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LOWER SNAKE RIVER COMPENSATION PLAN
TUCANNON RIVER SPRING CHINOOK SALMON
HATCHERY EVALUATION PROGRAM

1991 ANNUAL REPORT

by

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ABSTRACT

This report summarizes activities of the Washington Department of Fisheries' Lower Snake River Hatchery Evaluation Program from 1 April 1991 to 31 March 1992. 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 rack, located at the Tucannon Fish Hatchery (FH), was 311 salmon. Expanded escapement to the Tucannon River was 458 salmon. We expanded escapement to the rack to account for salmon spawning downstream of our trap in 1991, and we revised escapement estimates for 1989 and 1990. The expanded estimates for hatchery and natural-origin (wild) salmon returns to the Tucannon River were 297 (202 fish to the rack), and 161 (109 fish to the rack) respectively. We collected 89 hatchery and 41 wild salmon for broodstock at the Tucannon FH. Prior to spawning, 17 hatchery females (and no wild females) died in the holding pond. Peak of spawning in the hatchery was 10 September, for both hatchery and wild fish, which coincides well with natural spawning in the river. Twenty-eight females were spawned; 11 hatchery and 17 wild. Eggtake totaled 91,275 eggs; 27,683 from hatchery females, and 63,592 from wild females. Mortality prior to hatching was 11,679 eggs (12.8% of total) for a total of 79,596 fry that hatched.

We estimated 328 salmon escaped to spawn naturally in the Tucannon River. A total of 90 redds were constructed in the Tucannon River between 28 August and 1 October 1991 (which is substantially below counts in previous years). We inserted radio transmitters in 18 salmon collected and released upstream of the Tucannon FH rack. Ten salmon were radio tracked through spawning season. We found a difference in "holding" and spawning locations between wild and hatchery salmon. We observed males spawning with multiple females, as we did in 1990. Circumstantial evidence again indicates possible poaching of adult salmon from the Tucannon River.

Survival of 1986 brood hatchery salmon is estimated to be 0.28%, with 0.65% survival estimated for wild salmon (similar to results for the 1985 brood). This estimate does not include 1991 sport and commercial catch (data were not available for this report). Both survival estimates are well below the LSRCP design objective of 0.87%. Survival of 1987 brood hatchery and wild salmon through age 4 is estimated at 0.12% and 0.22%, respectively.

Tucannon FH released 99,057 yearling (1989 brood) spring chinook salmon to volitionally emigrate from the acclimation pond from 1-12 April 1991. Mean fork length (with coefficient of variation) and total poundage of released smolts were 160.3 mm (15.0) and 11,006 lbs, respectively. No significant fish health problems were encountered during incubation, rearing, or acclimation. Egg-to-smolt survival was 74.6%. Modal travel time to the downstream migrant trap approximately 40 km downstream of the hatchery was 2-4 days.

An extensive habitat inventory survey was conducted in the Wilderness Stratum. Depth was most often scored as the limiting factor for rearing salmon. Velocity and substrate scored equally as factors limiting spawning in this stratum. We deployed ten thermographs along 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.

We operated a downstream migrant trap intermittently from 20 November 1990 to 31 March 1991 and continuously from 1 April to 30 June 1991. We trapped 2,916 wild spring chinook salmon smolts during this period. Based on an unweighted trap efficiency of 14.4%, we estimate that 25,862 ±1,099 juvenile spring chinook salmon emigrated from the Tucannon River during the 1990/1991 season.

Stock profile analysis of wild and hatchery spring chinook salmon was continued. Average fecundity of wild and hatchery females spawned for broodstock was 3,741 and 2,517 eggs, respectively. Sex ratio of wild salmon collected for broodstock was 0.71 females per male. Sex ratio for hatchery salmon was 0.47 females per male. Morphometric analysis of samples collected in 1989-1991 are provided. We found no significant difference in overall body shape between hatchery and wild-origin adult salmon. Differences were found in juveniles from different origins and different brood years, mainly because of date of sampling or size of fish at sampling. Analysis of juvenile meristic data was not completed in time for this report.

We provide seven recommendations to improve performance of the Tucannon chinook salmon hatchery program, and to improve natural production and survival of Tucannon River salmon.

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LOWER SNAKE RIVER COMPENSATION PLAN
TUCANNON RIVER SPRING CHINOOK SALMON
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SECTION 1: INTRODUCTION

1.1: Compensation Objectives

Congress authorized the Lower Snake River Fish and Wildlife Compensation Plan (LSRCP) in 1976. As a result of that plan, Lyons Ferry and Tucannon Fish Hatcheries (FH) were designed, constructed and are currently under operation. A partial objective of these hatcheries is to compensate for loss of 1,152 adult spring chinook salmon, Tucannon River stock (USACE 1975). An evaluation program was initiated in 1984 to monitor the success of these hatcheries in meeting 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 1991). A list of the evaluation program's objectives is outlined in Appendix A.

This report summarizes all work performed by Washington Department of Fisheries' LSRCP Spring Chinook Salmon Evaluation Program for the period 1 April 1991 through 31 March 1992. A report on the fall chinook salmon evaluation program for the same period is presented separately (Mendel et al. 1992).

1.2: Description of Facilities

Lyons Ferry FH is located at the confluence of the Palouse River with the lower Snake River at river kilometer (RK) 90 (Figure 1). The 1991 Tucannon spring chinook salmon production program 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 at Tucannon FH. Lyons Ferry FH has a single pass well water system through the incubators, two adult holding ponds, and 28 raceways. A satellite facility is maintained on the Tucannon River (RK 61; Figure 2) for collection of spring chinook salmon adults and subsequent release of yearling progeny. It has an adult collection trap and one holding pond, which was used for both broodstock and yearlings. Returning adult spring chinook salmon were trapped and spawned at Tucannon FH. Eggs were fertilized, incubated, and the fry reared to parr size at Lyons Ferry FH, then trucked back to Tucannon FH for acclimation and release.

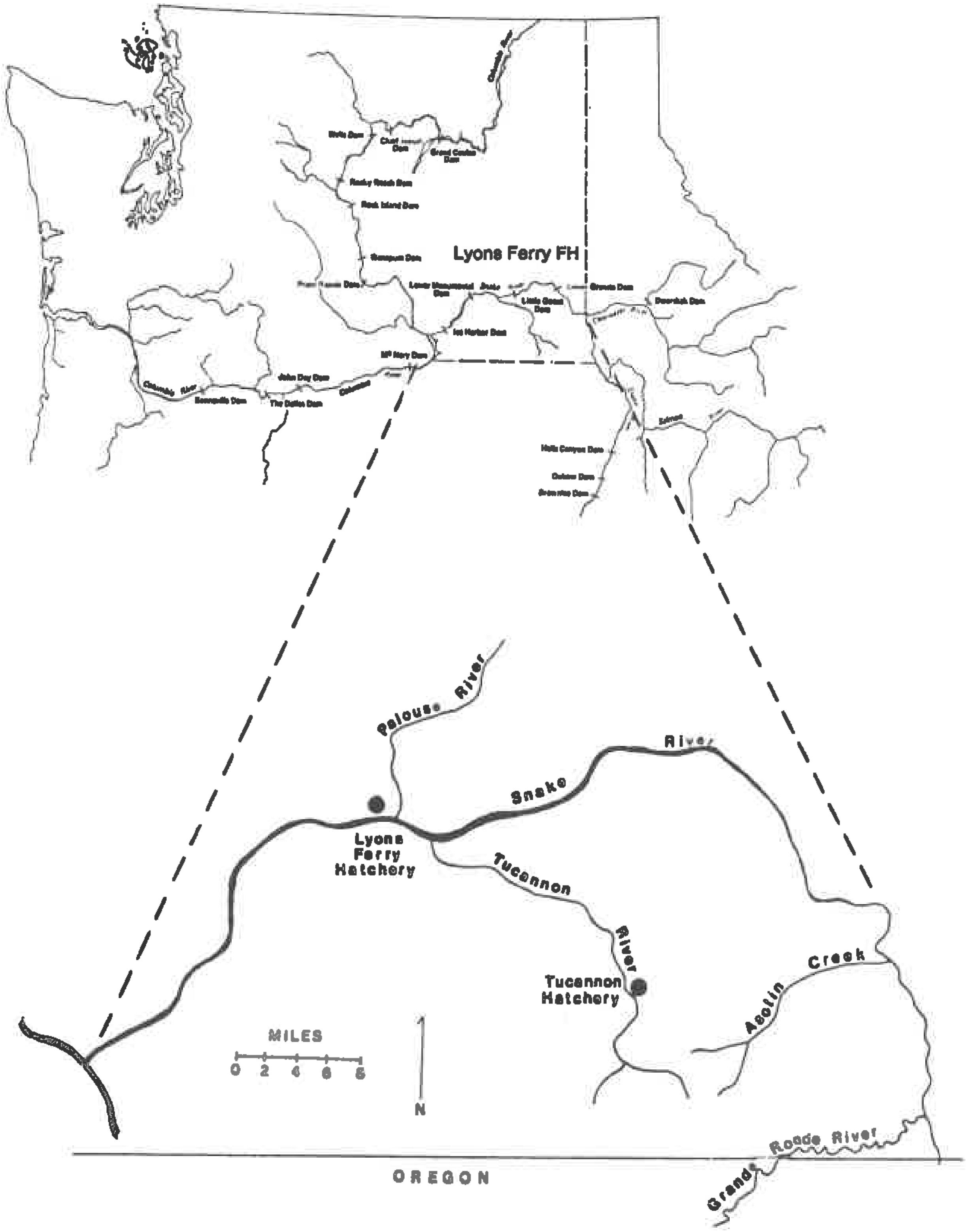

Figure 1. Location of Lyons Ferry and Tucannon Fish Hatcheries within the Lower Snake River Basin.

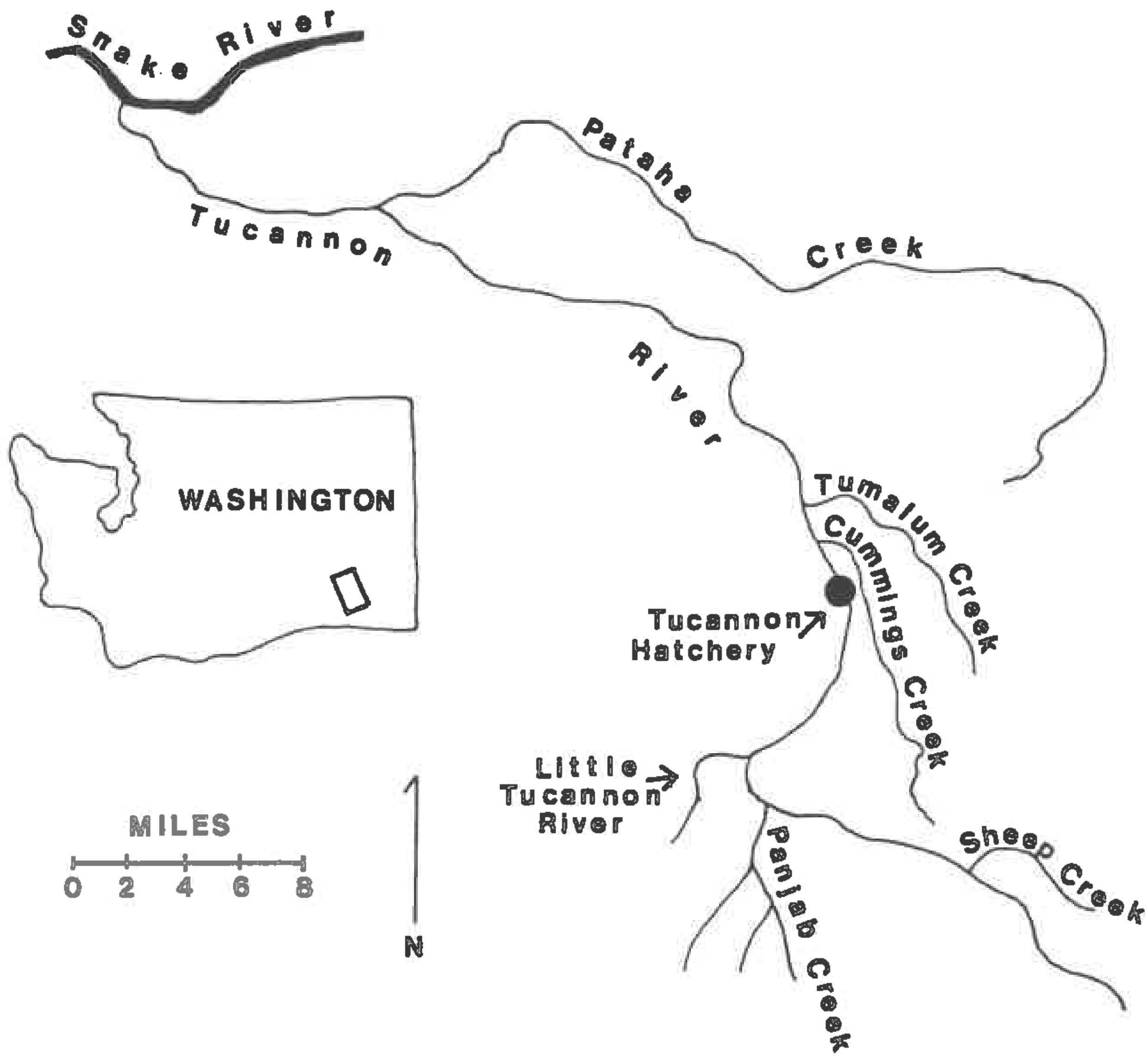

Figure 2. Location of Tucannon Fish Hatchery within the Tucannon River Basin.

SECTION 2: HATCHERY PERFORMANCE

2.1: Broodstock Collection

Evaluation and hatchery personnel operated a permanent adult trap with a floating weir adjacent to the Tucannon FH to collect wild[1], natural, and hatchery-origin salmon[2] for broodstock. We operated the trap daily from May through September. We collected one fish for every one allowed to pass upstream of the rack for natural spawning. Fish were collected for broodstock approximately every other day and allowed to pass upstream on subsequent days. Our objective was to take equal numbers of wild and hatchery-origin salmon for broodstock, but not to exceed 50 hatchery and 50 wild salmon. This number was developed using previous years broodstock survival, egg and fry loss, growth rate, feed conversion and projected time and size at release. All hatchery salmon have the adipose-fin removed and are coded-wire tagged (CWT), allowing their recognition as adults.

In 1991, the first salmon arrived at the rack on 15 May; the last adult arrived on 24 September. Peak of salmon arrival was 3-8 June. We collected a total of 89 adults and 41 jacks[3] for broodstock. We passed 134 adults and 47 jacks upstream. Total escapement to the rack was 223 adults and 88 jacks, of which 104 adults and 5 jacks were wild and 119 adults and 83 jacks were of hatchery origin (Table 1). This was the first year "natural-origin salmon" returned to the rack (age 3). Jacks were categorized by fork length (≤61 cm) when collected. Subsequent coded-wire tag analysis revealed salmon categorized as jacks were actually age 3 adults. We have no record of age 2 jacks returning to the Tucannon River since the initiation of this project in 1984.

Salmon run timing and size has changed little since we began broodstock collection. In 1991 hatchery salmon arrival peaked on 4 June; wild fish peaked on 11 June, compared to 23 May for hatchery and 22 May for wild in 1990. The rack was submerged 19

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1 Throughout this report the term "wild salmon" indicates fish that have no hatchery parentage and "natural salmon" may be the progeny of either wild or hatchery fish that spawned in the river. The first return of hatchery adults was in 1988.

2 To ease reader burden, the term "salmon" refers to Tucannon stock spring chinook salmon, unless otherwise noted.

3 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. The remainder of this report deals with these fish as adults based on actual age (CWT analysis).

to 23 May because of high flows, so some salmon may have passed without being counted. A second smaller peak of wild fish occurred at the onset of spawning activity on 11 September (Figure 3). Between 29 August and 24 September 1991, 54 salmon arrived at the rack. Duration of salmon capture at the Tucannon FH rack was 110 days for wild fish and 90 for hatchery fish in 1991. This compares to 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.

Since hatchery supplementation began in 1987 the number of age 3 salmon, based on CWT and scale analysis (generally ≤61 cm), returning to Tucannon FH has increased substantially. In 1991, 84 hatchery and 5 wild age 3 salmon returned; in 1990, 28 hatchery and 6 wild; 72 hatchery in 1989; and 15 wild in 1988. Arrival of these fish was evenly distributed from 8 June to 13 July in 1991.

Table 1. Escapement and collection of spring chinook salmon to the Tucannon Fish Hatchery rack in 1991.

Week	Escaped to rack		Passed upstream		Collected	
ending	wild	hatchery	wild	hatchery	wild	hatchery
18 May	1		1			
25 May						
01 Jun	3	17	2	10	1	7
08 Jun	26	48	10	30	16	18
15 Jun	23	44	16	19	7	25
22 Jun	2	14	1	6	1	8
29 Jun	1	13	1	9		4
06 Jul	2	18		7	2	11
13 Jul	3	18	2	13	1	5
20 Jul		6				6
27 Jul	3	7	1	3	2	4
03 Aug		1		1		
10 Aug	4	2	2	1	2	1
17 Aug	1				1	
31 Aug	1	1			1	1
07 Sep	11	2	8	1	3	1
14 Sep	19	2	16	2	3	
21 Sep	7	5	5	5	2	
28 Sep	2	3	2	3		
05 Oct		1		1		
Totals[a]	109	202	67	111	42	91

[a] Weekly escapements were estimated and numbers were corrected at the end of spawning. Actual escapement to the rack was 311 salmon, of which 130 (41 wild, 89 hatchery) were collected for broodstock.

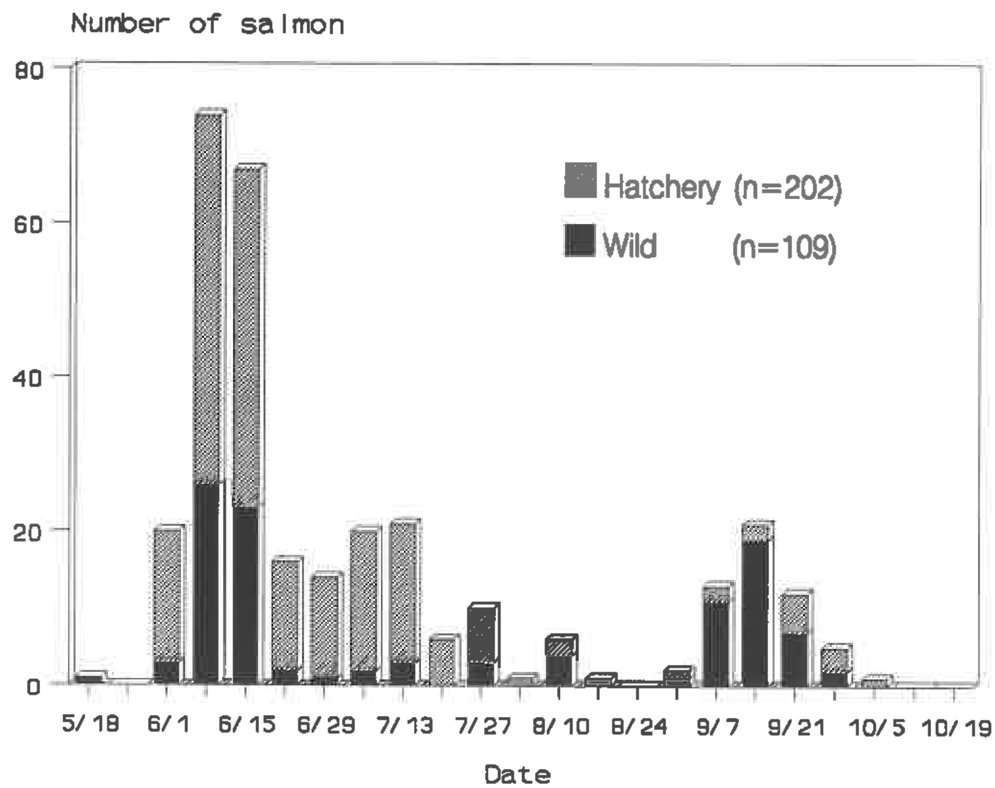

Figure 3. Weekly arrivals of wild and hatchery-origin spring chinook salmon to the Tucannon Fish Hatchery rack, 1991.

2.2: Smolt-to-Adult Survival

Smolt-to-adult survival estimates prior to 1991 were based only on actual salmon counts at the Tucannon FH rack. Redd counts conducted in 1990 and 1991 show a high number of salmon spawning downstream of the permanent rack. We believe few adult salmon move downstream over the rack. Therefore rack counts do not accurately reflect the total number of salmon escaping to the Tucannon River because salmon remaining downstream of the rack are not included. This year we have revised our estimate to include all known salmon in the Tucannon River (Section 3.2.4). We have also revised the escapement estimates for 1989 and 1990. Total estimated escapement is then separated into wild or hatchery-origin based on the proportion of hatchery-to-wild salmon that escaped to the rack for that year.

2.2.1: Hatchery-origin salmon

This year (1991) was the fourth year of hatchery salmon returns to the Tucannon River. Expanded returns from the 1988 (1986 brood) release through age 5 is 437 fish (0.28%). Returns for 1989 and 1990 releases are not complete (Table 2). Appendix B lists specific CWT recoveries for all release years.

Table 2. Known (and expanded) returns of hatchery spring chinook salmon to the Tucannon River for brood years 1985-1988. Ages are based on coded-wire tag recoveries through 1991.

Year released (brood)	Number of smolts released	Escapement			Percent returns (expanded)
		Age 3	Age 4	Age 5	
1987 (1985)	12,922	9 (-)	23 (27)	0 (0)	0.25 (0.28)
1988 (1986)	153,725	72 (90)	185 (334)	4 (13)	0.17 (0.28)
1989 (1987)	152,165	28 (25)	107 (150)	- -	0.09 (0.12)
1990 (1988)	145,146	87(134)	- -	- -	0.06 (0.09)

2.2.2: Wild-origin salmon

Expanded smolt-to-adult survival for 1986 brood wild salmon in the Tucannon River was 0.65% (376 salmon) through age 5 (Table 3). This survival rate is 132% higher than for hatchery salmon (0.28%, 1986 BY). Survival of wild salmon exceeds survival of hatchery salmon so far for the 1987 brood as well (incomplete returns).

Table 3. Known (and expanded) returns of wild (and natural-1988 brood) spring chinook salmon to the Tucannon River rack for brood years 1985-1988. Ages are fitted by fork lengths based on scale impressions.

Brood year	Number of smolts emigrating[a]	Escapement			Percent returns (expanded)
		Age 3	Age 4	Age 5	
1985	35,600	3 (-)	133 (133)	68 (105)	0.60 (0.67)
1986	58,200	1 (2)	164 (315)	44 (59)	0.37 (0.65)
1987	44,000	0 (0)	62 (98)	- -	0.17 (0.22)
1988	37,500	3 (4)	- -	- -	0.00 (0.01)

[a] Refer to Section 3.3.6 for smolt yield estimation.

2.2.3: Stray returns

Coded-wire tags (CWT) are extracted and read prior to fertilizing the eggs to prevent mixing of genetic material from stray stocks into the Tucannon River stock. Based on CWT recoveries during spawning at Tucannon FH and redd counts on the Tucannon River, no stray salmon returned to the Tucannon River during 1991. In 1990 we recovered two CWT fish from Meacham Creek, Umatilla River, and one CWT fish from Lookingglass FH, Grande Ronde River.

2.3: Lyons Ferry/Tucannon Hatchery Practices

2.3.1: Adult holding and spawning

Overall prespawning mortality was 45%; 17 hatchery females (29% of total), 40 hatchery males (69% of total), and 1 wild male (2% of total) died in the pond before spawning (Table 4); The mortality of females (29%) was consistent with data from previous years (16% in 1986, 14% in 1987, 30% in 1988, 26% in 1989, and 38% in 1990).

All salmon were spawned at the Tucannon FH. Spawning occurred from 27 August to 24 September 1991, with peak eggtake on 10 September (Table 5). Peak of spawning was the same for both wild and hatchery salmon. Total eggtake was 91,275 with 12.8% lost before eye up, for a total of 79,596 eggs (Section 2.3.4). Gametes were bagged (oxygen added to semen), labelled and kept cool for transport to Lyons Ferry FH for fertilization, incubation, hatching, and rearing.

Table 4. Spawning and holding mortality of hatchery and wild spring chinook salmon at Tucannon Fish Hatchery in 1991.

Date	Hatchery salmon spawned male	Hatchery salmon spawned female	Hatchery salmon mortality male	Hatchery salmon mortality female	Wild salmon spawned male	Wild salmon spawned female	Wild salmon mortality male	Wild salmon mortality female
30 Jul			2					
6 Aug			2					
13 Aug			1					
20 Aug			2	3			1	
27 Aug			8	4		1		
3 Sep	2	2	4	3		4		
10 Sep	9	9	12	7	1	8		
17 Sep	3		6		21[a]	4		
24 Sep	6	1	3		1			
Totals	20	12[b]	40	17	23	17	1	0

[a] Wild males were live-spawned and tallied when they were killed.

[b] One hatchery female was not ripe when spawned.

Table 5. Duration and peak of spawning of spring chinook salmon at Tucannon Fish Hatchery, 1986-1991.

Year	Duration (days) Wild	Duration (days) Hatchery	Peak date Wild	Peak date Hatchery
1986	21	- -	Sep 17	- -
1987	35	- -	Sep 15	- -
1988	21	- -	Sep 7	- -
1989	28	21	Sep 5	Sep 12
1990	14	28	Sep 4	Sep 11
1991	28	21	Sep 10	Sep 10

2.3.2: Hatchery matings

We continued an experiment to examine genotypic and phenotypic differences between separate matings of hatchery-origin and wild-origin salmon. Eggs from hatchery-origin females were fertilized with sperm from hatchery-origin males and eggs from wild-origin females were fertilized with sperm from wild-origin 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. Our initial crosses were one male to one female. Using this strategy altered so eggs from one female were divided into two lots, each lot was then fertilized by a different male (Withler 1988). After waiting 30 seconds, semen from a second male was added to each lot. The delay in adding semen from a second male allowed the sperm from the first male an opportunity to fertilize the eggs and maintain our experimental design, the second male ensures that viable eggs were not lost because of non-viable semen. The two lots from each female were then combined and incubated as one "family".

Twenty-nine females were spawned; 12 hatchery-origin salmon (one was not ripe) and 17 wild-origin salmon. Hatchery staff counted eggs from each family after shocking. A total of 27,683 eggs were collected from hatchery parents and 63,592 eggs from wild parents. Egg survival was better than last year, probably because of improved spawning and egg handling procedures (use of oxygen with semen and keeping gametes cool). Egg mortality was higher in hatchery-origin progeny (x= 34.85%, s= 26.93, range: 0.8-79.7%) compared to progeny from wild salmon (x= 5.35%, s= 3.97, range: 1.1-12.1%). A total of 19,130 eggs from hatchery parents (69.1% of total) and 60,466 eggs from wild parents (95.1% of total) survived to eye up. The results of hatchery matings include one hatchery female freshly dead in the pond, but her eggs were taken and fertilized. She was counted as spawned and 51% of her eggs survived.

2.3.3: Sperm cryopreservation and evaluation

In 1991 we continued our work to develop a sperm bank. This sperm will be used to fertilize ripe eggs when we have a shortage of semen from live males. This will also increase the number of males used as broodstock and thereby increase the available gene pool. Age 4 and 5 year old males were selected for freezing to preserve the wild genome. We collected and froze semen from 12 wild salmon. We evaluated sperm quality through motility analysis. 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 to a liquid nitrogen tank. An inventory of cryopreserved semen for 1991 and specific cryopreservation procedures are listed in Appendix C.

2.3.4: Incubation and rearing

<u>1990 brood</u> The 1990 brood salmon were reared as three separate groups according to their parentage; hatchery/hatchery, wild/wild, and mixed origin parents (Table 6, Bugert et al. 1991). Rearing conditions such as water temperature, feeding schedule, and pond loadings were kept as similar as possible among all groups. The fish were ponded from 10-27 December.

