ELSEVIER

Deep-Sea Research II 53 (2006) 1141–1143

DEEP-SEA RESEARCH
PART II

www.elsevier.com/locate/dsr2

Editorial

Topical studies in oceanography: The Gulf of Cádiz oceanography: A multidisciplinary view

Historically, the basins adjacent to the Strait of Gibraltar have acted as linking nodes for the cultural exchange between Europe and Africa, role that can be extended to the oceanographic field on the basis of the numerous and relevant feedback processes that take place through the strait among the two seas surrounding southern Europe, the Mediterranean and the NE Atlantic. Thus, the reciprocal oceanographic interchange between both basins exerts a profound influence on the circulation of the neighboring oceanic regions, the Alborán Sea and the Gulf of Cádiz, one that occurs throughout the entire water column.

However, more effort had been dedicated traditionally to the understanding of the dynamics governing surface processes on the Mediterranean side or the characteristics of bottom deep features in the Gulf. The 'deep' attraction of oceanographers for the Gulf of Cádiz has been a consequence of its strategic position. Situated at mid latitude in the NE Atlantic, the basin is the first domain where the dense (salty, warm) Mediterranean outflow encounters the open ocean after crossing the Strait of Gibraltar. The fate of the Mediterranean waters markedly affects the large-scale circulation of the North Atlantic, including the meridional overturning; thereby, most studies performed have dealt with the intermediate-deep layer circulation rather than surface oceanographic patterns.

By the end of the 20th century, the Spanish oceanographic community became aware of this imbalance and, being conscious of the lack of information about a basin that plays a significant role in feeding the Mediterranean, holds considerable living resources, and contributes to the Atlantic biogeochemical cycles, a consortium of investigators decided to implement intensive field work in the area. This initiative commenced in 1999, supported by funding of the Spanish Ministerio de Educación y Ciencia (project MAR99-0643) and the Junta the Andalucía regional government. The most outstanding results of these efforts, performed until 2002, are now gathered in 18 manuscripts contained in this special Deep Sea Research Part II.

This issue constitutes then the first volume of papers arising from the studies accomplished in the Gulf of Cádiz over that period of time, and, collectively, the contributions included here represent a rich and remarkable beginning in our knowledge of the basin. The papers have been arranged according to their subjects; articles dealing with surface circulation are presented first, followed by those focused on physical issues. Phytoplankton and other related variables are subsequently introduced, preceding zooplankton studies, concluding with two contributions on the dynamics of bottom sediments in the area.

Most of the analyses on the surface circulation in the Gulf of Cádiz have been based on remotely sensed sea-surface temperature (SST) or climatological data (Fiúza et al., 1982; Fiúza, 1983; Folkard et al., 1997; Vargas et al., 2003; Sánchez and Relvas, 2003) and only a few papers have examined in situ records suited to describe the three-dimensional structure of the mass and velocity fields. The pioneer work by Stevenson (1977) used SST and visible satellite imagery to identify the accumulation of warm surface water over the Spanish continental shelf and also showed a set of features that were coined as "Portuguese upwelling zone", "Huelva front", and "Tarifa eddy". These features are now better known, but there still remain unresolved questions. The first group of papers in this volume reviews these questions and provides new insights

0967-0645/$ - see front matter © 2006 Published by Elsevier Ltd.
doi:10.1016/j.dsr2.2006.06.001

and explanations on the origin and implications of the above-mentioned physical structures. The papers by Criado-Aldeanueva et al. (2006) and Machín et al. (2006) consider aspects of the basin-scale circulation and its coupling with the eastern boundary current and the North African upwelling system.

The continental shelf of the Gulf of Cádiz possesses an extraordinary commercial interest for fisheries and, consequently, knowledge of the physical processes taking place in the zone benefits considerably fishery management. In particular, the dynamics of the coastal current that flows westward near the shore and eventually reaches Cape San Vicente before proceeding northwards is of particular interest. It has been observed that the current responds to wind stress in the sense that westerlies hamper its westward progression while easterlies favour the pushing of waters in that direction (Fiúza, 1983; Folkard et al., 1997; Relvas and Barton, 2002). The origin of the process is not clear yet although the presence of an alongshore pressure gradient usually has been invoked as the driving force of the counterflow (Relvas and Barton, 2002). Papers by García-Lafuente et al. (2006) and Sánchez et al. (2006) delve deeply into this interesting subject, using, for the first time, in situ observations. Other physical considerations of the continental shelf-slope dynamics are presented in Bruno et al. (2006).

