Characterization of Deep-Sea Habitat Distribution on Two Seamounts of the Papahānaumokuākea Marine National Monument

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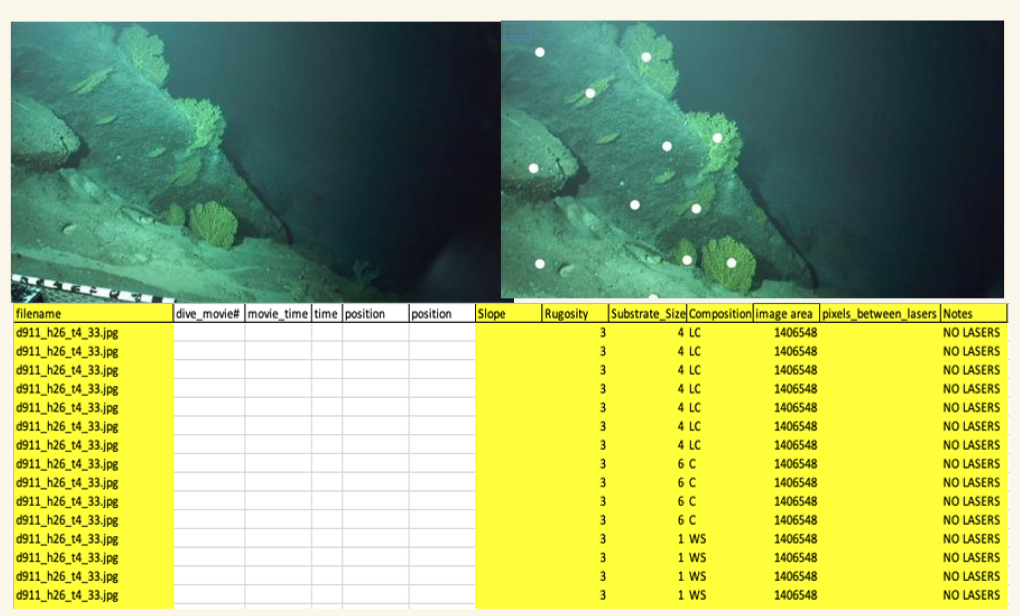
Background

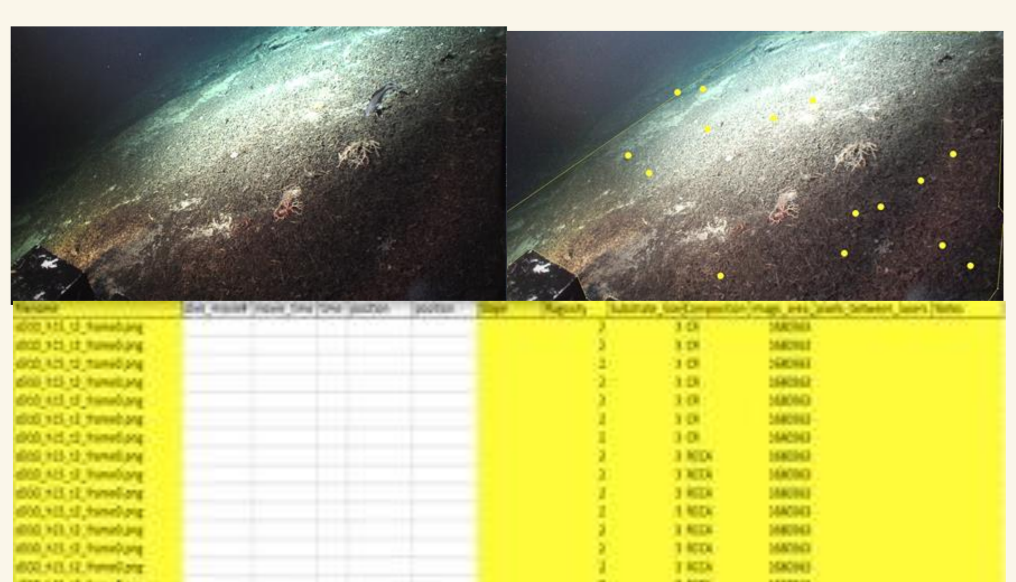
The North Pacific Ocean stretches from the Eastern Coast of Asia to the Western Coast of the North American continent. Undersea mountains formed from past volcanic eruptions, known as seamounts, make up nearly 28.8 square kilometers of Earth's surface (NOAA) with their highest abundance in the Pacific. Seamounts are most important for the biological richness they provide as underwater habitats. These seamounts feature different levels of rugosity, substrate types, and substrate sizes. These factors have a significant impact on seamount community composition, as do the dominant corals which also provide habitat to many different species (Rogers, 2018).

