Morphological Analysis of Tablemounts Near Wake Island, Western North Pacific

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ABSTRACT

The National Oceanic and Atmospheric Administration's Office of Ocean Exploration and Research collected multibeam sonar data 3.15 km south of Wake Island, Pacific Ocean in March of 2016. Multibeam data were collected by the NOAA Ship *Okeanos Explorer* using a Kongsberg EM302 and post-processed with CARIS HIPS 9.1 software to create 2D and 3D bathymetric surfaces for interpretation. Ten seamounts were mapped, including 4 seamounts with extremely flat tops, referred to as tablemounts or guyots. These seamounts are remarkably similar in their general morphology. Within the survey area, most have their shoalest points at a depth of approximately 1.1 km, with some as deep as 2 km. Five tablemounts from the expedition were examined in this study. Each has a broad, flat top with flank slopes no greater than 6°. Since no ground truthing data were available, only quantitative measurements of the slope and symmetry of the tablemounts were measured and interpreted. This research serves as a window into little-known bathymetric features that are in close proximity to major islands of the western North Pacific and indicates the need for more research to be conducted in these areas.

Location of Study Site

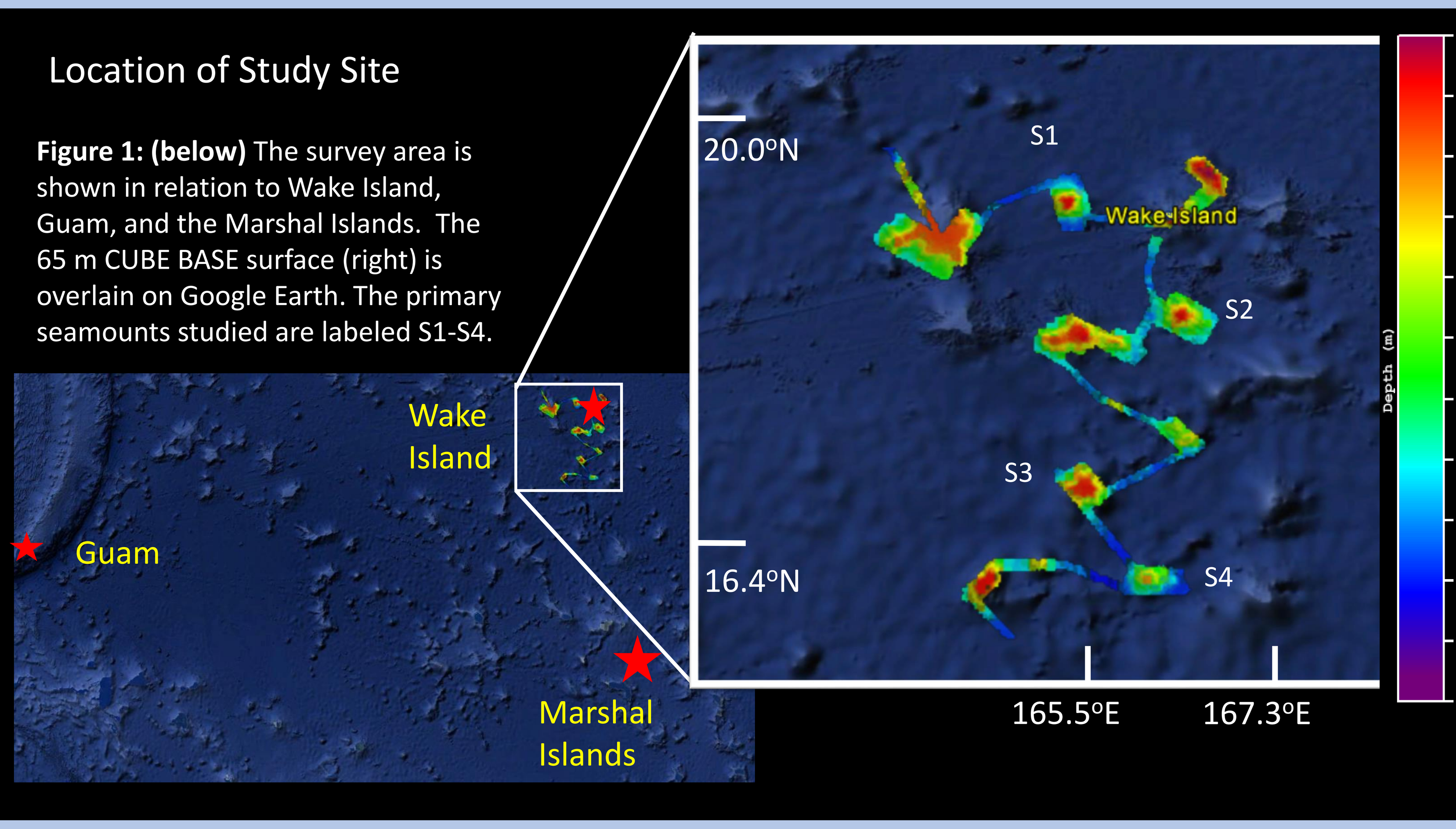


Figure 1: (below) The survey area is shown in relation to Wake Island, Guam, and the Marshal Islands. The 65 m CUBE BASE surface (right) is overlain on Google Earth. The primary seamounts studied are labeled S1-S4.

BACKGROUND

The Pacific Ocean is home to many volcanic activities which have produced many volcanic islands, atolls, and seamounts such as Wake Island (Fig. 1) (Jordan and Smith 1988). Wake Island is currently home to a US Airforce base and is surrounded by seamounts. These seamounts are volcanic in origin, specifically formed from active geothermal hotspots throughout the Pacific Plate (Woodroffe et al. 1999). A striking similarity among the seamounts is that most are flat topped, a characteristic of guyots which are also referred to as tablemounts. How guyots/tablemounts get their flat tops is not completely understood, but their submergence is a result of the cooling and contraction of the ocean floor and subsequent erosion by wave action (Winterer and Metzler 1984). The Pacific Ocean has high geothermal activity which has resulted in a seafloor littered with seamounts, many of which share the common feature of a flat top with steeply flanked slopes.

