Geomorphic Characterization of Seafloor Classification: Gray's Reef National Marine Sanctuary

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Figure 1. Gray's Reef National Marine Sanctuary (GRNMS), 32.4 km east of Sapelo Island, GA.

Abstract

Gray's Reef National Marine Sanctuary (GRNMS) is located on the continental shelf of the southeastern US, 32.4 km east of Sapelo Island, Georgia. The sanctuary covers approximately 58 km^2, with average depths ranging between 14.8 to 22 m. In May, 2011, the NOAA Ship *Nancy Foster* collected bathymetric and backscatter data for the reef using a Reson 7125 multibeam sonar system. These data were processed in CARIS HIPS 7.1.2 to map the bathymetry at a 2m resolution, and backscatter at 1m resolution. Cross-sectional profiles indicate sand waves are potentially encroaching on the colonized hard bottom reef. Backscatter values roughly correspond to previously identified main bottom types found in Gray's Reef: flat sand, ripples sand, densely colonized hard bottom and sparsely colonized hard bottom. This study provides a baseline for comparison to earlier benthic surveys and can aid in future management decisions for the sanctuary.

Introduction

Gray's Reef National Marine Sanctuary (GRNMS) is a Marine Protected Area established in 1981 because of its critical role as a "live bottom" marine habitat. The reef, named after Milton "Sam" Gray, former Director of the University of Georgia Marine Institute, is located 32.4 km east of Sapelo Island, GA, (Fig. 1) and is the only federally protected reef on the US continental shelf (NOAA, 2006). The sanctuary is approximately 58 km^2 in area, with depths ranging from 14.8 to 22 m. (Fig. 2) Its seafloor is generally characterized into four main bottom types: flat sand, rippled sand, densely colonized hard bottom and sparsely colonized hard bottom (Fig. 4), with 75% of the reef being flat sand and rippled sand (Kendall et al., 2005). The Pliocene carbonate hardbottom is predominantly flat (97%), with the remaining 3% displaying various habitat-forming bathymetric features including plains, caves, scarps, and rocky overhangs. These features were formed through processes such as subaerial weathering, stream erosion, karst formation, bioerosion and storms during historic high and low sea-level stands (Riggs, 1996). Most features show little vertical relief, with only some ledges being higher than 2 m. Densely colonized hard bottom makes up for <1% of the entire benthic zone in the reef (Kendall et al., 2007). Despite this rather small cover, the rocky substrate features provide a critical habitat for over 150 species of fish, 200 species of invertebrates and 65 species of macroalgea (Kendall et al., 2005).

Methods

In May of 2011 the NOAA Ship *Nancy Foster* collected bathymetric and backscatter data for GRNMS using its RESON 7125 shallow water multibeam echo sounder system. Data acquisition was split between HYPACK for bathymetry, and RESON Snippets for backscatter. Raw data were then processed using CARIS HIPS 7.1.2. Tides were calculated and applied based on verified zonal tides provided by NOAA. A concatenated SVP master filed was utilized by compiling daily SVP data. The final BASE surface was calculated using the CUBE algorithm at a 2m resolution. Backscatter was calculated using the Geocoder engine. Finally, a mosaic at a 1m resolution was created.

