RECONNAISSANCE SAND INVENTORY: OFF LEEWARD MOLOKAI AND MAUI

By

J. F. CAMPBELL, B. R. ROSENDAHL, W. T. COULBOURN,
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Prepared under the

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National Oceanic and Atmospheric Administration
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ABSTRACT

The leeward coasts of the islands of Molokai and Maui have been surveyed for shallow-water sand resources. Sediment deposits of 4.0×10^9 cubic yards were discovered using seismic reflection techniques. Twenty-four surface sediment samples collected during the survey indicate that much of the sediment is either finer or coarser than sand size. This reconnaissance survey discovered 5 areas where sand volume and quality indicate that detailed surveying and mapping are desirable.

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ILLUSTRATIONS

Location

The leeward coast of Molokai from Halena Gulch to Pukoo Harbor has been surveyed. Figure 1 shows the location of the surface sediment samples collected along this coast, and the sectors into which the coast has been divided for the purposes of this report. Figures 2A and 2D show individual sectors with the location of the ship's tracks along which seismic reflection records were obtained.

The leeward coast of Maui was surveyed from Hana Kaoo Point to Ahihi Bay. Figure 3 shows the location of the sectors into which this coast has been divided and the location of the surface samples that were collected during the survey. Figures 4A to 4D show individual sectors and the location of the ship's tracks along which seismic reflection records were obtained.

Generally, the ship moved in a zig-zag pattern along the coast, but some traverses were run parallel to the shore to check on the continuity of the sediment body between profiles. An attempt was made to survey the area between depths of 60 feet and 300 feet. Off the Maui coast, however, the 300-foot contour is so far from shore that we could not have reasonably covered the whole area in the time available, so the survey was concentrated on areas closer to the island. The shallow end of traverses often stopped deeper than the 60-foot contour, due to decisions by the captain concerning the safety of his ship where the bottom was rising rapidly.

Methods and Analysis

The survey was conducted with the same sparker-type seismic

reflection system that was used off leeward Oahu (Campbell *et al.*, 1970). This system is limited in usefulness to depths of water greater than about 60 feet. The length of the out-going pulse masks shallower records. This problem also limited our ability to interpret the minimum thickness of sediment shown on the profiles. Where the bottom and sub-bottom surfaces are parallel, thicknesses less than 60 feet are difficult to see; but where they are opposed at some angle to each other, thicknesses as small as 5 feet can sometimes be seen.

Analysis of the reflection records was made by tracing the bottom and all sub-bottom reflections, and then by picking the water depth and sub-bottom travel time at a set interval across the records. Sediment thicknesses were calculated from sub-bottom travel times using a velocity of 5400 feet/second for the sediment layer. This velocity had been determined from seismic refraction lines shot in sand in Kaneohe Bay, Oahu (Moberly and Campbell, 1969). Surface samples collected during this present survey range in median grain size from 0.10 mm to 0.96 mm. Since grain size is indicative of sound velocity (Hamilton, 1970) this velocity of 5400 feet/second is probably not always the correct one. However, the relatively small differences would be less than 10%, so no attempt was made to adjust the velocity for known sediment characteristics.

Unlike leeward Oahu where sediment bodies appeared to be separated by rock outcrops, there appears to be a general, fairly uniform layer of sediment off the leeward coasts of Molokai and Maui. There are occasional places off the Maui coast where the records show mound-like characteristics that are interpreted as reefs. Figures 5A-D

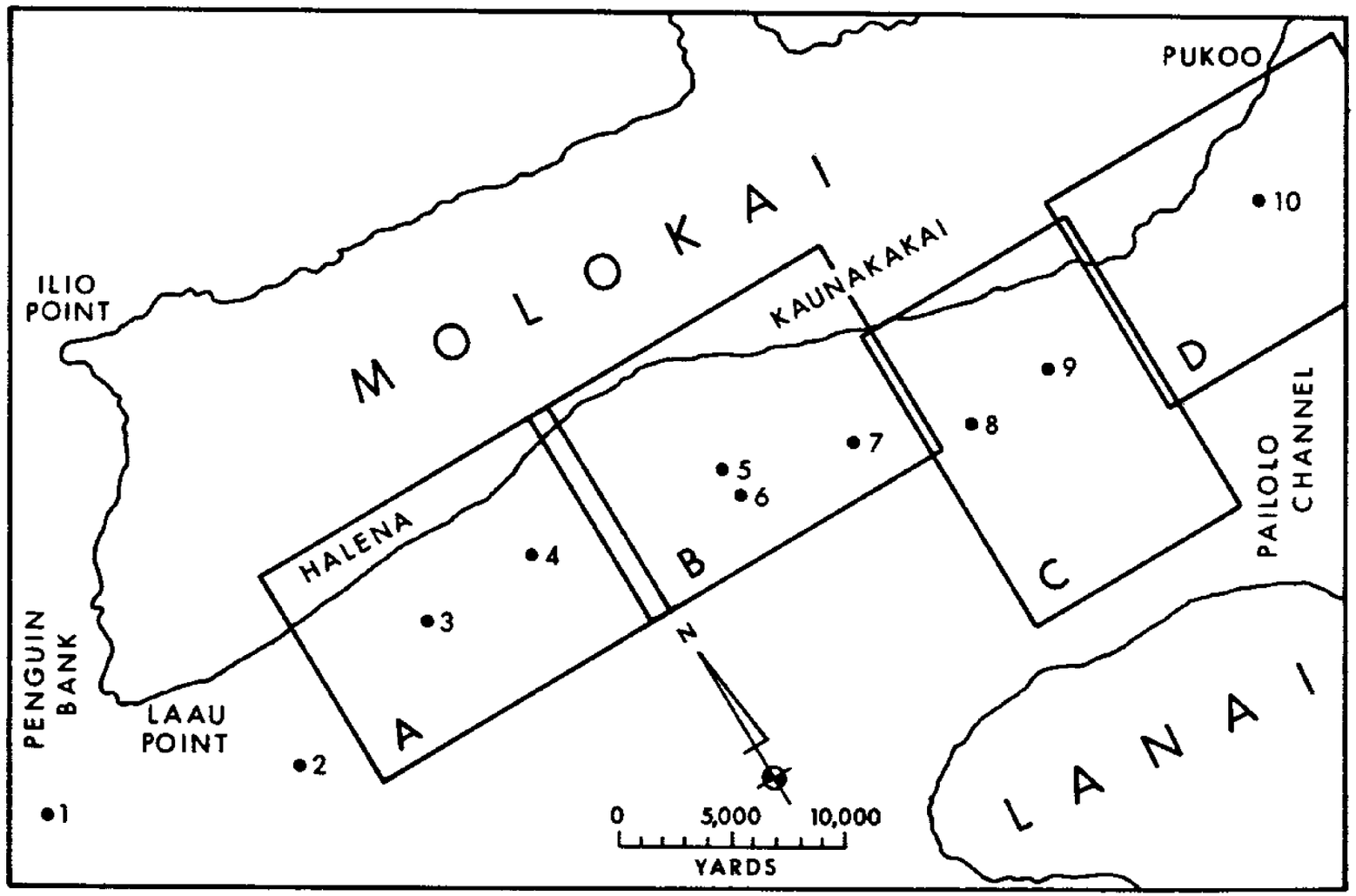

Fig. 1. Map of Molokai, Hawaii, showing sections of reconnaissance surveys.

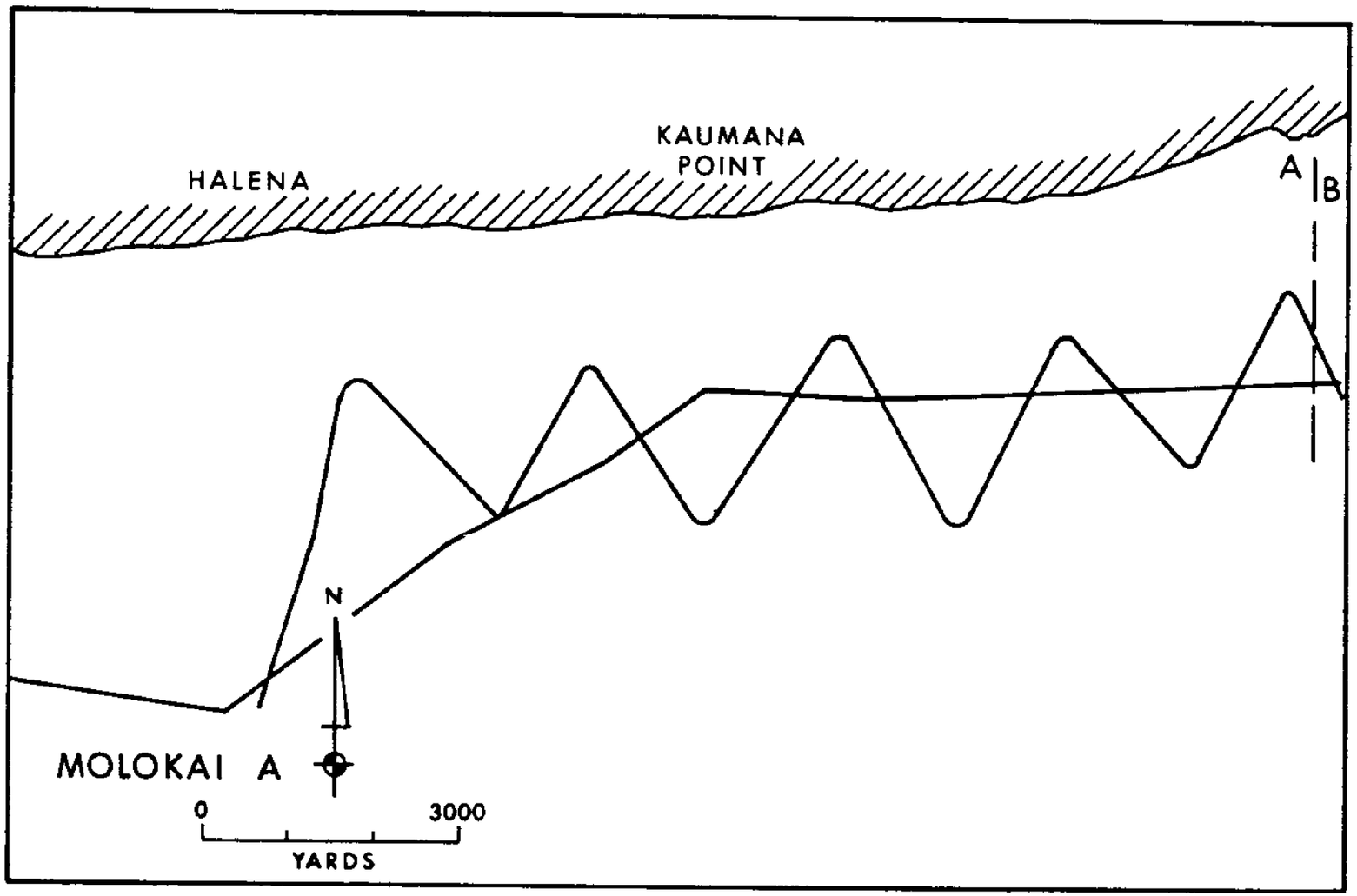

Fig. 2A. Ship tracks in Molokai sector A.

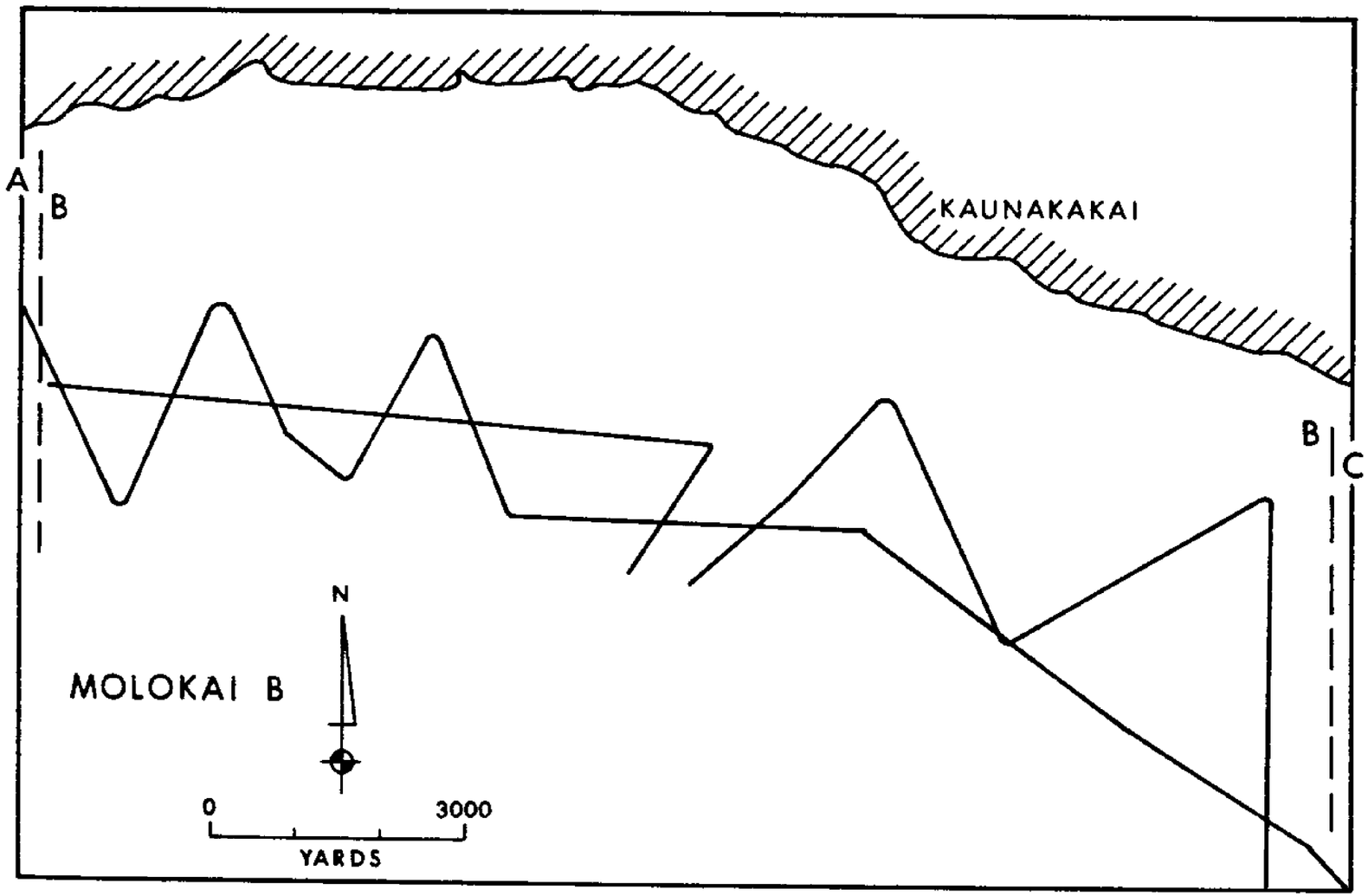

Fig. 2B. Ship tracks in Molokai sector B.

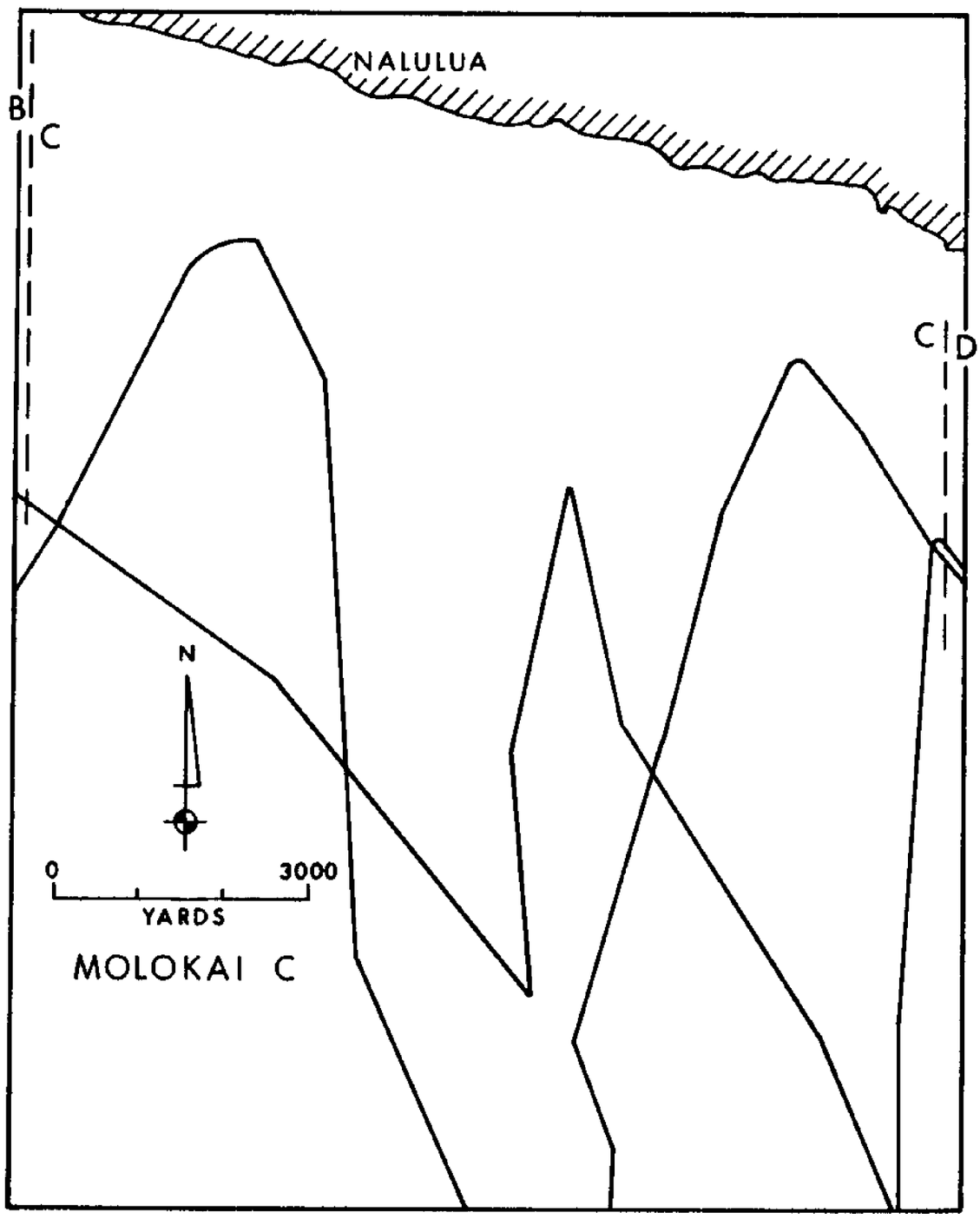

Fig. 2C. Ship tracks in Molokai sector C.

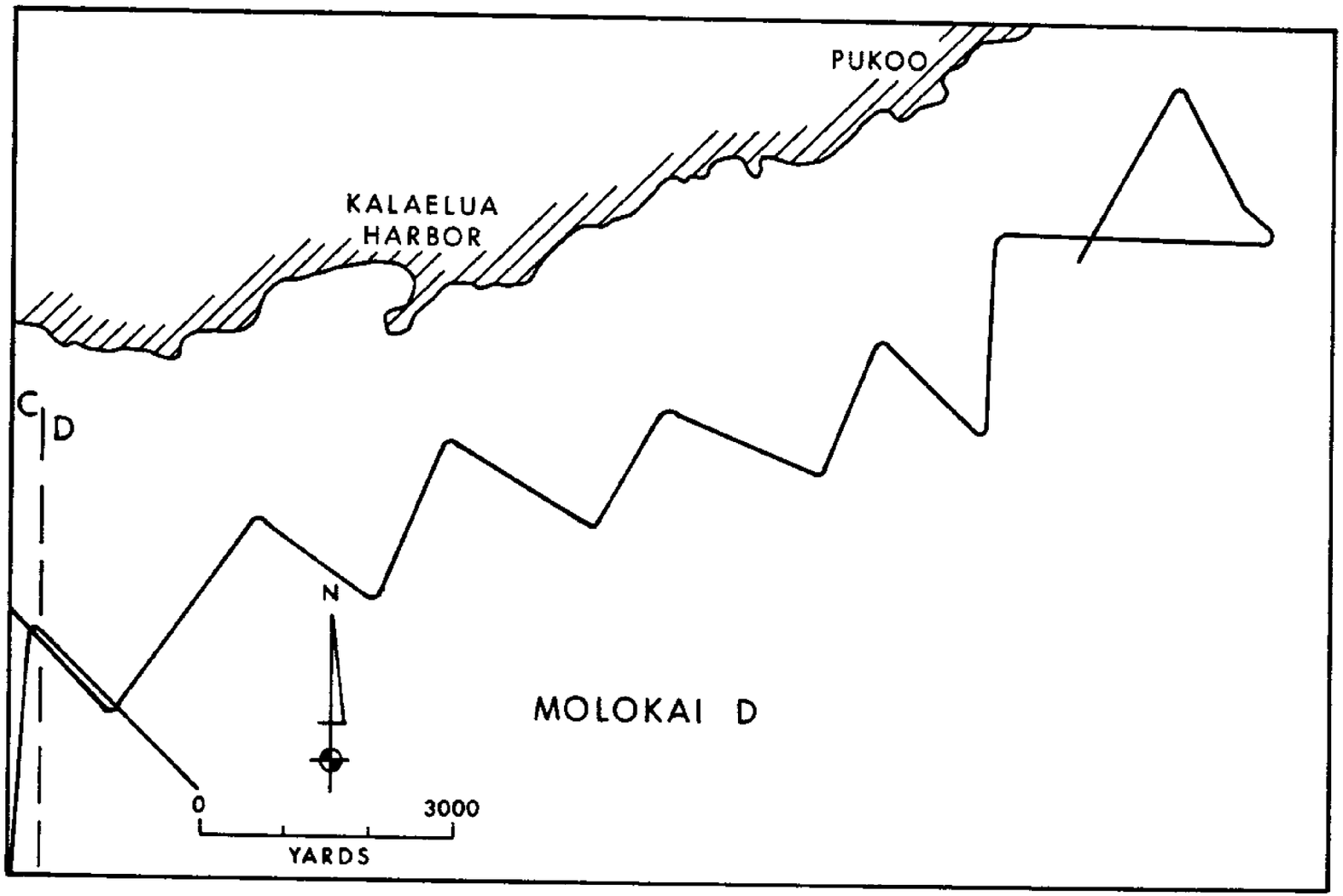

Fig. 2D. Ship tracks in Molokai sector D.

