Sediment Dynamics on the West Florida Inner Continental Shelf

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14. ABSTRACT

Most inner continental shelves are dynamic environments, subject to current flows on a variety of temporal and spatial scales that are relevent to processes of mine scour and burial. We propose to quantify the response of a non-cohesive seabed to these flows on spatial scales of 10-2 to 104 m and on temporal scales of seconds to years by using a combination of acoustic remote sensing and in situ instrumentation. These studies will be undertaken in support of the ONR Mine Scour and Burial Study Site west of Indian Rocks Beach (IRB), on the west-central Florida coast.

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LONG-TERM GOALS

Most inner continental shelves are dynamic environments, subject to current flows on a variety of temporal and spatial scales that are relevent to processes of mine scour and burial. We propose to quantify the response of a non-cohesive seabed to these flows on spatial scales of 10^{-2} to 10^{4} m and on temporal scales of seconds to years by using a combination of acoustic remote sensing and *in situ* instrumentation. These studies will be undertaken in support of the ONR Mine Scour and Burial Study Site west of Indian Rocks Beach (IRB), on the west-central Florida coast.

OBJECTIVES

Our specific goals for this funding period were the initiation of measurement programs to: 1) quantify the sediment distribution and the associated fine-scale bathymetry in water depths of about 10 m, 2) quantify fine-scale bathymetric change of the seafloor on temporal scales of seconds, minutes, hours, days, weeks, and months, 3) investigate forcing mechanisms (processes) for particle erosion, vertical particle mixing, sediment transport through advection, and bed elevation change, and 4) document the effects of these processes on both seafloor character and activity, and the development of shallow subsurface facies. We will also provide data and logistical support to other ONR-supported scientists preparing for and conducting field experiments at the IRB site during the winters of 2002 and 2003 and provide ground truth bathymetric and bottom type data for the HyCODE program site off Sarasota, FL.

APPROACH

The objectives related to large scale seabed characteristics are approached through multiple detailed geoacoustic and sedimentological surveys of the IRB study area to assess the spatial and temporal variability of sediments and their related acoustic facies, the shallow stratigraphy, and fine-scale (cm) bathymetric variations. Shipborne geoacoustic data are acquired using an EG&G Model 272 TD side-scan sonar system, and a Kongsberg Simrad EM3000 (300 kHz) multibeam sonar system. Future plans call for surveys to include a vertical beam chirp sonar system. Seabed textural changes will be assessed using backscatter data sets (side-scan sonar, multibeam) and vertical-beam bottom classification techniques using QTC-IMPACT software designed to classify seafloor sedimentary facies based on bottom-sampling calibrations. In an effort to integrate the large-scale geologic processes with the local processes measure with *in situ* instrumentation, we will map the Task 2 area several times during the year using a nested sampling scheme with a minimum recurrence of 1 day (for a small area) and maximum interval near the duration of this proposal. This will not only help place the Task 2 area in a larger context, but also provide temporal control to the larger Task 1 survey area. These nested surveys will commence late in FY01 or early in FY02 as storms begin to impact the study area.

Central to the task of integrating these geophysical techniques is an assessment of the calibration and repeatability of the various acoustic systems as we transition from qualitative to quantitative applications of these geophysical tools. Therefore a key component of the study includes ground-truthing of the geophysical date sets with sedimentary facies data. Sediment samples will be obtained using underway sampling techniques, diver deployed push cores, and underwater vibracore techniques. Textural analyses will include grain size, % carbonate, % organics (if present), and grain count of grain types for compositional analysis.

The hydrodynamic forcing that produces and maintains the sedimentologic facies and shallow stratigraphy will be measured at one site on a routine basis. The geologic signature will also be measured so that we may work toward an understanding of this highly non-linear process of bed evolution. We will make detailed measurements of the combined-flow bottom boundary layer using a combination of acoustic current meters. An upward-looking ADP measures mean flows from approximately 60 cm above the bed to near the surface. A tripod-mounted, downward-looking PC-ADP will measure the instantaneous flows in roughly the bottom 150 cm (in 5 cm bins) with a sampling rate of 2 Hz. A downward-looking ADV will measure instantaneous flow at a point at rates of up to 25 Hz. Measurements of pressure will allow calculation of directional wave spectra. The downward looking instruments will also give measurements of distance to the bed, allowing us to track erosion and accretion. These spot measurements will be put in context of local (~10^2 m^2) changes using high-resolution rotary fan-beam and scanning pencil beam sonars.

