Sediment Dispersal in the Gulf of Lions:
Water Column Dynamics and Potential for Cross-Margin Transport

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LONG-TERM GOALS

The most general long-term goals of this study, as part of EuroSTRATAFORM, are to investigate a) the oceanic processes that erode, transport, and deposit sediment in the margin system; and b) how fine sediment erosion, transport and accumulation impact water-column turbidity and seabed strata where modern fluvial sediment is transferred across a continental shelf.

OBJECTIVES

This project is a continuation of the EuroSTRATAFORM project and the objectives over the past year focused on analysis and synthesis of results from PASTA (Po and Apennine Sediment Transport and Accumulation); preliminary analyses of results from field work in the Gulf of Lions; and examination of the optical response to sediment resuspension events using an Autonomous Profiler in collaboration with the OASIS project taking place at the Marthas Vineyard Coastal Observatory.

APPROACH

To understand the mechanisms responsible for dispersal of sediment once delivered to the marine environment, a combination of water column (surface to very near bottom) and bottom-boundary layer time-series measurements are necessary. Hydrographic surveys have been combined with time-series measurements in the Adriatic and the Gulf of Lions to investigate sediment resuspension and transport and the means of transporting sediment across the continental shelf.

Additional effort has been focused on a new instrument package, the Autonomous Profiler (AP). The AP, equipped with a CTD and Optical Backscatterance Sensor (OBS), is attached to a programmable, submersible winch. The buoyant instrument package when reeled in sits on the bottom, and is released to the surface at a pre-programmed time interval, and then reeled back down to the bottom, recording CTD/OBS. Combined with an upward looking ADCP, quasi-continuous high resolution (vertically) water column properties, suspended sediment, and velocity are obtained throughout the entire water column. In the case of the Gulf of Lions, where changes from well-mixed to stratified (upwelling) conditions may determine the likely pathway for sediment dispersal (i.e. coastal current or episodic gravity flows), quasi-continuous records of the entire water column would be useful for assessing the importance of these different pathways. In other environments (e.g. the Marthas Vineyard Coastal Observatory), the AP provides measurements useful for distinguishing between local resuspension and advection.

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WORK COMPLETED

Results from the Adriatic have been presented at several professional meetings and collaborative manuscripts are in the submittal and revision stages. Field work in the Gulf of Lions was executed between October 2004 and April 2005. Delayed permission from the French to deploy instrumentation combined with a shortened deployment of the AP due to an electronics failure resulted in a limited data set. Numerous hydrographic and ADCP surveys were completed on each of the three cruises with a combination of instruments – the ship's rosette/CTD system for deep water casts, a Seabird CTD and Ocean Sensors CTD with a single Niskin bottle for shallow water and near bottom suspended sediment samples. Suspended sediment was determined from filtered water samples obtained from each cast and calibrations of the optical sensors have been completed. Integration of the hydrographic surveys with the time series measurements is in progress.

The AP was repaired, tested, and deployed at the Marthas Vineyard Coastal Observatory in conjunction with the OASIS project which is examining the optical and acoustic response to sediment resuspension events.

RESULTS

A summary figure for transport on the Apennine margin (PASTA) is presented in Figure 1. Three cross-shelf transects off the Chienti River show an idealized picture of the response of the water column during Bora events, based on direct observations and model results. During 'ambient' conditions fine suspended sediments are confined to relatively shallow water typically <10 m, close to the Apennine Rivers, and concentrations are around 10 mg/l throughout the water column. During Bora conditions, sediments are resuspended by waves, the coastal current widens and deepens, and the region of maximum sediment concentrations moves farther offshore, to ~ 15 m depth. After the Bora passes, stratification is re-established, and sediments settle in deeper water. The area where the bottom front moves on and offshore roughly corresponds to the location of the sand-mud transition. With repeated Bora events throughout the winter, sediments that are introduced to the coast from local rivers are moved offshore through resuspension, settling and adjustment of the coastal current.

Results from the AP OASIS deployment are presented in Figure 2. The top panel shows temperature which determines the density (salinity was nearly vertically homogenous). The bottom panel shows the suspended sediment concentration for the lower 5 m of the water column (determined from the Optical Backscatterance Sensor calibrated with bottom sediment from the field site) with wave height superimposed. Suspended sediment near the bed increased on September 7 and 9, coinciding with an increase in wave height. There were other periods of increased backscatterance from September 10 to 12 which do not coincide with an increase in wave height. September 10 to 12 does experience cooler water temperatures which could indicate the sediment suspension signals during this time are advective and the OBS might also be responding to a change in particle characteristics. The issue of resuspension versus advection is often one of the critical questions for suspended sediment time-series observations. These data will be useful in combination with observations of particle characteristics and detailed flow measurements carried out by other investigators (Boss, Hill, Milligan, Trowbridge).

