Palmer LTER: The first profiles of marine snow aggregate abundance from Antarctica

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Various, and at times contradictory, conclusions have been drawn regarding the modes of vertical export of particulate material during and after blooms in the southern oceans. For example, Wefer and Fischer (1991) reported that sediment-trap samples were dominated by fecal pellets, indicating that zooplankton grazing dominated the packaging and removal of phytoplankton. In contrast, Von Bodungen et al. (1986) reported samples composed of loosely aggregated phytoplankton material, and Smetacek (1985) proposed that as nutrients are consumed, the phytoplankton enter a senescent phase and settle rapidly to the seafloor to await resuspension and more favorable nutrient conditions the following year. Leventer (1991) confirmed this hypothesis using sediment-trap samples from the Antarctic Peninsula area; Leventer's

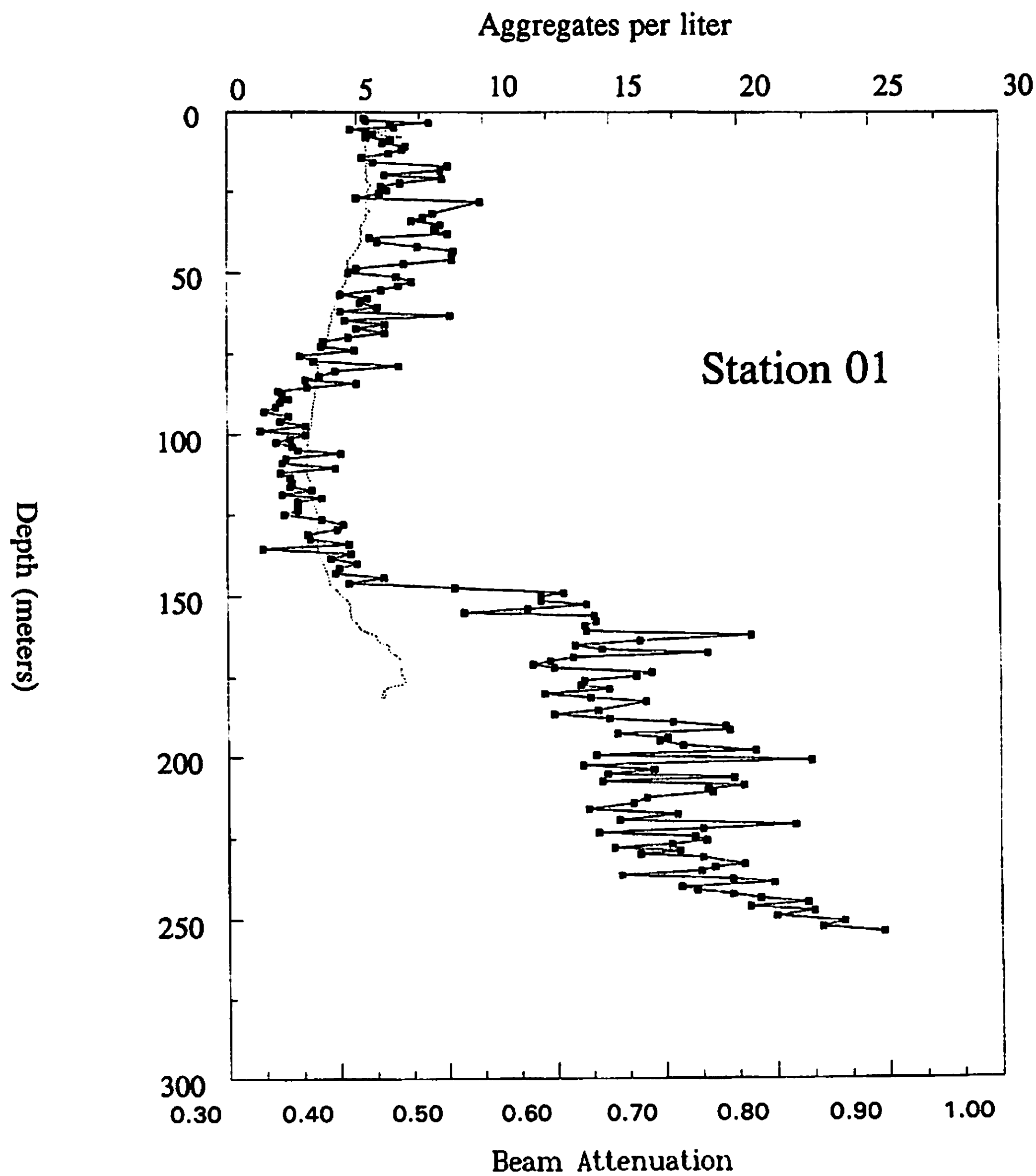

Figure 1. Plot of the abundance of aggregates larger than 1 millimeter (■) and beam attenuation coefficient (●) vs. depth at a station near the Antarctic Peninsula.

samples contained large amounts of diatom material, much of which was in the form of resting spores.

