bottom water out of the Weddell Sea and, thus, to estimate the formation rate of Antarctic Bottom Water. Unfortunately, we were once again frustrated in our recovery attempts. The acoustic releases that we planned to use to recover the deep moorings either had dead batteries or were defective in design. In addition, it proved to be very difficult to conduct grappling operations from the *Palmer*, and we were successful in recovering only one current meter out of 19 instruments deployed.

A preliminary analysis of the potential temperature data from the long hydrographic section from about 62°57'S 54°25'W to 65°40'S 40°00'W is shown in figure 2. The structure of the potential temperature field is similar to that which we obtained for this same section in 1987 and 1991 with the exception of the surface layers where there are some differences due to seasonal effects. More significantly, the region of newly formed bottom water, indicated by potential temperatures below about –0.8°C, closely resembled those of 1987 and 1991. This may be evidence that bottom water forms all year long in the western Weddell Sea; however, we will need the current velocity and temperature records from the current-meter moorings to prove this conjecture.

The field party consisted of Kevin G. Cannariato, Theodore D. Foster, Kimberly A. Kloecker, Leslie E. Long, Lisa A. Miller, Rafael A. Olivieri, and Kenneth E. Vicknair from the University of California, Santa Cruz; Douglas M. Masten and James A. Schmitt from the University of California, San Diego; and Thomas F. Stocker from Columbia University.

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Helium isotope results from Ice Station Weddell 1

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As part of the Ice Station Weddell 1 hydrography/tracer program, we collected about 400 helium isotope samples. Most of the samples were taken along the drift track of the ice floe (figure 1). Additionally, a small sample set was obtained from stations occupied by the Russian icebreaker *Akademik Fedorov* during the ice station deployment cruise.

The first helium isotope data show very low isotopic helium-3 (δ^3He) values in a thin bottom layer [about 100 meters (m) thick] along the drift track of the ice station (figure 2). This reflects the fact that the shelf- and surface-water masses that contribute to the formation of bottom water have a δ^3He signal that is in or close to thermodynamic equilibrium with the atmosphere (δ^3He=–1.8 percent). The increase of the surface mixed layer δ^3He values with latitude (higher values toward the north) is the result of entrainment of higher fractions of Circumpolar Deep Water (CDW) into the surface mixed layer by convective erosion of the pycnocline (for example, Schlosser et al. 1987). CDW is advected from the Circumpolar Current into the Weddell Sea and has relatively high δ^3He values (about 8 percent). The highest δ^3He signals were found at a depth of about 800 m with weak gradients between 500 and 1,500 m. Below about 2,000-m depth, there is an extremely strong δ^3He gradient toward the bottom.

The ^{4}He concentrations of the surface waters reflect the ice cover during the time of sampling. Gas exchange is reduced because of the ice cover, and ^{4}He accumulates as CDW entrains into the surface layer. Low ^{4}He concentrations indicate that the water exposed to the surface nearly reached solubility equilibrium with the atmosphere (about 4.1×10^{-5} cubic centimeters standard temperature and pressure per kilogram) during the time when the ice cover is not closed. At station 9, the gradient between surface water and CDW is well pronounced (figure 3), which is an indication of a well-mixed surface layer and rapid gas exchange with the atmosphere.

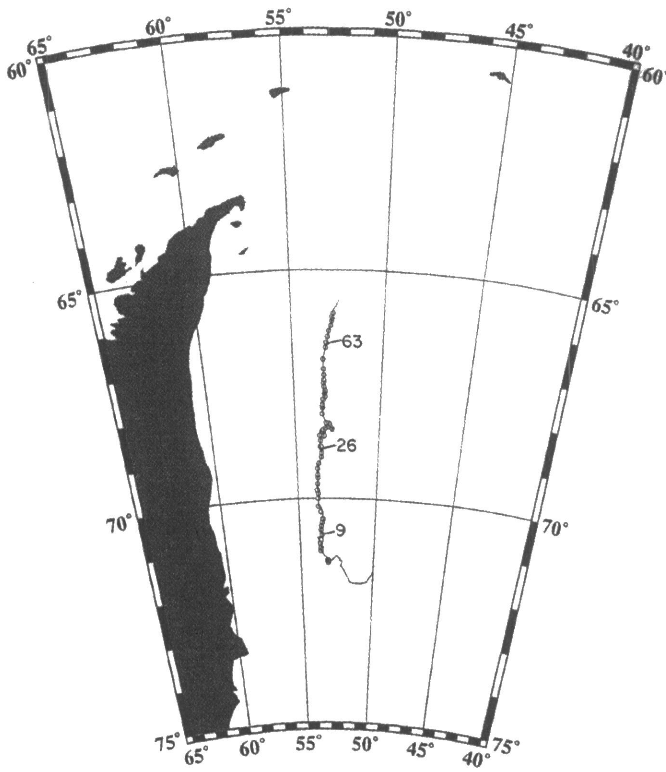

Figure 1. Geographical position of the Ice Station Weddell 1 tracer stations.

