Ocean Acidification in Coastal Systems

Challenges for the US East Coast and Chesapeake Bay

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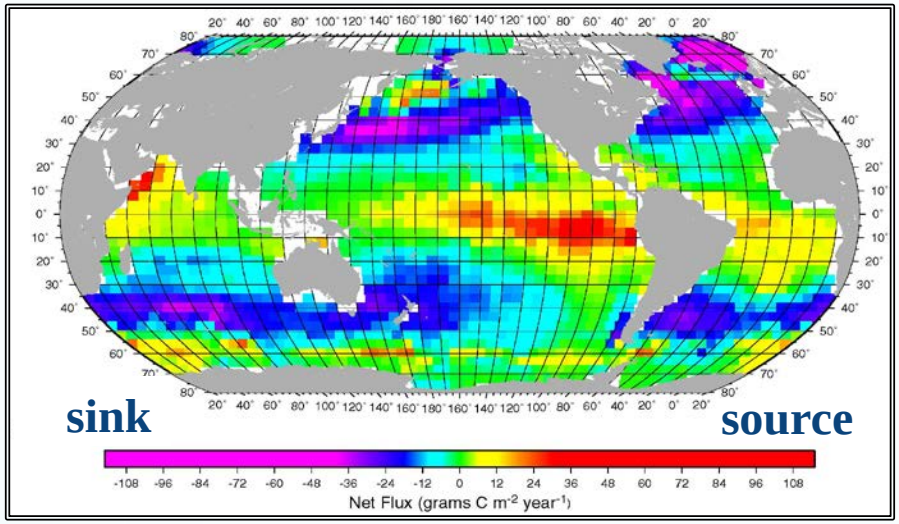
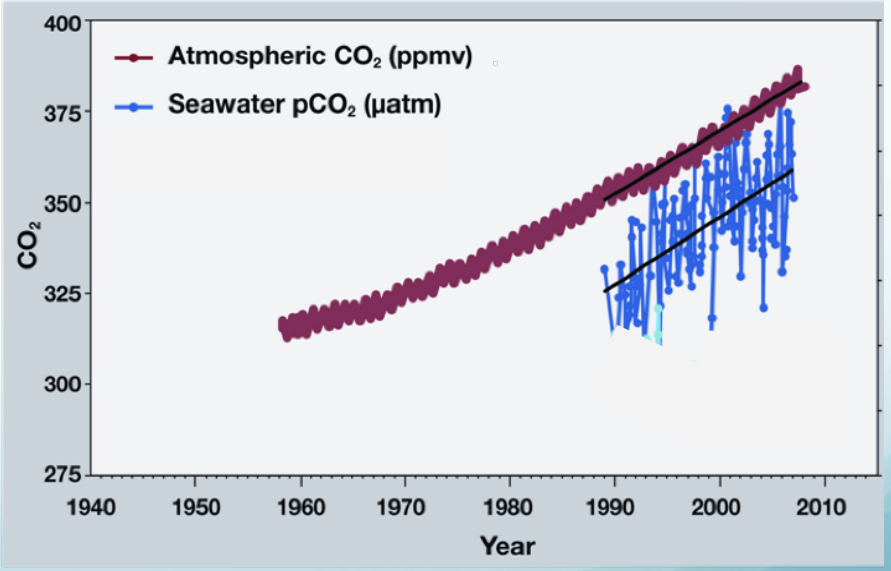
Ocean Uptake of Atmospheric CO_2



CO_2 is both **absorbed by** (sink) and **released from** (source) the surface of the ocean.

