ATCM XXXVIII- CEP XVIII, Sofia, 2015

Scientific Committee on Antarctic Research
Antarctic Science Lecture

Southern Ocean Acidification

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Chair of the SCAR Action Group on Ocean Acidification

Acknowledgements

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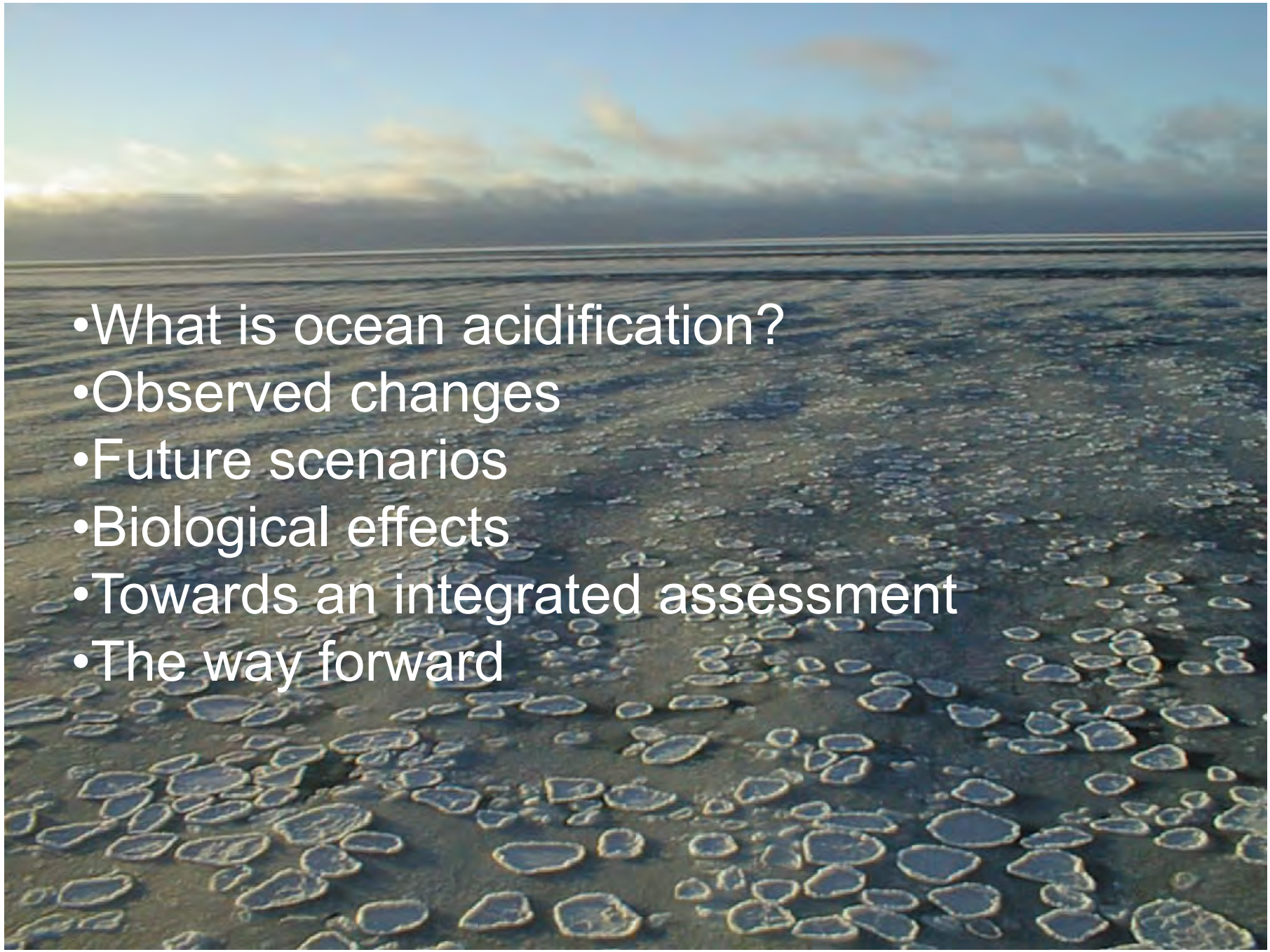
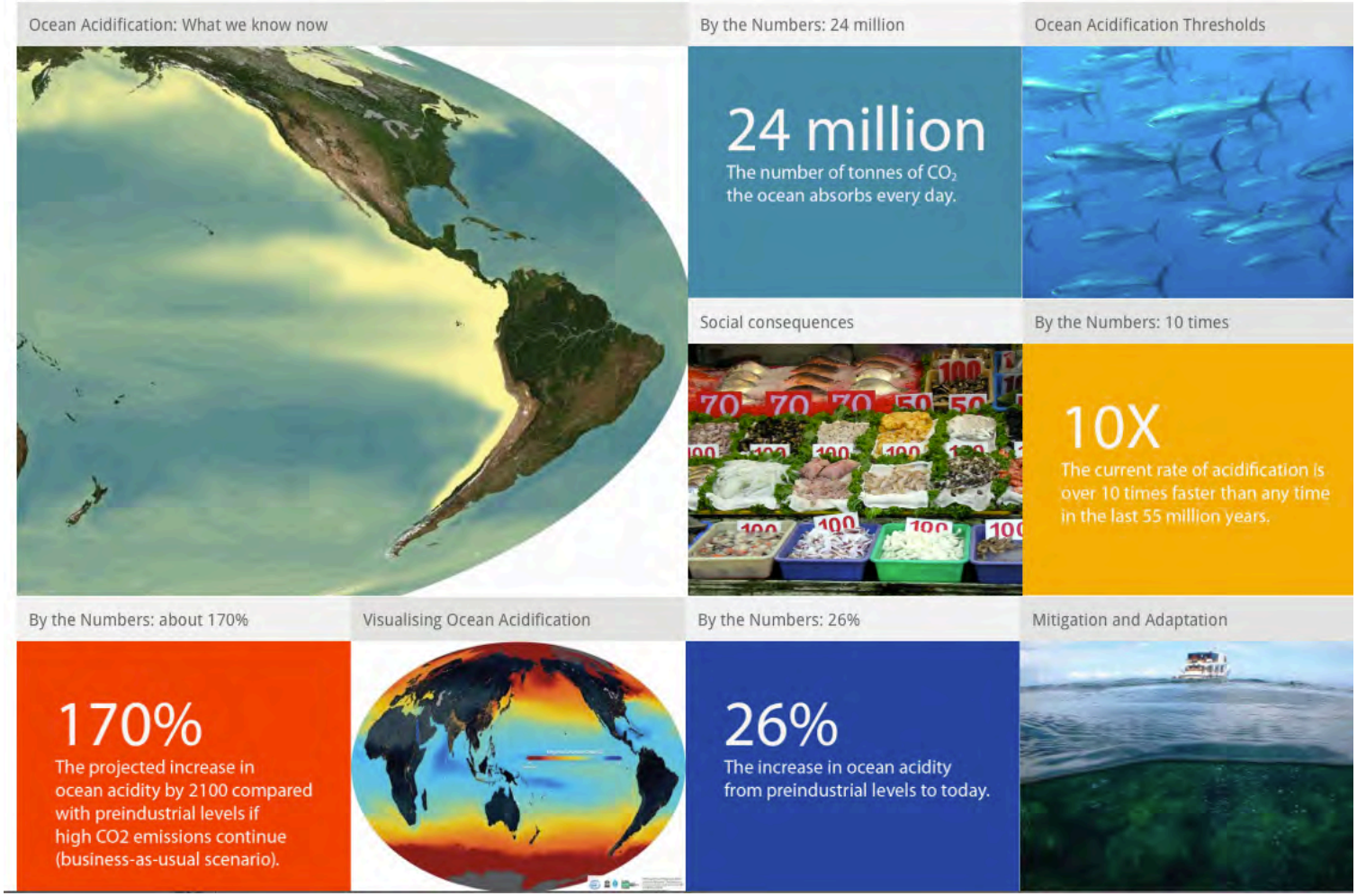

•What is ocean acidification?
•Observed changes
•Future scenarios
•Biological effects
•Towards an integrated assessment
•The way forward

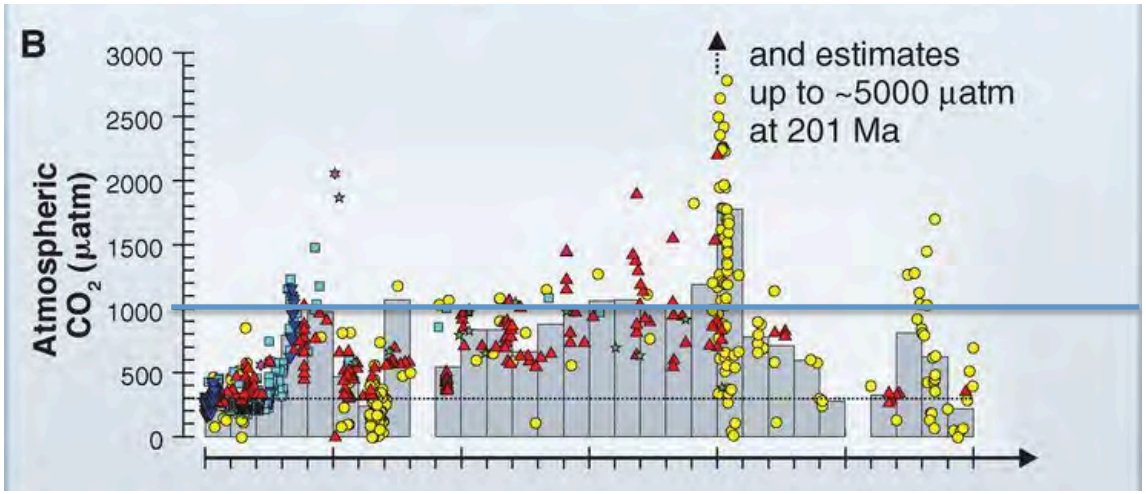
What is ocean acidification?

