J. mar. biol. Ass. India, 1976, 18 (1) : 99-109

SEASONAL WAVE CHARACTERISTICS OF THE ARABIAN SEA AND THE BAY OF BENGAL*

P. K. VIJAYARAJAN, M. J. VARKEY AND M. X. JOSEPH

Naval Physical and Oceanographic Laboratory, Cochin

ABSTRACT

Wave data reported in the Indian Daily Weather Reports for the period 1960-64 have been used to evaluate seasonal wave characteristics for each 2-degree square areas of the Arabian Sea and the Bay of Bengal. These results are presented in the form of charts. The maxima of the average heights in both the Arabian Sea and the Bay of Bengal (3.2 m and 3.1 m) have been observed during the monsoon season even though the number of cyclone and depression days were maximum in May and November, respectively in the Arabian Sea and Bay of Bengal. The most prominent period of waves in all seasons in both the regions was '5 or less than 5' seconds.

INTRODUCTION

IN two previous papers by Srivastava *et al.* (1968, 1970) the monthly wave characteristics of Arabian Sea and Bay of Bengal were studied. On the basis of the prevailing wind pattern over the Arabian Sea and Bay of Bengal four distinct seasons could be made out. In the present paper seasonal wave and wind characteristics of these two regions are studied. Attempt is also made to compare the influences of cyclones and steady monsoon winds on the sea state.

Authors are thankful to Shri M. S. Narayanan, Director, NPOL for his guidance and Shri P. S. Srivastava formerly of Oceanographic group of NPOL for his suggestions.

METHOD OF ANALYSIS

Wave data given in the Indian Daily Weather Reports from 1960-64 were grouped for two degree square zones of Arabian Sea and Bay of Bengal. In total 35,933 data have been collected, 18,839 from Arabian Sea and 17,094 from Bay of Bengal. This data was then processed to find out the wave characteristics. The heights reported in the weather charts are the significant heights. So to get the average (highest 10%) heights, the value of average significant height of each zone for every season was multiplied by the factor 1.27. Similarly the reported maximum significant height of each zone was multiplied by 1.27 to get the maximum (highest 10%) height (Anon, 1966).

* Presented at the 'Symposium on Indian Ocean and Adjacent Seas—Their Origin, Science and Resources' held by the Marine Biological Association of India at Cochin from January 12 to 18, 1971.

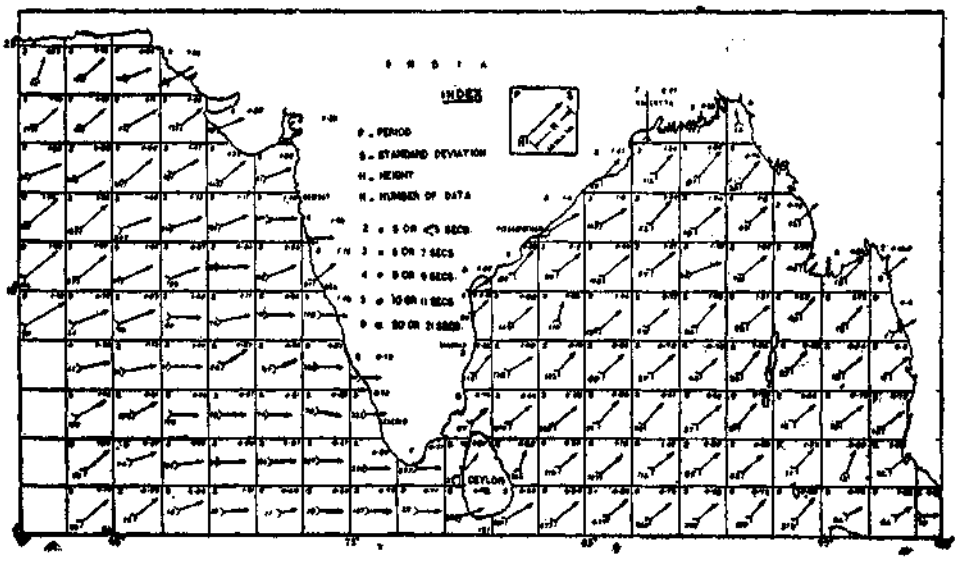

Fig. 1. Mean seasonal wave characteristics—south-west monsoon (May-September).

