STATE OF WASHINGTON August 2006

Tucannon River Spring Chinook Salmon Hatchery Evaluation Program

2005 Annual Report

by Michael P. Gallinat and Lance A. Ross

Washington Department of
FISH AND WILDLIFE
Fish Program
Science Division

FPA 06-09

Tucannon River Spring Chinook Salmon Hatchery Evaluation Program

2005 Annual Report

by

Michael P. Gallinat
Lance A. Ross

Washington Department of Fish and Wildlife
Fish Program/Science Division
600 Capitol Way North
Olympia, Washington 98501-1091

Prepared for:

U.S. Fish and Wildlife Service
Lower Snake River Compensation Plan Office
1387 S. Vinnell Way, Suite 343
Boise, Idaho 83709
Cooperative Agreement: 1411-05-J056

August 2006

Acknowledgments

The Tucannon River Spring Chinook Salmon Hatchery Evaluation Program is the result of efforts by many individuals within the Washington Department of Fish and Wildlife (WDFW) and from other agencies.

We would like to express sincere gratitude to Steve Rodgers, Lyons Ferry Complex Manager, for his coordination efforts. We thank Hatchery Specialists Doug Maxey, Dick Rogers, and Severin Erickson 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.

We thank Lynn Anderson and the Coded-Wire Tag Lab staff for their assistance in coded-wire tag verification. Todd Kassler and Denise Hawkins, WDFW Genetics Lab, provided information from the baseline genetics analysis. Annette Hoffman and Kristen Ryding provided invaluable help with the smolt trap estimates. We also thank John Sneva for reading scales, and Steve Roberts for providing information on fish health issues that arose during the year. We thank Brian McTeague for the new map.

We thank the staff of the Snake River Lab, in particular Joe Bumgarner, Jerry Dedloff, Jeromy Jording, Debbie Milks, Jule Ponti, and Michelle Varney who helped collect the information presented in this report.

We also thank Joe Bumgarner, Glen Mendel, Todd Pearsons, Mark Schuck, and Jim Scott for providing critical reviews of the draft report.

The United States Fish and Wildlife Service through the Lower Snake River Compensation Plan Office funded the supplementation program. The captive broodstock program was funded through the Bonneville Power Administration’s Fish and Wildlife Program.

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 supplementation production goal is 132,000 fish for release as yearlings at 30 g/fish (15 fish per pound). The captive brood production goal is 150,000 yearlings at 30 g/fish. 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 2005 to April 2006.

Two hundred forty-five salmon were captured in the TFH trap in 2005 (125 natural adults, 6 natural jacks, 94 hatchery adults, and 20 hatchery jacks); 100 were collected and hauled to LFH for broodstock and the remaining fish were passed upstream. During 2005, five salmon that were collected for broodstock died. Prespawning mortality has been low since broodstock began being held at LFH in 1992, and is generally less than 10% each year.

Spawning of supplementation fish in 2005 at LFH occurred between August 23 and September 20, with peak eggtake on September 6. A total of 161,345 eggs were collected from 25 natural and 24 hatchery-origin fish. Egg mortality to eye-up was 3.2% (5,239 eggs), with an additional loss of 10,827 (6.9%) sac-fry. Total fry ponded for production in the rearing ponds was 145,279.

A total of 167 captive brood females were spawned from August 31 to October 11, 2005 producing 261,845 eggs. Egg mortality to eye-up was 60.4% leaving 103,812 live eggs. An additional 9,841 dead eggs/fry (9.5%) were picked at ponding leaving 93,971 fish for rearing.

WDFW staff conducted spawning ground surveys in the Tucannon River between August 31 and September 29, 2005. Forty-six redds and 22 carcasses were found above the adult trap and 56 redds and 29 carcasses were found below the trap. Based on redd counts, broodstock collection, and in-river pre-spawning mortalities, the estimated escapement for 2005 was 420 fish (286 natural adults, 3 natural jacks and 123 hatchery-origin adults, 8 hatchery jacks).

Snorkel surveys were conducted during the summer of 2005 to determine the population of subyearling and yearling spring Chinook in the Tucannon River. We estimated 30,809 subyearlings (BY 2004) and 586 yearlings (BY 2003) were present in the river. Evaluation staff also operated a downstream migrant trap. During the 2004/2005 emigration, we estimated that 23,003 (BY 2003) natural spring Chinook smolts emigrated from the Tucannon River.

Monitoring survival rate differences between natural and hatchery-reared salmon continues. Smolt-to-adult return rates (SAR) for natural salmon consistently average about five times higher than for hatchery salmon. However, hatchery salmon survive about three times greater than natural salmon from parent to adult progeny. Due to the low SAR for hatchery fish, the mitigation goal of 1,152 salmon of Tucannon River stock was not achieved as only 131 hatchery-origin fish returned in 2005. Beginning with the 2006 brood year, the annual smolt goal will be increased from 132,000 to 225,000 to help offset for the higher mortality of hatchery-origin fish after they leave the hatchery. In conjunction with this we also plan to conduct an experiment to examine size at release as a possible means to improve SAR of hatchery fish.

Table of Contents

List of Tables

List of Figures

List of Appendices

Introduction

Program Objectives

Legislation under the Water Resources Act of 1976 authorized the establishment of the Lower Snake River Compensation Plan (LSRCP) to help mitigate for the expected losses of salmon and steelhead runs due to construction and operation of the Snake River dams and included hatcheries in Washington, Idaho, and Oregon (USACE 1975). In Washington, 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. The WDFW also initiated the Tucannon River Spring Chinook Captive Broodstock Program in 1997, which is funded by the Bonneville Power Administration (BPA) through its Fish and Wildlife Program. The project goal is to rear captive salmon selected from the supplementation program (1997-2002 brood years) to adults, rear their progeny, and release approximately 150,000 smolts (30 g/fish) annually into the Tucannon River between 2003-2007. These smolt releases, in combination with the current hatchery supplementation program (goal = 132,000 smolts; 30 g/fish) and natural production, are expected to produce 600-700 returning adult spring Chinook to the Tucannon River each year from 2005-2010. This report summarizes work performed by the WDFW Spring Chinook Evaluation Program from April 2005 through April 2006.

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 and returned to TFH for final rearing and 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.

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 36% grazed rangeland, 33% dry cropland, 23% forest, 6% WDFW, and 2% other use (Tucannon Subbasin Summary 2001). Five unique strata have been distinguished by predominant land use, habitat, and landmarks (Figure 1; Table 1) and are referenced throughout this report.

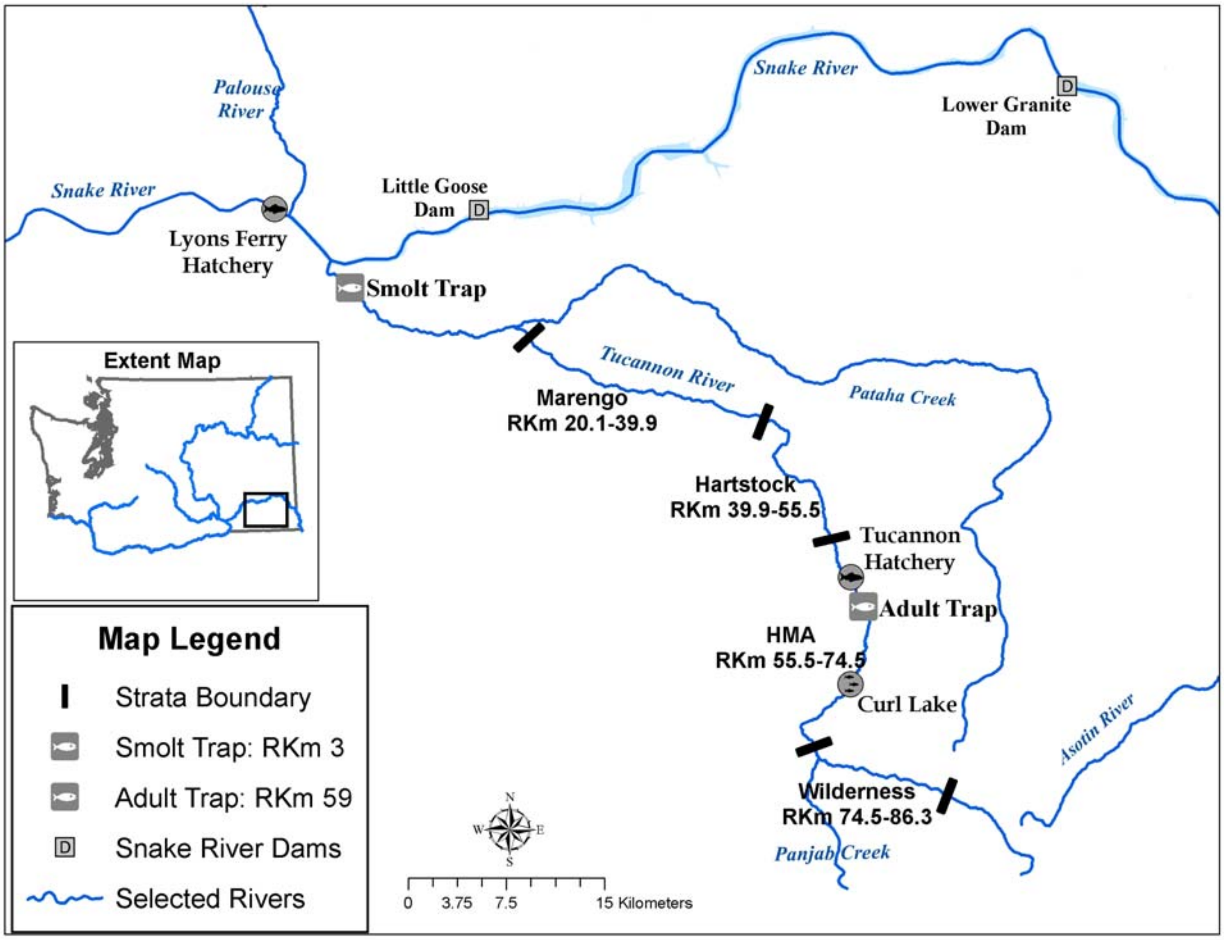

Figure 1. Location of the Tucannon River, and Lyons Ferry and Tucannon Hatcheries within the Snake River Basin.

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

Strata	Land Ownership/Usage	Spring Chinook Habitat	River Kilometer[a]
Lower	Private/Agriculture & Ranching	Not-Usable (temperature limited)	0.0-20.1
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

[a] Rkm descriptions: 0.0–mouth at the Snake River; 20.1-Territorial Rd.; 39.9–Marengo Br.; 55.5-HMA Boundary Fence; 74.5-Panjab Br.; 86.3-Rucherts Camp.

Evaluation program staff deployed 19 continuous recording thermographs throughout the Tucannon River to monitor daily minimum and maximum water temperatures (temperatures are recorded every hour) from May through October. Data from each of these water temperature recorders are kept on an electronic file in our Dayton office. During 2005, maximum temperatures where spring Chinook juveniles were rearing during the hottest part of the summer ranged from 15.1° C (59.1° F) in the upper HMA stratum (rkm 74.5) to 23.1° C (73.6° F) in the lower Hartsock stratum (rkm 43.3)(Figure 2).

The upper lethal temperature for Chinook fry is 25.1° C (77.2° F) while the preferred temperature range is 12-14° C (53.6-57.2° F) (Scott and Crossman 1973, McCullough 1999). The optimum range of temperature in freshwater, which controls the rate of growth and survival of young, is 13-17° C (55.4-62.6° F) (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 23.9° C (75° F) (or average mean temperature of 20° C (68.0° F)). Based on the preferred and optimum temperature limits, fish returning to the upper watershed have the best chance for survival (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 delivery 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 present in the early 1980s 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.

Noteworthy are the fact that drought conditions and a forest fire (52,000 acre School Fire) occurred in the Tucannon Watershed during 2005.

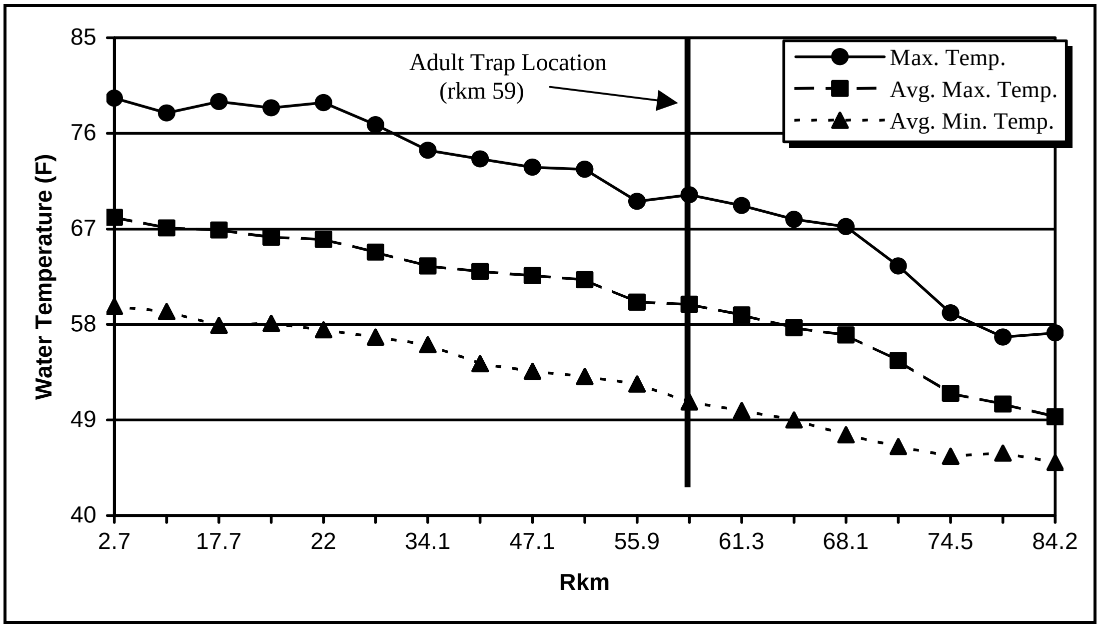

Figure 2. Maximum temperature, average maximum temperature, and average minimum temperature recorded by thermographs at 19 selected sites along the Tucannon River, May-October, 2005.

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 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 were identified by coded-wire tag (CWT) in the snout or presence of a visible implant elastomer tag. Adipose clipped fish were killed outright as strays, as we no longer utilize that mark for management within the Tucannon River.

The TFH adult trap began operation in February (for steelhead) with the first spring Chinook captured May 7. The trap was operated through September. A total of 245 fish entered the trap (125 natural adults, 6 natural jacks, 94 hatchery adults, and 20 hatchery jacks), and 49 natural (48 adults, 1 jack) and 51 hatchery (50 adults, 1 jack) spring Chinook 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 cc/4.5 kg); jacks were given half dosages. Fish received formalin drip treatments during holding at 167 ppm every other day at LFH to control fungus.

Based on previous years' returns, we anticipated catching unmarked Umatilla River origin hatchery fish. Prior to broodstock trapping we decided that scale samples would be collected from all unmarked fish for scale pattern analysis in the hope of identifying hatchery origin fish. Unmarked fish collected for broodstock were injected with a Passive Integrated Transponder (PIT) tag for individual identification. If scale analysis determined that a "natural" fish collected for broodstock was actually of hatchery origin, that fish would be identified by its PIT tag number and killed. None of the natural fish kept for broodstock in 2005 had hatchery origin scale patterns.

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 1986-2005.

Year	Captured at Trap		Trap Mortality		Broodstock Collected		Passed Upstream	
	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	267	9	0	0	116	9	151	0
1989	156	102	0	0	67	102	89	0
1990	252	216	0	1	60	75	191	134
1991	109	202	0	0	41	89	68	105
1992	242	305	8	3	47	50	165	202
1993	191	257	0	0	50	47	130	167
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	33	7
1997	99	160	0	0	43	54	47	76
1998 [a]	50	43	0	0	48	41	1	1
1999 [b]	1	139	0	1	1	135	0	0
2000 [c]	28	177	0	17	12	69	13	94
2001	405	276	0	0	52	54	353	222
2002	168	610	0	0	42	65	126	545
2003	84	151	0	0	42	35	42	116
2004	311	155	0	0	51	41	260	114
2005 [d]	131	114	0	3	49	51	82	60

[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] Seventeen stray LV and ADLV fish were killed at the trap.
[d] Three AD clipped stray fish were killed at the trap.

Broodstock Mortality

Five of the 100 salmon collected for broodstock died prior to spawning in 2005 (Table 3). Table 3 shows that prespawning mortality in 2005 was comparable to the mortality documented since broodstock holding at LFH began in 1992. Higher mortality was experienced when fish were held at TFH (1986-1991).

Table 3. Numbers of pre-spawning mortalities and percent of fish collected for broodstock at TFH and held at TFH (1985-1991) or LFH (1992-2005).

	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
2001	0	0	0	0.0	0	0	0	0.0
2002	0	0	0	0.0	1	1	0	3.1
2003	0	1	0	2.4	0	0	1	2.9
2004	0	3	0	5.9	0	0	1	2.4
2005	2	0	0	4.1	1	2	0	5.9

Broodstock Spawning

Spawning at LFH occurred once a week from August 23 to September 20, with peak eggtake occurring on September 6. A total of 161,345 eggs were collected (Table 4). Eggs were initially disinfected and water hardened for one hour in iodophor (100 ppm). Fungus on the incubating eggs was controlled with formalin applied every-other day at 1,667 ppm for 15 minutes. Mortality to eye-up was 3.2% with an additional 6.9% (10,827) loss of sac-fry, which left 145,279 fish for production.

To prevent any stray fish from contributing to the population, all CWTs were read prior to spawning. No hatchery strays were found in the broodstock in 2005. Scales from unmarked fish were read prior to spawning to check for hatchery growth patterns. As the broodstock were positive for IHN (Infectious Hematopoietic Necrosis), carcasses were not returned to the upper Tucannon River for stream nutrient enrichment.

Table 4. Number of fish spawned and killed, estimated egg collection, and egg mortality of Tucannon River spring Chinook salmon at LFH in 2005.

	Natural			Hatchery		
Spawn Date	**Male[a]**	**Female**	**Eggs Taken**	**Male[a]**	**Female**	**Eggs Taken**
8/23		1	5,669			
8/31		5	17,818	2	6	17,543
9/06		8	32,528	4	9	25,519
9/13		5	17,842	6	5	14,690
9/20	22	6	20,472	12	4	9,264
Totals	**22**	**25**	**94,329**	**24**	**24**	**67,016**
Egg Mortality			1,419			3,820

[a] Does not include live spawned fish.

Eggs were also collected as part of the Tucannon River Captive Broodstock Program. A total of 167 captive brood females were spawned from August 31 to October 11, 2005. From the total 261,845 captive brood eggs collected, mortality to eye-up was 60.4%, leaving 103,812 live eggs. An additional 9,841 dead eggs/fry (9.5%) were picked at ponding leaving 93,971 live fish for rearing. The Tucannon River Captive Broodstock Program results achieved to date are more thoroughly described in the annual Tucannon River Spring Chinook Captive Broodstock Report (Gallinat 2006).

Natural Spawning

Spawning ground surveys were conducted on the Tucannon River weekly from August 31 to September 29, 2005. One hundred two redds were counted and 41 natural and 10 hatchery origin carcasses were recovered (Table 5). Forty-six redds (45% of total) and 22 carcasses (43% of total) were found above the adult trap.

While conducting redd surveys in 2005 we also snorkeled 24 redds to look for the presence of precocial juveniles spawning with adults. We observed 15 adults (10 females, 5 males) and 1 jack on or near the redds. We observed and captured, using a cast net, 52 juvenile natural and one hatchery spring Chinook in or near the redds. Twenty-seven of the 52 natural fish were precociously mature (52%) and the one hatchery spring Chinook was a mature male.

Table 5. Numbers and general locations of salmon redds and carcasses recovered on the Tucannon River spawning grounds, 2005 (the Tucannon Hatchery adult trap is located at rkm 59).

			Carcasses Recovered	
Stratum	**Rkm[a]**	**Number of redds**	**Natural**	**Hatchery**
Wilderness	78-84	4	1	
	75-78			
HMA	73-75	4		
	68-73	12	1	
	66-68	4		1
	62-66	14	3	1
	59-62	8	9	6
-------------------------Tucannon Fish Hatchery Trap-------------------------				
	56-59	27	20	2
Hartsock	52-56	16	5	
	47-52	7	2	
	43-47	2		
	40-43			
Marengo	34-40	4		
	28-34			
Totals	**28-84**	**102**	**41**	**10**

[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.; 28-Enrich Br.

Historical Trends

Two general trends were evident (Figure 3) from the program's inception in 1985 through 1999:

1) The proportion of the total number of redds occurring below the trap increased; and
2) The density of redds (redds/km) decreased in the Tucannon River.

In part, this resulted from a greater emphasis on broodstock collection to keep the spring Chinook population from extinction. However, increases in the SAR rates beginning with the 1995 brood have subsequently resulted in increased spawning above the trap and higher redd densities (Figure 3; Table 6). Also, moving the release location from TFH upstream to Curl Lake AP has affected the spawning distribution, with higher numbers of fish and redds in the Wilderness and HMA strata compared to previous years (Table 6).

