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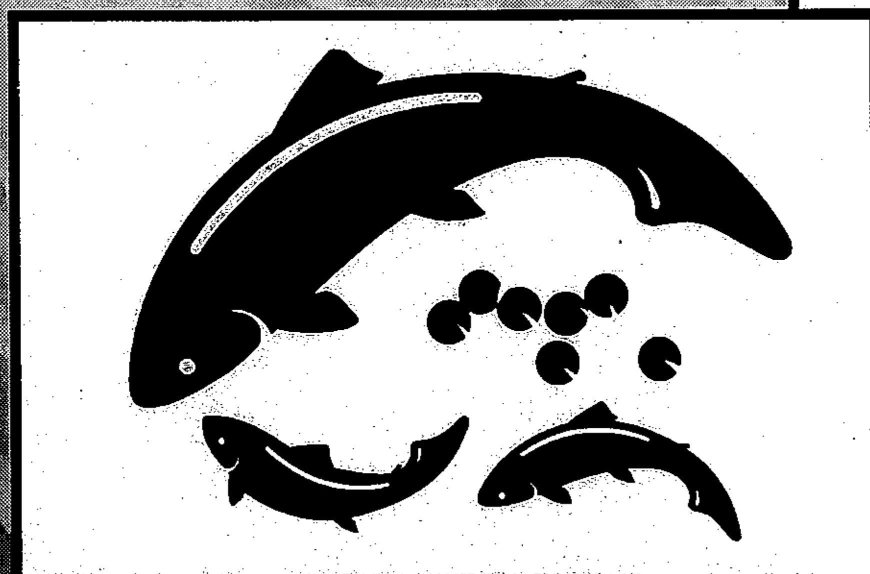
Tucannon River Spring Chinook Salmon Hatchery Evaluation Program

1998 and 1999 Annual Reports



by Joseph Bumgarner, Lance Ross and Michelle Varney

Washington Department of FISH AND WILDLIFE
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Science Division

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Abstract

Lyons Ferry (LFH) and Tucannon (TFH) hatcheries were built/modified under the Lower Snake River Fish and Wildlife Compensation Plan. One objective was to compensate for the loss of 1,152 spring chinook (Tucannon River stock) caused by hydroelectric projects on the Snake River. The standard production goal for the program is 132,000 fish for release as yearlings at 30 g/fish or 15 fish per pound (fpp). This report summarizes activities of the Washington Department of Fish and Wildlife Lower Snake River Hatchery Evaluation Program for Tucannon River spring chinook for the period April 1998 to April 2000.

Ninety-three fish were captured in the TFH trap in 1998 (50 natural adults, 31 hatchery adults, and 12 hatchery jacks); 89 were collected and hauled to LFH for broodstock. One-hundred forty fish (94 adults and 46 jacks) were captured in the TFH trap in 1999; 136 fish were collected and hauled to LFH for broodstock [four wild (three adults, one jack) and 132 hatchery (88 adults, 44 jacks)].

In 1998, three salmon that were collected for broodstock died. In 1999, five salmon that were collected for broodstock died. Prespawning mortality in 1998 and 1999 was comparable to the mortality documented since broodstock began being held at LFH in 1992, and is generally less than 10% each year.

Spawning in 1998 at LFH occurred between 18 August and 29 September, with peak eggtake on 11 September. A total of 161,019 eggs were collected. Egg mortality to eye-up was 18,544 eggs, with an additional loss of 6,448 sac-fry. Total fry ponded for production in the rearing ponds was 136,027.

Spawning in 1999 occurred between 24 August and 21 September, with peak egg take on 14 September. A total of 113,544 eggs were collected. Fewer eggs were collected in 1999 compared to 1998 because fecundity was lower and about one-third of the fish collected for broodstock were jacks. Egg mortality to eye-up was 2,320, with an additional loss of 2,761 sac-fry. An additional 1,583 eggs were destroyed from one female because she was spawned with a stray male. Total fry ponded for production in the rearing ponds was 106,880.

During spawning in 1998, evaluation staff collected and cryogenically preserved semen from 11 natural origin salmon. Staff did not cryogenically preserve any semen in 1999 due to the lack of wild fish in the broodstock.

Four radio tagged fish that entered the Tucannon River were tracked in 1998. Two were captured at the adult trap, transported, and spawned at LFH. One was recovered as a prespawning mortality about six kilometers below TFH. The fourth fish escaped the adult trap and spawned in the river. No radio tagged fish entered the Tucannon River in 1999.

WDFW staff conducted spawning ground surveys between 27 August and 5 October in 1998, and 1 and 23 September in 1999. In 1998 and 1999, respectively, 26 and 41 redds were counted in the Tucannon River. Redd concentrations have shifted and redd densities have declined in recent years (due to low returns). Based on annual redd counts, broodstock collection and in-river prespawning mortalities, the estimated escapement for 1998 was 144 fish (128 adults and 16 jacks), and in 1999 the estimated escapement was 245 fish (181 adults and 64 jacks).

Length, weight and Organosomatic samples were periodically collected throughout the rearing cycle on 1997 and 1998 BY juveniles at LFH and TFH, and A Curl Lake acclimation pond. All 1997 and 1998 BY juveniles were marked in September, transported to TFH in October, and transported again in February to Curl Lake for acclimation and volitional release during March and April each year.

A captive broodstock program at LFH was initiated using 1997 BY fish. Fish were collected from the 1998 BY juveniles as well. All 1997 BY fish were uniquely marked by family in January 1999. Full program funding to continue with the captive broodstock program was not secured at completion of this report. Therefore, the future of the program is uncertain.

Snorkel surveys were conducted during the summer of 1998 and 1999 to determine the population of subyearling spring chinook in the Tucannon River. For 1998 and 1999, we estimate 32,913 subyearlings (1997 BY), and 8,453 subyearlings (1998 BY), respectively, were present in the river. The large difference between subyearling production was directly correlated to the number of redds in 1997 (73 redds) and 1998 (26 redds). Evaluation staff also operated a downstream migrant trap to estimate natural smolt migration from the Tucannon River. During the 1997/98 and 1998/99 outmigration, we estimated that 1,612 (1996 BY) and 21,057 (1997 BY) wild spring chinook smolts, respectively, migrated from the river.

Returns of adult salmon from the controlled matings study were complete following the 1998 return of spring chinook to the river. Overall, survival from smolt release to adult return of hatchery x hatchery crosses was greater than mixed or wild x wild crosses, though the difference was not significant. Further, we documented very few differences between study groups in age-at-return, fecundity and size. However, differences in early life rearing conditions at LFH make it difficult to fully interpret the results.

Monitoring survival rate differences between natural and hatchery reared salmon continues. Smolt-to-adult return rates (SAR) for natural salmon continue to average about four times higher than hatchery salmon. However, hatchery salmon survive about four to five times greater than natural salmon from parent to adult progeny. Natural fish survival remains below the replacement level, while hatchery fish are nearly three times above it. Due to the low SAR's in hatchery fish, the mitigation goal of 1,152 salmon of Tucannon River stock has not been achieved.

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Introduction

Program Objectives

Congress authorized implementation of the Lower Snake River Fish and Wildlife Compensation Plan (USACE 1976). As a result, Lyons Ferry Hatchery (LFH) was constructed and Tucannon Fish Hatchery (TFH) was modified. One objective of these hatcheries is to compensate for the loss of 1,152 Tucannon River spring chinook salmon adults caused by hydroelectric projects on the Snake River. In 1984, Washington Department of Fish and Wildlife (WDFW) began to evaluate the success of these two hatcheries in meeting the mitigation goal, and identifying factors that would improve performance of the hatchery fish. This report summarizes work performed by the WDFW Spring Chinook Evaluation Program from April 1998 through April 2000.

Facility Descriptions

LFH is located on the Snake River (rkm 90) at its confluence with the Palouse River. LFH is used for adult broodstock holding and spawning, and early life incubation and rearing. All juvenile fish are marked (adipose fin clipped and coded wire-tagged (CWT)) and returned to TFH for acclimation. TFH, located at rkm 59 on the Tucannon River, has an adult collection trap on site. Juveniles rear at TFH through winter. In spring, the fish are transported to Curl Lake Acclimation Pond (AP) and volitionally released. The brood year production goal is 132,000 fish for release as yearlings at 30 g/fish or 15 fish per pound (fpp).

Tucannon River Watershed Characteristics

The Tucannon River empties into the Snake River between Little Goose and Lower Monumental dams (Figure 1). Stream elevation rises from 150 m at the mouth to 1,640 m at the headwaters. Total watershed area is about 1,120 km^2. Local habitat problems related to logging, road building, recreation, and agriculture/livestock grazing have limited the production potential of spring chinook in the Tucannon River. Five unique strata have been distinguished by predominant land use, habitat, and landmarks (Table 1).

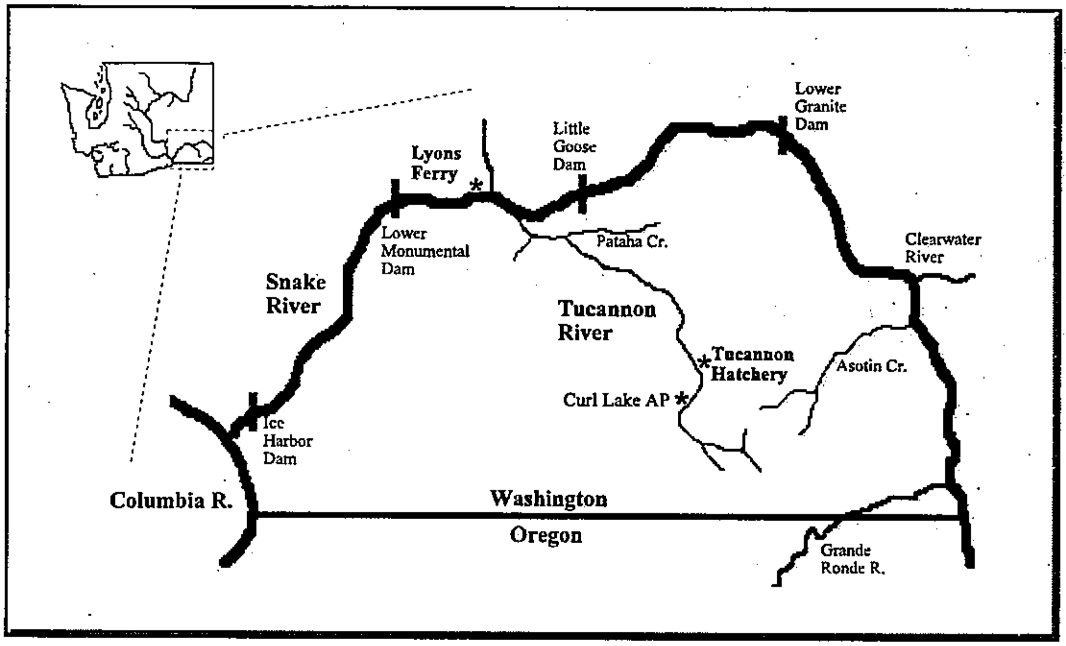

Figure 1. Location of the Tucannon River, Lyons Ferry and Tucannon hatcheries within the Snake River Basin.

Table 1. Description of five strata within the Tucannon River.

Strata	Land Ownership/Usage	Spring Chinook Habitat	River Kilometer
Lower	Private/Agriculture & Ranching	Not-Usable (temperature limited)	0.0-21.0
Marengo	Private/Agriculture & Ranching	Marginal (temperature limited)	20.1-39.9
Hartsock	Private/Agriculture & Ranching	Fair to Good	39.9-55.5
HMA	State & Forest Service/Recreational	Good/Excellent	55.5-74.5
Wilderness	Forest Service/Recreational	Excellent	74.5-86.3

1998

Program staff deployed 13 continuous recording thermographs throughout the Tucannon River to monitor daily minimum and maximum water temperatures (temperatures are recorded every 1 or 1.2 hours) from May through October. Data from each of these water temperature recorders are kept on an electronic file in our Dayton office. In 1998, maximum temperatures near the mouth (rkm 3) of the Tucannon River reached more than 80°F on 23 different days; seven were consecutive. Maximum temperatures where spring chinook juveniles were rearing during the hottest part of the summer ranged from 68°F in the upper HMA Stratum (rkm 65) to 74°F in the upper Hartsock Stratum (rkm 51.5).

1999

Program staff deployed 24 continuous recording thermographs throughout the Tucannon River to monitor daily minimum and maximum water temperatures from May through October. Data from each of these water temperature recorders are kept on electronic file in our Dayton office. A brief summary of the data collected in 1999 was presented in a Tucannon River Habitat Evaluation Report (Bumgarner et al, 2000 in draft). In 1999, maximum temperatures near the mouth (rkm 3) of the Tucannon River reached more than 80°F on only one day. Maximum temperature where spring chinook juveniles were rearing during the hottest part of the summer ranged from 64°F in the upper HMA Stratum (rkm 65) to 72°F in the upper Hartsock Stratum (rkm 51.5).

Adult Salmon Evaluation

Broodstock Trapping

The annual collection goal for broodstock is 50 natural and 50 hatchery adults collected throughout the duration of the run. Additional jack salmon may also be collected to contribute to the broodstock if necessary. Jack contribution to the broodstock can be no more than their percentage in the overall run. Returning hatchery salmon are identified by lack of the adipose fin.

1998

The TFH adult trap began operation in February with the first spring chinook captured 13 May. The trap was operated until 28 September. A total of 93 fish entered the trap (50 natural adults, 31 hatchery adults, and 12 hatchery jacks), 92 were captured, and 89 were collected and hauled to LFH for broodstock (Table 2, Appendix A). One radio tagged fish escaped the trap and went upstream. One hatchery jack was later transported to the same location as the radio tagged female for spawning. Two other males not needed for the hatchery broodstock were hauled downstream late in the spawning season for natural spawning in the river. These fish were not passed upstream as only one fish was intentionally passed upstream of the trap. Adults collected for broodstock were injected with erythromycin and oxytetracycline (0.5 ml / 4.5 kg) when trapped; jacks were given half dosages. Fish received formalin drip treatments during holding at 1:7,000 mg/l every other day during holding at LFH to control fungus.

Table 2. Numbers of spring chinook salmon captured, trap mortalities, fish collected for broodstock, or passed upstream to spawn naturally at the TFH trap from 1986-1999.

	Captured at Trap		Trap Mortality		Broodstock Collected		Passed Upstream	
Year	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery
1986	247	0	0	0	116	0	131	0
1987	209	0	0	0	101	0	108	0
1988	276	9	0	0	116	9	151	0
1989	258	102	0	0	67	102	89	0
1990	252	216	0	1	60	75	192	140
1991	109	202	0	0	41	89	68	113
1992	242	305	8	3	47	50	187	252
1993	191	257	0	0	50	47	141	210
1994	36	34	0	0	36	34	0	0
1995	10	33	0	0	10	33	0	0
1996	76	59	1	4	35	45	40	10
1997	99	160	0	0	43	54	56	106
1998 [a]	50	43	0	0	48	41	1	1
1999 [b]	4	136	0	1	4	132	0	0

[a] Two males (one natural, one hatchery) captured were transported back downstream to spawn in the river.
[b] Three Hatchery males that were captured were transported back downstream to spawn in the river.

