Deep Coral Habitat Characterization of the North End of Raita Bank, Papahānaumokuākea Marine National Monument in the Northwestern Hawaiian Islands

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ABSTRACT

The purpose of this study is to characterize and explore the north end of Raita Bank in the Northwestern Hawaiian Islands, to assess where deep marine coral would most likely grow and flourish. The bank is located within the largest U.S marine protected area, the Papahānaumokuākea Marine National Monument (PMNM), 1,120 km northwest of Honolulu, Hawaii. Multibeam sonar data were collected by the Schmidt Ocean Institute using the R/V *Falkor's* Kongsberg EM302 and EM710 during an exploratory cruise within the PMNM in May-June 2014. Raita Bank hosts both shallow and deep coral; however, this study was focused on potential deep coral habitat at depths ranging 400 to 3000 m. The bank stretches approximately 44 km east-west and 35.8 km north-south and has its shallowest point at a depth of 320 m. Overall gradients between 400 and 3000 m depths range from 0.083 to 0.304, including major terraces ending at approximately 500 and 1000 m depths. The steeper gradients and terraced cliff areas indicate favorable conditions for deep coral. A bathymetric map created with CARIS HIPS and SIPS 9.0 software was used to visualize seafloor geomorphology and characterize deep coral habitat by examining slope relief, distance to shelf edge, and other geomorphologic features. Additionally, backscatter was used to analyze the seafloor's relative hardness to identify hard-bottom seafloor areas that would be more likely to support deep coral. Maps generated from this study will be invaluable for future explorations of deep coral habitat on the bank.

