Comparison of Connected, Individual and Ridge Scarp Mounds on the South East U.S. Continental Margin

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NOAA Ship *Okeanos Explorer*

ABSTRACT

A portion of the Southeastern United States was mapped during the *Windows to the Deep and 2019 Southeastern U.S. Deep Sea Exploration* expeditions. Multibeam sonar data was collected by NOAA Ship *Okeanos Explorer* on the EX1906 cruise and was used to create bathymetry, backscatter, slope and aspect surfaces. The purpose of this study is to further explore recent studies comparing the multiple mound types Individual, Ridge Scarp, and Connected classified by Horn and Sautter (2019). EX1907 Dive 02 footage was used to examine the multiple species of coral, and sea life along the track. The Eastern Million Mounds study area is located northeast of Cape Canaveral and southeast of Jacksonville. The area has three smaller study sites classified as, Individual Mounds (IM), Ridge Scarp Mounds (RSM) and Connected Mounds (CM). Profiles of each mound type were collected and used to compare the geomorphology. There is weak to no correlation between slope and backscatter intensity among the mound types. A range of backscatter intensities were found along the mound types suggesting that the seafloor is a mixture of hard substrate and soft unconsolidated sediments. Living coral was generally found on the flatter (less sloped) mound tops where the backscatter ranged from low to high. Therefore backscatter intensity and slope is not always a useful tool for finding coral habitats.

METHODS

- Multibeam sonar data were collected by NOAA Ship *Okeanos Explorer* with a Kongsberg EM302 echosounder during EX1906.
- CARIS HIPS and SIPS 11.2 was used to examine multibeam data and create 17m, 20m and 50m resolution CUBE BASE bathymetric surfaces.
- Slope, Aspect, and Backscatter Intensity surfaces were created.
- 3D images and profiles were generated on each type of mound feature.
- Slope and Backscatter intensity data points were collected randomly along the top of each set of mounds to compare the relationship between slope and intensity.
- Dive footage and high definition screen grabs were acquired by ROV *Deep Discoverer* on EX1907 show the contrasting life on the seafloor.