In other regions of the world, large aggregates (termed "marine snow") have been shown to be important or even dominant in the vertical transfer of material from the euphotic zone to the seafloor. In the Panama Basin, for example, Honjo (1982) collected time-series sediment-trap samples which contained a single large spike of coccolithophorid material which arrived in traps at all depths at essentially the same time. Microscopic examination of the material revealed no pelletization, yet the sinking speed estimated from the depth traveled during the sampling interval approached 100 meters (m) per day. This flux mechanism was confirmed several years later at the same station when photographic sediment traps observed large fluxes of aggregates at 3,800 m, leading to the conclusion that, in this area, aggregates dominated vertical transport of particulate matter (Asper 1987).

In addition to vertical flux, aggregates have also been shown to be important in the lateral transport of particles. In the Panama Basin, subsurface maxima in aggregate abundance appear to be generated at depth by seafloor sources located along the continental shelf and slope. These deep injections of aggregates can be traced for hundreds of kilometers, suggesting that not all aggregates settle rapidly and, in fact, some aggregates may function as parachutes and slow the descent of particles or even maintain them in suspension (Asper, Honjo, and Orsi 1992).

During a recent cruise to the Antarctic Peninsula area aboard the R/V *Polar Duke*, we collected the first marine snow abundance data from Antarctica (figures 1 and 2) using the noncontact photographic profiling system developed by Honjo et al. (1984). These profiles show some of the highest concentrations of aggregates ever recorded by this system and, in general, are characterized by relatively low numbers near the surface, increasing abundances with depth, and maximum abundances near the seafloor. Figure 2, for example, shows a very thin peak near the surface (15 aggregates per liter), lower numbers at mid depth (5–7 aggregates per liter), and the highest concentrations (25 aggregates per liter) at 190 m. Figure 1 shows a remarkable increase in aggregate abundance at 150 m at station 1. This abrupt transition into an intense nepheloid layer has not been described elsewhere

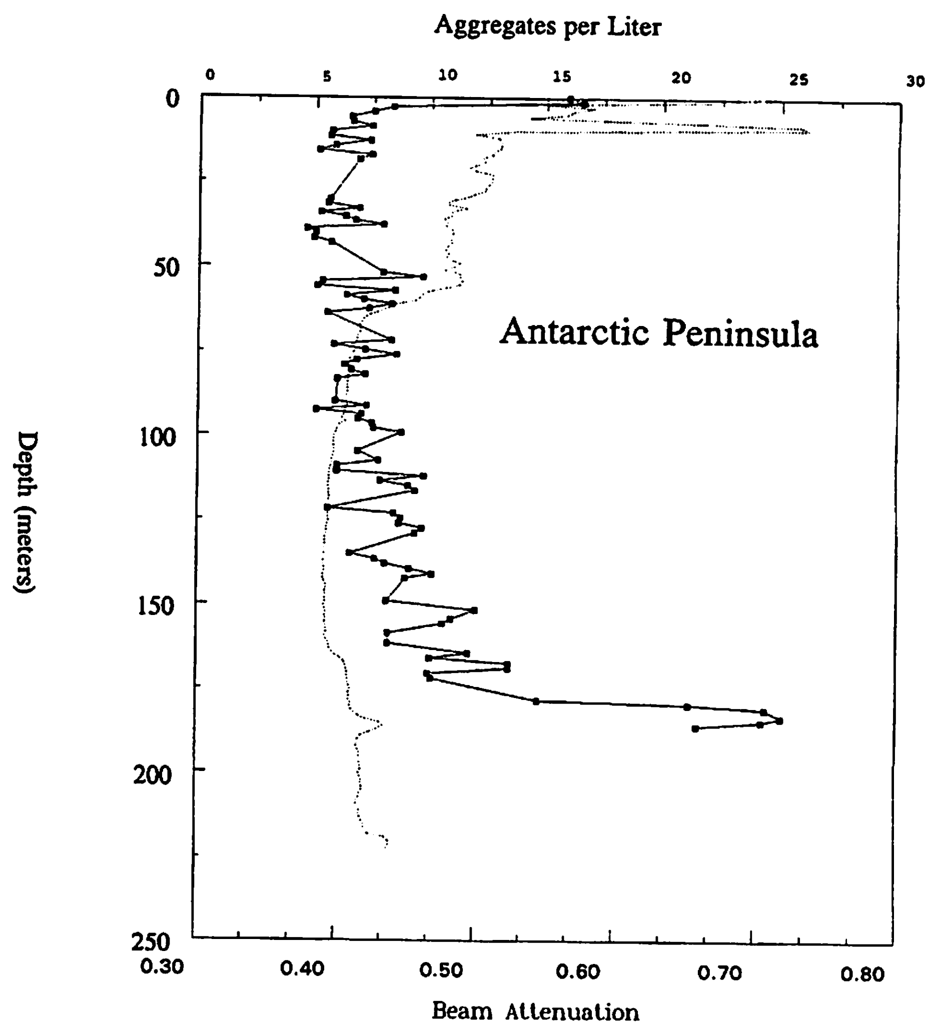

Figure 2. Aggregate abundance (■) at a station near the Antarctic Peninsula increases dramatically near the seafloor; beam attenuation (●) shows only a modest increase.

and may have resulted from the density stratification that characterizes this region. In each of these profiles, the record abundances of aggregates in the bottom nepheloid layer may be indicative of resuspension or lateral transport of phytoplankton debris.