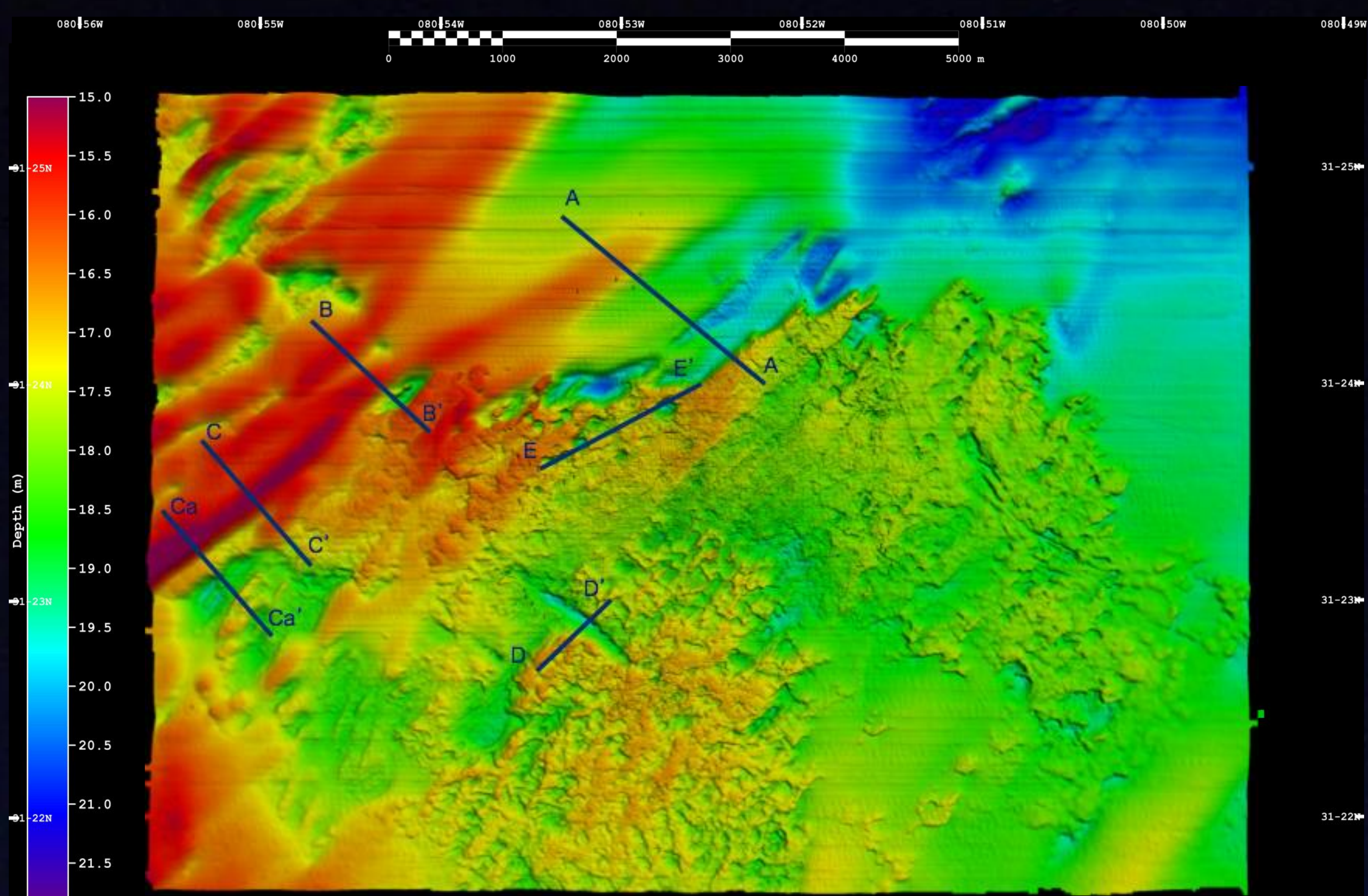


Figure 2. Bathymetry of GRNMS shown using a 3D perpendicular view, with 20x vertical exaggeration (VE) to best illustrate geomorphic features. Depths range 14.8 m to 22 m. Cross-sectional profiles displayed in detail below.

