

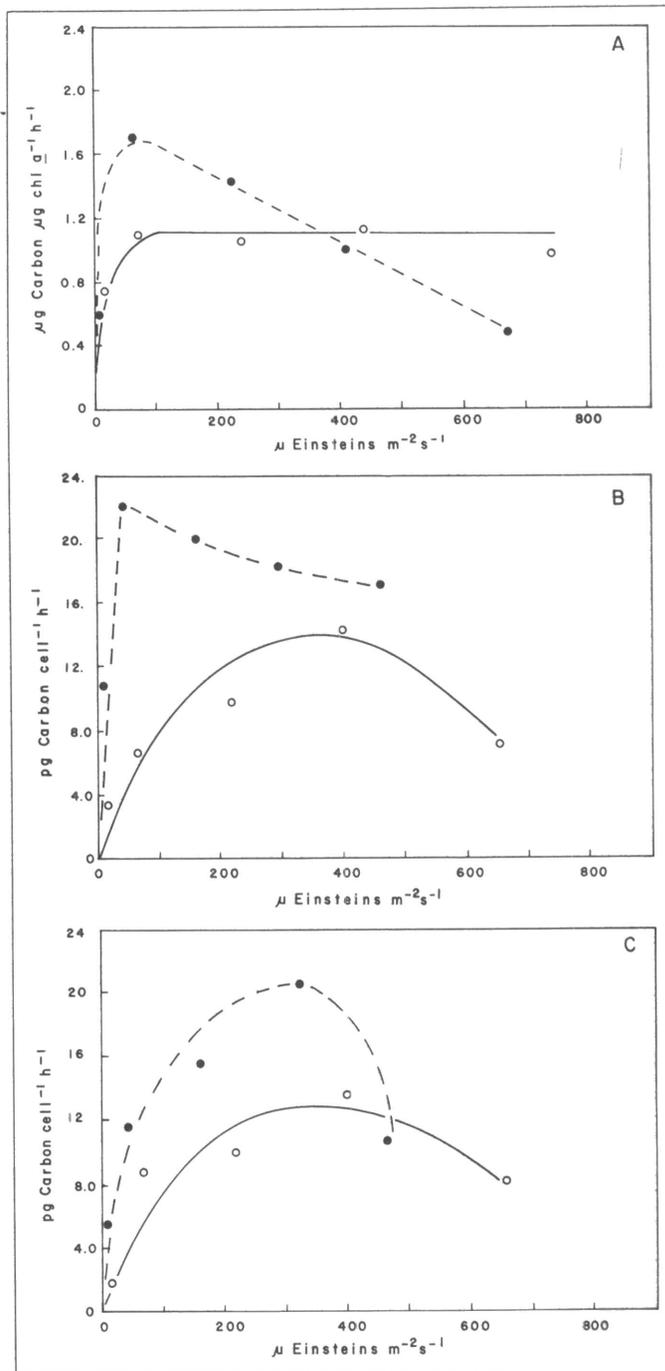
Photoadaptations of photosynthesis and carbon metabolism by antarctic phytoplankton: Species-specific and community responses

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In most aquatic environments, temperature, nutrients, and light are the primary factors regulating the production and growth of the phytoplankton (Bunt 1964; Holm-Hansen et al. 1977; Falkowski 1980). In the Antarctic, inorganic-nutrient concentrations are high, and temperatures are low and relatively uniform. Thus adaptations to the variable light regime will, for the most part, regulate photosynthesis and growth. Photoadaptations which enhance the absorption of light, fixation of carbon or the synthesis of energetic or structural polymers could be of selective advantage (Morris 1981). Species-specific adaptations which influence cell division rates may ultimately be reflected in spatial and temporal differences in species composition. Rates of photosynthesis and cell division, the mechanisms and time course of photoadaptations, and the expression of the photoadaptations of photosynthesis in altered cell division rates would be species-specific. A water sample collected in any aquatic environment would contain a large number of different species of phytoplankton; thus, to discriminate between the extent to which a measured change is due to an adaptation per se or to a change in the species composition, it is essential that adaptations of photosynthesis, carbon metabolism, and growth be evaluated for individual species rather than just for the entire phytoplankton community. The overall objective of this research is to develop an understanding of the interactions between the photoadaptations of photosynthesis and carbon metabolism and the expression of these adaptations in altered cell-division rates.

