

Vertical Particulate Carbon fluxes in the Ligurian Sea :
A time-series study

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In open Mediterranean waters the downward flux of particulate material may originate from either an allochthonous source (atmospheric fallout, terrigenous input) or an autochthonous source (export from the photic zone). The latter comprises particles basically originating from the primary production of particulate organic matter and the associated build up of mineral particles such as carbonates and opal. In the framework of the French JGOFS activities in the Mediterranean Sea (DYFAMED programme), a time-series study on particle, major and trace element fluxes in the water column was initiated in the Ligurian Sea in 1986 to ascertain the role and importance of these various sources. The importance and magnitude of the atmospheric input has already been discussed by FOWLER *et al.* (1987) and BUAT-MENARD *et al.* (1989). In the present paper we report data on the downward carbon fluxes, primarily those associated with primary production in the upper waters.

Since 1987, we have regularly monitored particle fluxes at two offshore stations out of the influence of the Ligurian Current, one near Corsica (42°44 N and 8°32 E, 1987-1988) and the other near the French Riviera (43°25 N and 7°52 E, 1988-1990). Automated sediment traps (models Technicap PPS-3; cylindro-conical; 0.125 m² surface opening and PPS-5, conical; 1 m² surface opening) were moored at 100, 200 and 1000 m depth, and samples were sequentially collected every 9 to 15 days. The sites were visited every three months both to check the mooring line and to exchange the sample collectors. Cup collectors were filled with a 2% buffered formaldehyde solution to prevent microheterotrophic activity and to limit the impact of leaching and autolysis on the collected particles. Swimmers were carefully removed by sieving and hand-picking using forceps under a dissecting microscope.

The carbon fluxes, like total particulate fluxes, varied substantially over time. Important and rapid changes in fluxes were normally recorded simultaneously at the three depths surveyed indicating a rapid settling of particles through the water column. The sinking velocities were estimated to be at least 60 to 90 m per day. Carbon fluxes were the highest in late spring, and maxima were recorded in June 1987, June 1988 and May 1990 (Fig.1). Winter carbon fluxes were also important but not as high as spring fluxes. Year 1989 was particular in that the maximum amount of sedimenting carbon occurred in winter and not in spring. In general, carbon fluxes were the lowest in autumn.

Since the 200 m trap was collecting particles under the euphotic zone and the mean vertical flux of organic carbon at that depth is generally considered to be equivalent to "export production" from the overlying waters, we discuss here only the 200 m data. The average carbon flux over the entire 4-year period was 14.7 mg m⁻² d⁻¹ and ranged from a minima of 2-4 mg m⁻² d⁻¹ to a maximum of 68 mg m⁻² d⁻¹ (June 1988). The organic carbon flux was relatively high and, at 200 m, had a mean value of 11 mg m⁻² d⁻¹ (ranging from 1 to 60 mg m⁻² d⁻¹). For both total and organic carbon, the fluctuations in flux observed were considerable and varied over the year by a factor of 30 to 60. Aside from the general seasonal pattern, a pronounced variability on shorter time scales was also observed during the continual, high resolution flux experiments. For example, short pulses of enhanced sedimentation lasting only 48 hours were recorded in spring 1990. On an annual basis, total particulate carbon export from the surface layers was 5.1 g m⁻² y⁻¹ of which 4.0 mg m⁻² d⁻¹ was organic (POC, export production) and 1.1 mg m⁻² d⁻¹ was carbonate carbon. Total particle flux followed approximately the same pattern as the carbon flux, however, the highest mass fluxes occurred both in winter and in spring.

Vertical fluxes measured in the relatively unproductive Ligurian Sea (NW Mediterranean Sea) during the years 1987-1990 are of a similar magnitude as those reported for other oligotrophic oceanic waters. A seasonal signal in carbon flux is clearly observed and is related to both the seasonality of the physical environment (water column mixing in winter) and biological activity (spring phytoplankton bloom).

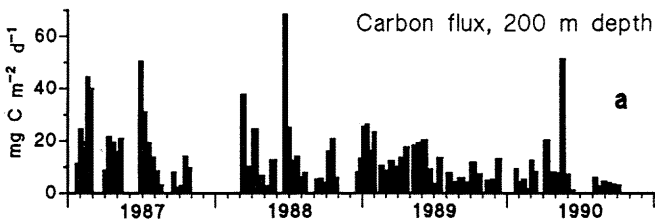


Fig. 1. Vertical flux of particulate carbon at 200 m depth in the Ligurian Sea, Northwestern Mediterranean, from 1987 to 1990.

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