Location of Study Site

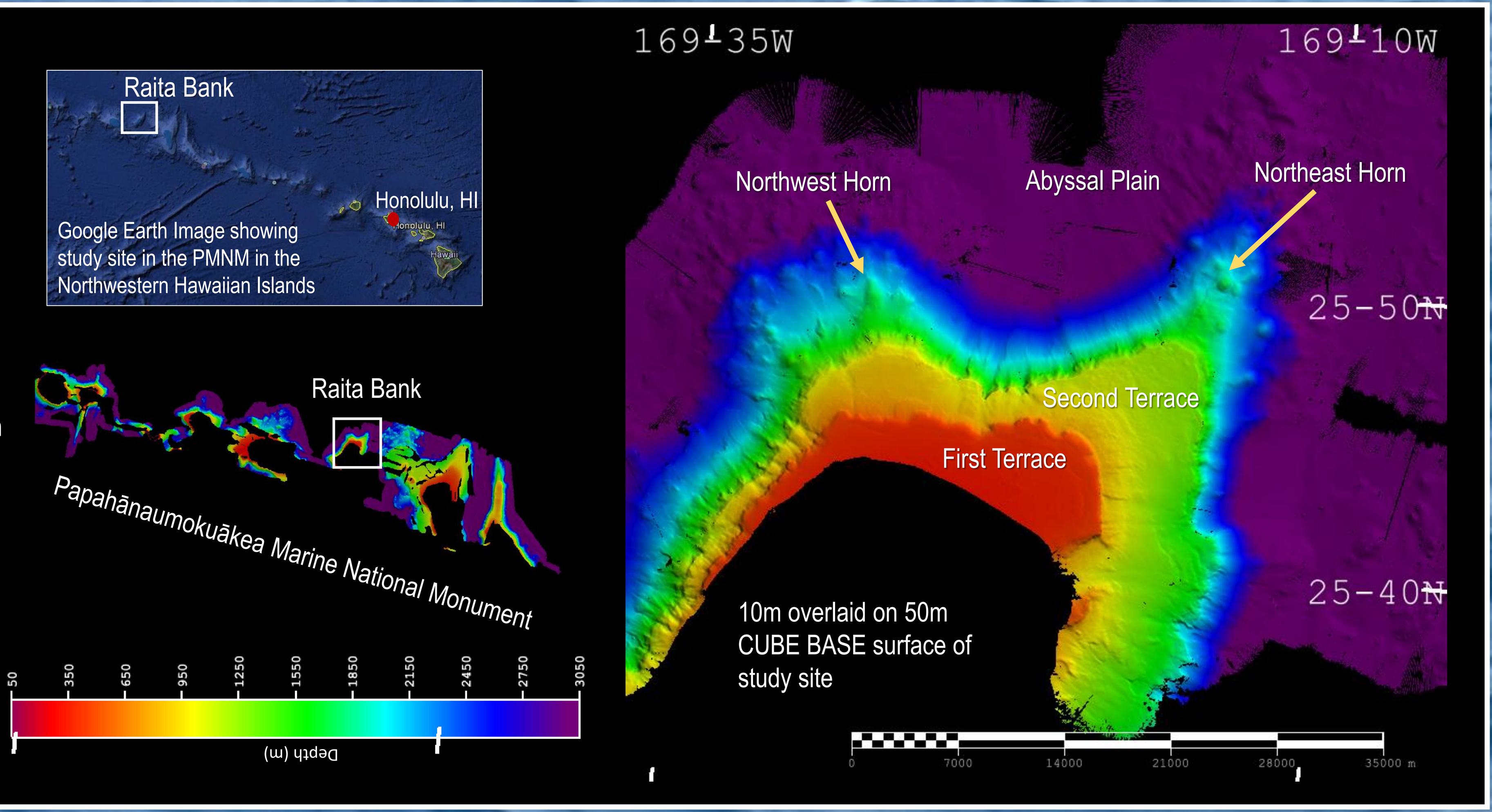


FIGURE 1
Raita Bank is in the Papahānaumokuākea Marine National Monument in the Northwestern Hawaiian Islands about 1,120 km northwest of Honolulu, HI. The Bank is one of many ancient seamounts that were formed as part of the Hawaiian Island Chain. Over millions of years, volcanic islands have moved away from the hot spot and have been eroded and subsided beneath the ocean surface creating Marine environments for coral and other benthic-dwelling organisms.

BACKGROUND

The purpose of this study is to characterize Raita Bank to determine which areas are most prone to supporting deep sea coral habitat. Raita Bank is located in the Papahānaumokuākea Marine National Monument (PMNM), 1,120 km NW of Honolulu, HI (Fig. 1). This area is home to diverse coral/sponge habitats, an array of marine mammals, fish, and resources (Kelly, 2014). This area is protected to keep its largely unexplored habitats safe. However, it has the most valuable manganese crust in the world known as the Prime Crust Zone (PCZ) at 1,000-2,500 m depths; which coincidentally, is the optimal depth range for deep sea coral habitat (Kelly, 2014). During the cruise in which the data for this study were collected, Kelly categorized the PCZ. Deep sea, or "cold water," corals grow on hard substrate, sides of carbonate mounds, and steep gradients (Roberts et al., 2009). This area in particular not only has a large area of deep coral growth, but it also is in a tropical region which extends the depths at which these corals can grow to 4,000 m in tropical regions like Raita Bank (Roberts et al., 2006). These fragile, vital ecosystems are threatened from human activity, and it is crucial to map and protect their existence.

METHODS

- Bathymetry and backscatter intensity data were collected by the Schmidt Ocean Institute using the R/V *Falkor's* Kongsberg EM302 and EM710 during an exploratory cruise within the PMNM in May-June 2014.
- CARIS HIPS and SIPS 9.0 was used for data post-processing.
- CUBE BASE surfaces were created at 10m resolution overlain on a 50m resolution.
- Backscatter intensity (dB) was classified and used to determine which areas would be more optimal for deep coral habitat. The classified backscatter surface was overlain on the 3D BASE surface to combine bathymetric and backscatter data to determine which areas and features host favorable conditions for deep coral growth.
- Profiles were made at varied locations across the bank to see relief and calculate overall slope data, as well as slopes of the terraced cliffs.
- Slope data in conjunction with backscatter intensity data were used to identify areas that are most favorable as deep sea coral habitat.

