

2015

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

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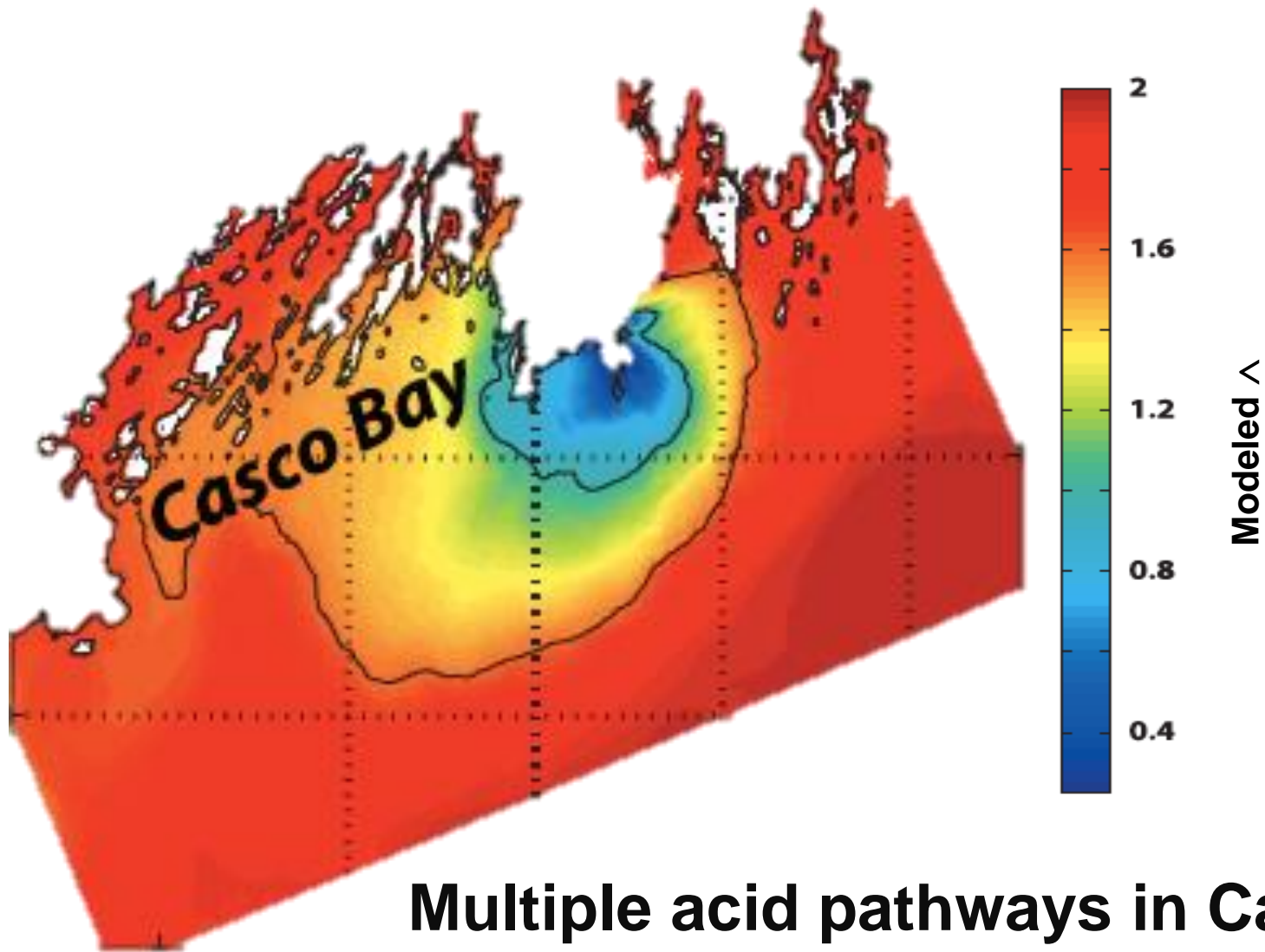
S. Shellito

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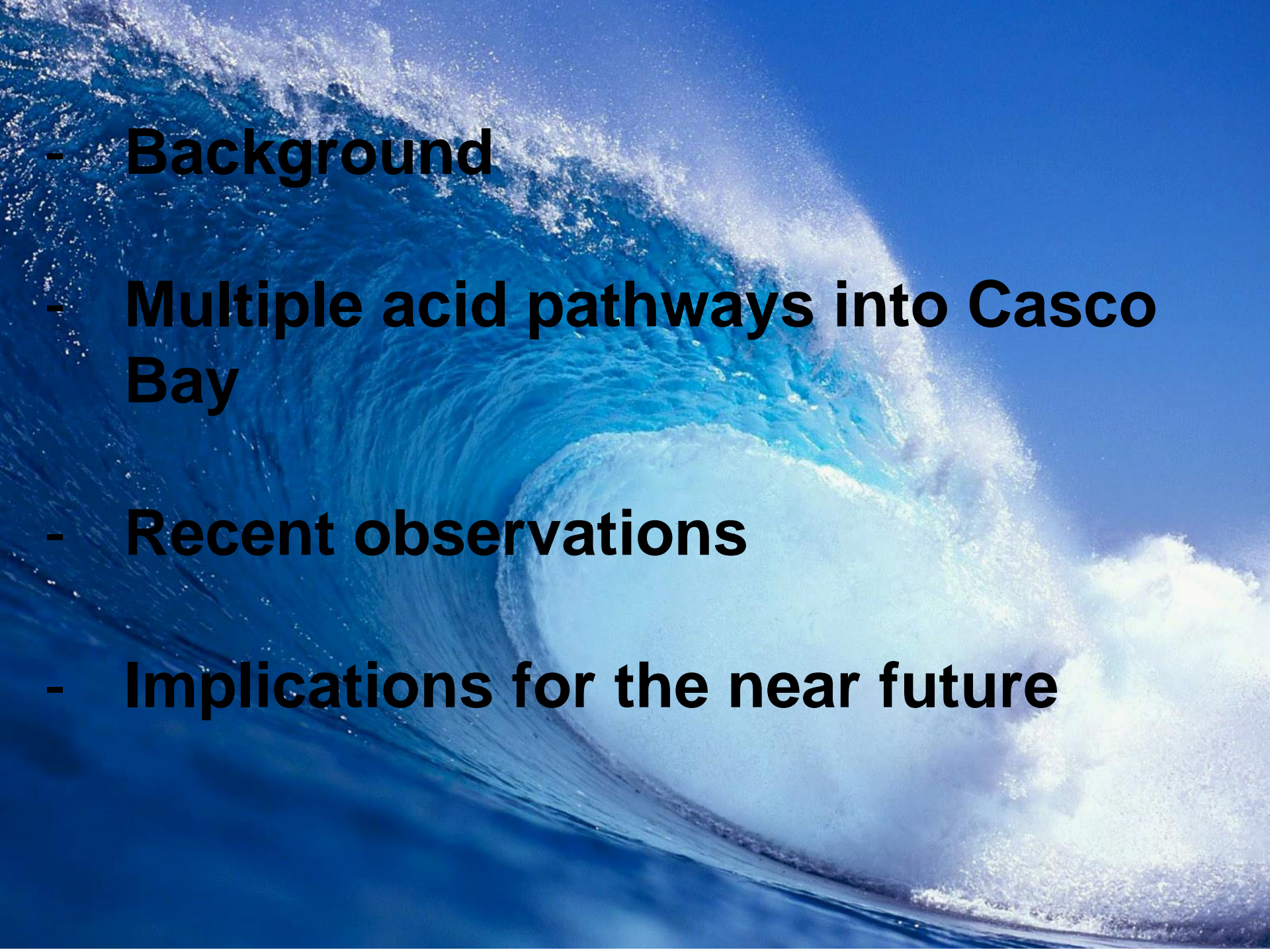
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Multiple acid pathways in Casco Bay: Implications for the next 25 years

