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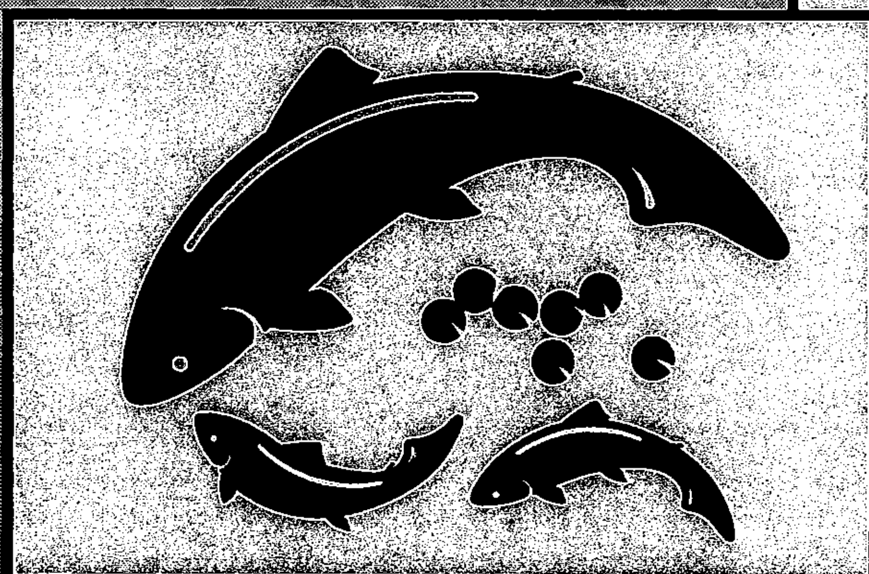
Tucannon River Spring Chinook Salmon Hatchery Evaluation Program

2000 Annual Report



by Michael P. Gallinat, Joseph Bumgarner, Lance Ross and Michelle Varney

Washington Department of FISH AND WILDLIFE
Fish Program
Science Division

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We would like to express sincere gratitude to Butch Harty, Lyons Ferry Complex Manager, for his coordination efforts. We thank Hatchery Specialists Doug Maxey, Bruce Walters and Steve Jones for their cooperation with hatchery sampling, providing information regarding hatchery operations and hatchery records, and their input on evaluation and research activities. We also thank all additional hatchery personnel who provide the day-to-day care of the spring chinook and for their assistance with hatchery spawning, sampling, and record keeping.

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Abstract

Lyons Ferry Hatchery (LFH) and Tucannon Fish Hatchery (TFH) were built/modified under the Lower Snake River Fish and Wildlife Compensation Plan. One objective was to compensate for the estimated annual 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 2000 to April 2001.

Two hundred five fish were captured in the TFH trap in 2000 (18 natural adults, 7 natural jacks, 169 hatchery adults, and 11 hatchery jacks); 81 were collected and hauled to LFH for broodstock and the remaining fish were passed upstream. Seventeen externally marked (AD/LV or LV) stray fish were removed from the river at the TFH trap and killed to prevent possible interbreeding with wild stock. Two of the natural origin fish collected for broodstock were determined to be hatchery origin by scale pattern analysis.

During 2000, three salmon that were collected for broodstock died. Prespawning mortality 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 2000 at LFH occurred between August 29 and September 19, with peak eggtake on September 5. A total of 128,980 eggs were collected. Egg mortality to eye-up was 2,639 eggs, with an additional loss of 3,028 sac-fry. Total fry ponded for production in the rearing ponds was 123,313. Twelve mature 1997 brood year females from the captive broodstock program were spawned in 2000. Mean fecundity was 1,298 eggs/female based on 11 fully spawned females; egg survival was 47.3%. During spawning in 2000, we collected and cryogenically preserved semen from four natural origin salmon.

Two radio tagged fish (one wild and one hatchery female tagged at Bonneville Dam) that entered the Tucannon River were tracked in 2000. Both fish spawned below the adult trap and their carcasses were recovered.

WDFW staff conducted spawning ground surveys in the Tucannon River between August 29 and September 27 in 2000. Forty-five redds and 31 carcasses were found above the adult trap and 47 redds and 44 carcasses were found below the trap in 2000. Based on annual redd counts, broodstock collection, and in-river pre-spawning mortalities, the estimated escapement for 2000 was 339 fish (306 adults and 33 jacks).

Length and weight samples were collected twice during the rearing cycle for 1999 BY juveniles at TFH and Curl Lake Acclimation Pond. All 1999 BY juveniles were marked (AD clip and coded- wire tag) in September at LFH, transported to TFH in October, and transported again in February to Curl Lake for acclimation and volitional release during March and April.

Snorkel surveys were conducted during the summer of 2000 to determine the population of subyearling and yearling spring chinook in the Tucannon River. We estimated 15,944 subyearlings (BY 1999) and 361 yearlings (BY 1998) were present in the river. Evaluation staff also operated a downstream migrant trap. During the 1999/2000 outmigration, we estimated that 5,508 (BY 1998) wild spring chinook smolts migrated from the Tucannon River.

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 survival is nearly three times above it. Due to the low SAR for hatchery fish, and below replacement level of natural 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 1975). 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 estimated annual 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 2000 through April 2001.

Facility Descriptions

Lyons Ferry Hatchery is located on the Snake River (rkm 90) at its confluence with the Palouse River (Figure 1). It 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. Tucannon Fish Hatchery, located at rkm 59 on the Tucannon River, has an adult collection trap on site (Figure 1). Juveniles rear at TFH through winter. In February, the fish are transported to Curl Lake Acclimation Pond (AP) and volitionally released. The yearly 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 approximately 622 rkm from the mouth of the Columbia River (Figure 1). Stream elevation rises from 150 m at the mouth to 1,640 m at the headwaters (Bugert et al. 1990). Total watershed area is approximately 1,295 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. Land use in the Tucannon watershed is approximately 37% cropland, 35% rangeland, and 27% forest (McCullough 1999). Five unique strata have been distinguished by predominant land use, habitat, and landmarks (Table 1).

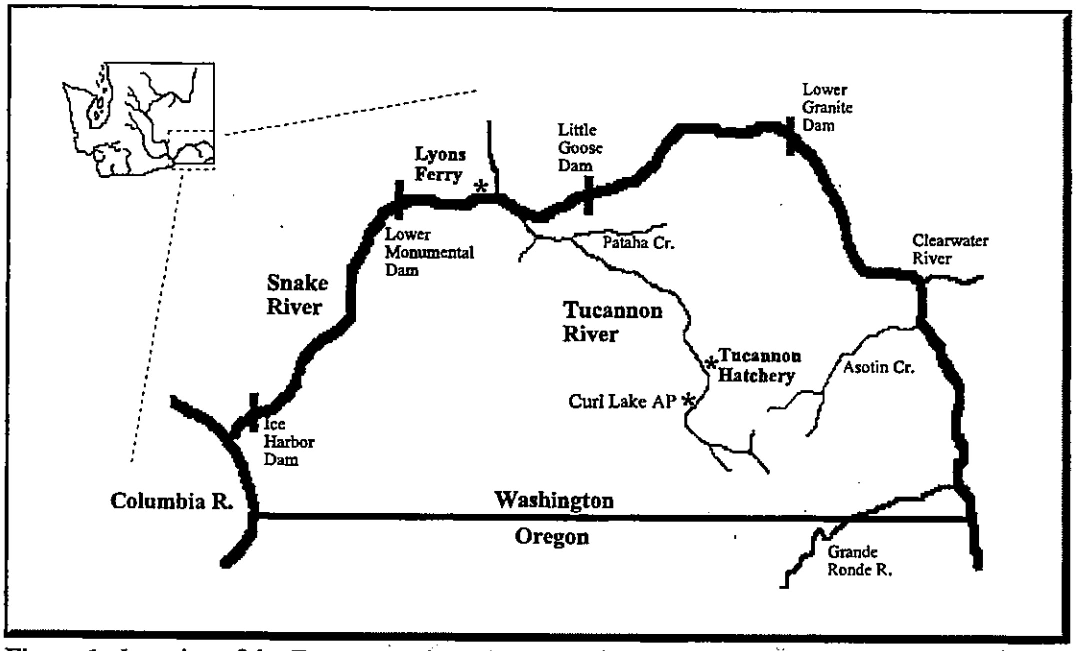

Figure 1. Location of the Tucannon River, Lyons Ferry, and Tucannon hatcheries within the Snake River Basin.

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

Program staff deployed 22 continuous recording thermographs throughout the Tucannon River to monitor daily minimum and maximum water temperatures (temperatures are recorded every 1 to 1.2 hours) from May through September. Data from each of these water temperature recorders are kept on an electronic file in our Dayton office. During 2000, maximum temperatures near the mouth (rkm 3) of the Tucannon River reached 80°F (26.7°C) on 4 different days. Maximum temperatures where spring chinook juveniles were rearing during the hottest part of the summer ranged from 60°F (15.6°C) in the upper HMA Stratum (rkm 74.5) to 73°F (22.8°C) in the lower Hartsock Stratum (rkm 43.3) (Figure 2).

