



4TH ANNUAL CAPE COASTAL CONFERENCE

Coastal & Ocean Acidification

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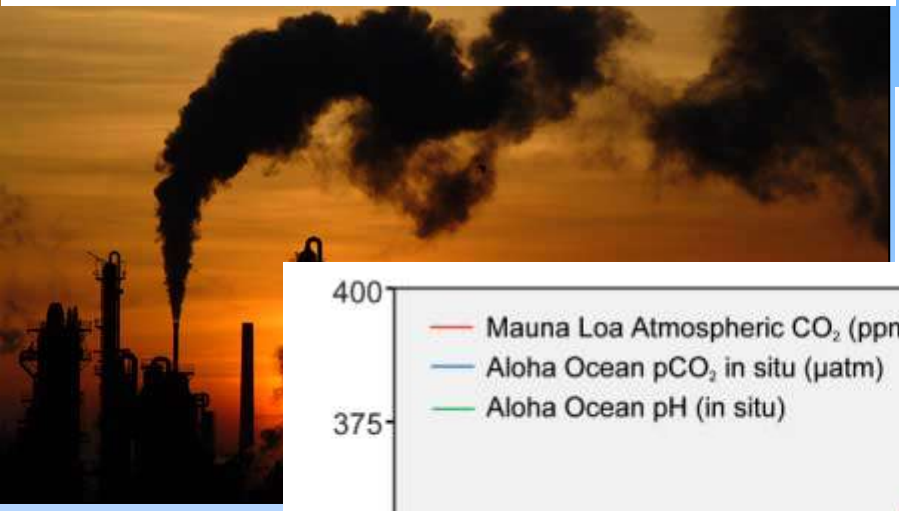
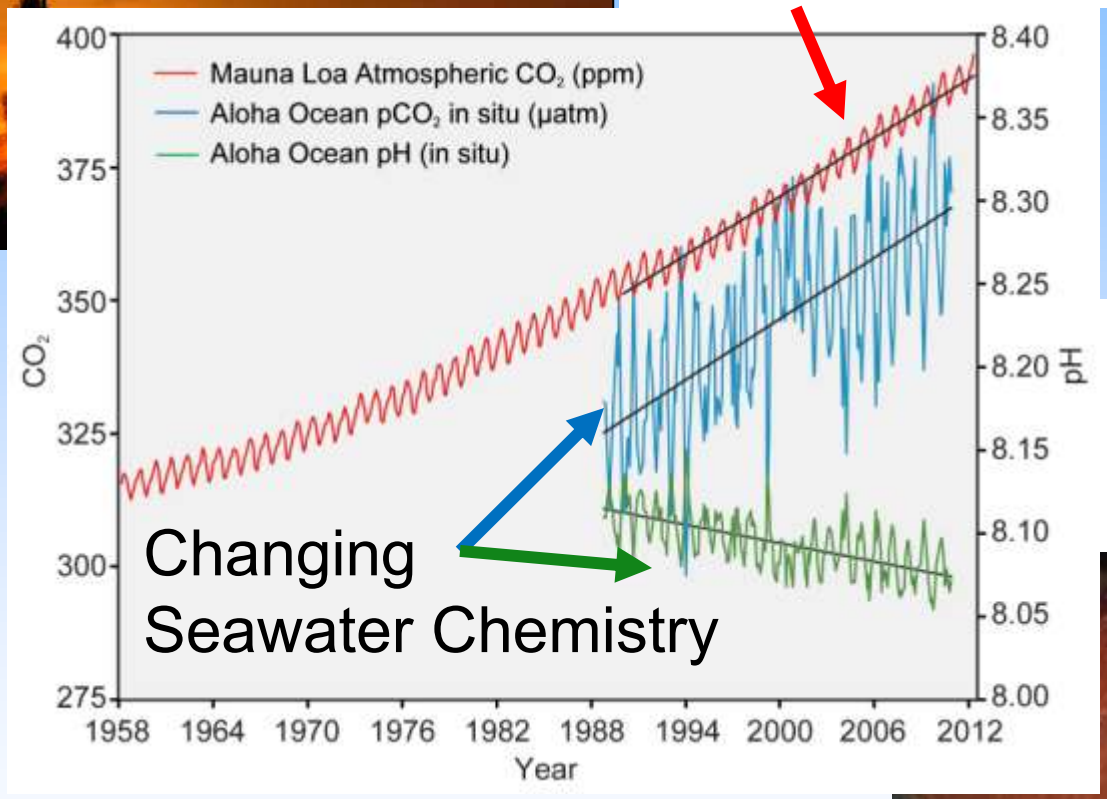
Ocean Acidification Basics

Fossil Fuel Carbon Emissions



Rising Atmospheric Carbon Dioxide



Impacts on Shellfish & Other Marine Life

Feely et al. Oceanography 2009
National Climate Assessment
Walsh et al. 2014

Fate of Anthropogenic CO_2 Emissions (2006-2015)

Fossil Fuels 90%

+ ~10 billion tons carbon per year

Deforestation 10%

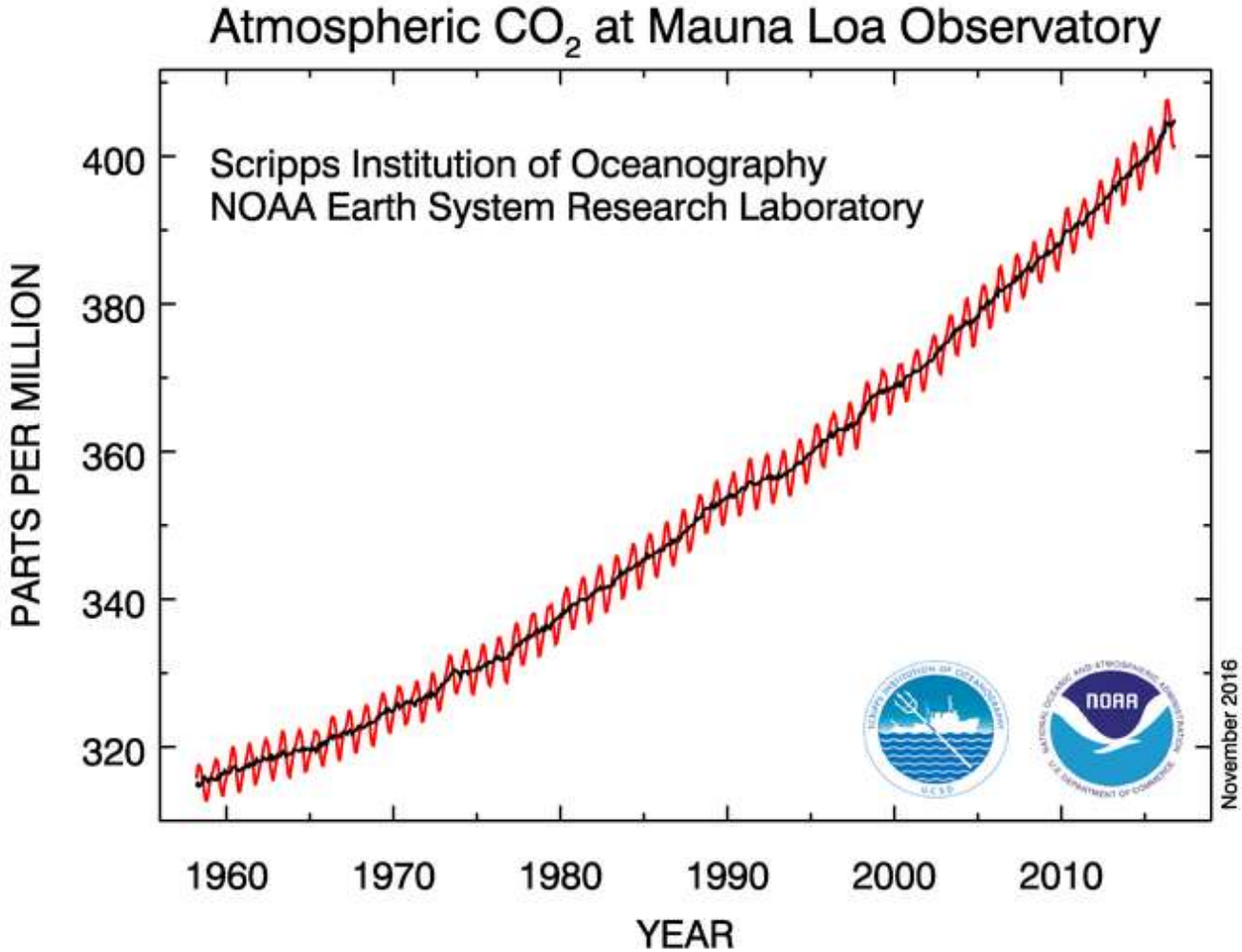
Atmosphere 45%

Land 30%

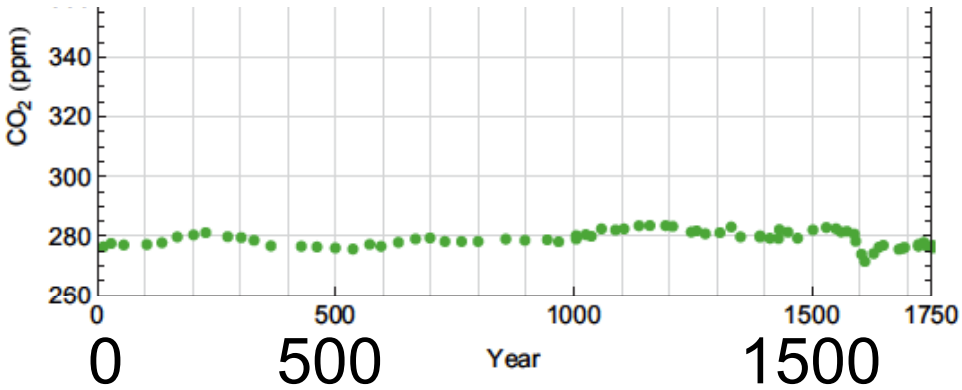
Oceans 25%

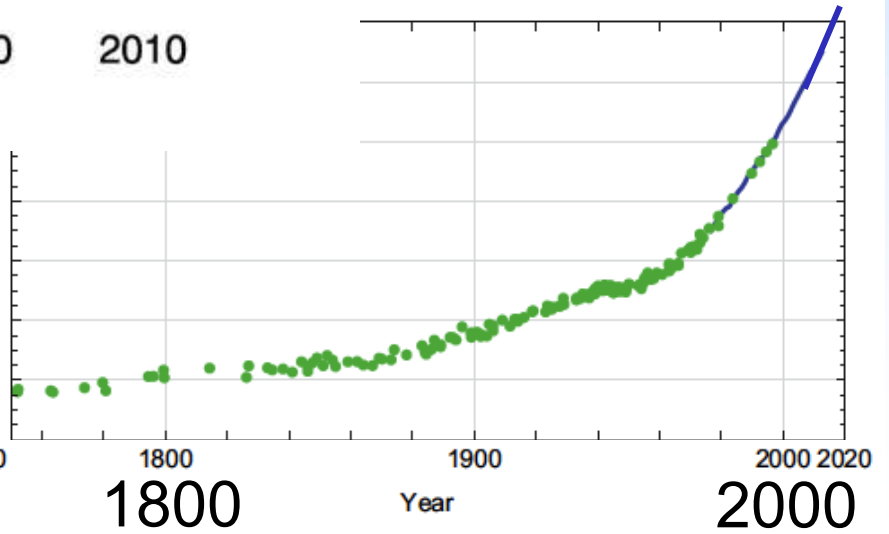
LeQuere et al. Earth Systems Science Data 2016; Global Carbon Project 2016