The sole water supply to Lyons Ferry FH was damaged on 28 May resulting in a loss of 49,200 L/min of water. On 2-4 June all salmon were transferred to the WDF Eastbank FH on the Columbia River upstream of Richland during repair of the water supply intake. Mortality and weight gain while at Eastbank FH was 342 fish and 889 lbs, respectively. The 1990 brood was coded-wire tagged while at Eastbank FH. Three distinct CWT codes were used to identify the separate experimental groups. Hatchery and wild salmon cross experimental groups were also blank-wire tagged (bwt) in opposite cheeks, according to group (Appendix D). Survival from eggtake to release for progeny of hatchery, wild and mixed parent crosses were 40.8%, 68.5%, and 85.4%, respectively. Fish were returned to Lyons Ferry FH on 12-16 August with 21,186 hatchery/hatchery (39 fpp), 51,260 wild/wild (35 fpp), and 13,563 mixed origin fish (46 fpp) for a total of 86,009 fish. We began a volitional release on 30 March 1992.

Table 6. Comparison of the estimated number of progeny of wild/wild, hatchery/hatchery, and mixed wild/hatchery crosses of 1990 brood Tucannon spring chinook salmon at six stages of development.

	Hatchery	Wild	Mixed	Totals	Weight (lbs)
Matings	19	19	6	44	
Eggtake [a]	51,700	74,634	15,788	142,122	
Ponded	22,534	51,867	13,902	88,303	65
Tagging	21,386	51,664	13,620	86,670	1,024
To Tucannon FH	21,161	51,208	13,548	85,917	3,089
At release	21,108	51,149	13,480	85,797	7,798

[a] Total at picking.

<u>1991 brood</u> Hatchery fish did not survive quite as well as wild fish in the incubation and hatching stages of routine hatchery rearing (Table 7). A loss of 3.9% of fry occurred in the hatchery salmon from the eyed stage to ponding compared to a loss of 2.7% in the wild salmon fry. A similar disparity in survival of hatchery salmon compared to wild salmon was also noted in 1990 (hatchery = 2.52%, wild = 0.75%). Fry were ponded from 17 December 1991 to 8 January 1992.

Table 7. Comparison of the estimated number of progeny of wild/wild, and hatchery/hatchery crosses of 1991 brood Tucannon spring chinook salmon at three stages of development.

	Hatchery	Wild	Mixed	Totals	Weight (lbs)
Matings	11	17	0	28	
Eggtake [a]	27,683	63,592	0	91,275	
Ponded	18,377	58,848	0	77,225	122

[a] Total at picking.

2.3.5: Disease incidence

The 1990 brood salmon were given three Gallimycin feedings during rearing; in February, June, and September 1991. The June treatment was interrupted and was not completed because of the transfer to Eastbank FH. This is the second brood year given three prophylactic treatments for Bacterial Kidney Disease (BKD).

In January 1992, WDF pathologist T. Black[1] noted inclusion bodies in the red blood cells of the 1990 brood. No gross anemia or loss of fish was detected.

The 1991 adult salmon were injected with both Erythromycin and Liquimycin (0.5 cc/10 lbs) at time of trapping, and twice again prior to spawning to treat Bacterial Kidney Disease (BKD) and Flexibacter columnaris. Flush treatments of formalin (1:5,000 dilution rate) were applied to adults every other day to control fungus infection. No fish health problems occurred in the 1991 brood during the study period (1 April 1991 to 31 March 1992).

2.3.6: Acclimation

<u>1990 brood</u> Lyons Ferry staff transported 85,868 yearling (1990 brood year) salmon to the adult holding pond at Tucannon FH on 15 November 1991. This was the first year we split acclimation conditions at the Tucannon FH to study any possible effects of water temperature on the expression of Erythrocytic Inclusion Body Syndrome (EIBS). The pond was divided into two sections. The upper section (177 m^3) received mixed river and well water and the lower section (40 m^3) received only river water. Fingerlings from all three groups were mixed before being split into the pond sections. Numbers of juveniles acclimated was 69,875 and 15,993 salmon in the upper and lower sections, respectively. The average water temperature was 2.6oC warmer in the upper section (6.4oC compared to 3.8oC). No conclusions can

be made from this experiment because the fish did not get EIBS. On 9 February the sections were combined and acclimation continued on river water alone until release.

2.3.7: Smolt releases

<u>1989 brood</u> Fish were allowed to volitionally migrate from 1-12 April, 1991. An estimated 99,057 smolts (11,006 lbs; 9 fish/lb) were released. Mean fork length and coefficient of variation of smolts at release were 160.3 mm and 15.0, respectively (Figure 4). The pre-release sample exhibits a bimodal distribution which is consistent with previous pre-release samples. Overall feed conversion rate for these fish was 1.16. Egg-to-smolt survival was 74.6% and mortality from ponding to release was 5.63%. Mortality during acclimation was 0.25%. All fish were coded-wire tagged and adipose-fin clipped. All hatchery releases of spring chinook salmon since initiation of the Tucannon FH program in 1985 are listed in Appendix D.

Program staff monitored travel time of hatchery smolts to the downstream migrant trap 40 km downstream of the hatchery (Section 3.3.6). Modal travel time for the smolts was 2-4 days. We sampled 0.53% of total (521) hatchery smolts released.

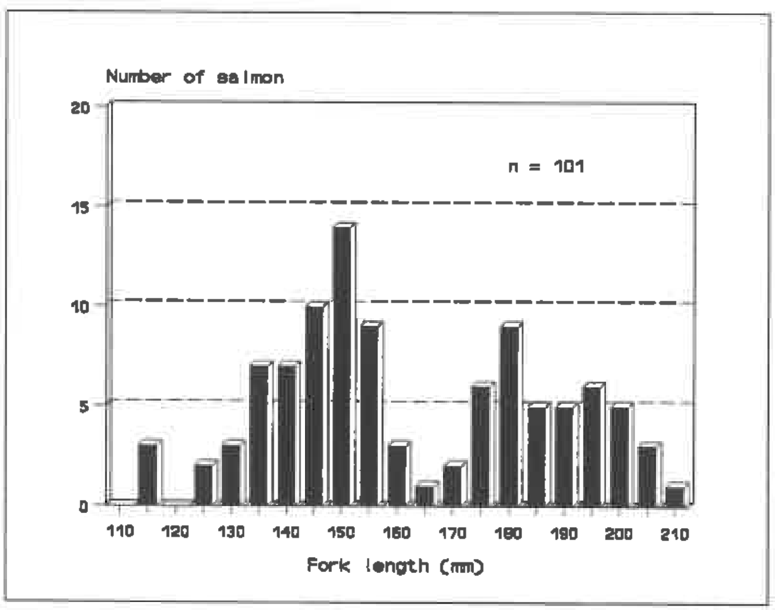

Figure 4. Length frequency distribution of 1989 brood spring chinook salmon released from Tucannon Fish Hatchery in 1991.

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

SECTION 3: NATURAL PRODUCTION

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

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-origin salmon spawned in the Tucannon River. The following discussion pertains to research on the population dynamics aspects of this program.

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

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

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

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

3.1: Stream Habitat Studies

3.1.1: Habitat inventory surveys

Program staff conducted an extensive stream habitat inventory survey in the Wilderness Stratum of the Tucannon River from 16- 25 June 1991. This stratum was also surveyed in 1985. Inventory data were collected for the HMA Stratum in 1985 and 1987; Hartsock Stratum in 1987; and Marengo Stratum in 1990. We collected data in a random systematic order in four sections within the Wilderness Stratum. We sampled at 30 m intervals in the mainstem and at 15 m intervals in side channels. We used habitat terminology suggested by Helm (1985). Inventory data included wetted width (Table 8), gradient (percent), and habitat type (riffle, run, pool, side channel). Surveys in this stratum in 1985 did not include side channel as a habitat type. Each site was scored by quality of rearing habitat as in previous years (Bugert et al. 1987, and 1991). We evaluated 351 mainstem and 222 side channel sites within the Wilderness Stratum. The riffle:run:pool:side channel ratio is 50:31:3:16, compared to a riffle:run:pool ratio of 74:15:11 in 1985. The mean wetted width for the mainstem in 1991 was 7.9 m, compared to 8.2 m in 1985. There was no change in the gradient from 1985 to 1991. Depth was most often scored as the limiting factor for rearing salmon in this stratum. Velocity and substrate scored equally as the factor limiting spawning in both mainstem and side channels.

Table 8. Mean wetted width and gradient of the Tucannon River by river kilometer within the Wilderness Stratum, 1991.

River kilometer	Wetted width (m)	Gradient (percent)
85.3-83.2	6.46	1.3
83.2-79.0	8.26	1.2
79.0-77.5	8.20	1.5
77.5-75.8	8.66	1.6

3.1.2: Stream temperature/discharge monitoring

Program staff deployed 10 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) 300 m downstream of Panjab Creek confluence (RK 76), 2) near the downstream outlet of Big 4 Lake (RK 66), 3) near the downstream outlet of Beaver-Watson Lakes (RK 64), 4) near the downstream outlet of Deer Lake (RK 62), 5) 100 m downstream of the Cummings Creek confluence (RK 58), 6) Bridge 14 (RK 53), 7) Bridge 12 (RK 48), 8) Marengo Bridge (RK 41), 9) WDF smolt trap (RK 21), and 10) Power's Bridge

(RK 3). Miscellaneous river discharges calculated from transect measurements made using a current meter and modified USGS techniques, as well as raw temperature data are presented in Appendix E.

In general, stream temperatures in June through September increased in varying increments from the furthest upstream location to the furthest downstream (Tables 9 and 10). Mean maximum temperatures increased consistently from Panjab Creek downstream to the Deer Lake outlet. However, mean maximum stream temperatures were lower below the Cummings Creek confluence than temperatures below Deer Lake, 5 km upstream. This temperature difference contrasts with our results for 1989, but it is similar to our data for 1987, 1988 and 1990. The Marengo thermograph recorded a high temperature of 27.2°C on 21 July and 6 August. Temperatures of 20°C or above were recorded regularly from 30 May to 29 September during 1991. The thermograph at Power's Bridge malfunctioned, no useable data were recovered.

Table 9. Mean monthly ranges (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 Creek	Big 4 Lake	Beaver Lake	Deer Lake	Cummings Creek
Apr 1991	5.3-11.7[a]	7.9-15.0[a]	7.5-15.1	8.0-16.1	7.5-14.7
May 1991	7.0-12.7	- -	8.8-17.0	9.1-17.0	9.0-15.0
Jun 1991	8.4-15.4	- -	11.4-20.2	10.5-20.7	11.2-18.4
Jul 1991	11.4-18.2	- -	13.5-19.5	14.2-24.4	14.1-22.6
Aug 1991	12.2-18.5[a]	- -	14.2-22.8	14.2-24.7	15.0-23.0
Sep 1991	- -	- -	11.0-20.0	11.5-22.0	12.1-20.0
Oct 1991[a]	- -	- -	9.9-16.6	10.4-17.9	11.0-17.5

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

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

Month	Bridge 14	Bridge 12	Marengo	Smolt trap
Apr 1991	3.9-13.3	4.4-13.9	9.6-18.9[a]	- -
May 1991	5.6-13.3	6.1-13.9	11.2-18.7	- -
Jun 1991	7.2-17.2	7.8-17.8	13.0-22.6	12.2-18.9
Jul 1991	11.1-21.1	11.7-22.2	16.8-27.2	13.9-24.4
Aug 1991	11.7-21.7	11.7-22.2	17.0-27.2	12.8-24.4
Sep 1991	8.9-18.9	8.9-19.4	14.0-24.0	9.4-20.6
Oct 1991	2.8-15.0	2.8-15.6	12.7-19.8[a]	2.8-17.2
Nov 1991	2.2- 9.4	2.2-10.0	- -	0.0-15.6
Dec 1991	- -	- -	- -	1.7- 8.3
Jan 1992	- -	- -	- -	1.7- 5.6

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

3.2: 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.

3.2.1: Snorkel surveys

In 1991 as in 1990, the rack remained in the river and was checked daily from May through September. We have two objectives for adult snorkel surveys downstream of the rack: 1) refine our estimate of total escapement to the river (upstream and downstream of the rack), and 2) assess in-river movement prior to spawning. We counted 13 adult salmon on 6 August from the Tucannon FH rack downstream to Bridge 14 via snorkel surveys, 25 and 29 adults were seen during two surveys in 1990. Forty-seven adults arrived at the rack between 29 August and 24 September 1991 (Figure 3), compared to 118 in 1990. The late arrival of these fish indicates that snorkel surveys underestimate the actual number of adults holding below the rack. The rack does not entirely prevent fish from moving downstream. However, we believe downstream movement is limited by the rack. Because of the high number of redds and the low number of fish observed below the rack during our survey in 1990 and 1991, we feel this one count does not adequately reflect the number of adult salmon holding downstream of the rack.

3.2.2: Radio telemetry

Migrating adult salmon were either passed upstream or collected for broodstock at the Tucannon FH rack. On a random basis we anesthetized salmon with carbon dioxide and inserted radio tags into the esophagus prior to releasing them upstream. We recorded fork length, post-orbital to hypural plate length, general condition, and if possible, sex of each fish at the time of tagging. Each radio transmitted a unique frequency/pulse combination enabling us to track individual fish. Fish were tracked at approximately three-day intervals while they were least active. Tracking was intensified as spawning time approached. General tracking was conducted from vehicles along the road. We identified precise locations for each salmon apparently holding for long periods of time in one location. 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, we verified the sex of tagged fish by underwater observation.

Radio tags were inserted into 18 fish (12 hatchery and six wild) between 29 May and 26 June, 1991 (Appendix F). 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/stomach. Six tags were regurgitated and recovered from hatchery fish within five days of tagging. One tag was found in a dead fish the day after tagging. Internal examination indicated that mortality was caused by rupture of the stomach during tagging. One tag was recovered 0.5 RK downstream of the rack 20 days after it was inserted; the carcass was partially eaten by an animal.

Radio tagged wild salmon moved farther upstream in their initial movements and moved more frequently (Figures 5 and 6) than tagged hatchery fish (Figures 7 and 8). 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. Hatchery fish initially moved a short distance upstream of the hatchery rack (≤0.1 km) after tagging while wild fish moved farther upstream before holding (≥ 4.5 km above the rack). Two tagged wild fish moved upstream into the Wilderness Stratum; one salmon moved back downstream into the HMA Stratum prior to spawning, and the other remained within the Wilderness Stratum, but was not observed on a redd. 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 101 days (compared to a maximum of 90 days in 1990, and 77 days in 1989). Tagged hatchery salmon held for longer periods of time and used fewer holding areas than wild fish. One radio tagged wild salmon was observed holding in an area immediately downstream of the confluence of a spring. This fish held for 79 days in the same area. The mean temperature of the spring in August was 12.2°C (11.1-13.9, n=5). The mean temperature of the river above the spring was 15.4°C (12.8-20.0, n=5). On average, the spring decreased the river temperature where the fish was holding by 1.2°C (0-3.3).

Ten tagged fish were tracked into the spawning season, including one tagged fish where only the tag found on shore at the beginning of spawning season. Another wild male survived through spawning season within the Wilderness Stratum, yet we are unable to confirm that he actually spawned. Eight tagged salmon spawned; four were hatchery females, and four were wild fish (one male and three females). Spawning of radio tagged fish occurred from 4-24 September 1991. Hatchery fish generally spawned later than wild fish, but this may be merely a reflection of their downstream locations in the river. All tagged fish observed during spawning were within the HMA Stratum. Tagged hatchery fish spawned nearer the hatchery rack (within 6.9 km of the rack) than tagged wild fish (between 7.4-12.5 km above the rack). We did not document observe hatchery and wild fish spawning together. However, both tagged and untagged hatchery fish were observed spawning in the upstream reaches of the HMA Stratum in the vicinity of untagged wild fish.

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). After completing a redd, females remained on or near their redds, for about 10 days, until death. Carcasses of females were usually found within 100 m of their respective redds.

As in previous years, circumstantial evidence again indicated possible poaching of salmon from the Tucannon River, as in previous years. A transmitter was found during spawning season 10 m from the river within a popular campground in the HMA Stratum.

One radio-tagged fish moved downstream of the rack and was recaptured in the trap 15 days later. Our tracking of that fish leads us the believe it moved downstream shortly after it had been tagged. This occurred while the modified panels were installed at the rack. A wooden board attached to the last panel left a small gap (1-2 in) between the last panel and the concrete trap structure, which may have allowed this fish to move downstream of the rack.

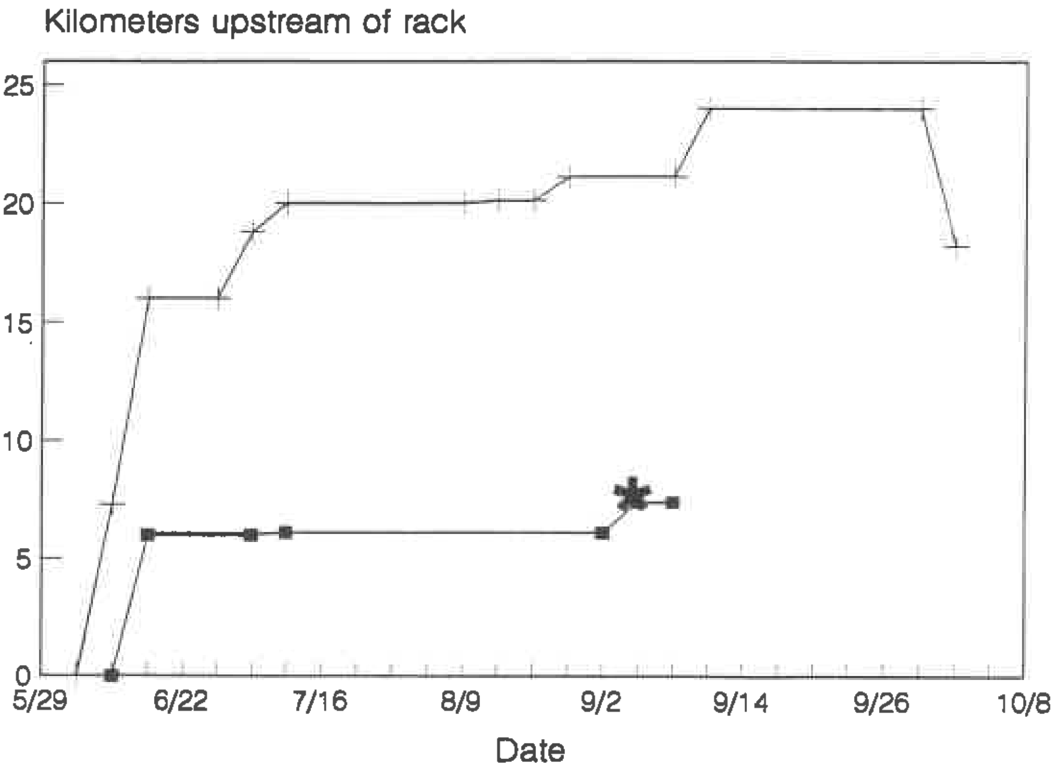

Figure 5. Movement of two radio tagged (tags 12C and 13B) wild male spring chinook salmon past the Tucannon Fish Hatchery in 1991 (* indicates redd construction).

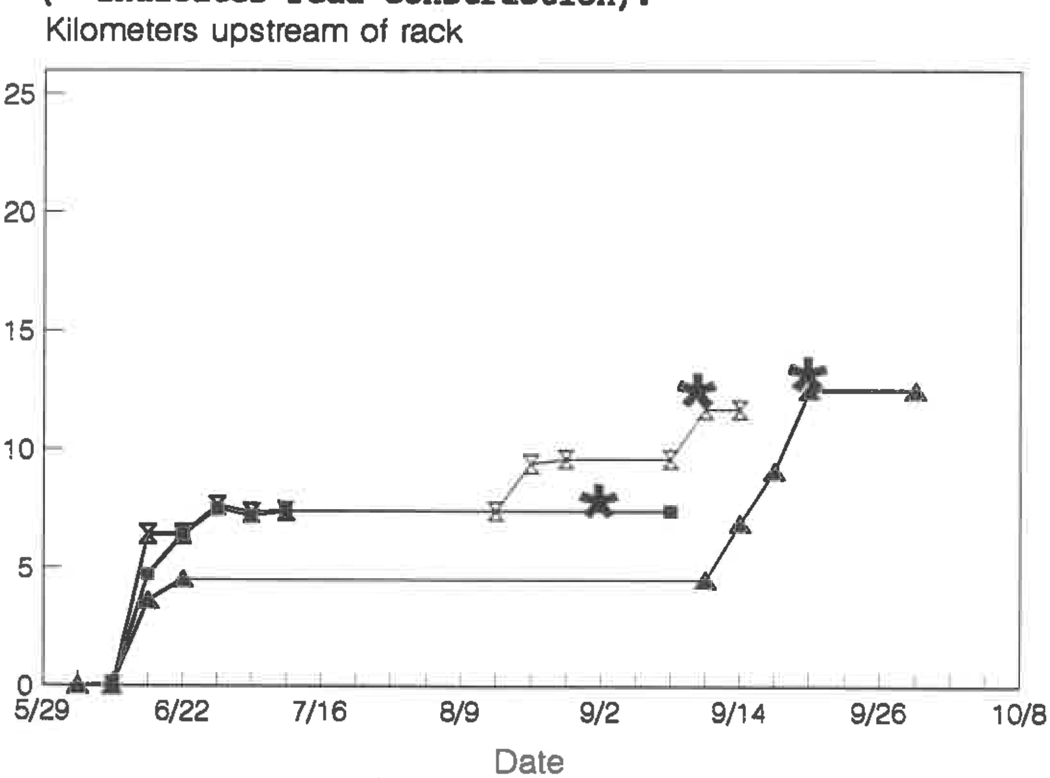

Figure 6. Movement of three radio tagged (tags 12B, 14B, and 14C) wild female spring chinook salmon past the Tucannon Fish Hatchery in 1991 (* indicates redd construction).

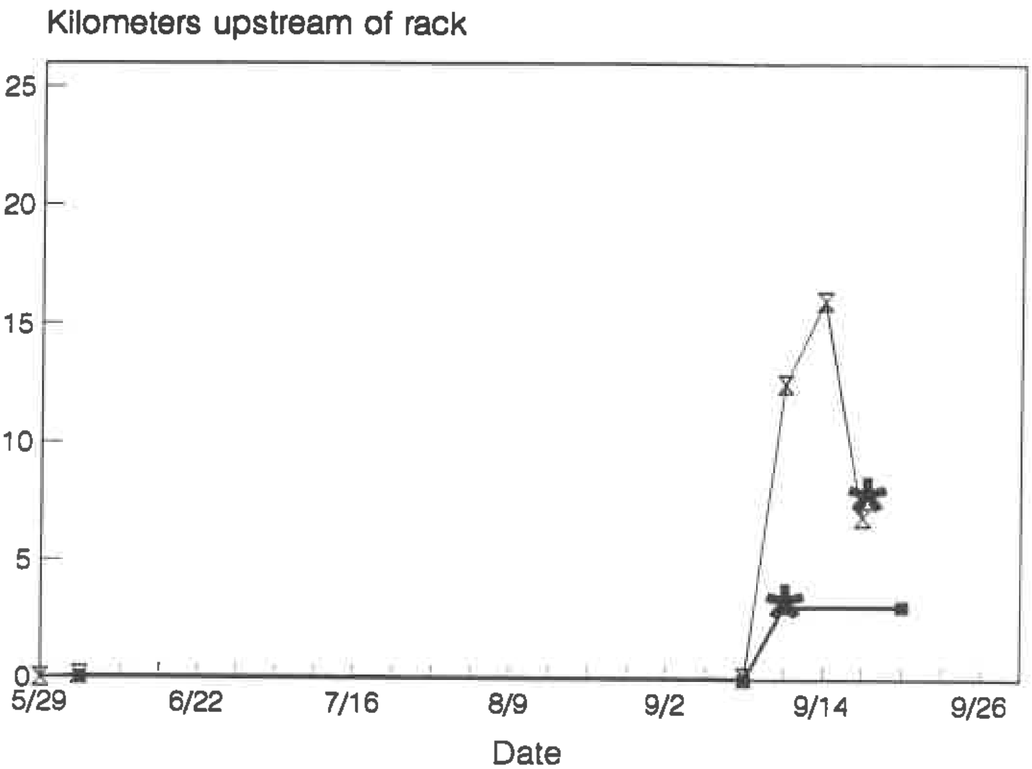

Figure 7. Movement of two radio tagged (tags 3B and 9C) hatchery female spring chinook salmon past the Tucannon Fish Hatchery in 1991 (* indicates redd construction).

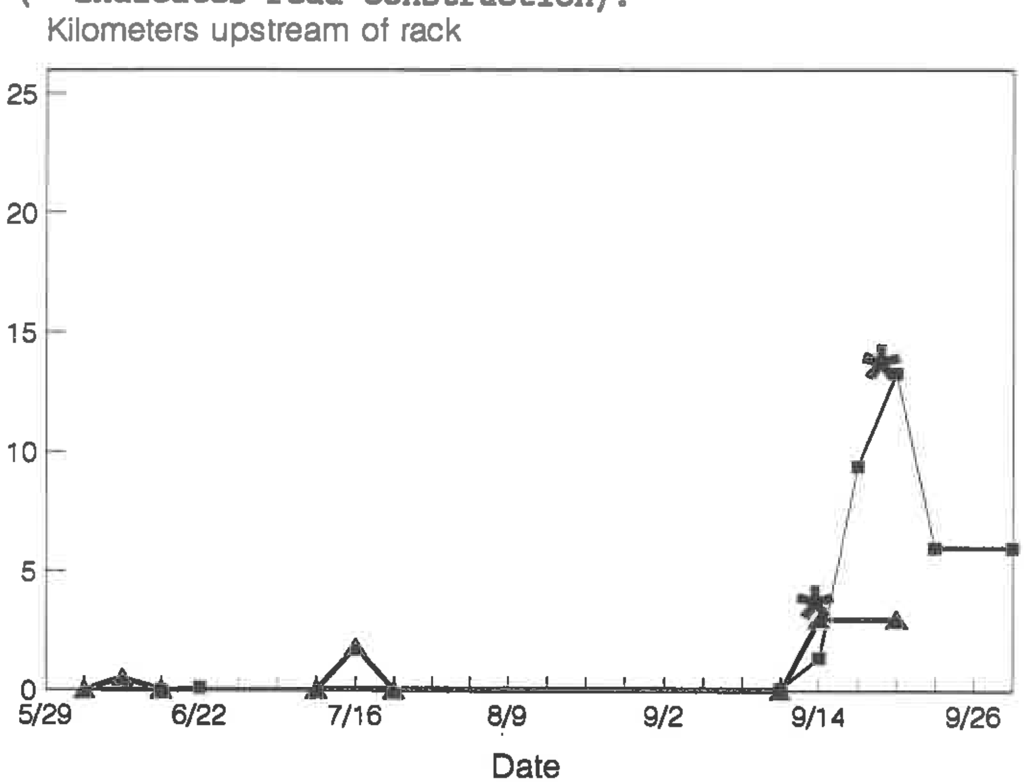

Figure 8. Movement of two radio tagged (tags 5B and 5C) hatchery female spring chinook salmon past the Tucannon Fish Hatchery in 1991 (* indicates redd construction).

This was our third year of radio telemetry, but only our second year of tracking hatchery fish. Over the last two years tagged hatchery fish have had higher mean regurgitation rates and higher overall loss than wild fish (Table 11). Generally fish reduced their movements and began to "stage" or "hold" in mid-May to mid-June. Tagged fish limited their movements until mid-August or early September, often increasing movement and changing their locations just prior to spawning. Tagged wild salmon moved further upstream of the rack (x = 11.2 km, s = 4.6, n = 17) before staging, and moved more often, compared to their tagged hatchery cohorts (x = 1.4 km, s = 2.2, n = 8). 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 fish in 1991 (20 days), 2 wild fish in 1990 (44 and 54 days), and one wild fish in 1989 (6 days). Wild females spawned considerably further upstream (x = 13.1 km) of the hatchery rack than hatchery females (x = 4.8 km), while wild and hatchery males appeared to spawn in similar locations (note: small sample size of 4 wild and 2 hatchery - range 7-17 km above the rack). Once spawning began females tended to stay in the vicinity of their redd (mean of 10 days), while males covered large areas seeking mates.

