

AD-A103 379

NAVAL OCEANOGRAPHIC OFFICE NSTL STATION MS
MORPHOLOGICAL CHARACTERISTICS OF NORTH ATLANTIC AND NORTH PACIF--ETC(U)
MAR 81 D R BRACEY
NOO-TR-266

F/6 8/10

UNCLASSIFIED

NL

1 of 1
AD A
03A 70

END DATA FORMED 10-81 DTIC
--

12
14 Nov -
TR - 266

TECHNICAL REPORT

LEVEL

**MORPHOLOGICAL CHARACTERISTICS OF
NORTH ATLANTIC AND NORTH PACIFIC
SEAMOUNTS AS FACTORS FOR DESIGNING
EFFECTIVE SURVEY DETECTION STRATEGIES.**

AD A103379

DEWEY R. BRACEY

MARCH 1981

DTIC
ELECTE
AUG 27 1981
S D A

Approved for public release; distribution unlimited.

DTIC FILE COPY

PREPARED BY
COMMANDING OFFICER,
NAVAL OCEANOGRAPHIC OFFICE
NSTL STATION, BAY ST. LOUIS, MS 39522

PREPARED FOR
COMMANDER
NAVAL OCEANOGRAPHY COMMAND
NSTL STATION, BAY ST. LOUIS, MS 39529

AB



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
	AD-A103	379	
4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED	
Morphological Characteristics of North Atlantic and North Pacific seamounts as factors for designing effective survey detection strategies.			
6. PERFORMING ORG. REPORT NUMBER		7. AUTHOR(s)	
		Dewey R. Bracey	
8. CONTRACT OR GRANT NUMBER(s)		9. PERFORMING ORGANIZATION NAME AND ADDRESS	
		Code 8230 U. S. Naval Oceanographic Office Bay St. Louis, MS 39522	
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS		11. CONTROLLING OFFICE NAME AND ADDRESS	
12. REPORT DATE		13. NUMBER OF PAGES	
March, 1981		31	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report)	
		UNCLASSIFIED	
15a. DECLASSIFICATION DOWNGRADING SCHEDULE		16. DISTRIBUTION STATEMENT (of this Report)	
		Approved for public release; distribution unlimited.	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		18. SUPPLEMENTARY NOTES	
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		20. ABSTRACT (Continue on reverse side if necessary and identify by block number)	
SEAMOUNT DETECTION SEAMOUNT SURVEY STRATEGY SEAMOUNT MORPHOLOGY		This report defines bathymetric and geophysical survey strategies, based on seamount morphological parameters, for the detection of North Atlantic and North Pacific seamounts. Characteristics derived from the morphological data are used to develop required survey track orientations and track spacing to maximize seamount encounter probability in these oceans using the most economical survey pattern.	

Approved for Distribution/Availability Codes	<input type="checkbox"/>
Special	<input type="checkbox"/>
A	<input type="checkbox"/>

CONTENTS

	<u>Page</u>
Introduction.....	1
I. North Atlantic seamounts.....	2
II. North Pacific seamounts.....	10
III. Limitations and conclusions.....	17

FIGURES

Figure 1. Histograms of North Atlantic seamount basal dimension distributions.....	3
Figure 2. North Atlantic seamount short vs. long axis basal dimension plot.....	4
Figure 3. Seamount height vs. water depth in the North Atlantic.....	6
Figure 4. Percent probability of encountering a North Atlantic seamount with a given track spacing.....	8
Figure 5. Histograms of North Pacific seamount basal dimensions.....	11
Figure 6. North Pacific seamount short vs. long axis basal dimension plot.....	12
Figure 7. Seamount height vs. water depth in the North Pacific.....	14
Figure 8. Percent probability of encountering a North Pacific seamount with a given track spacing.....	15
Figure 9. Example of survey track spacing reduction that may be required due to ambient bottom relief ("background noise")...	18

APPENDIXES

Appendix A. North Atlantic seamount morphological parameters.....	23
Appendix B. North Pacific seamount morphological parameters.....	26

INTRODUCTION

To develop an effective search technique, one must first have as clear an understanding as possible of the object of the search. This report attempts to define seamount morphological characteristics (size, shape, orientation) in the North Atlantic and North Pacific Oceans. The factors resulting from this definition can then be used for the development of efficient bathymetric or geophysical survey strategies to locate and delineate those seamounts which may constitute navigational hazards or that may be of interest to other Navy programs.

A resultant corollary is that those areas that have sufficient survey coverage within accepted probability limits can be quickly identified and excluded from further survey effort, while those areas with limited coverage can be filled in with the required track spacing for adequate delineation of any existing seamount.

I. NORTH ATLANTIC SEAMOUNTS

Appendix A presents morphological data for 72 isolated seamounts, randomly selected from the Bathymetric Atlas of the North Atlantic (C), (1975), at depths equal to or greater than 2000 meters. These data reveal that the seamounts can be divided into two morphological classes: 1) Elongated, oval-shaped seamounts (64%); and 2) conical seamounts (35%).

Figure 1 shows the basal axial dimension distribution of the seamounts. The distribution, while random, is not normal but seems to follow a chi-square or F distribution pattern. A possible explanation is that while there is a minimum basal dimension size, the maximum basal dimension can increase without limit.

Also shown on this figure are the basal dimensions of those seamounts less than or equal to 1000 meters in depth, the seamounts of particular interest in this study.

Figure 2 is a plot of short versus long axial dimensions. The mean and standard deviations of the seamount dimensions are also plotted; they are 16.8×23.5 nm and $\pm 6.0 \times \pm 8.5$ nm, respectively.

The linear regression line for the elongated seamounts is also shown in figure 2. The line is determined by $A_S = 0.56A_L + 1.53$, where A_S and A_L are the short and long axial dimensions in nm, respectively. The line indicates that the long axis of the average elongated seamount is about 1.5 times the short axis dimension. Statistical evidence indicates that the elongation is significant at the 95% confidence level.

As shown in Appendix A, the long axes of the elongated seamounts tend to parallel the direction of sea-floor spreading. Fifty-seven percent of the elongated axes fall within $\pm 30^\circ$ of the sea-floor spreading direction, while 80% fall within $\pm 45^\circ$ of this azimuth. Two possible explanations for this

