Characterizing the Geomorphology of Richardson 'Jellyfish' Scarp on the Blake Plateau, Southeast U.S. Continental Margin

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ABSTRACT

The Richardson Hills Region of the southeastern U.S. continental margin's Blake Plateau was explored during two NOAA Ocean Exploration and Research (OER) expeditions on board the NOAA Ship *Okeanos Explorer: Windows to the Deep 2018* and *2019.* Each expedition's goal was to map and gather information of seafloor characteristics and identify potential deep-sea coral and sponge habitats. The purpose of this study was to characterize the geomorphology of a northwestern section of the Blake Plateau referred to as the Richardson Hills Region, located approximately 250 km east of Hilton Head Island, South Carolina, where depths range from 400 to 950 m. Multibeam sonar data collected during cruise EX1805 were used to produce bathymetric, backscatter intensity and slope surfaces of the seafloor which reveal a nearly circular basin surrounded by flat-lying strata. The basin's scarp is composed of hard substrate, and has a steep incline of approximately 50°, with a vertical relief of nearly 250 m. During *Windows to the Deep 2019*, NOAA OER explored the scarp, nicknaming it Richardson "Jellyfish," using the ROV *Deep Discoverer* to capture high definition video of the geomorphologic features, as well as thriving benthic habitats. This study uses the EX1805 bathymetric data and EX1903 high definition video to characterize the Richardson "Jellyfish" Scarp's geomorphology, as well as the geomorphology of the benthic habitats.

Figure 2:

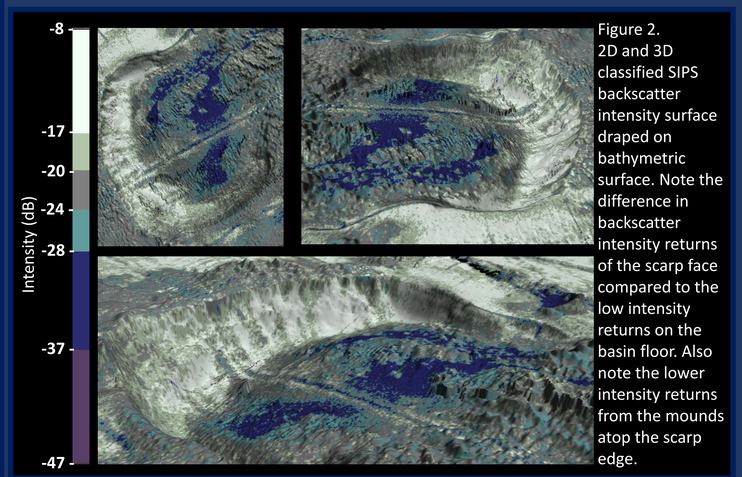


Figure 2. 2D and 3D classified SIPS backscatter intensity surface draped on bathymetric surface. Note the difference in backscatter intensity returns of the scarp face compared to the low intensity returns on the basin floor. Also note the lower intensity returns from the mounds atop the scarp edge.

METHODS

- Multibeam sonar data were collected aboard the NOAA Ship *Okeanos Explorer*, using a Kongsberg EM302, during expedition cruise EX1805 in May and June, 2018, as well as during cruise EX1903 in July 2019.
- QPS Qimera 2.0.2 was used for post-processing raw sonar data.
- A 10m resolution CUBE bathymetric surface was created to characterize the study site's geomorphology.
- Backscatter intensity mosaics were manually classified using CARIS HIPS and SIPS 11.2.
- Slope and intensity data were collected at 100 random points on the scarp face, and basin floor, to examine for correlation.
- Cross-sectional profiles were made for each study area.
- High definition video footage captured by ROV *Deep Discoverer* during expedition cruise EX1903 was used to ground truth locations of benthic habitats in the study area.

