Ecosystem effects of ocean acidification

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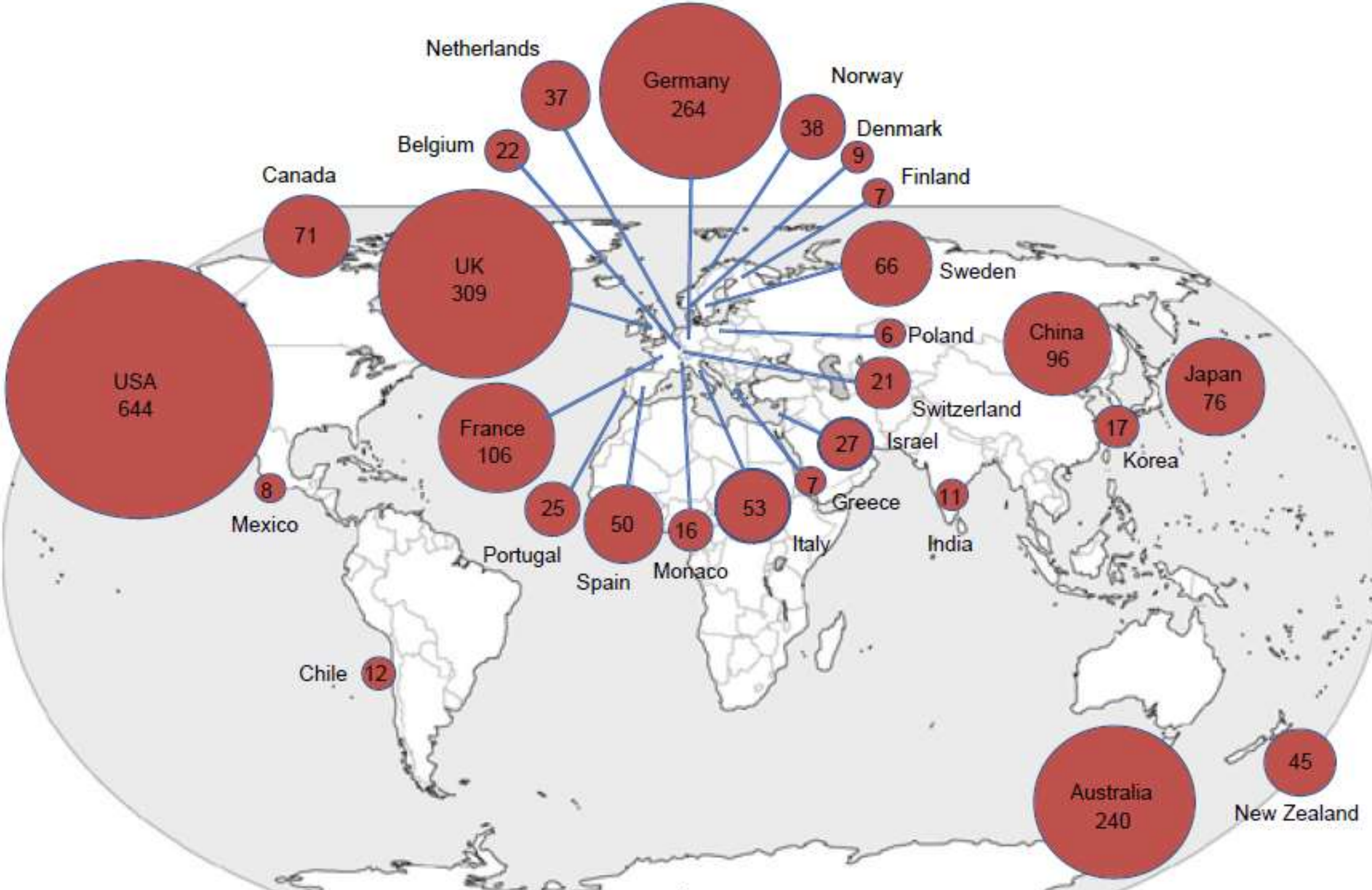
PLYMOUTH UNIVERSITY

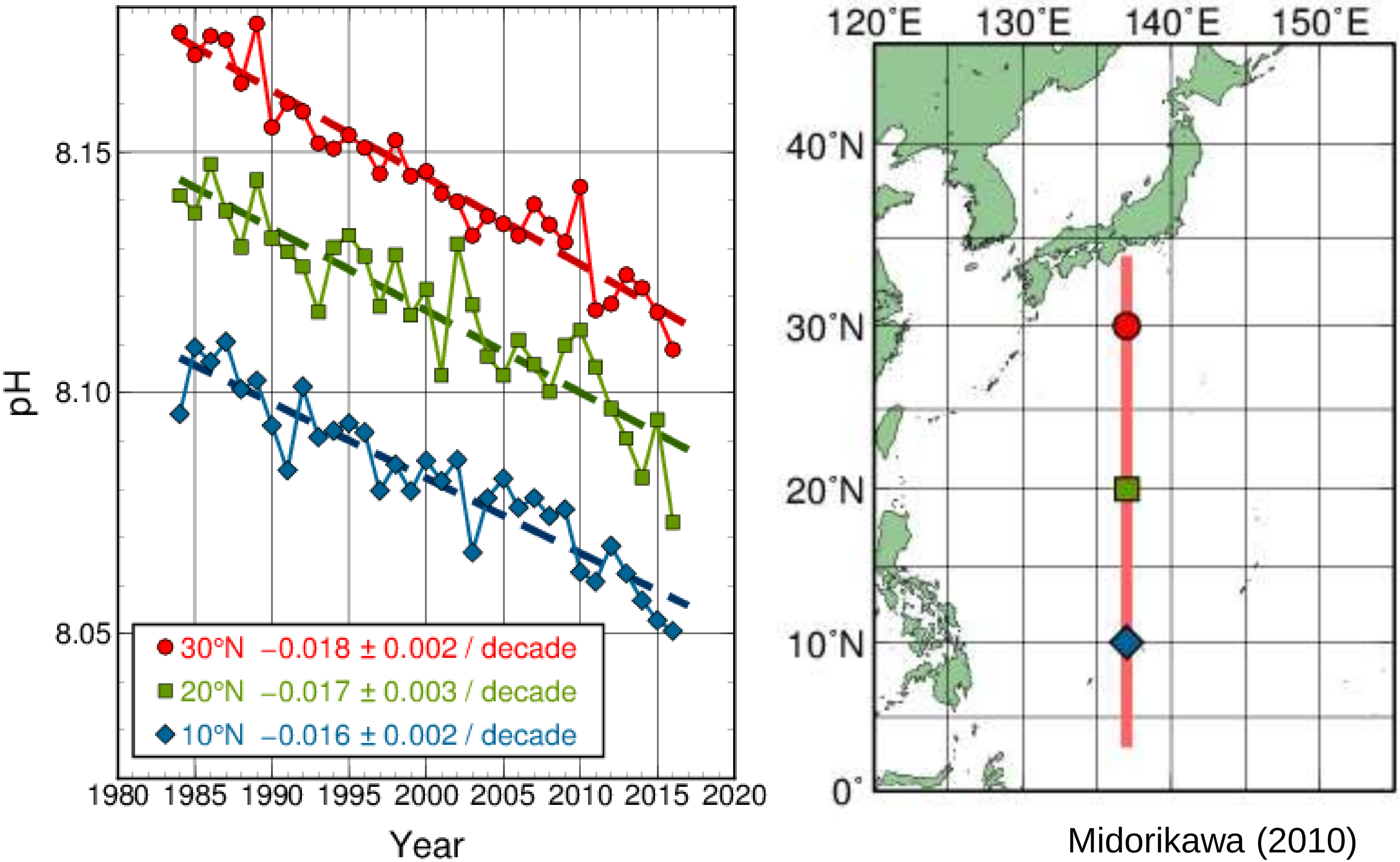
28 October 2018

SPF Promoting international exchange, international cooperation, international understanding.
THE SASAKAWA PEACE FOUNDATION

Less ocean acidification research in Asia than US, UK and Australia. Japan is a regional leader