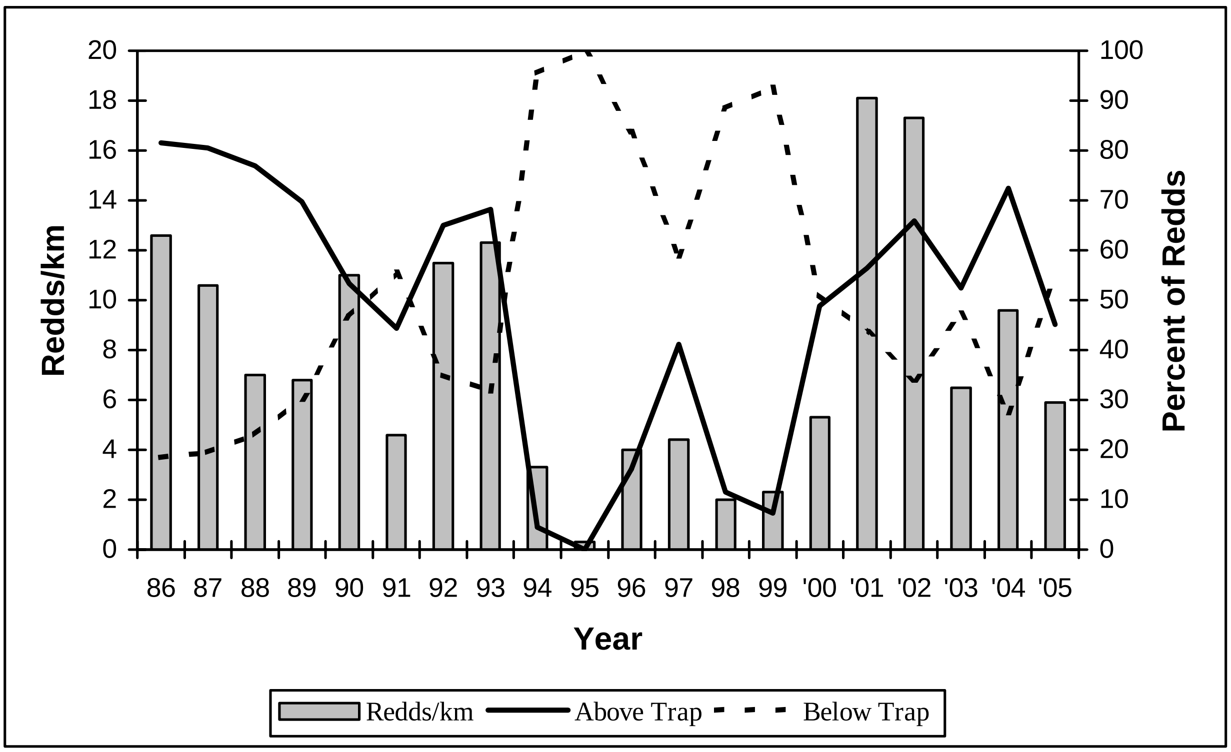

Figure 3. Number of redds/km and percentage of redds above and below the adult trap on the Tucannon River, 1986-2005.

Table 6. 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, 1985-2005.

	Strata					TFH Adult Trap			
Year	Wilderness	HMA	Hartsock	Marengo	Total Redds	Above	%	Below	%
1985	97 (8.2)	122 (6.2)	–	–	219	–	–	–	–
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	58	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
2001	24 (2.7)	189 (9.9)	84 (5.3)	1 (0.2)	298	168	56.4	130	43.6
2002	13 (1.4)	227 (11.9)	46 (2.9)	13 (1.1)	299	197	65.9	102	34.1
2003	0 (0.0)	90 (4.7)	28 (1.8)	0 (0.0)	118	62	52.5	56	47.5
2004	17 (1.9)	124 (6.5)	19 (1.2)	0 (0.0)	160	116	72.5	44	27.5
2005	4 (0.4)	69 (3.6)	25 (1.6)	4 (0.3)	102	46	45.1	56	54.9

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

Genetic Sampling

During 2005 we collected 148 DNA samples (operculum punches) from adult salmon (87 natural origin and 61 hatchery origin) and 200 samples from captive broodstock spawners. These samples were sent to the WDFW genetics lab in Olympia, Washington for analysis.

A total of 937 Tucannon River spring Chinook samples collected in 2003 and 2004 were genotyped at 14 microsatellite loci (Ogo-2, Ogo-4, Ots-3M, Ssa-197, Oki-100, Ots-201b, Ots-208b, Ssa-408, Omm-1080, Ots-213, Ots-G474, Ots-9, Ots-211, and Ots-212) using an Applied Biosystems 3730 DNA analyzer. Analysis to date (Appendix B) provides evidence that the captive broodstock program has been an effective method of preserving genetic variation in Tucannon River spring Chinook while providing additional smolts for release. Also, supplementation hatchery practices (despite using only a small percentage of the entire escapement each year) have been effective in minimizing differences between the hatchery reared and natural-origin fish (Kassler and Hawkins 2006). Genotypes, allele frequencies, and tissue samples are stored at WDFW's Genetics Laboratory in Olympia.

Age Composition, Length Comparisons, and Fecundity

One objective of the monitoring program is to track the age composition of each year's returning adults. This allows us to annually compare ages of natural and hatchery-reared fish, and to examine long-term trends and variability in 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).

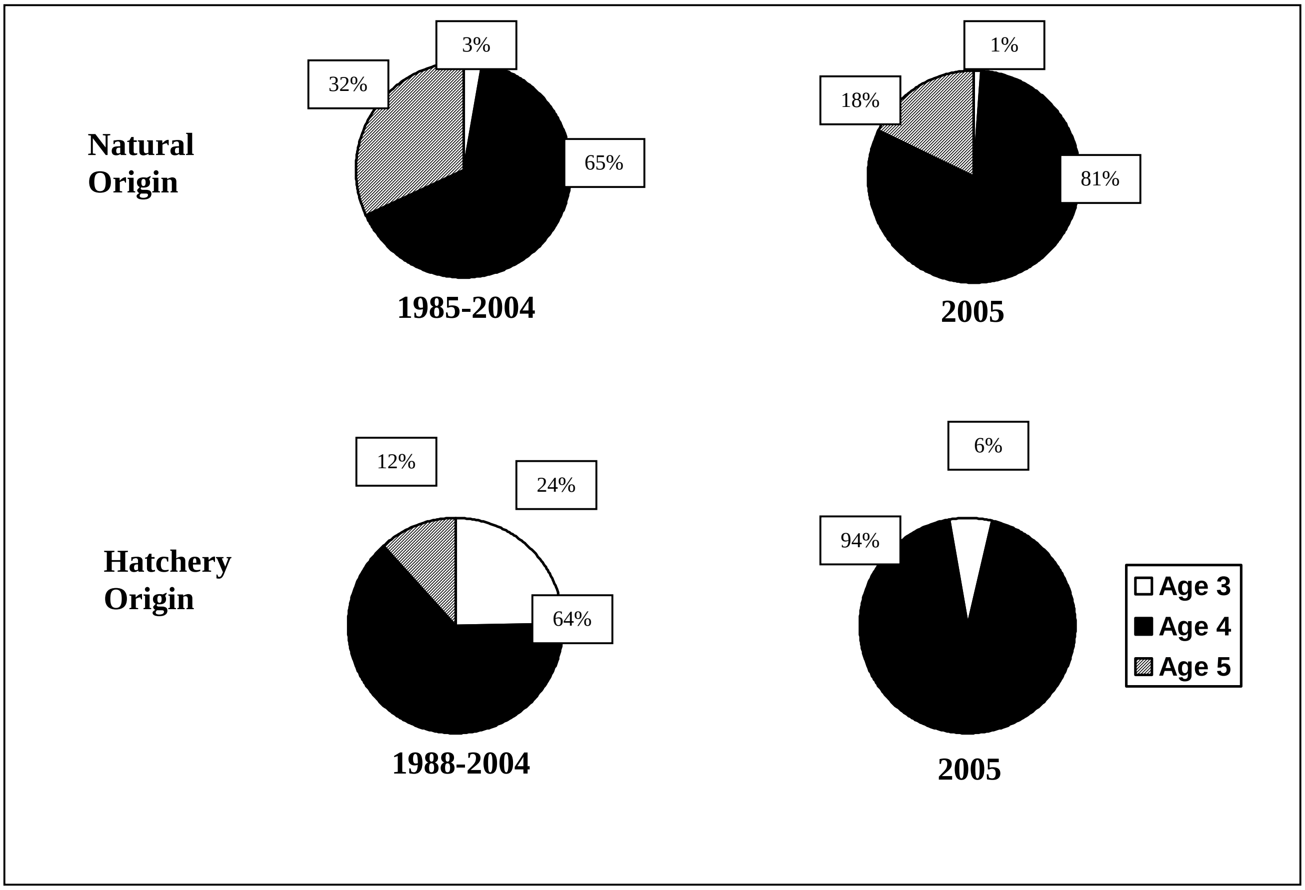

Figure 4. Historical (1985-2004), and 2005 age composition for spring Chinook in the Tucannon River.

Low proportions of Age 3 and Age 5 fish were observed during the 2005 run for both the hatchery and natural components of the population (Figure 4). This may have resulted from lower survival rates associated with recent drought events and poor ocean conditions.

Another comparison we conduct on returning adult natural and hatchery origin fish is the difference between mean post-eye to hypural-plate lengths. Bumgarner et al. (1994) reported in the past 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. However, for returns to date, there is no significant difference ($P>0.05$) in mean length between natural and hatchery-origin fish (Figure 5), even though they migrate as smolts at significantly different sizes (Bugert et al. 1990; Bugert et al. 1991).

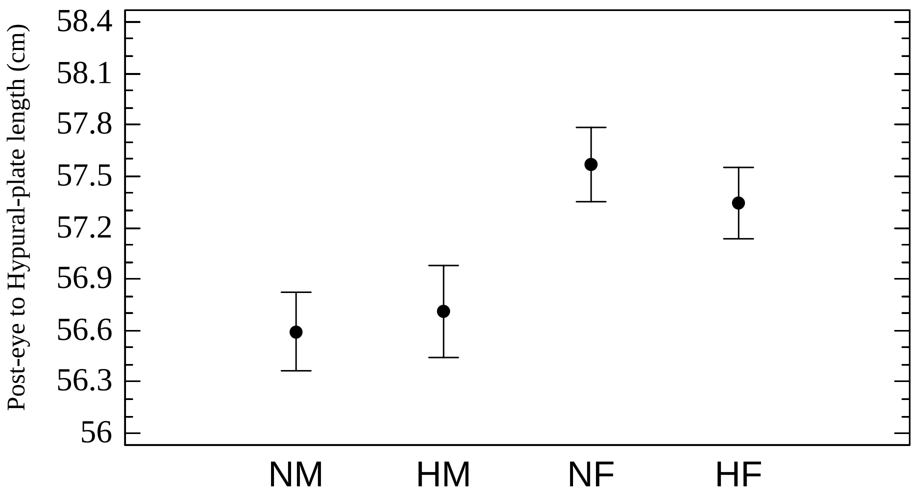

Figure 5. Mean post-eye to hypural-plate length comparisons between Age 4 natural and hatchery-origin males (WM and HM) and natural and hatchery-origin females (WF and HF) for the years 1985-2005.

Fecundities (number of eggs/female) of natural and hatchery origin fish from the Tucannon River program have been documented since 1990 (Table 7). Analysis of variance was performed to determine if there were significant differences in mean fecundities at the 95% confidence level. Natural origin females were significantly more fecund than hatchery origin fish for both Age 4 ($P<0.001$) and Age 5 fish ($P<0.001$).

Mean egg size of natural origin Age 4 spring Chinook from the Tucannon River was 0.225 g/egg and hatchery origin eggs averaged 0.237 g/egg. This difference was significant at the 95% confidence level ($P<0.05$). This may explain why Age 4 hatchery origin females are less fecund. Mean egg size in Age 5 salmon was 0.270 g/egg for natural origin and 0.284 g/egg for hatchery origin females. Although the difference was not significant ($P= 0.09$), we suspect that egg size contributes to the fecundity difference.

Table 7. Average number of eggs/female (n, SD) by age group of Tucannon River natural and hatchery origin broodstock, 1990-2005.

Year	Age 4				Age 5			
	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, 1,111.0)	3,320	(34, 545.4)	3,618	(1, 000.0)	4,208	(1, 000.0)
2001	3,612	(27, 508.4)	3,225	(24, 690.6)	No Fish		3,585	(2, 842.5)
2002	3,584	(14, 740.7)	3,368	(24, 563.7)	4,774	(7, 429.1)	No Fish	
2003	3,342	(10, 738.1)	2,723	(2, 107.0)	4,428	(7, 894.7)	3,984	(17, 772.1)
2004	3,376	(26, 686.9)	2,628	(17, 385.9)	5,191	(1, 000.0)	2,151	(1, 000.0)
2005	3,399	(18, 545.9)	2,903	(22, 654.2)	4,734	(7, 1,025.0)	No Fish	
Mean	**3,531**		**3,128**		**4,416**		**3,649**	
SD	**617.4**		**662.9**		**862.3**		**771.4**	

Coded-Wire Tag Sampling

Broodstock collection, pre-spawn mortalities, and carcasses recovered during spawning ground surveys provide representatives of the annual run that can be sampled for CWT study groups (Table 8). In 2005, based on the estimated escapement of fish to the river, we sampled approximately 37% of the run (Table 9).

Table 8. Coded-wire tag codes of hatchery salmon sampled at LFH and the Tucannon River, 2005.

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 (Age 4)			2			5	7
63-06-81	3		44			3	50
63-17-91			1			2	3
No tags			1[a]				1
AD/No wire				3[b]			3
Total	3	0	48	3	0	10	64

[a] This fish did not have CWT but it did have a right red VIE and was Age 4 which would make it 63-06-81.
[b] Adipose clipped/no wire fish were killed at the trap as strays.

Table 9. Spring Chinook salmon (natural and hatchery) sampled from the Tucannon River, 2005.

	2005		
	Natural	**Hatchery**	**Total**
Total escapement to river	289	131	420
Broodstock collected	49	51	100
Fish dead in adult trap	0	3	3
Total hatchery sample	49	54	103
Total fish left in river	240	77	317
In-river pre-spawn mortality	0	0	0
Spawned carcasses recovered	41	10	51
Total river sample	41	10	51
Carcasses sampled	90	64	154

Arrival and Spawn Timing Trends

Peak arrival and spawn timing have always been monitored to determine whether the hatchery program has caused a shift (Table 10). 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 weekly redd count.

Peak arrival to the trap during 2005 was within the expected historical range (Table 10). Peak spawning date of hatchery fish was also within the range found from previous years. The peak of active spawning in the Tucannon River was equal to the historical mean.

Table 10. Peak dates of arrival of natural and hatchery salmon to the TFH adult trap and peak (date) and duration (number of days) for spawning in the hatchery and river, 1986-2005.

	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
2000	6/06	5/22	–	9/05	22	9/13	30
2001	5/23	5/23	9/11	9/04	20	9/12	35
2002	5/29	5/29	9/10	9/03	22	9/11	42
2003	5/25	5/25	9/09	9/02	36	9/12	37
2004	6/04	6/02	9/14	9/07	29	9/08	30
Mean	**5/30**	**6/03**	**9/12**	**9/10**	**28**	**9/14**	**35**
2005	6/01	5/31	9/06	9/06	28	9/14	28

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

Total Run-Size

In general, redd counts have been directly related to total run-size entering the Tucannon River and passage of adult salmon at the TFH adult trap (Bugert et al. 1991). For 2005, we used sex ratios from collected broodstock and sex ratio observations on the spawning grounds to estimate the number of fish/redd. The run-size estimate for 2005 was calculated by adding the estimated number of fish upstream of the TFH adult trap, the estimated fish below the weir calculated from the fish/redd ratio, the number of pre-spawn mortalities below the weir, and the number of broodstock collected (Table 11). Run-size for 2005 was estimated to be 420 fish (286 natural adults, 3 natural jacks and 123 hatchery-origin adults, 8 hatchery jacks). Historical estimates since 1985 are provided in Appendix C.

Table 11. Estimated spring Chinook salmon run to the Tucannon River, 1985-2005.

Year[a]	Total Redds	Fish/Redd Ratio[b]	Spawning fish In the river	Broodstock Collected	Pre-spawning Mortalities[c]	Total Run-Size	Percent Natural
1985	219	2.60	569	22	0	591	100
1986	200	2.60	520	116	0	636	100
1987	185	2.60	481	101	0	582	100
1988	117	2.60	304	125	0	429	96
1989	106	2.60	276	169	0	445	76
1990	180	3.39	611	135	8	754	66
1991	90	4.33	390	130	8	528	49
1992	200	2.82	564	97	92	753	56
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	16	232	63
1997	73	2.00	146	97	45	288	47
1998	26	1.94	51	89	4	144	59
1999	41	2.60	107	136	2	245	1
2000	92	2.60	239	81	19	339	24
2001	298	3.00	894	106	12	1,012	71
2002	299	3.00	897	107	1	1,005	35
2003	118	3.10	366	77	1	444	56
2004	160	3.00	480	92	1	573	70
2005	102	3.10	317	100	0	420	69

[a] 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.

[b] 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.

[c] Effort in looking for pre-spawn mortalities has varied from year to year with more effort expended during years with poor conditions.

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 (Appendix D). However, in 1999 and 2000, Umatilla River strays accounted for 8 and 12%, respectively, of the total Tucannon River run (Gallinat et al. 2001). The increased number of strays, particularly from the Umatilla River, is a concern since it exceeds the allowable 5% stray rate of hatchery fish deemed acceptable by NOAA Fisheries, and is contrary to WDFW's management intent for the Tucannon River. In addition, the Oregon Department of Fish and Wildlife (ODFW) and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) did not mark a portion of Umatilla River origin spring Chinook with an RV or LV fin clip (65-70% of releases) for the 1997-1999 brood years. Because of this action, some stray fish that returned from those brood years were physically indistinguishable from natural origin Tucannon River spring Chinook. Scale samples were collected from adults in those brood years to determine hatchery-origin fish based on scale pattern analysis. However, scale analysis is not as accurate as genetic analysis and in future years we hope to identify a genetic marker that will allow us to separate unmarked Umatilla origin fish (1997-1999 BYs) from natural Tucannon origin fish. The proportion of hatchery and natural fish (Table 11) may change for the affected years after this analysis is completed. Beginning with the 2000 BY, Umatilla River hatchery-origin spring Chinook are 100% marked. This will help ensure that Tucannon River spring Chinook genetic integrity is maintained by allowing selective removal of strays from the hatchery broodstock.

No known (CWT) hatchery strays were recovered during 2005. However, we did recover three AD only clipped fish [2 - Age 4 (01BY) and 1 - Age 3 (02 BY)] on the spawning grounds. Based on our marks for those age classes (VIE/CWT), and past straying events, we believe those fish were likely Umatilla River origin strays. After expansions, those strays accounted for an estimated 1.4% of the total run (Appendix D).

Hatchery Rearing, Marking, and Release

Hatchery Rearing and Marking

Conventional supplementation juveniles (2004 BY) were marked with a red elastomer tag (VIE) behind the right eye and tagged with CWTs on September 13-20, 2005 (67,722 fish). Supplementation fish were transported to TFH during October. The 2004 BY captive brood juveniles (132,680 fish) were marked September 21-27 with a CWT in the snout and transported to TFH during October.

Length and weight samples were collected twice on the 2004 BY fish during the rearing cycle (Table 12). During February, fish were sampled for length, weight and mark quality, and were PIT tagged for outmigration comparisons (1,001 supplementation fish and 1,002 captive brood progeny) before transfer to Curl Lake AP.

Table 12. Sample sizes (N), mean lengths (mm), coefficients of variation (CV), condition factors (K), and fish/lb (fpp) of 2004 BY juveniles sampled at TFH and Curl Lake.

Brood/ Date	Progeny Type	Sample Location	N	Mean Length	CV	K	FPP
2004							
2/06/06	Supplementation	TFH	250	127.2	9.7	1.21	17.9
4/04/06	Supplementation	Curl Lake	250	139.5	10.1	1.21	13.4
2/07/06	Captive Brood	TFH	250	122.6	9.8	1.22	19.8
4/04/06	Captive Brood	Curl Lake	250	132.9	13.3	1.21	15.3

2004 Brood Release

The 2004 BY pre-smolts were transported to Curl Lake in February 2006 for acclimation and volitional release. Volitional release began April 3 and continued until April 26 when the remaining fish were forced out. Mortalities were low in Curl Lake and WDFW released an estimated 67,542 supplementation fish (13.4 fish/lb) and 132,312 captive broodstock progeny (15.3 fish/lb) (Table 13). Historical hatchery releases are summarized in Appendix E.

Table 13. Yearling spring Chinook releases in the Tucannon River, 2004 brood year.

Release Year	(BY)	Release Location	Release Date	CWT Code	Total Released	Number CWT	Additional Mark	lbs	Fish// lb
2006	(04)	Curl Lake	4/03-4/26	63/28/87	67,542	67,272	Rt. Red VIE	5,040	13.4
2006	(04CB)	Curl Lake	4/03-4/26	63/28/65	132,312	127,162	None	8,648	15.3

Natural Parr Production

Program evaluation staff surveyed the Tucannon River at index sites in 2005 to estimate the density and population of subyearling (Table 14, Appendix F) 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) for a stratum by the estimated total area within each stratum. Fifty 50 m sites were snorkeled in 2005 (July 18–August 25), representing approximately 5.2% of the suitable rearing habitat in the Tucannon River. A total of 1,574 subyearling and 31 yearling spring Chinook were counted during the surveys. We estimated that 30,809 (± 8,607) BY 04 subyearling and 586 (± 351) BY 03 yearling (residual) spring Chinook were present in the river (Table 14).

Table 14. Number of sites, area snorkeled, mean density (fish/100 m2), population estimates, and 95% confidence intervals for subyearling and yearling spring Chinook within the Tucannon River, 2005.

			Subyearling			Yearling		
Stratum	Number of sites	Area (m^2) Snorkeled	Mean Density	Pop. Estimate	C.I.	Mean Density	Pop. Estimate	C.I.
Marengo	6	3,164	2.87	1,755	1,920	0.23	142	167
Hartsock	14	9,079	4.36	7,807	4,882	0.01	10	20
HMA	20	11,666	7.91	17,541	6,691	0.20	434	321
Wilderness	10	3,682	5.19	3,706	2,380	0.00	0	0
Total	**50**	**27,591**	**5.77**	**30,809**	**8,607**	**0.11**	**586**	**351**

Natural Smolt Production

Program staff operated a 1.5 m rotary screw trap at rkm 3 on the Tucannon River from October 11, 2004 to June 30, 2005 to estimate numbers of migrating natural and hatchery spring Chinook. Numbers of selected species captured during the 2005 outmigration can be found in Appendix G. Other data such as peak outmigration, other species captured, etc., have not been reported here for simplicity. Those data are available upon request.

