Sediment Dynamics on the West Florida Inner Continental Shelf

Peter A. Howd, Stanley D. Locker, Albert C. Hine, David F. Naar
College of Marine Science, University of South Florida
140 Seventh Avenue South, St. Petersburg, FL 33701-5016
Howd phone: (727) 553-1158 fax: (727) 553-1189 email: phowd@marine.usf.edu
Locker phone: (727) 553-1502 fax: (727) 553-1189 email: stan@marine.usf.edu
Hine phone: (727) 553-1161 fax: (727) 553-1189 email: hine@marine.usf.edu
Naar phone: (727) 553-1637 fax: (727) 553-1189 email: naar@usf.edu

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LONG-TERM GOALS

Our long-term goals have been to document the broader geological context of the continental shelf in the vicinity of the Winter 2003 mine burial experiments off Indian Rocks Beach Florida. The major tasks have included developing a site survey database prior to the Winter 2003 experiment that was necessary for selecting suitable seafloor locations for the deployments. These data sets included a 13-month record of hourly waves, currents and bottom boundary layer characteristics, side-scan sonar mapping of bottom types, subbottom imaging using high-resolution seismic and chirp methods for mapping sediment thickness and stratigraphic framework, and sedimentological characteristics of the study area using surface samples and vibracores, and multiple bathymetric surveys using multibeam. Additionally, we monitored the seafloor during the Winter 2003 experiments using 3 benthic boundary layer quadpods, side-scan sonar and underwater video were designed to provide some ground truthing observations of scour and burial processes over the duration of the experiment. Overall, these data provide the basic geologic information to associate with the mine scour and burial processes. Also we can better characterize both the long-term response and short-term behavior of this mixed carbonate-siliciclastic sand-ridge depositional environment to high-energy seasonal events (winter frontal passages).

These data will greatly assist the Navy goal to develop and test the accuracy of the predicted mine scour and burial during the two month experiment in the Gulf of Mexico near Indian Rocks Beach, Florida.

OBJECTIVES

Our effort this fiscal year focused in two areas, data analysis in support of selecting the specific seafloor locations for deployments, and repeated surveys to image seafloor changes during the January-March experiment. Specifically, for the Mine Burial Experiment:

1. Obtain and provide high-resolution bathymetric data at the beginning, middle, and end of the experiment period. These multibeam images can be used to monitor changes in the bedform morphology surrounding instrumented mine-like objects and produce a series of bathymetric maps and changes in bathymetry due to frontal passage that occurred over a two-month duration.

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14. ABSTRACT

Our long-term goals have been to document the broader geological context of the continental shelf in the vicinity of the Winter 2003 mine burial experiments off Indian Rocks Beach Florida. The major tasks have included developing a site survey database prior to the Winter 2003 experiment that was necessary for selecting suitable seafloor locations for the deployments. These data sets included a 13-month record of hourly waves, currents and bottom boundary layer characteristics, side-scan sonar mapping of bottom types, subbottom imaging using high-resolution seismic and chirp methods for mapping sediment thickness and stratigraphic framework, and sedimentological characteristics of the study area using surface samples and vibracores, and multiple bathymetric surveys using multibeam. Additionally, we monitored the seafloor during the Winter 2003 experiments using 3 benthic boundary layer quadpods, side-scan sonar and underwater video were designed to provide some ground truthing observations of scour and burial processes over the duration of the experiment. Overall, these data provide the basic geologic information to associate with the mine scour and burial processes. Also we can better characterize both the long-term response and short-term behavior of this mixed carbonate-siliciclastic sand-ridge depositional environment to high-energy seasonal events (winter frontal passages).

15. SUBJECT TERMS

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2. Obtain and provide side-scan and video imagery of the experiment site before, during at at the conclusion of the experiment.
3. Obtain and provide near-bottom processes measurements at multiple locations within the experiment site. These include directional wave spectra from 5 sites, and combined wave-current bottom boundary layer measurements at three sites.

