BASIN-WIDE CONSEQUENCES FOR THE HYDRODYNAMICS AND BIOGEOCHEMICAL CONDITIONS IN THE MEDITERRANEAN SEA OF A CLOSURE IN THE STRAIT OF GIBRALTAR. A MODELLING STUDY.

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Abstract

The Strait of Gibraltar is the only connection between the Mediterranean Sea and the open ocean and controls the majority of its water and substances budgets. Water circulation in the Strait is set by the hydric deficit in the Mediterranean and by the quasi-continuous transformation of surface waters into deep ones but the specific role of this circulation on the basin wide characteristics is not fully understood. We use a set of numerical simulations of the hydrological and biogeochemical conditions of the Mediterranean to explore the consequences of a total and partial closure of the Strait of Gibraltar. Our results show that surface properties are affected in large fractions of the basin. Also the strength of the vertical stratification, winter mixing and associated production is affected in many places of the Mediterranean

Keywords: Circulation models, Primary production, Straits and channels, Gibraltar Strait, Mediterranean Sea

The Strait of Gibraltar is the unique connection between the Mediterranean Sea and the open ocean. The water and heat budget in the Mediterranean is, hence, controlled by the water interchange through this narrow connection [1] where relatively fresher Atlantic waters flow in at the surface while saltier Mediterranean waters flow out at depth [2]. This antiestuarine exchange has been proposed to have far-reaching consequences for the whole Mediterranean basin as, for example, tidal propagation [3], salinity anomalies [4] and thermohaline circulation [5]. However, up to date, no specific ad-hoc quantitative assessment of the basin-wide consequences of the water interchange through the strait has been done. In this work we have used a hydrodynamic-biogeochemical coupled model of the entire Mediterranean basin to perform a set of different model runs covering the period 1990 – 2000 only changing the conditions in the Strait of Gibraltar. In the first simulation (‘realistic’) the strait is treated as an open boundary imposing climatologic temperature and salinity conditions. In the second simulation a closed boundary is imposed at the Strait (e.g., like with a concrete dam) while in the third simulation, a certain flux of Atlantic water is allowed through the boundary in order to maintain the sea level stable within the Mediterranean (i.e., compensating the evaporative losses). We evaluate the difference between the different runs in terms of sea surface temperature, surface salinity, surface kinetic energy, deep water convection and integrated primary production rate in the whole Mediterranean basin. We found that, as expected, conditions in the western basin are much more affected than in the eastern although some variables did also significantly change in the central Mediterranean Sea. In short, restricting the circulation at the Strait creates a surface salinity anomaly that alters the vertical stability of the water column in large fractions of the basin. That enhances winter mixing and foster primary production (Figure 1).

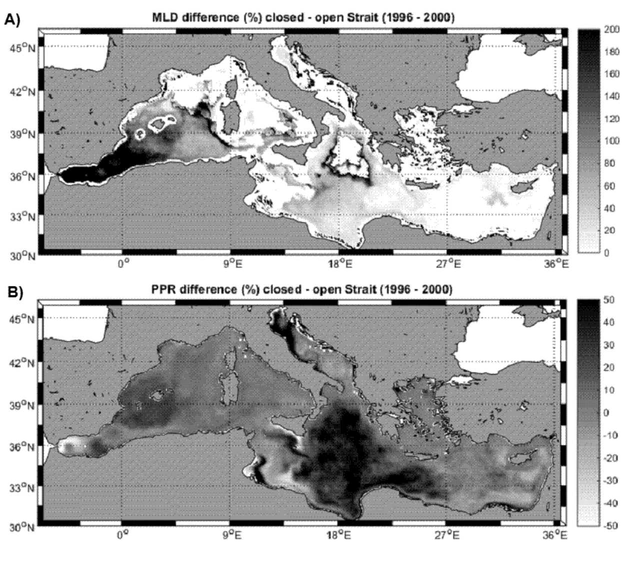

Fig. 1. A) Winter mixed layer depth differences (%) between closed and open Strait simulations. B) Integrated primary production differences (%) between closed and open Strait simulations

On the other hand, surface kinetic energy within the basin tends to reduce specially along the north-western coast, changing the position and strength of the main surface currents. With this work we have, for the first time, explored the basin-wide consequences of the water interchange through the Strait of Gibraltar for the entire Mediterranean Sea. Our results clearly indicate that this local interchange is important not only to determine the hydrological and biogeochemical conditions of the nearby Alboran Sea (the most affected region) but also for the entire western basin and even for some properties within the Ionian Sea. These results, thus, demonstrate the necessity to accurately represent the interchange processes in Gibraltar in order obtain a good representation of the basin-wide Mediterranean properties with numerical models.

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