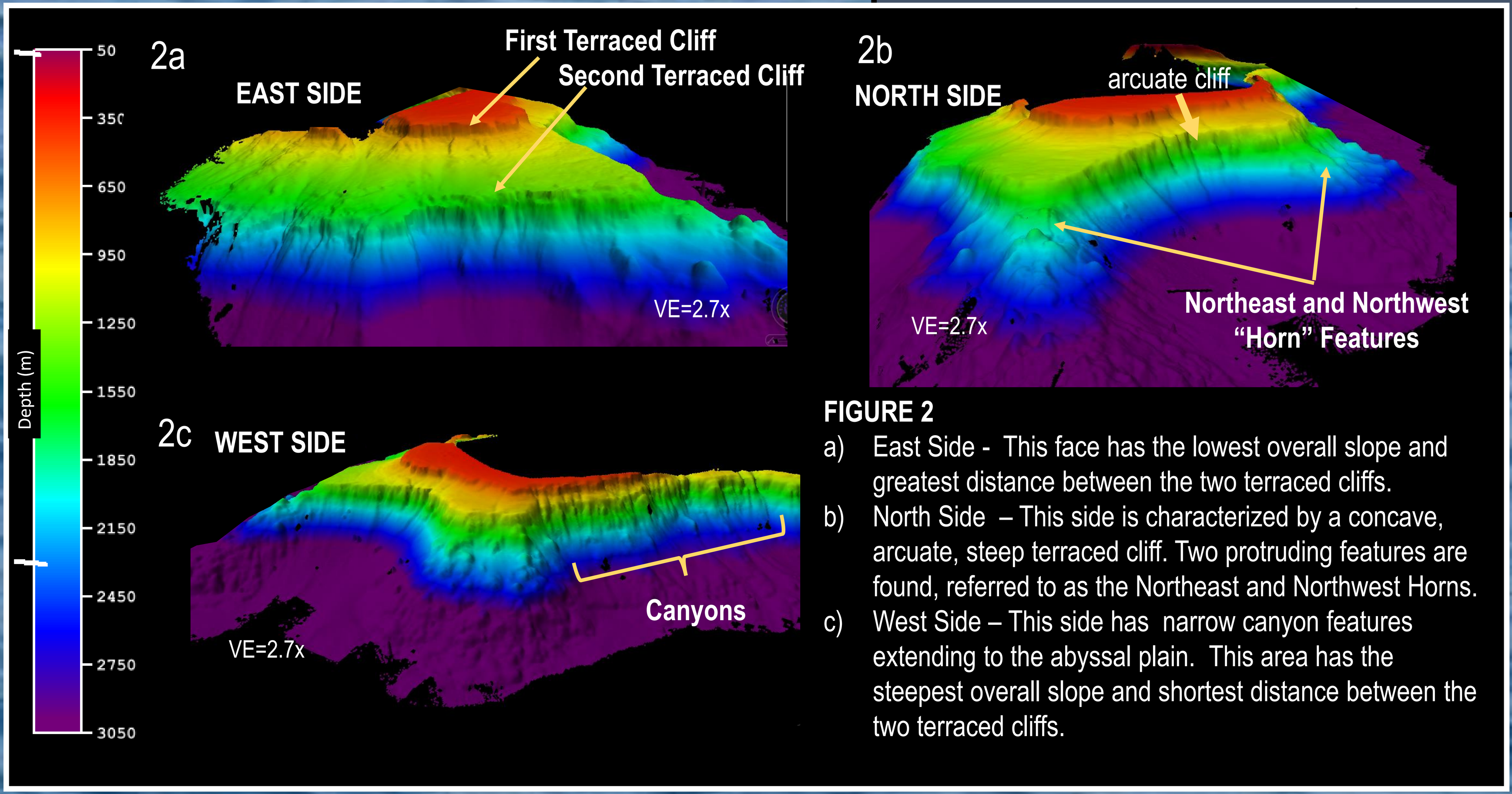
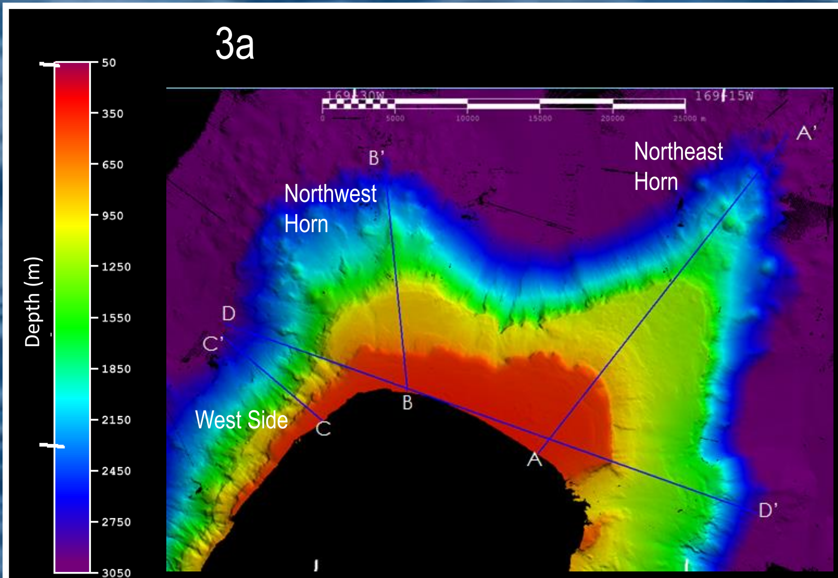


