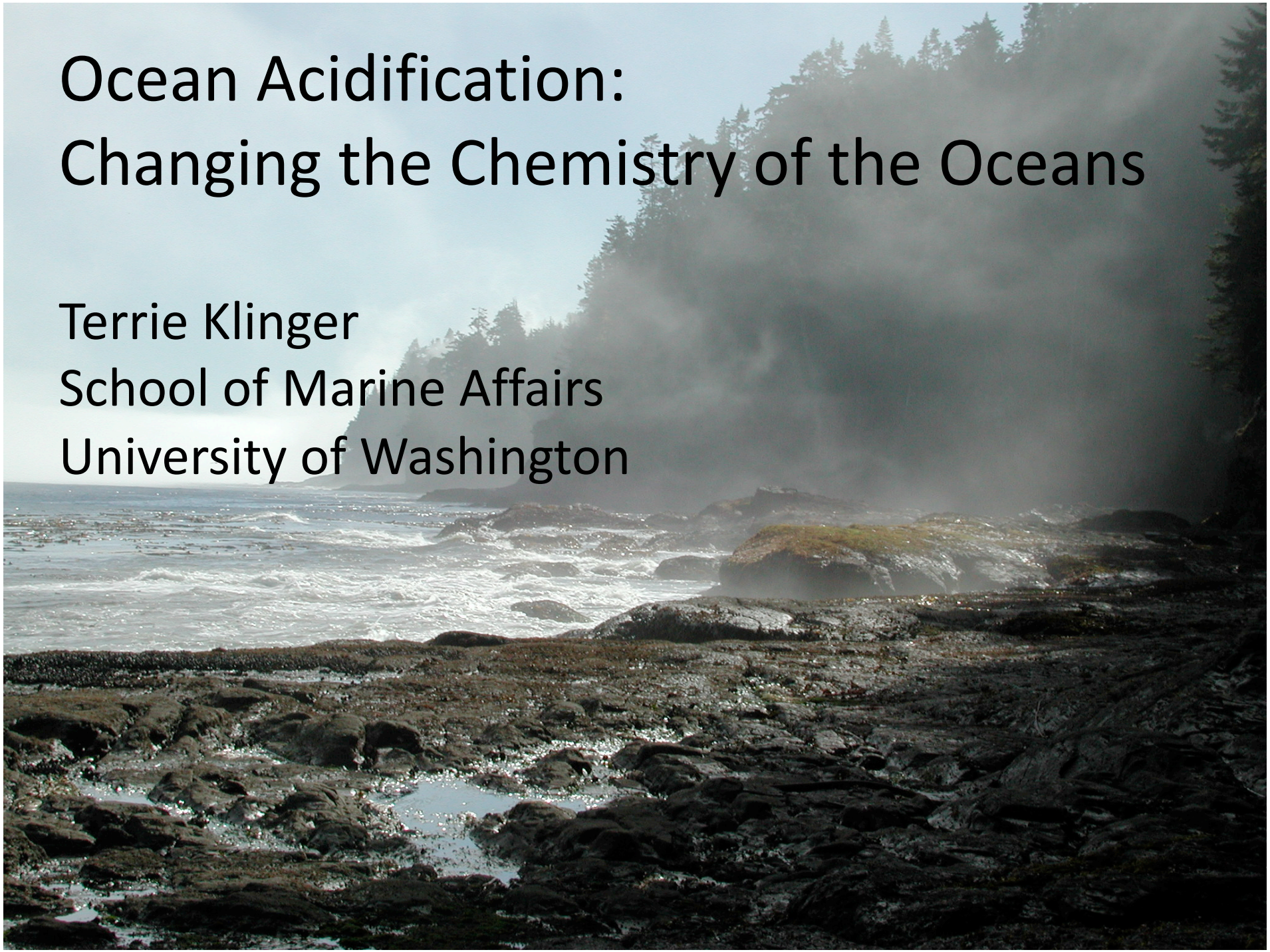
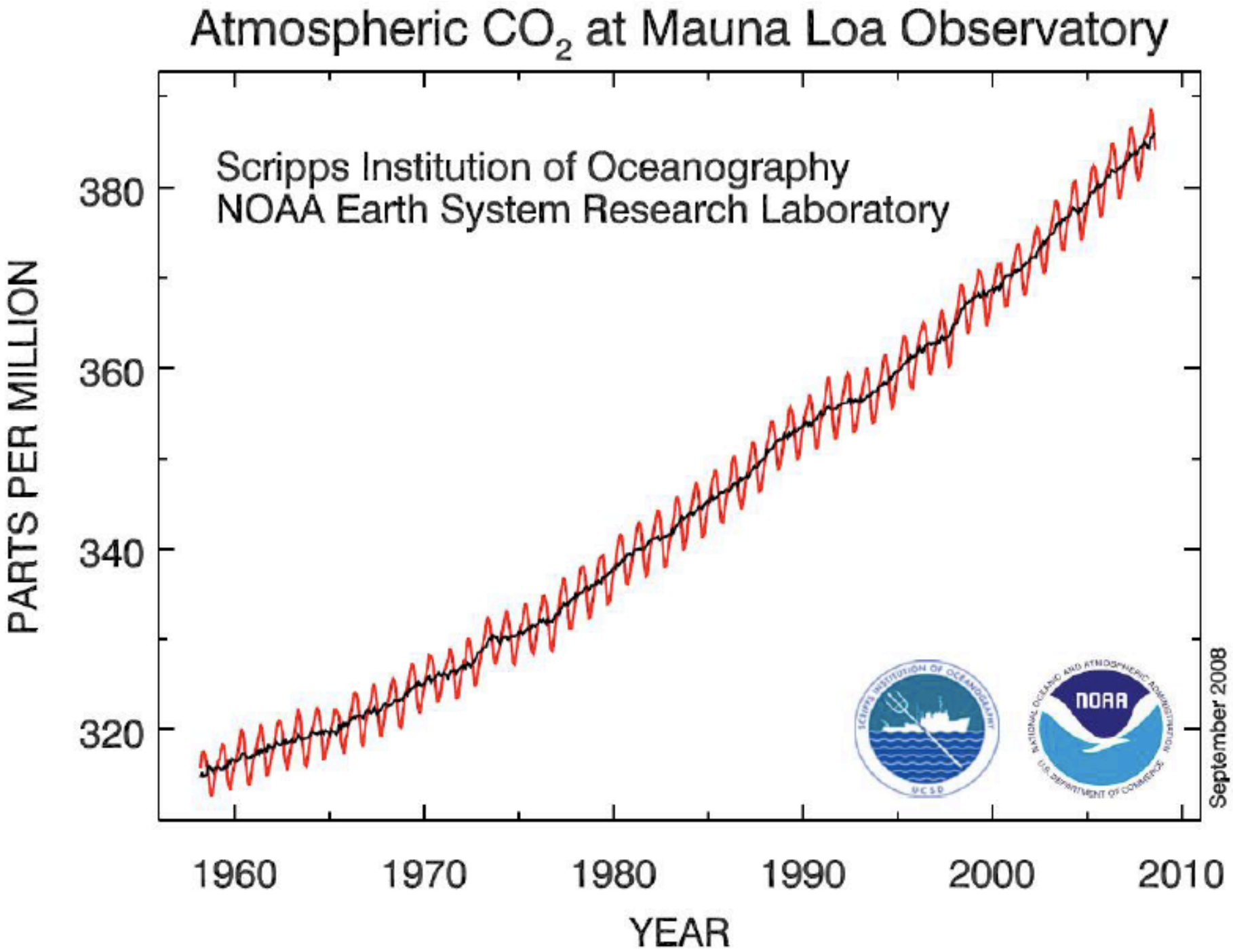