The upper lethal temperature for chinook fry is 77.2°F (25.1°C) while the preferred temperature range is 53.6-57.2°F (12-14°C) (Scott and Crossman 1973). The optimum range of temperature in freshwater, which controls the rate of growth and survival of young, is 55.4-62.6°F (13-17°C)

(Becker 1983). Theurer et al. (1985) estimated that spring chinook production in the Tucannon River would be zero for all stream reaches having maximum daily July water temperatures greater than 75°F (23.9°C) (or average mean temperature of 68.0°F (20°C)). Based on the preferred and optimum temperature limits, fish returning to the upper watershed have the best chance for survival, and recovery efforts should be maximized in this area (Figure 2).

It is hoped that recent initiatives to improve habitat within the Tucannon Basin, such as the Tucannon River Model Watershed Program, will, 1) restore and maintain natural stream stability, 2) reduce water temperatures, 3) reduce upland erosion and sediment rates, and 4) improve and re-establish riparian vegetation. Theurer et al. (1985) estimated that improving riparian cover and channel morphology in the Tucannon River mainstem would increase chinook rearing capacity by a factor of 2.5. Habitat restoration efforts should permit increased utilization of habitat by spring chinook salmon in the marginal sections of the middle reaches of the Tucannon River and increase fish survival.

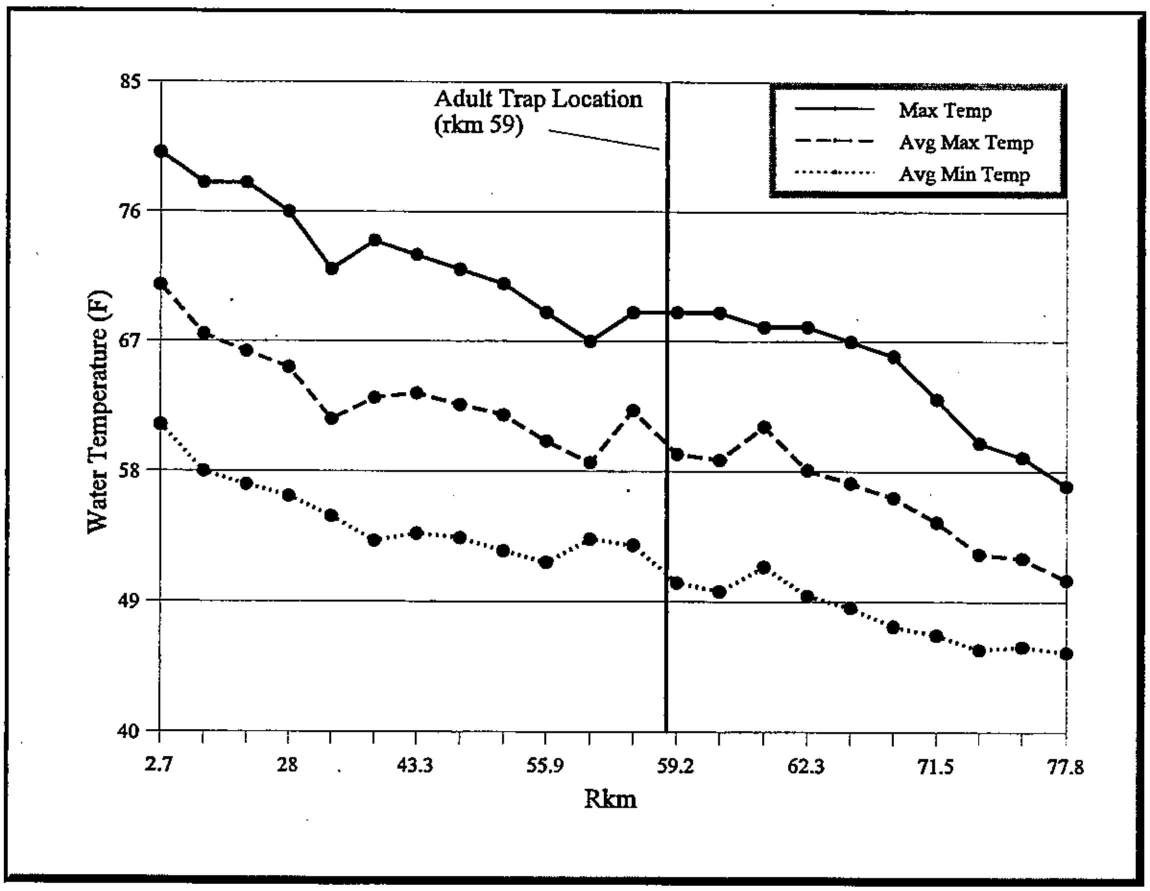

Figure 2. Maximum temperature, average maximum temperature, and average minimum temperature recorded by thermographs at 22 selected sites along the Tucannon River, May-September, 2000.

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.

The TFH adult trap began operation in February with the first spring chinook captured May 3. The trap was operated through November. A total of 205 fish entered the trap (18 natural adults, 7 natural jacks, 169 hatchery adults, and 11 hatchery jacks), and 81 were collected and hauled to LFH for broodstock (Table 2, Appendix A). Fish not collected for broodstock were passed upstream. Adults collected for broodstock were injected with erythromycin and oxytetracycline (0.5 ml/4.5 kg); jacks were given half dosages. Fish received formalin drip treatments during holding at 1 mg/7,000 L every other day at LFH to control fungus.

From previous years trapping data, we anticipated that externally marked stray salmon (AD/LV or LV fin clipped) fish would arrive at the TFH trap. WDFW fish management and the co-managers (Umatilla Tribe and Nez Perce Tribe) decided prior to broodstock trapping that externally marked stray fish would be removed from the river and killed, with the carcasses returned to the river for nutrient enhancement. This would prevent accidental collection of these fish for the hatchery broodstock, and also remove them from the river where they might spawn with Tucannon origin fish. TFH personnel removed 17 stray (LV or AD/LV) fish in 2000.

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 1986-2000.

	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
2000 [c]	25	180	0	17	12	69	13	94

[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.
[c] 17 stray LV and ADLV fish were killed at the trap.

Broodstock Mortality

Three of the 81 salmon (3.7%) collected for broodstock died (Table 3) in 2000. All prespawning mortalities were frozen and retained until spawning was completed for nutrient enrichment in the Tucannon River. Table 3 shows that prespawning mortality in 2000 was comparable to the mortality documented since broodstock began being held at LFH in 1992. Higher mortality was experienced when fish were held 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 (1992-2000).

	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	3.8
2000	0	0	0	0.0	1	2	0	3.7

Broodstock Spawning

Spawning at LFH occurred once a week from August 29 to September 19, with peak eggtake on September 5. A total of 128,980 eggs were collected (Table 4). Percent mortality to eye-up was 2.0% with an additional 2.4% loss of sac-fry, which left 123,313 fish for production.

Chilled water was not used on the spring chinook eggs in 2000. Costs associated with chiller operation and maintenance, and concerns about reduced survival have convinced managers to discontinue use of the chiller at this time. Feeding strategies and feed types will be modified to achieve the release size goal. Based on the mortality rates in eggs from 1999 and 2000 eggtakes, not using chilled water has been beneficial, as mortality to eye-up has been 2% for both years. This is compared to 76% in 1997 and 12% in 1998 using chilled water. Fungus on the incubating eggs was controlled with formalin applied every other day at 1 mg/700 L.

To prevent any stray fish from contributing to the population, all externally marked (AD/RV, AD/LV, or LV, RV clipped) stray fish were removed from the broodstock collected and all coded wire tags from AD clipped fish were read before spawning. One Klickitat origin AD clipped female (CWT 63/63/30) was spawned with a Tucannon origin male. According to the spawning protocol, eggs that are fertilized by stray fish need to be destroyed. Unfortunately, due to an oversight, these fish were retained (3,631 eggs), and are now part of the production fish which will be released in 2002.

Table 4. Number of fish spawned, estimated egg collection, and egg mortality of Tucannon River spring chinook salmon at LFH in 2000.

	Natural			Hatchery		
Spawn Date	**Male**	**Female**	**Eggs Taken**	**Male**	**Female**	**Eggs Taken**
8/29		1	3,618	6	5	17,071
9/05	2[a]	1	5,255	13	14[b]	50,749
9/12	2			7	11	34,471
9/19	1	1	3,033	4	5	14,783
Totals	**5**	**3**	**11,906**	**30**	**35**	**117,074**
Egg Mortality			245			2,394

[a] One wild male was live spawned on 9/05 and spawned again on 9/19.
[b] Stray fish found in broodstock, 9/05 - 1 Klickitat female (spawned).

Twelve mature 1997 brood year females from the captive broodstock program were spawned in 2000. Mean fecundity was 1,298 eggs/female based on 11 fully spawned females. Egg survival was 47.3%. High egg mortality was most likely related to age of spawners and was expected for 3-year old captive brood females. Production of 3-year old females is not a goal for the program. The Tucannon River captive broodstock program was funded through BPA and results achieved to date are more thoroughly described in the annual Tucannon River Spring Chinook Captive Broodstock Report (Bumgarner and Gallinat 2001).

Cryopreservation

During spawning in 2000, evaluation staff collected and cryogenically preserved semen from four natural origin salmon (Table 5). The 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 test will allow managers to make the best use of cryopreserved semen on hand to maximize survival in the hatchery program. We will continue to evaluate the need to collect semen for the future.

Table 5. Natural-origin Tucannon River spring chinook semen cryogenic samples collected during September, 2000.