North Atlantic Seamounds

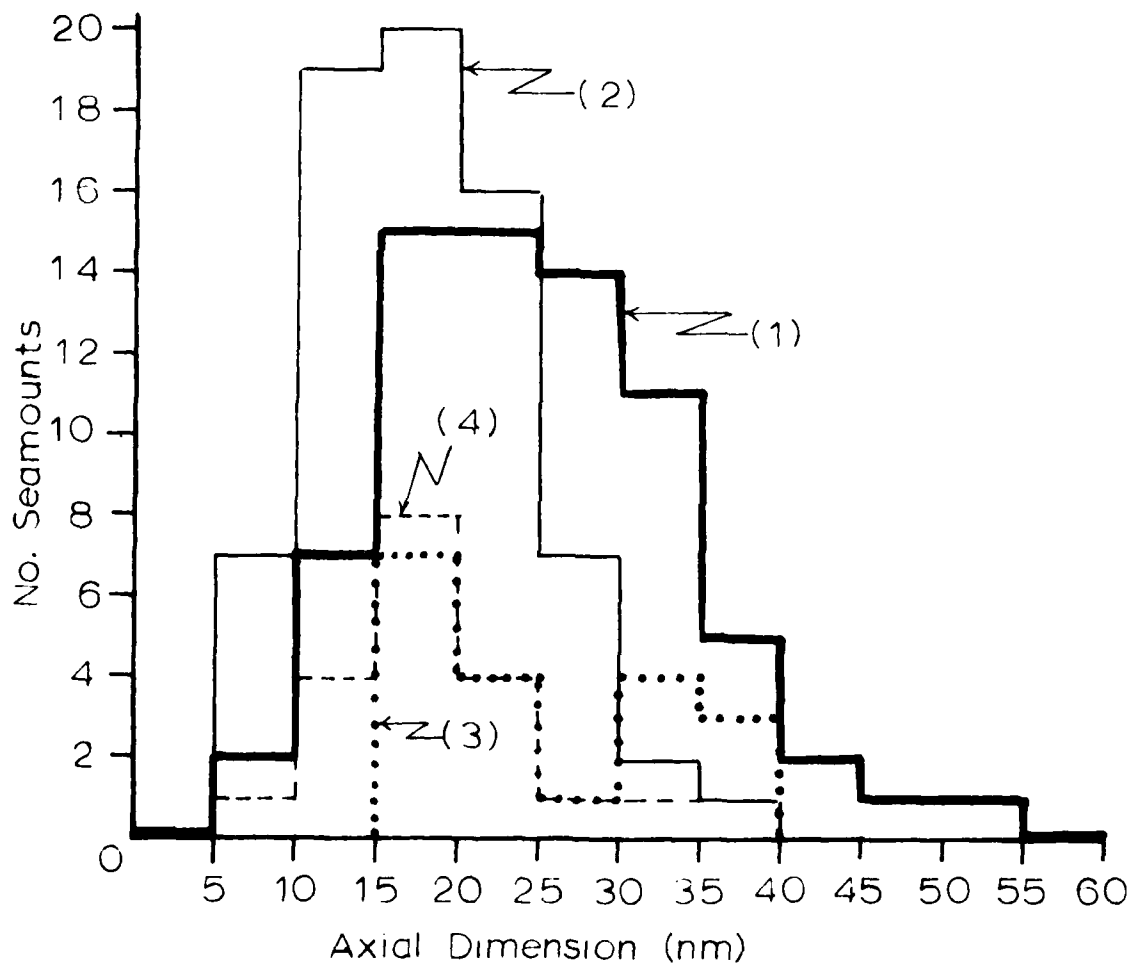


Figure 1. Histograms of North Atlantic seamound basal dimension distributions. Histogram (1) shows long axis distributions, (2) shows short axis distributions, and (3) and (4) show the same respective data for seamounds with peaks ≤ 1000 m in depth. Conical seamounds are included in the distributions.

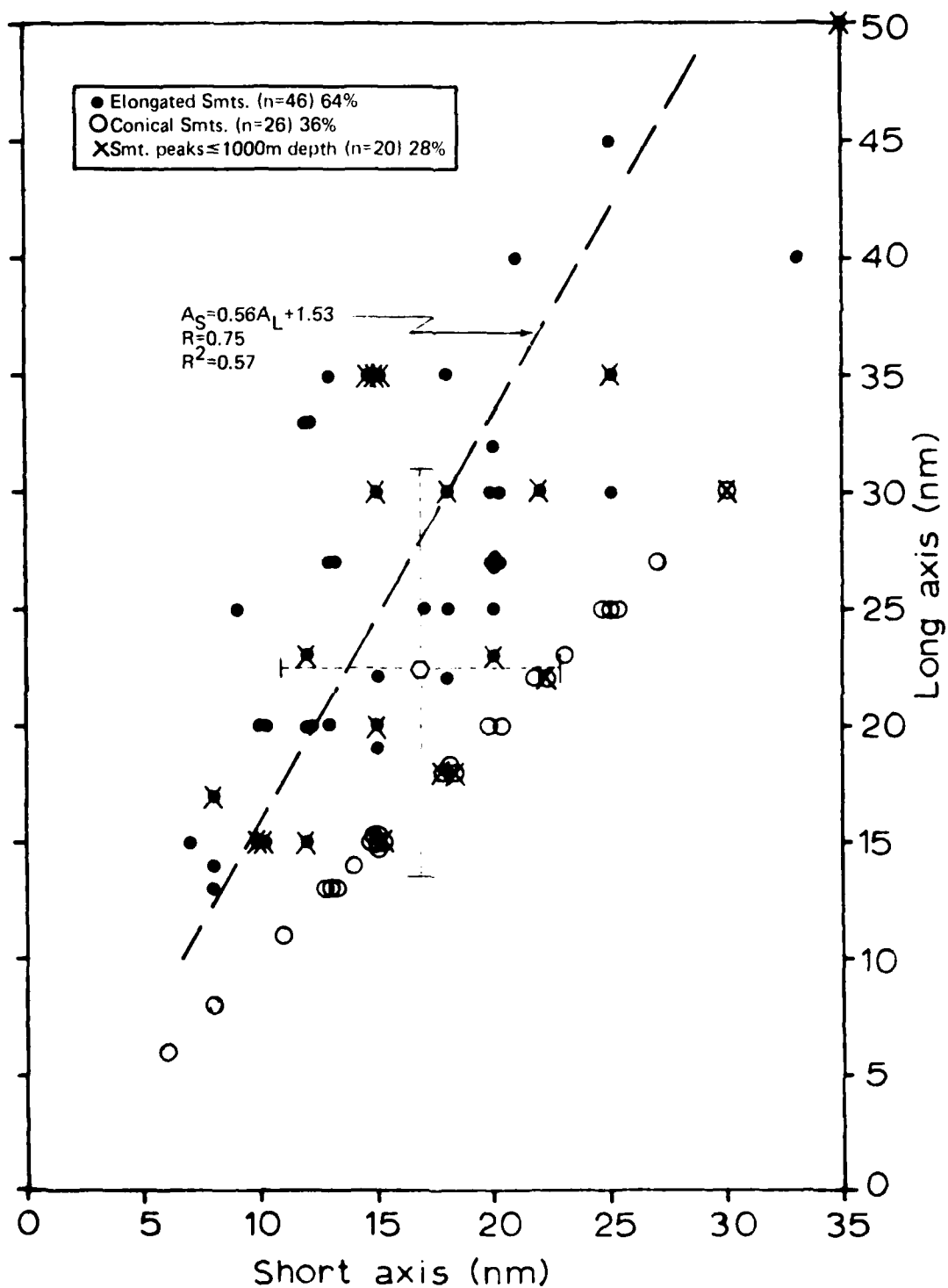


Figure 2. North Atlantic seamount short vs. long axis basal dimension plot. Mean dimension and standard deviations for all seamounts indicated by hexagon and light dashed lines, respectively. Linear regression line for elongated seamounts shown by heavy dashed line. R^2 and R are goodness of fit and correlation coefficient, respectively.

phenomenon are offered: 1) the source of the seamount-forming magma may have been stationary in the upper mantle beneath the moving oceanic crust, depositing the magma pile on progressively younger crust and elongating the seamount in the spreading direction; 2) the magma source may have been located in the oceanic crust which was moving outward and downward (due to crustal cooling and shrinkage) from the spreading axis, resulting in the outpouring magma to tend to flow "downhill" under the influence of gravity, resulting in elongation of the seamount in the spreading direction.

Figure 3 shows that the height of the average North Atlantic seamount is 2378 ± 872 (s.d.) meters and that the seamount occurs in water depths of 4092 ± 772 (s.d.) meters. Statistical tests show that there is no significant linear regression (increase in height with depth) for either all the seamounts considered together or for the conical seamounts alone. There is significant regression for those seamounts ≤ 1000 meters in depth, as shown in figure 3; but this is simply a mathematical expression of the obvious-- in order to reach within 1000 meters of the surface, heights would have to increase with depth.

In the ocean basins, crustal depths are also a function of age (Sclater, and others, 1971). The approximate age taken from their age versus depth plot for the North Atlantic is shown as one of the ordinates in figure 3. This must be considered as only a rough estimate of age due to the uncertainties involved but may prove useful in areas where crustal ages have been established by magnetic anomaly identifications.

One interesting feature of figure 3 is that there appear to be no seamounts in water depths between 2200 and 3000 meters ($\sim 2-5$ m.y. B.P.). This may, however, result from the sampling technique and should be regarded with caution.