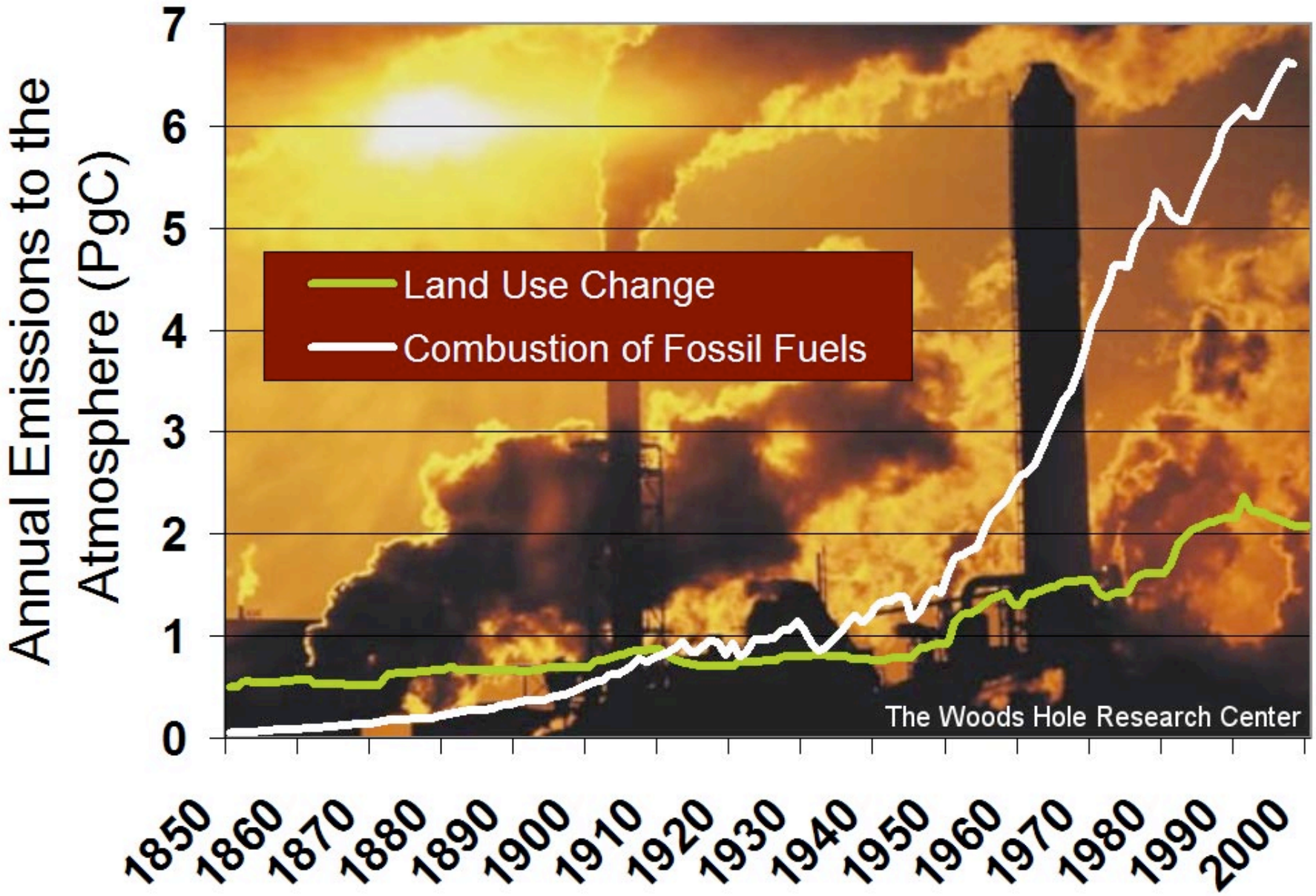
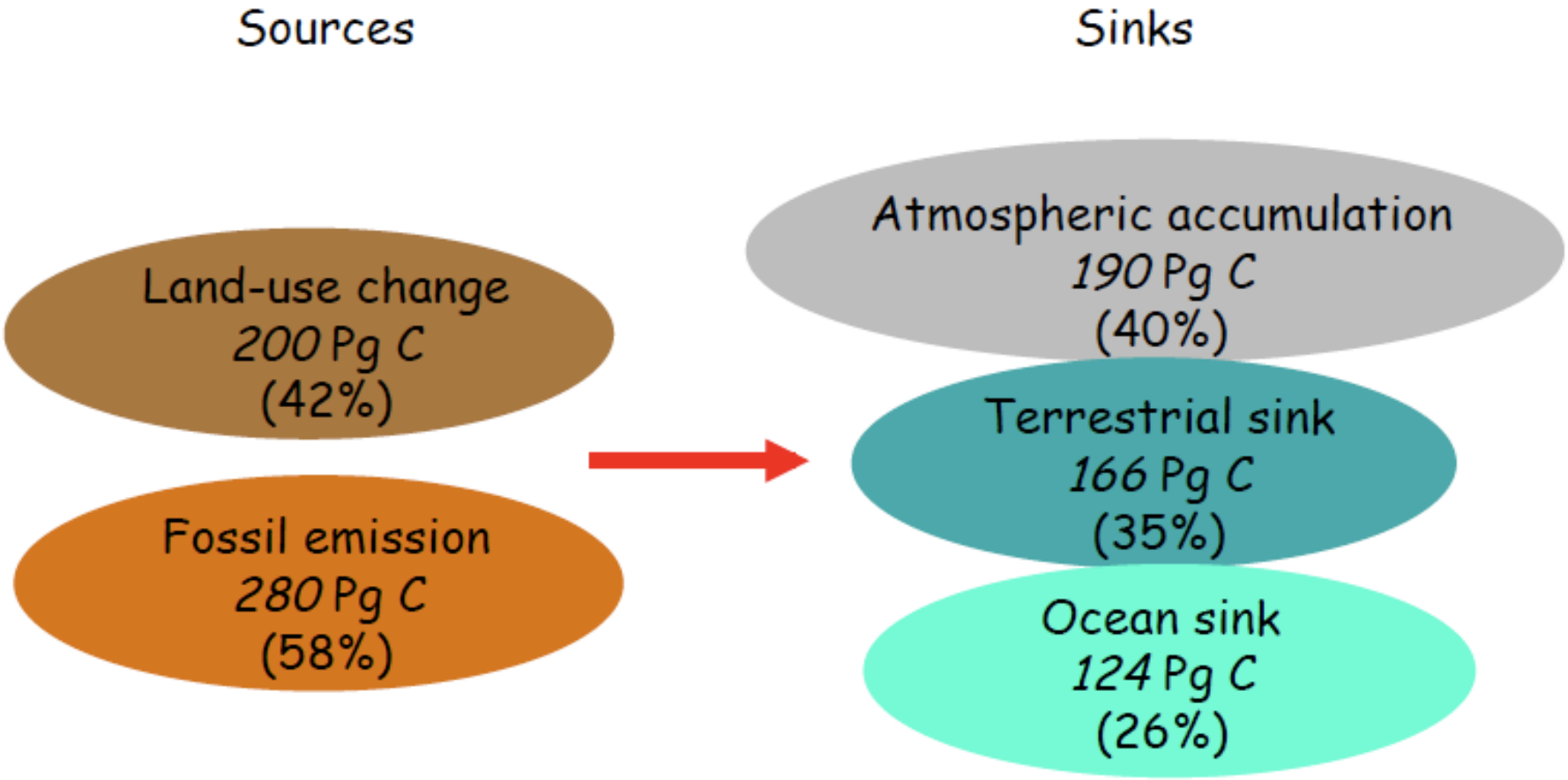