1999

The first fish was collected on 29 May, with the last fish arriving on 15 September. In 1999, 140 spring chinook salmon (94 adults and 46 jacks) were captured in the TFH trap (Table 2, Appendix A). Of those, four were natural origin (three adults, one jack) and 136 were hatchery origin (91 adults and 45 jacks). One spring chinook salmon died in the trap in 1999 (jack - RV clip- Umatilla River stray). For broodstock purposes, 136 fish were collected (four natural; three adults, one jack, and 132 hatchery; 88 adults, 44 jacks). However, after spawning it was determined that three of the four natural fish were hatchery origin based on scale patterns. For lack of positive identification, we have assumed these fish are Tucannon River in origin.

Broodstock Mortality

1998 & 1999

Three salmon (3.4%) collected for broodstock died (Table 3) in 1998. All three were Tucannon origin and all died from jumping out of the adult holding raceway. Five salmon (3.7%) collected for broodstock died in 1999. Two died from jumping out of the adult raceway, one died of unknown causes before spawning season, and the remaining two died during the spawning season (these fish had not yet spawned). Three mortalities were Tucannon origin fish and two were strays from the Umatilla River (RV clipped). Prespawning mortality in 1998 and 1999 was comparable to the mortality documented since broodstock began being held at LFH in 1992, as compared to mortality experienced at TFH (1985-1991).

Table 3. Numbers of prespawning mortalities and percent of fish collected for broodstock at TFH and held at TFH (1985-1991) or LFH (1992-1999).

	Natural				Hatchery			
Year	**Male**	**Female**	**Jack**	**% of collected**	**Male**	**Female**	**Jack**	**% of collected**
1985	3	10	0	59.1	—	—	—	—
1986	15	10	0	21.6	—	—	—	—
1987	10	8	0	17.8	—	—	—	—
1988	7	22	0	25.0	—	—	9	100.0
1989	8	3	1	17.9	5	8	22	34.3
1990	12	6	0	30.0	14	22	3	52.0
1991	0	0	1	2.4	8	17	32	64.0
1992	0	4	0	8.2	2	0	0	4.0
1993	1	2	0	6.0	2	1	0	6.4
1994	1	0	0	2.8	0	0	0	0.0
1995	1	0	0	10.0	0	0	3	9.1
1996	0	2	0	5.7	2	1	0	6.7
1997	0	4	0	9.3	2	2	0	7.4
1998	1	2	0	6.3	0	0	0	0.0
1999	0	0	0	0.0	3	1	1	3.7

Broodstock Spawning

1998

Spawning at LFH occurred once or twice a week from 18 August to 29 September, with peak eggtake on 11 September. A total of 161,019 eggs were collected (Table 4). Percent mortality to eye-up was 11.5% with an additional 4% loss of sac-fry, which left 136,027 fish for production. Water hardening procedures were changed following the high egg loss in 1997. Chilled water (7°C) was taken from the incubation stacks and iodophor added to create a 100 ppm disinfection solution which was then added to the egg buckets. The eggs were then kept in the fertilization buckets, and packed with ice to keep the water chilled to 7°C for one hour. Based on mortality rates documented, we feel the new procedure was only marginally successful, if at all. Mortality rate in 1998 was similar to rates observed in 1991, 1993, and 1994, when the chiller was operated as well. Fungus on the incubating eggs was controlled with formalin applied every other day at 1:700 mg/L.

To eliminate any stray fish from contributing to the population, all externally marked (ADRV, ADLV, or LV, RV clipped) stray fish were removed from the broodstock when identified during the sorting of broodstock for fish ripeness. In addition, all coded wire tags are read prior to spawning. In 1998 no stray salmon were collected for broodstock.

1999

Spawning occurred once a week from 24 August to 21 September, with peak egg take on 14 September. A total of 113,544 eggs were collected (Table 4). Fewer eggs were collected in 1999 compared to 1998 because even though broodstock numbers were greater, there were more jacks in the broodstock and all but one of the females were hatchery origin which are generally less fecund than natural origin females. Mortality to eye-up was 2.04% with an additional 1% loss of sac fry. An additional 1,583 eggs were destroyed from one female because they were inadvertently fertilized by a stray male. Total fish left for production in the rearing ponds was 106,880. Water hardening procedures were again changed in 1999. Eggs were not placed on chilled water due to excessive maintenance problems with the chiller, and suspicion that the chilled water was causing higher egg loss. Egg survival improved in 1999 over survival from previous years.

To eliminate any stray fish from contributing to the population, all externally marked (ADRV or RV clipped) stray fish were removed from the broodstock when identified during the sorting of broodstock for fish ripeness. Seven of 10 stray adults were removed from the broodstock by external identification in 1999. Two others died of natural causes as spawning time approached. One stray CWT fish was not identified until after spawning.

Table 4. Number of fish spawned and estimated egg collection, egg and sac-fry mortality, and the number of fry ponded of Tucannon spring chinook salmon at LFH in 1998 and 1999.

	Natural			Hatchery		
Spawn Date	Male	Female	Eggs Taken	Male	Female	Eggs Taken
1998						
25 Aug.[a]	1	5	21,816	4	1	3,430
01 Sept.		1	4,289			
08 Sept.	1	8	33,373	7	2	5,491
11 Sept.		8	32,841	8	2	7,213
15 Sept.	11	3	11,549	2	5	15,605
22 Sept.[b]		4	14,819	6	4	8,250
29 Sept.[b]	2	1	2,343			
Totals	**15**	**30**	**121,030**	**27**	**14**	**39,989**
Eye-up Mortality			9,582			8,962
Fry Mortality			3,353			3,096
Total fry ponded			**108,096**			**27,931**
1999						
31 Aug.				3	1	3,342
07 Sept.[c]		1	2,239	33	12	37,675
14 Sept.	3[d]			37	19	59,882
21 Sept.[c]				9	4	10,406
Totals	**3**	**1**	**2,239**	**82**	**36**	**111,305**
Eye-up Mortality			305			2,015
Fry Mortality			32			2,729
Total fry ponded			**1,902**			**104,978**

[a] One male was killed and spawned, but semen from that fish was not used to fertilize any females.
[b] One hatchery female on 9/22 and one natural female on 9/29 were partially spawned out.
[c] Natural fish on 9/07 may have been partially spawned out, and one hatchery fish on 9/21 may have been partially spawned out.
[d] Natural origin males were later identified to be hatchery origin based on scale pattern analysis.

Cryopreservation

During spawning in 1998, evaluation staff collected and cryogenically preserved semen from 11 natural origin salmon (Table 5). The majority of semen collected will be saved for potential future use if run sizes become critically low. We may evaluate some of the frozen semen on a non-listed spring chinook population to test its success in fertilizing eggs. This sort of pre-use evaluation will allow managers to best use the cryopreserved semen on hand to maximize survival in the hatchery program. Due to low number of natural salmon available in 1999, no semen was cryopreserved from any natural fish from the broodstock. We will continue to evaluate the need to collect semen for the future.

Table 5. Natural-origin semen cryogenic samples collected, 15 and 22 September, 1998.							
Date Frozen	Male ID#	Fork Length	Brood Year	Genetic Number	Straws Frozen Regular	Straws Frozen Test	Sperm Motility (%)
9/15	HR130	95	93	EL29	10	3	>75
9/15	HR134	89	93	EL31	10	3	>75
9/15	HR133	94	93	EL28	10	3	>75
9/15	HR135	78	94	EL30	10	3	>75
9/15	771	100	93	EL34	7	3	>75
9/15	772	94	93	EL35	10	3	>75
9/15	774	88	93	EL36	8	3	>75
9/15	775	77	93	EL37	10	3	>75
9/15	776	84	93	EL38	8	3	>75
9/22	HR136	90	93	EL44	5	3	>75
9/22	HR137	89	93	EL45	5	3	>75

Radio Tracking

1998

Four radio tagged fish that entered the Tucannon River were tracked. These fish were part of the University of Idaho radio telemetry study (Table 6). Fish had been trapped, tagged, and released at Bonneville Dam. Migration speed after river entry, timing and movements upstream, and if possible, spawning success, were documented every 2-3 days (Appendix B). WDFW did not radio tag any spring chinook in the Tucannon River during 1998 because of the small run size.

Table 6. Radio tagging and recovery data of spring chinook salmon recovered in the Tucannon River in 1998 from the University of Idaho study.

Channel/ Code	Tagging Information Date	Origin	Sex	FL (cm)	VI tag	Recovery Data Date	Sex	FL (cm)	Spawned
24 / 66[a]	4/22	Hat.	M	67.0	M86	9/15	F	67.0	Yes
24 / 81[a]	4/14	Natural	F	88.5	N58	8/25	M	90.2	Yes
24 / 108[b]	4/19	Natural	F	77.5	LT7	9/10	F	–	No
25 / 26[c]	4/30	Hat.	M	67.5	FB3	8/12	M	–	No

[a] Fish was identified as male or female at tagging, but was confirmed the opposite sex upon carcass recovery.
[b] Only the radio tag was recovered.
[c] Radio tag and fish carcass were recovered separately.

All four fish were detected by mobile radio tracking in the Tucannon River shortly after they entered (Figure 2). Some were detected lower in the river than others. Mean travel time expressed in rkm/day from the lower river to rkm 57 (about 1 kilometer below the Tucannon Hatchery) were as follows: 24/66 = 1.0, 24/81 = 3.4, 24/108 = 2.8, and 25/26 = 1.5. These travel rates are similar to past upstream migration rates documented in other years (Mendel et al 1993, Bumgarner et al 1997).

Radio tag 24/66 had a slightly slower migration rate due to the slow rate at which it first moved upstream. The fish was first detected at just below Starbuck Dam, and stayed in the same place or moved slowly downstream for nearly a month before it finally migrated upstream to cooler waters. Once 25/26 decided to move upstream, migration speed was similar to other fish. It is unknown if the water diversion dam injured the fish temporarily and delayed its migration.

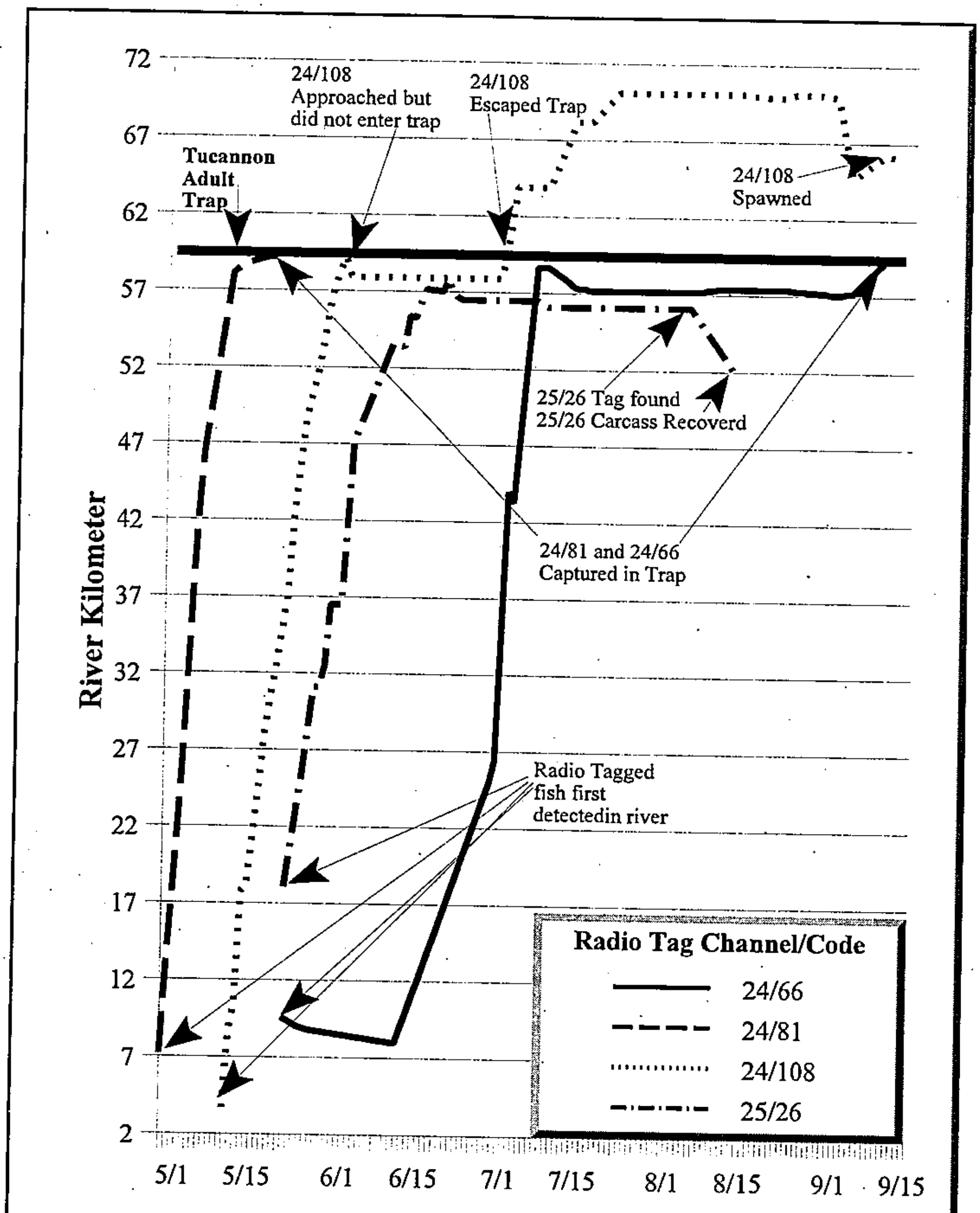

Figure 2. Movements of four radio tagged spring chinook salmon in the Tucannon River 1998 (based on data collected and presented in Appendix B of this report).

Of the four radio tagged salmon tracked, two (24/66 and 24/81) were captured at the adult trap, transported, and spawned at Lyons Ferry. One radio tagged fish (24/108) escaped the adult trap, traveled eight rkm upstream, and is then believed to have been killed by an animal or illegally harvested while making a redd. The radio tag was found on the bank less than 50 m from the redd. The last tagged fish (25/26) was a pre-spawning mortality in the river below the adult trap. The fish was recovered on 12 August. The cause of death could not be determined.

