Geomorphologic Analysis of Eastern Slope of Glover's Reef: a Coral Atoll on the Continental Margin of Belize

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ABSTRACT

Multibeam sonar data of the eastern slope of Glover's Reef atoll were collected by NOAA marine biologist Dr. Peter Etnoyer, aboard the E/V *Nautilus* in August 2014. Glover's Reef is an atoll within the Mesoamerican Reef, located approximately 45 km east of the Belize mainland. Prior to 2014, the eastern flank of Glover's Reef, had not been studied extensively. This study of the geomorphology of the seafloor could potentially lead to a better understanding of the entire biological system of deep sea coral habitat. Sonar data were collected with a Kongsberg EM302, and post-processed using CARIS HIPS 8.1. Bathymetric 2D and 3D images were generated, and backscatter was used to determine the character of the seafloor, including probable locations for deep-sea corals. The results of the bathymetric images show various interesting features including canyons and depths over 2,800 meters below sea level. The seafloor characteristics that were defined using backscatter allowed the potential locations of deep-sea coral habitats to be determined. Detecting these environments is crucial for the continuation Dr. Etnoyer's work studying the deep-sea corals of this atoll.

BACKGROUND

In August 2014, when the E/V *Nautilus* and its team of NOAA scientists embarked on a mission to collect data to map the sea floor of the Mesoamerican Reef, they also sent out ROV *Hercules* for ground-truthing and observation of deep-sea corals and ecosystems (Etnoyer et al., in press). Their results confirmed that deep-sea corals in this area are most likely to be found on hard, rocky surfaces of the seafloor. Deep-sea corals typically thrive in areas of diverse geomorphological features, such as seamounts, ridge systems, slopes, and continental margins (Roberts et al., 2006). Deep corals can survive in approximate temperatures between 4 and 12° C. Waters of this temperature can be found at depths up to 4000 meters in lower latitude regions (Roberts et al., 2006). Due to knowledge of the study area's ecosystems provided by NOAA scientists, regions of study focused on areas with depths between 400 and 600 meters, and 1800 to 2100 meters (Etnoyer et al. in press).

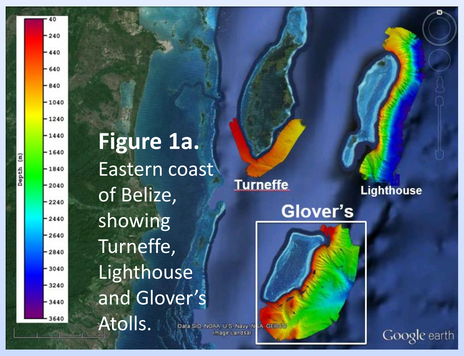


Figure 1a. Eastern coast of Belize, showing Turneffe, Lighthouse and Glover's Atolls.

Figure 1b. The Mesoamerican Reef lies off the eastern coast of Central America.

METHODS

- Ocean Exploration Trust's E/V *Nautilus* was used to acquire sonar data using a Kongsberg EM302 system (8/9/2014-8/11/2014).
- Caris HIPS and SIPS 8.1 was used to post process raw data and create a 10 m resolution Swath Angle BASE surface .
- Backscatter data were also processed.
- Slope data were generated using Caris BASE Editor 4.1.
- Sediment type was analyzed using Caris HIPS and SIPS 8.1.
- Two main study areas were chosen for a detailed analysis based on their depth, hardness, and slope characteristics.

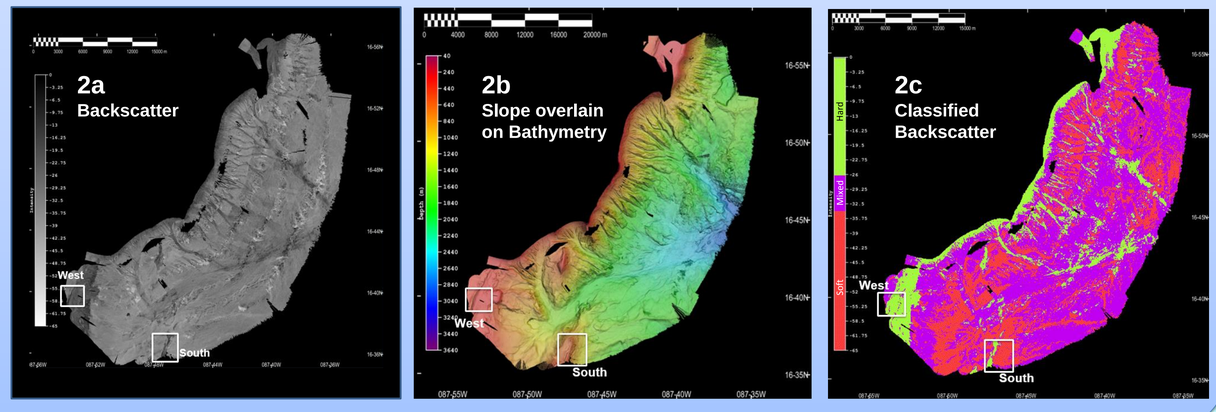


Figure 2. Focused study areas "West" and "South" are shown on maps of backscatter (2a), slope overlain on bathymetry (2b), and classified backscatter (2c). Green areas in 2c show hardest surfaces.

