STATE OF WASHINGTON September 2007

Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 2006 Annual Report

by Michael P. Gallinat and Lance A. Ross

Washington Department of
FISH AND WILDLIFE
Fish Program
Science Division

FPA 07-09

Tucannon River Spring Chinook Salmon Hatchery Evaluation Program

2006 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: 1411-06-J013

September 2007

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 our sincere gratitude to Steve Rodgers, Lyons Ferry Complex Manager, for his coordination efforts. We thank Hatchery Specialists Doug Maxey, Dick Rogers, Severin Erickson, and Steve Jones for their cooperation with hatchery sampling, providing information regarding hatchery operations and hatchery records, and their input on evaluation and research activities. We also thank all additional hatchery personnel who provide the day-to-day care of the spring Chinook and for their assistance with hatchery spawning, sampling, and record keeping.

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

We are indebted to Kim Engie, NOAA Fisheries, Mike McLean, Confederated Tribes of the Umatilla Indian Reservation, Bill Bosch, Yakama Nation, and Andrew Murdoch, WDFW, who provided the survival data used for comparisons with the Tucannon River spring Chinook.

We also thank 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 of the Plan is to compensate for the estimated annual loss of 1,152-spring Chinook (Tucannon River stock) caused by hydroelectric projects on the Snake River. The conventional supplementation production goal was revised in 2006 to 225,000 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 2006 to April 2007.

One hundred thirty-nine salmon were captured in the TFH trap in 2006 (57 natural adults, 4 natural jacks, 70 hatchery adults, and 8 hatchery jacks); 89 were collected and hauled to LFH for broodstock and the remaining fish were passed upstream. During 2006, one salmon that was collected for broodstock died prior to spawning.

Spawning of supplementation fish in 2006 at LFH occurred between 29 August and 26 September, with peak eggtake on 12 September. A total of 123,629 eggs were collected from 18 natural and 27 hatchery-origin fish. Egg mortality to eye-up was 5.4% (6,685 eggs), with an additional loss of 4,594 (3.9%) sac-fry. Total fry ponded for production in the rearing ponds was 112,350.

A total of 86 captive brood females were spawned from 5 September to 3 October, 2006 producing 162,736 eggs. Egg mortality to eye-up was 38.9% leaving 99,420 live eggs. An additional 19,988 dead eggs/fry (20.1%) were picked at ponding leaving 79,432 fish for rearing.

WDFW staff conducted spawning ground surveys in the Tucannon River between 8 September and 25 September, 2006. Sixty-two redds and 25 carcasses were found above the adult trap and 39 redds and 28 carcasses were found below the trap. Based on redd counts, broodstock collection, and in-river pre-spawning mortalities, the estimated escapement for 2006 was 253 fish (133 natural adults, 7 natural jacks and 109 hatchery-origin adults, 4 hatchery jacks).

Snorkel surveys were conducted during the summer of 2006 to determine the population of subyearling and yearling spring Chinook in the Tucannon River. We estimated 21,162 subyearlings (BY 2005) and 1,012 yearlings (BY 2004) were present in the river. Evaluation staff also operated a downstream migrant trap. During the 2005/2006 emigration, we estimated that 21,057 (BY 2004) 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 113 hatchery-origin fish returned in 2006. Beginning with the 2006 brood year, the annual smolt goal was increased from 132,000 to 225,000 to help offset 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 ii

List of Figures iv

List of Appendices v

Introduction 1
- Program Objectives 1
- Facility Descriptions 1

Tucannon River Watershed Characteristics 2

Adult Salmon Evaluation 5
- Broodstock Trapping 5
- Broodstock Mortality 6
- Broodstock Spawning 7
- Natural Spawning 8
- Historical Trends 10
- Genetic Sampling 11
- Age Composition, Length Comparisons, and Fecundity 12
- Coded-Wire Tag Sampling 14
- Arrival and Spawn Timing Trends 15
- Total Run-Size 16
- Stray Salmon into the Tucannon River 18
- Adult PIT Tag Returns 19

Juvenile Salmon Evaluation 20
- Hatchery Rearing, Marking, and Release 20
  - Hatchery Rearing and Marking 20
  - 2005 Brood Release 20
- Natural Parr Production 21
- Natural Smolt Production 22
- Juvenile Migration Studies 24

Survival Rates 25
- Survival Comparisons to Other Populations 33
- Fishery Contribution 34

Conclusions and Recommendations 36

Literature Cited 38

List of Tables

Table 1. Description of five strata within the Tucannon River 3

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 1986-2006 . 6

Table 3. Numbers of pre-spawning mortalities and percent of fish collected for broodstock at TFH and held at TFH (1985-1991) or LFH (1992-2006) 7

Table 4. Number of fish spawned and killed, estimated egg collection, and egg mortality of Tucannon River spring Chinook salmon at LFH in 2006 8

Table 5. Numbers and general locations of salmon redds and carcasses recovered on the Tucannon River spawning grounds, 2006 (the Tucannon Hatchery adult trap is located at rkm 59) 9

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, 1985-2006 11

Table 7. Average number of eggs/female (n, SD) by age group of Tucannon River natural and hatchery origin broodstock, 1990-2006 14

Table 8. Coded-wire tag codes of hatchery salmon sampled at LFH and the Tucannon River, 2006 15

Table 9. Spring Chinook salmon (natural and hatchery) sampled from the Tucannon River, 2006 15

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, 1986-2006 16

Table 11. Estimated spring Chinook salmon run to the Tucannon River, 1985-2006 17

Table 12 Returning adult spring Chinook final PIT tag detections from fish originally tagged as juveniles from the Tucannon River 19

Table 13. Sample sizes (N), mean lengths (mm), coefficients of variation (CV), condition factors (K), fish/lb (fpp), and precocity of 2005 BY juveniles sampled at TFH and Curl Lake 20

Table 14. Yearling spring Chinook releases in the Tucannon River, 2005 brood year 21

Table 15. Number of sites, area snorkeled, mean density (fish/100 m^2), population estimates, and 95% confidence intervals for subyearling and yearling spring Chinook within the Tucannon River, 2006 21

Table 16 Total population estimates (with 95% confidence interval) for natural and hatchery origin (supplementation and captive brood) emigrants from the Tucannon River, 2006 24

Table 17. 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 2006 (Fish were volitionally released from 4/03/06-4/26/06) 24

Table 18. Estimates of *natural* Tucannon spring Chinook salmon abundance by life stage for 1985-2006 broods 26

Table 19. Estimates of Tucannon spring Chinook salmon abundance (*spawned and reared in the hatchery*) by life stage for 1985-2006 broods 27

Table 20. Percent survival by brood year for juvenile salmon and the multiplicative advantage of hatchery-reared salmon over naturally-reared salmon in the Tucannon River 28

Table 21 Adult returns and SARs of natural salmon to the Tucannon River for brood years 1985-2001 29

Table 22. Adult returns and SARs of hatchery salmon to the Tucannon River for brood years 1985-2001 30

Table 23 Parent-to-progeny survival estimates of Tucannon River spring Chinook salmon from 1985 through 2002 brood years (2002 incomplete) 32

List of Figures

Figure 1. Location of the Tucannon River, and Lyons Ferry and Tucannon Hatcheries within the Snake River Basin 2

Figure 2. Maximum temperature, average maximum temperature, and average minimum temperature recorded by thermographs at 17 selected sites along the Tucannon River, May-October, 2006 4

Figure 3. Number of redds/km and percentage of redds above and below the adult trap on the Tucannon River, 1986-2006 10

Figure 4. Historical (1985-2005), and 2006 age composition for spring Chinook in the Tucannon River 12

Figure 5. Mean post-eye to hypural-plate length comparisons between Age 4 natural and hatchery-origin males (NM and HM) and natural and hatchery-origin females (NF and HF) with 95% confidence intervals for the years 1985-2006 13

Figure 6. Length frequency distribution of sampled natural spring Chinook salmon captured in the Tucannon River smolt trap, 2005/2006 season 22

Figure 7. Return per spawner (with replacement line) for the 1985-2002 brood years (2002 incomplete brood year) 31

Figure 8. Total escapement for Tucannon River spring Chinook salmon for the 1985-2006 run years 35

List of Appendices

Appendix A: Spring Chinook Captured, Collected, or Passed Upstream at the Tucannon Hatchery Trap in 2006 41

Appendix B: Total Estimated Run-Size of Tucannon River Spring Chinook Salmon (1985-2006) 43

Appendix C: Stray Hatchery-Origin Spring Chinook Salmon in the Tucannon River (1990-2006) 45

Appendix D: Historical Hatchery Releases (1985-2005 Brood Years)....48

Appendix E: Numbers and Density Estimates (Fish/100 m^2) of Juvenile Salmon Counted by Snorkel Surveys in the Tucannon River in 2006 51

Appendix F: Numbers of Other Selected Species Captured in the Tucannon River Smolt Trap During the 2006 Outmigration....54

Appendix G: Proportionate Natural Influence (PNI) for the Tucannon Spring Chinook Population (1985-2006) 56

Appendix H: Comparison of Mean Survival Rates for Various Life Stages from Different Spring Chinook Stocks 58

Appendix H Table 1. Comparison of mean natural-origin *egg-to-parr* survival rates from different river systems....59

Appendix H Table 2. Comparison of mean natural-origin *parr-to-smolt* survival rates from different river systems.... 60

Appendix H Table 3. Comparison of mean natural-origin *egg-to-smolt* survival rates from different river systems.... 61

Appendix H Table 4. Comparison of mean *smolt-to-adult* survival rates for *natural-origin* spring Chinook from different river systems.... 62

Appendix H Table 5. Comparison of mean smolt-to-adult survival rates for hatchery-origin spring Chinook from different river systems.... 63

Appendix I: Recoveries of Coded-Wire Tagged Salmon Released Into the Tucannon River for the 1985-2002 Brood Years....66

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 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 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 (WDFW et al. 1999). In an attempt to increase adult returns and come closer to achieving the LSRCP mitigation goal, the co-managers have agreed to increase the conventional supplementation program goal to 225,000 yearling smolts beginning with the 2006 brood year. This report summarizes work performed by the WDFW Spring Chinook Evaluation Program from April 2006 through April 2007.

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.