Rising Atmospheric CO_2



IPCC AR5
WG1 Chap. 6



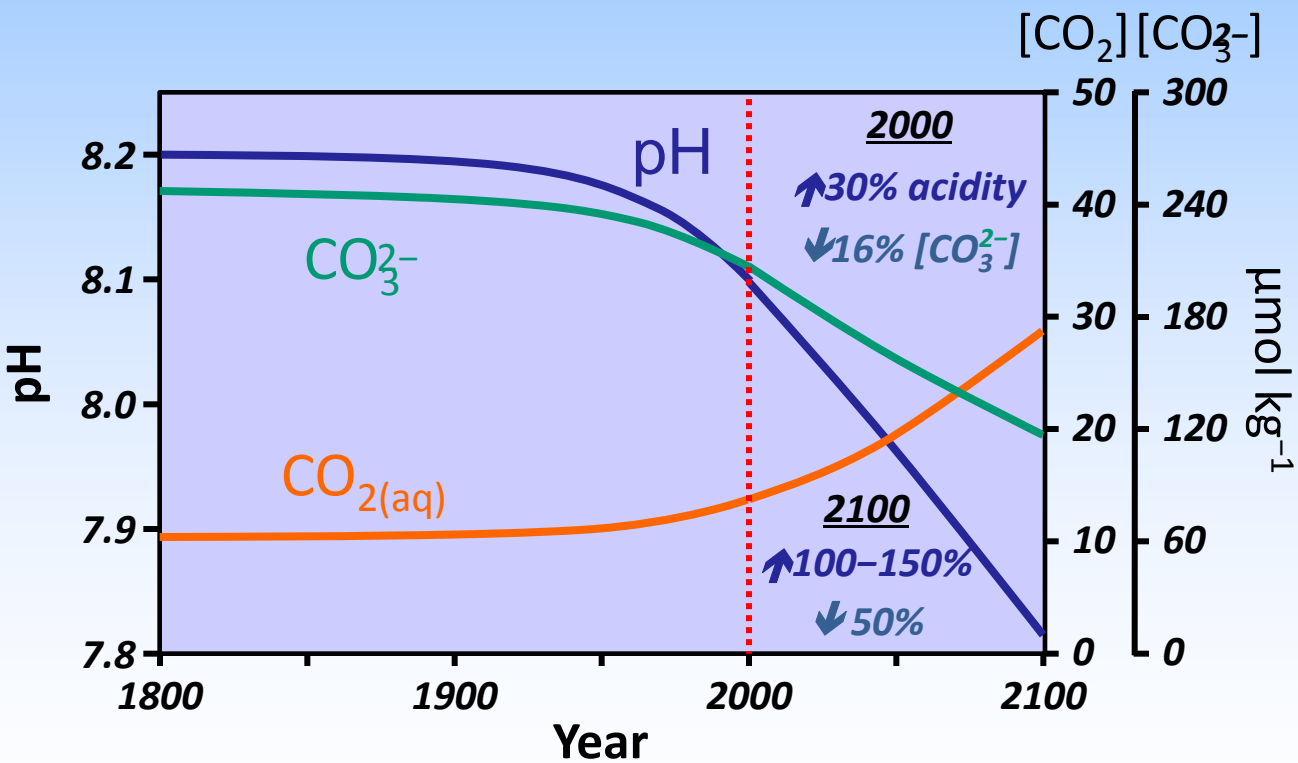


Ocean Acidification

$$CO_2 + H_2O \longrightarrow H^+ + HCO_3^-$$

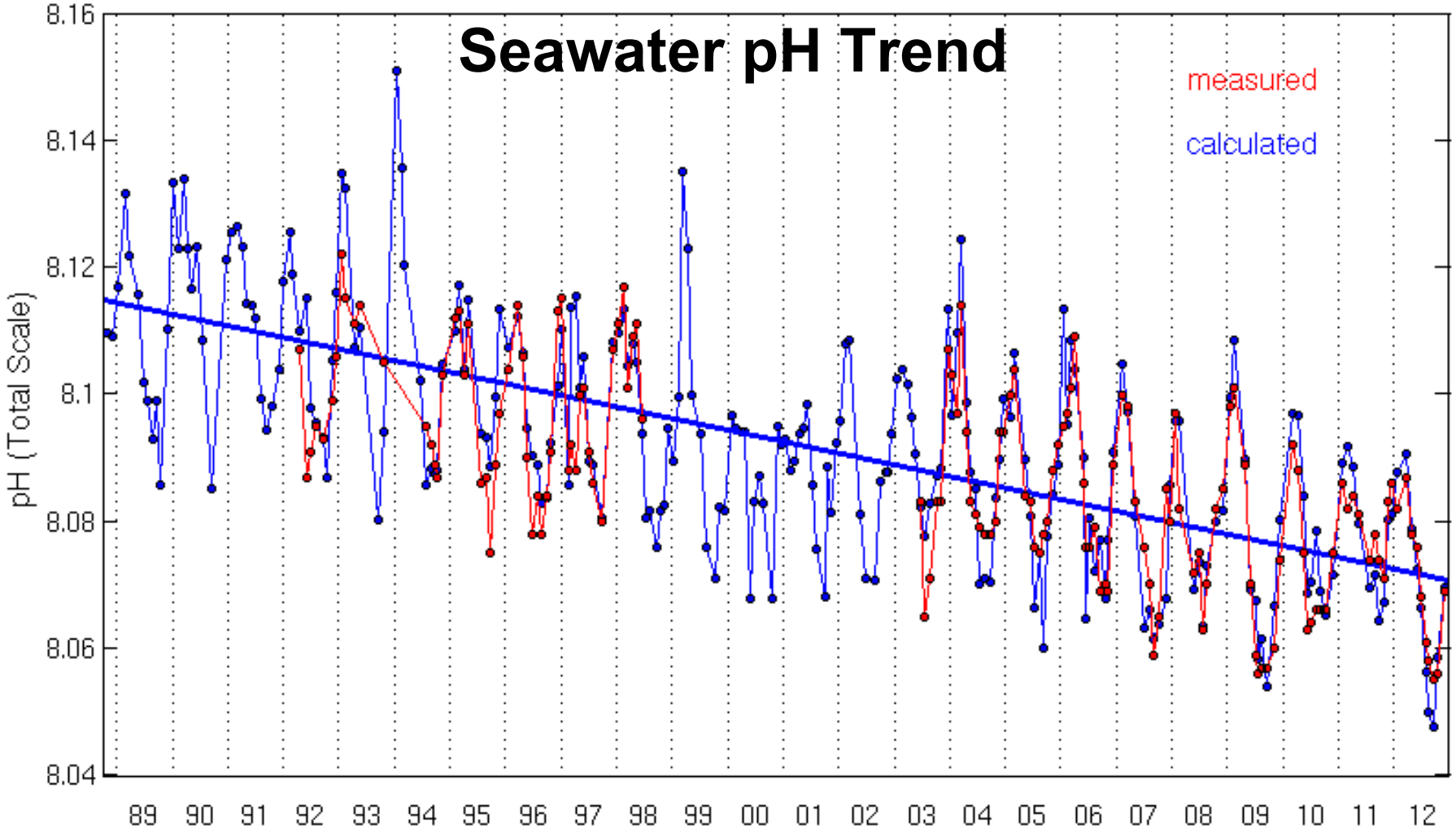
$$H^+ + CO_3^{2-} \longrightarrow HCO_3^-$$

$$CO_2 + CO_3^{2-} \longrightarrow 2HCO_3^-$$



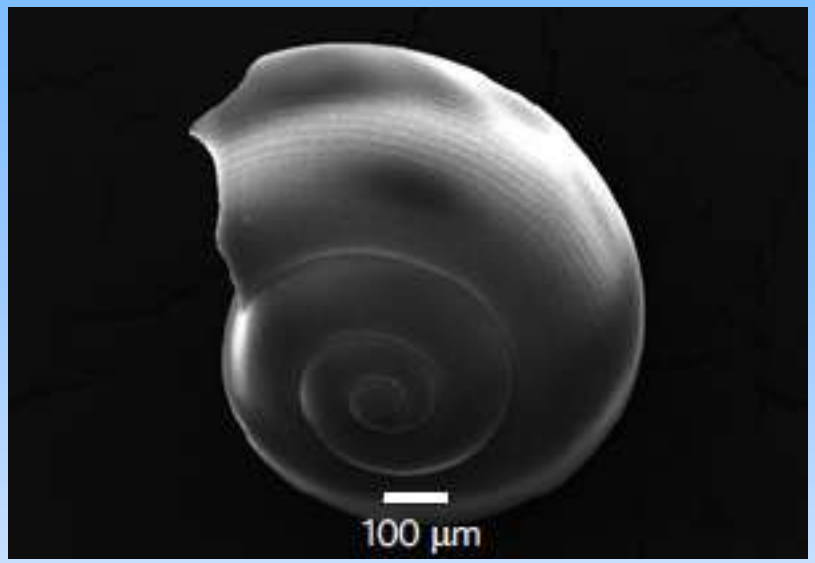
Wolf-Gladrow et al. 1999

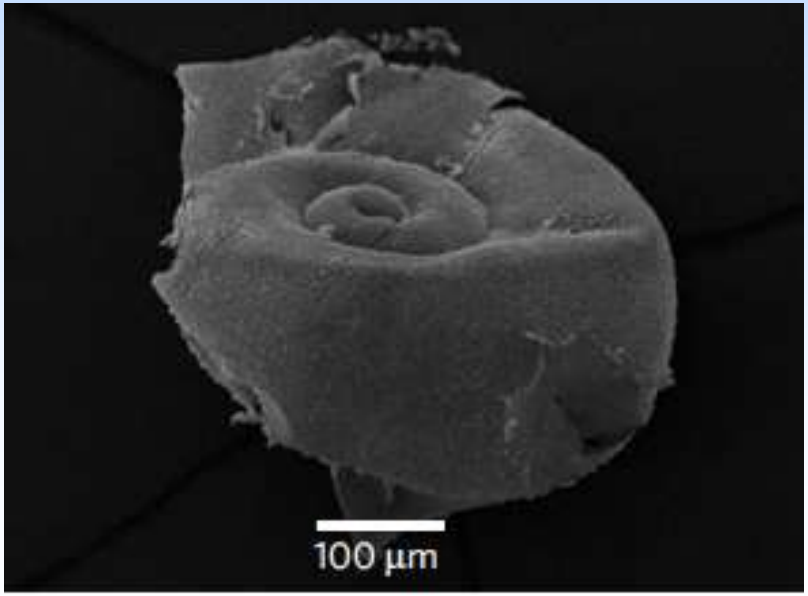
Seawater pH Trend



Surface ocean water
Hawaii Ocean Time-Series (HOT)