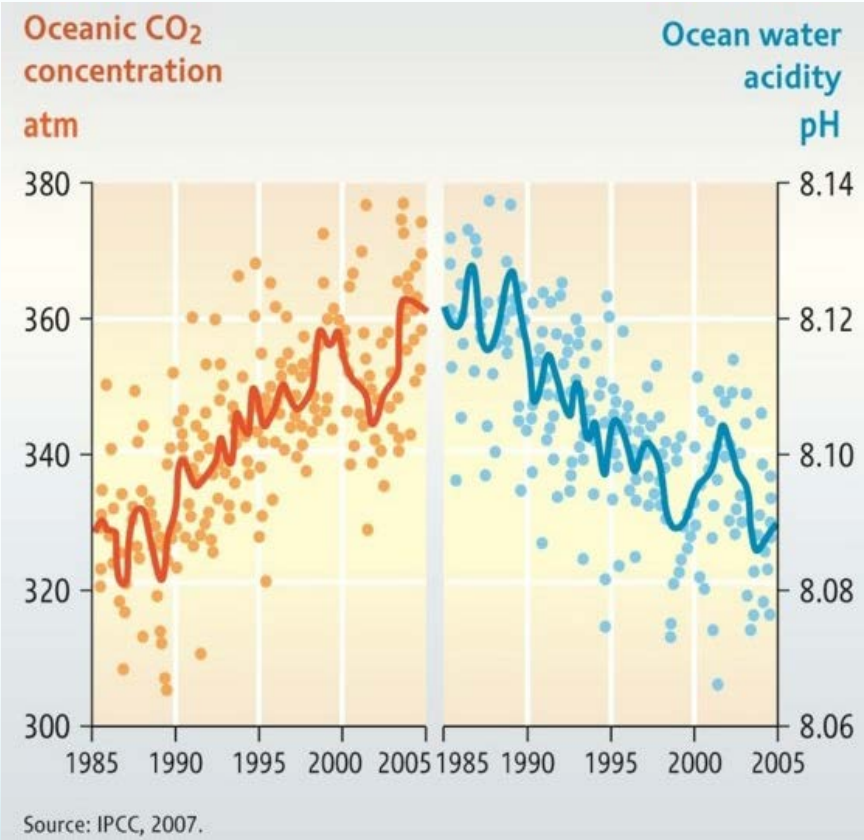
Observations from stations all around the world confirm that the surface ocean is tracking the increase in atmospheric CO_2.

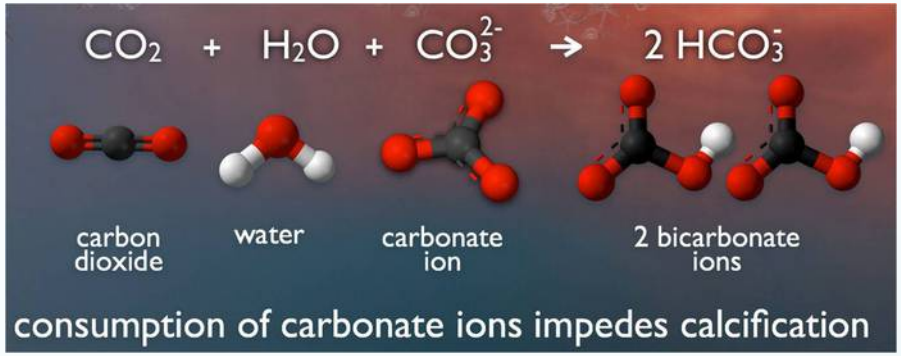


Takahashi et al., *DSR II* (2009); NOAA Hawaii Carbon Dioxide Time Series (www.pmel.noaa.gov)

Ocean Acidification

(the decrease in pH resulting from the uptake of anthropogenic CO_2)





When CO_2 reacts with seawater it not only decreases pH, but also carbonate ion (CO_3^{2-}) concentration.