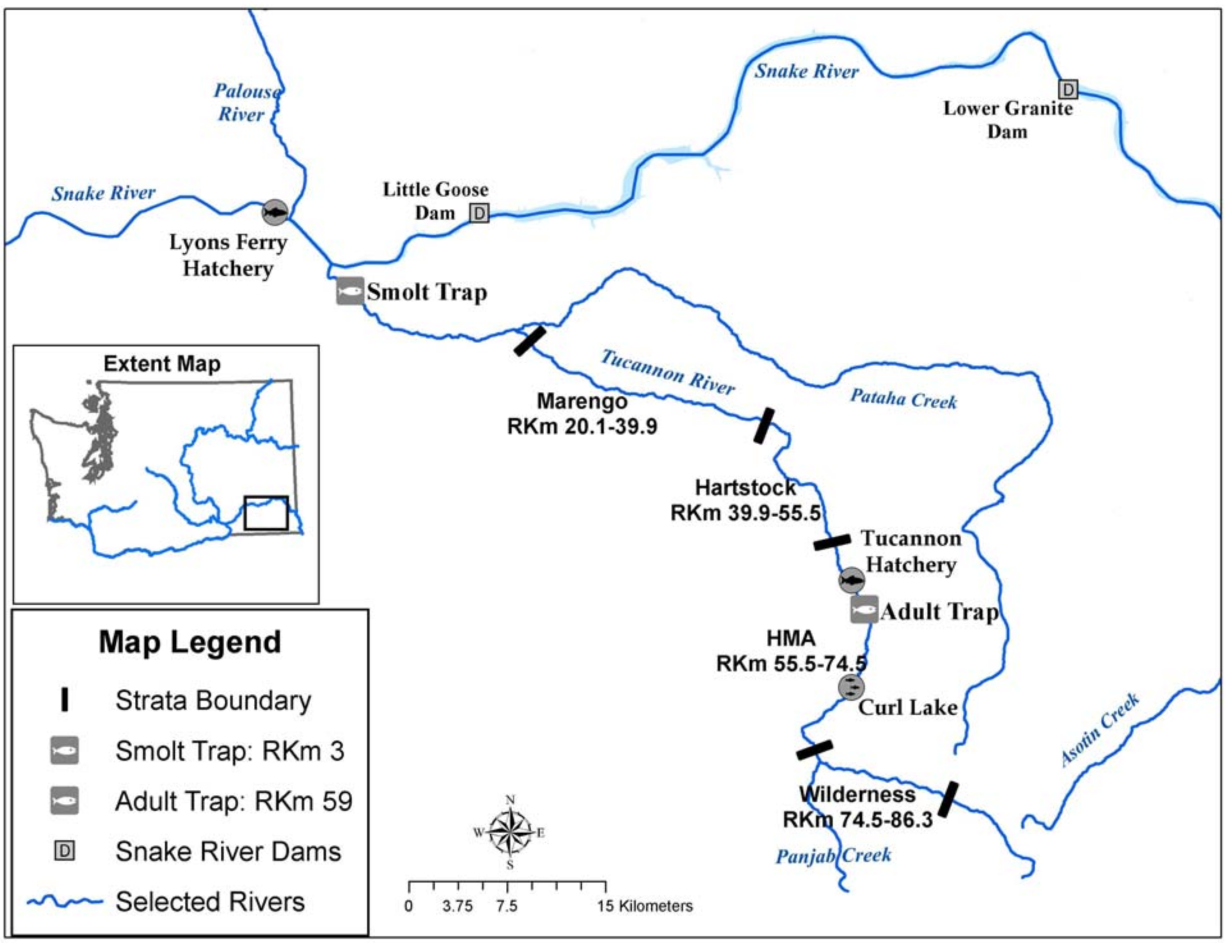

Figure 1. Location of the Tucannon River, and Lyons Ferry and Tucannon Hatcheries within the Snake River Basin.

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 17 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 2006, maximum temperatures where spring Chinook juveniles were rearing during the hottest part of the summer ranged from 17.3° C (63.2° F) in the upper HMA stratum (rkm 74.5) to 24.5° C (76.1° 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.

During 2006, for the second year in a row, a major forest fire (Columbia Complex Fire) occurred in the Tucannon Watershed. The fire limited access for some survey work in 2006.

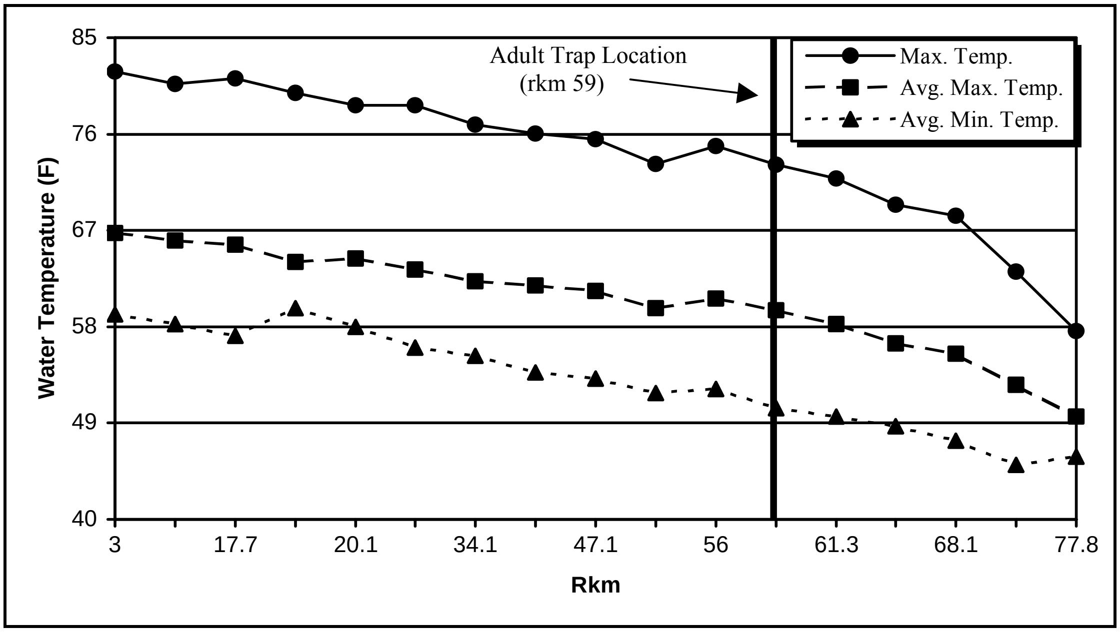

Figure 2. Maximum temperature, average maximum temperature, and average minimum temperature recorded by thermographs at 17 selected sites along the Tucannon River, May-October, 2006.

Adult Salmon Evaluation

Broodstock Trapping

The annual collection goal for broodstock was revised in 2006 to 85 natural and 85 hatchery adults collected throughout the duration of the run to meet the new smolt production/release goal of 225,000. 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 31 May. The trap was operated through September. A total of 139 fish entered the trap (57 natural adults, 4 natural jacks, 70 hatchery adults, and 8 hatchery jacks), and 36 natural (35 adults, 1 jack) and 53 hatchery (52 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 and killed. None of the natural fish kept for broodstock in 2006 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 1986-2006.

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
2006 [e]	61	78	0	3	36	53	25	22

[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 AD/LV fish were killed at the trap.
[d] Three AD clipped stray fish were killed at the trap.
[e] One AD/NO WIRE and one AD/LV/CWT stray fish were killed at the trap. The remaining trap mortality was a Tucannon hatchery-origin fish that died due to trapping.

Broodstock Mortality

One of the 89 salmon collected for broodstock died prior to spawning in 2006 (Table 3). Table 3 shows that prespawning mortality in 2006 was low and 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 (1992-2006).

	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
2006	0	0	0	0.0	1	0	0	1.9

Broodstock Spawning

Spawning at LFH occurred once a week from 29 August to 26 September, with peak eggtake occurring on 12 September. A total of 123,629 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 5.4% with an additional 3.9% (4,594) loss of sac-fry, which left 112,350 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 2006. Scales from unmarked fish were read prior to spawning to check for hatchery growth patterns. The broodstock were negative for IHNV (Infectious Hematopoietic Necrosis Virus), but problems with the freezer at the hatchery prevented carcasses from being stored for return 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 2006.

	Natural			Hatchery		
Spawn Date	Male[a]	Female	Eggs Taken	Male[a]	Female	Eggs Taken
8/29					3	8,860
9/05		4	11,596		5	14,358
9/12		9	27,435		12	29,683
9/19		5	12,934		6	16,263
9/26	11			21	1	2,500
10/3	7			4		
Totals	**18**	**18**	**51,965**	**25**	**27**	**71,664**
Egg Mortality			1,787			4,898

[a] Does not include live spawned fish.

Eggs were also collected as part of the Tucannon River Captive Broodstock Program. A total of 86 captive brood females were spawned from 5 September to 3 October, 2006. From the total 162,736 captive brood eggs collected, mortality to eye-up was 38.9%, leaving 99,420 live eggs. An additional 19,988 dead eggs/fry (20.1%) were picked at ponding leaving 79,432 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 and Ross 2007).

Natural Spawning

Spawning ground surveys were conducted on the Tucannon River weekly from 8 September to 25 September, 2006. One hundred-one redds were counted and 41 natural and 12 hatchery origin carcasses were recovered (Table 5). Sixty-two redds (61.4% of total) and 25 carcasses (47.2% of total) were found above the adult trap.

Eight additional redds were found below the Marengo reach (river kilometer 28) [rkms 23.0, 20.5, 18.5 (2 redds), 17.8, 17.7, 12.7, and 3.1]. Only one carcass was recovered (rkm 20.5) and it was a stray hatchery female summer run Chinook salmon from the South Fork Salmon River (McCall Hatchery). Since the origins of the fish that made the remaining redds are unknown, and the fact that they weren't made within historical spring Chinook spawning ground areas, we have assumed that they were also made by stray returns that dipped into the lower Tucannon River. These redds are excluded from further analysis in this report.

Due to the Columbia Complex Forest Fire we could not access the river to snorkel redds in 2006 to look for the presence of precocious juveniles spawning with adults. However, one natural-origin precocious male carcass (135 mm) was recovered at rkm 57.3. Snorkeling for precocious salmon is planned for 2007.

Table 5. Numbers and general locations of salmon redds and carcasses recovered on the Tucannon River spawning grounds, 2006 (the Tucannon Hatchery adult trap is located at rkm 59).

			Carcasses Recovered	
Stratum	**Rkm[a]**	**Number of redds**	**Natural**	**Hatchery**
Wilderness	78-84			
	75-78	2		
HMA	73-75	5		
	68-73	9	1	
	66-68	10	4	2
	62-66	23	10	2
	59-62	13	3	3
--------------------------Tucannon Fish Hatchery Trap--------------------------				
	56-59	18	12	2
Hartsock	52-56	13	10	3
	47-52	2		
	43-47	3		
	40-43	2		
Marengo	34-40	1	1	
	28-34			
Totals	**28-84**	**101**	**41**	**12**

[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).

