Bathymetric Analysis of Marine Environments on the Seafloor using Multibeam Sonar

Brendan Guthrie and Dr. Leslie R. Sautter
Dept. of Geology and Environmental Geosciences,
College of Charleston

Abstract:

The continental shelf off the southeastern US coast supports a benthic habitat for numerous marine species. This region is mostly composed of sand and migratory sand sheets, however, sediment starved areas allow for exposed rock with rocky reef ecosystems. "Hard bottom" or "live bottom" geomorphologies are suitable fish spawning and feeding grounds, and have become ecologically important, as many support important fisheries on the verge of exploitation. Marine Protected Areas (MPAs) are essential for protecting fish populations and have been shown to benefit many benthic and demersal fish species. In order to minimize the destruction of benthic habitats, future sites of possible MPAs are being identified using acoustic mapping techniques. Working with SC DNR MARMAP, the College of Charleston BEAMS Program surveyed a proposed mid-shelf (27 m deep) MPA site located off Charleston, SC aboard the R/V *Savannah* using a Kongsberg EM2040c. Multibeam bathymetry and backscatter data were post-processed in CARIS HIPS & SIPS 8.1. Hardground, migrating sand bodies, and incised meandering stream channels were mapped, and benthic habitat was characterized. Additional areas known to support essential fish species will be mapped over the next several years, contributing to potential designation of MPAs.

Introduction:

In the Atlantic Ocean, the region of the southeastern United States continental shelf margin is referred to as the South Atlantic Bight (SAB). It stretches from 35ºN near Cape Hatteras, NC to 27ºN at West Palm Beach, FL. At its midpoint the SAB extends 120 km off the coast of South Carolina and is bounded on the east by the Gulf Stream, a major supplier of nutrients to surrounding marine environments. The continental shelf is split into four zones; inner shelf (0-20 m depth), middle shelf (20-40 m depth), outer shelf (40-80 m depth) and the shelf edge (80-200 m depth) which connects the shelf to the continental slope and rise, and, ultimately the deep ocean.
Bathymetric mapping of submerged continental margins is critical to understanding the development and evolutionary history of paleo-landscapes and their archeological importance (Harris et. Al, 2013), as well as identifying a variety of benthic habitats that influence the species composition, abundance, and life history of fishes and invertebrates throughout the region (Schobernd & Sedberry, 2009). Areas of high productivity and complex bottom topography within the SAB provide hard-bottom reef habitats that support many ecologically and economically important reef fish species, such as snappers, groupers, and porgies, that live and spawn on the continental shelf and shelf edge (Schobernd & Sedberry, 2009). Using multibeam sonar, this study was conducted in an area not mapped previously, as most previous bathymetric surveys were conducted along the inner shelf 20 m isobaths and along the shelf edge (Harris et. al. 2013). By investigating and mapping the middle shelf region, specifically at depths ranging from 22 to 32 m (this study), extrapolations of benthic habitats and their associated marine species may be possible to nearby regions of lesser and greater depths.

