2015

Multiple acid pathways in Casco Bay: Implications for the next 25 years (2015 State of the Bay Presentation)

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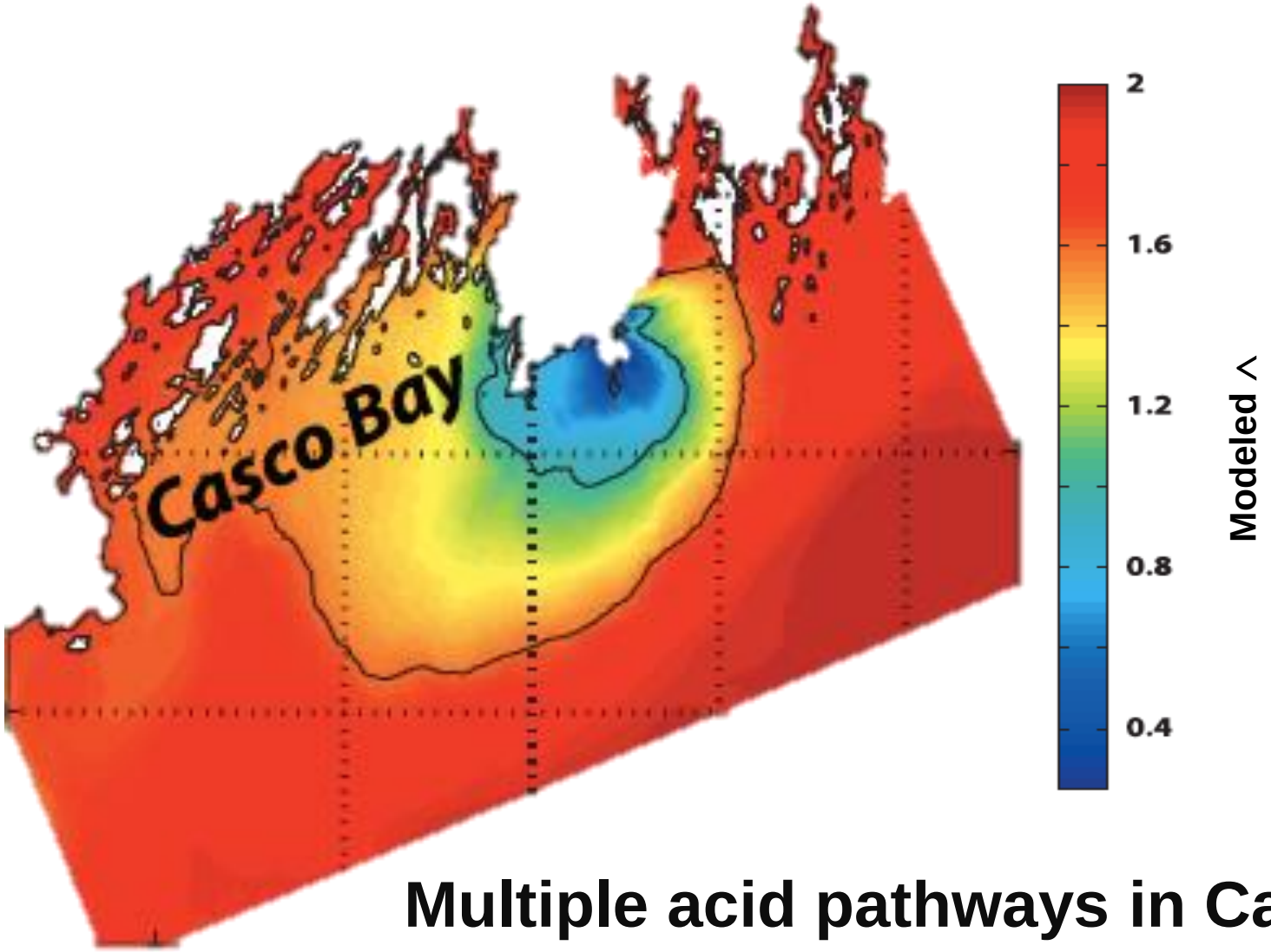

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J. Salisbury, D. Vandemark,
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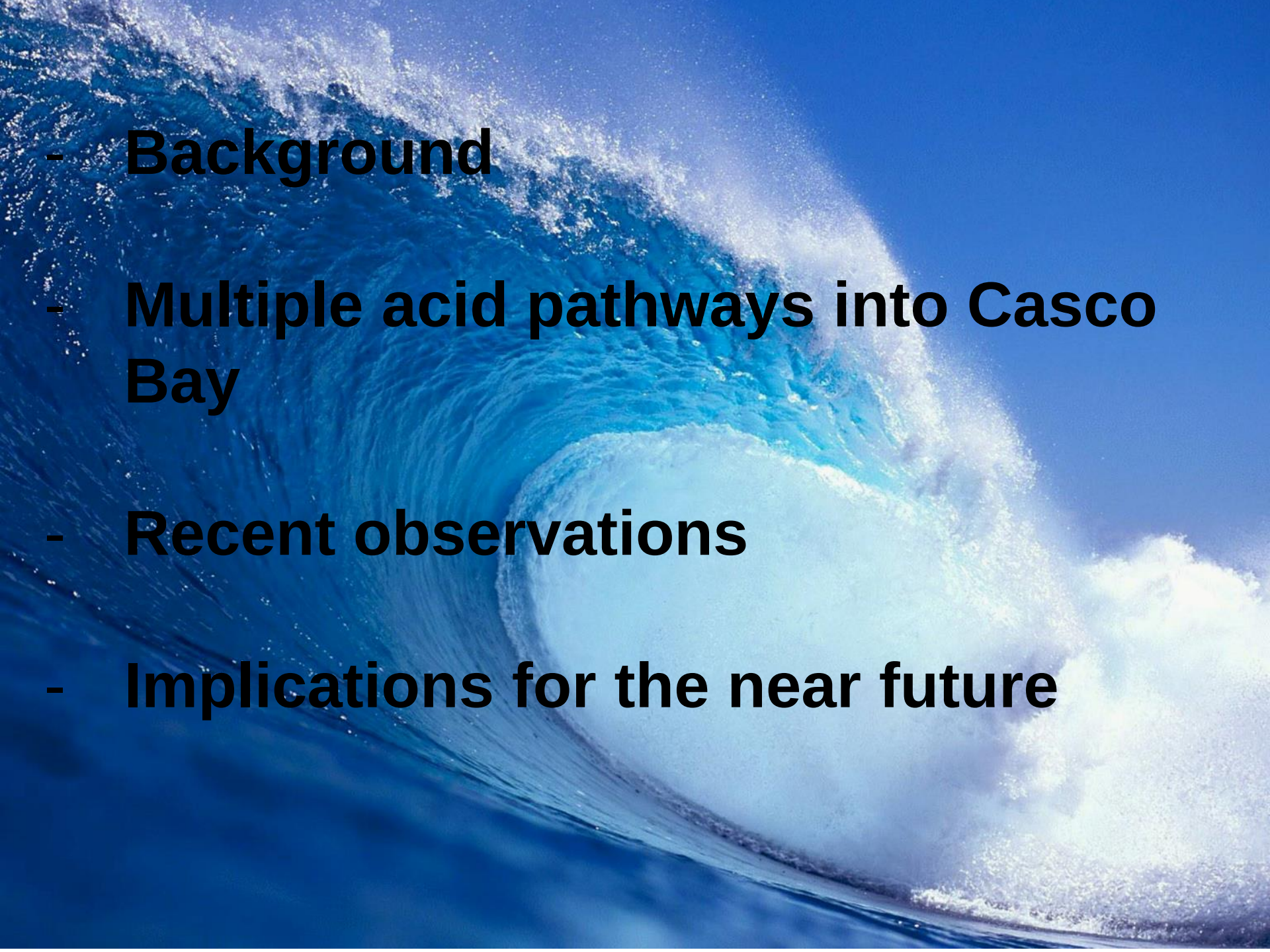

