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Isolation and identification of photosynthetic pigments in sea-ice communities in McMurdo Sound

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Microalgal communities living in the lower layers of sea ice in McMurdo Sound, Antarctica, are dominated by diatoms (Bunt and Wood 1963). Diatoms contain chlorophylls *a* and *c* and the carotenoid fucoxanthin as their primary light harvesting pigments, as well as lesser amounts of the carotenoids diatoxanthin, diadinoxanthin, and B-carotene. Light is sharply attenuated as it passes through surface snow and sea ice leaving typically <1 percent of surface downwelling irradiance available to diatoms in the lower congelation ice (coarse-grained ice) and platelet ice (unconsolidated ice crystal layer below congelation ice.) It is critical for sea-ice algae to be efficient in harvesting available light for photosynthesis. We have characterized light absorption by the total pigment complement using visible spectrometry, and isolated and quantified individual photosynthetic pigments using high-performance liquid chromatography to assess their relative contributions to light absorbance.

An acetone extract of total pigments in a sea-ice diatom community from a site in Wohlschlag Bay is shown in figure 1. This community was of special interest because it comprised a monospecific population of *Nitzschia stellata*, a common ice alga. We found a broad peak in spectral absorbance at 436 nanometers (chlorophylls and carotenoids) and at 668 nanometers (chlorophyll *a*; this absorbance spectrum is characteristic for diatoms.

Using reverse-phase, high-performance liquid chromatography (figure 2), we found that acetone extracts of sea-ice diatoms contained chlorophyll *c* (peak 1), fucoxanthin (peak 2), and chlorophyll *a* (peak 5). Trace amounts of diatoxanthin and diadinoxanthin were also present (peaks 3 and 4). B-carotene, a carotenoid whose primary function is photoprotection, was not detected in diatoms from this low-light, under-ice habitat. Phaeophytin and phaeophorbide, chlorophyll degradation products that have been proposed as indicators of grazing activity,

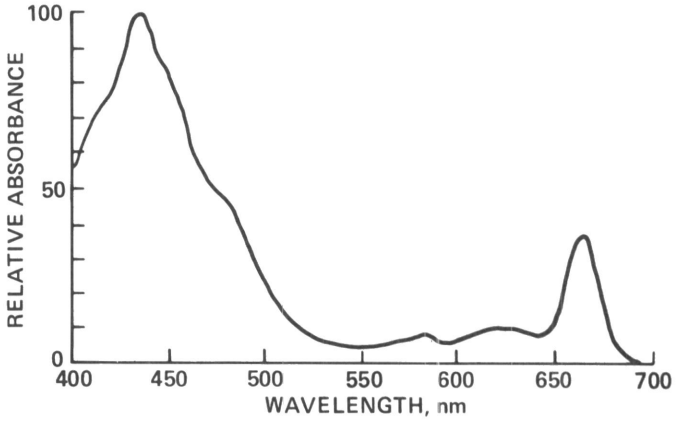

Figure 1. Absorbance spectrum of an acetone extract of a sea-ice diatom community at Wohlschlag Bay dominated by *Nitzschia stellata*.

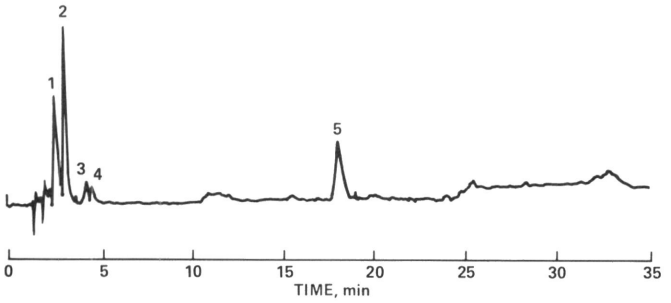

Figure 2. A high-performance liquid chromatogram of an acetone extract of a *Nitzschia stellata* community. Peaks represent absorbance at 440 nanometers. 1, chlorophyll *c*; 2, fucoxanthin; 3, diadinoxanthin; 4, diatoxanthin; 5, chlorophyll *a*.

were not detectable. This confirms our observations that congelation ice habitat in McMurdo Sound serves as a refugium inaccessible to many grazing animals. Chlorophyll *a'* (an isomer of chlorophyll *a*) and chlorophyllide, present in senescing or detrital diatom populations, were absent.

The molar proportions of the two accessory pigments—chlorophyll *c* and fucoxanthin—varied with respect to chlorophyll *a* by twofold in our samples with the highest proportion of accessory pigments in Granite Harbor congelation ice dominated by *Amphiprora* communities and the lowest proportion in Erebus Ice Tongue congelation ice samples containing several species of pennate and some centric diatoms (table). These variations may be due to photoadaptive strategies, species composition, or both. A decrease in growth irradiance may result in an increase in cellular photosynthetic pigments (Prezelin 1981). However, photoadaptation alone cannot explain the observed differences in pigment ratios. Moreover, at the Erebus Ice Tongue site, diatom communities in congelation ice had very similar ratios to diatom communities in the platelet ice below which receive significantly less irradiance (Sullivan, Palmisano, and SooHoo 1984).

Bidigare et al. (1986) reported chlorophyll *c/a* ratios of 0.23 ± 0.08 in planktonic diatoms in the southern ocean. The ratios in sea-ice diatoms were consistently higher averaging 0.35 ± 0.13; this may reflect the low photosynthetically available radiation in sea-ice microbial communities.

Our analyses of photosynthetic pigments in sea-ice diatoms indicated a healthy, growing population with limited grazing. Natural variability among under-ice communities in pigment profiles may reflect photoadaptive strategies and/or species differences. Further research is needed on pure cultures and monospecific natural populations to determine interspecies variability in pigments. More detailed analyses of the organization of pigments within pigment-protein complexes of *Nitzschia stellata* are currently in progress by Barbara Boczar.

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Molar ratios of principal photosynthetic pigments in sea-ice diatom communities

Site	Dominant species	Ratios: Chlorophyll *c* to chlorophyll *a*	Ratios: Fucoxanthin to chlorophyll *a*
Bottom congelation ice			
Granite Harbor	*Amphiprora* sp.	0.54	2.57
Wohlschlag Bay	*Nitzschia stellata*	0.33	1.52
Erebus Ice Tongue	*Berkeleya* sp., *N. stellata*, *Biddulphia* sp., *Amphiprora* sp.	0.26	1.68
Platelet ice			
Erebus Ice Tongue	Small centric diatoms (< 20 micrometers)	0.27	1.82