THICK BOTTOM NEPHELOID LAYERS IN THE WESTERN MEDITERRANEAN BASIN GENERATED BY DENSE SHELF WATER CASCADING

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Abstract

The analysis of a compilation of deep CTD cast conducted in the western Mediterranean from 1998 to 2009 have documented the role that dense shelf water cascading off the Gulf of Lions plays in transporting suspended particulate matter from the coastal regions down to the basin. Deep CTD casts revealed that after the 1999 and 2005-2006 major cascading events the Western Mediterranean Deep Water was characterized by the presence of a thick bottom nepheloid layer that scaled in thickness with a thermo-haline anomaly generated by the mixture of dense waters formed by deep convection at open sea and by cascading off the Gulf of Lions shelf. The aim of this contribution is to characterize the observed bottom nepheloid layers and determine their spreading and residence time in the western Mediterranean basin.

Keywords: Western Mediterranean, Hydrography, Sediment Transport, Gulf Of Lions

Suspended particulate matter in the oceans plays a key role as extractors from, transporters through and sources to the water column of many major and minor elements, being responsible for maintaining most oceanic chemical concentration gradients [1, 2]. Particles are introduced into the ocean by biological production, rivers, glaciers, wind and bottom sediments resuspension. Biological, chemical and gravitational influences then act to remove particles from the water column. These removal processes, however, occur on much shorter time scales than the formation, movement or mixing of oceanic water masses. Particles, therefore, do not act as pure conservative tracers of water masses. However, their presence and concentration can indicate the location and intensity of oceanographic processes, particularly those involving the resuspension of sediments in deep-sea environments due to strong bottom currents, and be used as a tracer of water motions [3, 4].

The northwestern Mediterranean is one of the regions of the world where massive open sea dense water formation occurs because of cooling and evaporation of surface waters during winter-time [5]. Concurrent with this oceanographic process, coastal surface waters over the wide shelf of the Gulf of Lions also become denser than the underlying waters and cascade downslope, usually through submarine canyons, until reaching their equilibrium depth [6].

Dense shelf water cascading (DSWC) can last for several weeks and the associated strong currents can induce erosion and resuspension of surface sediments in the outer shelf/upper slope [7, 8] and, therefore, generate bottom nepheloid layers (i.e. layers of water that contains significant amounts of suspended sediment). Such layers can be detached at intermediate levels when the density of the mixture of water and particles reach their neutral buoyancy depth. In very dry, windy and cold winters, such as in 1999, 2005 and 2006, DSWC off the Gulf of Lions was exceptionally intense and reached depths >2000 m, evolving into a thick bottom nepheloid layer that spread along the lower continental slope and across the basin (Fig. 1).

The observed bottom nepheloid layers scaled in thickness with the thermo-haline anomaly generated by the mixture of DSWC and dense waters formed by deep convection at open sea, the later only bringing "blue water" free of particles to the basin, being up to 650 and 1450 m thick after the1999 and 2005-2006 events, respectively. Concentrations within the bottom nepheloid layer in the central part of the basin were usually around 0.3 mg/l (i.e. 0.1 mg/l above background levels), reaching higher concentrations close to the continental rise, with near-bottom peaks up to 2 mg/l. These bottom nepheloid layers could be observed to progress from the Gulf of Lions and Catalan margin towards the central part of the northwestern Mediterranean basin, reaching south of the Balearic Islands and west of Sardinia after the 1999 event, and covering the entire basin after the 2005 and 2006 events. Thickness and concentration of the bottom nepheloid layer diminished with distance away from their source and also with time. The turbidity signal could be barely distinguished one year after the 1999 event, but the one generated after the 2005-2006 events can be still clearly detected, confirming that fine particles in dilute nepheloid layers can have residence times of several years [3].

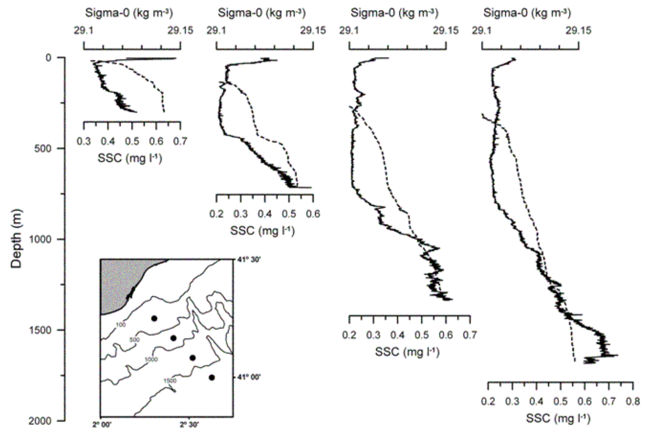

Fig. 1. Vertical profiles of suspended sediment concentration (SSC) and σθ from a hydrographical transect conducted across the Barcelona continental margin, from 300 down to 1700 m depth on 24 March 2005. The inset map shows the detailed location of the CTD casts.

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