Natural Spawning

1998

Spawning ground surveys were conducted on the Tucannon River weekly from 27 August to 5 October to determine the temporal and spatial distribution of spawners. Twenty-six redds were counted, and 17 natural and six hatchery origin carcasses were recovered (Table 7). Three redds and three carcasses were found above the adult trap. We assume that these fish escaped the trap similar to the radio tagged fish (24/108), or that the fish jumped the hatchery intake dam during high spring flows. In 1998, 69% of the redds were located within seven rkm of the adult trap.

1999

Spawning ground surveys were conducted on the Tucannon River from 1 September to 23 September. A total of 41 redds were observed (Table 7), with 3 natural and 40 hatchery origin carcasses recovered. However, two of the three natural origin carcasses were later determined to be hatchery origin based on scale pattern analysis. With a lack of positive identification, we have assumed these fish are Tucannon River origin spring chinook.

Even though no fish were passed upstream, three redds were located above the trap. We were able to recover one hatchery origin spawned out female just below one of the redd locations. It is unknown at this time if any males were present in the area to spawn with this female. Following 1998, the adult trap was slightly modified to prevent fish from escaping. Therefore, we assume that these fish jumped the hatchery intake dam during high spring time. In 1999, 90% of the redds were located within seven rkm of the adult trap.

Table 7. Numbers and general locations of salmon redds and carcasses recovered on the Tucannon River spawning grounds, 1998 and 1999. Note: The Tucannon Hatchery adult trap is located at Rkm 59.

		1998			1999		
			Carcasses Recovered			Carcasses Recovered	
Stratum	Rkm[a]	Number of redds	Natural	Hatchery	Number of redds	Natural	Hatchery
Wilderness	84-78	0	0	0	0	0	0
	78-74	0	0	0	1	0	0
HMA	74-73	0	0	0	0	0	0
	73-68	2	0	0	1	0	1
	68-66	0	0	0	0	0	0
	66-62	1	2	0	0	0	0
	62-59	0	1	0	1	0	0
	59-56	13	8	4	32	1	41
Hartsock	56-52	5	5	1	5	0	1
	52-47	2	1	0	1	0	0
	47-43	0	0	0	0	0	0
	43-40	0	0	1	0	0	0
Marengo	40-34	3	0	0	0	0	0
Totals	**83-34**	**26**	**17**	**6**	**41**	**1**	**43**

[a] Rkm descriptions: 84-Sheep Cr.; 78-Lady Bug Flat CG; 75-Panjab Br.; 73-Cow Camp Bridge; 68-Tucannon CG; 66-Curl Lake; 62-Beaver/Watson Lakes Br.; 59-Tucannon Hatchery Intake/Adult Trap; 56-HMA Boundary Fence; 52-Br. 14; 47-Br. 12; 43-Br. 10; 40-Marengo Br.; 34-King Grade Br.

Historical Trends

Since inception of the program in 1985, redd concentrations have shifted downstream, and redd densities (redds/km) have declined in recent years (Table 8) due to the low returns and a greater emphasis on broodstock collection to keep the spring chinook population at healthy levels.

Table 8. Number of spring chinook salmon redds and redds/km (in parenthesis) by stratum and year and the number and percent of redds above and below the TFH adult trap in the Tucannon River, 1985-1999.

	Strata					TFH Adult Trap			
Year	Wilderness	HMA	Hartsock	Marengo	Total Redds	Above	%	Below	%
1985	84 (7.1)	105 (5.3)	–	–	189	–	–	–	–
1986	53 (4.5)	117 (6.2)	29 (1.9)	0 (0.0)	200	163	81.5	37	18.5
1987	15 (1.3)	140 (7.4)	30 (1.9)	–	185	149	80.5	36	19.5
1988	18 (1.5)	79 (4.2)	20 (1.3)	–	117	90	76.9	27	23.1
1989	29 (2.5)	54 (2.8)	23 (1.5)	–	106	74	69.8	32	30.2
1990	20 (1.7)	94 (4.9)	64 (4.1)	2 (0.3)	180	96	53.3	84	46.7
1991	3 (0.3)	67 (2.9)	18 (1.1)	2 (0.3)	90	40	44.4	50	55.6
1992	17 (1.4)	151 (7.9)	31 (2.0)	1 (0.2)	200	130	65.0	70	35.0
1993	34 (3.4)	123 (6.5)	34 (2.2)	1 (0.2)	192	131	68.2	61	31.8
1994	1 (0.1)	10 (0.5)	28 (1.8)	5 (0.9)	44	2	4.5	42	95.5
1995	0 (0.0)	2 (0.1)	3 (0.2)	0 (0.0)	5	0	0.0	5	100.0
1996	1 (0.1)	33 (1.7)	34 (2.2)	0 (0.0)	68	11	16.2	57	83.8
1997	2 (0.2)	43 (2.3)	27 (1.7)	1 (0.2)	73	30	41.1	43	58.9
1998	0 (0.0)	3 (0.2)	20 (1.3)	3 (0.5)	26	3	11.5	23	88.5
1999	0 (0.0)	35 (1.8)	6 (0.4)	0 (0.0)	41	3	7.3	38	92.7

Note: – indicates the river was not surveyed in that section during that year.

Genetic Sampling

In 1998 and 1999, no electrophoretic samples were collected from spring chinook recovered in the river or from the hatchery spawning. However, we did collect DNA (fin clip or opercle punch) samples for future analysis. In 1998, we collected 110 DNA samples (63 natural origin and 47 hatchery origin). In 1999, we collected 117 DNA samples (4 natural origin and 113 hatchery origin). These samples will likely be analyzed in 2000. Three of the 4 natural origin DNA samples should be considered hatchery origin fish because of scale pattern analysis.

Age Composition, Length Comparisons, and Fecundity

One of the objectives of the monitoring program is to track the age composition of each year's return. This allows us to make annual comparisons between natural and hatchery reared fish, and to examine long-term trends and variability in the age structure. Overall, hatchery origin fish return at a younger age than natural origin fish (Figure 3). This difference is likely due to smolt size at release (hatchery origin smolts are generally 25-30 mm greater in length than natural smolts).

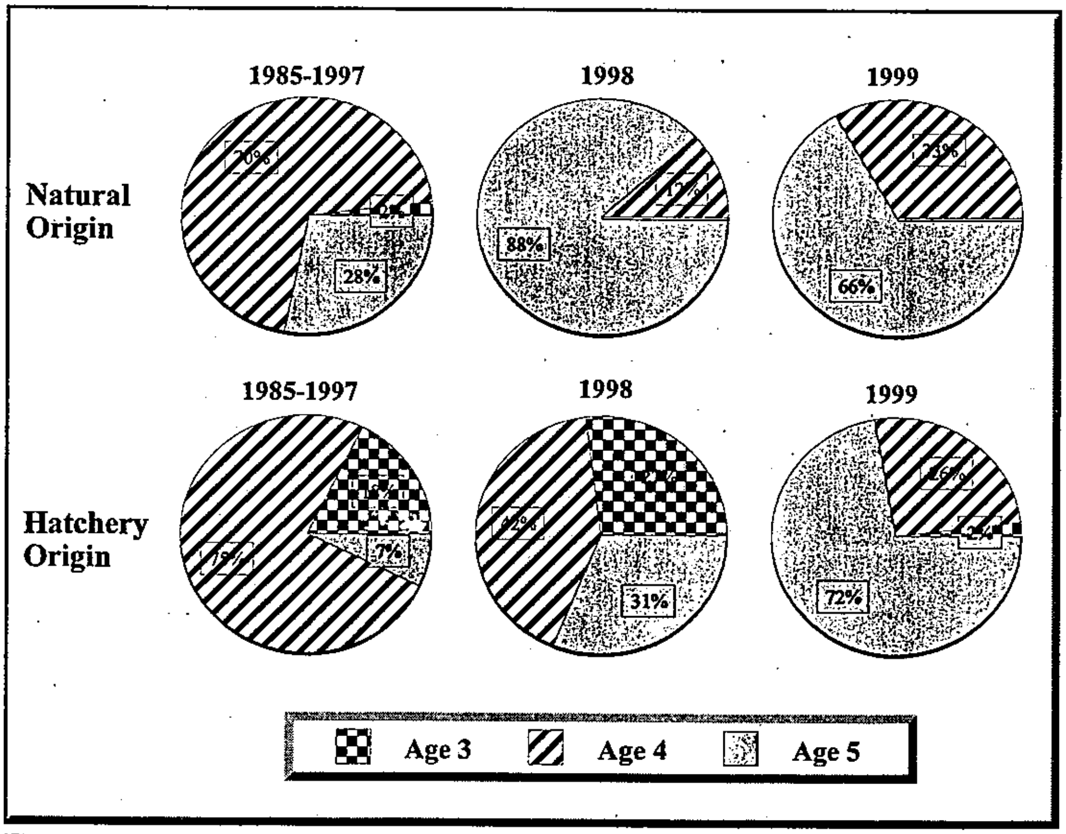

Figure 3. Historical (1985-1997, 1998 and 1999 age composition for spring chinook in the Tucannon River.

Age at return was not similar to historical data for natural origin fish in 1998 and 1999. Natural returns had more 5-year old fish than what is typically observed. However, for 1999, the sample size was small because only seven fish were unmarked (i.e. natural origin), and five of those were determined to be hatchery origin based on scale analysis. Age composition of hatchery fish in 1998 was significantly greater in 5-year old fish, but percent 3-year old fish in the return remained consistent for both years.

Another comparison is the difference between mean post-eye to hypural-plate lengths of returning adult natural and hatchery origin fish. We reported in the past (Bumgarner et al, 1994) that hatchery fish were generally shorter than natural origin fish of the same age. For many of the early return years this appeared to be true (Figures 4, 5, 6 and 7). {Note: Minimum sample size used each year within a single group were three fish (range 3-93 fish; mean = 27)}. However, overall there is no difference in mean length between natural and hatchery origin fish, even though they migrate as smolts at significantly different sizes.

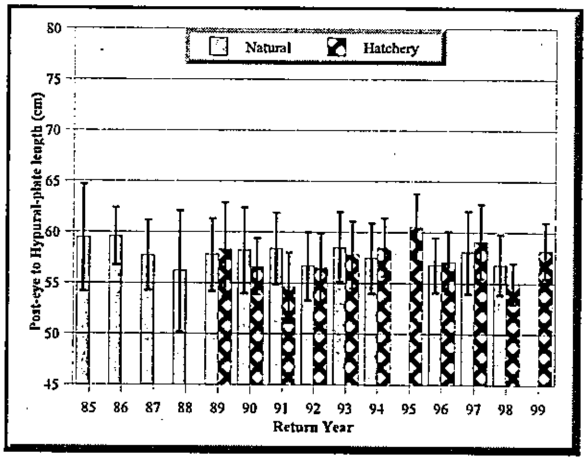

Figure 4. Mean length and SD of Age 4 females.

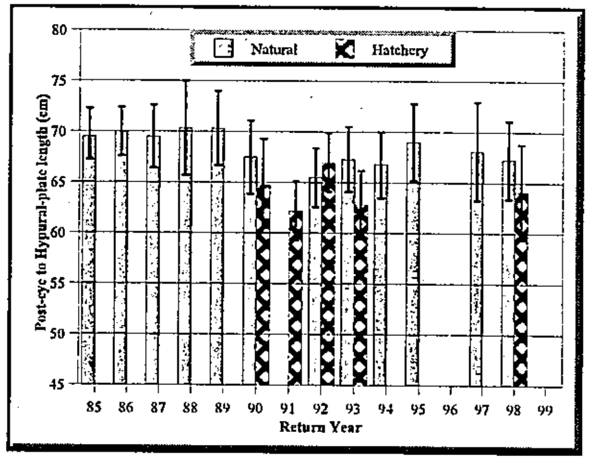

Figure 5. Mean length and SD of Age 5 females.

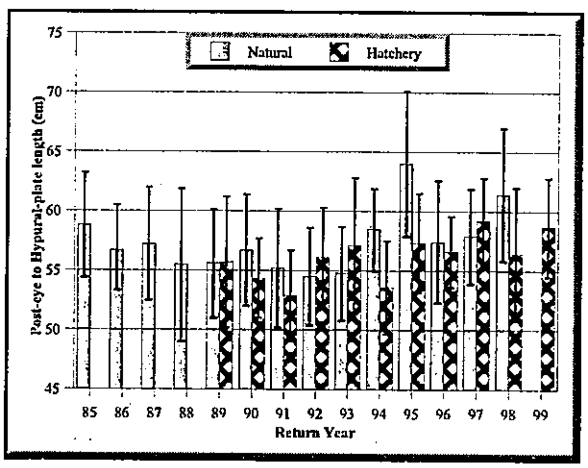

Figure 6. Mean length and SD of Age 4 males.

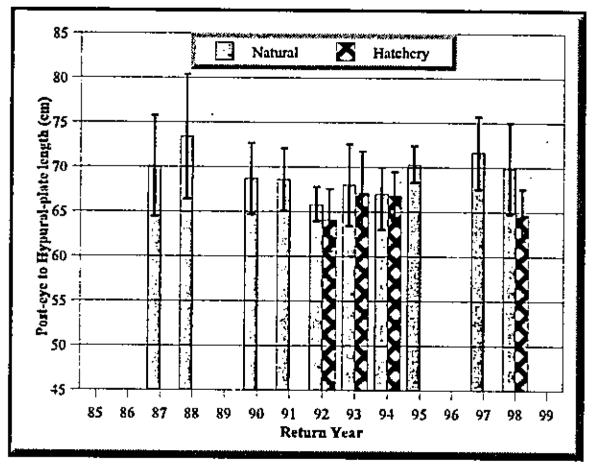

Figure 7. Mean length and SD of Age 5 males.

Fecundities (number of eggs/female) of natural and hatchery origin fish from the Tucannon River program have been documented since 1990 (Table 9). Natural origin females of either Age 4 or Age 5 have generally been more fecund than same age hatchery origin fish, though the difference between the two is not statistically significant. Mean size of natural origin eggs in age 4-year old spring chinook from the Tucannon River has averaged 0.210 g/egg and hatchery origin eggs have averaged 0.234 g/egg, which may be the main reason why hatchery origin females are less fecund. Mean eggs size in Age 5 salmon is 0.272 g/egg for natural origin and 0.267 g/egg for hatchery origin females.

Table 9. Average number of egg/female (n, SD) by age group of Tucannon River natural and hatchery origin broodstock, 1990-1999.