Natural spring Chinook emigrating from the Tucannon River (BY 2003) averaged 107 mm (Figure 6). This is in comparison to an average length of 139 mm for hatchery-origin fish (BY 2003) released from Curl Lake Acclimation Pond (Gallinat and Ross 2005).

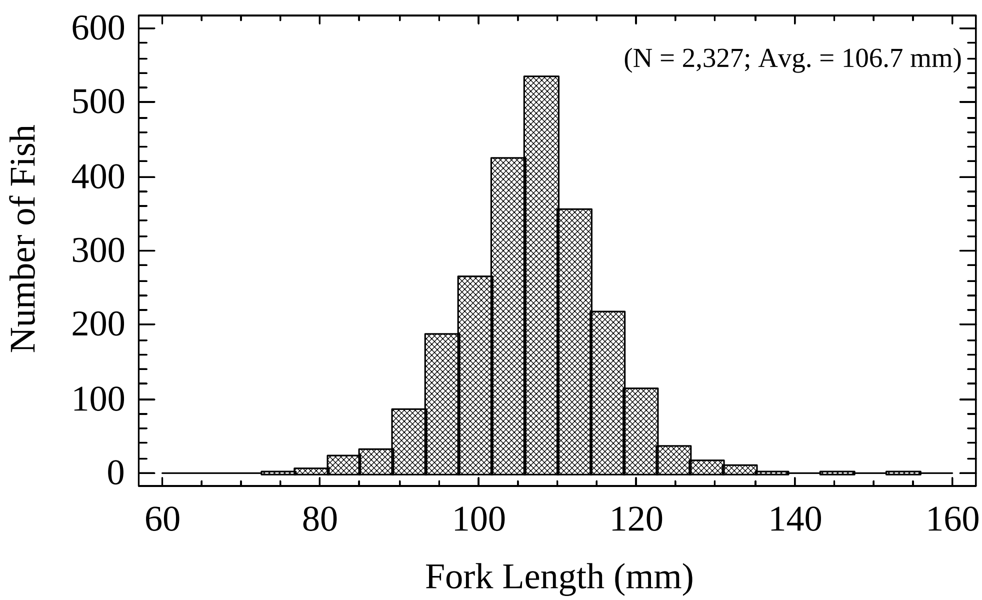

Figure 6. Length frequency distribution of sampled natural spring Chinook salmon captured in the Tucannon River smolt trap, 2004/2005 season.

Regression analysis was used to examine the influence of specific abiotic variables on spring Chinook emigration during the last eight trapping seasons (1997/1998 to 2004/2005). Significant relationships were found between the total number of natural spring Chinook smolts captured ($\log_{10}$ transformed for normality) emigrating from the Tucannon River and flow (ft^3/sec) ($r^2 = 0.13$, $P< 0.01$), staff gauge level ($r^2 = 0.24$, $P< 0.01$), time of year ($r^2 = 0.12$, $P< 0.01$), and water temperature ($r^2 = 0.05$, $P< 0.01$). 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 significant relationship (P >

0.05) was found between number of natural spring Chinook smolts emigrating and secchi disk reading (indicator of turbidity). Also, no significant relationships were found between the number of hatchery spring Chinook smolts captured ($\log_{10}$ transformed) and flow, staff gauge level, time of year, water temperature, or, secchi disk reading. As the hatchery fish were raised in an artificial environment they may be less attuned to environmental triggers for emigration.

Each week we attempted to determine trap efficiency by clipping a portion of the caudal fin on a representative subsample of captured migrants and releasing them one kilometer upstream. The percent of marked fish recaptured was used as an estimate of weekly trapping efficiency.

To estimate potential juvenile migrants passing when the trap was not operated for short intervals, 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.

In previous reports we attempted to relate trap efficiency to abiotic factors such as stream flow or staff gauge level based on similar juvenile outmigration studies (Groot and Margolis 1991, Seiler et al. 1999, Cheng and Gallinat 2004). Our relationships however were not significant. Using ANOVA, there was a significant (P > 0.05) year effect on trap efficiency (Annette Hoffman, WDFW, personal comm.) and so we used the average within year annual efficiency for each species following the work of Ryding (2001) on the Skagit River.

Smolt abundance on the i^{th} day was estimated by,

$$\hat{M}_i = \frac{C_i}{\hat{\bar{e}}},$$

where, $\hat{M}_i$ = the number of chinook smolts on the i^{th} day**,**
C = the number of fish caught in the trap i^{th} day,
$\hat{\bar{e}}$ = trap efficiency.

Using replicate releases of tagged fish released approximately one kilometer upstream of the trap, efficiency, e for each release group was estimated by,

$$\hat{e}_i = \frac{r_i}{m_i},$$

where, r_i = the number of marked fish recaptured in the trap from the i^{th} release group,
m_i = the number of marked fish in the i^{th} release group.

Overall trap efficiency, $\hat{\bar{e}}$, was estimated by,

$$\hat{\hat{e}} = \frac{\sum_{i=1}^{n} \hat{e}_i}{n}$$

where $\hat{e}_i$ = the recapture rate of the i^{th} release group.

Variance for the smolt estimates was calculated by,

$$V\hat{a}r\left(\hat{M}\right) = \sum_{i=1}^{N} \hat{M}_i^2 \left(\frac{\hat{M}_i \hat{\hat{e}}\left(1-\hat{\hat{e}}\right)}{C_i^2} + \left(1-\frac{n}{N}\right) \frac{\sum_{j=1}^{n}\left(e_j - \hat{\hat{e}}\right)^2}{n(n-1)\hat{\hat{e}}^2} \right)$$

where C_i = the number of smolts caught in the trap on the ith day, $i = 1, 2, ..., N$;

$\hat{M}_i$ = the estimated number of smolts migrating on the i^{th} day;

e_j = the jth trap efficiency estimate, $j = 1, 2, ..., n$;

n = the number of weeks with trap efficiency estimates;

N = the total number of weeks in the migration season;

$\hat{\hat{e}}$ = the average trap efficiency for the year, estimated by $\hat{\hat{e}} = \frac{\sum_{j=1}^{n} e_j}{n}$;

A number of assumptions are required to attain unbiased estimates of smolt production. How well the assumptions are met will determine the reliability of the estimates. These assumptions are:

- Survival from release to the trap was 100%.
- All marked fish are identified and correctly enumerated.
- Fish do not lose their marks.
- All fish in the tag release group emigrate (i.e., do not residualize in the area of release).

We estimated that 23,003, or 56% of the 2003 BY parr estimates, passed the smolt trap during 2004-2005 (Table 15). We also estimated that 34% of the conventional hatchery supplementation fish and 37% of the captive brood progeny released from Curl Lake AP (2003 BY) passed the smolt trap.

Table 15. Monthly and total population estimates (with 95% confidence interval) for natural and hatchery origin (supplementation and captive brood) emigrants from the Tucannon River, 2005.

Month	Natural	Supplementation	Captive Brood
Sept.-Feb.	3,911	0	0
March	1,809	0	4
April	9,597	11,142	24,851
May	7,566	12,817	23,120
June	120	109	248
Total	**23,003**	**24,068**	**48,223**
(+/- 95% C.I.)	**(+/- 790)**	**(+/- 1,145)**	**(+/- 2,109)**
% Survival [a]	**56.2**	**33.8**	**37.1**

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

Juvenile Migration Studies

In 2005, we used passive integrated transponder (PIT) tags to study the emigration timing and relative success of our supplementation hatchery fish with our captive brood progeny. We tagged 1,000 supplementation and 1,000 captive brood progeny hatchery-origin fish during early February before transferring them to Curl Lake AP for acclimation and volitional release (Table 16). Seven fish from each group died or lost their tags after tagging. Detection rates were low, but similar to rates from previous releases at Curl Lake AP (Bumgarner et al. 1997).

Table 16. Cumulative detection (one unique detection per tag code) and travel time in days (TD) of PIT tagged hatchery spring Chinook salmon released from Curl Lake Acclimation Pond (rkm 65.6) on the Tucannon River at downstream Snake and Columbia River Dams during 2005 (Fish were volitionally released from 3/28/05-4/15/05).

	Release Data				Recapture Data									
Hatchery		Mean		Mean	LMJ		MCJ		JDJ		BONN		Total	
Origin	N	Length	SD	Length	N	TD	N	TD	N	TD	N	TD	N	%
Supplementation	993	119.8	13.2	121.3	165	24.4	85	30.8	30	33.6	5	35.8	285	28.7
Captive Brood	993	123.8	16.1	127.1	142	21.8	65	30.9	28	33.3	9	39.4	244	24.6

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.

Survival probabilities were estimated by the Cormack Jolly-Seber methodology using the Survival Under Proportional Hazards (SURPH2) computer model. The data files were created using the CAPTHIST program. Data for input into CAPHIST was obtained directly from PTAGIS. Survival estimates from Curl Lake to Lower Monumental Dam were 0.45 (± 0.04) and 0.44 (± 0.05) for supplementation and captive brood progeny, respectively. While survival estimates were slightly lower for captive brood progeny fish the differences were not significant ($P > 0.05$).

Survival Rates

Point estimates of population sizes have been calculated for various life stages (Tables 17 and 18) of natural and hatchery-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 19) because they have been protected in the hatchery. However, smolt-to-adult return rates (SAR) of natural salmon were about five times higher than for hatchery-reared salmon (Tables 20 and 21). Mean hatchery SARs (0.15%) documented from the 1985-2000 broods were well below the LSRCP survival goal of 0.87%. Hatchery SARs for Tucannon River salmon need to substantially improve to meet the mitigation goal of 1,152 hatchery adult salmon.

Table 17. Estimates of *natural* Tucannon spring Chinook salmon abundance by life stage for 1985-2005 broods.

Brood Year	Females in River Natural	Females in River Hatchery	Mean[a] Fecundity Natural	Mean[a] Fecundity Hatchery	Number of Eggs	Number[b] of Parr	Number of Smolts	Progeny[c] (returning adults)
1985	219	-	3,883	-	850,377	90,200	42,000	392
1986	200	-	3,916	-	783,200	102,600	58,200	468
1987	185	-	4,096	-	757,760	79,100	44,000	238
1988	117	-	3,882	-	454,194	69,100	37,500	527
1989	103	3	3,883	2,606	407,767	58,600	30,000	158
1990	128	52	3,993	2,697	651,348	86,259	49,500	94
1991	51	39	3,741	2,517	288,954	54,800	30,000	7
1992	119	81	3,854	3,295	725,521	103,292	50,800	194
1993	112	80	3,701	3,237	673,472	86,755	49,560	204
1994	39	5	4,187	3,314	179,863	12,720	7,000	12
1995	5	0	5,224	0	26,120	0	75	6
1996	53	16	3,516	2,843	231,836	2,845	1,612	69
1997	39	33	3,609	3,315	250,146	32,913	21,057	799
1998	19	7	4,023	3,035	97,682	8,453	5,508	375
1999	1	40	3,965	3,142	129,645	15,944	8,157	141
2000	26	66	3,969	3,345	323,964	44,618	20,045	446
2001	219	79	3,612	3,252	1,047,936	63,412	38,079	235
2002	104	195	3,981	3,368	1,070,784	72,197	60,530	3
2003	67	51	3,789	3,812	448,275	40,900	23,003	
2004	117	43	3,444	2,601	514,791	30,809		
2005	77	25	3,773	2,903	363,096			

[a] 1985 and 1989 mean fecundity of natural females is the average of 1986-88 and 1990-93 brood years.
[b] Number of parr 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 or other out-of-basin recoveries.

Table 18. Estimates of Tucannon spring Chinook salmon abundance (*spawned and reared in the hatchery*) by life stage for 1985-2005 broods.

Brood Year	Females Spawned Natural	Females Spawned Hatchery	Mean[a] Fecundity Natural	Mean[a] Fecundity Hatchery	Number of Eggs	Number of Parr	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	339
1987	48	-	4,096	-	196,573	164,630	152,165	190
1988	49	-	3,882	-	182,438	150,677	146,200	447
1989	28	9	3,883	2,606	133,521	103,420	99,060	243
1990	21	23	3,993	2,697	126,334	89,519	85,800	28
1991	17	11	3,741	2,517	91,275	77,232	74,060	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	132,870	130,069	34
1995	6	15	5,224	0	85,772	63,935	62,272	180
1996	18	19	3,516	2,843	117,287	80,325	76,219	260
1997	17	25	3,609	3,315	144,237	29,650	24,184	181
1998	30	14	4,023	3,035	161,019	136,027	127,939	830
1999	1	36	3,965	3,142	113,544	106,880	97,600	29
2000	3	35	3,969	3,345	128,980	123,313	102,099	175
2001	29	27	3,612	3,252	184,127	174,934	146,922	128
2002	22	25	3,981	3,368	169,364	151,531	123,586	8
2003	17	20	3,789	3,812	140,658	126,400	71,154	
2004	28	18	3,444	2,601	140,459	128,877	67,542	
2005	25	24	3,773	2,903	161,345	145,279		

[a] 1985 and 1989 mean fecundity of natural females is the average of 1986-88 and 1990-93 brood years; 1999 mean fecundity of natural fish is based on the mean of 1986-1998 brood years.
[b] Numbers do not include down river harvest or other 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 19. 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 Parr**	**Parr to Smolt**	**Egg to Smolt**	**Egg to Parr**	**Parr to Smolt**	**Egg to Smolt**	**Egg to Parr**	**Parr to Smolt**	**Egg to Smolt**
1985	10.6	46.6	4.9	90.3	96.4	87.1	8.5	2.1	17.6
1986	13.1	56.7	7.4	94.3	86.7	81.8	7.2	1.5	11.0
1987	10.4	55.6	5.8	83.8	92.4	77.4	8.0	1.7	13.3
1988	15.2	54.3	8.3	82.6	97.0	80.1	5.4	1.8	9.7
1989	14.4	51.2	7.4	77.5	95.8	74.2	5.4	1.9	10.1
1990	13.2	57.4	7.6	70.9	95.8	67.9	5.4	1.7	8.9
1991	19.0	54.7	10.4	84.6	95.9	81.1	4.5	1.8	7.8
1992	14.2	49.2	7.0	97.0	57.8	56.1	6.8	1.2	8.0
1993	12.9	57.1	7.4	86.3	95.6	82.5	6.7	1.7	11.2
1994	7.1	55.0	3.9	82.2	97.9	80.4	11.6	1.8	20.7
1995	0.0	0.0	0.3	74.5	97.4	72.6	- -	- -	- -
1996	1.2	56.7	0.7	68.5	94.9	65.0	55.8	1.7	- -
1997	13.2	64.0	8.4	20.6	81.6	16.8	1.6	1.3	2.0
1998	8.7	65.2	5.6	84.5	94.1	79.5	9.8	1.4	14.1
1999	12.3	51.2	6.3	94.1	91.3	86.0	7.7	1.8	13.7
2000	13.8	44.9	6.2	95.6	82.8	79.2	6.9	1.8	12.8
2001	6.1	60.1	3.6	95.0	84.0	79.8	15.7	1.4	22.0
2002	6.7	83.8	5.7	89.5	81.6	73.0	13.3	1.0	12.9
2003	9.1	56.2	5.1	89.9	56.3	50.6	9.8	1.0	9.9
2004	6.0			91.8	52.4	48.1	15.3		
2005				90.0					
Mean	10.4	53.7	5.9	83.0	86.4	71.0	10.8	1.6	12.1
SD	4.8	15.4	2.5	16.4	14.4	16.9	11.5	0.3	4.8

Table 20. Adult returns and SARs of natural salmon to the Tucannon River for brood years 1985-2000.

		Number of Adult Returns, observed (obs) 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	42,000	8	19	110	255	36	118	0.93	0.89
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	30,000	5	12	47	120	23	26	0.53	0.49
1990	49,500	3	8	63	72	12	14	0.19	0.17
1991	30,000	0	0	4	5	1	2	0.02	0.02
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	8.00[c]	8.00[c]
1996	1,612	0	0	27	63	2	6	4.28	4.28
1997	21,057	6	14	234	703	29	82	3.79	3.73
1998	5,508	3	9	86	245	43	121	6.81	6.64
1999	8,157	3	9	44	124	3	8	1.73	1.62
2000	20,045	1	3	148	392	16	51	2.22	2.21
Geometric Mean of 1985-2000 broods								0.76	0.74

[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 21. Adult returns and SARs of hatchery salmon to the Tucannon River for brood years 1985-2000.

		Number of Adult Returns, known and expanded (exp.)							
		Age 3		Age 4		Age 5		SAR (%)	
Brood Year	Estimated Number of Smolts	Known	Exp.	Known	Exp.	Known	Exp.	w/ Jacks	No Jacks
1985	12,922	9	19	25	26	0	0	0.35	0.20
1986	153,725	79	83	99	238	8	18	0.22	0.17
1987	152,165	9	22	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
1996	76,219	44	60	100	186	5	14	0.34	0.26
1997	24,186	7	13	59	168	0	0	0.75	0.69
1998	127,939	36	103	164	577	39	150	0.65	0.57
1999	97,600	2	7	5	19	1	3	0.03	0.02
2000	102,099	7	27	53	148	0	0	0.17	0.14
Geometric Mean of 1985-2000 broods								0.15	0.12

As previously stated, overall survival of hatchery salmon to return as adults was higher than for naturally reared fish because of the early-life survival advantage (Table 19). With the exception of the 1988 and 1997-2000 brood years, naturally produced fish have been below the replacement level (Figure 7; Table 22). Based on adult returns from the 1985-2000 broods, naturally reared salmon produced only 0.6 adults for every spawner, while hatchery reared fish produced 1.8 adults.

Beginning with the 2006 brood year, the annual smolt goal will be increased from 132,000 to 225,000 to help offset for the higher mortality of hatchery-origin fish after they leave the hatchery. This should increase adult salmon returns back to the Tucannon River; however, based on current hatchery SARs this still would not produce enough adult returns to reach the current LSRCP mitigation goal. In conjunction with this we plan to conduct an experiment to examine size at release as a possible means to improve SAR of hatchery fish.

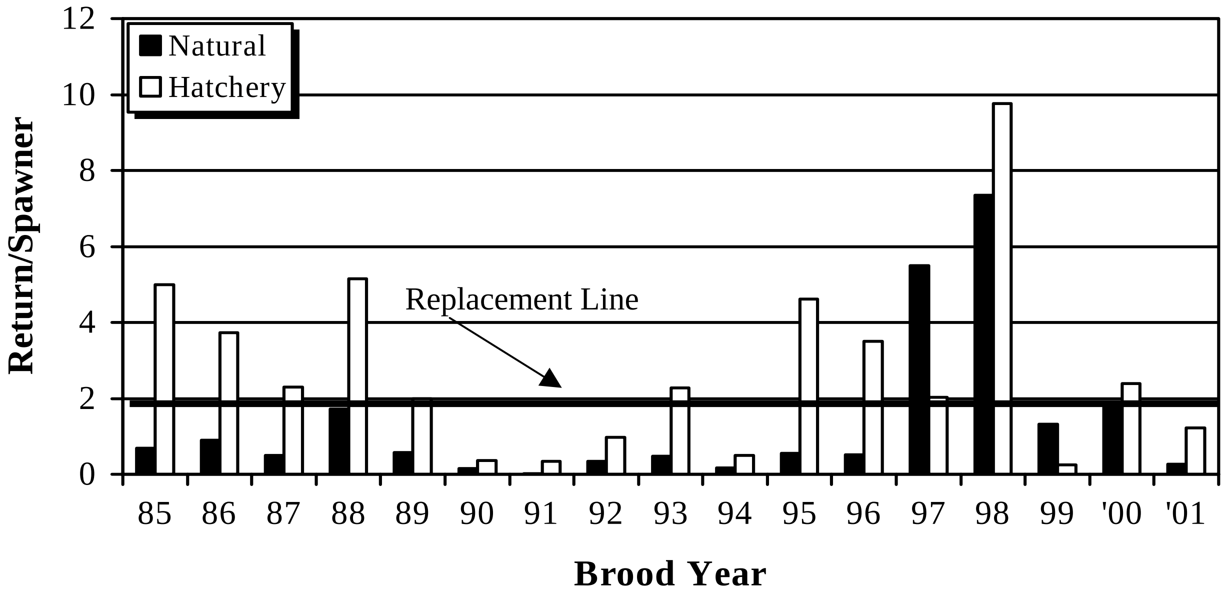

Figure 7. Return per spawner ratio (with replacement line) for the 1985-2001 brood years (2001 incomplete brood year).

Table 22. Parent-to-progeny survival estimates of Tucannon River spring Chinook salmon from 1985 through 2001 brood years (2001 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	569	392	0.69	9	45	5.00	7.2
1986	520	468	0.90	91	339	3.73	4.1
1987	481	238	0.49	83	190	2.29	4.7
1988	304	527	1.73	87	447	5.14	3.0
1989	276	158	0.57	122	243	1.99	3.5
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	136	69	0.51	74	260	3.51	6.9
1997	146	799	5.47	89	181	2.03	0.4
1998	51	375	7.35	85	830	9.76	1.3
1999	107	141	1.32	122	29	0.24	0.2
2000	239	446	1.87	73	175	2.40	1.3
2001	894	235	0.26	104	128	1.23	4.7
Geometric Mean			**0.60**			**1.75**	**2.9**

Fishery Contribution

An original goal of the LSRCP supplementation program was to enhance natural returns of salmon to the Tucannon River by providing 1,152 hatchery-reared fish (the number estimated to have been lost due to the construction of the Lower Snake River hydropower system) to the river. Such an increase would allow for limited harvest and increased spawning. However, hatchery adult returns have always been below the program goal. Moreover, natural escapement, with the exception of the 2001 run, has been low (Figure 8). Based on 1985-2000 brood year CWT recoveries from the RMIS database (Appendix H), sport and commercial harvest combined has only accounted for 8.2% of the adult hatchery fish recovered annually. However, fishing mortality (both sport and commercial) has increased in recent years to 33% and 22% for the 1997 and 1998 brood years, respectively (Appendix H). Fishing mortality is one form of mortality managers can control. Adipose clipped hatchery fish have traditionally been targeted in the sport fishery. This hatchery fin clip was abandoned for Tucannon River spring Chinook smolts starting with the 2000 BY to mitigate fishing mortality on this ESA listed population (Gallinat et al. 2001). Supplementation fish are now marked with a CWT and a red VIE tag behind the right eye. Captive brood progeny are marked only with agency-only wire tags or CWT to distinguish them from supplementation origin fish. Out-of-basin stray rates of Tucannon River spring Chinook have been low (Appendix H), with an average of 3.2% of the adult hatchery fish straying to other river systems/hatcheries for brood years 1985-2000 (range 0-20%).

