# The PCSGA Monitoring Program

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

Pacific Coast
SHELLFISH GROWERS ASSOCIATION
Partners with Mother Nature
sustainably farmed
oysters, clams, mussels, scallops

# Why monitor?

- **To put accurate, real-time data in the direct line of sight of growers and hatchery managers and make informed decisions to manage around highly variable water quality**

- To inform the public on the the *real* state of *today's* coastal oceans

# 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

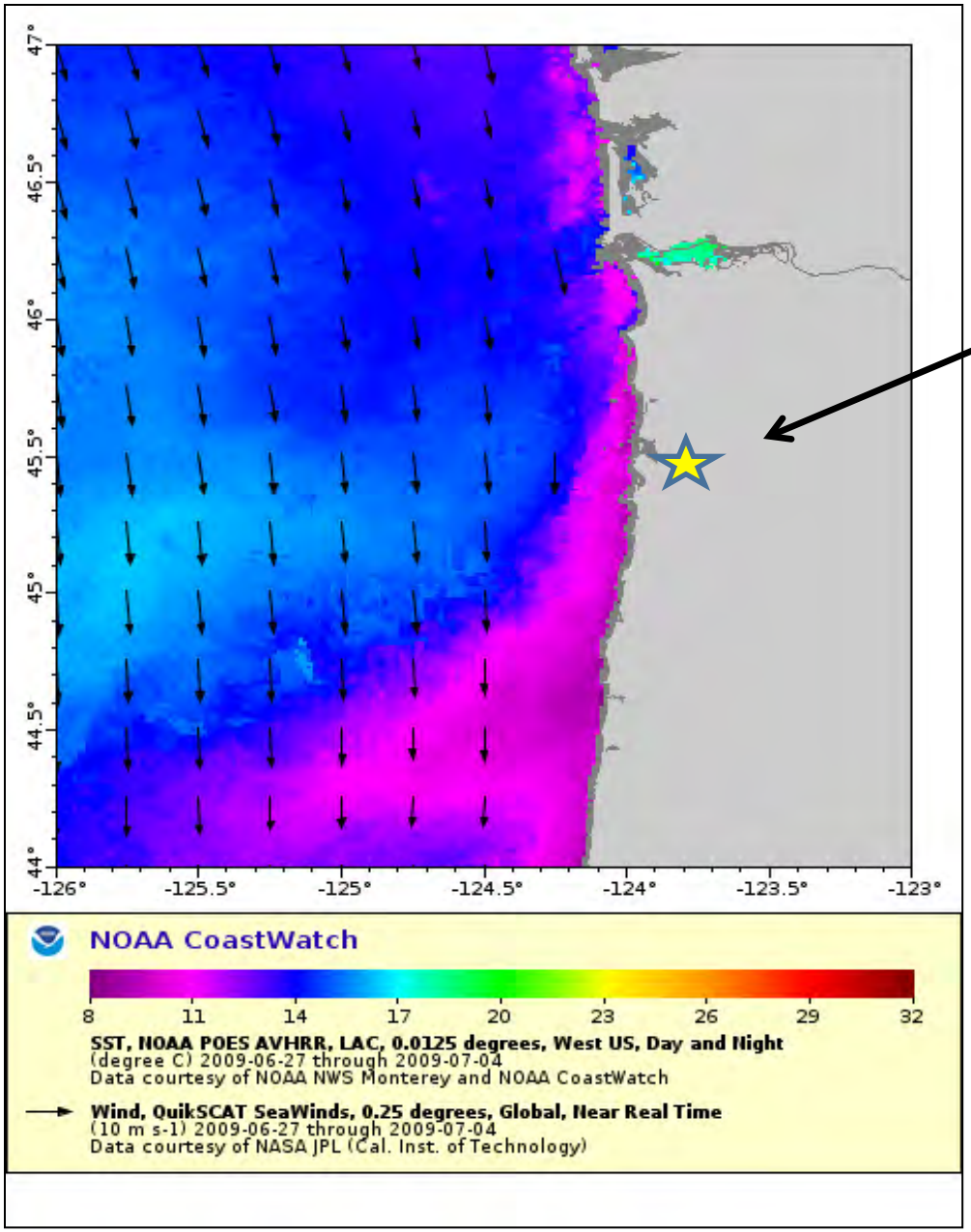
# Commercial Hatchery Production

*Three major commercial hatcheries supply larvae and seed to the Pacific Northwest shellfish industry*

- *Taylor Shellfish*
- *Coast Seafood*
- *Whiskey Creek Shellfish*


Whiskey Creek Shellfish Hatchery

- 30 year history of consistent production
- Experienced losses in 2007-2008 that reduced production to 25% of normal levels



