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SIMULATIONS OF BIOLOGICAL PRODUCTION IN THE RHODES AND IONIAN BASINS OF THE EASTERN MEDITERRANEAN

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ABSTRACT

The biological productivity of the Eastern Mediterranean is studied by concentrating on its two particular regions with contrasting physical characteristics. One of them is the Rhodes cyclonic gyre of the Northern Levantine Sea known to be a major, persistent sub-basin scale feature of the Eastern Mediterranean between the Rhodes and Cyprus Islands. The other is the anticyclonic gyre of the western Ionian Sea extending meridionally to the east of the Sicily Straits. Simulations are carried out using a one-dimensional vertically resolved pysical-biological model. It couples upper ocean dynamics of the physical model with the ecosystem dynamics of the biological model through the specification of vertical eddy diffusivity computed at each time step and over the water column using the Mellor-Yamada level 2.5 turbulence parameterization. The biological model includes only single aggregated compartments of phytoplankton, zooplankton and detritus, as well as ammonium and nitrate. The use of nitrate as a limiting nutrient might be questionable in the Eastern Mediterranean, but the recent data tend to support nitrate limitation within euphotic zone (about 100 m)of the Rhodes gyre region. The role of phosphate as a limiting nutrient is presently under investigation.

The Rhodes basin reveals a well-pronounced cyclonic circulation providing strong exchange between the surface and intermediate-deep waters through upwelling and intense vertical convective overturning processes. Therefore, the water column below the seasonal thermocline is typically characterized by relatively cold, saline and dense waters. On the contrary, the western anticyclonic Ionian gyre possesses very limited surface-intermediate water interactions because of the presence of less saline Modified Atlantic Waters (MAW) within the upper 100 m layer. The strong stratification introduced by the presence of MAW and LIW underneath prevents deep penetration of the vertical convection and, subsequently, the nutrient supply from deeper levels. Because of these two contrasting dynamical regimes, the two basins reveal quite different vertical nutrient structures. The upper levels of the Rhodes gyre are always rich in terms of its nitrate content. On the contrary, the nitrate concentrations between the 100 m and 300 m depths in the western Ionian anticyclone are almost half of those of the Rhodes gyre. In our simulations, these conditions are shown to lead to high biological production in the Rhodes area. The annual primary production is estimated as 97.4 gC m^{-2} yr^{-1}. This value is comparable with those of the Aegean, Adriatic and nortwestern Mediterranean basins. The corresponding value obtained by the analysis of the CZCS data is 87.6 gC m^{-2} yr^{-1}. Although these two numbers are consistent with each other, our model tends to underestimate the summer PP whereas their value does not incorporate the contribution of early winter and early spring blooms.The simulations also demonstrate how the physical conditions in the western Ionian basin limit the biological production.

The primary production in the western Ionian Sea amounts only 10% of the Rhodes case. Therefore, these two basins represent biologically two end members of the Eastern Mediterranean. The annual production cycle also differs slightly in these two basins. The Rhodes gyre possesses a classical production cycle consisting of a strong early spring bloom, a weaker early winter bloom and subsurface production during the summer. In the western Ionian basin, these two blooms are merged with each other to form a long lasting, gradually evolving winter bloom starting from the begining of January to the end of March. The early spring bloom of the Rhodes gyre, on the other hand, has a shorter lifetime, grows and decays exponentially. Our annual primary production estimates for both the Rhodes and western Ionian basins may be modified by several processes excluded within the limitations of the one dimensional approach. In the Rhodes case, the upward advective flux of nitrate associated with the permanent cyclonic circulation system is expected to promote stronger summer production below the seasonal thermocline. The atmospheric input and nitrogen fixation might be responsible for triggering biological activity by enhancing nitrate concentration inside the mixed layer. The lateral advection of flow through eddy fluxes might provide additional nitrate supply which enhance the primary production. Moreover, representation of phytoplankton and zooplankton in single aggregated compartments introduces strong limitation on the phytoplankton-zooplankton interactions during the year.On the other hand, introducing size fractionation for these groups enhances the subsurface production during the summer and autumn seasons as we experienced in our Black Sea biological modeling studies. This is, however, not yet feasible for the Mediterranean Sea because of the lack of sufficient data to represent the details of complicated trophic interactions.

Comparision of the model simulations with the available observations are fairly encouraging although, the observations can only provide support for the main features of the Rhodes and western Ionian ecosystems. In this respect, this study

clearly demonstrates the extreme importance and necessity of carrying out systematic intensive and extensive biochemical observational studies within the framework of international, multi-institutional collaborative research efforts.