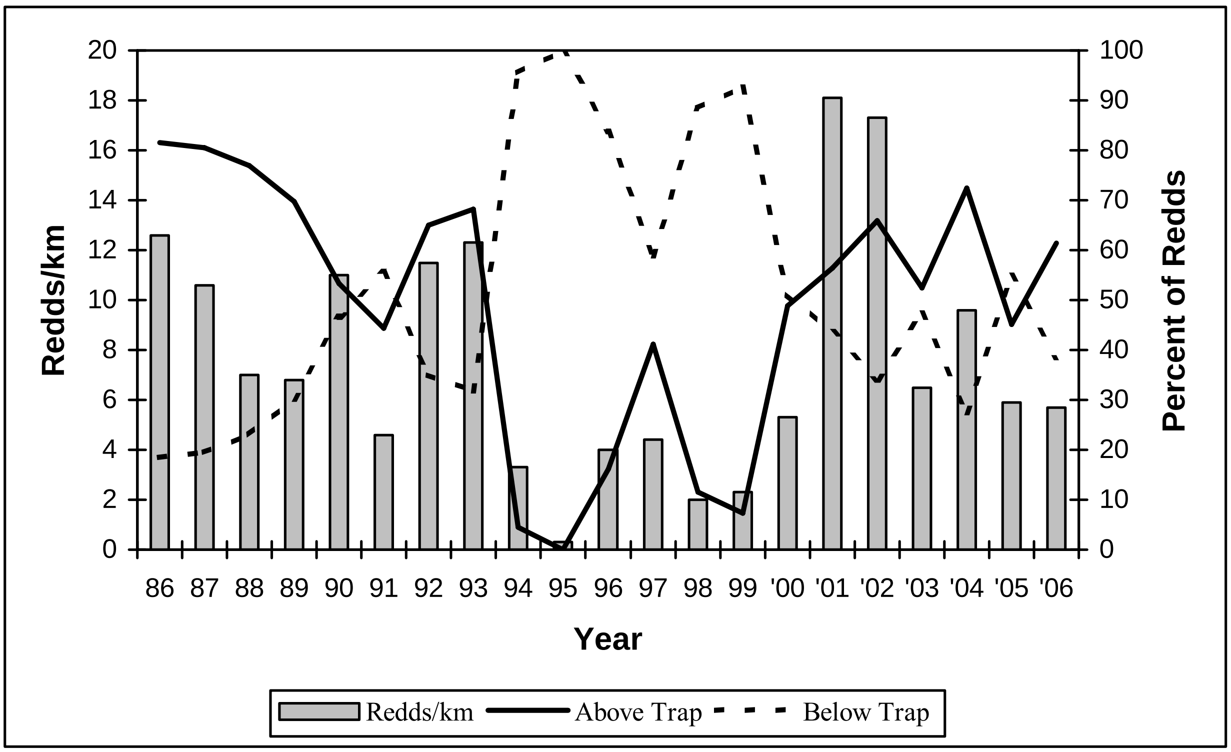

Figure 3. Number of redds/km and percentage of redds above and below the adult trap on the Tucannon River, 1986-2006.

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, 1985-2006.**

	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
2006	2 (0.2)	78 (4.1)	20 (1.3)	1 (0.1)	101	62	61.4	39	38.6

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

Genetic Sampling

During 2006 we collected 140 DNA samples (operculum punches) from adult salmon (73 natural origin and 67 hatchery origin) and 89 samples from captive broodstock spawners. These samples were sent to the WDFW genetics lab in Olympia, Washington for analysis.

A total of 343 Tucannon River spring Chinook samples collected in 2005 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 provides evidence that the captive broodstock program has been an effective method of preserving overall genetic variation in Tucannon River spring Chinook while providing additional smolts for release (Kassler and Hawkins 2007). Genotypes, allele frequencies, and tissue samples are stored at WDFW's Genetics Laboratory in Olympia.

Age Composition, Length Comparisons, and Fecundity

One metric evaluated by the monitoring program is 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).

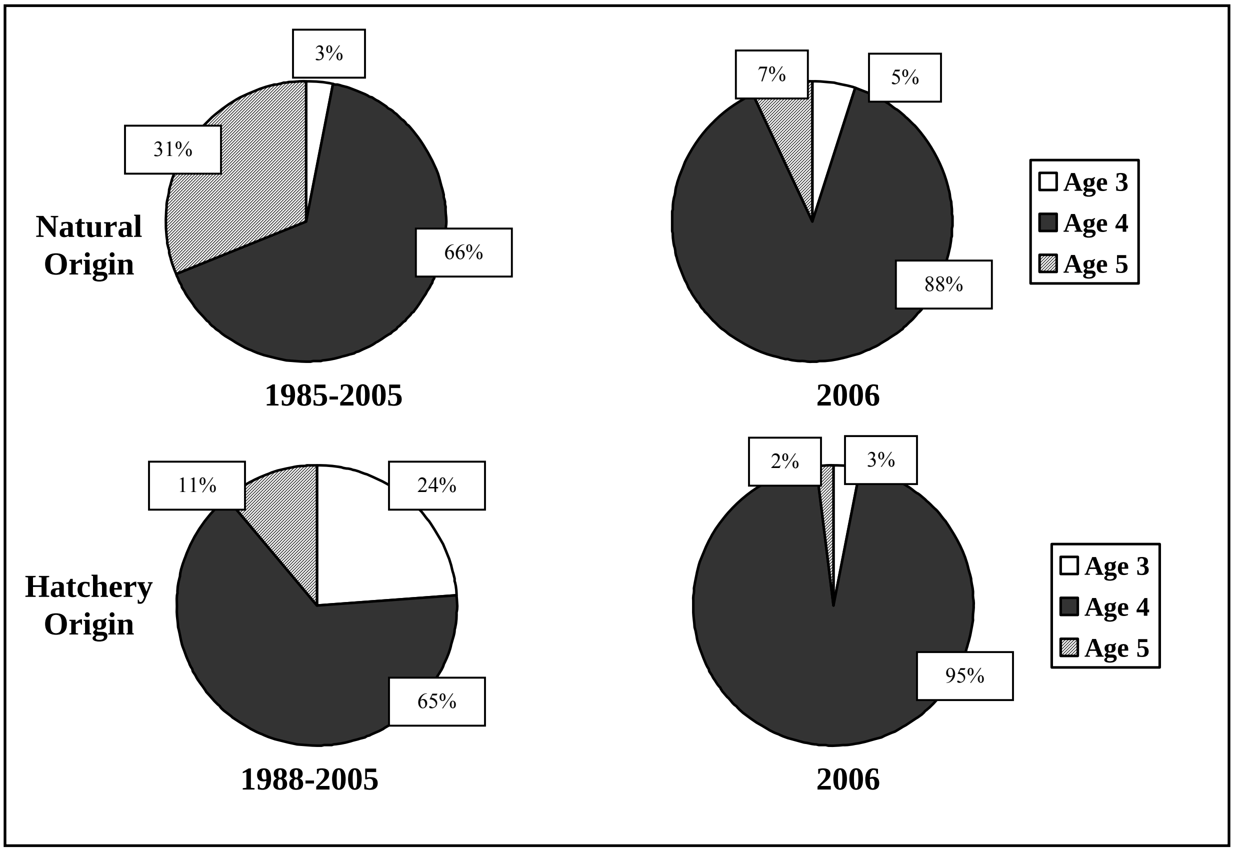

Figure 4. Historical (1985-2005), and 2006 age composition for spring Chinook in the Tucannon River.

Low proportions of Age 3 and Age 5 fish were observed during the 2006 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 metric we monitor on returning adult natural and hatchery origin fish is size at age, measured as the difference between mean post-eye to hypural-plate lengths. Bumgarner et al. (1994) reported in the past that returning 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).

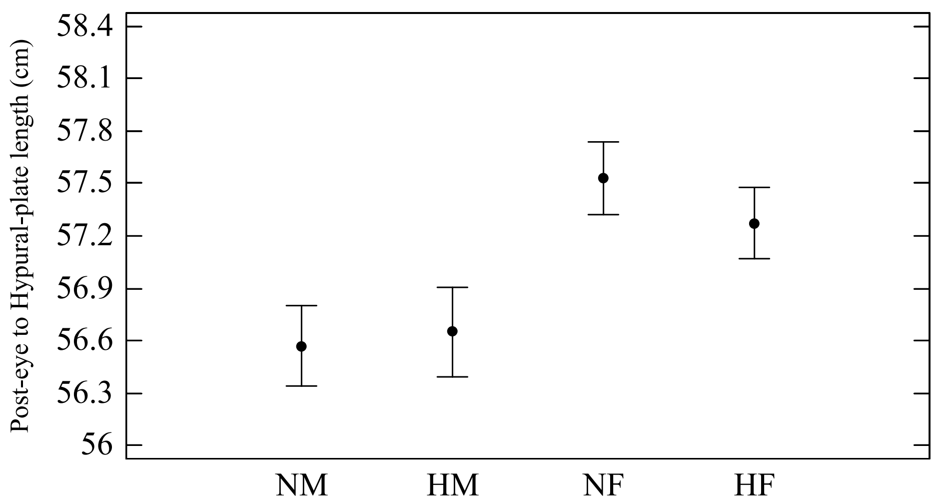

Figure 5. Mean post-eye to hypural-plate length comparisons between Age 4 natural and hatchery-origin males (NM and HM) and natural and hatchery-origin females (NF and HF) with 95% confidence intervals for the years 1985-2006.

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 $P < 0.05$. 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 0.236 g/egg. This difference was significant ($P<0.05$). 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 ($P= 0.06$), 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, 1990-2006.**

	Age 4				Age 5			
Year	Natural		Hatchery		Natural		Hatchery	
1990	3,691	(13, 577.3)	2,794	(18, 708.0)	4,383	(8, 772.4)	No Fish	
1991	2,803	(5, 363.3)	2,463	(9, 600.8)	4,252	(11, 776.0)	3,052	(1, 000.0)
1992	3,691	(16, 588.3)	3,126	(25, 645.1)	4,734	(2, 992.8)	3,456	(1, 000.0)
1993	3,180	(4, 457.9)	3,456	(5, 615.4)	4,470	(1, 000.0)	4,129	(1, 000.0)
1994	3,688	(13, 733.9)	3,280	(11, 630.3)	4,906	(9, 902.0)	3,352	(10, 705.9)
1995	No Fish		3,584	(14, 766.4)	5,284	(6, 136.1)	3,889	(1, 000.0)
1996	3,509	(17, 534.3)	2,833	(18, 502.3)	3,617	(1, 000.0)	No Fish	
1997	3,487	(15, 443.1)	3,290	(24, 923.3)	4,326	(3, 290.9)	No Fish	
1998	4,204	(1, 000.0)	2,779	(7, 375.4)	4,017	(28, 680.5)	3,333	(6, 585.2)
1999	No Fish		3,121	(34, 445.4)	No Fish		3,850	(1, 000.0)
2000	4,144	(2, 1,111.0)	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	
2006	2,857	(17, 559.1)	2,590	(26, 589.8)	3,397	(1, 000.0)	4,319	(1, 000.0)
Mean	**3,473**		**3,083**		**4,405**		**3,664**	
SD	**639.9**		**672.9**		**864.0**		**769.0**	

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 2006, based on the estimated escapement of fish to the river, we sampled approximately 58% of the run (Table 9).

Table 8. Coded-wire tag codes of hatchery salmon sampled at LFH and the Tucannon River, 2006.

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)[a]						1	1
63-06-81			1				1
63-17-91	1		50	1		8	60
63-24-82			1				1
63-27-78						1	1
-Strays-							
09-38-59[b]				1[d]			1
10-97-71[c]						1	1
AD/No wire				1[d]		2	3
Total	1	0	52	3	0	13	69

[a] Captive brood progeny.
[b] Umatilla River origin spring Chinook.
[c] South Fork Salmon River summer run Chinook from McCall Hatchery.
[d] Killed outright at the trap.

