

## Wave Characteristics of the Laccadive Sea (Lakshadweep)

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Waves in the Laccadive Sea were recorded during March-April 1978 (31st cruise of *R V Gaveshani*) using a ship-borne wave recorder. Zero-crossing period, significant wave height and spectral width parameter were determined and their distributions studied. Predominant significant wave height and zero-crossing period were 50 to 70 cm and 8 to 8.5 sec respectively. Seasonal variations in the wave characteristics for the area were also studied using the historical data reported by the ships. The predominant wave periods and wave heights were 5-6 sec and 0.5 to 1.5 m respectively during the fair weather season (October-May) and 5-9 sec and 1-3 m respectively during the rough weather season (June-September). A wide range of wave heights 0.5-5 m occurred during the rough season.

Information on wave characteristics in the offshore regions is required for navigation, offshore engineering works, etc. There is no published work of the recorded wave data from the Laccadive area. There are few studies conducted earlier on waves at certain coastal stations on the west coast of India<sup>1-4</sup>. The only data available on the waves for the offshore regions in the Arabian Sea are visual observations reported by ships. Studies on the wave characteristics of this area are of much importance because of the presence of several inhabited islands (atolls).

The present study is mainly based on the wave data recorded during March-April 1978 (31st cruise of *R V Gaveshani*). In addition, the wave data reported earlier by ships are also used to present a picture of wave climate of the region.

### Methods

Waves were recorded at 29 stations (Fig. 1) using a ship-borne wave recorder (IOS, Model 5254; Institute of Oceanographic Sciences, UK). At each station recording was done continuously for a minimum period of 15 min. At certain stations more than one record were obtained. In total, 45 records were collected. Only 10 min records were taken, and analysis was done following the method suggested by Draper<sup>5</sup>. Height of the highest crest (A) and depth of the lowest trough (C) from the mean water line drawn visually, number of upward zero-crossings ( $N_z$ ) and number of crests ( $N_c$ ) were measured from each record.

The following parameters were then computed from the above measurements. The height of the highest wave was computed as  $H = A + C$  and corrected for pressure attenuation and the instrument's response, finally giving  $H_1$ . The other parameters computed were

the significant wave height ( $H_s$ ), mean zero-crossing period ( $T_z$ ), mean crest period ( $T_c$ ), and spectral width parameter ( $\epsilon$ ).

The data were then grouped for further analysis, as there were no marked changes in the weather pattern during the cruise. Direction of the waves was observed visually, at a few stations.

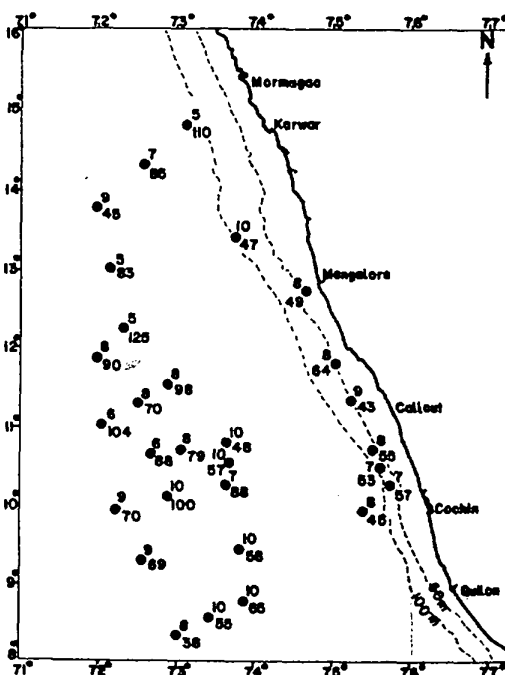


Fig. 1—Station-wise distribution of zero-crossing period (sec; upper number) and significant wave height (cm; lower number)

**Results and Discussion**

Fig. 1 shows  $T_z$  and  $H_s$  at each station. At those stations where more than one record were available, the maximum observed values of  $T_z$  and  $H_s$  were given. Generally low  $H_s$  were observed along the coast.

Fig. 2a gives the percentage occurrence of  $H_s$ . The predominant range of  $H_s$  was between 50 and 70 cm. The maximum  $H_s$  was 1.25 m. The highest recorded  $H_s$  was 2 m with a  $T_z$  of 5.2 sec. Fig. 2b gives the percentage occurrence of  $T_z$ . The most prominent group of  $T_z$  was from 8 to 8.5 sec with a percentage occurrence of 17. Distribution of percentage frequency showed that about 93% of the waves cover a range of period 5 to 10 sec. The maximum  $T_z$  observed was 10.2 sec.