RESULTS

- At its deepest point, the scarp has a relief of about 300 m, with the southwestern-most area of the scarp face reaching about 900 m in depth (Figs. 3 and 6).
- The scarp's west, south, and southeastern sides are characterized by relatively steep slopes, the steepest points being about 50° at the top of the scarp face. However, the north, and east edges of the basin are much broader, with very gradual slopes of approximately 10° (Figs. 3 and 6).
- The scarp is horseshoe shaped, creating a large underlying semi-circle shaped basin (Fig. 3).
- Backscatter intensity was significantly greater on the scarp face, compared to the bottom of the basin. However, intensity was lower on the mounds atop the escarpment (Fig. 2).
- Scatter-plot analysis of slope and intensity values of randomly selected points along the scarp, as well as the underlying basin floor, shows a relatively strong positive logarithmic correlation with a trendline equation of $y = 4.3968ln(x) - 31.752$, and an R^2 value of 0.5248 (Fig. 5).
- A series of numerous large mounds occurs along the top of the scarp, with the tallest having reliefs of about 50 m. These mounds are oriented along the edge of the escarpment (Fig. 3).
- High definition video footage captured by ROV *Deep Discoverer* revealed dead corals covering the flat seafloor in the deepest area of the scarp's basin. The mid-scarp face is characterized as having steep inclines composed mostly of rocky slopes and terraces. At the top of the scarp, mounds are covered by dead corals serving as habitats to numerous live corals, and other benthic animals (Fig. 4).

REFERENCES

- DiTommaso, A. and Sautter, L.R., 2019. Characterization of Deep Sea Coral Mounds Beneath the Gulf Stream Off the Southeast U.S. Coast (Poster, Hydro 2019).
- Mueller, J. and Sautter, L.R., 2019. Geomorphologic Characterization of the Richardson Hills Region of the Blake Plateau, Southeast U.S. Continental Margin (Poster, Hydro 2019)
- Roberts, J. M., Wheeler, J. A., Freiwald, A (2006). Reefs of the Deep: The Biology and Geology of Cold-Water Coral Ecosystems. http://science.sciencemag.org/content/312/5773/543.full.

Figure 1:

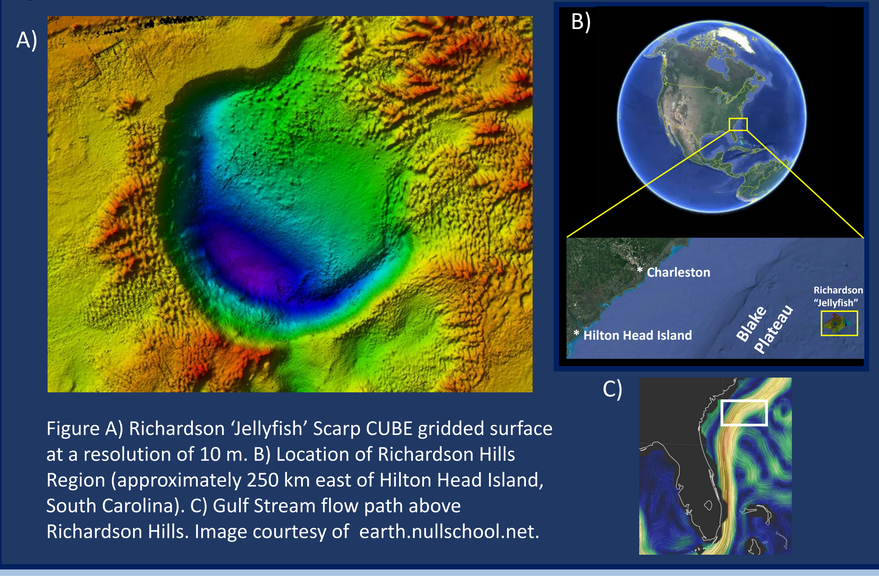


Figure A) Richardson 'Jellyfish' Scarp CUBE gridded surface at a resolution of 10 m. B) Location of Richardson Hills Region (approximately 250 km east of Hilton Head Island, South Carolina). C) Gulf Stream flow path above Richardson Hills. Image courtesy of earth.nullschool.net.

