

Characteristics of monsoon waves off Uran, west coast of India

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Waves were measured off Uran in the Dharamtar creek (lat. $18^{\circ}50'$ and long. $72^{\circ}55'$) during monsoon months from 26 June to 20 September 1984 using a Datawell wave rider buoy. The wave records were analysed using Tucker's and the spectral methods for determining various wave parameters. Monsoon wave climate was stronger with the occurrence of the highest significant wave height of 2.45 m and the corresponding maximum wave height of 3.9 m in July. Significant wave height varied from 0.45 to 2.45 m, maximum wave height from 0.6 to 3.9 m and the zero crossing wave period from 5 to 18.5 s during the study period.

The information on wave characteristics is extremely important for any project related to coastal and offshore development. The availability of instrumentally measured waves around the Indian coast is very limited¹⁻³ and it often becomes necessary to use the ship reported visual data for engineering applications. It would therefore, be of great value to carry out an instrumental wave measurement programme spreading over the vast coastal zone of India. In the present study, wave measurements have been made using wave rider buoy off Uran in the Dharamtar creek in the vicinity of Bombay metropolis. The study is intended to understand the monsoon wave characteristics which can help in the design of a marine outfall for discharging the effluents from the L.P.G. plant at Uran.

General oceanographic condition in the study area was dominated by the monsoon seasons with high waves throughout southwest monsoon period and comparatively calm sea during the rest of the year. The current pattern in the area was influenced by tides and the average spring and neap tidal ranges were about 4 and 1 m respectively.

Methods

Time series records on waves were obtained from 26 June to 20 September 1984. The depth of water at the wave rider location was about 10 m at mean sea level and it was located on the eastern limit of the Bombay harbour (Fig. 1). The waves were recorded for 20 min at 3 h intervals in analog form on a chart paper roll and in digital form on magnetic cassettes. The significant wave height, maximum wave height, zero-crossing wave period, wave peri-

od corresponding to the maximum wave height and spectral width parameters were computed from the analog records using the Tucker's method^{4,5}.

The wave steepness (S) is estimated as $S = H_s/L$, where H_s is significant wave height and L is wavelength at measured location with 10 m depth of water for the wave period of T_z using linear wave theory⁶.

Digital data were analyzed using the statistical and spectral methods. Fast Fourier Transform (FFT) algorithm was used for computing the raw spectrum of the wave record and a moving average of 6 raw spectral values was used for obtaining a smooth spectra^{7,8}.

