Field Measurements of Sediment Transport Processes in STRATAFORM: Extended Duration Observations

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LONG-TERM GOAL

The long-term goal of the sediment dynamics component of STRATAFORM is to link sediment transport processes on the continental shelf and slope to the formation and preservation of event beds in sediment deposits.

OBJECTIVES

Our objective is to maintain monitoring instrumentation on the shelf and slope to address the long-term dispersal of sediment in the along- and across-shelf directions. In particular, we are investigating the questions of,

- along- and across- shelf variability of sediment flux on the continental shelf,
- temporal variability of sediment flux on the continental shelf,
- existence and dynamics of fluid mud on temperate shelves, and
- delivery of suspended sediment to the continental slope and the formation of bottom and intermediate nepheloid layers.

APPROACH

A shelf tripod in 60 m water depth (S-60) and a slope mooring in 450 m (Y-450) have just completed their third year of data collection. Measurements of near-bed currents and suspended sediment by the tripod have been supplemented by box coring over the 3-year period. These data are valuable for establishing the dynamics of resuspension and transport over a variety of storm conditions, comparison of suspension during and after flood and non-flood intervals, and seasonal transport patterns. Extended duration observations at S-60 also support the plume study and rapid response sampling. This includes observations to track the increases of nearbed suspended sediment, and net flow directions of nearbed fluid mud layers during storm and flood events, and the correlation of the mud layers to strata development and analysis of sediment collected in the tripod sediment trap (e.g., size, Be-7). The current and suspended sediment instrumentation from the subsurface mooring provides data on the magnitude and mechanisms of particulate transport to the slope, and transport off the slope in the form of bottom and intermediate nepheloid layers.

Andrea Ogston is in the process of combining along- and across-shelf data sets of UW and USGS, investigating the fluid mud characteristics and density flows observed at K-60 and S-60 during the major storm and flood discharge event in February 1997. Josefa Guerra has begun working on the long term sediment flux in response to energetic wave/current events, the effects of interannual variability on shelf sediment transport, and any observed correlations between near-bed sediment

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suspensions, flood sediment discharge, and strata development (working closely with Dr. C. Nittrouer). Erika McPhee is investigating the role of internal waves in forming intermediate nepheloid layers and forcing off-shelf transport of suspended particulate matter. She has carried out model studies in a wave tank investigating the hydrodynamics of internal waves impinging on sloping topography to produce intermediate nepheloid layers, and is working with the USGS temperature-time-series data from the Y-450 mooring which documents the occurrence of internal waves on the slope, as well as CTD-Transmissometer characterization of the slope water column.

WORK COMPLETED

This fall, an additional mooring and guard buoys were deployed at the O-250 site, in addition to continued maintenance of the S-60 tripod and the Y-450 mooring. Baseline CTD-Transmissometer surveys of bottom and intermediate nepheloid layers on the slope were conducted in July and October as part of the investigation of the role of internal waves in forming intermediate nepheloid layers and forcing off-shelf transport of suspended particulate matter.

RESULTS

During the winter of 1996/1997, the Eel River reached the level of a 30-year recurrence interval flood. The sediment flux on the shelf (S-60) during this one extreme flood event accounted for 75% of the winter flood season sediment flux, and an identifiable flood deposit of up to 6 cm thickness has be attributed to this event. An attempt was made to collect grab samples on the inner shelf soon (~10 days) after the 1997 flood event, and this effort was marginally successful for recognizing the presence of ephemeral fluid mud. During this flood period, both the UW monitoring and USGS GEOPROBE tripods (located along the 60 m isobath) observed a thin layer of fluid mud (conc. >10 g/l), suggesting that fluid mud formation may be an active process on narrow, energetic shelves with episodic discharge from small mountainous rivers. As seen in Fig. 1A, extremely high sediment concentrations were observed at 10 cm above the bed (ab) over two 12 to 24 hour periods at the K-63 USGS GEOPROBE location. The resulting mean suspended sediment profiles are shown in Fig. 1B. Fluid muds may not have been observed on these types of shelves in prior studies because instruments have not been placed very close to the seabed.

The boundaries of flood deposits draw attention to the question of what controls their landward and seaward extent. Preliminary observations of the Eel River surface plume demonstrate a nearshore (<30 m water depth), northward trajectory during river flooding, whereas the flood deposit is centered on the 60 to 70 m isobaths. Persistent offshore flows are observed nearbed at S-60 during the winter high discharge season. The pathway of the sediment between the surface plume and the flood deposit is a fundament question for the fate of terrigenously derived sediments.

On the continental slope, sediment is accumulating at rates of 1 to 4 mm/y (Syvitski et al., 1996), and the primary mechanism, based on sediment trap analyses and seismic data, appears to be dispersive sedimentation via nepheloid layers and surface plumes (Walsh and Nittrouer, 1999). Current and temperature measurements obtained from the slope mooring reveal energetic tidal and higher frequency internal waves. Internal semi-diurnal currents at about 15 m above the seafloor occasionally exceed 40 cm/s and are correlated with considerable mixing above the seafloor as indicated by concurrent temperature records, and may provide a mechanism for transport of suspended materials through intermediate nepheloid layers into deeper water. It is hypothesized that sediment dispersal to the slope is focused in two pathways, through the mouth of the Eel Canyon and a convergence zone at the O-line. An additional subsurface mooring has been placed in 250 m water depth along the O-line this winter (98/99) and will subsequently be moved to a location near the head of the Eel Canyon the next winter (99/00) to investigate intermediate nepheloid layer development and the sediment dispersal in both of these areas.