Table 9. Spring Chinook salmon (natural and hatchery) sampled from the Tucannon River, 2006.

	2006: Natural	2006: Hatchery	2006: Total
Total escapement to river	140	113	253
Broodstock collected	36	53	89
Fish dead in adult trap	0	3	3
Total hatchery sample	36	56	92
Total fish left in river	104	57	161
In-river pre-spawn mortality	0	0	0
Spawned carcasses recovered	41	13	54
Total river sample	41	13	54
Carcasses sampled	77	69	146

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 2006 was a little later than the historical mean (Table 10). This was due to the unusually late run in 2006 that was the same for both hatchery and natural-origin fish. Peak spawning date of hatchery fish was within the range found from previous years. The peak of active spawning in the Tucannon River was similar 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, 1986-2006.

	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
2005	6/01	5/31	9/06	9/06	28	9/14	28
Mean	**5/30**	**6/03**	**9/11**	**9/09**	**28**	**9/14**	**35**
2006	6/12	6/09	9/12	9/12	28	9/8	---[b]

[a] Too few natural salmon were trapped in 1995 and 1999 to determine peak arrival.
[b] Access restrictions during the Columbia Complex Forest Fire prohibited spawning ground surveys during the beginning of spawning.

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 2006, 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 2006 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 2006 was estimated to be 253 fish (133 natural adults, 7 natural jacks and 109 hatchery-origin adults, 4 hatchery jacks). Historical estimates since 1985 are provided in Appendix B.

Table 11. Estimated spring Chinook salmon run to the Tucannon River, 1985-2006.

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
2006	101	1.60	161	89	0	253	55

[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 C). However, in 1999 and 2000, Umatilla River hatchery 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 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 reduce the effect of stray fish by allowing selective removal of strays from the hatchery broodstock. However, strays will still have access to spawning areas below the hatchery trap.

Two known (CWT) hatchery strays were recovered during 2006. One was an AD/LV clipped Umatilla River spring Chinook salmon (CWT 09/38/59) killed at the adult trap. The other stray was a South Fork Salmon River summer run Chinook salmon (CWT 10/97/71) from McCall Hatchery found spawning in the lower Tucannon River. We also recovered three Age 4 AD only clipped fish (one at the adult trap and two 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, strays accounted for an estimated 3.2% of the total run (Appendix C).

Adult PIT Tag Returns

Final detections of adult spring Chinook that had been PIT tagged as juveniles from the Tucannon River have been summarized in Table 12. It is interesting to note that over half (53%) overshot the Tucannon River and were detected at Lower Granite Dam. This "overshooting" does not appear to be related to origin as both hatchery and wild-origin fish overshot at approximately the same rate. This may have management implications regarding potential impacts of salmon fisheries conducted above Little Goose Dam.

Table 12 Returning adult spring Chinook final PIT tag detections from fish originally tagged as juveniles from the Tucannon River.

	Release Data			Adult Return Final Detection Data			
PIT Tag ID	Origin	Length (mm)	Release Date	OBS	OBS Date	Travel Time	Est. Age
5042423B61	H	139	3/25/97	LGR	5/29/99	795.1	4
50470F3608	H	142	3/25/97	LGR	6/17/99	813.7	4
517D1E0552	W	112	4/22/99	BON	4/17/01	726.2	4
5202622F42	W	110	4/22/99	BON	4/19/01	728.1	4
517D1A197C	W	118	4/22/99	LGR	4/21/01	730.0	4
5176172874	W	108	4/29/99	LGR	4/29/01	730.8	4
5200712827	W	103	4/29/99	LGR	5/12/02	1109.2	5
5177201601	H	151	5/6/99	LGR	5/31/01	755.9	4
517D22216B	H	137	5/12/99	LGR	5/15/01	734.3	4
3D9.1BF1677795	W	117	4/29/02	LGR	5/06/04	750.7	4
3D9.1BF16876C6	W	105	4/30/02	1CH	4/25/05	1100.4	5
3D9.1BF167698F	W	96	5/02/02	ICH	4/24/05	1097.1	5
3D9.1BF12F6891	H	136	4/21/03	ICH	5/09/04	392.0	3
3D9.1BF12F7182	H	115	4/21/03	ICH	5/19/04	396.1	3
3D9.1BF149E5EA	H	126	4/21/03	MCN	5/05/05	751.2	4

Abbreviations are as follows: BON – Bonneville Dam, MCN – McNary Dam, ICH – Ice Harbor Dam, LGR – Lower Granite Dam.

Hatchery Rearing, Marking, and Release

Hatchery Rearing and Marking

Conventional supplementation juveniles (2005 BY) were marked with a red elastomer tag (VIE) behind the right eye and tagged with CWTs from 16-22 September, 2006 (149,870 fish). Supplementation fish were transported to TFH during 2-3 October. The 2005 BY captive brood juveniles (90,260 fish) were marked 14-18 September with a CWT in the snout and transported to TFH on 28-29 September.

Length and weight samples were collected twice on the 2005 BY fish during the rearing cycle (Table 13). During February, fish were sampled for length, weight, precocity and mark quality, and were PIT tagged for outmigration comparisons (1,002 supplementation fish and 1,000 captive brood progeny) before transfer to Curl Lake AP.

Table 13. Sample sizes (N), mean lengths (mm), coefficients of variation (CV), condition factors (K), fish/lb (fpp), and precocity of 2005 BY juveniles sampled at TFH and Curl Lake.

Brood/ Date	Progeny Type	Sample Location	N	Mean Length	CV	K	FPP	% Precocity
2005								
2/05/07	Supplementation	TFH	250	135.0	10.9	1.27	14.0	0.0
4/05/07	Supplementation	Curl Lake	250	162.0	13.5	1.26	8.0	0.1
2/05/07	Captive Brood	TFH	250	136.1	12.9	1.23	14.0	0.0
4/05/07	Captive Brood	Curl Lake	250	166.3	14.3	1.25	7.4	0.0

2005 Brood Release

The 2005 BY pre-smolts were transported to Curl Lake in February 2007 for acclimation and volitional release. Volitional release began 2 April and continued until 23 April when the remaining fish were forced out. Mortalities were low in Curl Lake and WDFW released an estimated 149,466 supplementation fish (8.0 fish/lb) and 90,056 captive broodstock progeny (7.4 fish/lb) (Table 14). Historical hatchery releases are summarized in Appendix D.

Table 14. Yearling spring Chinook releases in the Tucannon River, 2005 brood year.

Release Year	(BY)	Release Location	Release Date	CWT Code	Total Released	Number CWT	Additional Mark	lbs	Fish/ lb
2007	(05)	Curl Lake	4/02-4/23	63/35/99	149,466	144,833	Rt. Red VIE	18,683	8.0
2007	(05CB)	Curl Lake	4/02-4/23	63/34/77	90,056	88,885	None	12,170	7.4

Natural Parr Production

Evaluation staff surveyed the Tucannon River at index sites in 2006 to estimate the density and population of subyearling (Table 15, Appendix E) 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 2006 (27 July–8 August), representing approximately 4.8% of the suitable rearing habitat in the Tucannon River. A total of 1,012 subyearling and 49 yearling spring Chinook were counted during the surveys. We estimated that 21,162 (± 4,365) BY 05 subyearling and 1,012 (± 433) BY 04 yearling (residual) spring Chinook were present in the river (Table 15).

Table 15. Number of sites, area snorkeled, mean density (fish/100 m^2), population estimates, and 95% confidence intervals for subyearling and yearling spring Chinook within the Tucannon River, 2006.

			Subyearling			Yearling		
Stratum	Number of sites	Area (m^2) Snorkeled	Mean Density	Pop. Estimate	C.I.	Mean Density	Pop. Estimate	C.I.
Marengo	6	3,413	1.77	1,170	872	0.07	45	56
Hartsock	14	7,782	3.59	6,218	2,048	0.21	368	214
HMA	20	11,676	5.30	12,701	4,019	0.21	496	340
Wilderness	10	3,753	1.48	1,075	738	0.14	103	152
Total	**50**	**26,624**	**3.63**	**21,162**	**4,365**	**0.18**	**1,012**	**433**

Natural Smolt Production

Evaluation staff operated a 1.5 m rotary screw trap at rkm 3 on the Tucannon River from 10 October, 2005 to 30 June, 2006 to estimate numbers of migrating natural and hatchery spring Chinook. Numbers of other selected species captured during the 2006 outmigration can be found in Appendix F. Data such as peak outmigration, efficiency estimates, etc., have not been reported here for simplicity. Those data are available upon request.

Natural spring Chinook emigrating from the Tucannon River (BY 2004) averaged 110 mm (Figure 6). This is in comparison to an average length of 139 mm for hatchery-origin fish (BY 2004) released from Curl Lake Acclimation Pond (Gallinat and Ross 2006).

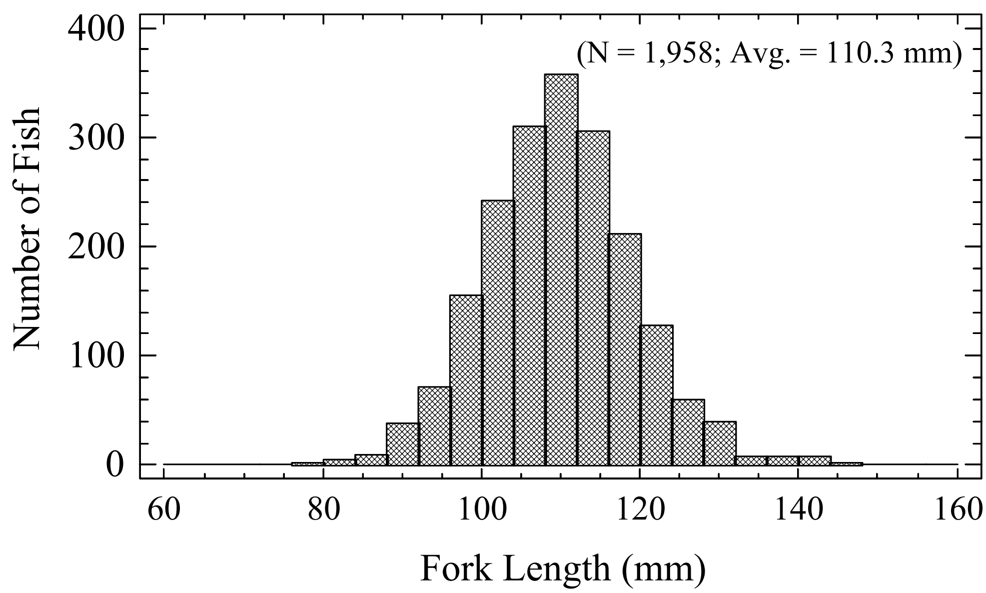

Figure 6. Length frequency distribution of sampled natural spring Chinook salmon captured in the Tucannon River smolt trap, 2005/2006 season.

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 approximately 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 mean 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.