Ocean Acidification: Changing the Chemistry of the Oceans

Terrie Klinger
School of Marine Affairs
University of Washington

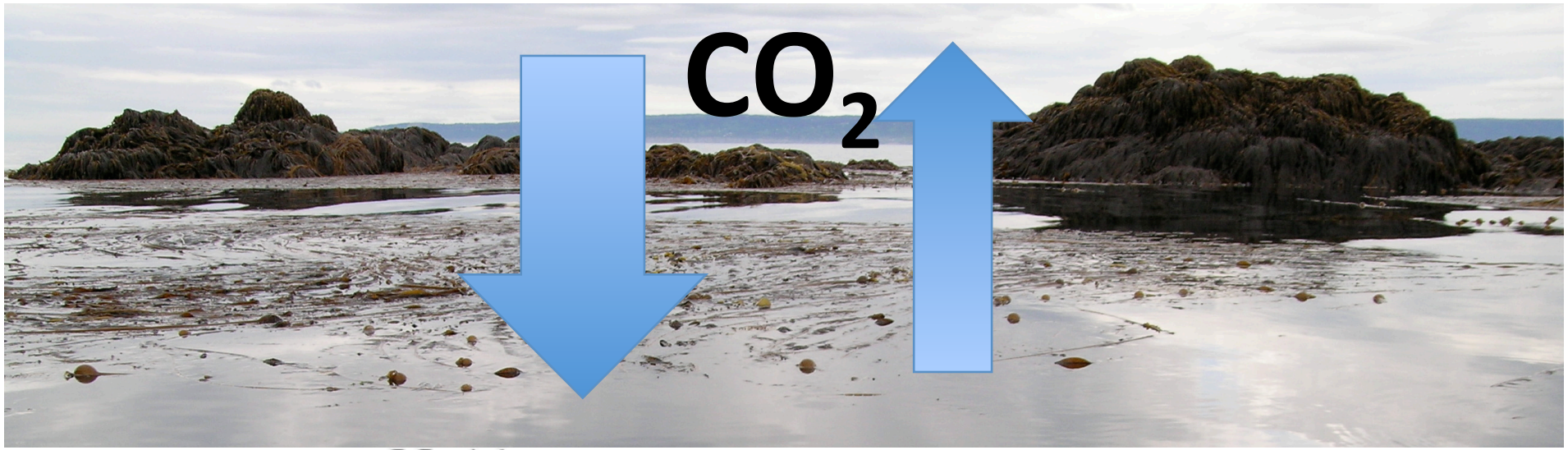

Atmospheric CO_2 at Mauna Loa Observatory
Scripps Institution of Oceanography
NOAA Earth System Research Laboratory
PARTS PER MILLION
380
360
340
320
1960
1970
1980
1990
2000
2010
YEAR
September 2008


Annual Emissions to the Atmosphere (PgC)
7
6
5
4
3
2
1
0
Land Use Change
Combustion of Fossil Fuels
The Woods Hole Research Center
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000



House et al. (2002) GCB

Feely 2008



Air

CO_2 (g)

Sea Water

CO_2 (aq) + H_2O ⟷ H_2CO_3 ⟷ $H^+ + HCO_3^-$

$H^+ + HCO_3^- \rightarrow H_2O$

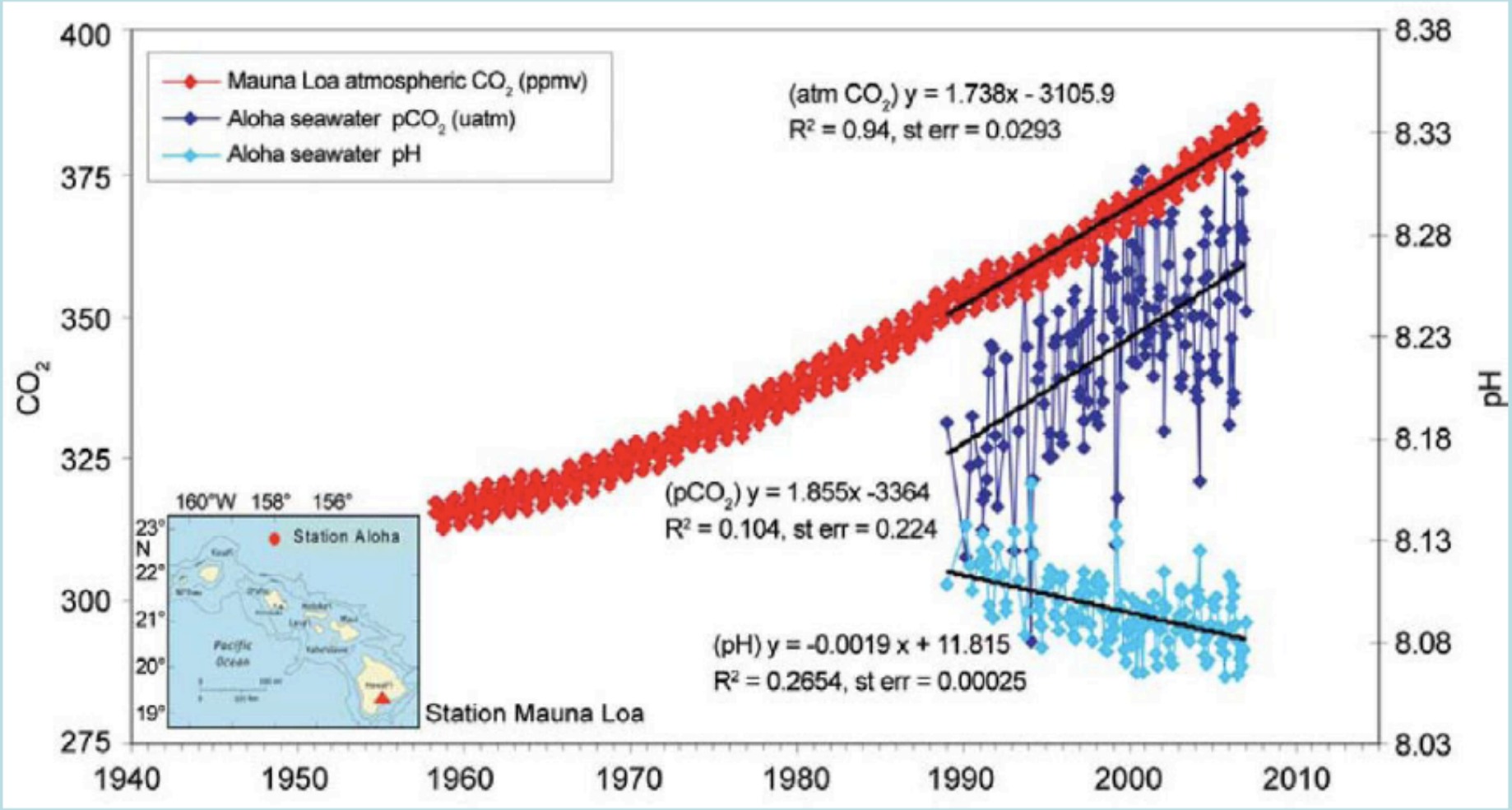
$CO_3^{2-} + H_2O$ ⟷ $OH^- + HCO_3^-$

$CaCO_3$ (s) (marine organisms) ⟷ CO_3^{2-} + Ca^{2+}

Sea bed – Rock, Soil, Sediments

$CaCO_3$ (s)

