# Geomorphic Characterization of Geologically Diverse Features within the Mariana Trench National Monument

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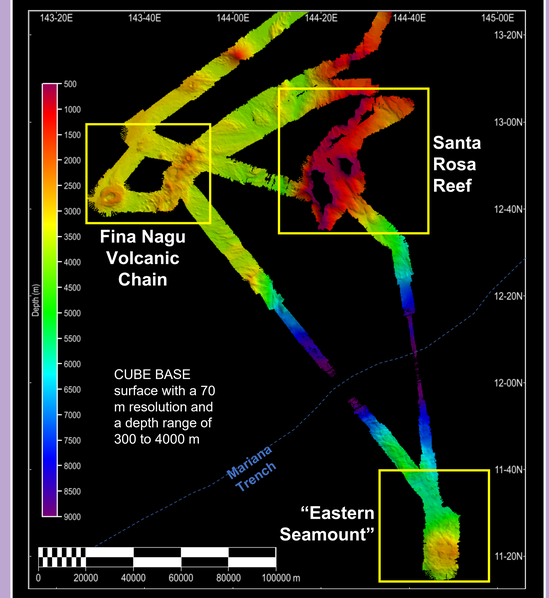
## BACKGROUND

In April 2016, the NOAA Ship *Okeanos Explorer* conducted expedition EX1605L1 to gain a better understanding of the southernmost portion of the Mariana Trench Marine National Monument (MTMNM) which is home to diverse geomorphology and biota as a result of the nearby Mariana Trench subduction zone. The Mariana Trench was formed from subduction of the Pacific Plate beneath the Philippine Plate, consequently creating the deepest location on Earth called Challenger Deep, 10,900 m beneath the sea surface (Amon et al, 2020). Subduction generated a volcanic arc west of the trench (Chadwick and Fryer, 2021), providing a region with varied geomorphology for diverse biota to thrive.

The study area includes a portion of the MTMNM approximately 25 km off the southwest coast of Guam and 70 km west of the Mariana Trench (Fig. 1). This study focuses on Fina Nagu Volcanic Chain, a portion of Santa Rosa Reef, and an unnamed seamount found 75 km east of the Mariana Trench hereafter referred to as "Eastern Seamount". The purpose of this study is to characterize and compare this portion of the MTMNM and determine how geological features relate to the deep-sea coral and fish habitats.

## Figure 1. Mariana Trench Study Area and Site Locations

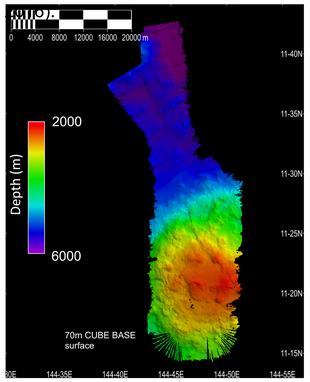


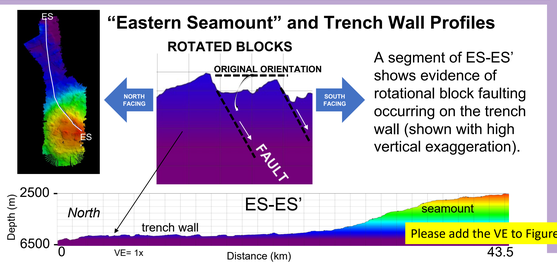

## METHODS

- Data were collected by NOAA Ship *Okeanos Explorer* using multibeam sonar Kongsberg EM302 during EX1605L1 from April 20- May 11, 2016.
- ROV *Deep Discoverer* collected high-definition video used to ground-truth sonar data.
- Specific dives referenced include EX1605L1-Dive01 (April 20, 2016), EX1605L1-Dive02 (April 21, 2016), EX1605L1-Dive04 (April 23, 2016), and EX1605L1-Dive05 (April 25, 2016).
- CARIS HIPS & SIPS 11.3 was used to process the sonar data and generate 2D and 3D bathymetric, slope, aspect, and classified backscatter intensity mosaic surfaces, as well as cross-sectional depth profiles to characterize the study area.
- Backscatter intensity and slope data were collected along cross-sectional profiles to identify a potential correlation

## Figure 2. "Eastern Seamount"

Eastern Seamount" is located on the Pacific Plate 75 km east of the Marianas Trench. The depth ranges from 2400 to 6400 m. Also included in the site is a portion of the Mariana Trench's eastern wall. This seamount may be located on the boundary between the Pacific Plate and an unnamed younger plate (NOAA,