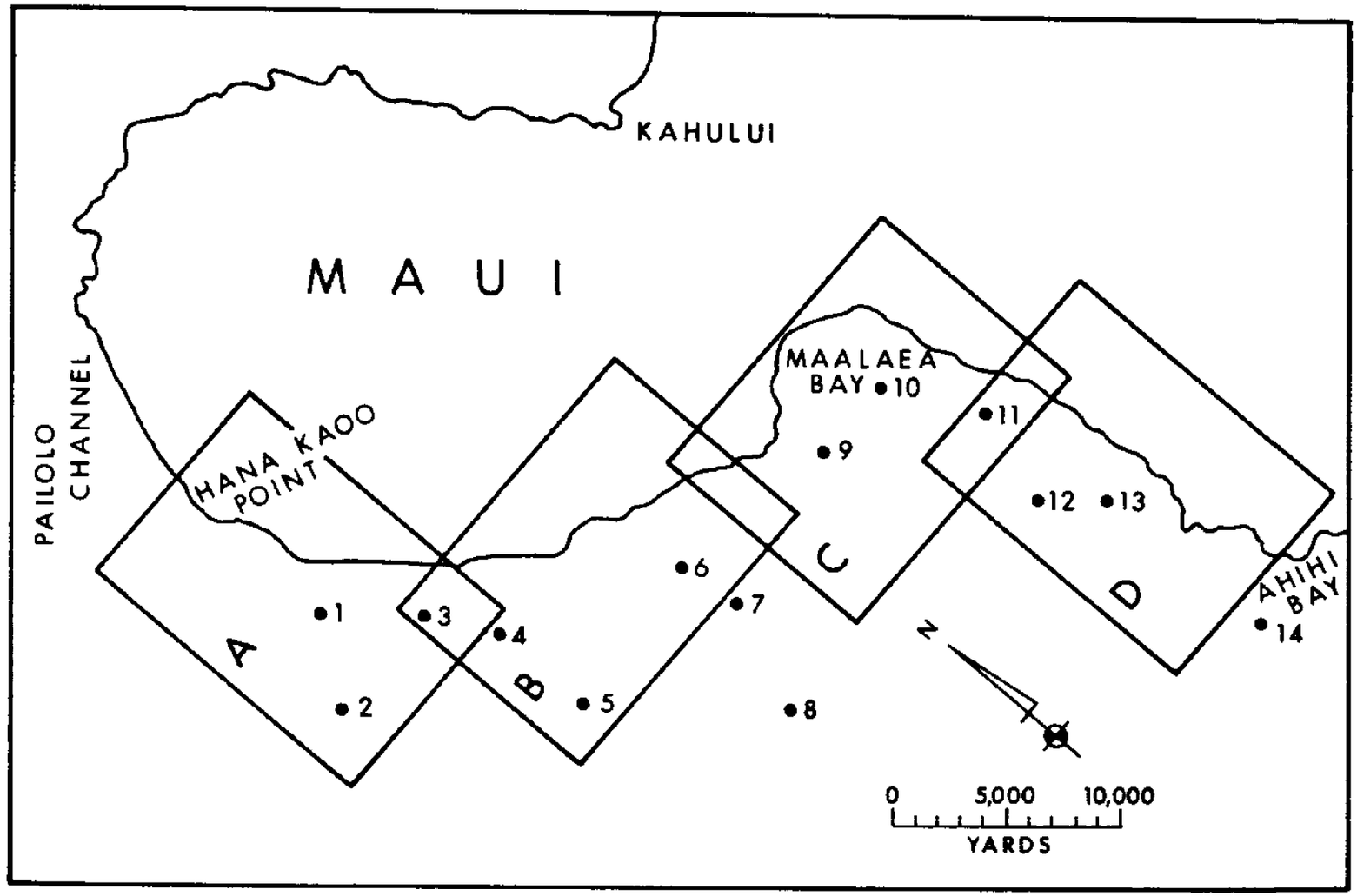

Fig. 3. Map of Maui, Hawaii, showing sectors of reconnaissance surveys.

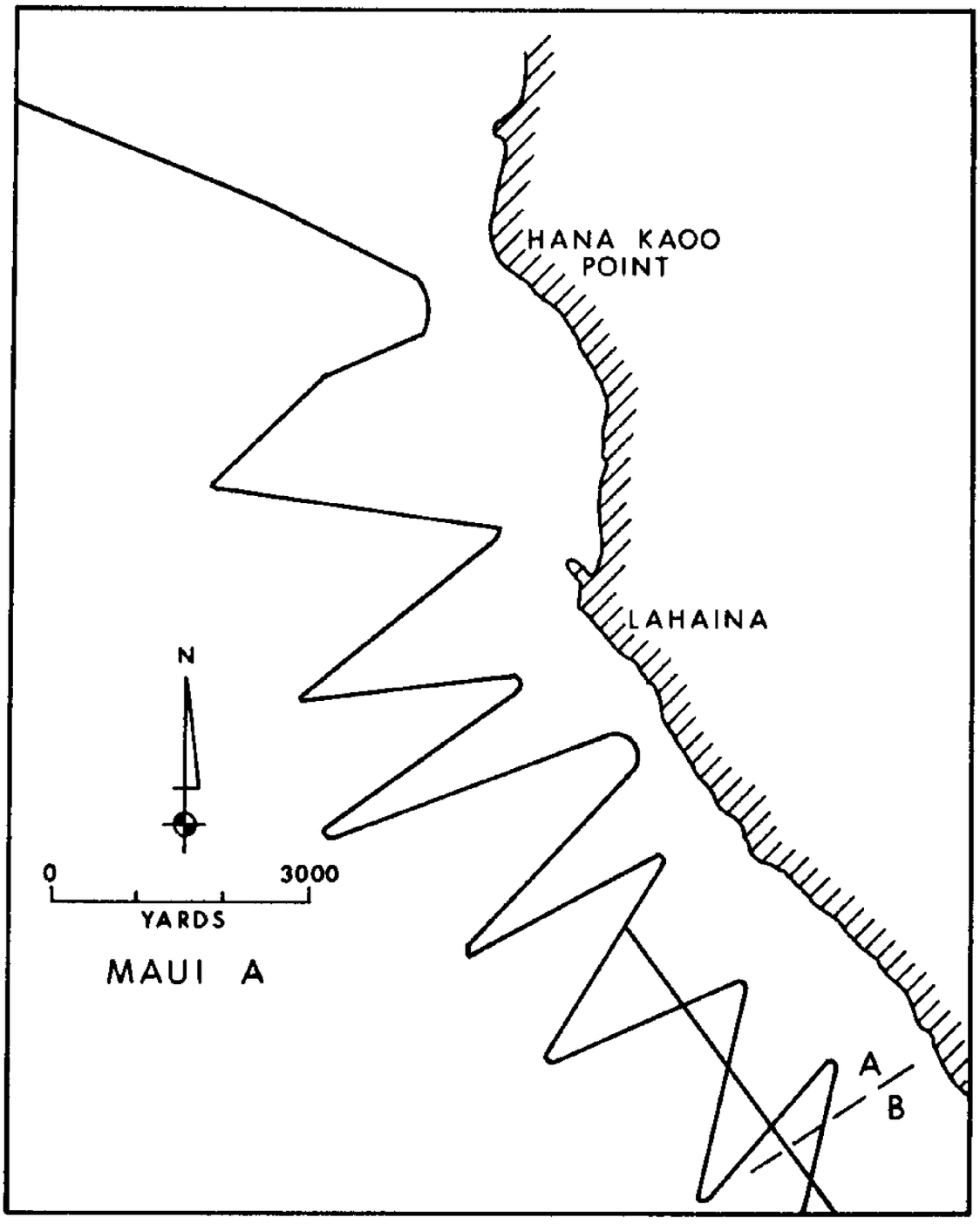

Fig. 4A. Ship tracks in Maui sector A.

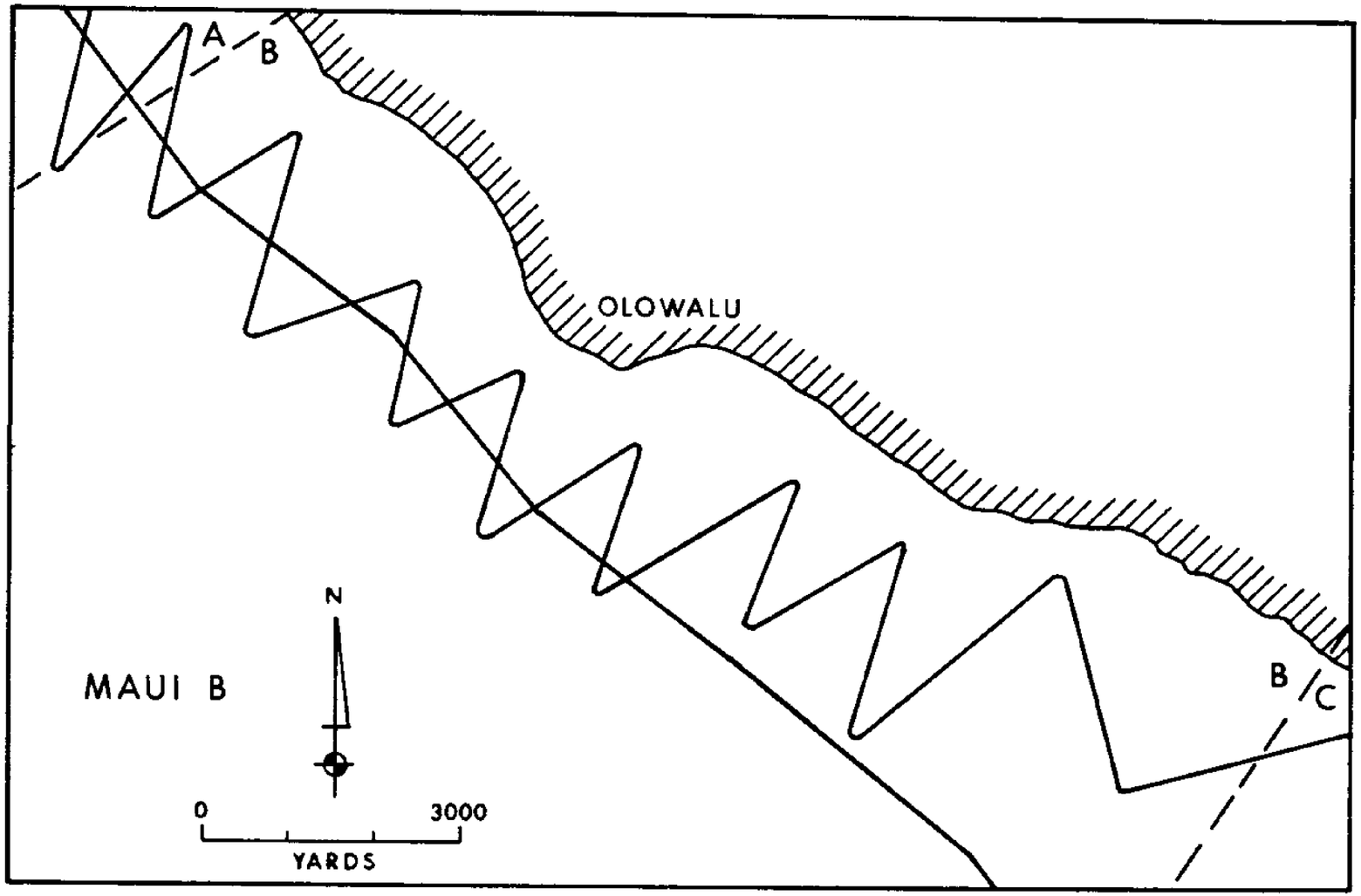

Fig. 4B. Ship tracks in Maui sector B.

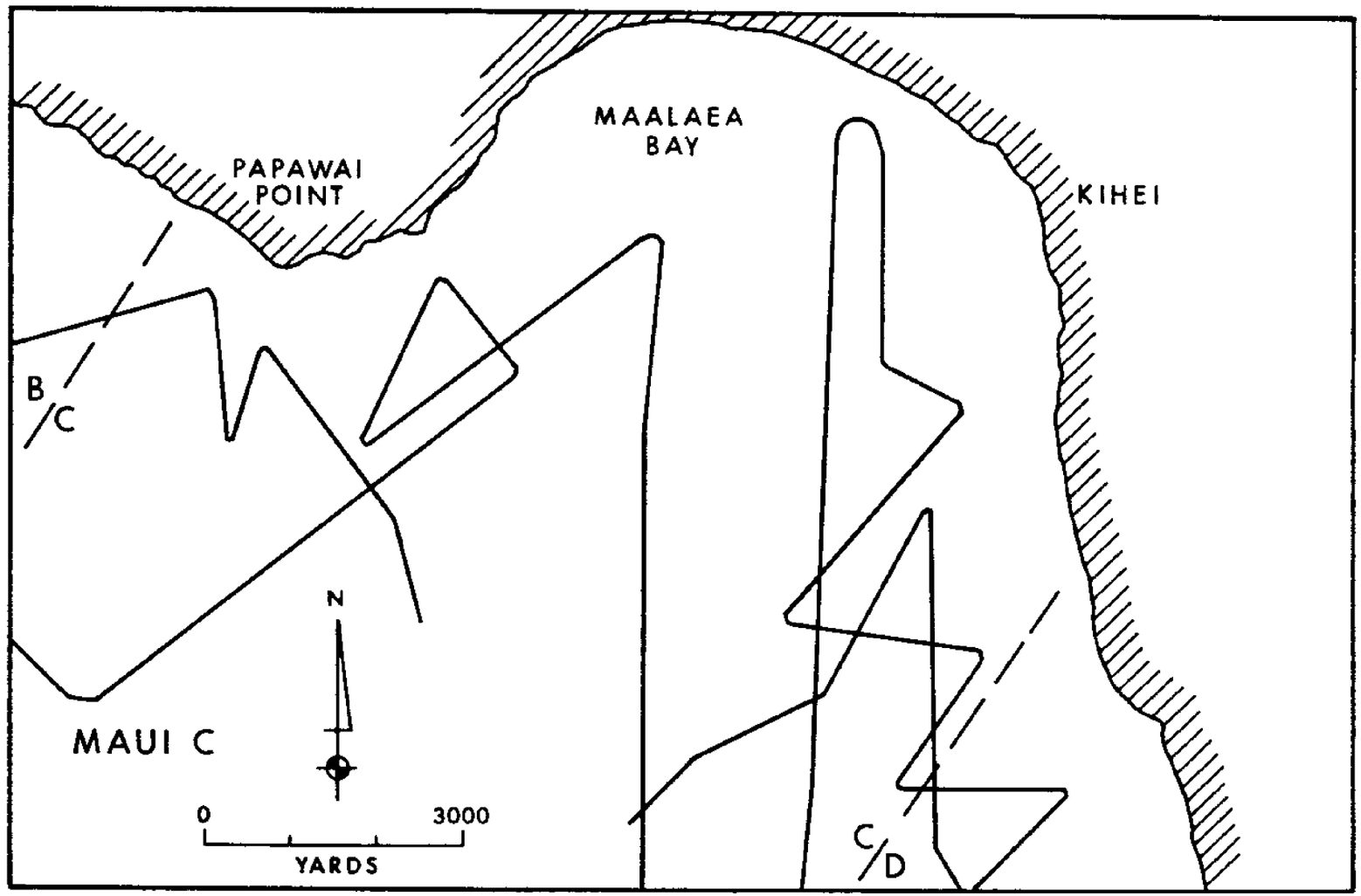

Fig. 4C. Ship tracks in Maui sector C.

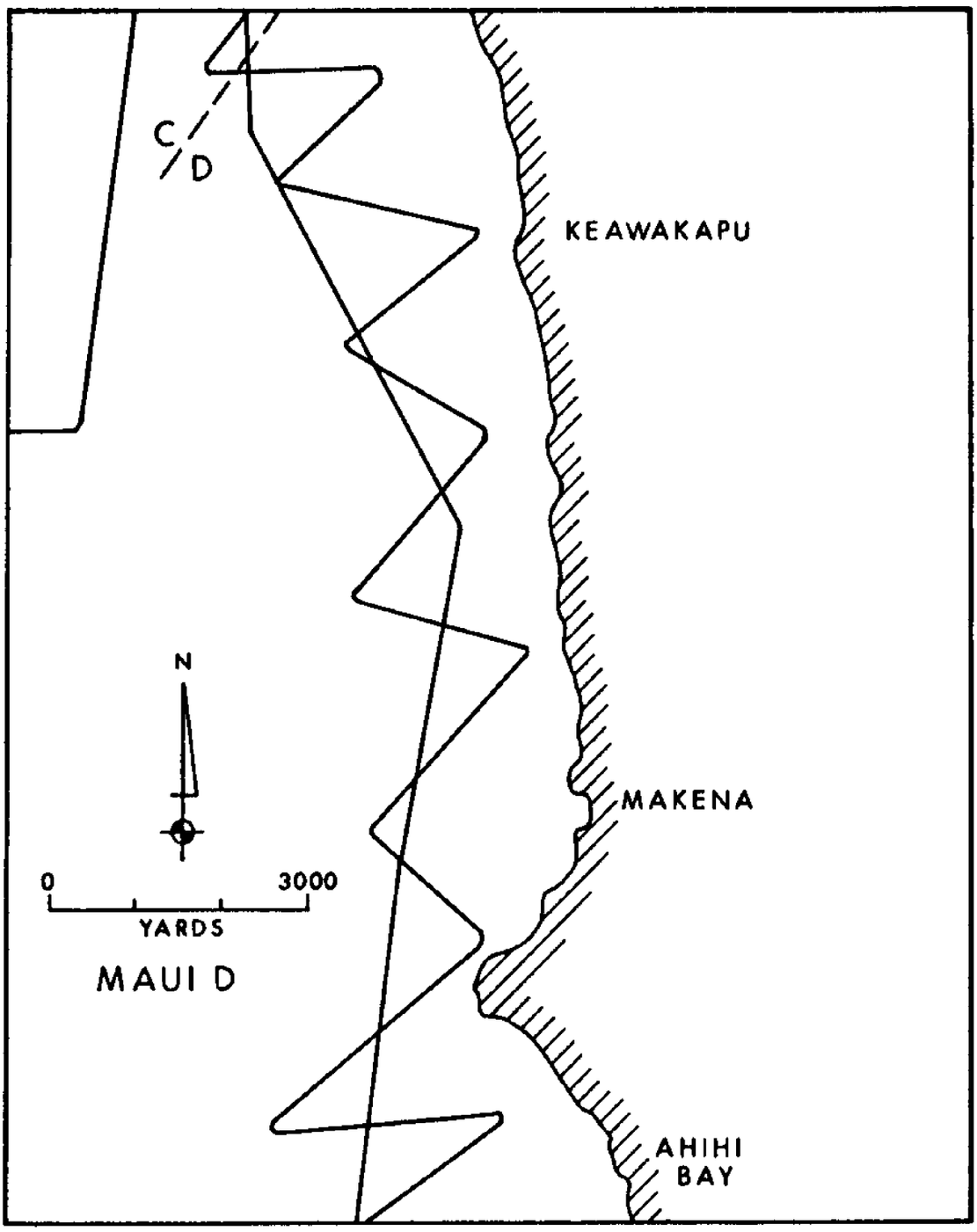

Fig. 4D. Ship tracks in Maui sector D.

and 6A-D show the aerial extent of the sediment bodies found off Maui and Molokai and the location of the profiles that are reproduced in Figures 7A-R and 8A-G.

The volume of sediment in each of the sectors was determined by multiplying the surface area by the average thickness of sediment on all the profiles in each sector. Table 1 gives the area, average thickness, and volume for each of the sectors.

Surface sediment samples were obtained in 24 locations during this reconnaissance. All but one of the samples were collected with a small pipe dredge. This method of bottom sampling is far from ideal for a study of this sort where we are looking at relatively thick sediment bodies. The pipe dredge scrapes a sample off the surface, and thus gives no indication of how the sediment might vary with depth. One sample was obtained with a gravity coring device, but apparently part of the material washed out on the way to the surface and thus the sample (Maui 14) is not very representative of what is on the bottom. The samples were analyzed using standard laboratory techniques and the results are shown in Table 2. Since many of the samples had an abundance of material that was not in the sand-size range, the grain-size parameters were recalculated to show the data for the sand-size material alone (Table 3). In effect, this gives information that would be relevant to someone mining these deposits if he were willing to screen the material to retain only the sand-size particles.

