Appendix A: Seamounts within the Exclusive Economic Zones of Samoa and American Samoa

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INTRODUCTION

Seamounts are underwater mountains of volcanic origin. They are often formed near mid-ocean ridges or subduction zones at the edges of tectonic plates but also occur over upwelling plumes ("hotspots") within plate boundaries (Wessel 2001). Like all geologic formations, seamounts change in shape and height over millions of years as a result of the gradual processes of volcanic growth upward out of the seafloor, growth of coral reefs if emergent or shallow enough, and eventually the processes of erosion and subsidence or sinking of the reshaped structure back into the seafloor. The Samoan Archipelago is part of a hotspot chain

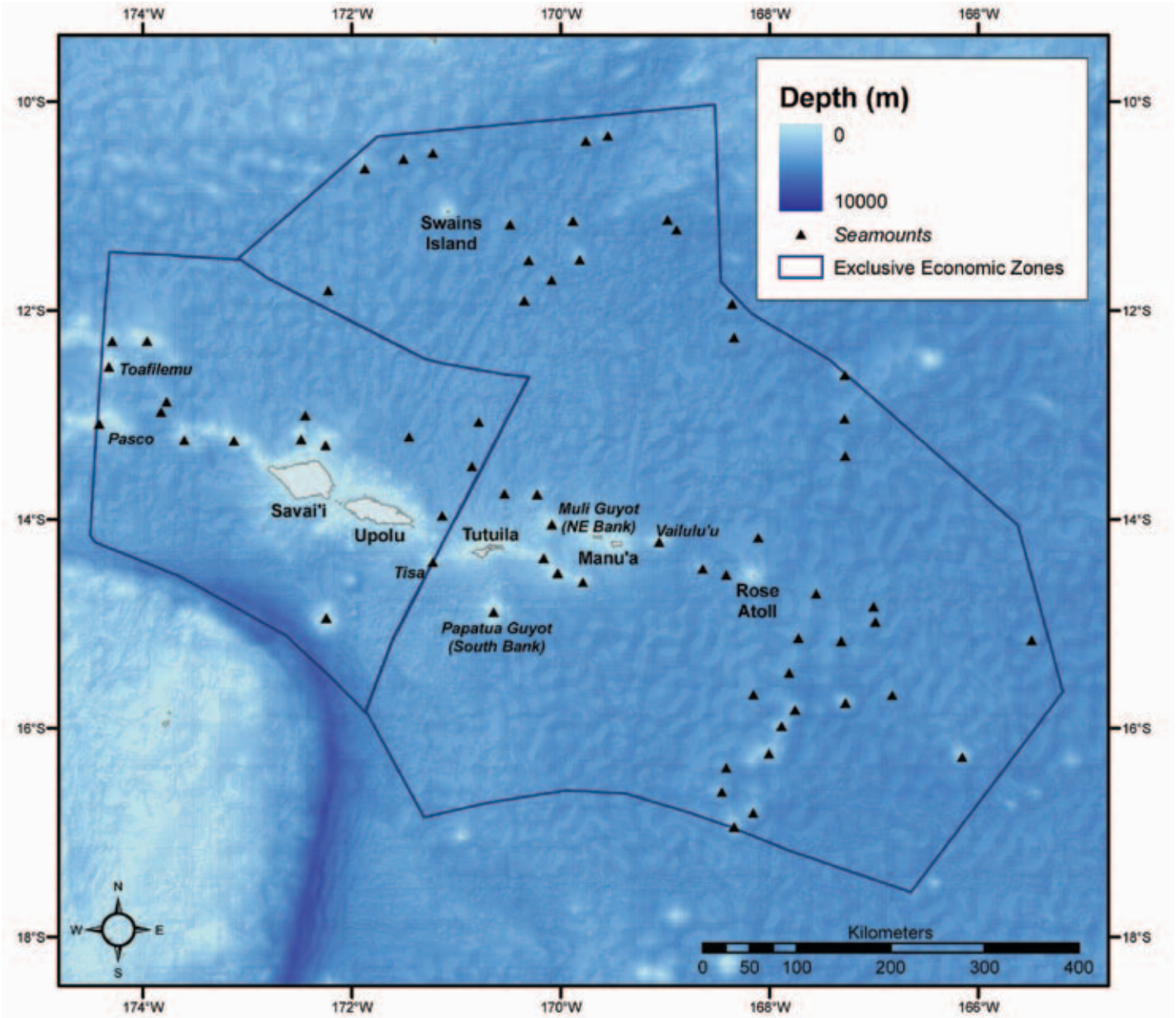

Figure A.1. Seamounts of the Samoan Exclusive Economic Zones.

