

# Effects of Ocean Acidification on Shellfish



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Emily Carrington

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# OCEAN ACIDIFICATION

Less acidic  More acidic

Atmospheric carbon dioxide  
 $\text{CO}_2$

$\uparrow \text{CO}_2 = \downarrow \text{pH} + \downarrow \text{Carbonate ions}$

Dissolved carbon dioxide  
 $\text{CO}_2$

Water  
 $\text{H}_2\text{O}$

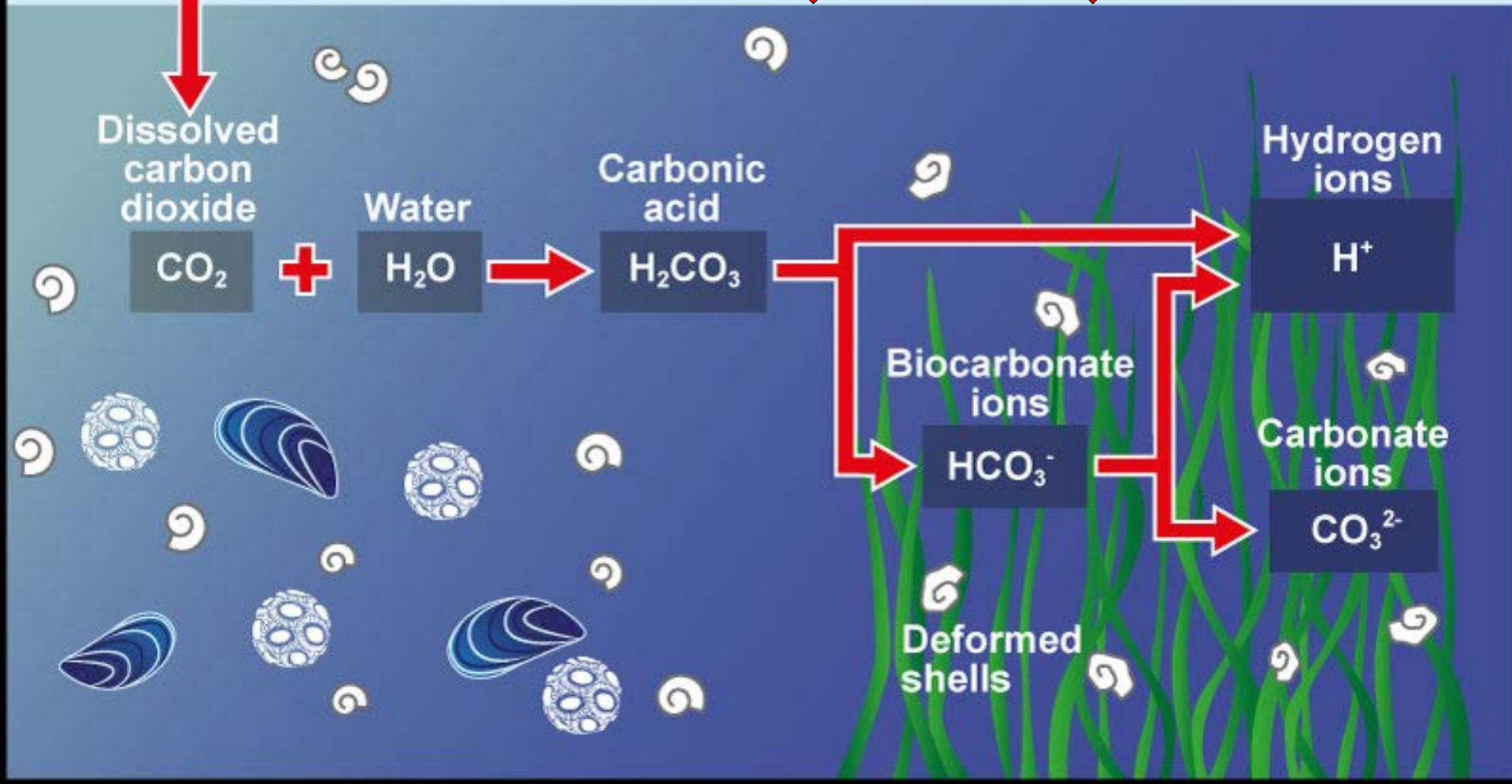
Carbonic acid  
 $\text{H}_2\text{CO}_3$

Biocarbonate ions  
 $\text{HCO}_3^-$

Hydrogen ions  
 $\text{H}^+$

Carbonate ions  
 $\text{CO}_3^{2-}$

Deformed shells





**Penn Cove Shellfish**

CLAMS OYSTERS CLAMS MUSSELS

MUSSELS OYSTERS

Coupeville Washington

Fresh From the Water - Not the Warehouse!

(360) 678-4803 • [www.penncoveshellfish.com](http://www.penncoveshellfish.com)

The graphic features a central illustration of a bay with a sun, mountains, and several small boats. In the foreground, there are large, detailed drawings of various shellfish: oysters, clams, and mussels. The entire scene is framed by a decorative border with repeating text labels for 'CLAMS', 'OYSTERS', and 'MUSSELS'.