WORK COMPLETED

The regional site survey cruise of the IRB area was conducted July 17-22, 2001 aboard the R/V SUNCOASTER. Our objectives were to conduct a reconnaissance-style survey for the purpose of documenting the broader geological framework of the sand-ridge systems within which a smaller 1 square km study area will be selected. Primary tasks were to acquire 100 kHz side-scan sonar backscatter imagery of the sand ridges and bottom types in this area, and to measure the sediment thickness using seismic techniques. In addition we collected 50 kHz echosounding data to test a new Quester Tangent system for acoustic bottom classification, and deployed an underway bottom sampler to collect 79 surface sediment samples. The survey area, approximately 22 by 11 km, consisted of a grid of parallel lines spaced 280 m apart, in 8-19 m water depth. Track lines were orientated 25 degrees east of North (NE-SW trends), so that the seismic profiles provided cross-sectional views approximately normal to the sand ridge trends. The side-scan sonar coverage was virtually 100% over the entire survey area, seismic coverage was nearly continuous, with minor down time for repair of a broken seismic cable. The QTC system was operated about 1/3 of the time due to occasional interference with both the side-scan and seismic systems.

Efforts in this past year have focused on the purchase and testing of field instrumentation, and on the initiation of surface wave modeling for the MBP study area. Four test deployments have been conducted, culminating in the initiation of monitoring in the IRB study area on August 20, 2001 following the geophysical surveys discussed above. The instrument suite presently deployed includes a 1.5 MHz bottom mounted acoustic Doppler profiler (SonTek ADP), a 5 MHz acoustic Doppler point current meter (SonTek Hydra), a 1.5 MHz pulse coherent boundary layer profiler (SonTek PC-ADP), a LISST-100 in situ grain size sensor, a SeaBird Microcat C-T sensor, 3 Downing and Assoc. OBS-3A optical backscatter sensors and 3 Druck pressure sensors. These instruments will provide measurements of the mean and instantaneous flow field throughout the water column, the estimation of the directional spectrum of surface gravity waves, and the resulting sediment resuspension. This initial collection period includes the passage of Tropical Storm Gabrielle. Data loggers for the bed imaging sonar systems are under development at WHOI as a joint project between the mine burial and EuroSTATRAFORM programs. Once designed and tested, additional data logging units will be fabricated at the USGS Center for Coastal Geology and these instruments will be added to the deployment package. The redundant sets of instruments that will allow continuous temporal coverage have been ordered and are expected near the end of FY01.

During FY01 our group also participated in the HyCODE program through collection of side scan sonar, multibeam bathymetry, and sediment data in order to more fully quantify the relationship between bottom type, bathymetry and optical remote sensing data (AVIRIS and PHILS overflight data) in the Sarasota study area. Bathymetry data and bottom characteristics were measured during two cruises, November 3-7, 2000, and April 16-20, 2001. *In situ* instruments were also deployed for the spring overflight.

RESULTS

A well-defined sand-ridge system was imaged, trending NW-SE. The sand ridges commonly are approximately 1 km wide and 4-8 km in length. The characteristics of these ridges are distinctly different than the sand ridges in < 8 m water that we have previously studied. Ridges in the offshore area tend to have a flatter morphology, with fewer smaller-scale sand waves. Some of the bedform patterns were quite unusual. These complex patterns imaged by the side-scan sonar will benefit from multibeam bathymetry data in our effort to understand the relationship between processes and products in this shelf setting. The boomer seismic data worked well to define the general thickness of these ridges (Figure 1). A sediment isopach map and general bathymetric map based on seismic data will be prepared in Fall 2001. Additionally, the side-scan sonar data will be further processed for an improved contrast and balanced image, and the QTC bottom classification data will be analyzed to assess the capabilities of acoustic bottom classification techniques. As soon as sediment thickness data are available, vibracore sites will be selected to verify seismic interpretations and to provide a first look at candidate sites for the 1 square km study area.

The Kongsberg Simrad EM 3000 multibeam bathymetry and backscatter system survey of the area has been postponed due to equipment failure and until upgrades to RTK are possible. FY01 surveys in support of HyCODE have detected small bedforms with wavelengths on the order of 0.5 m and amplitudes of 0.1 m. This detection level and absolute three-dimensional position will improve with the proposed RTK upgrades. The morphology and slope of the seafloor will be important considerations in selecting locations to deploy the equipped mines and also the rotary side-scan towers and other equipment to be deployed by other ONR investigators during the January-March 2003 experiment.

The first scheduled *in situ* instrumentation turnaround was cancelled due to the passage of TS Gabrielle on September 14, 2001, precluding inclusion of initial results in this report.

IMPACT/APPLICATIONS

This project will have a large and immediate impact on our collective ability to conduct successful mine burial experiments on the West Florida Shelf. From a larger perspective we will be collecting information important for understanding the coupled physical-geological system of inner-continental shelves where both waves and mean currents can be important. This zone is decidedly understudied relative to nearshore and mid-shelf environments.

TRANSITIONS

These data are being (or will be) used by a number of investigators outside our PI group. Bed elevation data will be transferred to others working on statistical descriptions of the variability. Process data will be provided to modeling groups for calibration and verification studies.

