Migratory patterns of Snake River spring Chinook salmon: comparison of hatchery and presumably wild yearlings

Jessica Miller\textsuperscript{1}, Cheryl A. Morgan\textsuperscript{1}, Brian R. Beckman\textsuperscript{2}, Brian J. Burke\textsuperscript{2}, Donald M. Van Doornik\textsuperscript{2}, and Laurie A. Weitkamp\textsuperscript{2}

\textsuperscript{1}Oregon State University, \textsuperscript{2}NOAA Northwest Fisheries Science Center
Ocean collections of juvenile salmon

- Ocean collections (May, June, September)
  - 1998-present
- Genetic ID of juvenile salmon
- Stock-specific ecological studies -- diet, growth, migration history --
- Other biological and physical data
- Interior Columbia River Chinook salmon >50% of overall catch but <10% unmarked
Interannual variation in survival of Columbia River interior spring stocks related to early marine growth and size attained during first ocean summer

- Do hatchery and wild fish display similar patterns of migration and early marine size, growth, and condition?
2015: Compare H/W and characterize transition from estuary to ocean
Need to increase catch of Interior Chinook salmon

- 4 days of sampling (as opposed to 8 in 2006 – 2012)
- Two sites (A & B)
- Site B = a completely different group of fish than Site A (size, IGF, etc.)
May survey redesign

2016: Maintain high catch but sample more broadly and recognize that fish emigrated early

- 7 days of sampling
- Started at WB
- Moved south to CR/LH – low catch
- Moved back north and caught fish
## Juvenile salmon catch and CPUE

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Number of Trawls</th>
<th>Chinook salmon (subyearling)</th>
<th>Chinook salmon (yearling)</th>
<th>Chinook salmon (mixed age juvenile)</th>
<th>Coho salmon (yearling)</th>
<th>Chum salmon (juvenile)</th>
<th>Sockeye salmon (juvenile)</th>
<th>Steelhead (juvenile)</th>
<th>Cutthroat trout</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015 May</td>
<td>27</td>
<td>4</td>
<td>411</td>
<td>19</td>
<td>1851</td>
<td>15</td>
<td>54</td>
<td>281</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>2016 May</td>
<td>50</td>
<td>6</td>
<td>516</td>
<td>101</td>
<td>760</td>
<td>489</td>
<td>531</td>
<td>28</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

### Catch Per Unit Effort

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Number of Trawls</th>
<th>Chinook salmon (subyearling)</th>
<th>Chinook salmon (yearling)</th>
<th>Chinook salmon (mixed age juvenile)</th>
<th>Coho salmon (yearling)</th>
<th>Chum salmon (juvenile)</th>
<th>Sockeye salmon (juvenile)</th>
<th>Steelhead (juvenile)</th>
<th>Cutthroat trout</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015 May</td>
<td>27</td>
<td>0.05</td>
<td>4.46</td>
<td>0.20</td>
<td>19.70</td>
<td>0.18</td>
<td>0.65</td>
<td>3.73</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>2016 May</td>
<td>50</td>
<td>0.03</td>
<td>2.85</td>
<td>0.52</td>
<td>4.11</td>
<td>2.57</td>
<td>2.94</td>
<td>0.16</td>
<td>0.03</td>
<td></td>
</tr>
</tbody>
</table>

2015 CPUE > 2016 CPUE

- Yearling Chinook
- Yearling coho
- Juvenile steelhead

2015 CPUE < 2016 CPUE

- JUMBO Chinook
- Juvenile chum
- Juvenile sockeye
# Juvenile salmon catch and CPUE

## Number

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Number of Trawls</th>
<th>Chinook salmon (subyearling)</th>
<th>Chinook salmon (yearling)</th>
<th>Chinook salmon (mixed age juvenile)</th>
<th>Coho salmon (yearling)</th>
<th>Chum salmon (juvenile)</th>
<th>Sockeye salmon (juvenile)</th>
<th>Steelhead (juvenile)</th>
<th>Cutthroat trout</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>May</td>
<td>27</td>
<td>4</td>
<td>411</td>
<td>19</td>
<td>1851</td>
<td>15</td>
<td>54</td>
<td>281</td>
<td>17</td>
</tr>
<tr>
<td>2016</td>
<td>May</td>
<td>50</td>
<td>6</td>
<td>516</td>
<td>101</td>
<td>760</td>
<td>489</td>
<td>531</td>
<td>28</td>
<td>6</td>
</tr>
</tbody>
</table>

