Development of a Near-Bed Sediment Flux Sensor

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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

In certain environments bedload or near-bottom suspended load can be the dominant mode of sand transport. In particular, these modes of sediment transport can have important impacts in terms of understanding erosion and deposition mechanisms in coarser sand environments with active bedform processes. These bedform processes, which may be forced by bedload transport, have been observed to change the local seafloor elevation tens of centimeters in time scales of hours to days. (Traykovski et al, 1999) However, there is a lack of suitable observational techniques to measure bedload and near bottom suspended sand transport and their relationship to the hydrodynamic forcing. Therefore, we are developing and testing acoustic Doppler instrumentation that can quantitatively measure the bedload and near bottom suspended load flux magnitude and direction on a rapid time scale and its relationship to the hydrodynamic forcing.

APPROACH

The approach for this project is based on a combination of modeling sensor geometry and response and testing actual systems in laboratory and field environments. The modeling effort is being used to guide development of sensor geometries and signal processing schemes. These will then tested in the WHOI 17m flume. In a previous flume experiment conducted before this contract began a simple monostatic Doppler geometry (Figure 1a) was used to test the conceptual ideas for measuring near bed sediment flux. The principle upon which this measurement is based is relatively simple. A series of acoustic pulses are scattered off the seafloor and bedload particles and the amplitude and phase of these pulses are recorded. This time series is then transformed to a spectral estimate via a Fourier transform. This spectral estimate consists of a series of backscattered amplitudes at different Doppler shift frequencies. Each different frequency corresponds to a velocity and the amplitude corresponds to a concentration at

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14. ABSTRACT
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15. SUBJECT TERMS

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that velocity. The complete scattered signal consists of a strong return from the stationary bottom and weaker returns from grains of sand moving as bedload at many different velocities. To estimate a bedload flux, the velocity for each Doppler shift frequency is multiplied by the corresponding amplitude and the results are summed. This procedure multiplies the strong amplitude of stationary bottom return by its zero velocity, thus effectively canceling this contribution from the estimate.

In upcoming flume tests we plan to examine the use of a bi-static geometries (Figure 1b). This bistatic configuration is similar to that used by Alex Hay in his Coherent Doppler Profiler (CDP) (Zedel and Hay, 1999). This allows measurement of 3 velocity axes and backscattered amplitude to estimate suspended sediment flux over the lower 30-50 cm above the seafloor. The bedload processing technique can then be used for the range bin that contains the strong return from the stationary seafloor and bedload transport immediately above it. The geometry of the sensing volumes will be tuned to optimize the performance tradeoff for measuring suspended and bedload flux.

The final product of the work will be a system that can fully resolve sediment transport phenomena that occur near the seafloor that present systems are not able to observe, and an understanding of the performance bounds of this system. This will allow future research to focus on the near bed processes that force large elevation changes in short time periods. An additional portion of the proposed work was to begin time series measurements of bedforms at the Martha’s Vineyard Coastal Observatory (MVCO) site to examine the feasibility of deploying the bedload sensor at this site.

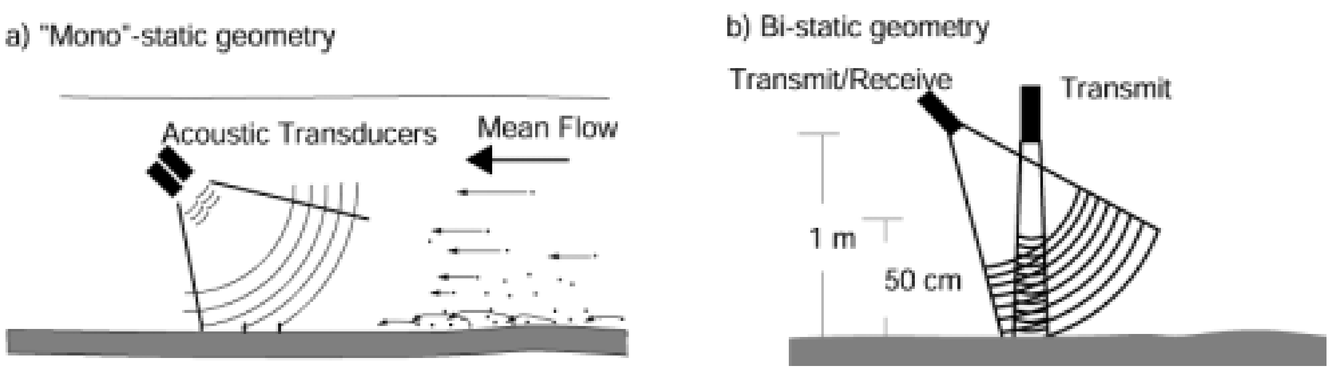

Figure 1. Doppler geometry schematic. a) The mono-static geometry was used for a proof of concept for the bedload flux measurement. b) The bi-static geometry will allow resolution of both bedload and suspended load fluxes.

