Effects of ice facies on small scale oceanic phenomena: R/V *Hero* Cruise 77-1

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Ice-dominated regions of the world's oceans are of special interest to students of marine ecosystems because an apparent anomaly exists whereby such cold waters have large, rich, and varied populations of birds, mammals, and fishes. Low temperature per se does not seem to inhibit strongly the biological activity. In arctic regions productivity at the photosynthetic level is highly seasonal, mostly occurring in spring. Typically a spring bloom in the ice adjacent to the water/ice interface is followed by a bloom in the water. Presumably this highly seasonally restricted activity is due to nutrient exhaustion during the summer months.

Antarctic waters, however, are known to be richer in nutrients, and therefore the seasonal production regime differs. On the other hand, ice-associated plant production is known to be important here also (Bunt, 1963; Meguro, 1962, and others). In addition, ice plays a significant role in determining the composition and structure of the sea water column in its immediate vicinity. The effect of such physical and chemical conditions on the biological system is of interest. We therefore proposed to study the effects of ice on the local near-shore system in the vicinity of Palmer Station, Antarctica, concentrating on low trophic level biology and on aspects of seawater chemistry.

Three cruise tracks for the R/V *Hero* were selected to carry out the field sampling and oceanographic observations. The first was directly outside Arthur Harbor, with a series of 10 stations in a grid west of Anvers Island taken over a 3-day period. The second was somewhat farther south, with several stations taken enroute, but basically a transect of four major stations was completed running out to sea off the Biscoe Islands at a longitude of 66°W. A few samples of sea ice, some newly forming, were collected. The third track was to the north of Palmer Station and included another transect at approximately 62°S. latitude, west of the South Shetland Islands. We also worked in the bay of Deception Island and took a series of surface samples on the run back to Palmer Station. The final aspect of our work was analysis of nutrient levels in glacial ice, snow, runoff, and precipitation, to be used in estimating nutrient input in the coastal regions. El-Sayed (1970) describes the shelf west of the Antarctic Peninsula as an area of high production; this may well be related to a relatively high nutrient input.

Chlorophyll values ranged from undetectable to 9 milligrams per cubic meter, with the highest values in the bay at Deception Island. Primary productivity as measured by the carbon-14 method (with deck incubation) showed a similar variation, and light versus photosynthesis experiments suggested two distinct populations with differing responses, possibly related to nutrient levels. The chlorophyll values

are in line with those found by other workers at the same time of year. Bienati *et al.* (1971) found high levels (13.5 milligrams per cubic meter) at the surface in late March in Paradise Harbor (Gerlache Strait). Summer primary productivity also was found to be high in that area (Bienati *et al.*, 1975). Previous work in the Arthur Harbor area has shown three algal blooms during the summer season, with the highest in midsummer (Krebs, 1974). Krebs suggests that cool surface water of low salinity due to glacial runoff and presence of brash ice may be a strong influence. Burckholder and Mandelli (1965) also found three production peaks during the summer. In our work we ultimately will be able to correlate light levels, light penetration, nutrient analyses, chlorophyll, and primary production with physical structure of the water column (salinity and temperature). Previous work has not included ammonia among the nutrients studied, although our results suggest that it is a major source of nitrogen for the phytoplankton populations and that it is sensitive to changes in productivity and influences algal light response. Warnke *et al.* (1973) describe the environment in the Arthur Harbor vicinity in terms of some chemical aspects and include some microbiological data.

A summary of data from the runoff and precipitation study is shown in the table. The numbers are means, taken from all the samples of each kind. There is a suggestion that runoff may be an important source of ammonia and that rainfall also could add significant amounts of this nutrient. The situation is similar for phosphate, although the results are not as clear.

One very distinct difference between the Arctic and the Antarctic is related to ice-algal communities. We were interested to find abundant algae associated with newly forming sea ice during our southern cruise track. These algae showed a high degree of light compensation, and the photosynthetic rates were not reduced greatly by lowering the light from full surface intensity to under-ice levels. We never have observed fall ice-algal production in the Arctic, although it is well documented for the Antarctic (Hoshiai, 1972). The area of sea ice that we studied near the Biscoe Islands was rich in birds, seals, and whales, suggesting that ice-related production may be important in the biological regime. This has been observed for localized areas of ice occurring during the spring season in the Bering Sea in the Subarctic (J. Burns, personal communication). However, it is possible that during the fall in the Bering Sea ice formation occurs at a time of too low light intensity to allow for algal growth or alternatively nutrient deficiencies may be prohibiting.

This work was supported by National Science Foundation grant DPP 75-15851. We appreciate the cooperation and support of Captain Peter Lenie of the R/V *Hero* and his crew. The facilities of Palmer Station were used as shore base. The invaluable assistance of Margie Young is acknowledged.

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Atmospheric contribution to oceanic productivity near Palmer Station, Antarctica.

$PO_4 - P$ (μg at/l)	$NO_2 - N$ (μg at/l)	$NH_4 - N$ (μg at/l)	pH	Alkalinity (meq/l)
Runoff (6 samples), 24 February - 7 March 1977				
1.3	0.09	3.0	6.46	0.07
Precipitation (6 samples), 24-26 February 1977				
1.9	0.17	5.4	5.66	0.007
Precipitation (4 samples), 1-6 March 1977				
0.19	0.16	12.0	—	—
Total snow accumulation (4 samples), 1-7 March 1977				
0.03	0.07	22	5.41	0.006
Glacier ice, top 3 cm, 7 March 1977				
0.31	0.11	0.92	5.85	0.012
Glacier ice, 3-6 cm, 7 March 1977				
0.12	0.03	0.48	5.56	0.008

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