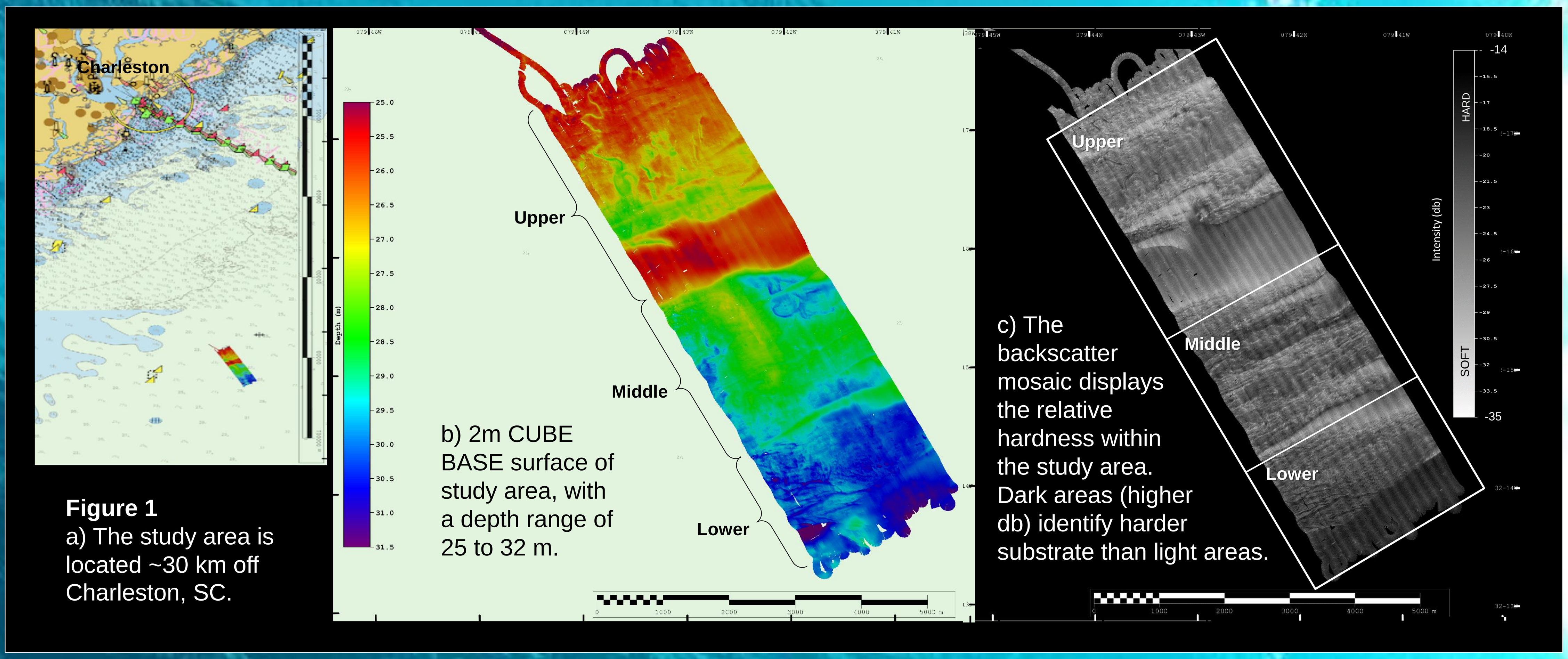


Figure 1
a) The study area is located ~30 km off Charleston, SC.
b) 2m CUBE BASE surface of study area, with a depth range of 25 to 32 m.
c) The backscatter mosaic displays the relative hardness within the study area. Dark areas (higher db) identify harder substrate than light areas.

Methods:

- Multibeam echosounding data were collected aboard the R/V *Savannah* by the College of Charleston's BEAMS '14 team
- The bathymetric survey was designated by the Marine Resources Monitoring, Assessment and Prediction (MARMAP) program, in collaboration with the SC Dept. of Natural Resources.
- Sonar data were collected using a Kongsberg EM2040c multibeam echosounder, loaned to the BEAMS Program by Kongsberg.
- Bathymetric data and backscatter mosaics were post-processed using CARIS HIPS & SIPS 8.1 and in CARIS Base Editor 4.1.
- Calculations of bathymetric and backscatter statistics were created and analyzed using ArcGIS MAP.

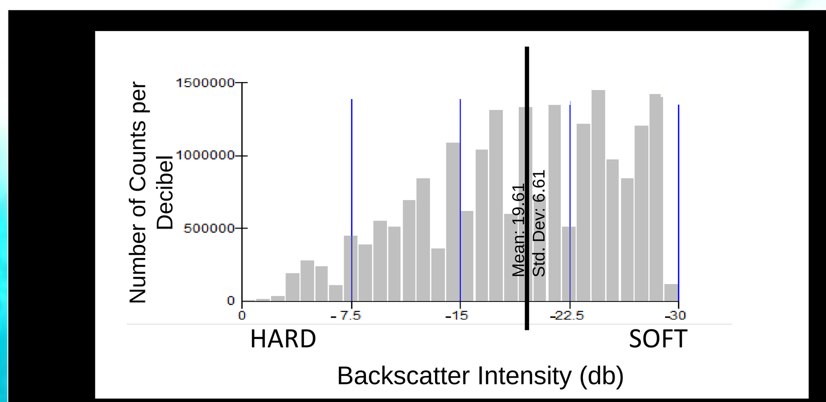


Figure 5: Frequency of the backscatter intensities for the study area. Relatively hard substrate occurs between 0 and -15 db. The majority of the study area is relatively soft substrate with backscatter intensity of -15 to -20 db. Intensity was then used to classify substrate, shown in Figs. 2, 3, 4, and 6.

