Comparing Geomorphology of Seamounts in the Johnston Atoll Unit Towards Identifying Regions of High-Density Deep-Sea Coral and Sponge Communities

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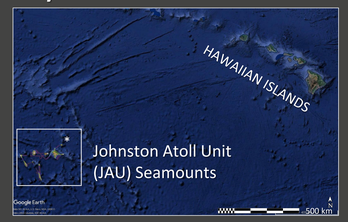
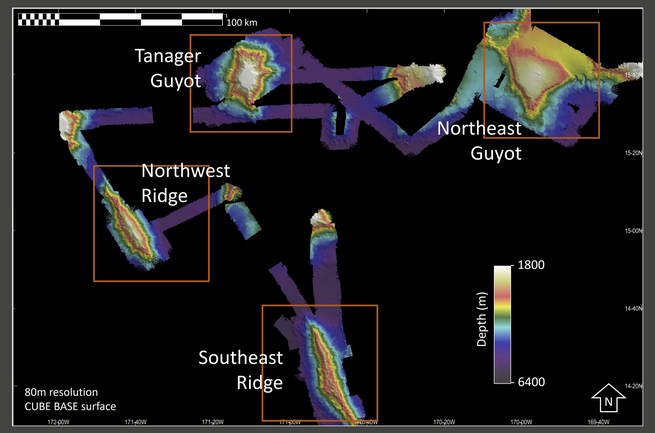
Study Area



NOAA Ship *Okeanos Explorer*

(above) Johnston Atoll Unit in relation to Hawaiian Islands.



(right) Four seamounts were examined, including two guyots and two elongate ridges.

BACKGROUND

The Johnston Atoll Unit (JAU) is known to harbor a large concentration of rare minerals and high densities of deep-sea coral and sponge communities. Deep-sea corals are typically found in depths ranging from 200 to 1200 m, and up to 4000 m in lower latitudes. They are found on hard substrates in elevated topographies provided by features including seamounts, slope margins, ridges, and canyons (Tracey et al., 2011). The JAU area is also home to many morphologically distinct seamounts, called guyots. Guyots are flat-topped due to erosion of an overlay of sediment and calcified reef from previous exposure to sea-level (Sato & Mogi, 1965). Being a part of the Pacific Remote Islands Marine National Monument (PRIMNM), the JAU previously had little geomorphologic and ecologic data – encouraging scientists to form an objective to further observe and map the region. In 2017, Drs. Christopher Kelley and Christopher Mah led a NOAA OER expedition (EX1706) from early July until August, mapping at least 20 new large morphologic features and embarking on 15 ROV dives with the ROV *Deep Discoverer*. The area is home to many species of precious corals, manganese-encrusted habitats, and important ecosystems for study to allow for reference of future management, protection, and research (NOAA, 2017).

The purpose of this study is to produce and analyze high resolution bathymetric maps of four seamounts within the mapped area to identify specific geomorphologies in which rare deep-sea corals and sponges may be present or are known to be present. In identifying such areas, sites for future research, protection, and management can be identified.

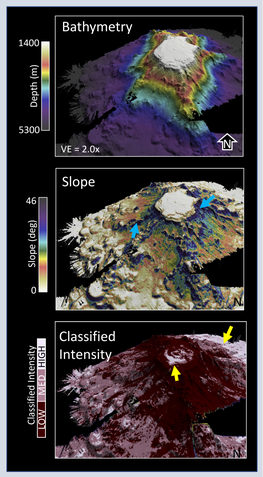
METHODS

- NOAA and other scientists collected multibeam sonar data beginning on July 7th until August 2nd, 2017, aboard NOAA Ship *Okeanos Explorer* using a Kongsberg EM302 during expedition EX1706 - Laulima O Ka Moana: "Exploring Deep Monument Waters Around Johnston Atoll".
- High-definition video recorded by the ROV *Deep Discoverer* during EX1706-Dive11 and Dive13 was used for ground-truth of sonar data.
- Sonar data were mapped in high resolution bathymetric CUBE surfaces using CARIS HIPS & SIPS 11.3 software.
- Each study site was analyzed using depth and slope surfaces, as well as backscatter intensity mosaics, all with an 80 m resolution.
- Depth profiles were generated to compare seamount geomorphology.
- Data describing differing slope (in degrees) and backscatter intensity (in decibels) were gathered and analyzed along profiles for different study sites.
- Intensity, slope, potential substrate composition, geomorphological makeup, and species present (as shown from ROV dives) were used to characterize existing and potential deep-sea coral habitats.