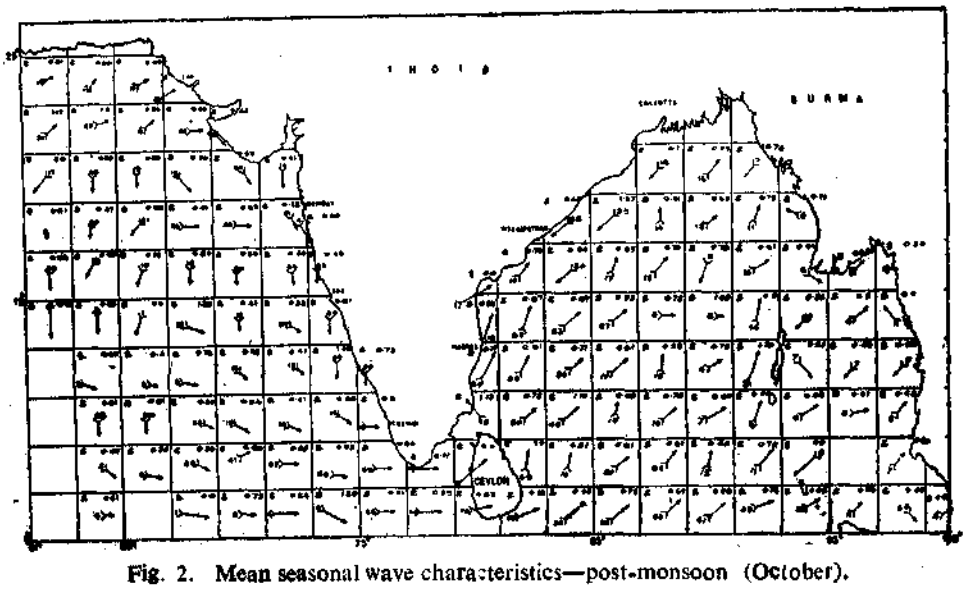

Fig. 2. Mean seasonal wave characteristics—post-monsoon (October).

For comparing the direction of the wave and wind, the area under study is divided into zones of 5 degree squares, for the IMD weather atlas gives the fifty year mean with data for five degree squares only. The wind direction and velocity reported from each zone and the direction and height of waves from corresponding zone for five years have been studied.

Number of days when cyclones and depressions were observed in the area under study for five years have also been studied to assess their impact on the sea state.

Discussion

Selection of Seasons : A study of the wind pattern over the Arabian Sea and the Bay of Bengal from the fifty years mean wind atlas gives a clear picture of the seasonal stability of wind. For a seasonal grouping of the wave characteristics the whole year is divided into four periods. This division slightly differs from the conventional climatological division. The present grouping is more suitable for this study since, the wave characteristic alone is the point of consideration and again the interest is limited only to the oceanic region. From the IMD atlas it could be observed that during period from May to September the direction of the wind, in general, is south-west with variation of 15-20 degrees towards north or south of it. Along the west coast of India the wind becomes westerly as it approaches the coast while throughout the Bay of Bengal, it is south westerly. This period from May to September has been classified as south-west monsoon period. In October, the direction of the wind in both Arabian Sea and Bay of Bengal is quite irregular. During November to February the mean direction of the wind is north-east with variation of about 20 degrees north or south of it, and hence this period is designated as north-east monsoon. Along the west coast of India the direction of the wind during this period is almost north but in the east coast the direction is north-east. During March and April the wind direction in this area is highly variable. In the Arabian Sea it varies between north-west and north-east while in the Bay of Bengal the pattern is quite irregular. As this period represents the transition from north-east to south-west monsoon, it is defined as pre-monsoon or transition period.

A comparison of the wind and wave directions shows that the direction of the wave in all these seasons is almost the same as the corresponding direction of the wind in each season (Fig. 13).

South-west monsoon (May-September) : During this season wave direction is mostly south-west, but along the west coast of India the direction is almost west (Fig. 1). Western part of Arabian Sea is comparatively more rough with the average (highest 10%) height of 3.2 m while eastern part is calm (Fig. 5). The central part of the Bay of Bengal is comparatively rough while the rest of it is calm. Along the east coast of India, except for a small rough region near Calcutta, the average (highest 10%) heights seldom exceed 2.3 m. As the wind, the direction of the wave in Bay of Bengal is south-west while that in the Arabian Sea varies between west and south-west. Considering the maximum (highest 10%) height (Fig. 9) the area between Visakhapatnam and Calcutta is rough. The area east of Sri Lanka is also rough with the wave height of 10.2 m. The most prominent period of the wave in both Arabian Sea and Bay of Bengal is 5 or less than 5 seconds.