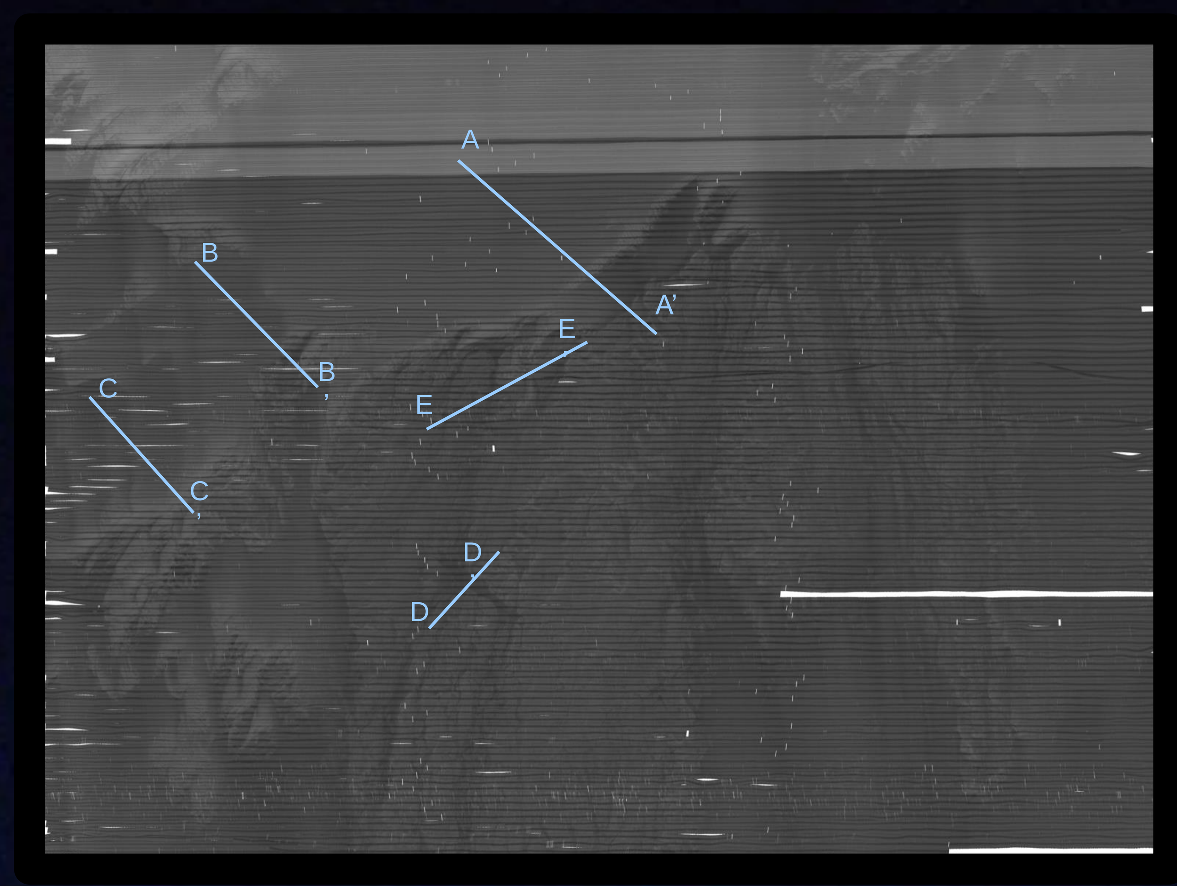


Figure 3. Backscatter depicted in grayscale with profile locations (blue lines). Dark areas indicate high intensity return from hard-bottom shelf, whereas lighter areas or low intensity indicate softer substrate sands.