The purpose of this study was to create a new preliminary classification system to quantitatively characterize the geomorphology of Pacific tablemounts using multibeam sonar data that could be applied to the many seamounts that lie in the Pacific and other ocean basins.

METHODS

- Derek Sowers (NOAA)was the lead scientist for expedition EX1502L2 aboard the *Okeanos Explorer* in March of 2016.
- Multibeam sonar bathymetric and backscatter intensity data were collected using a Kongsberg EM302 transducer.
- Post-processing was performed with CARIS HIPS 9.1 to create 3D images as well as 65 m resolution CUBE surface and profiles.
- Measurements were made of geomorphological symmetry and slopes of the flanks and summits of four of the 10 seamounts surveyed. These 4 seamounts are all tablemounts (i.e., guyots) with broad flat tops.
- The top is the flattest (lowest slope) part of the tablemount while the flanks are the steep sloping sides. The slope of the top and flanks of the seamount were measured using profiles generated from a central point (Fig. 2).
- Eight different profiles were constructed from a central point for each tablemount. The **longest axial distance** for each tablemount is shown by the combined distances of A-A' and C-C', whereas the combined B-B' and D-D' represent the **perpendicular axial distance**.
- Symmetry was calculated by dividing the perpendicular axial distance by the longest axial distance. A symmetry value of 1 represents high symmetry (square to circular) while values less than 1 represent a more oblong shape.
- Symmetry of the tablemount flat top was also measured, similarly.

FIGURE 2

Top Row: 3D images of the seamounts S1-S4 used in this study. S4 is labeled to show the top and example flank of the seamount. Notice how the tops of all 4 seamounts are flat and nearly featureless while the flanks of the seamounts are steep and have possible latent volcanic mounds.
Bottom Row: 2D BASE surfaces (65 m resolution) of each seamount. Eight profiles (A-A' to H-H') were constructed for each seamounts. Each profile was drawn from a central point within the seamount to a depth of approximately 3000 m as the data permitted.

