Grande Ronde Basin Spring Chinook Salmon Captive Broodstock Program: F₁ Generation

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Oregon Department of Fish and Wildlife
Background

Captive Broodstock Rearing

Captive Broodstock Program F_1 Generation vs. Conventional Hatchery Program
History

- Steady decline in Chinook salmon abundance in the Grande Ronde Basin since the late 1950’s.
- Lower Snake River Compensation Plan (LSRCP) was initiated in Oregon in the late 1970s - hatchery supplementation began with the 1982 cohort
  - Carson stock: 1982-1987 cohorts
  - Rapid River stock: 1986-1996 cohorts
- Neither stock performed well in the Grande Ronde Basin.
Adult Returns 1960-1995

Run year
Escapement
0
1000
2000
3000
4000
5000
Total
Catherine Creek
Lostine River
Upper Grande Ronde River
Snake River spring Chinook salmon were listed as threatened in 1992.

Grande Ronde Basin streams still had genetically distinct populations.

- ODFW began to manage for native stocks.
LSRCP Management Objectives

- Establish adequate broodstock to meet annual production needs.
- Restore and maintain natural spawning populations of spring Chinook salmon in the Grande Ronde Basin.
- Reestablish historic tribal and recreational fisheries.
- Mitigation goals for the Grande Ronde Basin:
  - Release 900,000 smolts annually
  - 0.65% smolt-to-adult survival
  - Establish an annual return of 5,820 hatchery fish.
- Minimize impacts of the hatchery program on resident stocks.
- Maintain endemic wild populations of spring Chinook salmon in the Minam and Wenaha rivers.
Life History of Captive Broodstock

1. Collect Wild Parr
2. Rear to Smolt
3. Post-smolt Rearing (Freshwater or Saltwater)
4. Spawn Within Stocks
5. Rear $F_1$ Generation to Smoltification
6. Release $F_1$ Generation in Parent’s Natal Stream
7. Returning Adults Allowed to Spawn in Nature
8. $F_2$ Generation
Captive Broodstock Results
## Targets & Results - Rearing

<table>
<thead>
<tr>
<th>Collection</th>
<th>500</th>
<th>Yes, except GR 1994, 1995, 1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex ratio</td>
<td>1F:1M</td>
<td>1F:1.08M</td>
</tr>
<tr>
<td>Growth</td>
<td>Similar to natural</td>
<td>~35% smaller</td>
</tr>
<tr>
<td>Survival</td>
<td>Parr-smolt</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>Smolt-adult</td>
<td>55%</td>
</tr>
<tr>
<td>Overall</td>
<td>50%</td>
<td>53%</td>
</tr>
</tbody>
</table>
## Targets & Results - Spawning

<table>
<thead>
<tr>
<th>Age at maturation</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Females</strong></td>
<td>0 / 0</td>
<td>6 / 1</td>
<td>78 / 88</td>
<td>16 / 11</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td>2 / 20</td>
<td>35 / 69</td>
<td>48 / 10</td>
<td>15 / 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spawn timing</th>
<th>August-September</th>
<th>September-October</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fecundity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predicted</td>
<td>1200</td>
<td>3000</td>
</tr>
<tr>
<td>Actual</td>
<td>1232</td>
<td>1715</td>
</tr>
</tbody>
</table>

~20% (0-77%) of collected eggs have been culled for BKD prevention.
## Targets & Results – $F_1$ Generation

<table>
<thead>
<tr>
<th></th>
<th>Predicted</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertility</td>
<td>75%</td>
<td>85%</td>
</tr>
<tr>
<td>Eyed egg-smolt survival</td>
<td>80%</td>
<td>83%</td>
</tr>
<tr>
<td>Return Rate</td>
<td>0.1%</td>
<td>0.35%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age Composition</th>
<th>Age 3</th>
<th>Age 4</th>
<th>Age 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted</td>
<td>10</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td>Actual</td>
<td>15</td>
<td>71</td>
<td>14</td>
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</table>
F1 Smolt Production

Catherine Creek

Grande Ronde River

Lostine River

Number of smolts

Captive Broodstock Target

Brood year


0 50000 100000 150000 200000 250000
Program Challenges

- Inability to collect 500 parr each year in the Grande Ronde River
- Reduce BKD-caused mortality
- Reduce BKD culling
- Improve growth of saltwater fish
- Synchronize maturation timing with wild fish
- Early detection of maturing fish
- Improve egg-to-smolt survival of $F_1$ generation
- Disposition of excess $F_1$ fish in years of overproduction

Success of program will be determined by returns of $F_2$ generation
Captive Broodstock Program
F₁ Generation
vs.
Conventional Hatchery Program
Eyed Egg-to-Smolt Survival

- Captive Broodstock
- Conventional Broodstock

Eyed egg-to-smolt survival

Catherine Creek
Grande Ronde River
Lostine River

Captive Broodstock
Conventional Broodstock

natural rate
Juvenile Survival to LGD

Catherine Creek

Grande Ronde River

Lostine River

Survival to Lower Granite Dam

Natural
Captive
Conventional

Survival to Lower Granite Dam

Brood year

Survival to Lower Granite Dam

Brood year

Survival to Lower Granite Dam

Brood year
Adult Returns

Catherine Creek  
LSRCP Goal = 970

<table>
<thead>
<tr>
<th>Brood year</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
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<tbody>
<tr>
<td>Adult escapement to stream</td>
<td>400</td>
<td>400</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>600</td>
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</table>

