Acidification of New Jersey’s Ocean & Coastal Waters

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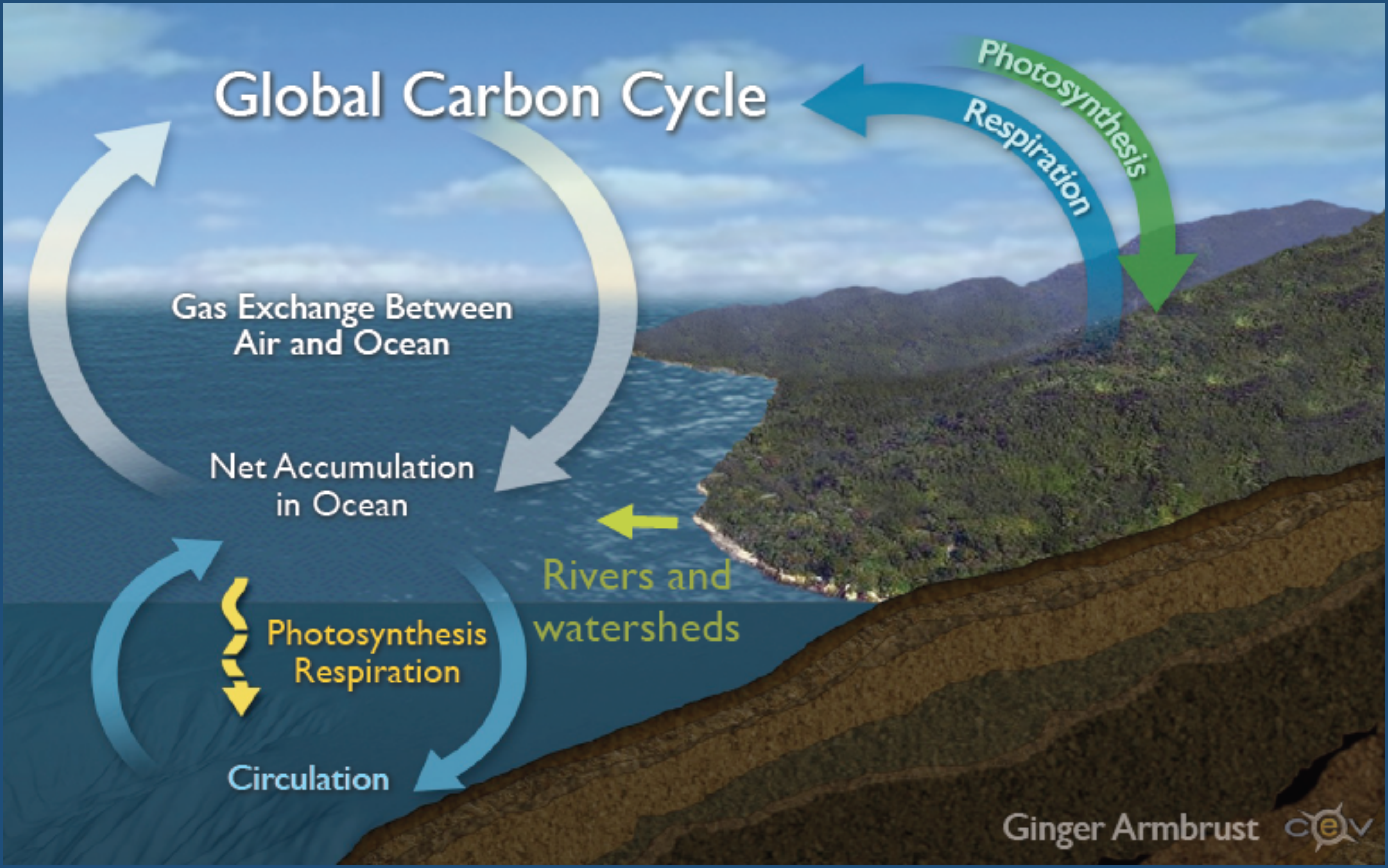
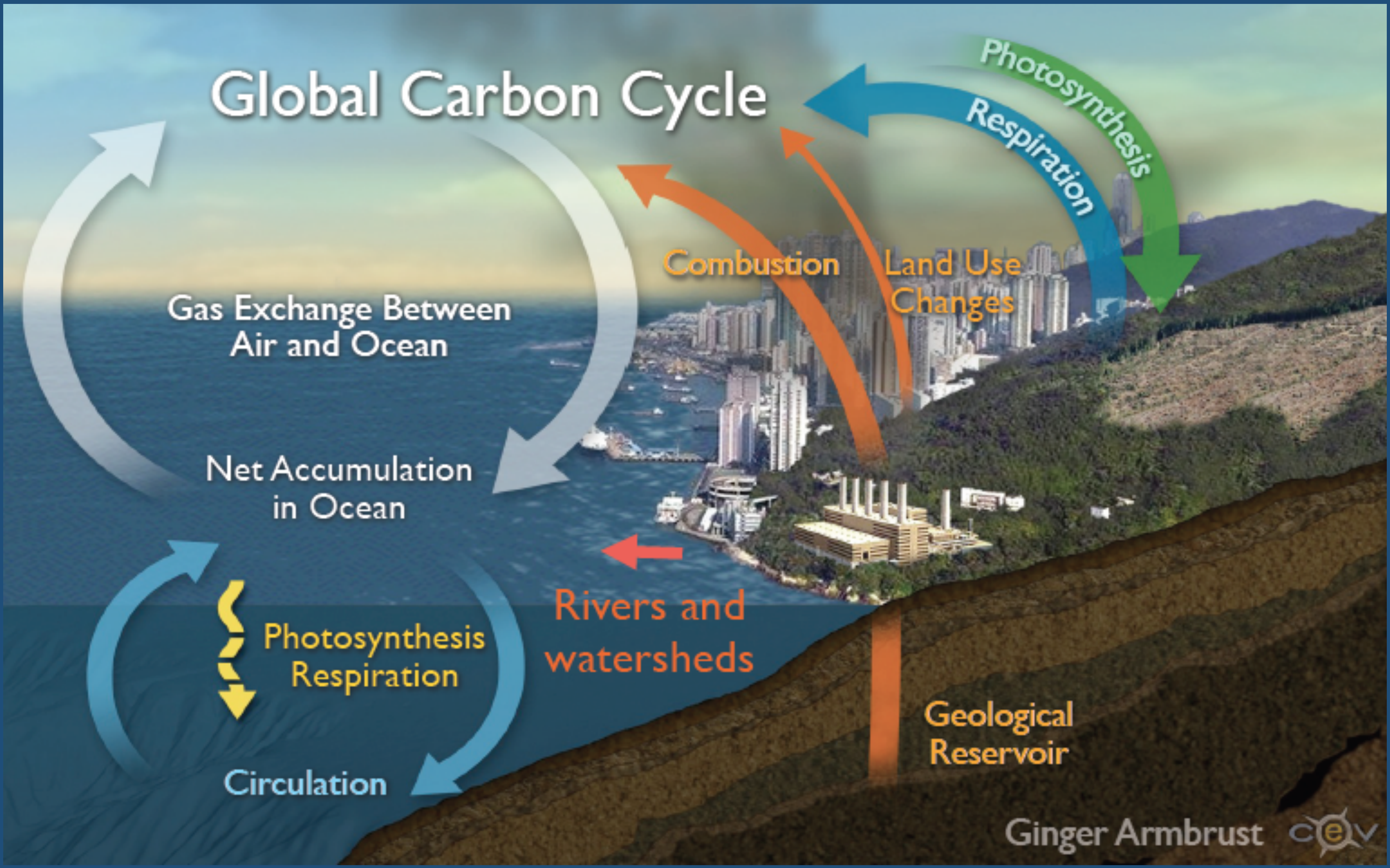
THE STATE UNIVERSITY OF NEW JERSEY

Summer Climate Academy
NJ Climate Change Resource Center

Earth's Natural "Greenhouse Effect"