Upper Area
(25-28 m)

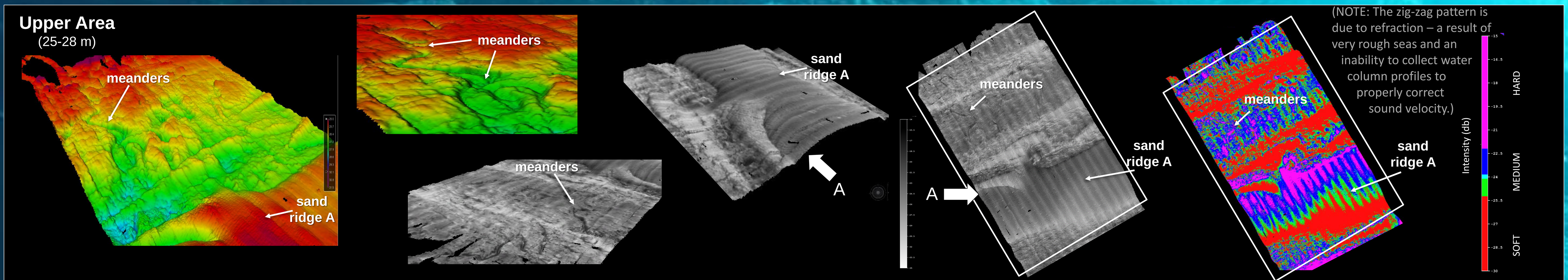
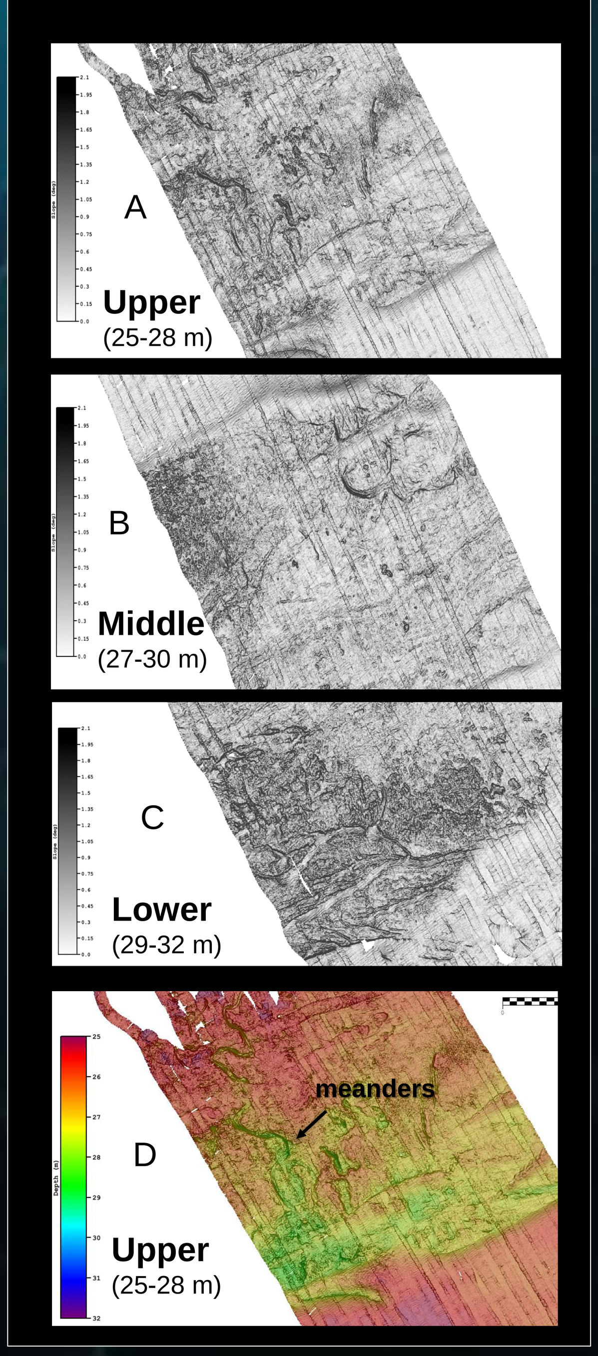


Figure 2: 3D bathymetry (left) & backscatter (grayscale images) surfaces of the upper, most shallow (25-28 m) portion of the mid-shelf study area are shown from different angles (V.E.=50x). A meandering channel cut into the substrate indicates a possible river formation. Arrow A shows the 3D view of a large sand ridge. Seabed classification from the backscatter data (far right) indicates that hardbottom (purple) occurs within the channel, while areas of relatively soft substrate (red) of possible migratory sand bodies occur on top of the moderately hard/mixed substrate (blue and green).

