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TUCANNON RIVER SPRING CHINOOK SUPPLEMENTATION STUDIES

LOWER SNAKE RIVER COMPENSATION PLAN

Washington Department of Fisheries

1990 Progress Report

AFF 1/LSR-91-14

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

1990 ANNUAL REPORT

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ABSTRACT

This report provides a synopsis of activities from 1 April 1990 to 31 March 1991 by the Washington Department Fisheries' Lower Snake River Hatchery Evaluation Program. This work was completed with Fiscal Year 1990 funds provided by the U. S. Fish and Wildlife Service under the Lower Snake River Fish and Wild-life 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 was 428 adults and 34 jacks; enumeration was by trapping adults with a rack adjacent to the hatchery. This was the first year we trapped through spawning; 118 adults arrived at the rack between 29 August and 25 September. In previous years we trapped only to mid-July. Adult returns were comprised of 243 wild salmon and 185 hatchery salmon. This was the first year hatchery salmon returned as adults (age 4+). We collected 126 adults (63 wild and 63 hatchery) and 6 hatchery jacks for broodstock at Tucannon FH. Five wild females (19% of total) and 22 hatchery females (49% of total) died in the holding pond before spawning. Peak of spawning in the hatchery, for both wild and hatchery fish, was 4 September, which coincided well with natural spawners. Eggtake was 147,309 with 33.7% lost before eye-up for a total of 97,708 to hatch.

Spring chinook salmon escapement to Tucannon River spawning grounds was 302 adults and 28 jacks; 180 redds were dug. We inserted radio transmitters in 32 salmon at the rack. We followed 12 tagged fish through spawning, and found a difference in rate of movement and prespawning activity between wild and hatchery fish. We did not find evidence of multiple redd construction by females as we did in 1989, but we saw males spawning with several females. We found indications of adult salmon poaching on Tucannon River.

Smolt-to-adult survival for 1985 brood hatchery salmon is 0.25% (which includes sport and commerical catch), survival for 1985 brood wild fish was 0.60%. Both values are well below the LSRCP design objective of 0.87%. Survivals of 1986 brood hatchery and wild salmon through age 4 are 0.17% and 0.29%, respectively.

Tucannon FH released 145,146 yearling (1988 brood) spring chinook smolts on a volitional basis from 30 March through 10 April 1990. Mean fork length (with coefficient of variation) and total poundage of released smolts were 141.6 mm (13.7) and 13,195, respectively. The salmon had no significant fish health problems during incubation, rearing, or acclimation. Egg-to-

smolt survival was 79.6%. Modal travel time to the downstream migrant trap 38 km downstream of the hatchery was 2- 4 days.

We quantitatively electrofished 30 sites in HMA Stratum, Tucannon River, and found mean spring chinook salmon rearing densities and biomass were 25.80 fish/100m^2 and 96.41 grams/100m^2, respectively. We estimate 40,527 subyearling (1989 brood) salmon reared in this stratum in 1990. We snorkeled 41 sites (with three replicates each) in all five strata, and estimated total late summer subyearling standing crop of 60,050 salmon. The estimate of parr abundance through snorkeling was within 10.6% of the estimate derived through electrofishing. We snorkeled 21 index sites (two replicates each) in the HMA, Hartsock, and Marengo Strata in winter; mean densities ranged from 0.10 fish/100m^2 to 40.33 fish/100m^2. Habitat inventory information is provided on Marengo and Lower Strata, and stream temperatures throughout the river.

We operated a downstream migrant trap from October 1989 through June 1990, and processed 5,778 wild spring chinook salmon. Overall trap efficiency was 20.2%. We estimate 37,484 (with 95 percent confidence interval of 1,317) wild salmon (1988 brood) outmigrated from the Tucannon River in the 1989/1990 season. The egg-to-fry survival rate for wild 1988 brood spring chinook salmon was 14.6%; fry-to-smolt survival for this same group was 53.8%. Overall egg-to-smolt survival for this group was 7.9%.

Stock profile analysis of wild and first generation hatchery spring chinook salmon is made. In 1990, average fecundity and individual egg weight of wild salmon (age 4 and 5) was 3,993 and 0.23 grams (n= 8); average fecundity and individual egg weight of age 4 hatchery salmon was 2,694 and 0.20 grams (n= 10). Sex ratio of wild salmon was 0.78 females per male; sex ratio of hatchery salmon was 1.42 females per male. Average fork length of age 4 wild salmon in 1990 was 712 mm; average fork length of age 4 hatchery salmon was 663 mm. Comparisons of length between other age classes could not be made because of small sample sizes.

Electrophoretic analysis of adult wild and hatchery salmon did not indicate any significant difference between the two populations at any locus studied. Sample sizes were fairly small however, for much statistical power in analyses (39 wild, 43 hatchery). We collected data for adult and juvenile morphometrics, and bilateral meristic symmetry in both wild and hatchery populations.

We provide seven recommendations to improve broodstock management and feeding strategies at both Lyons Ferry and Tucannon Fish Hatcheries, and to improve survival of naturally spawning salmon.

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ACKNOWLEDGMENTS

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This project was funded by the USFWS through the Lower Snake River Compensation Plan.

LOWER SNAKE RIVER COMPENSATION PLAN
TUCANNON RIVER SPRING CHINOOK SALMON
HATCHERY PROGRAM EVALUATION
1990 REPORT

SECTION 1: INTRODUCTION

1.1: Compensation Objectives

Congress authorized the Lower Snake River Fish and Wildlife Compensation Plan (LSRCP) in 1976. As a result of that plan, Lyons Ferry and Tucannon Fish Hatcheries (FH) were designed and are currently under operation. 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 1990). 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 Evaluation Program from the period 1 April 1990 through 31 March 1991. A report on the fall chinook salmon evaluation program for the same period is presented separately (Bugert et al. 1991).

1.2: Description of Facilities

Lyons Ferry FH is located at the confluence of the Palouse River with lower Snake River at river kilometer (RK) 90 (Lower Monumental Pool, Figure 1). For the spring chinook salmon program, design capacity is to rear 132,000 yearling smolts for release at 15 fish per pound (fpp; 8,800 pounds total). Lyons Ferry FH has a single pass wellwater system through the incubators, two adult holding ponds, and 28 raceways, which are used primarily for the fall chinook salmon program. A satellite facility is maintained on 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 is used for both broodstock and yearlings. Returning adult spring chinook salmon are trapped and spawned at Tucannon FH. Progeny are fertilized, incubated, and reared to parr size at Lyons Ferry FH, then trucked back to Tucannon FH for acclimation to river water and release. The first smolt release was in 1987.

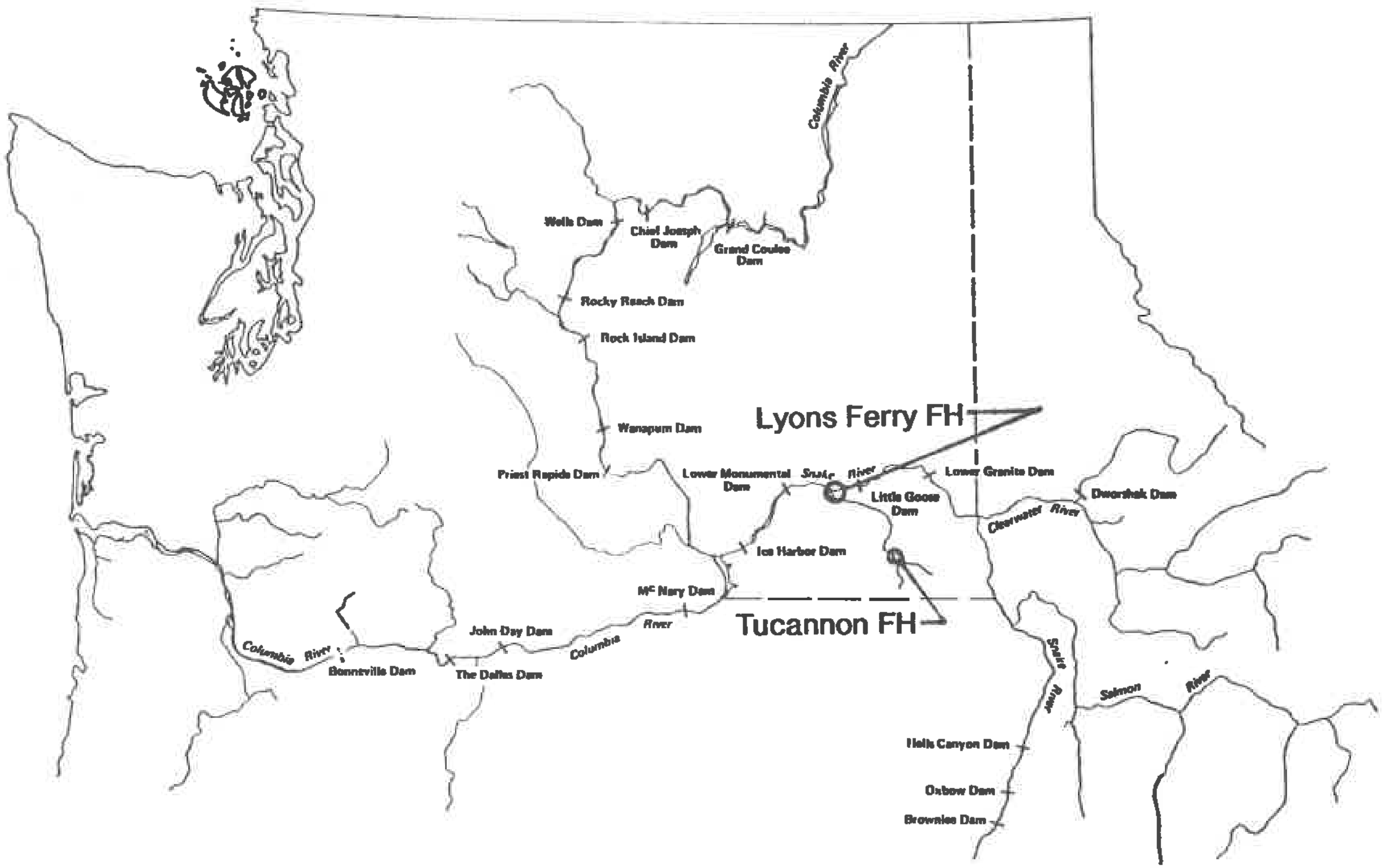

Figure 1. Lower Snake River Basin, showing location of Lyons Ferry and Tucannon Fish Hatcheries.

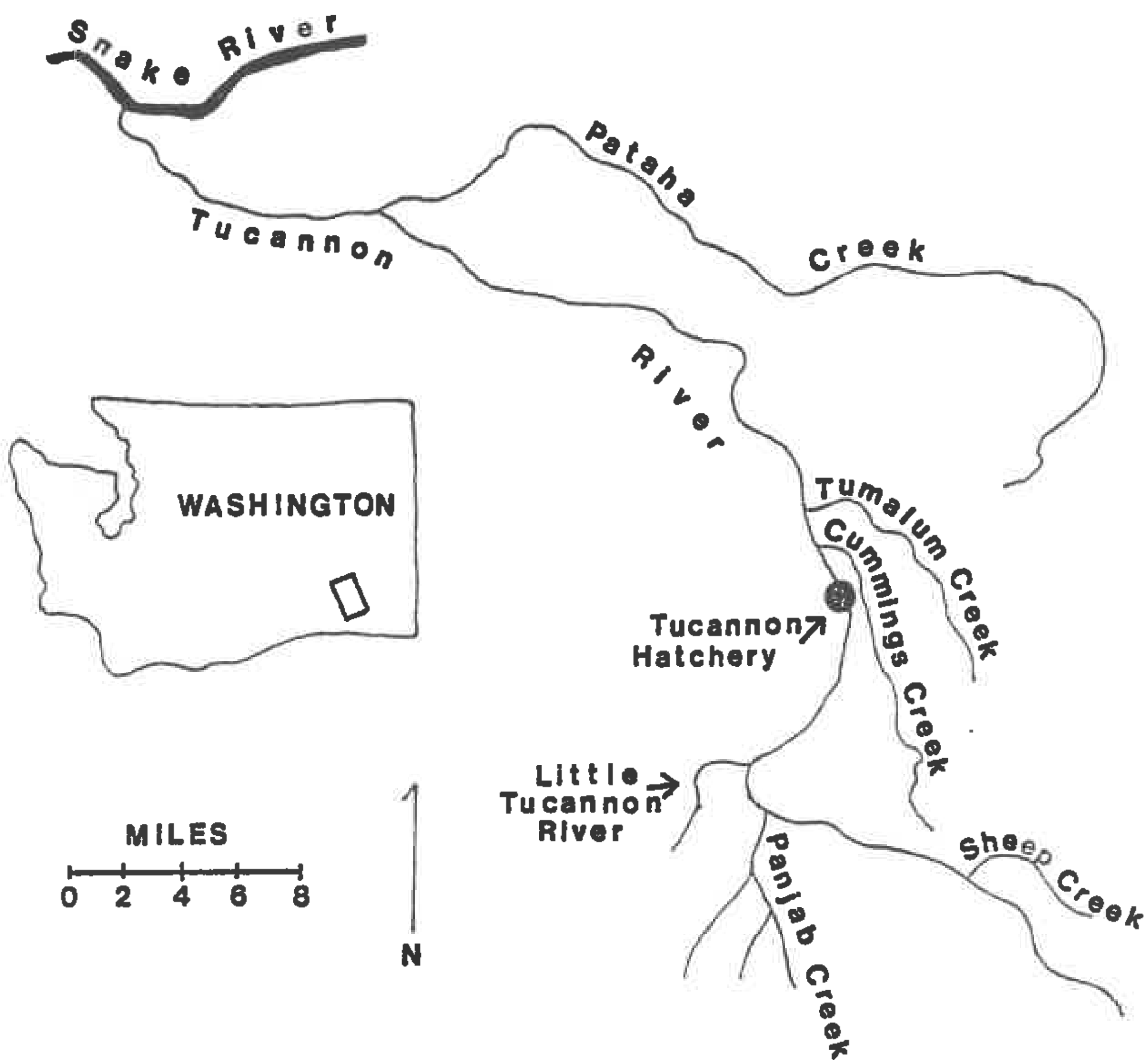

Figure 2. Tucannon River Basin, showing location of Tucannon Fish Hatchery.

SECTION 2: HATCHERY PERFORMANCE

2.1: Broodstock Establishment

The first full-production release of salmon[1] from Tucannon FH was in April 1988 (1986 brood); 1990 was therefore the first year of significant adult (age 4+) returns to the Tucannon River. Evaluation and hatchery personnel operated an adult trap adjacent to Tucannon FH to collect wild[2] and hatchery salmon for broodstock. On a random basis, we collected one fish for every two to three allowed to pass through the rack for natural spawning. Our objective was to take equal numbers of wild and hatchery-origin salmon for broodstock (refer to Section 2.3.3). All hatchery salmon are adipose-fin clipped and coded-wire tagged (cwt), allowing their recognition upon return as adults. The weir was installed in fall 1989, and modified in spring 1990 when styrofoam billets were placed under the floating panels.

In 1990, the first adult arrived at the rack on 7 May; the last adult arrived on 25 September. Peak day of adult arrival was 22 May. We collected 126 adults and 6 jacks for broodstock, and passed 302 adults and 28 jacks upstream. Total escapement to the rack was 428 adults and 34 jacks, of which 243 adults and 6 jacks were wild and 185 adults and 28 jacks were of hatchery origin (Table 1).

Wild salmon run timing and size has changed little since we began broodstock collection in 1986; 247 adult returned in 1986 with the peak on 27 May, 209 returned in 1987 with the peak on 15 May, 261 returned in 1988 with the peak on 24 May, and 188 returned in 1989 with the peak on 6 June. The 1990 peak hatchery salmon arrival was 23 May; wild fish was 22 May. A second arrival peak occurred at the onset of spawning activity; 7 September for hatchery fish and 5 September for wild fish (Figure 3). In past years the Tucannon FH rack was removed in early July, hence pre-spawning movement near the rack was difficult to observe. A permanent rack, first used in 1990, collects upstream migrants daily May through September. In 1990, 118 adults arrived at the rack between 29 August and 25 September. This late surge of fish movement to the rack during spawning was predominantly wild males.

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[1] *To ease reader burden, the term "salmon" refers to Tucannon stock spring chinook salmon, unless otherwise noted.*

[2] *Throughout this report the term "wild salmon" indicates fish that have no hatchery parentage. "Natural salmon" may be the progeny of either wild or hatchery fish which spawned in the river. The 1990 brood natural production will be progeny of either wild or hatchery salmon.*

Table 1. Escapement and collection of spring chinook salmon adults (age 4+) and jacks to Tucannon Fish Hatchery rack in 1990.

Week ending	Escaped to rack		Passed upstream		Collected	
	wild	hatchery	wild	hatchery	wild	hatchery
12 May	3	3	2	1	1	2
19 May	7	10/1a	4	6/1	3	4
26 May	41/1	71	22/1	51	19	20
02 Jun	25	25/2	15	18	10	7/2
09 Jun	19	21/6	7	11/3	12	10/3
16 Jun	16	13/4	12	8/3	4	5/1
23 Jun	6/1	4/3	3/1	2/3	3	2
30 Jun	19/1	9/3	13/1	3/3	6	6
07 Jul	5	2	5	2		
14 Jul	3	2/3	3	1/3		1
21 Jul	2	5	2	4		1
28 Jul	1/1	1/1	1/1	1/1		
01 Sep	13		13			
08 Sep	49/2	10/2	40/2	5/2	9	5
15 Sep	30	5/2	30	5/2		
22 Sep	5	4/1	5	4/1		
29 Sep	1	1	1	1		
Totals\b	245/6	186/28	178/6	123/22	67	63/6

[a] *Jacks are noted in the denominator of weekly escapement tallies.*

[b] *Weekly escapements were estimated; numbers were corrected at end of spawning. Actual numbers were 428 adults escaped (243 wild, 185 hatchery), of which 126 (63 wild, 63 hatchery) were collected for broodstock.*

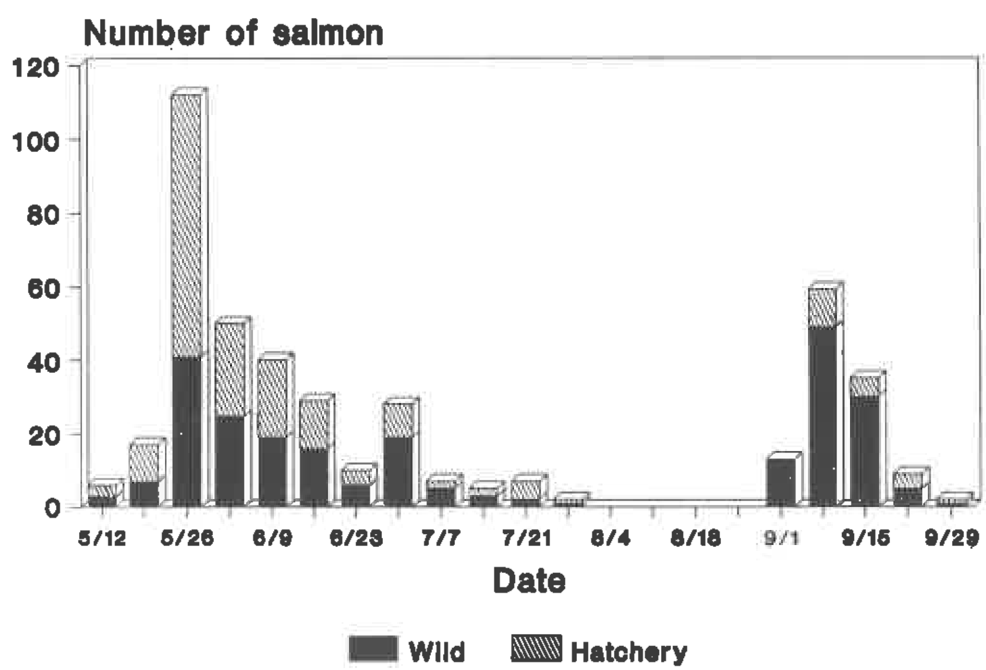

Figure 3. Weekly arrivals of wild and hatchery-origin spring chinook salmon adults to the Tucannon Fish Hatchery rack.

2.2: Smolt-to-Adult Survival

2.2.1: Hatchery-origin salmon

In 1990, no hatchery fish returned from the program's initial release of 12,922 salmon smolts from Tucannon FH (1985 brood year). Total returns of this release group through age 5 is 32 fish (0.25%, Table 2). None of these salmon were recovered in high seas or river fisheries. Total returns from the program's second smolt release of 153,725 smolts (1986 brood year) from Tucannon FH through age 4 is 257 (0.17%). An estimated 5 tagged fish were recovered in Columbia River fisheries, adjusting contribution survival to 262 (0.17%).

Table 2. Returns of hatchery-origin spring chinook salmon to the Tucannon River in 1990. Ages are based upon coded-wire tag recoveries.

Brood year	Smolts released	Escapement			Percent returns
		Age 3	Age 4	Age 5	
1985	12,922	9	23	0	0.25
1986	153,725	72	185[a]	- -	0.17
1987	152,165	28	- -	- -	- -

[a] *Expanded escapement, based upon broodstock collection at Tucannon FH rack.*

2.2.2: Wild-origin salmon

Smolt-to-adult survival for the 1985 brood wild salmon in Tucannon River was 0.60% through age 5 (Table 3), 142% higher than the 1985 brood hatchery salmon. The relative survival rate of the 1986 brood salmon through age 4 is similar in magnitude of difference.

Table 3. Returns of wild-origin spring chinook salmon to the Tucannon River in 1990. Ages are based upon scale impressions.

Brood year	Smolt yield	Escapement			Percent returns
		Age 3	Age 4	Age 5	
1985	35,600[a]	18	133	68	0.60
1986	58,200	5	164	- -	0.29
1987	44,000	11	- -	- -	- -

[a] *Refer to Section 3.2.7 for smolt yield estimation.*

2.2.3: Compensation progress

In 1990, 428 adult and 34 jack salmon returned to the Tucannon River, achieving 37% of the LSRCP mandate of 1,152 adults. This value reflects both wild and hatchery adults, the latter includes only fish through age 4. Our preliminary estimates show a hatchery smolt-to-adult survival rate well below the design objective of 0.87% (Table 2). It appears few salmon contribute to fisheries, based on cwt recoveries (Appendix B).

2.2.4: Stray returns

We recovered cwt from spring chinook salmon spawned at Tucannon FH that were strays: two cwt from Meecham Creek, Umatilla River, and one cwt from Lookingglass FH, Grande Ronde River (Appendix B, Table 6).