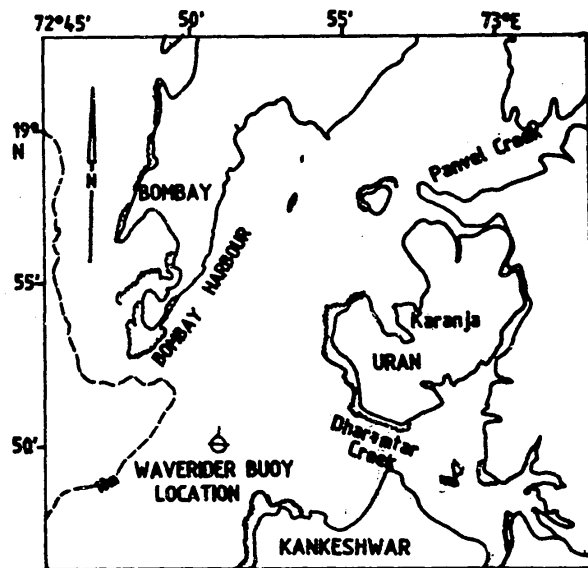


Fig. 1—Location map

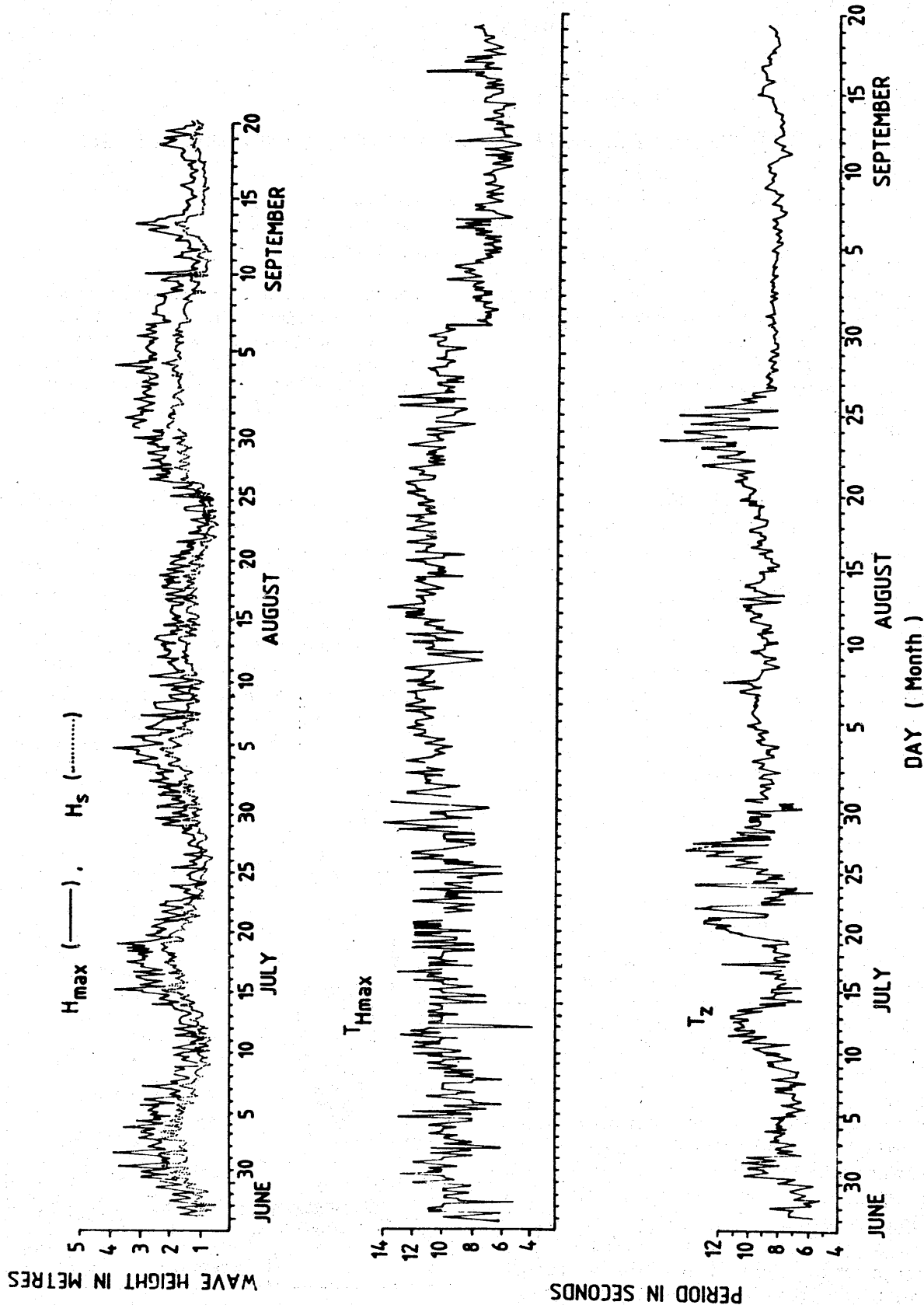


Fig. 2—Time history of H_s , H_{max} , T_z and T_{Hmax}

Results and Discussion

The daily variations of significant wave height (H_s), maximum wave height (H_{max}), zero-crossing wave period (T_z) and wave period corresponding to the maximum wave height (T_{Hmax}) are shown in Fig. 2. Significant wave heights varied from 0.63 to 2.45 m in July, 0.45 to 2.28 m in August and 0.62 to 1.83 m in September 1984. Maximum wave height varied from 0.8 to 3.9 m in July, 0.6 to 3.82 m in August and 0.9 to 3.08 m in September 1984. The highest significant wave height of 2.45 m and the highest maximum wave height of 3.9 m were observed on 2 July 1984.