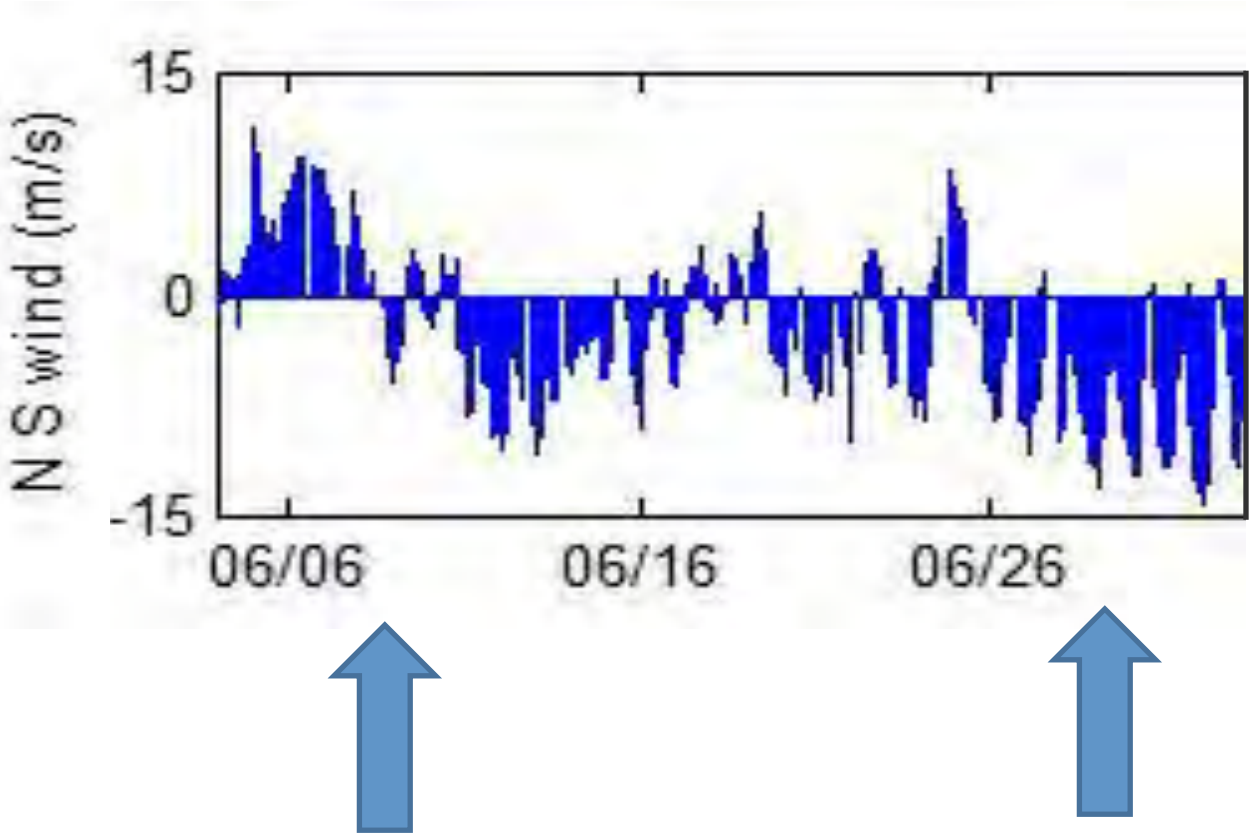

Whiskey Creek
Shellfish Hatchery
Netarts Bay, OR

Strong Upwelling Region

Winds from the North produce Upwelling of cold seawater (purple)