Calcium Carbonate Solubility Saturation State





$Ca^{2+} + CO_3^{2-} \longrightarrow CaCO_3$ (solid)

Saturation State

$\Omega = [Ca^{2+}][CO_3^{2-}] / K_{sp}$

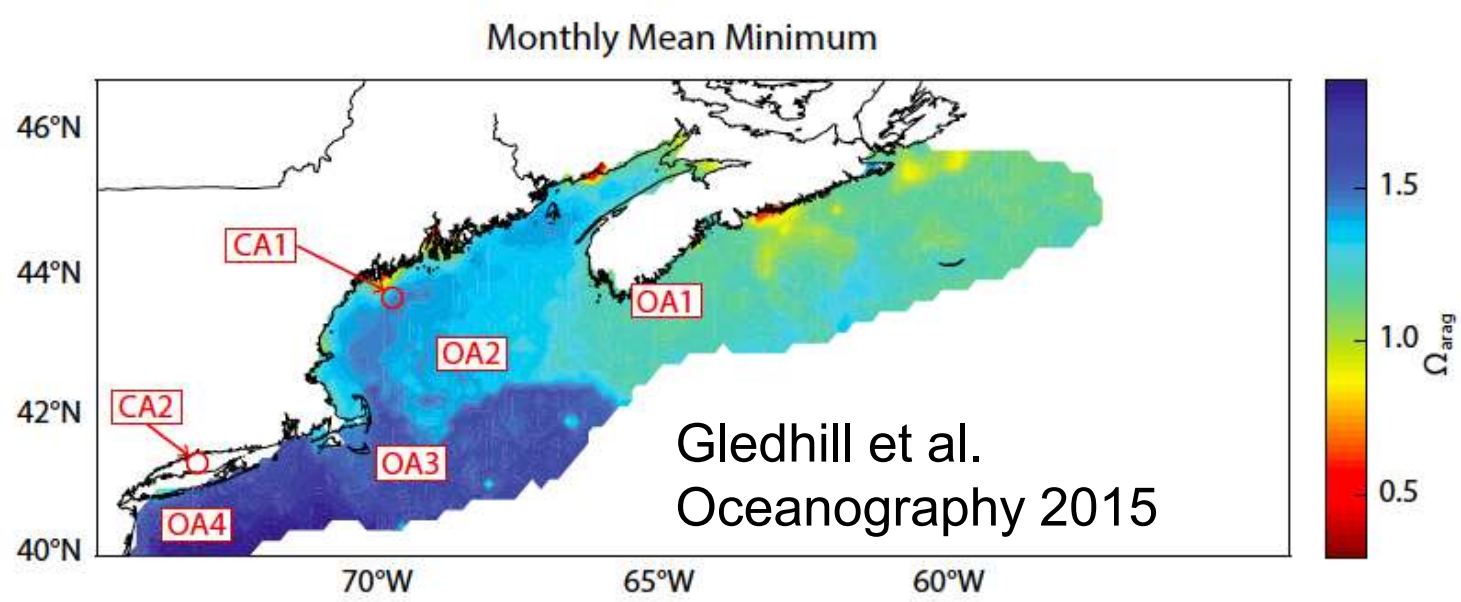
$\Omega > 1$ saturated

$\Omega < 1$ undersaturated

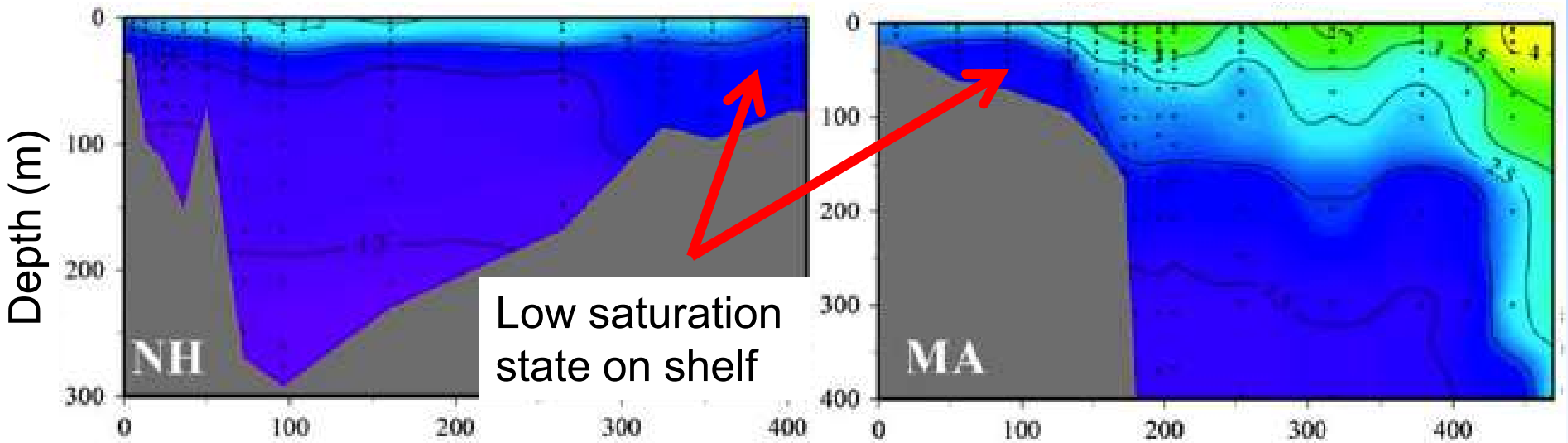
$CaCO_3$ solubility
-depends on mineral form
-increases with pressure

Feely et al. Nature 2005; Bednaršek Nature Geosci. 2012

Saturation State along Northeast Shelf



Gledhill et al. Oceanography 2015



Wang et al. Limnology & Oceanography 2013

Marine Life Susceptible to Ocean Acidification

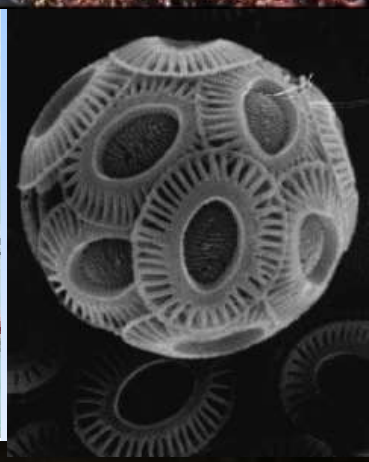
-Winners & losers

-Reduced shell & skeleton formation (calcification)

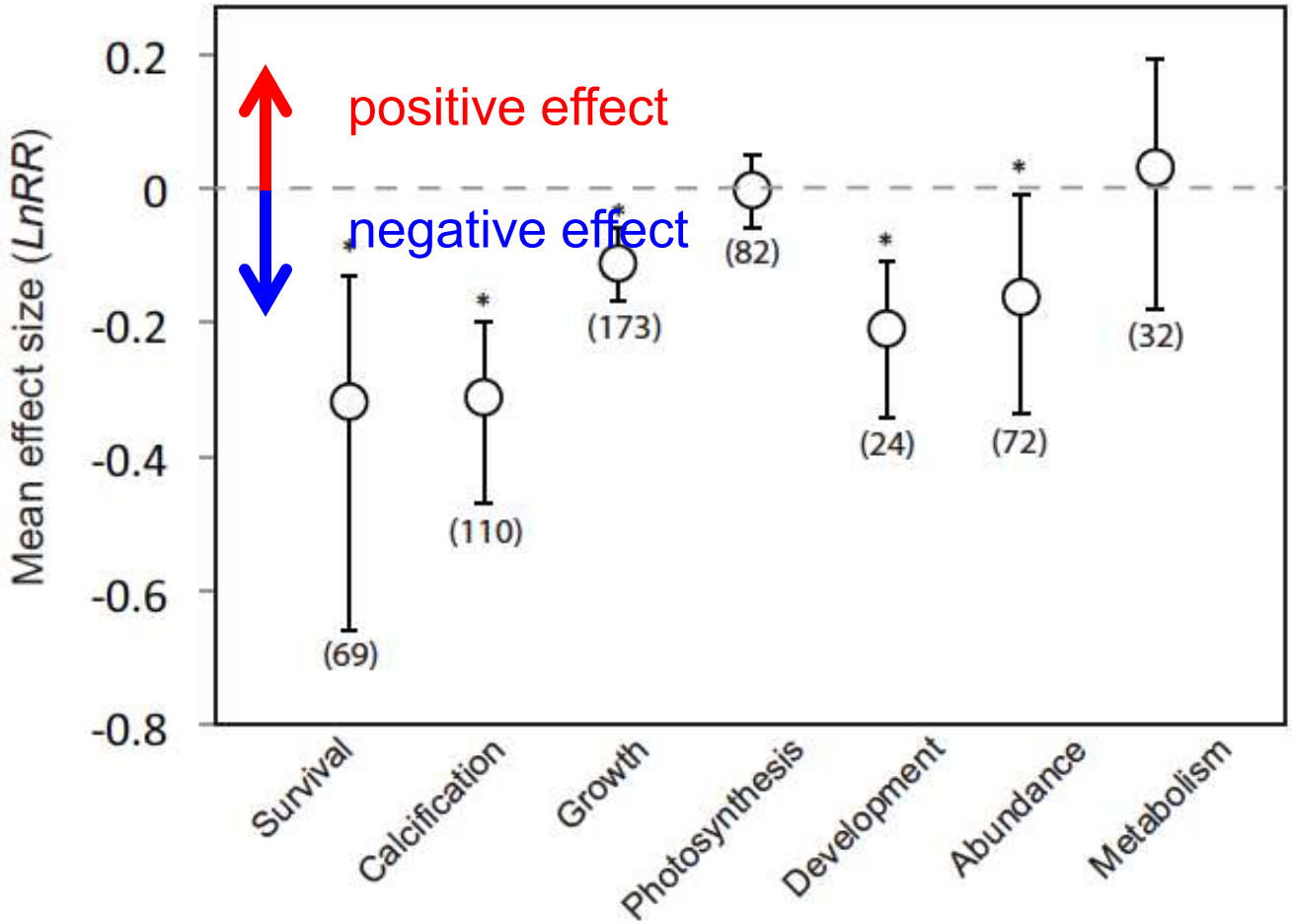
-Habitat loss

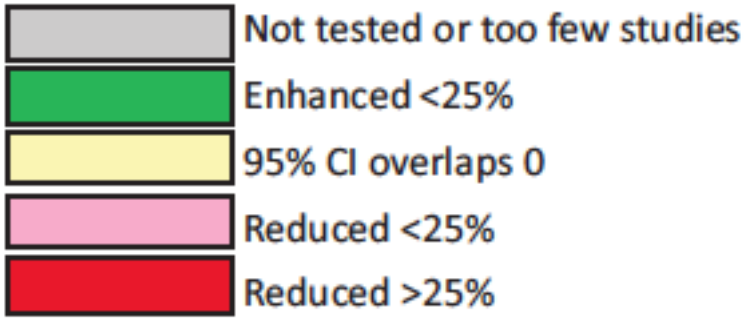
-Less available prey & smaller fisheries