Post-Monsoon (October) : In October the directions of the wind in Arabian Sea and Bay of Bengal are quite different. Along the west coast of India the direction

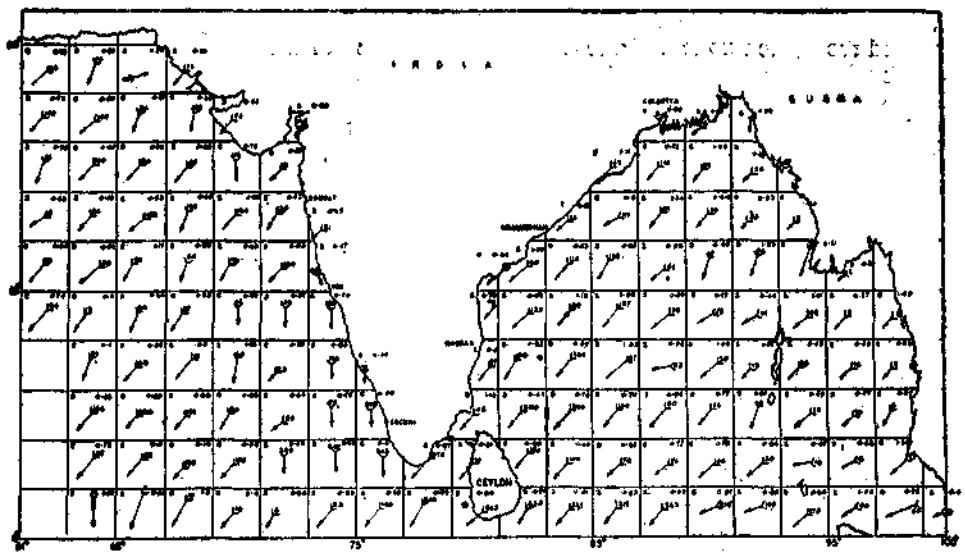

Fig. 3. Mean seasonal wave characteristics—north-east monsoon (November-February).

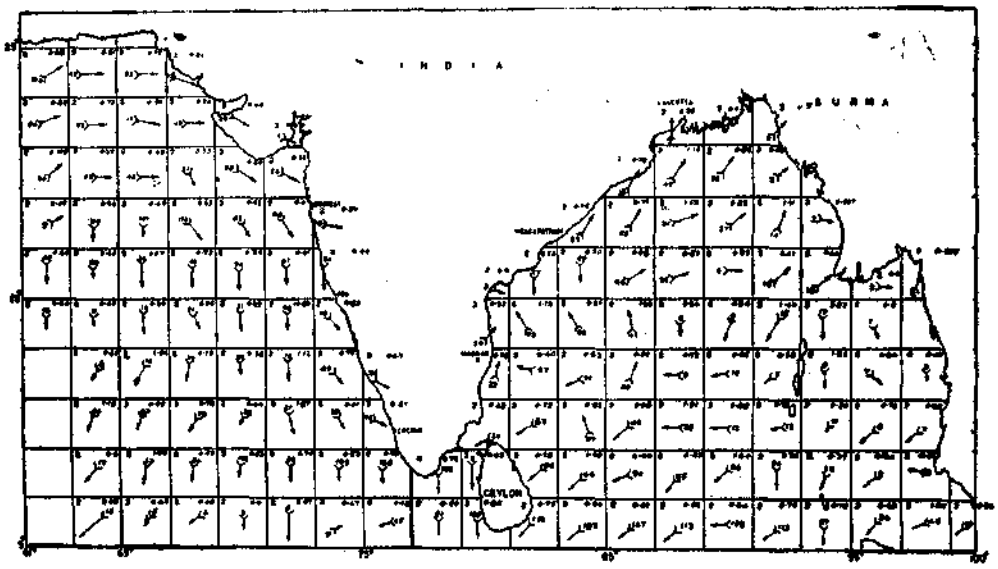

Fig. 4. Mean seasonal wave characteristics—pre-monsoon (March-April).