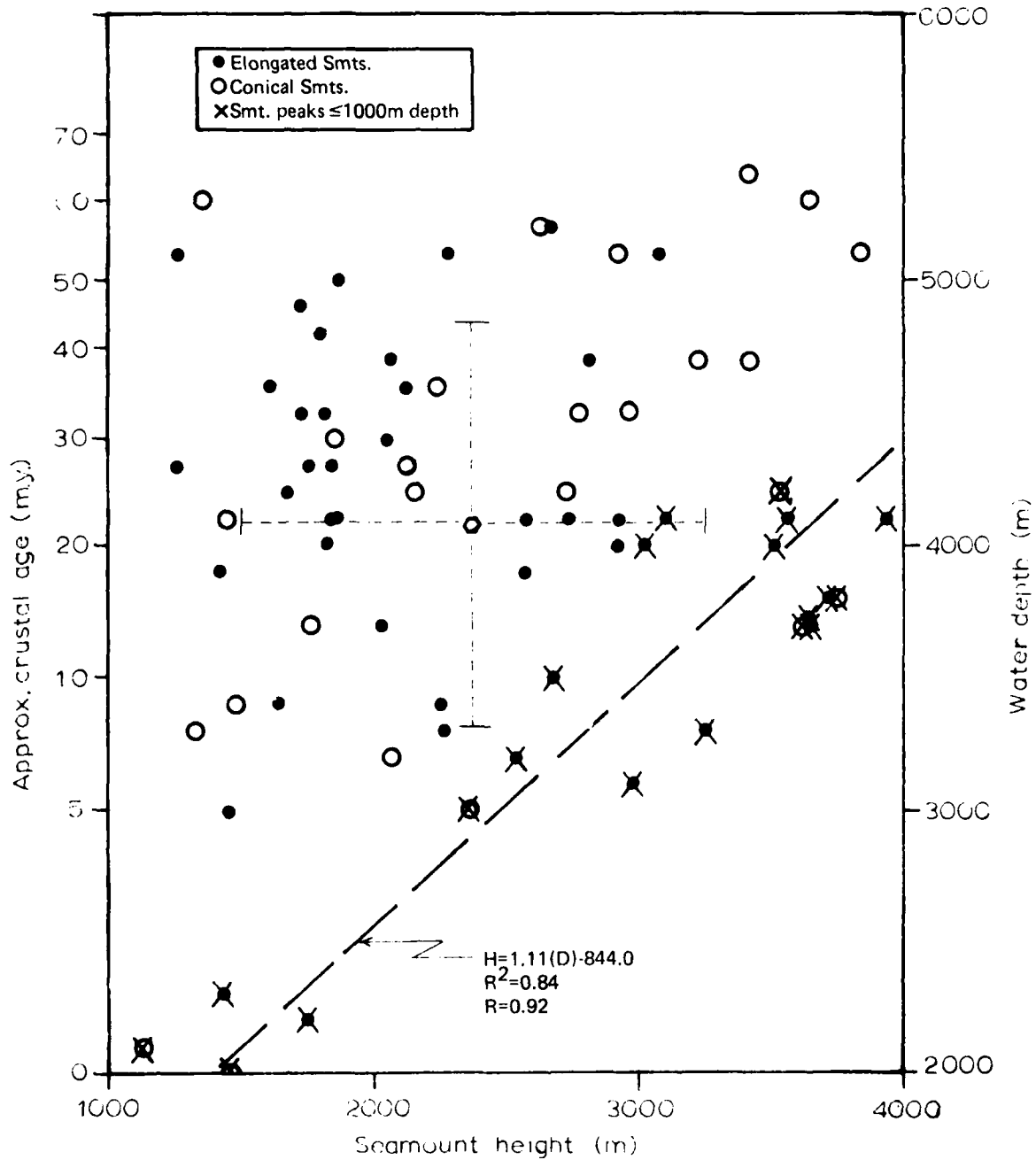


Figure 3. Seamount height vs. water depth and crustal age in the North Atlantic. Mean height/depth and standard deviations shown by hexagon and light dashed lines, respectively. Linear regression line for seamount peaks ≤ 1000 m depth shown by heavy dashed line. R^2 and R as in figure 2.

Another interesting feature is the total absence of seamounts shoaler than 1000 meters in water depths greater than 4100 meters (~ 2.5 m.y. B.P. age). It is doubtful that this phenomenon is also an artifact of the sampling technique since half the seamounts sampled were in water depths greater than 4100 meters.

The probability of encounter curves in figure 4 were developed by an empirical technique from the data of figure 1. The method consists of first normalizing the interval areas (0-5 nm, 5-10 nm, etc.) of histograms (1) and (2) of figure 1. The probability that a seamount will be encountered by a survey track spacing with a given interval is then determined by:

$$P_n = 1 + \sum_{i=0}^n (-N_i)$$

where i, \dots, n are the intervals considered
(0-5, 5-10, 10-15, etc.)

N is the normalized value of the interval,

and P_n is the probability of encounter in n intervals.

P_n is then plotted at the median point of the interval considered. Note that "encounter" means passing over any part of the seamount.

This method has an advantage in that it assumes no particular distribution (normal, chi-square, etc.) of the data but uses the actual data distribution. It does assume that the data are randomly distributed. By inspection of figure 1, this assumption seems warranted.

The curves in figure 4 give the probability of encountering a North Atlantic seamount under two conditions: 1) The long axis of elongated seamounts is perpendicular to the track, and 2) the long axis is parallel to the track. For example: A 95% probability of encounter would require an 8.5 nm spacing in case 1) and a 5 nm spacing in case 2).

To summarize some of the factors resulting from this study which will bear upon seamount survey strategy in the North Atlantic:

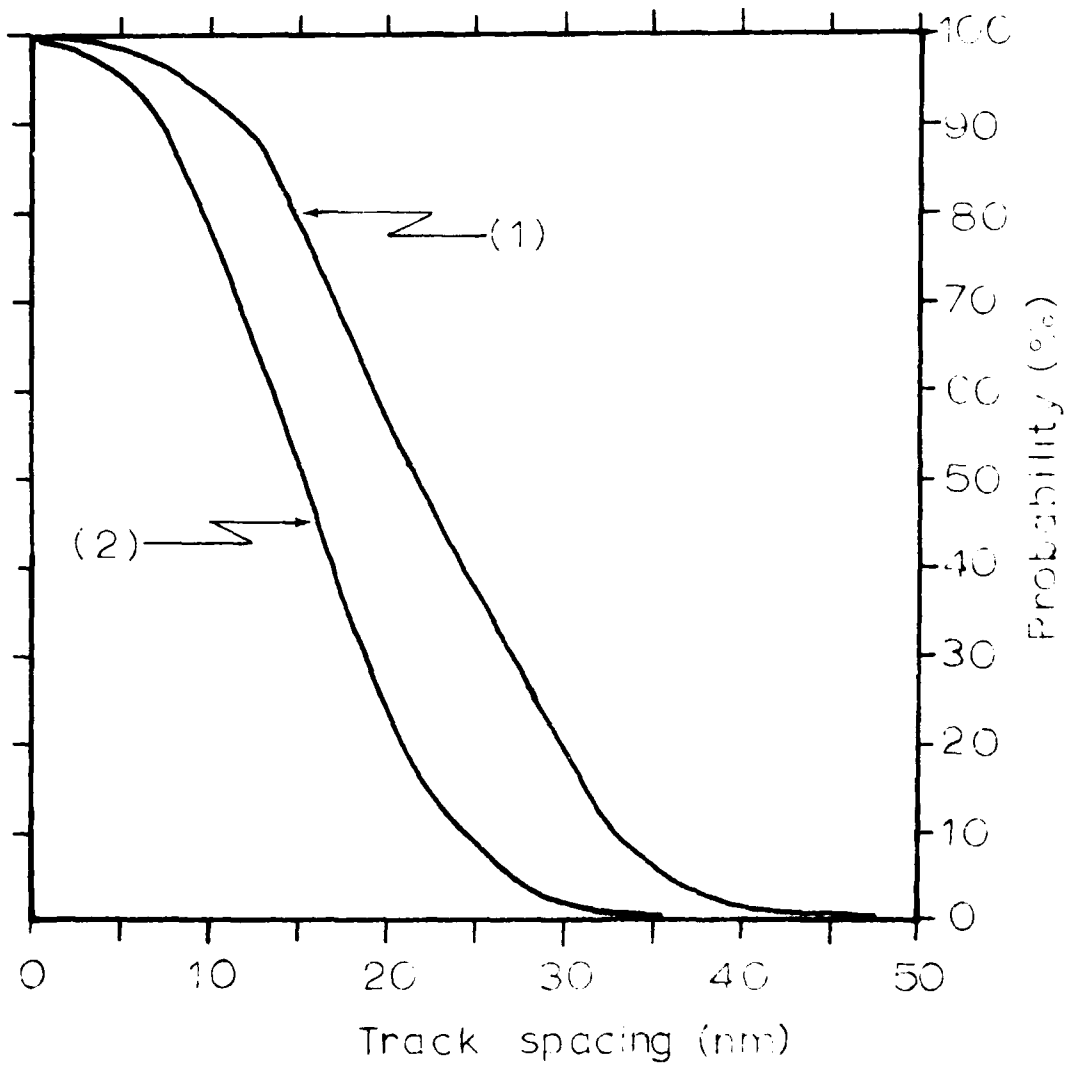


Figure 4. Percent probability (using empirical method) of encountering a North Atlantic seamount with a given track spacing. Curve (1) assumes that the long axis of elongated seamounts is normal to the track. Curve (2) assumes that the short axis is normal to the track, and includes conical seamounts.