During the 1984 – 1985 field season (mid-November to mid-February), we examined the relationship between photosynthesis and carbon metabolism (i.e., the pattern of polymer synthesis) for the individual phytoplankton species and that of the phytoplankton assemblage in McMurdo Sound. Samples were collected at the ice edge and through holes in the ice at 8 sites along a north to south transect on the eastern side of McMurdo Sound. Samples for physiological experiments were collected in 10-liter Niskin bottles or by vertically towing a 20-micrometer aperture, 0.20-meter plankton net. Whole-water and species-specific rates of carbon uptake, ribulose 1,5-bisphosphate carboxylase activity, chlorophyll *a* concentrations, and photosynthate labelling patterns were measured as previously described (Rivkin and Seliger 1981; Rivkin et al. 1982; Rivkin in press). Time course incubations were done in flowing seawater (-1.8°C) with incident insulation attenuated with neutral density filters.



Photosynthesis/irradiance relationship for (A) the phytoplankton community, (B) *Thalassiosira scotia*, and (C) *Fragilariopsis sp.* isolated from the ice edge (open symbols) or from under the sea ice 16 kilometers from the ice edge (filled symbols).

Reported herein is a comparison between the photosynthesis-irradiance relationships for two of the more common phytoplankton, *Thalassiosira scotia* and *Fragilariopsis sp.* and that of the phytoplankton community. Plankton were synoptically collected at the ice edge and from under the annual ice approximately 16 kilometers south of the ice edge. In this region the prevailing current flows south along the east side of McMurdo Sound. Phytoplankton would therefore be carried from the ice edge, where they would be exposed to relatively high irradiances, under the annual ice, where irradiances are low. This would thus represent ideal conditions to examine the *in situ* photoadaptations of photosynthesis and carbon metabolism

and cell division. The photosynthesis vs. irradiance relationship for the phytoplankton assemblage is shown in the figure, part A. The rate of carbon uptake for a sample collected from 15 meters at the ice edge saturated at approximately 75 microEinsteins per square meter per second with no photoinhibition during the approximate 6-hour incubation. The maximum rate of carbon uptake of samples collected from 15 meters under the annual sea ice saturated at approximately 55 microEinsteins per square meter per second with significant photoinhibition above 60 microEinsteins per square meter per second. The photosynthesis vs. irradiance relationships of *T. scotia* (figure, part B) and *Fragilariopsis* sp. (figure, part C) isolated from the ice edge were similar. Carbon uptake saturated approximately 350 to 400 microEinsteins per square meter per second and was photoinhibited over 450 microEinsteins per square meter per second. These diatoms apparently photoadapted to the reduced irradiances experienced during the transport beneath the annual ice. When isolated from under the annual ice, carbon uptake by *T. scotia* saturated at approximately 45 microEinsteins per square meter per second and was moderately photoinhibited above 60 microEinsteins per square meter per second. This contrasts with the responses of *Fragilariopsis* sp. where carbon uptake saturated at approximately 325 microEinsteins per square meter per second followed by a rapid onset of photoinhibition.

The slope of the light-limited region of the photosynthesis vs. irradiance relationship was greater for the diatoms isolated from under the annual ice (i.e., low-light adapted) compared to the ice edge (i.e., high-light adapted). This was not unexpected and suggests that these algae used low irradiances more efficiently (Prezelin 1981). The higher photosynthetic capacities for the low-light adapted diatoms was unexpected. Studies of the species-specific photoadaptations of phytoplankton from coastal and offshore temperate regions has not heretofore shown this pattern.

The results of this study serve to emphasize the differences in photoadaptations among species and between species-specific and community responses. Our continuing studies will examine the coupling between photoadaptations of photosynthesis, carbon metabolism, and cell division. By measuring these adaptations for individual species *in situ*, it may be possible to understand the factors which regulate physiological adaptations, growth, and succession of phytoplankton in the sea.

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Trophic position of benthic rhizopods in McMurdo Sound

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Benthic rhizopods may be an important component in energy transfer in the benthic food webs of McMurdo Sound. They represent large standing stocks and biomasses and are capable of rapid growth using a variety of food sources. Their impact on

microflora as bacteriovores and herbivores and on the micro- and meiofauna as predators is unknown. Their importance as a food source to higher trophic levels, especially small species and developmental stages of larger organisms may be significant. Research conducted in the Antarctic during the 1984 – 1985 austral summer was in response to a clear need to develop a better understanding of this diverse and abundant order.

The board objectives of the research program carried out both in the Antarctic and in the United States are (1) the examination of the distribution, ecology, and physiology of important antarctic benthic rhizopods and (2) the evaluation of the roles and significance of benthic rhizopods in the energy flux through benthic communities. These investigations were accomplished by assessing the range and concentration of food available in microhabitats inhabited by rhizopods and by measuring the ability of a selected suite of rhizopod species to use those food resources under laboratory conditions. The resulting feeding studies focused on the direct uptake of dissolved organic material (DOM) (amino acids, carbohydrates, and lipids) and the consumption of small particulate organic carbon (0.2 to 50 mi-