Bathymetric Analysis of Rogatien Ridge and Gardner Pinnacle in the Northwest Hawaiian Islands for Potential Deep Sea Coral Environment

William Oksen and Dr. Leslie Sautter
Department of Geology and Environmental Geosciences,
College of Charleston

ABSTRACT

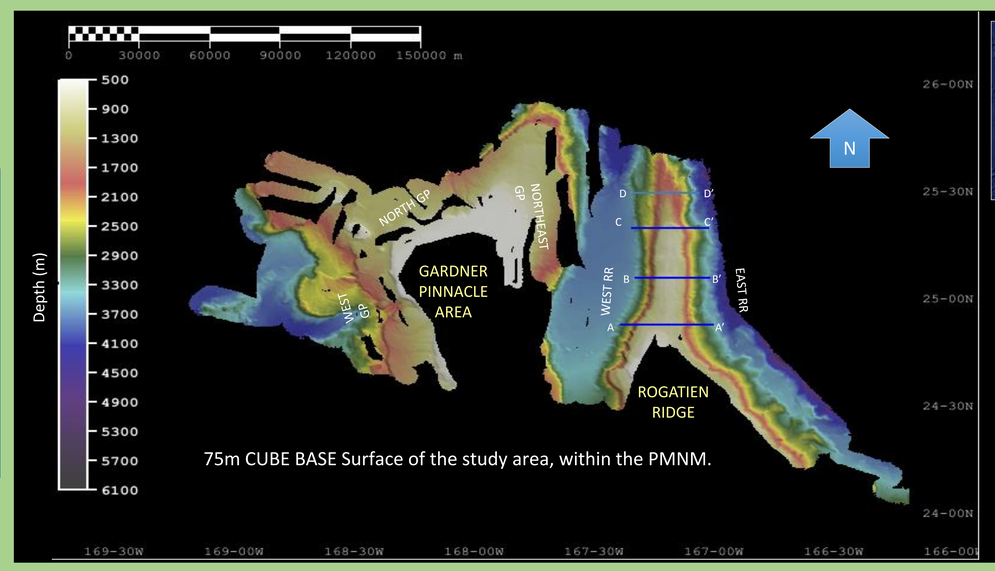
In May of 2014, the Schmidt Ocean Institute gathered multibeam sonar bathymetric data of the Papahānamokuākea National Monument including Rogatien Ridge and the areas surrounding Gardner Pinnacle. Prior to this cruise, minimal research had been conducted in this area to explore its potential for deep sea coral habitats. Deep sea corals have been found just west of Gardner Pinnacles at depths from 1000-2000 m. Using CARIS HIPS and SIPS 9.1, CUBE BASE surfaces and backscatter mosaics were generated to analyze the five study sites for their potential as a coral environment. Deep sea corals have been known to thrive in areas of high slope and high backscatter intensity, which lead to the data being collected from the areas north, northeast, and west of Gardner Pinnacles as well as the east and west banks of Rogatien Ridge.

BACKGROUND

Papahānamokuākea National Monument (PMNM) was established in June 2006, making it the largest nature conservancy area in the United States. The study site included the area surrounding Gardner Pinnacle and Rogatien Ridge (Figure 1). Rogatien Ridge is a newly identified feature within the PMNM, named after the St. Rogatien bank, which lies southeast in the French Frigate shoals. The Gardner Pinnacles is a five-acre island lying directly northwest of Rogatien Ridge and is home to a variety of animal and coral species below its surface. This project focuses on investigating five study sites (Figure 4) for their potential as deep-sea coral habitats. Deep-sea corals thrive in a temperature range from 4 to 12 ^{o}C, which in this area can be found at a depth range of up to 4000 m (Roberts, 2006). Deep-sea corals also tend to grow on areas of steep gradient as well as high intensity backscatter return, which indicates hard substrate (Smith, 2014). Three species of coral have been found in this area at depths ranging from 1000 to 2000m (Baco and Cairns, 2012).

METHODS

- The Schmidt Ocean Institute collected bathymetry data in May of 2014 on the *R/V Falkor.* They mapped most of the PMNM. Chief Scientist: Christopher Kelley (University of Hawaii).
- Multibeam sonar data were collected using Kongsberg EM302 and EM710 systems.
- Data were analyzed with CARIS HIPS and SIPS 9.1, and bathymetric surfaces were created using CUBE at a resolution of 75m. A slope surface was also generated.
- GeoCoder was used to generate a backscatter intensity surface.
- Data collection points were chosen at the five study sites along the 1000-2000 m contours where deep corals are known to exist. Backscatter intensity was then compared with slope for each collection point.



