Residence Times of Acoustic-Tagged Juvenile Salmon in Off-Channel, Tidal Freshwater Areas in the Lower Columbia River

Gary Johnson, Amanda Bryson, Eric Fischer, Matt Hennen, James Hughes, Ron Kaufmann, Gene Ploskey, Nikki Sather, Mark Weiland, and Shon Zimmerman

Pacific Northwest National Laboratory

Columbia River Estuary Conference
Astoria, Oregon, May 15, 2012
Objective

- Estimate residence times of juvenile salmon in off-channel areas in the vicinity of the Sandy River delta (rkm 200)
  - Spring and Summer – 2007 and 2008
  - Late Winter/Early Spring – 2010 and 2011
Background

- 2007 & 2008 research leveraged tagging of juvenile Chinook salmon (> 95 mm) as part of upstream studies.
- 2010 and 2011 research focused on capturing and tagging large (> 95 mm) Chinook salmon known to reside in the study area during winter.

![Graph showing fish length distribution by month: January, February, March.]

Sather et al. 2011
Study Area and Detection Arrays

**Spring/Summer**
April 27 – August 18, 2007
April 26 – July 25, 2008

**Late Winter/Early Spring**
February 27 – April 23, 2010
February 2 – May 17, 2011
Methods

- Juvenile Salmon Acoustic Telemetry System (JSATS)
  - Tag weight (g): 0.43 - 0.63

- Spring and Summer: 2007 & 2008
  - 20,000+ fish tagged upstream as part of other studies

- Late Winter/Early Spring: 2010 & 2011
  - ~50 fish tagged each year from beach seine collections at SRD

- Residence time = last detection date/time - release date/time
  - 2007-2008 by node; 2010-2011 for all nodes combined
Juvenile Salmon Tagging Summary

<table>
<thead>
<tr>
<th>Year</th>
<th>n</th>
<th>Location Tagged</th>
<th>Season Tagged</th>
<th>Fish</th>
<th>Mean Fork Length (mm)</th>
<th>Genetic Stock Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>&gt;23,000</td>
<td>Upstream of Bonneville</td>
<td>Spring Summer</td>
<td>Yearling CH Subyearling CH</td>
<td>145 105</td>
<td>No</td>
</tr>
<tr>
<td>2008</td>
<td>23,340</td>
<td>Upstream of Bonneville</td>
<td>Spring Summer</td>
<td>Yearling CH Subyearling CH</td>
<td>144 115</td>
<td>No</td>
</tr>
<tr>
<td>2010</td>
<td>51</td>
<td>SRD</td>
<td>Winter</td>
<td>Chinook</td>
<td>103</td>
<td>Yes</td>
</tr>
<tr>
<td>2011</td>
<td>12</td>
<td>SRD</td>
<td>Winter</td>
<td>Chinook</td>
<td>115</td>
<td>Yes</td>
</tr>
<tr>
<td>2011</td>
<td>36</td>
<td>SRD</td>
<td>Winter</td>
<td>Coho</td>
<td>116</td>
<td>No</td>
</tr>
</tbody>
</table>

JSATS Acoustic Micro-Transmitter (Top) and a PIT Tag (Bottom) (circa 2007)
6 mm width x 4 mm height x 16 mm length, weight 450 mg in air, volume 0.394 cm$^3$
Residence times were short (<4 hours)

The longest residence times were exhibited by subyearling Chinook salmon during 2007.
Late Winter/Early Spring 2010 & 2011: Residence Times (days)

<table>
<thead>
<tr>
<th>Year</th>
<th>Fish</th>
<th>n</th>
<th>Mean</th>
<th>Median</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Chinook</td>
<td>48</td>
<td>34.3</td>
<td>26.3</td>
<td>1.11</td>
<td>78.4</td>
</tr>
<tr>
<td>2011</td>
<td>Chinook</td>
<td>12(a)</td>
<td>24.7</td>
<td>11.6</td>
<td>0.09</td>
<td>73.7</td>
</tr>
<tr>
<td>2011</td>
<td>Coho</td>
<td>36</td>
<td>28.6</td>
<td>11.2</td>
<td>0.02</td>
<td>89.8</td>
</tr>
</tbody>
</table>