Fig. 3a shows the distribution of  $\epsilon$ . The modal class was observed to be 0.8 to 0.85 and the range was between 0.7 and 0.95. As all the values of  $\epsilon$  were close to unity, it can be concluded that during the periods of observation, the wave components covered a wide range of frequencies, i.e. long waves carry short waves on top of them<sup>5</sup>. In other words the local sea conditions were super-imposed on light swells. Fig. 3b gives the scatter diagram showing the inter-relationship between  $H_s$  and  $T_z$ . The most common situation with  $H_s$  50-60 cm and  $T_z$  7.5-8.5 sec had a percentage of occurrence about eleven (111 per thousand). The

scatter was wide, showing the occurrence of waves over a wide range of frequencies and heights. The highest waves were associated with shorter periods showing the dominance of local seas.

The directions of waves observed at limited number of stations, were between 330° and 360°N. This is in accordance with the wind direction and is also in agreement with the observations reported by ships (Table 1).

The distributions were compared with the other studies carried out at coastal stations along the west coast of India during fair-weather season (Table 2). Long period swells were predominant off Thumba and Mangalore as compared to the other places.

Distributions of wave parameters show that these were characteristic of the fair weather season, and were in accordance with the wind system of the season.

*Wave climate*—To give a picture of the wave climate in the region, the wave data reported by ships and published in the Indian Daily Weather Reports were

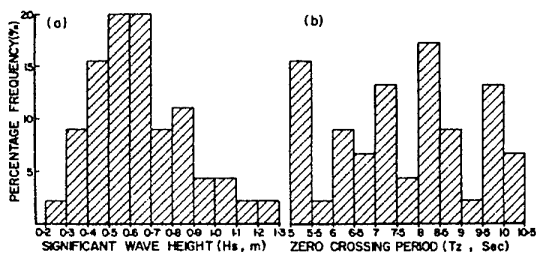


Fig. 2—Distribution of (a) significant wave height and (b) zero-crossing period

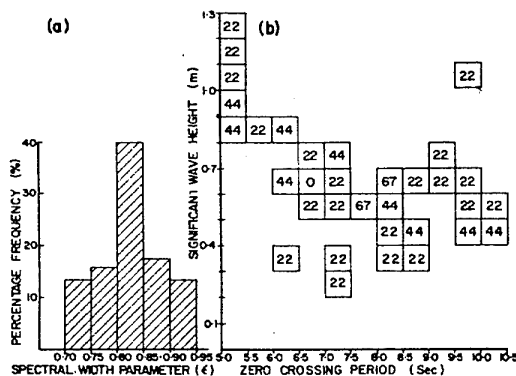


Fig. 3—Distribution of spectral width parameter (a) and scatter diagram (b) [Number in the square represents the number of occurrences of waves (parts per thousand) in a particular period-height group]

Table 1—Percentage Occurrence of Waves from Different Directions

Direction*	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
30°	1.6	13.3	15.8	15.9	8.7	—	—	—	—	—	—	—
60°	—	5.4	9.8	8.6	8.7	—	—	—	—	—	—	—
90°	1	3.6	10.8	2	2	—	—	—	—	—	—	—
120°	3.1	7.3	4.3	4.6	2	—	—	—	—	—	—	—
150°	5.8	5.4	4.3	2	—	—	—	—	—	—	—	2.5
180°	15.7	9.7	2.4	—	3.4	—	—	5.2	1.2	0.8	3.1	1
210°	9.9	5.5	2.4	—	—	—	—	7	5.4	5	7.1	6.5
240°	11	3.6	—	1.3	—	—	—	12.9	25	24.7	18.2	15.9
270°	13.6	—	—	—	2	—	9.2	25.2	40.7	51.7	51.1	35.8
300°	12.6	9.1	3.7	8.6	12.1	18.2	31.6	23.9	15	13.5	18.7	30.3
330°	18.3	19.4	20.7	28.5	34.9	45.3	39.8	23.2	3.3	3.5	—	6.5
360°	7.3	17	25	27	26.2	36.5	19.4	2.6	0.8	—	—	1.5

\*Clockwise from the north

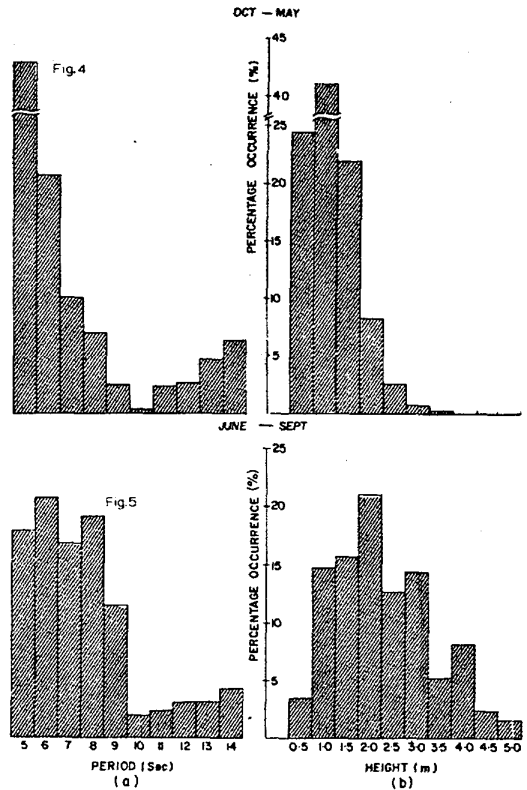
collected for a 5° grid between 10-15°N and 70-75°E for a period of 6 yr (1968-1973). The swell characteristics were compiled directionwise for each month. A preliminary study on the compiled data showed that the wave characteristics varied largely only between the 2 seasons, i.e. October to May (fair weather season) and June to September (rough weather season). Hence, the wave characteristics for these 2 seasons are presented separately only season-wise (Figs. 4 and 5). Percentage frequency of waves occurring in different directions are given for each month separately in Table 1. Although the table shows some changes in the directional pattern, scrutiny of the monthly data (available with authors) suggested that the characteristics (period and height) were largely the same from October to May and similarly from June to September.

