EUROSTRATAFORM: Sediment Transport Processes and Shelf Development

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LONG-TERM GOAL

The long-term goal of the sediment transport and accumulation component of Euro-STRATAFORM is to link sediment transport processes to the formation and preservation of event beds in sediment deposits.

OBJECTIVES

Our main objective within EuroSTRATAFORM is to investigate sediment dispersal mechanisms on the shelf. Instrumentation of the shelf on the Po River delta and in the Apennine Rivers region of the Adriatic Sea and subsequent data analyses allow us to:

1) investigate the range of processes responsible for shelf transport of sediment (including "storm-driven" and "density-driven" processes), their dominant pathways (surface plume, intermediate nepheloid layer, or bottom boundary layer), their relationship to grain size and their role in shelf development,

2) contrast results in the Adriatic Sea (from two study areas: one with concurrent oceanic forcing and river discharge, and one with oceanic forcing and river discharge disconnected in time) with results from STRATAFORM (the Eel shelf), and

3) provide a regional climatology of sediment transport processes (Po River delta & Apennine Rivers regions).

APPROACH

The two study areas within the Adriatic to be investigated as part of EuroSTRATAFORM provide a contrast to the Eel River shelf, and allow evaluation of two different end-member river systems discharging into a relatively low-energy oceanic basin. The two study areas are the *Po System* and the *Apennine System*. Discharge from the Po River comes from a large drainage basin and is relatively disconnected in time from energetic conditions in the Adriatic. The sediment deposit located to the south of the Po River mouth suggests alongshelf dispersal of sediment from this point source. In contrast, discharge from the Apennine rivers is highly episodic, coming from a distributed-source system of small, high-yield drainage basins. High discharge and more energetic oceanic conditions

probably occur concurrently. The shelf is characterized by steep slopes and a prograding clinoform feature which suggests that sediment discharged from the rivers is likely transported rapidly across-shelf. Similarly, the Eel River is also an episodic, high-yield system and floods occur contemporaneously with high-energy conditions in the ocean basin. However, the dominant depositional feature is a mid-shelf mud deposit rather than a clinoform.

Po System: A long-term monitoring tripod will be maintained near the mouth of the Po River on the modern sediment deposit through three winter periods ending May 2003. This will provide over a year of continuous data and an additional winter (high discharge period of the Po River) in three consecutive years. Continued profiling of the water column (CTD/suspended-sediment concentration and pumped samples) during instrument deployment/retrieval times at the time-series seabed coring sites provides information on spatial variability of sediment suspension and provide collaborative opportunities with investigations of seabed processes (Nittrouer, UW and Wheatcroft, OSU), flocculation dynamics (Hill, DAL, and Milligan, BIO) and flume studies of convective sedimentation (Parsons, UW). Interaction with A. Boldrin (CNR, Venice) provides biological significance to the proposed work (Boldrin et al., 2001).

Apennine System: An instrumented tripod will be deployed in the region of the Pescara River, as part of an overall array of boundary layer tripods (WHOI/USGS/Dalhousie/UW/ICM) designed to examine the sediment dispersal dynamics from the mouth of the Po to south of Pescara. The tripods are capable of examining boundary-layer processes, sediment characteristics, and water-column currents over the winter experiment. Our studies will be directly coordinated with studies of processes on the topset and foreset regions of the clinoform feature characteristic of this area (with Puig, ICM). They will also coordinate with studies of internal-wave dynamics in the crenulated region of the foreset (Puig, ICM and Cacchione). Profiling of the water column will occur at the deployment and retrieval times on transects located on the tripod array lines to evaluate the spatial variability in water column structure between the tripod locations. Profiling during instrumentation deployment will be coordinated with the more intense water-column studies in Feb 2003 (potentially in a pseudo-rapid-response mode during high discharge of the river) by Kineke (BC).

Adriatic Basin Sediment Transport Climatology: Between the experiments on the Po and Apennine systems, three winters and one summer of time-series data near the Po and one winter of data near Pescara will be collected. From these data a regional climatology of sediment transport events can be developed that will allow comparison to other systems. In addition to water-column profiling in the instrumented focus areas at deployment/retrieval times, we will coordinate with the regional coring to be performed by the seabed group to carry out a regional water-column study of the combined Po/Apennine systems to examine the differences between a point-source (Po) and distributed-source (Apennine) system, and the intermingling of the two systems. The objectives of the water-column work will be to: 1) provide a regional context for both the Po and Apennine studies, and 2) to examine suspended-sediment signals from the Po River, from the distributed source Apennine region, and from the region where the two systems merge.