Glover's West

RESULTS

Results of the detailed analysis of the western study area of Glover's Reef show depths, slope, and hardness correlating with predicted habitat characteristics of deep-sea corals. Depth range in this area is between approximately 370 and 450 m. Profiles (Figs. 3 and 4) display depth and slope ranges, which can be also seen in the 3D image (Fig. 5). The slope (Fig. 6) ranges from ~ 14 to 52°, indicating some highly sloped surfaces and some flatter surfaces. Backscatter (Figs. 7 & 8) displays hard surfaces in the study area, (indicated by higher decibel values and dark areas). For this study area, backscatter intensity between -10 and -20 dB is considered hard enough to be a potential location for deep-sea coral habitat.

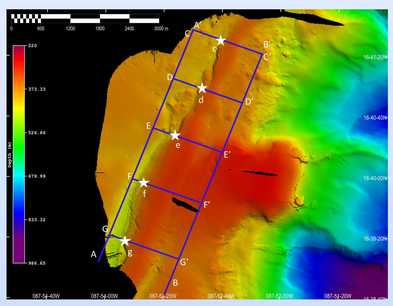


Figure 3. (above) Bathymetric view of study area West including locations of profiles and depth, slope, and backscatter intensity analyses.

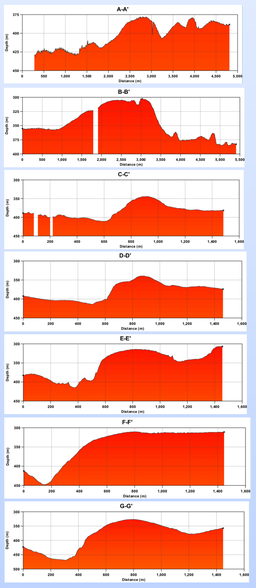


Figure 4. Profiles taken from lines drawn in Figure 3.

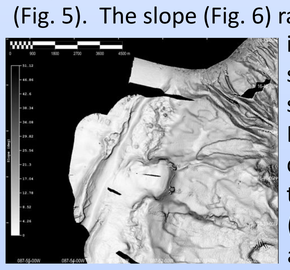


Figure 6. Slope image of study area West, darker areas show steeper slopes.

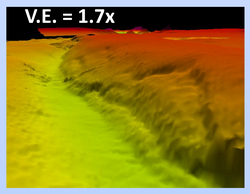


Figure 5. 3D image of study area West.

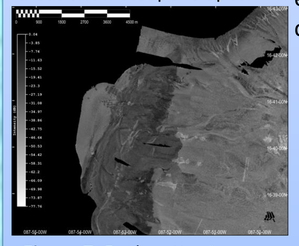


Figure 7. Backscatter image of study area West, darker areas show harder surfaces.

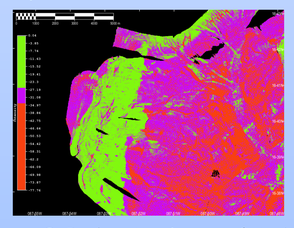


Figure 8. Backscatter image of study area West. Bright green areas are the hardest surfaces.

Location	Depth (m)	Slope (°)	Backscatter Intensity (dB)	Sediment Type	Sediment Type Confidence
c	406.84	14.44	-12.67	clayey sand	good
d	375.12	35.44	-24.20	very fine sand	good
e	363.09	44.74	-25.37	clayey sand	Inconclusive
f	436.64	23.68	-17.86	very fine sand	Inconclusive
g	451.05	51.78	-15.84	silty sand	Fair

Table 1. Data collected at points shown in Fig. 3.

Glover's South

RESULTS

Study area South was thoroughly examined to determine the likelihood that deep-sea corals exist in this location. Characteristics including the depth, slope, and hardness were analyzed. Depths range from approximately 650 to 1350 m, with shallower depths to the east (Figs. 9 and 10). This area is within suitable depths for deep-sea corals. Profiles were used to display changes in slope and depth (Fig. 11), both of which can also be observed in Figure 9. Slopes range from 14° to 32°, indicating the presence of gradual to steep gradients across the entire study area (Fig. 12). Backscatter analysis indicated hard substrate on the eastern side of the study area (Figs. 13 & 14), also seen in Fig. 15.

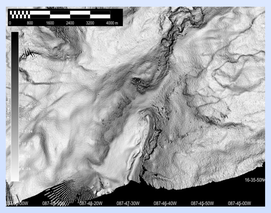


Figure 12. Slope image of study area South.

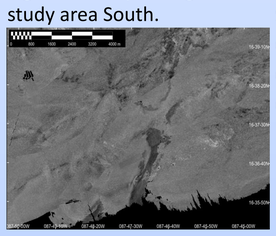


Figure 13. Backscatter image of study area South.

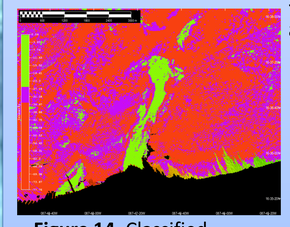


Figure 14. Classified backscatter of study area South. Bright green areas are the hardest surfaces.

