CHAPTER III

ANALYTICAL RESULTS

To fully understand the sedimentation processes of the area studied, emphasis was laid upon almost all parameters concerned, namely, topography, beach materials, hydrography and climate. Quantitative and semi-quantitative determinations of the information previously mentioned in order to assess the sedimentation model are required. In this connection, attempt has been made to acquire and integrate all necessary data for the synthesis of dynamic model where by proper interpretation and scientific prediction could be made.

The data obtained from the technical field survey programmed, laboratory analyses, and data from other sources will be presented and discussed in this Chapter.

3.1 DESCRIPTION OF THE AREA STUDIED.

The area of study is located on the north-northeast coastline of the Sattahip Bay near the Royal Fleet Pier. The observation site is the sandy beach approximately 2 kilometres long with the average width of 60 metres. The pier is situated in the central part of the area. Landward to the north is the Operation Fleet Headquarter and seaward to the south is the Sattahip Bay with islands, namely, Ko Mu, Ko Phra Noi etc. lying within the Bay. The bottom topography of the Bay is generally gentle sloping southward with an average water-depth of 4 metres. However, there is a small, shallow depression elongated in the north-northwest and south-southeast direction.

A close investigation of the beach reveals that the width of the beach varies on both sides of the pier. The beach on the eastern side of the pier is wider than the one on the other side. During the study period (July 1975 - July 1976) a prominent berm was developed and heavily vegetated. On the eastern beach of the pier the maximum width of the foreshore so far observed is about 100 metres. Most part of the beach is reached by waves. The topographic profile between foreshore and inshore zones is simple upward concaved similar to type B of beach profile (Shepard, 1948). However if the beach material in the foreshore zone is composed of fine sand, the topographic profile may tend to have a nearly uniform slope. The slope of the foreshore varies greatly from place to place and from time to time due to the nature of the variation of the textural characteristics of the beach materials and the intensity of wave-actions. Generally the slope is steeper on the coarse-grained sandy beach than on the fine-grained sandy beach. The principal reason for the relatively steeper slope of coarse-grained beach materials is the greater loss of water by percolation so that the force of the backswash is greatly reduced (Inman & Bagnold, 1962, Beach Erosion Board, 1963)

The Sattahip Bay is semi-circular shape so that the surf zone is relatively narrow as compared with straight beach (O'Rourke & Le blond, 1972).

3.2 CHANGES OF BEACH PROFILES.

Series of representative topographic sections have been chosen to illustrate some of the changes that occured over the one-year period of study within the area (Figs. 3.2.1 - 3.2.5). Almost all the beach profiles exhibit the parabolic shape which is due to the variation of beach materials. The coarser beach materials are in large part, concentrated on the upper part of the beach. The geometric form of the beach profile allow the waves to break closer inshore at high tide which in effect caused the accumulation of the coarse-grained beach materials on the upper part of beach. Further down along the profile on the seaward side approximately 40 metres from the reference stations, another zone of coarse-grained beach materials is present in almost every profile. This zone is at the points of maximum wave energy and therefore responsible for the change of the slope on the beach.

A variety of beach gradient were observed ranging from greater than 1:5 to lesser than 1:130. In conclusion, it is interesting to note that the drastic changes of beach profiles occur at the west end of the area, namely, profiles A, B, C and on both sides of the pier, which is represented by profile F and G. This is the result of greatest depletion and accretion of the beach materials. (Fig. 3.2.1, 3.2.3).

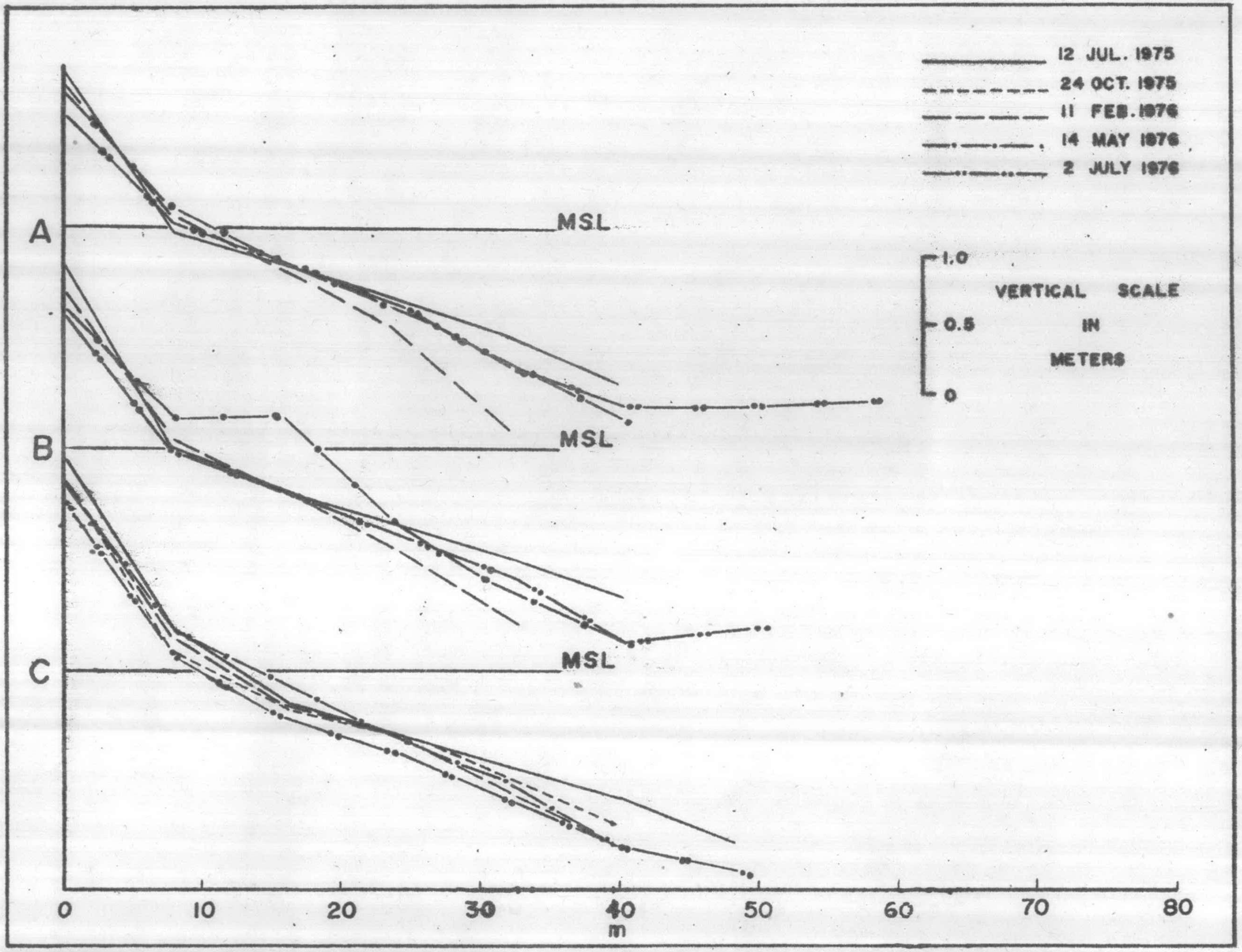

FIGURE 3.2.1. BEACH PROFILES A, B AND C BETWEEN 12 JULY 1975 AND 2 JULY 1976.

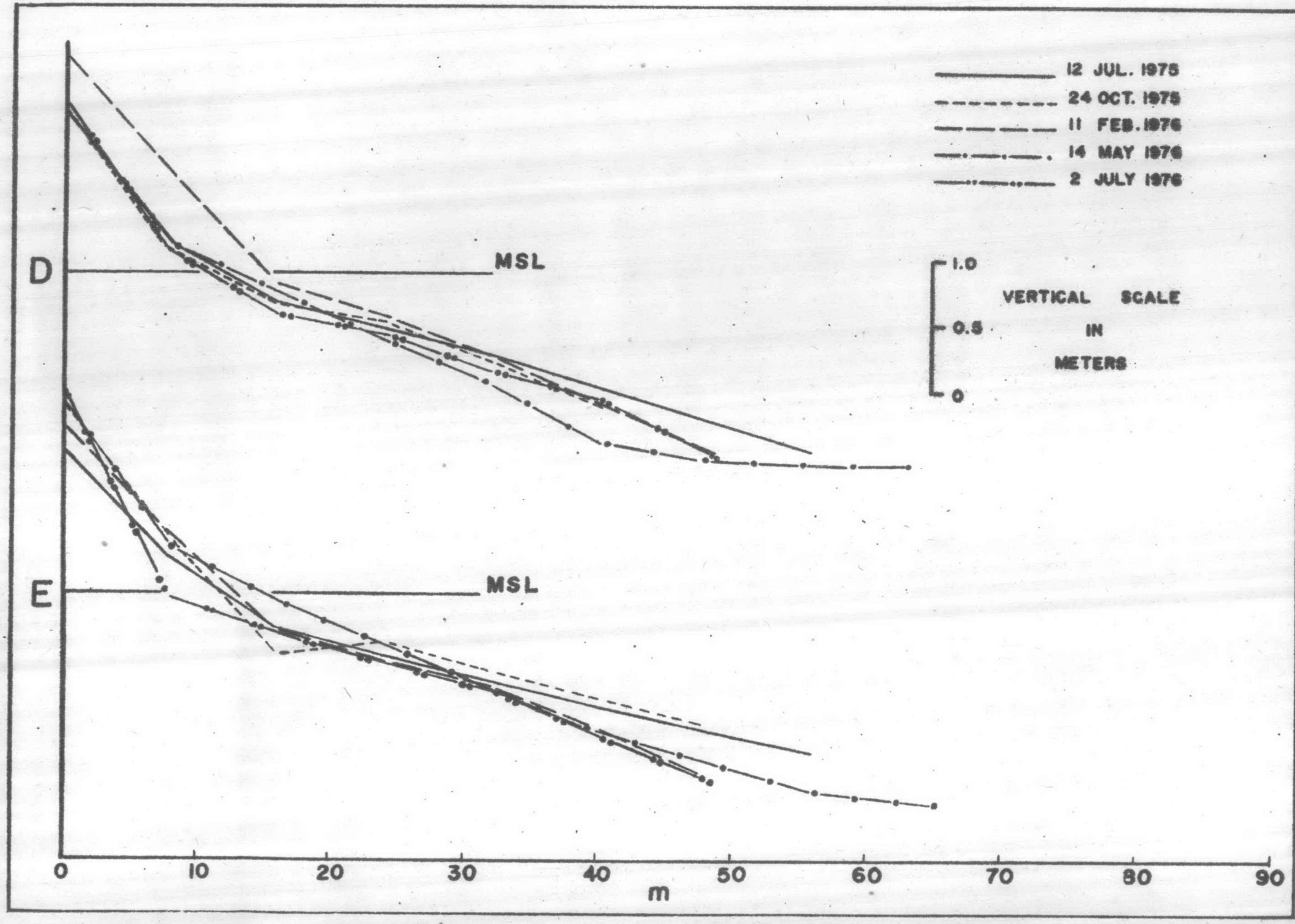

FIGURE 3.2.2: BEACH PROFILES D AND E BETWEEN 12 JULY 1975 AND 2 JULY 1976.

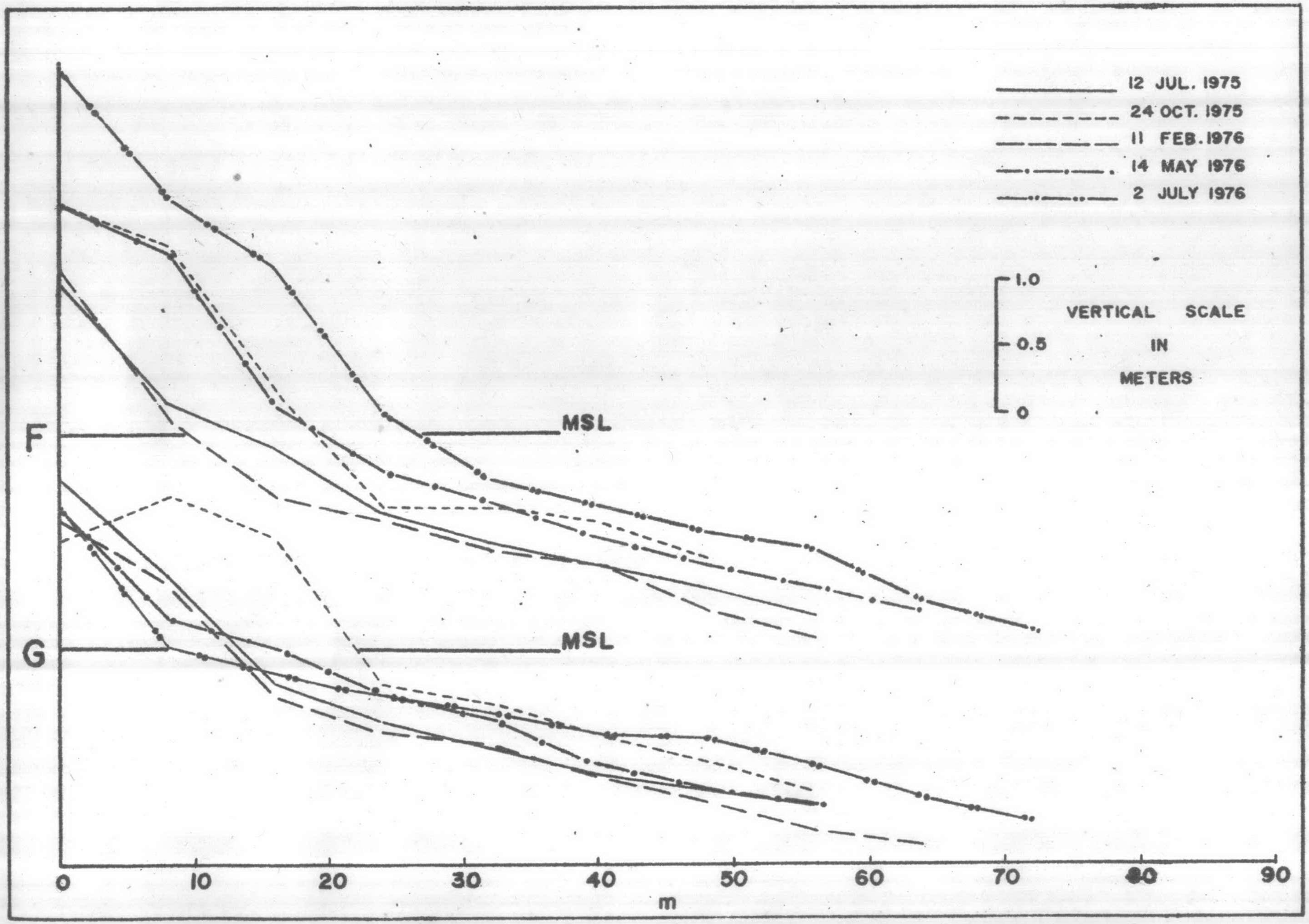

FIGURE 3.2.3. BEACH PROFILES F AND G BETWEEN 12 JULY 1975 AND 2 JULY 1976.

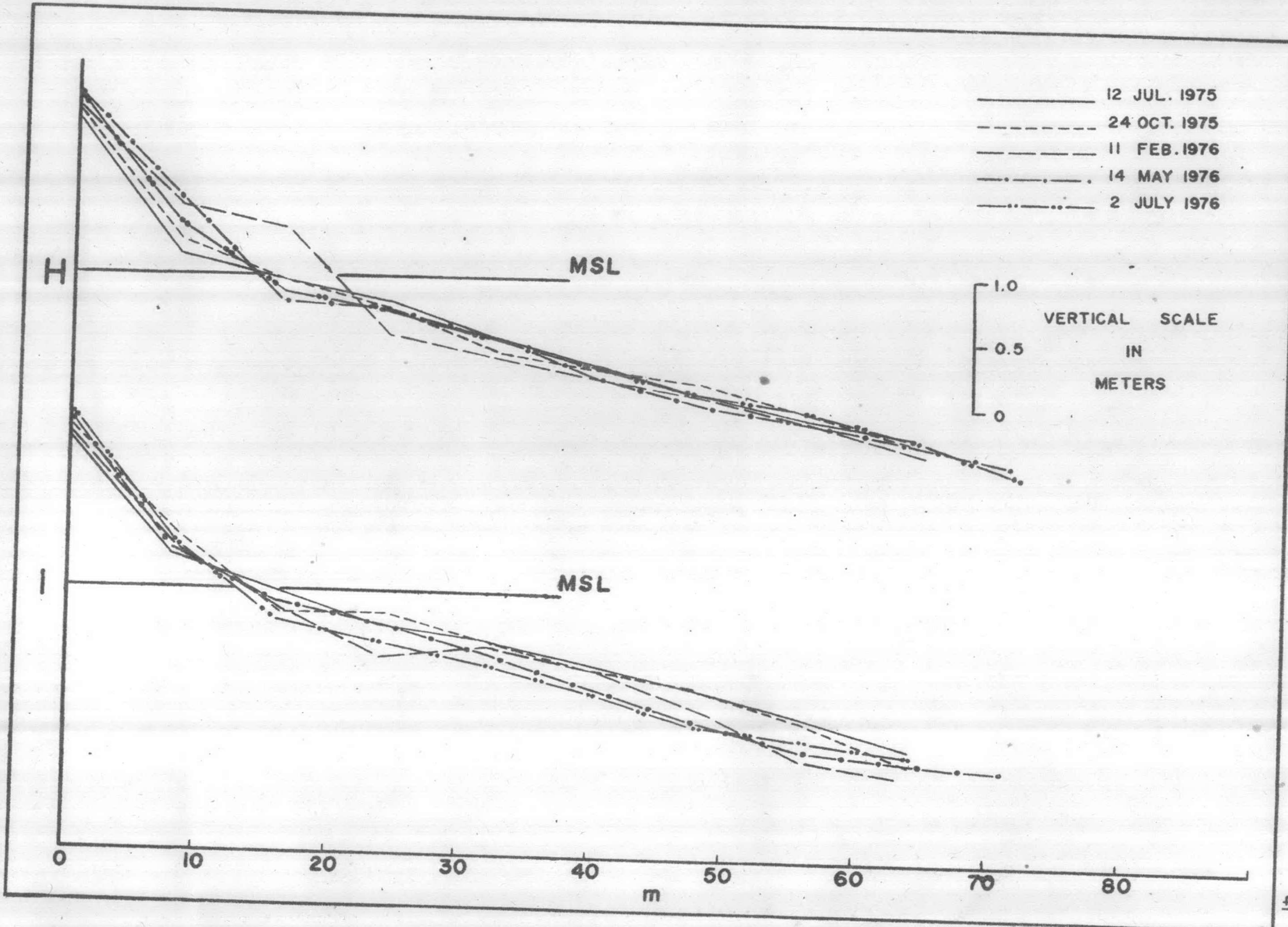

FIGURE 3.2.4. BEACH PROFILES H AND I BETWEEN 12 JULY 1975 AND 2 JULY 1976.