Reul et al. (2006) determine the signals produced by these dynamical features on the spatial distribution of pico- and nanoplankton communities in the basin, whereas the study by Prieto et al. (2006) models this connection for the case of phytoplankton-derived products, such as transparent exopolymer particles. The association between physical features and primary producers appears to be so tightly coupled that surface signals of chlorophyll are used by Ruiz and Navarro (2006) as an estimator to calculate vertical velocities in the area, applying a method that is contrary to the standard procedure of implementing physics to understand biology. This tight connection also is reflected in the three-dimensional distribution of chlorophyll occurring during the stratification period, which cannot be explained without considering the seasonal cycle in the basin. Navarro et al. (2006) propose a novel model to elucidate both the distribution and formation of the deep chlorophyll maximum in the region, which differs from existing hypotheses and can be extended to understand the nature of the formation and location of this important structure in the global ocean.

Phytoplankton force other oceanographic properties in the region, including those related to the carbon cycle. In fact, results obtained by Huertas et al. (2006) strongly suggest that the interlink between wind regime and phytoplankton dynamics in this area makes of the northeastern shelf of the Gulf of Cádiz a net sink for atmospheric CO_2 on annual basis. Aït-Ameur and Goyet (2006) explore further the spatial distribution of inorganic carbon in the Gulf with the aim to determine the export rate of anthropogenic carbon from the Mediterranean Sea to the Atlantic Ocean.

The forcing that physical features exert on the biota in the Gulf of Cádiz represents a leit motiv of different papers contained in this special issue, which also emphasize the significant economic impact of the physics when analyzing higher trophic levels of the marine food web. Navarro and Ruiz (2006) show, through empirical orthogonal functions of an extensive collection of SeaWiFS images, the singularities of a particular coastal fringe of the Gulf. Contrary to open-ocean waters, this fringe is rich in chlorophyll, being able to sustain high concentrations of primary producers even over the warm summer period, when the rest of the basin undergoes a profound oligotrophy. Warm and biologically productive waters are markedly suitable for the reproduction of many fish species, a subject that is explored by Baldó et al. (2006) and Catalán et al. (2006a) who respectively find distinctive icthyoplankton and benthic fish communities in connection with the coastal fringe and other hydrographic features of the basin. The influence of the circulation regime driven by wind on these exploited communities is analyzed by Catalán et al. (2006b), describing a net signal of westward transport for the spawning of coastal species in relation to the circulation regime describe by García-Lafuente et al. (2006). Subsequently, Ruiz et al. (2006) examine the consequences of the prevailing wind regime on the recruitment of anchovy, proposing a hypothesis based on the presence of easterly and rain events during the spawning period to explain the fluctuations in the catches observed in this species.

The last two articles of the volume address geological aspects of the Gulf of Cádiz. Hernández-Molina et al. (2006) propound a general sedimentary model for the basin whereas Leon et al. (2006) investigate the relationship between sea-floor features and the nature of hydrocarbon-enriched fluid and gas leaks from degassing of

deeply buried sediments along the continental margin of the gulf.

The set of articles contained in this special issue represents collectively the first attempt to generate an integrated understanding of the oceanography of the Gulf of Cádiz, from its physical constraint on currents and their control over biogeochemical cycles, primary producers and higher trophic levels of the food web under human exploitation. As such, we hope it will become a reference milestone for the oceanography of this unique region.

References

Aït-Ameur, N., Goyet, C., 2006. Distribution and transport of natural and anthropogenic CO_2 in the Gulf of Cádiz. Deep-Sea Research II.

Baldó, F., García-Isarch, E., Jiménez, M.P., Romero, Z., Sánchez-Lamadrid, A., Catalán, I.A., 2006. Spatial and temporal distribution of the early life stages of three commercial fish species in the North Eastern shelf of the Gulf of Cádiz. Deep-Sea Research II.

Bruno, M., Vázquez, A., Gómez-Enri, J., Vargas, J.M., García Lafuente, J., Vidal, J., 2006. Observations of internal waves and associated mixing phenomena in the Portimao canyon area. Deep-Sea Research II.

Catalán, I.A., Jiménez, M.T., Alconchel, J.I., Muñoz, J.L., 2006a. Spatial and temporal changes of coastal demersal assemblages in the Gulf of Cádiz (SW Spain) in relation to environmental conditions. Deep-Sea Research II.

Catalán, I.A., Rubín, J.P., Navarro, G., Prieto, L., 2006b. Larval fish distribution in two different hydrographic situations in the Gulf of Cádiz. Deep-Sea Research II.

Criado-Aldeanueva, F., García-Lafuente, J., Vargas, J.M., del Río, J., Vázquez, A., Reul, A., Sánchez, A., 2006. Distribution and circulation of water masses in the Gulf of Cádiz from in situ observations. Deep-Sea Research II.

Fiúza, A.F.D., de Macedo, M.E., Guerreiro, M.R., 1982. Climatological space and time variation of the Portuguese coastal upwelling. Oceanologica Acta 5 (1), 31–40.

