Ocean acidification impacts on Southern Ocean calcareous zooplankton

Will Howard, Donna Roberts, Andrew Moy, Jason Roberts, Tom Trull, Stephen Bray & Russ Hopcroft

Antarctic Climate & Ecosystems Cooperative Research Centre

Australian Government Department of Climate Change
Motivation for research

The Southern Ocean is a high anthropogenic CO$_2$ inventory region
(Sabine et al. 2004: Science; Gruber et al. 2009: GBC)

... and one of first regions to see low carbonate saturation levels
(Orr et al. 2005: Nature; McNeil & Matear 2008: PNAS)

SW Pacific sector Southern Ocean
+ anthropogenic CO$_2$ $\sim$ 60 \( \mu \text{mol kg}^{-1} \)
\[ \Delta [\text{CO}_3^{2-}] \sim -36 \ \mu \text{mol kg}^{-1} \]
\[ \Delta \text{pH} \sim -0.1 \] (Feely et al. 2004: Science)
Southern Ocean calcareous zooplankton

Planktonic foraminifera (calcite)

Globerigina bulloides

Pteropods (aragonite)

Limacina helicina antarctica

Carbonate ion concentration (µmol kg⁻¹)

Anthropogenic effect (est)
Modern mean ~ 155 µM

Aragonite saturation ~ 1200m
Calcite saturation ~ 3600m

Pre-industrial - Modern
Δ [CO₃²⁻] ~ -25%
Sediment Traps

- 47°S, 142°E
- 4500 m water

- provided modern foram shells:
  - 1000, 2000, 3800m
  - 97/98 - 03/04

- provided modern pteropod shells:
  - 2000m
  - 97/98 - 05/06

- each cup (21) treated with dense, buffered, biocide solution and open from 5 - 60 days
Sediment Cores

- provided pre-industrial and older foram shells
Past Foraminiferal Variability

- LGM* - Holocene* \(\uparrow\) pCO\(_2\) \(\sim\)80ppmv = \(\sim\)20\% \(\downarrow\) shell weight

(Moy et al. 2009: Nature Geoscience)
Pre-Ind’l - Modern Foraminifera

Modern shells

Pre-industrial shells

Shell weight loss slope - dissolution of CaCO₃

Pre-industrial - Modern

~35% ↓ shell weight

(Moy et al. 2009: Nature Geoscience)
Subantarctic Pteropods

Limacina helicina antarctica

(Howard et al. in prep: Deep Sea Research II)
Summary

• Lighter *G. bulloides* shells during interglacial intervals and in modern waters
  ~30-35% reduction in shell weight from pre-industrial to modern waters:
  attributable to higher CO$_2$
  (Moy et al. 2009: Nature Geoscience)

• Ongoing pteropod work establishing benchmark for future effects on aragonite calcifiers

• Implications for Southern Ocean, Pacific Ocean and global oceans
  Southern Ocean calcareous zooplankton may be sentinels for the impacts of acidification on lower-latitude Pacific Ocean ecosystems
Acknowledgements

Sponsors:

Co-Authors’ Institutions:

Thanks also to:

- Jelle Bijma & Gernot Nehrke
  (AWI, Germany)
- Gert-Jan Reichart
  (Utrecht University, Netherlands & AWI, Germany)
- Martin Palmer
  (SOC, Southampton, UK)
- Geoscience Australia