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Resolving the Ripples (and a Mine): High-Resolution Multibeam Survey of Martha's Vineyard ONR Mine Burial Program Field Area

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Resolving the Ripples (and a Mine): High-Resolution Survey of the Martha's Vineyard ONR Mine Burial Program Field Area

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Introduction

In an effort to better understand the coastal processes responsible for the burial and exposure of small objects on the seafloor, the Office of Naval Research is sponsoring the Mine Burial Program. Amongst the field areas chosen for this program is the site of the Martha's Vineyard Coastal Observatory (MVCO), a permanent instrumented node in 12 m of water about 1 km off the southern shore of Martha's Vineyard. In support of the ONR program, several site surveys of the MVCO area have been conducted (see Goff et al, Buynevich et al, and Kraft et al. posters); here we report the result of the most recent of these surveys, a very high-resolution multibeam survey aimed at establishing a detailed base map for the region and providing a baseline from which subsequent surveys can measure seafloor change.

The System:

The Reson 8125 is a dynamically focused, 455 kHz multibeam sonar (Fig. 1). It forms 240, 0.5 degree beams over a 120 degree sector. The dynamic focusing corrects for the curvature of the wavefront in the near-field allowing for a relatively long transmit array and thus very high resolution (Fig 2). The system was hull-mounted on the SAIC survey vessel OCEAN EXPLORER (Fig 3), aligned and surveyed in to precise specifications.

Fig. 1. Sonar head of Reson 8125 multibeam. Transmitter (vertical) is approx. .4m while receive array is approx. .5 m in length.

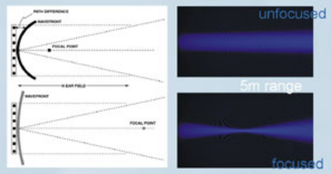


Fig. 2. Example of dynamic focusing used by 8125 to allow extremely high resolution (both vertical and lateral) in the near-field

Fig. 3. SAIC vessel OCEAN EXPLORER used for the Martha's Vineyard survey. Reson 8125 was hull-mounted on the vessel and surveyed in to assure stability and proper alignment and thus high accuracy.

Survey Control

Because the objectives of the survey were to obtain the highest resolution possible as well as to establish a baseline for repeat surveys, great care was taken to minimize positioning uncertainty. Positioning for the survey was undertaken using both inertially-aided real-time Differential GPS and post-processed Kinematic GPS. Real-time positioning and vessel motion were tracked using a POS-MV v.3 inertial motion sensor with 2 Novatel OEM-3 GPS receiver cards. Kinematic positioning information was collected by 2 Ashtech Z-12 receivers and 1 Trimble MS750 receiver on the survey vessel as well as 2 Ashtech Z-12 receivers and 1 Trimble Ms750 receiver located at control points on Martha's Vineyard. All kinematic GPS data was logged with GRIM and processed with DYNAPOS software from the XYZ's of GPS. Shore station data was converted to RINEX format and uploaded to the NOAA OPUS site in order to establish the precise position of the base stations. The post-processing of the kinematic data will take several months -- ALL DATA PRESENTED HERE HAVE ONLY DGPS POSITIONING APPLIED.

The Survey:

In late July we conducted a five day survey of an approximately 3 x 5 km area surrounding the MVCO node using the Reson 8125 focused multibeam sonar aboard the SAIC survey vessel Ocean Explorer. We conducted a super high-resolution (4 m spacing) survey in a small area surrounding the MVCO node and mine burial sites, a slightly lower resolution survey (12 - 25 m spacing) in a box approximately 1 x 1 km surrounding the "target box" and a lower resolution survey (25 - 40 m line spacing) in a 3 x 5 km region surrounding the 1 x 1 km box (Fig. 4). The Reson 8125 produced approximately 1 Gigabyte of data per hour. Water depths in large survey area range from 6.9 - 18.5 m.