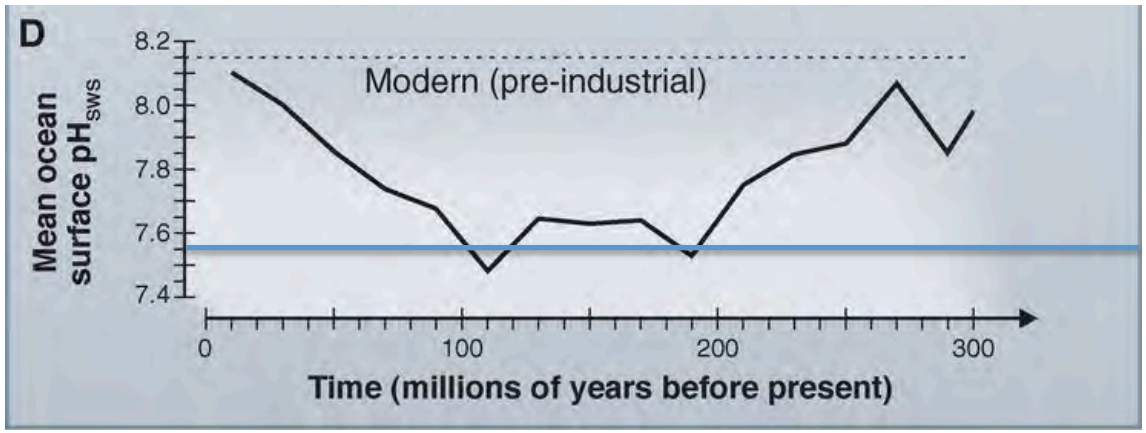
Ocean acidification in a nutshell

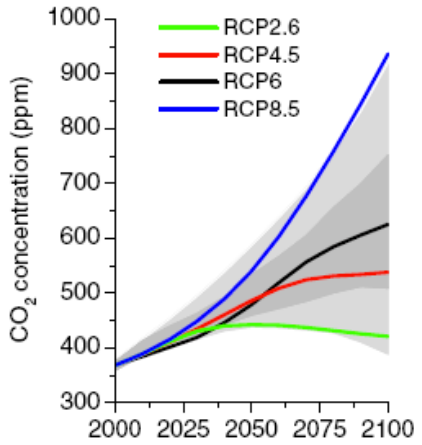


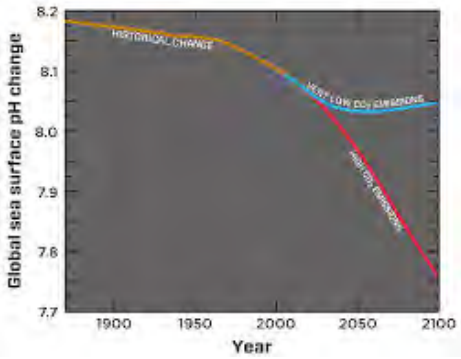
www.ocean-acidification.net

Present CO_2 in a geological perspective



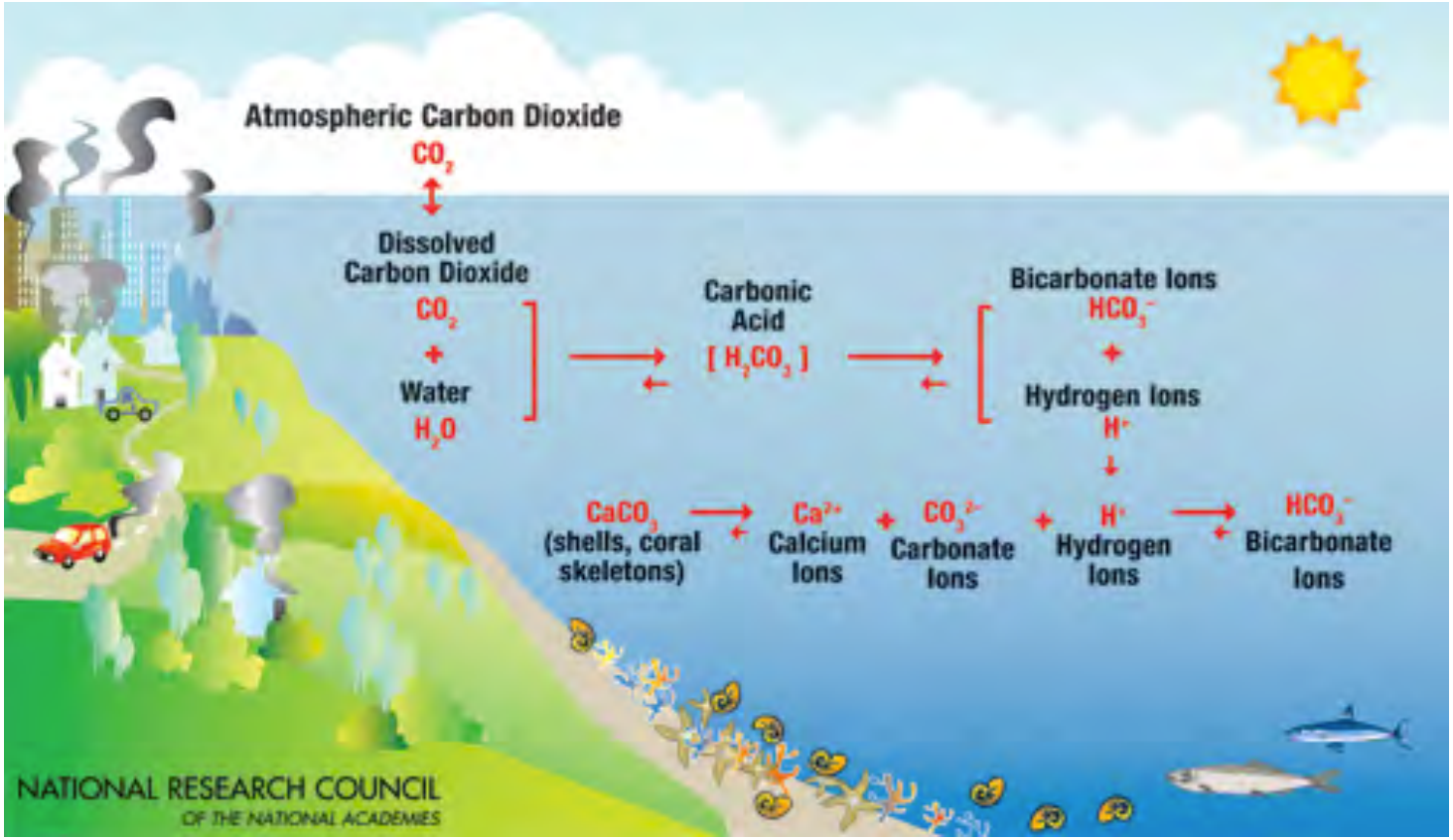






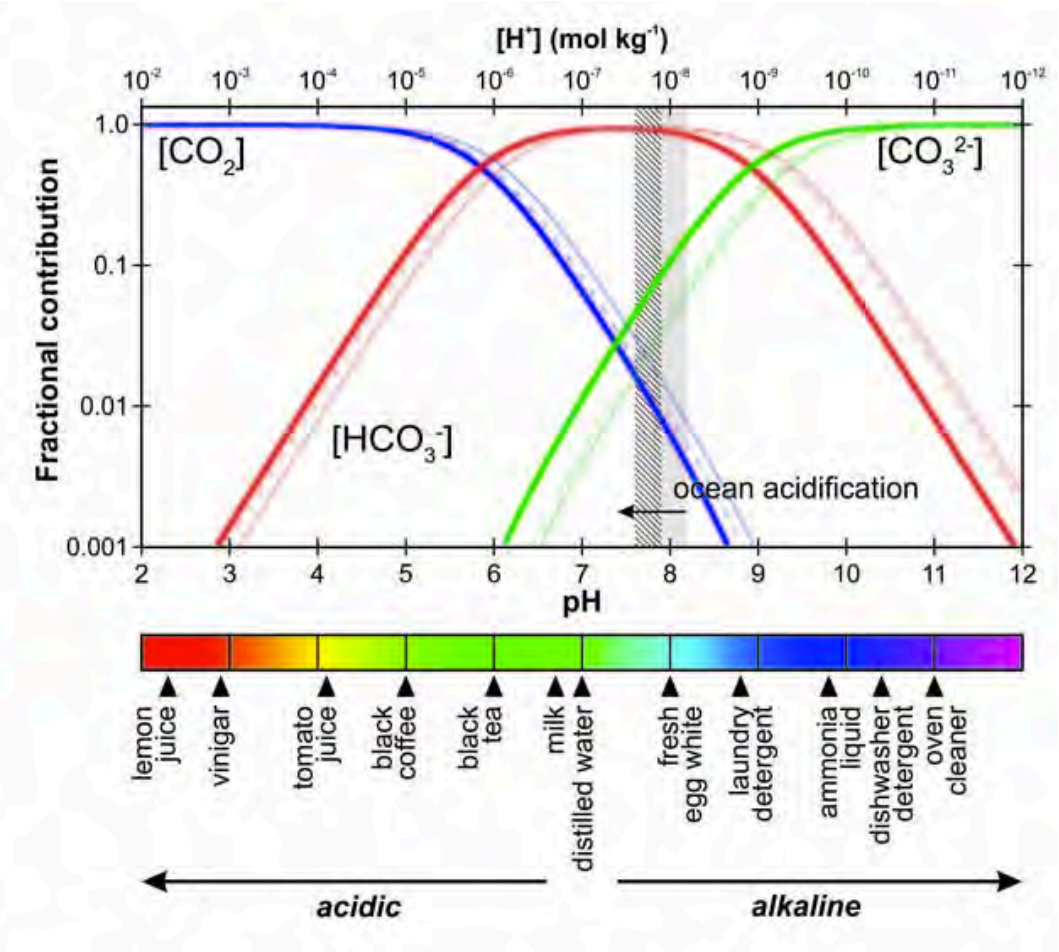
Hönisch et al., Science, 2012

Chemistry of the marine carbonate system



Ocean acidification has many forms

Ocean acidification is the transformation of seawater *towards* an acidic state – it does not mean that the oceans will become acidic