J. Salisbury, D. Vandemark,
C. Hunt, S. Shellito

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- A large, curling blue wave crashing against a clear blue sky. The wave is the central focus, with white foam at its base and crest. The sky is a deep, clear blue.
- **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%

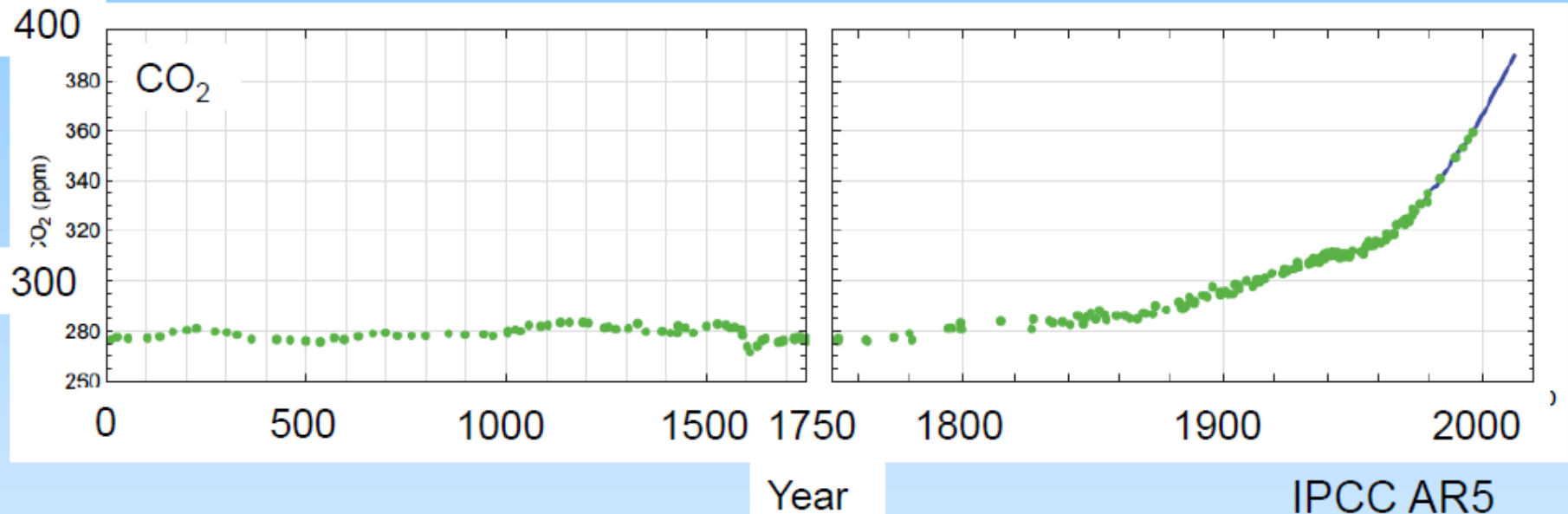


Calculated as the residual
of all other flux components

2.5 ± 0.5 PgC/yr
26%