Fiúza, A.F.D., 1983. Upwelling patterns off Portugal. In: Suess, E., Thiede, J. (Eds.), Coastal Upwelling. Plenum, New York, pp. 85–98.

Folkard, A.M., Davies, P., Fiúza, A.F.G., Ambar, I., 1997. Remotely sensed sea surface thermal patterns in the Gulf of Cádiz and the Strait of Gibraltar: variability, correlations and relationships with the surface wind field. Journal of Geophysical Research 102 (C3), 5669–5683.

García-Lafuente, J., Delgado, J., Criado-Aldeanueva, F., Bruno, M., del Río, J., Miguel Vargas, J., 2006. Water mass circulation on the continental shelf of the Gulf of Cádiz. Deep-Sea Research II.

Hernández-Molina, F., Llave, E., Stow, D.A., García, M., Somoza, L., Vázquez, J.T., Lobo, F., Maestro, A., Díaz del Río, V., León, R., Medialdea, T., Gardner, J., 2006. The Contourite Depositional System of the Gulf of Cádiz: a sedimentary model related to the bottom current activity of the Mediterranean Outflow Water and the continental margin characteristics. Deep-Sea Research II.

Huertas, I.E., Navarro, G., Rodríguez-Gálvez, S., Lubián, L.M., 2006. Temporal patterns of carbon dioxide in relation to hydrological conditions and primary production in the northeastern shelf of the Gulf of Cádiz (SW Spain). Deep-Sea Research II.

Leon, R., Somoza, L., Medialdea, T., Maestro, A., Díaz del Rio, V. (2006). Types of deep sea floor features associated with methane seepsalong the Gulf of Cádiz continental margin. Deep-Sea Research II.

Machín, F., Pelegrí, J.L., Marrero-Díaz, A., Laiz, I., Ratsimandresy, A.W., 2006. Near-surface circulation in the Southern Gulf of Cádiz. Deep-Sea Research II.

Navarro, G., Ruiz, J., 2006. Spatial and temporal variability of phytoplankton in the Gulf of Cádiz through remote sensing images. Deep-Sea Research II.

Navarro, G., Ruiz, J., Huertas, I.E., García, C.M., Criado Aldeanueva, F., Echevarría, F., 2006. Basin scale structures governing the position of the deep fluorescence maximum in the Gulf of Cádiz. Deep-Sea Research II.

Prieto, L., Navarro, G., Cózar, A., Echevarría, F., García, C.M., 2006. Distribution of TEP in the euphotic and upper mesopelagic zones of the southern Iberian coasts. Deep-Sea Research II.

Relvas, P., Barton, E.D., 2002. Mesoscale patterns in the Cape Sao Vicente (Iberian Peninsula) upwelling region. Journal of Geophysical Research 107 (C10), 3164.

Reul, A., Muñoz, M., Criado-Aldeanueva, F., Rodríguez, V., 2006. Spatial distribution of phytoplankton <13 mm in the Gulf of Cádiz in relation to water masses and circulation pattern under westerly and easterly wind regimes. Deep-Sea Research II.

Ruiz, J., Navarro, G., 2006. Upwelling spots and vertical velocities in the Gulf of Cádiz: an approach for their diagnose by combining temperature and ocean colour remote sensing. Deep-Sea Research II.

Ruiz, J., García-Isarch, E., Huertas, E., Prieto, L., Juárez, A., Muñoz, J.L., Sánchez La-Madrid, A., Rodríguez, S., Naranjo, J.M., Baldó, F., 2006. Meteorological forcing and ocean dynamics controlling Engraulis encrasicolus early life stages and catches in the Gulf of Cádiz. Deep-Sea Research II.

Sánchez, R., Relvas, P., 2003. Spring–summer climatological circulation in the upper layer in the Region of Cape St. Vincent, Southwest Portugal. ICES Journal of Marine Science 60, 1232–1250.

Sánchez, R.F., Mason, E., Relvas, P., da Silva, A.J., Peliz, A.J., 2006. On the inshore circulation in the Northern Gulf of Cádiz. Deep-Sea Research II.

Stevenson, R.E., 1977. Huelva Front and Malaga, Spain, Eddy chain as defined by satellite and oceanographic data. Deutsche Hydrographische Zeitschrift 30 (2), 51–53.

Vargas, J.M., García-Lafuente, J., Delgado, J., Criado, F., 2003. Seasonal and wind-induced variability of sea surface temperature patterns in the Gulf of Cádiz. Journal of Marine Systems 38 (3–4), 205–219.

Javier Ruiz, Jesús García-Lafuente

Departamento de Biologia y Ecologia, Facultad de Ciencias del Mar, Universidad de Cadiz, Apartado, num. 40, 1510 Puerto Real (Cadiz), Spain

E-mail address: javier.ruiz@icman.csic.es (J. Ruiz)