IMPACT/APPLICATIONS

The development of the Autonomous Profiler for deployment on the shelf is a technological advance with great potential for future work. It is analogous to the advance of single point velocity measurements from rotor or electromagnetic current meters to continuous water column profiles of velocity from an acoustic doppler current profiler. Combination of surface to bottom temperature, salinity, and backscatterance measurements provides greater perspective for detailed boundary layer time series, and potential spatial gaps that occur with CTDs mounted on moorings.

TRANSITIONS

See Related Projects below.

RELATED PROJECTS

Collaboration continues with Geyer (WHOI), and Sherwood (USGS) to complete model comparisons with large scale spatial observations from the hydrographic surveys and time-series measurements from the Apennine margin (PASTA). Similarly, nearshore time-series measurements at the Tet River site (Kineke, Wheatcroft) will be integrated with studies of particle dynamics (Hill, Milligan), cross-shelf hydrographic measurements (Kineke, Durrieu de Madron). Data collected with the Autonomous Profiler will be integrated with observations by other researchers involved with OASIS, particularly Boss (U Maine), Hill (Dalhousie), Milligan (Bedford Institute of Oceanography), and Trowbridge (WHOI).

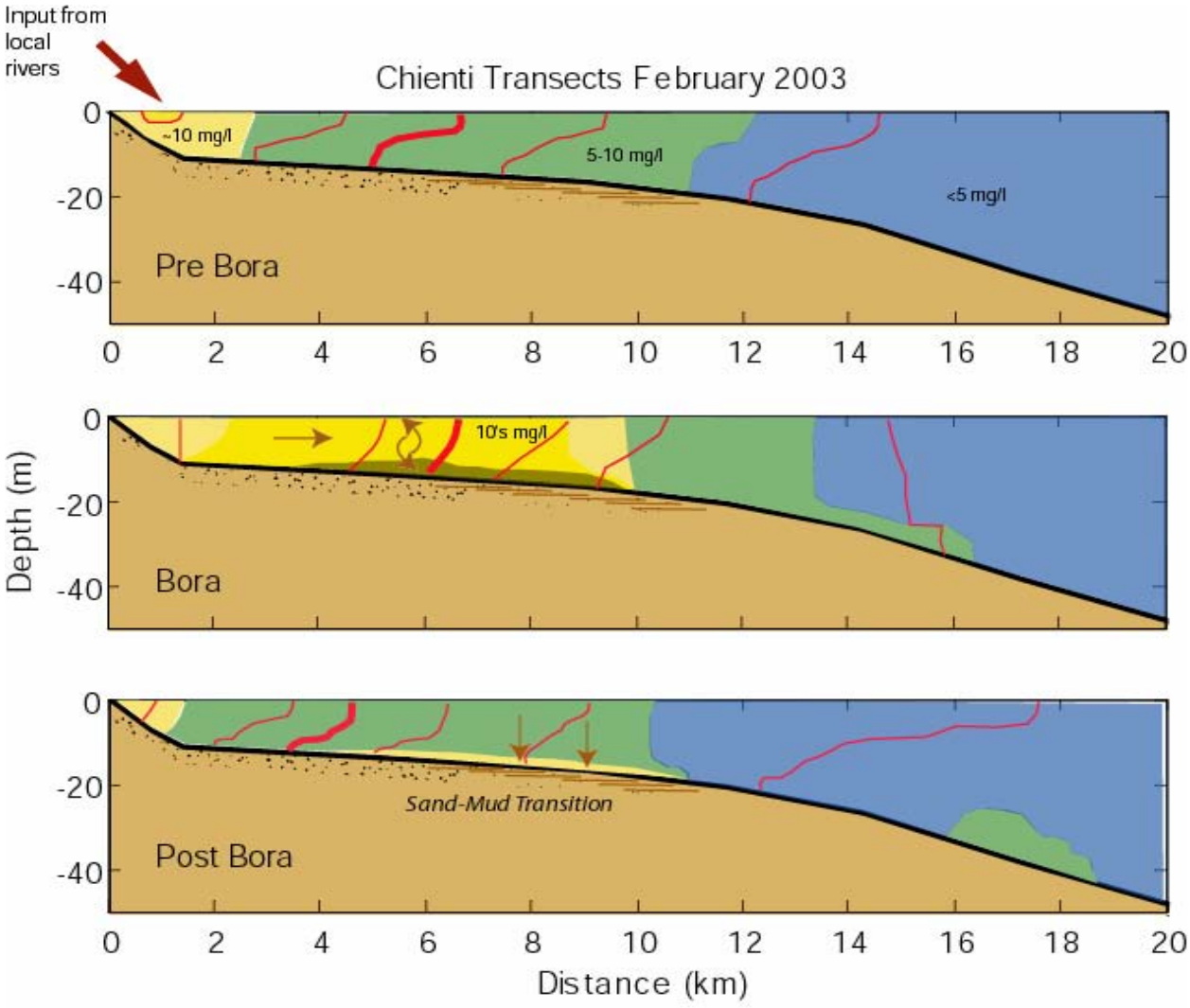

Figure 1. Three cross-shelf transects off the Chienti River on the Apennine margin show an idealized picture of the response of the water column during Bora events, based on direct observations and model results for the PASTA project. The transects show contours of density (sigma-t) in red with the thick line indicating 28 kg/m3. The background colors show suspended-sediment concentration (brown > 50 mg/L; yellow 10-50 mg/L; light yellow ~ 10 mg/L; green 5-10 mg/L; blue < 5 mg/L).