2.3: Lyons Ferry/Tucannon Hatchery Practices

2.3.1: Adult holding and spawning

Salmon were spawned at Tucannon FH; unfertilized gametes were transported to Lyons Ferry FH for fertilization, incubation, and rearing. Spawning occurred from 21 August to 25 September 1990, with peak eggtake on 4 September (compared to 17 September in 1986, 19 September in 1987, 7 September in 1988, and 5 September in 1989). Peak of spawning was roughly the same for both wild and hatchery salmon. Eggtake was 147,309 with 33.7% lost before eye up, for a total of 97,708 survival to hatch. This high egg mortality may be the result of 1) delayed retention time and warming of gametes before transport to Lyons Ferry FH for fertilization, or 2) infertile gametes used in single pair matings (Appendix C).

Five wild females (19% of total) and 22 hatchery females (49% of total) died in the pond before spawning (Table 4). This loss was higher than previous years (16% in 1986, 14% in 1987, 30% in 1988, and 26% in 1989), despite an aggressive inoculation program (Section 2.3.5). We cannot attribute the disparity in mortality between wild and hatchery salmon to any causes.

2.3.2: Sperm cryopreservation and evaluation

Cryopreservation Semen was collected from nine salmon for freezing. Cryoextender was mixed with sperm at a ratio of 3:1 (Wheeler and Thorgaard 1991). The mixture was then pulled into a 4 ml straw and both ends sealed. The straw was frozen on dry ice, then transferred to a liquid nitrogen tank.

Evaluation of sperm quality Motility and sperm cell density are two indicators of sperm quality. Motility is estimated by use of a microscope, and expressed as a percent. Sperm moving in a forward direction are considered motile. Motility is the easiest and more accurate indicator for sperm quality. Sperm cell density is another indicator. In a joint study with Washington State University (WSU) genetics staff, we calculated sperm cell density on four semen samples. Sperm cell density was correlated to optical density of a diluted sample of semen. Optical density was measured using a spectrophotometer.

Before using the spectrophotometer to read cell density, a regression line must be derived. Aliquots of a semen sample were diluted to a series of concentrations; we used 1/100, 1/200, 1/400, and 1/4000. Cell density in each of these samples was counted using a hemocytometer (through a microscope). Samples were counted four times each by two people and an average count was used to ensure accuracy. The optical density (% absorbance at 550*nm*) was then measured for these samples (Appendix C, Table 1). A linear regression of optical density on sperm cell concentration indicated a strong relationship (r^2=0.98). We saved this information for use whenever cell densities need to be measured.

Wheeler[1] recommended use of motility as the primary indicator for sperm quality. Samples of semen that appear thickest have been proven to be better samples than thin samples. In the field, observations of semen consistency and motility checks are best indicators for sperm quality.

2.3.3: Hatchery matings

We began an experiment to examine genotypic and phenotypic differences between inter se matings of hatchery-origin and wild-origin salmon. The objective of this study is to determine if measurable genetic differences occur in early survival, growth, or rate of return as a result of one generation of hatchery rearing.

Thirty-eight females were spawned, 19 hatchery/hatchery and 19 wild/wild matings. Another six females were spawned as a wild/hatchery mixed lot, but are not part of the study design (Table 4). Hatchery staff counted eggs after shocking. A total of 51,700 eggs was collected from hatchery parents and 74,634 eggs from wild parents. Egg survival in both groups was low; 27,563 hatchery-origin (53.3% of total) and 54,357 wild-origin (72.8% of total) eggs survived to eye up. Survival rate of mixed lot eggs was 75.3% (15,788).

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[1] *Paul Wheeler, Department of Zoology, Washington State University, Pullman, WA 99164.*

Table 4. Spawning and holding mortality of hatchery and wild spring chinook salmon at Tucannon Fish Hatchery in 1990.

	Hatchery salmon				Wild salmon			
	spawned		mortality		spawned		mortality	
Date	M	F	M	F	M	F	M	F
5 Jun				1				
5 Jul				1				
30 Jul								1
21 Aug	3	1	1	2	2			
28 Aug			2	2	3	1		
4 Sep		6	3	2		12		2
11 Sep	2	8	2	11	3	8	5	1
18 Sep	3	5	5	3			22	
25 Sep	1	3	1		1		4	1
Totals	9	23	14[a]	22	9	21	31[a]	5

[a] *Most males were live-spawned and tallied when they died.*

2.3.4: Incubation and rearing

<u>1989 brood</u> The 1989 brood salmon were given three Gallimycin feedings during rearing: in April, June, and August 1990. This is the first brood year given three prophylactic treatments for bacterial kidney disease (BKD), instead of two.

<u>1990 brood</u> In general, hatchery fish did not survive as well as wild fish in the incubation and hatching stages of routine hatchery rearing. A larger percentage of eggs from hatchery salmon did not hatch (x= 10.57%, s= 12.76, range: 0- 47.2%) compared to eggs of wild salmon (x= 4.52%, s= 5.90, range: 0- 23.8%). Moreover, a larger percentage of fry from hatchery salmon died during the period from hatching to ponding (x= 2.52%, s= 3.49, range: 0- 15.6%) compared to fry from wild salmon (x= 0.75%, s= 0.95, range: 0- 3.8%).

During routine examinations of fry one to three months after ponding, WDF pathologist T. Black[1] noted a higher percentage of deformed fry of hatchery salmon relative to fry of wild salmon. The period between fertilization and hatching was shorter in eggs of hatchery salmon than wild salmon. Temperatures and other environmental conditions were the same for both groups.

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

2.3.5: Disease incidence

The 1990 adult salmon were injected with both Erythromycin and Liquimycin at time of trapping, and twice again with Erythromycin prior to spawning to treat 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 disease problems occurred in the 1989 or 1990 broods during the study period (1 April 1990 to 31 March 1991).

2.3.6: Smolt releases

Lyons Ferry staff transported 152,933 yearling (1988 brood year) salmon to the adult holding pond at Tucannon FH on 15 November 1989. Fish were acclimated to river water up to five months prior to release. Fish were allowed a volitional release from 30 March through 10 April 1990. Number of fish released was 145,146 smolts (13,195 lbs; 11 fpp). Mean fork length and coefficient of variation of smolts at release were 141.6 mm and 13.7, respectively (Figure 4). Overall feed conversion rate for these fish was 1.50. Egg-to-smolt survival was 79.6%. Mortality from ponding to planting was 7.13%. Mortality during acclimation was 5.09%. All fish were coded-wire tagged and adipose-fin clipped. The female to male ratio at release was 1:1 (n= 30).

Program staff monitored travel time of hatchery smolts to the downstream migrant trap 38 km downstream of the hatchery (Section 3.2.7). Seventy-nine hatchery smolts (0.05% of total released) were sampled. Modal travel time for the smolts was 2-4 days. We found 47% were descaled in two or more zones.

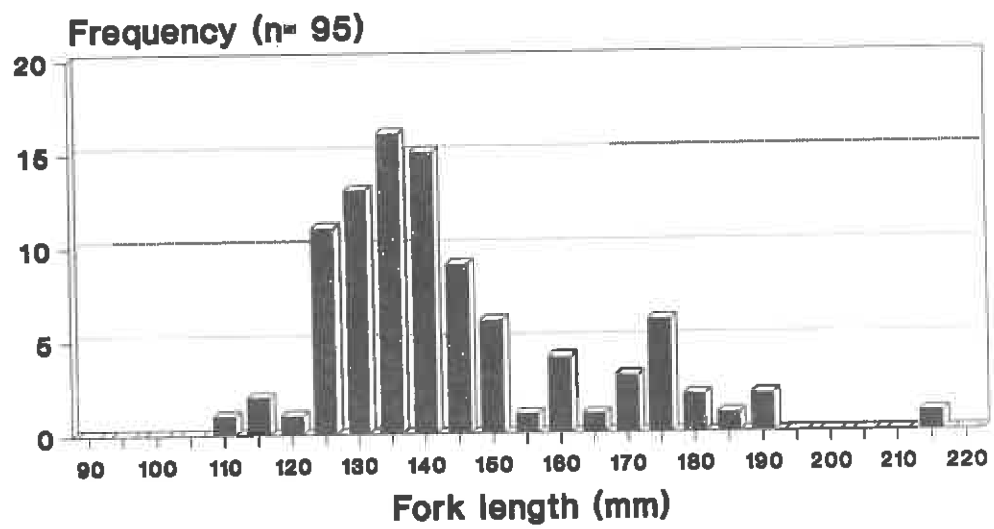


Figure 4. Length frequency distribution of 1988 brood spring chinook salmon released from Tucannon Fish Hatchery in 1990.

SECTION 3: NATURAL PRODUCTION

From 1985 to 1989, program staff collected biological information on 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. The first year significant numbers of hatchery fish returned to the Tucannon River was 1990.

We are evaluating the effects of supplementation through two complementary strategies: 1) stock profile analysis, using a combination of electrophoresis, morphometrics, meristics, and quantifiable measures of fish behavior and productivity (presented in Section 4), and 2) observation of the population dynamics of wild and hatchery-origin salmon naturally producing in the Tucannon River. The following discussion pertains to the research on the population dynamics aspects of this program.

<u>Watershed description</u> 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:

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

The Lower, Marengo, and Hartsock Strata are within agricultural bottomland which receives limited water diversion for summer irrigation. Sections of the stream within these strata have a poorly defined or braided stream channel. Banks are often unstable with limited riparian areas. Water temperatures often exceed the upper threshold of 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 in the life cycle. The Wilderness Stratum is in the Wenaha-Tucannon Wilderness Area, a part of the Umatilla National Forest.

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

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

3.1: 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, snorkeling surveys, and spawning ground surveys.

3.1.1 Snorkel surveys

We made two snorkeling surveys in July to count adults holding downstream of the rack. We had two objectives in these surveys: 1) refine our estimate of total escapement to the river (upstream and downstream of the rack), and 2) assess in-river movement prior to spawning. Typically we see about 40 adults (15 percent of total) holding below the rack. In 1990, two surveys were made; 25 and 29 adults were counted. Snorkeling surveys and redd counts in previous years suggest that fish hold downstream of the rack and move again prior to spawning.

In past years, the Tucannon FH rack was removed in July, making pre-spawning movement past the rack difficult to observe. In 1990, the rack remained in the river and was checked daily through September. One-hundred eighteen adults arrived at the rack between 29 August and 25 September (Figure 3). The late arrival of these fish indicates that snorkeling surveys under-estimate the actual number of adults holding below the rack. The rack probably does not prevent fish from moving downstream; we believe downstream movement may occur during spawning. Adults may move upstream to escape intolerable water temperatures during midsummer and move downstream to spawn when water temperatures decrease. Most fish trapped in September were wild males; these fish could be searching for females to ensure gamete contribution with several mates.

3.1.2: Radio telemetry

Migrating adults were either passed upstream or collected for broodstock at Tucannon FH rack. On a random basis we anesthetized some salmon at the rack with carbon dioxide and inserted radio tags into the esophagus prior to releasing them upstream. At time of tagging, we recorded fork length, post-orbital to hypural plate length, general condition, and if possible, sex of each fish. Each radio tag transmitted a unique frequency/pulse combination enabling us to track individual fish. Fish were tracked at approximately three day intervals. General tracking was done in vehicles from the road. We identified precise locations of salmon that appeared to be holding in one location six days or longer to record the type of habitat used. In August, we verified the sex of tagged fish by underwater observation.

Radio tags were inserted into 32 fish. Eight tags were regurgitated and recovered within seven days. Two tags were lost; one was assumed malfunctional because it never transmitted, the other either malfunctioned or was removed from the study area. Ten tags were recovered from fish found or presumed dead as a result of unknown causes. Twelve tagged fish spawned; four hatchery origin fish (two males and two females), and eight wild salmon (four males and four females).

Fish frequently held in a pool or an undercut bank, often for a period of up to 57 days (compared to a maximum of 73 days in 1989). Wild salmon generally moved further upstream in their initial movement (Figures 5 and 7) than hatchery fish (Figures 6 and 8). We observed several females spawning over redds previously dug by other salmon. In Wilderness Stratum, we observed nine adult and one jack salmon competing for a small spawning area, with females spawning over completed redds. We did not find evidence of females digging multiple redds, but we did see males spawning with several females, a phenomenon observed in coho salmon by Gross (1984, 1985). After completing a redd, females remained in that location until they died.

Several observations made during our radio tracking lead us to suggest that poaching of salmon occurs on Tucannon River: 1) one tag was recovered hidden on the bank under a tree root. There was no evidence that the fish was eaten by an animal and the tag position could not have been the result of regurgitation by the fish; 2) another tag was seen in a fish and the signal received at the hatchery intake during redd counts. The following day the tag could not be received anywhere along the river. The intake is a popular location for trout anglers; 3) one tag was found in the river at a campsite 1 km downstream of the rack. During our study, tagged salmon did not move downstream of the rack; the fish may have been carried there.

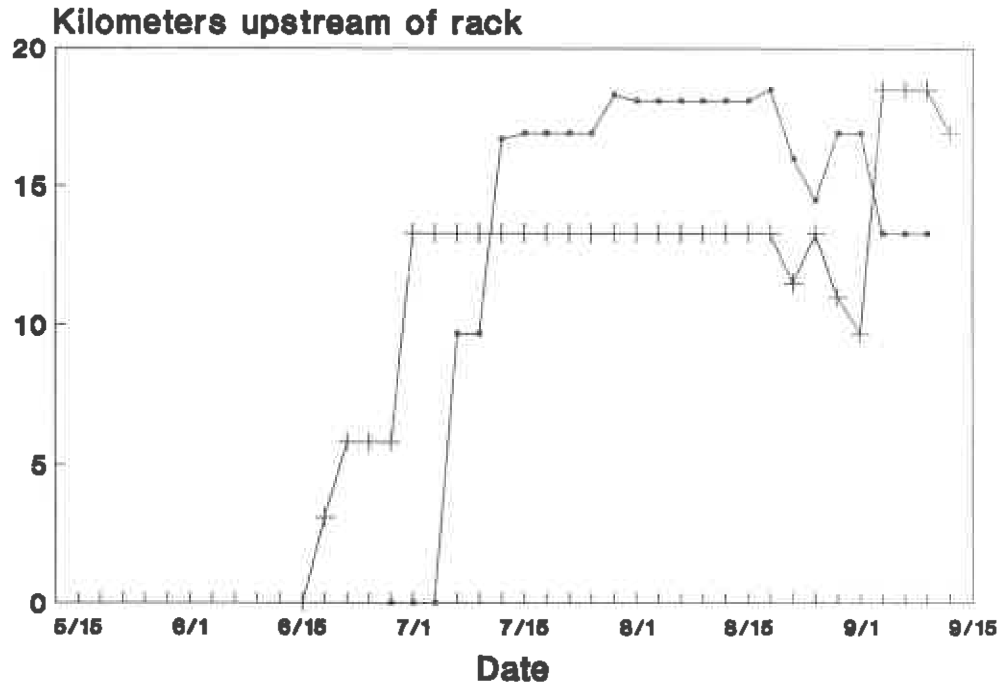


Figure 5. Movement of two radio tagged wild male spring chinook salmon past Tucannon Fish Hatchery rack in 1990.

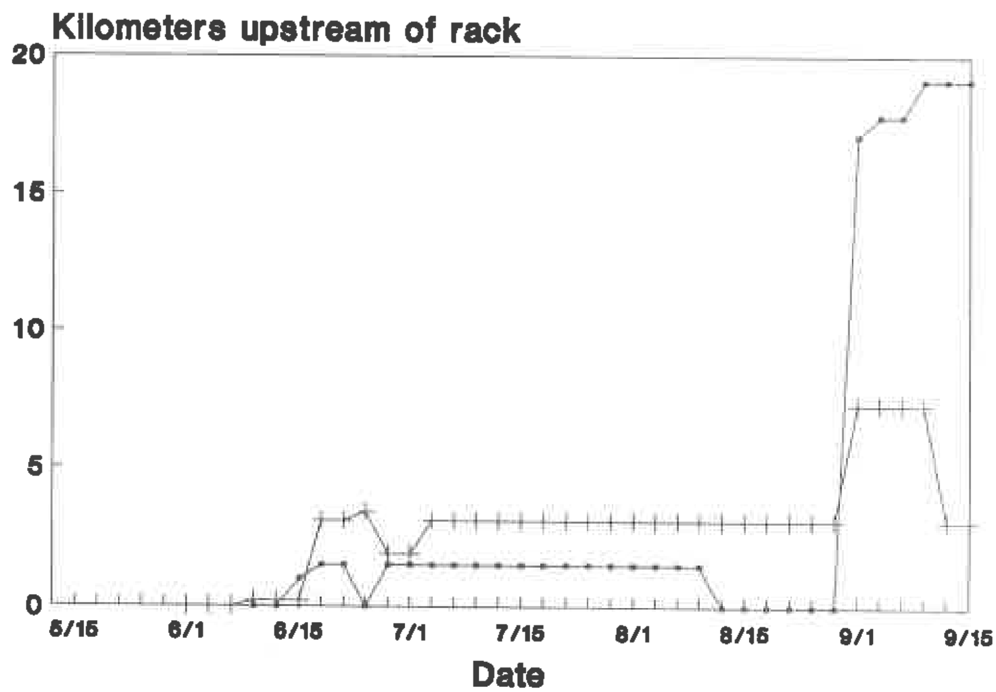


Figure 6. Movement of two radio tagged hatchery male spring chinook salmon past Tucannon Fish Hatchery rack in 1990.

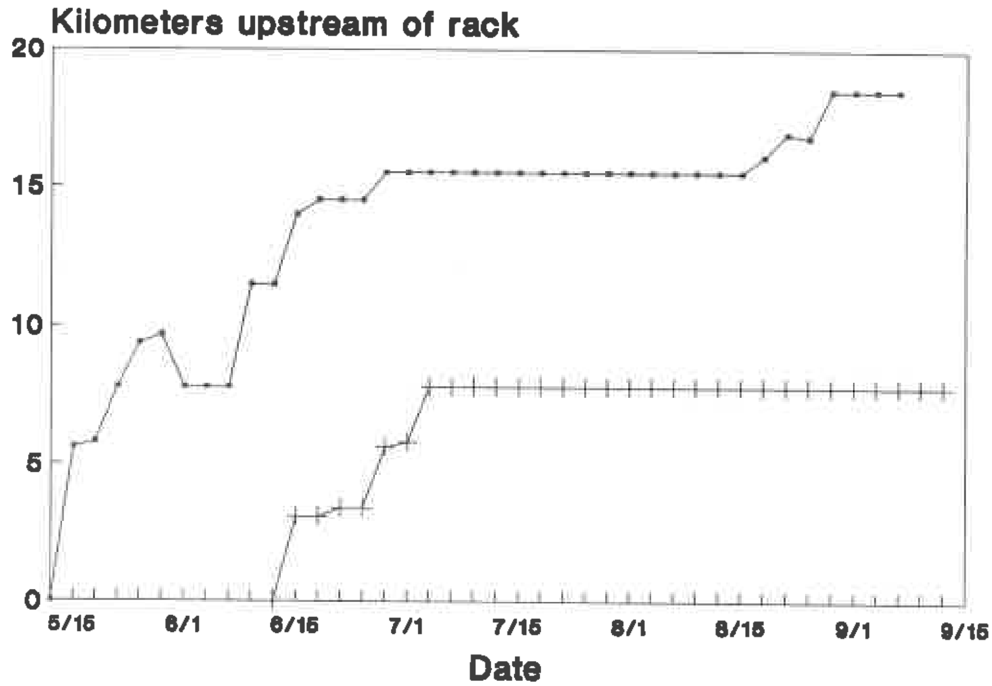


Figure 7. Movement of two radio tagged wild female spring chinook salmon past Tucannon Fish Hatchery rack in 1990.

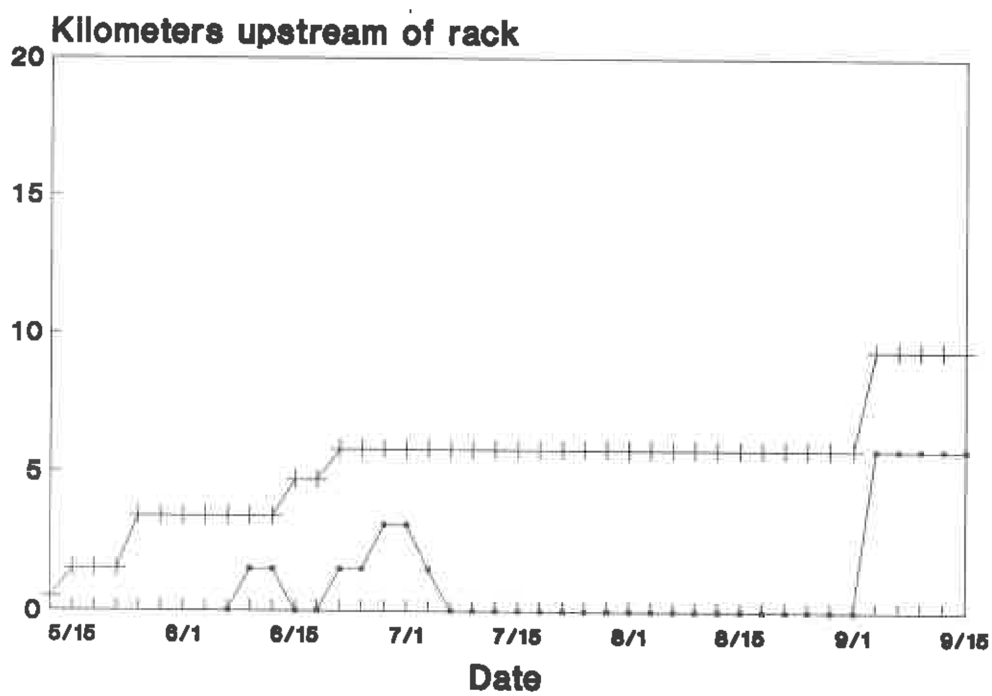


Figure 8. Movement of two radio tagged hatchery female spring chinook salmon past Tucannon Fish Hatchery rack in 1990.

3.1.3: Spawning ground surveys

Tucannon River Program staff surveyed salmon spawning grounds on the upper Tucannon River to determine the temporal and spatial distribution of spawning and to assess the abundance and density of spawners. Spawning grounds were surveyed on 29 August, 5, 12, 19, 20, 24, 26 September, 2, 4, and 11 October. Person-days required for the surveys were 4, 6, 7, 5, 5, 1, 4, 2, and 3 respectively. A composite survey on 19 and 20 September encompassed all known spring chinook salmon spawning areas in the Tucannon River.