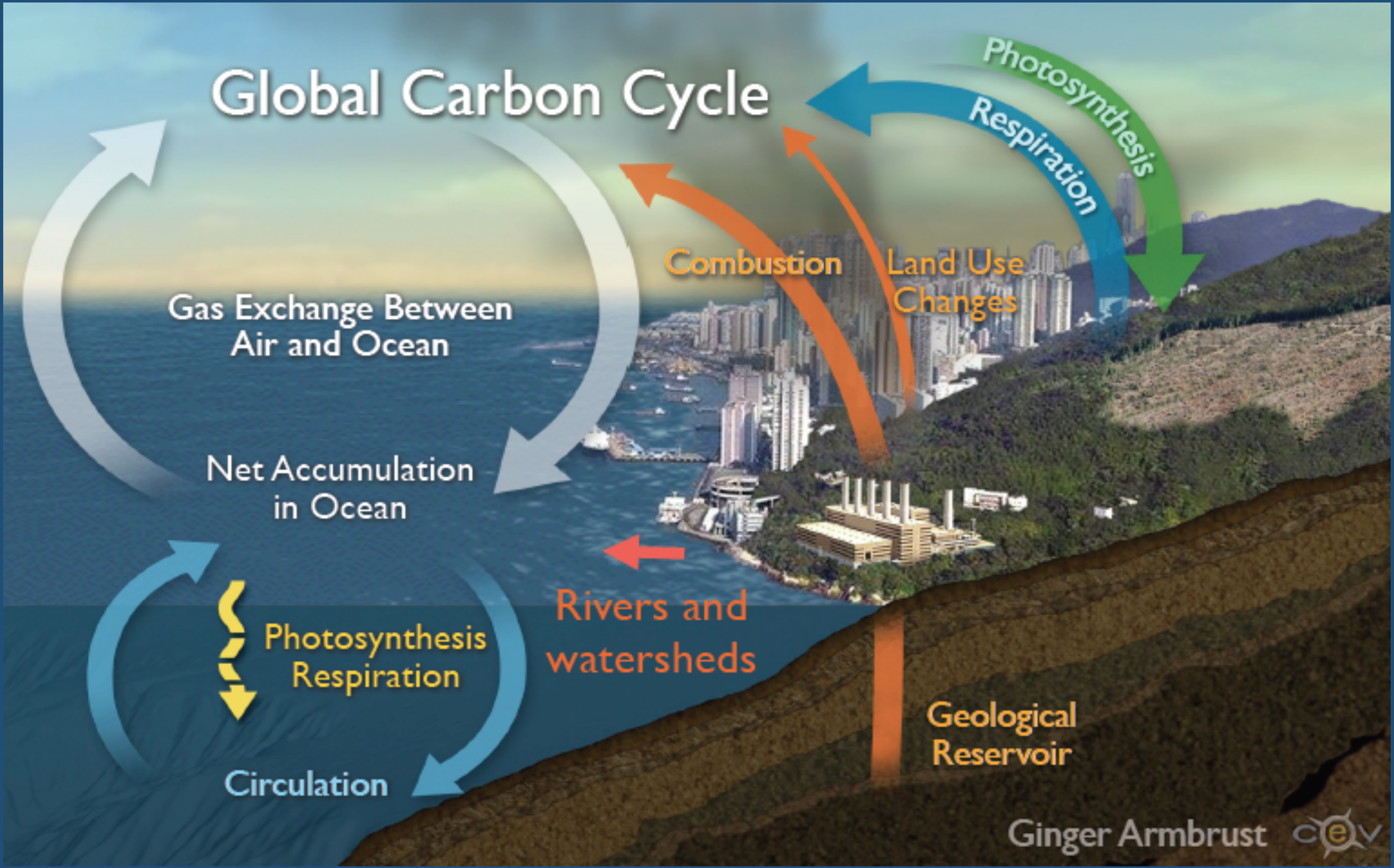


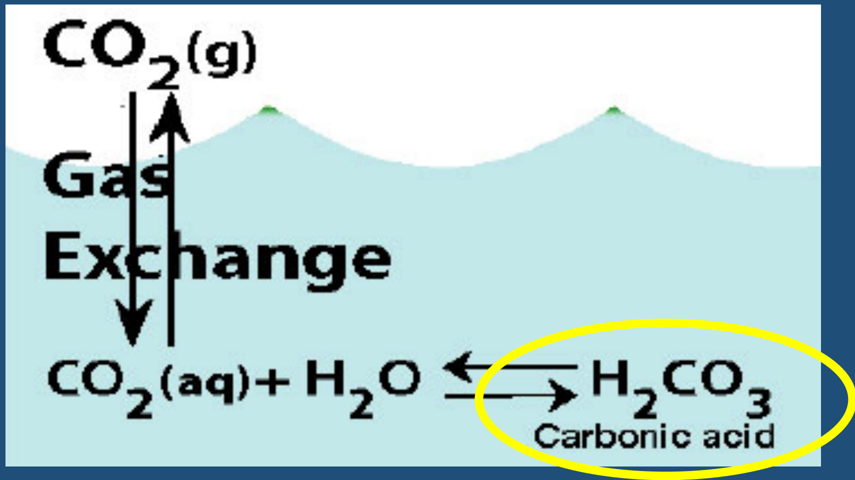
Earth's Enhanced "Greenhouse Effect"



Ocean Acidification

Driven by the ocean's absorption of increasing atmospheric carbon dioxide (CO_2)



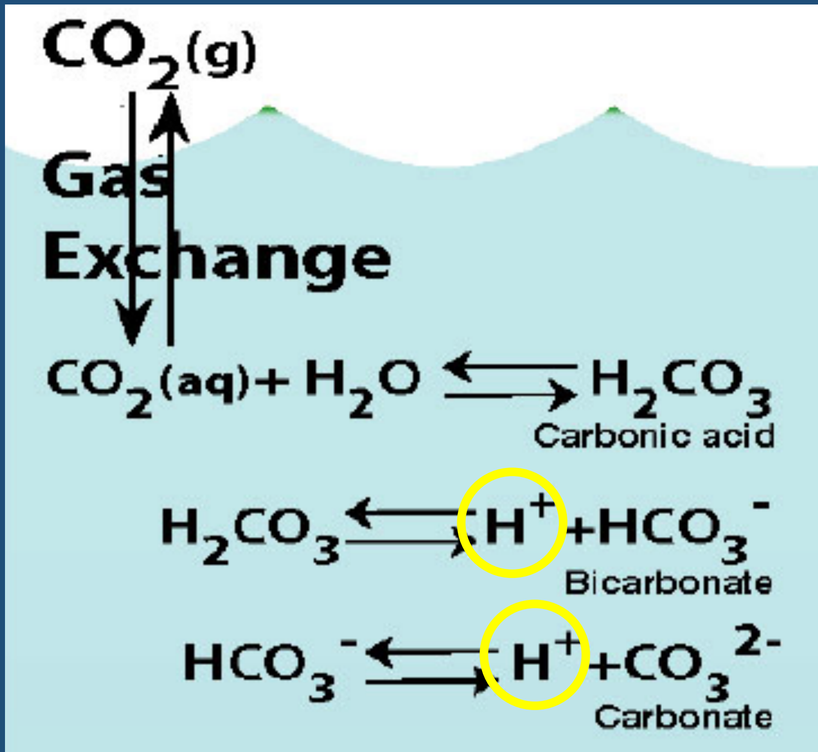


The chemistry of OA: carbonate chemistry

Increase in seawater CO_2:

- Increase in seawater carbonic acid, H_2CO_3

↑ CO_2

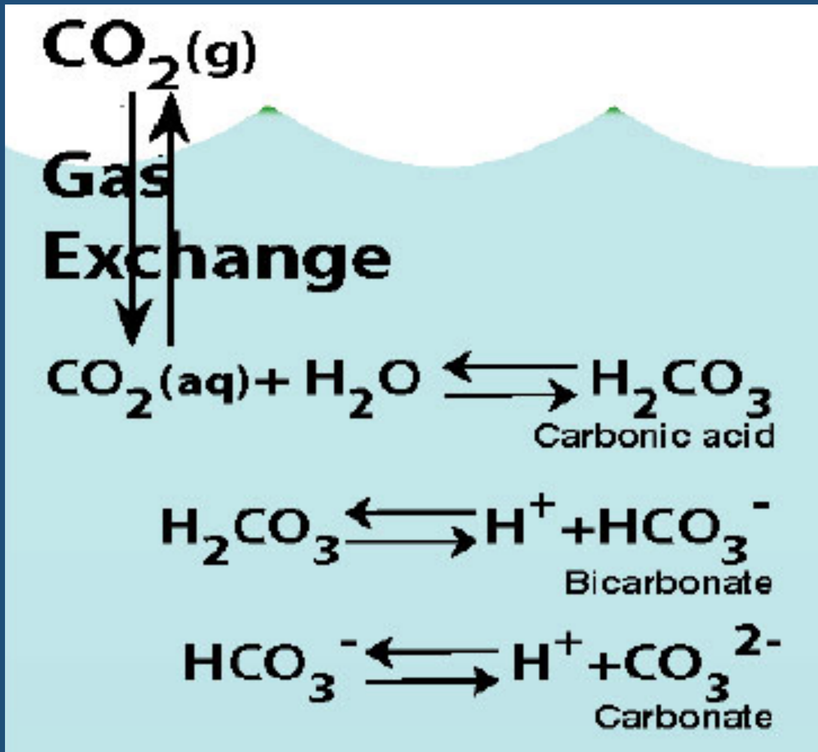


The chemistry of OA: carbonate chemistry

Increase in seawater CO_2:

- Increase in seawater carbonic acid, H_2CO_3
- Release of hydrogen, H^+, ions into the seawater
- Decrease pH = increase ocean acidity

↑ CO_2, ↓ pH



The chemistry of OA: carbonate chemistry

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

(dissolution)

($\Omega < 1$) ($\Omega > 1$)

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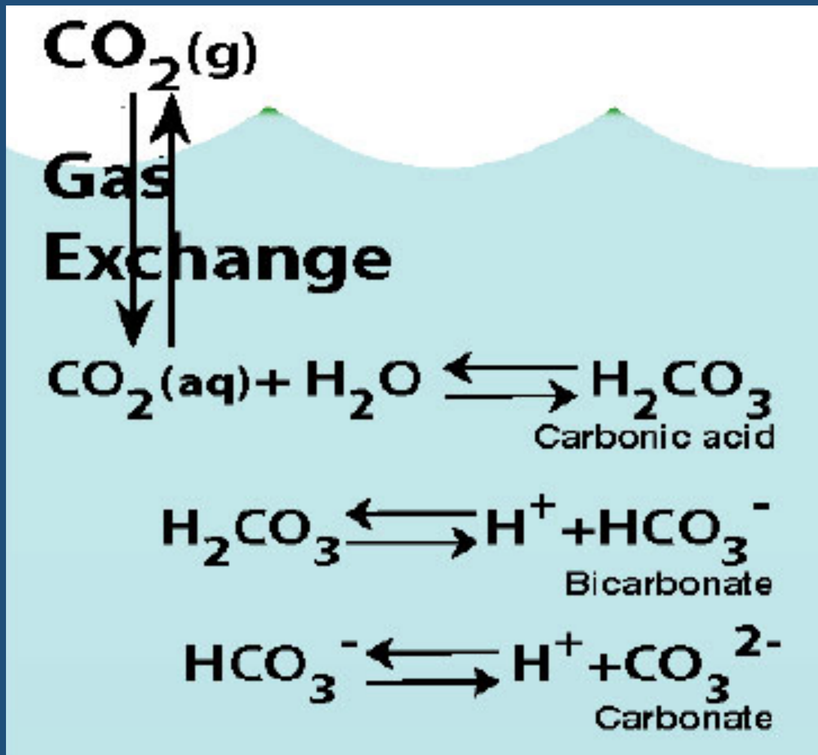
- Increase in seawater carbonic acid, H_2CO_3
- Release of hydrogen, H^+, ions into the seawater
- Decrease pH = increase ocean acidity
- Decrease in CO_3^{2-} ions (buffering process)

$\uparrow CO_2$, $\downarrow$ pH, $\downarrow \Omega$



The chemistry of OA: carbonate chemistry

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

(dissolution) (calcification)

($\Omega < 1$) ($\Omega > 1$)

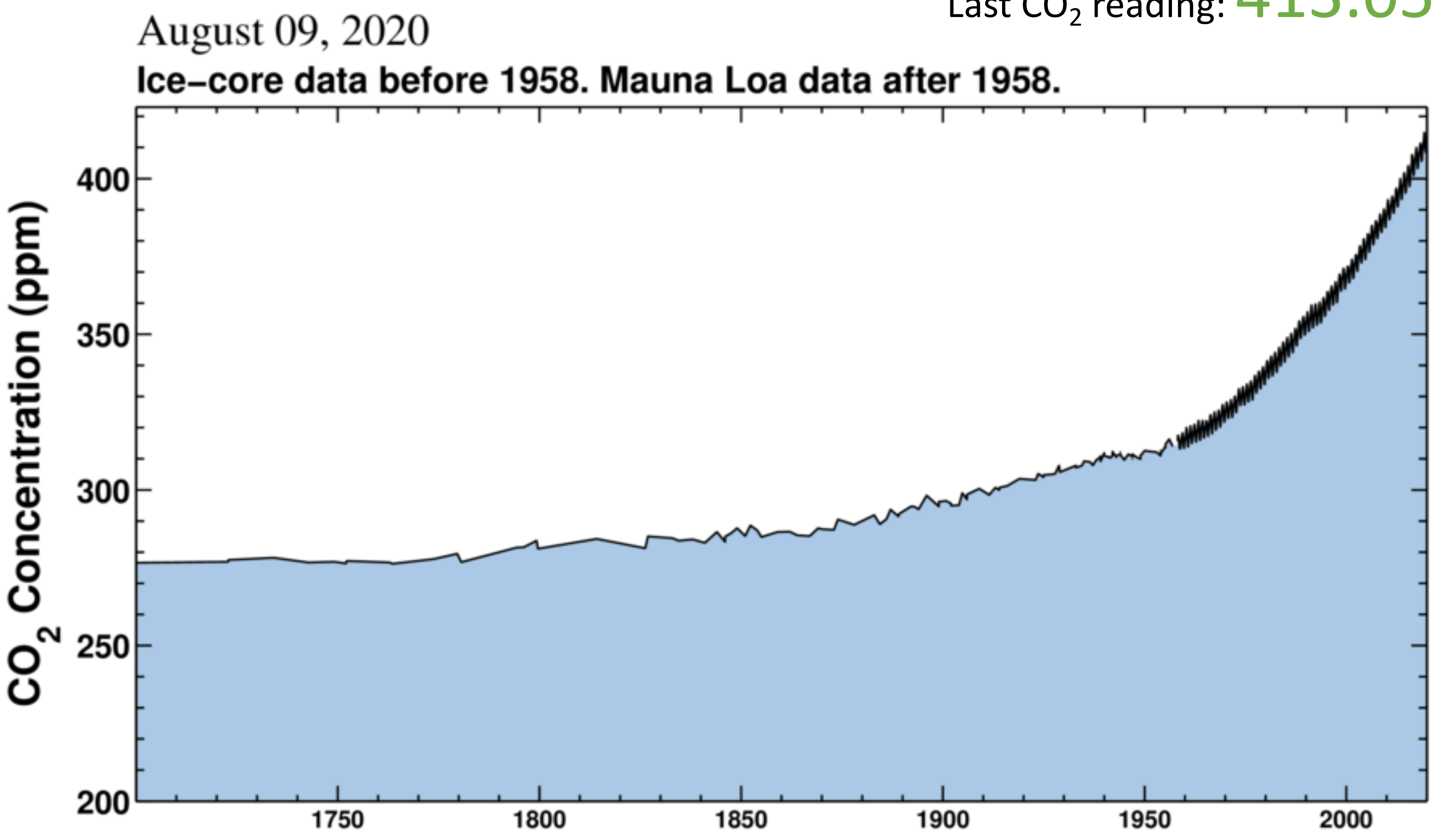
Increase in seawater CO_2:

