

Ocean Acidification: What is it?

Terrie Klinger

Barer Professor of Sustainability Science

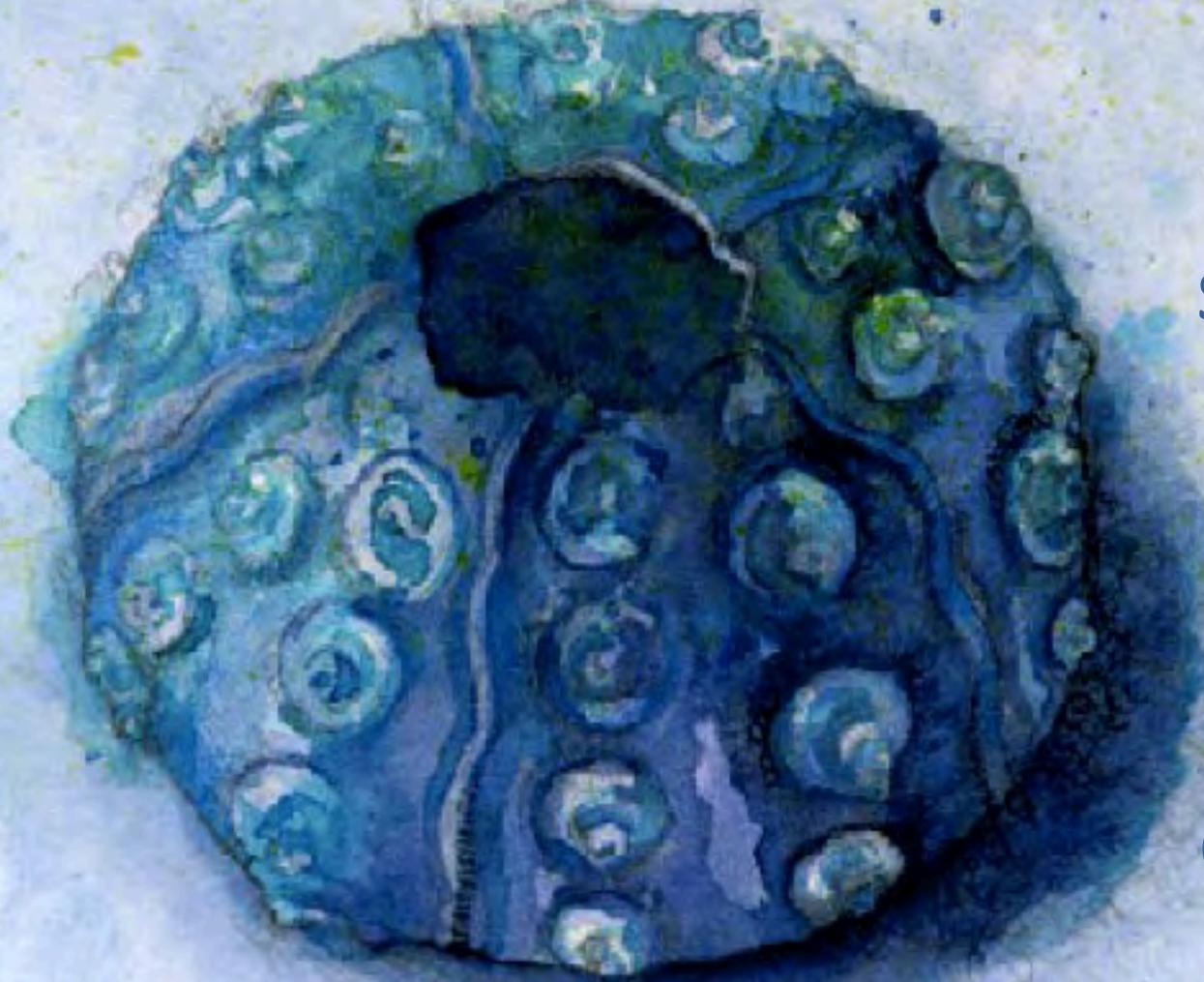
UW Marine and Environmental Affairs

Source: <http://kimprint.wordpress.com/>

Sea Urchin

Ocean Acidification: What is it?

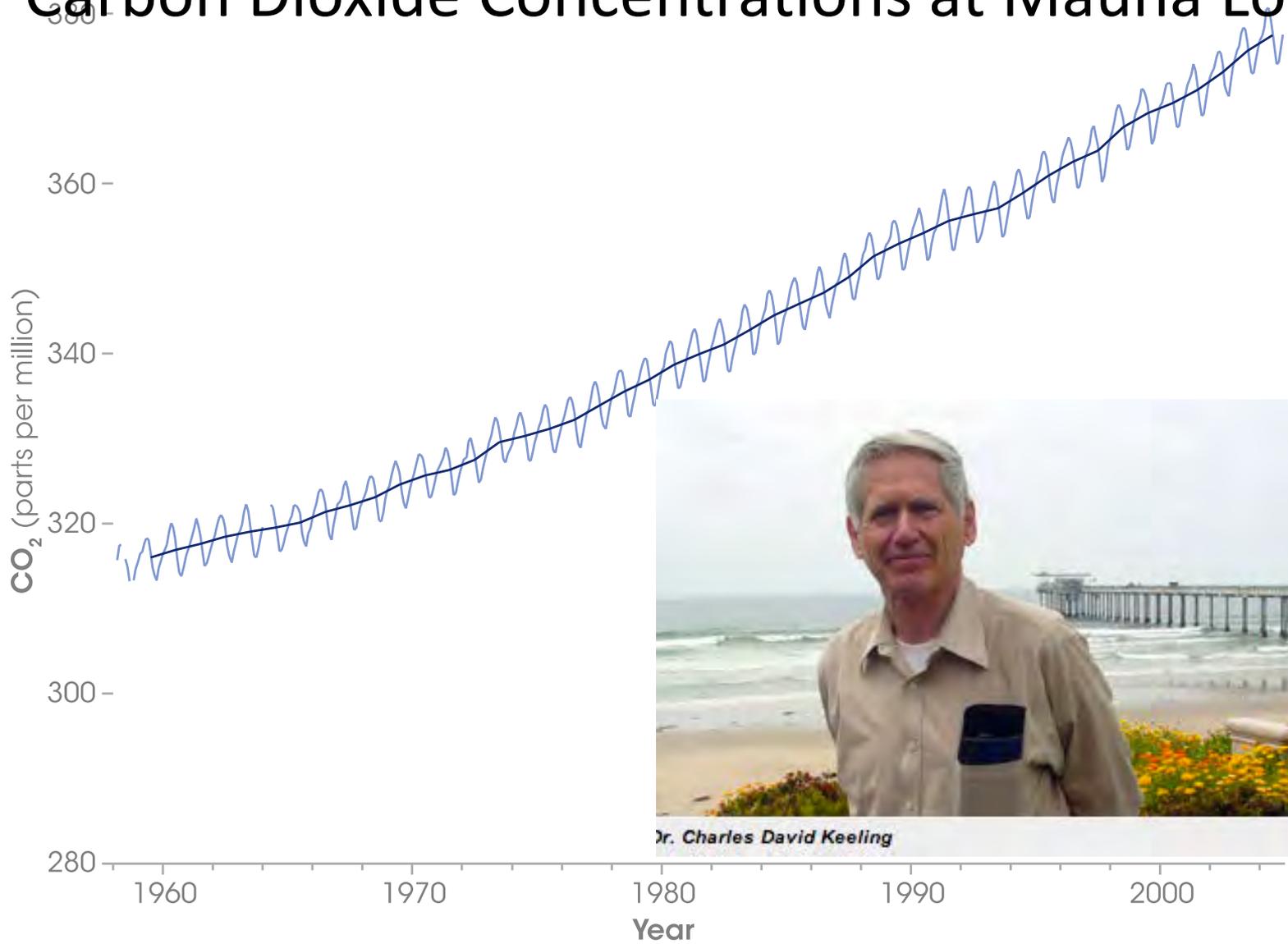
A prolonged reduction in seawater pH, driven by increasing levels of carbon dioxide (CO_2) in seawater



