SEAGRANT 70-2

HIG 70-10

RECONNAISSANCE SAND INVENTORY: OFF LEEWARD OAHU

By

J. F. CAMPBELL, W. T. COULBOURN, R. MOBERLY, JR.,
and
B. R. ROSENDAHL

JUNE 1970

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HAWAII INSTITUTE OF GEOPHYSICS

UNIVERSITY OF HAWAII

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ABSTRACT

The southern and western coasts of Oahu have been surveyed for shallow-water sand bodies, using a seismic reflection technique. Sand bodies discovered and mapped in water depths of between 60 and 400 feet contain about 370 million cubic yards of sand. Samples from a few locations were of fine-grained calcareous sand that was similar to, but finer than, most Hawaiian beach sands. The reconnaissance survey points to several localities where detailed sampling and mapping are warranted.

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ILLUSTRATIONS

Location

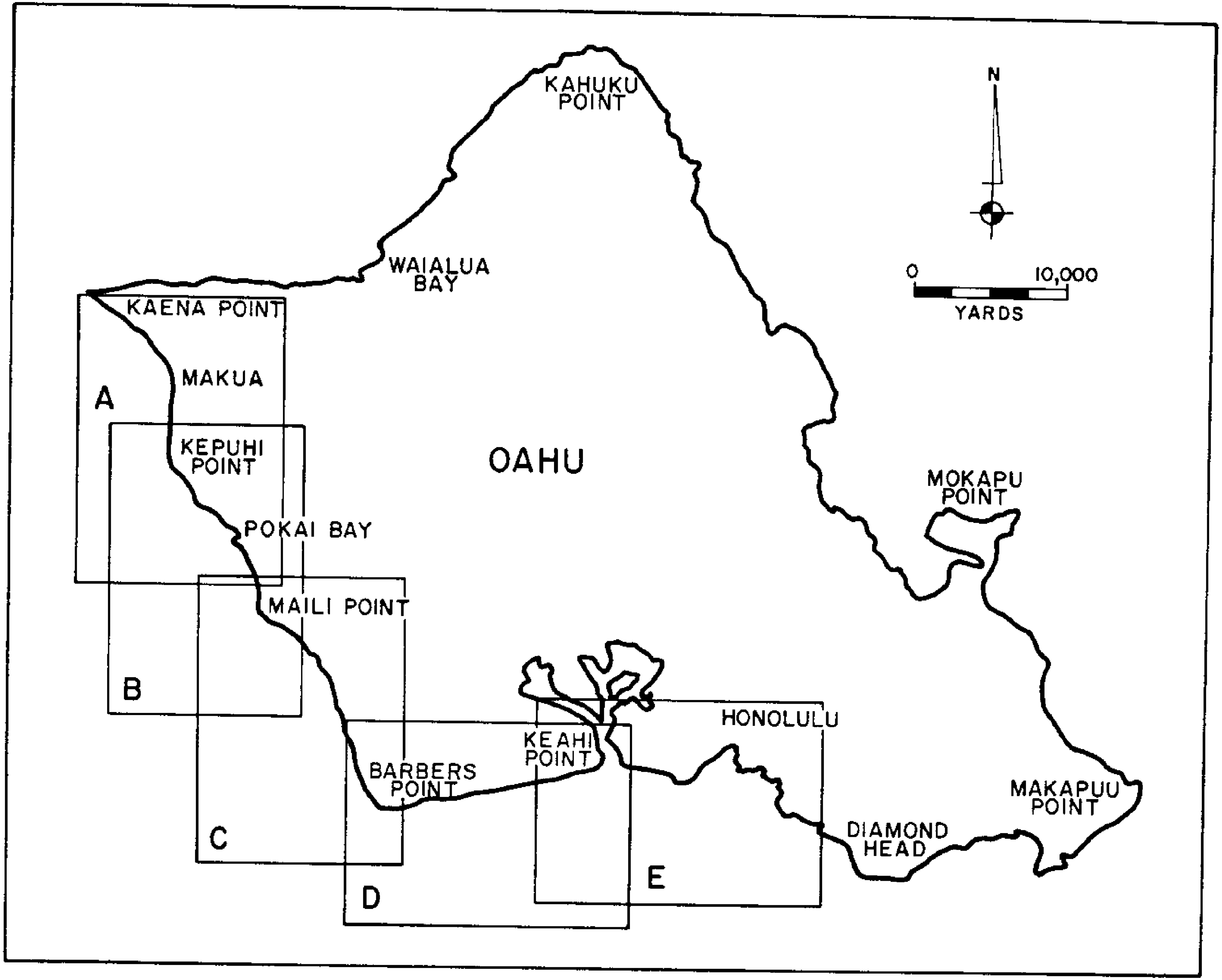
The leeward coast of Oahu from Makua to the entrance to Honolulu Harbor has been surveyed. This section of coastline, approximately 30 miles long, has been divided into five sectors for the purpose of this report (Fig. 1). These sectors are: Makua to Kepuhi Point, Kepuhi Point to Maili Point, Maili Point to Barbers Point, Barbers Point to Keahi Point and Keahi Point to the main, or eastern, entrance to Honolulu Harbor. Figures 2A-2E show the individual sectors with the location of the ship tracks. The ship generally moved in a zig-zag pattern, crossing in and out of shallow water. Altogether 69 crossings resulted in useful seismic profiles of the area inclosed by the 60- and 300-foot contours.

Methods

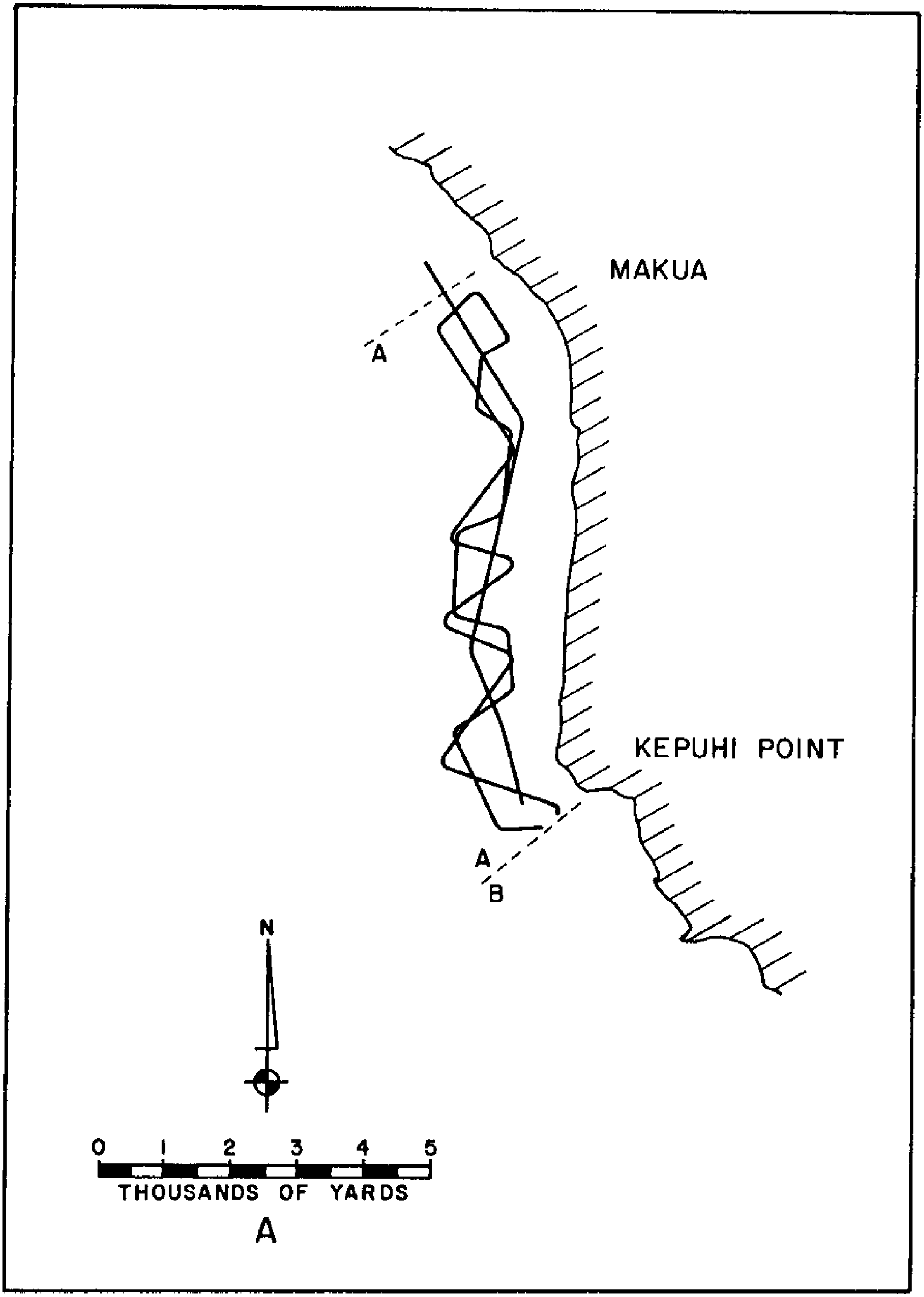
Prior to surveying the area, aerial photographs and available sampling charts were analyzed to determine areas of sand. Submarine sand bodies are commonly visible on aerial photographs to depths of 20 or 30 feet. Outlines of sandy areas were transferred to a common scale and plotted on a chart of the waters near the island of Oahu. These bodies, generally large sand-bottomed channels, are located off some of the larger beaches in the area and are believed to fill channels that were cut through the reefs during late Pleistocene times when sea level was lower than at present (Moberly, 1968). Sand moving through these channels to deeper water is completely lost to the beach system and is therefore of prime interest for any offshore sand mining operation. Sand channels located by this method are indicated on Figures 3A-3E.

The U. S. Coast and Geodetic Survey boat sheets showing their sample locations around Oahu and the type of bottom, e.g., sand, rock, etc., were examined and areas of sandy bottom were marked off and transferred to the same chart as the air photo results. The area covered by sand bottom was then measured and a minimum figure for the island of Oahu obtained. This was 10^7 square yards. In the area covered by this report the area of sandy bottom amounted to 1.7×10^6 square yards.

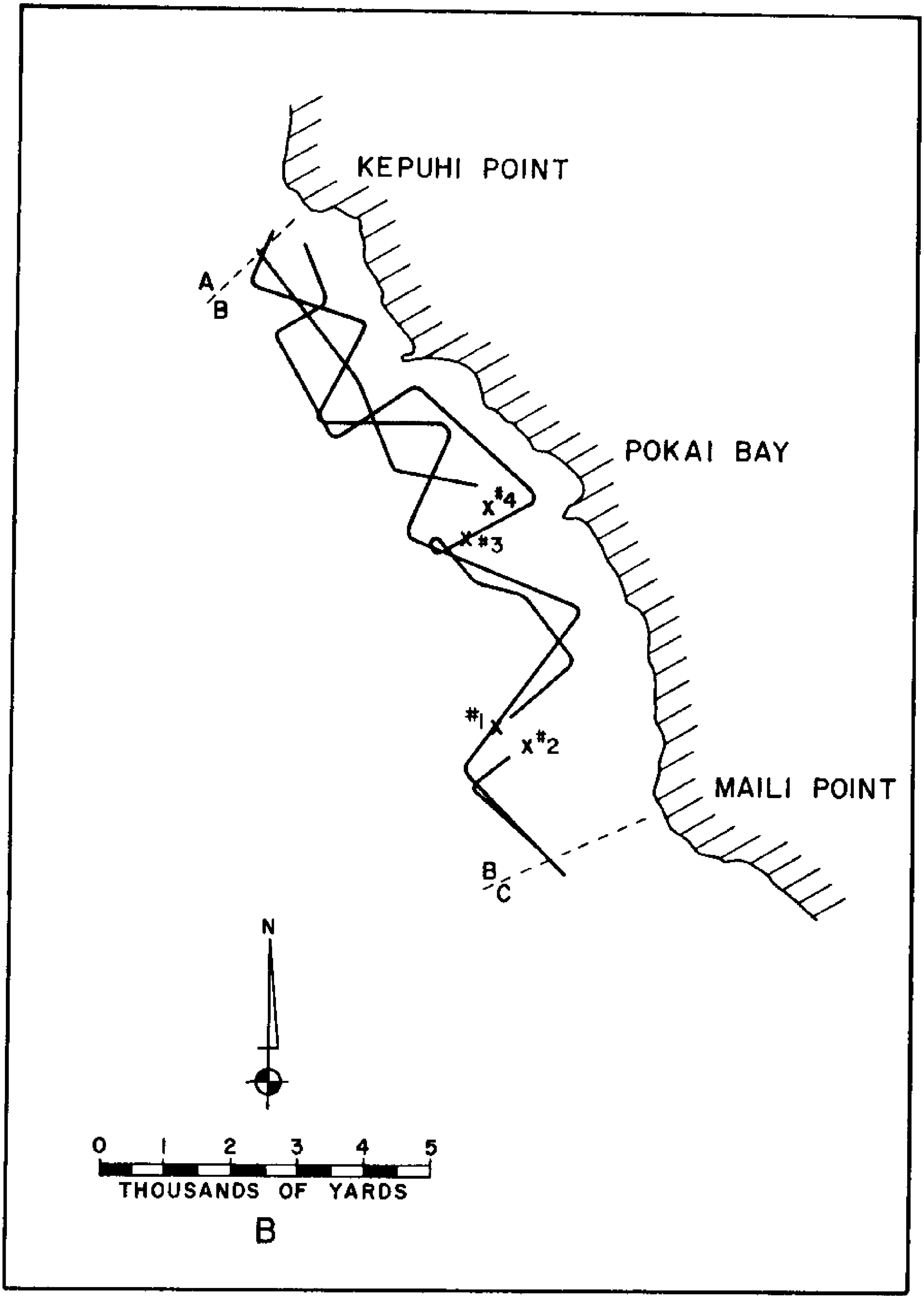
Next a reconnaissance survey using a sparker-type seismic reflection system of the Hawaii Institute of Geophysics (Kroenke and Woollard, 1966) was made. Basically the system consists of an EG&G sparker, an Alpine wet-paper recorder, a 25-foot towed hydrophone array, two Hewlett-Packard differential amplifiers, and two Khronhite filters. Figure 4 shows a schematic arrangement of the equipment. For this survey the sparker was operated at half-power, 500 joules, with a repetition rate of 0.5 second. A window between 200 and 500 Hz was set with the filters. The length of the outgoing pulse was about 20 msec. Working in water depths shallower than 60 feet was therefore a problem, because the reflection of the bottom was masked by the outgoing pulse and so could not be seen on the record. This difficulty with the outgoing pulse-length also limited our ability to interpret the minimum thickness of sand shown on the profiles. If the sub-bottom reflector is parallel to the bottom, a thickness of greater than 60 feet is needed to delineate clearly the sub-bottom surface. However, where the sub-bottom surface is at some angle to the bottom, the bottom and sub-bottom reflections can be traced with sufficient confidence that sediment as thin as 5 feet can be mapped.



