High-resolution Mapping and Backscatter Studies in Support of the Ripples DRI

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LONG-TERM GOALS

The long-term goal of the RIPPLES DRI is to develop the ability to predict the geometry and evolution of seafloor morphology and in particular the presence or absence of ripples which have been shown to affect the sub-seafloor penetration of acoustic energy. Specific goals are to:

1. Measure and model ripple morphology and gradients on scales ranging up to kilometers

2. Understand the response of ripples to changes in wave and wave-current forcing

3. Measure and model rates of biological degradation (or production) of seafloor morphology

4. Measure and model effects of a distribution of grain-scale properties (e.g. size, density, cohesion) on ripple morphology

5. Understand the role of ripples in generating surface and subsurface sedimentary structures.

OBJECTIVES

In support of these long-term goals, the UNH-CCOM team is conducting ultra-high-resolution, multifrequency, multibeam mapping program in order to:

1. establish the overall morphological context of the area of the RIPPLES DRI/SAX-04 experiment (bathymetry and acoustic backscatter)

2. establish the detailed distribution of ripples and other small scale features throughout the experimental area, before the start of the experiment, immediately after deployment of the sensors, and at intervals during the experiment

3. Explore techniques for using the backscatter recorded by the multibeam sonar as a means to remotely identify seafloor properties including acoustic parameters, grain size and biological components.

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APPROACH

At the crux of the RIPPLES DRI/SAX04 program is a multi-disciplinary experiment involving the deployment of a number of acoustic sensors in a small area off the coast of Destin FL. The area selected is the site of the SAX99 Experiment, an approximately 1 km^2 area with water depths of approximately 18 – 20 m located off the Florida Panhandle (with an extension to deeper water for the DRI program). In support of these efforts, and in order to address our specific objectives, we are conducting a series of multibeam sonar surveys of the RIPPLES DRI/SAX04 experiment site that serve multiple purposes. First and foremost, these surveys place the entire experiment in a morphological and lithological context that will allow all investigators to understand the local bottom relief spectra and sediment distribution over spatial scales ranging from a few kilometers to a few centimeters. At the same time, we will provide all investigators with the regional (100's to 1000's of meters) distribution of the bathymetry and sediment distribution but near the same level of resolution (10's of cm's). In addition to addressing questions of ripple morphology and distribution over many scales, we also hope to use the multibeam sonar(s) to determine the acoustic backscatter response of a rippled seafloor over a wide range of angles and under a number of conditions.

The surveys are being conducted on a 46' Naval Oceanographic Office hydrographic survey launch (HSL) that is based in Gulfport and equipped with precision navigation equipment and two state-of-the-art dynamically focused multibeam sonars (a 300 kHz – 130 degree, Simrad EM3002, and a 455 kHz , 120 degree, Reson 8125 -- the same sonar we used to resolve ripples and mines off Martha's Vineyard). Both systems also collect backscatter as a function of beam angle but in the configurations we are using, only the Simrad system provides a full time series of backscatter values across each beam footprint. The Reson system provides a single average value of backscatter for each beam (thus much lower resolution) or a full time series of backscatter values across the swath with no angular resolution (e.g. standard sidescan sonar). The NAVO vessel will not work in water shallower than 5 meters and for high-resolution survey work we would like to have significant overlap of one swath with the next. Also to ensure high quality data and dense enough data in the along-track direction we will keep survey speeds down to about 6 knots. For overlapping coverage, it is by far, more efficient to run parallel to the contours as the swath width stays constant.

Funding is available for approximately 20 days of survey work through the course of the experiment. We have proposed to divide these into 5, 4-day survey blocks so that we may examine both the short and long-term temporal and spatial variations in the ripples with respect to the local environmental conditions. We proposed to spread 4 of the survey blocks over the time period between early Sept and mid Nov and save one of the surveys for an "event response" - a survey conducted directly after a storm event. In planning our survey work we are trying to meet the objectives of the ONR DRI, the SAX-04 investigators as well as NRL researchers who are looking at coastal processes at a site near the SAX/DRI experiment (known as the TOWER SITE) and who are contributing to the cost of the field work.

