Tucannon River Spring Chinook Salmon Hatchery Evaluation Program

2003 Annual Report

by

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Abstract

Lyons Ferry Hatchery (LFH) and Tucannon Fish Hatchery (TFH) were built/modified under the Lower Snake River Fish and Wildlife Compensation Plan. One objective was to compensate for the estimated annual loss of 1,152-spring chinook (Tucannon River stock) caused by hydroelectric projects on the Snake River. The standard supplementation production goal is 132,000 fish for release as yearlings at 30 g/fish or 15 fish per pound (fpp). 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 2003 to April 2004.

Two hundred thirty-five fish were captured in the TFH trap in 2003 (78 natural adults, 6 natural jacks, 122 hatchery adults, and 29 hatchery jacks); 77 were collected and hauled to LFH for broodstock and the remaining fish were passed upstream.

During 2003, two salmon that were collected for broodstock died. Prespawning mortality has been low since broodstock began being held at LFH in 1992, and is generally less than 10% each year.

Spawning of supplementation fish in 2003 at LFH occurred between August 26 and September 30, with peak eggtake on September 9. A total of 140,658 eggs were collected from 17 wild and 20 hatchery-origin fish. Egg mortality to eye-up was 5.3% (7,451 eggs), with an additional loss of 6,807 (5.1%) sac-fry. Total fry ponded for production in the rearing ponds was 126,400.

A total of 223 captive brood females were spawned from September 9 to October 7, 2003 producing 309,416 eggs. Egg mortality to eye-up was 40% leaving 186,743 live eggs. An additional 21,943 dead eggs/fry (11.8%) were picked at ponding leaving 164,800 fish for rearing.

WDFW staff conducted spawning ground surveys in the Tucannon River between August 27 and October 2, 2003. Sixty-two redds and 27 carcasses were found above the adult trap and 56 redds and 35 carcasses were found below the trap. Based on redd counts, broodstock collection, and in-river pre-spawning mortalities, the estimated escapement for 2003 was 444 fish (245 wild adults, 3 wild jacks and 169 hatchery-origin adults, 27 hatchery jacks).

Length and weight samples were collected twice during the rearing cycle for 2002 BY juveniles at TFH and Curl Lake Acclimation Pond. All 2002 BY juveniles were marked in October at LFH, transported to TFH, and transported again in February to Curl Lake for acclimation and volitional release during April.

Snorkel surveys were conducted during the summer of 2003 to determine the population of
subyearling and yearling spring chinook in the Tucannon River. We estimated 72,197 subyearlings (BY 2002) and 940 yearlings (BY 2001) were present in the river. Evaluation staff also operated a downstream migrant trap. During the 2002/2003 emigration, we estimated that 38,079 (BY 2001) wild 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 three times higher than for hatchery salmon. However, hatchery salmon survive about four 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 196 hatchery-origin fish returned in 2003.
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Introduction

Program Objectives

Congress authorized implementation of the Lower Snake River Fish and Wildlife Compensation Plan (USACE 1975). As a result, Lyons Ferry Hatchery (LFH) was constructed and Tucannon Fish Hatchery (TFH) was modified. One objective of these hatcheries is to compensate for the estimated annual loss of 1,152 Tucannon River spring chinook salmon adults caused by hydroelectric projects on the Snake River. In 1984, Washington Department of Fish and Wildlife (WDFW) began to evaluate the success of these two hatcheries in meeting the mitigation goal, and identifying factors that would improve performance of the hatchery fish. 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 (1997-2001 brood years) to adults, rear their progeny, and release approximately 150,000 smolts (30 g/fish) annually into the Tucannon River between 2003-2007. These smolt releases, in combination with the current hatchery supplementation program (goal = 132,000 smolts; 30 g/fish) and wild production, are expected to produce 600-700 returning adult spring chinook to the Tucannon River each year from 2005-2010. This report summarizes work performed by the WDFW Spring Chinook Evaluation Program from April 2003 through April 2004.

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 (Table 1).

![Map of Tucannon River](image)

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

<table>
<thead>
<tr>
<th>Strata</th>
<th>Land Ownership/Usage</th>
<th>Spring Chinook Habitat</th>
<th>River Kilometer(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower</td>
<td>Private/Agriculture &amp; Ranching</td>
<td>Not-Usable (temperature limited)</td>
<td>0.0-20.1</td>
</tr>
<tr>
<td>Marengo</td>
<td>Private/Agriculture &amp; Ranching</td>
<td>Marginal (temperature limited)</td>
<td>20.1-39.9</td>
</tr>
<tr>
<td>Hartsock</td>
<td>Private/Agriculture &amp; Ranching</td>
<td>Fair to Good</td>
<td>39.9-55.5</td>
</tr>
<tr>
<td>HMA</td>
<td>State &amp; Forest Service/Recreational</td>
<td>Good/Excellent</td>
<td>55.5-74.5</td>
</tr>
<tr>
<td>Wilderness</td>
<td>Forest Service/Recreational</td>
<td>Excellent</td>
<td>74.5-86.3</td>
</tr>
</tbody>
</table>

\(^a\) Rkm descriptions: 0.0–mouth at the Snake River; 20.1-Territorial Rd.; 39.9-Marengo Br.; 55.5-HMA Boundary Fence; 74.5-Panjab Br.; 86.3-Rucherts Camp.
Evaluation program staff deployed 19 continuous recording thermographs throughout the Tucannon River to monitor daily minimum and maximum water temperatures (temperatures are recorded every 1 to 1.2 hours) from May through October. Data from each of these water temperature recorders are kept on an electronic file in our Dayton office. During 2003, maximum temperatures near the mouth (rmk 3) of the Tucannon River reached 26.7 °C (80 °F) on 4 different days. Maximum temperatures where spring chinook juveniles were rearing during the hottest part of the summer ranged from 15.8 °C (60.4 °F) in the upper HMA stratum (rmk 74.5) to 23.1 °C (73.6 °F) in the lower Hartsock stratum (rmk 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). 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.
Figure 2. Maximum temperature, average maximum temperature, and average minimum temperature recorded by thermographs at 19 selected sites along the Tucannon River, May-October, 2003.
Broodstock Trapping

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

The TFH adult trap began operation in February (for steelhead) with the first spring chinook captured May 5. The trap was operated through September. A total of 235 fish entered the trap (78 natural adults, 6 natural jacks, 122 hatchery adults, and 29 hatchery jacks), and 42 wild (42 adults, 0 jacks) and 35 hatchery (30 adults, 5 jacks) 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 year’s returns, we anticipated catching unmarked Umatilla origin hatchery fish. We decided prior to broodstock trapping 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 “wild” fish collected for broodstock was actually of hatchery origin, that fish would be identified by its PIT tag number and killed. None of the wild fish kept for broodstock 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 1986-2003.

<table>
<thead>
<tr>
<th>Year</th>
<th>Captured at Trap</th>
<th>Trap Mortality</th>
<th>Broodstock Collected</th>
<th>Passed Upstream</th>
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<tr>
<td></td>
<td>Natural</td>
<td>Hatchery</td>
<td>Natural</td>
<td>Hatchery</td>
</tr>
<tr>
<td>1986</td>
<td>247</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1987</td>
<td>209</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1988</td>
<td>267</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1989</td>
<td>156</td>
<td>102</td>
<td>0</td>
<td>0</td>
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<tr>
<td>1990</td>
<td>252</td>
<td>216</td>
<td>0</td>
<td>1</td>
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<td>1991</td>
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<td>1992</td>
<td>242</td>
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<td>1993</td>
<td>191</td>
<td>257</td>
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<td>2003</td>
<td>84</td>
<td>151</td>
<td>0</td>
<td>0</td>
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\(^a\) Two males (one natural, one hatchery) captured were transported back downstream to spawn in the river.
\(^b\) Three hatchery males that were captured were transported back downstream to spawn in the river.
\(^c\) 17 stray LV and ADLV fish were killed at the trap.

Broodstock Mortality

Two of the 77 salmon collected for broodstock died prior to spawning in 2003 (Table 3). Table 3 shows that prespawning mortality in 2003 was comparable to the mortality documented since broodstock holding at LFH began in 1992. Higher mortality was experienced when fish were held at TFH (1986-1991).

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural Male</th>
<th>Natural Female</th>
<th>Natural Jack</th>
<th>% of collected</th>
<th>Hatchery Male</th>
<th>Hatchery Female</th>
<th>Hatchery Jack</th>
<th>% of collected</th>
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<tr>
<td>1985</td>
<td>3</td>
<td>10</td>
<td>0</td>
<td>59.1</td>
<td>—</td>
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<td>1986</td>
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<td>10.0</td>
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<td>0</td>
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</tr>
<tr>
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<td>2</td>
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<td>0</td>
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<td>1</td>
<td>3.8</td>
</tr>
<tr>
<td>2000</td>
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<td>0</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>2001</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>2002</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3.1</td>
</tr>
<tr>
<td>2003</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2.4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Broodstock Spawning

Spawning at LFH occurred once a week from August 26 to September 30, with peak eggtake occurring on September 9. A total of 140,658 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 5.3% with an additional 5.1% (6,807) loss of sac-fry, which left 126,400 fish for production.

