

Arthur Harbor sediment fluxes for a spring bloom: Measurements of particulate organic carbon and total lipid

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Sediment fluxes of particulate organic carbon and the lipid component of this particulate organic carbon were determined for an Arthur Harbor site for the austral summer of 1988–1989. Collections were made over a 24-day period using stationary sediment traps containing a 10 percent formalin-sucrose solution as a preservative. Traps were of the design most efficient in collecting only the vertical downward component of particulate material (Hargrave and Burns 1979), with a baffled opening and a height-to-diameter ratio of 5. Traps were deployed by scuba divers at an Elephant Rocks study site in Arthur Harbor at a depth of 26 meters with the top of each trap 1.5 meters from the sediment surface to prevent collection of any resuspended benthic sediment material.

Preliminary rates of sediment fluxes for Arthur Harbor indicated substantial fluxes of 4.2 grams of particulate organic carbon per square meter per day to the sediments. Of the material collected, lipid made up approximately 1.8 percent (71 milligrams per square meter per day) of the total particulate organic carbon. Comparisons with various temperate, tropical, and two antarctic sites, indicate that rates for Arthur Harbor are among the highest reported for particulate organic carbon; however, lipid percentages were lower (table). Only a site along the coast of Peru in the rich upwelling El Niño region approached the amount of particulate organic carbon determined for Arthur Harbor and contained a substantially greater lipid percentage. This indicates a considerable amount of abiotic or lipid-poor material in the sediment flux for this Arthur Harbor near-shore environment.

Photosynthetic diatoms are typically lipid poor in temperate and tropical regions. Conversely, recent investigations (Nichols et al. 1986, 1988) have indicated antarctic sea-ice communities can contain a relatively high lipid content. Similarly, Smith, Clement, and Head (1989) have determined that the percentage of lipid in the composition of the particulate organic carbon fraction from arctic sea-ice algal communities ranges from 31.1 to 59.2 percent. Therefore, it is believed that our observations reflect a large influence of sedimenting abiotic material, and/or a dilution from carbon-rich/lipid-poor, planktonic organisms. Additionally, these planktonic algae may have become senescent with loss of cellular lipid and, therefore, devoid of the added benefit of buoyance from the lipid.

Comparison of sediment fluxes of particulate organic carbon and lipid.

	Depth ^a (meters)	POC ^b	Lipid ^b
Antarctic sites:			
King George Island ^c			
Antarctic Peninsula (62°S 57°W)	323	132.0	—
Riiser-Larsen Ice Shelf ^d			
Oceanic Weddell Sea (72°S 18°W)	80	16.5	—
Arthur Harbor ^e			
Antarctic Peninsula (64°S 64°W)	26	4,200.0	71.0
Temperate and tropical sites:^f			
Peru upwelling			
(15°S 75°W)	15	700.0	90.0
	50	280.0	40.5
California current			
(35°N 122°W)	100	70.0	20.0
	250	40.0	7.0
Central North Pacific			
(15°N 150°W)	400	3.0	0.2
	1,000	0.5	0.06
Equatorial North Atlantic			
(12°N 50°E)	400	6.0	2.0
	1,000	3.0	1.0
Sargasso Sea			
(30°N 52°E)	5,200	1.0	—

^a In meters.

^b Particulate organic carbon, in milligrams per square meter per day.

^c Bodungen (1986).

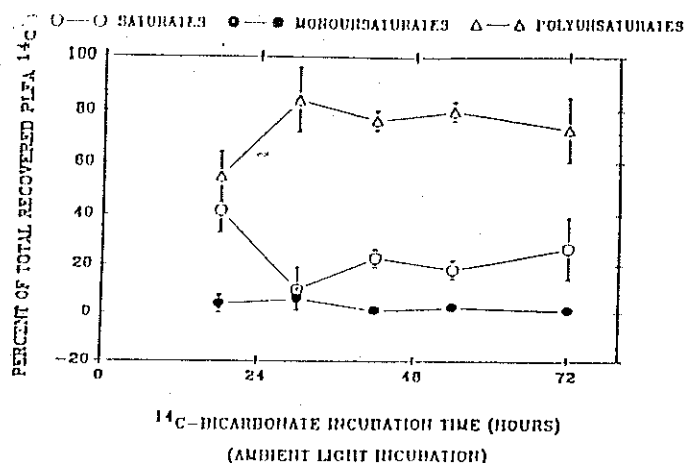
^d Bodungen et al. (1988).

^e Smith, G.A. et al. Unpublished data (1989) from Palmer study site.

^f Wakeman, S.G. et al. (1984).