Atmospheric CO_2 at Mauna Loa (ppmv) and **surface ocean pH** and pCO_2 (µatm) at Ocean Station Aloha in the subtropical North Pacific Ocean. (Feely 2008)



Mauna Loa data: Dr. Pieter Tans, NOAA/ESRL, www.esrl.noaa.gov/gmd/ccgg/trends; HOTS/Aloha data: Dr. David Karl, University of Hawaii, http://hahana.soest.hawaii.edu. **Graph excerpted from: Feely, R.A. 2008**. "Ocean Acidification." In: *State of the Climate in 2007*. Available at: http://www.ncdc.noaa.gov/oa/climate/research/2007/ann/bams/

Long-term change in seawater pH

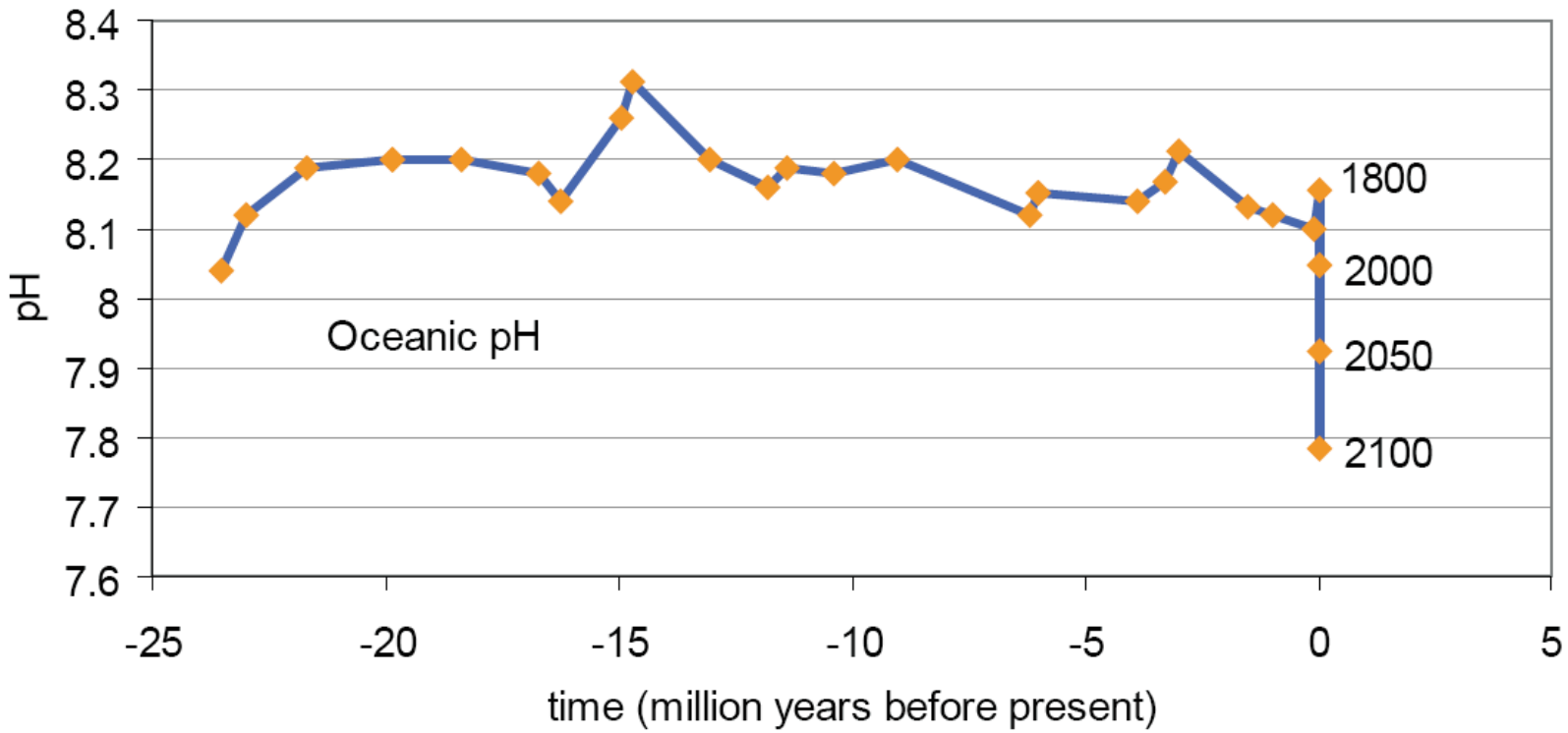
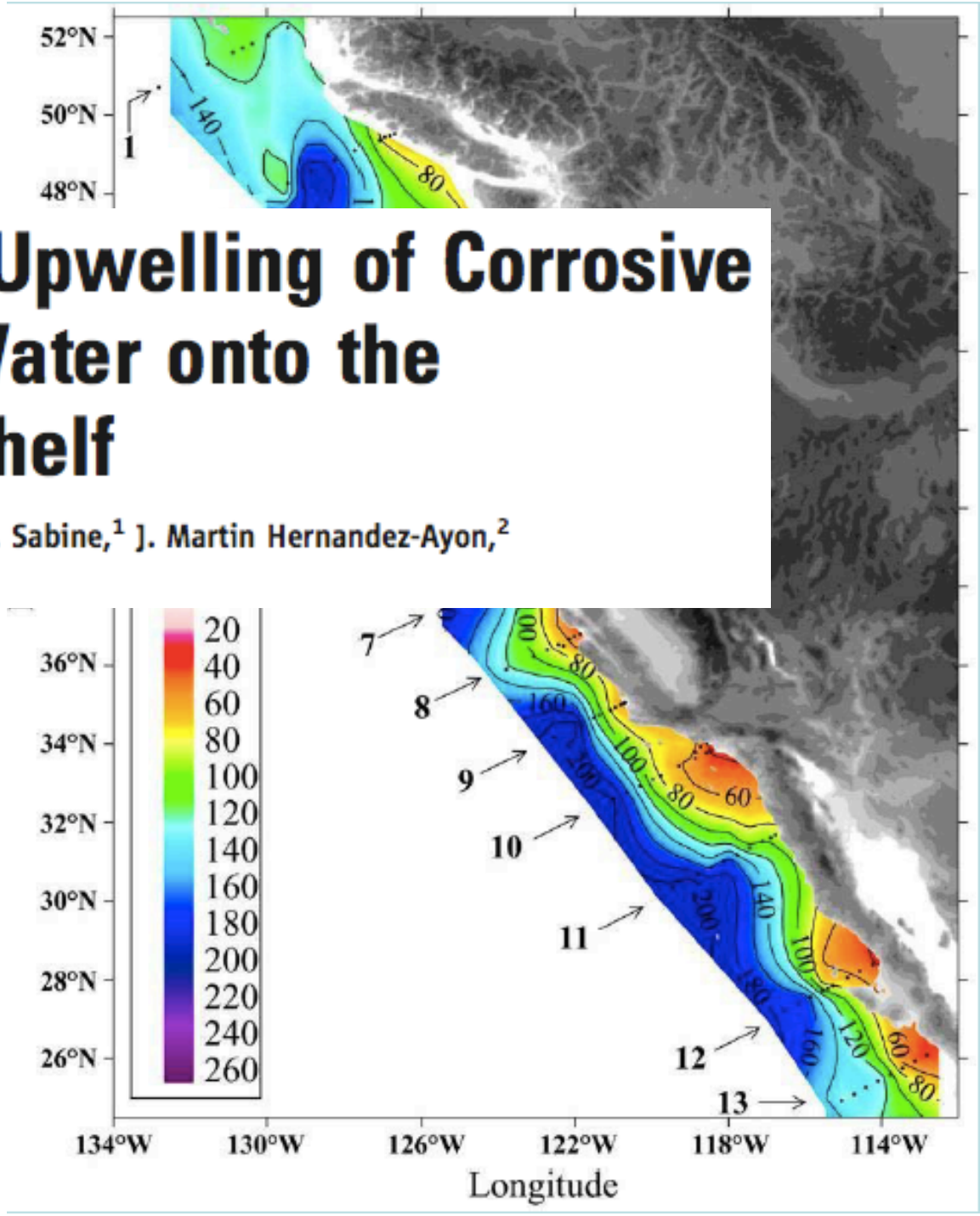