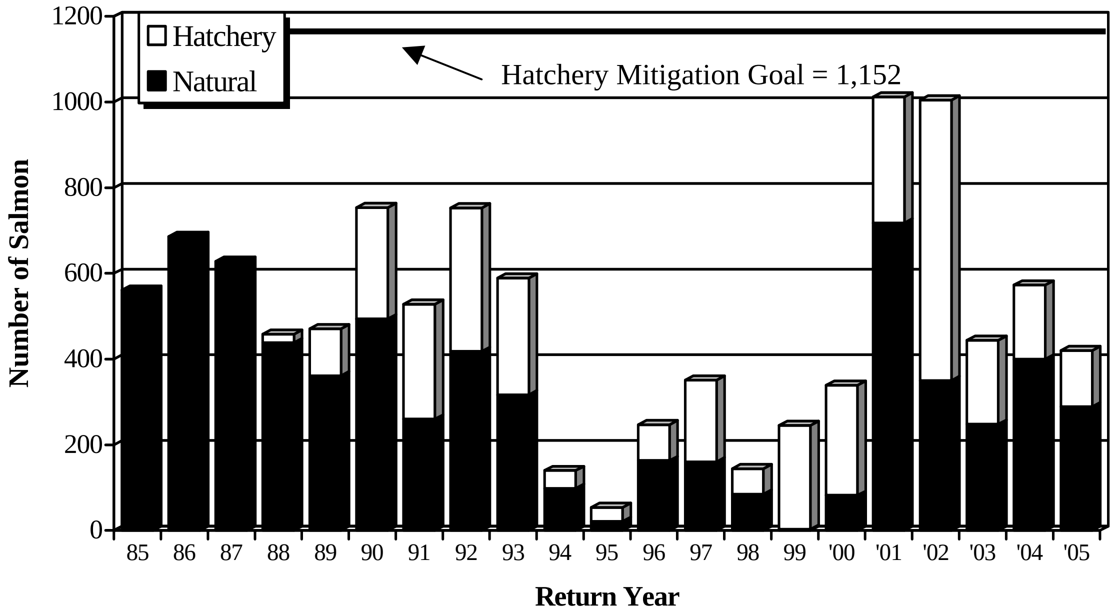

Figure 8. Total escapement for Tucannon River spring Chinook salmon for the 1985-2005 run years.

Conclusions and Recommendations

Washington's LSRCP hatchery spring Chinook salmon program has failed to return adequate numbers of adults to meet the mitigation goal. This has occurred because SARs of hatchery origin fish have consistently been lower than predicted, even though hatchery returns have generally been at 2-3 times the replacement level. Further, the natural spring Chinook population in the river has declined and remained below the replacement level for most years, with the majority (95%) of the mortality occurring between the green egg and smolt stages. Ocean conditions and mortality within the mainstem migration corridor have also contributed to poor survival. While this neither was, nor is the desired result of the program, in many ways the hatchery program has helped conserve the natural population by returning adults to spawn in the river. System survivals (in-river, migration corridor, ocean) must increase in the future for the hatchery program and the natural run to reach their full potential, and be sustainable over the long-term.

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 hatchery program and the natural population. Based on our previous studies and current data involving survival and physical characteristics we recommend the following:

1. We continue to see annual differences in 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 are little changed over the program's history. Further, genetic analysis to date indicates little change in the natural population as a result of hatchery actions.

   <u>Recommendation</u>: 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. Collect other biological data (length, run timing, spawn timing, DNA samples, juvenile parr production, smolt trapping, and life stage survival) to continue the documentation of the effects (positive or negative) that the hatchery program may have on the natural population.

2. The success of hatchery origin fish spawning in the river has become an important topic among managers within the Snake River Basin and with NOAA Fisheries. Little data exists on this subject. With the hatchery population in the Tucannon River intermixing with the natural population, we have an opportunity to study the effects of the hatchery spawners in the natural environment.

   Recommendation: Continue to seek funding for a DNA based pedigree analysis study to examine the reproductive success of hatchery fish in the natural environment. 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-year's parr production, smolt numbers and returning adults in context of the proportion of hatchery spawners in the river. Publish the results.

3. Subbasin and recovery planning for ESA listed species in the Tucannon River will identify factors limiting the spring Chinook population and strategies to recover the population. Development of a recovery goal for the population that is consistent with NOAA's Viable Salmonid Population criteria would be helpful in developing and evaluating recovery strategies for habitat, hydropower, harvest, and hatcheries.

   Recommendation: Assist subbasin planning in the development of a recovery goal for spring Chinook in the Tucannon River. Determine carrying capacity of the Tucannon River so that hatchery stocking is appropriate. Determine impacts to other species (e.g., steelhead).

4. We have documented that hatchery juvenile (egg-parr-smolt) survival rates are considerably higher than naturally reared salmon, and hatchery smolt-to-adult return rates are much lower. We need to identify and address the factors that limit hatchery SARs in order to meet mitigation goals. Beginning with the 2006 brood year, the annual hatchery smolt goal will be increased from 132,000 to 225,000 to help offset for the higher mortality of hatchery-origin fish after they leave the hatchery. This should increase adult salmon returns back to the river, however, based on current hatchery SARs this would still not produce enough adult returns to reach the LSRCP mitigation goal.

   Recommendation: Conduct an experiment to examine size at release as a possible means to improve SAR of hatchery fish. Evaluate survival rates from other watersheds to see if the LSRCP goal of 0.87% is a realistic goal under existing conditions. Increase PIT tagging to ascertain where the mortality is occurring.

Literature Cited

Becker, G. C. 1983. Fishes of Wisconsin. University of Wisconsin Press.

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

Bugert, R., C. Busack, G. Mendel, L. Ross, K. Petersen, D. Marbach, and J. Dedloff. 1991. Lower Snake River Compensation Plan Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 1990 Annual Report to U.S. Fish and Wildlife Service, AFF 1/LSR-91-14, Cooperative Agreement 14-16-0001-90524. Washington Department of Fisheries, Olympia, Washington.

Bumgarner, J. D., G. Mendel, L. Ross, D. Milks, and J. Dedloff. 1994. Lower Snake River Compensation Plan Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 1993 Annual Report to U.S. Fish and Wildlife Service, Aff1/LSR-94-09, Cooperative Agreement 14-16-0001-93539. Washington Department of Fish and Wildlife, Olympia, Washington.

Bumgarner, J., G. Mendel, D. Milks, L. Ross, J. Dedloff, and M. Varney. 1997. Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 1996 Annual Report to U.S. Fish and Wildlife Service, Cooperative Agreement 14-48-0001-96539. Washington Department of Fish and Wildlife, Olympia, Washington. Report # H97-07. 43 p.

Bumgarner, J., L. Ross, and M. Varney. 2000. Lower Snake River Compensation Plan Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 1998 and 1999 Annual Reports to U.S. Fish and Wildlife Service, Cooperative Agreements 1448-14110-98-J057 and CA-14110-9-J070. Washington Department of Fish and Wildlife, Olympia, Washington. Report # FPA00-17.

Cheng, Y. W., and M. P. Gallinat. 2004. Statistical analysis of the relationship among environmental variables, inter-annual variability and smolt trap efficiency of salmonids in the Tucannon River. Fisheries Research 70: 229-238.

Gallinat, M. P., J. D. Bumgarner, L. Ross, and M. Varney. 2001. Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 2000 Annual Report to U.S. Fish and Wildlife Service, Cooperative Agreement 1411-09-J070. Washington Department of Fish and Wildlife, Olympia, Washington. Report # FPA01-05.

Gallinat, M. P. and L. A. Ross. 2005. Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 2004 Annual Report to U.S. Fish and Wildlife Service, Cooperative Agreement 1411-04-J072. Washington Department of Fish and Wildlife, Olympia, Washington. Report # FPA 05-11.

Gallinat, M. P. 2006. Tucannon River Spring Chinook Salmon Captive Broodstock Program-FY2005 Annual Report. Washington Department of Fish and Wildlife, Olympia, Washington. Report to BPA. Project #2000-019-00.

Griffith, J. S. 1981. Estimation of the age-frequency distribution of stream-dwelling trout by underwater observation. Progressive Fish-Culturist 43: 51-53.

Groot, C., and L. Margolis. 1991. Pacific salmon life histories. UBC Press. Vancouver, B.C. 564 p.

Kassler, T.W. and D. K. Hawkins. 2006. Genetic assessment of the spring Chinook captive Brood program in the Tucannon River (2003 & 2004) using a microsatellite DNA analysis. Washington Dept. of Fish and Wildlife. Olympia, Washington. 37 p.

McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. Prepared by Columbia River Inter-Tribal Fish Commission for U.S. EPA. Report #EPA 910-R-99-010. 279 pp.

Ryding, K., 2001. Review: 2000 Skagit River wild 0+ Chinook production evaluation. Appendix to Seiler, D., S. Neuhauser, and L. Kishimoto. 2002. 2001 Skagit River Wild 0+ Chinook Production Evaluation Annual Report. Washington Department of Fish and Wildlife, Olympia, Washington. Report # FPA 02-11.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184.

Schill, D. J., and J. S. Griffith. 1984. Use of underwater observations to estimate cutthroat trout abundance in the Yellowstone River. North American Journal of Fisheries Management 4: 479-487.

Seiler, D., L. Kishimoto, and S. Neuhauser. 1999. 1998 Skagit River wild 0+ Chinook production evaluation. Washington Department of Fish and Wildlife. Olympia, Washington. 73 pp.

Theurer, F. D., I. Lines, and T. Nelson. 1985. Interaction between riparian vegetation, water temperature, and salmonid habitat in the Tucannon River. Water Resources Bull. 21(1): 53-64.

Tucannon Subbasin Summary. 2001. L. Gephart and D. Nordheim, editors. Prepared for the Northwest Power Planning Council. Dayton, Washington.

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

Appendix A: Spring Chinook Captured, Collected, or Passed Upstream at the Tucannon Hatchery Trap in 2005

Appendix A. Spring Chinook salmon captured, collected, or passed upstream at the Tucannon Hatchery trap in 2005. (Trapping began in February; last day of trapping was September 30).

	Captured in Trap		Collected for Broodstock		Passed Upstream		Killed Outright	
Date	**Natural**	**Hatchery**	**Natural**	**Hatchery**	**Natural**	**Hatchery**	**Natural**	**Hatchery**
5/7	1				1			
5/19		1		1				
5/20	2	5	1	3	1	2		
5/22	2	1	1	1	1			
5/23		2				2		
5/24	1	1	1			1		
5/25	2	2	1		1	2		
5/26	2	1	2	1				
5/27	14	7	9	4	5	3		
5/28	4	3			4	3		
5/29	7	1			7	1		
5/31	12	11	6	9	6	1		1
6/1	14	9	10	7	4	2		
6/2	7	8	4	5	3	2		1
6/3	5	7	3	2	2	5		
6/5	3				3			
6/6	7	4	4	1	3	3		
6/7	2	2	1	1	1	1		
6/8	1	2	1	2				
6/9	1	1			1	1		
6/10		1		1				
6/13	6	2	3		3	2		
6/15	1	1		1	1			
6/16	1				1			
6/20	4	3	2	1	2	2		
6/21	2		1		1			
6/22	2	3		1	2	2		
6/23		2		1		1		
6/24		1		1				
6/27	4	7		1	4	6		
6/29	1				1			
6/30		2				2		
7/1		1		1				
7/2	1				1			
7/7		2		1		1		
7/18	1				1			
7/20		1				1		
7/25		1		1				
8/1		1		1				
8/29	1				1			
8/31	1	1		1	1			
9/4		2				2		
9/6	4	6	1	2	3	3		1
9/7	1	3			1	3		
9/9	6	2			6	2		
9/10	3				3			
9/11	2				2			
9/12	1	1			1	1		
9/14	2	2			2	2		
9/16	1				1			
9/19	1	1			1	1		
Totals	**133**	**114**	**51**	**51**	**82**	**60**	**0**	**3**
Corrected #'s After spawning[a]	**131**	**114**	**49**	**51**	**82**	**60**	**0**	**3**

[a] We were short two natural fish collected for broodstock at the end of spawning.

Appendix B: 2003 & 2004 Microsatellite DNA Analysis

Genetic assessment of the spring Chinook captive brood program in the Tucannon River (2003 & 2004) using a Microsatellite DNA Analysis.

Genetic Assessment of the Spring Chinook Captive Brood Program in the Tucannon River (2003 & 2004) Using a Microsatellite DNA Analysis

by

Todd W. Kassler
Denise K. Hawkins

Washington Department of Fish and Wildlife
Genetics Laboratory
600 Capitol Way N
Olympia, WA 98501

April 2006

Abstract

A total of 937 spring Chinook samples from the Tucannon River were analyzed from collections made in 2003 and 2004 using 14 microsatellite loci. Analyses were performed on captive brood samples, supplementation spawners, and in-river spawners. The supplementation and in-river spawners were identified to be of natural or hatchery-origin and were partitioned into those groups to be re-analyzed. All collections were found to exhibit relatively high and similar levels of genetic diversity. Genotypic tests of differentiation indicated highly significant differences between the captive brood spawners and either the supplementation spawners or in-river spawners, but the supplementation spawners and in-river spawners were not different. Analysis of the collections re-grouped into hatchery and natural-origin (based on coded-wire tags) indicated highly significant differences among all groups. This provides evidence that the supplementation program has been effective in homogenizing the two-spawner groups (supplementation and in-river) based on the differences between the hatchery and natural-origin fish. The captive broodstock program has also been effective at maintaining genetic variation in spring-run Chinook in the Tucannon River while providing additional smolts for release.

Table of Contents

List of Tables

Introduction

Prior to 1985, only two fry releases of spring Chinook salmon (*O. tshawytscha*) occurred in the Tucannon River. In August 1962, 16,000 Klickitat River spring Chinook fry were released and in June 1964 there were 10,500 Willamette, Oregon spring Chinook fry released by the Washington Department of Fisheries into the Tucannon River. Neither of these releases is believed to have returned any significant number of adults (Gallinat 2004). In 1985, the hatchery spring Chinook production program was started by the Washington Department of Fisheries in the Tucannon River by capturing wild (unmarked) adults from the Tucannon River. Since 1988, hatchery-origin spring Chinook have been returning to the Tucannon River and beginning in 1989 the hatchery broodstock has consisted of both natural and hatchery-origin fish. This supplementation program is part of the Lower Snake River Compensation Plan (LSRCP) mitigation program, and will continue as long as mitigation is required under the LSRCP.

In 1994, the adult escapement declined severely to less than 150 fish, and the run in 1995 was estimated at 54 fish. In 1995, the Tucannon River spring Chinook population was listed as threatened under the ESA because of declining numbers of returning spring Chinook despite the supplementation program. As a result, WDFW and the co-managers believed intervention beyond the supplementation program was warranted in the form a captive broodstock program.

The plans for the captive broodstock program were determined and spring Chinook from the Tucannon River supplementation program were collected from 1997-2001 brood years (BY) to be raised to adults and spawned. Males were also collected from the 2002 BY in order to have enough to spawn with the captive brood females towards the end of the program. Each year, fish that mature from the initial group of captive broodstock are spawned. The captive brood program is scheduled to produce smolts for release through 2008.

Both the supplementation and captive brood programs are being conducted with the understanding that artificial propagation may have potentially deleterious direct and indirect effects on spring Chinook in the Tucannon River. These effects could include genetic and ecological changes that result in maladaptive genetic, physiological, or behavioral changes in the donor or target populations, thereby causing losses in natural productivity. A report by Gallinat (2004) describes the restoration program for spring Chinook in the Tucannon River.

The goal of this report is to analyze spring Chinook collected in 2003 and 2004 to assess the genetic differences in the captive brood program, the supplementation program, and fish that are spawning naturally in-river. Additional analyses will assess the genetic differentiation of hatchery-origin and natural-origin spawners to determine if the artificial production programs are having any genetic effects on the natural-origin Chinook.

Materials and Methods

A total of 937 spring-run Chinook samples from collections made from the Tucannon River supplementation program, captive brood program, and natural origin in 2003 and 2004 (Table 1) were analyzed at 14 microsatellite loci. Collections were grouped in two ways for analysis. The first comparisons (spawner) involved groups comprised of fish that actually spawned in the various environments (i.e., supplementation hatchery, in-river, or part of the captive brood program). Both the supplementation spawner and in-river spawner groups are comprised of natural and hatchery-origin fish. Marking and tagging operations in the hatchery made it possible to identify each Chinook as hatchery or natural-origin. Based on the identity of each fish they were re-distributed into groups based on their genetic-origin. The second comparison involved Chinook from the hatchery versus natural-origin (genetic origin). The captive brood group was the same in both sets of comparisons.

Tissue samples were collected for all fish spawned in both the supplementation and captive broodstock programs in 2003 and 2004. However, not all of the fish that spawned in-river were genetically sampled, therefore, the entire Tucannon River spring Chinook escapement was not represented. Collection codes, number of samples analyzed per collection, sample types and collection sources are given in Table 1.

DNA was extracted using silica membrane based kits obtained from Machery-Nagel. The protocol was: incubate tissue fragments 6 hours to overnight at 56°C in 200 µl proteinase K solution, add 200 µl Buffer B3 and 200 µl 100% ethanol, mix and transfer the supernatant into a Tissue Binding Plate containing the silica binding membranes, centrifuge 10 min, add 500 µl Buffer BW, centrifuge 2 min, add 700 µl Buffer B5, centrifuge 4 min, place Tissue Binding Plate on a collection rack, incubate 10 min at 70°C to remove residual ethanol, add 100 µl Buffer BE (elution buffer) at 70°C, incubate 1 min, centrifuge 2 min, dispose of Tissue Binding Plate, refrigerate eluted DNA or store at -20°C.

Descriptions of the loci assessed in this study and polymerase chain reaction (PCR) conditions are given in Table 2. PCR reactions were run separately for each microsatellite locus using an MJ Research PTC-200 thermalcycler, with a simple thermal profile consisting of: denaturation at 95°C for 3 min, denaturation at 95°C for 15 sec, anneal for 30 sec at the appropriate temperature for each locus (Table 2), extension at 72°C for 1 min, repeat cycle (steps 2-4), final extension at 72°C for 30 minutes. PCR products for each locus were subsequently combined into poolplexes to be processed with an ABI-3730 DNA Analyzer. Genotypes were visualized with a known size standard (GS500LIZ 3730) using GeneMapper 3.0 software. Allele binning and naming were accomplished using MicrosatelliteBinner-v.1.h (Young, WDFW available from the author).

MicrosatelliteBinner creates groups (bins) of alleles with similar mobilities (presumably alleles with the same number of repeat units). The upper and lower bounds of the bins are determined by identifying clusters of alleles separated by gaps (nominally 0.4 base pairs in size) in the distribution of allele sizes. The bins are then named as the mean allele size for the cluster rounded to an integer.

Both the 2003 and 2004 collections (grouped for both the spawner comparisons and the genetic origin comparisons) were genetically characterized and compared. Global tests (heterozygote deficiency and excess) of loci and populations was conducted to determine if there were any deviations from Hardy-Weinberg equilibrium (HWE) using GENEPOP v 3.4 (Raymond and Rousset 1995) with 10,0000 dememorizations, 100 batches, and 2,000 iterations. Each locus was also tested individually to determine if there was any deviation from HWE (GENEPOP v 3.4 with 10,000 dememorizations, 100 batches, and 5,000 iterations per batch). Linkage disequilibrium was compared for each collection using GENEPOP v 3.4 (10,000 dememorizations, 100 batches, and 5,000 iterations per batch). Linkage disequilibrium can be caused by genetic drift, inclusion of family groups within collections, assortative mating and/or analysis of an admixed collection. Allele frequencies were calculated with CONVERT 1.3 (Glaubitz 2003). Measures of within-population genetic diversity were calculated for each group (gene diversity, number of alleles per locus, and allelic richness – the number of alleles corrected for sample size (FSTAT 2.9.3, Goudet 2001); observed and expected heterozygosity (GDA 1.1 Lewis and Zaykin 2001); and the number of unique alleles found in each group (CONVERT 1.3, Glaubitz 2003). Weir and Cockerham's (1984) inbreeding coefficient (F_{IS}) was also calculated using GDA for each group across all loci to look for genetic effects of small population size. To explore population structure among the groups, pairwise F_{ST} values and pairwise genotypic population differentiation tests were calculated using GENEPOP 3.4. Statistical significance of all tests was determined using a Bonferroni corrected P-value to account for multiple, simultaneous tests (Rice 1989).

Results and Discussion

Good quality DNA was obtained and analyzed for all collections. Nearly complete genotypes were collected for most samples. All samples with genotypes for seven or more loci were included in the analysis, and over all six collections only 49 samples were excluded. The number of samples excluded for each collection is shown in Table 1. The hatchery-origin and in-river spawner groups had the lowest number of individuals that were scored at all loci and included in the analysis (Table 1). Samples collected from fish carcasses in-river were of lower quality given the state of tissue decomposition when collected. All other samples were handled in the hatchery facility while the fish were still alive providing higher quality tissue.

