Classifying Coral Mound Geomorphology at Stetson Mesa off the Southeastern U.S. Continental Margin

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ABSTRACT

Portions of the Blake Plateau on the Southeast U.S. Continental Margin were mapped during NOAA's Office of Ocean Exploration and Research (OER) *East Coast Mapping Expedition* (EX1403) and *Windows to the Deep 2018: Exploration of the Southeast U.S. Continental Margin* (EX1806) aboard NOAA Ship *Okeanos Explorer*. During expedition EX1806, the ROV *Deep Discoverer* conducted multiple dives to explore several deep sea coral mounds that are extremely abundant across the plateau. This study concentrates on the southern region of a broad feature called Stetson Mesa, located on Blake Plateau's western edge, approximately 184 km east of and parallel to Daytona Beach, FL. The mesa lies directly beneath the main axis of the Gulf Stream where current velocity, water temperature, and nutrient abundance are high. Multibeam sonar data from NOAA OER cruises EX1403 and EX1806 were used to examine the geomorphology of coral mounds where depths range 600 to 900 m. Coral mounds found within the southern region of Stetson Mesa were classified into three distinct morphological categories based on their association with geological seafloor features, length, height (relief), and number of peaks. Bathymetric, classified backscatter intensity, and slope surfaces were examined. However, profiles and 3D images were most important for the characterization of mound geomorphology. The final classification includes Ridge Scarp Mounds, Connected Mounds, and Individual Mounds. These results are significant for comparing deep sea coral habitat throughout the Blake Plateau region.

METHODS

- Multibeam sonar data were collected during May 2014 on EX1403 and June 2018 on EX1806 by NOAA Ship *Okeanos Explorer*, equipped with a Kongsberg EM302 multibeam sonar system.
- Survey areas from EX1403 and EX1806 included the Stetson Mesa region located 184 km east of and parallel to Jacksonville, Florida's coastline.
- CARIS HIPS and SIPS 11.0 was used to generate high resolution bathymetric (CUBE), classified backscatter intensity and classified slope surfaces at 12.5 m resolution.
- Classified backscatter was divided into high, medium, and low ranges based on the histogram.
- Coral mounds with slopes greater than 20° were chosen within each survey area to generate cross-sectional profiles and 3D images for morphological characterization.

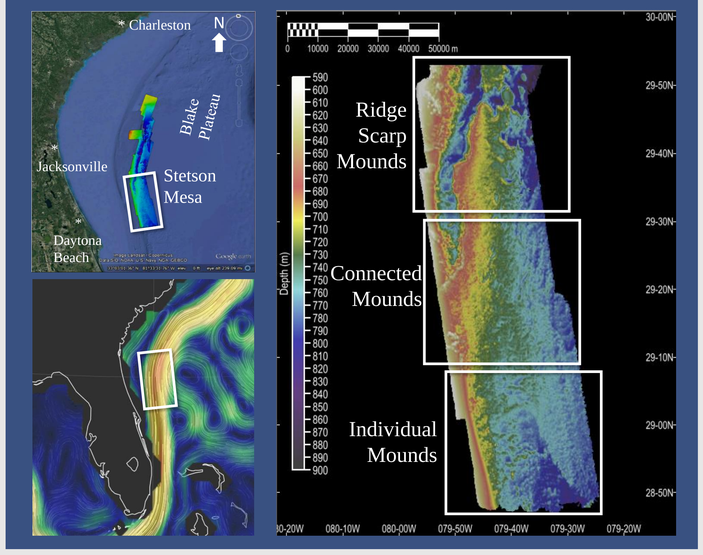


Figure 1. Location of Stetson Mesa 184 km off Florida's coastline (above left, Google Earth Pro). Stetson Mesa Southern region, "Million Mounds", 2D CUBE 12.5 m interpolated bathymetric surface (right). Gulf Stream flow path, directly over the mesa (below left, earth.nullschool.net, February 2019).