-Other effects on growth, behavior, diseases, …



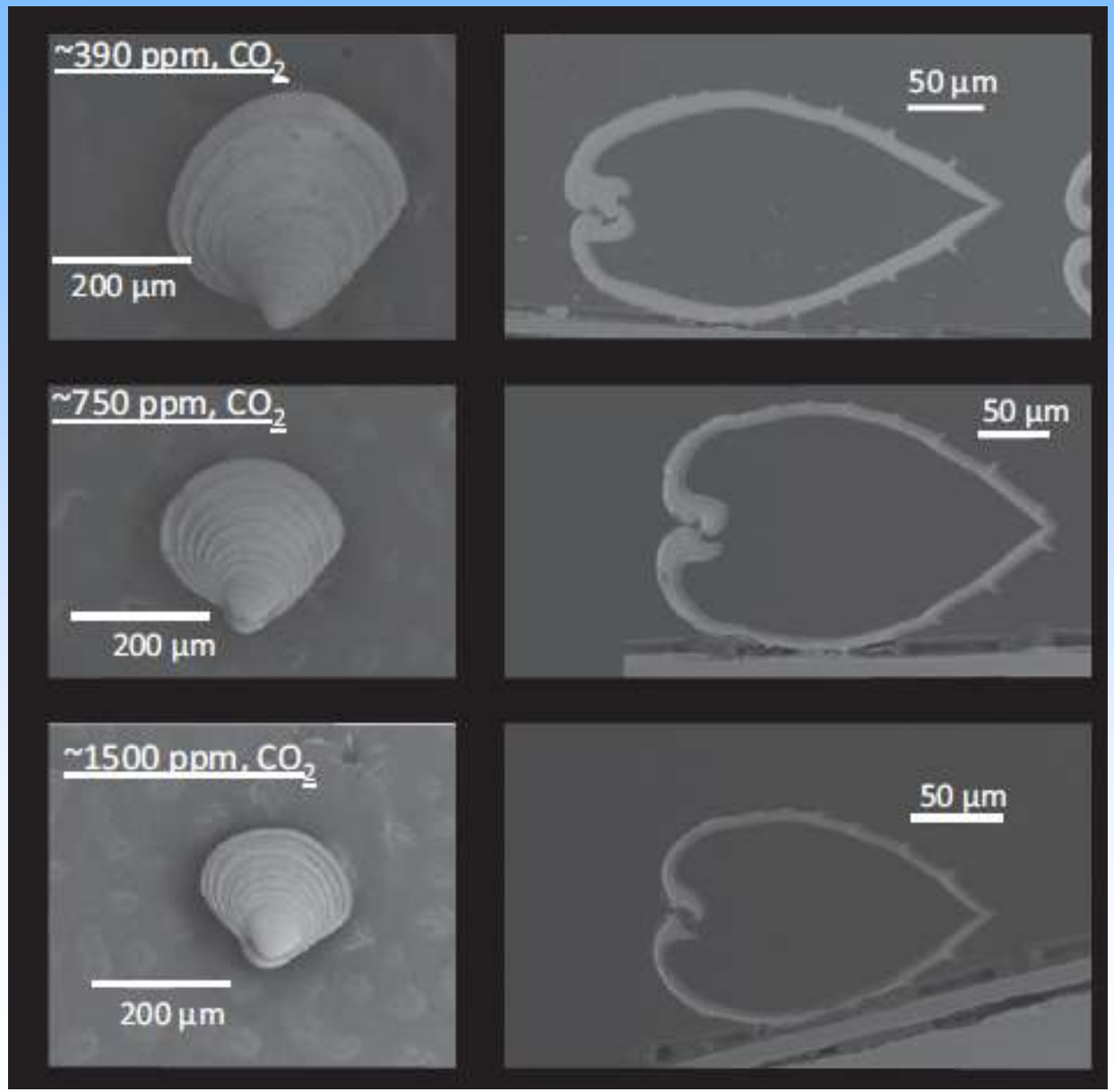
Biological Impacts on Molluscs





Kroecker et al. (2009; 2013)

Negative Impacts of CO_2 on Mollusks

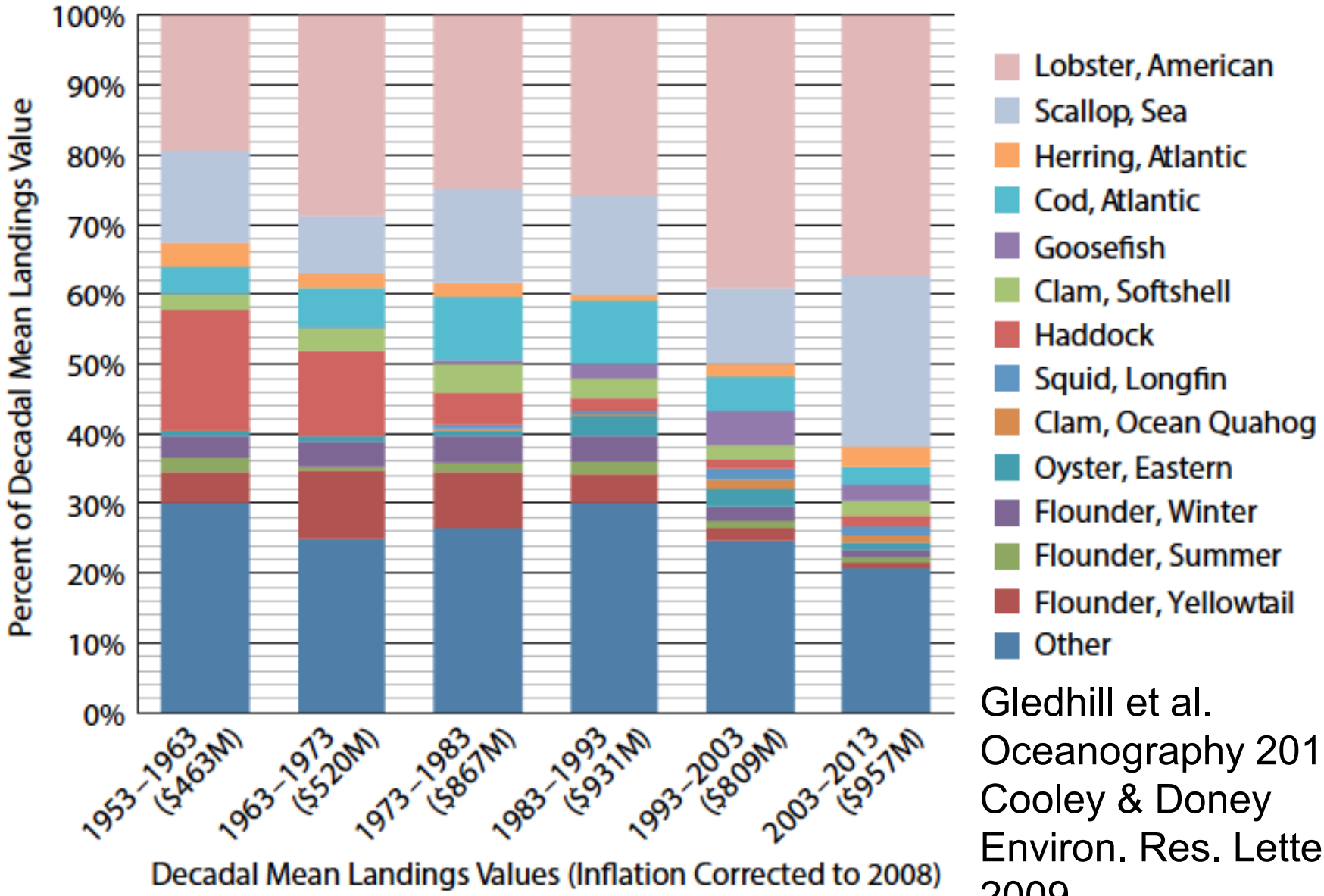


Present

Future
(estuaries)