APPROACH

Our approach was truly an integrated team approach involving several institutions and specialties. USF, NRL, USGS, and Eckerd College provided much of the initial studies in the area over the past several years, with additional site survey work performed in 2002 by USF (Table 1). Prior to January 2003, extensive coordination between USF, NRL, FWG, and many others resulted from several ONR sponsored meetings coordinated by Roy Wilkens, Dawn Lavoie, and Thomas Drake. Two main test sites in fine and coarse sediments (~13 m) were chosen to deploy optical and acoustic instrumented mine-like-objects, as well as other non-cylindrical, inert, mine-like-objects. A third fine sediment site in slightly deeper water was chosen to deploy two additional optical instrumented mine-like-objects, but without nearby environmental monitoring equipment.

The general approach was to use the R/V Suncoaster to map with multibeam and side-scan at night, deploy equipment during the day with SCUBA divers. The following nights were used to remap the area after the deployment of equipment and accurately locate their positions, then to transit to St. Petersburg to obtain more equipment to deploy. This process was repeated until all equipment was deployed, thereby providing a series of repeat maps and maximizing use of vessel.

The seafloor was imaged using side-scan sonar to document the bedform changes responding to the winter frontal passages. All of the mine targets were also imaged to observe the changes in backscatter surrounding the targets. Underwater video surveys were designed to ground truth burial and scour for comparison to sonar imagery and instrumented mine data. The video objectives included efforts to obtain compass headings of mine orientations, elevation change, burial, and biological activity that might impact burial processes.

Near-bottom physical processes were measured using 3 benthic quadpods and 5 bottom-mounted Doppler current profilers. Each quadpod carried a SonTek PC-ADP, SonTek Hydra, and various optical instruments for measuring suspended sediment characteristics. All current meters were paired with pressure sensors, compass and tilt sensors.

WORK COMPLETED

A summary of geophysical data acquired is shown in Table 1. This table coves the time period from October 22, 2002, through March 12, 2003, and includes the side-scan sonar survey, ROV video dives, Simrad multibeam surveys, and USF diver observations. All side-scan imagery has been processed, and most of the video imagery has been output to photo albums of still frame images that will be distributed on CD-ROM.

Post-processing of the multibeam data is still underway, and will require additional effort in converting files and their format to correct for sea-level fluctuations. Standard navigation and beam editing will be conducted. Tide-corrections (long-term sea level fluctuations including potential setup during

strong winds) will be attempted using two methods for comparison. First, using pressure sensor data from the deployed instrumentation will be used. Second, we will attempt to use the recorded Applanix POSMV navigation data to estimate ship elevation with respect to the ellipsoid using corrections transmitted from a base station we installed on the Adams Mark Hotel in Clearwater, Florida.

		Side-scan sonar 100 kHz	Side-scan sonar 390 kHz	ROV Video	300 kHz multibeam bathymetry & backscatter	Diver observations
October 22, 2002 *	Deep	X				
	Coarse	X	X	X		
	Shallow	X	X	X		
January 16-17, 2003	Deep				X	X
	Coarse	X	X		X	X
	Shallow	X	X		X	X
February 6, 2003	Deep		X		X	
	Coarse		X	X	X	
	Shallow		X	X	X	
March 12, 2003	Deep		X	X	X	X
	Coarse		X	X	X	X
	Shallow		X	X	X	X

* Chirp sub bottom also acquired in October 2002.

Table 1. Summary of geophysical data sets and dates acquired for USF ground truthing surveys.

Process data were collected every other hour for the 2-month experiment period. Burst duration was 1024 seconds. Initial processing has been completed and summary statistics files of wave and current parameters are available to program investigators through the Mine Burial Program website. Data processing continues for the previous 13 months of process measurements. We are focusing on two individual storm events and a climatological description of the combined wave-current BBL.

