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TUCANNON RIVER SPRING CHINOOK SALMON HATCHERY EVALUATION PROGRAM

1993 ANNUAL REPORT

LOWER SNAKE RIVER COMPENSATION PLAN
Hatchery Program

Washington Department of
Fish and Wildlife
Hatcheries Division

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1993 ANNUAL REPORT

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ABSTRACT

This report summarizes activities of the Washington Department of Fisheries' Lower Snake River Hatchery Evaluation Program from 1 April 1993 to 31 March 1994. In this report we describe the Spring Chinook Salmon Program at Lyons Ferry and Tucannon Fish Hatcheries (FH).

Spring chinook salmon escapement to the Tucannon FH trap in 1993 was 448 salmon. We collected 50 natural and 47 hatchery salmon for broodstock. Fifty females were spawned for a total eggtake of 168,366 eggs (mean fecundity = 3,436). Mortality prior to hatching was 15,482 eggs (9.2% of total) for a total of 152,884 eyed eggs.

Tucannon FH released 74,058 yearling salmon (1991 Brood) from the acclimation pond from 6-12 April 1992. The 1992 brood were scheduled for a volitional release beginning 15 March 1993. Evaluation staff conducted salmon parr production surveys using snorkel techniques. We estimate 103,292 subyearling and 1,046 yearling chinook salmon were in the Tucannon River in 1993. Smolt trapping started on 1 November 1993, and will continue through the trapping season.

Radio transmitters were inserted into 21 adult salmon (9 natural and 12 hatchery) collected at the Tucannon FH trap and outplanted in the Wilderness Stratum of the Tucannon River. Eight jaw tagged salmon were also outplanted. Six of 21 radio tagged salmon and one of eight jaw tagged salmon were verified to have spawned.

Evaluation staff also tracked 12 spring chinook that were radio tagged by the University of Idaho at John Day Dam and returned to the Tucannon River. Two of the 12 radio tagged salmon were confirmed prespawning mortalities. Six of 12 salmon survived into the spawning season.

Fifty-six salmon carcasses were recovered prior to spawning season. Forty-three of the 56 prespawning mortalities (77%) were hatchery salmon. Program staff surveyed spawning grounds from August to October and found 192 spring chinook salmon redds. Forty-nine natural and 31 hatchery salmon carcasses were recovered during spawning ground surveys.

Adult escapement and survival estimates for the Tucannon River were revised and updated. We estimate that 586 salmon escaped to the Tucannon River in 1993 (includes numbers of fish estimated to be below the weir). Smolt-to-adult survival of 1988 brood natural and hatchery salmon is estimated to be 1.14 % and 0.38%, respectively. Return per female spawner ratio of natural and hatchery salmon for the 1988 brood is 2.5:1 and 12.8:1, respectively. Fifty-seven percent of all fish sampled (natural and hatchery) in 1993 were classified as age 4, 41% were classified as age 5, and 2% were classified as age 3.

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SECTION 1: INTRODUCTION

Congress authorized the Lower Snake River Fish and Wildlife Compensation Program (LSRCP) in 1976. As a result of that plan, Lyons Ferry and Tucannon Fish Hatcheries (FH) were designed, constructed and are currently under operation. A partial objective of these hatcheries is to compensate for loss of 1,152 adult spring chinook salmon [1], Tucannon River stock (USACE 1975). An evaluation program was initiated in 1984 to monitor the success of these hatcheries in meeting this goal, and to identify any required adjustments in production to improve hatchery performance. Washington Department of Fisheries (WDF) has identified two broad based goals in its evaluation program: 1) monitor hatchery practices at Lyons Ferry and Tucannon FH to ensure quality smolt releases, high downstream migrant survival, and sufficient contribution to fisheries with escapement to meet the LSRCP compensation goals, and 2) gather genetic information which will help maintain the integrity of Snake River Basin salmon stocks (WDF 1993). A list of the evaluation program's objectives have been presented previously (Mendel et al. 1993).

This report summarizes all work performed by the WDF LSRCP Spring Chinook Salmon Evaluation Program for the period 1 April 1993 through 31 March 1994. A report on the fall chinook salmon evaluation program for the same period is presented separately (Mendel et al. 1994, Draft).

Lyons Ferry FH is located at the confluence of the Palouse River and Snake River at river kilometer (RK) 90, and 5 km from the mouth of the Tucannon River (see Mendel et al. 1993). Lyons Ferry FH has a single pass well water system which flows through the incubators, four adult holding ponds, and 28 raceways. A satellite facility is maintained on the Tucannon River for adult salmon collection and subsequent release of yearling progeny. Tucannon FH has an adult collection trap and one holding pond, which has been used for both broodstock collection and yearling releases.

Returning adult salmon are collected at a weir/trap on the Tucannon River adjacent to the Tucannon FH and hauled to Lyons Ferry FH for holding and spawning. Eggs are fertilized, incubated, and the fry reared to parr size at Lyons Ferry FH, then returned to Tucannon FH for acclimation and subsequent

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

release in the Tucannon River. The 1993 Tucannon spring chinook salmon hatchery production goal was 88,000 fish for release as yearlings at 15 fish per pound (fpp; 5,867 lbs). This is a revised goal, primarily based on a density index limitation of 0.18 lbs/ft^3/in at release.

SECTION 2: HATCHERY PERFORMANCE

2.1: Broodstock Collection

Hatchery and evaluation personnel operated the permanent adult trap with a floating weir to collect natural[1], and hatchery salmon for broodstock. The trap was operated daily from early May through September. In general, one salmon was collected for every four or five fish passed upstream for natural spawning. The objective was to collect 50 natural and 50 hatchery salmon for broodstock throughout the duration of the run (Appendix A). These numbers were developed after reviewing our 1992 broodstock collection and spawning protocol (Mendel et al. 1993). This review included data from previous years regarding broodstock survival, egg and fry loss, growth rate, feed conversion, and projected time and size at release. All hatchery salmon have adipose-fins removed and are coded-wire tagged (CWT), allowing their recognition as adults.

In 1993 we collected 97 salmon (50 natural and 47 hatchery) for broodstock. Broodstock were collected between 27 May and 7 August. Peak of arrival for natural and hatchery salmon were 31 and 27 May, respectively (Figure 1, Appendix B), a week later than peak arrival of salmon in 1992 (18-21 May). However, spring and summer months of 1993 were wetter and cooler than in 1992. Total escapement to the Tucannon FH trap was 448 adult salmon, of which 351 were passed upstream. Five salmon were observed jumping over the weir and we observed one salmon jumping downstream over the weir.

As in past years, we observed a second peak of arrival at the trap just prior to, and during, spawning in August and September (20.7% of the run of natural fish, 6.9% of the run of hatchery fish). Approximately 70% of the salmon arriving at the trap during this late migration were males.

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

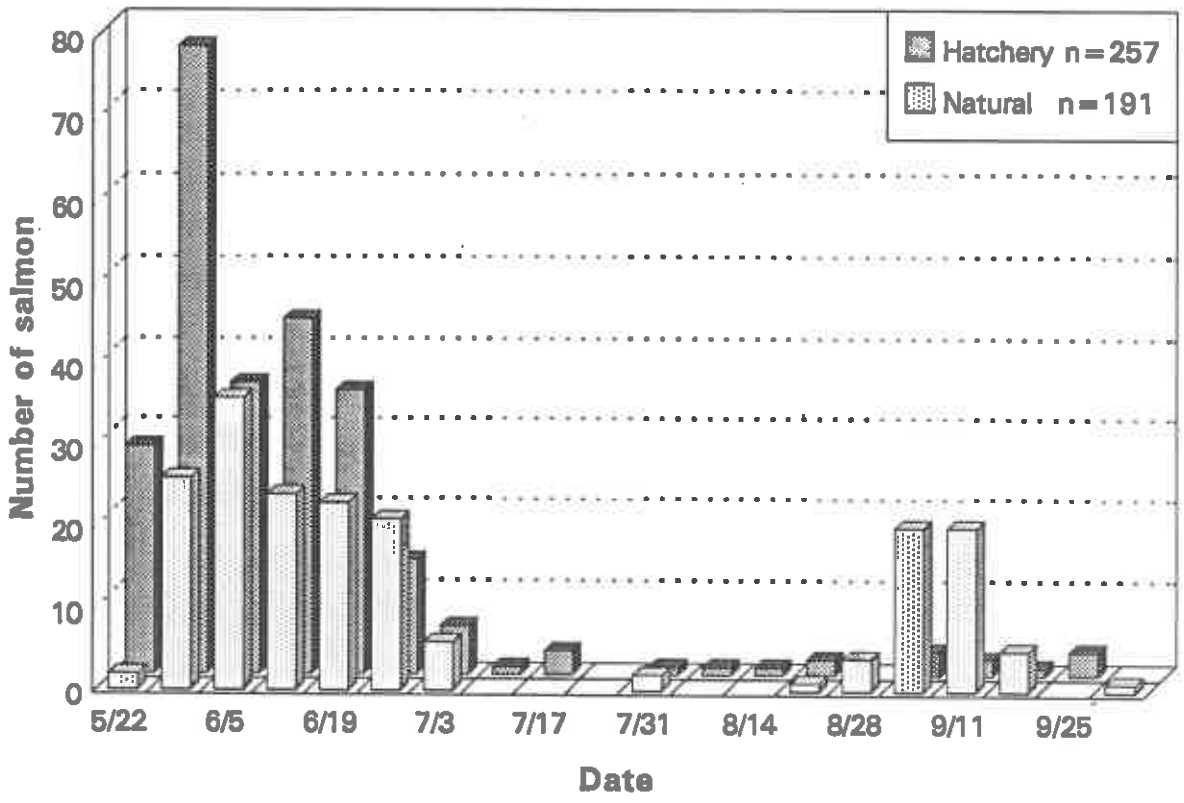

Figure 1. Weekly arrivals of natural and hatchery salmon to the Tucannon FH trap/weir, 1993.

2.2: Lyons Ferry/Tucannon Hatchery Practices

2.2.1: Adult holding and spawning

Salmon captured for broodstock were hauled from the Tucannon FH trap to Lyons Ferry FH each day fish were collected. We found that holding salmon in the cooler water at Lyons Ferry FH has reduced prespawning mortalities (Mendel et al. 1993). In 1993, three natural salmon (one male, two females), and three hatchery (two males, one female) collected for broodstock died before spawning. This is an 82% reduction in prespawning mortality from the 1985-1991 average when fish were held at Tucannon FH. Two of the females (one natural and one hatchery) jumped out the raceway at Lyons Ferry FH in 1993. A fence was constructed at the top of the raceway to prevent further mortalities.

Spawning at Lyons Ferry FH occurred weekly from 24 August to 20 September, with peak eggtake on 13 September (Table 1). Spawning and fertilization methods have been described previously (Mendel et al. 1993, 1993 protocol Appendix B). Coded-wire tags are normally extracted and read prior to fertilizing the eggs at the hatchery to remove marked strays from the population (Appendix A). However, in 1993 all males were live spawned

because we had fewer hatchery males for broodstock than required. Therefore, it was not possible to determine the origin of males until the final day of spawning when all the males were killed and CWTs were read. Although this procedure increased the risk of spawning a stray male, it ensured that we obtained genetic contribution from all males.

We recovered one stray male from collected broodstock. It was determined to be from Meachum Creek (CWT 7-51-10), a tributary to the Umatilla River, Oregon. Eggs (≈3,460) fertilized by this particular male (as the primary male) have been destroyed to maintain genetic purity. All other tagged salmon collected for broodstock, or recovered in the Tucannon River (n=131), originated from Tucannon spring chinook stock. Total eggtake (before destroying eggs fertilized with stray male) was 168,366 eggs with 9.2% lost before eye up; 152,884 eggs remained for rearing after picking (eyed eggs).

Table 1. Spawning and holding mortalities of Tucannon natural and hatchery spring chinook salmon at Lyons Ferry FH in 1993.

Week ending	Natural salmon spawned[a] male	Natural salmon spawned[a] female	Natural salmon mortality male	Natural salmon mortality female	Hatchery salmon spawned[a] male	Hatchery salmon spawned[a] female	Hatchery salmon mortality male	Hatchery salmon mortality female
29 May				1				
05 Jun			1					1
17 Jul							1	
31 Jul				1				
28 Aug						1[b]		
04 Sep						4[c]		
11 Sep		5				10		
18 Sep		8				7[b]	1	
25 Sep	26	8[b]			14	7		
Totals[d]	26	21	1	2	14	29	2	1

[a] Males were live-spawned and tallied as spawned when they were killed, 2
[b] natural males killed were not spawned.
[c] One female on each of these days were partially spawned females.
[d] One female on this date was green, no eggs collected.
Totals for hatchery salmon sum to 46. One salmon recorded as being collected as broodstock was never documented at the hatchery.

2.2.2: Sperm cryopreservation and evaluation

We did not freeze any semen, or conduct any experiments with spring chinook salmon in 1993. Experiments were conducted in 1993 to improve our techniques, but only on Lyons Ferry fall chinook salmon. Data and results from these experiments will be presented in the 1993 Fall Chinook Annual Report.

2.2.3: Hatchery matings (controlled matings study)

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

1991 brood: Progeny from natural fish constituted the majority of this brood (Mendel et al. 1993). Parental origin was designated by tagging each group with specific CWT codes and visual tags (VI) of red elastomer in the clear tissue behind the eye. Progeny from natural crosses were VI tagged on the left side while progeny from hatchery crosses were VI tagged behind the right eye. A total of 74,058 1991 brood year chinook salmon were released from the Tucannon FH from 6-12 April 1993.

1992 brood: Most of the matings and progeny were from hatchery crosses (Table 2). These fish were CWT and VI tagged in October 1993. Progeny were given unique CWT codes dependant on parentage, and eventual release site. Progeny from natural and hatchery crosses were tagged identically as were the 1991 brood. Fish to be released from the acclimation pond at the Tucannon FH were given a yellow elastomer (VI), and fish to be outplanted as pre-smolts in the upper Tucannon River received a red elastomer. A total of 57,316 were outplanted in the Tucannon River as subyearlings on 21, 22, and 25 October (Section 2.2.6), and 85,740 were transported to the Tucannon FH acclimation pond on 17 November for a volitional release in March 1994.

1993 brood: Matings and progeny produced were similar between natural and hatchery crosses (Table 3). Eight crosses were categorized as mixed. Fry were ponded on 18 January 1994.

Table 2. Comparison of the estimated number of adults and progeny for natural/natural and hatchery/hatchery crosses in 1992 (1992 Brood).

	Natural	Hatchery	Mixed	Totals	Weight (lbs)
To river [a]	324	410	- -	734	
To trap	242	305	- -	547	
Collected	47	50	- -	97	
Matings	18	27 [b]	- -	45	
Eggtake	69,376	85,983	- -	156,359	
Picking	68,527	85,067	- -	153,594	
Ponded	67,820	83,907	- -	151,727	106
Tagged	61,941	81,582	- -	143,523	
Outplanted (Tucannon R.)	25,134	32,182	- -	57,316	1,592
To Tucannon FH (acclimation)	36,782	48,958	- -	85,740	2,766

[a] Estimated adult escapement (revised 1994, see Section 3.3.4).
[b] Does not include one female that was already spawned out in the pond, but it includes a partly spawned out female that contributed eggs.

Table 3. Comparison of the estimated number of adults and progeny for natural/natural, hatchery/hatchery, and mixed natural/hatchery crosses in 1993 (1993 Brood).

	Natural	Hatchery	Mixed	Totals	Weight (lbs)
To river [a]	249	337	- -	586	
To trap	191	257	- -	448	
Collected	50	47	- -	97	
Matings	21	20 [b]	8 [c]	49	
Eggtake	70,448	71,279	26,639	168,366	
Picking	64,164	64,475	24,245	152,884	
Ponded	62,656	62,850	19,797 [d]	145,303	109

[a] Estimated adult escapement (revised 1994, see Section 3.3.4).
[b] Does not include one female that was green, but includes one hatchery female and two natural females which were partially green.
[c] Includes three matings with a stray male from Meachum Creek, Oregon.
[d] Does not include ≈3,460 fry destroyed from stray crosses.

2.2.4: Disease incidence and treatments

The 1993 returning adult salmon were injected with 0.5 cc of both Erythromycin and Liquimycin when trapped, and twice again with erythromycin prior to spawning. These procedures were taken to treat bacterial kidney disease (BKD) and Flexibacter columnaris. Flush treatments of formalin (1:7,000 dilution rate for 2 hours) were applied to adults every other day to control fungus infection. Prophylactic feed treatments for BKD were not given to the 1992 brood juvenile spring chinook salmon, and none were scheduled for the 1993 brood. Prophylactic feed treatments were given in the past, however, the prevalence of BKD in Tucannon spring chinook salmon has been recorded at low levels, and continued treatment of juveniles is not warranted at this time.

One pond of the hatchery/hatchery cross (1992 brood) salmon were discovered in August 1993 to be infected with Enterocytozoon salmonis. Fry loss due to the infection was elevated compared to the pond of natural/natural, or the additional pond (low density) of hatchery/hatchery crosses. The parasite was never detected in the natural/natural crosses or the low density group of hatchery/hatchery crosses. Disinfectant measures were taken to eliminate the parasite from the hatchery. The fish were cleared by our fish health specialist for tagging and outplanting in October, and transported to the acclimation pond in November. Chronic, slightly elevated losses occurred in the acclimation pond for the hatchery/hatchery fish until 15 February when the pond was switched to 100% river (colder) water. We continued to see some clinical signs of the parasite in the originally infected group until release. Disinfectant measures will be applied to the acclimation pond after the fish are released.

2.2.5: Acclimation

Lyons Ferry FH staff transported 85,740 yearling (1992 brood year) salmon to the adult holding pond at Tucannon FH on 10 November, 1993. We continued to use river water mixed with 50% well water to maintain warmer water temperatures in the pond than the river. This strategy enables us to control disease and improve fish growth. The percent of well water was reduced over two days until fish were entirely on river water (15 February 1994). This was done to ensure fish imprinted to the Tucannon River instead of the hatchery water supply for a month prior to scheduled release.

2.2.6: Smolt releases

1991 brood smolt release: We planned a one month volitional release period beginning the first part of March 1993. Unfortunately, our planned volitional release in 1993 was postponed until 6-12 April because of a delay in receiving a

Biological Opinion/Section 10 from NMFS. Two thirds of the fish moved out quickly after the volitional release began. The remaining one third were forced out of the pond on 12 April. A total of 74,058 (56,506 natural/natural, and 17,552 hatchery/hatchery) smolts were released.

1992 brood pre-smolt release: We outplanted 57,316 fish (1,592 lbs; 36 ffp) of the 1992 brood into the upper reaches of the Tucannon River in late October (Figure 2). Sampling prior to release consisted of measurements of length, weight, ATP-ase levels, and tag retention (CWT and Elastomer). Mean fork length, coefficient of variation, and condition factor of outplanted fish were 99.8 mm, 14.6, and 1.33, respectively (Figure 3). All outplanted fish were uniquely marked with CWT and VI (according to parentage) and released into 23 pre-selected sites in the Wilderness and upper HMA Strata. Specific coded-wire tag group releases for all brood years are listed in Appendix C.

Two trips (300 lbs of fish/trip) per day were transported from Lyons Ferry FH to the Tucannon River on 21, 22, and 25 October. Evaluation and hatchery staff netted 150-200 juveniles into five gallon buckets and carried them 10-150 m to the river. All release sites were pools or deep runs where river currents were slow. Several release and control sites were snorkeled for natural salmon densities prior to, during, and after release.