- 1) Elongated seamounts are more prevalent in the North Atlantic than conical seamounts (65% versus 36%).
- 2) The usual ratio of long to short axes of any elongated seamount is about 1.5:1.
- 3) The azimuths of the long axes of elongated seamounts tend to fall within $\pm 45^\circ$ of the local sea-floor spreading direction; therefore, track orientation should be normal to this direction (parallel to the magnetic sea-floor spreading anomalies) to allow the maximum possible chance of encounter. These directions are quite well established in the North Atlantic, and the choice of track orientation should present no problem. An additional advantage is that the fracture zones, with their associated high-relief ridges and any associated seamounts, will also be normal to the track.
- 4) Since seamount peaks ≤ 1000 meters in depth seem to occur in water depths of less than 4100 meters, first priority should be given to surveys in these depths.
- 5) Maximum track spacing for 95% encounter probability in the North Atlantic is 5 nm if we assume the "worse case" configuration of the seamounts (all long axes parallel to the track); but as we have seen in 3), this will usually not be the case. We may therefore be justified in expanding this spacing somewhat (to about 6 nm) and still remain in the 95% confidence range.

II. NORTH PACIFIC SEAMOUNTS

Morphological data for the 100 North Pacific seamounts, selected by the same criteria as were those in the North Atlantic, are given in Appendix B. The data were extracted from the Bathymetric Atlas of the North Pacific Ocean (1973).

Figure 5 shows the distribution of the North Pacific seamount axial dimensions in 5 nm intervals as in figure 1. The long axis distribution [(1) in figure 5] is very unusual and unlike either the North Atlantic distributions or the Pacific short axes distribution. The reason for this anomalous distribution is not clear.

As in the Atlantic, elongated seamounts predominate over conical seamounts (74% to 26%). A cautionary note should be added here. Bathymetric data in the North Pacific are generally not as dense as those in the North Atlantic. Therefore, elongation of some seamounts may have resulted from cartographic license.

The plot of short versus long axial dimensions in figure 6 indicates that the mean North Pacific seamount is somewhat larger than its North Atlantic counterpart by about 2 - 3 nm. The mean basal dimensions are 19.1 ± 6.4 (s.d.) \times 26.8 ± 10.4 (s.d.) nm. As in the North Atlantic, Pacific seamount long axial dimensions are approximately 1.5 times the short axis although the linear regression fit is not quite as good.

There is also a tendency here for the long axes of elongated seamounts to align themselves in the direction of sea-floor spreading. The data in Appendix B shows that 49% of the long axes fall within $\pm 30^\circ$ of the spreading direction, while 66% fall within $\pm 45^\circ$. While these percentages are less impressive than those in the Atlantic, there does seem to be significant

North Pacific Seamounts

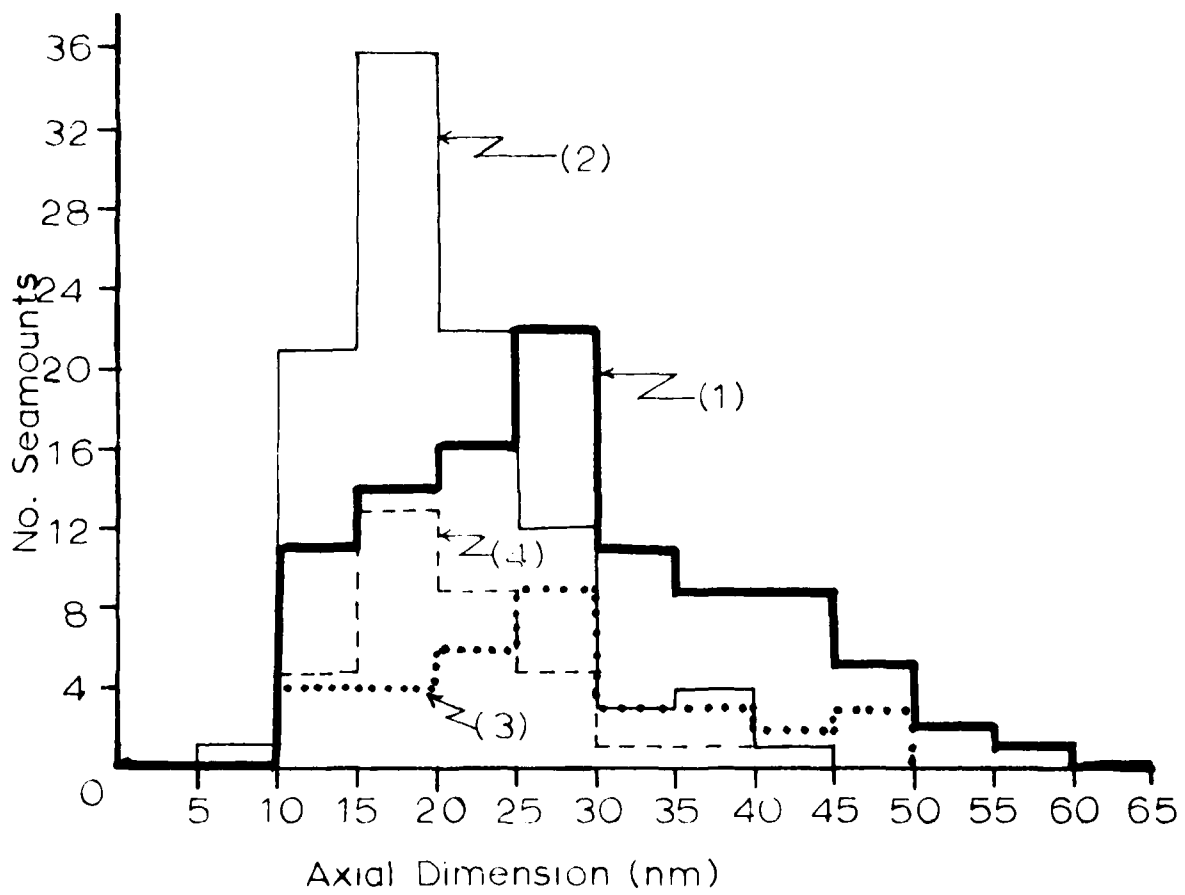


Figure 5. Histograms of North Pacific seamount basal dimension distributions. Histogram (1) shows long axis distributions, (2) shows short axis distributions, and (3) and (4) show the same respective data for seamounts with peaks ≤ 1000 m in depth. Conical seamounts are included in the distributions.