BACKGROUND

In 2018, NOAA OER sponsored a bathymetric surveying expedition, *Windows to the Deep 2018: Exploration of the Southeast U.S. Continental Margin* (EX1806), aboard NOAA Ship *Okeanos Explorer* to survey the Blake Plateau (NOAA OER, 2018). On the expedition, the ROV *Deep Discoverer* was used to explore the deep ocean enabling scientists to ground-truth diversity and distribution of deep sea ecosystems, and classify seafloor geomorphology (NOAA OER, 2018). The Blake Plateau is a broad, flat region with 500 m average depth extending 145 km east off the coasts of North Carolina, South Carolina, Georgia and Florida, between the southeastern U.S. continental margin and the ocean basin (Dillon, 1988). EX1806 also investigated coral habitat areas of particular concern (HAPC) designated by the South Atlantic Fisheries Management Council (SAFMC) (NOAA OER, 2014 and Geiger, 2007). This study concentrates on the southern portion of a mapped feature here referred to as "Stetson Mesa," roughly 3,924 km^2, located 184 km east of and parallel to Florida's coastline, which lies directly beneath the Gulf Stream's main axis (Fig. 1). This region is also called "Million Mounds" due to countless numbers of mounds observed and is designated as a marine protected area (MPA) by the SAFMC because of potential prime deep sea coral habitat (NOAA OER, 2018 and SAFMC, 2018). The Gulf Stream's high velocity northward flow has suitable water temperature and food abundance creating favorable environmental conditions for deep coral growth and mound development within the mesa (Lophelia.org). EX1806 Dives 05 and 06 on Stetson Mesa explored two mounds located at depths between 600 and 780 m with roughly 100 m of relief and sloped sides of 15 to 30°. Thick accumulations of dead coral rubble forming a 3D skeletal framework that serves as a habitat for deep sea organisms, were documented on mound crests. Living communities of the stony coral *Lophelia pertusa* were found where Gulf Stream current velocities were strongest (NOAA OER, 2018). The purpose of this study is to survey geomorphologic patterns of deep sea coral mounds within the southern portion of Stetson Mesa to better compare coral habitat throughout the Blake Plateau region. Deep sea coral mound research will support informed resource management decisions concerning future conservation of benthic habitat.

Ridge Scarp Mounds

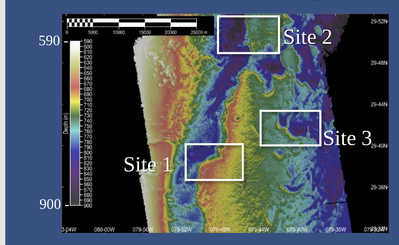
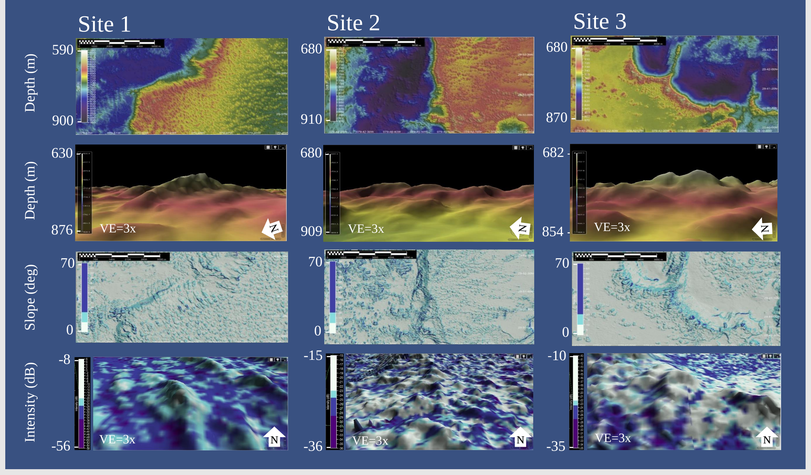


Figure 2. High relief coral ridges found associated with a rocky ridge scarp and extending thousands of meters in length. 2D surfaces are shown for each site, along with 3D views, slope, and 3D classified backscatter intensity.