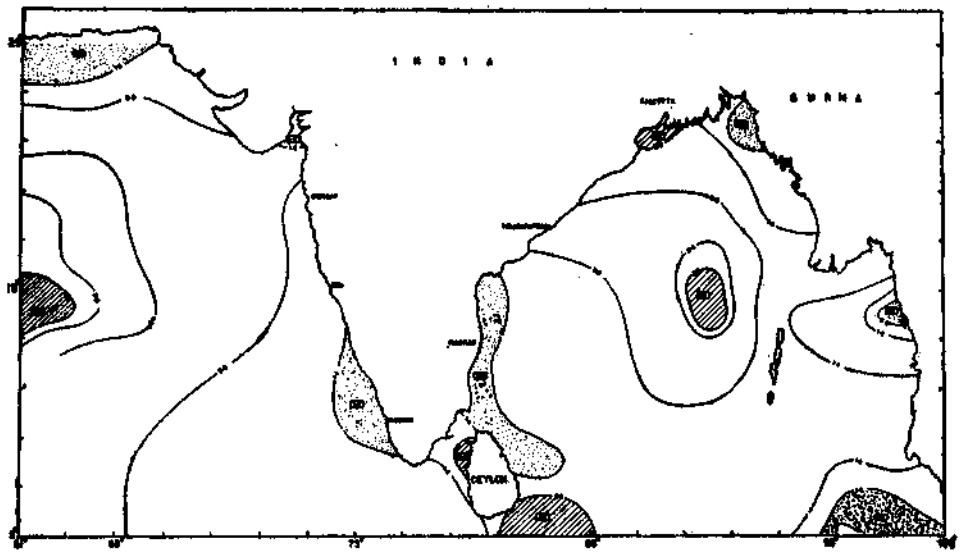

Fig. 5. Average 'highest ten per cent' (May-September).

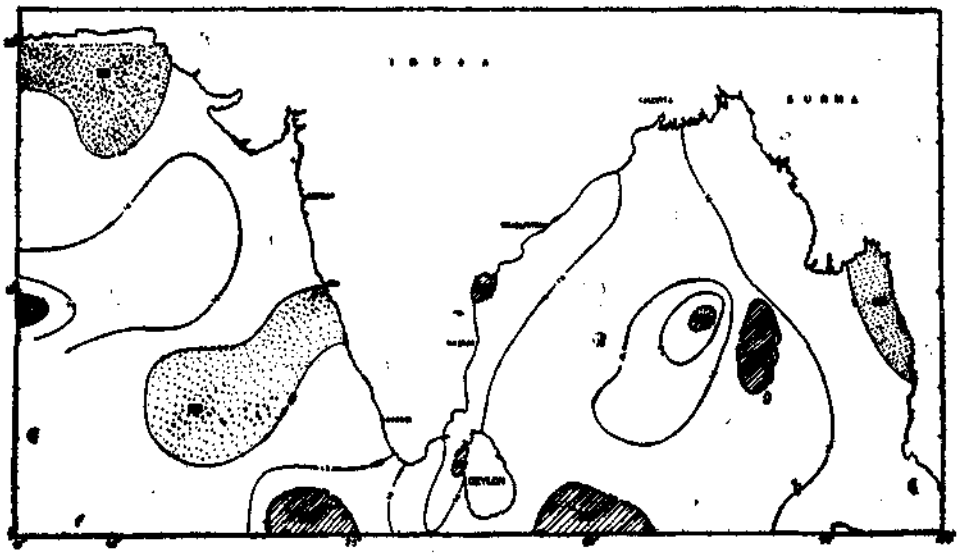

Fig. 6. Average 'highest ten per cent' (October).

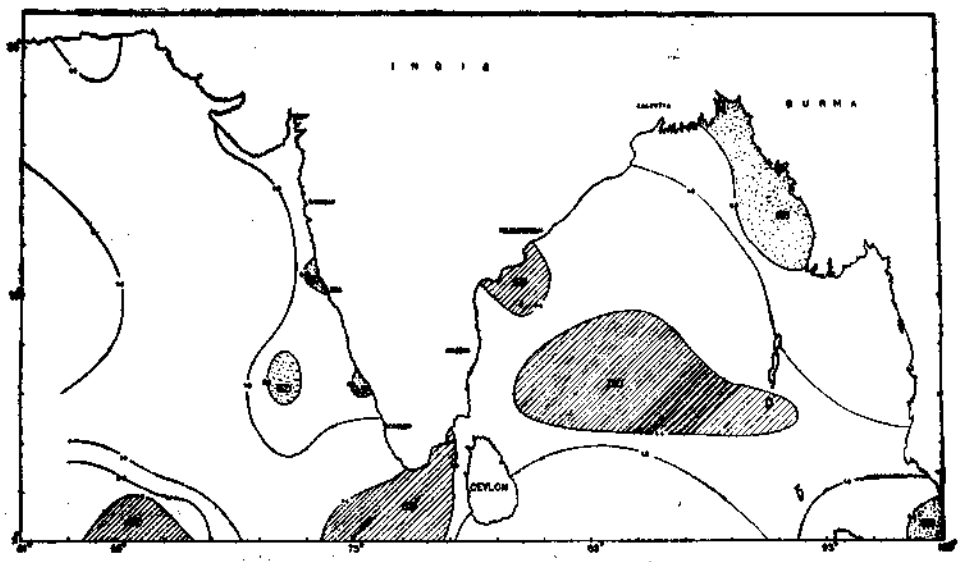

Fig. 7. Average 'highest ten per cent' (November-February).