The zero crossing wave periods varied from 6 to 13.5 s in July, 5.5 to 18.5 s in August and 5 to 9 s in September. Wave period corresponding to maximum wave height varied from 4 to 14 s in July, 5 to 13 s in August and 5 to 14 s in September. Dattatri¹ reported the maximum wave height varying from 0.4 to 5.6 m during the southwest monsoon off Mangalore along the west coast.

Monthwise percentage distribution of H_s , H_{max} , T_z and T_{Hmax} are shown in Fig. 3. Most of the time, the significant wave heights persisted between 1 and 1.5 m. Significant wave heights in this range occurred about 40% of the time in July, 50% of the time in August and 45% of the time in September. The maximum wave heights between 1 and 2.5 m occurred about 90% of the time in August and September and about 75% of the time in July. Maximum wave height of 2.5 to 3 m occurred 20% of the time in July. The zero crossing wave periods persisted between 8 and 9 s for about 27% of time in July

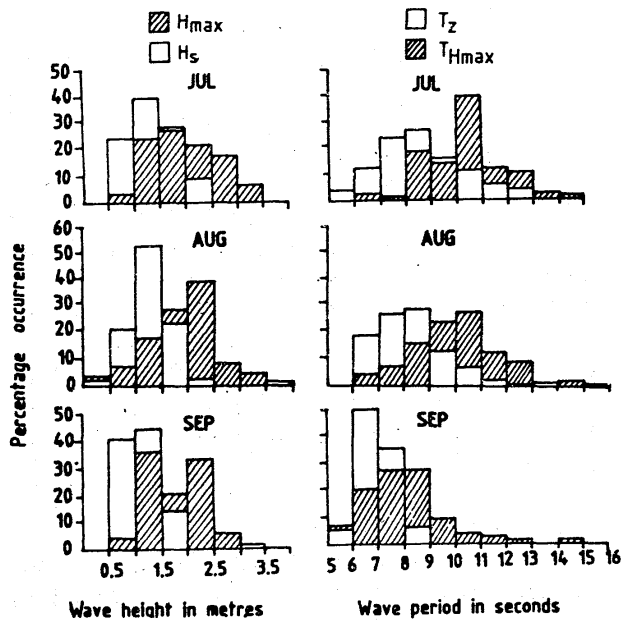


Fig. 3—Percentage distribution of H_s , H_{max} , T_z and T_{Hmax}

and August and about 50% of the time in September. The percentage occurrence of spectral width parameter (ϵ) and the wave steepness are shown in Fig. 4. The spectral width parameter mostly varied between 0.8 and 0.9 in July and between 0.7 and 0.8 in August and between 0.6 and 0.7 in September.

