# Granular-Fluid Interactions Near the Seabed

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## LONG-TERM GOAL

The long term goal is to develop a model which will predict local sand transport and bathymetric change due to waves and currents under time-varying conditions.

## OBJECTIVES

Accomplishment of the long-term goal will require significant improvement of our understanding of the relationships between hydrodynamics and sediment motion near the seabed, as well as the development of models derived from our understanding of the relevant physical processes. An accurate prediction of local bedforms is necessary in order to describe the mixing processes which effect both the hydrodynamics and the sediment motion. A related objective is to characterize and predict the suspended sediment concentration in terms of the reference concentration and a vertical distribution function. This requires coupling between hydrodynamic forcing, bedform response and feedback, bedload sediment transport response, and the suspended sediment response.

## APPROACH

A combination of experimental observations and model development is being pursued simultaneously. Field observations of nearbed suspended sediment and hydrodynamics provide a basis for the discovery of phenomena and development of models. Model development is focusing on the coupling of bedload to suspended load in order to describe the reference concentration, the description of vertical mixing processes which determine the structure of near bed sand suspension under waves, and the prediction of bedforms from local hydrodynamic and sediment characteristics.

## WORK COMPLETED

Field measurements have been obtained at Duck, North Carolina over the past several years, including the SANDYDUCK97 field experiment. Data were collected under a variety of conditions, including storm and storm recovery periods. A new multi-element transducer (MTA), designed to measure bedforms, was deployed at Duck as a component of a new Littoral Sedimentation Processes Measurement System. The MTA allows the measurement of bedform geometry with 2 to 3 millimeter vertical resolution and centimeter horizontal resolution over a profile length of 2.5 meters. The new measurement system also included multi-frequency acoustic backscatter sensors to measure suspended

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sediment concentration, a rotating side scan sonar to measure bedforms, an acoustic Doppler velocimeter to measure fluid velocity, and an underwater video camera pointed downward toward the bed. Nearly all of the data collected have undergone quality control and initial processing. Analysis of data has thus far been limited to a three-day storm period that occurred during SANDYDUCK97.

New algorithms were developed to invert multi-frequency acoustic backscatter measurements to obtain the vertical distributions of median grain size and suspended sediment concentration. New techniques have also been developed to process and interpret MTA data to obtain the dimensions of bedforms.

Theoretical development of a granular-flow based model of sheet-flow sand transport has been developed in collaboration with Dr. James Jenkins. This model provides the concentration profile and velocity profile within the bedload layer for the collision dominated regime. While further work is required for application under waves, this work provides a basis for the linking of bedload processes to suspended load processes, and the prediction of a reference concentration.

A review presentation on boundary layers and small-scale sedimentation processes was prepared and delivered at the Nearshore Sciences Workshop held on October 26-28, 1998, in St. Petersburg, Florida.

## RESULTS

A range of small-scale sedimentation processes were measured in the field under a variety of conditions. For example, Figure 1 shows the response of the nearbed region to a local wind-forced storm event at Duck during October, 1997. The southwestward wind forced a southeastward bottom current and local waves with Hmo of approximately 2 meters. These wave and current conditions resulted in the local suspension of sand, as characterized by the near bottom concentration (NBC). The sand was advected offshore by the prevailing mean currents. This resulted in significant, rapid erosion followed by slow accretion. Interestingly, the local hydrodynamic forcing was quite similar during both the erosion and accretion periods, indicating the three-dimensional nature of the processes, and the fact that morphological change is the result of transport gradients, rather than transport itself.

One of the unique features of our measurements in the accurate description of small-scale morphology we obtain from the MTA. Figure 2 shows an interesting example of the temporal evolution of a large wave ripple. Initially the ripple was approximately 136 cm in length and 3 cm in height. Over the course of a few hours the ripple evolved into two ripples approximately 60 cm in length and 1.7 cm in height. Full interpretation of these measurements requires information about the 3-dimensional structure of the seabed. We are working the with Rotating Side Scan images to interpret the 3-dimensional nature of the seabed morphology.

## IMPACT/APPLICATION

The connections between small scale and large scale sedimentation processes are important in order to develop a comprehensive understanding of nearshore sedimentation processes, and an ability to model bathymetric change. Our research provides new information on small-scale processes that will allow these connections to be discovered and verified.

