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Summer hydrography on the shelf off Terre Adélie/George V Land based on the ALBION and CEAMARC observations during the IPY

M. Lacarra [a,*], M.-N. Houssais [a], E. Sultan [a], S.R. Rintoul [b,c], C. Herbaut [a]

[a] LOCEAN, UMR CNRS/UPMC/IRD/MNHN, Université Pierre et Maris Curie, Paris, France
[b] CSIRO Marine and Atmospheric Research, Hobart, Australia
[c] ACE CRC, Hobart, Australia

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Abstract

We report on the hydrographic observations collected on the Antarctic continental shelf between 138°E and 146°E as part of the CEAMARC and ALBION projects in December 2007–January 2008. A total of 140 quasi-synoptic CTD (Conductivity–Temperature–Depth) casts were analysed to map the spatial distribution of the summer hydrographic properties. Seven distinct hydrographic regimes were identified based on regional topographic features and the presence of specific water masses. These regimes are associated with spatial contrasts in the distribution of the High Salinity Shelf Water (HSSW) and the Modified Circumpolar Deep Water (MCDW). In particular, the HSSW distribution confirms the unique character of Commonwealth Bay in terms of extreme bottom salinity and dissolved oxygen values. The bay appears to be a preferred region for both dense shelf water formation and storage. The systematic survey of the Adélie Depression shows the ubiquitous presence of HSSW in the depression, and over the Adélie Sill as a 60 m thick layer at the centre of the sill. This water is dense enough to mix down the continental slope and form Antarctic Bottom Water. Upstream of the sill, the HSSW is shown to sit over the topography with indications of recirculation. The D'Urville Trough, another deep basin on the shelf, is filled with warmer and fresher water that is too light to contribute to the formation of AABW. The D'Urville Trough appears to collect MCDW which enters at the shelf break over the Adélie Bank and spreads over the northern slope of the trough. Another branch of MCDW enters in the eastern Adélie Sill and is found almost everywhere in the Adélie Depression with the noticeable exception of the coastal bays. Additional CTD casts collected during the ALBION-2009 experiment in January 2009 suggest that most of the features observed in 2008 in the Adélie Depression should be robust on a year-to-year basis although summer 2009 was characterized by fresher dense shelf waters.

Keywords: Antarctica; Shelf water masses; Adélie land; Polynya

1. Introduction

The formation and export of Antarctic Bottom water (AABW) play an important role in the global ocean thermohaline circulation (Jacobs, 2004) and potentially in the global climate. AABW originates in the dense shelf waters formed around the Antarctic continent which subsequently mix with ambient waters during their descent of the continental slope to the deep Southern Ocean. The Australian-Antarctic Basin collects two major sources of AABW, the relatively

* Corresponding author.
E-mail address: mallod@locean-ipsl.upmc.fr (M. Lacarra).

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saline Ross Sea Bottom Water and the relatively fresh Adélie Land Bottom Water (ALBW) (e.g., Rintoul, 1998). Ross Sea Bottom Water was advected into the region from the Ross Sea sector to the east, while the ALBW is locally produced from dense water formed on the shelf off the Adélie Land/George V Land Coast (Gordon and Tchernia, 1972). The formation of the dense shelf water is tightly linked to the existence of a large coastal polynya system, the Mertz Glacier Polynya (MGP) (Massom et al., 1998; Zwally et al., 1985) maintained by the particularly severe katabatic winds in the region (Wendler et al., 1997) and the presence of an ice barrier formed by the Mertz Glacier Tongue (MGT, thick black line in Fig. 1) and the grounded icebergs further north (note that, in February 2010, the Mertz Glacier calved producing a giant iceberg which rapidly drifted out of the area and left behind a much shorter tongue reducing the barrier effect). High Salinity Shelf Water (HSSW) forms in the polynya from brine rejection during sea ice formation and, after mixing and recirculation within the Adélie Depression (also known as the George V Basin) (see Fig. 1 for a description of the bathymetry), is converted into an off-shelf export of some 0.1–0.5 Sv of dense shelf water through the Adélie Sill (Williams et al., 2008). Recent simulations performed with a high resolution ice-ocean model indicate that the Mertz-Ninnis polynya region is indeed one of the most active regions in terms of dense shelf water production in comparison to other coastal polynyas in East Antarctica (Kusahara et al., 2010).

The physical environment of the Southern Ocean has changed in recent decades. The region has warmed to depths exceeding 1000 m, with the strongest warming in the vicinity of the Antarctic Circumpolar Current (Böning et al., 2008; Gille, 2002, 2008). In the Australian Antarctic Basin, a freshening signal has been identified in the bottom water layer (Aoki et al., 2005; Jacobs, 2004, 2006; Rintoul, 2007; Whitworth, 2002). Whether this signal should be attributed to changes in the export volume of one or the other contributing source waters or to changes in their properties or to a mixture of these remains an open question. One way to make progress on this problem is to monitor the physical environment of the Antarctic shelf in the regions of dense shelf water formation and export in order to characterize the processes through which these waters acquire their final properties and to quantify their variability.

Changes in the physical environment of the Southern Ocean are expected to have repercussions on the biogeochemical state and on the biota. In order to quantify the vulnerability of the ecosystems, it is essential to identify the present state of the various communities and monitor their variability in relation to the physical environment. This aspect was a major goal of the CEAMARC (Collaborative East Antarctic Marine Census) programme. The Antarctic Shelf off the Adélie Land/George V Land Coast was selected as a target area of the programme. Apart from being a region poorly known compared to the Atlantic and Indian Ocean sectors, it was considered an exemplary

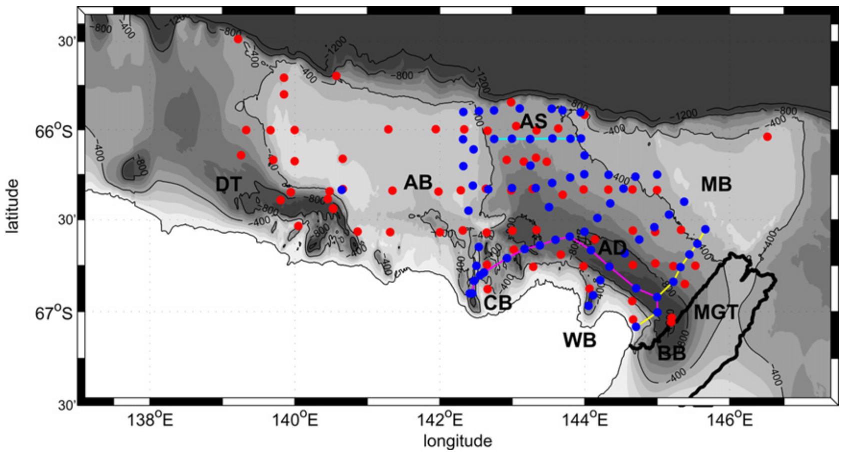

Fig. 1. Distribution of the ALBION (blue dots) and CEAMARC (red dots) CTD stations superimposed on the bathymetry of the continental shelf between 136 and 148°E and 65.5–67.5°S (after Beaman et al., 2011). Contour interval is 100 m with thin black contours indicating the 0 m, 400 m, 800 m and 1200 m isobaths. Major features of the topography are: D'Urville Trough (DT), Adélie Bank (AB), Adélie Depression (AD), Adélie Sill (AS), Mertz Glacier Tongue (MGT), Mertz Bank (MB), Commonwealth Bay (CB), Watt Bay (WB) and Buchanan Bay (BB). The bold solid line is the contour of the MGT in 2008. Also indicated as straight lines are the vertical sections shown in Fig. 9. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)