EFFECTS OF THE HYDROLOGICAL CONDITIONS ON THE SPATIAL DISTRIBUTION OF CHLOROPHYLL A AND NUTRIENTS CONCENTRATIONS IN AN UPWELLING AREA OF THE ALBORAN SEA

Teodoro Ramírez [1], Dolores Cortés [1], Jesús Mercado [1] and Esperanza Liger [2]*
[1] Department of Applied Physics II, University of Málaga - eliger@uma.es
[2] Instituto Español de Oceanografía, Centro Oceanográfico de Málaga

Abstract
The coupling between the spatial distribution of Chla (chlorophyll-a) and nutrient concentrations and the hydrological conditions in the NW Alboran Sea is examined in the present study by using data from 12 seasonal oceanographic cruises carried out over three years period.
Keywords: Chlorophyll-a, Nutrients, Alboran Sea, Upwelling

Introduction
The Alboran Sea is characterized by a very high hydrodynamic activity. The Atlantic seawater influx through Strait of Gibraltar produces a system of two anticyclonic gyres which occupy almost all the central part of the basin [1]. With the aim of providing new insights on the coupling among biological structures and the hydrology in this area [2-3], four seasonal oceanographic cruises per year were carried out along the coast of Malaga.

Material and Methods
Samplings were conducted in coastal (20-30 m), neritic (80-100 m) and oceanic stations (210-540 m), situated in six transects located off the coast of Málaga (Fig.1). At each sampling station, continuous vertical profiles of temperature and salinity and seawater samples for Chla and nutrient analysis were taken. The mean values of these variables in the upper 20 m during each cruise were used to generate horizontal distributions maps for the whole period of study.

Results and Discussion
Salinity and temperature in the upper 20 m reflected the general circulation pattern of the zone as well as the influenced of different fertilization mechanisms. Thus the oceanic stations of the western transects (P, F and T) were frequently under the influence of the Atlantic jet, where lower temperature values coincided with the lowest average salinity, possibly due to the incursions of cores of North Atlantic Central Water (NACW) in these stations. The eastern transects (M, R and V) were usually affected by warmer waters from the East and with relatively low salinities and high dissolved oxygen values, suggesting the presence in the eastern transects of surface water with a high residence time. On average, salinity showed a strong gradient towards the coast on the whole area, mainly due to the wind induced upwelling events in the coastal stations. This gradient was even more pronounced in the westernmost transects due to the greater Atlantic influence in the oceanic stations. Nutrient concentrations correlated significantly with salinity, showing the potential fertilization associated to the saltier Mediterranean waters. However, no correlation was found with neither the temperature nor the depth of the AMI (Atlantic Mediterranean Interface). Chla was greatly affected by the hydrological conditions and showed significant differences between the western and the eastern transects (Kruskal-Wallis, H (N=24)=13.96, $p<0.001$). In the western transects different fertilization mechanisms (geostrophic front, incursions of NACW and advection waters from the Strait of Gibraltar) leaded to the highest Chla values found during the studied period, which on average were always higher than 1 $\mu g\ L^{-1}$. In the eastern sector, Chla concentrations were always lower than 0.7 $\mu g\ L^{-1}$, coinciding with the presence in these transects of waters with a higher time of residence. In the Alboran Sea, the depth of the AMI (Atlantic Mediterranean Interface) has been frequently considered as an indicator of fertilization by different authors [1], as the Mediterranean waters are enriched in nutrients, and relationships between Chla and the AMI has been previously reported. However, the present study indicated that on overall the depth of the AMI was no good predictor of the vertical nutrient input towards the surface, though salinity did. In addition, no significant correlation was found neither between the mean values of Chla and salinity in each station, nor between Chla and the depth of the AMI. In contrast, Chla concentrations correlated significantly with the average temperature, dissolved oxygen and nutrient concentrations in the upper 20 m, indicating a close association between Chla concentrations and the thermal and biogeochemical features of the water masses. The lack of correlation between Chla and salinity was attributed to the existence of different fertilization mechanisms in the area of study, not only the upwelling of saltier Mediterranean of waters, as well as to the presence of water masses with different times of residence.

Acknowledgements. This work has been funded by IEO (ECOMALAGA project) and Spanish Ministry of Science and Innovation (NITROALBORAN CTM2006-00426 and TROFOALBORAN CTM2009-07776, co-funded from FEDER-EU).

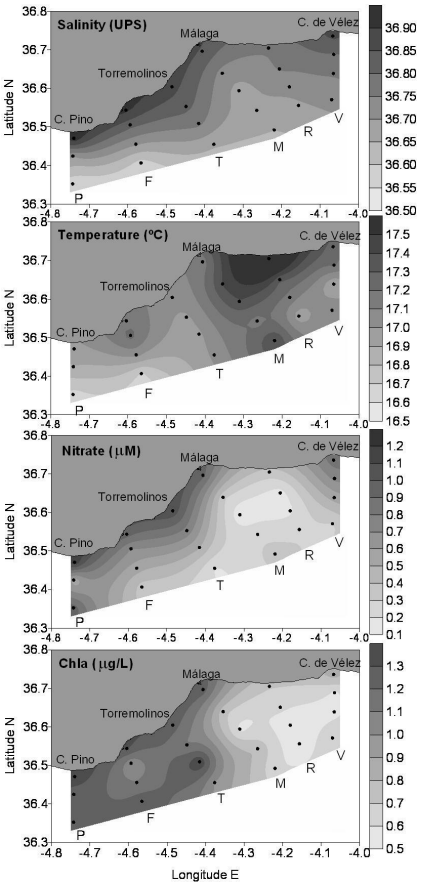

Fig. 1. Spatial distribution of the different variables in the study area

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