Field Studies of Sediment Transport in the Nearshore Environment

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Award #: N00014-96-1-0301
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LONG-TERM GOALS

The long-term goals of this program are to improve our understanding of sediment transport processes in the nearshore. The interactions between physical forcing mechanisms and sediments lead to spatial and temporal variations in sediment flux, beach erosion, and deposition which drives changes in nearshore morphology. Thus small-scale studies of sediment-fluid interactions provide the link to ultimately understanding large-scale beach response.

SCIENTIFIC OBJECTIVES

Our present objectives are to examine the processes of small-scale sediment transport with emphasis on the resuspension and vertical distribution of suspended sediment by turbulent forces generated by both surface-wave breaking and boundary shear flows. We have also initially explored sediment suspension as a function of differing bands of frequency forcing and are considering the impacts of very low-frequency to non-stationary forcing. Additionally, we have prepared the DUCK94 data for public distribution.

APPROACH

The overall approach has been to conduct detailed field studies of sea surface fluctuations, velocity, velocity fluctuations and suspended sediments within the surf zone to investigate the relationship between fluid forcing and sediment response. Specifically, as part of the DUCK94 experiments, we placed arrays of instruments in strategic locations in the nearshore zone and continually measured wave amplitudes, fluid velocity profiles, and suspended sediment profiles over extended time periods (days to weeks). The emphasis in FY00 has been on archiving and summarizing of the DUCK94 data for public release. In addition to spectral analysis techniques that have been used to partition energy in varying frequency bands, we are presently exploring non-stationary analysis techniques to evaluate impacts of very low-frequency and non-stationary processes.

TASKS COMPLETED

During FY00, a manuscript entitled “Effect of wave breaking on sediment eddy diffusivity, suspended-sediment concentration and longshore sediment flux profiles in the surf zone” was submitted and is now in revision for publication (Ogston and Sternberg, in revision).

Data archiving of the DUCK94 experiment data sets has been completed. DUCK94 data files have been transferred onto CD with intentional organizational structure for more efficient access to data for analysis. A summary of the entire data set has been passed to Kent Hathaway of the USACE for public release.

