

ANALYSIS OF WAVES OFF YANAM ON THE EAST COAST OF INDIA

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ABSTRACT

The wave climate off Yanam on the east coast of India was evaluated based on the time series data on waves collected by installing a Dutch wave rider buoy at an offshore station with about 90 m. water depth for the whole year from June 1983 to May 1984. The analogue wave records obtained on chart paper were analysed using the Tucker's method. Monthwise variation of the significant wave height (H_s) and zero-up-crossing period (T_z) and the cumulative distribution of significant wave height (H_s) and maximum wave height (H_{max}) are presented and discussed. Analysis of wave data for the southwest monsoon (June to September), the northeast monsoon (October to January) and the fair weather (February to May) periods have been undertaken to evaluate the wave climate in three seasons of the year.

INTRODUCTION

Yanam is situated on the east coast of India, about 15 km south of Kakinada Port town at the mouth of Godavari (Gautam) river. The wave climate in this region is dominated by the southwest and northeast monsoons. Severe wave conditions however, are found to occur during the southwest monsoon and during the periods of severe cyclones which are quite frequent on the east coast when compared to the west-coast. Continental shelf in this region is very narrow comparing to the adjoining coastal regions and is only about 20 km wide. The study of the wave climate in this region has attained very great importance due to the increasing drilling activities of the Oil and Natural Gas Commission of India for the exploration and exploitation of the offshore oil and gas. Study of wave climate is also useful in the evaluation of the coastal processes and development of nearby Kakinada port.

METHOD OF STUDY

A waverider buoy was deployed off Yanam at 90 m depth at the location shown in Fig. 1. The waves were recorded for 20 minutes duration for every 3 hours from June 1983 to May 1984 covering a period of one complete year thereby covering all the seasons. The analogue record of

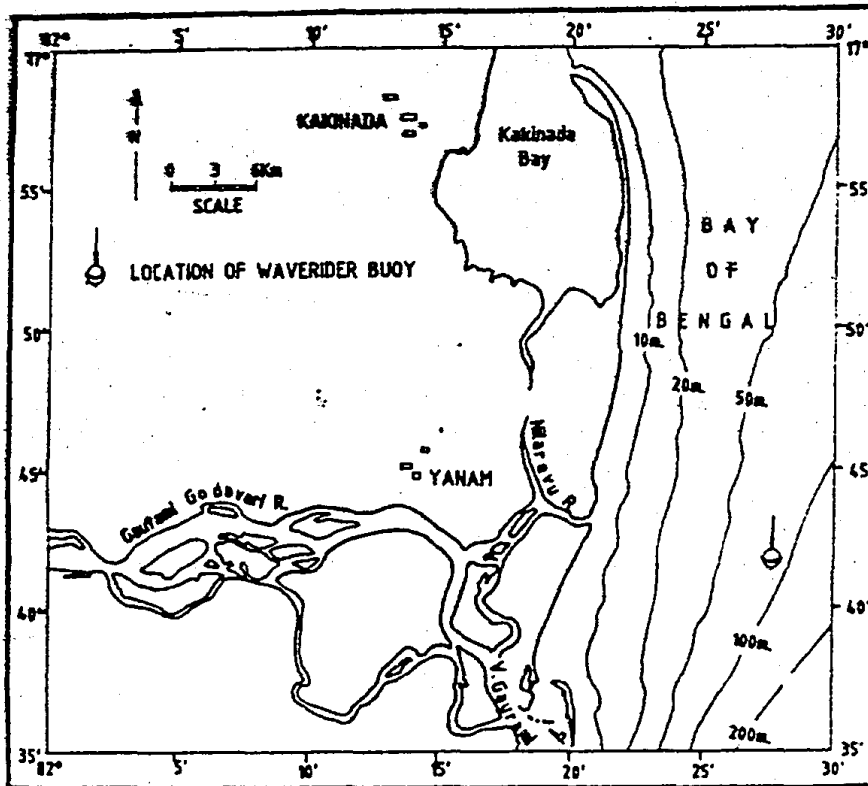


FIG. 1 LOCATION MAP

waves were obtained on chart paper roll and the digitized records for every 0.5 sec obtained on magnetic cassette tape. The chart paper records were analysed for important wave parameters using the Tucker's method (Tucker, 1963) and the results are presented in the paper. The usual equations used are