# Managing around the problem

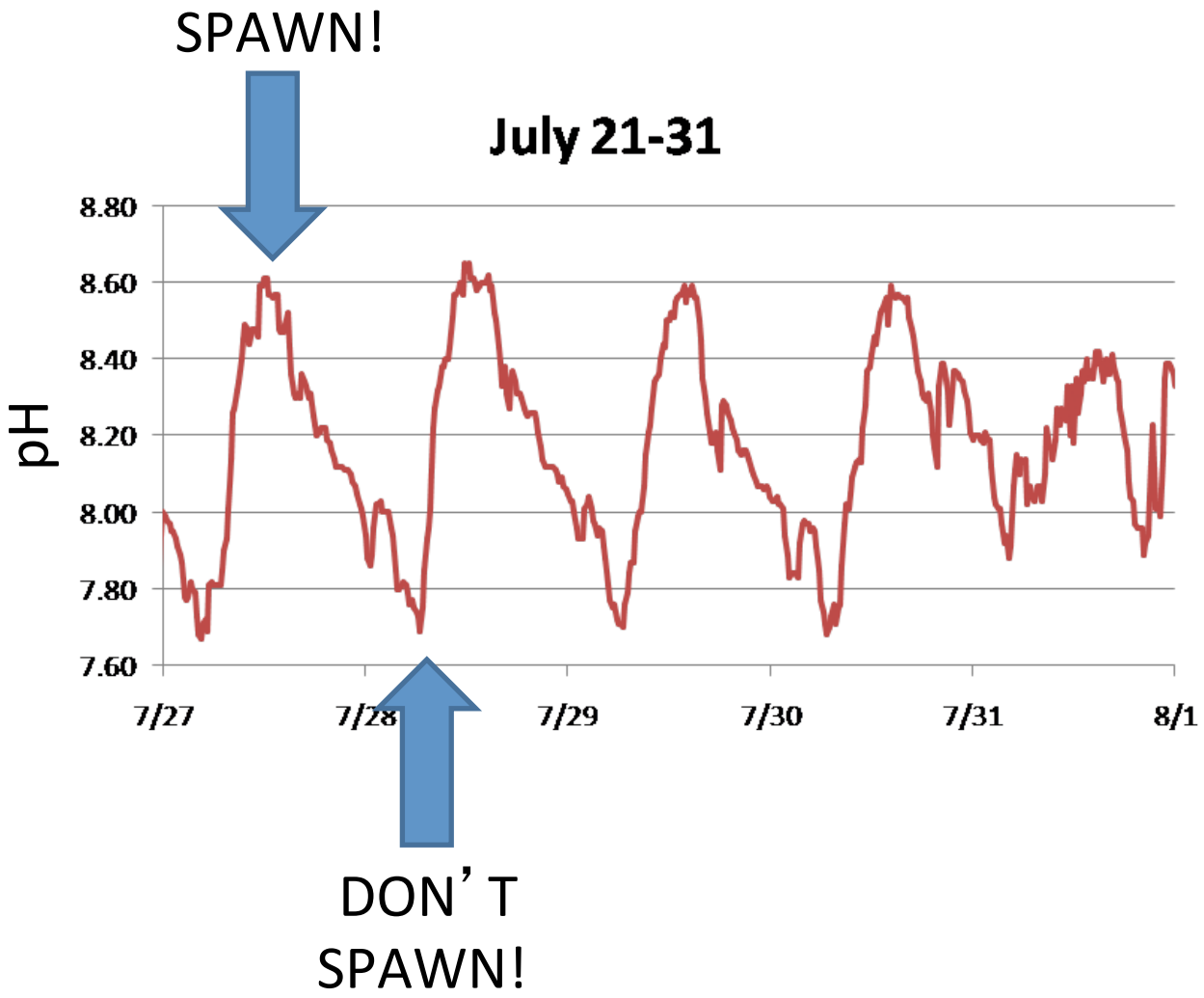
## Monitoring Winds




- North winds bring bad water
- 24 – 48 hour work window before 'bad' water hits

# Managing around the problem

## Monitoring pH



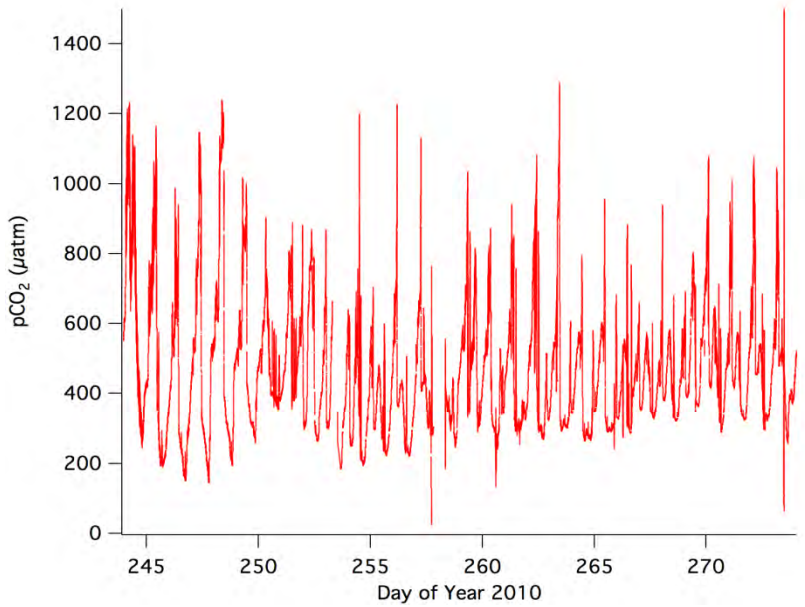

- pH fluctuates wildly every day
- Fill tanks in PM when pH is higher

# 2010 – Better Management Tools in the Hatchery

## Continuous pCO2 data – the 'Burkilator'

Burke Hales, Jesse Vance – OSU COAS

- Installed in April 2010
- Provides real-time pCO2 measurements of incoming seawater



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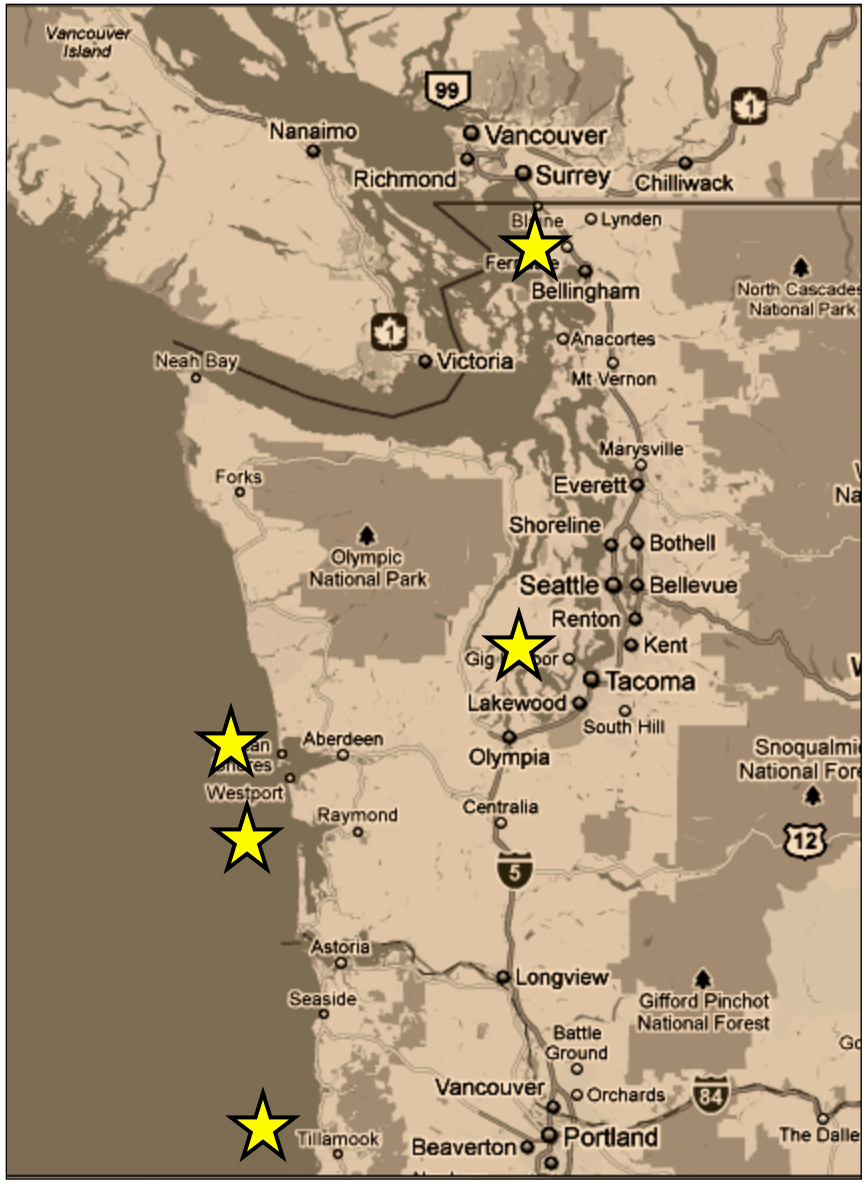
# NETARTS BAY - JUNE-AUGUST 2010

| pCO2 Threshold | % of time ≥ threshold |
| --- | --- |
| • 440 uatm | 63.5% |
| • 500 uatm | 52.4% |
| • 600 uatm | 37.4% |
| • 800 uatm | 14.2% |

# PCSGA Monitoring Program 2011 Monitoring Stations

- 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



# PCSGA monitoring program

Continuous $pCO_2$ data (Taylor, Whiskey Creek, Willapa)

Continuous monitoring of pH, temp., salinity, DO, ORP, etc.

