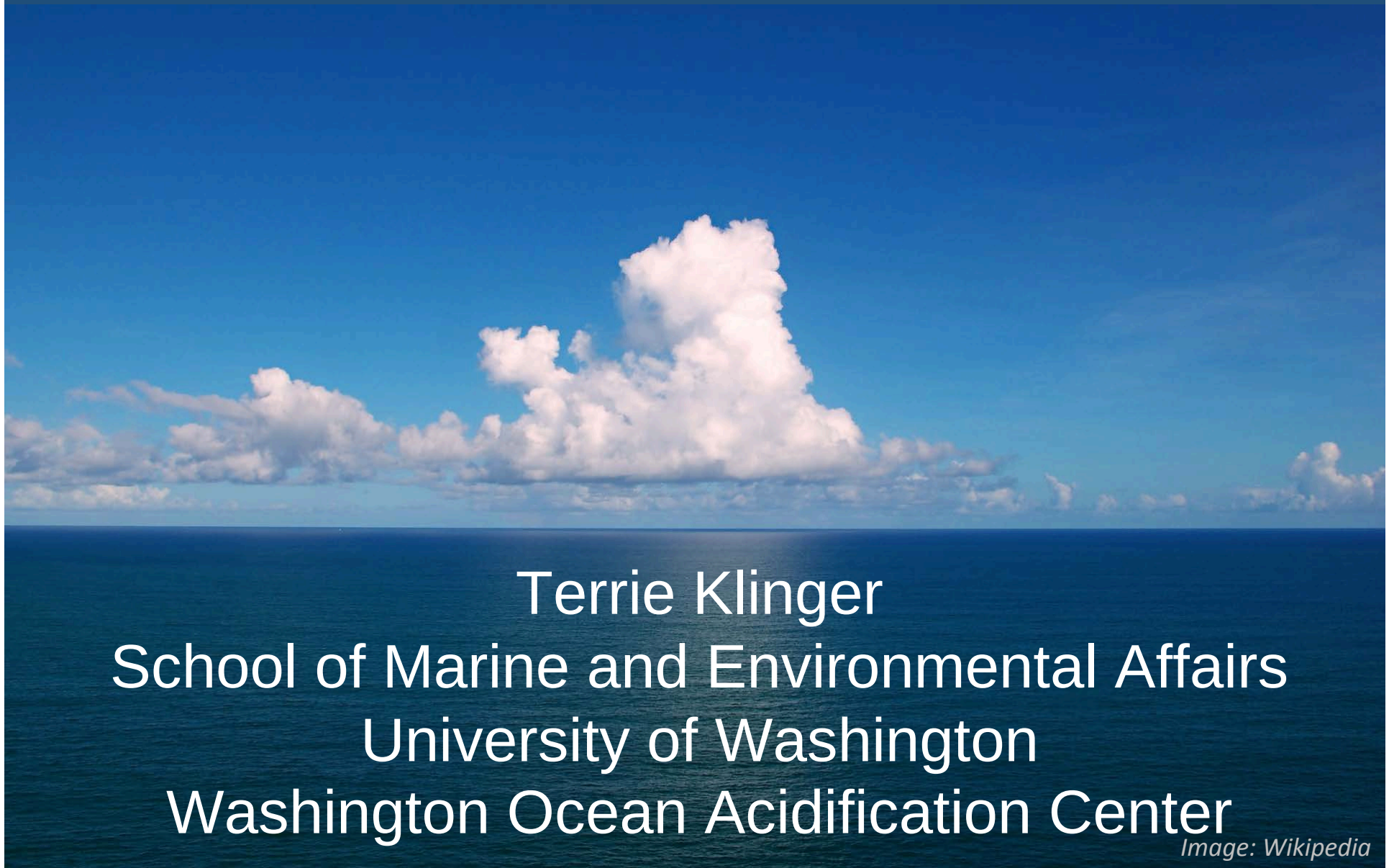
Ocean Acidification in Washington



Terrie Klinger
School of Marine and Environmental Affairs
University of Washington
Washington Ocean Acidification Center

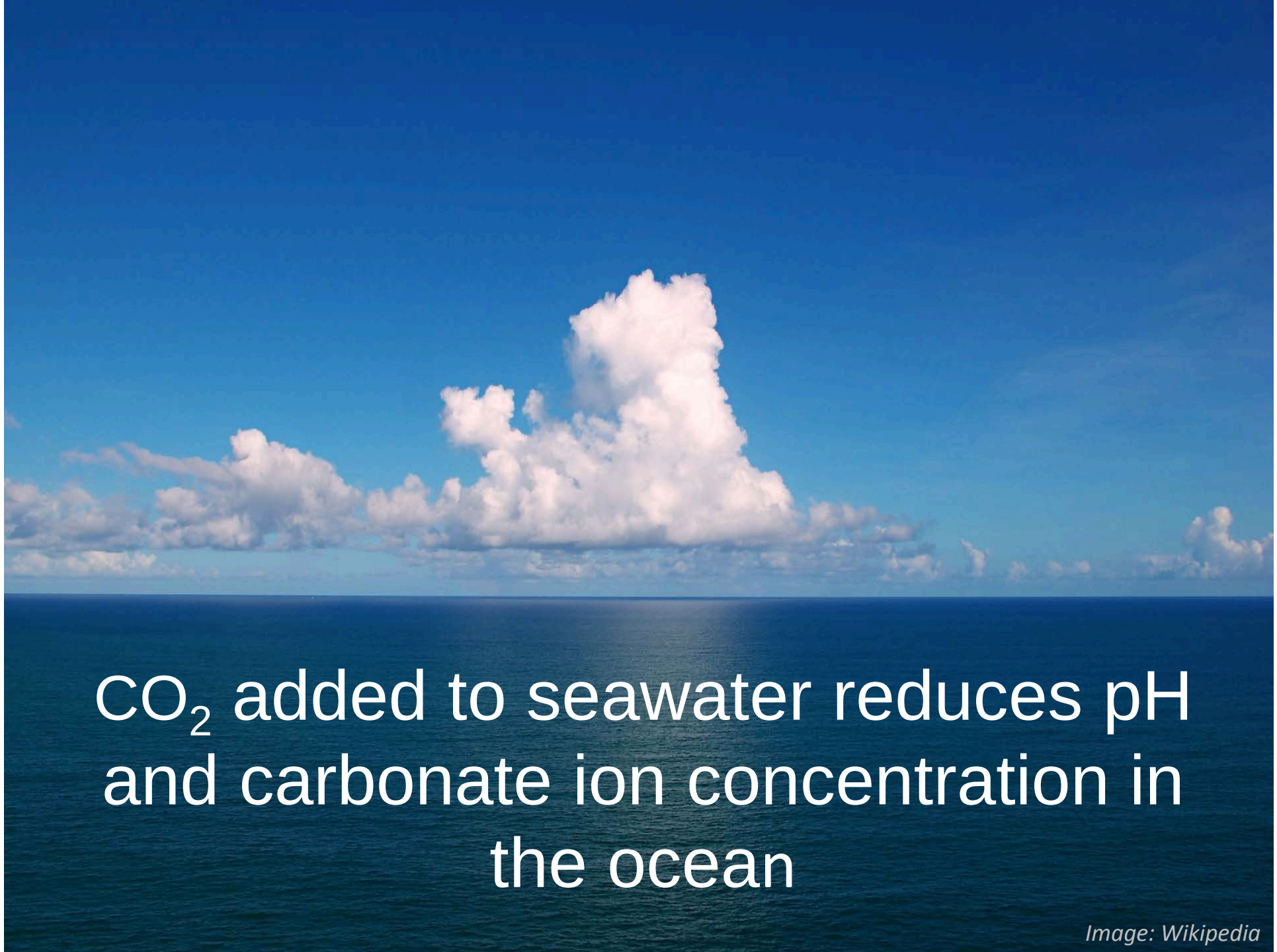
Image: Wikipedia

Image: mit.edu

The ocean has taken up about 28% of the carbon dioxide released by industry and deforestation