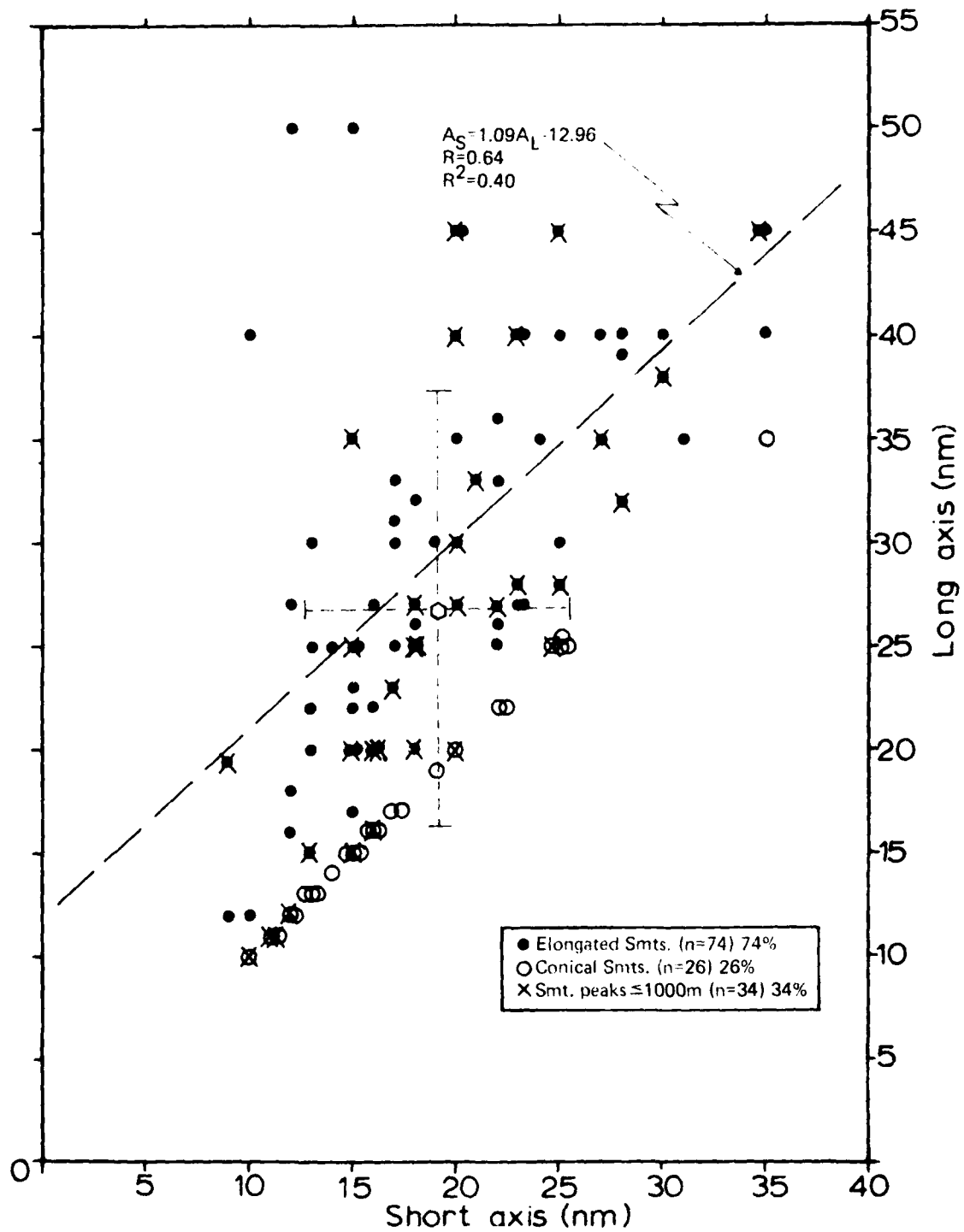


Figure 6. North Pacific seamount short vs. long axis basal dimension plot. Mean dimension and standard deviations for all seamounts indicated by hexagon and light dashed lines, respectively. Linear regression line for elongated seamounts shown by heavy dashed line. R^2 and R as in figure 2.

alignment of long axes in the spreading direction. The reasons for this alignment may be similar to those given for the Atlantic in Section I.

Unlike North Atlantic seamounts, statistical tests show that the linear regression plot of height versus depth for all the seamounts shown in figure 7 is real and significant at the 95% confidence level. It shows that there is a definite increase in seamount height with water depth (age). The reason for this phenomenon is not clear. Perhaps there has been a gradual decrease in seamount activity with time or a reactivation of the older seamounts.

Figure 7 also shows that there is no "cutoff" depth (age) for seamounts with peaks shoaler than 1000 meters as was the case in the North Atlantic for depths exceeding 4100 meters. In the Pacific, shoal seamounts are found to depths of 5700 meters.

The probability of encounter curves of figure 8 were computed by the same method as those of figure 4 from the distribution data in figure 5. The curves show that at the 95% confidence level, track spacings of 8.5 - 10.0 nm would be required for detection of North Pacific seamounts, depending on whether the assumption was made that the long axes were parallel to the track ("worse case") or normal to the track orientation.

This increased track spacing for the North Pacific relative to the North Atlantic can be attributed to the fact that the Pacific seamounts are generally larger than their Atlantic counterparts.

Again, a summary of morphological factors relating to the design of survey strategies to detect North Pacific seamounts is warranted:

- 1) As in the North Atlantic, elongated Pacific seamounts are more prevalent than conical seamounts.
- 2) The usual ratio of North Pacific long to short axes is also about 1.5:1.

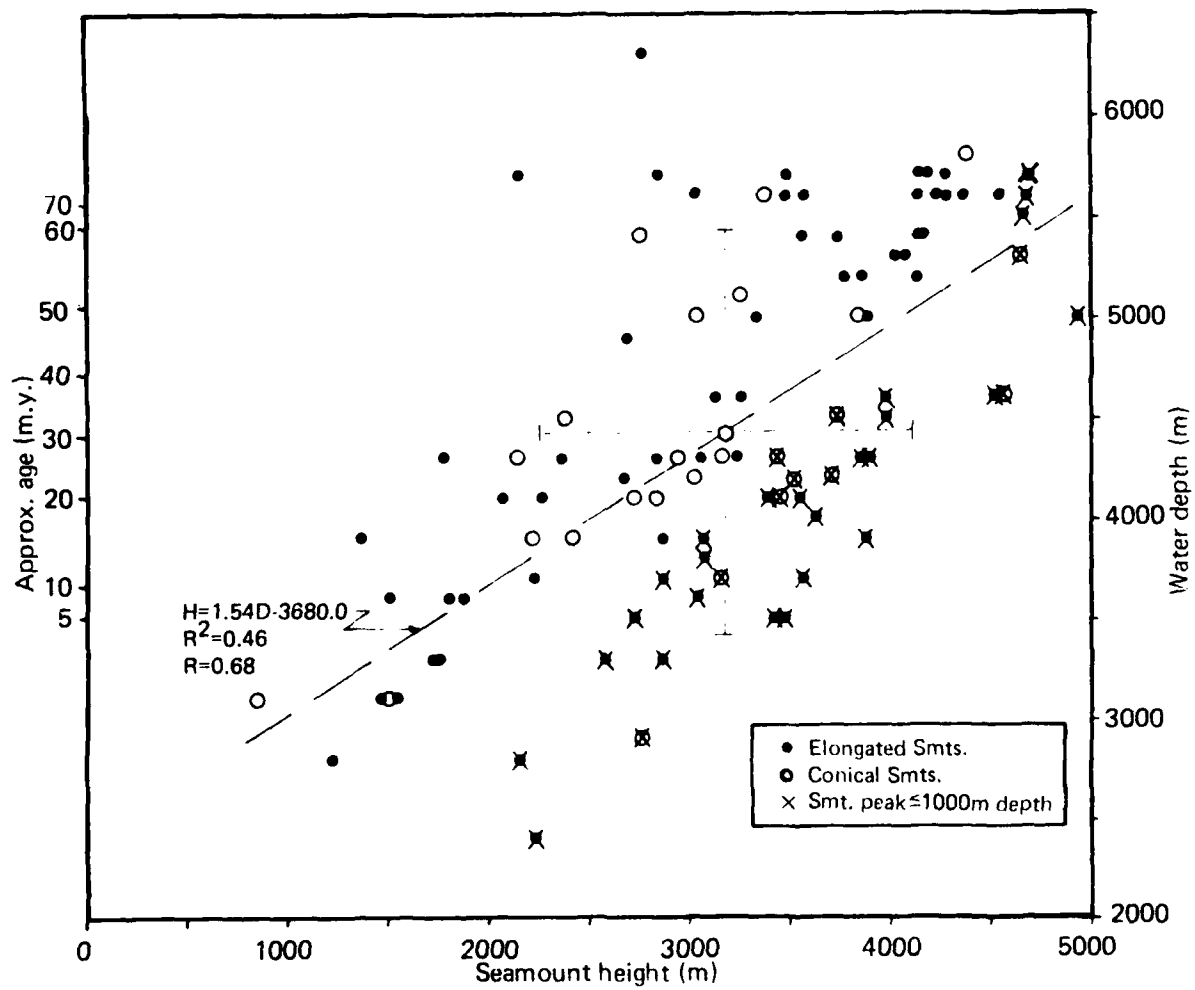


Figure 7. Seamount height vs. water depth and crustal age in the North Pacific. Mean height/depth and standard deviations shown by hexagon and light dashed lines, respectively. Linear regression line for all seamounts shown by heavy dashed line. R^2 and R as in figure 2.

