Relative diatom abundance as tool for monitoring winter sea ice fluctuations in southeast Atlantic

DAVID R. DEFELICE

Mobil Oil Corporation
9 Greenway Plaza, Suite 2700
Houston, Texas 77035

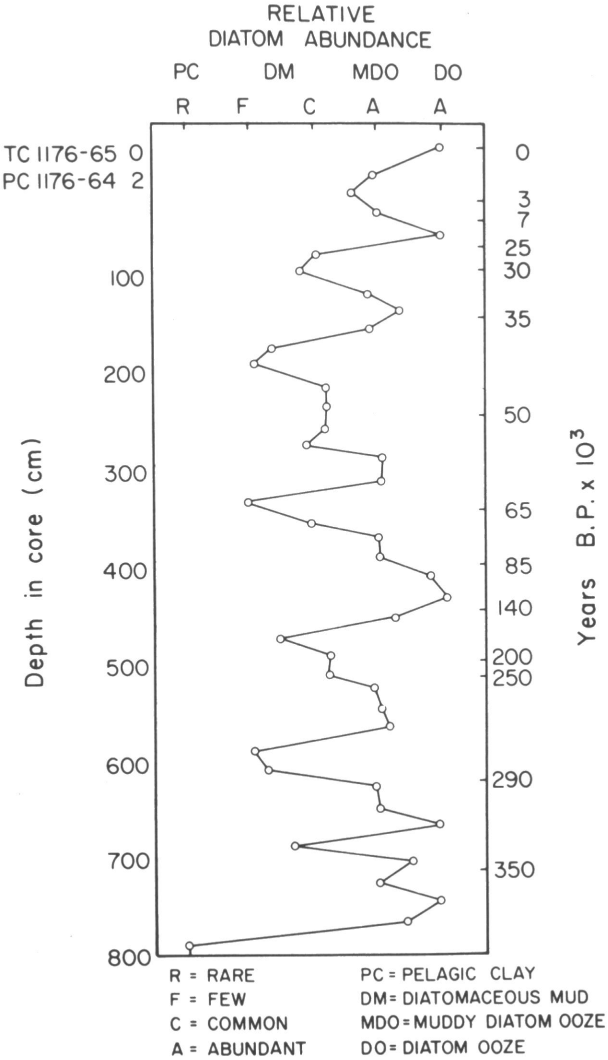
Although it has been shown that many species of diatoms are capable of living heterotrophically under or within sea ice (Bunt, 1968; Hornes, 1977; Hoshiagi, 1977), the bulk of sediment-forming species are not epontic and require unobstructed solar radiation to maintain metabolic processes. Their sensitivity to light quality makes relative diatom abundance a useful tool in monitoring fluctuations of the northern winter boundary between sea and ice and so of temperatures responsible for these fluctuations.

Analysis of surface sediment lithologies in the southeast Atlantic reveals that diatom ooze predominates south of the antarctic polar front to about latitude 60°S. South of 60°S, the most prominent surface sediment types are pelagic clay and diatomaceous mud (except on the Maud Rise, where the anomalous occurrence of diatom ooze possibly reflects polynya development and uninhibited photosynthetic activity [DeFelice, 1979]). The boundary between diatom ooze and pelagic clay in surface sediments corresponds roughly to the northern limit of winter sea ice. North of the ice front, diatoms are capable of uninhibited, yearround photosynthetic activity and thereby make up the major constituent in sediments. South of the ice front, diatoms are less abundant on account of the sea ice that covers the area for as much as eight months of the year.

The front fluctuates greatly between the summer and winter (Mackintosh, 1972). Any area covered by ice has to be recolonized by plankton during the months when the ice has receded. However, because many species are incapable of living in such an unpredictable and variable environment, diversity in the pelagic clay belt is significantly less than in the ooze belt (DeFelice, 1979).

Using present-day lithofacies patterns as a model, we examined *Islas Orcadas* core 1176–64, located on the ooze-clay boundary, for changes down-core in diatom abundance. Lithofacies variations down-core show evidence for numerous fluctuations of the winter ice front within the last 300,000 years. The accompanying figure illustrates down-core variation in relative diatom abundance that reflects the presence or absence of sea ice over the area at a particular time in the past.

Assuming that northward shifts of winter sea ice (characterized by pelagic clay) are a consequence of cooling and that southward shifts of the ice front (characterized by diatom ooze) are a consequence of warming, it is possible to use relative diatom abundance to reconstruct paleotemperature changes. Comparison of the curve in the figure with paleotemperature curves constructed using oxygen isotopes (Burckle, Clarke, and Shackleton, 1978), foraminifera (Williams, 1976), and radiolarians (Hays, Lozano, Shackleton, and Irvine, 1976), shows reasonably good correlation.



