

The Marginal Ice Zone



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In winter, Arctic sea ice covers approximately 15 million sq km (six million square miles), shrinking to about half this area each summer. The central regions of the pack ice are comparatively homogeneous; ice motion is sluggish and ice thickness, surface roughness, and the amount of open water within the pack all change slowly with position and time. Within about 100 km (60 mi) of the seaward change, the sea ice becomes less compact and more mobile, and conditions can change rapidly. This boundary region between consolidated pack ice and open ocean is known as the Marginal Ice Zone (MIZ). The actual ice/ocean boundary, determined primarily by wind forcing and ocean currents, can shift many tens of kilometers in a single day.

Ocean eddies, characterized by circular current patterns some tens of kilometers in diameter, have been observed in the MIZ. These eddies presently are a subject of research, as little is known about how they are generated and maintained. They appear to influence ice-edge retreat by breaking up the pack and driving warmer ocean water beneath the ice, resulting in a significant increase in melting. Enhanced melting may help explain why the MIZ is associated with increased biological activity. When the ice melts, there is release of relatively fresh water. This mixes with nutrient-rich sea water to form a low-salinity layer that stabilizes the water column because of the layer's low density. Phytoplankton "trapped" within this layer are subjected to prolonged exposure to sunlight, thus leading to phytoplankton blooms. In turn, the abundant phytoplankton are grazed on by other organisms, enriching higher levels of the food chain, including fish and whales.

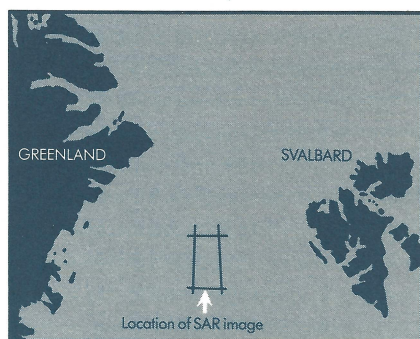
In the summer of 1984, a Marginal Ice Zone Experiment (MIZEX) was carried out in the Fram Strait off the northeastern tip of Greenland. The color image seen here (bottom) is an oblique aerial photograph, taken from an altitude of seven kilometers (23,000 ft), of an ocean eddy in this region. Although the swirling pattern of the currents is visible in the photograph, details of the eddy in the context of the ice edge are

much more clearly defined in the synthetic aperture radar (SAR) image (top) produced by Robert Schuchman at the Environmental Research Institute of Michigan. SAR holds great promise for investigating the MIZ. Because it operates at microwave frequencies, it is consequently unaffected by the clouds and fog which frequently shroud the MIZ, and it can operate day or night. (See: Arctic Pack-Ice Motion.)

The SAR image covers an area of 130 by 70 km (80 by 44 mi) and has a resolution of three meters (ten feet). The high backscatter of the ice relative to the water in this transition zone produces particularly sharp images so that the ice/water boundary is clearly depicted (1). Multiyear ice floes that make up the interior pack are seen in the upper left of the image (2). The most exciting feature is the large cyclonic (counterclockwise rotating) eddy (3) which is clearly visible because of the entrainment of relatively small (100-m or 300-ft) ice floes caught in the eddy current. Real-time SAR observations permitted MIZEX scientists to direct research ships to the eddy in time to make detailed measurements during its 30-day lifetime.

Satellite-tracked buoys placed within the eddy indicated a current speed of 50 cm/s (one mile/hour) and a southward movement of the entire eddy at seven kilometers/day (four miles/day). Eddies may play an important role in diffusing ice away from the pack into the ocean. As can be seen in the SAR image, concentrated ice fragments near the eddy are being forced out to sea (4).

In anticipation of forthcoming requirements for synoptic observations of MIZ, NASA is supporting efforts on the part of the Europeans, the Japanese, and the Canadians to deploy SAR-equipped satellites. For its part, NASA will establish a complementary SAR facility at the University of Alaska at Fairbanks for acquiring the resulting SAR data. This network of satellites and receiving facilities will provide unprecedented coverage of nearly the entire Arctic Ocean, thus facilitating exploration for petroleum and minerals, as well as aiding assessments of marine productivity.



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