CO_2 in the atmosphere contributes to climate change

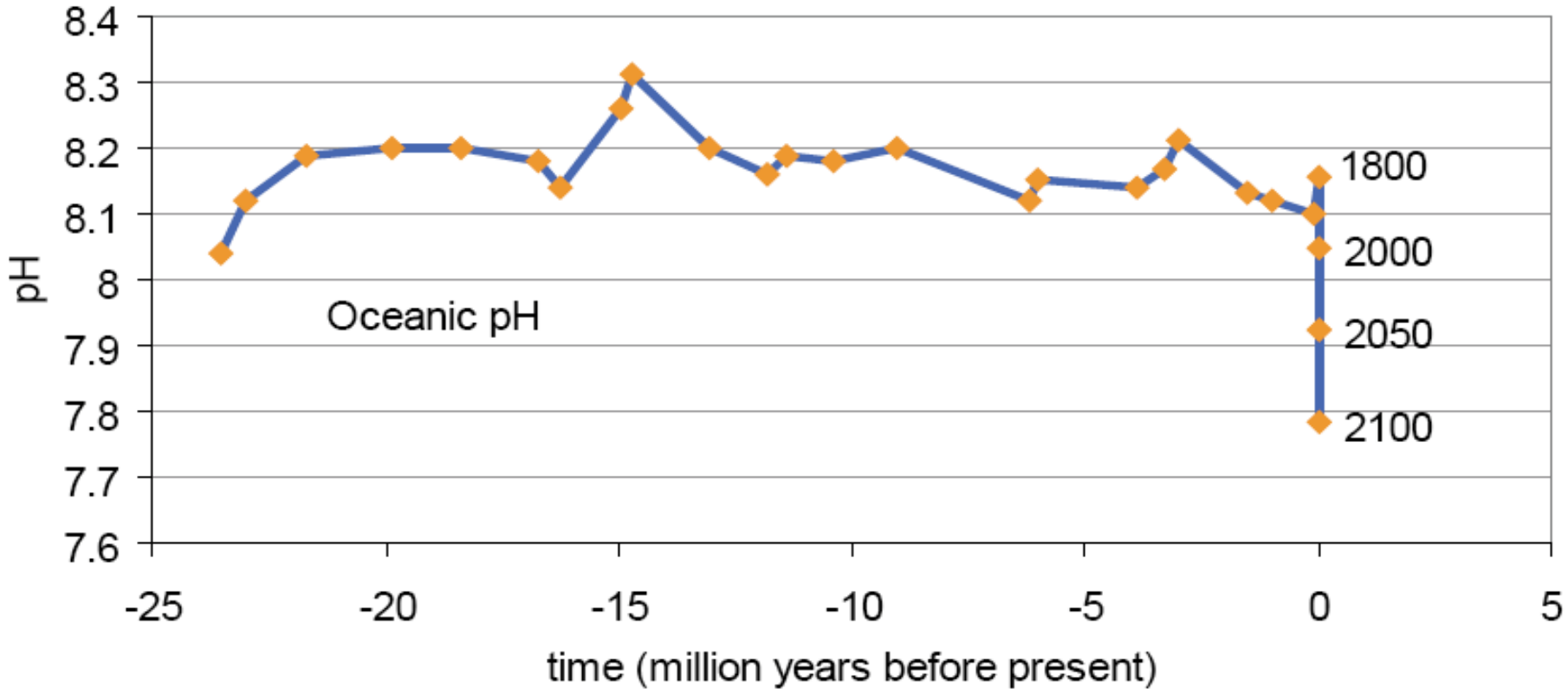
CO_2 in the water causes ocean acidification



CO_2 added to seawater reduces pH and carbonate ion concentration in the ocean

Image: Wikipedia

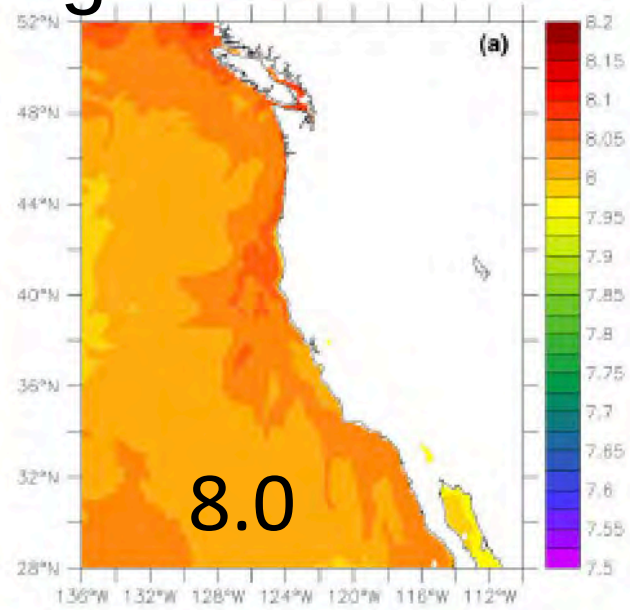
The rate of change is unprecedented in 25 million years



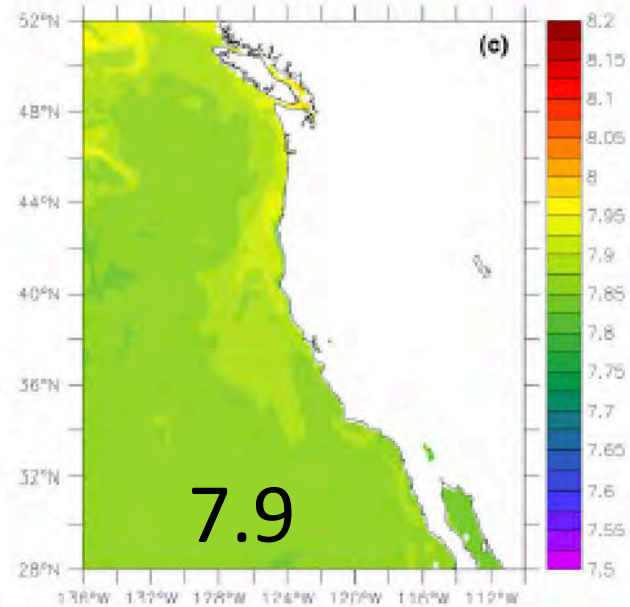
Source: Carol Turley, PML

pH in the California Current System is projected to decline
Declines will be greatest in surface waters