- Increase in seawater carbonic acid, H_2CO_3
- Release of hydrogen, H^+, ions into the seawater
- Decrease pH = increase ocean acidity
- Decrease in CO_3^{2-} ions (buffering process)
- Can impact calcification in organisms

$\uparrow CO_2, \downarrow pH, \downarrow \Omega$

Anthropogenic Change

Last CO_2 reading: 413.05



http://keelingcurve.ucsd.edu/

Anthropogenic Change

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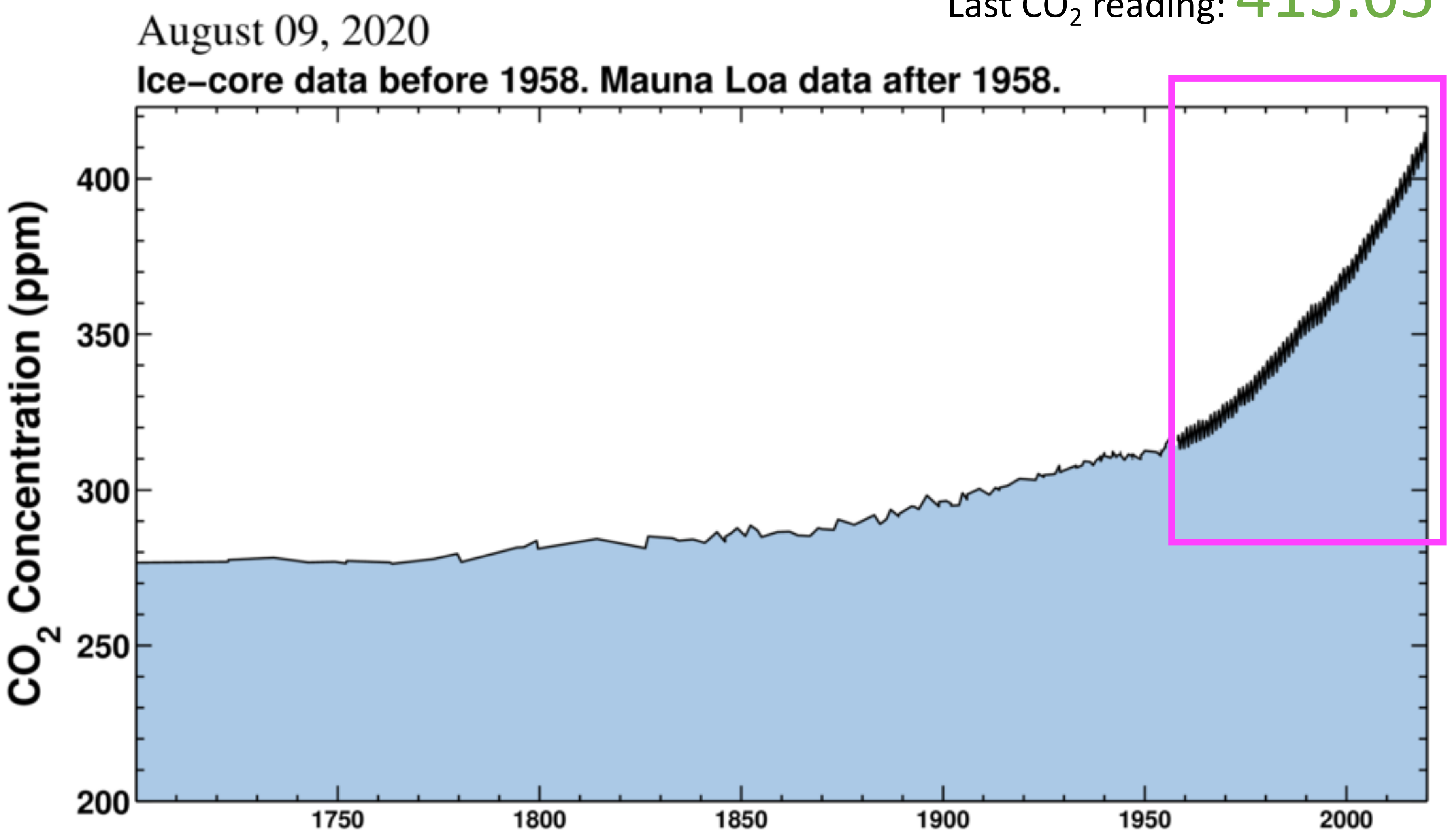
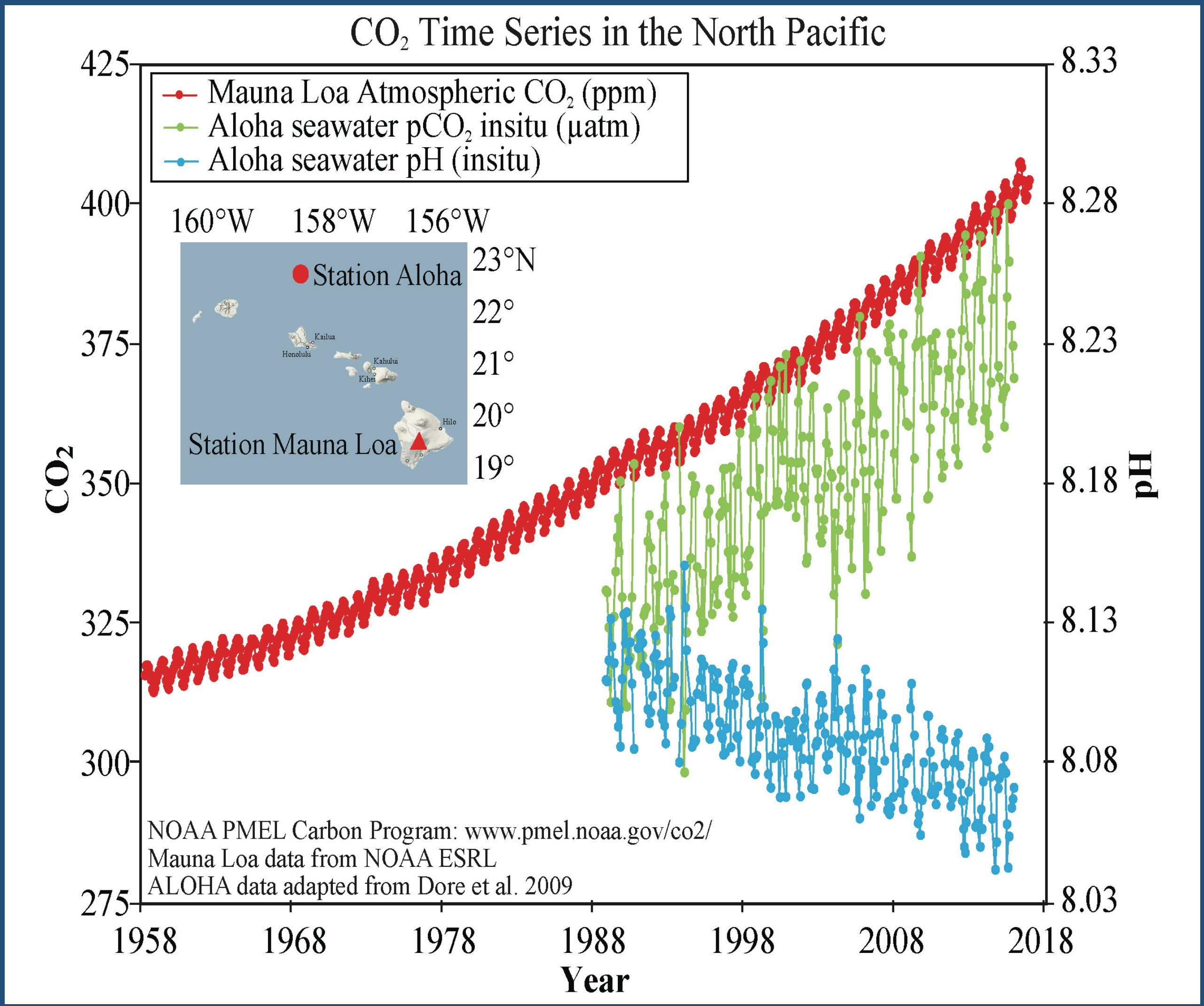