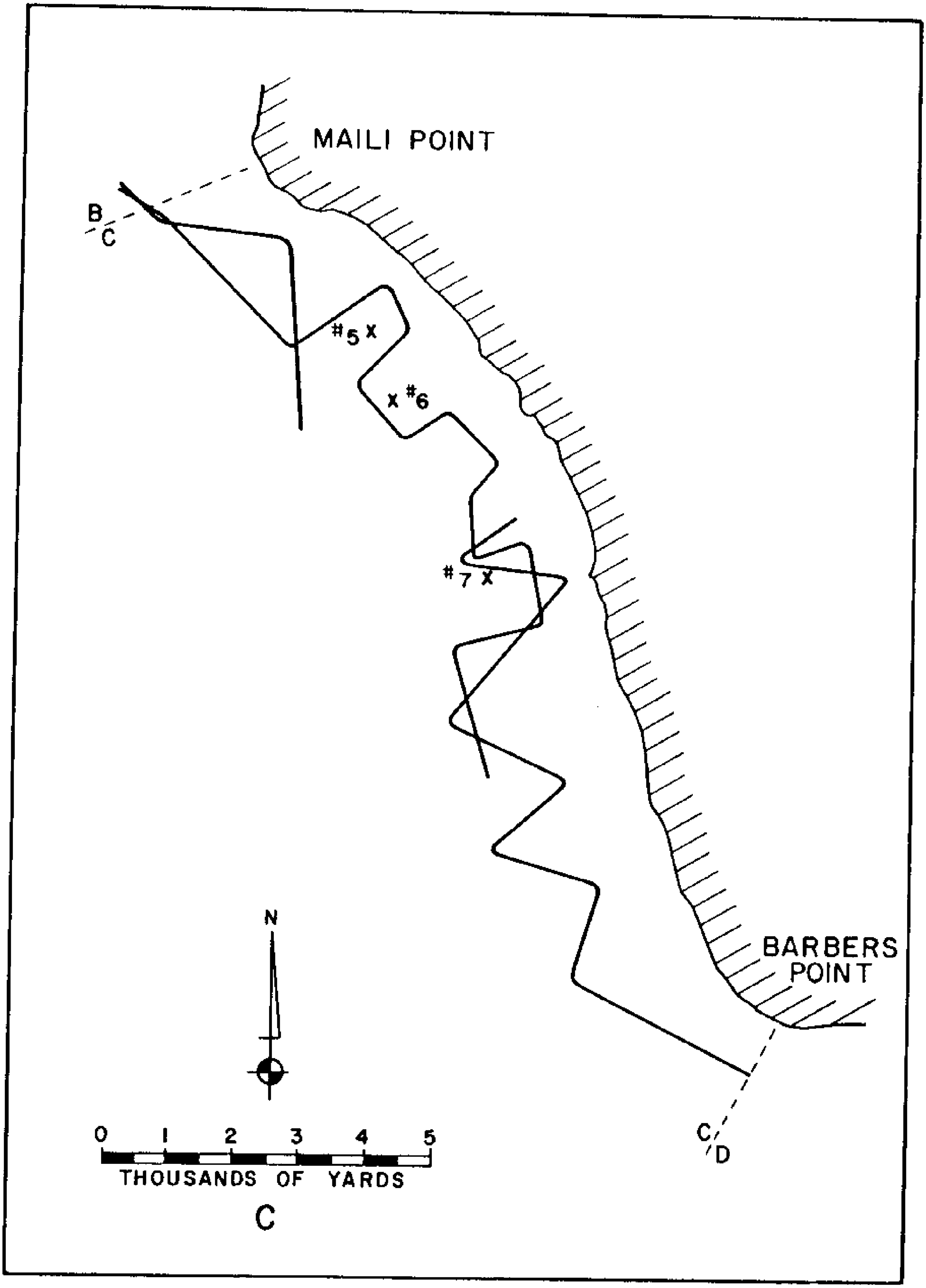
1. Map of Oahu, Hawaii, showing sectors of reconnaissance surveys.



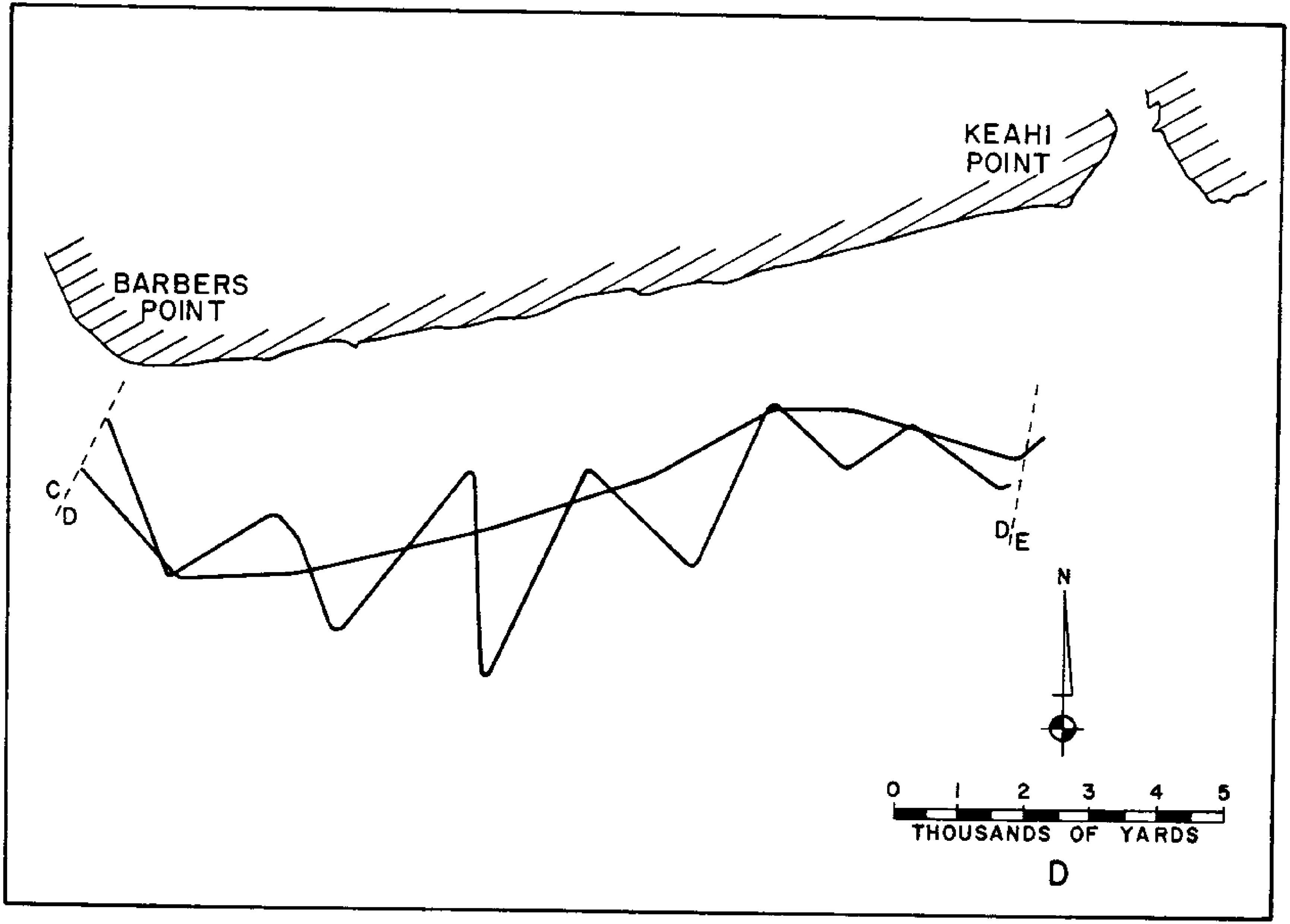
2A. Ship tracks between Makua and Kepuhi Point, leeward Oahu.



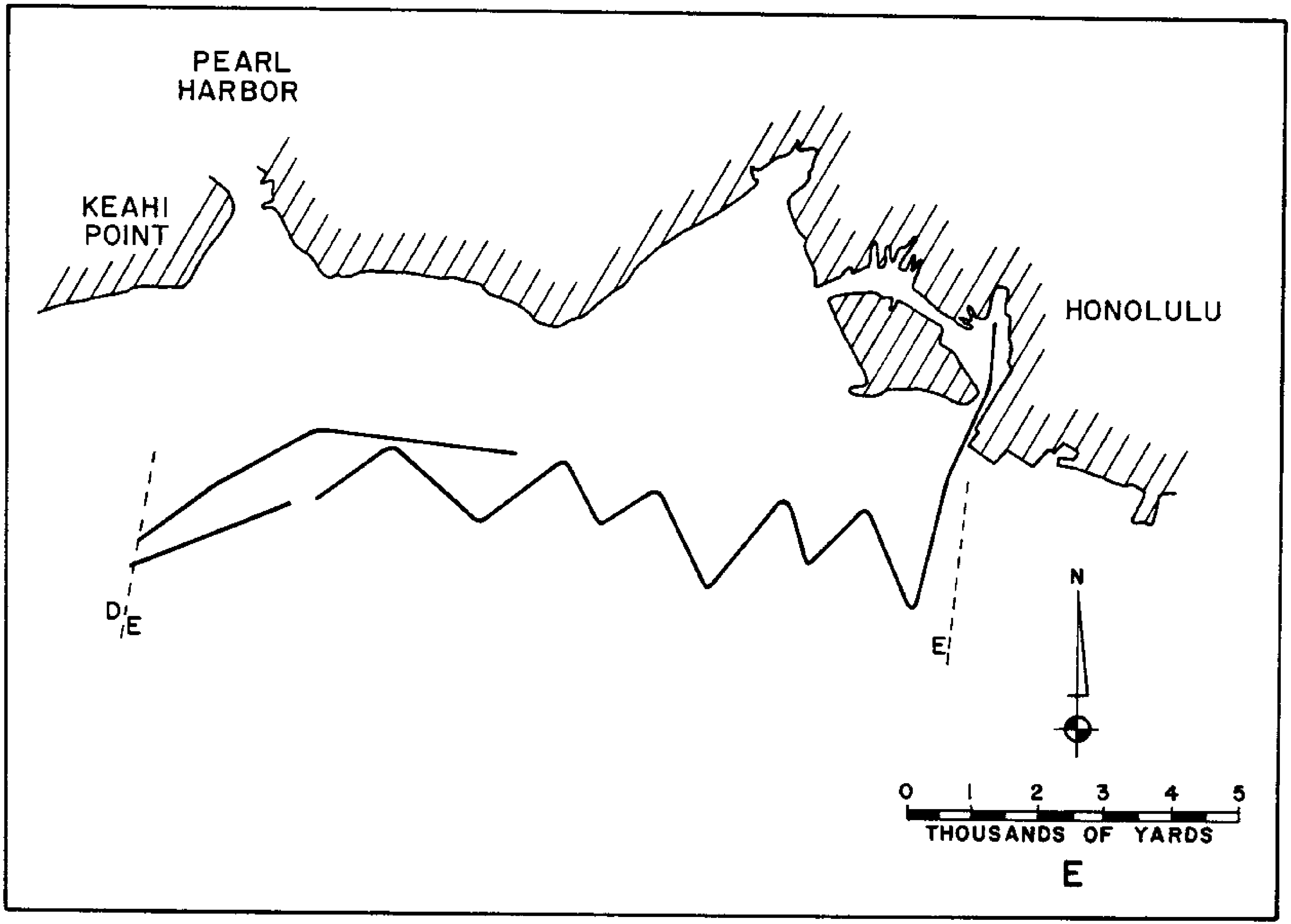
2B. Ship tracks and sample locations between Kepuhi Point and Maili Point, leeward Oahu.



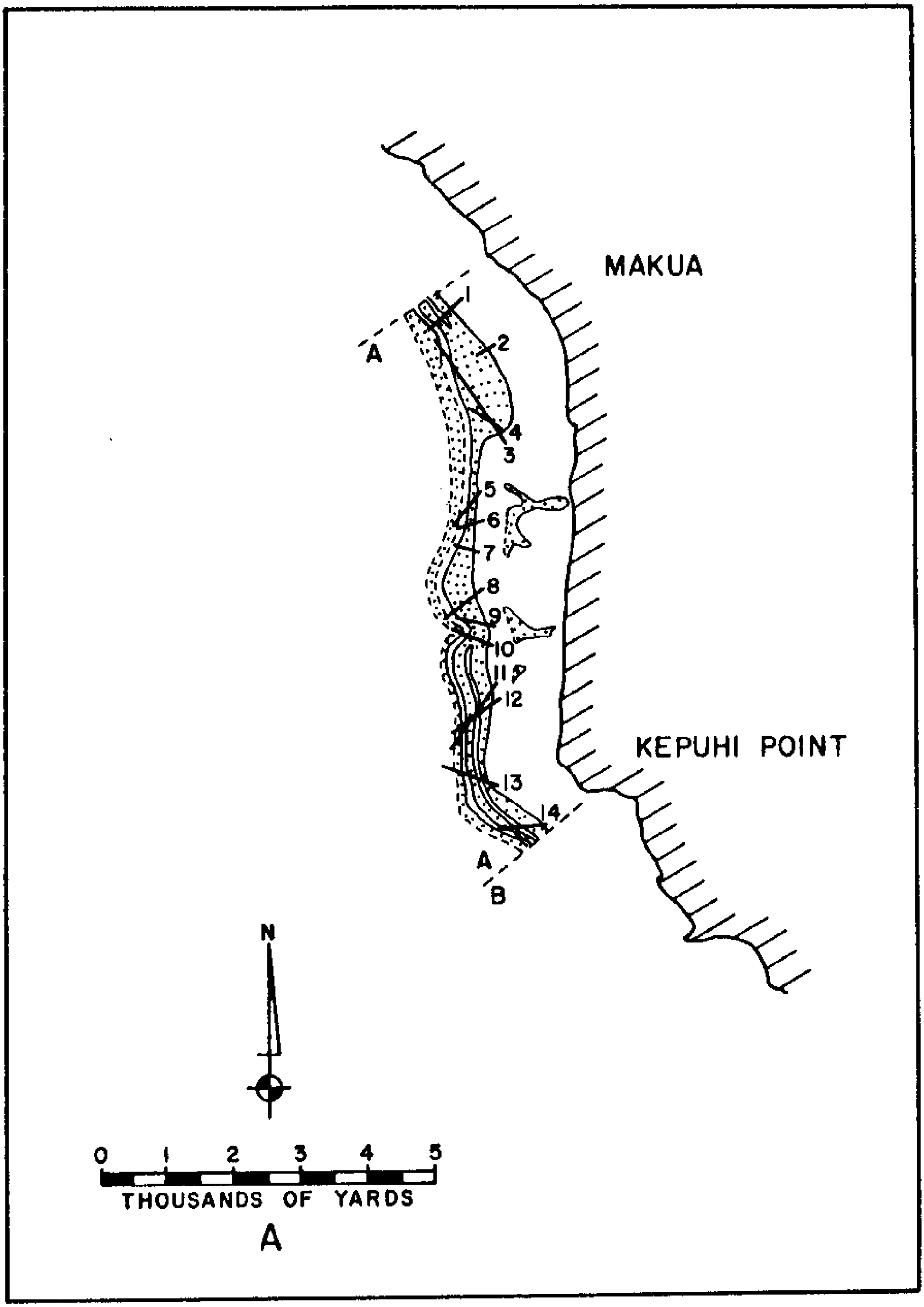
2C. Ship tracks and sample locations between Maili Point and Barbers Point, leeward Oahu.