RESULTS

The underwater video combined with the 390 kHz side-scan sonar imagery provided both direct calibration for burial measurements, and detection signatures as seem in side-scan imagery. On the fine sand bottom we find that the targets are best detected by the backscatter reflection form the target itself. Scour depressions and seafloor roughness due to worm tube exposure are additional influences

on backscatter character. However, on the coarse sand bottom the target reflection itself is less apparent, and the target's shadow is the most distinctive detection feature.

The underwater video was able to show both close up conformation of the instrumented mine's detector burial, but also provided a view of seafloor scour meters away from the targets (Figure 1). Low-angle views several meters distance from the targets illustrated the sinking of targets into scour depressions below the elevation of the surrounding seafloor in contrast to actual burial by sediment.

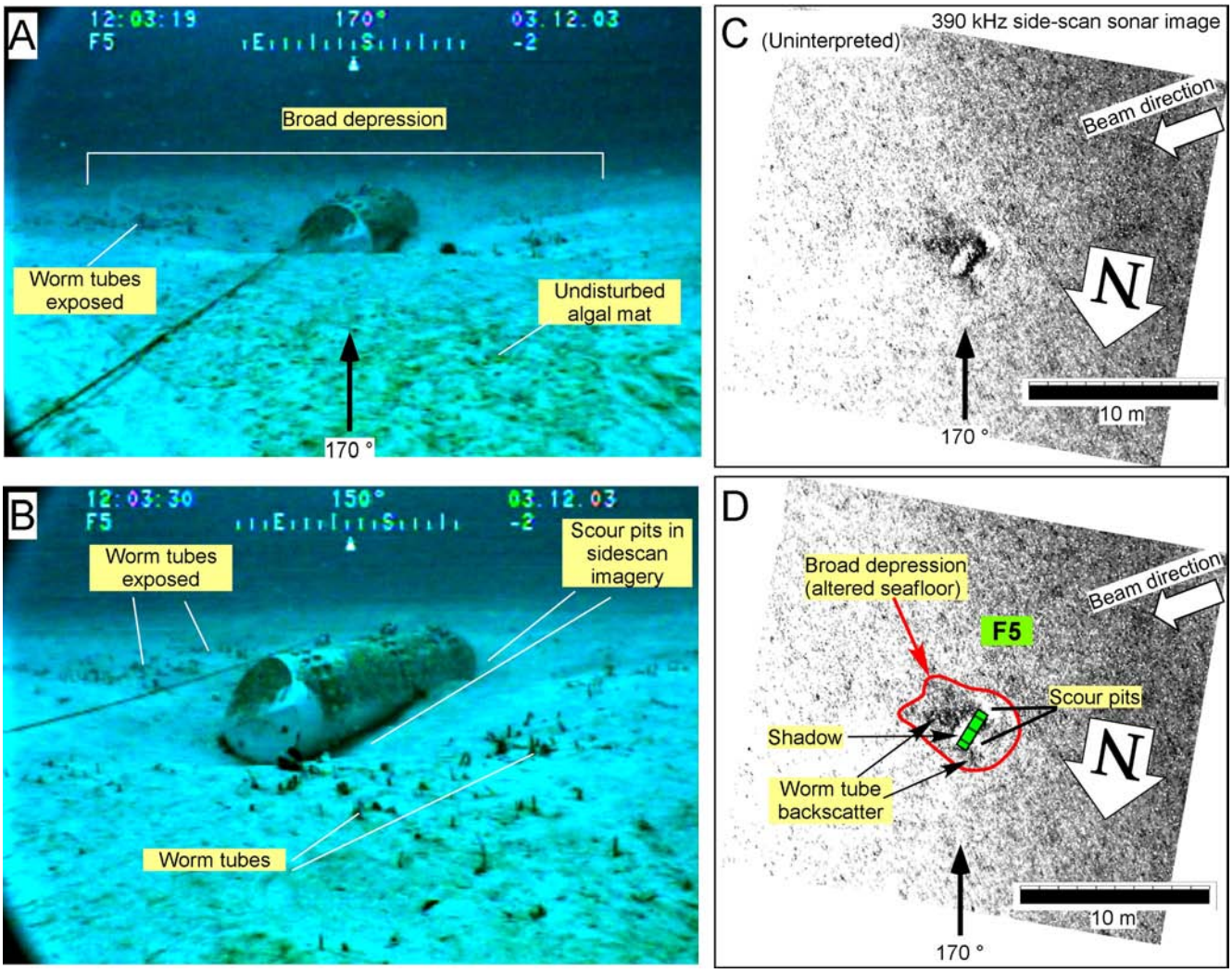

Figure 1. Comparison of side-scan imagery and ROV video images at optical mine F5 on March 12, 2003. Features created by scour around the mine are detected in the side-scan imagery. A) The sinking of the mine below the surrounding seafloor elevation is apparent, as well as a sense for the far-field affects of scour. B) Closer view of F5 showing worm tube exposures and scour pits. C) Uninterpreted side-scan image is rotated to match view in panel A. D) Interpretation of backscatter features linked to direct visual characteristics. The side-scan imagery suggests that an area of approximately 20 m^2 had been impacted by scour surrounding F5.

Although the multibeam bathymetry data are not yet post-processed, they clearly show that the resolution of the EM 3000 multibeam sonar is sufficient to monitor the changes that occurred during

the experiment. This first-order qualitative result is consistent with observations made with 100 and 390 kHz towed side-scan sonar, ROV video, SCUBA observations, and the instrumented mine-like objects, and the predictive models.

Process results show a clear link between frontal passage, increase in wave heights, and the resuspension of bed sediments as represented by acoustic backscatter levels (Figure 2). There does not appear to be a similar link between mean current velocity and bed activity.

