Ocean Acidification Effects on Shellfish Production: From Hatchery Failures to Actionable Science

George G. Waldbusser (and many others)
Introduction to the Problem of Ocean Acidification

Globally, we are increasing the amount of $CO_2$ in the oceans and coastal waters faster than earth’s systems can respond.

The increasing $CO_2$ in seawater reduces the stability of calcium carbonate minerals, and makes it harder for the organisms that make shells to do so.
Contributors to ocean acidification. In addition to global atmospheric CO₂, this figure depicts the major local (within 100 km) sources contributing to coastal ocean acidification. (Kelly et al. 2011)

- Many important marine resource species either reside or rely on the coastal zone.
- Local drivers can exacerbate or improve conditions locally.
- Local drivers also provide stop-gap opportunities to address this issue.
- However ultimately, the global carbon problem needs to be addressed.

*The organisms do not care what the driver is.*
Ground Zero of Ocean Acidification

- The water that upwells here is approximately 30-50 years "old".
- Monitoring has facilitated adaptation.

Hales and Vance unpubl
Barton et al. 2012

![Graph showing relative larval production vs. Ω_A in initial water with R^2 = 0.53 and p = 0.001.]

![Graph showing pCO2 (µatm) vs. Day of Year (2010) with smoothed daily average and pCO2 time series.]

Hales and Vance unpubl
Why are Bivalve Larvae so Sensitive? (The Canaries in the Coal Mine)

Sensitivity appears to be dependent on stage.

No external food until D-hinge complete.

Cannot isolate the calcifying fluids as well.

Must deposit a lot of shell.

approximately 2 weeks

floating fertilized egg  swimming straight-hinge veliger  swimming late veliger  swimming & crawling pediveliger

Oyster Life Cycle

spat settling and attaching to oyster shells or other hard structures

1 - 3 years

egg and sperm

adult males and females

Credit: Karen R. Stenevy/COSEE SJ/NSF

5 µm
So What Can We Do?

In Lieu of a Global Carbon Policy...

Support Adaptation Tools for Industry

Support Basic Research on Ocean Acidification

Determine Local Driver Solutions (short-term)

Increase Opportunities for Cooperative Research Partnerships

“The cost of responding to ocean acidification may be substantial, but it is still far less than the costs of inaction”

– Bill Ruckelshaus, co-chair Washington Blue Ribbon Panel on Ocean Acidification, November 27, 2012
Why Should We Do It?

Basic Research is a Strong Economic Driver
   *Takes Money to Make Money*

Shellfish Production is a Sustainable Food Production Model
   *Low Input, Low Impact, High Yield*

Our Ocean Chemistry is Changing in Fundamental Ways, Faster Than Predicted

Hauri et al. 2013