Source: <http://kimprint.wordpress.com/>

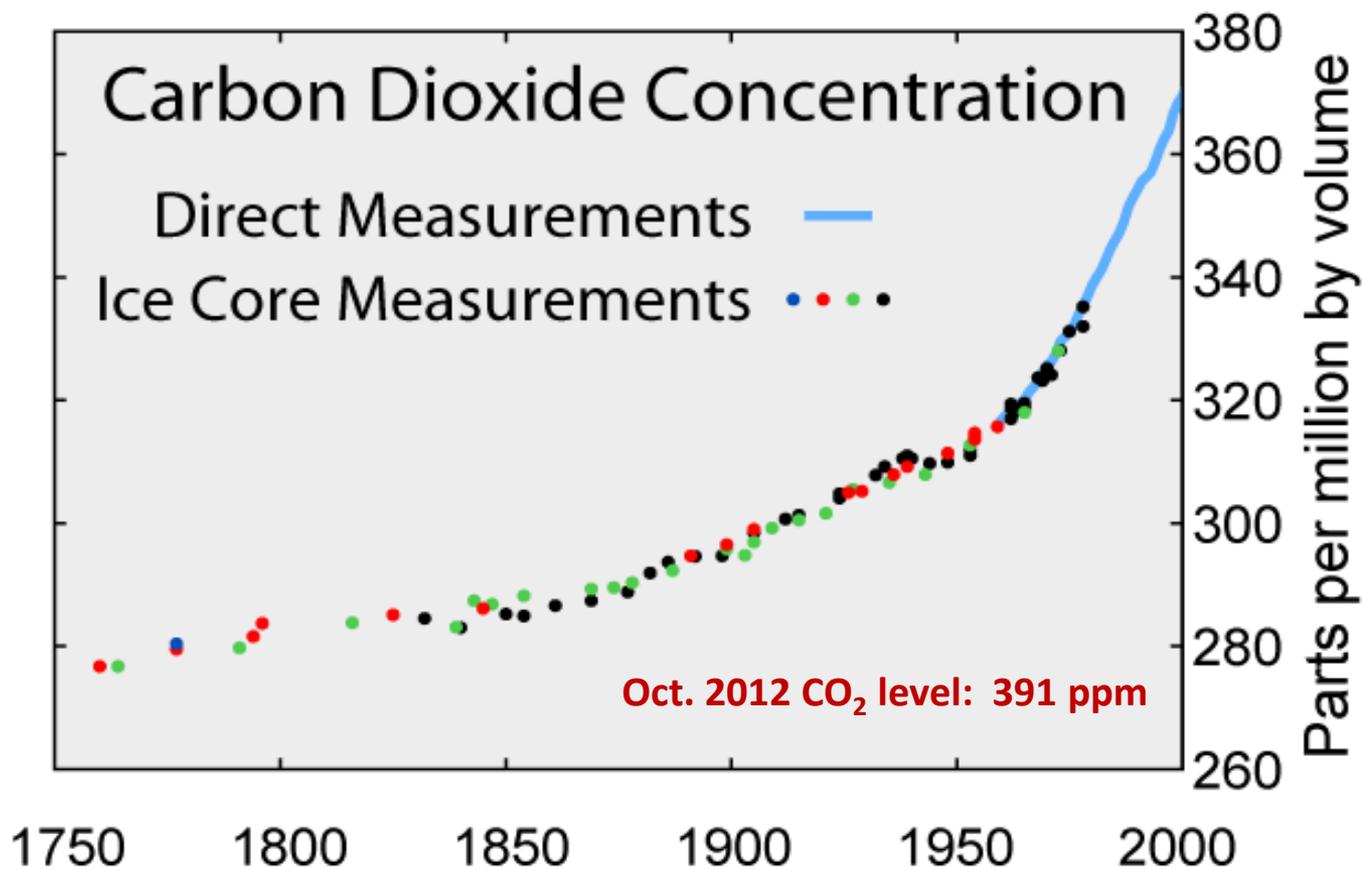
Sea Urchin

The Keeling Curve: Carbon Dioxide Concentrations at Mauna Loa

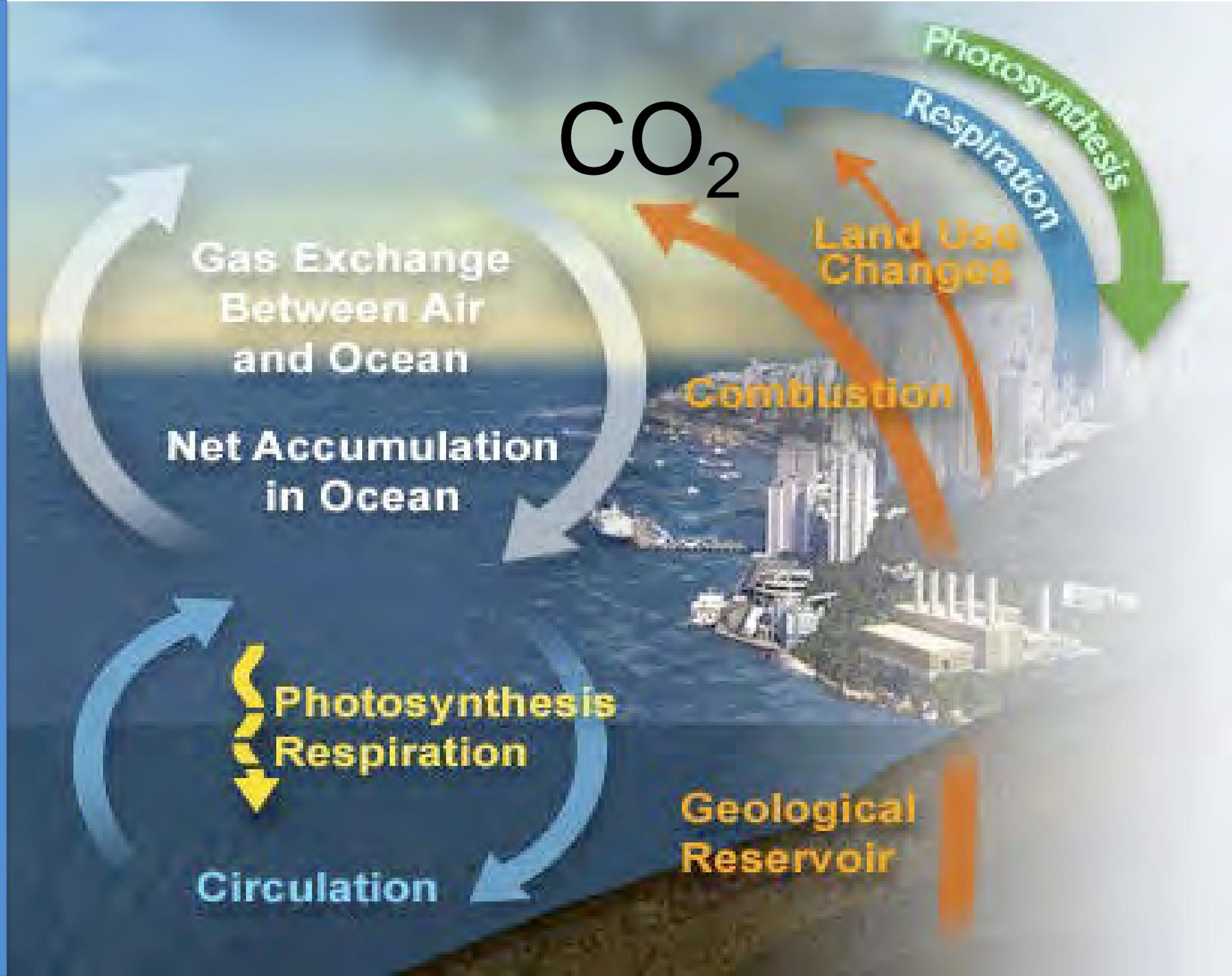


Dr. Charles David Keeling

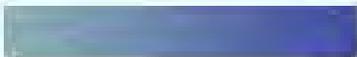
The rate of change is rapid

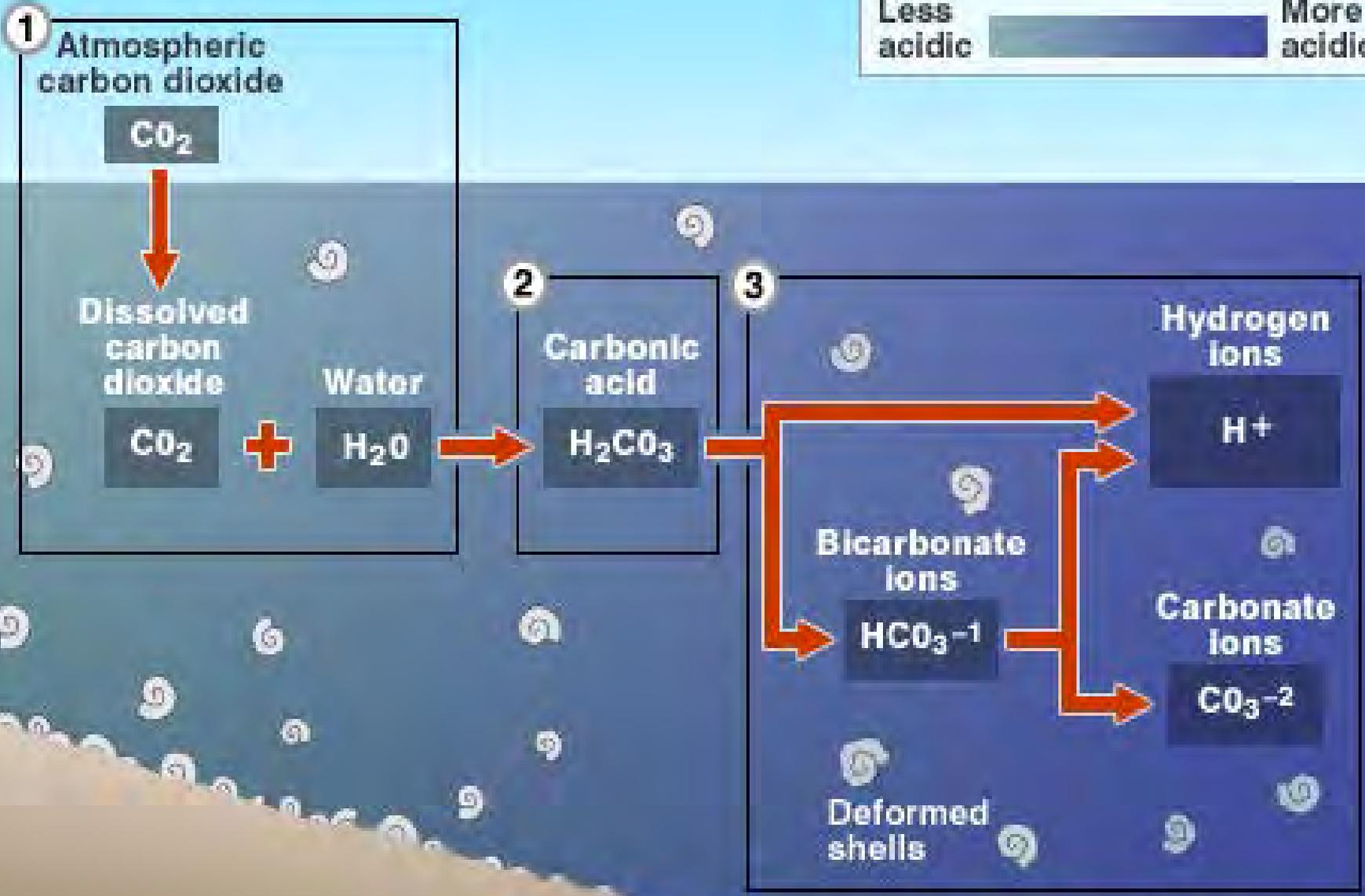


Cause of Ocean Acidification



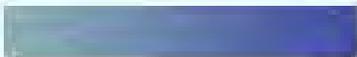