Relative diatom abundance down core 1176–64 (ages determined using nondestructive gamma spectrometry).

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Drifting buoy measurements on Weddell Sea pack ice

STEPHEN F. ACKLEY

U.S. Army Cold Regions Research and Engineering Laboratory
Hanover, New Hampshire 03755

Recent observations show that the Weddell Sea pack ice is sustained during the summer over an area of approximately 2 million square kilometers. It advances from the Weddell region (longitude 60°W to 30°E) to make a major contribution to the total pack ice that extends around Antarctica and covers about 7.5 million square kilometers of ocean at the winter maximum. The pack ice reaches to lower than latitude 55°S in the region of the 0° meridian (Ackley and Keliher, 1976; Ackley, 1979).

In our study, we deployed an array of air-dropped buoys with sensors to obtain information on the drift of the ice cover and its deformation by the driving forces of wind and ocean current. The buoys, designated ADRAMS (air-droppable random access measurement system), transmitted data on location, pressure, and temperature to the NIMBUS VI satellite that currently is in a near-polar orbit. The air drop from one of the National Science Foundation's LC-130 aircraft based at McMurdo Station was accomplished on 18–19 December 1978.

Initial locations of the six buoys are shown in table 1. As indicated in the table, two buoys ceased transmitting after two weeks, presumably because they were crushed or overridden by moving ice. The other four continued transmitting for approximately four months (in fact, two of them were still providing information in September 1979).

The drift record of the southernmost buoy (buoy 1433) that remained active for the four-month period is shown in figure 1. The drift is dominated by a relatively steady northward component throughout the period, with some cyclical movements probably associated with wind shifts from the movements of occasional low-pressure systems across the region. To validate this assumption, geostrophic wind data will be computed from the pressure field available from the records of all the buoys.

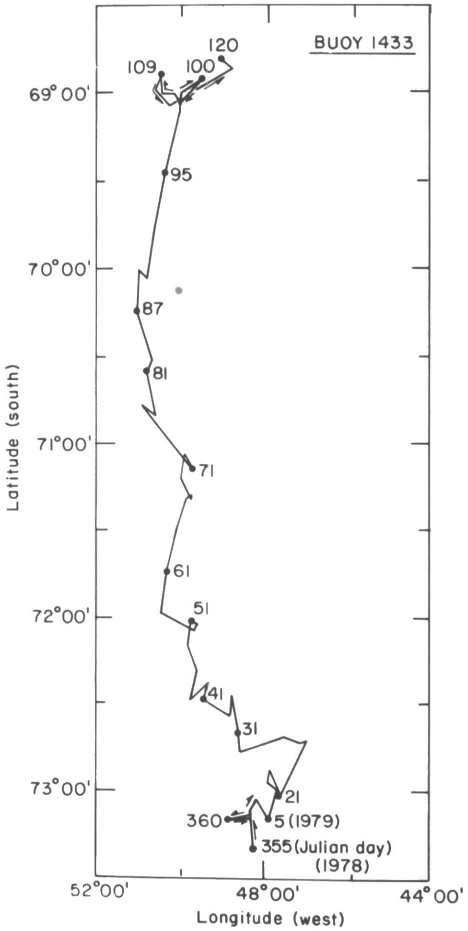

Figure 1. Drift track of buoy 1433 from late December 1978 through April 1979.

The mean drift speed of this buoy for four months was 3.85 kilometers per day, which is in close agreement with the mean drift speeds of *Endurance* and *Deutschland* during their ice entrapment (4.1 kilometers per day and 4.3 kilometers per day, respectively) (Ackley, 1979). The mean ten-day drift speeds for the buoy are shown in table 2. They indicate a tendency for several periods of fast drift (>7.5 kilometers per day) in the fall preceded by a longer period with speeds less than 3 kilometers per day. The periods of fast drift account for nearly 70 percent of the northward movement during only 25 percent of the time. The fastest drift period, averaging 10.5 kilometers per day from days 76 to 85, would require wind speeds averaging over 21 kilometers per hour (5.8 meters per second) for the ten-day period under free ice drift conditions (ice speed = 2 percent of wind speed [Zubov, 1945]).

The temperature record for the same buoy is shown in figure 2. The temperature sensor is located inside the hemispherical shell of the buoy, which is painted white