Figure 3:

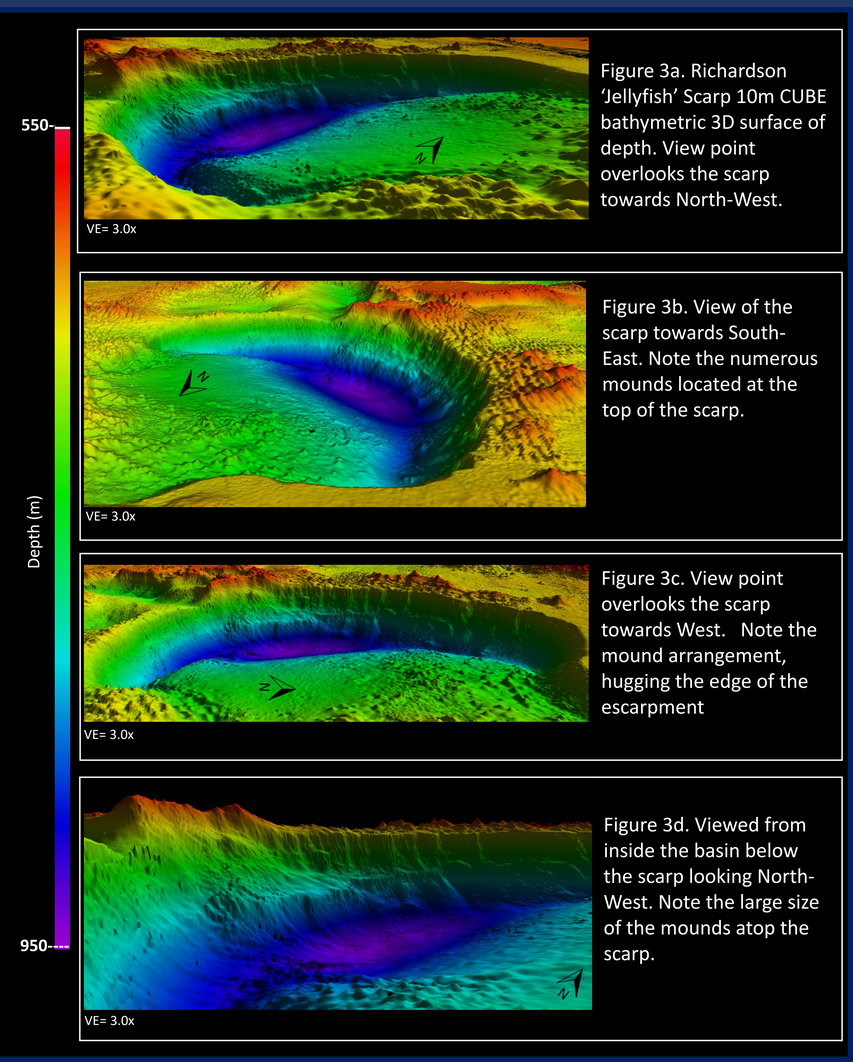


Figure 3a. Richardson 'Jellyfish' Scarp 10m CUBE bathymetric 3D surface of depth. View point overlooks the scarp towards North-West.

Figure 3b. View of the scarp towards South-East. Note the numerous mounds located at the top of the scarp.

Figure 3c. View point overlooks the scarp towards West. Note the mound arrangement, hugging the edge of the escarpment

Figure 3d. Viewed from inside the basin below the scarp looking North-West. Note the large size of the mounds atop the scarp.

Figure 5:

Slope (Degrees)	Intensity (dB)	Slope (Degrees)	Intensity (dB)	Slope (Degrees)	Intensity (dB)	Slope (Degrees)	Intensity (dB)	Slope (Degrees)	Intensity (dB)
4.885	-25.919	22.054	-17.574	5.881	-23.685	43.26	-18.777	6.883	-21.424
9.015	-22.306	7.169	-18.206	6.075	-24.435	40.232	-15.006	14.497	-16.927
0.674	-20.465	23.601	-17.824	4.404	-28.891	46.007	-16.67	11.278	-19.183
4.177	-23.686	19.097	-16.502	2.37	-33.673	35.377	-15.633	9.481	-16.899
10.44	-30.075	45.029	-19.858	2.068	-31.742	17.932	-18.038	40.816	-17.516
14.032	-26.937	6.081	-24.41	5.361	-28.694	21.52	-18.051	11.362	-16.79
6.53	-22.742	4.552	-22.695	5.318	-31.724	13.146	-18.722	15.489	-13.942
8.013	-18.838	4.84	-23.475	2.115	-34.649	13.476	-18.271	12.84	-17.946
4.589	-18.276	0.921	-18.184	4.707	-33.305	15.243	-19.722	8.542	-19.471
9.052	-16.552	18.627	-19.703	3.672	-30.656	16.965	-17.634	7.617	-25.856
15.215	-16.236	15.277	-13.696	1.417	-29.309	15.294	-19.419	15.92	-20.073
26.236	-14.687	35.201	-15.614	1.674	-30.931	14.757	-18.512	24.009	-13.105
31.047	-18.214	25.08	-15.182	7.721	-32.912	27.964	-16.8	46.007	-16.67
51.693	-13.125	30.504	-12.61	19.447	-20.238	43.85	-15.427	35.284	-15.445
22.841	-16.345	37.157	-15.925	20.504	-13.42	40.556	-13.854	32.599	-15.503
18.957	-16.75	32.129	-17.616	35.377	-15.633	35.757	-14.501	3.614	-34.335
38.873	-20.921	27.117	-17.882	24.998	-14.918	32.514	-15.769	4.636	-32.217
28.435	-15.31	18.661	-21.02	37.745	-17.662	4.408	-31.592	11.202	-25.628
24.998	-15.759	12.505	-17.873	46.243	-19.441	34.602	-15.497	3.235	-29.978
4.748	-21.784	25.216	-17.541	36.93	-16.256	32.599	-15.503	4.707	-33.305

Figure 5a. Tables of slope and intensity values for randomly selected points along the 'Jellyfish' scarp and on the basin floor.

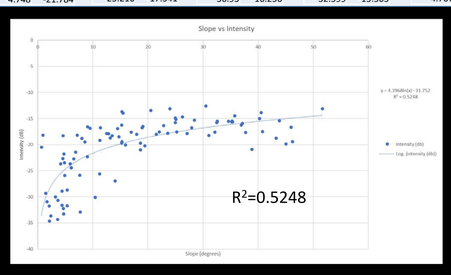


Figure 5b. Scatter-plot comparing slope and intensity values for points listed in Fig. 5a. Note the logarithmic trendline equation with R^2 = 0.5248.

Figure 6:

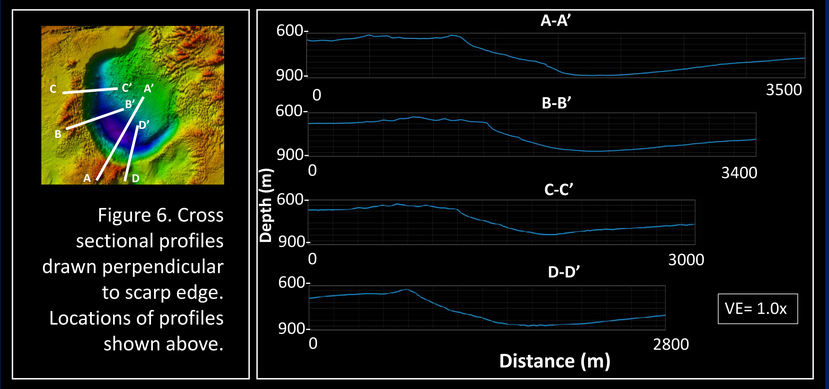


Figure 6. Cross sectional profiles drawn perpendicular to scarp edge. Locations of profiles shown above.

