Geomorphic Analysis of Richardson Scarp on the Southeast U.S. Continental Margin

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ABSTRACT

In May and June of 2018, the NOAA Office of Ocean Exploration and Research explored the Southeast U.S. Continental Margin as a part of the *Windows to the Deep 2018* expedition. The NOAA Ship *Okeanos Explorer* was used to obtain multibeam sonar data along with high definition video collected using the remotely operated vehicle (ROV) *Deep Discoverer*. The purpose of this study is to characterize the geomorphology of an extensive feature, Richardson Scarp, that lies approximately 240 km off the coast of Charleston, South Carolina, where water depths range from 800 to 1050 m. The scarp has an average vertical relief of 100 m and trends northeast-southwest for over 24 km. Deep sea coral mounds were discovered at the edge of the scarp during expedition ROV dives. Bathymetric surfaces as well as slope, aspect and backscatter intensity are used to analyze the geomorphology of the scarp to possibly predict additional deep coral habitat.

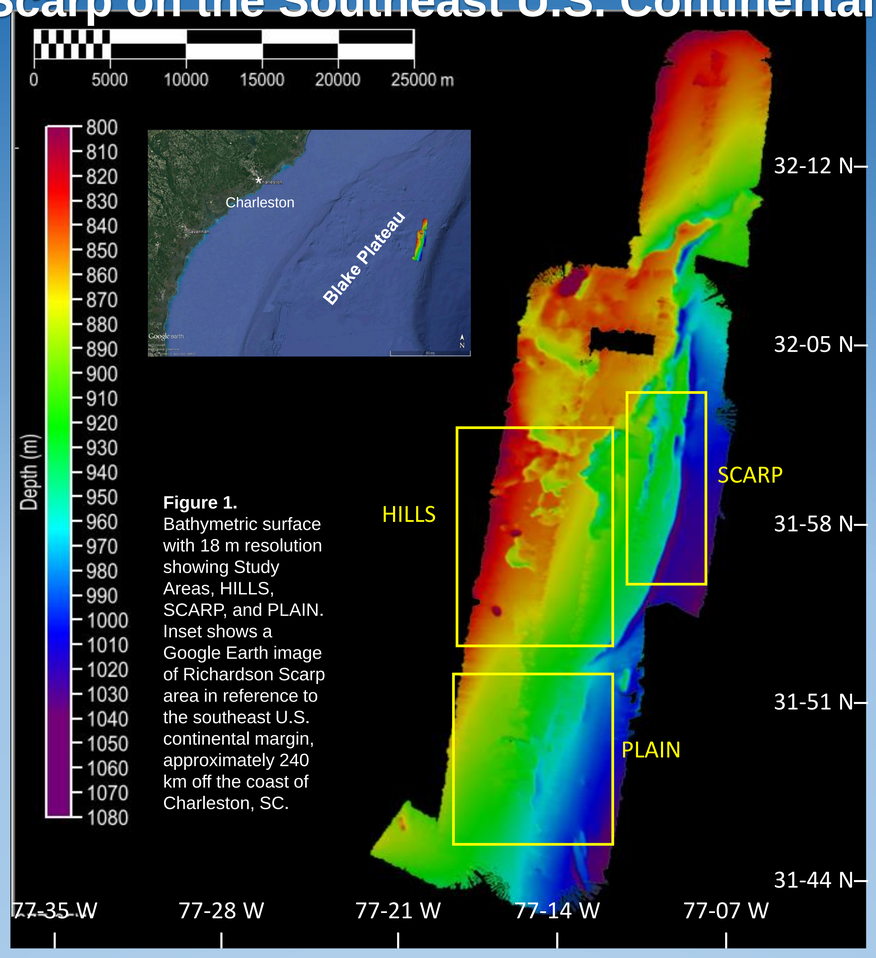


Figure 1. Bathymetric surface with 18 m resolution showing Study Areas, HILLS, SCARP, and PLAIN. Inset shows a Google Earth image of Richardson Scarp area in reference to the southeast U.S. continental margin, approximately 240 km off the coast of Charleston, SC.