Date Frozen	Male ID #	Fork Length	Brood Year	Genetic Number	Straws Frozen: Regular	Straws Frozen: Test	Sperm Motility (%)
9/12	WM3	75	96	BB25	7	4	90
9/12	WM4	56	97	BC45	10	4	90
9/12	WM5	74	96	BB18	10	4	90
9/19	WM7	78	96	BB32	10	4	90

Radio Tracking

Two radio tagged fish that entered the Tucannon River were tracked in 2000 (Table 6; Appendix B). These fish were tagged by the University of Idaho at Bonneville Dam. Migration speed after river entry, timing and movements upstream, and if possible, spawning success, were documented every 2-3 days. WDFW did not radio tag any spring chinook in the Tucannon River in 2000 due to the small run size.

Table 6. Radio tagging and recovery data of spring chinook salmon from the Tucannon River in 2000 for the University of Idaho study.

Channel/ Code	Tagging Information: Date	Origin	Sex	FL (cm)	VI tag	Recovery Data: Date	Sex	FL (cm)	Spawned
18/48[a]	4/12	Wild	M	67.5	A89	9/15	F	68.0	Yes
24/54[a]	4/28	Hatchery	M	69.5	F62	9/08	F	69.0	Yes

[a] Fish was identified as male at tagging, but was confirmed the opposite sex upon carcass recovery.

Mean travel time from the lower river to rkm 57 (about 1 kilometer below the Tucannon Hatchery) was 0.49 rkm/day for radio tagged fish 18/48. This travel rate was slower than upstream migration rates documented in other years (Mendel et al. 1993; Bumgarner et al. 1997). This was due to the fish holding in the river at rkm 52-54. Travel rate from the lower river could not be determined for radio tagged fish 24/54 as the fish was first detected at rkm 46. From initial detection in the river it traveled at a rate of 1.0 rkm/day to rkm 57.

Radio tagged fish 24/54 was a hatchery female and spent most of the summer directly across from the TFH (rkm 58) (Figure 3). It suddenly moved downstream and spawned approximately 3.2 km below the hatchery. The second radio tagged fish 18/48, which was a wild female, had been holding approximately 3.2 km below the hatchery before it moved upstream where it eventually spawned about 250 meters below the TFH adult trap (rkm 59). The radio receiver, which had been located at the adult trap, was downloaded and confirmed that this fish went to the trap entrance and stayed for about three hours before it returned downstream to spawn.

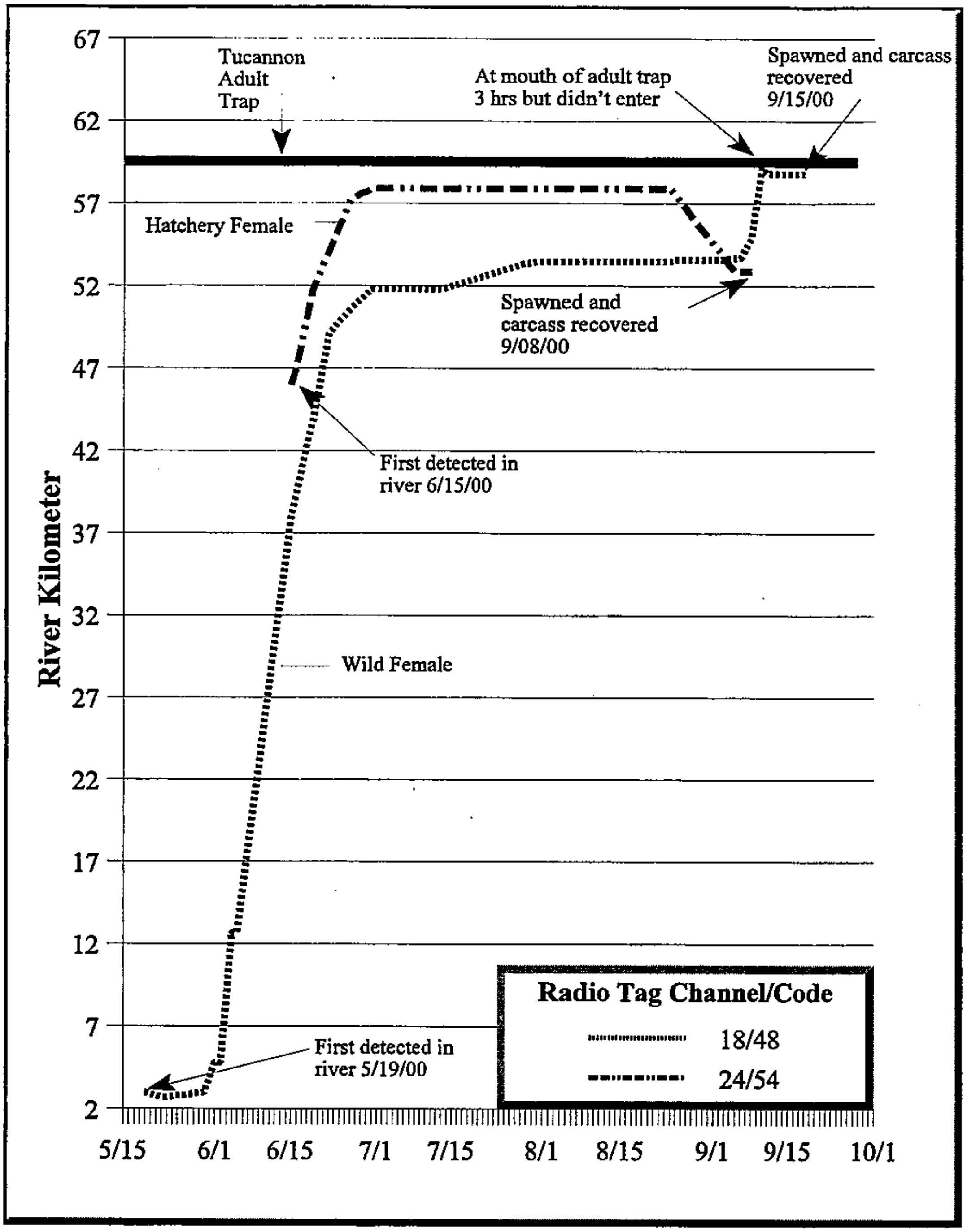

Figure 3. Movements of two radio tagged spring chinook salmon in the Tucannon River, 2000 (based on data collected and presented in Appendix B of this report).

Natural Spawning

Spawning ground surveys were conducted on the Tucannon River weekly from August 29 to September 27, 2000 to determine the temporal and spatial distribution of spawners. Ninety-two redds were counted and 23 natural and 52 hatchery origin carcasses were recovered (Table 7). Forty-five redds and 31 carcasses were found above the adult trap. In 2000, 46% 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, 2000. (The Tucannon Hatchery adult trap is located at rkm 59.)

Stratum	Rkm[a]	Number of redds	Carcasses Recovered	
			Natural	Hatchery
Wilderness	78-84	0	0	0
	74-78	4	2	0
HMA	73-74	2	0	3
	68-73	14	0	6
	66-68	6	0	5
	62-66	16	2	10
	59-62	3	0	3
	56-59	27	11	19
Hartsock	52-56	15	6	5
	47-52	5	2	1
	43-47	0	0	0
	40-43	0	0	0
Marengo	34-40	0	0	0
Totals	34-84	92	23	52

[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 the program's inception in 1985, redd concentrations have shifted downstream. Also, redd densities (redds/km) have declined in recent years (Table 8) due to low returns and a greater emphasis on broodstock collection to keep the spring chinook population above extinction. Number of redds in 2000 increased 124% from 1999 levels and 254% from 1998, but are still below the mean number of redds found from 1985-1993 (162 redds/year).

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, 1985-2000.

	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	1 (0.1)	34 (1.8)	6 (0.4)	0 (0.0)	41	3	7.3	38	92.7
2000	4 (0.4)	68 (3.6)	20 (1.3)	0 (0.0)	92	45	48.9	47	51.1

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

Genetic Sampling

No electrophoretic samples were collected from spring chinook recovered in the river or from the hatchery during spawning in 2000. We collected 106 DNA samples from adult salmon (43 natural origin and 63 hatchery origin). These samples have been sent to the WDFW genetics lab in Olympia for analysis.

Age Composition, Length Comparisons, and Fecundity

One objective of the monitoring program is to track the age composition of each year's return. This allows us to annually compare ages of 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 4). This difference is likely due to smolt size at release (hatchery origin smolts are generally 25-30 mm greater in length than natural smolts).