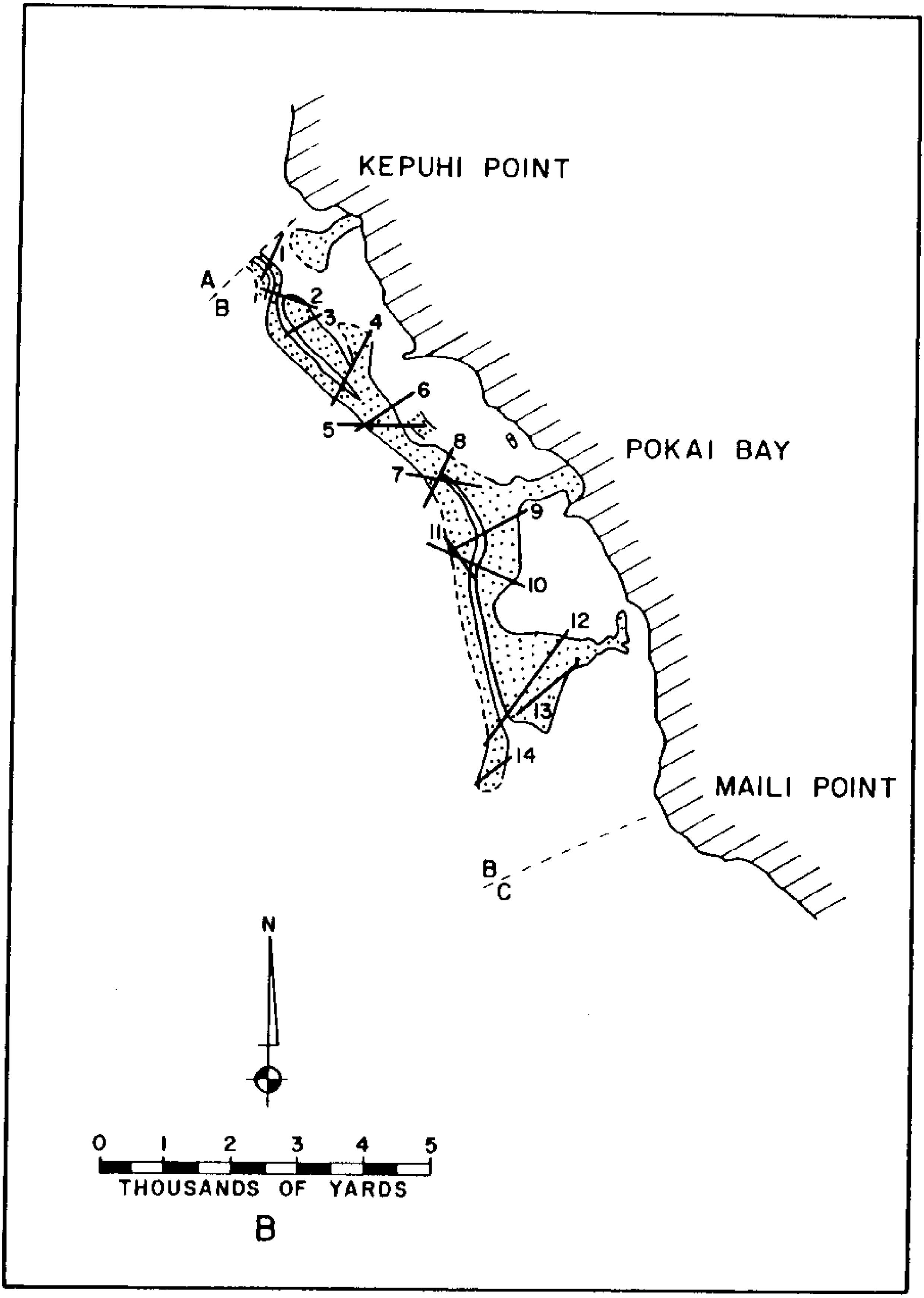
2D. Ship tracks between Barbers Point and Keahi Point, leeward Oahu.



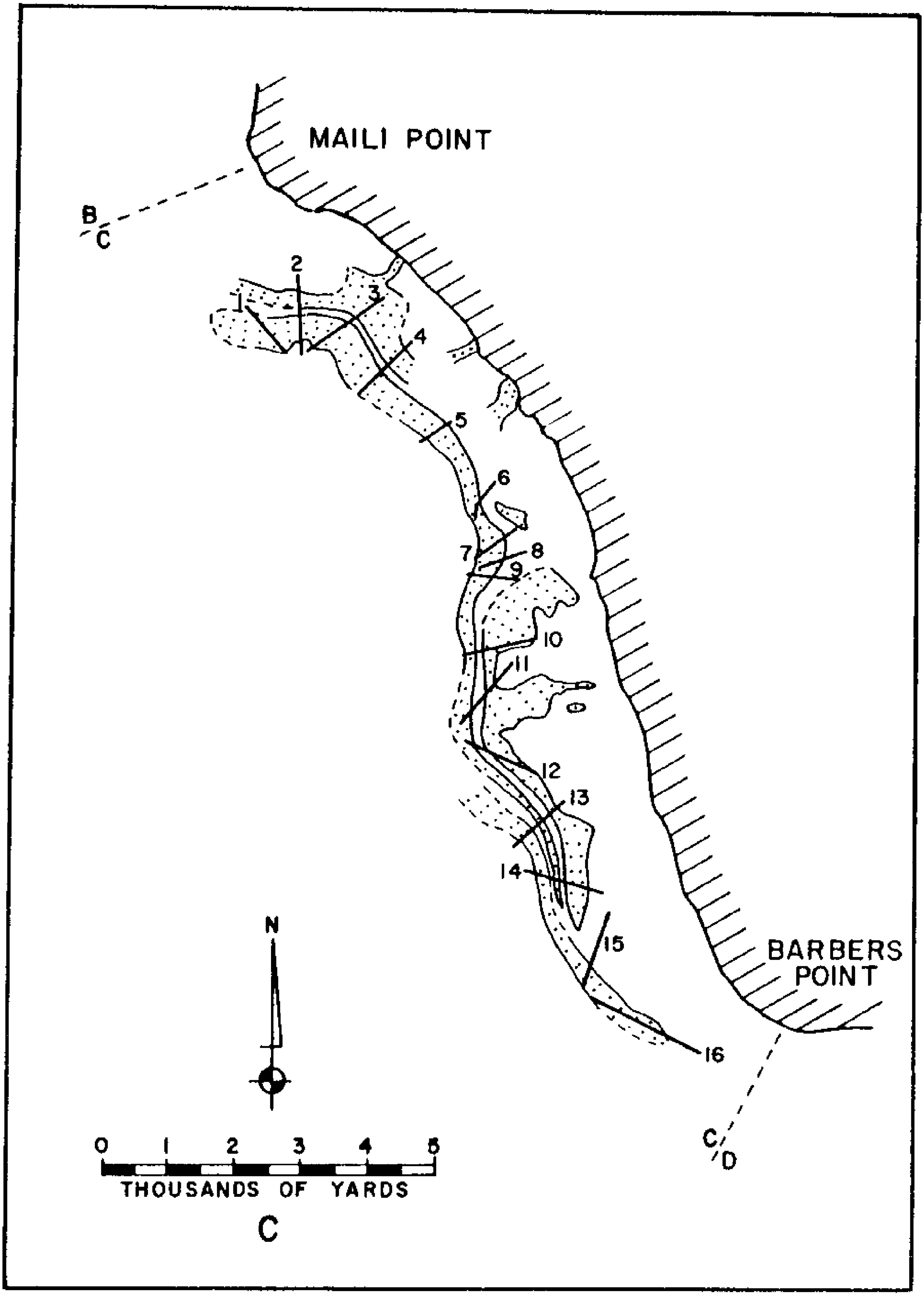
2E. Ship tracks between Keahi Point and Honolulu Harbor, leeward Oahu.



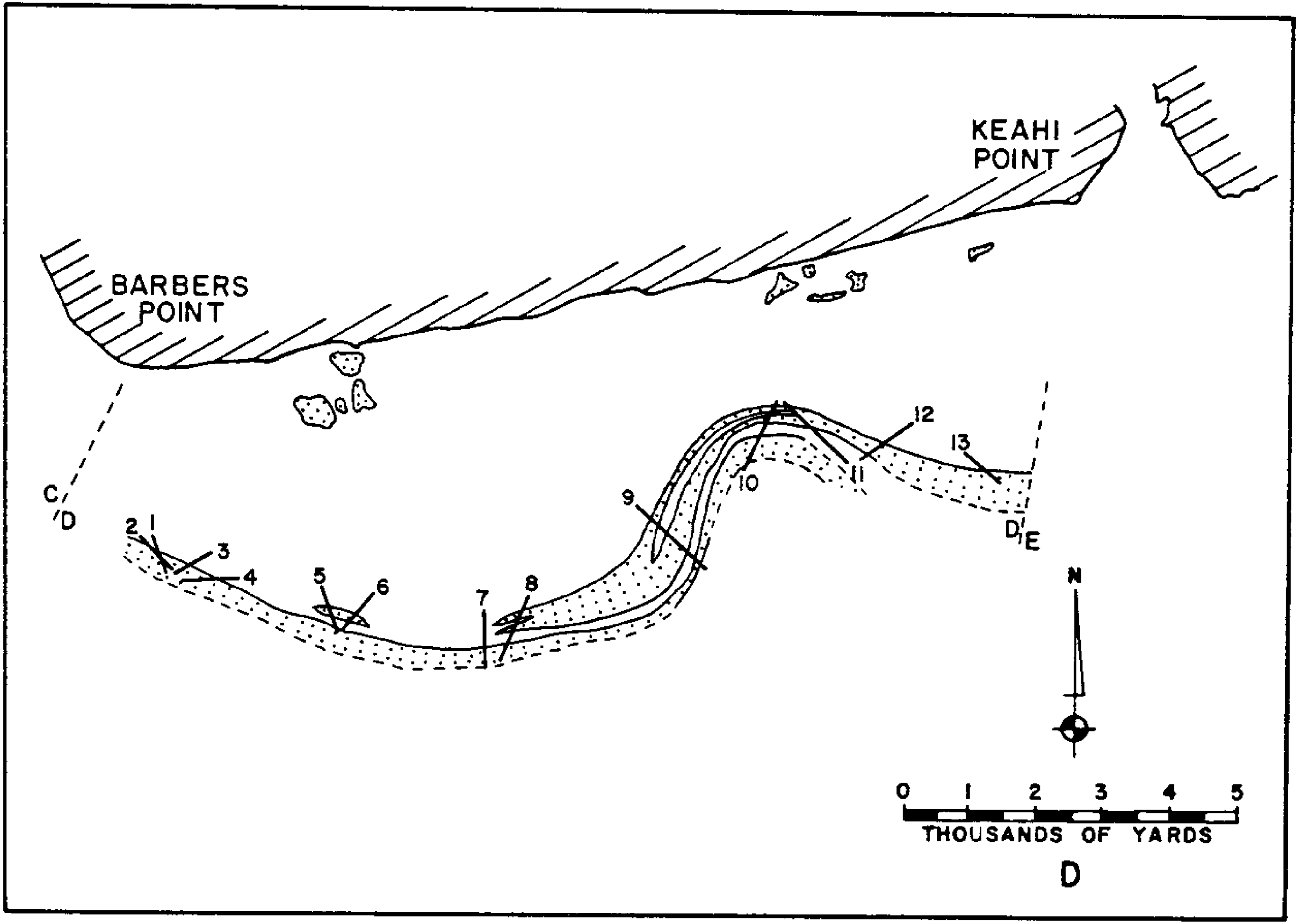
3A. Areas of sandy bottom, and seismic reflection traverses, sector A.



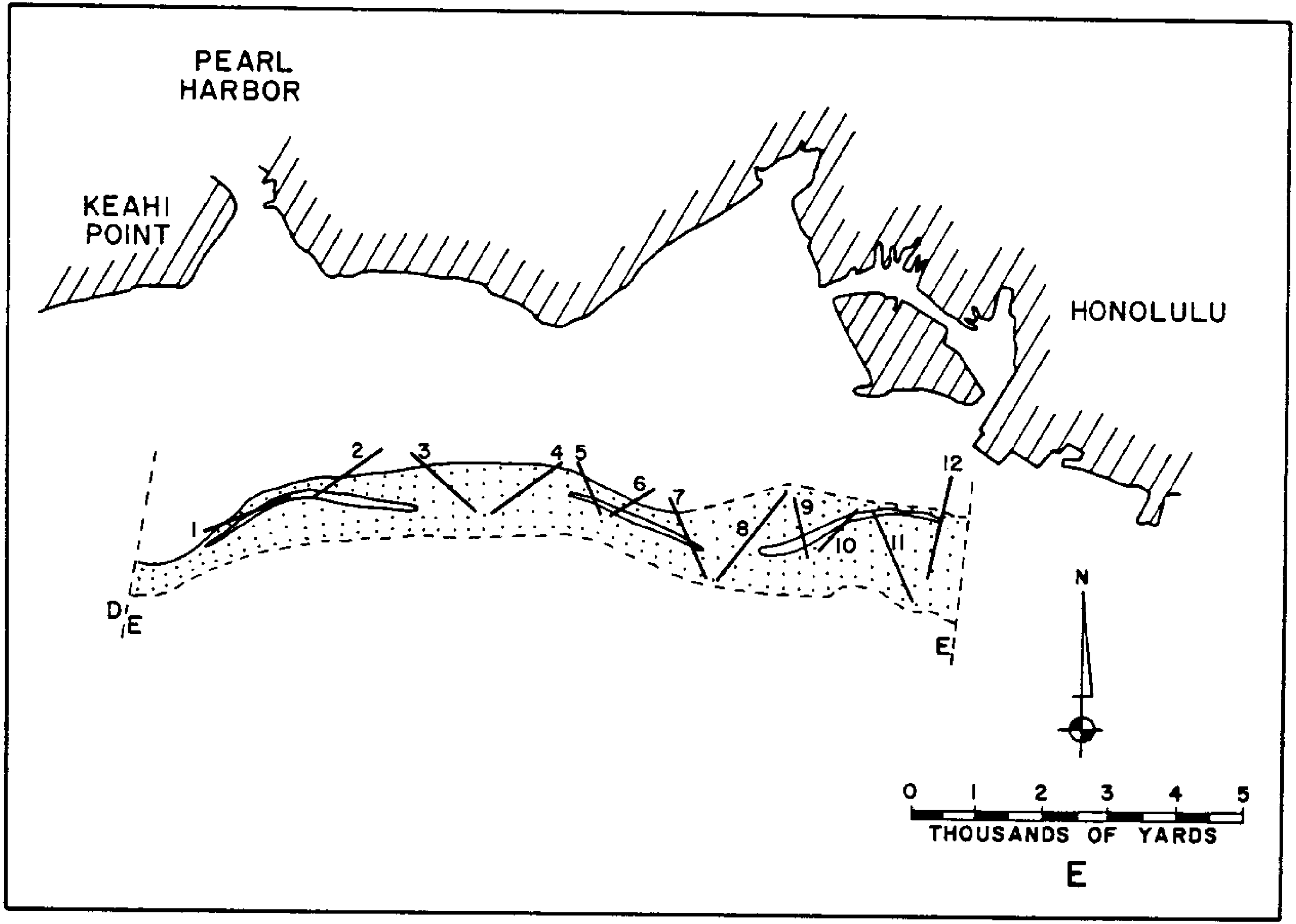
3B. Areas of sandy bottom, and seismic reflection traverses, sector B.



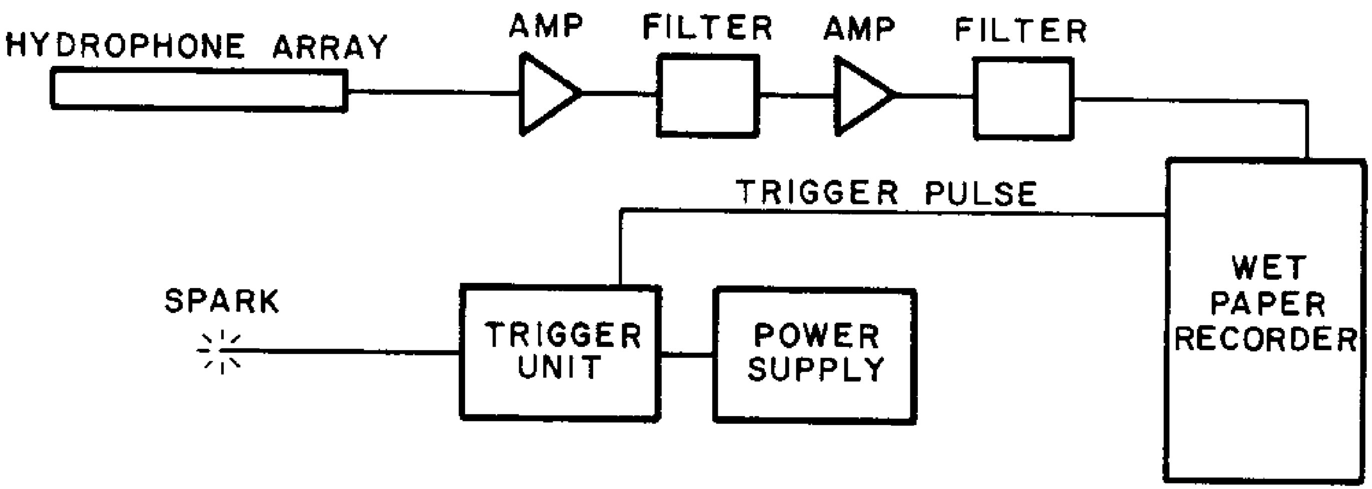
3C. Areas of sandy bottom, and seismic reflection traverses, sector C.



3D. Areas of sandy bottom, and seismic reflection traverses, sector D.