$$\frac{H_1}{\sqrt{m_0}} = 2 (2 \ln N_z)^{\frac{1}{2}} \left(1 + \frac{0.289}{\ln N_z} - \frac{0.247}{(\ln N_z)^2} \right) \quad \dots \quad 1$$

$$\frac{H_2}{\sqrt{m_0}} = 2 (2 \ln N_z)^{\frac{1}{2}} \left(1 - \frac{0.211}{\ln N_z} - \frac{0.103}{(\ln N_z)^2} \right) \quad \dots \quad 2$$

in which $H_1 = A + C$ and $H_2 = B + D$

The largest of m_0 obtained from equations 1 and 2 above is used for computing H_s from the following relationship

$$H_s = 4 \sqrt{m_0}$$

$$\frac{H_s}{N_c} = \frac{1200}{N_c}$$

where,

- A = The height of highest crest from MLL
- B = The height of second highest crest from MLL
- C = The depth of deepest trough from MLL
- D = The depth of second deepest trough from MLL
- N_z = Number of zero-upcrossing waves in each record.
- m_0 = Root mean square of the water surface elevation
- N_c = Number of crests in each record.

RESULTS AND DISCUSSION

Distribution of wave height:

During the year of wave measurements, the significant wave height (H_s) varied from 0.89 m to 2.60 m in June, 0.98 m to 2.60 m in July, 0.80 m to 2.52 m in August, 0.89 m to 2.48 m in September, 0.54 m to 2.48 m in October, 0.53 m to 2.45 m in November, 0.49 m to 1.94 m in December, 0.42 m to 1.46 m in January, 0.34 m to 2.60 m in February, 0.44 m to 1.30 m in March, 0.32 to 1.06 m in April and 0.93 m to 2.55 m in May.

It was observed that during the southwest monsoon period of June to September, the waves (H_s) were severe with heights ranging from 0.89 to 2.60 m and were moderately high during the north east monsoon of October to January between 0.42 and 2.45 m and the wave heights were less during the fair weather period from February to May ranging between 0.32 and 1.30 m.

The maximum wave height H_{max} varied from 1.2 to 3.8 m in June, 1.5 m to 4.4 m in July, 1.2 m to 3.2 m in August, 1.0 m to 3.1 m in September, 0.8 m to 3.8 m in October, 0.7 m to 3.6 m in November, 1.0 m to 3.2 m in December, 0.3 m to 2.4 m in January, 0.5 m to 4.4 m in February, 0.6 m to 1.8 m in March, 0.5 m to 1.6 m in April and 1.2 m to 4.2 m in May. The highest significant wave height of about 2.60 m was observed in June, July and February and the highest maximum wave height of about 4.40 m was observed in July and February. Figs 2 and 3 present monthwise distribution of H_s and H_{max} giving percentage occurrence of different wave heights for each month.

Distribution of wave period T_z :

During the study period, the zero up-crossing period (T_z) varied from 6.0 to 12.2 sec in June, 6.5 to 11.8 sec in July, 6.7 to 11.2 sec in August, 5.0 to 11.9 sec in September, 5.9 to 14.8 sec in October, 5.5 to 16.4 sec in November, 4.2 to 10.0 sec in December, 4.8 to 19.3 sec in January, 4.7 to 12.2 sec in February, 4.1 to 12.5 sec in March, 3.6 sec to 12.3 sec in April and 3.8 to 8.8 sec in May. In general the wave periods were low during the southwest monsoon (June to September) compared to that of the northeast monsoon and fair weather periods. Figs.4 and 5 present monthwise distribution of T_z and $T_{H_{max}}$ giving percentage occurrence of different wave periods for each month. $T_{H_{max}}$ is the wave period corresponding to the maximum wave height in each record.