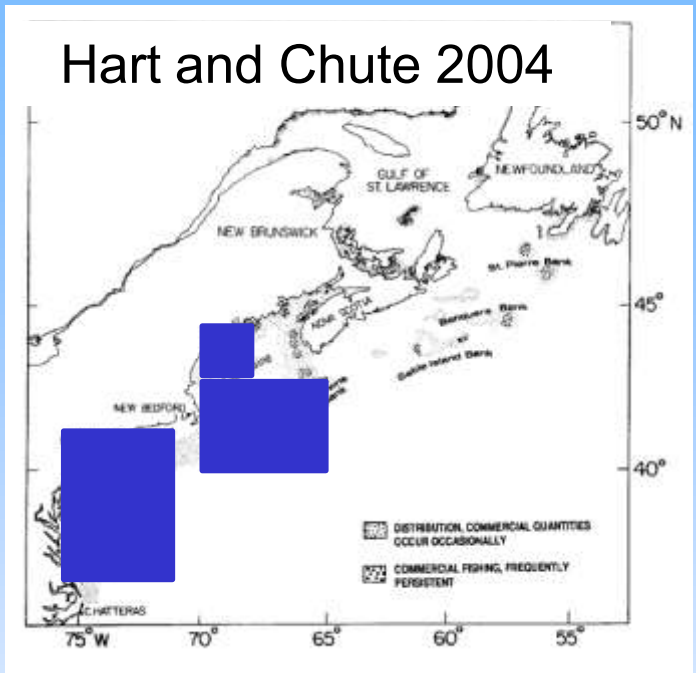
Talmage et al.
PNAS 2010

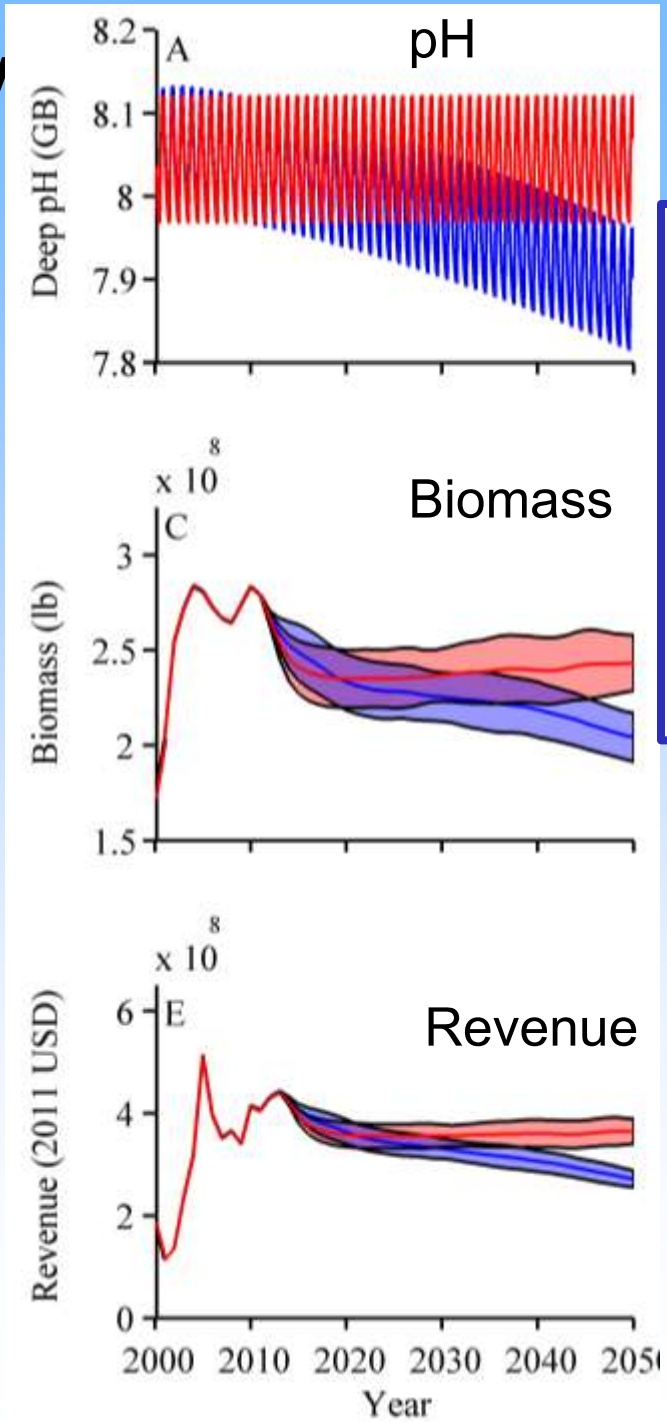
US Northeast Fisheries (Landings Value)



Gledhill et al. Oceanography 2015
Cooley & Doney Environ. Res. Letters 2009

Sea Scallop Fishery



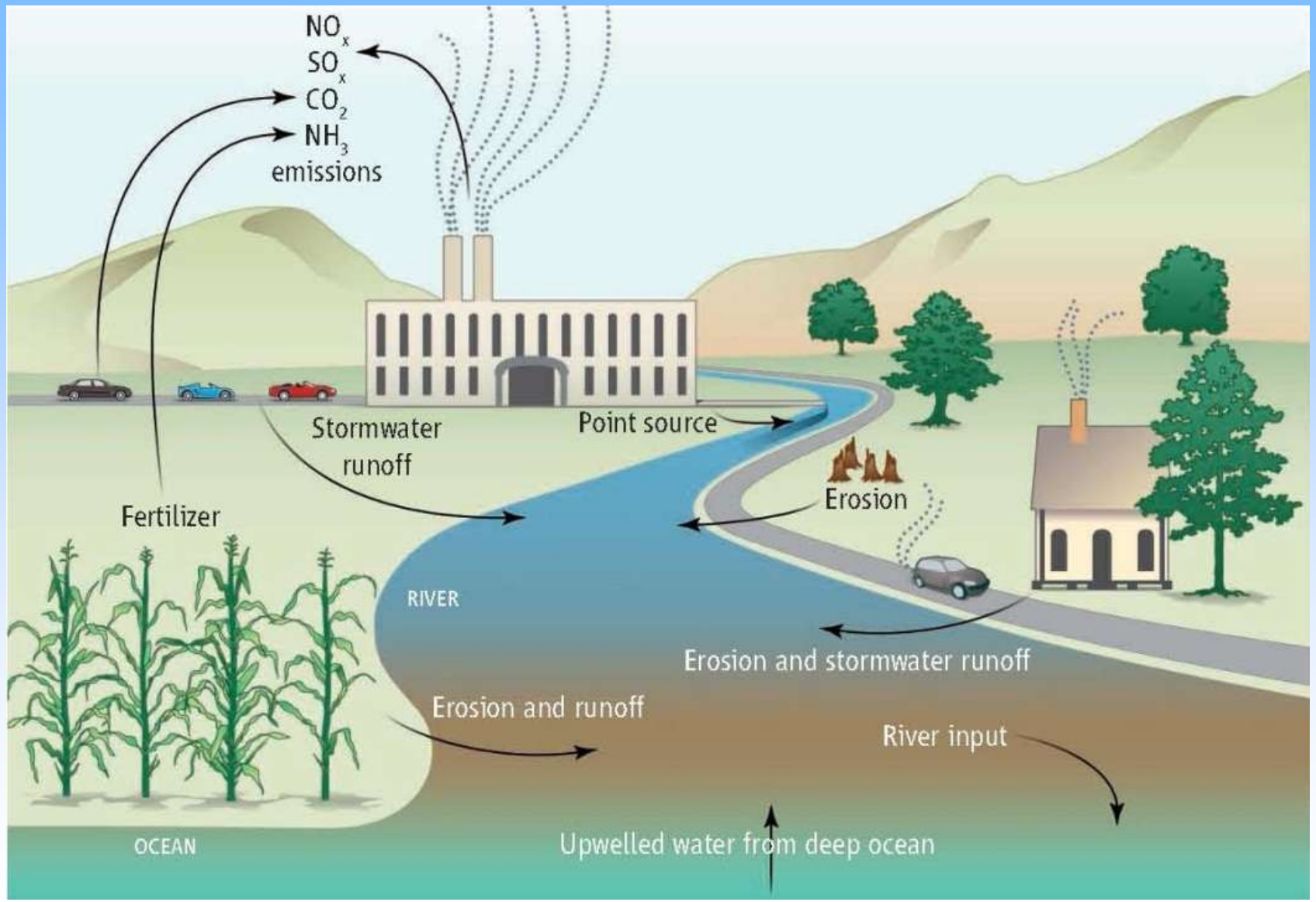


Integrated Assessment Model:

- biogeochemistry
- sea scallop population dynamics
- fishery socio-economics

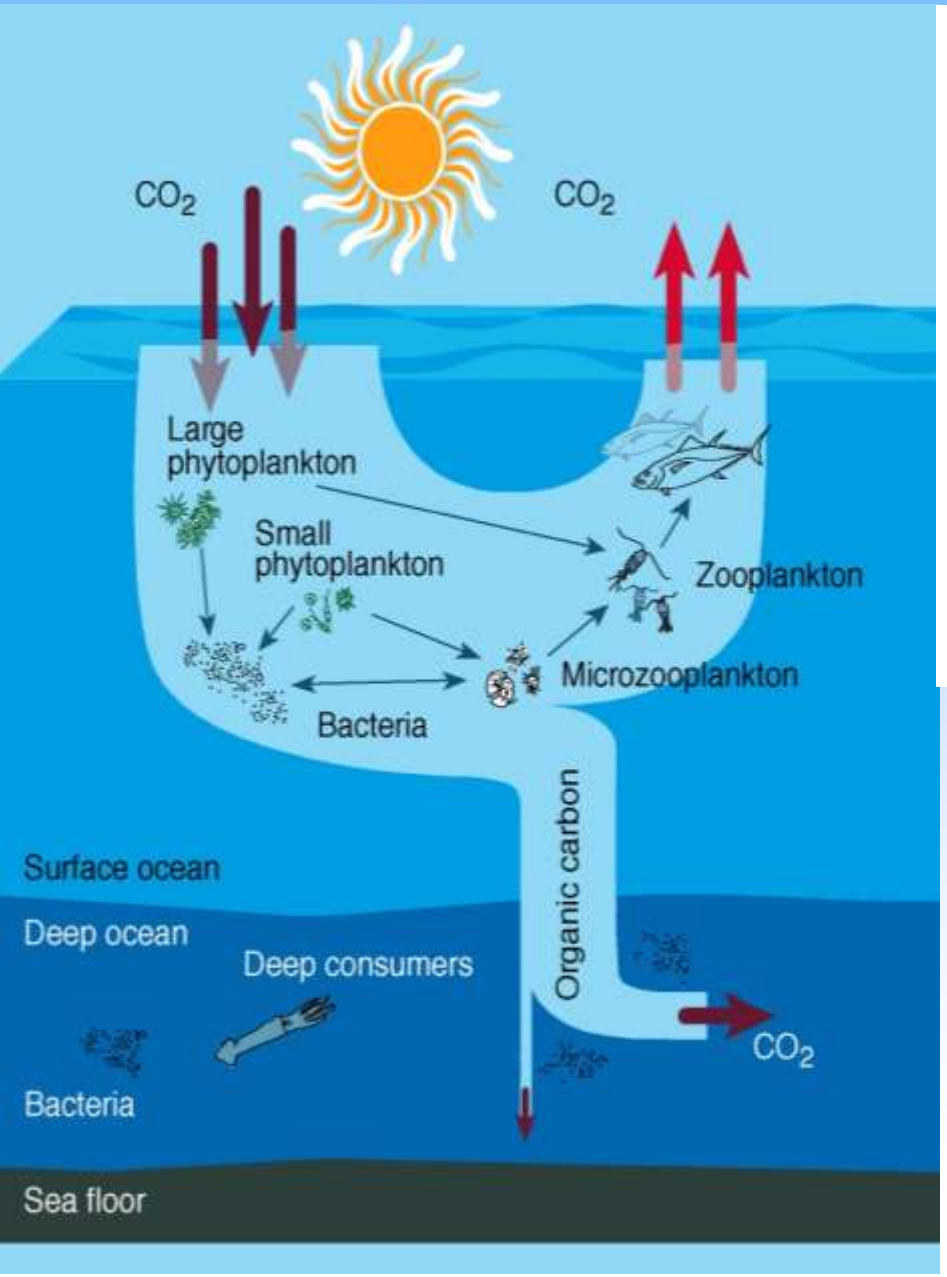
Cooley et al. PLoS One 2015

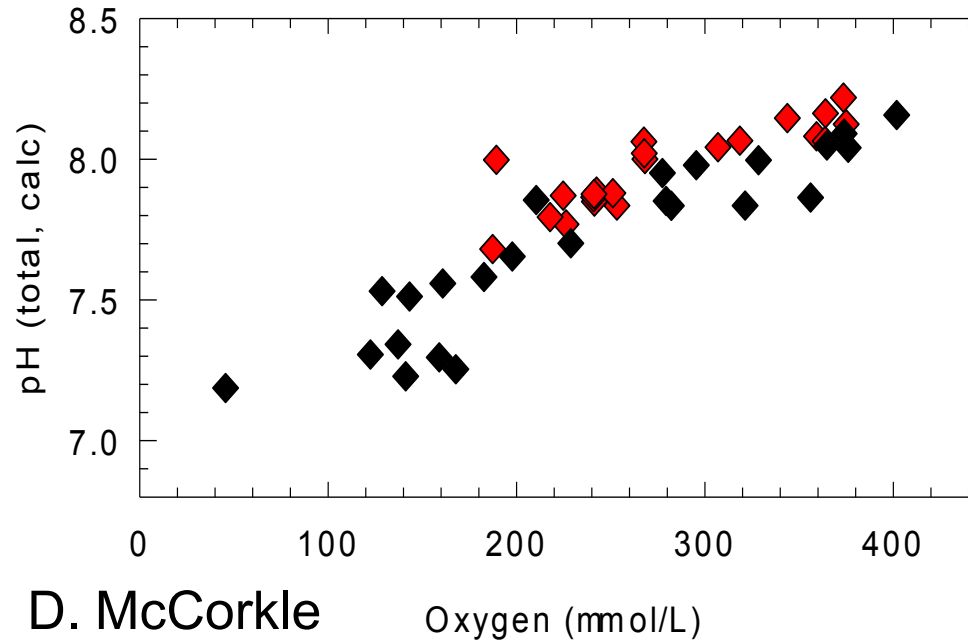
Other Local Sources of Coastal Acidification