(a) Two transmitters did not exit the study area
Exit Timing 2010/2011

2010 Chinook

2011 Chinook

2011 Coho
Residence Time and Length/Weight Relationships: 2010

\[ y = -0.545x + 90.741 \]
\[ R^2 = 0.0356 \]

\[ y = 0.4125x + 29.655 \]
\[ R^2 = 0.0024 \]
Residence Time and Length/Weight Relationships: 2011

a) Chinook
\[ y = -0.957x + 134.58 \]
\[ R^2 = 0.1135, P = 0.284 \]

b) Coho
\[ y = -1.1427x + 161.12 \]
\[ R^2 = 0.0713, P = 0.115 \]

c) Chinook
\[ y = -2.2591x + 60.108 \]
\[ R^2 = 0.1354, P = 0.239 \]

d) Coho
\[ y = -3.7541x + 88.919 \]
\[ R^2 = 0.1235, P = 0.036 \]
The two phases of this investigation revealed contrasting migration patterns for juvenile Chinook salmon (>95mm) in the SRD

- **Spring/Summer 2007 and 2008**
  - Fish collected at upriver juvenile bypass facilities
  - 3-11% of tagged juvenile salmonids migrated through off channel areas in the vicinity of the SRD
  - Tagged fish were actively migrating

- **Winter 2010 and 2011**
  - Fish collected by beach seine in SRD
  - Fish residing for extended periods
  - Tagged fish were not actively migrating

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean Residence Time*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>&lt;1-4 hrs</td>
</tr>
<tr>
<td>2008</td>
<td>&lt;1-2 hrs</td>
</tr>
<tr>
<td>2010</td>
<td>34 days</td>
</tr>
<tr>
<td>2011</td>
<td>25 days**</td>
</tr>
</tbody>
</table>

*2007/2008 by node; 2010/2011 for all nodes combined

**Coho and Chinook salmon combined
Management Implications

- Differences in residence time between the two phases likely reflects differences in life history strategies of juvenile Chinook salmon.
  - Spring/summer fish were actively migrating and had minimal use of SRD.
  - Late winter Chinook salmon were not actively migrating and were presumably using shallow water habitats for rearing.

- This study’s documentation of extended residence time during late winter/early spring in tidal freshwater by juvenile Chinook salmon indicates:
  - Restoration of shallow water habitats may benefit salmon populations in late winter and early spring.
  - Research should not necessarily focus just on the spring and summer peak migration periods for juvenile salmon.
  - Restoration actions which promote expression of multiple life history strategies (e.g. winter rearing) may increase salmon performance.
Limitations

- The 2010/2011 residence times estimates are conservative.
  - We do not know how long a sampled fish may have been in the area before it was captured and tagged.

- The maximum observable residence time is limited by tag life.
  - 2010 ~60 d and 2011 ~90 d tag life

- The migration characteristics we observed are not representative of all juvenile salmon life history stages in the LCRE year-round.
  - Size: juvenile salmon < 95 mm fork length could not be sampled.
  - Timing: juvenile salmon residence times during late summer, fall, and early winter were not estimated.
  - Species/stock: sockeye and chum were not studied and stock-specific estimates for Chinook salmon were not possible with the sample sizes available.

- Only a few off-channel areas of tidal freshwater have been studied.
  - Movements from the main channel to habitats up tributaries, sloughs, culverts, etc.

- While tag effects for JSATS transmitters have been thoroughly examined and are minimal, we do not know how the implanted tag may have affected fish behavior.
Recommendations

► Technology advances
  ■ Smaller transmitter
  ■ Long-life transmitter
  ■ Improved receiving detectability in shallow water

► Sampling design
  ■ Year-round tagging and monitoring
  ■ Stocks emigrating from the Columbia and Willamette in late summer, fall, and winter

► Integration and coordination
  ■ Multiple acoustic telemetry studies in different locations for different purposes
  ■ Many, if not all, have tagged fish entering and using the LCRE
Acknowledgements

- Funded by BPA and USACE
- Tracey Yerxa (BPA)
- David Teel (NMFS)
- Adam Storch, Tucker Jones, Erick Van Dyke, Christine Mallette (ODFW)
- Blaine Ebberts, Brad Eppard, Mike Langeslay (USCAE)
- Earl Dawley (NMFS-retired)
THANK YOU