

# RACER: Seasonal changes in the downward flux of biogenic matter

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Although most particulate matter in seawater is very fine and in suspension, evidence suggests that the bulk of the material removed from the euphotic zone and eventually deposited on the seafloor arrives via relatively rare, rapidly sinking large particles (McCave 1975). Therefore, in order to describe the ambient particle field and to understand the rates and mechanisms of biogeochemical cycling in the marine environment, it is imperative to employ sampling methods that enable the investigator to distinguish between suspended and sinking pools of particulate organic matter.

During the 1986–1987 austral summer, we measured the downward vertical flux rates of particulate organic carbon, particulate organic nitrogen, and particulate adenosine-5'-triphosphate (P-ATP) at five stations in the 25,000-square-kilometer study area of the Research on Antarctic Coastal Ecosystem Rates (RACER) program (Huntley et al., *Antarctic Journal*, this issue). On the slow-grid segment of each of the four RACER cruises, we deployed free-floating sediment trap arrays at stations 13, 20, 39, 43, and 48 where comprehensive biomass inventories and detailed biological rate processes were also measured. Each sediment trap experiment was deployed for 24 hours, and the samples were processed immediately upon recovery. The seasonal particulate organic carbon, particulate organic nitrogen, and ATP fluxes from the northern Gerlache Strait (station 43) only are presented in this report.

Particulate organic carbon, particulate organic nitrogen, and ATP fluxes at station 43 exhibited a pronounced and coupled seasonal progression from relatively high rates of vertical transport during the spring/summer bloom (January 1987) to late season (March 1987) rates that averaged less than 10 percent of the early summer maxima (table 1). In general, these fluxes are correlated to periods of high (December) and low (March) rates of primary production, which also varied by an order of magnitude during the observation period (Holm-Hansen, Letelier, and Mitchell, *Antarctic Journal*, this issue). However, it appears that there was a time lag between the production of organic matter in the surface waters and the downward flux to greater depths. For example, the rate of primary production was greatest in December (approximately 2,800 milligrams of carbon per square meter per day) and decreased to a much lower value by January (approximately 800 milligrams of carbon per square meter per day). The fluxes of total particulate organic carbon and particulate organic nitrogen, however, were higher in January than in December. These data suggest that the production of carbon at the beginning of the bloom is most likely coupled to a net increase in phytoplankton biomass rather than to enhanced particulate carbon flux to the benthos. As the bloom matures,

senescent algae, and end-products of metabolism and grazing contribute to the sinking particle field.

This suggested seasonal progression is also supported by the ATP flux data. In early summer (December), the particulate organic carbon collected in the sediment traps is exclusively comprised of living carbon (based on an assumed carbon to ATP ratio of 250, Karl 1980; see table 1). This is primarily the result of the rapid sinking of large chain-forming diatoms that dominated the upper water column biomass inventory (Tien et al., *Antarctic Journal*, this issue). As the season progresses, the ratio of sinking biomass carbon to total particulate organic carbon decreases to a value of approximately 10 percent in February. These results indicate that the bulk of the collected particulate organic carbon in late summer is comprised of detritus (e.g., dead algal cells, zooplankton fecal pellets, molts, etc.) rather than viable phytoplankton cells. At the present time we have no information on the magnitude of small-scale spatial (kilometers) or temporal (daily) variations in particle flux in our study area.

To date, several sediment trap experiments have been conducted in antarctic ecosystems (table 2) in addition to our own performed during the RACER program. From the limited data available, the flux of particulate organic carbon from the euphotic zone at a variety of locations south of 60° latitude appears to average 50–200 milligrams of carbon per square meter per day.

We thank the crew members of the R/V *Polar Duke* for expert logistics support, Skip Owen and Mike Simpson for their assistance in the sediment trap deployment/recovery operations, and T. Tagami for technical assistance. This research was supported by National Science Foundation grant DPP 85-18748, awarded to D.M. Karl. Contribution number 2000 of the Hawaii Institute of Geophysics.