Chemistry of Ocean Acidification

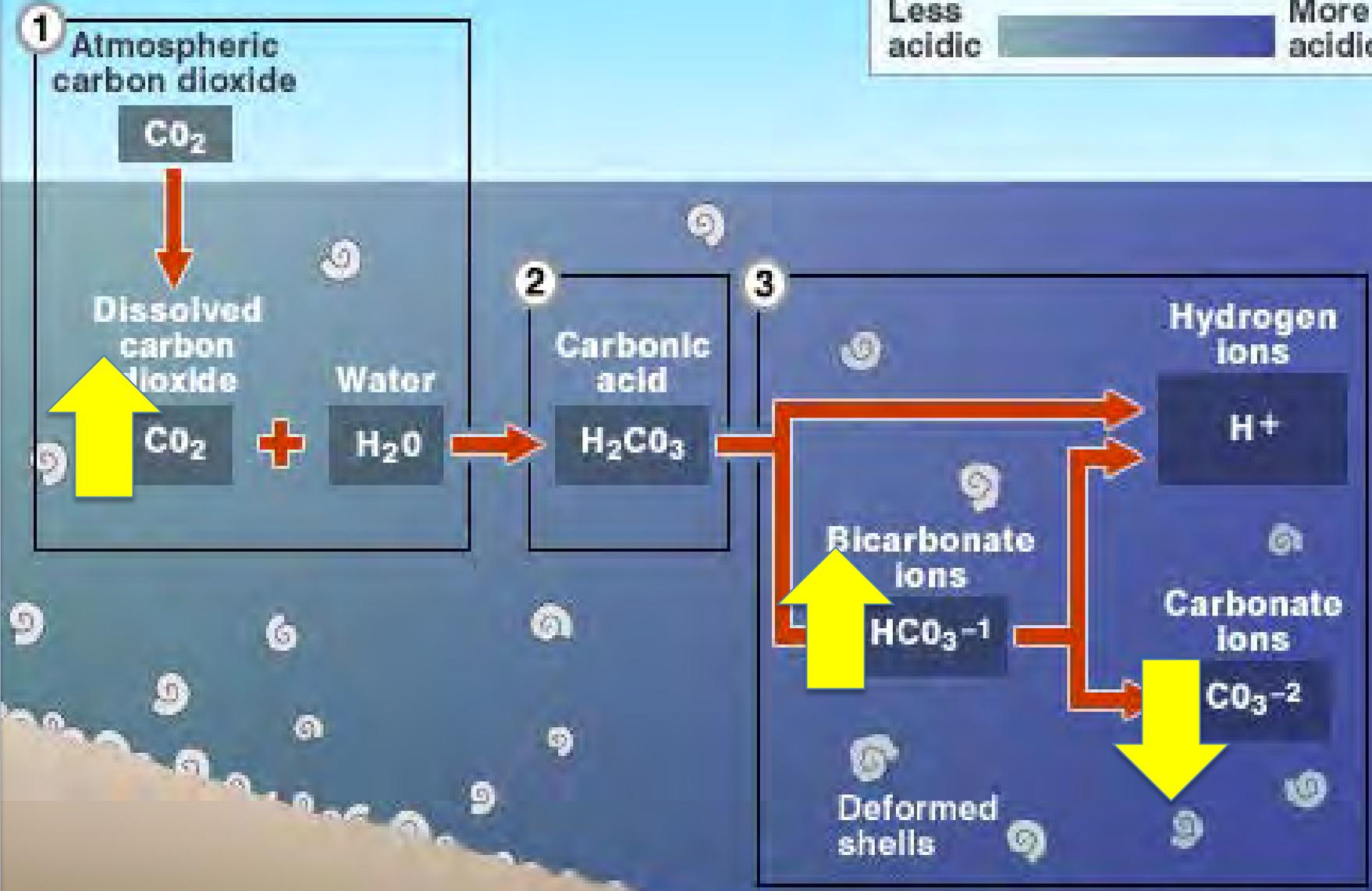
Less acidic  More acidic



Source: University of Maryland

Chemistry of Ocean Acidification

Less acidic  More acidic

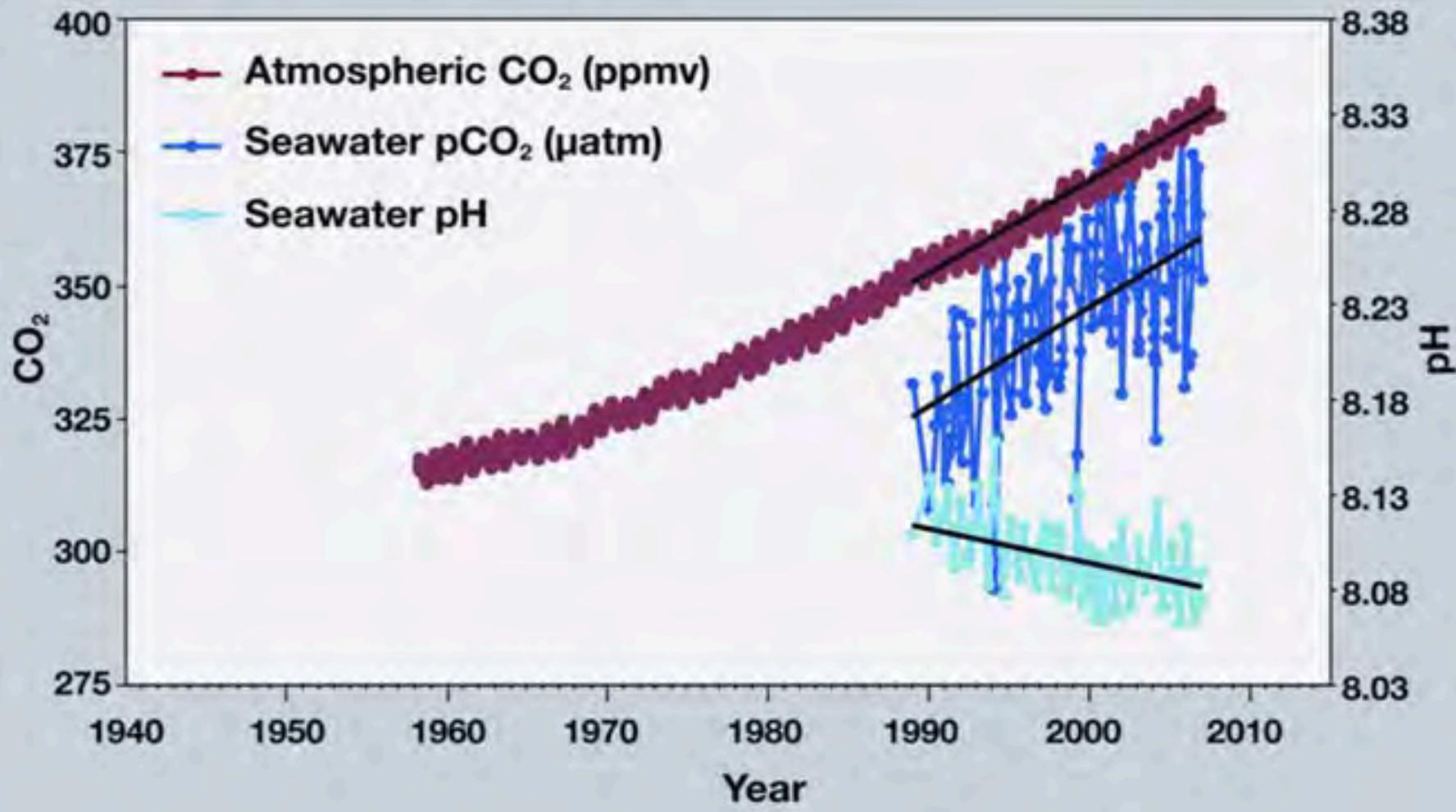


Source: University of Maryland



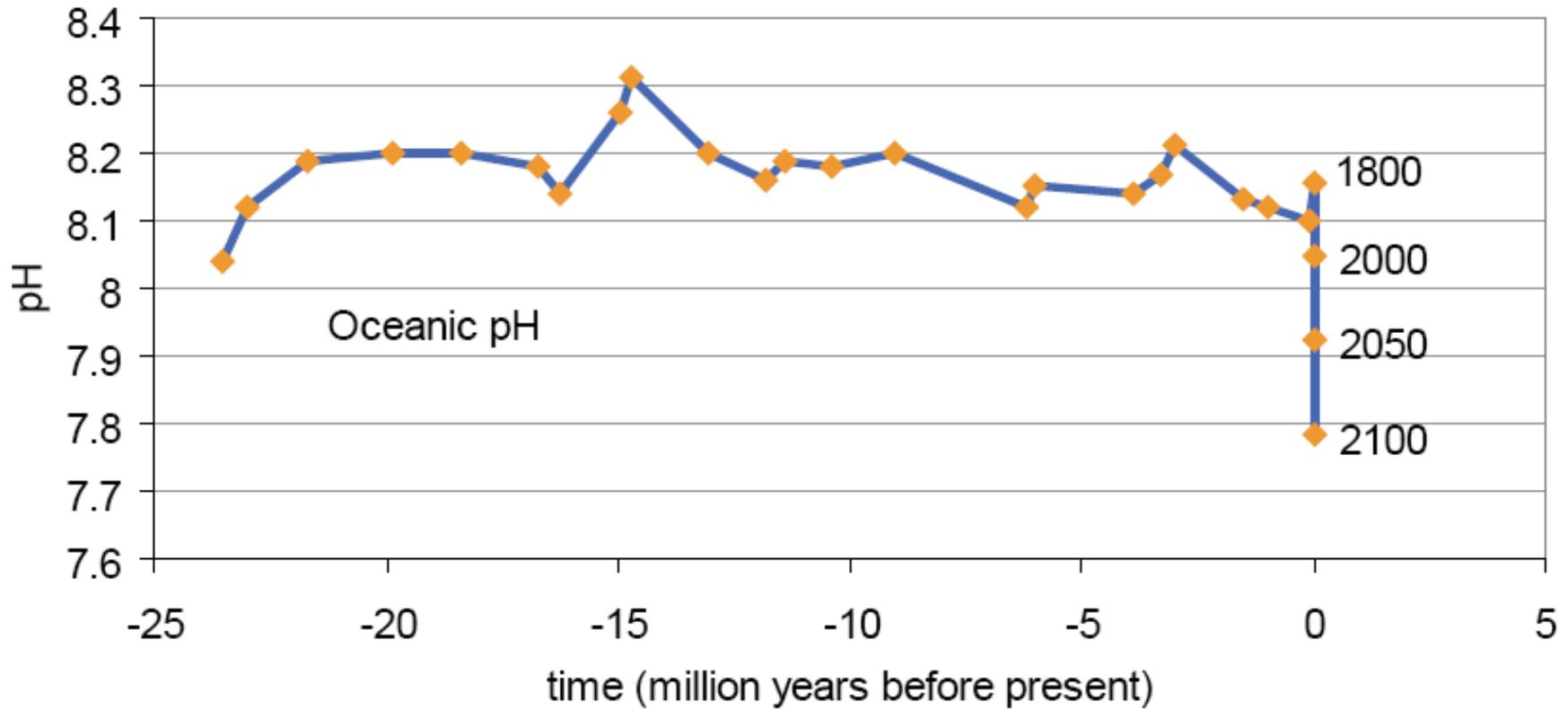
Atmospheric and Oceanic CO₂ and pH

Time Series

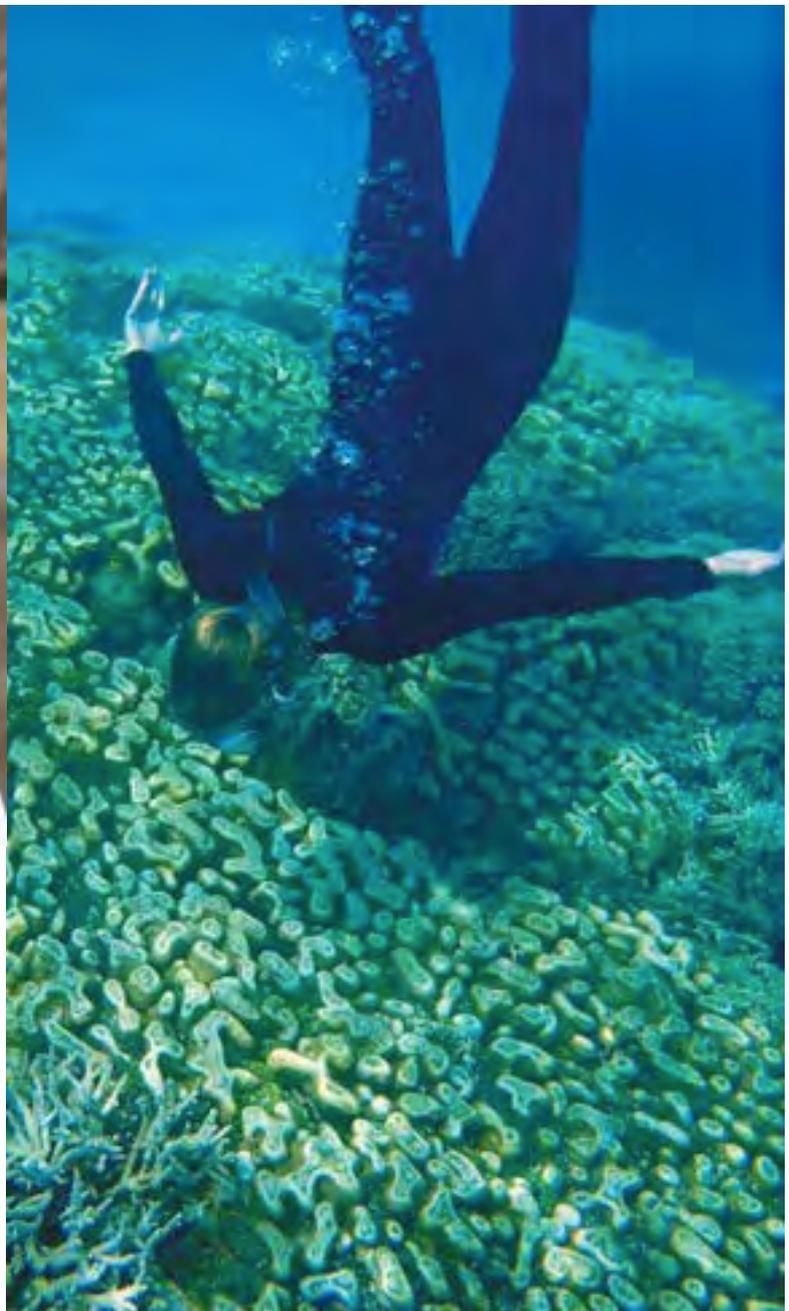


