Using a Near-Bed Sediment Flux Sensor to Measure Wave Formed Bedform Migration and Formation Processes and Sonar Observation of Mine Burial

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LONG-TERM GOALS

Our research program focuses on identifying and quantifying sediment erosion, transport, and deposition processes on the continental shelf through state of the art observational techniques in both fine grained and sandy environments. In sandy environments our goal is to understand the detailed interactions and feedbacks between hydrodynamics, bedforms, and the resulting sand transport. In fine grained environments we have been investigating the role fluid mud flows as a depositional mechanism in areas with high deposition rates.

OBJECTIVES

The primary goals of this work are: 1) To quantify the role of bedload vs. suspended load transport in forming and forcing the migration of wave orbital scale ripples based on measurements from a near-bed suspended and bedload sediment flux sensor. 2) To study the interactions of the forcing hydrodynamics, sand transport processes, and bed geometry by determining how the hydrodynamic wave and current boundary layer structure over the bedforms is modified by the presence of different scale bedforms, and investigating the mechanisms by which bedload and suspended load transport is controlled by the forcing hydrodynamics over the bedforms. In particular we plan to investigate the role of bedload transport vs. suspended load transport in controlling the transition from wave orbital scale to anorbital scale ripples.

Under the second grant number we plan to investigate the interactions of these bedforms with mines. Previously most mine burial models have focused on single mechanisms such as a large bedform migrating over a mine or scour allowing the mine to sink into the seafloor. These processes may be coupled, as scour pits could serve as an initiation site for the generation of bedforms or migrating bedforms could fill scour pits. Understanding these processes will allow better prediction of mine burial in sandy environments.

APPROACH

The objectives of this work will be met through an approach that will combine field measurements, data analysis, and modeling. The field measurements will include measurements of bedform topography on a rapid enough time scale to observe ripple migration and temporal changes in geometry. Velocity and suspended sand concentration measurements will resolve the wave boundary layer and lower portion of the current boundary layer, thus allowing estimates of sand flux in this

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14. ABSTRACT
Our research program focuses on identifying and quantifying sediment erosion, transport, and deposition processes on the continental shelf through state of the art observational techniques in both fine grained and sandy environments. In sandy environments our goal is to understand the detailed interactions and feedbacks between hydrodynamics, bedforms, and the resulting sand transport. In fine grained environments we have been investigating the role fluid mud flows as a depositional mechanism in areas with high deposition rates.

15. SUBJECT TERMS

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region. Most significantly, a bedload flux measurement will allow investigation of the processes that force bedform formation and migration (Traykovski et al , 1998). The proposed modeling work will result in a conceptual and quantitative model for the formation and migration of wave orbital ripples as well as the transition of these processes as the ripples become anorbital. The modeling effort will be closely guided by the data, since measurements will span the full set of processes that force the ripples. The observational portion of the work will take place at the Martha's Vineyard Coastal Observatory (MVCO), thus most of the work completed to date has been directed toward characterizing the site. An additional portion of work will be dedicated to understanding the relation between small scale bedform migration, i.e. wave ripples, in forming and maintaining large scale features such as Rippled Scour depressions.

To investigate the interactions of mines and bedforms we have deployed a rotary sidescan sonar to image an instrumented mine that will be deployed by Mike Richardson from N.R.L. The mine/sonar deployments will occur in both coarse and fine sand environments at the MVCO to study the interactions with both large and smaller scale bedforms.

WORK COMPLETED

Two cruises have conducted south of Martha's Vineyard associated with the first grant number in the first year (2000-2001). In the first cruise we used a Van Veen grab sampler to obtain samples of the top ten cm of the seafloor. A rotary sidescan sonar was mounted on the sampler to take cm scale resolution images of the seafloor bedforms before each grab sample. Grab samples were taken in approximately 30 locations guided by a previous sidescan sonar survey (Figure 1). A subsequent cruise conducted as part of the cable installation planning, and not associated with this project, took 1 to 2 m vibra-cores at some of the grab sample locations to examine sediment texture deeper in the seafloor. The previous sidescan sonar survey was also conducted as part of the cable installation procedure and mapped out a 2 km along-shore by 3 km across-shore (7 to 18m depths) box. This survey also took chirp sonar seismic profiles to investigate the shallow stratigraphy of the seafloor. The sidescan survey revealed a series of large-scale features called "Rippled Scour Depressions" extending from the nearshore to approximately 15 m water depths. These appear as "fingers" of high backscatter in the sidescan record. To further sample these features and to measure the bathymetry associated with these features supplemental funding to this project was requested to fund shiptime for a USGS/UNH/WHOI survey project. A portion of this survey was in completed September of 2001. This survey aims to extend the along-shore distance to 10 km and slightly extend the across-shore distance. In August 2002 two additional survey cruises were completed by UNH/WHOI/UT investigators. One cruise made ultra-high resolution bathymetric measurements in the MVCO area, and the second followed with grab samples and cores in the same area.