Joint distribution of H_s versus T_z :

The joint distribution of significant wave height H_s and the

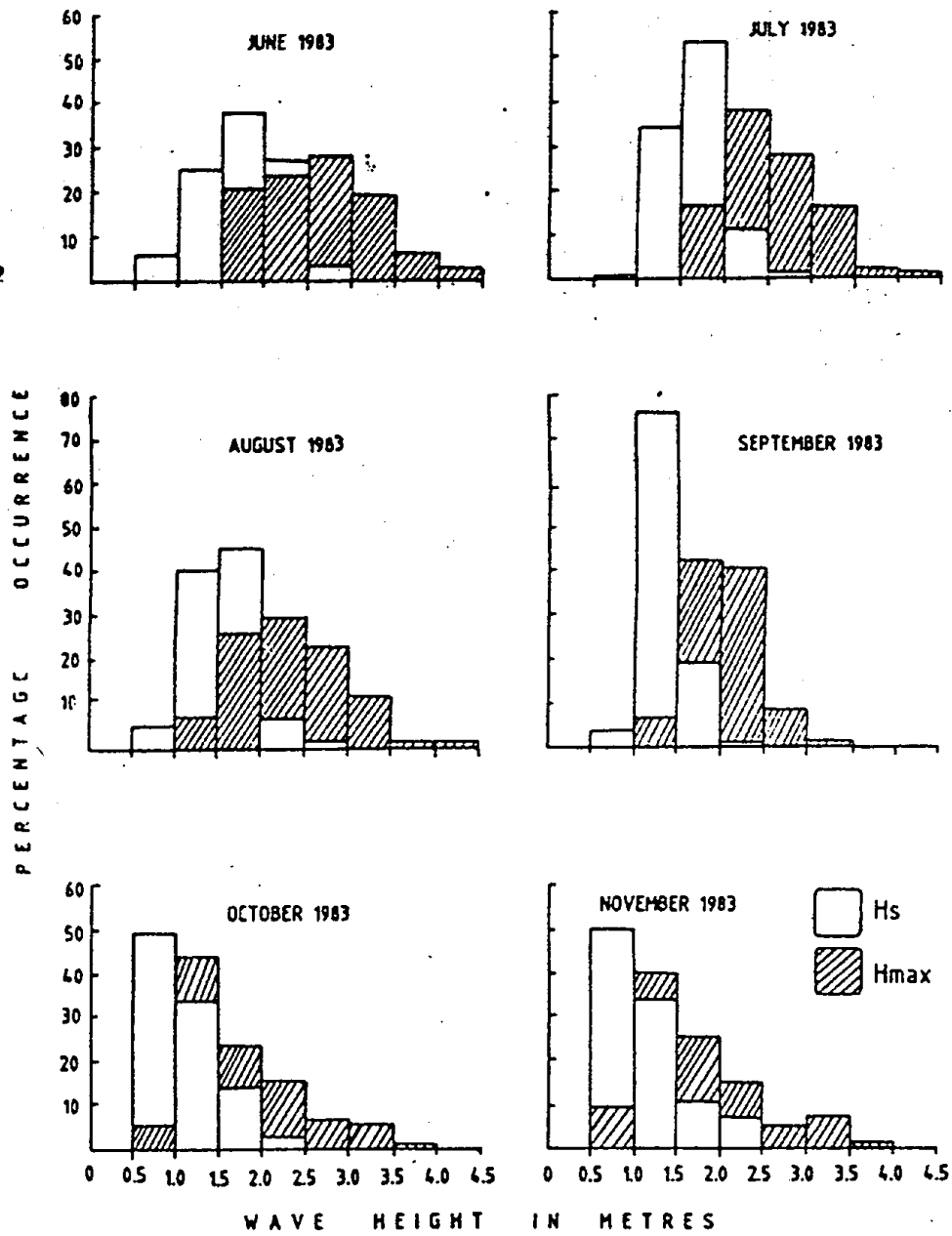


FIG. 2 MONTHWISE DISTRIBUTION OF H_s AND H_{max} .