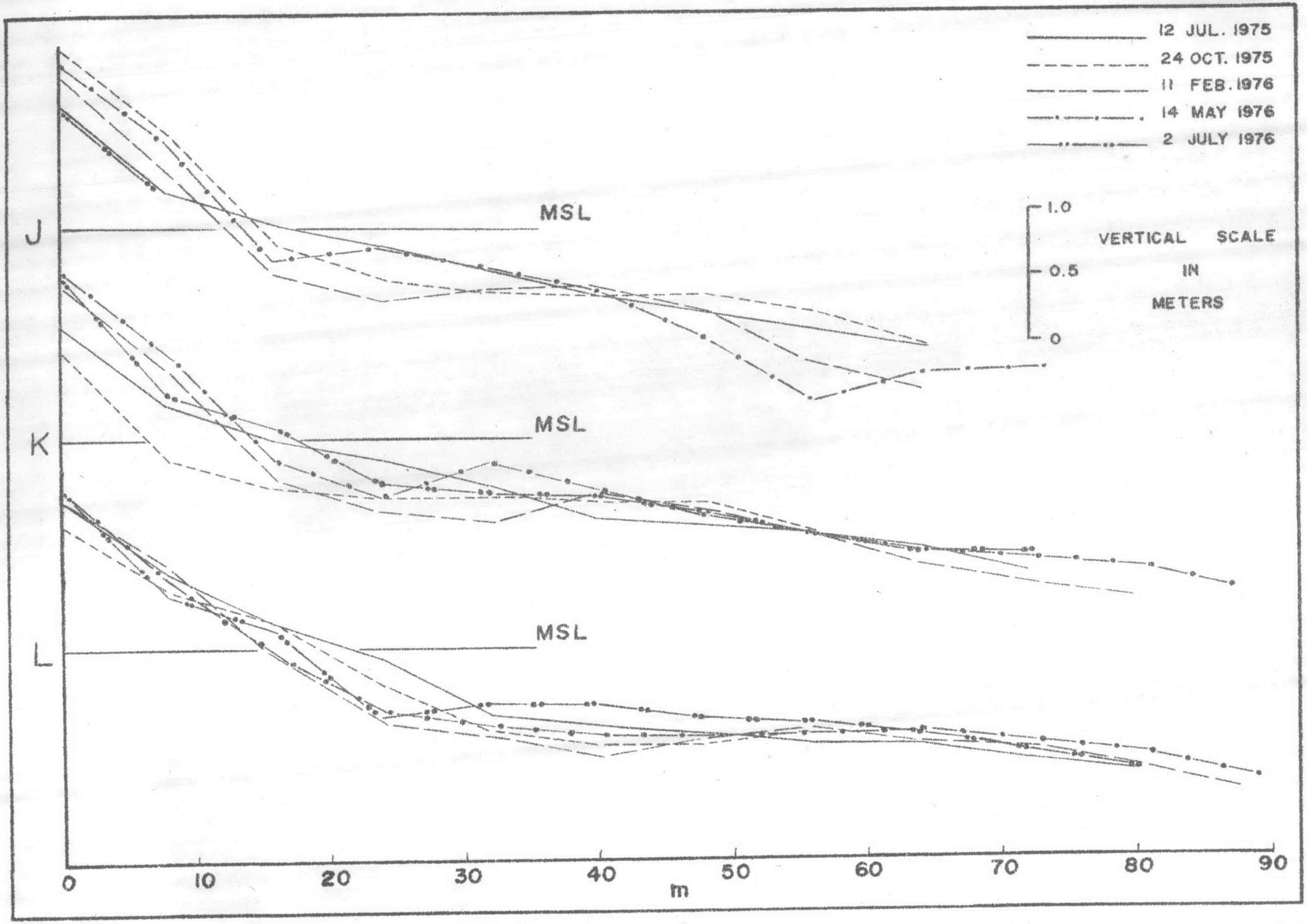

FIGURE 3.2.5. BEACH PROFILES J, K AND L BETWEEN 12 JULY 1975 AND 2 JULY 1976.

3.3 CHARACTERISTICS AND DISTRIBUTION OF SEDIMENTS.

Examinations of 500 beach sediment samples collected from 5 technical field survey programmes it is concluded the sources of these sediments are of types :

a) biogenous materials derived from mainly from skeletons of various marine organisms, notably, molluscs, coral, foraminifera and in addition, a certain amount of calcareous algae; and

b) terrigenous materials derived from weathering and erosion of the pre-existing rocks exposed in the neighbourhood of the area studied and are transported by streams and marine processes to the site of deposition.

Biogenous materials are mostly found in the coarse-grained fraction of sediments whereas terrigenous materials are more abundantly found in the fine-grained fraction. Shells and shell fragments are important in tropical beaches where biological productivity is high and chemical weathering of the land sources tends to be intense (Komar, 1976).

The grain-size analysis of 500 beach sand samples collected from 5 technical field survey programmes reveals that the most common beach sediments have a mean diameter ranging from -1.05 to 3.67 phi (or 2.07 to 0.88 mm.) corresponding with very fine gravel to very fine sand on Wentworth's scale (1922). The median diameter of the sediments range from -1.8 to 3.7 phi. The mean grain sizes are plotted according to the sampling locations for each profile. (Figs. 3.3.1 - 3.3.4).

Apart from this, aerial distribution of mean diameter of the sediments are shown as zones for each technical field survey programme (Figs. 3.3.5 - 3.3.8). The general pattern of grain size distribution generally exhibits the reduction of grain size in the eastward direction except for the profiles F and G on both sides of the pier which show an exceptionally complicated grain size pattern.

The coarse-grained sediments extraordinary accumulate on both sides of the pier. Elesewhere the coarser beach materials are found at the breaker zone, approximately 40 metres from the reference station on shore and at the top part of the berm. The mean grain size generally decreases corresponding with the increasing distance from shore with an exceptionally increase in grain size at the breaker zone.

Considering the seasonal variation of the grain size distribution, it is apparent that during the rainy season and cold season (July to February) the beach materials appear to be relatively coarser in grain size with a markedly "cut" profiles. The finer beach materials with "fill" profiles appear in the summer (May to July).

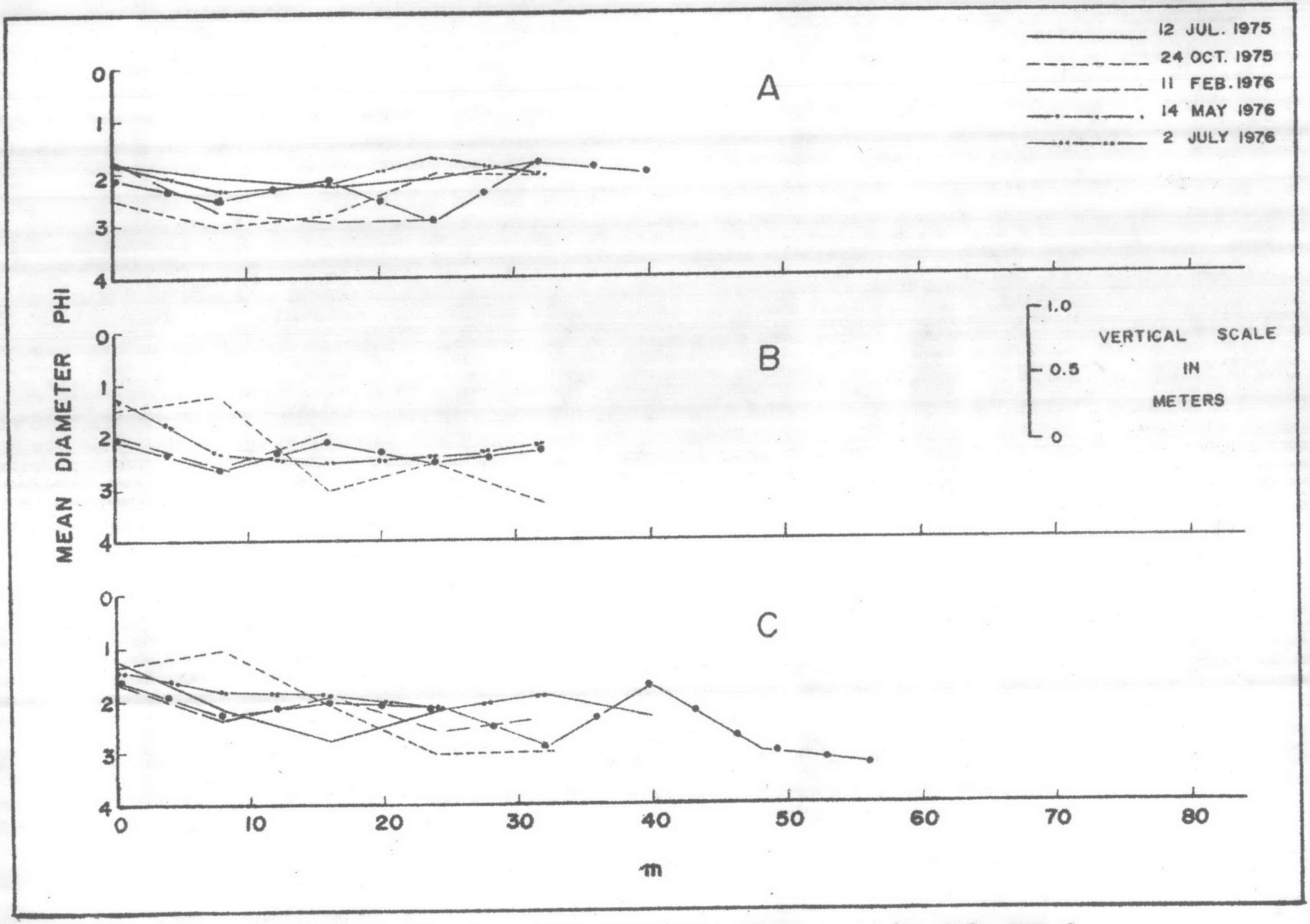

FIGURE 3.3.1. DISTRIBUTION OF MEAN DIAMETERS (PHI) ALONG PROFILES A, B AND C BETWEEN 12 JULY 1975 AND 2 JULY 1976.

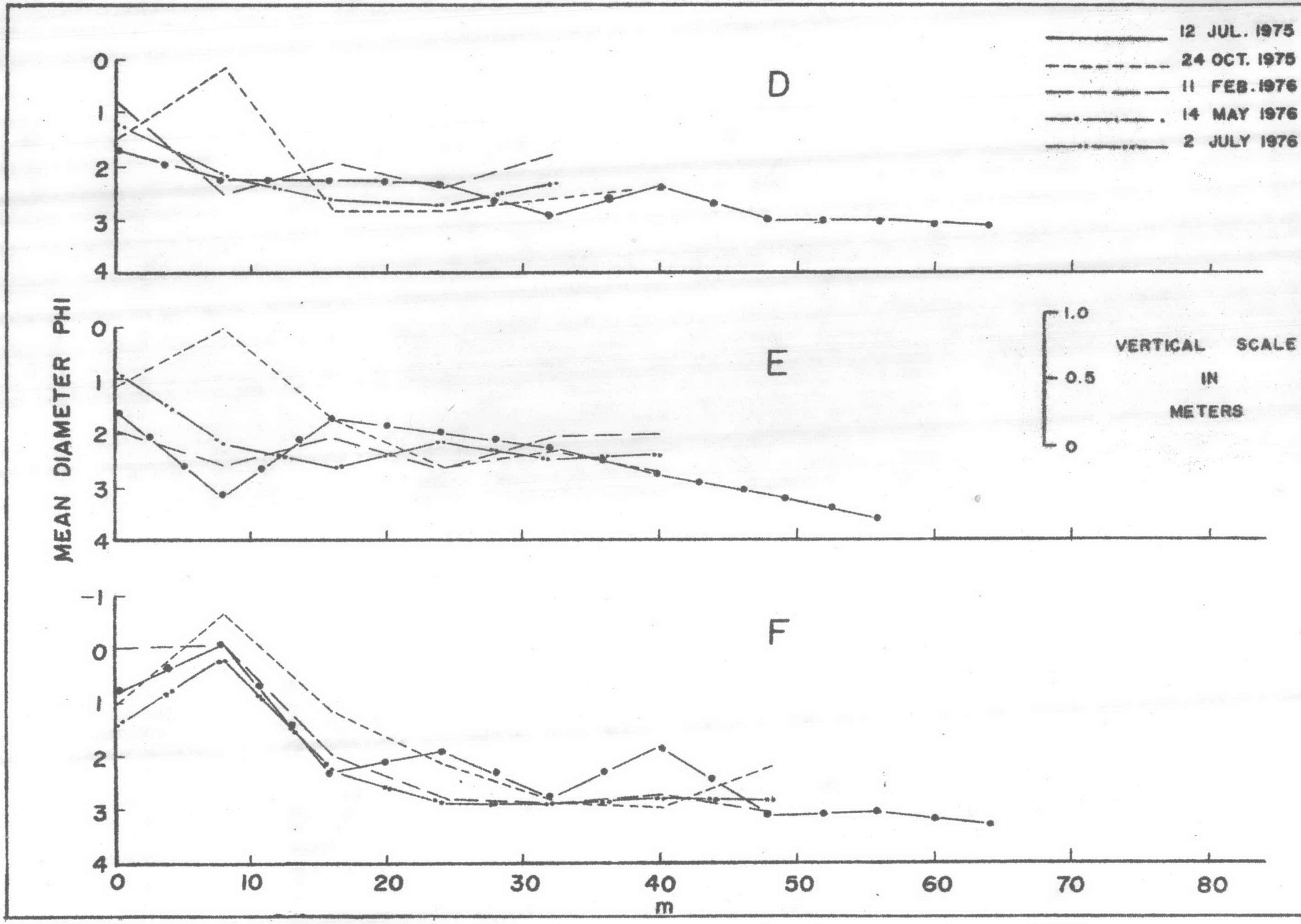

FIGURE 3.3.2. DISTRIBUTION OF MEAN DIAMETERS (PHI) ALONG PROFILES D, E AND F BETWEEN 12 JULY 1975 AND 2 JULY 1976.

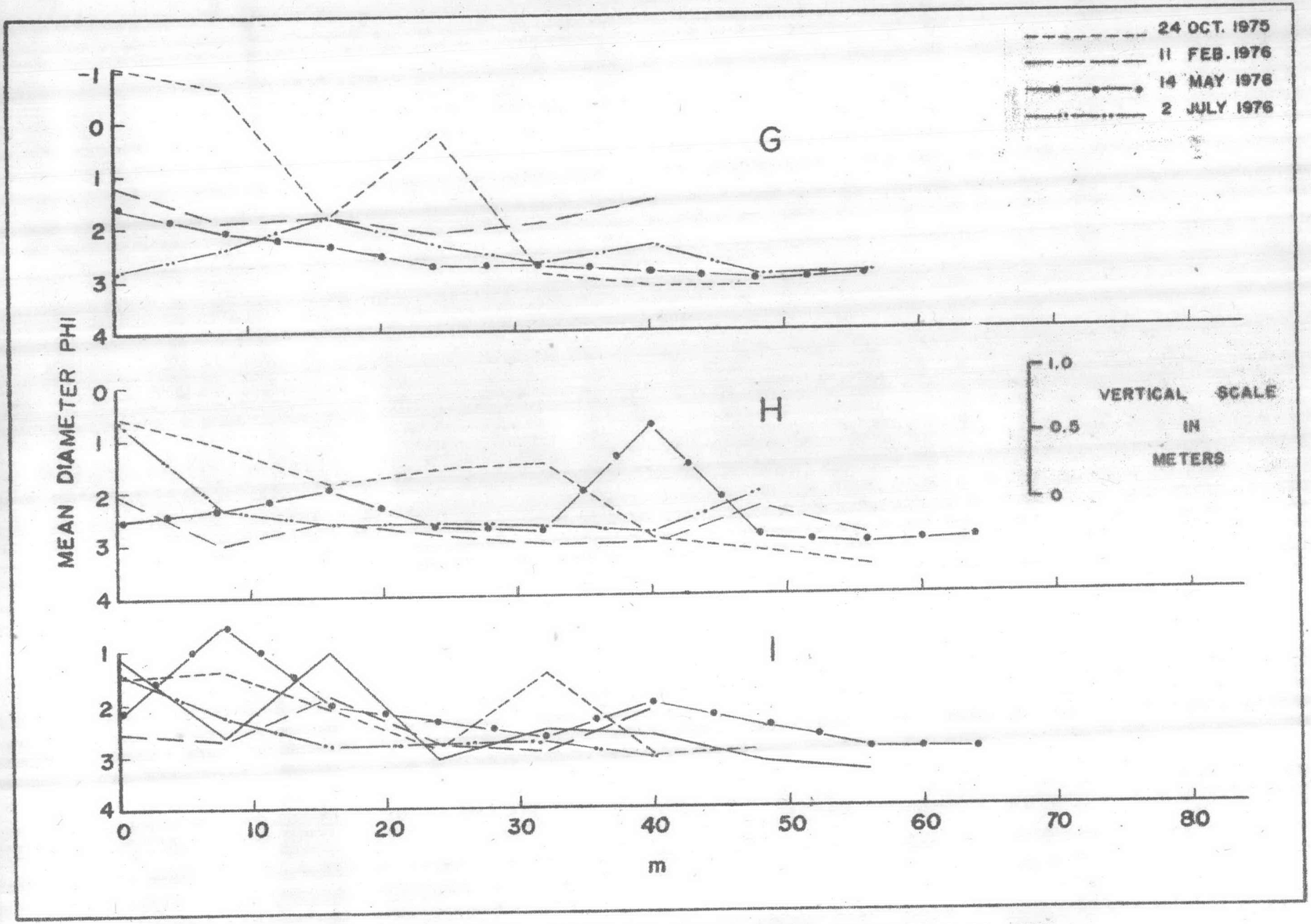

FIGURE 3.3.3. DISTRIBUTION OF MEAN DIAMETERS (PHI) ALONG PROFILES G, H AND I BETWEEN 12 JULY 1975 AND 2 JULY 1976.