FIGURE 2
a) East Side - This face has the lowest overall slope and greatest distance between the two terraced cliffs.
b) North Side – This side is characterized by a concave, arcuate, steep terraced cliff. Two protruding features are found, referred to as the Northeast and Northwest Horns.
c) West Side – This side has narrow canyon features extending to the abyssal plain. This area has the steepest overall slope and shortest distance between the two terraced cliffs.

RESULTS

The area of study can be broken down into separate features: First Terrace, First Terraced Cliff, Second Terrace, Second Terraced Cliff, and the abyssal plain (Figs. 1 and 2). The First Terrace is characterized by the softest substrate (Fig. 4a). The First Terrace seafloor is relatively shallow (320-500m) and almost flat with a slope of 0.070. The First Terraced Cliff however, is the steepest feature at an average 0.673 slope with a maximum at 0.923 (Table 2). In addition, the First Terraced Cliff exhibits intermediate to harder substrate, especially on the East Side (Fig. 4a). The Second Terrace is low in slope as well, but is characterized by an abundance of harder substrate, more so on the Northeast Horn (Figs. 4a and 5). The Second Terraced Cliff is steep (0.456), yet not as extreme as the First Terraced Cliff (Fig. 5). This cliff exhibits the strongest and most frequent hard substrate backscatter intensities. The highest readings (11.75-15.00 db) come mainly from both the Northeast and Northwest Horn features (Fig. 4a). The arcuate cliff on the North Side of the Second Terraced Cliff exhibits intermediate hardness substrate (10.00-11.75 db) overall with high readings at the rim (Fig. 4a). On the West Side of the bank, harder substrate is found concentrated in the canyon axes, but the entire location is dominated by intermediate substrate harness readings (Fig. 4a). The First Terrace exhibits the most low intensity readings (8.00-10.00 db) overall (Fig. 4a).



