge) 1954-1992.

Year	Date	Redds	Test Digs	Live	Dead	Jacks	Total
1954	3-Sep	33	N/A	52	3	0	55
1955	26-Aug	0	N/A	80	0	0	80
1956	N/A	NO SURVEY					
1957	5-Sep	168	N/A	232	51	0	283
1958	11-Sep	54	N/A	89	7	0	96
1959	3-Sep	27	N/A	56	1	0	57
1960	8-Sep	42	N/A	69	13	0	82
1961	11-Sep	102	N/A	63	23	0	86
1962	11-Sep	52	N/A	47	24	0	71
1963	10-Sep	21	N/A	25	11	0	36
1964	9-Sep	61	N/A	55	24	0	79
1965	9-Sep	24	N/A	20	4	0	24
1966	9-Sep	65	N/A	55	10	1	66
1967	8-Sep	40	N/A	40	8	1	49
1968	10-Sep	18	N/A	15	4	5	24
1969	10-Sep	61	N/A	53	28	2	83
1970	10-Sep	62	N/A	68	6	0	74
1971	7-Sep	6	N/A	11	1	0	12
1972	12-Sep	23	N/A	3	0	0	3
1973	11-Sep	24	N/A	18	3	0	21

Appendix J, continued.

Year	Date	Redds	Test Digs	Live	Dead	Jacks	Total
1974	11-Sep	18	N/A	12	5	0	17
1975	10-Sep	37	N/A	27	8	1	36
1976	28-Sep	13	N/A	0	11	0	11
1977	15-Sep	19	N/A	3	4	0	7
1978	N/A	NO SURVEY					
1979	N/A	NO SURVEY					
1980	8-Sep	38	N/A	47	3	0	50
1981	11-Sep	67	N/A	55	3	0	58
1982	N/A	27	N/A	5	11	0	16
1983	13-Sep	40	N/A	24	8	1	33
1984	11-Sep	31	N/A	23	15	3	41
1985	9-Sep	50	N/A	35	13	2	50
1986	9-Sep	20	5	30	2	1	33
1987	9-Sep	32	14	57	7	0	64
1988	14-Sep	7	4	14	6	2	22
1989	13-Sep	16	3	21	5	0	26
1990	12-Sep	13	6	24	7	0	31
1991	11-Sep	4	3	10	0	2	12
1992	9-Sep	27	10	35	2	2	39

Table 2. Tucannon River Supplemental Index Area (Panjab Creek Bridge to Cow Camp Bridge), 1980 to 1992.

Year	Date	Redds	Test Digs	Live	Dead	Jacks	Total
1980	8-Sep	8	N/A	6	2	1	9
1981	11-Sep	8	N/A	9	2	0	11
1982	N/A	19	N/A	4	8	0	12
1983	13-Sep	12	N/A	6	2	0	8
1984	9-Sep	21	N/A	14	9	2	25
1985	9-Sep	32	N/A	9	5	0	14
1986	9-Sep	15	1	9	2	0	11
1987	9-Sep	2	2	2	1	0	3
1988	14-Sep	6	4	9	2	1	12
1989	13-Sep	8	1	5	0	0	5
1990	12-Sep	7	3	11	0	1	12
1991	11-Sep	5	2	7	1	1	9
1992	9-Sep	9	7	21	0	0	21

Appendix J, continued.

Table 3. Description of spawning ground survey areas on the Tucannon River in 1992 (River Km were revised in 1992).

Stratum	River km	Area Description
Wilderness	86-78	Rucherts Camp to Wilderness Campground 3 (Ladybug Flats)
	78-75	Wilderness Campground 3 to Panjab Bridge
HMA	75-73	Supplemental Index Area-Panjab Bridge to Cow Camp Bridge
	73-68	Historical Index Area-Cow Camp Bridge to Camp Wooten Bridge
	68-66	Camp Wooten Bridge to Curl Lake Outlet
	66-62	Curl Lake Outlet to Beaver-Watson Bridge
	62-59	Beaver-Watson Bridge to Tucannon Hatchery Intake
	59-58	Tucannon Hatchery Intake to Tucannon Hatchery weir
	58-56	Tucannon Hatchery weir to HMA Boundary Fence
Hartsock	56-52	HMA Boundary Fence to Bridge 14
	52-47	Bridge 14 to Bridge 12
	47-43	Bridge 12 to Bridge 10
	43-40	Bridge 10 to Marengo Bridge
Marengo	40-34	Marengo Bridge to King Grade Bridge

APPENDIX K

Table 1. Allele frequencies at 24 loci in six collections of Tucannon spring chinook; two collections obtained in 1990 and four collections obtained in 1991. BY = brood year of juveniles; n = number of fish successfully screened at each locus.