Dicrete samples – weekly AM/PM samples

- Dissolved Oxygen
- Carbonate chemistry
- Nutrients
- Bacteria levels

Larval performance data

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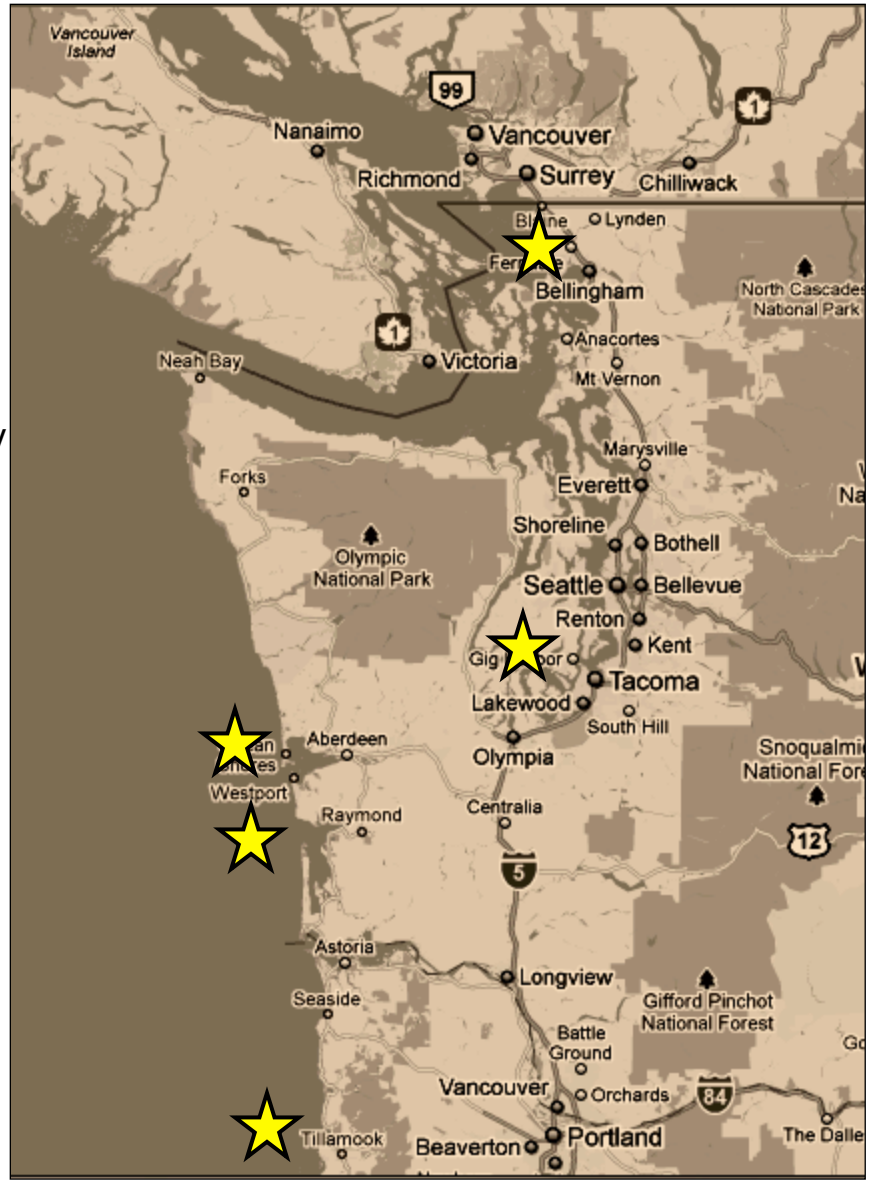
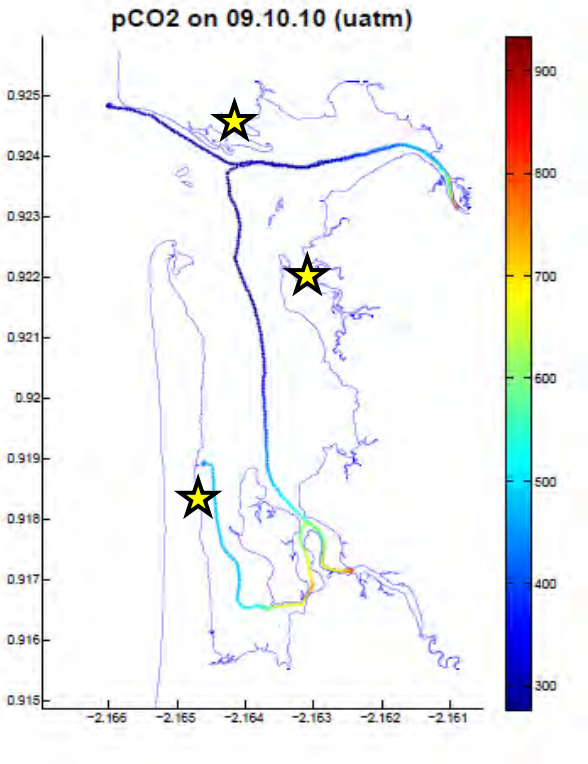
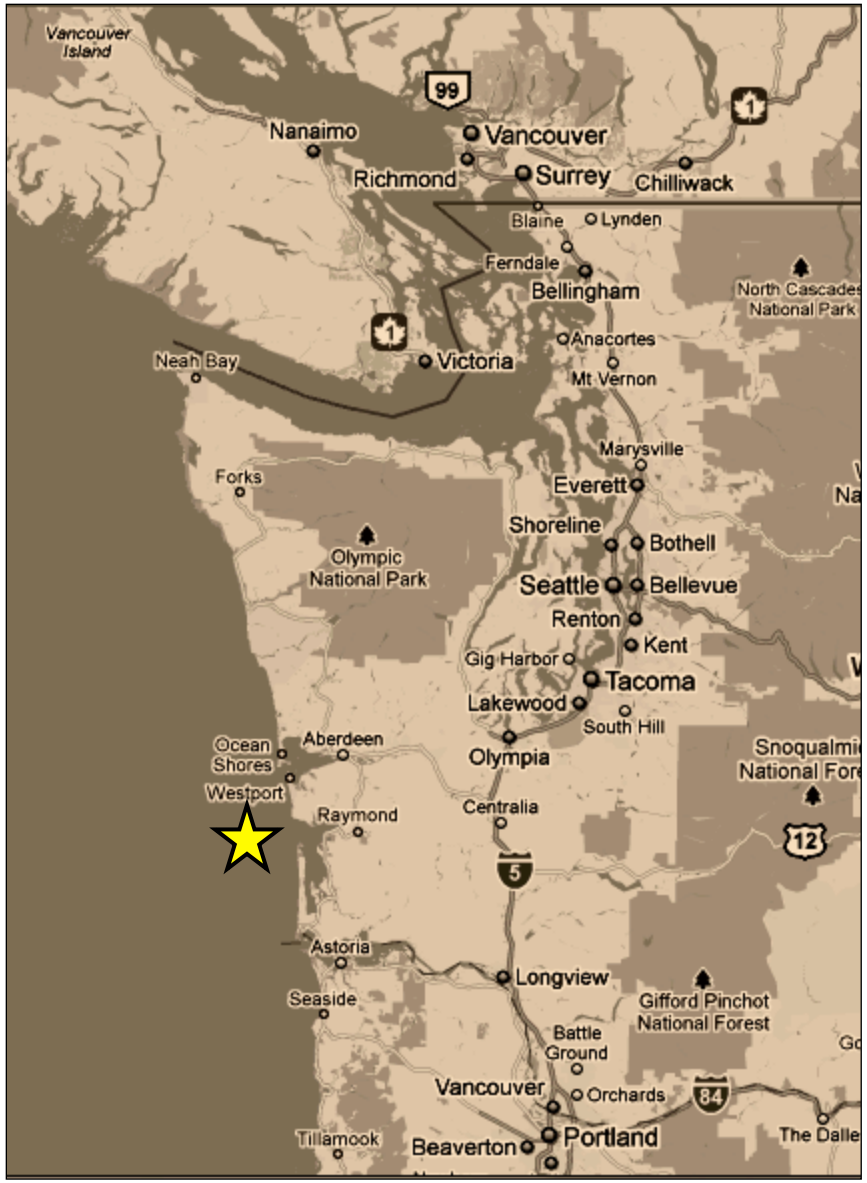


