Comparison of Individual Deep-Sea Coral Mounds at Three Sites in Relation to Gulf Stream Proximity

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ABSTRACT

As part of the Atlantic Seafloor Partnership for Integrated Research and Exploration (ASPIRE) campaign, the NOAA Ship *Okeanos Explorer* conducted two expeditions within the Blake Plateau. Located on the continental margin of the southeast United States, the Blake Plateau is a wide and relatively flat expanse of the continental slope extending off the coast from North Carolina down to Florida, with depths ranging from 600 to over 1800 m. During the expedition *Windows to the Deep 2019: Exploration of the Deep Sea Habitats of the Southeastern United States* (EX1903 Legs 1 & 2), bathymetric data were collected using multibeam sonar, and high definition videos were captured using the ROV *Deep Discoverer*. ROV dives examined previously unmapped areas along the Blake Plateau Knolls (754-826 m depth range) and within the Central Plateau (786-863 m), and explored deep-sea coral mounds found on the Stetson Mesa (770-805 m). Home to the site of the "Million Mounds" area, Stetson Mesa lies on the western edge of the Blake Plateau and is located approximately 160 km off the coast of and nearly parallel to Florida. The mesa sits directly beneath the Gulf Stream, which provides beneficial conditions in support of deep-sea coral communities. Stony corals form dense colonies which build atop each other over time to form bioherms, or mounds. A recent study classified these mounds into three categories: individual, connected and ridge scarp. Bathymetric data gathered at the Blake Plateau Knolls, located approximately 330 km off the coast southeast of Savannah, revealed undiscovered individual mounds. Three Blake Plateau study sites examined contain individual mounds at similar depths, located within Stetson Mesa, Central Plateau, and the Blake Plateau Knolls. Using bathymetry, slope, and shape indices this study compared the geomorphic characteristics of coral mounds and their resident communities within and outside the influence of the Gulf Stream's primary axis, further classifying individual mounds as single-peaked and multi-peaked.