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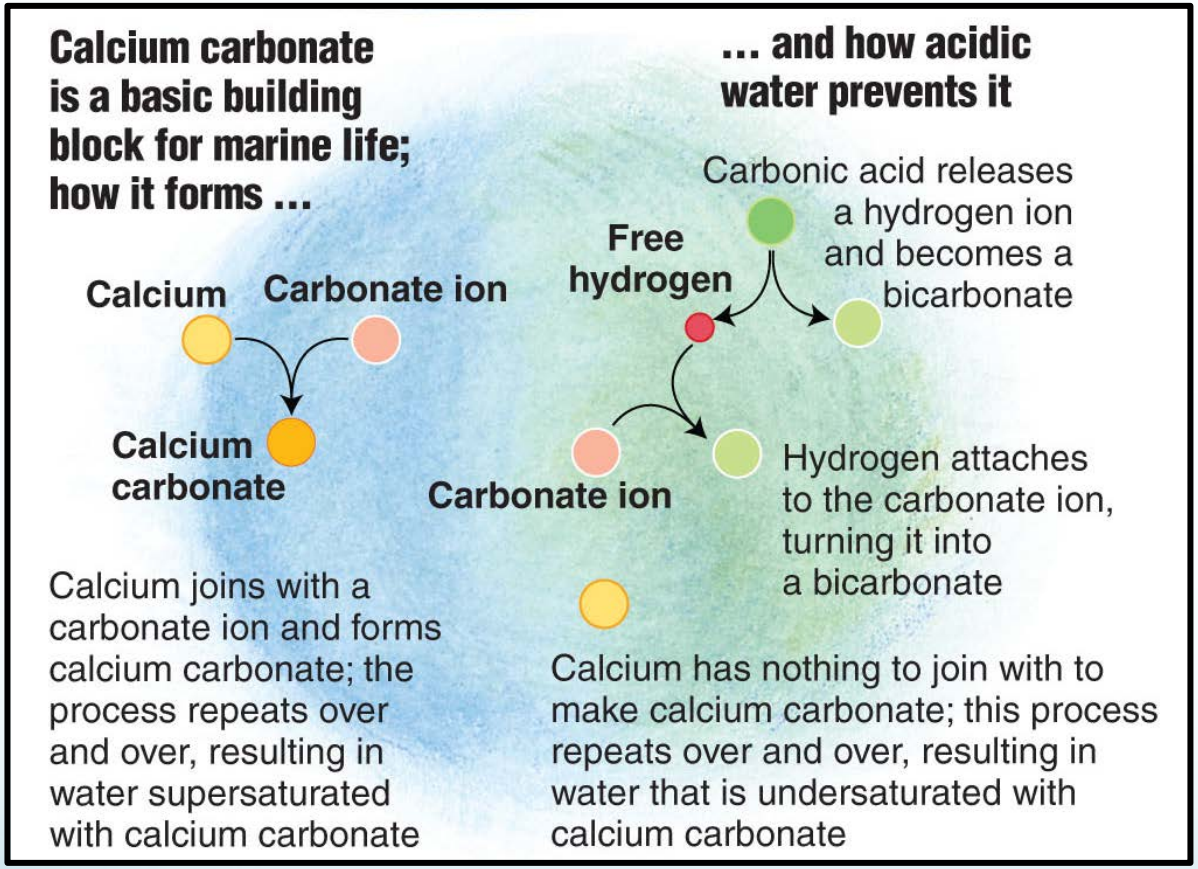
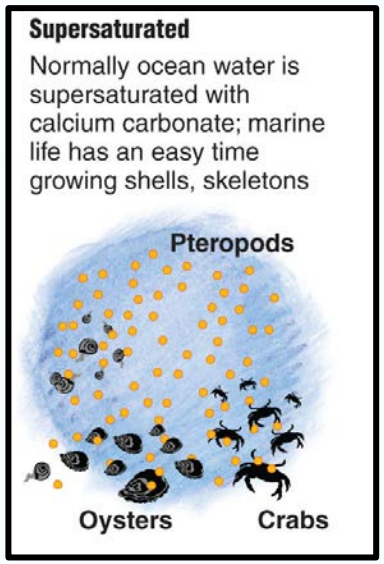
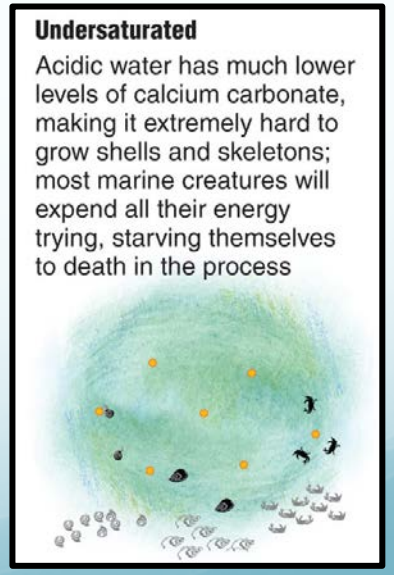
The Implications for Calcifying Organisms