IMPACT/APPLICATION

The finding of fluid mud on the Eel shelf suggests that our interpretation of shelf processes and resulting sediment transport have been too restrictive. Flow dominated and gravity dominated transport modes may not be limited to particular shelf types, as previously considered. These developments have broad implications regarding our observational methods, i.e., the need for instrumentation very close to the seabed, and concepts of transport and deposition of shelf sediments.

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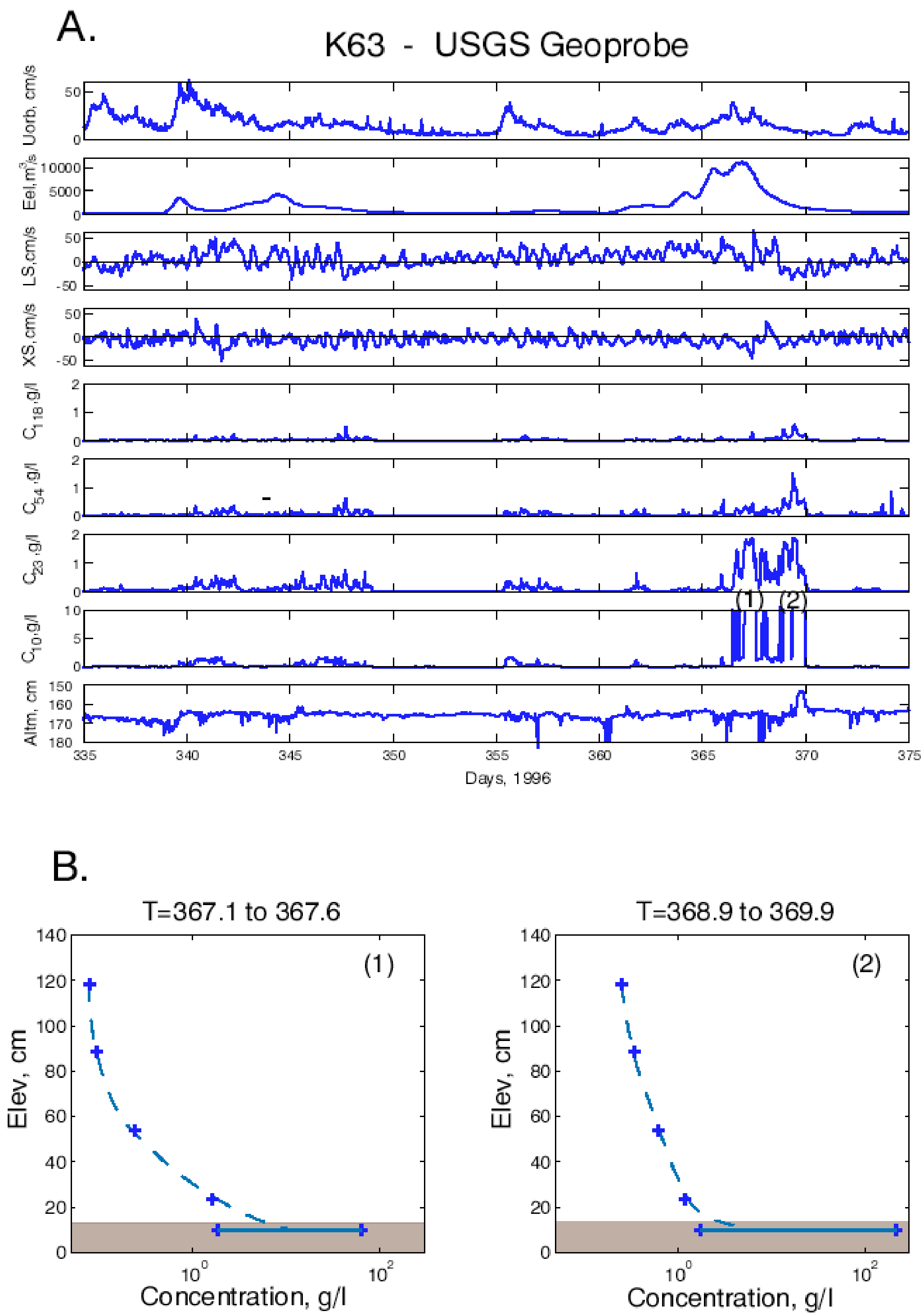

Figure 1. Time series data and mean sediment concentration profiles during time of fluid mud observations. (A) Wave orbital velocity, Eel River discharge, along-shelf and across-shelf velocity, suspended sediment concentration at 118, 54, 23, 10 cm ab, and distance to bed from altimeter measurements. (B) Mean concentration profiles for time periods marked (1) and (2) in A. The bar at 10 cm ab represents the difference between the full laboratory calibration of the OBS sensor (higher concentration), and the apparent concentration using only a partial calibration curve.

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