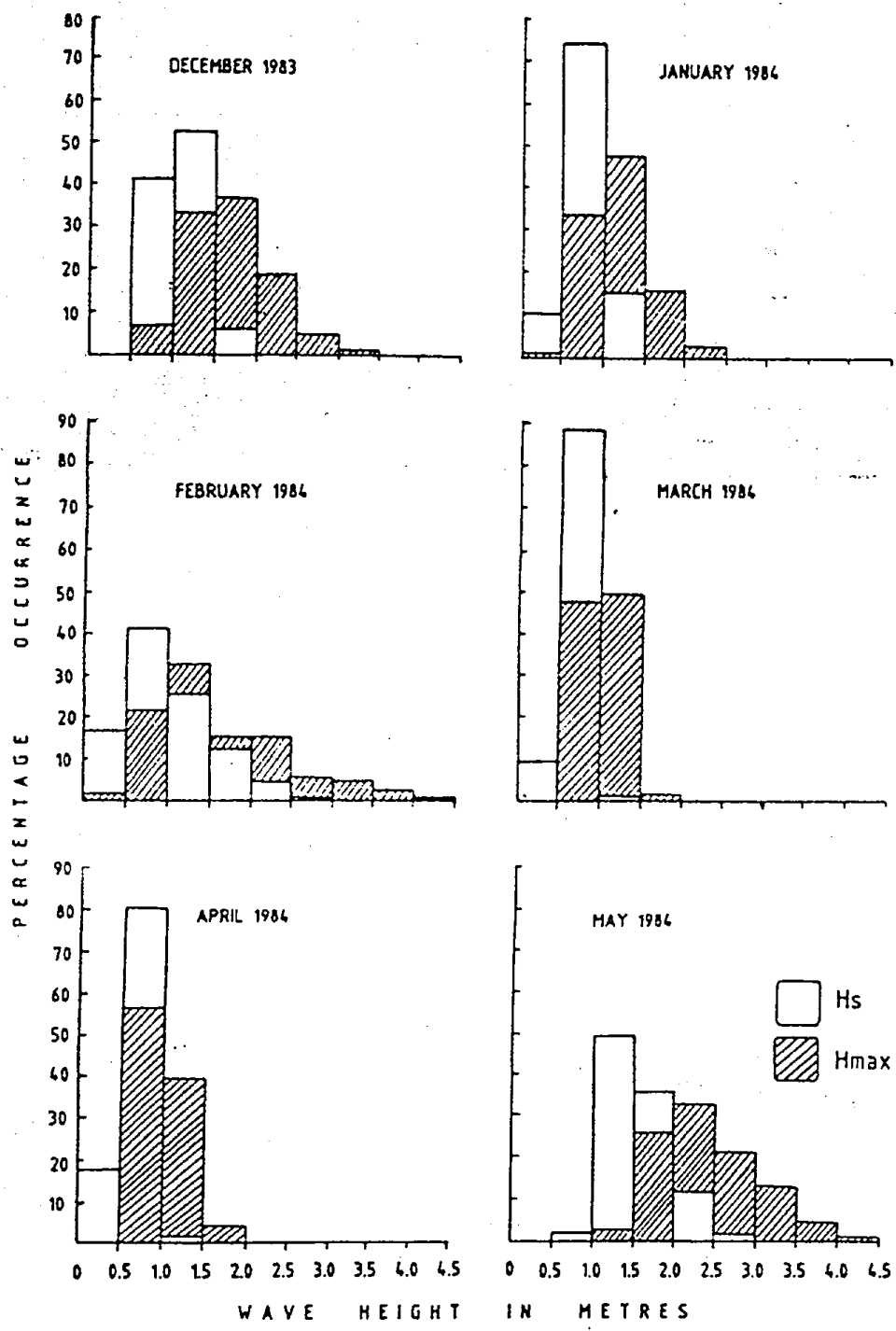


FIG. 3 MONTHWISE DISTRIBUTION OF Hs AND Hmax.