- Background
- Multiple acid pathways into Casco Bay
- Recent observations
- Implications for the near future

8.3±0.4 PgC/yr 90%

1.0±0.5 PgC/yr 10%

+

4.3±0.1 PgC/yr
46%

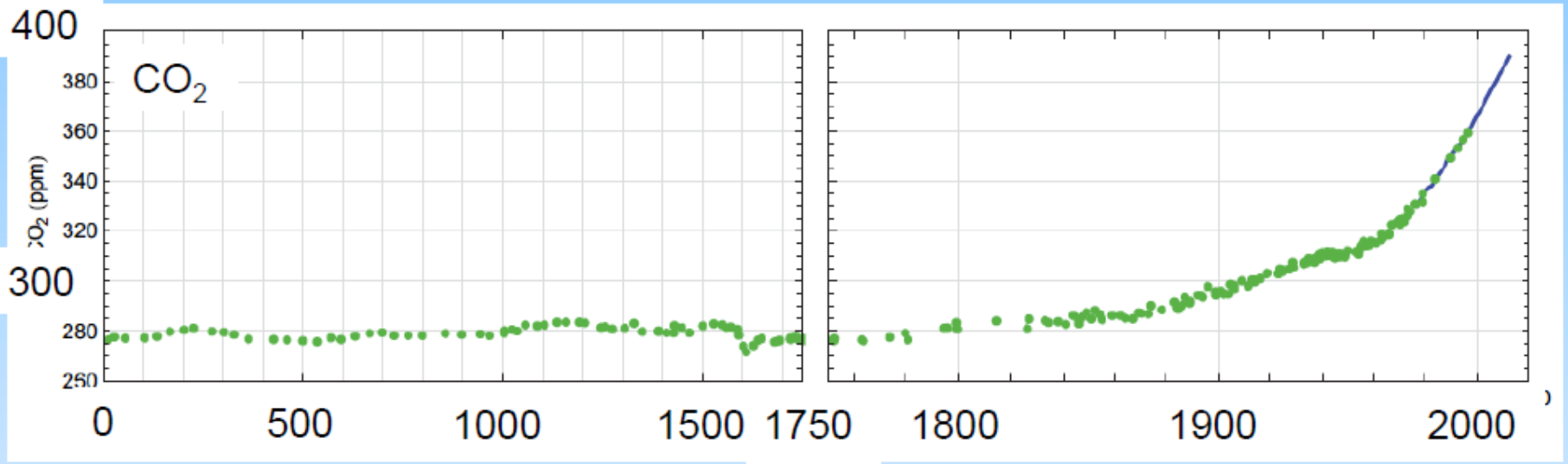
2.6±0.8 PgC/yr
28%

Calculated as the residual
of all other flux components

26%
2.5±0.5 PgC/yr

Source: Le Quéré et al. 2012; Global Carbon Project 2012

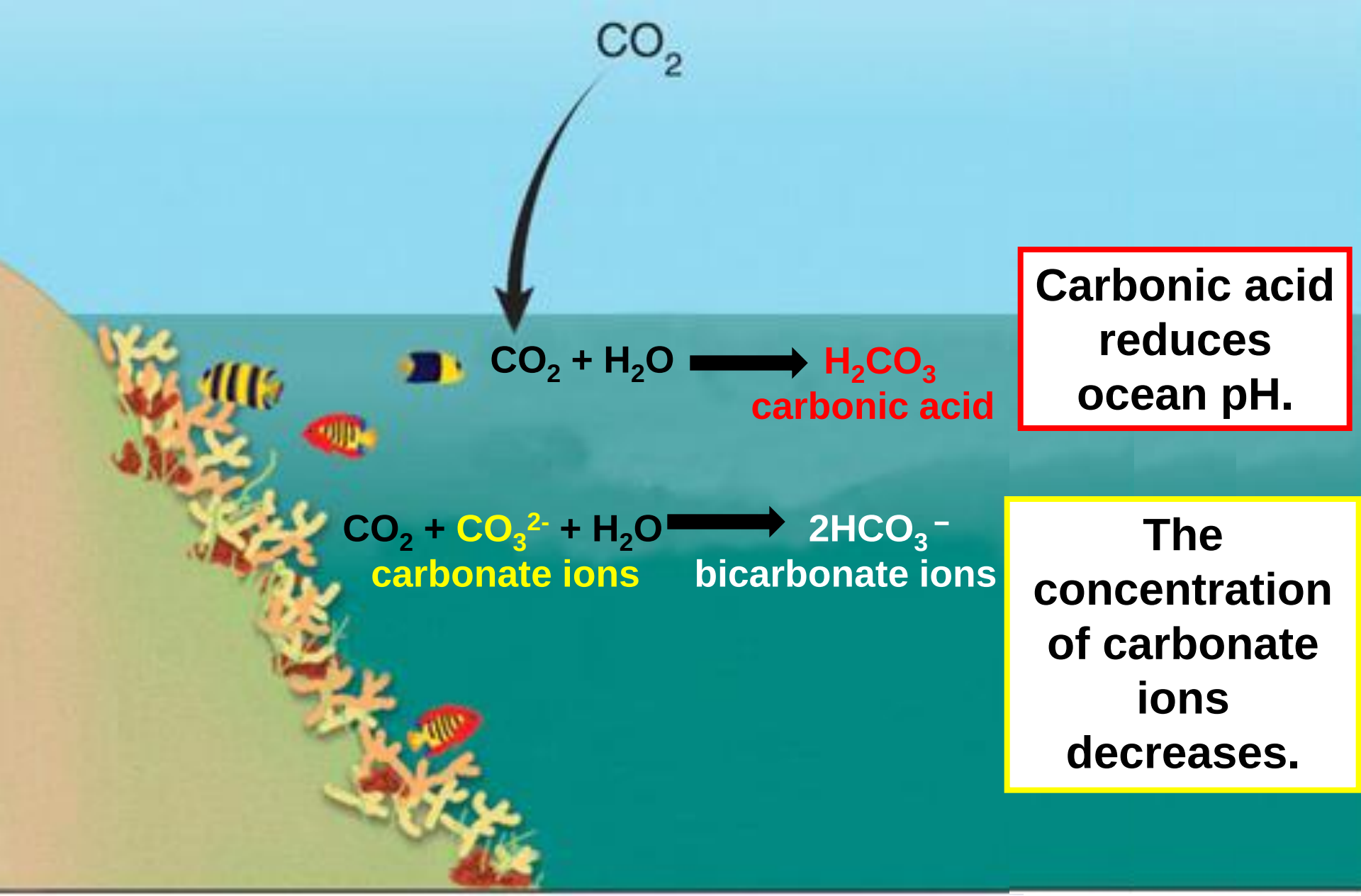
Rising Atmospheric CO_2



IPCC AR5
WG1 Chap. 6

Present-day CO_2 level highest in past several million years

Rate of increase 50-100 times larger than natural rates of change



Carbonic acid reduces ocean pH.

