DISTRIBUTION AND MECHANICS OF NEARSHORE BEDFORMS

Thomas G. Drake
Department of Marine, Earth and Atmospheric Sciences
1125 Jordan Hall, NCSU Box 8208
North Carolina State University
Raleigh, NC 27695-8208
phone: (919) 515-7838 fax: (919) 515-7802 email: drake@ncsu.edu
Award #: N00014-98-1-0502
Award #: N00014-98-1-0474 (AASERT)
http://www2.ncsu.edu/ncsu/pams/meas/faculty/drake/drake.html

LONG-TERM GOAL

To understand the physics of sediment transport by waves and currents and to use that understanding to predict the evolution of nearshore bathymetry given the nearshore fluid velocity field. A concomitant goal is to interpret the environment of deposition from the sedimentary record. These small-scale studies provide direct input to intermediate-scale understanding of morphologic evolution, in the form of sediment transport formulae; they also connect small-scale sedimentary and morphologic information to large-scale coastal evolution, via interpretation of the sedimentary record.

SCIENTIFIC OBJECTIVES

Present objectives are to identify characteristic bedform patterns and their modes of evolution in the nearshore enviroment at Duck, North Carolina using sidescan sonar images obtained during the SandyDuck '97 Nearshore Field Experiment; to describe bedload transport over non-planar sediment beds, with particular application to megaripples; to generate computer simulation models for evolution of nearshore morphology; and to improve or replace the energetics-based Bagnold-Bowen-Bailard models for surf zone sediment transport (Bagnold, 1966; Bowen, 1980; Bailard, 1981).

APPROACH

Field observations of bedform patterns generated by nearshore waves and currents were documented daily (weather permitting) during the SandyDuck '97 experiment. Digital sidescan sonar imagery was acquired using the Coastal Research Amphibious Buggy (CRAB) provided by the US Army Waterways Experiment Station, Field Research Facility as a sonar platform. During energetic conditions bubbles and suspended sediment frequently obscured bed morphology inside the single shore-parallel bar characteristic of the nearshore at Duck; however, outside the bar, in water typically exceeding 3 m depth, the images provide a valuable context for intermediate-scale fluid motion measurements by other Coastal Dynamics investigators during SandyDuck (Figure 1). Both bed morphology and a measure of sediment size are contained in sidescan image information; we are presently analyzing spatial correlation between morphologic states and a crude measure of grain-size characteristics.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**

4. TITLE AND SUBTITLE **Distribution and Mechanics of Nearshore Bedforms**	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) **North Carolina State University,Department of Marine, Earth and Atmospheric Sciences,1125 Jordan Hall,Raleigh,NC,27695-8208**	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
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

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

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

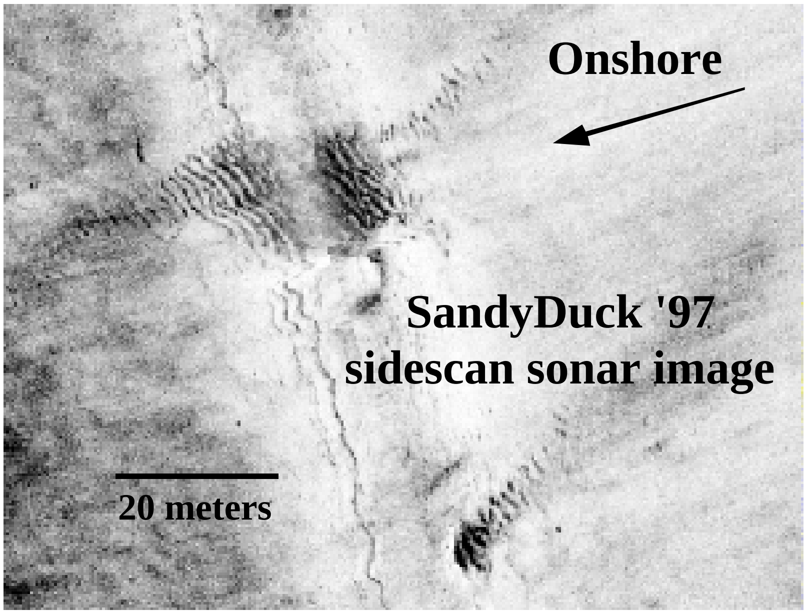

Figure 1. Sidescan sonar image acquired just outside the surf zone during the SandyDuck '97 Nearshore Field Experiment at Duck, North Carolina. The sidescan sonar is affixed to the CRAB at about one meter above the sea bed. Irregular patches of megaripples having spacings between 1 and 2 meters occur during times of rapid changes in nearshore wave climate.

On-going comparison of sidescan images and sonic altimeter measurements of bed elevation by SandyDuck collaborators E. Gallagher, E. Thornton and T. Stanton (Naval Postgraduate School) should allow us to interpolate quantitative measures of the geometrical roughness of the bed over the entire areal extent of the SandyDuck '97 experiment.

WORK COMPLETED

Development of sidescan sonar hardware and software for use in the SandyDuck ‘97 Coastal Field Experiment and subsequent development of processing and analysis software for the large daily image datasets. Graduate student Peter Dickson drove the CRAB and directed field studies during the experiment (Dickson and Drake, 1998) , and is working closely with Gallagher on subsets of the image data. Of particular interest is developing software to convert sidescan image data into Geographic Information System (GIS) formats, as a necessary first step towards merging bathymetric data with onshore topographic data.