$$Ca^{2+} + CO_3^{2-} \leftrightarrow CaCO_3$$







Ω = Saturation State (super- or under- saturated)

Figure modified from NOAA PMEL Carbon Program (www.pmel.noaa.gov)

Ocean Acidification in the Pacific Northwest

The Seattle Times

Environment | Food & Drink | Local News | Puget Sound

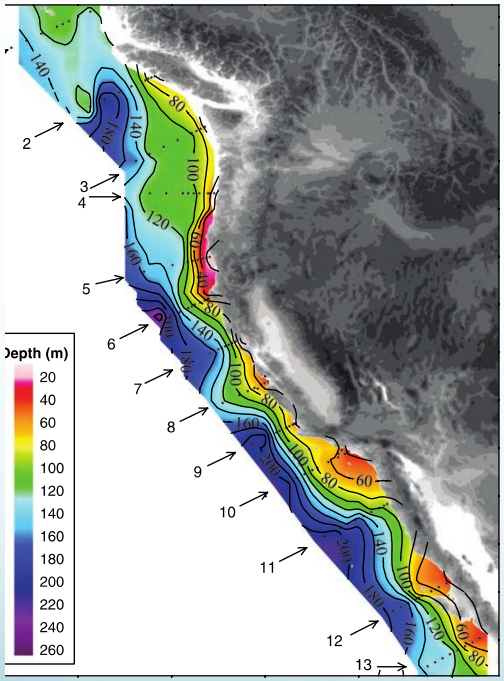
Oysters in deep trouble: Is Pacific Ocean's chemistry killing sea life?

Originally published June 14, 2009 at 12:00 am | *Updated October 18, 2012 at 9:52 am*

Environment | Local News

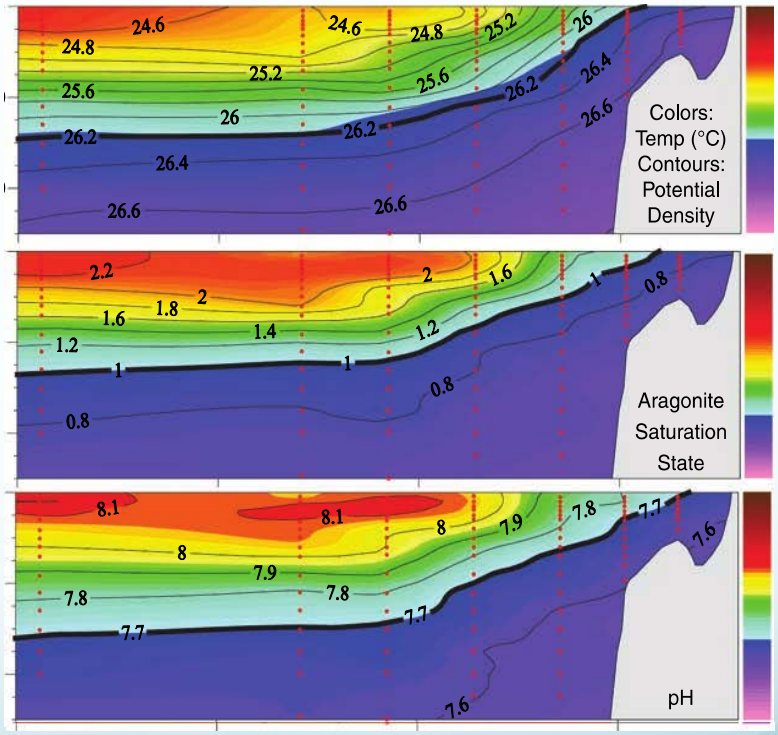
Acidity in ocean killed NW oysters, new study says

Originally published April 11, 2012 at 10:45 pm | *Updated April 12, 2012 at 5:54 am*



Depth of undersaturated water on the Pacific Northwest continental shelf.