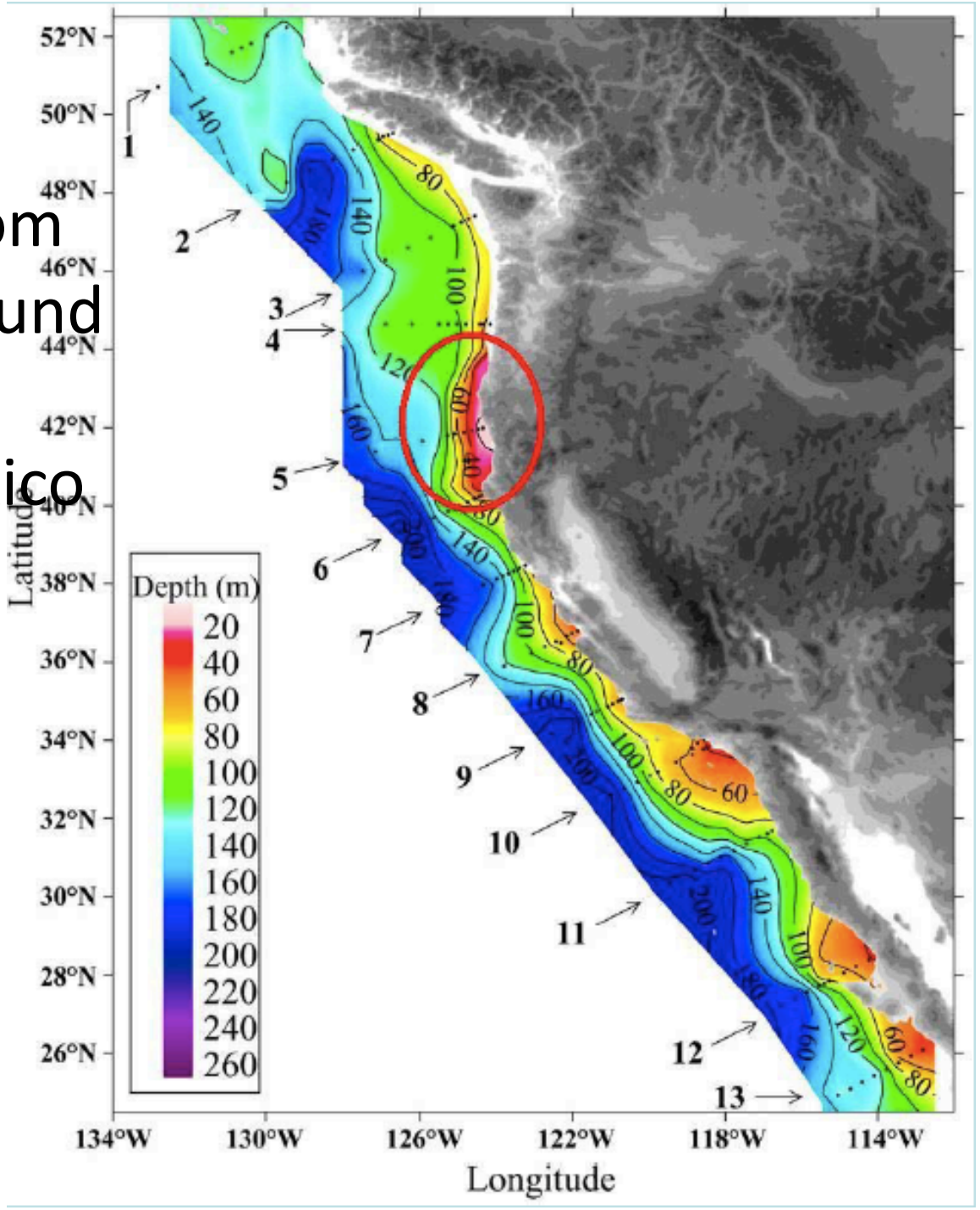
Figure 1. Past and contempory variability of marine pH. Future predictions are model derived values based on IPCC mean scenarios (from Turley *et al*, 2006. Cambridge University Press, 8, 65-70).

Evidence for Upwelling of Corrosive "Acidified" Water onto the Continental Shelf

Richard A. Feely,[1*] Christopher L. Sabine,[1] J. Martin Hernandez-Ayon,[2] Debby Ianson,[3] Burke Hales[4]