Source: NOAA Pacific Marine Environmental Laboratory

The rate of recent change is rapid



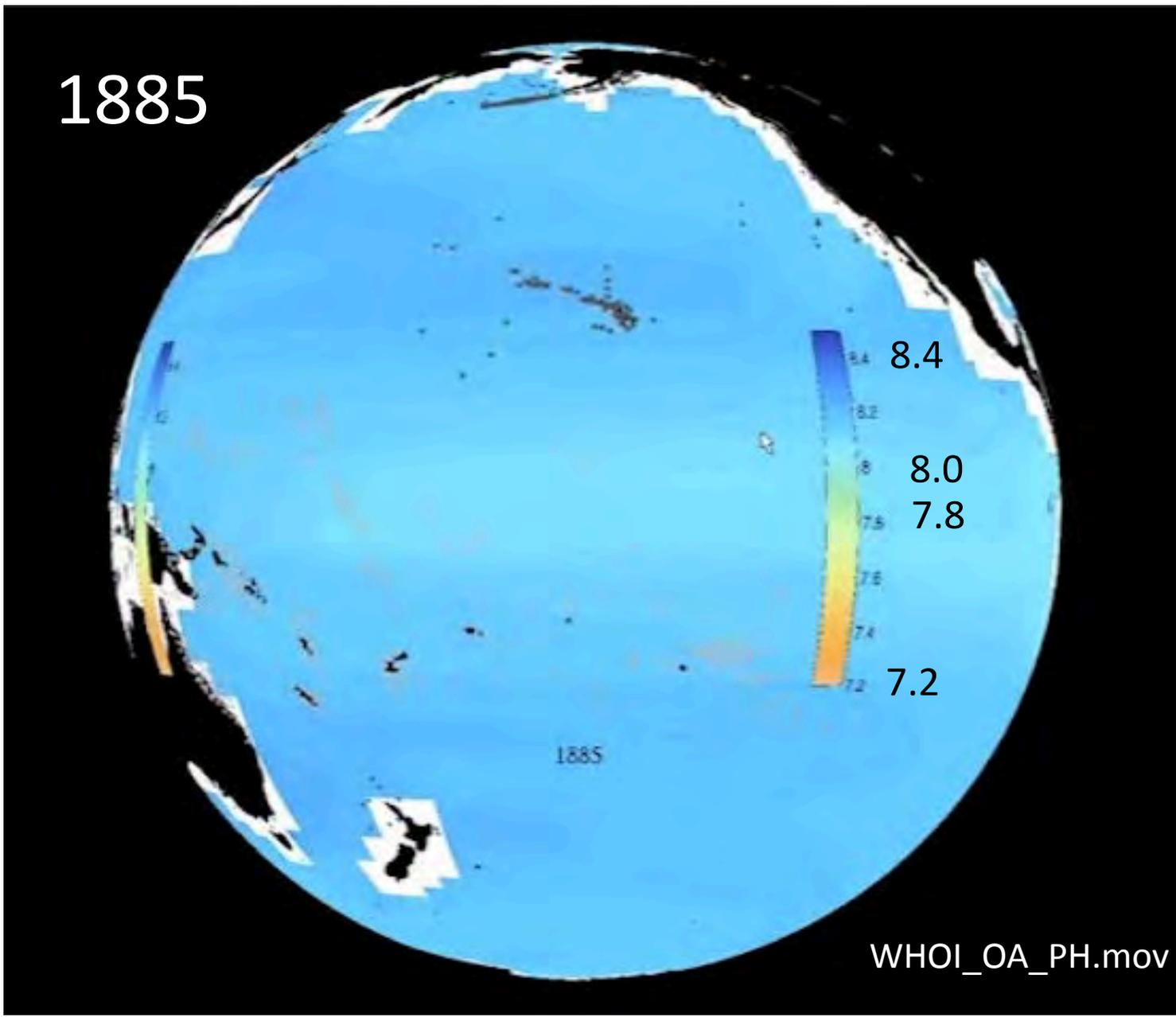
Source: Carol Turley, PML



“People wrote me and said you’re wrong...and I’m going to prove you’re wrong. And I took comfort in that. But the rebuttals never came. As people looked closely at the evidence ... they slowly came to realize that this is a serious issue.”