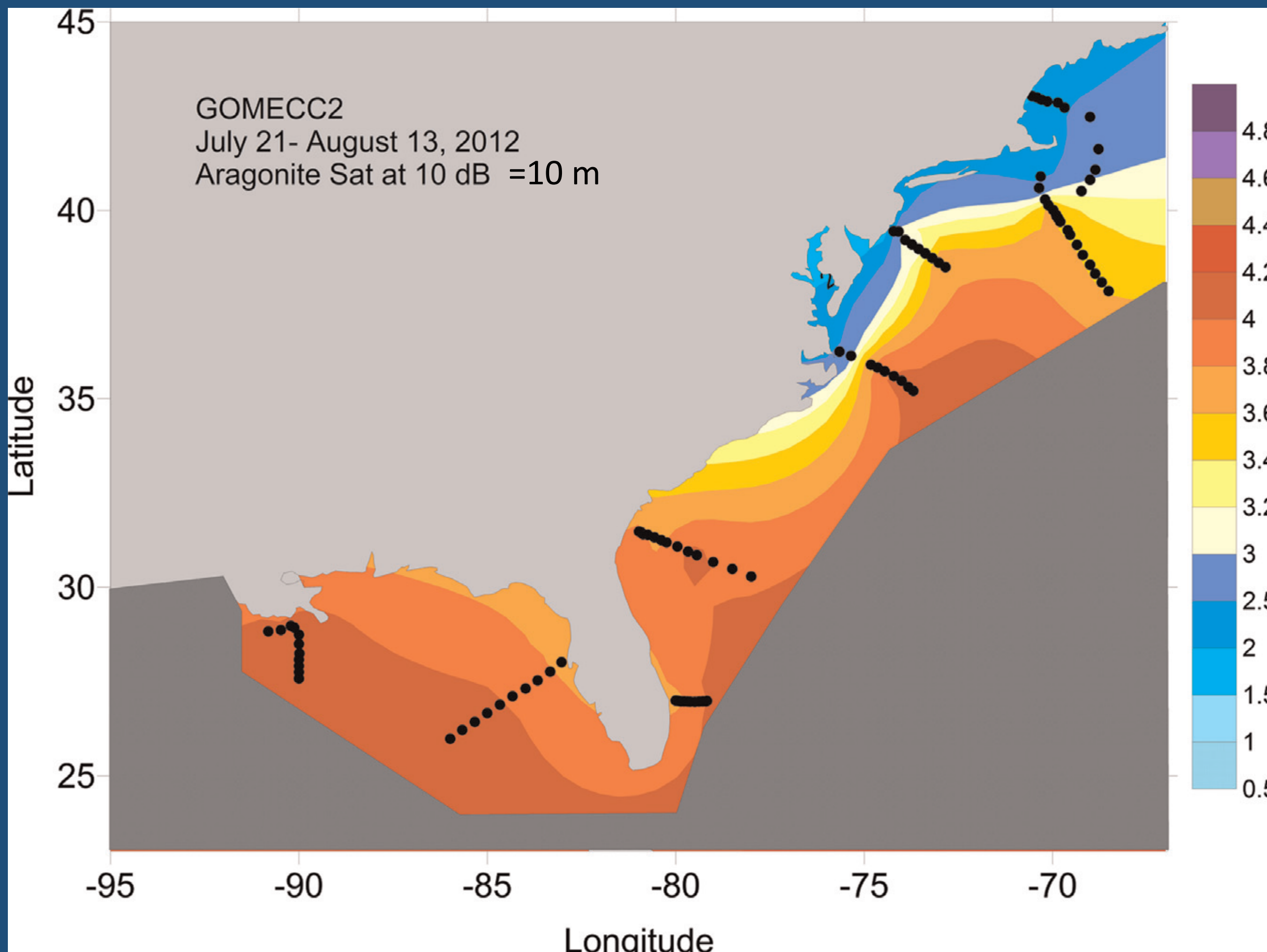
http://keelingcurve.ucsd.edu/

Ocean acidification: The "Other" CO_2 Problem

- Atmospheric CO_2 has increased 40% since the 1800s
  - Drop of 0.1 pH unit
  - 28% increase in ocean acidity
  - **10x faster than anything experienced over past 50 million years**
- CO_2 is projected to double by 2100 (IPCC)
  - Additional drop of 0.2-0.3 pH units
  - Equivalent to 100-150% increase in ocean acidity



Ocean Acidification Drivers in Mid-Atlantic



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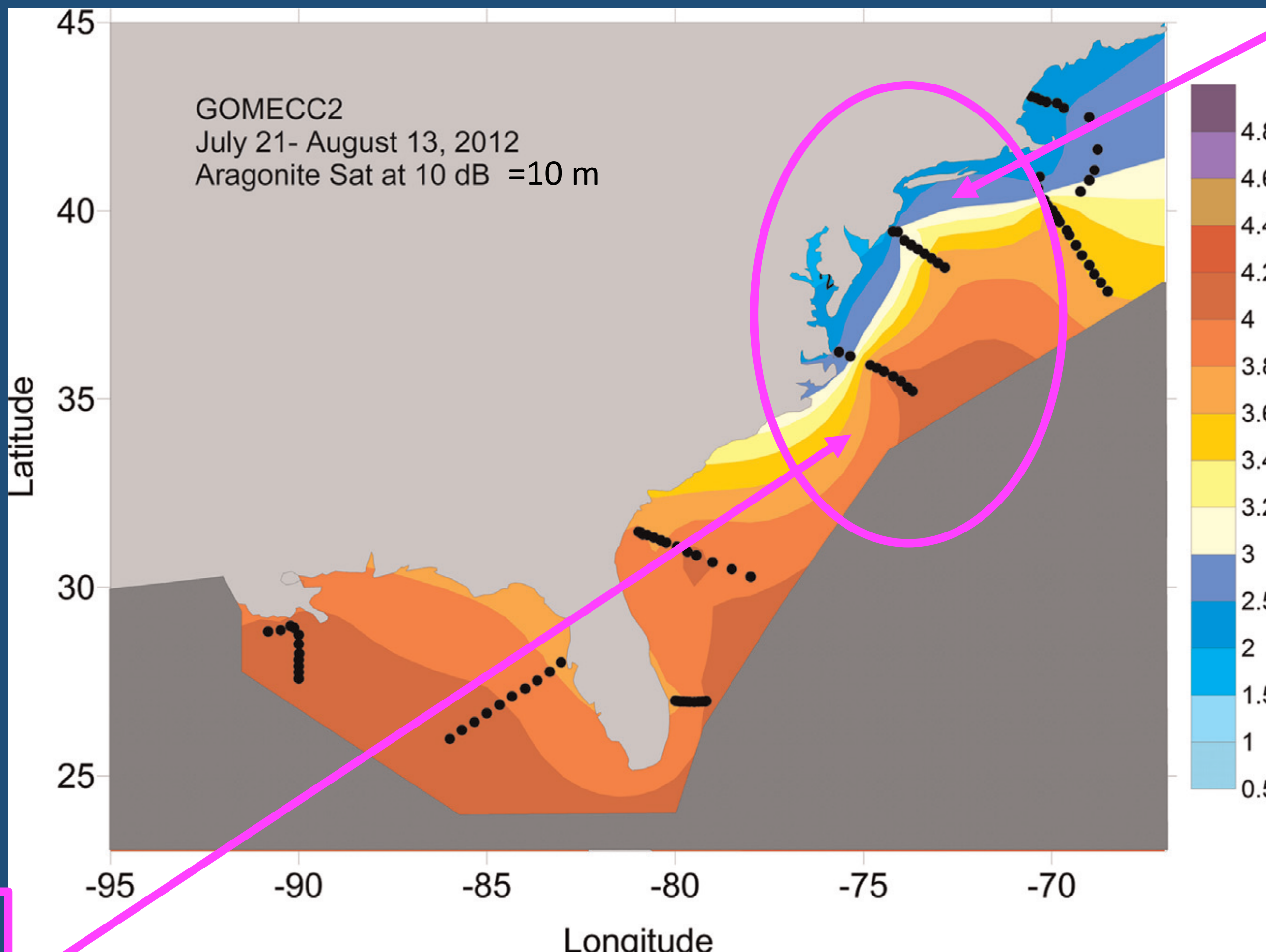
Wanninkhof et al. 2015