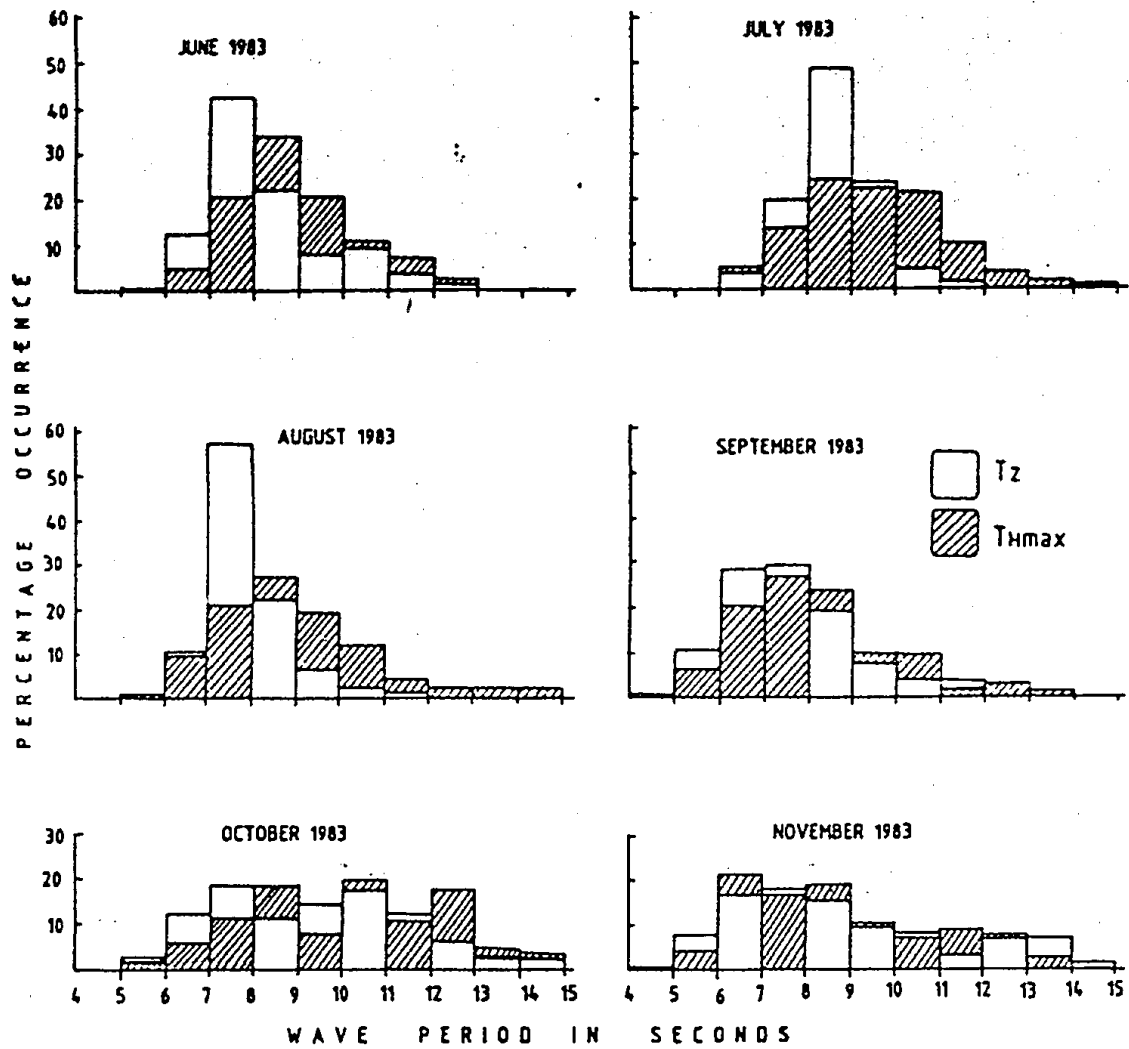


FIG. 4 MONTHWISE DISTRIBUTION OF Tz AND T_{max}.