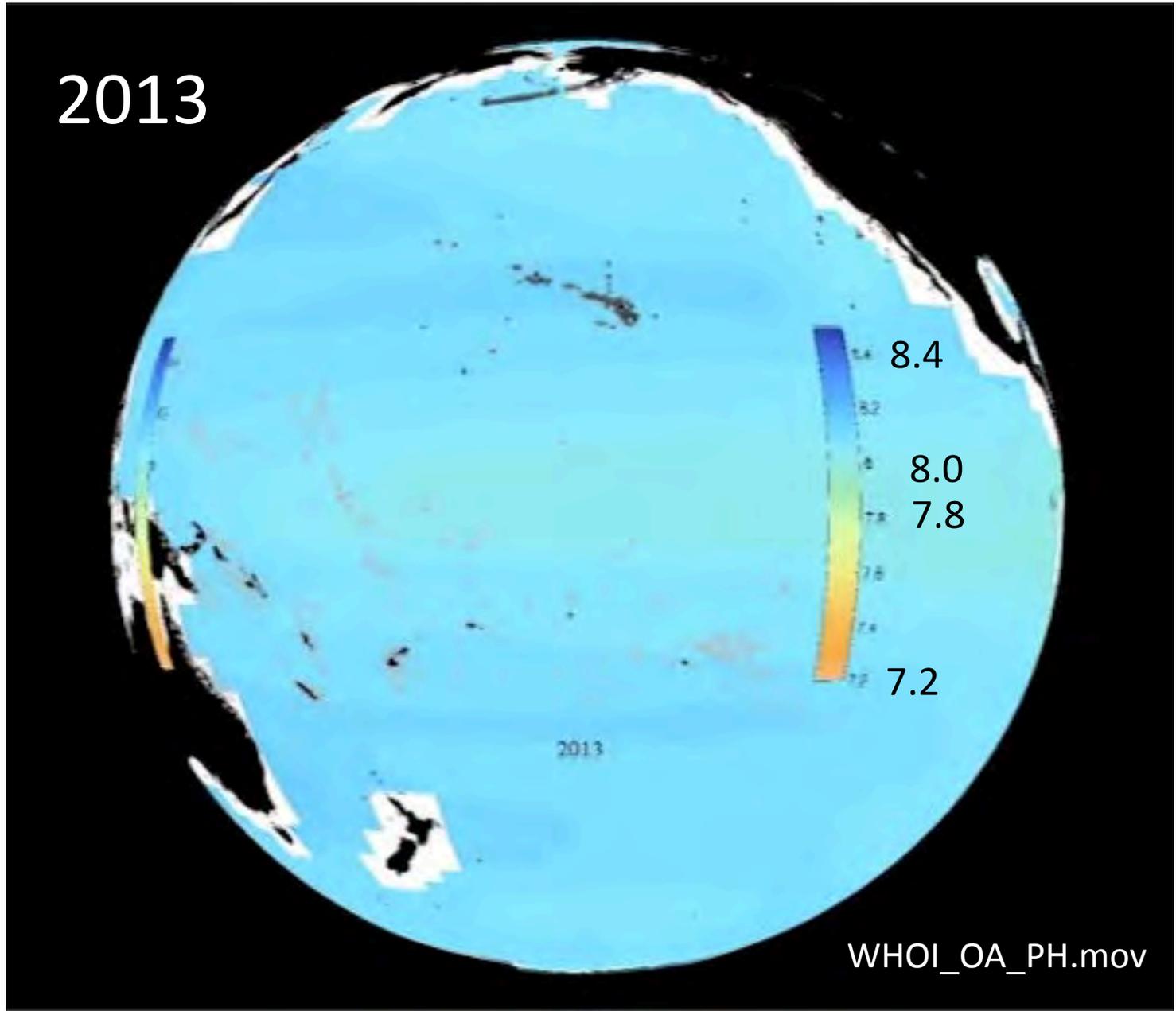
JOANIE KLEYPAS, NCAR

1885



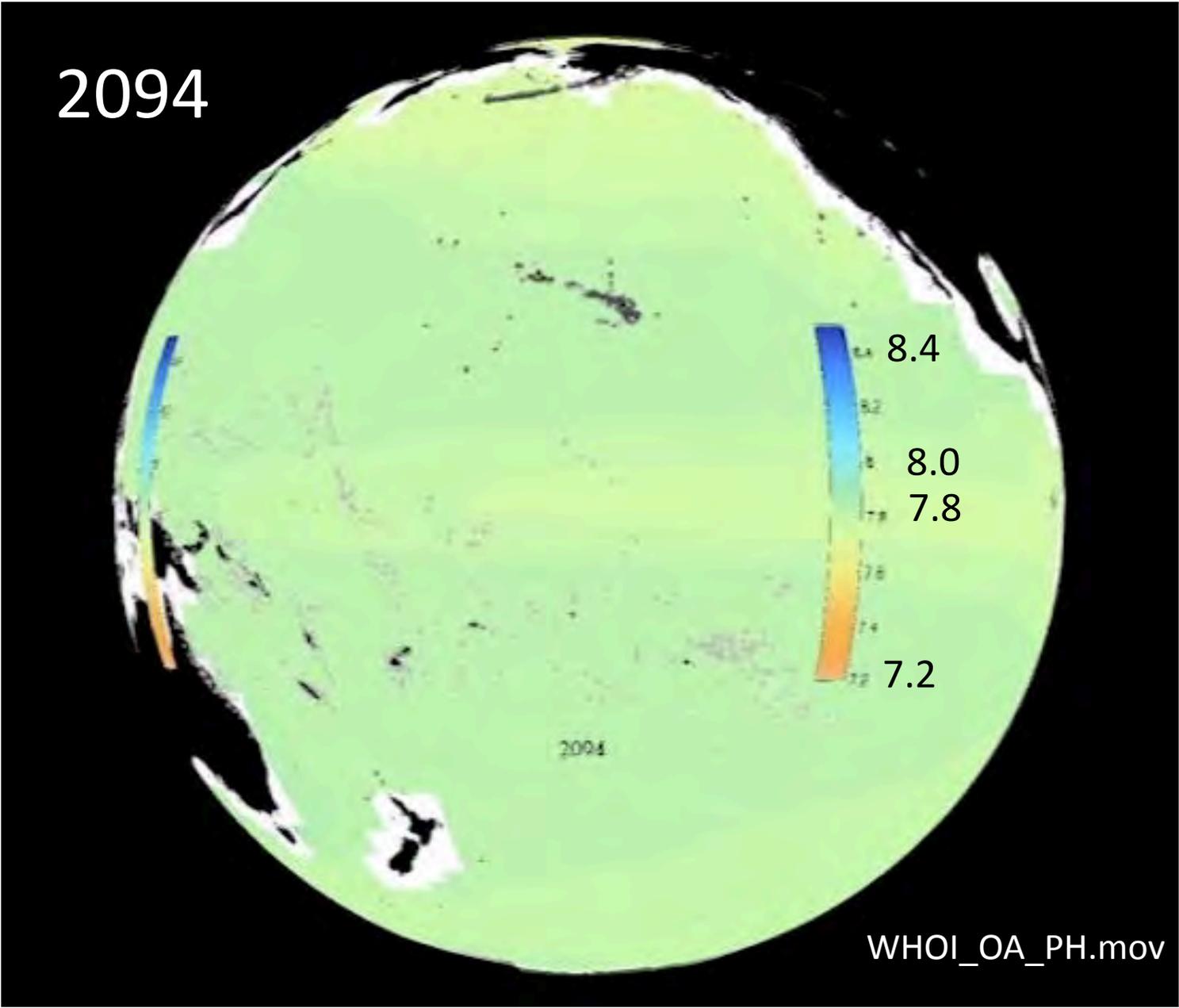
WHOI_OA_PH.mov

2013



WHOI_OA_PH.mov

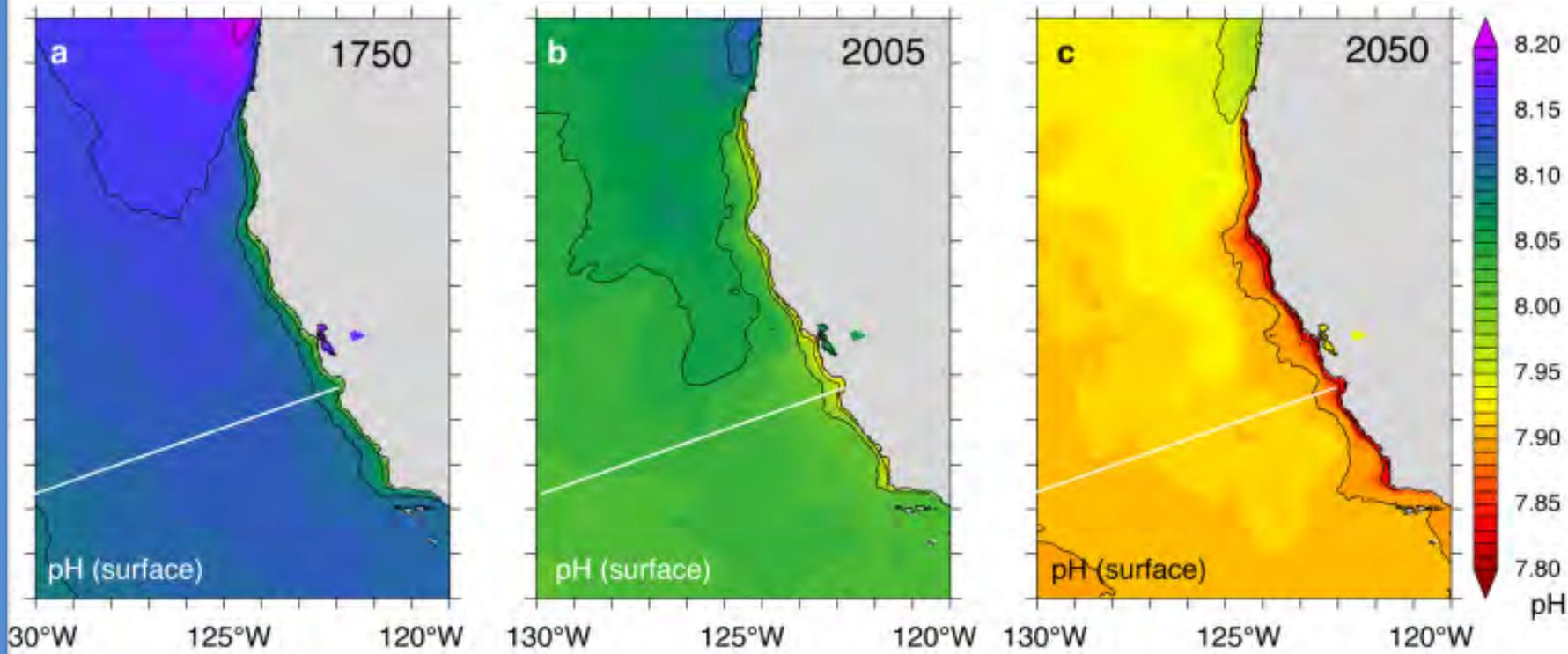
2094



WHOI_OA_PH.mov

Surface pH in the California Current System

Regional Expression of OA