## TRANSITIONS

ABSOLUTION, the inversion algorithms developed to interpret multi-frequency acoustic backscatter measurements, will be compared to other inversion algorithms in cooperation with Peter Thorne, Chris Vincent, and others in the European “Tridisma” project.

Eric Thosteson will begin a new job as an Assistant Professor at The Florida Institute of Technology (FIT) in January, 1999. Chris Jette, who received his Ph.D. in 1997, has started a small company to manufacture and sell the MTA.

## RELATED PROJECTS

Our NICOP project is closely related. As a part of that project, we are planning to deploy our littoral sedimentation processes measurement system in a large laboratory wave flume in Spring, 1999.

## PUBLICATIONS


Hanes, D.M., Y.S. Chang, C.D. Jette, E.D. Thosteson, and C.E. Vincent, “Field observations of small scale suspended sedimentation processes,” *26th International Conf. on Coastal Engineering, ASCE*, Copenhagen, Denmark, June 22-26, 1998.

Hanes, D.M., C. D. Jette, E. D. Thosteson, and C. E. Vincent. "Field observations of nearshore, wave-seabed interactions," Coastal Dynamics '97, ASCE, Ed Thornton, Editor, pp. 11-18, 1998.

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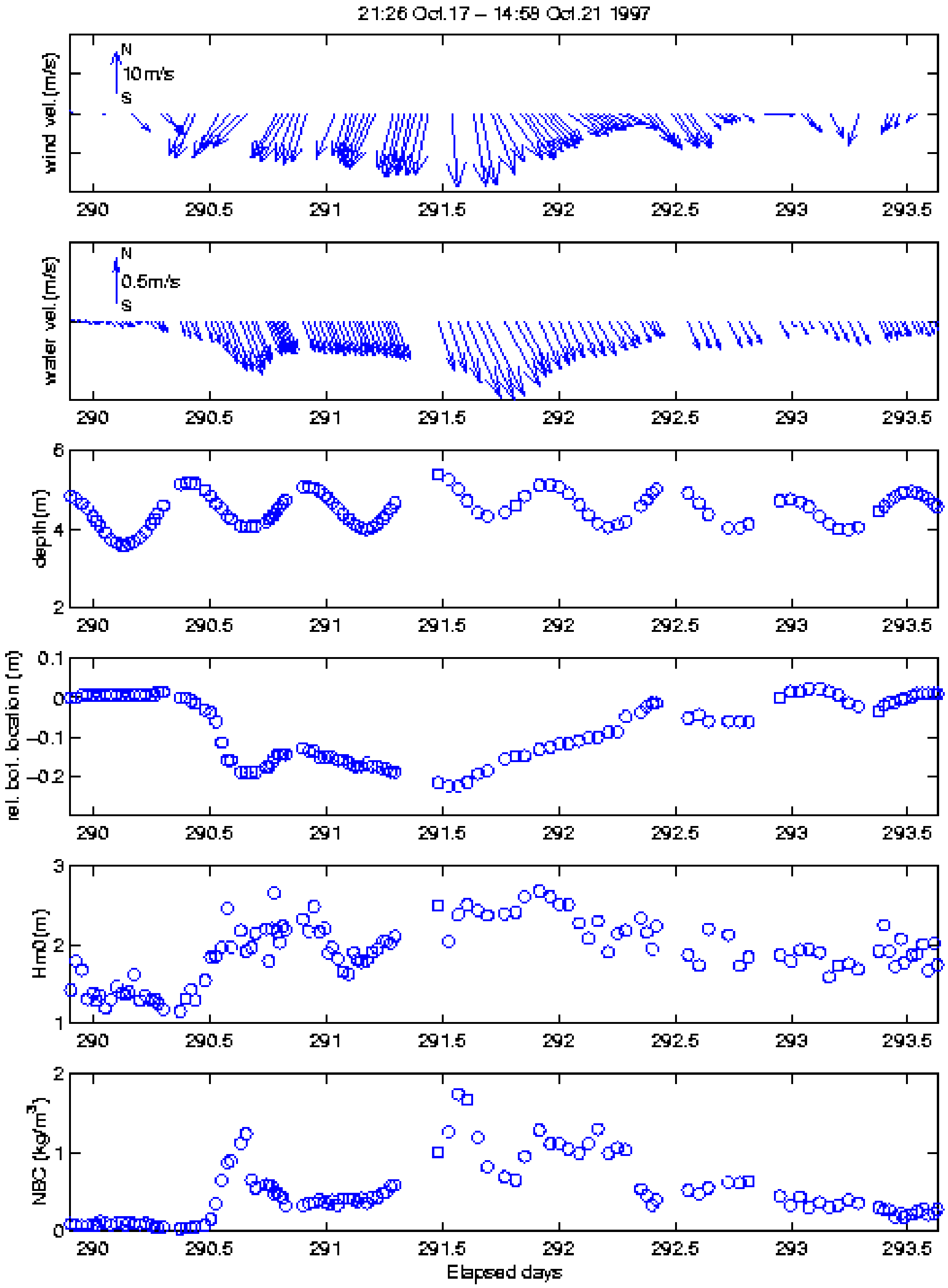