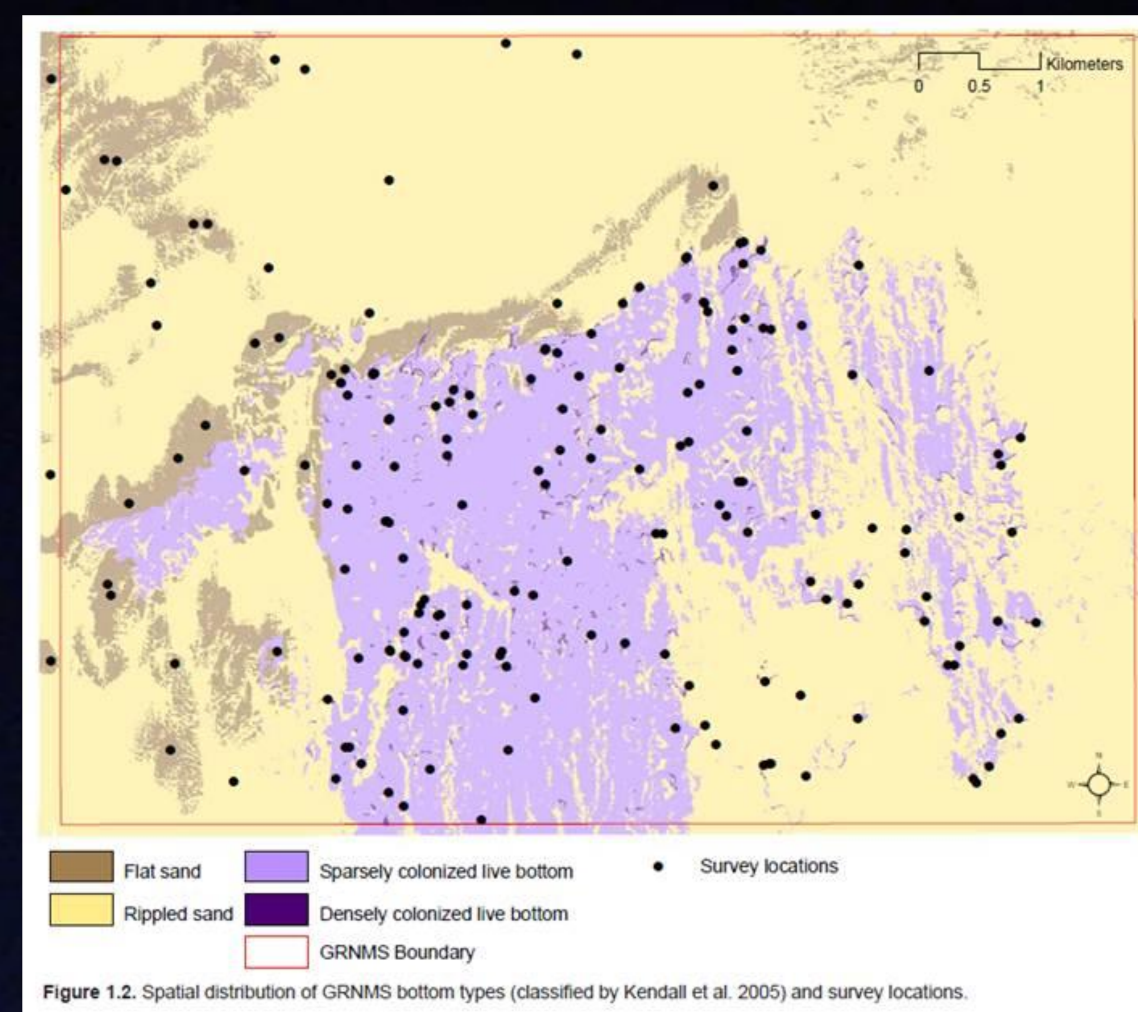


Figure 4. Spatial distribution of GRNMS bottom types classified by Kendall and others (2005), and survey locations (Kendall et al., 2007).

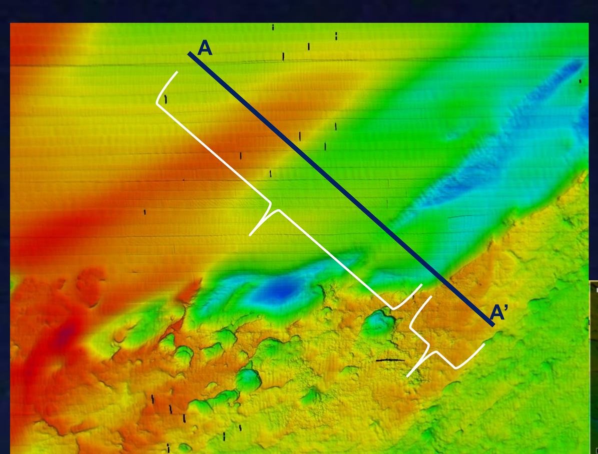
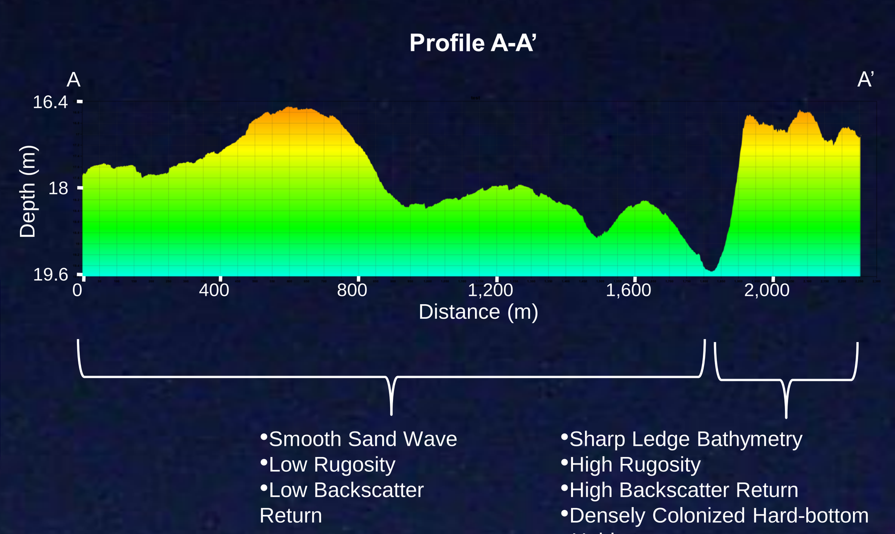


Figure 7. Area 1, 3D perpendicular view (VE=20x). Profile A-A' (right) showing the transition from sand wave to ledge. Note the apparent scour channel adjacent to the reef edge at ~1,800 m.



