Implementation and Effectiveness of Captive Broodstock for Conservation of Threatened Spring Chinook Salmon in the Grande Ronde Basin, Oregon

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Oregon Department of Fish and Wildlife
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Presentation Outline

• Background – Natural Population Status, Early Hatchery Efforts, Policy Influences

• Management Goals and Objectives

• Captive Program Goals and Objectives

• Rearing Program Description

• Rearing Program Performance – Parr to adult growth and survival, adult characteristics

• Captive Offspring Performance ($F_1$) – Comparisons with natural and conventional hatchery fish
Grande Ronde and Imnaha River Basins
Chinook Hatchery Facilities
Adult Returns 1949-2000

Run year

Adult returns

Total
Catherine Creek
Grande Ronde River
Lostine River
LSRCP Original 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:
  - Establish an annual return of 5,920 hatchery fish.
  - Release 900,000 smolts annually - Captive Broodstock offspring are used in the LSRCP program.
  - 0.65% smolt-to-adult survival
- Maintain endemic wild populations of spring Chinook salmon in the Minam and Wenaha rivers.
- Minimize impacts of the hatchery program on resident stocks.
History

- Steady decline in abundance since the late 1950’s.
- In response, the Lower Snake River Compensation Plan (LSRCP) was initiated in Oregon in the late 1970’s to compensate for the losses resulting from the four Lower Snake River Dams.
- Traditional hatchery approach in the Grande Ronde Basin in the early years of implementation using non local domestic stocks.
- Hatchery supplementation began with the 1982 cohort, using Rapid River hatchery stock Chinook salmon. Rapid River stock was used from 1986-1996 cohorts. Smolt and adult outplants into Catherine Creek and the Upper Grande Ronde populations.
- Hatchery origin fish comprised over 50% of spawners in most populations, including Minam and Wenaha, from 1986 - 1993.
- Comprehensive monitoring and evaluation program implemented from the beginning to guide adaptive management decisions.
Early Hatchery Program Summary

• Using Rapid River stock allowed us to achieve smolt production goals quickly and develop an adequate broodstock.

• Smolt-to-adult survival rates were consistently poor.

• Sufficient numbers of adults were not available to re-establish recreational fisheries. Tribal fishing opportunity was provided only in a few years in restricted locations.

• Hatchery origin fish were straying into the Lostine, Minam, and Wenaha rivers and represented a high percentage of fish spawning in nature.

• Natural population status was severely depressed and supplementation efforts had failed as shown by poor recruits per spawner and low abundance of natural spawners in supplemented populations.
Policy Influences

• Oregon’s Wild-Fish Management Policy (1990)
  Guidelines that specified limits on the proportion of natural spawners that were non-local hatchery origin

• Listing as threatened under ESA (1992) with eight independent populations in the Grande Ronde Imnaha MPG

The hatchery program was generating outcomes that were inconsistent with the Wild–Fish Policy guidelines, ESA recovery and sound conservation principles
To Inform Wise Hatchery Reform
Critical Biological Questions

What is the demographic status and the near term risk of extinction of Chinook salmon populations in the basin?

What genetic effects have resulted from prior releases and straying of non-endemic hatchery stocks?

Does there remain any genetic differentiation between natural and hatchery populations and between natural populations?
Natural Origin Recruits per Spawner

- Catherine Creek
- Upper Grande Ronde
- Lostine River

Year


Recruits per spawner

0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90
Conclusions

• Prior supplementation failed as indicated by low natural origin abundance and low recruits per spawner.

• Extinction risk was high based on population growth rate trends, low abundance of natural origin spawners, and low productivity.

• There was significant genetic differentiation between hatchery and natural populations and between the Minam, Wenaha, Upper Grande Ronde, Lostine, and Catherine Creek natural populations.

• Hatchery programs using endemic broodstock should be initiated immediately in Catherine Creek, the Upper Grande Ronde, and Lostine river populations.
Adaptive Management
Hatchery Reform Actions


• Initiated captive broodstock with collection of parr from Catherine Creek, the Upper Grande Ronde, and Lostine rivers in 1995.

• We began conventional supplementation programs (natural adult broodstock) in Catherine Creek, the Upper Grande Ronde, and Lostine rivers in 1997 using sliding scale management strategies. Use diverse approaches from low risk to high risk programs between populations.

• Constructed acclimation and adult capture facilities on Catherine Creek, Upper Grande Ronde and Lostine rivers and made significant modifications to Lookingglass Hatchery.