The concentration of carbonate ions decreases.

Saturation Index (Ω) of the mineral aragonite

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

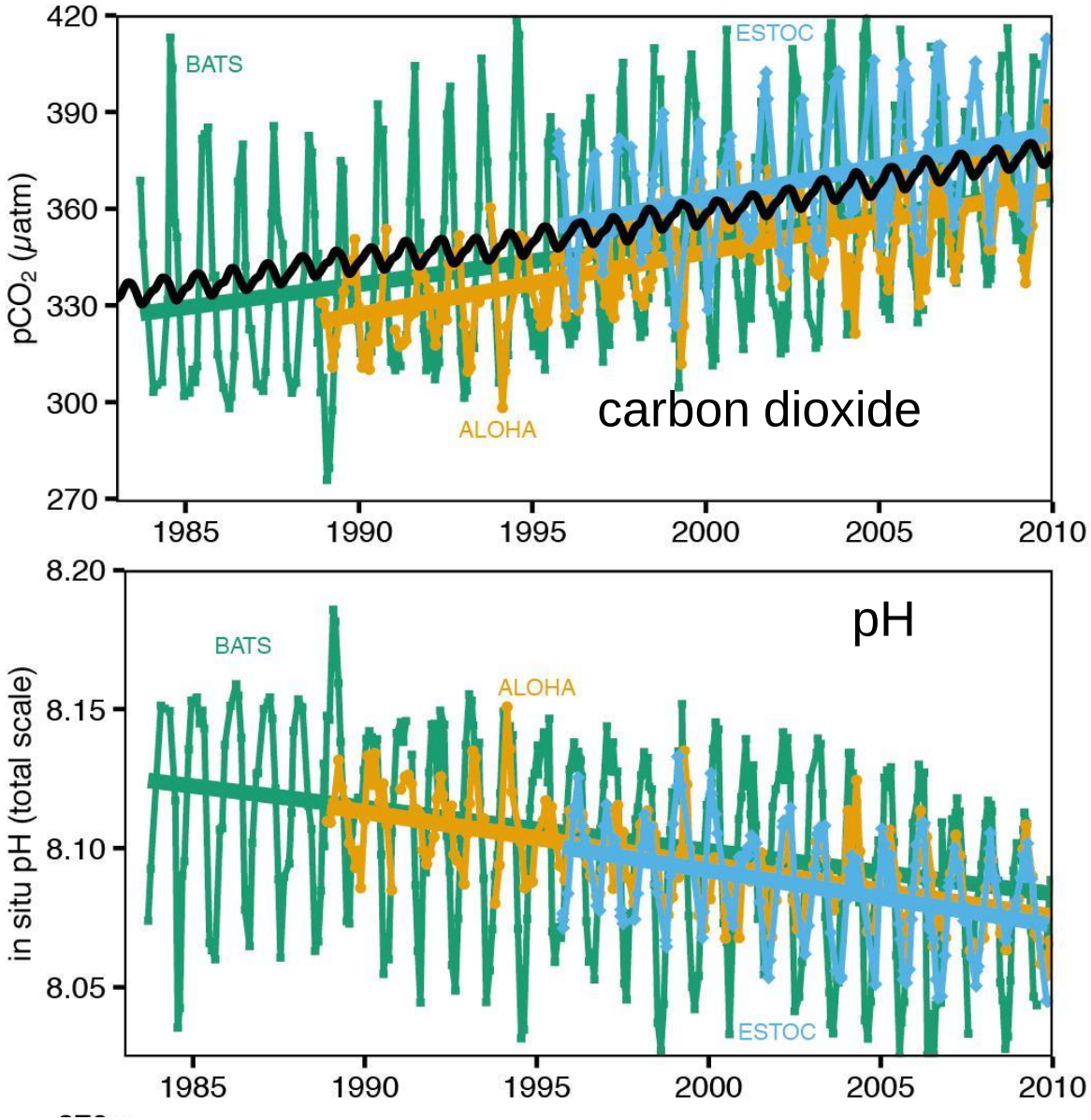
Ω> 1 animals can make shell
Ω>>1 easier to make shell
Ω< 1 shell dissolves

Affected by temperature: ↑Temp corresponds to ↑Ω.

Varies with CO_2: ↑ CO_2 corresponds to ↓Ω.

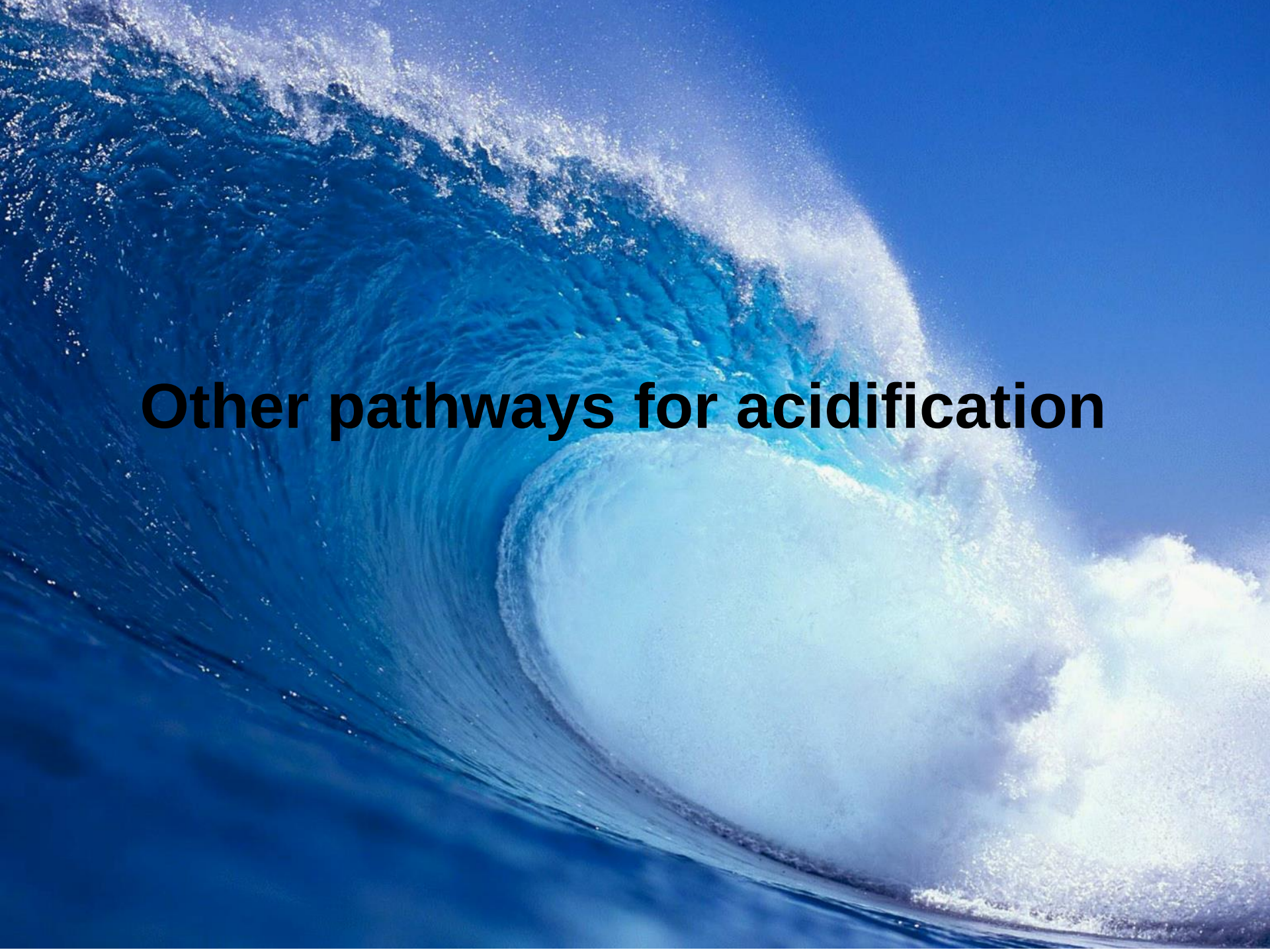
Varies with pH: ↑ pH corresponds to ↑Ω.