Detailed Survey Plan (Figure 1):

SAX04 Site -- an approximately 2 km (EW), 1 km (NS) box centered around (but slightly offset) the RV Seward Johnson and the buried target site. The survey box starts at approximately the 5 m contour and extends about 1 km offshore from there (to a depth of approximately 18-19 m) A box of this size can be fully covered with ripple-resolving resolution in approximately one survey day.

TOWER SURVEY Site -- an approximately 3 km (EW), 600m (NS) box directly offshore a coastal meteorology tower. This survey will start at the 5 m contour and continue about 600 m offshore (to approximately the 15m contour), A full coverage, high-resolution survey in this area will take about 1 survey day.

SAX04-deepwater lines (DRI Survey) -- The Ripples DRI objectives call for surveys out to 25 - 30 m depth. It is impossible to get full coverage over an area this large in the time available so we will run a series of individual N-S lines about 10 km long running from the southern boundary of the SAX04 survey box to approximately 25 - 27 m depth. These lines will have a swath width of about 2 x the water depth and thus will average about 40 m wide.

TOWER Site deepwater lines. – NRL would like to have some survey data further offshore but only to 18 m depth.

During each of the five survey blocks, the SAX04 shallow site, the Tower Survey site and the DRI deep water lines will be surveyed; as, and if, time permits, surveys will be also be conducted of the Tower Site deepwater lines and a second survey of the SAX shallow water (separated by two days from the first to better understand short-term adjustments of the floor).

Along with our bathymetric mapping objectives we hope to also continue our research into the potential role that multibeam sonar backscatter measurements can play in the remote identification of seafloor properties. As described in Fonseca, et al., 2002, we have been working with the composite roughness model of Jackson et al. (1986) to see how it can be applied to the analysis of multibeam sonar data. In the context of Fonseca, et al., we modified the model to explore the role of gassy in sediments and used this modified model to analyze multibeam sonar data from the Eel River margin. We have continued this work with the development of an interactive tool that is modeled after the AVO (amplitude vs offset) analyses that are standardly done in offshore petroleum exploration. The tool automatically ingests multibeam sonar bathymetry and backscatter data, makes all corrections necessary (including corrections for local slope) to calculate true backscatter, and then allows an iterative process that adjusts model input parameters (seafloor properties) until they best fit various pre-defined portions of the measured backscatter vs angle of incidence data.