We used a new estimation protocol for our smolt trap estimates in 2006. Based on work by Steinhorst et al. (2004) we used the Bailey-modified Lincoln-Peterson estimation with 95% bootstrap confidence intervals by running the Gauss Run-Time computer program for computing outmigration estimates (version 7.0). Bootstrap iterations numbered 1,000. The program allows for the division of the out-migration trapping season into similar strata. Strata with less than seven recaptures were grouped with either the proceeding strata or the following strata depending upon similarity in trapping/flow conditions.

Historically we used a standard Lincoln/Petersen estimation. The Bailey modified formula corrects for bias, but the reader is cautioned about using the estimates as completely comparable. We are reviewing our data from previous years, and may re-calculate our historical estimates with the modified formula. In that case, a fully modified data set will be presented.

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. Some of 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).
- Marked fish are caught at the same rate as unmarked fish.

We estimate that 21,057 migrant natural-origin spring Chinook (68% of the 2004 BY parr estimates) passed the smolt trap during 2005-2006 (Table 16). We also estimated that 46% of the conventional hatchery supplementation fish and 56% of the captive brood progeny released from Curl Lake AP (2004 BY) passed the smolt trap.

Table 16 Total population estimates (with 95% confidence interval) for natural and hatchery origin (supplementation and captive brood) emigrants from the Tucannon River, 2006.

	Natural	Supplementation	Captive Brood
Total Emigrants	21,057	31,196	74,575
95% C.I.	17,779-25,627	27,898-35,397	65,934-84,763
S.E.	2,095	1,913	4,630
% Survival[a]	68.3	46.2	56.4

[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 2006, 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 1,001 conventional supplementation and 1,002 captive brood hatchery-origin fish during early February before transferring them to Curl Lake AP for acclimation and volitional release (Table 17). No fish were killed during PIT tagging, though it is likely some minor delayed mortality occurred after transfer. Detection rates were low, but similar to rates from previous releases at Curl Lake AP (Bumgarner et al. 1997).

Table 17. 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 2006 (Fish were volitionally released from 4/03/06-4/26/06).

	Release Data				Recapture Data									
Hatchery		Mean		Mean	LMJ		MCJ		JDJ		BONN		Total[a]	
Origin	N	Length	SD	Length	N	TD	N	TD	N	TD	N	TD	N	%
Supplementation	1,001	128.0	13.1	128.3	136	13.6	97	16.1	40	21.2	18	22.5	327	32.7
Captive Brood	1,002	125.3	14.6	127.0	127	12.4	87	16.7	30	22.7	14	18.6	279	27.8

[a]Total includes detections at Ice Harbor Dam.
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 (SURPH) computer model. The data files were created using the PitPro version 4.8 computer program to translate raw PIT Tag Information System (PTAGIS) data of the Pacific States Marine Fisheries Commission (PSMFC) into usable capture histories for the SURPH program. Estimated survival probabilities from Curl Lake to Lower Monumental Dam were 0.84 (± 0.08) and 0.83 (± 0.08) 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 18 and 19) 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 20) 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 21 and 22). Mean hatchery SARs (0.15%) documented from the 1985-2001 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 18. Estimates of *natural* Tucannon spring Chinook salmon abundance by life stage for 1985-2006 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	20,049	446
2001	219	79	3,612	3,252	1,047,936	63,412	38,079	244
2002	104	195	3,981	3,368	1,070,784	72,197	60,530	127
2003	67	51	3,789	3,812	448,275	40,900	23,003	7
2004	117	43	3,444	2,601	514,791	30,809	21,057	
2005	77	25	3,773	2,903	363,096	21,162		
2006	65	36	2,887	2,654	283,199			

[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 19. Estimates of Tucannon spring Chinook salmon abundance (*spawned and reared in the hatchery*) by life stage for 1985-2006 broods.

Brood Year	Females Spawned		Mean[a] Fecundity		Number of Eggs	Number of Parr	Number of Smolts	Progeny[b] (returning adults)
	Natural	Hatchery	Natural	Hatchery				
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	129
2002	22	25	3,981	3,368	169,364	151,531	123,586	114
2003	17	20	3,789	3,812	140,658	126,400	71,154	2
2004	28	18	3,444	2,601	140,459	128,877	67,542	
2005	25	24	3,773	2,903	161,345	151,466	149,466	
2006	18	27	2,887	2,654	123,629	112,350		

[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 20. 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	68.3	4.1	91.8	52.4	48.1	15.3	0.8	11.8
2005	5.8			93.9	98.7	92.6	16.1		
2006				90.9					
Mean	10.1	54.4	5.8	83.5	87.0	72.0	11.1	1.5	12.1
SD	4.7	15.4	2.5	16.2	14.3	17.1	11.2	0.4	4.7

Table 21 Adult returns and SARs of natural salmon to the Tucannon River for brood years 1985-2001.

		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	8.00
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
2001	38,079	0	0	73	235	5	9	0.64	0.64
Mean								1.56[c]	1.53[c]
Geometric Mean								0.75[c]	0.73[c]

[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 22. Adult returns and SARs of hatchery salmon to the Tucannon River for brood years 1985-2001.

		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
2001	146,922	7	19	53	109	1	1	0.09	0.07
Mean								0.23	0.19
Geometric Mean								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 20). With the exception of the 1988 and 1997-2000 brood years, naturally produced fish have been below the replacement level (Figure 7; Table 23). Based on adult returns from the 1985-2002 broods, naturally reared salmon produced only 0.6 adults for every spawner, while hatchery reared fish produced 1.7 adults.

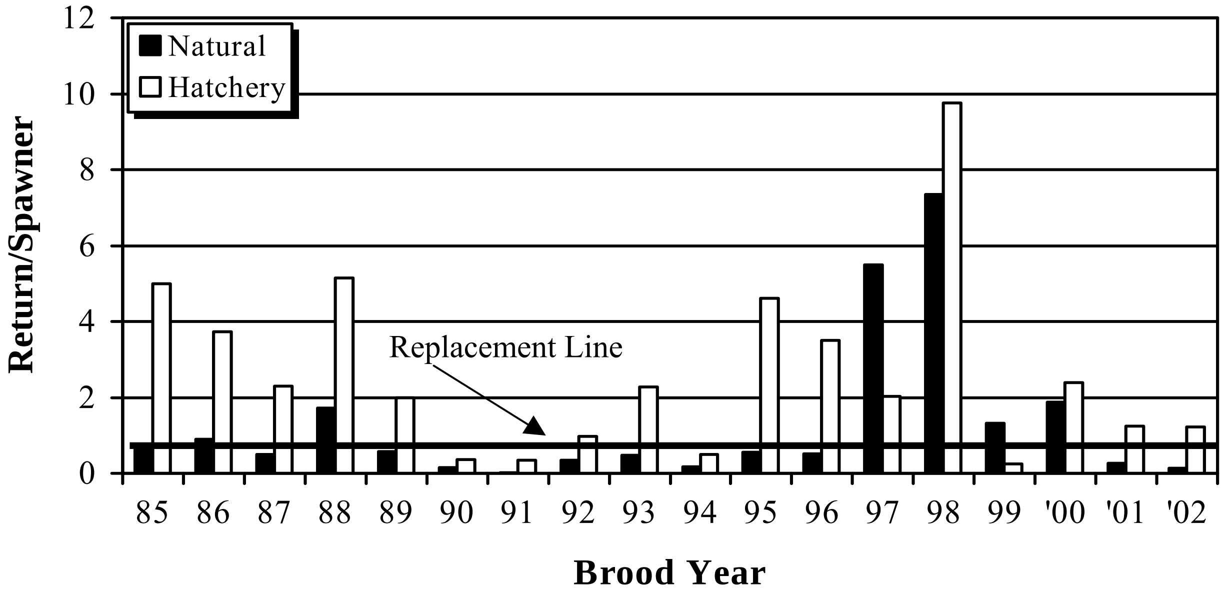

Figure 7. Return per spawner (with replacement line) for the 1985-2002 brood years (2002 incomplete brood year).

Table 23. Parent-to-progeny survival estimates of Tucannon River spring Chinook salmon from 1985 through 2002 brood years (2002 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	7.3
1986	520	468	0.90	91	339	3.73	4.1
1987	481	238	0.49	83	190	2.29	4.6
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	2.3
1991	390	7	0.02	72	25	0.35	19.3
1992	564	194	0.34	83	81	0.98	2.8
1993	436	204	0.47	91	207	2.27	4.9
1994	70	12	0.17	69	34	0.49	2.9
1995	11	6	0.55	39	180	4.62	8.5
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	244	0.27	104	129	1.24	4.5
2002	897	127	0.14	93	114	1.23	8.7
Mean			**1.28**			**2.65**	**4.8**
Geometric Mean			**0.56**			**1.72**	**3.1**

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 increased smolt production, we plan to conduct an experiment to examine size at release as a possible means to improve SAR of hatchery fish. These changes in the hatchery production program will likely result in a Proportionate Natural Influence (PNI) of less than 0.5. That level is generally not acceptable for supplementation programs and the Tucannon Spring Chinook Program has generally been above 0.5 (Appendix G). Decisions will need to be made by fish management whether the hatchery supplementation program is worth the potential adverse genetic risk to the population.

Survival Comparisons to Other Populations

We used the survival estimates calculated in the preceding section to compare Tucannon spring Chinook to spring Chinook populations in the Snake River Subbasin as well as other subbasins (Appendix H). This process may help identify the life stage or possible limiting factors where survival could be improved to increase adult returns back to the Tucannon River.

Natural-origin egg-to-parr survival rates were quite similar among the various watersheds (Appendix H, Table 1). Values ranged from the single digits to the mid-20s (30s in one case, but for a small sample size). At first glance, egg-to-parr survival does not appear to be the limiting factor for Tucannon spring Chinook when compared to other stocks. However, most of these stocks are also depressed and decreases in productivity may be occurring due to habitat degradation, a reduction in marine derived nutrients, or other factors. The range of egg-to-parr survival of spring Chinook from the John Day River is higher than the Tucannon's, which may be due to larger returns in that river. Even small increases in survival at this life stage would provide a significant boost to overall numbers.

Mean parr-to-smolt survival for natural-origin fish was variable and ranged from the low teens to the mid-50s (Appendix H, Table 2). Survival for Tucannon River spring Chinook averaged higher for this life stage than documented for the majority of the other systems. Achord et al. (2007) estimated parr-to-smolt survival to Lower Granite Dam from the Salmon River Basin to range from 3-48% for individual populations and from 8-25% for all streams combined.

Egg-to-smolt survival of natural-origin fish ranged from the low single digits to the low teens (Appendix H, Table 3). Again, values calculated for Tucannon spring Chinook were quite similar when compared to other populations. The egg-to-smolt survival in the Tucannon River does not appear to be unduly limiting when compared to other populations within the Snake River Subbasin and populations from other subbasins. However, most of these populations are either depressed or currently listed. Information from coastal or non-listed populations would greatly enhance this analysis.