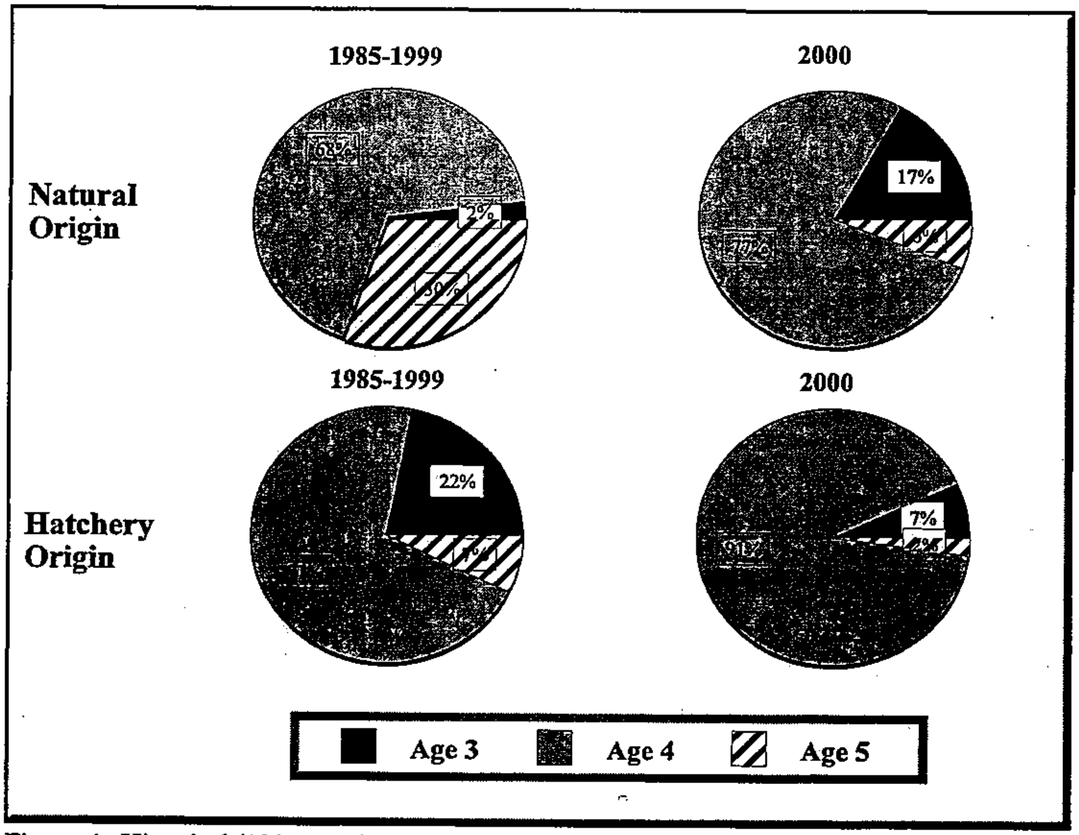

Figure 4. Historical (1985-1999), and 2000 age composition for spring chinook in the Tucannon River.

Age at return during 2000 was not similar to historical data for natural origin fish. Natural returns had more 3 year old, and fewer 5 year old fish than what is typically observed. The increased number of natural jacks could indicate an improved return of natural fish in 2001. Age composition of hatchery fish had fewer age 3 and age 5 fish than historically.

Another comparison we conduct on returning adult natural and hatchery origin fish is the difference between mean post-eye to hypural-plate lengths. 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 5, 6, 7 and 8). However, overall for all combined return years, there is no difference in mean length between natural and hatchery origin fish, even though they migrate as smolts at significantly different sizes (Bugert et al. 1990; Bugert et al. 1991).

Fecundities (number of eggs/female) of natural and hatchery origin fish from the Tucannon River program have been documented since 1990 (Table 9). A one-way analysis of variance was performed to determine if there were significant differences in mean fecundities at the 95% confidence level. Natural origin females had significantly higher fecundities than hatchery origin fish for both Age 4 ($P<0.001$) and 5 year old fish ($P<0.001$).

Mean size of natural origin eggs in age 4 spring chinook from the Tucannon River averaged 0.212 g/egg and hatchery origin eggs averaged 0.223 g/egg. This difference was statistically significant at the 95% confidence level ($P<0.001$). This may help explain why hatchery origin females are less fecund. Mean egg size in Age 5 salmon was 0.253 g/egg for natural origin and 0.270 g/egg for hatchery origin females, but the difference was not significant ($P= 0.87$).

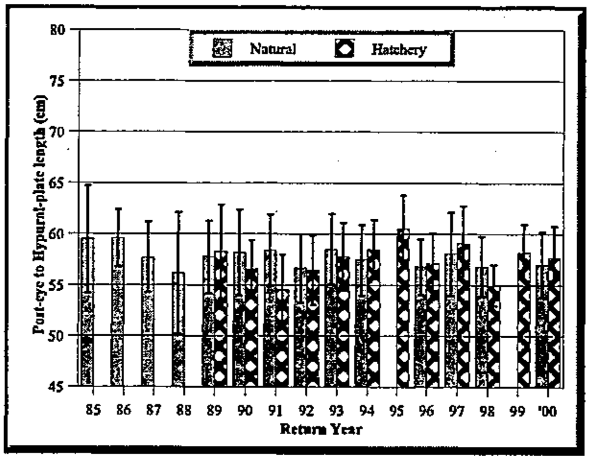

Figure 5. Mean length and SD of Age 4 females.

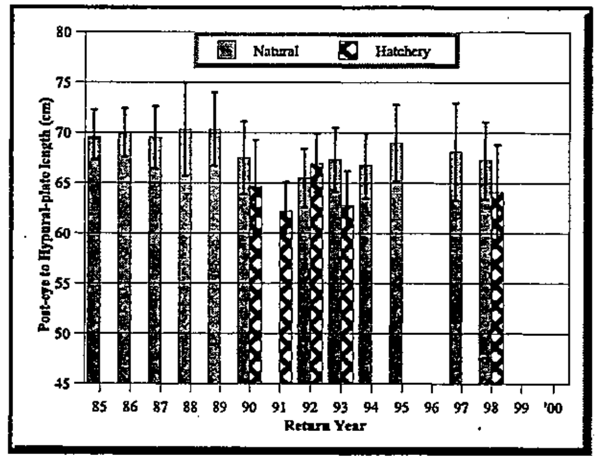

Figure 6. Mean length and SD of Age 5 females.

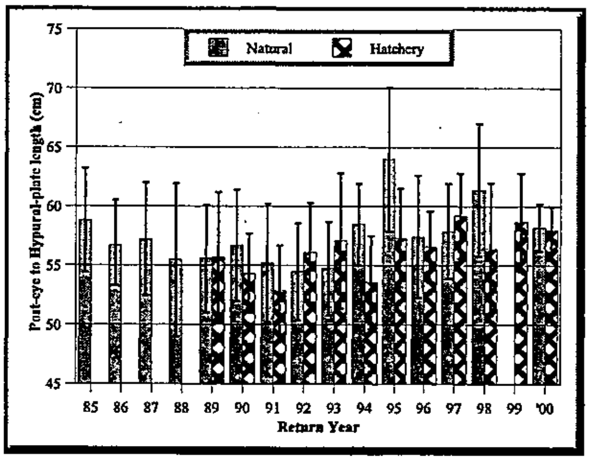

Figure 7. Mean length and SD of Age 4 males.

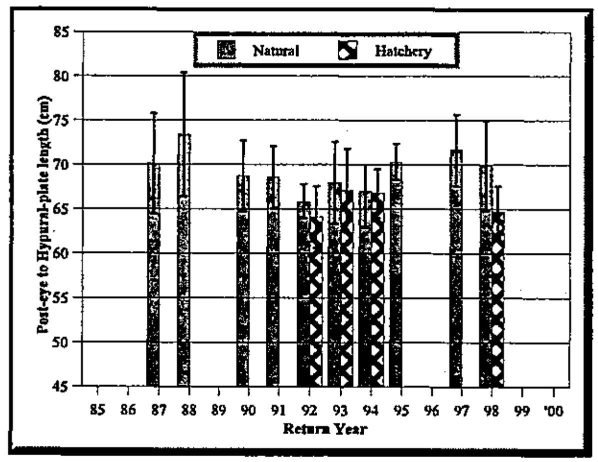

Figure 8. Mean length and SD of Age 5 males.

Table 9. Average number of eggs/female (n, SD) by age group of Tucannon River natural and hatchery origin broodstock, 1990-2000.

	Age 4		Age 5	
Year	Natural	Hatchery	Natural	Hatchery
1990	3,691 (13, 577.3)	2,794 (18, 708.0)	4,383 (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)
2000	4,144 (2, 1,571.2)	3,320 (34, 553.6)	3,618 (1, 000.0)	4,208 (1, 000.0)
Mean	3,592	3,164	4,337	3,463
SD	593.0	668.5	868.1	614.4

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). Stray fish were predominately from the Umatilla River, Oregon and are discussed in more detail in a later section of this report. In 2000, based on the estimated escapement of fish to the river, we sampled approximately 51.0% of the run (Table 11).

Table 10. Coded-wire tag codes of hatchery salmon sampled at LFH and the Tucannon River, 2000.

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
63-03-59	1		6			4	11
63-03-60	1		11			9	21
63-59-36			2				2
63-61-24	1		13			10	24
63-61-25			22		1 [a]	16	39
63-61-32			3			1	4
-Strays-							
09-22-59		4					4
09-22-60		1					1
09-22-62						1	1
10-51-37						1	1
63-63-30			1				1
63-63-21						1	1
LV		12				6	18
Lost tags			3				3
No tags[b]		1	4			2	7
Total	**3**	**18**	**65**	**0**	**1**	**51**	**138**

[a] Poached fish found on shore.
[b] Includes 3 wild origin fish later confirmed to be hatchery origin fish based on scale pattern analysis.

Table 11. Spring chinook salmon (natural and hatchery) sampled from the Tucannon River, 2000.