Tests for Hardy-Weinberg Equilibrium (HWE) revealed no significant deviations from expected values at any locus and therefore no loci were dropped from analysis (Table 2). All collections analyzed were also within the expected HWE expectations suggesting random mating within each group (Table 3).

Tests for linkage for the 2003 sample groups was consistent with those reported by Hawkins and Frye (2005). The largest number of significant linkage disequilibrium tests in both the 2003 and 2004 samples occurred in the captive brood spawners (Table 3). The linkage disequilibria detected in the captive brood collection is likely the result of sampling a relatively small number of families of related individuals, effectively creating an admixed collection. Two other groups in the 2004 samples demonstrated significant linkage disequilibrium tests (in-river spawners 2004 and natural-origin spawners 2004) that were not seen in the 2003 groups (Hawkins and Frye 2005). The increased linkage in the 2004 natural-origin spawners suggests they were more closely related or from fewer parents than the natural-origin spawners from 2003.

The 2004 in-river samples and supplementation spawners have a subset of both natural and hatchery-origin Chinook (Table 1). The 2004 in-river samples had more than four times natural-origin samples versus hatchery-origin samples while the 2004 supplementation group included approximately 50% of both natural and hatchery-origin samples. It is, therefore not surprising to see an increase in the number of significant linkages in the in-river spawners versus the supplementation spawners.

A large positive value of the inbreeding coefficient (F_{IS}) is an indication of an excess of homozygotes in a collection and can result from small population size and inbreeding (Table 3). Allelic richness is an additional measure of population diversity and therefore an indication of the health and stability of the population; high values indicate increased genetic diversity (Table 3). In general, all groups individually exhibited relatively high and similar levels of allelic richness (10.90 – 12.53), and neither the F_{IS} values nor the observed heterozygosities indicated an excess of homozygotes (which would be an indication of inbreeding).

Tests for allelic richness averaged over all loci for each of the collection types did not reveal any significant difference in the total number of alleles observed when the 2003 and 2004 data sets were combined. When comparing genetic-origin groups allelic richness was highest for the natural-origin samples (11.81), second for the captive brood samples (11.39), and lowest for the hatchery-origin samples (11.10). In spawner group comparisons, the in-river samples had the highest allelic richness value (12.14) compared with the supplementation samples (12.09), or captive brood. The in-river samples had a higher proportion of natural-origin fish than hatchery-origin; therefore it is not surprising to have a higher allelic richness value.

The overall number of alleles per locus ranged from 4 – 36 (*Ots-9** and *Omm-1080** respectively; Table 4). In theory, it would be expected that a natural population would exhibit higher genetic diversity and thus contain more alleles than captive broodstock or hatchery-origin samples derived from a limited number of founders. The analysis of the 2003 samples (Hawkins and Frye 2005), contradicts that theory because the captive brood group had more alleles observed than the natural-origin group for 11 of the 14 loci examined (Table 4). This may be explained because the captive brood collection had three times as many samples as the natural-origin collection. The captive brood in 2003 also included fish from four consecutive brood years (ages 2-5) while the natural-origin fish from 2003 was comprised mostly of adults from two brood years (ages 4 and 5). There were two age 3 fish included with the natural-origin samples, 44 samples that were age 4, and 43 age 5 samples. The analysis of the 2004 samples identifies more alleles at approximately half of the loci in the captive brood and half in the natural-origin samples. The 2004 captive brood samples included adults from three brood years and the natural-origin from two brood years (ages 4 and 5). However, the 2004 natural-origin samples were predominately age 4 (97 age 4 samples and only 2 age 5 samples). There are fewer total alleles over all loci in the 2004 captive broodstock than in the 2003 captive broodstock likely due to the representation of more family groups from more brood years in the 2003 captive brood than in the 2004 captive brood. The overall number of alleles present in both the 2003 and 2004 captive broodstock in comparison to the natural-origin spawners suggests that the captive brood program has maintained a similar level of genetic diversity similar to the natural-origin spring Chinook spawners in the Tucannon River.

Assessment of private alleles provides an understanding of the genetic differentiation among collections. A collection with a lot of private alleles indicates the collection has been isolated and alleles were lost in one collection while maintained in another, the sample was not random, or the sample sizes of each collection was not large enough to observe all alleles that exists in that collection area. In the case of a captive brood program, the presence of private alleles in the brood indicates alleles have been maintained through the program and may contribute to the overall genetic variation in the river where they are introduced.

Assessment of the private alleles detected in the 2003 samples versus the analysis of the combined datasets from 2003 and 2004 revealed some interesting patterns (Appendix 1a and 1b). Overall, the 2003 samples have a larger number of unique alleles than the 2004 samples for all groups analyzed. The highest number of unique alleles detected in the 2003 samples alone was in the captive brood spawners (36 alleles) and the lowest (4 alleles) in the hatchery-origin samples (Hawkins and Frye 2005). When data for both 2003 and 2004 were analyzed together, the highest number of unique alleles was found in the natural-origin spawners (24 alleles) and the lowest in the hatchery-origin spawners (4 alleles; Table 3). The number of unique alleles in the 2003 captive brood spawners dropped from 36 to 12 when the samples from 2003 and 2004 were analyzed together. Six of the 24 alleles that were no longer unique in the 2003 captive brood samples were found in the 2004 captive brood samples only. Eight of the 24 alleles were found in the 2004 captive brood, 2004 hatchery, and 2004 natural-origin samples. The remaining unique alleles to the 2003 captive brood were found in one or more of the 2004 collections. This result is expected as more samples are analyzed, the potential of detecting alleles that are present in only one collection goes down, however half of the 2003 captive brood unique alleles are still found in the captive brood samples alone. This suggests that releases from the captive brood may contribute to the genetic variation of the Tucannon River spring-run Chinook population and not cause a reduction in the overall genetic variability.

The number and distribution of the alleles observed in each group can give insights into the relationship among the different collection types. A side-by-side comparison of the unique alleles (Appendix 1a and 1b) provides an understanding of how the results differ depending on how the fish are grouped. In many cases, alleles that are unique to the natural- origin fish have been split between the supplementation and in-river spawners, effectively homogenizing the two groups and spreading the genetic diversity between the two-spawner groups. Because this hatchery program is a supplementation hatchery designed to augment the natural production, this homogenization and spreading of the natural genetic diversity is a desired result. The alleles of *Oki-100* are a good example of this effect. Two alleles, 315 and 327, are only observed in the natural groups. However, allele 315 is distributed between the supplementation spawners and the in-river spawners, while allele 327 is only present in the supplementation spawners.

The combined results of the pairwise F_{ST} tests and tests of genotypic differentiation (Table 5a and 5b) suggest that the collections are genetically differentiated with the exception of the supplementation and in-river spawners (Table 5a). The pairwise F_{ST} values are between 0.0006 - 0.0132 indicating a relatively low level of genetic difference among the collections (Table 5b). The F_{ST} values are highly affected by the level of heterozygosity at each locus and may limit the usefulness of these comparisons (Table 2). The tests for genotypic differentiation of captive brood, hatchery-origin, and natural-origin revealed that all three groups are highly significantly different from each other (Table 5a). Yet, when the hatchery-origin and natural-origin fish are re-grouped as either supplementation or in-river spawners, they are not significantly different (Table 5a).

Interestingly, the F_{ST} values between the 2003 and 2004 annual collections of hatchery-origin, natural-origin, supplementation, and in-river samples are larger than most other comparisons (Table 5b). This implies the samples between years are variable and support the observed differences seen in other analysis that there is genetic variability between years. In contrast, the 2003 and 2004 captive brood samples have a low F_{ST} value indicating these samples are not very different as would be expected in a captive brood program.

Conclusions

The measures of genetic diversity reported here suggest that the analyzed groups have not undergone a severe loss of diversity. Despite the fact that these groups were recently derived from natural-origin spring run Chinook in the Tucannon River, there were significant genetic differences observed among the groups (with the exception of the supplementation and in-river spawners). This result is most likely due to the high numbers and distribution of unique alleles and is not surprising given the overall small population size (causing genetic drift to have a strong affect), and the relatively small number of families (varying in the number of individuals per family) of both the supplementation spawners and the captive brood spawners. Non-random sampling for each year can also affect the quantity and distribution of alleles. The results and comparisons of the different collection types provides evidence both that the captive broodstock program has been an effective method of preserving genetic variation, and that the supplementation hatchery practices (despite using only a small percentage of the entire escapement each year) have been effective in minimizing differences between the hatchery and natural-origin fish.

Acknowledgements

Thank you to Cherril Bowman and Norm Switzler for laboratory help. Mike Gallinat for initiating the study and for providing background and biological information. Mike Gallinat, Mark Schuck, and Ken Warheit for providing editorial comment and review. The Snake River Lab staff collected samples and the Bonneville Power Administration (BPA) provided funding for this project.

Literature Cited

Belkhir, K., V. Castric, and F. Bonhomme. 2002. Identix, a software to test for relatedness in a population using permutation methods. Molecular Ecololgy Notes. 2:611-614.

Gallinat, M. P. 2004. Tucannon River Spring Chinook Captive Broodstock Program. BPA 2003 annual report. 39 pages.

Glaubitz, J.C. 2003. CONVERT (version 1.2): A user-friendly program to reformat diploid genotypic data for commonly used population genetic software packages. http://www.agriculture.purdue.edu/fnr/html/faculty/Rhodes/Students%20and%20Staff/glaubitz/software.htm.

Goudet, J. 2001. FSTAT, a program to estimate and test gene diversities and fixation indices (version 293). Updated from Goudet (1995). Available from http://www.unilch/izea/softwares/fstat.html.

Hawkins, D.K. and A. Frye. 2005. Microsatellite DNA analysis of Tucannon River spring Chinook: 2003 collections of supplementation hatchery spawners, redd survey carcasses from the river, and captive brood spawners. Unpublished WDFW Genetics Laboratory report submitted to Mike Gallinat at WDFW Snake River Laboratory.

Lewis, P. O. and D. Zaykin. 2001. Genetic Data Analysis: Computer program for the analysis of allelic data. Version 1.0 (d16c). Free program distributed by the authors over the internet from http://lewis.eeb.uconn.edu/lewishome/software.html

Raymond, M. and F. Rousset. 1995. GENEPOP (Version 3.3): Population genetics software for exact tests and ecumenicism. Journal of Heredity 86:248-249.

Rice, W.R. 1989. Analyzing tables of statistical tests. Evolution 43:223-225.

Weir, B.S. and C.C. Cockerham. 1984. Estimating F-statistics for the analysis of population structure. Evolution 38:1358-1370.

Table 1. Collection code, collection description, and number of samples collected and used in the 2003 and 2004 samples. Collection description includes the following: hatchery-origin, natural-origin, and captive broodstock (hatchery-origin fish originated in the hatchery in their respective brood year and all natural-origin fish were spawned naturally and originated in the river in their respective broodyear). The hatchery-origin and natural-origin samples were divided into supplementation hatchery and in-river spawners and re-analyzed.

Collection Description	Collection Code	# collected	# excluded[a]	# used in analysis
hatchery-origin	03EK	50	7	43
natural-origin	03EL	84	9	75
hatchery-origin	04EY	58	6	49
natural-origin	04EZ	99	10	89
supplementation - hatchery-origin	03EK	34	0	34
supplementation - natural-origin	03EL	41	0	41
supplementation spawners - total	03EK and 03EL	75	0	75
in-river - hatchery-origin	03EK	16	7	9
in-river - natural-origin	03EL	43	9	34
in-river spawners - total	03EK and 03EL	59	16	43
supplementation - hatchery-origin	04EY	40	1	39
supplementation - natural-origin	04EZ	42	1	41
supplementation spawners - total	04EY and 04EZ	82	2	80
in-river - hatchery-origin	04EY	14	4	10
in-river - natural-origin	04EZ	50	7	43
in-river spawners - total	04EY and 04EZ	64	11	53
captive broodstock	03EM	346	5	341
captive broodstock	04FA	300	12	288

[a] - Individual samples were excluded if data was not available for seven or more loci.

Table 2. PCR conditions and microsatellite locus information (number alleles/locus and allele size range) for poolplexed loci. Also included are the observed and expected heterozygosity (He and Ho) for each locus and P-values for deviations from Hardy-Weinberg equilibrium tested for heterozygote deficiency (HWE). Because HWE is dependent on the fish combined in a group, values are given for both the spawner group collections and the genetic origin collections (see text for detailed description of these groups).

PCR Conditions						Locus statistics		Heterozygosity		HWE	HWE
Poolplex	Locus	Dye Label	Annealing temp (^{O}C)	Primer conc. (mM)	Cycles	# Alleles/ Locus	Allele Size Range (bp)	H_o	H_e	Spawner group	Genetic origin
Ots-M	*Oki-100**	vic	50	0.36	40	21	248-327	0.9122	0.9064	0.9341	0.9168
	*Ots-201b**	6fam	50	0.32	40	28	182-330	0.9327	0.9143	0.9893	0.9984
	*Ots-208b**	ned	50	0.18	40	27	184-291	0.9305	0.9190	0.4347	0.6850
	*Ssa-408**	pet	50	0.20	40	25	211-324	0.8808	0.8943	0.1979	0.2167
Ots-N	*Ogo-2**	pet	63	0.07	40	11	231-261	0.6579	0.6581	0.9125	0.9744
	*Ssa-197**	ned	63	0.25	40	22	189-301	0.8791	0.8704	0.8306	0.7859
Ots-O	*Ogo-4**	6fam	56	0.18	40	12	165-198	0.7822	0.7866	0.5953	0.6559
	*Omm-1080**	vic	56	0.22	40	36	217-377	0.9153	0.9185	0.1603	0.1544
	*Ots-213**	ned	56	0.18	40	23	252-359	0.8859	0.8934	0.1899	0.1949
	*Ots-G474**	pet	56	0.14	40	9	187-235	0.5565	0.5178	0.9986	0.9992
Ots-P	*Ots-3M**	6fam	63	0.12	40	11	146-183	0.5121	0.4956	0.9405	0.9496
	*Ots-9**	ned	63	0.04	40	4	132-138	0.6286	0.6114	0.8928	0.9134
Ots-Q	*Ots-211**	ned	63	0.07	40	24	237-348	0.8780	0.8861	0.5275	0.5064
	*Ots-212**	6fam	63	0.30	40	18	160-258	0.8794	0.8769	0.5445	0.6197

Table 3. Descriptive statistics of the collections analyzed, including the number of significant pairwise linkage disequilibria detected (Linkage), observed and expected heterozygosities (Ho and He), P-values for deviations from Hardy Weinberg Equilibrium tested for heterozygote deficiency (HWE), allelic richness (number of alleles corrected for sample size, averaged over all loci), inbreeding coefficient (FIS), and the number of private alleles found in each collection when 2003 and 2004 samples were analyzed together and the total per collection group.

			Linkage	Heterozygosity					
Collection	Collection Code	Number of Fish Included in Analysis (scored at 8 or more loci)	(# locus pairs significant before/after Bonferroni correction) [a]	H_o	H_e	HWE P-value	Allelic Richness [b]	F_{IS}	Number of private alleles
Captive brood spawners	03EM	341	86 / 75	0.787	0.791	0.024	11.60	0.005	12
	04FA	288	85 / 64	0.808	0.796	0.998	11.20	-0.015	2
									14
Supplementation spawners	03EK and 03EL	75	11 / 2	0.795	0.798	0.305	12.53	0.003	9
	04EY and 04EZ	80	12 / 3	0.823	0.792	0.998	11.77	-0.039	1
									10
In-river spawners	03EK and 03EL	43	13 / 4	0.827	0.789	0.996	11.96	-0.049	7
	04EY and 04EZ	53	59 / 33	0.821	0.799	0.966	12.32	-0.028	5
									12
Hatchery origin	03EK	43	18 / 4	0.796	0.787	0.625	10.90	-0.012	2
	04EY	49	14 / 3	0.800	0.793	0.855	11.30	-0.009	2
									4
Natural origin	03EL	75	21 / 4	0.813	0.795	0.997	12.00	-0.022	18
	04EZ	89	55 / 25	0.836	0.793	1.000	11.63	-0.055	6
									24

a: 91 Pairwise comparisons and Bonferroni corrected P-value = 0.0006 (0.05/91)

b: Allelic richness based on 14 loci, and 33 individuals (spawner groups) or 30 individuals (genetic origin).

Table 4. Number of alleles observed per locus for each collection. See text for detailed description of the collections.

Collection	Collection Code	Average number of samples per locus included in analysis	Oki-100	Ots-201b	Ots-208b	Ssa-408	Ogo-2	Ssa-197	Ogo-4	Omm-1080	Ots-213	Ots-G474	Ots-3M	Ots-9	Ots-211	Ots-212
Captive brood spawners	03EM	322	18	25	21	19	9	18	12	30	19	7	7	4	19	15
	04FA	271	18	18	20	18	9	15	9	30	15	5	5	4	18	13
Supplementation spawners	03EK and 03EL	71	17	22	20	19	7	15	11	26	19	5	6	4	17	12
	04EY and 04EZ	77	19	20	22	18	8	13	9	23	14	5	5	4	17	13
In-river spawners	03EK and 03EL	39	16	16	15	19	7	13	10	23	17	4	7	4	12	11
	04EY and 04EZ	49	19	20	22	14	8	13	10	23	16	5	4	4	18	12
Hatchery origin	03EK	40	15	16	17	14	5	12	10	22	16	4	4	4	13	9
	04EY	46	15	18	20	17	7	12	9	17	14	4	5	4	17	12
Natural origin	03EL	70	18	23	19	21	7	17	10	25	18	5	6	4	18	14
	04EZ	84	19	21	20	15	8	14	10	25	16	6	4	4	19	13
Number of alleles in all collections			20	26	27	24	10	21	12	36	23	9	11	4	23	17

Table 5a. P-values for genotypic differentiation values across all loci (Fisher's method). Values in white type that are highlighted in black are not significantly different from zero. H.S. indicates highly significant results with a chi-squared value of infinity.

	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive
03 Hatchery	**X**					
03 Natural	**H.S.**	**X**				
03 Captive	**H.S.**	**H.S.**	**X**			
04 Hatchery	**0.00000**	**H.S.**	**0.00000**	**X**		
04 Natural	**H.S.**	**H.S.**	**H.S.**	**0.00001**	**X**	
04 Captive	**H.S.**	**H.S.**	**H.S.**	**0.00000**	**H.S.**	**X**

	03 Supplement	03 In-River	03 Captive	04 Supplement	04 In-River	04 Captive
03 Supplement	**X**					
03 In-River	**0.0884**	**X**				
03 Captive	**H.S.**	**H.S.**	**X**			
04 Supplement	**H.S.**	0.00000	0.00000	**X**		
04 In-River	0.00000	0.00000	0.00000	**0.06441**	**X**	
04 Captive	**H.S.**	**H.S.**	**H.S.**	0.00000	**H.S.**	**X**

Table 5b. Pairwise FST values across all loci (Fisher's method).

	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive
03 Hatchery	**X**					
03 Natural	**0.0079**	**X**				
03 Captive	**0.0102**	**0.0064**	**X**			
04 Hatchery	**0.0102**	**0.0091**	**0.0018**	**X**		
04 Natural	**0.0132**	**0.0108**	**0.0072**	**0.0050**	**X**	
04 Captive	**0.0078**	**0.0075**	**0.0023**	**0.0028**	**0.0086**	**X**

	03 Supplement	03 In-River	03 Captive	04 Supplement	04 In-River	04 Captive
03 Supplement	**X**					
03 In-River	**0.0006**	**X**				
03 Captive	**0.0056**	**0.0069**	**X**			
04 Supplement	**0.0090**	**0.0095**	**0.0037**	**X**		
04 In-River	**0.0065**	**0.0100**	**0.0063**	**0.0015**	**X**	
04 Captive	**0.0051**	**0.0075**	**0.0023**	**0.0047**	**0.0076**	**X**

Appendix 1A. Allele frequencies for the hatchery-origin, natural-origin, and captive broodstock spring Chinook in the Tucannon River in 2003 and 2004. The column labeled "private" identifies specific alleles that were only scored in the collection that is identified.