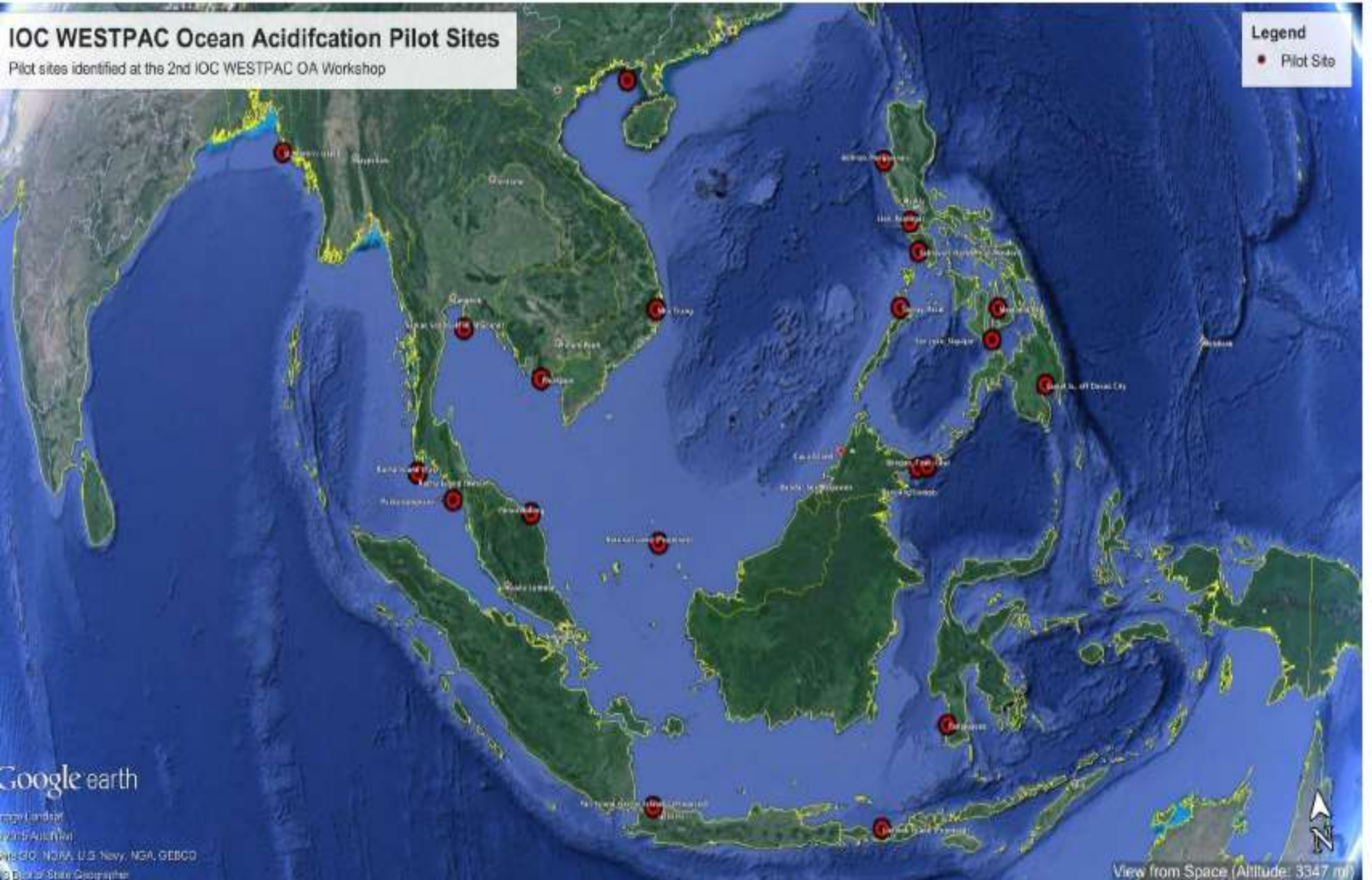


We know that seawater pH is falling rapidly off Japan

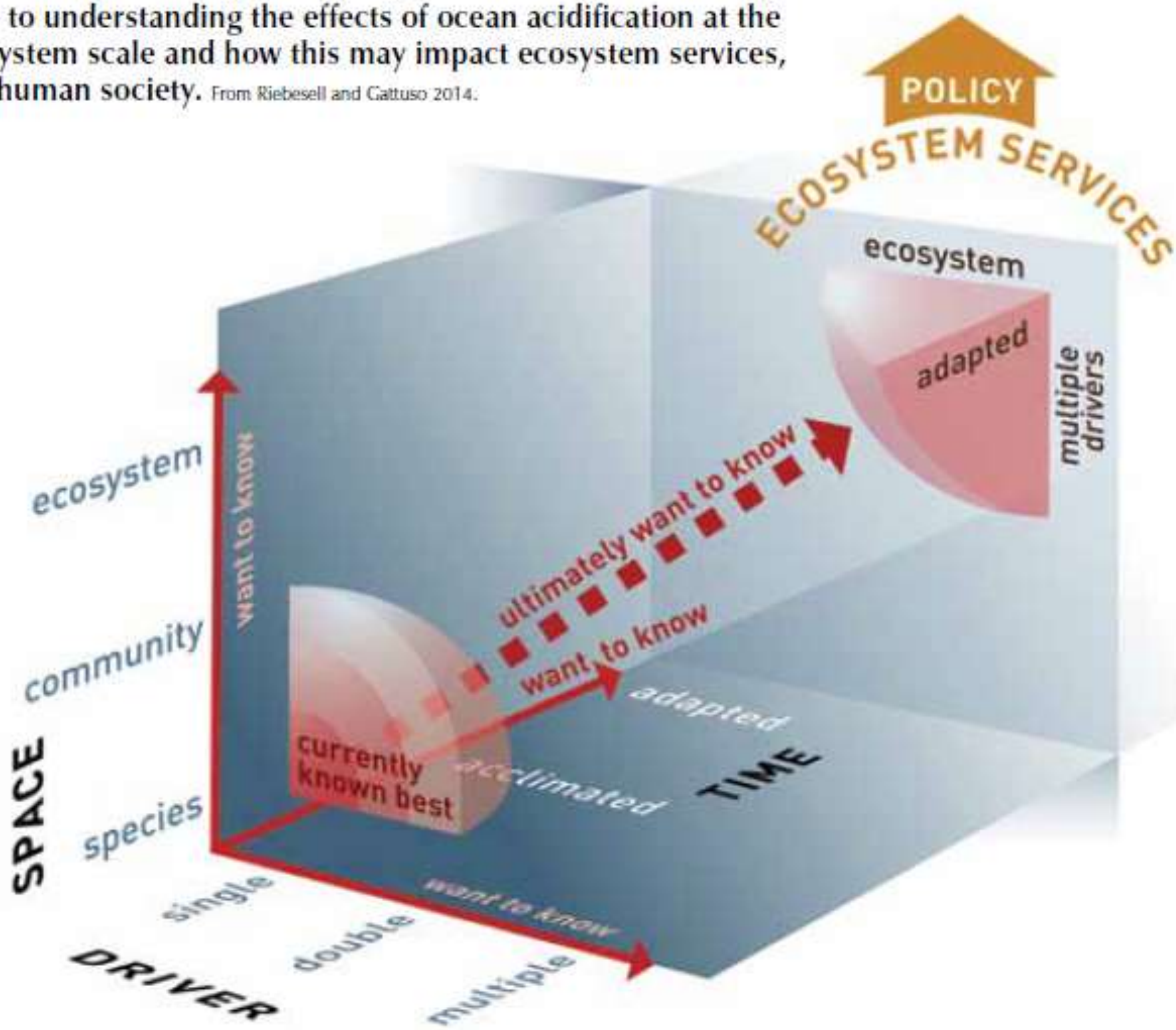


Midorikawa (2010)

Monitoring ocean acidification is now starting in SE Asia



The scientific challenge of moving from the current knowledge base to understanding the effects of ocean acidification at the ecosystem scale and how this may impact ecosystem services, and human society. From Riebesell and Gattuso 2014.



Problem..

Last IPCC report says that we do not yet know what the ecological effects will be – as it is difficult to scale-up from laboratory experiments.

Solution..

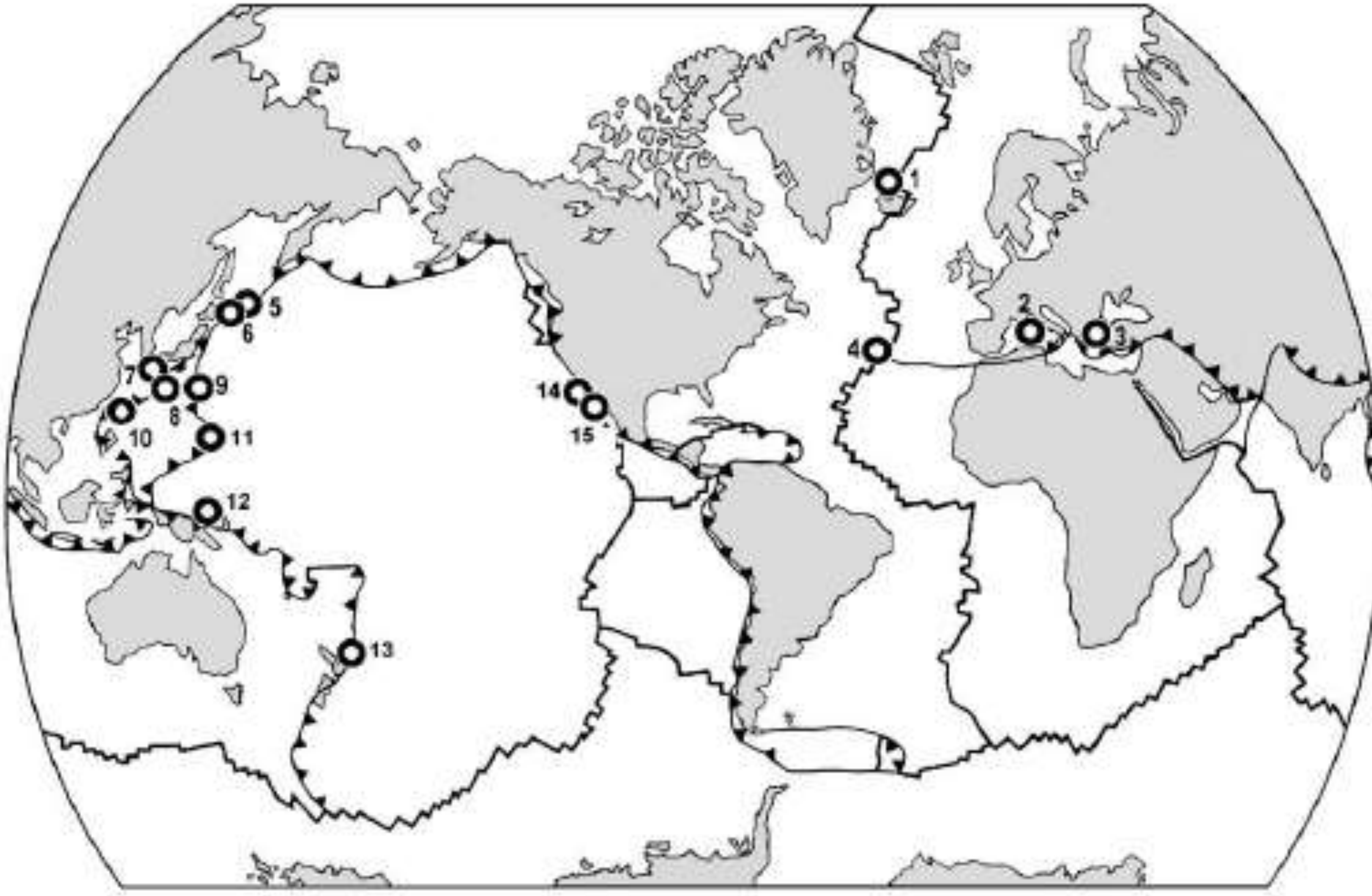
Areas with naturally high CO_2 can help show ecosystem responses to ocean acidification