Tanager Guyot

This guyot is one of the shallowest (~1400 m) in the study region, with steeply sloping ledges (>45°) along each flank. Blue arrows indicate areas of high slope which are found just off the ledge on the seamount's rim and continuing down the ridge flanks.

Classified backscatter intensity indicates high intensity areas (yellow arrows) are found mostly on the flat top and towards the seamount's base in surrounding flat areas. These areas are identified separately from those of high slope.

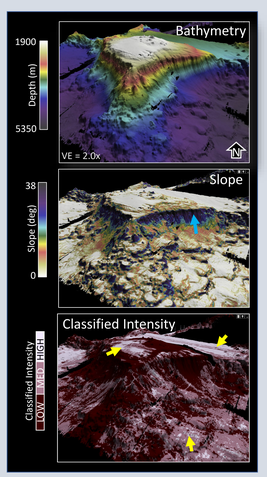


Northeast Guyot

Deepest of the four study sites, this guyot ranges from 1900 to 5350 m.

NE Guyot is larger in area than Tanager and lacks a circular shape. The flat-top is much broader and flank slopes have portions as high as 38°, with highest slopes on the seamount rim's southern flanks (blue arrows).

Areas with high intensity are on the perimeter of the guyot's flat top as well as near the bottom of the map. Only high intensity areas are identified with yellow arrows.

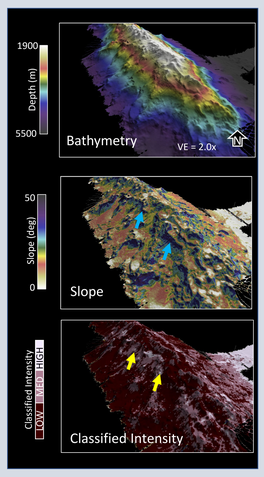


Northwest Ridge

This seamount is the most western in the study area. With steeply sloping flanks on all sides, it is slightly shorter in length and quite a bit shallower and less elongate than Southeast Ridge.

Steeply sloping sides occur alongside areas of high intensity return. Blue arrows refer to areas of high slope surrounding the ridge top, the highest slope reaching to 50°.

Areas of high intensity are identified with arrows above. This site had few large areas surrounding the ridge crest with such areas.

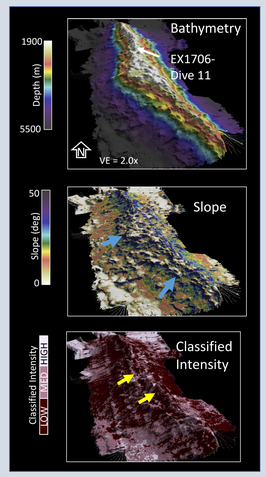


Southeast Ridge

The southernmost, deepest seamount of the study area, SE Ridge is slightly more elongate and narrower than NW Ridge, with more highly sloped areas.

Flanks slope steeply, up to 50°. Areas of high slope (blue arrows) hug the northern flank of the seamount on either direction where several high intensity areas can additionally be identified (yellow arrows).

Footage from ROV dive EX1706-Dive11 on the eastern side of the ridge (see location on top image) and supplements the geomorphologic evaluation shown on the next panel.



ROV Dives – Southeast Ridge

Dive footage from EX1706-Dive 11 and Dive 13.

HD Video frame grabs from these two dives highlight important geologic features of bathymetry studied, as well as important and uncommon biota observed. Dive EX1706-11 took place in the upper eastern flank of the Southeast Ridge study site, and EX1706-13 was located eastward at a slightly shallower depth.

Southeast Ridge (EX1706-Dive11)

(right) High density communities of sponges were found near the upslope of the seamount – communities predominantly consisted of Hexactinellids (glass sponges).

(left) Large glass sponges were abundant throughout the dive, particularly in areas of high currents near the top of the ridge.

