Goal

Replace Lost Adult Salmon & Steelhead Caused by the Construction and Operation of the Four Lower Snake River Dams

LSRCP Hatcheries

- Oregon
  - Lookingglass
  - Wallowa
  - Irrigon
  - Umatilla
- Washington
  - Lyons Ferry
  - Tucannon
- Idaho
  - Clearwater (CR, Red Powell)
  - Magic Valley
  - Dworshak NFH
  - Hagerman NFH
  - McCall
  - Sawtooth
- Idaho Power Company
  - Oxbow
- Nez Perce Tribe
  - Nez Perce Tribal Hatchery

From BPA Integrated Program Review Fish & Wildlife Program (2014)
Estimating Losses
(Using Steelhead As An Example)

Steps:

1) Estimate Escapement Prior to Dam Construction
   (Steelhead = 114,800 Adults)

2) Estimate Smolt Mortality at Each Dam
   (Steelhead = 15% Loss Per Dam, 48% Total Loss)

3) Estimate Number of Adults Lost Due to Dams
   (114,800 Adults x 48% = 55,100

   55,100 Became the LSRCP Return Goal for Steelhead)

Photo from M. Gallinat (2010)
Estimating Losses
(Using Steelhead As An Example)

Steps:

4) Estimate Smolt to Adult Return to Lower Granite Dam = 0.5%
   (No. of smolts needed to produce 55,100
    55,100/.005 = 11,020,00)

5) Estimate Egg-to-Smolt Survival
   (Assumed 65%, Therefore No. of Eggs Needed = 11.02 M /.65 = 16.95 M)
Mitigation Goals

- **Spring Chinook**
  - 58,700 Adults To Project Area
  - 234,800 Adults To Fisheries

- **Steelhead**
  - 55,100 Adults To Project Area
  - 110,200 Adults To Fisheries
  - 130,000 Angler Days

- **Fall Chinook**
  - 18,300 Adults To Project Area
  - 73,200 Adults To Fisheries
Unforeseen Factors Affected LSRCP

• Lower Smolt-to-Adult Survivals

• ESA Listings of:
  • Fall & Spring Chinook (1992)
  • Steelhead (1997)

• Downstream Harvests Curtailed & More Fish Back to Project Area

• US v. Oregon
  • Hatchery Production Set
  • New Stocks & Release Areas

• Harvest Mitigation Project Changed to Harvest & Conservation Project
ISRP Retrospective Review
LSRCP Steelhead, Fall & Spring Chinook Programs

Purpose Of Review

1) To determine if the Three Programs are:
   Based on Sound Science
   Benefit Fish & Wildlife
   Have Clearly Defined Objectives
   Contain M & E Programs

Photo Of Lyons Ferry Hatchery M. Key (2013)
Purpose Of Review

2) To Evaluate:
   In-Hatchery Performance
   Post-Release Performance
   Ecological Interactions
   Program Modifications

3) Consistent With Council’s FWP
   Artificial Production
   Standards & Strategies

Photo Of Irrigon Hatchery from Carmichael et al. (2012)
In-Hatchery Performance

Metrics:

• Broodstock Collection & Survival

• Egg-to-Smolt Survival

• Number of Smolts

Photo from E. Loudenslager (2011)
Broodstock Collection & Survival

Spring Chinook
  Survival Goal ≥ 80%
  Yrs Achieved 90%

Steelhead
  No Universal Goal
  For Survival

Fall Chinook
  Survival Goal 90%
  Yrs Achieved 86%

Photo From J. Bumgarner (2012)
Egg-to-Smolt Survival Goals

Spring Chinook
- Survival Goal ≥ 70%
- Yrs Achieved 92%

Steelhead
- Survival Goal 65%-70%
- Yrs Achieved 76%

Fall Chinook
- Survival Goal 70% - 80%
- Yrs Achieved 79%
Smolt Release Goal:
Spring Chinook