Observations of Southern Ocean acidification

The Southern Ocean carbon system is one of the most complex of the global oceans

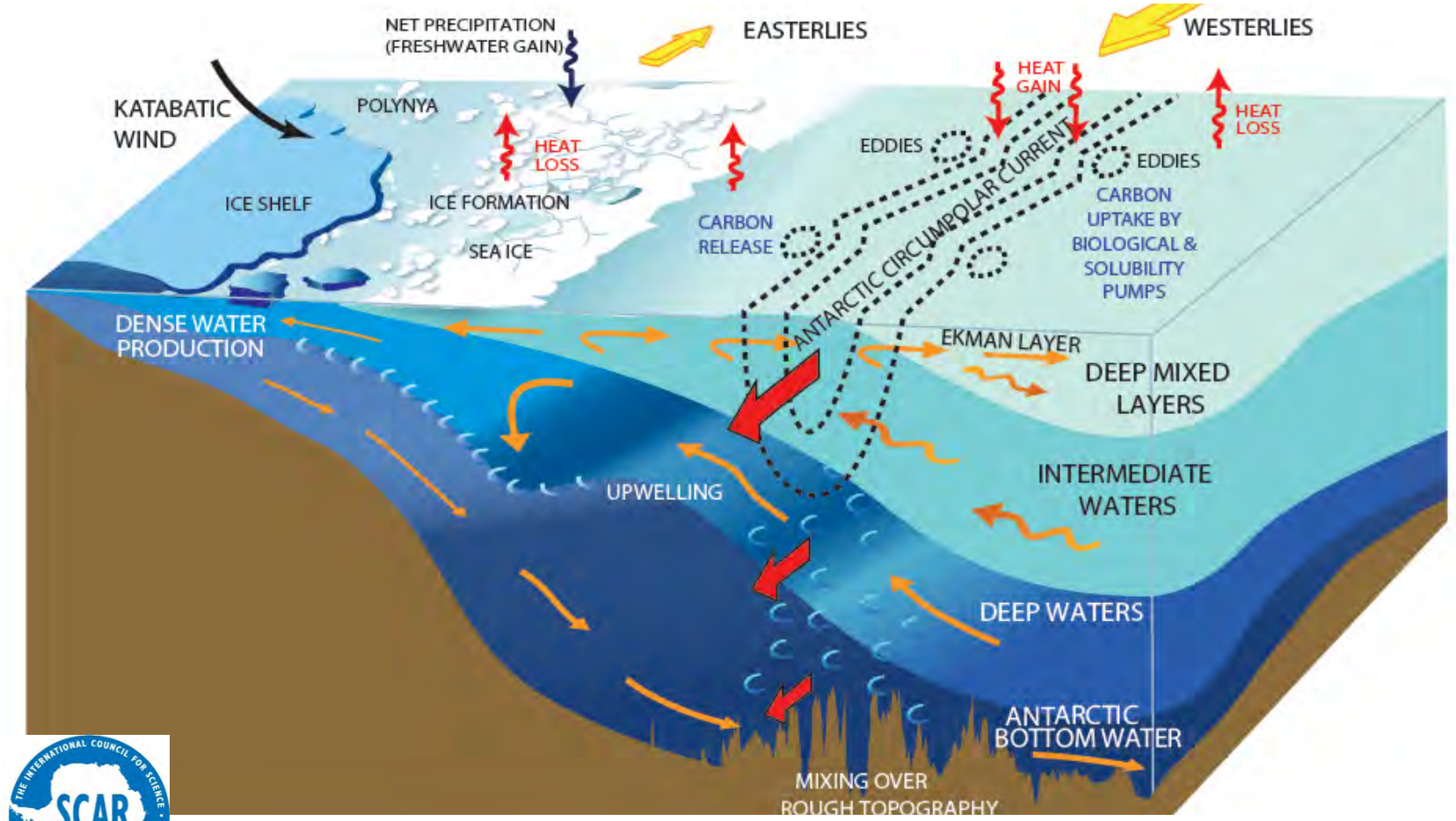
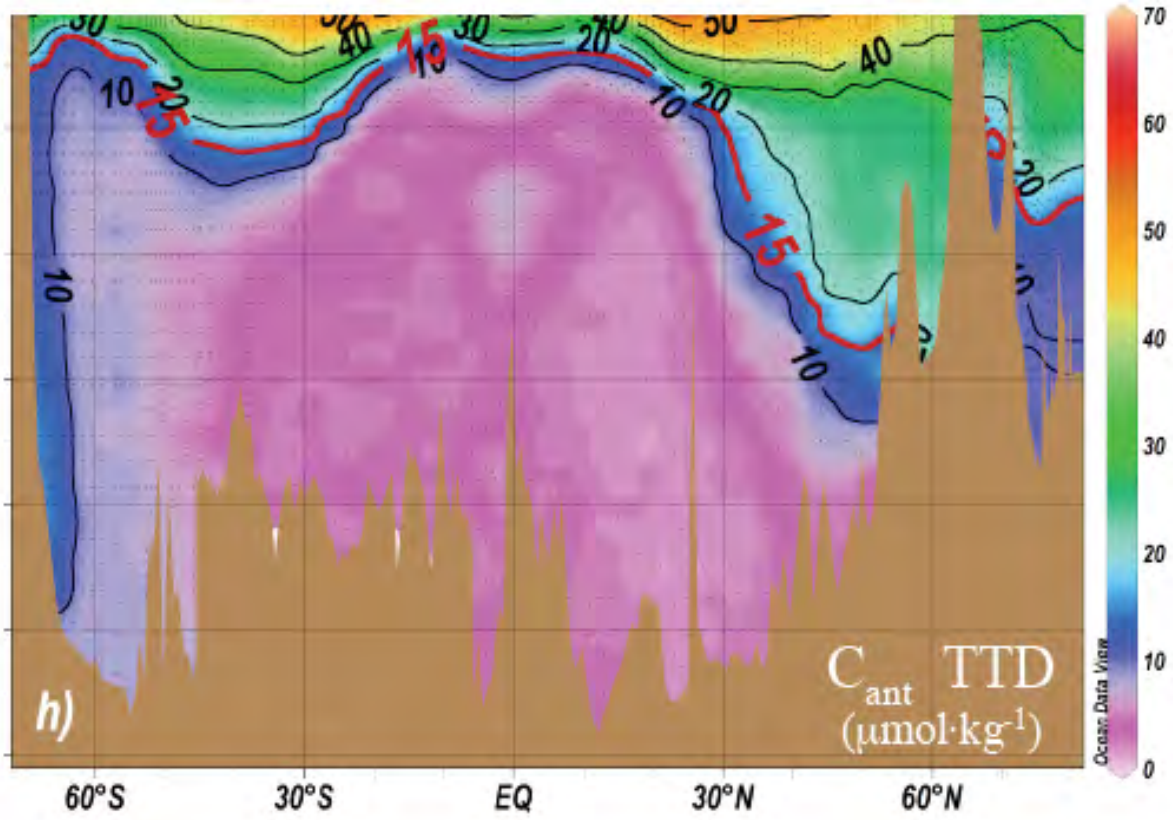


Image courtesy of Lynne Talley

Ocean anthropogenic carbon (and thus anthropogenic pH change) is already measurable