Ocean Acidification Drivers in Mid-Atlantic



Cold, higher CO_2, weakly buffered Labrador Sea Slope Water

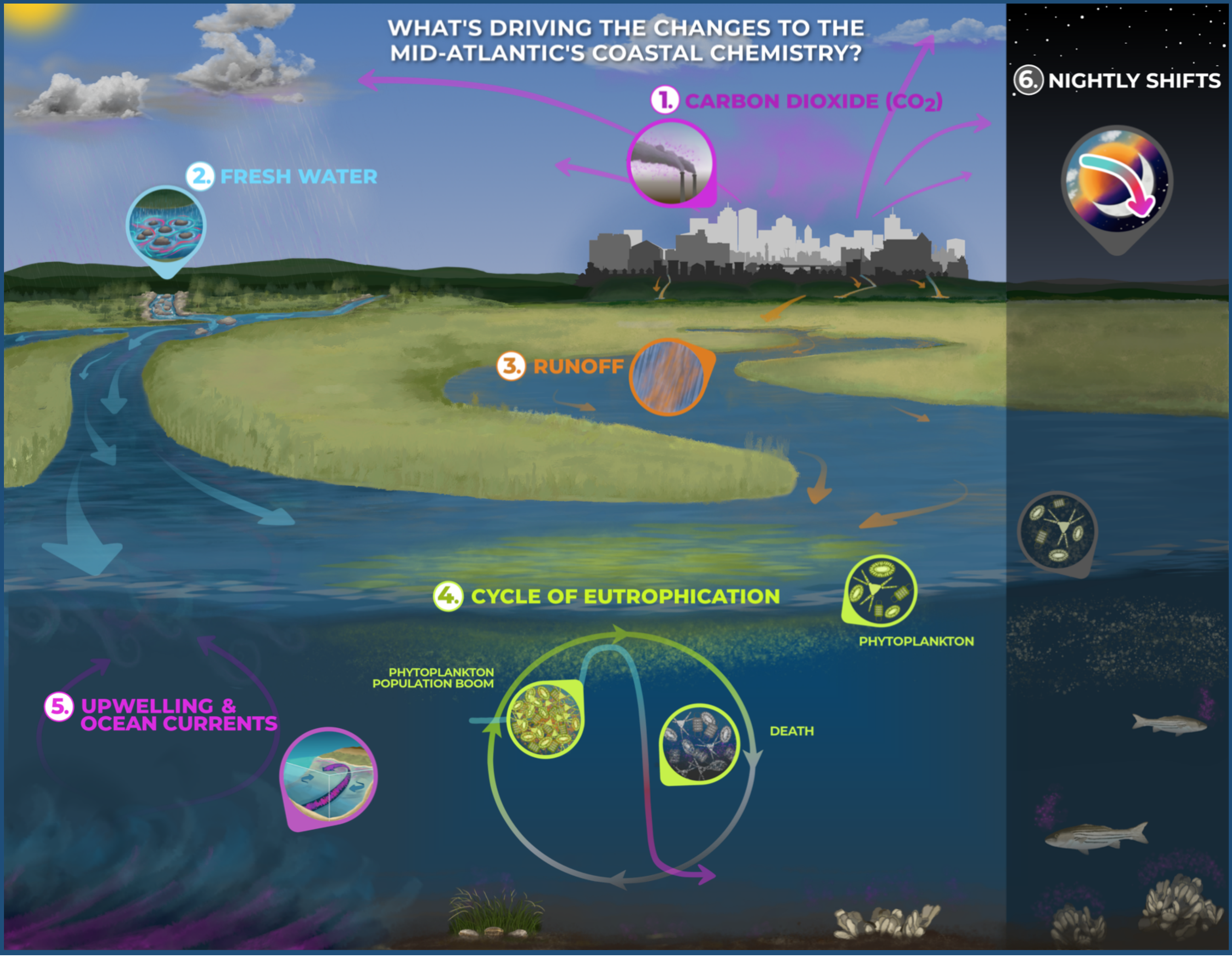
Ω

Warm, salty, well buffered Gulf Stream

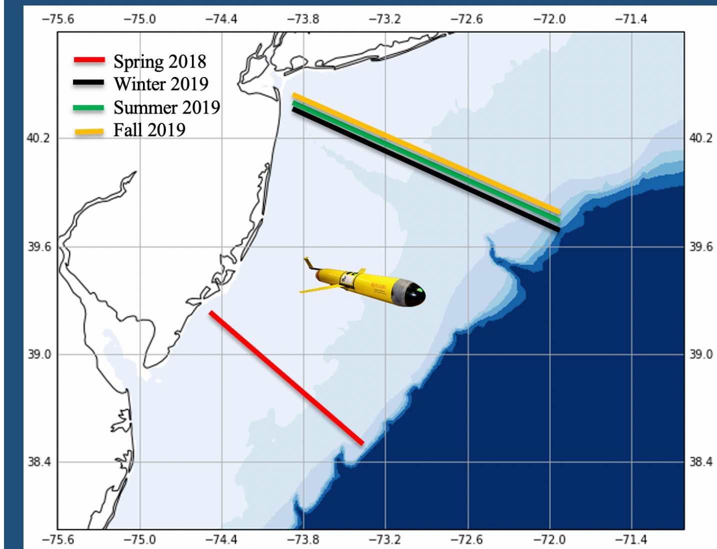
Wanninkhof et al. 2015

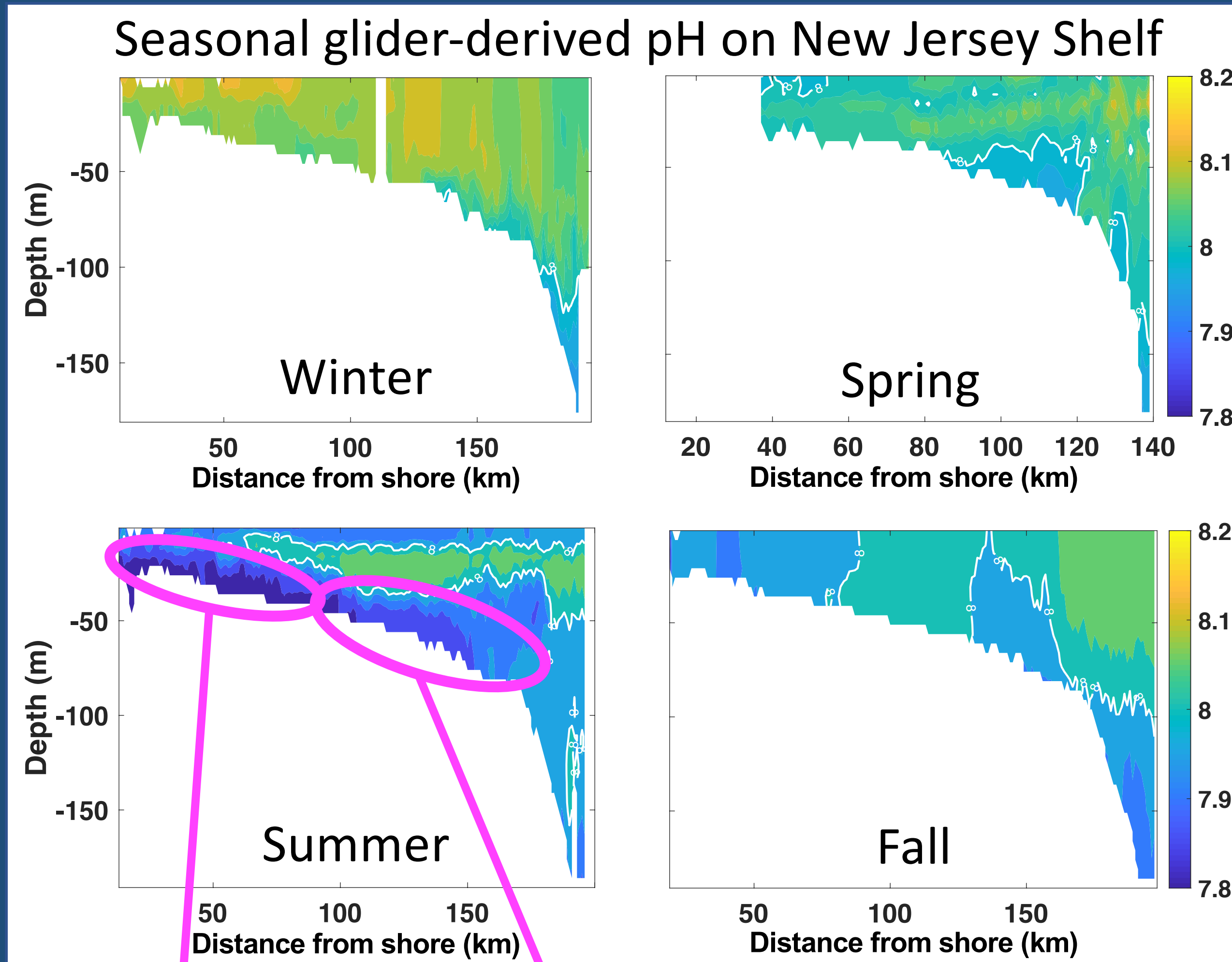
Drivers of Coastal Acidification

High variability and extremes in high CO_2/low pH due to a combination of natural and anthropogenic (human-caused) biogeochemical and physical processes



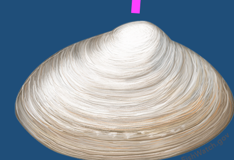
NJ Observations - Gliders



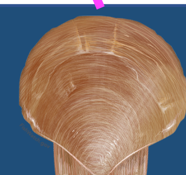


•Understand the baseline/climatology of OA conditions

•What are the seasonal conditions in known shellfish habitats?