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Oki-100	248	0.0256	0.0135	0.0393	0.0795	0.0244	0.0421	
Oki-100	256			0.0030	0.0114	0.0122	0.0096	
Oki-100	260	0.0128	0.0068	0.0166	0.0455	0.0488	0.0192	
Oki-100	264	0.0256	0.0338	0.0393	0.0795	0.0610	0.0211	
Oki-100	268	0.1282	0.0878	0.1254	0.1250	0.1280	0.1015	
Oki-100	272	0.0769	0.0270	0.0408	0.0795	0.0732	0.0824	
Oki-100	276	0.0385	0.0541	0.1012	0.0682	0.0671	0.0977	
Oki-100	280	0.0256	0.0203	0.0196		0.0244	0.0019	
Oki-100	284	0.0513	0.0338	0.0363	0.0227	0.0122	0.0421	
Oki-100	287	0.1026	0.1824	0.0937	0.0455	0.0366	0.0900	
Oki-100	291			0.0030	0.0341	0.0061	0.0019	
Oki-100	295	0.0897	0.0811	0.0861	0.0455	0.0488	0.0766	
Oki-100	297	0.0769	0.0270	0.0438	0.0455	0.0793	0.0575	
Oki-100	299	0.1923	0.1959	0.1782	0.1705	0.1951	0.1801	
Oki-100	303	0.0769	0.1149	0.0166	0.0114	0.0244	0.0287	
Oki-100	307	0.0256	0.0135	0.0196		0.0366	0.0115	
Oki-100	311	0.0513	0.0743	0.1239	0.1364	0.0793	0.1303	
Oki-100	315		0.0203			0.0183		
Oki-100	323		0.0068	0.0136		0.0244	0.0057	
Oki-100	327		0.0068					03_Natural
# of samples		39	74	331	44	82	261	

Appendix 1A. (continued)

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ots-201b	182			0.0015				03_Captive
Ots-201b	184	0.0500	0.0846	0.0540	0.0417	0.0349	0.0335	
Ots-201b	196		0.0154	0.0170			0.0112	
Ots-201b	200			0.0015	0.0312	0.0058		
Ots-201b	204			0.0031		0.0058		
Ots-201b	208	0.1125	0.0615	0.0586	0.0208	0.0640	0.0688	
Ots-201b	211	0.0500	0.0462	0.0756	0.0521	0.1221	0.0855	
Ots-201b	215	0.1875	0.1077	0.1451	0.1458	0.0814	0.1357	
Ots-201b	219	0.1000	0.1077	0.1728	0.2292	0.1860	0.1654	
Ots-201b	223	0.0625	0.0923	0.0478	0.0417	0.0291	0.0651	
Ots-201b	227	0.0125	0.0385	0.0370	0.0417	0.0174	0.0223	
Ots-201b	231		0.0231	0.0262		0.0349		
Ots-201b	235	0.0125	0.0231	0.0093		0.0465		
Ots-201b	239	0.0375	0.0385	0.0139	0.0521	0.0349	0.0204	
Ots-201b	243		0.0231	0.0324	0.0104	0.0116	0.0465	
Ots-201b	247	0.0625	0.0538	0.0633	0.0625	0.0523	0.0781	
Ots-201b	251	0.0750	0.1000	0.1204	0.1354	0.1105	0.1208	
Ots-201b	254	0.0625	0.0231	0.0309	0.0521	0.0640	0.0465	
Ots-201b	258		0.0077	0.0062	0.0208	0.0465	0.0130	
Ots-201b	262	0.0625	0.0077	0.0093	0.0104	0.0174	0.0167	
Ots-201b	266	0.0500	0.0538	0.0247	0.0104	0.0058	0.0279	
Ots-201b	275			0.0015				03_Captive
Ots-201b	278		0.0077	0.0015				
Ots-201b	282		0.0154	0.0123		0.0058		
Ots-201b	294				0.0104		0.0037	
Ots-201b	306	0.0500	0.0462	0.0340	0.0312	0.0233	0.0390	
Ots-201b	314	0.0125	0.0077					
Ots-201b	330		0.0154					03_Natural
# of samples		40	65	324	48	86	269	

Appendix 1A. (continued)

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ots-208b	184				0.0319			04_Hatchery
Ots-208b	188	0.0698	0.0685	0.0564	0.0106	0.0904	0.0436	
Ots-208b	193			0.0030			0.0018	
Ots-208b	200	0.0233						03_Hatchery
Ots-208b	204	0.0116		0.0198	0.0213	0.0181	0.0145	
Ots-208b	208		0.0137	0.0488	0.0319	0.0181	0.0418	
Ots-208b	212		0.0479	0.0091	0.0319	0.0120	0.0182	
Ots-208b	216			0.0168	0.0957	0.0301	0.0236	
Ots-208b	219	0.0233	0.0068	0.0381	0.0426	0.0301	0.0182	
Ots-208b	224	0.1744	0.1301	0.1341	0.0638	0.1024	0.1182	
Ots-208b	228	0.0814	0.0753	0.0168	0.0319	0.0602	0.0382	
Ots-208b	232	0.0465	0.0342	0.0030	0.0106	0.0181	0.0055	
Ots-208b	236	0.0233	0.0479	0.0259	0.0213	0.0241	0.0400	
Ots-208b	240	0.0465	0.0068	0.0610	0.0213	0.0241	0.0673	
Ots-208b	244		0.0548			0.0060		
Ots-208b	248	0.0349	0.0068	0.0534	0.0426	0.0361	0.0236	
Ots-208b	251	0.0233	0.0137	0.0091		0.0482	0.0218	
Ots-208b	255	0.0581	0.0479	0.0381	0.0426	0.0120	0.0291	
Ots-208b	259	0.1395	0.1301	0.1448	0.1596	0.1205	0.1600	
Ots-208b	263	0.1744	0.0342	0.0991	0.1170	0.1145	0.0945	
Ots-208b	267	0.0349	0.1370	0.1372	0.1489	0.1386	0.1218	
Ots-208b	271	0.0233	0.0616	0.0198	0.0106	0.0361	0.0545	
Ots-208b	275	0.0116	0.0753	0.0564	0.0426	0.0422	0.0636	
Ots-208b	279			0.0091		0.0120		
Ots-208b	283				0.0213			04_Hatchery
Ots-208b	287		0.0068					03_Natural
Ots-208b	291					0.0060		04_Natural
# of samples		43	73	328	47	83	275	

Appendix 1A. (continued)

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ssa-408	211	0.0571	0.0685	0.0579	0.0612	0.0730	0.0508	
Ssa-408	215	0.1714	0.1781	0.1409	0.1122	0.1685	0.1250	
Ssa-408	218	0.0429	0.0479	0.0401	0.0306	0.0112	0.0586	
Ssa-408	222	0.1429	0.1644	0.2255	0.1837	0.1742	0.2246	
Ssa-408	226	0.0857	0.0137	0.0208	0.0510	0.0506	0.0254	
Ssa-408	230	0.0286	0.1027	0.0519	0.1122	0.0337	0.0684	
Ssa-408	234	0.2000	0.1096	0.1261	0.1224	0.1180	0.1504	
Ssa-408	238	0.0857	0.0274	0.0401	0.0204	0.0562	0.0566	
Ssa-408	242		0.0137	0.0134	0.0204	0.0449	0.0391	
Ssa-408	249	0.0429	0.0548	0.0593	0.0816	0.0899	0.0605	
Ssa-408	253	0.0143	0.0137	0.0163	0.0102	0.0056	0.0059	
Ssa-408	257		0.0205	0.0178		0.0056		
Ssa-408	261		0.0068					03_Natural
Ssa-408	265	0.0429	0.0068		0.0102	0.0056	0.0078	
Ssa-408	269	0.0286		0.0163	0.0102		0.0098	
Ssa-408	273		0.0068	0.0104				
Ssa-408	277		0.0068					03_Natural
Ssa-408	296		0.0137					03_Natural
Ssa-408	300			0.0119	0.0714		0.0137	
Ssa-408	306		0.0068					03_Natural
Ssa-408	308		0.0137	0.0015			0.0137	
Ssa-408	312	0.0143	0.0479	0.0608	0.0408	0.0955	0.0410	
Ssa-408	320	0.0429	0.0753	0.0846	0.0510	0.0674	0.0449	
Ssa-408	324			0.0045	0.0102		0.0039	
# of samples		35	73	337	49	89	256	

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ogo-2	231			0.0015				03_Captive
Ogo-2	242	0.2333	0.1186	0.1369	0.1224	0.2378	0.0921	
Ogo-2	244	0.5667	0.5000	0.5893	0.5510	0.3963	0.5469	
Ogo-2	246		0.0254	0.0164	0.0306	0.0122	0.0325	
Ogo-2	248	0.1333	0.2203	0.1205	0.0714	0.1585	0.1245	
Ogo-2	250	0.0167	0.0932	0.0536	0.1020	0.0732	0.0704	
Ogo-2	252						0.0036	04_Captive
Ogo-2	254		0.0254	0.0134		0.0183	0.0271	
Ogo-2	256	0.0500		0.0283	0.0510	0.0244	0.0451	
Ogo-2	260		0.0169	0.0402	0.0714	0.0793	0.0578	
# of samples		30	59	336	49	82	277	

Appendix 1A. (continued)

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ssa-197	189		0.0133					03_Natural
Ssa-197	201	0.1163	0.0400	0.0791	0.1277	0.0488	0.1019	
Ssa-197	209		0.0133	0.0657	0.0319	0.0427	0.0389	
Ssa-197	217			0.0030				03_Captive
Ssa-197	221	0.0116	0.0133					
Ssa-197	233		0.0067			0.0061		
Ssa-197	242			0.0015				03_Captive
Ssa-197	249		0.0067	0.0149		0.0122	0.0148	
Ssa-197	253	0.0233	0.0400	0.0179			0.0185	
Ssa-197	257	0.0116	0.0400	0.1149	0.1064	0.0732	0.1056	
Ssa-197	261	0.0581	0.0733	0.0299	0.0638	0.0549	0.0389	
Ssa-197	265	0.1744	0.1933	0.2179	0.1596	0.2134	0.2204	
Ssa-197	269	0.0465	0.1200	0.0448	0.0851	0.0549	0.0148	
Ssa-197	273	0.2674	0.2133	0.1970	0.2447	0.3049	0.2500	
Ssa-197	277	0.0581	0.0667	0.0433	0.0426	0.0549	0.0333	
Ssa-197	281		0.0133	0.0299	0.0426	0.0427	0.0333	
Ssa-197	285	0.0698	0.0467	0.0567	0.0426	0.0244	0.0500	
Ssa-197	289	0.0233	0.0133	0.0104		0.0061	0.0093	
Ssa-197	293	0.1395	0.0867	0.0612	0.0426	0.0610	0.0444	
Ssa-197	297			0.0060			0.0259	
Ssa-197	301			0.0060	0.0106			
# of samples		43	75	335	47	82	270	

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ogo-4	165	0.0119	0.0400	0.0178		0.0233		
Ogo-4	169	0.0476	0.0867	0.0237	0.0326	0.0233	0.0326	
Ogo-4	171	0.0119		0.0074	0.0326	0.0116	0.0145	
Ogo-4	182	0.2143	0.2267	0.3269	0.3370	0.2674	0.2609	
Ogo-4	184			0.0104				03_Captive
Ogo-4	186		0.0133	0.0059				
Ogo-4	188	0.0357	0.0733	0.0266	0.0326	0.0349	0.0362	
Ogo-4	190	0.2857	0.3067	0.3107	0.2826	0.2674	0.2880	
Ogo-4	192	0.3214	0.1533	0.1450	0.1630	0.2558	0.2192	
Ogo-4	194	0.0476	0.0267	0.0355	0.0217	0.0233	0.0725	
Ogo-4	196	0.0119	0.0533	0.0399	0.0109	0.0233	0.0308	
Ogo-4	198	0.0119	0.0200	0.0503	0.0870	0.0698	0.0453	
# of samples		42	75	338	46	86	276	

Appendix 1A. (continued)

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Omm-1080	217	0.0125		0.0341	0.0375	0.0380	0.0360	
Omm-1080	221	0.0125	0.0294			0.0127		
Omm-1080	233		0.0956	0.0735	0.0875	0.0570	0.0780	
Omm-1080	241		0.0074	0.0072		0.0127	0.0120	
Omm-1080	245		0.0074	0.0305		0.0506	0.0060	
Omm-1080	249			0.0072	0.0625	0.0063	0.0120	
Omm-1080	253						0.0020	04_Captive
Omm-1080	257	0.1750	0.1765	0.2437	0.1625	0.1772	0.1960	
Omm-1080	261	0.0250	0.0368	0.0161	0.0125	0.0633	0.0260	
Omm-1080	269	0.0250	0.0147	0.0036			0.0060	
Omm-1080	273		0.0074					03_Natural
Omm-1080	277		0.0074					03_Natural
Omm-1080	281		0.0074				0.0060	
Omm-1080	285	0.0125	0.0368	0.0645	0.1250	0.0696	0.1280	
Omm-1080	289	0.0750	0.0074	0.0627	0.0750	0.0443	0.0420	
Omm-1080	293			0.0054			0.0040	
Omm-1080	297	0.0125	0.0515	0.0125		0.0063	0.0100	
Omm-1080	301		0.0147	0.0018				
Omm-1080	309	0.0250	0.0147	0.0305	0.0250	0.0127	0.0060	
Omm-1080	313	0.0125	0.0588	0.0018	0.0125	0.0253	0.0020	
Omm-1080	317	0.0250	0.0074	0.0108		0.0063	0.0060	
Omm-1080	322	0.0250	0.0221	0.0090	0.0125	0.0633	0.0180	
Omm-1080	326	0.0875	0.0515	0.0699	0.1000	0.0886	0.0540	
Omm-1080	330	0.1250	0.0735	0.0538	0.1125	0.0316	0.0680	
Omm-1080	334	0.0250	0.0221	0.0090			0.0120	
Omm-1080	338	0.0375		0.0018		0.0316		
Omm-1080	342	0.0250	0.0588	0.0143		0.0316	0.0080	
Omm-1080	346	0.0625	0.0515	0.0412	0.0375	0.0253	0.0600	
Omm-1080	350	0.0250		0.0197		0.0253	0.0120	
Omm-1080	354	0.0375	0.0735	0.0860	0.0625	0.0316	0.0920	
Omm-1080	358			0.0090	0.0250	0.0506	0.0080	
Omm-1080	362					0.0063		04_Natural
Omm-1080	365	0.1000	0.0662	0.0520	0.0125	0.0316	0.0580	
Omm-1080	369			0.0161	0.0375		0.0220	
Omm-1080	373	0.0375		0.0018			0.0080	
Omm-1080	377			0.0108			0.0020	
# of samples		40	68	279	40	79	250	

Appendix 1A. (continued)

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ots-213	252	0.0233	0.0200	0.0442	0.0106	0.0482	0.0434	
Ots-213	255			0.0030	0.0319	0.0060		
Ots-213	260	0.0698	0.0200					
Ots-213	263	0.0465	0.0267	0.0244	0.0213	0.0181	0.0208	
Ots-213	267		0.0133	0.0076				
Ots-213	275	0.0233	0.0133					
Ots-213	279			0.0030				03_Captive
Ots-213	283		0.0333					03_Natural
Ots-213	287	0.1047	0.1267	0.1570	0.1702	0.1807	0.2075	
Ots-213	291	0.0233	0.0333	0.0229	0.0532	0.0663	0.0170	
Ots-213	295	0.2442	0.2133	0.2043	0.1702	0.2229	0.1868	
Ots-213	299		0.0933	0.0107	0.0319	0.0422	0.0321	
Ots-213	303	0.0349	0.0467	0.0701	0.1277	0.0783	0.0660	
Ots-213	307	0.0581	0.0067	0.0137		0.0301	0.0189	
Ots-213	311					0.0060		04_Natural
Ots-213	315	0.0349	0.0467	0.0366	0.0426	0.0120	0.0396	
Ots-213	319	0.0349	0.0733	0.1082	0.0745	0.0663	0.1377	
Ots-213	323	0.0349	0.0800	0.0366	0.0106	0.0663	0.0528	
Ots-213	327	0.1047	0.0933	0.1037	0.1277	0.0482	0.0717	
Ots-213	331	0.0116	0.0467	0.0732	0.0106	0.0060	0.0170	
Ots-213	335	0.0116	0.0133	0.0137			0.0340	
Ots-213	339	0.1395		0.0625	0.1170	0.1024	0.0547	
Ots-213	359			0.0046				03_Captive
# of samples		43	75	328	47	83	265	

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ots-G474	187	0.6163	0.6533	0.6441	0.6562	0.7024	0.6259	
Ots-G474	195			0.0074			0.0018	
Ots-G474	199	0.3488	0.2000	0.2294	0.3021	0.2083	0.2806	
Ots-G474	211			0.0044				03_Captive
Ots-G474	215		0.0133					03_Natural
Ots-G474	219			0.0015		0.0060		
Ots-G474	223	0.0116	0.0733	0.0588	0.0208	0.0417	0.0468	
Ots-G474	231	0.0233	0.0600	0.0544	0.0208	0.0357	0.0450	
Ots-G474	235					0.0060		04_Natural
# of samples		43	75	340	48	84	278	

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ots-9	132	0.0349	0.0068	0.0185	0.0204	0.0115	0.0284	
Ots-9	134	0.4884	0.4054	0.3611	0.3061	0.2989	0.4202	
Ots-9	136	0.3953	0.5270	0.4938	0.5510	0.4885	0.4450	
Ots-9	138	0.0814	0.0608	0.1265	0.1224	0.2011	0.1064	
# of samples		43	74	324	49	87	282	

Appendix 1A. (continued)

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ots-211	237		0.0424	0.0196	0.0114		0.0036	
Ots-211	253		0.0169					03_Natural
Ots-211	264			0.0375	0.0227	0.0179	0.0217	
Ots-211	268	0.0429	0.0763	0.0857	0.0568	0.0476	0.0704	
Ots-211	272	0.0286	0.0254	0.0607	0.1364	0.0714	0.0812	
Ots-211	276				0.0227	0.0060		
Ots-211	280		0.0169	0.0054		0.0119		
Ots-211	284	0.0143	0.0085	0.0143	0.0227	0.0238	0.0253	
Ots-211	288	0.0286	0.0085	0.0125	0.0227	0.0119	0.0253	
Ots-211	292		0.0085	0.0071	0.0114	0.0060	0.0090	
Ots-211	296	0.0714	0.0508	0.0732	0.0795	0.1190	0.0975	
Ots-211	300	0.0571	0.0847	0.0625	0.0682	0.0476	0.0704	
Ots-211	304	0.3714	0.3898	0.2482	0.2614	0.2857	0.2112	
Ots-211	308	0.0714	0.0424	0.0321	0.0795	0.0298	0.0379	
Ots-211	312	0.1714	0.1610	0.0911	0.0909	0.0536	0.1354	
Ots-211	316	0.0286	0.0169	0.0839	0.0341	0.2024	0.0560	
Ots-211	320		0.0085	0.0411	0.0227	0.0179	0.0433	
Ots-211	324			0.0125			0.0217	
Ots-211	328					0.0060		04_Natural
Ots-211	332	0.0857	0.0254	0.0893	0.0455	0.0238	0.0650	
Ots-211	336	0.0143	0.0085	0.0089			0.0036	
Ots-211	340	0.0143	0.0085	0.0143	0.0114	0.0119	0.0217	
Ots-211	348					0.0060		04_Natural
# of samples		35	59	280	44	84	277	

Locus	Size	03 Hatchery	03 Natural	03 Captive	04 Hatchery	04 Natural	04 Captive	Private
Ots-212	160		0.0078	0.0222	0.0233	0.0305	0.0500	
Ots-212	165	0.0417	0.1172	0.0819	0.0930	0.0671	0.0259	
Ots-212	169	0.0833	0.0547	0.0751	0.0465	0.0610	0.0704	
Ots-212	173	0.1250	0.1484	0.1877	0.1628	0.1098	0.2074	
Ots-212	177	0.0833	0.0938	0.0188	0.0465	0.0366	0.0556	
Ots-212	181	0.2361	0.1406	0.1604	0.3023	0.2561	0.1574	
Ots-212	185	0.2778	0.1797	0.1792	0.1395	0.1037	0.1370	
Ots-212	189	0.0972	0.1719	0.1160	0.0814	0.1463	0.1352	
Ots-212	193	0.0278	0.0078	0.0666	0.0233	0.0732	0.0778	
Ots-212	197		0.0156	0.0137	0.0116	0.0183	0.0111	
Ots-212	201	0.0278	0.0234	0.0512	0.0465	0.0732	0.0407	
Ots-212	210		0.0234	0.0085				
Ots-212	214		0.0078					03_Natural
Ots-212	234			0.0068		0.0183	0.0111	
Ots-212	238			0.0102	0.0233	0.0061	0.0204	
Ots-212	254		0.0078					03_Natural
Ots-212	258			0.0017				03_Captive
# of samples		36	64	293	43	82	270	

Appendix 1B. Allele frequencies for the supplementation spawners (includes both natural- and hatchery-origin), in-river spawners (includes both natural- and hatchery-origin), and captive broodstock spring Chinook in the Tucannon River in 2003 and 2004. The column labeled "private" identifies specific alleles that were only scored in the collection that is identified.