Snorkelers documented behavior and densities of outplanted natural and hatchery fish. Snorkelers observed some hatchery fish being swept or rolling downstream when first placed in the river. However most of the hatchery fish went directly to the bottom, probably from the stress of being transported, and the substantial difference in water temperature between the river and the fish truck (11 °F). Within a few minutes, the hatchery fish came off the bottom and dispersed within the release site. Aggressive behavior from either natural or hatchery fish was not observed.

Densities of natural chinook parr and hatchery outplants were calculated for each site (Appendix D). Treatment and control sites were snorkeled periodically for 3 weeks following the release. Selected sites were also snorkeled in March 1994 to document densities of natural and hatchery salmon before outmigration occurred. Densities of natural salmon did not substantially decline over time. We were unable to confirm if natural salmon were forced out of their holding areas by the larger hatchery fish, or whether the parr went subsurface as water temperatures declined.

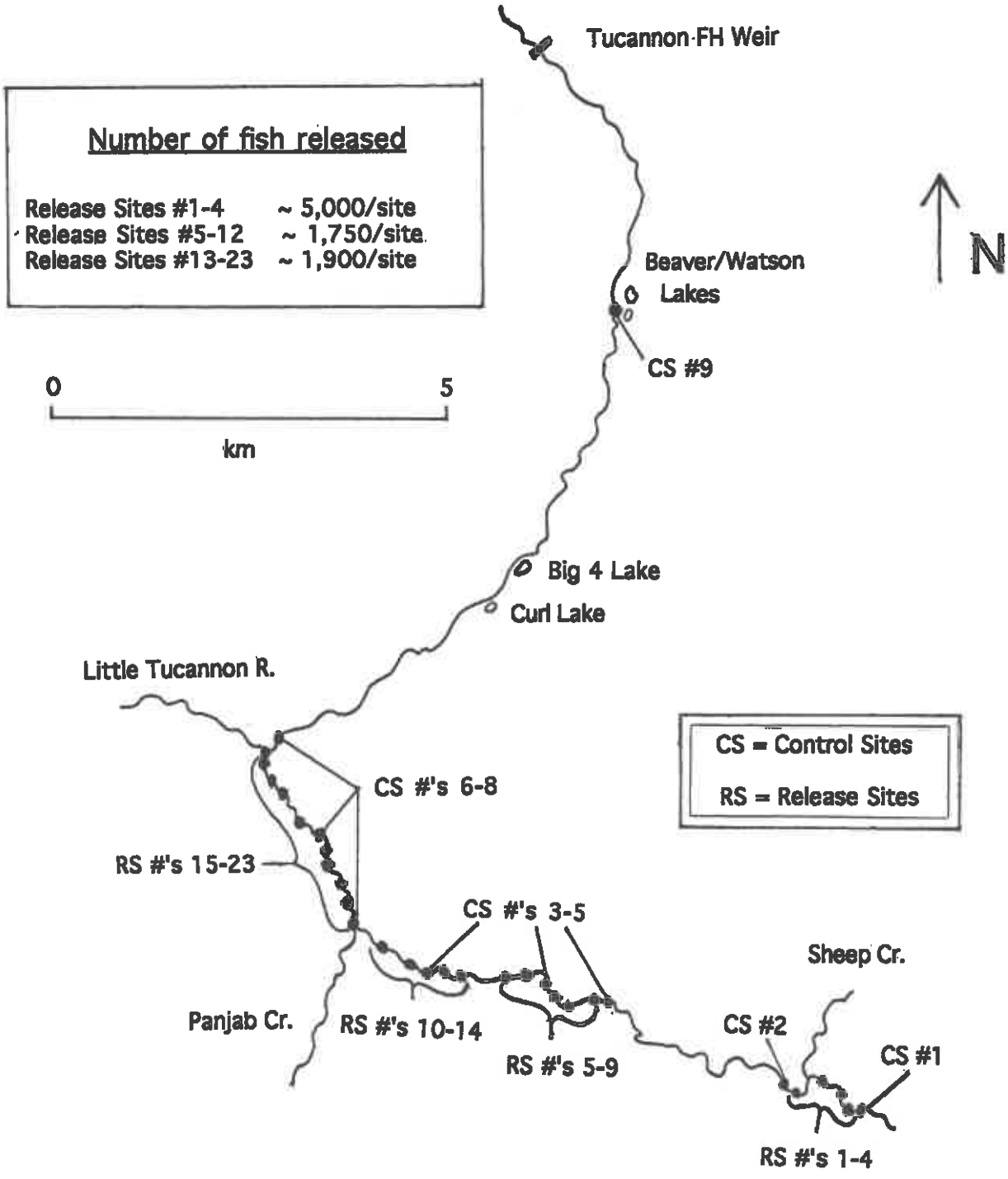

Figure 2. Locations of pre-smolt outplant release and control sites in the Tucannon River, and approximate numbers of fish released per site on 21, 22, and 25 October 1993.

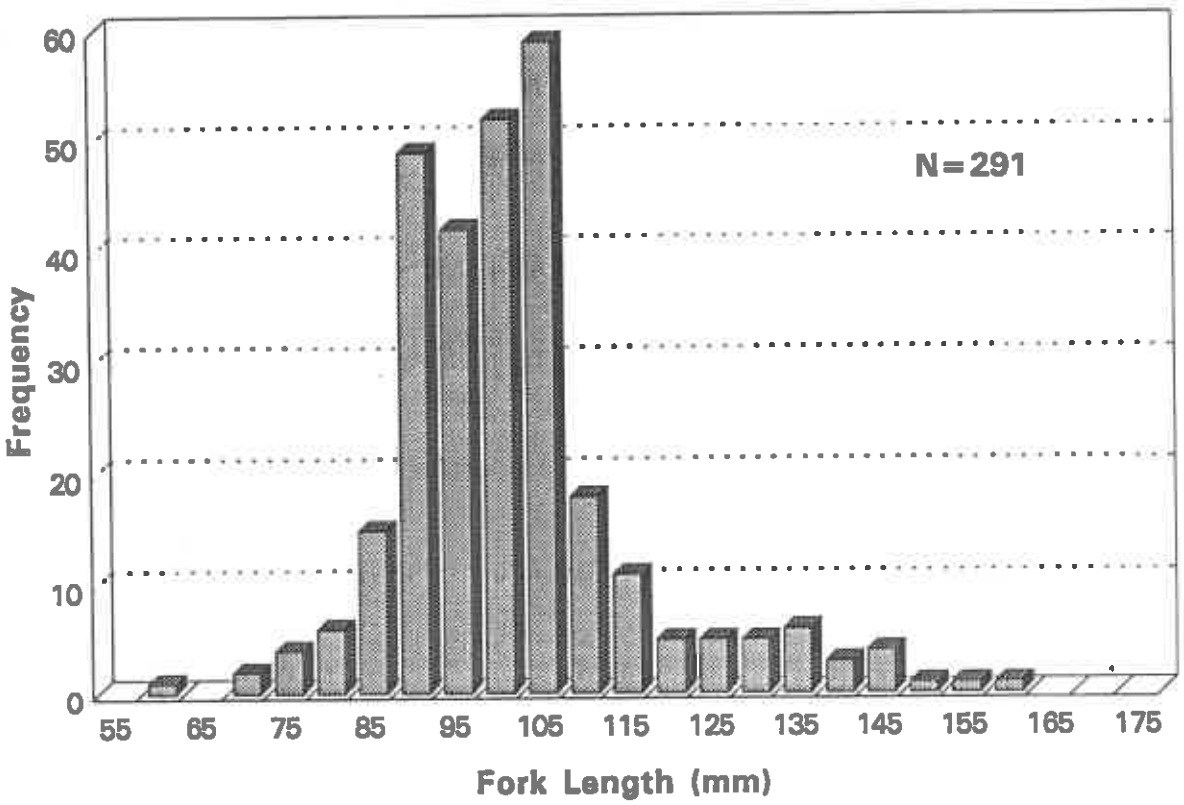

Figure 3. Length frequency distribution of 1992 brood hatchery salmon outplanted as presmolts in the Tucannon River on 21, 22, and 25 October 1993.

We were able to monitor the emigration of a portion of the outplanted fish as they passed our downstream migrant trap from November 1993 to March 1994. We captured one in November, five in December, two in January, none in February, and 68 in March. It appeared from these catches that outplanted salmon did not emigrate early. Snorkeling in March confirmed that many of the outplanted salmon were still near the release sites. Increased catches in March were encouraging, and we suspect more will be captured during peak emigration in late April. We will attempt to assess their over-wintering survival in the Tucannon River once the smolt emigration is completed for the season. Results will be presented in the 1994 Spring Chinook Annual Report.

1992 brood smolt release: We planned a one month volitional release period beginning 15 March 1993. Pre-release sampling occurred on 10 March. Evaluation staff collected lengths, weights, electrophoretic, organosomatic, and ELISA samples. Mean fork length, coefficient of variation and condition factor of smolts at the release were 125.5 mm, 9.2, and 1.2, respectively (Figure 4). A WDF&W fish health specialist was present to collect hindgut samples and to visually examine sampled fish for

clinical signs of Enterocytozoon salmonis. Only one of 200 fish sampled showed signs of Enterocytozoon salmonis. Fish began circling the pond on 17 March. Smolt release from the acclimation pond was delayed by NMFS because we were not issued a Section 10 Permit for release from the acclimation pond.

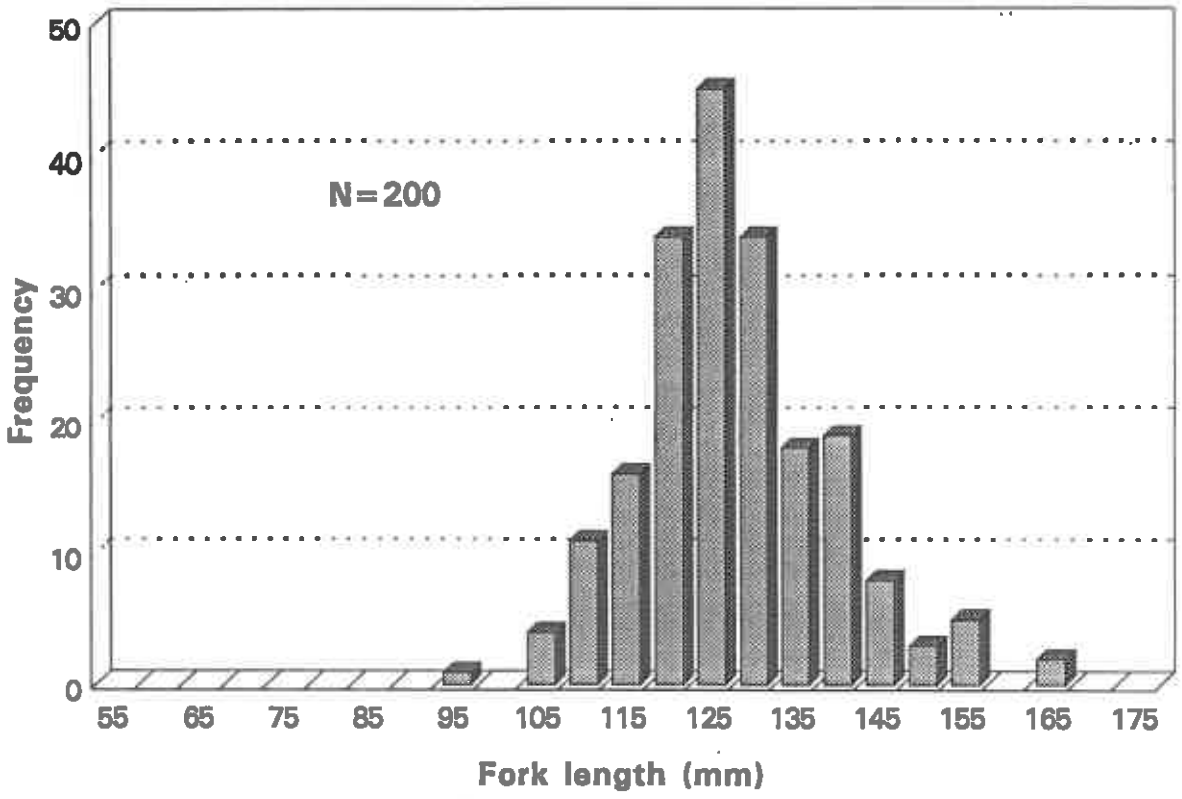

Figure 4. Length frequency distribution of 1992 brood salmon sampled on 10 March 1994 from Tucannon FH acclimation pond. Fish were released from the acclimation pond during 11-18 April 1994.

SECTION 3: RIVERINE EVALUATIONS

From 1985 to 1988, program staff collected biological information on natural salmon in the Tucannon River prior to hatchery supplementation. Since 1988, we have collected biological information from both natural and hatchery salmon. Information collected allows us to assess some short and long term effects of supplementation. We are evaluating the effects of supplementation through two complementary strategies: 1) stock profile analyses, using a combination of electrophoresis, morphometrics, meristics, and quantifiable measures of fish demographics (presented in Section 4), and 2) observation of the

population dynamics of natural and hatchery salmon in the Tucannon River. The following discussion pertains to research on the population dynamics aspects of this program. The Tucannon River Watershed and Strata have been described previously (e.g. Mendel et al. 1993).

3.1: Stream Temperature/Discharge Monitoring

Program staff deployed nine continuous-reading thermographs to record daily minimum and maximum water temperatures in the Tucannon River to monitor heat loading throughout the year. Locations of thermographs were as follows: 1) Panjab Bridge (RK 74.5), 2) near the downstream outlet of Big 4 Lake (RK 65), 3) near the downstream outlet of Beaver-Watson Lakes (RK 62), 4) near the downstream outlet of Deer Lake, 5) 100 m downstream of the Cummings Creek confluence (RK 56), 6) Bridge 14 (RK 52), 7) Marengo Bridge (RK 40), 8) WDF downstream migrant trap (RK 21.1), and 9) Power's Bridge (RK 4). Miscellaneous river discharges (using a current meter and modified USGS techniques) are periodically taken at our downstream migrant trap (RK 21.1). Temperatures and discharge measurements are on file at our Dayton office.

3.2: Juvenile Population Dynamics

In 1993 we conducted parr production surveys at index sites to estimate salmon parr densities in the Tucannon River. Summer electrofishing and snorkel surveys were conducted as in 1992 (Mendel et al. 1993) between 21 July and 15 September. Snorkeling was conducted during mid day (1000 - 1600 hrs) on sunny days to take advantage of the best light conditions. Descriptions of snorkel sites and area of each habitat type in each stratum are listed in Appendix D.

3.2.1: Snorkel surveys

We used a modified line transect (LT) snorkel method (Emlen 1971) and a total count (TC) snorkel method (Griffith 1981, Schill and Griffith 1984, Hillman 1992) for comparison of techniques at the same index sites (Mendel et al, 1993). Population estimates were derived by multiplying the mean density (fish per 100 m^2) of each habitat type by the total area of that habitat type within each stratum (Tables 4 and 5). Subyearling chinook salmon parr production in the Tucannon River for 1993 was estimated between 103,292 and 106,993 (range of TC and LT methods). Yearling chinook salmon production in the Tucannon River for 1993 was estimated between 1,027 and 1,220. We will use the parr production estimates from our total counts because they are from larger sampled areas.

Table 4. Subyearling spring chinook salmon density (mean number of fish per 100 m^2, number of sites, standard deviation) and population size estimated using two snorkel techniques (by habitat type) in the Tucannon River, 1993.

Stratum Habitat Type	Total count Density	Total count Population	Line transect Density	Line transect Population
Wilderness				
Riffle	5.09 (4, 8.3)	2,527	4.39 (4, 7.5)	2,179
Run	3.33 (4, 3.2)	1,042	4.72 (4, 3.9)	1,477
Pool	64.66 (4, 49.7)	1,715	41.16 (4, 39.4)	1,092
Side channel	42.84 (4, 39.4)	6,847	64.59 (4, 64.1)	10,324
Total		12,131		15,072
HMA				
Riffle	8.20 (5, 5.7)	10,234	10.23 (5, 3.2)	12,768
Run	38.26 (5, 27.5)	30,704	29.88 (5, 11.3)	23,979
Pool	64.56 (5, 23.1)	3,622	67.47 (5, 20.9)	3,785
Boulder	11.90 (4, 1.4)	2,528	13.89 (4, 10.2)	2,950
Side channel	50.46 (3, 35.9)	10,282	56.19 (3, 43.2)	11,449
Total		57,370		54,931
Hartsock				
Riffle	37.46 (3, 43.5)	11,494	13.46 (3, 8.8)	4,130
Run	40.74 (4, 22.3)	18,964	67.55 (4, 48.6)	31,433
Pool	29.79 (2, 24.1)	230	50.81 (2, 3.8)	392
Total		30,677		35,975
Marengo				
Riffle	2.73 (2, 3.8)	1,302	2.13 (2, 3.0)	1,016
Run	2.52 (2, 1.1)	1,817	0.00 (2, 0.0)	0
Pool	0.00 (2, 0.0)	0	0.00 (2, 0.0)	0
Total		3,114		1,016
Lower Tucannon				
Riffle	0.00 (1, 0.0)	0	- -	- -
Run	0.00 (1, 0.0)	0	- -	- -
Pool	0.00 (1, 0.0)	0	- -	- -
Total		0		- -
Totals		**103,292**		**106,993**

Table 5. Yearling spring chinook salmon density (mean number of fish per 100 m^2, number of sites, standard deviation) and population size estimated using two snorkel techniques (by habitat type) in the Tucannon River, 1993.

Stratum Habitat Type	Total count		Line transect	
	Density	Population	Density	Population
Wilderness				
Riffle	0.00 (4, 0.0)	0	0.92 (4, 1.8)	457
Run	0.00 (4, 0.0)	0	0.00 (4, 0.0)	0
Pool	1.71 (4, 2.5)	45	0.00 (4, 0.0)	0
Side channel	0.29 (4, 0.6)	46	0.37 (4, 1.3)	59
Total		91		516
HMA				
Riffle	0.00 (5, 0.0)	0	0.00 (5, 0.0)	0
Run	0.24 (5, 0.5)	193	0.00 (5, 0.0)	0
Pool	0.69 (5, 1.0)	39	0.49 (5, 1.1)	27
Boulder	0.00 (4, 0.0)	0	0.00 (4, 0.0)	0
Side channel	2.79 (3, 3.2)	569	0.00 (3, 0.0)	0
Total		801		27
Hartsock				
Riffle	0.00 (3, 0.0)	0	0.00 (3, 0.0)	0
Run	0.33 (4, 0.7)	154	0.00 (4, 0.0)	0
Pool	0.00 (2, 0.0)	0	0.00 (2, 0.0)	0
Total		154		0
Marengo				
Riffle	0.00 (2, 0.0)	0	1.42 (2, 2.0)	677
Run	0.00 (2, 0.0)	0	0.00 (2, 0.0)	0
Pool	0.00 (2, 0.0)	0	0.00 (2, 0.0)	0
Total		0		677
Totals		**1,046**		**1,220**

3.2.2: Electrofishing surveys

Electrofishing surveys were conducted from 10-13 August. Electroshockers were equipped with electronic circuits designed to reduce impacts to fish. All captured fish were anesthetized prior to handling (MS-222), and had fully recovered prior to release. We captured 266 chinook, of which 17 known mortalities occurred. Mortalities were attributed to multiple passes of the shocker that weakened and impinged the fish on the lower net. No population estimate was made from electrofishing surveys because of the small sample size of sites (Table 6). Percent mortality caused by electrofishing was 6.4% of the catch for 1993, which exceeded the 2% limit set by the NMFS. Therefore, electrofishing was terminated.

Table 6. Summary of electrofishing sites, number of salmon captured, mortalities, and density estimates (fish/100m^2) in the Tucannon River, 1993.