Gruber et al. 2012

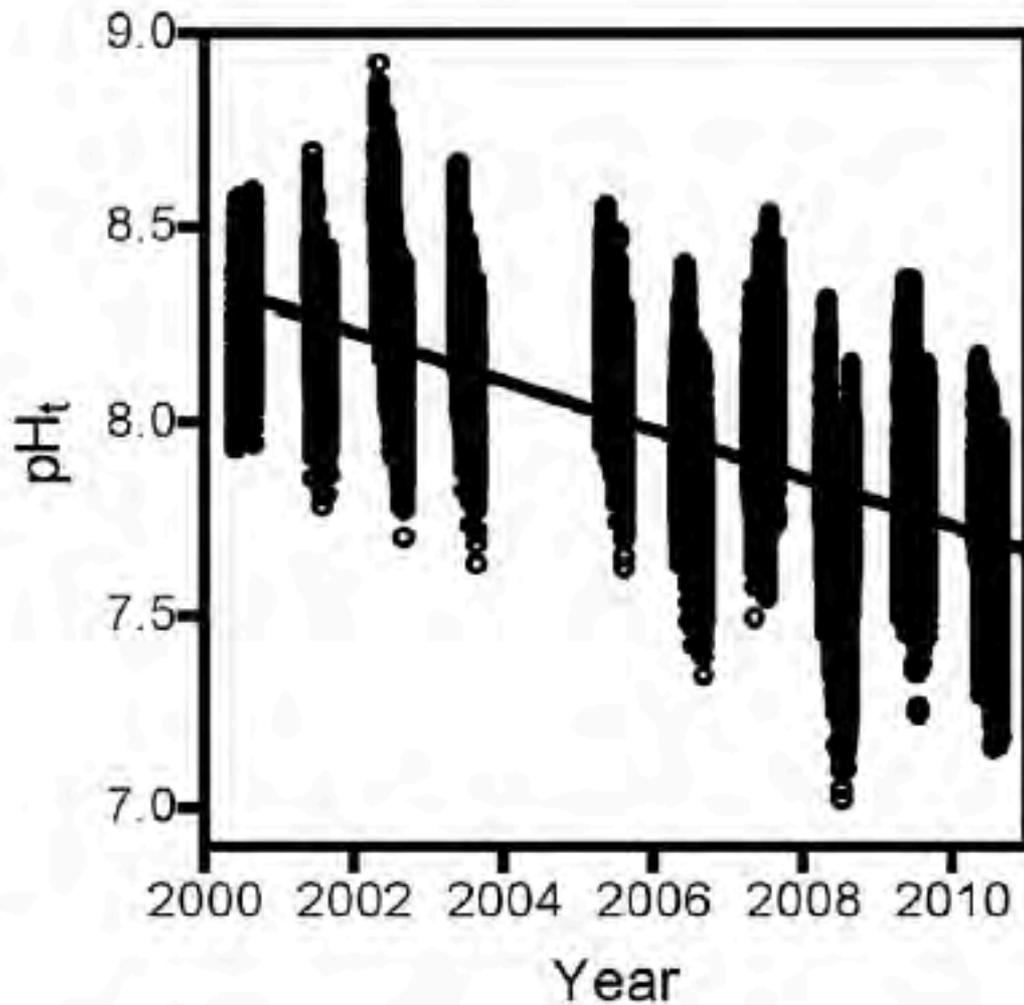


Figure 1. Trends in ocean pH taken from Tatoosh Island, Washington, from 2000-2010, expressed on the total scale. 2004 not reported because of probe failure. N = 37,038. doi:10.1371/journal.pone.0053396.g001