GVW 8000



# Oysters & Ocean Acidification

*all life stages affected*

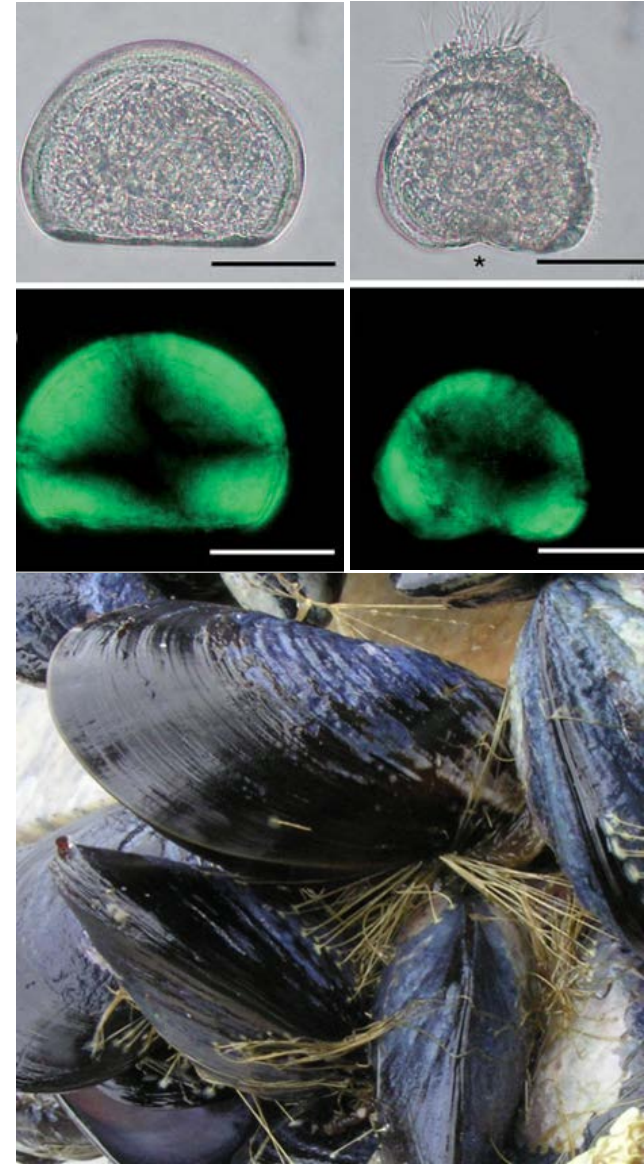
- Larval mortality in hatcheries (Barton et al. 2012)
- Juveniles with slower growth and higher mortality (Timmins-Schiffman et al. 2012)
- Broodstock with lower fecundity (Friedman & Davis unpub.)



# Mussels & Ocean Acidification

*all life stages affected*

- Larvae with slower growth and reduced calcification (Kurihara et al. 2008; Gaylord et al. 2011)
- Adults with slower growth and higher mortality, especially with **low food** (Melzner et al. 2011) and/or **high temperature** (Gazeau et al. 2014)



# Mussel “fall-off” occurs in natural and farmed populations



20-35% of population lost annually

# Mussel Byssal Attachment



3X Speed

M.E. Miller

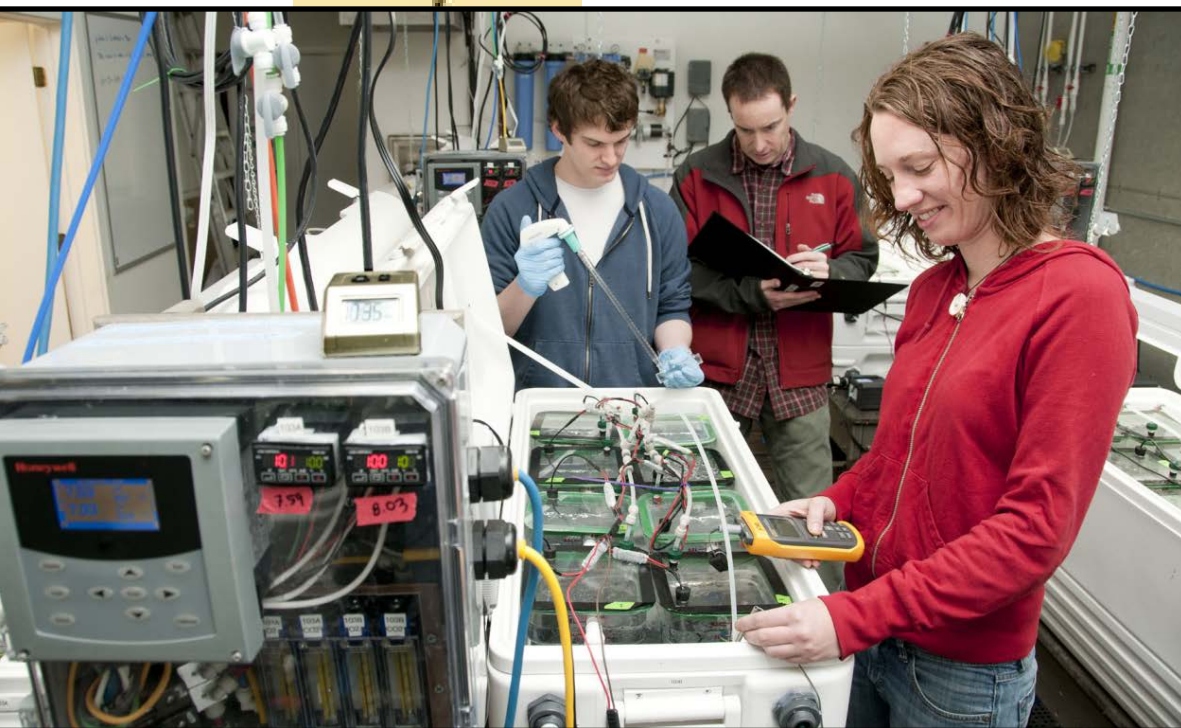






# OAEL

*Ocean Acidification Environmental Laboratory*



Mussels in controlled mixing reservoirs  
to manipulate:

