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Sediment transport event analysis on the western Adriatic continental shelf

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Abstract

The sediment-transport mechanisms that contribute to and redistribute the modern sediment deposits on the western Adriatic continental shelf were evaluated utilizing data collected from two instrumented benthic tripods deployed at 12-m water depth, one in the northern Adriatic basin on the Po River subaqueous delta, and the other in the central Adriatic basin on the Pescara River shelf. Sediment-resuspension events driven by cold, northeasterly Bora winds dominate the along-shelf transport climatology at both tripod locations, but at the Po delta site, the southwesterly Scirocco wind events also play a significant role. At the Pescara shelf site, interaction between Bora wind-driven currents and the Western Adriatic Coastal Current strongly contributes to the resuspension and advection of suspended sediment. Interannual variability of the forcing mechanisms (including strength, frequency, and relative mix of Bora and Scirocco wind events) is evident in the three winters of data collected on the Po River subaqueous delta. In both types of wind events, and throughout all years of data collection, the net along-shelf sediment transport is significantly larger than the net across-shelf transport at the 12-m sites. This may be characteristic of low-energy environments, where sediment resuspension and transport occurs in such shallow water that it is not subjected to strong downwelling features characteristic of higher-energy environments.

Keywords: Sediment flux; Sediment resuspension; In situ measurements; Nearbed sediment concentration; Adriatic sea; Po river; Pescara river

1. Introduction

Over the past 30 years, observational studies of nearbed sediment transport have occurred on many continental shelves. Winter storms and associated waves, as well as river input, have been found to be the dominant forcing mechanism of sediment flux in high-energy environments (e.g., Drake and Cacchione, 1985; Sherwood et al., 1994; Ogston and Sternberg, 1999). The strength of storms, the forcing of upwelling and downwelling conditions, and timing of storms with respect to river discharge are important factors in determining the amount of sediment transported along and across the continental shelf, and ultimately the fate of particles discharged to the ocean. The majority of these studies have been undertaken on relatively short time-scales, monthly to seasonal, and in high-energy

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environments. In studies on highly energetic coastal areas such as the Eel, Russian, and Columbia River continental shelves, episodic events have been found to dominate the transport regime (Drake and Cacchione, 1985; Sternberg, 1986; Sherwood et al., 1994; Ogston and Sternberg, 1999).

From 1995 to 2000, one of the few long-term comprehensive shelf studies (STRATAFORM) occurred on the high-energy northern California shelf, offshore of the Eel River. Scientists involved in this study showed that there was significant interannual variability in terms of sediment resuspension, near-bottom sediment flux, and dispersal direction on the Eel continental shelf (Ogston et al., 2004). The magnitude and distribution of sediment-suspension and transport events showed a strong seasonality, controlled primarily by winter storms and episodic floods (Ogston and Sternberg, 1999), the concurrence of which provided conditions for strong across-shelf transport due to both downwelling processes and fluid-mud formation (Ogston et al., 2000; Traykovski et al., 2000). In the lower-energy environment of the Ebro continental shelf, off the southeast coast of Spain, storms cause significant sediment transport in shallower water, i.e., on the inner shelf, and minimal sediment transport in deeper areas. On the Ebro shelf, sediment transport has been studied in a number of short deployments (Palanques et al., 2002; Puig et al., 2001) and along-shelf sediment transport was found to be an order of magnitude greater than across-shelf during a 3-month period (Palanques et al., 2002). Although lower-energy settings have not been studied extensively, processes controlled by the interaction between storms and floods that impact the offshelf sediment flux may differ from those on higher energy shelves.

As a contrast to the studies on the Eel River shelf, one component of the present study (EuroSTRATAFORM) has focused on sediment transport and accumulation processes in the Adriatic Sea. The region is characterized as an epicontinental basin with a relatively low-energy wave environment and spatially variable forcing by wind and river discharge. Studies of the delivery and redistribution of sedimentary deposits were undertaken along the western Adriatic continental shelf from December 2000 to May 2003. Bottom boundary layer (BBL) instrumentation was deployed on the Po River subaqueous delta to provide long-term monitoring of nearbed flow and sediment transport from 2000 to 2003. Additionally, BBL instrumentation was deployed on the Pescara River shelf, adjacent to one of the largest Apennine Rivers as part of a multi-investigator Po and Apennine Sediment Transport and Accumulation (PASTA) observational and modeling experiment. This focused study was designed to explore the regional variations of transport processes during winter 2002–2003.

One important component of the overall project is directed at understanding the pathways and mechanisms of sediment transport that both create and redistribute the modern sediment deposit along the western Adriatic continental shelf. The dominance of particular sediment-transport pathways and mechanisms are dependent on the interactions of specific storm systems with sediment supplied from rivers to the coastal zone. Not only is understanding the long-term variability of a transport system relevant for ecological and environmental studies, but it is also relevant for geologic studies of the ultimate fate of particulate matter in the marine environment and the resulting depositional structure.

In this paper, sediment-transport events along the western Adriatic shelf are described during various storm and river flow conditions. The main objective is to characterize spatial differences in frequency, duration, and magnitude of forcing mechanisms of sediment resuspension, and their implication for sediment deposition. The temporal (interannual) variability of transport processes on the Po River subaqueous delta is also addressed. The characteristics of transport events provide a basis to discuss implications for redistribution of modern sedimentary deposits in this low-energy system and to compare to areas of differing wave energy and river input.

2. Study area and event forcing

The Adriatic Sea is a semi-enclosed basin consisting of three morphologic domains: the northern, central and southern basins (Fig. 1). This analysis examines transport processes on the western side of the northern and central basins. The northern basin, into which the Po River flows, has shallow water depths and low slopes, while the central basin, into which the Apennine rivers flow, reaches depths of >200 m and has steeper slopes (Cattaneo and Trincardi, 1999). Multiple rivers discharge freshwater and sediment on both the east and west sides of the Adriatic Sea, but only on the western Adriatic has a significant nearshore mud