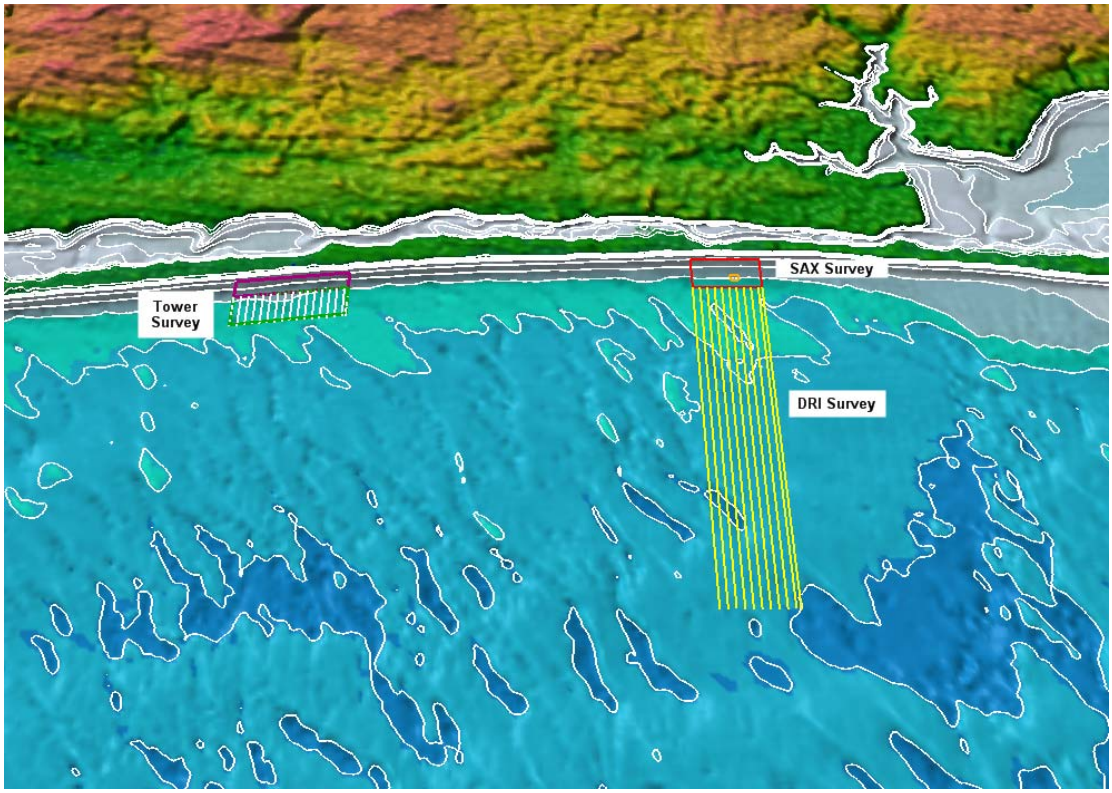

Figure 1. Overview of SAX04/Ripples DRI surveys
Bathymetric map of region offshore of Destin Fl., showing 1x2 km detailed survey area for SAX surveys, 10km long, N-S lines for DRI survey, 800m x 3km detailed survey area off met tower.

WORK COMPLETED

The first of the scheduled surveys (the pre-deployment survey) was conducted between 31 August and 3 September 2004 with both a Reson 8125 and Simrad 3002 multibeam echosounder using the NAVO HSL. The SAX04 detailed site, the DRI deepwater lines (nine) and the Tower Site were mapped and 120 Gbytes of data were collected in 4 days. Preliminary bathymetric maps were produced within a few days of the survey work and provided to the SAX04/DRI teams. This initial survey has produced a reasonable base map from which comparisons to future surveys will be made. We are now preparing an "event response" cruise following Hurricane Ivan.

RESULTS

Figure 2 shows the preliminary bathymetric map from the SAX04 area. No ripples were seen (within the resolution of the sonar [<5 cm vertical]) at this point in time. Several targets (clump anchors ~50 cm proud of the seafloor), however, are clearly seen.

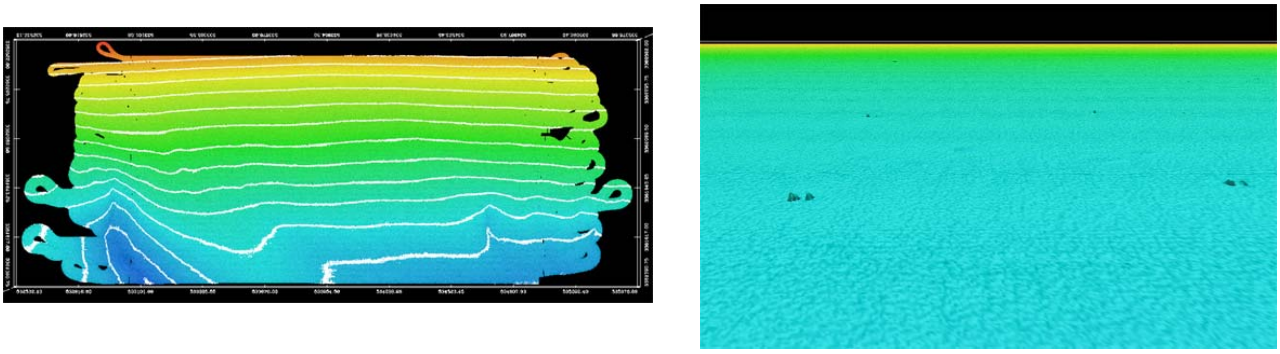

Figure 2. (left) Preliminary "pre-deployment" bathymetric map of 1x2 km "SAX04" detail survey box off Destin. Contours are at 1 m interval starting a 7 m and going to 20 m depth. Right- close-up of several clump anchors sitting about 50 cm proud of the seafloor in middle of survey area. There is no indication of resolvable ripples in the survey area.

IMPACT/APPLICATIONS

New start – none to date.

TRANSITIONS

New start- none to date.

RELATED PROJECTS

Mine Burial and Uncertainty DRI's

PUBLICATIONS

None – project has just begun

REFERENCES

Fonseca, L., Mayer, L.A., Orange, D., and Driscoll, N, 2002, The high-frequency backscattering angular response of gassy sediments: Model/data comparison from the Eel River Margin, Jour. Acoust. Soc., Am., vol. 111, no. 6, pp. 2621-2631

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