SEASONAL AND INTERANNUAL VARIABILITY OF SINKING PARTICULATE MATTER IN THE DEEP IONIAN SEA: ECOLOGICAL AND BIOGEOCHEMICAL PERSPECTIVES

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Abstract

Aiming to investigate the significant ecological and biogeochemical features and provide new insights on the sources and cycles of sinking particulate matter in the open Ionian Sea, we have examined long-term records of downward fluxes for Corg, N, d13Corg and d15N, along with the associated ballast minerals (opal, lithogenics and CaCO3), selected lipid biomarkers and coccolithophores.

Keywords: Ionian Sea, Particle flux, Organic matter, Coccolithophores, Deep sea basins

Formation and sinking of particulate matter drive the biological carbon pump via export and sedimentation of organic matter from the surface mixed layer to the deep ocean and sediments (reviewed by Honjo et al., 2008). Biotic processes that form, change, transport, and remineralize particulate organic carbon, opal, calcium carbonate, and other minor chemical species in the water column are central to the ocean's biogeochemical cycles and are of fundamental importance to the global carbon cycle. The present work focuses on the study of downward fluxes of Corg, N and their stable isotopes, along with the associated ballast minerals (opal, lithogenics and CaCO3), selected lipid biomarkers and coccolithophores (main calcifying primary producers), as recorded in sinking particulate matter intercepted by time-series sediment traps. A mooring line was deployed from 2006 to 2012 at 5 successive water column depths (700, 1200, 2000, 3200 and 4300 m) in the SE Ionian Sea, where the deepest part of the Mediterranean Sea is located ('NESTOR' site). The time-series dataset is used to identify mechanisms governing particle transport in the study area, and to explain (i) the seasonal, and (ii) the interannual variation of mass and main constituent fluxes, in relation to oceanographic conditions. The temporal distribution of total mass flux exhibited strong seasonal patterns, with higher fluxes recorded mainly in late winter/early spring followed by a second, more pronounced flux maximum period in late spring/summer and significantly lower fluxes in autumn/winter. This oscillation in total mass flux was observed throughout the experiment, although a marked interannual variability in export intensities is observed. Primary productivity in the Ionian Sea, as in most oligotrophic sites of the subtropical Mediterranean Sea, displays high seasonal variability with maximum rates observed during the winter/spring convective mixing period (Bosc et al., 2004; D'Ortenzio and Ribera d'Alcala, 2009). In our time-series, this feature was observed to coincide with relative increases in organic carbon and opal export and increase in the fluxes of planktonic biomarkers at all depths during late winter/early spring, and could be attributed to the development of siliceous blooms in the euphotic zone. In late spring/ summer period, nanophytoplankton species (coccolithophorides) gain more importance as primary producers, as it is witnessed by the increase in the carbonate contents and coccolithophorids' export. A considerable interannual variability in vertical distributions is observed in the total mass flux maxima at various depths, despite some similarities in the seasonal patterns. The main feature of the mass flux variability was the gradual increase of winter mass flux almost at all depths, followed by an evident analogous increase (with some exceptions) in spring and summer mass flux. Such an interannual change in flux patterns could be explained by the reinforcement of processes which produce and/or transfer particulate matter in the area. A plausible reason for the increase of fluxes from 2006 to 2010 could be related to the general circulation patterns at the study site, which exhibit strong interannual variability. During mid-late 1990s the large scale anticyclonic circulation observed during the 1980s and early 1990s was confined in the southern part and replaced by a cyclonic circulation in the northern Ionian (Gacic et al., 2011). In the years following 2006, the salinity and nutrient changes in the south Adriatic suggest that the Ionian circulation was changed back into anticyclonic (Civitarese et al., 2010). This latter circulation regime causes the upwelling of the nutricline in the periphery of the anticyclonic gyre and the weakening or even the absence of the Pelops gyre. The NESTOR site is obviously found at the edge of this anticyclone as revealed from the recurrent shoaling of the isohalines recorded in the nearby observational buoy of the Poseidon system. Furthermore, the remarkable enhancement of the fluxes from 2008 onwards seems to be directly dependent on the intensity of the intrusion in the upper layer of high salinity intermediate waters of Levantine/Cretan origin. The upward movement of these intermediate waters could favor upwelling of nutrients and enrichment of the upper layer, thus triggering surface productivity and the enhancement of downward particle fluxes. In respect to this hypothesis, the increased contribution of all biogenic (OC, carbonate, opal) constituents in late spring/summer of 2008 and 2009, suggests an effective nutrient fueling of the upper layer created by the dynamic conditions prevailing in the vicinity of NESTOR site. Finally, a pronounced increase of all biogenic fluxes was recorded in spring 2012, when atmospheric conditions involving particularly strong cold and dry northerly winds triggered intense winter convection mixing. Our study based on multi-biogeochemical parameters shows that large scale processes and oceanographic changes play a crucial role controling the ecological and biogeochemical functioning of the Ionian Sea on seasonal and interannual scales.

References

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