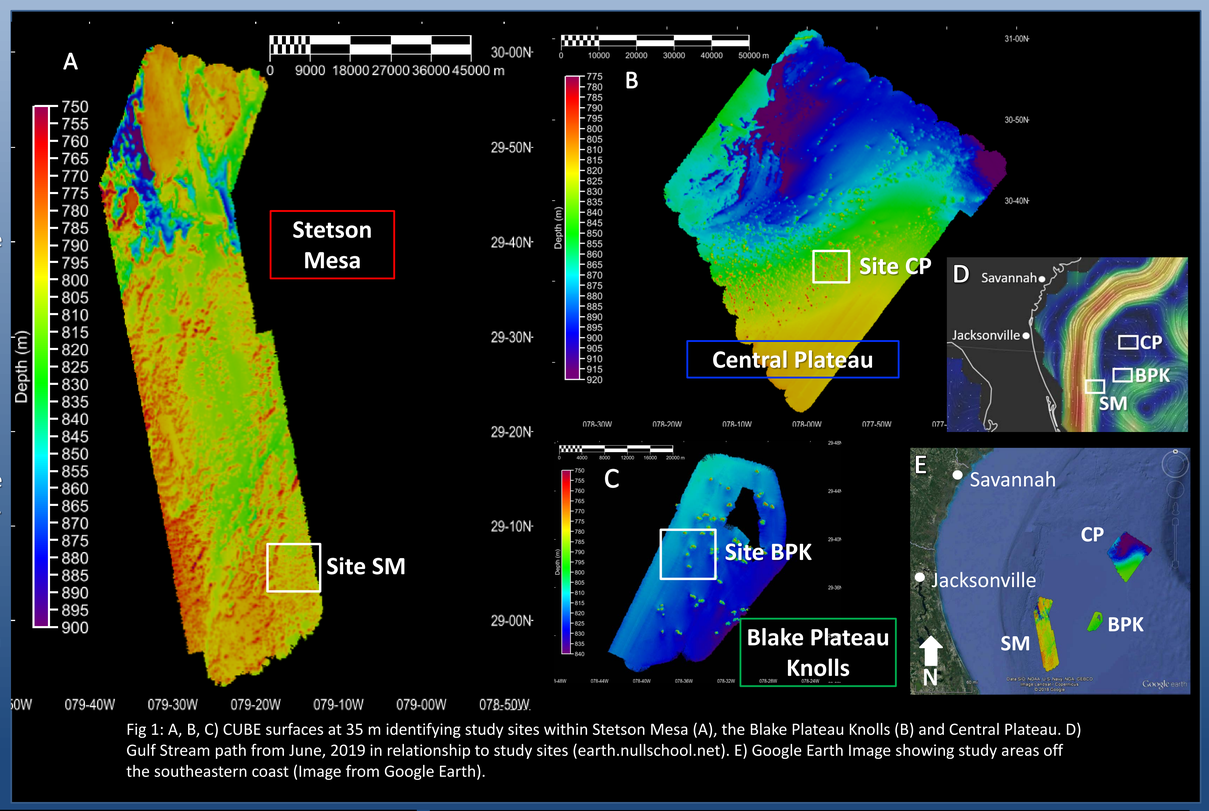

Fig 1: A, B, C) CUBE surfaces at 35 m identifying study sites within Stetson Mesa (A), the Blake Plateau Knolls (B) and Central Plateau. D) Gulf Stream path from June, 2019 in relationship to study sites (earth.nullschool.net). E) Google Earth Image showing study areas off the southeastern coast (Image from Google Earth).

BACKGROUND

The NOAA *Windows to the Deep 2019: Exploration of the Deep Sea Habitats of the Southeastern United States* continued to explore and map the expansive area known as the Blake Plateau aboard the NOAA vessel *Okeanos Explorer*. The Blake Plateau is a broad extension of the continental slope stretching from Florida to North Carolina. High variation of benthic habitats on the plateau is the result of variable conditions, including effects from Gulf Stream currents. The Gulf Stream brings warm, nutrient-rich waters onto the continental slope's western edge as it travels northward (Fig 1D). Nutrient influx and swift currents are ideal for a variety of fish and invertebrate species, including the stony coral *Lophelia pertusa*. These deep-sea corals form dense colonies which build atop the rubble of dead coral exoskeletons (Reed, 2002 and UNEP, 2004). Formations of mounded coral framework can be classified by their geomorphologies as connected, ridge-scarp, and individual mounds (Horn and Sautter, 2019). During EX1903, the ROV *Deep Discoverer* provided ground truthing for the immense populations of coral within three sites on the plateau, including Stetson Mesa, Central Plateau, and the Blake Plateau Knolls (Fig 1E). To date, the Knolls contain the largest density of live coral thickets that had been found (NOAA OER, 2019). The purpose of this study was to compare individual mound geomorphologies in three study sites directly influenced by the Gulf Stream (Stetson Mesa), and indirectly influenced (Blake Plateau Knolls, Central Plateau). Study sites were compared using slope and bathymetric measurements.

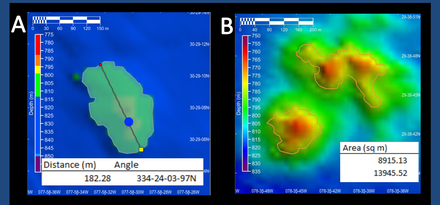

Fig 2. A) Classified CUBE surface marking the mound boundaries to calculate area 20 m below the shoalest peak. Length and orientation were measured on the mound's major axis dissecting the peak (blue dot). B) 12.5m CUBE surface at a multi-peaked mound, showing two peaks with areas summed to calculate total mound area.