**Table 1. Downward flux of biogenic matter at RACER station 43 in the northern sector of the Gerlache Strait**

Cruise	Depth (in meters)	Carbon flux <sup>a</sup>	Nitrogen flux <sup>b</sup>	ATP flux <sup>c</sup>	Biomass flux <sup>d</sup>
December 1986 (SA)	100	136.1	28.7	852.6	213.0
	200	104.6	18.3	398.4	99.6
January 1987 (SB)	100	373.3	58.6	626.3	156.6
	200	198.0	29.5	451.7	112.9
February 1987 (SC)	100	203.8	24.6	121.5	30.4
	200	87.0	18.0	95.3	8.3
March 1987 (SD)	100	ND <sup>e</sup>	6.06	57.3	14.3
	200	ND	4.00	36.3	9.1

<sup>a</sup> In milligrams of carbon per square meter per day.

<sup>b</sup> In milligrams of nitrogen per square meter per day.

<sup>c</sup> In micrograms of ATP per square meter per day.

<sup>d</sup> In milligrams of carbon per square meter per day. Biomass flux = ATP flux × 250.

<sup>e</sup> Sample value could not be resolved from the particulate organic carbon measured in the initial trap solution. Because the blank contained an undetectable level of particulate organic nitrogen, the nitrogen flux could be calculated in these collections.

**Table 2. Previously published sediment trap carbon flux estimations from antarctic ecosystems**

Location	Depth range (in meters)	Carbon flux <sup>a</sup>	Reference
62°S 151°E	521–3,110	120–176 <sup>b</sup>	Noriki and Tsunogai (1986)
63°S 58°W	100	28–39	Liebezeit (1985)
63°S 55°W	100	120–160	Liebezeit (1985)
65°S 125°E	50–1,000	5–184	Fujita and Nishizawa (1982)
65°S 160°E	50–1,000	4–101	Fujita and Nishizawa (1982)
61°S 57°W	965–2,540	13–14.8	Wefer et al. (1982)
62°S 57°W	100–323	30–132	von Bodungen (1986)
62°S 57°W	100	97–546	von Bodungen et al. (1986)
62°S 57°W	100	459–1,404	von Bodungen et al. (1986)

<sup>a</sup> In milligrams per square meter per day.

<sup>b</sup> Assumes carbon = organic matter × 0.5.

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## RACER: Feeding and egg production rates of some antarctic copepods

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The most important species of copepods in the Antarctic Peninsula region are *Calanoides acutus*, *Calanus propinquus*, *Metridia gerlachei*, and *Rhincalanus gigas* (Jazdzewski, Kittel, and Lotocki 1982). General features of their population dynamics are known for the southern ocean (Hardy and Gunther 1936; Marin 1986), but their relation to the annual cycle and regional variability of primary production is poorly understood. Very little is known of the feeding rates of antarctic copepods and, to our knowledge, egg production rates have never been measured. The known feeding rate measurements on major copepod species were made by Schnack (1983, 1985) and by Schnack et al. (1985). From studies conducted at three stations in the eastern Bransfield Strait in November and December, she concluded

that copepods could remove as much as 50 percent of the daily primary production.

There appears to be no information on copepod feeding in much richer regions such as we encountered in the western Bransfield and Gerlache straits during the Research on Antarctic Coastal Ecosystem Rates (RACER) program, nor is there any information on regional or temporal variability in copepod feeding rates.

We conducted egg production experiments on *Calanoides acutus* at six stations in the Bransfield and Gerlache straits during December, before its reproductive period ended in mid-January. Live females were sorted from plankton tows taken at 20–30 meters, and seawater for each experiment was pumped from the same depth. Groups of five females were placed in 1-liter (n = 4–16) containing a 250-milliliter plastic beaker whose base had been replaced with 505-micrometer Nitex mesh, and incubated for approximately 24 hours at 0–1°C. This arrangement permitted eggs to sink out and escape predation. Results showed no relationship between egg production and ambient chlorophyll *a* concentration (table). This is contrary to what one would expect from studies of other calanoid copepods such as the temperate *Calanus pacificus* (Runge 1984) or arctic *Calanus glacialis* (Hirche and Bohrer 1987). Aside from demonstrating a relationship of egg production to ambient food concentration, Hirche and Bohrer (1987) were also able, at 0–1°C, to decrease egg production of *C. glacialis* to zero after 3 days in filtered seawater, and restimulate egg production by exposure to 400 micrograms of carbon per liter after only 5–7 days. In an almost identical