## Willapa Bay, WA-

Tokeland, Bay Center, and
Nahcotta monitoring stations

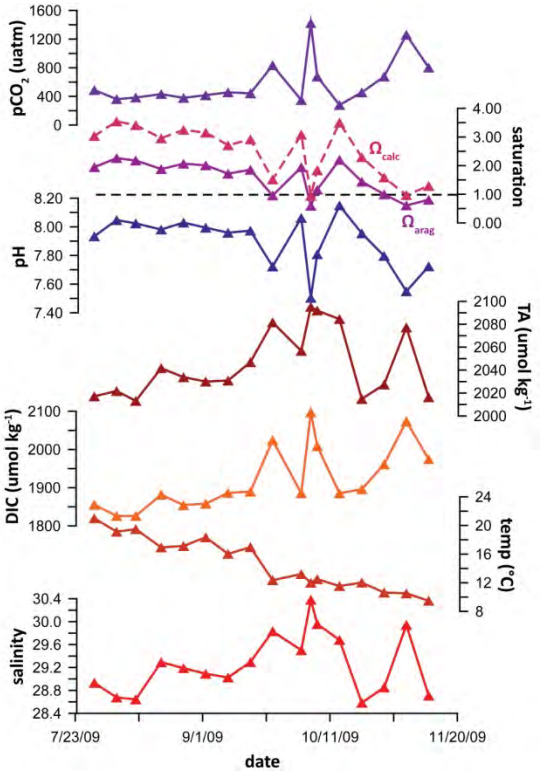
UW,PSI,WDFW,WRF partnership
Trimble,Suhrbier,Kaufman, etc.