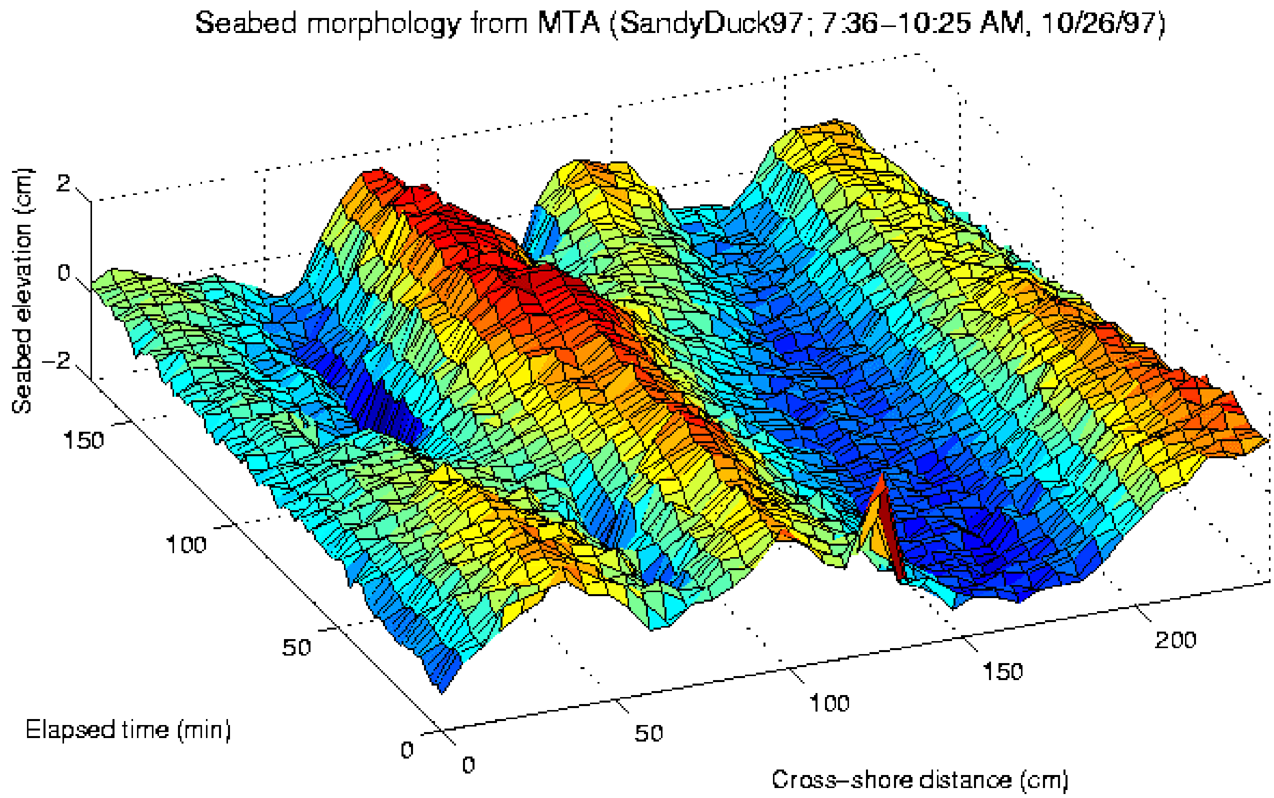
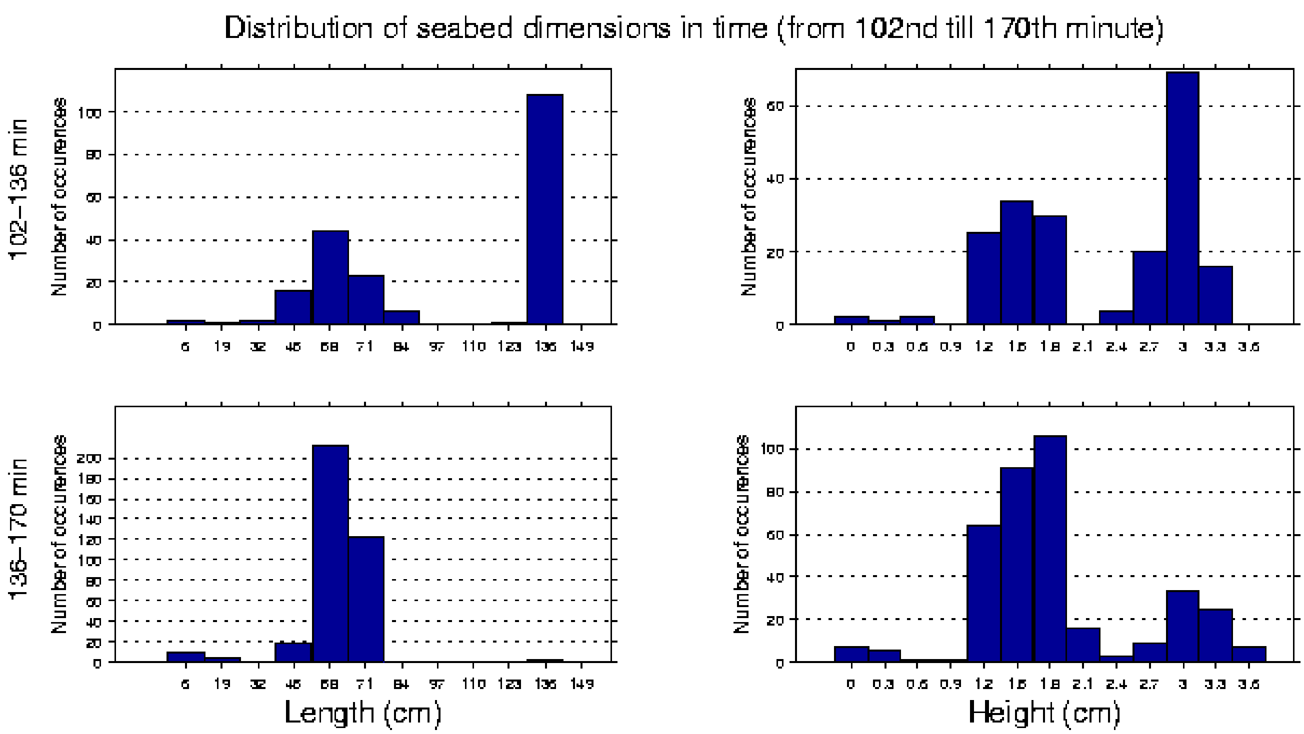
Thosteson, E.D. and D.M. Hanes, A simplified method for determining sediment size and concentration from multiple frequency acoustic backscatter measurements, Journal Acoustic Society of America, 104 (2), 820-830, 1998.

Measurements during a three day local storm event at SANDYDUCK97.




Seabed morphology from MTA (SandyDuck97; 7:36–10:25 AM, 10/26/97)
Seabed elevation (cm)
Elapsed time (min)
Cross–shore distance (cm)


Distribution of seabed dimensions in time (from 102nd till 170th minute)
102–136 min
136–170 min
Number of occurences
Length (cm)
Height (cm)