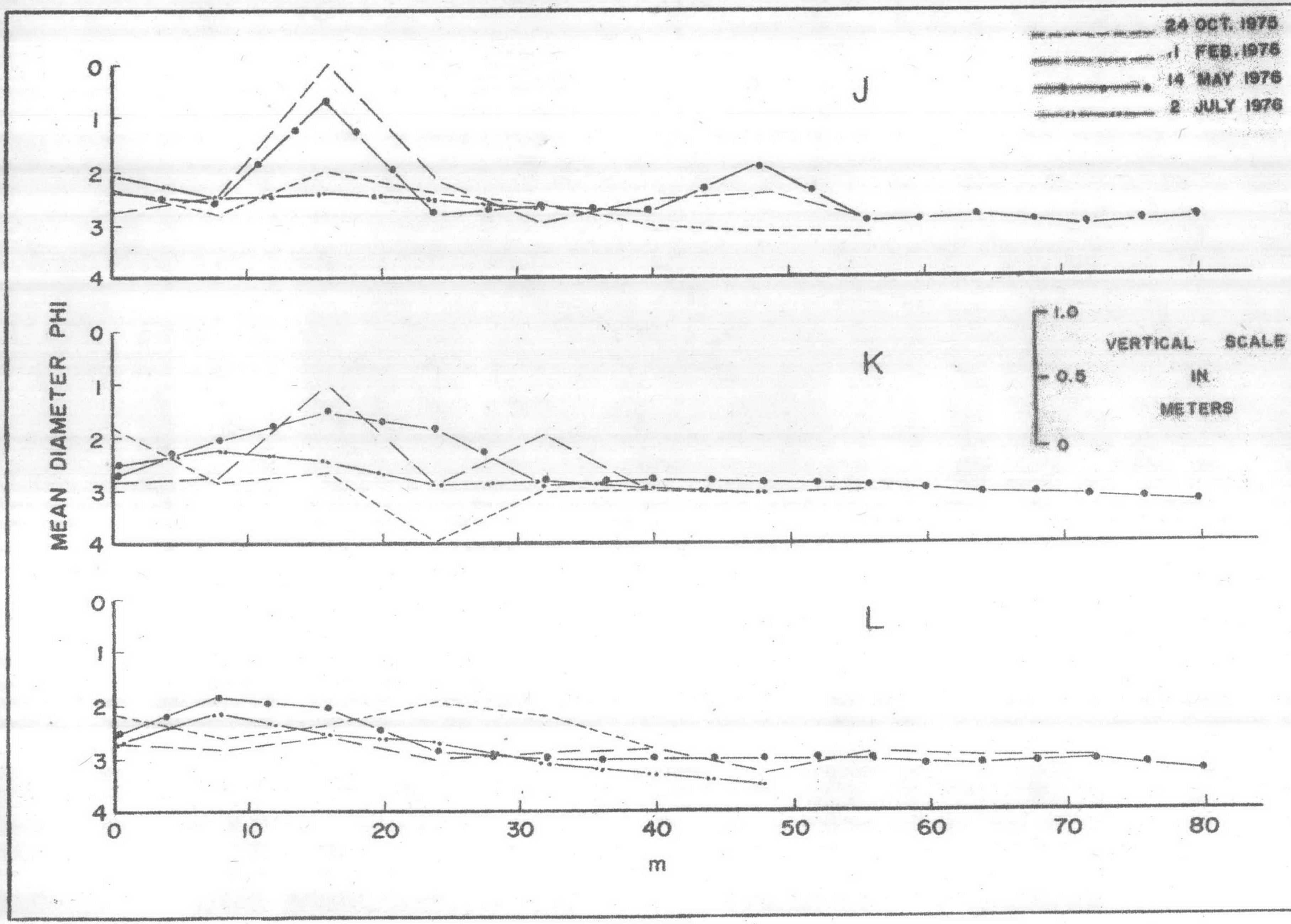

FIGURE 3.3.4. DISTRIBUTION OF MEAN DIAMETERS (PHI) ALONG PROFILES J, K AND L.
BETWEEN 12 JULY 1975 AND 2 JULY 1976.

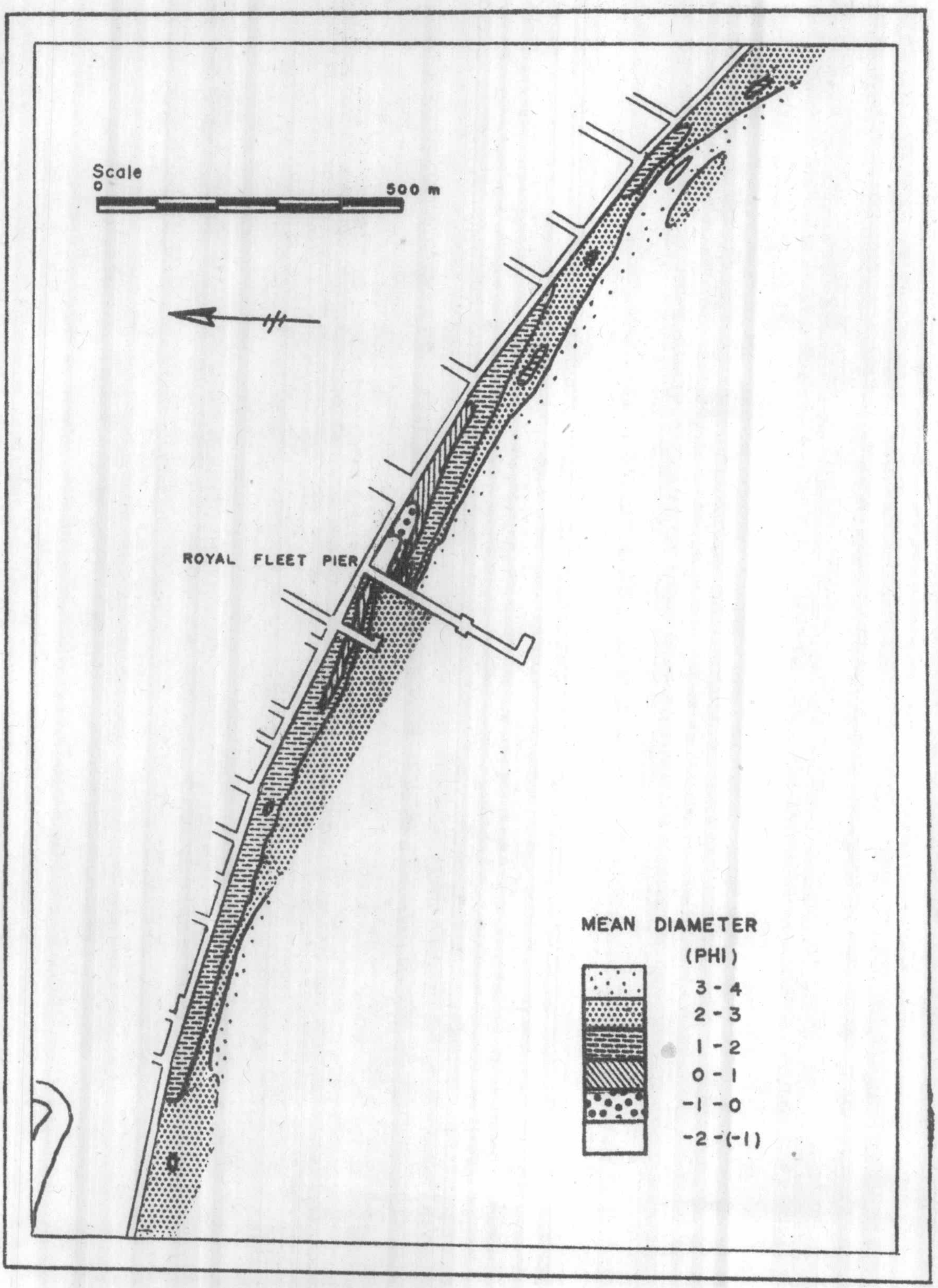

FIGURE 3.3.5. DISTRIBUTION OF MEAN DIAMETERS (PHI) OF SEDIMENTS ON 24 OCTOBER 1975 AROUND THE ROYAL FLEET PIER.

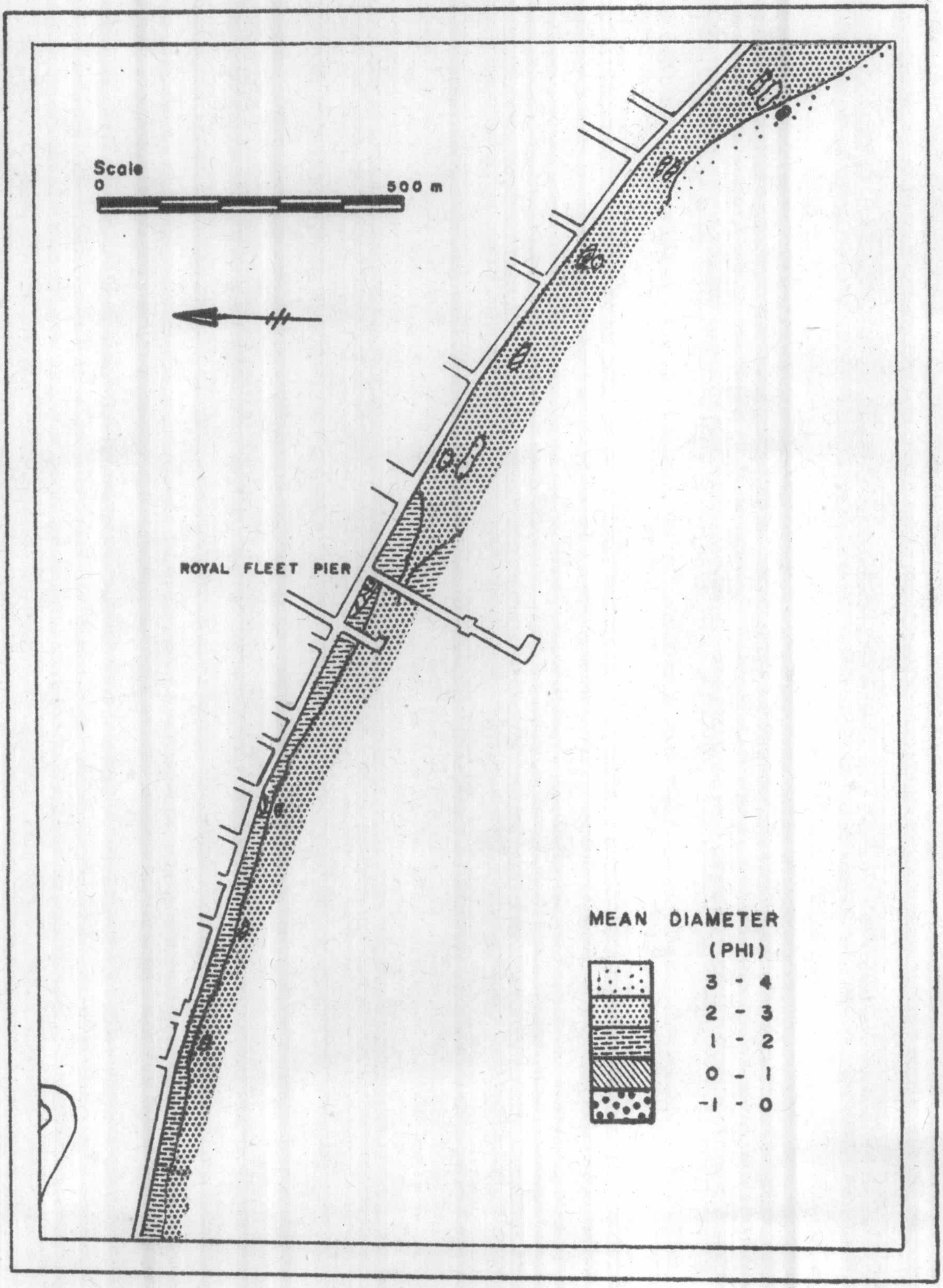

FIGURE 3.3.6. DISTRIBUTION OF MEAN DIAMETERS (PHI) OF SEDIMENTS ON 11 FEBRUARY 1976 AROUND THE ROYAL FLEET PIER.

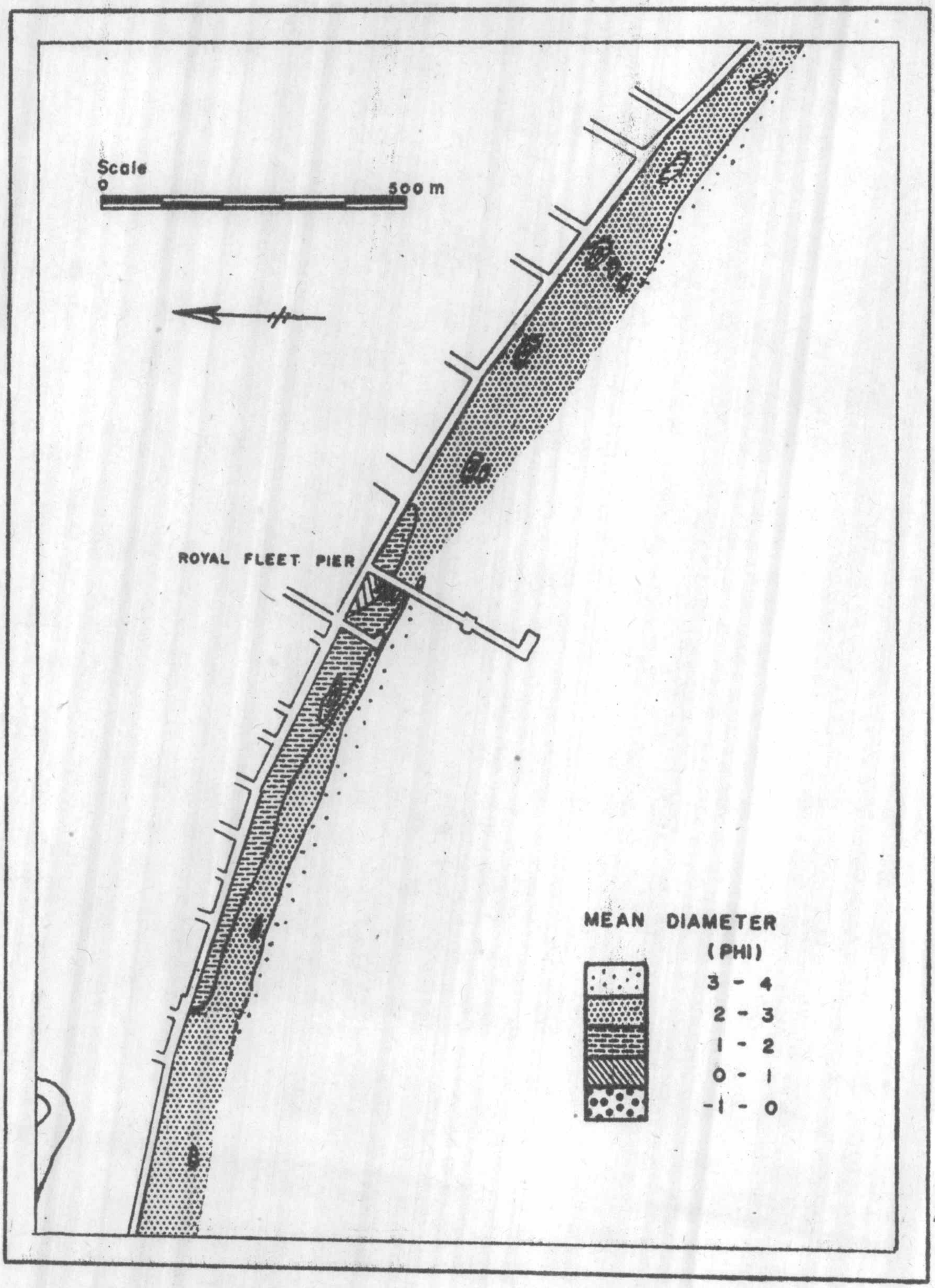

FIGURE 3.3.7. DISTRIBUTION OF MEAN DIAMETERS (PHI) OF SEDIMENTS ON 14 MAY 1976 AROUND THE ROYAL FLEET PIER.