In regards to second the grant number we have purchased two Imagenex digital rotary sidescan sonars and are expecting delivery soon. We have designed and built and data acquisition system for this sonar based on a Persistor CF1 data logger with a Big IDEa disk drive adapter that allows use of compact form PCMCIA 2Gb hard drives. The data acquisition system can either operate in autonomous mode with battery power or operate connected to the MVCO node. We are in the processes of finishing the hardware and software development and testing for this system and tank testing using a Imagenex sonar head borrowed from Doug Wilson (OGI).

Two rotary sonars with Nortek ADVs were deployed during the winter of 2001-2002. One was deployed in the coarse sand to study the geometric evolution and migration of orbital scale ripples. The

second was deployed within the field of view of an instrumented mine to investigate the interactions between the scour pit and bedforms in mine burial.

RESULTS

The site characterization work completed to date has revealed an interesting sandy sedimentary environment with the predominant features being the rippled scour depressions. The simultaneous Rotary Sonar Sampling and grab sampling shows that the rippled scour depressions contain coarse sand while the surrounding areas have a surface layer of fine sand. Cores revealed that this surface layer of fine sand is only 20-40 cm deep and is underlain by coarser sands. The coarse sands are capable of supporting large-scale (up to 1 m wavelength and 15cm height) wave orbital scale bedforms (Figure 1), while the finer sands contain smaller (10-15 cm wavelength, 1.5-2.5 cm height) an-orbital scale bedforms (Wiberg and Harris, 1994; Traykovski et al, 1999). The orbital ripples generally migrate in the direction of wave propagation forced by wave velocity skewness as observed previously. However, an interesting feature emerged in this data set as our previous dat sets contained no events with r.m.s velocities over 45 cm/s. At MVCO when velocities exceeded 45 cm/s the linear orbital scale ripples became irregular, with complex three dimensional shapes. They occasionally displayed characteristics of lunate mega ripples (Figure 1).

Seismic profiling shows that these surface RSD features are not related to deeper and presumably older features such as buried outwash channels that have been observed in this area. The three cruises (Feb 2001, Sept. 2001, and August 2002) that have sampled this area revealed that these features are migrating towards the east at rates up to 50 m per year (Figure 2). There is an interesting relation between the bathymetry associated with these features and the direction of migration (Figure 3). In the Eastern portion of the study are the depressions are deeper on the eastern side. i.e they are tilted in the direction of migration. They also have coarser grain size towards the eastern side as shown by sidescan backscatter amplitude and grab samples. In the western portion of the study area this trend is reversed, although there is no migration data in the western portion due to lack of survey overlap. Previous work (Traykovski et al 1999) has shown that the coarse sand motion is largely controlled by bedload forced migration of orbital scale ripples. Thus future work will try to understand the relation between the characteristics of the rippled scour depressions and small scale ripple migration.

The second sonar that was deployed in fine sand within the field of view of the N.R.L. instrumented mine produced two data sets on mine burial. The mine was initially deployed from Dec. 2001 to Feb 2002. During this period it buried completely in 38 days. It was the redeployed until July 2002, during which it did not bury completely. Results from the first deployment have been published in a proceeding paper (Richardson and Traykovski, 2002). In work planned for winter 2002-2003 we will deploy the instrumented mine in coarse sand to investigate the interactions of the larger orbital scale ripples with the scour pit.

TRANSITIONS

The primary transition to applications in these two projects will occur through the collaboration with N.R.L. investigator Mike Richardson. Understanding these mine scour / bedform interaction processes will allow better prediction of mine burial in sandy environments.

