Palmer LTER: Hydrography in the LTER region during August and September 1993

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One of the objectives of the Palmer Long-Term Ecosystem Research (LTER) program is to characterize the seasonal variations in the horizontal and vertical distributions of temperature and salinity in the continental shelf waters west of the Antarctic Peninsula. Researchers' ability to address this objective has been limited by the availability of winter hydrographic measurements. Therefore, a late-winter, multidisciplinary cruise was conducted west of the Antarctic Peninsula from 29 August to 23 September 1993 as part of the Palmer LTER. The hydrographic measurements obtained from this cruise constitute the majority of existing winter observations for this region (Gordon and Molinelli 1982; Olbers et al. 1992). This paper reports on a preliminary analysis of some of the hydrographic measurements. Previous LTER cruises have provided coverage of this region in the austral spring, summer, and fall.

The winter cruise provided coverage of the central portion (lines 300 to 600) of the LTER peninsula sampling grid (Waters and Smith 1992). Station spacing was 100 kilometers (km) alongshore and 20 km across-shore (figure 1). In spite of it being a low ice year, ice covered the entire region except for the outer shelf stations on the 600 line. Temperature and salinity measurements were made at 26 stations to 500 meters (m) depth, or the bottom if shallower, with a SeaBird CTD sensor mounted on a bio-optical profiling system (BOPS, described in Smith, Booth, and Starr 1984). At several stations where the depth was significantly greater than 500 m, temperature and salinity measurements were made to the bottom with the SeaBird CTD system aboard the R/V *Polar Duke*. Spatial resolution in the temperature field was increased to 10 km with expendable bathythermograph (XBT) probes released between the hydrographic sampling locations (30 profiles were taken on the cruise). Most hydrographic casts yielded reasonable observations. The water in the mixed layer was very near the freezing point, so special precautions were taken to keep the salinity sensor warm between casts and to make sure that no ice was in the cell before the sensor went into the water. Occasional difficulties were encountered, however, with the near-surface salinity measurements because ice sometimes formed in the conductivity cell, resulting in an anomalously low salinity value. These observations were removed from subsequent analysis.

The water-mass structure of the region sampled by the cruise is shown with a potential temperature-salinity (θ-S) diagram (figure 2) constructed from the hydrographic observations. Salinities ranged from about 33.7 to 34.8 and temperatures ranged between −1.88°C to slightly above 2.0°C. The cluster of points at temperatures greater than 1.5°C and salinities of 34.7 represents Circumpolar Deep Water (CDW). This water mass is found at great depths (3 km) in the center of the Antarctic Circumpolar Current but rises to the shelf break along the western side of the Antarctic Peninsula. Throughout the LTER peninsula sampling region, the influence of CDW is found below 150 to 200 m, and its clear effect extends onshore at least to the 150-m isobath. The influence of this water mass is also present in this region at other times of the year (Hofmann et al. 1993). In the upper 100–150 m of the water column, the temperature decreases to the freezing point of sea water, about −1.88°C. The θ-S diagram shows two distinct clusters for surface waters at salinities of 34.0 and 33.85. The higher surface salinities are associated with the more offshore stations whereas the lower salinity corresponds to the onshore stations. The cause for the lower onshore salinity is likely melting