	Age 4				**Age 5**			
Year	**Natural**		**Hatchery**		**Natural**		**Hatchery**	
1990	3,691	(13, 577.3)	2,794	(18, 708.0)	7,384	(8, 772.4)	No	Fish
1991	2,803	(5, 363.3)	2,463	(9, 600.8)	4,252	(11, 776.0)	3,052	(1, 000.0)
1992	3,691	(16, 588.3)	3,126	(25, 645.1)	4,734	(2, 992.8)	3,456	(1, 000.0)
1993	3,180	(4, 457.9)	3,456	(5, 615.4)	4,470	(1, 000.0)	4,129	(1, 000.0)
1994	3,688	(13, 733.9)	3,280	(11, 630.3)	4,906	(9, 902.0)	3,352	(10, 705.9)
1995	No	Fish	3,584	(14, 766.4)	5,284	(6, 136.1)	3,889	(1, 000.0)
1996	3,509	(17, 534.3)	2,833	(18, 502.3)	3,617	(1, 000.0)	No	Fish
1997	3,487	(15, 443.1)	3,290	(24, 923.3)	4,326	(3, 290.9)	No	Fish
1998	4,204	(1, 000.0)	2,779	(7, 375.4)	4,017	(28, 680.5)	3,333	(6, 585.2)
1999	No	Fish	3,121	(34, 445.4)	No	Fish	3,850	(1, 000.0)
Mean	**3,579**		**3,126**		**4,347**		**3,428**	
SD	568.2		686.0		870.2		606.0	

Coded-Wire Tag Sampling

Broodstock collection, pre-spawn mortalities and carcasses recovered from spawning ground surveys provide representatives of the annual run that can be sampled for CWT study groups (Table 10). In 1998, based on the estimated escapement of fish to the river, we sampled about 79.9% of the run (Table 11). In 1999, based on the estimated escapement to the river, we sampled about 73.9% of the run.

Table 10. Coded-wire tag codes of hatchery salmon sampled at LFH in the Tucannon River, 1998 and 1999.

CWT Code	Broodstock Collected: Died in Pond	Broodstock Collected: Killed Outright	Broodstock Collected: Spawned	Recovered in Tucannon River: Dead in Trap	Recovered in Tucannon River: Pre-spawn Mortality	Recovered in Tucannon River: Spawned	Totals
1998							
63-43-23			1				1
63-53-43			4			1	5
63-53-44			4			3	7
63-56-15			1				1
63-56-17			1				1
63-56-18			1				1
63-56-29			10[a]		1	2	13
63-57-29			6				6
63-59-36			7				7
63-61-40			3				3
63-61-41		1	2				3
Strays							
Lost tags							
No tags					1[b]		1
1998 Total		1	40		2	6	49
1999							
63-03-59			6				6
63-03-60		1	5				6
63-56-29		1	2				3
63-59-36			38		1	30	69
63-61-24	1		18				19
63-61-25			9				9
63-61-40	1		16			3	20
63-61-41	1		18			1	20
Strays	2	7	1	1		3	12
Lost tags			4			1	5
No tags			1			2	3
1999 Total	5	9	118	1	1	38	172

[a] For one fish, the CWT was lost but VI tag and estimated age from fork length makes it tag code 63-56-29.
[b] Head was partially eaten by the time the fish was recovered.

Table 11. Spring chinook salmon (natural and hatchery) sampled from the Tucannon River, 1998 and 1999.

	1998 Natural	1998 Hatchery	1998 Total	1999 Natural	1999 Hatchery	1999 Total
Total escapement to river	*85*	*59*	*144*	*11*	*232*	*243*
Broodstock collected	48	41	89	1	135	136
Fish dead in adult trap	0	0	0	0	1	1
Total hatchery sample	**48**	**41**	**89**	**1**	**136**	**137**
Total fish left in river	*37*	*18*	*55*	*7*	*99*	*106*
In-river prespawn mortality	1	2	3	0	1	1
Spawned carcasses recovered	17	6	23	1	42	43
Total river sample	**18**	**8**	**26**	**1**	**43**	**44**
Carcasses sampled	**66**	**49**	**115**	**2**	**179**	**181**

Arrival and Spawn Timing Trends

Peak arrival and spawn timing have always been monitored to determine if the hatchery program has caused a shift in arrival or spawn timing (Table 12). Peak arrival dates were based on greatest number of fish trapped on a single day. Peak spawn in the hatchery was determined by the day when the most females were spawned. Peak spawning in the river was determined by the highest daily redd counts.

Peak arrival in 1998 and 1999 was slightly later for all fish as compared to previous years; however, the trap was moved upstream by one mile. The further migration distance may have biased arrival time, though this is not very likely. Peak spawning date of natural fish in 1998 and 1999 was similar to previous years. Peak spawning of hatchery fish was slightly later, but falls within the range of previous years. The duration of active spawning in the Tucannon River was reduced in 1998 and 1999, but is likely because of fewer fish in the river, and that most of the spawning was below the hatchery. We know from our prior surveys on the river that the first spawning activity starts in the upper watershed and moves downstream through the spawning season. Also, for 1999, 90% of the spawning occurred within seven kilometers of the hatchery intake dam, thereby compressing all of the spawning into a small area and time frame in the river.

Table 12. Peak dates of arrival of natural and hatchery salmon to the TFH adult trap and peak (date) and duration (number of days) for spawn timing in the hatchery and river, 1986-1999.

	Peak Arrival at Trap		Spawning in Hatchery			Spawning in River	
Year	**Natural**	**Hatchery**	**Natural**	**Hatchery**	**Duration**	**Combined**	**Duration**
1986	5/27	–	9/17	–	31	9/16	36
1987	5/15	–	9/15	–	29	9/23	35
1988	5/24	–	9/07	–	22	9/17	35
1989	6/06	6/12	9/15	9/12	29	9/13	36
1990	5/22	5/23	9/04	9/11	36	9/12	42
1991	6/11	6/04	9/10	9/10	29	9/18	35
1992	5/18	5/21	9/15	9/08	28	9/09	44
1993	5/31	5/27	9/13	9/07	30	9/08	52
1994	5/25	5/27	9/13	9/13	22	9/15	29
1995[a]	–	6/08	9/13	9/13	30	9/12	21
1996	6/06	6/20	9/17	9/10	21	9/18	35
1997	6/15	6/17	9/09	9/16	30	9/17	50
Mean	**5/27**	**6/04**	**9/08**	**9/11**	**28**	**9/14**	**38**
1998	6/03	6/16	9/08	9/16	36	9/17	16
1999[a]	–	6/16	9/07	9/14	22	9/16	23

[a] Too few natural salmon were trapped in 1995 and 1999 to determine peak arrival.

Total Escapement

In general, redd counts have been directly related to total escapement and passage of adult salmon at the TFH adult trap (Bugert et al. 1991). However, with no salmon intentionally passed above the adult trap in 1998 or 1999, we had to use another method to calculate a fish/redd ratio for spawners in the river. Hence, for 1998 and 1999, we used sex ratios from collected broodstock and sex ratio observations on the spawning grounds to estimate the number of fish/redd. The escapement estimate for 1998 and 1999 was calculated by adding the estimated number of fish upstream of the TFH adult trap, the estimated fish below the weir based on an estimated fish/redd ratio, the number of pre-spawn mortalities below the weir, and the number of broodstock collected (Table 13). Total escapement for 1998 and 1999 was estimated at 144 (128 adults and 16 jacks), and 245 (181 adults and 64 jacks), respectively.

Table 13. Estimated spring chinook salmon escapement to the Tucannon River, 1985-1999.

Year[b]	Total Redds	Fish/Redd Ratio[a]	Spawning fish In the river	Broodstock Collected	Pre-spawning Mortalities	Total Escapement	Percent Natural
1985	189	2.85	539	22	0	561	100
1986	200	2.85	570	116	0	686	100
1987	185	2.85	527	101	0	628	100
1988	117	2.85	333	125	0	458	96
1989	106	2.85	302	169	0	471	77
1990	180	3.39	610	135	7	753	66
1991	90	4.33	390	130	8	528	49
1992	200	2.82	564	97	81	753	55
1993	192	2.27	436	97	56	589	54
1994	44	1.59	70	70	0	140	70
1995	5	2.20	11	43	0	54	39
1996	68	2.00	136	80	11	247	66
1997	73	2.00	146	97	45	351	46
1998	26	1.94	51	89	4	144	59
1999	41	2.60	107	136	2	245	1

[a] From 1985-1989 the TFH trap was temporary, thereby underestimating total fish passed upstream of the trap. The 1985-1989 fish/redd ratios were calculated from the 1990-1993 average, excluding 1991 because of a large jack run.

[b] In 1994, 1995, 1998 and 1999, fish were not passed upstream, and in 1996 and 1997, high pre-spawning mortality occurred in fish passed above the trap, therefore; fish/redd ratio was based on the sex ratio of broodstock collected.

Stray Salmon into the Tucannon River

Spring chinook from other river systems (strays) have periodically been recovered in the Tucannon River, though generally at a low proportion of the total run (Table 14). However, in 1999 we observed more stray fish into the Tucannon River than have been documented in the past. In 1999, and estimated 20 fish of the 245 total escapement (8.2%) were stray salmon. Nearly all strays were from the Umatilla River, and one was from Eagle Creek National Fish Hatchery on the Clackamas

River, Oregon. The increase in the number of strays, particulary from the Umatilla River, is a concern as it exceeds the allowable 5% stray rate of hatchery fish as deemed acceptable by National Marine Fisheries Service. Further, WDFW has been informed that RV or LV fin clipping of Umatilla River spring chinook has ceased. This will mean that by 2003, only adipose clipped and CWT tagged fish (about 25-30% of releases from the Umatilla River) will be identifiable, and can be removed from the river. Hence, many unmarked (i.e. natural origin looking) spring chinook from the Umatilla River could be incorporated into the hatchery broodstock.

Table 14. Summary of identified stray hatchery origin spring chinook salmon which escaped into the Tucannon River.

Year	CWT Code or Fin clip	Agency	Origin (stock)	Release Location / Release River	Number Observed/ Expanded[a]	Comb. % of Tuc. Run
1990	074327	ODFW	Carson (Wash.)	Meacham Cr. / Umatilla River	2 / 5	
	074020	ODFW	Rapid River	Lookingglass Cr. / Grande Ronde	1 / 2	
	232227	NMFS	Mixed Col.	Columbia River / McNary Dam	2 / 5	
	232228	NMFS	Mixed Col.	Columbia River / McNary Dam	1 / 2	**1.9**
1992	075107	ODFW	Lookingglass Cr.	Bonifer Pond / Columbia River	2 / 6	
	075111	ODFW	Lookingglass Cr.	Meacham Cr. / Umatilla River	1 / 2	
	075063	ODFW	Lookingglass Cr.	Meacham Cr. / Umatilla River	1 / 2	**1.3**
1993	075110	ODFW	Lookingglass Cr.	Meacham Cr. / Umatilla River	1 / 2	**0.3**
1996	070251	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	1 / 1	
	LV clip	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	1 / 2	**1.2**
1997	103042	IDFG	South Fork Salmon	Knox Bridge / South Fork Salmon	1 / 2	
	103518	IDFG	Powell	Powell Rearing Ponds / Lochsa R.	1 / 2	
	RV clip	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	3 / 5	**2.6**
1999	091751	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	2 / 3	
	092258	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	1 / 1	
	102646	UI	Eagle Creek NFH	Eagle Creek NFH / Clackamas R.	1 / 1	
	LV clip	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	2 / 2	
	RV clip	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	8 / 13	**8.2**

[a] All CWT codes recovered came from groups that were 100% marked, for a 1:1 expansion rate. For RV/LV fin clipped fish, the retention rate is between 95 and 100%, also for an expansion rate of 1:1 (Wes Stonecypher, Jr., ODFW biologist, August 2000). The expansion is based on the percent of stray carcasses to Tucannon River origin carcasses and the estimated total run in the river.

Juvenile Salmon Evaluation

Hatchery Rearing, Marking and Release

Hatchery rearing and marking

Length and weight samples were periodically collected throughout the rearing cycle on BY 1997 juveniles (Table 15). Length and weight samples were collected only twice on the 1998 BY fish due to their outbreaks of Bacterial Kidney Disease (BKD) during the rearing cycle. Handling the fish under such conditions to obtain the information was not considered wise. Samples collected on 25 August for the 1997 BY noted that fish were relatively fat, with mean condition factor (K) of 1.46. This was considered high compared to previous years sampled at similar times. Hatchery managers were notified and feeding rates were adjusted. All other samples collected for both brood years were within historical parameters.

All 1997 BY juveniles were adipose clipped and CWT marked on 22 September 1998. After CWT marking, LFH transported about 24,500 fish to TFH on 15 October. Fish were equally divided in two standard raceways (East & West) at TFH. All 1998 BY juveniles were adipose clipped and CWT marked on 11-15 September, 1999. After CWT marking, LFH transported about 131,800 fish to TFH on 28, 29 and 30 October 1999. Fish were placed in the east and west raceways, and the main acclimation pond at TFH. The fish were partitioned to provide the lowest possible density to lessen the potential of another outbreak of BKD in the population.

Table 15. Summary of sample sizes (N), mean lengths, coefficient of variations (CV), condition factors (K), and fish/lb (FPP) of 1997 and 1998 BY juveniles sampled at LFH, TFH, and Curl Lake.

Brood Date	Sample Location	Pond #	N	Mean Length	CV	K	FPP
1997							
8/25/98	LFH	1	271	93.5	9.1	1.46	37.4
2/18/99	TFH	East & West	233	124.7	12.5	1.27	17.9
4/16/99	Curl Lake	Curl Lake	291	136.3	10.7	1.11	15.6
1998							
2/11/00	TFH	East, West, Main	259	126.0	12.5	1.26	17.2
4/20/00	Curl Lake	Curl Lake	437	143.8	11.1	1.18	12.5

1997 Brood Release

About 24,500 1997 BY juveniles were transported to Curl Lake AP on 19 February 1999. The volitional release began on 9 March, and continued to 20 April with an estimated release of 24,186 fish (Table 16). An electronic counter was installed to monitor migration from the AP. We also installed a temperature recorder and light meter to correlate environmental factors that may influence the migration of fish from the AP. Based on the electronic counter, 61.8% of the fish left the pond before the final day of release, though 90% of the migration occurred in the final six days. The large surge in migration in the final six days coincided with an increase in water temperature and removal of dam boards from the outlet structure (Figure 8). Day length or light intensity were not correlated with migration rates.

1998 Brood Release

About 128,000 1998 BY juveniles were transported to Curl Lake AP on 16 and 18 February, 2000. The volitional release began on 20 March, and continued to 26 April, with an estimated release of 127,939 (Table 16). An electronic counter and water temperature recorder were again installed at the Curl Lake outlet to monitor migration. Based on the electronic counter, 1.4% of the fish left the pond before the final day of release, with vast majority of the migration occurring in the final eight days. The increase in migration from the lake during the last eight days coincided mainly with the removal of dam boards in the outlet structure of the lake (Figure 9).

Given the data collected over the last three years (1997: 20% migration from the lake), it appears that migration may be delayed because of the electronic counter, or that cool water temperatures that are delaying the smoltification process. Regardless of the reason, management calls for upstream acclimation so adults will return to the best possible habitat. We recommend that the electronic counter not be used any further, in case it is delaying migration from the lake.

Table 16. Summary of yearling spring chinook released from Curl Lake Acclimation Pond in the Tucannon River, 1997-1998 BY's.

