

Wave Characteristics in the Western & Northwestern Bay of Bengal during the Southwest Monsoon of 1978

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Wave data are analysed for significant wave height (H_s), R.M.S. wave height (H_{rms}), maximum wave height (H_{max}), zero-crossing period (T_z), average period (T_c) and spectral width parameter (E). A scatter diagram relating H_s and T_z is also presented. The range of H_s is wide varying within 30 and 220 cm while T_z is confined to 6 to 15.5 sec, with a maximum occurrence between 6.5 and 8 sec. The percentage occurrence of E indicates that T_z has exceeded T_c in most of the cases.

The data available on waves are very sparse in the Indian Ocean, being restricted to a few coastal places¹⁻³. In recent years some wave atlases^{4,5} for the Indian Ocean have been published utilising the Indian Daily Weather Reports (IDWR). Since these data are only visual observations, they are not very suitable to arrive at a comprehensive picture of different wave characteristics.

Materials and Methods

During the 37th to 40th cruises of *R V Gaveshani* in the southwest monsoon of 1978 (August and September) wave data were collected at 64 stations between 10° and 21° N and 80° and 90° E (Fig. 1) using a shipborne wave recorder. The wave recorder, designed and developed by the Institute of Oceanographic Sciences UK, is a modified version of the one earlier developed by Tucker⁶. The instrument was operated at 15 min at each station where the ship was stopped for hydrographic observations without anchoring. Station depths varied from 30 to >3000 m. A typical wave record is given in Fig. 2.

Wave records were analysed in accordance with the method suggested by Draper⁷. All the heights were corrected for depth attenuation effect. The following parameters were evaluated from each record—(i) height of the highest crest, A ; (ii) depth of the lowest trough, B ; (iii) number of zero-crossings, N_z ; and (iv) number of crests, N_c .

Significant wave height (H_s) was obtained from the values of A , B and N_z . The R.M.S. wave height (H_{rms}) was calculated from the relation,

$$H_{rms} = 1/2 H_1 (2\theta)^{-1/2} (1 + 0.289\theta^{-1} - 0.247\theta^{-2})^{-1}$$

where, $H_1 = (A + B)$ and $\theta = \ln N_z$.

The heights of H_s , H_{rms} and H_{max} are shown in Fig. 3 in the form of percentage exceedance curves.

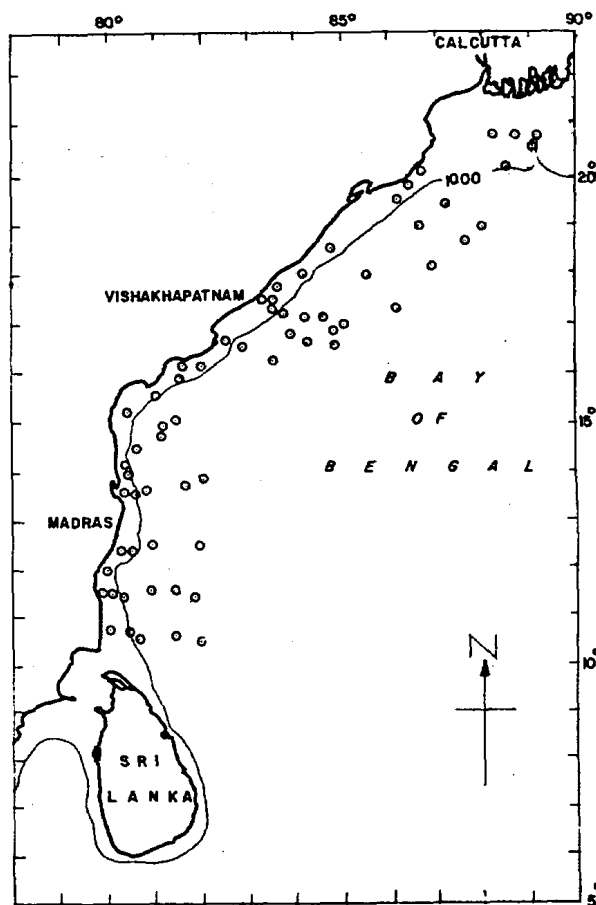


Fig. 1—Location of stations

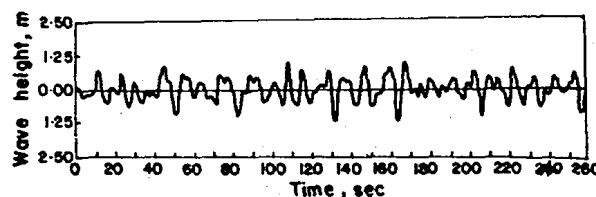


Fig. 2—A typical wave record

Logarithmic scale is chosen along X-axis to reduce the size of the figure.