Table 11. Summary and comparison of radio telemetry data for wild and hatchery spring chinook salmon adults in the Tucannon River, 1989-1991.

	1991		1990		1989	Total	
Category	wild	hat.	wild	hat.	wild	wild	hat.
No. of Fish Radio Tagged	6	12	20	12	16	42	24
No. of Tags Regurgitated (%)	0 0.0	6 50.0	5 25.0	2 16.7	2 12.5	7 16.7	8 33.3
No. of Mortalities	0	2	1	3	6	7	5
- from tagging	- -	1	0	0	2	2	1
- unknown causes	- -	1	1	3	4	5	4
No. of Lost Tags and Fish[a]	0	0	2	0	3[b]	5	0
Recovered Tag only[c]	0[d]	0	2[e]	3[f]	3[g]	5	3
No. Fish Tracked During "Holding"	6	4	9	4	2	17	8
- mean # of days	89.3	98.8	76.9	92.5	81.5	81.8	95.6
- std. dev.	9.9	2.9	15.0	16.1	34.6	15.9	11.2

Table 11. Continued.

Category	1991 wild	1991 hat.	1990 wild	1990 hat.	1989 wild	Total wild	Total hat.
- range (days)	79-106	95-101	53-100	77-115	57-106	53-106	77-115
- mean hold loc. (km)[h]	10.2	0.1	12.7	2.7	7.0	11.1	1.4
- mean no. sites/fish[i]	3.0	1.3	3.3	2.3	2.0	3.1	1.8
No. Fish Tracked to Spawning	6[d]	4	10	4	2	18	8
No. Observ. Spawning	4	4	8	4	2	14	8
- mean first spawning date	9/11	9/15	9/03	9/11	9/07	9/06	9/13
No. Females Observed Spawning	3	4	4	2	1	8	6
- mean spawning location (km)	10.5	4.8	15.9	4.8	9.6	13.1	4.8
- std. dev.	2.7	2.0	4.2	6.7	0.0	4.3	3.4
- range (km)	7.4-12.5	3.0-6.9	9.7-18.6	0.0-9.6	- -	7.4-18.6	0-9.6

[a] Transmitter and fish not recovered, possibly poached or transmitter malfunction. Includes one tag that never transmitted a signal and one lost near campgrounds from wild fish in 1990.

[b] Includes three lost near campgrounds.

[c] Fish possibly poached, or tag regurgitated.

[d] One male observed spawning had been tracked 102 days before the tag was found 10 m on shore. This fish counted under spawning data, but not under Recovered Tag Only category.

[e] Both tags recovered on shore, one under a stump.

[f] All tags found in the river near campgrounds.

[g] One tag turned in by an angler and two were found in the river below the rack on private property.

[h] A number of sites were used by each fish during holding behavior. Mean holding location was calculated using the one site with the longest holding duration for each fish.

[i] We defined a holding site as an area within 0.3 km, for ≥5 days.

3.2.3: Pre-spawning mortality

In 1991 we noted evidence of pre-spawning mortality of salmon in the Tucannon River. One male and seven females (all hatchery origin) were recovered dead between 3 June and 5 September, prior to spawning. Of these eight salmon, one female died as a result of radio tagging. Four females and one male died while entering the trap. The remaining two salmon died of unknown causes (one of these fish was a radio-tagged individual found dead and partially eaten below the rack).

3.2.4: 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. Seven spawning ground surveys were conducted over nine days; 28 August, 5, 11 and 12, 18, 25 and 26 September, 1, and 3 October. Person-days required for the surveys were 4, 4, 4, 2, 5, 5, 2, 4, and 2, respectively (partial survey days were counted as whole days).

We found 90 redds in the Tucannon River in 1991 (Table 12). The number of redds sighted this year decreased from the previous five-year mean of 158 redds, and 20 year mean of 127 redds. The Tucannon River tributaries were not surveyed in 1991 because we saw little evidence of spawning there in previous years.

During radio tracking and spawning surveys we found carcasses from 28 hatchery salmon and 43 wild salmon (Table 12). Sex ratios were roughly the same between wild and hatchery carcasses. We examined 23 wild female carcasses; one had retained all eggs, one had retained 30% of her eggs, one had retained 10% of her eggs, and the remaining 20 females had not retained any eggs. We examined eight hatchery female carcasses; none had retained eggs. Twenty-seven CWT were recovered from hatchery salmon in the river (pre-spawning mortality, radio tracking and spawning ground surveys) four were age 3, 19 were age 4, and four were age 5. One additional CWT was lost prior to reading.

Most salmon spawned within the HMA and Hartsock Strata, as in 1990 (Tables 12 and 13). Redd density in the Hartsock Stratum was substantially below redd density observed in 1990. Redd density within the Wilderness Stratum was the lowest documented since we began surveys in 1985. The surveys of Marengo Stratum were limited to the upper 8 km as in 1990.

Table 12. Number of spring chinook salmon redds observed and general locations of hatchery and wild carcasses recovered during radio tracking and spawning ground surveys on the Tucannon River, August and September, 1991.

Stratum	River km	Number of redds	Carcasses recovered [a]			
			Hatchery		Wild	
			male	female	male	female
Wilderness	85-75	3			1	1
HMA	75-69	17	1	1	3	4
	69-64	11	2	2	4	3
	64-55	39	5	8	9	6
Hartsock	55-48	8	2		3	3
	48-43	10				4
Marengo	43-35	2			1	2
Totals		90	10	11	21	23

[a] Does not include carcasses recovered prior to spawning season.

Spawning surveys have been conducted in an index area (from Cow Camp Bridge downstream to Camp Wooten Bridge) within the HMA Stratum since 1954 (Figure 9). The number of redds present in this area has declined substantially over the years, with a noticeable reduction since 1985. A similar reduction of redd numbers is also obvious in a secondary index area in the upper portion of the HMA Stratum from Panjab Bridge to Cow Camp Bridge, as well as throughout the Wilderness Stratum (Table 13). We do not know if this a result of behavioral changes due to the presence of the permanent rack, or the decrease in the number of wild salmon returning to the river. Carcasses of wild salmon were recovered from every strata; no hatchery-origin carcasses were found in the Wilderness or the Marengo strata during spawning ground surveys in 1991.

Table 13. Comparison of spring chinook salmon redd densities in redds/km (redds/ha) by stratum and year, Tucannon River, 1991.

Stratum	1985 redds/km (ha)	1986 redds/ km (ha)	1987 redds/km (ha)	1988 redds/km (ha)	1989 redds/km (ha)	1990 redds/km (ha)	1991 redds/km (ha)
Wilderness	8.32 (10.14)	5.25 (6.04)	1.49 (1.81)	1.78 (2.17)	2.87 (3.50)	1.98 (2.44)	0.30 (0.37)
HMA	5.33 (4.46)	5.79 (4.97)	6.93 (5.95)	3.91 (3.36)	2.67 (2.29)	4.65 (4.00)	3.32 (2.85)
Hartsock	- -	2.28 (1.84)	2.36 (1.90)	1.57 (1.27)	1.81 (1.45)	5.04 (4.09)	1.42 (1.15)
Marengo	- -	0.00	- -	- -	- -	0.25 (0.20)	0.25 (0.20)

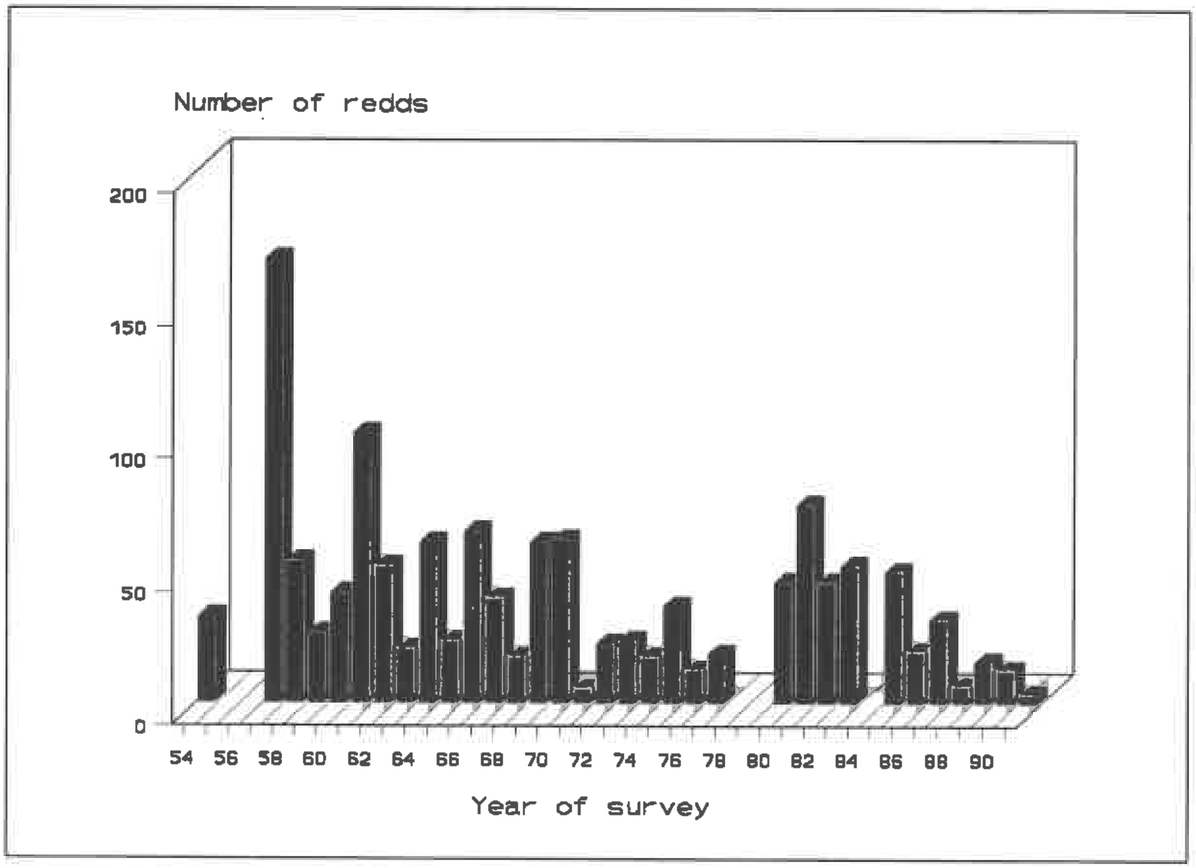

Figure 9. Spring chinook salmon redd counts (one survey/year) within a 4 km index area (Cow Camp Bridge to Camp Wooten Bridge) 1954-1991 (Temporary adult trap was used in 1986-1989, permanent trap installed for 1990-1991).

Spawning surveys from several portions of the Tucannon River indicate the peak of salmon spawning varied among strata. Peak spawning activity in the Wilderness and HMA Strata was approximately 11 September. Three redds were deposited in the Wilderness Stratum on 28 August and one new redd was dug in the Marengo Stratum on 1 October, indicating the duration of spawning to be at least 35 days, compared to 44 days in 1990.

Asotin Creek On 10 October we surveyed the North Fork of Asotin Creek from the South Fork confluence 7.2 km upstream. No redds were found. Two redds were constructed in this reach in 1990, no redds in 1989, one in 1988, three in 1987, and one redd in 1986.

Wenaha tributaries Tributaries of the Wenaha River that extend into Washington State and contain salmon are the North Fork Wenaha River and Butte Creek. We were unable to survey these streams in 1991 because of time constraints.

3.2.5: Adult escapement

In general, redd counts are directly related to escapement to the Tucannon FH rack (Bugert et al. 1991). We estimated the total escapement to the Tucannon River (salmon known upstream of rack plus salmon estimated downstream of rack) for 1989-1991 (Table 14). These estimates are a revision to the escapements reported in the 1989 and 1990 annual reports. The number of females above the rack is based on the female-to-male ratio of broodstock multiplied by the number of salmon released upstream of the rack. We then calculated the female-to-redd ratios upstream of the rack. This value, multiplied by the number of redds counted downstream of the rack, yields the number of females downstream. Based on the female-to-male ratio of broodstock we can extrapolate the number of males downstream of the rack. Total estimated escapement is the sum of the salmon counted (and released upstream of the rack) and the estimated number of salmon spawning downstream of the rack. The estimated escapement is separated into hatchery or wild origin based on the proportion of hatchery-to-wild salmon escaping to the rack for each year.

Revised escapement estimates for 1989-1990 are substantially higher than estimates (180 and 462, respectively) reported in previous reports. We now account for escapement downstream of the rack.

Table 14. Estimated total spring chinook salmon escapement to the Tucannon River, 1989-1991.

Year	Female/ male (broodstock)	Redds downstream of rack	Female/ redd[a]	Estimated escapement[b c]		
				hatchery	wild	total
1989	0.81[d]	32	0.52	117	178	295
1990	1.17	84	2.04	359	420	779
1991	0.54	50	1.19	297	161	458

[a] Estimated number of females above rack divided by number of redds counted upstream of rack.

[b] Female-to-redd ratio is applied to the number of redds downstream of the rack to estimate the number of females, which is extrapolated to estimate number of males based on proportion of females-to-males of the collected broodstock.

[c] Sum of salmon escaping to rack and estimated number downstream of rack based on percentage of hatchery/wild salmon at rack.

[d] 1989 ratio includes only wild salmon because all hatchery salmon were collected for broodstock.

3.2.6: Compensation progress

In 1991, we estimate 458 salmon returned to the Tucannon River, achieving 40% of the LSRCP mandate of 1,152 salmon. This value reflects expanded escapement of both wild and hatchery salmon. Our preliminary estimates show a hatchery smolt-to-adult survival rate (0.28%) substantially below the design objective of 0.87% (Table 3). It appears few salmon contribute to fisheries, based on CWT recoveries (Appendix B).

3.3: Juvenile Population Dynamics

Electrofishing surveys were not conducted in 1991. We instead, conducted snorkel surveys at index sites. We used a modified line transect sampling method (Emlen 1971) for snorkeling to estimate juvenile salmonid abundance in the Tucannon River. Summer snorkeling surveys occurred between 31 July and 17 October. All index sites were snorkeled two or three times (each time by a different person to reduce bias) to estimate densities of salmon parr.

A lead line, or rope, was placed as a transect line diagonally across each site. Snorkeling always started at the downstream end of the transect at 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. Duration of the survey was noted, and snorkelers attempted to standardize survey times. Each site was not snorkeled more than once per day.

We calculated the area surveyed by multiplying the mean transect length by 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). 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 strata.

3.3.1: Wilderness Stratum parr production

Some of the index sites established in 1985 were selected at random for parr production surveys in 1991. Nine sites were snorkel surveyed by program staff from 31 July to 29 August; three sites of each habitat type (riffle, run, pool). Total area snorkeled in the Wilderness Stratum was 305 m^2.

Mean densities (fish/100 m^2) from snorkel surveys were highest in pools and lowest in runs (Table 15). Densities for all four index sites snorkeled in 1991 were below densities for the same sites in 1990 (Bugert et al. 1991). We estimate that 1,861 subyearling parr reared in Wilderness Stratum in 1991. This estimate is only 28% of the 1990 estimate derived from snorkel surveys (6,578 salmon) for this stratum.

3.3.2: HMA Stratum parr production

We surveyed randomly selected index sites 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 replicates of each habitat type for a total of 25 index sites. Surveys were done in this stratum from 31 July to 24 September. Total area snorkeled in the 25 index sites was 1,114 m^2. Mean densities (fish/100 m^2) were highest in side channels and pools (Table 15). We estimate that 40,467 salmon parr reared in this stratum in 1991. This is a 11% decrease in the rearing population estimate derived through snorkel surveys in 1990 (45,350 salmon, Figure 10, Appendix G).

Table 15. Mean densities of juvenile salmon observed in snorkel surveys by stratum, and habitat type, Tucannon River, 1991.

	Mean density (fish/100m^2), n			
Habitat	Wilderness	HMA	Hartsock	Marengo[a]
Riffle	2.15, 3	6.19, 5	15.93, 3	1.05, 1
Run	0.61, 3	20.78, 5	34.18, 4	7.81, 1
Pool	22.70, 3	43.73, 5	29.16, 2	10.16, 1
Boulder	- -	7.57, 5	- -	- -
Side channel	- -	58.51, 5	- -	- -

[a] *Marengo Stratum densities were not included in summer rearing population estimate because of fall survey dates (9, 11, 17 October).*

3.3.3: Hartsock Stratum parr production

Several previously established index sites were selected at random for parr production estimates. We snorkeled nine index sites, three riffles, four runs, and two pools from 7 August to 26 September. Total area snorkeled in this stratum was 435 m^2. Mean density was highest in runs (Table 15). We estimate that 21,024 subyearling spring chinook reared in Hartsock Stratum during summer 1991. This estimate reflects a 145% increase compared to our 1990 estimate (8,590 salmon) derived from snorkeling in this stratum. Spawning densities were highest in this stratum in 1990 and much higher than we had observed in previous years.

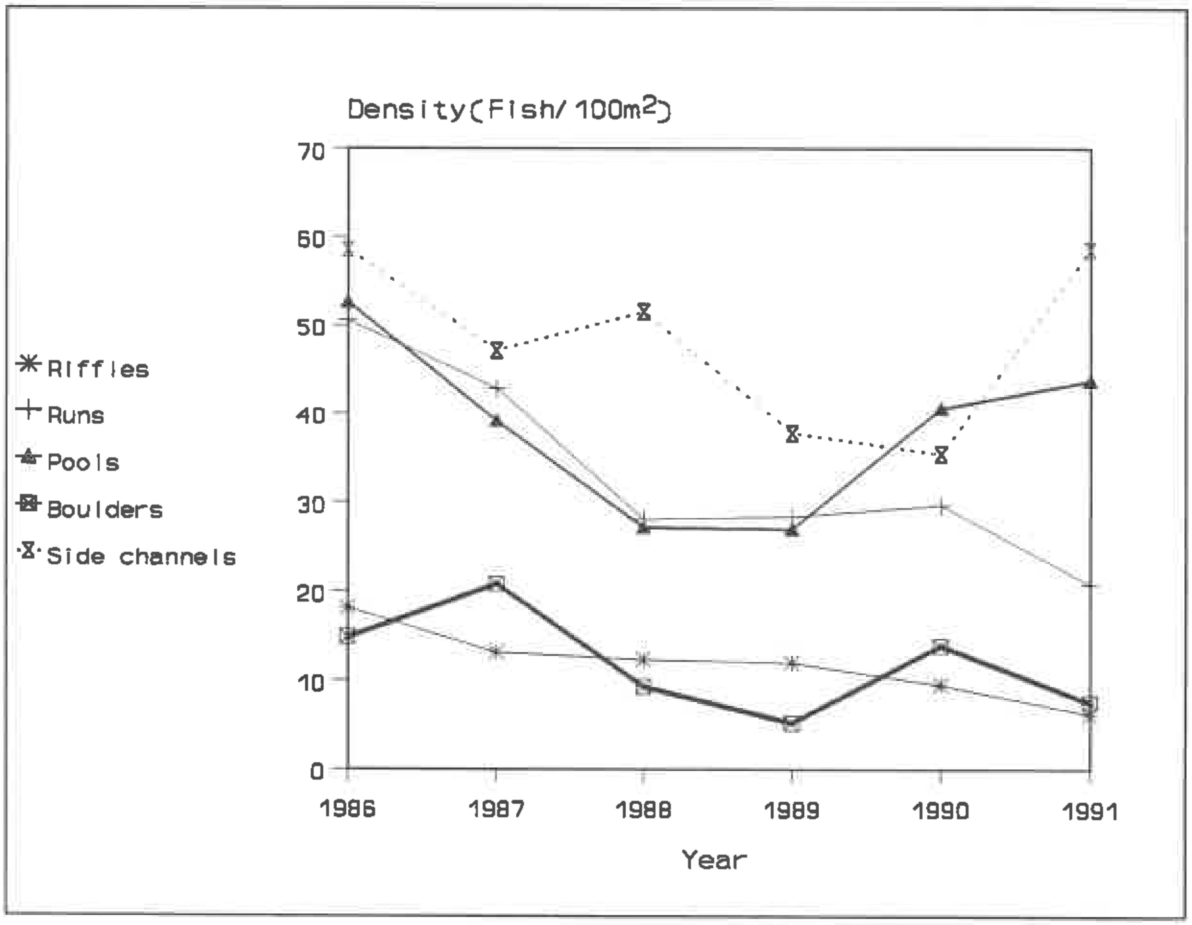

Figure 10. Comparison of spring chinook salmon rearing densities in HMA Stratum from 1986 to 1991. Density estimates for 1986-1989 were based upon multiple-pass depletion electrofishing surveys; snorkel surveys were used in 1990 and 1991.

3.3.4: Other Strata

We snorkeled three index sites (one site of each habitat type) in the Marengo Stratum in 1991, from the six sites established in 1990. Total area sampled was 87 m^2. Density was highest in the pool site (10.16 salmon/100 m^2, Table 15). No salmon parr were observed in any of the six sites sampled in 1990. The observed difference between 1990 and 1991 may be partially attributed to the date of our surveys. In 1991, surveys were conducted 9 to 17 October while in 1990 surveys were conducted 12 July to 23 August. Water temperatures cooled substantially by October. Therefore, we did not use these estimates to calculate summer standing crop. We did not snorkel any sites in the Lower Stratum, nor did we conduct winter snorkel surveys in 1991.

3.3.5: Yearlings

During snorkel surveys program staff noted large juvenile salmon which we assumed to be yearlings as in 1990 (Bugert et al. 1991). These yearlings are not included in our parr production or standing crop estimates for 1991. we may examine these data further and report yearling standing crop estimates for 1991 in a subsequent report. Yearling juvenile salmon were observed at four of the nine sites snorkeled in the Wilderness Stratum (38 yearlings, 87 subyearlings); nine of 25 sites surveyed in the HMA Stratum (28 yearlings, 853 subyearlings); one of the nine sites snorkeled in the Hartsock Stratum (1 yearling, 323 subyearlings); and one of three sites surveyed in the Marengo Stratum (1 yearling, 16 subyearlings). A total of 68 yearlings were observed in 15 different sites. Seventy-eight percent of the yearlings observed were in pools.

3.3.6: Downstream migrant trap operations

An important objective of our study is to estimate the magnitude, duration, periodicity, and peak of natural salmon emigration from the Tucannon River. To do this, we maintain a floating inclined plane downstream migrant trap at RK 21. We operated the trap intermittently from 20 November 1990 to 31 March 1991 and continuously from 1 April to 30 June 1991, excluding 25-28 May because of Memorial Day.

To calibrate trapping efficiency, we systematically marked (clipped the tip of a pelvic fin) captured natural smolts and transported them 10 km upstream of the trap for release. The percentage of marked fish captured was used to estimate the percentage of total downstream migrants trapped. We used a modified form of the standard Peterson mark-recapture method as previously described (Bugert et al. 1991).

Five mark/recapture trials were conducted during April-June to calibrate the trap. Mark/recapture trials were not conducted during other months because of low numbers of fish being caught. The trap was checked 380 times in the eight-month period. We caught 2,919 natural-origin salmon (excluding recaptures) and 1,180 hatchery-origin salmon during the 1990/1991 season (Appendix H). Based upon the overall unweighted trap efficiency estimate from marked fish and the number of fish trapped (14.4%), we estimate 25,862 natural-origin salmon juveniles emigrated. The 95% confidence limit to this estimate is ±1,099 fish. This is a minimum estimate derived from mark/recapture trials in May and June and applied to the entire trapping season. We were unable to calculate trap efficiency earlier in the season because we did not recapture sufficient numbers of marked fish. This trap efficiency is lower than the 1987-1990 estimate (range: 20.2-29.9%).

We assessed the amount of descaling, fin erosion, and the degree of smoltification for most fish collected (2909). We measured fork lengths on virtually all of the natural-origin fish collected (2,916) and weighed 938 (32%) fish on a random basis. Water temperature, velocity, and clarity (determined with a Secchi disk) were recorded to be used as covariates in explaining variability in smolt migrations.

In the eight-month trapping period, 95 natural-origin salmon (3.0%) were considered descaled in one or more zones, compared to 10.2% in the 1989/1990 season. Of these, 11 salmon (0.4% of total) were descaled in two or more zones, compared to 3.3% in the 1989/1990 season, 1.6% in the 1988/89 season, 2.2% in the 1987/88 season, and 6.9% in the 1986/87 season. Thirty-four fish had cuts or bruises. We saw very little descaling on fish captured and handled twice (recaptured marked fish; 0.05% were descaled). Overall, seven wild and four hatchery salmon were found dead in the trap during the eight-month season.

We classified 90% of the natural salmon caught as parr-smolt transitionals, while only 2% were classified as smolts, and 8% were parr (Table 16). Virtually all salmon emigrants were assumed to be yearlings based on fork length (Figure 11). Most parr were recently-emerged fry.

We sampled 521 of the 1,180 hatchery fish (adipose clipped) trapped (Figure 11). Of the fish sampled, 122 (23.4%) were descaled in one or more zones, 107 (20.5%) had damaged caudal fins, 16 (3.1%) had cuts, bruises or head injuries and four were found dead in the trap.

Table 16. Average condition factor for natural spring chinook salmon weighed at the Tucannon River downstream migrant trap November 1990 through June 1991.

Parr/smolt transformation	Sample size	Mean length (mm)	Mean weight (g)	Mean kfactor
Parr	21	41.8	1.8	1.01
Transitional	886	92.2	9.9	1.16
Smolt	31	106.5	12.5	1.16

Twenty-seven percent of the hatchery fish sampled were classified as smolts, 72% as parr/smolt transitionals and 1% as parr. The average fork length and weight for hatchery fish caught was 132.2 mm (n=521) and 29.6 g (n=130). This was smaller than mean length sampled at release (160.3 mm). The unimodal distribution and the smaller mean length of the fish sampled at the smolt trap contrasts the bimodal distribution and mean length of the pre-release sample taken at the Tucannon FH (Section 2.3.7). This suggests that only smaller hatchery fish were caught by our smolt trap.

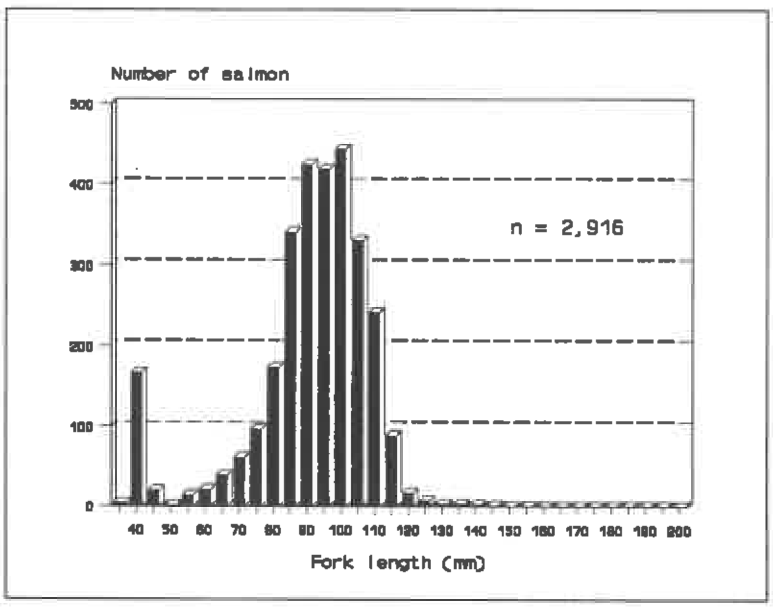

Figure 11. Length frequency distribution of natural spring chinook salmon caught at the Tucannon River downstream migrant trap, 1990/1991 season.

Composition and numbers of incidental species caught in the downstream migrant trap in 1990/1991 changed little from previous years (Appendix I).