BACKGROUND

The NOAA Office of Ocean Exploration and Research utilized the NOAA Ship *Okeanos Explorer* to conduct expedition *Windows to the Deep 2018*. During the months of May and June of 2018, *Okeanos* gathered multibeam sonar data during expedition cruise EX1805 to map the bathymetric surface of a region along the southeastern United States continental margin known as the Blake Plateau, an extensive, relatively flat feature formed during the Atlantic Ocean's formation (Dillon et al., 1988). One such area was the Richardson Hills region, located in the northwestern section of the plateau, about 250 km east of Hilton Head Island, South Carolina, where depths range from 400 to 950 m. Data gathered revealed seabed characteristics consisting mostly of flat-lying strata, shallow basins, steep scarps, as well as scattered deep-sea coral mounds. Several prominent geomorphologic features were studied and characterized (Mueller and Sautter, 2019). One of these features was a basin bordered by flat-lying strata. The upper areas of the basin's surrounding west, south, and southeastern scarp faces may serve as habitats for deep-sea corals. These areas are likely to have hard substrate, and steep slopes reaching ~50° which are favorable characteristics for deep-sea coral habitats. Bathymetric maps were then used during cruise EX1903, on which *Okeanos* utilized the ROV *Deep Discoverer* to acquire high definition video footage. One of the dive sites was the basin's scarp, which the NOAA OER named Richardson "Jellyfish" Scarp. Footage recorded on July 1, 2019 revealed abundant biological systems and habitats including multiple species of deep sea coral, fish, crustaceans, and cephalopods. The purpose of this study is to characterize Richardson Jellyfish Scarp's geomorphology to set criteria for predicting other deep-sea coral habitats in the Blake Plateau region.

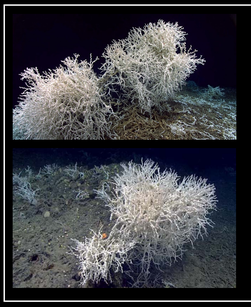
Figure 4:


ROV *Deep Discoverer*

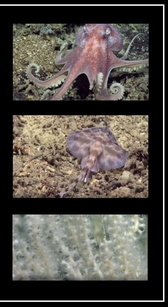
Locations of study sites shown below, along Dive 10 track, NOAA OER EX1903.

Screengrabs from HD video of 3 selected sites, courtesy of NOAA OER.

SITE 1

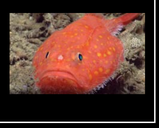


Site 1 is located on a mound that lies along the top edge of the scarp ridge. Note the presence of numerous *Lophelia pertusa* corals growing on dead corals. Also note the presence of various organisms, including octopus, and rays.

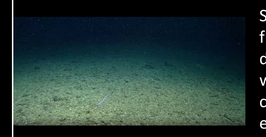


SITE 2

Site 2 is located at the mid-scarp face. Exposed rock creates a hard substrate, however there is little coral growth. Several fish find refuge within this area.



SITE 3



Site 3 is located on the basin's floor. Note the sediment over dead coral substrate. Fish were observed, but no living coral communities were encountered.

DISCUSSION and CONCLUSIONS

Portions of the Richardson 'Jellyfish' scarp serve as habitat for deep-sea stony coral, *Lophelia pertusa* which have formed numerous mound features along the edge of the horseshoe-shaped scarp ridge (Fig. 4, Site 1). These mounds hug the ridgeline along its southern and western areas. This ridge sits at the top of a scarp face that has a relief of 350 m (Fig. 4, Site 2 and Fig. 6) and is characterized by steep slopes with inclines reaching 50°, composed of rocky terraces. High intensity backscatter returns (Fig.2) indicate hard substrate on the scarp face. At the foot of the scarp face lies a large semicircle basin with depths reaching 900 m, where the seafloor is covered by stony coral rubble (Fig. 4, Site 3). These dead coral remains likely fell from the mounds that occur at the top of the scarp ridge. According to Roberts et al. (2006), steep slopes and hard substrate are favorable characteristics for deep sea coral habitats. At the 'Jellyfish' scarp, backscatter intensity would then suggest hard substrate where slopes are higher (Fig. 5). However, the coral mounds along the scarp edge show lower backscatter intensity when compared to both the scarp face and the the adjacent flat-lying strata. These findings agree with studies done by Mueller and Sautter (2019), as well as DiTommaso and Sautter (2019), suggesting that many of the deep-sea coral mounds in this region are composed of highly rugose, porous dead coral framework structure, which results in higher scattering and lower intensity backscatter return when compared to exposed rock substrate. These claims can also be supported by the fact that the basin floor, which is covered in dead corals (Fig. 4) also shows lower backscatter intensity values (Fig. 2). In conclusion, the Richardson 'Jellyfish' scarp to serve as a benthic habitat for deep sea corals and other benthic fauna, and helps to establish criteria for geomorphology that may be useful to locate deep sea coral habitats in the Blake Plateau region.