Release Year (BY)	Release Dates	CWT Code	AD + CWT	CWT only	AD only	Total Released	Lbs	Fish/lb
1999 (97)[a]	3/11-4/20	63-61-32	23,509	155	522	24,186	1,550	15.6
2000 (98)	3/20-4/26	63-12-11	124,093	1,099	2,747	127,939	10,235	12.5

[a]. 142 of the fish were deformed and had no snout. The CWT was placed in the right cheek muscle instead.

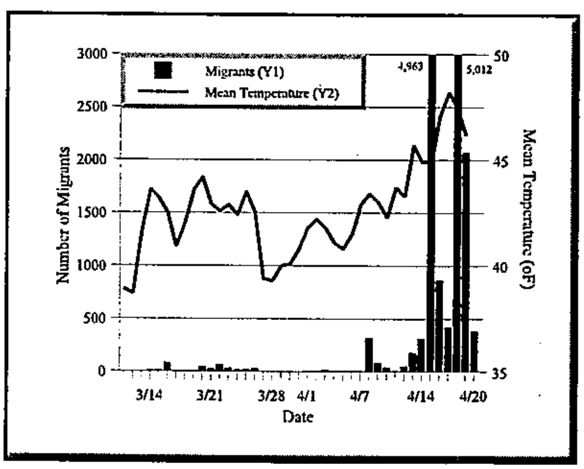

Figure 8. Migration of spring chinook salmon from Curl Lake AP during spring of 1999.

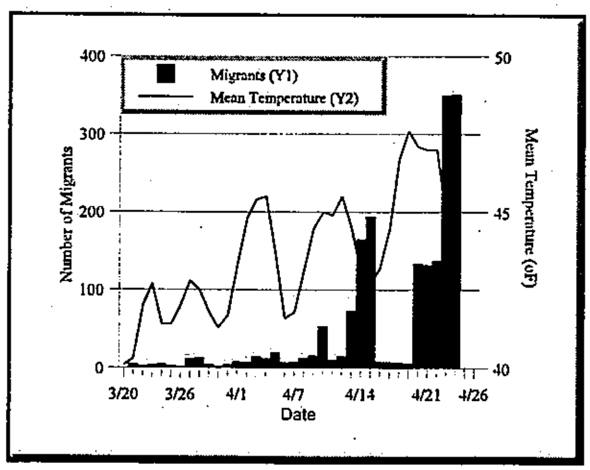

Figure 9. Migration of spring chinook salmon from Curl Lake AP during spring of 2000.

Captive Broodstock Rearing

We initiated a captive broodstock program at LFH using 1997 BY fish. This is the second attempt to initiate a captive broodstock program for Tucannon spring chinook. The first attempt was initiated in 1996 with the collection of 1995 BY juveniles (Bumgarner et al 1996). The first attempt was later aborted as it appeared through run size forecasts that returns would improve in 1996 and 1997. Unfortunately, run size forecasts were inaccurate, and returns were much lower than predicted in 1996. The goal of the captive broodstock program is to collect fish for five brood years (1997-2001), rear these fish to maturity at LFH, spawn them and rear their progeny to smolts (150,000), and release them back into the Tucannon River (WDFW et al 1999).

Fish selected for the captive broodstock program were collected from the incubator trays prior to ponding the fish. Selection of fish from each "family" unit was determined by origin of females, matings, and disease results. Fifteen "family" units have been chosen for each of the brood years, with about 80 fish selected from each "family" for initial rearing. Initial rearing took place in four foot circular rearing tanks at LFH. During marking of the regular production group, each of the "family" groups are reduced to 30 individuals (450 total population/brood year), with the excess marked and release as regular production as smolts. Fish for the captive broodstock program are tagged with CWT in the snout, adipose fin, and given a alpha/numeric tag behind the eye.

Limited funding for this program has severely curtailed the monitoring and evaluation to date. Length and weight samples have been collected during "family" marking on the 1997 and 1998 BY, and 1997 BY during Age 2 sorting (Table 17). To date, mature fish (all males) have been killed from the 1997 BY population (92 fish - October 1999). Mortality of immature fish at the end of the report period has remained low for both the 1997 and 1998 BY (Table 17).

Table 17. Mean length/weight summaries and cumulative mortalities (immature and mature) of captive brood fish from the 1997 and 1998 brood years.

							Mortalities			
BY Date	**N**	**Ln (mm)**	**CV**	**Wt (g)**	**FPP**	**K**	**Immature**	**Percent Immature**	**Mature**	**Percent Mature**
1997	1200									
Tag Reduction	450						155	12.9		
Intermediate							17	3.8		
01/11/99	433	116.0	9.1	21.5	21.1	1.34	1 [a]	0.2		
10/25/99	68	270.7	8.0	289.9	1.6	1.42	4	0.9	92	21.2
04/30/00							45	10.4		
1998	1200									
Tag Reduction	450						21	1.7		
10/05/99	438	120.7	12.6	22.4	20.3	1.22	8 [b]	1.8		
04/30/00							14	3.2		

[a] Fish died during CWT and VI tagging.
[b] All eight fish jumped from the holding tank the day after they were CWT and VI tagged.

Natural Parr Production

Program staff surveyed the Tucannon River at index sites in 1998 and 1999 to estimate the density and population of subyearling (Table 18, Appendix C) and yearling spring chinook salmon. Snorkel surveys were conducted using a total count method (Griffith 1981, Schill and Griffith 1984). Population size was determined by multiplying the mean fish density (fish/100 m^2) by the estimated total area within each stratum. Fifty-eight sites were snorkeled in 1998 (30 July to 12 August) and 64 sites in 1999 (5 to 30 August). Total area snorkeled each year equaled about 3.3% of the available rearing habitat in the Tucannon River. We estimated 432 yearlings from 1996 BY in 1998, and 637 yearling from the 1997 BY in 1999 were present in the river.

Table 18. Number of sites and the area snorkeled, population estimates and confidence interval for subyearling spring chinook within the Tucannon River, 1998 and 1999.

	1998				1999			
Stratum	Number of sites	Area (m^2) snorkeled	Est.	C.I.	Number of sites	Area (m^2) snorkeled	Est.	C.I.
Lower	--	--	--	--	6	2,256.6	523	623
Marengo	6	2,257.8	1,835	1,329	6	2,219.4	35	69
Hartsock	15	4,834.2	16,856	6,418	14	4,869.0	5,452	3,953
HMA	27	9,198.6	13,965	5,567	22	7,800.7	2,443	1,423
Wilderness	10	2,343.0	257	394	10	2,505.0	0	0
Total	**58**	**18,633.6**	**32,913**	**8,288**	**64**	**19,650.7**	**8,453**	**4,982**

Natural Smolt Production

Program staff operated a 5 ft rotary screw trap intermittently at rkm 3 on the Tucannon River from 8 September 1997 to 9 July 1998, and 26 October 1998 to 8 July 1999 to estimate numbers of migrating natural and hatchery spring chinook. Other data on natural and hatchery spring chinook smolts such as peak outmigration, lengths of smolts, descaling, etc.. have not been reported here for simplicity. Data of that nature for both the 1997-98 and 1998-99 migration years are available upon request. The number of days the trap was run during the 1997-1998 season September to July was as follows: (21, 15, 4, 8, 8, 11, 22, 23, 21, 22, and 5). The number of days the trap was run during the 1998-1999 season from October to July was as follows: (3, 4, 10, 13, 18, 24, 28, 23, 25, and 5).

Each week we attempted to determine trap efficiency by clipping a portion of the caudal fin on captured migrants and releasing them upstream about one kilometer. The percent of marked fish recaptured was used as an estimate of weekly trapping efficiency. When insufficient fish were captured for trap efficiency estimates, data from other time periods with similar flows and turbidity were used. During the peak out-migration (March-May) the trap was generally operated five days each week (Sunday 6-8:00 PM to Friday 2-3:00 PM). To estimate potential juvenile migrants passing when the trap was not operated, we calculated the average number of fish trapped for three days before and three day after non-trapping periods. The mean number of fish trapped daily, was then divided by the estimated trap efficiency to calculate fish passage. The estimated fish passing each day was then applied to each day the trap was not operated.

Few natural spring chinook salmon were captured during 1997-1998 (Table 19). Further, less than 50% of the hatchery fish released in 1998 were estimated to have passed the migrant trap. This may be due to errors in the estimate because of not continuously trapping.

Table 19. Monthly and total population estimates for natural and hatchery origin emigrants from the Tucannon River, 1998 and 1999. Percent survival to smolt based on estimated number of parr from summer snorkel surveys (natural origin) or from TFH release numbers (hatchery origin).

	1997-1998		1998-1999	
Month	**Natural**	**Hatchery**	**Natural**	**Hatchery**
Sept.-Feb.	45	0	709	0
March	125	14	3,229	10
April	243	10,232	13,058	4,355
May	862	15,865	3,932	10,847
June	337	27	130	480
Total	1,612	26,137	21,057	15,692
% Survival	57	35	64	64

A greater number of natural spring chinook salmon were captured during 1998-1999 (Table 19). In addition, we estimated that about 65% of the hatchery fish released in 1999 passed the migrant trap. The large between year difference for migration of hatchery origin fish past the smolt trap is unknown, but could be due to errors in our trapping estimates because of not continuously trapping, or errors in trapping efficiency estimates.

Smolt Migration Evaluation

1998

The 1996 BY fish were used in an exercise experiment during the fall of 1997 and early winter 1998 at TFH (see description in Bumgarner et al 1998). Before release, a sample of each of the groups was PIT tagged for downstream migrant evaluation. Release locations were as follows: TFH Acclimation (exercised), Curl Lake Acclimation (exercised), Curl Lake Acclimation (non-exercised), Curl Lake direct stream release (exercised), and Panjab Bridge direct stream release (exercise). Based on the PIT tag detections (Table 20), the unexercised group performed better than both direct stream release groups, and only slightly less than the exercised acclimated groups from TFH or Curl Lake. There was no statistical difference (Chi-square analysis, $\propto$=0.5) in the relative survivals.

Table 20. Cumulative unique detection summaries of PIT tagged salmon released at three locations on the Tucannon River in 1998.

Release site	Experiment	Release type	Pond type	Release date	River kilometer	Release number	Detection rate (%)
TFH	exercised	acclim.	round	3/11-4/17	58	401	30.4
Curl Lake	non-exercised	acclim.	lake	3/11-4/18	66	400	29.6
Curl Lake	exercised	acclim.	lake	3/11-4-18	66	400	30.3
Curl Lake	exercised	direct	–	4/03	66	402	27.6
Panjab Cr.	exercised	direct	–	4/03	74	397	25.4

1999

In 1999, we compared migration success between natural and hatchery origin smolts by PIT tagging fish captured at the smolt trap. Equal numbers of migrants (natural and hatchery) were to be tagged each week. Fifty to 100 fish were desired for each week's tagging. We tagged 371 natural and 336 hatchery origin spring chinook over a four week period. Detection rates were higher than anticipated based on past releases of hatchery fish from the TFH and other acclimation sites in the Tucannon River (Bumgarner et al, 1998). Detection rates were consistently higher for natural chinook, and mean travel days were consistently fewer for natural chinook (Table 21).

Table 21. Cumulative detection (one unique detection per tag code) and travel time (TD) summaries of PIT tagged spring chinook salmon released from the Tucannon River smolt trap (rkm 3) at downstream Snake and Columbia River dams in 1999.

Release Data				Recapture Data										
					LMJ		MCJ		JDJ		BONN		Total
Release Date	Origin	N	Mean length	Mean length	N	TD	N	TD	N	TD	N	TD	N (%)
4/22-23	W	104	110.6	110.4	57	6.6	14	12.2	3	16.3	2	16.9	**76 (73.1)**
	H	53	143.3	144.6	23	8.6	9	15.6	3	19.4	1	21.5	**36 (67.9)**
4/28-29	W	113	107.5	107.7	54	6.0	23	10.8	9	14.0	2	17.4	**88 (77.9)**
	H	95	142.4	143.5	39	6.6	15	12.3	4	17.9	1	20.1	**59 (62.1)**
5/05-07	W	99	107.3	107.4	44	4.5	16	8.9	7	12.6	4	14.6	**70 (70.7)**
	H	101	136.6	137.2	43	5.1	10	12.1	8	14.9	3	16.6	**64 (63.4)**
5/12-13	W	55	107.0	108.6	19	5.2	10	8.2	8	10.3	1	12.7	**38 (69.1)**
	H	87	134.6	134.9	27	3.6	10	9.9	3	12.5	3	15.1	**43 (49.4)**

Note: Mean travel times listed are from the total number of fish detected at each dam, not just unique recoveries for a tag code. Abbreviations are as follows: LMJ-Lower Monumental Dam, MCJ- McNary Dam, JDJ-John Day Dam, BONN-Bonneville Dam, TD- Mean Travel Days.

Controlled Matings Study

In the late 1980's, it was recognized by managers that the Tucannon River spring chinook stock represented a rare opportunity to study the effects of a hatchery supplementation program in a system with limited hatchery influence. The belief at the time of the study, was that hatchery fish may be less fit, and that domestication of the stock in the protected hatchery environment will eventually lower the productivity of the population. This may be particulary true when hatchery fish are allowed to spawn in the river with natural origin fish. The purpose of this experiment was to cross fish of similar origin (i.e. hatchery x hatchery or natural x natural), document differences (phenotypic and genotypic) and keep their progeny separate through rearing and be able to distinguish them upon adult return.

For the study, genotypic and phenotypic characteristics were collected. Genotypic Characterization consisted of electrophoretic samples collected from juveniles during each brood year of the study, and from returning adults during most years. A genetic report which includes juvenile and adult samples collected for the study and other purposes is currently in draft form and will be complete in 2000 (Craig Busack, WDFW Genetisist - pers. comm. August 1999). Morphometric samples were collected from the 1990-1991 BY, and meristic samples were collected for 1990, 1992, and 1993 BY's. Morphometric and meristic samples have not been analyzed at this time. Further, questions regarding sample collection (morphometric) and demonstrated variability among samplers collecting meristic characteristics (Hubert and Alexander, 1995) have made the samples suspect. Because of those concerns, we will focus our evaluation in this report on survival rates between various life stages (i.e. egg-to-smolt) in each of the treatment groups for each brood year, and other characteristics of returning adult fish (length, age, and fecundity).

Survival of Experimental Groups

Broodstock were collected from the Tucannon River with the goal to collect 50 natural and 50 hatchery origin spring chinook. However, depending on a particular year's run, the broodstock goal may not have been met. Further, when the fish matured and spawned, it was not always possible to make the crosses needed for the experiment. As such, some years were comprised of three separate groups (Table 22). Further study complications arose because of physical constraints at LFH. LFH was designed as a production facility, with little capability to rear small individual groups of fish as needed for the study. With only standard size raceways available for juvenile rearing, variable population sizes between years (Table 22), and the reluctance of hatchery managers to partition off raceways into equal density units, different rearing conditions existed (i.e within and among years density). It was not until after eight months of rearing in raceways that groups could be tagged, mixed, and then reared under identical conditions. This situation lessens the certainty of conclusions reached throughout the study.