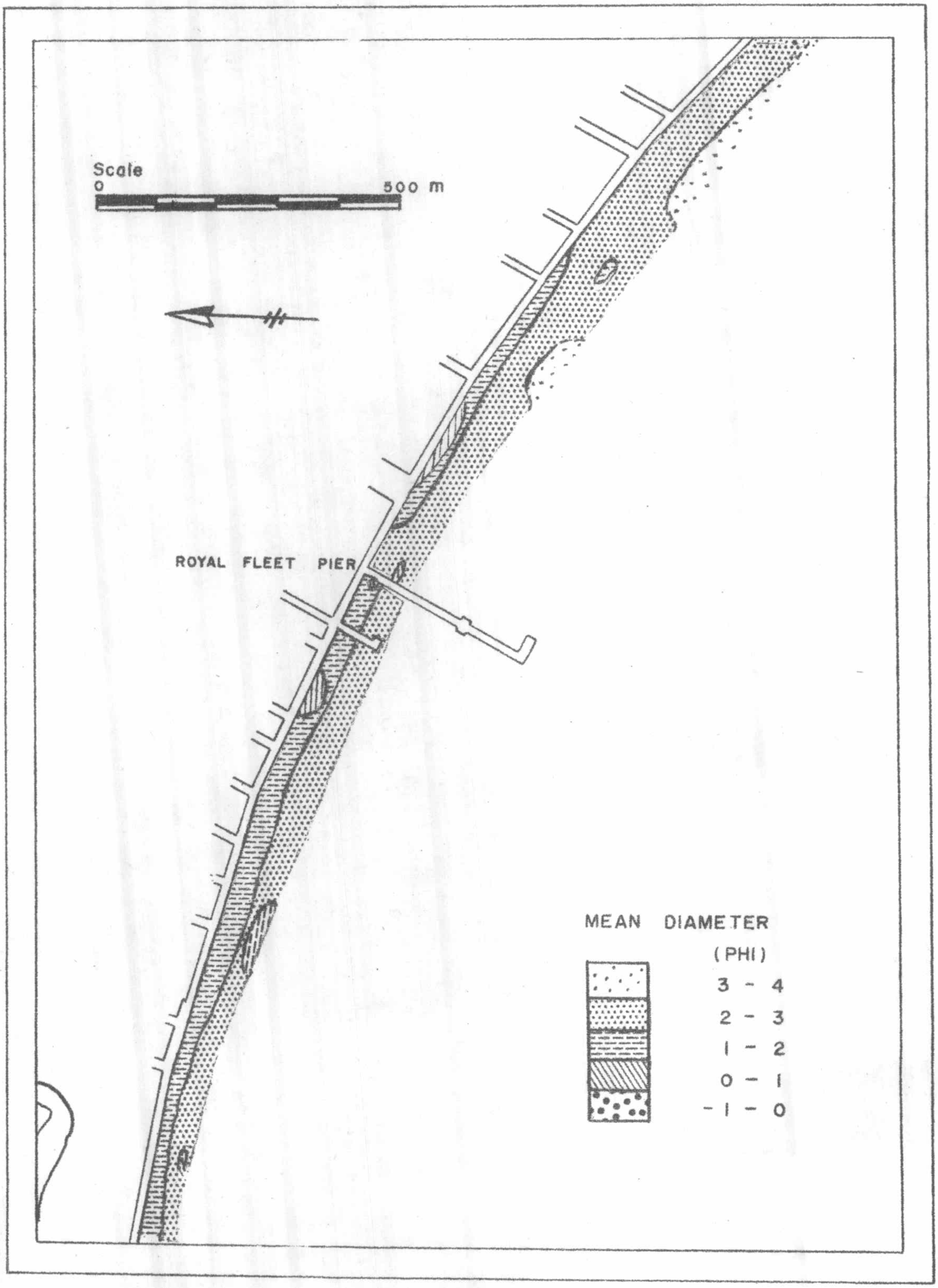

FIGURE 3.3.8. DISTRIBUTION OF MEAN DIAMETERS (PHI) OF SEDIMENTS ON 2 JULY 1976 AROUND THE ROYAL FLEET PIER.

In addition to the mean and median grain size patterns employed in this study, the sorting of the beach materials has been extensively studied. Generally the beach materials are very well-sorted to very poor-sorted with the values ranging from 0.09 to 2.34 (Folk & Ward, 1957). Whole shells as well as freshly broken shell fragments, wherever dominant in the sediments, make the sediments poorly sorted. The sorting of the sediment by moving water results in a segregation of the various sizes and the variation in velocity is an important factor in producing the diffrent degree of sorting of sediments on various part of the beach. (Evans, 1939)

The sorting of beach sediments are plotted against the sampling locations for every profiles (Figs. 3.3.9 - 3.3.12). the aerial distribution of different zone of the sorting is also illustrated for 5 technical field survey programmes (Figs. 3.3.13 - 3.3.16).

Apart from the field and laboratory studies of representative surface sediments on the beach, an attempt has also been made to randomly investigate the suspended sediments in the nearshore and offshore zones of the area concerned. Within the near shore zone it was found that the concentration of suspended load varied greatly with various stages of the tidal cycle and the strength of the tides. The most obvious picture was obtained from the near-bottom sampling at the station nos. i and 2. When the tidal stage changes from flood to ebb the concentration of near-bottom suspended load gradually increase and eventually reach maxima at the low tide stage.

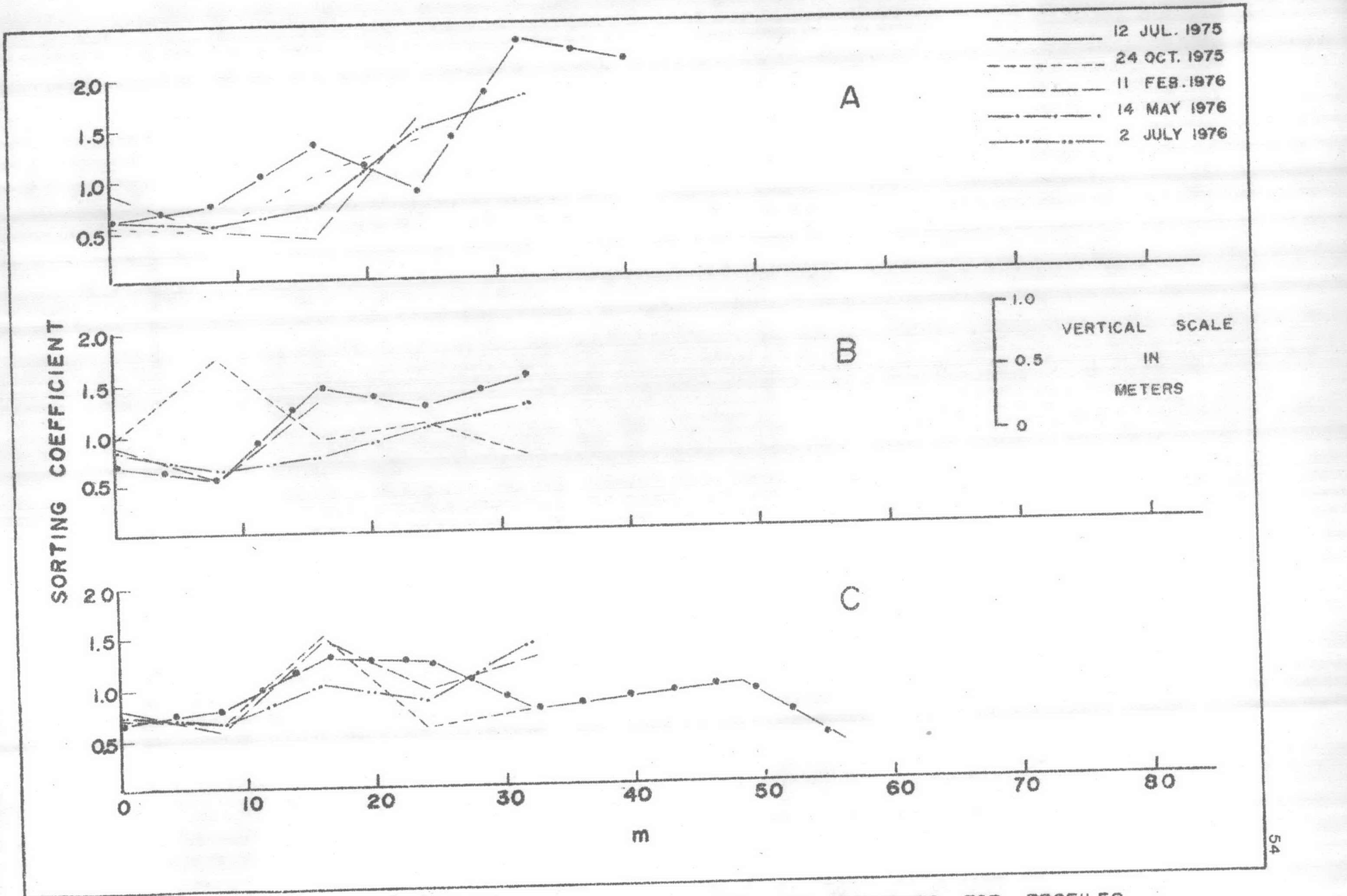

FIGURE 3.3.9. SORTING COEFFICIENTS (FOLK & WARD, 1957) OF SEDIMENTS FOR PROFILES A, B AND C BETWEEN 12 JULY 1975 AND 2 JULY 1976.

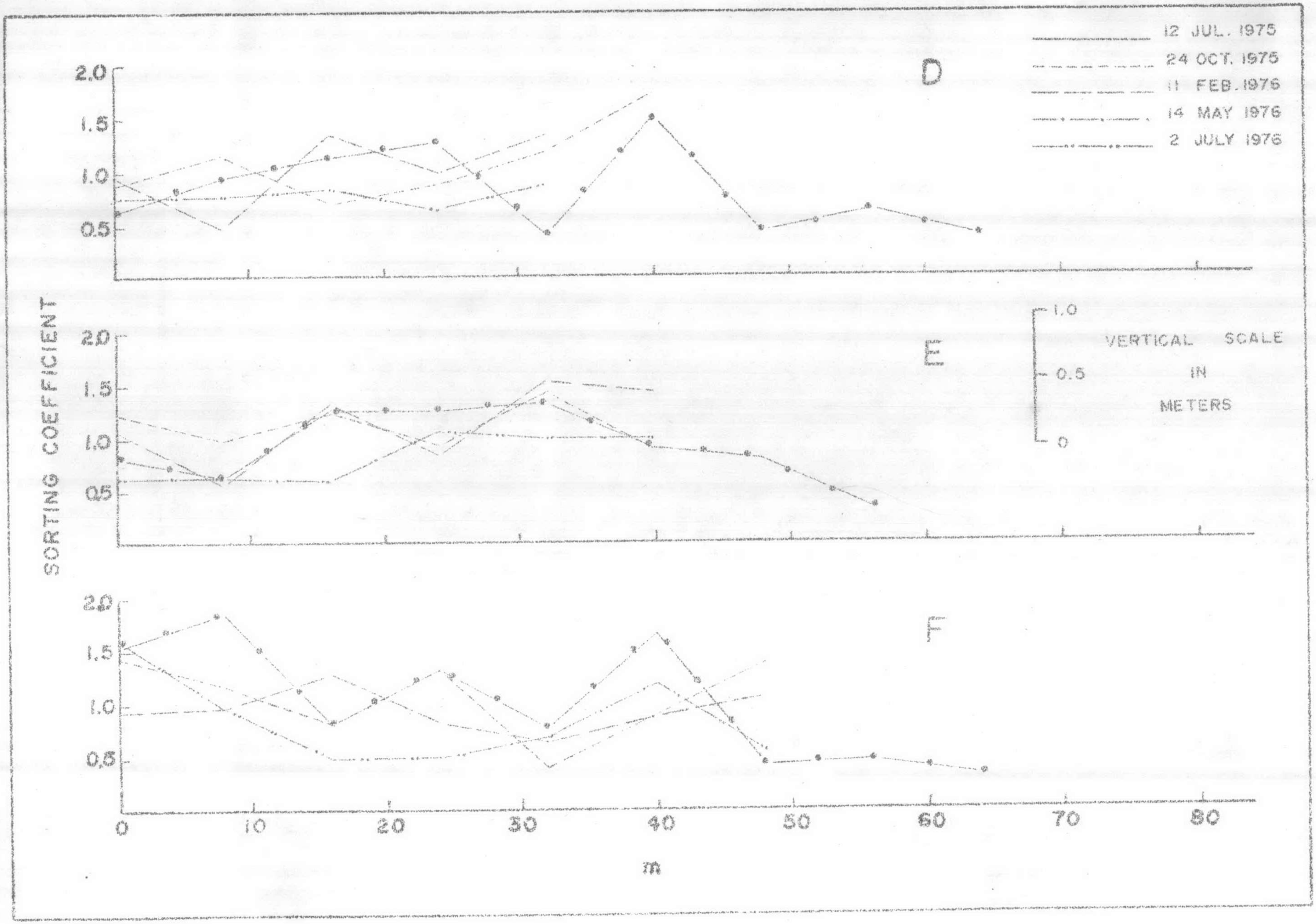

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FIGURE 3.3.10. SORTING COEFFICIENTS (FOLK & WARD , 1957) OF SEDIMENTS FOR PROFILES D, E AND F BETWEEN 12 JULY 1975 AND 2 JULY 1976.

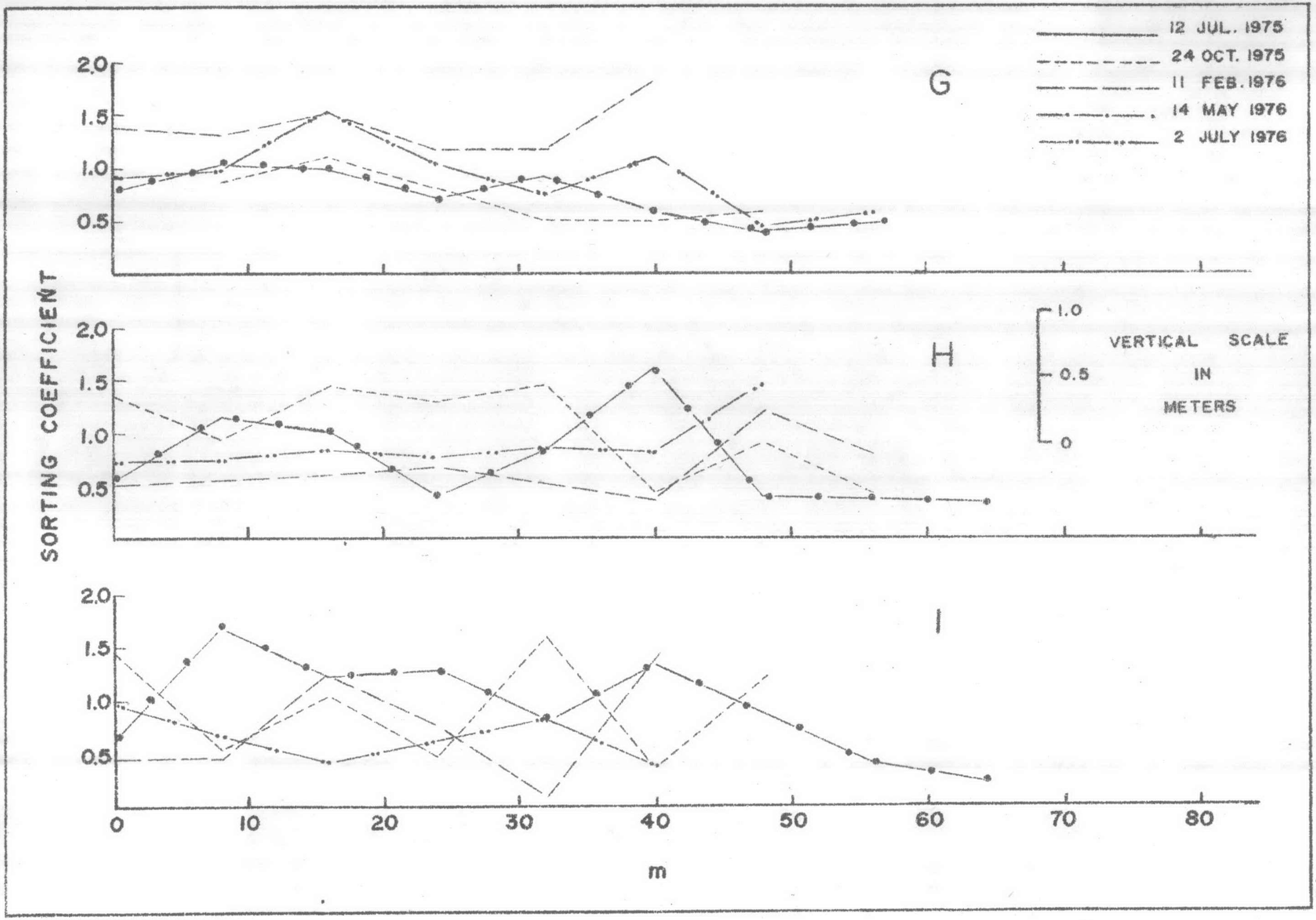


FIGURE 3.3.11. SORTING COEFFICIENTS (FOLK & WARD, 1957) OF SEDIMENTS FOR PROFILES G, H AND I BETWEEN 12 JULY 1975 AND 2 JULY 1976.

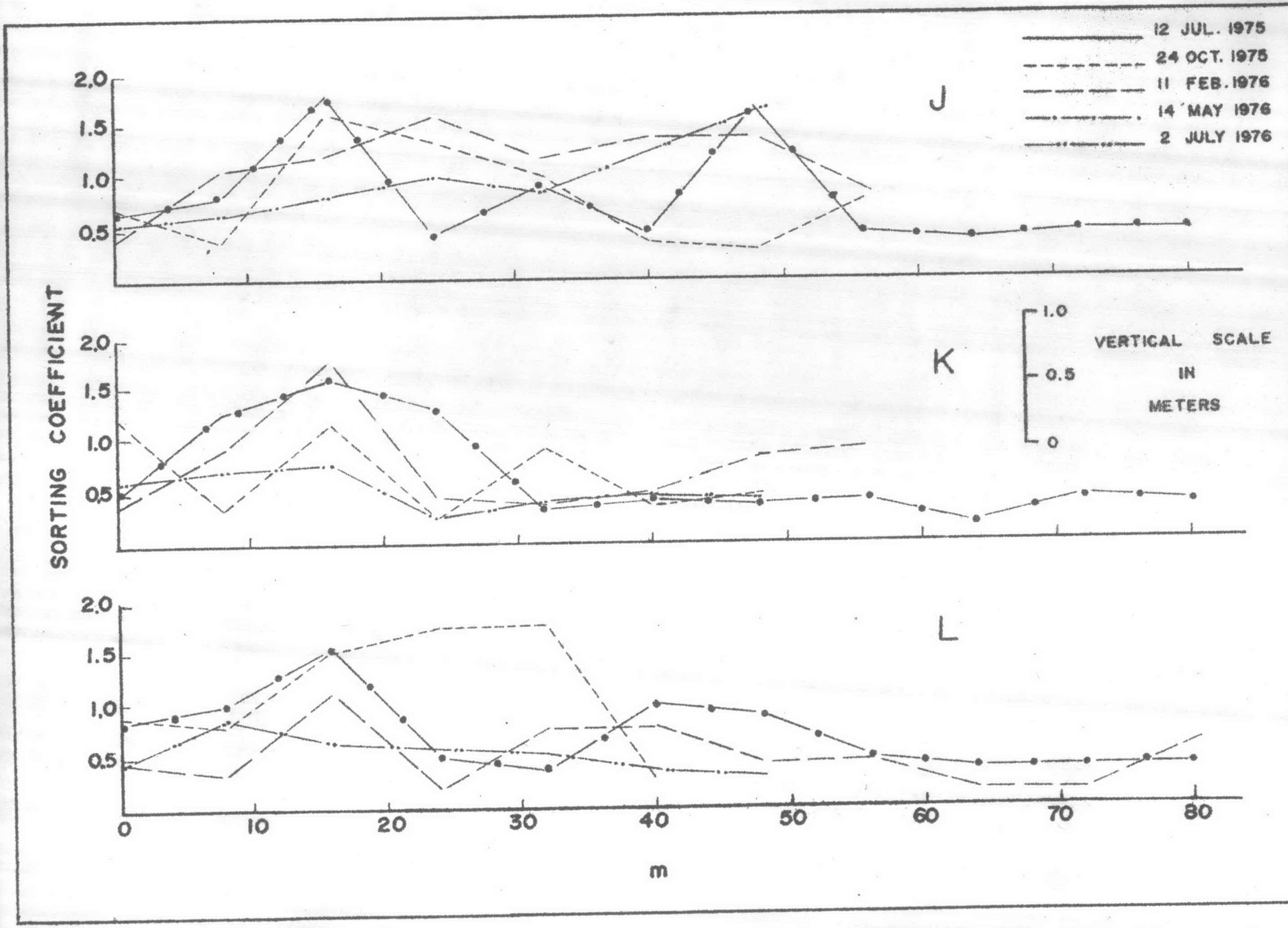


FIGURE 3.3.12. SORTING COEFFICIENTS (FOLK & WARD, 1957) OF SEDIMENTS FOR PROFILES J, K AND L BETWEEN 12 JULY 1975 AND 2 JULY 1976.