To prevent any stray fish from contributing to the population, all coded wire tags (CWT) were read prior to spawning. No hatchery strays were found in the broodstock in 2003. Scales from unmarked fish were read prior to spawning to check for hatchery growth patterns. Carcasses of spawned fish were buried instead of being used for nutrient enhancement due to the detection of Infectious Hematopoietic Necrosis virus in the broodstock.
Table 4. Number of fish spawned, estimated egg collection, and egg mortality of Tucannon River spring chinook salmon at LFH in 2003.

<table>
<thead>
<tr>
<th>Spawn Date</th>
<th>Male</th>
<th>Female</th>
<th>Eggs Taken</th>
<th>Male</th>
<th>Female</th>
<th>Eggs Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/26</td>
<td>2</td>
<td>2</td>
<td>11,027</td>
<td>2</td>
<td>2</td>
<td>9,134</td>
</tr>
<tr>
<td>9/02</td>
<td>8</td>
<td>1</td>
<td>4,276</td>
<td>2</td>
<td>9</td>
<td>33,852</td>
</tr>
<tr>
<td>9/09</td>
<td>8</td>
<td>8</td>
<td>25,382</td>
<td>5</td>
<td>5</td>
<td>18,600</td>
</tr>
<tr>
<td>9/16</td>
<td>3</td>
<td>4</td>
<td>16,509</td>
<td>4</td>
<td>4</td>
<td>14,655</td>
</tr>
<tr>
<td>9/23</td>
<td>2</td>
<td>1</td>
<td>4,718</td>
<td>4</td>
<td>4</td>
<td>14,655</td>
</tr>
<tr>
<td>9/30</td>
<td>1</td>
<td>1</td>
<td>2,505</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>24</td>
<td>17</td>
<td>64,417</td>
<td>14</td>
<td>20</td>
<td>76,241</td>
</tr>
<tr>
<td>Egg Mortality</td>
<td></td>
<td></td>
<td>4,304</td>
<td></td>
<td></td>
<td>3,147</td>
</tr>
</tbody>
</table>

Eggs were also collected as part of the Tucannon River Captive Broodstock Program. A total of 223 captive brood females were spawned from September 9 to October 7, 2003. From the total 309,416 captive brood eggs collected, mortality to eye-up was 39.6%, leaving 186,743 live eggs in the incubators. An additional 21,943 dead eggs/fry (11.8%) were picked at ponding leaving 164,800 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 2004).

**Radio Tracking**

A spring chinook that was radio tagged (channel 11, code 78, frequency 149.52 MHz) by the University of Idaho at Bonneville Dam was tracked in the Tucannon River during 2003. This fish was first detected on May 29 holding above Marengo Bridge (rkm 41.6). The radio tagged fish entered the mouth of the Tucannon Fish Hatchery adult trap (rkm 59) on June 7. Efforts to locate this fish after this were unsuccessful. The radio tag either quit working or the fish/transmitter left the area. Hatchery personnel did not observe any radio tagged fish in the trap.
Natural Spawning

Spawning ground surveys were conducted on the Tucannon River weekly from August 27 to October 2, 2003 to count redds and determine the temporal and spatial distribution of spawners. One hundred eighteen redds were counted and 46 natural and 16 hatchery origin carcasses were recovered (Table 5). Sixty-two redds (53% of total) and 27 carcasses (44% of total) were found above the adult trap.

While conducting redd surveys in 2003 we also snorkeled 5 active redds to observe adult hatchery/wild interactions and look for possible precocious male spawning. We observed 9 wild adults (5 males and 4 females) and 1 hatchery adult male on the redds. The hatchery male was large (probable 5 year old) and was observed spawning with a wild female and chasing smaller wild males away from the redd. We also observed 8 juvenile wild spring chinook salmon in and near the redds. These juvenile fish had the coloration of parr and were determined not to be precocious males. The observed parr were using the downstream side of the redd as protection against the current.

Table 5. Numbers and general locations of salmon redds and carcasses recovered on the Tucannon River spawning grounds, 2003. (The Tucannon Hatchery adult trap is located at rkm 59.)

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Rkma</th>
<th>Number of redds</th>
<th>Natural</th>
<th>Hatchery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilderness</td>
<td>78-84</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>75-78</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>HMA</td>
<td>73-75</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>68-73</td>
<td>14</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>66-68</td>
<td>9</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>62-66</td>
<td>26</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>59-62</td>
<td>8</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>28</td>
<td>16</td>
</tr>
<tr>
<td>Hartsock</td>
<td>56-59</td>
<td>28</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>52-56</td>
<td>17</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>47-52</td>
<td>9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>43-47</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>40-43</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Marengo</td>
<td>34-40</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>28-34</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>28-84</td>
<td>118</td>
<td>46</td>
<td>16</td>
</tr>
</tbody>
</table>

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 from the program’s inception in 1985 through 1999:

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

In part, this resulted from a greater emphasis on broodstock collection to keep the spring chinook population above 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 (Table 6). Also, changing the release location from TFH to Curl Lake has affected the spawning distribution.

<table>
<thead>
<tr>
<th>Year</th>
<th>Wilderness</th>
<th>HMA</th>
<th>Hartsock</th>
<th>Marengo</th>
<th>Total Redds</th>
<th>Above</th>
<th>%</th>
<th>Below</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>97 (8.2)</td>
<td>122 (6.2)</td>
<td>–</td>
<td>–</td>
<td>219</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>1986</td>
<td>53 (4.5)</td>
<td>117 (6.2)</td>
<td>29 (1.9)</td>
<td>0 (0.0)</td>
<td>200</td>
<td>163</td>
<td>81.5</td>
<td>37</td>
<td>18.5</td>
</tr>
<tr>
<td>1987</td>
<td>15 (1.3)</td>
<td>140 (7.4)</td>
<td>30 (1.9)</td>
<td>–</td>
<td>185</td>
<td>149</td>
<td>80.5</td>
<td>36</td>
<td>19.5</td>
</tr>
<tr>
<td>1988</td>
<td>18 (1.5)</td>
<td>79 (4.2)</td>
<td>20 (1.3)</td>
<td>–</td>
<td>117</td>
<td>90</td>
<td>76.9</td>
<td>27</td>
<td>23.1</td>
</tr>
<tr>
<td>1989</td>
<td>29 (2.5)</td>
<td>54 (2.8)</td>
<td>23 (1.5)</td>
<td>–</td>
<td>106</td>
<td>74</td>
<td>69.8</td>
<td>32</td>
<td>30.2</td>
</tr>
<tr>
<td>1990</td>
<td>20 (1.7)</td>
<td>94 (4.9)</td>
<td>64 (4.1)</td>
<td>2 (0.3)</td>
<td>180</td>
<td>96</td>
<td>53.3</td>
<td>84</td>
<td>46.7</td>
</tr>
<tr>
<td>1991</td>
<td>3 (0.3)</td>
<td>67 (2.9)</td>
<td>18 (1.1)</td>
<td>2 (0.3)</td>
<td>90</td>
<td>40</td>
<td>44.4</td>
<td>50</td>
<td>55.6</td>
</tr>
<tr>
<td>1992</td>
<td>17 (1.4)</td>
<td>151 (7.9)</td>
<td>31 (2.0)</td>
<td>1 (0.2)</td>
<td>200</td>
<td>130</td>
<td>65.0</td>
<td>70</td>
<td>35.0</td>
</tr>
<tr>
<td>1993</td>
<td>34 (3.4)</td>
<td>123 (6.5)</td>
<td>34 (2.2)</td>
<td>1 (0.2)</td>
<td>192</td>
<td>131</td>
<td>68.2</td>
<td>61</td>
<td>31.8</td>
</tr>
<tr>
<td>1994</td>
<td>1 (0.1)</td>
<td>10 (0.5)</td>
<td>28 (1.8)</td>
<td>5 (0.9)</td>
<td>44</td>
<td>2</td>
<td>4.5</td>
<td>42</td>
<td>95.5</td>
</tr>
<tr>
<td>1995</td>
<td>0 (0.0)</td>
<td>2 (0.1)</td>
<td>3 (0.2)</td>
<td>0 (0.0)</td>
<td>5</td>
<td>0</td>
<td>0.0</td>
<td>5</td>
<td>100.0</td>
</tr>
<tr>
<td>1996</td>
<td>1 (0.1)</td>
<td>33 (1.7)</td>
<td>34 (2.2)</td>
<td>0 (0.0)</td>
<td>68</td>
<td>11</td>
<td>16.2</td>
<td>58</td>
<td>83.8</td>
</tr>
<tr>
<td>1997</td>
<td>2 (0.2)</td>
<td>43 (2.3)</td>
<td>27 (1.7)</td>
<td>1 (0.2)</td>
<td>73</td>
<td>30</td>
<td>41.1</td>
<td>43</td>
<td>58.9</td>
</tr>
<tr>
<td>1998</td>
<td>0 (0.0)</td>
<td>3 (0.2)</td>
<td>20 (1.3)</td>
<td>3 (0.5)</td>
<td>26</td>
<td>3</td>
<td>11.5</td>
<td>23</td>
<td>88.5</td>
</tr>
<tr>
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<td>1 (0.1)</td>
<td>34 (1.8)</td>
<td>6 (0.4)</td>
<td>0 (0.0)</td>
<td>41</td>
<td>3</td>
<td>7.3</td>
<td>38</td>
<td>92.7</td>
</tr>
<tr>
<td>2000</td>
<td>4 (0.4)</td>
<td>68 (3.6)</td>
<td>20 (1.3)</td>
<td>0 (0.0)</td>
<td>92</td>
<td>45</td>
<td>48.9</td>
<td>47</td>
<td>51.1</td>
</tr>
<tr>
<td>2001</td>
<td>24 (2.7)</td>
<td>189 (9.9)</td>
<td>84 (5.3)</td>
<td>1 (0.2)</td>
<td>298</td>
<td>168</td>
<td>56.4</td>
<td>130</td>
<td>43.6</td>
</tr>
<tr>
<td>2002</td>
<td>13 (1.4)</td>
<td>227 (11.9)</td>
<td>46 (2.9)</td>
<td>13 (1.1)</td>
<td>299</td>
<td>197</td>
<td>65.9</td>
<td>102</td>
<td>34.1</td>
</tr>
<tr>
<td>2003</td>
<td>0 (0.0)</td>
<td>90 (4.7)</td>
<td>28 (1.8)</td>
<td>0 (0.0)</td>
<td>118</td>
<td>62</td>
<td>52.5</td>
<td>56</td>
<td>47.5</td>
</tr>
</tbody>
</table>