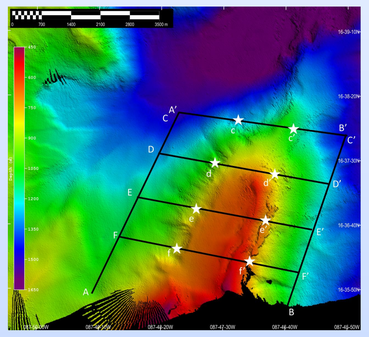


Figure 9. Bathymetric view with profile locations of prominent feature.

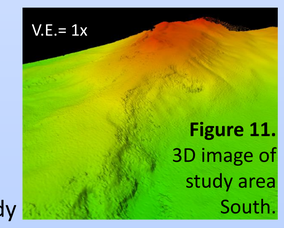


Figure 11. 3D image of study area South.

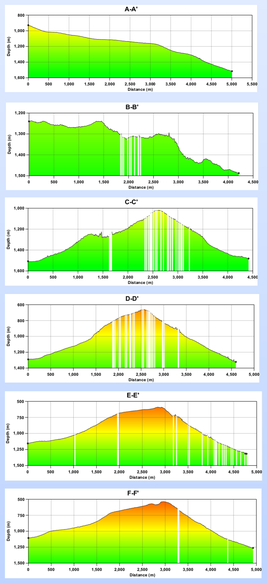
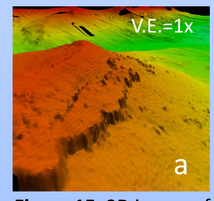


Figure 10. Profiles across the bathymetric feature (Fig. 8).



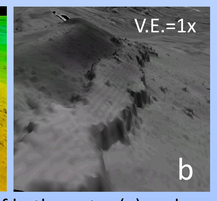


Figure 15. 3D image of bathymetry (a) and backscatter (b).

Location	Depth (m)	Slope (°)	Backscatter Intensity (dB)	Sediment Type	Sediment Type Confidence
c	1147.46	27.5	-40.09	clay	good
c'	1317.11	14.36	-21.69	coarse silt	good
d	999.25	31.15	-35.49	clay	very good
d'	805.16	24.02	-16.03	clay	inconclusive
e	878.28	23.17	-31.84	clay	very good
e'	701.65	31.65	-10.33	clay	inconclusive
f	837.4	25.56	-38.35	clay	very good
f'	661.18	15.65	-32.01	clay	fair

Table 2. Data collected at starred points shown in Fig. 8.

DISCUSSION & CONCLUSIONS

In order to determine areas on the eastern slope of Glover's Reef which are likely to contain deep-sea corals, a focused analysis of the reef's depth, slope, and backscatter intensity was completed. Study areas West and South were chosen based on their highly-sloped surface, relative hardness, and depth. Backscatter was classified (Fig. 2c) in order to easily determine the hardest areas (green areas are the hardest). This map was used to correlate the hardest areas with areas of the most plausible depths for deep-sea corals at depth of 400-600 m and 1800-2100 m. Hard areas located within suitable coral habitat depths were then analyzed based on their degree of slope to make conclusions about likely locations for deep-sea corals. While no parameters for slope were determined to be necessary for deep-sea coral habitats, it is known that corals exist on sloped surfaces (Etnoyer et al. in press). Profiles (Figs. 4 and 10) provide easy visualization of the sloped surface. Once study areas were established, a sediment type analysis was completed to analyze the composition of the sea floor. This analysis, completed using CARIS HIPS and SIPS, is a first order analysis, and ground-truthing using ROVs and sampling would be required for an accurate sediment type analysis. Study area West, which contains feasible depths for deep-sea coral, as well as a sloped and hard substrate, also consists of sediment types which (if accurate) would make this area questionable as a deep-sea coral habitat. Study area South is composed of a hard, sloped surface on the eastern side of the study area, and also contains the most probable sediment type for coral habitats of all the sediment type analyses results. However, a large portion of this study area is not within the depth range that corals are most likely to exist. The depth parameters used in this study are an estimate, as deep-sea corals have been known to exist in depths of up to 4000 m, so deeper portions of the region have not been ruled out as potential locations for corals. Photos taken by ROV *Hercules* (Fig. 16) show rocky outcrops, which could potentially alter the backscatter results, although these areas are still may still be suitable for deep sea coral habitats and should be further investigated (Etnoyer, et. al. 2011). Additional ground-truthing and sampling would be essential for the continuation of this study to determine the most probable locations of deep-sea corals. Using the methodologies employed for West and South sites, CARIS HIPs and SIPS and BASE editor can be used to complete a future analysis of the entire eastern slope of Glover's Reef.

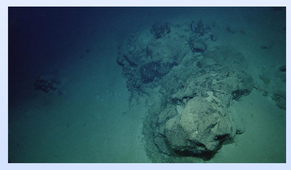


Figure 16. Image taken by ROV *Hercules* of ocean floor of the Mesoamerican Reef.

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