Ecosystem effects of ocean acidification and warming

We have new data on 100s of species including Bacteria, Cyanobacteria, Diatoms, Coccolithophores, Seaweeds, Seagrasses,
Sponges, Corals, Polychaetes, Crustaceans, Molluscs, Echinoderms & Fish

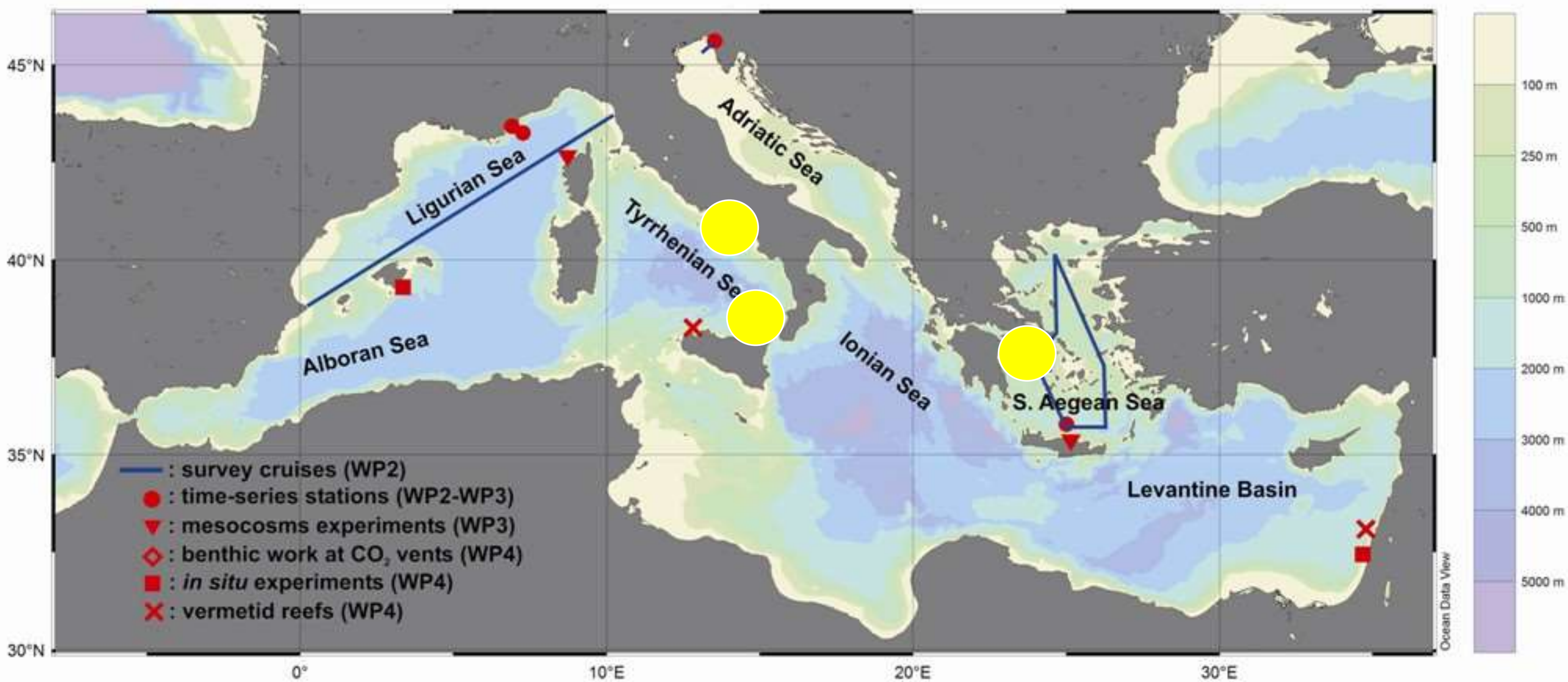
Hall-Spencer et al. 2008 Nature

Coastal CO_2 seeps worldwide



SEA CHANGE WITH PLYMOUTH UNIVERSITY

MedSeA
MEDITERRANEAN SEA ACIDIFICATION IN A CHANGING CLIMATE

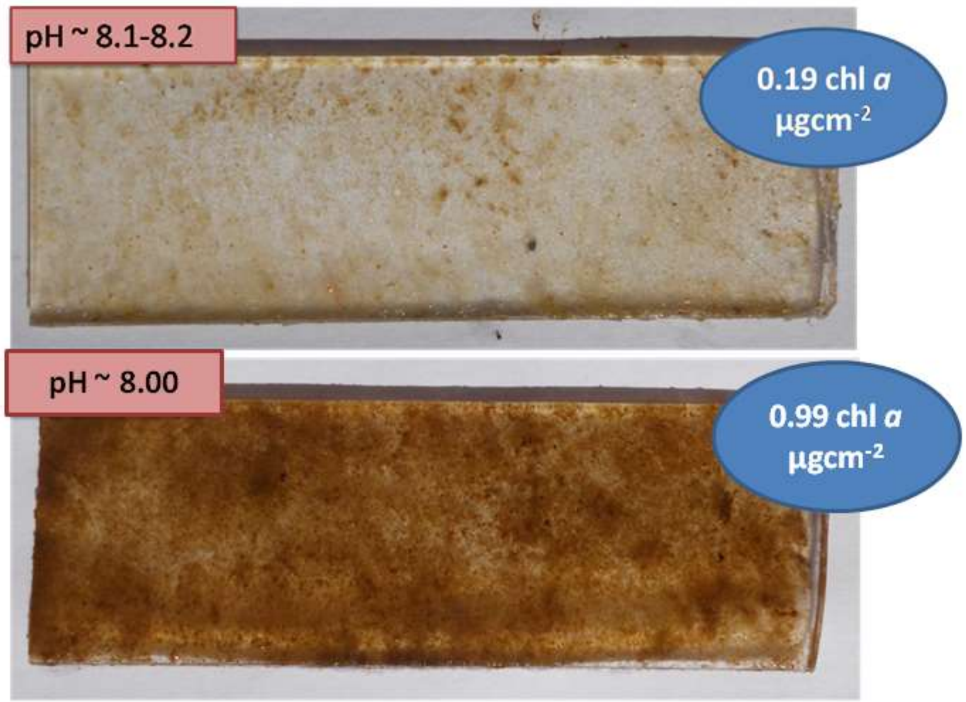


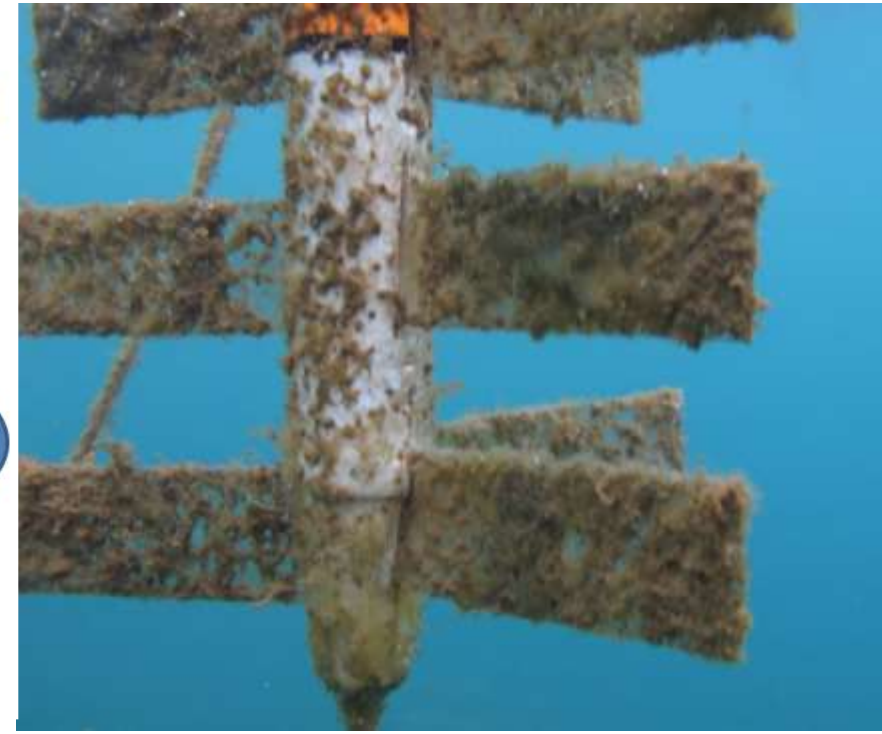
Fish reproduction is affected by acidification

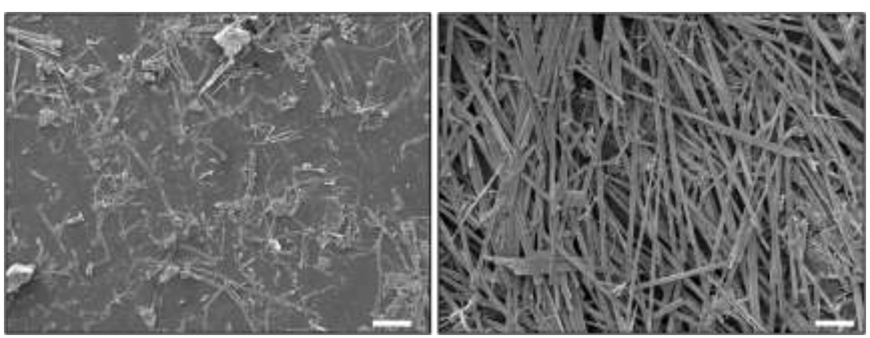
Paternity tests of the eggs show that sneaker males were less successful at high CO_2 (Milazzo et al. 2016 Proc Roy Soc)