3.3.7: Standing crop

Natural salmon population estimates have been derived for several brood years at the egg deposition, late summer rearing parr, and yearling emigrant life history stages. Currently, we have preliminary estimates for the 1985 through 1989 broods at all juvenile life stages. Estimates are being revised as we obtain additional information from on-going studies.

SECTION 4: STOCK PROFILE ANALYSIS

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

4.1: Population Structure

4.1.1: Fecundity and egg size

Seventeen wild and 12 (one was not ripe) hatchery females were spawned at Tucannon FH in 1991 (Table 5). Average fecundity and eggs/pound indices were 3,260 eggs and 2,002, respectively. Eggs/female was determined by dividing the total number of eggs taken by the number of females spawned. Mean female fecundity based on incubation room counts for hatchery-origin females was 2,517 eggs (s=798), and for wild-origin females 3,741 eggs(s=1064). Fecundity is higher for wild-origin females because they are older and larger than hatchery females (Section 4.1.2) and fecundity increases with size (Figure 12). Combined hatchery and wild fecundity and egg weight for the years 1986-1991 is 3,749 eggs (s=250.0) and 1,759 eggs/pound (s=243.8). (Note: Higher estimates of egg numbers and weights were obtained compared to hatchery estimates in 1990 by using a sampling method that employs 100 eggs and individual egg weights - Bugert et al. 1991).

y = 8.81x-2897.07
n = 81
R^2 = 0.3514
F = 3.86
P < 0.1
DF = 1, 79

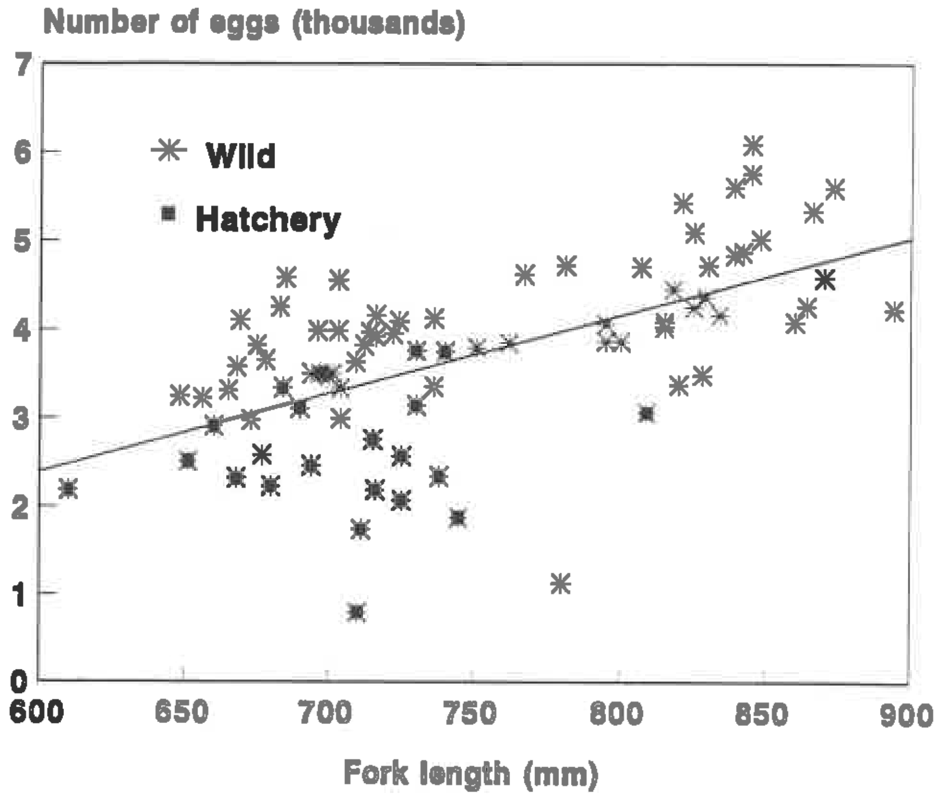

Figure 12. Relationship of fork length to mean fecundity of Tucannon spring chinook broodstock 1985-1991.

4.1.2: Age and sex structure

Wild salmon Sex ratio of wild salmon in the Tucannon River in 1991 was 0.71 females per male; this includes all age classes. Based upon scale analysis and including salmon fitted by fork length, 2.4% of the recovered salmon were age $3/_2$ (total age/years in freshwater), 61.0% were age $4/_2$ and 36.6% were age $5/_2$ in 1991 (Table 17, Figure 13). Salmon returning in 1991 at age 3 are the first returns of spawning naturally in the river that may be progeny of wild and/or hatchery parents. Since we began broodstock collection in 1985, average age classification is 1.3% age $3/_2$, 67.4% age $4/_2$, and 31.3% age $5/_2$ (n=527, Figures 14 and 17). This cumulative age classification includes 70 fish with unreadable scales or not scale sampled, fitted according to fork length.

Table 17. Sex, mean fork length (cm), and age (from scale impressions) of wild spring chinook salmon sampled at Tucannon Fish Hatchery, 1991 (s=standard deviation, n=sample size).

Sex	Mean length (s, n) at given age			Totals
	$^{3}/_{2}$	$^{4}/_{2}$	$^{5}/_{2}$	
Female	- -	72.0 (1.6, 2)	80.2 (6.7, 9)	11
Male	47.0 (-, 1)	68.9 (5.1,18)	87.1 (3.0, 4)	23
Totals	1	20	13	34

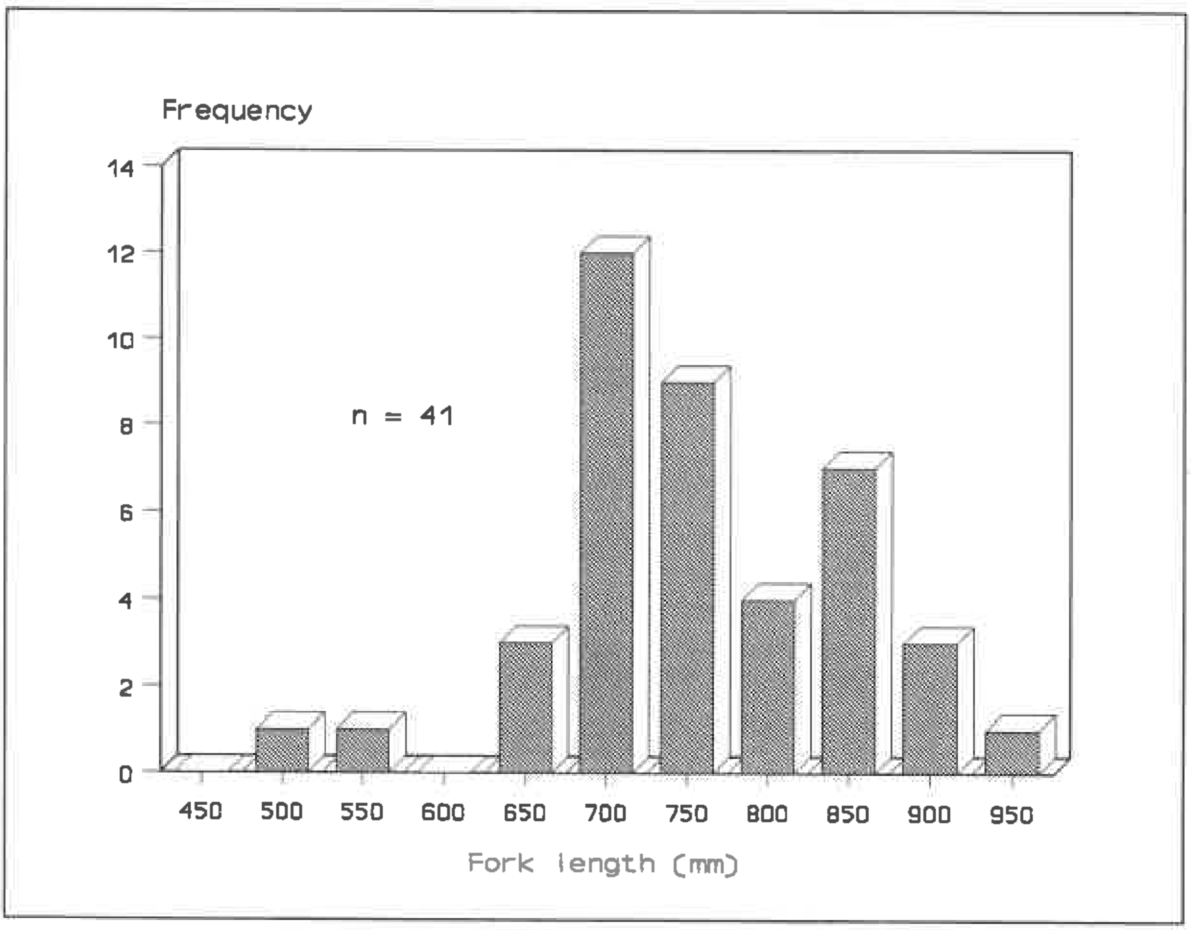

Figure 13. Length frequency distribution of wild spring chinook salmon adults sampled at Tucannon Fish Hatchery in 1991.

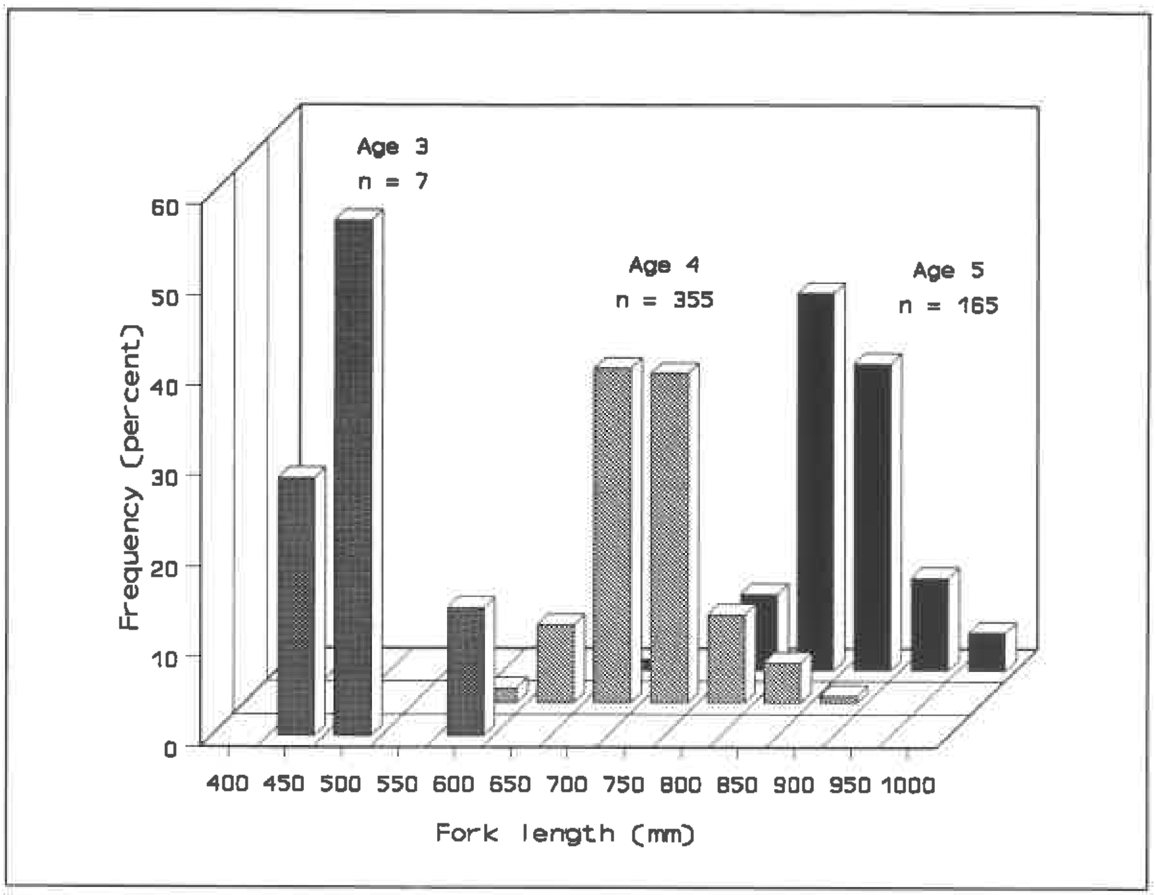

Figure 14. Fitted length-at-age data for all wild spring chinook salmon sampled from the Tucannon River, 1985-1991.

<u>Hatchery-origin salmon</u> Sex ratio of hatchery-origin salmon in the Tucannon River in 1991 was 0.47 females per male; this includes all age classes. Based upon CWT analyses, 45.5% of the salmon recovered in 1991 were age $3/_2$, 51.1% were age $4/_2$, and 3.4% were age $5/_2$ (Table 18, Figure 15). Cumulative age structure for hatchery salmon is 49.3% age $3/_2$, 49.6% age $4/_2$, and 1.1% age $5/_2$. Fitted length-at-age data for all hatchery salmon sampled since 1985 is presented in Figure 16. Returns of age 5 fish are limited to the 1991 return year (1985 and 1986 broods), therefore the cumulative age structure is not comparable to cumulative returns of wild salmon. Figure 17 shows the age structure of 1991 hatchery returns to cumulative wild returns (1985-1991).

Table 18. Sex, mean fork length (cm), and age (from code-wire tags) of hatchery-origin spring chinook salmon sampled at Tucannon Fish Hatchery, 1991 (s=standard deviation, n=sample size).

Sex	Mean length (s, n) at given age			Totals
	$3/_2$	$4/_2$	$5/_2$	
Female	- -	67.3 (4.3, 25)	80.7 (2.9, 3)	28
Male	48.7 (3.4, 36)	66.0 (4.7, 20)	- -	56
Totals	36	45	3	84

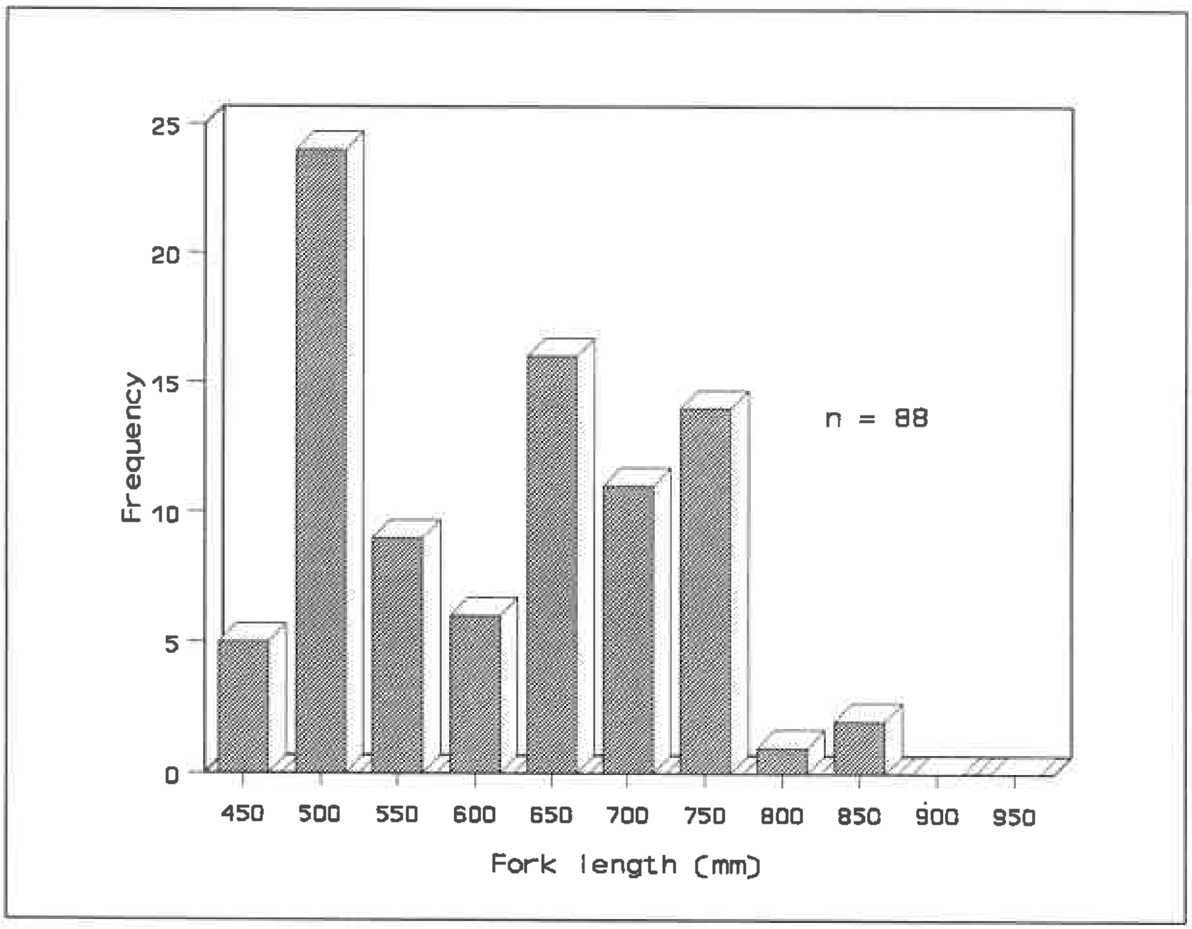

Figure 15. Length frequency distribution of hatchery spring chinook salmon sampled at Tucannon Fish Hatchery in 1991.

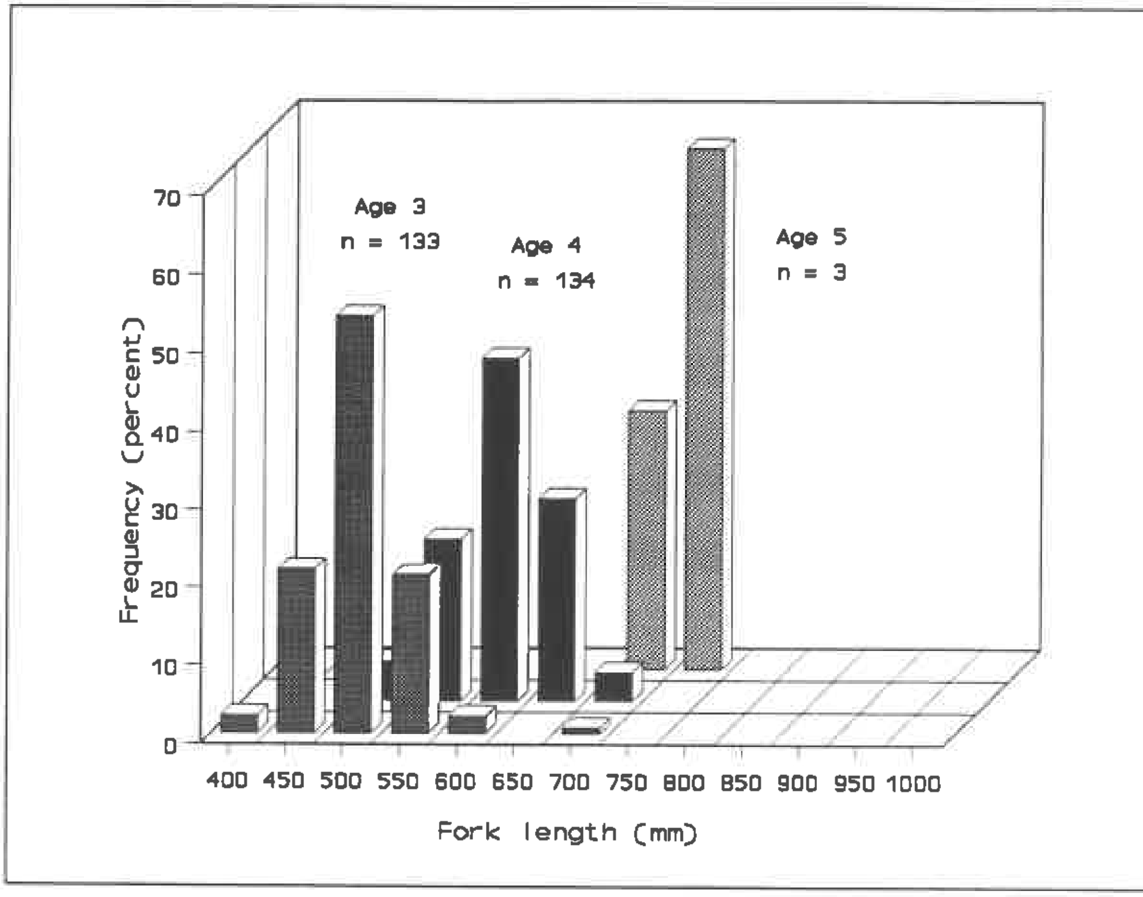

Figure 16. Fitted length-at-age data for all hatchery spring chinook salmon sampled from the Tucannon River, 1988-1991.

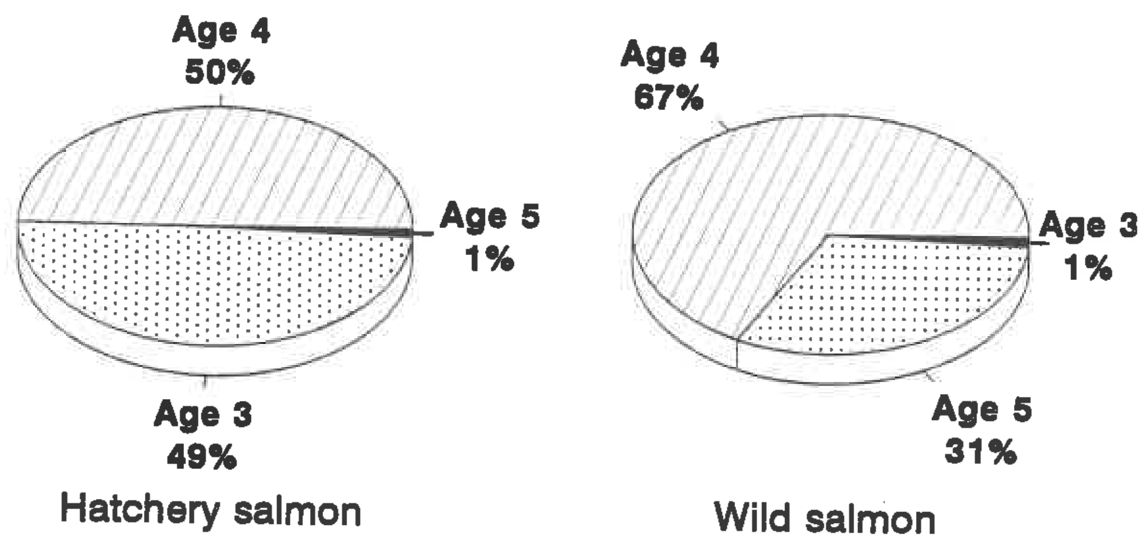

Figure 17. Age structure of wild (combined 1985-1991, n = 527) and hatchery (1991 only, n=89) salmon collected for broodstock.

4.2: Electrophoretic Analysis

In 1991, evaluation program staff collected 100 electrophoretic samples, each from 1990 brood hatchery chinook prior to release and wild fish collected at our smolt trap. We also collected samples from 53 wild-origin (13 from spawning surveys and 40 from broodstock collection) and 50 hatchery-origin adult spring chinook. We will present electrophoresis results in subsequent reports.

4.3: Morphometric Analysis

4.3.1: Adult morphometry

Our objective in using adult morphology is to compare phenotypic response of sexually mature salmon to lack of competition for spawning sites, as would be manifested by holding fish in a hatchery (Fleming and Gross 1989). The null hypothesis tested was: there is no difference in body morphometry of adults of common parentage reared in the Tucannon River or the hatchery. Analysis of these data set is preliminary, and will provide the baseline for future comparisons.

We measured body morphometry on wild and hatchery origin salmon during spawning at Tucannon FH. Data were collected in 1989 (64 wild and 73 hatchery salmon measured), in 1990 (45 wild and 52 hatchery salmon measured), and in 1991 (40 wild and 57 hatchery salmon measured). Twelve morphological characters on sexually mature adults (Figure 18) were measured with Vernier calipers to the nearest 0.05 mm, except for body (postorbital-hypural) length, fork length, and body depth, which were measured to the nearest 1 mm (Van den Berghe and Gross 1989). Any damaged characters were not measured, and adipose fin length was not measured on hatchery fish.

For both adult and juvenile body morphology (Section 4.3.2), we compared composite fish measurements using univariate (ANOVA) and multivariate (MANOVA) analyses of variance. Classifications were based upon canonical discriminant function analysis (CANDISC; SAS 1988). We made cross validation tests based upon classifications derived through CANDISC. The data appeared to meet the assumptions for parametric analyses; no transformations were required.

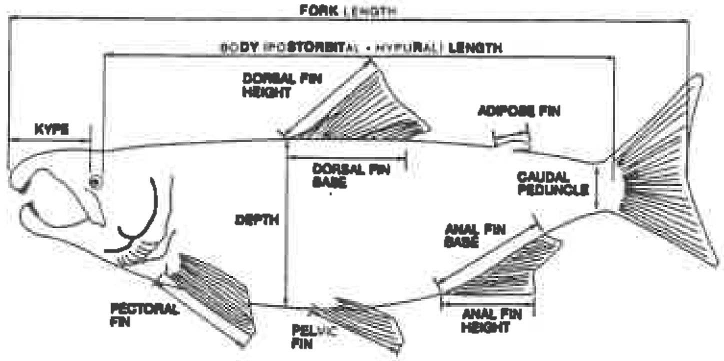

Figure 18. Morphological characters measured on sexually mature salmon at Tucannon FH (from Fleming and Gross 1989).

Based upon cross validation of the combined 1989, 1990, and 1991 data sets, 23.6% of females were incorrectly classified by origin (28.2% wild, 19.1% hatchery), and 21.3% of males were incorrectly classified (15.8% wild, 26.8% hatchery; Table 19). For both sexes, the multivariate analysis of variance indicated a high level of separation by origin (Wilk's lambda $p<0.0001$). All the variability was accounted for in the first standardized canonical coefficient (Appendix J, Table 1). Coefficients for both sexes were weighted heavily in length of the anal fin base.

Table 19. Cross validation summary using quadratic discriminant function of Tucannon spring chinook salmon adult body morphometry. Classification is based upon origin (hatchery and wild) for females and males returning in 1989, 1990, and 1991.

Sex Cross validation	Number (and percent) classified Wild origin	 Hatchery origin	 Total
Female			
Wild origin	79 (71.8)	31 (28.2)	110 (100.0)
Hatchery origin	13 (19.1)	55 (80.9)	68 (100.0)
Totals	92 (51.7)	86 (48.3)	178 (100.0)
Male			
Wild origin	85 (84.2)	16 (15.8)	101 (100.0)
Hatchery origin	11 (26.8)	30 (73.2)	41 (100.0)
Totals	92 (67.6)	46 (32.4)	142 (100.0)

The high level of misclassification for both sexes by origin indicates no strong difference in overall body shape between hatchery and wild-origin salmon. This test was based upon data from the three return years combined; we found similar results in comparisons on the individual return years. The multivariate analysis however, indicated a difference based upon origin, but it is probable the results of this test are of no biological significance (Rexstad et al. 1988).

4.3.2: Juvenile morphometry

In 1987, program staff began a baseline analysis of morphometric variation among stocks and origins (natural or hatchery) within a stock following methods of Riddell and Leggett (1981) and Taylor (1986). On an annual basis, we measured about 100 each of hatchery reared and either wild or natural salmon juveniles (Table 20). Salmon in the river were collected during electrofishing surveys and downstream migrant trap operations. Four null hypotheses were tested, and are discussed separately below.

Table 20. Origins, brood years, months and numbers collected, and mean fork lengths (mm) with standard deviations for juvenile Tucannon spring chinook salmon sampled for morphological studies.