AASERT-supported graduate student Joe Calantoni uses discrete-particle models to study bedload transport phenomena at various DoD High Performance Computing Facilities. Calantoni and Drake (1998a) demonstrated that present models for surf zone sediment transport underpredict transport under a variety of common wave conditions. Recent work (Calantoni and Drake, 1998b; 1998c) focuses on effects of fluid acceleration under breaking waves, which commonly exceeds 1/4 the gravitational acceleration in the surf zone. Only a velocity dependence appears in the prevailing sediment transport models. Our discrete-particle model also predicts such quantities as depth of motion in the sediment bed and sediment sorting by particle size and density, neither of which are addressed by previous models. Calantoni's presentation at the Spring 1998 Meeting of the American Geophysical Union earned an "Outstanding Student Presentation" award.

Continued development of cellular automata simulation models in light of SandyDuck sidescan sonar imagery builds on the work of Dickson and Drake (1996), which described rates of bedform and bedform imperfection migration rates in sediments having a uniform grain size. Topological evolution of bedform patterns is a rapidly developing area of nearshore research, and new abilities to observe such patterns in the field offers opportunities to test theories (e.g., Werner and Kelso, 1998). Present simulation work focuses on methodology for comparison of simulations and SandyDuck field data (Dickson and Drake, 1998). We are developing parallel codes for use on DoD Cray T3D massively parallel computers.

RESULTS

Data from the SandyDuck '97 Nearshore Field Experiment is presently being analyzed in conjunction with NPS collaborators.

Cellular-automata models for the topological evolution of bedforms and bedform imperfections compare favorably with laboratory observations. In particular, both model imperfections and physical ones migrate at about three to four times the migration rate defect-free bedforms, as predicted by recent theories (Werner and Kocurek, 1997).

Discrete-particle models for bedload transport provide a new, simple formula for use by intermediate-scale investigators to predict surf zone bathymetric evolution under sheet flow conditions. The new formulas predict transport in terms of fluid-motion quantities typically measured in the field.

IMPACT/APPLICATION

The ability to observe (and eventually predict) bedform geometry and orientation in the nearshore has very important implications for nearshore circulation models, and in turn, sediment transport at intermediate scales. Small-scale simulations provide much-improved relations for bedload sediment transport for use in intermediate-scale models for bathymetric evolution, for example, offshore and onshore bar migration. Small-scale simulations also predict sedimentary structures resulting from grain segregation processes, which are the chief means by which geologists interpret nearshore strata of importance to the large-scale coastal modeling community.

TRANSITIONS

We expect that our discrete-particle model will become the standard for modeling studies of intermediate-scale morphologic evolution; and that SandyDuck '97 sidescan imagery will find widespread application by other SandyDuck '97 investigators.

RELATED PROJECTS

SandyDuck ‘97 sidescan sonar studies were performed in collaboration with ONR Coastal Dynamics investigators E. Gallagher, E. Thornton and T. Stanton. Additional sidescan and shallow seismic geophysical studies in the Duck vicinity, supported by the Army Research Office, Terrestrial Sciences Program, provide geological context useful for this work and other ONR-supported work at Duck, North Carolina.

REFERENCES

Bagnold, R.A., 1966, An approach to the sediment transport problem from general physics, *U. S. Geological Survey Professional Paper*, *422* (I), 1-37.

Bowen, A.J., 1980, Simple models of nearshore sedimentation; beach profiles and longshore bars, in *The Coastline of Canada, Geological Survey of Canada Paper 80-10*, edited by S.B. McCann, pp. 1-11.

Bailard, J., 1981, An energetics total load sediment transport model for a plane sloping beach, *Journal of Geophysical Research*, *86* (C11), 10938-10954.

Calantoni, J., and Drake, T.G., 1998a, Discrete-particle model for nearshore bedload transport: *EOS Trans. AGU*, 79 (17), Spring Meeting Suppl., S122.

Calantoni, J., and Drake, T.G., 1998b, Effect of fluid acceleration on bedload sediment transport in the surf zone: accepted for Fall 1998 Nearshore Processes Special Session, American Geophysical Union

Calantoni, J., and Drake, T.G., 1998c, Discrete-particle model for bedload transport in oscillatory sheet flow: to be submitted to *Journal of Geophysical Research*

Dickson, P. J. and Drake, T. G., 1996, Nearshore bedform pattern evolution: lab studies, *EOS Transactions AGU*, v. 77, no. 46, p. F420.

Dickson, P.J., and Drake, T.G., 1998, Sidescan sonar studies of surf zone bed morphology: *EOS Trans. AGU*, 79(17), Spring Meeting Suppl., S121.

Werner, B. T. and Kelso, A., 1998, A model for nearshore bedform spacing, accepted for Fall 1998 Nearshore Processes Special Session, American Geophysical Union

Werner, B., and G. Kocurek, 1997, Bed-form dynamics: Does the tail wag the dog?, *Geology*, *25* (9), 771-774.