Grande Ronde River  
LSRCP Goal = 1617

<table>
<thead>
<tr>
<th>Brood year</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult escapement to stream</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
</tbody>
</table>

* CBS smolts w/o ad clip

No CBS released
Smolt-to-Adult Survival (SAR)

Catherine Creek

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>3.2</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Captive</td>
<td>1.1</td>
<td>1.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conventional</td>
<td>0.8</td>
<td>0.8</td>
<td></td>
<td></td>
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</table>

Grande Ronde River

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Target</td>
<td>4.0</td>
<td>4.0</td>
<td>1.7</td>
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</table>

LSRCP Captive Broodstock Target
Size at Maturity

Females
- Captive Broodstock
- Conventional Broodstock
- Natural

Males

Fork length (mm, ± SD)

Age:
- Females: 4, 5
- Males: 3, 4, 5
Age Composition

Catherine Creek

<table>
<thead>
<tr>
<th>Age class</th>
<th>Proportion</th>
</tr>
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<tbody>
<tr>
<td>3</td>
<td>0.0</td>
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<tr>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Grande Ronde River

<table>
<thead>
<tr>
<th>Age class</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>0.2</td>
</tr>
</tbody>
</table>
Recruits per Spawner

Catherine Creek

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural</th>
<th>Captive</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1999</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2000</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>2001</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>2002</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>2003</td>
<td>0</td>
<td>0</td>
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</tr>
<tr>
<td>2004</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2005</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Grande Ronde River

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural</th>
<th>Captive</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1999</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2000</td>
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<tr>
<td>2001</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2002</td>
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<td>2003</td>
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</tr>
<tr>
<td>2004</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2005</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Summary – $F_1$ Generation

- Egg-to-smolt survival better in Conventional Program
- Smolt production – rarely achieved CBS or LSRCP goals
- Survival to Lower Granite Dam better for Conventional Program
- Adult returns – usually met Captive Broodstock goal but not LSRCP goal
- SAR – met Captive Broodstock but not LSRCP
- Size at maturity – similar among programs and with Natural
- Age composition similar between programs but younger than Natural
- Stray rate higher in Captive Broodstock
- Run timing similar between program and with Natural
- Spawning distribution – hatchery fish tend to spawn near acclimation site
- Recruits per spawner higher in Conventional Program. CBS low due to low fecundity and fertility.
## CBS vs. CHP vs. Natural Production

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Natural</th>
<th>CHP</th>
<th>CBS</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rate</td>
<td>Number</td>
<td>Rate</td>
<td>Number</td>
</tr>
<tr>
<td>Fecundity</td>
<td>4,141</td>
<td>0.44</td>
<td>3,977</td>
<td>0.14</td>
</tr>
<tr>
<td>Fertility</td>
<td>0.906</td>
<td>1,840</td>
<td>0.891</td>
<td>570</td>
</tr>
<tr>
<td>Eyed-to-Parr</td>
<td>0.3</td>
<td>1,667</td>
<td>0.965</td>
<td>508</td>
</tr>
<tr>
<td>Number of parr</td>
<td>500</td>
<td></td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>Parr-to-Smolt</td>
<td>0.13</td>
<td>65</td>
<td>0.98</td>
<td>490</td>
</tr>
<tr>
<td>Smolt-to-Adult</td>
<td>0.019</td>
<td>1.2</td>
<td>0.005</td>
<td>2.3</td>
</tr>
<tr>
<td>Sex Ratio</td>
<td>0.5</td>
<td>0.6</td>
<td>0.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Fecundity</td>
<td>4,141</td>
<td>2,492</td>
<td>3,977</td>
<td>4,492</td>
</tr>
<tr>
<td>Fertility</td>
<td>0.906</td>
<td>2,258</td>
<td>0.0891</td>
<td>4,002</td>
</tr>
<tr>
<td>BKD Culling</td>
<td>1</td>
<td>2,258</td>
<td>0.99</td>
<td>3,962</td>
</tr>
<tr>
<td>Eyed-to-Smolt</td>
<td>0.039</td>
<td>88</td>
<td>0.965</td>
<td>3,824</td>
</tr>
<tr>
<td>Smolt-to-Adult</td>
<td>0.019</td>
<td>2</td>
<td>0.005</td>
<td>18</td>
</tr>
</tbody>
</table>
Conclusions

Captive Broodstock programs can rapidly increase numbers of returning adults but has issues to address:

- Growth and Fecundity
- Disease and Culling
- F₁ performance in hatchery and nature
- Amplifying genes in population?
F₂ Generation?
Questions?
Captive Broodstock Life History
Captive Broodstock Life History

[Map showing various river locations in Oregon and Washington: Grande Ronde River, Imnaha River, Wallowa River, Lostine River, Catherine Creek, River, etc.]
Captive Broodstock Life History

