Characterizing the Geomorphology of Stetson Mesa West on the Southeast U.S. Continental Margin

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ABSTRACT

As part of the 2019 southeastern U.S. Deep-sea exploration, NOAA and partners collected multibeam sonar data and high definition video of the Southeastern U.S. continental margin from October 31 through November 20, 2019. This 43-day, two-part expedition took place on the NOAA Ship *Okeanos Explorer*. The purpose of this study is to characterize the geomorphology of an area referred to as Stetson Mesa West, in order to gain better insight of which seafloor features dominate this area and make inferences about the processes that created them. Characterizing the geomorphology of this area is important in order to properly manage deep-sea benthic habitats, and determining whether this area should be protected from offshore drilling and cables. Data collected from three study sites indicate that this area is geologically diverse, and most likely controlled by processes such as slumping and deep currents.

METHODS

- CARIS HIPS 11.2 was used to create CUBE BASE surfaces from multibeam sonar data collected by the NOAA Ship *Okeanos Explorer* using a Kongsberg EM302 multibeam echosounder.
- High resolution bathymetry, classified backscatter, classified slope, and aspect images were created in order to characterize the geomorphology of each study site.
- Depth profiles, as well as intensity and slope bars, were generated to compare and contrast three major study sites.
- Numerical data were collected along each profile to determine if a correlation exists between intensity and slope, as well as to identify similarities and differences across the three study sites.
- High definition video frame-grabs from an ROV expedition in the Northeast Site was taken to ground truth locations along dive tracks.

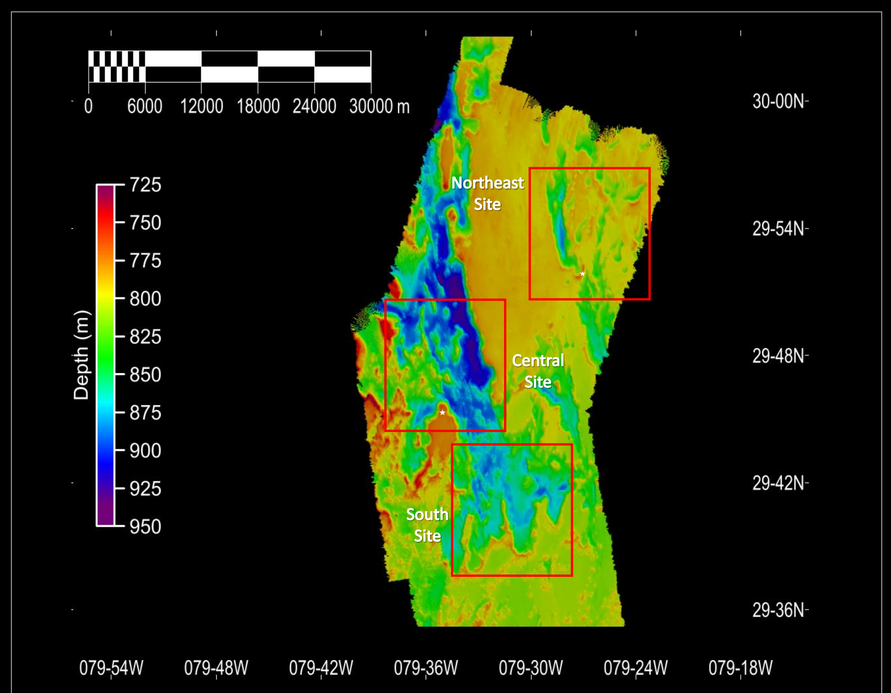


Figure 1

CUBE BASE surface of Stetson Mesa West at 20m resolution. The three focus sites are labeled; Northeast Site (Dive 03, EX1907), Central Site (Dive 03, EX1903), and South Site. Google Earth image (at right) shows the study site in relation to the Eastern seaboard. The study site is approximately 215 km southeast of Jacksonville, FL.