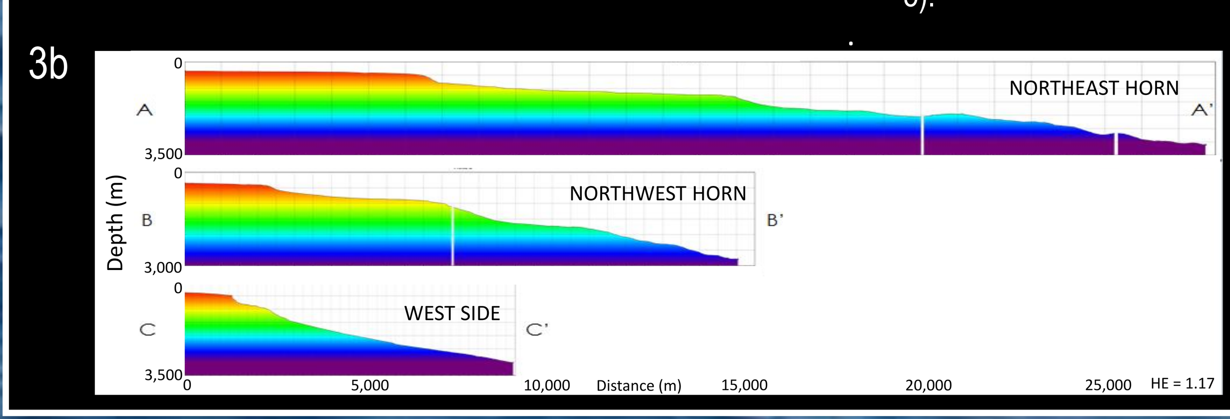


FIGURE 3
a) Locations of profiles drawn across Raita Bank. Profile sites were selected to include each of the bank's sides, as well as crossing noticeable features such as the terraces, terraced cliffs, and the seamount horns.
b) Profiles show the cross sectional view and visual slopes of Raita Bank. C-C' shows the steepest overall slope while profile A-A' has the lowest overall slope (Fig. 5).

DISCUSSION

The areas of highest potential for deep sea coral growth are the First Terraced Cliff, the Northeast Horn, and the East Side of the Second Terraced Cliff. These areas exhibit steeper gradients and harder substrate. These hardest areas are most likely the hard manganese crust that supports deep coral growth (Kelly, 2014). Areas of intermediate potential for deep coral growth are the eastern portion of the Second Terrace, the Northwest Horn, and the West Side. The eastern portion of the Second Terrace falls in this category because of its low slope, but hard substrate. The Northwest Horn is intermediate because of its mix of hard and intermediate substrate with a moderate slope. The West Side exhibits the steepest slopes, though its substrate readings are mainly intermediate. Additionally, these canyon features represent areas of likely turbidity flows which would be counterproductive to coral growth.

Overall, Raita Bank holds great potential for deep sea coral habitat. The abundance of hard bottom substrates and steep gradients provides the perfect set of conditions to foster growth. Certain areas, however, are more likely to support deep sea coral activity. The areas for highest potential are excellent sites for exploration to acquire visual data of coral habitats. Knowing locations of highest probability mitigates wasting money from failed ROV dives to explore these diverse and largely unexplored habitats, and knowing habitat localities also protects the coral from destruction during manganese extraction.

