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Nitrogen and carbon isotopic variability and nutrient dynamics in the open Mediterranean Sea

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The Mediterranean Sea is an olygotrophic semi-enclosed basin, surrounded by populated countries, where continental and atmospheric inputs play important roles in nutrient and carbon cycles.

Recently, studies of nitrogen and carbon stable isotopes have been introduced in order to better understand carbon sources and nitrogen biogeochemistry in the open Mediterranean environments. The use of these tracers is not simple, since their isotopic values are affected by the signature of the sources and are modified by the biological processes involved in nutrient assimilation, primary production and trophic relations within the food web.

Here, we report some results obtained during three cruises in the Mediterranean Sea carried out in spring and early summer 2002 and 2003, in three key areas: the North Balearic Front (NBF), the Algero – Provencal Basin (APB), and a station off Creta in the Cretan Sea (CS).

Our aim was to deepen the knowledge on the dynamics of nitrogen and carbon isotopes in suspended particulate organic matter (POM) in relation to the gradients in nutrient concentration, the nutrient availability, the biological productivity, and the water circulation, in order to use these isotopic tools in the study of the nitrogen dynamics in the euphotic zone.

An additional goal was to evaluate the variations of δ^{13}C – POC related to biological activity in the high productive NBF zone to asses the potential use of δ^{13}C signature to trace terrestrial organic matter also in open Mediterranean sea.

The NBF has been studied during a spring convection period, characterized by strong

mesoscale activity, weak stratification and great spatial variability. Average nutrients concentration in the euphotic zone were high (DIN = 2.4 μM, PO_4 = 0.14 μM , DIN/PO_4 = 14.5) and sustained an intense phytoplankton bloom, as suggested by the high values of PON (18.3 μg dm^{-3}). δ^{15}N – PON varied between –3.0 per mill and 1.4 per mill and were often associated with gradients in nitrate concentration underlying the mayor role of new production in sustaining the phytoplankton bloom and suggesting the importance of the biological fractionation (besides the nitrogen source) in determining the δ^{15}N – PON signature measured.

The APB has been studied in June and was characterized by a stratified and oligothropic environment, where a small cyclone induced a shoaling of the nitracline and of the deep chlorophyll maximum. Nutrients availability and biomass were lower (average concentrations: DIN = 0.47 μM, PO_4 = 0.05 μM, DIN/PO_4 = 8.7, PON = 5.1 μg dm^{-3}) and the important role of nitrate supplied from below, in sustaining phytoplancton production, was suggested by the δ^{15}N – PON profile near the centre of the gyre with a minimum value at the bottom of the euphotic zone.

The experimental site in the CS has been studied in April, after the spring phytoplankton bloom, at the onset of summer stratification. It showed an extremely oligotrophic environment (average concentrations DIN = 0.20 μM, PO_4 = 0.04 μM), with low DIN/PO_4 ratios (5.4) and primary production dominated by recycled production ($f$ratio = 0.21) which sustained levels of biomass similar to those of the Algero –Provenzal Basin (PON = 4.8 μg dm^{-3}).

Despite the biogeochemical and spatial variability, the average δ^{15}N – PON values in the euphotic layer did not show meaningful variations passing from NBF (-0.2 per mill $\pm$ 0.8 per mill to APB (0.1 per mill $\pm$ 0.8 per mill and to the olygotrophic CS (0.9 per mill $\pm$ 0.4 per mill: the low values and the scarce dynamics observed are consistent with previous studies in the Mediterranean Sea, and confirm the peculiarity of the nitrogen dynamics in this basin.

In the NBF δ^{13}C – POC was extremely variable (from –17.1 per mill to –25.1 per mill and its dynamic seemed to be mostly controlled by biological factors as species composition and production rates, rather than by temperature driven CO_2 concentration, as reported for surface oceanic waters. Since this variability is transferred through the trophic web to the sinking POC and to the sediments, δ^{13}C signature should be used with care as a tracer of organic matter of terrestrial origin in open Mediterranean Sea.