[1] NOAA/NOS/NCCOS/CCMA/Biogeography Branch and Consolidated Safety Services, Inc., Fairfax, VA, under NOAA Contract No. DG133C07NC0616

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that extends from the volcanically active Vailulu'u seamount in the east to west of the island of Savai'i (Hart et al. 2006) and includes examples of many stages in the seamount life cycle. The region also includes many seamounts not associated with the Samoan hotspot (Figure A.1).

Seamounts are not only interesting features geologically as described above, but also biologically in that they represent oases of biodiversity relative to the comparatively barren ocean and seafloor surrounding them. Seamounts offer an array of habitat opportunities, current fields, and depth zones for plankton, fish and corals to occupy, they play a role as "stepping stone" features connecting populations of reef fish and corals between islands, are known gathering sites for many pelagic fish species, and consequently are popular destinations for fishing and scientific study (Rogers 1994).

The scientific definition of a seamount has evolved over time (Staudigel et al. 2010) and has variously been based on some minimum height above the seafloor, gravity anomalies of even fully subsided or buried seamounts, and has included emergent islands by some definitions. In this assessment seamounts are defined as totally submerged but extending a minimum of 150 m above the seafloor. The objective of this appendix is to provide a characterization of seamounts within the Exclusive Economic Zones (EEZs) of Samoa and American Samoa. Of particular importance are those shallow enough to be colonized by reef fish and corals.

METHODS

Seamounts are typically mapped using sonar and satellite altimetry. While sonar based mapping is the most direct method and provides detailed resolution, it is expensive and generally limited in spatial coverage. Satellite altimetry in contrast, which can be used to detect seamounts indirectly due to variations in the Earth's gravity field (Wessel 2001, Wessel et al. 2010), is available at a global scale but is comparatively coarse resolution.

Two datasets were used to characterize seamounts in the Samoan Archipelago. The Global Seamount Census (Wessel 2001, Wessel et al. 2010) is a global database of ~12,000 seamount features from satellite-derived bathymetry (Smith and Sandwell 1997). The Seamount Biogeosciences Network provides a characterization for ~1,800 seamounts worldwide, including available multibeam data, relevant literature, and morphological characteristics (Koppers et al. 2010a). Seamounts from both sources were plotted and examined in concert with available bathymetry datasets. Three bathymetry data sources were used