• Maintain the Minam and Wenaha populations as unsupplemented reference wild fish management areas.
Captive Broodstock Program Objectives

• Prevent extinction of the native Catherine Creek, Lostine River and Upper Grande Ronde River 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 stabilize abundance and ensure a high probability of population persistence until causes of population declines have been addressed (mainstem hydrosystem and tributary habitat)

• Produce 150,000 smolts annually to ensure a minimum of 150 spawners annually in the Catherine Creek, Upper Grande Ronde and Lostine River populations.
Monitoring and Evaluation Objectives

- Monitor, assess and compare the effects of pre- and post-smolt rearing treatments, parr natural-accelerated growth, saltwater – freshwater smolt to adult rearing.
- Develop and evaluate the effectiveness of innovative methodologies for rearing, spawning and disease treatment and prevention.
- Monitor and assess the performance of captive broodstock offspring in captivity (pre-smolt) and in nature (post-smolt) and their offspring.
- Monitor and compare aspects of life history and production performance between Captive and Conventional broodstock programs.
- Assess our the success in achieving the genetic conservation goals and production benchmarks.
Adult Maturity Sort at Bonneville Facility
Mature Female
Life History of Captive Broodstock and Treatment Scenario

1. Collect Wild Parr (Throughout distribution)
2. Rear to Smolt (Natural and Accelerated Rates)
3. Post-smolt Rearing (Freshwater and Saltwater)
4. Spawn Within Stocks and Treatment Groups
5. Rear F₁ Generation to Smolt Stage
6. Release F₁ Generation in Parent’s Natal Stream
7. Returning Adults Allowed to Spawn in Nature
Captive Broodstock Results
## Targets and Performance - Production

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

<table>
<thead>
<tr>
<th>Age at maturation</th>
<th>2 (%)</th>
<th>3 (%)</th>
<th>4 (%)</th>
<th>5 (%)</th>
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<tbody>
<tr>
<td>Females</td>
<td>0 / 0</td>
<td>6 / 1</td>
<td>78 / 88</td>
<td>16 / 11</td>
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<tr>
<td>Males</td>
<td>2 / 20</td>
<td>35 / 69</td>
<td>48 / 10</td>
<td>15 / 1</td>
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<table>
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<tr>
<th>Spawn timing</th>
<th>August-September</th>
<th>September-October</th>
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<tr>
<td>Fecundity</td>
<td>Age 3</td>
<td>Age 4</td>
</tr>
<tr>
<td>Target</td>
<td>1200</td>
<td>3000</td>
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<tr>
<td>Performance</td>
<td>1232</td>
<td>1715</td>
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</table>

20% (0-77%) of collected eggs were culled for BKD prevention.
Disposition of Captive Broodstock

* Cohort 2000 Grande Ronde River was euthanized due to tumors.
Spawn Timing

- Wild
- Captive broodstock

Date (2000)

Percent spawning

0 5 10 15 20 25 30 35 40 45

AUG 1 8 15 22 29 5 12 19 26 5 12 19 OCT
Natural vs. Captive Broodstock Fecundity

Age

Stock

Treatment

Natural

Captive Broodstock

Fecundity
Summary

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

• Growth:
  • CBS fish grew slower than expected rate
  • Saltwater group grew slower than freshwater groups and natural grew faster than accelerated

• Survival:
  • Parr-to-Smolt survival was above the 95% expected
  • Smolt-to-Spawn survival was variable but slightly above the 55% expected
  • Natural growth treatment survived better in saltwater
Summary continued

• Sex ratio was about 1:1

• Mortality:
  • BKD and unknown were the largest causes of mortality

• Maturity:
  • Males matured earlier than expected – most Age 3, males in the accelerated treatment matured earlier
  • Females matured later than expected – fewer Age 4 and more Age 5

• Spawning:
  • Survival to spawning has increased and exceeded assumptions
  • CBS fish spawn ~3 weeks later than wild fish
Program Challenges

- Improve growth of saltwater fish
- Inability to collect 500 parr each year in the Grande Ronde River
- Reduce BKD-caused mortality
- Reduce BKD culling
- Synchronize maturation timing with wild fish
- Early detection of maturing fish
Captive Broodstock F1
Egg to Smolt to Adult Performance
Eyed Egg-to-Smolt Survival

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

<table>
<thead>
<tr>
<th>Location</th>
<th>Captive Broodstock</th>
<th>Conventional Broodstock</th>
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<tbody>
<tr>
<td>Catherine Creek</td>
<td>0.80</td>
<td>1.00</td>
</tr>
<tr>
<td>Grande Ronde River</td>
<td>0.60</td>
<td>0.80</td>
</tr>
<tr>
<td>Lostine River</td>
<td>0.40</td>
<td>0.60</td>
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</table>

*Note: The natural rate is indicated by dashed lines.*
F₁ Adult Returns

Catherine Creek

- Actual returns
- Return goal

Grande Ronde River

- Captive Broodstock Target
- No CBS released

* CBS smolts w/o ad clip
Smolt-to-Adult Survival (SAR)