3E. Areas of sandy bottom, and seismic reflection traverse, sector E.



SCHEMATIC ARRANGEMENT OF REFLECTION EQUIPMENT

4. Sparker-type seismic reflection system used.

During the survey of 10 to 13 November 1969, the sparker electrode and the hydrophone array were towed off the stern of the R/V TERITU. The ship cruised at a speed of about 4 knots to minimize noise and maximize the horizontal scale on the records. At each turning point the ship's position was determined by the ship's personnel using the ship's radar. The scientific party also obtained fixes at each turning point as well as at intermediate points where necessary, by horizontal sextant angles.

Analysis

Tracings were made of the bottom and sub-bottom reflections of all parts of the records showing seismic penetration of sediment (Figs. 5A-5R). Our interpretation of sediment thickness and location was transferred back to the track plots and correlated from track to track, using as additional control the bathymetry and data obtained from the aerial photo and sample location studies. The areal extent of the sediment bodies is shown on Figures 3A-3E.

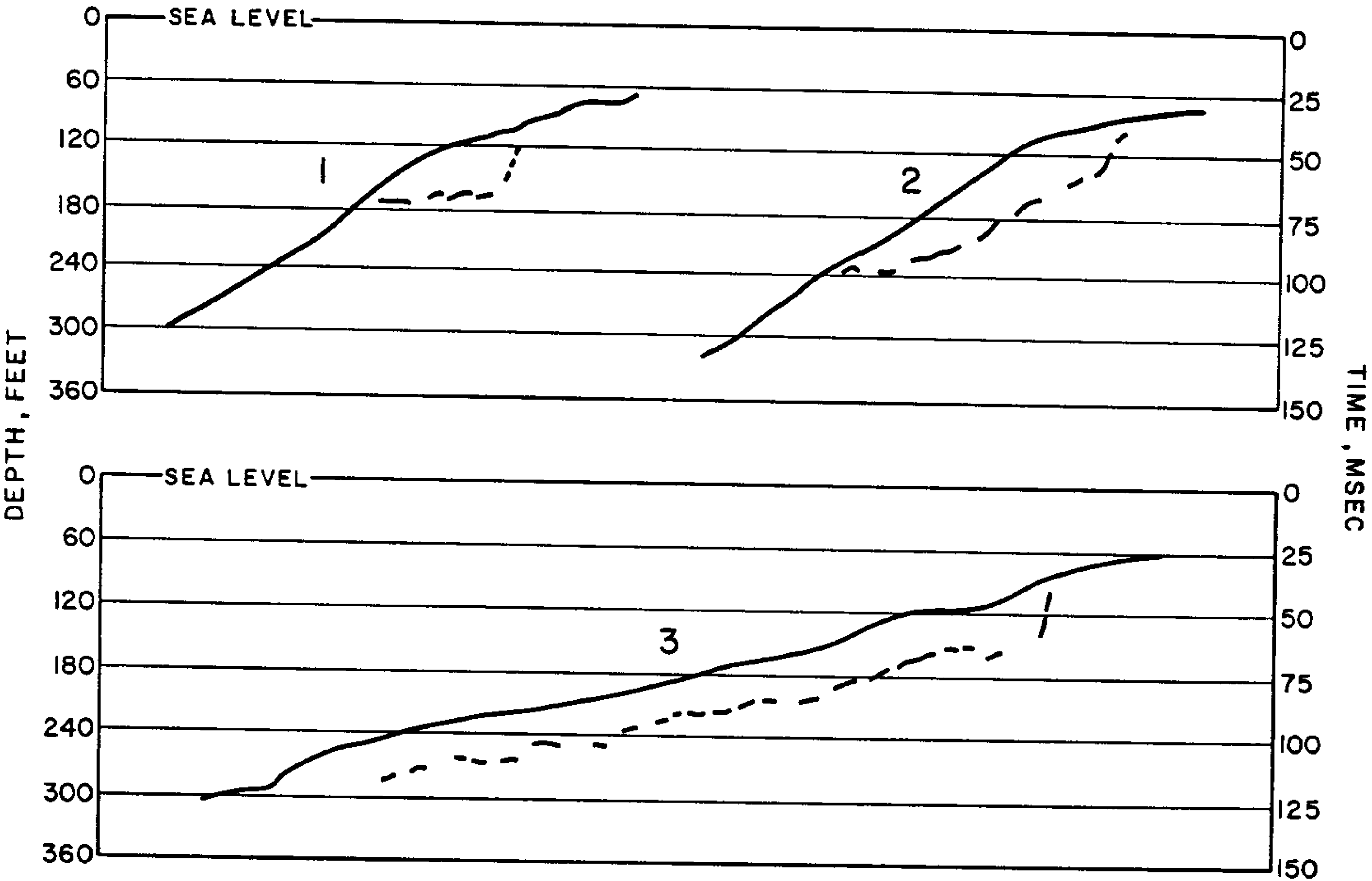
To determine cross-sectional area of sand along the tracks, the penetration time was measured along a set grid pattern across the profiles and an average penetration time used to calculate the thickness. To convert penetration time to sediment thickness, a velocity of 5,400 feet/sec was used for the sand. This velocity was determined from seismic refraction lines shot in Kaneohe Bay where the grain size of the sand is similar to that sampled from some of these sand bodies (Moberly and Campbell, 1969). Horizontal distances were determined by calculating the ship's speed from the track plots. A speed had to be determined for each crossing because the effect of currents and winds on the ship's movements varied with different headings and geographic locations. The time elapsed in crossing each of the sand bodies was picked off the tracing and multiplied by the ship's speed to get horizontal distance.

Cross-sectional areas in square yards per track were calculated for all crossings. The calculations were made separately for different depths of water: 60-120, 120-180, and 180-300 feet. The three separate compilations were made so that interested parties, knowing the depth capabilities of their own recovery equipment, can better calculate what they may be able to exploit. Calculations were also made of the average number of square yards per yard of coastline, by rotating the lines of sections into a plane perpendicular to the trend of the coastline or the sand body.

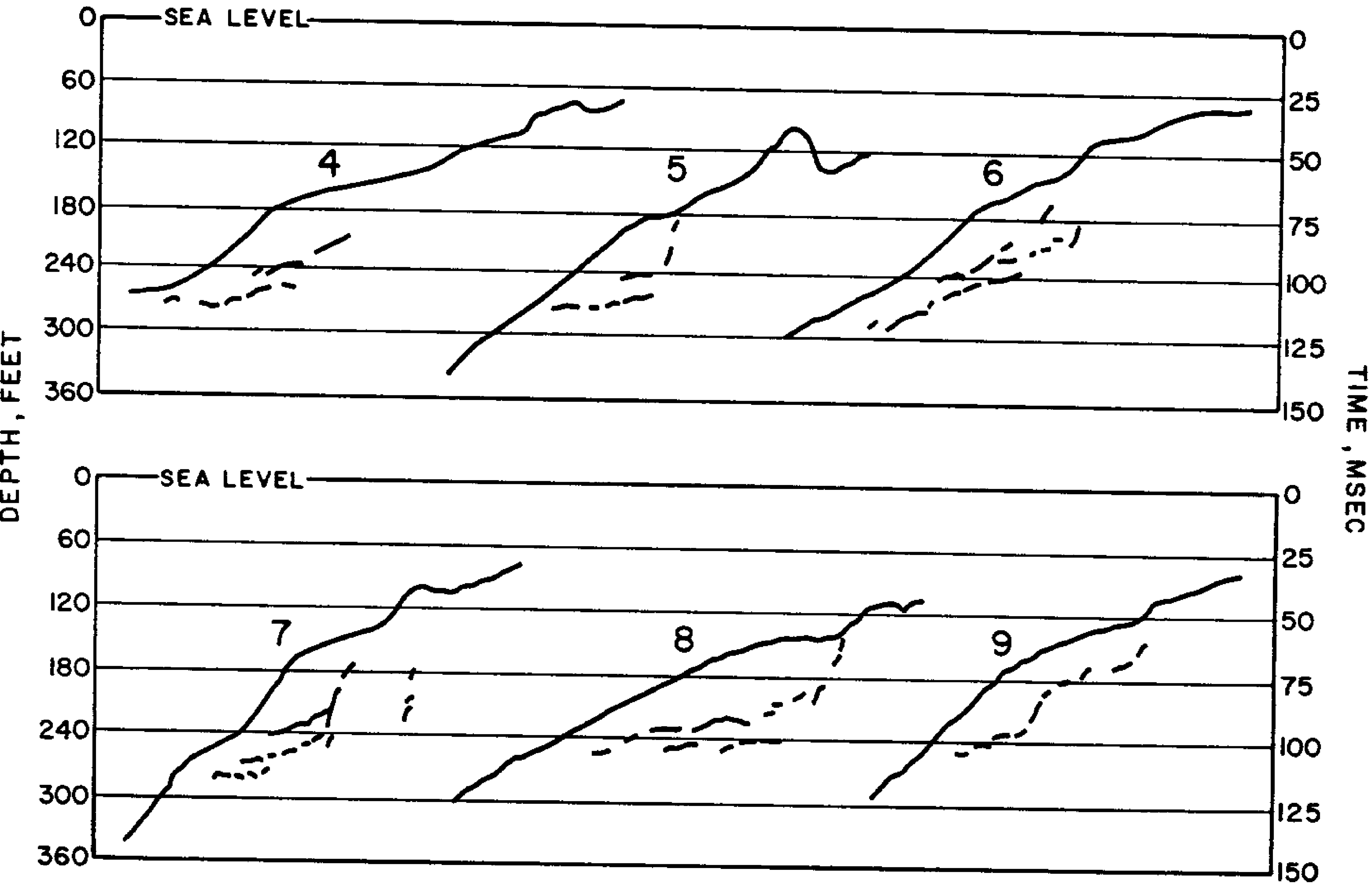
Sand was dredged from six of the seven sites where sampling was attempted (Fig. 2B and 2C). The samples were analyzed for grain-size and color (Tables 1 and 2).

Results

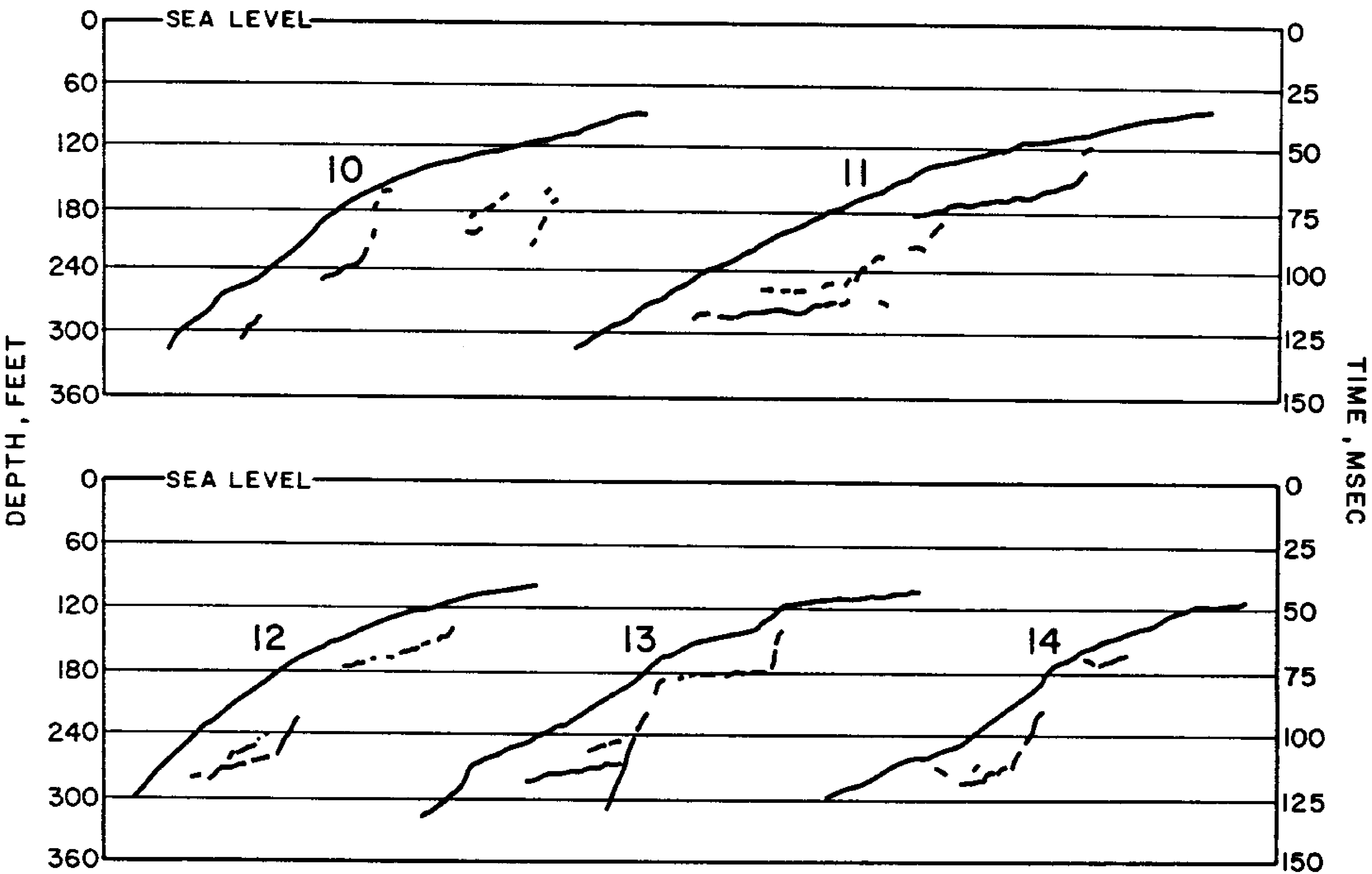
Table 3 summarizes the cross-sectional areas of sand found on each profile, corrected for direction of the traverses by rotation of the profiles. The sand in the 60- to 120-foot depth range is concentrated primarily in areas off the sand channels that were mapped from the air photos. In the 120- to 180-foot depth range, sand was found on 52 of the 69 crossings, indicating that sand bodies are fairly widespread at that depth. The profiles that do not show sand are off areas where



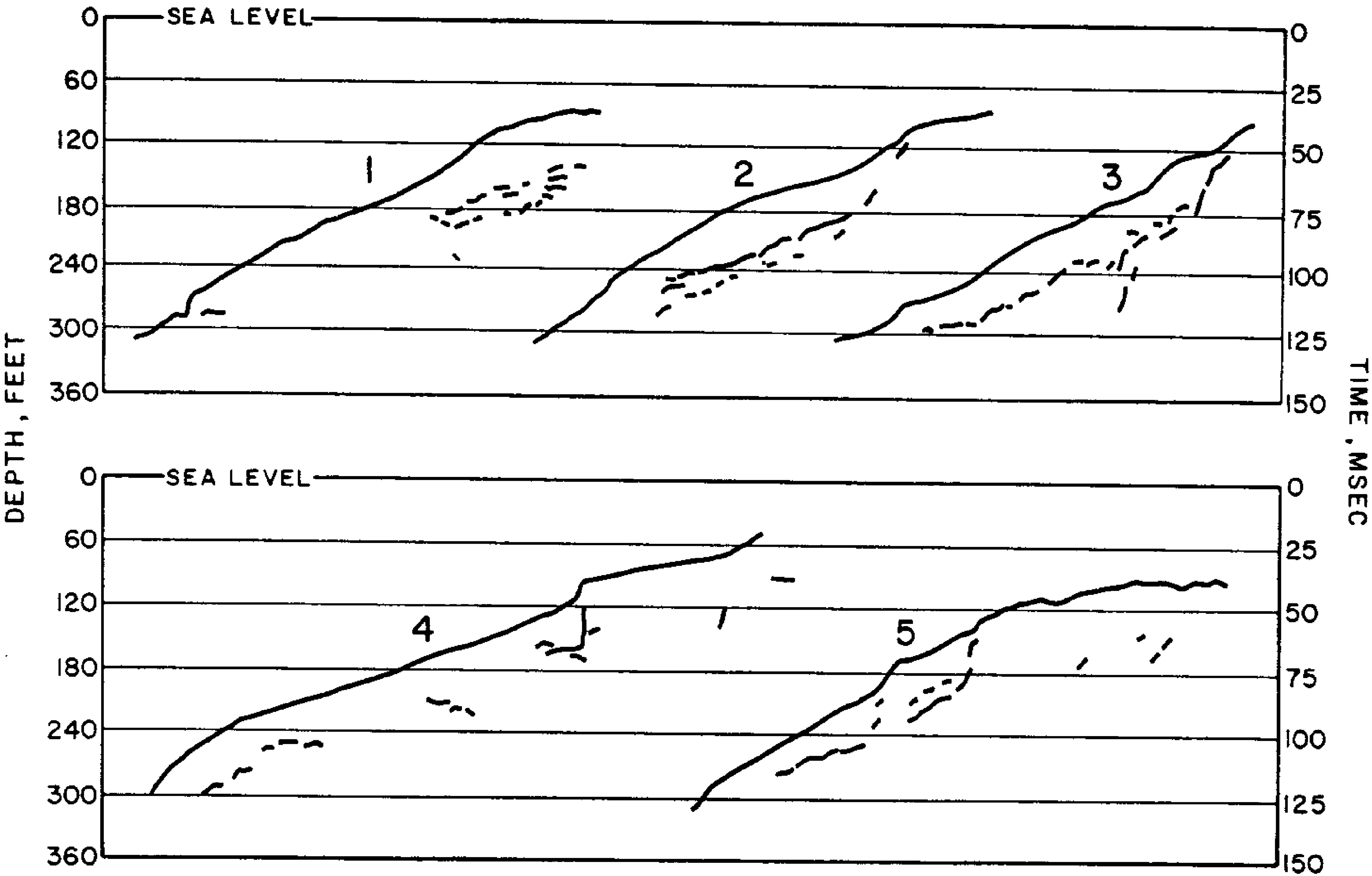
5A. Tracings of seismic reflection records, sector A. Traverses 1-3 shown on Figure 3A.