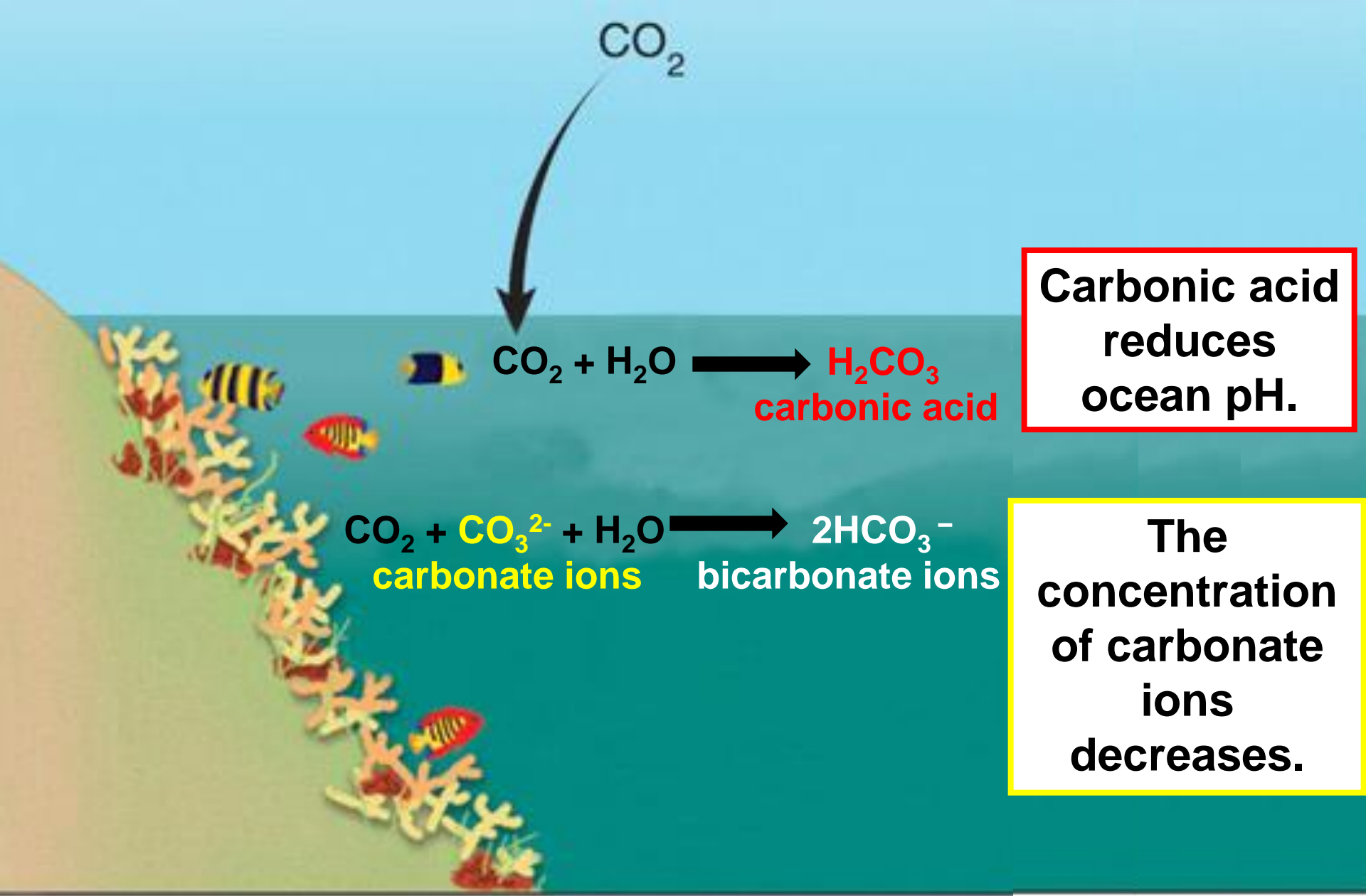


Rising Atmospheric CO₂



IPCC AR5
WG1 Chap. 6

Present-day CO₂ 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

$$\Omega = \frac{[\text{Ca}^{2+}][\text{CO}_3^{2-}]}{K_{sp}}$$

$\Omega > 1$ animals can make shell

$\Omega \gg 1$ easier to make shell

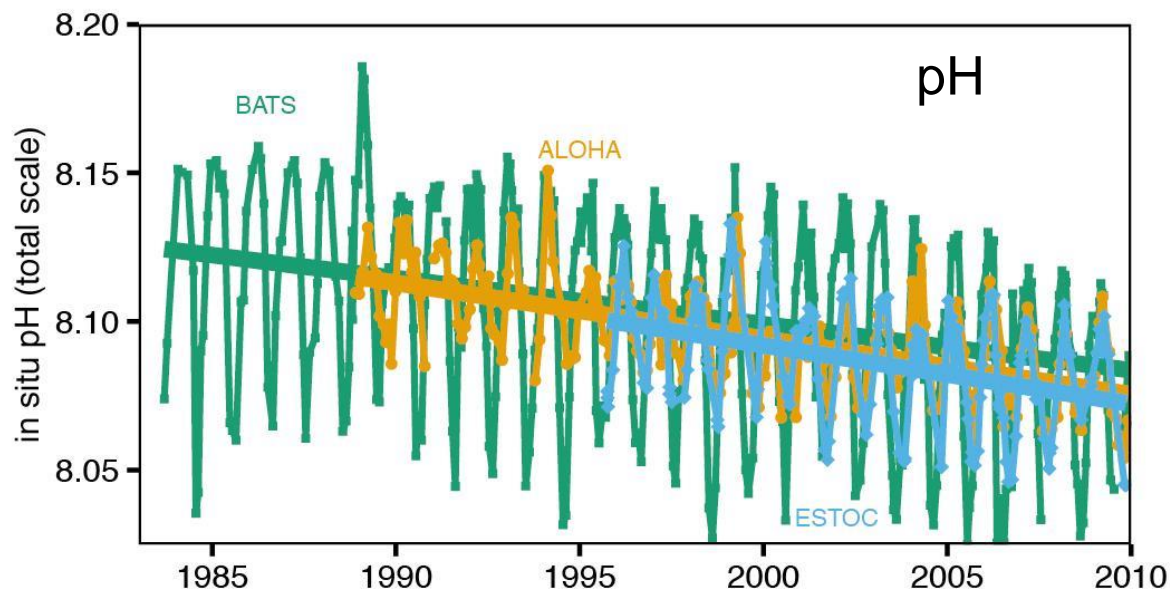
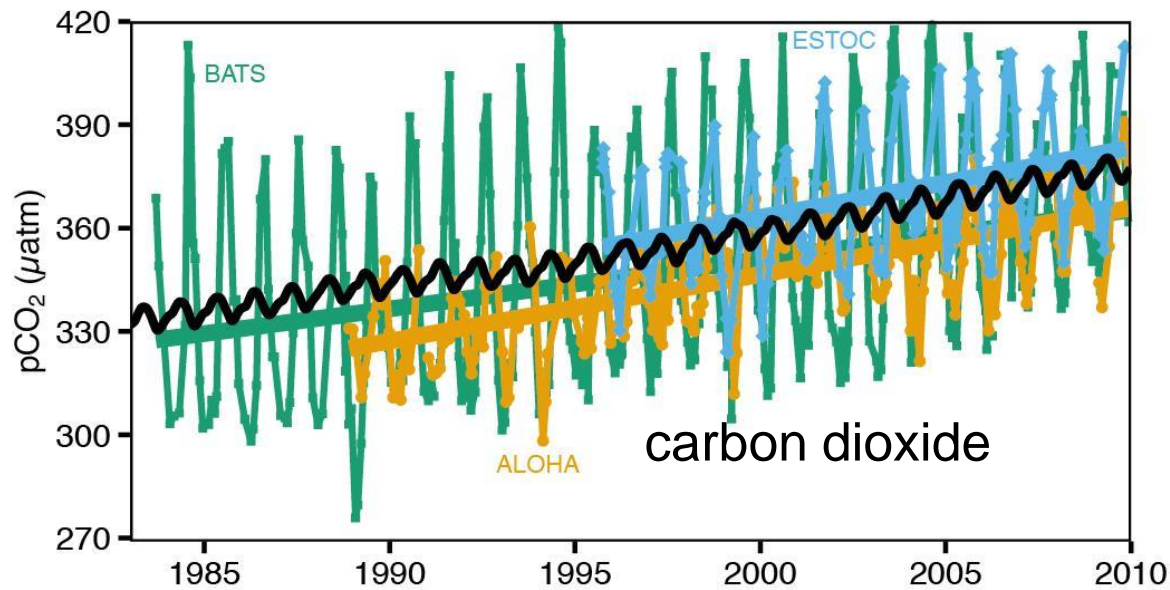
$\Omega < 1$ shell dissolves

Affected by temperature: \uparrow Temp corresponds to $\uparrow\Omega$.