Connected Mounds

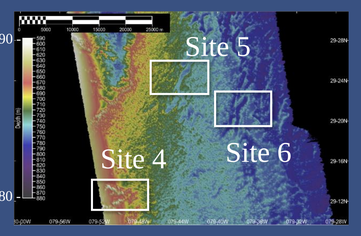
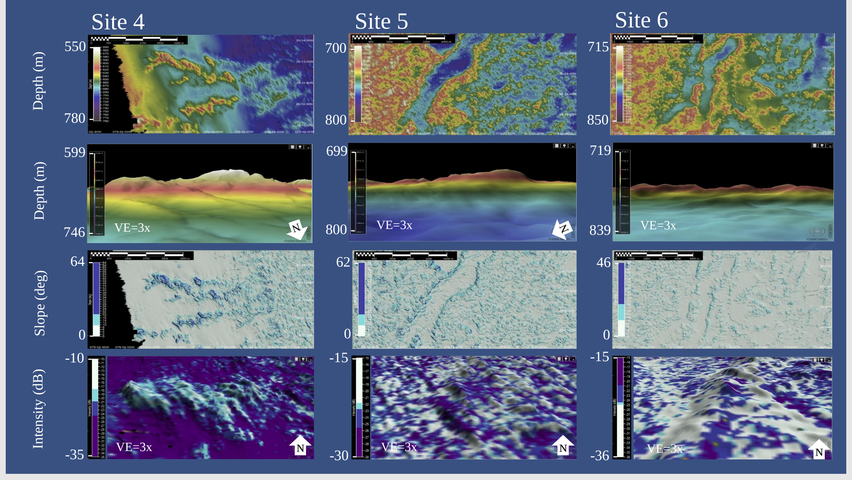


Figure 3. Connected coral mounds consisting of multiple peaks found in lengthy chain-like formation at depths ranging between 550 and 850 m. 2D surfaces are shown for each site, along with 3D views, slope, and 3D classified backscatter intensity.



Individual Mounds

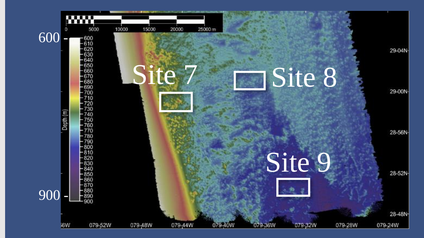


Figure 4. Individual coral mounds with a single peak, and short longitudinal and short transverse axis found most commonly at depths between 700 and 900 m. 2D surfaces are shown for each site, along with 3D views, slope, and 3D classified backscatter intensity.

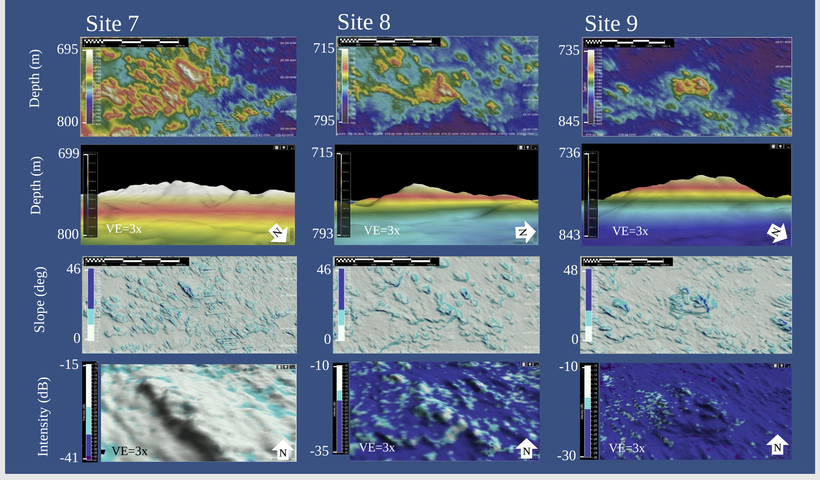


Figure 5. Profile locations A-A' and B-B' (left) for sites 1 – 9 on 2D bathymetric images. Along-chain A-A' profiles for Ridge Scarp and Connected Mounds, and long axis A-A' profiles for Individual Mounds are shown to scale. VE=1.25x.

