Response of Juvenile Walleye Pollock to Ocean Acidification

Elena Fernández, Tom Hurst, Jeremy Mathis
Rasmuson Fisheries Research Center Board Meeting
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Bridging Disciplines

- What is ocean acidification?
- CO₂ rearing system
- Juvenile studies
- Future directions
So... why pollock?

- Commercially important species
- Integral part of temperate and subpolar fisheries and food webs

M. Spencer 2010, adapted from Bailey et al. 1999
Ocean Acidification and Biological Consequences
Ocean Acidification

- Ocean pH has decreased since the Industrial Revolution
- Models show pH will continue to decrease
- High latitude oceans susceptible to acidification

\[
\begin{align*}
\text{CO}_2 + \text{H}_2\text{O} & \leftrightarrow \text{H}_2\text{CO}_3 \\
\text{H}_2\text{CO}_3 & \leftrightarrow \text{HCO}_3^- + \text{H}^+ \\
\text{HCO}_3^- + \text{H}^+ & \leftrightarrow \text{CO}_3^- + \text{H}^+
\end{align*}
\]

Figure from Caldiera and Wickett (2003)
Known Biological Consequences

- Decreased skeletal quality in corals
- Decreased shell thickness
- Developmental issues in echinoderms and calcifiers
- Problems with physiological processes in fish and benthic invertebrates
- Possible bottom-up effects
- Fish studies? There are still a lot of unknowns...
CO$_2$ Rearing System Design and Validation
Automated pH control system for larval and juvenile fish experiments

- pH meter controls CO₂ flow to exchanger
- Fluid-gas membrane exchanger on re-circulating pump
- Environmental CO₂ sensor
- pH-conditioned water pumped to fish tanks
- Ambient seawater inflow

Courtesy of Tom Hurst
Ambient Water to Header Tank

Acidic Water to Header Tank

SympHony pH meters

Overflow to UV Sterilizer
Header Tanks

Treatment Tanks: 4 per pH treatment level

Lines deliver treated water to tanks
Tank pH Monitoring

- Continuous monitoring: pH meters on tanks
- Long term monitoring: VINDTA titration
  ✦ Measures DIC and Total Alkalinity
- VINDTA readings show that the fish tanks were +/- 0.03 units from the target
Daily mean tank pH for juvenile walleye pollock ocean acidification experiments from 30 October 2009 until 17 December 2009

<table>
<thead>
<tr>
<th>Date</th>
<th>Tank pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-Oct-09</td>
<td>pH 7.2</td>
</tr>
<tr>
<td>6-Nov-09</td>
<td>pH 7.6</td>
</tr>
<tr>
<td>13-Nov-09</td>
<td>pH 7.9</td>
</tr>
<tr>
<td>20-Nov-09</td>
<td></td>
</tr>
<tr>
<td>27-Nov-09</td>
<td></td>
</tr>
<tr>
<td>4-Dec-09</td>
<td></td>
</tr>
<tr>
<td>11-Dec-09</td>
<td></td>
</tr>
</tbody>
</table>

Tank pH

Date

- Ambient Control
- pH 7.2
- pH 7.6
- pH 7.9
Response to Ocean Acidification: Juvenile Experiments
Integrated Bioassessment: The Shotgun Approach

- Get a comprehensive look at how an animal is responding to changes
- Potentially see parameter interactions
- Yields a starting point for future research
### Integrated Bioassessment: The Shotgun Approach

<table>
<thead>
<tr>
<th>Stress Indicators</th>
<th>Tissue Damage Indicators</th>
<th>Whole Body Indices</th>
<th>Blood Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Glucose</td>
<td>LDH</td>
<td>HSI</td>
<td>pCO₂</td>
</tr>
<tr>
<td>Blood Cortisol</td>
<td>ALT</td>
<td>Body Condition</td>
<td>pH</td>
</tr>
<tr>
<td>Cortisol Secretion</td>
<td>AST</td>
<td>Growth Rates</td>
<td>Bicarbonate</td>
</tr>
</tbody>
</table>
Incubation Setup

Control pH

pH 7.9

pH 7.2

pH 7.6

2 week tank acclimation
6 week incubation
Blood, length, and weight data collected for assays and body condition analysis.
Necropsy to collect tissues and otoliths.

Tissues include:
- Liver
- Kidney
- Spleen
- Gill
- Heart
Response of Blood Gas Parameters: pCO$_2$
Response of Blood Gas Parameters: Bicarbonate
Response of Blood Gas Parameters: pH

![Bar chart showing blood pH levels across different treatment pH values.}

- **A** at 7.2
- **B** at 7.6 and 7.9
- **C** at 8.05
The other parameters:

<table>
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<th>Stress Indicators</th>
<th>Tissue Damage Indicators</th>
<th>Whole Body Indices</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Response</td>
<td>No Response</td>
<td>No Response</td>
</tr>
</tbody>
</table>

There is a physiological response, but not enough to necessarily affect other systems.
The fish are more resilient than we initially thought!

Fish came from Port Townsend, WA... pH within physiological tolerance window?

Nonetheless...
This opens a few doors for future projects
On the horizon...

- Egg and larval experiments
  - Hatch timing, hatch success
  - Developmental parameters at hatch
- Growth rates, body condition indices of other commercially important species (i.e., Pacific cod)
- Synergistic effects?
Acknowledgements

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Any Questions?