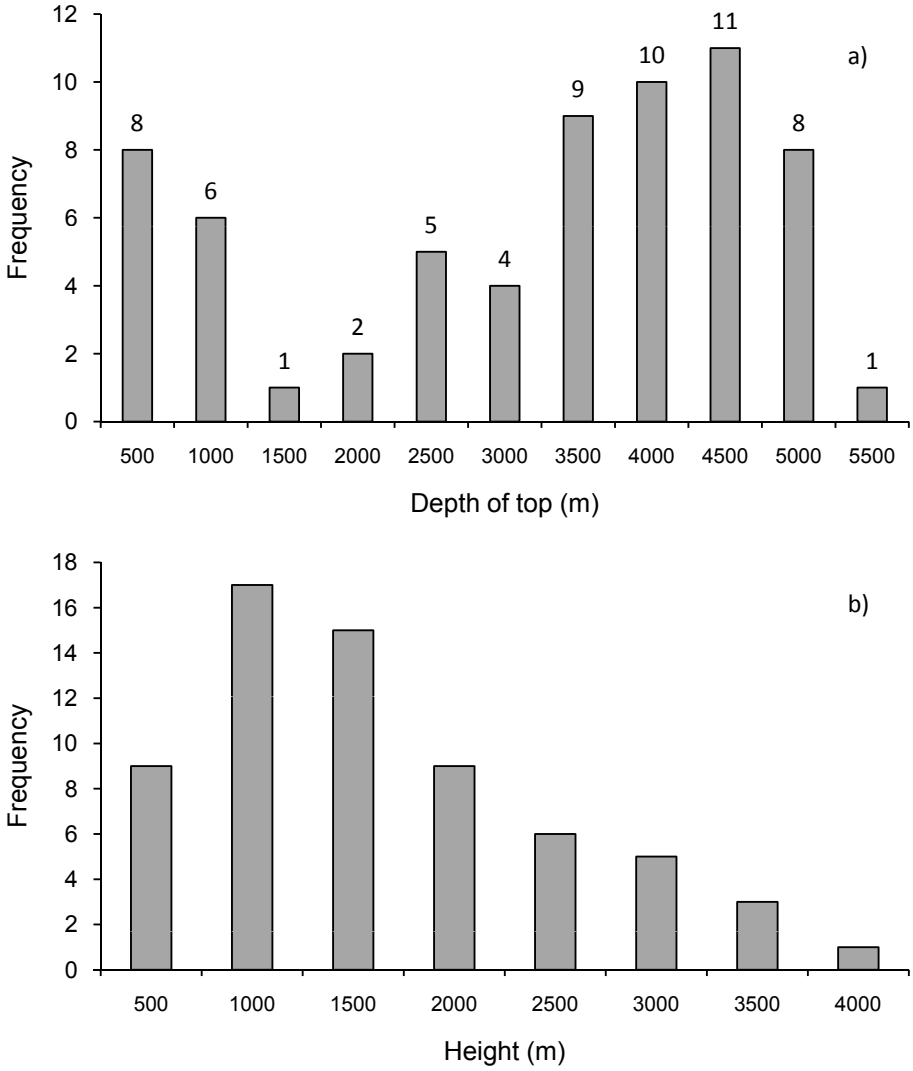

Figure A.2. Frequency distribution of seamounts within the Samoan and American Samoan EEZ based on a) depth of seamount top and b) height.

to obtain complete coverage of the study region. High resolution (5-40 m) bathymetry based on multibeam sonar was obtained from the Pacific Islands Benthic Habitat Mapping Center (http://www.soest.hawaii.edu/pibhmc.htm) for three seamounts: Vailulu'u, Muli (locally known as Northeast Bank) and Tulaga (Two-Percent Bank). Moderate resolution (180 m) bathymetry from merged multibeam and satellite data were downloaded from Koppers et al. (2010a). Last, one-minute bathymetry estimated from satellite altimetry, ship depth soundings, and other sources (http://topex.ucsd.edu, Smith and Sandwell 1997), was used where the two finer resolution datasets lacked coverage.

In many cases, seamount locations disagreed slightly between the two data sources and were therefore moved slightly in this characterization to more precisely identify the approximate peak of each seamount based on bathymetry. A few features from the satellite derived dataset (Wessel et al. 2010) lacked significant bathymetric relief and were removed. These features may have been gravity anomalies representing "buried" seamounts (Wessel 2001, Wessel et al. 2010). Additional features not included in either seamount dataset were identified within the EEZs of Samoa and American Samoa based on the bathymetry. Summary information for each seamount feature was compiled including peak coordinates, depth of peak, and total height above the seafloor. The depth of the peak and base of the seamount was estimated in ArcGIS and the height was calculated as the difference between these estimates. Seamounts are summarized in tabular form, as histograms based on peak height and depth, and in map format for both the region and as individual maps for features with potential reef communities.

RESULTS AND DISCUSSION

A total of 65 seamount features were identified; 48 within the EEZ of American Samoa, 16 within the EEZ of Samoa, and one, Tisa Seamount situated on the EEZ boundary (Figure A.1; Table A.1). Approximately 20 of the seamounts in the study area are derived from the Samoan hotspot and lie along the axis of the archipelago. This group includes many of the largest and shallowest seamounts in the region. In addition, there are two groups of smaller seamounts in the southeastern and northern regions of the American Samoa EEZ.