Atlantic Surfclam
Spisula solidissima

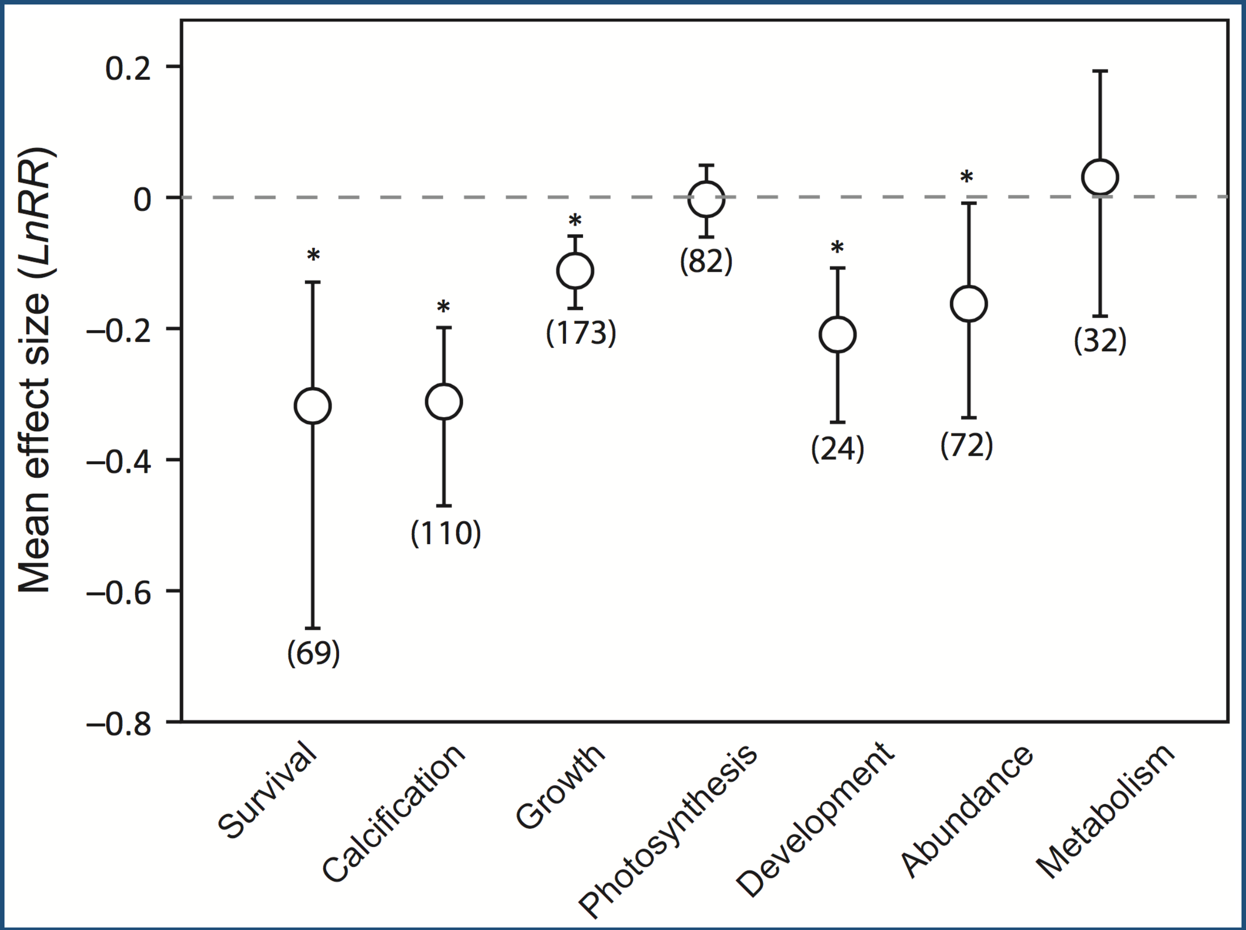


Atlantic Sea Scallop
Placopecten magellanicus

Saba et al., 2019

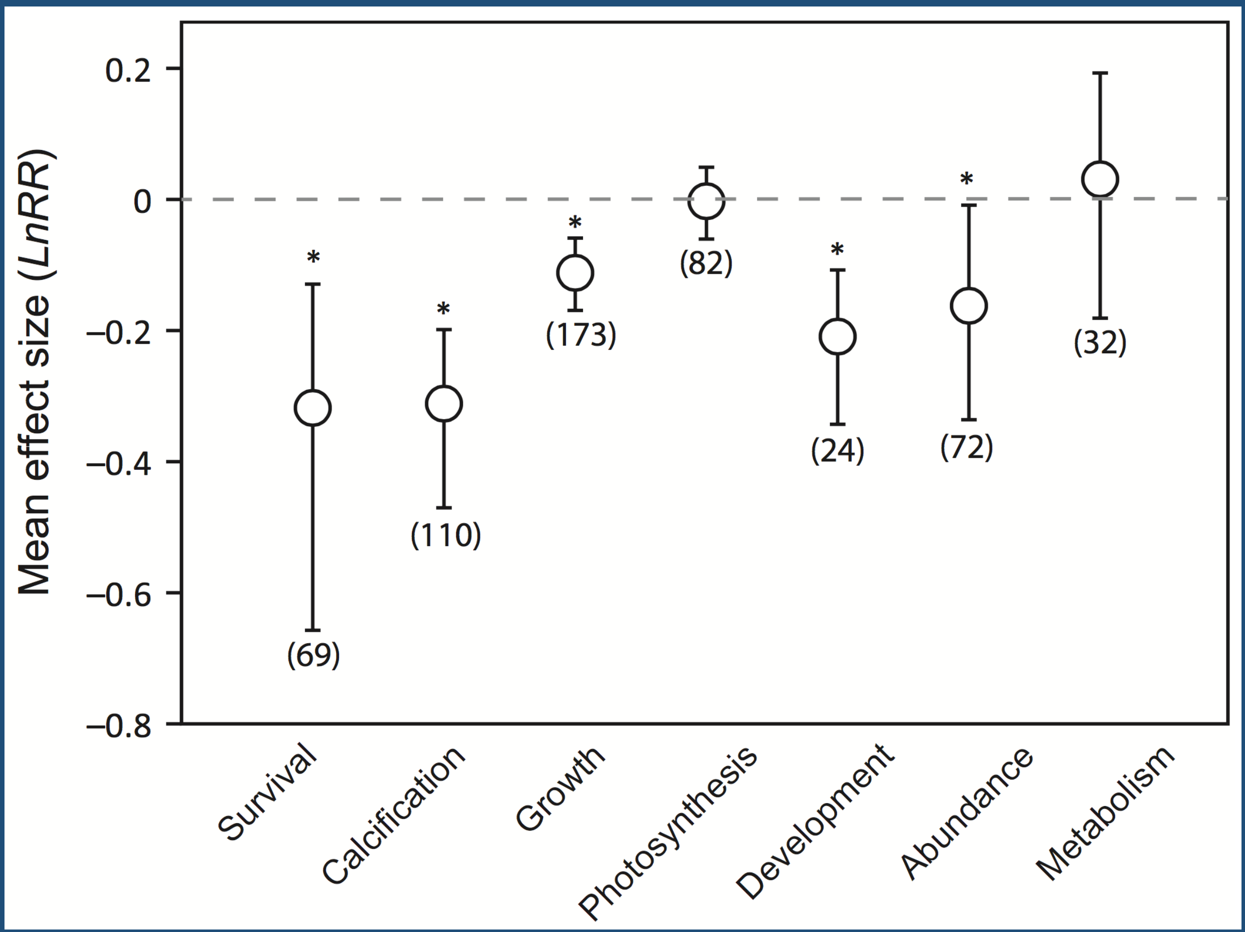
Wright-Fairbanks et al., in revision

Acidification Impacts on Organisms



Kroeker et al. 2013

Acidification Impacts on Organisms



Kroeker et al. 2013

AND……

- Reproduction
- Olfactory
- Behavior
- Swimming ability

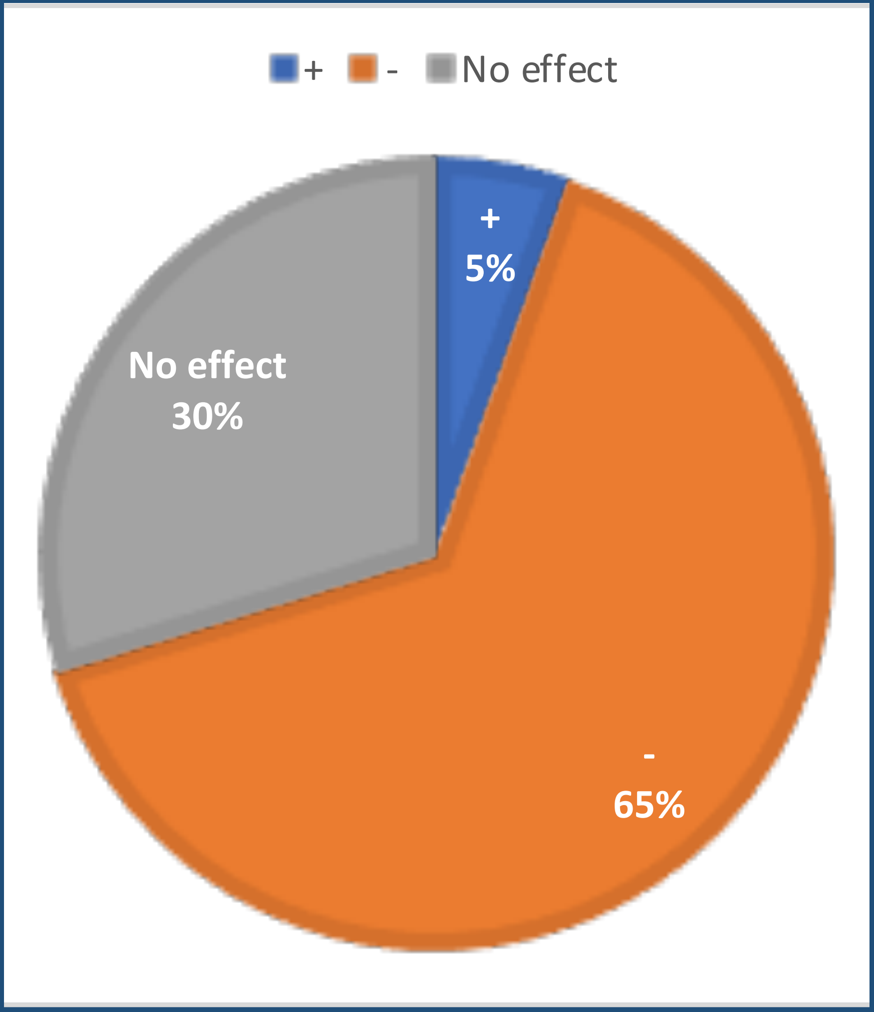
➢ Biotic interactions
➢ Biodiversity
➢ Ecosystem
➢ Acclimation???
➢ Adaptation???

Potential Impacts on Mid-Atlantic Species

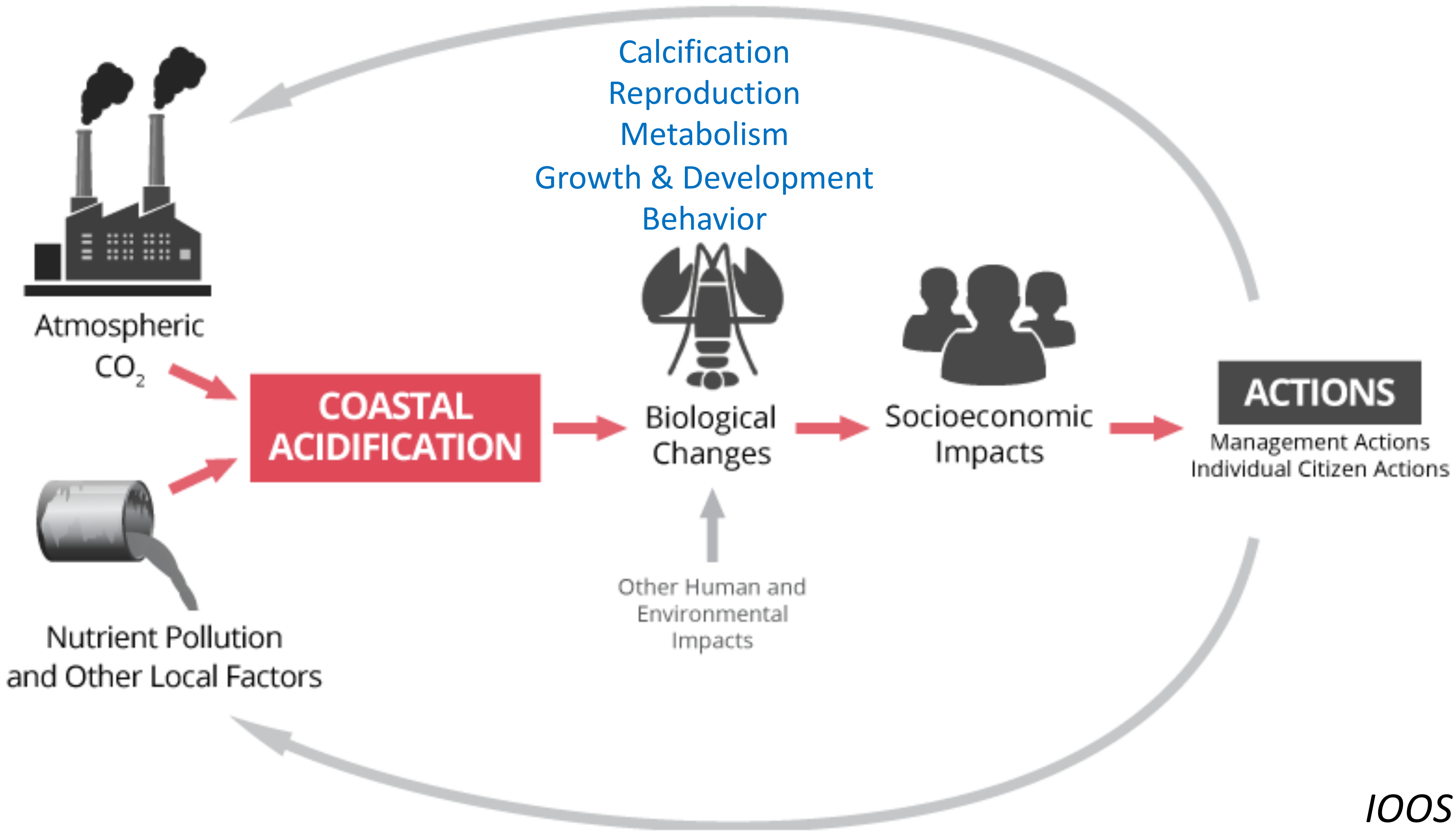
Saba et al., 2019: Estuarine, Coastal and Shelf Science

Data compiled from a review of acidification and multi-stressor studies conducted on economically important groups and species in the Mid-Atlantic:

- 18 species comprising of crustaceans, mollusks, finfish and elasmobranchs (from 59 studies)
- Species managed by MAFMC, ASMFC, NEFMC, NOAA and/or States
- Wide range of response variables



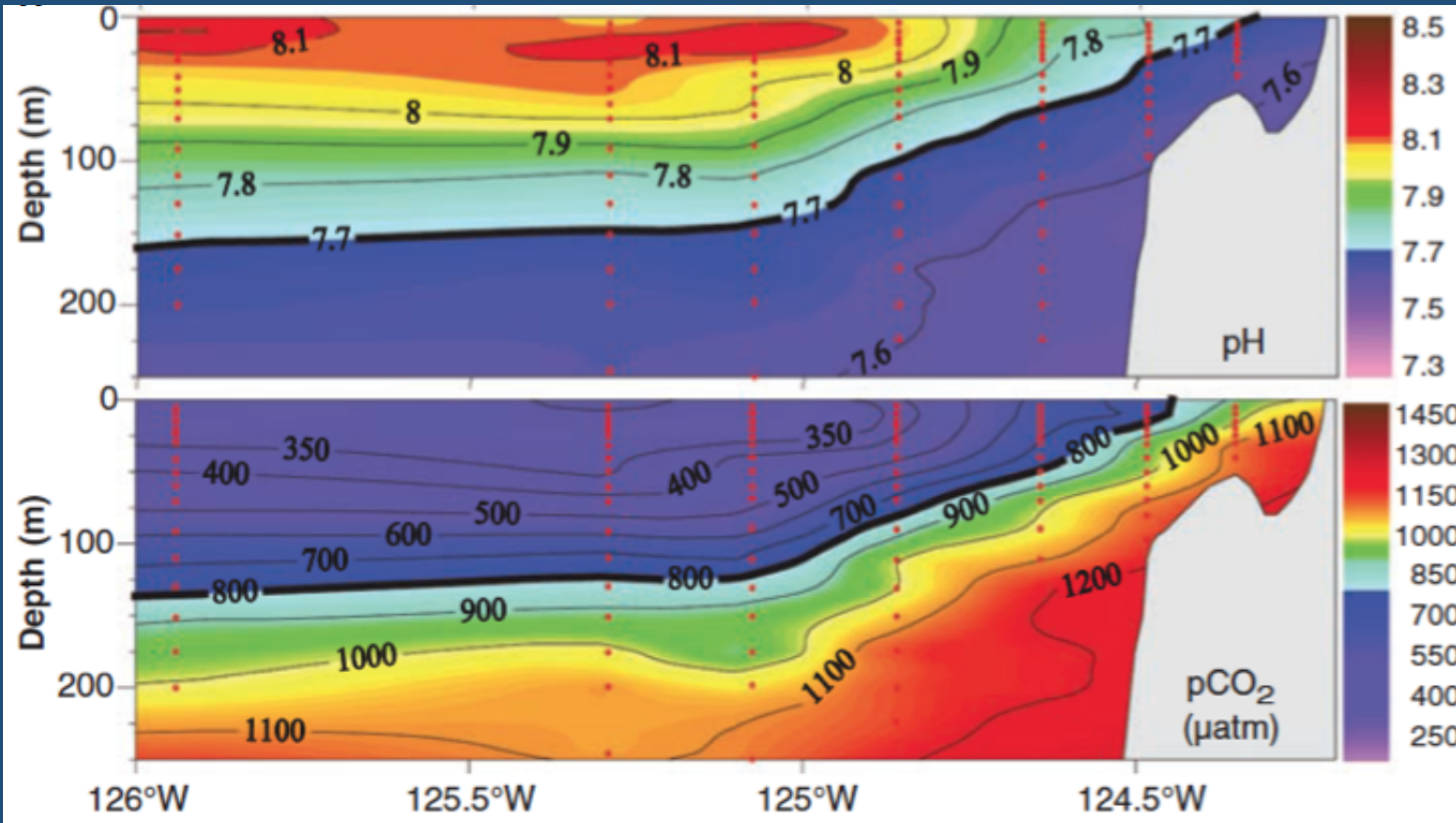
Links Between People and Coastal Acidification



