Impacts of high CO$_2$ from CO$_2$ seepage on marine ecosystems

Dr. Andrew K. Sweetman
Research Scientist
Norwegian Institute for Water Research
asw@niva.no
Phase dynamics of CO$_2$
Density of CO₂ in seawater

Zenz-House et al. 2006
Processes affected by CO₂

Porter et al. 2008
Effects will not be the same for the same species in different locations
Direct effects of CO$_2$ seepage on biodiversity

Hall-Spencer et al. 2008
Direct effects of CO$_2$ seepage on biodiversity

\[ \sqrt{S} = 1.245 + 0.537 \text{pH} \]
\[ \sqrt{S} = -53.49 + 15.74 \text{pH} - 1.68 \text{pH}^2 \]

\[ \log_{10} \text{NI} = -2.708 + 1.303 \text{pH} - 0.086 \text{pH}^2 \]
\[ \log_{10} \text{NI} = -19.28 + 5.668 \text{pH} - 0.379 \text{pH}^2 \]
Effects on sediment nutrient fluxes

Widdicombe and Needham, 2007
Sweetman 1. November 2010
Changes in organism behaviour

Control situation

pH 6.5

pH 5.6

Fauna moving towards sediment surface
What effect will changes in organism behaviour have?

Movement of fauna to the surface (as an escape mechanism) may reduce O₂ flux into the sediment surface.

Wenzhofer and Glud, 2004
However, growth may increase in response to CO$_2$ exposure.
Growth may increase in response to CO₂ exposure

Gooding et al. 2008
But, this may come at a cost...

Food availability could be very important to how an ecosystem responds to CO$_2$ seepage.

Feeding rate (mussels / seabed / day)

- 12°C 380 ppm
- 12°C 780 ppm
- 15°C 380 ppm
- 15°C 780 ppm

pH decreasing
Food supply (POC) modifies numerous ecosystem properties

Key:
- Macrofaunal biomass
- $^{210}$Pb $D_{b}$
- Megafaunal abundance
- Nematode biomass
- Macrofaunal abundance
- Mixed-layer depth
- Microbial biomass
- SCOC
Direct effects of CO$_2$ exposure on phytoplankton

Riebesell et al. 2000

pH decreasing

Riebesell et al. 2000
Reduction in food supply resulting from CO$_2$ seepage may also modify other processes.

Smith et al. 2008
Effects could be felt over a wide area

Blackford et al. 2009
Conclusions

• The risk of, and ecosystem effects from CO$_2$ seepage decrease with increasing water depth.

• Effects will be seen at the physiology level as well as at the community and ecosystem level.

• Effects may be greater at the extreme ends of an organisms distribution.

• All components of a marine ecosystem may be affected directly or indirectly by CO$_2$ seepage.