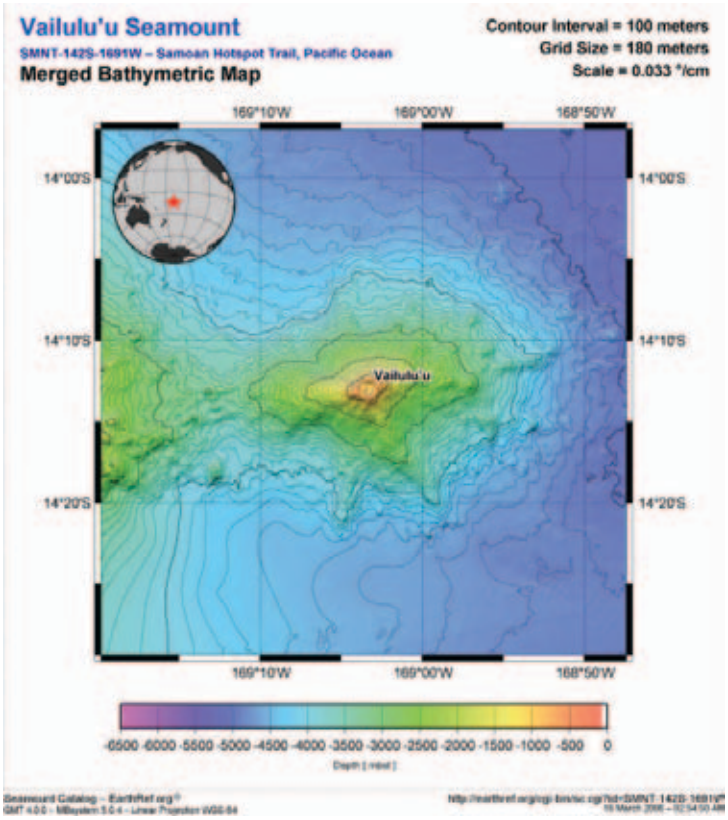

Figure A.3. Vailulu'u Seamount, the active hotspot for the Samoan Island Chain.

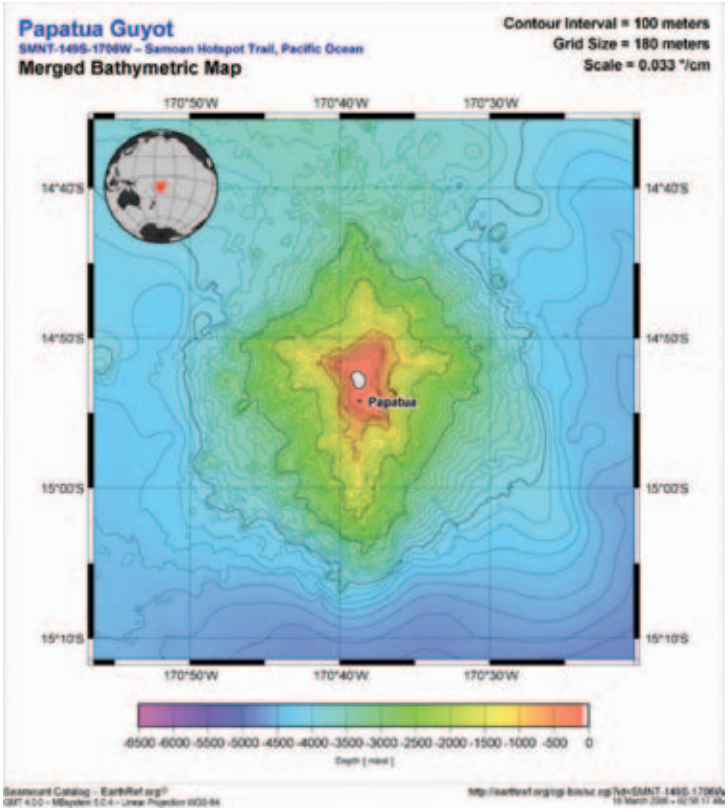

Figure A.4. Papatua Guyot (South Bank).

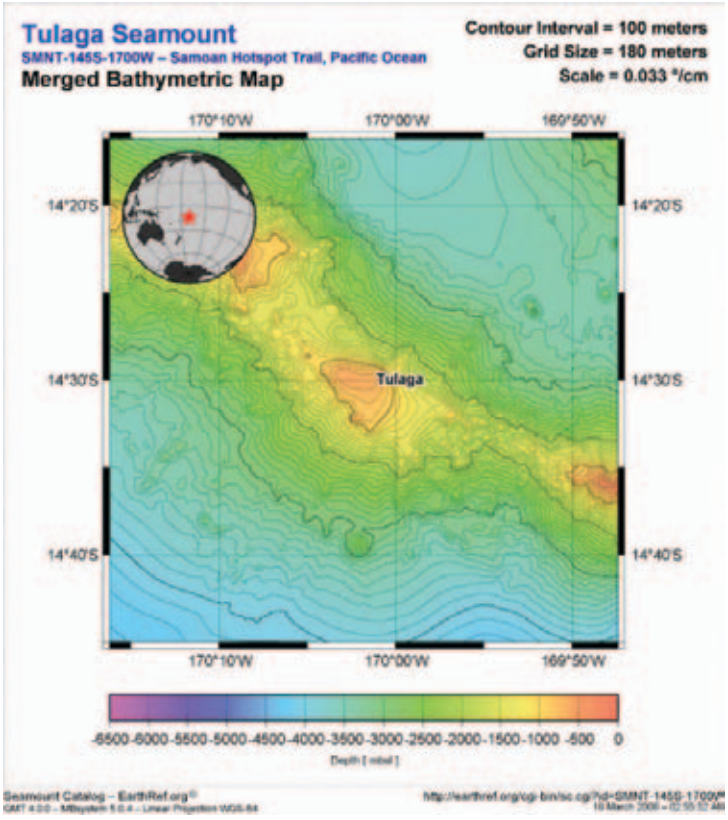

Figure A.5. Tulaga (East Bank).

