The Palmer LTER sediment trap array experiment: Initial results

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The continuous production of biogenic matter in the near-surface waters of the world ocean ultimately sustains the downward flux of particles at all ocean depths. Depending upon the source(s), chemical composition, and residence time in the water column, these particles are either remineralized en route to the seafloor or preserved in the sediment.

Particle flux measurements conducted in a variety of coastal, oceanic, and ice-edge habitats of the southern oceans have revealed tremendous seasonality and large interannual variability. For example, spring bloom exports of particulate carbon in coastal Antarctica may exceed 30 millimole of carbon per square meter per day (mmol C m^{-2} d^{-1}) (Karl, Tilbrook, and Tien 1991) compared to late winter fluxes of less than 1×10^{-4} mmol C m^{-2} d^{-1} (Fischer et al. 1988). Furthermore, the variance in the magnitude of the spring-summer export peak can change by an order of magnitude over consecutive years (Wefer 1989, pp. 139–153). It is not known whether interannual variability is driven by changes in particle formation (that is, primary production) or by uncoupling of production and exportation, or both. These production-export processes can exert a major influence on global carbon and associated cycles of bioelements. Consequently, the processes controlling particle production, particle export, and *in situ* mineralization in southern ocean habitats are topics of great interest in contemporary oceanography.

As one component of the Palmer Long-Term Ecological Research (LTER) program, we established three bottom-moored sequencing sediment traps within the central portion of Palmer Basin near Victor Hugo Island (figure 1). Because it is our intent to assess interannual habitat variability associated with the regional extent of ice cover, we considered it important first to ascertain the local variability (tens of kilometers) in particle export in a given year by deploying replicate traps. Eventually, this will allow us to resolve the true regional interannual variations. To our knowledge, this is the first time that "replicate" sediment traps (individual traps on separate moorings) have been deployed for this purpose.

Each mooring array was constructed of 220 meters (m) of Dacron® braid (13-millimeter diameter) with a single McLane Research Laboratories 21-cup sequencing sediment trap (PARFLUX model MK-7) positioned 176 m above the seafloor and a single Benthos acoustic release (model 865) positioned 20 m above the seafloor. Buoyancy was controlled by seven glass floats (43-centimeter diameter) and a 250-kilogram (kg) expendable concrete anchor. The moorings were identified as Andersson (A), Bruce (B), and Charcot (C) in honor of three exceptional pioneers of antarctic exploration and research. Gunnar Andersson was a member of the ill-fated 1901 Swedish antarctic expedition that culminated in the loss of their ship and a forced winter stay at Paulet Island. Despite these hardships, invaluable scientific data were collected throughout the winter. William Bruce, organizer and leader of the Scottish Scotia expedition, built the first station for scientific research in Antarctica in 1903 on Laurie Island from which he and others conducted research on botany and bacteriology. At the end of the Scotia expedition in 1904, this station was handed over to Argentina and is still in operation as

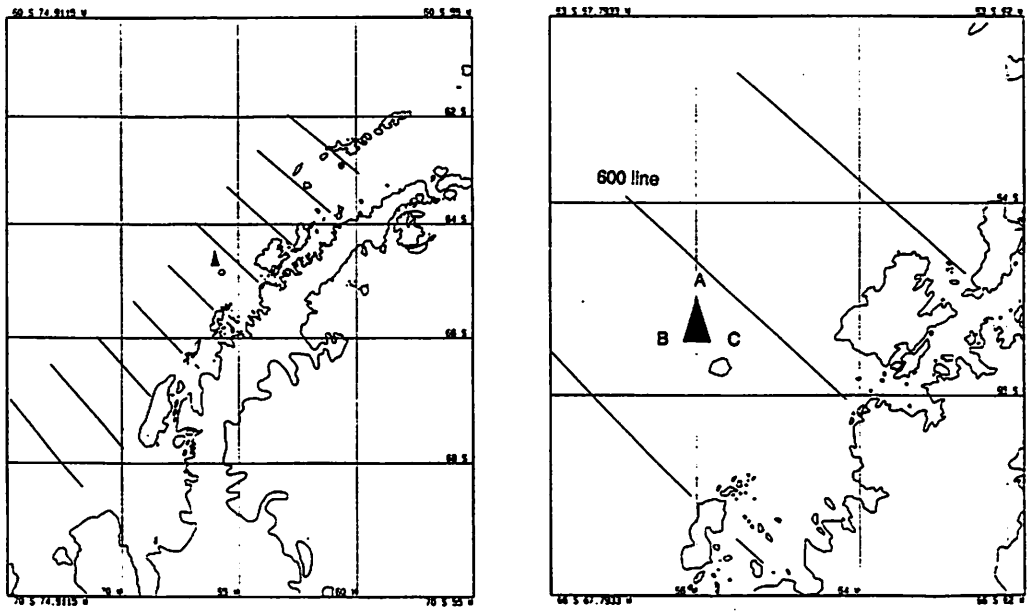

Figure 1. *Left.* A map showing the Palmer LTER study region with the separate LTER transect lines and the approximate location of the triangular sediment trap array. *Right.* Enlarged view of the trap array site showing the locations of the three separate moorings designated Andersson (A), Bruce (B), and Charcot (C) to the south of the LTER 600 line. The distances (in kilometers) between the moorings were A–B (14.1), A–C (14.6), and B–C (8.9).