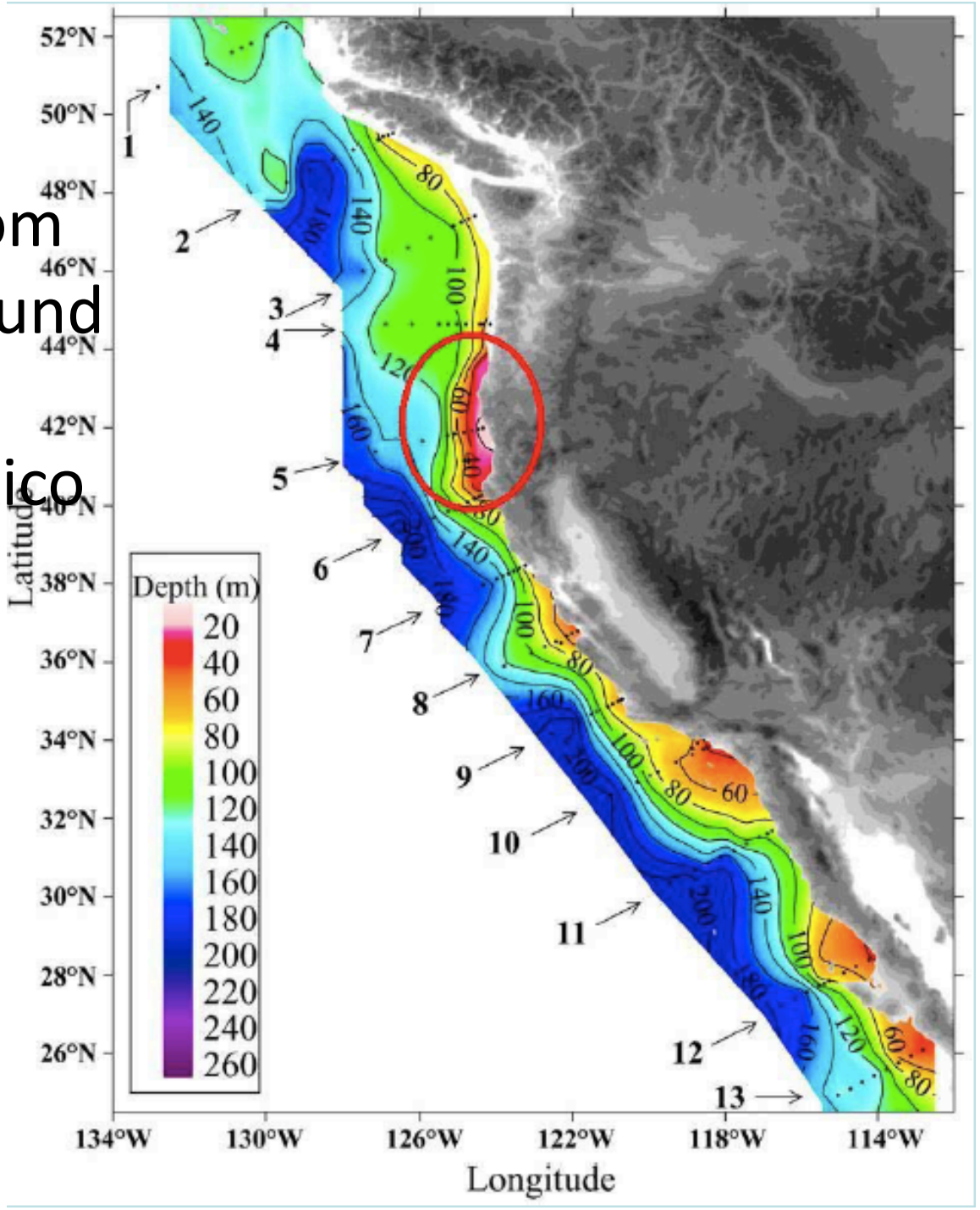


Corrosive water on continental shelf from Queen Charlotte Sound to Baja California, Mexico

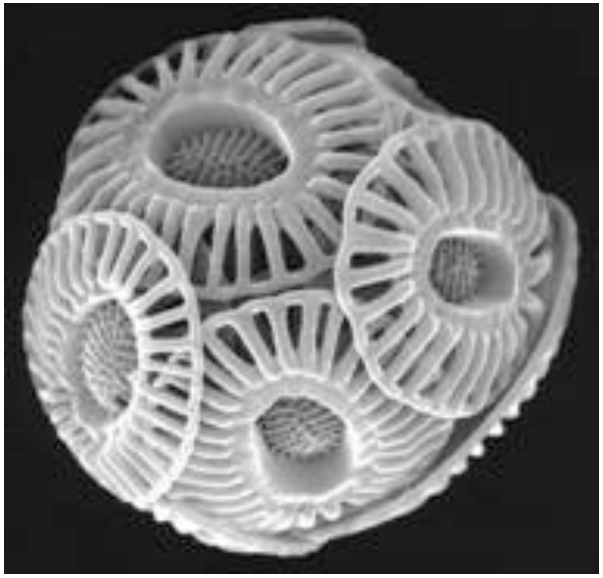


Corrosive water on continental shelf from Queen Charlotte Sound to Baja California, Mexico

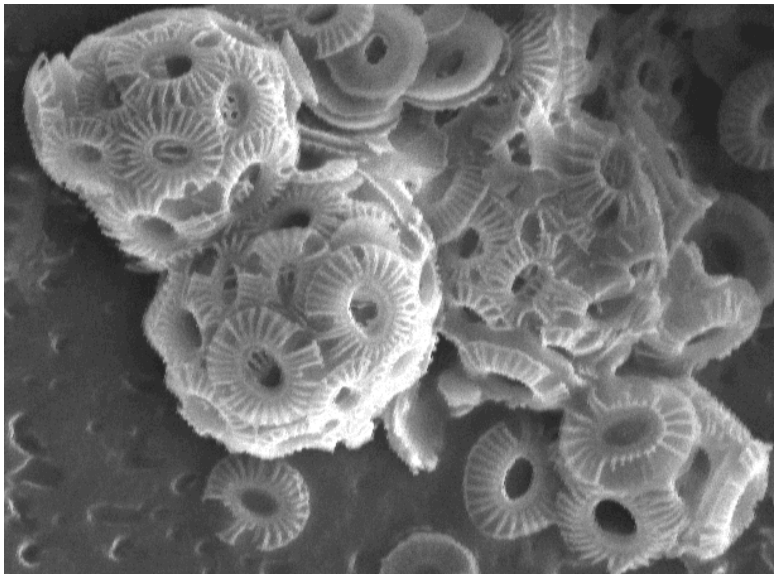
Corrosive water reaches surface in Oregon, northern California