Site	Habitat type	Water Temperature	Area	Salmon captured	Number of mortalities	Density
HMA 1	riffle	65.0	225.3	41	10	18.19
HMA 5	riffle	60.5	207.1	40	0	19.32
HMA 19	run	56.0	184.2	60	1	32.57
HMA 24	run	56.5	90.4	30	1	33.20
HMA 22	pool	56.0	124.1	72	4	58.01
HMA 23	boulder	57.0	196.9	14	1	7.11
HMAS 3	side channel	59.5	46.2	5	0	10.82
HMAS 4	side channel	59.0	91.1	4	0	4.39

3.2.3: Downstream migrant trap operations

An important objective of our study is to estimate the magnitude, duration, periodicity, and peak of natural salmon emigration from the Tucannon River. To do this, we maintain a floating inclined plane downstream migrant trap at RK 21.1.

<u>1991 brood trapping:</u> We were unable to monitor migration of our hatchery release or natural chinook salmon between February and May because our Section 10 Permit from NMFS to allow us to operate the smolt trap was withheld until 27 May. However, limited smolt trapping occurred from November to early February. Catches over that time period were relatively small and were consistent with previous years' catches.

1992 brood trapping: We began intermittent smolt trapping on 1 November 1993. We increased our trapping effort as peak smolt outmigration approached (spring 1994). Sampling summaries and population estimates for smolts emigrating from the Tucannon River during the 1993/1994 migration period will be presented in the 1994 Spring Chinook Annual Report.

3.3: Adult Population Dynamics

We continued the study, initiated in 1989, to evaluate movement, prespawning mortality, mate and habitat selection, and overall spawning success of adult salmon using a combination of upstream trapping, radio telemetry, and spawning ground surveys. Trapping results were discussed in Section 2.1.

3.3.1: Radio telemetry

WDF Radio Tagging in 1993: In 1993, we radio tagged 21 and jaw tagged another eight adult salmon (natural and hatchery origin). These fish were outplanted into the Wilderness Stratum of the Tucannon River to improve spawning distribution. Each radio transmitted a unique channel and code combination that enabled us to track individual fish. Radio tagging ceased on 15 June to minimize mortality that could be caused by increasing water temperatures or atrophy of the esophagus and stomach. Dates of tagging and individual tracking data and movements are presented in Appendix E.

Fixed site receivers were located on the Tucannon River at the downstream migrant trap (RK 21, 19 May to 20 July) and the Tucannon FH trap/weir (RK 58.8, 21 July to 13 September). During time of least activity fish were also tracked from vehicles at approximately three-day intervals. Salmon holding for long periods of time in one location were precisely located by snorkel observations. This verified if the radio tag was still in the salmon or had been regurgitated. We attempted to determine: 1) if outplanting adults increased the number of spawners in the upper Tucannon River, and 2) the amount of prespawning mortality and downstream movements. Additionally, we wished to continue our salmon radio tracking data collection regarding: prespawning movements, spawning time, redd location, number of redds per female, and interactions with other salmon for each radio tagged fish.

Four of twenty-one salmon radio tagged, regurgitated their radios during transport to the release sites, and one tag failed. Two of those tags were used again, to total 16 chinook salmon (eight natural, eight hatchery) with radio tags, and 13 salmon with jaw tags only.

Four of eight radio tagged natural chinook salmon survived to spawn. Two of these spawned in the Wilderness Stratum and two spawned downstream (Figure 5). One natural male (channel/code 1/23) was observed to have spawned three separate times, with three separate females in different locations. The two radio tagged salmon below the Wilderness Stratum were within 3.5 RK of the stratum boundary. Three of the four remaining radio tagged natural salmon regurgitated their tags before spawning occurred (all three in the Wilderness Stratum). It is unknown if these fish survived to spawn in the Wilderness Stratum or elsewhere. The fourth radio tagged natural fish was a pre-spawning mortality recovered on the Tucannon FH weir (RK 48.8), 25.7 RK downstream of the Wilderness boundary. Only one of the seven jaw tagged natural salmon was recovered after spawning in the Wilderness Stratum.

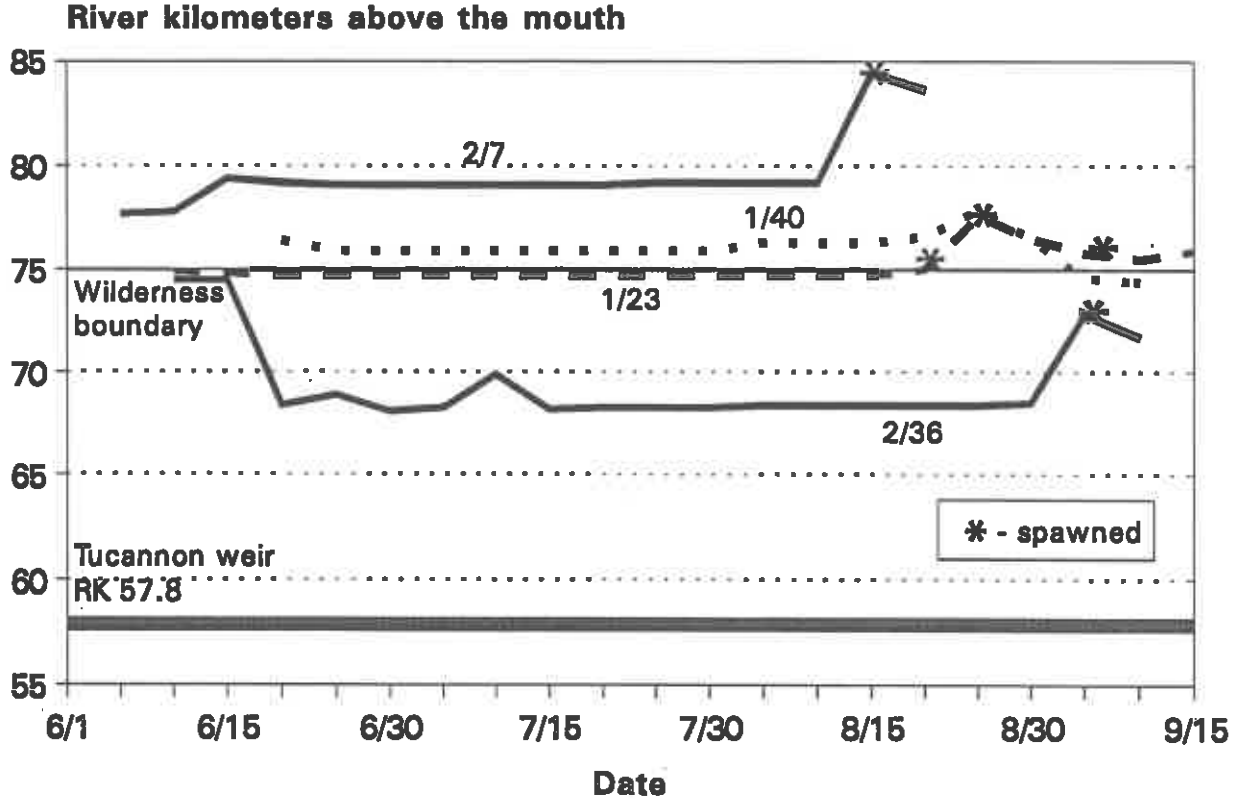

Figure 5. Movements of four radio tagged natural salmon (channel/code 2/7, 1/40, 1/23, and 2/36), released in the Wilderness Stratum of the Tucannon River, 1993. An (*) indicates observation of spawning, or a spawned out female.

Two of eight radio tagged hatchery chinook salmon survived to spawn. Of these two, one spawned in the Wilderness Stratum and one spawned 4.0 RK downstream of the Wilderness boundary (Figure 6). Three of the six remaining tags were recovered from pre-spawning mortalities. One pre-spawning mortality was in the Wilderness Stratum, and two were near the Tucannon FH water intake (15.3 RK downstream of the Wilderness boundary). The three remaining radio tagged hatchery salmon regurgitated their tags prior to spawning. Two of these tags were located in the Wilderness Stratum and one was located 1.2 RK below the boundary. The final fate of these is unknown.

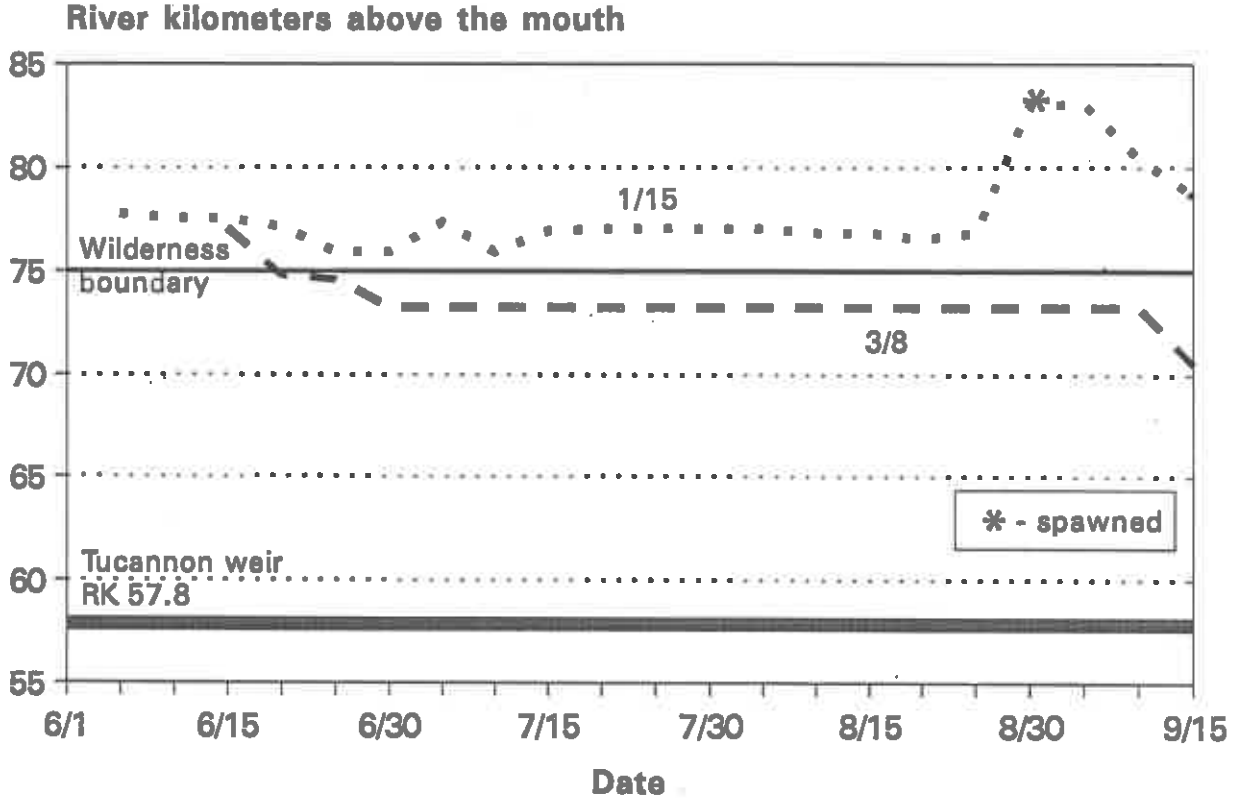

Figure 6. Movements of two radio tagged hatchery salmon (channel/code 1/15 and 3/8) released in the Wilderness Stratum of the Tucannon River, 1993. An (*) indicates observation of spawning, or a spawned out female.

University of Idaho radio tagged salmon: In 1993, we also tracked 13 radio tagged salmon that entered the Tucannon River from the Snake River. These 13 radio tagged salmon were a small portion of the total radio tagged spring chinook salmon by the University of Idaho (UI) at John Day Dam. One fish without a radio tag (VI FJ7) was seen at the adult trap on the Tucannon River and transported to Lyons Ferry FH for broodstock. We

recovered four of 12 tags without finding the fish in the Tucannon River. Pre-spawning mortality was confirmed for only two of the 12 radio tagged salmon that entered the river. Both of these carcasses were recovered in the HMA Stratum above the Tucannon weir. Of the 12 radio tagged fish, only six were verified alive in the river during spawning. Four of the six tagged salmon were recovered in areas with redds present nearby; we believe these four fish spawned. Two of these fish passed above the weir (Figure 7) and two remained below (Figure 8). The two fish that passed the weir, had first encountered the weir in late June. Neither of these fish passed until spawning had begun. Data from these two radio tagged salmon provide us with the first evidence that the trap/weir may cause a delay in salmon migration. Radio tagged salmon 5/49 was never recovered but believed to have spawned (see page 20). We recovered the tag from sixth fish (6/88), but were unable to observe the fish or any redds in the last known area.

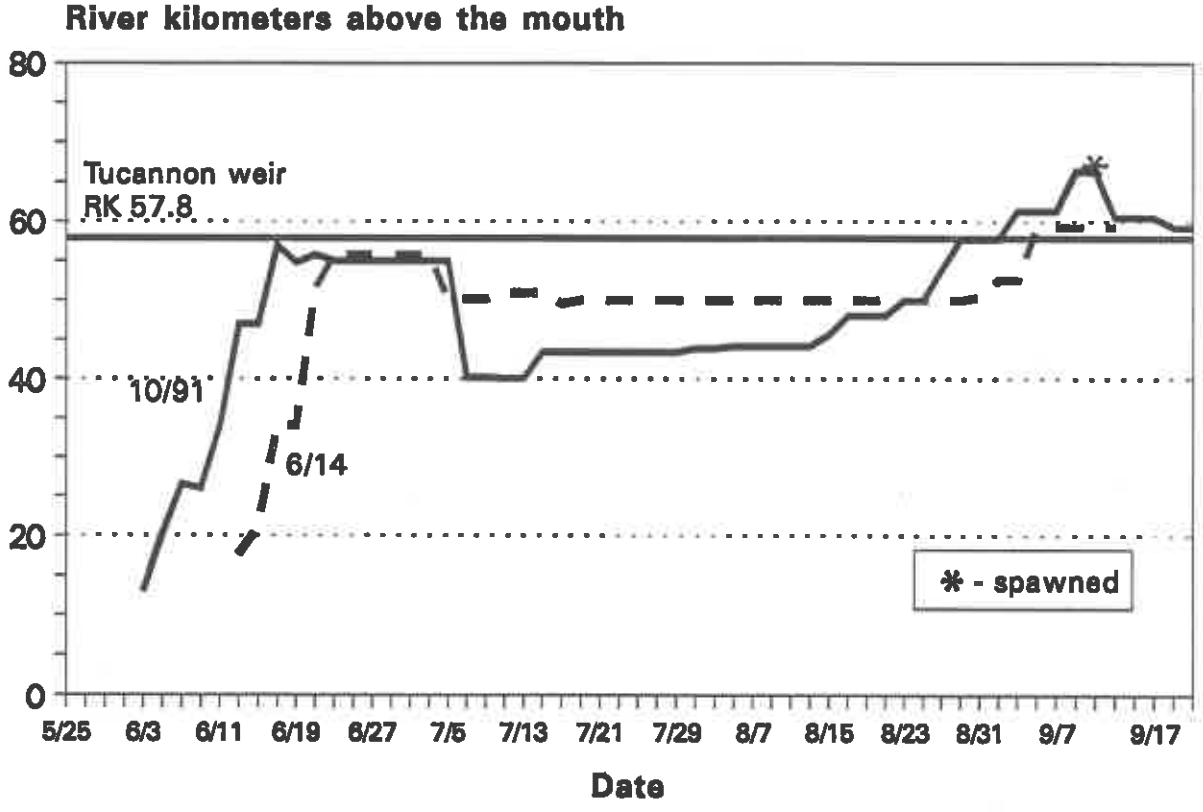

Figure 7. Movements of two University of Idaho radio tagged salmon (channel/code 10/91 and 6/47), tagged and released from John Day Dam and tracked in the Tucannon River, 1993. An (*) indicates observation of spawning, or a spawned out female.

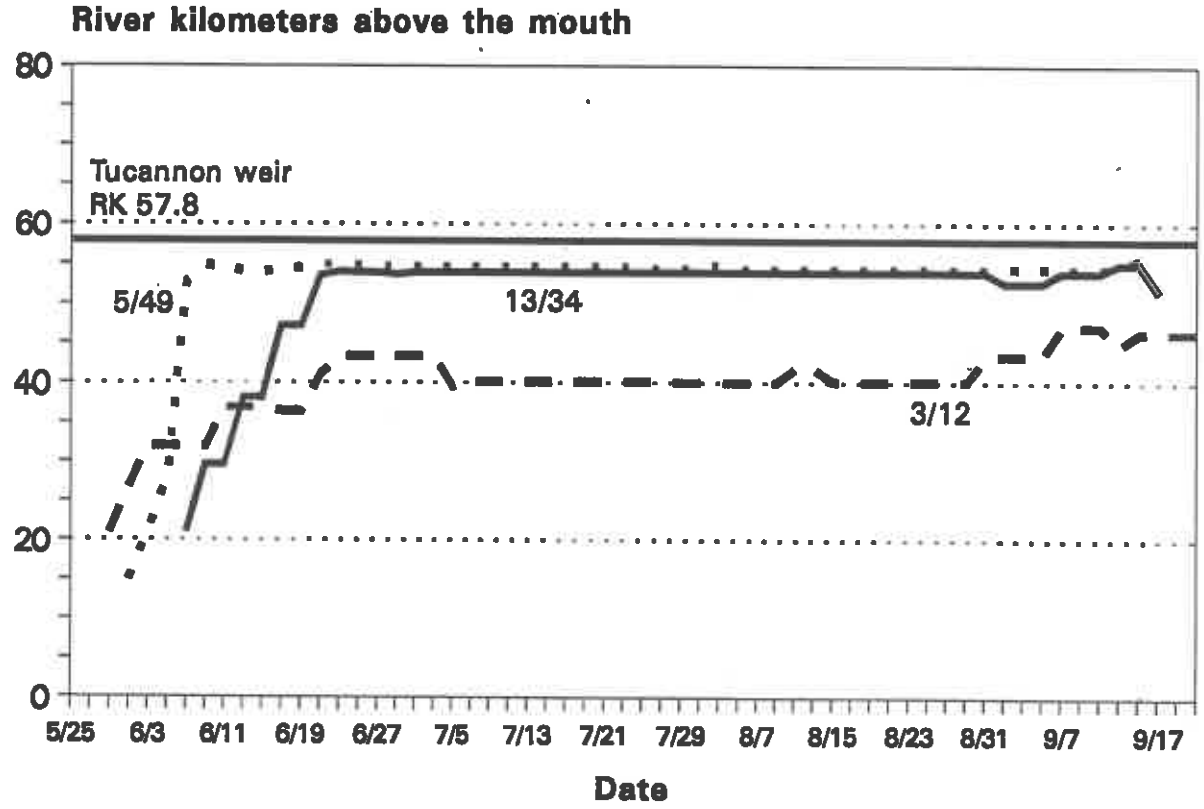

Figure 8. Movements of three University of Idaho radio tagged salmon released (channel/code 5/49, 13/34, and 3/12), tagged and released at John Day Dam and tracked in the Tucannon River, 1993.

Poaching on the Tucannon River: As in previous years, circumstantial evidence indicated possible poaching of radio tagged salmon from the Tucannon River. In 1993, three salmon (two WDF and one UI) were possibly poached. The two WDF tags (2/16 and 2/38) were found in rip rap next the river bank. We are unsure how the tags got there. Finally, the last tracked location of another tagged salmon (5/49) was near a campground frequented by anglers and hunters. This radio tagged salmon was pinpointed in a deep pool the day before it vanished, with a large redd directly above the pool. Other evidence of poaching included recovery of a fresh salmon head cut off by a knife, and another salmon carcass which was filleted.