METHODS

- The *Windows to the Deep 2019* Expedition aboard NOAA Ship *Okeanos Explorer* gathered multibeam sonar data using a Kongsberg EM302 multibeam sonar system.
- Study sites of equal size were selected in each of three study areas that exhibited individual mounds within 50 m depth range of each site.
- CARIS HIPS and SIPS 11.2 was utilized to create CUBE bathymetric and slope surfaces at 12.5 m resolution.
- Mounds were selected with slopes greater than 20° and a vertical relief of at least 20 m.
- Areas were measured 20 m below shoalest point using the area feature tool on CARIS HIPS and SIPS 11.2 (Fig. 2A).
- Lengths and widths were measured 20 m below shoalest point.
- Shape index was calculated as Length/Width. Larger values indicated increasing elongation.
- Length and width measurements at multi-peaked mounds were summed to calculate shape index.
- Area measurements at multipeaked mounds were summed to measure total area (Fig. 2B).

REFERENCES

- Davies, A., Wisshak, M., Orr, J., and Roberts, M., 2008, Predicting suitable habitat for the cold-water coral *Lophelia pertusa*: Elsevier
- Horn, B. and Sautter, L. 2019 US Hydro Meeting, Biloxi, MS
- NOAA OER, 2019, Dive Report for Dive 04 from the Windows to The Deep Exploration of the Deep-Sea Habitats of the Southeastern United States (EX1903), https://oceanexplorer.noaa.gov/okeanos/explorations/ex1903/dailyupdates/june24/june24.html (accessed October 2019)
- Reed. J, 2002, Comparison of deep-water coral reefs and lithoherms off southeastern USA, Hydrobiologia 471: 57–69, https://doi-org.nuncio.cofc.edu/10.1023/A:1016593018389
- UNEP World Conservation Monitoring Centre, 2004, UNEP-WCMC Biodiversity Series No 22: https://archive.org/details/coldwatercoralre04frei (accessed October 2019)

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Fig 3. Single-peak and multi-peak mound selections from each of the three study sites; Stetson Mesa (A), Blake Plateau Knolls (C), and Central Plateau (C). 3D images and profile locations on a 2D surface are shown for each mound.