Total number of redds observed in the Tucannon River in 1990 was 180 (Table 5). Number of redds sighted increased from the previous five year mean of 159 redds (Table 6), and the 20 year mean of 127 redds. The Tucannon River tributaries were not surveyed in 1990 because we saw no evidence of spawning there since our studies began in 1985.

A large percentage of carcasses was found in the spawning ground surveys, particularly wild salmon (51% of total known spawners). We found fewer hatchery carcasses (20% of total known spawners, Table 5). Sex ratios were roughly the same between wild and hatchery carcasses. We examined 28 wild female carcasses; one had retained all eggs, and the remaining 27 females spent all eggs. We examined 11 hatchery female carcasses; one had spent about 65% of its eggs, the remaining 10 females spent all eggs.

Table 5. Number of spring chinook salmon redds observed and general location of hatchery (H) and wild (W) carcasses recovered in Tucannon River spawning ground surveys, 1990.

Stratum	River km	Number of redds	Carcasses recovered: Females (H, W)	Males (H, W)	Jacks (H, W)
Wilderness	85- 75	20	1, 1	0, 0	1, 0
HMA	75- 69	24	3,11	3, 9	0, 1
	69- 64	36	7, 1	2, 8	0, 0
	64- 55	34	1, 7	0, 8	0, 0
Hartsock	55- 48	37	4,18	3,17	0, 1
	48- 43	27	1, 5	0, 6	0, 0
Marengo	43- 35	2	0, 0	0, 1	0, 1
Totals		180	17,43	8,49	1, 3

Table 6. Comparison of spring chinook salmon redd densities (redds/km and redds/ha) by stratum and year, Tucannon River, Washington.

Stratum	1985 km (ha)	1986 km (ha)	1987 km (ha)	1988 km (ha)	1989 km (ha)	1990 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)
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)
Hartsock	- -	2.28 (1.84)	2.36 (1.90)	1.57 (1.27)	1.81 (1.45)	5.04 (4.09)
Marengo	- -	0.00	- -	- -	- -	0.25 (0.20)

Redd densities increased in the lower HMA and Hartsock Strata (Table 6), which appeared to be where the majority of hatchery-origin salmon spawned. Twenty redds were observed in Wilderness Stratum of Tucannon River, which is 10.1 km long, resulting in a density of 1.98 redds/km (2.44 redds/ha). We found 94 redds in the 20.2 km long HMA Stratum, which is a density of 4.65 redds/km (4.00 redds/ha). In the 12.7 km long Hartsock Stratum we observed 64 redds for a density of 5.04 redds/km (4.09 redds/ha). We surveyed the upper 8.0 km of Marengo Stratum and saw two redds for a density of 0.25 redds/km (0.20 redds/ha).

From the nine counts on the Tucannon River, we concluded that the peak of spawning for salmon varied between strata. Peak of spawning in the Wilderness and HMA Strata was 12 September and 24 September in the Hartsock Stratum. One redd was deposited in the Wilderness Stratum on 29 August and one new redd was dug in the Marengo Stratum on 11 October, indicating the duration of spawning to be at least 44 days.

In general, redd counts are directly related to escapement past the Tucannon FH rack (Figure 9); since 1986, the ratio of adults allowed past the rack to total river redd deposition is 0.86 (range: 0.58- 1.21).

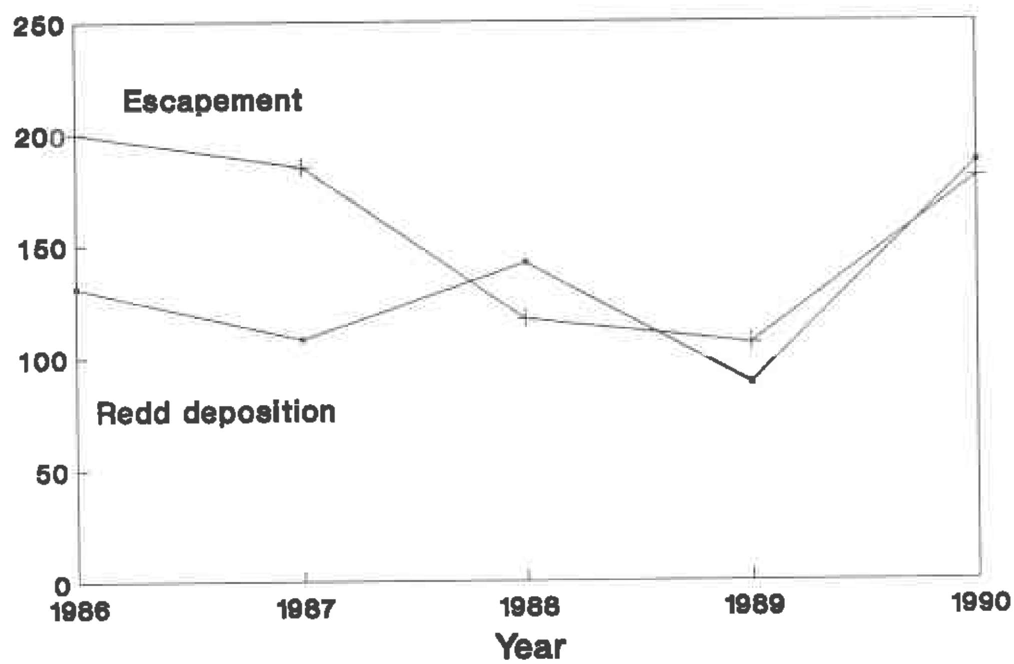


Figure 9. Spring chinook redds deposited in upper Tucannon River in relation to escapement past the hatchery rack, 1986 to 1990.

<u>Asotin Creek</u> On 10 October we surveyed the North Fork of Asotin Creek from the South Fork confluence 7.2 km upstream. Two redds were found; density is 0.28 redds/km (0.34 redds/ha). There were no redds deposited in this reach in 1989, one redd in 1988, three redds in 1987, and one redd in 1986.

<u>Wenaha tributaries</u> Tributaries of Wenaha River that extend into Washington State and have salmon are North Fork Wenaha River and Butte Creek. We were unable to survey these streams in 1990 because of time constraints.

3.2: Juvenile Population Dynamics

We conducted electrofishing surveys on Tucannon River from 1 August through 25 September 1991. Annually we sample selected index sites within each stratum to determine trends in juvenile salmonid production (Refer to our FY 1988 report for a description of site locations). Sampling design and methods for these surveys are presented in our FY 1986 report. Habitat types are defined as suggested by Helm (1985, Appendix D). We did not survey parr production by electrofishing in Wilderness and Hartsock Strata in 1990; estimates of standing crop there were made from WDW electrofishing data, and snorkel surveys by program staff (Section 3.2.1).

We used the depletion method to calculate population estimates of juvenile salmon (Zippin 1958) from our electrofishing surveys, and analyzed these data using the Burnham Maximum Likelihood method (Van Deventer and Platts 1983). We conducted snorkel surveys in Wilderness, HMA, and Hartsock Strata during summer to compare electrofishing and snorkeling techniques (Appendix E) and provide population estimates for these strata.

We conducted snorkel surveys at index sites during summer to provide complementary information to the electrofishing data. We also snorkeled some sites during winter to gain information on overwinter survival and habitat use (Section 3.2.6).

We used a modified line transect sampling method (Emlen 1971) for snorkeling to estimate juvenile salmonid abundance during summer and winter in Tucannon River. Summer snorkeling surveys were done between 24 July and 1 October, within the electrofishing time frame, enabling us to compare these two techniques for population estimation. All electrofishing index sites were snorkeled three times (each time by a different person to reduce bias) to estimate densities of salmon parr.

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

We calculated the area surveyed by multiplying the mean transect length (measured to the nearest decimeter) by the furthest 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 three replicates.

3.2.1: Wilderness Stratum parr production

Methods Some of the index sites established in previous years (representing three distinct habitat types; riffles, runs, pools) were selected at random for parr production surveys in 1990. Seven index sites in Wilderness Stratum were electrofished by WDW between 24 July and 25 August 1990 (S. Martin[1]). Six sites were

[1] *Steve Martin, Washington Department of Wildlife, 411 South First St., Dayton, WA 99328.*

snorkel surveyed by program staff between 16 July and 18 August; two sites of each habitat type (riffle, pool, run), with three replicate surveys. At least two replicates of each habitat type were sampled using each survey method.

<u>Results</u> Mean density and biomass for subyearling spring chinook collected by electrofishing was 18.67 fish/100m^2 and 41.50 grams/100m^2 (Table 7). Washington Department of Wildlife personnel measured 93 subyearling salmon parr during the 1990 electrofishing surveys (Figure 10); mean length was 61.6mm (s= 8.5). Mean weight of those salmon parr weighed was 4.19gm (s= 0.98, n= 27); average condition factor was 1.256 (s= 0.455, n= 27). Nine parr were assumed to be yearlings; average length was 112.8mm (s= 8.0).

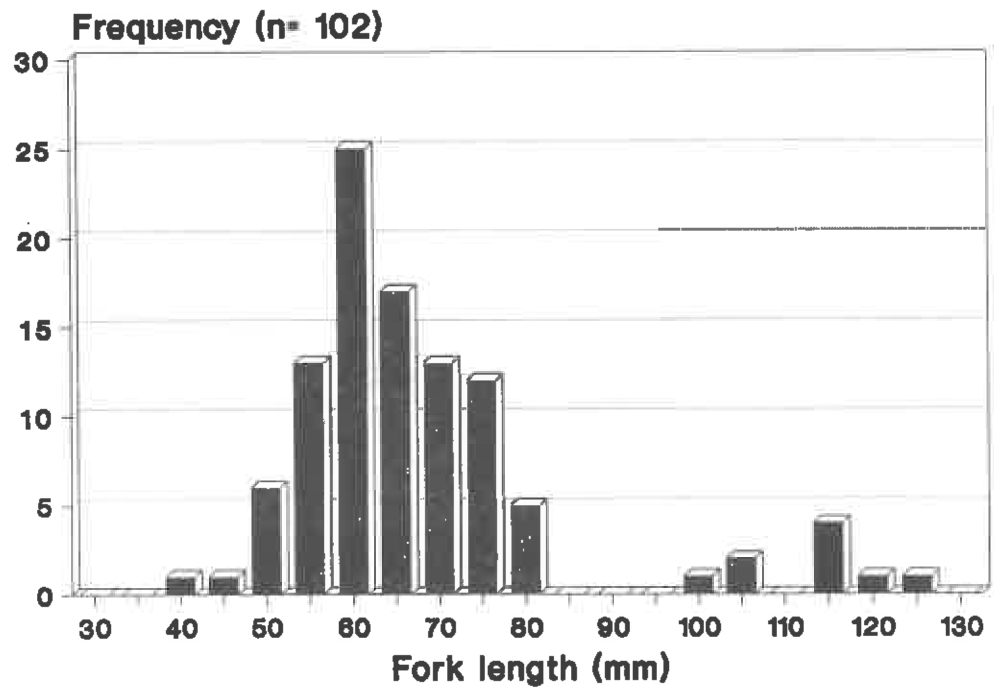


Figure 10. Length frequency distribution of spring chinook salmon measured during electrofishing surveys in Wilderness Stratum, 1990.

Table 7. Subyearling spring chinook salmon parr densities and biomass by habitat type in Wilderness Stratum, 1990. Values are derived from snorkeling and electrofishing surveys.

Habitat type[a] site	Snorkeling density (fish/100m^2)	Electrofishing Density (fish/100m^2)	Electrofishing Biomass (grams/100m^2)
Riffle			
Wild 4		10.7	22.79
Wild 13		10.4	26.00
Wild 14	7.6	10.0	21.93[b]
Wild 12	2.0		
Mean	4.80	10.37	23.57
Run			
Wild 9		11.3	23.39
Wild 15	11.3	16.3	35.75[b]
Wild 10	6.8		
Mean	9.05	13.80	29.57
Pool			
Wild 11	60.2	58.3	127.85[b]
Wild 19		13.8	32.77
Wild 3	41.8		
Mean	51.00	36.05	80.31

[a] *Area available in Wilderness Stratum for each habitat type is 61,595m^2 of riffle, 10,763m^2 of run, and 5,212m^2 of pool.*

[b] *Too few weights taken; we used the overall mean weight of 2.19 grams/fish for subyearlings sampled in Wilderness Stratum.*

Mean densities from snorkel surveys were 4.78 fish/100m^2 in riffles, 9.06 fish/100m^2 in runs, and 50.95 fish/100m^2 in pools. Mean densities from both snorkeling and electrofishing techniques were highest in pools and lowest in riffles. Densities for three of four index sites in 1990 exceeded densities for the same sites in 1989 (Appendix E, Table 3). On average, density estimates derived from snorkeling and electrofishing methods differed 24% for all habitat types.

We estimate from the electrofishing data that 9,509 subyearling (1989 brood) salmon parr reared in Wilderness Stratum during summer 1990. This estimate was obtained by multiplying mean densities of subyearlings for each habitat type by the total area within each habitat type for the Wilderness Stratum (based on a habitat inventory conducted in 1985). This estimate of subyearling parr production is double the 1989 production estimate (4,589 parr).

We also calculated a population estimate of subyearling parr based on mean densities derived from our snorkeling of the different habitat types. Our estimate derived through snorkeling is that 6,578 subyearling parr reared in Wilderness Stratum in 1990. While both methods provide higher population estimates than in 1989, they provide substantially different population estimates for 1990. The population estimate derived by electrofishing in 1990 is most comparable to population estimates for previous years because electrofishing was used for all previous parr production estimates. Average length of parr measured in Wilderness Stratum was larger than in HMA Stratum, but condition factors were lower (Figures 10, 12).

3.2.2: HMA Stratum parr production

Methods We surveyed established index sites selected at random during previous years that consisted of five distinct habitat types in the HMA Stratum: riffles, pools, runs, boulders and side channels. We snorkeled and electrofished six replicates of each habitat type for a total of 30 index sites for each sampling method. These sites have been electrofished yearly since 1986.

Results We surveyed 1.65% of the stream during electrofishing surveys of HMA Stratum. Mean densities and biomass were 25.80 fish/100m^2 and 96.41 grams/100m^2 respectively. Parr production was highest in pools, and lowest in riffles (Table 8). Given these densities, we estimate 40,527 subyearling (1989 brood) salmon reared in HMA Stratum during summer 1990. This estimate is based on a habitat inventory conducted in 1987 and weighted by habitat quality (FY 1987 report, Appendix D). Parr production in 1990 was 9.7% less than during 1989 (Figure 11, and Appendix E, Table 1). We measured 927 salmon parr during the 1990 electrofishing surveys; mean length was 67.3 mm (s= 10.9, Figure 12). Mean weight of all weighed salmon was 4.59 grams (s= 3.86, n= 467); average condition factor was 1.294 (s= 0.211, n= 467).

Snorkel survey estimates of mean densities were higher in pools, boulders, riffles and side channels than estimates derived from a multiple-pass electrofishing method (Appendix E, Table 2). Densities were higher in the runs using the estimates from electrofishing. Our estimate of parr abundance in the HMA Stratum using snorkel surveys was within 10.6% of estimates derived through electrofishing (Table 9); we found the separate estimates were within 0.1% in 1989. Total area snorkeled in the 30 index sites was 1,141m^2, compared to 4,168m^2 electrofished. Time spent in HMA snorkel surveys was 22 person-days, compared to 34 person-days electrofishing.

Table 8. Subyearling spring chinook salmon parr densities and biomass by habitat type in HMA Stratum, 1990. Sample size was six sites per habitat type.

Habitat type	Mean density (fish/100m^2)	Mean biomass (grams/100m^2)
Riffle	9.54	37.11
Run	29.69	122.21
Pool	40.54	151.34
Boulder	13.88	56.57
Side channel	32.05	114.83

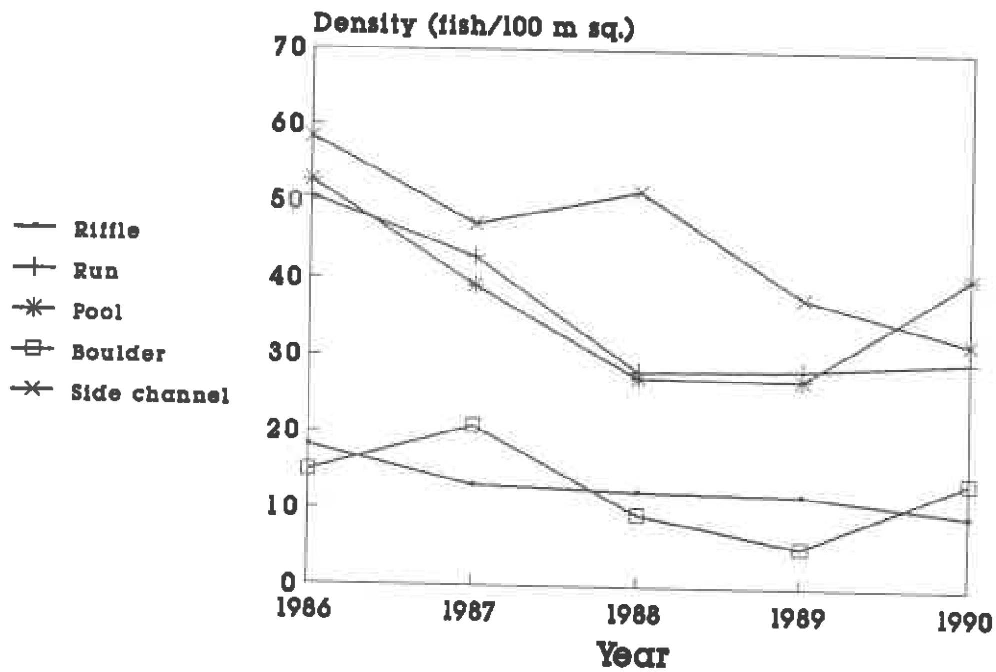


Figure 11. Comparison of spring chinook salmon rearing densities in HMA Stratum from 1986 to 1990.

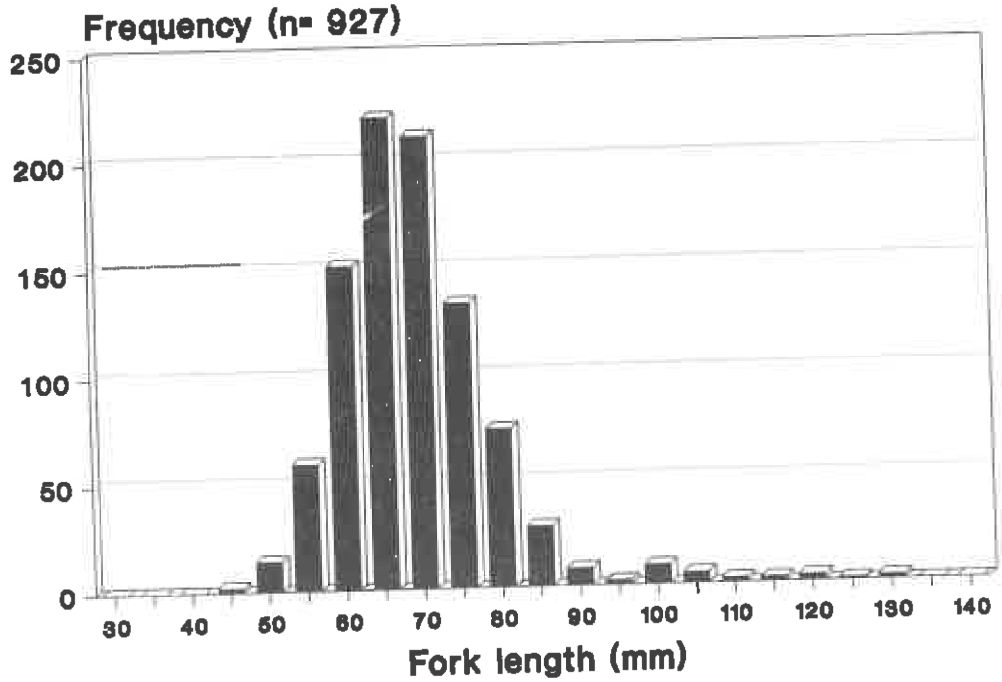


Figure 12. Length frequency distribution of spring chinook salmon measured during HMA Stratum electrofishing surveys in 1990.

Table 9. Estimates of 1990 spring chinook salmon parr mean densities and population size by habitat type within HMA Stratum, Tucannon River, Washington. Estimates are based on snorkeling and electrofishing surveys; sample size was six sites per habitat type.

Habitat type	Snorkeling		Electrofishing	
	density (fish/100m²)	population estimate	density (fish/100m²)	population estimate
Riffle	9.94	8,144	9.54	9,218
Run	28.62	19,410	29.69	17,918
Pool	56.23	2,892	40.54	2,216
Boulder	15.00	3,185	13.88	2,424
Side channel	61.28	11,719	32.05	8,751
Totals		45,350		40,527

3.2.3: Hartsock Stratum parr production

Methods Several previously established index sites were selected at random for parr production estimates. Sampling was similar to that described for Wilderness Stratum (Section 3.2.1). We did not electrofish index sites in Hartsock Stratum in 1990, the first time since 1985. However, we did snorkel six index sites, two of each habitat type of riffle, pool, and run, with three replicates.

Results Mean densities were 7.08 fish/100m^2 in riffles, 16.82 fish/100m^2 in runs, and 17.49 fish/100m^2 in pools (Table 10). To estimate parr production in this stratum, we multiplied the mean density for each habitat type by the total area available for each habitat type (from our 1987 habitat survey of this stratum). Given these densities, we estimate that 8,590 subyearling spring chinook reared in Hartsock Stratum during summer 1990. This estimate reflects a 58% decrease in production in Hartsock Stratum from 1989. The 1990 estimate was obtained from snorkeling, however, while all previous population estimates for this strata were calculated using electrofishing data (appendix E, Table 4). Population estimates are similar between electrofishing and snorkeling within HMA Stratum, although we do not know if that relationship is maintained within Hartsock Stratum.

Table 10. Subyearling spring chinook salmon densities from snorkeling index sites in Hartsock Stratum, Tucannon River, 1990.

Habitat type[a]	Site	Density (fish/100m^2)
Riffle	Hart 8	10.38
	Hart 9	3.78
Run	Hart 2	33.63
	Hart 5	0.00
Pool	Hart 4	25.58
	Hart 7	9.40

[a] *Total area available by habitat type is 30,684m^2 of riffle, 46,548 m^2 of run, and 771 m^2 of pool (from our 1987 habitat survey).*

3.2.4: Other strata

We established six index sites in Marengo Stratum in 1990, two of each habitat type, with three replicates (Appendix F). No salmon parr were observed in any of the sites. Three sites were established in Lower Stratum in 1990, one of each habitat type. Each site was snorkeled twice--no salmon parr were observed.