BACKGROUND

In November 2019, NOAA conducted seafloor mapping and ROV operations on board the NOAA Ship *Okeanos Explorer*. Their primary goal was to collect baseline information about unexplored and poorly understood areas off the Southeastern U.S. continental margin (NOAA, 2019). These areas contain a wide range of deep-water habitats and geological features of interest. The full extent of deep-sea biological communities is unknown since only 5 percent of this area's seafloor has been mapped, which is why further research in this field is extremely important (NOAA, 2019). Deep-sea biological communities are vulnerable to human interactions such as oil exploration and undersea cable installations. They depend on microscopic organisms that flow in ocean currents, and areas near the Gulf Stream are expected to have high biodiversity and many biological communities (NOAA, 2020). The Stetson Mesa is an isolated flat-topped region within the larger Blake Plateau (Fig. 1). The mesa lies directly beneath the Gulf Stream, with depths ranging 700 to 1000 m. This area contains a wide range of geological features, including canyons, scarps, ridges, and mounds. The Eastern U.S. continental margin is passive, with less tectonic activity shaping its geomorphology. This area is most affected by sedimentation, ocean and turbidity currents, and slumping (Laughton and Roberts, 1978); processes that significantly influence and control Stetson Mesa's seafloor geomorphology. This study focuses on an area referred to as Stetson Mesa West approximately 219 km southeast of Jacksonville, Florida. Three sites were chosen to examine closely (Fig. 1). Northeastern site is the shallowest of the three, ranging from 760 to 900 m, and contains a broad plateau. Central site is the most geomorphologically varied site, with depths ranging from 720 to 960 m, and includes what may be deep-sea coral mounds. South site has numerous semi-circular ridges and mounds, with depths ranging from 720 to 910 m. The purpose of the study is to characterize the area's complex geomorphology which could lead to discoveries that correlate different types of seafloor features with biological diversity.

Figure 2

3D CUBE BASE surfaces of A) Northeast Site with a SW view direction, B) Central Site with a NW view direction, and C) South Site with a SW view direction showing bathymetry, classified backscatter, aspect, and classified slope at 15m resolution. VE= 2.9X

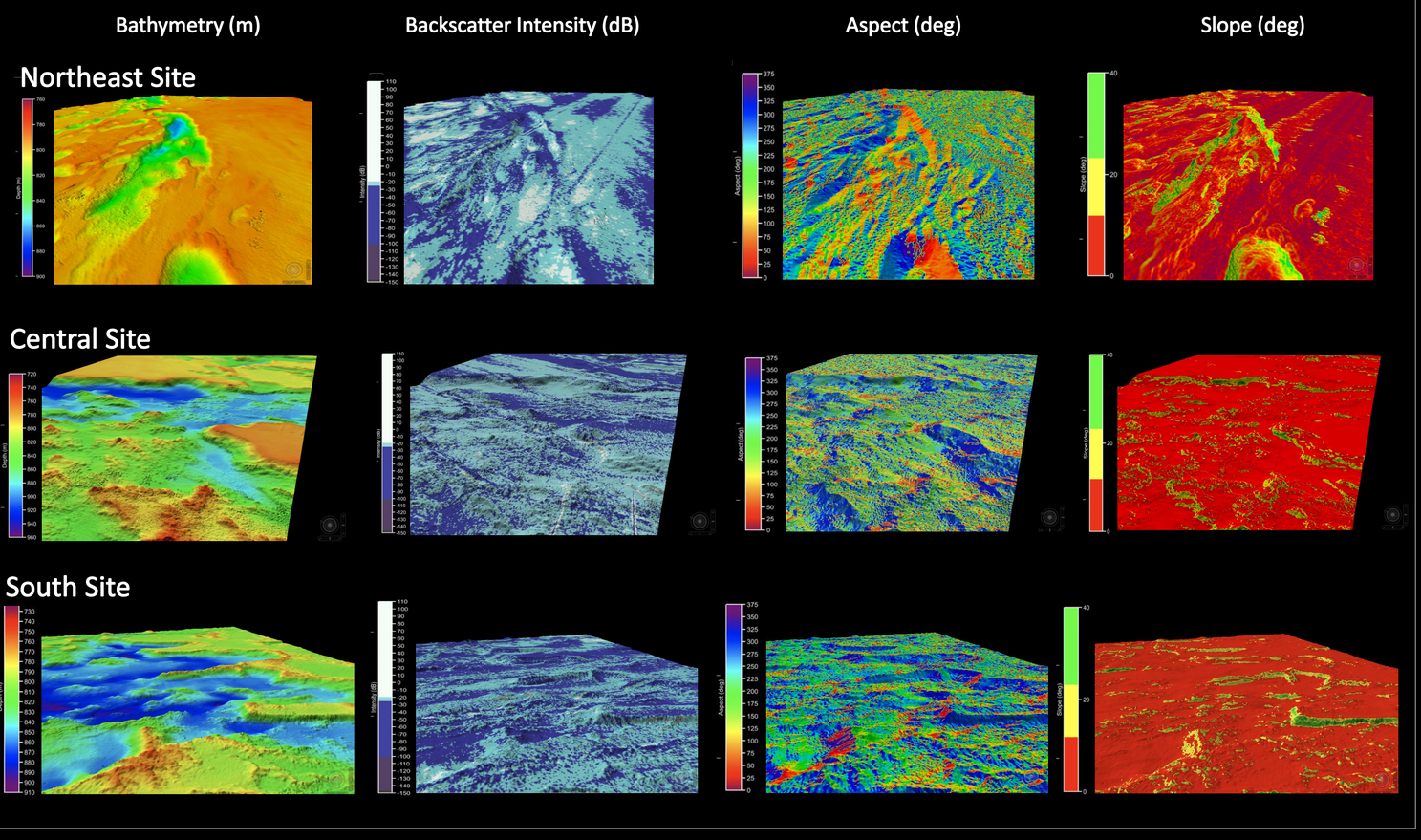


Figure 3

Three bathymetric profiles were collected from each study area. Each profile has a classified backscatter intensity bar and a classified slope bar below it. Profile locations are shown above and to the right of the profiles. Intensity and slope legends are shown to the right.

