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References

Ackley, S.F., K.R. Buck, and S. Taguchi. 1979. Standing crop of algae in the sea ice of the Weddell Sea region. *Deep Sea Research*, 26, 269–282.

Ackley, S.F., S.J. Smith, and D.B. Clarke. 1982. Observations of pack ice properties in the Weddell Sea. *Antarctic Journal of the U.S.*, 17(5), 105–106.

Clarke, D.B., and S.F. Ackley. 1984. Sea ice structure and biological activity in the antarctic marginal ice zone. *Journal of Geophysical Research*, 89, 2087–2095.

Garrison, D.L., S.F. Ackley, and K.R. Buck. 1983. A physical mechanism for establishing algal populations in frazil ice. *Nature*, 306, 363–365.

Garrison, D.L., and K.R. Buck. 1986. Personal communication.

Govoni, J., S.F. Ackley, and E.T. Holt. 1983. Surface roughness of Ross Sea pack ice. *Antarctic Journal of the U.S.*, 17(5), 123–124.

Sullivan, C.W., and A.C. Palmisano. 1984. Sea ice microbial communities: Distribution, abundance and diversity of ice bacteria in McMurdo Sound, Antarctica in 1980. *Applied Environmental Microbiology*, 47, 788–795.

Antarctic benthic and sea-ice microalgal interactions: Food chain processes and physiology

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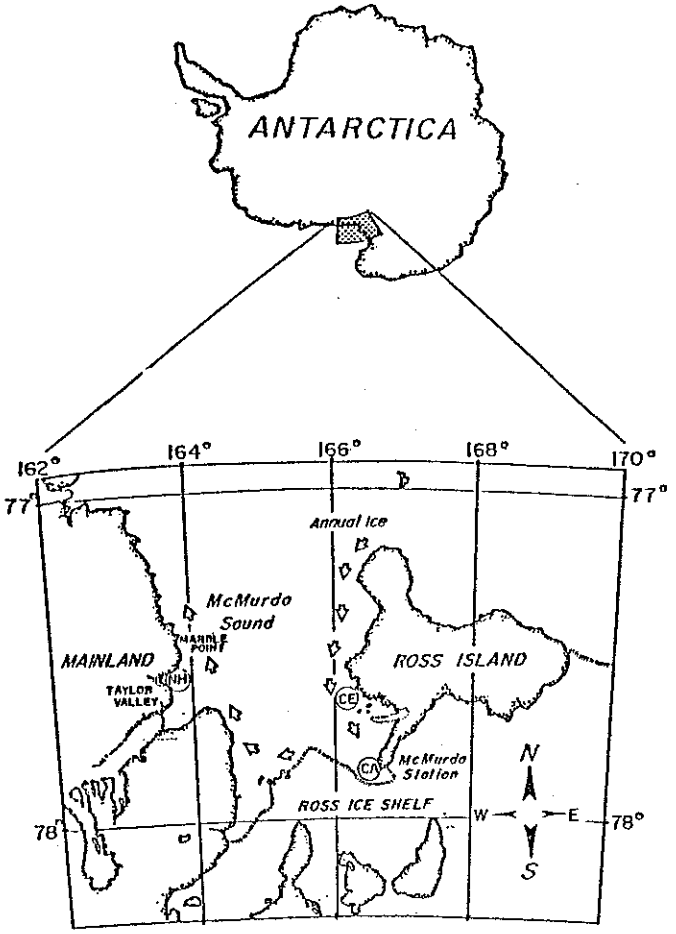
Annual sea-ice in McMurdo Sound in known to provide an extensive microhabitat for microalgae. These communities contain a high biomass within the lower 5 centimeters at the water/ice interface, with an estimated annual production of 4.1 grams of carbon per square meter (Palmisano and Sullivan 1983). Upon senescence, this microalgal population contributes a large amount of carbon to the benthic biota. Annually this ice algal fall-out adds to the already substantial benthic microbial biomass shown to be present (White, Smith, and Stanton 1984; White et al. 1985).

Total biomass as measured by membrane phospholipids of benthic microorganisms from three sites in McMurdo Sound were comparable to those of a Florida estuary and greater than those of deep-sea trenches (White et al. 1984). In addition to total biomass, changes in community structure of the sediments at the McMurdo study sites of Cape Evans, Cape Armitage, and New Harbor (figure) are detectable by detailed fatty-acid profiles of phospholipid membranes (Smith, Nichols, and White in press). These data are comparable to studies of the benthic macrofauna from McMurdo Sound which indicated that the east Sound sites are more productive than the west (Dayton and Oliver 1977; Hodson et al. 1981). The east Sound sediment sites were found to contain the greatest amount of the phospholipid fatty acid, 16:1w7c (16 carbon atoms in chain, one unsaturation, 7 carbons from the alkyl end of the molecule with unsaturation in the cis confirmation) a major component of the sea-ice diatom *Nitzschia cylindrus* (Nichols et al. 1985).

Bacterial biomarkers indicated little difference in total biomass between the sites but did reveal community structure differences. Saturated, branched, and odd carbon fatty acids, 14:0, i15:0, a15:0, 15:0, i17:0, a17:0, and 17:0 (14:0 indicates a 14 carbon chain with no unsaturation, suffixes c and g indicate iso



McMurdo Sound study sites. "CE" denotes "Cape Evans"; "CA" denotes "Cape Armitage"; and "NH" denotes "New Harbor." Arrows indicate dominant current flow.