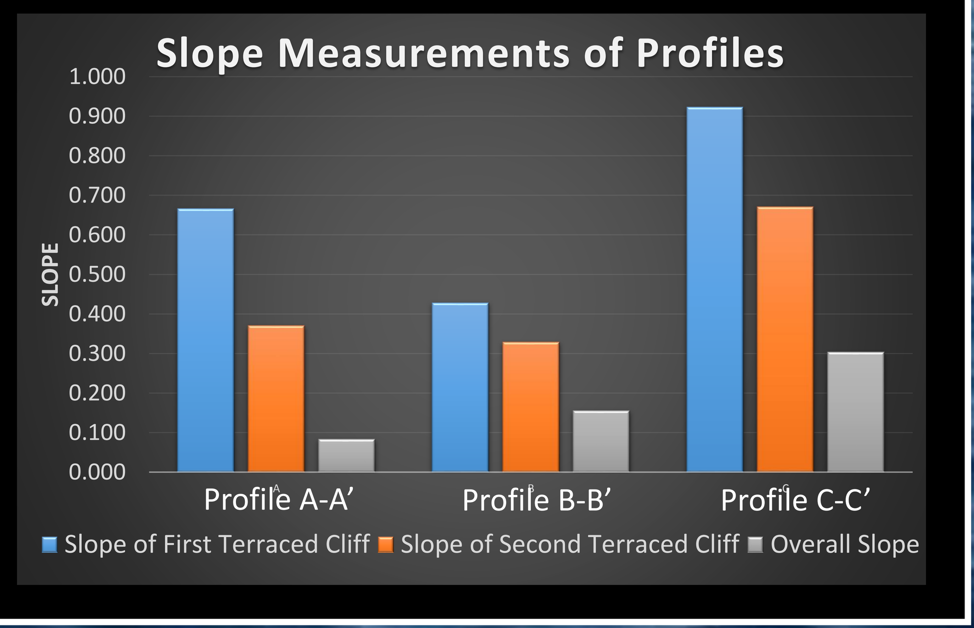
Table 1. Depths and distances of terraced cliffs using the profiles in Figure 3.

MEASUREMENT DESCRIPTION (all measurements in meters)	Profile		
	A-A'	B-B'	C-C'
Initial Depth	475	350	450
Distance to 2500 m Depth	24300	13800	6750
Distance to Top of First Terraced Cliff	6500	2250	1325
Distance to Top of Second Terraced Cliff	14950	7050	2255
Depth of Top of First Terraced Cliff	500	450	500
Depth of Top of Second Terraced Cliff	1300	1000	990
Distance to Bottom of First Terraced Cliff	6950	2600	1650
Distance to Bottom of Second Terraced Cliff	16300	9025	3000
Depth of Bottom of First Terraced Cliff	800	600	800
Depth of Bottom of Second Terraced Cliff	1800	1650	1490

Table 2. Slopes derived from Table 1 data.

Measured Profile	Profile (m)		
	A-A'	B-B'	C-C'
Slope of First Terraced Cliff	0.667	0.429	0.923
Slope of Second Terraced Cliff	0.370	0.329	0.671
Overall Slope	0.083	0.156	0.304

FIGURE 5 (below)
Slope measurements of profiles made at Raita Bank (Fig. 3). Positions are as follows:
A-A' = Northeast Horn
B-B' = Northwest Horn
C-C' = West Side



