Tide Gate Impacts on Juvenile Coho Salmon Movement and Migration

Arthur Bass
Guillermo Giannico

Oregon State University
Department of Fisheries and Wildlife
What is a tide gate?

Side Hinged

Top Hinged

Tide gate function is determined by hydraulic head differential.

Giannico and Souder 2005
Where are tide gates used?

- Palouse Creek
- Larson Creek
Side-Hinged Gate Opening Cycle
Top-Hinged Gate Opening Cycle
Coho Nomads

- Age 0 coho start arriving in upper estuary in March
- Move between streams, return to freshwater
- Grow at higher rate than stream counterparts
- Special case for tide gates

Tschaplinski 1982
How do tide gates impact fish?

- Habitat Access - Passage
- Water Quality
- Migration Timing
- Rearing Conditions (For Better or Worse)
- Predation
Habitat Access - Passage

Palouse (Top Hinged)

Larson (Side Hinged)
Water Quality: Temperature
Water Quality: Salinity

Graph showing average salinity (ppt) from April 2009 to October 2009 with three different lines representing PTG U/S, BAY, and LTG U/S.
Rearing Conditions: Substrate and Vegetation
Research Questions

Passage: For what portion of a tide gate’s opening cycle is passage possible?

Migration Timing: Do tide gates affect the outmigration rate of coho smolts?
Methods: Field Sites

No tide gate - reference (Winchester)

Side Hinged (Larson)

Top Hinged (Palouse)
Methods: Data Collection at Tide Gates

Temp = 17.7 °C
Salinity = 13.3 ppt
WSE = -0.02 m NVGD

5/27/09 9:00
10.1°

Temp = 17.8 °C
Salinity = 14.3 ppt
WSE = -0.83 m NVGD

3D9.1C2D13444D = coho, 5/18/09, Palouse Reservoir, FL = 108 mm, W = 16.4 g
Salmonid Presence at all Sites

Graphs showing the presence of different salmonid species at various sites:

- **Palouse (Top Hinged)**
- **Larson (Side Hinged)**
- **Winchester (No Gate)**

Species tracked include:
- Coho smolt
- Coho Age 0
- Cutthroat
- Chinook
- Coho adult
- Coho jack
- Steelhead

Dates range from Mar-09 to Jan-10.
Passage

For what portion of a tide gate’s opening cycle is passage possible?

For coho smolts and nomads

Both Upstream and Downstream

Use-Availability Approach
Passage: Gate Variables

- Gate Angle
- Tailwater Depth
Passage Results: Smolts in 3 Streams
Passage Results: Use - Availability

Downstream Passage
• Smolts selected greater angles and deeper tailwater at both gates

Upstream Passage
• Age 0 selected smaller angles and small range of tailwater at top-hinged
Passage Results: Use - Availability

(Top Hinged)

Gate Angle (degrees)

N = 17

(Side Hinged)

Gate Angle (degrees)

N = 16

Tailwater Depth (m)

N = 16

- Available angles
- Age 0 coho
Passage Results: Age 0 coho at Top Hinged Gate
Passage: Conclusions

• Coho smolts showed selectivity at both gates when passing downstream

• Age 0 coho limited to small window for passing upstream at top-hinged gate

• Side-hinged, deep tailwater, leaky tide gate may allow best habitat access
Migration Timing

Do tide gates affect outmigration rate of coho smolts?

