ECOHYDRODYNAMICS RELATED TO THE CALVI CANYON (CORSICA): A NUMERICAL STUDY.

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Abstract

A 3-D, high resolution model is used to investigate the impact of the Calvi canyon on the ecohydrodynamics in early spring conditions. Numerical runs are performed to simulate the nitrate distribution. Results show that the canyon topography generates high downwelling (upwelling) in the western (eastern) part of the canyon. Downwelling is larger than upwelling within the canyon leading to a net downward nitrate transport there, while upstream and downstream of the canyon there are regions of upwelled water richer in nitrate. Simulations are performed for NE, upwelling favorable, wind conditions where data of nitrate concentration are available for model validation.

Keywords: Upwelling; Coastal models, Continental slope; Primary production.

Introduction

Submarine canyons appear to be preferential sites for shelf-slope exchanges and vertical motion, features which can have important implications on the dynamics of plankton ecosystems. The deflection of deeper offshore currents up canyon can induce a nutrient transport into the euphotic zone, on the continental shelf, leading to the enhancement of primary production. Observations in the Calvi coastal area highlighted a complex flow structure with an anticyclonic gyre in the western part of the Calvi Bay and an offshore flow downstream of the canyon head[1]. A high horizontal gradient of nitrate concentration is observed across the canyon axis. In the present study a numerical modeling approach is used to estimate the impact of the canyon hydrodynamics on the ecological processes in the area.

Model

The study is based on the GHER 3-D baroclinic nonlinear primitive equation model using a *k-l* turbulent closure and a double-sigma coordinate system (1). The model has been applied in weakly stratified conditions corresponding to a typical early spring pre-bloom situation. A run is first performed in negligible wind conditions to reach the topography induced steady state circulation, and then in the case of a NE upwelling favorable wind. The initial conditions for nitrate distribution are determined by available measurements on the shelf.

Results

Results show that upstream of the canyon the flow is deviated onshore in shallow depths and the resulting negative relative vorticity generates a closed anticyclonic circulation in the western part of the Calvi bay, while over the canyon the flow acquires positive potential vorticity due to the depth increase and a cyclonic circulation is formed. Downwelling is generated on the western side of the canyon, whereas upwelling of lower intensity is generated on the eastern side (Fig. 1a). Nitrate concentration at 20 m depth (Fig. 2a) is everywhere lower than the initial one, consistent with a net downward motion within the canyon. On either side of the canyon there are regions of upwelled water of higher nitrate concentration. The region downstream of the canyon presents the highest values (3-4 times higher than the initial value). Simulations performed with a NE wind (10 m/s during 24 hours), show an increase of cyclonic vorticity and of vertical velocities over the canyon with upwelling almost compensating downwelling motion (Fig. 1b). Nitrate distribution pattern presents higher values over the canyon with respect to the no wind case. Increased upwelling and wind driven turbulent mixing lead to a nitrate transport through the nitracline. The regions of upwelled nitrate downstream and upstream of the canyon are now confined on the slope domain. A drastic increase of upwelling velocities and of nitrate concentration (6-7 times higher than in the no wind case) is simulated within and around the Bay (Fig. 2b) in agreement with field observations (2) (Fig.3). A phytoplankton bloom often occurs within the bay with a chlorophyll concentration maximum generally observed some days after the passage of a NE wind. On the other hand, observations do not show such efficient nitrate enrichment of the Bay during SW wind events.

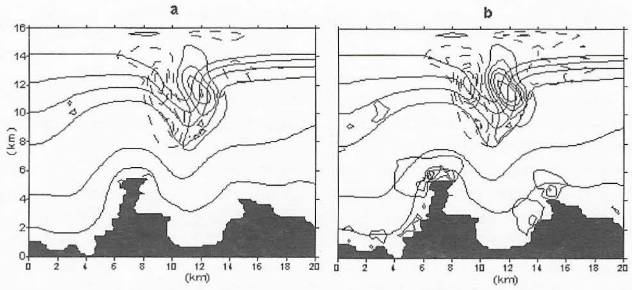
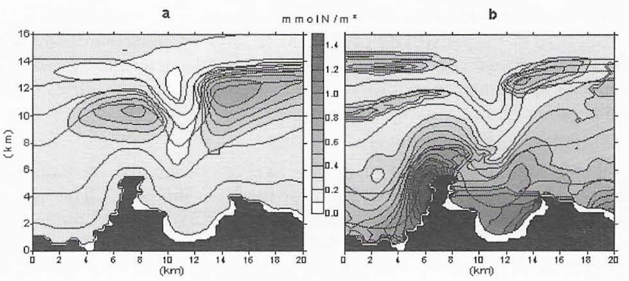


Fig. 1: Mean vertical velocities (m/s) in the upper 50m for the no wind (a) and for the NE wind (b) case. The thick solid and dashed lines indicate upward and downward flow, respectively. The contour interval is 0.0005 m/s. The 50-, 100-, 200-, 300-, 400- and 500-m isobaths are plotted with thin solid lines.

Fig. 2: Horizontal nitrate distribution at 20m for the no wind (a) and for the NE wind (b) case.



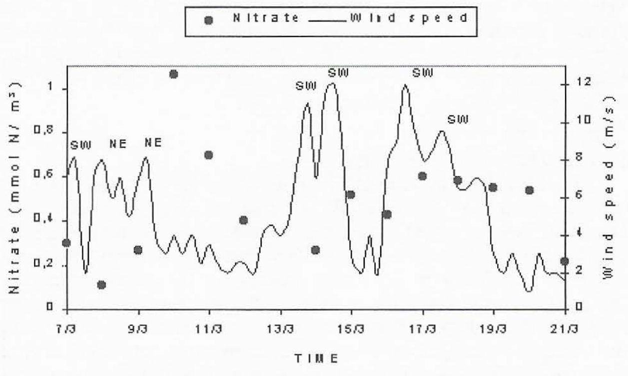


Fig. 3: Time variations of measured surface nitrate concentration (dots) and wind intensity (solid line) measured in the western part of the bay (7-21 March 1988). Headings indicate NE and SW wind event (intensity higher than 7 m/s during at least 12 hours).

References

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