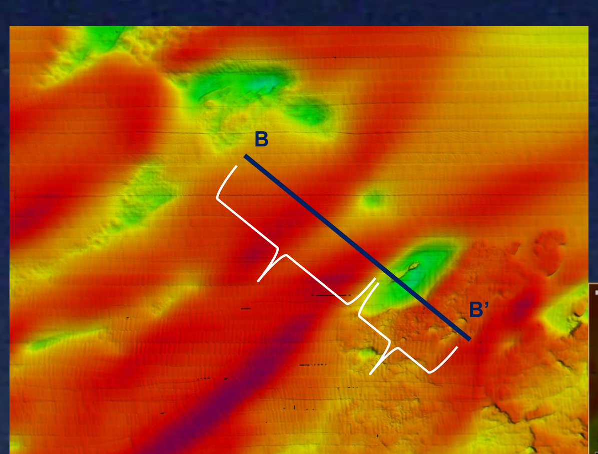
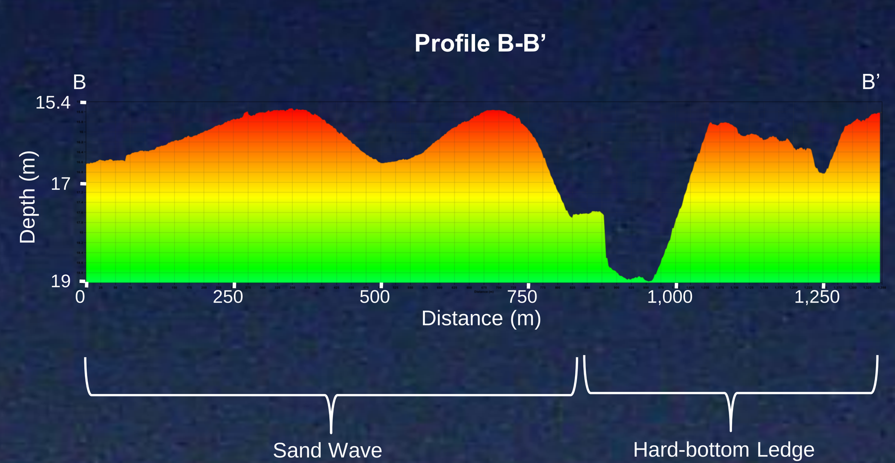


Figure 8. Area 2, 3D perpendicular view (VE=20x). Transition from sand waves to ledge are shown in profile B-B' (right). The scour region is more pronounced.



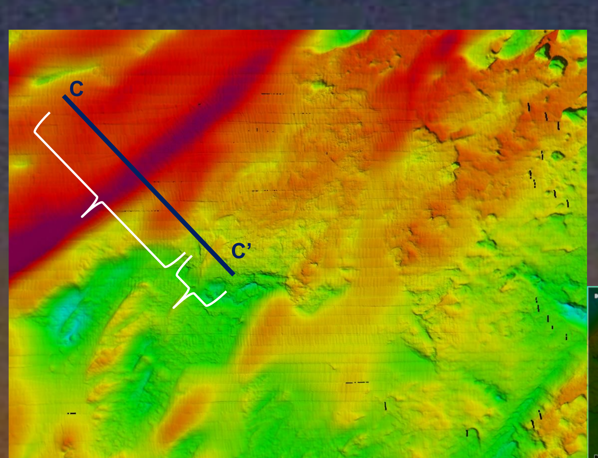
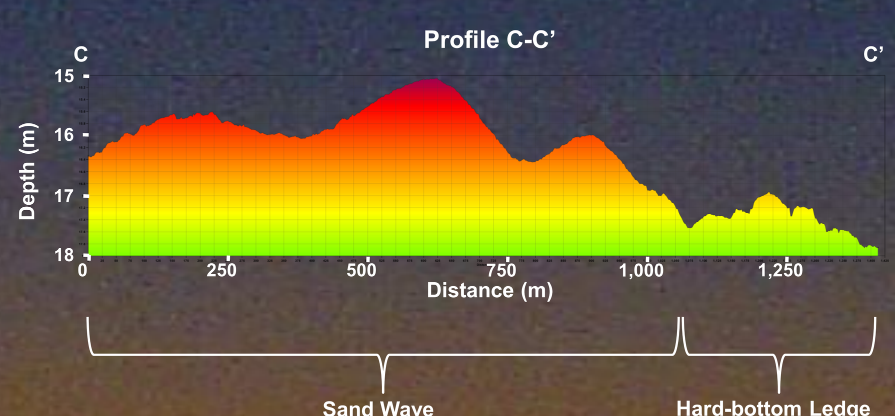


Figure 9. Area 3, 3D perpendicular view (VE=20x), showing the encroachment of sand waves onto the ledge through profile C-C' (right). No scour channel is observed as in Figures 7 and 8.