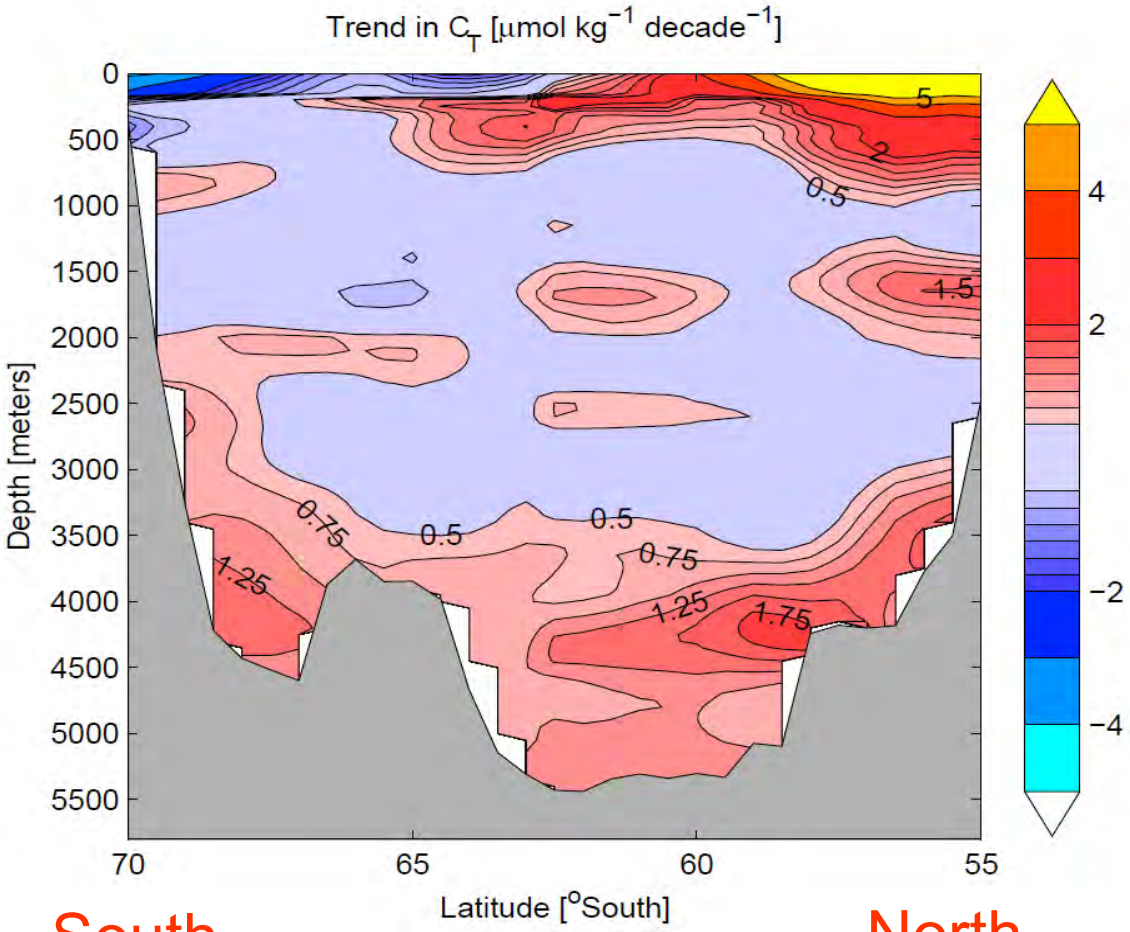


Antarctica

Arctic

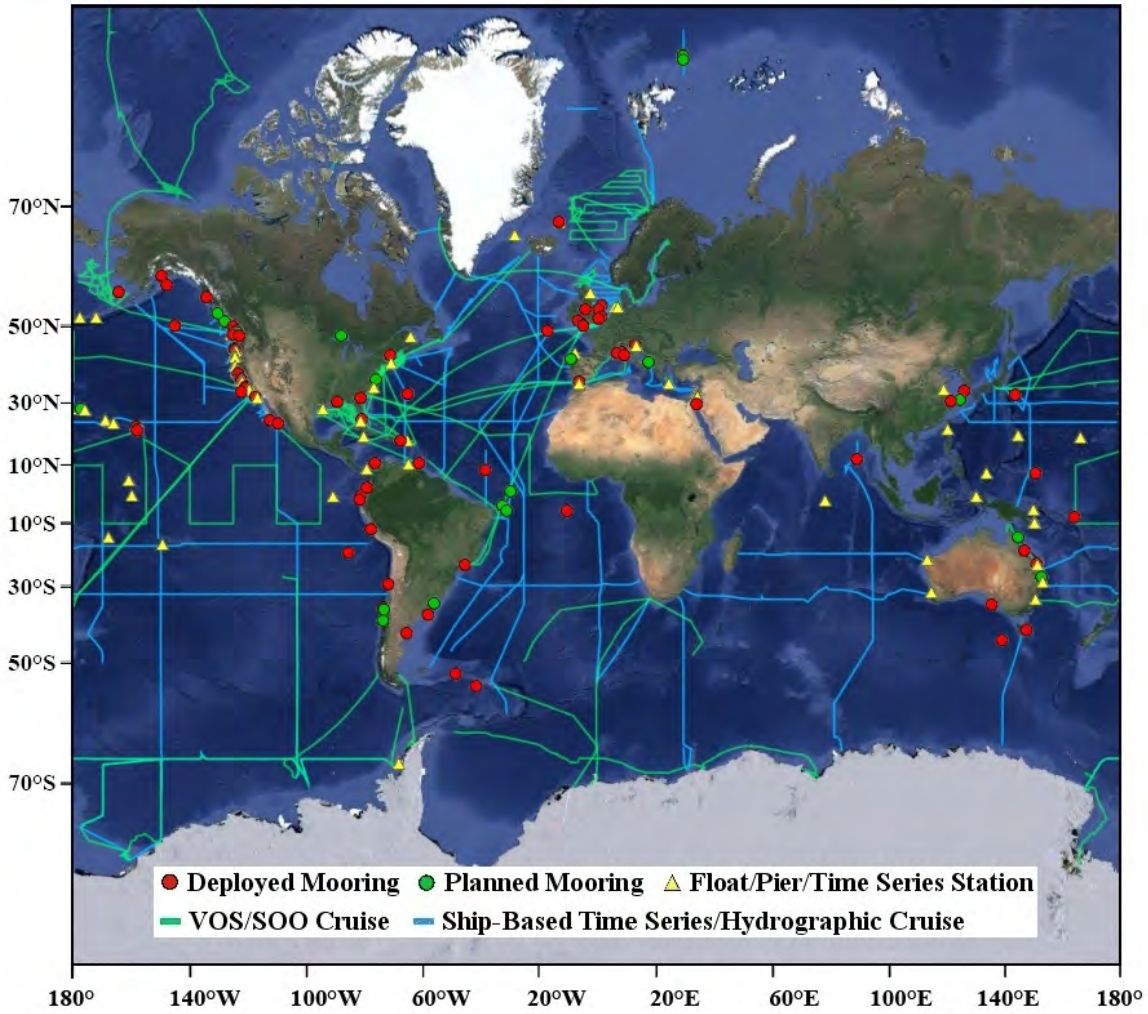
Vázquez Rodríguez et al 2009

There is great regionality and water column variability



Van Heuven et al. 2011

Global ocean acidification observing assets

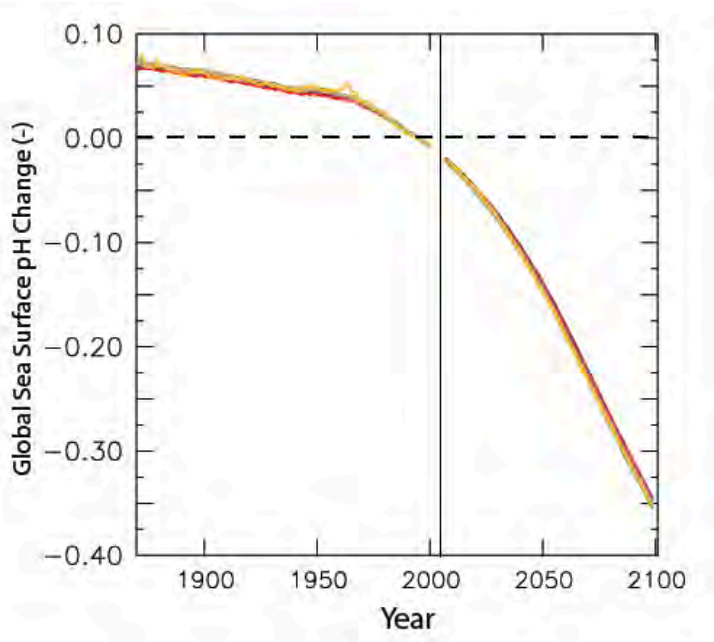


Interactive map by Cathy Cosca, NOAA

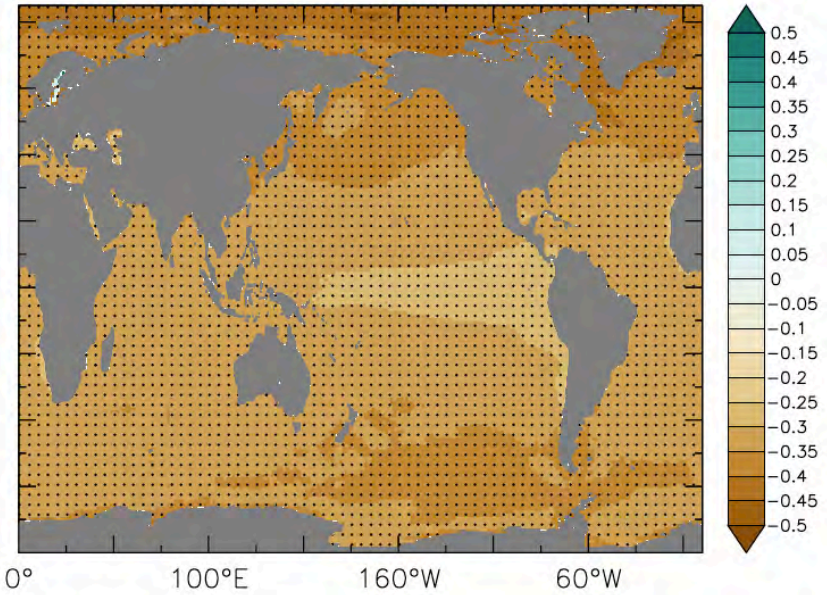
GOA-ON
Global Ocean Acidification Observing Network

Future ocean acidification

The global marine carbon system is changing fast



Comparison of Earth System models gives excellent inter-model agreement at “mean” global pH