Smolt-to-adult survivals of natural-origin Tucannon River spring Chinook were slightly higher than the other populations in the Snake River Watershed (Appendix H, Table 4). This may result from the Tucannon population negotiating fewer dams. Populations from outside the Snake River Subbasin had higher overall survival. This may be due to their closer proximity to the ocean, because they have even fewer dams to negotiate than the Tucannon population, or they may be intrinsically more productive (ecologically or genetically). Notably, none of the Snake River Subbasin natural-origin populations meet the LSRCP goal of 0.87% when the overall means are examined.

We also examined smolt-to-adult survivals of hatchery-origin spring Chinook (Appendix H, Table 5). Smolt-to-adult survivals of Tucannon River spring Chinook were slightly lower than other populations from the Snake River Subbasin. This may be due in part to our long history of data collection compared to other populations within the subbasin, as our values are comparable to the Chiwawa River (outside the subbasin), which also has a long dataset.

Based on our comparisons it appears that there are a number of factors at each life stage that are contributing to low numbers of adult returns. Larger populations may be able to absorb this overall mortality more readily than small populations. Smaller populations than the Tucannon, such as Asotin Creek spring Chinook have already become functionally extinct. We are taking steps (i.e., increasing release goal to 225,000 yearling smolts) to ameliorate the effects of this overall mortality and will be examining size at release in our attempt to increase survival of hatchery fish. Of all the life stages, smolt-to-adult survival of hatchery-origin fish may be the most easily modified by changing hatchery-rearing practices.

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 and natural adult returns have always been below the mitigation goal (Figure 8). Based on 1985-2001 brood year CWT recoveries from the RMIS database (Appendix I), sport and commercial harvest combined accounted for an average of less than 3% of the adult hatchery fish recovered for the 1985-1996 brood years, but increased fishery impacts occurred for the 1997 through 1999 broods (fishery harvest comprised an average of 23% for recoveries). The subsequent cessation of adipose clipping of hatchery production (Gallinat et al. 2001), and additional fishery restrictions, resulted in a less than 2% fishery impact on the 2000 and 2001 broods (this excludes CWT 63-14-29 from the 2001 BY where the lone recovery was from a commercial gillnet). Conventional 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 I), with an average of 2.8% of the adult hatchery fish straying to other river systems/hatcheries for brood years 1985-2001 (range 0-20%).

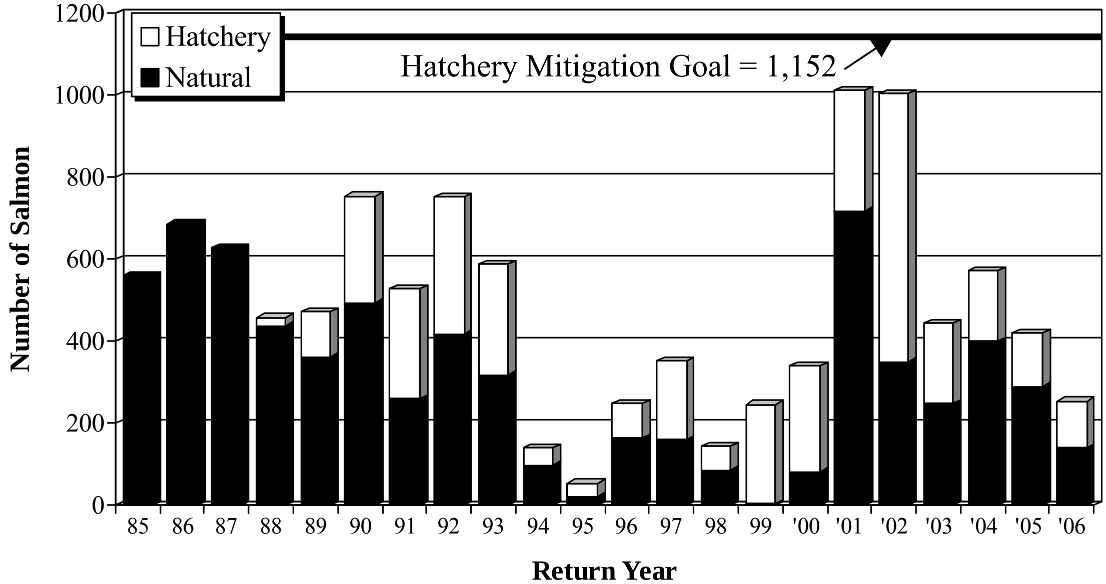

Figure 8. Total escapement for Tucannon River spring Chinook salmon for the 1985-2006 run years.

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 (spawner: recruit) 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 near future for the hatchery program and the natural run to be persistent over the short-term or to 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 changed to improve 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.

   Recommendation: Continue to collect as many carcasses as possible for the most accurate age composition data. Continue to assist hatchery staff with picking eyed eggs to obtain fecundity estimates for each spawned female. Collect other biological data (length, run timing, spawn timing, DNA samples, 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. Examine the relationship between redd counts and the following-year's 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 and productivity of the Tucannon River so that hatchery stocking is appropriate, and hatchery and natural performance is measured against basin capacity. Determine impacts to other species of concern (e.g., steelhead, bull trout).

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 was increased from 132,000 to 225,000 to help offset 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. Continue to 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

Achord, S., R.W. Zabel, and B. P. Sandford. 2007. Migration timing, growth, and estimated parr-to-smolt survival rates of wild Snake River spring-summer Chinook salmon from the Salmon River Basin, Idaho, to the Lower Snake River. Transactions of the American Fisheries Society 136: 142-154.

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. 2007. Tucannon River Spring Chinook Salmon Captive Broodstock Program-FY2006 Annual Report. Washington Department of Fish and Wildlife, Olympia, Washington. Report to BPA. Project #2000-019-00.

Gallinat, M. P. and L. A. Ross. 2006. Tucannon River Spring Chinook Salmon Hatchery Evaluation Program 2005 Annual Report to U.S. Fish and Wildlife Service, Cooperative Agreement 1411-05-J056. Washington Department of Fish and Wildlife, Olympia, Washington. Report # FPA06-09.

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. 2007. Genetic assessment of spring Chinook in the Tucannon River (2005) using a microsatellite DNA analysis. Washington Dept. of Fish and Wildlife. Olympia, Washington. 30 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.

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.

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

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.

Steinhorst, K., Y. Wu, B. Dennis, and P. Kline. 2004. Confidence intervals for fish outmigration estimates using stratified trap efficiency methods. Journal of Agricultural, Biological, and Environmental Statistics 9: 284-299.

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.

Washington Department of Fish and Wildlife, Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation. 1999. Master plan for Tucannon River spring Chinook captive broodstock program. 34 pp.

Appendix A: Spring Chinook Captured, Collected, or Passed Upstream at the Tucannon Hatchery Trap in 2006

Appendix A. Spring Chinook salmon captured, collected, or passed upstream at the Tucannon Hatchery trap in 2006. (Trapping began in February; last day of trapping was September 30).

	Captured in Trap		Collected for Broodstock		Passed Upstream		Killed Outright		Trap Mortality	
Date	**Natural**	**Hatchery**	**Natural**	**Hatchery**	**Natural**	**Hatchery**	**Natural**	**Hatchery**	**Natural**	**Hatchery**
5/31		3		2		1				
6/1	2	1		1	2					
6/2	3	1	3	1						
6/5	3	2		2	3					
6/6	2	3		1	2	1		1		
6/7	2	5	1	3	1	2				
6/8	2	3	1	2	1	1				
6/9	3	7	2	4	1	3				
6/12	5	6		3	5	2				1
6/13	2	3	2	2		1				
6/14	2	4		3	2	1				
6/15	1				1					
6/16	2	2	2	1		1				
6/19	1	6	1	4		2				
6/20	1	1	1	1						
6/21	2	2	1	1	1	1				
6/22	2	2	1	2	1					
6/23	1	2	1	1		1				
6/24	1	2			1	2				
6/26	3	4	1	3	2	1				
6/27	1	1		1	1					
6/28	1	3	1	3						
6/29		5		4		1				
6/30	1	1	1	1						
7/3	4	3	4	2		1				
7/10	1		1							
7/18	1		1							
7/24	1		1							
7/26	1		1							
8/9		1		1						
8/10		1						1		
8/29		1		1						
9/1	1		1							
9/5	3		3							
9/6		2		2						
9/7	3		2		1					
9/8	2	1	2	1						
9/13	1		1							
Totals	**61**	**78**	**36**	**53**	**25**	**22**	**0**	**2**	**0**	**1**

Appendix B: Total Estimated Run-Size of Tucannon River Spring Chinook Salmon (1985-2006)

Appendix B Total estimated run-size of spring Chinook salmon to the Tucannon River, 1985-2006. (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 Suppl.	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
2006	7	133	140	4[c]	109[c]	113	109	4	253

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

Appendix C: Stray Hatchery-Origin Spring Chinook Salmon in the Tucannon River (1990-2006)

Appendix C Summary of identified stray hatchery origin spring Chinook salmon that escaped into the Tucannon River (1990-2006).

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 C (continued). Summary of identified stray hatchery origin spring Chinook salmon that escaped into the Tucannon River (1990-2006).

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]**
2006	109771	IDFG	Sum. Ch. - S Fk Sal.	McCall Hatch./S. Fk. Salmon R.	1/1	
	093859	ODFW	Umatilla R.	Umatilla Hatch./Umatilla River	1/1	
	Ad clip	Unknown	Unknown[d]	Unknown	3/6	
				Total Strays	8	**3.2**
				Total Umatilla River[d]	7	**2.8**

[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.

[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.

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

Appendix D: Historical Hatchery Releases (1985-2005 Brood Years)

Appendix D Historical hatchery spring Chinook releases from the Tucannon River, 1985-2005 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 D (continued). Historical hatchery spring Chinook releases from the Tucannon River, 1985-2005 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]**			
2007	2005	C-Acc	4/02-4/23	35/99	144,833	4,633[e]	Mixed	18,683	8.0
Total					**144,833**	**4,633[e]**			
2007	2005CB	C-Acc	4/02-4/23	34/77	88,885	1,171[f]	CB, Mixed	12,170	7.4
Total					**88,885**	**1,171[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 E: Numbers and Density Estimates (Fish/100 m^2) of Juvenile Salmon Counted by Snorkel Surveys in the Tucannon River in 2006

Appendix E Numbers and density estimates of subyearling and yearling natural spring Chinook salmon counted by snorkel surveys in the Tucannon River, 2006.