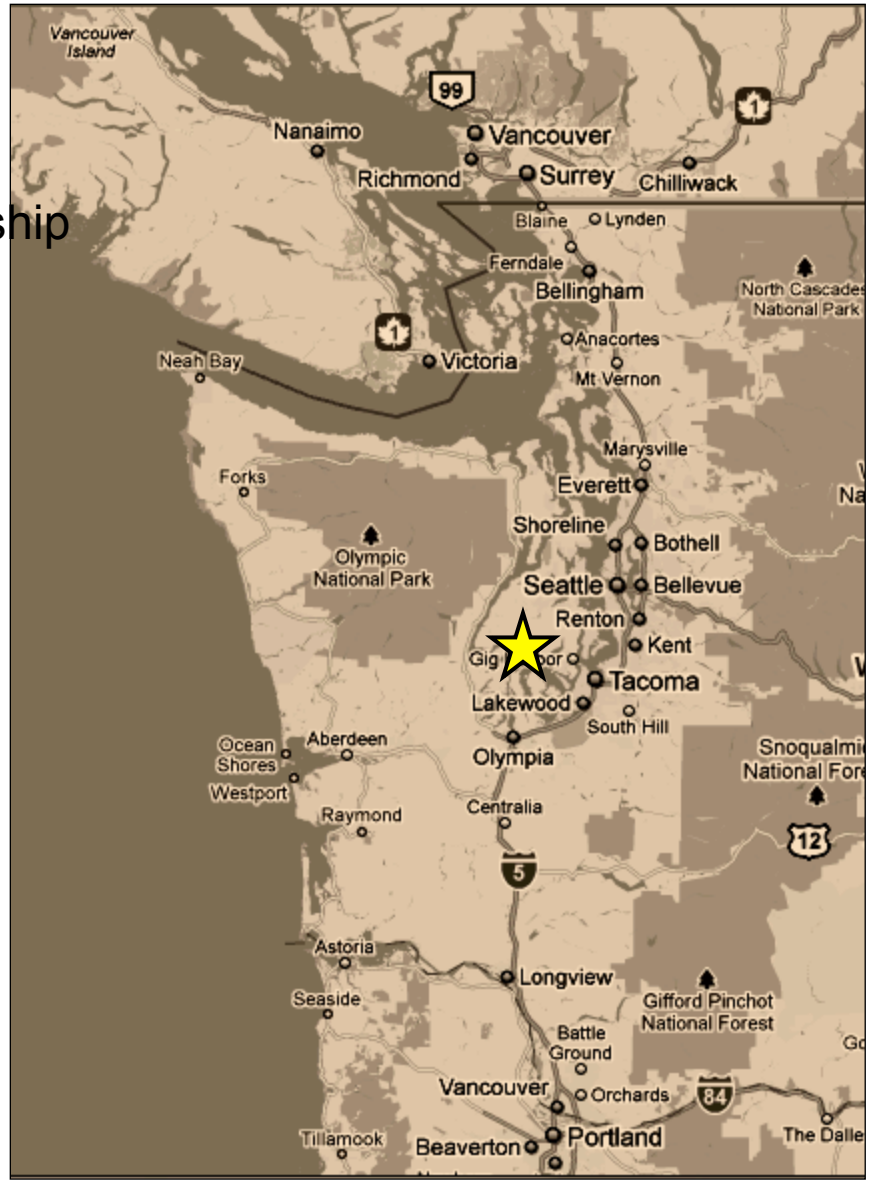


Dabob Bay, WA- Taylor Shellfish Hatchery

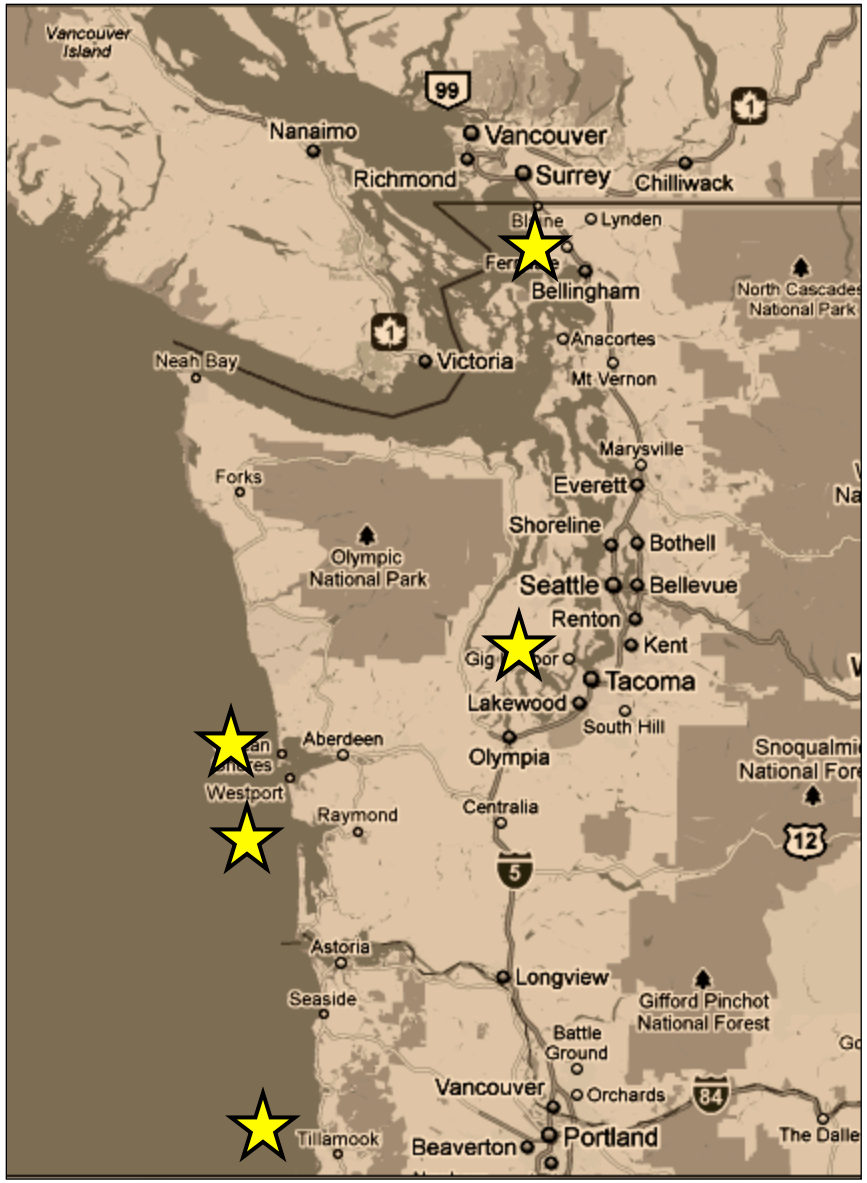
NOAA, UW, PCSGA, PSRF partnership
Newton, Feely, Sabine,etc.



The real strength of this monitoring project …

**Hatcheries collect biological data every day**




## PCSGA New Partners

- NOAA
- Oregon State University: University of Washington
- Puget Sound Restoration Fund
- Pacific Shellfish Institute
- Local Growers and Hatcheries Managers
- Washington Department of Fish and Wildlife

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SHELLFISH GROWERS ASSOCIATION
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# Thanks to:

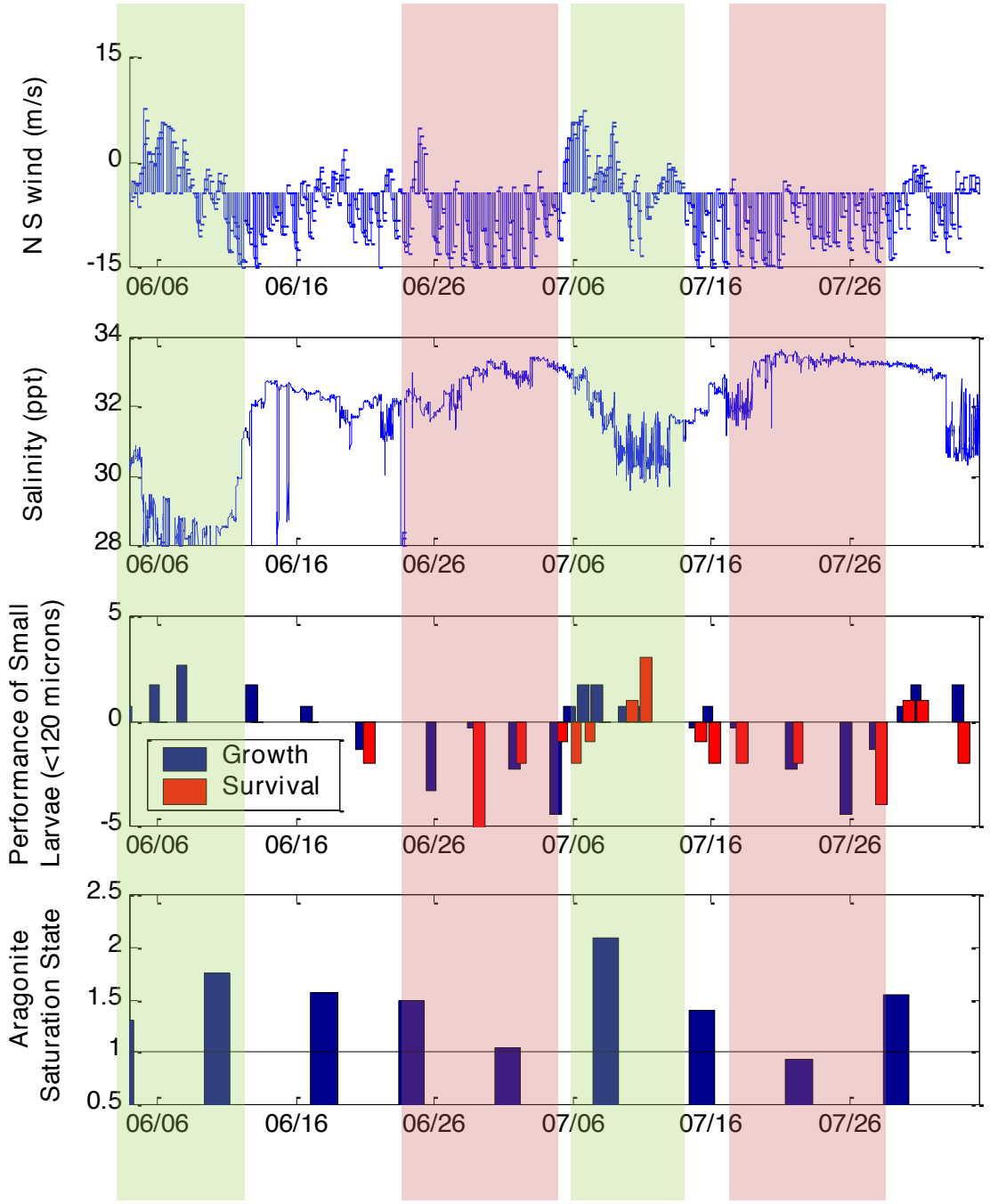

- NOAA and Senator Maria Cantwell's office
- Chris Langdon and the Molluscan Broodstock Program
- Burke Hales, Jesse Vance, George Walbusser, and Joe Jennings (COAS)
- Richard Feely, Chris Sabine, and Jan Newton (UW,NOAA)
- Alan Trimble (UW), Andy Suhrbier (PSI), and Bruce Kaufman (WDFW)
- Ralph Elston (Aquatechnics), Claudia Hase (OSU), Carolyn Friedman, Steven Roberts, and Brent Vadopalas (UW)

**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**



# FACT: Young oyster larvae are extremely sensitive to low W

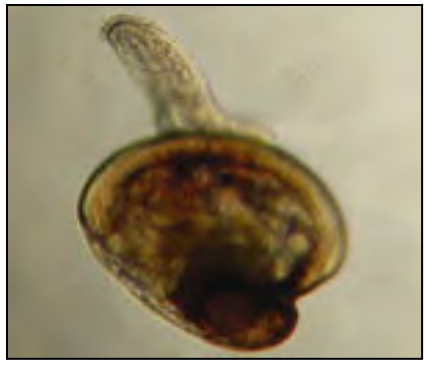
$$W = \frac{[Ca^{2+}][CO_3^{2-}]}{K_{sp}}$$

W > 1 animals can make shell
W >>1 easier to make shell (Langdon & Atkinson, 2005)
W < 1 shell dissolves

**Adult oyster shell** - calcite
harder to dissolve

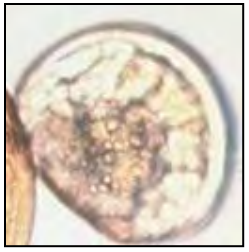
**Larval oyster shell** - aragonite
easier to dissolve