Figure 7: The upper (A), middle (B) and lower (C) portions of the study area show slope variance. Darker shading represents greater steepness and is therefore more likely rocky exposure, and potential fish habitat. (D) The slope surface is overlain on the bathymetry, illustrating the steep channelization at the meanders.



Middle Area
(27-30 m)

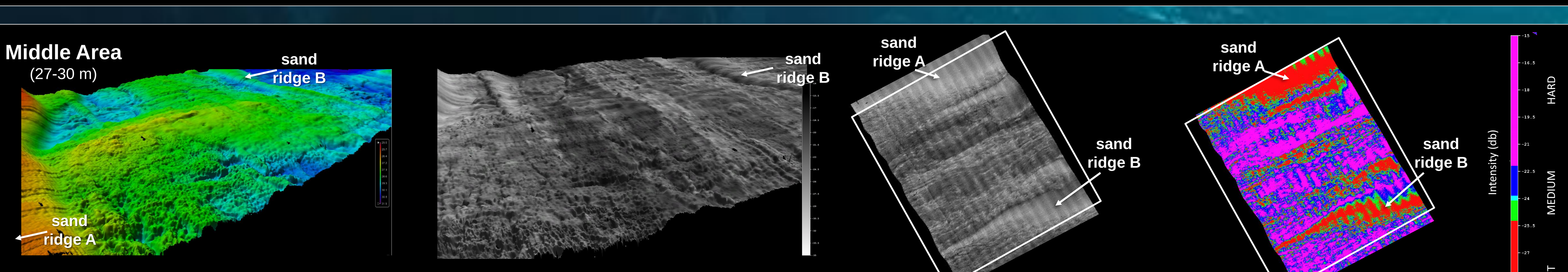


Figure 3: 3D images of bathymetry and backscatter of the Middle Area (25-28 m) (V.E.=50x) reveal the complex morphologies of this portion of the study area. Backscatter intensity ranged significantly and shows relatively hard substrate which may be habitable hardground. Backscatter classification (right) shows significant areas of hard substrate, with sand ridges A and consisting of soft to medium hardness. Sand ridge B is likely migrating across the hardground.

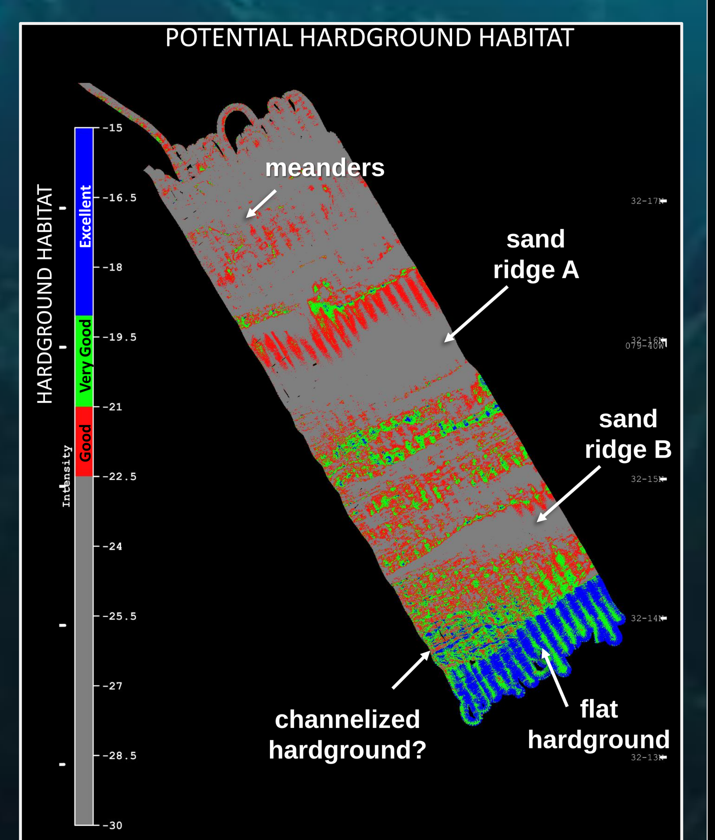


Figure 6: Classified hard-bottom seen in Figs. 2, 3, and 4 was sub-classified into Good, Very Good and Excellent sites to investigate as potential benthic habitat. The Upper Area has the least amount of suitable habitat, whereas the Lower Area is mostly classified as Very Good and Excellent.