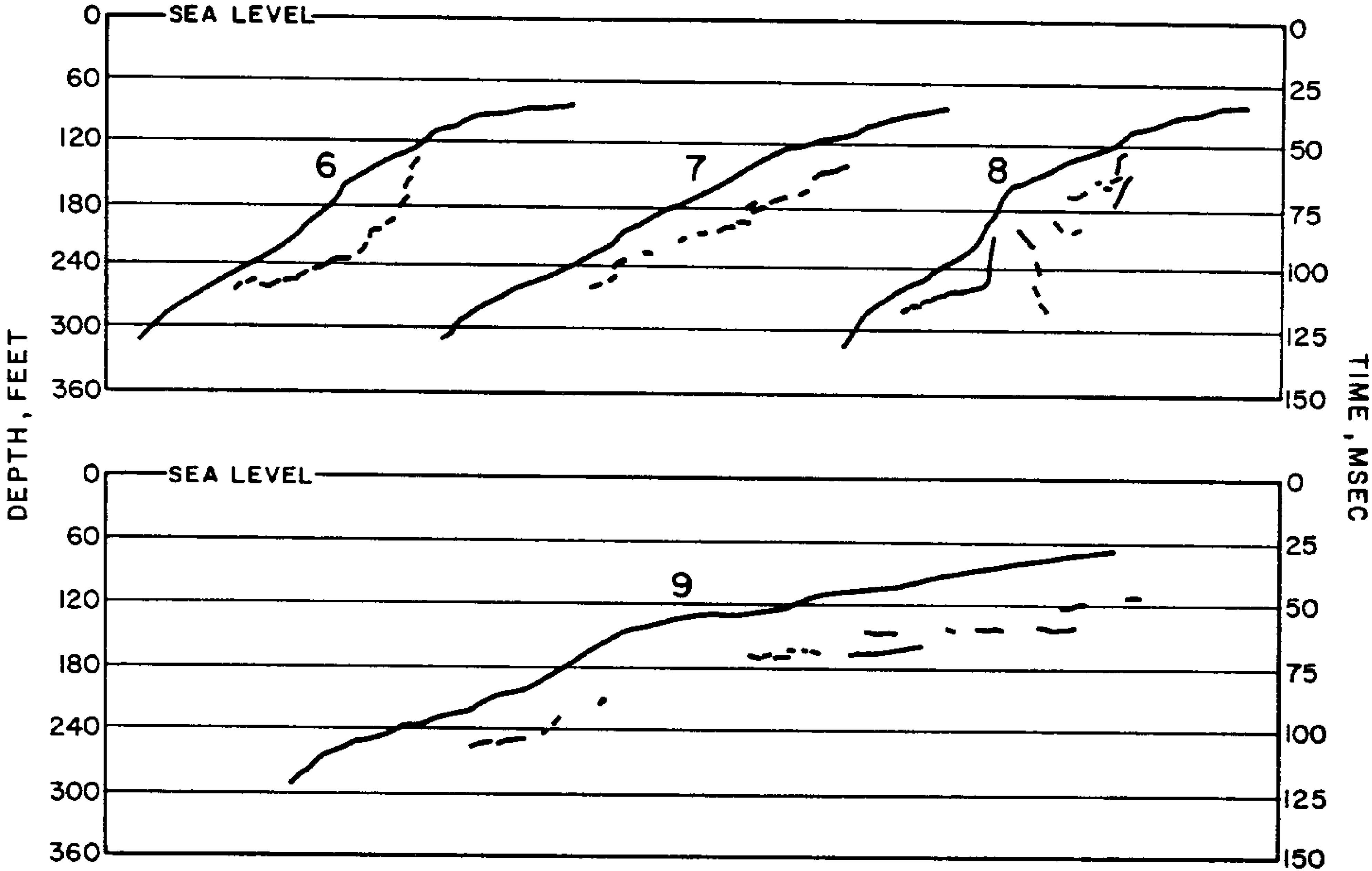
5B. Tracings of seismic reflection records, sector A. Traverses 4-9 shown on Figure 3A.



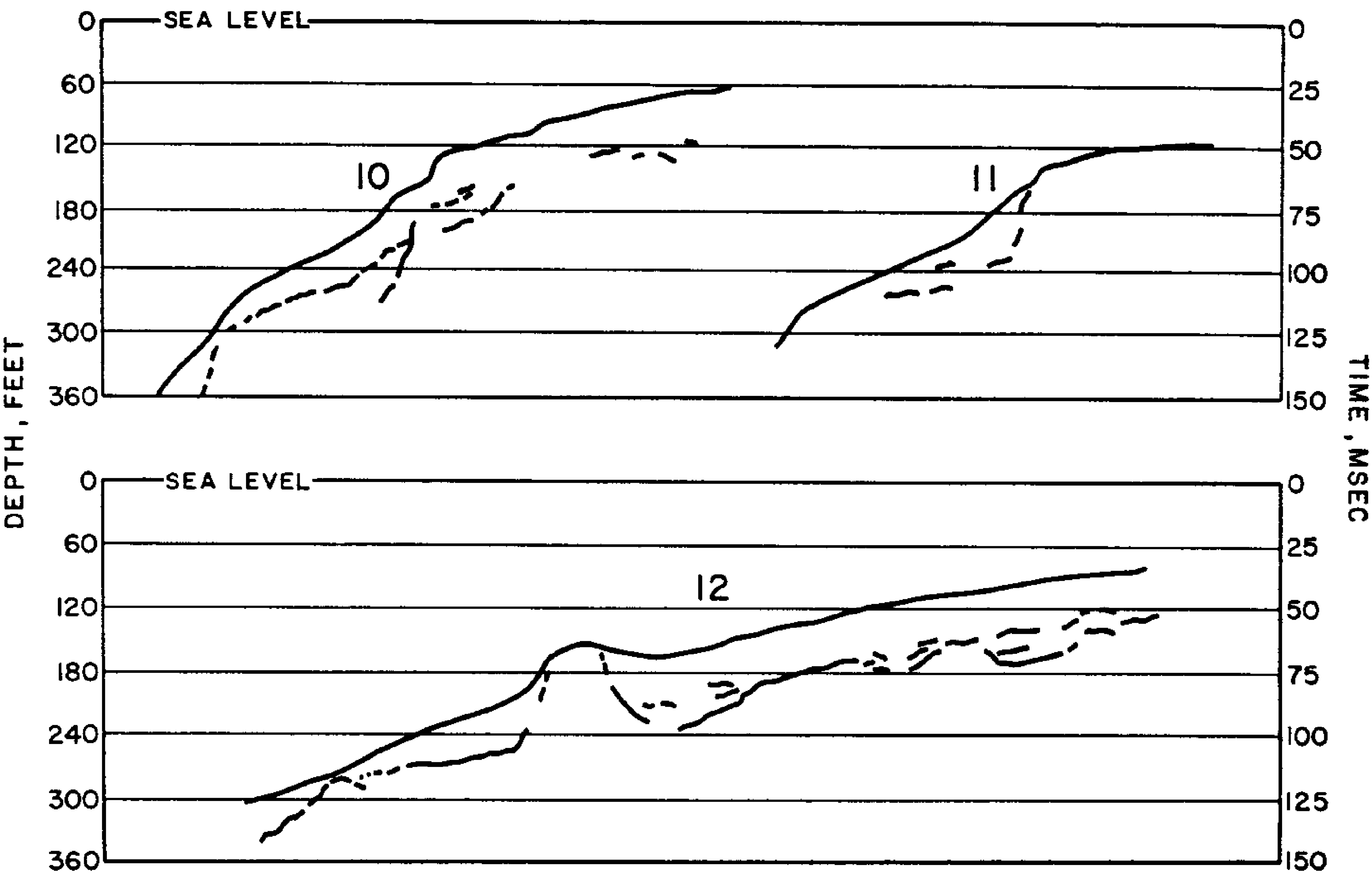
5C. Tracing of seismic reflection records, sector A. Traverses 10-14 shown in Figure 3A.



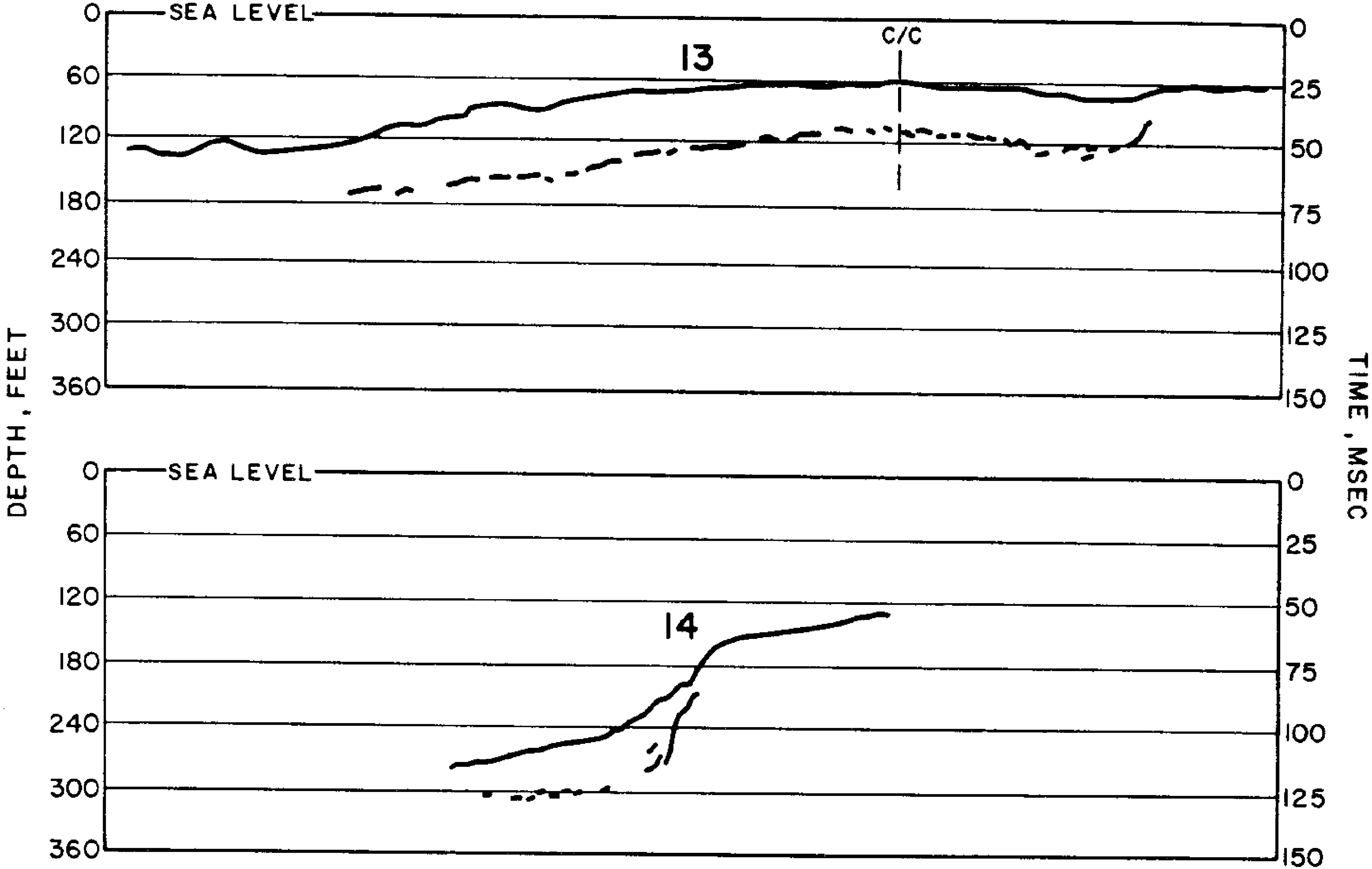
5D. Tracings of seismic reflection records, sector B. Traverses 1-5 shown on Figure 3B.



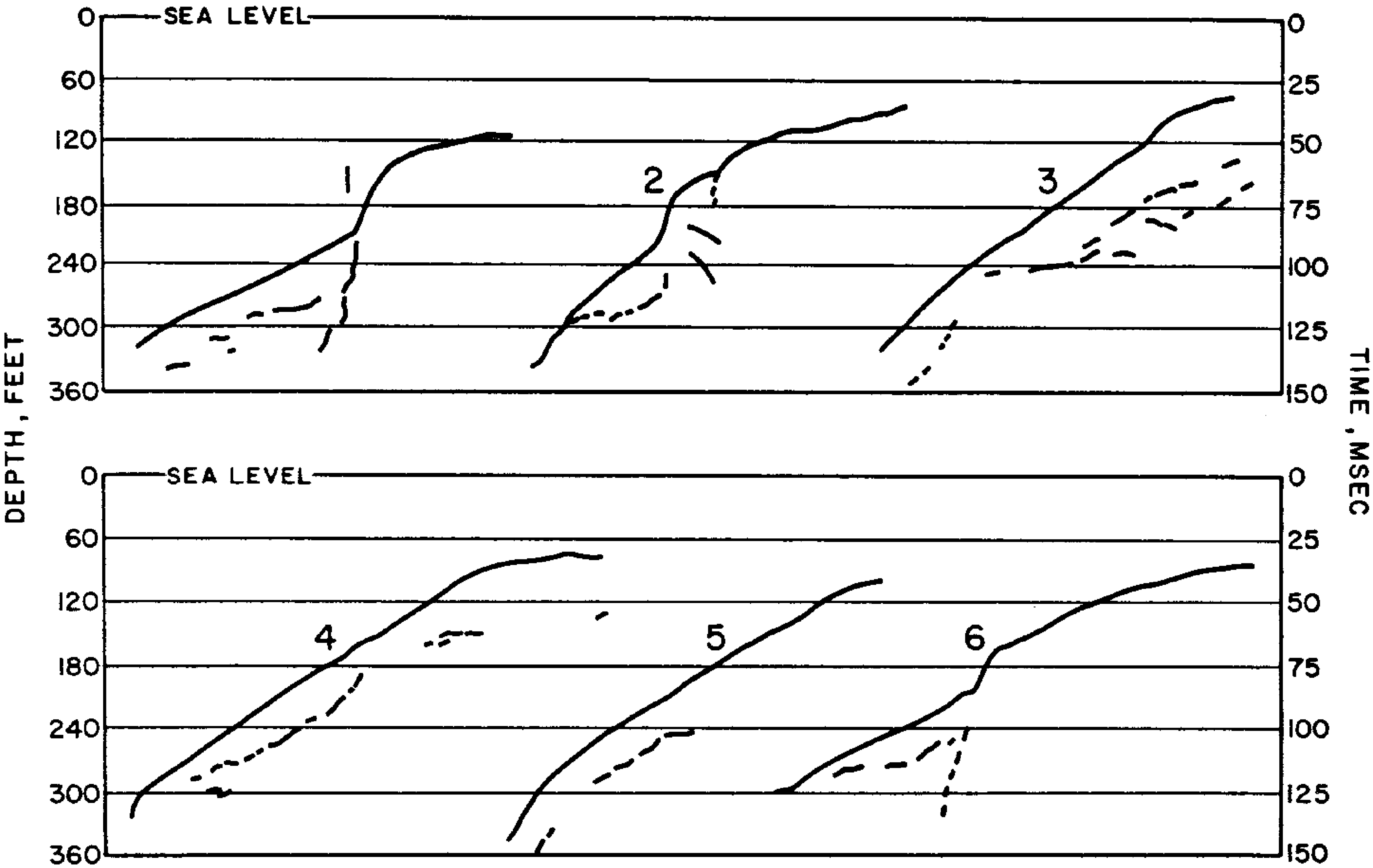
5E. Tracings of seismic reflection records, sector B. Traverses 6-9 shown on Figure 3B.