Salmon movements: All tagged salmon "staged", or "held" (remained relatively stationary for weeks or months with only relatively short movements between holding areas), during most of the summer. Tagged fish generally held in a pool or run associated with undercut banks, or woody debris. As spawning time approached, movements of salmon increased, moving as much as 5 km upstream to spawn. University of Idaho salmon were tracked from the mouth of the Tucannon River. Radio tagged salmon generally took from four to 12 days before they reached areas of the river suitable for "holding" during the summer.

Spawning: Twelve fish (six WDF and six UI) were tracked into the spawning season. Seven were verified to have spawned (spawned out or observed on redds with other salmon), others were recovered with redds nearby, but not observed spawning. We believe that all but one of these fish spawned. One individual male (1/23) was observed spawning with three different females in three different locations.

Discussion: We obtained limited information on the success of our outplanting strategy. Six of 16 outplanted radio tagged salmon retained their tags and survived to spawn. Only three of which spawned in the Wilderness Stratum. However, the remaining three were located within four RK of the Wilderness boundary.

Prespawning mortality of outplanted radio tagged salmon was similar (12.5%) to overall prespawning mortality documented in the river (9.6%, see section 3.3.2). Downstream movement was common among almost all outplanted fish. Downstream movements were generally less than 5 RK from the outplant location. Only two of 16 radio tagged salmon were documented as having moved downstream greater than 15 RK.

Generally fish reduced their movements and began to "stage" or "hold" in mid-May or early-June. Tagged fish limited their movements until mid-August or early September, increasing the frequency of movement and changing their locations just prior to spawning. Natural and hatchery salmon usually selected pools and runs with undercut banks or overhanging logs and root wads to provide cover during holding. Boulder sites constructed in 1984 (Hallock and Mendel, 1985) were used for holding to a lesser degree; one natural female (eight days maximum) in 1993, and additional use in previous years (Mendel et al. 1993).

3.3.2: Pre-spawning mortality

Salmon carcasses (56 total) were found on the Tucannon FH weir or during carcass, snorkel, and radio telemetry surveys prior to spawning season. Five pre-spawning mortalities were found in May, 18 in June, 25 in July, and eight in August. All carcasses located were examined in an effort to determine the cause of death. We were not successful at determining the cause of death for most fish, although many fish were heavily fungused on, or near, the head. Forty-three of the 56 pre-spawning mortalities were hatchery origin (30 females, 9 males, four unknown). Seven natural females, five natural males, and one natural (unknown sex) died prior to spawning. Pre-spawning mortalities for 1993 was estimated to be 9.6% of the run, higher than the 8.5% pre-spawning mortality in 1992. The high incidence of pre-spawning mortalities in hatchery females (54%) was consistent with our observations from 1992 (67%).

3.3.3: Spawning ground surveys

Tucannon River: Program staff surveyed salmon spawning grounds on the Tucannon River to determine temporal and spatial distribution of spawning and assess the abundance and density of spawners. Eight weekly spawning ground surveys were conducted over 11 days; 18 and 25 August, 1, 8, 15, 16, 22, 23 and 29 September, and 5 and 6 October. We found 192 redds in the Tucannon River in 1993, which was slightly above the seven-year mean of 181 redds. Peak of spawning was between 8 and 15 September. Duration of spawning was 52 days.

Redd densities doubled in the Wilderness Stratum as compared to 1992, but densities in other strata remained similar (Figure 9, Appendix F). Few recoveries from our adult outplant study limited us from evaluating its success. Assuming that all unrecovered outplanted females spawned in the Wilderness Stratum, we can estimate that 10 redds could have been made from these females. However, the chance that all the outplanted females survived and spawned in the Wilderness Stratum is unlikely. Therefore, the increase in redds in the Wilderness stratum can not be attributed exclusively to our adult outplants, but to an overall increase in the number of adults that returned to the Wilderness Stratum in 1993.

Forty-nine natural and 31 hatchery salmon carcasses were recovered during spawning ground surveys. Appendix C lists a breakdown of the total number of carcasses sampled on the spawning ground for CWT expansions, and lists the CWT samples of all hatchery salmon that returned in 1993.

We surveyed Panjab Creek and Cummings Creek (both tributaries of the Tucannon River) for salmon redds. The survey of Cummings Creek was qualitative as we determined no suitable spawning habitat for adult salmon existed. No redds were found in a 3 km survey of Panjab Creek in 1993, though redds have been found there in the past.

Historical Index: Spawning surveys have been conducted in an index area (from Cow Camp Bridge downstream to Camp Wooten Bridge - RK 72.9-68.1) in the HMA Stratum since 1954. Twenty-two redds were observed in the Historical Index Area in the HMA Stratum in 1993. A Supplemental Index area was established in 1980 which includes additional portions of the HMA Stratum from Panjab Bridge (RK 74.6) to Cow Camp Bridge (RK 72.9). Thirty-five redds were found in the combined Index and Supplemental Index areas in 1993. The number of redds observed in the historical index area has declined substantially over the years, with a noticeable reduction since 1985 (Mendel et al. 1993). A decline has also occurred in the Wilderness Stratum as a whole.

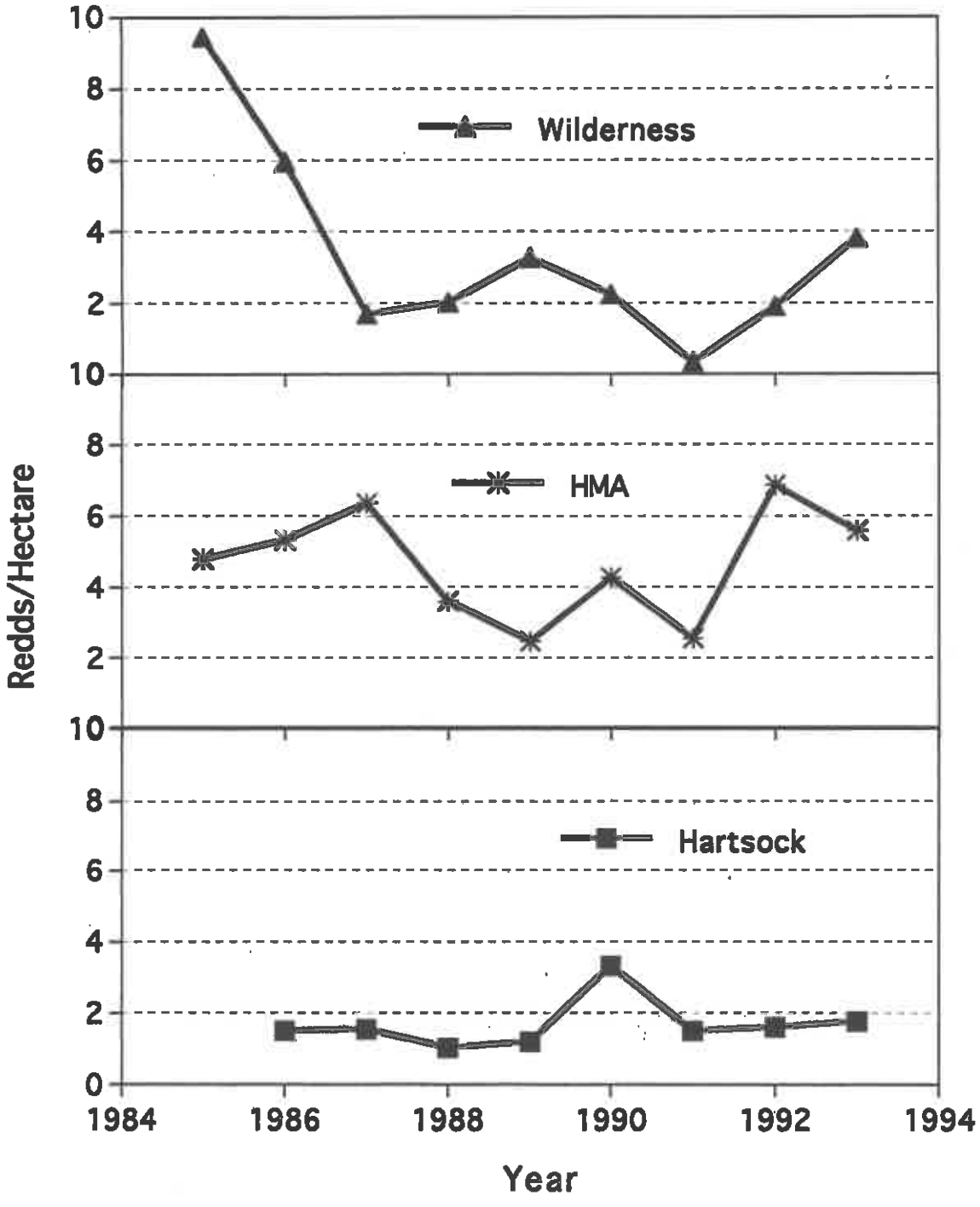

Figure 9. Spring chinook salmon redd densities (redds/hectare) in the Wilderness, HMA, and Hartsock Strata, 1985-1993. Surveys were not conducted in the Hartsock Stratum in 1985.

Asotin Creek: On 9 and 30 September we surveyed the North Fork of Asotin Creek from Lick Creek upstream 13-14 km to the confluence of South Fork North Asotin Creek for spring chinook salmon redds. Prior to our spawning surveys, Washington Department of Wildlife biologists saw a live adult salmon in the river. During our surveys we found two redds, a partial carcass of a female, and an opercle plate from another salmon. The carcass was located 5-6 km above the redds. No redds were found in 1992, or in 1991. Two redds were observed in 1990, none in 1989, one in 1988, three in 1987, one in 1986, and redds in 1985.

Wenaha tributaries: Tributaries of the Wenaha River that extend into Washington State and contain spring chinook salmon are the North Fork Wenaha River and Butte Creek. No survey was conducted on the North Fork Wenaha River in 1993. We surveyed Butte Creek from the confluences of Dickinson Creek and West Fork Butte Creek downstream to the Oregon/Washington border on 12 and 13 September. Five redds were observed in approximately 6.4 km for a density of 0.8 redds/km. No salmon were seen.

3.3.4: Adult escapement

In general, redd counts are directly related to escapement to the Tucannon FH weir/trap (Bugert et al. 1991). We have therefore estimated the total escapement to the Tucannon River (salmon known upstream of weir plus salmon estimated downstream) for 1985-1993 based on redd counts (Table 7). These numbers are revisions or additions to escapements estimated in earlier reports.

We developed five separate models to estimate total spring chinook escapement to the Tucannon River. The models developed used various combinations of female/male ratios, female/redd ratios, and fish/redd ratios. The model chosen uses fish/redd ratios based on trap/weir counts. We feel this model best represents returns of adults to the Tucannon River, and requires the least amount of assumptions that could bias results. To calculate the fish/redd ratio, the number of fish passed upstream of the weir (minus known prespawning mortalities) are divided by the number of redds counted upstream of the weir. This value, multiplied by the total number of redds counted in the river, yields the estimated number of adult salmon in the river. Total estimated escapement to the river is the sum of the estimated number of fish in the river, fish collected for broodstock and known prespawning mortalities. From 1989-1993, natural salmon comprised 44% (range: 35 to 54%) of the estimated annual escapement (Figure 10).

Table 7. Estimated adult chinook salmon escapement to the Tucannon River from 1985 through 1993.

year	fish passed upstream [a]	fish/redd ratio [b]	total number of redds	fish in river	broodstock collected	number of prespawn mortalities [c]	total escapement
1985	- -	2.85	189	539	15	-	554
1986	131	2.85	200	570	116	-	686
1987	108	2.85	185	527	101	-	628
1988	142	2.85	117	333	119	-	452
1989	88	2.85	106	302	92	-	394
1990	323	3.36	180	606	126	6	738
1991	170	4.25	90	383	130	8	521
1992	388	2.92	200	567	97	70	734
1993	297	2.27	192	435	97	54	586

[a] Fish passed upstream for 1990 to 1993 are lower than previously reported in reports because pre-spawning mortalities recovered above the weir are taken out.

[b] Fish/redd ratios calculated from the number of fish passed upstream minus known prespawning mortalities above the weir divided by the number of redds counted above the weir. The 1985-1989 fish/redd ratios calculated from the 1990, 1992 and 1993 average. The 1991 fish/redd ratios was higher than normal due to a large jack return which would create bias in the average.

[c] Number of prespawning mortalities reported are lower than in previous reports because only prespawning mortalities above the weir are included.

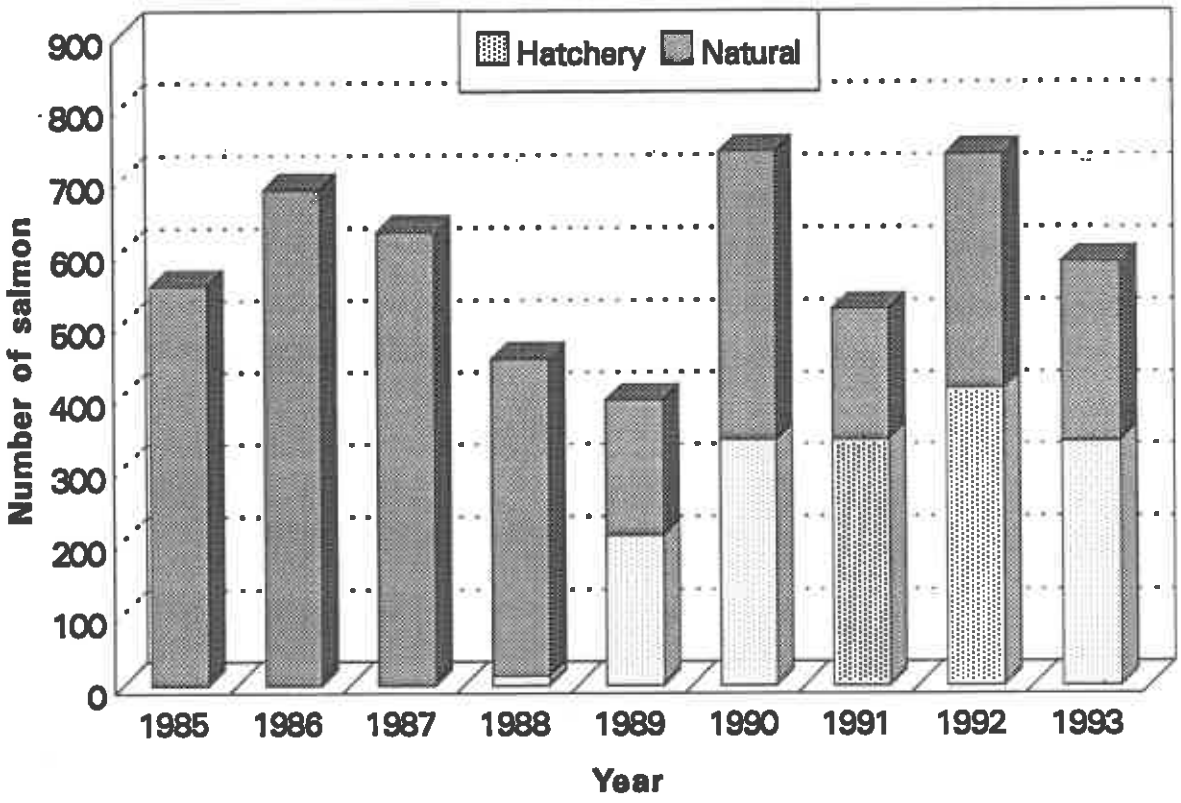

Figure 10. Estimated escapement of natural and hatchery spring chinook salmon to the Tucannon River, 1985-1993.

3.4: Survival Rates

Using egg deposition, juvenile population, smolt, and adult escapement estimates, as well as proportions of natural and hatchery returns each year by age, we are able to calculate various survival rates for natural and hatchery reared salmon. We can then compare survival rates between natural and hatchery production. Estimated salmon populations and survival rates in the river are expanded and revised from earlier reports because we modified adult escapement estimates.

We have estimated salmon populations in the river and have documented populations of salmon at various life stages at the hatchery since the 1985 brood (Appendix G). From these population estimates, we calculated survival rates between various life stages (Figure 11; natural, Figure 12; hatchery) to compare between the two rearing strategies. Mean egg-to-fry survival rates for natural salmon (9.4%; n=8 yrs.) are 12% of the mean egg-to-fry survival rates documented for salmon spawned and reared at either Lyons Ferry or Tucannon FH (81.3%; n=8 yrs.).

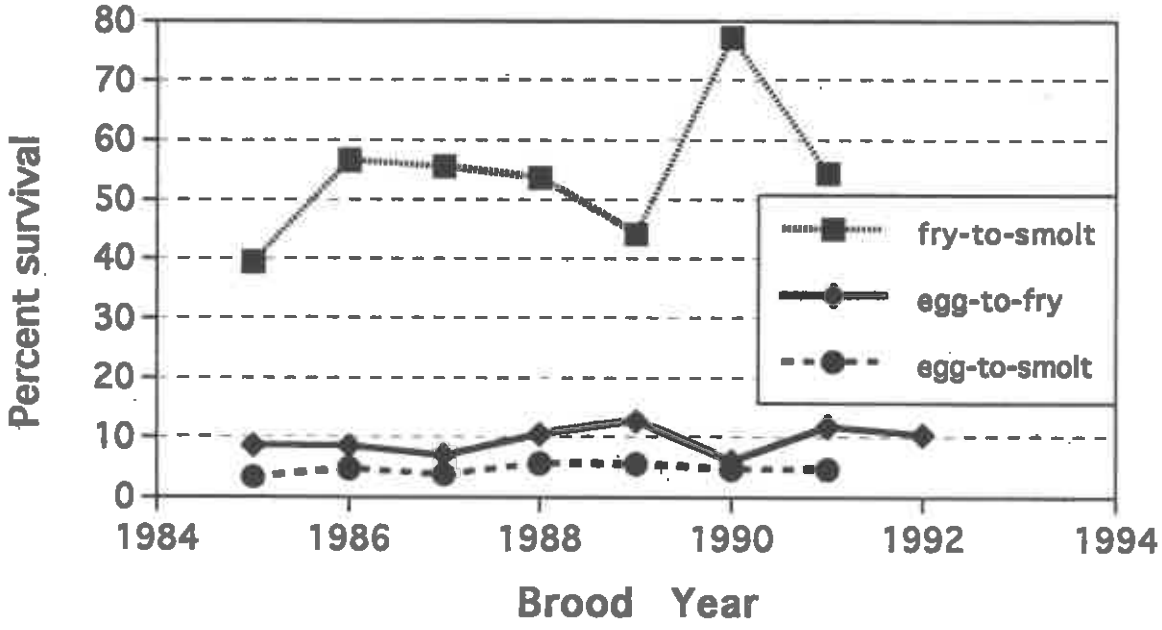

Figure 11. Survival rates by brood year for naturally reared Tucannon River spring chinook salmon.