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Oki-100	248	0.0135	0.0256	0.0393	0.0541	0.0312	0.0421	
Oki-100	256			0.003	0.0135	0.0104	0.0096	
Oki-100	260	0.0135		0.0166	0.0405	0.0625	0.0192	
Oki-100	264	0.0338	0.0256	0.0393	0.0743	0.0625	0.0211	
Oki-100	268	0.1081	0.0897	0.1254	0.1351	0.125	0.1015	
Oki-100	272	0.0473	0.0385	0.0408	0.0946	0.0521	0.0824	
Oki-100	276	0.0473	0.0513	0.1012	0.0608	0.0625	0.0977	
Oki-100	280	0.027	0.0128	0.0196	0.0135	0.0208	0.0019	
Oki-100	284	0.0541	0.0128	0.0363	0.0135	0.0104	0.0421	
Oki-100	287	0.1419	0.1795	0.0937	0.0405	0.0312	0.09	
Oki-100	291			0.003	0.0135	0.0208	0.0019	
Oki-100	295	0.0743	0.1026	0.0861	0.0405	0.0521	0.0766	
Oki-100	297	0.0541	0.0256	0.0438	0.0743	0.0625	0.0575	
Oki-100	299	0.1959	0.1923	0.1782	0.1622	0.2292	0.1801	
Oki-100	303	0.0946	0.1154	0.0166	0.0068	0.0312	0.0287	
Oki-100	307	0.0203	0.0128	0.0196	0.027	0.0104	0.0115	
Oki-100	311	0.0541	0.0897	0.1239	0.1149	0.0833	0.1303	
Oki-100	315	0.0135	0.0128		0.0135	0.0104		
Oki-100	323		0.0128	0.0136	0.0068	0.0312	0.0057	
Oki-100	327	0.0068						03 Supp
# of samples		74	39	331	74	48	261	

Appendix 1B (continued)

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ots-201b	182			0.0015				03 Captive
Ots-201b	184	0.0903	0.0303	0.054	0.0321	0.049	0.0335	
Ots-201b	196	0.0139		0.017			0.0112	
Ots-201b	200			0.0015	0.0064	0.0196		
Ots-201b	204			0.0031		0.0098		
Ots-201b	208	0.1042	0.0303	0.0586	0.0513	0.049	0.0688	
Ots-201b	211	0.0486	0.0455	0.0756	0.0833	0.1078	0.0855	
Ots-201b	215	0.1181	0.1818	0.1451	0.1026	0.1176	0.1357	
Ots-201b	219	0.0972	0.1212	0.1728	0.2179	0.1765	0.1654	
Ots-201b	223	0.0625	0.1212	0.0478	0.0321	0.0196	0.0651	
Ots-201b	227	0.0417		0.037	0.0449		0.0223	
Ots-201b	231	0.0208		0.0262	0.0128	0.0294		
Ots-201b	235	0.0139	0.0303	0.0093	0.0321	0.0294		
Ots-201b	239	0.0486	0.0152	0.0139	0.0321	0.0588	0.0204	
Ots-201b	243	0.0208		0.0324	0.0128	0.0098	0.0465	
Ots-201b	247	0.0764	0.0152	0.0633	0.0513	0.0588	0.0781	
Ots-201b	251	0.0625	0.1515	0.1204	0.1218	0.1275	0.1208	
Ots-201b	254	0.0417	0.0303	0.0309	0.0705	0.049	0.0465	
Ots-201b	258	0.0069		0.0062	0.0385	0.0294	0.013	
Ots-201b	262	0.0208	0.0455	0.0093	0.0192	0.0098	0.0167	
Ots-201b	266	0.0417	0.0758	0.0247	0.0064	0.0098	0.0279	
Ots-201b	275			0.0015				03 Captive
Ots-201b	278	0.0069		0.0015				
Ots-201b	282	0.0139		0.0123		0.0098		
Ots-201b	294				0.0064		0.0037	
Ots-201b	306	0.0417	0.0606	0.034	0.0256	0.0294	0.039	
Ots-201b	314	0.0069	0.0152					
Ots-201b	330		0.0303					03 In-river
# of samples		72	33	324	78	51	269	

Appendix 1B (continued)

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ots-208b	184				0.0064	0.0213		
Ots-208b	188	0.0548	0.093	0.0564	0.0641	0.0426	0.0436	
Ots-208b	193			0.003			0.0018	
Ots-208b	200	0.0137						03 Supp
Ots-208b	204	0.0068		0.0198	0.0256	0.0106	0.0145	
Ots-208b	208		0.0233	0.0488	0.0385		0.0418	
Ots-208b	212	0.0137	0.0581	0.0091	0.0192	0.0213	0.0182	
Ots-208b	216			0.0168	0.0705	0.0319	0.0236	
Ots-208b	219	0.0205		0.0381	0.0513	0.0106	0.0182	
Ots-208b	224	0.1644	0.1163	0.1341	0.0577	0.1383	0.1182	
Ots-208b	228	0.0822	0.0698	0.0168	0.0385	0.0745	0.0382	
Ots-208b	232	0.0411	0.0349	0.003	0.0064	0.0319	0.0055	
Ots-208b	236	0.0479	0.0233	0.0259	0.0192	0.0319	0.04	
Ots-208b	240	0.0342		0.061	0.0256	0.0213	0.0673	
Ots-208b	244	0.0274	0.0465			0.0106		
Ots-208b	248	0.0274		0.0534	0.0321	0.0532	0.0236	
Ots-208b	251	0.0205	0.0116	0.0091	0.0256	0.0319	0.0218	
Ots-208b	255	0.0479	0.0581	0.0381	0.0256	0.0213	0.0291	
Ots-208b	259	0.137	0.1279	0.1448	0.1218	0.1702	0.16	
Ots-208b	263	0.0822	0.093	0.0991	0.1346	0.0851	0.0945	
Ots-208b	267	0.1027	0.093	0.1372	0.141	0.1277	0.1218	
Ots-208b	271	0.0479	0.0465	0.0198	0.0385	0.0106	0.0545	
Ots-208b	275	0.0205	0.1047	0.0564	0.0449	0.0319	0.0636	
Ots-208b	279			0.0091	0.0064			
Ots-208b	283				0.0064	0.0106		
Ots-208b	287	0.0068						03 Supp
Ots-208b	291					0.0106		04 In-river
# of samples		73	43	328	78	47	275	

Appendix 1B (continued)

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ssa-408	211	0.0652	0.0641	0.0579	0.0625	0.0755	0.0508	
Ssa-408	215	0.1594	0.2051	0.1409	0.1187	0.1792	0.125	
Ssa-408	218	0.0362	0.0641	0.0401	0.0187	0.0094	0.0586	
Ssa-408	222	0.1377	0.1923	0.2255	0.175	0.1887	0.2246	
Ssa-408	226	0.0435	0.0256	0.0208	0.0375	0.066	0.0254	
Ssa-408	230	0.0725	0.0897	0.0519	0.0875	0.0283	0.0684	
Ssa-408	234	0.1594	0.1026	0.1261	0.1313	0.1038	0.1504	
Ssa-408	238	0.0652	0.0128	0.0401	0.0312	0.066	0.0566	
Ssa-408	242	0.0145		0.0134	0.0563	0.0094	0.0391	
Ssa-408	249	0.0652	0.0256	0.0593	0.0875	0.0755	0.0605	
Ssa-408	253	0.0145	0.0128	0.0163	0.0063	0.0094	0.0059	
Ssa-408	257	0.0145	0.0128	0.0178	0.0063			
Ssa-408	261	0.0072						03 Supp
Ssa-408	265	0.0145	0.0256		0.0063	0.0094	0.0078	
Ssa-408	269	0.0145		0.0163	0.0063		0.0098	
Ssa-408	273		0.0128	0.0104				
Ssa-408	277		0.0128					03 In-river
Ssa-408	296	0.0072	0.0128					
Ssa-408	300			0.0119	0.0437		0.0137	
Ssa-408	306		0.0128					03 In-river
Ssa-408	308	0.0072	0.0128	0.0015			0.0137	
Ssa-408	312	0.0362	0.0385	0.0608	0.075	0.0849	0.041	
Ssa-408	320	0.0652	0.0641	0.0846	0.0437	0.0943	0.0449	
Ssa-408	324			0.0045	0.0063		0.0039	
# of samples		69	39	337	80	53	256	

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ogo-2	231			0.0015				03 Captive
Ogo-2	242	0.1818	0.1176	0.1369	0.1772	0.234	0.0921	
Ogo-2	244	0.5364	0.5	0.5893	0.4937	0.3617	0.5469	
Ogo-2	246	0.0182	0.0147	0.0164	0.019	0.0213	0.0325	
Ogo-2	248	0.1818	0.2059	0.1205	0.1203	0.1277	0.1245	
Ogo-2	250	0.0364	0.1176	0.0536	0.0886	0.0851	0.0704	
Ogo-2	252						0.0036	04 Captive
Ogo-2	254	0.0182	0.0147	0.0134	0.0063	0.0213	0.0271	
Ogo-2	256	0.0273		0.0283	0.019	0.0638	0.0451	
Ogo-2	260		0.0294	0.0402	0.0759	0.0851	0.0578	
# of samples		55	34	336	79	47	277	

Appendix 1B (continued)

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ssa-197	189	0.0133						03 Supp
Ssa-197	201	0.06	0.0814	0.0791	0.0855	0.0714	0.1019	
Ssa-197	209	0.0133		0.0657	0.0329	0.051	0.0389	
Ssa-197	217			0.003				03 Captive
Ssa-197	221	0.02						03 Supp
Ssa-197	233	0.0067				0.0102		
Ssa-197	242			0.0015				03 Captive
Ssa-197	249		0.0116	0.0149		0.0204	0.0148	
Ssa-197	253	0.0467	0.0116	0.0179			0.0185	
Ssa-197	257	0.02	0.0465	0.1149	0.125	0.0204	0.1056	
Ssa-197	261	0.0533	0.093	0.0299	0.0461	0.0714	0.0389	
Ssa-197	265	0.1867	0.186	0.2179	0.1908	0.1837	0.2204	
Ssa-197	269	0.0667	0.1395	0.0448	0.0526	0.0918	0.0148	
Ssa-197	273	0.2467	0.2093	0.197	0.2632	0.3163	0.25	
Ssa-197	277	0.08	0.0349	0.0433	0.0329	0.0816	0.0333	
Ssa-197	281		0.0233	0.0299	0.0526	0.0306	0.0333	
Ssa-197	285	0.0733	0.0233	0.0567	0.0395	0.0204	0.05	
Ssa-197	289	0.02	0.0116	0.0104	0.0066		0.0093	
Ssa-197	293	0.0933	0.1279	0.0612	0.0658	0.0306	0.0444	
Ssa-197	297			0.006			0.0259	
Ssa-197	301			0.006	0.0066			
# of samples		75	43	335	76	49	270	

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ogo-4	165	0.0405	0.0116	0.0178		0.0392		
Ogo-4	169	0.0541	0.1047	0.0237	0.0263	0.0294	0.0326	
Ogo-4	171	0.0068		0.0074	0.0263	0.0098	0.0145	
Ogo-4	182	0.1892	0.2791	0.3269	0.3224	0.2647	0.2609	
Ogo-4	184			0.0104				03 Captive
Ogo-4	186	0.0068	0.0116	0.0059				
Ogo-4	188	0.0676	0.0465	0.0266	0.0395	0.0196	0.0362	
Ogo-4	190	0.3108	0.2791	0.3107	0.2632	0.2549	0.288	
Ogo-4	192	0.2432	0.1628	0.145	0.2105	0.2451	0.2192	
Ogo-4	194	0.0473	0.0116	0.0355	0.0197	0.0294	0.0725	
Ogo-4	196	0.0203	0.0698	0.0399	0.0197	0.0196	0.0308	
Ogo-4	198	0.0135	0.0233	0.0503	0.0724	0.0882	0.0453	
# of samples		74	43	338	76	51	276	

Appendix 1B (continued)

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Omm-1080	217	0.0068		0.0341	0.0473	0.0125	0.036	
Omm-1080	221	0.0135	0.0441		0.0068	0.0125		
Omm-1080	233	0.0405	0.1029	0.0735	0.0743	0.0625	0.078	
Omm-1080	241		0.0147	0.0072	0.0068	0.0125	0.012	
Omm-1080	245	0.0068		0.0305	0.027	0.05	0.006	
Omm-1080	249			0.0072	0.0405		0.012	
Omm-1080	253						0.002	04 Captive
Omm-1080	257	0.2027	0.1176	0.2437	0.1486	0.2375	0.196	
Omm-1080	261	0.0338	0.0294	0.0161	0.0338	0.05	0.026	
Omm-1080	269	0.0203	0.0147	0.0036			0.006	
Omm-1080	273		0.0147					03 In-river
Omm-1080	277	0.0068						03 Supp
Omm-1080	281		0.0147				0.006	
Omm-1080	285	0.0338	0.0147	0.0645	0.1081	0.025	0.128	
Omm-1080	289	0.0405	0.0147	0.0627	0.0541	0.0625	0.042	
Omm-1080	293			0.0054			0.004	
Omm-1080	297	0.0338	0.0441	0.0125		0.0125	0.01	
Omm-1080	301	0.0135		0.0018				
Omm-1080	309	0.0203	0.0147	0.0305	0.0203	0.0125	0.006	
Omm-1080	313	0.0338	0.0588	0.0018	0.0068	0.05	0.002	
Omm-1080	317	0.0135	0.0147	0.0108		0.0125	0.006	
Omm-1080	322	0.027	0.0147	0.009	0.0541	0.0375	0.018	
Omm-1080	326	0.0473	0.1029	0.0699	0.0743	0.1125	0.054	
Omm-1080	330	0.1014	0.0735	0.0538	0.0676	0.05	0.068	
Omm-1080	334	0.0338		0.009			0.012	
Omm-1080	338	0.0135	0.0147	0.0018	0.0203	0.025		
Omm-1080	342	0.0405	0.0588	0.0143	0.027	0.0125	0.008	
Omm-1080	346	0.0608	0.0441	0.0412	0.0338	0.025	0.06	
Omm-1080	350	0.0135		0.0197	0.0135	0.025	0.012	
Omm-1080	354	0.0473	0.0882	0.086	0.0473	0.025	0.092	
Omm-1080	358			0.009	0.0338	0.0625	0.008	
Omm-1080	362					0.0125		04 In-river
Omm-1080	365	0.0878	0.0588	0.052	0.0338		0.058	
Omm-1080	369			0.0161	0.0203		0.022	
Omm-1080	373	0.0068	0.0294	0.0018			0.008	
Omm-1080	377			0.0108			0.002	
# of samples		74	34	279	74	40	250	

Appendix 1B (continued)

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ots-213	252	0.0333		0.0442	0.04	0.02	0.0434	
Ots-213	255			0.003	0.02	0.01		
Ots-213	260	0.0467	0.0233					
Ots-213	263	0.04	0.0233	0.0244	0.0133	0.02	0.0208	
Ots-213	267	0.0133		0.0076				
Ots-213	275	0.02	0.0116					
Ots-213	279			0.003				03 Captive
Ots-213	283	0.02	0.0233					
Ots-213	287	0.1333	0.093	0.157	0.16	0.21	0.2075	
Ots-213	291	0.0067	0.0698	0.0229	0.0533	0.08	0.017	
Ots-213	295	0.2067	0.2558	0.2043	0.1867	0.21	0.1868	
Ots-213	299	0.04	0.093	0.0107	0.0267	0.06	0.0321	
Ots-213	303	0.0467	0.0349	0.0701	0.12	0.07	0.066	
Ots-213	307	0.0267	0.0233	0.0137		0.05	0.0189	
Ots-213	311					0.01		04 In-river
Ots-213	315	0.0333	0.0581	0.0366	0.0267	0.02	0.0396	
Ots-213	319	0.0467	0.0814	0.1082	0.0933	0.03	0.1377	
Ots-213	323	0.0533	0.0814	0.0366	0.04	0.05	0.0528	
Ots-213	327	0.1067	0.0814	0.1037	0.08	0.08	0.0717	
Ots-213	331	0.04	0.0233	0.0732	0.0067	0.01	0.017	
Ots-213	335	0.0133	0.0116	0.0137			0.034	
Ots-213	339	0.0733	0.0116	0.0625	0.1333	0.07	0.0547	
Ots-213	359			0.0046				03 Captive
# of samples		75	43	328	75	50	265	

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ots-G474	187	0.62	0.6744	0.6441	0.6923	0.6633	0.6259	
Ots-G474	195			0.0074			0.0018	
Ots-G474	199	0.2733	0.2209	0.2294	0.2308	0.2653	0.2806	
Ots-G474	211			0.0044				03 Captive
Ots-G474	215	0.0133						03 Supp
Ots-G474	219			0.0015		0.0102		
Ots-G474	223	0.0533	0.0465	0.0588	0.0256	0.051	0.0468	
Ots-G474	231	0.04	0.0581	0.0544	0.0449	0.0102	0.045	
Ots-G474	235				0.0064			04 Supp
# of samples		75	43	340	78	49	278	

Appendix 1B (continued)

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ots-3M	146		0.0116					03 In-river
Ots-3M	159		0.0116					03 In-river
Ots-3M	163			0.0015				03 Captive
Ots-3M	169	0.0133		0.041	0.025		0.0195	
Ots-3M	171			0.0046				03 Captive
Ots-3M	173	0.0133	0.0349					
Ots-3M	175			0.0198	0.0375	0.049	0.023	
Ots-3M	177	0.3133	0.3023	0.2432	0.2375	0.2059	0.3032	
Ots-3M	179	0.6333	0.6163	0.6657	0.6813	0.7353	0.6348	
Ots-3M	181	0.02	0.0116	0.0243	0.0187	0.0098	0.0195	
Ots-3M	183	0.0067	0.0116					
# of samples		75	43	329	80	51	282	

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ots-9	132	0.02	0.0119	0.0185	0.0125	0.0196	0.0284	
Ots-9	134	0.4467	0.4167	0.3611	0.2938	0.3235	0.4202	
Ots-9	136	0.46	0.5119	0.4938	0.55	0.4412	0.445	
Ots-9	138	0.0733	0.0595	0.1265	0.1437	0.2157	0.1064	
# of samples		75	42	324	80	51	282	

Appendix 1B (continued)

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ots-211	237	0.0246	0.0303	0.0196		0.0104	0.0036	
Ots-211	253	0.0082	0.0152					
Ots-211	264			0.0375	0.0133	0.0312	0.0217	
Ots-211	268	0.0902	0.0152	0.0857	0.06	0.0417	0.0704	
Ots-211	272	0.0164	0.0455	0.0607	0.12	0.0625	0.0812	
Ots-211	276				0.0067	0.0104		
Ots-211	280	0.0164		0.0054	0.0067	0.0104		
Ots-211	284	0.0164		0.0143	0.04		0.0253	
Ots-211	288	0.0246		0.0125	0.0133	0.0208	0.0253	
Ots-211	292	0.0082		0.0071	0.0133		0.009	
Ots-211	296	0.041	0.0909	0.0732	0.12	0.0625	0.0975	
Ots-211	300	0.0902	0.0455	0.0625	0.0467	0.0625	0.0704	
Ots-211	304	0.3361	0.4697	0.2482	0.2733	0.2917	0.2112	
Ots-211	308	0.0656	0.0303	0.0321	0.0467	0.0521	0.0379	
Ots-211	312	0.1475	0.197	0.0911	0.0867	0.0417	0.1354	
Ots-211	316	0.0246	0.0152	0.0839	0.1	0.1979	0.056	
Ots-211	320		0.0152	0.0411	0.02	0.0208	0.0433	
Ots-211	324			0.0125			0.0217	
Ots-211	328					0.0104		04 In-river
Ots-211	332	0.0574	0.0303	0.0893	0.0267	0.0417	0.065	
Ots-211	336	0.0164		0.0089			0.0036	
Ots-211	340	0.0164		0.0143	0.0067	0.0208	0.0217	
Ots-211	348					0.0104		04 In-river
# of samples		61	33	280	75	48	277	

Locus	Size	03 Supp	03 In-river	03 Captive	04 Supp	04 In-river	04 Captive	Private
Ots-212	160	0.0076		0.0222	0.0203	0.0435	0.05	
Ots-212	165	0.0909	0.0882	0.0819	0.1014	0.0435	0.0259	
Ots-212	169	0.0606	0.0735	0.0751	0.0676	0.0326	0.0704	
Ots-212	173	0.1136	0.1912	0.1877	0.1216	0.1304	0.2074	
Ots-212	177	0.0909	0.0882	0.0188	0.027	0.0543	0.0556	
Ots-212	181	0.1894	0.1471	0.1604	0.3041	0.2391	0.1574	
Ots-212	185	0.2348	0.1765	0.1792	0.1014	0.1413	0.137	
Ots-212	189	0.1364	0.1618	0.116	0.1149	0.1304	0.1352	
Ots-212	193	0.0227		0.0666	0.0473	0.0652	0.0778	
Ots-212	197		0.0294	0.0137	0.0068	0.0326	0.0111	
Ots-212	201	0.0303	0.0147	0.0512	0.0541	0.0761	0.0407	
Ots-212	210	0.0152	0.0147	0.0085				
Ots-212	214		0.0147					03 In-river
Ots-212	234			0.0068	0.0135	0.0109	0.0111	
Ots-212	238			0.0102	0.0203		0.0204	
Ots-212	254	0.0076						03 Supp
Ots-212	258			0.0017				03 Captive
# of samples		66	34	293	74	46	270	

Appendix C: Total Estimated Run-Size of Tucannon River Spring Chinook Salmon (1985-2005)

Appendix C. Total estimated run-size of spring Chinook salmon to the Tucannon River, 1985-2005. (Includes breakdown of conventional hatchery supplementation and captive brood hatchery program components).

Run Year	Natural Jacks	Natural Adults	Total Natural	Hatchery Jacks	Hatchery Adults	Total Hatchery	Total Conventional	Total Captive Brood	Total Run-Size
1985	0	591	591	0	0	0	0	0	591
1986	6	630	636	0	0	0	0	0	636
1987	6	576	582	0	0	0	0	0	582
1988	19	391	410	19	0	19	19	0	429
1989	2	334	336	83	26	109	109	0	445
1990	0	494	494	22	238	260	260	0	754
1991	3	257	260	99	169	268	268	0	528
1992	12	406	418	15	320	335	335	0	753
1993	8	309	317	6	266	272	272	0	589
1994	0	98	98	5	37	42	42	0	140
1995	2	19	21	11	22	33	33	0	54
1996	2	145	147	15	70	85	85	0	232
1997	0	134	134	3	151	154	154	0	288
1998	0	85	85	16	43	59	59	0	144
1999	0	3	3	60	182	242	242	0	245
2000	14	68	82	16	241	257	257	0	339
2001	9	709	718	111	183	294	294	0	1,012
2002	9	341	350	11	644	655	655	0	1,005
2003	3	245	248	27	169	196	196	0	444
2004	0	400	400	22[a]	151	173	170	3	573
2005	3	286	289	8	123[b]	131	117	14	420

[a] Three of which are captive brood progeny.
[b] Fourteen of which are captive brood progeny.

Appendix D: Stray Hatchery-Origin Spring Chinook Salmon in the Tucannon River (1990-2005)

Appendix D. Summary of identified stray hatchery origin spring Chinook salmon that escaped into the Tucannon River (1990-2005).

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**	**1.3**
				Total Umatilla River	**3**	**1.3**
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**

[a] All CWT codes recovered from groups that were 100% marked were given a 1:1 expansion rate. Groups that were not 100% marked were expanded based on the percentage of unmarked fish. The expansion is based on the percent of stray carcasses to Tucannon River origin carcasses and the estimated total run in the river.

Appendix D (continued). Summary of identified stray hatchery origin spring Chinook salmon that escaped into the Tucannon River (1990-2005).