normal coccolithophorid

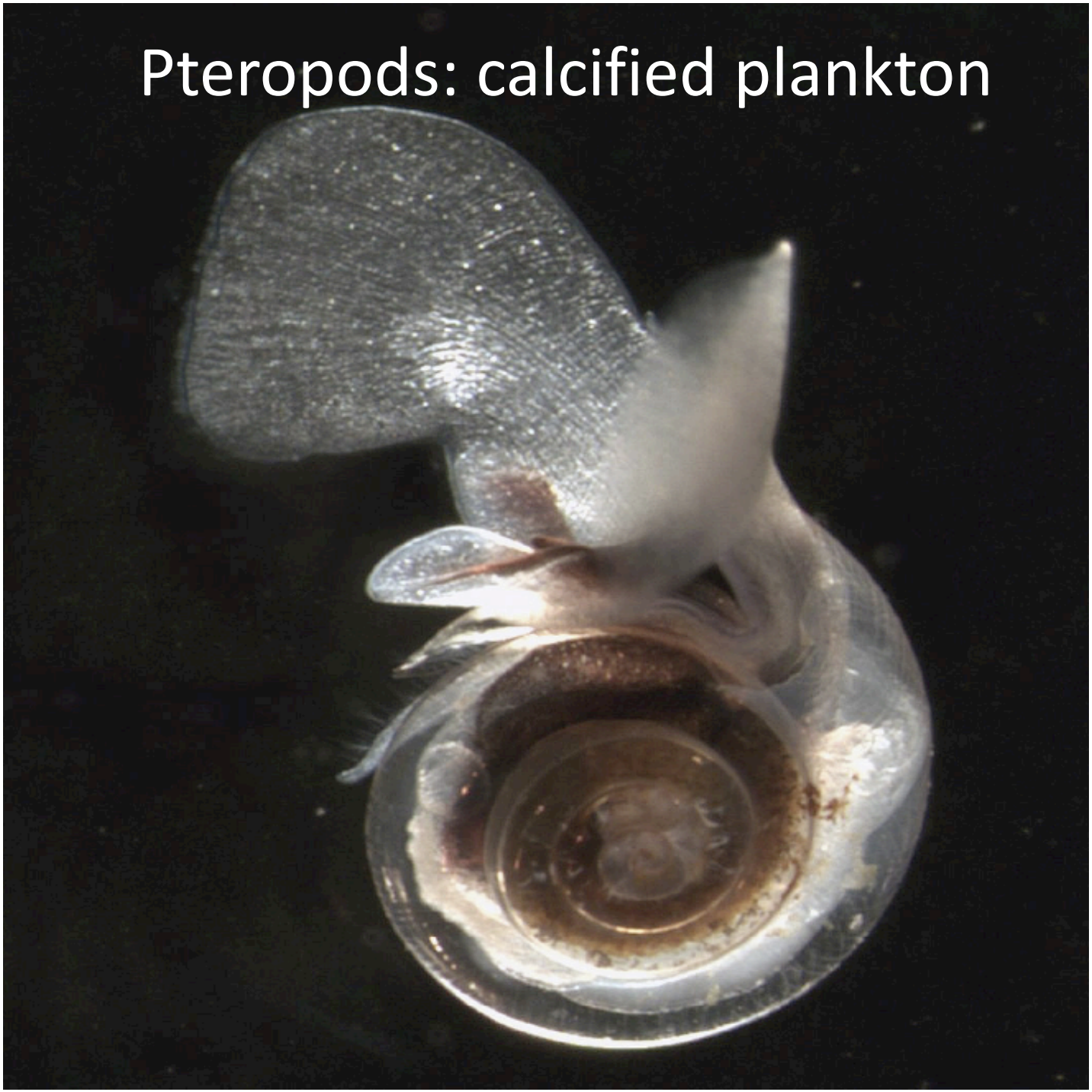


coccolithophorids
at low pH

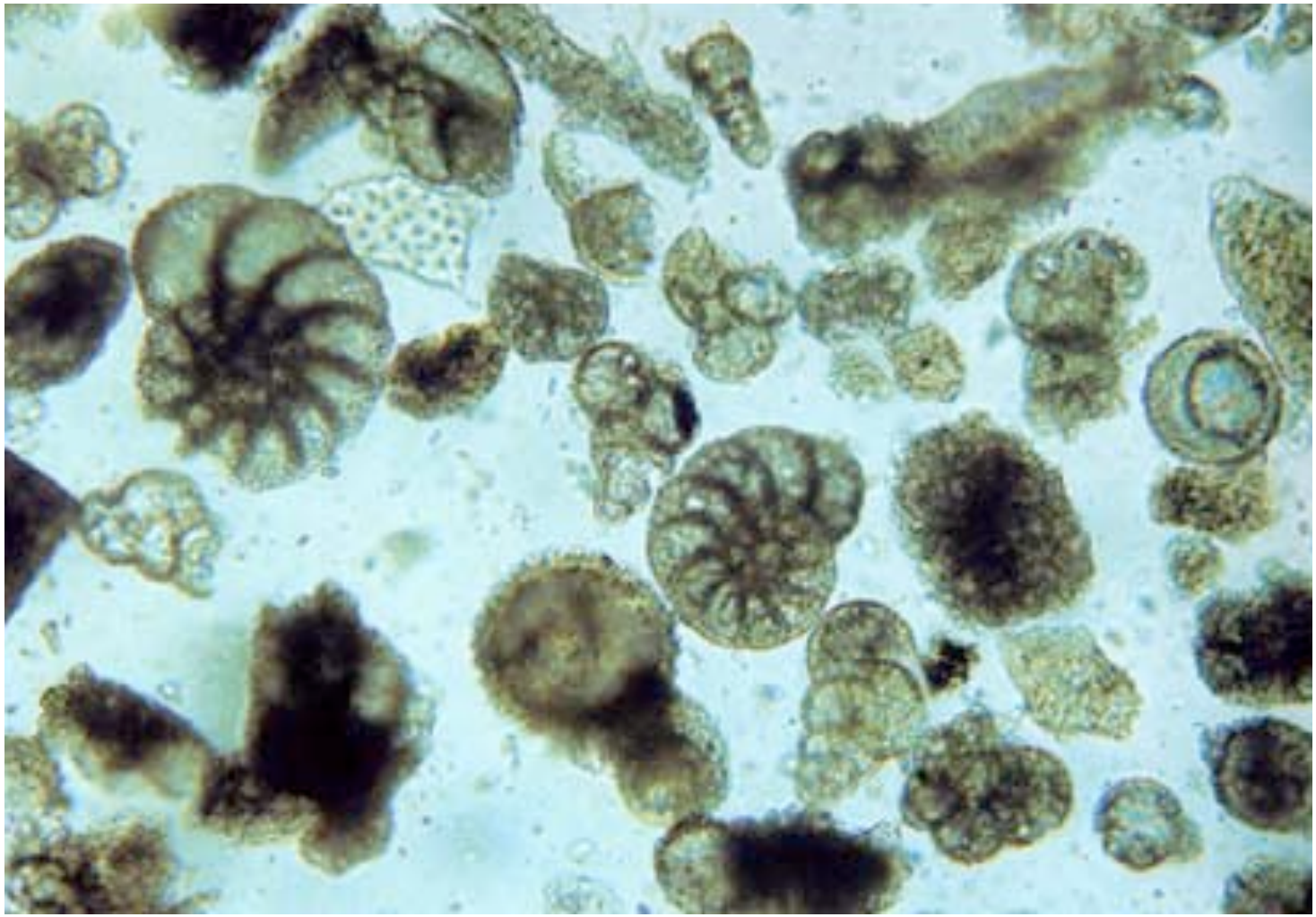


Riebesell et al. 2000

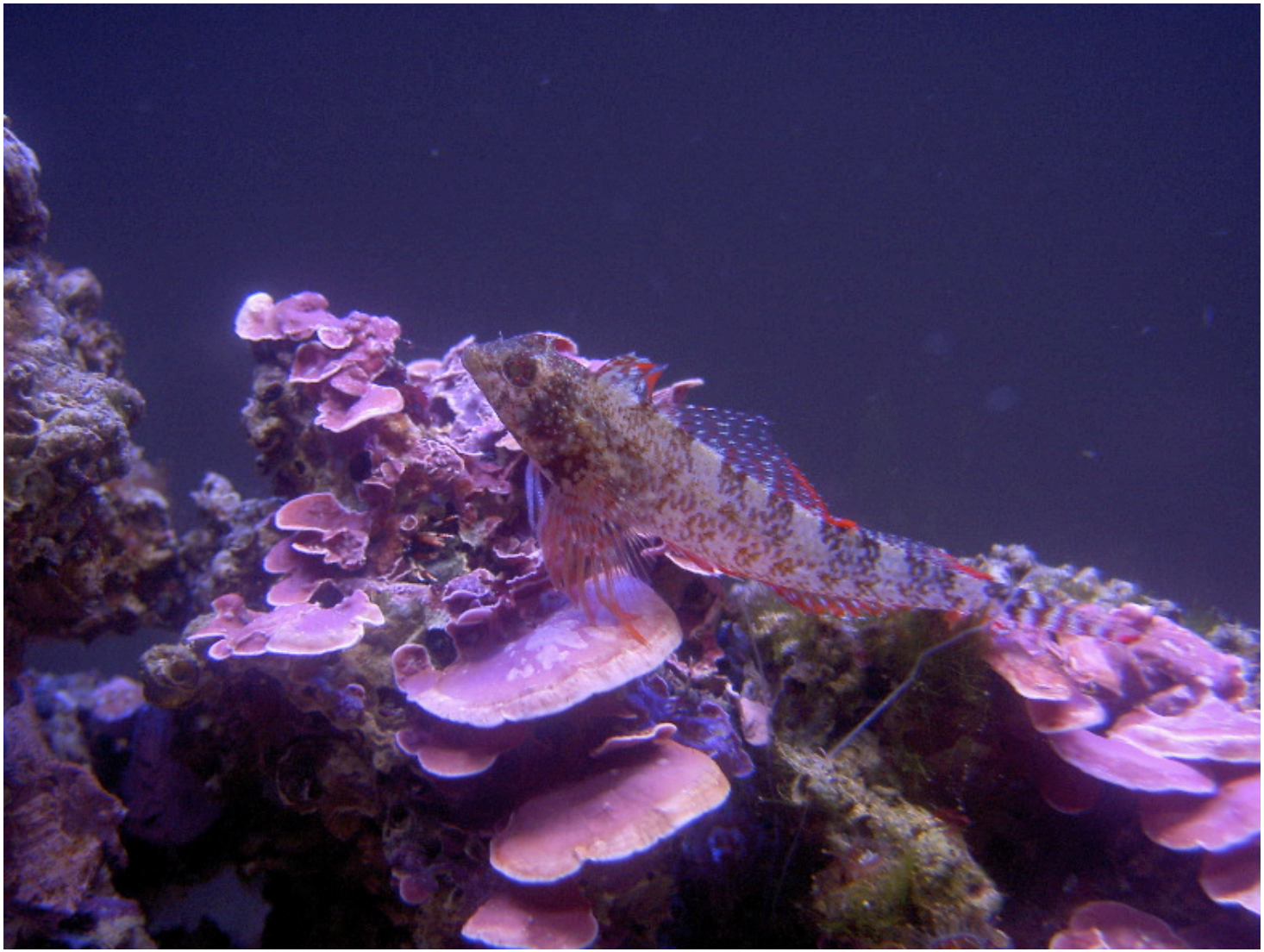
Pteropods: calcified plankton



Calcified foraminifera benthic and planktonic



Calcified red algae

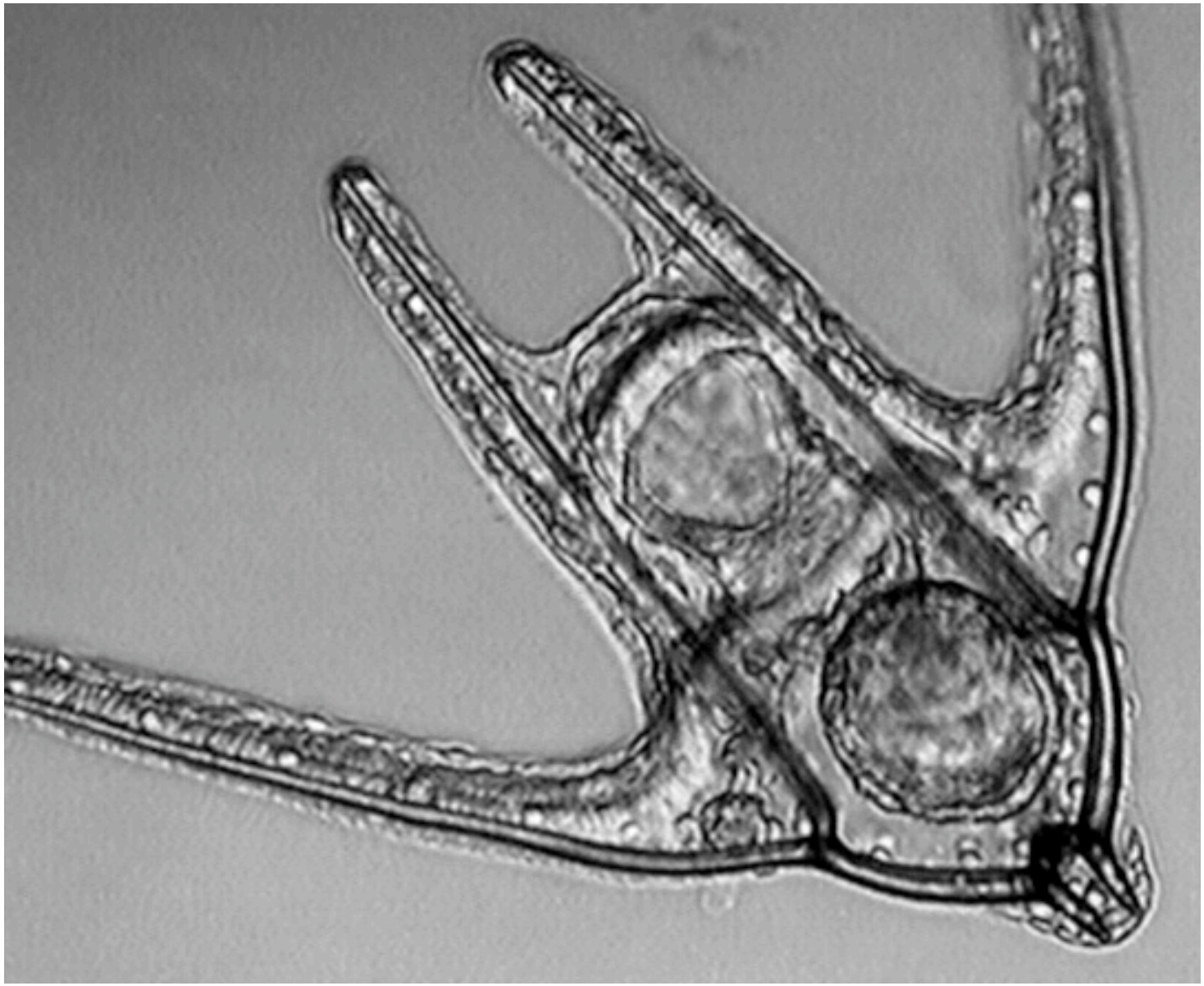


Calcified red algae

Cold-water corals

Barnacles and Mussels

Calcified larvae



Kelps?

Seagrasses: faster growth?


Problem calls for new research,
rapid growth in knowledge,
rapid institutional responses

Ocean Monitoring in partnership with NOAA

Existing moorings:
Aberdeen
Newport
Monterey
Los Angeles

Friday Harbor Labs

New facilities for experimental study of biological effects

Five West Coast Sanctuaries:
adopted resolutions urging coordinated research
and monitoring,
use of Sanctuaries as sentinel sites

Ocean Acidification and the Channel Islands National Marine Sanctuary:
Cause, effect, and response

Red abalone, urchins, and coralline algae— familiar calcifiers of the Northern Channel Islands. Photo: *CINMS*

A report by the Conservation Working Group of the CINMS Advisory Council

Adopted by the CINMS Advisory Council September 19, 2008

Prepared by:
Shiva Polefka, Marine Conservation Analyst, and Julia Forgie, Program Intern,
Environmental Defense Center, Santa Barbara, California (*contact:* shiva@edcnet.org)

Project director:
Linda Krop, CINMS Advisory Council Conservation Seat and Chief Counsel,
Environmental Defense Center

Supported by the Marisla Foundation