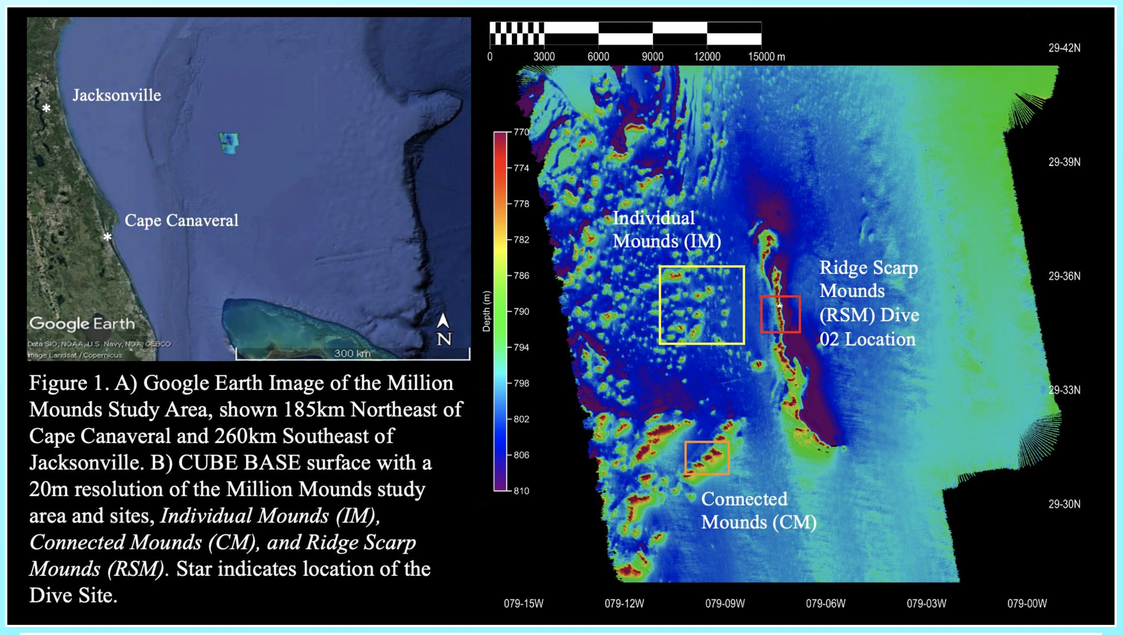


Figure 1. A) Google Earth Image of the Million Mounds Study Area, shown 185km Northeast of Cape Canaveral and 260km Southeast of Jacksonville. B) CUBE BASE surface with a 20m resolution of the Million Mounds study area and sites, *Individual Mounds (IM), Connected Mounds (CM), and Ridge Scarp Mounds (RSM)*. Star indicates location of the Dive Site.

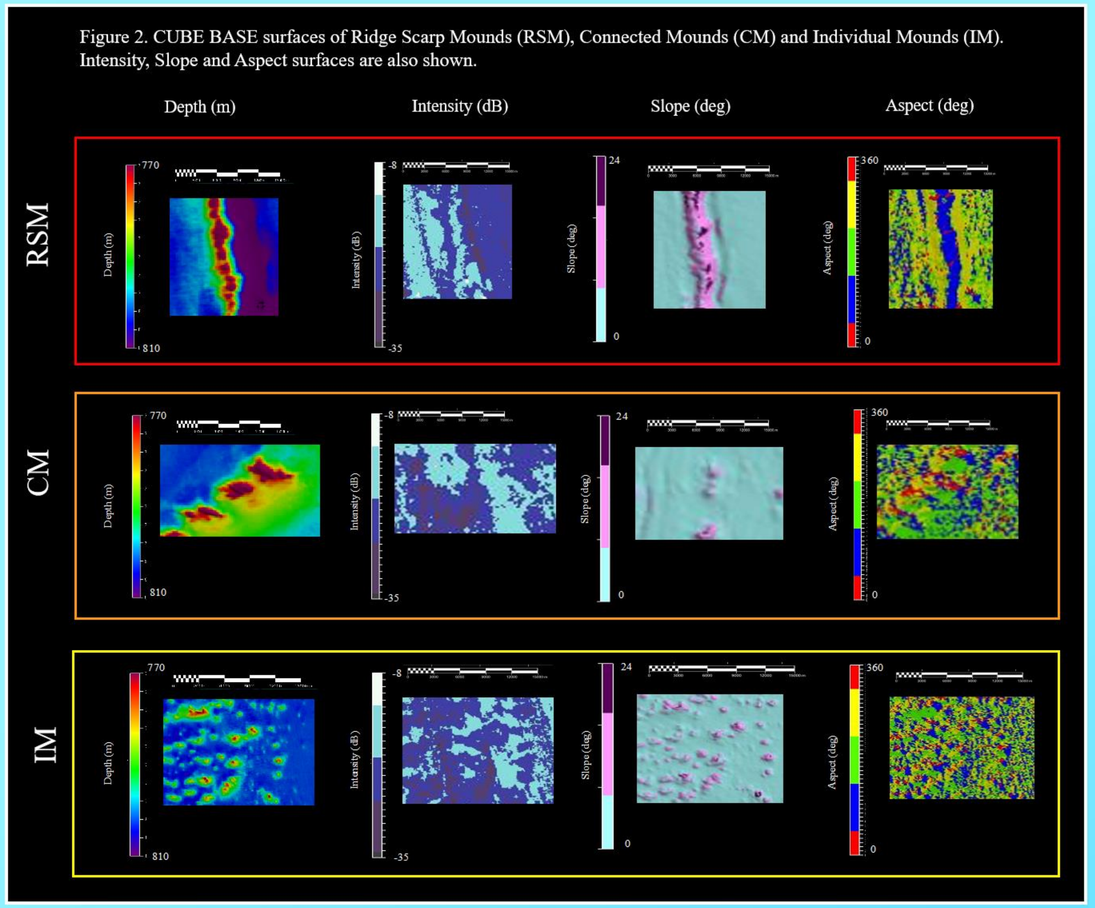


Figure 2. CUBE BASE surfaces of Ridge Scarp Mounds (RSM), Connected Mounds (CM) and Individual Mounds (IM). Intensity, Slope and Aspect surfaces are also shown.