HILLS Study Area

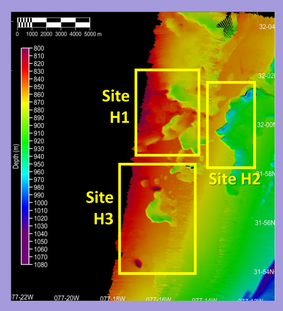
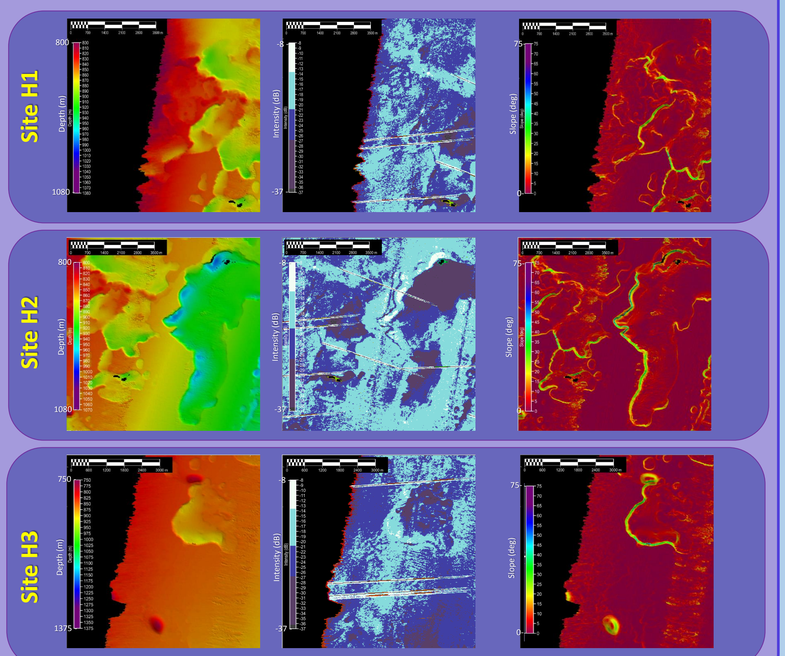


Figure 2.
(Left) HILLS Study Area CUBE surface with 18 m resolution with delineated study sites H1, H2, H3. (Below) Bathymetry, classified backscatter intensity, and slope band for each site. Note different color legends. This Study Area is characterized by a southeast slating low relief area populated by asymmetrical basins and two mounds. To the west of each basin, note the high relief areas that are well illustrated in the slope band and the areas of high intensity in white in the backscatter band. Note the basins are infilled with purple medium low intensity values.



SCARP Study Area

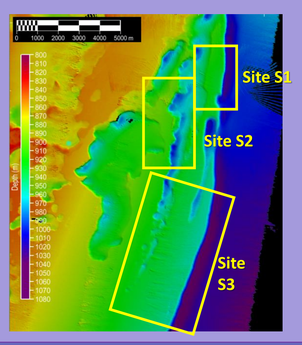
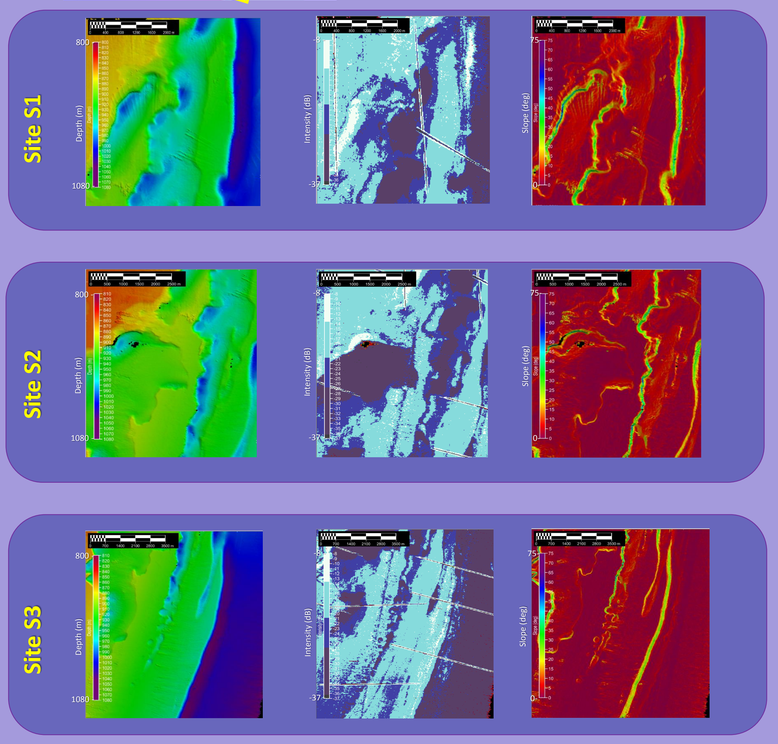