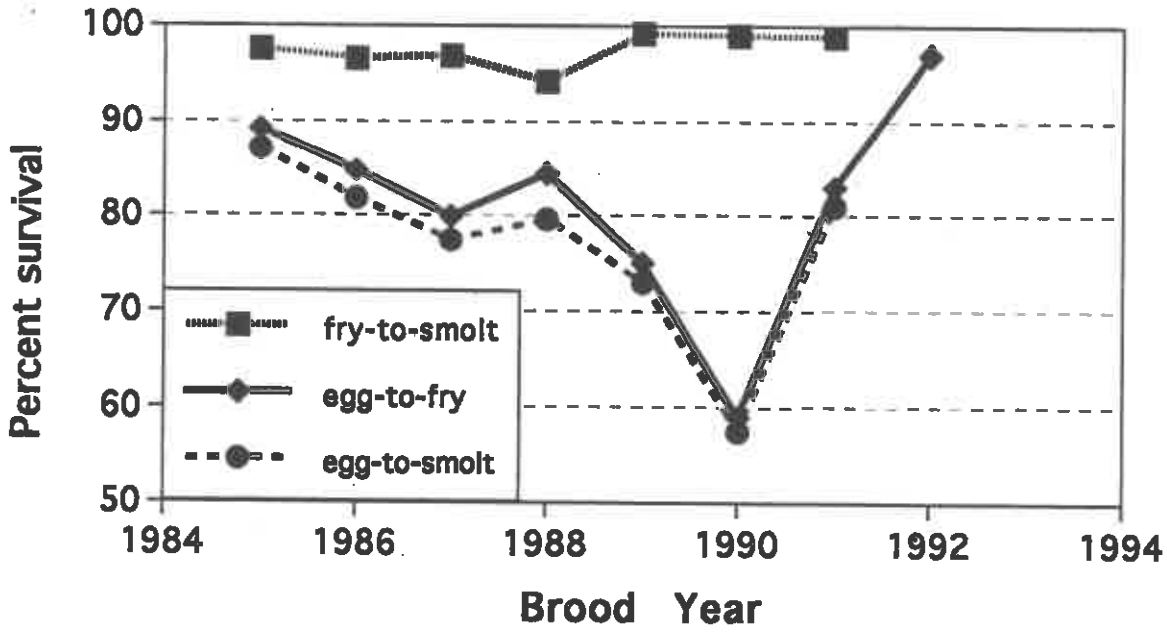

Figure 12. Survival rates by brood year for hatchery reared Tucannon River spring chinook salmon.

Mean egg-to-smolt survival rates for natural salmon (4.7%; n=6 yrs.) are 6% of the mean egg-to-smolt survival rates documented for salmon spawned and reared at either Lyons Ferry or Tucannon FH (77.0%; n=7 yrs.). As expected, salmon raised in the hatchery have a greater egg-to-smolt survival than salmon in the river.

Smolt-to-adult survival rates were also calculated to compare naturally and hatchery produced fish. Smolt-to-adult survival estimates are based on annual estimated escapements for natural and hatchery fish and their estimated age structure. Recoveries of Tucannon spring chinook salmon in fisheries or outside the Tucannon River Basin are few (Mendel et al. 1993), and are not included in the smolt-to-adult survival estimates. Age structure was derived from annual broodstock collections and carcass recoveries from the river. Ages were determined from CWT recoveries and fitted ages (by length or scale analysis) through 1993. Known recoveries from all age groups for a particular return year were multiplied by the estimated number of natural and hatchery salmon escapement to the river for that year.

Expanded smolt-to-adult survival for the 1988 brood natural salmon produced in the Tucannon River was 1.14% (427 salmon) through age 5 (Table 8). Expanded smolt-to-adult survival for the 1988 brood hatchery salmon produced in the Tucannon River was 0.38% (560 salmon) through age 5 (Table 9). The 1988 brood smolt-to-adult survival rate for naturally produced salmon is 300% higher than for salmon produced in the hatchery. Overall, survival from smolt-to-adult is generally two times greater for natural salmon than for hatchery salmon for each brood year.

Juvenile salmon raised in the hatchery have substantially higher survival rates than juveniles that rear naturally in the river, though natural fish have greater smolt-to-adult survivals. Based on these confounding results, we decided to further evaluate success of the program by calculating return per spawner estimates of natural and hatchery salmon (Figure 13, 1989 brood incomplete). Mean return per female spawner for natural salmon is 1.3 for the 1985-1988 brood years (n=4 yrs; range 0.6 to 2.5). Mean return per female spawner for hatchery salmon is 11.0 for the 1985-1988 brood years (n=4 yrs; range 5.1 to 15.2). These data suggest an 8.5:1 advantage for fish reared in the hatchery. Under current conditions the natural population in the Tucannon River is not replacing itself. Future management strategies for this stock will need to focus on this problem.

Table 8. Known and expanded returns (based on escapement estimates and age composition) of **natural** salmon to the Tucannon River for brood years 1985-1990 (smolt-to-adult survivals).

Brood year	Estimated number of smolts migrating	Age 3	Age 4	Age 5	Percent returns (expanded)
1985	35,600	9 (22)	110 (141)	36 (94)	0.44 (0.72)
1986[a]	58,200	1 (1)	116 (305)	28 (63)	0.25 (0.64)
1987	44,000	0 (0)	52 (117)	21 (44)	0.17 (0.37)
1988	37,500	1 (2)	126 (267)	74 (158)	0.54 (1.14)
1989	25,900	5 (11)	40 (85)	- (-)	0.17 (0.37)
1990	49,500	3 (6)	- (-)	- (-)	- (-)

[a] One known (expanded to two) age six salmon was recovered.

Table 9. Known and expanded returns (based on escapement estimates and age composition) of **hatchery** salmon to the Tucannon River for brood years 1985-1990 (smolt-to-adult survivals).

Brood year	Number of smolts released	Age 3	Age 4	Age 5	Percent returns (expanded)
1985	12,922	9 (13)	24 (48)	0 (0)	0.26 (0.47)
1986	153,725	79 (160)	104 (315)	8 (21)	0.12 (0.32)
1987	152,165	8 (24)	72 (194)	8 (21)	0.06 (0.16)
1988	146,200	46 (124)	139 (370)	25 (66)	0.14 (0.38)
1989	99,057	7 (19)	99 (263)	- (-)	0.11 (0.28)
1990	85,800	3 (8)	- (-)	- (-)	- (-)

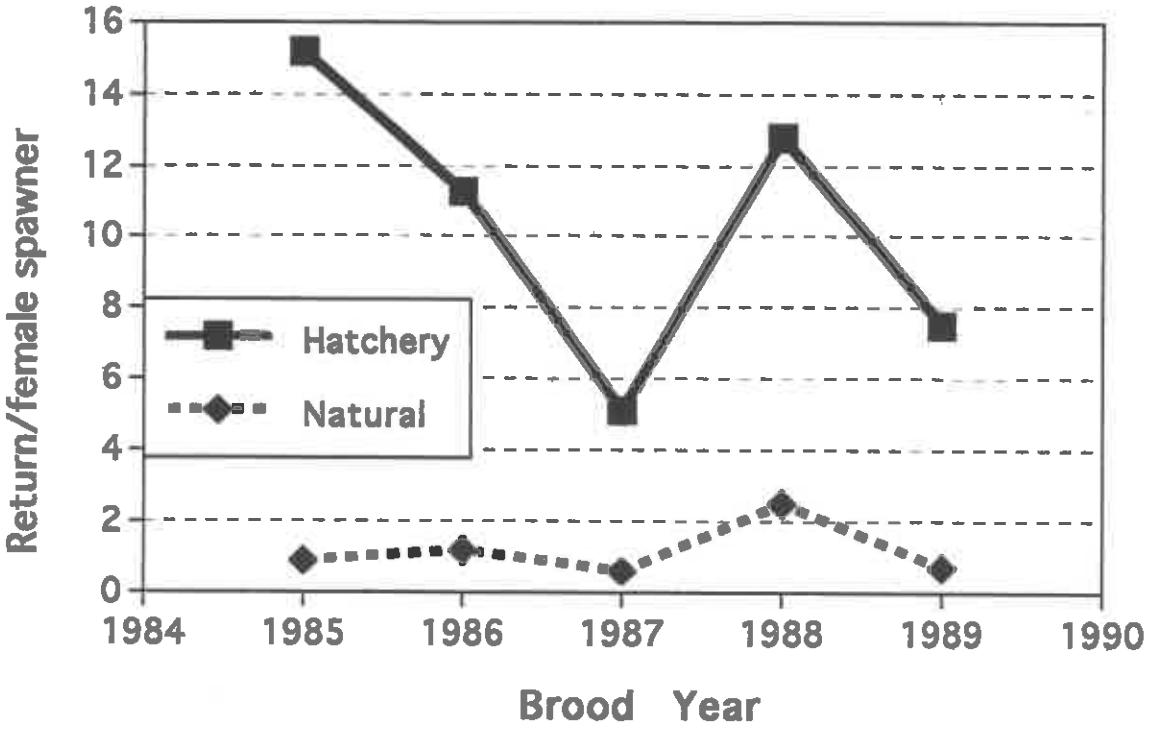

Figure 13. Return per female spawner ratios for natural and hatchery salmon from the Tucannon River, 1985-1989 Broods (1989 brood incomplete).

SECTION 4: STOCK PROFILE ANALYSIS

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

4.1: Population Structure

4.1.1: Fecundity and egg size

Fifty females were spawned in 1993; 21 natural and 29 hatchery (Table 2). Average fecundity and egg size (number/pound) were 3,436 and 1,817, respectively (n=49). This estimate includes two partially green females, but does not include one completely green female. Mean fecundity based on incubation room counts for individual natural females (n=21) was

3,701, and 3,237 for hatchery females (n=28). Fecundity is higher for natural females because they are generally older and larger than hatchery females and fecundity increases with size (Bugert et al. 1992, Mendel et al. 1993). Natural females spawned in 1993 consisted of seven age 4 fish and 13 age 5 fish, and one of undetermined age. Hatchery females spawned consisted of 25 age 4 fish and four age 5 fish.

4.1.2: Sex and age structure

Natural salmon: The sex ratio for all natural salmon that returned to the Tucannon River in 1993 was 1.0 females/male; this includes all age classes recovered from the river, or as broodstock at the hatchery (n=117 fish). The sex ratio for natural salmon sampled in the river was 1.1 females/male, where as natural salmon sampled at Lyons Ferry FH was 0.88 females/male.

Hatchery salmon: Sex ratio of all hatchery salmon that returned to the Tucannon River in 1993 was 2.1 females per male; this includes all age classes recovered from the river, or as broodstock at the hatchery (n=127 fish). The sex ratio for hatchery salmon sampled in the river was 2.2 females/male, where as hatchery salmon sampled at Lyons Ferry FH was 2.0 females/male. We recovered 30 hatchery female prespawning mortalities (total prespawning mortalities of natural and hatchery salmon was 56) in the river during 1993 which greatly affects the calculated female/male ratios. The female/male ratio of all hatchery salmon without the prespawning mortalities was 1.3 females/male. Female/male ratios are used to calculate naturally reared juvenile survival estimates in the river. Including prespawning mortalities would create errors in the estimates.

Natural salmon collected as broodstock differed in age and length to natural fish sampled from the river (Figure 14, 15). Hatchery fish collected as broodstock were similar in age and length compared to all hatchery fish sampled in 1993 (Figure 16, 17). This is reverse to a trend seen in 1992, where hatchery fish collected differed slightly in age and length and natural fish were similar. We are not entirely clear as to why the age and length distribution are different in the natural fish. We attribute the differences to biases in the collection of carcasses on the river, and to the small sample size of broodstock collected. We do not feel that our broodstock collections procedures are at fault.

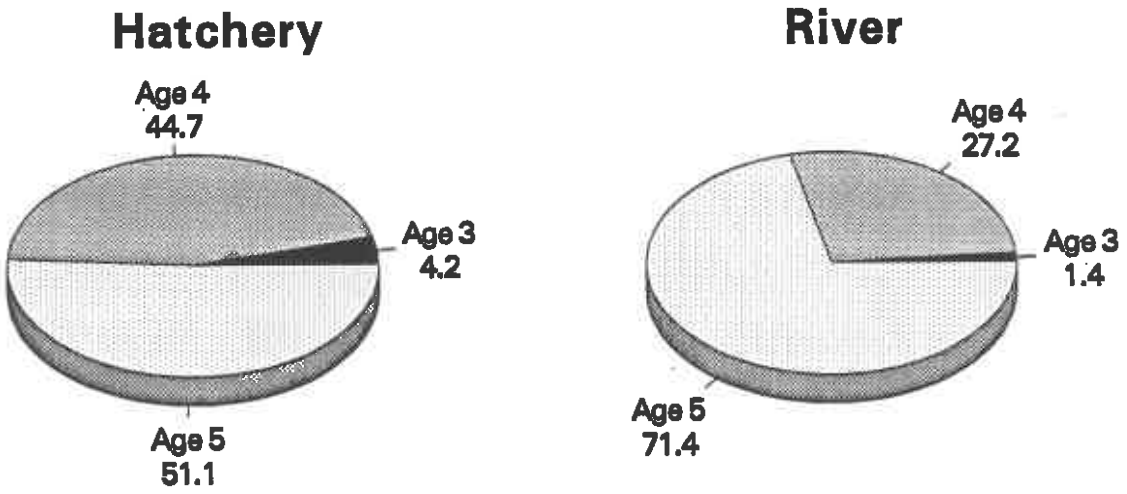

Figure 14. Age distribution of natural salmon adult collected from broodstock at Lyons Ferry FH and from salmon carcasses recovered in the river, 1993.

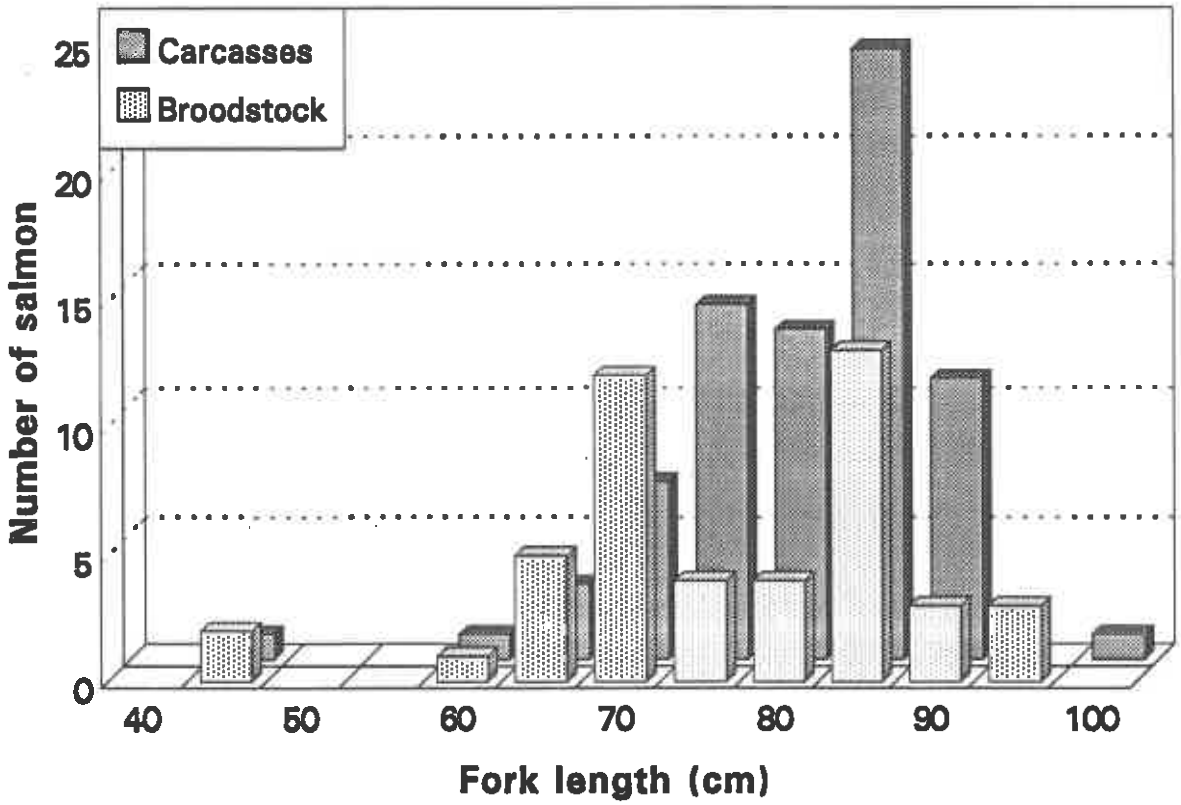

Figure 15. Length frequency distribution of natural salmon adults sampled as carcasses in the Tucannon River and at Lyons Ferry FH, 1993.

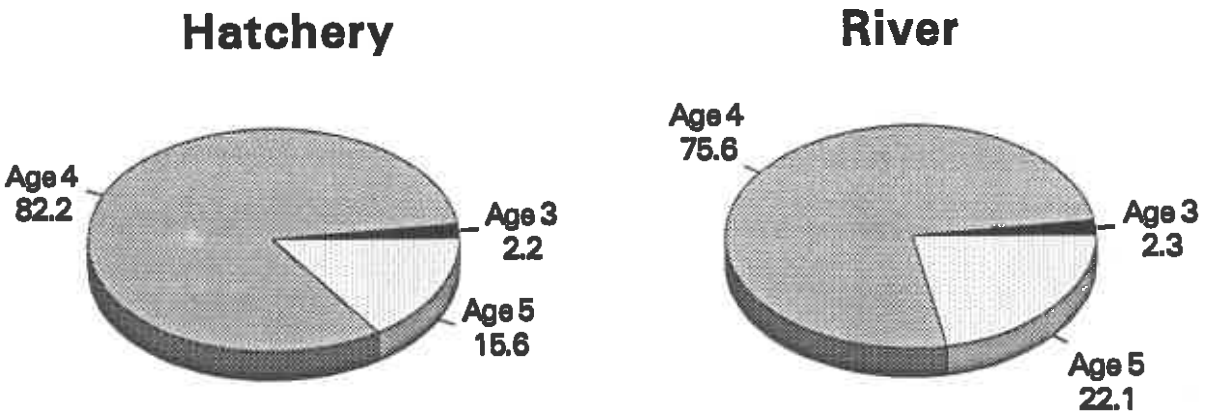

Figure 16. Age distribution of hatchery adult salmon collected from broodstock at Lyons Ferry FH and from salmon carcasses recovered in the river, 1993.

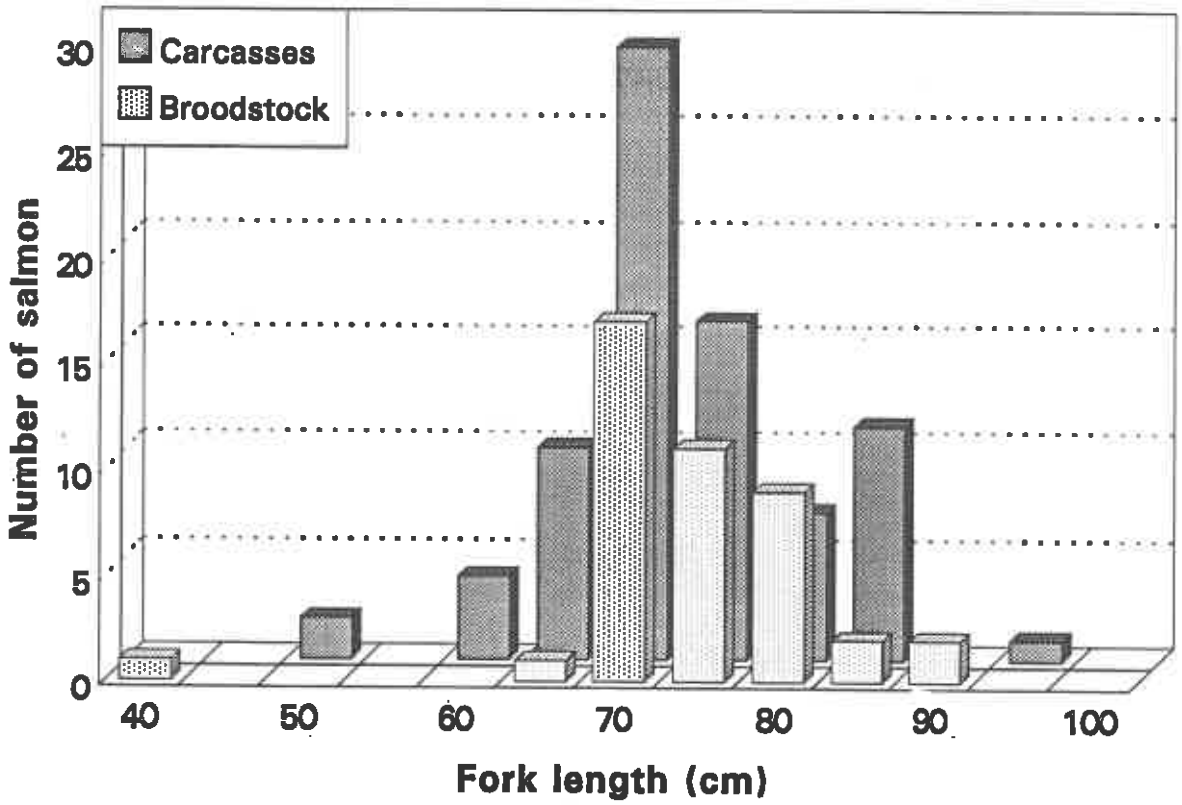

Figure 17. Length frequency distribution of adult hatchery salmon sampled in the Tucannon River and at Lyons Ferry FH, 1993.