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

Genetic Sampling

During 2003 we collected 134 DNA samples (opercle punches) from adult salmon (84 natural origin and 50 hatchery origin) and 346 samples from captive broodstock spawners. These samples were sent to the WDFW genetics lab in Olympia for analysis.

Age Composition, Length Comparisons, and Fecundity

One objective of the monitoring program is to track the age composition of each year’s 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 3). This difference is likely due to smolt size-at-
release (hatchery origin smolts are generally 25-30 mm greater in length than natural smolts).

An unusually large proportion of Age 5 fish were observed during the 2003 run for both the hatchery and wild components of the population (Figure 3). This was likely due to the large number of Age 4 fish in 2002 and desirable ocean conditions.

Another comparison we conduct on returning adult natural and hatchery origin fish is the difference between mean post-eye to hypural-plate lengths. We reported in the past (Bumgarner et al. 1994) that hatchery fish were generally shorter than natural origin fish of the same age. For many of the early return years this appeared to be true (Figures 4, 5, 6, and 7). However, overall for all combined return years, there is no difference in mean length between natural and hatchery origin fish, even though they migrate as smolts at significantly different sizes (Bugert et al. 1990; Bugert et al. 1991).

Figure 3. Historical (1985-2002), and 2003 age composition for spring chinook in the Tucannon River.
Figure 4. Mean length and SD of Age 4 females.

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

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

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

Fecundities (number of eggs/female) of natural and hatchery origin fish from the Tucannon River program have been documented since 1990 (Table 7). Analysis of variance was performed to determine if there were significant differences in mean fecundities at the 95% confidence level. Natural origin females had significantly higher fecundities than hatchery origin fish for both Age 4 (P<0.001) and 5-year-old fish (P<0.001).
Mean egg size of natural origin Age 4 spring chinook from the Tucannon River averaged 0.225 g/egg and hatchery origin eggs averaged 0.239 g/egg. This difference was statistically significant at the 95% confidence level (P<0.05). This may help 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 0.282 g/egg for hatchery origin females, but the difference was not significant (P=0.14).

### Table 7. Average number of eggs/female (n, SD) by age group of Tucannon River natural and hatchery origin broodstock, 1990-2003.

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural</th>
<th>Hatchery</th>
<th>Natural</th>
<th>Hatchery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>3,691</td>
<td>2,794</td>
<td>4,383</td>
<td>No Fish</td>
</tr>
<tr>
<td>1991</td>
<td>2,803</td>
<td>2,463</td>
<td>4,252</td>
<td>3,052</td>
</tr>
<tr>
<td>1992</td>
<td>3,691</td>
<td>3,126</td>
<td>4,734</td>
<td>3,456</td>
</tr>
<tr>
<td>1993</td>
<td>3,180</td>
<td>3,456</td>
<td>4,470</td>
<td>4,129</td>
</tr>
<tr>
<td>1994</td>
<td>3,688</td>
<td>3,280</td>
<td>4,906</td>
<td>3,352</td>
</tr>
<tr>
<td>1995</td>
<td>No Fish</td>
<td>3,584</td>
<td>5,284</td>
<td>3,889</td>
</tr>
<tr>
<td>1996</td>
<td>3,509</td>
<td>2,833</td>
<td>3,617</td>
<td>(1,000.0)</td>
</tr>
<tr>
<td>1997</td>
<td>3,487</td>
<td>3,290</td>
<td>4,326</td>
<td>3,290.9</td>
</tr>
<tr>
<td>1998</td>
<td>4,204</td>
<td>2,779</td>
<td>4,017</td>
<td>3,333</td>
</tr>
<tr>
<td>1999</td>
<td>No Fish</td>
<td>3,121</td>
<td>4,017</td>
<td>3,850</td>
</tr>
<tr>
<td>2000</td>
<td>4,144</td>
<td>3,320</td>
<td>3,618</td>
<td>4,208</td>
</tr>
<tr>
<td>2001</td>
<td>3,612</td>
<td>3,225</td>
<td>3,858</td>
<td>(2,842.5)</td>
</tr>
<tr>
<td>2002</td>
<td>3,584</td>
<td>3,368</td>
<td>4,774</td>
<td>No Fish</td>
</tr>
<tr>
<td>2003</td>
<td>3,342</td>
<td>2,723</td>
<td>4,428</td>
<td>3,984</td>
</tr>
<tr>
<td>Mean</td>
<td>3,577</td>
<td>3,182</td>
<td>4,381</td>
<td>3,685</td>
</tr>
<tr>
<td>SD</td>
<td>606.7</td>
<td>661.6</td>
<td>849.8</td>
<td>743.3</td>
</tr>
</tbody>
</table>

### Coded-Wire Tag Sampling

Broodstock collection, pre-spawn mortalities, and carcasses recovered from spawning ground surveys provide representatives of the annual run that can be sampled for CWT study groups (Table 8). In 2003, based on the estimated escapement of fish to the river, we sampled approximately 32% of the run (Table 9).
Table 8. Coded-wire tag codes of hatchery salmon sampled at LFH and the Tucannon River, 2003.

<table>
<thead>
<tr>
<th>CWT Code</th>
<th>Died in Pond</th>
<th>Killed Outright</th>
<th>Spawned</th>
<th>Died in Trap</th>
<th>Pre-spawn Mortality</th>
<th>Spawned</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>63-02-75</td>
<td>3</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>63-08-87</td>
<td>1</td>
<td>3</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>63-12-11</td>
<td>27</td>
<td></td>
<td></td>
<td>12</td>
<td></td>
<td></td>
<td>39</td>
</tr>
<tr>
<td>-Strays-100472</td>
<td>1*</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>No tags</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1</strong></td>
<td><strong>0</strong></td>
<td><strong>34</strong></td>
<td><strong>0</strong></td>
<td><strong>0</strong></td>
<td><strong>17</strong></td>
<td><strong>52</strong></td>
</tr>
</tbody>
</table>

* This fish did not have CWT but it did have a right red VIE and was a jack (Age 3) which would make it 63-08-87.


<table>
<thead>
<tr>
<th>2003</th>
<th>Natural</th>
<th>Hatchery</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total escapement to river</strong></td>
<td>248</td>
<td>196</td>
<td>444</td>
</tr>
<tr>
<td>Broodstock collected</td>
<td>42</td>
<td>35</td>
<td>77</td>
</tr>
<tr>
<td>Fish dead in adult trap</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total hatchery sample</td>
<td>42</td>
<td>35</td>
<td>77</td>
</tr>
<tr>
<td><strong>Total fish left in river</strong></td>
<td>206</td>
<td>161</td>
<td>367</td>
</tr>
<tr>
<td>In-river pre-spawn mortality</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Spawned carcasses recovered</td>
<td>45</td>
<td>17</td>
<td>62</td>
</tr>
<tr>
<td>Total river sample</td>
<td>46</td>
<td>17</td>
<td>63</td>
</tr>
<tr>
<td><strong>Carcasses sampled</strong></td>
<td>88</td>
<td>52</td>
<td>140</td>
</tr>
</tbody>
</table>

**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 during 2003 was slightly earlier than the average historical date, but within the expected range compared to peak arrival before hatchery influence (1986-1988). Peak spawning date of hatchery fish was also earlier than in previous years, although within the range found from previous years. The duration of active spawning in the Tucannon River was also within the expected range based on historical data.
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, 1986-2003.

<table>
<thead>
<tr>
<th>Year</th>
<th>Peak Arrival at Trap</th>
<th>Spawning in Hatchery</th>
<th>Spawning in River</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Natural</td>
<td>Hatchery</td>
<td>Natural</td>
</tr>
<tr>
<td>1989</td>
<td>6/06</td>
<td>6/12</td>
<td>9/15</td>
</tr>
<tr>
<td>1990</td>
<td>5/22</td>
<td>5/23</td>
<td>9/04</td>
</tr>
<tr>
<td>1993</td>
<td>5/31</td>
<td>5/27</td>
<td>9/13</td>
</tr>
<tr>
<td>1995a</td>
<td>–</td>
<td>6/08</td>
<td>9/13</td>
</tr>
<tr>
<td>1998</td>
<td>6/03</td>
<td>6/16</td>
<td>9/08</td>
</tr>
<tr>
<td>1999a</td>
<td>–</td>
<td>6/16</td>
<td>9/07</td>
</tr>
<tr>
<td>2000</td>
<td>6/06</td>
<td>5/22</td>
<td>–</td>
</tr>
<tr>
<td>2002</td>
<td>5/29</td>
<td>5/29</td>
<td>9/10</td>
</tr>
<tr>
<td>Mean</td>
<td>5/30</td>
<td>6/04</td>
<td>9/12</td>
</tr>
</tbody>
</table>

*aToo few natural salmon were trapped in 1995 and 1999 to determine peak arrival.