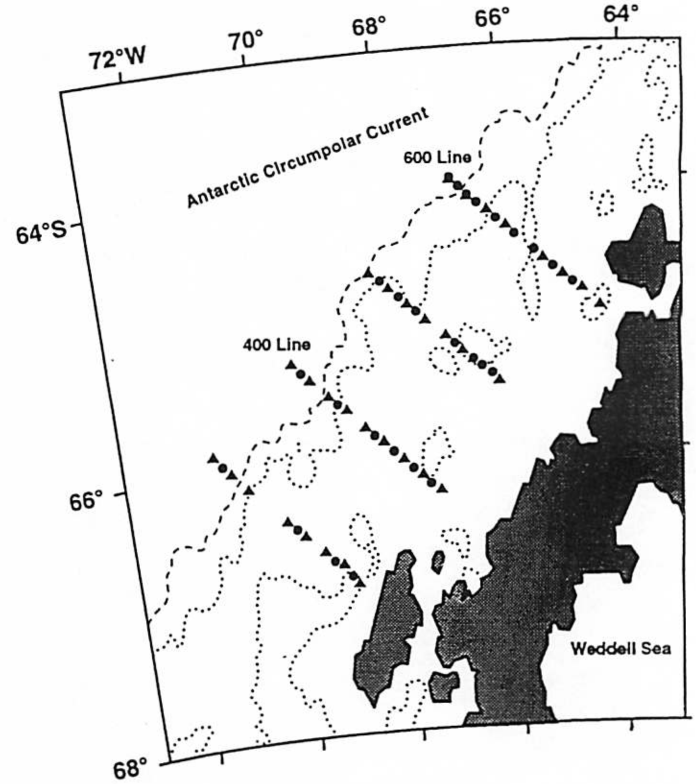

Figure 1. Distribution of stations at which winter hydrographic observations were made. Triangles and circles indicate stations for BOPS and XBT measurements, respectively.

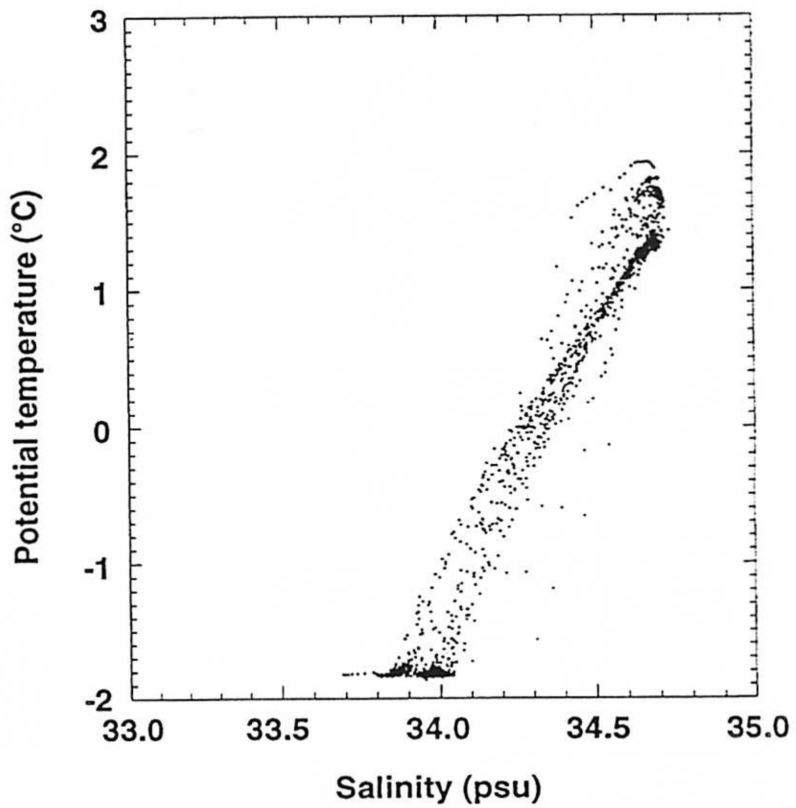

Figure 2. Potential temperature-salinity diagram constructed from winter hydrographic measurements. (psu denotes practical salinity units.)

during the previous summer of sea ice or glaciers. This distinct partitioning of the surface waters suggests limited exchanges between inshore and offshore near-surface environments.

The across-shelf variation in the vertical temperature structure is illustrated by the section along the 600 line (figure 3*A*) which shows that freezing water exists in the upper 80 to 100 m. There is a clear increase in the mixed layer depth offshore of about 160 km. Ice covered the ocean surface inshore from this point. Offshore from this point, the isotherms deepen indicating the effect of wind mixing. The temperature below 150 m increases to more than 1.0°C due to the presence of CDW. There is a monotonic offshore increase in temperature at each depth which reinforces the conclusion that warm water is intruding onto the shelf from the shelf break. The temperature structure along other lines is similar although not always as simple as indicated in figure 3*A*. It is possible to find warm water in the inner parts of the shelf along other sampling lines.