Age structure of hatchery salmon in 1993 closely resembled the age structure of natural salmon collected from 1988-1992 (Figure 18.) This was the first year that age 5 hatchery salmon returned in substantial numbers. However, the number of returning age 5 natural and hatchery salmon was greatly above the normal expected return, not only in the Tucannon River, but also in the Columbia and Snake River basins. As in past years, the proportion of hatchery fish that were age 5 was much less than for natural fish.

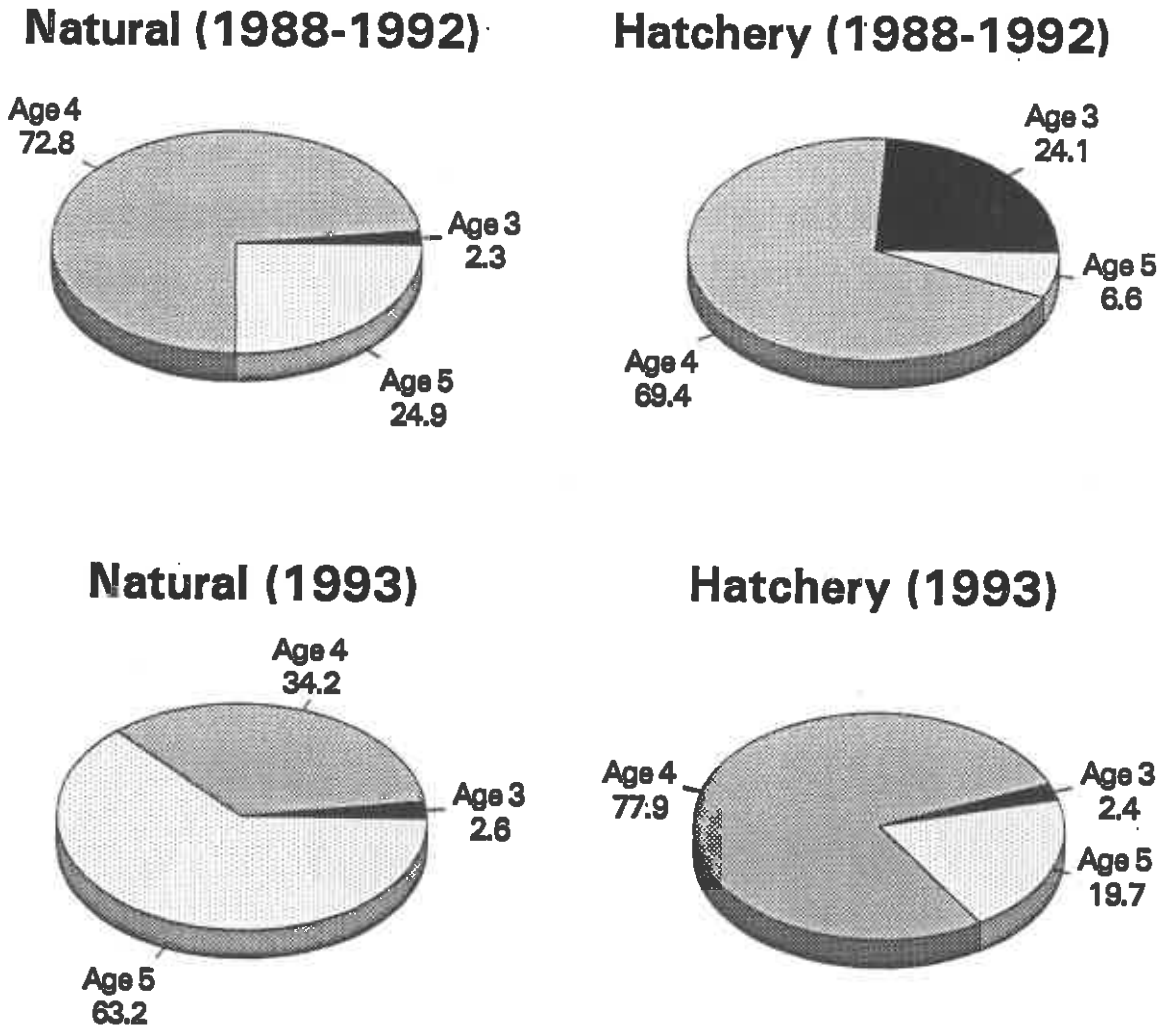

Figure 18. Historical age structure of natural (1988-1992) and hatchery (1988-1992) salmon (based on CWT, scale analysis, or fitted lengths) and age structure of natural and hatchery fish from recoveries along the Tucannon River and at Lyons Ferry FH, 1993.

4.1.3: Morphometrics, meristics, and electophoretics

Morphometric samples were not taken on any juvenile or adult fish during 1993. Meristic samples were collected from the 1992 brood of natural/natural and hatchery/hatchery progeny prior to release. Evaluation staff began collections of natural juvenile salmon captured at our downstream migrant trap for meristic and electrophoretic sampling. Evaluation staff collected 100 electrophoretic samples each from hatchery chinook salmon of hatchery/hatchery and natural/natural progeny prior to release (1991 and 1992 Broods). Electrophoretic samples from adult salmon were collected from river carcasses and broodstock. We collected sixty-one samples from natural salmon, and 67 samples from hatchery salmon in 1993. We will document results of these samples in subsequent annual reports.

SECTION 5: COMPENSATION PROGRESS

We estimate 586 salmon returned to the Tucannon River in 1993. This value represents escapement of both natural and hatchery salmon. Our preliminary estimates show a hatchery smolt-to-adult survival rate (0.16-0.47%) substantially below the design objective of 0.87%. Based on CWT recoveries, it appears that few salmon contribute to fisheries, or are recovered outside the Tucannon River Basin (Mendel et al. 1993).

In addition to total returns and return rates, we have some biological information that needs to be considered regarding the supplementation program, and its interaction with naturally produced fish in the Tucannon River.

1) Documentation of high annual prespawning mortalities (particularly hatchery females) at the hatchery weir or in the river during any given year.

2) Adult returns differ in regards to spawning distribution and age composition of spawners since initiation of the hatchery program. Also, hatchery salmon are slightly smaller at a given age than natural salmon.

3) Potential impacts of <u>Enterocytozoon salmonis</u> on salmonids in the Tucannon River.

4) Smolt-to-adult survival of Tucannon hatchery salmon is approximately half that of natural salmon in the Tucannon River.

5) The potential adverse impacts of the weir/trap on spawning distribution, passage, and prespawn mortalities.

6) The possibility that broodstock collected is not representing the overall run (Section 4.1.2) and the potential genetic impacts of matings with a small population.

7) Low return per spawner ratios of naturally produced salmon compared to salmon raised in the hatchery. Naturally produced salmon are apparently not replacing themselves.

All of these points are concerns which may affect or guide the supplementation program and management strategies in the future.

SECTION 6: RECOMMENDATIONS

We provide seven recommendations to improve performance of the Tucannon salmon program.

Fish Culture

1) Initiate discussions between hatchery and evaluation personnel to potentitally rear fish for the acclimated yearling program to a projected smaller size at release (25 ffp). This practice would accomplish two objectives:

   a) lessen gonadosomatic development and possibly modify the age structure of hatchery fish (bring the hatchery fish more in line with natural fish age structure).

   b) size of fish from the acclimation pond would be similar in size to natural fish in the river, potentially causing less competition and displacement of natural fish by hatchery fish.

2) Increase sampling in the rearing and acclimation ponds to monitor and document densities and growth rates throughout the rearing period.

3) Continue individual incubation as standard operating procedure after the controlled matings study is complete. This will allow us to track success of individual families in the egg stage, and provide detailed records of fecundity.

4) The volitional release period for the acclimated yearlings should be extended substantially. Acclimated salmon should be allowed a controlled opportunity to emigrate in early February through late April.

Broodstock Management

5) Improve passage and holding at the adult trap. Install a camera system for enumeration of adult salmon upstream of the weir without having to handle all fish passing the weir. This should reduce trapping and handling stress, and injuries.

6) Increase the collection and preservation of sperm, particularly from natural salmon. Continue to refine cryopreservation techniques in the hopes of increasing fertilization rates. Investigate and/or develop new technology for short term egg and sperm storage to increase genetic contribution and management options.

7) Update previous estimates of adult spring chinook full seeding into the Tucannon River. This revision is warranted since we have revised our escapement estimates, and management strategies in the future will rely on a full seeding adult escapement goal.

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APPENDIX A

LYONS FERRY FISH HATCHERY COMPLEX
TUCANNON SPRING CHINOOK PROGRAM
1993 BROODSTOCK COLLECTION PROTOCOL

Background

Production goal The 1993 brood Tucannon spring chinook salmon production at Lyons Ferry Fish Hatchery (FH) will be released in two separate groups: 1) 64,000 fish released in October 1994 as presmolts at 50 fish per pound (fpp; 1,300 pounds), and 2) 88,000 fish released as yearlings in March/April 1995 at 15 fpp (5,867 pounds). The purpose of this document is to identify those factors which affect this production goal, and to provide guidelines for broodstock collection and spawning. This protocol is intended for the 1993 season but may be applied in 1994.

Eggtake requirements To meet this production goal, 96 spawning salmon are required, based upon the following assumptions:

average fecundity of 3,750,
average sex ratio of 1.0:1.0,
average prespawning survival of females of 96%,
average egg to presmolt survival of 90%,
average egg to smolt survival of 80%.

Given this information, 181,111 eggs are needed to produce 64,000 presmolts and 88,000 smolts. This eggtake would require spawning of 48 females, which requires the collection of 100 adults, based upon the prespawning survival rate. Therefore, in this document, the collection goal is 100 salmon, required for the production goal of 96 salmon.

Broodstock goals will be adjusted downward if the Snake River spring chinook run size is projected to be less than 60% of the recent ten-year average as measured at Ice Harbor Dam. The collection goal will remain unchanged if the Snake River run size exceeds 60% of the ten-year average. Based on the recent ten-year counts, downward adjustments would occur 10% of the years. Reductions in the goal, if necessary, will be proportionate to the reduction in the overall Snake River run. For 1993, a Snake River run projection and a decision on the broodstock goal will be made on May 15. This date is the average 70% cumulative passage point during recent years, it is late enough into the run for a reliable projection, and yet is early in the Tucannon trapping period.

Collection methods On an annual basis, natural and hatchery-origin spring chinook adults are collected for broodstock at a floating weir, which is located adjacent to Tucannon FH at river kilometer 61. This weir/trap has a high trapping efficiency. An undetermined number of salmon however, remain downstream of the

weir/trap. All hatchery smolts are marked with coded-wire tag and adipose clip, enabling one to distinguish hatchery versus natural production upon recovery at the weir/trap.

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

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

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

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

Biological Information

Available habitat Current estimates of natural production of salmon in Tucannon River suggest that escapement of 400 salmon upstream of the weir/trap approaches full seeding. Combined upstream escapement was 82% of full seeding in 1990, 42% in 1991, and 115% in 1992.

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

Weir/trap escapement For the period 1986- 1992, the average natural salmon escapement to the Tucannon FH weir/trap was 211 (range: 109- 261). Of this, an average of 130 natural salmon (range 67- 197) have been passed upstream. For the period 1990-1992, average hatchery-origin salmon escapement to the weir/trap was 240, with an average of 172 fish passed upstream. Hatchery fish comprised 54% of the upstream escapement in those years (range: 44%- 62%).

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

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

Broodstock Collection Guidelines

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

1) No more than 50 natural salmon and 50 hatchery-origin salmon will be retained for broodstock. (This number may be reduced on May 15 when Snake River run size projections are made).

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

3) Broodstock collected and, likewise, those passed upstream are a representative sample of the size, age, sex, and run timing of the overall population of hatchery or wild salmon arriving at the weir/trap. Natural origin jacks (fork length less than 26 inches) should be retained in proportion to their overall abundance in the run. No hatchery jacks will be retained for production, to meet agreements with co-managing tribes.

4) Salmon that die in the trap, or are killed by the weir during upstream migration will be included in the collection tally.

5) All salmon from the 1990 brood experimental crossings will be passed upstream. These will be identified by having adipose clips, blank-wire tags, and coded-wire tags.

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

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

Stray salmon During spawning, all hatchery-origin salmon will have their coded-wire tags read prior to fertilization. In 1993, jack-size salmon collected at the Tucannon weir/trap that have an adipose clip, but no blank-wire tag, will be retained to determine its origin. Gametes from stray fish will be transferred to the hatchery of origin if feasible, or destroyed.

Spawning Guidelines

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

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

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

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

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

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

APPENDIX B

Table 1. Escapement and broodstock collection of spring chinook salmon to the Tucannon Fish Hatchery weir in 1993.

Week ending	Escaped to weir		Passed upstream		Collected	
	natural	hatchery	natural	hatchery	natural	hatchery
22 May	2	28	2	28		
29 May	26	77	21	63	5	14
05 Jun	36	36	26	25	10	11
12 Jun	24	44	17	37	7	7
19 Jun	23	35	18	32	5	3
26 Jun	21	14	17	11	4	3
03 Jul	6	6	4	3	2	3
10 Jul						
17 Jul		3		1		2
24 Jul						
31 Jul	2	1		1	2	
07 Aug		1		1		
14 Aug		1				1
21 Aug	1	2		1	1	1
28 Aug	4		1		3	
04 Sep	20	3	14	3	6	
11 Sep	20	2	16	1	4	1
18 Sep	5	1	4		1	1
25 Sep		3		3		
30 Sep		1		1		
Totals [a]	191	257	141	210	50	47

[a] Numbers of salmon collected for broodstock are estimated at time of collection. Salmon ≤61 cm are included here as adults.

APPENDIX C

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

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

Appendix C. Table 1. (Continued).

Brood year	Parents male	Parents female	Release dates mon/day	Yr.	Number Released	No. lbs.	Fish/ pound	CWT code	
1991	11	11	4/6-4/12	93	16,745	1,116		63-46-47	f
					807	54		ad only	
	17	17		93	55,716	3,714		63-46-25	g
					790	53	15	ad only	
					74,058	4,937			
1992	25	18	10/22-25	93	25,134	698	36	63-48-23	g
			3/15-4/12	94			15	63-48-10	h
	20	27	10/22-25	93	24,985	694	36	63-48-24	f
			10/22-25	93	7,197	200	36	63-48-56	i
			3/15-4/12	94			15	63-49-05	
			3/15-4/12	94			15	63-48-55	

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

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

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

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

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

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

[g] Natural cross progeny have red elastomer tags behind left eye.

[h] Natural cross progeny (released from the acclimation pond) have yellow elastomer tags behind the left eye.

[i] Hatchery cross progeny (released from the acclimation pond) have yellow elastomer tags behind the right eye.

Appendix C (Continued).

Table 2. Summary of the number spring chinook salmon (natural and wild) sampled from the Tucannon River, 1993.

Total escapement to Tucannon River:	586		
Broodstock collected	97	[a]	
Fish dead in trap	0		
Total	489		
In-river CWT sampled fish:			
Prespawning mortality	56	(43H,13W)	
Spawned carcasses recovered	109	(42H,67W)	
Spawning ground CWT sample	165		
Total number of carcasses sampled in 1992	**261**		

[a] Only 96 carcasses were sampled from broodstock collection.

Table 3. Summary of all hatchery salmon sampled from the Tucannon River, 1993.

CWT code	Broodstock collected	Dead in trap	Pre-spawn mortality	Spawned in river	Total
63-01-31	6		16	6	28
63-01-42	4			3	7
63-14-61	31		17	24	72
63-40-21	1			1	2
63-43-11				1	1
63-55-01	3		7	4	14
Strays	1				1
Lost or no tags			3	3	6
Total	**46**	**0**	**43**	**42**	**131**

[a] Broodstock stray (CWT: 07-51-10)

[b] Lost or no tags includes fish that were sampled, but heads were not taken on all of them. Heads were sometimes missing from positively identified hatchery fish during spawning ground surveys. Of the 6 lost or no tags, 4 were from fish with no heads when found, but identified as hatchery salmon.

APPENDIX D

Table 1. Densities (fish/100 m^2) of natural and hatchery parr at outplant release and control sites by date.

Site Type	Date 9/14	10/21	10/22	10/25	10/28	11/10	3/29
Release sites							
#2							
Natural	0.0	0.0	- -	- -	0.0	0.0	- -
Hatchery	0.0	0.0	- -	- -	869.2	13.0	- -
#5							
Natural	55.7	- -	- -	85.0	64.0	17.0	- -
Hatchery	0.0	- -	- -	0.02	38.1	22.7	- -
#7							
Natural	77.6	- -	- -	63.2	54.6	48.9	- -
Hatchery	0.0	- -	- -	0.0	100.6	123.6	- -
#11							
Natural	5.8	- -	- -	0.0	0.0	2.9	- -
Hatchery	0.0	- -	- -	0.0	26.1	5.8	- -
#14							
Natural	20.2	- -	0.0	- -	0.0	0.0	- -
Hatchery	0.0	- -	0.0	- -	0.0	0.0	- -
#17							
Natural	125.0	- -	92.4	- -	79.4	99.4	23.8
Hatchery	0.0	- -	0.0	- -	1192.6	1192.6	26.8
#21							
Natural	44.6	59.5	- -	- -	6.0	3.0	0.0
Hatchery	0.0	0.0	- -	- -	41.6	8.9	0.0
Control sites							
#1							
Natural	- -	0.0	- -	- -	0.0	0.0	- -
Hatchery	- -	0.0	- -	- -	0.0	0.0	- -
#2							
Natural	- -	0.0	- -	- -	0.0	0.0	- -
Hatchery	- -	0.0	- -	- -	65.4	8.2	- -
#3							
Natural	- -	136.0	- -	- -	117.7	172.8	- -
Hatchery	- -	0.0	- -	- -	88.2	132.4	- -
#4							
Natural	- -	79.9	- -	- -	75.0	120.0	- -
Hatchery	- -	0.0	- -	- -	124.9	65.0	- -
#5							
Natural	- -	165.7	- -	- -	78.1	87.6	- -
Hatchery	- -	0.0	- -	- -	21.3	28.4	- -

Appendix D, Table 1 continued.