Lower Area
(29-32 m)

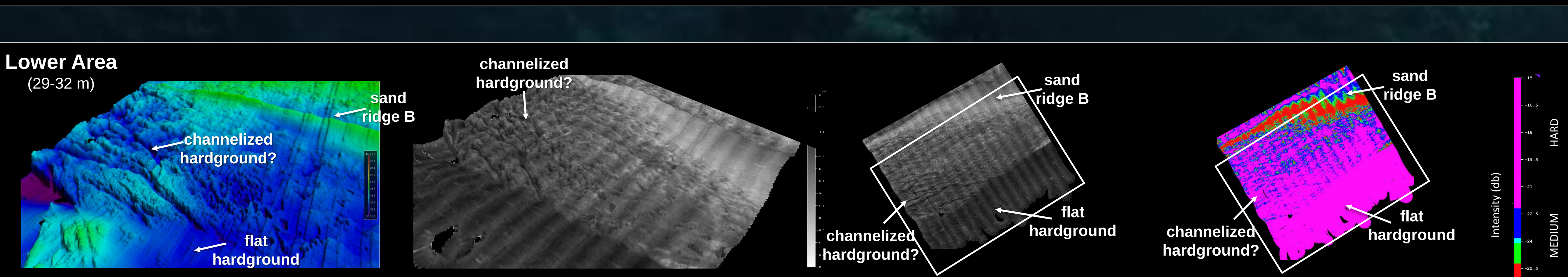


Figure 4: 3D bathymetry and backscatter of the Lower Area (29-32 m) (V.E.=50x) show a dramatic seabed morphology, with both flat and channelized (or fractured?) areas. Backscatter classification shows that most of this area is mostly hard substrate and has the largest coverage of hardground of the three areas studied. The two possible sand bodies from Figures 2 and 3 are partially covering hardground areas. These channels may be riverbed scours from a lower stand of sea level, showcase a promising area that currently sustains marine life on the seafloor.

Discussion & Conclusions:

Complex geomorphologic features are evident at this mid-shelf study area (Fig. 1), and reveal possible rocky outcrops as well as migratory sand bodies that vary in size and depth. Figures 2, 3, and 4 show comparisons between 3D bathymetry and bathymetry overlain with 3D backscatter, revealing possible substrate character of bathymetric features. In order to determine whether the study area has a hard bottom and is a likely fish habitat, the backscatter statistics were used (Fig. 5). Decibel readings range from -14 to -30 db (hard to soft, respectively), with the mean near -19 dbs, showing that the majority of the study area is composed of substrate – likely sand. However, seabed classification using backscatter intensity (Fig. 2, 3, and 4 in the right image, and Fig. 6) shows that portions of the area contain extensive hard bottom and can likely support benthic marine life. Figure 7 illustrates the three main areas of hard bottom by showing the variance in slope on the seafloor. The darker regions are associated with a steeper slope and suggest that these areas are possible rocky outcrops or hard bottom habitat. These relatively hard bottom geomorphologies most likely support a variety of marine organisms. By examining an area of shallower depth relevant to existing MPAs along the coastline, new guidelines may come into consideration to grow existing MPAs and contain a larger area of marine environment.

In summary, future research should focus ground-truth efforts along the river meander and along channelized hardground in the Lower Area to examine the composition of the benthic features and substrate. Other suggestions for possible study would be to collect water column data to see where marine fish species are more concentrated over the study area. Future studies can investigate the hardground discovered from this study, along with fish trap data to determine what species inhabit the area, and classify whether this particular study area should be considered as a future MPA site.

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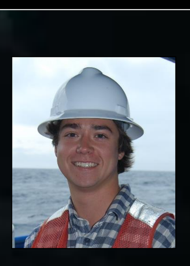

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