Origin	Brood year	Month collected	Sample size	Mean length (cm)	Standard deviation
Wild	1985	August	128	55.6	10.5
	1986	August	66	62.6	10.6
	1987	August	58	60.9	10.6
	1988	March	31	77.8	9.8
		April	33	85.7	6.3
		July	13	50.9	2.5
		August	23	58.4	7.3
	1989	April	97	93.0	9.8
Hatchery	1986	August	99	80.4	14.7
	1987	July	100	97.4	8.7
	1988	February	76	128.7	17.4
		November	24	118.7	12.3
	1989	March	50	139.8	22.0
		April	47	129.5	15.9

Fish were immediately frozen and retained for measurement at a convenient date, or fish were measured while fresh. We thawed individual specimens to room temperature when frozen, and gently teased the fins into extended position on a 10 cm x 15 cm card. We marked 15 selected fin and body locations of the fish (Figure

19) onto cards with pins; this method was based upon techniques of Winans (1984). We recorded fork length (mm) and origin (wild or hatchery) for each fish. Euclidean distances between each of the 15 points on the cards (32 distances total) were determined using a digitizer. Composite measurements of individual fish were then used for morphologic analysis. Statistical analysis methods were previously described (Section 4.3.1)

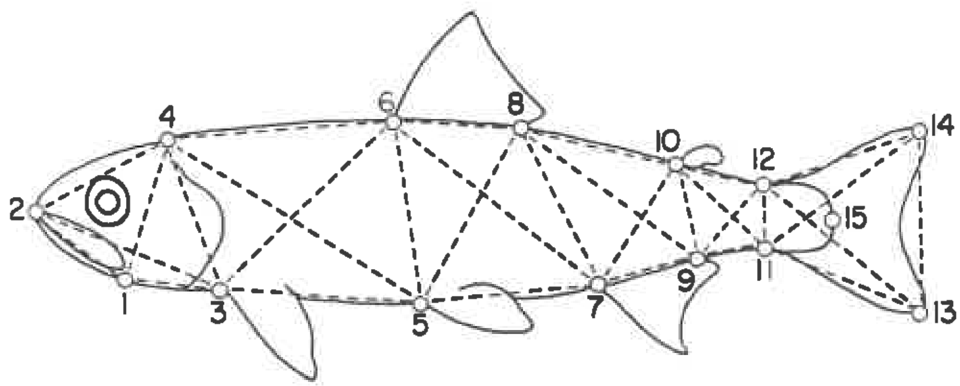

Figure 19. Locations of 15 landmarks used to calculate truss network (broken lines) for morphometric comparisons in juveniles. The landmarks are described in detail in Winans (1984) and Swain et al. (1991).

Null hypotheses

1) Ho: There is no difference in month of collection on juvenile truss body morphometry.

We attempted to standardize our technique for sampling and measuring of juveniles. Juveniles were collected at various times of the year however, because of some logistical constraints. Body morphometry changes throughout the freshwater stage because of several factors, mostly related to smoltification (Gorbman et al. 1982). A preliminary test was to examine differences between months of collection.

We tested four months of collection for one brood year (1988)-- March, April, July, and August, and found an overall difference among month of collection (Wilk's lambda $p<0.0001$). The first two standard canonical coefficients, which accounted for 56% and 36% of the variability, were weighted primarily in anterior truss measurements (example: head-pelvic fin, dorsal fin-pectoral fin; Appendix J, Table 2). A plot of the first two canonical coefficients (Figure 20) shows classification between spring months versus summer months on the primary axis, and a strong separation between July and August on the second axis.

2) Ho: There is no difference in truss body morphometry between the 1989 brood, hatchery-reared juveniles and the 1988 brood year of the same rearing location.

3) Ho: There is no difference in truss body morphometry between the 1989 brood, river-reared juveniles and the 1988 brood year of the same rearing location.

In 1989, hatchery-origin adults returned to the river and mated with wild (or other hatchery) salmon: the fish used for this analysis are the progeny of this pedigree. The 1988 brood were progeny of wild x wild matings only. The two hypotheses are complementary: the first one tests for an assumed mating of hatchery x wild fish in the river, while the second one tests for known (controlled) wild x hatchery matings in the hatchery.

In the hatchery analysis (second null hypothesis), most samples of the 1988 brood were collected in February, with some collected in November; samples of the 1989 brood were collected equally in March and April (Table 20). Differences were detected between the 1988 brood (with wild parents only) and the 1989 brood (with wild and hatchery parentage; Wilk's lambda $p<0.0001$). One standardized canonical coefficient explained the variability; most differences appeared to be related to relative lengths of the caudal peduncle and posterior/ventral areas (Appendix J, Table 3).

In the natural production analysis (third null hypothesis), samples were taken equally in March and April. One standardized canonical coefficient explained the variability, based on a difference between brood years (Wilk's lambda $p<0.0001$). As in the analysis of salmon reared in the hatchery, most differences were related to relative lengths of posterior/ ventral areas (Appendix J, Table 4).

The most consistent classification based upon first three morphometric analyses was related to time of collection. Our analysis indicated significant changes in body form among classes, which are probably associated with parr-smolt transformation. These results are similar to those of Winans and Nishioka (1987), who found different growth rates of the ventral portion of the caudal peduncle relative to body length to be a consistent indicator of parr-smolt transformation. Based upon class separation by canonical coefficients, most changes occurred in that body area, regardless of brood year or origin. Gill ATP-ase activity (a physiological indicator of parr-smolt transformation) of 1987 brood salmon showed little change from January to April (Bugert et al. 1990). The multivariate analysis of body morphology however, indicated a strong separation between March and April.

Discrimination between the 1988 and 1989 brood years (and therefore parentage), are most likely confounded by time of collection. We omitted the 1984-1987 brood from this analysis because samples were taken primarily as summer subyearlings; the 1988 and 1989 broods were taken as yearlings and therefore were most comparable.

4) Ho: There is no difference in truss body morphometry between juveniles of common parentage reared at Tucannon Fish Hatchery versus those reared in the river.

The basic tenet to this hypothesis is that environmental factors, rather than genetic, may cause differences in body shape. Separate analyses were performed on each of the 1986 through 1988 broods. Samples of river-reared and hatchery-reared juveniles were taken at roughly the same period within each brood year (Table 20).

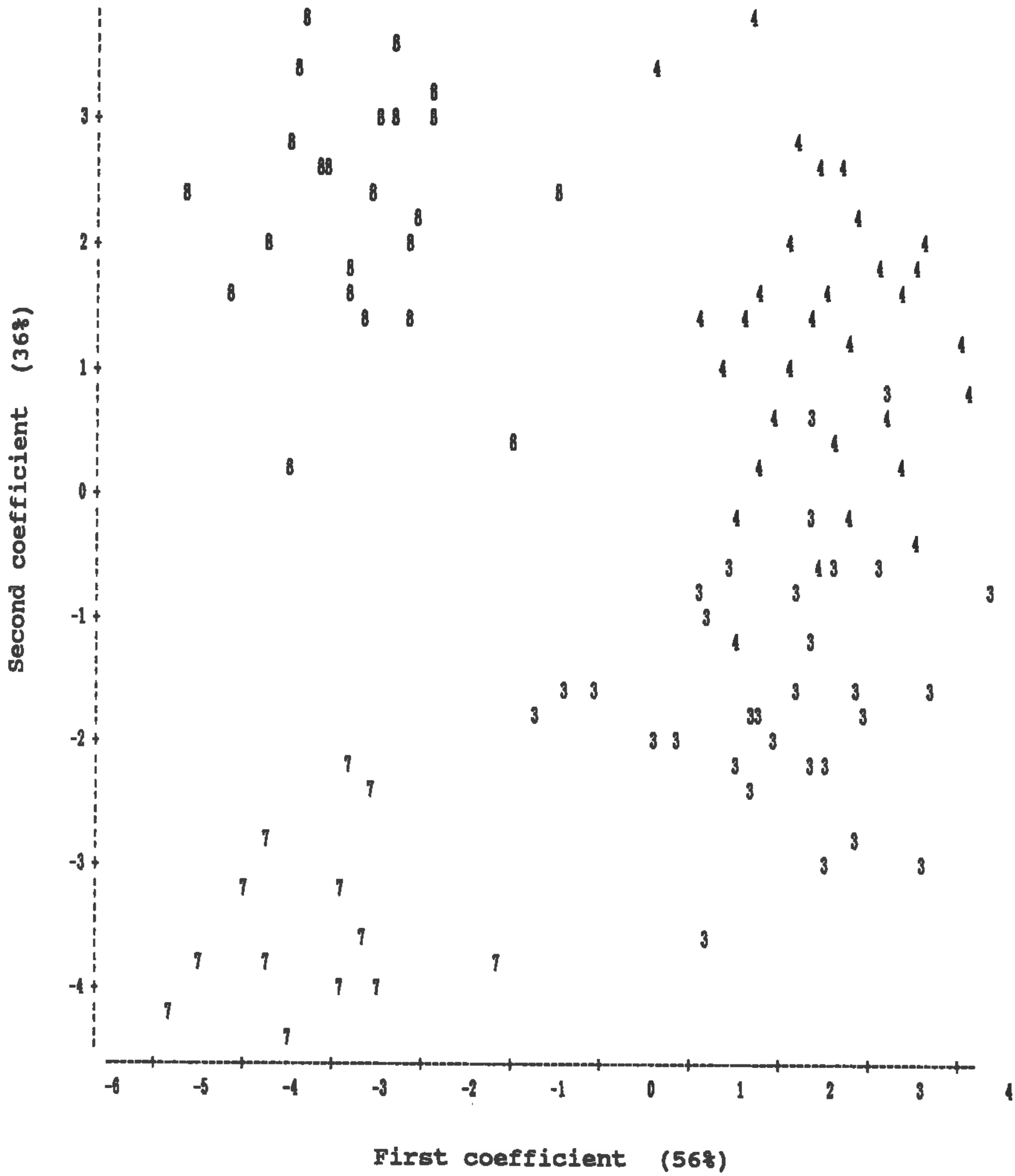

Figure 20. Plot of first two standardized canonical coefficients for 1988 brood wild-origin Tucannon spring chinook salmon collected in March (3), April (4), July (7), August (8).

Differences were detected between river-reared and hatchery-reared juveniles within each brood year (Wilk's lambda $p<0.0001$). For each analysis, one standardized canonical coefficient accounted for the variability (Appendix J, Table 5). We saw no general trends in relative weights of coefficients for each year. These results are consistent with those found in our previous analysis (FY 1987 report).

Adults taken for broodstock in 1986 though 1988 were a random collection from a wild population; any differences in body shape between hatchery and river-reared progeny would be a result of different incubation and rearing environments. The obvious difference between salmon reared in the hatchery and in the river is in overall body size. At time of sampling, average fork lengths of hatchery-reared salmon were 47% larger than fish reared in the river (Table 20). This size disparity however, did not appear to affect relative changes in body morphometry. Swain et al. (1991) suggest differences in relative sizes of body depth and median fin size may occur in response to higher growth rates in hatchery versus river environments. We saw no strong trends in this direction.

4.4: Meristic Analysis

The objective of this study is to measure phenotypic similarity of the right and left sides of individual fish as an index of developmental stability. We made bilateral meristic counts for 1986 through 1989 brood years on Tucannon wild juvenile salmon. We also made meristic counts for 1986 through 1989 brood years on hatchery juveniles to compare with wild juveniles.

Methods used for the meristic counts are similar to those used by Leary et al. (1985). We counted the number of rakers on the upper and lower gill arches from the right and left sides, and the number 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 (brood year and origin). 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.

Analysis of juvenile meristic data was not completed at the time of publication; results will be presented in subsequent reports.

<u>Otoliths</u> We retained otoliths on 41 wild and 72 hatchery-origin adults as a possible supplement in stock identification (Neilson et al. 1985). No analysis has been made on these samples.

SECTION 5: RECOMMENDATIONS

We provide seven recommendations to improve performance of the Tucannon salmon program. Some recommendations provided in the FY 1990 report will be implemented in 1992 also.

1) The irrigation dam on the Tucannon River near Starbuck may hinder migration of spring chinook salmon. Modification of this dam is desired to improve passage.

2) Impacts of stray spring chinook salmon on the genetic integrity of the Tucannon stock need to be reduced. Coded-wire tags of marked fish should be read prior to spawning of adults. This method ensures only the culling of marked strays, however, and only allows culling from adults collected for broodstock. There is an acute need for a benign mark on all salmon released from Columbia River hatcheries.

The concerns stated in items 1 and 2 can be partially rectified by construction of an upstream migrant trap and fishway at Starbuck Dam. Stray salmon with external marks could then be removed from the spawning grounds and hatchery broodstock. This trap site may also enable us to accurately enumerate adult spring chinook salmon escapement into the Tucannon River and possibly implement a radio telemetry study of adult salmon within the marginal habitat of the lower and middle Tucannon River.

3) Broodstock should be transferred from the Tucannon FH holding pond to Lyons Ferry FH daily to reduce pre-spawning mortality. This action reduces holding water temperature, and also eliminates the need to hold and transfer unfertilized gametes.

4) The incubation water chiller installed at Lyons Ferry FH in October 1991 has provided several benefits: more uniform time period for ponding fry from multiple eggtakes, capability for higher feed ration, and potential for reduced pond loadings at acclimation. Increased water chiller capacity may be required in the future to supplement the current chiller which lowers 40 gpm from 11.5^{o}C to 6.7^{o}C. We may need the capability to incubate separate eggtakes in staggered water temperatures, and achieve a minimum water temperature of 3.5^{o}C.

5) Organic solids from the earthen pond at Tucannon FH settle in the adult trap and are also flushed downstream. We believe this may have adverse affects upon fish health, water quality, and trap capability. Slow drawdown of the pond may substantially reduce the quantity of solids transported downstream until a settling pond (or other means) is constructed.

6) We are concerned about the apparent decrease of spawning escapement into the Wilderness Stratum, and the increase of spawning below the hatchery rack. We recommend consideration of the following:

1) transporting salmon smolts to the Wilderness Stratum for direct release, or implementation of a hatchery egg box program for the wilderness area in 1993 (or site and construct an acclimation pond for the future releases);
2) experimentally manipulating the source and quantity of attraction water at the trap in an attempt to improve trapping/passage efficiency; and
3) that a radio telemetry study, and spawning survey comparisons, be conducted to determine whether adult salmon passage is being hindered by the hatchery rack and to determine adult salmon behavior in the lower river.

7) We have identified high water temperatures and other habitat issues as potential problems for both juvenile salmon rearing and adult salmon holding in the river below the HMA Stratum. Poaching has been an apparent problem for several years, as indicated by our radio telemetry. Therefore, we recommend the following:

1) Habitat improvement projects to increase stream canopy and stabilize banks (such as planting cottonwoods and other native species or riparian fencing).
2) Construction of log weirs to create holding habitat for migrating adults.
3) Increase enforcement and awareness (educational programs and signs) of salmon problems on the Tucannon River.

REFERENCES

Bugert, R., P. LaRiviere, D. Marbach, S. Martin, L. Ross, and D. Geist. 1990. Lower Snake River Compensation Plan Lyons Ferry Evaluation Program 1989 Annual Report to U.S. Fish and Wildlife Service, AFF 1/LSR-90-08, Cooperative Agreement 14-16-0001-89525. Washington Department of Fisheries, Olympia, Washington.

Bugert, R.,and P.Seidel. 1988. Production and survival of juvenile spring chinook salmon in a southeast Washington stream. Pages 156- 164 in B.G. Sheperd (editor), Proceedings of the Chinook/Coho Workshop, North Pacific International Chapter, American Fisheries Society.

Bugert, R., P. Seidel, P. LaRiviere, D. Marbach, S. Martin, and L. Ross. 1989. Lower Snake River Compensation Plan Lyons Ferry Evaluation Program 1988 Annual Report to U.S. Fish and Wildlife Service, AFF 1/LSR-89-10, Cooperative Agreement 14-16-0001-88519. Washington Department of Fisheries, Olympia, Washington.

Bugert, R., P. Seidel, P. LaRiviere, D. Marbach, S. Martin, and L. Ross. 1988. Lower Snake River Compensation Plan Lyons Ferry Evaluation Program 1987 Annual Report to U.S. Fish and Wildlife Service, AFF I/LSR-88-12, Cooperative Agreement 14-16-0001-87512. Washington Department of Fisheries, Olympia, Washington.

Emlen, J.T. 1971. Population densities of birds derived from transect counts. The Auk 88:323-342.

Fleming, I.A., and M.R. Gross. 1989. Evolution of adult female life history and morphology in a Pacific salmon (coho: Oncorhynchus kisutch). Evolution: 43(1):141-157.

Gorbman, A., W.W. Dickhoff, J.L. Mighell, J.L. Prentice, and F.W. Waknitz. 1982. Morphological indices of developmental progress in the parr-smolt coho salmon Oncorhynchus kisutch.Aquaculture, 28:1-19.

Hallock, D., and G. Mendel. 1985. Instream habitat improvement in southeastern Washington, 1984 Annual Report (Phase III), to U.S. Army Engineer District, Walla Walla, WA and U.S. Fish and Wildlife Service, Portland OR.

Helm, W. T. (ed.) 1985. Glossary of stream habitat terms. Habitat Inventory Committee, Western Division, American Fisheries Society, Department of Fisheries and Wildlife, Utah State University, Logan, Utah.

Leary, R.F., F.W. Allendorf, and K.L. Knudsen. 1985. Developmental instability as an indicator of reduced genetic variation in hatchery trout. Transactions of the American Fisheries Society 114:230-235.

Mendel, G., K. Petersen, B. Bugert, L.Ross, J. Dedloff, D. Milks, and L. LaVoy. 1992. Lyons Ferry Fall Chinook Salmon Hatchery Evaluation Program, 1991 Annual Report (In progress) to U.S. Fish and Wildlife Service, Cooperative Agreement 14-16-0001-91534. Washington Department of Fisheries, Olympia, Washington.

Neilson, J. D., G. H. Geen, and B. Chan. 1985 Variability in dimensions of salmonid otolith nuclei: implications for stock identification and microstructure interpretation. Fishery Bulletin 83(1):81-89.

Platts,W. S.,W. F. Megahan, and G.W. Minshal. 1983. Methods for evaluating stream, riparian, and biotic conditions. General Technical Report INT-138. U.S. Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Rexstad, E.A., D.D. Miller, C.H. Flather, E.M. Anderson, J.W. Hump, and D.R. Anderson. 1988. Questionable multivariate statistical inference in wildlife habitat and community studies. Journal of Wildlife Management 52:794-798.

Riddell, B.E., and W.C. Leggett. 1981. Evidence of an adaptive basis for geographic variation in body morphology and time of downstream migration of juvenile Atlantic salmon (Salmo salar). Canadian Journal of Fisheries and Aquatic Science. 38:308-320.

SAS Institute. 1988. SAS/STAT user's guide, release 6.03 edition. SAS Institute, Cary, North Carolina.

Swain, D.P., B.E. Riddell, and C.B. Murray. 1991. Morphological differences between hatchery and wild populations of coho salmon (Oncorhynchus kisutch): environmental versus genetic origin. Canadian Journal of Fisheries and Aquatic Science 48:1783-1791.

Taylor, E.B. 1986. Differences in morphology between wild and hatchery populations of juvenile coho salmon. The Progressive Fish Culturist 48:171-176.

USACE (U.S. Army Corps of Engineers), 1975. Special Report: Lower Snake River Fish and Wildlife Compensation Plan. Walla Walla, Washington.

Van den Berghe, E.P., and M.R. Gross. 1989. Natural selection resulting from female breeding competition in a Pacific salmon (Coho: Oncorhynchus kisutch). Evolution 43(1): 125-140.

WDF (Washington Department of Fisheries) 1990. Lower Snake River Compensation Plan, Snake River Hatchery Evaluation Program Five-Year Plan 1991- 1995. Washington Department of Fisheries, Olympia, Washington.

Wheeler, P.A., and G.H. Thorgaard. 1991. Cryopreservation of rainbow trout semen in large straws. Aquaculture 93:95-100.

Winans, G.A., and R.S. Nishioka. 1987. A multivariate description of change in body shape of coho salmon Oncorhynchus kisutch during smoltification. Aquaculture, 66:235-245.

Winans, G.A. 1984. Multivariate morphometric variability in Pacific salmon: technical demonstration. Canadian Journal of Fisheries and Aquatic Science 41:1150-1159.

Withler, R.E. 1988. Genetic consequences of fertilizing chinook salmon (Oncorhynchus tshawytscha) eggs with pooled milt. Aquaculture 68:15-25.

APPENDIX A

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

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

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

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

4) **Document downstream 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 developed. These data include qualitative loci analysis through electrophoresis, and quantitative analysis of such factors as meristics, adult and juvenile body morphometry, adult size, run timing, and disease susceptibility.

6) **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 sufficient 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

Contribution of 1986-1988 broods Tucannon spring chinook salmon to various fisheries and returns to the hatchery rack. Returns for 1991 fisheries were not available at time of printing and will be updated in the 1992 annual report.

Table 1. Recoveries of 1985 brood spring chinook salmon released from Tucannon Fish Hatchery 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.

Year Recovery location and agency	Observed recoveries	Estimated recoveries
1988		
Tucannon FH, WDF	9	9
1989		
Test Fishery Net - ODFW	1	1
Tucannon FH, WDF	23	23
Totals for tagcode 633442:	33	33

Table 2. Recoveries of 1986 brood spring chinook salmon released from Tucannon Fish Hatchery 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.

Year Recovery location and agency	Observed recoveries	Estimated recoveries
1989		
Tucannon FH, WDF	20	20
1990		
Test fishery net, ODFW	1	1
Treaty ceremonial, ODFW	1	2
Tucannon FH, WDF	19	19
1991		
Tucannon FH, WDF	1	1
Spawning Grounds, WDF	2	2
Totals for tagcode 634146:	44	45

Appendix B, continued.

Table 3. Recoveries of 1986 brood spring chinook salmon released from Tucannon Fish Hatchery 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	Estimated recoveries
1989		
Spawning Grounds, WDF	1	1
Tucannon FH, WDF	33	33
1990		
Treaty ceremonial, ODFW	1	2
Ocean Troll (Non-treaty), CDFO	1	4
Tucannon FH, WDF	15	15
1991		
Tucannon FH, WDF	2	2
Spawning Grounds, WDF	2	2
Totals for tagcode 634148:	55	59

Table 4. Recoveries of 1986 brood spring chinook salmon released from Tucannon Fish Hatchery 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	Estimated recoveries
1989		
Treaty Troll, WDF	1	2
Tucannon FH, WDF	21	21
1990		
Tucannon FH, WDF	22	22
1991		
Tucannon FH, WDF	1	1
Totals for tagcode 633325:	45	46

Appendix B, continued.

Table 5. Recoveries of 1987 brood spring chinook salmon released from Tucannon Fish Hatchery 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	Estimated recoveries
1990		
Tucannon FH, WDF	5	5
1991		
Tucannon FH, WDF	45	45
Spawning Grounds, WDF	19	19
Totals for tagcode 634950:	69	69

Table 6. Recoveries of 1988 brood spring chinook salmon released from Tucannon Fish Hatchery 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	Estimated recoveries
1991		
Tucannon FH, WDF	45	45
Spawning Grounds, WDF	19	19
Totals for tagcode 630142:	69	69

Table 7. Recoveries of 1988 brood spring chinook salmon released from Tucannon Fish Hatchery from 3 March to 10 April 1990. Tagcode was 635501. Mark rate was 95.80% (68,591 out of 69,656 total released). Size of fish at release was 11 fpp.

Year Recovery location and agency	Observed recoveries	Estimated recoveries
1991		
Tucannon FH, WDF	12	12
Totals for tagcode 635501:	12	12

APPENDIX C

Tucannon River spring chinook salmon semen cryoperservation summary and techniques.

Table 1. Wild Tucannon spring chinook salmon semen evaluation and cryogenics, 1991.

Date frozen	Fork length (cm)	Brood year [a]	Sperm motility (%) [b]	Number frozen WDF	Number frozen WSU
Sep 18	64	1987	OK	4	0
Sep 18	65	1987	90	5	2
Sep 18	66	1987	OK	10	2
Sep 18	70	1987	90	4	2
Sep 18	70	1987	90	10	2
Sep 18	70	1987	90	10	0
Sep 18	72	1987	90	12	2
Sep 18	72	1987	90	7	3
Sep 18	73	1987	90	14	3
Sep 18	85	1986	OK	7	2
Sep 18	92	1986	OK	4	0
Sep 18	87	1986	90	0	5
Sep 18	77	1987	80	0	0
Sep 18	73	1987	90	0	0

[a] Fitted by fork length based on scale analysis.

[b] Motility rating of OK implies motility greater than 60%.

Appendix C, continued.

SEMEN CRYOPRESERVATION TECHNIQUES COOKBOOK (modified from Wheeler and Thorgaard, 1991).

Materials

Semen collection: Whirl packs, paper towels, a bottle of oxygen (this can be small because you just want to fill the bags before storing the semen), a cooler, wet ice, newspaper (to put between the ice and semen), and permanent marker to number bags.

Motility testing: A microscope with 100x power (10x ocular and 10x objective will do), non-coated slides, non-heparinized capillary tubes, kimwipes (for cleaning the slides and objectives), NaCl powder, distilled water, scale (measures to 0.1 g), graduated cylinder (100 ml), and a 100 ml glass jar.

Freezing: Dextrose powder, Dimethyl Sulfoxide (DMSO) liquid, distilled water, fresh hens egg yolk, 100 ml cylinder, 1 L glass bottle for storage, scale (measures to 0.1 g), 10 ml pipettes (10 in 1/10 ml, with plug, disposable polystyrene, sterile), pipette pump, parafilm wax (it comes in a roll the thickness of paper), disposable test tubes (we use falcon 2057 type, 17 x 100 mm, clear with cap. Note: although you will only put 4 ml in each test tube, you need a larger tube so when you draw the extender through the straw, you won't get bubbles in the extender). You will also need a test tube rack, 5 ml syringe, 3 inches of surgical tubing (take your straw and syringe to the store for sizing the tubing), 7 3/4 inch long clear plastic drinking straws (This is the normal size you get with your drinks at restaurants. You can purchase these from a restaurant supply store), colored tape for straw identification, impulse sealer (8" 110 v, part no. 92987RX, approx $95 in 1991, from Consolidated Plastics Company, Inc. in Twinsburg, Ohio at 1-800-362-1000), dry ice, cooler, liquid nitrogen tank [MVE, Minnesota Valley Engineering Inc. (Manufacturer), Model XC34/18, approx $616 in 1991, from Polar Cryogenics in Portland, Ore at (503)239-5252]. Note* this semen tank has 6 canisters, each will hold approx 45 of the straws you will use, thus 270 straw capacity. You can get your liquid nitrogen delivered by any of the breeders services like ABS or Select Sires. Don't forget data sheets, a pencil, and permanent marker! (Most of the items listed can be purchased through VWR Scientific Supply (206)575-1500).

Thawing and activating: NaCl, Tris Base Buffer(VWR catalog JTX171-5, or Sigma catalog T-1503), Glycine, Theophylline, distilled or hatchery water, cooler for water bath, crushed ice, thermometer (oC), timer (seconds), scissors, paper towels, graduated cylinder (100 ml), and a dish or bucket in which to fertilize your eggs.

Freezing procedures

Collection of semen: Wipe exterior of each male dry. Make sure the sample is free of feces or blood. The best sample will be thick and white. Milk male into whirl pack bag. Try to get at least 4 ml from each male, if you are planning on a one-to-one cross. A 1 ml semen sample will fertilize approximately 1,000 eggs. Try to get a little more than you expect to use (you need 1 ml per straw, get 1 1/4 because some will be left on the bag). Fill bag with oxygen, seal, and place in cooler with paper or burlap between the bag and ice. Semen can be stored in a refrigerator up to one week, but it is advised that you freeze it as soon as possible to maintain the quality. If you decide to keep the fresh semen in the refrigerator, be sure to mix the sample before measuring it for freezing (sometimes the sperm and seminal fluids separate).