Figure 3.
(Left) Richardson Scarp area SCARP CUBE surface with 18 m resolution with delineated study sites S1, S2, and S3. (Below) Bathymetry, classified backscatter intensity, and slope band for each site. Note different color legends. This Study Area is characterized by the scarp feature that trends northeast-southwest as well as shallow elongated basins to the west of the scarp.



PLAIN Study Area

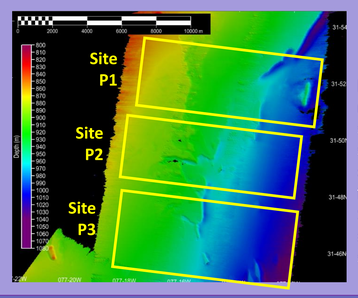
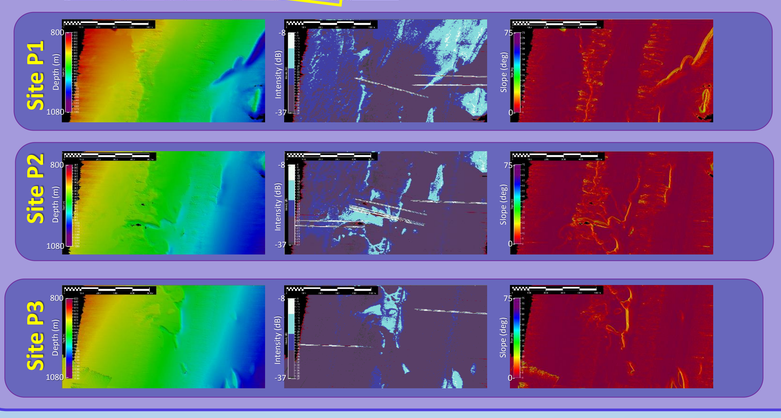


Figure 4.
(Left) Richardson Scarp area PLAIN CUBE surface with 18 m resolution with delineated study sites P1, P2, and P3. (Below) Bathymetry, classified backscatter intensity, and slope band for each site. Note different color legends. This Study Area is characterized by a very low relief and almost no high intensity backscatter with low slopes.



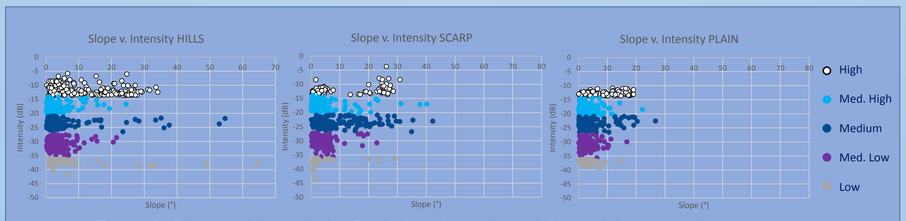


Figure 6. Slope and intensity by Study Area for points within each intensity class, color coded by classes shown in legend at right.