Total Run-Size

In general, redd counts have been directly related to total run-size entering the Tucannon River and passage of adult salmon at the TFH adult trap (Bugert et al. 1991). For 2003, 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 2003 was calculated by adding the estimated number of fish upstream of the TFH adult trap, the estimated fish below the weir based on the fish/redd ratio, the number of pre-spawn mortalities below the weir, and the number of broodstock collected (Table 11). Total run-size for 2003 was estimated at 444 fish (245 wild adults, 3 wild jacks and 169 hatchery-origin adults, 27 hatchery jacks). The total run for jacks and adults by origin has been estimated since 1985 (Appendix B).

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Redds</th>
<th>Fish/Redd Ratio</th>
<th>Spawning fish In the river</th>
<th>Broodstock Collected</th>
<th>Pre-spawning Mortalities</th>
<th>Total Run-Size</th>
<th>Percent Natural</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>219</td>
<td>2.60</td>
<td>569</td>
<td>22</td>
<td>0</td>
<td>591</td>
<td>100</td>
</tr>
<tr>
<td>1986</td>
<td>200</td>
<td>2.60</td>
<td>520</td>
<td>116</td>
<td>0</td>
<td>636</td>
<td>100</td>
</tr>
<tr>
<td>1987</td>
<td>185</td>
<td>2.60</td>
<td>481</td>
<td>101</td>
<td>0</td>
<td>582</td>
<td>100</td>
</tr>
<tr>
<td>1988</td>
<td>117</td>
<td>2.60</td>
<td>304</td>
<td>125</td>
<td>0</td>
<td>429</td>
<td>96</td>
</tr>
<tr>
<td>1989</td>
<td>106</td>
<td>2.60</td>
<td>276</td>
<td>169</td>
<td>0</td>
<td>445</td>
<td>76</td>
</tr>
<tr>
<td>1990</td>
<td>180</td>
<td>3.39</td>
<td>611</td>
<td>135</td>
<td>8</td>
<td>754</td>
<td>66</td>
</tr>
<tr>
<td>1991</td>
<td>90</td>
<td>4.33</td>
<td>390</td>
<td>130</td>
<td>8</td>
<td>528</td>
<td>49</td>
</tr>
<tr>
<td>1992</td>
<td>200</td>
<td>2.82</td>
<td>564</td>
<td>97</td>
<td>92</td>
<td>753</td>
<td>56</td>
</tr>
<tr>
<td>1993</td>
<td>192</td>
<td>2.27</td>
<td>436</td>
<td>97</td>
<td>56</td>
<td>589</td>
<td>54</td>
</tr>
<tr>
<td>1994</td>
<td>44</td>
<td>1.59</td>
<td>70</td>
<td>70</td>
<td>0</td>
<td>140</td>
<td>70</td>
</tr>
<tr>
<td>1995</td>
<td>5</td>
<td>2.20</td>
<td>11</td>
<td>43</td>
<td>0</td>
<td>54</td>
<td>39</td>
</tr>
<tr>
<td>1996</td>
<td>68</td>
<td>2.00</td>
<td>136</td>
<td>80</td>
<td>16</td>
<td>232</td>
<td>63</td>
</tr>
<tr>
<td>1997</td>
<td>73</td>
<td>2.00</td>
<td>146</td>
<td>97</td>
<td>45</td>
<td>288</td>
<td>47</td>
</tr>
<tr>
<td>1998</td>
<td>26</td>
<td>1.94</td>
<td>51</td>
<td>89</td>
<td>4</td>
<td>144</td>
<td>59</td>
</tr>
<tr>
<td>1999</td>
<td>41</td>
<td>2.60</td>
<td>107</td>
<td>136</td>
<td>2</td>
<td>245</td>
<td>1</td>
</tr>
<tr>
<td>2000</td>
<td>92</td>
<td>2.60</td>
<td>239</td>
<td>81</td>
<td>19</td>
<td>339</td>
<td>24</td>
</tr>
<tr>
<td>2001</td>
<td>298</td>
<td>3.00</td>
<td>894</td>
<td>106</td>
<td>12</td>
<td>1,012</td>
<td>71</td>
</tr>
<tr>
<td>2002</td>
<td>299</td>
<td>3.00</td>
<td>897</td>
<td>107</td>
<td>1</td>
<td>1,005</td>
<td>35</td>
</tr>
<tr>
<td>2003</td>
<td>118</td>
<td>3.10</td>
<td>366</td>
<td>77</td>
<td>1</td>
<td>444</td>
<td>56</td>
</tr>
</tbody>
</table>

* 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, Umatilla River strays accounted for 8% of the total Tucannon River run, and that rate increased to 12% in 2000 (Gallinat et al. 2001). The increase in the number of strays, particularly from the Umatilla River, is of concern since it exceeds the allowable 5% stray rate of hatchery fish as deemed acceptable by NOAA Fisheries (formerly NMFS) and is contrary to WDFW management intent for the Tucannon River. Beginning with the 1997 brood year releases, the Oregon Department of Fish and Wildlife (ODFW) and Confederated Tribes of the Umatilla Indian Reservation (CTUIR) ceased marking a portion of Umatilla River origin spring chinook with an RV or LV fin clip (65-70% of releases). Because of this action, fish that returned in 2003 were physically indistinguishable from wild origin spring chinook from the Tucannon River. For 2003, scale samples were collected from all wild fish collected for broodstock and passed upstream at the adult trap. None of these fish were determined to be of hatchery origin 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 wild Tucannon origin fish. The proportion of hatchery and wild 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 will be 100% marked. This will help ensure that Tucannon River spring chinook genetic integrity is maintained by allowing selective removal of strays from the hatchery broodstock.
Juvenile Salmon Evaluation

Hatchery Rearing, Marking, and Release

Hatchery Rearing and Marking

Supplementation juveniles (2002 BY) were marked with a red elastomer tag (VIE) behind the right eye and tagged with CWTs on September 23-October 1, 2003 (127,640 fish). Supplementation fish were transported to TFH during October. The 2002 BY captive brood juveniles (45,236 fish) were marked on September 25-26 with an agency-only wire tag in the snout and transported to TFH during October.

Length and weight samples were collected twice on the 2002 BY fish during the rearing cycle (Table 12). During February, fish were sampled for length, weight and hatchery mark quality, and were PIT tagged for outmigration comparisons (1,016 supplementation fish and 1,029 captive brood progeny) before transfer to Curl Lake.

<table>
<thead>
<tr>
<th>Brood/ Date</th>
<th>Progeny Type</th>
<th>Sample Location</th>
<th>N</th>
<th>Mean Length</th>
<th>CV</th>
<th>K</th>
<th>FPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2/04/04</td>
<td>Supplementation</td>
<td>TFH</td>
<td>266</td>
<td>139.2</td>
<td>13.7</td>
<td>0.88</td>
<td>18.1</td>
</tr>
<tr>
<td>4/05/04</td>
<td>Supplementation</td>
<td>Curl Lake</td>
<td>250</td>
<td>141.7</td>
<td>15.6</td>
<td>1.30</td>
<td>11.7</td>
</tr>
<tr>
<td>2/05/04</td>
<td>Captive Brood</td>
<td>TFH</td>
<td>254</td>
<td>135.5</td>
<td>10.7</td>
<td>0.92</td>
<td>19.1</td>
</tr>
<tr>
<td>4/05/04</td>
<td>Captive Brood</td>
<td>Curl Lake</td>
<td>250</td>
<td>135.0</td>
<td>15.1</td>
<td>1.33</td>
<td>13.2</td>
</tr>
</tbody>
</table>

2002 Brood Release

The 2002 BY pre-smolts were transported to Curl Lake in February 2004 for acclimation and volitional release. Volitional release began April 1 and continued until April 20 when the remaining fish were forced out. Mortalities were low in Curl Lake and WDFW released an estimated 123,586 supplementation fish (11.7 fish/lb) and 44,784 captive broodstock progeny (13.2 fish/lb) (Table 13). Historical hatchery releases are summarized in Appendix D.