Catherine Creek

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural</th>
<th>Captive</th>
<th>Conventional</th>
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</thead>
<tbody>
<tr>
<td>1998</td>
<td>1.4</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td>2000</td>
<td>3.2</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>2002</td>
<td>4.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>2004</td>
<td>4.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>2006</td>
<td>1.7</td>
<td>0.0</td>
<td>0.0</td>
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Grande Ronde River

<table>
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<tr>
<th>Year</th>
<th>Natural</th>
<th>Captive</th>
<th>Conventional</th>
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<tbody>
<tr>
<td>1998</td>
<td>4.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
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<td>1.7</td>
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<tr>
<td>2004</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>2006</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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</table>

Graph showing SAR (Smolt to Adult Survival) for Catherine Creek and Grande Ronde River from 1998 to 2006, with different colors representing natural, captive, and conventional methods.
Size at Maturity

**Females**
- Captive Broodstock
- Conventional Broodstock
- Natural

**Males**

<table>
<thead>
<tr>
<th>Age</th>
<th>Captive Broodstock</th>
<th>Conventional Broodstock</th>
<th>Natural</th>
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<tbody>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
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Age Composition

Catherine Creek

<table>
<thead>
<tr>
<th>Age class</th>
<th>Natural</th>
<th>Captive</th>
<th>Conventional</th>
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</thead>
<tbody>
<tr>
<td>3</td>
<td>0.8</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>4</td>
<td>0.7</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>0.4</td>
<td>0.5</td>
<td>0.0</td>
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Grande Ronde River

<table>
<thead>
<tr>
<th>Age class</th>
<th>Natural</th>
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<th>Conventional</th>
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<tr>
<td>3</td>
<td>0.1</td>
<td>0.1</td>
<td>0.0</td>
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<tr>
<td>4</td>
<td>0.2</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>0.3</td>
<td>0.3</td>
<td>0.0</td>
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# CBS vs. CHP vs. Natural Production

## Adult Production Effectiveness Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Natural</th>
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<th>CHP</th>
<th></th>
<th>CBS</th>
<th></th>
<th>Units</th>
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<tbody>
<tr>
<td>Number of parr</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td>Parr F₀</td>
</tr>
<tr>
<td>Parr-to-Smolt</td>
<td>0.13</td>
<td>0.98</td>
<td>0.97</td>
<td></td>
<td></td>
<td></td>
<td>Smolts F₀</td>
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<tr>
<td>Smolt-to-Adult</td>
<td>0.019</td>
<td>0.005</td>
<td>0.55</td>
<td></td>
<td></td>
<td></td>
<td>Adults F₀</td>
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<tr>
<td>Sex Ratio</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
<td>Females F₀</td>
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<tr>
<td>Fecundity</td>
<td>4,141</td>
<td>3,977</td>
<td>1,795</td>
<td></td>
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<td></td>
<td>Eggs F₁</td>
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<tr>
<td>Fertility</td>
<td>0.906</td>
<td>0.0891</td>
<td>0.811</td>
<td></td>
<td></td>
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<td>Eyed F₁</td>
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<tr>
<td>BKD Culling</td>
<td>1</td>
<td>0.99</td>
<td>0.8</td>
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<td>Eyed F₁</td>
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<td>Eyed-to-Smolt</td>
<td>0.039</td>
<td>0.965</td>
<td>0.688</td>
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<td>Smolts F₁</td>
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<tr>
<td>Smolt-to-Adult</td>
<td>0.010</td>
<td>0.005</td>
<td>0.003</td>
<td></td>
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<td>Adults F₁</td>
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Catherine Creek Total Adult Spawners in Nature

ReturnYear

Adult spawners in nature

ICTRT Viability Threshold

Natural
Hatchery
Minam River

Summary – Conclusions $F_1$ Generation

- Egg-to-smolt survival better in Conventional Program
- Smolt production – rarely achieved for CBS
- Adult returns – often met Captive Broodstock goal
- SAR – met Captive Broodstock but lower than conventional and natural
- Size at maturity – similar among programs and with natural
- Age composition similar between programs but younger than natural
- Run timing similar between programs and with natural
- Spawning distribution – hatchery fish tend to spawn near acclimation site
Conclusions

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

- Growth / Fecundity are slower and lower
- Disease / Culling are a significant challenge
- F₁ performance in hatchery slightly poorer
- Uncertain relative genetic risk between CBS and CHP from amplifying genes from a small number of parents and unequal family contributions?

Captive broodstocks discontinued with the 2003 BY, except for the Upper Grande Ronde Safety Net Program
**Pedigree analysis**

- Genotyped for 10 microsatellites
- Pedigrees reconstructed by exclusion
- Relative Reproductive Success (RRS) calculated, normalized to wild
- *Generalized Linear Modeling to determine which phenotypic factors are most important for RRS.*
Catherine Creek RRS by Parent Origin
(adult to adult)

Geomean hatchery = 0.818
Catherine Creek RRS Captive vs. Conventional (juvenile and adult offspring)
Questions?