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Particle transport in the Bari Canyon (southern Adriatic Sea)

M. Turchetto [a,*], A. Boldrin [a], L. Langone [b], S. Miserocchi [b], T. Tesi [b], F. Foglini [b]

[a] ISMAR–CNR, Sede di Venezia, Castello 1364/A, 30122 Venice, Italy
[b] ISMAR–CNR, Sede di Bologna, Via Gobetti 101, 40129 Bologna, Italy

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Abstract

To define the sediment transport pathways along the southern Adriatic shelf and slope, two oceanographic cruises were carried out in the southern Adriatic, in July 2004 and in March–April 2005. To study the role of the Bari Canyon System on sediment dispersal, three moorings, including sediment traps and current meters, have been deployed near the bottom, at depths of ~600 m, for one year (March 2004–March 2005). Two moorings were deployed within the canyon (station B in the northern branch and station C in the southern branch) and one on the adjacent open slope, north of the canyon system (station A).

Total mass fluxes (TMFs) measured by sediment traps were always higher in the canyon than on the adjacent slope. The highest values were measured at station C (average 8.07 g m^{-2} d^{-1}), roughly double those of station B (3.07 g m^{-2} d^{-1}), and the lowest outside the canyon at station A (1.69 g m^{-2} d^{-1}). The highest TMF were recorded in spring 2004, a period characterized by the lowest water temperatures and the highest current speeds (up to 72 cm^{-1}), which were associated with the highest across-slope current component, along the canyon axes. The simultaneous variations of fluxes occurring at the three stations imply that similar processes are active along the entire southern Adriatic margin, and that they are amplified inside the canyon.

In spring a vein of southward flowing North Adriatic Dense Water (NAdDW) was observed along the Adriatic shelf. This was related to an enhanced across-slope current component, which was responsible for the higher particle fluxes, both on the open slope and at the canyon stations. These data suggest that the Bari Canyon is an efficient conduit for sediment from the Adriatic continental shelf to the deep basin. Downcore profiles of ^{210}Pb in sediments collected below the traps have been used to estimate sediment mass accumulation rates (MARs) on a century scale. On the open slope, the annual trap flux recorded in 2004–2005 was lower than MAR. On the contrary, in the Bari Canyon, the annual trap flux was higher than MAR, indicating that the lateral advection of particles becomes predominant and that a fraction of the particles intercepted by sediment traps was only in transit through the canyon.

Keywords: Bari Canyon; water dynamics; particle fluxes; southern Adriatic Sea

1. Introduction

Canyons act as trapping areas for sediments and provide a direct conduit for sediment transport from the continental shelf to the deep sea depositional systems (Puig and Palanques, 1998; Granata et al., 1999). These studies contribute to the understanding of continental

* Corresponding author. Tel.: +39 041 2404721; fax: +39 041 5204126.
E-mail address: margherita.turchetto@ismar.cnr.it (M. Turchetto).

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margin architecture and strata formation under contrasting and climate induced (glaciated and non-glaciated) settings. Furthermore, canyons influence the water flow along the continental shelf margins by forcing a cross-shelf exchange (Davies and Xing, 2005) and dense water channelizing to the deep basins (Chapman and Gawarkiewicz, 1995; Shaw and Chao, 2003), thus modulating in turn also the amount of particle export. For example, in the Gulf of Lions, downward particle fluxes differ up to three orders of magnitude over a 6-year period (Monaco and Peruzzi, 2002) with interannual variability caused by both particulate inputs and the intensity of the oceanic transport processes including storms, fluctuation of cyclonic currents and dense water cascading (Bethoux et al., 2002). Yet, coastal upwelling under the prevailing wind regime induces high nutrient availability and primary production, which are enhanced where canyon heads are situated close to the coastline. Shelf-indented canyons may be closely related to a fluvial system (Twichell and Roberts, 1982; Farre et al., 1983), constituting a more or less detached element of a large river–sea system. This type of setting is the most frequent on modern continental margins (Liu and Lin, 2004). In the Mediterranean Sea, several studies (Monaco et al., 1990; Peinert and Miquel, 1994; Puig and Palanques, 1998; Monaco et al., 1999; Fabres et al., 2002; Palanques et al., 2005) found relationships between storms and river flood events and increases in particle fluxes inside submarine canyons.

The modern Adriatic Sea is a narrow epicontinental basin (ca. 200 × 800 km) with a low topographic gradient in the north, and a steeper shelf farther south. The basin is dominated by a cyclonic circulation driven by thermohaline currents (Franco et al., 1982; Poulain, 2001). The primary fluvial dispersal system entering the Adriatic Sea is the Po River, with additional contributions from many smaller Alpine, at north, and Apennine rivers at south (Nittrouer et al., 2004).

In modern high-stand conditions, riverine sediment transport and deposition on the Adriatic shelf occur in a narrow belt along the western coast following the main cyclonic current (Sherwood et al., 2004), but the process is step-by-step, constituted by a series of transport events (Nittrouer et al., 2004). Maximum sediment accumulation occurs in three different areas respectively the Po prodelta area, along the central Adriatic margin and in the Gargano area (Cattaneo et al., 2003; Cattaneo et al., 2004; Frignani et al., 2005; Palinkas and Nittrouer, 2007). Century-scale mass budgets of fine sediment in the western Adriatic continental shelf gave an unbalance between sedimentation and riverine sediment supply in the order of 4.6 Tg y^{-1} (Frignani et al., 2005). Although these estimates are affected by a high degree of uncertainty, the balance suggests a net sediment export from the Adriatic continental shelf to the south Adriatic basin and/or the Mediterranean Sea of about $\leq$10% of the estimated riverine input.

The Bari Canyon System is a morphological structure (Trincardi et al., 2007-this issue; Ridente et al., 2007-this issue) that dissects the western Adriatic shelf in the southern basin. It probably represents the conduit through which the sediment derived from the Po River (~600 km far away) approaches the ultimate repository, potentially capturing sediment in transit and transporting it into the southern Adriatic basin. The Bari Canyon is generally assumed to play an important role in dense water sinking (Bignami et al., 1990a; Vilibić and Orlić, 2002) and sediment transfer to the deep Adriatic basin. However, no direct observations are presently available to explain water dynamics and sediment transport associated with the Bari Canyon System.

To test the efficiency of the Bari Canyon as a major transfer conduit of sediment (coming from north) towards the deep southern Adriatic basin and to evidence the link with water mass dynamics of the basin, three moorings were deployed for one year (March 2004–March 2005) as part of the EU-funded EuroSTRATAFORM-WP2 Project. Specific objectives of this study were: i) to define the sediment transport pathways along the Adriatic shelf and slope; ii) to study the role of the Bari Canyon System on sediment dispersal, and iii) to characterise particle transport, fluxes and accumulation associated with and forced by canyon dynamics.

2. The southern Adriatic margin and the Bari Canyon System

2.1. Oceanographic setting

The Adriatic Sea is commonly divided into three sub-basins: the northern Adriatic, a broad shelf with depths shallower than 100 m (north of Ancona), the middle Adriatic including the Middle Adriatic Pit (270 m depth) and, from the Pelagosa Sill to the Otranto Strait, the southern Adriatic basin, with a depression (the South Adriatic Pit) of about 1200 m (Fig. 1).

The main water masses recognized in the southern Adriatic basin are: at the surface, the Adriatic Surface Water (ASW), the less saline and particle rich water flowing on the western Italian side, and the warmer and more saline Ionian Surface Water (ISW) on the eastern side. The intermediate layer is characterised by the Levantine Intermediate Water (LIW), coming from the eastern Mediterranean with high salinity (>38.70) and a