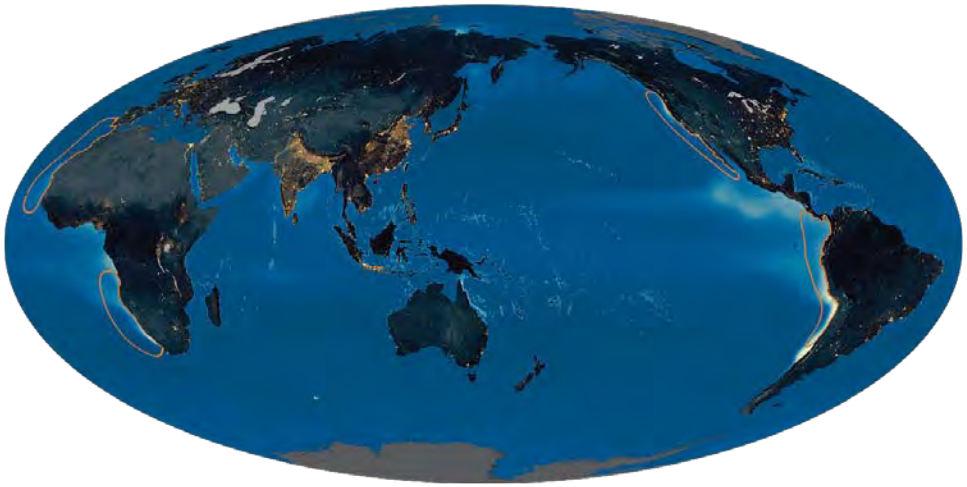


The high latitudes will have the greatest pH reduction

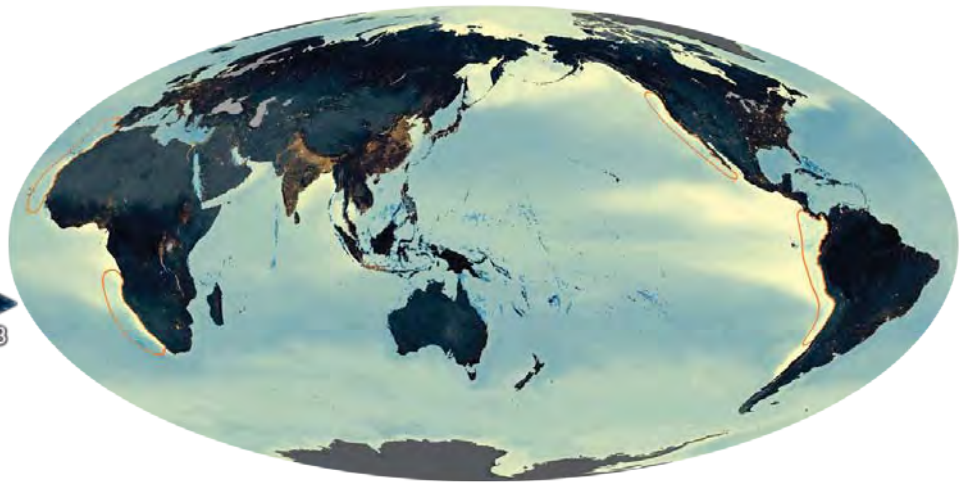
Bopp et al., 2013

Global ocean pH simulations

1850



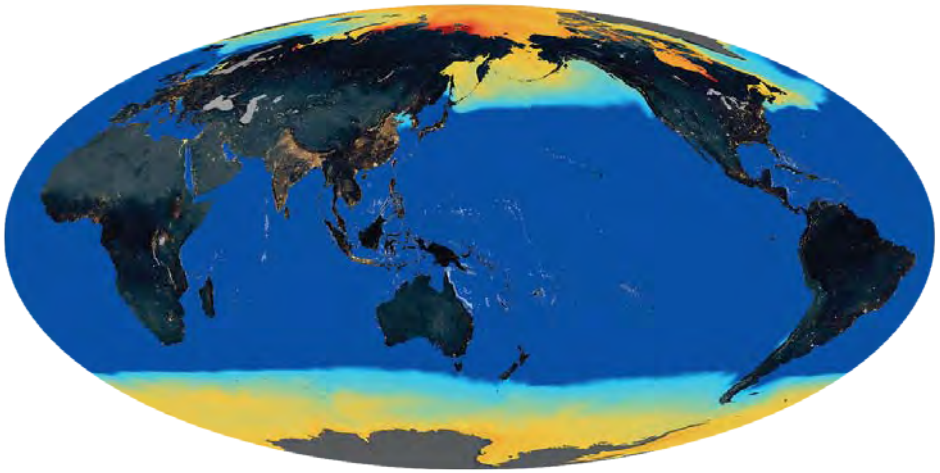
2100



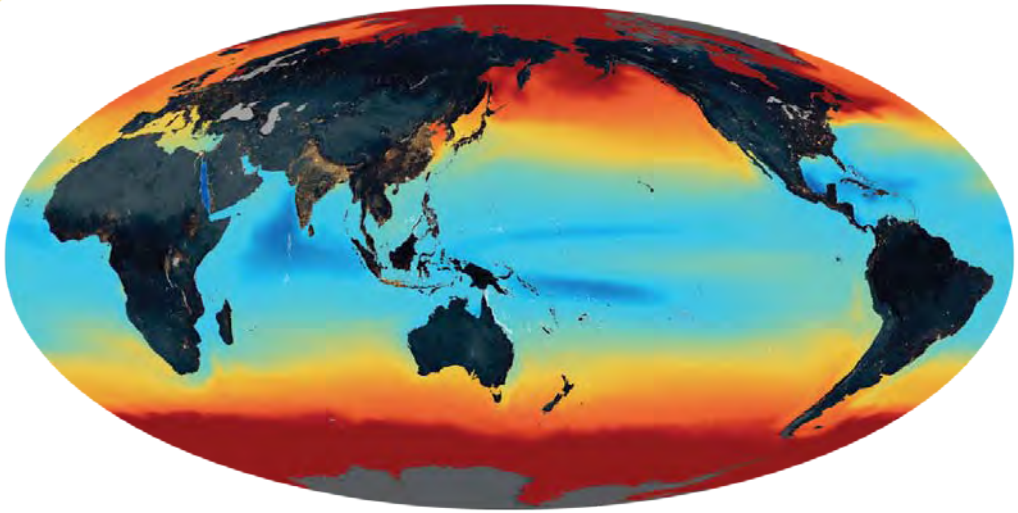
OA summary for policy makers, 2013

Global aragonite saturation state

1850

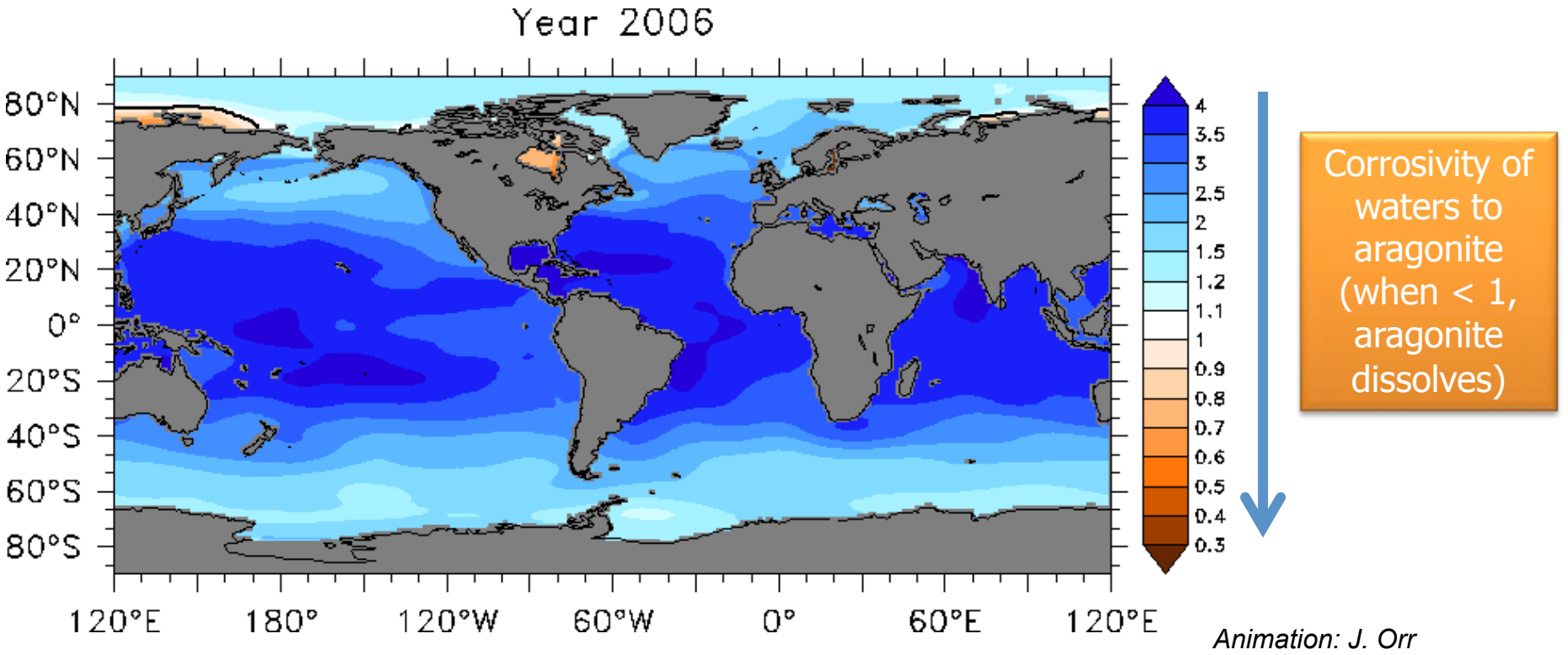


2100



OA summary for policy makers, 2013

Southern Ocean will soon become corrosive to aragonite found in some marine shells & skeletons



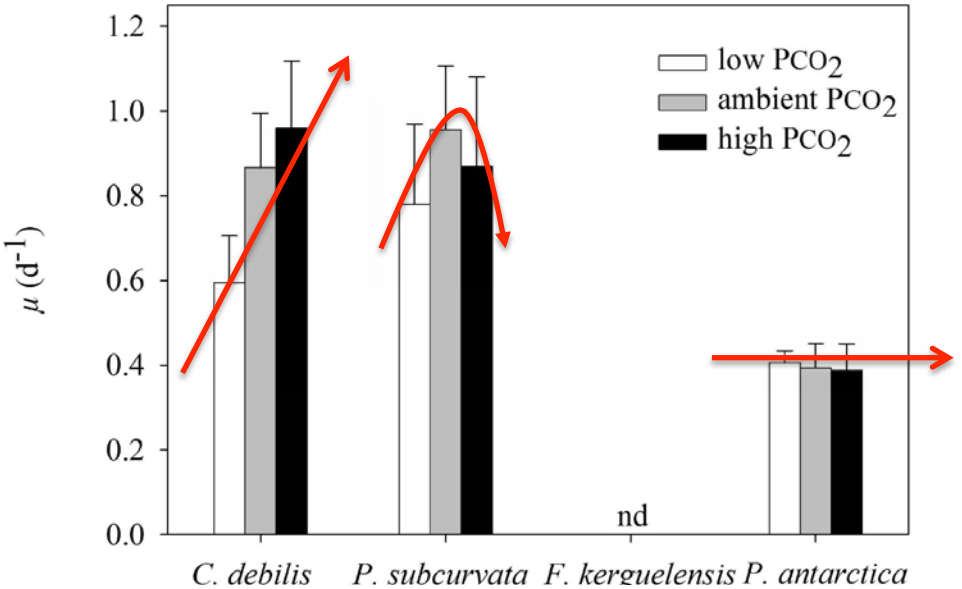
Animation: J. Orr

Latest model projections (IPCC AR5 WG1, 2013)