Site Type	Date 9/14	10/21	10/22	10/25	10/28	11/10	3/29
Control sites							
#6							
Natural	- -	62.6	- -	- -	32.7	35.4	- -
Hatchery	- -	0.0	- -	- -	19.1	2.7	- -
#7							
Natural	- -	67.3	- -	- -	33.7	25.3	- -
Hatchery	- -	0.0	- -	- -	25.3	14.7	- -
#8							
Natural	- -	175.4	- -	- -	92.1	81.1	35.1
Hatchery	- -	0.0	- -	- -	329.0	548.3	54.8
#9							
Natural	- -	62.7	- -	- -	58.1	52.9	5.9
Hatchery	- -	0.0	- -	- -	0.0	0.7	0.0

Appendix D, Table 2 continued.

Site	Site Length(m)	Marker Location	Habitat Type	Road Mile	Description and Reference point
HMA STRATUM					
HMA-1	18.2	LB,LE	riffle	34.7	147 m below Cummings Cr. bridge
HMA-2	26.0	LB,LE	boulder	34.9	first road on left past Cummings Creek bridge; day use
HMA-3	17.8	-	run	35.2	day use area on left; road is blocked off
HMA-4	18.5	-	run [b]	35.4	day use area on left across from Blue Lake, at LE follow trail to river, site is 37 m downstream from end of trail
HMA-5	27.0	RB,LE	riffle	36.0	UE is just below Tuc FH bridge
HMA-6	15.5	LB,LE	run	36.5	279 m downstream from Tucannon Hatchery intake
HMA-7	19.1	LB,LE	boulder	37.0	CG 4, LE is immediately above rock weir
HMA-8	15.1	LB,LE	pool	37.7	day use area across from CG 5; 152 m downstream from LE of day use, LB split
HMA-9	16.8	RB,LE	riffle	38.2	Below Beaver-Watson; pull out on left with dirt pile
HMA-10	19.5	LB,LE	run	39.3	192 m downstream from LE CG 6
HMA-11	19.8	RB,LE	boulder	39.7	LE CG 7; behind outhouse; site is 43 m upstream
HMA-12	17.1	RB,LE	pool	40.4	LE CG 8; site on main river above Big Four Lake intake, UE is under upper part of large log
HMA-13	19.7	-	riffle	41.1	across from USFS Guard Station at LE of pullout
HMA-14	14.8	LB,LE	run	41.7	UE is 274 m downstream from the Tucannon CG bridge
HMA-15	17.8	RB,LE	boulder	42.3	810 m upstream from Tucannon CG bridge
HMA-16	21.3	-	pool	43.1	first blocked off cutback road before second cattleguard
HMA-17	16.0	-	boulder	43.6	LE CG 9; 38 m downstream
HMA-18	14.4	-	riffle	43.6	UE CG 9; 90 m upstream from HMA-17
HMA-19	17.5	RB,LE	run	44.3	UE is just below cow camp bridge
HMA-20	16.4	RB,LE	riffle	44.7	first cutback road on right before private cabins; 136 m downstream from LE of road
HMA-21	16.6	-	pool	45.4	LE CG 10; 97 m upstream from outhouse, entrance at lower gate
HMA-22	14.5	RB,LE	pool	45.5	UE CG 10; entrance at upper gate, straight across from new outhouse
HMA-23	18.5	-	boulder	45.6	UE is 26 m downstream from Panjab bridge
HMA-24	14.3	LB,LE	run	45.7	LE is 46 m upstream from Panjab bridge
HMAS-1	14.8	LB,MID	side channel	40.4	UE is 19 m down from Big Four intake

Appendix D, Table 2 continued.

Site	Site Length(m)	Marker Location	Habitat Type	Road Mile	Description and Reference point
HMAS-2	22.2	-	side channel	44.3	below cow camp bridge, first RB channel along rock wall
HMAS-3	13.2	LB,LE	side channel	44.35	169 m upstream from cow camp bridge, extreme LB channel
HMAS-4	14.0	-	side channel	44.4	LE is 103 m upstream from HMAS-3, extreme LB channel
HMAS-5	12.5	RB,LE	side channel	44.45	LE is 40 m upstream from HMAS-4, same LB channel as S-4
HMAS-6	17.0	-	side channel	45.35	RB channel below HMA-21, LE is at mouth of channel
HARTSOCK STRATUM					
HART-1	11.1	-	run	27.6	47 m upstream from bridge 11 to LE
HART-2	- -	LB,LE	run	29.1	116 m upstream from bridge 12 to LE
HART-3	18.2	-	riffle	30.2	181 m downstream from bridge 13 to UE
HART-4	13.5	-	pool	30.4	15 m upstream from bridge 13 to LE
HART-5	17.1	-	run	31.6	620 m downstream from bridge 14 to UE
HART-6	30.4	-	run	32.3	305 m upstream from bridge 14 to LE
HART-7	10.4	-	pool	33.3	80 m downstream from upper most gabion at Herm Dahm's
HART-8	24.5	-	riffle	33.35	36 m upstream from upper most gabion at Herm Dahm's
HART-9	18.0	-	riffle	34.5	30 m downstream from HMA boundary fence to UE
MARENGO STRATUM					
MAR-1	16.0	-	run [b]	12.6	below smolt trap along rock wall
MAR-2	16.3	-	riffle [b]	13.0	47 m downstream from Mom's Cafe, below metal pump shed
MAR-3	14.0	-	riffle	15.3	174 m above Frame's bridge
MAR-4	9.8	-	pool	17.05	87 m downstream from Enrich bridge
MAR-5	11.0	-	riffle [a]	18.9	5.35 miles up Tucannon Rd
MAR-6	12.0	-	run [c]	23.3	upstream from SCS silt basin on Hovruds property
LOWER STRATUM					
LS-1	10.0	-	riffle	1.5	45 m upstream from highway 261 bridge
LS-2	13.5	-	run	7.0	78 m upstream from Smith Hollow bridge
LS-3	17.7	-	pool	9.8	upstream from Kessels; second turnoff past driveway

[a]
[b] used to be a run.
[c] used to be a pool.
[h] used to be a riffle.
RB - right bank, LB - left bank, LE - lower end, UE - upper end, CG - campground
[f]
[j] WILD CG 2 and 2.5 have been blocked off.
Road mileage starts at the mouth of the Tucannon.

Table 3. Washington Department of Fish and Wildlife area (m^2) estimates of habitat type within four designated stratum of the Tucannon River Watershed.

Stratum [a] Habitat	Length available (m)	Average width (m)	Area available (m^2)
Wilderness			
Riffle	5,910	8.4	49,644
Run	4,230	7.4	31,302
Pool	390	6.8	2,652
Side Channel	3,330	4.8	15,984
HMA			
Riffle	10,230	12.2	124,806
Run	7,500	10.7	80,250
Pool	510	11.0	5,610
Boulder	1,770	12.0	21,240
Side Channel	4,245	4.8	20,376
Hartsock			
Riffle	9,270	12.7	30,684[b]
Run	6,570	11.9	46,548[b]
Pool	480	11.1	771[b]
Marengo			
Riffle	4,008	11.9	47,695
Run	6,616	10.9	72,114
Pool	602	9.9	5,960

[a] Survey years: Wilderness in 1991, HMA in 1987, Hartsock in 1987, and Marengo in 1990.

[b] Listed areas are what have been used in past population estimates. Actual areas are: riffle = 117,729 m^2, run = 78,183 m^2, pool = 5,328. These areas have not been used in past population estimates, as densities dramatically decline in the lower stretch of the Hartsock Stratum.

APPENDIX E

Table 1. Summary of spring chinook salmon marked (radio and/or jaw tagged), transported upstream and released in the Tucannon River, 1993.

Radio Tag	Jaw tag no.	Date tagged	Sex [a]	Fork length (cm)	Age [b]	Recovery: Days tracked	Recovery: date	Recovery: locale (RK) [c]	Recovery: carcass	Comment
Natural Salmon										
2/07		6/04	M	67	4	78	8/20	83.6	no	spawned in Wilderness
1/23	w788	6/07	M	83	5	98	9/12	75.9	yes	spawned in Wilderness
2/05	w775	6/07	M	74	4	0	6/07	–	no	tag regurgitated in truck
2/26	w774	6/07	M	88	5	32	7/08	74.6	no	tag found, no fish, HMA
2/36	w751	6/07	M	83	5	98	9/12	71.7	yes	spawned in HMA
3/20	w867	6/10	M	89	5	30	7/09	84.2	no	tag found, no fish, Wilderness
1/40	w859	6/14	M	91	5	89	9/10	74.4	no	spawned in HMA
2/24	w856	6/14	M	81	5	46	7/29	76.1	no	tag found, no fish, Wilderness
1/28	w795	6/15	F	73	4	25	7/09	48.8	yes	pre-spawn mortality, HMA
	w857	6/16	F	80	5	–				no data
	w882	6/16	F	79	5	–				no data
	w861	6/17	F	82	5	–				no data
	w858	6/18	F	74	4	90	9/15	83.0	yes	spawned in Wilderness
	w885	6/22	F	62	4	–				no data
	w873	6/25	F	79	5	–				no data
Hatchery Salmon										
1/04		6/04	F	74	4	49	7/22	75.3	yes	pre-spawn mortality, Wilderness
1/15	g796	6/04	M	72	4	103	9/14	78.6	yes	spawned in Wilderness
2/08	w786	6/04	F	82	5	–	lost	–	yes	tag lost-no signal
3/08	w783	6/07	F	74	4	0	6/07	–	yes	tag regurgitated in truck
3/20	w789	6/07	M	87	5	0	6/07	–	no	tag regurgitated in truck
2/38	w772	6/07	F	71	4	23	6/29	–	no	tag located in rocks, HMA
2/13	w784	6/10	M	72	4	30	7/09	84.2	no	tag found, no fish, Wilderness
2/16	w765	6/10	F	71	4	0	6/10	–	no	tag regurgitated in truck
3/08	w763	6/11	M	72	4	96	9/14	70.5	no	spawned in HMA
2/16	w768	6/11	M	71	4	46	7/26	59.2	no	tag found, no fish, HMA
2/43	w869	6/14	M	91	5	46	7/29	73.3	no	tag found, no fish, HMA
2/40	w800	6/14	M	70	4	25	7/08	76.0	no	tag found, no fish, Wilderness
	w860	6/17	F	73	4	–				no data
	w870	6/17	F	66	4	–				no data

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

[b] Estimated age based on fork length or coded-wire tags (hatchery fish).

[c] Estimated river kilometers from Tucannon River mouth.

Appendix E, continued.

Table 2. Summary of spring and summer chinook salmon radio tagged by the University of Idaho and released at John Day Dam, Columbia River, and found in the Tucannon River, 1993.

Radio Tag	Jaw tag no.	Date tagged	Sex [a]	Fork length (cm)	Age [b]	Recovery: Days tracked	Recovery: date	Recovery: locale (RK) [c]	Recovery: carcass	Comment
Natural Salmon										
1/11	FE5	4/21	M	85	5		8/16	73.3	yes	pre-spawn mortality
3/12	DC5	5/04	M	86	5		9/21	46.3	yes	
4/50	HH6	5/19		75			7/07	4.0	no	
5/49	HA4	5/17		80			9/16	55.5	no	tag quit
6/47	--	5/13	M	85	5		9/14	59.2	yes	
6/88	JA9	6/22	F	72	4		7/29	75.9	no	
9/14 [d]	DA1	5/03		78			8/05	54.5	no	
13/34	HB8	5/17	M	67	4		9/16	51.5	yes	
Hatchery Salmon										
1/16	FJ7	4/28		71			5/27	57.8	yes	to hatchery
2/01	FF8	4/27		66			6/04	52.7	no	
10/91	HK5	5/19	M	66	4		9/21	59.2	yes	
13/22	DX8	5/12	F	78			7/16	71.6	yes	pre-spawn mortality
13/23	DV8	5/11		77			6/29	57.8	no	

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

[b] Estimated age based on fork length or coded-wire tags (hatchery fish).

[c] Estimated river kilometers from Tucannon River mouth.

[d] Classified as a Summer Chinook salmon based on passage date at John Day Dam.

Table 3. Radio telemetry movements of spring chinook salmon tagged by the Washington Department of Fisheries at the Tucannon FH trap, and released in various locations in the Wilderness Stratum of the Tucannon River, 1993.

Chan. /Code	River km	Date	Location	Comments
1/4	77.7	6/04	Wild 11	Tagged/released
	77.3	6/09-14	↓ Wild 10	
	75.4	6/21-7/20	↓ Wild 4	7/8-Saw fish, clean 7/15-Saw fish, fungus on right pectoral and caudal fin
	75.3	7/22	↓ Wild 4	Recovered fish @ tag (female)
1/15	77.7	6/04	Wild 11	Tagged/released
	77.5	6/9-14	↑ Wild 10	
	77.1	6/21	Lower end C.G. #W2.5-W9	
	75.9	6/25-28	200M ↑ Wild C.G. #W2	6/25-fish in run with logs
	77.3	7/06	Wild C.G. #W2.5	
	75.9	7/9	200m ↓ lower end C.G. W2.5	Fish located in run, saw fish, looks in good shape
	76.9	7/15	75m ↓ Wild 9	Saw fish, looks good
	77.0	7/20-8/03	↓ Wild 9	7/29-Saw fish, looks good 8/03-Saw fish, looks good
	76.8	8/13-8/24	200m ↑ Wild 8	8/13-Saw fish in riffle
	76.9	8/27	75m ↓ Wild 9	
	83.0	8/30-9/03	↑ Wild 17	8/30-in pool 9/03-Hatchery female on redd with 3 natural males
	80.4	9/10	100m ↑ Wild 15	looks spawned out
	78.6	9/14	300m ↑ Wild 14	recovered tag @ fish (female)
1/23	--	6/07		Tagged/released (JT W788)
	74.9	6/09	Wild 2	Fish in pool
	74.8	6/14	Upper end C.G. #W1	
	74.7	6/21-8/13	Lower end C.G. #W1	6/22-8/09, pinpointed fish many times,in pool or run with undercut bank, saw small scrape on caudal, but healthy.
	75.0	8/20	100m ↓ Wild 3	Fish on redd
	77.6	8/24-27	130m ↓ L.B.F.	Possibly spawned with hatchery female, redd with female 20m ↑ where fish was holding.
	76.5	8/30	Upper end C.G. #W2	Upstream side of log jam
	75.8	9/03	Upper end C.G. #W2	On redd with natural female
	75.5	9/12	200m ↓ Wild 6	Small pool
	75.9	9/12	200m ↑ Wild 6	Recovered tag and fish (male), probably spawned out
1/28	--	6/15		Tagged/released (JT W795)
	78.2	6/21	Upper end L.B.F. C.G., Wild 13	
	78.0	6/25	100m ↑ Wild 13	Undercut bank, in run
	78.3	6/28-7/06	400m ↑ Wild 13	
	77.9	7/09	75m ↓ Wild 11	Recovered tag and fish Fish was fungused on head
1/40	--	6/14	Lower end C.G. W2	Tagged/released (JT W859)
	76.4	6/21	↑ Wild C.G. #2	
	75.9	6/25-7/29	Upper end Wild C.G. #2	6/25-fish in run w/logs 7/9-29-fish in run w/logs and roots from undercut bank, saw fish, looks healthy
	76.3	8/3-20	100m ↑ Wild 7	8/03-fish in pool/log jam
	76.6	8/24	100m ↓ L.B.F. C.G.	
	77.9	8/27	100m ↓ Wild 11	
	76.5	8/30	60m ↑ upper end Wild C.G. #2	Fish in pool w/log jam

Appendix E, Table 3, continued.

Chan. /Code	River km	Date	Location	Comments
1/40	74.6	9/03	↓ Wild C.G. 1	Fish in pool
	74.4	9/10	100m ↓ Panjab Creek	Recovered tag and fish (male)
2/5	--	6/07		Tagged/released (JT W775)
				Tag regurgitated in truck
2/7	77.7	6/04	Wild 11	Tagged/released
	77.8	6/09-14	Wild 12	
	79.4	6/15	↓ Wild S.C. 4	
	79.2	6/21	150m ↓ Wild 17	
	79.1	6/28-7/26	300m ↓ Wild 17	6/28-Fish in run w/logs
	79.2	7/29-8/03	200m ↓ Wild 17	7/29-Fish in pool
	84.4	8/13-17	200m ↑ Sheep Cr.	8/13-Fish (male) on redd with female (unknown origin)
	83.6	8/20	150m ↓ Cold Cr.	recovered tag/no fish, tag snagged on branch in water
2/8	77.7	6/04	Wild 11	Tagged/released
		6/14	Not able to locate	
				On redd, spawned
2/13	84.2	6/10-14	Mouth of Sheep Creek	Tagged/released (JT W784)
	84.3	6/21	100m ↑ Sheep Creek	
	84.2	6/25-7/09	Mouth of Sheep Creek	
	84.2	7/09	Mouth of Sheep Creek	Recovered tag, no fish
2/16	84.2	6/10	Mouth of Sheep Creek	Tagged/released (JT W765)
				Tag regurgitated in truck
2/16	--	6/11		Tagged/released (JT W768)
	74.8	6/14	Wild 2	
	73.4	6/21	↓ Forest Service log weir	
	66.8	6/28	200m ↑ HMA 13	Fish in run
	64.4	6/29	Lower end C.G. #7	Saw fish, looked healthy
	59.6	7/02	Lower end C.G. #4	
	59.2	7/6-26	Hatchery Intake	
	59.2	7/26	Hatchery Intake	Tag in rip rap, no fish
2/24	--	6/14	Lower end Wild C.G. #2	Tagged/released (JT W856)
	76.3	6/21	Wild 7	
	76.0	6/24-28	50 ↓ Wild 6	
	75.9	7/06-26	Lower end Wild C.G. #2	7/08-Saw fish, fungus on head
				7/15-Saw fish, fungus on head
	75.9	7/29	Lower end Wild C.G. #2	Recovered tag, no fish
2/26	--	6/07		Tagged/released
	74.6	6/09-21	100m ↓ C.G. #W1	
	74.5	6/24-7/06	100m ↑ Panjab Creek	
	74.5	7/08	100m ↑ Panjab Creek	Recovered tag, no fish

Appendix E, Table 3, continued.

Chan. /Code	River km	Date	Location	Comments
2/36	--	6/07		Tagged/released (JT W751)
	74.5	6/09-14	Lower end C.G. #W1	
	68.4	6/21	Camp Wooten	
	68.5	6/22	U.E. Camp Wooten	
	68.9	6/28	100m ↑ HMA 15	Fish in run
	68.1	7/01	Camp Wooten	
	68.3	7/06	Camp Wooten	
	69.9	7/07	100m ↑ HMA 15	Saw fish, looks heathy
	68.2	7/15	200m ↓ HMA 15	Fish in run
	68.3	7/20	200m ↑ Tucannon C.G.	
	68.3	7/22-29	150m ↑ Tucannon C.G.	Fish in pool
	68.4	8/03-24	300m ↑ Tucannon C.G.	Fish in small run
	68.5	8/30	Boulder Site ↑ HMA 15	
	72.8	9/03	↓ Cow Camp Bridge	On redd with male, female was chasing a jack off redd, 56 °F
	71.7	9/12	50m ↑ Little Tucannon River	Recovered tag and fish (female)
2/38	--	6/07		Tagged/released (JT W772)
	74.6	6/09	Upper end, Wild C.G. #1	
	67.9	6/14	HMA 14	
	68.5	6/21-22	↑ Camp Wooten	
	59.6	6/29	Day use area, ↑ C.G. #4	Saw fish, fungused head
	58.9	7/02	↓ HMA 6	
	58.8	7/07-20	200m ↑ Rainbow Lake outlet	7/07-saw fish, still fungused 7/20-saw fish, still has small patch of fungus on the head, but very healthy besides
	58.7	7/22	150m ↑ Rainbow Lake outlet	Tag in rip rap, under large rock
2/40	--	6/14	Lower end Wild C.G. #2	Tagged/released (JT W800)
	75.8	6/21	Wild 5	
	75.9	6/24	150m ↓ Wild 6	
	75.8	7/06	↑ Wild 5	
	75.8	7/08	↑ Wild 5	Recovered tag, no fish
2/43	--	6/14	Lower end Wild C.G. #2	Tagged/released (JT W869)
	75.8	6/21	Wild 5	
	75.4	6/24-28	15m ↓ Wild 4	
	73.4	7/06-26	↓ Forest Service log weir	
	73.2	7/29	30m ↓ log jam	Recovered tag, no fish Was in fish week before
3/8	--	6/07	Tagged/released	Jaw Tag W783 Tag regurgitated in truck
	57.8	7/04	Tucannon Weir	Dead on weir
3/8	--	6/11		Tagged/released (JT W763)
	77.0	6/14	Upper end C.G. #2	
	74.8	6/21	Wild 2	Fish in pool
	74.6	6/24	Wild C.G. #1	
	73.2	6/28-8/30	↓ Forest Service log weir	7/15-saw fish, looked healthy, in pool with lots of woody debris
	70.5	9/14	Upper end C.G. #9	Recovered tag, no fish

Appendix E, Table 3, continued.