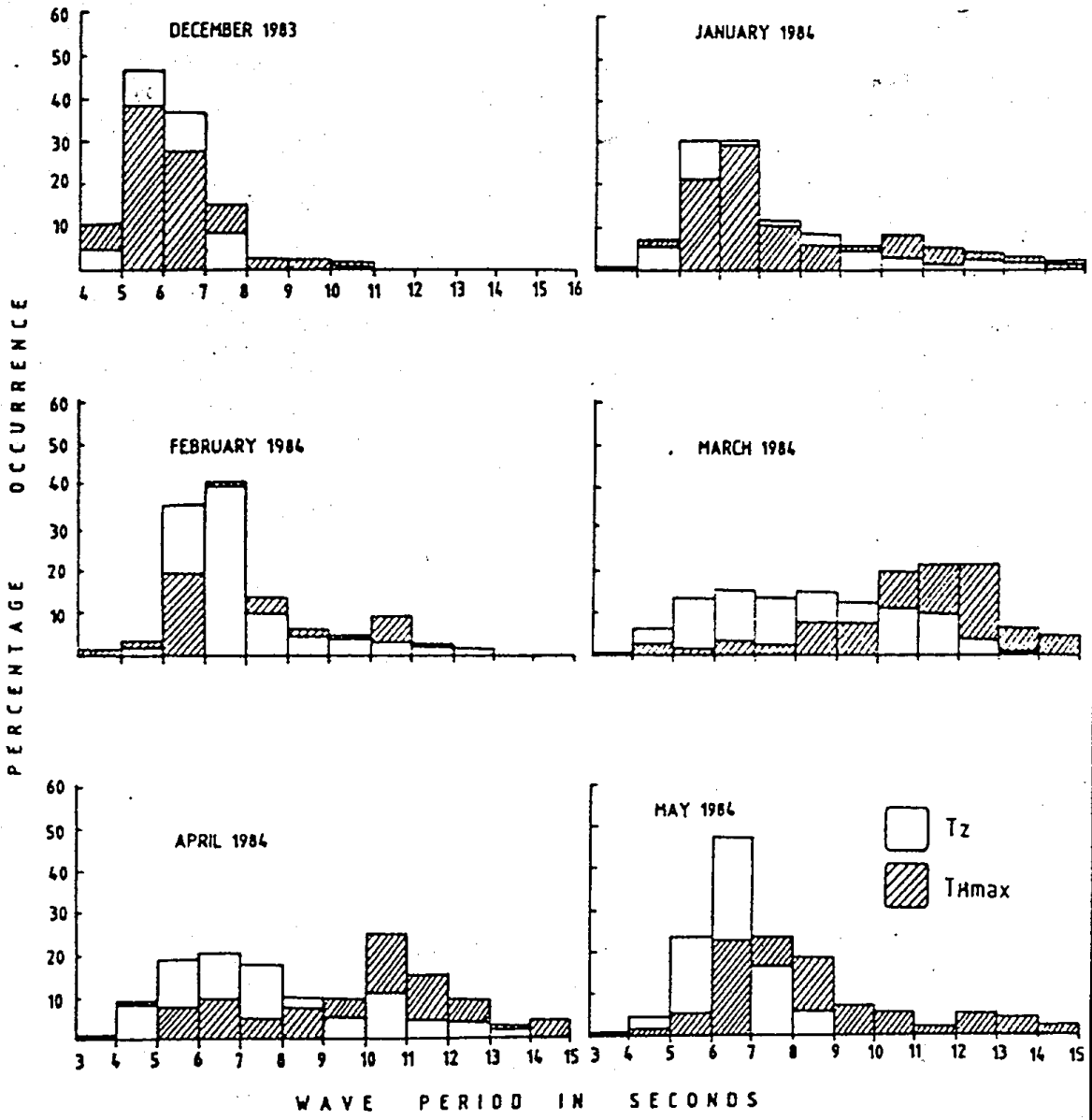


FIG. 5 MONTHWISE DISTRIBUTION OF T_z AND T_{1max} .

corresponding zero-up-crossing wave period T_z for the three different seasons namely, the southwest monsoon, the northeast monsoon and the fair