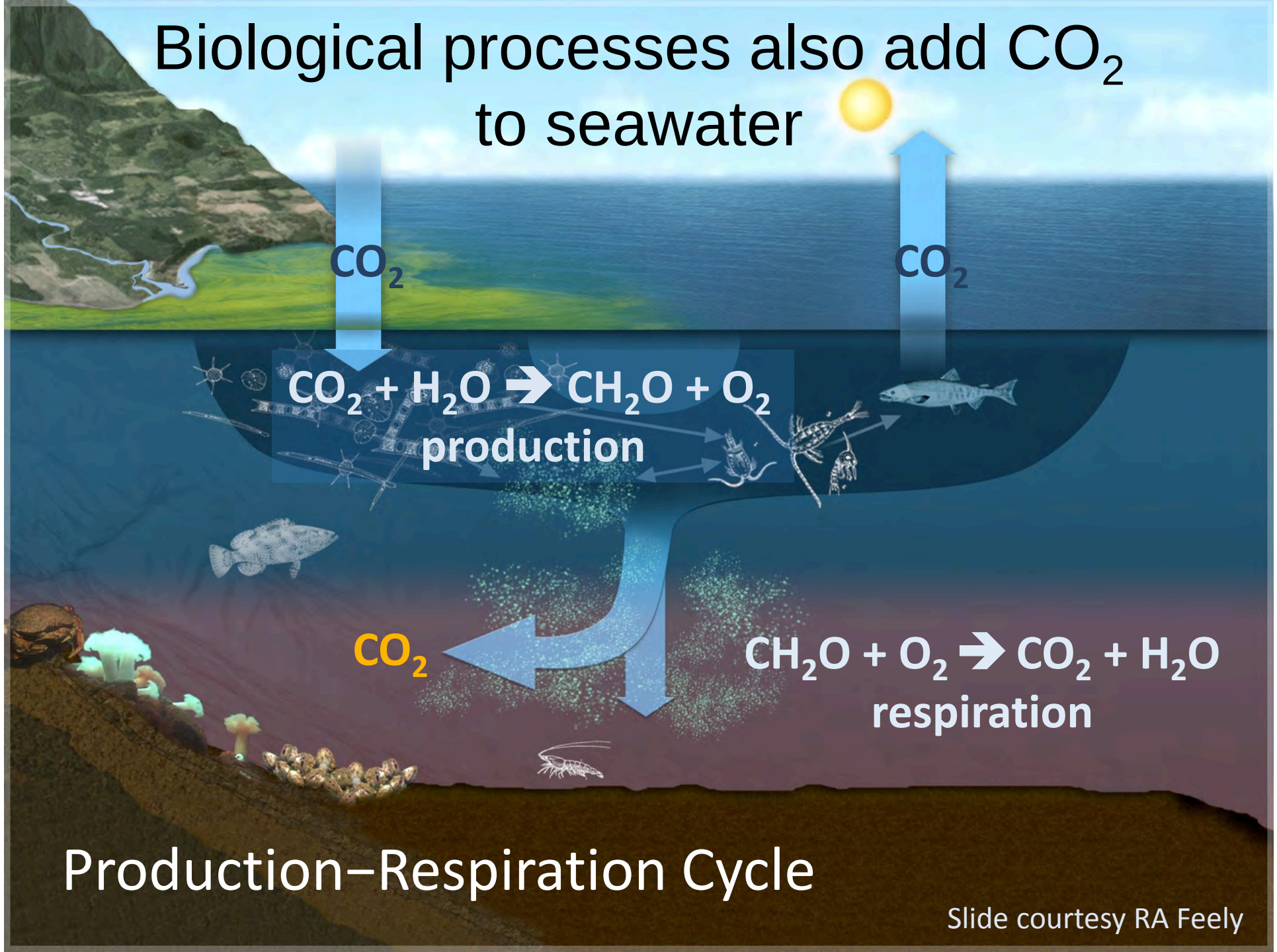
pH at surface
August 2013

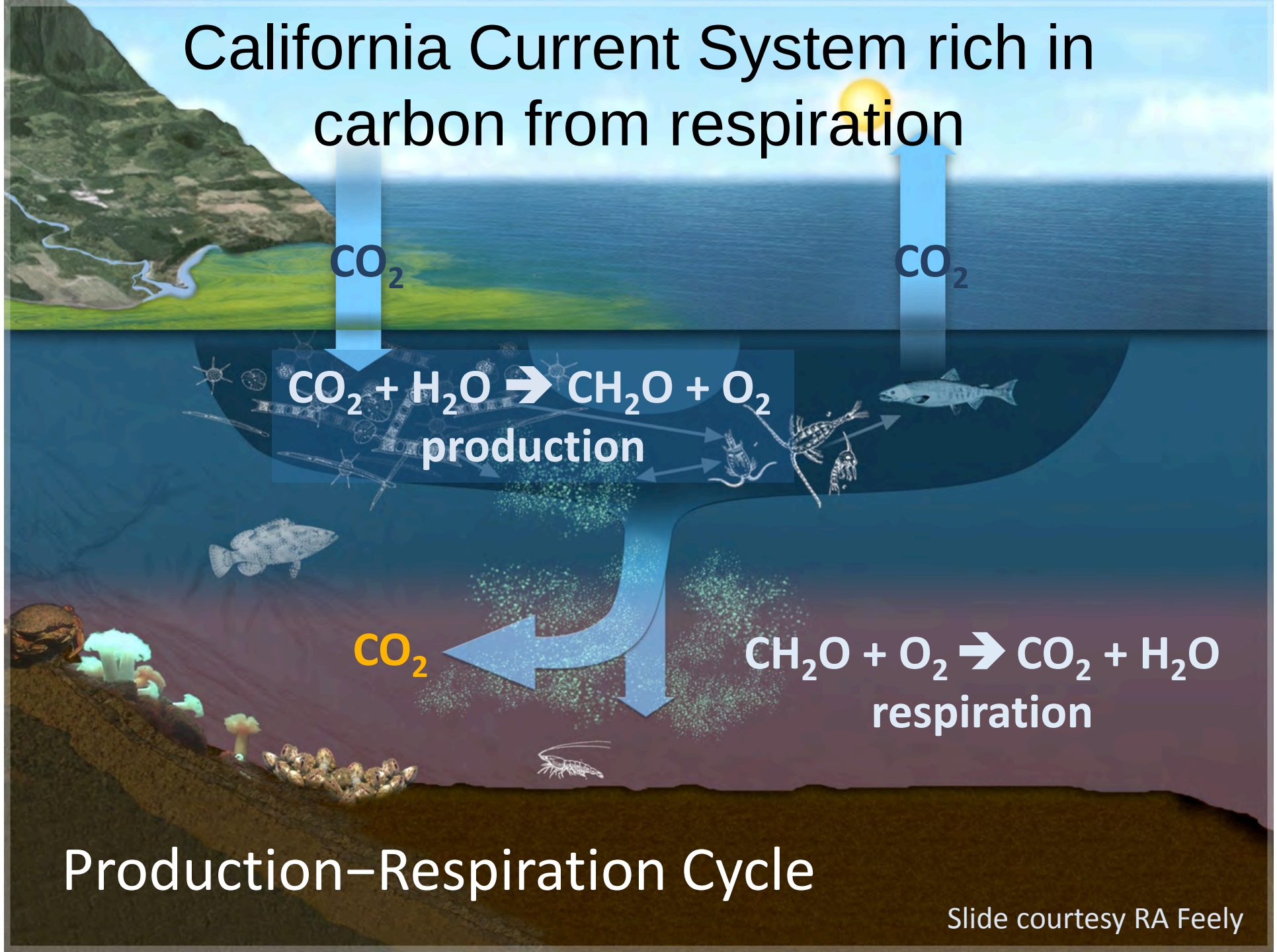


pH at surface
August 2063



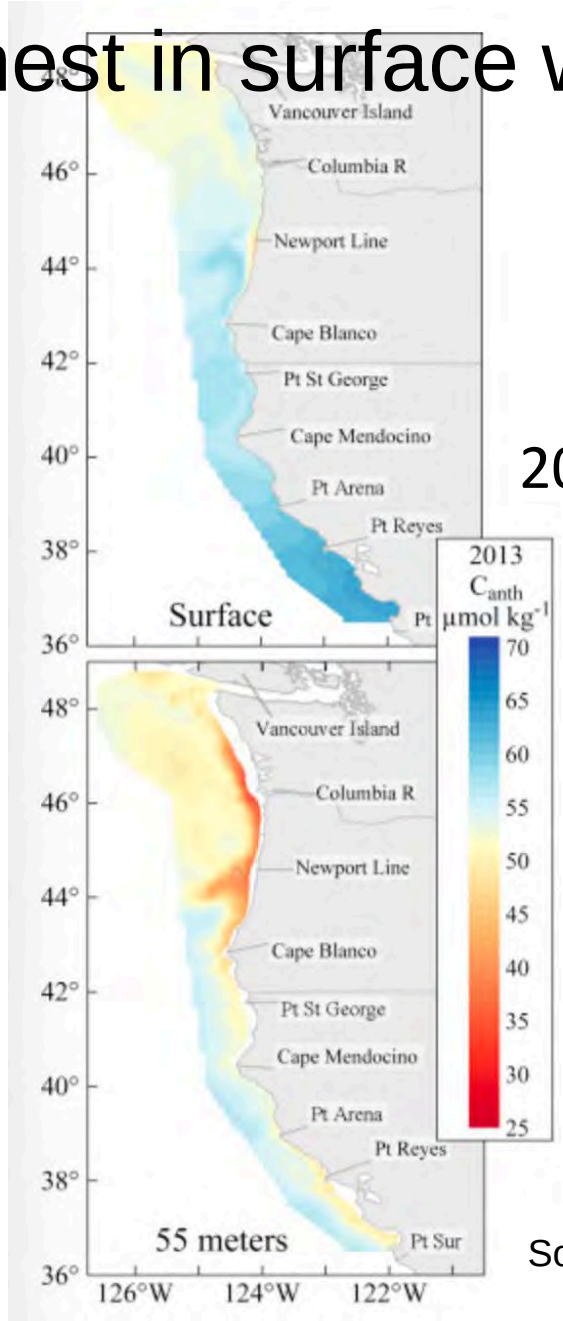
Source: Marshall et al. 2017


Biological processes also add CO_2 to seawater
CO_2
CO_2
$CO_2 + H_2O \rightarrow CH_2O + O_2$
production
CO_2
$CH_2O + O_2 \rightarrow CO_2 + H_2O$
respiration
Production–Respiration Cycle
Slide courtesy RA Feely


California Current System rich in carbon from respiration
CO_2
CO_2
$CO_2 + H_2O \rightarrow CH_2O + O_2$
production
CO_2
$CH_2O + O_2 \rightarrow CO_2 + H_2O$
respiration
Production–Respiration Cycle
Slide courtesy RA Feely

The anthropogenic fraction of carbon can be calculated and is highest in surface waters