RELATED PROJECTS

This project is closely related to, and is dependent on the completion of the Near Bed Sediment Flux Sensor development project. The Near Bed Sediment Flux Sensor will be used to measure the relative roles of bedload and suspended load in forcing bedform migration and geometric evolution.

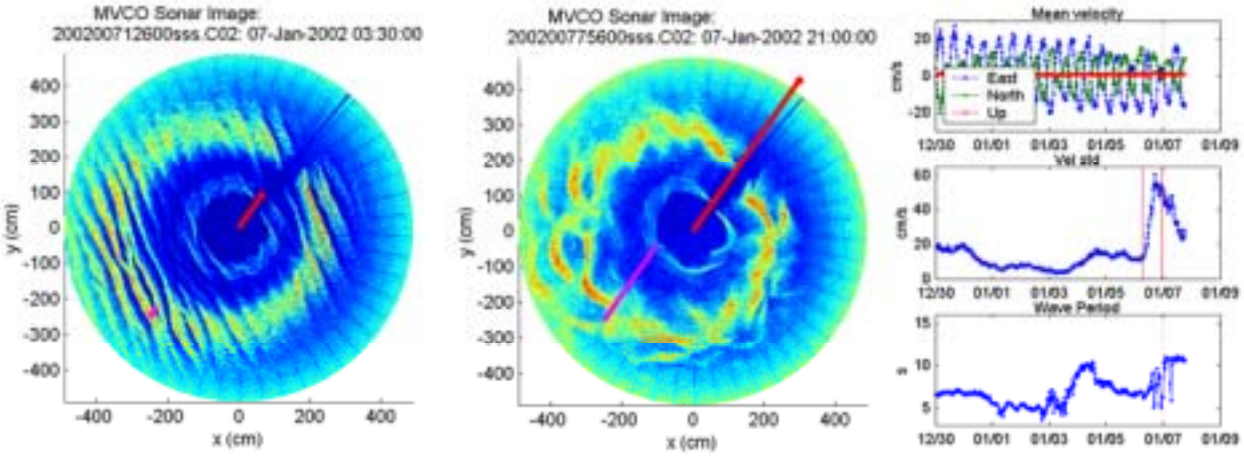

Figure 1. Transition of bedforms from linear orbital scale ripples to irregular three dimensional lunate ripples in coarse sand at MVCO during a high energy event.

