Mediterranean Sea trophic characteristics interpreted through three-dimensional coupled ecohydrodynamical models

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Abstract

The spatial variability of the Mediterranean ecosystem in response to the variability in nutrient supply and demand is addressed through basin-wide aggregated ecological hydrodynamical coupled models. A discussion of a multi-nutrient two-phytoplankton ecosystem submodel is presented together with a more aggregated implementation including dissolved inorganic nitrogen, phytoplankton and detritus. This modelling effort gives an interpretation of the nutrients gradients in terms of the effects of the interplay between both biological and dynamical processes. The general oligotrophy of the Mediterranean Sea is in principle explained by the inverse estuarine circulation. Three elements in particular seem to be relevant in creating the North-South and East-West gradients: the different physiography of the two subbasins, the detrital fall-out from the fertile zone and the cyclonic and anticyclonic wind driven structures. The vertical fluxes of biogenic material and the nutrient exchanges at the bottom of the euphotic zone seem to play an important role in modifying the N:P ratio at depth along the east-west axis.

Introduction

The Mediterranean has long been recognized as one of the largest macronutrients-depleted areas in the world with a trophic concentration too low to sustain relevant biomass concentrations (McGill, 1961). The general oligotrophic regime is explained by the inverse estuarine circulation: the estimates of nitrate fluxes at Gibraltar Strait agree on a net loss (inflow in the superficial layer minus outflow in the bottom one) ranging from 1.25 Mtons/year (Sarmiento et al., 1988) to 3.11 Mtons/year (Béthoux, 1979), compensated by

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natural and anthropogenic sources (such as river runoff, atmospheric inputs, and nitrogen fixation). This general picture alone is not sufficient to explain the well known east-west increasing trophic gradient, which is present both in the surface and in depth. This paper focuses on how these gradients arise from the interactions between general circulation processes and the biogeochemical cycles. The interplay between these phenomena has been investigated by means of a 3D coupled ecohydrodynamical model. In it the cycles of nitrogen has been simulated through a very simplified schematization of its major functional compartments. The rationale in aggregating the overwhelming complexity of a marine system in a lumped variable deterministic approach is that a model is, in any case, a simplification of reality. This implies that the first aim of a model, in our opinion, is not a detailed forecasting of a multitude of parameters, but rather to capture the major features of the ecosystem machinery, so gaining a keener insight on the driving mechanisms , and learning something about processes and large scale ecological responses of the ecosystem to different scenarios of environmental conditions.

Trophic gradient(s) and dynamical processes of the Mediterranean Sea.

The Mediterranean peculiarity is mainly derived from the different dynamics active in the Eastern and Western Mediterranean (henceforth E.Med and W.Med). This difference can be explained in terms of several factors that can be summarized in the table 1.

Process	Western Mediterranean	Eastern Mediterranean
Biochemical exchanges	Atlantic Ocean and E.Med	Marginal seas and W.Med
Deep water formation	Within the basin	Mostly outside the basin
Coastal upwellings	Intense in the northern sector	Scarce
Euphotic Layer	Shallow	Deep
Nutricline	Shallow	Deep
Buoyancy content	Low	High

Tab.1 Typical features of the Eastern and Western Mediterranean Sea in relation to the oligotrophic regime.