Evolution of Fine-Grained Sediment Deposits Over Moderate to Long Time Scales

Patricia Wiberg
Department of Environmental Sciences
University of Virginia
Charlottesville, VA 22901
phone: (804) 924-7546 fax: (804) 982-2137 email: pw3c@virginia.edu
Award #: N0001491J1349

LONG-TERM GOAL

My long-term goal within the STRATAFORM program is to increase our understanding of the processes controlling the formation, reworking and preservation of event-scale stratigraphy on the continental shelf.

OBJECTIVES

The objectives of this project for FY98 have been to 1) participate in the analysis and interpretation of the bottom boundary layer field studies; 2) test and apply a 2-dimensional, time-dependent model of shelf sediment transport to investigate the importance of advection and flux divergence to event bed formation and the emplacement of flood deposits; and 3) incorporate flocculation effects into the shelf sediment transport model and evaluate the importance of this process to storm-driven transport.

APPROACH

My approach combines model development and application with data analysis to increase our understanding of shelf sediment transport processes, facilitate data analysis, and improve our predictive capabilities. Over short time scales (deployments), this approach provides a means for extending the measurements in vertical and horizontal spatial dimensions. This approach also provides a means of estimating sediment flux, deposition, and event bed formation over time scales of decades to a hundred years.

WORK COMPLETED

Our two-dimensional, time-dependent model of shelf sediment transport is operational and has been used this year to examine the conditions under which advection and flux divergence are important for sediment redistribution and event-bed formation on the continental shelf.

A simple characterization of flocculated particles in the water column has been included in both our one- and two-dimensional models. Results from the one-dimensional model with flocs have been compared to winter 1995-96 and 1997-98 tripod data from S60 where flocs are known to be present.

I have compared the sediment transport environments on the Eel and Russian River shelves using available historical data. I am now extending this analysis to investigate preservation potential for stratigraphy on event-dominated shelves.

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RESULTS

Courtney Harris' two-dimensional, time-dependent shelf sediment transport model is complete and has been used to investigate the effect of sediment-size variations, water depth, and current patterns on cross-shelf advection and flux divergence during sediment transport events (Harris and Wiberg, submitted). The results demonstrate 1) that advection and limited availability of fine-grained sediment on the inner shelf produce time-dependent sediment fluxes even under steady flow conditions (Figure 1); 2) that advection and flux divergence on the inner to mid shelf produce a sharp transition from predominantly sandy to predominantly silty sediment even in shelf systems with initial spatially uniform silty sand or sandy silt beds; and 3) that flux convergence occurs on the mid shelf owing to a combination of reduced bed stress in the seaward direction and limited fine-grained sediment availability on the inner shelf.