Table 22. Estimated numbers of spring chinook salmon at various life stages from WxW, HxH, or mixed (HxW) crosses from the 1990-1993 BY's. Adult return numbers shown are expanded for the entire BY.

Brood year	Matings	# of eggs collected	# after picking	# of fish ponded	# of fish tagged	# of fish released[a]	# of adult returns
1990							
WxW	19	74,634	53,988	52,275	51,664	51,149	16
HxH	19	51,784	25,962	22,151	21,368	21,108	11
Mixed	6	20,975	15,656	14,079	13,620	13,480	1
1991							
WxW	17	63,592	60,466	58,848	57,113	56,506	12
HxH	11	27,683	19,130	18,377	17,739	17,552	13
Mixed	0	0	0	0	0	0	0
1992							
WxW	18	69,376	68,527	67,820	65,479	61,410	35
HxH	27	86,983	85,067	83,907	81,582	79,315	45
Mixed	0	0	0	0	0	0	0
1993							
WxW	21	70,448	64,164	62,656	59,722	59,780	73
HxH	20	71,279	64,475	62,850	61,063	60,764	113
Mixed [b]	8	26,639	24,245	19,797	18,379	18,304	21

[a] For the 1992 BY, a portion of the fish (25,134 WxW, and 32,182 HxH) were released into the Wilderness Stratum in October, 1993, with remaining brood released April, 1994. An estimated 4,182 fish survived the winter and migrated as smolts.

[b] The majority of loss shown between eye-up and ponding was due to 3,460 eggs that were destroyed due to stray fish crosses.

Survival rates at various life stages were not different between groups (Table 23). Poor green egg to "eye up" survival was noted during the first two years of the study, but can largely be explained by spawning practices used at the time. During 1990 and 1991 fish were spawned at TFH and the eggs were transported to LFH. Eggs likely warmed too much during spawning and transport, resulting in higher loss. Survivals at other life stages are consistent among years and remained generally greater than 95% while the fish were rearing in the raceways at LFH or TFH. HxH crossed progeny had overall greater smolt-to-adult survival rates among the groups. However, the differences are small and were calculated from very small return numbers. The 1994 and 1995 adult return (comprised mainly of 4-year old fish from the 1990 and 1991 BY's) were the lowest documented returns ever to the Tucannon River. These fish were subjected to El Nino ocean conditions, and we suspect survival was greatly reduced by the event.

Based on the survivals documented during rearing at LFH and TFH, and the resulting survivals documented from each of the three groups, parental origin appears to have little, if any, influence on survival. Environmental factors (El Nino ocean conditions, and drought years which affected downstream migrant survival) and differences in growth and size which were likely not detected during the study probably influenced the resulting survivals, not parental origin.

Table 23. Estimated percent survival of spring chinook salmon at various life stages from WxW, HxH, or mixed (HxW) crosses from the 1990-1993 BY's.

Brood year	green egg to "eye up"	"eye up" to fry ponded	fry ponded to fish tagged	fish tagged to smolt release	egg to smolt release	smolt to adult return
1990						
WxW	72.3	96.8	98.8	99.0	68.5	0.03
HxH	50.1	85.2	95.6	98.7	40.8	0.05
Mixed	74.6	89.9	96.7	98.9	64.3	0.01
1991						
WxW	95.1	97.3	97.1	98.9	88.9	0.02
HxH	69.1	96.1	96.5	98.9	63.4	0.07
1992						
WxW	98.8	98.9	96.5	93.8	88.5	0.05
HxH	97.8	98.6	97.2	97.2	91.2	0.06
1993						
WxW	91.1	97.6	95.3	-- [a]	84.9	0.12
HxH	90.5	97.5	97.2	99.5	85.2	0.19
Mixed	91.0	81.7	95.2	99.6	79.0	0.11

[a] An estimate could not be derived as an overage of fish were found during tagging, however it is estimated to be close to the survival observed by the other two groups.

Age at Return, Fecundity, and Size at Return of Experimental Groups

Age at return for each of the experimental groups were not different from each other (Table 24), nor were they different than the historical age at return for hatchery fish documented from the program (refer to Figure 2). Mean lengths (post-eye to hypural plate) were not different from each other either (Table 25), though sample sizes were relatively small for some age groups. Mean fecundity (age 4 females) was also not significantly different between the WxW or HxH groups, and compared to natural origin females of the same brood year (Table 26). However, mean fecundity of natural origin females produced from the river was greater than both of the experimental hatchery groups (HxH or WxW). Based on these three results, and similar to comments regarding survival, parental origin appears to have little, if any, influence on phenotypic characteristics at adult returns.

Table 24. Age at return for the 1990-1993 BY's from controlled matings study. Sample sizes are based on expanded recoveries of fish to the river.

Group	Age 3		Age 4		Age 5	
Brood Year	N	Percent	N	Percent	N	Percent
WxW						
1990	4	25.0	11	68.7	1	6.3
1991	1	8.3	11	91.7	0	0.0
1992	6	17.1	29	82.9	0	0.0
1993	6	8.2	58	79.5	9	12.3
Combined	**17**	**12.5**	**109**	**80.1**	**10**	**7.4**
HxH						
1990	2	18.2	8	72.7	1	9.1
1991	4	30.8	9	69.2	0	0.0
1992	5	10.9	37	80.4	4	8.7
1993	6	5.3	99	87.6	8	7.1
Combined	**17**	**9.3**	**153**	**83.6**	**13**	**7.1**
Mixed						
1990	0	0.0	1	100.0	0	0.0
1993	3	14.3	17	80.9	1	4.8
Combined	**3**	**13.6**	**18**	**81.8**	**1**	**4.6**

Table 25. Sample size (N), mean post-eye to hypural plate length (Ln), and standard deviation (SD) of fish returning from the controlled mating study, 1990-1993 BY's combined.

	Age 3			Age 4			Age 5		
Group	N	Ln	SD	N	Ln	SD	N	Ln	SD
WxW	11	38.7	3.7	65	58.7	3.2	9	64.1	5.4
HxH	13	37.7	2.7	88	57.9	3.6	9	66.5	3.0
Mixed	2	39.5	2.1	9	56.0	5.9	1	62.0	0.0

Table 26. Sample size (N), mean number of eggs (eggs), and standard deviation (SD) of Age 4 fish returning from the controlled mating study (WxW and HxH crosses), and fish of natural origin from the Tucannon River, 1990-1993 BY's. Note: Very few Age 4 fish from the Mixed groups (4 total), and only five Age 5 fish from the hatchery experimental groups were sampled for fecundity estimates.

	WxW Cross			HxH Cross			Natural Origin		
BY	N	Eggs	SD	N	Eggs	SD	N	Eggs	SD
1990	7	3,347	367.4	4	3,162	1012.5	13	3,688	733.9
1991	6	3,855	802.3	8	3,382	718.1	0	---	---
1992	9	2,905	444.0	8	2,752	596.5	17	3,510	534.3
1993	5	3,087	710.5	15	3,320	919.1	15	3,487	443.1
Combined	**27**	**3,264**	**654.1**	**35**	**3,187**	**824.1**	**45**	**3,554**	**566.4**

Survival Rates

Point estimates of population sizes have been calculated for various life stages (Table 27 and 28) of natural origin fish from spawning ground and juvenile mid-summer population surveys, smolt trapping and fecundity estimates. From these two tables, survivals between life stages have been calculated for both natural and hatchery salmon to assist in the evaluation of the hatchery program. These survival estimates provide insight as to where efforts should be directed to improve not only the survival of fish produced within the hatchery, but fish in the river as well.

As expected, juvenile (egg-parr-smolt) survival rates for hatchery fish are considerably higher than for naturally reared salmon (Table 29) because they have been protected in the hatchery environment. However, smolt-to-adult return rates (SAR) of natural salmon were about four times higher than hatchery reared salmon (Table 30 and 31). The mean SAR's (natural=0.58%; hatchery=0.16%) documented from 1985-1994 broods were below the goal SAR of 0.87% established under the LSRCP. Natural and hatchery SAR's from Tucannon River salmon need substantial improvement if we ever hope to meet the mitigation goal of 1,152 salmon.

While SAR's were lower for hatchery salmon, overall survival of hatchery salmon to return as adults was higher than naturally reared fish because of the early life survival advantage provided by the hatchery (Table 29). Naturally produced fish remain below the replacement level (Table 32). Based on adult returns from the 1985-1995 broods, naturally reared salmon produced 0.5 adults for every spawner, while hatchery reared fish produced 2.4 adults.

Table 27. Estimates of *natural* Tucannon spring chinook salmon abundance by life stage for 1985-1999 broods.

Brood year	Females in river		Mean [a] fecundity		Number of eggs	Number [b] of fry	Number of smolts	Progeny [c] (returning adults)
	natural	hatchery	natural	hatchery				
1985	270	-	3,883	-	1,048,410	90,200	35,600	410
1986	309	-	3,916	-	1,210,044	102,600	58,200	470
1987	282	-	4,095	-	1,155,072	79,100	44,000	227
1988	168	-	3,882	-	652,176	69,100	37,500	547
1989	133	4	3,883	2,606	526,863	58,600	25,900	148
1990	196	108	3,993	2,694	1,073,904	64,100	49,500	94
1991	104	68	3,741	2,517	560,220	54,800	26,000	7
1992	168	129	3,854	3,295	1,072,527	103,292	50,800	194
1993	156	109	3,701	3,237	930,189	86,755	49,600	204
1994	38	5	4,187	3,314	175,676	12,720	6,900	12
1995	5	0	5,284	3,604	36,568	0	75	1
1996	61	14	3,516	2,843	254,278	2,845	1,612	
1997	40	34	3,609	3,315	257,070	32,913	21,050	
1998	24	5	4,023	3,075	111,927	8,453		
1999	1	40	3,965	3,142	129,645			

a 1985 and 1989 mean fecundity of natural females is average of 1986-88 and 1990-93.
b Number of fry estimated from electrofishing (1985-1989), Line transect snorkel surveys (1990-1992), and Total Count snorkel surveys (1993-1999).
c Numbers do not include down river harvest estimates or out of basin recoveries.

Table 28. Estimates of Tucannon spring chinook salmon abundance (spawned and reared in the hatchery) by life stage for 1985-1999 broods.

Brood year	Females spawned natural	Females spawned hatchery	Mean [a] fecundity natural	Mean [a] fecundity hatchery	Number of eggs	Number of fry	Number of smolts	Progeny [b] (returning adults)
1985	4	-	3,883	-	14,843	13,401	12,922	45
1986	57	-	3,916	-	187,958	177,277	153,725	328
1987	48	-	4,095	-	196,573	164,630	152,165	185
1988	49	-	3,882	-	182,438	150,677	145,146	447
1989	28	9	3,883	2,606	133,521	103,420	99,057	243
1990	21	23	3,993	2,694	126,334	89,519	85,797	28
1991	17	11	3,741	2,517	91,275	77,232	74,058	25
1992	28	18	3,854	3,295	156,359	151,727	87,752[c]	81
1993	21	28	3,701	3,237	168,366	145,303	138,848	207
1994	22	21	4,187	3,314	161,707	148,148	130,069	34
1995	6	15	5,284	3,604	85,772	63,935	62,272	176
1996	18	19	3,516	2,843	117,287	81,326	76,219	
1997	17	25	3,609	3,315	144,237	29,650	24,186	
1998	30	14	4,023	3,075	161,019	136,027	127,939	
1999	1	36	3,969	3,142	111,961	106,880		

[a] 1985 and 1989 mean fecundity of natural females is average of 1986-88 and 1990-93, 1999 mean fecundity of natural fish is the based on the mean of 1986-1998 .

[b] Numbers do not include down river harvest estimates or out of basin recoveries.

[c] Number of smolts is less than actual release number. 57,316 parr were released in October 1993, with an estimated 7% survival. Total number of hatchery fish released from the 1992 brood year was 140,725. We therefore use the listed number of 87,752 as the number of smolts released.

Table 29. Percent survival rates by brood year for juvenile salmon and the multiplicative advantage of hatchery reared salmon over naturally reared salmon in the Tucannon River.

Brood Year	Natural			Hatchery			Hatchery Advantage		
	Egg to fry	Fry to smolt	Egg to smolt	Egg to fry	Fry to smolt	Egg to smolt	Egg to fry	Fry to smolt	Egg to smolt
1985	8.6	39.5	3.4	90.3	96.4	87.1	10.5	2.4	25.6
1986	8.5	56.7	4.8	94.3	86.7	81.8	11.1	1.5	17.0
1987	6.8	55.6	3.8	83.8	92.4	77.4	12.2	1.7	20.3
1988	10.6	54.3	5.7	82.6	97.0	80.1	7.8	1.8	13.9
1989	11.1	44.2	4.9	77.5	95.8	74.2	7.0	2.2	15.1
1990	6.0	77.2	4.6	70.9	95.8	67.9	11.9	1.2	14.7
1991	9.8	47.5	4.6	84.6	95.9	81.1	8.7	2.0	17.5
1992	9.6	49.2	4.7	97.0	57.8	56.1	10.1	1.2	11.8
1993	9.3	57.2	5.3	86.3	95.6	82.5	9.3	1.7	15.5
1994	7.2	54.2	3.9	82.2	97.9	80.4	11.3	1.8	20.5
1995	0.0	0.0	0.2	74.5	97.4	72.6	-	-	--
1996	1.1	56.7	0.6	68.5	94.9	65.0	61.2	1.7	--
1997	12.8	64.0	8.2	20.6	81.6	16.8	1.6	1.3	2.0
1998	7.6			84.5	94.1	79.5	11.2		
1999				91.0					
Mean	7.8	50.5	3.9	78.4	91.4	71.6	13.4	1.7	15.8
SD	3.6	17.8	2.3	18.5	10.7	17.8	14.6	0.4	5.9

Table 30. Adult returns and SAR's of **natural** salmon to the Tucannon River for brood years 1985-1994.

Brood Year	Estimated number of smolts	Number of Adult Returns, observed and expanded (exp)[a]						SAR (%)	
		Age 3		Age 4		Age 5			
		obs	exp	obs	exp	obs	exp	w/jacks	no jacks
1985	35,600	8	20	110	274	36	118	1.16	1.10
1986[b]	58,200	1	2	115	376	28	90	0.80	0.80
1987	44,000	0	0	52	167	29	71	0.54	0.54
1988	37,500	1	3	136	335	74	189	1.41	1.40
1989	25,900	5	14	47	120	23	26	0.61	0.56
1990	49,500	3	8	63	72	12	14	0.19	0.17
1991	26,000	0	0	4	5	1	2	0.03	0.03
1992	50,800	2	2	84	159	16	33	0.38	0.38
1993	49,600	1	2	62	127	58	75	0.41	0.41
1994	6,000	0	0	8	10	1	2	0.20	0.20
Mean of 1985-1994 broods								**0.58**	**0.56**

[a] Expanded numbers are calculated from the proportion of each known age salmon recovered in the river and from broodstock collections in relation to the total estimated return to the Tucannon River. Expansions do not include down river harvest or Tucannon River fish straying to other systems.