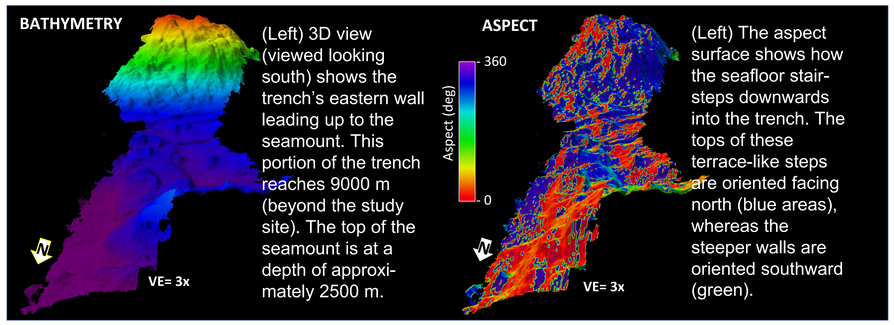



A segment of ES-ES' shows evidence of rotational block faulting occurring on the trench wall (shown with high vertical exaggeration).

Please add the VE to Figure 2 and 4 profiles

NOAA *Okeanos Explorer*

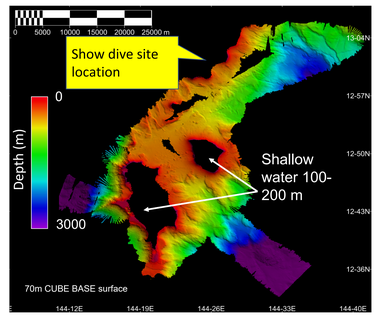


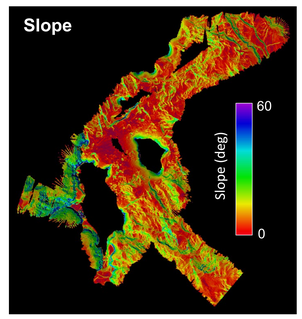

(Left) 3D view (viewed looking south) shows the trench's eastern wall leading up to the seamount. This portion of the trench reaches 9000 m (beyond the study site). The top of the seamount is at a depth of approxi-mately 2500 m.

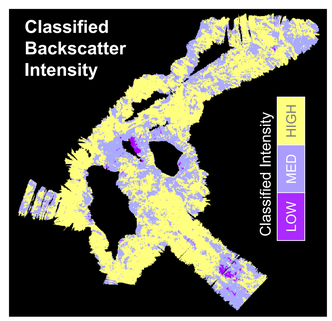
(Left) The aspect surface shows how the seafloor stair-steps downwards into the trench. The tops of these terrace-like steps are oriented facing north (blue areas), whereas the steeper walls are oriented southward (green).

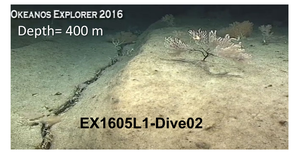
## Figure 3. Santa Rosa Reef

Santa Rosa Reef encompasses a portion of a shallow water area with abundant reef habitat with depths less than 100 m. Within this study, the focus is on a portion of the area 50 km southwest of Guam that has been identified as having significant coral and commercial bottomfish habitat (Amon et al., 2020). The southern portion of the MTMNM has been found to have greater coral reef ecosystems due to larger seamounts that have relatively low slopes providing plentiful habitat (NOAA, 2010).




(Left) Deep-sea corals were mainly located on hard, flat substrate particularly carbo-nate platforms.

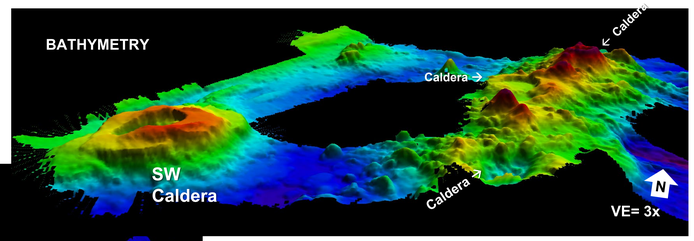
(Above) Most of Santa Rosa Reef has slopes ranging from 5-25º, however, steeper slopes of 40 º are found on the western flanks of the more southern seamount.

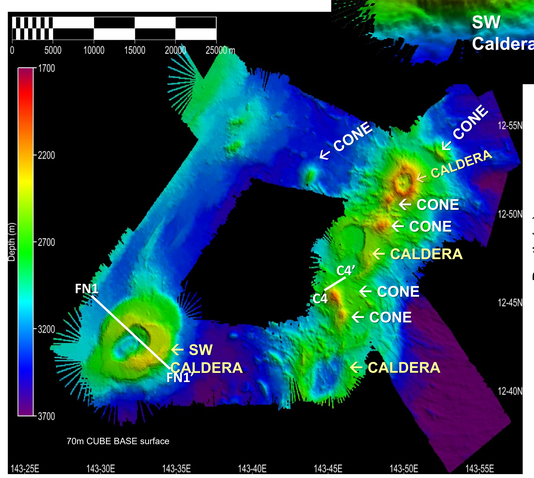
(Above) The reef has many areas of relatively high backscatter intensity and few with low intensity, most of which are concentrated on the flanks of the southern seamount. These data suggest that much of the seafloor in this site consists of hard, flat substrate.