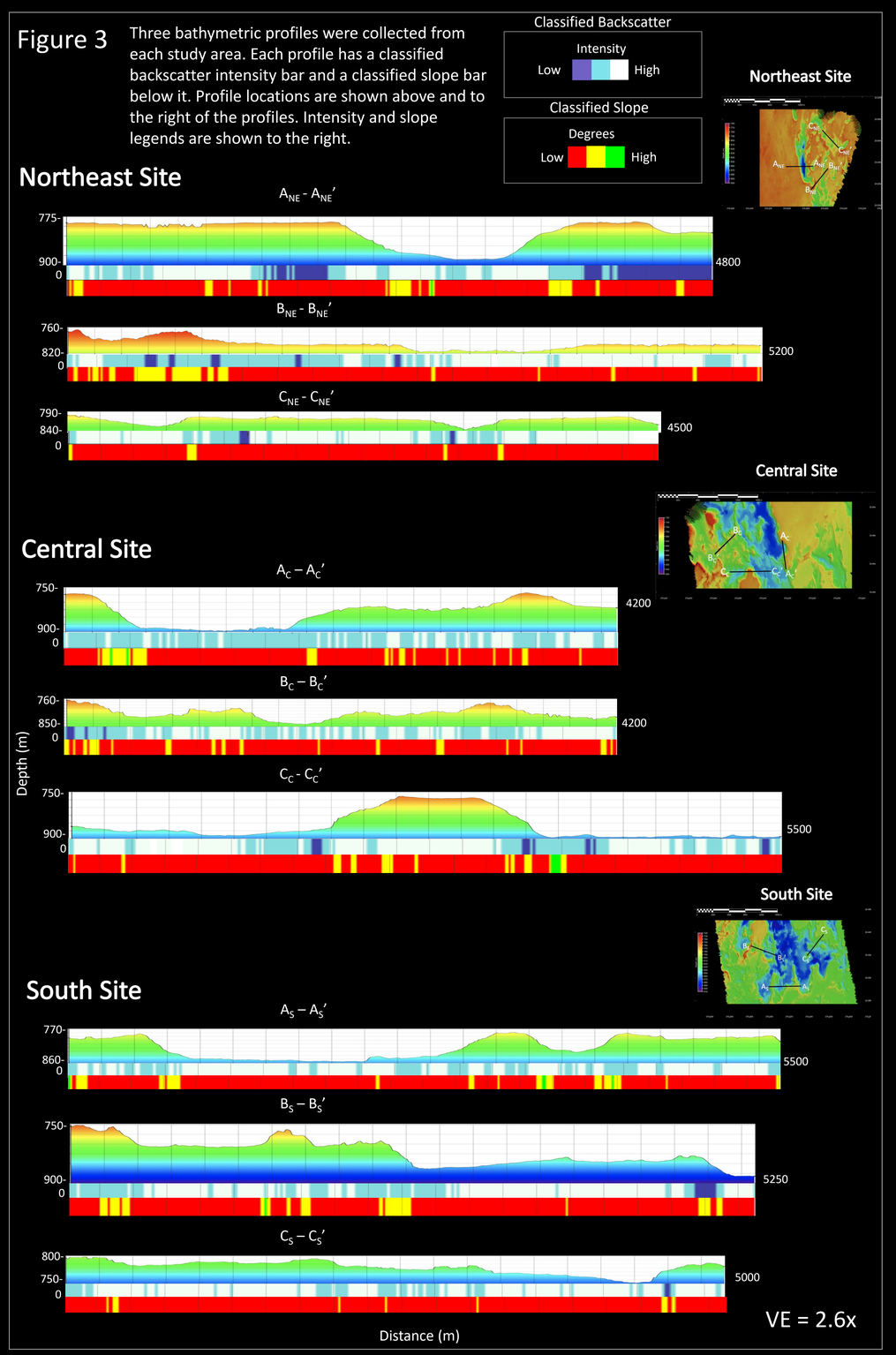


Figure 4

A) Scatter plots of relationship between slope and intensity at each site using data collected along profiles shown in Figure 3. R^2 lines are located in the upper right corner of each scatter plot.
B) Average slope for each of the three study sites.
C) Average depth for each of the three study sites.