**pH, Temperature, Food Supply**



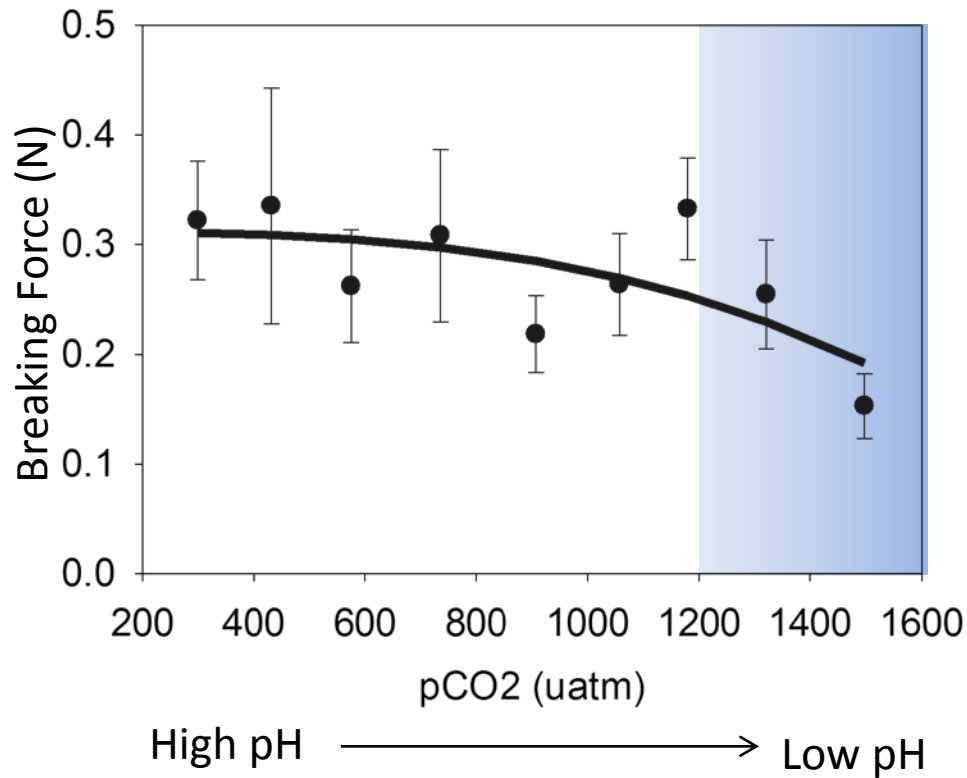
**Byssal thread  
strength**



# OAEL

*Ocean Acidification Environmental Laboratory*

*Mytilus trossulus* weak attachment at low pH



*O'Donnell et al. 2013*

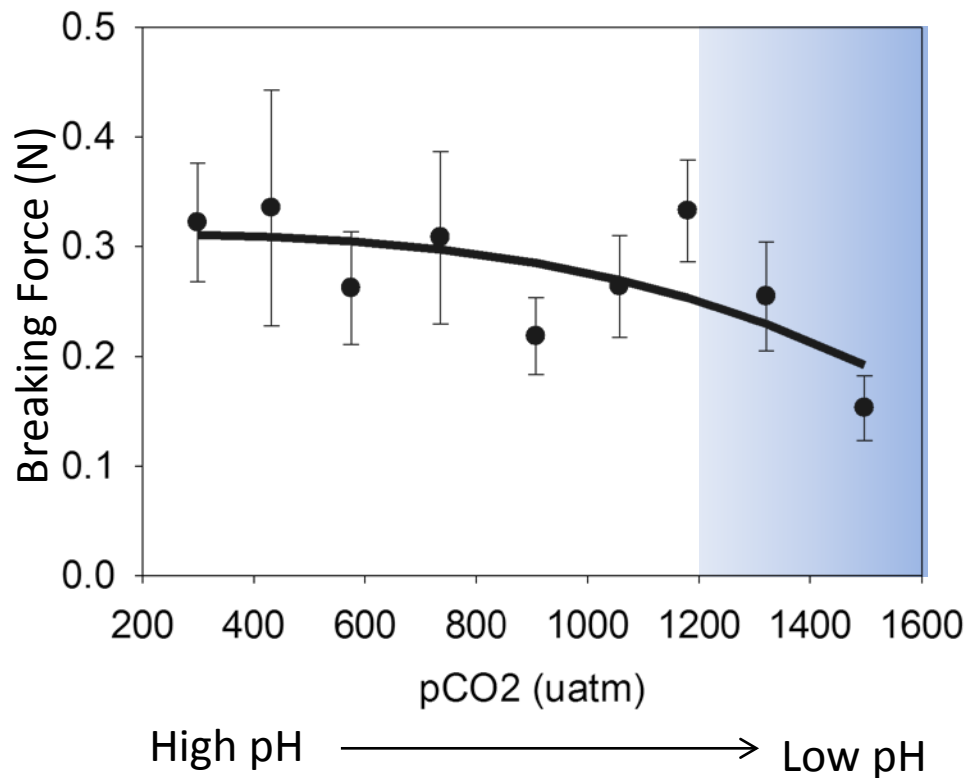


# OAEL

*Ocean Acidification Environmental Laboratory*

< 7.6

*Mytilus trossulus* weak attachment at low pH



*O'Donnell et al. 2013*

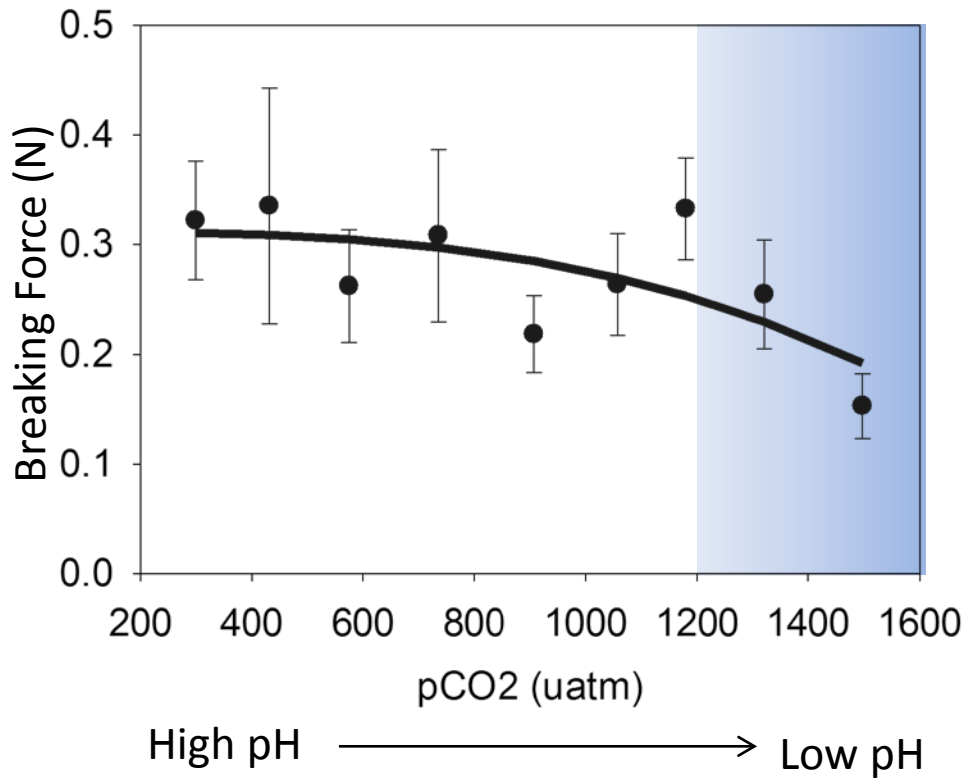


# OAEL

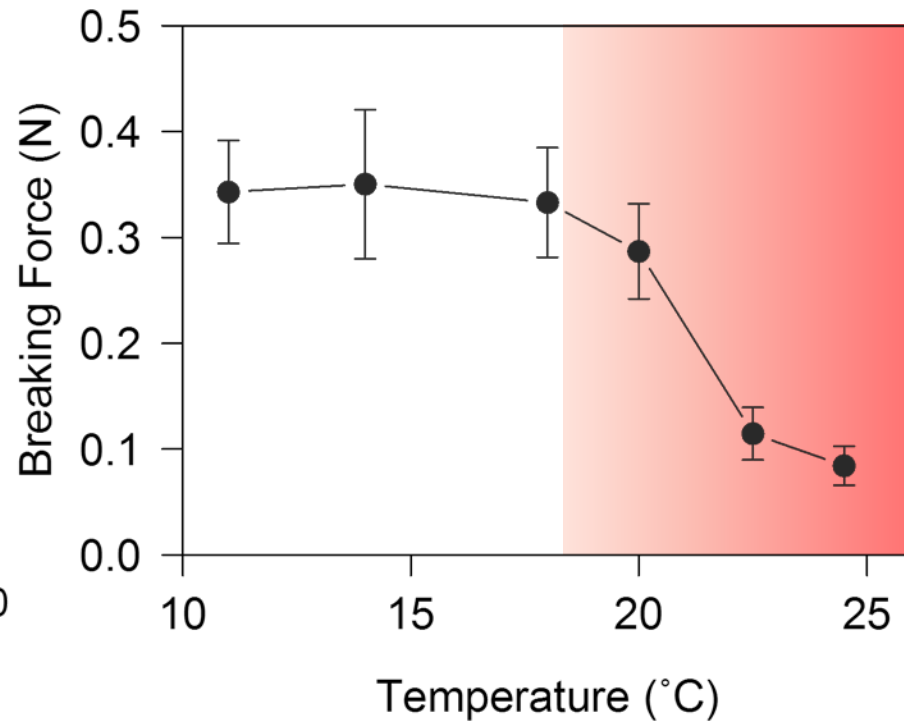
*Ocean Acidification Environmental Laboratory*