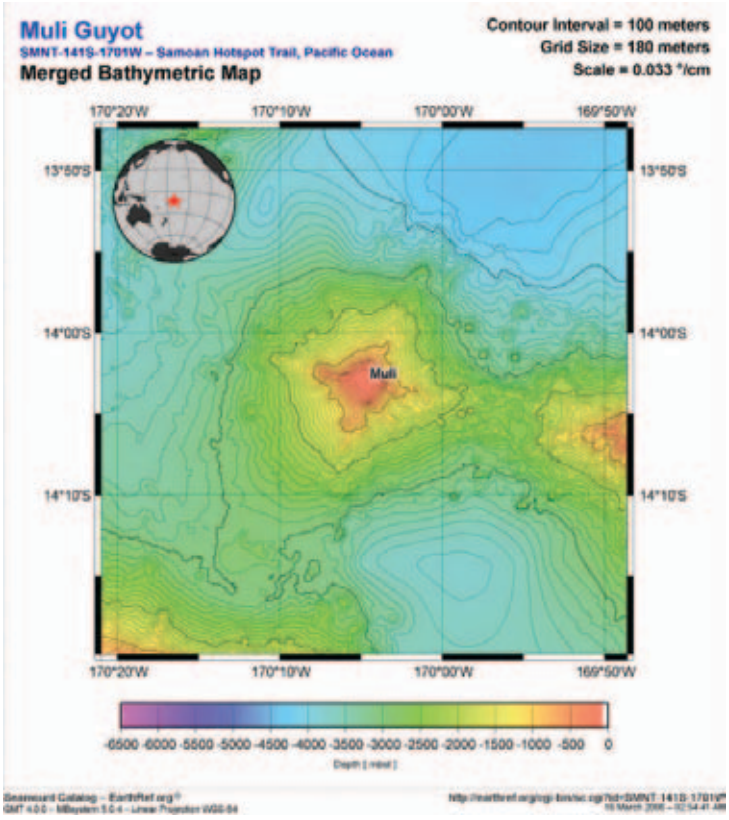

Figure A.6. Muli Guyot (NE Bank).

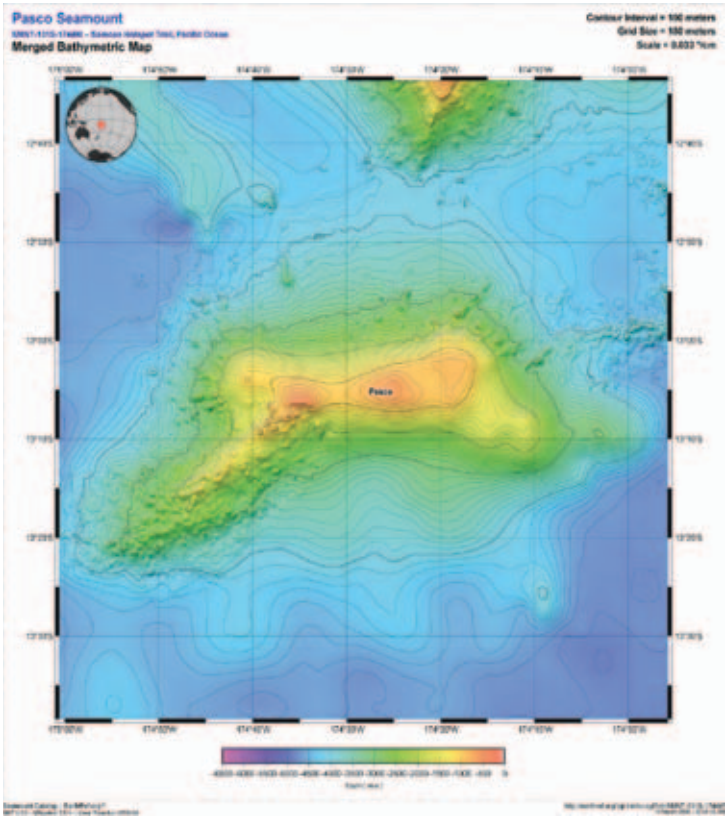

Figure A.7. Pasco Seamount.