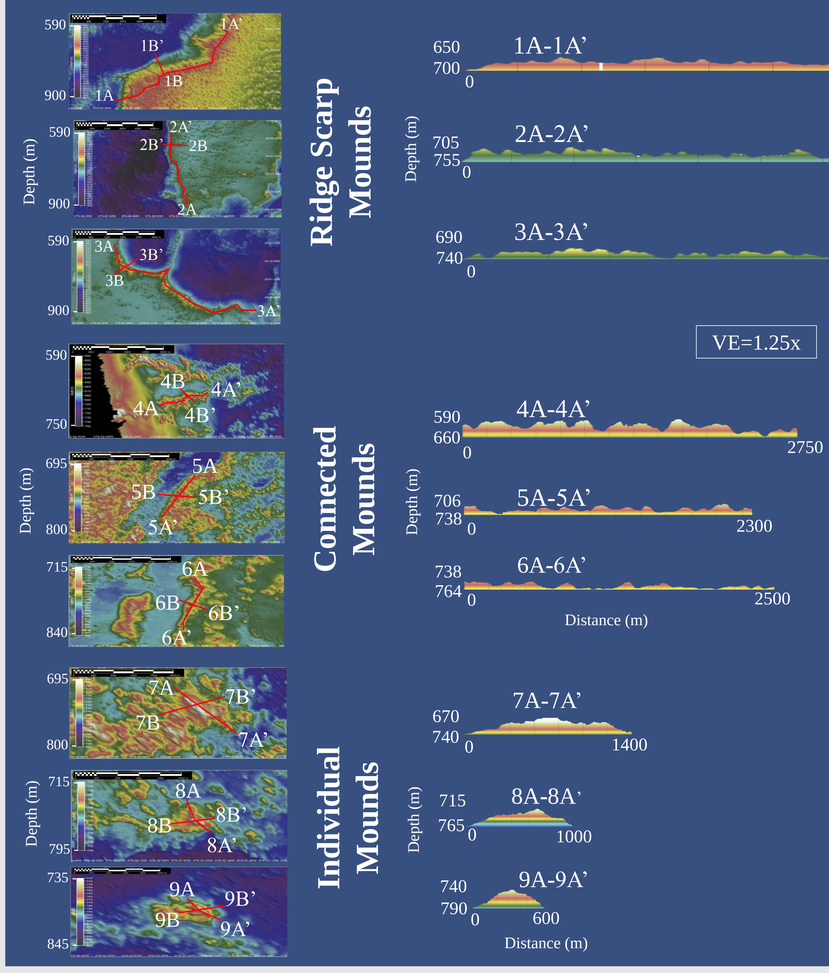
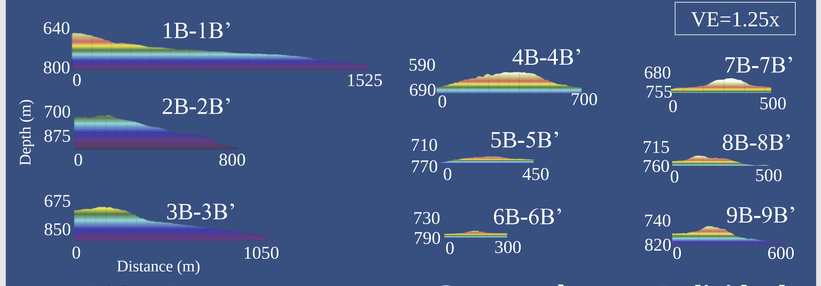


Figure 6. Profiles B-B' perpendicular to A-A; profiles for sites 1 - 9 shown to scale. VE=1.25x. (Fig 6. scale reduced from Fig. 5) (Refer to Fig. 5 for profile locations).



RESULTS

Ridge Scarp Mounds - Geomorphology

- Ridge Scarp Mounds are characterized by their long axis running adjacent to the length of an escarpment, and contain numerous mound peaks (Fig. 2).
- Sites 1 - 3 have long perpendicular axes ranging 800 to 1525 m and high vertical relief ranging 160 to 175 m (Fig. 6). These sites are portions of ridge scarps that have along-chain axes ranging 8.5 to 9.0 km. Note that some ridges exceed lengths of 9.0 km in other regions of the Blake Plateau (Fig. 5).