Orcadas Station. The French oceanographer, Jean Charcot was briefly married to the granddaughter of the novelist Victor Hugo (hence the island's name), who later divorced him for "dissertion" while he was on an extended antarctic expedition. Charcot was among the first to explore and map much of the LTER region from Anvers Island south to Marguerite Bay (his second wife was Marguerite!), most notably aboard the *Pourquoi Pas?*.

In the design of our sediment trap experiment, we endeavored to select a region free from steep topographic relief to ensure the reference depths for each of the three traps would be similar. This is a critical criterion because it is well known that particle flux is dependent upon water column depth (Suess 1980; Pace et al. 1987). We only partially achieved this goal during our first deployment period (table). All three moorings were deployed on 6 November 1992 by scientists aboard the R/V *Polar Duke* and were successfully recovered on 7 April 1993 by scientists aboard the R/V *Nathaniel B. Palmer*. Each sample cup corresponded to a collection period of 6.71 days. Following recovery, the formalin-preserved samples (1 percent final concentration) were sealed and shipped to our laboratories at the University of Hawaii for analysis of total mass; particulate carbon, nitrogen, phosphorus, and silica; and dissolved nutrients, including opal; and for microscopic analysis, including bacteria, phytoplankton, and biogenic aggregates. To date, only the mass determinations, reported here, have been completed.

Our particle flux results from the three separate sediment trap moorings display coherence in selected, broad features but also reveal significant differences in the details of the time-series data set (figure 2). For example, all documented a springtime export pulse with peak mass fluxes of 1.41, 1.31 and 0.86 grams per square meter per day (g m^{-2} d^{-1}) for moorings A, B, and C, respectively. By 1 January 1993, the mass fluxes recorded by all three traps had decreased to less than 5 percent of the spring bloom maxima suggesting that particle production in these waters had also decreased substantially. Furthermore, these results imply that the "growing season" is fairly short in these waters despite ample light and inorganic nutrients.

Palmer LTER sediment trap array positions and deployment depths. All traps were deployed on 6 November 1992 and recovered on 7 April 1993.

Trap site	Deployment position	Depth (m)	
		Trap[a]	Water
Andersson (A)	64°30.2'S 66°01.7'W	169	345
Bruce (B)	64°43.7'S 66°11.0'W	124	300
Charcot (C)	64°44.1'S 65°51.2'W	183	359

[a]Depth below sea surface.

Among the major differences observed over this limited geographical region were the following:

- variable total integrated springtime mass exports (20.7, 21.9, and 16.1 mg m^{-2} for traps A, B, and C, respectively, for the 27-day period from 7 November to 4 December 1992),
- dramatic mass flux decreases for traps A and C, compared to the more gradual decrease at site B, and
- evidence for a "fall bloom" at site B.

At this point in our analyses, it is too early to speculate on the potential cause or causes for these fundamental differences. Nevertheless, it is sobering to reflect on the variability that was observed among these "replicate" experiments deployed over spatial scales of only tens of kilometers. Until we confirm the reproducibility of replicate sediment traps, we cannot comment on the ecological implication of our implied habitat or process variations over relatively small spatial scales (tens of kilometers). Consequently, during phase two of this study (1993–1994), we positioned two separate trap moorings at site A within approximately 200 m of each other to assess the true reproducibility in the measurement of particle flux for this study area.

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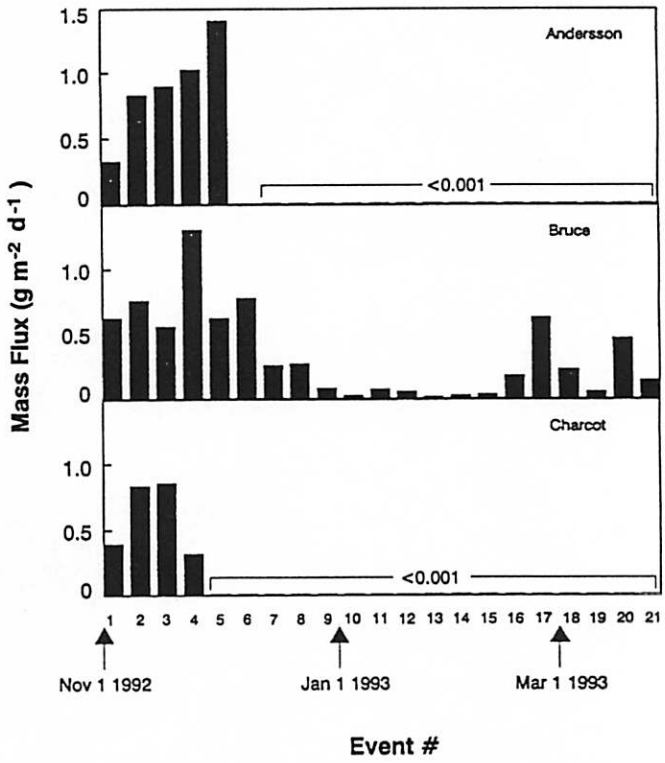

Figure 2. Time-series of mass fluxes (expressed in milligrams of total mass per square meter per day) for three sediment trap moorings located near Hugo Island (*see* table for exact coordinates). Each event was equivalent to a collection period of 6.71 days.

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