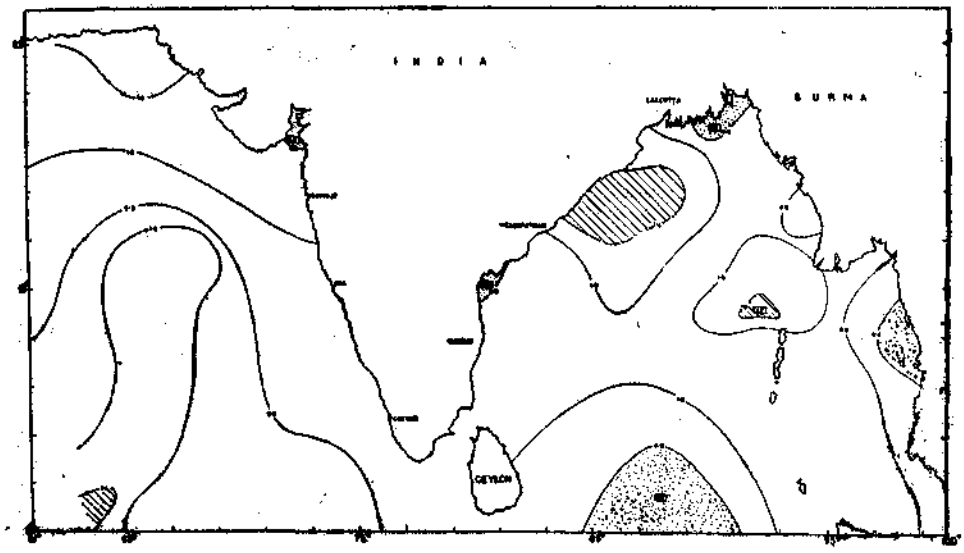

Fig. 8. Average 'highest ten per cent' (March-April).

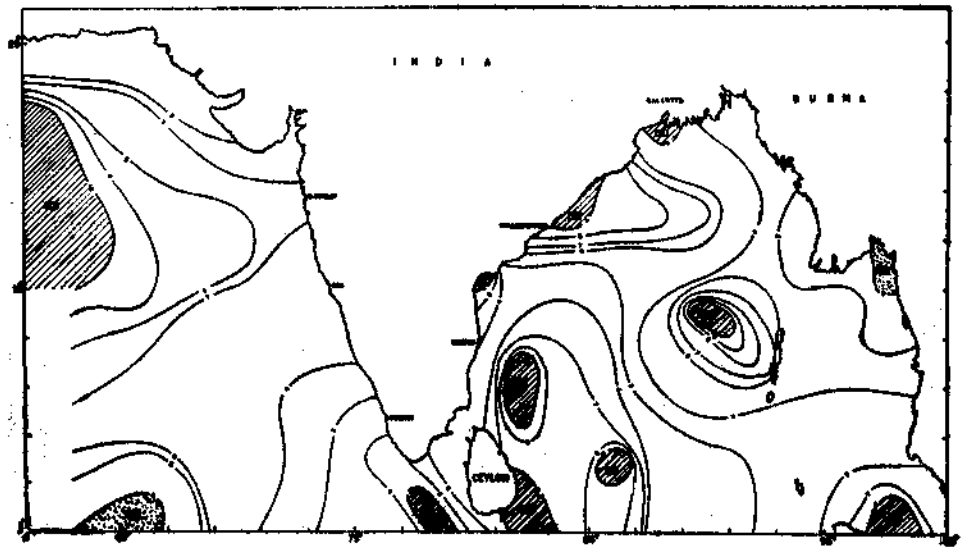

Fig. 9. Maximum 'highest ten per cent' (May-September).