Geophysical data will be provided to interested MB investigators. All appropriate data will be made available for those working on data base projects, including those that are WWW-based. Since these data are recent, these transitions will be affected in FY02 and forward.

RELATED PROJECTS

All other IRB Mine Burial efforts in MG should benefit from these data and analyses. Those most closely related are those of lead PIs Holman and Wilson.

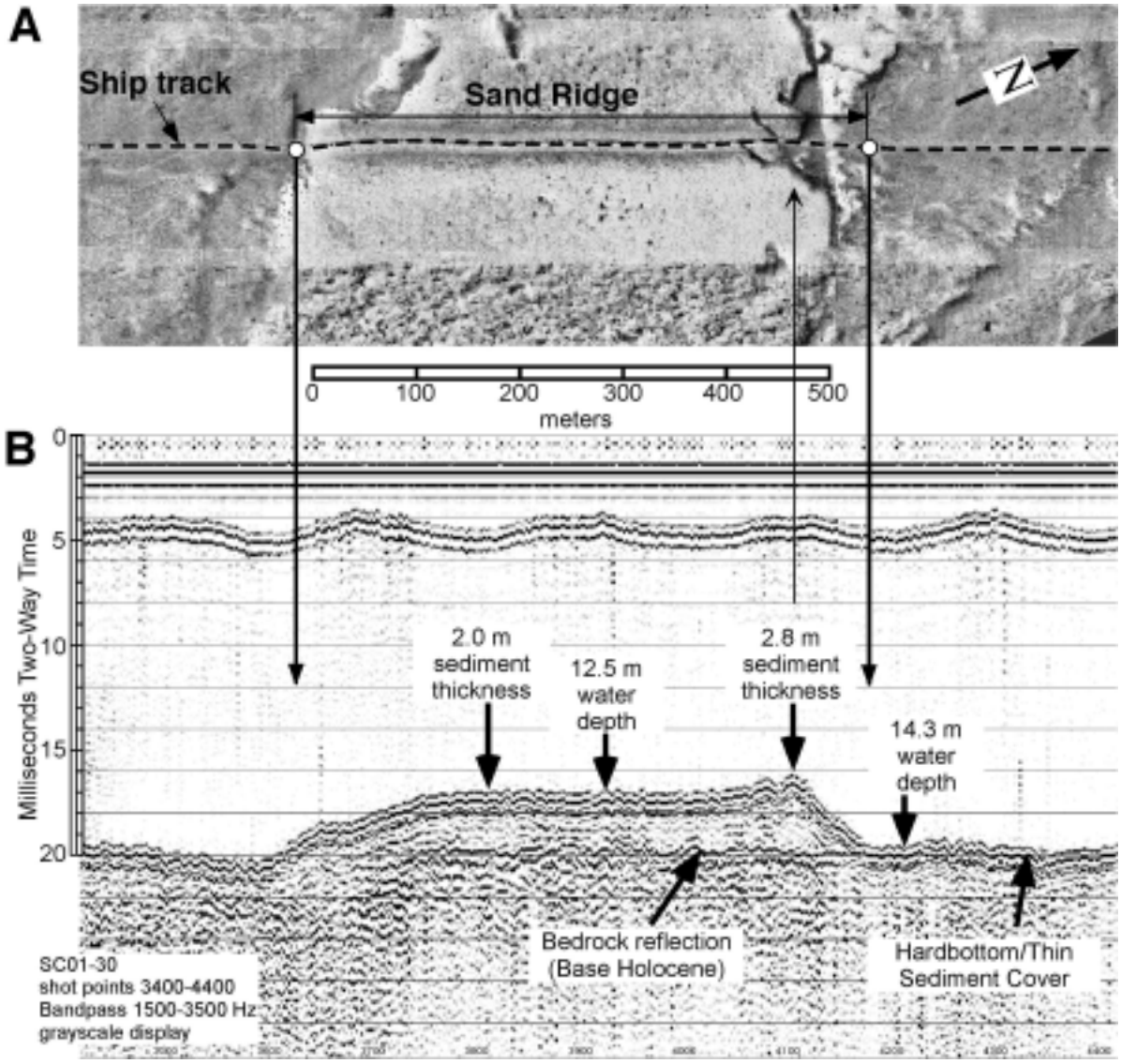

Figure 1: A) Unprocessed side-scan sonar imagery showing sand ridge defined by low backscatter (light shades). B) Example of sand ridge thickness defined by boomer seismic data. Note asymmetry of the ridge crest located near the northern edge.
[Two-panel figure showing an approximately 1 by 0.3 km section of side scan mosaic of a 500 m wide sand ridge with the associated seismic. The ridge sediments are on average 2 m thick.]

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