	2000		
	Natural	**Hatchery**	**Total**
Total escapement to river	*82*	*257*	*339*
Broodstock collected	12	69	81
Fish dead in adult trap	0	17*	17
Total hatchery sample	12	86	98
Total fish left in river	*70*	*169*	*239*
In-river prespawn mortality	0	1	1
Spawned carcasses recovered	23	51	74
Total river sample	23	52	75
Carcasses sampled	**35**	**138**	**173**

*17 strays killed outright at trap.

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 during 2000 was slightly later for natural fish and earlier for hatchery fish as compared to previous years. Peak spawning date of hatchery fish in 2000 was also slightly earlier than in previous years, although within the range found from previous years. The duration of active spawning in the Tucannon River was also similar to previous years.

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, 1986-2000.

	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
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
Mean	**5/31**	**6/05**	**9/12**	**9/12**	**28**	**9/15**	**35**
2000	6/06	5/22	–	9/05	22	9/13	30

[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). For 2000, 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 2000 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 2000 was estimated at 339 fish (306 adults and 33 jacks).

Table 13. Estimated spring chinook salmon escapement to the Tucannon River, 1985-2000.							
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
2000	92	2.60	239	81	2	339	24

[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 (Bumgarner et al. 2000). Through 1998 the incidence of stray spring chinook salmon was negligible (Table 14). However, in 1999, Umatilla River strays accounted for 8% of the total Tucannon River run, and that rate increased to 12% in 2000. The increase in the number of strays, particularly 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 (NMFS). Beginning with the 1997 brood year releases, the Oregon Department of Fish and Wildlife (ODFW) and Confederated Tribes of the Umatilla Indian Reservation (CTUIR) ceased marking Umatilla River origin spring chinook with an RV or LV fin clip (65-70% of releases). Because of this action, age 3 fish that returned in 2000 were not distinguishable from wild origin spring chinook from the Tucannon River. This forced WDFW to kill and examine all age 3 fish and exclude them from the broodstock in 2000. This problem is expected to be compounded in the future as more brood years of unmarked Umatilla strays enter the Tucannon River and mix with returning wild spring chinook. It is imperative that hatchery origin spring chinook in the Umatilla program be 100% marked to ensure that genetic integrity can be maintained for ESA listed spring chinook in the Tucannon River.

Table 14. Summary of stray hatchery origin spring chinook salmon which escaped into the Tucannon River (1990-2000).

Year	CWT Code or Fin clip	Agency	Origin (stock)	Release Location / Release River	Number Observed/ Expanded [a]	% 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	
				Total Strays	**14**	**1.9**
				Total Umatilla River	**5**	**0.7**
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	
				Total Strays	**10**	**1.3**
				Total Umatilla River	**4**	**0.5**
1993	075110	ODFW	Lookingglass Cr.	Meacham Cr. / Umatilla River	1 / 2	
				Total Strays	**2**	**0.3**
				Total Umatilla River	**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	
				Total Strays	**3**	**1.2**
				Total Umatilla River	**3**	**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	
				Total Strays	**9**	**2.6**
				Total Umatilla River	**5**	**1.4**
1999	091751	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	2 / 3	
	092258	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	1 / 1	
	104626	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	
				Total Strays	**20**	**8.2**
				Total Umatilla River	**19**	**7.8**
2000	092259	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	4 / 4	
	092260	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	1 / 1	
	092262	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	1 / 3	
	105137	IDFG	Powell	Walton Creek/ Lochsa R.	1 / 3	
	636330	WDFW	Klickitat (Wash.)	Klickitat Hatchery	1 / 1	
	636321	WDFW	LFH Fall Chinook	Lyons Ferry / Snake River	1 / 1	
	LV clip	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	18 / 31	
	No Ad	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	2 / 2	
				Total Strays	**46**	**13.6**
				Total Umatilla River	**41**	**12.1**

[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

All 1999 BY juveniles were adipose clipped and tagged with CWT's on September 19-22, 2000. After tagging, LFH personnel transported 104,927 fish to TFH on October 16-18. Fish were placed into Pond A (main raceway) at TFH.

Length and weight samples were collected only twice on the 1999 BY fish due to an outbreak 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 February 7 for the 1999 BY noted that fish were relatively fat, with a mean condition factor (K) of 1.30 (Table 15). Hatchery managers were notified and feeding rates were adjusted. Samples were collected again at Curl Lake as the outmigration started. Fish were very large and exceeded the release goal of 15 fish/lb. Adjustments to the rearing regime will need to be made with future production to achieve the size at release goal.

Table 15. Summary of sample sizes (N), mean lengths, coefficient of variations (CV), condition factors (K), and fish/lb (FP) of 1999 BY juveniles sampled at TFH and Curl Lake.

Brood Date	Sample Location	Pond	N	Mean Length	CV	K	FPP
1999							
2/07/01	TFH	Main (A)	200	130.7	10.6	1.30	15.1
4/09/01	Curl Lake	Curl Lake	204	151.6	11.7	1.16	10.9

1999 Brood Release

A total of 99,275 1999 BY juveniles were transported to Curl Lake AP in mid-February, 2000. The volitional release began on March 19, and continued until April 25 when fish were forced out, with an estimated release of 97,600 fish (Table 16).

Table 16. Summary of yearling spring chinook released from Curl Lake Acclimation Pond in the Tucannon River, 1999 BY.

Release Year (BY)	Release Dates	CWT Code	AD + CWT	CWT only	AD only	Total Released	Lbs	Fish/lb
2001 (99)	3/19-4/25	63-02-75	94,647	2,089	864	97,600	9,207	10.6

Natural Parr Production

Program staff surveyed the Tucannon River at index sites in 2000 to estimate the density and population of subyearling (Table 17, 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. Thirty-two sites were snorkeled in 2000 (July 31 to August 24). Total area snorkeled was approximately 3.2% of the suitable rearing habitat in the Tucannon River. A total of 569 subyearling and 13 yearling spring chinook were counted during the surveys. We estimated that 15,944 (+/- 7,945) subyearling and 361 (+/- 382) yearling chinook were present in the river.

Table 17. Number of sites, area snorkeled, population estimates, and 95% confidence intervals for subyearling and yearling spring chinook within the Tucannon River, 2000.

Stratum	Number of sites	Area (m^2) snorkeled	Subyearling Estimate	Subyearling C.I.	Yearling Estimate	Yearling C.I.
Lower	--	--	--	--	--	--
Marengo	3	1,750	275	345	--	--
Hartsock	11	7,577	9,790	5,987	53	71
HMA	13	7,148	5,457	5,865	308	361
Wilderness	5	1,937	422	388	--	--
Total	**32**	**18,412**	**15,944**	**7,945**	**361**	**382**

Natural Smolt Production

Program staff operated a 5 ft rotary screw trap nearly continuously at rkm 3 on the Tucannon River from October 3, 1999 to June 29, 2000 to estimate numbers of migrating natural and hatchery spring chinook. The smolt trap was pulled for seven days during the trapping season (11/27/99 and 12/23/99-12/28/99). 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. Those data are available upon request.

We examined the influence of specific abiotic variables on spring chinook emigration during the last three trapping seasons (1997/1998 to 1999/2000) using correlation analysis. Significant relationships were found between the total number of wild spring chinook smolts captured ($\log_{10}$ transformed for normality) emigrating from the Tucannon River and flow (ft^3/sec) ($r^2 = 0.06$, $P < 0.05$), staff gauge level ($r^2 = 0.09$, $P < 0.05$), time of year ($r^2 = 0.17$, $P < 0.01$), and water temperature ($r^2 = 0.05$, $P < 0.10$). Although these variables are statistically significant, they account for only a small amount of the variability in the number of emigrating fish. This is understandable as smoltification is a physiological process and the resulting outmigration may only be slightly influenced by abiotic factors. No statistically significant relationships were found between the number of wild spring chinook smolts and air temperature or turbidity.

Similarly, no significant relationships were found between the total number of hatchery spring chinook smolts captured (log_{10} transformed) and flow, staff gauge level, time of year, water temperature, air temperature, or turbidity.

Each week we attempted to determine trap efficiency by clipping a portion of the caudal fin on a few representative captured migrants and releasing them about one kilometer upstream. The percent of marked fish recaptured was used as an estimate of weekly trapping efficiency. To calculate trapping efficiency during weeks when low numbers of fish were caught we examined the relationship between trap efficiency and the variables flow, staff gauge, number of fish captured, water temperature, and time of year (week). There was a statistically significant relationship between trap efficiency for wild spring chinook and time of year at the 95% confidence level ($r^2 = 0.17$). No statistically significant relationship was found between trap efficiency for hatchery spring chinook and any of the variables examined. Despite the lack of statistical significance, we believe that trap efficiency decreases as flow increases.

Flow is the dominant factor affecting downstream migrant trapping operations in any system according to Seiler et al. (1999). Groot and Margolis (1991) state that the rate of downstream migration of chinook fingerlings appears to be both time and size dependent and may also be related to river discharge and the location of fish in the river. They state that during years of low and stable river flow, the rate of downstream migration was negatively correlated with discharge, whereas, when flows were higher and more variable, the rate of migration was positively correlated with discharge.