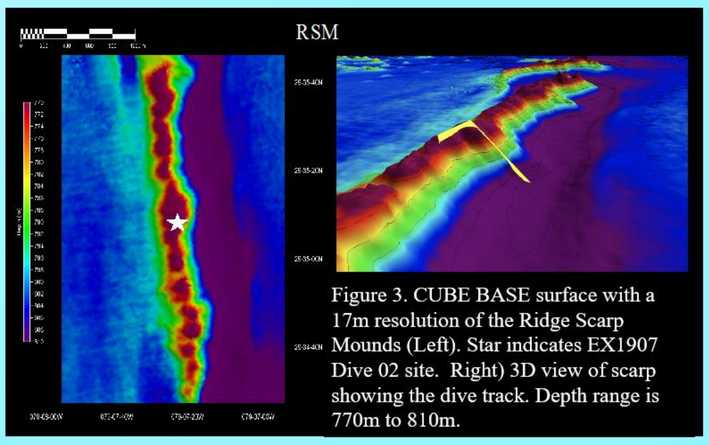


Figure 3. CUBE BASE surface with a 17m resolution of the Ridge Scarp Mounds (Left). Star indicates EX1907 Dive 02 site. Right) 3D view of scarp showing the dive track. Depth range is 770m to 810m.

BACKGROUND

The NOAA Ship *Okeanos Explorer* gathered seafloor data in a series of mapping expeditions off the Southeastern United States coast during the *Windows to the Deep and 2019 Southeastern U.S. Deep Sea Exploration* expeditions (NOAA, 2020). Multibeam sonar data were collected on cruise EX1906, and additional dive footage collected by the remotely operated vehicle (ROV) *Deep Discoverer* was acquired on EX1907. The purpose of collecting these data was to explore areas of interest within the Blake Plateau, a broad feature located between the continental shelf and the deep ocean basin. Bathymetric surveys from EX1906 explored an extension of the Southern Blake Plateau known as the Stetson Mesa, an area that lies beneath the Gulf Stream, approximately 230 km southeast of Savannah, GA and 260 km northeast of Jacksonville, FL (Fig.1). The three study sites are Ridge Scarp Mound (RSM), Connected Mounds (CM), and Individual Mounds (IM) (Fig. 1). This portion of the mesa is also referred to as Million Mounds East, due to the presence of thousands of deep-sea mounds, most of which are likely constructed by dead coral rubble. Deep-sea coral mounds are bathymetric features of medium scale known to be found in bathyl and abyssal settings (Meredyk, 2020). Horn and Sautter (2019) examined different geomorphologies of mounds in this area, and classified them as Individual, Connected, and Ridge-Scarp Mounds. The *Individual mounds* are separated and apart from one another whereas *Connected mounds* are joined together by a low relief area on the seafloor. *Ridge Scarp Mounds* are a series of connected mounds on a ridge with a scarp. ROV dive footage from EX1907 Dive 02 (depth range 748 to 825 m) showed large frameworks of stony coral rubble with an small amount of living *Lophelia pertusa* on the slope and top of the mound, as well as other invertebrates such as feather stars, sea urchins, and glass sponges.

The purpose of this study is to further expand recent studies, comparing multiple sites in the vicinity of EX1907 Dive 02 by looking at the differences and similarities among the mound types, Ridge Scarp Mound (RSM), Connected Mounds (CM), and Individual Mounds (IM) (Fig. 1). EX1907 Dive 02 occurred on the eastern side of Million Mounds and showed a field of dead coral rubble covered in ferromanganese crust at the base of the mound. As the dive progressed up the slope of the mound, there was an abundance of dead coral rubble. EX1907 Dive 02 will be used as a foundation to support the surfaces created in CARIS HIPS and SIPS 11.2.