Our proposed work is not only directed at a few specific scientific questions, but the longer-term (3-yr) and extensive along-shelf observations provide a regional context in which others can frame their results. We plan to collaborate with and to supply input to the seabed, modeling and plume efforts.

WORK COMPLETED

Since this project started in October 2001 (and with pre-project funding in response to the October 2000 flood in the Po River), we have maintained a boundary-layer tripod near the mouth of the Po for a total period of 15 months (Jan 2001 – Apr 2002). During instrument deployment and turnaround times, we have conducted detailed water-column profiling near the Po mouth (6 seasonally varying cruises). In April 2002, we preformed a large-scale survey of water-column properties from the mouth of the Po to the southern edge of the Apennine region that will be the focus of our studies this coming winter. As a result of this survey and a planning meeting of the observational PI's on the EUROSTRATAFORM project, a coordinated observational plan has been put in place for the coming winter studies.

RESULTS

Sediment transport processes have been studied on the continental shelf in a variety of environments and the role of waves and wave-current interaction on sediment resuspension and transport has been investigated. The Adriatic provides a lower-wave energy environment in which to test our concepts of shelf sediment transport. We are still in the process of collecting data and the following are preliminary results based on analyses of data near the Po River.

Results of the water column profiling show that on the Po River delta, there is sediment in suspension within three separate transport pathways: the surface plume, an intermediate nepheloid layer, and the bottom boundary layer. There is strong season variation in both the water column density structure and suspended load relating to these pathways in the water column. The surface plume thickness can be related to changes in river discharge and is most well-defined directly off the individual distributary mouths of the Po. Suspended sediment concentrations are relatively low (typically <30 mg/l) implying that much of the sediment from the river is removed from suspension at very shallow depths, probably due to flocculation within the river itself (Milligan & Hill). A weak intermediate nepheloid layer is seen persistently over the shelf, although of low suspended sediment concentration, and therefore probably not a dominant transport pathway except during calm, low river flow conditions. The bottom boundary layer always shows an increase in suspended sediment concentration, with the magnitude depending on the rapidly changing sea conditions. The water column profiling results lead us to believe that the majority of the sediment delivered from the Po River is rapidly delivered to the seabed (typically within the 10-m isobath) under normal river flow conditions. Subsequent remobilization by bottom boundary layer processes during energetic transport events then provides the transport mechanism for redistribution.

Time-series results show that sediment is resuspended on the shallow shelf (12-m water depth) during the more energetic conditions in the Adriatic. Although these events are of relatively low wave height and short period, their effect is felt within the bottom boundary layer at shallow depths. These small storms occur frequently throughout the winter, decaying in magnitude and frequency into the spring. The net transport through the the 15 month record on the Po delta is directed primarily along-bathymetry to the SW. Examination of individual events that make up the net flux shows that events related to Bora winds contribute the most to the net flux. Events associated with Scirocco wind also contribute to the net transport, but with less magnitude and, at present, with no obvious transport pattern. We are working with modelers (Pullen, NRL and Harris, VIMS) to provide verification for regional models that will help put our measurements into perspective and help us understand these two