Note: <1.6 may be a threshold for optimal larval growth in clams and oysters (Barton et al, 2012; Salisbury et al, 2008).



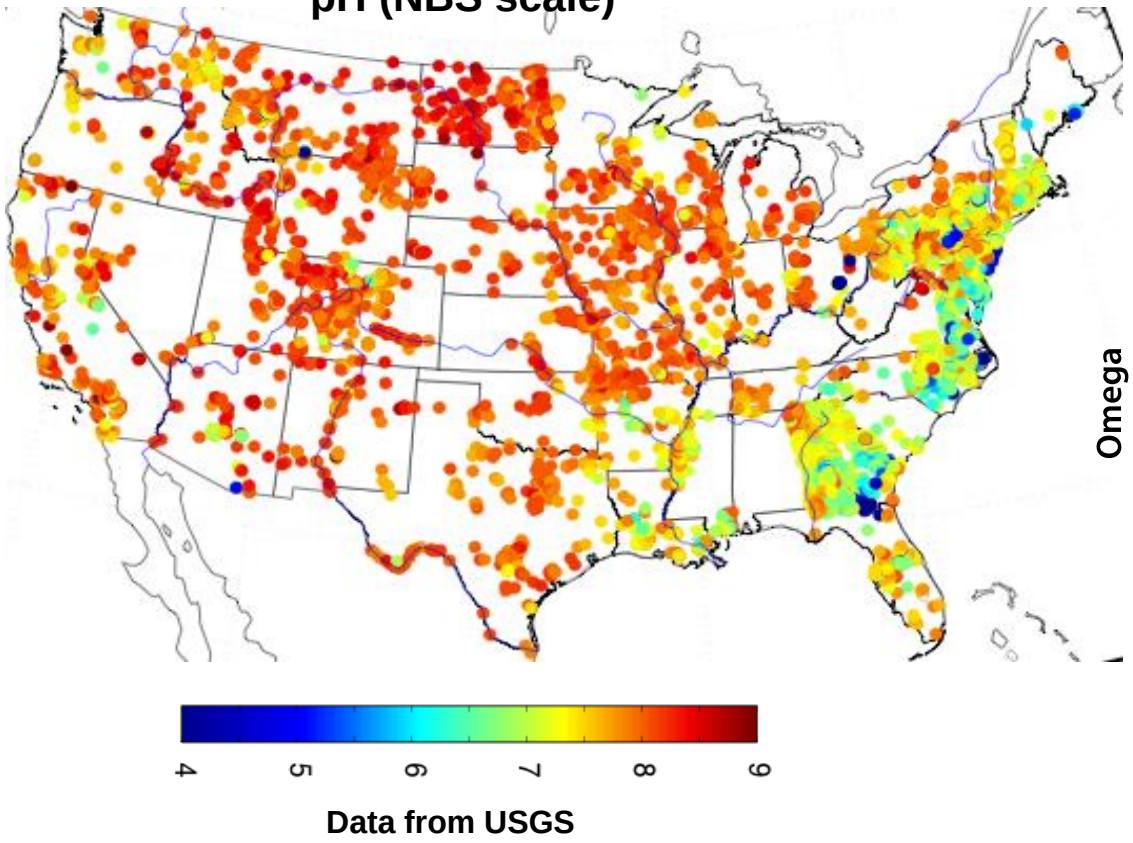
Changing Seawater Chemistry

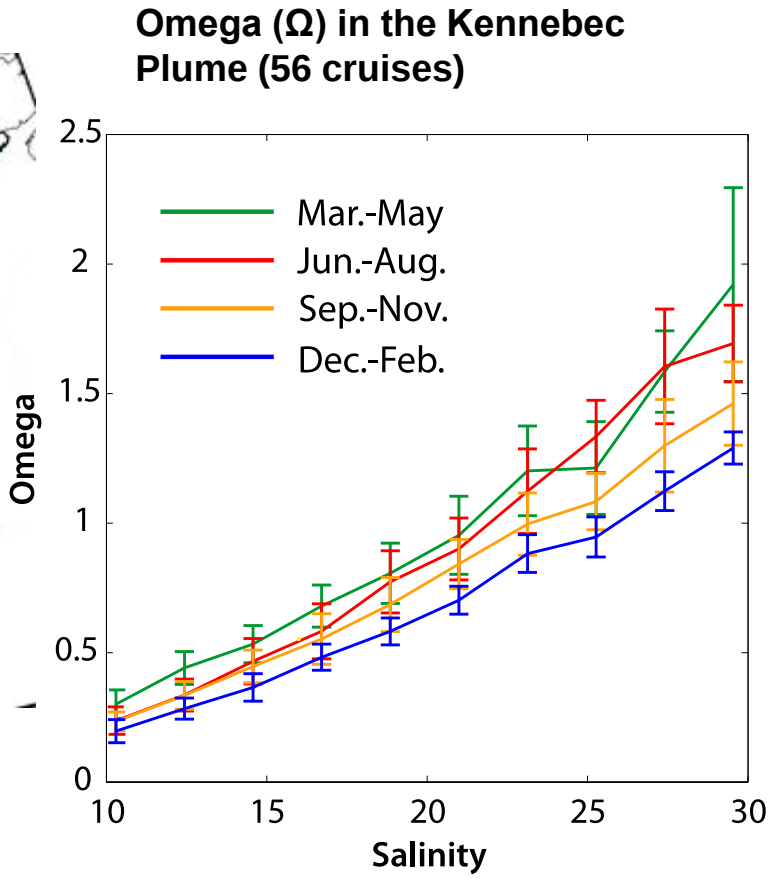
IPCC 2014
WG1, Chapter 3
Doney et al. Ann. Rev. Mar. Sci. 2009
Dore et al. PNAS 2009