IOOS

Learning by Example: Shellfish Growers in the Pacific Northwest

Upwelling of acidic water



Feely et al. 2008

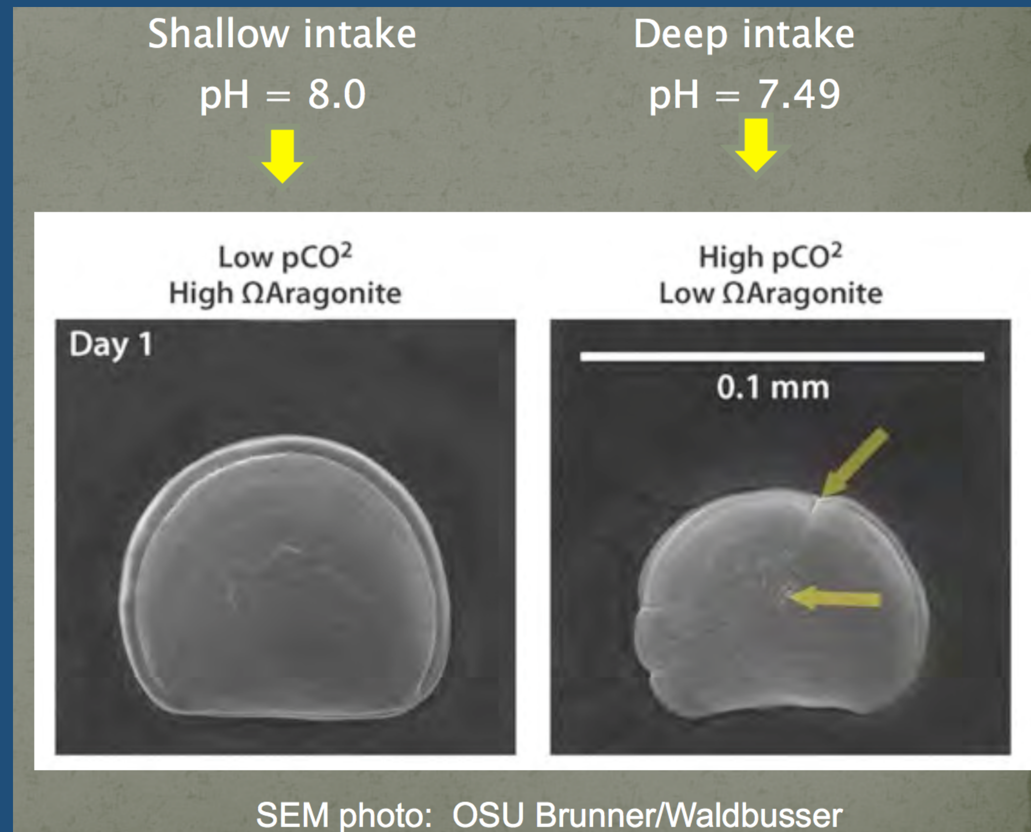
Learning by Example:
Shellfish Growers in the Pacific Northwest

Affected growers

Taylor Shellfish Farms;
Dabob Bay Hatchery

Goose Point Oyster Co.

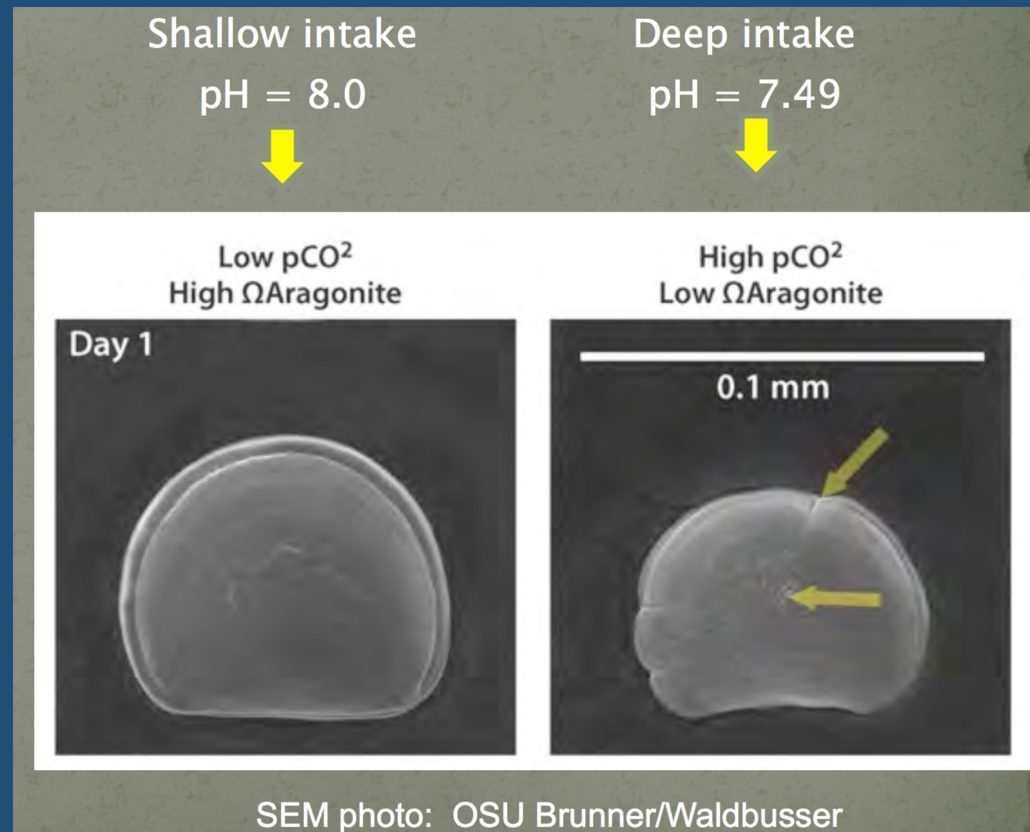
Whiskey Creek Hatchery



80% decrease in oyster production in 2007/2008 linked to ocean acidification

Learning by Example:
Shellfish Growers in the Pacific Northwest


The Seattle Times
Sunday
OYSTERS IN DEEP TROUBLE
Is the Pacific Ocean's chemistry killing sea life?



80% decrease in oyster production in 2007/2008 linked to ocean acidification

Learning by Example: Shellfish Growers in the Pacific Northwest

Panic/Adaptation

- Ramped up research and monitoring at hatcheries
- Expanded larvae production capacity at Kona, Hawaii
- Treating hatchery rearing water
- Breeding OA resistant oysters

Slide by Bill Dewey, Taylor Shellfish Farms

Industry Need Leads to Policy Actions

Ocean Acidification Blue Ribbon Panel

A panel of science and policy experts to address the effects of OA on WA's shellfish resources

In March, Gov. Chris Gregoire convened an Ocean Acidification Blue Ribbon Panel, the first of its kind in the nation.

- Convened in 2012
- Identified 42 actions toward increasing "capacity to understand, reduce, remediate, and where possible adapt to the consequences of ocean acidification" – First state OA Action Plan
- Region-wide impact led to multi-state Pacific Coast Collaborative

Several other U.S. States Follow Suit

State Department of Environmental Conservation Releases Final Ocean Action Plan for New York

Plan introduces integrated, adaptive approach to managing, restoring, and protecting state's ocean resources

New Law Creating Ocean Acidification Task Force Leads The Nation

KENNETH P. LAVALLE December 12, 2016 | ISSUE: CLEAN WATER

- Many states join OA Alliance (International Alliance to Combat OA)
- Bipartisan support for 4 OA bills currently in House committee
- Regional Acidification Networks established (e.g., MACAN)

U.S. Member States in the International OA Alliance

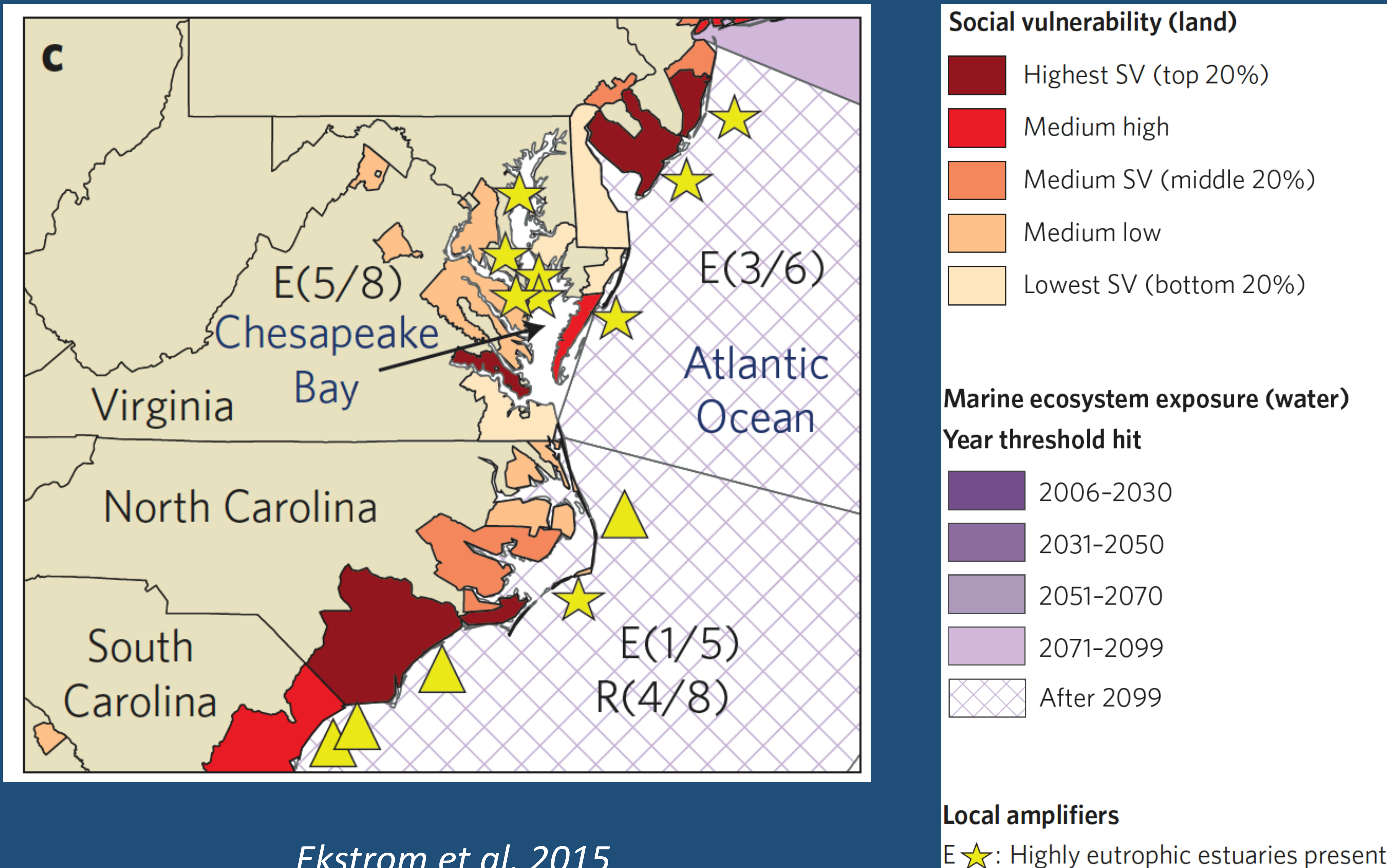
California
Hawaii
Maine
Maryland
New York
Oregon
Virginia
Washington

NJDEP Recognizes OA Risks

"New Jersey is at increased risk to the effects of ocean acidification due to its economic dependence on shellfish harvests, with southern New Jersey counties ranking second in the United States in economic dependence on shelled mollusks. While it is predicted that New Jersey will not see unfavorable acidification conditions for shellfish until 2100, given the State's dependence on shellfish resources, there will be high social and economic impacts."