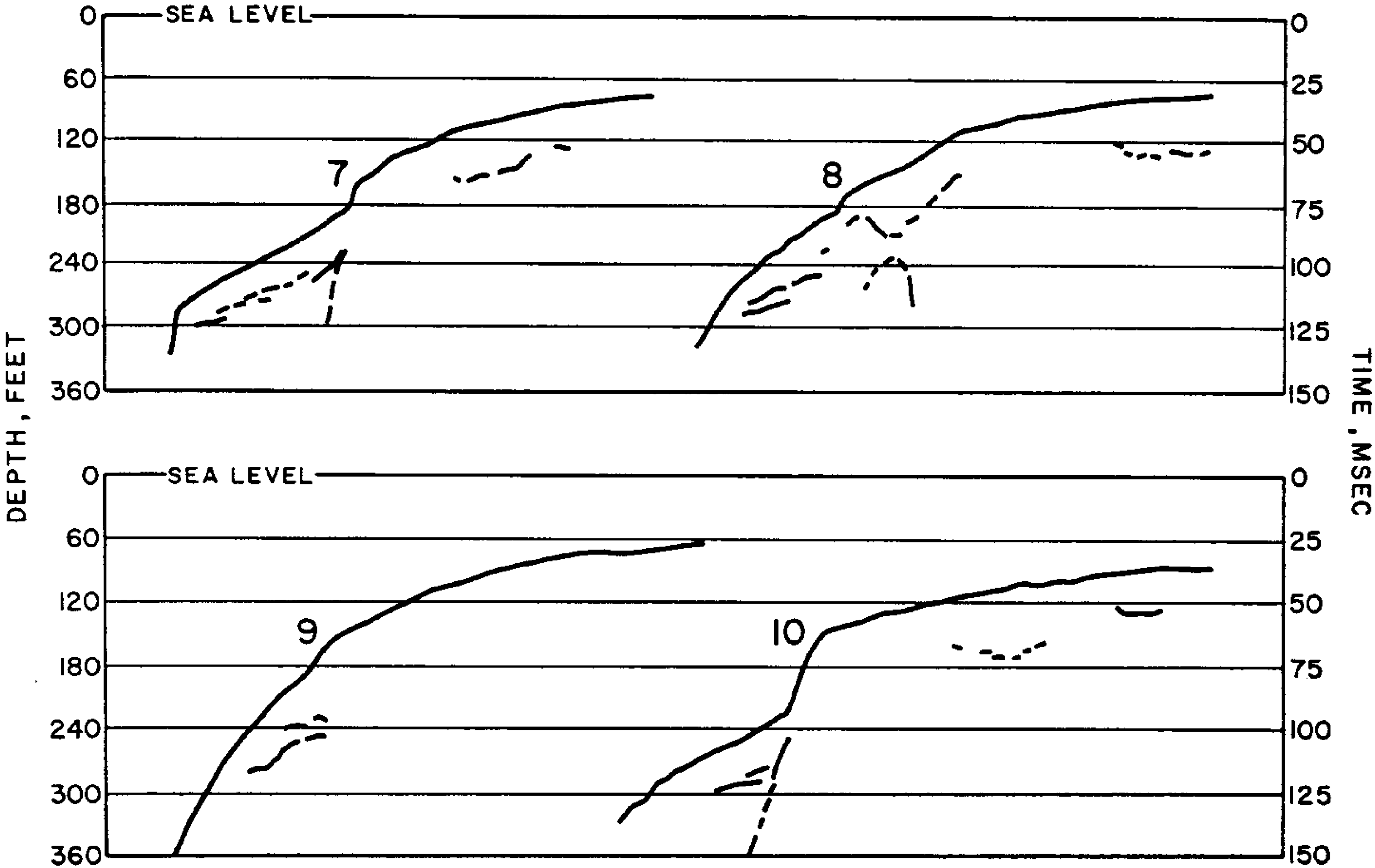
5F. Tracings of seismic reflection records, sector B. Traverses 10-12 shown on Figure 3B.



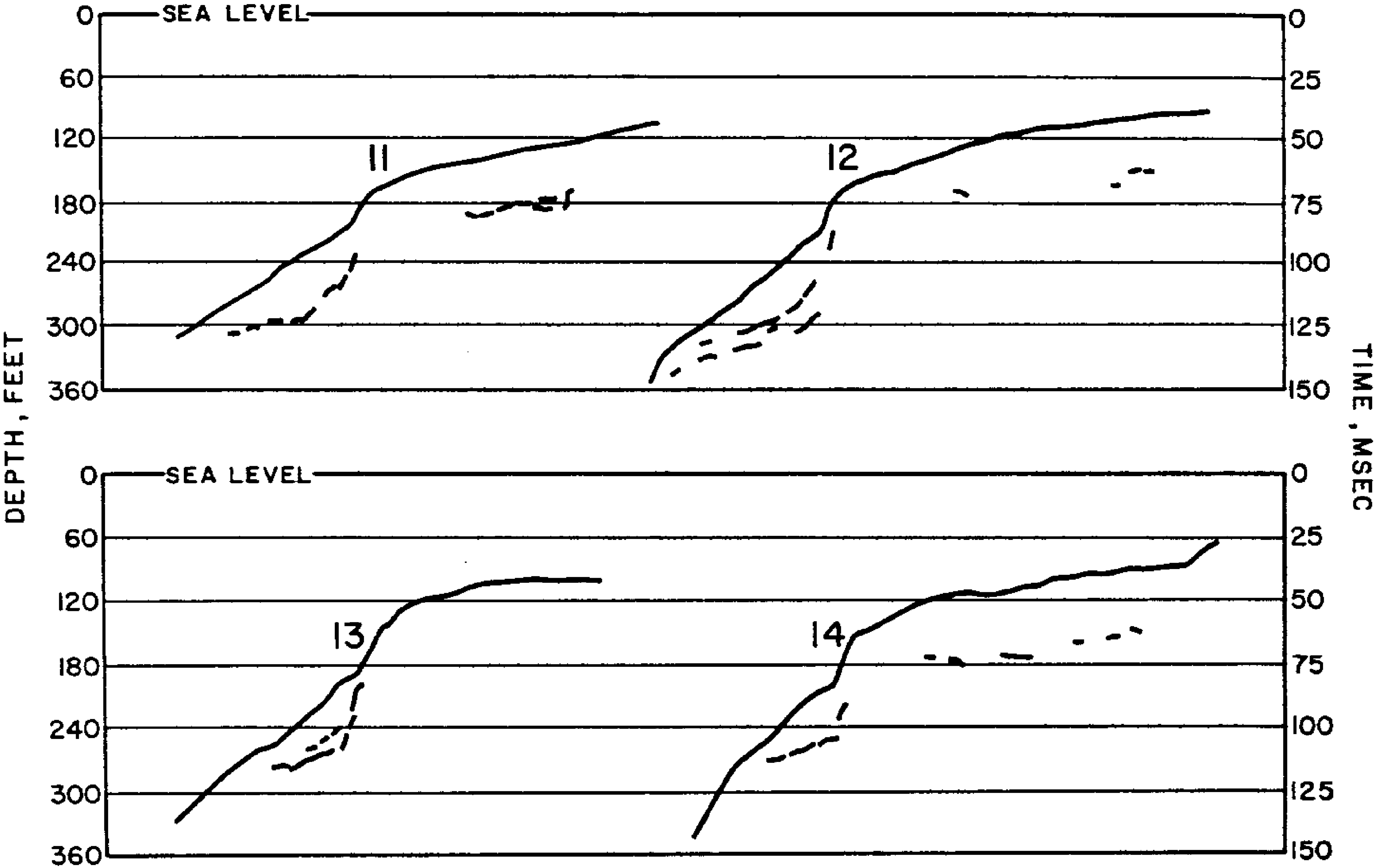
5G. Tracings of seismic reflection records, sector B. Traverses 13-14 shown on Figure 3B.



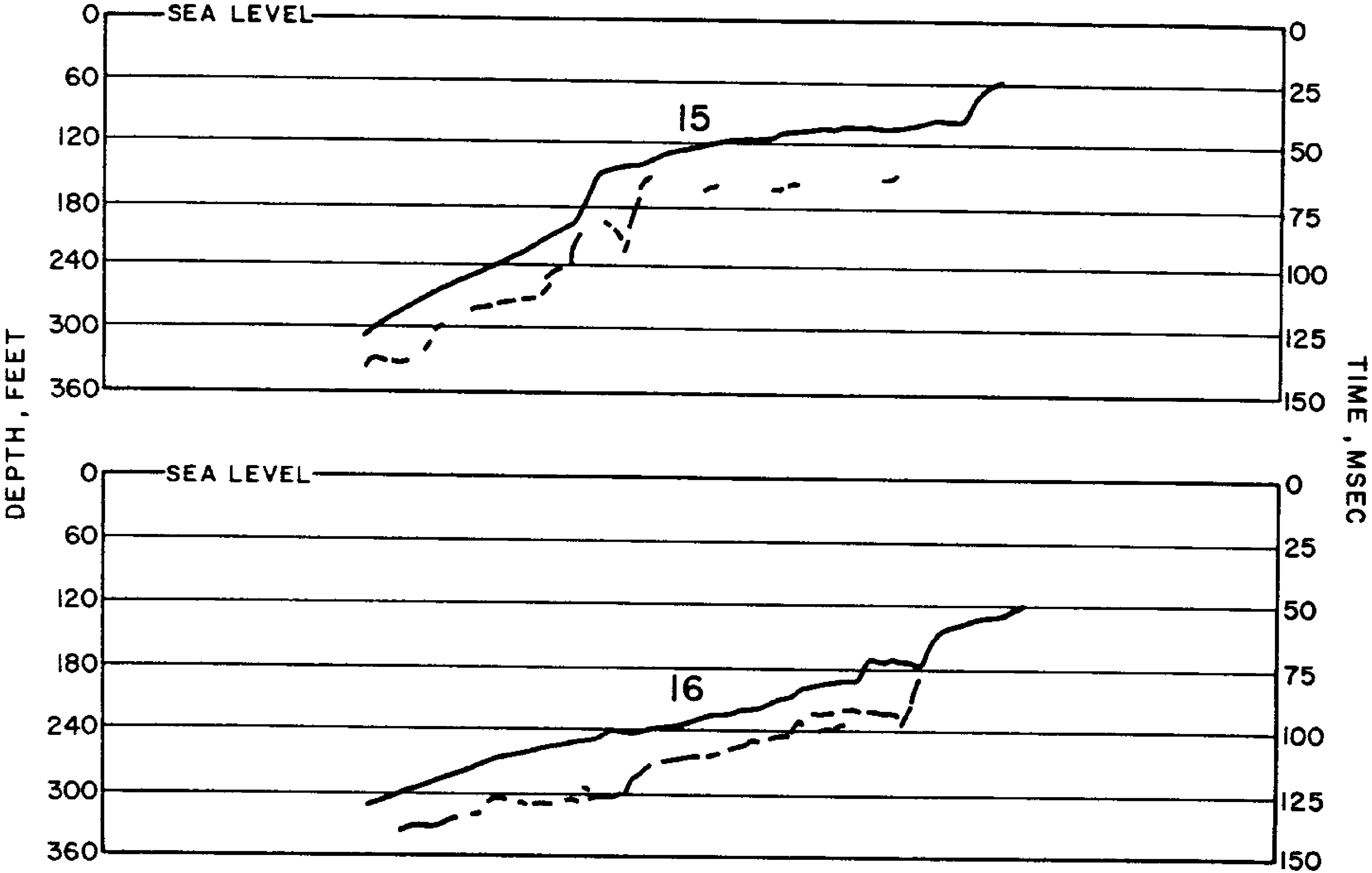
5H. Tracings of seismic reflection records, sector C. Traverses 1-6 shown on Figure 3C.



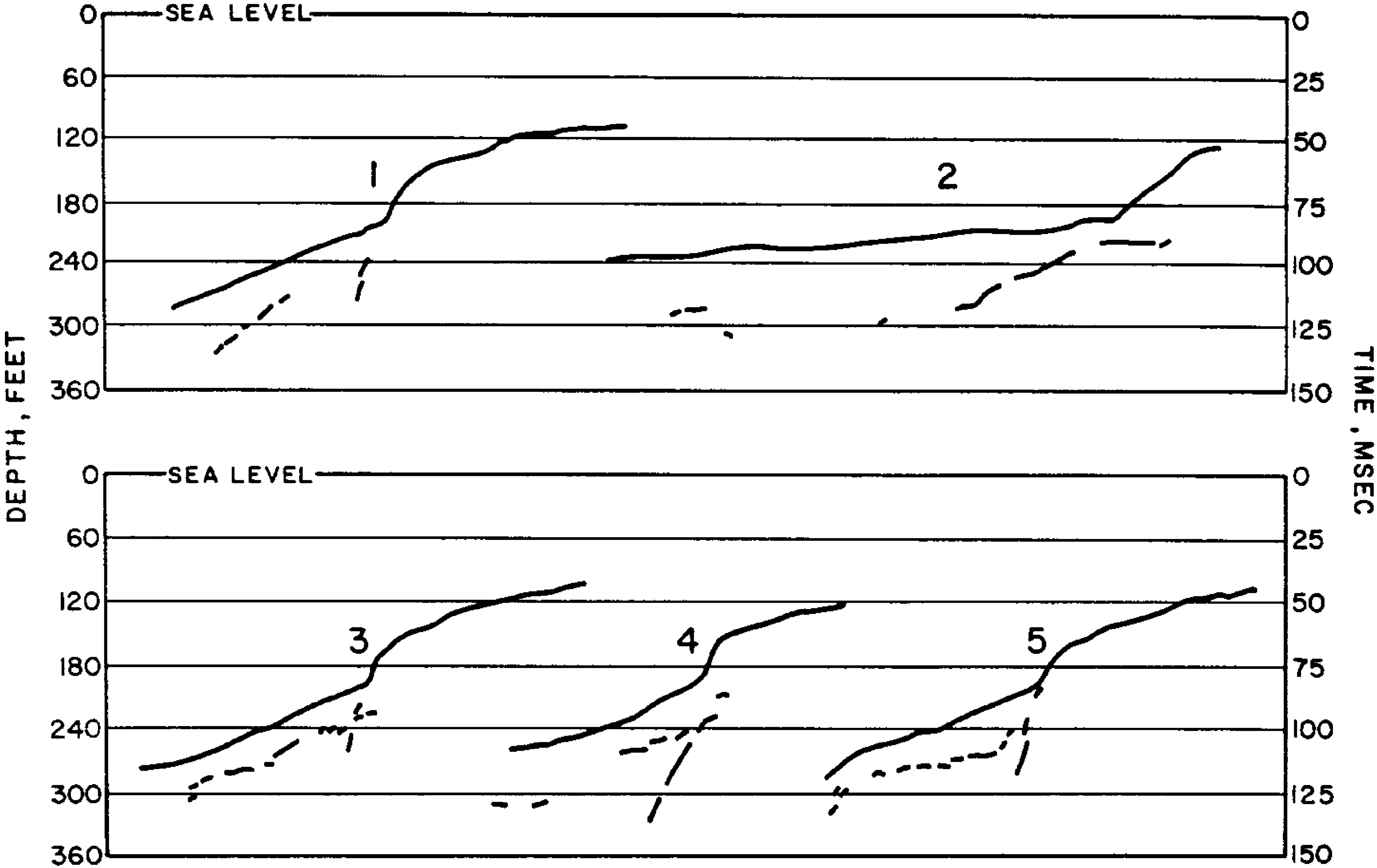
5I. Tracings of seismic reflection records, sector C. Traverses 7-10 shown on Figure 3C.