Anthropogenic Carbon
Higher at surface



2013

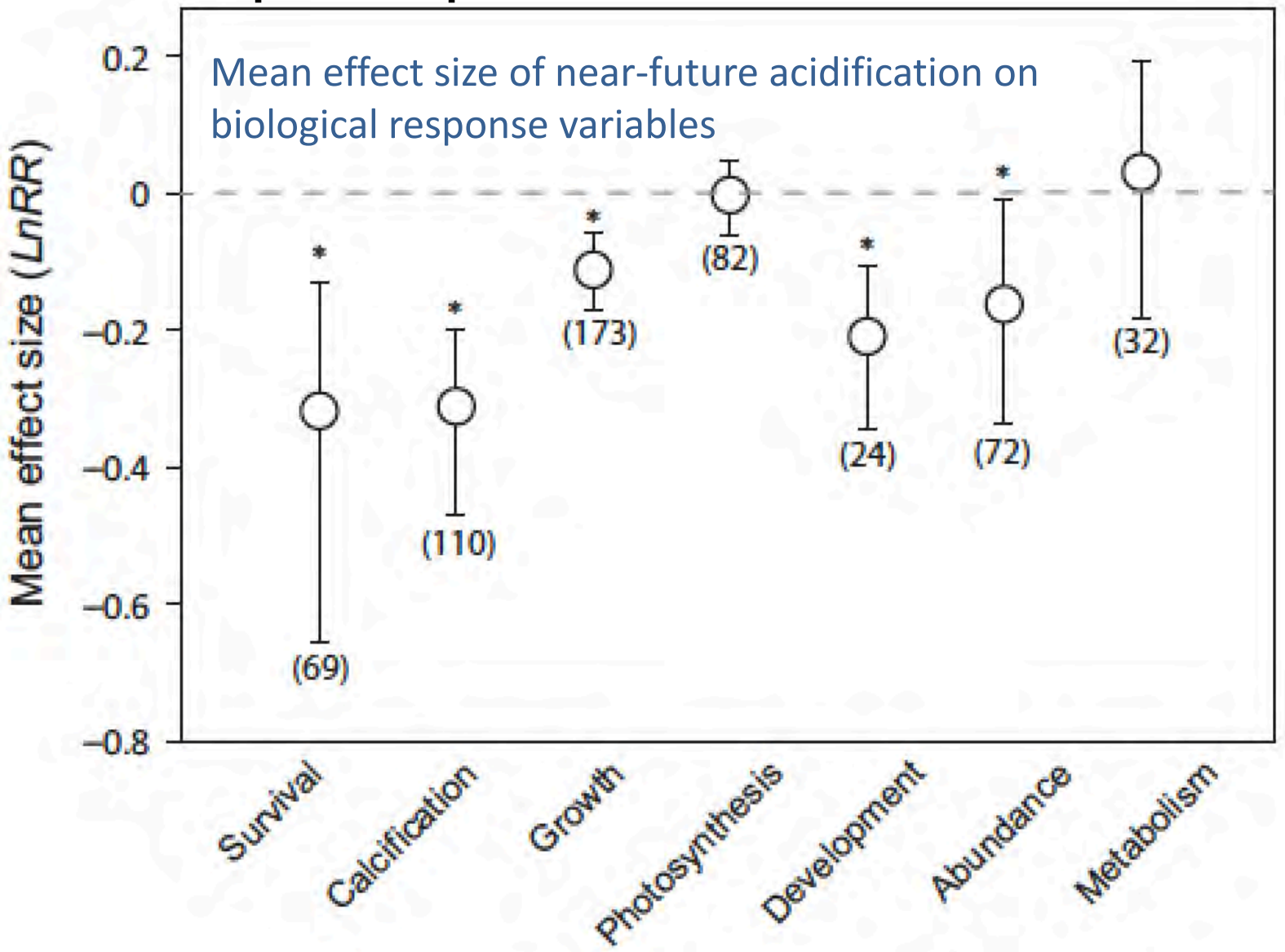
Anthropogenic Carbon
Lower at depth

Source: Feely et al. 2016

Biological effects?

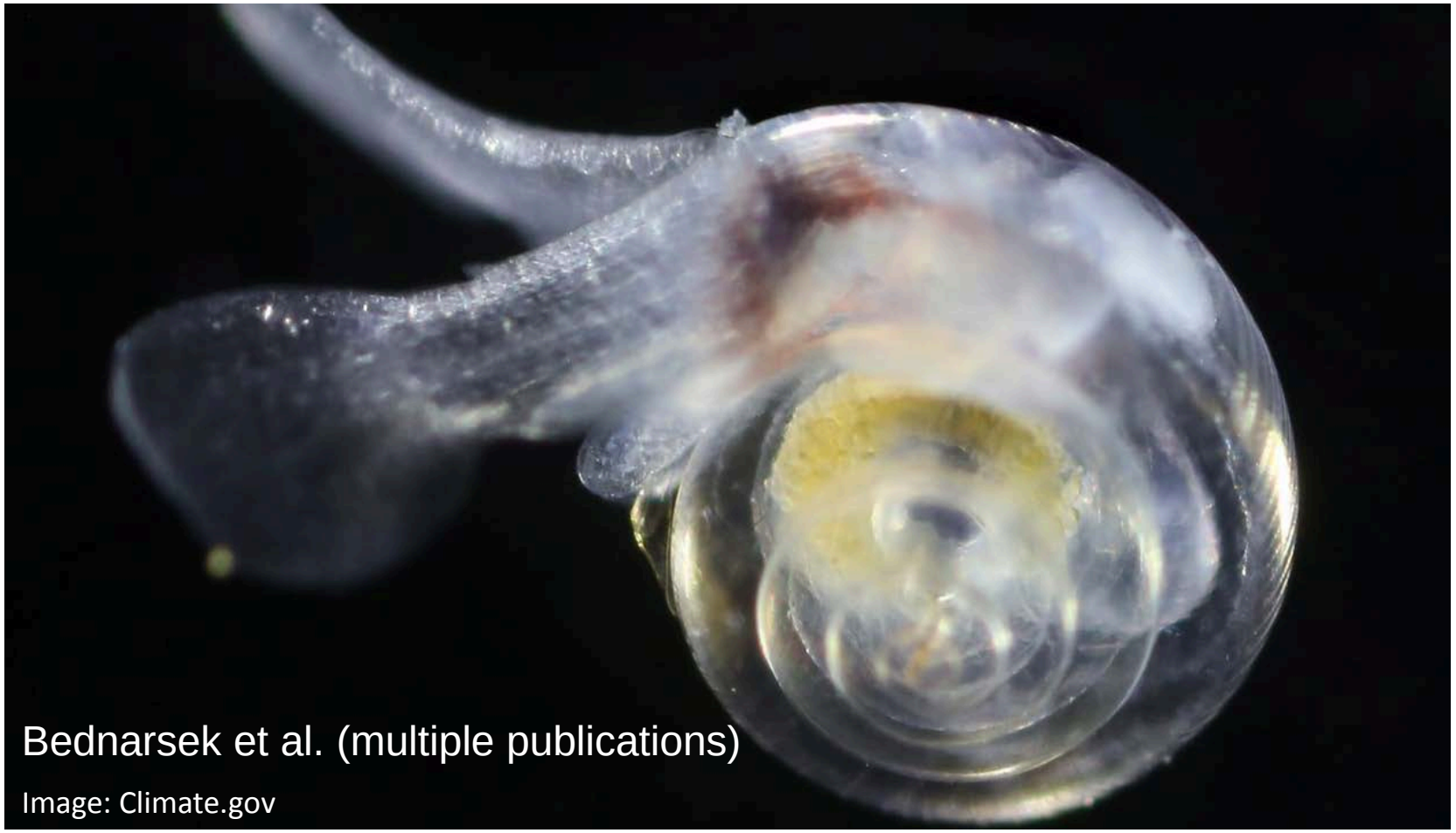
Photo credit: George Grall

Biological effects occur across critical life processes, multiple trophic levels, and habitats



Kroeker et al. 2013
Haigh et al. 2015
Sunday et al. 2016

Planktonic shells are thinner under OA conditions
Calcification rates decline
Changes in behavior occur



Bednarsek et al. (multiple publications)