			Number of Salmon			Density (fish/100m²)	
			Natural			Natural	
Stratum	**Site[a]**	**Date**	**0+**	**> 1+**	**Snorkeled Area (m^2)**	**0+**	**> 1+**
Marengo	TUC01	7/31	2	0	624	0.32	0.00
↓	01A	7/31	11	1	512	2.15	0.20
	TUC02	7/31	4	0	477	0.84	0.00
	02A	7/31	7	0	649	1.08	0.00
	TUC03	7/31	9	0	685	1.31	0.00
	03A	7/31	23	1	466	4.94	0.21
Hartsock	TUC04	7/31	4	0	494	0.81	0.00
↓	04A	7/31	11	0	694	1.59	0.00
	TUCO5	7/31	20	3	534	3.75	0.56
	05A	7/31	11	1	490	2.24	0.20
	TUC06	7/31	11	1	559	1.97	0.18
	06A	7/31	2	0	611	0.33	0.00
	TUC07	7/31	22	0	599	3.67	0.00
	07A	7/31	49	0	685	7.15	0.00
	TUC08	7/31	30	3	435	6.90	0.69
	08A	7/31	9	0	515	1.75	0.00
	TUC09	7/31	37	2	599	6.18	0.33
	09A	7/31	18	2	530	3.40	0.38
	TUC10	7/31	21	2	440	4.77	0.45
	010A	7/31	34	1	597	5.70	0.17
HMA	TUC11	7/27	33	0	592	5.57	0.00
↓	011A	7/27	79	6	589	13.42	1.02
	TUC13	8/2	30	0	518	5.79	0.00
	13A	8/2	33	0	531	6.21	0.00
	TUC14	8/1	48	3	692	6.94	0.43
	14A	8/1	40	1	580	6.90	0.17
	TUC16	8/3	40	1	682	5.87	0.15
	16A	8/3	20	0	450	4.44	0.00
	TUC17	8/1	48	3	781	6.15	0.38
	17A	8/1	80	7	632	12.66	1.11
	TUC19	8/7	39	2	581	6.71	0.34
	19A	8/7	12	1	458	2.62	0.22
	TUC20	8/8	46	1	593	7.76	0.17
	20A	8/8	32	0	342	9.37	0.00

Appendix E (continued). Numbers and density estimates of subyearling and yearling natural spring Chinook salmon counted by snorkel surveys in the Tucannon River, 2006.

			Number of Salmon			Density (fish/100m^2)	
			Natural			Natural	
Stratum	**Site[a]**	**Date**	**0+**	**> 1+**	**Snorkeled Area (m^2)**	**0+**	**> 1+**
HMA	TUC21	8/1	18	0	662	2.72	0.00
(cont.)	21A	8/1	1	0	563	0.18	0.00
↓	TUC22	8/1	9	1	692	1.30	0.14
	22A	8/1	5	0	503	0.99	0.00
	TUC23	8/1	2	0	639	0.31	0.00
	23A	8/1	0	0	596	0.00	0.00
Wilderness	TUC24	8/1	9	0	472	1.91	0.00
↓	24A	8/1	24	0	464	5.17	0.00
	TUC25	8/1	6	0	350	1.71	0.00
	25A	8/1	11	0	397	2.77	0.00
	TUC26	8/1	5	0	290	1.72	0.00
	26A	8/1	0	1	272	0.00	0.37
	TUC27	8/1	7	5	476	1.47	1.05
	27A	8/1	0	0	562	0.00	0.00
	TUC28	8/1	0	0	263	0.00	0.00
	28A	8/1	0	0	207	0.00	0.00
Totals			**1,012**	**49**	**26,624**	**3.63**	**0.18**

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

Appendix F: Numbers of Other Selected Species Captured in the Tucannon River Smolt Trap During the 2006 Outmigration

Appendix F. Numbers of other selected species captured in the Tucannon River smolt trap during the 2006 outmigration.

Species	Number Captured
Fall Chinook	3,069
Coho salmon	406
Bull trout	6
Steelhead - smolts	1,743
Steelhead - parr	786
Pacific lamprey - ammocetes	1,076
Pacific lamprey - macropthalmia	446
Pacific lamprey - adults	2
Grass pickerel	4
Smallmouth bass	131
Bluegill	5
Pumpkinseed sunfish	3
Sand Roller	4
Chiselmouth	436
Speckled dace	14
Longnose dace	5
Northern pikeminnow	18
Bridgelip sucker	23
Brown bullhead	5

Appendix G: Proportionate Natural Influence (PNI) for the Tucannon Spring Chinook Population (1985-2006)

Appendix G. Proportionate Natural Influence (PNI)[a] for the Tucannon River spring Chinook population (1985-2006). Note: Pre-spawn mortalities excluded from the analysis.

Spawned Hatchery Broodstock			River Spawning Fish			
Year	**Total**	**% Natural (PNOB)**	**Total**	**% Hatchery (PHOS)**	**PNI**	**PNI < 0.50**
1985	8	100.00	569	0.00	1.00	
1986	91	100.00	520	0.00	1.00	
1987	83	100.00	481	0.00	1.00	
1988	90	100.00	304	3.29	0.97	
1989	122	45.08	276	2.54	0.95	
1990	62	48.39	611	29.13	0.62	
1991	71	56.34	390	43.85	0.56	
1992	82	45.12	564	40.43	0.53	
1993	87	51.72	436	41.74	0.55	
1994	69	50.72	70	11.43	0.82	
1995	39	23.08	11	0.00	1.00	
1996	75	44.00	136	23.53	0.65	
1997	89	42.70	146	46.58	0.48	*
1998	86	52.33	51	27.45	0.66	
1999	122	0.82	107	98.13	0.01	*
2000	73	10.96	239	70.71	0.13	*
2001	104	50.00	894	26.40	0.65	
2002	93	45.16	897	65.66	0.41	*
2003	75	54.67	366	43.99	0.55	
2004	88	54.55	480	27.29	0.67	
2005	95	49.47	317	24.29	0.67	
2006	88	40.91	161	35.40	0.54	

[a] PNI = PNOB/PNOB + PHOS.
PNOB = Percent natural origin fish in the hatchery broodstock.
PHOS = Percent hatchery origin fish among naturally spawning fish.

Appendix H: Comparison of Mean Survival Rates for Various Life Stages from Different Spring Chinook Stocks

Appendix H, Table 1. Comparison of mean natural-origin *egg-to-parr* survival rates from different river systems.

System	Percent Survival (Range)	Source
Snake River Subbasin		
Tucannon River, WA	10.1 (0-19)	Gallinat and Ross (this report)
Crooked River, ID	15.9 (9.6-25.9)	Kiefer and Lockhart (1999)
Catherine Creek, OR	12.7 (6.6-15.6)	Reischauer et al. (2003)
Lookingglass Creek, OR	9.5 (6.4-13.8)	Burck (1994)
Lostine Creek, OR	15.9 (6.3-23.1)	Reischauer et al. (2003)
Upper Lemhi River, ID	0.53 (0.13-1.09)	Gebhards (1961), Bjornn (1978)
Lemhi River, ID	20.6	Bjornn (1978)
Upper Salmon River, ID	25.5	Kiefer and Lockhart (1999)
Marsh Creek, ID	32.5	Petrosky and Holubetz (1988) Zabel and Achord (2004)
Bear Valley, Elk Creek, ID	3.5 (1.2-8.2)	Petrosky and Holubetz (1988) Zabel and Achord (2004)
Other Subbasins		
Chiwawa River, WA	11.9 (2.7-22.1)	Hillman and Miller (2004)
John Day River, OR	20.6 (14.5-24.5)	Lindsay et al. (1986)

Appendix H, Table 2. Comparison of mean natural-origin *parr-to-smolt* survival rates from different river systems.

System	Percent Survival (Range)	Source
Snake River Subbasin		
Tucannon River, WA	54.4 (44.9-83.8)	Gallinat and Ross (this report)
Crooked River, ID	30.0 (12-44.2)	Kiefer and Lockhart (1999)
Catherine Creek, OR	42.3 (19-64)	Reischauer et al. (2003)
Lookingglass Creek, OR	17.4 (12.5-22.5)	McLean, M. personal comm. 92-94 and 96-97 BYs
Lostine Creek, OR	49 (41-60)	Reischauer et al. (2003)
Upper Grande Ronde, OR	29.2 (21-54)	Reischauer et al. (2003)
Grande Ronde Basin, OR	56.1 (37.6-68.9)	Reischauer et al. (2003)
Upper Salmon River, ID	18.1	Kiefer and Lockhart (1999)
Marsh Creek	16.1 (11.5-22.5)	Petrosky and Holubetz (1988) Zabel and Achord (2004)
Bear Valley, Elk Creek	16.6 (8.3-21.9)	Petrosky and Holubetz (1988) Zabel and Achord (2004)
E. Fork Salmon River, ID	11.2 (7.8-13.7)	Zabel and Achord (2004)
Camus Creek, ID	18.3 (10-23.3)	Zabel and Achord (2004)
Loon Creek, ID	27 (18.9-34.7)	Zabel and Achord (2004)
Sulfur Creek, ID	15.5 (8.8-21.7)	Zabel and Achord (2004)
S. Fork Salmon River, ID	12.5 (9-15.2)	Zabel and Achord (2004)
Secesh River, Lake Ck., ID	15.2 (10.5-22.8)	Zabel and Achord (2004)
Other Subbasins		
Chiwawa River, WA	40.7 (20-67)	Murdoch et al. (1999), Miller (2004)
Upper Yakima River, WA	41.4 (15.7-78.2)	Fast et al. (1991)
John Day River, OR	29.8 (24.7-35.2)	Lindsay et al. (1986)

Appendix H, Table 3. Comparison of mean natural-origin *egg-to-smolt* survival rates from different river systems.

System	Percent Survival (Range)	Source
Snake River Subbasin		
Tucannon River, WA	5.8 (0.3-10.4)	Gallinat and Ross (this report)
Crooked River, ID	4.7 (2-8.1)	Kiefer and Lockhart (1999)
Catherine Creek, OR	13.4 (10.0-19.9)	Reischauer et al. (2003)
Lookingglass Creek, OR	8.7 (7.0-9.6)	Burck (1994) – endemic stock BY 1967-69
Lookingglass Creek, OR	12.0 (4.9-18.0)	McLean, M. personal comm. Rapid River stock
Lostine Creek, OR	12.7 (5.0-20.9)	Reischauer et al. (2003)
Upper Lemhi River, ID	9.8 (4.0-15.9)	Gebhards (1961), Bjornn (1978)
Upper Salmon River, ID	4.7 (1.2-8.9)	Kiefer and Lockhart (1999)
Other Subbasins		
Chiwawa River, WA	9.0 (4.6-13.2)	Hillman and Miller (2004)
John Day River, OR	5.6 (3.6-8.6)	Lindsay et al. (1986)
Upper Yakima River, WA	5.8 (1.3-3.0)	Fast et al. (1991)
Yakima River, WA	10.9 (5.4-16.4)	Major and Mighell (1969)
Warm Springs River, OR	2.0 (0.74-3.64)	Lindsay et al. (1989)

Appendix H, Table 4. Comparison of mean *smolt-to-adult* survival rates for *natural-origin* spring Chinook from different river systems.