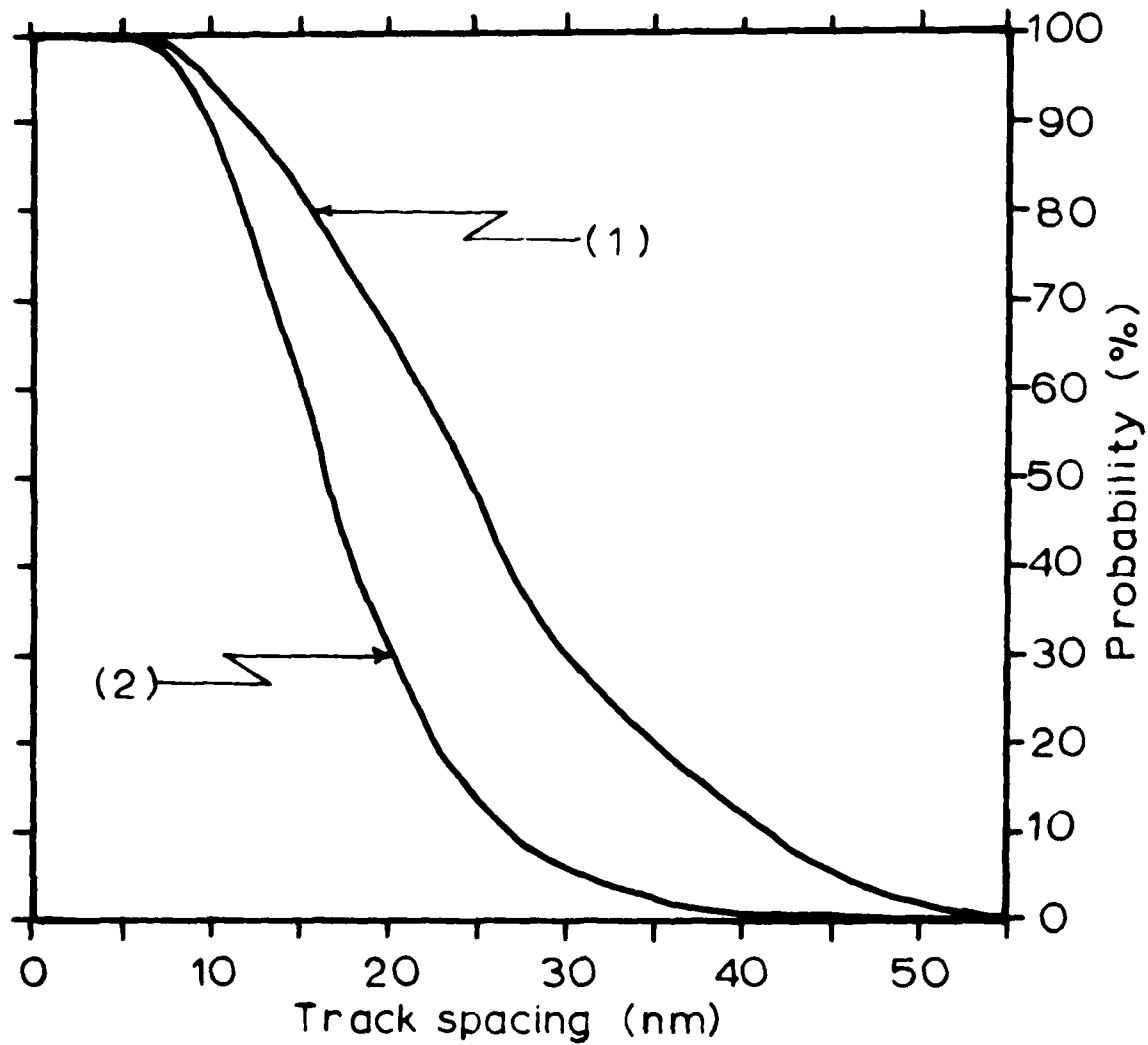


Figure 8. Percent probability (using empirical method) of encountering a North Pacific Seamount with a given track spacing. Curve (1) assumes that the long axis of elongated seamounts is normal to the track. Curve (2) assumes that the short axis is normal to the track, and includes conical seamounts.

3) Azimuths of elongated North Pacific seamount long axes tend to parallel the direction of sea-floor spreading. Survey track orientation should therefore be normal to this direction. While not nearly as well established as those in the North Atlantic, sea-floor spreading directions are known in the Pacific to a degree that will allow proper track orientation. The remarks made in the summary of Section I as to fracture zone orientations also apply here.

4) There are no indications here of a decrease in the number of shoal seamounts with depth/age--quite the contrary. There is, therefore, no reason to assign areal priorities on that basis.

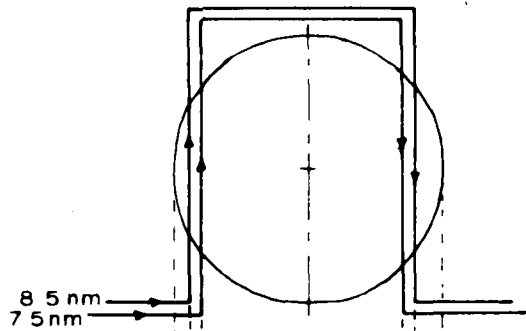
5) The maximum track spacing in the North Pacific under "worse case" conditions is 8.5 nm. However, there may be some justification for expanding this somewhat (~ 9 nm) based on the knowledge of a preferred orientation of seamount long axes normal to track. Also, the observed increase in seamount size with age/depth may allow an expansion of the track spacing in the older/deeper areas of the North Pacific.

III. LIMITATIONS AND CONCLUSIONS

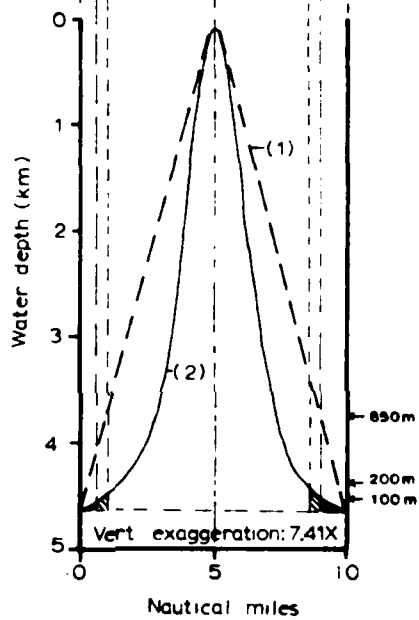
As noted earlier, the probability of encounter curves of figures 4 and 8 are predicated upon passing over any part of a given seamount. If seamounts were perfect and regular conic structures, resting on perfectly flat ocean floor, the track spacings given for various probabilities of encounter would be sufficient to positively identify any feature encountered (bathymetric or geophysical) as a seamount. Unfortunately, seamounts are neither perfect cones nor, in most cases, do they rest on perfectly flat ocean floor. The seafloor may contain features (knolls, etc.) that are indistinguishable from a flanking seamount profile. A "worse case" situation is selected to illustrate this point.

Figure 9 shows, in plan (A) and profile (B), the smallest (in basal dimensions) North Pacific seamount lying within 1000 meters of the surface. The plan view (A) shows the 8.5 nm track spacing specified for North Pacific seamounts at the 95% probability of encounter for long axis parallel to track, plotted at the worst possible encounter configuration (minimum relief encounter). If the seamount were a cone as shown in (B)-(1), the bathymetric profile would show 850 meters maximum relief (and geophysical profiles would show commensurate displacements); and there should be no problem in identifying the feature as a seamount flank. If, however, the seamount profile was as (B)-(2), which is probably a more realistic gradient (there is no single representative gradient known to this author which holds for all seamounts) for at least the deeper part of the seamount, the maximum relief encountered would be only 100 meters. If the area contains other bottom features of this magnitude and shape ("background noise"), unique identification of this feature as a seamount from this profile would be impossible.

(A)



(B)



(C)

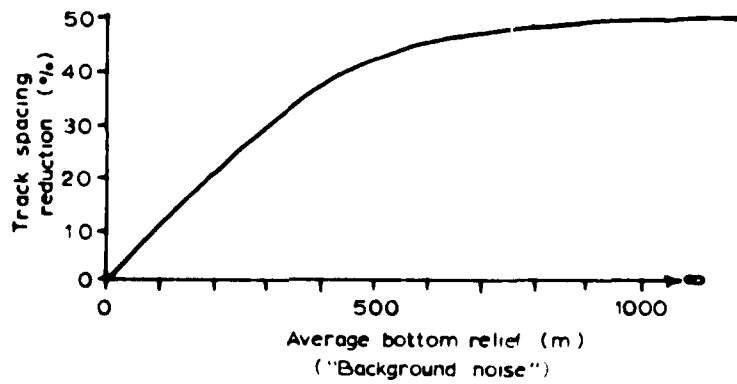


Figure 9. An example of survey track spacing reduction that may be required due to ambient bottom relief ("background noise").