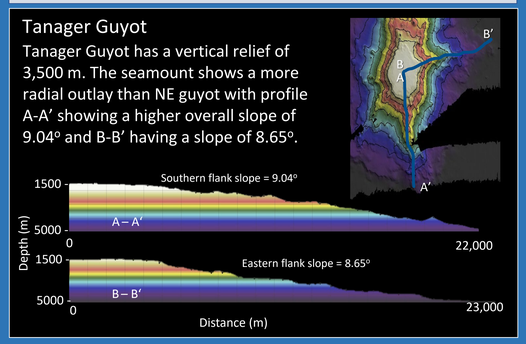
East of Southeast Ridge (EX1706-Dive13)

(above) Unlike Southeast Ridge, prolific Octocorallia colonies (specifically of the Plexauridae family) were found on a shallower nearby ridge.

(right) Several Antipatharia species also live on the rocky, hard substrate of the seamount's sloped flank

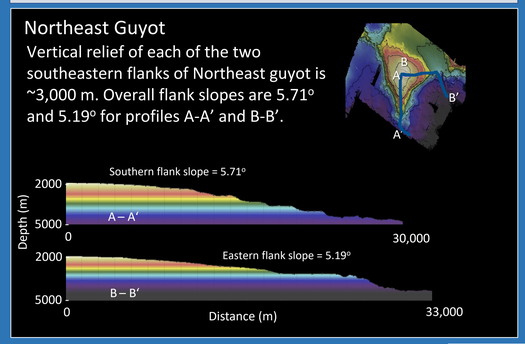
Tanager Guyot

Tanager Guyot has a vertical relief of 3,500 m. The seamount shows a more radial outlay than NE guyot with profile A-A' showing a higher overall slope of 9.04° and B-B' having a slope of 8.65°.



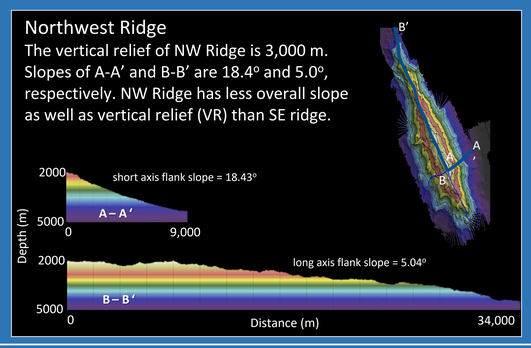
Northeast Guyot

Vertical relief of each of the two southeastern flanks of Northeast guyot is ~3,000 m. Overall flank slopes are 5.71° and 5.19° for profiles A-A' and B-B'.



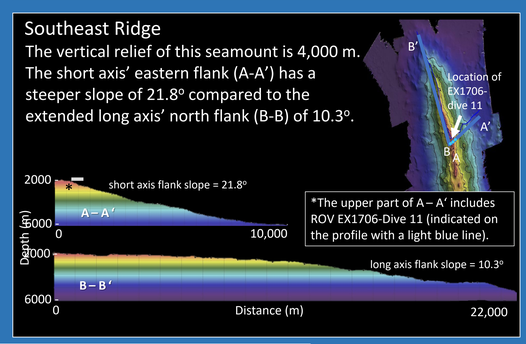
Northwest Ridge

The vertical relief of NW Ridge is 3,000 m. Slopes of A-A' and B-B' are 18.4° and 5.0°, respectively. NW Ridge has less overall slope as well as vertical relief (VR) than SE ridge.



Southeast Ridge

The vertical relief of this seamount is 4,000 m. The short axis' eastern flank (A-A') has a steeper slope of 21.8° compared to the extended long axis' north flank (B-B) of 10.3°.

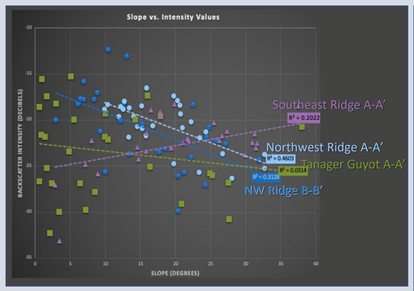


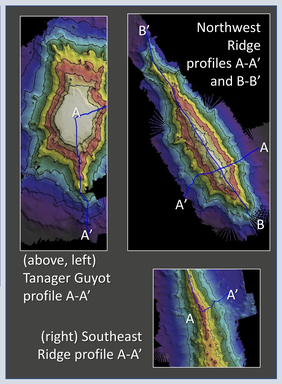
Data Analysis

Slope and Backscatter Intensity Analysis

Slope and backscatter intensity values collected along different depth profiles were recorded for three sites. Values were plotted in a scatterplot with combined data, trendlines, and R^2 values.