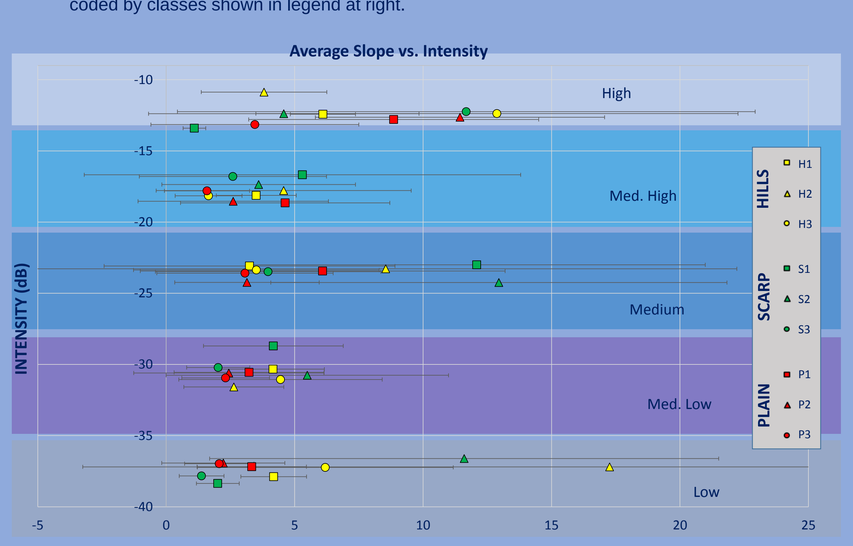


Figure 7. Average slope and average intensity values for all points within each of the 9 Sites (Table 1), within each intensity class. Intensity classes (low to high) are color coded as shown in Fig. 6. Standard deviation is included for slope.

BACKGROUND

Richardson Scarp is a bathymetric feature along the Blake Plateau roughly 240 km off the coast of Charleston, South Carolina on the Southeast United States Continental Margin. Previous to the NOAA expedition, *Windows to the Deep 2018* the area was virtually unexplored, and few high resolution maps existed. During the expedition, several important geomorphological discoveries were made, including numerous scarps and intraslope terraces. An intraslope terrace is characterized as an area of low relief with flat lying strata outcrop forming stair-like steps [Coe and Sautter, 2019], where exposed rock often results in hard bottom substrate. On the Blake Plateau, terraces are found in depths of 0.5 to 3.0 km [NOAA OER, 2018], housing a high diversity of benthic organisms. Abundant deep-water stony coral habitats have been predicted for this area [Cantwell, 2018], and several were explored during the EX1806 expedition. The Richardson Scarp area has several distinguishing features which could provide suitable habitat for benthic communities and stony corals. The flat step areas have many Mn-nodules and carbonate strata have areas coated with Mn crust [NOAA OER, 2018], identifying a possible mineral sink. Rock slabs provide a suitable substrate for soft corals and sponges [Coe and Sautter 2019]. The purpose of this study is to characterize Richardson Scarp geomorphologic features for possible use in deep sea coral habitat modeling. Results of this study may apply to other locations worldwide to better understand deep sea ecosystems.

METHODS

- Mapping cruise EX1805 on NOAA Ship *Okeanos Explorer* used a Kongsberg EM302 multibeam echosounder to map the area of this study. During expedition cruise EX1806 the ROV *Deep Discoverer* dove at the northern end of the study area (Dive 08, on June 22nd).
- 18 m resolution CUBE BASE surfaces with depth, slope and backscatter mosaics were created in CARIS HIPS and SIPS 11.0.
- Post-processing was completed using CARIS HIPS and SIPS 11.0 and previous research was used to characterize different regions.
- Bathymetry, slope and aspect bands were produced. The SIPS Mosaic Backscatter engine was used to create a backscatter mosaic, which was then manually classified into 5 classes.
- Bathymetry, slope and backscatter layers were used to characterize the seafloor in 3 distinctly different areas: HILLS, SCARP, and PLAIN.
- 3 Sites were selected for each area for analysis of slope and backscatter intensity.
- Random points (n>5) were selected for each site within 5 intensity range classes. Each point had an associated intensity, slope, depth and aspect value, but for the purpose of this study only slope and intensity were used. (Table 1).

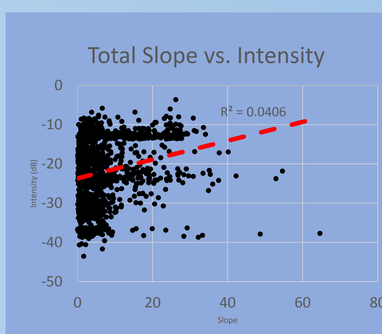


Figure 5. Slope and intensity values from all data for 9 sites, with a linear regression line and an $R^2 = 0.0406$, showing that no correlation exists between these variables.