Biological responses ocean acidification

Growth rates of Antarctic phytoplankton are sensitive to ocean acidification

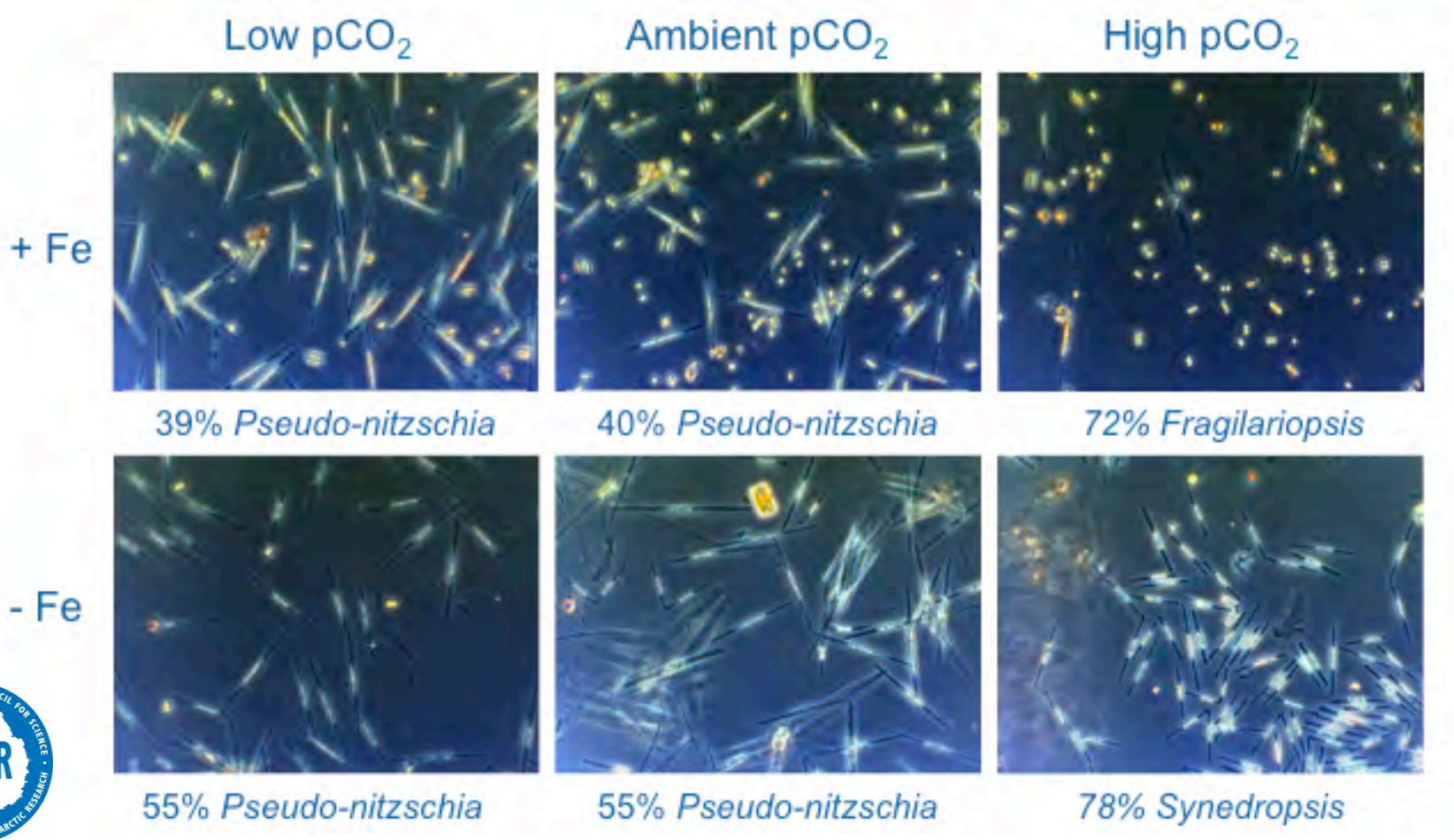
Some plankton will do better than others changing the structure and functioning of the surface productive ocean



Trimborn et al, L&O 2013

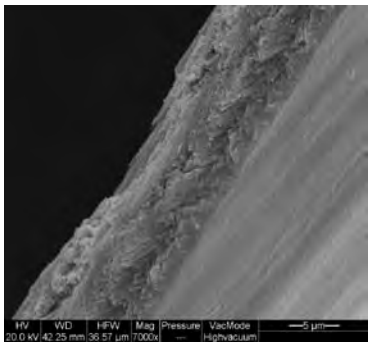
The plankton community is modiefied under increasing CO_2

This has huge consequences for food quality and energy supply to the Ocean

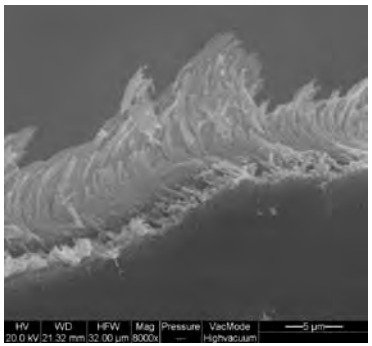


Pteropods are very sensitive to ocean acidification

up to 90% of the zooplankton in highly productive regions of the Southern Ocean



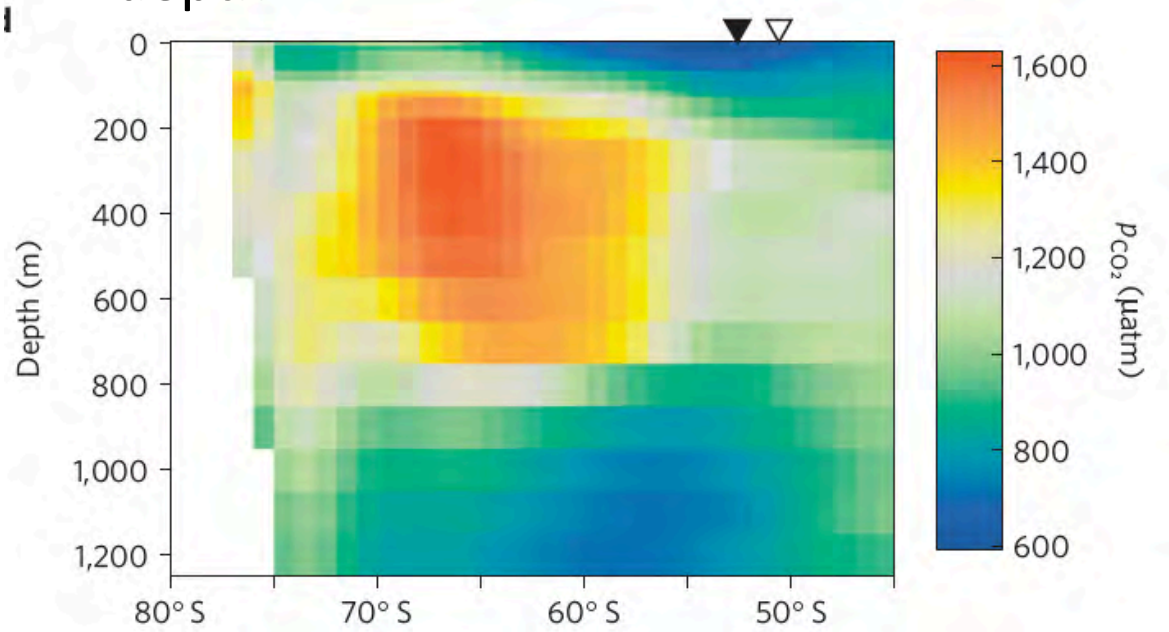
Modern day CO_2



End of century CO_2

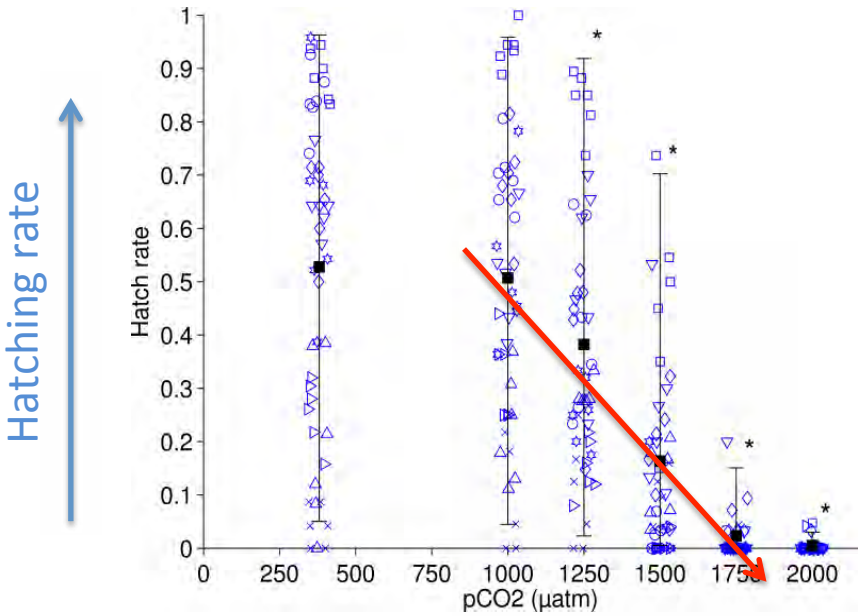
Ocean acidification will be greatest at Krill migration depths