Results

- Bathymetric High: 14.8 m, Bathymetric Low: 22 m (Fig. 2).
- Ledges have 1 to 3 m relief (Profiles A-A', B-B', C-C', D-D', E-E').
- Exposed carbonate hard-bottom shelf is predominantly found in the south and southeast section of the sanctuary (Fig. 3).
- Sand waves oriented SW-NE predominantly found in the northwestern section of the sanctuary (Fig. 5).
- Profiles A-A' and B-B' show a scour channel separating the rocky ledge of the reef and a sand wave, not seen in C-C'.
- Predicted and verified tide data were applied without effect on correcting line offset, most strongly visible in the sand dominated northwestern section (Fig. 2).

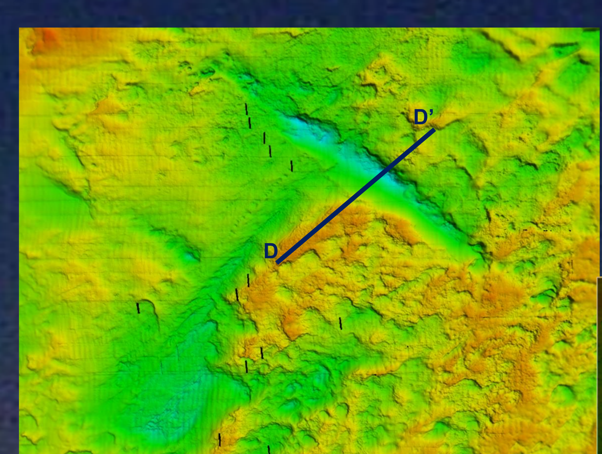


Figure 10. Area 4, 3D perpendicular view (VE=20x), with profile D-D' across potential fault, with ~ 3.5 m relief.

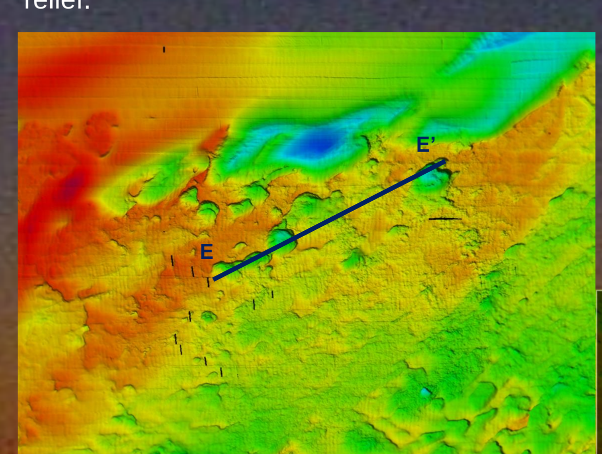


Figure 11. Area 5, 3D perpendicular view (VE=20x). Profile E-E' lies across circular scour pockets or small collapse features (i.e., sink holes) with up to 3 m ledges.