Mean daily flow data was provided by the U.S.G.S. gauge at Starbuck, WA (rkm 12.7). Correlation analysis indicated a statistically significant relationship between flow and the staff gauge level at the smolt trap at the 99% confidence level ($r^2 = 0.93$). As the U.S.G.S. flow data is computer monitored on a continuous basis, is in relatively close proximity to the smolt trap, and there was a strong statistically significant relationship between the variables, we estimated trap efficiencies with the following equations:

<u>Wild Spring Chinook</u>

Trap Efficiency = 33.529 - 0.041 (Flow)

<u>Hatchery Spring Chinook</u>

Trap Efficiency = 30.073 - 0.071 (Flow)

To estimate potential juvenile migrants passing when the trap was not operated, such as periods when freshets washed out large amounts of debris from the river, we calculated the average number of fish trapped for three days before and three days 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 number of fish passing each day was then applied to each day the trap was not operated.

We estimated that 5,508, or 65.2% of the 1998 BY parr estimates, passed the smolt trap during 1999-2000. (Table 18). We also estimated that 76% of the hatchery fish released from Curl Lake Acclimation Pond (1999 BY) passed the smolt trap.

Table 18. Monthly and total population estimates, with 95% confidence intervals, for natural and hatchery origin emigrants from the Tucannon River, 2000.

Month	Natural	+/- 95% C. I.	Hatchery	+/- 95% C. I.
Sept.-Feb.	830	14	0	--
March	901	39	0	--
April	3,177	186	652	77
May	596	44	95,833	7,945
June	4	2	134	20
Total	5,508	285	96,619	8,042
% Survival [a]	65.2		75.5	

[a] Percent survival to smolt based on estimated number of parr from summer snorkel surveys (natural origin) or from TFH release numbers (hatchery origin).

Survival Rates

Point estimates of population sizes have been calculated for various life stages (Table 19 and 20) 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-fry-smolt) survival rates for hatchery fish are considerably higher than for naturally reared salmon (Table 21) 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 22 and 23). The mean SAR's (natural=0.57%; hatchery=0.17%) documented from 1985-1995 broods were below the goal SAR of 0.87% established under the LSRCP. Hatchery SAR's for Tucannon River salmon need substantial improvement if we ever hope to meet the mitigation goal of 1,152 salmon.

We found a significant relationship between survival calculated from CWT returns through the Regional Mark Information System (RMIS) database and size of smolts at release, with larger fish (6-10 fish/lb) having higher survival ($r^2 = 30.9$, $P<0.01$) (Appendix D). However, years in which smaller fish (14-19 fish/lb) were released also coincided with poor ocean conditions and flood events within the Tucannon River watershed. Decreasing the release size of smolts has allowed hatchery fish to more closely resemble wild fish and decrease the incidence of precocious fish and returning jacks, but overall survival appears to have decreased. An experimental release of fish at 15/lb and 10/lb during the same year would provide a direct comparison of differences in survival and age structure of adult returns.

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 21). Naturally produced fish remain below the replacement level (Figure 9; Table 24). Based on adult returns from the 1985-1996 broods, naturally reared salmon produced 0.5 adults for every spawner, while hatchery reared fish produced 2.6 adults.

Table 19. Estimates of *natural* Tucannon spring chinook salmon abundance by life stage for 1985-2000 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	412
1986	309	-	3,916	-	1,210,044	102,600	58,200	468
1987	282	-	4,095	-	1,155,072	79,100	44,000	238
1988	168	-	3,882	-	652,176	69,100	37,500	527
1989	133	4	3,883	2,606	526,863	58,600	25,900	158
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	7	0	5,284	3,604	36,568	0	75	6
1996	61	14	3,516	2,843	254,278	2,845	1,612	63
1997	40	34	3,609	3,315	257,070	32,913	21,057	14
1998	24	5	4,023	3,075	111,727	8,453	5,508	
1999	1	40	3,965	3,142	129,645	15,944		
2000	43	73	3,969	3,345	414,852			

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 20. Estimates of Tucannon spring chinook salmon abundance (*spawned and reared in the hatchery*) by life stage for 1985-2000 broods.

Brood year	Females spawned		Mean [a] fecundity		Number of eggs	Number of fry	Number of smolts	Progeny [b] (returning adults)
	natural	hatchery	natural	hatchery				
1985	4	-	3,883	-	14,843	13,401	12,922	46
1986	57	-	3,916	-	187,958	177,277	153,725	327
1987	48	-	4,095	-	196,573	164,630	152,165	189
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	180
1996	18	19	3,516	2,843	117,287	81,326	76,219	297
1997	17	25	3,609	3,315	144,237	29,650	24,186	16
1998	30	14	4,023	3,075	161,019	136,027	127,939	
1999	1	36	3,969	3,142	111,961	106,880	97,600	
2000	3	35	3,969	3,345	128,980	123,313		

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

	Natural			Hatchery			Hatchery Advantage		
Brood Year	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	47.4	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	57.1	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	65.2	4.9	84.5	94.1	79.5	11.1	1.4	16.2
1999	12.3			94.1	91.3	86.0	7.8		
2000				95.6					
Mean	7.8	51.5	4.3	79.4	91.4	72.6	13.6	1.7	15.8
SD	3.6	17.5	2.0	18.3	10.3	17.5	15.3	0.4	5.7

Table 22. Adult returns and SAR's of **natural** salmon to the Tucannon River for brood years 1985-1995.

		Number of Adult Returns, observed and expanded (exp)[a]							
		Age 3		Age 4		Age 5		SAR (%)	
Brood Year	Estimated number of smolts	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	12	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	49,560	1	2	62	127	58	75	0.41	0.41
1994	6,000	0	0	8	10	1	2	0.20	0.20
1995	75	0	0	1	1	2	5	8.0[c]	8.0[c]
Mean of 1985-1994 broods								**0.57**	**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 6 salmon was recovered.

[c] 1995 SAR not included in mean.

Table 23. Adult returns and SAR's of **hatchery** salmon to the Tucannon River for brood years 1985-1995.

Brood Year	Estimated number of smolts	Age 3 known	Age 3 exp.	Age 4 known	Age 4 exp.	Age 5 known	Age 5 exp.	SAR (%) w/jacks	SAR (%) no jacks
		Number of Adult Returns, known and expanded (exp.)							
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	85,500	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	4	5	0.03	0.02
1995	62,272	13	16	117	160	2	4	0.29	0.26
Mean of 1985-1995 broods								**0.17**	**0.14**

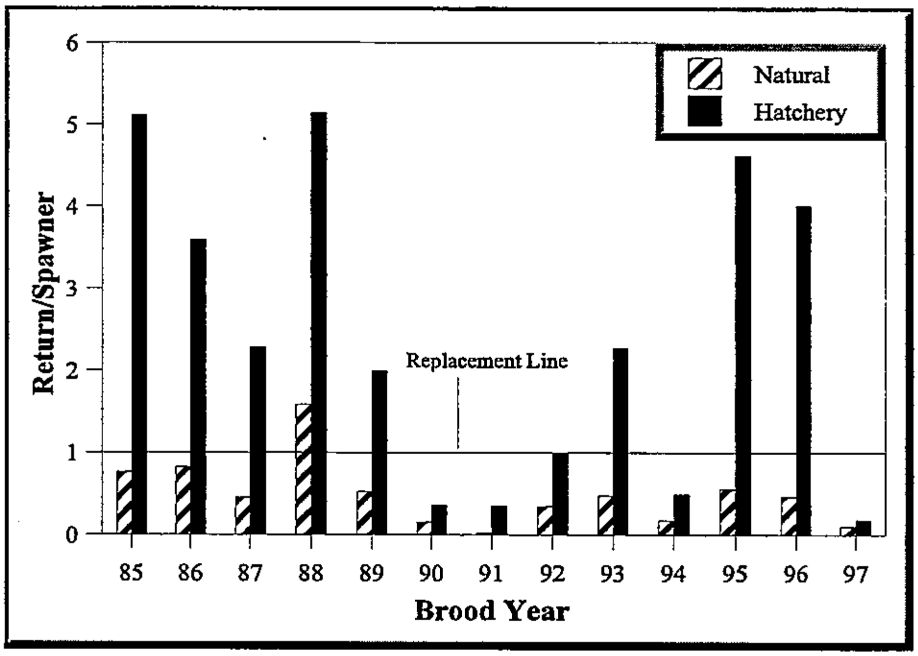

Figure 9. Return per spawner ratio (with replacement line) for the 1985-1997 brood years.

Table 24. Parent-to-progeny survival estimates of Tucannon River spring chinook salmon from 1985 through 1996 brood years (1996 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	412	0.76	9	46	5.11	6.7
1986	570	468	0.82	91	327	3.59	4.4
1987	527	238	0.45	83	189	2.28	5.1
1988	333	527	1.58	87	447	5.14	3.3
1989	302	158	0.52	122	243	1.99	3.8
1990	611	94	0.15	78	28	0.36	2.4
1991	390	7	0.02	72	25	0.35	17.5
1992	564	194	0.34	83	81	0.98	2.9
1993	436	204	0.47	91	207	2.27	4.8
1994	70	12	0.17	69	34	0.49	2.9
1995	11	6	0.55	39	180	4.62	8.4
1996	138	63	0.46	74	297	4.01	8.7
Mean			**0.52**			**2.60**	**5.0**

Fishery Contribution

An original goal of the LSRCP supplementation program was to enhance wild (natural) returns of salmon to the Tucannon River by providing 1,152 hatchery reared fish to the system. Such an increase would allow for limited harvest of the stock and increased spawning. Unfortunately, hatchery adult returns have been below the program goal and natural escapement has further declined (Figure 10). Based on 1985-1995 brood year CWT recoveries from the RMIS database (Appendix D), harvest has accounted for approximately 6.1% of the hatchery adult fish recovered annually and accounted for as high as 40% of the returns for one brood year based on a small number of recoveries. While exploitation has been relatively low, fishing mortality is the one form of mortality fisheries managers can control. Adipose clipped hatchery fish have traditionally been targeted in the sport fishery. This hatchery fin clip should be abandoned in the future and an alternative mark selected to mitigate fishing mortality on this listed population. Out-of-basin stray rates of Tucannon River spring chinook have been low (Appendix D), with an average of 4.7% of the adult hatchery fish straying to other river systems/hatcheries for the 1985-1995 brood years (range 0-20%).