Making cryoextender: Mix extender fresh each day. Make sure the egg you use is fresh. This recipe will yield 100 ml of cryoextender, enough to freeze about 33 straws (3 ml extender to 1 ml semen per straw). Measure 100 ml of distilled water in a glass bottle and mark the bottle at the top of the liquid with a permanent marker. Now empty the bottle and start making the recipe. Add 40 ml distilled water, 5.4 g dextrose. To mix, take a piece of parafilm and stretch over the bottle and turn upside down with your hand over the end. If the dextrose doesn't dissolve, place the jar in a hot water bath until dissolved. Add 9 ml DMSO using a pipette and pipette pump to the mixture, mix. (Note: DMSO freezes at temperatures less than 18oC, if this happens just set it in a hot water bath). Separate the yolk from the albumen and place in a separate dish, stir yolk. Using the same pipette, draw up 10 ml yolk and add to bottle, mix (one egg yields approximately 10 ml of yolk). Add the remainder of water necessary to fill the bottle to the 100 ml mark. This mixture can be refrigerated and kept several days. This mixture should be kept cool during the semen freezing procedure.

Saline solution for motility testing: Mix 0.9 g NaCl with enough distilled water to equal 100 ml. This mixture can be kept for a long period of time in the refrigerator.

Motility testing: Motility of semen should be tested prior to freezing. Use a microscope with 100x magnification. Clean a slide with kimwipes and place on microscope. Using non-heparinized capillary tubes, place a small drop of the saline solution on the slide. Use another capillary tube to place a small smear of semen on the saline. Look at the mixture immediately observe overall movement to determine motility. If there is greater than 60% motility, the semen can be frozen.

Appendix C, continued.

Set up for cryogenics: Place test tubes with their caps removed in a test tube rack in groups of five or ten for easy counting. Label straws with colored tape for quick I.D. and code each for individual male I.D. Attach 3 inches of surgical tubing to a 5 ml syringe with parafilm wax. Slide straw (labeled) into the open end of the surgical tubing and set aside. Plug in impulse sealer and set it at temperature setting 5. Test the sealer out before actually using it (the sealer should shut off before the straw burns through). Attach the pipette pump to a pipette and set aside. Have approximately 10 lbs of unwrapped dry ice in a cooler ready for use.

Cryopreservation techniques:

Note: One part sperm (1 ml) to three parts (3 ml) extender per straw. One straw will fertilize approximately 1,000 eggs. Try to get at least four straws per male.

1) Measure 3 ml of the cryoextender with a pipette and pump, place into a vial. Several (5) vials with just the extender can be set up in advance.
2) Measure 1 ml semen with another pipette (one pipette per male) and pump, and place in the vial. Put the pipette back in the same bag until next usage. (Note: Five vials may be mixed at a time if you work quickly. If you are not experienced in this procedure mix one vial at a time).
3) Cap the vial and mix the two liquids carefully to avoid bubbles.
4) Pull up into the straw 4 ml of the mixture from the vial (1 ml semen, 3 ml extender). Leave a space at the bottom and top of the straw.
5) Seal one end of the straw with the impulse sealer, then the other, leaving an air bubble on the end with the tape.
6) Immediately put the straw on dry ice.
7) After approximately 2 or 3 minutes when the straw is frozen, put it in a liquid nitrogen tank for final storage. Place the tape side up in the canister. (Note: The shorter the time between addition of the cryoextender and the time it is frozen the better!)

Appendix C, continued.

Thawing and activating cryopreserved semen

Mixing of activator: Activator can be prepared and stored in the refrigerator for long periods of time. If the mixture gets cloudy, discard it. Thus, prepare one or two liters worth and save it. This recipe yields one liter of activator. Approximately 100 ml will be used with 1000 eggs, or just enough to cover the eggs. Measure a liters worth of distilled or non-chlorinated water into a bottle and mark the level. Pour part of the water out and add the following: 9 g NaCl, 1.21 g Tris Base Buffer, 1.5 g Glycine, 0.9 g Theophylline. Fill the bottle with more water to the one liter mark, mix, and refrigerate.

Thawing and activating procedure:

1) Prepare a $5^{o}C$ water bath.
2) Place a straw in the water bath for 90 seconds. Remove ice build up on the straw once (this happens almost immediately when it touches the bath).
3) After 90 seconds dry the straw and cut it open. Add the straw contents directly to the eggs (the mixture should be slushy/chunky).
4) Add activator (approximately 100 ml/1,000 eggs) to the eggs, mix, and let sit for about 2 minutes. There should be just enough activator to cover the eggs, adjust as necessary.
5) Rinse eggs two more times in non-chlorinated water before placing in incubation tray.

APPENDIX D

Summary of spring chinook salmon yearling releases for the Tucannon River, 1985-1991 brood years.

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	1,328		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	41	49	3/30-4/10	90	68,591	6,236		63-55-01R3
					1,065	118		ad only
					70,459	6,405		63-01-42R3
					3,089	281		ad only
					145,146	13,195	11	
1989	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	33	44	3/30-4/10	92	51,149	4,649		63-40-21 [a]
					21,108	1,924		63-43-11 [b]
					13,480	1,225		63-37-25
					85,797	7,798	11	

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

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

APPENDIX E

Table 1. Comparison of minimum and maximum stream temperatures in the Tucannon River near confluences of Panjab and Cummings Creeks, outlets of Big Four, Beaver/Watson, and Deer Lake and Marengo Bridge from 10 April to 8 October, 1991. Temperatures are in Fahrenheit.

	PANJAB CREEK		BIG 4 LAKE		BEAVER LAKE		DEER LAKE		CUMMINGS CREEK		MARENGO BRIDGE	
DATE	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
10-Apr	42	45	46	48	47	50	46	51	47	50	-	-
11-Apr	43	47	47	53	46	53	46	54	46	52	50	59
12-Apr	42	49	47	57	46	51	46	57	46	55	49	60
13-Apr	44	49	47	53	48	54	47	55	46	54	50	62
14-Apr	45	48	47	55	48	53	49	53	49	52	53	59
15-Apr	44	47	48	55	48	51	48	52	48	51	52	56
16-Apr	45	48	49	55	48	51	48	53	50	52	50	56
17-Apr	45	49	49	59	47	54	48	53	47	53	51	58
18-Apr	45	50	49	57	47	47	48	57	47	56	51	63
19-Apr	45	50	50	55	47	56	48	56	48	55	53	62
20-Apr	45	51	48	54	48	57	49	57	49	57	53	64
21-Apr	45	53	48	53	49	61	49	61	49	58	54	66
22-Apr	46	51	46	53	50	60	50	60	50	57	55	66
23-Apr	46	51	47	55	50	57	54	59	50	55	55	62
24-Apr	47	49	46	55	51	55	52	55	51	54	55	58
25-Apr	45	48	46	53	51	54	49	54	48	52	52	59
26-Apr	44	48	46	58	46	55	47	56	46	53	50	60
27-Apr	44	49	47	58	47	56	50	56	47	55	51	60
28-Apr	44	51	-	-	47	48	48	58	48	55	51	61
29-Apr	44	48	-	-	47	53	48	54	48	52	52	57
30-Apr	44	52	-	-	46	59	47	60	46	57	51	64
01-May	45	51	-	-	48	60	49	60	48	57	53	64
02-May	45	52	-	-	49	59	49	59	50	56	53	63
03-May	46	52	-	-	48	59	49	59	48	57	53	63
04-May	47	52	-	-	50	59	51	59	51	48	55	65
05-May	47	52	-	-	50	56	51	57	51	55	55	60
06-May	48	51	-	-	51	55	50	57	52	55	56	60
07-May	48	51	-	-	50	56	51	56	51	55	55	60
08-May	48	50	-	-	51	54	52	56	53	55	56	60
09-May	46	48	-	-	48	53	48	53	48	53	51	57
10-May	46	51	-	-	50	54	50	54	49	54	52	59
11-May	47	52	-	-	50	58	50	58	51	57	54	62
12-May	48	50	-	-	50	53	51	58	52	54	57	56
13-May	47	49	-	-	49	53	50	54	50	53	53	57
14-May	48	52	-	-	50	59	51	59	51	58	54	63
15-May	46	53	-	-	48	60	49	61	50	59	53	63
16-May	48	52	-	-	52	57	53	61	53	57	56	62
17-May	49	50	-	-	52	53	53	57	53	54	57	58
18-May	49	53	-	-	52	59	52	60	53	59	55	63

Appendix E, continued.

	PANJAB CREEK		BIG 4 LAKE		BEAVER LAKE		DEER LAKE		CUMMINGS CREEK		MARENGO BRIDGE	
DATE	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
19-May	48	50	-	-	50	54	52	60	50	54	55	58
20-May	47	53	-	-	49	57	50	58	50	57	53	62
21-May	48	54	-	-	51	59	52	59	52	58	55	62
22-May	48	53	-	-	51	59	52	59	51	58	54	62
23-May	47	52	-	-	50	58	51	59	51	58	54	62
24-May	48	52	-	-	51	57	52	59	52	56	55	62
25-May	48	51	-	-	50	57	51	58	51	57	54	61
26-May	46	50	-	-	49	55	50	58	50	55	54	62
27-May	48	50	-	-	51	56	51	55	51	56	54	63
28-May	47	53	-	-	50	59	51	58	51	57	55	63
29-May	48	51	-	-	51	55	52	59	52	55	57	58
30-May	49	51	-	-	50	55	53	55	52	54	55	58
31-May	48	55	-	-	51	63	51	63	50	61	55	66
01-Jun	49	57	-	-	52	64	53	64	53	62	57	68
02-Jun	50	58	-	-	54	65	54	65	55	64	59	69
03-Jun	50	57	-	-	54	62	54	66	55	61	58	65
04-Jun	47	52	-	-	50	57	51	62	51	57	55	62
05-Jun	49	51	-	-	53	54	53	57	53	55	56	58
06-Jun	49	55	-	-	52	61	52	61	52	59	55	65
07-Jun	50	55	-	-	54	61	54	62	55	60	58	66
08-Jun	51	55	-	-	54	63	55	63	55	61	59	67
09-Jun	50	58	-	-	54	66	54	66	55	64	58	69
10-Jun	52	60	-	-	56	68	56	69	57	66	61	73
11-Jun	54	58	-	-	59	66	59	69	60	64	64	70
12-Jun	49	55	-	-	55	63	55	66	55	61	59	65
13-Jun	49	52	-	-	53	59	54	63	55	58	59	65
14-Jun	49	54	-	-	53	64	53	62	54	60	57	67
15-Jun	50	55	-	-	53	60	54	62	54	60	58	65
16-Jun	51	56	-	-	55	64	55	64	56	61	58	67
17-Jun	50	55	-	-	55	65	54	63	54	61	58	68
18-Jun	50	56	-	-	53	64	54	65	55	62	59	67
19-Jun	51	59	-	-	55	67	56	67	56	64	60	69
20-Jun	53	54	-	-	56	58	57	67	57	58	60	64
21-Jun	52	55	-	-	55	61	56	60	55	55	59	64
22-Jun	52	55	-	-	55	61	55	61	55	59	58	64
23-Jun	51	56	-	-	55	66	55	66	55	63	59	69
24-Jun	52	55	-	-	56	62	57	66	57	61	61	66
25-Jun	53	55	-	-	57	64	57	64	57	63	61	70
26-Jun	52	54	-	-	56	59	57	66	57	60	61	65
27-Jun	51	54	-	-	55	63	55	64	56	63	60	70
28-Jun	54	56	-	-	57	64	58	64	58	63	63	68
29-Jun	54	55	-	-	58	61	58	65	59	61	63	65
30-Jun	54	59	-	-	57	64	57	69	58	65	61	71
01-Jul	53	60	-	-	56	64	58	71	57	67	62	74
02-Jul	54	63	-	-	59	66	59	73	60	69	65	77

Appendix E, continued.

DATE	PANJAB CREEK MIN	PANJAB CREEK MAX	BIG 4 LAKE MIN	BIG 4 LAKE MAX	BEAVER LAKE MIN	BEAVER LAKE MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX
03-Jul	55	64	-	-	60	67	59	75	62	71	67	79
04-Jul	56	64	-	-	61	67	62	73	63	70	67	77
05-Jul	55	63	-	-	60	67	60	73	61	69	66	75
06-Jul	54	61	-	-	59	66	59	71	59	67	62	74
07-Jul	53	62	-	-	58	66	58	71	59	68	63	75
08-Jul	54	62	-	-	59	66	59	73	60	69	64	77
09-Jul	55	61	-	-	60	66	60	71	60	68	66	75
10-Jul	54	62	-	-	59	66	59	72	60	68	64	75
11-Jul	54	62	-	-	59	66	59	72	60	69	64	76
12-Jul	55	64	-	-	61	67	60	75	62	72	66	79
13-Jul	58	64	-	-	64	67	64	74	65	71	70	77
14-Jul	57	63	-	-	63	67	62	73	63	70	68	76
15-Jul	55	60	-	-	61	66	60	68	61	67	66	73
16-Jul	55	60	-	-	61	65	61	68	62	66	66	70
17-Jul	56	59	-	-	61	65	61	67	62	65	66	71
18-Jul	54	62	-	-	59	65	58	72	59	68	64	75
19-Jul	54	62	-	-	59	66	59	72	60	68	64	75
20-Jul	54	63	-	-	60	66	59	73	60	69	65	77
21-Jul	55	64	-	-	61	66	60	73	61	70	66	77
22-Jul	55	64	-	-	62	67	61	75	62	71	67	79
23-Jul	56	65	-	-	63	67	62	76	64	73	68	81
24-Jul	58	62	-	-	64	66	64	76	66	70	71	75
25-Jul	58	62	-	-	64	66	64	70	64	69	70	75
26-Jul	55	64	-	-	62	67	61	73	62	69	67	77
27-Jul	55	64	-	-	62	67	59	74	62	71	67	78
28-Jul	56	64	-	-	63	67	62	75	63	72	68	79
29-Jul	56	64	-	-	63	67	62	75	64	72	69	77
30-Jul	56	64	-	-	63	67	62	75	64	72	68	78
31-Jul	56	64	-	-	63	67	62	75	64	72	68	80
01-Aug	58	64	-	-	65	67	64	75	65	71	70	78
02-Aug	55	63	-	-	63	67	61	74	63	71	67	79
03-Aug	55	64	-	-	63	67	62	75	63	72	68	80
04-Aug	55	64	-	-	63	67	63	75	64	72	69	80
05-Aug	58	63	-	-	65	67	65	75	66	70	71	76
06-Aug	59	64	-	-	65	68	64	76	66	73	71	80
07-Aug	58	64	-	-	65	68	65	76	66	72	71	79
08-Aug	58	65	-	-	65	73	64	76	66	73	71	81
09-Aug	58	65	-	-	64	73	64	76	65	73	71	80
10-Aug	59	63	-	-	64	73	64	76	66	70	70	75
11-Aug	54	61	-	-	59	70	60	73	61	68	65	75
12-Aug	55	62	-	-	60	71	60	72	61	69	65	76
13-Aug	55	61	-	-	60	71	61	72	62	69	66	76
14-Aug	55	62	-	-	61	71	61	73	63	70	67	76
15-Aug	55	62	-	-	61	71	61	73	63	68	67	75
16-Aug	56	62	-	-	62	70	62	73	64	70	68	77

Appendix E, continued.

DATE	PANJAB CREEK MIN	PANJAB CREEK MAX	BIG 4 LAKE MIN	BIG 4 LAKE MAX	BEAVER LAKE MIN	BEAVER LAKE MAX	DEER LAKE MIN	DEER LAKE MAX	CUMMINGS CREEK MIN	CUMMINGS CREEK MAX	MARENGO BRIDGE MIN	MARENGO BRIDGE MAX
17-Aug	56	62	-	-	63	70	63	72	64	71	69	77
18-Aug	-	-	-	-	63	71	63	75	65	73	70	80
19-Aug	-	-	-	-	65	71	65	76	67	73	72	80
20-Aug	-	-	-	-	64	71	64	75	66	73	71.	79
21-Aug	-	-	-	-	63	71	63	74	65	72	69	78
22-Aug	-	-	-	-	63	71	63	74	64	72	69	77
23-Aug	-	-	-	-	63	70	63	73	64	69	69	76
24-Aug	-	-	-	-	61	68	61	73	63	69	67	75
25-Aug	-	-	-	-	62	67	62	68	64	67	66	73
26-Aug	-	-	-	-	58	67	58	69	59	66	63	73
27-Aug	-	-	-	-	59	66	60	69	60	65	64	69
28-Aug	-	-	-	-	61	67	61	68	62	66	66	72
29-Aug	-	-	-	-	61	69	61	72	62	66	66	75
30-Aug	-	-	-	-	61	69	62	72	63	70	66	75
31-Aug	-	-	-	-	61	68	62	72	63	69	67	75
01-Sep	-	-	-	-	63	68	63	72	64	67	67	75
02-Sep	-	-	-	-	57	67	58	69	59	66	67	71
03-Sep	-	-	-	-	57	67	58	68	59	66	64	71
04-Sep	-	-	-	-	58	67	59	69	60	67	63	72
05-Sep	-	-	-	-	59	67	60	69	61	67	64	72
06-Sep	-	-	-	-	59	67	60	69	61	68	64	73
07-Sep	-	-	-	-	61	68	61	70	63	68	65	73
08-Sep	-	-	-	-	59	64	59	70	60	64	67	72
09-Sep	-	-	-	-	57	64	57	65	58	64	63	68
10-Sep	-	-	-	-	58	64	58	66	59	64	61	68
11-Sep	-	-	-	-	57	64	57	66	59	65	62	70
12-Sep	-	-	-	-	57	57	58	67	59	66	63	70
13-Sep	-	-	-	-	59	62	59	67	60	64	63	71
14-Sep	-	-	-	-	55	62	55	64	57	62	64	68
15-Sep	-	-	-	-	55	63	55	64	56	63	61	67
16-Sep	-	-	-	-	55	63	56	65	57	64	60	68
17-Sep	-	-	-	-	56	64	56	65	58	64	61	68
18-Sep	-	-	-	-	57	64	57	66	59	64	62	69
19-Sep	-	-	-	-	57	64	57	66	58	64	63	69
20-Sep	-	-	-	-	57	63	57	66	59	64	62	69
21-Sep	-	-	-	-	55	60	55	64	57	61	63	67
22-Sep	-	-	-	-	52	59	53	62	54	59	59	64
23-sep	-	-	-	-	53	59	53	61	55	60	57	64
24-Sep	-	-	-	-	52	62	55	63	56	62	58	64
25-Sep	-	-	-	-	55	63	56	64	56	63	59	66
26-Sep	-	-	-	-	56	63	57	65	57	64	59	67
27-Sep	-	-	-	-	57	63	57	65	58	64	61	68
28-Sep	-	-	-	-	58	62	59	65	59	61	62	68
29-Sep	-	-	-	-	59	63	57	65	58	64	64	67
30-Sep	-	-	-	-	56	63	57	64	58	64	62	68

Appendix E, continued.

DATE	PANJAB CREEK		BIG 4 LAKE		BEAVER LAKE		DEER LAKE		CUMMINGS CREEK		MARENGO BRIDGE	
	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
01-Oct	-	-	-	-	57	62	57	64	59	64	62	68
02-Oct	-	-	-	-	55	60	55	64	57	61	63	67
03-Oct	-	-	-	-	53	58	53	62	55	59	61	65
04-Oct	-	-	-	-	50	55	51	59	52	56	59	63
05-Oct	-	-	-	-	50	56	51	58	52	57	55	61
06-Oct	-	-	-	-	51	57	52	59	53	58	55	61
07-Oct	-	-	-	-	52	57	53	59	54	58	55	61
08-Oct	-	-	-	-	50	54	52	59	53	57	58	61

Appendix E, continued.

Table 2. Comparison of minimum and maximum stream temperatures in the Tucannon River at Bridge 14, Bridge 12 and the smolt trap from 1 April, 1991 to 14 January, 1992. Temperatures are in Fahrenheit.

DATE	BRIDGE 14 MIN	BRIDGE 14 MAX	BRIDGE 12 MIN	BRIDGE 12 MAX	SMOLT TRAP MIN	SMOLT TRAP MAX
01-Apr-91	45	55	46	56	-	-
02-Apr-91	44	50	45	51	-	-
03-Apr-91	42	49	42	49	-	-
04-Apr-91	45	49	46	50	-	-
05-Apr-91	44	49	45	50	-	-
06-Apr-91	41	50	42	51	-	-
07-Apr-91	42	49	42	51	-	-
08-Apr-91	39	47	40	48	-	-
09-Apr-91	41	48	42	49	-	-
10-Apr-91	39	47	40	48	-	-
11-Apr-91	40	50	41	51	-	-
12-Apr-91	40	52	41	53	-	-
13-Apr-91	41	51	42	53	-	-
14-Apr-91	44	49	44	50	-	-
15-Apr-91	43	47	44	49	-	-
16-Apr-91	42	48	43	49	-	-
17-Apr-91	42	49	42	50	-	-
18-Apr-91	42	53	42	55	-	-
19-Apr-91	43	51	44	53	-	-
20-Apr-91	44	54	44	55	-	-
21-Apr-91	44	56	45	57	-	-
22-Apr-91	45	54	46	56	-	-
23-Apr-91	45	52	46	53	-	-
24-Apr-91	45	51	46	52	-	-
25-Apr-91	43	50	44	51	-	-
26-Apr-91	41	50	42	52	-	-
27-Apr-91	42	51	43	53	-	-
28-Apr-91	42	52	43	53	-	-
29-Apr-91	43	49	44	51	-	-
30-Apr-91	42	54	42	56	-	-
01-May-91	43	55	44	56	-	-
02-May-91	44	53	44	55	-	-
03-May-91	43	54	44	56	-	-
04-May-91	45	55	46	56	-	-
05-May-91	46	51	47	52	-	-
06-May-91	46	51	47	53	-	-
07-May-91	45	51	46	52	-	-
08-May-91	44	50	46	52	-	-
09-May-91	42	49	43	50	-	-
10-May-91	43	49	44	51	-	-

Appendix E, continued.

DATE	BRIDGE 14 MIN	BRIDGE 14 MAX	BRIDGE 12 MIN	BRIDGE 12 MAX	SMOLT TRAP MIN	SMOLT TRAP MAX
11-May-91	45	53	46	53	-	-
12-May-91	46	49	47	50	-	-
13-May-91	44	49	45	50	-	-
14-May-91	45	54	46	55	-	-
15-May-91	44	55	44	55	-	-
16-May-91	47	52	48	54	-	-
17-May-91	47	49	48	50	-	-
18-May-91	46	54	47	55	-	-
19-May-91	45	49	46	50	-	-
20-May-91	43	53	44	54	-	-
21-May-91	46	53	47	54	-	-
22-May-91	45	53	46	54	-	-
23-May-91	45	53	46	54	-	-
24-May-91	46	52	46	53	-	-
25-May-91	44	52	45	53	-	-
26-May-91	44	51	45	53	-	-
27-May-91	45	53	46	55	-	-
28-May-91	45	53	46	54	-	-
29-May-91	46	50	47	51	-	-
30-May-91	46	50	47	50	-	-
31-May-91	45	56	46	57	-	-
01-Jun-91	47	58	48	60	-	-
02-Jun-91	49	60	50	61	-	-
03-Jun-91	49	56	50	57	-	-
04-Jun-91	45	52	46	54	-	-
05-Jun-91	47	49	48	50	-	-
06-Jun-91	46	56	47	57	-	-
07-Jun-91	49	56	50	58	-	-
08-Jun-91	49	56	50	58	-	-
09-Jun-91	49	60	50	61	-	-
10-Jun-91	51	63	52	64	-	-
11-Jun-91	53	61	54	62	-	-
12-Jun-91	50	58	50	59	-	-
13-Jun-91	49	54	49	56	-	-
14-Jun-91	47	57	48	59	-	-
15-Jun-91	49	56	50	58	-	-
16-Jun-91	50	58	50	60	-	-
17-Jun-91	48	58	49	60	-	-
18-Jun-91	49	58	50	60	-	-
19-Jun-91	51	61	51	62	-	-
20-Jun-91	51	54	52	55	-	-
21-Jun-91	50	55	51	56	-	-
22-Jun-91	50	55	50	57	-	-
23-Jun-91	50	59	50	60	-	-
24-Jun-91	52	57	53	59	-	-

Appendix E, continued.

DATE	BRIDGE 14 MIN	BRIDGE 14 MAX	BRIDGE 12 MIN	BRIDGE 12 MAX	SMOLT TRAP MIN	SMOLT TRAP MAX
25-Jun-91	52	60	53	62	56	66
26-Jun-91	52	56	52	57	56	63
27-Jun-91	50	60	51	62	54	66
28-Jun-91	53	59	53	60	58	66
29-Jun-91	53	57	54	57	58	61
30-Jun-91	52	62	52	64	55	66
01-Jul-91	52	64	53	66	58	70
02-Jul-91	54	66	55	68	60	73
03-Jul-91	56	68	57	70	61	75
04-Jul-91	57	68	57	69	63	73
05-Jul-91	56	66	56	68	61	71
06-Jul-91	54	65	55	66	59	70
07-Jul-91	53	65	54	67	57	71
08-Jul-91	54	66	55	68	59	73
09-Jul-91	55	66	56	67	60	71
10-Jul-91	55	66	55	67	59	71
11-Jul-91	54	66	55	68	59	72
12-Jul-91	56	69	57	70	60	74
13-Jul-91	59	68	60	69	66	74
14-Jul-91	58	67	58	68	61	71
15-Jul-91	56	64	56	65	60	67
16-Jul-91	56	62	57	63	61	64
17-Jul-91	56	61	57	63	60	67
18-Jul-91	53	66	54	67	58	70
19-Jul-91	54	66	55	67	59	71
20-Jul-91	55	67	55	69	59	72
21-Jul-91	55	68	56	69	61	73
22-Jul-91	57	69	57	71	60	74
23-Jul-91	58	70	59	72	62	76
24-Jul-91	60	67	61	68	66	74
25-Jul-91	60	66	60	67	64	71
26-Jul-91	56	67	57	69	61	72
27-Jul-91	56	68	57	70	62	73
28-Jul-91	57	69	58	71	63	75
29-Jul-91	58	69	59	71	64	74
30-Jul-91	58	70	58	71	63	75
31-Jul-91	58	70	59	71	62	75
01-Aug-91	60	69	60	70	64	74
02-Aug-91	57	69	58	71	61	74
03-Aug-91	57	70	58	71	62	75
04-Aug-91	58	70	59	72	63	76
05-Aug-91	61	66	61	67	66	73
06-Aug-91	60	71	61	72	66	76
07-Aug-91	61	69	61	71	66	74
08-Aug-91	60	71	60	72	65	76

Appendix E, continued.

DATE	BRIDGE 14 MIN	BRIDGE 14 MAX	BRIDGE 12 MIN	BRIDGE 12 MAX	SMOLT TRAP MIN	SMOLT TRAP MAX
09-Aug-91	60	71	60	72	65	76
10-Aug-91	59	67	59	68	62	70
11-Aug-91	55	66	55	67	59	70
12-Aug-91	55	67	56	68	59	71
13-Aug-91	56	67	56	68	60	72
14-Aug-91	56	67	57	69	60	73
15-Aug-91	57	68	58	70	61	73
16-Aug-91	58	67	58	69	62	74
17-Aug-91	58	69	59	71	63	75
18-Aug-91	59	71	60	72	64	76
19-Aug-91	61	71	61	72	66	76
20-Aug-91	60	71	60	71	65	75
21-Aug-91	58	69	59	71	64	74
22-Aug-91	58	69	59	70	64	74
23-Aug-91	58	68	59	69	64	72
24-Aug-91	56	66	57	67	62	70
25-Aug-91	56	63	56	64	60	67
26-Aug-91	53	65	53	66	55	68
27-Aug-91	55	62	55	63	58	65
28-Aug-91	56	63	56	64	60	67
29-Aug-91	56	67	56	68	61	71
30-Aug-91	56	67	57	69	61	73
31-Aug-91	57	67	57	68	62	71
01-Sep-91	56	64	56	65	61	67
02-Sep-91	53	64	54	65	57	67
03-Sep-91	53	64	54	65	55	67
04-Sep-91	54	65	55	66	57	68
05-Sep-91	55	65	55	66	57	69
06-Sep-91	55	65	55	67	58	69
07-Sep-91	56	66	57	66	61	68
08-Sep-91	55	60	55	62	56	63
09-Sep-91	52	60	52	61	54	63
10-Sep-91	53	62	54	63	55	64
11-Sep-91	53	63	53	63	56	66
12-Sep-91	53	63	54	64	56	66
13-Sep-91	54	60	55	61	58	64
14-Sep-91	51	60	52	61	54	62
15-Sep-91	51	61	51	62	52	63
16-Sep-91	51	61	52	62	53	64
17-Sep-91	52	62	53	63	54	64
18-Sep-91	53	62	54	63	56	65
19-Sep-91	52	62	53	63	54	64
20-Sep-91	53	60	54	61	57	64
21-Sep-91	50	58	51	58	53	59
22-Sep-91	48	56	48	57	49	58

Appendix E, continued.