LSRCP Goal = 6.75 M

From Mark Shuck LSRCP Roll-up (2010)
Smolt Release Goal:
Steelhead

- 1989- 6.25M
- 2010- 5.35M

Smolts Released (Millions)

Migration Year

WA, OR, ID

From B. Leth Steelhead Roll-up (2012)

Photo B. Leth Steelhead Roll-up (2012)
Smolt Release Goal
Fall Chinook

From J. Hesse PPT to NPPC Council 2014
Factors Affecting Release Goals

Spring Chinook
- Broodstock Scarcity
- Reductions in Rearing Densities
- Water Shortages at Some Hatcheries

Steelhead
- Greater Smolt Size Goal Set
- Decreases in Water Availability
- Shift in Production to Spring Chinook

Fall Chinook
- Broodstock Scarcity

Lyons Ferry Hatchery
Photo by D. Gloyn (2013)
Post Release Metrics

- Survival to Lower Granite Dam
- Smolt-to-adult survival (SAS)
- Smolt-to-adult Return (SAR)
- Recruits per Spawner (R/S)
- Harvest (below and within project area)

Photo from B. Leth steelhead roll-up (2012)
Smolt Survival to Lower Granite Dam: Steelhead

Survival Migration Year

1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011

Average
Imnaha
Grande Ronde OR
Salmon River
Clearwater
Grande Ronde WA

B. Leth steelhead roll-up (2012)
Smolt Survival to Lower Granite Dam:
Spring Chinook

Potential Factors Affecting Survival

- River Flow
- Water Temperature
- Turbidity
- Travel Distance
- Date of Release
- Type of Release
  - Direct-Release
  - Acclimation Pond
- Fish Size
  - Yearling
  - Sub-Yearling
- Smoltification Stage
- Fish Health
- Time Of Release
  - Diurnal
  - Nocturnal

From Mark Shuck LSRCP Roll-up (2010)
Smolt-to-Adult Survival & Return Rates
Steelhead & Spring Chinook

Spring Chinook

SAS Goal 3.25% - 4.35%
Years Achieved = 0%

SAR Goal 0.1% - 0.87%
Years Achieved = 41%

Steelhead

SAS Goal 1.5% - 2.61%
Years Achieved = 38%

SAR Goal 0.5% - 0.87%
Years Achieved = 83%
Recruits Per Spawner

Hatchery Steelhead

1981-2006
Average = 18.6

From B. Leth steelhead roll-up (2012)
Adult Abundance
Spring Chinook Salmon

Project Area Goal = 58,700
Total Fish Goal = 293,500

From Mark Shuck roll-up (2010)
Adult Steelhead Abundance
Above Project

From B. Leth Steelhead Roll-up (2012)
Adult Fall Chinook Abundance

Snake River

Hatchery Fall Chinook Returns

Natural Origin Fall Chinook Returns

From J. Hesse Fall Chinook Roll-up (2013)

From J. Hesse PPT to NPPC Council 2014
Spring Chinook Harvest

Fisheries In Project Area

No Fisheries From 1975 – 1995

In 2010:
  9 % Of Historical Harvest
  31% Of Historical Area
  16% Of Historical Fishing Days

Fishing Opportunities are Growing With Increases in Abundance

M. Shuck spring Chinook Roll-up (2010)
Steelhead Harvest
In Project Area

Pre Project Harvest & Effort

• Average of 26,000 Caught Per Year
• Average Angler Effort 130,000 days

Post Project 1998 – Present

• Average of 62,000 Caught Per Year
• Average Angler Effort 475,000 days

B. Leth Steelhead Roll-up (2012)

Photo From L. Clarke et al. (2012)
# Fall Chinook Harvest

## Snake River

### Exploitation Rates

Brood Years 1994-2007 (Ad Clipped CWT Fish)