	Juveniles				Adults	
LOCUS alleles	BY-88 Hatchery	BY-88 Wild	BY-89 Hatchery	BY-89 Wild	1991 Hatchery	1991 Wild
mAAT-1						
-100	0.945	0.898	0.990	0.918	0.951	0.962
-104	0.055	0.102	0.010	0.082	0.049	0.037
(n)	(100)	(108)	(98)	(92)	(51)	(40)
sAAT-1,2						
100	1.000	0.997	0.997	0.995	1.000	1.000
85	0.000	0.003	0.003	0.005	0.000	0.000
(n)	(100)	(108)	(101)	(101)	(51)	(40)
sAAT-4						
100	0.923	0.902	0.874	0.918	0.886	0.903
63	0.077	0.098	0.126	0.082	0.114	0.097
(n)	(91)	(108)	(95)	(92)	(44)	(36)
ADA-1						
100	0.910	0.894	0.980	0.975	0.961	0.987
83	0.090	0.106	0.020	0.025	0.039	0.012
(n)	(100)	(108)	(101)	(101)	(51)	(40)
mAH-4						
100	0.990	0.991	1.000	0.985	0.990	0.962
119	0.010	0.009	0.000	0.015	0.010	0.037
(n)	(100)	(108)	(101)	(99)	(51)	(40)
sAH						
100	0.965	0.968	0.990	0.946	0.969	0.925
86	0.035	0.032	0.010	0.054	0.031	0.075
(n)	(100)	(108)	(100)	(101)	(49)	(40)
FDHG						
100	0.920	0.912	0.856	0.891	0.882	0.950
143	0.080	0.088	0.144	0.109	0.118	0.050
(n)	(100)	(108)	(101)	(101)	(51)	(40)
GPI-B2						
100	0.980	0.991	0.975	0.975	0.990	0.962
60	0.020	0.009	0.025	0.025	0.010	0.037
(n)	(98)	(107)	(99)	(100)	(51)	(40)

Appendix K, continued.

LOCUS alleles	Juveniles BY-88 Hatchery	BY-88 Wild	BY-89 Hatchery	BY-89 Wild	Adults 1991 Hatchery	1991 Wild
sIDHP-1						
100	0.875	0.792	0.811	0.856	0.824	0.862
74	0.125	0.208	0.189	0.144	0.167	0.137
(n)	(100)	(108)	(98)	(101)	(51)	(40)
LDH-B2						
100	1.000	1.000	0.975	1.000	1.000	1.000
112	0.000	0.000	0.025	0.000	0.000	0.000
(n)	(100)	(108)	(101)	(101)	(51)	(40)
LDH-C						
100	0.955	0.995	0.926	0.995	0.980	0.987
90	0.000	0.005	0.000	0.000	0.010	0.012
84	0.045	0.000	0.074	0.005	0.010	0.000
(n)	(100)	(105)	(101)	(101)	(50)	(40)
mMDH-2						
100	0.685	0.750	0.827	0.767	0.765	0.750
200	0.315	0.250	0.173	0.233	0.235	0.250
(n)	(100)	(108)	(101)	(101)	(51)	(40)
sMDH-B1,2						
100	1.000	1.000	1.000	1.000	0.995	1.000
126	0.000	0.000	0.000	0.000	0.005	0.000
(n)	(100)	(108)	(101)	(101)	(51)	(40)
sMEP-1						
100	0.045	0.083	0.064	0.035	0.060	0.075
92	0.955	0.917	0.936	0.965	0.940	0.925
(n)	(99)	(108)	(101)	(100)	(50)	(40)
MPI						
100	0.935	0.866	0.830	0.886	0.882	0.975
109	0.065	0.134	0.170	0.114	0.118	0.025
(n)	(100)	(108)	(100)	(101)	(51)	(40)
PEPA						
100	0.892	0.824	0.926	0.921	0.902	0.837
90	0.108	0.171	0.074	0.079	0.098	0.162
81	0.000	0.005	0.000	0.000	0.000	0.000
(n)	(97)	(108)	(101)	(101)	(51)	(40)
PEPB-1						
100	0.900	0.902	0.891	0.936	0.922	0.962
130	0.065	0.024	0.035	0.025	0.020	0.025
-350	0.035	0.057	0.074	0.040	0.059	0.012
(n)	(100)	(106)	(101)	(101)	(51)	(40)

Appendix K, continued.

LOCUS alleles	Juveniles BY-88 Hatchery	BY-88 Wild	BY-89 Hatchery	BY-89 Wild	Adults 1991 Hatchery	1991 Wild
PEP-LT						
100	0.990	0.981	0.965	0.990	0.990	1.000
110	0.010	0.019	0.035	0.010	0.010	0.000
(n)	(100)	(108)	(101)	(101)	(51)	(40)
PGK-2						
100	0.090	0.111	0.079	0.064	0.078	0.087
90	0.910	0.889	0.921	0.936	0.922	0.912
(n)	(100)	(108)	(101)	(101)	(51)	(40)
mSOD						
100	0.900	0.963	0.930	0.985	0.980	0.937
142	0.100	0.037	0.070	0.015	0.020	0.062
(n)	(100)	(107)	(100)	(100)	(51)	(40)
sSOD-1						
-100	0.815	0.829	0.785	0.723	0.765	0.800
-260	0.185	0.171	0.215	0.277	0.235	0.200
(n)	(100)	(108)	(100)	(101)	(51)	(40)
TPI-4						
100	0.920	0.917	0.805	0.911	0.922	0.962
104	0.080	0.083	0.195	0.089	0.078	0.037
(n)	(100)	(108)	(100)	(101)	(51)	(40)