Varies with CO_2 : $\uparrow \text{CO}_2$ corresponds to $\downarrow\Omega$.

Varies with pH: \uparrow pH corresponds to $\uparrow\Omega$.

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

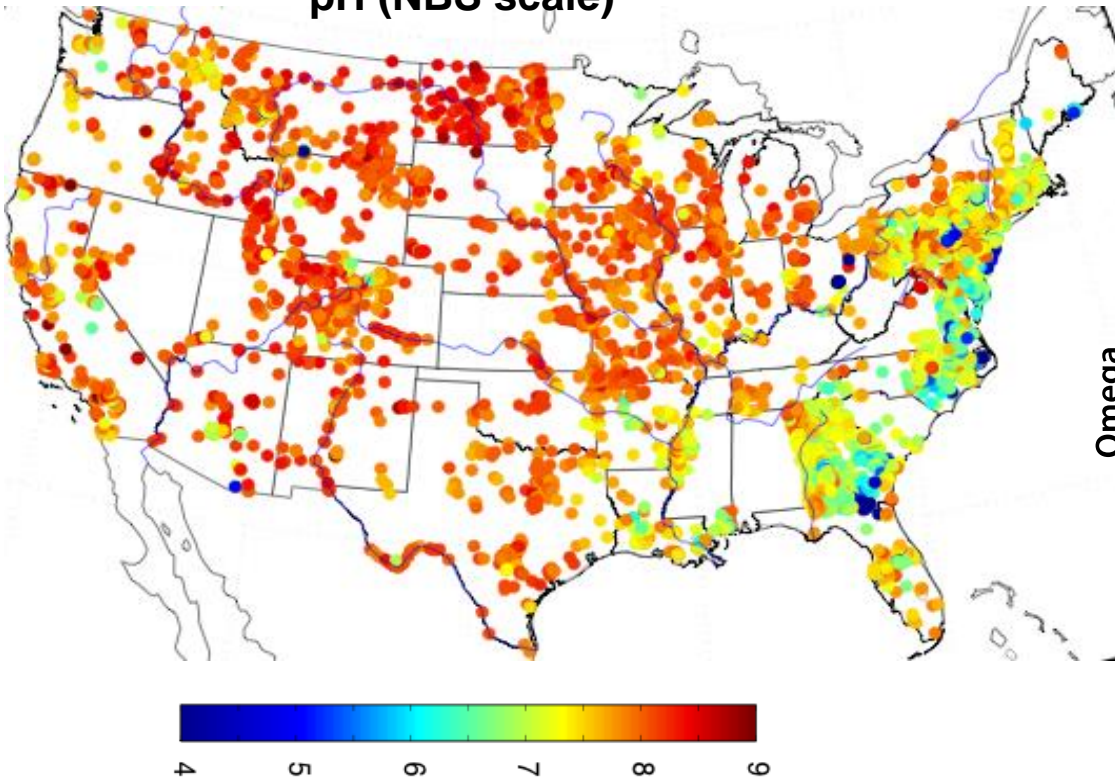
IPCC 2014
 WG1, Chapter 3
 Doney et al. Ann. Rev. Mar. Sci. 2009
 Dore et al. PNAS 2009

A large, curling blue wave is crashing against a sandy beach. The water is a deep, vibrant blue, and the crest of the wave is breaking into white foam. The sky is a clear, bright blue. The overall scene is dynamic and powerful.

Other pathways for acidification

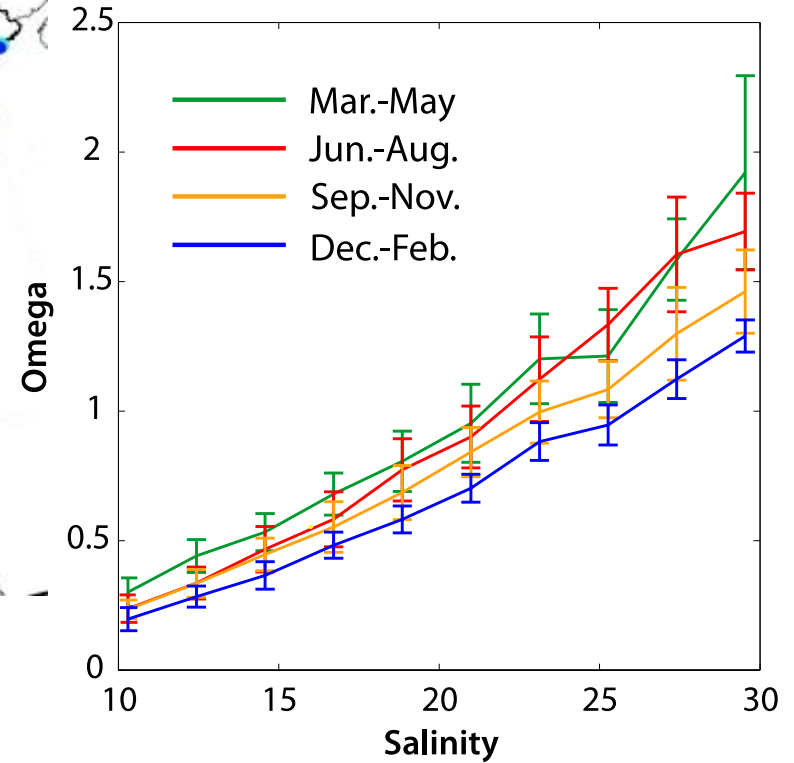
Coastal and Estuarine Acidification – River water freshens the coast and alters its ability to buffer against acid

pH (NBS scale)



