Sediment Flux and Trapping on the Skagit Tidal Flats

W. Rockwell Geyer
Woods Hole Oceanographic Institution
MS 11, Woods Hole, MA 02543
phone: 508-289-2868 fax: 508-457-2194 email: rgeyer@whoi.edu

Peter Traykovski
MS 12, Woods Hole Oceanographic Institution
Woods Hole, MA 02543
phone: 508-289-2638 fax: 508-457-2194 ptraykovski@whoi.edu
508 289-2638

David K. Ralston
MS 12, Woods Hole Oceanographic Institution
Woods Hole, MA 02543
phone: 508-289-2587 fax: 508-457-2194 dralston@whoi.edu
508 289-2587

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LONG-TERM GOALS

The long-term objective is to determine the hydrodynamic processes controlling sediment transport and the associated morphologic response on tidal flats.

OBJECTIVES

The objectives of our 2008-2009 research program are:

- quantify the influence of barotropic (tidal) convergence on the lower Skagit tidal flats as a mechanism of sediment trapping and creation of ephemeral mud and sand deposits;
- determine the role of density fronts in creating and transporting high-concentration sediment suspensions, and assess the influence of these processes on sediment deposition and short-term morphological change;
- distinguish the influence of wave-induced sediment transport from tidal/fluvial processes, and determine how variations in tidal, fluvial and wind/wave forcing alter the bedform geometry, transport pathways, surficial sediment characteristics and tide-flat morphology .

APPROACH

We will deploy an array of instrument platforms on Skagit Flats during two 2-month observational intervals, the first in May-July 2009, and the other Oct-Dec 2009. High-resolution surveys of the currents and suspended sediment distributions will be conducted in concert with the deployments. The deployment time intervals were selected to correspond with historical peak flow periSediment fluxods: the May-July period of 1,000 m^3/s, and the Oct-Dec period with an expected maximum discharge of

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1,200 m^3/s (median seasonal maxima based on 68 years of discharge data from the Skagit measured at Mount Vernon).

The deployment array (Fig. 1) is designed is to distinguish the flow and sediment-transport processes in channels and on the flats as well as in different locations across the flats. The platforms at the lower channel and flats (*LC*, *LF* and *lf*, where upper case letters indicate a large pod and lower case letters indicate a minipod) will document the barotropic and baroclinic trapping processes (cf. Fig. 1), which are expected to be most intense in the lower flat channels during neap tides. The mid-flats and channel platforms (*MC, MF* and *mf*) will provide a contrast with the lower flat conditions and will document variation in strength of the trapping as the frontal zone advects onshore. The upper channel pod (*uc*) will measure riverine input of fresh water and sediment, and the lower channel pod (*lc*) will provide an offshore boundary condition for salinity and suspended sediment. All tripods on the flats will measure