Results

Off the leeward coast of Molokai there are $1{,}138 \times 10^6$ cubic yards

Table 1

Area and Average Thickness Value for Each Sector

Island	Sector	Area (sq yds) $\times 10^6$	Average thickness(yds)	Volume($yd^3 \times 10^6$)
Maui	A	30.9	24.9	769.4
	B	30.8	24.0	739.2
	C	40.3	25.3	1019.6
	D	15.6	23.7	369.7
		Maui Total		2897.9×10^6 yd^3
Molokai	A	13.3	12.6	167.6
	B	24.6	13.6	334.6
	C	29.7	16.0	475.2
	D	7.4	21.7	160.6
		Molokai Total		1138.0×10^6 yd^3
		Molokai and Maui Total		4035.9×10^6 yd^3

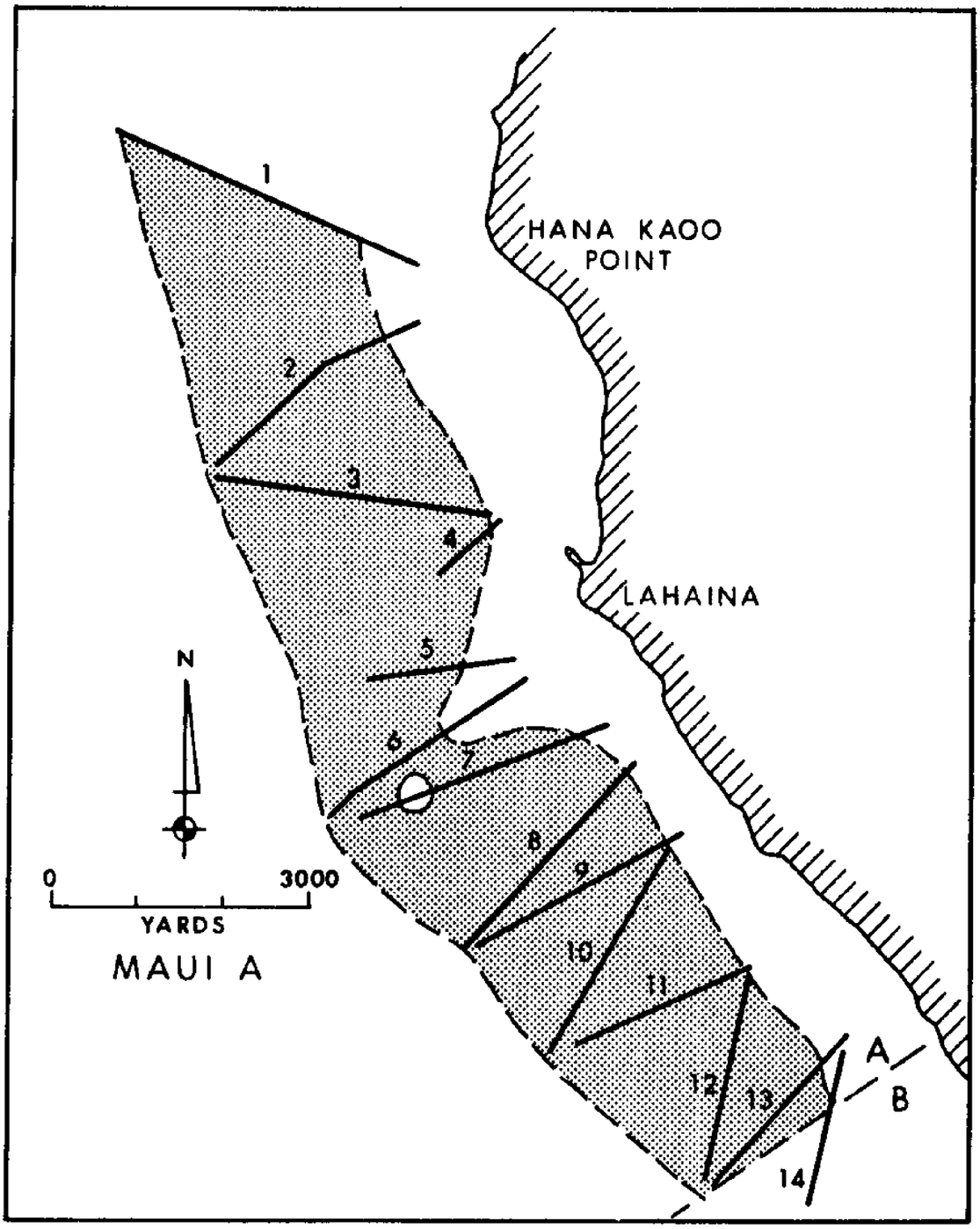

Fig. 5A. Areas of sandy bottom and seismic reflection traverses, Maui sector A.

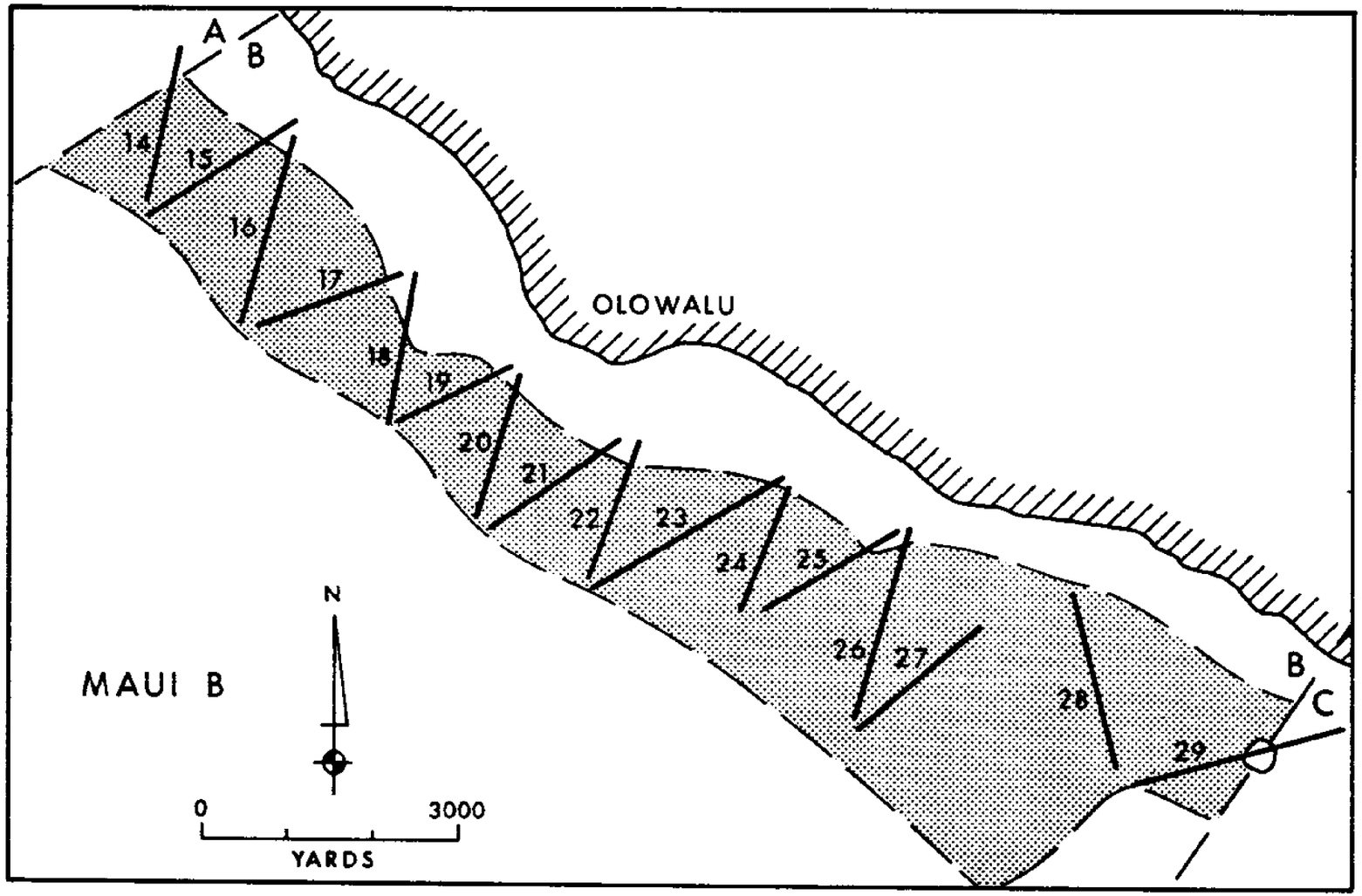

Fig. 5B. Areas of sandy bottom and seismic reflection traverses, Maui sector B.

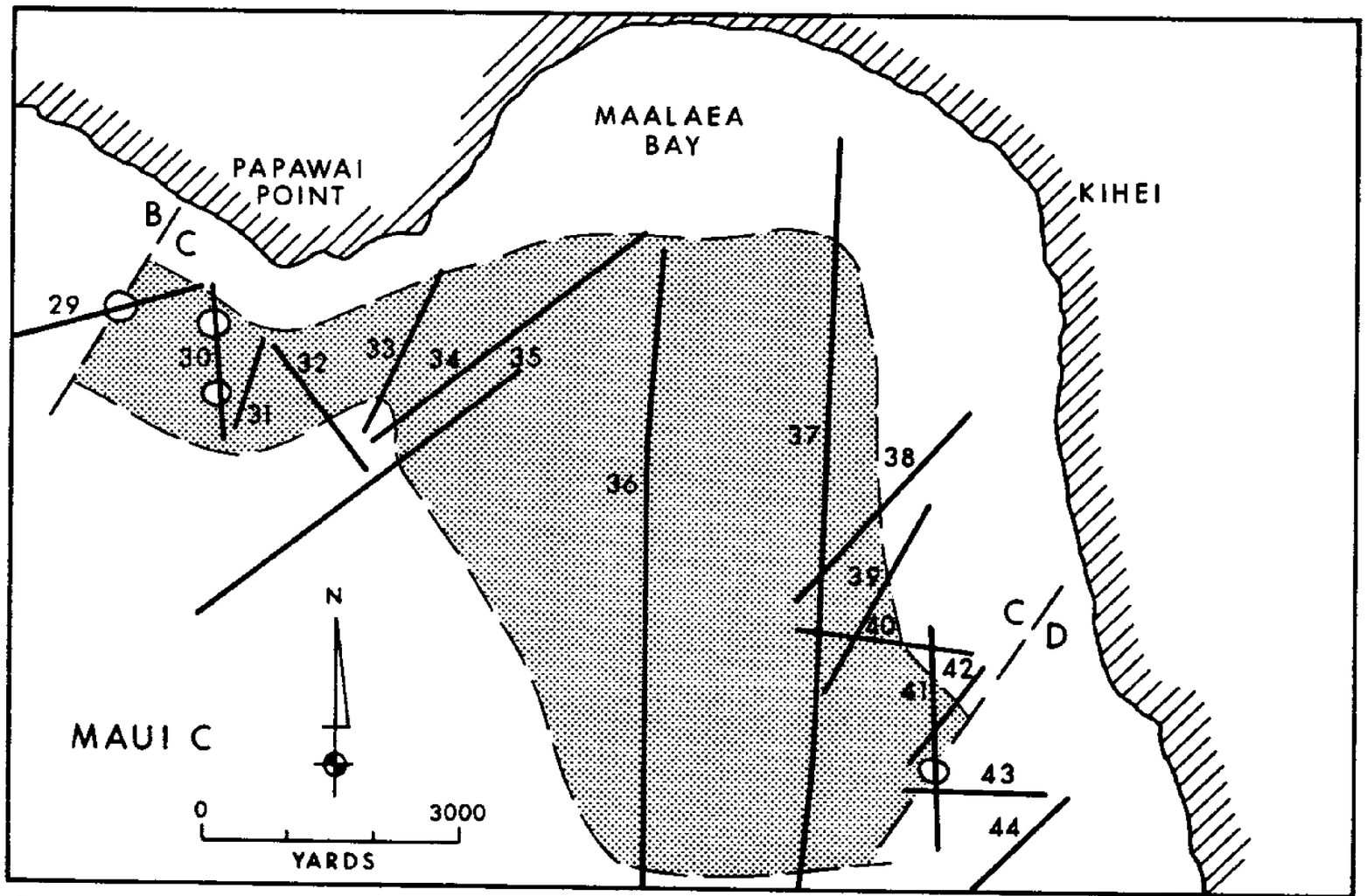

Fig. 5C. Areas of sandy bottom and seismic reflection traverses, Maui sector C.

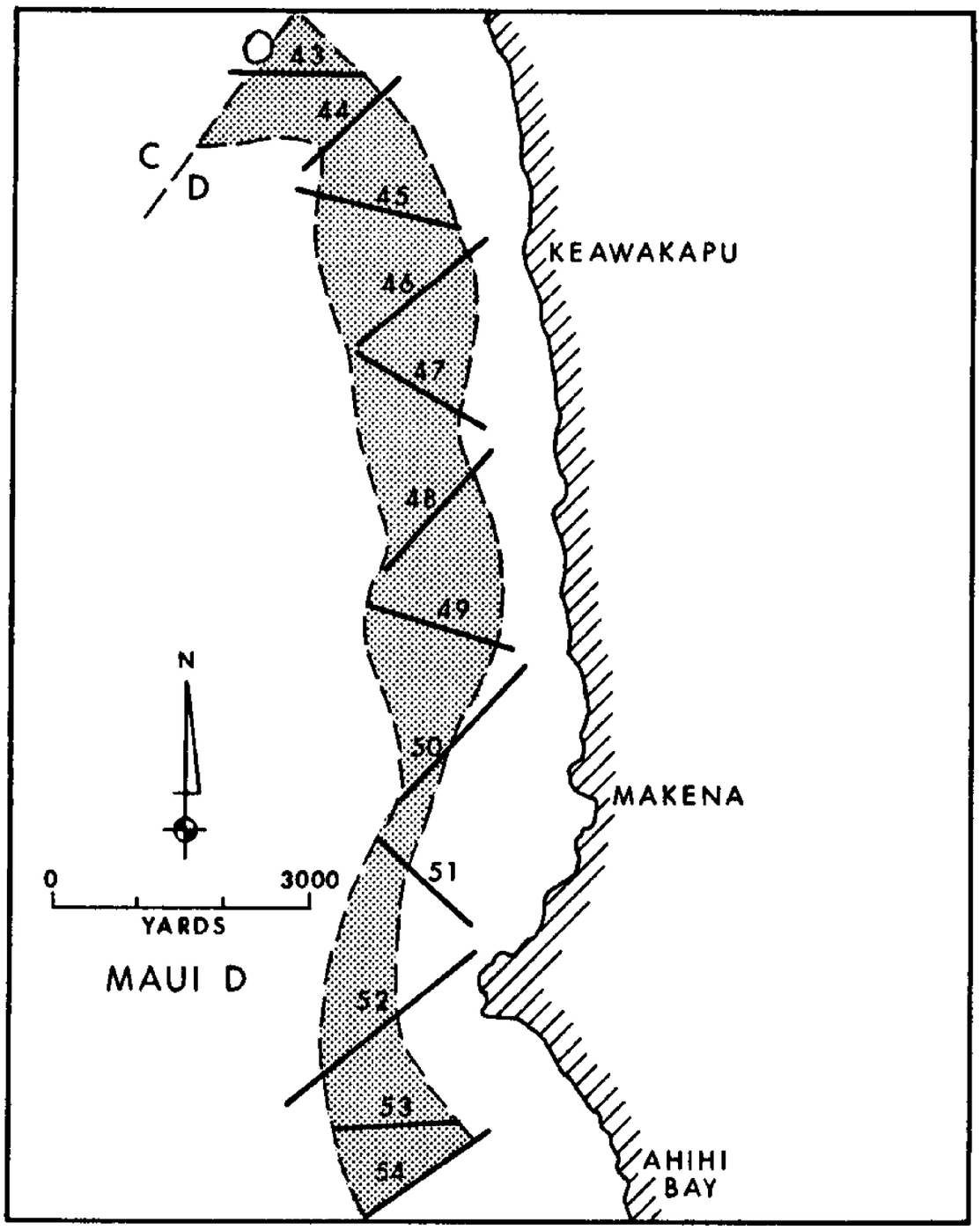

Fig. 5D. Areas of sandy bottom and seismic reflection traverses, Maui sector D.

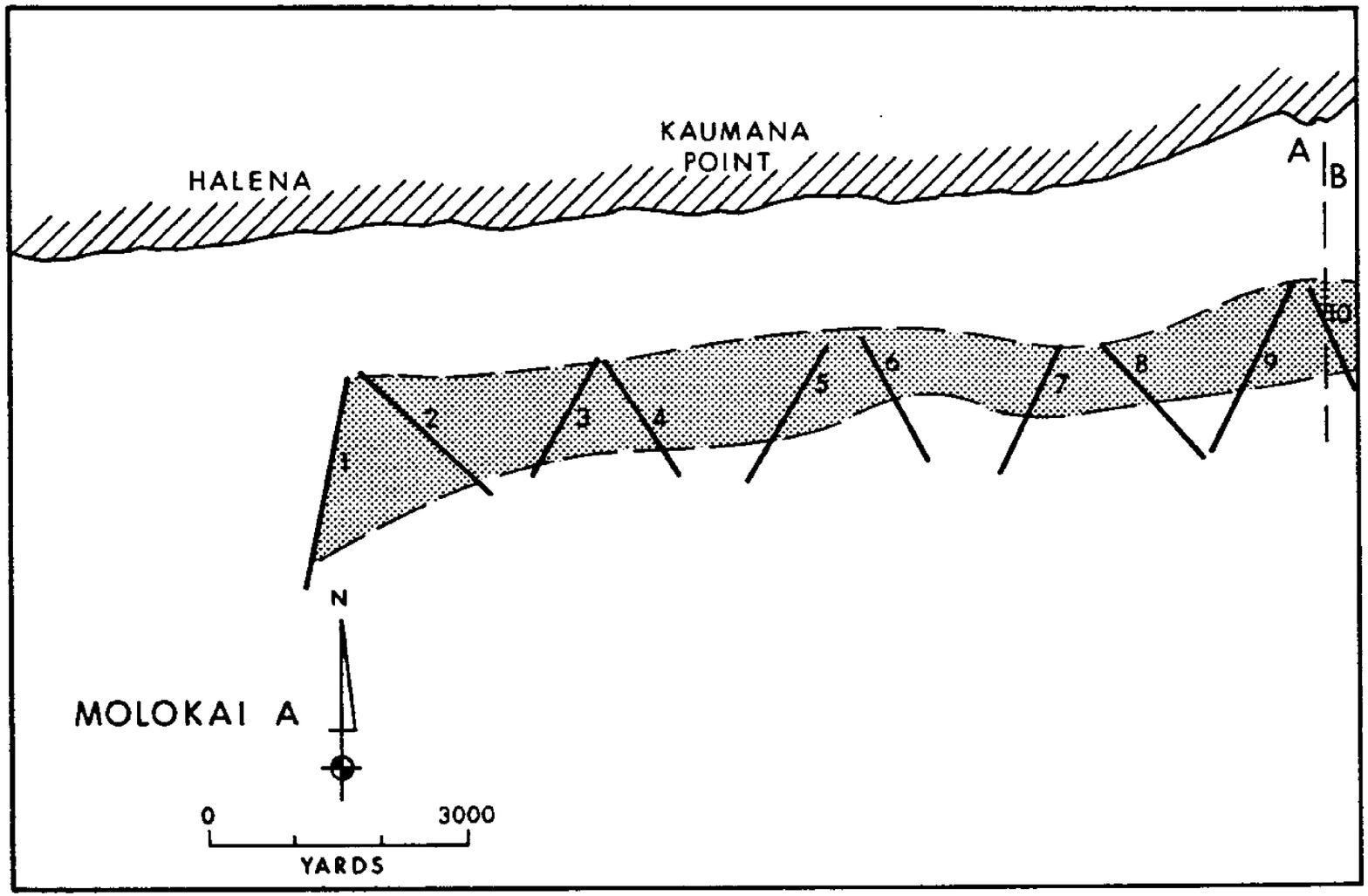

Fig. 6A. Areas of sandy bottom and seismic reflection traverses, Molokai sector A.

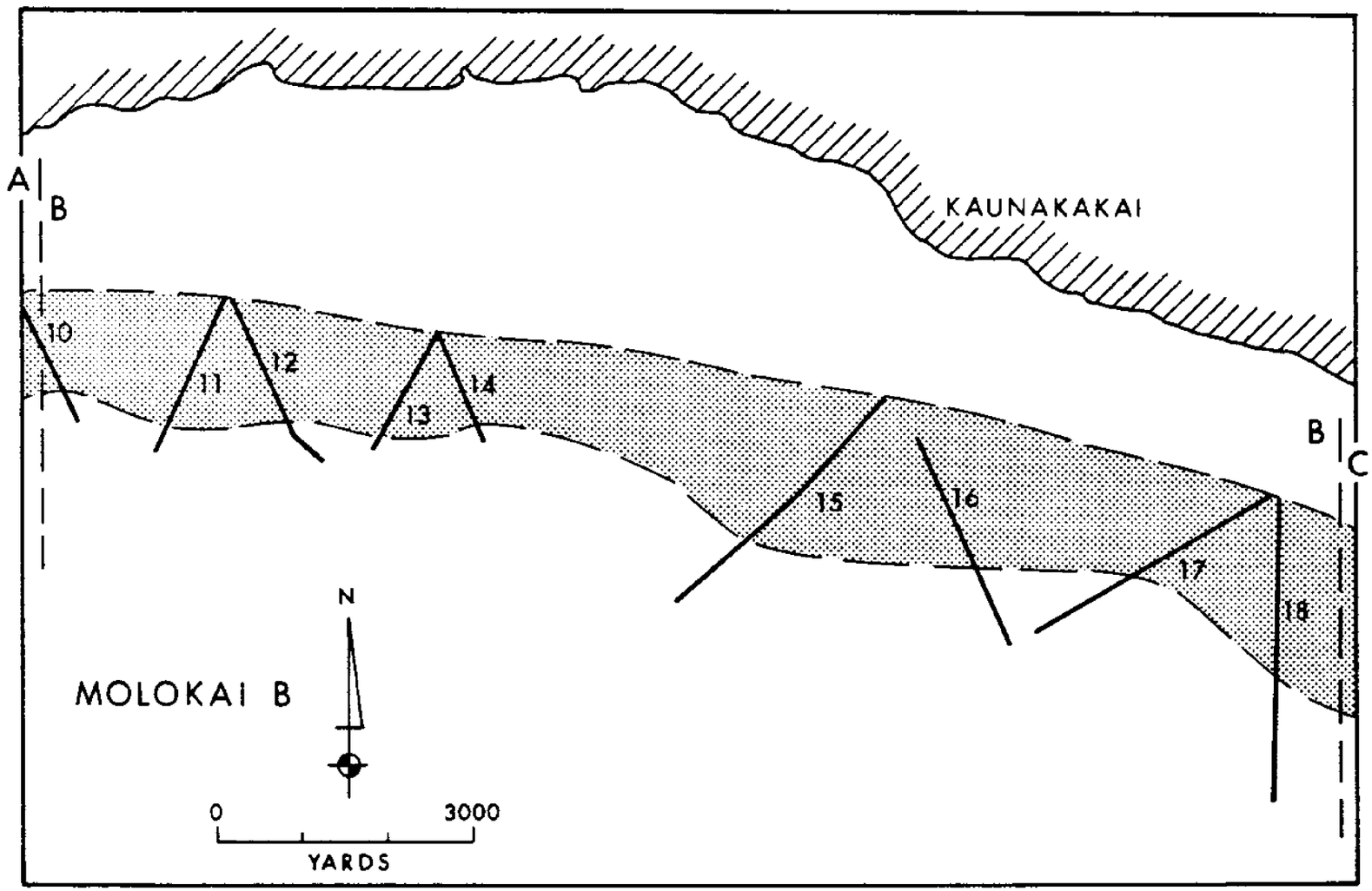

Fig. 6B. Areas of sandy bottom and seismic reflection traverses, Molokai sector B.