Neutral lipid components of McMurdo sediments: Triglyceride fatty acid methyl esters and sterols

	CA		CE		NH	
	nM/gdw[b]	% Mole	nM/gdw	% Mole	nM/gdw	% Mole
Total triglyceride Fatty acids	20.2		222.8		32.1	
Total polyenoic Fatty acids[a]	2.4	11.6	36.8	16.3	7.2	22.2
Total sterols	0.4		0.6		0.2	
Cholesterol	0.2	45.6	0.3	48.2	0.1	49.4
22-Dehydrocholesterol	0.07	19.5	0.01	22.5	0.06	23.0

[a] Sum of all fatty acids with two or more unsaturations.

[b] nM/gdw - nanomoles/gram dry weight; % mole = mole percent.

and antiso branching), were present in similar relative proportions. Cape Armitage showed increased amounts of 10Me16:0 (10 methyl palmitate) and cyclopropyl 17:0, both major components of sulfate-reducing bacteria from the genus *Desulfobacter* (Taylor and Parkes 1983: Smith et al. in press).

Fatty acids from triglyceride and sterols from the neutral lipid fractions of the sediments indicated a similar pattern to that of the phospholipid biomasses, with the east Sound sites containing greater amounts. A major diatom sterol trans-22-dehydrocholesterol (Nichols et al. 1985) found in amounts of 19.5 to 23.0 percent (Smith in preparation) of the total sediment composition (table). Trans-22-dehydrocholesterol was also found to be a significant portion in the stomach content of a common benthic nematode, genus *Deontostoma* and the sea star, genus *Odantaster* from a Cape Armitage site (Nichols unpublished data). Stomach contents from these organisms also showed high amounts of the fatty acids 16:1w7c, 18:1w7c, and 18:1w9c, all of which are components of antarctic ice diatoms (Nichols et al. 1985).

Metabolic activities at the sites were measured by their incorporation of radiolabeled precursors into bacterial DNA and lipid classes. A trend parrelleling the biomass was observed, with the east Sound sites exhibiting the greatest activity when compared to the west Sound site. Metabolic activities of the sediments measured during a *Phaeocystis* bloom indicated that the algal input to the sediments was a stimulus, with significant differences noted between the activities of the sites (White et al. 1984).

Lipid and metabolic activity monitoring has proven to be a useful technique in ice algal physiology studies. Such studies using carbon-14/sodium biocarbonate as precursor for sea-ice microalgal lipids showed changes in metabolic pathways throughout the growth period (see Palmisano et al., *Antarctic Journal*, this issue).

Recent improvements in gas chromatography and gas chromatography/mass spectrometry have permitted confirmation of unique microbial lipids and insight into community structure and physiology. These techniques, as developed in this laboratory, have been of great assistance in understanding the microbial ecology of polar extreme environments. Further investigations are required to assess fully the interactions of the sea-ice microbial community's influence upon the antarctic near-shore benthic communities. Ice-algal physiology studies using lipid techniques are also a useful complement to such invesigations, and should be carried out in parallel with sediment studies.

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References

Dayton, P.K., and J.S. Oliver. 1977. Antarctic soft-bottom benthos in oligotrophic and eutrophic environments. *Science*, 197, 55–58.

Hodson, R.E., F. Azam, A.F. Carlucci, J.A. Fuhrman, D.M. Karl, and O. Holm-Hansen. 1981. Microbial uptake of dissolved organic matter in McMurdo Sound, Antarctica. *Marine Biology*, 61, 89–94.

Nichols, P.D., A.C. Palmisano, G.A. Smith, and D.C. White. 1985. Lipids of the Antarctic sea ice diatom *Nitzschia cylindrus*. *Journal of Phytochemistry*, 25, 1649–1653.

Palmisano, A.C., G.A. Smith, D.C. White, P.D. Nichols, M.P. Lizotte, G. Cota, and C.W. Sullivan. 1986. Changes in photosynthetic metabolism of sea-ice microalgae during a spring bloom in McMurdo Sound. *Antarctic Journal of the U.S.*, 21(5).

Palmisano, A.C., and C.W. Sullivan. 1983. Sea ice microbial communities (SIMCO) I. distribution, abundance and primary production of ice microalgae in McMurdo Sound, Antarctica. *Polar Biology*, 2, 171–177.

Smith, G.A., Lipid analysis of antarctic sediments. In preparation.

Smith, G.A., P.D. Nichols, and D.C. White. In press. Fatty acid composition and microbial activity of benthic marine sediments from McMurdo Sound, Antarctica. *FEMS Microbiology Ecology*.

Taylor, J., and J. Parkes. 1983. The cellular fatty acids of the sulphate-reducing bacteria, *Desulfobacter* sp., *Desulfobulbus* sp. and *Desulfovibrio desulfuricans*. *Journal of General Microbiology*, 129, 3303–3309.

White, D.C., G.A. Smith, and G.R. Stanton. 1984. Biomass, community structure, and metabolic activity of the microbiota in benthic marine sediments and sponge spicule mats. *Antarctic Journal of the U.S.*, 19(5), 125–126.

White, D.C., G.A. Smith, P.D. Nichols, G.R. Stanton, and A.C. Palmisano. 1985. Lipid composition and microbial activity of selected recent antarctic benthic marine sediments and organisms: A mechanism for monitoring and comparing microbial populations. *Antarctic Journal of the U.S.* 20(5), 130–132.