The Antarctic Marine LTER: Studying an Ecosystem Dominated by Ice

Palmer Station and the surrounding waters have been chosen by the National Science Foundation as the first Antarctic Long Term Ecological Research (LTER) site. Palmer Station is the smallest of the three U.S. Antarctic research stations managed by the NSF. The Station is located in a protected harbor on an island midway down the Antarctic Peninsula (64°40'S, 64°00'W), and more than 600 miles from the tip of South America. The climate in the Palmer region is typically maritime Antarctic, with snow and rain common any time of the year. The temperature at Palmer Station is relatively mild, averaging about -10°C in July and 2°C in January. The extent of sea ice in the region is highly variable, with particularly severe ice conditions occurring at about 7-to-10-year intervals. Within the last two decades, each interval has lasted 2 to 3 years. The areal extent of ice can vary by 25% between years.

There are several groups of islands with seabird rookeries between Palmer Station and Palmer Basin, the only deep basin in the area. Species of interest for the LTER program include the Adelie penguin (*Pygoscelis adeliae*), which dominates the seabird assemblage, and the south polar skua (*Catharacta maccormicki*), a gull-like migratory seabird. During the breeding season, penguins and south polar skuas forage in the upper water column within a 100-km radius of the rookeries, moving southwest into Palmer Basin and west into the open ocean. The summer foraging region and wintering grounds of the seabirds help define the scale of the region to be investigated.

Effects of the ice cycle

The Antarctic LTER program will focus on the pelagic marine ecosystem and the ecological processes that link the extent of annual pack ice to the biological dynamics of different trophic levels. In these polar waters the annual cycle of ice formation and melting affects about 50% of the open sea. Because pack ice is postulated to be the major physical determinant of temporal/spatial changes in the structure and function of polar biota, interannual cycles and trends in the annual extent of pack ice are likely to have significant effects on all levels of the food web, from total annual primary production to breeding success in seabirds. For example, recent studies suggest a connection between the extent of winter sea ice and the overwintering or reproductive success of the seabirds and their prey. Both Adelie penguins and Antarctic krill (*Euphausia superba*), which is the penguins' favored prey, are positively affected when ice cover is most extensive. Conversely, reproductive success in south polar skuas appears to be connected to the abundance of one age group of the Antarctic silverfish (*Pleuragramma antarcticum*), which seems to do better when ice cover is less extensive.

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The overall objectives of the Antarctic marine LTER are (1) to document interannual variability in the development and extent of annual pack ice, and in life-history parameters of primary producers and populations of key species from different trophic levels; (2) to quantify the processes that underlie natural variation in these representative populations; (3) to construct models that link ecosystem processes to physical environmental variables, and that simulate the spatial/temporal relationships between representative populations; and (4) to employ such models to predict and validate the impacts of altered periodicities in the annual extent of pack ice on ecosystem dynamics.

The general approach of the LTER program capitalizes on populations that are easily accessible near Palmer Station during prolonged breeding seasons, and that sample the surrounding marine environment. Beginning in October 1991 (austral spring) a suite of critical biological and environmental variables will be measured continuously on a small spatial scale representing the seabird summer foraging area, but on a long and recurrent temporal scale (every year, for the entire breeding season). Satellite imagery will provide a means to continuously monitor certain environmental parameters such as sea ice extent and thickness, sea surface temperature, and ocean color on larger spatial scales and throughout the year. In addition, automatic weather stations at several selected positions in the regions will continuously monitor atmospheric pressure, wind speed and direction, and air temperature. Research at Palmer Station and in the surrounding nearshore waters will focus on the seabirds, the prey of the seabirds, primary production, and hydrographic characteristics of the water column. The LTER program will provide measurements of processes (reproduction, recruitment) and parameters (food availability) that are sensitive to environmental change and are important in the structure and function of the communities. The inherent interannual variability in the extent of pack ice allows for natural experiments on the effects of different pack ice cover on the various trophic levels.

The spatial scale of sampling prey distribution, abundance, and physiological condition, water column properties, primary production estimates, and hydrographic measurements will be extended during two types of research cruises: (1) time-series cruises in the late spring; and (2) process-oriented cruises at critical times in biological cycles. The results obtained from these cruises are essential for verification of the models of regional processes, such as primary production, oceanic circulation, and the biological/physical models of prey abundance. ■

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