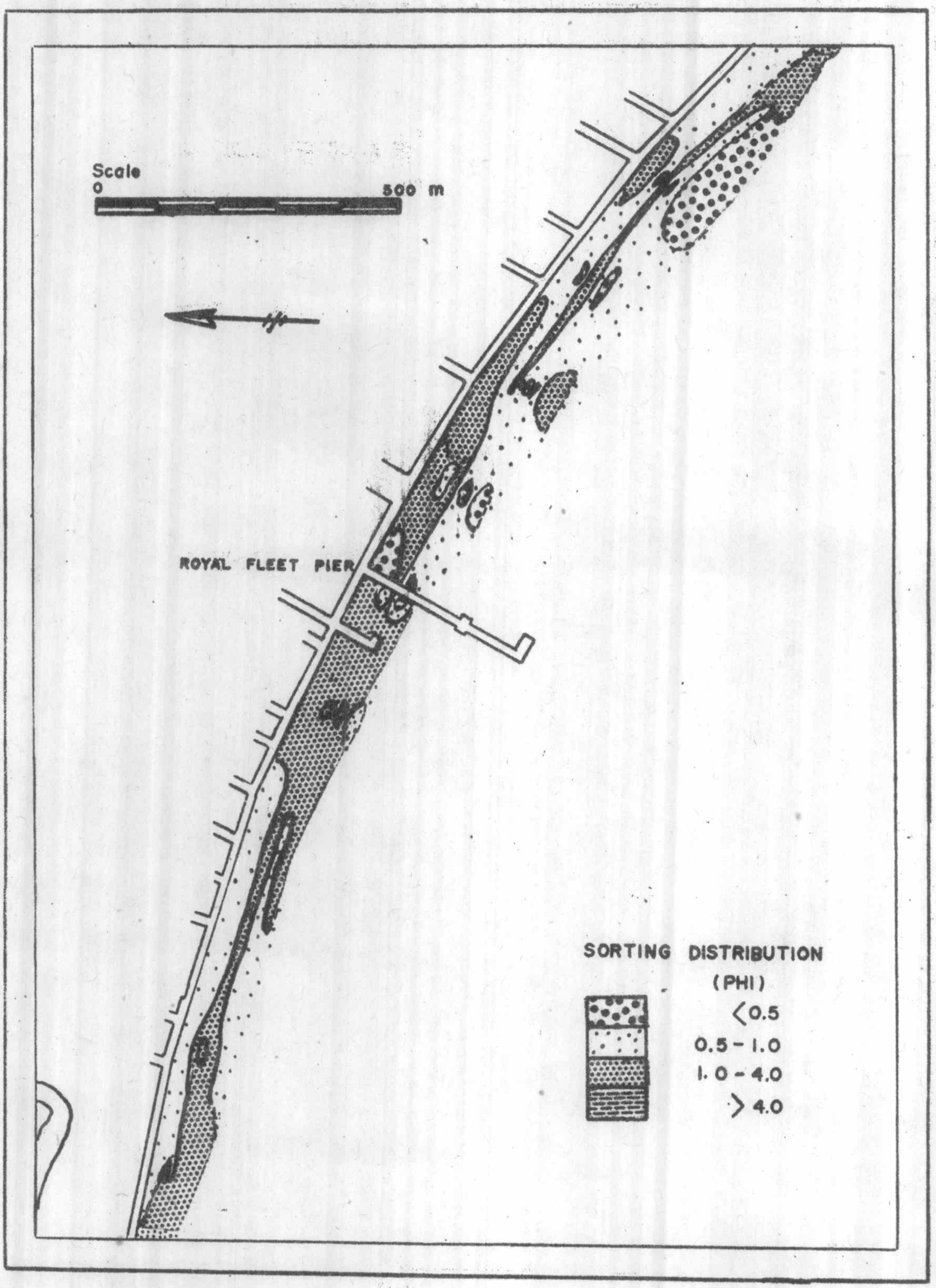


FIGURE 3.3.13. DISTRIBUTION OF SORTING COEFFICIENTS OF SEDIMENTS ON 24 OCTOBER 1975 AROUND THE ROYAL FLEET PIER.

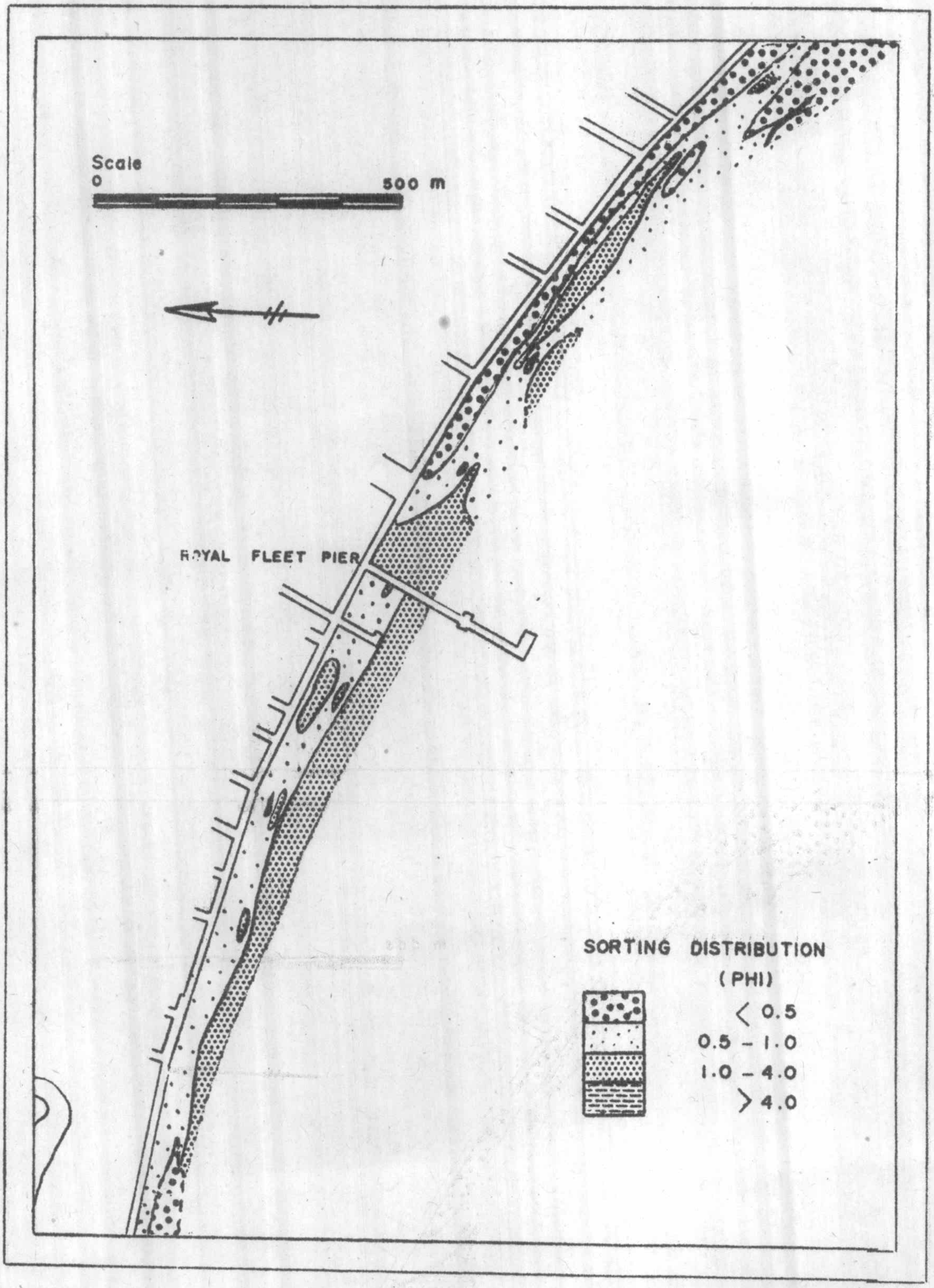


FIGURE 3.3.14. DISTRIBUTION OF SORTING COEFFICIENTS OF SEDIMENTS ON 11 FEBRUARY 1976 AROUND THE ROYAL FLEET PIER.

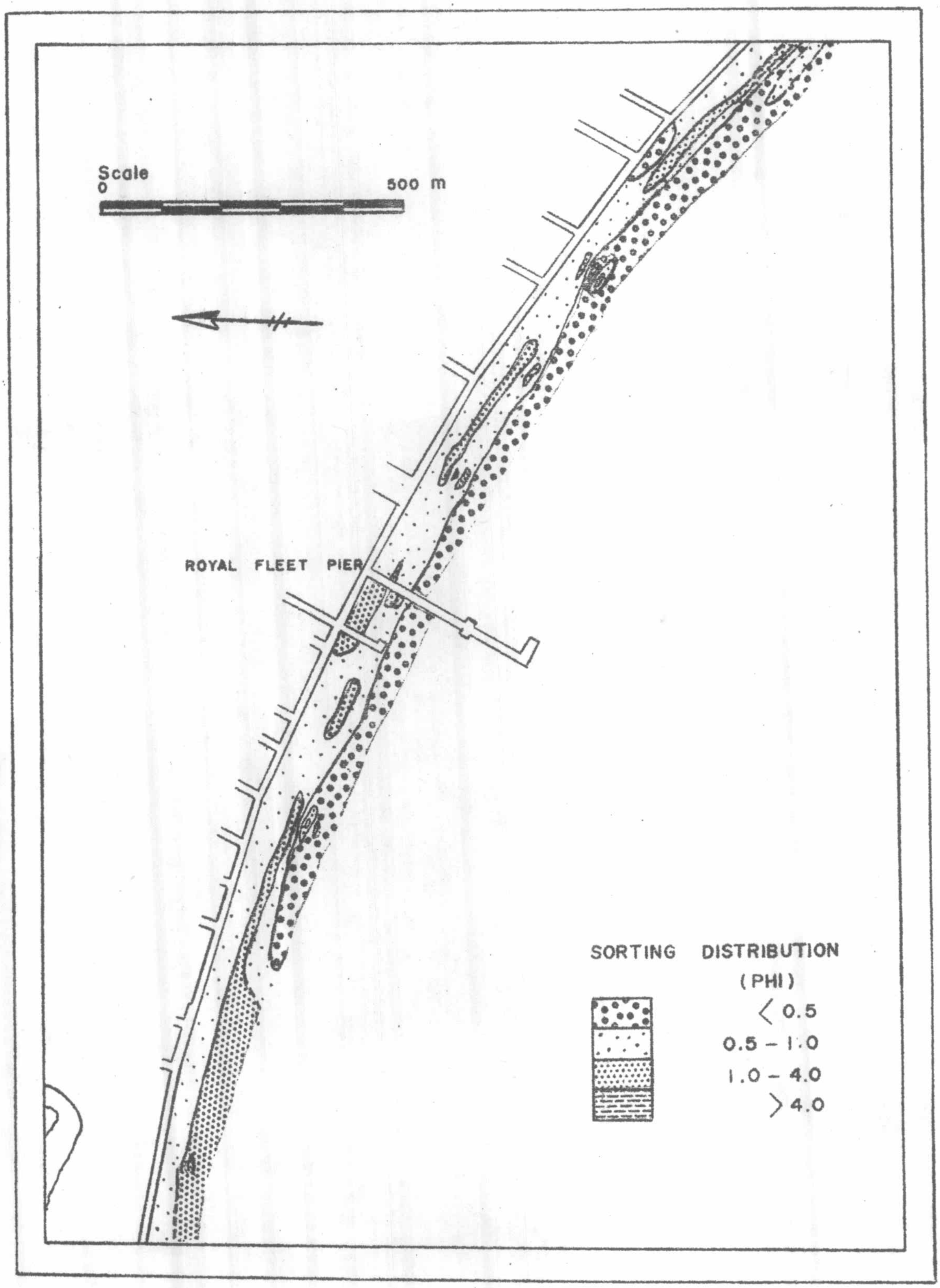


FIGURE 3.3.15. DISTRIBUTION OF SORTING COEFFICIENTS OF SEDIMENTS ON 14 MAY 1976 AROUND THE ROYAL FLEET PIER.

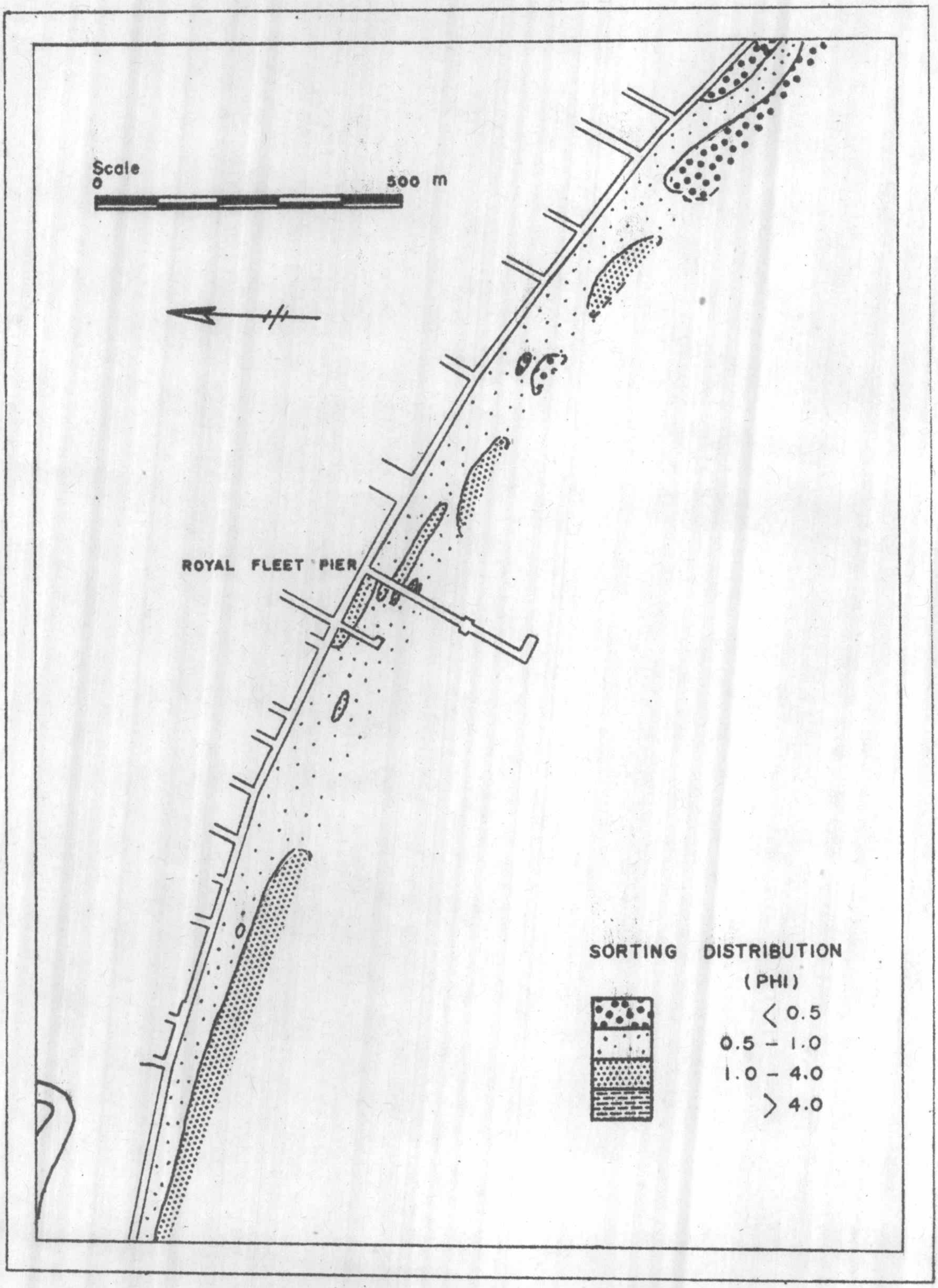


FIGURE 3.3.16. DISTRIBUTION OF SORTING COEFFICIENTS OF SEDIMENTS ON 2 JULY 1976 AROUND THE ROYAL FLEET PIER.