Other pathways for acidification

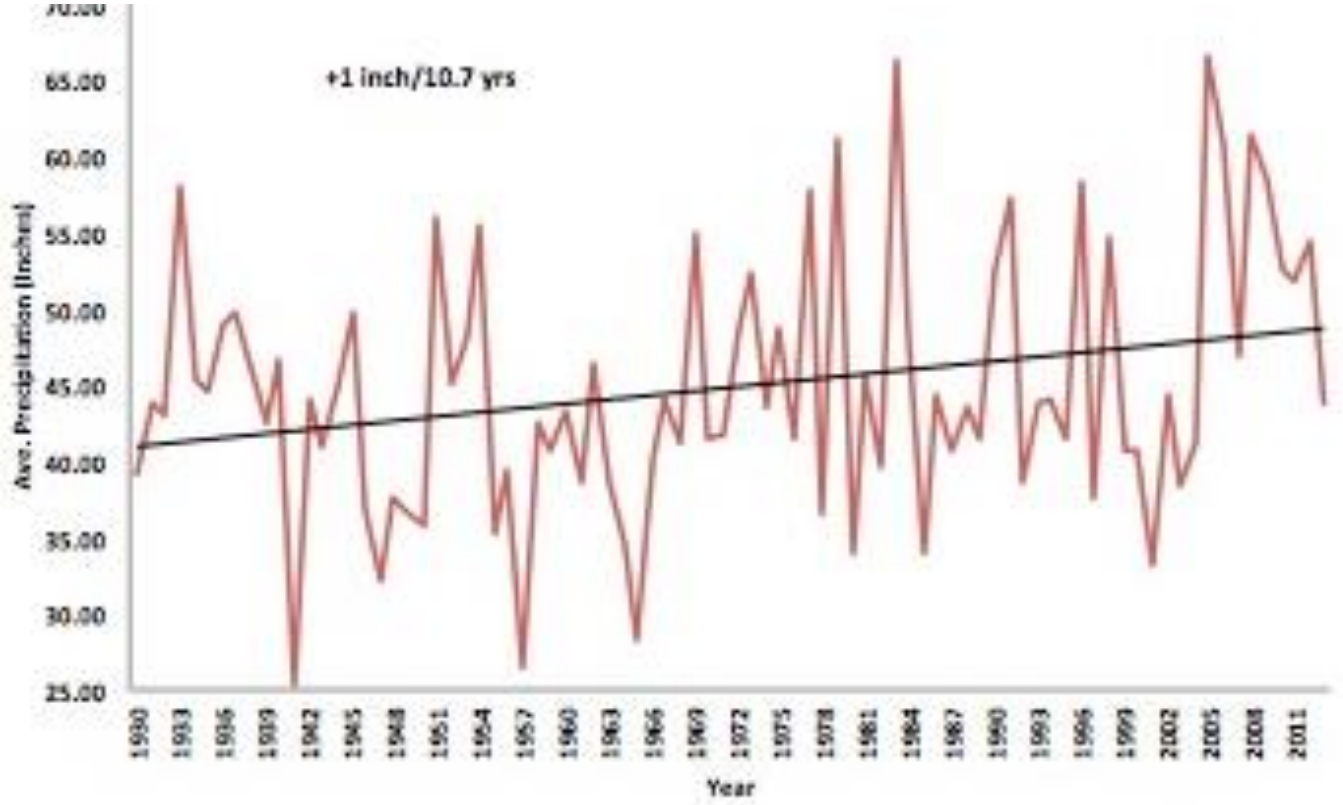
Coastal and Estuarine Acidification – River water freshens the coast and alters its ability to buffer against acid





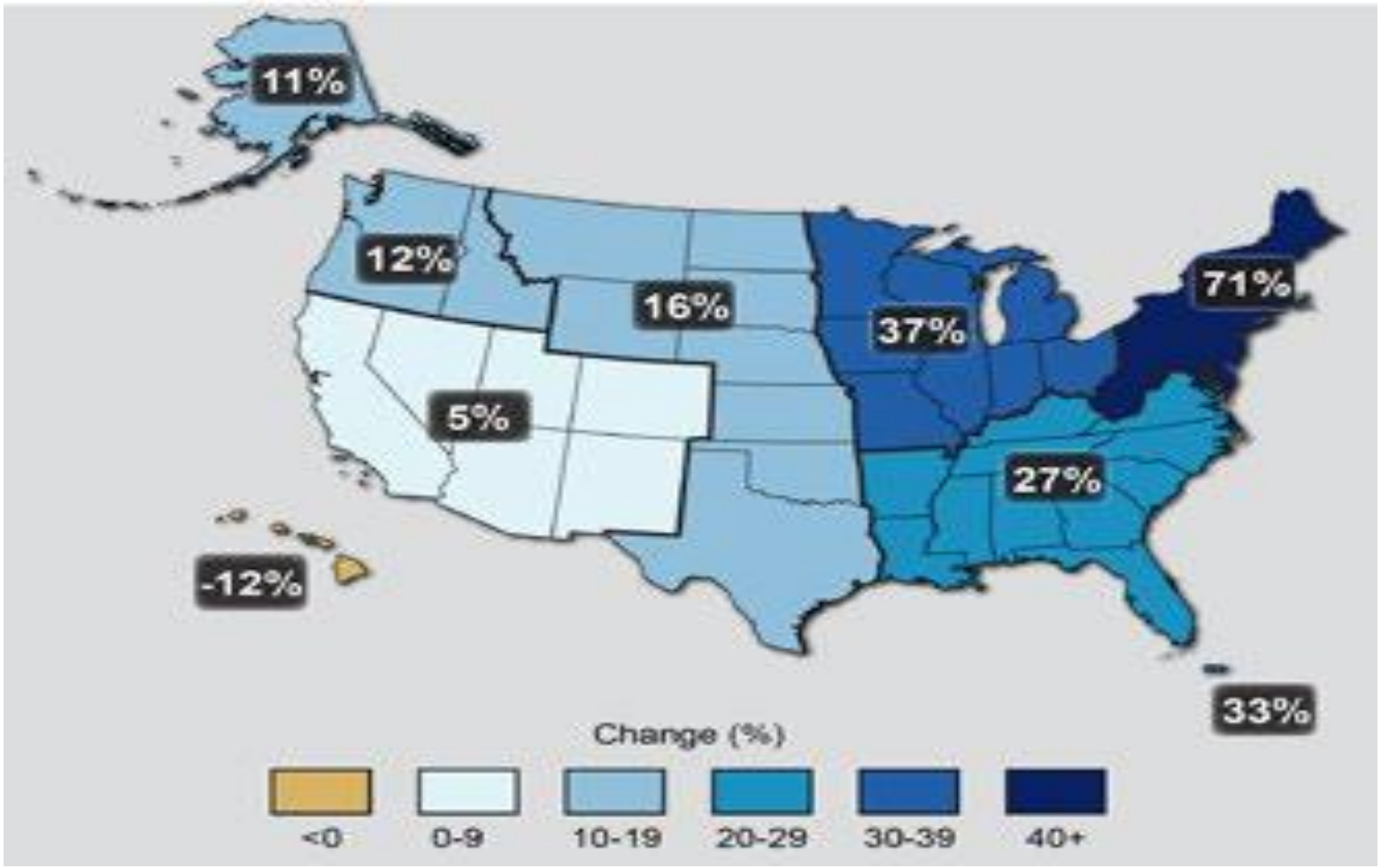
Waldbusser and Salisbury, 2014

Precipitation is increasing, making the coastal ocean a bit fresher and more poorly buffered against pH