< 7.6

*Mytilus trossulus* weak attachment at **low pH** and **high temperature**



*O'Donnell et al. 2013*



*Newcomb et al., unpub.*



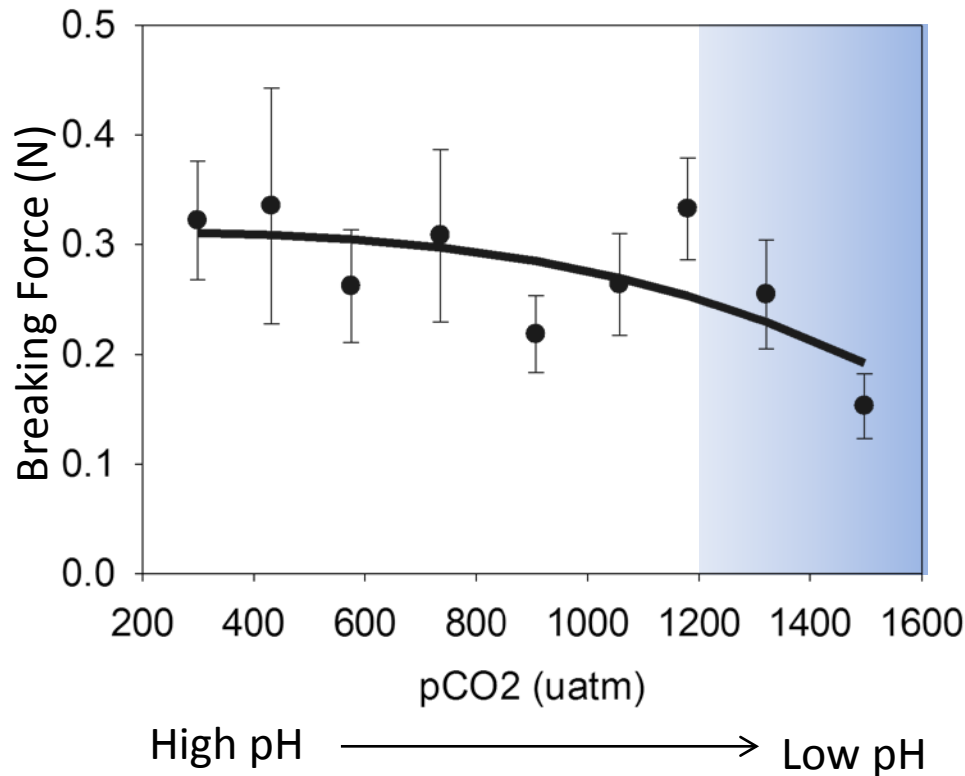
# OAEL

*Ocean Acidification Environmental Laboratory*

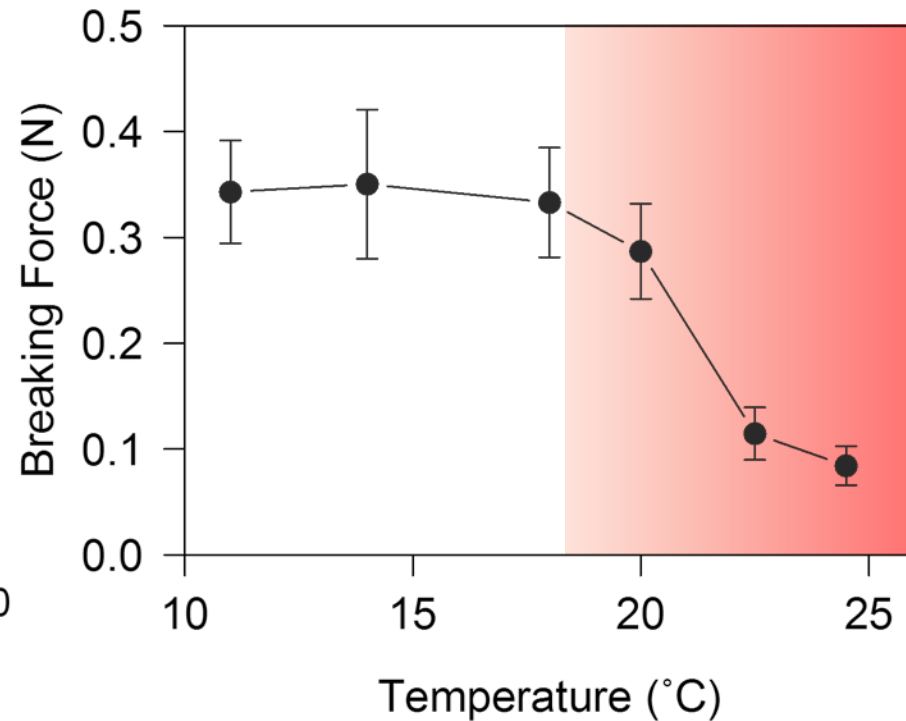
< 7.6

> 18°C

*Mytilus trossulus* weak attachment at low pH and high temperature



*O'Donnell et al. 2013*



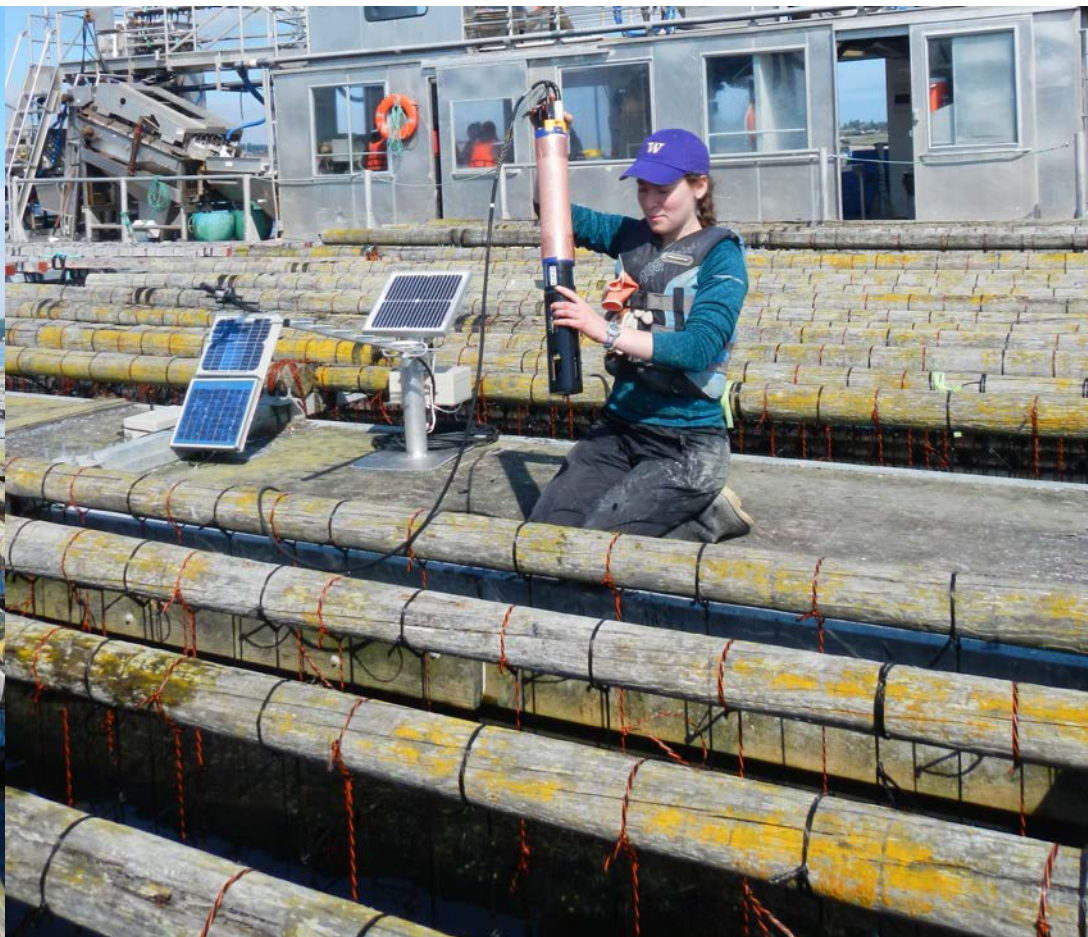
*Newcomb et al., unpub.*

Do mussels ever experience  
low pH (< 7.6) and/or high temperature >18°C?