Fish reproduction is affected

Large increase in diatom productivity on slides, on rock and on sediment. Not much increase in cyanobacteria until extremely high CO_2 levels







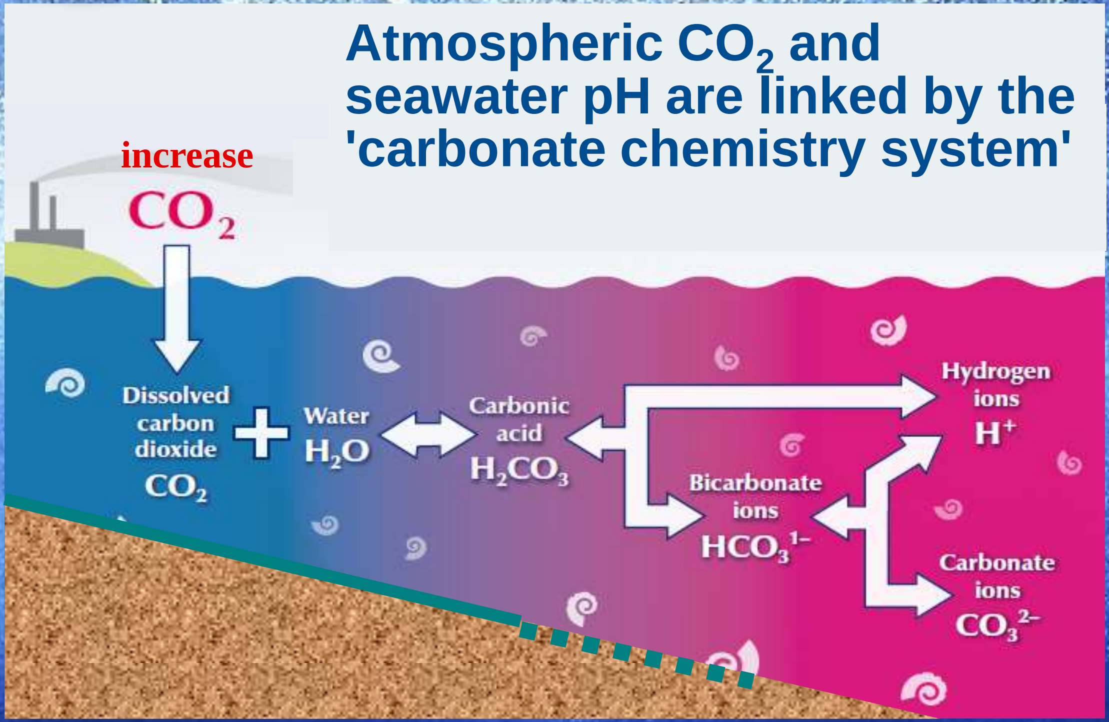
Johnson VR et al. (2015)

J. Mar. Sci. Eng. 3, 1425-1447

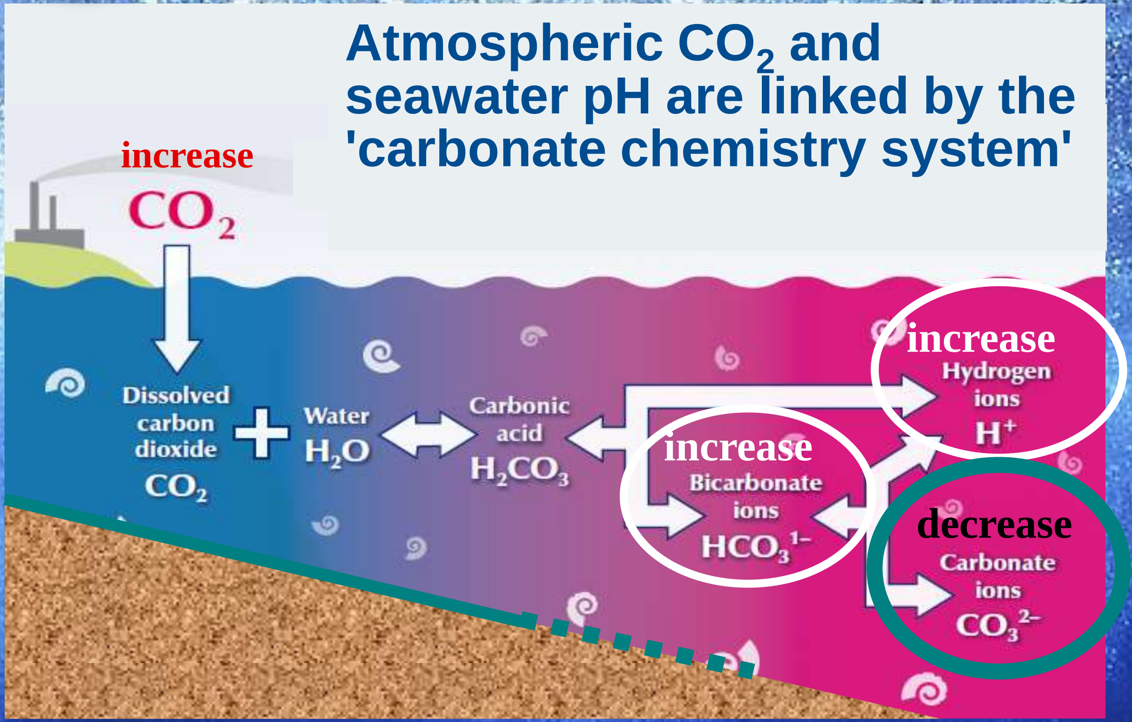
Recruitment from the plankton severely disrupted at high CO_2

Cigliano et al. (2010) Marine Biology,
Smith et al. (2016) Nature Climate Change
Allen et al. (2017) Mar. Poll. Bull.

Atmospheric CO_2 and seawater pH are linked by the 'carbonate chemistry system'

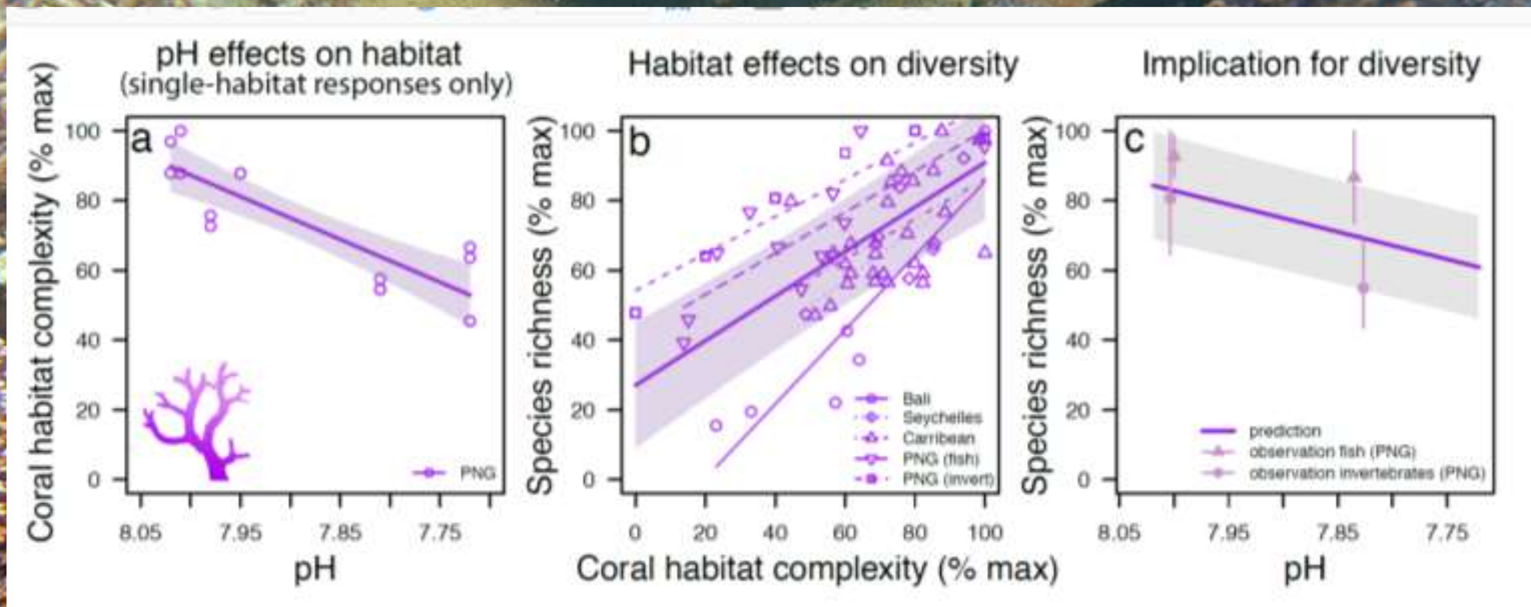


Ocean acidification is not just pH change
It is a multiple stressor



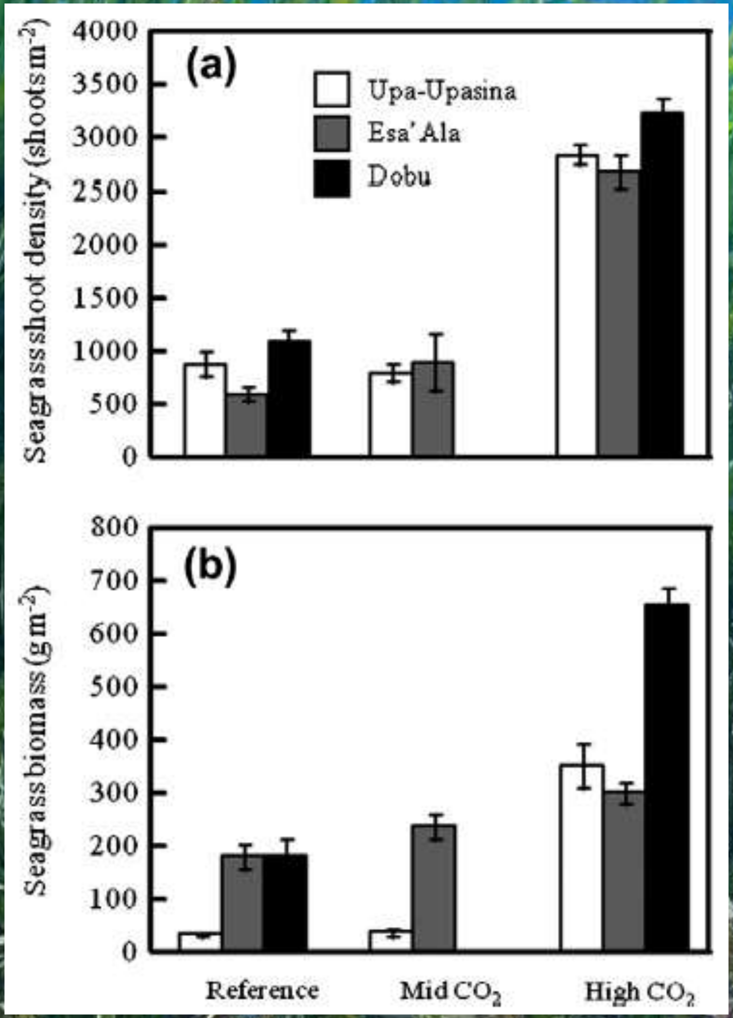
Increased DIC can be a resource for primary producers. Decreased carbonate saturation can corrode shells and skeletons.