Connected Mounds - Geomorphology

- Connected Mounds are characterized by multiple mound peaks joined in a lengthy side-by-side chain commonly found at depths between 550 and 850 m (Fig. 3).
- Most mounds are elongate perpendicular to the along-chain axis.
- Sites 4 - 6 have vertical relief ranging 60 to100 m (Fig. 6).
- These along-chain axes extend from 2300 to 2750 m, and perpendicular axes (the long axis of each mound) measure between 300 and 700 m (Fig. 5 and 6).

Individual Mounds - Geomorphology

- Individual Mounds are characterized by a single peak and are much larger in area than Ridge Scarp and Connected Mounds (Fig. 5).
- Overall, individual mounds have shorter long axes compared to both Ridge Scarps and Connected Mounds that range from 600 to 1400 m (Fig. 6).
- Their perpendicular axes range from 500 to 600 m and are similar in length compared to Connected Mounds (Fig. 6).
- These types of mounds are most commonly found at depths between 700 and 900 m (Fig. 4), where individual peaks have vertical relief of 45 to 80 m (Fig. 6).

Backscatter Results

- Ridge Scarp Mounds' backscatter intensity at mound crests and on flanks is moderately high for site 1, and low to high, for sites 2 and 3 (Fig. 2).
- Connected Mounds have moderately low intensity at site 4, and sites 5 and 6 are mixed (Fig. 3).
- Individual Mounds vary greatly, with site 7 having high intensity and sites 8 and 9 having moderately low to low intensity (Fig. 4).

DISCUSSION and CONCLUSIONS

Coral mound formations are classified into three distinct categories based on their morphology and association with geologic features. **Ridge Scarp Mounds** with extensive along-chain axes are concentrated primarily in the study region's northern survey area in association with a long escarpment (Fig. 1). **Connected Mounds** contain multiple, linked peaks, and dominate the central region. Most are found at depths between 550 and 850 m (Fig. 1). **Individual Mounds** have a single mound crest, are most common in the southern region of the mesa's study area, and are abundant where depths range between 700 and 900 m (Fig.1). Individual mounds appear large, providing more surface area for possible coral habitat. Both Connected and Individual Mounds, however, occur throughout the Stetson Mesa study area (Fig. 1). Ridge Scarp Mounds appear to extend northward of the study area (Fig. 1).

Dive footage from EX1806 (specifically, dives 05, 06, and 07), provide evidence for locating both living corals and coral rubble framework on mound and ridge formations (NOAA OER, 2018). Previous studies have suggested that high intensity backscatter return is a valuable method for identifying deep coral habitat sites (Roberts et al., 2006 and Davies et al., 2008). In this study, however, sites 1 though 9 display variable backscatter intensity return atop mound crest(s) and flanks (Fig. 2, 3, and 4). Site 7 has a high intensity backscatter return and therefore, supports previous research (Fig. 4). In contrast, sites 1, 4, 8, and 9 have moderate to low intensity backscatter return (Fig. 2, 3, and 4). Furthermore, sites 2, 3, 5, and 6 show a mix of both high and low intensity backscatter (Fig. 2 and 3). These findings support the work completed by DiTommaso and Sautter (2019) suggesting that the backscatter signal reflected off high rugosity, porous, semi-hard substrate, i.e. coral framework, which results in higher scattering and lower intensity return. Thus, high intensity backscatter return is not an optimal method for locating high abundance areas of living deep sea corals in areas of coral mounds.

Exploration of the Stetson Mesa and other portions of the Blake Plateau has led to the discovery of vast areas of potential, prime deep sea coral habitat. Future expeditions within Stetson Mesa and the greater Blake Plateau region should include ROV dive surveys of all three geomorphological mound classifications in order to truly confirm the presence and abundance of deep sea coral habitat at mound crests, and to verify that all mound geomorphologic types support diverse deep sea ecosystems.

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