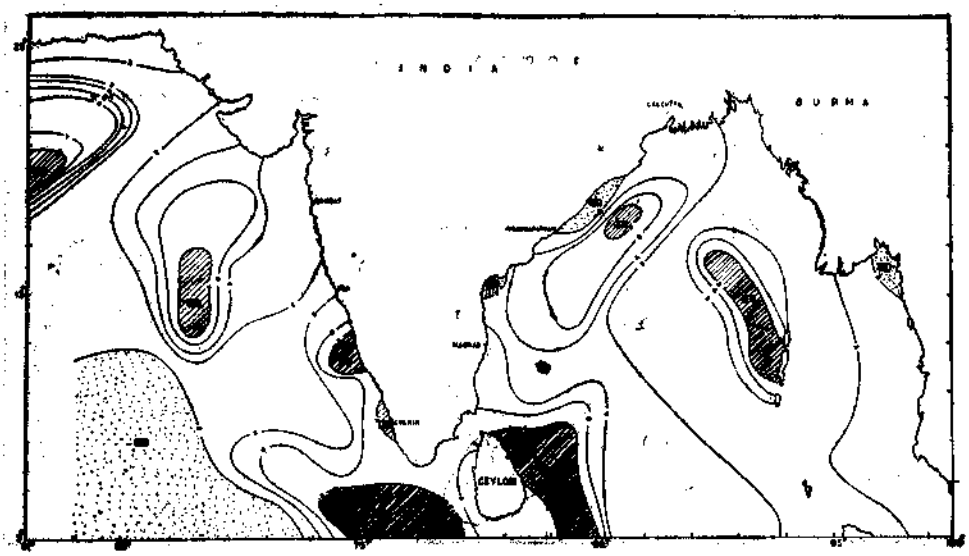

Fig. 10. Maximum 'highest ten per cent' (October).

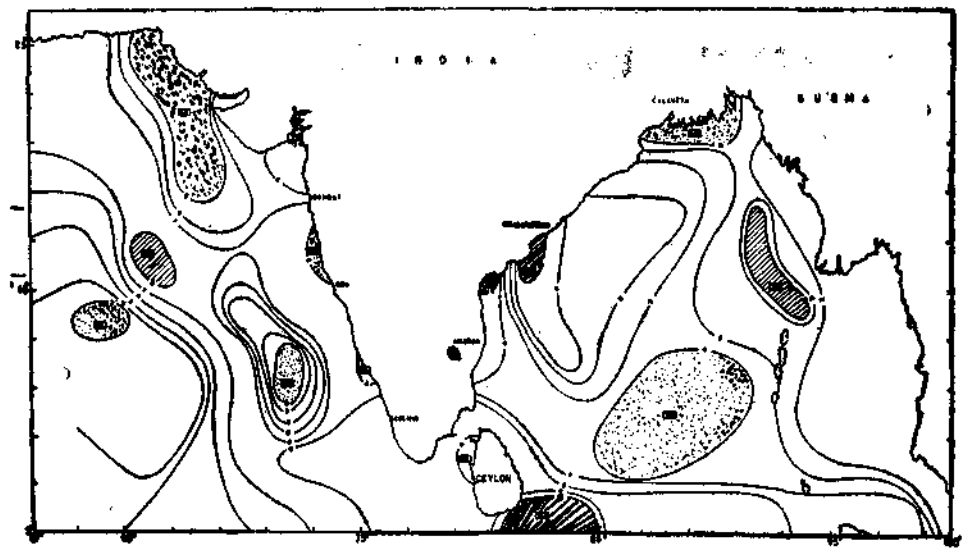

Fig. 11. Maximum 'highest ten per cent' (November-February).

