Journal of Marine Systems 111–112 (2013) 130–138

Contents lists available at SciVerse ScienceDirect

Journal of Marine Systems

journal homepage: www.elsevier.com/locate/jmarsys

Nepheloid layer distribution in the Gulf of Valencia, northwestern Mediterranean

M. Ribó *, P. Puig, J. Salat, A. Palanques

Institut de Ciències del Mar, ICM-CSIC. Pg. Marítim de la Barceloneta, 37-49, E-08003 Barcelona, Spain

ARTICLE INFO

Article history:
Received 1 June 2012
Received in revised form 9 October 2012
Accepted 11 October 2012
Available online 22 October 2012

Keywords:
Marine circulation
Sediment dynamics
Nepheloid layers
Gulf of Valencia
NW Mediterranean

ABSTRACT

According to previous studies, the surface circulation of the Gulf of Valencia (GoV) is characterized by a convergence between the southwestward Northern Current carrying old Atlantic Waters (oAW) and the northward intrusions of recent Atlantic Waters (rAW) imported through the Ibiza Channel. This paper focuses on the distribution of the suspended sediment concentration in the GoV obtained from a dense grid of CTD observations in June 1995 during the oceanographic cruise MESO'95 (MESOscale processes). We evaluate the relation between currents, water masses and the nepheloid structure at the time of the survey. Results showed higher suspended sediment concentration (SSC) in the oAW than in the rAW. At the shelf-break depth, an important detachment of particulate matter was observed off Cap La Nao, extending seawards all across the Ibiza Channel. The presence of this intermediate nepheloid layer detachment indicates a preferential off-shelf sediment export at the southern end of the GoV, where the orientation of the continental margin changes, and oAW and rAW merge. On the continental slope, several nepheloid layers detachments were observed between 400 and 600 m, where the Levantine Intermediate Water (LIW) interacts with the seafloor, suggesting the possible presence of internal waves causing sediment resuspension and/or maintaining particles in suspension in the mid-slope region. A bottom nepheloid layer was also observed at deeper locations along the central and southern part of the GoV continental slope, but not at the Ibiza Sill.

1. Introduction

Several studies have shown that shelf-slope fronts and geostrophic currents are the most important factors controlling particulate matter distribution (including all solid particles, lithogenic and biogenic particles) in the water column (e.g. Baker and Hickey, 1986; Durrieu de Maddron et al., 1992; Palanques and Biscaye, 1992; Puig and Palanques, 1998). Terrigenous or lithogenic particles, as suspended sediment, do not act like purely conservative tracers of water masses, but their presence in nepheloid layers, defined as layers containing high concentration of particulate matter located at different depths of the water column, can indicate the location and intensity of oceanographic processes, particularly those involving the resuspension of sediment due to strong bottom currents (Gardner and Walsh, 1990; McCave, 1986).

The general surface circulation in the northwestern Mediterranean is cyclonic. It is dominated by a baroclinic current, carrying old Atlantic Waters (oAW) that flows southwestwards contouring the continental slope from the Gulf of Genoa to the Gulf of Valencia (GoV) (Font and Miralles, 1978; Font et al., 1988; Salat and Font, 1987). This current, the Northern Current, is in geostrophic equilibrium with a shelf/slope density front, the Continental Front, due to salinity differences between the slope and shelf waters, with a marked seasonal variability (Béthoux et al., 1982; Castellón et al., 1990; Font et al., 1988).