75m CUBE BASE Surface of the study area, within the PMNM.

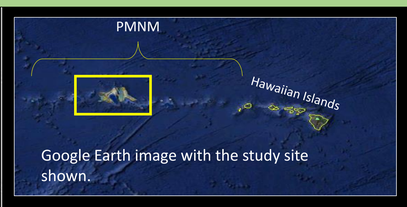


Figure 1: A 75 m resolution CUBE BASE surface of Rogatien Ridge and Gardner Pinnacle on the northwestern side of Papahanaumokuakea National Monument (PNMN). Five sites were used within this study, including 3 areas surrounding the Gardner Pinnacle area and 2 on the eastern and western flanks of Rogatien Ridge. The BASE surface includes profile lines A-A', B-B', C-C', and D-D' shown in Figure 2.

RESULTS

- Rogatien Ridge is a feature within the PMNM unlike any other seafloor feature in this area, positioned perpendicular to most other features in this area (Figures 1&3).
- Profiles (Figure 2) show that the thinnest and steepest sections of the ridge are at profile B-B' and C-C'. The slope of the ridge seems to be steepest predominantly at its head and the gradient gradually decreases as the depth increases.
- Varying angles of slope were measured, from 0 to 35^{o} with one outlier at 45^{o} (Table 1). Rogatien Ridge slopes <u>averaged</u> approximately 23^{o} (East) and 25^{o} (West), whereas slopes of the Gardner Pinnacle area averaged 6^{o} (Northeast), 4^{o} (Northern) and 9^{o} (Western) (Fig. 3).
- Backscatter intensities (figures 4b & 4c) vary throughout the entire study sites, with highest intensities found along the eastern and western portions of Rogatien Ridge (Table 2).
- Average Backscatter Intensities at depths of 1000 to 2000 m were moderately high across the study sites, ranging from approximately -21 dB to -18 dB, in comparison to intensities measured across the entire study area (~ -60 to 3 dB).
- Slope and backscatter data show minimal to no correlation for 4 of the 5 sites (Figures 4b & 4c), but are positively correlated at the Northeast GP site (R^2=0.6914).

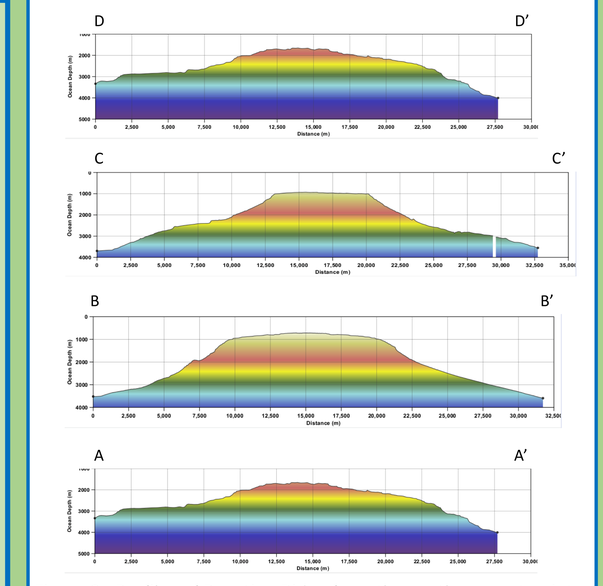


Figure 2: Profiles of Rogatien Ridge from the southernmost point (A-A') to the Northernmost point (D-D') all shown to the same scale, with a VE=1.3x. Refer to Figure 1 for profile locations.

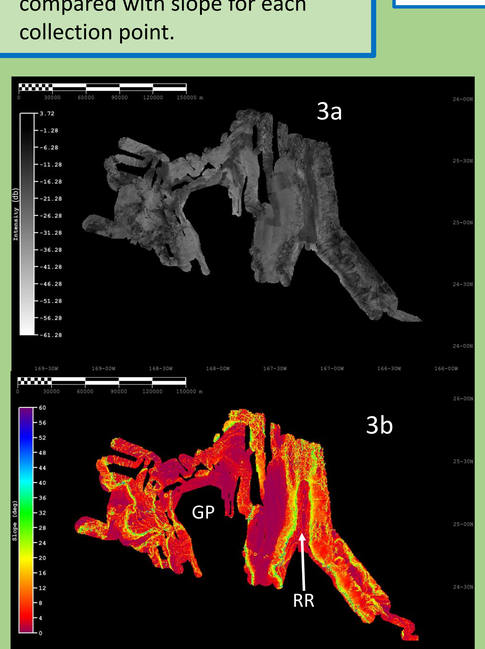


Figure 3:
3a) 75m resolution GeoCoder backscatter mosaic.
3b) Slope surface generated from the BASE surface. Note the relatively steep slopes (bright yellow) on the east and west flanks of Rogatien Ridge (RR) compared to the Gardner Pinnacle area (GP).

