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Physical oceanographic observations, Antarctic Marine Ecosystems Research in the Ice-Edge Zone program, March 1986

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Temperature and salinity observations were carried out in the northwestern Weddell Sea marginal ice zone (MIZ) during March 1986 as part of the Antarctic Marine Ecosystems Research in the Ice-Edge Zone (AMERIEZ) project. The purpose of these observations was to define the oceanic temperature, salinity, and density fields. Particular emphasis was placed on features, such as vertical stratification in the upper ocean layers, which were expected to impact local biological processes.

The observations were carried out from two vessels. One, the U.S. Coast Guard icebreaker *Glacier,* operated at and within the ice edge. The second vessel, the *R/V Melville,* operated in the open water seaward of the ice edge. Observations from both vessels were made using Neil Brown Mark IV CTD (conductivity/temperature/depth) profiling systems. During the March 1986 program, 66 CTD stations were occupied from the *Glacier* and 49 from the *Melville.* Geographical locations of these stations are shown on figure 1. Most of the CTD casts extended downward to depths greater than 500 meters; more than half of them extended to 1,500 meters.

The study area was characterized by three major water masses, each identifiable based upon its temperature and salinity characteristics (figure 2). (See, for example, Carmack 1977.) The uppermost layer was the surface water. During the March AMERIEZ program, the temperature of this layer was at or near the freezing point (about -1.8°C), where it underlay the sea ice and increased up to about -0.2°C some 200 kilometers east of the ice edge. Salinities varied from 33 to 34 parts per thousand; the higher salinities occurred in areas where freezing was occurring. The layer was vertically well mixed and varied in thickness from less than 25 meters to greater than 40 meters.

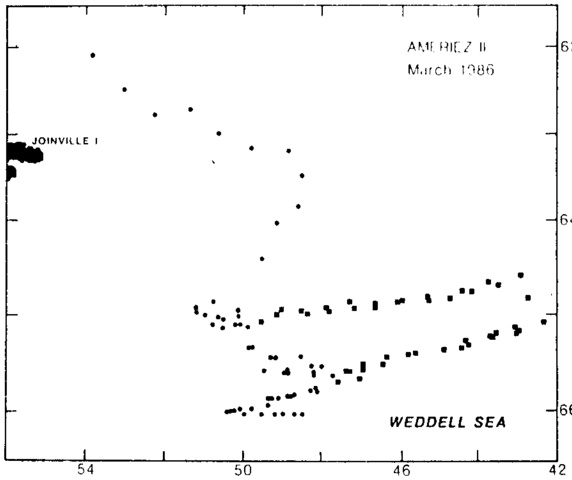

Figure 1. Locations of CTD Stations occupied by U.S. Coast Guard Icebreaker *Glacier* (circles) and R/V *Melville* (squares) during the March 1986 AMERIEZ field program. Arrow indicates approximate location of station shown in figure 2.

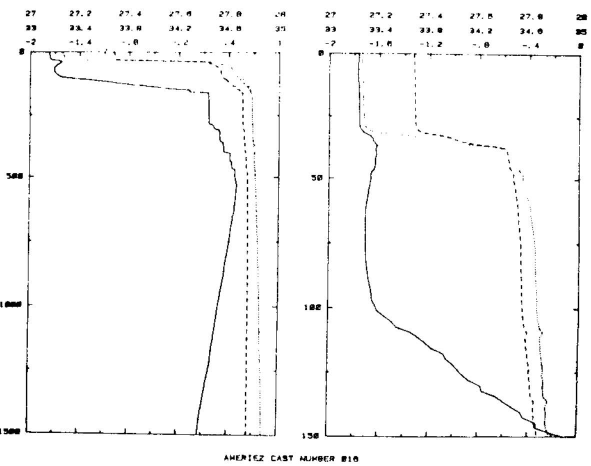

Figure 2. Vertical profiles of temperature (solid curves), salinity (dashed curves), and density as sigma-t (dotted curves) derived from a CTD station taken near the ice edge during the March 1986 AMERIEZ program. Left-hand plot shows mid-depth step structures, which are especially pronounced in temperature, and right-hand plot shows upper layer detail. Depths are in meters. Station location is indicated on figure 1.

Underlying the surface water all locations was the Weddell winter water. This layer reflected cooling and freezing which occurred during the preceding winter and had temperatures between about -1.5° and -1.7°C and a salinity of about 34.5 parts per thousand. The winter water extended from just beneath the surface water to about 100 meters and was separated from the upper waters by a region of very strong vertical gradients in temperature, salinity, and density. A weak (0.1°–0.2°C) temperature maximum layer 10–20 meters thick was often present between the surface and winter water layers. This thermal feature was a remnant due to absorption of incoming solar radiation during the preceding summer.

The deepest water mass observed was the Weddell warm water, which extended from the bottom of the winter water at about 100 meters to more than the 1,500 meters maximum cast depths. Temperatures in this layer varied between 0°C and 0.5°C, and salinities were 34.65 parts per thousand at the upper boundary of the layer increasing to 34.7 parts per thousand at the greatest observed depths. The greatest observed temperatures in this layer occurred at about 500 meters depth. The region between this temperature maximum and the top of the layer at about 100 meters was characterized, over much of the study region, by large (more than 100 meters in vertical extent) temperature and salinity steps. These features have also been noted by Middleton and Foster (1980). There is as yet no satisfactory explanation for their presence, though they may play a significant role in vertical heat fluxes.

Dynamic heights relative to the 1,500-decibar level were computed to estimate whether appreciable baroclinic circulation was present over the study region. The total dynamic relief was of the order of only a few dynamic centimeters over the entire area, indicating that the baroclinic circulation was negligible.

During the field program, two separate "rapid transects" were occupied by both vessels. There were attempts to sample along transects over time intervals which were short relative to the periods over which changes might be expected to occur in the water column. No significant variations were detected between occupations of these transects, suggesting that the physical system was reasonably steady-state during the 30-day duration of the cruise.

Finally, no strong horizontal gradients, or frontal systems, were observed. This was in contrast to the AMERIEZ I program, which sampled in November 1983 along the strong frontal system separating the outflowing Weddell Sea water from the waters of the Eastern Scotia Sea. The region sampled during the March 1986 program was characterized only by very gradual horizontal variation—primarily in the upper layers, in moving from west to east away from the sea-ice edge.

The northwestern Weddell Sea MIZ region was intensively sampled, revealing three water masses: the Weddell surface water, the Weddell winter water, and the Weddell warm water. The dominant upper layer feature was the widespread surface water layer, which was underlain by very strong vertical gradients. Such gradients imply that little vertical mixing is occurring through the bottom of the upper layer. The dominant deep feature was the presence of vertical temperature steps which may be related to region-wide vertical heat transfer.

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References

Carmack, E.C. 1977. Water characteristics of the Southern Ocean south of the Polar Front. In M. Angel (Ed.), *A voyage of discovery*. New York: Pergamon Press.

Middleton, J.H., and T.D. Foster. 1980. Fine structure measurements in a temperature-compensated halocline. *Journal of Geophysical Research*, 85(C2), 1107–1122.