SCAR 2012-2013 Fellowship Final Report

Net community production and its regulating factors in the Australian Sector of the Southern Ocean

Home Institution:
Dr. Elizabeth H. Shadwick
Antarctic Climate & Ecosystems
Cooperative Research Centre
University of Tasmania
Hobart, Tasmania, Australia

Host Institution:
Dr. Nicolas Cassar
Division of Earth & Ocean Sciences
Nicholas School of the Environment
Duke University
Durham, North Carolina, USA

***Project Objectives*:**

- Receive training in the operation of the EIMS system for measurements of O_2/Ar in the Southern Ocean.
- Use existing data to investigate the factors regulating biological production in the Australian sector of the Southern Ocean.
- Use the EIMS technique on a 2013 voyage to investigate changes in summer net community production in the Mertz Polynya.

***Background and Rationale*:**

The Southern Ocean is a region of considerable interest due to its major role in global biogeochemical cycles[1] and its influence on oceanic CO_2 uptake, both natural and anthropogenic[2,3]. The Southern Ocean is responsible for an estimated 30% of the global ocean uptake of human-induced CO_2 emissions[2] (Fig. 1). This uptake occurs through the combination of physical and biological processes. Cold waters formed at the surface in the south of the Polar Front sink under warmer waters in the Sub-Antarctic zone (Fig. 2), transporting CO_2 and oxygen into the deep ocean, out of contact with the atmosphere. This physical process not only sequesters CO_2, but also supplies oxygen to deep ocean ecosystems, and supplies nutrients to much of the global ocean[1]. In addition, intense blooms of phytoplankton (responsible for half of the oxygen in the atmosphere), and the subsequent sinking of these organisms, work as a biological pump, transporting CO_2 from the surface to the deeper ocean.

Although the availability of light and/or iron limits productivity over much of the Southern Ocean[4,5], iron fertilisation can occur[6,7], and particularly high rates of productivity, with large spatial-temporal variability, have been observed in coastal polynyas in Antarctica[8]. Despite the importance of the region with respect to global biogeochemical cycles, fine-scale (10 to 100 km) distribution and variability of dissolved gases (other than CO_2) and associated biological production remain poorly described.

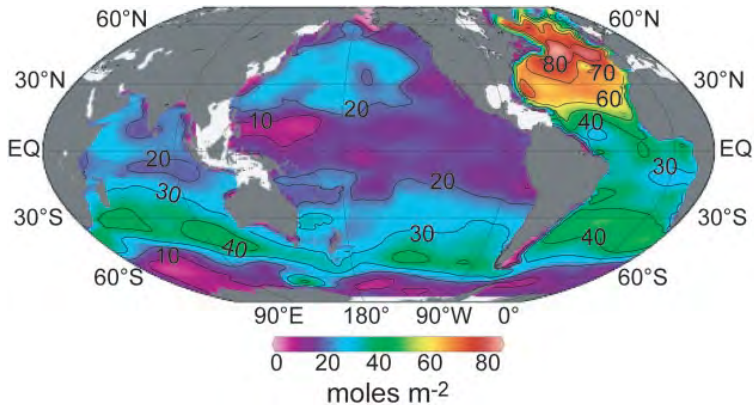

Figure 1: Colum inventory of anthropogenic (man-made) CO_2 taken up by the ocean. Strong CO_2 uptake occurs in regions of water mass formation, such as the North Atlantic and Southern Ocean (Sabine et al., 2004)

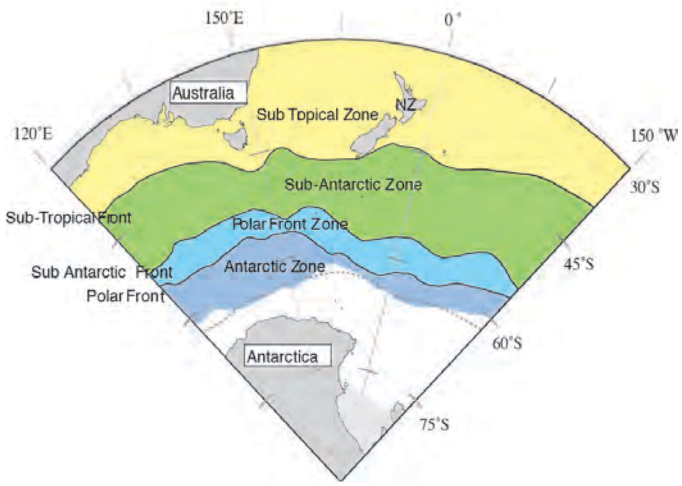

Figure 2: The Polar Front represents a boundary separating distinct biogeochemical regimes: the Sub-Antarctic Zone to the north where water depleted in silicate (Si), a nutrient essential for the growth of a class of phytoplankton called diatoms, sinks below subtropical water and begins a northward transit; south of the Polar Front is the Antarctic Zone, where waters with much higher (winter) Si concentrations result from the upwelling of deep water.

Work Undertaken in 2012-2013:

A 3-week visit to Duke University was made in September/October 2012. While in the U.S. training with technique called Equilibrator Inlet Mass Spectrometry (EIMS)[9] was undertaken in the Cassar Laboratory. This method allows biologically driven changes in surface ocean oxygen to be quantified, yielding high-resolution estimates of net community production. While at Duke University, analysis of data collected (in January 2012) along a transect between Antarctica and Australia was undertaken, and a manuscript (now published, see below) was outlined. From January to March 2013, the EIMS technique was employed on a voyage to the Mertz Polynya region of East Antarctica as part of a joint Australia-New Zealand project. The data collected on this voyage have been processed, and a manuscript is in preparation (with anticipated submission in March, 2014, see below).

Project Outcomes:

- Presentation of preliminary results at the 45th International Liège Colloquium (Primary Production in the ocean: from the synoptic to the global scale), Liège, Belgium (May 2013).
- Publication in a Special Issue of the Journal of Marine Systems: E.H. Shadwick, B. Tilbrook, N. Cassar, T.W. Trull and S.R. Rintoul. (2014) Summertime physical and biological controls on O_2 and CO_2 in the Australian Sector of the Southern Ocean. *J. Marine Syst.*, doi: 10.1016/j.jmarsys.2013.12.008
- Preparation of a second manuscript with anticpated submission in March 2014: E.H. Shadwick, B. Tilbrook, and S.R. Rintoul (in prep.) O_2/Ar and CO_2 system observations reveal persistent changes to summertime biological production and the surface CO_2 sink in the Mertz Polynya.

Project Budget:

Activity	Cost
Return flight Hobart (AUS) – Durham (USA) for visit to Duke University and 3 weeks accommodation and meals	$4800
Return flight Hobart (AUS) – Wellington (NZ) for the 2013 voyage to the Mertz Polynya and accommodation and meals pre- and post-departure (6 days) in Wellington	$2800
Total:	$7600 AUD

References:

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4. Martin, J. H., Gordon, R. M. & Fitzwater, S. E. Iron in Antarctic waters. *Nature* 345, 156-158 (1990).
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7. Sokolov, S., & Rintoul, S. R. On the relationship between fronts of the Antarctic Circumpolar Current and surface chlorophyll concentrations in the Southern Ocean. *J. Geophys. Res.* **112**: C07030, doi: 10.1029/2006JC004062 (2007).
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