Image: Climate.gov

Chitinous taxa are negatively affected, with consequence for prey availability

McLaskey et al. 2016

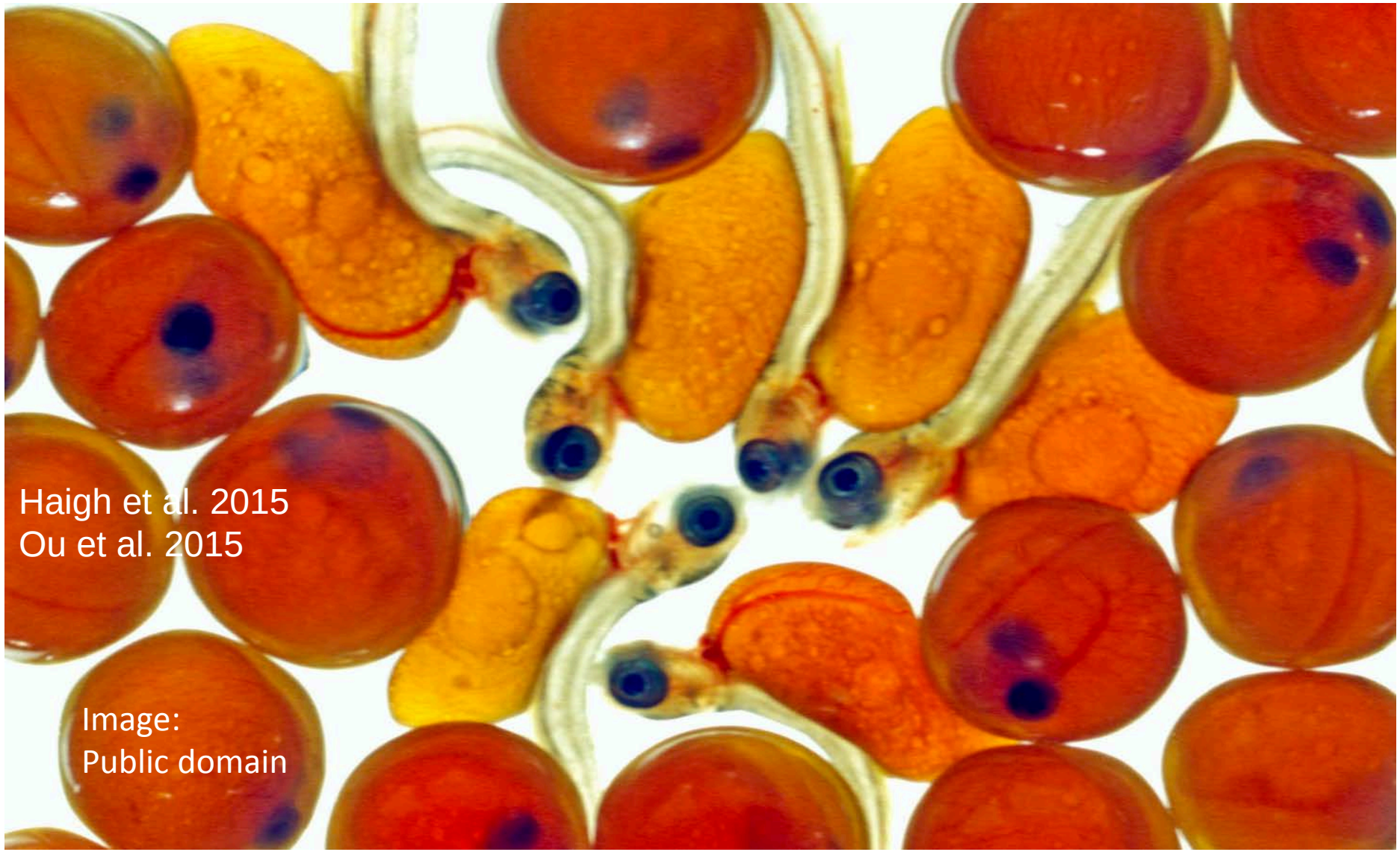
Image: Peter J. Bryant

Bivalve shells and byssus are smaller, weaker under OA conditions

Mortality of Dungeness crab larvae and juveniles increases under OA conditions

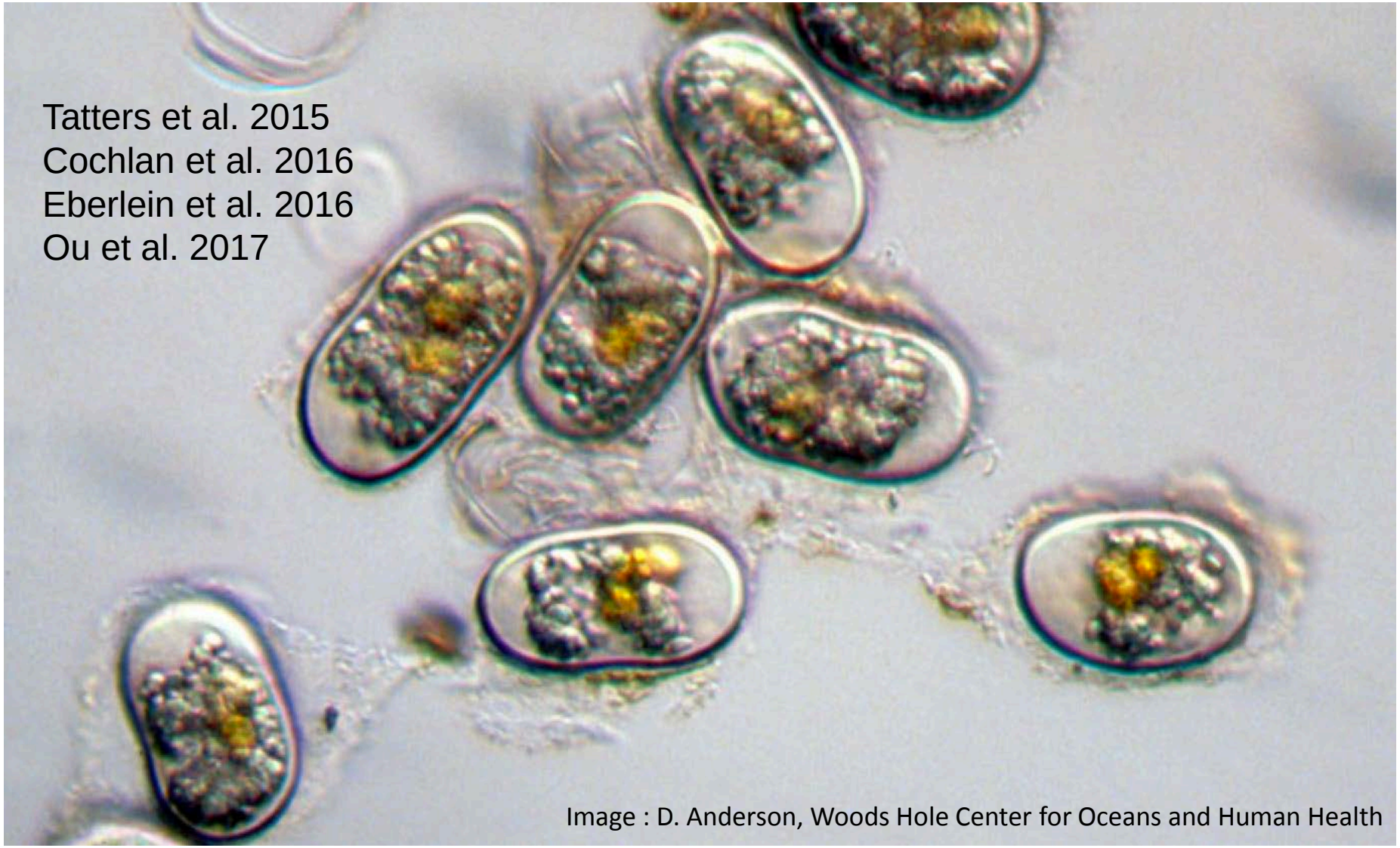
Copper rockfish show changes in behavior under OA conditions