## Figure 4. Fina Nagu Volcanic Chain

The Fina Nagu Volcanic Chain is located 100 km southwest of Guam, this volcanic island chain includes 10 seamounts whose depths range from 2000 to 3700 m (figures below). Six of these seamounts have cone-shaped geomorphology and four have calderas. A caldera forms when a volcano's magma chamber has emptied and the rock above the chamber collapses from its weight.

Within this study site, seamounts with calderas are both taller (greater vertical relief) and wider than cone-shaped seamounts. Cone-shaped seamounts range in vertical relief from 510 to 750 m and with widths of approximately 2900 m, while the seamounts with calderas range from 400 to 1150 m and 5800 to 12500 m, respectively.

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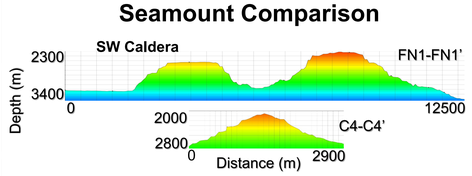



Depth profiles FN1-FN1'and C4-C4' (shown at the same scale) represent the largest of the caldera and cone-shaped seamounts at this site.

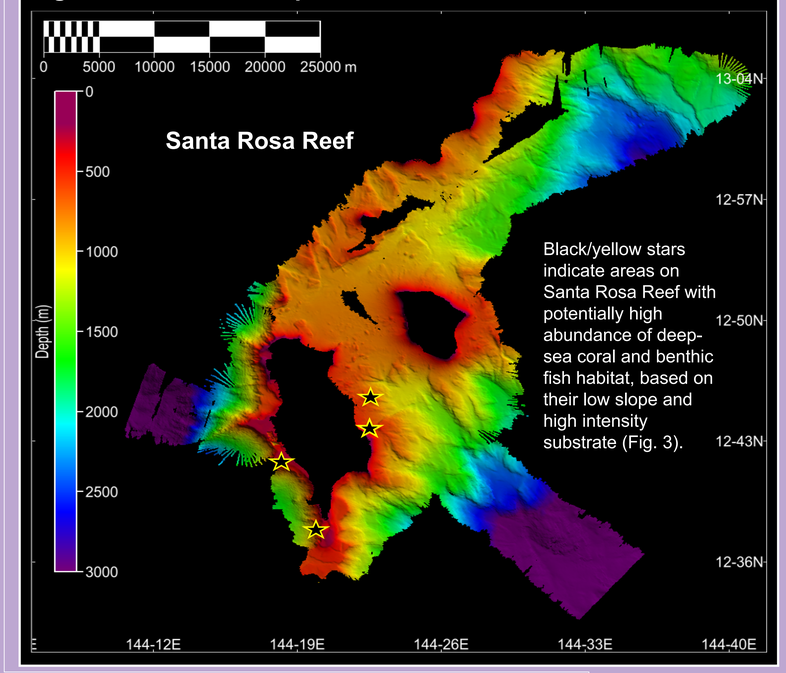
## DISCUSSION and CONCLUSIONS

The three study sites each had very different and distinctive geomorphology. The **Fina Nagu Volcanic Chain** included numerous seamounts that likely vary in age. The caldera seamounts may be older seamounts as the caldera would have formed after the volcano stopped erupting allowing the magma chamber to collapse and form the caldera. The cone-shaped seamounts are likely to be younger than the caldera seamounts as they still have a typical volcanic shape. The cone-shaped volcanoes are similar in height and width, though the caldera seamounts are significantly larger and vary more in size due to differences in age and likely the degree of erosion and subsidence.

Based on ROV dive observations, **Santa Rosa Reef** was the site with the highest biological diversity. A large expanse of high-intensity areas and shallow depths provided ideal habitat for corals and bottom fish. A higher abundance of corals and fishes were observed in areas with hard, rocky (i.e., higher intensity) substrate and lower slopes. Diverse groups of coral with some fish species were found mainly atop flat, carbonate platforms.

The "**Eastern Seamount**" study site included a portion of the trench wall. At first, it appeared the seafloor stair-stepped downwards into the trench, but a profile revealed that the rock on the trench wall had undergone rotational block faulting. Rotational block faulting occurs when tensional stress creates a normal fault on which the rock slides downward due to gravity and rotates. Tensional stress is produced when gravity pulls the subducting plate's rock slab down into the trench and causes flexure at the slab's bend at the surface. This study site is the closest to the subduction zone, so its morphology is largely impacted by subduction.

## Figure 5. Potential Deep Sea Coral Habitats

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