Year	CWT Code or Fin clip	Agency	Origin (stock)	Release Location / Release River	Number Observed/ Expanded [a]	% of Tuc. Run
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	Lyons Ferry (Wash.)	Lyons Ferry / Snake River	1 / 1	
	LV clip	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	18 / 31	
	Ad clip	ODFW	Carson (Wash.)	Imeques AP / Umatilla River	2 / 2	
				Total Strays	**46**	**13.6**
				Total Umatilla River	**41**	**12.1**
2001	076040	ODFW	Umatilla R.	Umatilla Hatch. /Umatilla River	1/7	
	092828	ODFW	Imnaha R. & Tribs.	Lookinglass/Imnaha River	1/3	
	092829	ODFW	Imnaha R. & Tribs.	Lookinglass/Imnaha River	1/3	
				Total Strays	**13**	**1.3**
				Total Umatilla River	**7**	**0.7**
2002	054208	USFWS	Dworshak	Dworshak NFH/Clearwater R.	1/29	
	076039	ODFW	Umatilla R.	Umatilla Hatch./Umatilla River	1/8	
	076040	ODFW	Umatilla R.	Umatilla Hatch./Umatilla River	2/16	
	076041	ODFW	Umatilla R.	Umatilla Hatch./Umatilla River	2/16	
	076049	ODFW	Umatilla R.	Umatilla Hatch./Umatilla River	1/8	
	076051	ODFW	Umatilla R.	Umatilla Hatch./Umatilla River	1/8	
	076138	ODFW	Umatilla R.	Umatilla Hatch./Umatilla River	1/8	
	105412	IDFG	Powell	Clearwater Hatch./Powell Ponds	1/4	
				Total Strays	**97**	**9.7**
				Total Umatilla River	**64**	**6.4**
2003	100472	IDFG	Salmon R.	Sawtooth Hatch./Nature's Rear.	1/1	
				Total Strays	**1**	**0.2**
				Total Umatilla River	**0**	**0.0**
2004	Ad clip	Unknown	Unknown[b]	Unknown	6/17	
				Total Strays	**17**	**3.0**
				Total Umatilla River[b]	**17**	**3.0[b]**
2005	Ad clip	Unknown	Unknown[c]	Unknown	3/6	
				Total Strays	**6**	**1.4**
				Total Umatilla River[c]	**6**	**1.4[c]**

[a] All CWT codes recovered from groups that were 100% marked were given a 1:1 expansion rate. Groups that were not 100% marked were expanded based on the percentage of unmarked fish. The expansion is based on the percent of stray carcasses to Tucannon River origin carcasses and the estimated total run in the river.

[b] Based on the mark (Ad clip, no wire), brood year (2000), historical stray rates, and large number of releases (670,570) we believe these fish are probable Umatilla River origin strays.

[c] Based on the mark (Ad clip, no wire), brood years (2001 and 2002), historical stray rates, and large number of releases (602,347 BY01 and 701,798 BY02) we believe these fish are probable Umatilla River origin strays.

Appendix E: Historical Hatchery Releases (1985-2004 Brood Years)

Appendix E. Historical hatchery spring Chinook releases from the Tucannon River, 1985-2004 brood years. (Totals are summation by brood year and release year.)

Release Year	Brood	Release Type[a]	Release Date	CWT Code[b]	Number CWT	Ad-only marked	Additional Tag/location/cross[c]	Lbs	Fish/lb
1987	1985	H-Acc	4/6-10	34/42	12,922			2,172	6
Total					**12,922**				
1988	1986	H-Acc	3/7	33/25	12,328	512		1,384	10
		"	"	41/46	12,095	465		1,256	10
		"	"	41/48	13,097	503		1,360	10
		"	4/13	33/25	37,893	1,456		3,735	10
		"	"	41/46	34,389	1,321		3,571	10
		"	"	41/48	37,235	1,431		3,867	10
Total					**147,037**	**5,688**			
1989	1987	H-Acc	4/11-13	49/50	151,100	1,065		16,907	9
Total					**151,100**	**1,065**			
1990	1988	H-Acc	3/30-4/10	55/01	68,591	3,007		6,509	11
Total					**139,050**	**6,096**			
1991	1989	H-Acc	4/1-12	14/61	75,661	989		8,517	9
Total					**97,779**	**1,278**			
1992	1990	H-Acc	3/30-4/10	40/21	51,149		BWT, RC, WxW	4,649	11
		"	"	43/11	21,108		BWT, LC, HxH	1,924	11
		"	"	37/25	13,480		Mixed	1,225	11
Total					**85,737**				
1993	1991	H-Acc	4/6-12	46/25	55,716	796	VI, LR, WxW	3,714	15
		"	"	46/47	16,745	807	VI, RR, HxH	1,116	15
Total					**72,461**	**1,603**			
1993	1992	Direct	10/22-25	48/23	24,883	251	VI, LR, WxW	698	36
		"	"	48/24	24,685	300	VI, RR, HxH	694	36
		"	"	48/56	7,111	86	Mixed	200	36
Total					**56,679**	**637**			
1994	1992	H-Acc	4/11-18	48/10	35,405	871	VI, LY, WxW	2,591	14
		"	"	49/05	35,469	2,588	VI, RY, HxH	2,718	14
		"	"	48/55	8,277	799	Mixed	648	14
Total					**79,151**	**4,258**			
1995	1993	H-Acc	3/15-4/15	53/43	45,007	140	VI, RG, HxH	3,166	14
		"	"	53/44	42,936	2,212	VI, LG, WxW	3,166	14
		P-Acc	3/20-4/3	56/15	11,661	72	VI, RR, HxH	782	15
		"	"	56/17	10,704	290	VI, LR, WxW	733	15
		"	"	56/18	13,705	47	Mixed	917	15
		Direct	3/20-4/3	56/15	3,860	24	VI, RR, HxH	259	15
		"	"	56/17	3,542	96	VI, LR, WxW	243	15
		"	"	56/18	4,537	15	Mixed	303	15
Total					**135,952**	**2,896**			
1996	1994	H-Acc	3/16-4/22	56/29	89,437		VI, RR, Mixed	5,123	17.7
		P-Acc	3/27-4/19	57/29	35,334	35	VI, RG, Mixed	2,628	15.2
		Direct	3/27	43/23	5,263		VI, LG, Mixed	369	13.3
Total					**130,034**	**35**			

Appendix E (continued). Historical hatchery spring Chinook releases from the Tucannon River, 1985-2004 brood years. (Totals are summation by brood year and release year.)

Release Year	Brood	Release Type[a]	Release Date	CWT Code[b]	Number CWT	Ad-only marked	Additional Tag/location/cross[c]	Lbs	Fish/lb
1997	1995	H-Acc	3/07-4/18	59/36	42,160	40	VI, RR, Mixed	2,411	17.5
		P-Acc	3/24-3/25	61/41	10,045	50	VI, RB, Mixed	537	18.8
		Direct	3/24	61/40	9,811	38	VI, LB, Mixed	593	16.6
Total					**62,016**	**128**			
1998	1996	H-Acc	3/11-4/17	03/60	14,308	27	Mixed	902	15.9
		C-Acc	3/11-4/18	61/25	23,065	62	"	1,498	15.8
		"	"	61/24	24,554	50	"	1,557	15.8
		Direct	4/03	03/59	14,101	52	"	863	16.4
Total					**76,028**	**191**			
1999	1997	C-Acc	3/11-4/20	61/32	23,664	522	Mixed	1,550	15.6
Total					**23,664**	**522**			
2000	1998	C-Acc	3/20-4/26	12/11	125,192	2,747	Mixed	10,235	12.5
Total					**125,192**	**2,747**			
2001	1999	C-Acc	3/19-4/25	02/75	96,736	864	Mixed	9,207	10.6
Total					**96,736**	**864**			
2002	2000	C-Acc	3/15-4/23	08/87	99,566	2,533[e]	VI, RR, Mixed	6,587	15.5
Total					**99,566**	**2,533[e]**			
2002	2000CB	C-Acc	3/15/4/23	63	3,031	24[f]	CB, Mixed	343	8.9
Total					**3,031**	**24[f]**			
2002	2001	Direct	5/06	14/29	19,948	1,095	Mixed	170.5	123.4
Total					**19,948**	**1,095**			
2002	2001CB	Direct	5/06	14/30	20,435	157	CB, Mixed	124.8	165
Total					**20,435**	**157**			
2003	2001	C-Acc	4/01-4/21	06/81	144,013	2,909[e]	Mixed	11,389	12.9
Total					**144,013**	**2,909[e]**			
2003	2001CB	C-Acc	4/01-4/21	63	134,401	5,995[f]	CB, Mixed	10,100	13.9
Total					**134,401**	**5,995[f]**			
2004	2002	C-Acc	4/01-4/20	17/91	121,774	1,812[e]	Mixed	10,563	11.7
Total					**121,774**	**1,812[e]**			
2004	2002CB	C-Acc	4/01-4/20	63	42,875	1,909[f]	CB, Mixed	3,393	13.2
Total					**42,875**	**1,909[f]**			
2005	2003	C-Acc	3/28-4/15	24/82	69,831	1,323[e]	Mixed	5,603	12.7
Total					**69,831**	**1,323[e]**			
2005	2003CB	C-Acc	3/28-4/15	27/78	125,304	4,760[f]	CB, Mixed	9,706	13.4
Total					**125,304**	**4,760[f]**			
2006	2004	C-Acc	4/03-4/26	28/87	67,272	270[e]	Mixed	5,040	13.4
Total					**67,272**	**270[e]**			
2006	2004CB	C-Acc	4/03-4/26	28/65	127,162	5,150[f]	CB, Mixed	8,648	15.3
Total					**127,162**	**5,150[f]**			

[a] Release types are: Tucannon Hatchery Acclimation Pond (H-Acc); Portable Acclimation Pond (P-Acc); Curl Lake Acclimation Pond (C-Acc); and Direct Stream Release (Direct).
[b] All tag codes start with agency code 63.
[c] Codes listed in column are as follows: BWT - Blank Wire Tag; CB - Captive Brood; VI-Visual Implant (elastomer); LR - Left Red, RR - Right Red, LG-Left Green, RG - Right Green, LY - Left Yellow, RY - Right Yellow, LB - Left Blue, RB - Right Blue; Crosses: WxW - wild x wild progeny, HxH - hatchery x hatchery progeny, Mixed – wild x hatchery progeny.
[d] No tag loss data due to presence of both CWT and BWT in fish.
[e] VI tag only.
[f] No wire.

Appendix F: Numbers and Density Estimates (Fish/100 m^2) of Juvenile Salmon Counted by Snorkel Surveys in the Tucannon River in 2005

Appendix F. Numbers and density estimates of subyearling and yearling natural spring Chinook salmon counted by snorkel surveys in the Tucannon River, 2005.

			Number of Salmon			Density (fish/100m^2)	
			Natural			Natural	
Stratum	Site[a]	Date	0+	> 1+	Snorkeled Area (m^2)	0+	> 1+
Marengo	TUC01	7/26	0	0	542	0.00	0.00
↓	01A	7/26	4	0	481	0.83	0.00
	TUC02	7/18	0	0	502	0.00	0.00
	02A	7/18	17	2	554	3.07	0.36
	TUC03	7/26	18	1	625	2.88	0.16
	03A	7/26	48	4	460	10.43	0.87
Hartsock	TUC04	7/26	1	0	472	0.21	0.00
↓	04A	7/26	18	0	790	2.28	0.00
	TUCO5	7/26	4	0	679	0.59	0.00
	05A	7/26	15	0	470	3.19	0.00
	TUC06	7/26	5	0	569	0.88	0.00
	06A	7/26	3	0	630	0.48	0.00
	TUC07	7/25	60	1	1247	4.81	0.08
	07A	7/25	51	0	1248	4.09	0.00
	TUC08	7/26	73	0	424	17.22	0.00
	08A	7/26	7	0	568	1.23	0.00
	TUC09	7/26	18	0	641	2.81	0.00
	09A	7/26	9	0	528	1.70	0.00
	TUC10	8/24	33	0	456	7.24	0.00
	010A	8/24	51	0	357	14.29	0.00
HMA	TUC11	7/26	65	0	619	10.50	0.00
↓	011A	7/26	66	1	572	11.54	0.17
	TUC13	7/26	18	0	597	3.02	0.00
	13A	7/26	56	0	594	9.43	0.00
	TUC14	7/27	168	8	593	28.33	1.35
	14A	7/27	14	0	636	2.20	0.00
	TUC16	7/27	23	1	436	5.28	0.23
	16A	7/27	14	0	546	2.56	0.00
	TUC17	7/27	41	1	730	5.62	0.14
	17A	7/27	45	0	687	6.55	0.00
	TUC19	8/23	105	3	673	15.60	0.45
	19A	8/23	21	1	498	4.22	0.20
	TUC20	7/27	12	0	562	2.14	0.00
	20A	7/27	12	1	495	2.42	0.20

Appendix F (continued). Numbers and density estimates of subyearling and yearling natural spring Chinook salmon counted by snorkel surveys in the Tucannon River, 2005.

			Number of Salmon			Density (fish/100m²)	
			Natural			Natural	
Stratum	Site[a]	Date	0+	> 1+	Snorkeled Area (m²)	0+	> 1+
HMA	TUC21	7/27	21	0	666	0.00	0.00
(cont.)	21A	7/27	22	1	469	0.21	0.21
↓	TUC22	8/25	37	0	513	0.00	0.00
	22A	8/25	72	1	492	0.20	0.20
	TUC23	7/27	5	0	630	0.00	0.00
	23A	7/27	121	5	658	0.76	0.76
Wilderness	TUC24	8/24	61	0	385	0.00	0.00
↓	24A	8/24	22	0	482	0.00	0.00
	TUC25	7/28	6	0	315	0.00	0.00
	25A	7/28	22	0	360	0.00	0.00
	TUC26	7/28	48	0	406	0.00	0.00
	26A	7/28	27	0	312	0.00	0.00
	TUC27	7/28	4	0	410	0.00	0.00
	27A	7/28	11	0	547	0.00	0.00
	TUC28	7/28	0	0	219	0.00	0.00
	28A	7/28	0	0	246	0.00	0.00
Totals			**1,574**	**31**	**27,591**	**5.77**	**0.11**

[a] Specific site locations are available by request from the Snake River Lab.

Appendix G: Numbers of Selected Species Captured in the Tucannon River Smolt Trap During the 2005 Outmigration

Appendix G. Numbers of selected species captured in the Tucannon River smolt trap during the 2005 outmigration.

Coho Salmon	Fall Chinook	Bull Trout	Grass Pickerel	Sand Roller	Tench	Mountain Whitefish	Shad	Steelhead Smolts	Steelhead Parr	Pacific Lamprey		
										Ammocoetes	Macropthalmia	Adults
1,298	11,691	3	3	1	1	4	7	2,134	583	324	724	3

Appendix H: Recoveries of Coded-Wire Tagged Salmon Released Into the Tucannon River for the 1985-2001 Brood Years

Appendix H. 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 1985-2001 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[a]	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	84	28	130
Kalama R., Wind R.						
Fish Trap - F.W.						
Treaty Troll			1	2		
Lyons Ferry Hatch.[b]	32	38	136	280	53	71
F.W. Sport			1	4		
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						
Dworshak NFH						
IDFG						
Hatchery						
Total Returns	33	39	172	379	82	203
Tucannon (%)	97.4		96.0		99.0	
Out-of-Basin (%)	0.0		0.0		0.0	
Commercial Harvest (%)	2.6		1.3		1.0	
Sport Harvest (%)	0.0		2.6		0.0	
Survival	0.30		0.26		0.13	

[a] WDFW agency code prefix is 63. [b] Fish trapped at TFH and held at LFH for spawning.

Appendix H (continued). 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 1985-2001 brood years. (Data from RMIS database.)

Brood Year	1988		1989		1990	
Smolts Released	139,050		97,779		85,737	
Fish/Lb	11.0		9.0		11.0	
CWT Codes[a]	01/42, 55/01		01/31, 14/61		37/25, 40/21, 43/11	
Release Year	1990		1991		1992	
Agency (fishery/location)	Observed Number	Estimated Number	Observed Number	Estimated Number	Observed Number	Estimated Number
WDFW						
Tucannon River	107	370	61	191	2	6
Kalama R., Wind R.						
Fish Trap - F.W.	1	1				
Treaty Troll			2	2		
Lyons Ferry Hatch.[b]	83	86	55	55	19	19
F.W. Sport	1	4				
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						
Dworshak NFH	1	1				
IDFG						
Hatchery						
Total Returns	204	482	124	258	21	25
Tucannon (%)	94.6		95.3		100.0	
Out-of-Basin (%)	0.4		0.0		0.0	
Commercial Harvest (%)	4.1		3.9		0.0	
Sport Harvest (%)	0.8		0.8		0.0	
Survival	0.35		0.26		0.03	

[a] WDFW agency code prefix is 63. [b] Fish trapped at TFH and held at LFH for spawning.

Appendix H (continued). 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 1985-2001 brood years. (Data from RMIS database.)

Brood Year	1991		1992		1992	
Smolts Released	72,461		56,679		79,151	
Fish/Lb	15.0		36.0		14.0	
CWT Codes[a]	46/25, 46/47		48/23, 48/24, 48/56		48/10, 48/55, 49/05	
Release Year	1993		1993		1994	
Agency (fishery/location)	Observed Number	Estimated Number	Observed Number	Estimated Number	Observed Number	Estimated Number
WDFW						
Tucannon River					11	34
Kalama R., Wind R.						
Fish Trap - F.W.						
Treaty Troll						
Lyons Ferry Hatch.[b]	24	24	2	2	45	49
F.W. Sport						
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
Dworshak NFH						
IDFG						
Hatchery						
Total Returns	26	30	4	5	69	102
Tucannon (%)	80.0		40.0		81.4	
Out-of-Basin (%)	10.0		20.0		15.7	
Commercial Harvest (%)	10.0		40.0		0.9	
Sport Harvest (%)	0.0		0.0		2.0	
Survival	0.04		0.01		0.13	

[a] WDFW agency code prefix is 63.
[b] Fish trapped at TFH and held at LFH for spawning.

Appendix H (continued). 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 1985-2001 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[a]	56/15, 56/17-18, 53/43-44		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	42	138	3	8	36	92
Kalama R., Wind R.						
Fish Trap - F.W.						
Treaty Troll						
Lyons Ferry Hatch.[b]	66	138	21	24	94	93
F.W. Sport						
ODFW						
Test Net, Zone 4						
Treaty Ceremonial	3	3				
Three Mile, Umatilla R.						
Spawning Ground	3	3			1	1
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						
Dworshak NFH						
IDFG						
Hatchery						
Total Returns	117	287	24	32	132	187
Tucannon (%)	96.2		100.0		98.9	
Out-of-Basin (%)	1.7		0.0		1.1	
Commercial Harvest (%)	1.0		0.0		0.0	
Sport Harvest (%)	1.0		0.0		0.0	
Survival	0.21		0.02		0.30	

[a] WDFW agency code prefix is 63.
[b] Fish trapped at TFH and held at LFH for spawning.

Appendix H (continued). 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 1985-2001 brood years. (Data from RMIS database.)

Brood Year	1996		1997		1998	
Smolts Released	76,028		23,509		124,093	
Fish/Lb	16.0		16.0		13.0	
CWT Codes[a]	03/59-60, 61/24-25		61/32		12/11	
Release Year	1998		1999		2000	
Agency (fishery/location)	Observed Number	Estimated Number	Observed Number	Estimated Number	Observed Number	Estimated Number
WDFW						
Tucannon River	43	139	17	85	147	680
Kalama R., Wind R.						
Fish Trap - F.W.						
Treaty Troll						
Lyons Ferry Hatch.[b]	96	99	44	46	83	121
F.W. Sport					3	13
Non-treaty Ocean Troll					1	2
ODFW						
Test Net, Zone 4					1	1
Treaty Ceremonial					5	5
Three Mile, Umatilla R.						
Spawning Ground					1	1
Fish Trap - F.W.	1	1	2	2	8	10
F.W. Sport					2	4
Hatchery	2	2	1	1		
Columbia R. Gillnet			7	50	32	111
Columbia R. Sport			2	15	17	94
CDFO						
Non-treaty Ocean Troll						
Mixed Net & Seine						
Ocean Sport						
USFWS						
Warm Springs Hatchery						
Dworshak NFH						
IDFG						
Hatchery	1	1	1	--		
Total Returns	143	242	74	199	300	1,042
Tucannon (%)	98.3		65.8		76.9	
Out-of-Basin (%)	1.7		1.5		1.6	
Commercial Harvest (%)	0.0		25.1		10.8	
Sport Harvest (%)	0.0		7.5		10.7	
Survival	0.32		0.85		0.84	

[a] WDFW agency code prefix is 63.
[b] Fish trapped at TFH and held at LFH for spawning.

Appendix H (continued). 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 1985-2001 brood years. (Data from RMIS database.)

Brood Year	1999		2000		2001[c]	
Smolts Released	97,600		102,099		146,922	
Fish/Lb	10.6		15.5		12.9	
CWT Codes[a]	02/75		08/87		06/81	
Release Year	2001		2002		2003	
Agency (fishery/location)	Observed Number	Estimated Number	Observed Number	Estimated Number	Observed Number	Estimated Number
WDFW						
Tucannon River	2	12	13	37	3	7
Kalama R., Wind R.						
Fish Trap - F.W.						
Treaty Troll						
Lyons Ferry Hatch.[b]	6	10	39	44	4	4
F.W. Sport						
Non-treaty Ocean Troll						
ODFW						
Test Net, Zone 4						
Treaty Ceremonial						
Three Mile, Umatilla R.						
Spawning Ground						
Fish Trap - F.W.						
F.W. Sport						
Hatchery						
Columbia R. Gillnet	1	3	1	1		
Columbia R. Sport						
CDFO						
Non-treaty Ocean Troll						
Mixed Net & Seine						
Ocean Sport						
USFWS						
Warm Springs Hatchery						
Dworshak NFH						
IDFG						
Hatchery						
Total Returns	9	25	53	82	7	11
Tucannon (%)	88.0		98.8		100.0	
Out-of-Basin (%)	0.0		0.0		0.0	
Commercial Harvest (%)	12.0		1.2		0.0	
Sport Harvest (%)	0.0		0.0		0.0	
Survival	0.03		0.08		0.01	

[a] WDFW agency code prefix is 63.
[b] Fish trapped at TFH and held at LFH for spawning.
[c] Data for the 2001 brood year is incomplete.