Field Studies Of Sediment Transport In The Nearshore Environment

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Award #: N0014-96-1-0301
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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

Based on results from past efforts, we are presently concentrating on 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.

APPROACH

The overall approach is 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 and SandyDuck 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). Individual instrument arrays included electromagnetic current meters (at four elevations), a pressure transducer, and fiber optic backscatter sensors (at 19 elevations). Up to nine instrument arrays were deployed in coherent cross-shore and longshore patterns. The emphasis in FY99 has been on data archiving, data analysis and publication.

TASKS COMPLETED

During FY99, a manuscript entitled "Effect of wave breaking on sediment eddy diffusivity, suspended-sediment concentration and longshore sediment flux profiles in the surf zone" has been completed and submitted for publication (Ogston and Sternberg, submitted).
Data archiving of the DUCK94 and SandyDuck experiment data sets has been undertaken. DUCK94 data files have been transferred from 8mm tapes onto CD with intentional organizational structure for more efficient access to data for analysis. Data analysis is ongoing, with focus on investigating wave

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1999**	2. REPORT TYPE	3. DATES COVERED **00-00-1999 to 00-00-1999**
4. TITLE AND SUBTITLE **Field Studies Of Sediment Transport In The Nearshore Environment**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Washington,School of Oceanography,Seattle,WA,98195**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT	b ABSTRACT	c THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

breaking impacts on suspended sediment concentration profiles and the relationship between eddy viscosity for momentum and eddy diffusivity for sediment under unbroken and broken waves.

RESULTS

Based on the combined observations from a previous prototype-scale laboratory experiment and the DUCK94 experiment, an eddy diffusivity profile that characterizes the effects of boundary shear and wave breaking has been parameterized and used to model suspended sediment profiles under unbroken and broken wave conditions. 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 and is the major mechanism accounting for observed suspended sediment profiles. Turbulence intensity from breaking waves is scaled by breaker height and depth below the surface. Position across the surf zone relative to plunge point, appears to be of secondary importance. 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.

Also, the relationship in the nearbed between eddy diffusivity for sediment estimated from the DUCK94 sediment concentration data, and the eddy viscosity for momentum estimated from the measured velocity was examined. Under unbroken waves a ratio of 0.48 was found between them (Fig. 1a, cross symbols). Under broken waves, no relationship could be determined (Fig. 1b, diamond symbols), suggesting methodology used to describe turbulent diffusion outside the surf zone is not necessarily applicable inside the surf zone and bottom boundary shear may not be the primary mechanism responsible for the vertical distribution of suspended sediment, even in the nearbed region.

IMPACT FOR SCIENCE

The results of this investigation suggest some mechanisms that have important implications to our concept of surf zone sediment transport. Although a nearbed shear layer is observed throughout the surf zone (2-3 δ), eddy diffusivity profiles (and thus the resulting sediment concentration profiles) under broken waves do not show correlation to turbulence estimated from

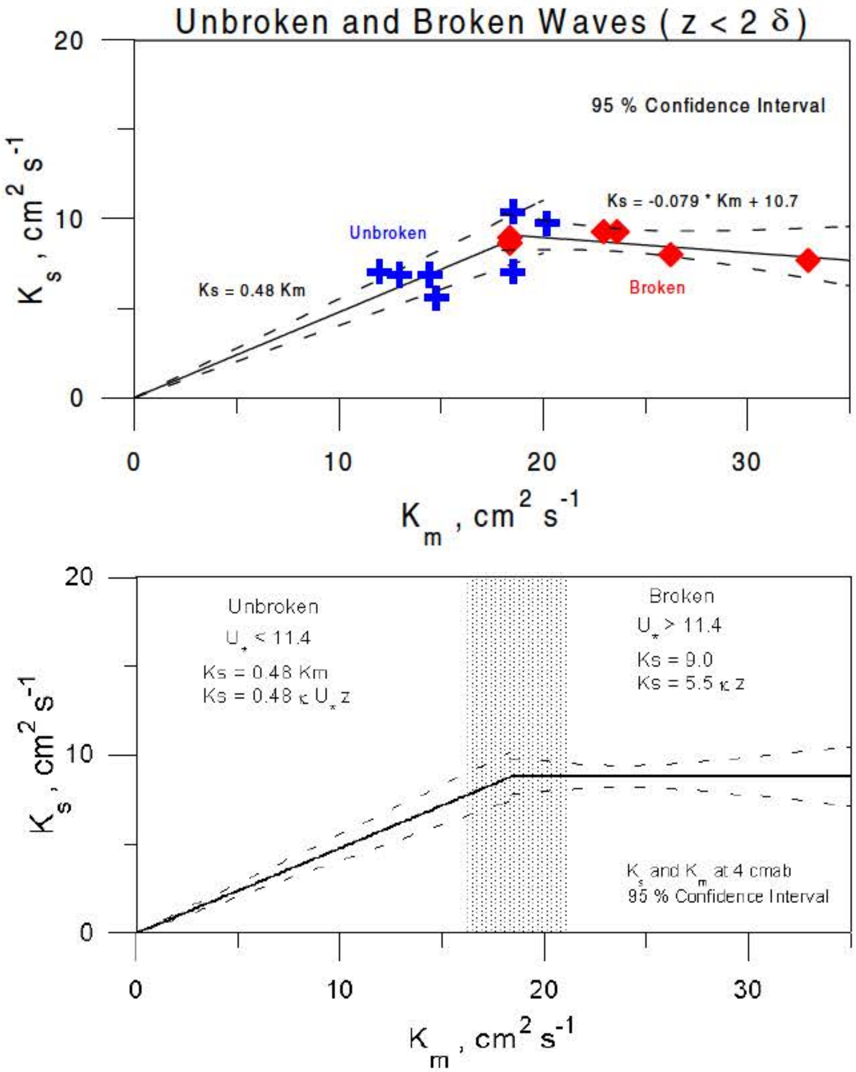

Fig. 1. Relationship between K_s and K_m (a) at 4 cmab under unbroken and broken wave conditions from DUCK94 suspended sediment data and (b) conceptual, with stippling marking the zone of transition between the unbroken wave formulation and the broken wave formulation.

wave characteristics. This implies that $K_S \bullet f(kU_*z)$ or K_m in contrast to what is observed under unbroken waves (U_* estimated from Johnsson friction factor). Rather, eddy diffusivity and concentration profiles are best correlated to the broken wave height to water depth ratio and relative elevation in the water column (i.e., sediment suspension is dominated by turbulence generated by wave breaking which penetrates into the water column, mixing particles upward as the turbulent bore progresses). 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.

The SandyDuck experiment will provide an independent data set for testing of some of the concepts discussed above and will provide detailed longshore suspended sediment information to look at longshore coherence scales.

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), will 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 (submitted), Effect of wave breaking on sediment eddy diffusivity, suspended-sediment concentration and longshore sediment flux profiles in the surf zone. *Continental Shelf Research.*