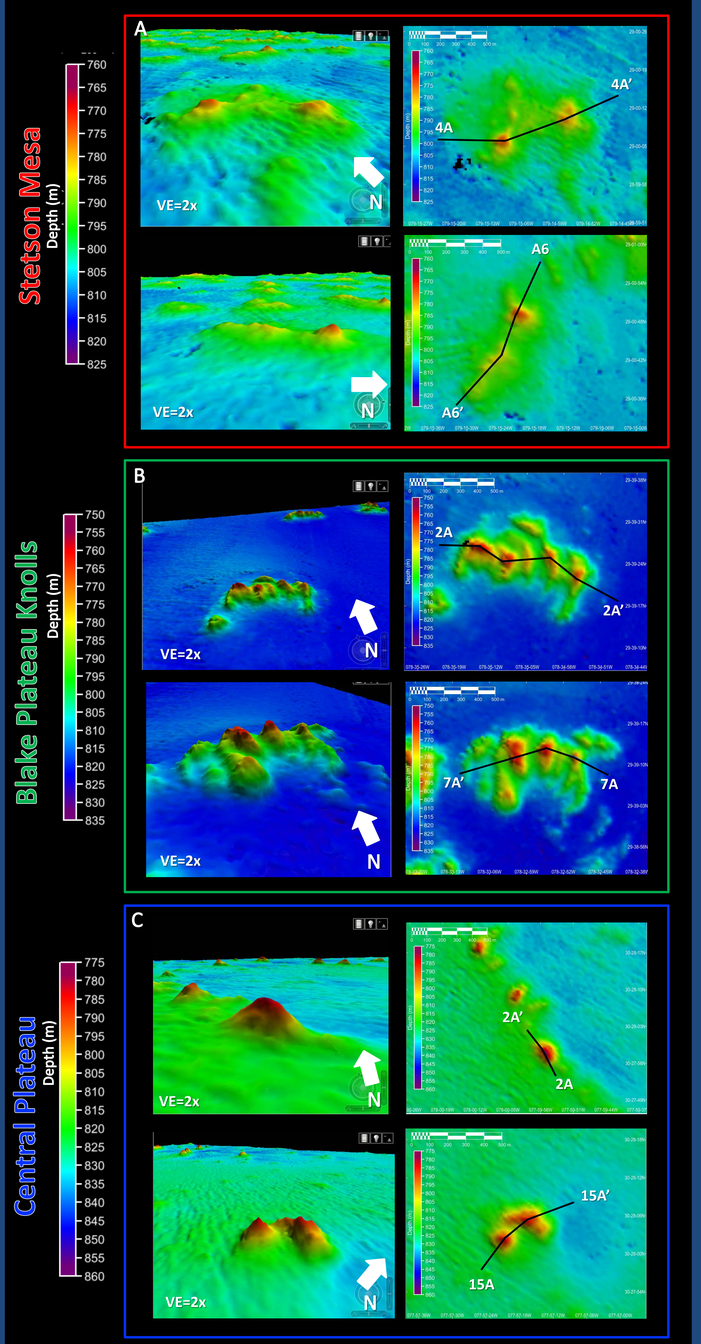
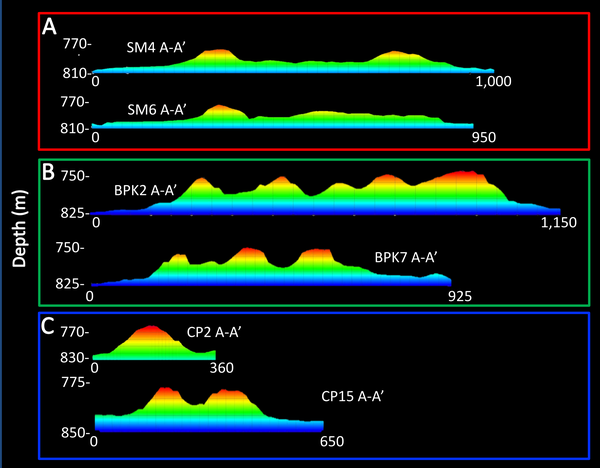


Fig 4. Profiles of selected mounds shown in 2D surfaces from Figure 3. A) Stetson Mesa sites only had single-peaked mounds, B) Blake Plateau Knolls' mounds are predominantly multi-peaked, and C) Central Plateau has mostly single-peaked mounds. All profiles are shown at VE=2.0x.



RESULTS

- Individual mounds varied in geomorphology and were further categorized as single-peaked and multi-peaked.
- Multi-peaked mounds exhibit two or more areas at 20 m from the shoalest peak (Fig. 2B).
- No trend in correlation exists between total mound area and shape index of single-peaked and multi-peaked mounds (R^2=0.019) (Fig. 5A).
- Multi-peaked mounds showed a positive correlation between elongation (shape index) and area (R^2=0.6684) (Fig. 5B).
- Stetson Mesa and Central Plateau showed no trend in orientation, while Blake Plateau Knolls showed weak orientation trends from NW-SE (Fig. 5C).
- Stetson Mesa exhibited larger mound areas but did not contain peaks with the greatest vertical relief (Fig. 5D, Fig. 6B, Fig. 6C).
- No significant difference in shape index existed across the three sites (Fig. 6A).
- At 20 m below the shoalest point, Stetson Mesa and Central Plateau contained 100% and 87.5% single-peaked mounds, respectively, whereas only 11.1% of Blake Plateau Knoll individual mounds were single-peaked (Fig. 6D).