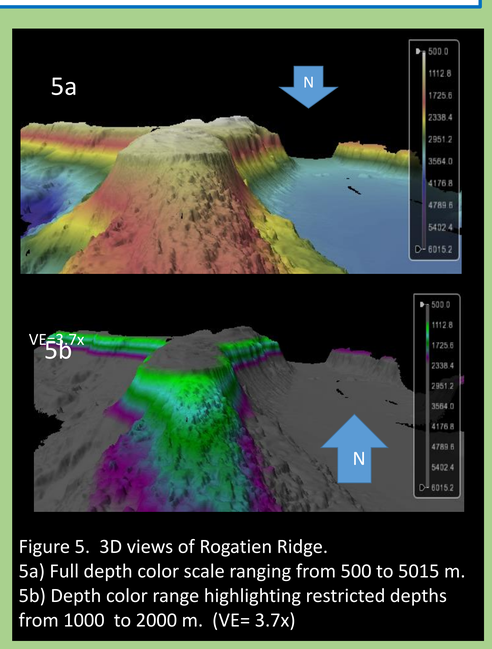


Figure 5. 3D views of Rogatien Ridge.
5a) Full depth color scale ranging from 500 to 5015 m.
5b) Depth color range highlighting restricted depths from 1000 to 2000 m. (VE= 3.7x)

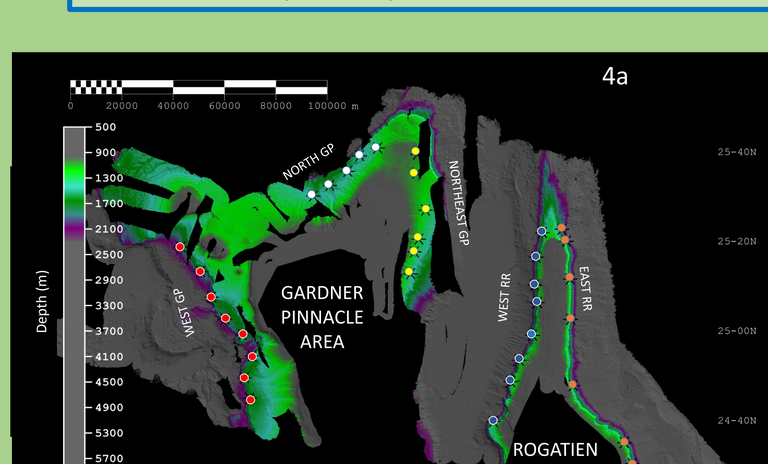


Table 1. **Gardner Pinnacle** area slope, intensity and depth data.

NEGP	slope(°)	Intensity(db)	Depth(m)
1	8.424	-16.809	1420.6
2	5.065	-29.343	1377.3
3	4.989	-16.778	1219.1
4	3.866	-27.553	1254.3
5	2.648	-27.109	1238.7
6	10.235	-10.991	1230.1

NGP	Slope(°)	Intensity(db)	Depth(m)
1	4.3660	-26.791	1399.4
2	2.0570	-24.513	1586.5
3	5.3890	-23.902	1458.6
4	10.7600	-18.876	1471.8
5	2.4170	-19.804	1262.4
6	0.0117	-10.668	1036.1

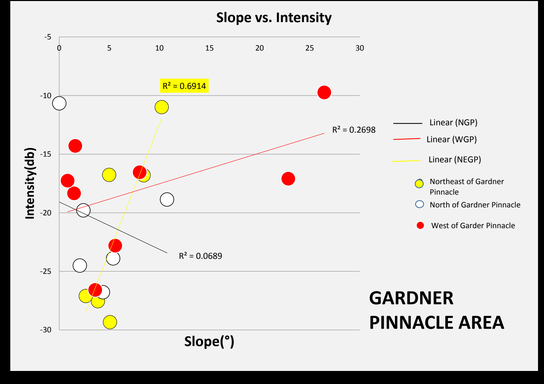
WGP	Slope(°)	Intensity(db)	Depth(m)
1	1.477	-18.344	1697.7
2	0.830	-17.265	1644.6
3	22.862	-17.096	1788.6
4	26.459	-9.737	1631.7
5	1.601	-14.301	1820.0
6	8.023	-16.545	2044.6
7	3.590	-26.586	1942.5
8	5.593	-22.814	1901.1

Table 2. **Rogatien Ri**dge slope, intensity and depth data.