3.2.5: Yearling standing crop

During parr production surveys, program staff saw unusually high numbers of large (> 85mm) juvenile salmon, that we assumed were yearlings, rearing in Tucannon River. Yearlings (1988 brood) were observed in 12 of 30 HMA Stratum index sites electrofished (11 of 30 sites snorkeled); in two of seven Wilderness index sites electrofished (three of six sites snorkeled); and two of six Hartsock Stratum index sites snorkeled. Densities of yearlings were generally highest in pools (Table 11). Length frequencies indicated that 8.8% of the total sample of parr examined from the Wilderness Stratum were apparently yearlings (Figure 10, Section 3.2.2). The separation between subyearlings and yearlings was not nearly as obvious for length frequencies from HMA Stratum (Figure 12).

Table 11. Yearling spring chinook salmon parr densities (derived by electrofishing and snorkeling) and biomass by habitat type and stratum, in Tucannon River, 1990.

Stratum Habitat type	Sample size[a]	Sample method	Mean density (fish/100 m^2)	Mean biomass ($gm/100m^2$)
Wilderness				
Run	1	snorkel	1.75[b]	- -
	1	electrofish	1.63[b]	33.79[c]
Pool	2	snorkel	2.24[b]	- -
	1	electrofish	11.63[b]	241.12[c]
HMA				
Riffle	1	electrofish	0.55	4.95
Run	2	electrofish	1.12	20.67
	5	snorkel	1.85	- -
Pool	5	electrofish	6.52	107.92
	5	snorkel	3.28	- -
Boulder	2	electrofish	0.56	7.66
	1	snorkel	0.77	- -
Side channel	2	electrofish	5.26	68.02
Hartsock				
Run	1	snorkel	1.82	- -
Pool	1	snorkel	1.76	- -

[a] *Number of sites where yearlings were found.*

[b] *The same site was snorkeled and electrofished. For run habitats both densities are presented in this table. For pool habitat the yearling density estimate from the snorkeled site was 1.18.*

[c] *Estimates are based on a pooled mean weight of 20.73 gm/fish from two electrofished sites.*

3.2.6: Winter Snorkel Surveys

Methods We surveyed every other index site in HMA Stratum, three of each habitat type (15 total, with two replicates of each) from 3 December 1990 to 6 February 1991. We surveyed four sites in Hartsock Stratum (two pools, one riffle, and one run). We surveyed two pools in Marengo Stratum, with two replicates of each site. Winter methods were the same as summer methods.

Results Mean densities within HMA Stratum were less than 0.10 fish/m^2 in riffles, runs, boulders, and side channels, and 40.33 fish/100m^2 in pools (Appendix E, Table 5). Mean densities within pools in Hartsock Stratum were 1.37 fish/100m^2. No fish were observed within the riffle or run habitats in Hartsock Stratum. No juvenile salmon were observed in the two sites (pools) snorkeled in Marengo Stratum.

3.2.7: Downstream migrant trap operations

An important objective of our study is to estimate the magnitude, duration, periodicity, and peak of salmon outmigration 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 October 25 1989 to 30 June 1990. A description of trap operations is in our FY 1986 report.

Methods To calibrate trapping efficiency, we marked (clipped the tip of the pelvic fin) captured smolts and transported them 10 km upstream of the trap for release. Only wild-origin smolts were used. The percentage of marked fish captured was used to estimate percent total downstream migrants trapped. With these data, we used a modified form of the standard Peterson mark-recapture method (Chapman 1948, Steinhorst[1]). We estimate the number of outmigrants using the equation:

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

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

where:

m = *number of periods fish were marked*
p = *proportion of fish caught that were marked on period i*
y = *number of recaptured fish on period i*
n = *number of fish marked on period i*

[1] *Steinhorst, R. K. Department of Mathematics and Applied Statistics, University of Idaho, Moscow, Idaho.*

For the first time, we did not trap continuously during the peak of outmigration. Rather, we performed mark/recapture trials during established five-day periods throughout the peak of outmigration. We assumed the number of fish emigrating during off-trapping days was the same as during trapping periods. In general, the trap was operated five nights a week, with one mark/recapture trial during that period. The trap was checked 237 times in the nine-month period.

We caught 7,574 wild salmon and 4,090 hatchery salmon during the 1989/1990 season (Appendix G). Based upon this, we estimate 37,484 wild salmon smolts outmigrated. The 95% confidence limit to this estimate is 1,317, and is based upon an average unweighted trap efficiency of 20.2%. This trap efficiency is somewhat lower than the 1987- 1989 data (range: 22.1- 29.9%).

On most wild salmon collected, we assessed the amount of descaling (Achord et al. no date), fin erosion, and the degree of smoltification. We measured fork lengths on 76% of wild fish collected (5,778) and weighed 918 (16%) fish on a random basis. Water temperature, flow, velocity, clarity (determined with a 25 cm Secchi disk), and photoperiod were recorded daily to be used as covariates in explaining variability in smolt migrations.

In the nine-month trapping period, 591 of the wild salmon processed (10.2%) were descaled in one or more zones. Of these, 188 salmon (3.3% of total) were descaled in two or more zones, compared to 1.6% in the 1988/89 season, 2.2% in the 1987/88 season, and 6.9% in the 1986/87 season. Eighteen fish had cuts or bruises this year. We saw negligible difference in descaling between fish captured once (3.3% were descaled) and those captured and handled twice (recaptured marked fish; 3.0% were descaled). Overall, seven wild and nine hatchery salmon died in the trap during the nine-month season.

We classified 86% of the salmon caught as parr-smolt transitionals, 13% were smolts, and 1% were parr (Table 12). Virtually all salmon outmigrants were yearlings (Figure 13). Most parr were recently-emerged fry collected in June.

Table 12. Average condition factor for spring chinook salmon weighed at the Tucannon River downstream migrant trap in 1990.

Parr/smolt transformation	Sample size	Mean length	Mean weight	Mean kfactor
Parr	9	71.7	4.30	1.15
Transitional	786	96.6	10.22	1.10
Smolt	123	106.5	13.77	1.11
All salmon	918	97.7	10.64	1.10

Composition and numbers of incidental species caught in the downstream migrant trap in 1989/1990 changed little from previous years (Appendix H).

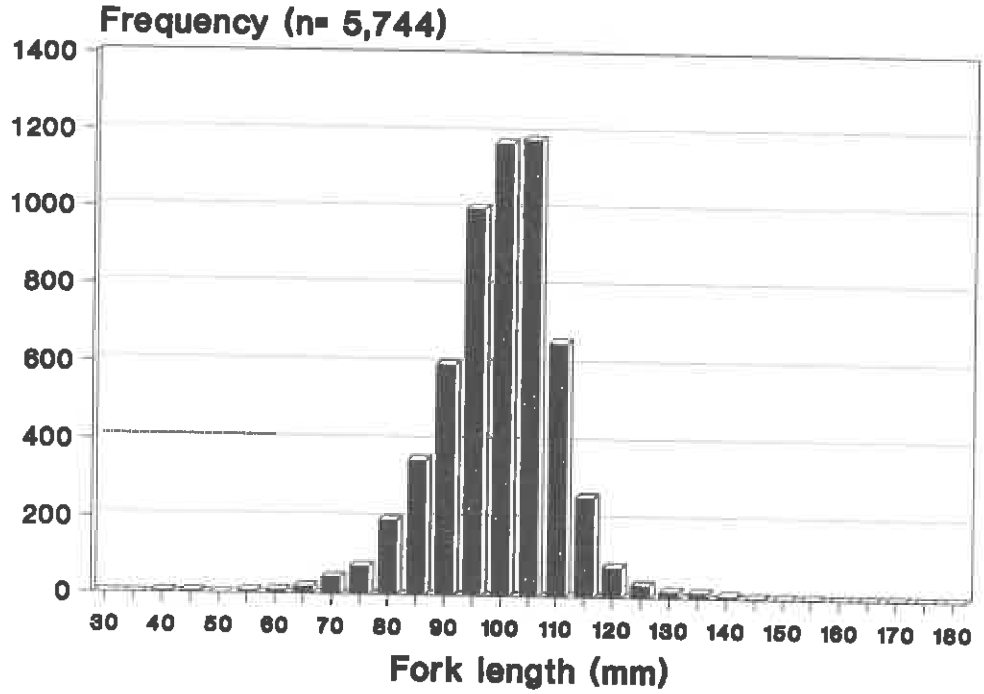


Figure 13. Length frequency distribution of wild spring chinook salmon caught at the Tucannon River downstream migrant trap, 1989/1990 season.

3.2.8: Standing crop

Wild salmon population estimates have been derived for several brood years at the egg deposition, late summer rearing fry, and yearling outmigrant stages of life history. Currently, we have estimates for the 1985 through 1988 broods at all juvenile life stages. Estimates are preliminary and periodically revised as we obtain additional information from ongoing studies.

We estimate the number of eggs deposited by calculating the product of 1) number of adults allowed to pass the hatchery rack for natural spawning (refer to Sections 2.1 and 3.1), and 2) the mean fecundity of those fish collected at the rack for spawning in the hatchery (Section 4.1.1). We have five years' data to date (1986 to 1990 broods), and are able to extrapolate these data to the 1985 brood.

The rearing fry population estimate is the product of 1) parr production density estimates (Section 3.2), and 2) areal measurements of the stream derived from previous habitat surveys (Section 3.3 and FY 1985 and 1987 reports). Both estimators are stratified by stream reach, habitat type, and habitat quality. We have five years' data to date (1985 through 1989 broods).

We have estimates of smolt yield for four brood years (1985 through 1988; Section 3.2.6), and can calculate egg-to-smolt survival by comparing population estimates by life stage (Figure 14, Table 13, Bugert and Seidel 1988).

Egg-to-late summer rearing fry survival rate for the 1988 brood was 14.6%. Fry-to-smolt survival was 53.8%. Overall freshwater survival (egg-to-smolt) for the 1988 brood salmon was 7.9%. Average egg-to-fry survival for the 1985 through 1989 broods is 31.44% (s= 11.80, n= 5). Average fry-to-smolt survival for the 1985 through 1988 broods is 51.68% (s= 7.50, n= 4). Average freshwater survival is 14.51% (s= 6.12, n= 4, Figure 14).

Table 13. Estimates of Tucannon River spring chinook salmon abundance by life stage for 1985 through 1990 broods.

Brood year	Redds	Adults	Eggs	Parr	Smolts
1985	189[a]	138[b]	276,300[c]	90,200	35,600
1986	200	131	256,500	102,600	58,200
1987	185	151	309,200	79,100	44,000
1988	117	180	475,800	69,700[d]	37,500
1989	106	88	136,500	58,600	--
1990	180	299[e]	545,300	--	--

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

[b] *The female to male ratio of adults trapped for broodstock was 1:1 in 1986 and 1987. The ratio was 1.36 females per male in 1988, and 0.86 females per male in 1989. The 1990 combined (wild and hatchery origin) sex ratio was 1.04 females per male. We assume the 1985 value was 1:1.*

[c] *Average fecundity was 3,916 in 1986, 4,095 in 1987, 3,882 in 1988, 3,608 in 1989, and 3,507 in 1990. We assume the 1985 value to be the average of 1986 and 1987 (4,006).*

[d] *Estimate includes yearlings observed in 1990 subyearling parr production estimates.*

[e] *Duration of adult count in 1990 went through September; prior counts went only through July.*

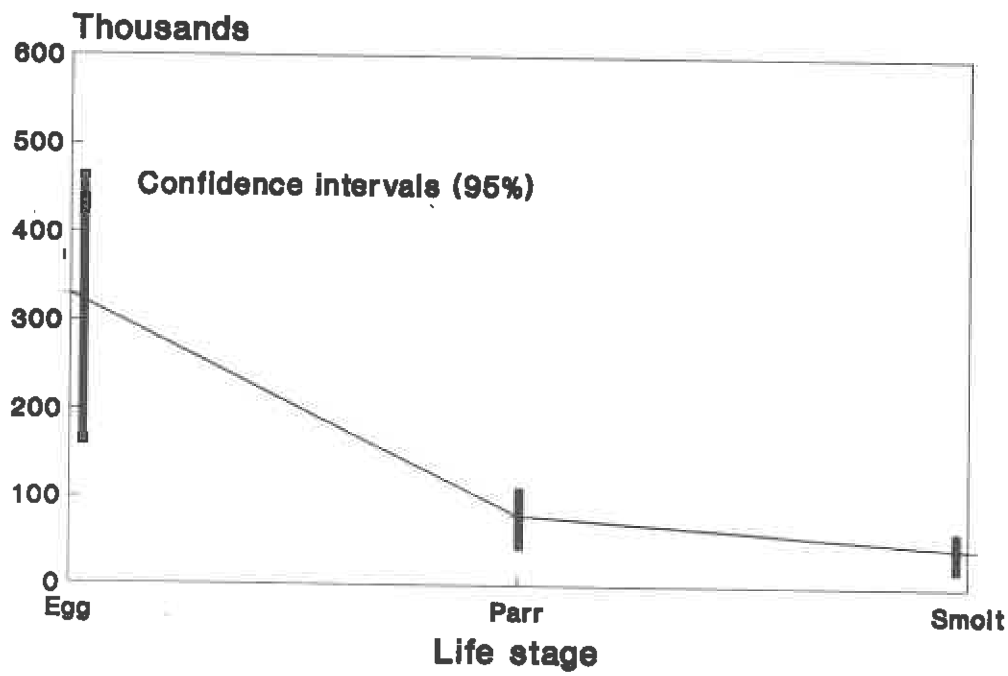


Figure 14. Tucannon River spring chinook salmon freshwater survival rates for 1985- 1988 brood years.

3.3: Stream Habitat Studies

3.3.1: Habitat inventory surveys

Program staff inventoried stream habitat type in Marengo Stratum, Tucannon River, from 3 July to 18 July 1990. Inventory data for Wilderness, HMA, and Hartsock Strata were taken in 1985 and 1987. We collected data in a random systematic order in four sections within Marengo Stratum from RK 21.0 to 22.6, 25.6 to 28.7, 31.6 to 34.7, 38.4 to 40.8. Each section was sampled at 30 m intervals (see FY 1987 report for detailed method). Inventory data included wetted width (measured to 0.1 m precision), gradient (percent; Table 14), habitat type (riffle, run, pool). We used habitat terminology suggested by Helm (1985). Each site was scored by quality of rearing habitat (Appendix D). We evaluated 359 sites within Marengo Stratum. The riffle:run:pool ratio is 35:59:6.

Table 14. Mean wetted width and gradient of Marengo Stratum by river kilometer in the Tucannon River, Washington, 1990.

River kilometer	Wetted width (m)	Gradient (percent)
21.0- 22.6	11.18	0.6
25.6- 28.7	11.23	0.6
31.6- 34.7	11.42	0.6
38.4- 40.8	13.20	0.8

3.3.2: Stream temperature monitoring

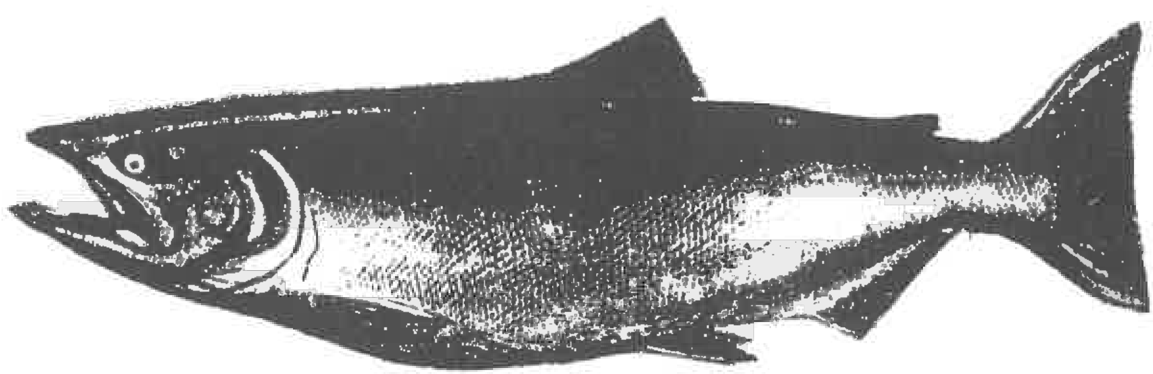
Program staff deployed five continuous-reading thermographs in Tucannon River to monitor heat loading throughout the year. Thermographs recorded daily maximum and minimum water temperatures from 14 September 1989 through 10 April 1991. Locations of thermographs were as follows: 1) 300 m downstream of 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) and 6) at the Marengo Bridge (RK 40.8).

In general, spring and summer (June through September) stream temperatures increased in varying increments from the furthest upstream location to the furthest downstream (Table 15). Minimum temperatures were lower at the Big 4 Lake outlet than near Panjab Creek, and decreased further near the Beaver Lake outlet. 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, five km upstream. This temperature difference contrasts with our results for 1989, but it is similar to our data for 1987 and 1988. The Marengo thermograph recorded a high temperature of 26.1° C on 12 July. Temperatures of 20° C or above were recorded regularly from 19 June to 12 September during 1990. Daily maximum and minimum temperatures for the six thermographs are presented in Appendix I.

Table 15. Mean monthly ranges (minimum to maximum) water temperatures at six Tucannon River sampling locations from September 1989 to April 1991. Temperatures are listed in degrees Celsius.

Month	Panjab Creek	Big 4 Lake	Beaver Lake	Deer Lake	Cummings Creek	Marengo
Sep 1989	11.2-13.1[a]	10.7-14.3[a]	- -	11.9-15.7[a]	9.0-12.0[a]	11.4-14.5[a]
Oct 1989	8.8-10.4	8.2-10.5	- -	11.0-13.7	6.6- 8.5	5.5- 9.8
Nov 1989	7.3- 8.5	6.7- 7.9	- -	9.3-10.9	4.4- 5.9	5.4- 6.9
Dec 1989	6.0- 7.0	4.5- 5.7	- -	6.8- 8.0	2.0- 3.1	2.7- 3.6
Jan 1990	6.1- 7.1	5.0- 6.2	- -	7.1- 8.1	2.5- 3.4	3.0- 4.1
Feb 1990	5.5- 6.7[a]	4.2- 5.9[a]	- -	6.5- 8.2	1.8- 3.5[a]	2.5- 4.4[a]
Mar 1990	- -	- -	- -	7.8-10.5[a]	- -	- -
Apr 1990	2.9- 4.4[a]	2.8- 5.1[a]	- -	5.3- 7.8[a]	6.9- 8.4[a]	7.9- 9.6[a]
May 1990	4.0- 6.5	3.9- 7.2	- -	7.3-10.8	8.0-10.6	10.1-13.3
Jun 1990	6.2- 9.1	6.7-10.8	12.3-18.4[a]	10.0-14.5	10.5-13.7	13.2-17.4
Jul 1990	8.9-12.8	10.1-15.9	12.6-19.1	13.2-19.9	14.3-18.3	17.4-22.8
Aug 1990	9.2-12.1	10.5-15.0	13.3-18.3	13.9-18.8	14.5-17.6	17.3-21.8
Sep 1990	8.2-11.2[a]	8.6-13.2[a]	11.9-16.6	11.9-16.7	12.7-15.7	15.4-19.5
Oct 1990	5.6- 7.0[a]	4.8- 6.6[a]	6.3- 8.4	6.4- 8.6	6.7- 8.5	10.4-12.4
Nov 1990	4.5- 5.9	3.3- 4.7	3.5- 4.9	3.7- 5.3	3.9- 5.2	8.2- 9.4
Dec 1990	2.1- 3.0	0.5- 1.5	0.5- 1.4	0.5- 1.7	1.0- 1.9	4.2- 5.3
Jan 1991	2.1- 3.1	0.6- 1.9	0.5- 1.4	0.7- 2.0	0.9- 1.9	4.9- 5.8[a]
Feb 1991	3.3- 4.5	2.5- 4.4[a]	2.4- 3.9	2.7- 4.8	2.5- 4.1	6.9- 9.5[a]
Mar 1991	3.3- 4.9	- -	2.1- 4.7	2.5- 5.2	2.9- 4.9	- -
Apr 1991	- -	- -	4.0- 6.7[a]	4.9- 7.6[a]	4.4- 6.7[a]	- -

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



SECTION 4: STOCK PROFILE ANALYSIS

To monitor long-term trends in stock profile characteristics of Tucannon salmon, we annually collect stock identification data through 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.

Section 4.1: Population Structure

4.1.1: Fecundity and egg size

Twenty-one wild and 23 hatchery females were spawned at Tucannon FH in 1990 (Table 4). Average fecundity for the combined group was 3,507. Fecundity was determined by dividing the total number of eggs taken by the number of females spawned. A more precise way to estimate fecundity is to weigh a sample of about 100 eggs from an individual female, compute single egg weight, then divide it into the total egg weight of that female. We calculated fecundity using this method on 18 randomly chosen females and compared our results to the egg counts done in the incubation room (Appendix C, Table 2). Average female fecundity based on our calculations for sampled females was 3,272 (s= 877), compared to 3,179 (s= 749) obtained by incubation room counts for the same 18 females. Average egg weight was 0.21 grams (s= 0.04) or 2,160 eggs/pound by our estimation and 1,844 eggs/pound by hatchery techniques. Average fecundity and egg weight for the years 1986- 1990 is 3,802 (s= 239.7) and 1,710 eggs/pound (s= 237.8, Table 16). Average fecundity and individual egg weight for sampled wild females was 3,993 eggs, 0.23 grams (n= 8), and 2,694 eggs, 0.20 grams for hatchery females (n= 10).

Table 16. Average fecundity and egg size of Tucannon spring chinook females spawned for hatchery broodstock. Fecundity values are total eggtake divided by number of females spawned.

Brood year	Average fecundity	Eggs/ pound
1986	3,916	1,796
1987	4,095	1,748
1988	3,882	1,293
1989	3,608	1,870
1990	3,507	1,844

4.1.2: Age and sex structure

Wild salmon Sex ratio of wild salmon in the Tucannon river in 1990 was 0.78 females per male; this includes all age classes. Based upon scale analyses, 70% of the recovered adults were age $4/_2$ and 30% were age $5/_2$ (Table 17). Mean length of wild adults sampled was 75.13 cm (Figure 15). Since we began brood stock collections in 1985, average age classification is 2.5% age $3/_2$, 66.2% age $4/_2$, and 31.3% age $5/_2$ (Figure 16).