- determine whether environmental conditions impacted by tide gates influence migration rate
Migration Timing: Palouse Creek, Top Hinged Gate

Water Quality Parameters
Migration Timing

Survival Analysis: Proportional Hazards Regression

- Allows censored data
- Estimate timing and duration – compare groups
- Test fixed and time dependent explanatory variables

Anderson 2009: Passage Delays of Migrating Redband Trout
Migration Timing: Proportional Hazards Regression

Explanatory Variables:

• Salinity – 24 hr average
• Temperature – 24 hr average
• Precipitation – 48 hr cumulative
• Fork length at tagging
• Date of Tagging

\[ h_{i(t)} = \lambda_0(t) \exp [\beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i}] \]
### Migration Timing Results

#### Product-Limit Survival Estimates

<table>
<thead>
<tr>
<th>Reach</th>
<th>Total</th>
<th>% Censored</th>
<th>Mean Delay (Days)</th>
<th>Median Delay [C.I.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stream: rkm 6 to 3</td>
<td>257</td>
<td>39.7</td>
<td>3.4</td>
<td>1.7 [1.4-2.2]</td>
</tr>
<tr>
<td>Reservoir: rkm 3 to 0</td>
<td>145</td>
<td>26.9</td>
<td>12.5</td>
<td>9.1 [7.9-11.9]</td>
</tr>
<tr>
<td>Through Tide Gate</td>
<td>125</td>
<td>11.2</td>
<td>4.1</td>
<td>0.001 [0.0 – 0.04]</td>
</tr>
</tbody>
</table>
Migration Timing Results

Temperature: 25% more likely to leave per each °C increase in temp
Fork Length: 2% more likely to leave per each mm increase in FL

Temperature: 30% more likely to leave per each °C increase in temp
Fork Length: 8% more likely to leave per each mm increase in FL

Salinity: 6% less likely to leave per each ppt increase in salinity
Fork Length: 3% more likely to leave per each mm increase in FL
Migration Timing: Conclusions

Travel Rate:
- ↑ Fork Length and Temperature = ↑ Emigration Rate
- ↑ Salinity = ↓ Emigration Rate
- Nothing to compare to! No emigration rate baseline

Implication:
- Tide Gates have potential to alter emigration rate
- Easy opening, leaky tide gate may be preferable
Management

Ideal Tide Gate for fish?
- Easy to Open (Side-hinged)
- “Leaky”
- Deep Tailwater

Options Exist

Each Case is Unique
Needed Research

- Predation at tide gates
- Impact on Coho Nomads
- Acoustic Tags
  - Directly measure survival
  - Follow smolts in estuary
- DIDSON
  - Works well under dynamic conditions
  - Monitor passage of more organisms
Thanks!

Funding: Oregon Watershed Enhancement Board

OSU Oregon State University

NOAA FISHERIES SERVICE

Antenna Construction
Gabriel Brooks
Bruce Hansen
Earl Prentice
Chris Jordan

Giannico Lab
Matt Anderson
George Boxall
Adam Weybright

Field
Adam Weybright
Justin Arriola
Andrew McClary
John Winkowski
Bruce Miller
Donald Danesi

Volunteers
Matt Sloat
Dennis Feeny
Nathan Hostetter
Shivonne Nesbit
Brett Hanshew
Erin Kunisch
Véronique Thériault
Craig Cornu

Committee
Joe Ebersole
Marv Pyles
Jon Souder
Jesse Ford
# Efficiency info

All values for 12 mm tags

<table>
<thead>
<tr>
<th></th>
<th>Palouse Smolts DS</th>
<th>Larson Smolts DS</th>
<th>Palouse Age 0 US</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>69</td>
<td>24</td>
<td>21</td>
</tr>
<tr>
<td>$E_{row\ 1}$</td>
<td>.58</td>
<td>.21</td>
<td>.76</td>
</tr>
<tr>
<td>$E_{row\ 2}$</td>
<td>.54</td>
<td>.21</td>
<td>.67</td>
</tr>
<tr>
<td>$E_{row\ 3}$</td>
<td>.19</td>
<td>.29</td>
<td>.14</td>
</tr>
<tr>
<td>$E_{combined}$</td>
<td>.84</td>
<td>.56</td>
<td>.93</td>
</tr>
<tr>
<td>$E_{pass}$</td>
<td>.31</td>
<td>.04</td>
<td>.51</td>
</tr>
</tbody>
</table>

No efficiency estimates for Winchester