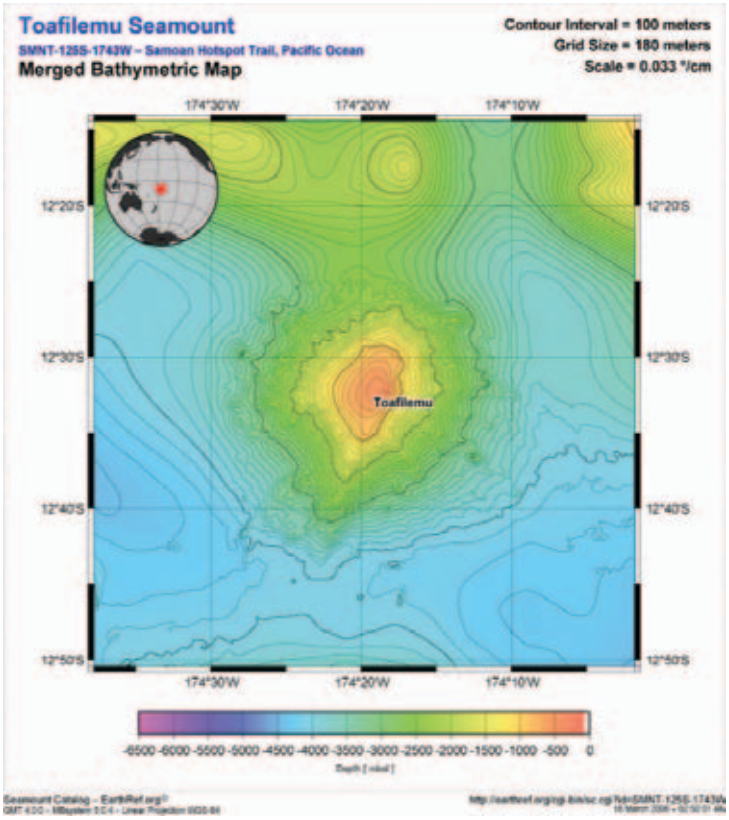

Figure A.8. Toafilemu Seamount.

Table A.1. Locations and morphological characteristics of seamounts within the EEZ of American Samoa and Samoa. 1= Koppers et al. 2010a; 2= Wessel et al. 2010; 3= estimates based on bathymetry from Koppers et al. (2010a); 4= estimates based on bathymetry from Smith and Sandwell (1997), 5=estimates based on bathymetry from NOAA PIBMC, 6= seamounts identified from visual inspection of the bathymetry. Names are based on seamount databases with local names provided in parenthesis where known.