Young pink salmon show changes in critical life-history and behavioral traits

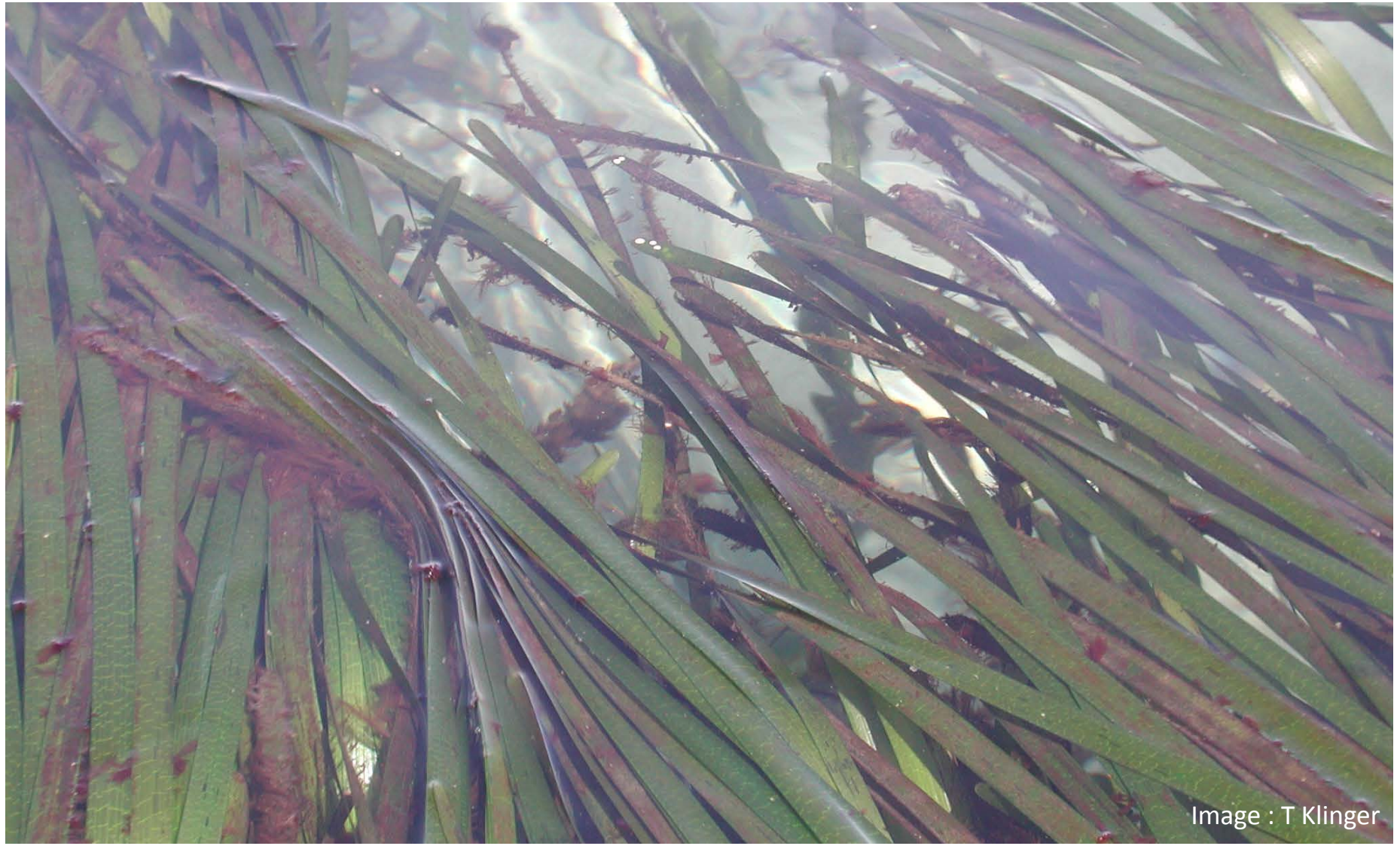


Predator detection is affected in juvenile Coho salmon

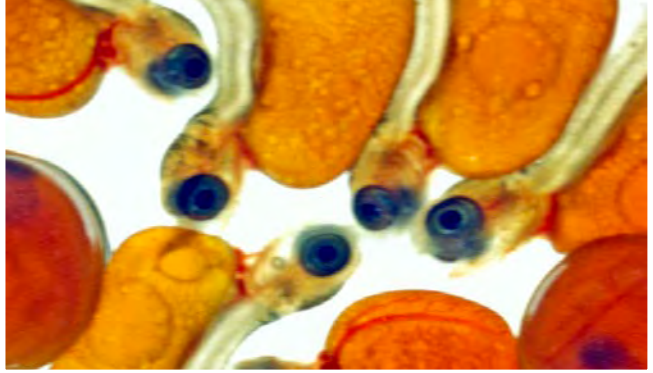
Harmful algae grow faster and are more toxic under OA conditions



Seagrass, other vegetation may ameliorate local seawater conditions



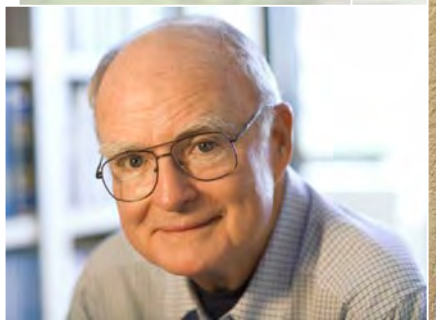
Response Options?


Political leadership has led to actions in Washington and elsewhere









Research Priorities for Washington

- Understand status and trends of OA in Washington’s marine waters
- Quantify the relative contribution of different acidifying factors to OA in Washington’s marine waters
- Describe biological responses of local species to OA and associated stressors
- Describe real-time corrosive seawater conditions, develop short-term forecasts and long-term projections of global and local acidification effects