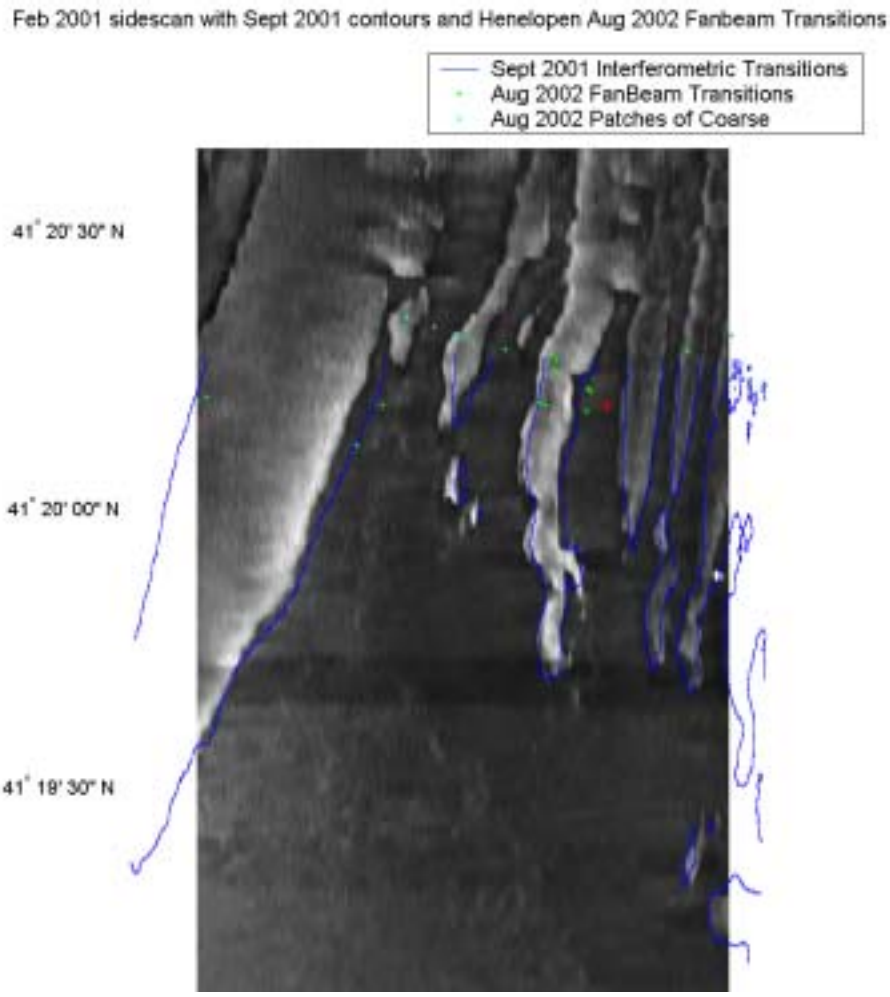

Figure 2. Martha's Vineyard Coastal Observatory Sidescan from Feb. 2001, contours of transitions (blue lines) from a repeat survey in Sept 2002 and green dots indicating transitions in Aug of 2002 .The features are generally migrating towards the East. The MVCO node location is shown as the red *.

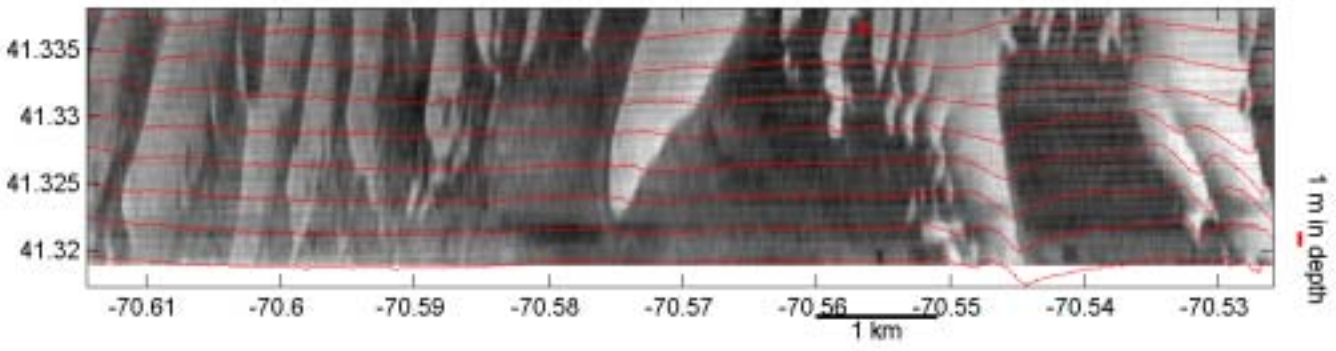

Figure 3. Sept 2001 Sidescan Imagery of Rippled Scour Depressions south of Martha's Vineyard with horizontal variability in bathymetry along dotted red lines plotted in red. The MVCO node location is shown as the red *.

REFERENCES/PUBLICATIONS

Traykovski, P., J. D. Irish, and J. F. Lynch, Motivations for using a pulsed full spectrum Doppler to measure bedload and near-bottom suspended sediment transport, Jour. Acoust. Soc. of Am., Vol.103(5), 2866, 1998

Traykovski, P., A.E. Hay, J.D. Irish and J.F. Lynch, "Geometry, migration and evolution of wave orbital scale ripples at LEO-15", J. Geophys. Res., Vol. 104, No C1, p. 1505-1524, 1999

Wiberg, P.L., and C.K. Harris, Ripple geometry in wave-dominated environments, *J. Geophys. Res., 99*, 775-789, 1994.

Richardson, M.D. and P Traykovski. 2002. Real-time observations of mine burial at the Martha's Vineyard Coastal Observatory. 11 pps., *Proceedings of the 5th International Symposium on Technology and the Mine Problem*. Naval Postgraduate School, Monterey California, 22-25 May 2002