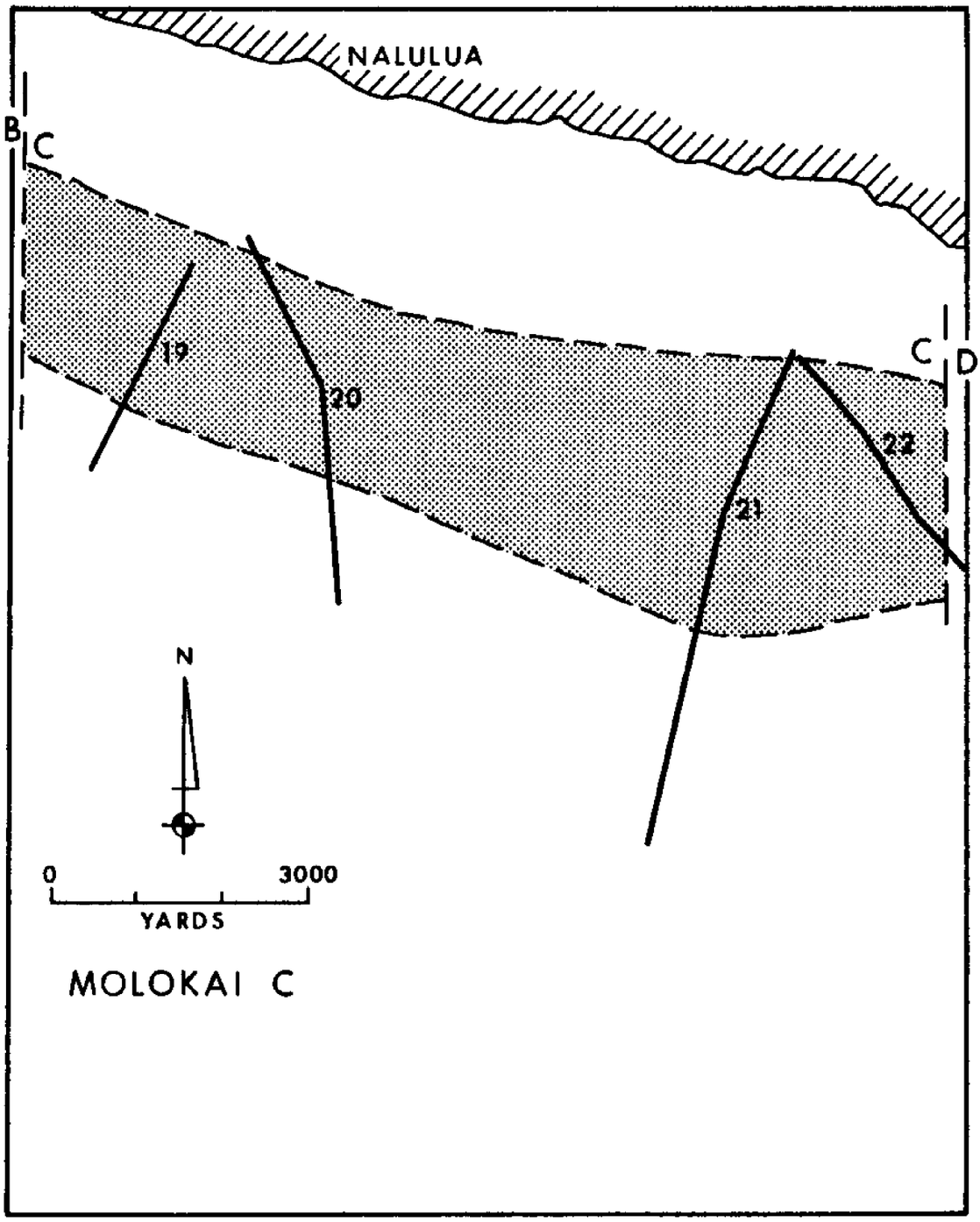

Fig. 6C. Areas of sandy bottom and seismic reflection traverses, Molokai sector C.

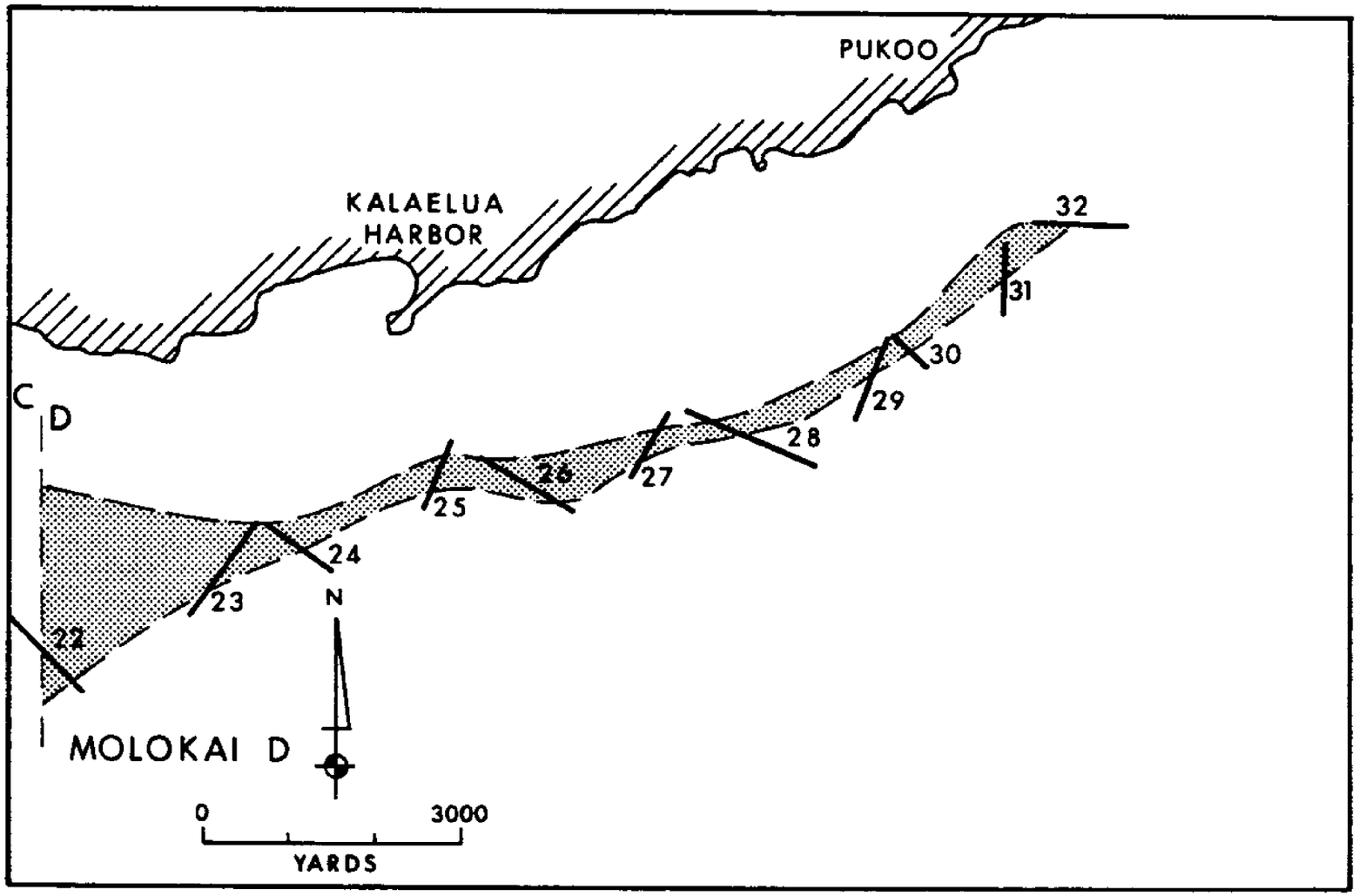

Fig. 6D. Areas of sandy bottom and seismic reflection traverses, Molokai sector D.

Table 2

Grain Size Parameters

Sample No.	Median Grain Size			Sorting	
	Phi	mm	Wentworth Class	Phi Deviation	Friedman Class
			Molokai		
1	-1.2	2.20	Granule	*	
2	1.3	0.40	Medium Sand	1.50	Poorly sorted
3	2.2	0.22	Fine Sand	1.15	Moderately
4	2.3	0.21	Fine Sand	*	
5	1.5	0.36	Medium Sand	1.40	Moderately
6	**			*	
7	**			*	
8	1.1	0.48	Medium Sand	1.58	Poorly
9	0.4	0.75	Coarse Sand	1.03	Moderately
10	o.7	0.62	Coarse Sand	2.10	Very poorly
			Maui		
1	0.1	0.96	Coarse Sand	1.25	Moderately
2	1.6	0.34	Medium Sand	1.40	Moderately
3	0.7	0.62	Coarse Sand	*	
4	-1.4	2.60	Granule	*	
5	0.4	0.75	Coarse Sand	1.78	Poorly
6	0.6	0.65	Coarse Sand	*	
7	-1.2	2.20	Granule	*	
8	3.0	0.13	Very Fine Sand	*	
9	1.8	0.79	Medium Sand	1.70	Poorly
10	2.8	0.14	Fine Sand	*	
11	1.2	0.44	Medium Sand	*	
12	1.4	0.38	Medium Sand	2.23	Very poorly
13	1.3	0.40	Medium Sand	*	
14	0.4	0.75	Coarse Sand	1.20	Moderately

* Complete analysis of the non-sand fraction was not made, thus sorting could not be calculated.

** More than 50% silt or finer.

the coarse and fine material. The area that looks most promising and thus most deserving of further study is the area northwest of Lahaina. As is the case for the eastern Molokai area listed above, this area is close to Pailolo Channel and its higher wave-energy conditions. Another area of possible interest is that covered by sector B. Samples from this sector all meet the ASTM specifications after the coarse and fine material are discarded; however, this would mean discarding nearly half of any material dredged. If a use for the coarse and fine material such as for land fill were found, then this operation might be feasible. The area off the eastern side of Maalaea Bay also has similar sediment characteristics and may be of some future interest.

It must be emphasized that the number of samples is very small and the total volume of sediment is enormous. Therefore, it is important not only to sample the five indicated areas in detail,including cored samples below the surface, but also to obtain additional spot surface samples at closer spacings off the Molokai and Maui leeward coasts.

References Cited

Campbell, J. F., Coulbourn, W. T., Moberly, R.,Jr., and Rosendahl, R. R., 1970, Reconnaissance sand inventory off leeward Oahu: Hawaii Institute Geophys. Report 70-16, Sea Grant Report 70-2, 14 pp.

Moberly, R., Jr., and Campbell, J. F., 1969, Hawaiian shallow marine sand inventory, Part 2, Ahu o Laka Sand Deposit, Kaneohe Bay, Oahu: Hawaii Inst. Geophys. Report 69-10, Sea Grant 69-1, 24 pp.

Hamilton, E. L., 1970, Sound velocity and related properties of marine sediments, North Pacific: Jour. Geophys. Res., v. 75, p. 4423-4446.

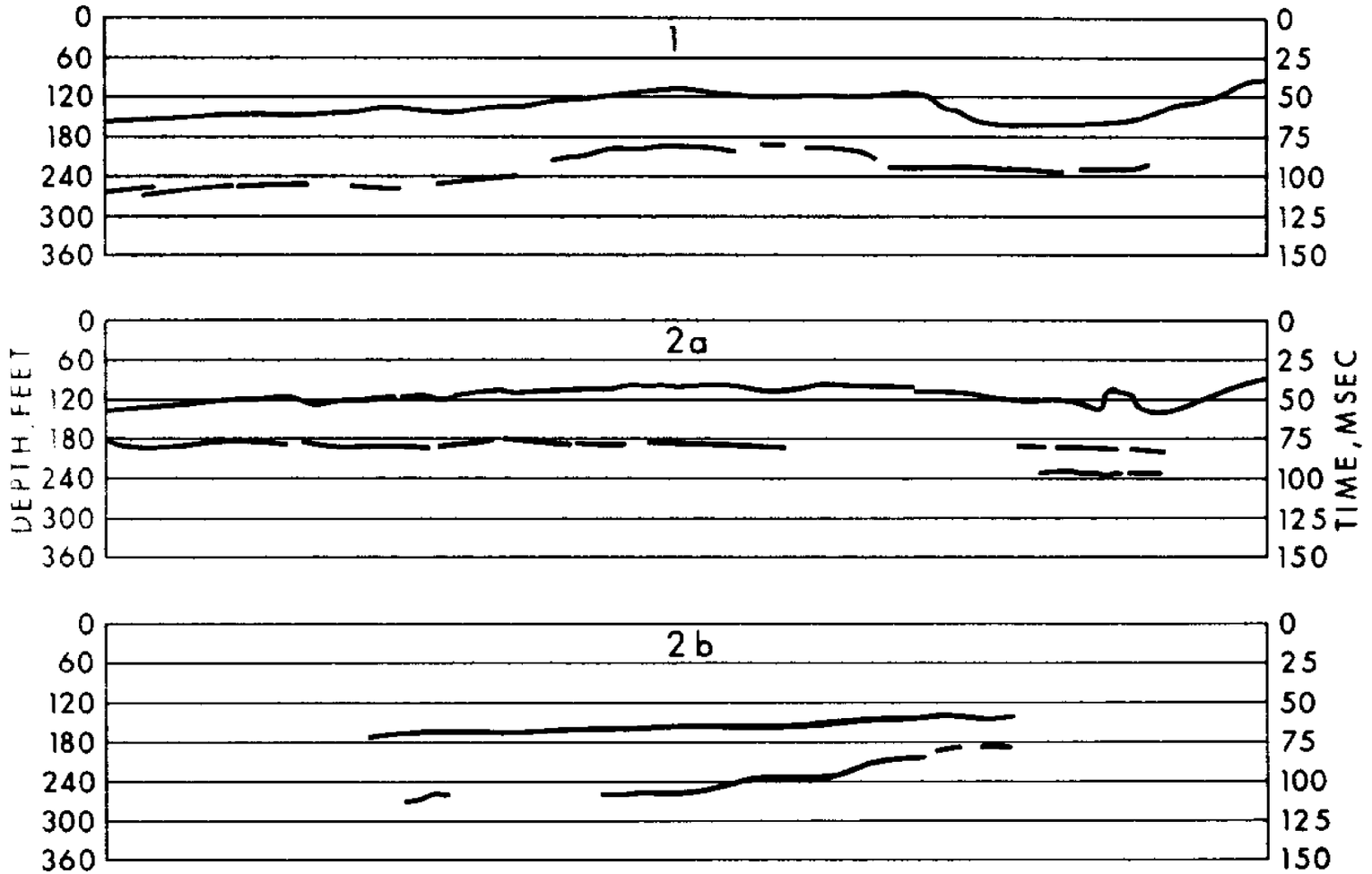

Fig. 7A. Tracings of seismic reflection records, Maui sector A. Traverses 1-2 shown in Fig. 5A.

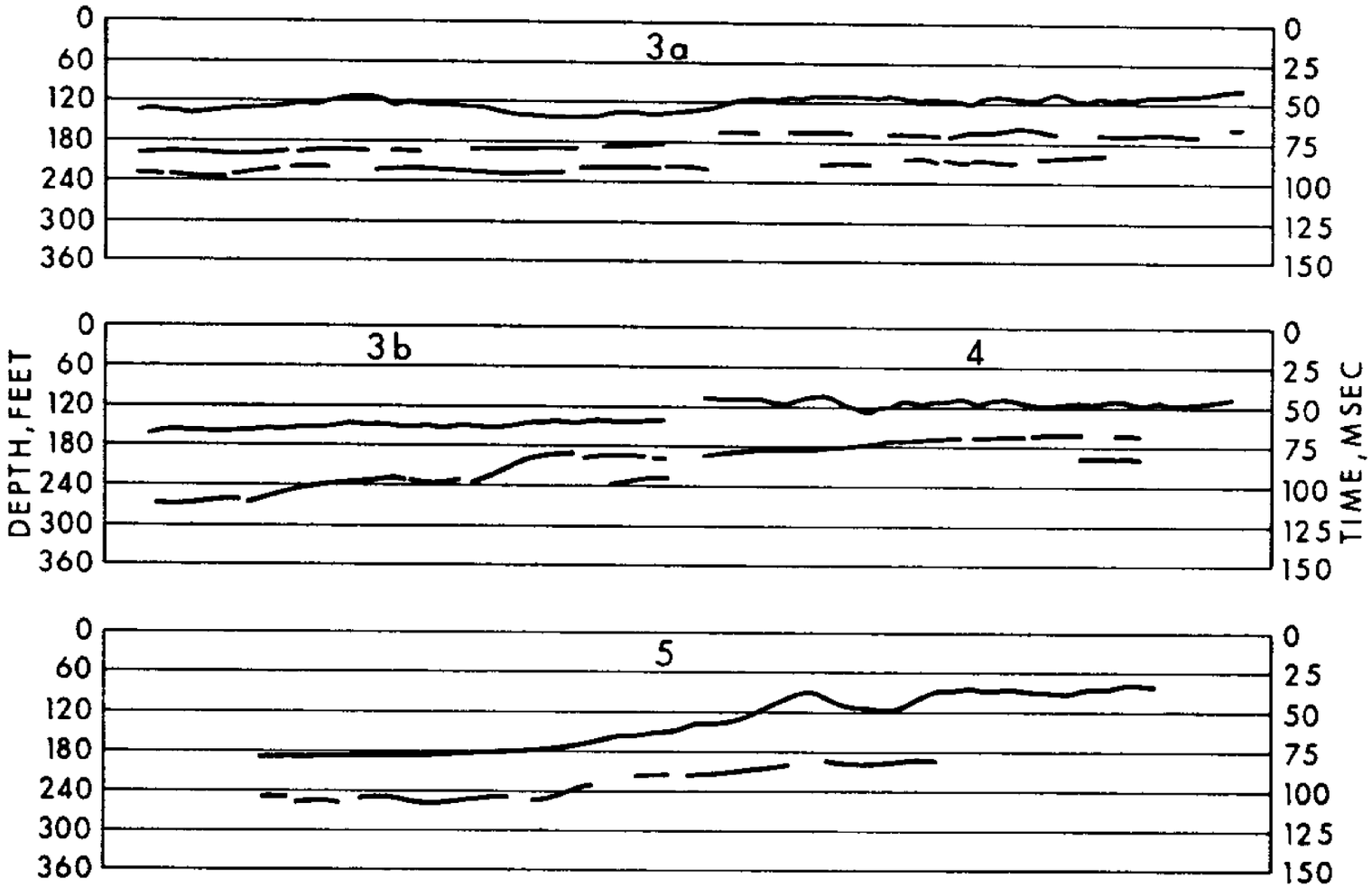

Fig. 7B. Tracings of seismic reflection records, Maui sector A. Traverses 3-5 shown in Fig. 5A.

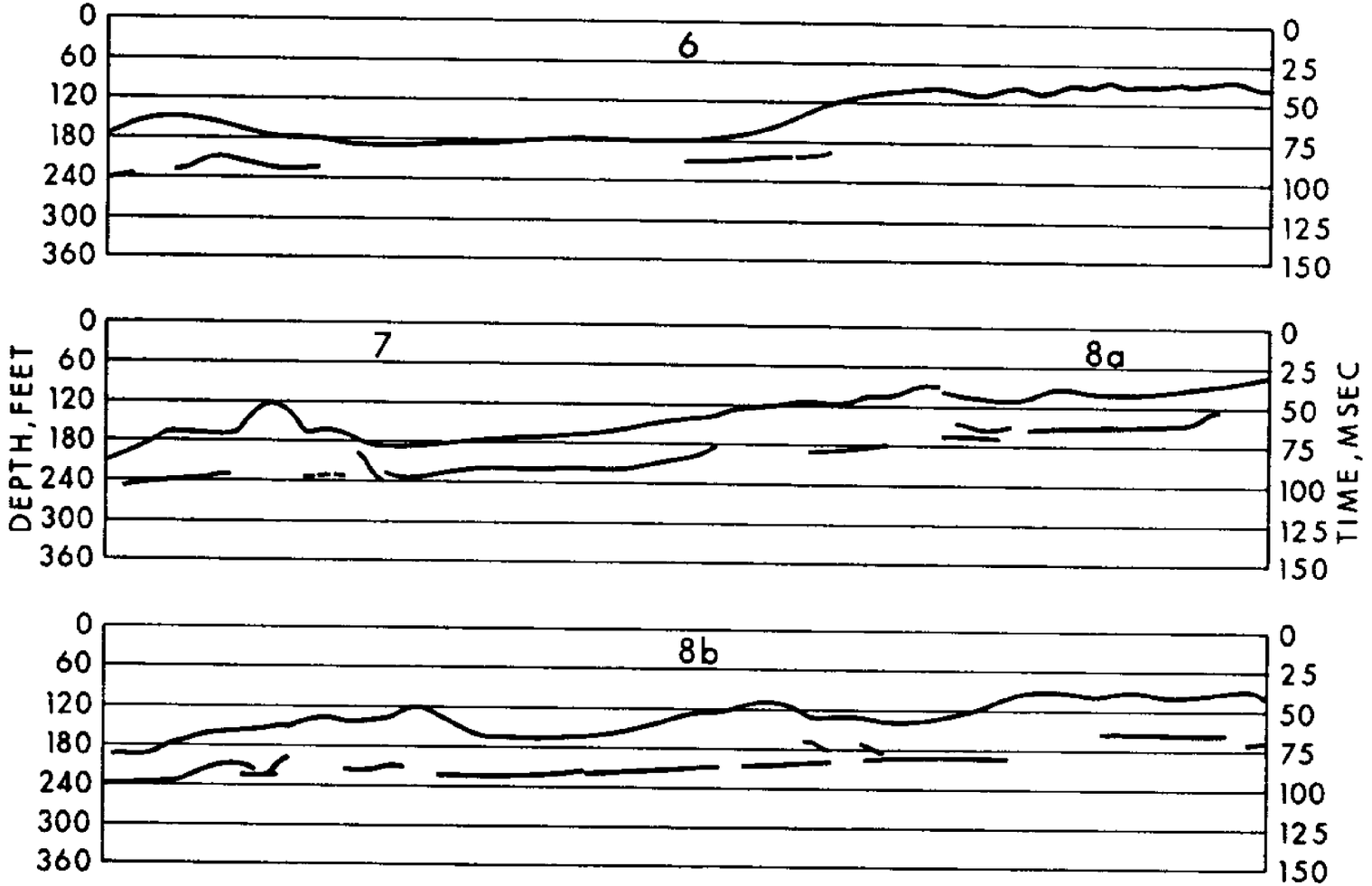

Fig. 7C. Tracings of seismic reflection records, Maui sector A. Traverses 6-8 shown in Fig. 5A.