<table>
<thead>
<tr>
<th>Release Year</th>
<th>(BY)</th>
<th>Release Location</th>
<th>CWT Code</th>
<th>Number CWT</th>
<th>AD-only marked</th>
<th>Additional mark/cross</th>
<th>Fish/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>(02)</td>
<td>Curl Lake</td>
<td>63/17/91</td>
<td>123,586</td>
<td>N/A</td>
<td>Rt. Red VI, Mixed</td>
<td>10,563</td>
</tr>
<tr>
<td>2004</td>
<td>(02CB)</td>
<td>Curl Lake</td>
<td>63</td>
<td>44,784</td>
<td>N/A</td>
<td>No VI, Mixed</td>
<td>3,393</td>
</tr>
</tbody>
</table>

N/A = Not applicable.
Natural Parr Production

Program evaluation staff surveyed the Tucannon River at index sites in 2003 to estimate the density and population of subyearling (Table 14, 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 sites were snorkeled in 2003 (July 30–August 4), representing approximately 5.0% of the suitable rearing habitat in the Tucannon River. A total of 3,635 subyearling and 49 yearling spring chinook were counted during the surveys. We estimated that 72,197 (± 12,743) subyearling and 940 (± 597) yearling chinook were present in the river (Table 14).

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Number of sites</th>
<th>Area (m$^2$) Snorkeled</th>
<th>Mean Density</th>
<th>Pop. Estimate</th>
<th>C.I.</th>
<th>Mean Density</th>
<th>Pop. Estimate</th>
<th>C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marengo</td>
<td>6</td>
<td>2,911</td>
<td>9.84</td>
<td>5,539</td>
<td>3,381</td>
<td>0.00</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hartsock</td>
<td>14</td>
<td>8,104</td>
<td>11.50</td>
<td>20,763</td>
<td>8,387</td>
<td>0.01</td>
<td>23</td>
<td>45</td>
</tr>
<tr>
<td>HMA</td>
<td>20</td>
<td>11,812</td>
<td>18.04</td>
<td>40,481</td>
<td>9,725</td>
<td>0.20</td>
<td>459</td>
<td>406</td>
</tr>
<tr>
<td>Wilderness</td>
<td>10</td>
<td>3,657</td>
<td>7.63</td>
<td>5,413</td>
<td>2,564</td>
<td>0.64</td>
<td>457</td>
<td>326</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>26,484</td>
<td>13.14</td>
<td>72,197</td>
<td>12,743</td>
<td>0.21</td>
<td>940</td>
<td>597</td>
</tr>
</tbody>
</table>

Natural Smolt Production

Program staff operated a 1.5 m rotary screw trap at rkm 3 on the Tucannon River from October 14, 2002 to July 1, 2003 to estimate numbers of migrating natural and hatchery spring chinook. Other data such as peak outmigration, other species captured, etc., have not been reported here for simplicity. Those data are available upon request.

Natural spring chinook emigrating from the Tucannon River (BY 2001) averaged 104 mm (Figure 8). This is in comparison to an average length of 139 mm for hatchery-origin fish (BY 2001) released from Curl Lake Acclimation Pond (Gallinat et al. 2003).
Regression analysis was used to examine the influence of specific abiotic variables on spring chinook emigration during the last six trapping seasons (1997/1998 to 2002/2003). Significant relationships were found between the total number of wild spring chinook smolts captured (log$_{10}$ transformed for normality) emigrating from the Tucannon River and flow (ft$^3$/sec) ($r^2 = 0.30$, $P<0.01$), staff gauge level ($r^2 = 0.30$, $P<0.01$), time of year ($r^2 = 0.27$, $P<0.01$), and water temperature ($r^2 = 0.13$, $P<0.01$). Although these variables are statistically significant, they account for only a small amount of the variability in the number of emigrating fish. This is understandable as smoltification is a physiological process and the resulting outmigration may only be slightly influenced by abiotic factors. No significant relationship was found between number of wild spring chinook smolts emigrating and secchi disk reading (indicator of turbidity). No significant relationships were also found between the number of hatchery spring chinook smolts captured (log$_{10}$ transformed) and flow, staff gauge level, time of year, water temperature, or secchi disk reading.

Each week we attempted to determine trap efficiency by clipping a portion of the caudal fin on a few representative captured migrants and releasing them one kilometer upstream. The percent of marked fish recaptured was used as an estimate of weekly trapping efficiency. To calculate trapping efficiency during weeks when low numbers of fish were caught we examined the relationship between trap efficiency and the variables flow, staff gauge, number of fish captured, water temperature, and time of year (week). There were no statistically significant relationships.
between trap efficiency for wild and hatchery spring chinook and any of the variables examined.

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

Mean daily flow data was provided by the U.S. Geological Survey gauge station at Starbuck, WA (rkm 12.7). Correlation analysis indicated a statistically significant relationship between flow and the staff gauge level at the smolt trap at the 99% confidence level ($r^2 = 0.97$). As the staff gauge is in close proximity to the smolt trap, trap efficiencies were estimated based on the staff gauge level with the following equations:

**Wild Spring Chinook**
\[
\text{Trap Efficiency} = 28.89 - 0.24 \times \text{(Staff Gauge Level)} \quad (P=0.61)
\]

**Hatchery Spring Chinook**
\[
\text{Trap Efficiency} = 35.52 - 0.58 \times \text{(Staff Gauge Level)} \quad (P=0.31)
\]

To estimate potential juvenile migrants passing when the trap was not operated for short intervals, such as periods when freshets washed out large amounts of debris from the river, we calculated the average number of fish trapped for three days before and three days after non-trapping periods. The mean number of fish trapped daily was then divided by the estimated trap efficiency to calculate fish passage. The estimated number of fish passing each day was then applied to each day the trap was not operated.

It was estimated that 38,079, or 60% of the 2001 BY parr estimates, passed the smolt trap during 2002-2003 (Table 15). We also estimated that 55% of the hatchery supplementation fish and 57% of the captive brood progeny released from Curl Lake Acclimation Pond (2001 BY) passed the smolt trap.
Table 15. Monthly and total population estimates for natural and hatchery origin (supplementation and captive brood) emigrants from the Tucannon River, 2003.

<table>
<thead>
<tr>
<th>Month</th>
<th>Natural</th>
<th>Hatchery</th>
<th>Captive Brood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept.-Feb.</td>
<td>3,243</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>March</td>
<td>4,581</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>April</td>
<td>22,751</td>
<td>50,468</td>
<td>47,194</td>
</tr>
<tr>
<td>May</td>
<td>7,365</td>
<td>30,589</td>
<td>32,694</td>
</tr>
<tr>
<td>June</td>
<td>139</td>
<td>81</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>38,079</td>
<td>81,138</td>
<td>79,909</td>
</tr>
</tbody>
</table>

% Survival\(^a\)  
60.1  
55.2  
56.9

\(^a\) 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 2003, WDFW 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 1,010 supplementation and 1,007 captive brood progeny hatchery-origin fish during the middle of February before transferring them to Curl Lake Acclimation Pond for acclimation and volitional release (Table 16). No fish were killed during PIT tagging, though it is likely that some delayed mortality occurred after release. Detection rates and mean travel days were slightly higher for hatchery spring chinook from the supplementation program than from the captive brood program.

Table 16. Cumulative detection (one unique detection per tag code) and travel time in days (TD) of PIT tagged hatchery spring chinook salmon released from Curl Lake Acclimation Pond (rkm 65.6) on the Tucannon River at downstream Snake and Columbia River dams during 2003. (Fish were volitionally released from 4/01/03-4/21/03).

<table>
<thead>
<tr>
<th>Hatchery Origin</th>
<th>Release Data</th>
<th>Recapture Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean Length</td>
</tr>
<tr>
<td>Supplementation</td>
<td>1,010</td>
<td>125.5</td>
</tr>
<tr>
<td>Captive Brood</td>
<td>1,007</td>
<td>116.5</td>
</tr>
</tbody>
</table>

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

Survival probabilities were estimated by the Cormack Jolly-Seber methodology using the Survival Under Proportional Hazards (SURPH2) computer model. The data files were created using the CAPTHIST program. Data for input into CAPHIST was obtained directly from PTAGIS. Survival estimates from Curl Lake to Lower Monumental Dam were 0.62 (± 0.06) and 0.55 (± 0.06) for supplementation and captive brood progeny, respectively. While survival estimates were slightly lower for captive brood progeny fish the differences were not significant.
Survival Rates

Point estimates of population sizes have been calculated for various life stages (Tables 17 and 18) of natural origin fish from spawning ground and juvenile mid-summer population surveys, smolt trapping, and fecundity estimates. From these two tables, survivals between life stages have been calculated for both natural and hatchery salmon to assist in the evaluation of the hatchery program. These survival estimates provide insight as to where efforts should be directed to improve not only the survival of fish produced within the hatchery, but fish in the river as well.

As expected, juvenile (egg-parr-smolt) survival rates for hatchery fish are considerably higher than for naturally reared salmon (Table 19) because they have been protected in the hatchery. However, smolt-to-adult return rates (SAR) of natural salmon were about three times higher than for hatchery-reared salmon (Tables 20 and 21). The mean hatchery SAR’s (0.17%) documented from the 1985-1998 broods were below the goal SAR of 0.87% established under the LSRCP. Hatchery SAR’s for Tucannon River salmon need to substantially improve to meet the mitigation goal of 1,152 salmon.
Table 17. Estimates of natural Tucannon spring chinook salmon abundance by life stage for 1985-2003 broods.