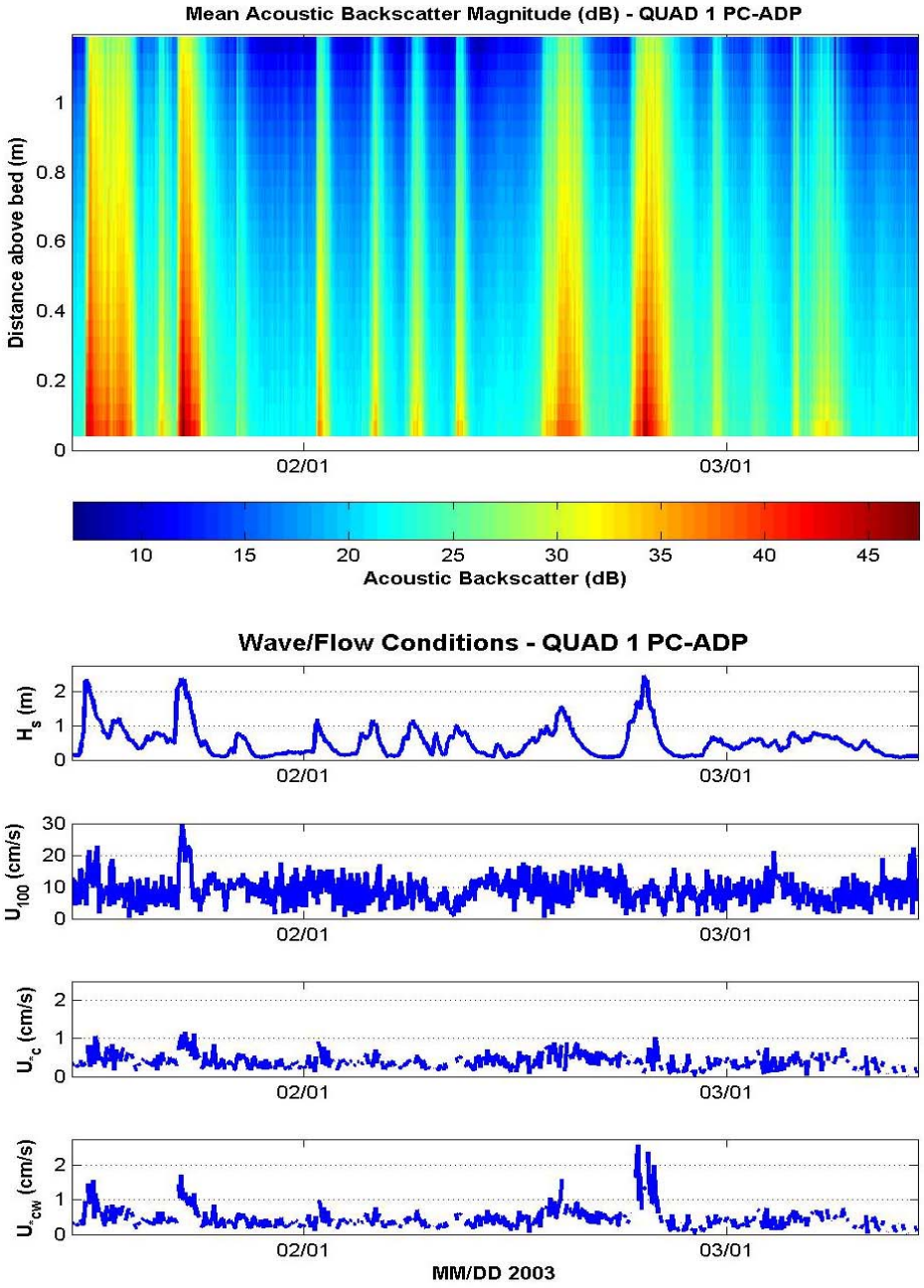

Figure 2. Process summary from Quadpod 1 (fine sediments). From top, near-bed acoustic backscatter profiles, significant wave height, mean current speed 1 m above bed, U_{*C} calculated from mean current profiles, U_{*CW} from slightly modified Grant-Madsen formulation.

IMPACT/APPLICATIONS

The suite of direct observations provide a unique calibration of instrumented mine measurements, and assessment of model predictions for mine burial. We are working to complete a time-series catalog of video and side-scan sonar observations, multibeam surveys and process data that will be useful for investigators conducting both in situ measurements and predictive modeling. This study will also allow us to better characterize the origin and evolution of sand-ridge depositional environments on multiple spatial and temporal scales. One important finding has been a new awareness of the important role ripple scour depressions may play in the sedimentological and stratigraphic architecture of sand ridges.

TRANSITIONS

The data collected as part of this study will be directly applied as the mine burial models are transitioned to Navy use. A potential transition that has not yet occurred but will occur, is the transfer of all nearshore multibeam data to the Naval Oceanographic Hydrographic Office. This includes all EM 3000 multibeam data we have collected and the retrieval of lost NOAA digital bathymetry data collected in the 1970's (which USF provided Scott Jenkins (SIO) for his wave predictions). Both these data sets will be provided to the Naval Oceanographic Hydrographic Office after post-processing is completed. Preliminary email communications have begun with Ed Gente and Barbara Reed.

RELATED PROJECTS

In preparation for an NSF project in Papua New Guinea, we (Brian Donahue and I) have successfully mobilized the R/V Melville (UNOLS Fleet) and conducted sea trials during a transit funded by ONR UNOLS ship funds from Darwin, Australia to Cairns, Australia. The Royal Australian Navy Hydrographic Office, paid for two additional days of ship time, in which we conducted several patch and calibration tests and target detection tests in a certified test patch area near Cairns, Australia. The results of this test, clearly identified the scour surrounding three separate 1-meter cubes. Depth comparisons using predicted tides on board for a preliminary postprocessed em3000 data set with the certified RAN depths matched very well.

The instruments utilized in process measurements portion will be deployed during the MVCO Mine Burial Experiment, October 2003-March 2004.

The process data collected during all phases of these experiments will be made available to collaborators in the scientific community involved in the development of a shelf sediment transport community model.

PUBLICATIONS

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