Grande
Ronde
River Snake
Imnaha River
Wallowa River
Lostine River
La Grande
Catherine Creek
Washington
Idaho
Oregon
Snake River
Imnaha River
Captive Broodstock Life History

- Grande
- Ronde
- Imnaha
- Wallowa
- Lostine River
- La Grande
- Catherine Creek
- Imnaha River
- Snake River
- Idaho
- Oregon
- Washington
Captive Broodstock Life History

- Grande River
- Grande Ronde River
- Imnaha River
- Wallowa River
- Lostine River
- Catherine Creek
- Snake River
- Idaho
- Washington
- Oregon
Spawning Distribution

- Catherine Creek
- Lostine River
- Upper Grande Ronde River

Proportion of female carcasses

Reach (upstream ➔)

- Weir
- Acclimation
- Natural
- Captive Broodstock
- Conventional
Run Timing

Catherine Creek - 2006

Week of the year
22 23 24 25 26 27 28 29 30 31
Proportion
0.0
0.1
0.2
0.3
0.4
0.5
Natural
Captive
Conventional

Grande Ronde River - 2005

Week of the year
22 23 24 25 26 27 28 29 30 31
Proportion
0.0
0.1
0.2
0.3
0.4
0.5
Natural
Captive
Conventional
F1 Migration Timing – Grande Ronde River

Percent of migrants detected at Snake/Columbia river dams

- Captive broodstock F1’s
- Wild fish

Forced Release: 15 MAR
Assumptions/Targets

Collection .................. 500 parr/stock/year

Sex ratio ............................................. 1:1

Age at maturation:

<table>
<thead>
<tr>
<th>Age</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent females</td>
<td>0</td>
<td>6</td>
<td>78</td>
<td>16</td>
</tr>
<tr>
<td>Percent males</td>
<td>2</td>
<td>35</td>
<td>48</td>
<td>15</td>
</tr>
</tbody>
</table>
Assumptions/Targets continued

Female maturation timing .............. Aug/Sept

Female gamete production:

<table>
<thead>
<tr>
<th>Age</th>
<th>Number of eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1200</td>
</tr>
<tr>
<td>4</td>
<td>3000</td>
</tr>
<tr>
<td>5</td>
<td>4000</td>
</tr>
</tbody>
</table>

Survival .......................... 90% parr to smolt
                     55% smolt to adult
                     50% overall
Assumptions/Targets continued

Egg viability.........................................................75%

F₁ egg-to-smolt survival.................................80%

Return Rate of F₁’s.............................................0.1%

F₁ age of maturity:

<table>
<thead>
<tr>
<th>Age</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent return</td>
<td>10%</td>
<td>60%</td>
<td>30%</td>
</tr>
</tbody>
</table>
Summary

- **Parr Collections:**
  - Met goal of 500 parr/stock/year (except for Grande Ronde River BY’s 1994, 1995 and 1999)

- **Growth:**
  - Growth was slower than expected

- **Survival:**
  - Parr-to-Smolt survival was above 95% expected
  - Smolt-to-Spawn survival met the 55% goal but varied widely

- **Mortality:**
  - BKD was the largest causes of mortality

- **Maturity and Spawning:**
  - Males matured earlier than expected – most Age 3
  - Females matured later than expected – fewer Age 4, more Age 5
  - Fecundity was 60% lower than expected
Endpoints and Off ramps

- Disposition of excess F\textsubscript{1} fish in years of overproduction.
  - We have outlet streams into which we can stock excess production.
- Endpoints for program - goal of consistent return of 150 adults spawning in nature.
  - We have achieved this goal for the Catherine Creek and Lostine River populations. The 2005 brood year was the last collected for these populations.
  - Upper Grande Ronde River population has not achieved this goal and the program is continuing as a Safety Net Program.
Captive Broodstock Program Objectives

- Prevent extinction of the native Catherine Creek, Lostine River and upper Grande Ronde River Chinook salmon populations.
- Maintain genetic diversity of indigenous artificially propagated Chinook salmon populations.
- Maintain the genetic diversity in wild, endemic Chinook salmon populations in the Minam and Wenaha rivers.
- Provide a future basis and methodologies to reverse declines in stock abundance and ensure a high probability of population persistence until causes of population declines have been addressed.
- Establish an annual supply of spring Chinook salmon broodstock capable of meeting annual hatchery production goals.
- Restore and maintain naturally spawning populations of spring Chinook salmon.

Captive Broodstock offspring would be incorporated into the Lower Snake River Compensation Plan production.
Monitoring and Evaluation Objectives

- Monitor, assess and compare the effects of pre- and post-smolt rearing treatments.
- Develop and evaluate the effectiveness of innovative methodologies for rearing, spawning and disease treatment and prevention.
- Monitor and compare aspects of life history and production performance between Captive and Conventional broodstock programs.
- Monitor and assess the performance of captive broodstock offspring in captivity (pre-smolt) and in nature (post-smolt) and their offspring.
- Assess our ability to achieve the genetic conservation goals and production benchmarks.
- Develop and maintain a comprehensive database for the program.