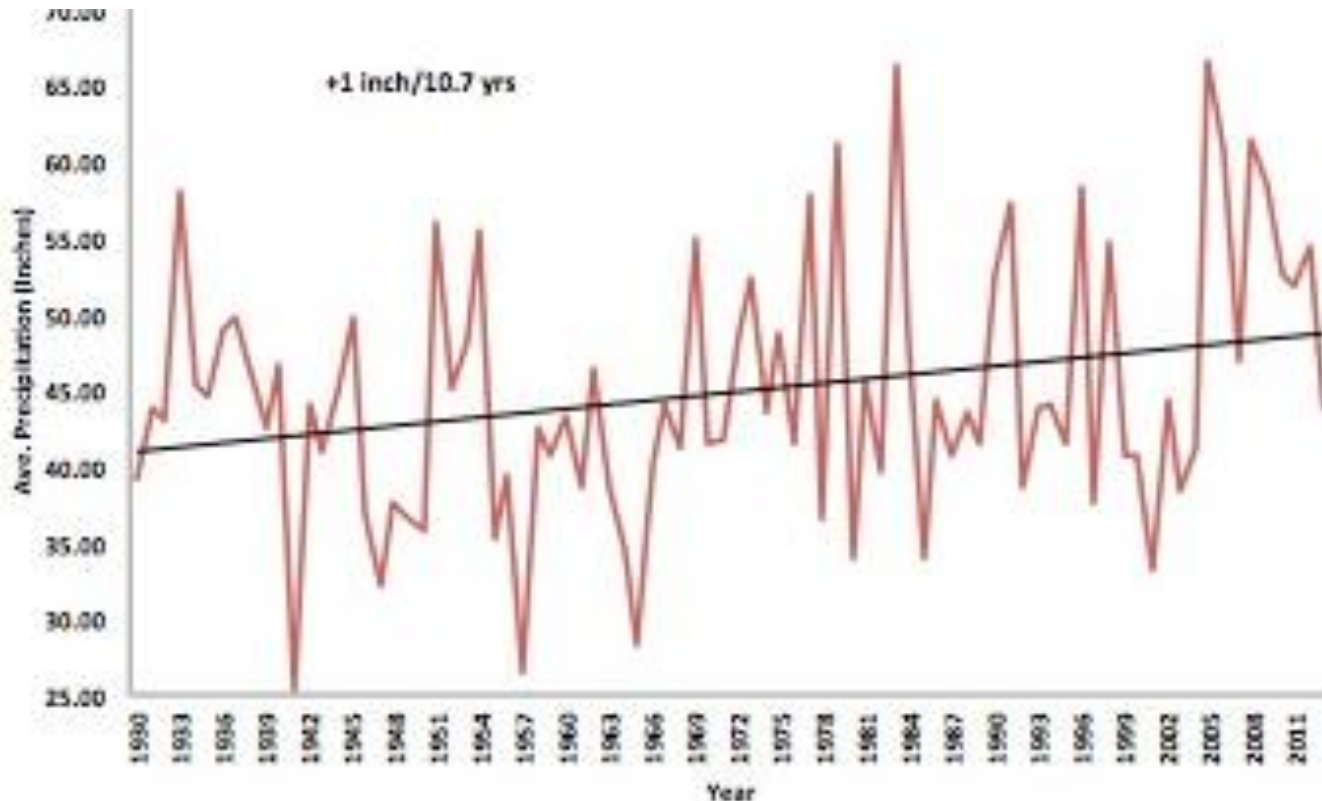
Data from USGS

Omega (Ω) in the Kennebec Plume (56 cruises)