OA mediates biodiversity shifts via biogenic habitat modifications

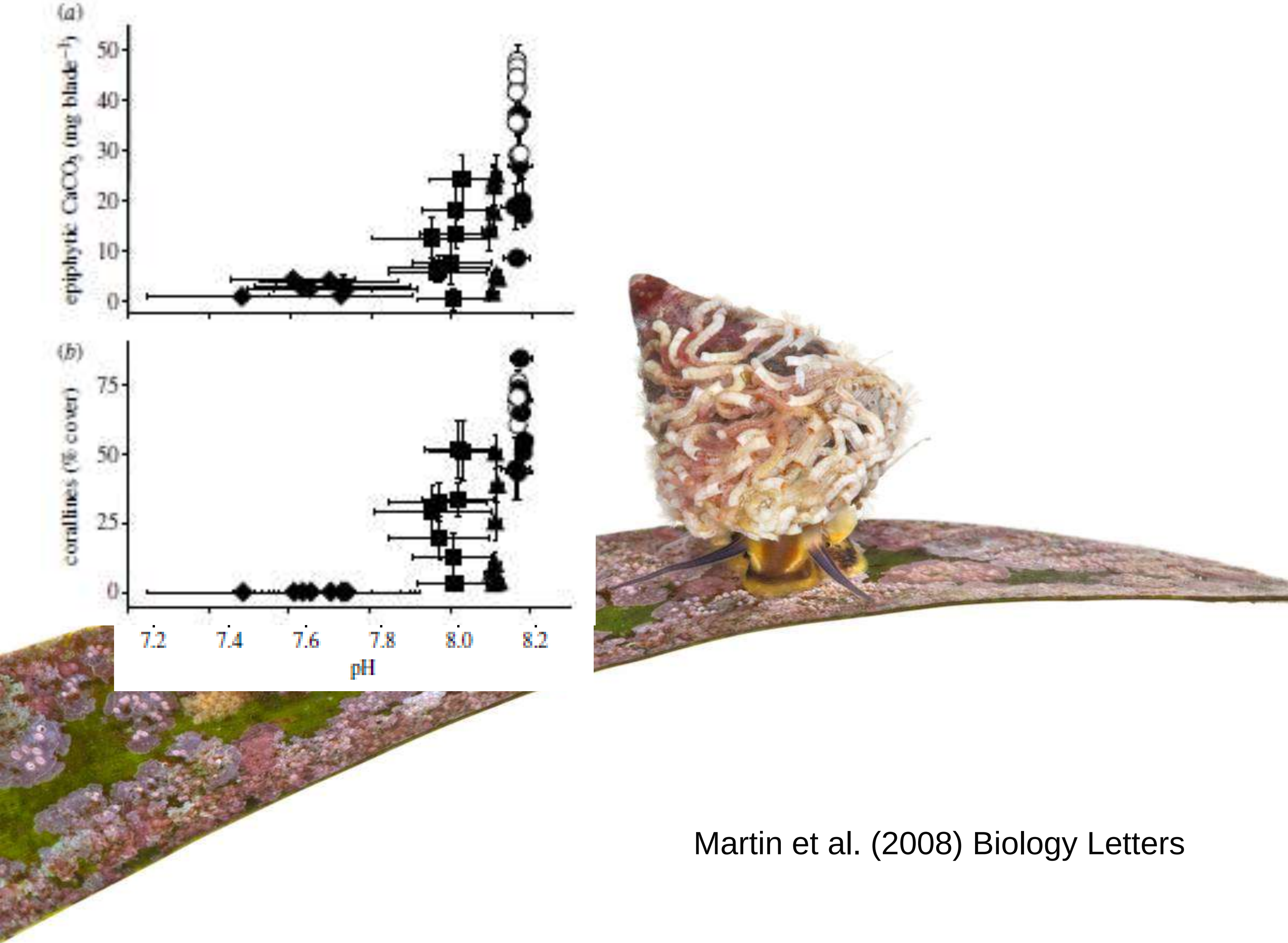


Sunday et al. (2017) Nature Climate Change

Seagrass is carbon limited; it grows well at the seeps



Russell BD et al. (2013) Marine Pollution Bulletin 73, 463-469.



Martin et al. (2008) Biology Letters

We used δ13C values as a proxy for CO_2:HCO_3^- use

Porzio et al. 2010 J Exp Mar Biol Ecol

Cornwall et al. (2017) Scientific Reports

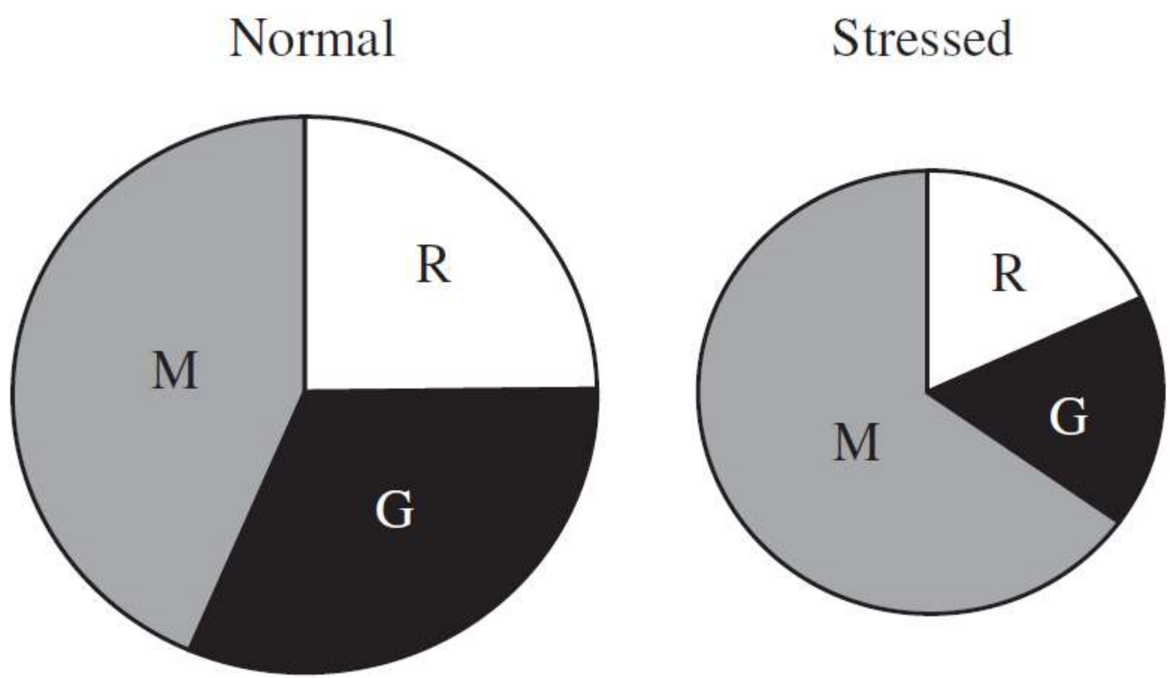
nature climate change

Garilli et al. (2015)