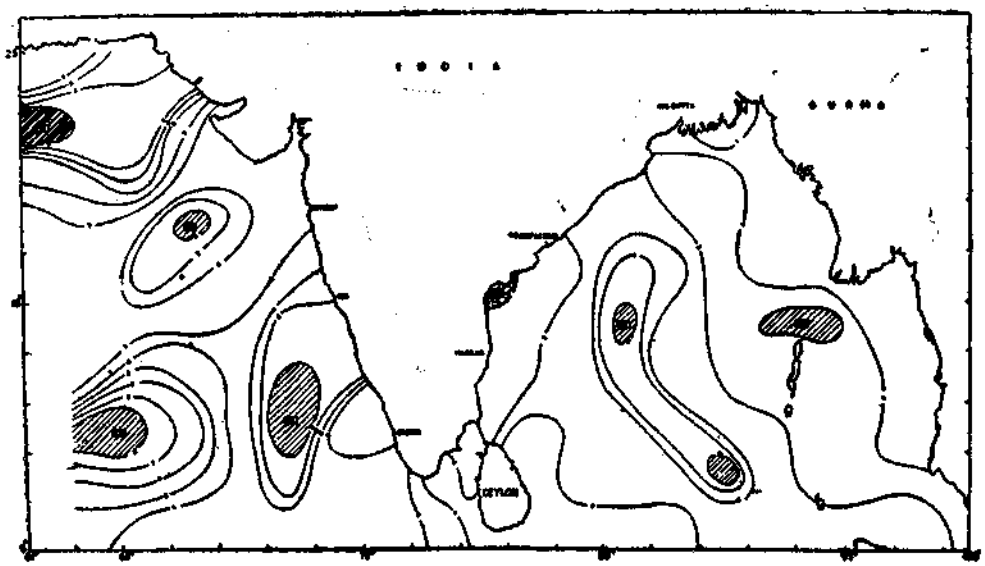

Fig. 12. Maximum 'highest ten per cent' (March-April).

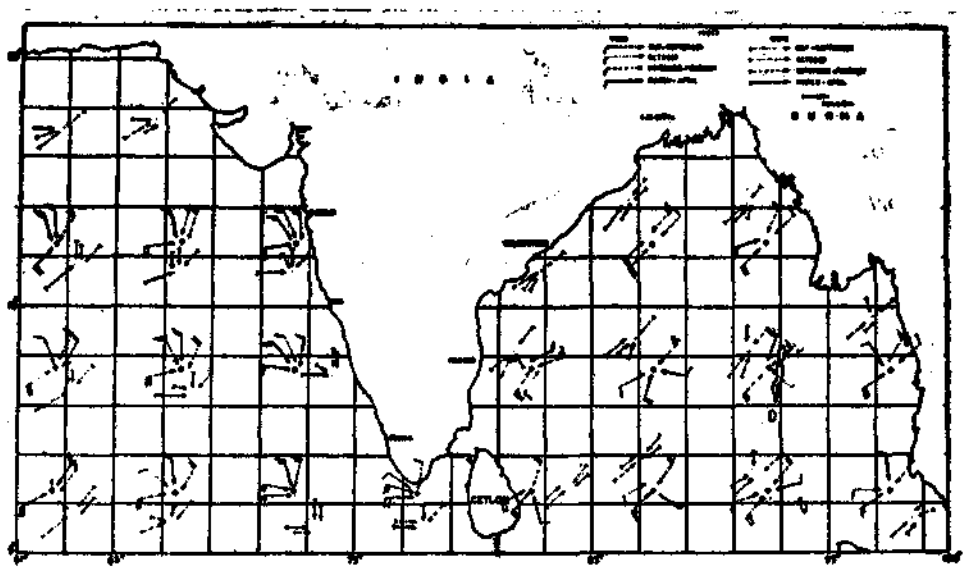

Fig. 13. Mean wind and wave conditions.

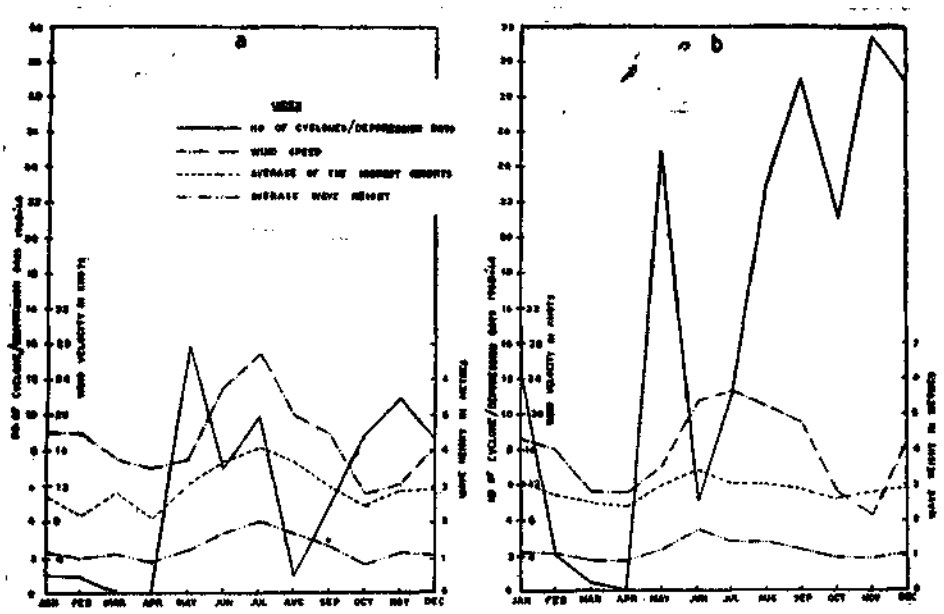

Fig. 14. (a) Arabian Sea and (b) Bay of Bengal.

of the wave is north-northwest which is the same as the direction of the prevailing wind. In Bay of Bengal the direction of the wave follows the irregular pattern of the wind (Fig. 2). The maximum (highest 10%) heights in Arabian Sea and Bay of Bengal are 8.7 m and 8.9 m respectively (Fig. 10). These are a little higher than the values for pre-monsoon period. As far as the average (highest 10%) sea state is concerned central parts of both Arabian Sea and Bay of Bengal are very calm with the heights of 0.5 m and 0.3 m respectively (Fig. 6).