Hatchery origin salmon Sex ratio of hatchery salmon in Tucannon river in 1990 was 1.42 females per male; this sample is skewed towards age $3/_2$ and $4/_2$ because of the small release number of the 1985 brood (12,922 smolts). Based upon cwt analyses, 92% of the recovered adults were age $4/_2$ and 8% were age $3/_2$ (Table 18). Mean length of hatchery adults sampled was 65.05 cm (Figure 17).

Table 17. Sex, mean fork length (cm), and age (from scale impressions) of wild spring chinook salmon sampled at Tucannon Fish Hatchery, 1990 (s = standard deviation, n = sample size).

	Mean length (s, n) at given age			
Sex	3_2	4_2	5_2	Totals
Female	- -	69.1 (2.1, 10)	82.6 (5.1, 10)	20
Male	- -	72.1 (5.2, 22)	88.2 (3.7, 4)	26
Totals	0	32	14	46
Percent	0	70	30	100

Table 18. Sex, mean fork length (cm), and age (code-wire tags) of hatchery-origin spring chinook salmon sampled at Tucannon Fish Hatchery, 1990 (s = standard deviation, n = sample size).

	Mean length (s, n) at given age			
Sex	3_2	4_2	5_2	Totals
Female	- -	66.3 (5.2, 38)	- -	38
Male	50.0 (2.4, 5)	66.5 (4.4, 20)	- -	25
Totals	5	58	- -	63
Percent	8	92	0[a]	100

[a] *The 1985 brood release was less than full production, which may account for lack of age 5 fish in the 1990 returns.*

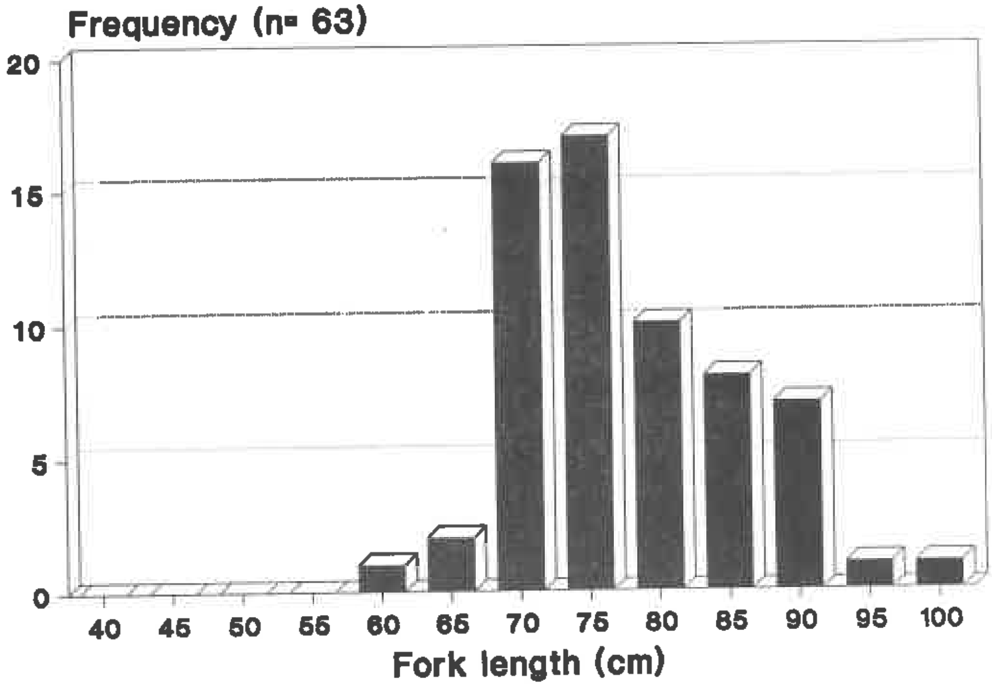


Figure 15. Length frequency distribution of wild spring chinook salmon adults sampled at Tucannon Fish Hatchery in 1990.

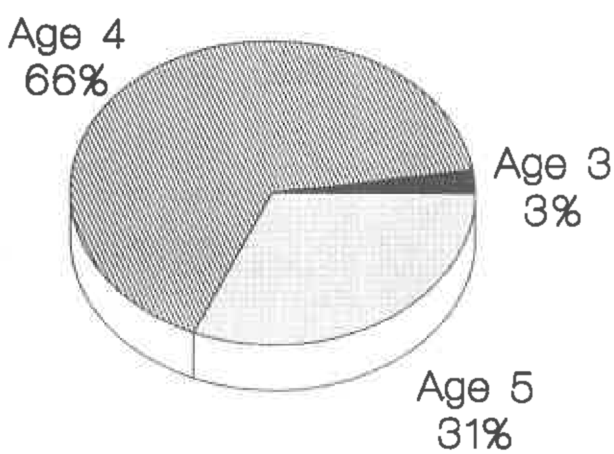


Figure 16. Age structure of wild salmon collected for broodstock from 1985 through 1990 (n= 476).

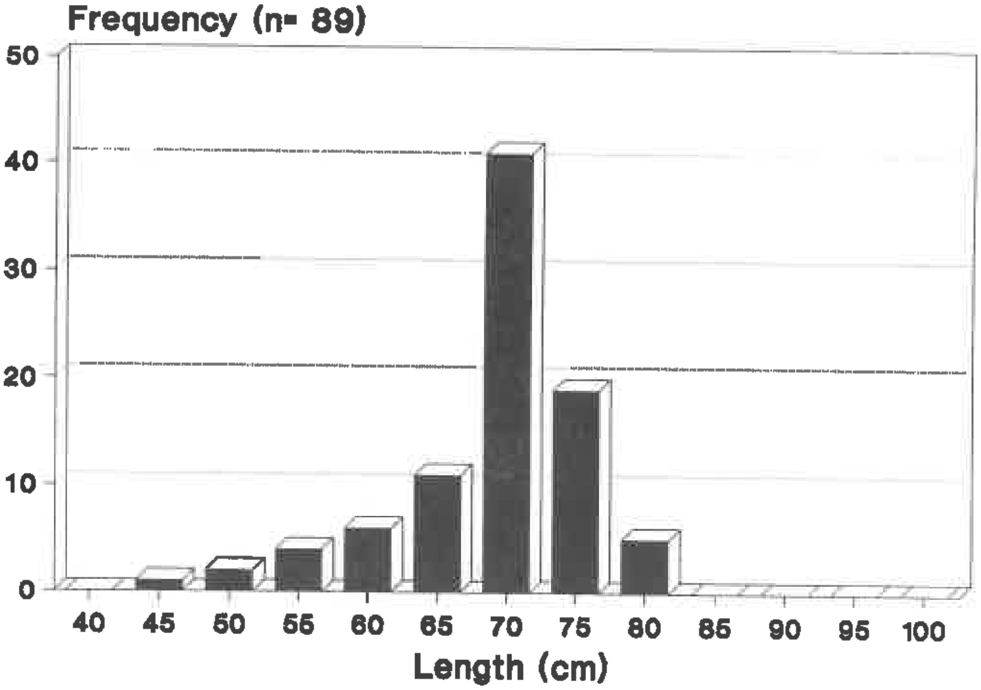


Figure 17. Length frequency distribution of hatchery-origin spring chinook salmon adults sampled at Tucannon Fish Hatchery in 1990.

4.2: Electrophoretic Analysis

Evaluation program staff collected 39 electrophoretic samples from 1990 wild-origin adults and 43 samples from 1990 hatchery-origin adults trapped at Tucannon FH. Horizontal starch-gel electrophoresis was done at the WDF Genetics Unit Lab, using standard procedures for chinook salmon (Marshall et al. 1991, Appendices 3-5). Results are presented below for 39 loci accepted coastwide, with coastwide pooling conventions (excluding those required only for fishery analysis; see Marshall et al. 1991). Locus nomenclature follows the system of Shaklee et al. (1990). To facilitate comparisons with earlier reports in this series, in cases where the new names differ substantially from the old, old locus names are given in parentheses in the text and in Appendix I.

No variability was observed at 21 loci: sAAT-1,2* (AAT-1,2), sAAT-3* (AAT-3), ADA-2*, mAH-1*, mAH-3*, GPI-A* (GPI-3), GPI-r* (GPI-H), GR*, mIDHP-2* (IDH-2), sIDHP-2* (IDH-4), LDH-B2* (LDH-4), sMDH-A1,2* (MDH-1,2), mMDH-1*, sMEP-2* (MDHP-2), PEPD* (PDPEP-2), PEP-LT*, PGDH*, PGM-1*, PGM-2*. Allele frequencies at the 18 variable loci are presented in Appendix I. Chi-square tests of genotype frequency correspondence to Hardy-Weinberg expectations were done for each variable locus. Only one significant departure was found, at the TPI-4* locus (p=0.0000) in the collection of wild fish. Although this departure seems quite large, based on the p-value, it is probably not biologically significant, but rather an artifact of small sample size. The low number of heterozygotes and alternate homozygotes expected justifies pooling of these two classes. If this is done, the chi-square value drops far below significance.

Chi-square heterogeneity tests were carried out separately on each variable locus to evaluate genetic differences between the hatchery and wild collections. Because chi-square values are additive, a total over all loci was also computed. Results are presented in Table 19. The two collections did not differ significantly at any locus; the closest to significance was the comparison at MAAT1 (p=0.07). The overall p-value was 0.26, again not even approaching significant. Although the null hypothesis of no difference between the hatchery and wild fish cannot be rejected, it should be kept in mind that these collections were small, so experimental power was low. Sample sizes approaching 100 would have provided a much more powerful test of this hypothesis.

Table 19. Chi-square heterogeneity test over all loci for 1990 adult Tucannon spring chinook salmon.

Locus	Alleles	Chi-square	D.F.	p
sAAT-4*	2	0.695	1	0.40450
mAAT-1*	2	3.246	1	0.07159
ADA-1*	2	1.317	1	0.25116
sAH*	2	0.231	1	0.63103
mAH-4*	2	0.976	1	0.32313
PEPA*	2	2.859	1	0.09089
GPI-B2*	2	0.913	1	0.33943
HAGH*	2	0.378	1	0.53843
sIDH-1*	2	0.034	1	0.85436
LDH-C*	2	1.790	1	0.18098
sMDH-B1,2*	2	1.106	1	0.29294
mMDH-2*	2	0.000	1	0.99069
sMEP-1*	2	0.773	1	0.37931
MPI*	2	1.955	1	0.16207
PGK-2*	2	1.489	1	0.22244
sSOD-1*	2	2.118	1	0.14560
mSOD*	2	1.596	1	0.20643
PEPB-1*	3	0.721	2	0.69729
TPI-4*	2	1.394	1	0.23777
Total		23.589	20	0.26080

4.3: Morphometric Analysis

4.3.1: Adult morphometry

Our objective in adult morphology is to examine phenotypic response, if any, of sexually mature salmon that are held until maturation in a hatchery pond. We measured body morphometry on 45 wild and 52 hatchery salmon adults during spawning at Tucannon FH in 1990. In 1989, we measured 64 wild adults and 73 hatchery adults and jacks. Twelve morphological characters on sexually mature adults were measured with Vernier calipers to the nearest 0.1 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.

Analysis of adult morphometric data was not completed at time of publication; results will be presented in the FY 1991 report.

4.3.2: Juvenile morphometry

In 1987, program staff began a baseline analysis of morphometric variation among fish stocks (Taylor 1986) and origins (natural or hatchery) within a stock. On an annual basis, we measured about 100 each of hatchery reared and wild salmon juveniles. Wild salmon were collected during electrofishing surveys and downstream migrant trap operations on the Tucannon River. We separated fish within both groups by degree of smoltification. Composite measurements of individual fish were then used for morphologic analysis.

Methods Fish were immediately frozen and retained for measurement at a convenient date. We thawed individual specimens to room temperature, 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 onto the cards with pins; this method was based upon the techniques of Winans (1994). We recorded fork length and origin (wild or hatchery) for each fish. Euclidean distances between each of the 15 points on the cards (31 distances total) were determined using a digitizer.

Analysis of juvenile morphometric data was not completed at time of publication; results will be presented in the FY 1991 report.

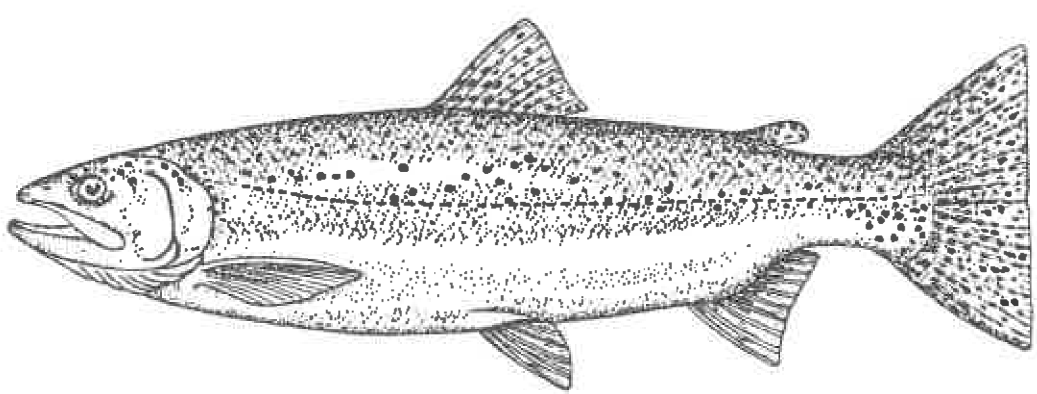
4.4: Meristic analysis

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 counted bilateral meristic counts for 1986 through 1989 brood years Tucannon wild juvenile salmon. We also made meristic counts for 1986 through 1989 brood years 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 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 time of publication; results will be presented in the FY 1991 report.

Otoliths We retained otoliths on 50 wild and 50 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. Recommendations which alter hatchery programming or practices will be implemented in 1991. Some recommendations provided in the FY 1989 report will be implemented in 1991 also.

1) Harassment and poaching of prespawning salmon in HMA and Wilderness Strata impact spawning success. Funding for law enforcement in southeast Washington may be a cost-efficient means to improve salmonid production, relative to other programs.

2) The defunct hydroelectric dam on the Tucannon River near Starbuck hinders migration of spring chinook salmon, and completely blocks fall chinook salmon passage. Modification of this dam is necessary.

3) Impacts of stray spring chinook salmon on the genetic integrity of the Tucannon stock need to be reduced. Coded-wire tags of marked fish need to be read prior to spawning of adults. This method ensures only the culling of marked strays, however, and only from the 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 2 and 3 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.

4) Egg loss needs to be reduced; we do not know if the high mortality in 1990 eggtake was a result of the one male to one female mating practices or warming of eggs prior to transfer to Lyons Ferry FH for fertilization. To mitigate this loss in 1991, we recommend two actions:

a) Retain unfertilized gametes in cooled, insulated containers during spawning and in transport to Lyons Ferry FH.

b) Split eggs from each female into two lots of roughly two thousand each; fertilize each lot from two males. After mixing the gametes, retain four lots in separate trays of an incubation stack (Withler 1988).

To mitigate this loss in subsequent years, adults should be transferred from Tucannon holding pond to Lyons Ferry FH in July. This action has two benefits: 1) lower holding water temperature, and 2), no need to hold and transfer unfertilized gametes.

5) Decrease eggtake to meet poundage capacity at Tucannon acclimation pond (8,800 pounds at release). Based upon prespawning adult, egg, and fry mortality rates from previous years, and the programmed fish size at release of 10 fpp, the number of eggs required is 135,385. We then require 50 females (25 natural and 25 hatchery).

6) To reduce variation in size of salmon reared at Lyons Ferry FH, feeding strategies should be examined and modified. This may include extending the time on smaller size pellets and decreasing feeding times (Black, personal communication[1]).

7) Organic solids from the earthen pond at Tucannon FH settle in the adult trap. We believe this may have adverse affects upon fish health and trap capability. A settling pond (or other means) to remove the solids is necessary.

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APPENDIX A

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

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

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

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

4) **Document downstream 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 and 1987 broods Tucannon spring chinook salmon to various fisheries and returns to the hatchery rack, and a listing of coded-wire tag recoveries from stray salmon at Tucannon FH.

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		
Tucannon FH, WDF	23	23
Totals for tagcode 633442:	32	32

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
Totals for tagcode 634146:	41	42

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		
Tucannon FH, WDF	33	33
1990		
Treaty ceremonial, ODFW	1	2
Tucannon FH, WDF	15	15
Totals for tagcode 634148:	49	50

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		
Tucannon FH, WDF	21	21
1990		
Tucannon FH, WDF	22	22
Totals for tagcode 633325:	43	43

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
Totals for tagcode 634950:	5	5

Table 6. Origin of coded-wire tags from stray spring chinook salmon recovered at Tucannon Fish Hatchery in 1990. Expansion includes natural escapement.

Tagcode	Agency	Release location	Observed recoveries	Estimated contribution
23 22/27	NMFS	McNary Dam	1[a]	- -
07 43/27	ODFW	Meecham Creek	2	6
07 40/20	ODFW	Lookinglass FH	1	3

[a] *Tagged in summer outmigrant study; origin of fish is not known.*

APPENDIX C

Table 1. Tucannon spring chinook salmon semen evaluation and cryogenics, 1990.

Take number	Origin	Fork length (mm)	Gonad weight (gm)	Sperm motility	Semen optic density	Number frozen	Cell Density
9-4-1	Hatchery	673	136.9	80	0.210	4	15.9x10 6
9-4-2	Hatchery						
9-4-3	Hatchery	689	109.5	60	0.560	4	
9-4-4	Hatchery	702	121.2	50	0.520	4	
9-4-5	Hathcery	678	175.1	80	0.440	4	32.6x10 6
9-4-7	Hatchery						
9-4-6	Hatchery						
9-4-11	Wild						
9-4-12	Wild	753	129.9	80	0.295	4	21.9x10 6
9-4-13	Wild						
9-4-14	Wild						
9-4-15	Wild						
9-4-16	Wild						
9-4-17	Wild	731	122.8	5			
9-4-18	Wild						
9-4-19	Wild						
9-4-20	Wild						
9-4-21	Wild	662	112.0	80	0.600	4	44.8x10 6
9-11-1	Hatchery	733	149.8	20			
9-11-6	Hatchery	597	75.7	80	0.455	4	
9-11-23	Wild	728	110.8	90	0.445	4	
9-11-22	Wild	727	121.8	80	0.395	4	

Appendix C, continued.

Table 2. Origin/fork length/egg size/fecundity relationships of 1990 Tucannon River spring chinook salmon.

Origin	Fork length (mm)	Mean egg size (gm)	Total egg weight (gm)	Estimated fecundity
Hatchery	610	0.1780	400.2	2,248
	651	0.2028	506.3	2,497
	660	0.1741	533.8	3,065
	680	0.1042	258.1	2,476
	684	0.1986	546.8	2,753
	694	0.2248	520.2	2,314
	697	0.2747	928.5	3,380
	725	0.1813	410.3	2,263
	730	0.2613	1,104.3	4,226
	745	0.1672	287.8	1,722
Average	688	0.1967	549.6	2,694
Wild	696	0.1880	765.5	4,072
	709	0.1879	677.0	3,602
	716	0.2571	1,031.2	4,010
	762	0.2277	882.5	3,876
	815	0.2457	994.6	4,048
	820	0.2515	1,155.8	4,596
	828	0.2291	774.7	3,382
	894	0.2648	1,154.6	4,361
Average	780	0.2315	929.5	3,993

APPENDIX D

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

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

APPENDIX E

Table 1. Comparison of 1986 through 1990 spring chinook salmon rearing density estimates for riffles, runs, pools, boulder sites, and side channels within HMA Stratum, Tucannon River, Washington.

Habitat type	Site[a]	Density (fish/100m²) by year				
		1986	1987	1988	1989	1990
Riffle	HMA 1	23.37	19.77	20.86	12.55	5.15
	HMA 5	24.10	12.79	26.66	20.19	17.53
	HMA 9	11.77	10.33	7.10	4.41	7.86
	HMA 13	17.35	9.74	8.87	11.94	9.87
	HMA 18	13.87	7.91	8.66	14.23	5.95
	HMA 20	18.37	18.19	1.93	8.62	10.85
Run	HMA 3	24.75	45.09	44.16	13.02	17.09
	HMA 6	19.91	6.78	2.31	4.86	2.70
	HMA 10	20.72	65.54	24.04	41.42	28.78
	HMA 14	96.68	56.43	29.03	31.04	51.27
	HMA 19	48.94	37.43	33.44	18.88	36.56
	HMA 24	92.45	45.48	35.33	61.24	41.71
Pool	HMA 4	12.14	4.43	9.00	20.98	58.32
	HMA 8	10.53	47.53	31.73	9.48	31.42
	HMA 12	38.73	33.04	14.51	4.76	22.00
	HMA 16	67.43	46.80	34.63	20.27	23.44
	HMA 21	60.89	31.40	34.57	41.12	62.50
	HMA 22	126.26	71.64	38.77	65.55	45.55
Boulder	HMA 2	8.95	7.48	14.82	6.42	10.81
	HMA 7	13.68	37.48	13.57	3.73	27.11
	HMA 11	12.99	9.00	7.72	3.50	12.00
	HMA 15	12.79	34.87	11.68	4.33	6.12
	HMA 17	22.96	20.53	6.87	8.89	14.89
	HMA 23	17.73	15.39	1.46	4.57	12.36
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
	HMAS 3	41.22	49.07	13.34	32.89	12.53
	HMAS 4	35.23	23.33	27.09	4.54	20.20
	HMAS 5	122.11	19.41	82.81	55.90	17.63
	HMAS 6	53.20	30.21	33.86	29.06	32.25
Averages		38.91	32.60	25.68	22.08	25.80

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

APPENDIX E, continued.

Table 2. Comparison of density estimates from summer snorkeling and electrofishing surveys by habitat type and site, for spring chinook salmon parr in HMA Stratum, Tucannon River, Washington, 1990.

Habitat type	Site[a]	Density (fish/100m^2) Snorkeling	Electrofishing
Riffle	HMA 1	4.39	21.32
	HMA 5	12.94	17.53
	HMA 9	18.45	7.86
	HMA 13	10.03	9.87
	HMA 18	4.03	5.95
	HMA 20	9.77	10.85
Run	HMA 3	18.35	17.09
	HMA 6	2.26	2.70
	HMA 10	21.34	28.78
	HMA 14	57.44	51.27
	HMA 19	29.94	36.56
	HMA 24	43.31	41.71
Pool	HMA 4	68.75	58.32
	HMA 8	60.35	31.42
	HMA 12	24.14	22.00
	HMA 16	60.82	23.44
	HMA 21	64.06	62.50
	HMA 22	59.27	45.55
Boulder	HMA 2	10.04	10.81
	HMA 7	32.60	27.11
	HMA 11	7.81	12.00
	HMA 15	12.61	6.12
	HMA 17	14.67	14.89
	HMA 23	12.26	12.36
Side channel	HMAS-1	92.59	43.40
	HMAS-2	180.79	86.27
	HMAS-3	10.42	12.53
	HMAS-4	9.28	20.20
	HMAS-5	33.73	17.63
	HMAS-6	40.89	32.25

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

Appendix E, continued.