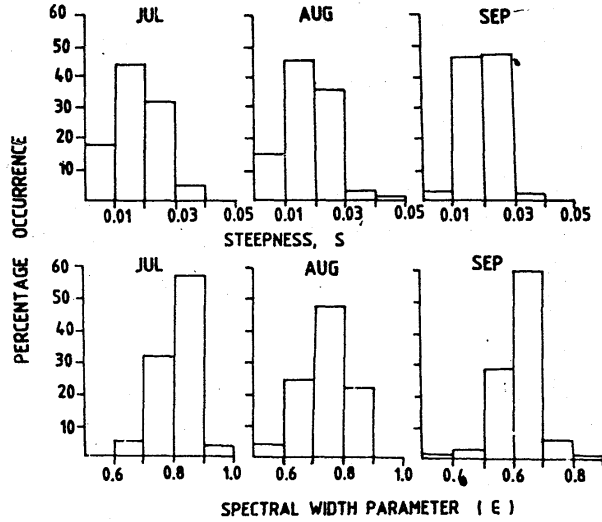


Fig. 4—Percentage distribution of ϵ and S

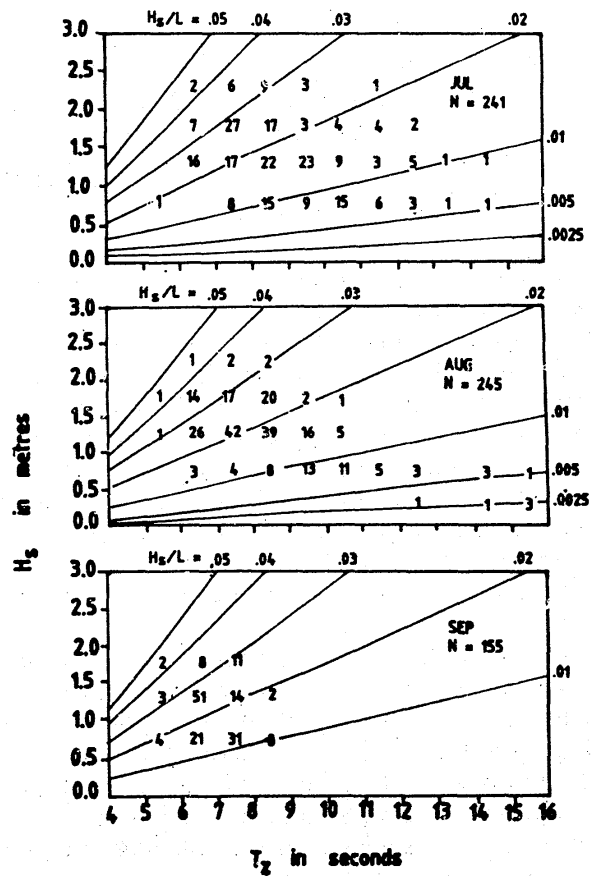


Fig. 5—Joint distribution of H_s and T_z

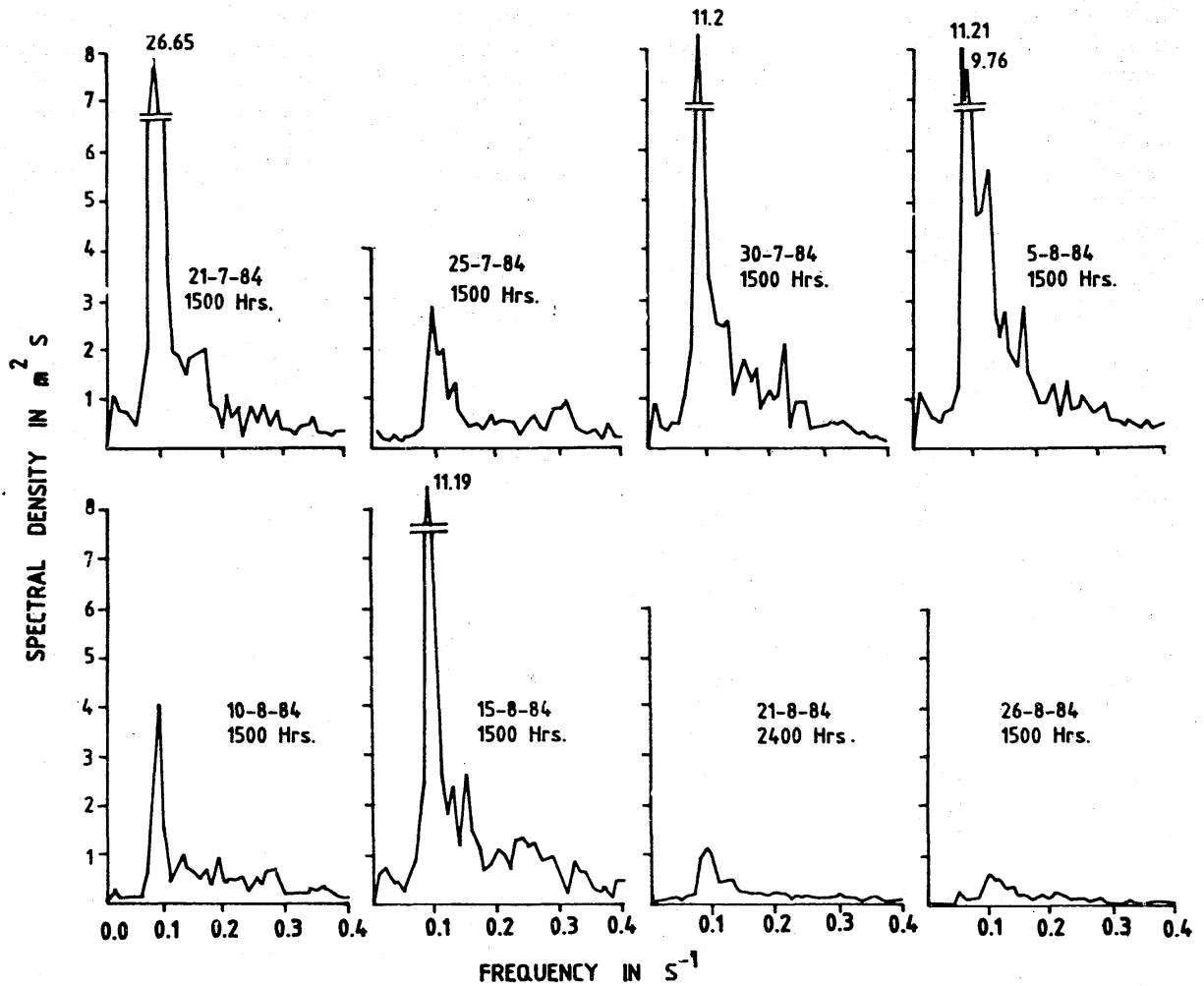


Fig. 6—Representative sample by computed wave spectra

The high values of spectral width parameters indicated that the monsoon waves in July and August were distributed in a broad frequency band.

The joint distribution of significant wave height and zero crossing wave period for different months are plotted in the form of scatter diagram in Fig. 5. The line of constant wave steepness (H_s/L) superimposed on the scatter diagram indicates that the monsoon waves have the steepness mostly lying between 0.015 and 0.03. Similar observations were also made in earlier studies off Mangalore coast¹ and off Kerala coast⁹.

Typical wave spectra representing the monsoon wave climate pertaining to July and August are presented in Fig. 6. In general, the wave spectra were single peaked but a few records with the occurrence of 2 peaks were observed in July indicating the superposition of 2 independent wave trains at the wave measurement location. This phenomenon was also observed at other parts of the Indian west coast^{1,10}.