North-east Monsoon (November-February) : During this period the direction of the wave in the off-shore waters of Arabian Sea is north-east while that in near-shore region is north (Fig. 3). Throughout Bay of Bengal the direction of wave is north-east. All these are in close conformity with the corresponding direction of the prevailing wind of each region. Considering the average (highest 10%) sea state Arabian Sea, especially west coast of India is comparatively calmer than the Bay of Bengal (Fig. 7). In the south-western part of Arabian Sea the average (highest 10%) height reaches upto 2.7 m. In some places like south-eastern side of Sri Lanka and the coast south-east of Vishakhapatnam the maximum (highest 10%) height becomes 10 m (Fig. 11). The most prominent wave period in this season in both Arabian Sea and Bay of Bengal is 5 or less than 5 seconds.

TABLE 1

	ARABIAN SEA			BAY OF BENGAL		
	Average wind speed (knots)	Average wave height (m)	Average of highest height (m)	Average wind speed (knots)	Average wave height (m)	Average of highest height (m)
SOUTH-WEST MONSOON ..	20.8	1.6	3.5	19.6	1.4	3.1
NORTH-EAST MONSOON ..	16.2	1.1	2.5	14.5	1.1	2.9
PRE-MONSOON (MARCH-APRIL)	14.5	1.0	2.4	11.2	0.9	2.5
POST-MONSOON (OCTOBER) ..	11.2	0.8	2.5	11.0	1.0	2.6

Pre-Monsoon (March-April) : The direction of the wave in the Arabian Sea, as in the case of wind varies mostly between north-west and north-east but in the case of Bay of Bengal direction of the wave, as the wind, changes very irregularly (Fig. 4). From a closer study of the wind pattern during this season an anticyclonic trend in circulation can be observed in Bay of Bengal. The same trend may be observed in the case of wave direction also. As far as the average (highest 10%) heights are concerned, Arabian Sea and Bay of Bengal are much calmer during this period than south-west and north-east monsoon periods with heights reaching maxi-

mum of only 1.6 m and 1.7 m respectively (Fig. 8). The average conditions are almost identical in both the regions. The maximum (highest 10%) heights are also much lower, the maximum values being 8.5 m and 8.3 m for Arabian Sea and Bay of Bengal respectively, than during south-west and north-east monsoon (Fig. 12).

Effect of Cyclones and Depressions

From a study of cyclones and depressions in different months and the corresponding sea state and wind velocities, it is observed that though the cyclone/depression days are more in May in Arabian Sea, the maximum wave height occurs in July when the wind velocity is maxium (Fig. 14a). In the case of Bay of Bengal cyclone/depression days are maximum in November while the maximum wave height is observed in June when the wind velocity is nearing the maximum (Fig. 14b). From these it may be concluded that it is the steady and high monsoon which influences the sea state considerably and not the cyclones and depressions, that strike infrequently. Wave height of each season shows direct relation to the corresponding wind velocity (Table 1).

References

Anonymous. 1966. Shore Protection, Planning and Design. Tech. Rep. No. 4. *In*: 3rd Edn. *US Army Coastal Engineering Research Centre, Department of the Army Corps of Engineers.*

Hogben, N. and F. E. Lumb 1967. Ocean Wave Statistics. *Ministry of Technology National Physical Laboratory, Her Majesty's Stationary Office, London.*

Srivastava, P. S., P. K. Nair and K. R. Raman Kartha 1968. Monthly wave characteristic of the Arabian Sea. *Indian J. Met. Geophysics*, 19(3) : 329-330.

Vijayarajan, P. K. and M.X. Joseph 1970. Monthly Wave Characteristics of the Bay of Bengal. *Ibid.*, 21 (1) : 111-114.

Weather Atlas. India Meteorological Department.

Wind Waves at sea Breakers and Surf. HO Pub. No. 602, US Navy Hydrographic Office.