Ocean acidification:

a polar perspective

Paul Rodhouse

British
Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Polar regions - remote but relevant

Critical regions for physical and biological removal of CO_2 from the atmosphere

Major refrigerator of the world's oceans: regulate regional and global climate

Antarctic Peninsula, Siberia and Alaska three of fastest warming regions on earth

Global food security

Biodiversity

Sea level rise

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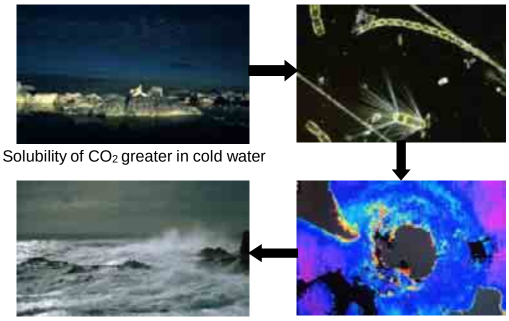
Southern Ocean CO_2 sink

Critical region for physical + biological removal of CO_2 from atmosphere

Southern Ocean CO_2 sink weakened over last 2 decades*

Attributed to increase in Southern Ocean winds – increased outgassing



Solubility of CO_2 greater in cold water

Increasing wind and outgassing

High productivity over large areas

*Le Quéré et al Science 316 1735-1738

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Acidity and cold oceans

Solubility of CO_2 greater in cold water

Slowing of Southern Ocean carbon sink will slow acidification?

Warming will reduce solubility – happening now regionally?

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Calcification in cold water

Solubility of $CaCO_3$ varies with CO_3, pH, pressure, salinity, temperature

$CaCO_3$ more soluble at low temperature and high pressure

Saturation levels already low in the Southern Ocean – especially aragonite

Compensation depth shallower (~700m Antarctica; ~5000m N Atlantic)

Aragonite (corals/molluscs) more soluble than calcite (coccoliths/forams): any temp

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Implications of acidification for calcifying species

Molluscs and other calcite forming species will be most vulnerable to acidification

Coccoliths/forams less vulnerable

Cost of calcification higher in cold and deep water

This may explain thinner shells (or absence of crabs/lobsters?)

Polar calcifiers vulnerable to acidification as compensation depth rises

However, they are pre-adapted to conditions of low $CaCO_3$ saturation

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Implications for wider aspects of physiology

Enzymes: photosynthesis, respiration, growth, reproduction…

Narrow range of pH tolerance

Cellular regulation of pH

Energy cost

Stress: disease, scope for growth and activity, reduced Darwinian fitness

Pteropods

Dominant calcifiers in Southern Ocean?

Replace krill as dominant zooplankton?

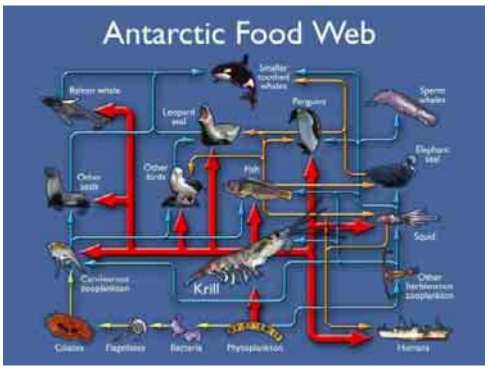
Significant part of biological pump?

Food for fish?

Food for baleen whales?

Foraminiferans

Food for baleen whales??



Ducklow et al. 2006 Deep-Sea Research II 53 834-852 (interannual variations food web structure – Antarctic Peninsula and Ross Sea)

Effects of acidification on Southern Ocean ecology

Decline of pteropods would have some impact

Potential for effects on whole food web much greater

Physiological effects translated into ecological effects

Diatoms, Antarctic krill, copepods, mesopelagic fish, squid all have enzymes

Development, growth, reproduction, moulting, photosynthesis, respiration etc

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Conclusions

Polar regions important in ocean acidification context

Chemistry will be modified by climate change and feedback effects:

Degassing, warming, loss of sea ice

Need to understand acidification in context of polar marine food webs

Ecological consequences will go beyond simple calcification effects

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Multi-factor effects in relation to acidification

Warming
Loss of ice
Ocean circulation
Mixed layer depth
Outgassing
Food webs
Fishery effects

Acidification effects must be understood in the wider context!

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