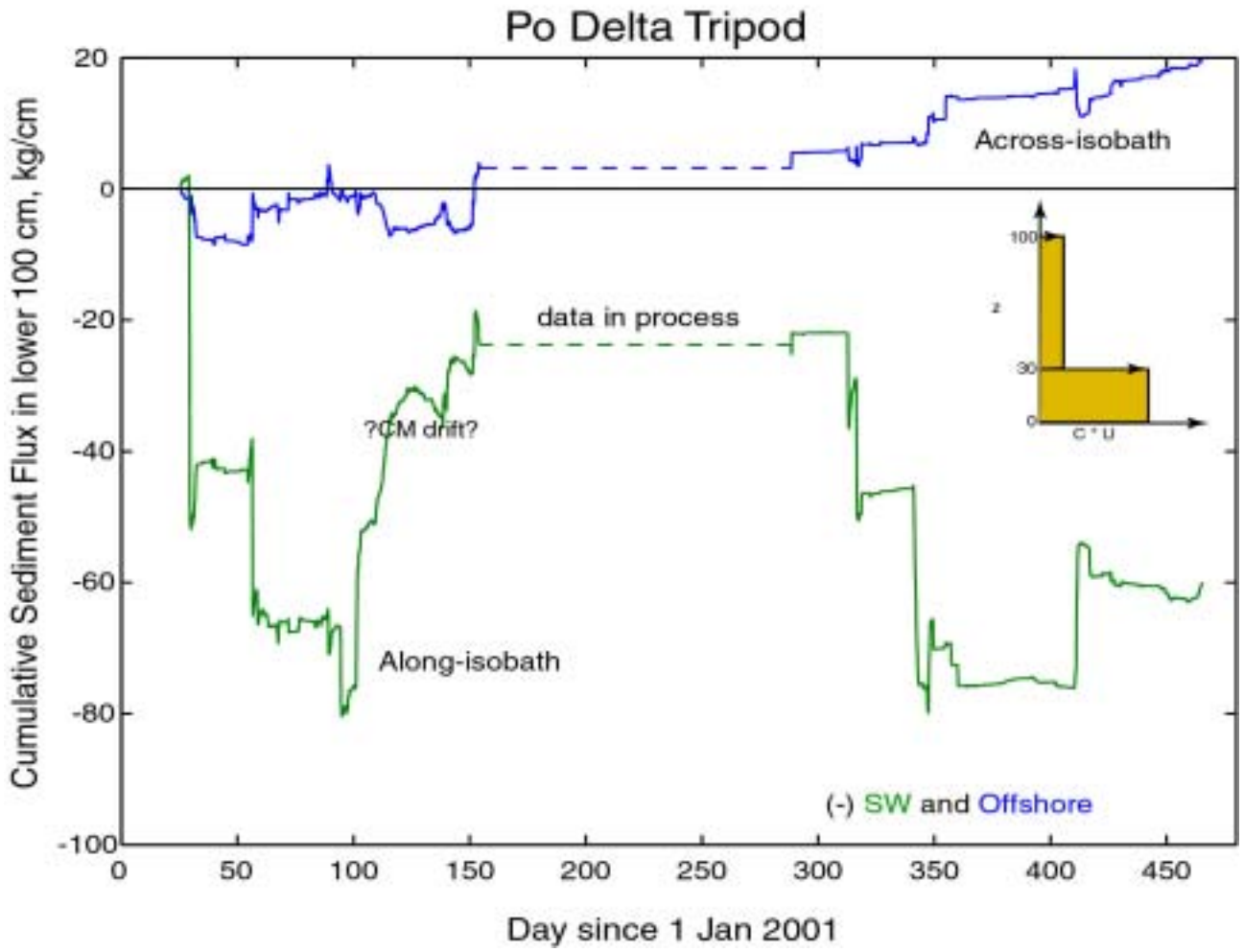

Figure 1. Cumulative sediment flux for the 15-mo record on the Po River delta. The net flux over this period is dominantly to the SW and slightly offshore. The large Bora wind events appear to drive the net sediment flux in the alongshelf direction with the smaller Scirocco events having less impact.

dominant flow regimes. In the net, sediment moves to the south along the bathymetry, with little offshelf dispersal, consistent with seabed observations.

Suspended sediment concentrations reached up to 2 g/l in the largest events at 13 cmab, but did not appear to reach fluid mud concentrations. High levels of backscatter recorded with an ABS at the time

series site suggest that higher concentrations may occur in a very thin layer (2-3 cm) during the strongest event of the 15-mo record. It is not likely that this thin layer produces significant downslope flow due to density changes. Fluid mud (or gravity driven) processes do not appear to take a large role in the across-shelf transport in this lower-energy system.

IMPACT/APPLICATION

This work will allow the sediment transport community not only to extend results from the STRATAFORM project, but also to gain new insights on transport processes in a relatively low wave energy environment. Studies near the mouth of the Po River allow investigation of transport processes where floods and storms are not necessarily concurrent in contrast to those of the Eel River shelf. The two study areas within the Adriatic provide a comparison between transport processes away from the mouth of a point source (Po Region) and at the downstream end of a multiple source system (Apennine Region).

TRANSITIONS

The EuroSTRATAFORM program is a collaborative project among many investigators. Understanding of the sediment dispersal mechanisms in these systems is important to the overall success of this project, if we are to attain the long-term goal of linking modern transport processes to formation and preservation of strata. The data collected is being used by multiple investigators in the EuroSTRATAFORM program. Specifically, Pullen (NRL) and Harris (VIMS) are using time-series data to validate their physical oceanographic and sediment transport models. Sediment size and settling velocity data from the time-series location is being used by Hill (Dalhousie).

PUBLICATIONS

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