<table>
<thead>
<tr>
<th>Program</th>
<th>Returns + Harvest</th>
<th>% Col R &amp; Ocean</th>
<th>% Snake River</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPC</td>
<td>24,791</td>
<td>20</td>
<td>0.1</td>
<td>20</td>
</tr>
<tr>
<td>LSRCP</td>
<td>104,684</td>
<td>44</td>
<td>0.3</td>
<td>44</td>
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<tr>
<td>FCAP</td>
<td>45,284</td>
<td>44</td>
<td>0.3</td>
<td>45</td>
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<tr>
<td>NPTH</td>
<td>8,334</td>
<td>26</td>
<td>&lt;0.1</td>
<td>26</td>
</tr>
</tbody>
</table>

From Milks et al. (2013)
Fish & Wildlife Program
Artificial Production Standards and Strategies

- Operate in an Experimental & Adaptive Manner
- Minimize Adverse Effects on Other Stocks Through Straying & Harvest
- Preserve Natural Populations Where Habitat is Intact
- Restore, Preserve, and Rebuild Natural Populations
Average Annual Deschutes River Straying By Snake River Hatchery Steelhead

![Bar chart showing average annual straying rates by location.](Photo Of Lower Deschutes River From Findfish.com)

Figure From Clarke et al. 2012
Potential Factors Affecting Straying Frequencies

- Incubation, Rearing, and **Release Strategies**
- Release Location
- Stock Origin
- Seaward Migration Pathways (In-river vs. Transported)
- Columbia River and Deschutes Water Temperatures

From R. Carmichael (2012)
Acclimated vs. Direct Release Studies
Steelhead

Wallowa Hatchery Studies

1. Acclimated vs. Direct Releases

2. Volitional vs. Forced Release

From Clarke et al. (2012)
Results of Acclimated v. Direct Releases
Steelhead

Acclimated vs. Direct Release

1. Smolt-to-adult Survival
   (33.3% higher survival for acclimated releases $p = 0.013$)

4. Stray frequency
   (70% higher stray rates for direct releases $p = 0.001$)

From Clarke et al. 2012

Photo from J. Bumgarner (2012)
Results of Volitional vs. Forced Releases
Steelhead

Results of Volitional vs. Forced Releases

1. **Smolt-to-adult Survival**
   (no difference detected $p = 0.658$)

2. **Straying frequency**
   (no difference detected $p = 0.852$)

Big Canyon Acclimation Pond
Photo from Clarke et al. (2012)

From Clarke et al. (2012)
Results of Volitional vs. Forced Releases

Steelhead

Results of **Volitional** vs. **Forced** Releases

3. Volitional Releases Allow the Removal of “Residual” Males at End of the Release Period

When 70% of the Fish Remaining in a Pond are Males—they are Trucked and Released into Local Ponds for Fisheries

Photo by Mike Croxford

From Clarke et al. (2012)
Acclimation Ponds Studies
Spring Chinook

Effects of Duration Of Acclimation Period

1. 4 Months vs. 2 Months

2. Fish Acclimated for 4 Months Had Higher Smolt-to-Adult Survival Rates (p < 0.005)

Umatilla River
Photo nwwaterfrontrealestate.com
Protecting Natural Production Areas
Steelhead & Spring Chinook

Natural Spawning & Rearing Areas in Idaho, Oregon, & Washington are Being Protected & Monitored

South Fork Salmon River
Photo by panoramio.com
Wild Stock Protection
Grande Ronde Spring Chinook

Incidence Of Strays

1. 1986-1994 > 50%

2. Endemic Broodstock & Acclimation Ponds 2000

3. Present Occurrence of Strays 2002 – Present < 5%

From R. Carmichael (2010)
Conservation via Captive Brood Program
Grande Ronde Spring Chinook

Approach Of Captive Brood Program

1) Collect 500 Parr in the Grande Ronde River, Catherine Creek, & Lostine River

Photo From T. Hoffnagle et al. (2010)
Conservation via Captive Brood Program
Spring Chinook

Approach Of Captive Brood Program

2) Rear Wild Parr to Maturation

Juvenile Chinook Salmon, Tucannon River
From M. Gallinat (2010)
Conservation via Captive Brood Program