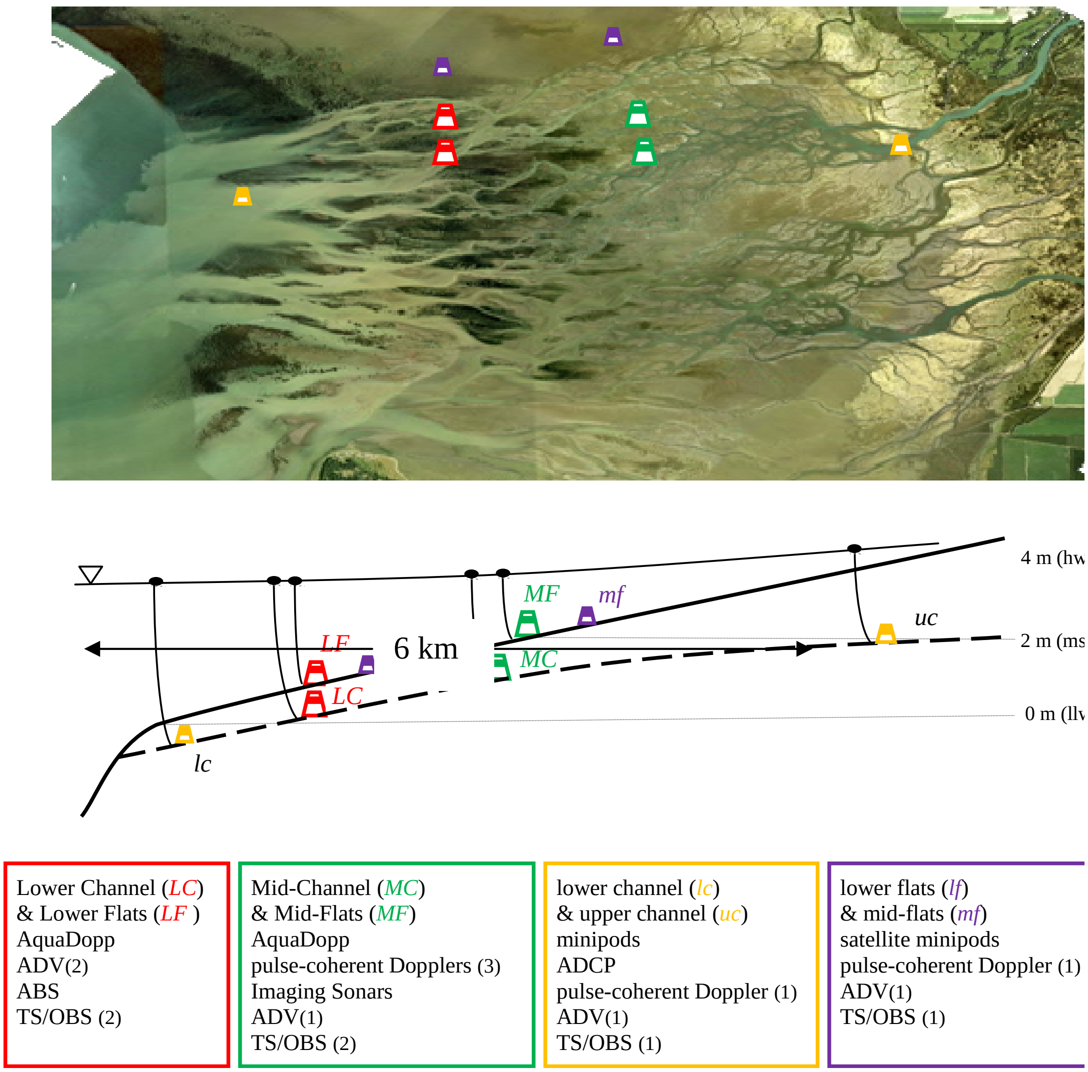

Figure 1. Proposed tripod array on Skagit Flats, to be deployed in April-June 2009 and Oct-Dec 2009.

sediment flux associated with wave resuspension.

All of the larger pods and the minipods in the channels (*LC*, *LF*, *MC*, *MF*, *uc* and *lc*) will have accompanying surface mooring with TS/OBS sensors, to quantify baroclinic salinity and sediment gradients.

The instrumentation at all tripod stations will measure acoustic profiles and optical point measurements of suspended sediment concentration, bed elevation, horizontal and vertical velocity, conductivity, temperature and depth. The acoustic profiles of sediment concentration and bed elevation will be measured with Acoustic Backscatter Sensors (ABSs) and Pulse Coherent Dopplers. Multiple pods will allow measurement of sediment flux and convergence of both mud and sand, and the resulting deposition or erosion. All pods will have an Acoustic Doppler Velocimeters (ADVs, with pressure sensor) sampling 15 cm above the bed for a near bed measurement of tidal currents, waves and turbulence. The ADVs will have cabled probes mounted horizontally, so will be capable of measuring velocities to water depths as shallow as 20 cm.

WORK COMPLETED

We have designed the tripods and developed the strategy for our field activities. Our field efforts have been delayed as a result of permitting issues. We have been purchasing and preparing, and repairing equipment using DURIP funding. Some of this work involves upgrading our existing ABS sensors from Aquatec with new higher resolution and fidelity electronics. The new ABS units will also include an upward long range, lower resolution channel for surface to seafloor profiles of sediment concentration, which are essential to quantify sediment flux.

Using funding from the DURIP and the “Mechanisms of wave dissipation over muddy seafloors” MURI project we are continuing the development of our next generation of Doppler and Backscattered intensity profilers in Collaboration with E. Terray and T. Austin. An example of data collected during the 2008 Louisiana shelf experiements is shown in Figure 2. In this experiment we configured the system to have several vertical beams (only one is shown) and one beam pointed 15° off vertical similar to a standard ADCP. While is still much work to do in processing the velocity data (e.g. removing phase ambiguities and rotating into a u-w coordinate system), and quantifying the intensity data is always a challenge at these high concentrations, this data shows the potential of these systems to understand fluid mud and stratified turbulence processes.