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Females in river</th>
<th>Mean&lt;sup&gt;a&lt;/sup&gt; fecundity</th>
<th>Number of eggs</th>
<th>Number&lt;sup&gt;b&lt;/sup&gt; of parr</th>
<th>Number of smolts</th>
<th>Progeny&lt;sup&gt;c&lt;/sup&gt; (returning adults)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>219</td>
<td>-</td>
<td>3,883</td>
<td>850,377</td>
<td>90,200</td>
<td>42,000</td>
</tr>
<tr>
<td>1986</td>
<td>200</td>
<td>-</td>
<td>3,916</td>
<td>783,200</td>
<td>102,600</td>
<td>58,200</td>
</tr>
<tr>
<td>1987</td>
<td>185</td>
<td>-</td>
<td>4,096</td>
<td>757,760</td>
<td>79,100</td>
<td>44,000</td>
</tr>
<tr>
<td>1988</td>
<td>117</td>
<td>-</td>
<td>3,882</td>
<td>454,194</td>
<td>69,100</td>
<td>37,500</td>
</tr>
<tr>
<td>1989</td>
<td>103</td>
<td>3</td>
<td>3,883</td>
<td>407,767</td>
<td>58,600</td>
<td>30,000</td>
</tr>
<tr>
<td>1990</td>
<td>128</td>
<td>52</td>
<td>3,993</td>
<td>651,348</td>
<td>86,259</td>
<td>49,500</td>
</tr>
<tr>
<td>1991</td>
<td>51</td>
<td>39</td>
<td>3,741</td>
<td>288,954</td>
<td>54,800</td>
<td>30,000</td>
</tr>
<tr>
<td>1992</td>
<td>119</td>
<td>81</td>
<td>3,854</td>
<td>725,521</td>
<td>103,292</td>
<td>50,800</td>
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<tr>
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<tr>
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<td>39</td>
<td>5</td>
<td>4,187</td>
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<td>7,000</td>
</tr>
<tr>
<td>1995</td>
<td>5</td>
<td>0</td>
<td>5,224</td>
<td>26,120</td>
<td>0</td>
<td>75</td>
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<tr>
<td>1996</td>
<td>53</td>
<td>16</td>
<td>3,516</td>
<td>231,836</td>
<td>2,845</td>
<td>1,612</td>
</tr>
<tr>
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<td>3,609</td>
<td>250,146</td>
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<td>21,057</td>
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<td>19</td>
<td>7</td>
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<td>97,682</td>
<td>8,453</td>
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<td>40</td>
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<td>129,645</td>
<td>15,944</td>
<td>8,157</td>
</tr>
<tr>
<td>2000</td>
<td>26</td>
<td>66</td>
<td>3,969</td>
<td>323,964</td>
<td>44,618</td>
<td>20,045</td>
</tr>
<tr>
<td>2001</td>
<td>219</td>
<td>79</td>
<td>3,612</td>
<td>1,047,936</td>
<td>63,412</td>
<td>38,079</td>
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<tr>
<td>2002</td>
<td>104</td>
<td>195</td>
<td>3,981</td>
<td>1,070,784</td>
<td>72,197</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>67</td>
<td>51</td>
<td>3,789</td>
<td>448,275</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> 1985 and 1989 mean fecundity of natural females is the average of 1986-88 and 1990-93 brood years.

<sup>b</sup> Number of parr estimated from electrofishing (1985-1989), Line transect snorkel surveys (1990-1992), and Total Count snorkel surveys (1993-1999).

<sup>c</sup> Numbers do not include down river harvest or other out-of-basin recoveries.
Table 18. Estimates of Tucannon spring chinook salmon abundance (spawned and reared in the hatchery) by life stage for 1985-2003 broods.

<table>
<thead>
<tr>
<th>Females spawned</th>
<th>Mean(^a) fecundity</th>
<th>Number of eggs</th>
<th>Number of parr</th>
<th>Number of smolts</th>
<th>Progeny(^b) (returning adults)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brood Year</td>
<td>natural</td>
<td>hatchery</td>
<td>natural</td>
<td>hatchery</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>4</td>
<td>-</td>
<td>3,883</td>
<td>-</td>
<td>14,843</td>
</tr>
<tr>
<td>1986</td>
<td>57</td>
<td>-</td>
<td>3,916</td>
<td>-</td>
<td>187,958</td>
</tr>
<tr>
<td>1987</td>
<td>48</td>
<td>-</td>
<td>4,096</td>
<td>-</td>
<td>196,573</td>
</tr>
<tr>
<td>1988</td>
<td>49</td>
<td>-</td>
<td>3,882</td>
<td>-</td>
<td>182,438</td>
</tr>
<tr>
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<td>28</td>
<td>9</td>
<td>3,883</td>
<td>2,606</td>
<td>133,521</td>
</tr>
<tr>
<td>1990</td>
<td>21</td>
<td>23</td>
<td>3,993</td>
<td>2,697</td>
<td>126,334</td>
</tr>
<tr>
<td>1991</td>
<td>17</td>
<td>11</td>
<td>3,741</td>
<td>2,517</td>
<td>91,275</td>
</tr>
<tr>
<td>1992</td>
<td>28</td>
<td>18</td>
<td>3,854</td>
<td>3,295</td>
<td>156,359</td>
</tr>
<tr>
<td>1994</td>
<td>22</td>
<td>21</td>
<td>4,187</td>
<td>3,314</td>
<td>161,707</td>
</tr>
<tr>
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<td>6</td>
<td>15</td>
<td>5,224</td>
<td>0</td>
<td>85,772</td>
</tr>
<tr>
<td>1996</td>
<td>18</td>
<td>19</td>
<td>3,516</td>
<td>2,843</td>
<td>117,287</td>
</tr>
<tr>
<td>1997</td>
<td>17</td>
<td>25</td>
<td>3,609</td>
<td>3,315</td>
<td>144,237</td>
</tr>
<tr>
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<td>30</td>
<td>14</td>
<td>4,023</td>
<td>3,035</td>
<td>161,019</td>
</tr>
<tr>
<td>1999</td>
<td>1</td>
<td>36</td>
<td>3,965</td>
<td>3,142</td>
<td>113,544</td>
</tr>
<tr>
<td>2000</td>
<td>3</td>
<td>35</td>
<td>3,969</td>
<td>3,345</td>
<td>128,980</td>
</tr>
<tr>
<td>2001</td>
<td>29</td>
<td>27</td>
<td>3,612</td>
<td>3,252</td>
<td>184,127</td>
</tr>
<tr>
<td>2002</td>
<td>22</td>
<td>25</td>
<td>3,981</td>
<td>3,368</td>
<td>169,364</td>
</tr>
<tr>
<td>2003</td>
<td>17</td>
<td>20</td>
<td>3,789</td>
<td>3,812</td>
<td>140,658</td>
</tr>
</tbody>
</table>

\(^a\) 1985 and 1989 mean fecundity of natural females is the average of 1986-88 and 1990-93 brood years; 1999 mean fecundity of natural fish is based on the mean of 1986-1998 brood years.

\(^b\) Numbers do not include down river harvest or other out-of-basin recoveries.

\(^c\) Number of smolts is less than actual release number. 57,316 parr were released in October 1993, with an estimated 7% survival. Total number of hatchery fish released from the 1992 brood year was 140,725. We therefore use the listed number of 87,752 as the number of smolts released.
Table 19. Percent survival by brood year for juvenile salmon and the multiplicative advantage of hatchery-reared salmon over naturally-reared salmon in the Tucannon River.

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Natural</th>
<th>Hatchery</th>
<th>Hatchery Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Egg to parr</td>
<td>Parr to smolt</td>
<td>Egg to smolt</td>
</tr>
<tr>
<td>1985</td>
<td>10.6</td>
<td>46.6</td>
<td>4.9</td>
</tr>
<tr>
<td>1986</td>
<td>13.1</td>
<td>56.7</td>
<td>7.4</td>
</tr>
<tr>
<td>1987</td>
<td>10.4</td>
<td>55.6</td>
<td>5.8</td>
</tr>
<tr>
<td>1988</td>
<td>15.2</td>
<td>54.3</td>
<td>8.3</td>
</tr>
<tr>
<td>1989</td>
<td>14.4</td>
<td>51.2</td>
<td>7.4</td>
</tr>
<tr>
<td>1990</td>
<td>13.2</td>
<td>57.4</td>
<td>7.6</td>
</tr>
<tr>
<td>1991</td>
<td>19.0</td>
<td>54.7</td>
<td>10.4</td>
</tr>
<tr>
<td>1992</td>
<td>14.2</td>
<td>49.2</td>
<td>7.0</td>
</tr>
<tr>
<td>1993</td>
<td>12.9</td>
<td>57.1</td>
<td>7.4</td>
</tr>
<tr>
<td>1994</td>
<td>7.1</td>
<td>55.0</td>
<td>3.9</td>
</tr>
<tr>
<td>1995</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
</tr>
<tr>
<td>1996</td>
<td>1.2</td>
<td>56.7</td>
<td>0.7</td>
</tr>
<tr>
<td>1997</td>
<td>13.2</td>
<td>64.0</td>
<td>8.4</td>
</tr>
<tr>
<td>1998</td>
<td>8.7</td>
<td>65.2</td>
<td>5.6</td>
</tr>
<tr>
<td>1999</td>
<td>12.3</td>
<td>51.2</td>
<td>6.3</td>
</tr>
<tr>
<td>2000</td>
<td>13.8</td>
<td>44.9</td>
<td>6.2</td>
</tr>
<tr>
<td>2001</td>
<td>6.1</td>
<td>60.1</td>
<td>3.6</td>
</tr>
<tr>
<td>2002</td>
<td>6.7</td>
<td>89.5</td>
<td>13.3</td>
</tr>
<tr>
<td>Mean</td>
<td>10.7</td>
<td>51.8</td>
<td>6.0</td>
</tr>
<tr>
<td>SD</td>
<td>4.9</td>
<td>14.4</td>
<td>2.6</td>
</tr>
</tbody>
</table>
Table 20. Adult returns and SAR’s of natural salmon to the Tucannon River for brood years 1985-1998.