DATE	BRIDGE 14 MIN	BRIDGE 14 MAX	BRIDGE 12 MIN	BRIDGE 12 MAX	SMOLT TRAP MIN	SMOLT TRAP MAX
23-Sep-91	49	57	49	58	50	59
24-Sep-91	50	59	50	60	52	61
25-Sep-91	51	60	51	61	53	62
26-Sep-91	51	61	52	62	53	63
27-Sep-91	52	61	53	62	55	64
28-Sep-91	53	59	54	59	58	62
29-Sep-91	52	61	53	61	55	63
30-Sep-91	52	61	52	61	54	63
01-Oct-91	53	59	54	60	57	63
02-Oct-91	51	58	51	59	55	61
03-Oct-91	49	56	50	56	52	58
04-Oct-91	46	54	46	55	47	55
05-Oct-91	46	54	46	55	46	54
06-Oct-91	46	54	47	55	47	55
07-Oct-91	48	55	48	56	50	57
08-Oct-91	47	55	47	55	48	55
09-Oct-91	47	55	47	55	49	56
10-Oct-91	48	55	48	56	49	56
11-Oct-91	48	56	48	56	49	56
12-Oct-91	50	56	50	57	50	58
13-Oct-91	47	54	48	55	49	55
14-Oct-91	47	54	47	55	48	55
15-Oct-91	48	56	49	56	49	56
16-Oct-91	50	54	50	55	52	56
17-Oct-91	45	51	46	52	47	52
18-Oct-91	44	49	44	50	44	50
19-Oct-91	46	52	47	52	48	52
20-Oct-91	45	52	46	53	46	53
21-Oct-91	47	53	48	54	50	56
22-Oct-91	44	49	45	50	47	51
23-Oct-91	44	49	45	49	46	48
24-Oct-91	44	48	45	48	46	49
25-Oct-91	44	48	45	49	46	49
26-Oct-91	44	47	45	47	46	49
27-Oct-91	42	44	43	45	43	46
28-Oct-91	41	44	41	45	41	44
29-Oct-91	40	43	40	44	40	44
30-Oct-91	37	42	37	43	37	41
31-Oct-91	39	41	40	42	39	41
01-Nov-91	39	43	39	44	40	43
02-Nov-91	36	41	36	41	37	40
03-Nov-91	37	41	37	42	37	40
04-Nov-91	41	45	41	46	40	44
05-Nov-91	44	48	44	49	44	50
06-Nov-91	43	47	44	47	44	50

Appendix E, continued.

DATE	BRIDGE 14 MIN	BRIDGE 14 MAX	BRIDGE 12 MIN	BRIDGE 12 MAX	SMOLT TRAP MIN	SMOLT TRAP MAX
07-Nov-91	42	46	43	46	42	48
08-Nov-91	44	49	44	49	43	51
09-Nov-91	45	48	45	49	44	51
10-Nov-91	44	49	45	49	42	54
11-Nov-91	43	48	44	49	44	51
12-Nov-91	48	49	48	50	51	60
13-Nov-91	43	47	44	48	37	55
14-Nov-91	42	46	43	47	32	48
15-Nov-91	38	43	40	44	32	43
16-Nov-91	37	44	38	44	40	44
17-Nov-91	42	44	43	45	44	46
18-Nov-91	42	43	42	44	43	46
19-Nov-91	-	-	-	-	42	46
20-Nov-91	-	-	-	-	45	47
21-Nov-91	-	-	-	-	42	45
22-Nov-91	-	-	-	-	39	42
23-Nov-91	-	-	-	-	38	42
24-Nov-91	-	-	-	-	42	44
25-Nov-91	-	-	-	-	44	47
26-Nov-91	-	-	-	-	44	46
27-Nov-91	-	-	-	-	42	44
28-Nov-91	-	-	-	-	40	43
29-Nov-91	-	-	-	-	40	42
30-Nov-91	-	-	-	-	38	40
01-Dec-91	-	-	-	-	40	44
02-Dec-91	-	-	-	-	42	44
03-Dec-91	-	-	-	-	42	45
04-Dec-91	-	-	-	-	43	45
05-Dec-91	-	-	-	-	43	47
06-Dec-91	-	-	-	-	46	47
07-Dec-91	-	-	-	-	43	46
08-Dec-91	-	-	-	-	43	45
09-Dec-91	-	-	-	-	43	45
10-Dec-91	-	-	-	-	42	44
11-Dec-91	-	-	-	-	41	44
12-Dec-91	-	-	-	-	42	46
13-Dec-91	-	-	-	-	40	42
14-Dec-91	-	-	-	-	37	40
15-Dec-91	-	-	-	-	35	39
16-Dec-91	-	-	-	-	38	39
17-Dec-91	-	-	-	-	37	38
18-Dec-91	-	-	-	-	38	40
19-Dec-91	-	-	-	-	39	40
20-Dec-91	-	-	-	-	36	39
21-Dec-91	-	-	-	-	37	40

Appendix E, continued.

DATE	BRIDGE 14 MIN	BRIDGE 14 MAX	BRIDGE 12 MIN	BRIDGE 12 MAX	SMOLT TRAP MIN	SMOLT TRAP MAX
22-Dec-91	-	-	-	-	40	42
23-Dec-91	-	-	-	-	41	42
24-Dec-91	-	-	-	-	41	42
25-Dec-91	-	-	-	-	41	42
26-Dec-91	-	-	-	-	40	41
27-Dec-91	-	-	-	-	39	41
28-Dec-91	-	-	-	-	37	40
29-Dec-91	-	-	-	-	37	39
30-Dec-91	-	-	-	-	39	42
31-Dec-91	-	-	-	-	40	41
01-Jan-92	-	-	-	-	39	40
02-Jan-92	-	-	-	-	39	42
03-Jan-92	-	-	-	-	37	40
04-Jan-92	-	-	-	-	39	42
05-Jan-92	-	-	-	-	39	41
06-Jan-92	-	-	-	-	40	41
07-Jan-92	-	-	-	-	37	39
08-Jan-92	-	-	-	-	35	37
09-Jan-92	-	-	-	-	36	38
10-Jan-92	-	-	-	-	35	39
11-Jan-92	-	-	-	-	39	40
12-Jan-92	-	-	-	-	38	40
13-Jan-92	-	-	-	-	38	41
14-Jan-92	-	-	-	-	40	40

Appendix E, continued.

Table 3. Discharge measurements of Tucannon River at selected sites and tributaries in 1991. Measurements made using modified U.S. Geological Survey techniques (Platts et al. 1983).

Location (RK)	Date	Discharge (m^3/sec)
Panjab Creek (78) [a]	6 Jun	0.541
	19 Jun	0.445
	1 Jul	0.314
	10 Jul	0.269
	18 Jul	0.290
Tucannon FH rack (61) [b]	10 Jul	1.466
	18 Jul	1.964
Cummings Creek (58) [c]	6 Jun	0.201
	19 Jun	0.155
	1 Jul	0.174
	10 Jul	0.148
	18 Jul	0.066
Tucannon River smolt trap (21) [d]	3 May	3.482
	6 Jun	4.535
	19 Jun	3.070
	1 Jul	2.855
	18 Jul	2.029

[a] 200 m above mouth of Panjab Creek

[b] 5 m above adult rack

[c] 75 m above mouth of Cummings Creek

[d] 70 m above smolt trap

APPENDIX F

Summary of spring chinook salmon radio tagged and released upstream of the Tucannon FH rack, 1991.

Tag no.	Date tagged	Sex[a]	Fork length (cm)[b]	Age[c]	Days tracked	Recovery date	Recovery locale (km)[d]	Recovery carcass	Comments
WILD SALMON									
12B	5/31	F	81	5	120	9/24	12.5	yes	spawned
12C	6/04	M	73	4	127	10/11	0.0	yes	possibly spawned
13B	6/11	M	80	5	91	9/10	7.4	yes	spawned
14B	6/11	F	86	5	90	9/10	7.4	yes	spawned
14C	6/11	F	74	4	98	9/16	11.7	yes	spawned
13C	6/04	M	69	4	102	9/13	15.9	no	tag 10 m on shore
HATCHERY SALMON									
9C	5/29	F	68	4	108	9/20	6.9	yes	seen with 1 wild and 2 hatchery males
5C	6/11	F	68	4	111	9/30	6.0	yes	seen and held near 2 redds
5B	6/04	F	82	5	112	9/23	3.0	yes	seen with 1 wild and 1 hatchery male
3B	5/31	F	75	4	116	9/23	3.1	yes	seen with 1 wild and 2 hatchery males
11C	6/04	F	71	4	14	6/18	0.0	no	regurgitated
9B	6/06	F	75	4	1	6/06	0.0	no	regurgitated
7C	6/06	M	62	3	1	6/06	0.0	no	regurgitated
7C	6/11	M	73	4	6	6/17	0.0	no	regurgitated
7B	6/13	F	71	4	1	6/14	0.0	no	regurgitated
3C	5/29	M	60	3	5	6/04	0.0	no	regurgitated
7B	6/19	F	78	4	19	7/08	-0.5	yes	carcass eaten
3C	6/26	F	65	3	1	6/27	0.0	yes	ruptured stomach

[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 fork length or coded-wire tags (hatchery fish).

[d] Estimated river kilometers upstream of Tucannon FH rack where tag was recovered.

APPENDIX G

Comparison of 1986 through 1991 spring chinook salmon rearing density estimates for riffles, runs, pools, boulder sites, and side channels within the HMA Stratum, Tucannon River, Washington.

Habitat type	Site	Density (fish/100m2) by year 1986	1987	1988	1989	1990	1991
Riffle	HMA 1	23.37	19.77	20.86	12.55	5.15	3.79
	HMA 5	24.10	12.79	26.66	20.19	17.53	15.22
	HMA 9	11.77	10.33	7.10	4.41	7.86	1.27
	HMA 13	17.35	9.74	8.87	11.94	9.87	1.03
	HMA 18	13.87	7.91	8.66	14.23	5.95	9.66
	HMA 20	18.37	18.19	1.93	8.62	10.87	- -
	Mean	18.14	13.12	12.35	11.99	9.54	6.19
Run	HMA 3	24.75	45.09	44.16	13.02	17.09	11.85
	HMA 6	19.91	6.78	2.31	4.86	2.70	1.90
	HMA 10	20.72	65.54	24.04	41.42	28.78	- -
	HMA 14	96.68	56.43	29.03	31.04	51.27	47.40
	HMA 19	48.94	37.43	33.44	18.88	36.56	19.37
	HMA 24	92.45	45.48	35.33	61.24	41.71	23.37
	Mean	50.58	42.79	28.05	28.41	29.69	20.78
Pool	HMA 4	12.14	4.43	9.00	20.98	58.32	48.92
	HMA 8	10.53	47.53	31.73	9.48	31.42	- -
	HMA 12	38.73	33.04	14.51	4.76	22.00	24.55
	HMA 16	67.43	46.80	34.63	20.27	23.44	48.38
	HMA 21	60.89	31.40	34.57	41.12	62.50	26.66
	HMA 22	126.26	71.64	38.77	65.55	45.55	70.14
	Mean	52.66	39.14	27.20	27.03	40.54	43.73
Boulder	HMA 2	8.95	7.48	14.82	6.42	10.81	11.92
	HMA 7	13.68	37.48	13.57	3.73	27.11	- -
	HMA 11	12.99	9.00	7.72	3.50	12.00	4.02
	HMA 15	12.79	34.87	11.68	4.33	6.12	0.85
	HMA 17	22.96	20.53	6.87	8.89	14.89	9.22
	HMA 23	17.73	15.39	1.46	4.57	12.36	11.85
	Mean	14.85	20.79	9.35	5.24	13.88	7.57
Side channel	HMAS 1	75.44	36.89	38.19	17.95	43.40	- -
	HMAS 2	23.79	123.60	113.33	86.05	86.27	96.89
	HMAS 3	41.22	49.07	13.34	32.89	12.53	4.51
	HMAS 4	35.23	23.33	27.09	4.54	20.20	45.51
	HMAS 5	122.11	19.41	82.81	55.90	17.63	33.45
	HMAS 6	53.20	30.21	33.86	29.06	32.25	112.21
	Mean	58.50	47.09	51.44	37.73	35.38	58.51
Yearly mean =		38.95	32.59	25.68	22.08	25.80	27.36

APPENDIX H

Tucannon River 1990/1991 spring chinook salmon downstream migrant trap data. Columns 4 through 12 are as follows: 4) fish marked (left partial ventral clip) and transported 10 km with 5) subsequent recaptured, 6) fish marked (right partial ventral clip) and transported 10 km with 7) subsequent recaptures, 8) fish that were not marked and released downstream of trap, 9) fish sampled for electrophoresis, morphometrics, or meristic analysis, 10) mortalities incurred at the trap, 11) the sum of columns 4 through 10 for that row, 12)the sum of columns 11 and 12 for that row.

1 Date	2 Time Checked	3 Time Reset	4 Mark LPV	5 Recapture LPV	6 Mark RPV	7 Recapture RPV	8 No Marks	9 Sampled	10 Morts	11 Total Wild	12 Total Hatchery	13 Total Fish
08-Nov-90	730	0	0	0	0	0	0	0	0	0	0	0
14-Nov-90	830	0	0	0	0	0	0	0	0	0	0	0
15-Nov-90	900	0	0	0	0	0	0	0	0	0	0	0
20-Nov-90	645	0	0	0	0	0	2	0	0	2	0	2
27-Nov-90	700	0	0	0	0	0	1	0	0	1	0	1
28-Nov-90	815	0	0	0	0	0	9	0	0	9	1	10
29-Nov-90	715	0	0	0	0	0	9	0	0	9	0	9
04-Dec-90	645	0	0	0	0	0	3	0	0	3	0	3
05-Dec-90	815	0	0	0	0	0	4	0	0	4	1	5
06-Dec-90	800	0	0	0	0	0	3	0	0	3	0	3
11-Dec-90	830	0	0	0	0	0	14	0	0	14	1	15
11-Dec-90	1530	0	0	0	0	0	0	0	0	0	0	0
12-Dec-90	800	0	0	0	0	0	2	0	0	2	2	4
12-Dec-90	1615	0	0	0	0	0	1	0	0	1	0	1
13-Dec-90	805	0	0	0	0	0	4	0	0	4	0	4
13-Dec-90	1600	0	0	0	0	0	2	0	0	2	0	2
18-Dec-90	800	0	0	0	0	0	1	0	1	1	0	1
19-Dec-90	830	0	0	0	0	0	4	0	0	4	0	4
16-Jan-91	1040	0	0	0	0	0	10	0	0	10	0	10
16-Jan-91	1605	0	0	0	0	0	8	0	0	8	0	8
17-Jan-91	815	0	0	0	0	0	13	0	0	13	2	15
17-Jan-91	1530	0	0	0	0	0	29	0	0	29	0	29
18-Jan-91	715	0	0	0	0	0	19	0	0	19	1	20
22-Jan-91	1715	0	0	0	0	0	5	0	0	5	0	5
23-Jan-91	800	0	0	0	0	0	19	0	0	19	0	19
23-Jan-91	1600	0	0	0	0	0	3	0	0	3	0	3
24-Jan-91	845	0	0	0	0	0	26	0	0	26	1	27
24-Jan-91	1500	0	0	0	0	0	10	0	0	10	0	10
25-Jan-91	730	0	0	0	0	0	7	0	0	7	0	7
04-Feb-91	1500	0	0	0	0	0	2	0	0	2	0	2
06-Feb-91	700	0	0	0	0	0	2	0	0	2	0	2
06-Feb-91	1530	0	0	0	0	0	0	0	0	0	0	0
07-Feb-91	715	0	0	0	0	0	3	0	0	3	0	3
08-Feb-91	715	0	0	0	0	0	1	0	0	1	0	1
12-Feb-91	740	805	0	0	0	0	7	0	0	7	0	7
13-Feb-91	700	715	0	0	0	0	3	0	0	3	0	3
14-Feb-91	715	725	0	0	0	0	7	0	0	7	0	7
14-Feb-91	1600	0	0	0	0	0	0	0	0	0	0	0
15-Feb-91	715	pulled	0	0	0	0	5	0	0	5	0	5
19-Feb-91	1630	1640	0	0	0	0	1	0	0	1	0	1
20-Feb-91	720	730	0	0	0	0	4	0	0	4	0	4
21-Feb-91	710	720	0	0	0	0	3	0	0	3	0	3
22-Feb-91	710	pulled	0	0	0	0	2	0	0	2	0	2
26-Feb-91	830	0	0	0	0	0	0	0	0	0	0	0
27-Feb-91	700	0	0	0	0	0	4	0	0	4	0	4
28-Feb-91	700	0	0	0	0	0	4	0	0	4	0	4
01-Mar-91	700	715	0	0	0	0	3	0	1	3	0	3
05-Mar-91	745	pulled	0	0	0	0	1	0	0	1	0	1
06-Mar-91	710	730	0	0	0	0	3	0	0	3	0	3
07-Mar-91	750	820	0	0	0	0	4	0	0	4	0	4
08-Mar-91	730	pulled	0	0	0	0	3	0	0	3	0	3
12-Mar-91	710	720	0	0	0	0	6	0	0	6	0	6
12-Mar-91	1505	1520	0	0	0	0	4	0	0	4	0	4
13-Mar-91	700	720	0	0	0	0	10	0	0	10	0	10
14-Mar-91	715	730	0	0	0	0	2	0	0	2	0	2

Appendix H, continued.

1 Date	2 Time Checked	3 Time Reset	4 Mark LPV	5 Recapture LPV	6 Mark RPV	7 Recapture RPV	8 No Marks	9 Sampled	10 Morts	11 Total Wild	12 Total Hatchery	13 Total Fish
15-Mar-91	815	pulled	0	0	0	0	5	0	0	5	0	5
19-Mar-91	728	800	0	0	0	0	34	0	0	34	0	34
20-Mar-91	705	730	0	0	0	0	29	0	0	29	0	29
21-Mar-91	705	725	0	0	0	0	6	0	0	6	0	6
22-Mar-91	930	pulled	0	0	0	0	49	0	0	49	0	49
26-Mar-91	715	730	0	0	0	0	5	0	0	5	0	5
27-Mar-91	700	725	0	0	0	0	3	0	0	3	0	3
28-Mar-91	705	725	0	0	0	0	0	0	0	0	0	0
29-Mar-91	745	pulled	0	0	0	0	3	0	0	3	0	3
01-Apr-91	400	415	0	0	0	0	0	0	0	0	0	0
01-Apr-91	910	925	0	0	0	0	0	0	0	0	1	1
01-Apr-91	1345	1600	0	0	0	0	0	0	0	0	0	0
02-Apr-91	2400	15	0	0	0	0	0	0	0	0	1	1
02-Apr-91	600	630	0	0	0	0	2	0	0	2	1	3
02-Apr-91	1230	1752	0	0	0	0	0	0	0	0	1	1
02-Apr-91	1545	1600	0	0	0	0	0	0	0	0	0	0
02-Apr-91	2045	2110	0	0	0	0	1	0	0	1	2	3
03-Apr-91	600	630	0	0	0	0	12	12	0	12	16	28
03-Apr-91	2055	2120	0	0	0	0	2	0	0	2	14	16
03-Apr-91	2340	2400	0	0	0	0	4	0	0	4	13	17
04-Apr-91	240	250	0	0	0	0	1	0	0	1	7	8
04-Apr-91	600	630	0	0	0	0	2	2	0	2	5	7
04-Apr-91	2055	2120	0	0	0	0	0	0	0	0	2	2
05-Apr-91	15	40	0	0	0	0	2	0	0	2	5	7
05-Apr-91	255	315	0	0	0	0	2	0	0	2	10	12
05-Apr-91	630	645	0	0	0	0	1	1	0	1	6	7
06-Apr-91	10	30	0	0	0	0	5	0	0	5	4	9
06-Apr-91	240	305	0	0	0	0	6	0	0	6	5	11
06-Apr-91	630	650	0	0	0	0	2	0	0	2	11	13
06-Apr-91	2055	2115	0	0	0	0	1	0	0	1	3	4
06-Apr-91	2355	20	0	0	0	0	6	0	0	6	5	11
07-Apr-91	320	345	0	0	0	0	6	0	0	6	4	10
07-Apr-91	615	645	0	0	0	0	1	0	0	1	10	11
07-Apr-91	1600	1620	0	0	0	0	2	0	0	2	0	2
07-Apr-91	2340	2350	0	0	0	0	1	0	0	1	2	3
08-Apr-91	235	245	0	0	0	0	17	0	0	17	13	30
08-Apr-91	651	640	0	0	0	0	5	5	0	5	6	11
08-Apr-91	2037	2050	0	0	0	0	0	0	1	0	4	4
08-Apr-91	2310	2325	0	0	0	0	3	0	0	3	1	4
09-Apr-91	300	325	0	0	0	0	2	0	0	2	10	12
09-Apr-91	630	700	0	0	0	0	7	7	0	7	8	15
09-Apr-91	1940	2000	0	0	0	0	1	0	0	1	0	1
09-Apr-91	2230	2240	0	0	0	0	2	0	0	2	2	4
10-Apr-91	40	50	0	0	0	0	13	0	0	13	9	22
10-Apr-91	305	325	0	0	0	0	6	0	0	6	8	14
10-Apr-91	630	700	0	0	0	0	7	5	0	7	7	14
10-Apr-91	2145	2155	0	0	0	0	0	0	0	0	1	1
11-Apr-91	115	215	0	0	0	0	4	0	0	4	6	10
11-Apr-91	315	325	0	0	0	0	2	0	0	2	6	8
11-Apr-91	630	700	0	0	0	0	5	5	0	5	4	9
11-Apr-91	1940	2005	0	0	0	0	1	0	0	1	1	2
11-Apr-91	2250	2310	0	0	0	0	0	0	0	0	0	0
12-Apr-91	2250	245	0	0	0	0	4	0	0	4	0	4
12-Apr-91	630	700	0	0	0	0	4	4	0	4	3	7
12-Apr-91	2215	2225	0	0	0	0	0	0	0	0	1	1
13-Apr-91	145	200	0	0	0	0	2	0	0	2	0	2
13-Apr-91	630	700	0	0	0	0	8	5	0	8	4	12
13-Apr-91	2130	2150	0	0	0	0	1	0	0	1	1	2
14-Apr-91	45	130	0	0	0	0	30	0	0	30	0	30
14-Apr-91	510	530	0	0	0	0	7	0	0	7	5	12
14-Apr-91	1110	113	0	0	0	0	1	0	0	1	11	12
14-Apr-91	1620	1630	0	0	0	0	1	0	0	1	0	1

Appendix H, continued.

1 Date	2 Time Checked	3 Time Reset	4 Mark LPV	5 Recapture LPV	6 Mark RPV	7 Recapture RPV	8 No Marks	9 Sampled	10 Morts	11 Total Wild	12 Total Hatchery	13 Total Fish
14-Apr-91	2030	2055	0	0	0	0	0	0	0	0	4	4
15-Apr-91	0	57	0	0	0	0	5	0	0	5	40	45
15-Apr-91	300	330	0	0	0	0	8	0	0	8	34	42
15-Apr-91	710	745	0	0	0	0	6	6	0	6	82	88
15-Apr-91	2030	2100	0	0	0	0	0	0	0	0	2	2
16-Apr-91	5	39	0	0	0	0	6	0	0	6	38	44
16-Apr-91	300	320	0	0	0	0	3	0	0	3	32	35
16-Apr-91	640	751	0	0	0	0	8	8	0	8	97	105
16-Apr-91	2130	2142	0	0	0	0	0	0	0	0	1	1
17-Apr-91	15	45	0	0	0	0	4	0	0	4	17	21
17-Apr-91	300	330	0	0	0	0	10	0	0	10	56	66
17-Apr-91	705	720	0	0	0	0	14	14	0	14	65	79
17-Apr-91	2045	2100	0	0	0	0	1	0	0	1	1	2
18-Apr-91	20	40	0	0	0	0	3	0	0	3	0	3
18-Apr-91	300	315	0	0	0	0	5	0	0	5	25	30
18-Apr-91	645	700	0	0	0	0	8	8	0	8	64	72
19-Apr-91	30	40	0	0	0	0	0	0	0	0	3	3
19-Apr-91	310	330	0	0	0	0	5	0	0	5	7	12
19-Apr-91	651	645	0	0	0	0	8	8	0	8	18	26
19-Apr-91	2035	2050	0	0	0	0	0	0	1	0	2	2
20-Apr-91	35	45	0	0	0	0	1	0	0	1	2	3
20-Apr-91	305	330	0	0	0	0	2	0	0	2	13	15
20-Apr-91	630	645	0	0	0	0	6	6	0	6	12	18
20-Apr-91	2355	20	0	0	0	0	3	0	0	3	0	3
21-Apr-91	225	235	0	0	0	0	1	0	0	1	2	3
21-Apr-91	620	645	0	0	0	0	9	5	0	9	9	18
21-Apr-91	1540	1600	0	0	0	0	1	0	0	1	1	2
21-Apr-91	2055	2115	0	0	0	0	1	0	0	1	0	1
22-Apr-91	10	20	0	0	0	0	1	0	0	1	1	2
22-Apr-91	305	320	0	0	0	0	3	0	0	3	0	3
22-Apr-91	745	800	0	0	0	0	4	0	0	4	5	9
22-Apr-91	2040	2100	0	0	0	0	7	0	0	7	1	8
23-Apr-91	30	120	0	0	0	0	12	0	0	12	4	16
23-Apr-91	330	345	0	0	0	0	20	0	0	20	11	31
23-Apr-91	745	800	0	0	0	0	29	0	0	29	6	35
23-Apr-91	2030	2100	0	0	0	0	6	0	0	6	2	8
24-Apr-91	15	30	0	0	0	0	6	0	0	6	6	12
24-Apr-91	300	330	0	0	0	0	12	0	0	12	6	18
24-Apr-91	700	715	0	0	0	0	27	0	0	27	27	54
24-Apr-91	1500	1515	0	0	0	0	4	0	0	4	2	6
24-Apr-91	2030	2120	0	0	0	0	13	0	0	13	5	18
24-Apr-91	30	120	0	0	0	0	41	0	0	41	7	48
25-Apr-91	300	330	0	0	0	0	23	0	0	23	10	33
25-Apr-91	630	700	0	0	0	0	51	0	0	51	23	74
25-Apr-91	1500	1515	0	0	0	0	9	0	0	9	4	13
25-Apr-91	2050	2110	0	0	0	0	8	0	0	8	4	12
26-Apr-91	30	105	0	0	0	0	15	0	0	15	9	24
26-Apr-91	351	340	0	0	0	0	28	0	0	28	4	32
26-Apr-91	645	715	0	0	0	0	37	0	0	37	2	39
26-Apr-91	1500	1515	0	0	0	0	8	0	0	8	1	9
26-Apr-91	2055	2115	0	0	0	0	2	0	0	2	2	4
27-Apr-91	30	45	0	0	0	0	7	0	0	7	1	8
27-Apr-91	300	315	0	0	0	0	8	0	0	8	2	10
27-Apr-91	630	700	0	0	0	0	22	0	0	22	5	27
27-Apr-91	2130	2150	0	0	0	0	6	0	0	6	0	6
28-Apr-91	20	35	0	0	0	0	5	0	0	5	0	5
28-Apr-91	320	340	0	0	0	0	8	0	0	8	3	11
28-Apr-91	715	135	0	0	0	0	12	0	0	12	7	19
28-Apr-91	1830	1900	0	0	0	0	6	0	0	6	0	6
28-Apr-91	2215	2250	0	0	0	0	4	0	0	4	3	7
29-Apr-91	30	50	0	0	0	0	6	0	0	6	3	9
29-Apr-91	300	330	0	0	0	0	10	0	0	10	0	10

Appendix H, continued.