Source: Wootton and Pfister 2012

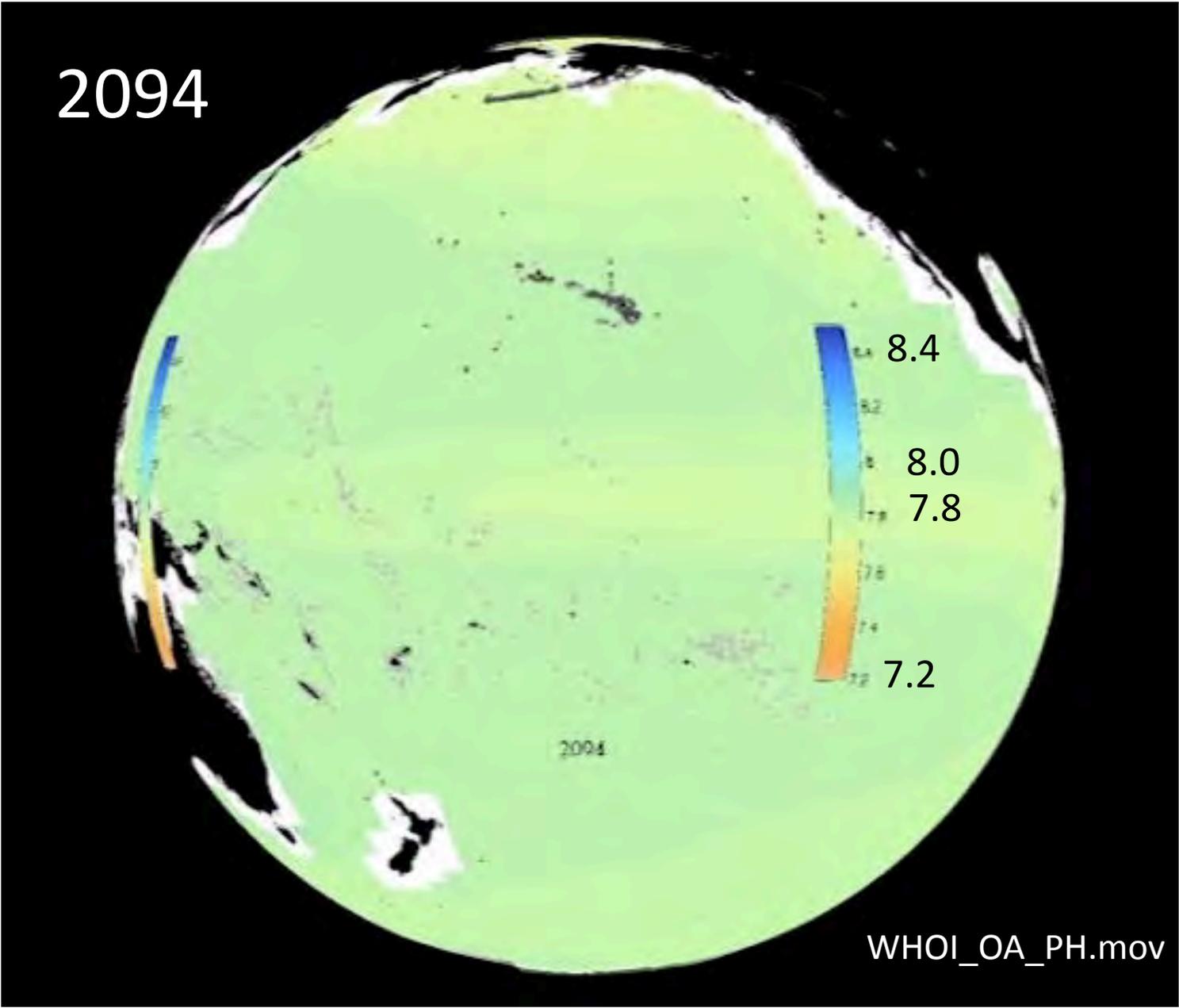
Water Quality Variables Cattle Pass Autumn 2011

Local Expression of OA

South Station					
Measurement	Minimum	Maximum	Average	Standard Deviation	Range
pH	7.59	7.78	7.71	0.05	0.18
pCO₂ (µatm)	750.28	1192.88	912.05	120.63	442.61
Calcite	1.04	1.52	1.31	0.14	0.49
Aragonite	0.65	0.96	0.82	0.09	0.30
Dissolved Oxygen (mg/L)	3.77	8.14	5.56	1.17	4.37
Salinity (ppt)	29.82	32.87	31.28	1.05	3.05
Temperature (C)	7.94	10.30	9.01	0.71	2.35
Anthropogenic DIC	10.07	16.40	13.60	1.84	6.32

Data Source: Connie Sullivan, UW

2094



WHOI_OA_PH.mov

Washington is Particularly Vulnerable to Acidification

Ocean acidification is appearing in Washington decades *sooner* than anticipated.

A combination of regional factors can exacerbate acidification caused by global CO₂ emissions:

- Coastal upwelling** of CO₂-rich waters
- Runoff** of nutrients and organic carbon from land-based activities
- Decay of organic matter** in subsurface waters
- Emissions** of acidifying gasses (NO_x and SO_x)



Source: WA Dept Ecology

Washington Coast; Photo: Russ McMillan



New Instruments and Observing Capacity (NOAA and UW)



New Experimental Facilities at Friday Harbor, Shannon Point, and NOAA Seattle

Regional Efforts



Washington State Panel Reports

Regional Efforts

NOAA OAR Special Report

Washington Shellfish Initiative
Blue Ribbon Panel on Ocean Acidification

Scientific Summary of Ocean Acidification in Washington State Marine Waters



Ocean Editors

Richard A. Feely NOAA Pacific Marine Environmental Laboratory
Terrie Klinger University of Washington School of Marine & Environmental Affairs
Jan A. Newton University of Washington Applied Physics Laboratory
Meg Chadsey Washington Sea Grant