weather period are presented in the form of scatter diagram in fig. 6. Lines of same wave steepness parameter (H_s/T_z) are also drawn in the same figure.

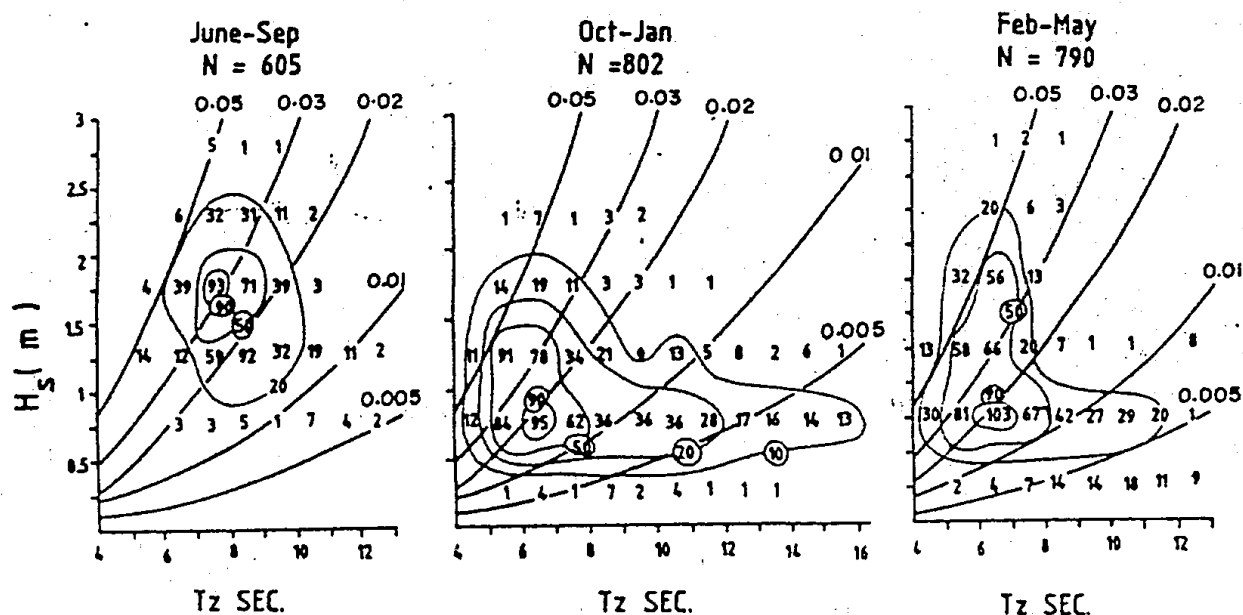


FIG. 6 JOINT DISTRIBUTION OF H_s AND T_z .