Wind events push surface water offshore. This water is replaced with cold, CO_2-rich, water with low pH and Ω from below.



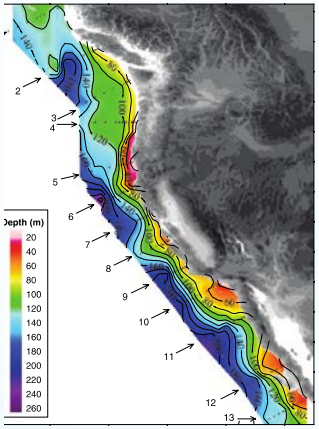
Offshore **Coast**

Figures modified from Feely et al., *Science* **320** (2008)

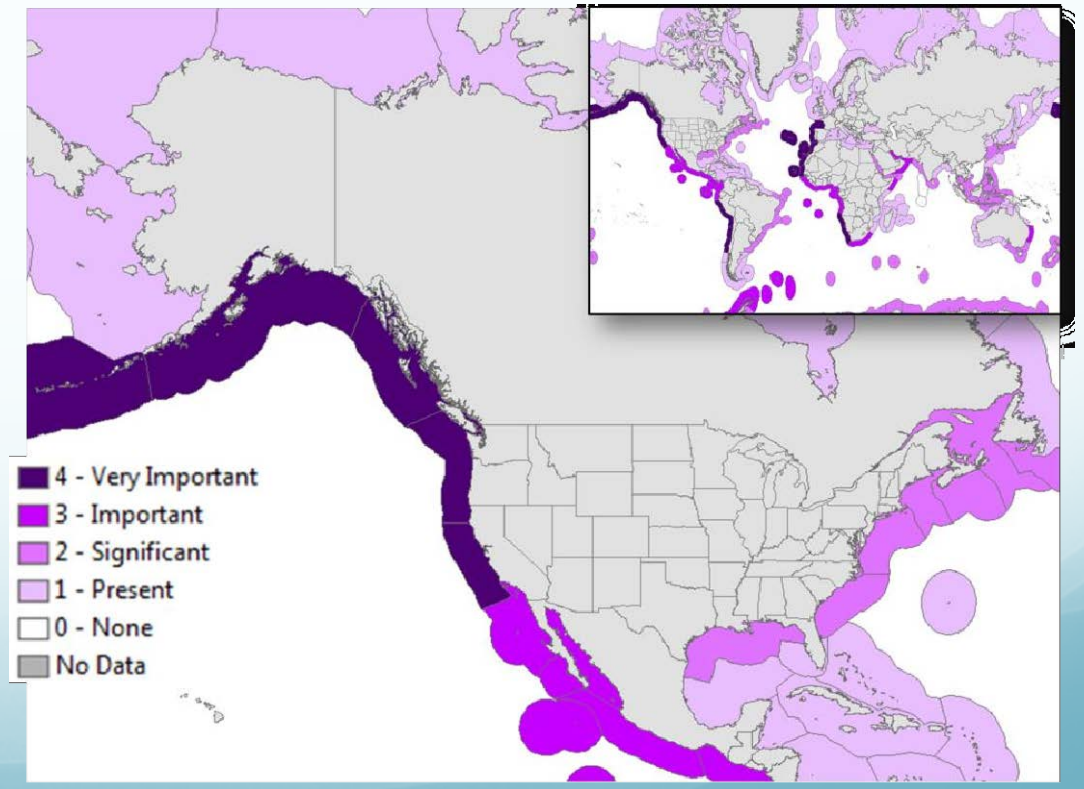
What About the East Coast and Chesapeake Bay?