System	Natural-Origin Percent Survival (Range)	Source
Snake River Subbasin		
Tucannon River, WA	0.76* (0.02-6.81)	Gallinat and Ross (this report)
Tucannon River, WA	1.56 (0.02-6.81)	Gallinat and Ross (this report)
Catherine Creek, OR	0.243 BY96	McLean, M. - personal comm.
Catherine Creek, OR	0.581 BY97	McLean, M. - personal comm.
Catherine Creek, OR	1.296 BY98	McLean, M. - personal comm.
Catherine Creek, OR	0.406 BY99	McLean, M. - personal comm.
Catherine Creek, OR	0.368 BY00	McLean, M. - personal comm.
Catherine Creek, OR	0.173 BY01	McLean, M. - personal comm.
Lookingglass Creek, OR	1.040 BY67	Burck (1994) – endemic stock
Lookingglass Creek, OR	0.711 BY68	Burck (1994) – endemic stock
Lookingglass Creek, OR	0.439 BY69	Burck (1994) – endemic stock
Lookingglass Creek, OR	0.420 BY92	McLean, M. – Rapid River stock
Lookingglass Creek, OR	0.066 BY93	McLean, M. – Rapid River stock
Lookingglass Creek, OR	0.576 BY94	McLean, M. – Rapid River stock
Lookingglass Creek, OR	0.440 BY96	McLean, M. – Rapid River stock
Lookingglass Creek, OR	0.311 BY97	McLean, M. – Rapid River stock
Other Subbasins		
Chiwawa River, WA	0.63* (0.07-2.4)	Murdoch, A. - personal comm.
Upper Yakima River, WA	3.8 (1.8-6)	Fast et al. (1991)
Yakima River, WA	2.28* (0.57-11.16)	Bosch, B. – personal comm.
John Day River, OR	1.1 (1.0-1.3)	Lindsay et al. (1986)

* Geometric mean.

Appendix H, Table 5. Comparison of mean *smolt-to-adult* survival rates for *hatchery-origin* spring Chinook from different river systems.

System	Hatchery-Origin Percent Survival (Range)	Source
Snake River Subbasin		
Tucannon River, WA	0.15* (0.03-0.75)	Gallinat and Ross (this report)
Tucannon River, WA	0.23 (0.03-0.75)	Gallinat and Ross (this report)
Catherine Creek, OR	0.568 BY98 Captive	McLean et al. 2007
Catherine Creek, OR	0.153 BY99 Captive	McLean et al. 2007
Catherine Creek, OR	0.365 BY00 Captive	McLean et al. 2007
Catherine Creek, OR	0.111 BY01 Captive	McLean et al. 2007
Catherine Creek, OR	0.213 BY01 Conventional	McLean et al. 2007
Upper Grande Ronde, OR	0.199 BY98 Captive	McLean et al. 2007
Upper Grande Ronde, OR	0.354 BY99 Captive	McLean et al. 2007
Upper Grande Ronde, OR	0.245 BY00 Captive	McLean et al. 2007
Upper Grande Ronde, OR	0.112 BY01 Captive	McLean et al. 2007
Upper Grande Ronde, OR	0.256 BY01 Conventional	McLean et al. 2007
Lostine River, OR	2.07 BY97 Conventional	Cleary et al. 2006
Lostine River, OR	1.65 BY98 Captive	Cleary et al. 2006
Lostine River, OR	0.23 BY99 Captive	Cleary et al. 2006
Other Subbasins		
Chiwawa River, WA	0.16* (0.04-0.95)	Murdoch, A. - personal comm.
Yakima River, WA	1.77* (0.19-8.54)	Bosch, B. – personal comm.

* Geometric mean.

Literature Cited for Appendix H

Burck, W. A. 1994. Life history of spring Chinook salmon in Lookingglass Creek, Oregon. ODFW Information Report 94-1, Oregon Department of Fish and Wildlife, Portland, OR.

Bjornn, T. C. 1978. Survival, production, and yield of trout and Chinook salmon in the Lemhi River, Idaho. Idaho Department of Fish and Game Bulletin 27, Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow.

Cleary, P., J. Harbeck, and D. Bright. 2006. Evaluation of spring Chinook salmon (*Oncorhynchus tshawytscha*) supplementation in the Lostine River, Oregon, 1997-2004 Progress Report, Project No. 199800702, 114 electronic pages, BPA Report DOE/BP-00004219-1.

Fast, D., J. Hubble, M. Kohn, and B. Watson. 1991. Yakima River spring Chinook enhancement study Final Report 1991. DOE/BP-39461-9, Yakima Indian Nation, Portland, OR.

Gebhards, S. V. 1961. Emergence and mortality of Chinook salmon fry in the natural redd. Progressive Fish-Culturist 23: 91.

Hillman, T. W., and M. D. Miller. 2004. Abundance and total numbers of Chinook salmon and trout in the Chiwawa River Basin, Washington 2003. Bonneville Power Administration, Portland, OR.

Kiefer, R. B., and J. N. Lockhart. 1999. Intensive evaluation and monitoring of Chinook salmon and steelhead trout production, Crooked River and Upper Salmon River sites. Annual Progress Report 00-15, Idaho Department of Fish and Game, Boise, ID.

Lindsay, R. B., W. J. Knox, M. W. Flesher, B. J. Smith, E. A. Olsen, and L. S. Lutz. 1986. Study of wild spring Chinook salmon in the John Day River system 1985 Final Report. Oregon Department of Fish and Wildlife, Portland, OR.

Major, R. L., and J. L. Mighell. 1969. Egg-to-migrant survival of spring Chinook salmon (*Oncorhynchus tshawytscha*) in the Yakima River, Washington. U.S. Fish and Wildlife Service Fishery Bulletin 67: 347-359.

McLean, M., R. Seeger, and L. Hewitt. 2007. Grande Ronde satellite facilities operation and maintenance 2006 Annual Report, Project No. 199800703, 57 electronic pages, BPA Report DOE/BP-00025348-1.

Miller, T. 2004. 2004 Chiwawa and Wenatchee River smolt estimates. Washington Department of Fish and Wildlife, Wenatchee, WA.

Murdoch, A., K. Petersen, T. Miller, M. Tonseth, and T. Randolph. 1999. Freshwater production and emigration of juvenile spring Chinook from the Chiwawa River in 1998. Washington Department of Fish and Wildlife, Olympia, WA.

Petrosky, C. E., and T. B. Holubetz. 1988. Idaho habitat evaluation for off-site mitigation record. Annual Report Contract No. DE-A179-84BP13381, Project 83-7, Idaho Department of Fish and Game, Bonneville Power Administration, Boise, ID.

Reischauer, A. G., F. R. Monzyk, E. S. Van Dyke, B. C. Jonasson, and R. W. Carmichael. 2003. Investigations into the early life-history of naturally produced spring Chinook salmon and summer steelhead in the Grande Ronde River basin annual report 2001. DOE/BP-00004119-1, Oregon Department of Fish and Wildlife, Portland, OR.

Zabel, R. W., and S. Achord. 2004. Relating size of juveniles to survival within and among populations of Chinook salmon. Ecology 85: 795-806.

Appendix I: Recoveries of Coded-Wire Tagged Salmon Released Into the Tucannon River for the 1985-2002 Brood Years

Appendix I. 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 1985-2002 brood years. (Data downloaded from RMIS database on 4/20/07.)

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	129
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	202
Tucannon (%)	97.4		96.0		99.0	
Out-of-Basin (%)	0.0		0.0		0.0	
Commercial Harvest	2.6		1.8		0.0	
(%)	0.0		1.1		0.0	
Sport Harvest (%)	0.0		1.1		1.0	
Treaty Ceremonial (%)	0.30		0.26		0.13	
Survival						

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

Appendix I (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 1985-2002 brood years. (Data downloaded from RMIS database on 4/20/07.)

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 (%)	0.6		1.6		0.0	
Sport Harvest (%)	0.8		0.0		0.0	
Treaty Ceremonial (%)	3.5		3.1		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 I (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 1985-2002 brood years. (Data downloaded from RMIS database on 4/20/07.)

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 (%)	0.0		40.0		0.0	
Sport Harvest (%)	0.0		0.0		2.0	
Treaty Ceremonial (%)	10.0		0.0		0.9	
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 I (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 1985-2002 brood years. (Data downloaded from RMIS database on 4/20/07.)

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 (%)	0.0		0.0		0.0	
Sport Harvest (%)	1.0		0.0		0.0	
Treaty Ceremonial (%)	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 I (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 1985-2002 brood years. (Data downloaded from RMIS database on 4/20/07.)

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	83
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	1		
Total Returns	143	242	74	200	300	1,004
Tucannon (%)	98.3		65.5		76.0	
Out-of-Basin (%)	1.7		2.0		1.4	
Commercial Harvest (%)	0.0		25.0		11.4	
Sport Harvest (%)	0.0		7.5		10.7	
Treaty Ceremonial (%)	0.0		0.0		0.5	
Survival	0.32		0.85		0.81	

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

Appendix I (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 1985-2002 brood years. (Data downloaded from RMIS database on 4/20/07.)

Brood Year	1999		2000		2001	
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	6	26
Kalama R., Wind R.						
Fish Trap - F.W.						
Treaty Troll						
Lyons Ferry Hatch.[b]	6	6	39	39	50	50
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	21	53	77	56	76
Tucannon (%)	86.0		98.7		100.0	
Out-of-Basin (%)	0.0		0.0		0.0	
Commercial Harvest (%)	14.0		1.3		0.0	
Sport Harvest (%)	0.0		0.0		0.0	
Treaty Ceremonial (%)	0.0		0.0		0.0	
Survival	0.02		0.08		0.05	

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

Appendix I (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 1985-2002 brood years. (Data downloaded from RMIS database on 4/20/07.)

Brood Year	2001		2002[c]			
Smolts Released	21,043		123,586			
Fish/Lb	123.4		11.7			
CWT Codes[a]	14/29		17/91			
Release Year	2002		2004			
Agency (fishery/location)	Observed Number	Estimated Number	Observed Number	Estimated Number	Observed Number	Estimated Number
WDFW						
Tucannon River			2	12		
Kalama R., Wind R.						
Fish Trap - F.W.						
Treaty Troll						
Lyons Ferry Hatch.[b]			1	1		
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	1				
Columbia R. Sport						
CDFO						
Non-treaty Ocean Troll						
Mixed Net & Seine						
Ocean Sport						
USFWS						
Warm Springs Hatchery						
Dworshak NFH						
IDFG						
Hatchery						
Total Returns	1	1	3	13		
Tucannon (%)	0.0		100.0		0.0	
Out-of-Basin (%)	0.0		0.0		0.0	
Commercial Harvest (%)	100.0		0.0		0.0	
Sport Harvest (%)	0.0		0.0		0.0	
Treaty Ceremonial (%)	0.0		0.0		0.0	
Survival	0.00		0.01		0.00	

[a] WDFW agency code prefix is 63.
[b] Fish trapped at TFH and held at LFH for spawning.
[c] Data for the 2002 brood year is incomplete.

This program receives Federal financial assistance from the U.S. Fish and Wildlife Service Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972. The U.S. Department of the Interior and its bureaus prohibit discrimination on the bases of race, color, national origin, age, disability and sex (in educational programs). If you believe that you have been discriminated against in any program, activity or facility, please write to:

U.S. Fish and Wildlife Service
Office of External Programs
4040 N. Fairfax Drive, Suite 130
Arlington, VA 22203