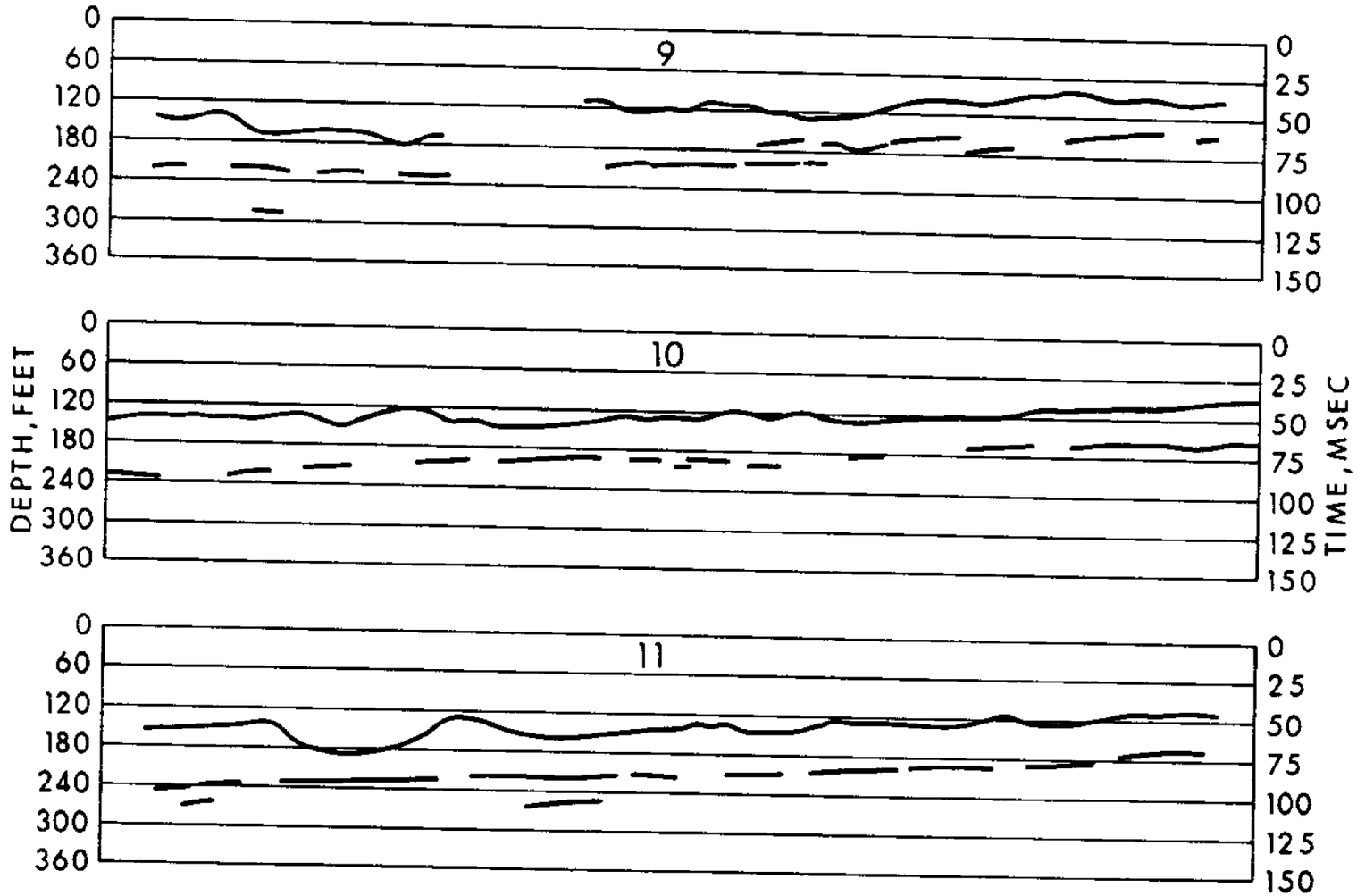

Fig. 7D. Tracings of seismic reflection records, Maui sector A. Traverses 9-11 shown in Fig. 5A.

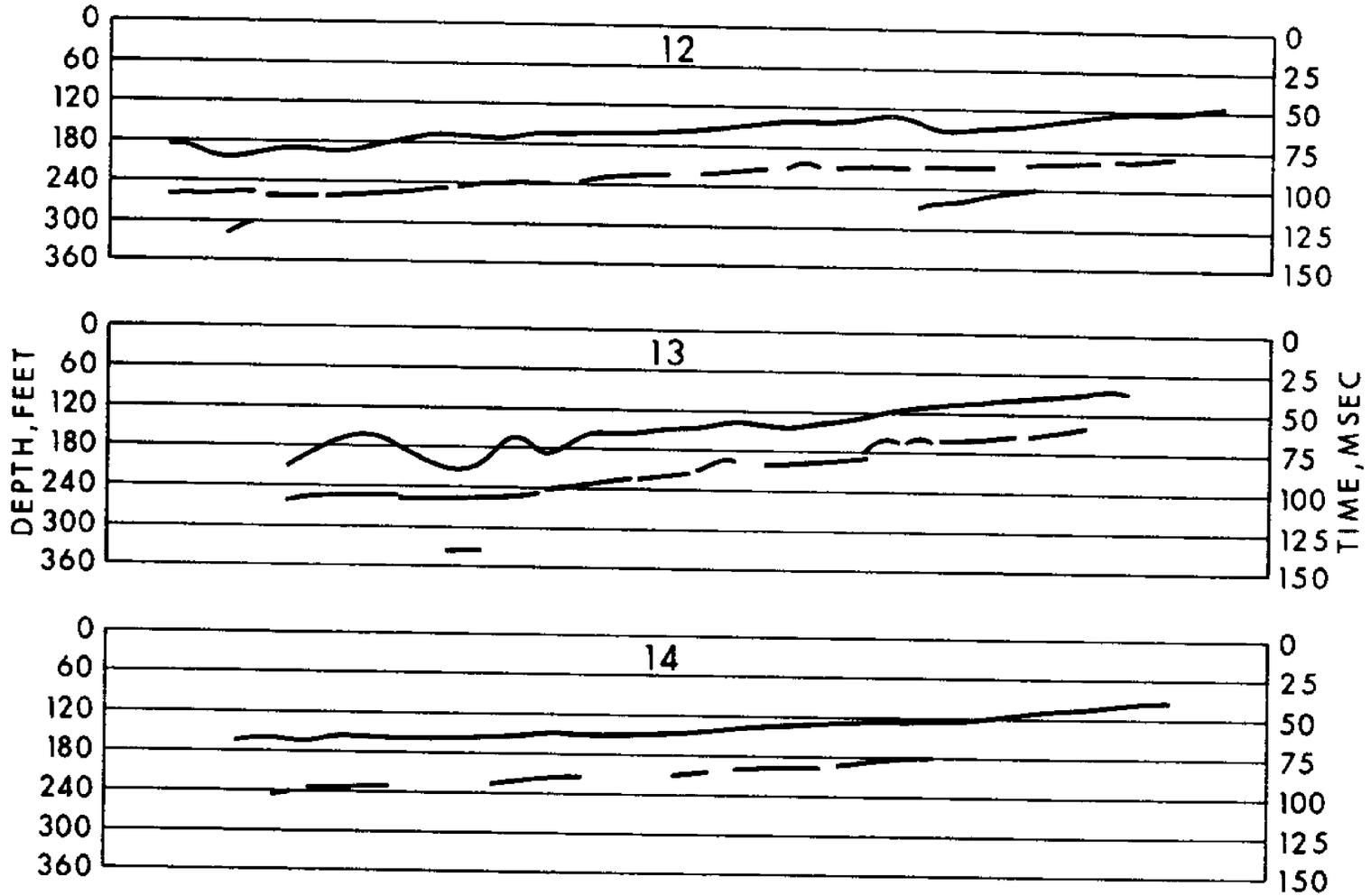

Fig. 7E. Tracings of seismic reflection records, Maui sector A. Traverses 12-14 shown in Fig. 5A.

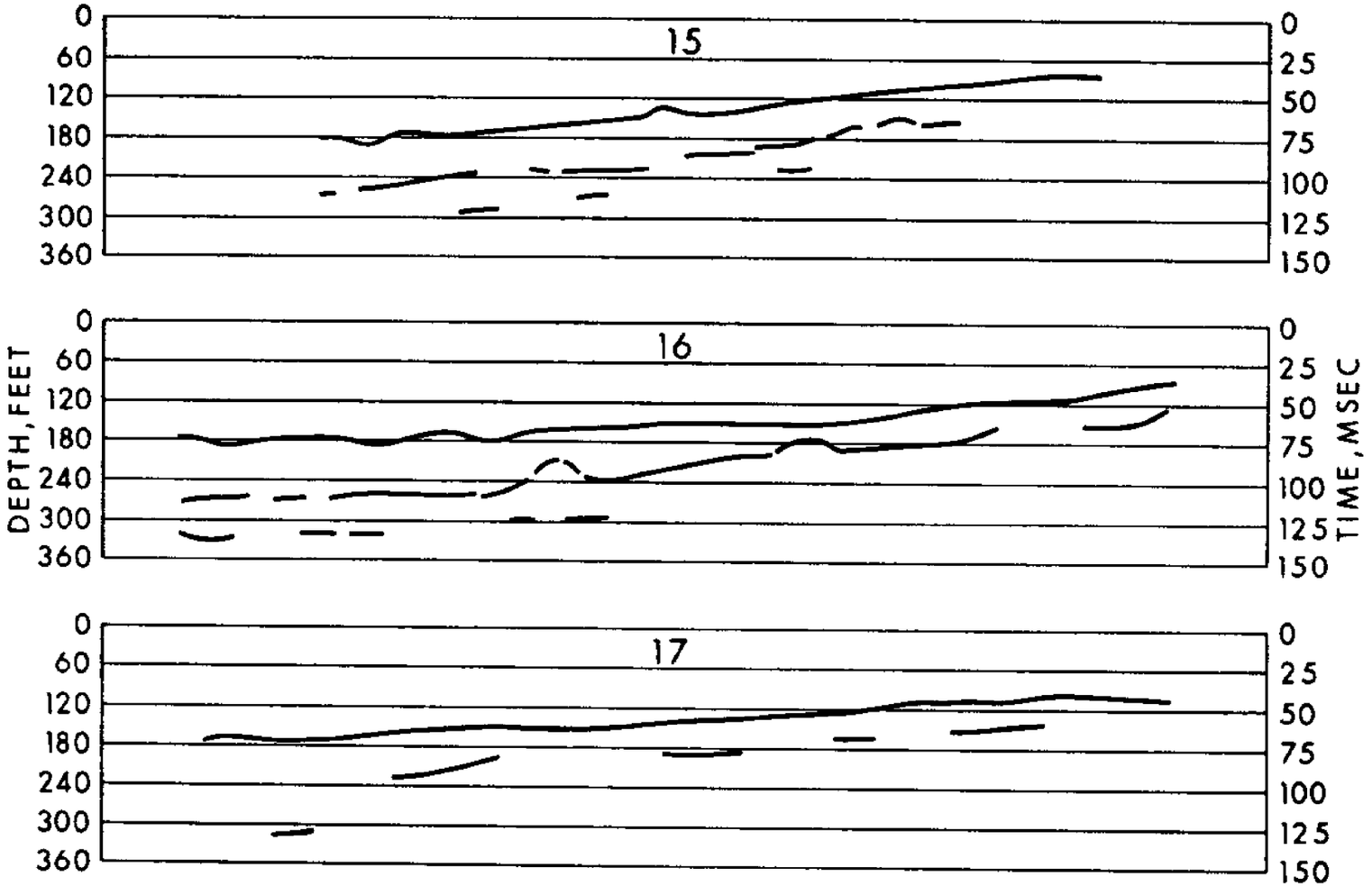

Fig. 7F. Tracings of seismic reflection records, Maui sector B. Traverses 15-17 shown in Fig. 5B.

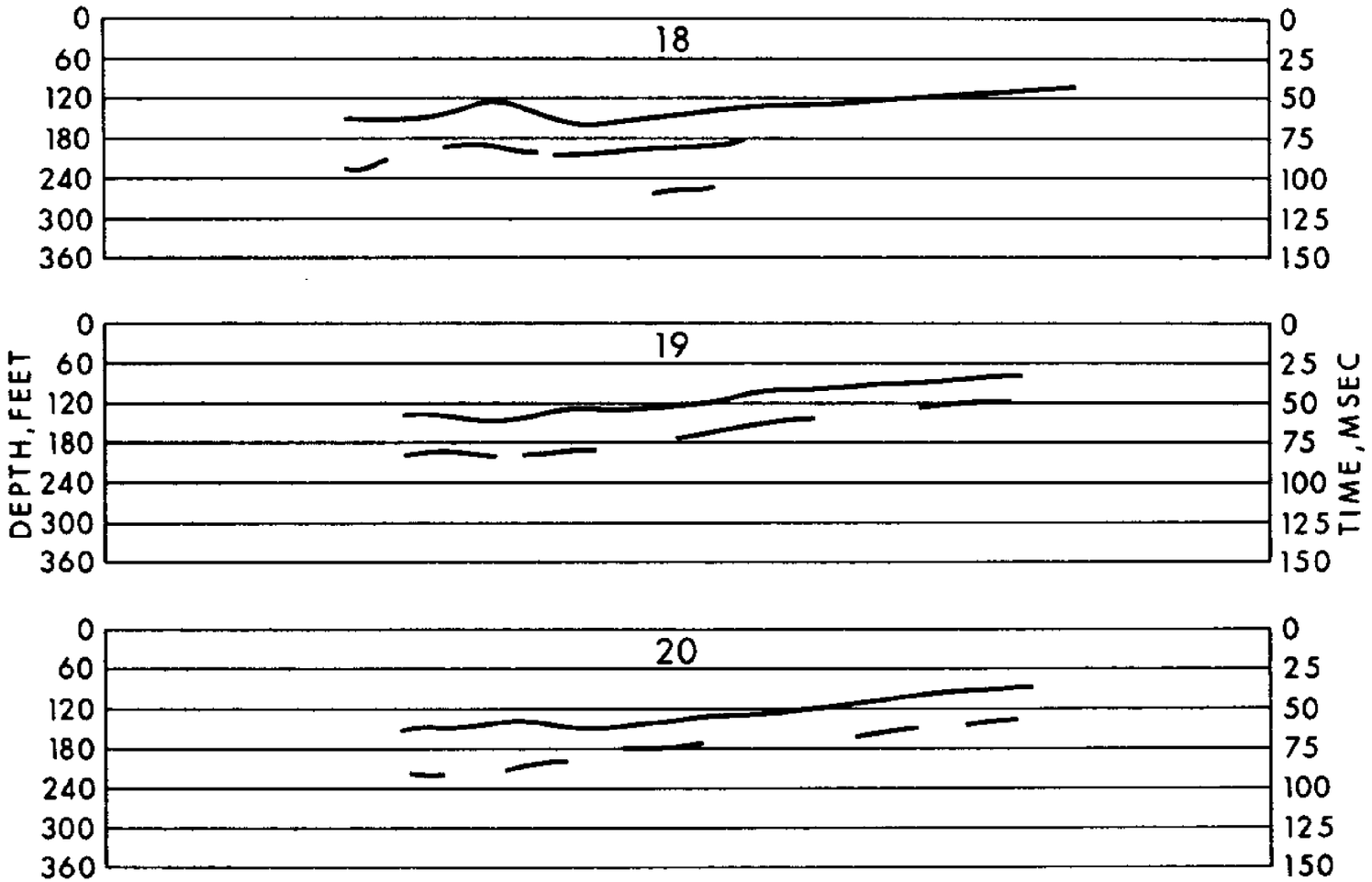

Fig. 7G. Tracings of seismic reflection records, Maui sector B. Traverses 18-20 shown in Fig. 5B.

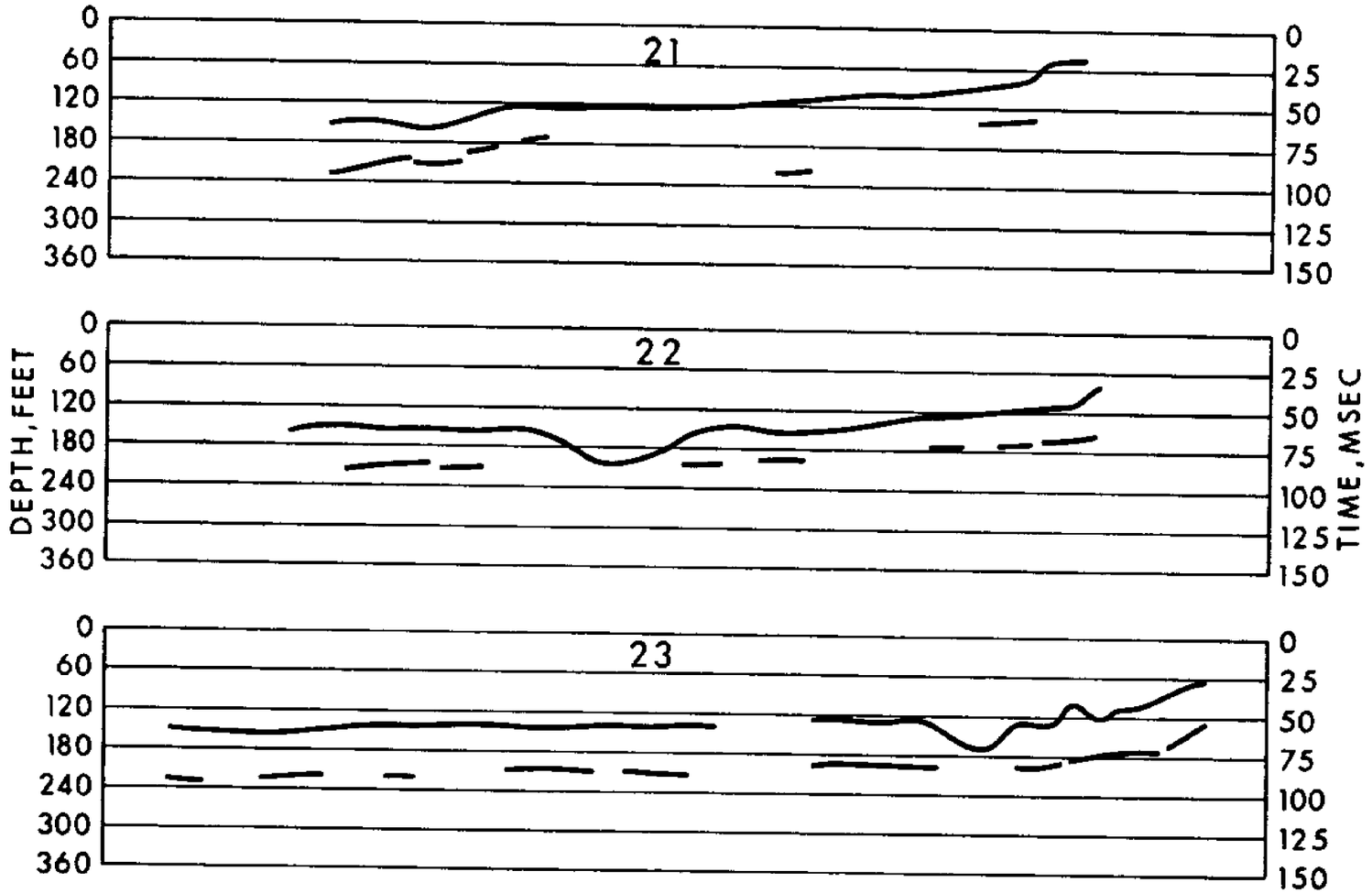

Fig. 7H. Tracings of seismic reflection records, Maui sector B. Traverses 21-23 shown in Fig. 5B.

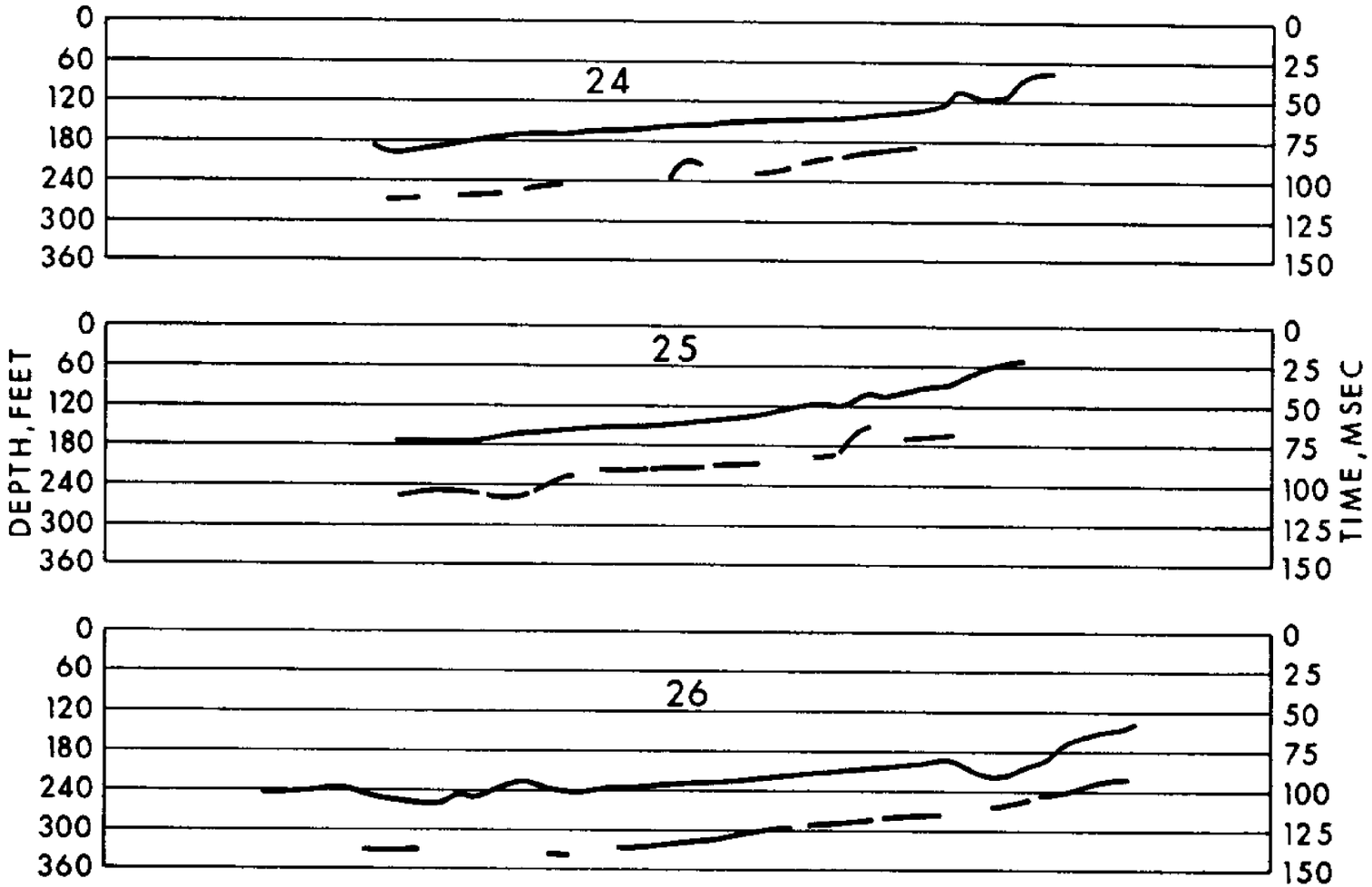

Fig. 7 I. Tracings of seismic reflection records, Maui sector B. Traverses 24-26 shown in Fig. 5B.