Although these profiles are "snapshots" of aggregate abundance, other data confirm earlier hypotheses that these suspended aggregates are eventually scavenged from the water and contribute to vertical flux (Asper et al. 1992). All of the sediment-trap samples collected by Dunbar, Leventer, and Stockton (1989) in the McMurdo Sound showed substantial increases in vertical flux near the seafloor. In one case, the total flux was more than 10 times greater at 700 m than it was near the sea surface. These samples were dominated by biogenic silica, which showed even greater increases than total mass flux. These data were interpreted as indicating resuspension of aggregated diatom remains from the seafloor and lateral transport of the material via the general clockwise circulation existing in McMurdo Sound.

An important characteristic of these aggregates is their large size and the fact that conventional particle detectors, such as transmissometers, do not accurately assess their abundance. In figures 1 and 2, beam attenuation is plotted along with aggregate abundance, and in all cases, the transmissometer detected a nepheloid layer but underestimated its magnitude. In figure 2, the transmissometer found the highest concentrations of the fine particles to which it is most sensitive near the surface, the lowest concentrations at mid depths and a slight increase near the seafloor. In contrast, the aggregate data show a continuous increase in abundance with depth. An intriguing aspect of this data set is that these high abundances were obtained at a time when all other indicators of productivity were low, including high nutrient levels, low pigment levels, and low carbon-14 uptake rates. The source of these aggregates remains somewhat of an enigma, but it can be inferred from these studies that aggregate data are required if one is interested in detecting the large particles that are thought to be important in the vertical flux of particulate matter.

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References

Asper, V.L. 1987. Measuring the flux and sinking speed of marine snow aggregates. *Deep-Sea Research*, 34(1), 1–17.

Asper, V.L., S. Honjo, and T.H. Orsi. 1992. Distribution and transport of marine snow aggregates in the Panama Basin. *Deep-Sea Research*, 39(6), 939–952.

Dunbar, R.B., A.R. Leventer, and W.L. Stockton. 1989. Biogenic sedimentation in McMurdo Sound, Antarctica. *Marine Geology*, 85, 155–179.

Honjo, S. 1982. Seasonality and interaction of biogenic and lithogenic particulate flux at the Panama Basin. *Science*, 218(26 November), 883–884.

Honjo, S., K.W. Doherty, Y.C. Agrawal, and V.L. Asper. 1984. Direct optical assessment of large amorphous aggregates (marine snow) in the deep ocean. *Deep-Sea Research*, 31(1), 67–76.

Leventer, A. 1991. Sediment trap diatom assemblages from the northern Antarctic Peninsula region. *Deep-Sea Research*, 38(8/9), 1127–1143.

Smetacek, V.S. 1985. Role of sinking in diatom life-history cycles: Ecological, evolutionary and geological significance. *Marine Biology*, 84, 239–251.

Von Bodungen, B., V.S. Smetacek, M.M. Tilzer, and B. Zeitzschel. 1986. Primary production and sedimentation during spring in the Antarctic Peninsula region. *Deep-Sea Research*, 33(2), 177–194.

Wefer, G., and G. Fischer. 1991. Annual primary production and export flux in the southern ocean from sediment trap data. *Marine Chemistry*, 35, 597–613.

Palmer LTER: Hydrogen peroxide in the Palmer LTER region: I. An introduction

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The Palmer long-term ecological research (LTER) program is a coordinated multi-investigator and interdisciplinary study of an ice-dominated, high-latitude marine ecosystem. Our interest in studying hydrogen peroxide (H_2O_2) dynamics in this southern oceans habitat was inspired by two ecological applications of these data. First, it has been suggested that H_2O_2 concentrations, when coupled with production and decay rates, can be used as a tracer for vertical advection in surface ocean waters (Johnson et al. 1989). To the extent that vertical mixing is a critical variable in determining the production of southern oceans ecosystems (Mitchell and Holm-Hansen 1991), this information is fundamental to the objectives of the Palmer LTER program. Second, because H_2O_2 is a common intermediate or reaction product of photochemical reactions of oxygen with organic compounds (Zafiriou 1983), it may provide a convenient analytical procedure for assessing photolytic alteration of dissolved organic matter (DOM) in sea water. Recent studies suggest that photochemical processes may play a previously unrecognized role in the global carbon cycle (Mopper and Zhou 1990).

We considered it essential, for several reasons, to evaluate the magnitude of these potential photochemical processes in