Northwest Ridge profiles A-A' and B-B' both show a moderate negative correlation (R^2 = 0.3128, 0.4603) suggesting that lower slopes are associated with higher backscatter intensities and harder substrate. The Southeast Ridge data show a weak positive correlation (R^2 = 0.2022) indicating higher slopes may be associated with higher intensities. Tanager Guyot showed no correlation (R^2 = 0.0314) and had a wider range of intensities compared with other sites.





(above, left) Tanager Guyot profile A-A'

(right) Southeast Ridge profile A-A'

DISCUSSION and CONCLUSIONS

This study examined four separate sites within the JAU study area to determine suitability of high-density benthic habitat suitable for deep-sea coral and sponge communities. Areas of high intensity and high slope are often thought to host high-density deep-sea coral communities (Tracey et al., 2011). In this study, no conclusive and consistent correlation was found between backscatter intensity and slope, however moderate negative correlations were found on each flank of the Northwest Ridge. Though the four sites all shared some similar morphologies, differing slope ranges and backscatter intensities could be observed at each location.

Due to the lack of conclusive analytical data related to substrate character, ground-truth observations are likely the most essential tool for identifying, locating, and analyzing deep-sea coral and sponge communities in this region. ROV dive footage from one dive on the Southeast Ridge provided insight into benthic communities that were present at a depth of 2330 m. These communities were dominated by glass sponges (Plexauridae and Hexactinellid families) and are found living on hard substrate and steep slopes. In contrast, Antipatharia and Octocorallia communities were observed at a shallower (1350 m) nearby seamount not included in this study. Though deep-sea corals and sponges were present in both locations, the data associated with this footage could indicate presence of high-density communities of corals at shallower depths when observing other study sites, such as the two guyot sites, in comparison to presence of deep-water sponges seen at much greater depths.

REFERENCES

Davies, A. J., Wisshak, M., Orr, J. C., and Roberts, J. M. (2008). Predicting suitable habitat for the cold-water coral *Lophelia pertusa* (Scleractinia). *Deep Sea Res. I* 55, 1048–1062. doi: 10.1016/j.dsr.2008.04.010.

Gammon, M. J., Tracey, D. M., Marriott, P. M., Cummings, V. J., & Davy, S. K. (2018). The physiological response of the deep-sea coral *Solenosmilia variabilis* to ocean acidification. *PeerJ Life & Environment Aquatic Biology*, *6*, e5236.

Mock-Bunting, L., & Wiener, C. (2018, December 3). *Eyes below the surface: Mapping Johnston Atoll*. Schmidt Ocean Institute. Retrieved December 9, 2021, from https://schmidtocean.org/cruise/eyes-testing-uavs-mapping-johnston-atoll/.

NOAA (2017). Exploring Deep Monument Waters Around Johnston Atoll. https://oceanexplorer.noaa.gov/okeanos/explorations/ex1706/welcome.html

Sato, T., & Mogi, A. (1965). Guyots found from the Marshall and East Caroline ridges. *Journal of the Oceanographical Society of Japan*, *21*(4), 139–147.

Tracey D.M., Rowden A.A,. Mackay K.A., and Compton T. (2011). Habitat-forming cold-water corals show affinity for seamounts in the New Zealand region. *Marine Ecology Progress Series*. 2011;430:1–22.

ACKNOWLEDGEMENTS

This research would not have been possible without NOAA OER and the crew of the NOAA Ship *Okeanos Explorer*, who all had their part in the collection of these data. Additionally, we would like to thank CARIS for Academic Partnership, and the support from the CofC School of Science & Math and Dept. of Geology and Environmental Geosciences. This project was conducted as a part of the College of Charleston BEAMS Program. Support to attend this meeting was generously provided by the Matt Christie BEAMS Support Fund.