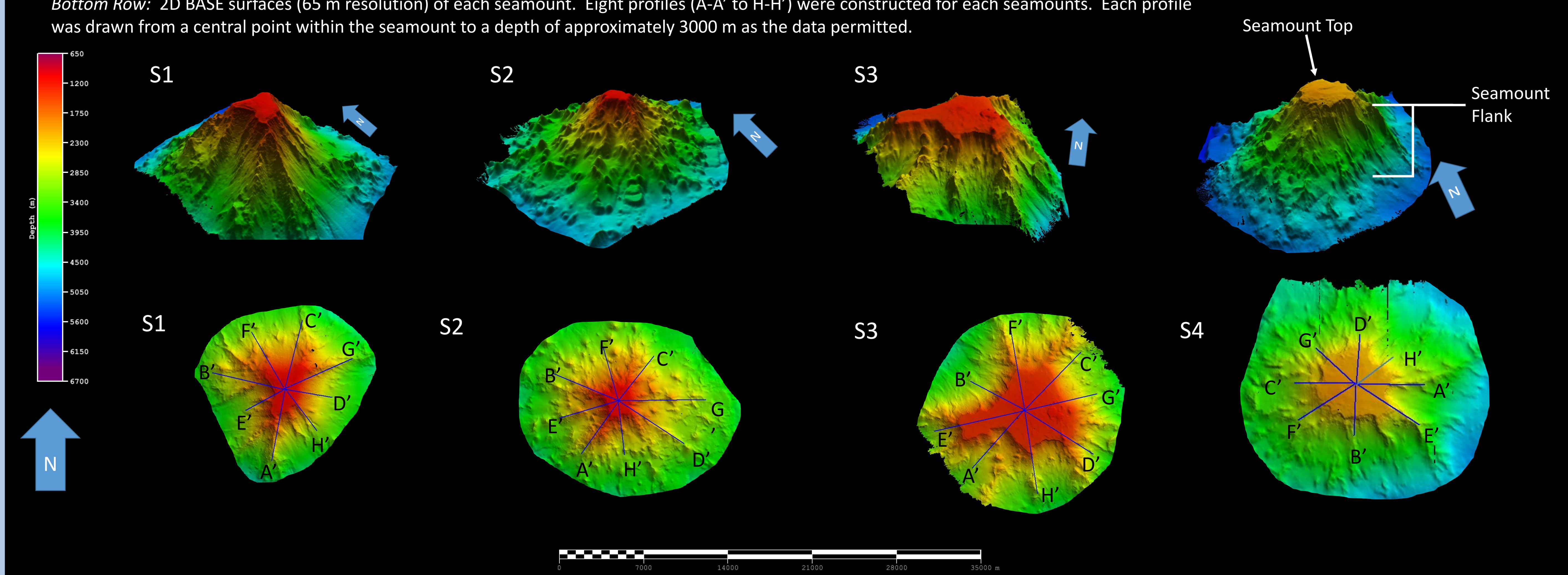
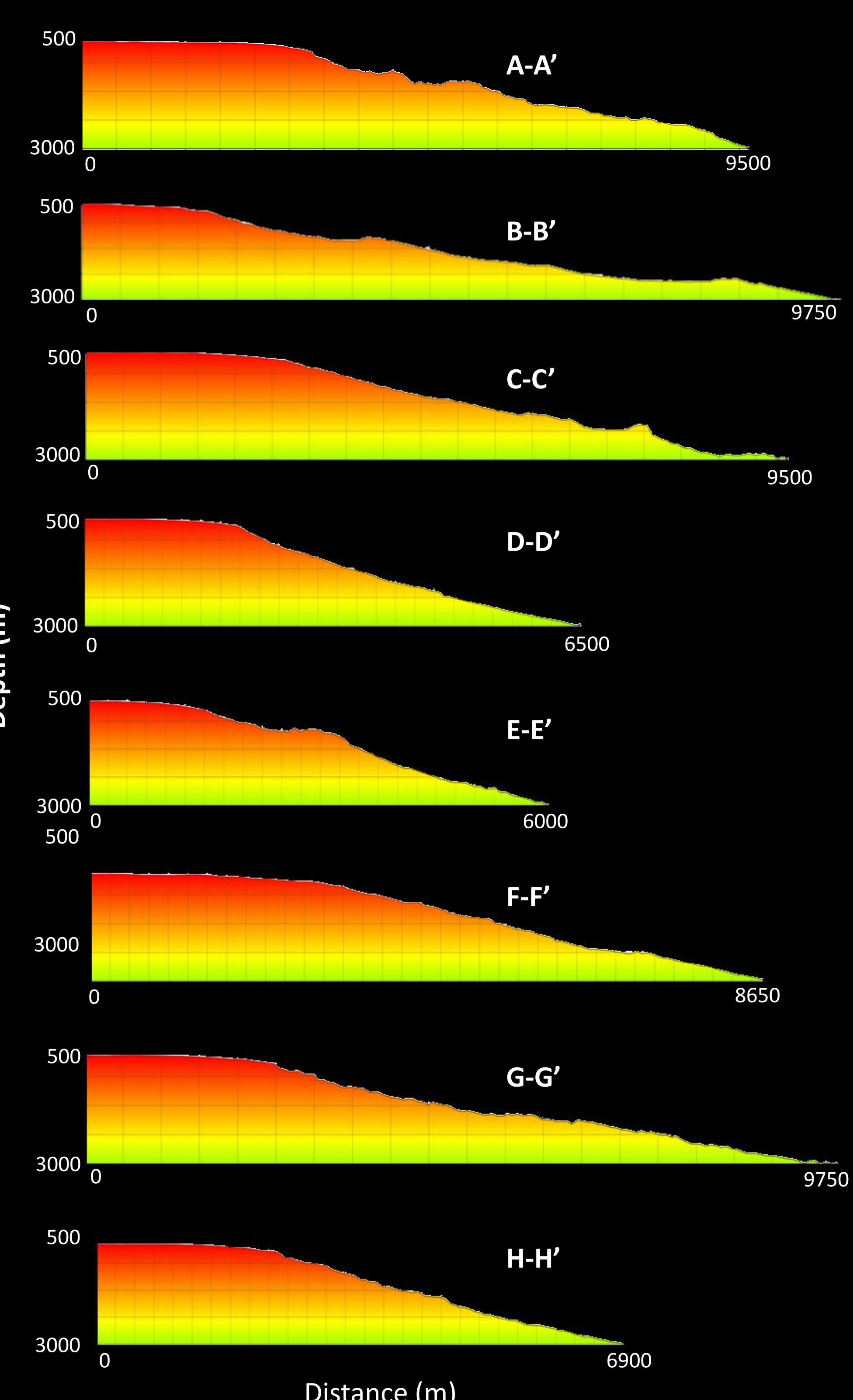