WORK COMPLETED

After much delay we received 3 Doppler (DopBeam) transceivers from Sontek and we are in the process of developing a data acquisition system. The data acquisition is PC based and uses a 12-bit simultaneous 16-channel analog-to-digital converter that will allow 0.7 cm range bin resolution. We have also adapted software to use the DopBeam internal analog to digital converter that allows 1.5 cm range bin resolution. Flume tests using this system in a bistatic mode as described above are planned for this fall.

We have also completed preparations for deployment of our previously purchased Simrad/Mesotech rotary sidescan sonar and a Nortek Vector ADV at the Martha's Vineyard Coastal Observatory site. This involved adapting the data acquisition system to interface with the data telemetry and power supply of the MVCO node. We designed and build a "uni-pod" mounting system for these instruments, which is essentially a single pole that can be jetted into the seafloor. This eliminated bulky tripods and allows deployment by scuba divers from a small boat. We plan to deploy this equipment at the next available weather window after some routine maintenance has been completed on the node. Much of the expertise in interfacing with the node that we will have gained via this preliminary deployment will be useful when planning more complex deployments in the future.

RESULTS

The work completed to date has largely been oriented to designing and building the system and thus has not produced scienitific results. The primary results toward the research goals of this project to date were achieved with the preliminary proof-of-concept flume tests. In these experiments we found an excellent agreement between the Doppler bedload flux compared to a bedload trap placed further down stream (Figure 2) (Traykovski et al, 1998).

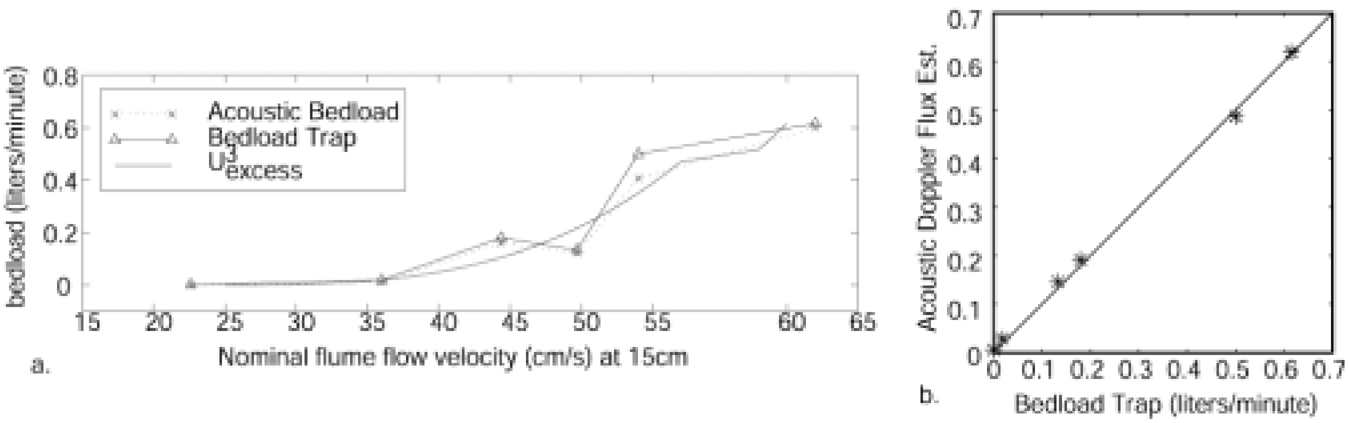

Figure 2. Results from a proof of concept test in WHOI RCRC 17m flume. The Bedload trap and Doppler sensor show excellent agreement with each other and are similar the first order theoretical dependence of bedload flux on U^3_{excess}

TRANSITIONS

The primary transition in this project will be from a conceptual system to a field deployable instrument. We anticipate the ability to coherently measure suspended and near bed transport processes will shed light on migration and geometry of bedforms.

RELATED PROJECTS

This project was motivated by our work at LEO-15 where we observed wave orbital scale ripples to migrate in the onshore direction while suspended transport was in the offshore direction. The hypothesis is that bedload transport forced by asymmetric wave motions was responsible for forcing the ripple migration. The LEO-15 project is still active as we are analyzing data collected during the winter of 1999-2000 and completing a paper describing the interfacing of the sensors to the LEO-15 node for inclusion in a I.E.E.E. special issue.

This project is closely related to the Y.I.P. award project “Using a Near-Bed Sediment Flux Sensor to Measure Wave Formed Bedform Migration and Formation Processes” in that the Y.I.P. project will use the technology developed in this project to measure the relative roles of bedload and suspended load flux in forcing bedform migration and geometric evolution.

REFERENCES/PUBLICATIONS

Zedel, L., and A. E. Hay.. A Coherent Doppler Profiler for High Resolution Particle Velocimetry in the Ocean: Laboratory Measurements of Turbulence and Particle Flux. J. Atmos and Ocean. Tech., 16, 1102-1117. 1999

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