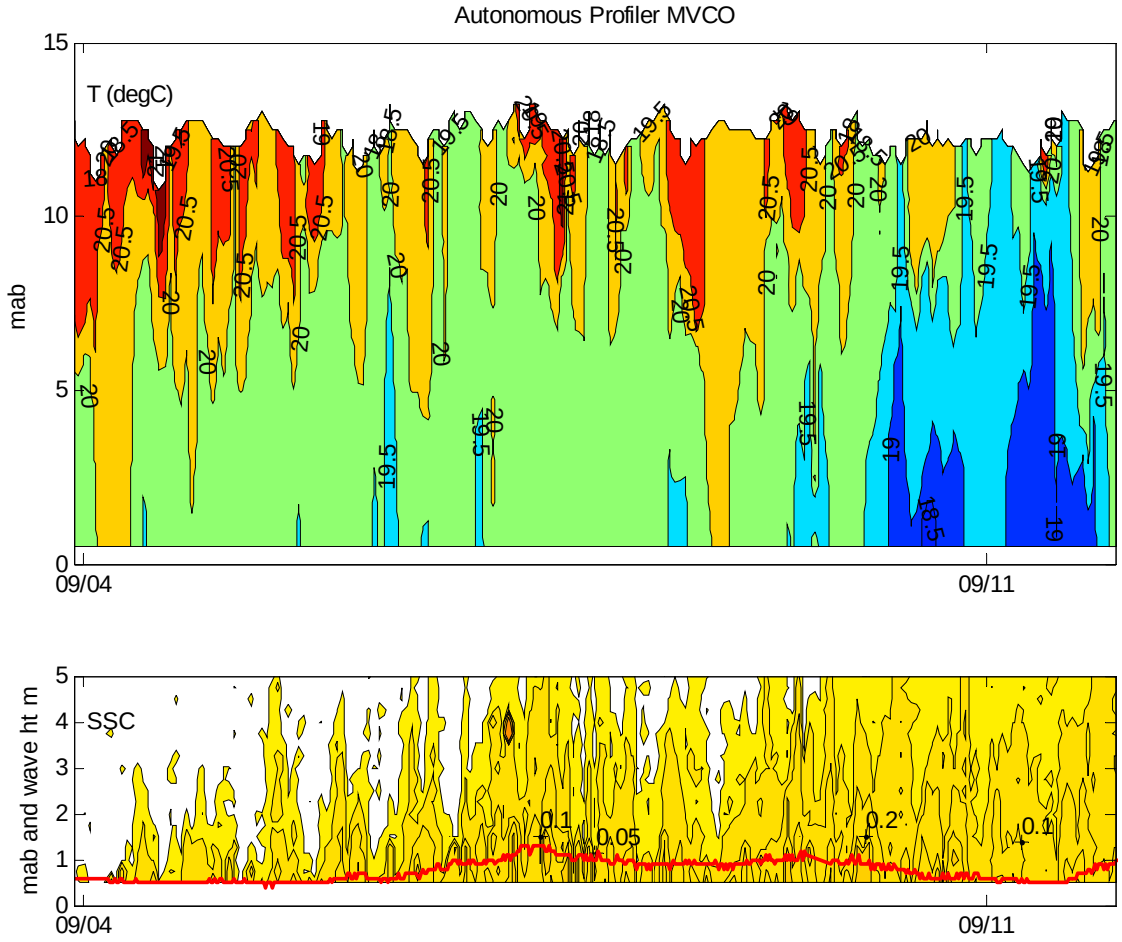

Figure 2. Data from the Autonomous Profiler deployment at Marthas Vineyard Coastal Observatory (MVCO), September 2005. Data were obtained from hourly casts. The top panel presents temperature, which dominates the density signal, and shows a cooling of bottom waters at the end of the deployment. The bottom panel shows suspended sediment concentration in the lower five meters of the water column, determined from an Optical Backscatterance Sensor, calibrated in the laboratory using sediments from the deployment site. Superimposed on the suspended sediment contours is the wave height obtained from the MVCO web site (http://www.whoi.edu/mvco; Woods Hole Oceanographic Institution 9/30/2005). The suspended sediment is correlated with wave height for September 7 and 9, but events on September 10 through 12 are not and may be advected with the cooler water mass.