Number of Adult Returns, observed (obs) and expanded (exp)*

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Estimated number of smolts</th>
<th>Age 3</th>
<th></th>
<th>Age 4</th>
<th></th>
<th>Age 5</th>
<th></th>
<th>SAR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>obs</td>
<td>exp</td>
<td>obs</td>
<td>exp</td>
<td>obs</td>
<td>exp</td>
<td>w/ jacks</td>
</tr>
<tr>
<td>1985</td>
<td>42,000</td>
<td>8</td>
<td>19</td>
<td>110</td>
<td>255</td>
<td>36</td>
<td>118</td>
<td>0.93</td>
</tr>
<tr>
<td>1986*</td>
<td>58,200</td>
<td>1</td>
<td>2</td>
<td>115</td>
<td>376</td>
<td>28</td>
<td>90</td>
<td>0.80</td>
</tr>
<tr>
<td>1987</td>
<td>44,000</td>
<td>0</td>
<td>0</td>
<td>52</td>
<td>167</td>
<td>29</td>
<td>71</td>
<td>0.54</td>
</tr>
<tr>
<td>1988</td>
<td>37,500</td>
<td>1</td>
<td>3</td>
<td>136</td>
<td>335</td>
<td>74</td>
<td>189</td>
<td>1.41</td>
</tr>
<tr>
<td>1989</td>
<td>30,000</td>
<td>5</td>
<td>12</td>
<td>47</td>
<td>120</td>
<td>23</td>
<td>26</td>
<td>0.53</td>
</tr>
<tr>
<td>1990</td>
<td>49,500</td>
<td>3</td>
<td>8</td>
<td>63</td>
<td>72</td>
<td>12</td>
<td>14</td>
<td>0.19</td>
</tr>
<tr>
<td>1991</td>
<td>30,000</td>
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<td>0</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>0.02</td>
</tr>
<tr>
<td>1992</td>
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<td>2</td>
<td>84</td>
<td>159</td>
<td>16</td>
<td>33</td>
<td>0.38</td>
</tr>
<tr>
<td>1993</td>
<td>49,560</td>
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<td>2</td>
<td>62</td>
<td>127</td>
<td>58</td>
<td>75</td>
<td>0.41</td>
</tr>
<tr>
<td>1994</td>
<td>6,000</td>
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<td>0</td>
<td>8</td>
<td>10</td>
<td>1</td>
<td>2</td>
<td>0.20</td>
</tr>
<tr>
<td>1995</td>
<td>75</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>8.00c</td>
</tr>
<tr>
<td>1996</td>
<td>1,612</td>
<td>0</td>
<td>0</td>
<td>27</td>
<td>63</td>
<td>2</td>
<td>6</td>
<td>4.28</td>
</tr>
<tr>
<td>1997</td>
<td>21,057</td>
<td>6</td>
<td>14</td>
<td>234</td>
<td>703</td>
<td>29</td>
<td>82</td>
<td>3.79</td>
</tr>
<tr>
<td>1998</td>
<td>5,508</td>
<td>3</td>
<td>9</td>
<td>86</td>
<td>245</td>
<td>43</td>
<td>121</td>
<td>6.81</td>
</tr>
</tbody>
</table>

Geometric Mean of 1985-1998 broods 0.65 0.64

* 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>
<thead>
<tr>
<th>Brood Year</th>
<th>Estimated number of smolts</th>
<th>Number of Adult Returns, known and expanded (exp.)</th>
<th>SAR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Age 3</td>
<td>Age 4</td>
</tr>
<tr>
<td>1985</td>
<td>12,922</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td>1986</td>
<td>153,725</td>
<td>79</td>
<td>83</td>
</tr>
<tr>
<td>1987</td>
<td>152,165</td>
<td>9</td>
<td>22</td>
</tr>
<tr>
<td>1988</td>
<td>146,200</td>
<td>46</td>
<td>99</td>
</tr>
<tr>
<td>1989</td>
<td>99,057</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>1990</td>
<td>85,500</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>1991</td>
<td>74,058</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>1992</td>
<td>87,752</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>1993</td>
<td>138,848</td>
<td>11</td>
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</tr>
<tr>
<td>1994</td>
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<td>4</td>
</tr>
<tr>
<td>1995</td>
<td>62,272</td>
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<td>16</td>
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<td>1996</td>
<td>76,219</td>
<td>44</td>
<td>60</td>
</tr>
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<td>1997</td>
<td>24,186</td>
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</tr>
<tr>
<td>1998</td>
<td>127,939</td>
<td>36</td>
<td>103</td>
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</table>

Geometric Mean of 1985-1998 broods

0.17

0.14
While SAR’s were lower for hatchery salmon, overall survival of hatchery salmon to return as adults was higher than for naturally reared fish because of the early-life survival advantage provided by the hatchery (Table 19). With the exception of the 1988 and 1997-1999 brood years, naturally produced fish have been below the replacement level (Figure 9; Table 22). Based on adult returns from the 1985-1999 broods, naturally reared salmon produced 0.6 adults for every spawner, while hatchery reared fish produced 1.7 adults.

Figure 9. Return per spawner ratio (with replacement line) for the 1985-1999 brood years.
Table 22. Parent-to-progeny survival estimates of Tucannon River spring chinook salmon from 1985 through 1999 brood years (1999 incomplete).

<table>
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<tr>
<th>Brood Year</th>
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<th></th>
<th></th>
<th>Hatchery Salmon</th>
<th></th>
<th></th>
<th></th>
<th>Hatchery to Natural advantage</th>
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</thead>
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<td></td>
<td>Number of spawners</td>
<td>Number of returns</td>
<td>Return/spawner</td>
<td>Number of spawners</td>
<td>Number of returns</td>
<td>Return/spawner</td>
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<td>339</td>
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</tr>
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<td>87</td>
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<td>3.0</td>
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<td>1.99</td>
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<td>91</td>
<td>207</td>
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<td>1994</td>
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<td>69</td>
<td>34</td>
<td>0.49</td>
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<td>74</td>
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<td>89</td>
<td>181</td>
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<td>122</td>
<td>26</td>
<td>0.21</td>
<td>0.2</td>
<td></td>
</tr>
</tbody>
</table>

Geometric Mean | 0.59 | 1.74 | 3.0 |
Fishery Contribution

An original goal of the LSRCP supplementation program was to enhance wild (natural) returns of salmon to the Tucannon River by providing 1,152 hatchery-reared fish (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 of the stock and increased spawning. However, hatchery adult returns have always been below the program goal. Moreover, natural escapement, with the exception of the 2001 and 2002 runs, has been low (Figure 10). Based on 1985-1998 brood year CWT recoveries from the RMIS database (Appendix F), sport and commercial harvest combined has only accounted for 7.6% of the adult hatchery fish recovered annually. However, fishing mortality (both sport and commercial) has increased in recent years to 22% and 20% for the 1997 and 1998 brood years, respectively (Appendix F). Fishing mortality is one form of mortality managers can control. Adipose clipped hatchery fish have traditionally been targeted in the sport fishery. This hatchery fin clip was abandoned for Tucannon River spring chinook smolts starting with the 2000 BY to mitigate fishing mortality on this ESA listed population (Gallinat et al. 2001). Supplementation fish are now marked with a CWT and a red VIE tag behind the right eye. Captive brood progeny are marked only with agency-only wire tags to distinguish them from supplementation origin fish. Out-of-basin stray rates of Tucannon River spring chinook have been low (Appendix F), with an average of 3.5% of the adult hatchery fish straying to other river systems/hatcheries for brood years 1985-1998 (range 0-20%).
Figure 10. Total escapement for Tucannon River spring chinook salmon for the 1985-2003 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 of the program. This occurred because SARs of hatchery origin fish have consistently been below the expected SAR as described under the LSRCP, even though hatchery returns have generally been at 2-3 times the replacement level. Further, the natural population of spring chinook salmon 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. The result has been a slow but steady replacement of the natural population with the hatchery population. While this neither was, nor is the desired result of the program, in many ways the hatchery program has helped conserve the natural population within the river by returning adults to spawn in the river. System survivals (in-river, migration corridor, ocean) must increase in the future for the hatchery program and the natural run to reach their full potential, and the spring chinook run returned to its historic levels.

Until that time, the evaluation program will continue to document and study life history survivals, genotypic and phenotypic traits, and examine procedures within the hatchery that can be improved to benefit the program 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 difference between natural and hatchery populations.

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

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

   Recommendation: Continue to seek funding for a DNA based pedigree analysis study to examine the reproductive success of hatchery fish in the natural environment. Continue to
use snorkel surveys during the summer months to estimate spring chinook parr production in the river. Examine the relationship between redd counts and the following-year’s parr production, smolt numbers and returning adults in context of the proportion of hatchery spawners in the river. Publish the results.