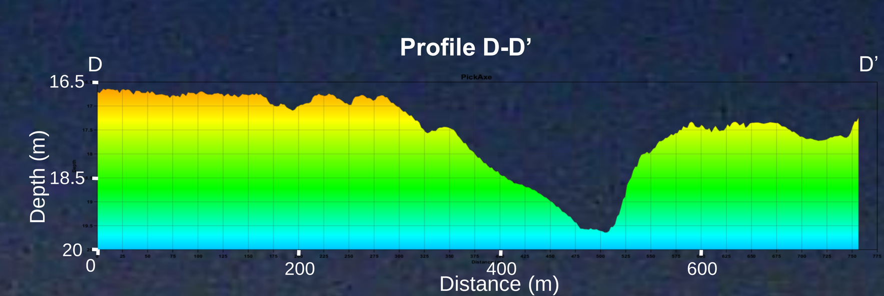
Discussion

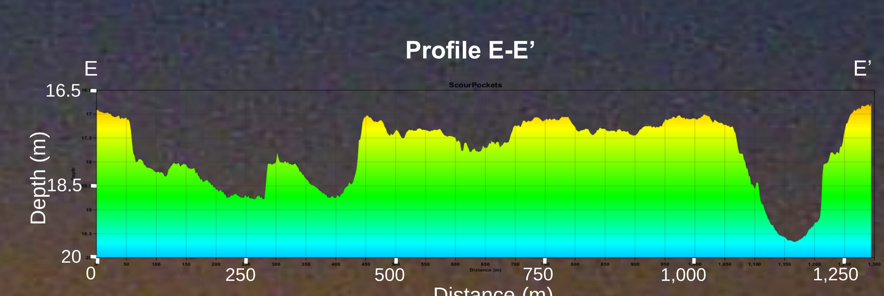
Profiles A-A', B-B', C-C'

- Cross-sectional profiles indicate sand waves are potentially encroaching on the colonized hard bottom reef. A time series comparison of sand waves may provide insight into which direction they are migrating and what energy type (tidal, storm or waves) governs the local sediment transport (Fig. 5).
- High intensity backscatter values appear to correlate to rugose hard-bottom bathymetry. We define rugose as displaying a greater benthic surface area over a given distance. Low intensity backscatter returns seem to correlate with smooth sandy bathymetry.
- The next step will be to import bathymetric data into ArcGIS Benthic Terrain Modeler, calculate rugosity, change in slope and aspect, in an effort to identify parameters that indicate densely colonized live bottom locations.

Bottom Types and Seabed Morphology

- Backscatter values seen in Figure 3 reveal the four main bottom types identified previously (Kendall et al., 2005) (Fig.4). In an effort to correlate backscatter values with live bottom habitat, we propose overlaying ground-truthed data in ArcGIS, then extracting and displaying backscatter values that correlate to known live bottom locations.
- There is a potential fault striking northwest in the center of the sanctuary that may have caused offset in erosional patterns apparent throughout the karst bathymetry of this carbonate shelf (Fig. 10).
- Numerous circular depressions with >3.5 m of relief suggest strong scouring or karst-related collapse, such as small sink holes.
- Conchoidal (arcuate) patterns suggest the possibility of a small impact crater or faulted depression in the northeastern section of the sanctuary (Fig. 6).





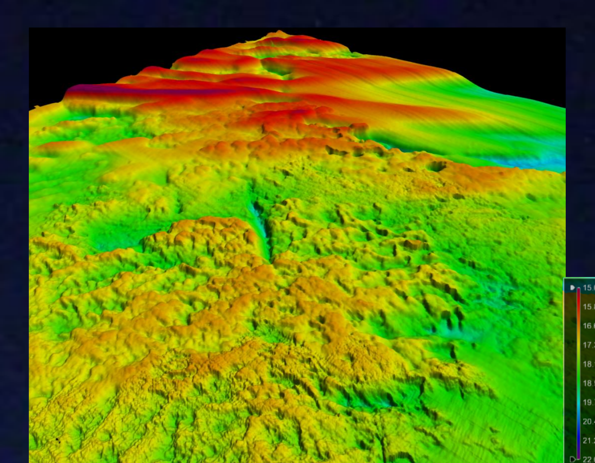


Figure 5. 3D northwestern oblique view of sand waves at 50x VE.

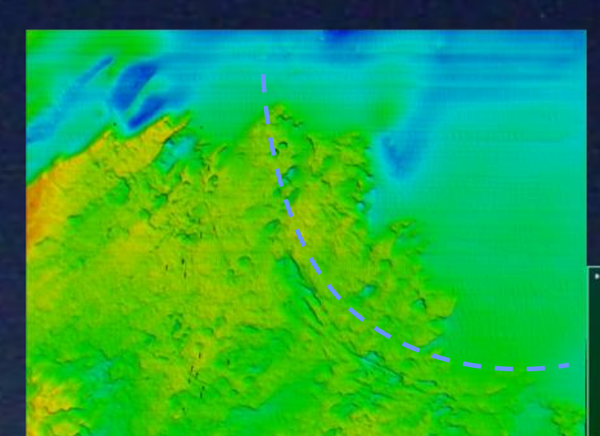


Figure 6. 3D perpendicular view at 20x VE of impact crater or arcuate depression in northeastern section of the sanctuary.

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Author Information

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