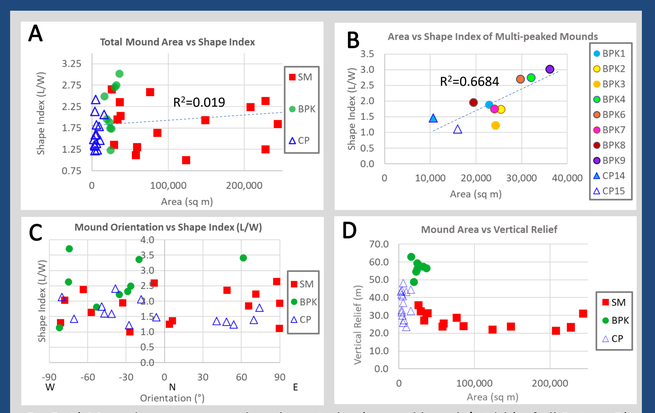


Fig 5. A) Mound area compared to shape index (mound length/width) of all 3 sites. B) Multi-peaked mound area compared to shape index. C) Mound orientation compared to shape index, with orientations ranging from due West (-90°) to East (90°). D) Mound area compared to vertical relief of mounds, measured from the shoalest point to base of mound.

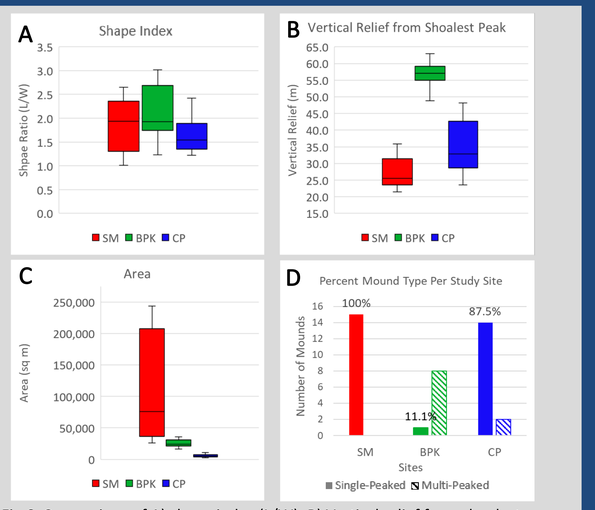


Fig 6. Comparison of A) shape index (L/W), B) Vertical relief from shoalest peak, C) mound area, D) Total mound number by type for three study sites.

DISCUSSION

Characterizing mound geomorphologies allows for further understanding of the influences that affect deep sea coral habitats. Comparing different mound types across sites within and outside of the Gulf Stream's primary axis revealed variation in mound size, shape, and orientation. Individual mounds discovered with two or more peaks were classified as multi-peaked, further expanding the classification of individual coral mounds (Fig. 2B). Recent work in a more northern region of Stetson Mesa (Croft and Sautter, 2019) showed that individual mound orientation and shape are likely influenced by Gulf Stream currents. However, individual mounds found along the Gulf Stream path in the more southern Stetson Mesa used in this study showed no trends in orientation. Stetson Mesa mounds had the largest areas within the three study sites due to the expansiveness of their bases 20 m below the peak. Differences in area measurements between Blake Plateau Knolls and Central Blake Plateau showed much smaller areas within each site, at both single-peaked and multi-peaked mounds (Fig. 6C). Overall, mounds positioned well east of direct Gulf Stream currents showed greater vertical relief and increased peakedness, resulting in lower mound area, whereas Stetson Mesa mounds were lower relief and broad at their base.

Lophelia pertusa plays a vital ecosystem role. ROV dives within each study area observed a diverse array of benthic organisms associated with coral habitats (Dives 02, 04, and 05, EX1903). The discovery of the densest colonies of stony coral occurred during an ROV dive on one of the Knolls' mounds. Dives within each study area provided ground-truthing for thriving coral communities, particularly at mound slopes and peaks. Within the deep sea, coral habitats thrive where limited nutrients are augmented by local as well as persistent currents like the Gulf Stream (Davies et al., 2008). This study shows the degree to which individual coral mound geomorphologies vary on the Blake Plateau. As studies continue to identify deep-sea coral habitats, ongoing seafloor exploration continues to provide greater knowledge of the southeast U.S continental margin.