FIGURE 3

Seamount S1 profiles A-A' through H-H' are shown as an example of profiles made for each of the 4 seamounts. Measurements of profile lengths and slope for both the flank and top of the tablemount were made from these profiles (Table 1) in order to determine if there is a correlation between similarly shaped tablemounts. A-A' + C-C' = longest axial distance, whereas B-B' + D-D' = perpendicular axis, used in calculating tablemount symmetry, as described in the Methods section.



RESULTS

- Refer to Table 1 for measurements.
- The average slope for the tops and flanks of the tablemounts is 4 and 24°, respectively.
- Tablemount symmetry varied between 0.81 and 0.99, while tablemount top symmetry varied from 0.59 to 0.92.
- Tablemount symmetry as a whole was relatively high, with S3 being most symmetric (0.99).
- Generally, the morphology of the flat top is not very reflective of the morphology of the total tablemount, however, weak correlations were observed between:
  - Total Distance (of the profile) and Top Distance (positive, R^2=0.2323), indicating that Top Distance generally increases with Total Axial Distance of the tablemount.
  - Top Slope and Top Distance (negative, R^2=0.1769), indicating that as the distance or breadth of the tablemount's top increases slope decreases.
  - Flank Slope and Top Slope (positive, R^2=0.1271), indicating that a steeper sloped flank is likely to have a steeper sloped top.
- The strongest correlation (negative, R^2=0.3082) was observed between the Total Profile Distance and Top Slope, and indicates that larger tablemounts tend to have flatter tops.

DISCUSSION

Tablemounts of the western mid-Pacific ocean are characterized by flat tops and sharply sloped flanks. This morphology would fall in line with the theory that tablemounts were once volcanic island that were eroded flat by wave action during submergence (Winterer and Metzler 1984). One striking difference among the four studied tablemounts is their variability among the slopes and axial distances. With only four tablemounts studied, no definite conclusions can be drawn, however, collecting similar profile data for numerous additional tablemounts would determine if the studied variable show true correlations.

To aid in the classification and understanding of tablemounts, a classification system using morphologic features and hopefully the integration of core data of many tablemounts/guyots is needed to help further flesh out a quantitative characteristic classification for these mostly unknown features.

Figure 4. Data from Table 1 compared for 4 Tablemounts.