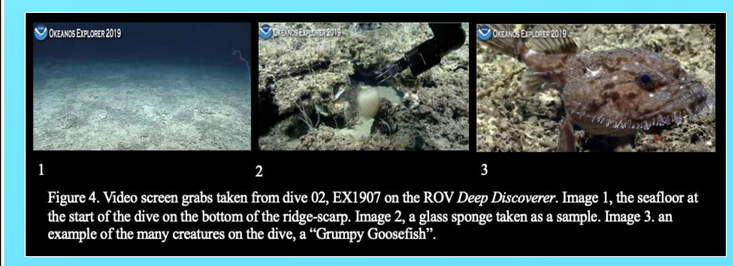


Figure 4. Video screen grabs taken from dive 02, EX1907 on the ROV *Deep Discoverer*. Image 1, the seafloor at the start of the dive on the bottom of the ridge-scarp. Image 2, a glass sponge taken as a sample. Image 3. an example of the many creatures on the dive, a "Grumpy Goosefish".

Figure 5. Profiles of an example mound at each site. Dive track 02 (ridge scarp mound) at the Million Mounds study site, Connected Mounds, and Individual Mounds. Each profile has a Classified Backscatter bar (blue and white; white = high, dark blue = low) and a Slope bar (pink and blue) . Profile locations are shown at right. Profiles have a VE=2x.

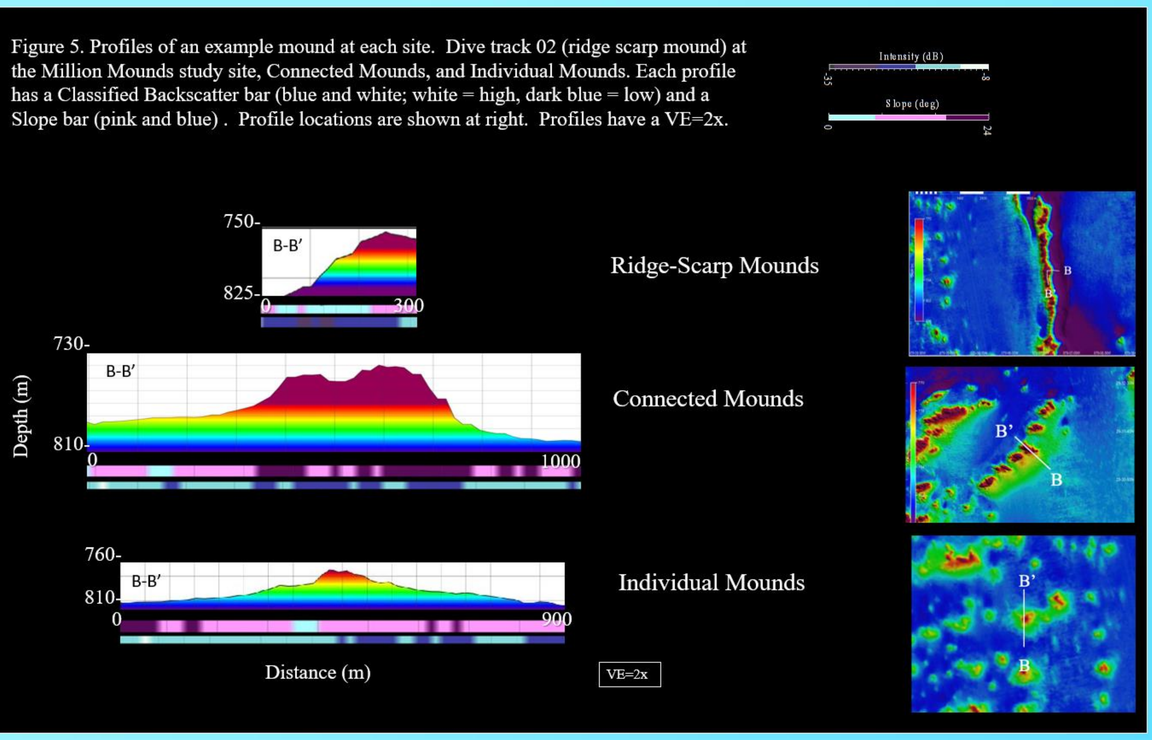
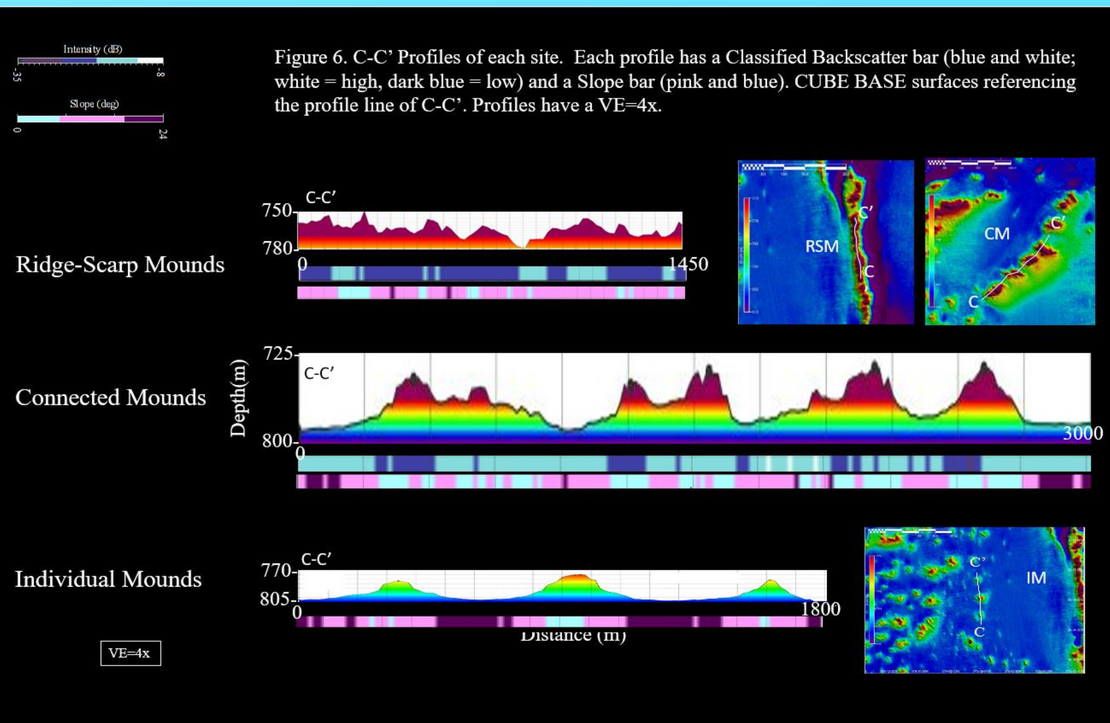