LETTERS

PUBLISHED ONLINE: 20 APRIL 2015 | DOI: 10.1038/NCLIMATE2616

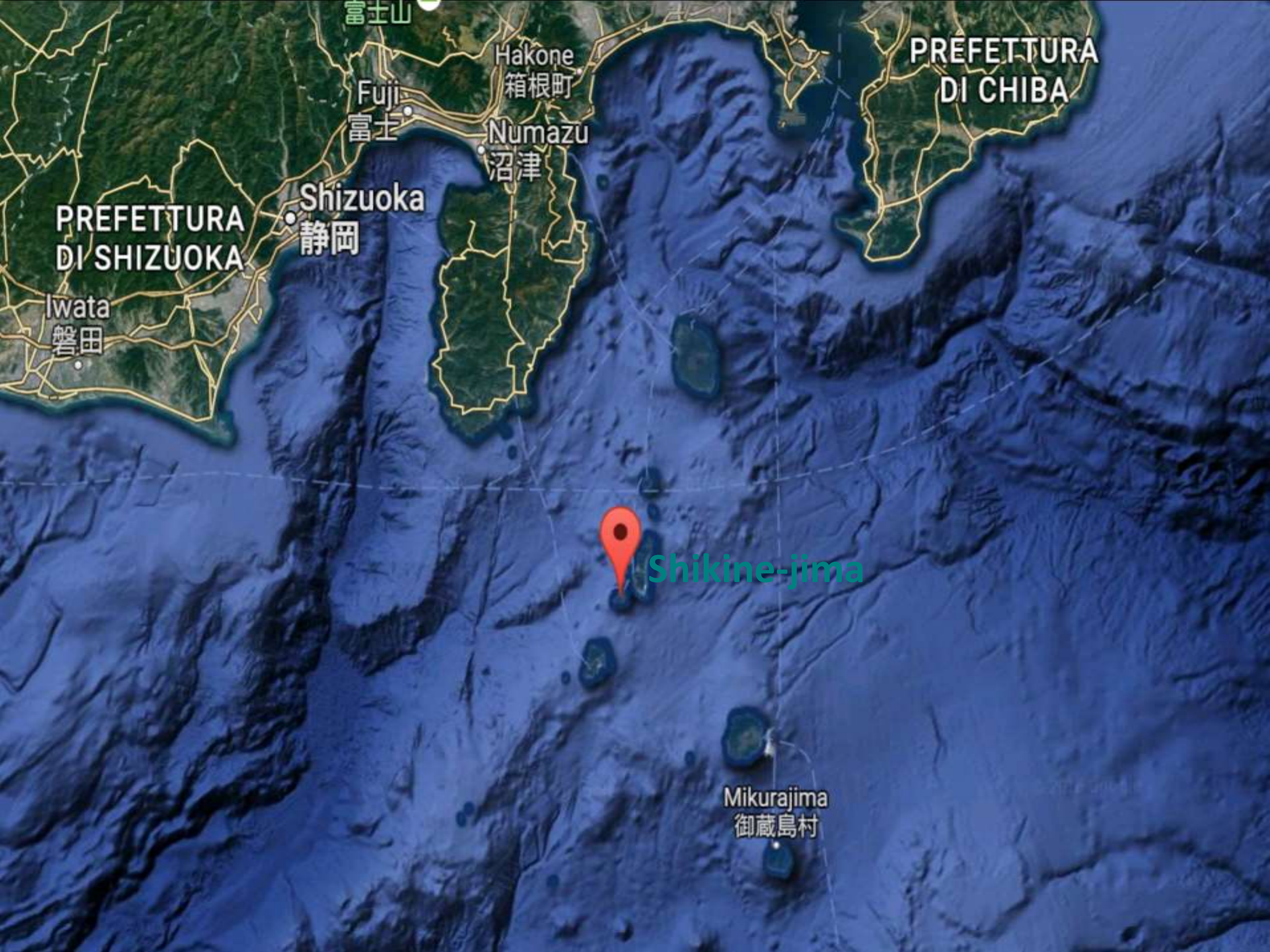
Physiological advantages of dwarfing in surviving extinctions in high-CO_2 oceans



Metabolism, Reproduction and Growth are adversely affected by stress

High CO_2 | High CO_2 plus warming

Warming makes many organisms more susceptible to ocean acidification (Rodolfo-Metalpa et al. 2011 Nature Climate Change)



富士山
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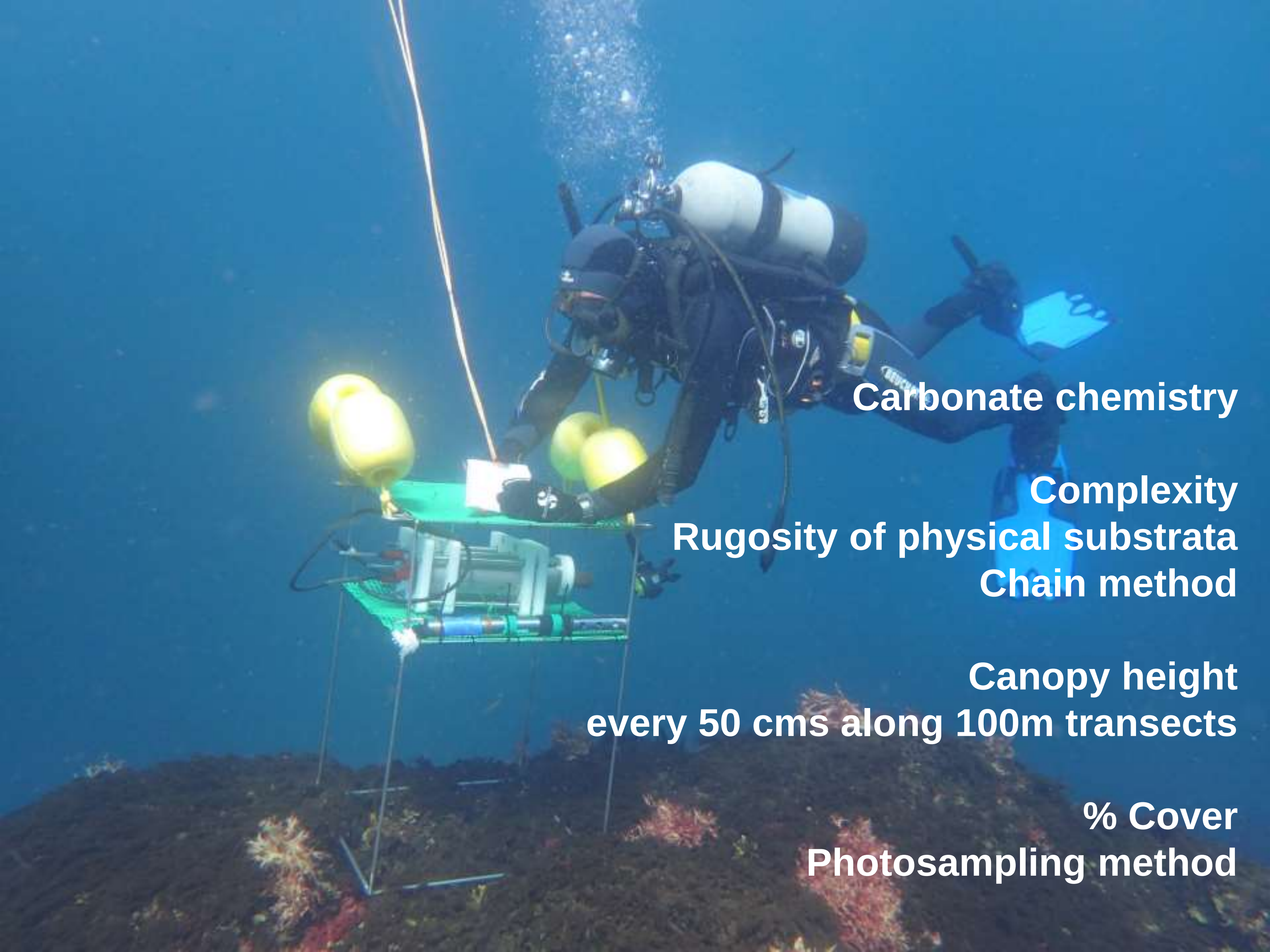
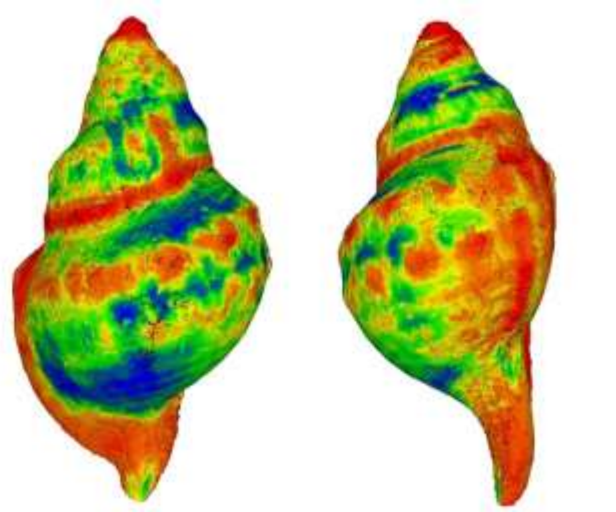
静岡
PREFETTURA DI SHIZUOKA
Iwata
磐田
PREFETTURA DI CHIBA
Shikine-jima
Mikurajima
御蔵島村