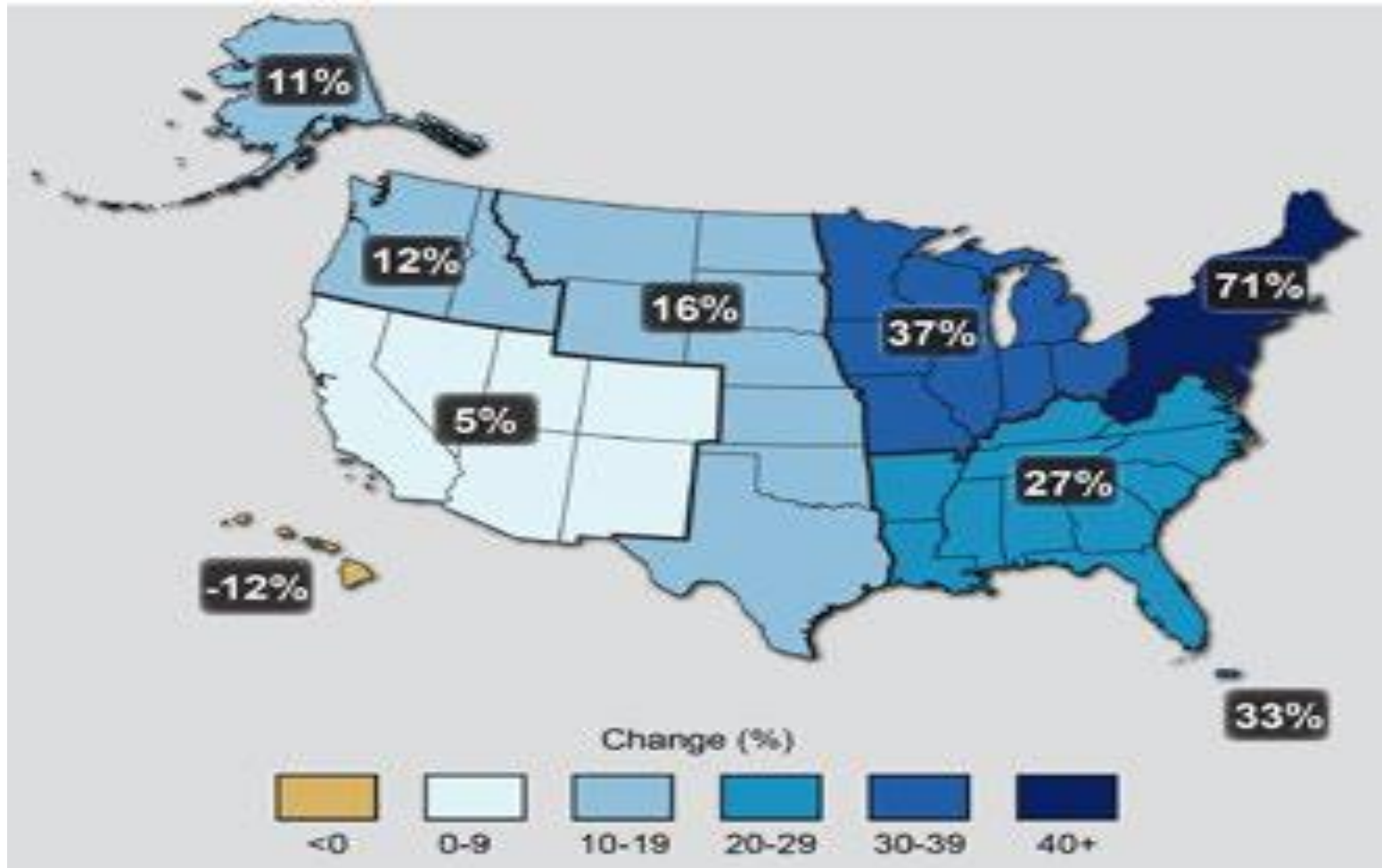
Waldbusser and Salisbury, 2014

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



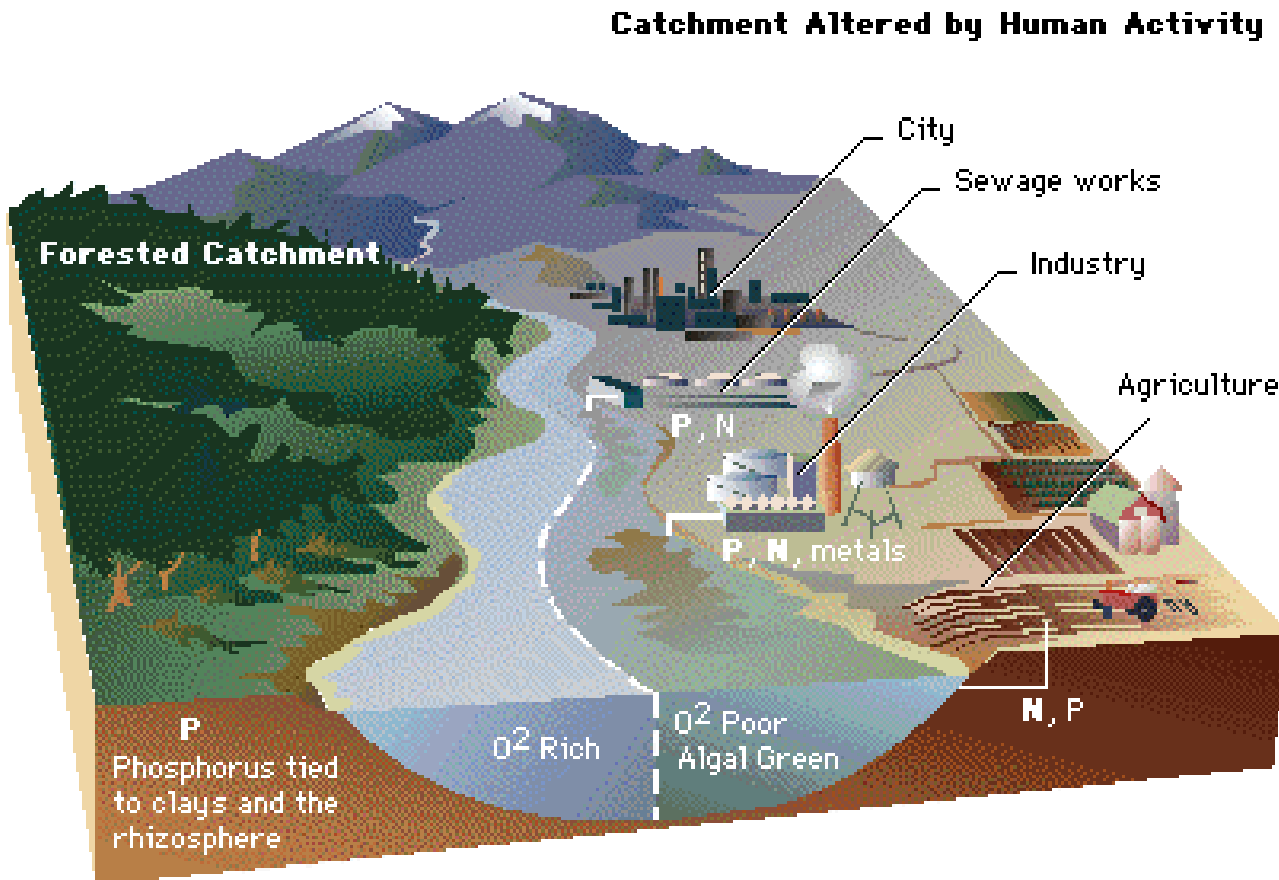
Average Annual Precipitation in Portland Maine 1930 -2013.
Created from data obtained at <http://ncdc.noaa.gov/cag>

... 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 \rightarrow CO₂ + H₂O \rightarrow acid

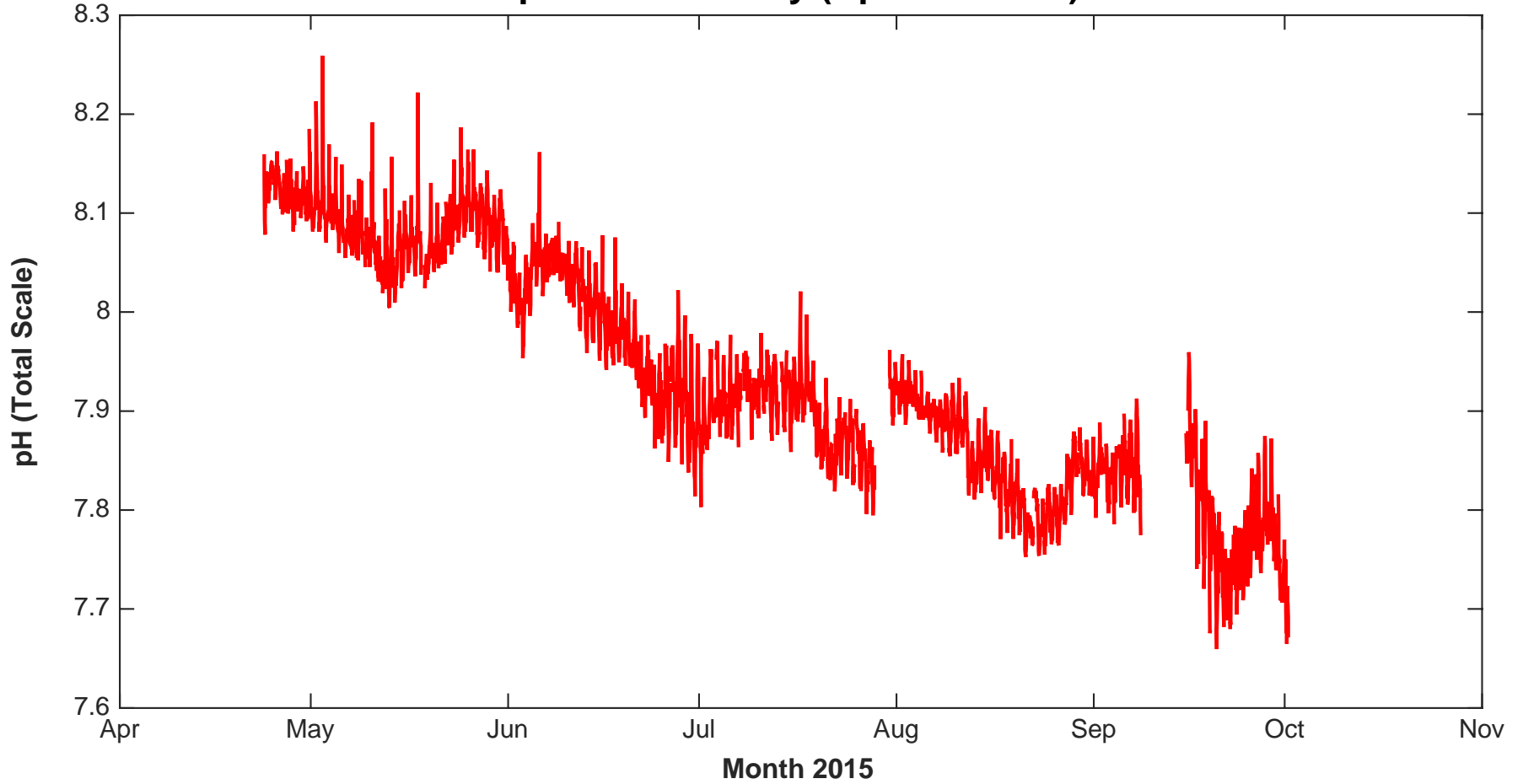
How does this affect Casco Bay?