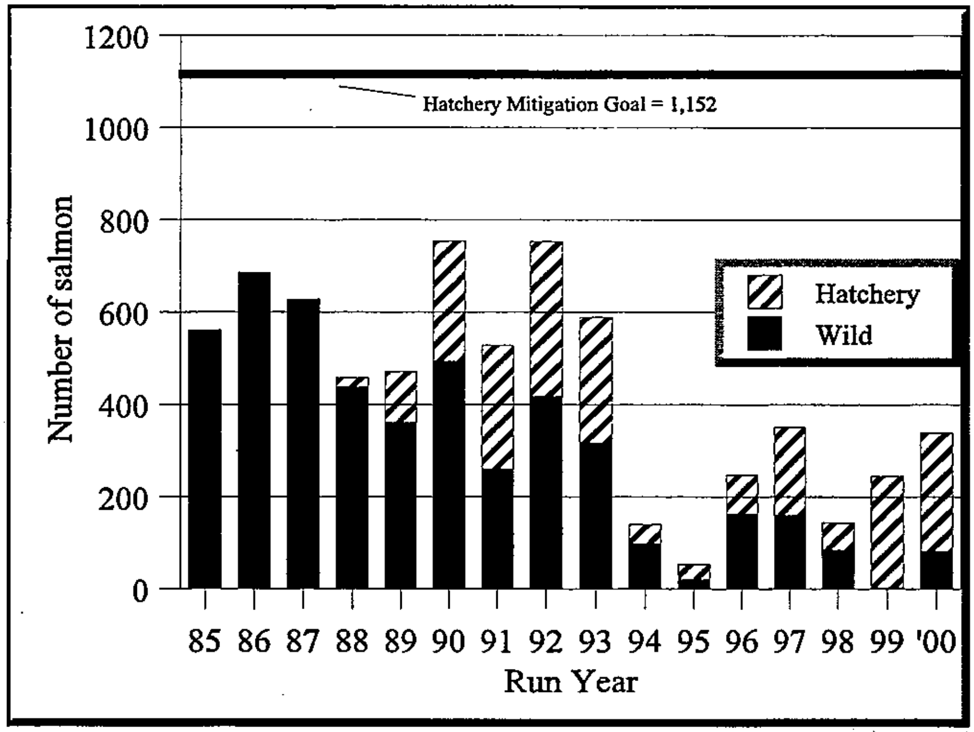

Figure 10. Total escapement for Tucannon River spring chinook salmon for the 1985-2000 run years.

Conclusions and Recommendations

Washington's LSRCP spring chinook salmon program has failed to return 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 have 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 stages. 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 neither was, nor 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. System survivals (in-river, ocean) may increase enough in the coming years so that the program may reach its full potential, and the spring chinook run can 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 can 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 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 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 5 years, provide a complete summary of water temperature data collected from the Tucannon River since program inception.

2. Smolt-to-adult returns are about four times higher for naturally reared salmon than hatchery reared salmon. Examine the use of different fish culture rearing strategies that could enhance hatchery smolt survival.

   Recommendation: Experiment with exercising hatchery fish to condition fish for outmigration and compare their survival rates to a control group of unexercised fish. Examine differences in survival based on PIT tag returns of smolts and CWT returns of adults.

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, smolt trapping, and life stage survival) to continue the documentation of effects (positive or negative) that the hatchery program may have on the natural population.

4. 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 with 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 environment.

   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.

5. 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 trapping efficiency.

6. Stray salmon were documented in relatively high proportion in the 2000 return compared to previous years (greater than the 5% stray rate proposed by NMFS). While this is relative to the total return of Tucannon River origin fish, the absolute number of strays recovered has increased. WDFW has been informed by the Oregon Dept of Fish and Wildlife, that use of the RV or LV fin clip was 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: Recommend that spring chinook released from the Umatilla River be 100% marked (preferably with RV or LV fin clips) for external identification at the TFH adult trap. For upcoming return years, all unmarked salmon 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 spawning, results from the scale samples will allow hatchery staff to remove any potentially stray salmon before it is crossed with a Tucannon origin fish, thereby protecting the genetic integrity of the stock.

7. During 2001, a fishery was opened for spring chinook on the Snake River for the first time in 30 years. The Tucannon River spring chinook is an ESA listed species (both wild and hatchery components) and annual runs of hatchery fish are not meeting hatchery mitigation goals and a wild escapement goal has not been agreed upon.

   Recommendation: The adipose fin clip should be abandoned in exchange for an alternative method of marking to prevent this listed population from potential harvest in the sport fishery. We also need to start the process of establishing an escapement goal for wild spring chinook salmon for the Tucannon River.

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Appendix A
Spring chinook captured, collected, or passed upstream at the Tucannon Hatchery trap in 2000

Appendix A. Spring chinook salmon captured, collected, or passed upstream at the Tucannon Hatchery trap in 2000. 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
5/03	1		1			
5/10	1	2		1	1	1
5/15		6		2		4
5/16		2				2
5/17	1	6		3	1	3
5/18	1	9	1	2		7
5/19	1	10	1	9		
5/20	2	5			2	5
5/21		5				5
5/22		15				14
5/23		9		9		
5/24		8				8
5/26		1				1
5/28		7				5
5/30		13				13
6/01		3		2		
6/02		3		2		
6/03		3				2
6/04	2	5	1		1	5
6/05	2	5	1	3	1	
6/06	3	4			3	4
6/07	1	2	1			2
6/08		7		6		
6/13		2		2		
6/14	1	1	1	1		
6/15	2	4	1	4	1	
6/16		4		3		
6/19	1	5	1	4		
6/21	1	5	1	2		2
6/22		1				
6/26	1	2	1	1		1
7/01		2				2
7/05	1	1			1	
7/14		1		1		
7/24		1				
7/27		1		1		
8/17		1				
8/28		1		1		
8/29		1				1
8/31		1		1		
9/01	1	2	1	1		1
9/05	2	1	2			1
9/06		3				3
9/11	2	2	1	1	1	1
9/13	1	1			1	1
9/15		4		4		
Totals	28	177	15	66	13	94

Appendix B
Movements of two radio tagged spring chinook in the Tucannon River, 2000

Appendix B. Movements of two radio tagged spring chinook in the Tucannon River, 2000. Both 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
18/48			
4/12	COL	Bonneville Dam	Tagged (natural male, 67.5 cm, VI-A89)
5/19	3.0	Smolt Trap	Fixed Site
5/20	2.9	below Smolt Trap	pp
5/23	2.7	Highway 261 Bridge	pp
5/26	2.8	above Highway 261 Bridge	
5/30	3.0	Smolt Trap	Fixed Site
6/01-6/02	4.8	below Little Goose Turnoff	
6/05	12.7	Smith Hollow Bridge	
6/07	17.9	above Kessel's Bridge	
6/12	30.5	Tucannon milepost 5.2	
6/15	38.1	Silo below Marengo Bridge	
6/19	43.8	below Bridge 11	
6/22	49.1	above Bridge 13	
6/26	50.6	Fowl Farm	
6/30-7/13	51.8	above Bridge 14	
7/31-8/24	53.5	Dahm's	
9/05-9/06	53.7	above Dahm's; RB debris pile	pp
9/08	54.9	below CG1	pp, saw fish in run
9/10	59.2	Tucannon Adult Trap	Fixed Site; fish did not enter trap
9/11-9/18	58.8	below HMA 6	pp, saw fish with 3 others near redds, saw fish on uppermost redd
			Recovered tag, fish spawned; natural female
24/54			
4/28	COL	Bonneville Dam	Tagged (hatchery male, 69.5 cm, VI-F62)
6/15	46.0	above Bridge 11	
6/16	47.1	Bridge 12	
6/19	51.8	above Bridge 14	
6/23	54.9	below Campground 1	
6/26	57.2	above Campground 2	
6/30-8/24	57.9	near Tuc. Fish Hatchery; RB pool	pp
9/05-9/08	52.9	Last Resort above Tumalum Creek	pp, saw fish on redd
			Recovered tag, fish spawned; female 69 cm

Appendix C
Numbers and density estimates (fish/100 m^2) of juvenile salmon counted by snorkel surveys in the Tucannon River in 2000

Appendix C. Numbers and density estimates of subyearling and yearling natural salmon, and yearling hatchery chinook counted by snorkel surveys in the Tucannon River, 2000.