## Catch Per Unit Effort

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Number of Trawls</th>
<th>Chinook salmon (subyearling)</th>
<th>Chinook salmon (yearling)</th>
<th>Chinook salmon (mixed age juvenile)</th>
<th>Coho salmon (yearling)</th>
<th>Chum salmon (juvenile)</th>
<th>Sockeye salmon (juvenile)</th>
<th>Steelhead (juvenile)</th>
<th>Cutthroat trout</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>May</td>
<td>27</td>
<td>0.05</td>
<td>4.46</td>
<td>0.20</td>
<td>19.70</td>
<td>0.18</td>
<td>0.65</td>
<td>3.73</td>
<td>0.19</td>
</tr>
<tr>
<td>2016</td>
<td>May</td>
<td>50</td>
<td>0.03</td>
<td>2.85</td>
<td>0.52</td>
<td>4.11</td>
<td>2.57</td>
<td>2.94</td>
<td>0.16</td>
<td>0.03</td>
</tr>
</tbody>
</table>

2015 CPUE > 2016 CPUE

**Yearling Chinook**
Ocean collections of juveniles

Snake River Sp/Su Chinook salmon
ESA status: Threatened

>90% yearling emigrants

NOAA NWFSC
# Interior Chinook salmon yearling stocks

<table>
<thead>
<tr>
<th></th>
<th>Snake River spring/summer Chinook salmon</th>
<th>Mid-Upper Columbia River spring Chinook salmon</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2015</strong></td>
<td>5/163 = 3%</td>
<td>6/79 = 7.6%</td>
</tr>
<tr>
<td><strong>2016</strong></td>
<td>31/341 = 9%</td>
<td>3/38 = 7.9%</td>
</tr>
</tbody>
</table>
Interior Chinook salmon yearling stocks

Snake River spring/summer Chinook salmon

<table>
<thead>
<tr>
<th>Year</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>5/163 = 3%</td>
</tr>
<tr>
<td>2016</td>
<td>31/341 = 9%</td>
</tr>
</tbody>
</table>
Snake River spring/summer Chinook salmon survival

Smolt-to-adult return ratio

CSS LGR-GRA SARs
Snake River spring/summer Chinook salmon

Better characterize migration patterns
Wild – Hatchery Comparison (2016)

• Size
• Condition (mass-length residuals)
• Size and timing of freshwater emigration & Growth
  (otolith chemistry & structure)
**Sr/Ca**: Ocean (8 mmol/mol) > Rivers (<5 mmol/mol)

**Ba/Ca**: Ocean (2-5 μmol/mol) > Rivers (>5 μmol/mol)
Sr/Ca: Ocean (8 mmol/mol) > Rivers (<5 mmol/mol)
Ba/Ca: Ocean (2-5 µmol/mol) > Rivers (>5 µmol/mol)
Wild fish smaller, lighter, and enter ocean at smaller sizes but better condition at capture

\[ n = 30, 78 \]
Interior Columbia River Spring Chinook otolith chemistry

- Sr:Ca mmol/mol
- Ba:Ca μmol/mol

Freshwater emigration
Sr/Ca (mmol/mol)

Ba/Ca (μmol/mol)

Ventral edge --- Core ---- Dorsal edge

Shortest marine residence (1-2 d)

Category 1

Category 2

Category 3

Category 4

~2-3 d

~3-10 d

Longest marine residence (>10 d)
Category by latitude

Duration of marine residence important factor when examining early marine residence
River $^{87}\text{Sr}/^{86}\text{Sr}$ varies with age & composition of rock

Ocean value

Ocean = 0.70918

$^{87}\text{Sr}:^{86}\text{Sr} = 0.709 - 0.710$

$^{87}\text{Sr}:^{86}\text{Sr} = 0.70918$

$^{87}\text{Sr}:^{86}\text{Sr} = 0.704 - 0.705$

$^{87}\text{Sr}:^{86}\text{Sr} = 0.712$
Size at freshwater emigration

Size in lower river

Size difference = conservative estimate of lower Columbia River mainstem growth
Sr:Ca
Ba:Ca
$^{87}\text{Sr}^{86}\text{Sr}$

Freshwater emigration
Lower Col. R. mainstem
Willamette R. emigration

Willamette River
Spring Chinook salmon
In 2016, wild fish displayed more growth in lower river and tended toward earlier emigration, and slower marine growth

\[ n = 12, \ 78 \]
Wild emigration a bit later and more protracted

PIT tag data – detections at Bonneville

Wild

H = 901,536
W = 83,712

Hatchery
Conclusions

• Targeted sampling can increase collection of wild fish

• Juveniles change rapidly during migration

• Wild fish entered ocean at smaller sizes but were in much better condition upon capture

• Trend towards wild fish growing more in lower river but similar ocean growth

• Wild fish entered ocean a bit earlier than hatchery fish, with protracted emigration (PIT tags)
Acknowledgements

NOAA NWFSC
Bonneville Power Administration

Lab/Field Assistance:

Thomas Murphy
Bill Peterson
Ric Brodeur
Kym Jacobson
Susan Hinton
Many, many others…

F/V Frosti