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Evidence of bottom-up control of marine productivity in the Mediterranean Sea during the last 50 years

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The temporal dynamics of biogeochemical variables derived from a coupled 3D hydrodynamic-biogeochemical model of the entire Mediterranean Sea is evaluated during the last 50 years (1960 – 2010). Realistic atmospheric forcing and river discharge are used to force the dynamics of the coupled model system. The time evolutions of primary and secondary productions in the entire basin are assessed against available independent data on fisheries yields and catches per unit effort for the same time period. Concordant patterns are found in the time-series of all biological variables (from the model and from fisheries statistics), with low values at the beginning of the series, a later increase with maximum values reached at the end of the 1990's and a posterior stabilization or a small decline.

Spectral analysis of the annual biological time-series reveals coincident low-frequency signals in all of them; the first, more energetic signal, peaks at 2000 while the second one (less energetic) presents maximum values at around 1982. Almost identical low-frequency signals are found in the nutrient loads of the main rivers of the basin and in the integrated (0-100 meters) mean nutrient concentrations in the marine ecosystem.
Nitrate concentration shows an increasing trend up to 1998 with a later stabilization or a slight decline to present day values. This nitrate evolution seems to be driving the first low-frequency signal found in the biological time series. Phosphate, on the other hand, shows maximum concentrations around 1982 and a posterior sharp decline. This nutrient seems to be responsible for the second low-frequency signal observed in the biological time-series.

Our analysis shows that the control of marine productivity (from plankton to fish) in the Mediterranean basin seem to be principally mediated through bottom-up processes that could be traced back to the characteristics of riverine discharges. Other types of control could not be excluded from our analysis (e.g., top-down processes) but seems to be of secondary relevance in this particular marine basin. Appropriate river management appears then as a key issue to determine and to reduce the future anthropogenic pressure on this heavily populated and exploited marine basin.