In general, the wave climate on the west coast of India is dominated by 2 different seasons distinguished by the southwest monsoon period from June to September and the non-monsoon period from October to May. High waves with comparatively short periods have been observed during the southwest monsoon. The results of the wave parameters obtained from the present study are based on the limited period of observation of about 3 months. Though measurements for 1 year would be essential for evaluating the variation of wave parameters over an annual cycle, the wave climate of the monsoon which covers the roughest season of the year, reported in the present study, will be of value in design applications.

Acknowledgement

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References

- 1 Dattatri J, *J Waterways Harbour Div ASCE*, 99 (1973) 39.
- 2 Baba M & Harish C M, *Indian J Mar Sci*, 14 (1985) 1.
- 3 Dattatri J & Nampoothiri S M, *I Nat Conf on Dock and Harb Engg* (Indian Institute of Technology, Bombay), 1985, E87.
- 4 Tucker M J, *Proc Inst Civil Engrg London*, 1 (1963) 305.
- 5 Tucker M J, *Ocean Wave Spectra*, (Prentice-Hall, New Jersey) 1963, 219.
- 6 Weigel R L, *Oceanographical Engineering* (Prentice-Hall, New Jersey) 1963.
- 7 Torsethaugen K & Krogstad H E, *NEPTUN—A computer program for the analysis of ocean wave records*, Report (Continental Shelf Institute, Trondheim), 1979.
- 8 Cooley J W & Tuckey J W, *Math Comp*, 19 (1965) 297.
- 9 Hameed T S S & Baba M, *Ocean Engrg*, 12 (1985) 309.
- 10 Harish C M & Baba M, *Ocean Engrg*, 13 (1986) 239.