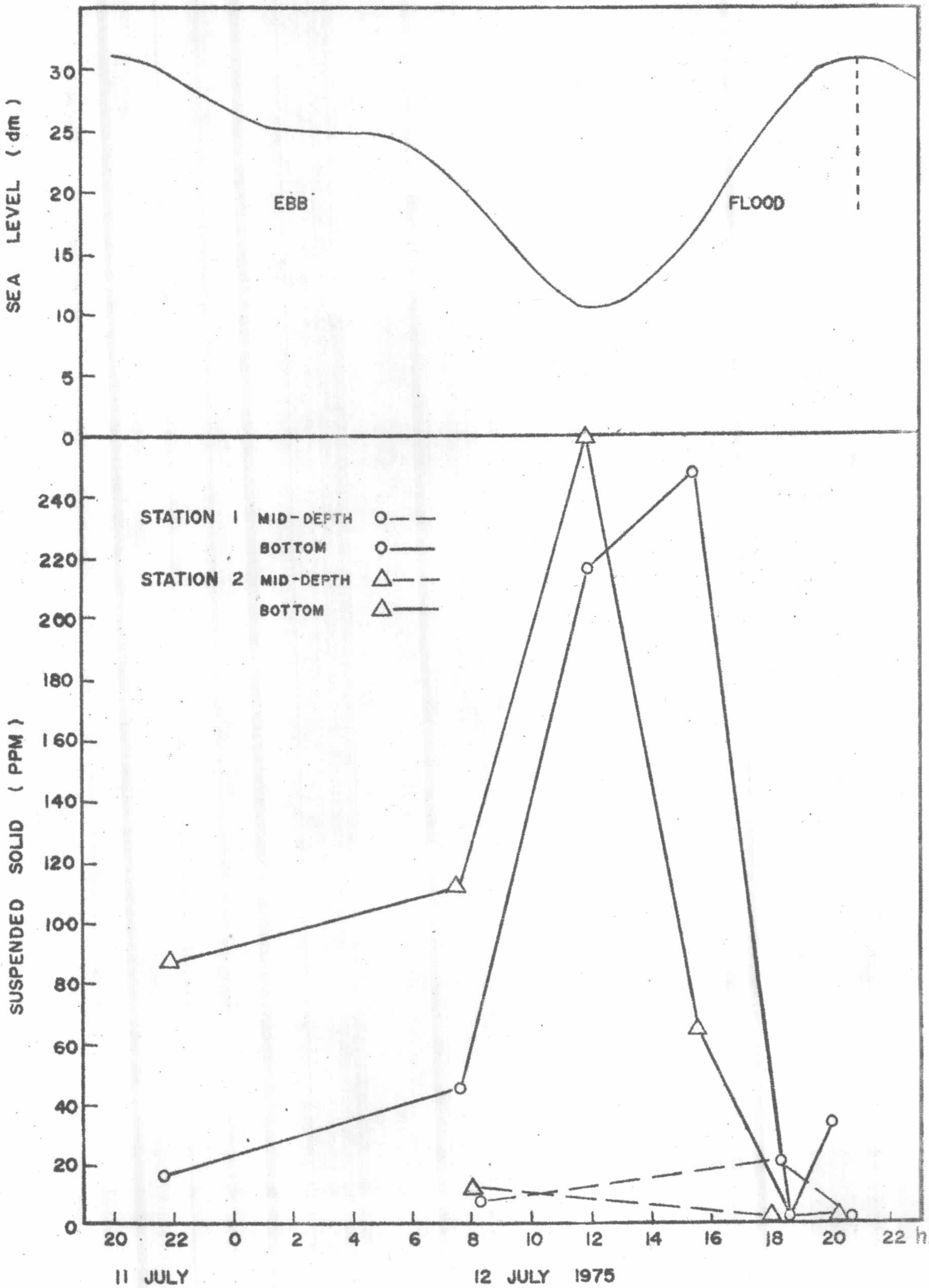


FIGURE 3.3.17. SEA LEVEL AND CONTENTS OF SUSPENDED SOLID (ppm) OF STATIONS 1 AND 2 ON 11-12 JULY 1975.

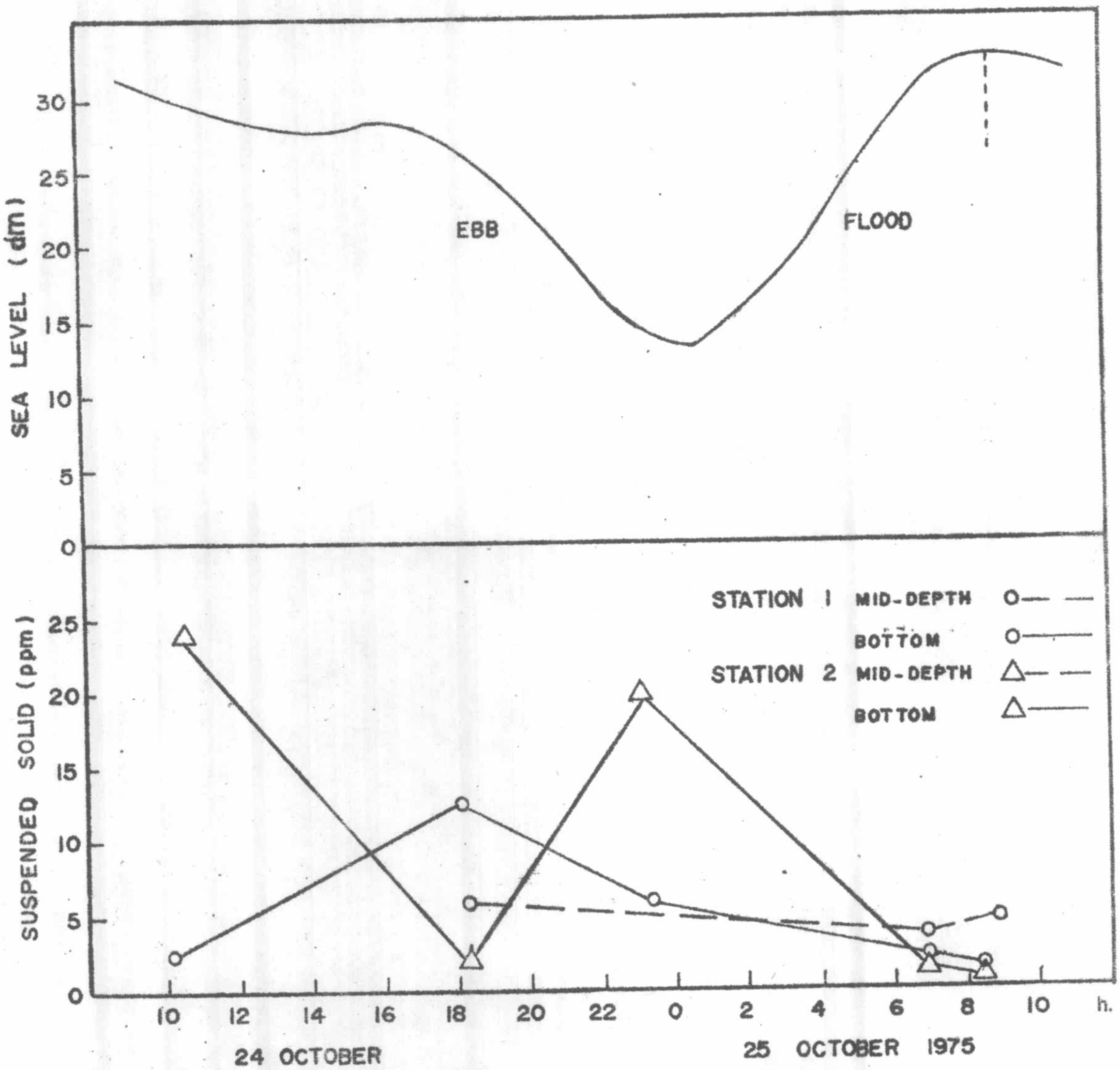


FIGURE 3.3.18. SEA LEVEL AND CONTENTS OF SUSPENDED SOLID (ppm) OF STATIONS 1 AND 2 ON 24-25 OCTOBER 1975.

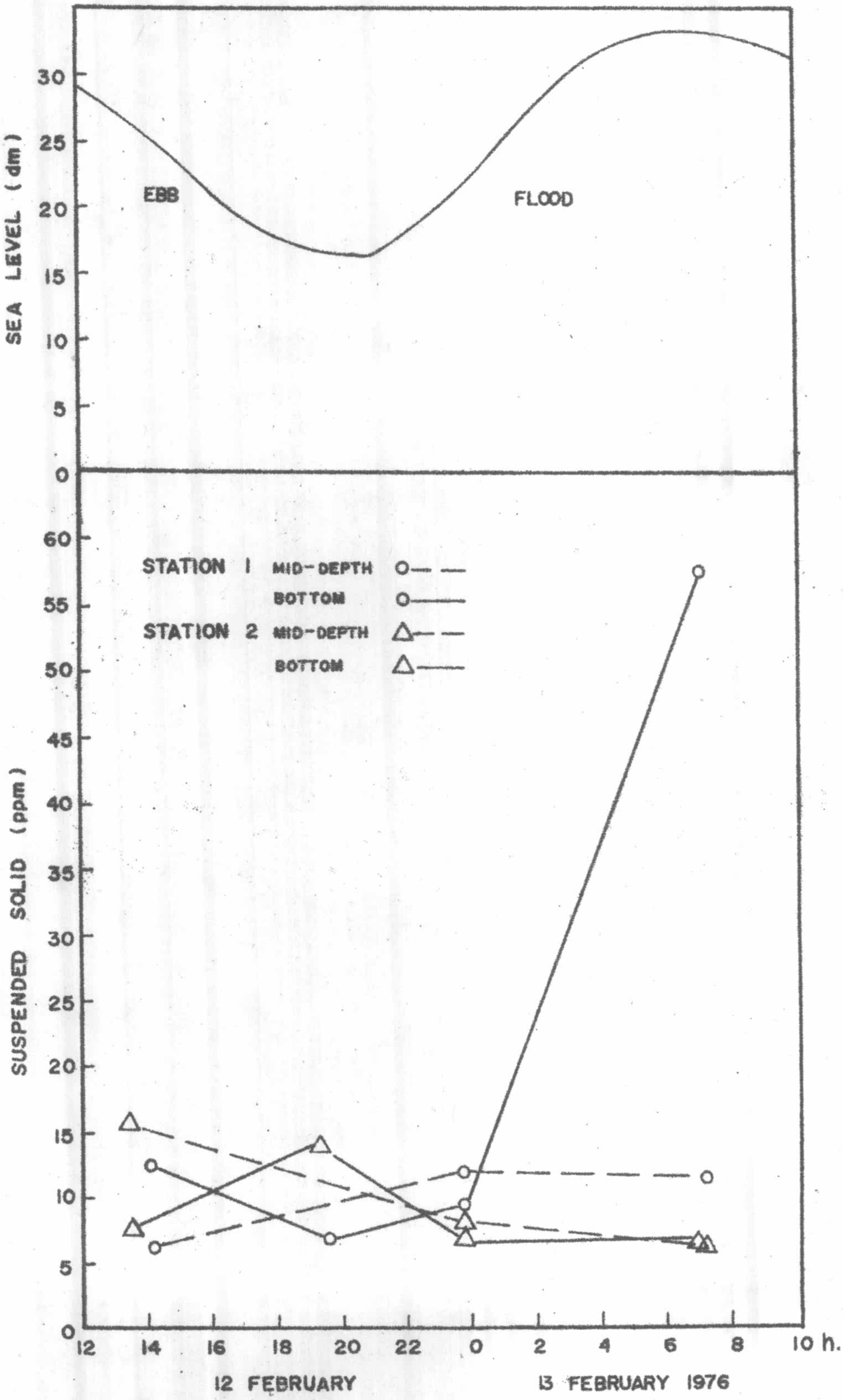


FIGURE 3.3.19. SEA LEVEL AND CONTENTS OF SUSPENDED SOLID (ppm) OF STATIONS 1 AND 2 ON 12-13 FEBRUARY 1976.

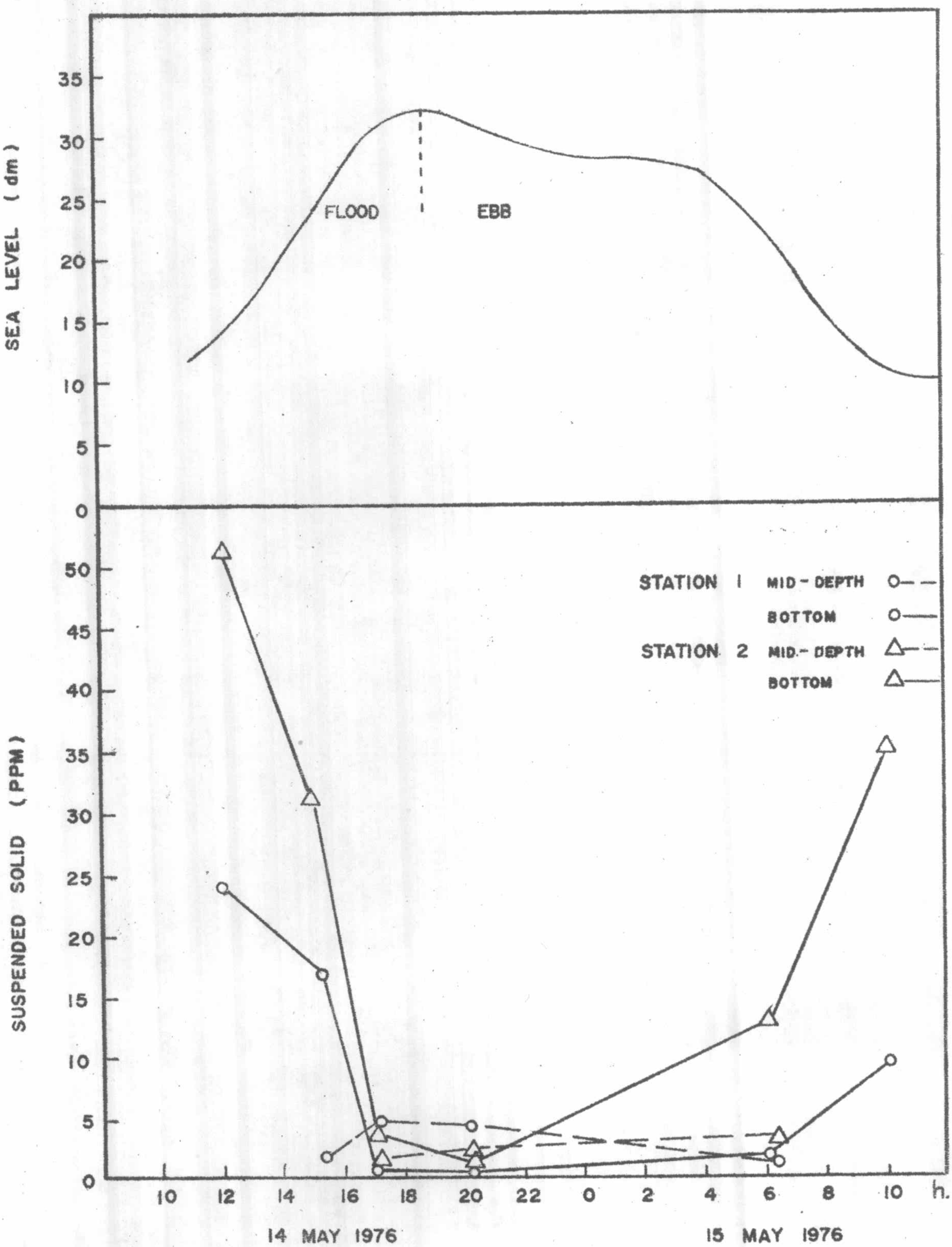


FIGURE 3.3.20. SEA LEVEL AND CONTENTS OF SUSPENDED SOLID (ppm) OF STATIONS 1 AND 2 ON 14-15 MAY 1976.

The swash action is believed to play an important role in the increasing concentration of suspended load in this case. When the tidal stage changes from ebb to flood the concentration of near-bottom suspended load gradually decrease and reach the more or less minima at the high tide stage. The relationships between suspended load and tides are summarized and presented in Figs.3.3.17, 3.3.18, 3.3.19, 3.3.20.

The other 2 stations, namely, station nos. 3 and 4 are meant to observe the background value of suspended load in the offshore area. It has been found the values range from 0.6 to 33.3 ppm. and these have no significant relation with various tidal stages.

3.4 CLIMATIC AND HYDROGRAPHIC CONDITIONS.

Generally speaking the type of climate of Sattahip area is savanna climate with annual average temperature 28-30° C and annual average pressure of 1,010.0 to 1,010.5 Milibars. The annual rainfall ranges from 1,200 to 1,400 milimetres and the average relative humidity is between 75 to 80 %. The annual evaporation is between 800 to 1,000 millimetres.

The climate in the area is of the monsoon type with north-easterly winds during the cold season and south-westerly winds during the hot season. The northeast monsoon prevails from November to February with winds from north, north-east and east. Winds are variable from east, south-east and south during March, April and May. The South-west monsoon from May to September, which is generally weaker than the north-east monsoon, blows from South-west with frequent variations due to tropical storms and depressions over the South China Sea. During October the winds are variable while the main direction. gradually changes to the north-east.

During the period of study, July 1975 to July 1976, the data on winds collected from the Klong Phai Meteorological Station are summarized and presented in Figs.3.4.1,3.4.2 and 3.4.3. However the data for August, September, October 1975 and May, June, July 1976 were not available due to the technical mal-function of the instrument.

It is apparent that during December and January, the winds comes mainly from the north with the maximum speed of 3-4 beauforts or 9-13 knots. The south-westerly wind come during February and June at speeds up to 4 beauforts or 13 knots in June and at speed of 3 beauforts in April. The change from south-westerly winds to north-easterly winds occurs in October and the wind speeds during this period are generally moderate.

Occasionally, tropical depression, storm and typhoon occur in the Pacific Ocean and the South China Sea. The Gulf of Thailand however, is generally clear of the area of intensive typhoons as most of those which take place above 15° north lattitude. Storm data during July 1975 to July 1976 obtained from daily weather observation are summarized in Fig. 3.4.5 and Table 3.4.1.

TABLE 3.4.1

Data concerning storms between July 1975 - July 1976.