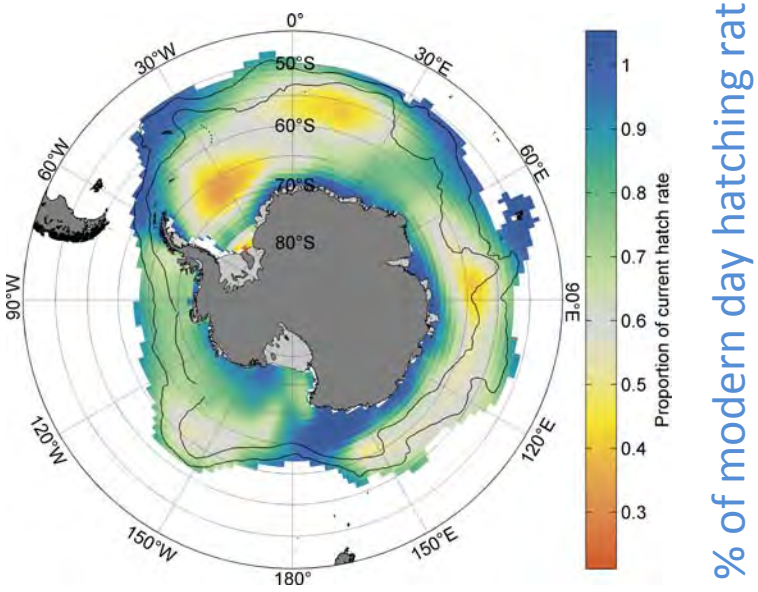
At 700ppm atmospheric CO2, the ocean CO_2 concentrations may be over 1600ppm at intermediate depth



Kawaguchi et al., 2013

Experiments suggest that ocean acidification will challenge krill hatching success

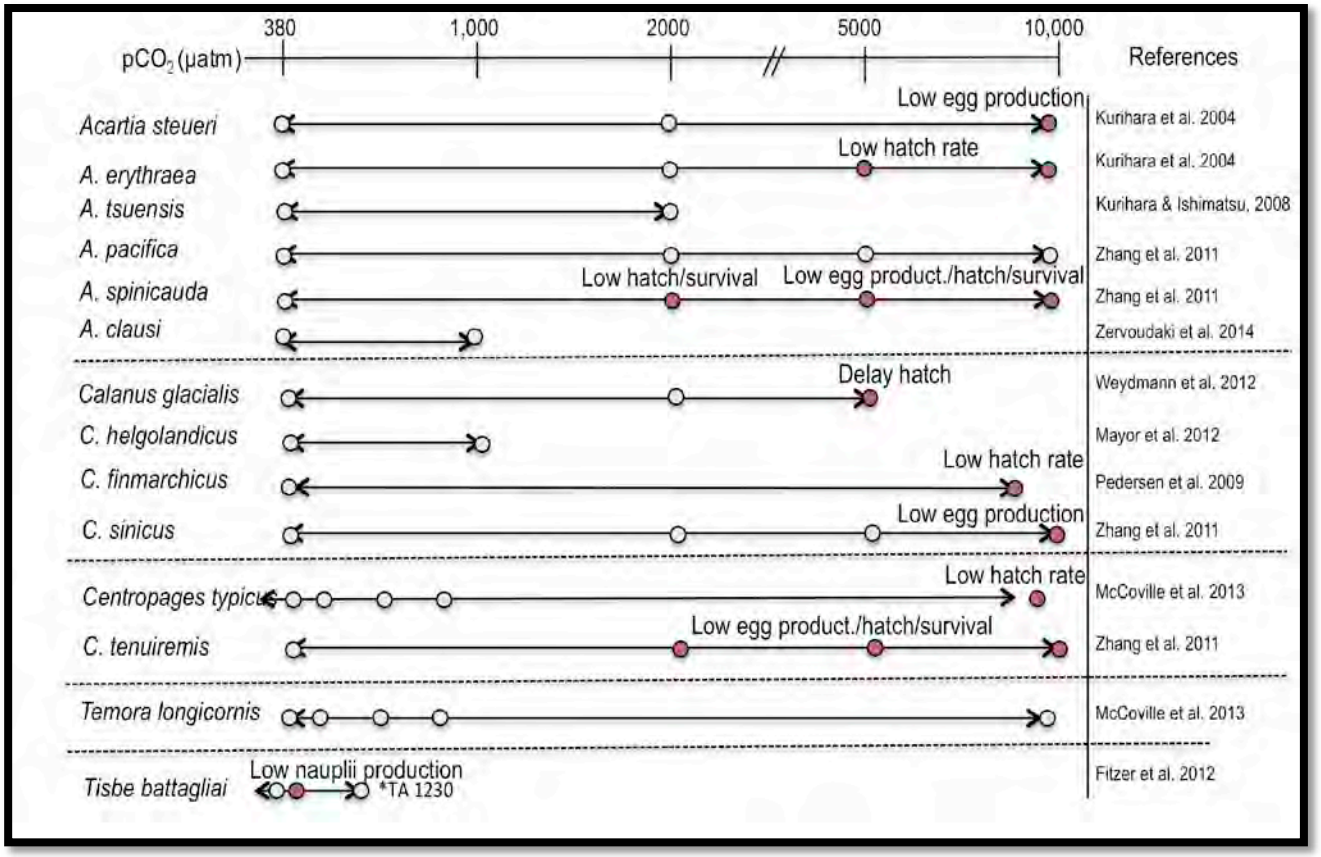




Kawaguchi et al., 2013

Effects of ocean acidification on copepods have many faces.

Ocean acidification



Ocean acidification response

Benthic organism that show an acidification response are especially vulnerable

Most organisms have such slow generation times that their chance to adapt to new conditions is very low

Southern Ocean species

Temperate species

Time between generations

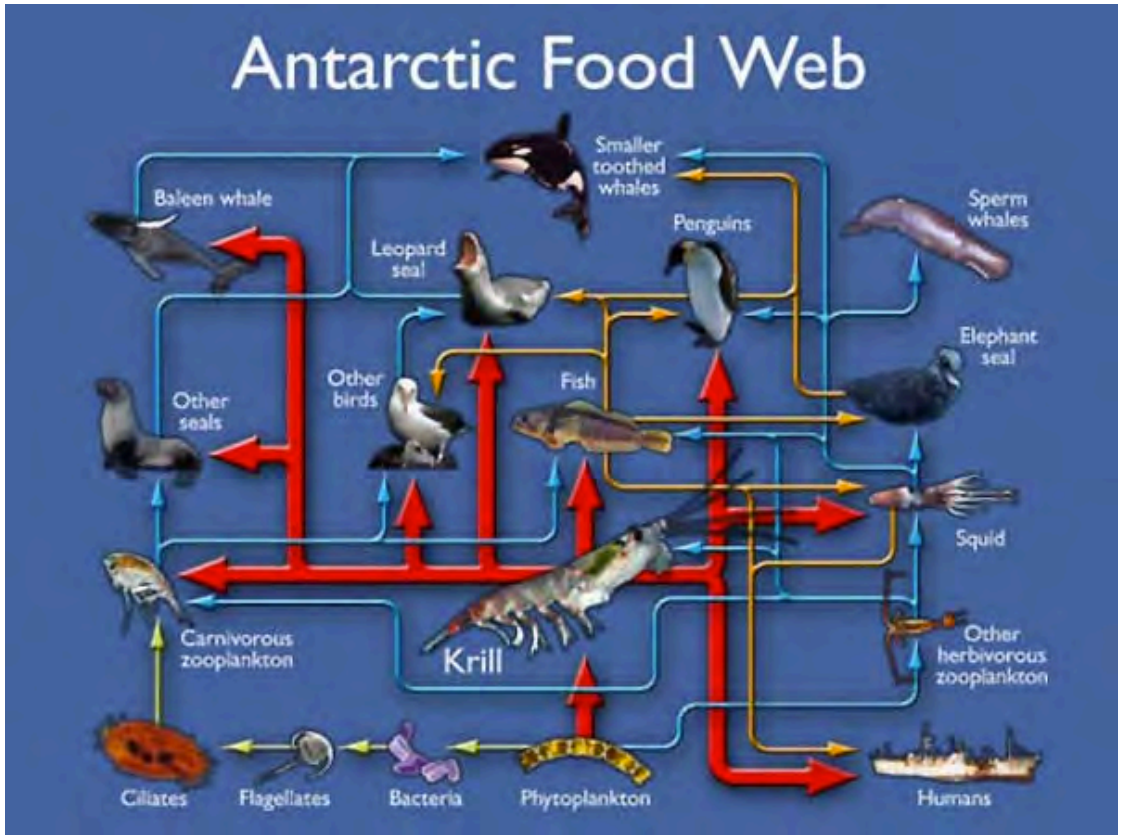
Oikonos.org

Hans Hillewaert

The Antarctic sea urchin, *Sterechinus neumayeri* (left), has less chance to acclimate and adapt

The Southern Ocean ecosystem is complex

And it houses many keystone species that are sensitive to ocean acidification

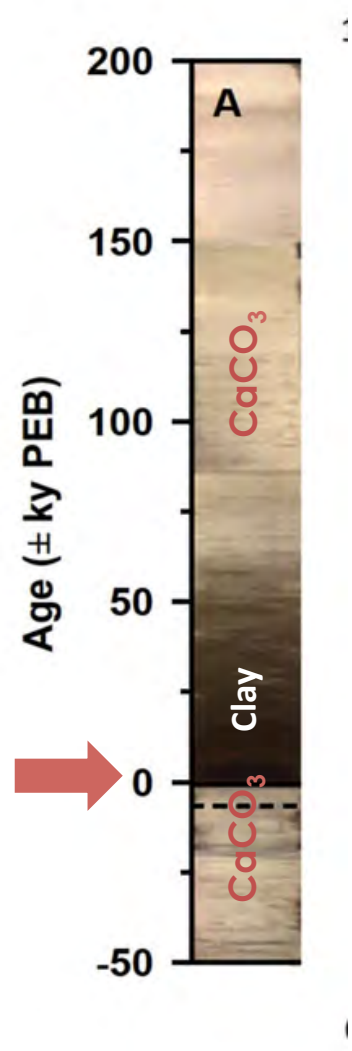


A disappearance of $CaCO_3$ in the sediments

A sign of massive ecological change?