Improving or declining?

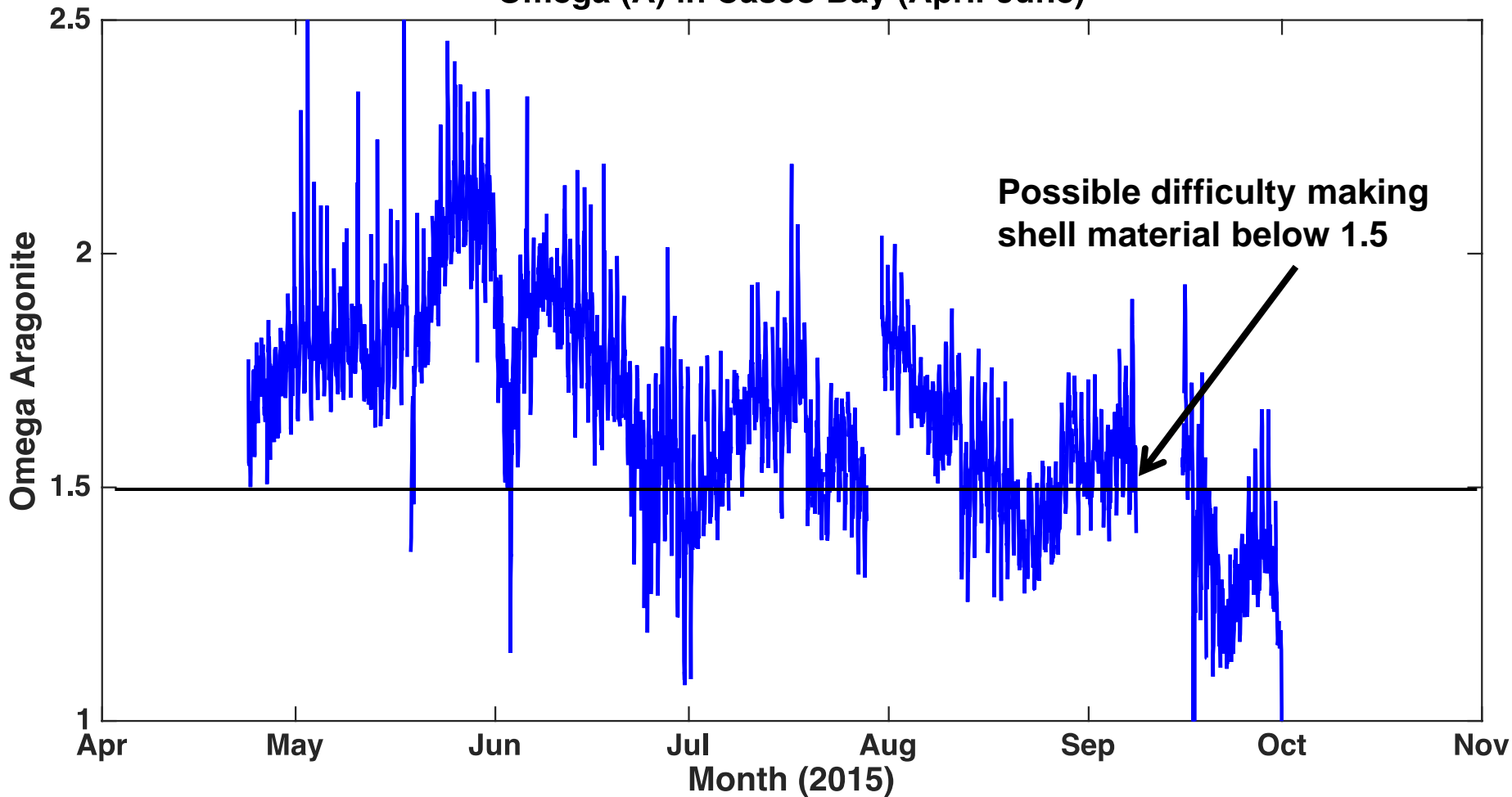
A large, curling blue wave crashing under a clear blue sky. The wave is the central focus, with its crest curling over and creating a tunnel-like structure. The water is a vibrant blue, and the sky is a deep, clear blue. The overall scene is dynamic and powerful.

Recent observations and their implications for the near future

pH in Casco Bay (April-October)