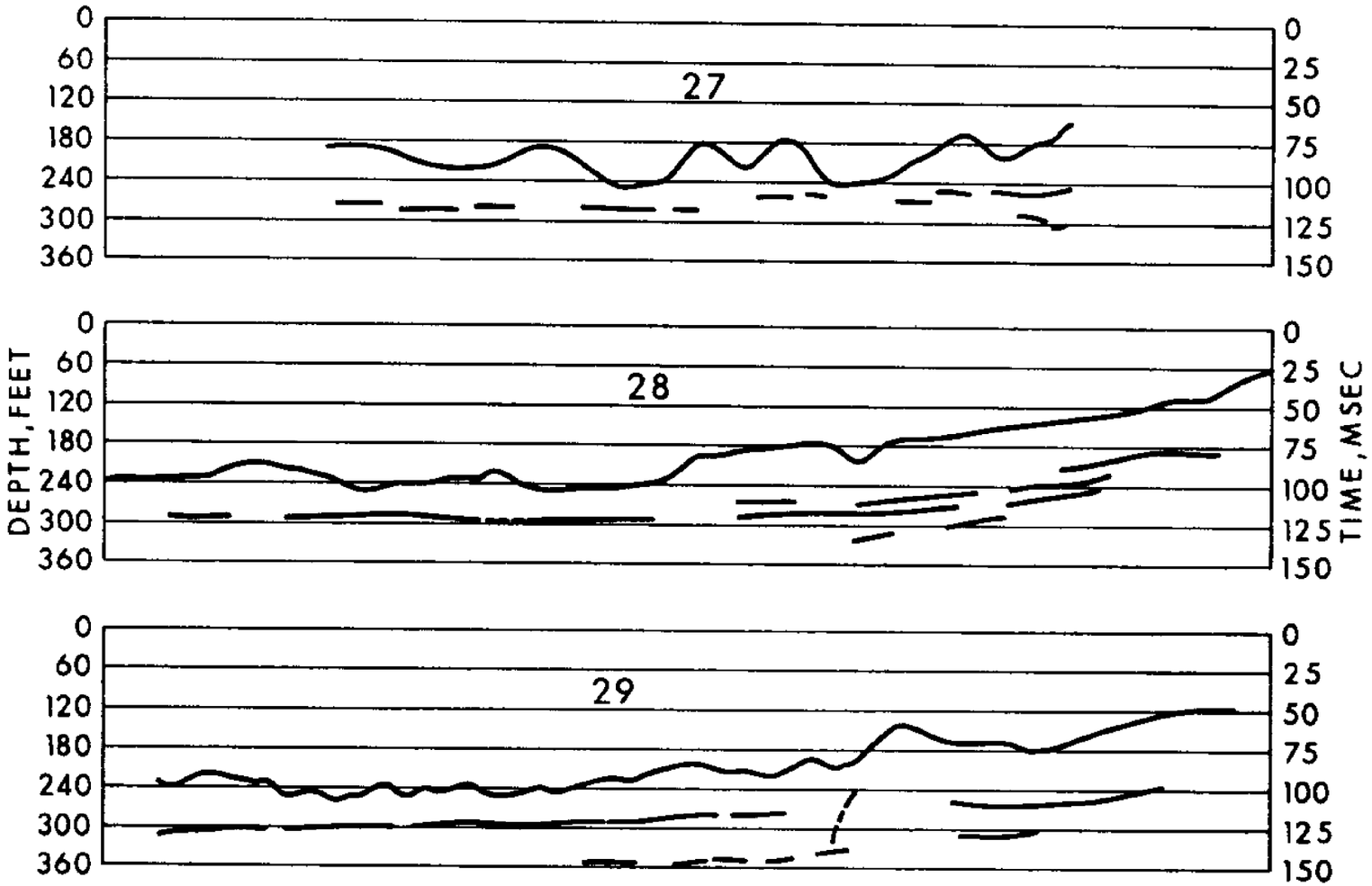

Fig. 7J. Tracings of seismic reflection records, Maui sector B. Traverses 27-29 shown in Fig. 5B.

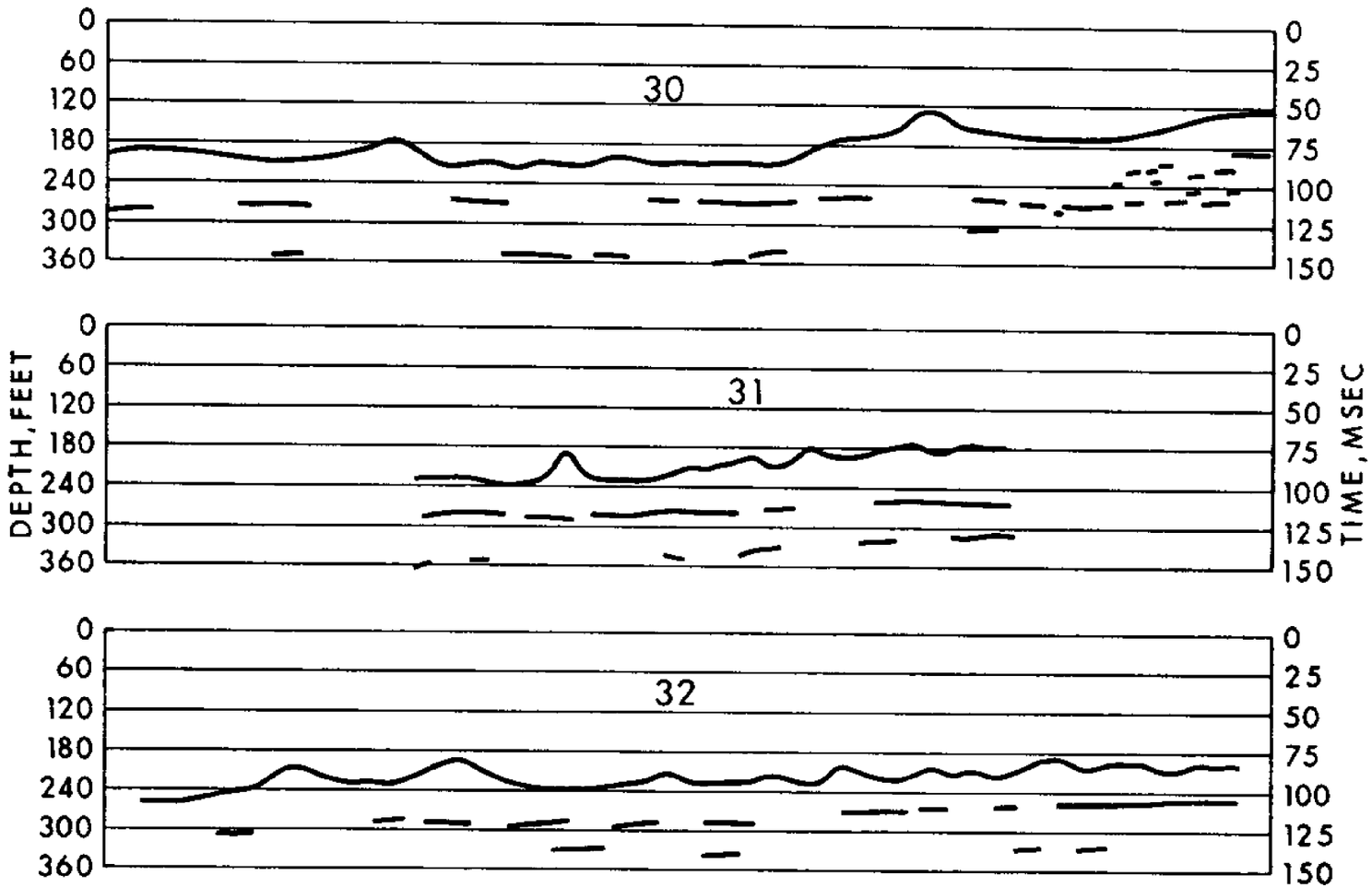

Fig. 7K. Tracings of seismic reflection records, Maui sector C. Traverses 30-32 shown in Fig. 5C.

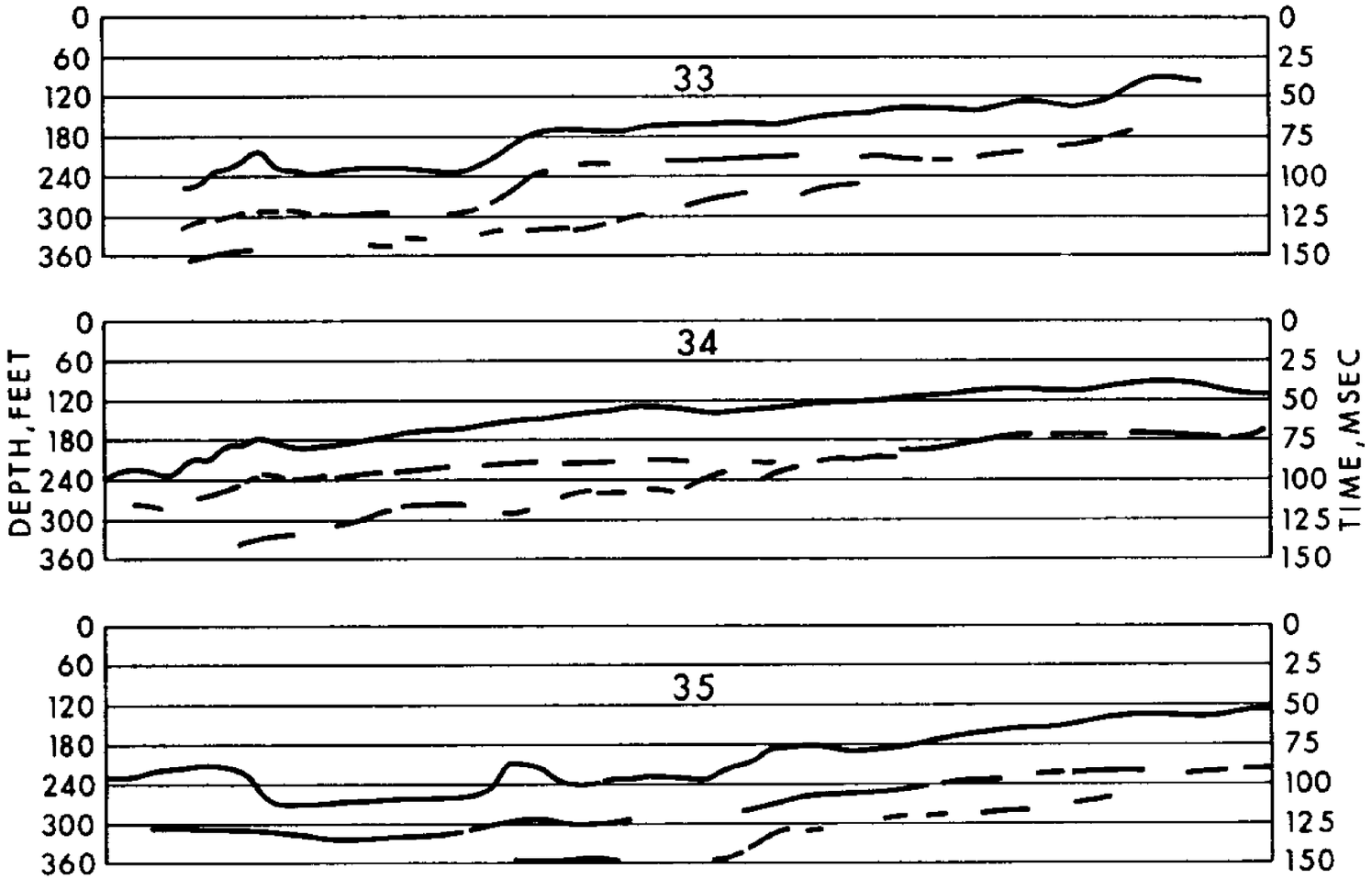

Fig. 7L. Tracings of seismic reflection records, Maui sector C. Traverses 33-35 shown in Fig. 5C.

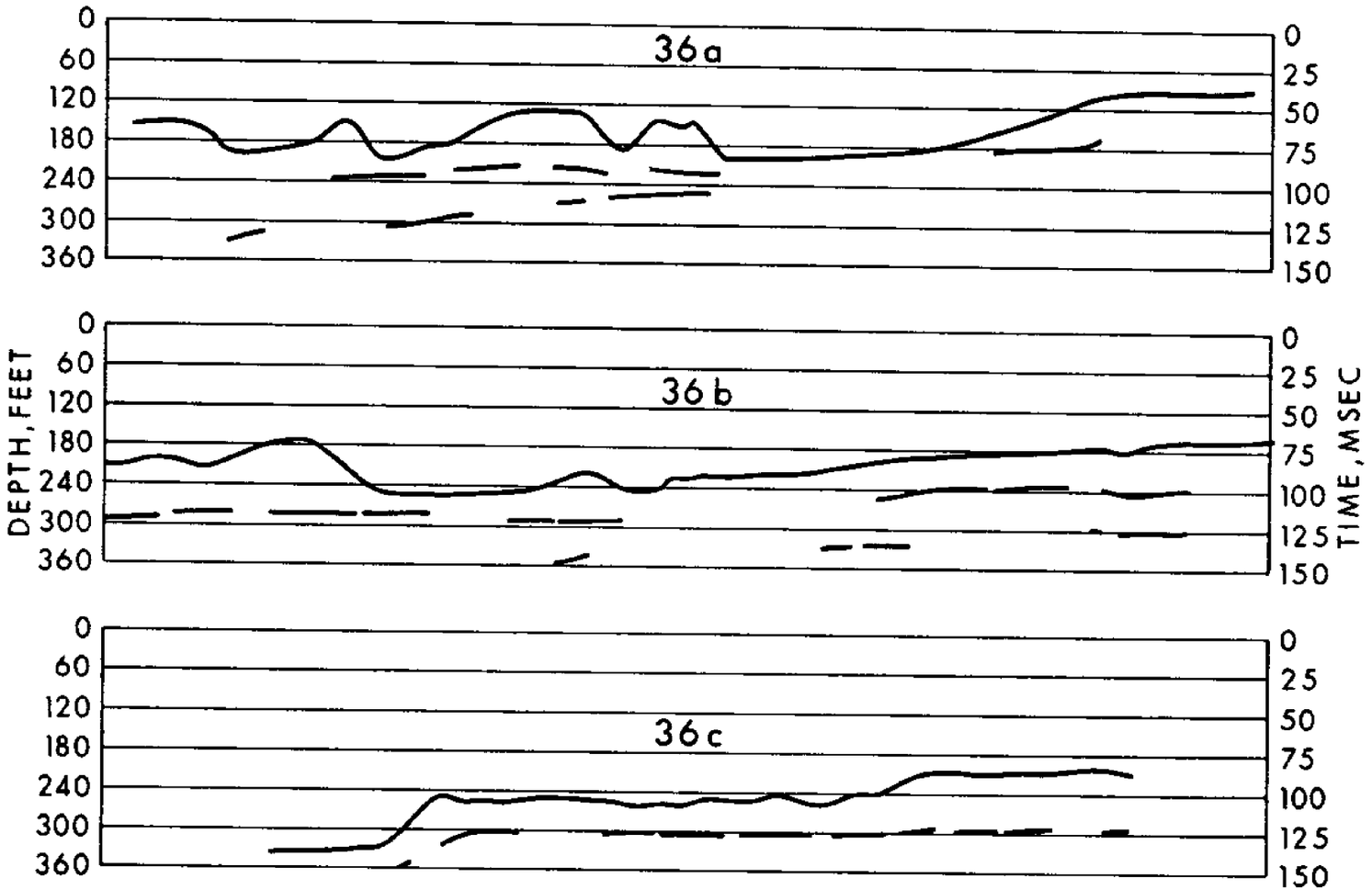

Fig. 7M. Tracings of seismic reflection records, Maui sector C. Traverse 36 shown in Fig. 5C.

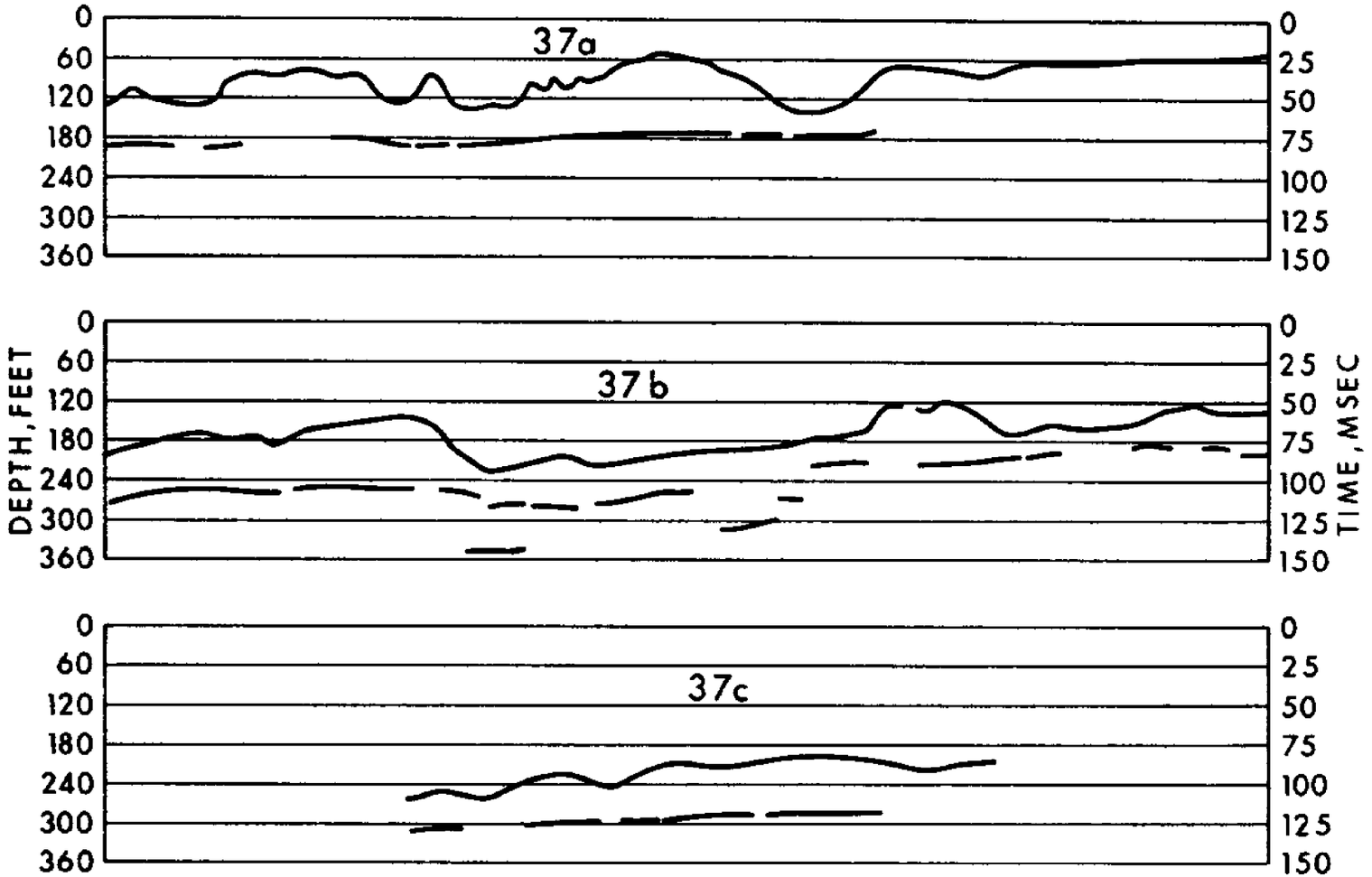

Fig. 7N. Tracings of seismic reflection records, Maui sector C. Traverse 37 shown in Fig. 5C.