Doney et al. PNAS 2007; Doney Science 2010; Kelly et al. Science 2011

Ocean Biological Pump, Acidification & Low Oxygen

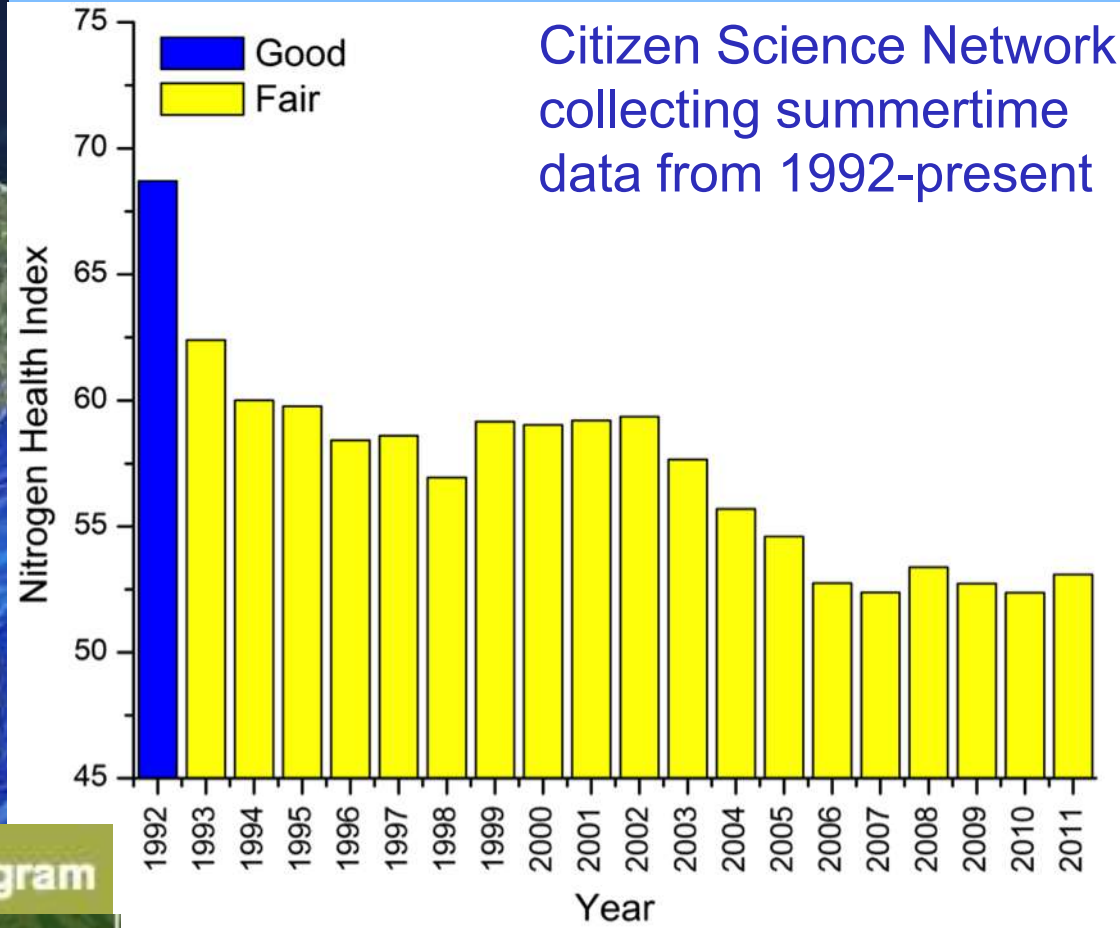




D. McCorkle
WHOI

Excess nutrients from local pollution sources can lead to low oxygen & acidic waters