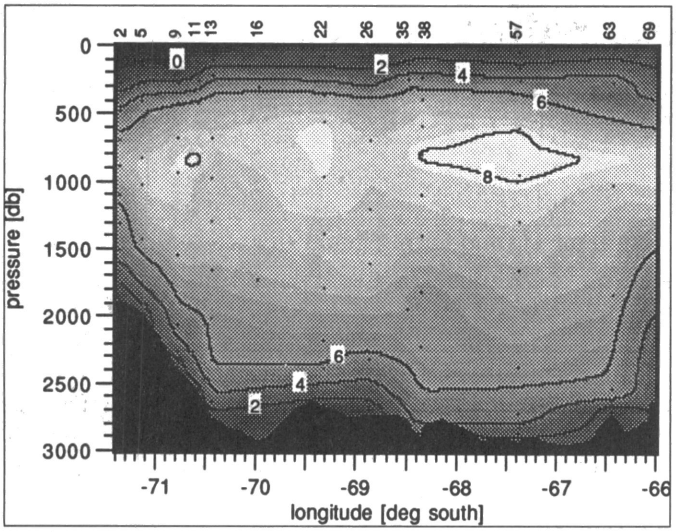

Figure 2. δ³He section along the drift track of Ice Station Weddell 1.

Further to the north (stations 26 and 63, figure 3), the ^{4}He concentrations in the surface layer cannot be distinguished from those in most of the underlying waters because of incomplete gas exchange and upwelling of CDW into the surface layer.

^{4}He concentrations increase slightly with depth, and we generally observe a maximum at about 100 m above the bottom (figure 3). We interpret this pattern as an indication that there are different types of shelf water contributing to the deep and bottom waters formed in the western Weddell Sea. There are basically two hypotheses concerning the process of Weddell Sea Bottom Water (WSBW) formations. One hypothesis is that during the "Foster/Carmack" process (Foster and Carmack 1976; Foster, Foldvik, and Middleton 1987) mixing of CDW, Winter Water, and Western Shelf Water (WSW) results in WSBW with a low ^{4}He concentration, because the initial ^{4}He concentration of the involved shelf waters are close to solubility equilibrium with the atmosphere. The second hypothesis concerns WSBW formation by mixing of CDW with Ice Shelf Water (ISW). ISW forms when WSW interacts with glacial ice at the underside of the Filchner/ Ronne Ice Shelf (Foldvik, Gammelsrød, and Tørresen 1985). This process adds helium to the water by dissolution of air included in glacial ice during melting at the underside of ice shelves (Schlosser 1986; Schlosser et al. 1990).

WSBW with a high ^{4}He signal seems to be less dense than the WSBW with low ^{4}He concentrations. The signal can be found in a well-defined thin layer about 100 m above the bottom. Toward the north, the ^{4}He peak in the near bottom water decreases. This implies that the major source for the high ^{4}He bottom water we found along the drift track is in the southwestern part of the Weddell Sea. Schlosser et al. (1990) showed that the Filchner Depression in the southeastern part of the Weddell Sea is a source of high ^{4}He waters contributing to WSBW. It is likely that similar processes take place in the Ronne Depression, which is a possible source of the high ^{4}He concentrations we observed at several Ice Station Weddell 1 stations.

The combination of the full He isotope and oxygen isotope data sets will allow a more detailed interpretation of the observed signals.

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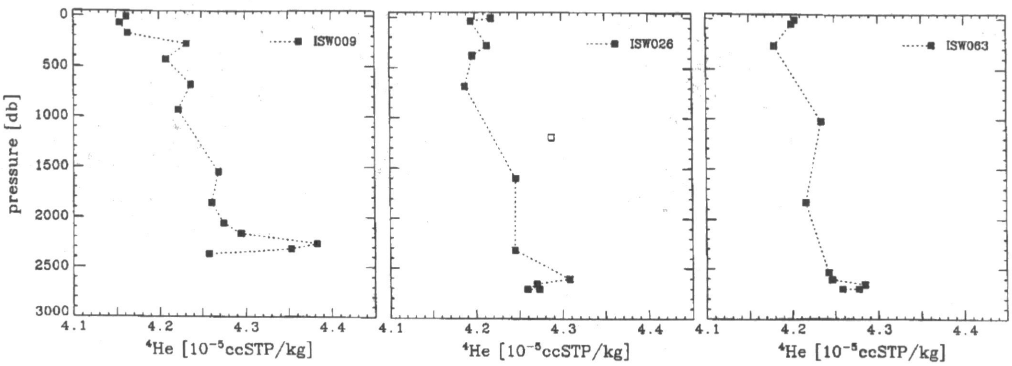

Figure 3. ^{4}He profiles of a station at the southern end (station 9), the center (station 26), and the northern end (station 63) of the drift track of Ice Station Weddell 1.