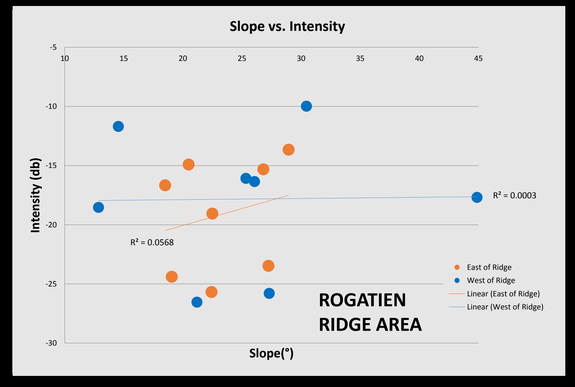
East ridge	Slope(°)	Intensity(db)	Depth(m)
ER01	20.482	-14.902	1511.0
ER02	22.487	-19.041	1376.4
ER03	18.492	-16.654	1457.1
ER04	28.935	-13.646	1553.8
ER05	26.799	-15.309	1623.8
ER06	22.422	-25.670	1809.1
ER07	19.058	-24.382	1847.5
ER08	27.233	-23.4550	1865.4

West ridge	Slope(°)	Intensity(db)	Depth (m)
WR01	30.452	-9.978	2062.7
WR02	26.056	-16.341	2009.9
WR03	27.300	-25.792	1790.7
WR04	21.194	-26.537	1925.7
WR05	44.877	-17.678	1396.9
WR06	25.334	-16.076	1683.6
WR07	12.864	-18.525	1948.3
WR08	14.541	-11.683	1643.2

Figure 4.
4a) 75m resolution CUBE BASE surface of the study area highlighting depth ranges from 1000 to 2000 m. Colored circles indicate the data collection points shown in Table 1. Colors indicate the 5 study areas.
4b) Slope and Intensity values for data collected in the 3 Gardner Pinnacle sites (Table 1)
4c) Slope and Intensity values for data collected on the east and west sides of Rogatien Ridge (Table 2).



4b.



4c.

DISCUSSION

Analysis of the study sites began by comparing slope and backscatter intensity at depths between 1000 and 2000 m where deep corals are known to exist in this area (Baco and Cairns, 2012). All of the data collection points (Fig. 4a) were located within this depth range. Backscatter intensity data have a high enough return to indicate hard substrate that could potentially support deep-sea corals. A moderately strong positive correlation between slope and backscatter intensity found at the Northeast GP site may prove useful for identifying future deep coral habitats in this region, however low angle slopes were found there. However, the lack of correlation between slope and backscatter intensity for the remaining 4 sites suggests that *both* steep slope and hard substrate may not be required for deep coral habitat. Rogatien Ridge could be a potential deep coral habitat because these corals can be fed by a process known as Ekman drainage, where minerals and nutrients in sediment settle at the top of a feature (such as a ridge), and ocean currents slowly let these nutrients ooze into the areas below (Roberts, 2006). Rogatien Ridge is oriented perpendicular to prevailing ocean currents which could cause a seepage on the western bank of the ridge. Further studies that can be conducted would include collecting surface sediment samples at the top of the ridge to see if they contain essential coral growth nutrients. The Gardner Pinnacle area shows small areas where Ekman drainage could occur, possibly due to a lack of a soft substrate to feed into the areas that were studied. Gardner Pinnacles is a known area of diverse life including abundant benthic invertebrates living in its shallow waters, which may produce a high amount of organic material that can drain to where deep corals inhabit.

REFERENCES

- Baco, A.R., and Cairns, S.D., 2012, Comparing Molecular Variation to Morphological Species Designations in the Deep-Sea Coral Narella Reveals New Insights into Seamount Coral Ranges: PLoS ONE, v. 7, doi: 10.1371/journal.pone.0045555.
- Roberts, J.M., 2006, Reefs of the Deep: The Biology and Geology of Cold-Water Coral Ecosystems: Science, v. 312, p. 543–547, doi: 10.1126/science.1119861.
- Smith, J.R. A Ridge of Monumental Proportions - Schmidt Ocean Institute: Schmidt Ocean Institute, https://schmidtocean.org/cruise-log-post/a-ridge-of-monumental-proportions/ (accessed December 2016).

ACKNOWLEDGEMENTS

We would like to thank CARIS for their Academic Partnership, The College of Charleston Department of Geology, The Schmidt Ocean Institute, and NOAA for making the data available to research. This poster was made as part of the College of Charleston BEAMS Program.