# “Testing the waters” at Penn Cove

Partnership with **academia, industry, state and federal** agencies



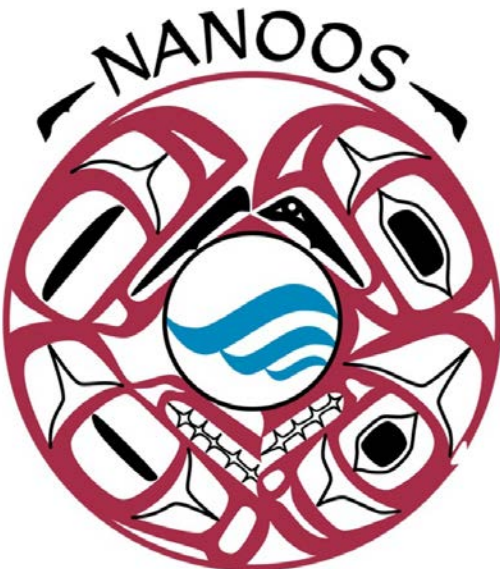
WASHINGTON STATE DEPARTMENT OF  
**Natural Resources**



# Real time observations

Asset List Help

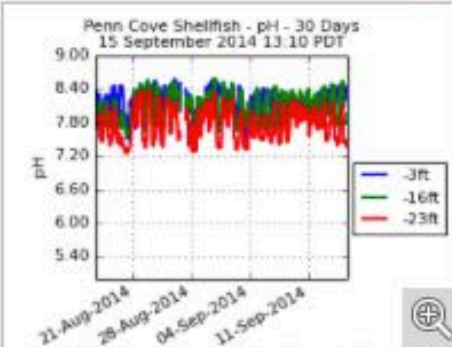
Terrain



### Penn Cove Shellfish, Coupeville - Whidbey Island

Observations Details History

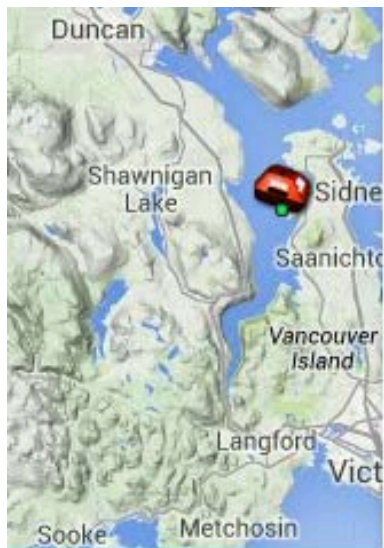
Provider: PennCoveShel Data Updated: 15 Sep 2014 12:00 PDT