			Number of Salmon				Density (fish/100m²)		
			Natural		Hatchery	Snorkeled Area (m²)	Natural		Hatchery
Stratum	Site	Date	0+	> 1+	> 1+		0+	> 1+	> 1+
Marengo	TUC01	7/31	0	0	0	584	0.00	0.00	0.00
⇓	TUC02	7/31	5	0	0	564	0.89	0.00	0.00
	TUCO3	7/31	2	0	0	602	0.33	0.00	0.00
Hartsock	TUC04	7/31	14	0	0	828	1.69	0.00	0.00
⇓	A	8/24	5	0	0	597	0.84	0.00	0.00
	TUCO5	7/31	17	0	0	552	3.08	0.00	0.00
	TUC06	7/31	2	0	0	590	0.34	0.00	0.00
	B	8/24	10	0	0	698	1.43	0.00	0.00
	TUC07	7/30	136	1	0	880	15.45	0.11	0.00
	TUC08	7/31	52	0	0	734	7.08	0.00	0.00
	C	8/24	12	0	0	1,012	1.19	0.00	0.00
	TUC09	7/30	17	0	0	674	2.52	0.00	0.00
	D	8/24	47	1	0	640	7.34	0.16	0.00
	TUC10	7/31	34	0	0	372	9.14	0.00	0.00
HMA	TUC11	7/31	100	0	0	673	14.86	0.00	0.00
⇓	E	8/24	70	2	0	532	13.16	0.38	0.00
	TUC13	7/30	20	0	0	594	3.37	0.00	0.00
	TUC14	8/24	3	0	0	604	0.50	0.00	0.00
	TUC16	8/24	0	0	0	491	0.00	0.00	0.00
	TUC17	7/31	0	1	0	483	0.00	0.21	0.00
	F	8/24	2	0	0	491	0.41	0.00	0.00
	TUC19	7/31	1	0	0	596	0.17	0.00	0.00
	TUC20	7/31	4	0	0	466	0.86	0.00	0.00
	TUC21	7/31	4	7	0	624	0.64	1.12	0.00
	G	8/24	0	0	0	480	0.00	0.00	0.00
	TUC22	7/31	0	1	0	470	0.00	0.21	0.00
	TUC23	7/31	0	0	0	644	0.00	0.00	0.00
Wilderness	TUC24	8/01	6	0	0	478	1.26	0.00	0.00
⇓	TUC25	8/01	2	0	0	408	0.49	0.00	0.00
	TUC26	8/01	4	0	0	377	1.06	0.00	0.00
	TUC27	8/01	0	0	0	390	0.00	0.00	0.00
	TUC28	7/31	0	0	0	284	0.00	0.00	0.00
Totals			569	13	0	18,412			

Appendix D
Recoveries of coded-wire tagged salmon released into the Tucannon River for the 1985-1995 brood years

Appendix D. Observed and estimated recoveries of coded-wire tagged salmon released into the Tucannon River with percent return to the Tucannon Basin, out-of-basin returns, and estimated survival and exploitation rates for the 1985-1995 brood years. (Data from RMIS database.)

Brood Year	1985		1986		1987	
Smolts Released	12,922		147,037		151,100	
Fish/Lb	6.0		10.0		9.0	
CWT Codes*	34/42		33/25, 41/46, 41/48		49/50	
Release Year	1987		1988		1989	
Agency (fishery/location)	**Observed Number**	**Estimated Number**	**Observed Number**	**Estimated Number**	**Observed Number**	**Estimated Number**
WDFW						
Tucannon River			30	21	28	160
Kalama R., Wind R.						
Fish Trap - F.W.						
Treaty Troll			1	2		
Lyons Ferry Hatch.	32	60	136	287	53	71
F.W. Sport			1	4		
IDFG						
Dworshak Hatchery						
ODFW						
Test Net, Zone 4	1	1	1	1		
Treaty Ceremonial			2	4	1	2
Three Mile, Umatilla R.						
Spawning Ground						
Fish Trap - F.W.						
F.W. Sport						
Hatchery						
CDFO						
Non-treaty Ocean Troll			1	4		
Mixed Net & Seine						
Ocean Sport						
USFWS						
Warm Springs Hatchery						
Total Returns	33	61	172	323	82	233
Tucannon (%)	98.4		95.4		99.1	
Out-of-Basin (%)	0.0		0.0		0.0	
Harvest (%)	1.6		4.6		0.9	
Survival	0.47		0.22		0.15	

* WDFW agency code prefix is 63.

Appendix D. Observed and estimated recoveries of coded-wire tagged salmon released into the Tucannon River with percent return to the Tucannon Basin, out-of-basin returns, and estimated survival and exploitation rates for the 1985-1995 brood years. (Data from RMIS database.)

Brood Year **Smolts Released** **Fish/Lb** **CWT Codes*** **Release Year**	1988 139,050 11.0 01/42, 55/01 1990		1989 97,779 9.0 01/31, 14/61 1991		1990 85,737 11.0 37/25, 40/21, 43/11 1992	
Agency (fishery/location)	**Observed Number**	**Estimated Number**	**Observed Number**	**Estimated Number**	**Observed Number**	**Estimated Number**
WDFW						
Tucannon River	107	378	61	191	2	6
Kalama R., Wind R.						
Fish Trap - F.W.	1	0				
Treaty Troll			2	2		
Lyons Ferry Hatch.	83	86	55	55	19	19
F.W. Sport	1	4				
IDFG						
Dworshak Hatchery						
ODFW						
Test Net, Zone 4	3	3	2	2		
Treaty Ceremonial	8	17	4	8		
Three Mile, Umatilla R.						
Spawning Ground						
Fish Trap - F.W.						
F.W. Sport						
Hatchery						
CDFO						
Non-treaty Ocean Troll						
Mixed Net & Seine						
Ocean Sport						
USFWS						
Warm Springs Hatchery	1	1				
Total Returns	204	489	124	258	21	25
Tucannon (%)	94.9		95.3		100.0	
Out-of-Basin (%)	0.2		0.0		0.0	
Harvest (%)	4.9		4.7		0.0	
Survival	0.35		0.26		0.03	

* WDFW agency code prefix is 63.

Appendix D. Observed and estimated recoveries of coded-wire tagged salmon released into the Tucannon River with percent return to the Tucannon Basin, out-of-basin returns, and estimated survival and exploitation rates for the 1985-1995 brood years. (Data from RMIS database.)

Brood Year **Smolts Released** **Fish/Lb** **CWT Codes*** **Release Year**	1991 72,461 15.0 46/25, 46/47 1993		1992 56,679 36.0 48/23, 48/24, 48/56 1993		1992 79,151 14.0 48/10, 48/55, 49/05 1994	
Agency (fishery/location)	**Observed Number**	**Estimated Number**	**Observed Number**	**Estimated Number**	**Observed Number**	**Estimated Number**
WDFW						
Tucannon River					10	31
Kalama R., Wind R.						
Fish Trap - F.W.						
Treaty Troll						
Lyons Ferry Hatch.	24	24	2	2	45	49
F.W. Sport						
IDFG						
Dworshak Hatchery						
ODFW						
Test Net, Zone 4						
Treaty Ceremonial	1	3			1	1
Three Mile, Umatilla R.						
Spawning Ground	1	3			2	4
Fish Trap - F.W.			1	1	5	9
F.W. Sport					2	2
Hatchery						
CDFO						
Non-treaty Ocean Troll						
Mixed Net & Seine			1	2		
Ocean Sport						
USFWS						
Warm Springs Hatchery					3	3
Total Returns	26	30	4	5	68	99
Tucannon (%)	80.0		40.0		80.8	
Out-of-Basin (%)	10.0		20.0		16.2	
Harvest (%)	10.0		40.0		3.0	
Survival	0.04		0.01		0.13	

* WDFW agency code prefix is 63.

Appendix D. Observed and estimated recoveries of coded-wire tagged salmon released into the Tucannon River with percent return to the Tucannon Basin, out-of-basin returns, and estimated survival and exploitation rates for the 1985-1995 brood years. (Data from RMIS database.)

Brood Year	1993		1994		1995	
Smolts Released	135,952		130,034		62,016	
Fish/Lb	14.0-15.0		13.0-18.0		17.0-19.0	
CWT Codes*	56/15, 56/17-18, 56/43-44		43/23, 56/29, 57/29		59/36, 61/40, 61/41	
Release Year	1995		1996		1997	
Agency (fishery/location)	**Observed Number**	**Estimated Number**	**Observed Number**	**Estimated Number**	**Observed Number**	**Estimated Number**
WDFW						
Tucannon River	1	3				
Kalama R., Wind R.						
Fish Trap - F.W.						
Treaty Troll						
Lyons Ferry Hatch.	66	138	18	21	15	14
F.W. Sport						
IDFG						
Dworshak Hatchery						
ODFW						
Test Net, Zone 4						
Treaty Ceremonial	3	3				
Three Mile, Umatilla R.						
Spawning Ground	3	3				
Fish Trap - F.W.	1	1				
F.W. Sport						
Hatchery	1	1			1	1
CDFO						
Non-treaty Ocean Troll						
Mixed Net & Seine						
Ocean Sport	1	3				
USFWS						
Warm Springs Hatchery						
Total Returns	76	152	18	21	16	15
Tucannon (%)	92.8		100.0		93.3	
Out-of-Basin (%)	3.3		0.0		6.7	
Harvest (%)	3.9		0.0		0.0	
Survival	0.11		0.02		0.02	

* WDFW agency code prefix is 63.