Advance Copy - November 2012

Washington State Blue Ribbon Panel on Ocean Acidification



Ocean Acidification: From Knowledge to Action

Washington State's Strategic Response



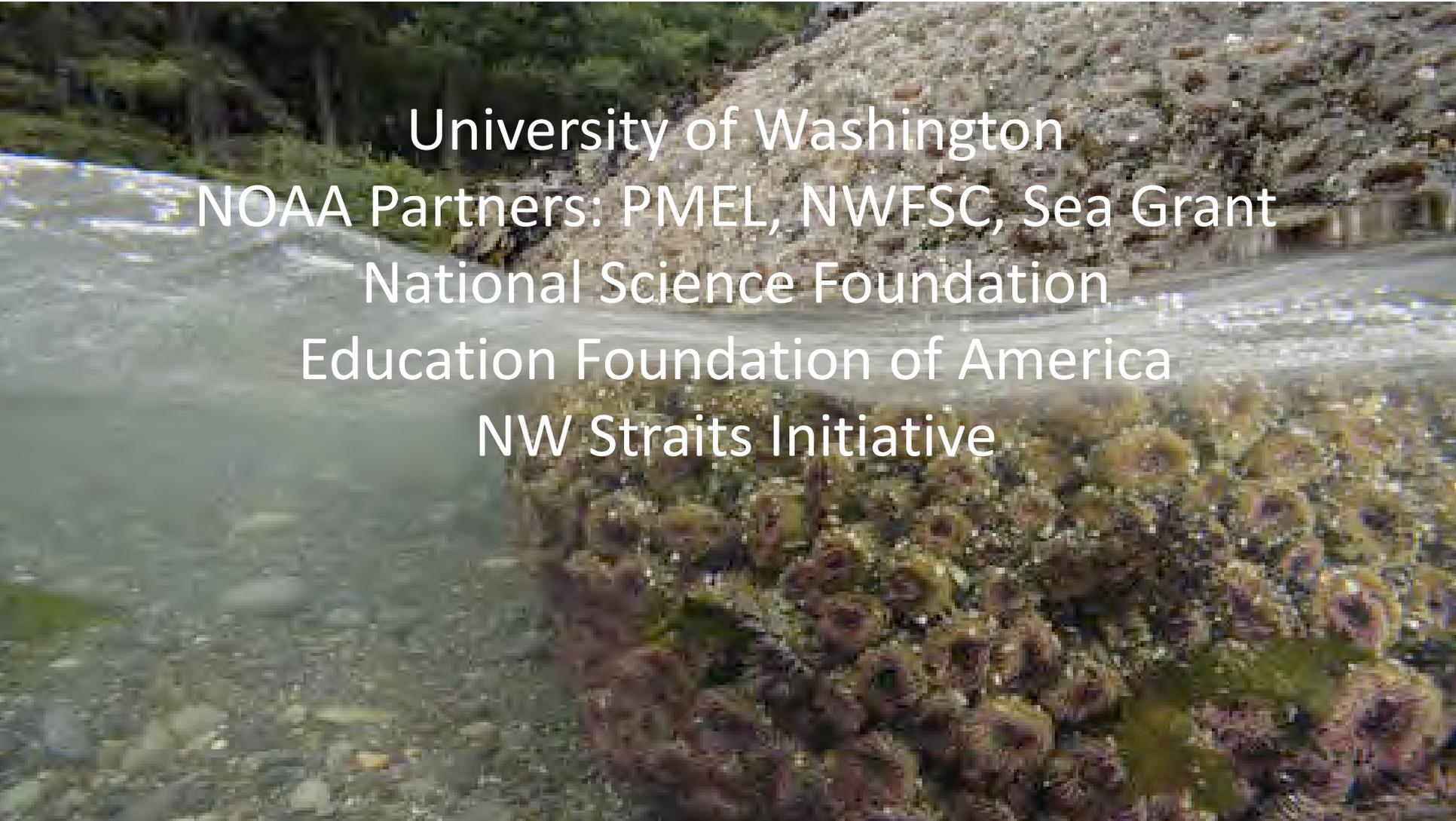
November 2012

<http://www.ecy.wa.gov/water/marine/oceanacidification.html>

Three Big Challenges in OA Research

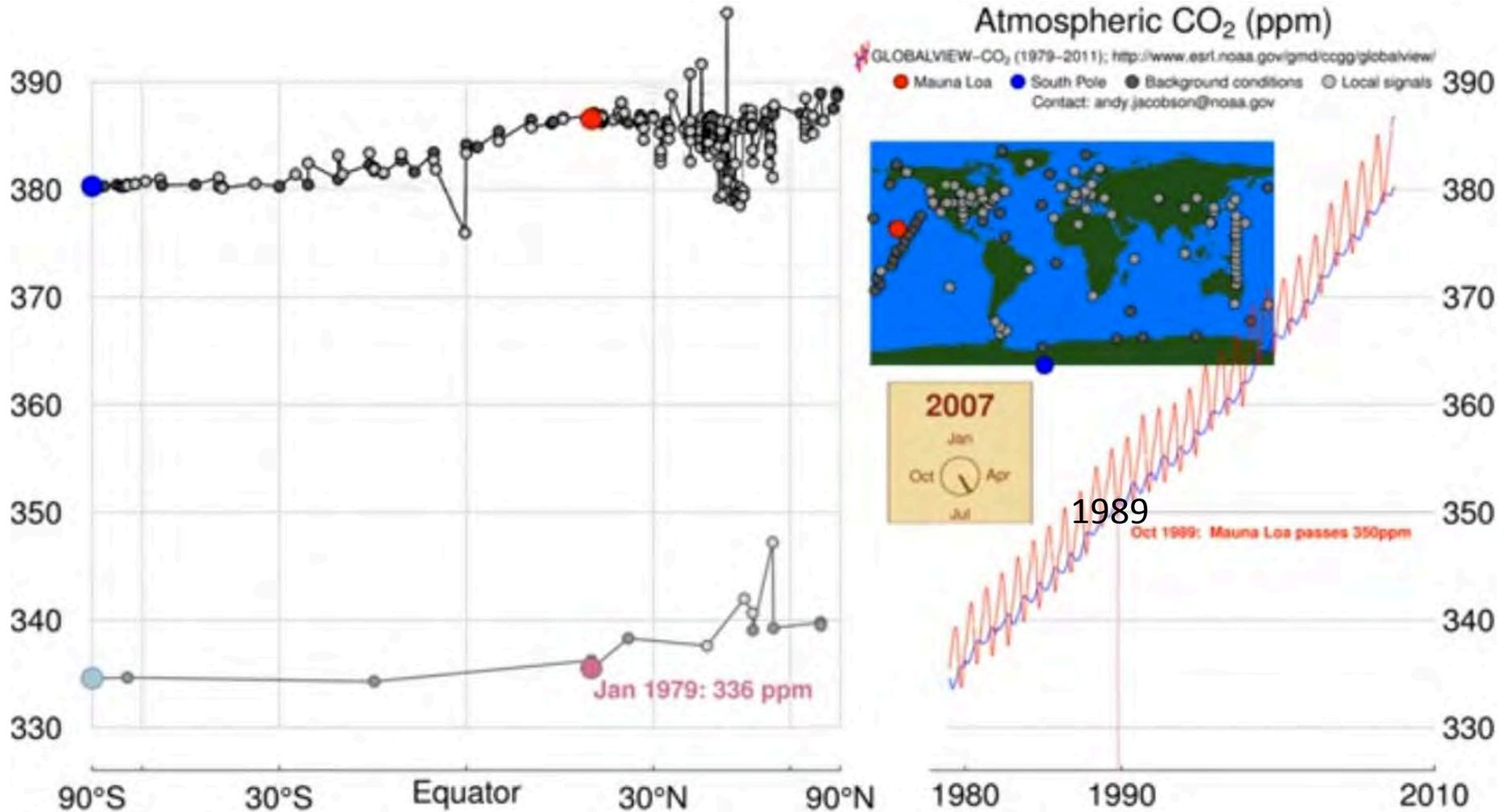
1. Describe local and regional conditions
1. Identify biological & ecological responses
1. Mitigate societal impacts

Acknowledgements

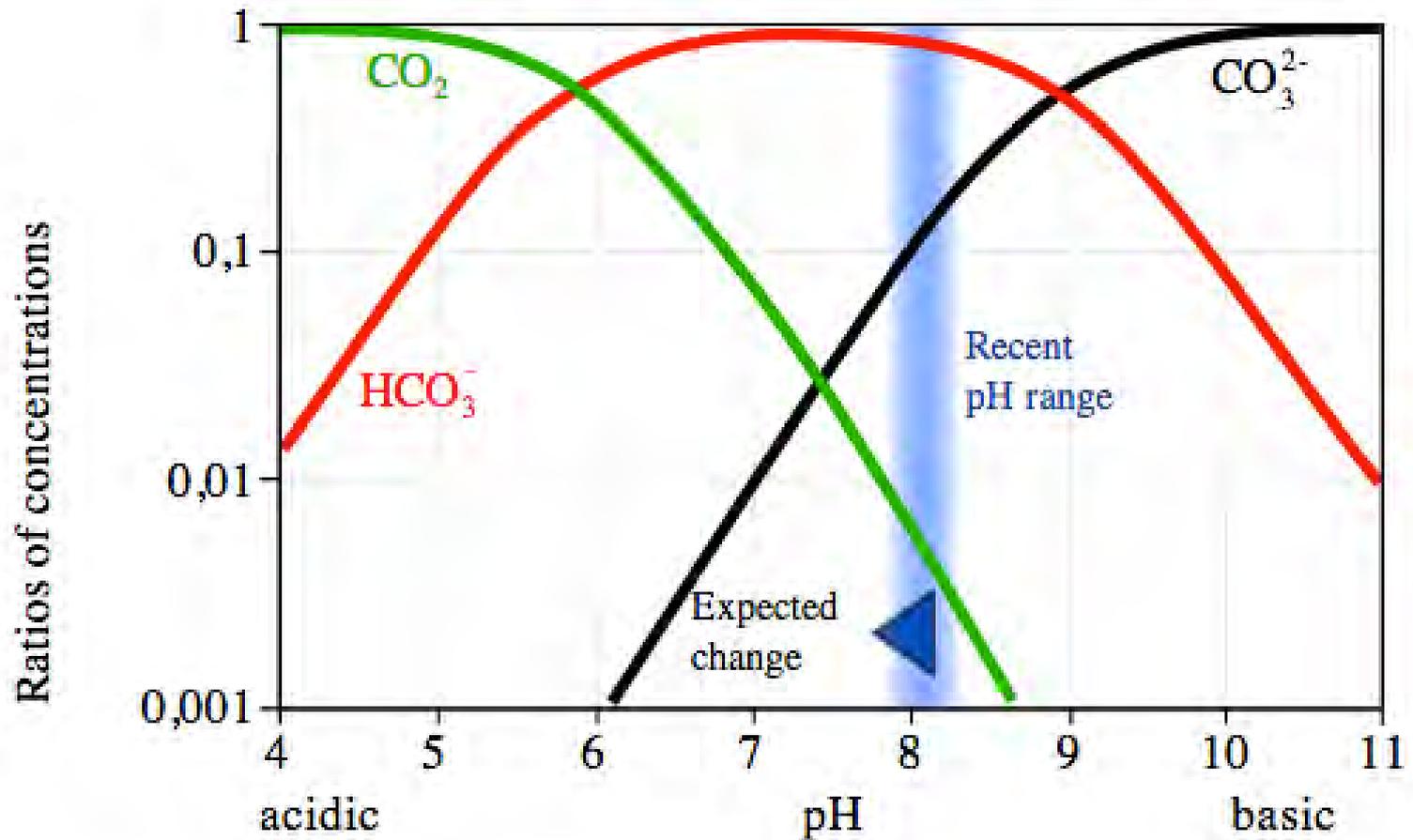


University of Washington
NOAA Partners: PMEL, NWFSC, Sea Grant
National Science Foundation
Education Foundation of America
NW Straits Initiative

Time history of atmospheric carbon dioxide from 800,000 years ago until 2007



Seawater Carbonate System



OCEAN ACIDIFICATION

HOW WILL CHANGES IN OCEAN CHEMISTRY AFFECT MARINE LIFE?

CO₂ absorbed from the atmosphere



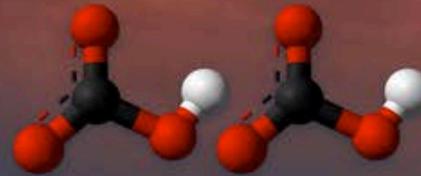
carbon dioxide



water



carbonate ion



2 bicarbonate ions

consumption of carbonate ions impedes calcification