www.channelislands.noaa.gov

Potential responses:

mitigation (reduce emissions)

risk management (minimize impacts)

adaptation (learn to live with changes)

Mitigation:
Reduce CO_2 emissions and carbon footprints

Risk management:
Reduce/remove other sources of stress
Implement Ecosystem-Based Management
Maintain species and genetic diversity

Adaptation:
Look for ‘winners’; conserve and cultivate

Policy responses:

Federal Ocean Acidification Research and Monitoring (FOARAM) Act

directs federal agencies to collaborate in on OA research and education;

establishes OA program within NOAA

Enacted by Congress (March 25, 2009)

Signed by President Obama

New funds authorized for NOAA and NSF

Conclusions:

Changing ocean chemistry is certain

Biological, ecological responses largely unknown

Responses are not uniform across species

Species distribution, abundance, food webs

    all could be affected

Biogeochemical cycles could be affected

Conclusions:

Changing ocean chemistry is certain

Biological, ecological responses largely unknown

Responses are not uniform across species

Species distribution, abundance, food webs
all could be affected

Biogeochemical cycles could be affected

Need to confront the problem on multiple levels:
research, education, monitoring, institutional
and policy responses, including carbon policies

Acknowledgements:
University of Washington
Friday Harbor Laboratories
National Science Foundation
Education Foundation of America
NOAA PMEL/RA Feely
Channel Islands National Marine Sanctuary