Approach Of Captive Brood Program

3) Artificially Spawn Reared Adults

4) Rear Subsequent Progeny to Smolt Stage and Release

5) Allow Resulting F₁ Adults to Spawn in Nature

Tucannon River Captive-reared Adult Spring Chinook—Photo from M. Gallinat (2010)
## Comparison of $F_1$ Adult Production

<table>
<thead>
<tr>
<th>Type</th>
<th>No. Of Parr</th>
<th>No. Adult Females Produced</th>
<th>No. Of $F_1$ Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captive Brood</td>
<td>500</td>
<td>133</td>
<td>370</td>
</tr>
<tr>
<td>Conv. Hatch</td>
<td>500</td>
<td>1.1</td>
<td>18</td>
</tr>
<tr>
<td>Natural</td>
<td>500</td>
<td>0.6</td>
<td>2</td>
</tr>
</tbody>
</table>

Data From T. Hoffnagle et al. (2010)
Results Of Captive Brood Program
Grande Ronde Spring Chinook

1. Contributed Smolts to Hatchery Releases
2. Increased Adult Abundance in Targeted Streams
3. Reduction in Smolts Per Spawner as Spawner Densities Increased

From T. Hoffnagle et al. (2010)
Regional & LSRCP Challenges

RM&E

1. Identifying Factors Responsible for Density-Dependency in Natural Spawning and Rearing Habitats

2. Assessing & Reducing Stray Rates

3. Regulating Numbers of Hatchery Fish on Spawning Grounds

4. Evaluating the Utility of Supplementation

5. Identification of Project Fish in Fisheries & on Spawning Grounds

Spring Chinook Smolts
Photo from kera-kw.com
LSRCP Challenges

Regional & Basin-Wide Management


7. Using Artificial Production to Augment Harvest While Simultaneously Implementing Recovery Actions for ESA-Listed Steelhead & Chinook

8. To Achieve Mitigation Goals Will Require Action Beyond the Responsibilities of the LSRCP
Egg-to-Smolt Survival: Steelhead Across All Projects

Photo from J. Bumgarner (2012)

From B. Leth steelhead roll-up (2012)
Smolt Release Goals

Spring Chinook
Goal = 6 – 7.5 Million
Yrs Achieved = 42%

Steelhead
Goal = 5.3 – 6.8 Million
Yrs Achieved = 57%

Fall Chinook
0+ Goal = 4.6 Million
Yrs Achieved = 69%

1+ Goal = 0.9 Million
Yrs Achieved = 95%

Spring Chinook smolts
Photo workareaonline.com
Yearling Fall Chinook Survival To Lower Granite Dam Acclimation Pond Releases

From M. Key (2013)
Smolt-to-Adult Returns (SAR)

Spring Chinook

From Mark Shuck roll-up (2010)
Snake River Hatchery Steelhead Stocks

From Clarke et al. (2012)
Effects of Barging On Straying Steelhead

Stray rates into the Deschutes

Stray rates were:
Higher for Transported Fish
Within Transported Fish:
Hatchery > Natural

Photo From M.L. Keefer and C. Caudill Tech. Rept. 2012-6 Draft

R. Carmichael & T. Hoffnagle (2012)
Wild Stock Protection
Salmon River Steelhead

• Hatchery Releases
  Little Salmon R. and
  Upper Salmon R

• No Releases
  South Fork
  Middle Fork
  North Fork
  Mainstem Salmon downstream of the North Fork

