Palmer LTER: Upper-ocean circulation in the LTER region from historical sources

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The long-term ecological research program (LTER) sampling region encompasses an area long the Antarctic Peninsula that is roughly 900 kilometers alongshore and 200 kilometers offshore. This region includes portions of Bransfield Strait, Gerlache Strait, and the Bellingshausen Sea and is influenced by adjacent areas such as Drake Passage, the Weddell Sea, and Marguerite Bay. The Antarctic Circumpolar Current forms the northern boundary of the study region.

Historical descriptions of water mass distributions and circulation patterns are available for selected portions of the LTER region. These previous studies were either concentrated on subareas within the LTER study area or were at the periphery of the LTER region. The purpose of this paper is to synthesize the existing hydrographic and current observations to provide a description of the major circulation features in the LTER study region. This circulation pattern is shown schematically in figure 1 and is described below.

The circulation of the northern section of the LTER region is based on descriptions from Bransfield Strait. A dynamic topography map (relative to 1800 decibars) constructed from data collected during the R/V *Discovery* cruises (Clowes 1934) shows flow from Drake Passage into Bransfield Strait through the gap (maximum 500 meters, figure 2) between Smith and Snow Islands. This flow continues to the northeast along the southern side of the South Shetland Islands and at the eastern end of Bransfield Strait turns north to exit between King George Island and Elephant Island or continues eastward towards the Weddell Sea.

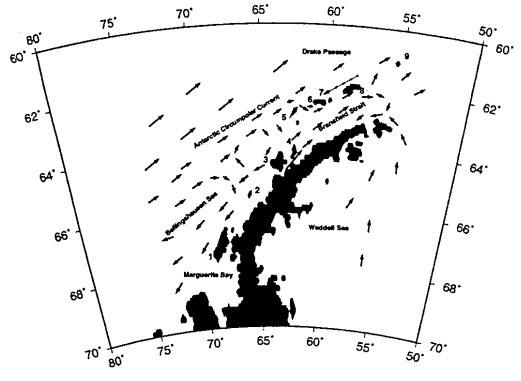

Figure 1. Schematic of the circulation in the upper 200-300 meters in the LTER study region. Circulation patterns were derived from the sources discussed in the text. The Polar Slope Current is indicated by the *dotted arrow*. The *vectors with lighter shading* in the eastern Bellingshausen Sea represent the possibility of a single cyclonic gyre in this region. Islands are identified as: *1*, Adelaide; *2*, Renaud; *3*, Anvers; *4*, Brabant; *5*, Smith; *6*, Snow; *7*, Livingston; *8*, King George; *9*, Elephant. Gerlache Strait is between Anvers and Brabant Islands and the Antarctic Peninsula.

A recent analysis of historical temperature data from the Bransfield Strait (Capella et al 1992a) indicates that Circumpolar Deep Water (CDW) enters the Strait from Drake Passage between Smith and Snow Islands. This water mass, which is characterized by temperature greater than 0 °C, is found throughout Drake Passage and the Bellinghausen Sea between 200 and 700 meters (Sievers and Nowlin 1984). Inside the Strait, CDW is found along the southern side of the Islands and between King George and Elephant Islands. Thus, the climatological temperature distributions support the circulation described between Clowes (1934). Additionally, in 1979 a First GARP (Global Atmospheric Research Program) Global Experiment buoy drifted from Drake Passage between Smith and Snow Islands into the Strait and continued eastward to about 55° W, which is in agreement with the circulation proposed by Clowes (1934) and Capella et al. (1992a). However, the buoy then turned and drifted to the west (Klinck 1991), suggesting the presence of a cyclonic gyre in the surface waters of the Bransfield Strait.

To the north of the South Shetland Islands, below 200-300 meters, is the westward flowing Polar Slope Current (Nowlin and Zenk 1988). This current, which is thought to originate in the Weddell Sea, is narrow (10 kilometers) and cold (less than 0 °C) and flows counter to the predominant surface flow in that region.