By reducing the track spacing to 7.5 nm (12%), and again using a minimum relief encounter configuration [figure 9 (A)], the maximum relief now encountered is 200 meters, 100 meters above the assumed background noise; and the feature would warrant further investigation.

In figure 9 (C) an attempt is made to relate background noise to required track spacing reductions. This figure is based on several assumptions, the most dubious being that all seamount gradients approximate those shown in figure 9 (B)-(2). If these limitations are recognized, however, the principles involved may serve as a useful tool in designing approximating track spacing reduction graphs in areas of various levels of background noise. One of the more obvious conclusions to be drawn from the figure is that track spacing need never be reduced more than 50% no matter how severe the background noise.

The conclusions reached in this study as to survey track orientation (normal to the sea-floor spreading direction) will be valid for any detection method, whether echo-sounding surveys or geophysical (shipboard or airborne gravity/magnetics) surveys. The track spacings given may require modification based upon the type of detection equipment used. For example: A wide-beam sonar array survey system may allow some increase in track spacing, depending on the characteristics of the equipment used, while an airborne gravity or magnetic survey may require a decrease in the given track spacing due to the limitations imposed by the decrease in the amplitude of these potential fields by the inverse square or cube (respectively) of the distance of the sensor from the source.

Finally, unless it can be determined by some independent means that there are no seamounts present in a given areas (that is, seamounts are not randomly distributed), the track spacings indicated here (or their modifications) will

be required to ascertain the presence or absence of seamounts in the oceanic areas indicated.

REFERENCES

Sclater, J. G.; Anderson, R. H.; and Bell, M. L.; Elevation of ridges of the Central East Pacific, Jour. Geophys. Res. 76, 7888-7916, 1971.

Naval Oceanographic Office, Bathymetric Atlas of the North Pacific Ocean (U), Spec. Pub. No. 1301-2-3, 172, 1973, UNCLASSIFIED

Naval Oceanographic Office, Bathymetric Atlas of the North Atlantic Ocean (U), Spec. Pub. No. 1304, 130, 1975. CONFIDENTIAL

APPENDIX A

NORTH ATLANTIC SEAMOUNT MORPHOLOGICAL PARAMETERS

Lat. (deg.)	Long. (deg.)	Depth to Top (m)	Bottom Depth (m)	Delta Depth (m)	Short Axis (nm)	Long Axis (nm)	Long Axis Azim. (deg.)	Sea-Floor Spreading Azim. (deg.)	Delta Azim. (deg.)
00.6S	006.3E	1538	3000	1462	13	35	020	070	-50
02.5S	005.2E	2512	4200	1688	7	15	030	070	-40
03.6S	003.5E	3000	4800	1800	20	27	020	075	-55
02.8S	002.7E	3038	4300	1262	20	30	050	075	-25
02.4S	002.5E	2698	4500	1802	25	45	040	075	-35
01.8S	001.3E	2342	4600	2258	15	15	-	-	--
01.3S	001.0E	2625	4700	2075	20	27	035	070	-35
00.3S	001.7E	2486	4600	2114	10	20	050	070	-20
01.3N	002.4E	2775	4500	1725	10	20	030	070	-40
*	*	2269	4400	2131	15	15	-	-	--
*	*	1078	4000	2922	18	25	090	085	5
*	*	37	3800	3763	18	30	095	085	10
*	*	37	3700	3663	15	35	160	085	75
*	*	1528	4500	2972	22	22	-	-	--
*	*	47	3300	3253	15	35	080	085	-5
*	*	112	3100	2988	15	30	090	085	5
*	*	56	3700	3644	20	20	-	-	--
*	*	49	3700	3651	15	20	140	085	55
*	*	56	3800	3744	22	30	050	085	-35
02.9N	040.5W	1706	4500	2794	18	18	-	-	--
01.3N	040.9W	2531	4300	1769	12	33	090	095	-5
04.9N	027.6W	1222	4100	2878	12	33	090	085	5
06.1N	024.9W	1462	4300	2838	20	27	045	085	-40
06.3N	022.7W	1320	3900	2580	17	25	100	085	15
06.9N	021.9W	1140	3400	2260	33	40	085	085	0
07.3N	022.2W	2325	4100	1775	21	40	070	085	-5
07.9N	021.9W	1359	4100	2741	18	35	065	085	-20
08.4N	020.7W	534	4100	3566	12	15	100	085	15
07.3N	021.4W	1940	3700	1760	14	14	-	-	--
08.4N	021.3W	2051	4200	2149	13	13	-	-	--

APPENDIX A (Cont'd.)

Lat. (deg.)	Long. (deg.)	Depth to Top (m)	Bottom Depth (m)	Delta Depth (m)	Short Axis (nm)	Long Axis (nm)	Long Axis Azim. (deg.)	Sea-Floor Spreading Azim. (deg.)	Delta Azim. (deg.)
08.4N	020.7W	2656	4100	1444	8	8	-	-	--
08.8N	020.1W	1188	4100	2912	15	22	010	085	-75
05.6N	033.0W	1905	3400	1495	15	15	-	-	--
08.6N	042.9W	3187	4900	1713	20	30	090	095	-5
15.3N	021.9W	488	4000	3512	20	23	010	110	-100
10.5N	024.2W	3938	5300	1362	25	25	-	-	--
*	*	2192	4000	1808	27	27	-	-	--
*	*	3113	5000	1887	12	20	085	105	-20
*	*	1275	4700	3425	20	20	-	-	--
*	*	2810	5100	2290	18	22	055	105	-50
*	*	994	4100	3106	20	27	160	115	45
*	*	1511	4100	2589	20	32	010	110	-100
*	*	979	4000	3021	35	50	140	105	35
*	*	169	4100	3931	25	35	075	105	-30
*	*	671	4200	3529	18	18	-	-	--
*	*	806	3500	2694	12	23	100	085	15
33.5N	057.0W	2531	5200	2669	25	30	145	120	25
34.4N	052.5W	1968	5400	3432	23	23	125	125	0
*	*	1894	4700	2806	20	25	150	130	20
*	*	2343	4400	2057	12	20	155	130	25
*	*	1479	4200	2721	13	13	-	-	--
*	*	1650	5300	3650	25	25	-	-	--
*	*	1269	5100	3831	25	25	-	-	--
*	*	2010	5100	3090	13	20	035	135	-100
*	*	1471	4700	3229	22	22	-	-	--
*	*	2193	5100	2907	15	15	-	-	--
*	*	2531	5200	2669	13	13	-	-	--
*	*	619	3000	2381	15	15	-	-	--
*	*	1127	3200	2073	11	11	-	-	--
41.1N	052.7W	3827	5100	1273	8	14	130	085	45
*	*	2999	4600	1601	9	25	060	085	-25
47.7N	041.6W	2548	4400	1852	15	15	-	-	--

APPENDIX A (Cont'd.)

Lat. (deg.)	Long. (deg.)	Depth to Top (m)	Bottom Depth (m)	Delta Depth (m)	Short Axis (nm)	Long Axis (nm)	Long Axis Azim. (deg.)	Sea-Floor Spreading Azim. (deg.)	Delta Azim. (deg.)
08.4N	020.7W	2656	4100	1444	8	8	-	-	--
08.8N	020.1W	1188	4100	2912	15	22	010	085	-75
05.6N	033.0W	1905	3400	1495	15	15	-	-	--
08.6N	042.9W	3187	4900	1713	20	30	090	095	-5
15.3N	021.9W	488	4000	3512	20	23	010	110	-100
10.5N	024.2W	3938	5300	1362	25	25	-	-	--
*	*	2192	4000	1808	27	27	-	-	--
*	*	3113	5000	1887	12	20	085	105	-20
*	*	1275	4700	3425	20	20	-	-	--
*	*	2810	5100	2290	18	22	055	105	-50

* Only UNCLASSIFIED geographic locations listed.