24 Hours 7 Days 30 Days 60 Days

↓

Parameter	Depth	Value
Chlorophyll	-3ft	0.5 µg/L
	-23ft	4.9 µg/L
Oxygen Conc.	-3ft	14.4 mg/L
	-16ft	2.4 mg/L
	-23ft	3.6 mg/L
Oxygen Pct. Sat.	-3ft	169.1 %
	-16ft	26.2 %
	-23ft	39.5 %
pH	-3ft	8.5
	-16ft	8
	-23ft	7.5
Salinity	-3ft	26.1 PSU



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15 September 2014 1:10 pm PDT



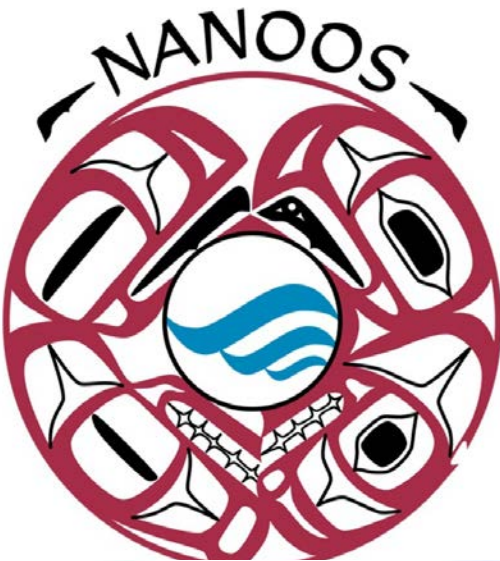


# Real time observations

Asset List

Help

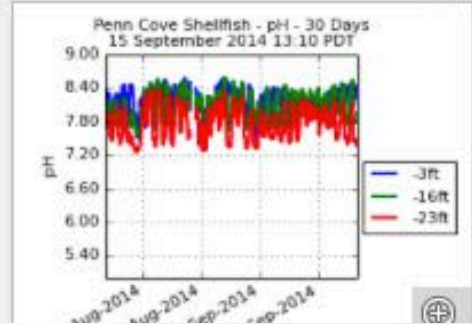
Terrain



## Penn Cove Shellfish, Coupeville - Whidbey Island

Observations      Details      History

Provider: PennCoveShel      Data Updated: 15 Sep 2014 12:00 PDT



Chlorophyll		
-3ft:	0.5	µg/L
-23ft:	4.9	µg/L

Oxygen Conc.		
-3ft:	14.4	mg/L
-16ft:	2.4	mg/L
-23ft:	3.6	mg/L

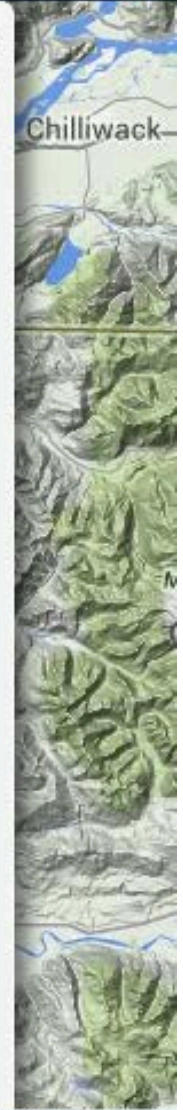
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-3ft:	8.5	
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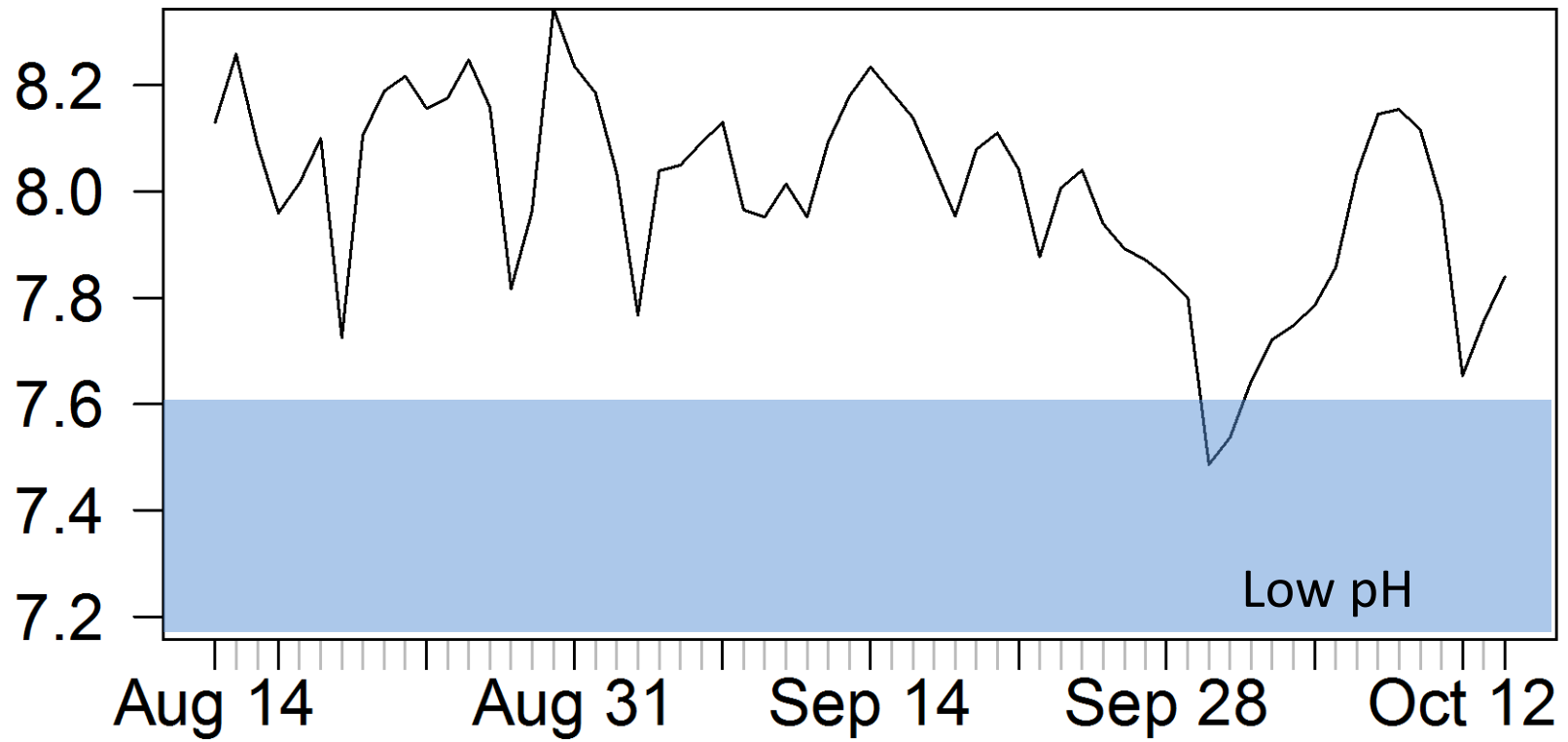
Salinity		
-3ft:	26.1	PSU