From Brian Leth (2012)
# Wild Stock Protection

## Clearwater Steelhead

<table>
<thead>
<tr>
<th>Natural Population</th>
<th>Tributary</th>
<th>Avg. Pairwise F&lt;sub&gt;ST&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colt Cr</td>
<td></td>
<td>0.023</td>
</tr>
<tr>
<td>Storm Cr</td>
<td></td>
<td>0.025</td>
</tr>
<tr>
<td>Crooked Fork</td>
<td></td>
<td>0.018</td>
</tr>
<tr>
<td>Lake Cr</td>
<td></td>
<td>0.025</td>
</tr>
<tr>
<td>Fish Cr</td>
<td></td>
<td>0.018</td>
</tr>
<tr>
<td>Canyon Cr</td>
<td></td>
<td>0.013</td>
</tr>
<tr>
<td>Selway R.</td>
<td>Lochsa R. No</td>
<td>0.024</td>
</tr>
<tr>
<td>No Releases</td>
<td></td>
<td>0.023</td>
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<tr>
<td>Whitecap Cr</td>
<td></td>
<td>0.024</td>
</tr>
<tr>
<td>Bear Cr</td>
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<td>0.025</td>
</tr>
<tr>
<td>NF Moose Cr</td>
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<td>0.018</td>
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<tr>
<td>Three Links Cr</td>
<td></td>
<td>0.026</td>
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<tr>
<td>Gedney Cr</td>
<td></td>
<td>0.016</td>
</tr>
<tr>
<td>O'Hara Cr</td>
<td></td>
<td>0.011</td>
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<tr>
<td>Clear Cr</td>
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<td>0.011</td>
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<tr>
<td>Crooked R</td>
<td>SF Clearwater</td>
<td>0.004</td>
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<tr>
<td>Releases</td>
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<td>0.011</td>
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<tr>
<td>Tenmile Cr</td>
<td></td>
<td>0.021</td>
</tr>
<tr>
<td>John's Cr</td>
<td></td>
<td>0.010</td>
</tr>
</tbody>
</table>

Stiefel and Leth (2012)
Hatcheries, Supplementation & Conservation
Operational Definition Of Supplementation

Wild Fish To Hatchery → 1<sup>st</sup> Generation Hatchery Adults To The Wild → NORs From 1<sup>st</sup> Generation Hatchery Parents = A

Wild Fish To Wild → Wild Fish To Wild → Wild Fish To Wild = B

Is A ≥ B?
Key Assumptions Of Supplementation:

1) Hatchery-Origin Fish Are Reproductively Competent When Allowed To Spawn Under Natural Conditions

Photo: Oceanmdx
www.skyscrapercity.com
Key Assumptions Of Supplementation

2) Progeny Produced By Hatchery Origin Adults Can Survive In Nature

Spring Chinook Juvenile
Photo grantpud.org
Key Assumptions of Supplementation

3) The Receiving Environments Are Productive & Complex Enough To Accommodate Additional Juveniles

Grande Ronde River
Photo commons.wikimedia.org
Changes In Smolt Origin

Catherine Creek

Data From T. Hoffnagle et al. (2010)
Captive Brood Adult Returns

Catherine Creek

Number of Adults

<table>
<thead>
<tr>
<th>Year</th>
<th>CB Adults</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>400</td>
<td>100</td>
</tr>
<tr>
<td>1999</td>
<td>300</td>
<td>100</td>
</tr>
<tr>
<td>2000</td>
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<td>2003</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2004</td>
<td>100</td>
<td>100</td>
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</tbody>
</table>

Data from T. Hoffnagle et al. (2010)

Photo pinterest.com
Results Of Captive Brood Program
Grande Ronde Spring Chinook

Parr Collections: Generally Met
Growth: Slower than Expected
Survival: Wild Parr-to-Smolt > 95%
  Wild Smolt-to-Adult ~ 55%
Mortality: BKD Largest Cause
Maturity: Male matured earlier than expected – most at age 3
  Females matured later, more 5’s than expected
Fecundity: 60% Lower than expected

From T. Hoffnagle et al. (2010)
Captive Broodstock Challenges

Recognized Challenges In The Captive Broodstock Program

- F₀ Smolt-to-Adult Growth
- F₀ Fecundity
- Egg Culling & Disease During Rearing
- Hatchery Performance of F₁'s
- Potential Gene Amplification

From Hoffnagle et al. (2010)

Photo from Venditti et al. (2005)