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 O2/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 and its influence on oceanic CO2 uptake, both natural and anthropogenic. The Southern Ocean is responsible for an estimated 30% of the global ocean uptake of human-induced CO2 emissions (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 CO2 and oxygen into the deep ocean, out of contact with the atmosphere. This physical process not only sequesters CO2, but also supplies oxygen to deep ocean ecosystems, and supplies nutrients to much of the global ocean. 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 CO2 from the surface to the deeper ocean.

Although the availability of light and/or iron limits productivity over much of the Southern Ocean, iron fertilisation can occur, and particularly high rates of productivity, with large spatial-temporal variability, have been observed in coastal polynyas in Antarctica. 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 CO2) and associated biological production remain poorly described.
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) 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).
- Preparation of a second manuscript with anticipated submission in March 2014: E.H. Shadwick, B. Tilbrook, and S.R. Rintoul (in prep.) O₂/Ar and CO₂ system observations reveal persistent changes to summertime biological production and the surface CO₂ sink in the Mertz Polynya.

**Project Budget:**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Return flight Hobart (AUS) – Durham (USA) for visit to Duke University</td>
<td>$4800</td>
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<tr>
<td>and 3 weeks accommodation and meals</td>
<td></td>
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<tr>
<td>Return flight Hobart (AUS) – Wellington (NZ) for the 2013 voyage to</td>
<td>$2800</td>
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<td>the Mertz Polynya and accommodation and meals pre- and post-departure (6</td>
<td></td>
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<tr>
<td>days) in Wellington</td>
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<tr>
<td><strong>Total:</strong></td>
<td><strong>$7600 AUD</strong></td>
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**References:**