Figure 6. C-C' Profiles of each site. Each profile has a Classified Backscatter bar (blue and white; white = high, dark blue = low) and a Slope bar (pink and blue). CUBE BASE surfaces referencing the profile line of C-C'. Profiles have a VE=4x.



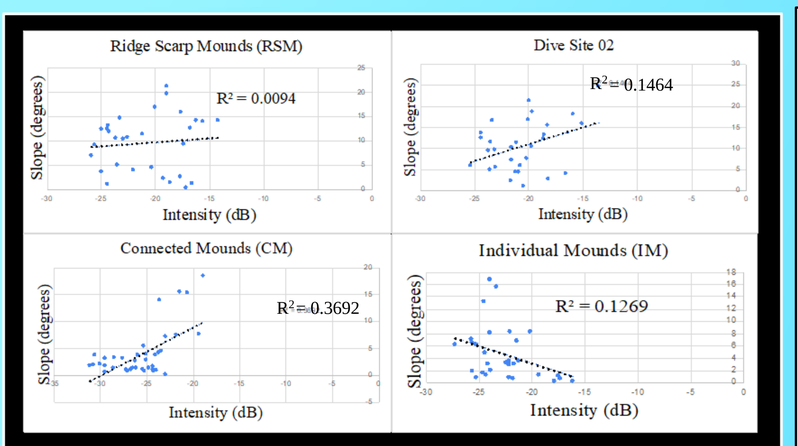


Figure 7. Graphs of data points taken across the tops of mounds at each site. Data shows a relationship between slop (degrees) and backscatter intensity (dB).