Storm	Track	Period	Av. Velocities (km/hr)	Type of Storm
1	Fig. 3.4.5 a	Aug. 28-31, 1975	15	A tropical depression from south of Ko Hainan and northwestward moving coastal at Thanh Hoa.
2	Fig. 3.4.5 b	Sept. 6-11, 1975	18	A depression moving westward from the South China Sea, passed Vietnam and Loas to the northeast of Thailand.
3	Fig. 3.4.5 b	Sept. 16-22, 1975	20	A typhoon "Alice" moving westerly from Luzon Islands passed Vietnam and Loas to the north of Thailand.
4	Fig. 3.4.5 c	Oct. 4-7, 1975	15	A tropical depression moving northwesterly from the South China Sea.

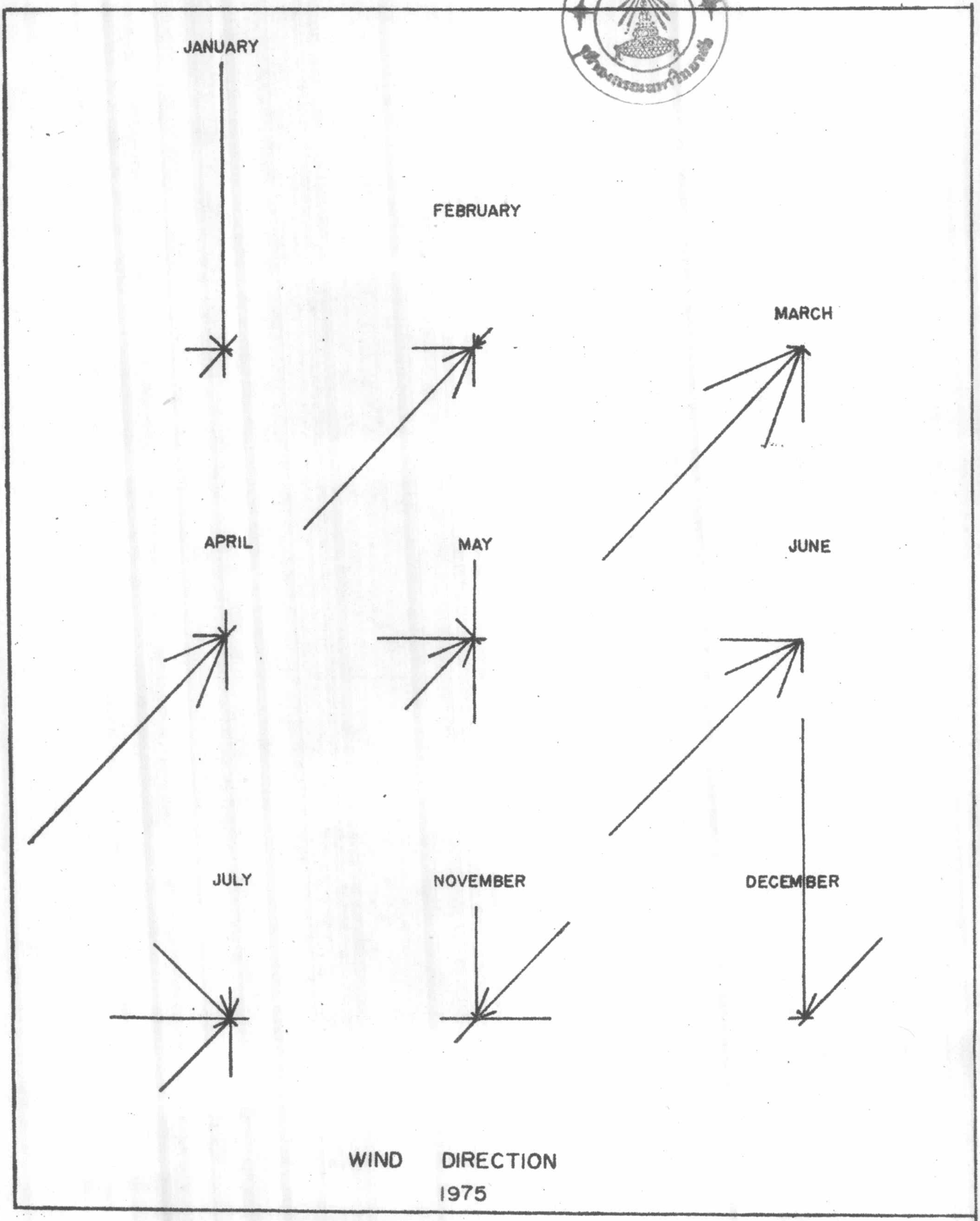


FIGURE 3.4.1. PERCENTAGE FREQUENCY OF WIND DIRECTIONS, DATA COLLECTED AT KLONG PHAI, SATTAHIP, IN 1975.

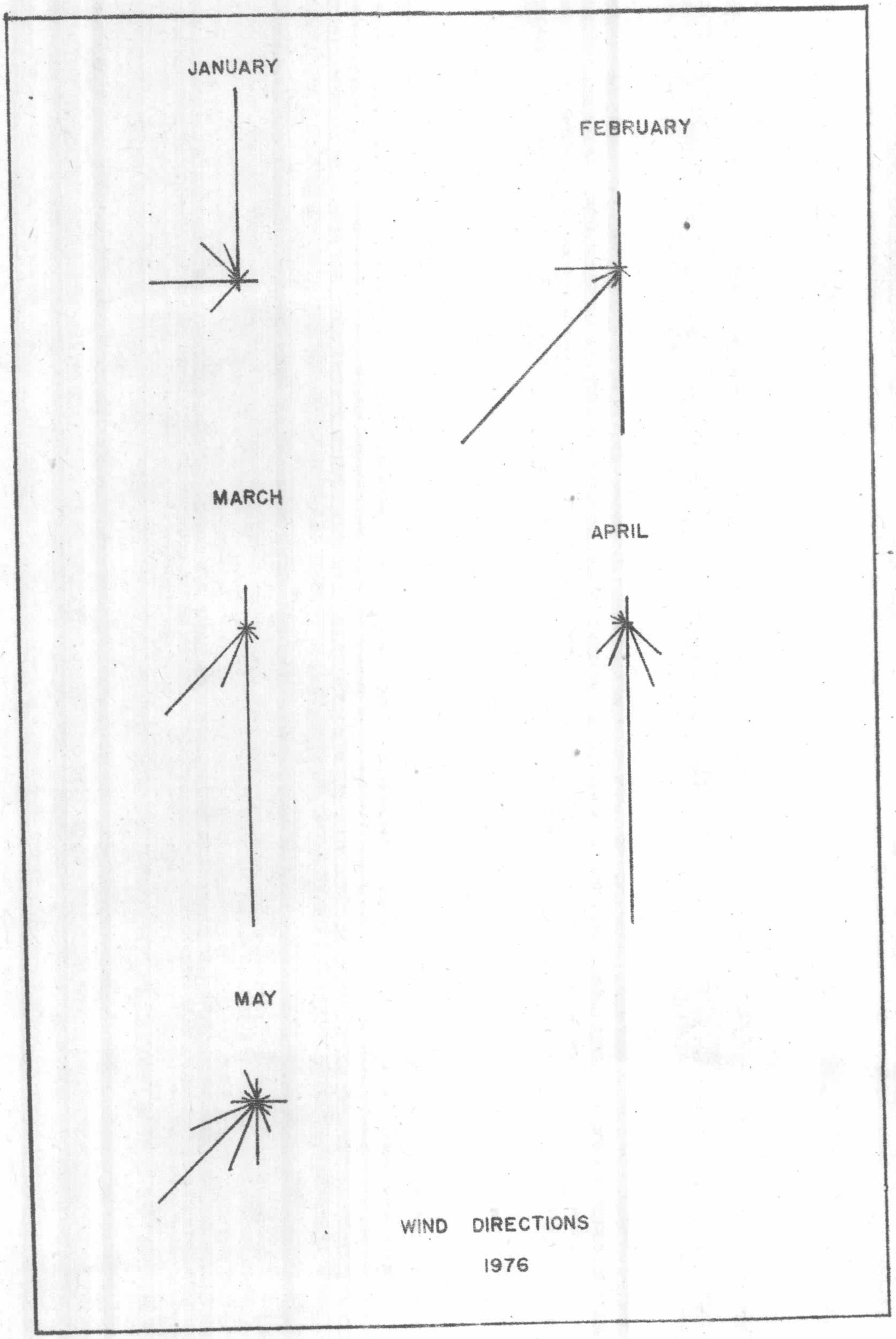


FIGURE 3.4.2. PERCENTAGE FREQUENCY OF WIND DIRECTIONS, DATA COLLECTED AT KLONG PHAI IN 1976.

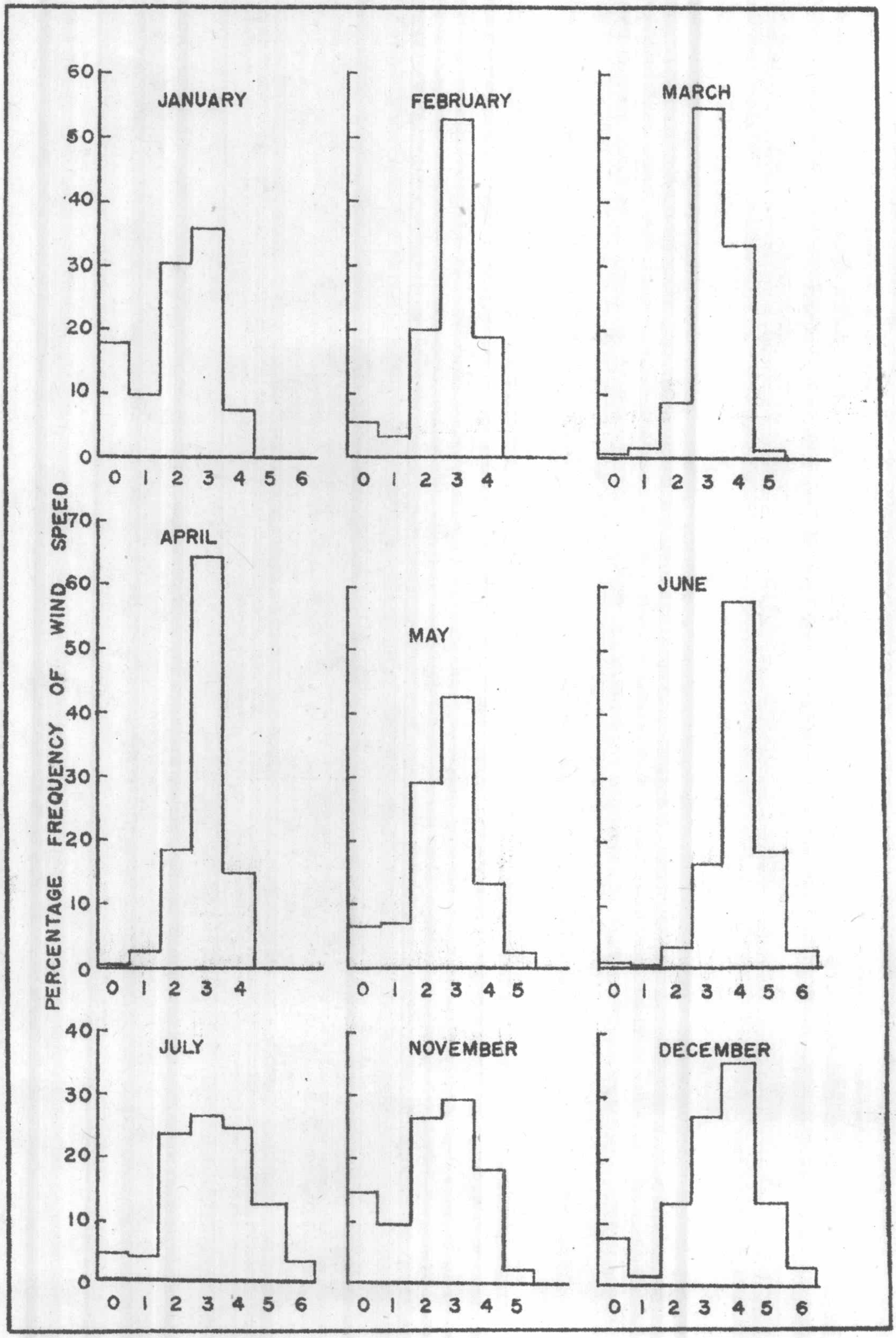


FIGURE 3.4.3. PERCENTAGE FREQUENCY OF WIND SPEEDS IN BEAUFORT SCALE, AT KLONG PHAI (1975).

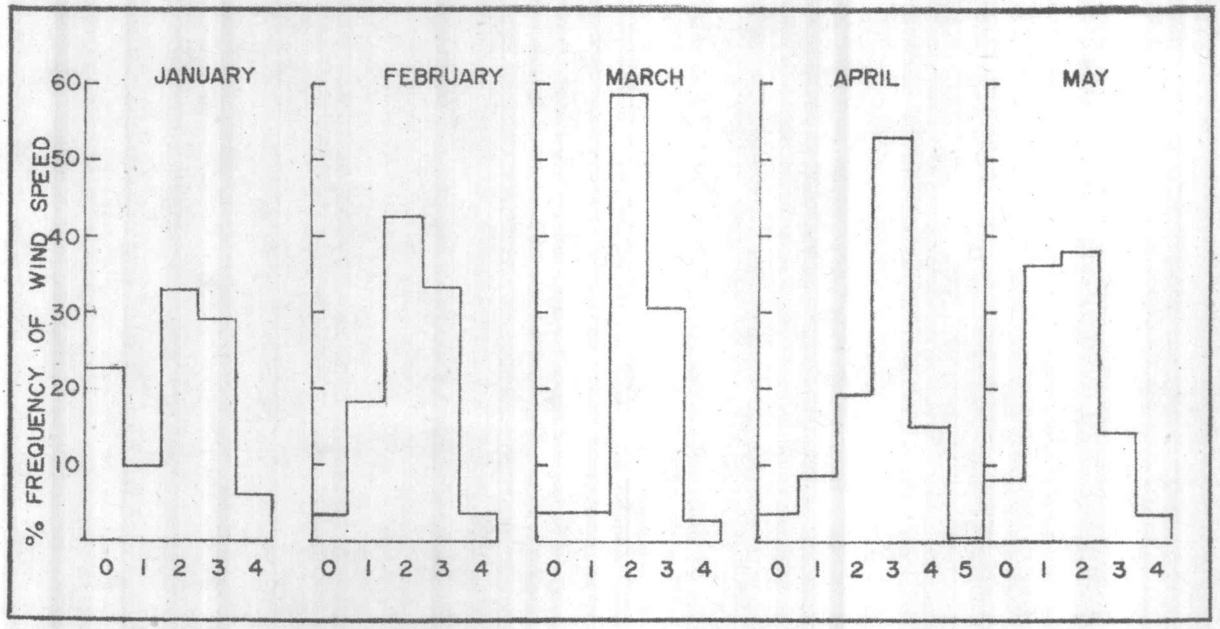


FIGURE 3.4.3 a. PERCENTAGE FREQUENCY OF WIND SPEEDS IN BEAUFORT SCALE, AT KLONG PHAI (1976).