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

Table 31. Adult returns and SAR's of **hatchery** salmon to the Tucannon River for brood years 1985-1994.

Brood Year	Estimated number of smolts	Number of Adult Returns, known and expanded (exp.)						SAR (%)	
		Age 3		Age 4		Age 5			
		known	exp.	known	exp.	known	exp.	w/jacks	no jacks
1985	12,922	9	20	25	26	0	0	0.36	0.20
1986	153,725	79	84	99	225	8	18	0.21	0.16
1987	152,165	9	21	70	151	8	17	0.12	0.11
1988	146,200	46	99	140	295	26	53	0.31	0.24
1989	99,057	7	15	100	211	14	17	0.25	0.23
1990	85,800	3	6	16	20	2	2	0.03	0.03
1991	74,058	4	5	20	20	0	0	0.03	0.03
1992	87,752	11	11	50	66	2	4	0.09	0.08
1993	138,848	11	15	93	174	15	18	0.15	0.14
1994	130,069	2	4	21	25	3	5	0.03	0.02
Mean of 1985-1994 broods								**0.16**	**0.12**

Table 32. Parent-to-progeny survival estimates of Tucannon River spring chinook salmon from 1985 through 1995 brood years (1995 incomplete).

	Natural Salmon			Hatchery Salmon			
Brood year	Number of spawners	Number of returns	Return/ spawner	Number of spawners	Number of returns	Return/ spawner	Hatchery to Natural advantage
1985	539	410	0.76	9	45	5.00	6.6
1986	570	470	0.82	91	328	3.60	4.4
1987	527	227	0.43	83	185	2.23	5.3
1988	333	547	1.64	87	447	5.14	3.5
1989	302	148	0.49	122	243	1.99	4.1
1990	611	94	0.15	78	28	0.36	2.3
1991	390	7	0.02	72	25	0.35	17.5
1992	564	193	0.34	83	81	0.98	2.9
1993	436	212	0.49	91	213	2.34	7.3
1994	70	12	0.17	69	34	0.49	3.2
1995	11	1	0.09	39	176	4.51	50.1
Mean			**0.49**			**2.45**	**5.00**

Conclusions and Recommendations

Washington's LSRCP spring chinook salmon program has failed to returned adequate numbers of hatchery origin adults to meet the mitigation goals of the program. The program has failed because SAR's of hatchery origin fish has consistently fallen below the assumed SAR of hatchery smolts as described under the LSRCP, even though hatchery returns have generally been at 2-3 times the replacement level. Further, the program has failed because the natural population of spring chinook salmon in the river remain below the replacement level, with the majority (95%) of the mortality occurring between the green egg and smolt stage. Mortality within the migration corridor has also contributed to the decline. The end result has been a slow but steady replacement of the natural population with the hatchery stock. While this was not, or is, the desired result of the hatchery program, in many ways the hatchery program has helped conserve the natural population within the river by returning enough adults to allow some spawning in the river. Hopefully, the system survivals (in-river, ocean) will increase enough in the coming years so the program may reach it's full potential, and the spring chinook run may be returned to historical levels.

Until that time, the evaluation program will continue to document and study life history survivals, genotypic and phenotypic traits, and examine procedures within the hatchery that may be improved to benefit the program. Based on our previous studies and current data sets involving survival and physical characteristics we recommend the following:

1. Monitoring of water temperatures in the Tucannon River has expanded in the last two years with assistance from the local Conservation District with more emphasis being placed on instream and riparian restoration work within the river. These water temperature data series will continue to document the physical environment of the river as it hopefully changes over time. The desired change (cooling of the river) will likely benefit the natural spring chinook population in the river.

   Recommendation: Continue to assist local Conservation District with the long term monitoring of water temperatures in the Tucannon River. Within the next 2-3 years, provide a complete summary of water temperature data collected from the Tucannon River since program inception.

2. In 1999, the water chiller at LFH was not used for two reasons. 1) use of the chilled water was somewhat responsible for the large egg loss experienced in 1997, and lesser loss in other years, 2) the annual maintenance of the water chiller was becoming cost prohibited given the small size of the program. The end result for 1999 was high egg survival, and no maintenance cost on the chiller, both benefits to the program.

   Recommendation: Continue with current practice to not use the water chiller at LFH. Continue to develop and refine feeding strategies that will maintain program smolt release size of 15 fish/lb.

3. We continue to see annual differences on phenotypic characteristics of returning salmon (i.e. hatchery fish are generally younger in age and less fecund than natural origin fish), yet other traits such as run and spawn time have changed little over the programs history. Further, genetic analysis to date indicates little change between the natural and hatchery population.

   Recommendation: Continue to collect as many carcasses as possible for the most accurate age composition data. Continue to assist hatchery staff with picking eyed eggs to obtain fecundity estimates for each spawned female. Continue to collect other biological data (lengths, run timing, spawn timing, DNA samples, juvenile parr production, and smolt trapping, life stage survival) to continue the documentation of effects (positive or negative) that the hatchery program may have on the natural population.

4. Releases of juvenile spring chinook from Curl Lake AP has occurred over the past three years. Observations on the condition of smolts released from Curl Lake and subsequently captured in the smolt trap in the lower river suggests that the releases have been beneficial (fish have been very fit with little descaling or injuries compared to previous years). Monitoring the migration from the lake with an electronic counter has not produced the results desired to date, and may be delaying the volitional migration from the lake.

   Recommendation: Continue to release all spring chinook smolts from Curl Lake AP, continue to monitor their growth in the lake, and their physical condition upon capture at the smolt trap. Because of the possible delay of smolts, discontinue any efforts to use the electronic fish counter in the outlet structure of the lake.

5. Documenting the success of hatchery origin fish spawning in the river has become an increasingly frequent topic among managers within the Snake River Basin and National Marine Fisheries Service. Little, if any, data to date exists on this subject. With the hatchery population in the Tucannon River slowly replacing the natural population, we are offered an opportunity to study the effects of the hatchery spawners in the natural.

   Recommendation: Continue to use snorkel surveys during the summer months to estimate spring chinook parr production in the river. Examine the relationship between redd counts and the following years parr production in context of the proportion of hatchery spawners in the river.

6. The new adult trap was installed in 1998 around the TFH water intake dam. In 1998 and 1999, no fish were intentionally passed above the trap for natural spawning in the river. However, each year redds and fish have been found during spawning ground surveys. An estimator for the number of fish that bypass the trap each year is needed to allow managers to estimate the total run to the river more accurately.

   Recommendation: Mark (opercle punch) all fish captured and released at the TFH adult trap. Document the number of recaptures in the trap during the season to document fall back rate. Examine all carcasses recovered above the trap during spawning and carcass surveys for marks to estimate trap efficiency.

7. Stray salmon were documented in relatively high proportion in the 1999 return compared to previous years, and is greater than the 5% stray rate proposed by NMFS. While this is relative to the total return to Tucannon River origin fish, the total number of strays recovered has increased. Further, in the 2000 return (not shown in this report), many more stray fish were captured at the Tucannon Adult trap than even recorded before (RV or LV fin clipped Umatilla River origin spring chinook). WDFW has been informed by the Oregon Dept of Fish and Wildlife, that use of the RV or LV fin clip had been discontinued, starting with the 1997 brood year. Consequently, for the 2001 return year, age 3 and age 4 salmon from the Umatilla River will be unmarked and will appear to be natural origin salmon. Protocols for collecting natural origin salmon for the hatchery broodstock will have to be addressed.

   Recommendation: Complete a summary of stray fish into the Tucannon River (through the 2000 return) and provide to NMFS and WDFW Policy personnel. Recommend that spring chinook released from the Umatilla Rive be 100% marked (preferably with RV or LV fin clips) for external identification at the TFH adult trap. For upcoming return years, all natural origin salmon (i.e. unmarked) arriving at the TFH adult will have scale samples collected from them. In addition, any natural salmon collected for broodstock will be PIT tagged and linked to a scale sample to determine origin (hatchery or natural). Prior to broodstock spawning, results from the scale samples will allow hatchery staff to remove any potential stray salmon before it is crossed with a Tucannon origin fish, thereby promoting the genetic integrity of the stock to continue.

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Appendix A

Spring chinook captured, collected, or passed upstream at the Tucannon Hatchery trap in 1998 and 1999

Appendix A Table 1. Spring chinook salmon captured, collected, or passed upstream at the Tucannon Hatchery trap in 1998. Trapping began in mid-February; last day of trapping was 28 September.

	Captured in trap		Collected for broodstock		Passed upstream	
Date	**Natural**	**Hatchery**	**Natural**	**Hatchery**	**Natural**	**Hatchery**
5/13	1		1			
5/18	2		2			
5/19	1		1			
5/20	2		2			
5/21	2		2			
5/23		1		1		
5/26	1		1			
5/28	1		1			
5/29	1	1	1	1		
6/02	3		3			
6/04	4		4			
6/05		1		1		
6/06	1		1			
6/08	4	2	4	2		
6/09	1	1	1	1		
6/12	2	1	2	1		
6/13	1	1	1	1		
6/16	3	3	3	3		
6/18	1	1	1	1		
6/19	1	2	1	2		
6/30	1		1			
7/01		1		1		
7/02[a]	1	1		1	1	
7/04	1	1	1	1		
7/06		1		1		
7/07		1		1		
7/08		1		1		
7/09		2		2		
7/13		1		1		
8/01	1	1	1	1		
8/08		1		1		
8/19		1		1		
8/24	1		1			
8/26	1		1			
8/31	2	1	2	1		
9/08		1		1		
9/09	1	4	1	4		
9/10	4	3	4	3		
9/11		1				1
9/12	1		1			
9/14	1	6	1	6		
9/15	1		1			
9/22[b]	1	1			1	1
Totals	**50**	**43**	**48**	**41**	**2**	**2**

[a] Radio tagged fish entered the trap and escaped upstream.

[b] Both fish captured were males. Spawning above the trap and the hatchery was nearly complete so both fish were trucked about 3 river kilometers downstream and released to spawn with other fish in the river.

Appendix A Table 2. Spring chinook salmon captured, collected, or passed upstream at the Tucannon Hatchery trap in 1999. Trapping began in mid-February; last day of trapping was 27 September.

	Captured in trap		Collected for broodstock		Passed upstream	
Date	Natural	Hatchery	Natural	Hatchery	Natural	Hatchery
5/29		2		2		
6/02		1		1		
6/04		2		2		
6/05		1		1		
6/09		2		2		
6/11		1		1		
6/13		8		8		
6/14		1		1		
6/16		16		16		
6/17		10		10		
6/18		5		5		
6/22		1		1		
6/23		5		5		
6/24		2		2		
6/25		2		2		
6/26		1		1		
6/29		4		4		
6/30		1		1		
7/01		3		3		
7/02		4		4		
7/06		3		3		
7/08		4		4		
7/10		1		1		
7/12		6		6		
7/13	1	1	1	1		
7/14	1		1			
7/17		1		1		
7/19		2		2		
7/21	1		1			
7/23		1		1		
7/29	1	1	1	1		
7/31		1		1		
8/04		1		1		
8/10		1		1		
8/12		1		1		
8/17	1		1			
8/20		2		2		
8/23	2		1		1[a]	
8/24	2	1	2	1		
8/26		1		1		
8/28		1		1		
8/31	1		1			
9/07		7		7		
9/09		10		10		
9/10	1	4	1	4		
9/13		3		2		1[b]
9/15		4		2		2[b]
Totals	**11**	**129**	**10**	**126**	**1**	**3**

[a] trap mort
[b] excess males hauled downstream to spawn naturally

Appendix B

Movements of four radio tagged spring chinook in the Tucannon River, 1998

Appendix B Table 1. Movements of four radio tagged spring chinook in the Tucannon River, 1998. All were tagged and released by the University of Idaho at Bonneville Dam. Abbreviations used: **pp** = pinpoint, to locate fish within 10-20m of stream side, **CG** = campground, **COL** = Columbia River, **HMA** = #'s refer to snorkel index sites, **SNR** = Snake River, **Rkm** = river kilometer, **RB, LB** = right bank, left bank

Chan/ Code Date	Tuc Rkm	Location	Comments
24/66			
4/22	COL	Bonneville Dam	Tagged (hatchery male, 67cm, VI-M86)
5/21	9.6	Fletcher's Dam	
5/26	8.8	milepost 7, Highway 261	
6/11	8.0	behind Jackson's and Starbuck School	
6/29	26.4	.25 mi. below Becky White's	
7/02	43.3	Bridge 10	
7/06-08	58.7	pool near Rainbow Lake Outlet and S-curve	pp
7/13	57.4	lower end of Blue Lake	
7/16	57.2	HMA 3	
7/21	57.2	above Campground 2, at HMA 3	
7/23	57.3	above upper end of clover field	
7/30	57.2	below Blue Lake	
8/04	57.3	pull-out across from clover field	pp
8/05	57.2	HMA 3; under big pine tree	pp; snorkeled, fish swam upstream
8/10-20	57.4	moved upstream, 200m above HMA 3	pp
8/24	57.3	150, above HMA 3	pp
8/28	57.2	HMA 3; under pine tree	pp
8/31	57.1	60m downstream of HMA 3	pp
9/03	57.2	HMA 3; under pine tree	pp
9/09	59.2	Tucannon Adult Trap	fish transported to Lyons Ferry Hatchery
9/15	SNR	Lyons Ferry Fish Hatchery	Recovered tag, fish spawned; female
24/81			
4/14	COL	Bonneville Dam	Tagged (natural female, 88.5cm, VI-N58)
4/28	7.2	above Kellogg Creek in Starbuck	
4/29	12.9	above Smith Hollow Bridge	
5/01	22.8	250m above Highway 12 Bridge	
5/04	41.8	Tuc. milepost 12 (1.5 miles above Marengo)	
5/05	46.4	1 mile above Bridge 11	
5/10	58.1	100m below Tucannon Hatchery Bridge	
5/12	58.7	100m above Rainbow Lake Outlet	
5/18	59.2	Tucannon Adult Trap	fish transported to Lyons Ferry Hatchery
8/25	SNR	Lyons Ferry Fish Hatchery	Recovered tag, fish spawned; male 92.0cm
24/108			
4/19	COL	Bonneville Dam	Tagged (natural female, 77.5cm, VI-LT7)
5/10	3.7	Powers Bridge	
5/11	8.7	above Starbuck	
5/12	10.4	milepost 6, Highway 261	
5/13	17.8	above Kessel's Bridge	
5/14	18.1	above the mouth of Pataha Creek	
5/17	28.0	Enrich Bridge	
5/18	30.5	Tuc. milepost 5.2 (above Broughton Land)	
5/19	32.5	below King Grade Road	
5/21	37.0	Tuc. milepost 9.4 (0.5 mi. above Kimball's)	
5/22	42.0	above Bridge 9	
5/24	48.6	between Bridge 12 and Bridge 13	