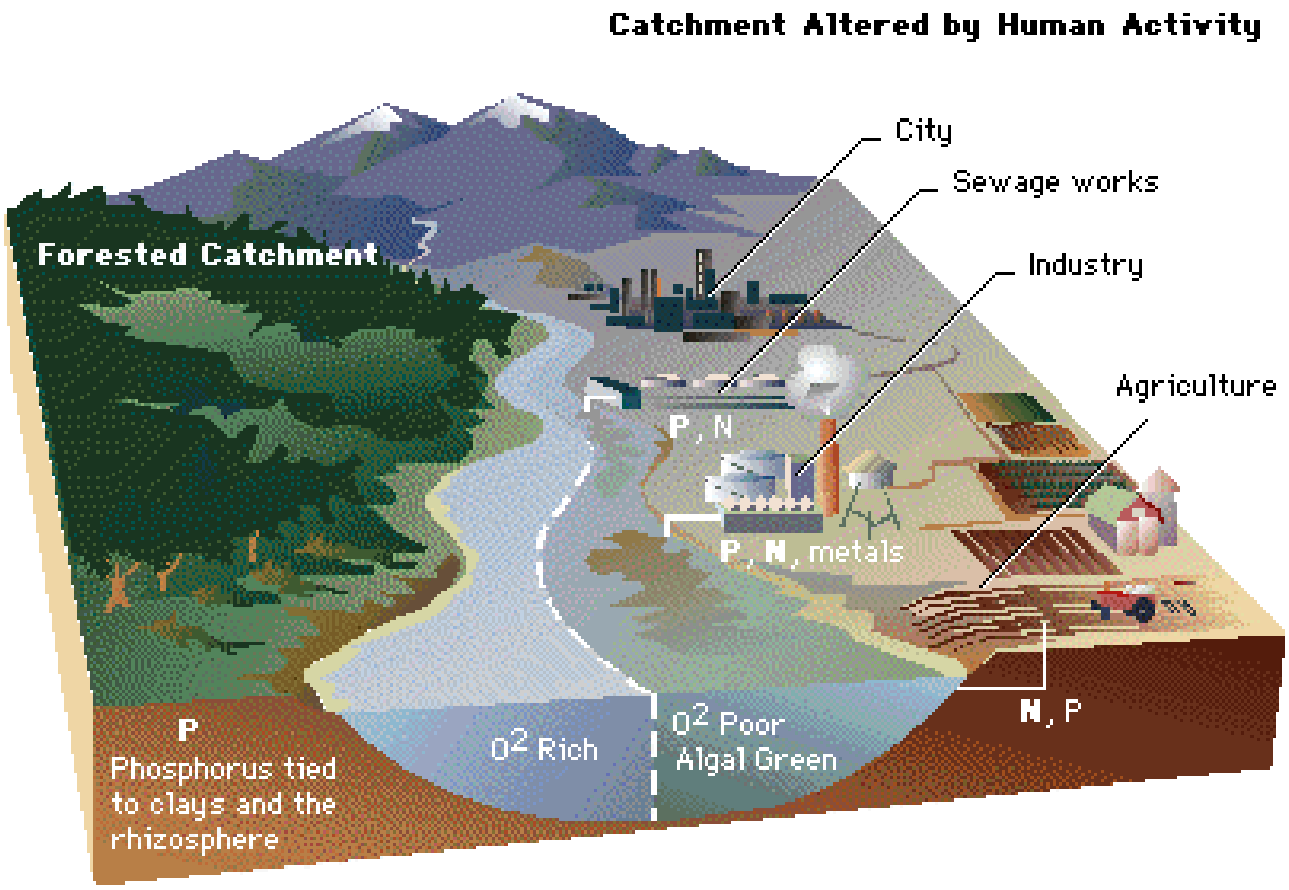
Average Annual Precipitation in Portland Maine 1930 -2013.
Created from data obtained at htpp://ncdc.noaa.gov/cag

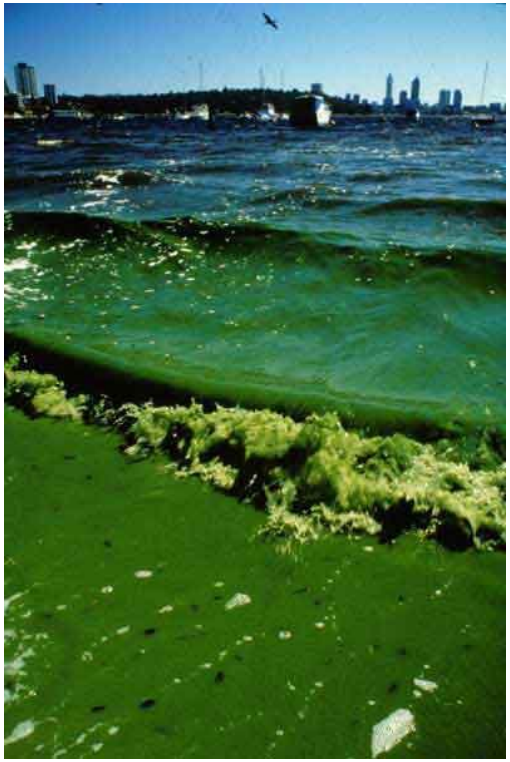
… and is likely to continue over the next 25 years (*Rawlins et al, 2015*)



Change in Precipitation Patterns: *Intense precipitation events (the heaviest 1 percent) in the continental U.S. from 1958 to 2012. Image Credit: Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville, 2014: Ch. 2: Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT*