Table 3. Comparison of 1989 (electrofishing) and 1990 (snorkeling) subyearling spring chinook salmon rearing densities in selected index sites in Wilderness Stratum, Tucannon River.

Habitat type	Site	Density (fish/100m^2) 1989	1990
Riffle	Wild 12	0.00	1.99
Run	Wild 10	3.77	6.82
Pool	Wild 3	57.88	41.75
	Wild 11	12.50	60.15

Table 4. Comparison of 1989 (electrofishing) and 1990 (snorkeling) subyearlig spring chinook salmon rearing densities for selected index sites within Hartsock Stratum, Tucannon River.

Habitat type	Site	Density (fish/100m^2) 1989	1990
Riffle	Hart 5	1.43	0.00[a]
	Hart 8	4.47	10.38
Run	Hart 2	44.40	33.63
Pool	Hart 4	- -	25.58
	Hart 7	- -	9.40

[a] *Classified as a run habitat in 1990, instead of riffle habitat in previous years.*

APPENDIX E, continued.

Table 5. Comparison of mean snorkel density estimates for riffles, runs, pools, boulder sites, and side channels between summer 1990 and winter 1990/91 in HMA Stratum, Tucannon River.

Habitat type	Site[a]	Summer 1990 (fish/100m^2)	Winter 1990/91 (fish/100m^2)
Riffle	HMA 1	4.39	0.00
	HMA 9	18.45	0.00
	HMA 18	4.03	0.00
Run	HMA 3	18.35	0.00
	HMA 10	21.34	0.00
	HMA 19	29.94	0.00
Pool	HMA 4	68.75	118.93
	HMA 12	24.14	2.07
	HMA 21	64.06	0.00
Boulder	HMA 2	10.04	0.00
	HMA 11	7.81	0.00
	HMA 17	14.67	0.00
Side channel	HMAS 1	92.59	0.00
	HMAS 3	10.42	0.00
	HMAS 5	33.73	0.00

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

APPENDIX F

Washington Department of Fisheries' electrofishing and snorkeling index site location and identification for Marengo and Lower Strata, Tucannon River. Index site locations for Wilderness, HMA, and Hartsock Strata are in the FY 1988 report.

Site	Site length	Habitat type	Road mile	Description and reference point
<u>Marengo Stratum</u>				
Mar-1	16.0	run	13	30m above smolt trap at Krouse's Trailer Park
Mar-2	16.3	pool	14.5	Cross field 47m downstream from Mom's cafe, below metal pump shed.
Mar-3	14.0	riffle	15.9	174m above Frames bridge (farm with poplars and llamas)
Mar-4	9.8	pool	17.6	87m below Robertson bridge
Mar-5	11.0	run	22.5	5.35 miles up Tucannon road, alfalfa field power pole at edge of steep bank to river.
Mar-6	12.0	riffle	23.8	SCS silt basin on Hovruds property, WDW fish screen in field
<u>Lower Stratum</u>				
LS-1	10.0	riffle	1.5	45m upstream from highway 261 bridge. (or 15m above train trestle bridge)
LS-2	13.5	run	7.2	78m above Smith Hollow bridge. (Meads pig ranch)
LS-3	17.7	pool	10.1	0.1 mile above Kessel's sheep ranch, second turn off upstream from Kessel's driveway. Log crosses the upper end of site.

APPENDIX G

Tucannon River 1989/1990 spring chinook salmon downstream migrant trap data. Columns 3 through 12 are as follows: 3) fish marked (left partial ventral clip) and transported 10 km with 4) subsequent recaptures, 5) fish marked (right partial ventral clip and transported 10 km with 6) subsequent recaptures, 7) fish that were not marked and released downstream of trap, 8) fish sampled for electrophoresis, morphometrics, or meristic analysis, 9) mortalities incurred at the trap 10) the sum of columns 3 through 9 for that row, 11) spring chinook salmon released from Tucannon Fish Hatchery and caught at the trap, and 12) the sum of columns 10 and 11 for that row.

1 Date	2 Time	3 Mark LPV	4 Recapture LPV	5 Mark RPV	6 Recapture RPV	7 No Marks	8 Sampled	9 Morts	10 Total Wild	11 Total Hatchery	12 Total Fish
11-Oct-89	900	0	0	0	0	0	0	0	0	0	0
30-Oct-89	800	0	0	0	0	1	0	0	1	0	1
02-Nov-89	800	0	0	0	0	10	0	0	10	0	10
07-Nov-89	630	0	0	0	0	0	0	0	0	0	0
08-Nov-89	700	0	0	0	0	1	0	0	1	0	1
14-Nov-89	630	0	0	0	0	2	0	0	2	0	2
15-Nov-89	810	0	0	0	0	2	0	0	2	0	2
16-Nov-89	750	0	0	0	0	2	0	0	2	0	2
28-Nov-89	1130	0	0	0	0	3	0	0	3	1	4
29-Nov-89	845	0	0	0	0	1	0	0	1	0	1
30-Nov-89	800	0	0	0	0	16	0	0	16	0	16
06-Dec-89	1315	0	0	0	0	1	0	0	1	0	1
07-Dec-89	800	0	0	0	0	9	0	0	9	0	9
12-Dec-89	900	0	0	0	0	9	0	0	9	0	9
14-Dec-89	900	0	0	0	0	23	0	0	23	2	25
18-Dec-89	1400	0	0	0	0	61	0	0	61	2	63
19-Dec-89	830	0	0	0	0	19	0	0	19	0	19
21-Dec-89	1100	0	0	0	0	4	0	0	4	0	4
27-Dec-89	1400	0	0	0	0	4	0	0	4	0	4
28-Dec-89	1000	0	0	0	0	2	0	0	2	0	2
03-Jan-90	1500	0	0	0	0	0	0	0	0	0	0
04-Jan-90	815	0	0	0	0	0	0	0	0	0	0
09-Jan-90	615	0	0	0	0	1	0	0	1	0	1
10-Jan-90	730	0	0	0	0	7	0	0	7	0	7
11-Jan-90	730	0	0	0	0	3	0	0	3	0	3
12-Jan-90	900	0	0	0	0	12	0	0	12	3	15
17-Jan-90	730	0	0	18	0	0	0	0	18	2	20
18-Jan-90	730	0	0	32	2	16	0	0	50	2	52
19-Jan-90	900	0	0	0	3	22	0	1	26	0	26
20-Jan-90	1215	0	0	0	1	14	0	0	15	0	15
23-Jan-90	800	0	0	0	0	23	0	0	23	2	25
24-Jan-90	700	18	0	0	2	1	0	0	21	1	22
25-Jan-90	700	14	1	0	0	0	0	0	15	0	15
26-Jan-90	1000	0	5	0	0	23	0	0	28	0	28
30-Jan-90	800	0	0	0	0	7	0	0	7	0	7
31-Jan-90	730	0	0	0	0	7	0	0	7	0	7
01-Feb-90	930	0	0	0	0	3	0	0	3	0	3

Appendix G, continued.

1 Date	2 Time	3 Mark LPV	4 Recapture LPV	5 Mark RPV	6 Recapture RPV	7 No Marks	8 Sampled	9 Morts	10 Total Wild	11 Total Hatchery	12 Total Fish
02-Feb-90	830	0	0	0	0	21	0	0	21	0	21
06-Feb-90	1400	0	0	0	0	3	0	0	3	0	3
07-Feb-90	1030	0	0	0	0	2	5	0	7	0	7
08-Feb-90	800	0	0	0	0	2	0	0	2	0	2
09-Feb-90	800	0	0	0	0	5	2	0	7	0	7
14-Feb-90	830	0	0	0	0	6	0	0	6	0	6
22-Feb-90	745	0	0	0	2	27	0	0	29	0	29
23-Feb-90	730	0	0	0	0	16	5	0	21	1	22
24-Feb-90	1000	0	0	0	0	15	0	0	15	0	15
27-Feb-90	800	11	0	0	0	1	0	1	13	1	14
28-Feb-90	730	38	1	0	0	5	0	0	44	2	46
01-Mar-90	730	0	1	0	0	11	10	0	22	1	23
02-Mar-90	730	0	2	0	0	21	0	0	23	0	23
03-Mar-90	1100	0	0	0	0	7	0	0	7	1	8
05-Mar-90	800	0	0	0	0	15	0	0	15	0	15
09-Mar-90	730	0	0	0	0	15	0	0	15	0	15
10-Mar-90	1100	0	0	0	0	0	0	0	0	0	0
12-Mar-90	730	0	0	0	0	5	0	0	5	0	5
13-Mar-90	730	0	0	0	0	11	0	0	11	2	13
14-Mar-90	730	0	0	0	0	22	0	0	22	0	22
15-Mar-90	830	0	0	0	0	20	0	0	20	0	20
16-Mar-90	945	0	1	0	0	24	0	0	25	1	26
20-Mar-90	800	0	0	0	0	13	0	0	13	0	13
21-Mar-90	800	0	0	0	0	53	5	0	58	2	60
22-Mar-90	800	0	0	0	0	20	5	0	25	3	28
23-Mar-90	1026	0	0	0	0	44	0	0	44	3	47
27-Mar-90	2200	0	0	0	0	70	5	0	75	4	79
28-Mar-90	100	0	0	31	0	30	0	0	61	4	65
28-Mar-90	2200	0	0	0	0	26	5	0	31	3	34
28-Mar-90	1000	0	0	0	7	63	0	1	71	1	72
29-Mar-90	200	0	0	19	0	38	0	0	57	3	60
29-Mar-90	800	0	0	0	1	35	0	0	36	1	37
29-Mar-90	2200	0	1	0	2	20	5	0	28	1	29
30-Mar-90	230	0	0	0	0	34	0	0	34	3	37
30-Mar-90	900	0	0	0	0	35	0	0	35	2	37
30-Mar-90	2200	0	0	0	0	16	0	0	16	0	16
31-Mar-90	300	0	0	0	0	44	0	0	44	4	48
02-Apr-90	1030	0	0	0	0	0	0	0	0	1	1
02-Apr-90	1545	0	0	0	0	0	0	0	0	0	0
02-Apr-90	2100	0	0	0	0	2	0	0	2	6	8
03-Apr-90	30	0	0	0	0	12	0	0	12	10	22
03-Apr-90	300	0	1	0	0	29	0	0	30	20	50
03-Apr-90	730	0	0	0	0	48	0	0	48	31	79
03-Apr-90	1600	0	0	0	0	2	0	0	2	0	2
03-Apr-90	2100	0	0	0	0	2	0	0	2	5	7

Appendix G, continued.

1 Date	2 Time	3 Mark LPV	4 Recapture LPV	5 Mark RPV	6 Recapture RPV	7 No Marks	8 Sampled	9 Morts	10 Total Wild	11 Total Hatchery	12 Total Fish
04-Apr-90	300	0	0	0	0	10	5	0	15	0	15
04-Apr-90	900	0	0	0	0	35	5	0	40	35	75
04-Apr-90	1545	0	0	0	0	1	0	0	1	2	3
04-Apr-90	2200	0	0	0	0	3	0	0	3	13	16
05-Apr-90	300	0	0	0	0	13	0	0	13	21	34
05-Apr-90	730	0	0	0	0	50	0	0	50	62	112
05-Apr-90	2300	0	0	0	0	13	0	0	13	13	26
06-Apr-90	300	0	0	0	0	11	0	0	11	14	25
06-Apr-90	745	0	0	0	0	16	0	0	16	25	41
06-Apr-90	1440	0	0	0	0	2	0	0	2	0	2
08-Apr-90	1530	0	0	0	0	3	0	0	3	0	3
09-Apr-90	2200	0	0	0	0	1	0	0	1	3	4
10-Apr-90	300	0	0	0	0	6	4	0	10	15	25
10-Apr-90	800	0	0	0	0	7	0	0	7	23	30
10-Apr-90	1600	0	0	0	0	1	0	0	1	0	1
10-Apr-90	2330	0	0	0	0	0	9	1	10	27	37
11-Apr-90	330	0	0	0	0	9	0	0	9	31	40
11-Apr-90	800	0	0	0	0	12	0	0	12	123	135
11-Apr-90	1600	0	0	0	0	2	0	0	2	18	20
11-Apr-90	2130	0	0	0	0	5	0	0	5	57	62
12-Apr-90	215	0	0	0	0	7	0	0	7	122	129
12-Apr-90	1430	0	0	0	0	1	0	0	1	24	25
12-Apr-90	2100	0	0	0	0	1	0	0	1	44	45
13-Apr-90	100	0	0	0	0	14	10	0	24	544	568
13-Apr-90	315	0	0	0	0	9	0	0	9	147	156
13-Apr-90	1330	0	0	0	0	2	0	0	2	4	6
16-Apr-90	220	6	0	0	0	0	0	0	6	32	38
17-Apr-90	200	18	0	0	0	2	0	0	20	102	122
17-Apr-90	800	26	0	0	0	9	0	0	35	163	198
17-Apr-90	1830	0	2	0	0	8	0	0	10	12	22
17-Apr-90	2330	0	2	0	0	9	0	0	11	61	72
18-Apr-90	300	0	0	0	0	14	0	0	14	135	149
18-Apr-90	1700	0	0	0	0	5	0	0	5	12	17
18-Apr-90	2300	0	0	0	0	4	0	0	4	60	64
19-Apr-90	300	0	1	0	0	41	0	0	42	209	251
19-Apr-90	800	0	0	0	0	13	10	0	23	80	103
19-Apr-90	1930	0	0	0	0	4	0	0	4	15	19
19-Apr-90	2300	0	0	0	0	16	0	0	16	30	46
20-Apr-90	300	0	0	0	0	27	0	0	27	38	65
20-Apr-90	800	0	1	0	0	22	0	0	23	48	71
20-Apr-90	1900	0	0	0	0	16	0	0	16	11	27
21-Apr-90	30	0	0	0	0	49	0	0	49	133	182
21-Apr-90	300	0	0	0	0	43	0	0	43	92	135
23-Apr-90	2300	0	0	0	0	41	0	0	41	24	65
24-Apr-90	300	0	0	0	0	89	0	0	89	57	146

Appendix G, continued.

1 Date	2 Time	3 Mark LPV	4 Recapture LPV	5 Mark RPV	6 Recapture RPV	7 No Marks	8 Sampled	9 Morts	10 Total Wild	11 Total Hatchery	12 Total Fish
24-Apr-90	800	0	0	0	0	47	0	0	47	24	71
24-Apr-90	1030	0	0	0	0	1	0	0	1	2	3
24-Apr-90	1900	0	0	0	0	8	0	0	8	7	15
24-Apr-90	2330	0	1	0	0	41	0	0	42	33	75
25-Apr-90	300	0	0	0	0	101	0	0	101	50	151
25-Apr-90	730	0	0	0	0	43	0	0	43	27	70
25-Apr-90	2300	0	0	0	0	26	0	0	26	25	51
26-Apr-90	300	0	1	0	0	91	0	0	92	35	127
26-Apr-90	730	0	0	0	0	61	0	0	61	17	78
26-Apr-90	2230	0	0	0	0	22	0	0	22	18	40
27-Apr-90	200	0	0	0	0	199	0	0	199	82	281
27-Apr-90	730	0	0	0	0	44	10	0	54	23	77
27-Apr-90	1830	0	0	0	0	9	0	0	9	6	15
27-Apr-90	2230	0	0	0	0	57	0	0	57	25	82
28-Apr-90	200	0	0	0	0	141	0	0	141	74	215
30-Apr-90	330	0	0	50	0	44	0	0	94	0	94
30-Apr-90	730	0	0	0	0	15	0	0	15	2	17
30-Apr-90	2100	0	0	0	0	13	0	0	13	2	15
01-May-90	30	0	0	38	7	37	0	0	82	28	110
01-May-90	300	0	0	0	0	30	0	0	30	12	42
01-May-90	730	0	0	0	1	37	0	0	38	12	50
01-May-90	1930	0	0	0	1	10	0	0	11	4	15
01-May-90	2330	0	0	0	2	21	0	0	23	4	27
02-May-90	230	0	0	0	4	47	0	0	51	20	71
02-May-90	830	0	0	0	2	25	10	0	37	32	69
02-May-90	2300	0	0	0	1	34	0	0	35	9	44
03-May-90	300	0	0	0	0	45	0	0	45	32	77
03-May-90	900	0	0	0	1	35	0	0	36	25	61
03-May-90	1830	0	0	0	0	6	0	0	6	7	13
04-May-90	30	0	0	0	0	10	0	0	10	6	16
04-May-90	300	0	0	0	0	9	0	0	9	9	18
04-May-90	615	0	0	0	0	18	0	0	18	20	38
04-May-90	1500	0	0	0	0	2	0	0	2	5	7
04-May-90	2100	0	0	0	0	5	0	0	5	0	5
05-May-90	30	0	0	0	0	3	0	0	3	6	9
05-May-90	300	0	0	0	0	5	0	0	5	5	10
07-May-90	1000	0	0	0	0	1	0	0	1	1	2
07-May-90	2100	2	0	0	0	0	0	0	2	6	8
08-May-90	15	16	0	0	0	1	0	0	17	21	38
08-May-90	300	19	0	0	0	1	0	0	20	16	36
08-May-90	830	13	0	0	0	4	0	0	17	15	32
08-May-90	1930	0	1	0	0	14	0	0	15	12	27
09-May-90	30	0	1	0	0	31	1	1	34	45	79
09-May-90	300	0	0	0	0	37	0	0	37	14	51
09-May-90	800	0	3	0	0	35	0	0	38	14	52

Appendix G, continued.

1 Date	2 Time	3 Mark LPV	4 Recapture LPV	5 Mark RPV	6 Recapture RPV	7 No Marks	8 Sampled	9 Morts	10 Total Wild	11 Total Hatchery	12 Total Fish
09-May-90	1830	0	1	0	0	16	0	0	17	11	28
10-May-90	100	0	1	0	1	42	0	0	44	25	69
10-May-90	300	0	0	0	2	42	0	0	44	22	66
10-May-90	800	0	0	0	0	1	35	0	36	16	52
10-May-90	2330	0	1	0	0	31	0	0	32	8	40
11-May-90	300	0	0	0	0	23	0	0	23	13	36
11-May-90	715	0	0	0	0	36	0	0	36	17	53
11-May-90	1900	0	0	0	0	14	0	0	14	2	16
12-May-90	15	0	0	0	0	51	0	0	51	13	64
12-May-90	300	0	0	0	0	45	0	0	45	6	51
14-May-90	2215	0	0	0	0	18	0	0	18	6	24
15-May-90	200	0	0	32	1	98	0	0	131	39	170
15-May-90	740	0	0	0	2	34	0	0	36	11	47
15-May-90	1830	0	0	0	0	3	0	0	3	1	4
15-May-90	2000	0	0	0	0	1	0	0	1	1	2
16-May-90	130	0	0	0	9	72	0	0	81	31	112
16-May-90	330	0	0	0	0	17	0	0	17	6	23
16-May-90	815	0	0	0	0	22	0	0	22	16	38
16-May-90	1830	0	0	0	0	1	0	0	1	1	2
16-May-90	2300	0	0	0	0	29	0	0	29	9	38
17-May-90	300	0	0	0	0	75	0	0	75	24	99
17-May-90	800	0	0	0	0	19	0	0	19	9	28
17-May-90	1930	0	0	0	0	3	0	0	3	0	3
18-May-90	300	0	0	0	0	46	0	0	46	4	50
18-May-90	830	0	0	0	0	16	0	0	16	9	25
18-May-90	1930	0	0	0	0	0	0	0	0	0	0
18-May-90	2300	0	0	0	0	24	0	0	24	5	29
19-May-90	300	0	0	0	0	39	0	0	39	10	49
21-May-90	2130	3	0	0	0	0	0	0	3	1	4
22-May-90	100	27	0	0	0	5	0	0	32	12	44
22-May-90	730	22	5	0	0	11	0	0	38	5	43
22-May-90	2000	0	0	0	0	3	0	0	3	1	4
23-May-90	30	0	1	0	0	13	0	0	14	5	19
23-May-90	300	0	1	0	0	27	0	0	28	10	38
23-May-90	745	0	1	0	0	27	0	0	28	6	34
23-May-90	2200	0	0	0	0	40	0	0	40	6	46
24-May-90	200	0	0	0	0	57	0	0	57	16	73
24-May-90	800	0	0	0	0	24	0	0	24	3	27
24-May-90	1900	0	0	0	0	8	0	0	8	3	11
24-May-90	2330	0	1	0	0	9	0	0	10	6	16
25-May-90	300	0	0	0	0	19	0	0	19	7	26
25-May-90	830	0	1	0	0	8	0	0	9	3	12
25-May-90		0	0	0	0		0	0	0		0
25-May-90		0	0	0	0		0	0	0		12
26-May-90	200	0	0	0	0	16	0	0	16	0	16

Appendix G, continued.

1	2	3	4	5	6	7	8	9	10	11	12
Date	Time	Mark LFV	Recapture LFV	Mark RFV	Recapture RFV	No Marks	Sampled	Morts	Total Wild	Total Hatchery	Total Fish
30-May-90	800	0	0	0	0	36	0	0	36	1	37
31-May-90	800	0	0	0	0	26	0	0	26	1	27
01-Jun-90	730	0	0	0	0	109	0	0	109	3	112
04-Jun-90	800	0	0	36	0	5	0	0	41	0	41
05-Jun-90	730	0	0	0	4	44	0	0	48	1	49
06-Jun-90	745	0	0	0	0	26	0	0	26	3	29
07-Jun-90	800	0	0	0	1	70	0	0	71	5	76
08-Jun-90	800	0	0	0	1	23	0	0	24	0	24
11-Jun-90	800	43	0	0	0	13	0	0	56	0	56
12-Jun-90	830	0	5	0	0	52	0	0	57	0	57
13-Jun-90	745	0	1	0	0	24	0	0	25	0	25
14-Jun-90	800	0	0	0	0	5	0	0	5	0	5
15-Jun-90	800	0	0	0	0	8	0	0	8	0	8
18-Jun-90	800	0	0	0	0	17	0	0	17	0	17
19-Jun-90	840	0	0	0	0	4	0	0	4	0	4
20-Jun-90	830	0	0	0	0	4	0	0	4	0	4
21-Jun-90	930	0	0	0	0	0	0	0	0	0	0
22-Jun-90	800	0	0	0	0	4	0	0	4	0	4
25-Jun-90	740	0	0	0	0	3	0	0	3	0	3
26-Jun-90	815	0	0	0	0	0	0	0	0	0	0
27-Jun-90	815	0	0	0	0	0	0	0	0	0	0
28-Jun-90	800	0	0	0	0	0	0	0	0	0	0
29-Jun-90	800	0	0	0	0	0	0	0	0	0	0

APPENDIX H

Incidental species caught in the Tucannon River downstream migrant trap during 1989/1990 season, with an indication of relative abundance.