The Northwest Pacific Ocean has been affected by global warming and human activity. It is also one of the most biologically diverse regions in the world hosting tens of thousands of marine species (Liao et al. 2018). The oceans are mostly made up of areas beyond national jurisdiction (ABNJ), which are key in biodiversity that is not possessed by States. Many ABNJ areas have deteriorated due to the lack of regulations on human activities (IUCN. 2023). Trawling in the Hawaiian Ridge and Emperor Seamount Chain in past years has led to near-total devastation of the benthic communities on parts of the underwater mountain range. Near entire ecosystems were depleted of corals and suffered as a consequence. Over years of protection, however, signs of life have begun to return despite their slow growth. It's been shown that over a 30-40 year period, measurable, but not total, recovery is possible (Baco et al 2019).

Brooks Bank



Southeast Hancock



Methods I

Over the past decade, the destruction of deep-sea habitats has led to serious problems on earth. We wanted to look at two different seamounts found in the Hawaiian Ridge. Our study focused on Southeast Hancock and the Brooks Banks seamounts. The human-occupied vehicles Pisces IV and Pisces V, were used to collect all the images. To analyze and collect data from these images we used two programs; Excel and ImageJ. In ImageJ, we uploaded the images and used the software to determine the area and rugosity of the substrate. Rugosity is the roughness of a surface. We then proceeded to use a tool called "region of interest" (ROI) that would create fifteen randomized points to be categorized in terms of substrate composition and size. The rugosity scale ranged from 1-4 from low to high and the substrate size scale ranged from 1-8. This data was then collated in order to be statistically analyzed via a 2 tailed T-test in XX software.

Methods II

Pisces IV

Pisces V

Figure 1 and 2. Images of the human-occupied deep-submergence vehicles used to collect video footage of the seamounts.

Statistics

	Substrate Composition													
Site	dive	transect	C	CR	DC	DIR	GS	LC	LR	M	RCA	RCCA	S	WS
BB	915	1	0.09138577	0	0.06217228	0	0.72808989	0.00374532	0	0.01198502	0	0	0	0.10262172
BB	915	2	0.32380952	0	0.06349206	0	0.51111111	0.00634921	0	0.08571429	0	0	0	0.00952381
BB	915	3	0.23707753	0	0.05914513	0	0.61033797	0.00894632	0	0.0139165	0	0	0.00298211	0.06759443
SE	310	2	0.67246041	0.01042874	0	0	0.07300116	0.01853998	0	0.15372731	0.0405562	0	0	0.03128621
SE	310	3	0.55820896	0.0761194	0.00149254	0	0.11492537	0.04626866	0.01044776	0.18955224	0	0	0	0.00298507
SE	875	3	0.28076923	0.25769231	0	0	0.18846154	0.04230769	0	0.23076923	0	0	0	0
SE	310	4	0.50649351	0.03670243	0.01016375	0.35911914	0.03387916	0.0310559	0.00225861	0.00169396	0.00225861	0.0107284	0	0.00564653
		BB:SE	C	CR	DC	DIR	GS	LC	LR	M	RCA	RCCA	S	WS
	t.test	p.value	0.04314055	0.18646456	1.3516E-05	0.39100222	0.00481078	0.01735064	0.29051622	0.12314842	0.36147377	0.39100222	0.42264973	0.20151378