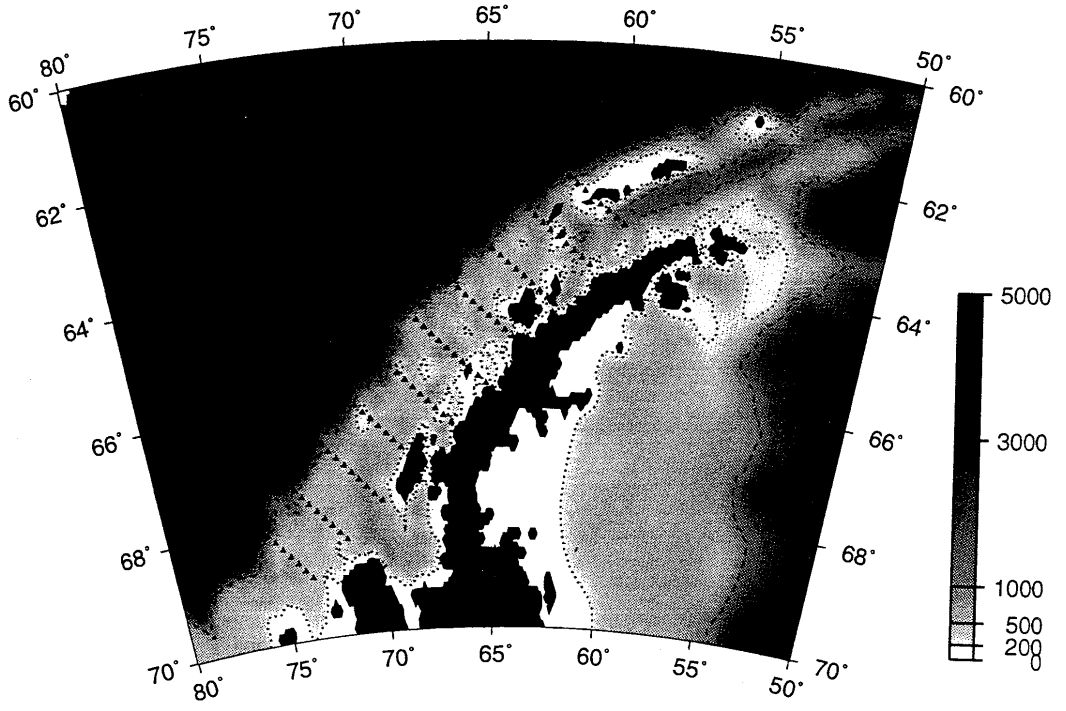

Figure 2. The LTER hydrographic grid. Hydrographic stations are indicated by *triangles*. Depth in meters is indicated by the *shading*. The 200 and 1,000 meter isobaths are indicated by the *dotted* and *dashed lines*, respectively. The bathymetric contours are from the ETOPO5 bathymetry data set, which is available through the National Center for Atmospheric Research in Boulder, Colorado.

The circulation of the central and southern sections of the LTER region is based on descriptions from hydrographic surveys and surface drifter studies in the Gerlache Strait and eastern Bellingshausen Sea made as part of the Research on Coastal Ecosystem Rates (RACER) program (Huntley et al. 1990). The dynamic topography maps (relative to 200 decibars) and drifter trajectories show that surface flow in the Gerlache is northeast along the axis of the Strait and exists to the northeast into the southern reaches of the Bransfield Strait (Amos et al. 1990; Niiler et al. 1990). Similarly, the surface flow in the near-shore coastal waters off Brabant Island appears to be to the north towards Bransfield Strait (Amos et al. 1990; Niiler et al. 1991). This northward flow turns southeastwards as it enters the southwest portion of Bransfield Strait. However, the circulation in this region is complex and likely has seasonal variations. For example, a westward surface flow has been observed in this region (Stein 1982). Similarly, seasonal variations are associated with flow from the Weddell Sea into the Bransfield Strait (Capella et al. 1992b).

Hydrographic surveys conducted in the eastern Bellingshausen Sea as part of the Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS) program show southward flow offshore of Anvers Island (Stein 1982, 1988) and between and Anvers and Renaud Islands (Kock and Stein 1978). More recently Stein (1991) presented dynamic topography contours (relative to 200 decibars) constructed from a larger scale hydrographic survey which suggest that the circulation in the upper water column consists of two cyclonic gyres: one near Anvers and Brabant Islands and one near Adelaide Island. This is similar to the circulation pattern presented in Stein (1988). However, given the spatial resolution of the measurement used by Stein (1991), it is equally possible that there is only a single cyclonic gyre in the Bellingshausen Sea. In fact, the trajectory traced by a FGGE buoy that drifted through the Bellingshausen Sea in 1979 (Klinck 1991) supports a single cyclonic gyre. This possibility is indicated by the dashed line in figure 1.

One of the goals of the LTER study is to define the large-scale distribution of water masses and circulation in a region of sufficient size to encompass areas that could potentially contribute larvae of *Euphausia superba* to the region around Palmer Basin. Previous studies (e.g., Capella et al. 1992b) have shown that *E.superba* larvae can be transported considerable distances (hundreds of kilometers) from their spawning area. In the LTER region, potential source sites of *E.superba* larvae are Marguerite Bay, the eastern Bellingshausen Sea, Gerlache Strait, and Bransfield Strait. This then defines the north and south extent of the hydrographic sampling grid. The across-shelf extent of the grid must be sufficient to include CDW, which is believed to be important to reproducing *E.superba* (Hofmann et al. 1992).

Given these requirements, the LTER hydrographic survey grid (figure 2) was designed with an along-shelf spacing of 100 kilometers and an across-shelf station spacing of 20 kilometers. Most across-shelf transects extend offshore beyond the 1,000-meter isobath and terminate inshore of the 200-meter isobath. It should be stressed that this is the basic hydrographic grid. Modifications will be made as needed to accommodate sampling requirements. In particular, stations may be added in certain regions to better define circulation features. We anticipate sampling the entire grid during an LTER cruise scheduled for austral fall (March-April) 1993.

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