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

APPENDIX I

Comparison of minimum and maximum stream temperatures in the Tucannon River near confluences of Panjab and Cummings Creeks, outlets of Big 4, Beaver-Watson, and Deer Lakes, and Marengo Bridge (River km 41) from September 1989 to April 1991. Temperatures are in degrees F.

	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
14-Sep	54	57	55	61	-	-	-	-	54	59	-	-
15-Sep	52	57	50	59	-	-	56	66	48	55	-	-
16-Sep	52	57	50	59	-	-	57	64	48	54	-	-
17-Sep	54	55	52	55	-	-	59	61	50	52	-	-
18-Sep	52	55	51	57	-	-	57	61	48	52	-	-
19-Sep	50	54	50	57	-	-	55	63	46	52	-	-
20-Sep	50	54	48	57	-	-	54	63	46	52	54	59
21-Sep	50	54	48	57	-	-	55	64	46	52	50	57
22-Sep	50	55	50	57	-	-	55	64	46	54	50	57
23-Sep	52	55	50	59	-	-	57	66	48	54	52	59
24-Sep	52	55	52	59	-	-	57	66	48	55	52	59
25-Sep	52	57	52	59	-	-	57	65	50	55	52	59
26-Sep	54	57	54	57	-	-	58	64	50	54	54	59
27-Sep	52	55	51	57	-	-	56	64	48	54	52	57
28-Sep	52	55	52	59	-	-	57	64	48	54	52	59
29-Sep	54	57	52	59	-	-	58	66	50	55	54	59
30-Sep	54	55	53	55	-	-	61	63	52	54	55	56
01-Oct	52	54	52	55	-	-	57	61	48	52	50	54
02-Oct	50	52	48	52	-	-	54	59	45	48	48	52
03-Oct	48	50	46	52	-	-	52	57	43	46	45	52
04-Oct	48	50	45	52	-	-	50	57	43	48	45	52
05-Oct	48	52	48	54	-	-	52	60	45	50	46	54
06-Oct	48	52	48	54	-	-	54	60	45	50	48	54
07-Oct	48	52	48	54	-	-	54	61	45	50	48	54
08-Oct	48	54	48	55	-	-	54	61	46	50	48	54
09-Oct	48	52	48	54	-	-	52	60	45	50	47	54
10-Oct	49	54	48	54	-	-	54	61	46	51	48	54
11-Oct	50	52	50	52	-	-	54	57	46	50	48	50
12-Oct	50	54	50	54	-	-	55	59	48	50	49	52
13-Oct	50	54	50	54	-	-	55	59	46	50	48	52
14-Oct	50	52	50	52	-	-	55	59	46	48	48	50
15-Oct	46	48	45	48	-	-	49	55	41	45	43	48
16-Oct	45	48	43	48	-	-	48	54	41	45	41	46
17-Oct	45	48	43	48	-	-	48	54	41	45	41	48
18-Oct	46	50	45	50	-	-	50	56	43	46	43	49
19-Oct	48	52	46	52	-	-	52	57	45	48	45	50
20-Oct	50	54	50	52	-	-	55	59	46	50	48	50
21-Oct	51	52	50	52	-	-	55	57	48	50	49	50
22-Oct	50	52	48	52	-	-	54	57	46	48	48	50

Appendix I, 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
23-Oct	50	52	50	52	-	-	55	57	46	48	48	50
24-Oct	46	50	46	50	-	-	50	55	43	46	45	48
25-Oct	48	50	46	50	-	-	52	55	45	46	45	48
26-Oct	46	48	45	48	-	-	50	54	41	45	43	46
27-Oct	48	49	46	48	-	-	52	54	43	45	45	46
28-Oct	45	46	45	46	-	-	48	52	41	43	43	45
29-Oct	43	45	41	45	-	-	46	50	37	41	39	43
30-Oct	43	46	41	45	-	-	46	50	37	41	39	43
31-Oct	45	46	43	45	-	-	46	50	37	43	39	43
01-Nov	43	45	41	43	-	-	45	49	37	39	39	43
02-Nov	43	46	41	45	-	-	45	50	36	39	37	43
03-Nov	45	48	43	48	-	-	48	54	39	45	41	46
04-Nov	48	49	48	49	-	-	54	55	44	45	46	48
05-Nov	46	48	45	48	-	-	50	52	41	43	43	45
06-Nov	45	48	45	46	-	-	49	52	41	43	43	46
07-Nov	46	47	46	47	-	-	51	52	41	43	43	45
08-Nov	45	48	45	46	-	-	48	52	41	43	43	45
09-Nov	48	52	48	52	-	-	54	58	43	48	46	52
10-Nov	48	52	50	52	-	-	55	58	46	48	50	52
11-Nov	48	52	48	52	-	-	54	57	46	48	48	50
12-Nov	48	50	48	50	-	-	53	55	45	46	46	50
13-Nov	46	48	45	46	-	-	50	52	41	43	43	45
14-Nov	45	46	45	46	-	-	48	52	39	41	41	43
15-Nov	43	46	43	45	-	-	46	50	37	41	39	43
16-Nov	45	48	43	46	-	-	48	52	39	43	41	43
17-Nov	46	48	45	46	-	-	50	52	41	43	42	43
18-Nov	45	48	43	46	-	-	48	52	39	43	41	43
19-Nov	46	48	45	48	-	-	48	54	39	45	41	46
20-Nov	46	48	46	48	-	-	50	54	43	45	45	46
21-Nov	46	48	46	48	-	-	50	54	43	45	45	46
22-Nov	45	46	43	45	-	-	46	50	39	43	39	43
23-Nov	45	46	43	45	-	-	48	50	39	41	41	43
24-Nov	45	46	43	45	-	-	48	50	39	41	41	43
25-Nov	45	46	43	45	-	-	48	50	39	43	41	43
26-Nov	45	46	43	44	-	-	48	49	39	40	40	41
27-Nov	43	45	41	43	-	-	45	48	36	39	37	41
28-Nov	42	43	39	41	-	-	45	46	36	37	37	39
29-Nov	42	43	39	41	-	-	45	46	36	37	36	37
30-Nov	41	45	39	41	-	-	43	45	36	37	36	37
01-Dec	41	43	39	41	-	-	43	45	34	36	36	37
02-Dec	43	45	39	41	-	-	45	46	34	36	36	37
03-Dec	45	46	41	45	-	-	45	50	36	41	37	40
04-Dec	46	48	45	46	-	-	50	52	41	43	43	46
05-Dec	45	46	45	46	-	-	50	52	41	43	43	45
06-Dec	45	46	45	46	-	-	48	50	39	41	41	43

Appendix I, 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
07-Dec	43	46	41	45	-	-	46	50	37	41	39	41
08-Dec	46	48	45	46	-	-	50	51	41	43	41	43
09-Dec	45	46	43	45	-	-	48	50	39	41	39	43
10-Dec	43	45	41	43	-	-	45	46	37	39	37	39
11-Dec	41	43	39	41	-	-	43	45	34	36	36	37
12-Dec	41	43	37	39	-	-	41	45	34	36	36	37
13-Dec	41	43	37	41	-	-	43	45	34	36	34	36
14-Dec	43	45	39	43	-	-	45	46	34	37	36	37
15-Dec	43	44	41	42	-	-	45	46	36	37	36	37
16-Dec	41	43	39	41	-	-	43	45	36	37	37	38
17-Dec	40	41	39	40	-	-	45	46	36	37	36	37
18-Dec	41	43	37	39	-	-	43	45	34	36	36	37
19-Dec	43	45	39	43	-	-	42	45	34	36	36	37
20-Dec	43	45	41	43	-	-	45	46	36	37	36	39
21-Dec	43	45	41	43	-	-	45	46	36	37	37	39
22-Dec	43	45	39	41	-	-	43	45	34	36	36	37
23-Dec	43	46	41	45	-	-	43	48	36	39	36	39
24-Dec	43	44	41	43	-	-	43	45	36	37	36	37
25-Dec	43	44	39	41	-	-	43	45	35	36	36	37
26-Dec	41	43	39	40	-	-	41	45	34	36	36	37
27-Dec	41	45	37	39	-	-	41	43	34	35	36	37
28-Dec	43	45	39	40	-	-	42	43	34	35	34	36
29-Dec	41	43	37	39	-	-	41	43	32	34	34	36
30-Dec	41	43	39	41	-	-	43	45	34	36	34	36
31-Dec	43	45	39	43	-	-	41	45	34	36	34	36
01-Jan	43	45	41	43	-	-	45	46	36	37	36	37
02-Jan	41	45	37	41	-	-	41	45	34	37	36	37
03-Jan	39	43	37	41	-	-	41	45	32	34	34	36
04-Jan	43	45	41	43	-	-	45	46	34	37	36	39
05-Jan	43	45	41	43	-	-	45	46	36	39	37	41
06-Jan	45	46	43	45	-	-	46	48	37	39	40	42
07-Jan	45	46	43	45	-	-	48	49	39	41	41	42
08-Jan	45	46	43	45	-	-	48	49	39	40	40	41
09-Jan	45	46	45	46	-	-	48	50	39	42	41	45
10-Jan	45	46	43	46	-	-	46	50	39	43	41	45
11-Jan	45	46	43	45	-	-	46	48	37	39	39	41
12-Jan	45	46	43	45	-	-	47	48	39	40	39	41
13-Jan	46	48	44	45	-	-	48	49	39	40	39	41
14-Jan	45	46	44	45	-	-	48	49	39	40	40	41
15-Jan	45	46	43	45	-	-	48	49	39	40	39	40
16-Jan	45	46	43	45	-	-	47	48	39	40	39	41
17-Jan	44	45	43	44	-	-	46	47	37	39	39	40
18-Jan	41	43	39	41	-	-	43	45	36	37	36	37
19-Jan	41	43	39	41	-	-	41	43	34	36	36	37
20-Jan	41	43	39	41	-	-	43	45	34	36	36	37

Appendix I, 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
21-Jan	41	45	39	43	-	-	43	46	34	36	34	37
22-Jan	43	45	43	44	-	-	45	46	36	37	37	39
23-Jan	41	43	39	43	-	-	44	45	36	37	37	38
24-Jan	41	43	39	43	-	-	43	45	34	37	36	37
25-Jan	43	45	41	43	-	-	45	46	36	38	37	39
26-Jan	41	43	39	41	-	-	43	45	36	37	36	37
27-Jan	41	43	39	40	-	-	42	43	36	37	36	37
28-Jan	43	45	39	43	-	-	43	46	36	37	36	39
29-Jan	41	43	39	41	-	-	43	45	35	36	36	37
30-Jan	41	43	39	43	-	-	43	45	36	37	36	39
31-Jan	42	43	39	41	-	-	43	45	36	37	36	39
01-Feb	41	43	39	43	-	-	43	45	36	37	37	39
02-Feb	43	45	41	45	-	-	45	48	36	39	37	41
03-Feb	43	45	41	43	-	-	45	46	37	39	39	41
04-Feb	42	43	41	42	-	-	45	46	36	39	37	39
05-Feb	41	43	39	41	-	-	43	45	36	37	36	39
06-Feb	41	43	39	41	-	-	43	45	36	37	36	39
07-Feb	41	43	37	41	-	-	41	43	34	36	34	37
08-Feb	39	43	36	41	-	-	41	45	34	37	36	39
09-Feb	43	45	41	43	-	-	45	47	36	39	37	41
10-Feb	45	46	43	46	-	-	47	50	39	43	40	46
11-Feb	45	46	43	45	-	-	46	50	39	41	41	43
12-Feb	42	43	41	43	-	-	45	46	36	37	36	37
13-Feb	41	43	39	41	-	-	43	45	34	37	34	36
14-Feb	39	43	37	41	-	-	41	45	32	36	32	36
15-Feb	39	43	37	41	-	-	41	45	32	36	32	37
16-Feb	41	43	39	43	-	-	43	45	36	37	34	37
17-Feb	41	43	39	41	-	-	43	45	34	36	34	37
18-Feb	39	41	35	41	-	-	40	43	30	34	36	43
19-Feb	39	41	39	41	-	-	40	43	30	36	37	43
20-Feb	41	45	37	41	-	-	41	46	32	37	39	43
21-Feb	45	46	43	46	-	-	46	50	37	41	39	41
22-Feb	44	45	41	46	-	-	45	50	37	41	39	43
23-Feb	42	46	41	43	-	-	45	50	36	41	-	-
24-Feb	45	46	-	-	-	-	46	51	37	43	-	-
25-Feb	47	48	-	-	-	-	46	50	37	41	-	-
26-Feb	-	-	-	-	-	-	45	48	37	39	-	-
27-Feb	-	-	-	-	-	-	45	48	36	39	-	-
28-Feb	-	-	-	-	-	-	45	48	36	39	-	-
01-Mar	-	-	-	-	-	-	45	48	36	41	-	-
02-Mar	-	-	-	-	-	-	45	50	36	41	-	-
03-Mar	-	-	-	-	-	-	46	48	37	39	-	-
04-Mar	-	-	-	-	-	-	46	50	37	42	-	-
05-Mar	-	-	-	-	-	-	48	50	39	41	-	-
06-Mar	-	-	-	-	-	-	45	50	37	43	-	-

Appendix I, 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
07-Mar	-	-	-	-	-	-	46	52	37	43	-	-
08-Mar	-	-	-	-	-	-	46	49	37	41	-	-
09-Mar	-	-	-	-	-	-	46	50	37	43	-	-
10-Mar	-	-	-	-	-	-	48	49	39	40	-	-
11-Mar	-	-	-	-	-	-	46	48	37	41	-	-
12-Mar	-	-	-	-	-	-	43	48	-	-	-	-
13-Mar	-	-	-	-	-	-	45	50	-	-	-	-
14-Mar	-	-	-	-	-	-	45	50	-	-	-	-
15-Mar	-	-	-	-	-	-	45	52	-	-	-	-
16-Mar	-	-	-	-	-	-	48	52	-	-	-	-
17-Mar	-	-	-	-	-	-	48	54	-	-	-	-
18-Mar	-	-	-	-	-	-	48	54	-	-	-	-
19-Mar	-	-	-	-	-	-	48	55	-	-	-	-
20-Mar	-	-	-	-	-	-	45	54	-	-	-	-
21-Mar	-	-	-	-	-	-	48	54	-	-	-	-
22-Mar	-	-	-	-	-	-	-	-	-	-	-	-
23-Mar	-	-	-	-	-	-	-	-	-	-	-	-
24-Mar	-	-	-	-	-	-	-	-	-	-	-	-
25-Mar	-	-	-	-	-	-	-	-	-	-	-	-
26-Mar	-	-	-	-	-	-	-	-	-	-	-	-
27-Mar	-	-	-	-	-	-	-	-	-	-	-	-
28-Mar	-	-	-	-	-	-	-	-	-	-	-	-
29-Mar	-	-	-	-	-	-	-	-	-	-	-	-
30-Mar	-	-	-	-	-	-	-	-	-	-	-	-
31-Mar	-	-	-	-	-	-	-	-	-	-	-	-
01-Apr	-	-	-	-	-	-	-	-	-	-	-	-
02-Apr	-	-	-	-	-	-	-	-	-	-	-	-
03-Apr	-	-	-	-	-	-	-	-	-	-	-	-
04-Apr	-	-	-	-	-	-	-	-	-	-	-	-
05-Apr	-	-	-	-	-	-	-	-	-	-	-	-
06-Apr	-	-	-	-	-	-	-	-	-	-	-	-
07-Apr	-	-	-	-	-	-	-	-	-	-	-	-
08-Apr	-	-	-	-	-	-	-	-	-	-	-	-
09-Apr	-	-	-	-	-	-	-	-	-	-	-	-
10-Apr	-	-	-	-	-	-	-	-	-	-	-	-
11-Apr	-	-	-	-	-	-	-	-	-	-	-	-
12-Apr	-	-	-	-	-	-	-	-	-	-	-	-
13-Apr	-	-	-	-	-	-	-	-	-	-	-	-
14-Apr	-	-	-	-	-	-	-	-	-	-	-	-
15-Apr	-	-	-	-	-	-	-	-	-	-	-	-
16-Apr	-	-	-	-	-	-	-	-	-	-	-	-
17-Apr	-	-	-	-	-	-	-	-	-	-	-	-
18-Apr	-	-	-	-	-	-	-	-	-	-	-	-
19-Apr	-	-	-	-	-	-	-	-	-	-	-	-
20-Apr	-	-	-	-	-	-	-	-	-	-	-	-

Appendix I, 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
21-Apr	-	-	-	-	-	-	-	-	-	-	-	-
22-Apr	-	-	-	-	-	-	-	-	-	-	-	-
23-Apr	39	41	39	42	-	-	-	-	46	48	-	-
24-Apr	39	41	38	43	-	-	-	-	45	50	-	-
25-Apr	37	39	37	39	-	-	42	45	45	46	-	-
26-Apr	37	41	37	43	-	-	43	48	45	48	50	52
27-Apr	37	39	37	39	-	-	43	45	45	46	46	48
28-Apr	36	37	36	37	-	-	41	42	41	43	45	46
29-Apr	36	39	36	41	-	-	39	46	42	46	45	50
30-Apr	37	43	36	45	-	-	41	50	46	50	45	50
01-May	37	43	37	45	-	-	43	50	43	50	46	49
02-May	39	43	39	43	-	-	45	50	46	50	50	55
03-May	37	45	37	46	-	-	43	54	45	52	48	58
04-May	39	45	39	46	-	-	45	54	45	52	50	59
05-May	39	46	39	48	-	-	45	55	46	54	50	59
06-May	39	41	39	43	-	-	45	48	46	48	50	54
07-May	37	39	37	39	-	-	43	45	43	46	46	50
08-May	37	41	36	41	-	-	43	46	43	46	45	52
09-May	37	45	36	46	-	-	41	52	43	50	46	56
10-May	37	45	37	46	-	-	43	54	45	52	48	57
11-May	39	45	37	46	-	-	45	54	45	52	49	57
12-May	39	43	39	43	-	-	45	50	46	49	50	55
13-May	39	43	39	45	-	-	45	50	46	50	50	57
14-May	39	43	37	43	-	-	43	50	45	49	48	55
15-May	39	45	39	46	-	-	45	54	46	52	50	58
16-May	39	45	37	45	-	-	45	52	45	52	50	57
17-May	40	45	39	46	-	-	46	54	47	52	52	57
18-May	39	43	39	46	-	-	45	54	46	52	50	57
19-May	37	43	37	45	-	-	43	52	45	52	49	58
20-May	41	43	40	45	-	-	46	51	48	50	52	55
21-May	39	46	40	49	-	-	46	55	48	54	52	59
22-May	41	46	41	47	-	-	48	54	50	54	54	59
23-May	41	45	41	47	-	-	48	54	50	54	54	57
24-May	39	41	41	43	-	-	46	50	48	50	50	55
25-May	39	45	40	45	-	-	46	52	46	52	50	59
26-May	39	45	40	46	-	-	46	52	48	54	52	58
27-May	41	45	41	45	-	-	48	50	50	52	54	55
28-May	41	43	41	43	-	-	48	50	50	52	54	55
29-May	42	43	43	45	-	-	48	49	50	51	54	55
30-May	41	45	41	46	-	-	46	52	46	51	52	55
31-May	41	42	41	43	-	-	46	48	46	50	52	54
01-Jun	39	41	40	43	-	-	45	48	46	48	50	52
02-Jun	39	43	39	45	-	-	45	52	46	52	50	57
03-Jun	41	45	41	45	-	-	48	52	48	52	52	57
04-Jun	41	45	41	46	-	-	46	54	48	52	52	59

Appendix I, 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
05-Jun	40	45	41	46	-	-	46	52	46	52	52	60
06-Jun	41	45	42	45	-	-	48	52	48	52	54	57
07-Jun	41	46	43	47	-	-	48	50	48	52	54	59
08-Jun	41	46	43	48	-	-	48	51	49	54	54	61
09-Jun	43	50	43	54	-	-	49	61	50	57	55	66
10-Jun	45	46	45	48	-	-	50	54	52	54	55	59
11-Jun	41	43	41	45	-	-	48	52	48	52	52	59
12-Jun	41	43	41	45	-	-	46	52	48	51	52	55
13-Jun	41	45	41	46	-	-	46	52	48	52	52	57
14-Jun	40	46	41	49	-	-	46	55	46	54	52	60
15-Jun	41	48	41	50	-	-	47	58	48	55	54	63
16-Jun	43	48	45	54	-	-	50	61	51	57	46	55
17-Jun	43	46	43	46	-	-	50	54	50	54	55	57
18-Jun	43	50	43	54	-	-	50	61	50	59	55	66
19-Jun	45	51	45	55	-	-	52	63	54	59	57	68
20-Jun	45	50	46	55	-	-	52	63	52	59	59	68
21-Jun	45	52	45	57	-	-	52	64	52	61	57	70
22-Jun	46	50	48	52	-	-	54	57	55	58	61	63
23-Jun	46	50	48	58	-	-	54	66	55	63	61	72
24-Jun	46	54	48	59	-	-	54	66	55	64	61	72
25-Jun	46	54	48	59	-	-	54	67	55	63	61	72
26-Jun	46	55	48	59	54	66	54	66	55	63	61	72
27-Jun	46	52	48	56	54	63	54	63	55	61	61	70
28-Jun	46	52	48	57	54	63	55	63	55	61	61	70
29-Jun	46	55	48	61	54	68	54	68	55	64	61	73
30-Jun	48	55	50	61	55	66	55	68	57	64	63	73
01-Jul	48	55	50	61	54	67	55	68	57	64	63	73
02-Jul	48	50	50	52	54	57	55	57	55	57	58	61
03-Jul	45	52	45	56	50	63	50	63	52	59	57	68
04-Jul	45	52	46	57	52	63	52	64	54	63	59	72
05-Jul	48	52	50	55	55	61	55	63	57	61	63	68
06-Jul	48	52	50	55	54	61	55	63	56	61	61	68
07-Jul	45	54	46	59	50	64	52	66	54	61	59	70
08-Jul	46	55	48	61	52	66	54	68	55	64	61	73
09-Jul	46	55	48	61	54	68	54	70	55	66	61	75
10-Jul	48	57	50	63	54	69	55	70	57	66	65	76
11-Jul	49	57	51	64	55	69	57	72	59	68	64	77
12-Jul	50	57	54	63	59	69	59	70	61	68	66	79
13-Jul	50	59	52	64	57	71	59	72	61	68	68	77
14-Jul	48	57	50	63	55	69	57	72	59	68	64	77
15-Jul	49	57	52	64	55	69	57	72	59	68	64	77
16-Jul	49	57	52	63	55	69	57	70	59	68	66	76
17-Jul	48	57	50	63	55	68	56	70	58	66	64	75
18-Jul	48	56	50	63	55	68	55	70	57	66	64	74
19-Jul	48	56	50	63	55	68	55	70	57	66	63	75