APPENDIX B

NORTH PACIFIC SEAMOUNT MORPHOLOGICAL PARAMETERS

Lat. (deg.)	Long. (deg.)	Depth to Top (m)	Bottom Depth (m)	Delta Depth (m)	Short Axis (mm)	Long Axis (mm)	Long Axis Azim. (deg.)	Sea-Floor Spreading Azim. (deg.)	Delta Azim. (deg.)
03.3N	090.8W	176	2400	2224	15	20	115	180	-65
10.0N	108.8W	93	3500	3407	18	25	090	080	10
08.5N	107.0W	2000	3500	1500	17	31	150	080	70
06.0N	104.8W	1700	3500	1800	13	25	095	080	0
14.3N	107.1W	1611	3500	1889	20	30	095	080	15
14.1N	108.7W	2518	3900	1382	12	50	085	090	-5
12.9N	103.5W	1630	3100	1470	13	30	035	080	-45
13.4N	102.6W	1600	3100	1500	13	13	-	-	--
18.5	109.6W	2260	3200	940	15	15	-	-	--
21.6N	108.4W	1593	2800	1207	10	12	020	105	-85
19.6N	108.1W	1593	3100	1507	12	27	070	100	-30
06.9N	111.1W	815	3900	3085	16	20	025	080	-55
06.4N	111.1W	824	3700	2876	25	45	070	090	-20
16.9N	117.5W	28	3500	3472	17	23	100	100	0
13.5N	119.9W	524	4500	3976	21	33	090	080	10
16.6N	114.8W	552	3700	3148	11	11	-	-	--
10.5N	115.1W	1185	4200	3015	19	19	-	-	--
10.1N	111.5W	756	3500	2744	15	35	080	080	0
16.2N	111.6W	639	2800	2161	15	25	140	100	40
15.2N	111.3W	1574	3300	1726	18	32	060	095	-35
15.4N	110.9W	417	3300	2883	22	27	070	095	-25
13.3N	110.5W	1445	3700	2225	15	50	150	090	60
21.0N	119.3W	1491	3900	2409	12	12	-	-	--
20.6N	116.7W	1689	3900	2211	13	13	-	-	--
18.2N	111.9W	1565	3300	1735	10	40	070	100	-30
25.3N	119.6W	393	4000	3607	18	20	040	080	-40
27.7N	119.3W	1018	3900	2882	18	26	040	080	-40
24.6N	117.1W	704	3800	3096	13	15	010	075	-65

APPENDIX B (Cont'd.)

Lat. (deg.)	Long. (deg.)	Depth to Top (m)	Bottom Depth (m)	Delta Depth (m)	Short Axis (nm)	Long Axis (nm)	Long Axis Azim. (deg.)	Sea-Floor Spreading Azim. (deg.)	Delta Azim. (deg.)
24.9N	115.9W	111	3700	3589	23	40	055	075	-20
26.2N	115.0W	704	3300	2596	18	25	120	080	40
14.6N	124.3W	2519	4300	1781	12	16	130	080	50
22.6N	127.5W	2160	4300	2140	22	22	-	-	-
20.4N	121.5W	1361	4300	2939	16	16	-	-	-
17.8N	123.8W	496	4200	3704	16	16	-	-	-
17.7N	124.1W	695	4200	3505	16	16	-	-	-
20.3N	121.5W	1361	4100	2739	16	16	-	-	-
25.0N	121.7W	704	4100	3396	27	35	000	085	-85
23.1N	125.1W	648	4100	3452	12	12	-	-	-
27.1N	123.0W	2037	4100	2063	14	25	040	080	-40
27.5N	122.8W	1837	4100	2263	16	27	065	080	-15
32.3N	127.8W	445	4300	3855	23	28	080	080	0
32.2N	127.3W	1141	4300	3159	17	17	-	-	-
32.1N	126.9W	865	4300	3435	20	20	-	-	-
31.8N	126.3W	1148	4300	3152	15	17	100	090	10
30.5N	122.7W	556	4100	3544	16	20	060	080	-20
30.6N	123.2W	1282	4100	2818	17	17	-	-	-
33.1N	121.0W	559	3600	3041	18	27	020	080	-60
40.9N	128.9W	1190	3200	2010	9	12	030	100	-70
00.0N	134.8W	1524	4200	2676	31	35	010	070	-60
22.5N	131.1W	1333	4600	3267	13	20	105	090	15
28.9N	135.8W	1478	4300	2822	15	22	105	85	20
32.8N	132.5W	417	4300	3833	20	30	120	85	35
39.0N	131.1W	1945	4300	2355	13	22	150	85	65
28.0N	137.5E	1094	4300	3206	15	25	140	155	-15
24.5N	135.2E	1483	4600	3117	16	22	040	155	-115
19.1N	133.7E	2222	5700	3478	12	18	145	150	-5
04.7N	130.8E	787	4500	3713	15	15	-	-	-
40.6N	146.9E	1346	5200	3854	16	20	165	165	0
40.9N	144.9E	3543	6300	2757	15	20	085	165	-80
35.8N	144.3E	1418	5700	4282	22	26	035	155	-120

APPENDIX B (Cont'd.)

Lat. (deg.)	Long. (deg.)	Depth to Top (m)	Bottom Depth (m)	Delta Depth (m)	Short Axis (mm)	Long Axis (mm)	Long Axis Azim. (deg.)	Sea-Floor Spreading Azim. (deg.)	Delta Azim. (deg.)
32.8N	148.4E	1422	5800	4378	25	25	-	-	--
23.8N	148.8E	1000	5700	4700	28	32	045	050	-5
27.3N	145.2E	76	5000	4924	20	27	005	150	-145
12.5N	149.6E	2593	5600	3007	17	25	035	045	-10
12.2N	146.6E	926	5600	4674	25	28	145	?	?
05.5N	149.2E	9	3900	3891	20	40	100	?	?
29.4N	153.5E	1333	5600	4267	30	40	120	155	-35
31.6N	151.2E	1393	5600	4207	25	30	130	155	-25
26.5N	152.1E	2037	5600	3563	22	36	045	045	0
18.6N	158.2E	1482	5600	4118	20	35	050	045	5
21.3N	153.2E	1074	5600	4526	27	40	055	045	10
19.2N	152.8E	1296	5400	4134	24	35	050	045	10
15.7N	152.1E	1250	5600	4350	28	40	155	?	?
11.2N	159.3E	1852	5400	3548	22	33	150	?	?
14.4N	155.8E	1574	5700	4126	23	40	025	?	?
07.0N	156.9E	2130	4500	2370	15	15	-	-	--
39.8N	166.5E	2654	5400	2746	22	22	-	-	--
27.9N	168.9E	1518	5700	4182	23	27	050	045	5
24.9N	165.6E	3574	5700	2126	17	33	030	050	-20
23.6N	168.8E	2871	5700	2829	15	23	050	060	-10
19.4N	166.0E	1120	5300	4180	22	25	085	050	35
21.2N	166.5E	1185	5000	3815	35	35	-	-	--
19.8N	164.9E	1409	5200	3791	40	55	165	050	115
07.8N	163.1E	1203	4900	3697	35	40	015	?	?
08.8N	163.1E	1111	5000	3884	35	45	165	?	?
32.6N	178.8E	1667	5000	3333	15	20	015	050	-35
34.0N	178.1E	1118	2900	2782	11	11	-	-	--
29.2N	175.7E	1852	5100	3248	25	25	-	-	--
28.2N	178.0E	1981	5000	3019	13	13	-	-	--
22.1N	171.6E	1281	5400	4119	23	27	140	040	100
22.7N	176.5E	1685	5400	3715	28	39	050	050	0
13.1N	179.3E	2130	5600	3470	25	40	065	060	5

APPENDIX B (cont'd.)

Lat. (deg.)	Long. (deg.)	Depth to Top (m)	Bottom Depth (m)	Delta Depth (m)	Short Axis (nm)	Long Axis (nm)	Long Axis Azim. (deg.)	Sea-Floor Spreading Azim. (deg.)	Delta Azim. (deg.)
13.4N	179.9E	2222	5600	3378	14	14	-	-	--
05.9N	173.3E	15	4600	4585	10	10	-	-	--
29.8N	174.0W	648	5300	4652	25	25	-	-	--
30.7N	173.1W	1074	5200	4126	17	30	160	070	90
28.0N	171.1W	604	4600	3996	20	45	135	070	65
28.6N	176.7W	65	4700	4535	30	38	155	070	85
13.5N	173.4W	852	5000	4648	35	45	165	025	140
01.0	179.4W	1296	5300	4004	20	45	080	170	-90

DISTRIBUTION LIST

ONR	2
CNO (OP-212, PME-124)	4
COMNAVOCEANCOM	3
NORDA (330)	4
NRL (8100)	4
Western Electric	2
DTIC	12

**DATE
FILMED
- 8**