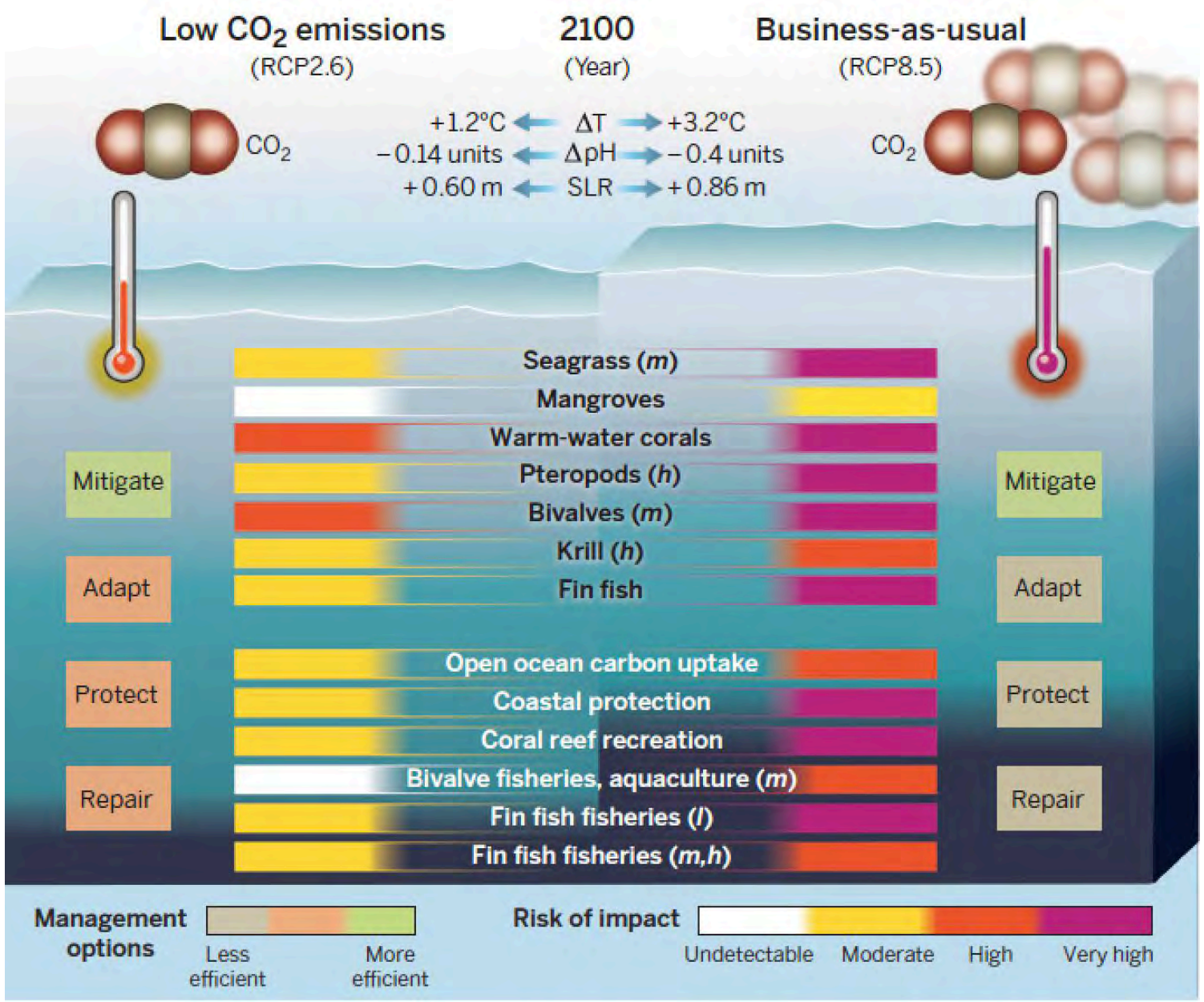
What Can MRCs Add?
Lead or advocate for actions to

- Understand status and trends of OA in nearshore habitats
- Consider the effects of land use strategies on condition of nearshore habitats
- **Explicitly include carbon in management strategies**
  - Reduce carbon inputs from atmospheric and terrestrial sources
  - Protect and preserve aquatic vegetation
  - Increase carbon retention and sequestration in nearshore habitats
  - Preserve carbon already stored in nearshore habitats

We can choose between alternative futures

Lower CO_2

Better options to adapt and manage



Higher CO_2

Fewer options to adapt and manage

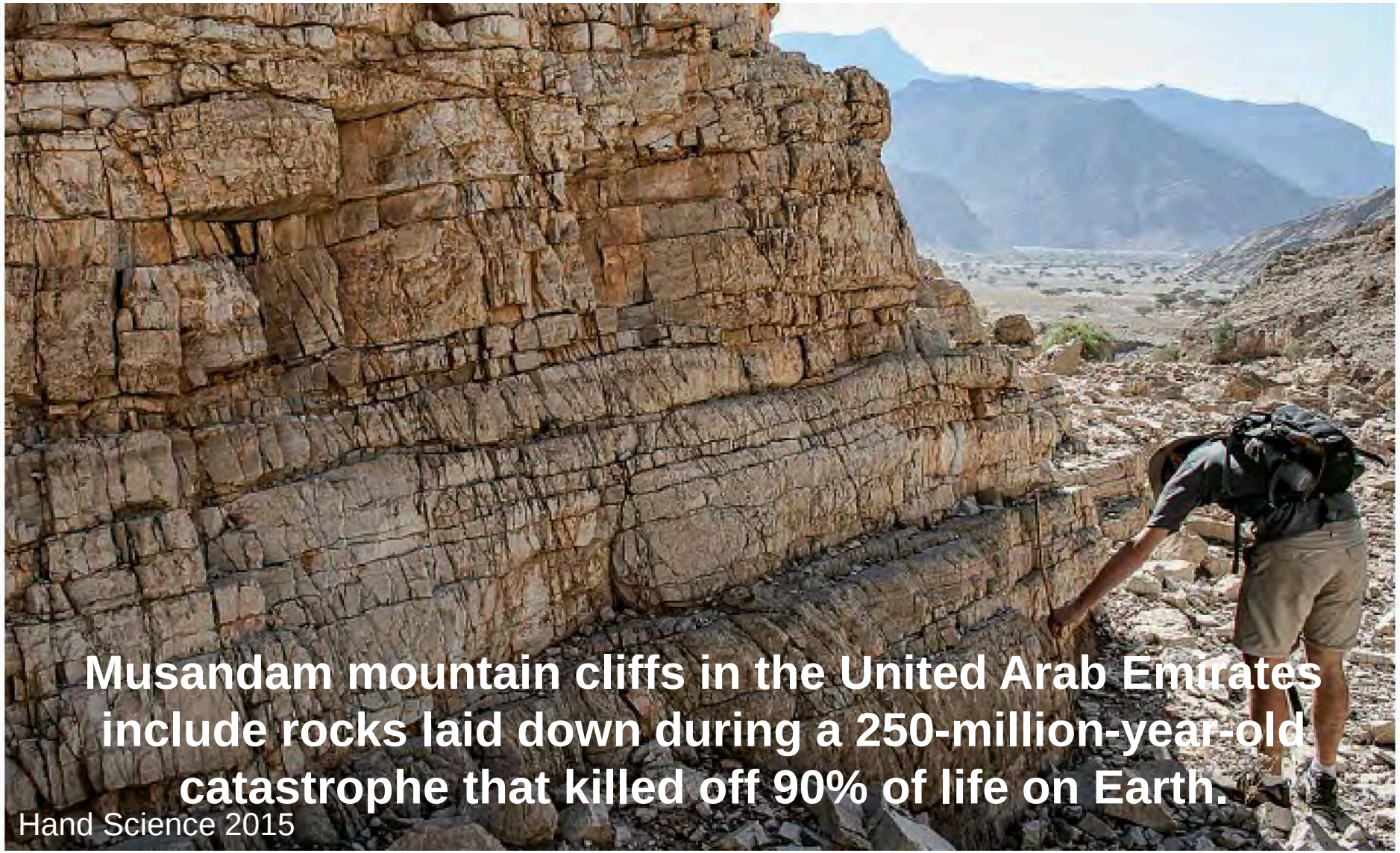
Gattuso et al. 2015

theguardian

Global atmospheric CO2 levels hit record high

UN warns that drastic action is needed to meet climate targets set in the Paris agreement

“Signature of acidification found in Permian extinctions 250 million years ago” [E. Hand, Science 2015]



Musandam mountain cliffs in the United Arab Emirates include rocks laid down during a 250-million-year-old catastrophe that killed off 90% of life on Earth.

Hand Science 2015