CO_2 seeps at Shikine-Jima

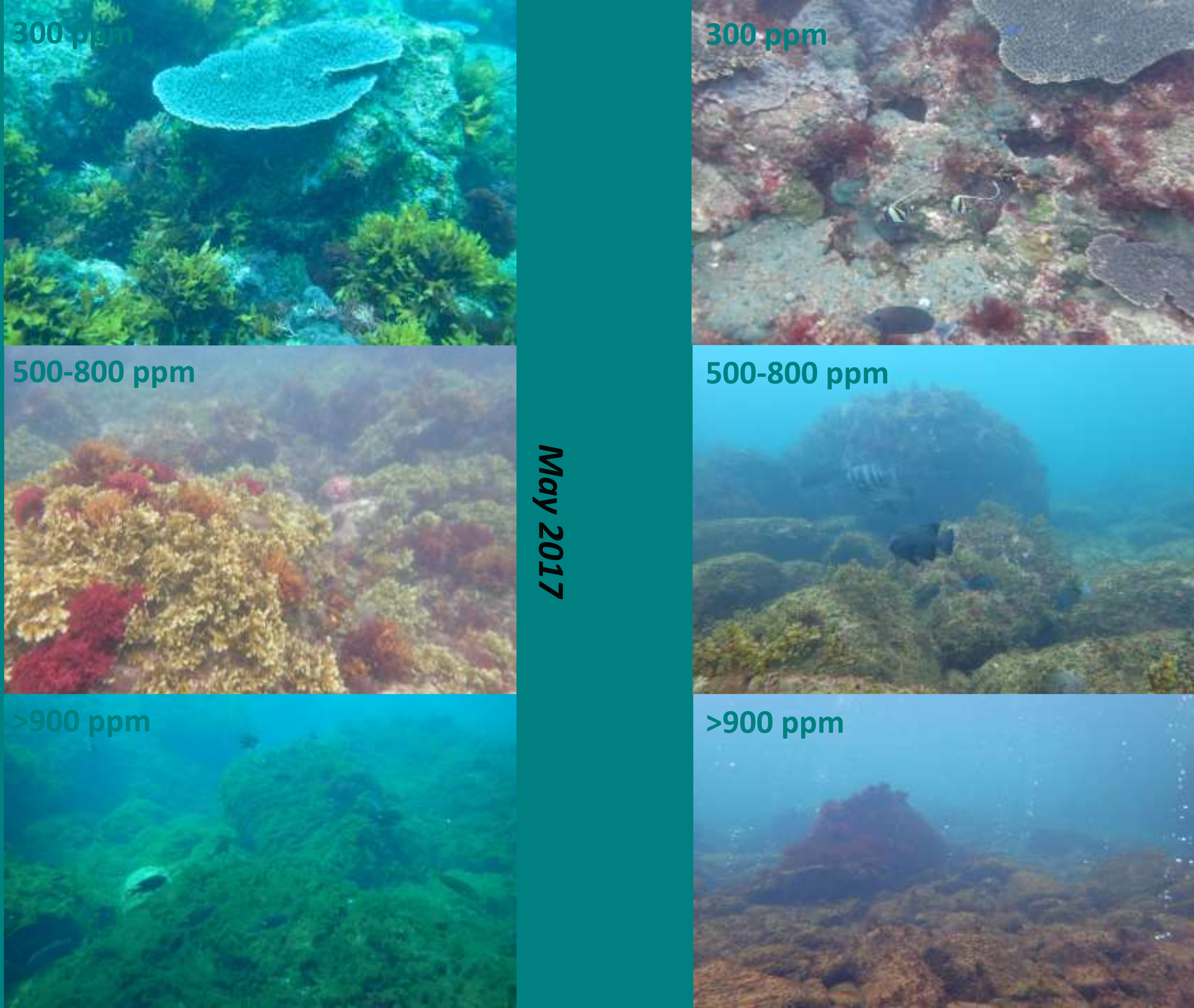
Agostini et al. (2018) Sci Rep


Carbonate chemistry
Complexity
Rugosity of physical substrata
Chain method
Canopy height
every 50 cms along 100m transects
% Cover
Photosampling method

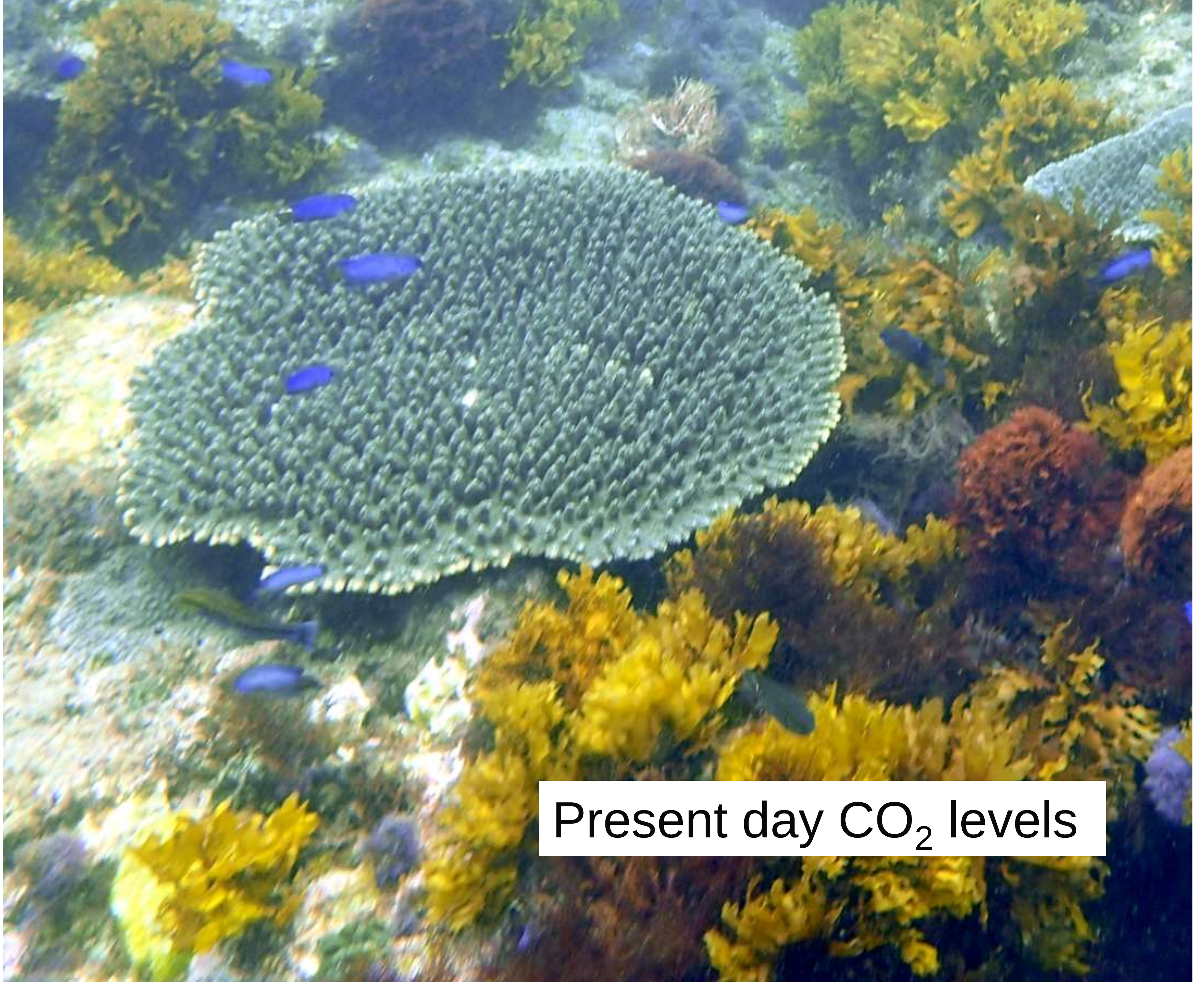
Using computed tomography (CT) scanning, we measured the thickness, density and structure of the shells. Shell thickness was halved in areas with raised CO2 while average shell length was reduced from 178 mm in sites with present day levels to 112 mm. In some cases, body tissue exposed, with the corrosive effects of acidification far more pronounced around the oldest parts of the shell.