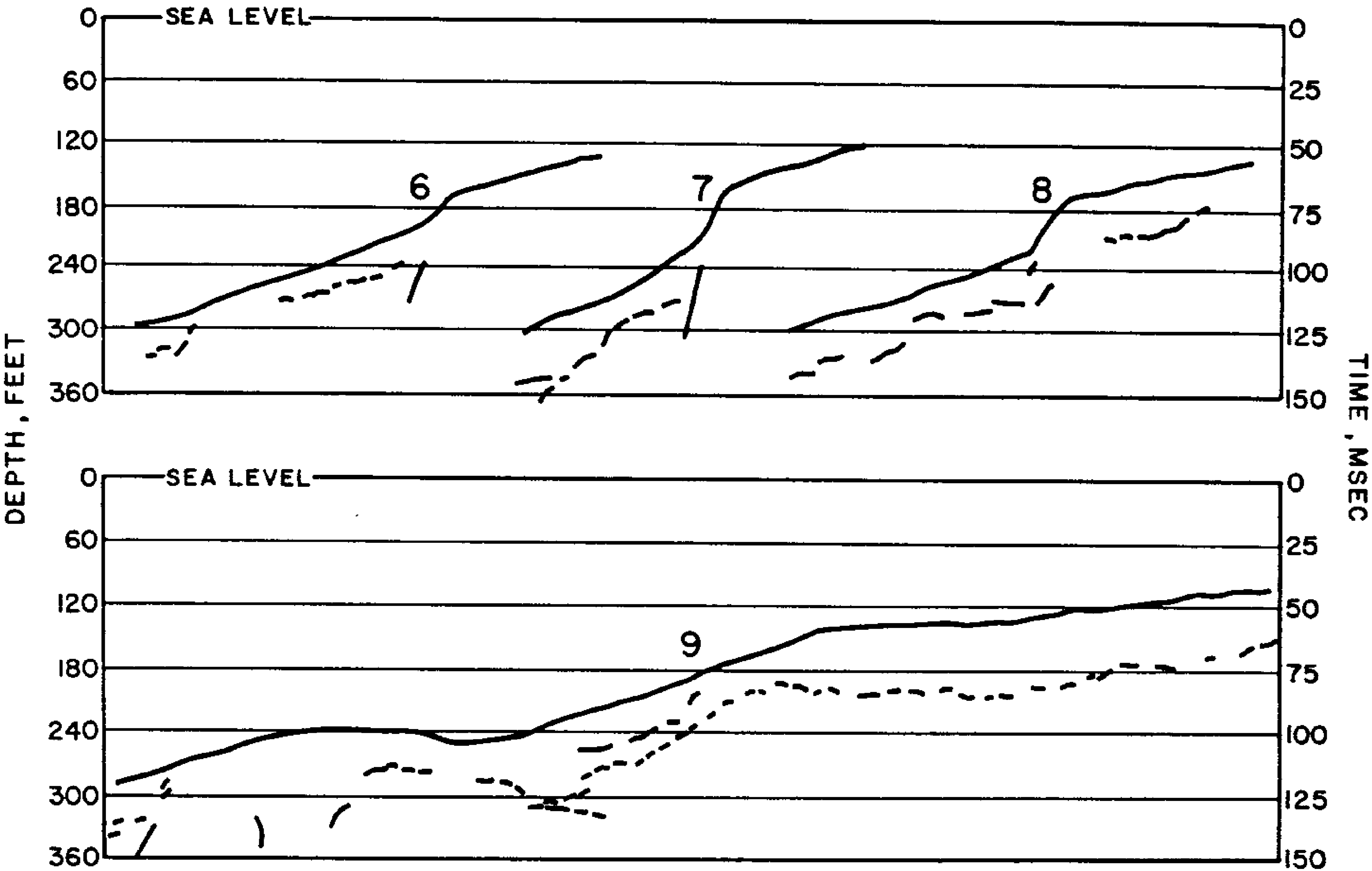
5J. Tracings of seismic reflection records, sector C. Traverses 11-14 shown on Figure 3C.



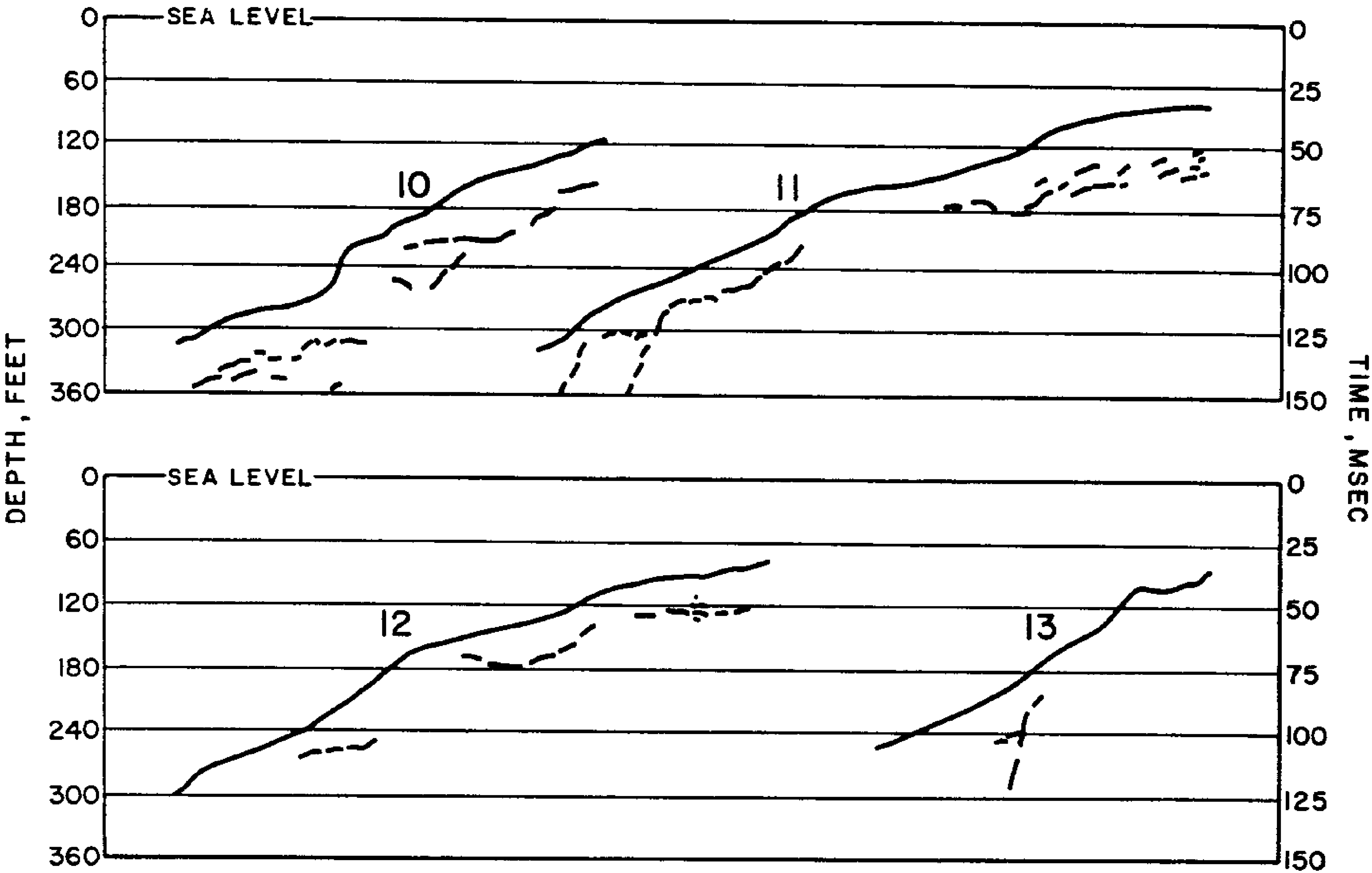
5K. Tracings of seismic reflection records, sector C. Traverses 15-16 shown on Figure 3C.



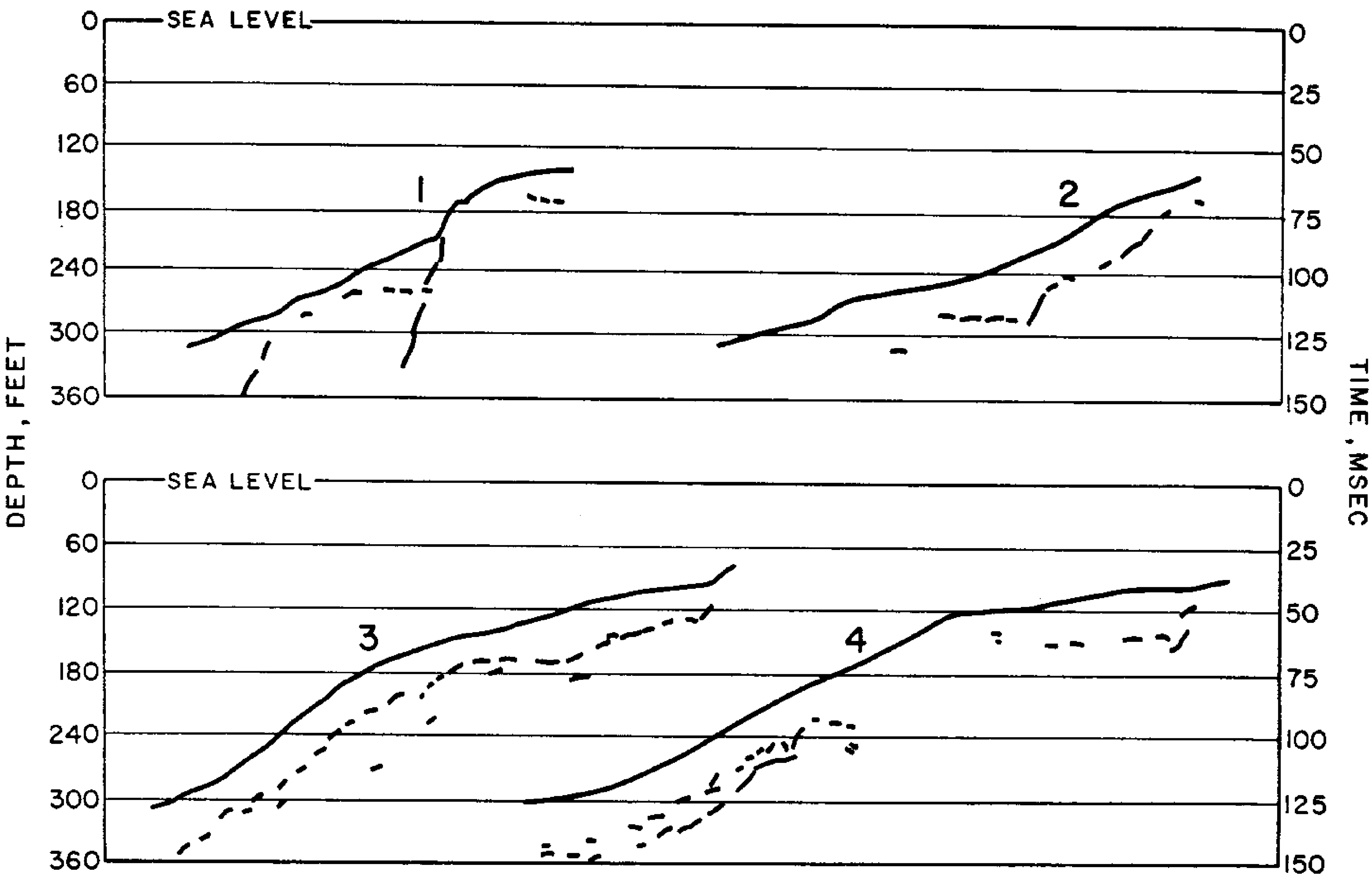
5L. Tracings of seismic reflection records, sector D. Traverses 1-5 shown on Figure 3D.



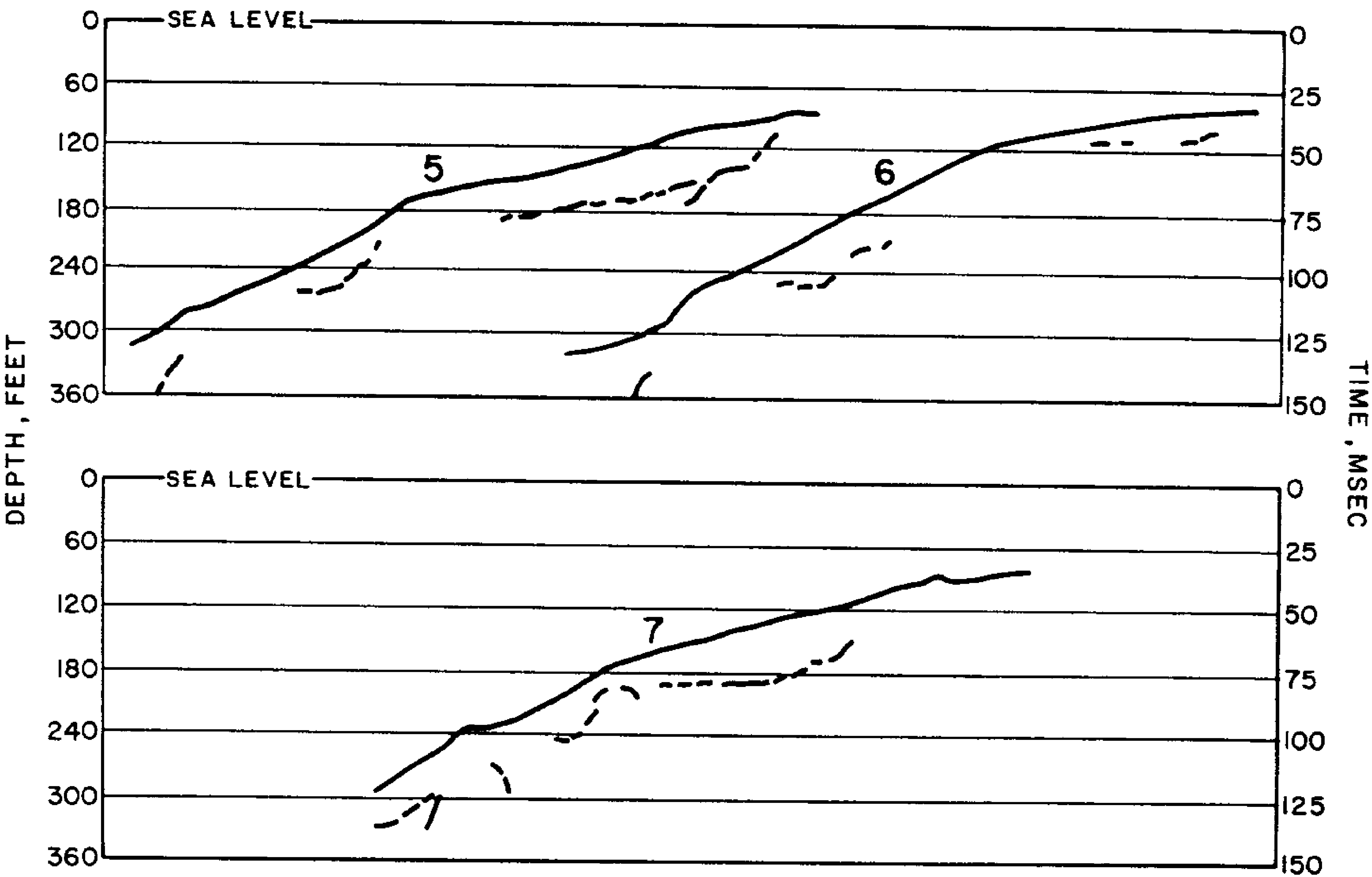
5M. Tracings of seismic reflection records, sector D. Traverses 6-9 shown on Figure 3D.