Name	EEZ	Source	Longitude	Latitude	Depth of top (m)[1,3,4]	Height (m)[1,3,4]
Malu Malu Seamount	American Samoa	1,2	-169.7856	-14.6006	286 (3)	1,884 (3)
Malulu Seamount	American Samoa	1,2	-168.6422	-14.4728	2380 (3)	1,396 (3)
Muli Guyot (NE Bank)	American Samoa	1,2	-170.0822	-14.0479	49 (5)	2,926 (3)
Papatua Guyot (South Bank)	American Samoa	1,2	-170.6433	-14.8880	23 (3)	3,629 (3)
Soso Seamount	American Samoa	1,2	-170.2254	-13.7608	1,820 (3)	1,714 (3)
Tama'l Seamount	American Samoa	1	-170.5393	-13.7544	2,666 (3)	1,146 (3)
Tulaga Seamount (East Bank)	American Samoa	1,2	-170.0267	-14.5125	78 (5)	1,313 (3)
Vailulu'u Seamount	American Samoa	1,2	-169.0577	-14.2160	583 (5)	2,700 (3)
Unnamed Seamount 1	American Samoa	1	-167.5555	-14.7115	3,722 (3)	1,304 (3)
Unnamed Seamount 2	American Samoa	2	-171.8754	-10.6409	3,342 (3)	566 (3)
Unnamed Seamount 3	American Samoa	2	-171.5049	-10.5500	4,028 (3)	749 (3)
Unnamed Seamount 4	American Samoa	2	-171.2254	-10.4921	3,861 (3)	798 (3)
Unnamed Seamount 5	American Samoa	2	-170.4845	-11.1755	3,674 (3)	1,180 (3)
Unnamed Seamount 6	American Samoa	2	-170.3508	-11.9043	2,957 (3)	2,012 (3)
Unnamed Seamount 7	American Samoa	2	-170.3072	-11.5180	4,068 (3)	940 (3)
Unnamed Seamount 8	American Samoa	2	-169.8827	-11.1421	3,037 (3)	1,990 (3)
Unnamed Seamount 9	American Samoa	2	-169.8170	-11.5138	3,552 (3)	1,384 (3)
Unnamed Seamount 10	American Samoa	2	-169.5490	-10.3254	3,237 (3)	1,679 (3)
Unnamed Seamount 11	American Samoa	2	-168.8920	-11.2256	3,968 (3)	943 (3)
Unnamed Seamount 12	American Samoa	2	-168.4578	-16.6080	2,985 (4)	2,086 (4)
Unnamed Seamount 13	American Samoa	2	-168.4156	-16.3762	4,420 (4)	582 (4)
Unnamed Seamount 14	American Samoa	2	-168.3594	-11.9369	4,997 (3)	238 (3)
Unnamed Seamount 15	American Samoa	2	-168.3415	-12.2581	5,091 (3)	167 (3)
Unnamed Seamount 16	American Samoa	2	-168.3411	-16.9409	2,690 (4)	2,192 (4)
Unnamed Seamount 17	American Samoa	2	-168.1575	-16.8079	3,146 (4)	1,523 (4)
Unnamed Seamount 18	American Samoa	2	-168.1088	-14.1747	4,494 (3)	499 (3)
Unnamed Seamount 19	American Samoa	2	-168.0070	-16.2408	2,438 (4)	2,125 (4)
Unnamed Seamount 20	American Samoa	2	-167.8859	-15.9792	3,480 (3)	1,254 (3)
Unnamed Seamount 21	American Samoa	2	-167.2823	-12.6179	3,162 (3)	1,756 (3)
Unnamed Seamount 23	American Samoa	2	-167.2741	-15.7566	3,916 (3)	1,587 (3)
Unnamed Seamount 24	American Samoa	2	-166.8266	-15.6801	4,444 (4)	768 (4)
Unnamed Seamount 25	American Samoa	2	-166.1574	-16.2741	2,064 (4)	3,025 (4)
Unnamed Seamount 26	American Samoa	2	-165.4911	-15.1572	4,666 (4)	705 (4)
Unnamed Seamount 29	American Samoa	6	-167.7583	-15.8242	4,243 (3)	758 (3)
Unnamed Seamount 33	American Samoa	6	-172.2244	-11.8078	4,092 (3)	619 (3)
Unnamed Seamount 34	American Samoa	6	-169.7597	-10.3760	3,572 (3)	1,308 (3)
Unnamed Seamount 35	American Samoa	6	-167.2844	-13.0375	4,198 (3)	647 (3)
Unnamed Seamount 36	American Samoa	6	-167.2790	-13.3913	4,363 (3)	660 (3)
Unnamed Seamount 37	American Samoa	6	-170.1634	-14.3718	353 (3)	1,206 (3)
Unnamed Seamount 44	American Samoa	6	-170.0859	-11.7090	4,250 (3)	650 (3)
Unnamed Seamount 45	American Samoa	6	-166.9862	-14.9812	3,711 (3)	1,223 (3)
Unnamed Seamount 46	American Samoa	6	-167.0048	-14.8347	4,704 (3)	282 (3)
Unnamed Seamount 47	American Samoa	6	-167.3141	-15.1643	4,799 (3)	234 (3)
Unnamed Seamount 48	American Samoa	6	-167.7249	-15.1334	4,858 (3)	290 (3)
Unnamed Seamount 49	American Samoa	6	-167.8125	-15.4669	4,915 (3)	353 (3)

Table A.1 cont. Locations and morphological characteristics of seamounts within the EEZ of American Samoa and Samoa. 1= Koppers et al. 2010a; 2= Wessel et al. 2010; 3= estimates based on bathymetry from Koppers et al. (2010a); 4= estimates based on bathymetry from Smith and Sandwell (1997); 5=estimates based on bathymetry from NOAA PIBMC; 6= seamounts identified from visual inspection of the bathymetry. Names are based on seamount databases with local names provided in parenthesis where known.