The across-shelf variation in the salinity distribution (figure 3*B*) is very much like that for temperature. The upper 80–100 m is well mixed and the offshore deepening of the mixed layer is reflected in the salinity isopleths. The water below 150 m has increasing salinity with depth as is expected due to CDW. The offshore increase in salinity at each depth is consistent with the interpretation of water intruding over the shelf from the shelf break. As with temperature, the salinity structure is similar along other lines but not always having a monotonic offshore increase. This fact indicates that the flooding of the shelf with offshore water occurs along several paths and is not a uniform intrusion along the entire length of the shelf break.

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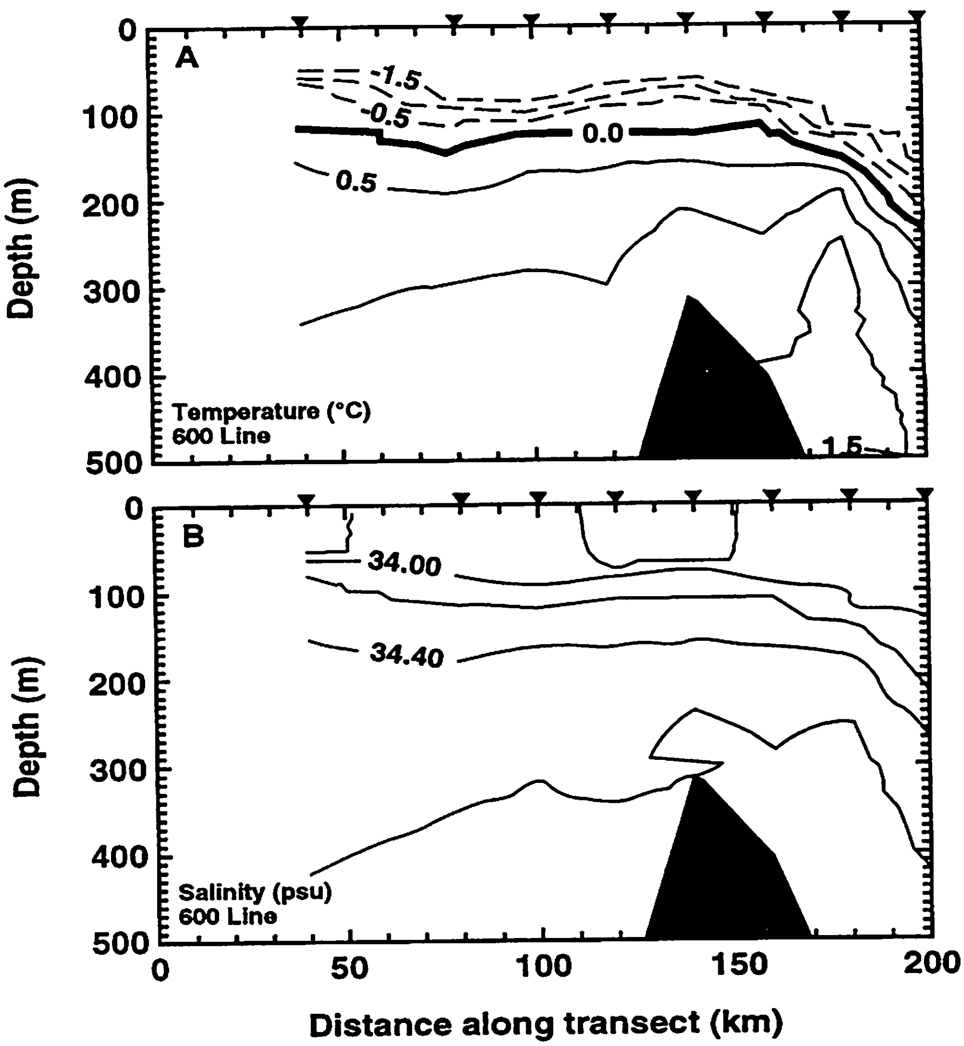

Figure 3. Vertical sections of temperature (*A*, top graph) and salinity (*B*, bottom graph) along the 600 line across-shelf transect of the Palmer LTER peninsula sampling grid. Contour intervals are 0.5°C and 0.2, respectively. Negative temperatures are indicated by dashed lines. The shaded areas indicate bottom topography. Station locations are shown by triangles.

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