Grande Ronde Basin Spring Chinook Salmon Captive Broodstock Program: $F_1$ Generation

Tim Hoffnagle, Rich Carmichael, Joseph Feldhaus, Deb Eddy, Nick Albrecht and Sally Gee

Oregon Department of Fish and Wildlife
Adult Returns 1960-1995

_escapement_ vs. _run year_

- Total
- Catherine Creek
- Lostine River
- Upper Grande Ronde River
History

- Steady decline in abundance 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.
- Snake River spring Chinook salmon were listed as threatened in 1992.
- ODFW began to manage for native stocks.
  - Grande Ronde Basin streams still had genetically distinct populations.
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.
Captive Broodstock Program Objectives

ียว 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 (F₁ generation) would be incorporated into the LSRCP 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.
Life History of Captive Broodstock

1. Collect Wild Parr
2. Rear to Smolt (accelerated or natural growth)
3. Post-smolt Rearing (Freshwater or Saltwater)
4. Spawn Within Stocks
5. Rear F₁ Generation to Smoltification
6. Release F₁ Generation in Parent’s Natal Stream
7. Returning Adults Allowed to Spawn in Nature
Grande Ronde River Basin

Grande River
Ronde River
Snake River
Imnaha River
Wallowa River
Catherine Creek
La Grande
Washington
Oregon
Idaho
Snake River
Imnaha River
Captive Broodstock Results
## Assumptions/Targets - Production

<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>Parr-smolt</td>
<td>90%</td>
<td>97%</td>
</tr>
<tr>
<td>Smolt-adult</td>
<td>55%</td>
<td>55%</td>
</tr>
<tr>
<td>Overall</td>
<td>50%</td>
<td>53%</td>
</tr>
</tbody>
</table>

BKD was the greatest cause of mortality
## Assumptions/Targets - 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>Females</td>
<td>0 / 0</td>
<td>6 / 1</td>
<td>78 / 88</td>
<td>16 / 11</td>
</tr>
<tr>
<td>Males</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>Fecundity</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 were culled for BKD prevention.
### Assumptions/Targets – F<sub>1</sub> Generation

<table>
<thead>
<tr>
<th></th>
<th>Age 3</th>
<th>Age 4</th>
<th>Age 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predicted</strong></td>
<td>10</td>
<td>60</td>
<td>30</td>
</tr>
<tr>
<td><strong>Actual</strong></td>
<td>15</td>
<td>71</td>
<td>14</td>
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</table>
F_1_ Returns

Catherine Creek

<table>
<thead>
<tr>
<th>Brood year</th>
<th>Actual returns</th>
<th>Return goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
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<td>2001</td>
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<tr>
<td>2002</td>
<td></td>
<td></td>
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<tr>
<td>2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grande Ronde River

<table>
<thead>
<tr>
<th>Brood year</th>
<th>Actual returns</th>
<th>Captive Broodstock Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
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<tr>
<td>2001</td>
<td></td>
<td></td>
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<tr>
<td>2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 vs. Conventional Hatchery Program
Eyed egg-to-smolt survival

- **Captive Broodstock**
- **Conventional Broodstock**

<table>
<thead>
<tr>
<th>River</th>
<th>Captive Broodstock</th>
<th>Conventional Broodstock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catherine Creek</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>Grande Ronde</td>
<td>0.7</td>
<td>0.9</td>
</tr>
<tr>
<td>Lostine River</td>
<td>0.7</td>
<td>0.9</td>
</tr>
</tbody>
</table>
Smolt Release

Catherine Creek

Grande Ronde River

Lostine River

Number of smolts

Captive Broodstock

Conventional Broodstock

Brood year

LSRCP target

CBS target
Juvenile Survival to LGD

Catherine Creek
- Natural
- Captive
- Conventional

Grande Ronde River

Lostine River

Survival to Lower Granite Dam

Brood year
- 1998
- 2000
- 2002
- 2004
- 2006
Smolt-to-Adult Survival (SAR)

Catherine Creek

- Natural
- Captive
- Conventional

Grande Ronde River

- LSRCP Target
- Captive Broodstock Target

SAR (to stream)
Size at Maturity

Females
- Captive Broodstock
- Conventional Broodstock
- Natural

Males
Age Composition

Catherine Creek

Age class 3 4 5

Proportion

Natural Captive Conventional

Grande Ronde River

Age class 3 4 5
Stray Rate

Catherine Creek

Stray rate (proportion)

Brood year

1998 1999 2000 2001 2002 2003 2004

Captive

Conventional

Grande Ronde River

Stray rate (proportion)

Brood year

1998 1999 2000 2001 2002 2003 2004
Recruits per Spawner

Catherine Creek

Brood year
1998 1999 2000 2001 2002 2003 2004

R:S (total offspring / female parent)

Captive
Conventional

Grande Ronde River

Brood year
1998 1999 2000 2001 2002 2003 2004
Summary – $F_1$ Generation

- Egg-to-smolt survival better in Conventional Program
- Smolt production – rarely achieved CBS or LSRCP goals
- Survival to LGD better for Conventional Program
- Adult returns – often met Captive Broodstock goal but not LSRCP
- 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 can rapidly increase numbers of returning adults but has issues to address:

- Growth / Fecundity
- Disease / Culling
- $F_1$ performance in hatchery
- Amplifying genes in population?
### Adult Returns 1960-2009

<table>
<thead>
<tr>
<th>Run year</th>
<th>Escapement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>0</td>
</tr>
<tr>
<td>1970</td>
<td>1000</td>
</tr>
<tr>
<td>1980</td>
<td>2000</td>
</tr>
<tr>
<td>1990</td>
<td>3000</td>
</tr>
<tr>
<td>2000</td>
<td>4000</td>
</tr>
</tbody>
</table>

**Graph Key:**
- Total
- Catherine Creek
- Lostine River
- Upper Grande Ronde River
F₂ Generation?
Questions?
F<sub>1</sub> Migration Timing – Grande Ronde River

**Percent of migrants detected at Snake/Columbia river dams**

- **Captive broodstock F1's**
- **Wild fish**

**Forced Release 15 MAR**
**F\textsubscript{1} Migration Timing – Lostine River**

- **Percent of migrants detected at Snake/Columbia river dams**

  - **Volitional**
  - **Forced**

- **Dates:** 1 APR, 8 APR, 15 APR, 22 APR, 29 APR, 6 MAY, 13 MAY, 20 MAY, 27 MAY, 3 JUN, 10 JUN, 17 JUN, 24 JUN, 1 JUL, 8 JUL, 15 JUL, 22 JUL

- **Graph:**
  - Captive broodstock F1's (red)
  - Wild fish (blue)

- **Legend:**
  - Captive broodstock F1's
  - Wild fish
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>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of eggs</td>
<td>1200</td>
<td>3000</td>
<td>4000</td>
</tr>
</tbody>
</table>

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

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

F$_1$ egg-to-smolt survival..........................80%

Return Rate of F$_1$’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 $F_1$ 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.
Background

Captive Broodstock Rearing

Captive Broodstock Program vs. Conventional Hatchery Program