Buzzards Bay Water Quality



Citizen Science Network collecting summertime data from 1992-present

Buzzards Bay National Estuary Program

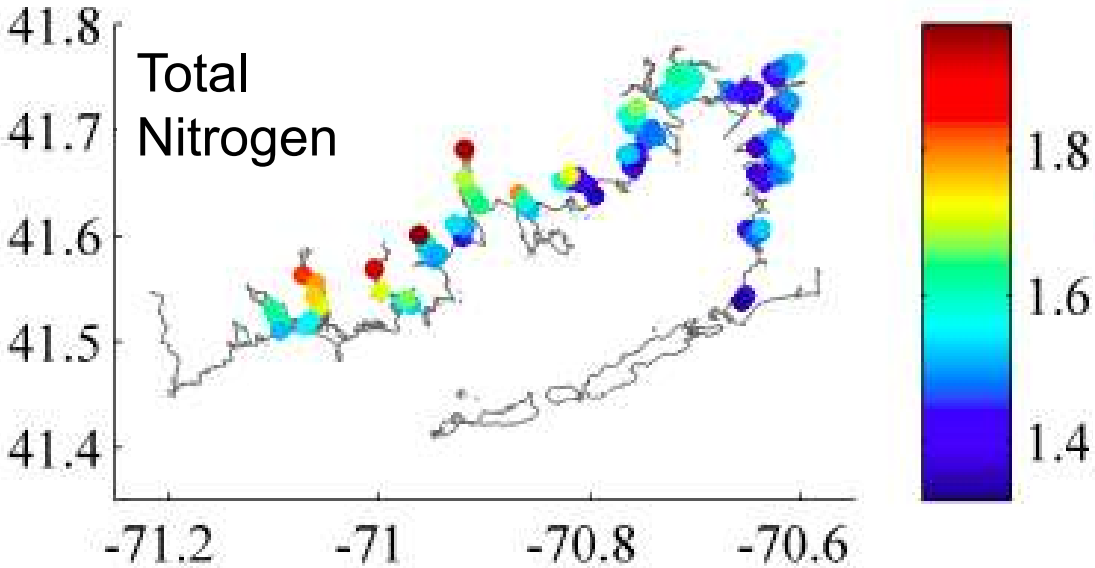
buzzards BAY COALITION

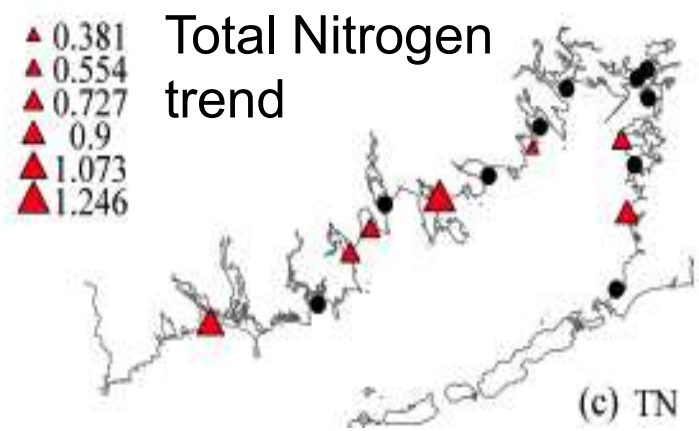
MBL®

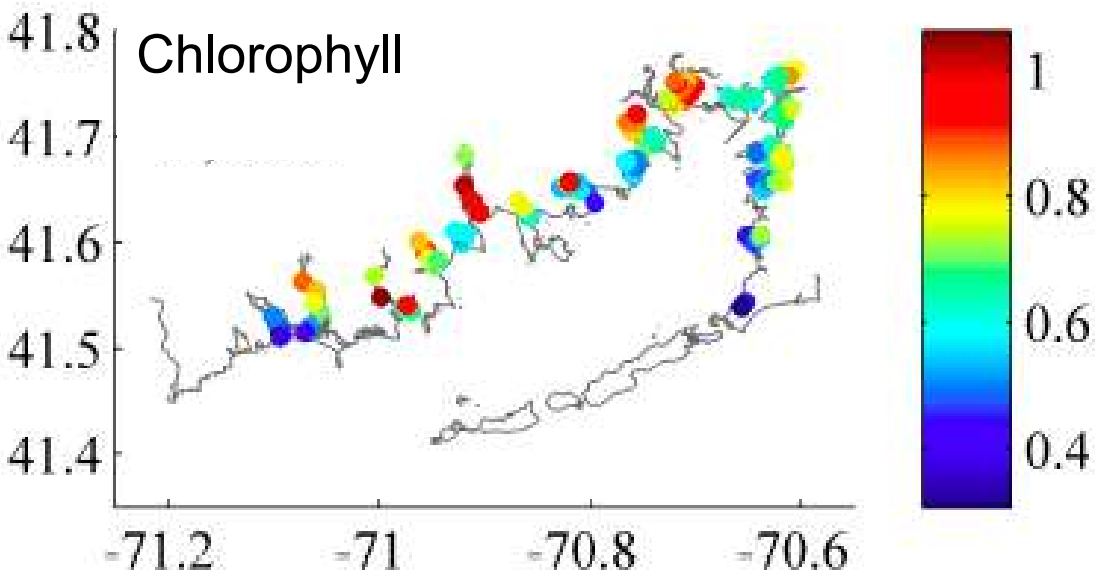
The Ecosystems Center

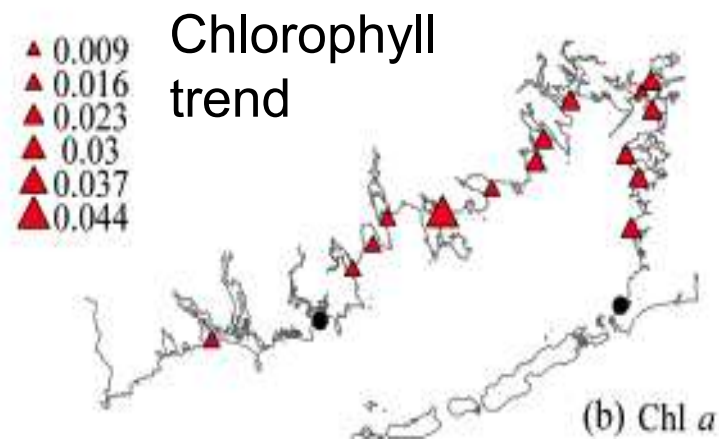
Buzzards Bay Coalition

Buzzards Bay Eutrophication



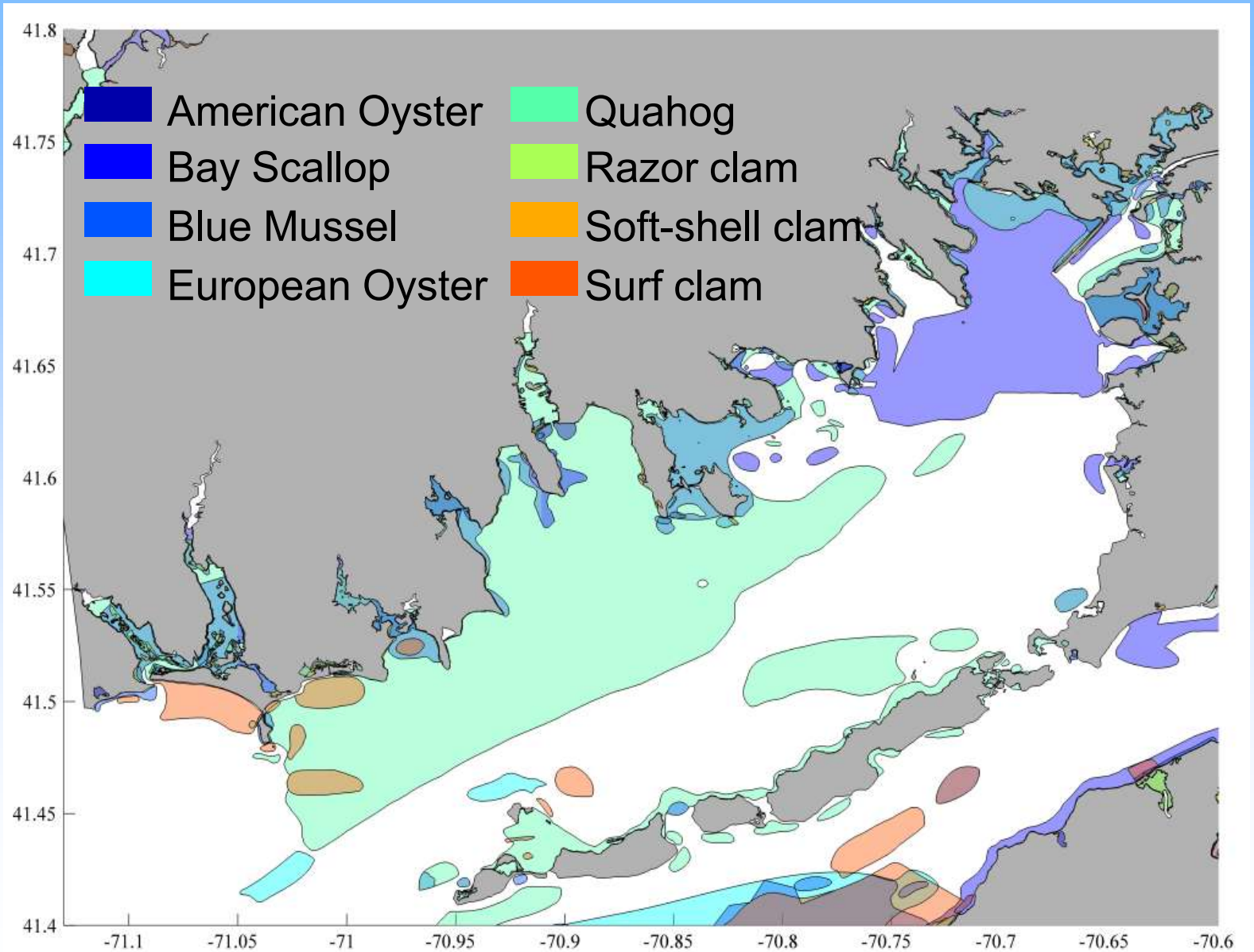




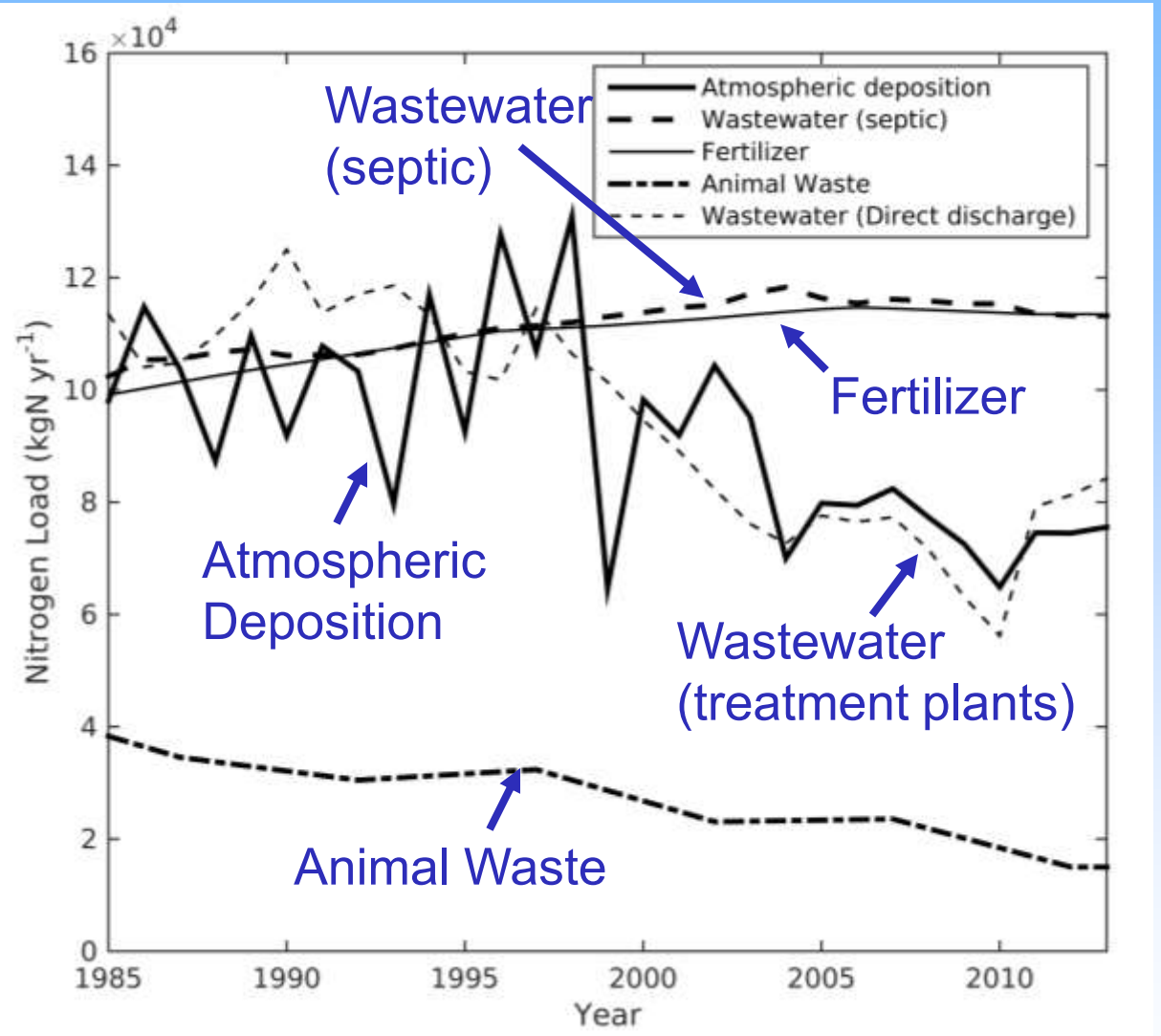


Rheuban et al.
Biogeosciences 2016

Shellfish Suitability & Coastal Acidification

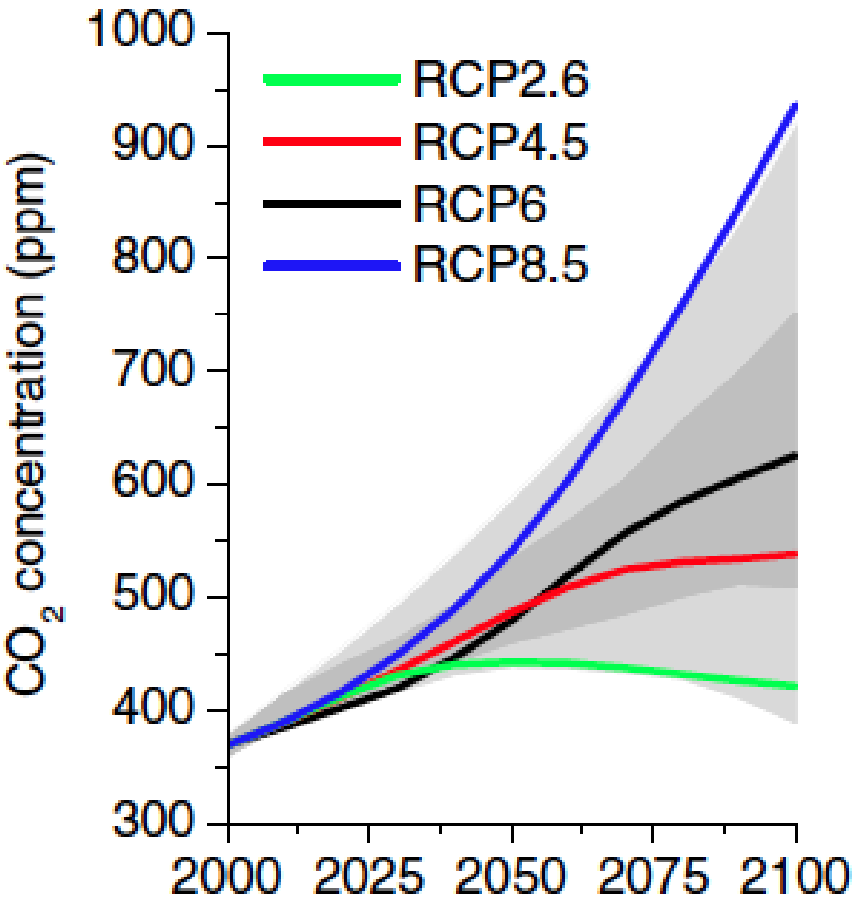


Human Nitrogen Source Trends

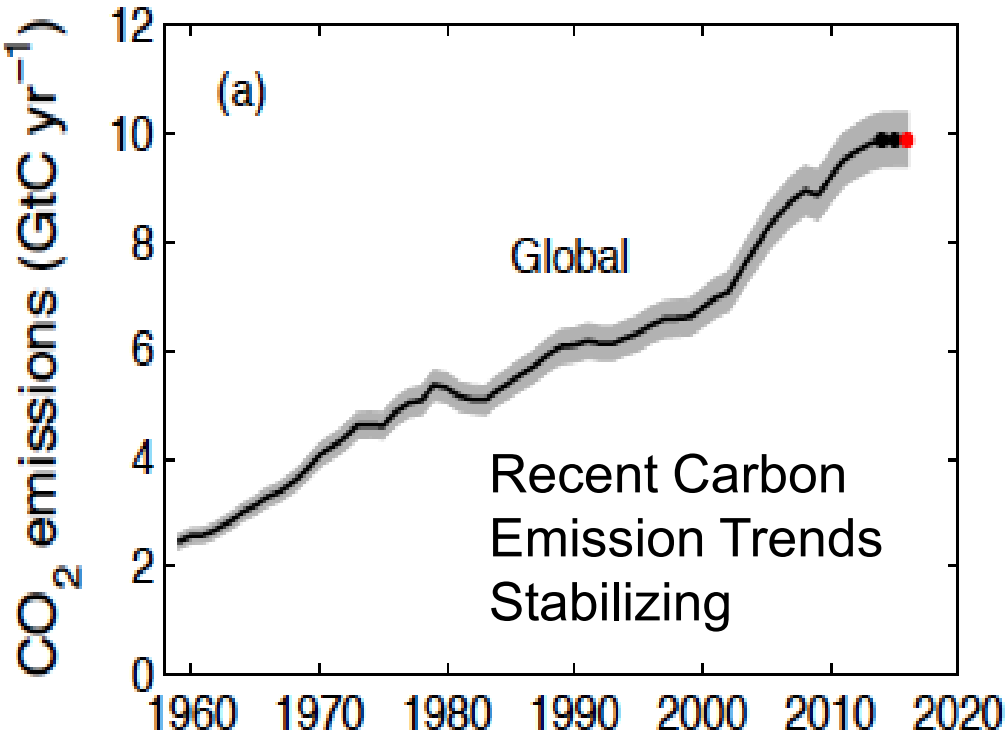


Williamson, Rheuban et al. Frontiers of Marine Science, submitted

Ocean Acidification Depends on Human Activities



Van Vuuren et al.
Climatic Change 2011

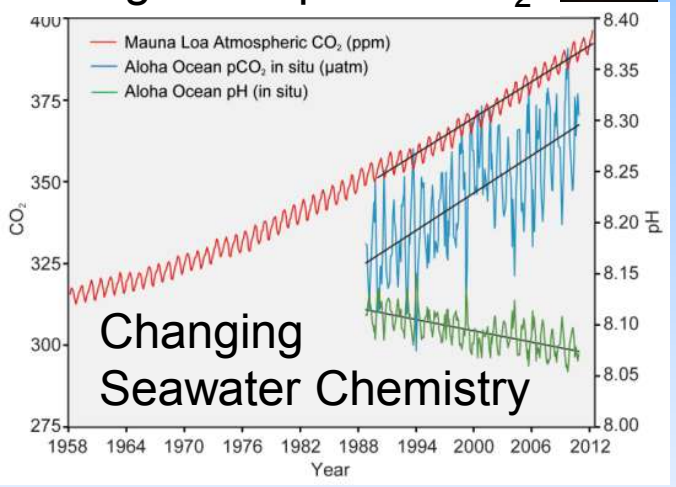


Le Quere et al.