Nutrient enhanced acidification



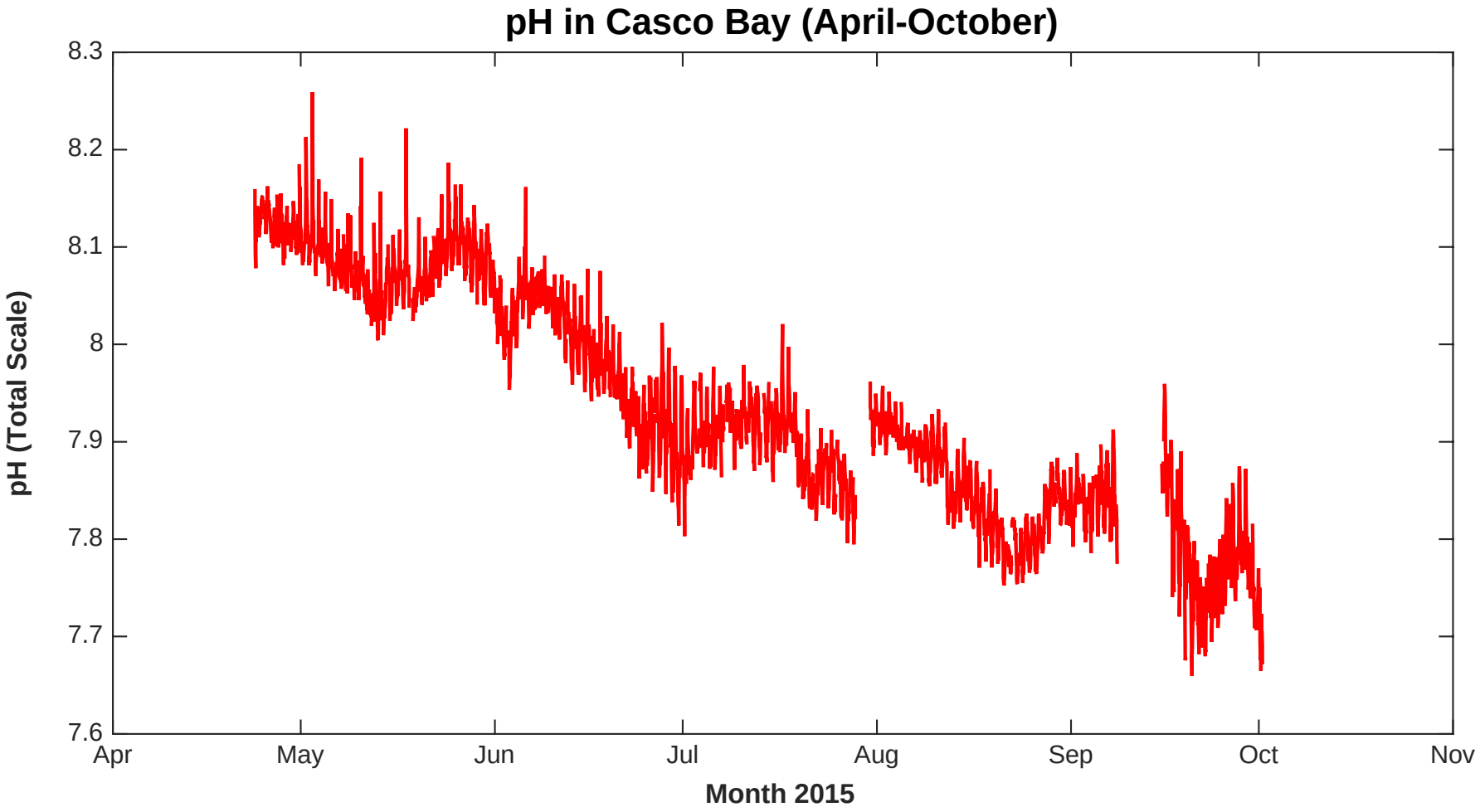


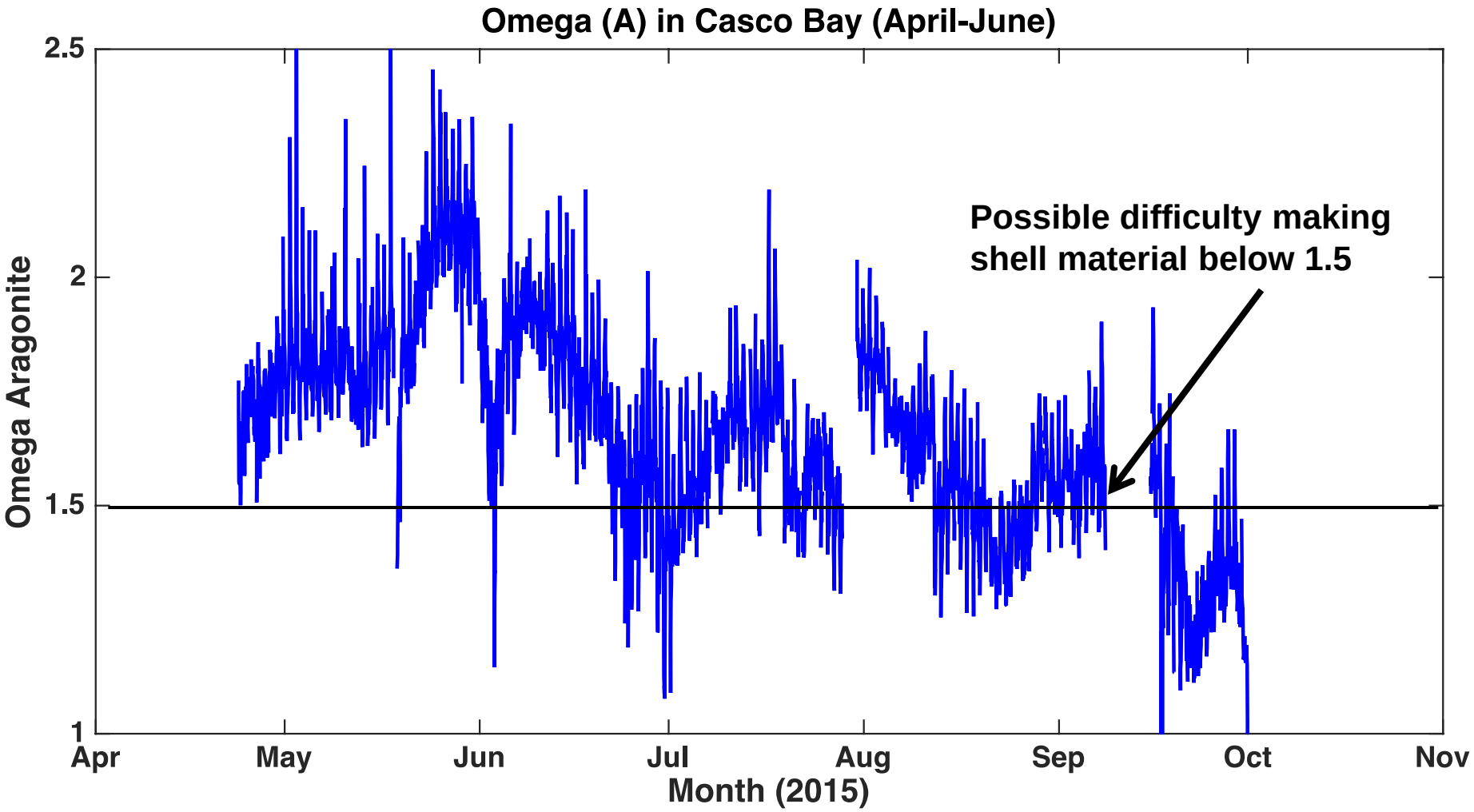
Oxygen + decomposing plant matter → CO_2 + H_2O → acid

How does this affect Casco Bay?

Improving or declining?