Substrate Size											
site	dive	transect	1	2	3	4	5	6	7	8	NA
BB	915	1	0.72734082	0.02097378	0.05692884	0	0.09213483	0.10262172	0	0	0
BB	915	2	0.45873016	0.03650794	0.06349206	0.00634921	0.02539683	0.24444444	0	0.16507937	0
BB	915	3	0.58399602	0.01888668	0.08151093	0	0.08996024	0.19831014	0	0.02733598	0
SE	310	2	0.09575234	0	0.03851692	0.01727862	0.03239741	0	0.00071994	0.74730022	0.06803456
SE	310	3	0.11851852	0	0.07555556	0.0562963	0	0	0	0.74222222	0.00740741
SE	875	3	0.16065574	0	0.21967213	0.03606557	0	0	0	0.43606557	0.14754098
SE	310	4	0.03896104	0.00056465	0.03670243	0.42405421	0	0	0	0.49915302	0.00056465
		BB:SE	1	2	3	4	5	6	7	8	
	t.test	p.value	0.01668886	0.04490515	0.60282763	0.26961076	0.09366391	0.04893951	0.39100222	0.00285151	

		Rugosity						
	ive-transect	dive	transect	1	2	3	4	NA
SE	310-2	310	2	0.2562995	0.55291577	0.10043197	0.02159827	0
SE	310-3	310	3	0.1762963	0.70814815	0.06518519	0.04296296	0.00740741
SE	875-3	875	3	0.46557377	0.1442623	0.19344262	0.04918033	0
SE	310-4	310	4	0	0.46583851	0.29644269	0.23715415	0.00056465
BB	915-1	915	1	0.72659176	0.17078652	0.10262172	0	0
BB	915-2	915	2	0.43015873	0.24285714	0.3031746	0.02380952	0
BB	915-3	915	3	0.49353877	0.30815109	0.19483101	0	0
		SE:BB	1	2	3	4	NA	
	t-test	p-value	0.05776471	0.15125989	0.66179305	0.20992418	0.35119935	

Table 1. Shows the p-values of each test highlighted text shows statistical significance.