RESULTS

Ridge Scarp Mounds (RSM)

- High backscatter intensities occur on the mound portions of the B-B' profile of the dive site, (Fig. 5).
- High definition video from EX1907 Dive 02 shows a ridge scarp covered in ferro-manganese crust including a series of high relief (100 m) mounds covered in coral rubble, (Figs. 2 and 4).
- A mix of high and low backscatter intensities occur along the C-C' Profile of *RSM* (Fig.6).
- Along profile B-B' of *RSM*, a weak positive correlation exists between slope and backscatter intensity ($R^2 = 0.1464$), (Fig. 5).
- High degrees (20<) of slope is shown on the east side of the Ridge Scarp mounds (Fig. 2)
- Dive track shows the ROV *Deep Discoverer* travelled up the northeast side of the ridge and headed south to cross the top of the ridge (Fig. 3).
- The mounds along the ridge are rounded in shape and along the line of the scarp.

Connected Mounds (CM)

- Moderate backscatter intensities and high degrees of slope are present at the top of the mound on profile B-B' (Fig.5).
- A series of elongated connected mounds is present in the *CM* site all connected by a low relief of the seafloor. (Fig.6) Profile C-C' along these connected mounds shows a moderate positive correlation between slope and backscatter intensity ($R^2 = 0.3692$). (Fig.6)
- *CM* backscatter intensity has a low return on the top of the series of mounds, whereas higher intensity occurs at the bottom of the mounds. (Fig.6)

Individual Mounds (IM)

- High degrees of slope occur incline of the southwest portion of profile B-B'. (Fig.5)
- A series of individual mounds is present at the *IM* site. Each mound in profile C-C' is separated by a 100-200 m stretch of flat seafloor. (Fig. 6)
- Along profile B-B' a weak positive correlation was found between slope and backscatter intensity ($R^2 = 0.202$). (Fig.7)
- The shape of the individual mounds are rounded and scattered along the seafloor.

DISCUSSION and CONCLUSIONS

The three different mound sites, *Ridge Scarp Mounds (RSM), Individual Mounds (IM)* and *Connected Mounds (CM),* can all be found within the Eastern Million Mounds study area located off the Southeastern United States. The individual mounds are clustered together on the north-west portion of the study area, the connected mound types are most common on the southwest portion of the area. A large portion of the ridge scarp mounds are located in the center of the study area, this includes EX1907 Dive 02.

As seen in figure 3, EX1907 Dive 02 started at the bottom of the scarp and moved up and across the top of the ridge. The backscatter intensities ranged from low to high across the mound types (Fig. 5 and 6) showing 'soft' (likely unconsolidated sediments) to hard-bottom substrates. Both the Ridge Scarp mounds and Individual mounds have a weak positive correlation between backscatter intensity and slope (Fig. 7) in comparison to the Connected mounds, having a stronger positive correlation between backscatter intensity and slope with an $R^2 = 0.3692$. The CM correlation is weak but shows a slight relationship.

High backscatter intensity on the seafloor and the mounds reveals a hardbottom surface but, high intensity does not always correlate with good coral growth (DiTommaso, Sautter, 2019). Figures 5 and 6 show a mix of high and low backscatter intensities on the top of the RSM mounds, according to EX1907 Dive 02, the coral thrived at these different locations. EX1907 Dive 02 conducted by the ROV *Deep Discoverer* showed an abundance *Lophelia pertusa* coral rubble and only a small amount of living *Lophelia pertusa.* The dive also revealed creatures and other large corals living on the mounds. It is important to do more research to support that there is little to no association with high backscatter and coral growth, and that coral features are found on the flatter mound tops and not on the steep slopes. Future mapping and exploration can aim to focus on the three different mound types and therefore confirm the abundance of sea life on the surface of the ocean at these locations and mounds around the world.

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