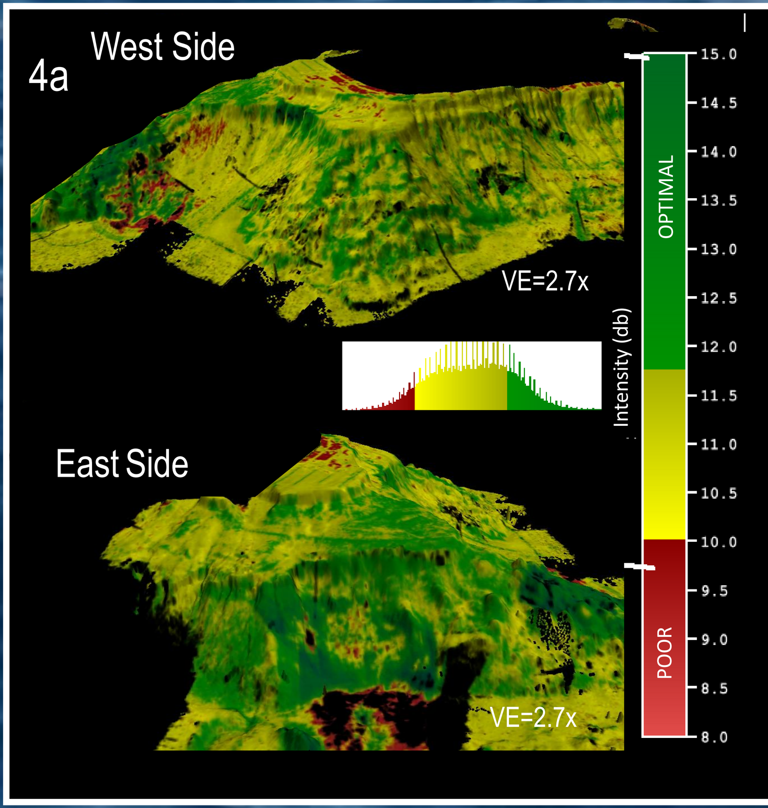
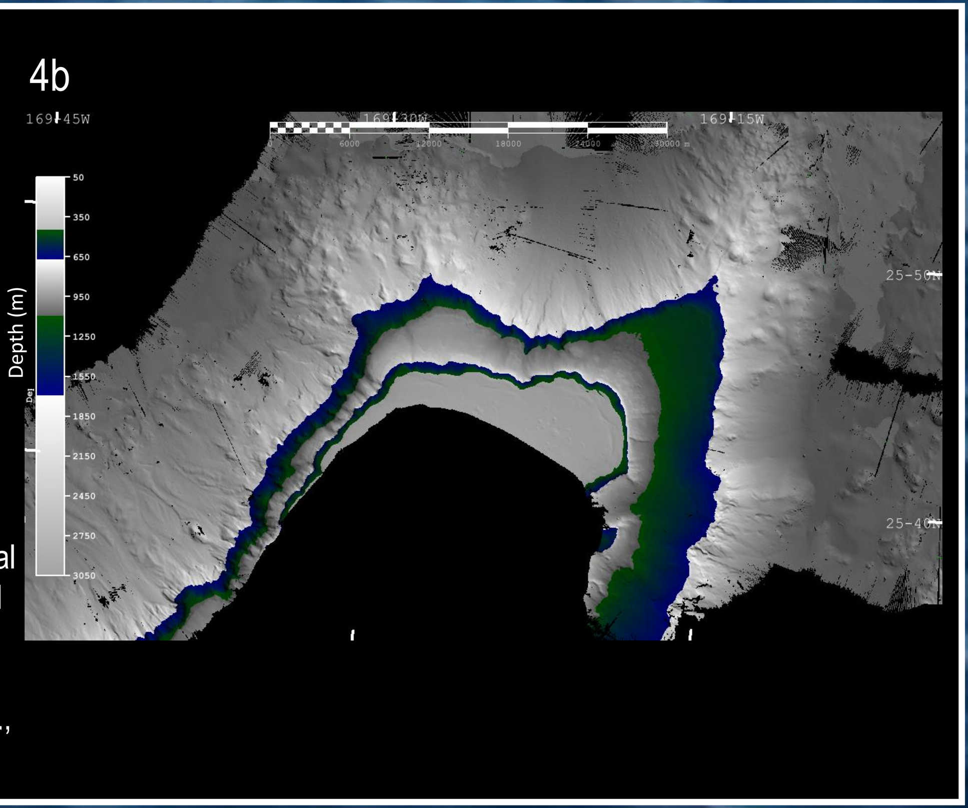


FIGURE 4
a) (left) West and East Side view of a classified backscatter mosaic draped over a blackened 50m CUBE BASE surface. Using the histogram, the intensity scale has been subdivided into optimal habitat hardness = green, intermediate=yellow, and poor=red. The more optimal conditions for deep coral are focused around the terraced cliff rims and the horn structures. Harder substrates are conducive to coral habitat (Roberts et al., 2009).
b) (right) The steeper slope portions of the two terraces where coral growth would be more optimal are shown. Green represents the top of a terraced cliff while blue is the cliff's base. The shallower First Terrace is steeper and therefore would be even more optimal for coral growth (Roberts, et al., 2009).



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