Chan. /Code	River km	Date	Location	Comments
3/20	--	6/07	Tagged/released	Jaw Tag W789
				Tag regurgitated in truck
3/20	84.2	6/10-14	Sheep Creek	Tagged/released
	84.3	6/21-25	100m ↑ Sheep Creek	
	84.2	6/28-7/09	Sheep Creek	6/28-Saw fish, looked healthy, in run with overhanging logs
	84.2	7/09	Sheep Creek	Recovered tag, no fish

Table 4. Radio telemetry movements of spring chinook salmon tagged by the University of Idaho at John Day Dam on the Columbia River and found in the Tucannon River, 1993.

Chan. /Code	River km	Date	Location	Comments
1/16	--	4/28	John Day Dam	Tagged/released (VI FJ7)
	57.8	5/27	Adult trap	VI tag only, no radio tag
1/11	--	4/24	John Day Dam	Tagged/released (no VI)
	21.0	5/25	Smolt trap	
	21.9	5/25	↑ Mom's Cafe	
	29.0	5/27	Mp4	
	32.0	5/28	1/2 mi. ↑ mp6	
	36.9	6/01	↑ Mp9	
	44.0	6/03	Mp12	
	53.6	6/07-08	Corner above Dahm's	
	57.7	6/10	↓ adult trap	
	57.8	6/12	Adult trap	
	62.1	6/14	Mp25	
	73.2	6/23-8-16	↓ Forest Service log weir	8/09-Saw fish, white spot on front of dorsal fin
	73.2	8/16	Between S.C. 4 and 5	Recovered tag and fish (male)
2/1	--	4/27	John Day Dam	Tagged/released (VI FF8)
	21.0	5/10	Smolt trap	
	30.0	5/12	Mile post 5	
	36.9	5/13	Mile post 9	
	49.2	5/17	Between Howards House and Mp 13	
	50.9	5/18	↑ bridge 14	
	52.7	5/20-6/01	Tumalum Creek	
	52.7	6/03	200m ↑ Tumalum Cr.	Recovered tag, no fish

Appendix E, Table 4, continued.

Chan. /Code	River km	Date	Location	Comments
3/12	- -	5/04	John Day Dam	Tagged/released (VI DC5)
	21.0	5/31	Smolt trap	
	26.7	6/01	↑ Becky White's	
	31.9	6/03-10	Mp6	
	36.9	6/11-14	Mp9	
	36.4	6/18	↓ mp9	
	41.0	6/21	Bridge 9	
	43.3	6/22-23	↑ bridge 10	
	39.5	7/06	400m ↓ bridge 9	
	40.1	7/08-26	100m ↓ mp12	7/28-fish in pool
	40.0	7/30-8/09	200m ↓ mp12, fish in pool,	temperatures from 60 to 63°F
	41.8	8/13	↑ mp12	Fish in pool
	40.1	8/16-27	↓ mp12	
	43.2	8/31	↓ bridge 10	
	43.4	9/02	↑ bridge 10	
	47.0	9/07	150m ↓ bridge 12	
	44.6	9/13	↑ bridge 11	
	46.3	9/16	↑ bridge 11	Fish in pool
	46.3	9/21	↑ bridge 11	Recovered tag and fish (male), probably spawned
4/50	- -	5/19	John Day Dam	Tagged/release (VI YHH6)
	4.0	6/08-7/01	Bartons hog barn	Appears to be in pool, but have not seen fish
	4.0	7/07	Bartons hog barn	Recovered tag, no fish
5/49	- -	5/17	John Day Dam	Tagged/released (VI HA4)
	15.0	6/02	HWY 261, b/w Mp 3 and 4	
	21.0	6/03	Smolt trap	
	17.4	6/03	Enrich Bridge	
	52.7	6/07-08	Tumalum Creek	
	54.7	6/10	↓ Bruegmans'	
	53.9	6/14	Russel's house	
	54.4	6/18	↓ Bruegmans'	
	54.9	6/21	Bruegmans'	
	54.7	6/30-7/19	↓ Bruegmans'	Fish was healthy, holding in run, within 20m of radio tag fish
	54.4	7/26	↑ Shannessys	
	54.9	8/03	Behind Bruegmans'	
	54.4	8/05-9/07	↑ Shannessys	Fish in pool
	55.0	9/13	↓ Bruegmans'	
	55.5	9/16	200m ↓ HMA Boundary fence	Pinpointed tag to large pool with redd directly in front, fish probably spawned, on returning the next day the tag quit or fish was poached, hunting campground nearby.

Appendix E, Table 4, continued.

Chan. /Code	River km	Date	Location	Comments
6/47	--	5/13	John Day Dam	Tagged/released (no VI)
	17.7	6/14	Cliffs ↑ Kessels	
	21.0	6/15	Smolt trap	
	34.1	6/18	King Grade bridge	
	51.5	6/21	Bridge 14	
	55.9	6/23	↑ Cummings Cr. bridge	Saw fish, white patch of fungus on top of caudal fin
	50.1	7/06-08	↑ Hartsock grade	
	50.9	7/12-15	↑ Hartsock grade, Mp 18	
	49.5	7/16	Across from Dices	
	50.0	7/19-8/27	↑ Dices	7/30-Fish in pool 8/06-Fish in run, 71 °F 8/16-Fish in riffle
	50.4	8/31	↑ Dices	
	52.6	9/02	↓ Prices	
	59.2	9/14	↑ Tuc. hatchery intake	Recovered tag and fish (male), Probably spawned
6/88	--	6/22	John Day Dam	Tagged/released (VI YJ89)
	27.5	7/26	B/W Whites and Enrich Br.	
	27.3	7/29	↑ Becky Whites house	Fish in deep pool,small patch of fungus near back of head
	28.4	8/03-9/13	200m ↓ Enrich Br.	9/02-Saw fish (female), looked healthy, fungus patch gone
	28.4	9/21	200m ↓ Enrich Br.	Recovered tag, no fish, Unsure if spawned
9/14	--	5/03	John Day Dam	Tagged/released (VI YDA1)
	21.0	6/07-08	Smolt trap	
	36.5	6/10	↓ Mp9	
	50.9	6/18	Building ↑ Dices	
	53.4	6/21	Hartsock 7	
	54.7	6/22-7/19	↓ Bruegmans	7/16-fish holding in pool 20m above radio tagged fish 5/49
	54.5	7/26	↑ Shannessys	
	54.5	8/05	↑ Shannessys	Recovered Tag, no fish
13/22	--	5/12	John Day Dam	Tagged/released (VI DX8)
	7.2	6/04	↑ Starbuck	
	21.0	6/05	Smolt trap	
	31.9	6/07	↑ Mp6	
	40.2	6/08	↑ Marengo	
	52.7	6/10	↓ Tumalum Creek	
	57.8	6/12	Adult trap	
	56.2	6/14	↓ Tuc. hatchery br.	
	66.8	6/21	Forest Service guard station	
	68.2	6/22	↑ Tucannon C.G.	
	72.9	6/30	Cow Camp	
	73.0	7/01	100m ↑ Cow Camp	
	71.6	7/06-12	100m ↑ Little Tucannon R.	
	71.6	7/16	100m ↑ Little Tucannon R.	Recovered tag and fish (female)

Appendix E, Table 4, continued.

Chan. /Code	River km	Date	Location	Comments
10/91	- -	5/19	John Day Dam	Tagged/released (VI HK5)
	13.0	6/04	↑ Smith Hollow Br.	
	20.2	6/06	Smolt trap	
	26.5	6/07	↑ Mp 2	
	26.0	6/08	↓ Mp 2	
	34.0	6/10	↓ King Grade	
	47.0	6/14	↓ bridge 12	
	57.8	6/18	Adult trap	
	54.8	6/21	C.G. ↓ Bruegmans	
	55.8	6/22	↓ Cummings Cr. Bridge	
	55.6	6/23	↑ HMA 1	
	40.2	7/08	↓ mp12	Saw fish, small patch of fungus
	40.1	7/12	↓ mp12	
	43.4	7/15-26	↑ bridge 10	
	43.9	7/30	Across from Howards	Fish in pool
	44.1	8/05-13	Across from Howards	8/6-13-Fish in run, patch of fungus on right side of head
	45.4	8/16	300m ↑ bridge 11	
	48.0	8/17-20	↑ bridge 12	
	50.0	8/24	Between bridge 13 @ 14	
	53.9	8/27	↑ Russels	
	57.8	8/30	Adult trap	Passed trap, fish healthy
	61.3	9/07	100m ↑ C.G. #5	
	66.4	9/10	↑ Curl Lake	
	60.5	9/14	300m ↑ Deer L. intake	Fish on redd, spawned
	59.2	9/21	↓ Tuc. hatchery intake	Recovered tag and fish (male) Fish was blind in left eye
13/23	- -	5/11	John Day Dam	Tagged/released (VI YDV8)
	21.0	6/07-08	Smolt trap	
	28.0	6/10	Mp4	
	45.1	6/14	↓ Bridge 11	
	57.8	6/18-21	Adult trap	
	58.1	6/22	150m ↓ Tuc. hatchery br.	
	57.8	6/29	Adult trap	Recovered tag, no fish, 20m ↑ Tucannon Weir
13/34	- -	5/17	John Day Dam	Tagged/released (VI Y88)
	21.0	6/07	Smolt trap	
	29.6	6/10	Mp5	
	38.1	6/14	Mp 10	
	47.2	6/18	↑ bridge 12	
	53.6	6/21	Cliffs above Dahms	
	54.0	6/22	↑ Russels house	
	53.9	6/23	Across from Russels house	
	53.7	6/30	↓ Russels house	
	53.9	7/01-8/30	Across from Russels house	7/16-saw fish in riffle, healthy 8/05-saw fish in pool, healthy 8/30-saw fish, holding in shallow undercut bank, healthy
	52.6	9/02	↓ Prices	
	53.9	9/07	↓ Russels house	
	55.0	9/13	1/4 mi. ↓ Bruegmans	
	51.5	9/16	Blind Grade Rd.	Recovered tag and fish (male), probably spawned

Appendix F

Table 1. Numbers of spring chinook salmon redds observed and general locations of hatchery and wild salmon carcasses recovered during spawning ground surveys on the Tucannon River 1993.

Stratum	River km	Number of redds	Carcasses recovered[a] Hatchery male	Hatchery female	Hatchery jack	Natural male	Natural female	Natural jack
Wilderness	86-78	13				1	1	
	78-75	21		3		2	3	
HMA	75-73[b]	14	1					
	73-68	29	1	1		5	3	
	68-66	18	1	5		1	1	
	66-62	12	1	5			1	
	62-59	12		1		4	5	
	59-58	12	5	4	1	4	4	
	58-56	26				2	7	
Hartsock	56-52	16	1			1	3	
	52-47	10					1	
	47-43	3		1		1		
	43-40	5						
Marengo	40-34	1						
Totals		192	10	20	1	21	28	

[a] Does not include carcasses recovered prior to spawning season or during radio tracking surveys.

[b] Historical index area.

Table 2. Redd distribution in relation to the hatchery weir, 1986-1992 (not surveyed below the weir site in 1985, Marengo not surveyed in 1987-1989).

Year	Redds above weir	Redds below weir	Total Redds	Percent below weir
1986	163	37	200	18.5
1987	149	36	185	19.5
1988	90	27	117	23.1
1989	74	32	106	30.2
1990	96	84	180	46.7
1991	40	50	90	55.6
1992	130	70	200	35.0
1993	131	61	192	31.8

Appendix F, continued.

Table 3. Comparison of spring chinook salmon redd densities in redds/km (redds/ha) and total redds by stratum and year, Tucannon River.

Stratum	1985 redds/km (/ha) redds	1986 redds/km (/ha) redds	1987 redds/km (/ha) redds	1988 redds/km (/ha) redds	1989 redds/km (/ha) redds	1990 redds/km (/ha) redds	1991 redds/km (/ha) redds	1992 redds/km (/ha) redds	1993 redds/km (/ha) redds
Wilderness	7.10 (9.45) 84	4.49 (5.96) 53	1.27 (1.69) 15	1.53 (2.02) 18	2.46 (3.26) 29	1.69 (2.25) 20	0.25 (0.34) 3	1.44 (1.91) 17	2.88 (3.82) 34
HMA	5.33 (4.78) 105	6.16 (5.32) 117	7.37 (6.37) 140	4.16 (3.59) 79	2.84 (2.46) 54	4.95 (4.28) 94	2.95 (2.55) 67	7.95 (6.87) 151	6.47 (5.59) 123
Hartsock	--[a]	1.86 (1.51) 29	1.92 (1.56) 30	1.28 (1.04) 20	1.47 (1.20) 23	4.10 (3.33) 64	1.86 (1.51) 18	1.99 (1.61) 31	2.18 (1.77) 34
Marengo	--[a]	0.00 0	--[a]	--[a]	--[a]	0.34 (0.26) 2	0.34 (0.26) 2	0.17 (0.13) 1	0.17 (0.13) 1
Total redds	189	200	185	117	106	180	90	200	192

[a] No survey conducted in these strata that year.

APPENDIX G

Table 1. Summary of survival rates by brood year for Tucannon River spring chinook salmon spawned and reared at the Tucannon/Lyons Ferry FH.

Brood year	Percent egg-to-fry	Percent fry-to-smolt	Percent egg-to-smolt
1985	89.2	97.6	87.1
1986	84.7	96.6	81.8
1987	79.9	96.9	77.4
1988	84.4	94.3	79.6
1989	74.8	99.2	74.2
1990	58.7	99.0	58.1
1991	82.0	98.9	81.1
1992	97.0		

Table 2. Summary of survival rates by brood year for natural salmon in the Tucannon River.

Brood year	Percent egg-to-fry	Percent fry-to-smolt	Percent egg-to-smolt
1985	8.6	39.5	3.4
1986	8.5	56.7	4.8
1987	6.9	55.6	3.8
1988	10.5	53.8	5.7
1989	12.7	44.2	5.6
1990	6.0	77.2	4.7
1991	11.7	54.5 [a]	4.7 [b]
1992	10.4	- -	- -

[a] Average of 1985-1990 fry-to-smolt survival.
[b] Average of 1985-1990 egg-to-smolt survival.

Appendix G, continued.

Table 3. Estimates of natural Tucannon spring chinook salmon abundance by life stage for 1985 through 1992 broods.

Brood year	Females [a] in river natural/hatchery	Mean [b] fecundity natural/hatchery	Number of eggs	Number of [c] fry	Number of [d] smolts
1985	269 / - -	3,883 / - -	1,129,692	90,200	35,600
1986	308 / - -	3,916 / - -	1,170,884	102,600	58,200
1987	282 / - -	4,095 / - -	1,175,265	79,100	44,000
1988	169 / - -	3,882 / - -	830,748	69,700	37,500
1989	65 / 80	3,883 / 2,606	483,472	58,600	25,900
1990	148 / 175	3,993 / 2,694	1,062,621	64,100	49,500
1991	62 / 94	3,741 / 2,517	515,080	54,800	26,000 [e]
1992	121 / 160	3,854 / 3,295	1,046,628	103,292	- -
1993	97 / 134	3,701 / 3,237	845,256	- -	- -

[a] Number of females estimated from total adult returns, percentage of natural and hatchery returns, sex ratios of natural and hatchery fish respectively, and subtraction of known prespawning mortalities.

[b] Mean fecundity based on incubation room counts. 1985 (natural) and 1989 natural and hatchery mean fecundities are the mean average of other years. In 1985 very few fish were spawned (n=5), and in 1989 natural and hatchery incubation counts were not kept separate.

[c] Number of fry (parr) estimated from electrofishing (1985-1989), Line Transect snorkel surveys (1990-1992), and Total Count snorkel surveys (1993).

[d] Number of smolts estimated from smolt trapping.

[e] Approximated number of out-migrating smolts based on mean egg-to-smolt, and mean fry-to-smolt survival using previous years data.

APPENDIX H

Table 1. Sex, mean fork length (cm), and age (from code-wire tags and scale analysis) of all hatchery salmon sampled from the Tucannon River and Lyons Ferry FH, or just at Lyons Ferry FH , 1992 (s=standard deviation, n=sample size).

Sex	Mean length (s, n) at given age $3_{/2}$	$4_{/2}$	$5_{/2}$	Total
Salmon at Lyons Ferry FH				
Female	- -	72.2 (4.1, 26)	80.5 (1.9,4)	30
Male	40.0 (0.0, 1)	75.5 (6.7, 11)	86.0[a] (6.1, 3)	15
Totals	1	37	7	45
All salmon				
Female	- -	71.1 (4.0, 70)	81.3 (2.6, 15)	85
Male	46.0 (4.3, 3)	72.7 (7.0, 27)	84.6[a] (5.5, 10)	40
Totals	3	97	25	125

[a] does not include an 89cm male from Meachum Creek, Oregon

Table 2. Sex, mean fork length (cm), and age (from scale impressions or fitted by fork length) for all natural salmon sampled in the Tucannon River and Lyons Ferry FH, or just at Lyons Ferry FH, 1992 (s=standard deviation, n=sample size).

Sex	Mean length (s, n) at given age $3_{/2}$	$4_{/2}$	$5_{/2}$	Total
Salmon at Lyons Ferry FH				
Female	- -	71.5 (1.3, 8)	82.9 (4.7, 14)	22
Male	46.0 (1.0, 2)	69.5 (5.7, 13)	88.7 (5.8, 10)	25
Totals	2	21	24	47
All salmon				
Female	- -	70.6 (4.5, 15)	83.6 (3.8, 44)	59
Male	46.3 (0.9, 3)	67.5 (14.6, 25)	87.1 (5.5, 30)	58
Total	3	40	74	117

Appendix H, continued.

Table 3. Numbers and percent age composition (known and fitted by length) of natural and hatchery spring chinook salmon sampled in the Tucannon River and Lyons Ferry FH, 1993.

Sex	$3_{/2}$	$4_{/2}$	$5_{/2}$	Total
Natural salmon				
Female	- -	15 (25.4)	44 (74.6)	59
Male	3 (5.2)	25 (43.1)	30 (51.7)	58
Total	3 (2.6)	40 (34.2)	74 (63.2)	117
Hatchery salmon				
Female	- -	70 (82.4)	15 (17.6)	85
Male	3 (7.5)	27 (67.5)	10 (25.0)	40
Total	3 (2.4)	99[a] (77.9)	25 (19.7)	127[a]

[a] Includes 2 fish of undetermined sex.