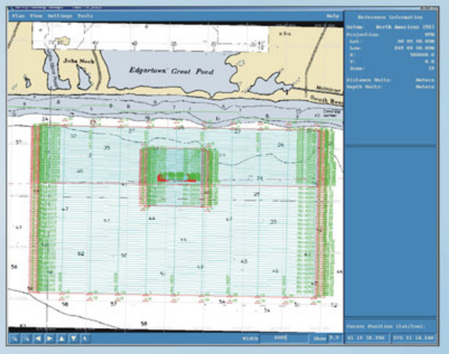
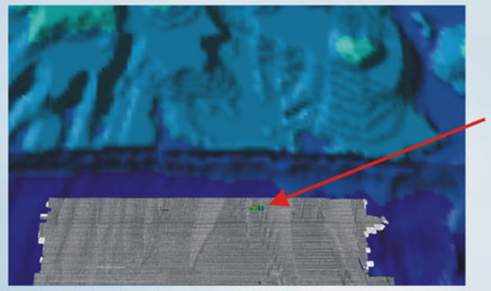


Fig. 4. Plot of tracklines for July MVCO mine burial survey showing three levels of survey detail. The most detailed survey box, centered around MVCO and potential mine burial sites, has 4 m line spacing, middle box has 12-25 m line spacing and large box has 25-40 m line spacing.



MVCO detailed survey area

Fig. 5. Overview of Martha's Vineyard mine burial survey site. Gray image is 117 kHz backscatter data collected with Submetrix phase-comparison sonar by USGS Woods Hole. High backscatter is represented by lighter shades of gray. Detailed (4m line spacing) survey area centered around MVCO is located at arrowhead.

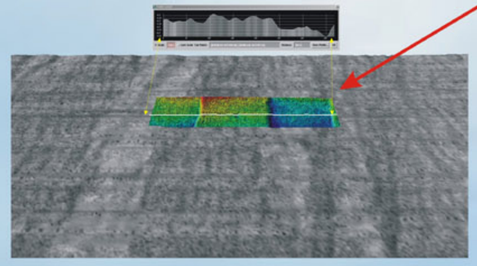
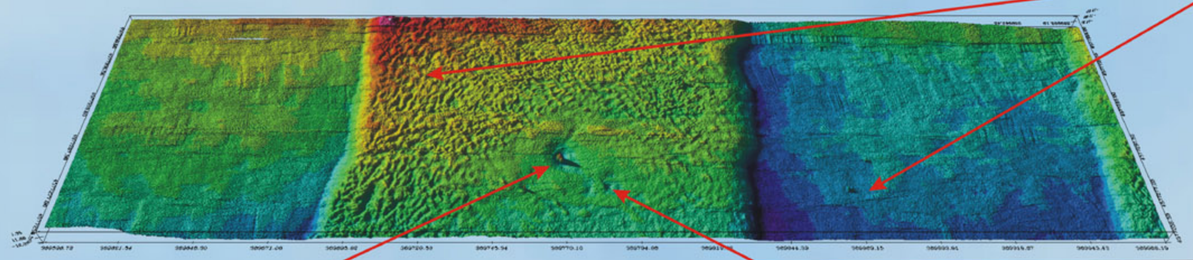


Fig. 6. Color-coded bathymetry of 400 m x 100 m detailed survey area surveyed with Reson 8125 superimposed on Submetrix backscatter. The detailed survey was designed to cross two "Rippled-Scour Depressions" and an intermediate topographic high. Profile at top of figure corresponds to white line on color-coded bathymetry. The shape of the profile represents the bathymetry while the gray-scale represents the relative backscatter value from the Submetrix sonar. Note that the backscatter boundaries do not directly correspond to the topographic boundaries (see Goff et al., poster for discussion of relationships amongst backscatter, bathymetry and grain size).



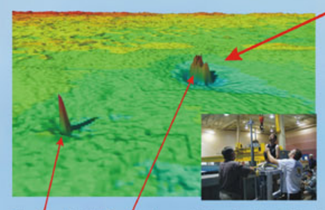


Fig. 7 - The MVCO tower (upper right) and a diver-deployed sonar target as seen with the Reson 8125 multibeam echo sounder, gridded (20cm) and rendered in 3-D. Sonar targets (seen in lab in photo on right) were jetted in by divers to serve as positional control (fiducials) for repeat surveys that will be carried out to understand the temporal changes in the seafloor after deployment of instrumented mines.