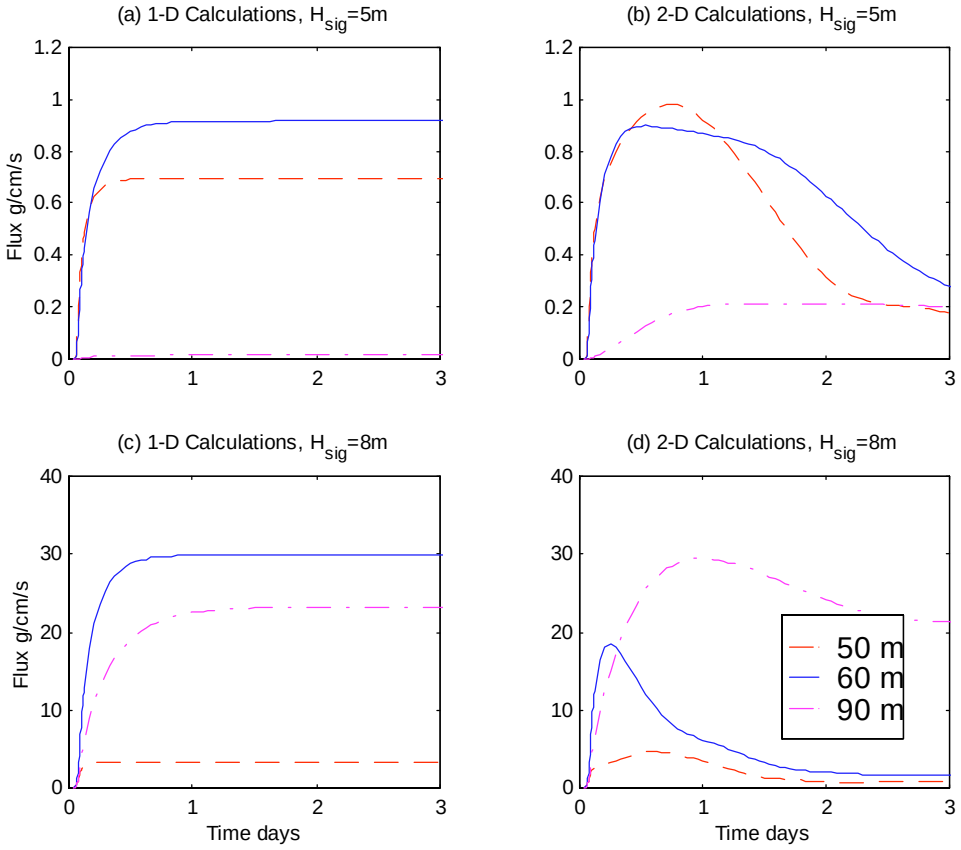

Figure 1. Comparison of 1D and 2D time-dependent model calculations of suspended sediment flux on a graded shelf with silty sand on the inner shelf (50 m) and sandy silt to silt on the mid shelf (60 and 90 m) for constant waves of 5 m and 8m and a steady current directed offshelf and poleward. Advection and winnowing create time-dependent effects in the 2D model under steady forcing conditions whereas the 1D model reaches a steady state.

We have applied our 1D and 2D models of shelf sediment transport to the Eel shelf. Using the 2D model we have computed the transport of sediment between S50 and S70 during the winter of 1995-96 when measurements are available at 4 sites on the S-line within this depth range. Our particular focus has been on the relative magnitudes of the local and advective contributions to suspended sediment

concentrations. The results show that under most conditions, local resuspension dominates measured suspended sediment concentrations, making it difficult to identify the presence of advection during a resuspension event from near-bed suspended sediment measurements.

I have used the 1D model to examine the relative abundance and properties of flocs in the water column during resuspension events. Data from bottom tripod velocity and suspended sediment measurements, particularly at S60, suggest that the particles in the water column during resuspension events are partially flocculated. The flocs appear to be a significant factor in maintaining the steep concentration gradients observed in near-bed suspended sediment concentration measurements at S60 based on data from the winters of 1995-96 and 1997-98 (Figure 2). My preliminary results are summarized in Wiberg (1998, Coastal Ocean Processes Symposium Proceedings). I have also used the 1D model in combination with data from NDBC buoys, USGS gaging stations, NCCCS moorings, and STRESS and STRATAFORM bed and near-bed sampling, to compare transport conditions and sediment retention on the Eel and Russian River shelves (Wiberg et al, 1998 Ocean Sciences Meeting). Larger waves and currents and a finer-textured bed result in calculated transport rates 4 times larger at a depth of 90 m on the Eel River shelf than the Russian River shelf.