Results

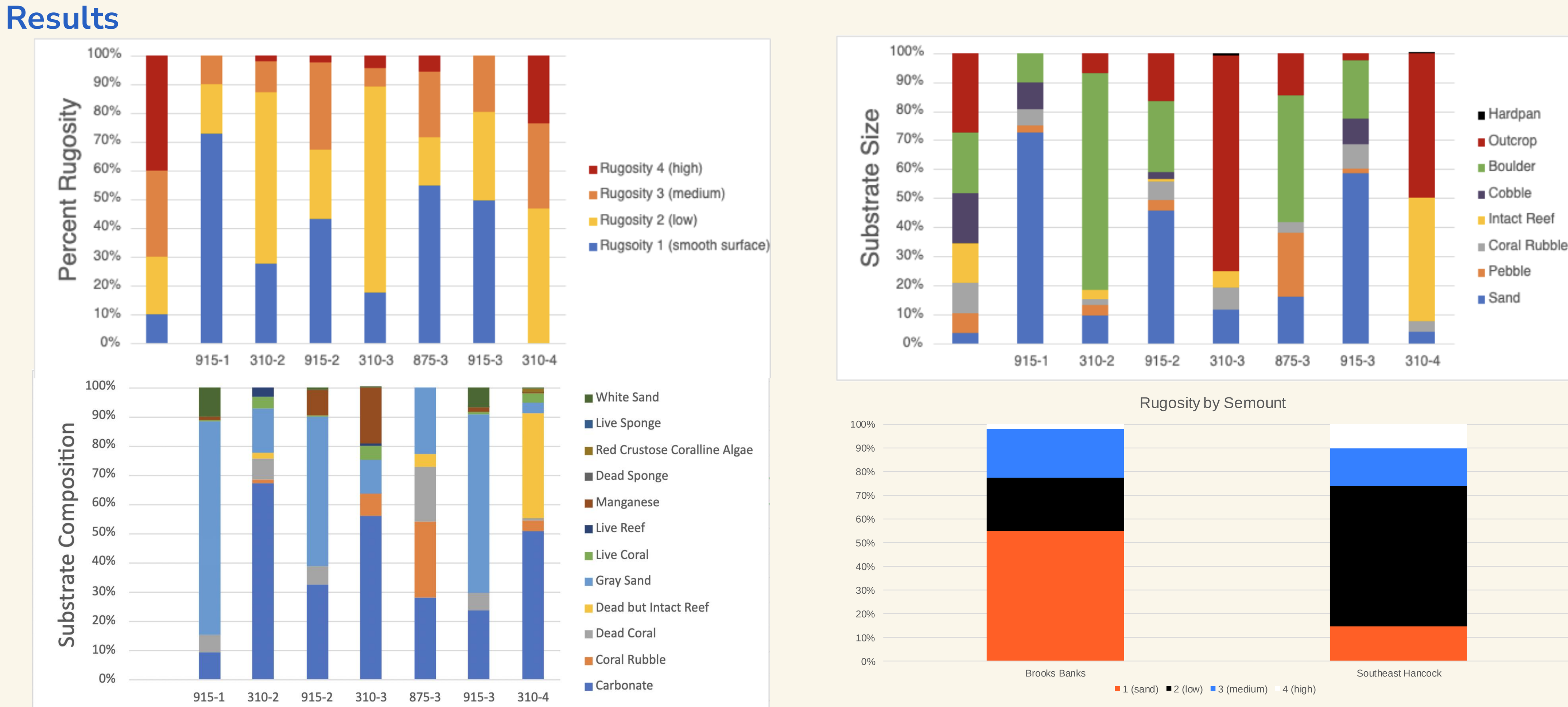


Figure 3. Overall percentage composition of (A) rugosity, (B) substrate size, and (C) substrate on Southeast Hancock and Brooks Bank seamounts.

Figure 4. Rugosity levels on the Southeast Hancock seamount showed a trend of being higher compared to the Brooks Bank seamount with all levels having a p-value > 0.05, we can conclude that there is a significant difference between the characteristic of both seamounts.