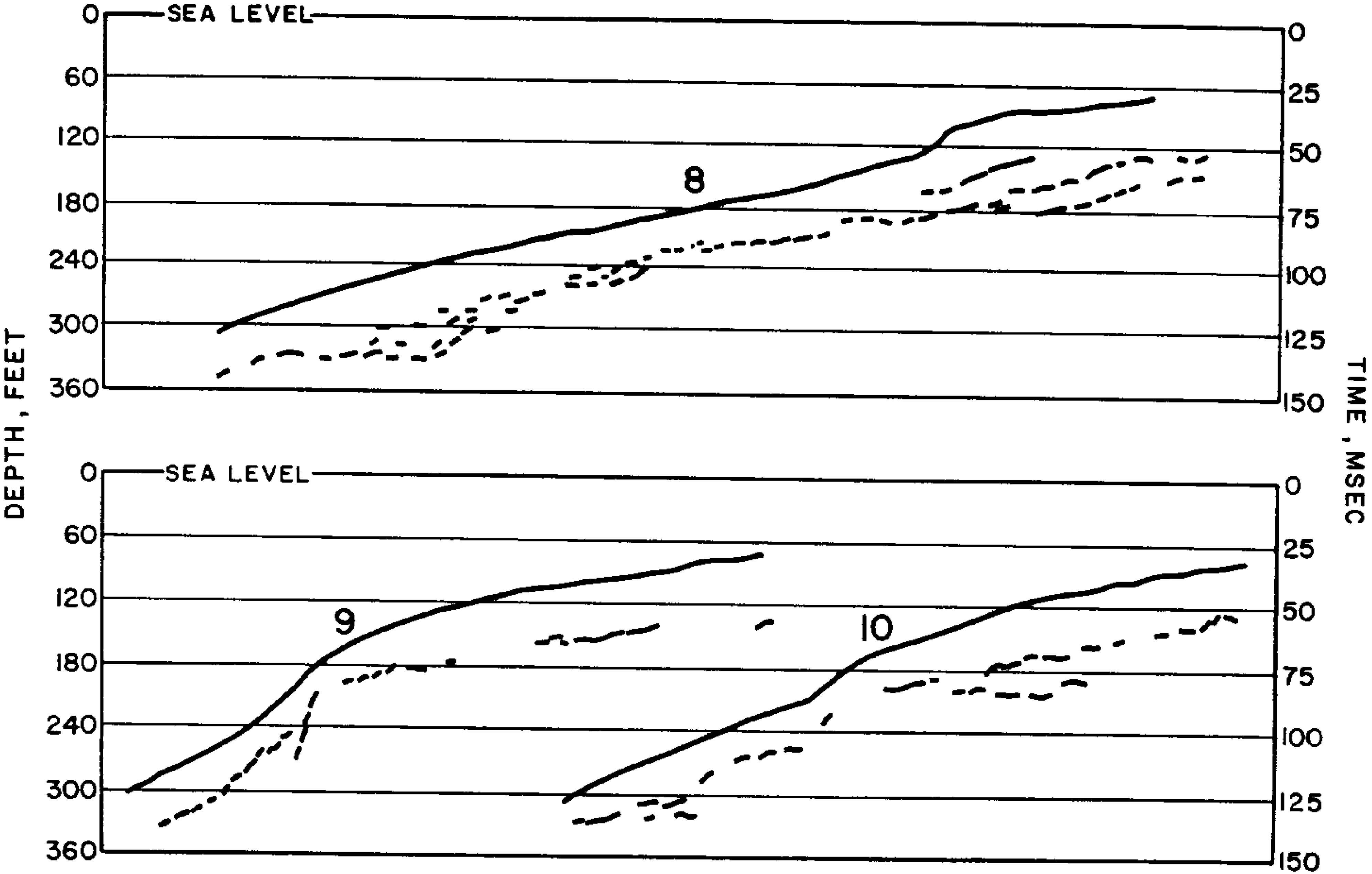
5N. Tracings of seismic reflection records, sector D. Traverses 10-13 shown on Figure 3D.



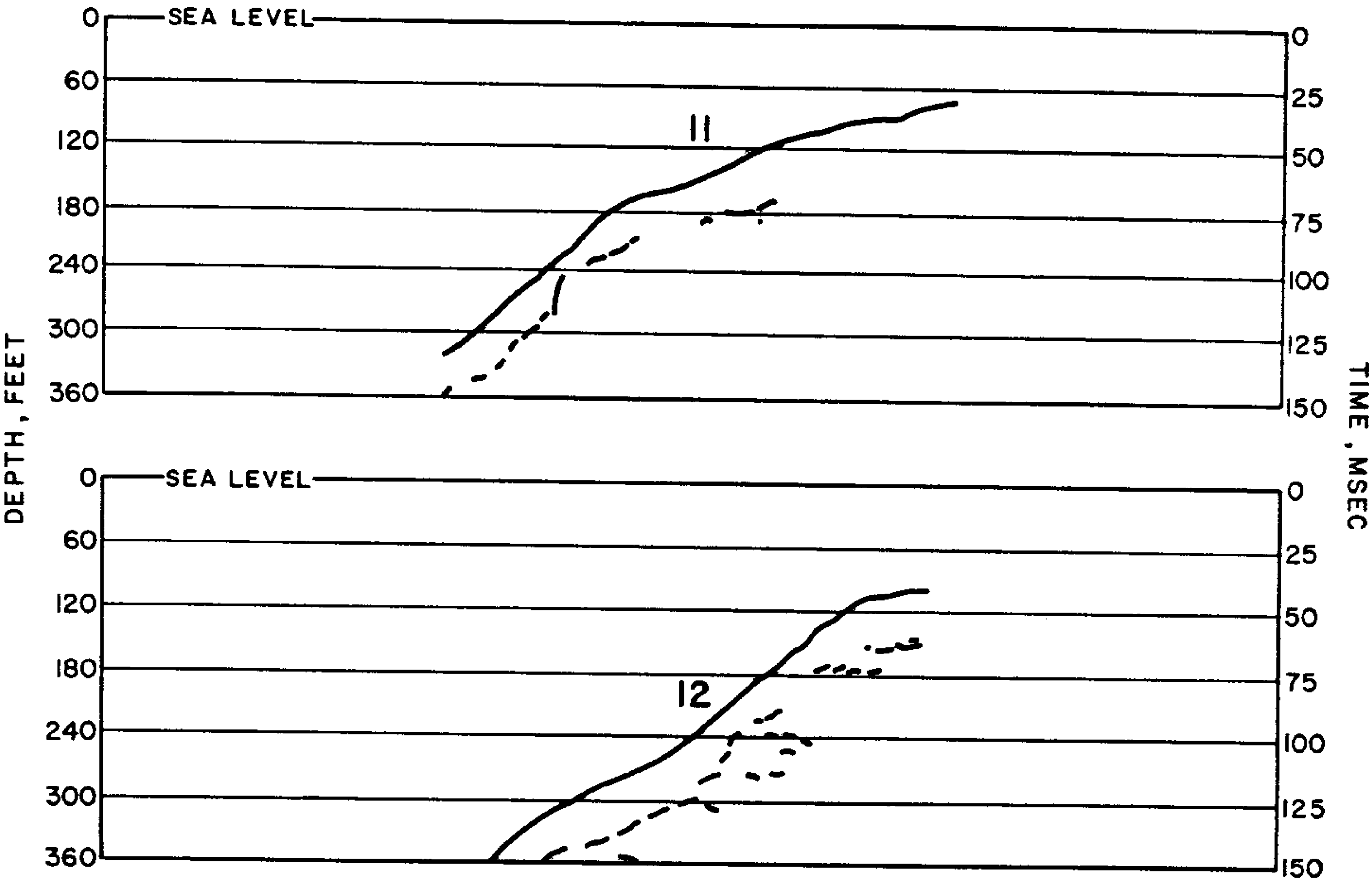
50. Tracings of seismic reflection records, sector E. Traverses 1-4 shown on Figure 3E.



5P. Tracings of seismic reflection records, sector E. Traverses 5-7 shown on Figure 3E.



5Q. Tracings of seismic reflection records, sector E. Traverses 8-10 shown on Figure 3E.



5R. Tracings of seismic reflection records, sector E. Traverses 11-12 shown on Figure 3E.

Table 1. Texture of sediment dredged near Pokai Bay, Oahu

Sample No.	Median Grain Size			Sorting	
	Phi	mm	Wentworth Class	Phi Deviation	Friedman Class
1	0.3	0.8	Coarse sand	2.35	Very poorly sorted
2	-1.4	2.6	Granules	2.00	Poorly sorted
3	2.5	0.18	Fine sand	1.37	Moderately sorted
4	2.3	0.22	Fine sand	1.02	Moderately sorted
5	(Coral gravel)				
6	2.05	0.24	Fine sand	1.25	Moderately sorted
7	2.2	0.20	Fine sand	1.48	Poorly sorted

Table 2. Color of sediment dredged near Pokai Bay, Oahu

Sample No.	Color (and Munsell Code)			
	As Dredged	After Exposure to Sun, in Days		
		2	6	22
1	Yellowish gray (5Y 7/2)	Yellowish gray (5Y 8/2)	Grayish yellow (10YR 8/4)	Very pale orange (10YR 8/2)
2	Yellowish gray (5Y 7/2)	Yellowish gray (5Y 8/2)	Yellowish gray (5Y 7/2)	Very pale orange (10YR 8/2)
3	Med. dk. gray (N4)	Med. lt. gray (N6)	Lt. gray (N7)	Lt. gray (N7)
4	Olive gray (5Y 4/1)	Lt. gray (N7)	Lt. gray (N7)	Very lt. gray (N8)
5	(Coral gravel)			
6	Lt. olive gray (5Y 5/2)	Dk. yellowish brown (10YR 4/2)	Med. gray (N5)	Med. lt. gray (N6)
7	Olive gray (5Y 4/1)	Lt. olive gray (5Y 6/1)	Lt. olive gray (5Y 6/1)	Lt. gray (N7)

Table 3. Sand indicated on continuous reflection profiles, leeward Oahu, by coastal sector and by depth interval. Corrected for direction of traverses.

Sector Traverse	Area on Record (sq. yds. corrected)			
	60-120 ft.	120-180 ft.	180-300 ft.	Total
A				
1	269	2201		2470
2	756	1947	1489	4192
3	311	1646	3137	5094
4		584	2378	2962
5			2609	2609
6		982	3265	4247
7		411	1857	2268
8		1544	3823	5367
9		2550	3180	5730
10		211	2412	2623
11	153	3224	5965	9342
12		2444	5242	7686

Table 3 (continued)

Sector Traverse	Area on Record (sq. yds. corrected)			
	60-120 ft.	120-180 ft.	180-300 ft.	Total
A				
13		3664	3530	7194
14		614	2761	3375
Mean, profiles w/sand:	372	1694	3203	
Mean, all profiles:				4654 sq. yds.

(i.e., sector A averages 4654 yd^3 per yd. of coast.)

Length of sector A: 8400 yds.

Volume, sector A: 39,100,000 cu. yds.

Sector Traverse	60-120 ft.	120-180 ft.	180-300 ft.	Total
B				
1	1160	4588	1989	7737
2		1233	3531	4764
3		2035	5379	7414
4		2097	7084	9181
5		501	3249	3750
6		1570	4521	6091
7	133	1602	2053	3788
8		1790	1615	3405
9	4207	9225	4686	18118
10		124	3819	3943

Table 3 (Continued)

Sector Traverse	Area on Record (sq. yds. corrected)			
	60-120 ft.	120-180 ft.	180-300 ft.	Total
B				
11		70	1760	1830
12	2500	6111	5925	14536
13	9714	5514		15228
14			3930	3930
Mean, profiles w/sand:	3542	2804	3810	
Mean, all profiles:				7408 sq. yds.

Length of sector B: 10,300 yds.

Volume, sector B: 76,300,000 cu. yds.

C				
1			4000	4000
2		556	3007	3563
3	2088	5844	6875	14807
4	330	1985	3954	6269
5			2222	2222
6			1473	1473
7	944	2389	1733	5066
8	2108	2728	3274	8110
9			4372	4372

Table 3 (Continued)

Sector Traverse	Area on Record (sq. yds. corrected)			
	60-120 ft.	120-180 ft.	180-300 ft.	Total
C				
10	2061	5008	1718	8787
11		2148	2773	4921
12	831	4316	1908	7055
13			2484	2484
14	1642	5282	1239	8163
15	1704	5134	3209	10047
16			6627	6627
Mean, profiles w/sand:	1463	3539	3179	
Mean, all profiles:				6122 sq. yds.
Length of sector C: 14,200 yds.				
Volume, sector C: 86,900,000 cu. yds.				
D				
1			4416	4416
2			4152	4156
3			2787	2787
4			1303	1303
5			2887	2887
6			2952	2952

Table 3 (Continued)

Sector Traverse	Area on Record (sq. yds. corrected)			
	60-120 ft.	120-180 ft.	180-300 ft.	Total
D				
7			3225	3225
8		820	3164	3984
9	410	7794	9431	17635
10		1578	2129	3707
11	1308	2735	1379	5422
12	1084	2225	1426	4735
13			945	945
Mean, profiles w/sand:	934	3030	3092	
Mean, all profiles:				4473 sq. yds.

Length of sector D: 17,900 yds.

Volume, sector D: 80,100,000 cu. yds.

Sector Traverse	60-120 ft.	120-180 ft.	180-300 ft.	Total
E				
1			920	920
2		392	4392	4784
3	768	2994	3243	7005
4	596	1458	2526	4580
5	1081	4599	1978	7658
6	620	43	1481	2144

Table 3 (Continued)

Sector Traverse	Area on Record (sq. yds. corrected)			
	60-120 ft.	120-180 ft.	180-300 ft.	Total
E				
7		3873	2301	6174
8	2936	4145	7432	14513
9	1105	6224	3223	10552
10	1599	4982	4320	10901
11		2395	3154	5549
12	503	3026	3633	7162
Mean, profiles w/sand:	1151	3102	3216	
Mean, all profiles:				6828 sq. yds.

Length of sector E: 13,300 yds.

Volume, sector E: 90,800,000 cu. yds.

Total Volume sectors A-E: 373,200,000 cu. yds.

ridges on land approach the shore or where promentories break the shoreline into littoral cells, for example off Kepuhi, Maili, and Barbers Points. The sand in the 180- to 300-foot depth range appears on all but two of the profiles. One of these does not cross this depth zone and the other is at the very northern end of the surveyed area, where Brock and Chamberlain (1968) observed only patchy sand in depths down to and below the depths of present interest.

The sector between Makua and Kepuhi Point contains about 40 million cubic yards of sand, the lowest sand volume of the 5 coastal segments. About 2/3 of the sand is found between the 180- and 300-foot depths, and very little is shallower than 120 feet. This sector of coast would probably receive a low priority for future offshore exploratory and exploitative work. Between Kepuhi and Maili points the survey indicated about 75 million cubic yards of sand. That coastal segment is a prime candidate for additional detailed work, because major bodies of sand were found at depths shallower than 60 feet. From Maili Point to Barbers Point there is about 85 million cubic yards of sand, nearly half of which is in the 120- to 180-foot depth range. The last two sectors, Barbers Point to Keahi Point, and Keahi Point to Honolulu Harbor entrance, have about 80 million and 90 million cubic yards of sand, respectively, and in each sector the sand is about evenly split between the 120- to 180- and the 180- to 300-foot depth intervals; only modest amounts of sand are in shallower depths than 120 feet.

Summary

The sand resources off the leeward coast of Oahu are on the order of 3.7×10^8 cubic yards. Their great volume indicates the need of detailed inventories of this resource.

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