1 Date	2 Time Checked	3 Time Reset	4 Mark LPV	5 Recapture LPV	6 Mark RPV	7 Recapture RPV	8 No Marks	9 Sampled	10 Morts	11 Total Wild	12 Total Hatchery	13 Total Fish
29-Apr-91	700	740	28	0	0	0	0	0	0	28	7	35
29-Apr-91	1350	1410	0	0	0	0	2	0	0	2	2	4
29-Apr-91	2030	2110	8	0	0	0	0	0	0	8	0	8
30-Apr-91	100	130	14	0	0	0	0	0	0	14	3	17
30-Apr-91	300	345	0	2	0	0	26	0	0	28	1	29
30-Apr-91	700	740	0	0	0	0	24	0	0	24	2	26
30-Apr-91	1250	1320	0	0	0	0	2	0	0	2	0	2
30-Apr-91	2045	2115	0	0	0	0	1	0	0	1	1	2
01-May-91	100	130	0	0	0	0	13	0	0	13	0	13
01-May-91	315	330	0	0	0	0	3	0	0	3	0	3
01-May-91	630	710	0	0	0	0	17	0	0	17	4	21
01-May-91	2155	2205	0	0	0	0	1	0	0	1	0	1
02-May-91	130	150	0	0	0	0	9	0	0	9	1	10
02-May-91	330	350	0	0	0	0	2	0	0	2	1	3
02-May-91	630	700	0	0	0	0	15	0	0	15	2	17
02-May-91	2120	2155	0	0	0	0	0	0	0	0	0	0
03-May-91	50	115	0	0	0	0	9	0	0	9	2	11
03-May-91	320	340	0	0	0	0	6	0	0	6	0	6
03-May-91	630	700	0	0	0	0	14	0	0	14	4	18
03-May-91	1020	1110	0	0	0	0	3	0	0	3	0	3
03-May-91	2115	2130	0	0	0	0	3	0	0	3	1	4
04-May-91	30	50	0	1	0	0	6	0	0	7	1	8
04-May-91	305	325	0	0	0	0	7	0	0	7	2	9
04-May-91	1000	1030	0	0	0	0	11	0	0	11	2	13
04-May-91	2050	2115	0	0	0	0	1	0	0	1	2	3
05-May-91	305	320	0	0	0	0	2	0	0	2	1	3
05-May-91	630	700	0	0	0	0	14	0	0	14	1	15
05-May-91	2115	2145	0	0	0	0	3	0	0	3	0	3
06-May-91	100	130	0	0	0	0	5	0	0	5	0	5
06-May-91	300	330	0	0	0	0	5	0	0	5	4	9
06-May-91	700	740	0	0	0	0	4	0	0	4	1	5
06-May-91	1210	1235	0	0	0	0	4	0	0	4	0	4
06-May-91	1625	1645	0	0	0	0	1	0	0	1	0	1
06-May-91	2115	2135	0	0	0	0	3	0	0	3	0	3
07-May-91	10	30	0	0	0	0	8	0	0	8	0	8
07-May-91	300	330	0	0	0	0	11	0	0	11	0	11
07-May-91	645	715	0	0	0	0	6	0	0	6	0	6
07-May-91	1345	1400	0	0	0	0	1	0	0	1	0	1
07-May-91	2030	2100	0	0	0	0	1	0	0	1	0	1
08-May-91	30	50	0	0	0	0	2	0	1	2	1	3
08-May-91	310	325	0	0	0	0	4	0	0	4	0	4
08-May-91	645	705	0	0	0	0	9	0	0	9	3	12
08-May-91	2055	2120	0	0	0	0	2	0	0	2	1	3
09-May-91	35	100	0	0	0	0	3	0	0	3	2	5
09-May-91	315	330	0	0	0	0	13	0	0	13	3	16
09-May-91	630	700	0	0	0	0	9	0	0	9	2	11
09-May-91	1300	1315	0	0	0	0	0	0	0	0	0	0
09-May-91	2050	2115	0	0	0	0	4	0	0	4	1	5
10-May-91	25	50	0	0	0	0	4	0	0	4	4	8
10-May-91	330	350	0	0	0	0	10	0	0	10	3	13
10-May-91	730	755	0	0	0	0	14	0	0	14	2	16
10-May-91	1450	1515	0	0	0	0	1	0	0	1	2	3
10-May-91	2130	2150	0	0	0	0	2	0	0	2	0	2
11-May-91	15	30	0	0	0	0	9	0	0	9	2	11
11-May-91	300	320	0	0	0	0	14	0	0	14	4	18
11-May-91	630	700	0	0	0	0	6	0	0	6	0	6
11-May-91	2045	2100	0	0	0	0	2	0	0	2	1	3
12-May-91	15	30	0	0	0	0	4	0	0	4	2	6
12-May-91	410	430	0	0	0	0	6	0	0	6	2	8
12-May-91	705	720	0	0	0	0	4	0	0	4	1	5
13-May-91	645	715	0	0	0	0	8	0	0	8	1	9
13-May-91	1330	1400	0	0	0	0	1	0	0	1	0	1

Appendix H, continued.

1 Date	2 Time Checked	3 Time Reset	4 Mark LPV	5 Recapture LPV	6 Mark RPV	7 Recapture RPV	8 No Marks	9 Sampled	10 Morts	11 Total Wild	12 Total Hatchery	13 Total Fish
13-May-91	1920	1930	0	0	0	0	1	0	0	1	0	1
13-May-91	2235	2250	0	0	0	0	2	0	0	2	0	2
14-May-91	640	700	0	0	0	0	9	0	0	9	1	10
15-May-91	20	50	0	0	0	0	4	0	0	4	0	4
15-May-91	645	700	0	0	0	0	8	0	0	8	2	10
15-May-91	2040	2045	0	0	0	0	0	0	0	0	0	0
15-May-91	340	400	0	0	0	0	5	0	0	5	1	6
15-May-91	630	700	0	0	0	0	9	0	0	9	1	10
16-May-91	1000	1020	0	0	0	0	0	0	0	0	0	0
16-May-91	2055	2105	0	0	0	0	2	0	0	2	0	2
17-May-91	110	135	0	0	0	0	18	0	0	18	2	20
17-May-91	305	320	0	0	0	0	13	0	0	13	1	14
17-May-91	720	755	0	0	0	0	6	0	0	6	1	7
17-May-91	1230	1245	0	0	0	0	0	0	0	0	0	0
17-May-91	1615	1630	0	0	0	0	1	0	0	1	0	1
17-May-91	2115	2130	0	0	0	0	0	0	0	0	0	0
18-May-91	30	45	0	0	0	0	30	0	0	30	1	31
18-May-91	300	320	0	0	0	0	38	0	0	38	2	40
18-May-91	845	930	0	0	0	0	26	0	0	26	1	27
18-May-91	1550	1605	0	0	0	0	0	0	0	0	1	1
18-May-91	2055	2115	0	0	0	0	1	0	0	1	2	3
19-May-91	10	35	0	0	0	0	15	0	0	15	3	18
19-May-91	305	325	0	0	0	0	9	0	0	9	1	10
19-May-91	830	1020	0	0	0	0	4	0	0	4	0	4
19-May-91	1500	2130	0	0	0	0	2	0	0	2	0	2
19-May-91	2320	2335	0	0	0	0	0	0	0	0	0	0
20-May-91	345	400	0	0	0	0	1	0	0	1	0	1
21-May-91	150	220	0	0	0	0	0	0	0	0	1	1
21-May-91	640	700	0	0	0	0	1	0	0	1	0	1
21-May-91	1100	1115	0	0	0	0	1	0	0	1	0	1
21-May-91	2320	2350	0	0	0	0	2	0	0	2	1	3
22-May-91	150		0	0	0	0	4	0	0	4	1	5
22-May-91	300	340	0	0	0	0	6	0	1	6	0	6
22-May-91	640	700	0	0	0	0	3	0	1	3	1	4
22-May-91	1035	1045	0	0	0	0	4	0	0	4	0	4
22-May-91	1245	1300	0	0	0	0	1	0	0	1	0	1
22-May-91	1530	2045	0	0	0	0	0	0	0	0	0	0
22-May-91	2245	2300	0	0	0	0	1	0	0	1	1	2
23-May-91	110	130	0	0	0	0	6	0	0	6	4	10
23-May-91	300	320	0	0	0	0	6	0	0	6	2	8
23-May-91	700	715	0	0	0	0	5	0	0	5	2	7
23-May-91	1600	2045	0	0	0	0	3	0	0	3	0	3
23-May-91	2245	2300	0	0	0	0	3	0	0	3	0	3
24-May-91	50	110	0	0	0	0	7	0	0	7	0	7
24-May-91	300	315	0	0	0	0	11	0	0	11	0	11
24-May-91	625	700	0	0	0	0	15	0	0	15	0	15
25-May-91	50	115	0	0	0	0	11	0	0	11	2	13
25-May-91	330	350	0	0	0	0	11	0	0	11	2	13
25-May-91	715	pulled	0	0	0	0	10	0	0	10	0	10
28-May-91	2030	2045	0	0	0	0	4	0	0	4	0	4
29-May-91	100	150	0	0	0	0	22	0	0	22	0	22
29-May-91	300	315	0	0	0	0	10	0	0	10	0	10
29-May-91	645	715	0	1	0	0	18	0	0	19	0	19
29-May-91	2030	2100	0	0	0	0	3	0	0	3	0	3
30-May-91	100	200	0	0	0	0	3	0	0	53	1	54
30-May-91	300	315	0	0	0	0	8	0	0	8	0	8
30-May-91	645	700	0	0	0	6	12	0	0	18	2	20
30-May-91	1230	1245	0	0	0	0	2	0	0	2	0	2
30-May-91	2035	2050	0	0	0	0	1	0	0	1	0	1
31-May-91	100	130	0	0	0	9	38	0	0	47	0	47
31-May-91	300	320	0	0	0	0	22	0	0	22	0	22
31-May-91	725	750	0	0	0	0	13	0	0	13	0	13

Appendix H, continued.

1 Date	2 Time Checked	3 Time Reset	4 Mark LPV	5 Recapture LPV	6 Mark RPV	7 Recapture RPV	8 No Marks	9 Sampled	10 Morts	11 Total Wild	12 Total Hatchery	13 Total Fish
31-May-91	1610	1620	0	0	0	0	0	0	0	0	0	0
01-Jun-91	25	50	0	0	0	2	27	0	0	29	0	29
01-Jun-91	300	320	0	0	0	0	21	0	0	21	0	21
01-Jun-91	800	815	0	0	0	0	12	0	0	12	3	15
01-Jun-91	1640	1655	0	0	0	0	2	0	0	2	0	2
01-Jun-91	2140	2155	0	0	0	0	2	0	0	2	0	2
01-Jun-91	300	330	0	0	0	0	73	0	0	73	4	77
02-Jun-91	830	845	0	0	0	0	9	0	0	9	1	10
02-Jun-91	1600	1615	0	0	0	0	2	0	0	2	1	3
02-Jun-91	2130	2230	2	0	0	0	0	0	0	2	0	2
03-Jun-91	230	310	48	0	0	0	13	0	0	61	2	63
03-Jun-91	750	810	0	0	0	0	10	0	0	10	0	10
03-Jun-91	1900	1920	0	2	0	0	1	0	0	3	0	3
04-Jun-91	230	315	0	7	0	0	42	0	0	49	0	49
04-Jun-91	735	750	0	1	0	0	19	0	0	20	0	20
04-Jun-91	2000	2020	0	0	0	0	0	0	0	0	0	0
05-Jun-91	300	345	0	0	0	0	63	0	0	63	0	63
05-Jun-91	650	710	0	0	0	0	24	0	0	24	0	24
05-Jun-91	2130	2145	0	0	0	0	0	0	0	0	0	0
06-Jun-91	230	315	0	0	50	0	29	0	0	79	0	79
06-Jun-91	650	705	0	0	0	0	15	0	0	15	0	15
07-Jun-91	15	35	0	0	0	3	19	0	0	22	0	22
07-Jun-91	315	335	0	0	0	0	14	0	0	14	1	15
07-Jun-91	750	800	0	0	0	0	11	0	0	11	1	12
07-Jun-91	1515		0	0	0	0	1	0	0	1	0	1
07-Jun-91	2145	2155	0	0	0	0	1	0	0	1	0	1
08-Jun-91	300	315	0	0	0	1	19	0	0	20	1	21
08-Jun-91	845	905	0	0	0	0	12	0	0	12	1	13
08-Jun-91	1535	1550	0	0	0	0	2	0	0	2	0	2
08-Jun-91	2040	2055	0	0	0	0	1	0	0	1	0	1
09-Jun-91	300	320	0	0	0	0	17	0	0	17	1	18
09-Jun-91	830	845	0	0	0	0	4	0	0	4	0	4
09-Jun-91	1600	1610	0	0	0	0	0	0	0	0	0	0
09-Jun-91	2030	2050	0	0	0	0	0	0	0	0	0	0
10-Jun-91	315	345	0	0	0	0	19	0	0	19	1	20
10-Jun-91	700	715	0	0	0	0	5	0	0	5	0	5
11-Jun-91	230	330	0	0	38	0	2	0	0	40	0	40
11-Jun-91	645	705	0	0	7	0	0	0	0	7	0	7
11-Jun-91	2115	2140	0	0	0	0	2	0	0	2	0	2
12-Jun-91	315	340	0	0	0	4	18	0	0	22	0	22
12-Jun-91	640	650	0	0	5	0	0	0	0	5	0	5
12-Jun-91	2045	2100	0	0	0	0	0	0	0	0	0	0
12-Jun-91	220	235	0	0	0	0	6	0	0	6	0	6
13-Jun-91	635	650	0	0	0	0	10	0	0	10	0	10
13-Jun-91	2045	2100	0	0	0	0	1	0	0	1	0	1
14-Jun-91	315	325	0	0	0	0	20	0	0	20	0	20
14-Jun-91	630	655	0	0	0	0	9	0	0	9	0	9
14-Jun-91	2115	2130	0	0	0	0	1	0	0	1	0	1
15-Jun-91	315	330	0	0	0	0	10	0	0	10	0	10
15-Jun-91	1110	1125	0	0	0	0	2	0	0	2	0	2
15-Jun-91	2045	2100	0	0	0	0	0	0	0	0	0	0
16-Jun-91	500	525	0	0	0	0	5	0	0	5	0	5
17-Jun-91	20	40	0	0	0	0	5	0	0	5	0	5
17-Jun-91	640	650	0	0	0	0	5	0	0	5	0	5
17-Jun-91	2330	340	0	0	0	0	0	0	0	0	0	0
18-Jun-91	650	700	0	0	0	0	2	0	0	2	0	2
19-Jun-91	700	715	0	0	0	0	0	0	0	0	0	0
19-Jun-91	1515	525	0	0	0	0	1	0	0	1	0	1
19-Jun-91	2330	340	0	0	0	0	0	0	0	0	0	0
20-Jun-91	630	700	0	0	0	0	7	0	0	7	0	7
20-Jun-91	1520	530	0	0	0	0	0	0	0	0	0	0
20-Jun-91	2315	330	0	0	0	0	3	0	0	3	0	3

Appendix H, continued.

1 Date	2 Time Checked	3 Time Reset	4 Mark LPV	5 Recapture LPV	6 Mark RPV	7 Recapture RPV	8 Marks	9 No Sampled	10 Morts	11 Total Wild	12 Total Hatchery	13 Total Fish
21-Jun-91	825	445	0	0	0	0	12	0	0	12	0	12
21-Jun-91	2320	335	0	0	0	0	0	0	0	0	0	0
22-Jun-91	840	855	0	0	0	0	4	0	0	4	0	4
22-Jun-91	0005	15	0	0	0	0	1	0	0	1	0	1
23-Jun-91	950	1020	0	0	0	0	2	0	0	2	0	2
23-Jun-91	1440	1450	0	0	0	0	0	0	0	0	0	0
23-Jun-91	2330	2345	0	0	0	0	0	0	0	0	0	0
24-Jun-91	650	700	0	0	0	0	0	0	0	0	0	0
25-Jun-91	650	710	0	0	0	0	2	0	0	2	0	2
26-Jun-91	705	715	0	0	0	0	1	0	0	1	0	1
26-Jun-91	1705	1730	0	0	0	0	0	0	0	0	0	0
27-Jun-91	700	715	0	0	0	0	4	0	0	4	0	4
28-Jun-91	915	940	0	0	0	0	2	0	0	2	0	2
29-Jun-91	800	820	0	0	0	0	2	0	0	2	0	2
30-Jun-91	650	710	0	0	0	0	0	0	0	0	0	0
end of season												

APPENDIX I

Incidental species caught in the Tucannon River downstream migrant trap during 1990/1991 season, with an indication of relative abundance.

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

APPENDIX J

Standardized canonical coefficients for Euclidean (morphormetric) distances classified by origin and/or brood year.

Table 1. Standardized canonical coefficients for Euclidean (morphometric) distances classified by origin (hatchery versus wild) 1989, 1990, and 1991 adult female and male Tucannon spring chinook salmon.

Euclidean distance	First canonical coefficient	
	female	male
Fork length	-0.255694371	-0.011287298
Postorbital-hypural	-0.148657501	-1.363338488
Kype	0.253807891	0.317370306
Dorsal fin height	0.233547101	0.078233819
Dorsal fin base	0.245806559	-0.833223184
Caudal peduncle	0.496842318	-1.192264108
Anal fin base	1.398398639	2.514031700
Anal fin height	0.160271955	-0.125555460
Body depth	-0.293051921	1.231476064
Pelvic fin	0.069861450	0.271461338
Pectoral fin	-0.747993355	-0.070913039

Appendix J, continued.

Table 2. Standardized canonical coefficients for Euclidean (morphometric) distances classified by month of collection for wild-origin 1988 brood juvenile Tucannon spring chinook salmon.

Euclidean distance	Standardized canonical coefficients		
	First	Second	Third
Snout-maxillary	1.05363786	4.13467983	-3.88212872
Maxillary-pectoral fin	-0.12296211	2.51376775	-1.66593313
Snout-pectoral fin	-0.05978985	-6.40472696	3.01989997
Neurocranium-maxillary	0.26528638	-1.62556268	0.03728561
Snout-neurocranium	-0.85359431	-0.19982641	-1.16278034
Neurocranium-pectoral fin	-7.21504910	-3.26272013	-0.69130166
Pectoral fin-pelvic fin	-12.95318542	-3.45876126	-0.03728167
Neurocranium-pelvic fin	25.36538324	5.51532618	3.44272191
Pectoral fin- anterior dorsal fin	14.70449927	7.72722379	2.07802066
Neurocranium-anterior dorsal fin	-13.35196767	-6.33800572	-1.13292398
Pelvic fin- anterior dorsal fin	-8.68212442	-0.55383421	2.29986743
Pelvic fin-anterior anal fin	-0.25821545	1.74704492	2.22168820
Anterior anal fin-anterior dorsal fin	0.02934317	-5.42118466	-12.74290188
Pelvic fin-posterior dorsal fin	0.75996663	-0.94704738	-3.58947486
Anterior dorsal fin-posterior dorsal fin	0.35009235	1.63191346	3.57201579
Anterior anal fin-posterior dorsal fin	0.24376887	5.15097810	6.44858402
Anterior anal fin-posterior anal fin	-0.33931235	0.90860292	0.67529523
Posterior anal fin-posterior dorsal fin	0.79277045	-1.58410258	1.30876262
Adipose fin-anterior anal fin	-0.75093675	-0.45159174	0.30480806
Adipose fin-posterior dorsal fin	0.19717933	-0.73497866	0.33912806
Posterior anal fin-adipose fin	-0.11664206	0.26772632	2.59458466
Posterior anal fin-dorsal peduncle	-0.27107946	-0.32081736	3.49647273
Adipose fin-dorsal peduncle	0.65473301	1.37359676	-6.17971963
Posterior anal fin-ventral peduncle	-0.15513166	3.32885630	-5.11816818
Adipose fin-ventral peduncle	-1.03984834	-1.41723855	3.81407147
Dorsal peduncle-ventral peduncle	1.91286518	-2.17555832	1.88277439
Dorsal peduncle-ventral caudal fin	8.25999574	-1.22521416	-2.69135494
Ventral peduncle-ventral caudal fin	-10.76959379	1.80431518	2.81953602
Dorsal peduncle-dorsal caudal fin	-8.94273352	4.18256356	2.76600229
Ventral peduncle-dorsal caudal fin	7.25657810	-4.26517305	-1.42644768
Dorsal caudal fin-bottom caudal fin	3.40247710	-0.81549880	-0.95440088
Snout-hypural plate	3.13189778	1.18036910	-1.00947716

Appendix J, continued.

Table 3. Standardized canonical coefficient for Euclidean (morphometric) distances classified by brood year (1988 versus 1989) for juvenile Tucannon spring chinook salmon reared at the hatchery.

Euclidean distance coefficient	Standardized canonical
Snout-maxillary	0.359491517
Maxillary-pectoral fin	2.579216301
Snout-pectoral fin	-0.543207551
Neurocranium-maxillary	-3.980608750
Snout-neurocranium	-1.119014836
Neurocranium-pectoral fin	1.755561243
Pectoral fin-pelvic fin	-1.097955892
Neurocranium-pelvic fin	-0.105473631
Pectoral fin- anterior dorsal fin	3.710554435
Neurocranium-anterior dorsal fin	0.294068987
Pelvic fin- anterior dorsal fin	-2.535373154
Pelvic fin-anterior anal fin	-0.267151790
Anterior anal fin-anterior dorsal fin	-1.260015615
Pelvic fin-posterior dorsal fin	1.548433589
Anterior dorsal fin-posterior dorsal fin	-1.043099023
Anterior anal fin-posterior dorsal fin	0.046658923
Anterior anal fin-posterior anal fin	0.976843837
Posterior anal fin-posterior dorsal fin	1.445673621
Adipose fin-anterior anal fin	-8.034346018
Adipose fin-posterior dorsal fin	7.009593960
Posterior anal fin-adipose fin	0.410301167
Posterior anal fin-dorsal peduncle	-0.485583705
Adipose fin-dorsal peduncle	3.406973785
Posterior anal fin-ventral peduncle	3.990451657
Adipose fin-ventral peduncle	-3.237763899
Dorsal peduncle-ventral peduncle	-2.154138792
Dorsal peduncle-ventral caudal fin	0.761819401
Ventral peduncle-ventral caudal fin	-0.582319956
Dorsal peduncle-dorsal caudal fin	1.920907253
Ventral peduncle-dorsal caudal fin	-2.165897887
Dorsal caudal fin-bottom caudal fin	-0.211490969
Snout-hypural plate	-0.014296376

Appendix J, continued.

Table 4. Standardized canonical coefficient for Euclidean (morphometric) distances classified by brood year (1988 versus 1989) for juvenile Tucannon spring chinook salmon reared in the river (wild).

Euclidean distance coefficient	Standardized canonical
Snout-maxillary	2.672225561
Maxillary-pectoral fin	-1.647337564
Snout-pectoral fin	-1.688193264
Neurocranium-maxillary	0.132318948
Snout-neurocranium	-1.822838037
Neurocranium-pectoral fin	1.402605226
Pectoral fin-pelvic fin	0.500826528
Neurocranium-pelvic fin	3.047406063
Pectoral fin- anterior dorsal fin	-0.957721191
Neurocranium-anterior dorsal fin	-0.405665902
Pelvic fin- anterior dorsal fin	-1.401965428
Pelvic fin-anterior anal fin	0.888491400
Anterior anal fin-anterior dorsal fin	-2.439475632
Pelvic fin-posterior dorsal fin	1.077314526
Anterior dorsal fin-posterior dorsal fin	1.976136373
Anterior anal fin-posterior dorsal fin	-4.968742956
Anterior anal fin-posterior anal fin	1.381048501
Posterior anal fin-posterior dorsal fin	0.219874070
Adipose fin-anterior anal fin	-1.383931789
Adipose fin-posterior dorsal fin	2.416623334
Posterior anal fin-adipose fin	-3.028403972
Posterior anal fin-dorsal peduncle	-1.004000098
Adipose fin-dorsal peduncle	0.885094586
Posterior anal fin-ventral peduncle	3.566230995
Adipose fin-ventral peduncle	-0.238024285
Dorsal peduncle-ventral peduncle	-0.529103205
Dorsal peduncle-ventral caudal fin	-0.994849183
Ventral peduncle-ventral caudal fin	0.290231030
Dorsal peduncle-dorsal caudal fin	0.539186169
Ventral peduncle-dorsal caudal fin	-0.493263735
Dorsal caudal fin-bottom caudal fin	-0.050403947
Snout-hypural plate	0.812045969

Appendix J, continued.

Table 5. First standardized canonical coefficients for Euclidean (morphometric) distances classified by incubation and rearing environment (river versus hatchery) for the 1986, 1987, and 1988 brood years of juvenile Tucannon spring chinook salmon.

Euclidean distance	Standardized canonical coefficients		
	1986 brood	1987 brood	1988 brood
Snout-maxillary	2.135928536	-1.421695438	4.06292686
Maxillary-pectoral fin	-0.102571293	0.377895926	6.08499922
Snout-pectoral fin	-4.470158088	-0.205809667	-10.77641553
Neurocranium-maxillary	-0.327422693	2.616684184	-1.57406995
Snout-neurocranium	1.932809293	-0.714682499	0.69296900
Neurocranium-pectoral fin	-1.082780037	0.326366966	-2.07305920
Pectoral fin-pelvic fin	-5.616624641	-0.440931157	-3.86507747
Neurocranium-pelvic fin	9.336933769	0.843791207	9.56059842
Pectoral fin- anterior dorsal fin	5.628954420	0.960432043	7.98280953
Neurocranium-anterior dorsal fin	-5.025764237	0.264144074	-7.29326033
Pelvic fin- anterior dorsal fin	-4.258989455	-3.288502281	-4.01028489
Pelvic fin-anterior anal fin	0.657464582	-1.355675290	-1.49775039
Anterior anal fin-anterior dorsal fin	-0.573375037	2.105022189	5.01288771
Pelvic fin-posterior dorsal fin	0.205721662	4.958436479	0.63027164
Anterior dorsal fin-posterior dorsal fin	0.148315300	-0.605728737	-1.25584914
Anterior anal fin-posterior dorsal fin	-2.707705949	-1.958102352	1.51262657
Anterior anal fin-posterior anal fin	-1.888190826	0.134591558	0.72278820
Posterior anal fin-posterior dorsal fin	5.164149282	-0.599719201	-2.87069069
Adipose fin-anterior anal fin	3.515210374	0.454154794	1.61769005
Adipose fin-posterior dorsal fin	-1.920642343	-0.099558675	-1.68179051
Posterior anal fin-adipose fin	0.260324889	0.100708867	0.40890667
Posterior anal fin-dorsal peduncle	2.127267975	-0.156279575	-0.04902134
Adipose fin-dorsal peduncle	-3.317786621	0.268659795	2.20152232
Posterior anal fin-ventral peduncle	-4.802443961	0.401901283	0.39757085
Adipose fin-ventral peduncle	5.530762538	0.092856924	-1.61679724
Dorsal peduncle-ventral peduncle	0.958066797	-0.397455306	0.61891880
Dorsal peduncle-ventral caudal fin	-1.235789414	-0.120677476	-1.38959753
Ventral peduncle-ventral caudal fin	1.893837712	0.461759967	1.20806371
Dorsal peduncle-dorsal caudal fin	0.056976409	0.539509818	-3.51105746
Ventral peduncle-dorsal caudal fin	0.341590374	-0.718512752	3.25761079
Dorsal caudal fin-bottom caudal fin	-1.265356016	-0.662129531	0.44187759
Snout-hypural plate	0.362326172	2.461442229	0.84961144