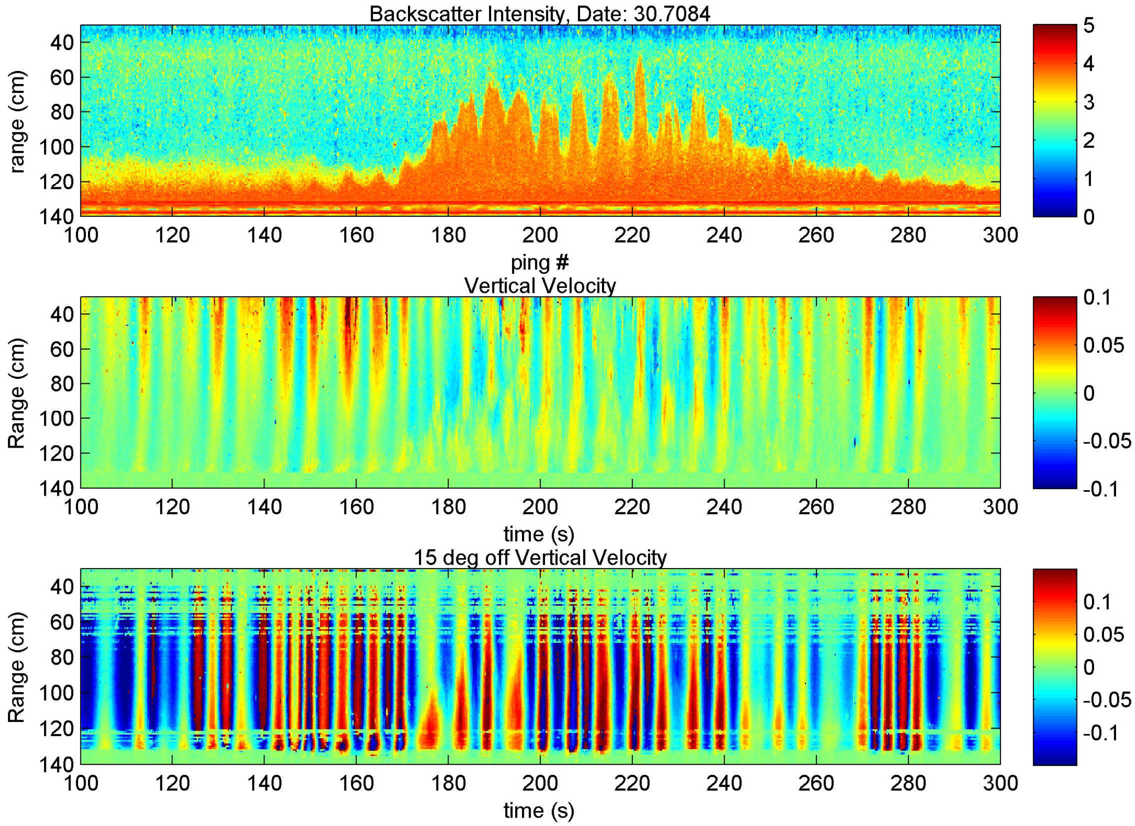

Figure 2. Data from the next generation Doppler sensors taken from the Louisiana Mud-MURI experiment. The intensity data shows a fluid mud layer "bursting" after a the passage of a wave group. At the beginning of the record (t<170 s) the lutocline has a weak gradient with a length scale of L ~10 cm as the velocity gradients show a similar scale. Just before the bursting event the gradients tighten to L ~ 2 cm and maintain the tight gradients throughout the burst. The velocity shear in the 15° off vertical axis is large during the bursting event. Large amplitude internal waves on the lutocline are visible after the bursting event.

RESULTS

There are no results to report.

IMPACT/APPLICATIONS

The probable impact of this project is to improve the predictive skill of morphodynamic models of tidal flats, with application to naval environmental assessment. Future models will be capable of predicting spatial and temporal variability of sediment consolidation state and bathymetric variability, as influenced by sediment transport processes on tidal flats. The development of these models requires the quantitative field data provided by this study.

RELATED PROJECTS

As discussed above this project s closely related to the DURIP: “Instrumentation for Quantifying Nearshore Sediment Transport and Turbulence“. Ralston is PI on a closely related project entitled “Sediment transport at density fronts in shallow water”, which involves modeling of the Skagit Flats using FVCOM. These two projects are tightly coupled. We are also collaborating closely with the other investigators in the DRI.