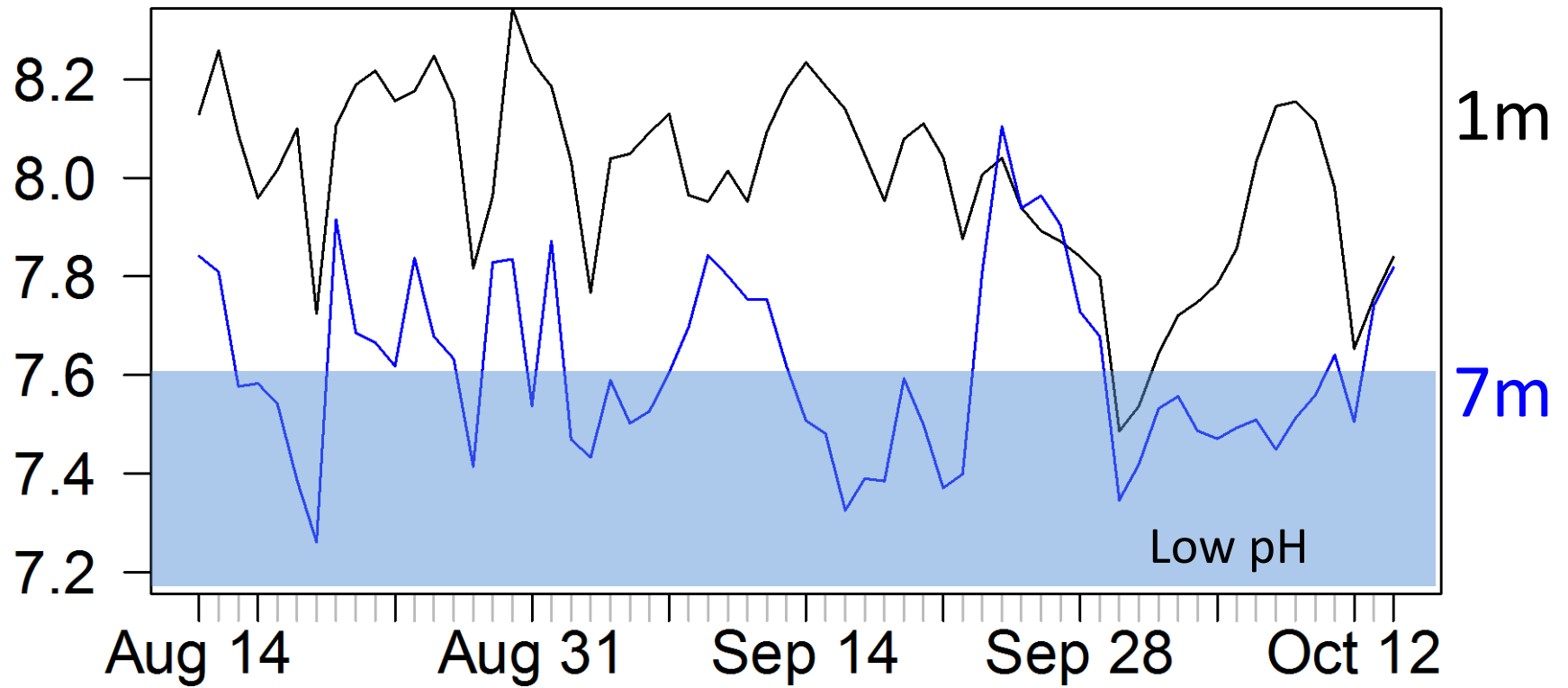
Google 10 km Terms of Use Report a map error