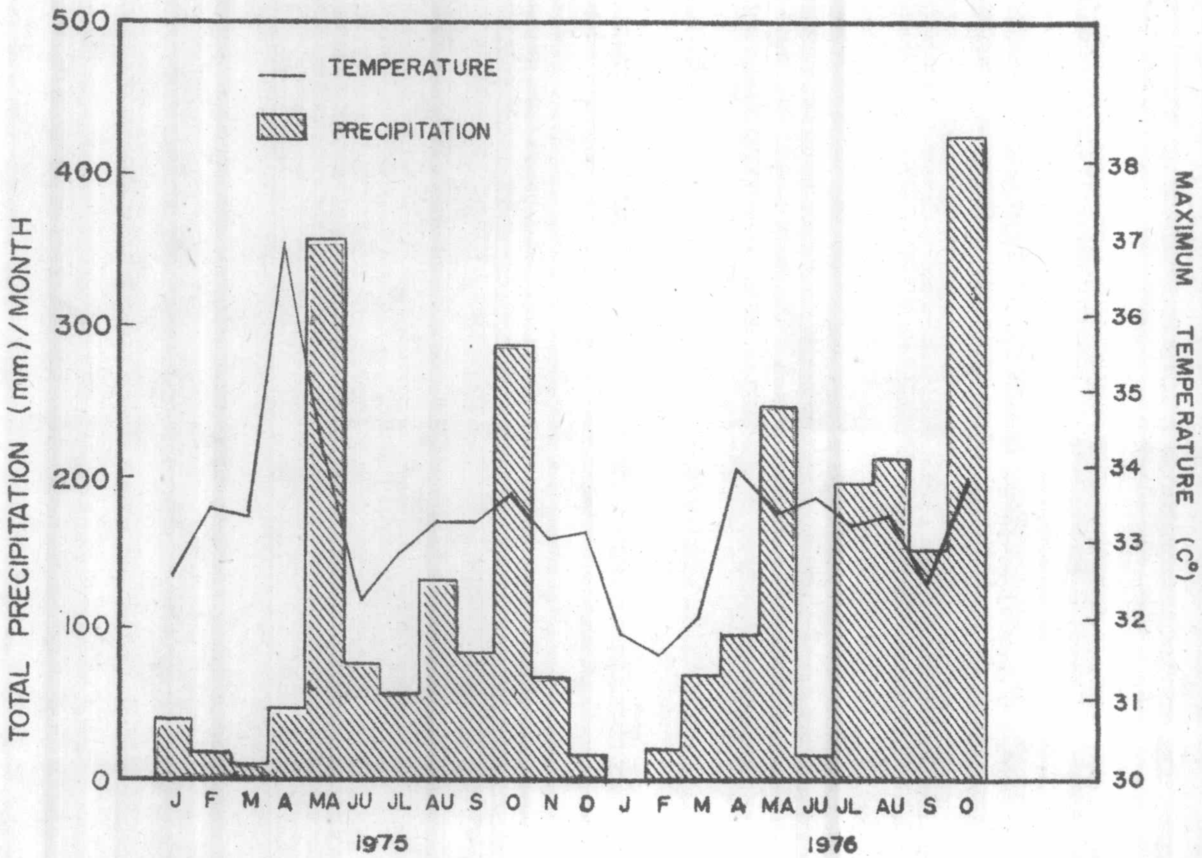
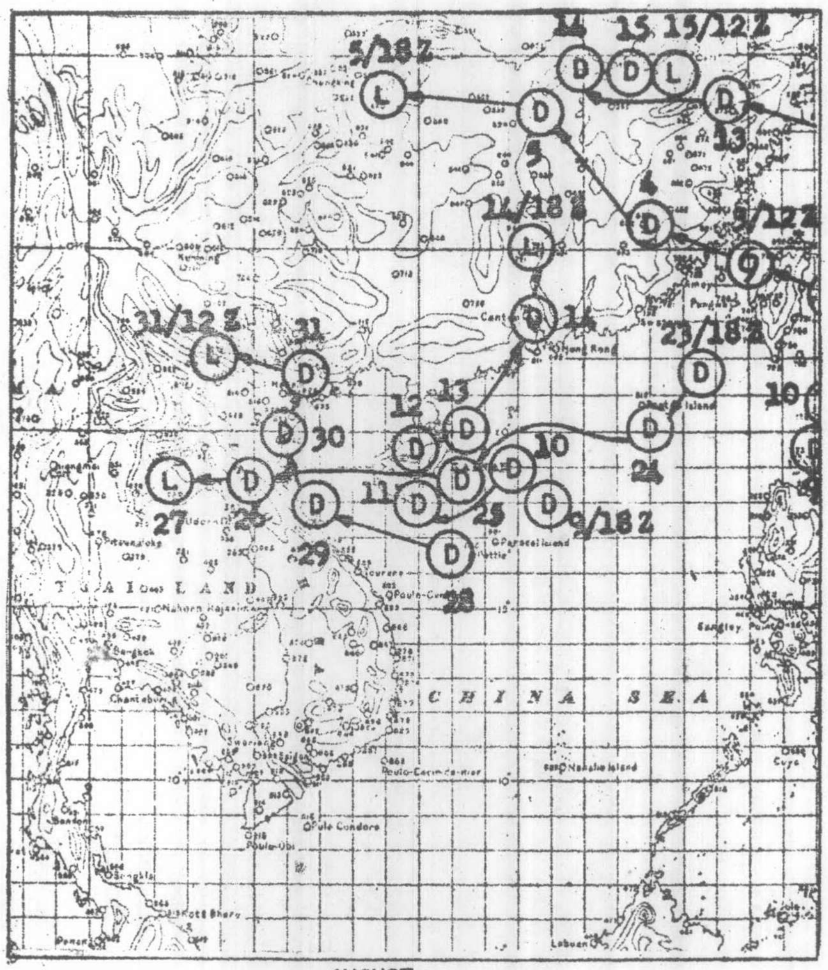
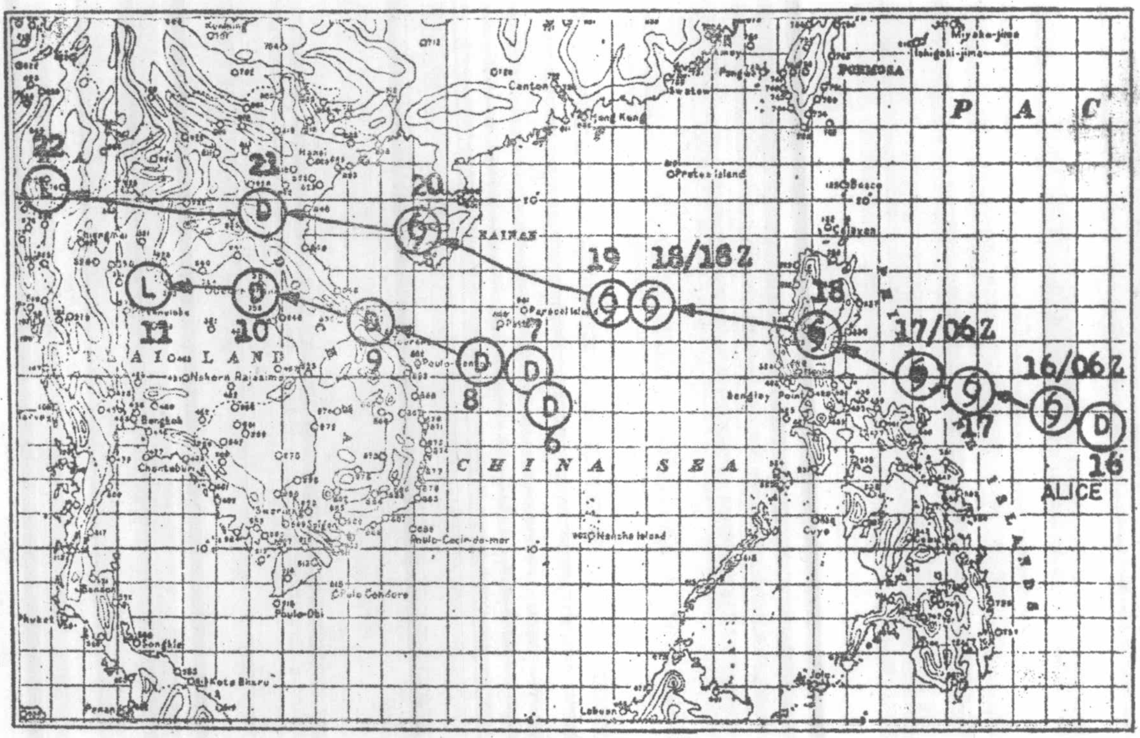


FIGURE 3.4.4. MONTHLY VALUE OF TOTAL PRECIPITATION IN (mm), AIR TEMPERATURE (C°) AT KLONG PHAI, 1975 - 1976.

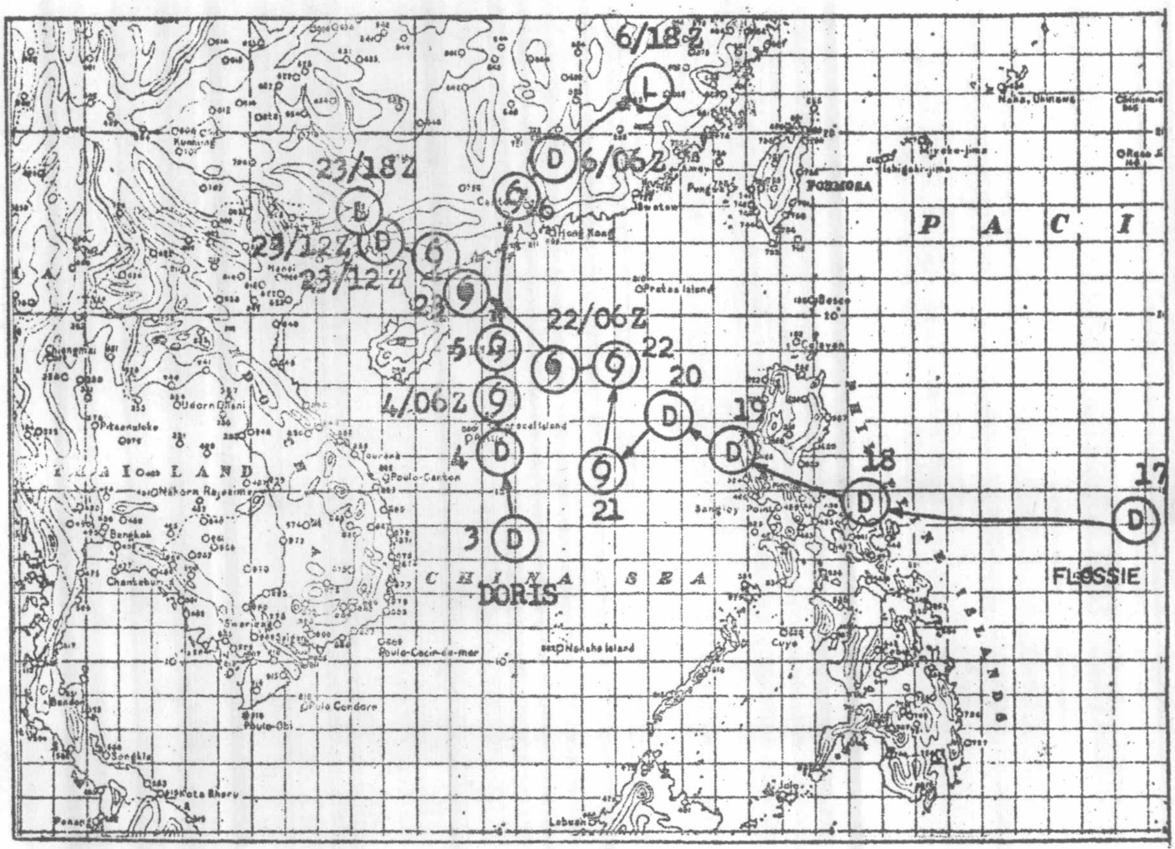


AUGUST

FIGURE 3.4.5 a. ILLUSTRATING THE STORM TRACKS DURING THE PERIODS OF JULY 1975 AND JULY 1976.



(b) SEPTEMBER



(c) OCTOBER

FIGURE 3.4.5 b,c. CONT.

The tidal range in the Sattahip Bay during the period of study, July 1975 to July 1976, are summarized and presented in Appendix H-1 and Fig. 3.4.6. These data includes the monthly values of maximum, minimum and mean tide level with reference to the local mean sea level. It is apparent that the monthly average sea level exhibits the seasonal variation (Pattullo et. al, 1955; Pattullo, 1966). The lowest sea level generally occurs in the hot season and the highest sea level occurs in the cold season. The seasonal variation ranges in the order of $\pm$ 2.0 dms. less than those in the higher lattitude. (Pattullo et. al, 1955).

The sea levels during the technical field survey programmes are given in Table 3.4-2.

The characteristics of tidal currents differ from Wind-induced currents in that they show littlle decrease in velocity with depth except very near the bottom (shepard, 1948), which the ebb and flood do not necessarily follow the same path (e.g., Robinson, 1956), and do not have the same maximum velocity.

There are two types of tidal oscillations one is the progressive type and the other is the standing - weve type of tide develops in partially enclosed bodies of water. Here the maximum velocity occurs approximately at halftide, flowing into the bay during flood tide and out of the bay during ebb tide (Shepard, 1948). This would result in the movement of sediment landward in the flood and seaward in the ebb path (e.g., Oomkens, 1960).

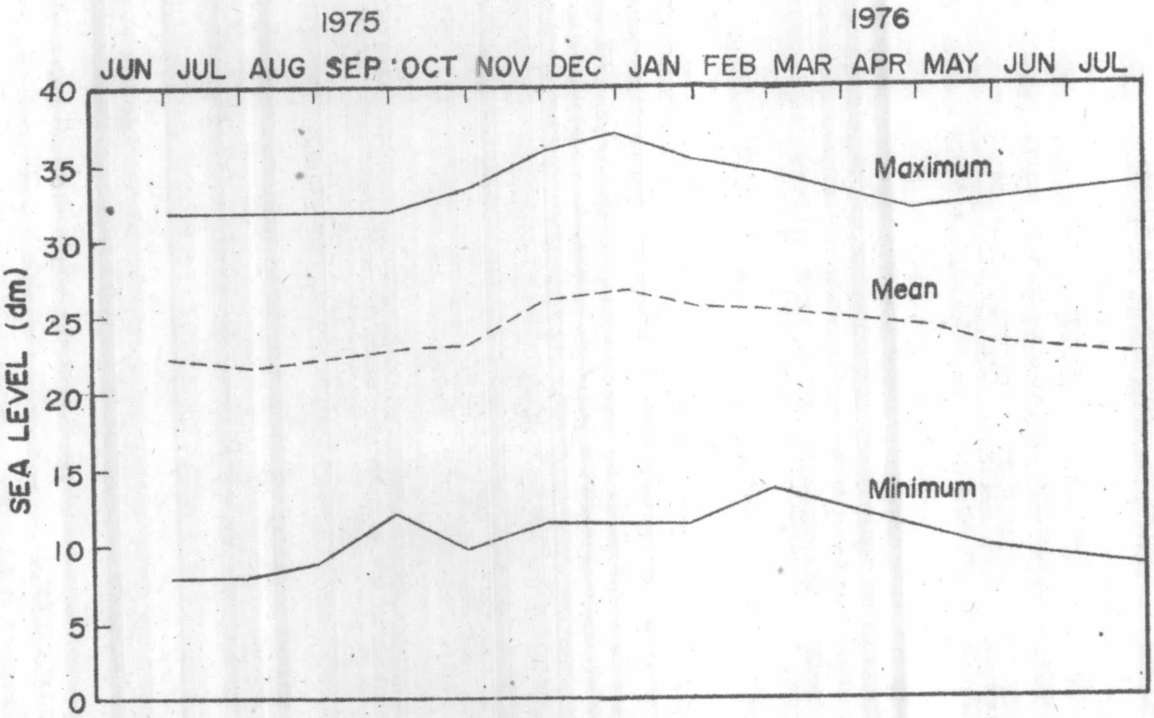


FIGURE 3.4.6. TIDAL DATA FOR THE PERIOD 1 JUNE 1975 TO 31 JULY 1976 AT SATTAHIP BAY.

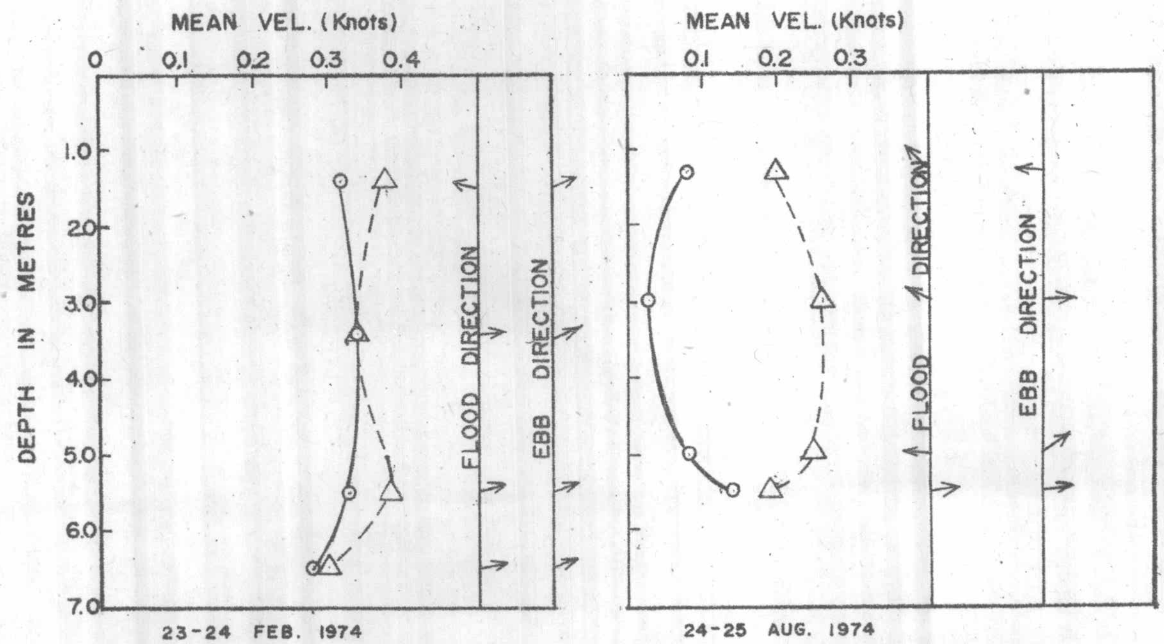


FIGURE 3.4.7. OBSERVED TIDAL CURRENTS AT C3 (12° 39' 10" N. AND 100° 53' 48" E.), SATTAHIP BAY, ○– FLOOD VEL. AND △– EBB VEL.

Maximum speeds of tidal currents (Tables 3.4-3, 3.4-4) varied with season and station location. Almost all the high speeds were associated with tidal flow, the winter values were higher by 0.04-0.31 knots than maximum summer values. Bottom flood current velocities average 0.21 knots, where as bottom ebb current velocities average 0.25 knots at Station C_3, which is near the study area. Within the Bay, tidal currents reach maximum surface velocities of 0.77 knots during ebb tide between Laem Pu chao and Ko Tao Mo in the Winter. Bottom currents velocities reach maxima of 0.8 knots during ebb tide at station between Laem Pu chao and Ko Tao Mo in the summer. Tidal current velocity and directional data reported in this paper were obtained by and Ekman current meter, (Fig.3.4.7).

TABLE 3.4-2 Tide data on the day of beach profile measurement.

Date	Tide				
		Time	High dms	Low dms	Range dms
12 July 1975	Low	1204		10.0	21.1
	High	2046	31.1		
24 October 1975	Low	0003		11.9	19.5
	High	0830	31.4		
11 February 1976	High	0700	33.0		14.8
	Low	1920		18.2	
14 May 1976	High	0215	27.7		14.9
	Low	0950		12.8	
	High	1805	32.2		4.4
	Low	2300		27.8	
2 July 1976	Low	1300		14.1	17.6
	High	2100	31.7		

Time and height of tide from Hydrographic Department tide gage on the Naval Base Pier at Sattahip Bay, Datum is MSL.

TABLE 3.4-3 Tidal currents in Sattahip Bay between 23-26 February 1974

Station	Flood tide		Ebb tide		Velocity Difference Max. Flood and Max. Ebb (Knot)
	Max. Vel. (Knot)	Assoc.Depth Meter	Max. Vel. (Knot)	Assoc.Depth Meter	
1	0.64	3.0	0.84	7.5	0.20
2	0.58	1.7	0.30	1.7	0.28
3	0.34	3.4	0.34	3.4	0
4	0.64	1.8	0.21	4.5	0.43
5	0.62	9.6	0.71	6.0	0.09
6	0.32	3.4	0.21	3.8	0.11

TABLE 3.4-4 Tidal currents in Sattahip Bay between 24-26 August 1974.

Station	Flood tide		Ebb tide		Velocity Difference Max. Flood and Max. Ebb (Knot)
	Max. Vel. (Knot)	Assoc.Depth (Meter)	Max. Vel. (Knot)	Assoc.Depth Meter	
1	0.35	7.0	0.80	13.0	0.45
2	0.27	4.5	0.22	1.8	0.05
3	0.14	5.5	0.26	3.0	0.12
4	0.36	4.0	0.30	7.0	0.06