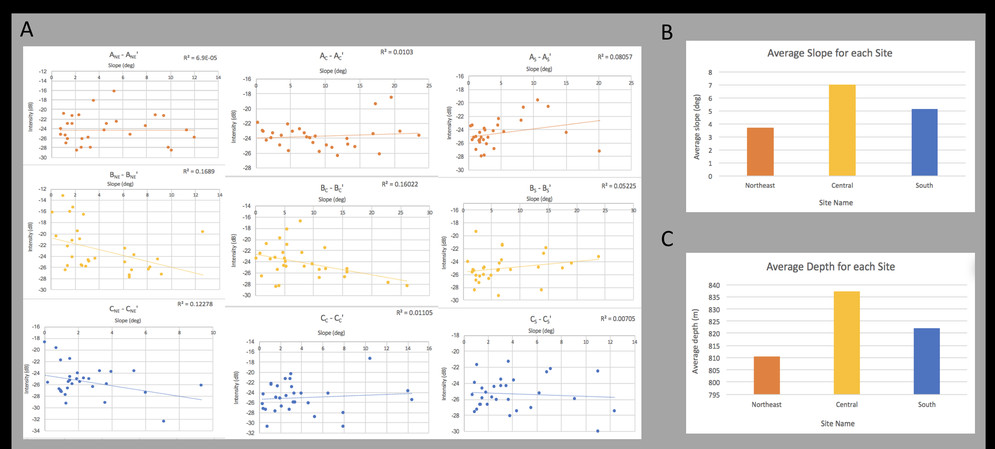
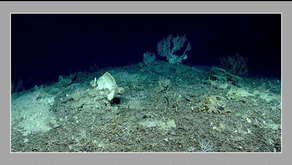


Figure 5

Video frame-grabs of seabed during EX1907 Dive 03.



Coral rubble was observed along the ridge where the dive was conducted in the Northeast Site. Live coral was established on the rubble, as well as other invertebrates such as sponges.

Small piles of sand were observed behind sponges. The sponges absorb most of the current allowing for sediments to deposit instead of being swept away.

RESULTS

- Northeast site's geomorphology is dominated by a large plateau, while also containing ridges and a small canyon (Fig. 2).
- Central site's geomorphology is extremely diverse, containing plateaus, mounds, scarps, ridges, and canyons (Fig. 2).
- South site's geomorphology is dominated by a large canyon that is surrounded by many scarps and ridges (Fig.2).
- No correlation was found between slope and intensity at any of the three study sites in the area (Fig. 4A). All R^2 values were below 0.01689.
- Central Site had the highest average slope (7°) and depth (836 m) compared to the other two study sites (Fig. 4B & 4C).
- Central Site had the greatest depth range (720-960 m) compared to the other two study sites.
- Northeast Site had the lowest average slope (3.7°) and depth (810 m) compared to the other two study sites (Fig. 4B & 4C).
- Northeast Site has the lowest range of slope values collected from its profiles (12.638°).
- Central Site had the highest range of slope values collected from its profiles (25.984°).
- South Site had a moderate range of slope values collected from its profiles (18.786°).
- Characteristic profiles (Fig. 3) show some of the geomorphological features of each site and illustrate how each site is different from the others.

DISCUSSION

For this study area, each site was shown to have its own unique geomorphology. Northeast Site was the shallowest of the sites, with a low occurrence of steep slopes. The majority of the area can be defined as a flat plateau containing some regions of depression. These depressed regions could be from slumping or the result of erosion by currents. Central Site had the deepest points of the entire study area at 960 m, as well as many high slopes. This locale was found to contain many mounds, a deep canyon, and a large escarpment. The deep canyon in Central Site could be a direct result of the Gulf Stream or turbidity currents, which would remove sediments creating these depressions. South Site was the most intermediate site in this study regarding depth and slope. This section is uniquely characterized by semi-circular ridges which could also be caused by currents. No correlation was found between intensity and slope data collected from profiles taken at each study site. While a positive correlation between intensity and slope has been used to predict where we might find hard, steep substrate that supports biological communities, we cannot apply that method to this study area. Instead, using high definition video filmed on ROV expeditions, we are able to confirm that Northeast Site contains biological communities characterized by coral rubble, live corral, and many invertebrates. Therefore, the area referred to as Stetson Mesa West can be described as having dynamic geomorphology that is likely controlled by processes such as slumping and deep currents, while also showing evidence of deep-sea biological communities. In the future, more dives should be conducted in this area to better understand a connection between its geological features and where biological communities occur.

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