Southern Ocean Acidification

Richard Bellerby

East China Normal University, Shanghai, China
and
Norwegian Institute for Water Research, Norway

Chair of the SCAR Action Group on Ocean Acidification
Acknowlegdements

Co-authors and lead authors of the SCAR Ocean Acidification report currently under development:

- Claire Lo Monaco, IPSL, Paris, France
- Nikki Lovenduski, University of Colorado, Boulder, USA
- Andrew Lenton, CSIRO, Hobart, Australia
- Kurihara Haruko, University of the Ryukyus, Okinawa, JAPAN
- Scarlett Trimborn, Alfred Wegener Institute, Bremerhaven, Germany
- Mario Hoppema, Alfred Wegener Institute, Bremerhaven, Germany
- Coleen Suckling, University of Bangor, UK
- Michael Meridith, British Antarctic Survey, UK
- Eugene Murphy, British Antarctic Survey, UK
- Andrew Constable, Australian Antarctic Division, Australia
• 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

Ocean Acidification: What we know now

By the Numbers: 24 million

24 million
The number of tonnes of CO₂ the ocean absorbs every day.

Ocean Acidification Thresholds

Social consequences
By the Numbers: 10 times

10X
The current rate of acidification is over 10 times faster than any time in the last 35 million years.

By the Numbers: about 170%
Visualising Ocean Acidification

170%
The projected increase in ocean acidity by 2100 compared with preindustrial levels if high CO₂ emissions continue (business-as-usual scenario).

By the Numbers: 26%
Mitigation and Adaptation

26%
The increase in ocean acidity from preindustrial levels to today.

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.
Ocean anthropogenic carbon (and thus anthropogenic pH change) is already measurable.
There is great regionality and water column variability

Van Heuven et al. 2011
Global ocean acidification observing assets

Interactive map by Cathy Cosca, NOAA
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.

Latest model projections (IPCC AR5 WG1, 2013)

Corrosivity of waters to aragonite (when < 1, aragonite dissolves)
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 modified 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.
Ocean acidification will be greatest at Krill migration depths

At 700ppm atmospheric CO$_2$, 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.
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

10 yrs

Temperate species

2 yrs

Time between generations

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

Oikonos.org

Hans Hillewaert
The Southern Ocean ecosystem is complex

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

 Antarctcic Food Web
A disappearance of CaCO$_3$ in the sediments

A sign of massive ecological change?

During an ocean acidification period 55 million years ago no CaCO$_3$ 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

High atmospheric CO$_2$ and ocean acidification will be around for a very long time.

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

Richard Bellerby

East China Normal University, Shanghai, China
and
Norwegian Institute for Water Research, Norway

Chair of the SCAR Action Group on Ocean Acidification