Greetings from the Coal Mine:

Understanding the Effects of Acidified Seawater on the Pacific Northwest Shellfish Industry
Pacific Northwest Shellfish Industry

- Commercial harvest of shellfish in the Pacific Northwest dates from the 1860s

- Currently provides over 3000 family wage jobs for workers in WA, OR, CA, AK, and Hawaii

- Farm gate value of $110 million per year, representing a total contribution of $278 million annually to rural coastal communities
Pacific Coast Shellfish Growers Association (PCSGA)

Represents shellfish growers in Oregon, Washington, Alaska, California, and Hawaii

Over 100 member companies growing Pacific and Kumomoto oysters, Manila and Geoduck Clams, and mussels

Oysters: 94 million lbs/yr
Manila clams: 8.5 million lbs/yr.
Pacific Coast Shellfish Growers Association (PCSGA)
Oyster Farming
a way of life
Adapting to a Changing Ocean

Farmers like Brian Sheldon, whose family has relied on natural recruitment for three generations, are now being forced to look for new sources of seed.
Upwelling on the Oregon Coast

Water corrosive enough to dissolve aragonite shell has been found over the Oregon continental shelf each summer since 2008.

This condition was not expected to occur in open ocean surface waters until 2050.

Feely et al 2008
Understanding the Large Scale Forcings with NANOOS / Coastwatch Data
Water corrosive enough to dissolve aragonite shell has been found over the Oregon continental shelf each summer since 2008. This condition was not expected to occur in open ocean surface waters until 2050.

Feely et al. 2008

South winds produce downwelling
Lower salinity
Ω >> 1 (easy to form shell)
Fast growth and good survival of small larvae

North winds produce upwelling
Higher salinity
Ω <= 1 (difficult or impossible to build shell)
Poor growth and mass mortality of small larvae
Oyster Larvae from Taylor Shellfish Hatchery, Dabob Bay, WA

Shallow Water
pCO2  300-400 uatm

Deep Water
pCO2  >1000 uatm
pH distribution in surface waters
from the NCAR CCSM3 model projections using the
IPCC A2 CO$_2$ Emission Scenarios

Feely, Doney and Cooley,
*Oceanography* (2009)
Narrowing the Focus – Global vs. Coastal Scales
Bellingham, WA - Lummi Hatchery

Dabob Bay, WA - Taylor Shellfish Hatchery

Gray’s Harbor, WA - setting stations

Willapa Bay, WA -
  Tokeland, Bay Center, and Nahcotta monitoring stations

Netarts Bay, OR -
  Whiskey Creek Shellfish Hatchery
Continuous pCO2 data – the ‘Burkilator’

Burke Hales, Jesse Vance – OSU COAS

- PSCGA owns three units
  Whiskey Creek, Taylor, Willapa

- Provides real-time pCO2 measurements of incoming seawater
<table>
<thead>
<tr>
<th>pCO2 Threshold</th>
<th>% of time ≥ threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>440 uatm</td>
<td>63.5%</td>
</tr>
<tr>
<td>500 uatm</td>
<td>52.4%</td>
</tr>
<tr>
<td>600 uatm</td>
<td>37.4%</td>
</tr>
<tr>
<td>800 uatm</td>
<td>14.2%</td>
</tr>
</tbody>
</table>
Continuous measurement of Saturation State

Burke Hales, Jesse Vance – OSU COAS

- Provides the ‘holy grail’ of water chemistry monitoring – real time calculation and display of $\Omega$

(from direct measurement of $tCO_2$ and $pCO_2$)

$$\Omega = \frac{[Ca^{2+}][CO_3^{2-}]}{K_{sp}}$$

- $\Omega > 1$ animals can make shell
- $\Omega >> 1$ easier to make shell (Langdon & Atkinson, 2005)
- $\Omega < 1$ shell dissolves
Managing Around the Problem

Monitoring pH

SPAWN!

July 21-31

- pH fluctuates wildly every day
- Fill tanks in PM when pH is higher
Commercial Oyster Farming

Hatchery Production of Eyed Oyster Larvae

Plantout and Harvest of Adult Product
Commercial Oyster Farming

Hatchery Production of Eyed Oyster Larvae

Plantout and Harvest of Adult Product
Willapa Bay Monitoring Stations
Real-time Water Quality Data
for Shellfish Growers in the Pacific NW
A pilot project between NANOOS and the National Estuarine Research Reserve System

**Make Informed Decisions Based on Real-Time Data!**
This pilot project represents an effort to bring existing real-time water quality data to shellfish growers in the Pacific Northwest. The project currently has thirteen monitoring sites in Alaska, Washington, and Oregon. Expansion to other sites is anticipated.

**Alaska**
Are you at risk for a *Vibrio* bacterium outbreak in Kachemak Bay? Check temperature and other readings here.

**Washington**
Do your oysters have enough oxygen to thrive in the Hood Canal? Get the latest information now.

**Oregon**
What impact did the last rainfall have on salinity? See what’s happening near Charleston and Valino Island.

**Spotlight Data**

**Hood Canal : Twanoh**
Tawah, WA
47° 22' 22.1 N 123° 0' 18.0 W
Sat 11/10/2012 12:15 PM
Continuous measurement of Saturation State

\[ \Omega = \frac{[Ca^{2+}][CO_3^{2-}]}{K_{sp}} \]

- There's are several ways to get to omega
- All of them are hard (to get right)
Suggestions For Tomorrow’s IOOS

• Increased emphasis on monitoring carbonate chemistry in coastal estuaries
• Improved utilization of data streams through development of user-friendly interfaces
• Establish standards, protocols, and adequate technical support to improve the quality of data submitted by user groups
Greetings from the Coal Mine:

Understanding the Effects of Acidified Seawater on the Pacific Northwest Shellfish Industry