Preliminary indirect indications are that the response of benthic microbial trophic systems may be coupled, at least seasonally, to this flux. Time course (72-hour incubation) studies of radiolabeled precursor carbon incorporation into phospholipids fatty acids of sediment microbial communities did not indicate any algal-bacterial coupling (i.e., transfer of autotrophically fixed carbon-14-bicarbonate into bacterial monounsaturated phospholipid fatty acids) during early stages of the bloom (figure). This does not provide a definitive uncoupling, but reveals a close association between the sediment flux and microbial trophic responses that may be diluting out, or "short circuiting," any sediment algal-bacterial coupling signal during this seasonal algal bloom.

We intend, with further analysis of the 1988–1989 data and comparisons with past investigation of sediment microbial communities (Smith et al. 1989), as well as future field seasons, to define more thoroughly this trophic-level transfer of carbon, thereby providing information on the apparently very important sedimentation flux to benthic microbial communities. Such investigations will focus great emphasis upon water-column organisms (i.e., phytoplankton) and their ecology. For, if its abundance is affected by future anthropogenic contamination



Carbon-14 bicarbonate incorporation into phospholipid fatty acid classes.

or by the depletion of atmospheric ozone with its consequences of increased ultraviolet radiation, serious aberrations in the meiofaunal-microbial trophic relationships within benthic sediments may become apparent. These aberrations may surely lead to serious trophic-level consequences throughout this high-latitude food chain.

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References

- Bodungen, B.V. 1986. *Polar Biology*, 6, 153-160.
 Bodungen, B.V., E.M. Nollig, and Q. Sol. 1988. *Comparative biochemistry and physiology*, 90B(3), 475-487.
 Hargrave, B.T., and N.T. Burns. 1979. Assessment of sediment trap collection efficiency. *Limnology and Oceanography*, 24(6), 1,124-1,136.
 Nichols, P.D., A.C. Palmisano, G.A. Smith, and D.C. White. 1986. Lipids of the Antarctic sea ice diatom *Nitzschia cylindrus*. *Phytochemistry*, 25(7), 1,649-1,653.
 Nichols, P.D., J.K. Volkman, A.C. Palmisano, G.A. Smith, and D.C. White. 1988. Occurrence of an isoprenoid C₁₉ diunsaturated alkene and high neutral lipid content in Antarctic sea ice diatom communities. *Journal of Phycology*, 24, 90-96.
 Smith, G.A., J.D. Davis, A.M. Muscat, R.L. Moe, and D.C. White. 1989. Lipid composition and metabolic activities of benthic near-shore microbial communities of Arthur Harbor, Antarctic Peninsula: Comparisons with McMurdo Sound. *Polar Biology*, 9, 517-524.
 Smith, R.E.H., P. Clement, and E. Head. 1989. Biosynthesis and Photosynthate allocation patterns of Arctic ice algae. *Limnology and Oceanography*, 34(3), 591-605.
 Wakeham, S.G., C. Lee, J.W. Farrington, and R.B. Gagosian. 1981. *Biogeochemistry of particulate organic matter in the oceans: Results from sediment trap experiments*.

Phycoerythrin-containing cyanobacteria in surface waters of the Drake Passage during February 1987

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Although unicellular cyanobacteria in the marine environment were described almost 80 years ago (Lohmann 1911), their widespread distribution and importance as a component of oceanic food webs has become apparent only during the last decade. In 1979, Johnson and Sieburth (1979) and Water-

bury et al. (1979) reported the presence of large concentrations of a chroococcalean cyanobacterium assignable to the genus *Synechococcus* in the open ocean. Li et al. (1983) and Platt, Subba Rao, and Irwin (1983) presented evidence that in Atlantic oligotrophic areas the picoplanktonic fraction of the phytoplankton, often dominated by *Synechococcus*, may contribute more than 40 percent of the total chlorophyll biomass and up to 60 percent of the total primary production.

In Antarctica, elevated concentrations of cyanobacteria have been found in selected saline lakes (Wright and Burton 1981) and, during the austral winter, in coastal marine habitats (Marchant, Davidson, and Wright 1987). Nevertheless, it appears that antarctic marine cyanobacteria are present in considerably lower abundances when compared with values for tropical and temperate marine ecosystems. For example, the concentration of cyanobacteria in surface waters between Australia and Antarctica showed a strong decrease in abundance south of the Antarctic Convergence (Marchant et al. 1987). Here we present data on the distribution and abundance of phycoerythrin-containing cyanobacteria in the surface waters of the Drake Passage, based on samples collected during the 1986-1987 austral summer.

Samples were collected from the R/V *Polar Duke* along a transect from the South Shetland Islands (62°S 57°W) to the Beagle Channel (55°S 70°W), on 4-7 February 1987 (figure 1). Surface water was sampled continuously by a pumping system used for the shipboard aquaria. Every 2 hours, duplicate 50-milliliter samples for the enumeration of cyanobacteria were withdrawn, filtered onto Nuclepore filters (0.2 micrometer), mounted on microscope slides with immersion oil and stored