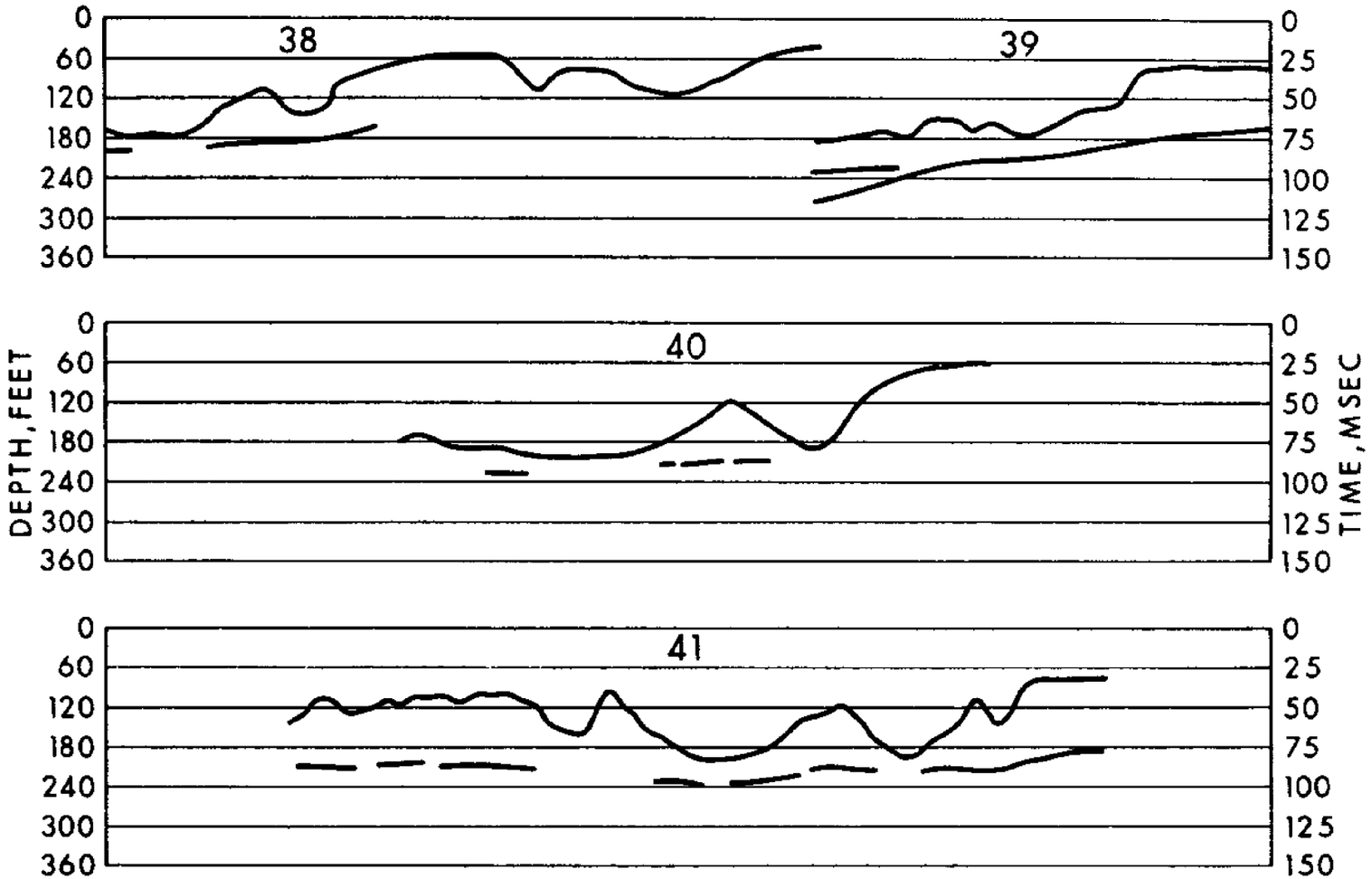

Fig. 70. Tracings of seismic reflection records, Maui sector C. Traverses 38-41 shown in Fig. 5C.

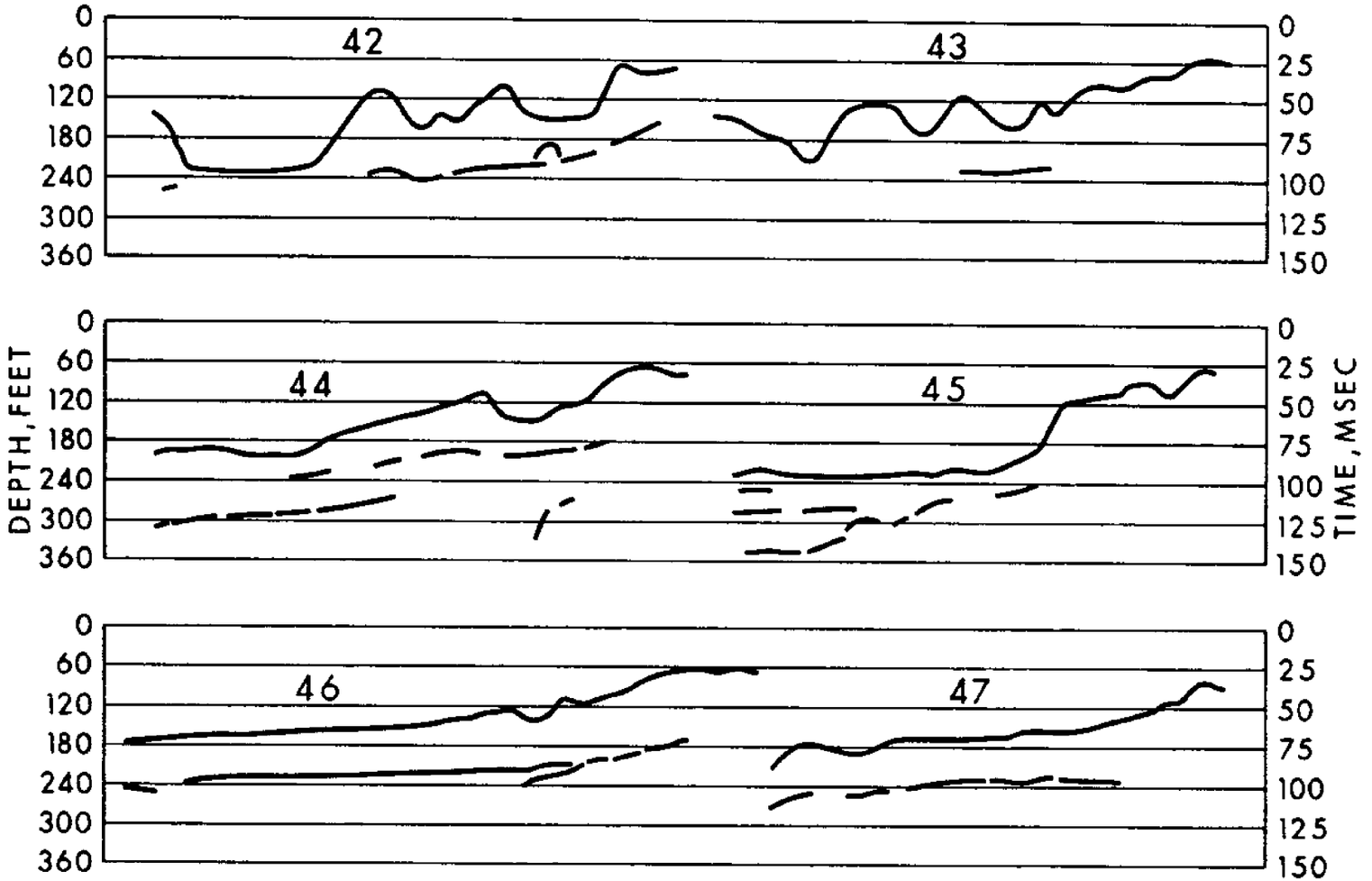

Fig. 7P. Tracings of seismic reflection records, Maui sector D. Traverses 42–47 shown in Fig. 5D.

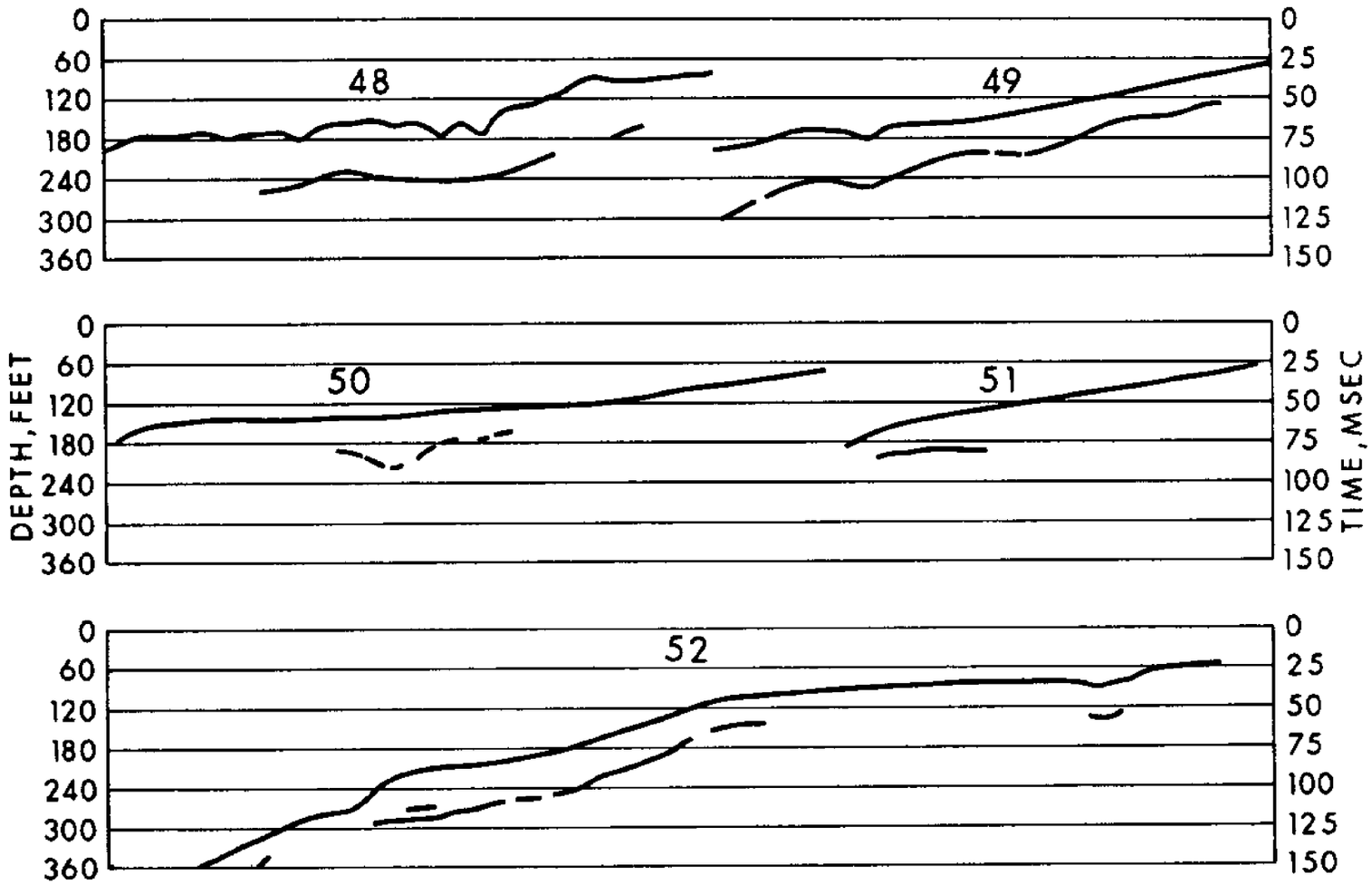

Fig. 7Q. Tracings of seismic reflection records, Maui sector D. Traverses 48-52 shown in Fig. 5D.

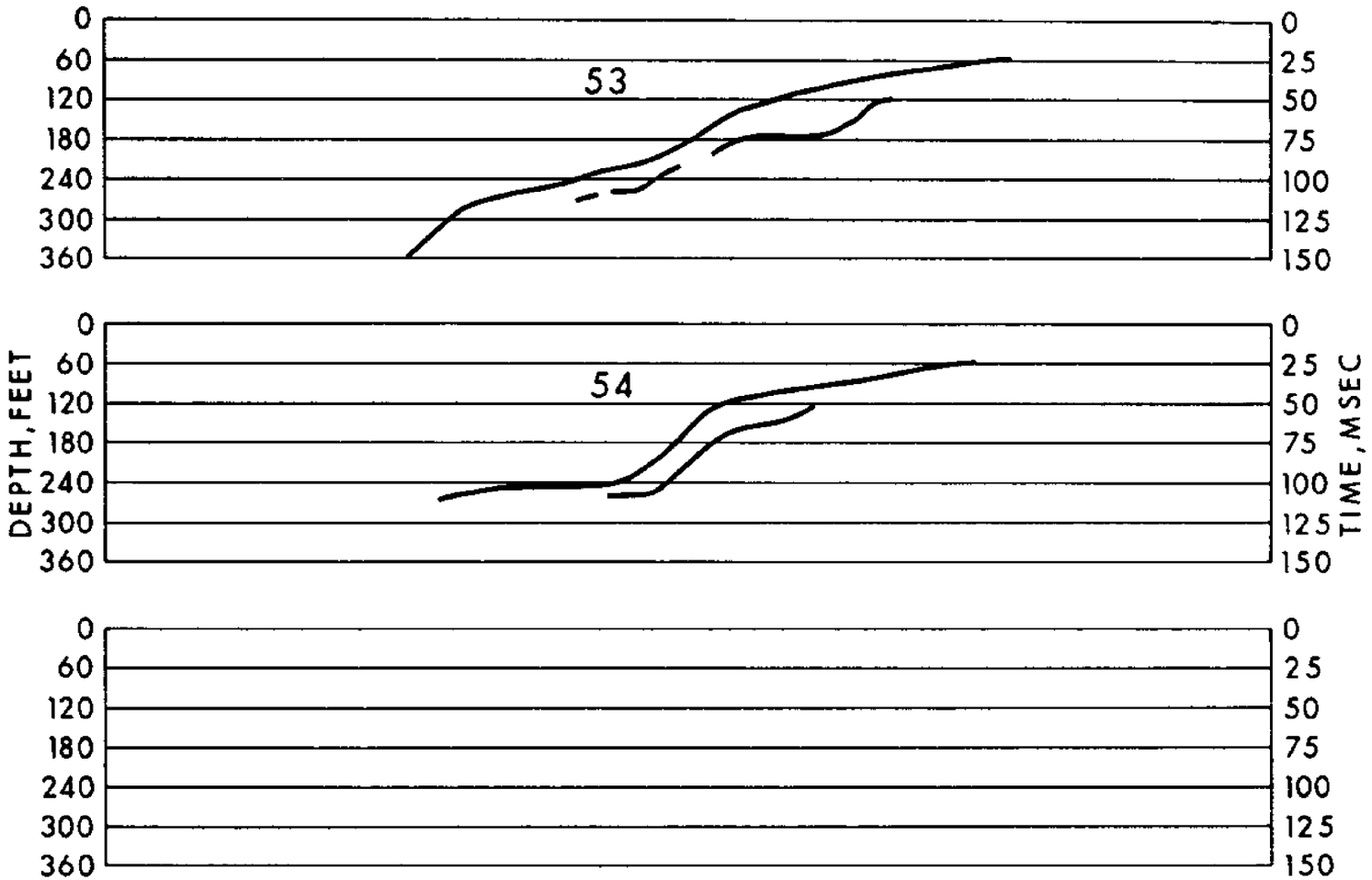

Fig. 7R. Tracings of seismic reflection records, Maui sector D. Traverses 53-54 shown in Fig. 5D.

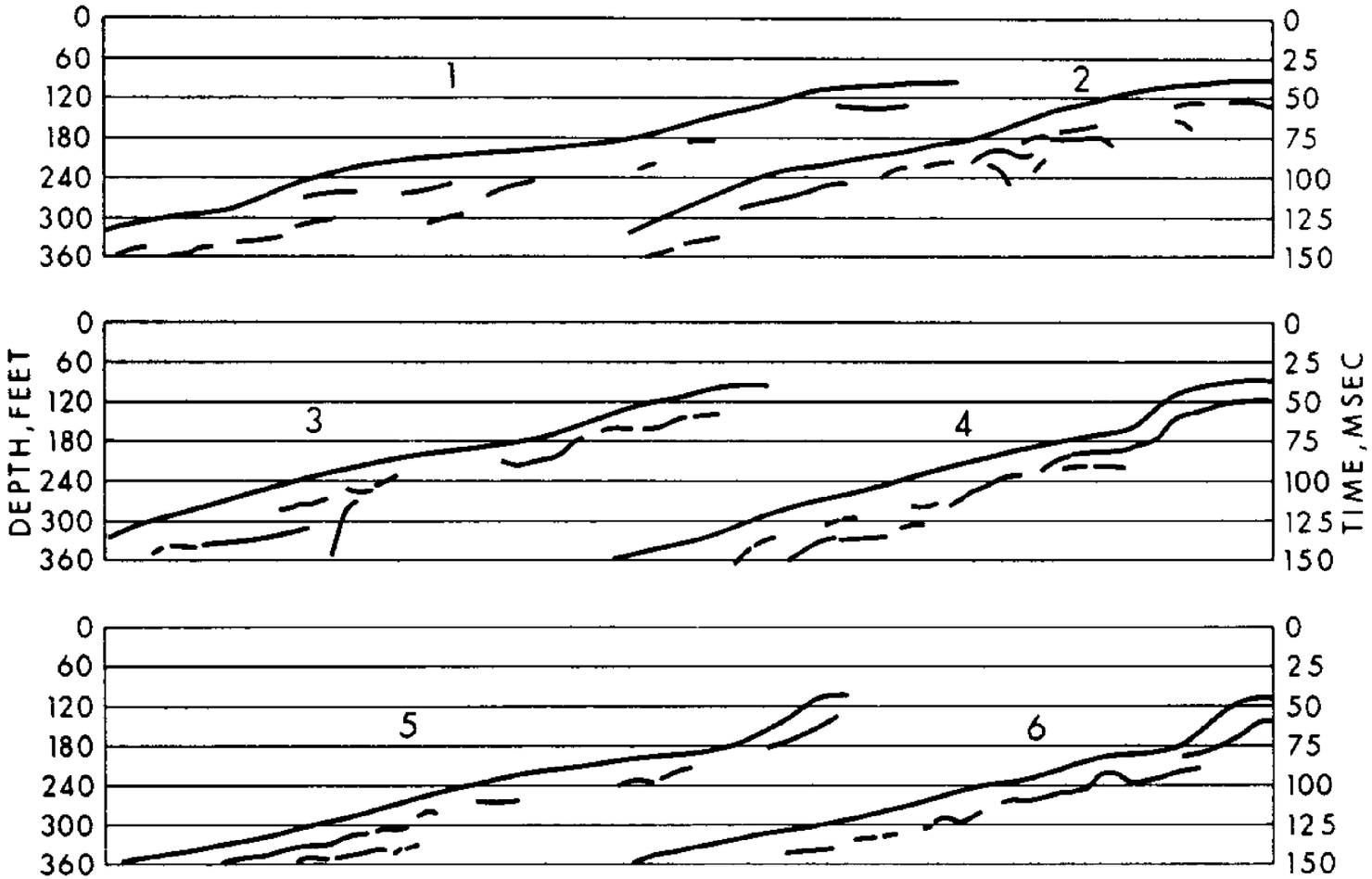

Fig. 8A. Tracings of seismic reflection records, Molokai sector A. Traverses 1-6 shown in Fig. 6A.

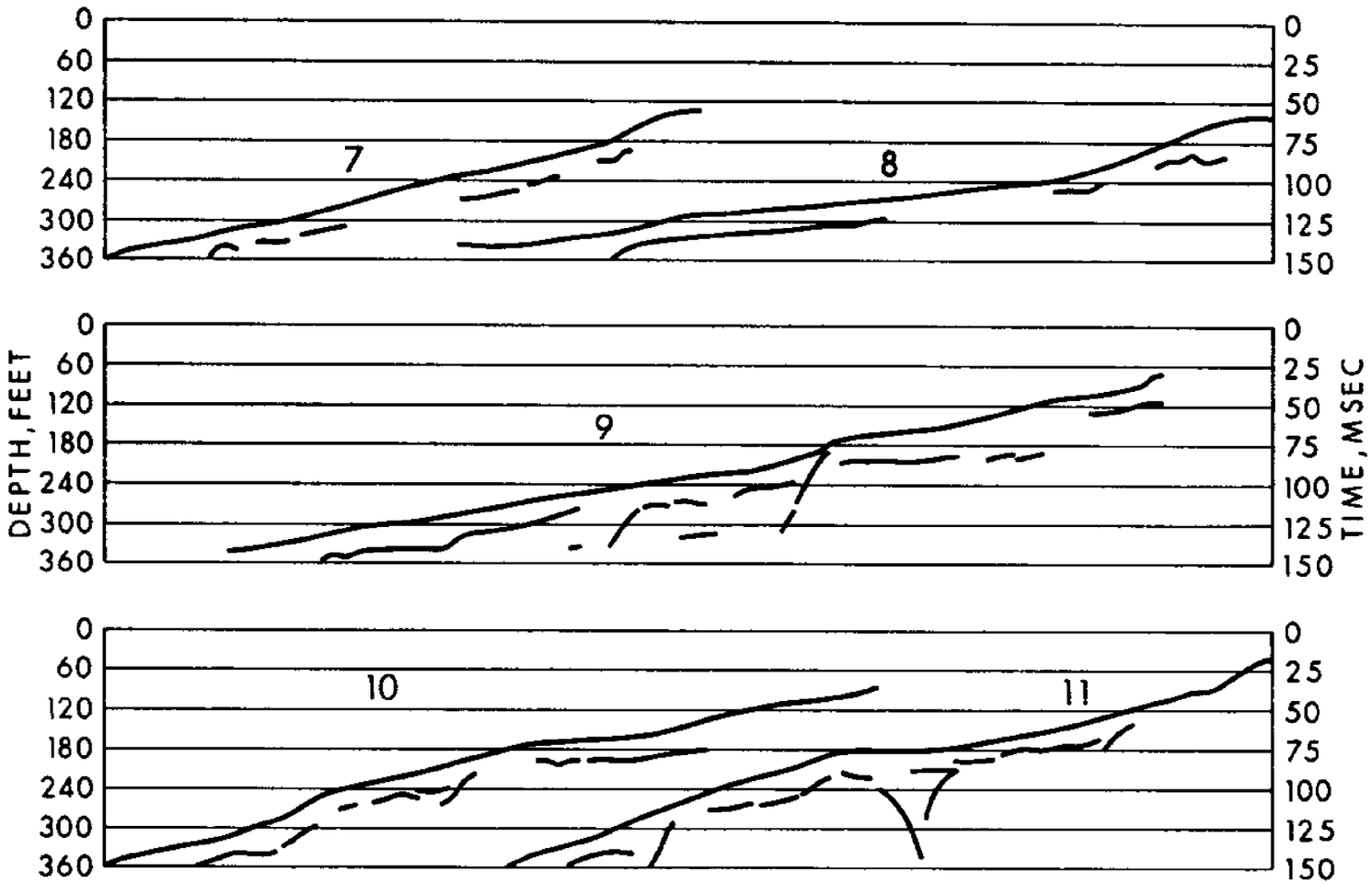

Fig. 8B. Tracings of seismic reflection records, Molokai sectors A and B. Traverses 7-11 shown in Figs. 6A and 6B.