Ω is controlled by a number of natural and anthropogenic processes.

Upwelling (brings, CO_2-rich, low pH water to the surface)



Upwelling Significance in North American Coastal Regions



Figures modified from Feely et al., *Science* **320** (2008) and Ekstrom et al., *Nature Climate Change* (2015)

What About the East Coast and Chesapeake Bay?

Freshwater input exerts a more dominant control in the Chesapeake Bay Estuary.

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Rivers deliver nutrients as well as freshwater

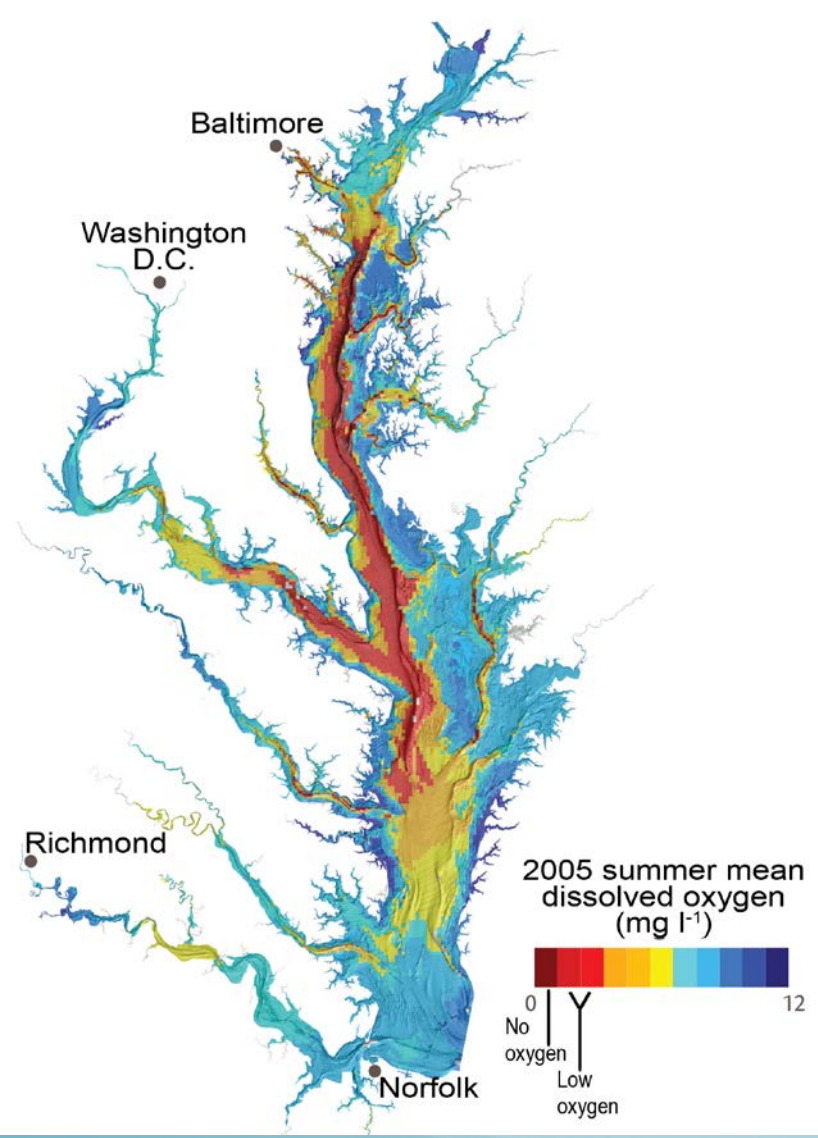
Freshwater has low saturation state

Increased riverine discharge will decrease Ω.

EPA Water Quality Monitoring Stations

Figures modified from Salisbury et al., *EOS* (2008); Feng et al., *JGR-Biogeosciences (2015)*

What About the East Coast and Chesapeake Bay?