The bottom topography of the GoV forms a deep trough (>1000 m), the Valencia Trough, bounded by the wide Ebro margin to the north, and the Ibiza Sill to the south. The GoV shelf has a varying width, exceeding 60 km in the north, at the Columbretes Islands, from where it rapidly narrows towards the south, to around 20 km and changes its direction from SW to SE off Cap La Nao (Fig. 1). At the entrance of the GoV, a significant part of the flow of the Northern Current proceeds southward, detached from the continental shelf-break where the shelf narrows, directly towards the Ibiza Channel (Pinot et al., 1995; Salat, 1995). The presence of the Balearic Current on the south, towards the NE closes the surface cyclonic circulation in the GoV (Fig. 1). This current carries recent Atlantic Waters (rAW) from the southwestern Mediterranean through the Balearic passages, mainly the Ibiza Channel, between Cap La Nao and Ibiza (Font et al., 1988; Salat, 1995). The Balearic Current is also in geostrophic equilibrium with a density front, the Balearic Front, caused by the low salinity of the rAW. In coherence with the water exchanges at Gibraltar, this front has a limited vertical extension and is not attached to the bathymetry (Salat, 1995).

The hydrographic structure of the GoV is thus dominated by a two current system (Fig. 1), and their associated fronts, subjected to seasonal and mesoscale variability. The occurrence of mesoscale eddies in the GoV has been described by several authors (García et al., 1994; La Violette et al., 1990; Pinot and Ganachaud, 1999; Pinot et al., 1995, 2002). Some of the observed anticyclonic eddies have

* Corresponding author.
E-mail address: mribo@icm.csic.es (M. Ribó).

0924-7963/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jmarsys.2012.10.008