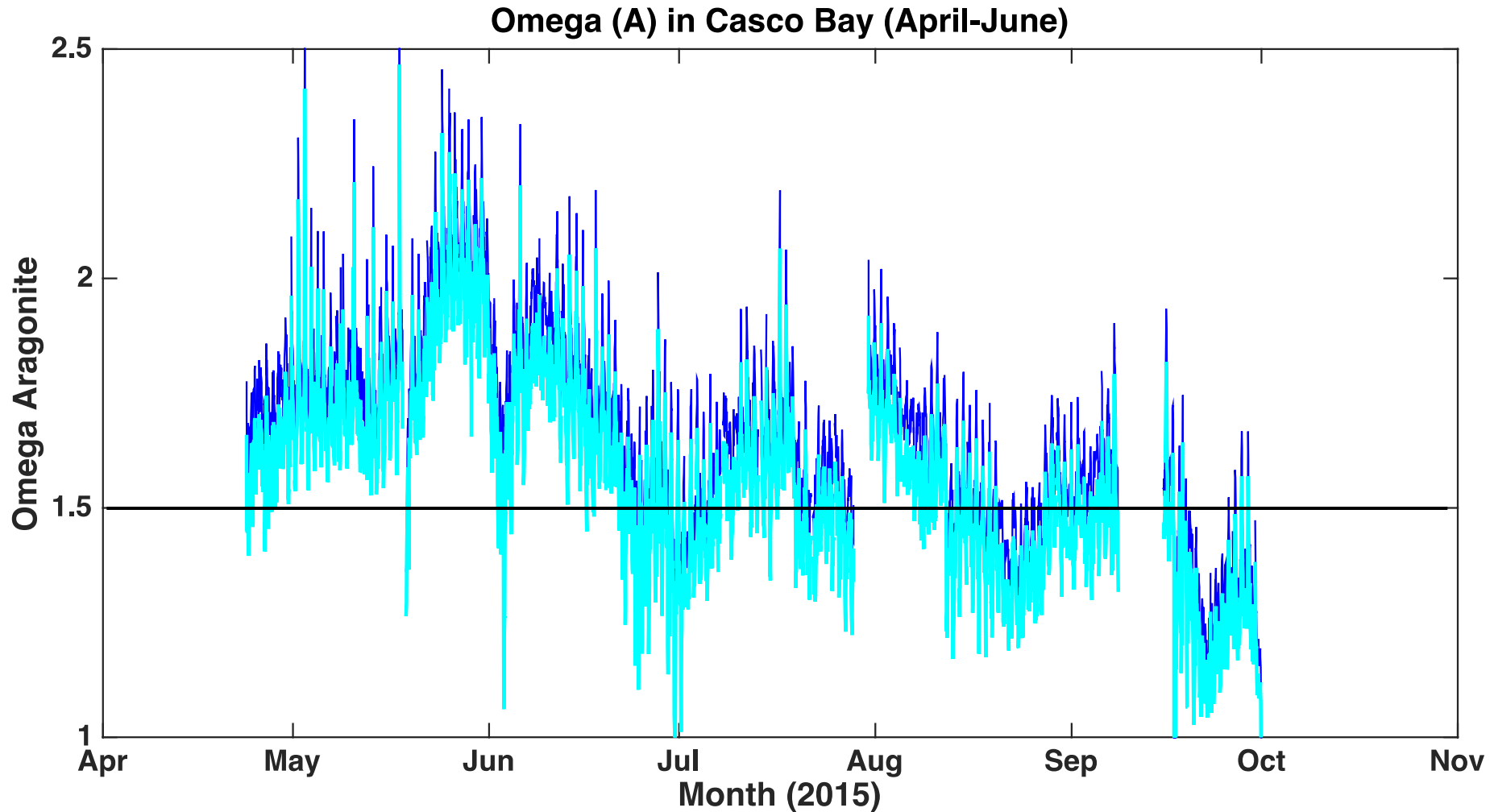


Omega (A) in Casco Bay (April-June)



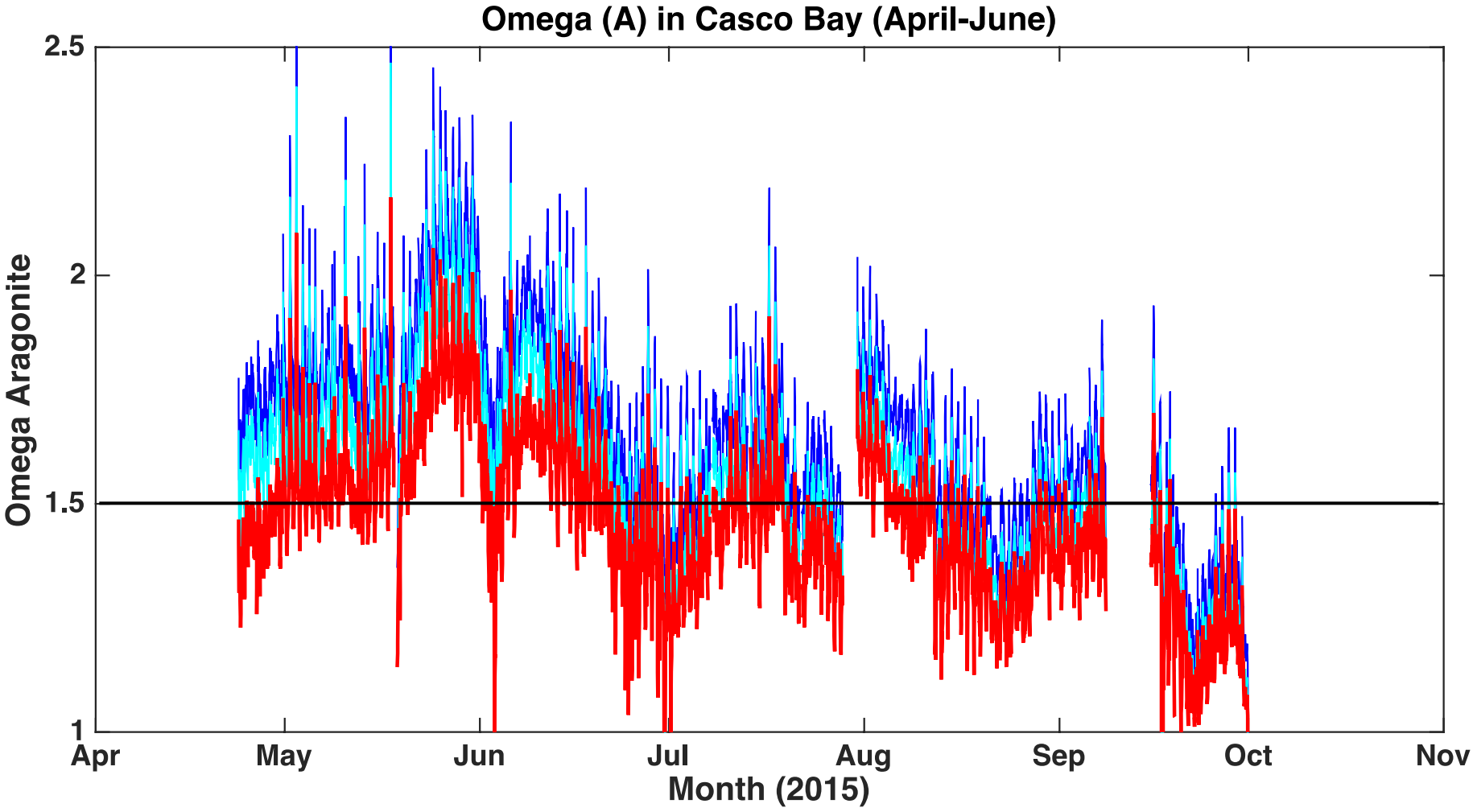
So far, we've observed 34 of 150 days at <1.5

... 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 CO₂ increase over the next 25 years (red)



In this scenario we could experience 89 days at <1.5

A large, curling blue wave crashing against a clear blue sky. The wave is the central focus, with white foam at its base and crest. The sky is a deep, clear blue.

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