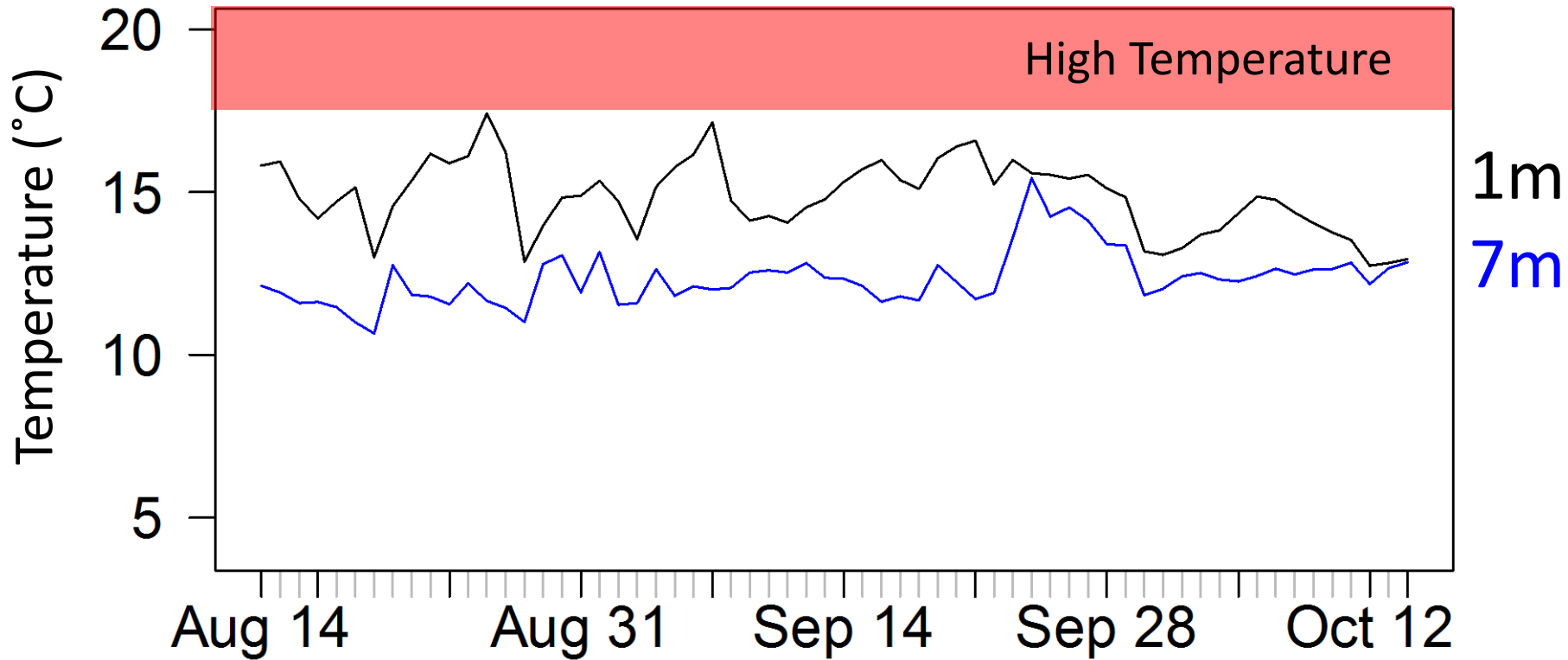
Do we see “low pH” conditions in the field?



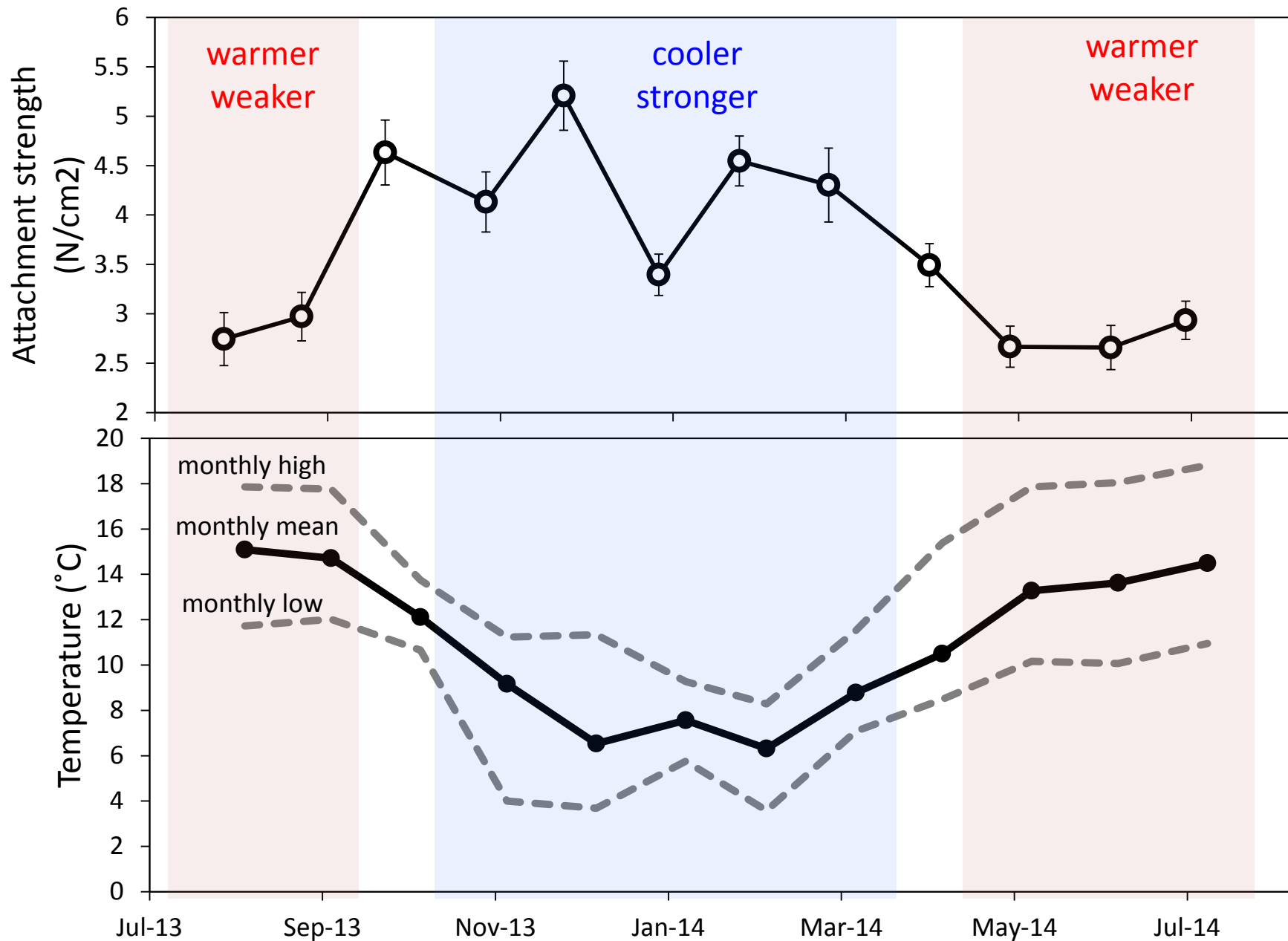
Do we see “low pH” conditions in the field?



Do we see “high temperature” conditions in the field?



# Native mussel attachment varies seasonally with temperature



# Linking lab studies to field observations

- What triggers fall-off events?  
(Temp, pH, food...)
- Develop adaptation strategies  
(e.g., timing of resocking and harvesting)
- Predictions for future scenarios  
( $\uparrow$ CO<sub>2</sub>, land use/runoff)
- Which species in which location?



# Expanding Our Network of Observations



# Acknowledgements

Laura Newcomb, Ian Jefferds and Carolyn Friedman  
and

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Taylor Shellfish  
WA-DNR

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