Eutrophication is a major issue in Chesapeake Bay.

Nutrient inputs generate algal blooms – if/when this material sinks out of the surface layer it is respired producing CO_2 and lowering pH and Ω.

Bottom waters may not be 'reset' with deep winter mixing, leading to an accumulation of low-pH water from one year to the next.

BUT surface waters will have a seasonal enrichment of Ω due to the uptake of CO_2 by the algal bloom.

Chesapeake Bay Program (www.chesapeakebay.net)

IMPACTS ON THE CARBONATE SYSTEM

Warming

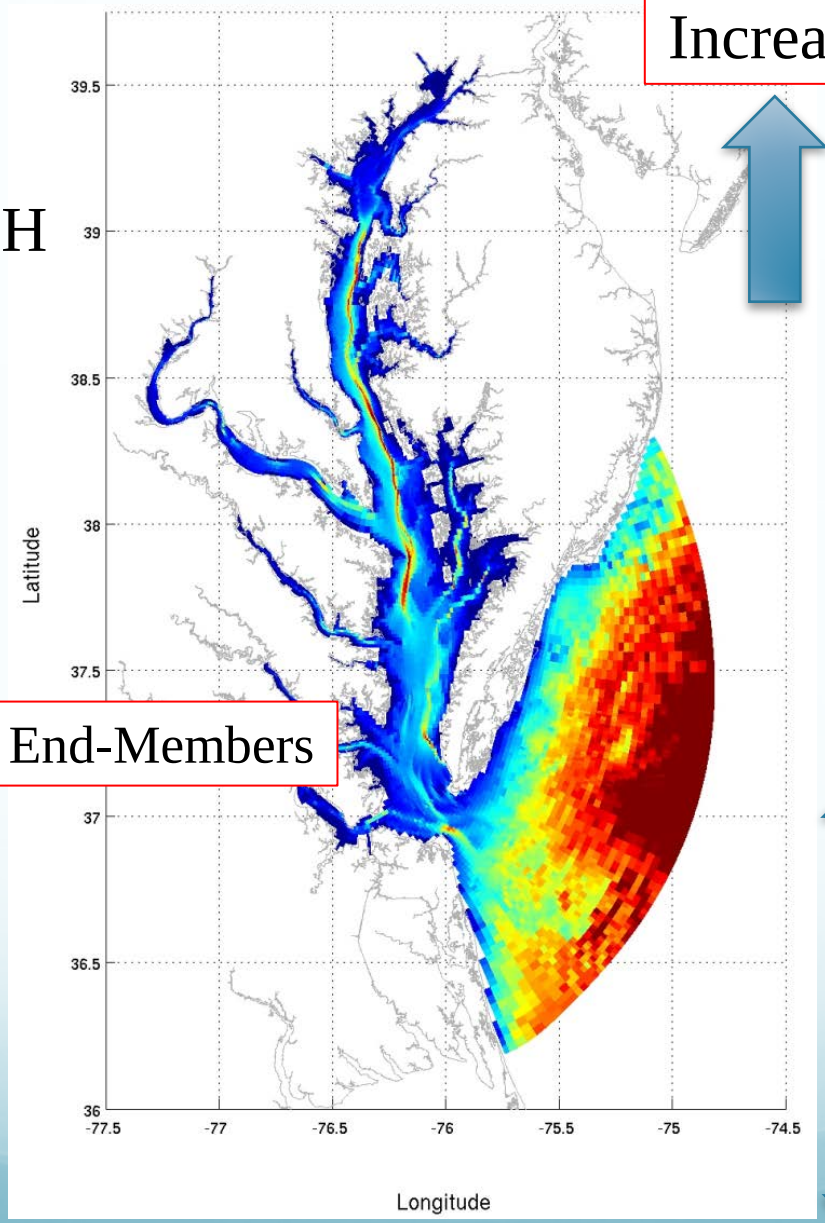
pCO_2 , Ω

pH

Increased Atmospheric CO_2

pCO_2

pH, Ω



Changing Freshwater End-Members

TA, pH, Ω

Eutrophication

SURFACE

pH, Ω

pCO_2

SUBSURFACE

pH, Ω

pCO_2

Chesapeake Bay Model Bathymetry from http://tidesandcurrents.noaa.gov/images/cbofs2_bathy.png