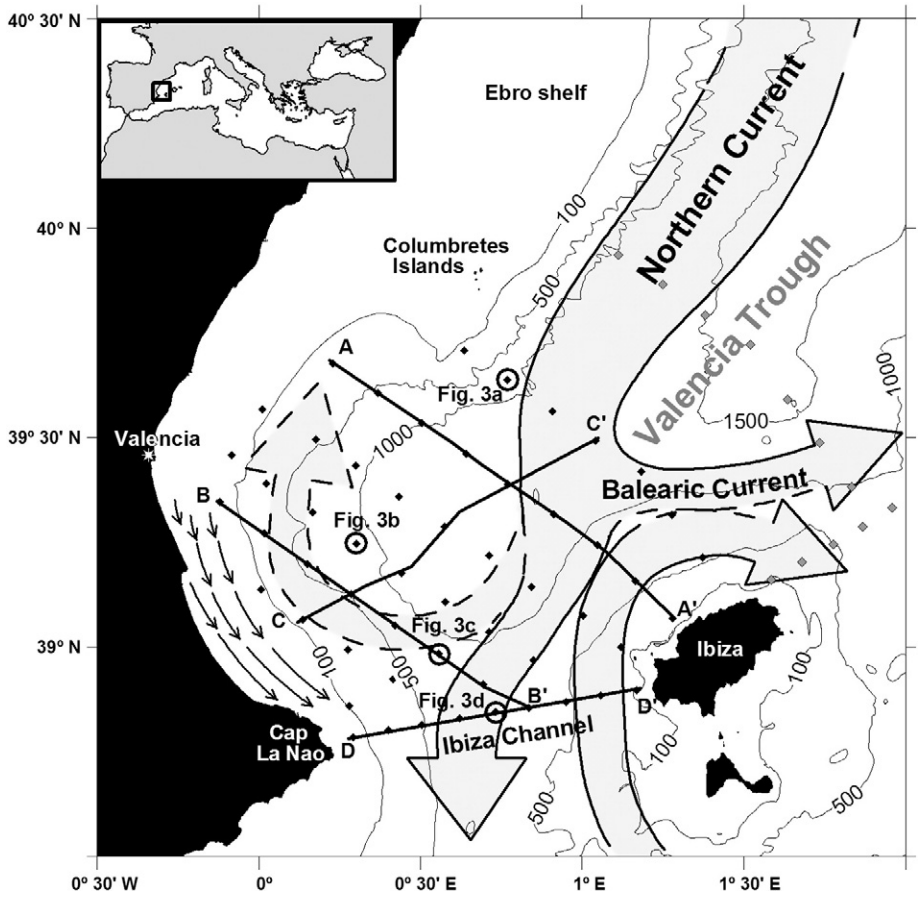

Fig. 1. Map of the Gulf of Valencia showing the position of the CTD stations analyzed in this study (black diamonds) and the additional CTD stations used to compute the geostrophic field (grey diamonds). Transects A–A′, B–B′, C–C′, D–D′, and the stations in which each vertical profile was examined (Fig. 3a, b, c and d) are also shown in this map. Inner shelf circulation is indicated with simple arrow based on Han et al. (1983). General circulation in the GoV and rAW intrusion are indicated with filled arrows, and dashed arrows indicate mesoscale structures, as anticyclonic eddies, based on Pinot et al. (2002).

been found trapped near the slope region of the inner GoV, south of the Columbretes Islands, where the narrowing of the shelf is affecting the circulation. The slope circulation in the GoV is seasonally dominated by these eddies, and are frequently induced by meandering of the Catalan and Balearic fronts (Font et al., 1988). Meandering activity is strong during winter, as a result of the intensification of the Northern Current during the winter–spring season, and probably to it, becoming more unstable (Pinot et al., 2002). This seasonal modulation of mesoscale activity in the Northern Current was already observed off the Ebro Delta (Font et al., 1995). Millot (1999) suggested that these mesoscale structures could also be produced by fluctuations of rAW entering through the Ibiza Channel and to instabilities in the GoV circulation caused by the interaction with the bathymetry. Eddies produced at the GoV can also cross the Ibiza Channel and strongly perturb the water exchange, forcing the retroflection of northern waters back to the northeast into the Balearic Current below the rAW (Pinot et al., 2002) (Fig. 1).

The circulation over the GoV shelf, as it has been described in the Ebro shelf, is highly affected by the wind pattern (Espino et al., 1998; Font, 1990), and local mesoscale events are forced by wind bursts and also by the Ebro River discharges (Wang et al., 1988; Salat, 1995; Salat et al., 2002). Han et al. (1983) studied the circulation on the continental shelf in the GoV. They observed that on the outer shelf currents are dominated by the flow imposed from offshore in the Catalan Sea, and by wind stress. They also observed that currents on the inner shelf are intensified as the shelf width narrows to the south, from Valencia to near the southern boundary of the study area, at Cap La Nao (Fig. 1).

The sedimentary dynamics on the GoV continental shelf was initially studied in detail by Young et al. (1983) during the EOPC project (Estudio Oceanográfico de la Plataforma Continental), when three tripods equipped with a current meter and optical transmissometer, measured turbidity at about 50 cm above the bottom, and were deployed off Valencia between depths varying from 10 to 52 m. They observed that periods of high near-bottom water turbidity (increase of suspended material in the water sampled), occurred independently of flow speed events, and were well correlated with high wave energy events. Later on, during the EBROMS project (EBRO Margin Study) (Maldonado and Nelson, 1990), boundary layer measurements were obtained by the benthic tripod GEOPROBE at 60 m on the Ebro shelf (Cacchione et al., 1990), and Palanques and Drake (1990) described the main trends of suspended sediment distribution. After this initial observational effort, during the FANS project (Fluxes Across Narrow Shelves), the general pattern and magnitude of sediment fluxes at several locations across the shelf were analyzed in Palanques et al. (2002). A focused study of the principal mechanisms that contribute to the sediment transport near the bottom and control the variability of the suspended sediment particles within the water column was conducted by Puig et al. (2001), addressing the role of storms and near inertial internal waves over the shelf.

All these studies indicated that on the GoV and Ebro continental shelf, the mean along-shelf sediment flux towards SSW is dominant over the mean seaward cross-shelf flux, and that maximum near-bottom sediment fluxes are mainly associated with storm events. Further studies of sedimentary dynamics on the Ebro shelf were conducted on the framework of the RESPONSE project (RESPONSE of benthic communities and sediment to different regimens of fishing disturbance in European coastal waters) that studied the effects induced by trawling on benthic organisms and in the remobilisation of surface sediments.