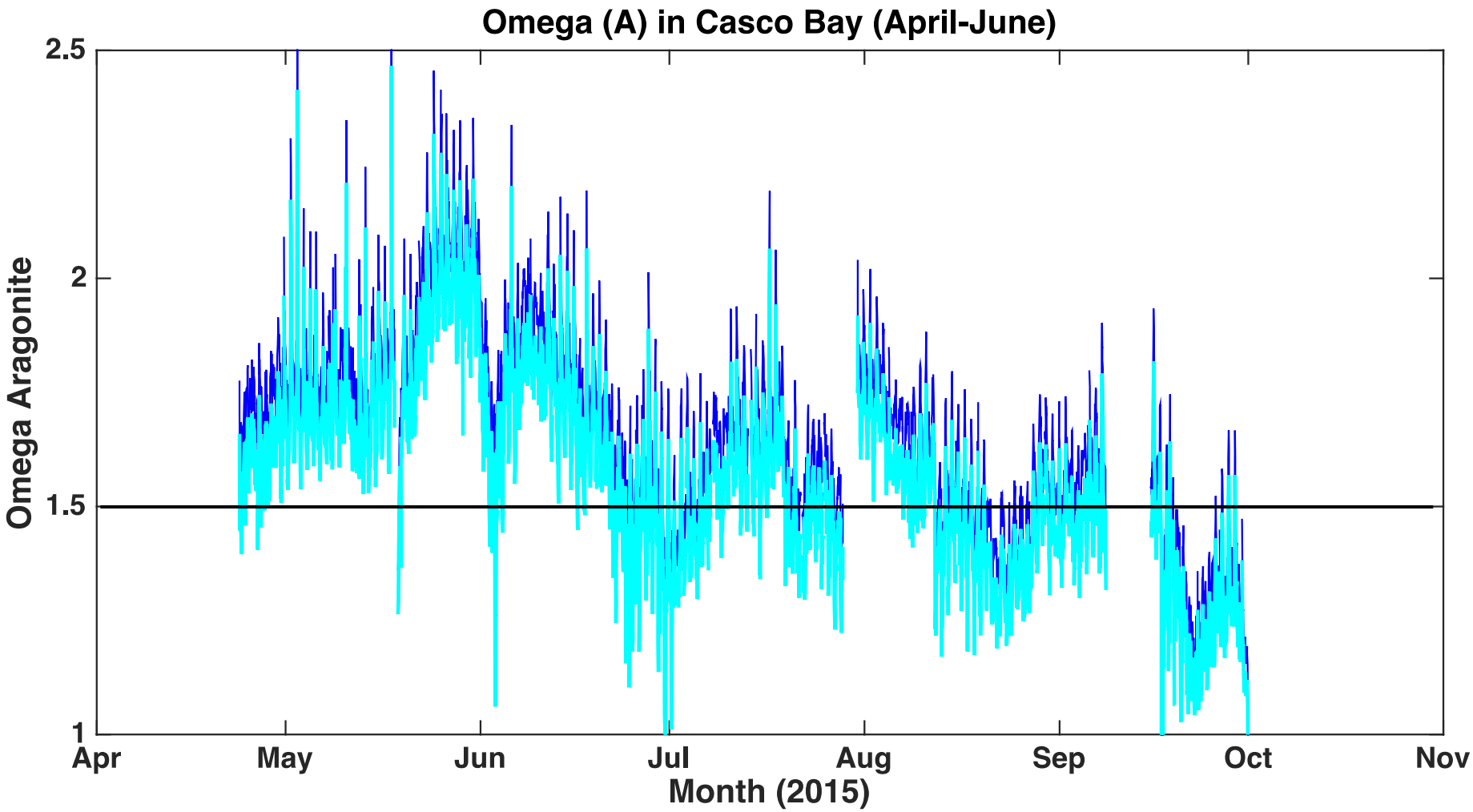

Recent observations and their
implications for the near future


pH in Casco Bay (April-October)
pH (Total Scale)
8.3
8.2
8.1
8
7.9
7.8
7.7
7.6
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Month 2015



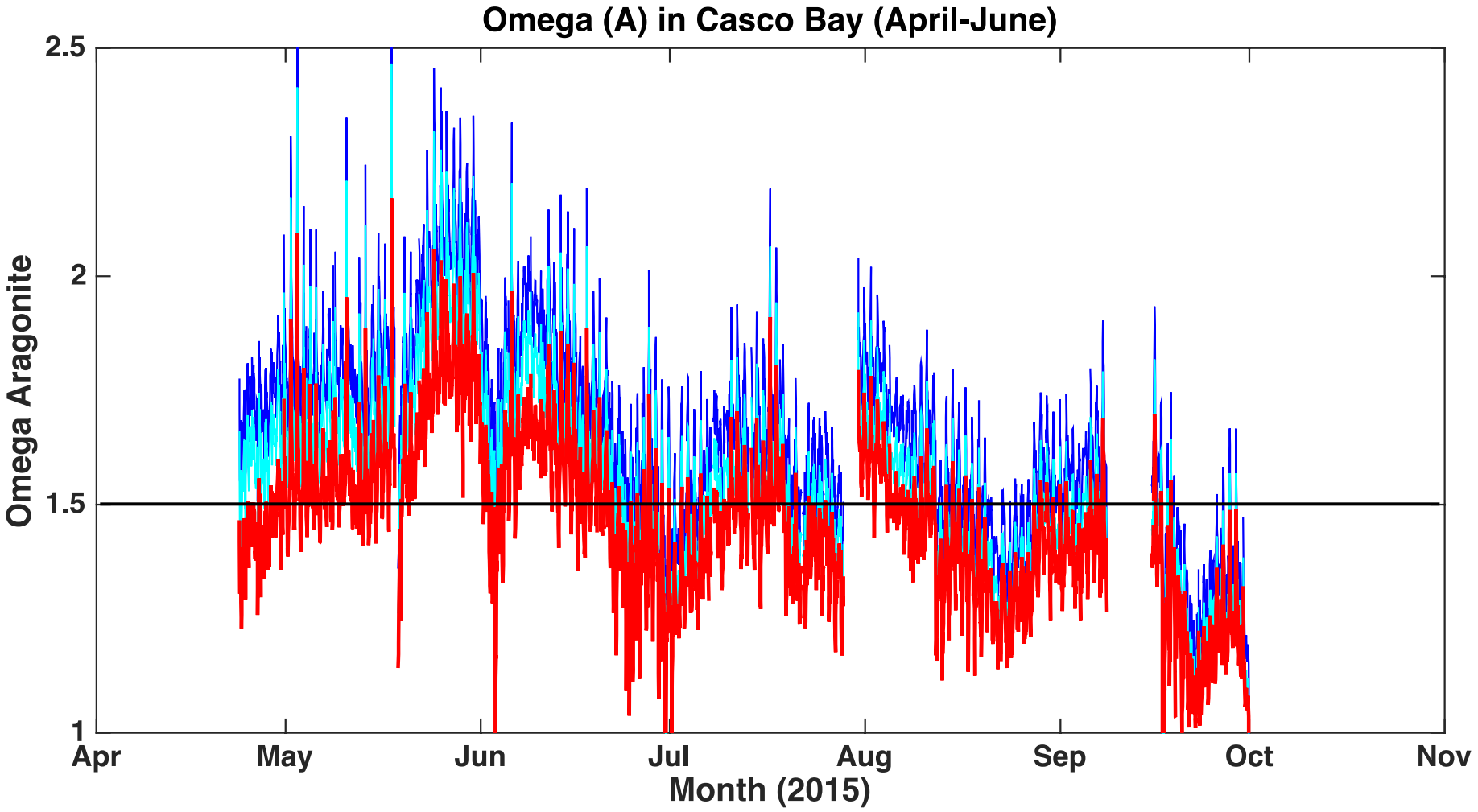
So far, we've observed 34 of 150 days at <1.5

… now freshen the coast on average by 1 salinity unit (1:31)



Given a similar time series, we would likely experience 58 days at <1.5

… now freshen plus add in the expected CO_2 increase over the next 25 years (red)



In this scenario we could experience 89 days at <1.5

Concluding remarks:

Slow atmospheric acidification

Coastal variability can put organisms beyond certain thresholds

Casco Bay sensitive to OA from multiple pathways and may be changing quickly

But we need to know a lot more about how drivers amplify or dampen OA