In figure 6, distinct differences in characteristics of wave are observed in the three different seasons. During the southwest monsoon, most predominant values of H_s and T_z are observed to be 1.75 m and 7 sec respectively, whereas in the northeast monsoon they are 1.0 m and 6 sec respectively and in the fair weather period the most predominant H_s and T_z are 0.75 m and 7 sec respectively. Predominantly the waves were found to occur with steepness parameter lying between 0.02 and 0.04 in the southwest monsoon, 0.01 and 0.04 in the northwest monsoon and 0.01 and 0.04 in the fair weather period. Thus the joint distribution diagram of figure 6 indicates that the monsoon waves are found to be steeper and higher when compared to those occurring in the fair weather period. An important feature of the waves is that the wave steepnesses at the place of measurement are much lower than those for the waves occurring in the generating area (Draper 1966). If the waves are predominantly swell, the wave steepness would be much lower than that of the wave in the generation area where the steepness parameter can even exceed 0.08 (Powers *et al.* 1968).

Cumulative distribution of H_s , H_{max} and T_z :

The percentage exceedance of significant wave height, H_s the maximum wave height H_{max} and the zero-up-crossing period T_z observed during

the year are shown in Fig. 7. It is observed that the significant wave height of 1.5 m exceeded 6% of the time, 1.0 m exceeded 24% of the time and 0.5 m exceeded 57% of the time. The maximum wave height of 2.0 m exceeded 18% of the time 1.5 m exceeded 37% of the time, 1.0 m exceeded 58% of the time and 0.5 m exceeded 84% of the time. The zero-up-crossing period of 9 sec exceeded 13% of the time, 8 sec exceeded 21% of the time, 7 sec exceeded 36% of the time, 6 sec exceeded 56% of the time, 5 sec exceeded 80% of the time and 4 sec exceeded 97% of the time.

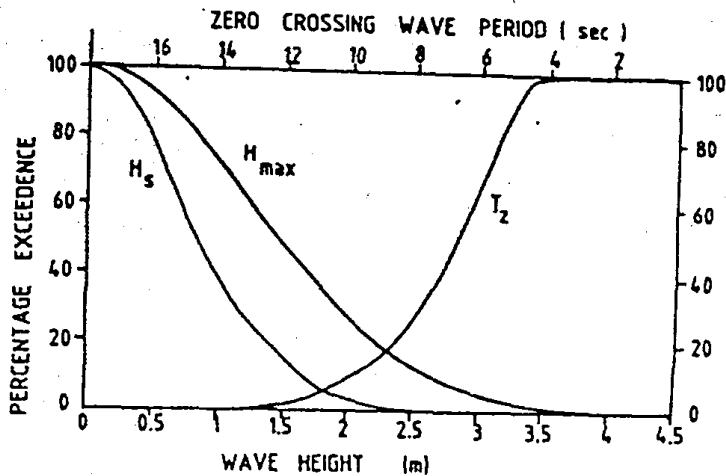


Fig.7 Cumulative distribution of H_s , H_{max} and T_z

CONCLUSION

From the analysis of one year wave data, it is observed that the wave climate off Yanam on the east coast of India is dominated by the two monsoons namely the southwest and the northeast monsoons. The wave heights were found to be higher and steeper during the southwest monsoon (June-September) with the significant wave height, varying between 0.89 to 2.60 m followed by the northwest monsoon (October-January) during which wave heights are moderately high varying from 0.42 to 2.45 m. Whereas during the fair weather period (February to May) the waves are low with heights varying between 0.32 and 1.30 m.

Though the east coast is prone to frequent cyclones, no major cyclone occurred during the study period. The wave measurements during the occurrence of a cyclone would be of great importance for the east coast of India. Design wave has to be arrived at based on extreme waves generated as a result of cyclones occurring in the region. For this purpose, it would be necessary to select a few severe cyclones which occurred during the past 10 to 20 years and using a reliable wave hind-casting model, predict the highest waves for each cyclone. The wave data

generated for these cyclones can be used for extreme value statistical analysis for determining the design wave height for various return periods of interest.

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