Name	EEZ	Source	Longitude	Latitude	Depth of top (m)[1,3,4]	Height (m)[1,3,4]
Unnamed Seamount 50	American Samoa	6	-168.1543	-15.6757	4,887 (3)	269 (3)
Unnamed Seamount 51	American Samoa	6	-168.4162	-14.5275	4,104 (3)	730 (3)
Unnamed Seamount 53	American Samoa	6	-168.9760	-11.1330	4,608 (3)	378 (3)
Tisa Seamount	American Samoa /Samoa	1,2	-171.2235	-14.4073	861 (3)	2,140 (3)
Agavale Seamount	Samoa	1,2	-172.4833	-13.2333	995 (3)	1,986 (3)
Pasco Seamount	Samoa	1,2	-174.4157	-13.0865	94 (4)	3,051 (3)
Si'usi'u Seamount	Samoa	1,2	-173.6039	-13.2414	1,269 (3)	2,359 (3)
Taumatau Seamount	Samoa	1,2	-172.2503	-13.2894	842 (3)	1,890 (3)
Toafe'ai Seamount	Samoa	1,2	-173.9573	-12.2925	488 (3)	2,976 (3)
Toafilemu Seamount	Samoa	1,2	-174.3238	-12.5384	30 (4)	2,737 (3)
Tuapi'o Seamount	Samoa	1,2	-173.1259	-13.2477	425 (3)	2,966 (3)
Uo Mamae Seamount	Samoa	1	-172.2427	-14.9441	645 (3)	3,169 (3)
Unnamed Seamount 27	Samoa	1	-170.7861	-13.0671	3,796 (3)	1,004 (3)
Unnamed Seamount 30	Samoa	6	-173.7718	-12.8724	3,032 (3)	601 (3)
Unnamed Seamount 38	Samoa	6	-173.8263	-12.9707	2,349 (3)	1,379 (3)
Unnamed Seamount 39	Samoa	6	-174.2913	-12.2940	1,711 (3)	1,250 (3)
Unnamed Seamount 40	Samoa	6	-172.4459	-13.0042	3,098 (3)	698 (3)
Unnamed Seamount 41	Samoa	6	-171.4520	-13.2108	3,451 (3)	1,326 (3)
Unnamed Seamount 42	Samoa	6	-170.8492	-13.4912	3,711 (3)	941 (3)
Unnamed Seamount 43	Samoa	6	-171.1356	-13.9646	2,430 (3)	1,297 (3)

Peak depth ranged from 23 m to deeper than 5,000 m. The frequency of peak height by depth exhibited a bi-modal pattern, with the majority of seamount peaks located in water over >2000 m in depth (Figure A.2a). The majority of seamounts (60%) were less than 1,500 m in height (Figure A.2b).

Only Vailulu'u seamount (Figure A.3) is characterized as hydrothermally active, whereas the remaining seamounts are extinct volcanoes (Koppers et al. 2010b). The biological community varies among different locations on Vailulu'u and includes polychaetes, crinoids, octocorals, sponges, and a population of cutthroat eels (Staudigel et al. 2006).

In general, there is a lack of information on biological communities for other seamounts within the EEZ of Samoa and American Samoa. Seamounts Online (Stocks 2009) is a global database of user-contributed data on species distributions on seamounts. However, there was no data available for seamounts on the Samoan Archipelago at this time. The estimated depths of the top of the seamount features were used to determine whether shallow or mesophotic reefs were potentially present. Generally, mesophotic reefs range from ~30 to 150 m depth, although deeper records of zoxanthellate corals and coralline algae have been documented (Hinderstein et al. 2010). The estimated peaks of the seamount features were only shallower than 150 m depth for 5 out of 65 features, suggesting that mesophotic reefs are potentially present. Three of these seamounts are located within the American Samoa EEZ (Figures A.4-A.6) while the latter two features are located on the western edge of the Samoa EEZ (Figures A.7-A.8). Paputua Guyot, locally known as South Bank, has been identified as a drowned atoll in recent bathymetric surveys although development of mesophotic reef communities is lacking (R. Brainard, personal communication, NOAA Coral Reef Ecosystem Division, Honolulu, HI). All the remaining seamount features are estimated to be greater than 300 m deep, although actual depths should be interpreted with caution due to the scale and estimation methods of the bathymetry data. For example, there was a large difference in the depth of Tulaga Seamount, locally known as East Bank, when measured by multibeam sonar (78 m, PIBHMC) versus satellite altimetry (> 700 m).

CONCLUSIONS

A wide range of seamount morphologies exist within the Samoan EEZs. Approximately one third of the seamounts in the study area are derived from the Samoan hotspot which is presently located at Vailulu'u with the rest scattered in two main groups in the American Samoa EEZ. The five seamount features with potential mesophotic reef communities were evaluated further and used as inputs for understanding reef connectivity in Chapter 3 of this assessment.

ACKNOWLEDGEMENTS

The seamount databases available online and cited in this document are an excellent resource. We gratefully acknowledge Dr. Anthony Koppers for allowing us permission to use the original seamount maps available at EarthRef.org in our report.

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