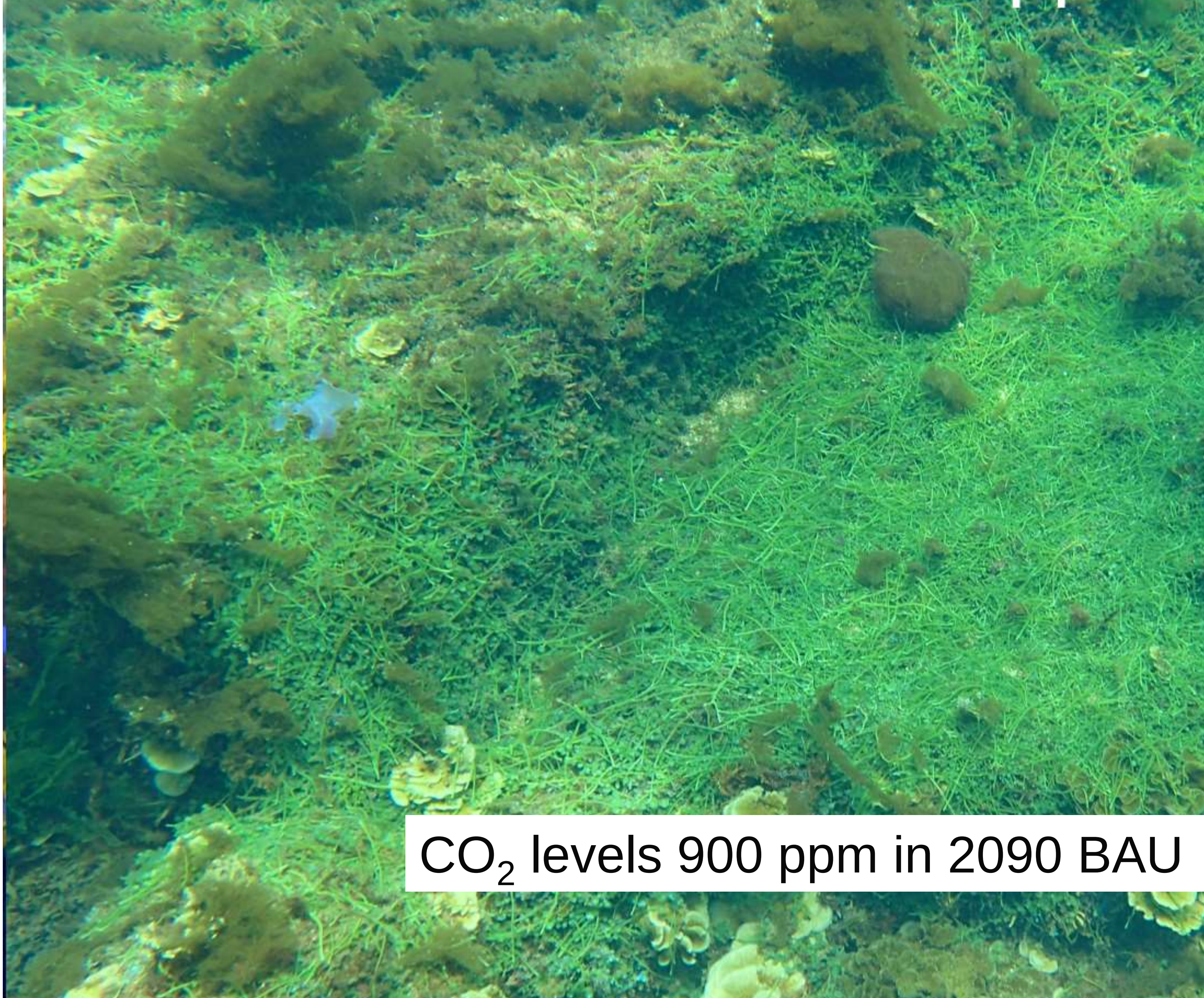


Harvey et al. 2018
Frontiers in Marine Science

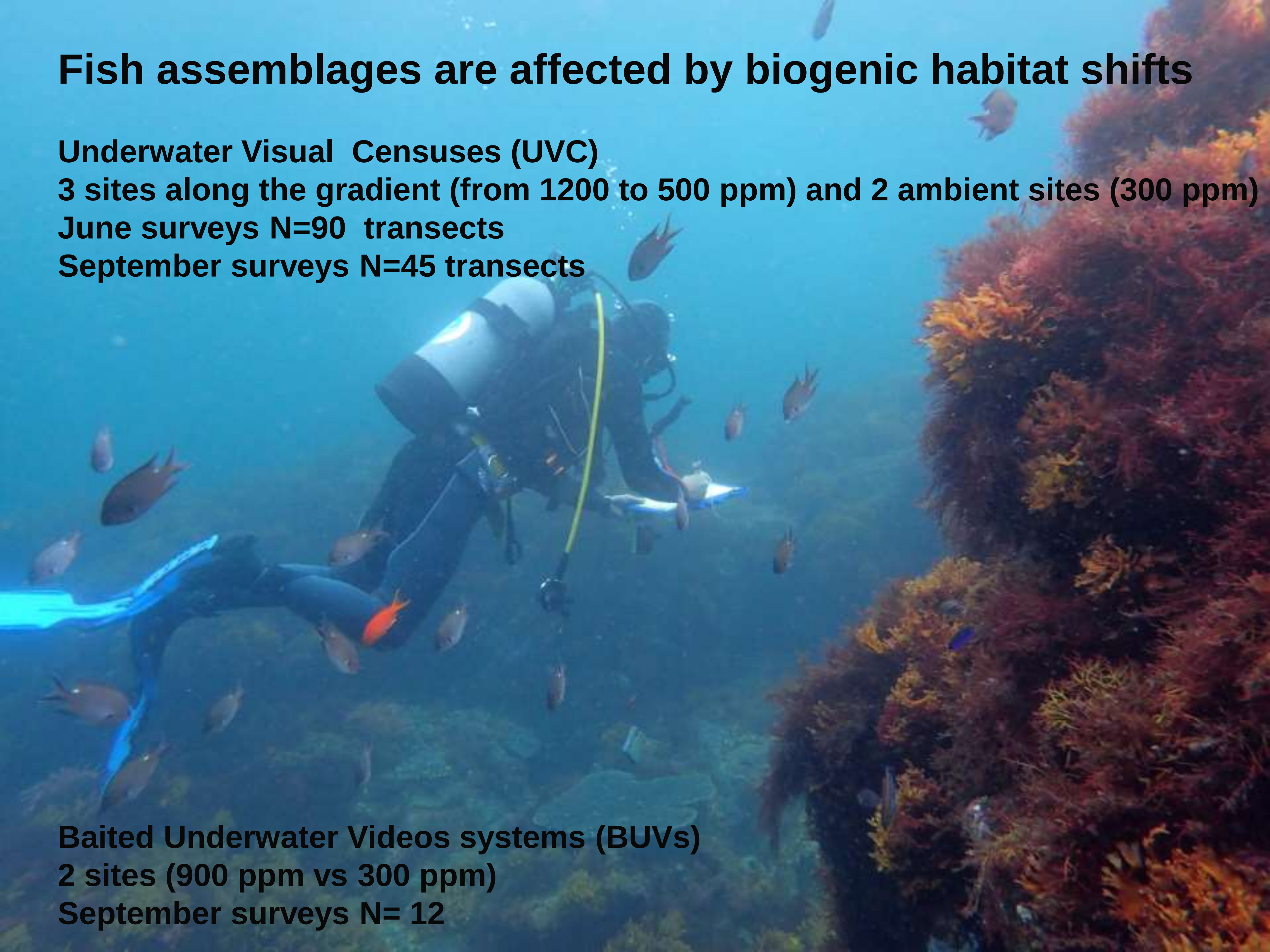


September 2017


Present day CO_2 levels


CO_2 levels 900 ppm in 2090 BAU

Fish assemblages are affected by biogenic habitat shifts



Underwater Visual Censuses (UVC)
3 sites along the gradient (from 1200 to 500 ppm) and 2 ambient sites (300 ppm)
June surveys N=90 transects
September surveys N=45 transects

Baited Underwater Videos systems (BUVs)
2 sites (900 ppm vs 300 ppm)
September surveys N= 12

Ambient CO_2

↑ Canopy
↑ Corals

↑↑ Fish diversity
↑ Fish abundance

900 ppm CO_2
In 2090 if follow BAU

Total of ca. 70 fish spp.

94% in Ambient CO_2 only
56% in Elevated CO_2

Current cuts are not enough!

CO_2 emissions	Δ sea surface temperature (°C)	Δ surface ocean pH
Present day	0.83	-0.11
RCP 2.6	1.13	-0.15
NDCs*	2.0 to 2.6	-0.26 to -0.32
RCP8.5	3.15	-0.41

Paris World

NDCs

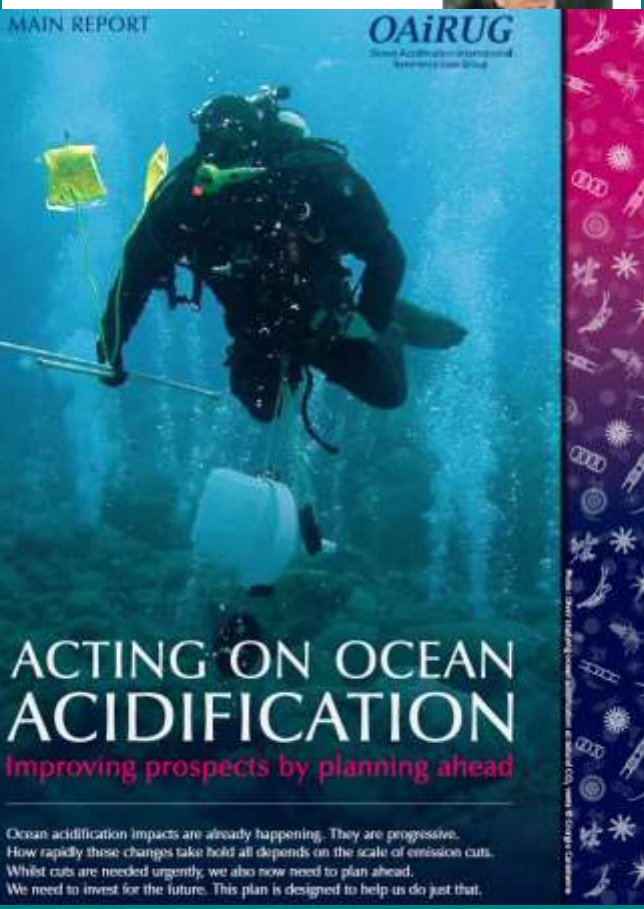
BAU

Global mean values in 2090-2099 relative to 1870-1899

*Nationally Determined Contributions from Climate Action Tracker and Climate Interactive

Amended from Magnan et al (2016) Nature Climate Change

Can we produce a 4-page information pamphlet, tailored to Japanese and/or Asian stakeholders?



20 FACTS about Ocean Acidification

This document presents the highlights of the *Frequently Asked Questions* about Ocean Acidification (2010, 2012; www.whoi.edu/OCB-OA/FAQs), a detailed summary of the state of ocean acidification research and understanding. The *FAQs* and this fact sheet are intended to
scientists, science communicators, and science policy advisors asked to comment on details about
ean acidification. In all, 63 scientists from 47 institutions and 12 countries participated in writing
FAQ, which was produced by the Ocean Carbon and Biogeochemistry Project (www.us-ocb.org),
United Kingdom Ocean Acidification Programme (www.oceanacidification.org.uk), and the
ropean Project on Ocean Acidification (EPOCA). More information and contacts can be found at
y of these websites or at the Ocean Acidification International Coordination Centre's website
ww.iaea.org/ocean-acidification). The Intergovernmental Panel on Climate Change (IPCC) Fifth
sessment Report findings on ocean acidification can be viewed at www.ipcc.ch.

Ocean acidification (OA) is a progressive increase in the acidity of the ocean over an extended period, typically
ades or longer, which is caused primarily by uptake of car-
dioxide (CO_2) from the atmosphere. It can also be caused
enhanced by other chemical additions
ubtractions from the ocean.
dification can be more severe
areas where human activities
impacts, such as acid rain and
rient runoff, further increase
dity.

OA has been well documented with
bal observations
ducted over sev-
decades by hun-
ds of researchers.
as been definitively
ibuted to human-generat-
CO_2 in the atmosphere that has been released primarily
fossil fuel combustion and land use changes.

Acidity may be thought of as simply the hydrogen ion concentration (H^+) in a liquid, and pH is the loga-
rmic scale on which this concentration is measured. It is
portant to note that acidity increases as the pH decreases.

Average global surface ocean pH has already fallen from
a pre-industrial value of 8.2 to 8.1, corresponding to an in-
ase in acidity of about 30%. Values of 7.8–7.9 are expected
2100, representing a doubling of acidity.

5 The pH of the open-ocean surface layer is unlikely to ever become acidic (i.e. drop below pH 7.0), because seawater is buffered by dissolved salts. The term "acidification" refers to a pH shift towards the acidic end of the pH scale, similar to the way we describe an increase in temperature from -20°C to -0°C (-4°F to 32°F): it's still cold, but we say it's "warming."

6 OA is also changing seawater carbonate chemistry. The concentrations of dissolved CO_2, hydrogen ions, and bicarbonate ions are increasing, and the concentration of carbonate ions is decreasing.

7 Changes in pH and carbonate chemistry force marine organisms to spend more energy regulating chemistry in their cells. For some organisms, this may leave less energy for other biological processes like growing, reproducing or responding to other stresses.