Percentage occurrence of zero-crossing period (T_z) is shown in Fig. 4 at intervals of 1/2 sec. The spectral width parameter (E) was determined by the relation⁸

$$E^2 = 1 - \left[\frac{T_c}{T_z} \right]^2$$

The average period (T_c) used in this relation refers to all waves in a record irrespective of whether they cross zero-line or not; whereas the zero-crossing period T_z is the average period of exclusively those waves which cross zero-line. Fig. 5 shows the distribution of spectral width parameter as percentage occurrence for different ranges of values.

Scatter diagram relating H_s and T_z for 59 out of 64 stations is presented in Fig. 6. The number of occurrences for wave height are selected in the range of 25 cm each and for the period of 1 sec interval.

Results and Discussion

Cumulative distribution of wave heights (Fig. 3) indicates the percentage of wave heights exceeding a particular value during the entire span of observations. For example in 80% of cases H_s exceeds 60 cm whereas in no case it exceeds 225 cm (i.e. highest recorded value of H_s is < 225 cm). For each range of wave height the values of H_{rms} are very low compared to H_s or H_{max} and the highest value of H_{rms} is not > 50 cm while majority of values of H_s or H_{max} are > 50 cm. The low value of H_{rms} compared to H_s or H_{max} indicates that although a few high waves are always associated with each record, the overall wave heights are very low.

It is seen from Fig. 4 that periods between 6.5 and 8 sec are abundant, the most frequent period being 6.5-7 sec. A secondary mode of periods is found between 10 and 11 sec while periods between 13.5 and 14 sec are absent. Fig. 6 indicates that the values of wave heights and wave periods are widely spread over the entire

range. This may be because a very large area of the Bay was covered during the cruises. It may also be attributed to the fact that these observations were

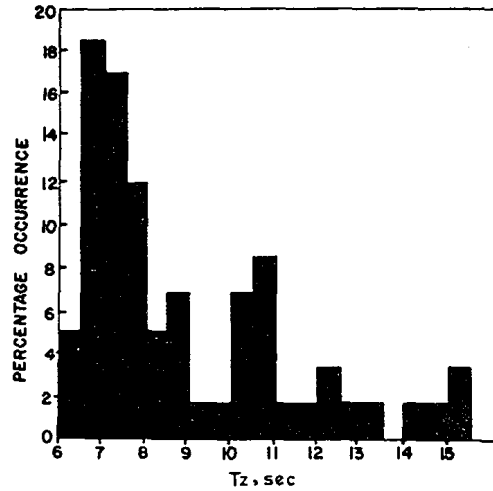


Fig. 4—Distribution of zero-crossing period

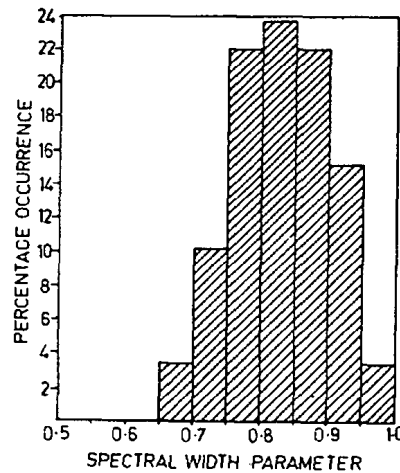


Fig. 5—Distribution of spectral width parameter

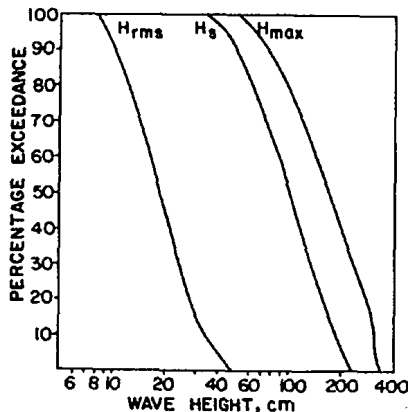


Fig. 3—Cumulative distribution of R.M.S. wave height, significant wave height and maximum wave height