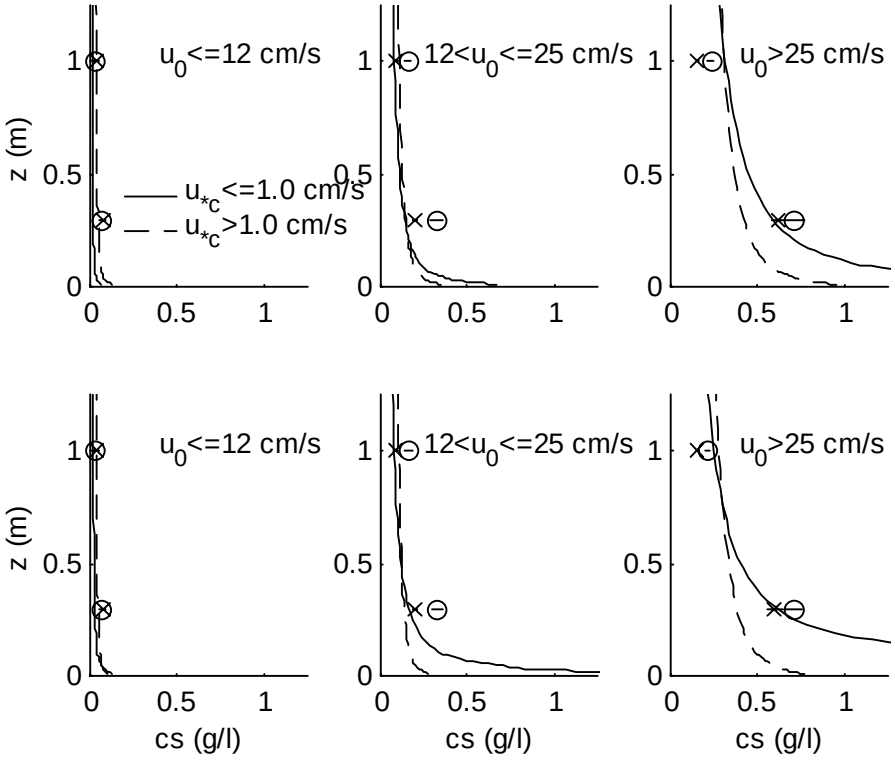

Figure 2. Average measured (symbols) and calculated (curves) near-bed suspended sediment profiles for a range of bottom wave conditions (u_0) and current shear velocities (u_{*c}). Top row: all sediment <45 μm is assumed to be flocculated. Bottom row: no flocculation, but effects of stratification and limited availability are included.

IMPACT/APPLICATION

The results of the 2D model demonstrate the importance of advection and flux divergence to fine-grained sediment redistribution on the shelf. The results of the 1D model demonstrate the effects of flocs on the distribution and transport of fine-grained sediment resuspended during storms, particularly in maintaining a steep near-bed concentration gradient. These results have direct implications for issues related to event-bed characteristics and preservation potential as well as transport rates on fine-grained shelves.

TRANSITIONS

The addition of a characterization of flocs in the water column to the 1D model permits more realistic calculations of sediment-associated contaminant transport and desorption during resuspension events on the continental shelf. These calculations will be carried out as part of a study funded by the ONR Harbor Processes Program. As currently planned, the 2D model will be incorporated into Syvitski's integrated margin stratigraphic model. I am also working with other STRATAFORM researchers to develop appropriate characterizations of shelf transport for more parameterized models of long-term margin evolution.

RELATED PROJECTS

I am using my 1D model to investigate transport and desorption of sediment-associated contaminants in fine-grained shelf environments.

PUBLICATIONS

C.K. Harris and P.L. Wiberg, A two-dimensional, time-dependent model of suspended sediment transport and bed reworking for continental shelves, submitted to *Computers and Geoscience,* Special Issue on Sediment Transport in the Marine Environment.

C.K. Harris, Cross-shelf sediment transport and bed reworking by energetic waves and currents; a quantitative approach, Ph.D Dissertation, Univeristy of Virginia, December 1998.

Cacchione, D.A. and P.L. Wiberg, J.F. Lynch, J.D. Irish, and P. Traykovski, in press. Estimates of suspended-sediment flux and bedform activity on the inner shelf off northern California during STRATAFORM, *Marine Geology*.

Wiberg, P.L., Controls on the volume and distribution of resuspended fine sediment on the continental shelf, Coastal Ocean Processes Symposium Proceedings, Woods Hole Technical Report, December 1998.