Appendix B Table 1. Movements of four radio tagged spring chinook in the Tucannon River, 1998. All were tagged and released by the University of Idaho at Bonneville Dam. Abbreviations used: **pp** = pinpoint, to locate fish within 10-20m of stream side, **CG** = campground, **COL** = Columbia River, **HMA** = #'s refer to snorkel index sites, **SNR** = Snake River, **Rkm** = river kilometer, **RB, LB** = right bank, left bank

Chan/ Code Date	Tuc Rkm	Location	Comments
5/26	51.5	Bridge 14	
5/27	53.4	Dahm's	
5/28	55.8	CG 1; below Cummings Creek Bridge	
5/29	57.4	below old Adult Trap (Tuc. Hatchery)	fish approached ladder (2200hrs)
5/31	59.2	Tucannon Adult Trap fixed site	
6/01	58.0	near Tucannon Hatchery buildings	pp
6/02-29	57.9	pool 150m above old Adult Trap	passed fixed site (0130hrs)
6/30	59.2	Tucannon Adult Trap fixed site	
7/02	63.9	below CG 6	pp
7/06-08	63.9	above pullout and below CG 6	
7/13	68.2	above Wooten Bridge	
7/16	68.2	above Wooten Bridge at 1st pullout on left	drive by
7/21-8/4	70.1	2nd cattleguard above Camp Wooten	pp, snorkeled and saw fish w/antenna
8/05	70.1	in large pool; RB under woody debris	pp
8/10-12	70.1	in large pool; same	pp
8/20	69.9	65m above old HMA 16	pp
8/24-28	70.1	in large pool	pp
8/31	69.9	in LB undercut and debris pool	pp
9/03	64.7	100m downstream of day use area at Big 4	pp; saw fish; had started test dig
9/09	66.2	50m above Curl Lake Intake	pp; saw fish alongside test dig
9/10	66.2	50m above Curl Lake Intake	Recovered tag on gravel bar; no carcass
9/11	66.1	3m below Curl Lake Intake pool; RB	
25/26			
4/30	COL	Bonneville Dam	Tagged (hatchery male, 67.5cm, VI-FB3)
5/21	18.1	above the mouth of Pataha Creek	
5/24	25.4	Dave Frame's house	
5/26	31.1	1.9 miles below King Grade Road	
5/27	31.1	Tuc.milepost 5.5	
5/28	32.5	downstream of Tuc. milepost 7.7	
5/29-6/1	36.5	Kimble's, 1.6 mi. below Tuc. Milepost 10	
6/02	47.2	Bridge 12	
6/09	53.6	between Dahm's and Russel's	
6/11	53.4	RB, under cabled logs at Dahm's	pp
6/15	57.2	above Campground 2	
6/18	57.0	100m below Campground 2	pp
6/22-7/6	56.5	above mouth of Cummings Creek	pp
7/08-30	56.1	in undercut run above Cummings Cr. mouth	pp
8/04	56.1	above mouth of Cummings Creek	Recovered tag; no fish
8/12	52.0	above Bridge 14	Recovered carcass; identified by VI tag

Appendix C

Numbers and density estimates (fish/100m^2) of juvenile salmon counted by snorkel surveys in theTucannon River in 1998 and 1999

Appendix C Table 1. Numbers and density estimates of subyearling and yearling natural salmon, and yearling hatchery chinook counted by snorkel surveys in the Tucannon River, 1998.

Stratum	Site	Date	Number of Salmon: Natural 0+	Number of Salmon: Natural > 1+	Number of Salmon: Hatchery > 1+	Snorkeled Area (m^2)	Density (fish/100m^2): Natural 0+	Density (fish/100m^2): Natural > 1+	Density (fish/100m^2): Hatchery > 1+
Marengo ⇓	TUC01	7/30	18	0	0	285.0	6.32	0.00	0.00
	TUC01A	7/30	2	0	0	318.6	0.63	0.00	0.00
	TUC02	7/30	6	0	0	517.2	1.16	0.00	0.00
	TUC02A	7/30	16	0	1	378.0	4.23	0.00	0.26
	TUC03	7/30	8	0	0	415.2	1.93	0.00	0.00
	TUC03A	7/30	3	0	0	343.8	0.87	0.00	0.00
Hartsock ⇓	TUC04	7/30	42	0	1	420.0	10.00	0.00	0.24
	TUC04A	7/30	15	0	0	212.4	7.06	0.00	0.00
	TUC05	7/30	54	0	0	324.0	16.67	0.00	0.00
	TUC05A	7/30	3	0	0	388.2	0.77	0.00	0.00
	TUC06	7/30	4	0	0	347.4	1.15	0.00	0.00
	TUC06A	7/30	26	0	0	290.4	8.95	0.00	0.00
	TUC07	7/30	14	0	0	358.2	3.91	0.00	0.00
	TUC07A	7/30	71	0	0	324.6	21.87	0.00	0.00
	TUC08	8/03	12	0	0	487.2	2.46	0.00	0.00
	TUC08A	8/03	22	3	0	390.6	5.63	0.77	0.00
	TUC09	8/03	7	0	0	397.8	1.76	0.00	0.00
	TUC09A	8/03	43	0	0	311.4	13.81	0.00	0.00
	TUC10	8/03	30	0	0	179.4	16.72	0.00	0.00
	TUC10A	8/03	35	1	0	274.8	12.74	0.36	0.00
HMA ⇓	TUC11	8/03	23	0	0	483.6	4.76	0.00	0.00
	TUC11A	8/03	54	0	1	315.0	17.14	0.00	0.32
	TUC12	8/04	24	0	0	423.6	5.67	0.00	0.00
	TUC12A	8/04	10	0	0	365.4	2.74	0.00	0.00
	TUC13	8/04	55	0	0	379.8	14.48	0.00	0.00
	TUC13A	8/04	22	0	1	455.4	4.83	0.00	0.22
	TUC14	8/04	36	0	0	280.2	12.85	0.00	0.00
	TUC14A	8/04	24	0	0	358.8	6.69	0.00	0.00
	TUC15	8/04	79	0	0	340.8	23.18	0.00	0.00
	TUC15A	8/04	31	0	0	577.2	5.37	0.00	0.00
	TUC16	8/04	11	0	1	268.8	4.09	0.00	0.37
	TUC16A	8/04	10	0	0	356.4	2.81	0.00	0.00
	TUC17	8/04	5	0	0	372.6	1.34	0.00	0.00
	TUC17A	8/04	0	0	0	437.4	0.00	0.00	0.00
	TUC18	8/04	27	0	1	296.4	9.11	0.00	0.34
	TUC18A	8/04	2	0	0	202.8	0.99	0.00	0.00
	TUC19	8/04	22	0	0	403.8	5.45	0.00	0.00
	TUC19A	8/04	36	0	0	235.2	15.31	0.00	0.00
	TUC20	8/05	7	0	0	327.6	2.14	0.00	0.00
	TUC20A	8/05	1	0	0	348.0	0.29	0.00	0.00
	TUC21	8/05	1	0	0	308.4	0.32	0.00	0.00
	TUC21A	8/05	7	0	0	347.4	2.01	0.00	0.00
	TUC22	8/04	20	6	0	314.4	6.36	1.91	0.00
	TUC22A	8/04	1	0	0	249.6	0.40	0.00	0.00
	TUC23	8/05	1	0	0	335.4	0.30	0.00	0.00
	TUC23A	8/05	1	0	0	360.6	0.28	0.00	0.00

Appendix C Table 1. Numbers and density estimates of subyearling and yearling natural salmon, and yearling hatchery chinook counted by snorkel surveys in the Tucannon River, 1998.

			Number of Salmon				Density (fish/100m²)		
			Natural		Hatchery	Snorkeled Area (m²)	Natural		Hatchery
Stratum	**Site**	**Date**	**0+**	**> 1+**	**> 1+**		**0+**	**> 1+**	**> 1+**
Wilderness	TUC24	8/05	6	3	0	229.8	2.61	1.31	0.00
⇓	TUC24A	8/05	2	0	0	257.4	0.78	0.00	0.00
	TUC25	8/05	0	0	0	268.2	0.00	0.00	0.00
	TUC25A	8/05	0	2	0	349.2	0.00	0.57	0.00
	TUC26	8/05	0	0	0	267.6	0.00	0.00	0.00
	TUC26A	8/05	0	0	0	189.6	0.00	0.00	0.00
	TUC27	8/05	0	0	0	252.0	0.00	0.00	0.00
	TUC27A	8/05	0	0	1	204.6	0.00	0.00	0.49
	TUC28	8/05	0	0	0	151.2	0.00	0.00	0.00
	TUC28A	8/05	0	0	0	173.4	0.00	0.00	0.00
Hartsock	TUCSC1	8/06	27	0	0	127.8	21.13	0.00	0.00
HMA	TUCSC2	8/12	11	0	0	54.0	20.38	0.00	0.00
Totals			**987**	**15**	**7**	**18,633.6**			

Appendix C Table 2. Numbers and density estimates of subyearling and yearling natural salmon, and yearling hatchery chinook counted by snorkel surveys in the Tucannon River, 1999.

			Number of Salmon				Density (fish/100m²)		
			Natural		Hatchery	Snorkeled Area (m²)	Natural		Hatchery
Stratum	Site	Date	0+	> 1+	> 1+		0+	> 1+	> 1+
Marengo ⇓	TUC01	08/23	1	0	0	341.4	0.29	0.00	0.00
	TUC01A	08/23	0	0	0	334.2	0.00	0.00	0.00
	TUC02	08/23	0	0	0	298.8	0.00	0.00	0.00
	TUC02A	08/23	0	0	0	515.4	0.00	0.00	0.00
	TUC03	08/05	0	0	0	384.6	0.00	0.00	0.00
	TUC03A	08/05	0	0	0	345.0	0.00	0.00	0.00
Hartsock ⇓	TUC04	08/05	3	0	0	457.8	0.66	0.00	0.00
	TUC04A	08/05	1	0	0	285.6	0.35	0.00	0.00
	TUC05	08/05	7	0	0	335.4	2.09	0.00	0.00
	TUC05A	08/05	0	0	0	389.4	0.00	0.00	0.00
	TUC06	08/05	0	0	0	354.6	0.00	0.00	0.00
	TUC06A	08/05	7	0	0	340.2	2.06	0.00	0.00
	TUC07	08/05	5	0	0	651.6	0.77	0.00	0.00
	TUC07A	08/05	49	0	0	342.0	14.33	0.00	0.00
	TUC08	08/24	0	0	0	303.6	0.00	0.00	0.00
	TUC08A	08/24	14	0	0	262.8	5.33	0.00	0.00
	TUC09	08/05	13	0	0	366.0	3.55	0.00	0.00
	TUC09A	08/30	3	0	0	302.4	0.99	0.00	0.00
	TUC10	08/05	9	0	0	190.2	4.73	0.00	0.00
	TUC10A	08/05	11	0	1	287.4	3.83	0.00	0.35
HMA ⇓	TUC11	08/05	10	0	0	516.0	1.94	0.00	0.00
	TUC11A	08/05	15	1	0	378.6	3.96	0.26	0.00
	TUC13	08/05	13	3	0	381.6	3.41	0.79	0.00
	TUC13A	08/05	5	0	1	435.6	1.15	0.00	0.23
	TUC14	08/09	9	3	2	331.2	2.72	0.91	0.60
	TUC14A	08/09	3	0	0	570.0	0.53	0.00	0.00
	TUC16	08/09	6	0	0	305.4	1.96	0.00	0.00
	TUC16A	08/09	0	0	0	370.2	0.00	0.00	0.00
	TUC17	08/09	0	0	0	459.0	0.00	0.00	0.00
	TUC17A	08/09	1	0	0	580.8	0.17	0.00	0.00
	TUC19	08/09	8	0	0	404.4	1.98	0.00	0.00
	TUC19A	08/09	0	0	0	259.2	0.00	0.00	0.00
	TUC20	08/09	0	0	0	332.4	0.00	0.00	0.00
	TUC20A	08/09	0	0	0	361.8	0.00	0.00	0.00
	TUC21	08/09	14	12	0	368.5	3.80	3.26	0.00
	TUC21A	08/09	1	0	0	264.2	0.38	0.00	0.00
	TUC22	08/09	0	2	0	384.0	0.00	0.52	0.00
	TUC22A	08/09	0	0	0	286.2	0.00	0.00	0.00
	TUC23	08/09	0	0	0	335.4	0.00	0.00	0.00
	TUC23A	08/24	0	0	0	335.4	0.00	0.00	0.00
Wilderness ⇓	TUC24	08/24	0	0	0	256.2	0.00	0.00	0.00
	TUC24A	08/24	0	0	0	268.8	0.00	0.00	0.00
	TUC25	08/24	0	0	0	274.2	0.00	0.00	0.00
	TUC25A	08/24	0	0	0	351.0	0.00	0.00	0.00
	TUC26	08/24	0	0	0	210.6	0.00	0.00	0.00
	TUC26A	08/24	0	0	0	233.4	0.00	0.00	0.00

Appendix C Table 2. Numbers and density estimates of subyearling and yearling natural salmon, and yearling hatchery chinook counted by snorkel surveys in the Tucannon River, 1999.

			Number of Salmon				Density (fish/100m²)		
			Natural		Hatchery	Snorkeled Area (m²)	Natural		Hatchery
Stratum	Site	Date	0+	> 1+	> 1+		0+	> 1+	> 1+
	TUC27	08/24	0	0	0	187.8	0.00	0.00	0.00
	TUC27A	08/24	0	0	0	208.2	0.00	0.00	0.00
	TUC28	08/30	0	0	0	336.0	0.00	0.00	0.00
HMA	TUC28A	08/30	0	0	0	178.8	0.00	0.00	0.00
HMA	TUCSC2	08/30	0	0	0	115.1	0.00	0.00	0.00
Lower	TUCSC3	08/30	0	0	0	25.7	0.00	0.00	0.00
⇓	TUC A	08/23	0	0	0	447.6	0.00	0.00	0.00
	TUC B	08/23	0	0	0	322.8	0.00	0.00	0.00
	TUC C	08/23	5	0	0	389.4	1.28	0.00	0.00
	TUC D	08/23	0	0	0	324.6	0.00	0.00	0.00
	TUC E	08/23	2	0	0	375.0	0.53	0.00	0.00
	TUC F	08/23	1	0	0	397.2	0.25	0.00	0.00
Totals			**216**	**21**	**4**	**19,650.7**			