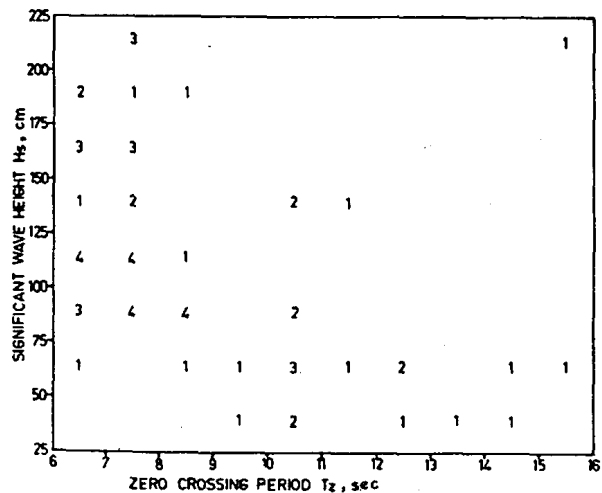


Fig. 6—A scatter diagram relating significant wave height to zero-crossing period

made during monsoon. It may be mentioned here that even though the winds were predominantly from south and southwest, their speeds varied over a wide range (calm-40 knots). Such fast changing conditions of the wind field may also be generating waves of various periods and heights. However, it is seen in Fig. 6 that 31 out of 59 stations (53%) are having periods between 6 and 8 sec. Incidentally this range of periods (6 to 8 sec) happens to be the dominant one as already revealed in Fig. 4. Similarly another small group of 9 values (16%) is confined to a range of periods between 10 and 11 sec. The scatter diagram also shows that usually waves with high values of H_s are associated with low values of T_z . There is only one case (at $22^\circ 52' N$ and $89^\circ 09' E$) where unusually long period waves (15.3 sec) had a high value of H_s (205 cm).

Statistical distribution of wave heights can reasonably be represented by a spectral width parameter (E). The value of E (which varies between 0 and 1) is determined by the relative magnitudes of T_c and T_z . For example if in a given situation a wide range of wave heights is present, T_z becomes far greater than T_c . Since many wave components may not be crossing zero-line, the resulting E in this case is nearing unity. However, if wave heights are confined to a small range, the result is a usual swell and most of the waves cross the zero-line. In this case T_z does not differ much from T_c and E is close to zero.

It is seen from Fig. 5 that there is no value < 0.65 and the highest occurrence lies between 0.8 and 0.85. This

shows that the spectral width parameter is nearing one. We may conclude from this diagram that the monsoonal wave heights in the western and northwestern Bay of Bengal are spread over a wide range. It is interesting to note that the scatter diagram (Fig. 6) also indicates similar feature.

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References

- 1 Dattatri J, *J Waterways Harbours Coast Eng*, **99** (1973) 39.
- 2 Sundara Raman K V, Varkey M J, Vijaya Rajan P K, John V C & Joseph M X, *Indian J Met Geophys*, **25** (1974) 453.
- 3 *Report on environmental studies in relation to beach erosion at Thumba* (National Institute of Oceanography, Dona Paula, Goa) 1977.
- 4 *Indian Ocean wave atlas* (National Institute of Oceanography, Dona Paula, Goa) under publication.
- 5 *Indian Ocean wave atlas* (Naval Physical and Oceanographic Laboratory, Naval Base, Cochin) 1978.
- 6 Tucker M J, *Trans Inst Naval Architects London*, **98** (1956) 23.
- 7 Draper L, *Proceedings of 10th conference on coastal engineering Tokyo*, Vol. 1 (American Society of Civil Engineers, New York) 1967, 1.
- 8 Tucker M J, *Proc Civ Eng*, **26** (1963) 305.