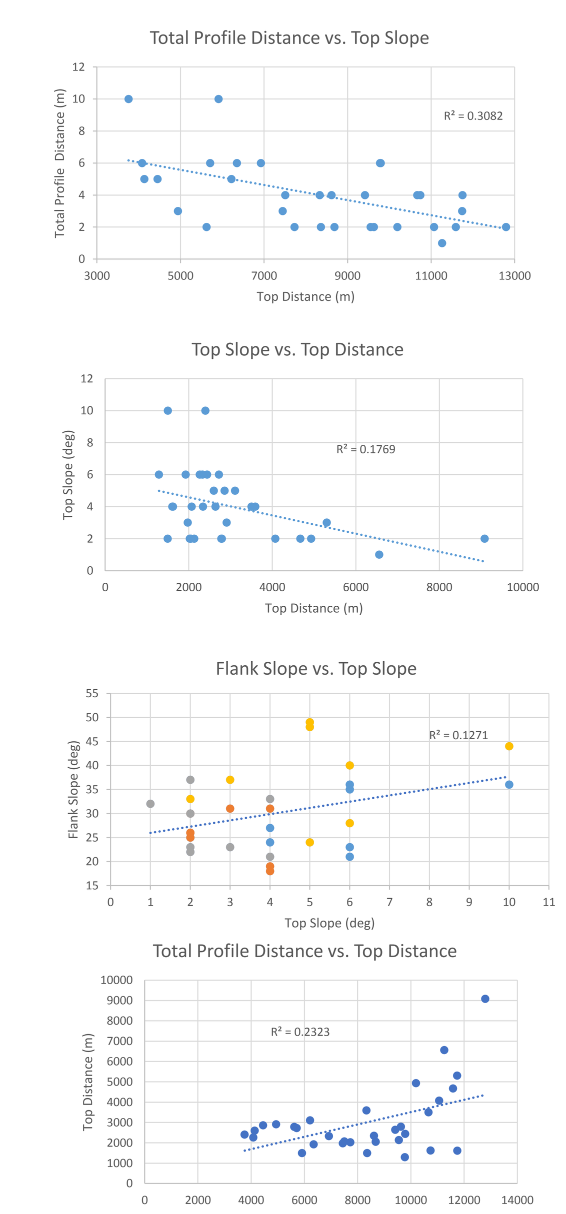


Table 1. Measurements Tablemounts S1-S4.

Seamount Number	Profile Name	Total Profile Distance (m)	Top Distance (m)	Slope: Top (deg)	Slope: Flank (deg)	Mount Symmetry (m)	Top Symmetry (m)	Depth (m)
S1	A-A'	9629.52	2792.98	2	25	0.85	0.59	1145
	B-B'	9778.26	1288.46	6	21			
	C-C'	9417.96	2642.72	4	24			
	D-D'	6350.39	1927.31	6	36			
	E-E'	5912.18	1498.55	10	36			
	F-F'	8617.03	2342.33	4	27			
	G-G'	9792.18	2438.6	6	23			
	H-H'	6924.91	2330.46	6	35			
S2	A-A'	8685.46	2047.95	2	26	0.81	0.92	1165
	B-B'	9551.98	2133.84	2	25			
	C-C'	7731.8	2026.03	2	30			
	D-D'	10740.68	1622.16	4	19			
	E-E'	8361.34	1495.95	2	26			
	F-F'	7506.69	2069.32	4	31			
	G-G'	11750.62	1608.76	4	18			
	H-H'	7444.68	1977.43	3	31			
S3	A-A'	12795.19	9084.44	2	37	0.99	0.71	1251
	B-B'	11743.91	5302.19	3	23			
	C-C'	10193.81	4932.68	2	30			
	D-D'	11589.74	4672.09	2	23			
	E-E'	8332.85	3591.03	4	33			
	F-F'	11068.29	4072.72	2	22			
	G-G'	11261.01	6558.75	1	32			
	H-H'	10666.94	3502.39	4	21			
S4	A-A'	5710.8	2723.71	6	28	0.88	0.87	2067
	B-B'	4136.18	2599.78	5	49			
	C-C'	4937.98	2908.8	3	37			
	D-D'	4082.22	2263.99	6	40			
	E-E'	6217.87	3107.19	5	24			
	F-F'	5624.08	2781.53	2	33			
	G-G'	4453.01	2858.48	5	48			
	H-H'	3757.11	2400.73	10	44			

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