3. Smolt trapping is our most valuable tool in estimating the number of fish emigrating from the river. Having accurate emigration estimates and knowing the confidence limits of those estimates is pertinent in calculating reliable survival rates.

**Recommendation**: Work with WDFW statisticians to refine our smolt trapping methods and statistical analyses. Publish statistical methods relating abiotic factors to smolt trap efficiency rates in the scientific literature.

4. Subbasin and recovery planning for 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 would be helpful in developing and evaluating recovery strategies for habitat, hydropower, harvest and hatcheries.

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

5. Smolt and adult detection capabilities for PIT tagged salmon within the Columbia and Snake River basins are becoming more widespread. These capabilities can help estimate survival rates for release groups to aid in evaluation of program success.

**Recommendation**: Utilize the SURPH2 PIT tag model software and present summaries of juvenile rates in future reports. Increase sample size of PIT tags if necessary, and document stray Tucannon fish above lower Granite Dam.

6. 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 SAR’s in order to meet mitigation goals.

**Recommendation**: Initiate a meeting between biologists working with spring chinook, both within and outside of the Snake River Basin, to compare survival rates from different watersheds under different rearing and release strategies. Provide recommendations to improve SAR, or a list of recommended research topics for managers to consider that would provide answers to improve hatchery survival.


Griffith, J. S. 1981. Estimation of the age-frequency distribution of stream-dwelling trout by


Appendix A

Spring chinook captured, collected, or passed upstream at the Tucannon Hatchery trap in 2003
Appendix A. Spring chinook salmon captured, collected, or passed upstream at the Tucannon Hatchery trap in 2003.
(Trapping began in February; last day of trapping was September 30).

<table>
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<tr>
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<th>Collected for broodstock</th>
<th>Passed upstream</th>
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</thead>
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<td></td>
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<td>Natural Hatchery</td>
<td>Natural Hatchery</td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
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<tr>
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<td></td>
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Appendix A (continued). Spring chinook salmon captured, collected, or passed upstream at the Tucannon Hatchery trap in 2003.

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Appendix B

Estimated total run-size of Tucannon River spring chinook salmon (1985-2003)

<table>
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<th>Wild Jacks</th>
<th>Wild Adults</th>
<th>Total Wild</th>
<th>Hatchery Jacks</th>
<th>Hatchery Adults</th>
<th>Total Hatchery</th>
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<td>169</td>
<td>196</td>
<td>444</td>
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</table>
Appendix C

Appendix C. Summary of identified stray hatchery origin spring chinook salmon that escaped into the Tucannon River (1990-2003).

<table>
<thead>
<tr>
<th>Year</th>
<th>CWT Code or Fin clip</th>
<th>Agency</th>
<th>Origin (stock)</th>
<th>Release Location / Release River</th>
<th>Number Observed/ Expanded&lt;sup&gt;a&lt;/sup&gt;</th>
<th>% of Tuc. Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>074327 ODFW</td>
<td>Carson (Wash.)</td>
<td>Meacham Cr. / Umatilla River</td>
<td>2 / 5</td>
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<td></td>
</tr>
<tr>
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<td>074020 ODFW</td>
<td>Rapid River</td>
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<td>Mixed Col.</td>
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<td>232228 NMFS</td>
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<td>Columbia River / McNary Dam</td>
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<td>1 / 2</td>
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<td>Knox Bridge / South Fork Salmon</td>
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</tr>
<tr>
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<td>103518 IDFG</td>
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<tr>
<td></td>
<td>104626 UI</td>
<td>Eagle Creek NFH</td>
<td>Eagle Creek NFH / Clackamas R.</td>
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<td>ODFW</td>
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<td>2 / 2</td>
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<sup>a</sup> 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 (1990-2003).

<table>
<thead>
<tr>
<th>Year</th>
<th>CWT Code or Fin clip</th>
<th>Agency</th>
<th>Origin (stock)</th>
<th>Release Location / Release River</th>
<th>Number Observed/Expanded</th>
<th>% of Tuc. Run</th>
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<td>2000</td>
<td>092259 ODFW</td>
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<td>092262 ODFW</td>
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<tr>
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<td>105137 IDFG</td>
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<td>Walton Creek/Lochsa R.</td>
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<td>636330 WDFW</td>
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<tr>
<td></td>
<td>636321 WDFW</td>
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<td>Umatilla Hatch./Umatilla River</td>
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<td>Lookinglass/Immaha River</td>
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<td>Dworshak</td>
<td>Dworshak NFH/Clearwater</td>
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<td>Umatilla Hatch./Umatilla River</td>
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<td>076138 ODFW</td>
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<td>Total Umatilla River</td>
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</table>

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

Historical hatchery releases
(1985-2002 brood years)
## Appendix D. Historical hatchery spring chinook releases from the Tucannon River, 1985-2002 brood years.  (Totals are summation by brood year, not by release year.)

<table>
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<th>Release Year</th>
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<th>CWT Number</th>
<th>Ad-only marked</th>
<th>Additional Tag/location/cross</th>
<th>Lbs</th>
<th>Fish/lb</th>
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* 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).

* All tag codes start with agency code 63.

* 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.

* No tag loss data due to presence of both CWT and BWT in fish.

* VI tag only.

* No wire.
Appendix E

Numbers and density estimates (fish/100 m$^2$) of juvenile salmon counted by snorkel surveys in the Tucannon River in 2003
Appendix E. Numbers and density estimates of subyearling and yearling natural salmon, and yearling hatchery chinook counted by snorkel surveys in the Tucannon River, 2003.

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Tucannon River Spring Chinook Salmon Hatchery Evaluation Program

September 2004

2003 Annual Report

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Totals 3,635 49 0 26,484
Appendix F

Recoveries of coded-wire tagged salmon released into the Tucannon River for the 1985-1998 brood years
**Appendix F.** 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 1985-1998 brood years. (Data from RMIS database.)

<table>
<thead>
<tr>
<th>Brood Year</th>
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| 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    |                 |                  |                 |                 |                 |                 |
| Mixed Net & Seine         |                 |                  |                 |                 |                 |                 |
| Ocean Sport               |                 |                  |                 |                 |                 |                 |

| USFWS                     |                 |                  |                 |                 |                 |                 |
| Warm Springs Hatchery     |                 |                  |                 |                 |                 |                 |
| Dworshak NFH              |                 |                  |                 |                 |                 |                 |

**Total Returns**

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¹ WDFW agency code prefix is 63.
² Fish trapped at TFH and held at LFH for spawning.
**Appendix F.** 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 1985-1998 brood years.
(Data from RMIS database.)

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<th>Release Year</th>
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1 WDFW agency code prefix is 63.
2 Fish trapped at TFH and held at LFH for spawning.
return to the Tucannon Basin, out-of-basin returns, and estimated survival and exploitation rates for the 1985-1998 brood years.
(Data from RMIS database.)

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¹ WDFW agency code prefix is 63.
² Fish trapped at TFH and held at LFH for spawning.
Appendix F. 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 1985-1998 brood years. (Data from RMIS database.)

<table>
<thead>
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<th>Brood Year</th>
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</table>

| Total Returns              | 117             | 287             | 24              | 32              | 132            | 187             |

| Tucannon (%)               | 96.2            | 100.0           | 98.9            |                 |                 |                 |
| Out-of-Basin (%)           | 1.7             | 0.0             | 1.1             |                 |                 |                 |
| Commercial Harvest (%)     | 1.0             | 0.0             | 0.0             |                 |                 |                 |
| Sport Harvest (%)          | 1.0             | 0.0             | 0.0             |                 |                 |                 |
| Survival                   | 0.21            | 0.02            | 0.30            |                 |                 |                 |

¹ WDFW agency code prefix is 63.
² Fish trapped at TFH and held at LFH for spawning.
Appendix F. 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 1985-1998 brood years. (Data from RMIS database.)

<table>
<thead>
<tr>
<th>Brood Year</th>
<th>Smolts Released</th>
<th>Fish/Lb</th>
<th>CWT Codes¹</th>
<th>Release Year</th>
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<td>76,028</td>
<td>23,509</td>
<td>124,093</td>
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<td>16.0</td>
<td>16.0</td>
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<tr>
<th>Agency (fishery/location)</th>
<th>Observed Number</th>
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<th>Observed Number</th>
<th>Estimated Number</th>
<th>Observed Number</th>
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<tr>
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<table>
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<tr>
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<th>73</th>
<th>171</th>
<th>245</th>
<th>844</th>
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<td>76.6</td>
<td>78.9</td>
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<td>Out-of-Basin (%)</td>
<td>1.2</td>
<td>1.7</td>
<td>1.2</td>
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<tr>
<td>Commercial Harvest (%)</td>
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<td>12.9</td>
<td>8.2</td>
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<tr>
<td>Sport Harvest (%)</td>
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<td>8.8</td>
<td>11.7</td>
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<td>Survival</td>
<td>0.32</td>
<td>0.73</td>
<td>0.68</td>
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</tbody>
</table>

¹ WDFW agency code prefix is 63.
² Fish trapped at TFH and held at LFH for spawning.
This program receives Federal financial assistance from the U.S. Fish and Wildlife Service. It is the policy of the Washington State Department of Fish and Wildlife (WDFW) to adhere to the following: 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 contact the WDFW ADA Coordinator at 600 Capitol Way North, Olympia, Washington 98501-1091 or write to:

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