During an ocean acidification period 55 million years ago no CaCO3 shells or skeletons were preserved.

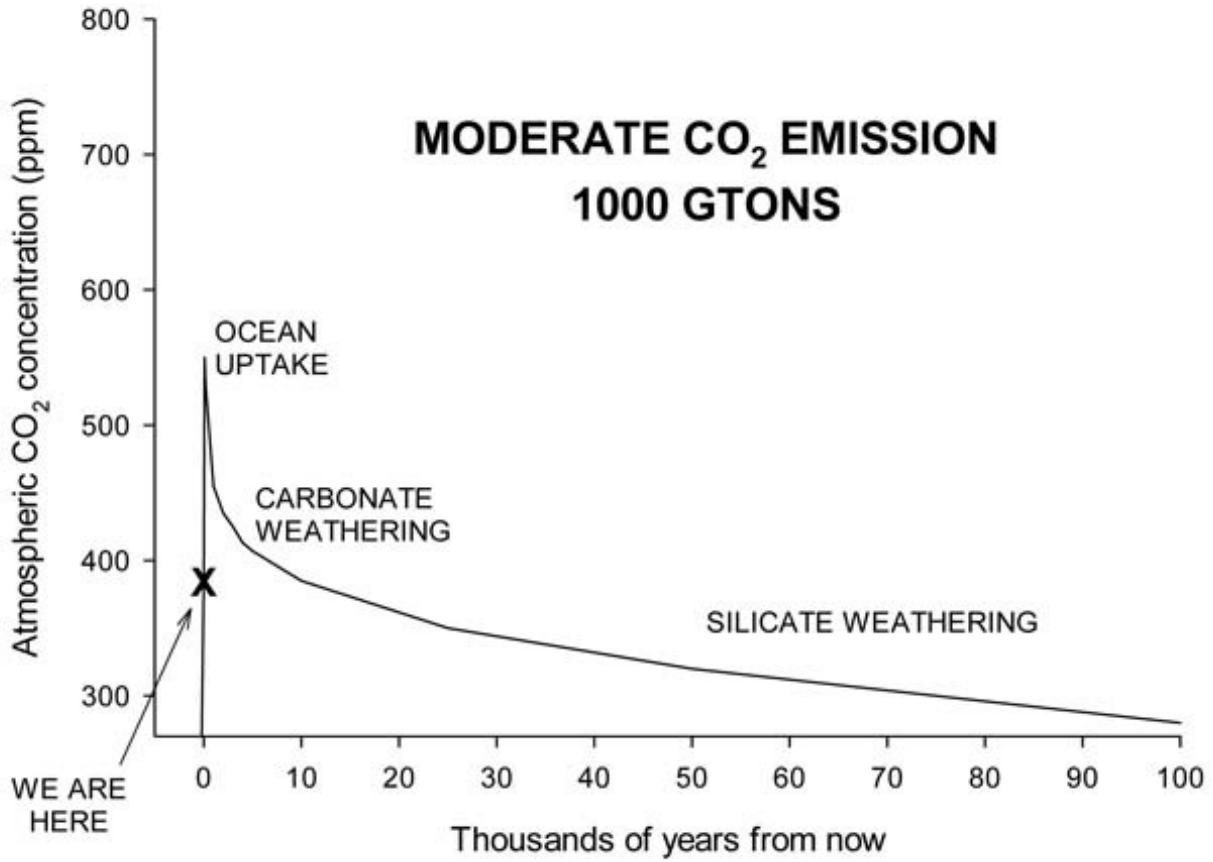
Recovery from the high CO_2 event took tens of thousands of years



Start of PETM event 55 million years ago

Turley et al., 2006, Foster et al., 2013

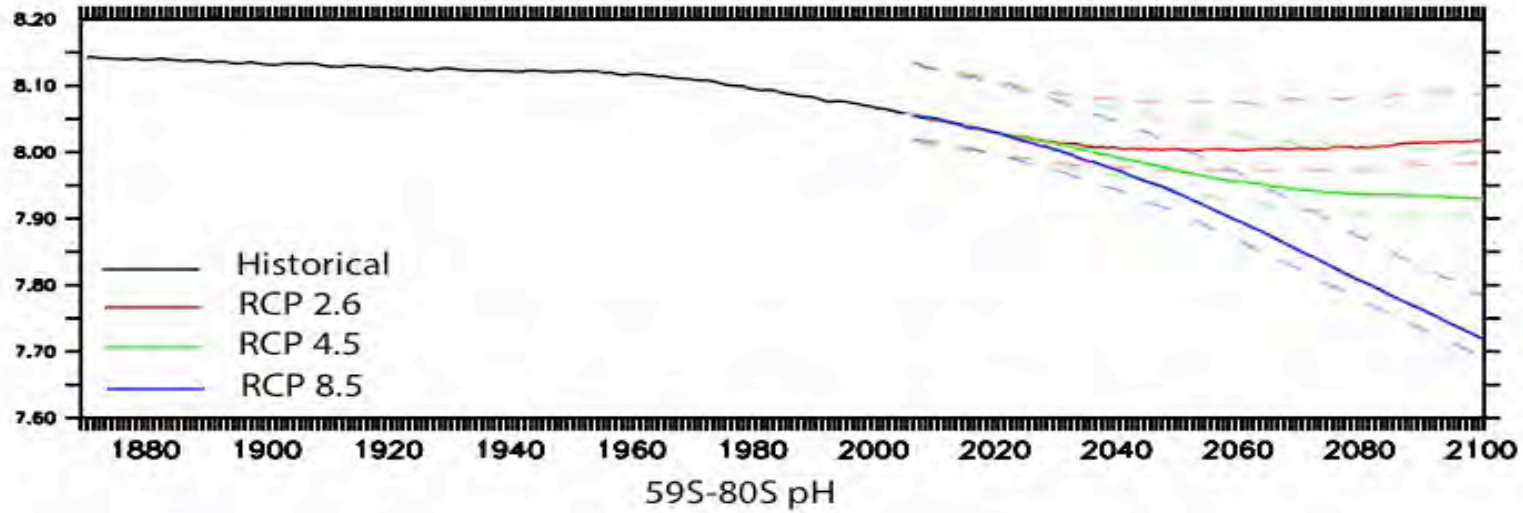
High atmospheric CO_2 and ocean acidification will be around for a very long time



Archer, 2005; Stager, Nature Education, 2012.

It may not be too late to reduce the extent of future Southern Ocean Acidification

pH



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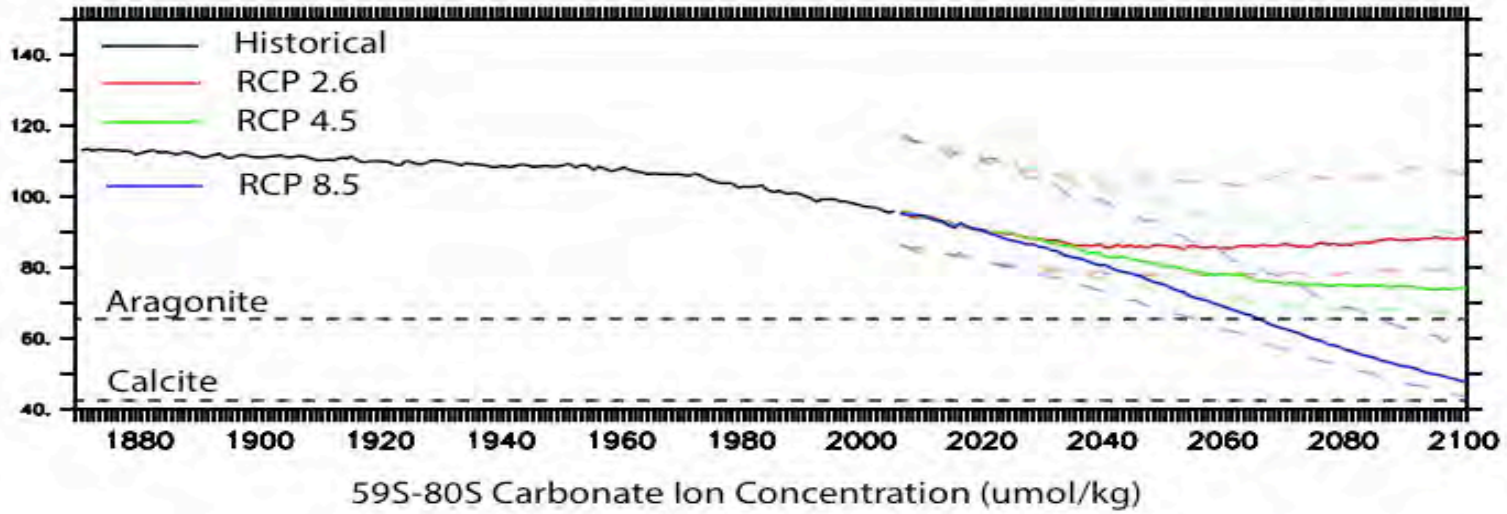

Summary

- Ocean acidification is our carbon footprint
- It is happening now in the Southern Ocean
- It is changing the ocean services the Southern Ocean provides:
  - Ocean carbon uptake
  - Ecosystem productivity
  - Biodiversity

Policy recommendations

- A global reduction in atmospheric CO_2 concentration
- A sustained international integrated monitoring system (an international polar decade/century?). Here COMNAP can play an important role.
- Protection of important ecosystems (i.e. marine protected areas) in conjunction with CCAMLR

Thank you for your attention

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