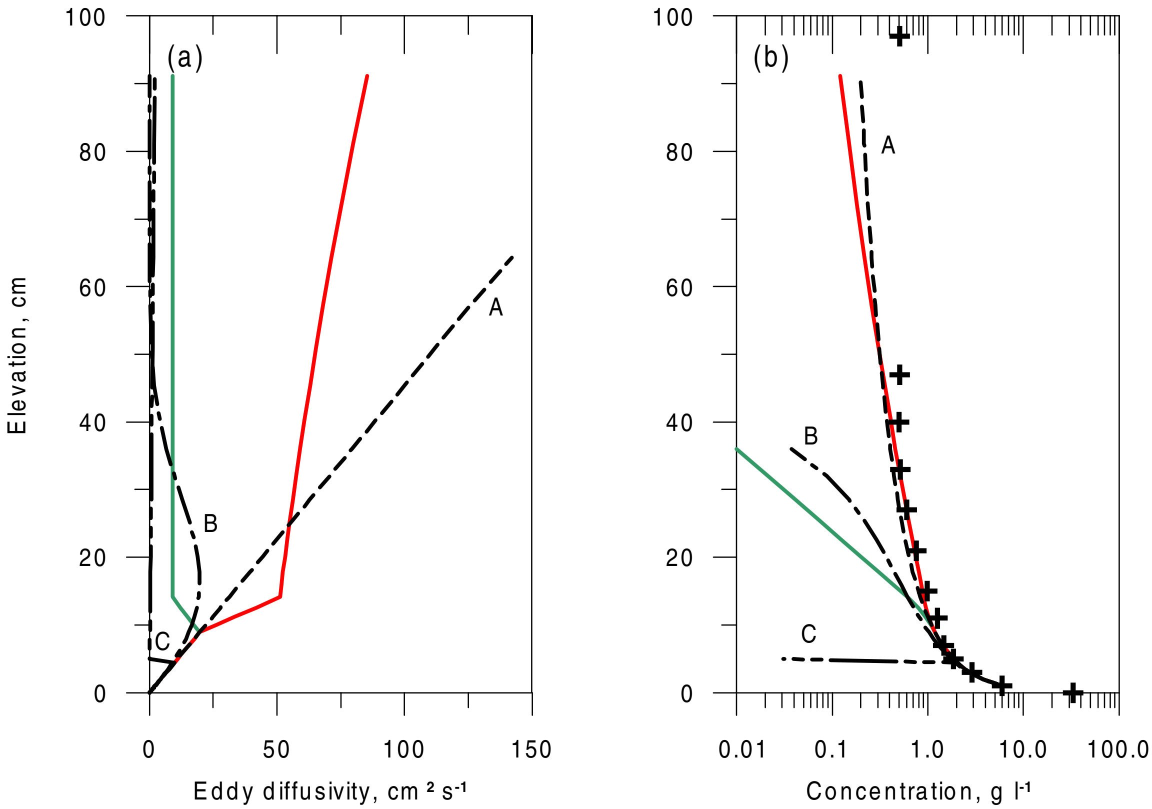

Fig. 1. Example broken wave suspended sediment concentration data (b, cross symbols) illustrating the impact of the vertical profile of the eddy diffusivity relationship (a) on the prediction of suspended sediment concentration (b, lines). The red and green lines are the profiles developed in the present work, and reflect the difference between unbroken waves (green) and broken waves (red). The other eddy diffusivity profiles are typical for boundary layer flow where turbulence is created solely at the seabed, except for line A which extends the wave boundary layer profile throughout the water column, and is conceptually unsatisfying.

RESULTS

Results from the DUCK94 experiment include characterization of an eddy diffusivity profile that incorporates the effects of both boundary shear and wave breaking (Fig. 1a, red line). This eddy diffusivity profile was used to model suspended sediment profiles under unbroken and broken wave conditions (Fig. 1b). Under unbroken waves, suspended sediment profiles exhibit the influence of turbulence generated by boundary shear in a nearbed region of 2–3 times the thickness of the wave boundary layer (2–3 δ; typically 10-15 cm) above which very little sediment can be suspended. Under broken waves, the breaking-generated turbulence enables sediment to be suspended above the bottom boundary layer (Fig. 1b, cross symbols) and is the major mechanism accounting for observed suspended sediment profiles. Wave-breaking turbulence intensity is scaled by breaker height and depth below the surface. A procedure is presented for constructing vertical eddy coefficient profiles reflecting broken or unbroken wave conditions and using that profile to predict suspended sediment profiles and resulting longshore particle flux.

The DUCK94 data summary consists of hourly, 17-min average pressure, currents and suspended sediment concentration profiles (19 elevations above the bed within a vertical expanse of 50 cm) over the experiment period. Bed elevation changes can also be inferred from the suspended sediment sensor response. This data set was sent to Kent Hathaway at the USACE Field Research Facility (FRF) to be incorporated in a web-based data server. The summary will allow public access to processed data so that periods of time of interest can be readily determined and the raw high-frequency data can be requested. The entire raw data set will be archived at the FRF.

IMPACT FOR SCIENCE

Our analyses suggest that sea-surface wave-breaking turbulence has important implications to our concept of surf zone sediment transport. In contrast to what is observed under unbroken waves, elevated levels of turbulence intensity is observed not only in the nearbed shear layer (2-3 δ), but also throughout the water column. This can be seen not only in the analysis of turbulence intensity, but also in the high levels of suspended sediment concentration throughout the water column under broken waves.

Inclusion of turbulence generated by wave breaking in the surf zone can account for observed increases in longshore sand transport, as much as 50% greater than predicted by present theories that use only turbulence generated by boundary shear flows.

TRANSITIONS ACCOMPLISHED AND EXPECTED

These results represent concepts and analytical techniques that have not been included in surf zone sediment transport models to date. It is expected that these results, which are based on DUCK94 data (limited spatial extent), could be compared to SandyDuck results, which are more extensive (extending across the surf zone). If these concepts and techniques are substantiated, they should have a significant impact on future modeling of sediment transport in the surf zone.

PUBLICATIONS

Ogston, A.S., and R.W. Sternberg (in revision), Effect of wave breaking on sediment eddy diffusivity, suspended-sediment concentration and longshore sediment flux profiles in the surf zone. *Continental Shelf Research.*