**Young oyster larvae- (first 96 hours after fertilization)** ACC?
*really* easy to kill



# FACT: Early season high pCO2 effects on larvae are very different late season high pCO2 effects on larvae

- Scenario 1 - Direct Effects of Upwelling



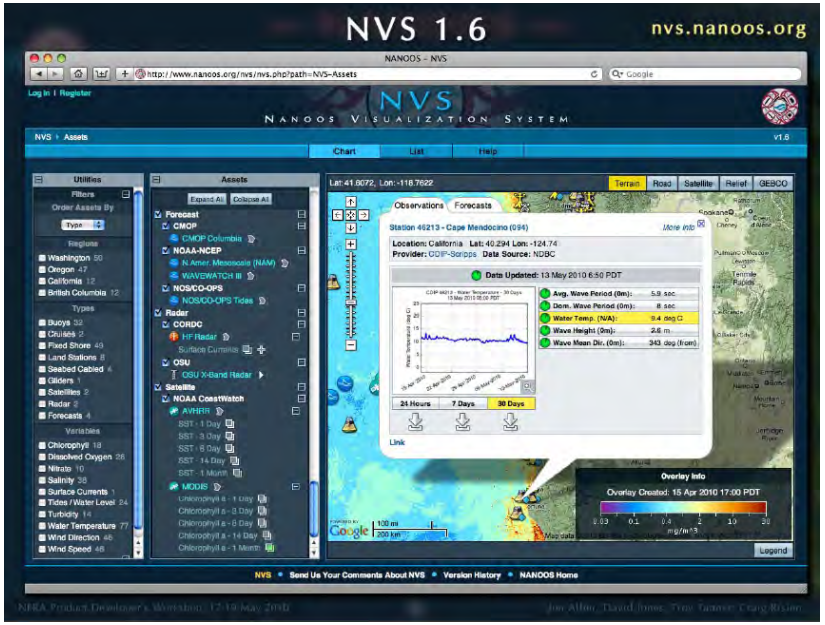
- Elevated pCO2 concentrations (and lower pH)
- Slow growth and mass mortality of *small* larvae after 10-12 days

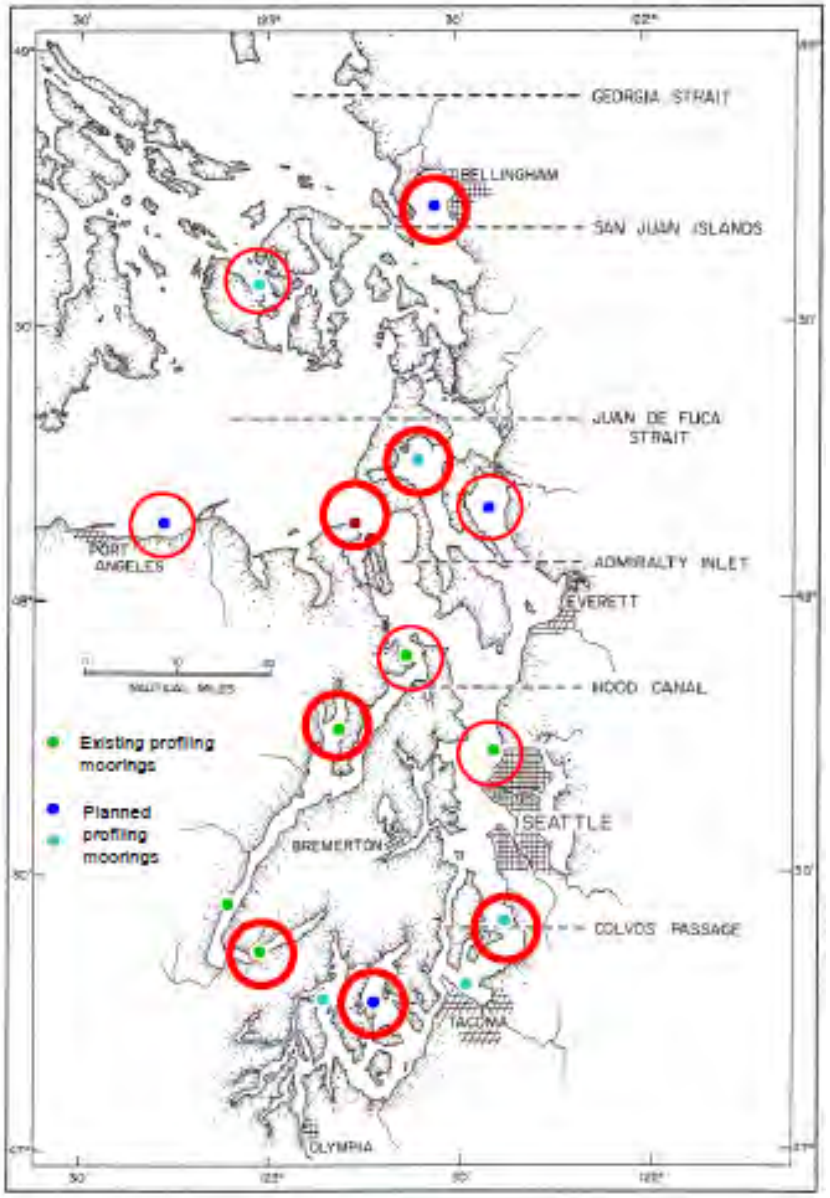
- Scenario 2 - Indirect Effects of Upwelling

- Prolonged upwelling through the summer leads to high concentrations of decaying organic matter and low $O_2$, high $pCO_2$ concentrations
- Mortality of larvae of *all sizes* in the hatchery

★ Dabob Bay, WA- Taylor Shellfish Hatchery

NOAA, UW, PCSGA, PSRF partnershi
Newton, Feely, Sabine,etc.



# Egg Development – delayed mortality

| | Treated Seawater (buffered and degassed) | Control (untreated) |
|---|---|---|
| | pCO2= 349uatm @ 25°C, pH=8.25, tCO2=2580.97 | pCO2=759uatm @25°C pH=7.80, tCO2=2159.54 |
| Initial Survival– | 76.7% | 65.8% |
| Survival at Day 10- | 66.0% | **0%** |

*Seawater conditions were manipulated for egg development ONLY
After the first water change (t=48hrs), all larvae in the experiment were stored in untreated seawater, and both groups saw identical water conditions until day 10
The Control larvae in this experiment were irreparably damaged during egg development, but mortality was not observed until day 10
Data shown are average values from two replicate 6000 gallon tanks per treatment

# Prolonged effects of seawater treatment on small larvae

| | Treated Seawater (buffered and degassed) | Control (untreated) |
|---|---|---|
| | pCO2= 350-370uatm @ 25°C | pCO2=650-900uatm @25°C |
| Initial Survival– | 64.2% | 71.5% |
| Survival at Day 12- | 58.2% | **27.2%** |
| Size class at Day 12- (% of larvae ≥ +100um screen) | 41.0% | 31.9% |

*Treatment of seawater continued throughout the 12 day experiment
Data shown are average values from three replicate 6000 gallon tanks per treatment