3-D rendering of color-coded bathymetry (gridded at 20 cm with weighted mean grid) from detailed 400 m x 100 m survey located around the MVCO. Data is preliminary and not fully processed -- several motion and tide artifacts are present in the data. Nonetheless, the MVCO tower is clearly imaged in middle of survey area (Fig 8) as are several diver-installed reflectors (metal poles with targets attached) that act as survey fiducials (Fig 7). Also seen are two fundamentally different types and scales of seafloor features. On the topographic high between the "Rippled-Scour Depressions" (typically med-fine sand) are irregular bedforms with 4-8 m horizontal scale and vertical scales of 5 - 10 cm (Fig 9). The depressions to either side of the topographic high are characterized by much more regular, NW-SE oriented ripples with horizontal scales of 10's of meters and vertical scales of 5 cm or less (Fig 10). The relationship amongst the topography, the backscatter and the bedforms as well as evidence for the migration of the seafloor features is presented in the Goff et al poster.

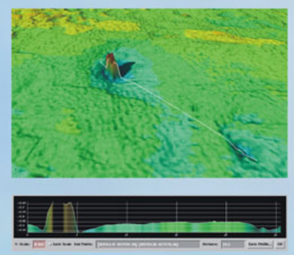


Fig. 8. MVCO tower and the instrumented mine deployed by NRL (see Traykovski and Richardson poster). Mine is located 20 m from tower. Detail of mine in Figure 11.

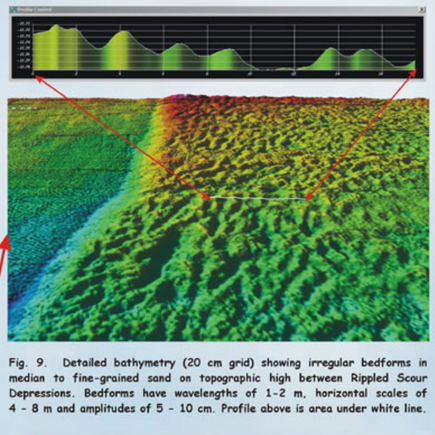


Fig. 9. Detailed bathymetry (20 cm grid) showing irregular bedforms in median to fine-grained sand on topographic high between Rippled Scour Depressions. Bedforms have wavelengths of 1-2 m, horizontal scales of 4 - 8 m and amplitudes of 5 - 10 cm. Profile above is area under white line.

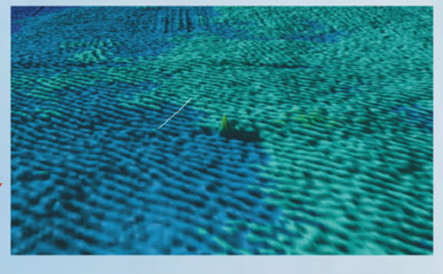


Fig. 10. Detailed bathymetry (20 cm grid) from the coarse-grained eastern Rippled Scour Depression with regularly spaced small-scale ripples with approximately 50 cm wavelength and <5cm amplitude. One of the sonar targets is also visible in the center of the image. Profile above is area under white line.

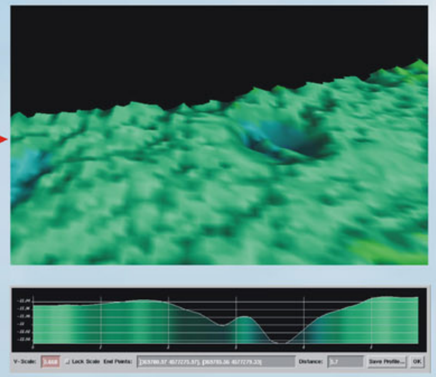


Fig. 11. Rendered 3-D image of instrumented NRL mine deployed in 12 m of water, 20 m southeast of the MVCO tower. Mine is 1.5 m long and .47 m in diameter and is sitting in an approximately 15 cm deep scour pit. It is only several cm proud of base of scour pit. In this configuration, the mine would not be detected with sidescan sonar. See Traykovski and Richardson poster for details of mine burial and excavation.