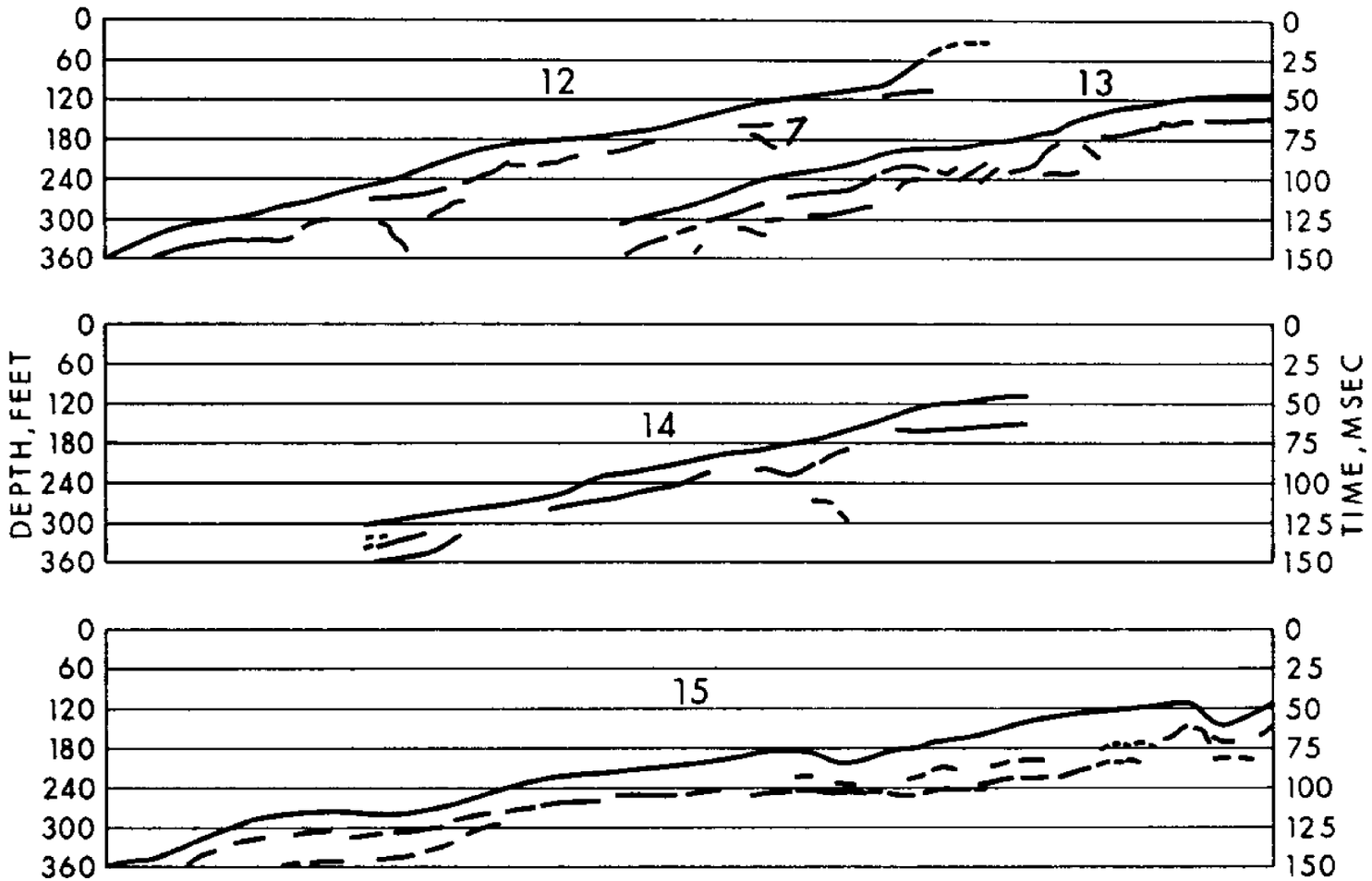

Fig. 8C. Tracings of seismic reflection records, Molokai sector B. Traverses 12-15 shown in Fig. 6B.

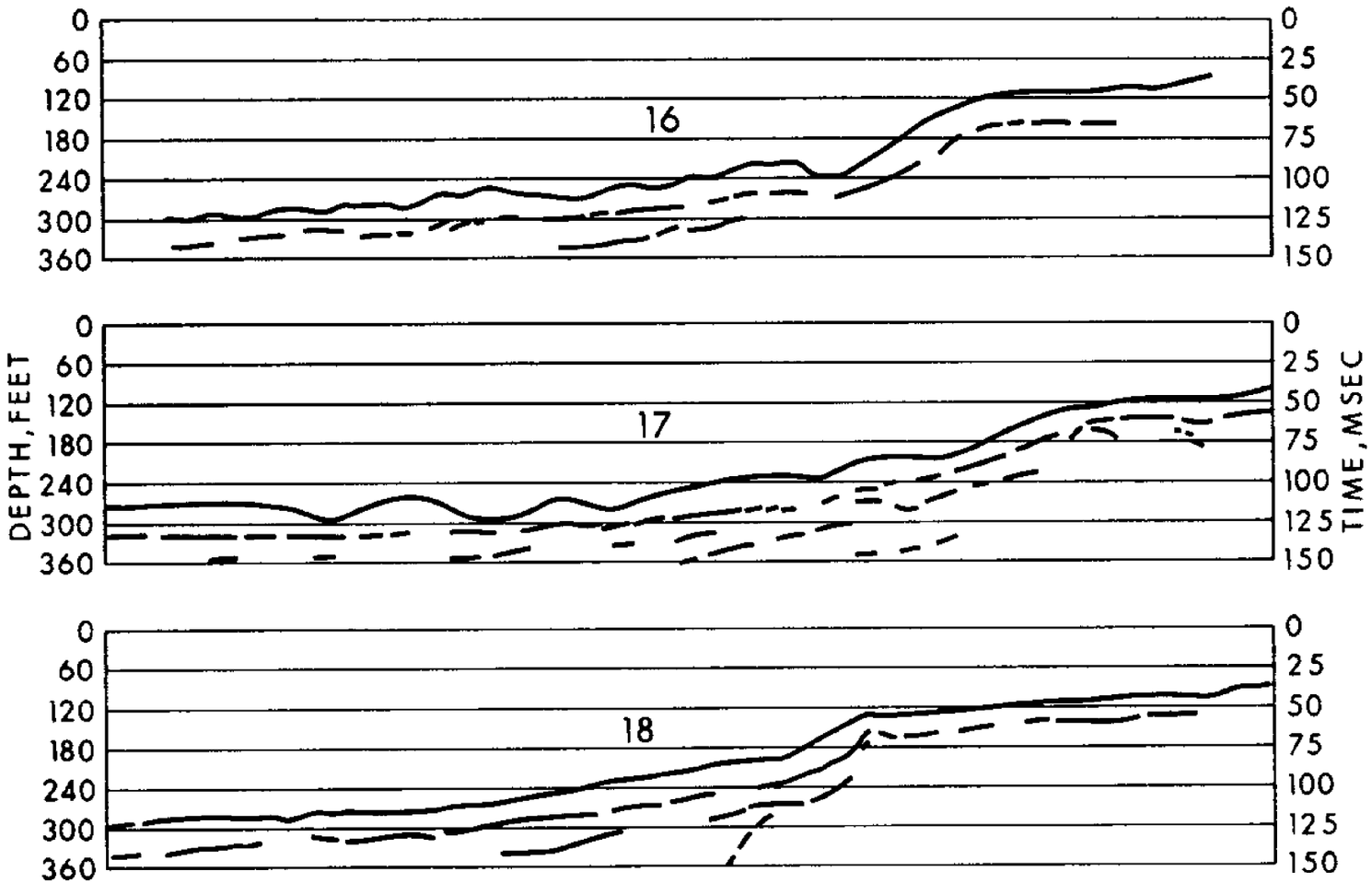

Fig. 8D. Tracings of seismic reflection records, Molokai sector B. Traverses 16-18 shown in Fig. 6B.

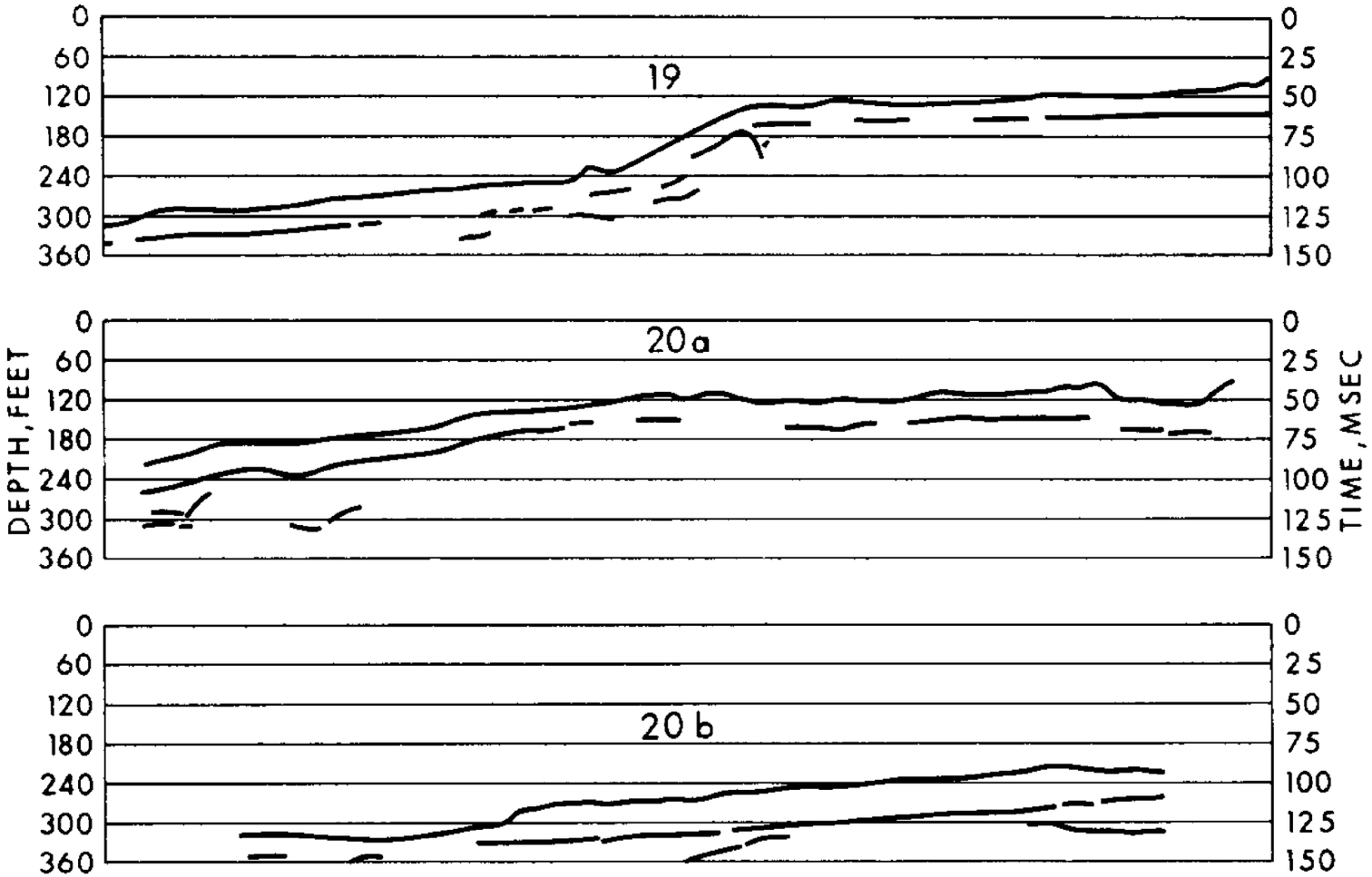

Fig. 8E. Tracings of seismic reflection records, Molokai sector C. Traverses 19-20 shown in Fig. 6C.

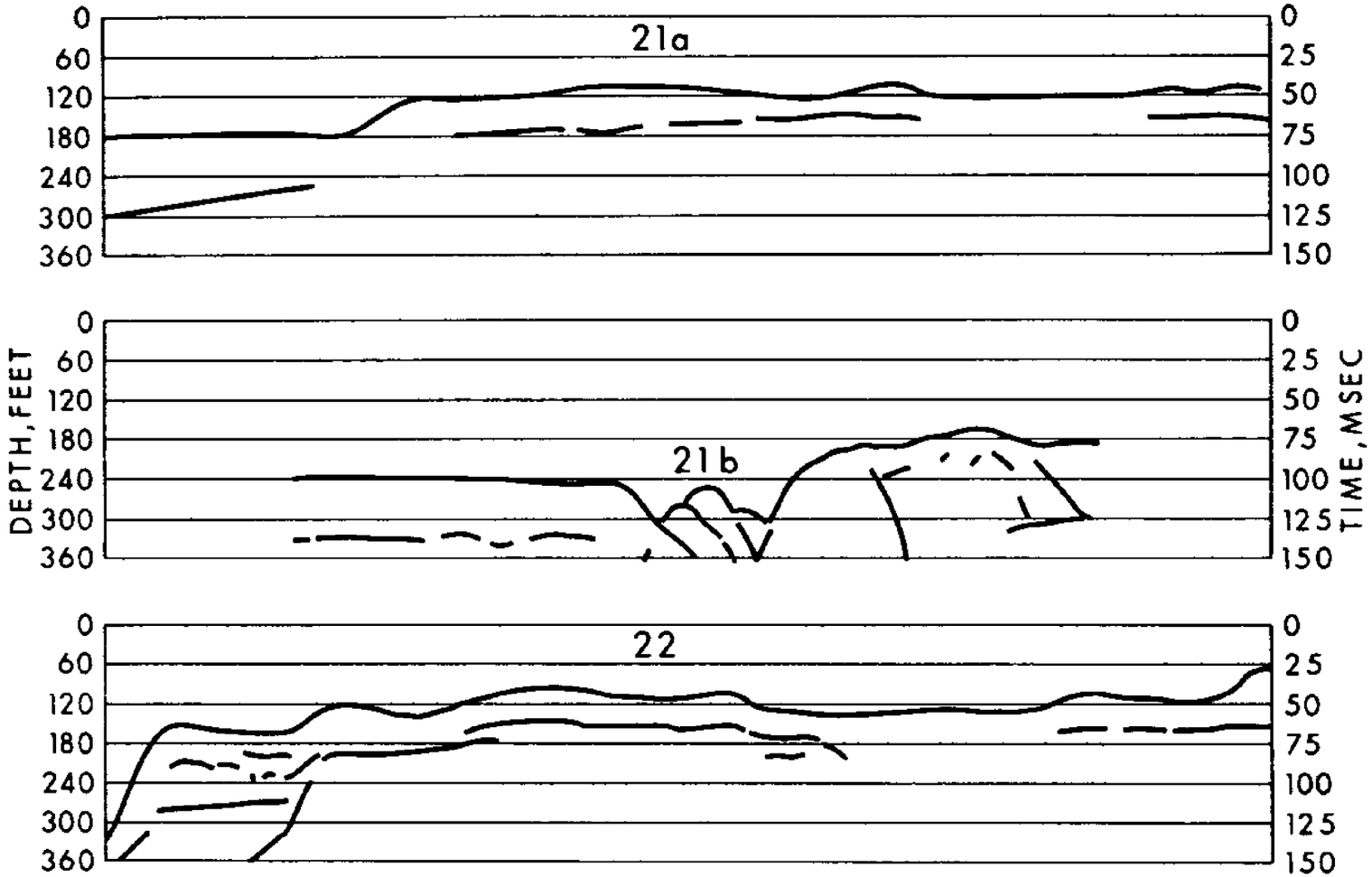

Fig. 8F. Tracings of seismic reflection records, Molokai sector C. Traverses 21-22 shown in Fig. 6C.

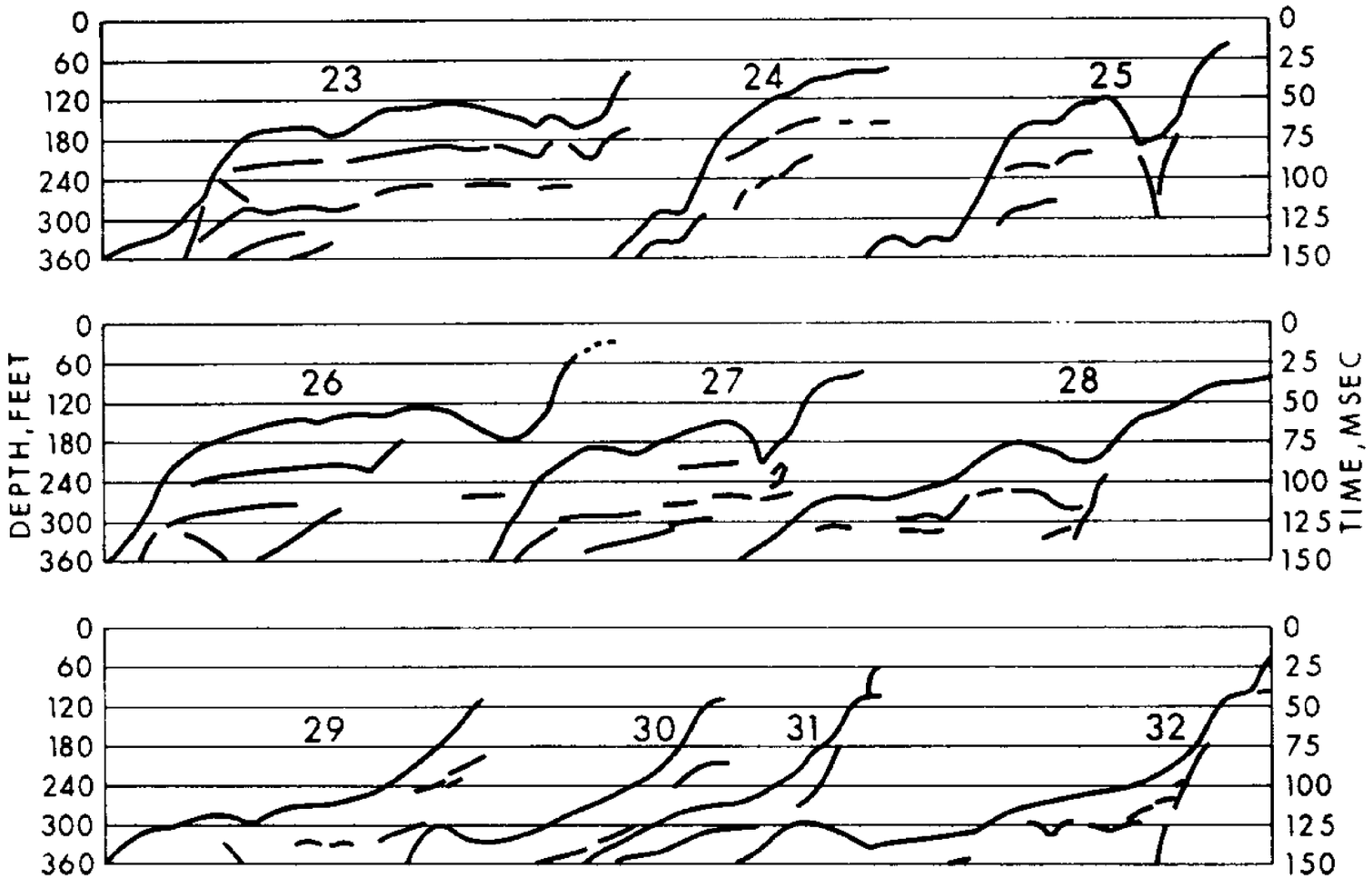

Fig. 80. Tracings of seismic reflection records, Molokai sector D. Traverses 23-32 shown in Fig. 50.

of sediment in depths ranging down to 300 feet. Much of the surface sediment of the central and western part of the island--sectors A, B, and the western side of C--is very fine and even after discarding all but the sand-size material the median grain size is still lower than that required by the ASTM standards for concrete aggregrate.

Two areas off Molokai are deserving of further investigation. One is the area off the southwest end of the Island and out onto Penguin Bank. The one sample we have from this area (Molokai 1) is of very coarse sand with 36 per cent of the sample being coarser than sand size. Of all the samples collected to date, this sample is most like the sand currently being used. No reflection profiles have yet been obtained in this area so the aerial distribution and thickness of this material is not known. The other area of interest is between Kamalo Harbor and the eastern extent of the survey. This area is of interest because the samples from there have a median size in the coarse-sand range and have very low percentages of non-sand-size material. The aerial extent of the sand body as shown in Figure 6D is in a narrow band 300-400 yards wide. The shallow edge of the band is not well defined, so the sand body is probably somewhat larger than shown. The deep edge is well defined by an abrupt change in bottom slope. Both of these areas are exposed to higher energy waves than most of the leeward coast and this probably accounts in part for the lack of finer grained material.

The area surveyed off Maui contains $2,898 \times 10^6$ cubic yards of sediment. Much of the surface sediment sampled had low percentages of sand-size material, and half of the samples were still too fine to meet the ASTM median grain-size standard even after discarding all

the coarse and fine material. The area that looks most promising and thus most deserving of further study is the area northwest of Lahaina. As is the case for the eastern Molokai area listed above, this area is close to Pailolo Channel and its higher wave-energy conditions. Another area of possible interest is that covered by sector B. Samples from this sector all meet the ASTM specifications after the coarse and fine material are discarded; however, this would mean discarding nearly half of any material dredged. If a use for the coarse and fine material such as for land fill were found, then this operation might be feasible. The area off the eastern side of Maalaea Bay also has similar sediment characteristics and may be of some future interest.

It must be emphasized that the number of samples is very small and the total volume of sediment is enormous. Therefore, it is important not only to sample the five indicated areas in detail,including cored samples below the surface, but also to obtain additional spot surface samples at closer spacings off the Molokai and Maui leeward coasts.

References Cited

Campbell, J. F., Coulbourn, W. T., Moberly, R.,Jr., and Rosendahl, R. R., 1970, Reconnaissance sand inventory off leeward Oahu: Hawaii Institute Geophys. Report 70-16, Sea Grant Report 70-2, 14 pp.

Moberly, R., Jr., and Campbell, J. F., 1969, Hawaiian shallow marine sand inventory, Part 2, Ahu o Laka Sand Deposit, Kaneohe Bay, Oahu: Hawaii Inst. Geophys. Report 69-10, Sea Grant 69-1, 24 pp.

Hamilton, E. L., 1970, Sound velocity and related properties of marine sediments, North Pacific: Jour. Geophys. Res., v. 75, p. 4423-4446.