Appendix I, 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
20-Jul	48	57	50	63	55	68	56	70	59	67	64	77
21-Jul	48	57	52	63	55	69	57	72	59	68	64	77
22-Jul	48	55	50	63	55	69	57	70	59	68	65	77
23-Jul	50	55	52	63	57	68	59	70	61	66	66	75
24-Jul	50	52	52	55	57	61	57	61	59	61	64	68
25-Jul	49	50	51	54	55	59	57	60	59	60	63	64
26-Jul	48	52	50	57	55	63	55	63	57	61	63	68
27-Jul	48	55	50	61	54	67	55	68	57	65	63	73
28-Jul	48	55	50	63	54	68	55	69	57	66	63	75
29-Jul	48	57	50	63	55	69	57	72	59	68	64	77
30-Jul	49	55	52	63	57	68	58	69	59	67	66	77
31-Jul	50	57	52	63	57	68	59	69	61	68	66	77
01-Aug	50	57	52	63	57	68	58	69	59	66	65	75
02-Aug	48	55	50	61	55	67	55	68	57	64	63	73
03-Aug	46	55	50	63	54	68	55	69	57	65	63	75
04-Aug	48	56	50	63	55	68	57	70	59	67	64	77
05-Aug	49	57	52	64	56	69	58	72	59	68	64	77
06-Aug	50	57	52	64	57	69	59	72	61	68	66	77
07-Aug	50	57	52	64	57	69	57	72	60	68	64	77
08-Aug	50	57	52	63	57	68	59	69	60	68	64	76
09-Aug	52	55	54	59	59	66	61	67	63	66	68	73
10-Aug	52	54	54	57	59	64	60	65	61	64	66	72
11-Aug	50	57	59	63	57	69	59	72	59	68	64	77
12-Aug	50	57	54	64	59	69	59	72	61	68	66	77
13-Aug	50	57	52	63	57	69	59	72	61	68	66	77
14-Aug	50	57	52	63	57	68	68	69	61	67	66	75
15-Aug	52	55	54	61	59	66	61	68	61	66	66	72
16-Aug	49	54	52	61	55	66	57	66	59	64	64	72
17-Aug	48	52	50	55	55	61	57	63	58	61	63	70
18-Aug	50	51	52	53	57	59	57	59	59	60	64	65
19-Aug	48	50	50	52	55	57	55	57	55	57	61	63
20-Aug	46	50	48	54	54	59	54	59	55	59	59	65
21-Aug	48	50	50	54	55	59	55	59	57	59	61	63
22-Aug	48	52	50	55	57	64	56	63	57	61	63	70
23-Aug	49	52	50	59	57	66	55	64	57	63	63	70
24-Aug	45	52	47	57	52	63	54	63	55	61	59	68
25-Aug	48	50	50	55	55	61	55	61	55	60	61	66
26-Aug	46	50	48	54	54	60	54	60	55	59	61	66
27-Aug	46	55	48	57	54	63	54	63	55	61	59	68
28-Aug	46	52	48	59	54	66	54	66	55	63	61	70
29-Aug	48	52	50	57	55	63	55	64	57	63	63	68
30-Aug	48	52	50	57	55	64	55	64	57	63	61	68
31-Aug	46	52	48	57	54	63	54	63	55	61	59	68
01-Sep	46	52	48	57	54	64	54	64	55	61	59	69
02-Sep	46	52	48	57	54	64	54	64	55	61	61	69

Appendix I, 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-Sep	46	52	48	57	54	64	54	64	55	63	61	70
04-Sep	48	51	48	59	55	64	55	66	57	63	61	70
05-Sep	48	54	50	59	57	66	57	66	58	64	63	72
06-Sep	-	-	50	59	56	66	55	66	57	64	63	72
07-Sep	-	-	51	57	57	64	57	64	59	64	64	72
08-Sep	-	-	50	59	56	66	57	66	57	63	63	72
09-Sep	-	-	50	59	57	66	57	66	58	64	63	72
10-Sep	-	-	50	59	55	66	55	66	57	63	63	72
11-Sep	-	-	50	59	55	64	55	64	57	63	63	70
12-Sep	-	-	48	56	54	63	54	63	55	61	61	68
13-Sep	-	-	46	55	52	63	52	63	54	60	59	67
14-Sep	-	-	46	55	52	61	52	61	54	60	58	66
15-Sep	-	-	48	54	54	64	54	61	54	59	59	66
16-Sep	-	-	48	52	54	59	54	60	54	58	59	64
17-Sep	-	-	46	54	52	61	52	61	54	59	59	65
18-Sep	-	-	46	54	52	59	52	60	54	59	57	65
19-Sep	-	-	45	54	52	59	52	60	54	59	57	65
20-Sep	-	-	45	52	50	58	51	59	52	57	57	63
21-Sep	-	-	45	52	50	59	50	59	52	57	55	64
22-Sep	-	-	45	54	50	59	50	60	52	59	57	65
23-Sep	-	-	46	54	52	61	52	61	54	59	58	66
24-Sep	-	-	46	54	52	61	52	61	54	59	59	66
25-Sep	-	-	46	52	52	59	54	59	54	59	59	66
26-Sep	-	-	48	54	54	59	54	59	55	59	61	63
27-Sep	-	-	48	54	54	61	54	61	54	59	59	65
28-Sep	-	-	46	54	52	59	52	59	54	59	59	64
29-Sep	-	-	46	52	52	59	52	59	54	58	57	64
30-Sep	-	-	-	-	50	57	50	57	52	57	56	61
01-Oct	-	-	-	-	50	54	50	59	41	55	55	59
02-Oct	-	-	-	-	48	52	50	52	50	54	54	57
03-Oct	-	-	-	-	48	52	50	54	50	54	54	58
04-Oct	-	-	-	-	52	57	52	59	54	57	57	63
05-Oct	-	-	-	-	52	54	52	56	54	55	55	57
06-Oct	-	-	-	-	45	50	45	51	48	50	50	54
07-Oct	-	-	-	-	43	48	43	48	45	48	48	54
08-Oct	-	-	-	-	43	48	43	48	45	48	48	54
09-Oct	-	-	-	-	45	50	45	50	46	50	50	55
10-Oct	-	-	-	-	48	50	48	51	50	52	54	55
11-Oct	-	-	42	43	43	45	44	49	45	48	46	50
12-Oct	42	45	43	45	43	46	43	46	44	46	54	57
13-Oct	42	45	43	45	43	46	43	45	45	46	52	55
14-Oct	41	45	41	43	41	45	41	43	43	45	52	54
15-Oct	43	45	41	45	43	47	41	46	43	47	52	57
16-Oct	43	45	43	45	43	46	43	45	43	46	52	54
17-Oct	40	43	39	43	39	45	39	43	40	43	48	52

Appendix I, 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
18-Oct	42	43	41	43	43	45	43	45	43	45	51	52
19-Oct	43	45	41	43	41	43	41	43	42	43	50	52
20-Oct	39	43	37	41	37	43	37	43	39	43	46	52
21-Oct	41	42	39	43	41	43	41	43	41	45	50	54
22-Oct	41	43	39	42	41	43	41	43	41	45	47	52
23-Oct	41	43	39	43	39	45	39	45	41	43	48	52
24-Oct	41	43	39	45	39	45	41	45	41	45	48	54
25-Oct	43	47	41	46	41	46	41	47	43	46	49	55
26-Oct	43	45	43	45	43	45	43	46	42	45	52	53
27-Oct	43	46	41	45	41	46	41	46	41	45	48	52
28-Oct	45	46	41	45	43	45	43	45	43	45	50	52
29-Oct	41	45	39	43	39	45	41	45	41	43	50	52
30-Oct	43	46	41	45	41	45	41	45	43	45	50	52
31-Oct	45	46	42	43	43	45	43	44	42	45	50	52
01-Nov	41	45	39	41	39	41	39	43	39	41	48	50
02-Nov	40	41	37	41	37	39	37	40	37	39	46	48
03-Nov	39	43	36	41	37	41	37	41	37	41	45	48
04-Nov	41	43	41	42	41	43	41	43	41	43	49	52
05-Nov	41	43	39	41	39	41	39	43	40	41	48	49
06-Nov	39	41	37	39	36	39	37	40	37	39	45	48
07-Nov	39	41	37	39	38	39	37	41	37	41	45	49
08-Nov	41	43	39	41	39	43	39	43	40	43	48	50
09-Nov	43	45	41	43	41	45	41	45	43	45	50	52
10-Nov	43	45	41	45	43	45	43	46	43	46	51	53
11-Nov	41	45	39	43	39	43	41	45	41	43	48	52
12-Nov	41	45	39	43	39	43	39	45	40	42	48	52
13-Nov	43	45	41	43	41	43	41	43	43	45	50	52
14-Nov	41	45	37	42	41	43	41	43	39	43	48	49
15-Nov	40	43	37	40	37	41	37	41	39	41	46	49
16-Nov	39	41	36	39	36	39	36	39	37	39	45	48
17-Nov	39	43	36	41	36	41	36	39	37	41	45	48
18-Nov	42	43	40	41	40	42	41	43	41	43	48	50
19-Nov	41	43	39	41	39	41	39	42	40	41	46	47
20-Nov	40	41	37	38	36	39	37	39	37	39	45	46
21-Nov	37	39	37	38	36	37	36	37	37	39	45	46
22-Nov	39	43	37	41	38	41	38	41	39	41	46	49
23-Nov	41	43	39	41	39	41	41	43	41	43	48	50
24-Nov	43	45	41	43	41	43	41	43	41	43	49	50
25-Nov	41	45	37	43	37	43	41	43	39	43	46	50
26-Nov	39	41	36	37	37	38	37	39	37	38	45	46
27-Nov	37	39	36	37	36	37	37	38	37	38	45	46
28-Nov	38	39	36	37	36	37	36	38	36	39	45	46
29-Nov	38	39	37	38	37	38	37	39	37	40	45	46
30-Nov	37	39	36	37	36	37	37	39	36	39	43	44
01-Dec	36	37	32	36	33	36	34	36	36	36	41	42

Appendix I, 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
02-Dec	37	39	34	37	34	36	34	37	34	37	41	44
03-Dec	37	39	36	37	36	37	36	39	36	39	43	46
04-Dec	37	39	36	37	36	37	37	39	37	39	45	46
05-Dec	38	39	36	37	36	37	37	38	36	37	43	44
06-Dec	37	39	34	36	34	36	34	37	36	37	43	45
07-Dec	37	38	34	36	34	36	34	36	34	36	41	43
08-Dec	37	39	34	37	36	37	34	38	36	39	41	45
09-Dec	39	41	37	41	37	40	37	41	39	41	45	48
10-Dec	40	41	39	41	39	40	39	41	41	42	46	48
11-Dec	39	41	36	39	36	39	36	41	36	40	43	44
12-Dec	36	39	34	36	34	36	34	36	34	36	41	43
13-Dec	37	38	36	37	35	36	36	37	36	37	43	45
14-Dec	36	37	34	36	34	36	34	36	34	36	41	43
15-Dec	36	37	34	36	34	36	34	36	34	36	39	41
16-Dec	37	38	34	36	34	36	34	36	34	36	41	43
17-Dec	37	39	36	37	34	37	34	37	36	38	43	45
18-Dec	37	39	36	39	34	37	34	37	34	38	39	43
19-Dec	34	37	30	32	30	34	30	34	32	34	36	37
20-Dec	34	35	30	31	30	31	30	31	32	33	36	37
21-Dec	34	35	30	31	30	31	30	31	32	33	36	37
22-Dec	34	35	30	31	30	31	30	31	31	32	36	37
23-Dec	34	35	30	31	30	31	30	31	31	32	36	37
24-Dec	34	35	30	31	30	31	30	31	31	32	36	37
25-Dec	34	35	30	31	30	31	30	31	31	32	36	37
26-Dec	34	37	30	31	30	31	30	31	31	32	36	37
27-Dec	36	37	30	32	30	31	30	31	31	32	36	39
28-Dec	34	36	30	32	30	31	30	31	31	32	36	39
29-Dec	32	33	30	31	30	31	30	31	31	32	36	37
30-Dec	33	34	30	31	30	31	30	31	30	31	36	37
31-Dec	33	37	30	31	30	31	30	31	31	32	36	39
01-Jan	37	38	30	36	30	33	30	31	31	34	39	42
02-Jan	36	37	32	35	32	34	34	35	33	34	40	41
03-Jan	34	36	31	32	31	32	32	34	33	34	39	40
04-Jan	34	36	31	32	30	31	30	31	32	33	38	39
05-Jan	34	35	30	32	30	31	30	31	32	34	37	38
06-Jan	34	36	30	32	30	31	30	31	32	33	37	38
07-Jan	36	37	30	36	30	35	30	34	32	34	37	38
08-Jan	37	39	35	36	34	36	34	37	34	36	38	41
09-Jan	37	39	35	36	34	36	34	37	34	36	39	40
10-Jan	37	39	36	37	34	36	34	36	35	36	41	43
11-Jan	37	39	36	37	36	37	36	38	36	37	43	45
12-Jan	37	39	36	37	36	37	37	38	36	37	45	46
13-Jan	37	39	36	37	36	37	37	38	37	38	45	46
14-Jan	38	39	37	38	36	37	37	39	37	39	45	46
15-Jan	37	39	36	37	36	37	37	39	37	38	45	46

Appendix I, 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
16-Jan	37	39	36	38	36	37	36	39	36	38	43	45
17-Jan	39	40	37	39	37	38	38	40	38	40	46	48
18-Jan	37	39	36	39	37	38	37	39	37	39	43	46
19-Jan	36	39	35	36	36	37	36	38	35	36	41	43
20-Jan	36	37	32	34	34	36	34	36	34	35	39	41
21-Jan	34	36	32	34	32	34	32	34	32	34	39	41
22-Jan	36	37	32	36	32	34	32	36	32	36	39	41
23-Jan	36	37	34	36	32	33	32	34	34	36	39	41
24-Jan	36	37	34	36	33	34	34	36	34	36	41	42
25-Jan	34	36	30	34	30	34	32	34	32	34	-	-
26-Jan	34	36	30	32	30	32	30	34	32	34	-	-
27-Jan	34	36	30	34	30	32	30	34	31	34	-	-
28-Jan	34	36	32	34	31	32	32	34	32	33	-	-
29-Jan	32	36	30	32	30	31	30	31	30	31	-	-
30-Jan	34	37	30	36	30	34	30	36	30	34	-	-
31-Jan	36	39	34	37	34	36	34	37	34	37	-	-
01-Feb	37	39	36	39	36	37	36	39	37	39	-	-
02-Feb	38	41	37	39	36	38	37	40	38	41	-	-
03-Feb	39	41	37	39	37	39	37	40	37	41	-	-
04-Feb	39	41	37	41	37	39	37	41	30	32	-	-
05-Feb	39	41	36	39	38	39	39	41	31	32	-	-
06-Feb	37	39	34	39	36	37	34	39	36	39	-	-
07-Feb	37	39	36	39	36	37	36	40	36	39	-	-
08-Feb	37	40	36	40	36	38	36	41	36	40	-	-
09-Feb	37	39	36	39	36	37	36	39	36	39	-	-
10-Feb	37	39	34	39	36	37	36	39	36	37	-	-
11-Feb	37	41	36	40	36	38	36	40	36	38	-	-
12-Feb	39	41	37	39	37	40	37	41	37	40	-	-
13-Feb	39	41	37	41	37	39	38	41	38	39	-	-
14-Feb	39	41	39	43	39	41	40	43	39	43	-	-
15-Feb	39	41	37	41	38	39	38	41	39	41	-	-
16-Feb	39	41	39	40	38	39	39	41	39	41	-	-
17-Feb	37	39	36	39	36	37	36	39	36	39	-	-
18-Feb	37	39	36	39	36	37	36	39	36	38	-	-
19-Feb	39	41	37	41	37	41	39	43	37	41	-	-
20-Feb	41	42	39	41	39	43	40	43	40	43	48	51
21-Feb	39	41	37	41	37	41	38	43	39	43	46	50
22-Feb	39	41	37	41	36	41	37	41	37	41	46	50
23-Feb	38	39	36	39	36	39	36	41	36	39	43	48
24-Feb	37	39	36	39	34	39	36	40	36	39	43	48
25-Feb	37	39	34	39	34	40	36	41	36	41	43	48
26-Feb	37	39	36	40	34	39	36	41	36	40	43	49
27-Feb	37	39	-	-	34	40	36	41	36	40	43	49
28-Feb	37	41	-	-	34	40	36	41	36	40	-	-
01-Mar	38	40	-	-	36	37	37	38	37	38	-	-

Appendix I, 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
02-Mar	39	41	-	-	36	39	36	39	36	40	-	-
03-Mar	39	40	-	-	36	39	37	39	38	41	-	-
04-Mar	39	41	-	-	37	39	39	41	39	41	-	-
05-Mar	37	39	-	-	36	37	36	39	36	37	-	-
06-Mar	37	39	-	-	34	39	36	40	36	39	-	-
07-Mar	37	39	-	-	36	37	36	39	36	39	-	-
08-Mar	37	39	-	-	36	41	36	41	36	41	-	-
09-Mar	38	41	-	-	36	39	37	41	37	41	-	-
10-Mar	39	41	-	-	37	40	38	41	39	41	-	-
11-Mar	38	39	-	-	36	39	36	40	37	39	-	-
12-Mar	39	41	-	-	37	39	37	40	38	41	-	-
13-Mar	39	41	-	-	36	39	37	41	37	41	-	-
14-Mar	37	39	-	-	36	37	36	39	36	39	-	-
15-Mar	37	40	-	-	34	38	36	39	36	39	-	-
16-Mar	37	40	-	-	34	39	36	41	36	41	-	-
17-Mar	37	41	-	-	34	43	36	43	36	41	-	-
18-Mar	37	41	-	-	36	41	36	41	36	41	-	-
19-Mar	39	41	-	-	37	41	38	41	39	41	-	-
20-Mar	39	41	-	-	37	43	37	45	39	43	-	-
21-Mar	37	41	-	-	34	41	36	43	36	43	-	-
22-Mar	39	41	-	-	36	43	37	43	38	42	-	-
23-Mar	37	43	-	-	36	43	36	43	37	43	-	-
24-Mar	39	41	-	-	37	41	38	41	39	43	-	-
25-Mar	37	41	-	-	36	39	36	40	37	40	-	-
26-Mar	38	41	-	-	36	39	36	40	37	40	-	-
27-Mar	36	41	-	-	34	43	34	43	36	41	-	-
28-Mar	37	41	-	-	36	41	36	41	37	41	-	-
29-Mar	39	43	-	-	36	45	36	45	36	37	-	-
30-Mar	37	45	-	-	36	46	36	47	37	46	-	-
31-Mar	39	45	-	-	37	48	39	49	41	48	-	-
01-Apr	-	-	-	-	39	46	41	48	43	50	-	-
02-Apr	-	-	-	-	39	45	41	45	43	45	-	-
03-Apr	-	-	-	-	36	43	39	45	39	45	-	-
04-Apr	-	-	-	-	40	43	42	45	43	45	-	-
05-Apr	-	-	-	-	41	43	-	-	43	45	-	-
06-Apr	-	-	-	-	40	44	-	-	38	45	-	-
07-Apr	-	-	-	-	-	-	-	-	39	43	-	-
08-Apr	-	-	-	-	-	-	-	-	36	43	-	-
09-Apr	-	-	-	-	-	-	-	-	39	42	-	-
10-Apr	-	-	-	-	-	-	-	-	37	38	-	-

APPENDIX J

Allele frequencies at variable loci in Tucannon 1990 adult spring chinook salmon collections.

Locus	Collection: Hatchery	Wild
sAAT-4* (AAT-4)		
(N)	29	38
1	0.862	0.908
2	0.000	0.000
3	0.138	0.092
mAAT-1*		
(N)	39	43
1	0.987	0.930
2	0.000	0.000
3	0.013	0.070
ADA-1*		
(N)	39	43
1	0.962	0.919
2	0.038	0.081
sAH* (AH)		
(N)	39	43
1	0.923	0.942
2	0.077	0.058
mAH-4*		
(N)	38	43
1	0.947	0.977
2	0.053	0.023
PEPA* (DPEP-1)		
(N)	38	43
1	0.816	0.907
2	0.184	0.093
GPI-B2* (GPI-2)		
(N)	39	43
1	1.000	0.988
2	0.000	0.012
HAGH*		
(N)	39	43
1	0.923	0.895
2	0.077	0.105

Appendix I, continued.

Locus	Collection Hatchery	Wild
sIDH-1* (IDH-3)		
(N)	39	43
1	0.859	0.849
2	0.000	0.000
3	0.141	0.151
LDH-C* (LDH-5)		
(N)	38	43
1	1.000	0.977
2	0.000	0.000
3	0.000	0.023
sMDH-B1,2* (MDH-3,4)		
(N)	78	86
1	0.994	1.000
2	0.006	0.000
mMDH-2*		
(N)	39	43
1	0.744	0.744
2	0.256	0.256
sMEP-1* (MDHP-1)		
(N)	39	43
1	0.038	0.070
2	0.962	0.930
MPI*		
(N)	39	43
1	0.910	0.837
2	0.090	0.163
PGK-2*		
(N)	39	43
1	0.141	0.081
2	0.859	0.919
sSOD-1* (SOD-1)		
(N)	39	43
1	0.718	0.814
2	0.282	0.186
mSOD*		
(N)	39	43
1	0.949	0.895
2	0.051	0.105

Appendix I, continued.

Locus	Collection	
	Hatchery	Wild
PEPB-1* (TAPEP-1)		
(N)	39	43
1	0.910	0.872
2	0.026	0.047
3	0.064	0.081
TPI-4*		
(N)	39	43
1	0.923	0.965
2	0.077	0.035