The predominant direction of waves from October to May was 330° (N-NW) and from June to September 270° (W) (Table 1). The transition months appeared to be May and October when the direction changes. The directions of secondary dominance were 360° (N) from October to May and 240° (W-SW) from June to September.

Fig. 4 gives the distribution of wave periods and heights for the fair weather season (October-May). The predominant wave period was 5 sec in this season (Fig. 4a). About 80% of the waves had periods ranging between 5-8 sec (Fig. 4a). The predominant height was 1 m with a percentage frequency of nearly 41 (Fig. 4b). Almost 88% of the waves seem to occur within the range of 0.5 to 1.5 m height.

Percentage occurrences of wave period and height for the rough weather season (June-Sept.) are presented in Figs 5a and b. About 86% of the waves occurred with

periods ranging between 5 and 9 sec. The distribution was almost even within the range of 5 to 8 sec, though the 6 sec period had the highest frequency of occurrence (Fig. 5a). During this season, the



Figs 4 and 5—Distribution of percentage occurrence of (a) period and (b) height during October-May (4) and June-September (5)

Table 2—Ranges and Modes of Distribution of Periods and Heights Recorded at Different Locations

Location	Period of observation	Zero-crossing period ( $T_z$ sec)		Wave height (m)	
		Range	Mode	Range	Mode
Off Mangalore <sup>1</sup>	Oct-May 1968-69	7-15	11-12	0.2-1.4	0.4-0.5
Off Thumba <sup>4</sup>	April-May 1976	6-15	10-12	0.3-0.8	0.5-0.6
	Oct-March 1976-77			( $H_1$ )	( $H_1$ )
Off Goa <sup>3</sup>	Nov-May 1973-74	5-14	6-7	0.14-0.77	0.4-0.5
				( $H_2$ )	( $H_2$ )
Lakshadweep Sea*	March-April 1978	5-10.5	6-8.5	0.2-1.3	0.5-0.7
				( $H_2$ )	( $H_2$ )
				0.4-2	0.8-0.9
				( $H_1$ )	( $H_1$ )

\*Present study

$H_{max}$  = maximum wave height in a recording interval

$H_z$  = significant wave height

$H_1$  = corrected H

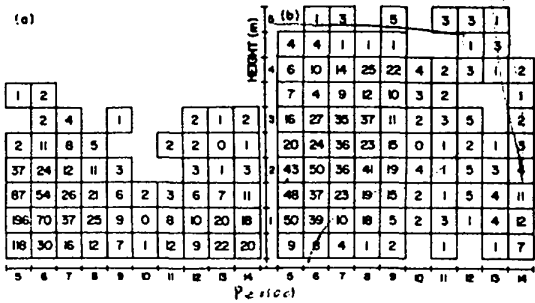


Fig. 6—Scatter diagrams for (a) fair weather season (October-May) and (b) rough weather season (June-September) [Number in the square represents frequency of occurrence of waves (per thousand) of same period and height]

predominant height seems to be 2 m with a percentage occurrence of about 21 (Fig. 5b). Nearly 80% of the waves occurred within the range of 1 to 3 m, though the range was fairly wide between 0.5 and 5 m.

Scatter diagrams relating period to height for fair weather season and rough weather season are presented in Figs 6a and 6b respectively. In the fair weather season (Fig. 6a) the most frequently occurring wave group was of period 5 sec and height 1 m (196 per thousand). In rough weather season (Fig. 6b) 2 groups of waves with period-height relationships 5 sec-1 m and 6sec-2m were predominant and occurred 50 per thousand or 5% of the time. A comparison of the scatter diagram of recorded waves (Fig. 3b) during March-April with that of fair weather season from

historical data (Fig. 6a) seem to be difficult in respect of the predominant period-height group. This is because the recorded data were limited to very short duration whereas the historical data were for the full season covering a period of 6 yr.

Comparison of wave characteristics between the 2 seasons revealed the following features. In the fair weather season, waves have predominantly shorter periods (5-6 sec) whereas in the rough weather season their predominant periods range between 5 and 9 sec. Distribution of height shows a wider range in rough weather with predominance of higher values as compared to those in the fair weather season.

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