Table 1. Averages of data points collected for each backscatter classification for Study Areas HILLS (H), SCARP (S), and PLAIN (P) and sites 1, 2 and 3 for each. Standard deviation of total data points collected. White (W) points denote high intensity, light blue (L) , blue (B), purple (P), and grey (G), in order of decreasing backscatter intensity. The same color coding is used in Figures 6 and 7.

	Average Slope (°)	Avg. slope standard deviation	Average Intensity (dB)
HW1	6.10	5.63	-12.42
HL1	3.50	3.70	-18.13
HB1	3.24	2.81	-23.09
HP1	4.16	3.70	-30.33
HG1	4.18	2.40	-37.88
HW2	3.81	2.44	-10.87
HL2	4.57	4.96	-17.79
HB2	8.54	13.67	-23.28
HP2	2.63	1.94	-31.58
HG2	17.26	20.51	-37.20
HW3	12.88	9.38	-12.38
HL3	1.65	1.30	-18.15
HB3	3.51	4.78	-23.37
HP3	4.45	3.96	-31.06
HG3	6.19	4.98	-37.23
SW1	1.10	0.44	-13.41
SL1	5.30	8.50	-16.68
SB1	12.09	8.89	-23.00
SP1	4.17	2.72	-28.70
SG1	2.01	0.83	-38.36
SW2	4.58	5.26	-12.39
SL2	3.60	3.77	-17.36
SB2	12.95	8.88	-24.25
SP2	5.49	5.50	-30.76
SG2	11.60	9.91	-36.61
SW3	11.68	11.24	-12.24
SL3	2.60	3.64	-16.80
SB3	3.97	4.39	-23.48
SP3	2.03	1.23	-30.22
SG3	1.38	0.87	-37.83
PW1	8.86	5.64	-12.79
PL1	4.63	4.07	-18.65
PB1	6.09	7.10	-23.44
PP1	3.23	2.92	-30.56
PG1	3.33	2.13	-37.18
PW2	11.44	5.79	-12.64
PL2	2.61	2.34	-18.54
PB2	3.14	3.04	-24.24
PP2	2.44	2.91	-30.60
PG2	2.22	2.15	-36.92
PW3	3.45	4.05	-13.15
PL3	1.59	1.66	-17.81
PB3	3.07	3.43	-23.59
PP3	2.31	1.71	-30.95
PG3	2.07	1.35	-36.97

RESULTS

- High backscatter intensity can be found on the perimeter of basins and scarps with high relief. (Figs. 2 & 3)
- Areas of low relief have medium low to low intensity backscatter. (Fig. 4)
- No correlation exists between slope and intensity ($R^2 = 0.0406$) for this area (Figs. 5 and 6).
- Little to no relationship exists for slope and intensity within any of the study areas. (Fig. 6)
- Average slopes have large standard deviation in areas of high, medium and low intensity. Small standard deviations for medium high and medium low intensity. (Fig. 7).

DISCUSSION and CONCLUSIONS

For intraslope terraces on the Blake Plateau, high backscatter intensity values have been found to indicate areas of hard substrate [Coe and Sautter, 2019] and also potential habitat for deep sea corals. For our study, high intensity substrate was only observed along the edges of basins and on the scarp edge (Figs. 2 & 3), where slope is highly variable.

The lack of correlation between slope and intensity found in this study (Fig. 5) does not support the general interpretation that high slopes are likely to have high intensity due to exposure of hard substrate. Because backscatter intensity is not high in areas of high relief at Richardson Scarp, this method may not be useful to identify locations of intraslope terraces and possible deep sea benthic communities.

Areas within the Richardson Scarp study area have variable slope and cannot be used to argue a clear relationship between slope and intensity. Thus, backscatter intensity as a tool for substrate and geomorphological classification should be reevaluated.

REFERENCES

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- NOAA OER, 2018, Final Dive Reports for EX1806 Dives 05 and 06 from the Windows to the Deep 2018, *Okeanos Explorer* Expedition 1806.
- Coe and Sautter, 2019, Geomorphology of Intraslope Terraces, Eastern Blake Plateau, US Hydro Conference, Biloxi, MS.

ACKNOWLEDGEMENTS

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