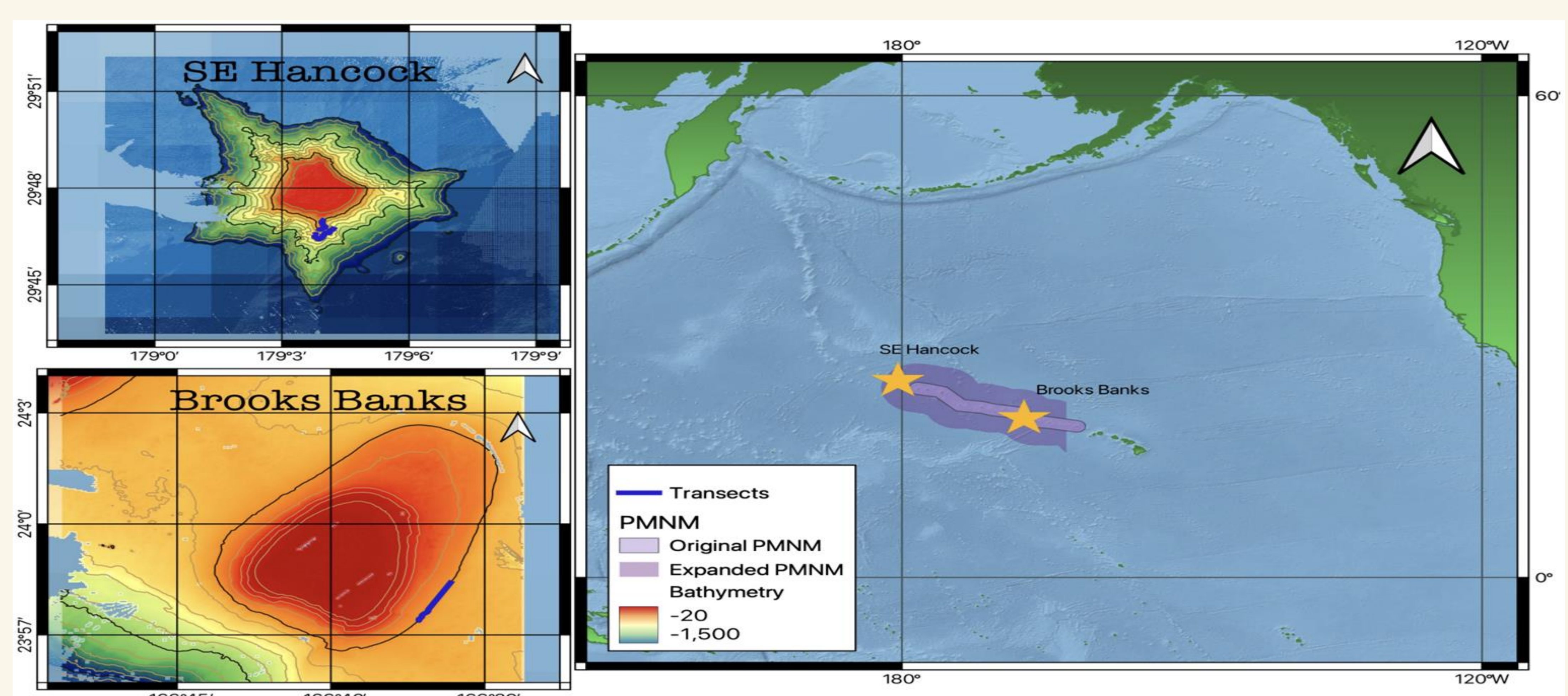


Figure 5. Bathymetric maps of both Southeast Hancock and Brooks Banks, as well as the relative location of each seamount within the Papahānaumokuākea Marine National Monument.

Conclusion

A statistical two sample two tailed t-test was used to compare rugosity levels, substrate composition, and substrate size on the Southeast Hancock and the Brook Banks. We obtained p-values less than or equal to 0.05 ($p<0.05$) for levels of substrate size, and for substrate composition. With a p-value that is less than our $\alpha=0.05$ we reject the null hypothesis and indicate there is a significant difference between substrate characteristics between the Southeast Hancock and Brooks Banks seamounts. Both seamounts have different characteristics that are able to sustain different ecosystems necessary for biodiversity. Brooks Banks has a lower level of rugosity which means fewer corals likely grow in this area since there's a low presence of boulders and larger substrates and mostly made up of sand where corals aren't able to grow. While Southeast Hancock has a larger presence of these hard substrates which allows corals to thrive.

Discussion

Biodiversity is essential for processes that support life on earth, without this a large range of organisms would not be able to have ecosystems that provide essential sources to sustain human life. Our research showed the difference among seamounts that each one supports to the diversity of ecosystems. Corals are an essential system of our oceans, they provide homes, food, and overall support for the well-being of marine life. Corals are common in transects with deeper depths and a higher presence of cobbles and boulders (Mortensen, and Mortensen, 2004). Southeast Hancock would be more likely to sustain a coral ecosystem due to the higher levels of rugosity. While other types of organisms thrive in habitats with low rugosity and smaller substrate composition, where Brooks Bank has an advantage over these organisms. The Hawaiian Ridge and the Emperor Seamount Chain stretch across the North Pacific and support vast biodiversity. However, there is no legal mechanism that provides protection for some of these areas which are critical to the survival of these areas that are being harmed by human activity like trawling. The overall goal of our project as well as many other scientists is to determine the location of these patches to bring up to the United Nations to include as part of areas where human activity is not allowed to be able to protect such critical organisms.

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