-NJDEP 2020, Science Report on Climate Change

High Regional Social Vulnerability



Ekstrom et al. 2015

Associated Economic Risks in NJ

- Marine resources in New Jersey have ecological, economical, social, and cultural significance
- New Jersey's commercial fishing industry is the fifth largest in the United States and provides more than 50,000 jobs
- The fishing and aquaculture industries contribute more than $1 billion annually to state's economy
- The most commercially important shellfish species in New Jersey include the Atlantic sea scallop, Ocean quahog, Atlantic surfclam, blue crabs, and the eastern oyster. Commercially and recreationally important finfish in NJ include Atlantic mackerel, summer flounder, black sea bass and squid.

Significant Research Gaps

Group	Common name	Scientific name
Molluscs	Atlantic surfclam[a]	*Spisula solidissima*
	Illex squid[a]	*Illex illecebrosus*
Crustaceans	Atlantic deep-sea red crab[c]	*Chaceon quinquedens*
	Horseshoe crab[b]	*Limulus polyphemus*
	Jonah crab[b]	*Cancer borealis*
Finfishes	American eel[b]	*Anguilla rostrata*
	Atlantic croaker[b]	*Micropogonias undulatus*
	Atlantic mackerel[a]	*Scomber scombrus*
	Atlantic menhaden[b]	*Brevoortia tyrannus*
	Atlantic Sturgeon[b]	*Acipenser oxyrinchus*
	Black drum[b]	*Pogonias cromis*
	Black sea bass[a,b]	*Centropristis striata*
	Bluefish[a,b]	*Pomatomus saltatrix*
	Butterfish[a]	*Peprilus triacanthus*
	Monkfish[a]	*Lophius americanus*
	Offshore hake[c]	*Merluccius albidus*
	Red hake[c]	*Urophycis chuss*
	River herring[b]	*Alosa pseudoharengus, Alosa aestivalis*
	Shad[b]	*Alosa sapidissima*
	Silver hake[c]	*Merluccius bilinearis*
	Spanish mackerel[b]	*Scomberomorus maculatus*
	Spot[b]	*Leiostomus xanthurus*
	Spotted seatrout[b]	*Cynoscion nebulosus*
	Tautog[b]	*Tautoga onitis*
	Golden tilefish[a]	*Lopholatilus chamaelonticeps*
	Blueline tilefish[a]	*Caulolatilus microps*
	Winter flounder[b]	*Pseudopleuronectes americanus*
Elasmobranchs	Spiny dogfish[a,b]	*Squalus acanthias*
	Winter skate[c]	*Leucoraja ocellata*

Of the 35 managed species in our region, 69% (24 species) have not yet been investigated for acidification impacts

Saba et al., 2019
Estuarine, Coastal and Shelf Science

Significant Research Needs

Additional and new studies focused on these important species are needed to investigate their responses to acidification and specifically include:

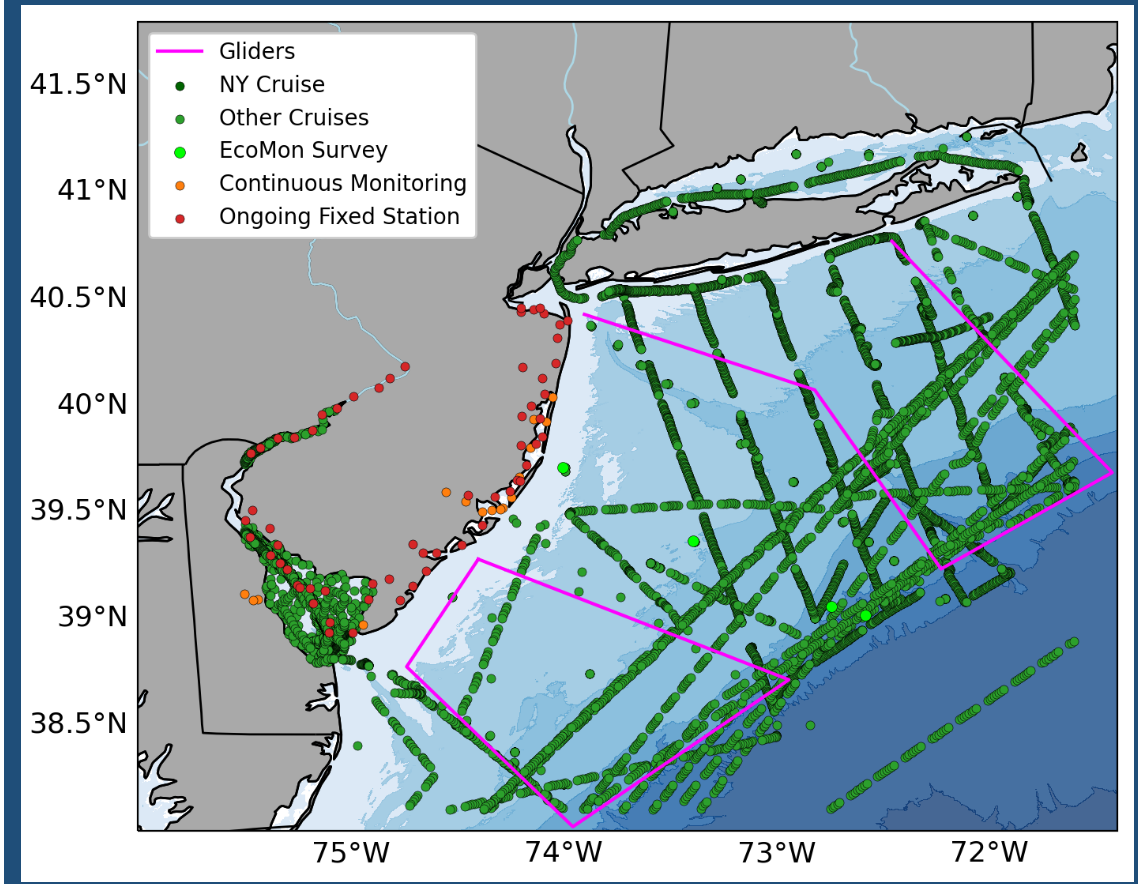
- The potential impacts to various life stages
- Acclimation and adaptation potential
- Potential thresholds of acidification
- Impacts on the food web, populations dynamics, and community structure

Continue and expand research on shellfish genetics to breed OA resilient species for aquaculture industry

Investigate mitigation strategies for aquaculture facilities, hatcheries, nurseries, and impacted waterways

Connect organism and ecosystem responses to ecosystem services and the economy

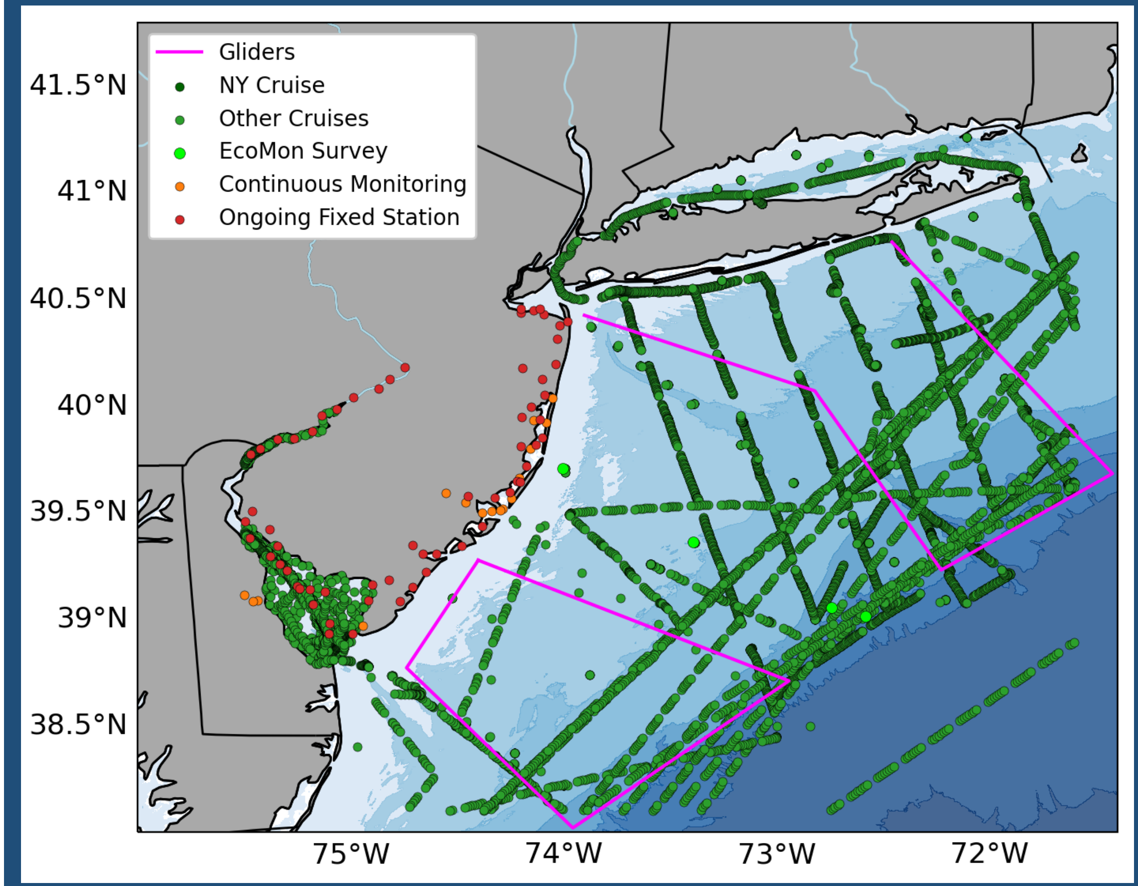
Observation Needs



- High sampling frequency
- Measurements of multiple carbonate chemistry parameters
- High-resolution depth-profiling measurements
- Monitor across a salinity gradient
- Observe OA with other stressors
- Co-located biological response monitoring

see Goldsmith et al., 2019

Observation Needs



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NJ would benefit from a comprehensive statewide monitoring network that can cohesively act to address observation needs

see Goldsmith et al., 2019

Thanks!

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IOOS | Integrated Ocean Observing System