MACAN: Mid-Atlantic Coastal Acidification Network

First conference call was October 31st 2016

Series of Webinars beginning in December
Webinar 1: State of the Science in the Mid-Atlantic Bight (**December 20th 11:30am**)

Steering Committee Members:

A.J. Erskine, KCB Oyster
Erica Ombres, NOAA OAP
Gabrielle Canonico, NOAA IOOS Program Office
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Elizabeth Shadwick, Virginia Institute of Marine Science
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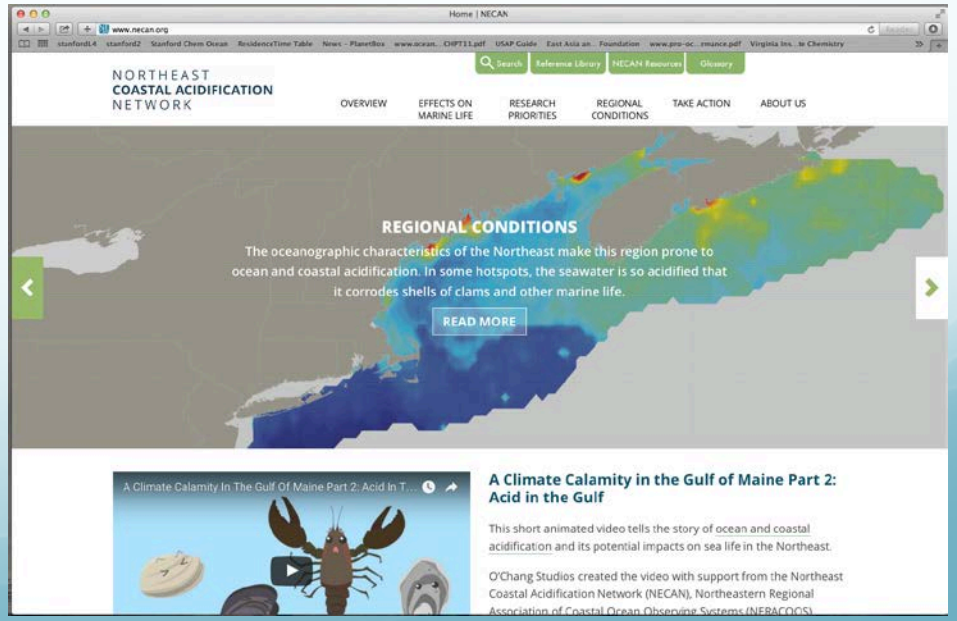
Sherilyn Lau, EPA/Mid-A RPB
Grace Saba, Rutgers University/MARACOOS
Kaity Goldsmith, MARCO
Peter Moore, MARACOOS

Website of NECAN (necan.org)



Summary

- Ocean Acidification will continue to drive changes in global seawater chemistry.
- Increasing atmospheric CO_2 (and declining ocean pH) will impact coastal and estuarine systems in complex ways.
- The US East Coast and Chesapeake Bay are vulnerable to changes in freshwater input, eutrophication and warming, in addition to acidification.
- Greater understanding of seasonal and shorter term variations in the CO_2 system could guide mitigation strategies.
- MACAN and other regional networks and organizations are essential in bringing different groups together and making relevant information available to those who need it.

Anthropogenic CO_2 (Ω ↓)

Upwelling (Ω ↓)
Freshwater input (Ω ↓)

Eutrophication (Ω ↓ bottom)
Eutrophication (Ω ↑ surface)

Warming (Ω ↑, pH ↓)