Development of a Near-Bed Sediment Flux Sensor

Peter A. Traykovski[1], Alex E. Hay[2], and James D. Irish[3]
[1,3]Woods Hole Oceanographic Institution
Woods Hole, MA 02543
[2]Dalhousie University
Halifax, NS, B3H4J1, Canada
[1]Tel.: (508) 289-2638, Fax: (508) 457-2194, Email: ptraykovski@whoi.edu
[2]Tel.: (902) 494-6657, Email: hay@Phys.Ocean.Dal.Ca
[3]Tel.: (508) 289-2732, Fax: (508) 457-2154, Email: jirish@whoi.edu

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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 such as the environments, Eel River shelf we have been investigating the role of gravitationally forced fluid mud flows in the wave boundary layer as a cross-shore transport mechanism.

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. 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 will be used to guide development of sensor geometries and signal processing schemes. These will then tested using the components of Coherent Doppler Profiler developed at Dalhousie University. 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

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WORK COMPLETED

As this phase of the project has only been underway for several months the new work is in progress. A feasibility test was performed before the contract began. This feasibility test used two transducers from our ABS system, a signal generator, and a digital oscilloscope to capture to backscattered Doppler-shifted signal. The test was performed in the WHOI 17m flume.

RESULTS

In the laboratory experiment a simple 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 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. The results were found to be in excellent agreement with a bedload trap placed further down stream (figure 1b).

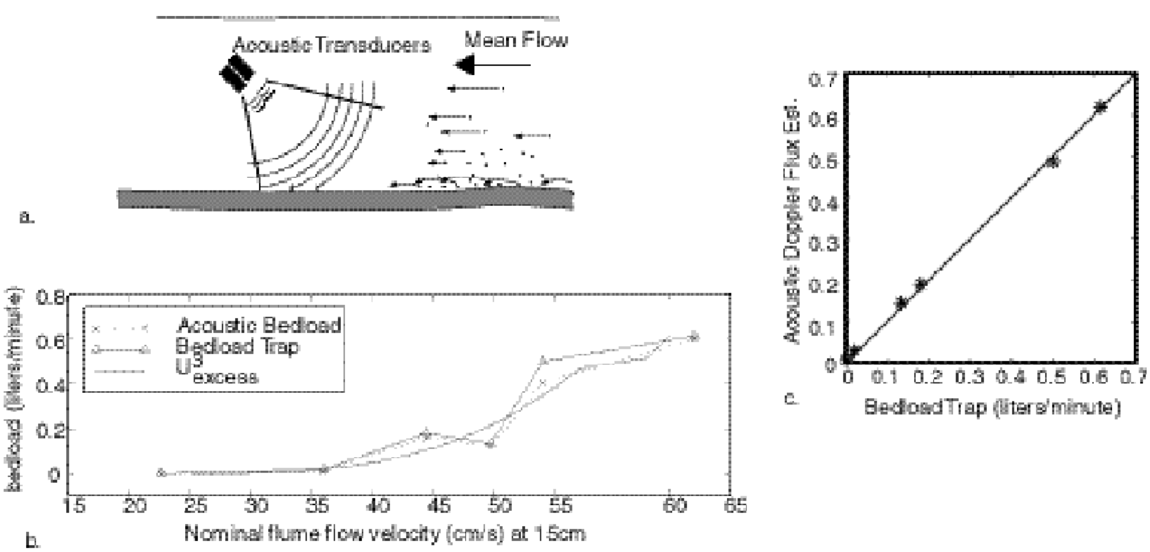

Figure 1. Geometry (a) and results (b and c) from a proof of concept test in WHOI RCRC 17m flume. The Bedload trap and Doppler sensor show excellent agreement with each other and are similar the first order theoretical dependence of bedload flux on U^3_{excess}

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. The most recent deployment featured acoustic imaging sonars that resolved the three dimensional structure of the suspension over the bedforms. The CDP was also deployed to measure the velocity structure over the bedforms. The near-bed flux sensor developed in this project will be deployed in future observational efforts planned at the Martha's Vineyard Observatory.

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