Earth System Science Data
2016

Ocean & Coastal Acidification

Fossil Fuel CO_2 Emissions

Rising Atmospheric CO_2



Impacts on Shellfish & Other Marine Life

-Rising atmospheric CO_2 levels are causing increased ocean acidity

-Acidification can be exacerbated in coastal waters by local nutrient pollution

-Shellfish may be vulnerable to ocean & coastal acidification

-Improved chemical & biological monitoring are needed for coastal waters

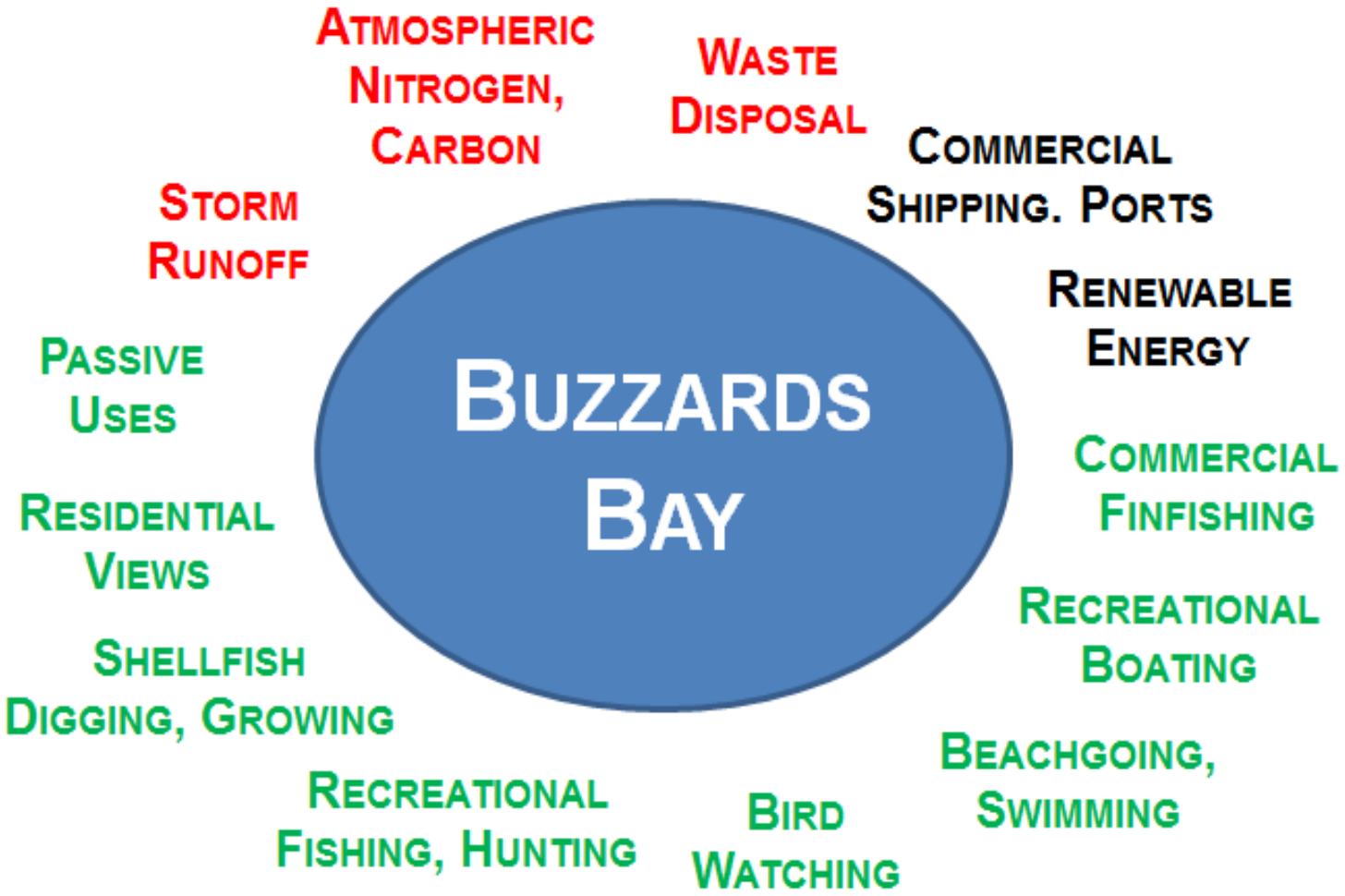
-More targeted work needed on sensitivity of key commercial & recreational shellfish fisheries

Extra Slides

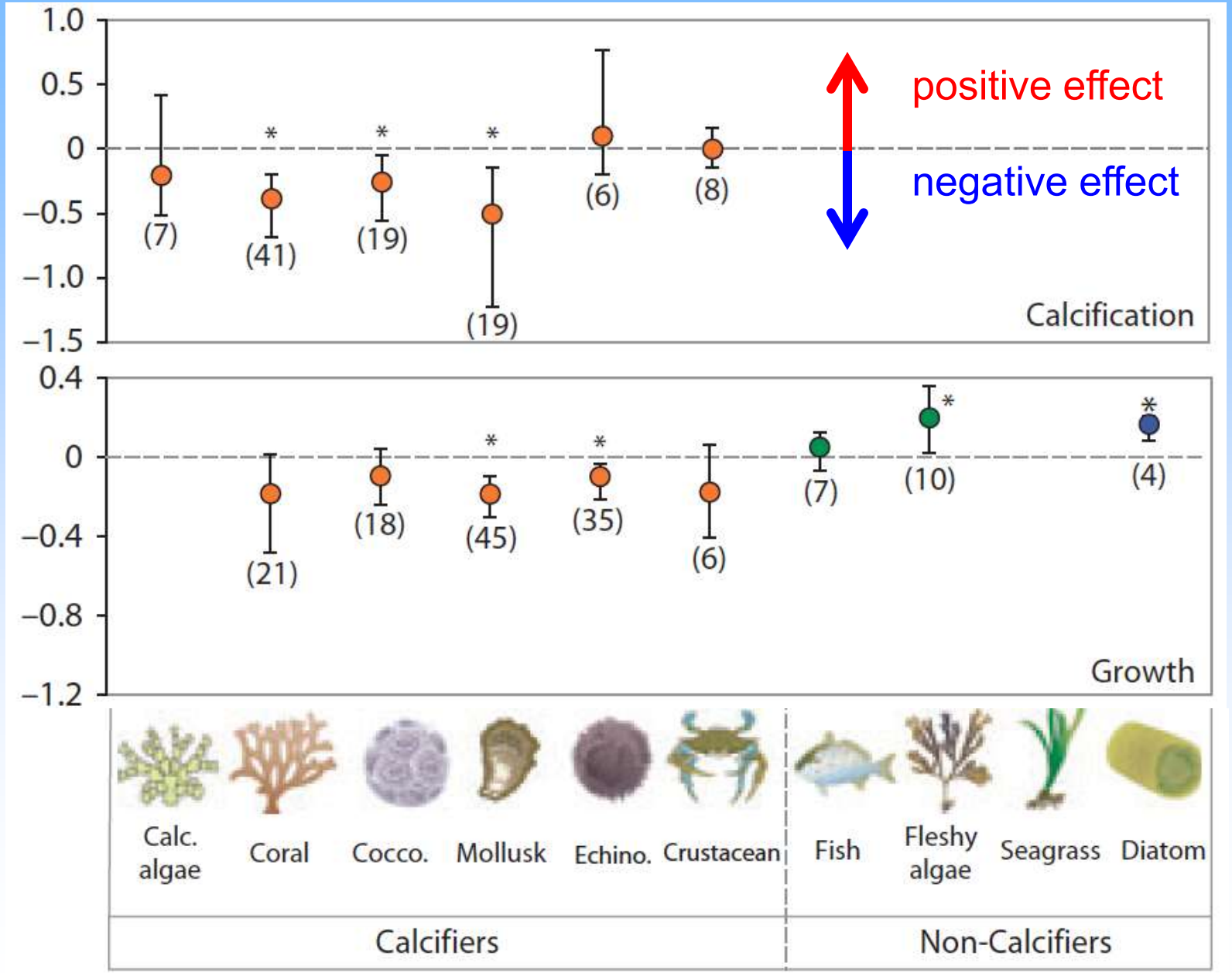
Valued Human Uses for Buzzards Bay

Uses with economic value in terms of avoided costs

Uses with diminished economic values from eutrophication, which may be exacerbated by warming, increased intense precipitation



Biological Impacts: Winners & Losers



Kroecker et al. Global Change Biology (2013)