

# Seasonal Distribution of Wave Heights off Yanam on the East Coast of India

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*Waves were measured off Yanam on the east coast of India for a period of one year from June 1983 to May 1984. The data were analysed using the Tucker's zero up-crossing and the spectral methods. Season-wise distribution of significant wave height, maximum wave height and zero crossing wave period are presented and discussed. Inter-comparison of wave parameters computed by the three different methods was also done and linear relationships were obtained by the method of least square.*

## INTRODUCTION

Yanam is situated on the east coast of India about 15 km south of the Kakinada port at the mouth of Gautami Godavari river (Fig 1). Continental shelf in this region is very narrow about 20 km in width.

The study of the wave climate in this region has attained great significance due to the increasing offshore oil drilling activities. The formation of a long recurved sand spit on the northern side of the Godavari confluence has provided an ideal location for the development of the Kakinada port. Huge sediment load brought by the Godavari river associated with a predominantly north bound longshore drift causes the sand spit to progressively grow.

Hence, the study of the wave climate has a very great importance in the study and evaluation of the coastal processes along this coastal region. Wave climate of the east coast of India is dominated by three different seasons namely, the southwest monsoon from June to September, the northeast monsoon from October to January and the non-monsoon period from February to May. The wave activity is generally quite intensive during the southwest monsoon (June to September) with comparatively calm period during the remaining part of the year. However, frequent occurrence of cyclones in the Bay of Bengal during the northeast monsoon period would considerably increase the wave activity along the east coast of India leading to extreme wave conditions. No cyclone however, occurred during the present study period of one year.

## METHOD OF STUDY

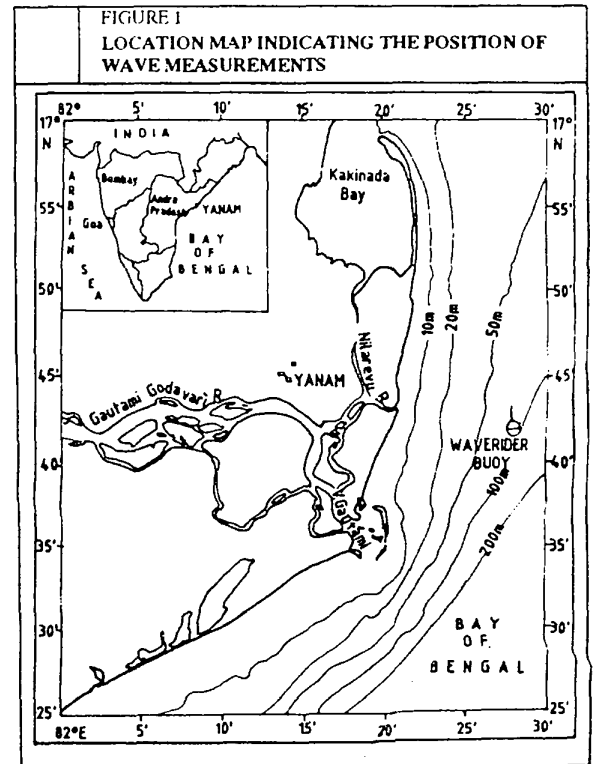
A wave rider buoy was deployed at 90 m depth as shown in Fig 1. Waves were recorded for 20 minutes duration at 3 hourly intervals in analog form on chart paper roll and in digital form on magnetic tape cassette from June 1983 to May 1984. The chart paper records were analyzed for various wave parameters using the Tucker's method<sup>1</sup>.

Digital records on cassette tapes were analyzed for various wave parameters using the statistical and the spectral methods. Fast Fourier Transform (FFT) technique is

used in the spectral analysis using 2048 data points sampled at every half a second<sup>2</sup>. In statistical method, the waves and their corresponding periods are identified by zero upcrossing method, when the time series record crosses the zero level from negative to positive values.

## RESULTS AND DISCUSSION

Seasonal distribution of the significant and the maximum wave heights are shown in Figs 2 and 3. Significant wave heights mostly varied between 1.0 and 2.0 m in the southwest monsoon from June to September, 0.5 and 1.5 m in the northeast monsoon from October to January and 0.5 and 1.0 m in the non-monsoon period from February to May. The maximum wave heights mostly varied between 1.5 and 3.5 m in the southwest monsoon, 1.0 and 2.0 m in the northeast monsoon and 0.5 and 1.5 m in the non-monsoon periods. From the wave height distribution diagrams, it may be observed that the waves are higher during the south-



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FIGURE 2  
PERCENTAGE DISTRIBUTION OF SIGNIFICANT WAVE HEIGHT

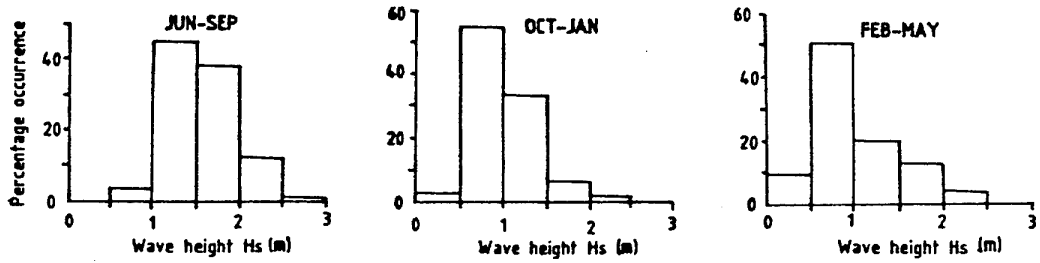


FIGURE 3  
PERCENTAGE DISTRIBUTION OF MAXIMUM WAVE HEIGHT

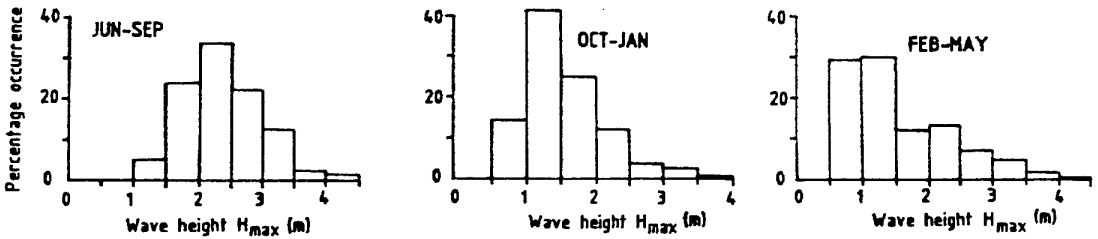


FIGURE 4  
PERCENTAGE DISTRIBUTION OF ZERO CROSSING WAVE PERIOD

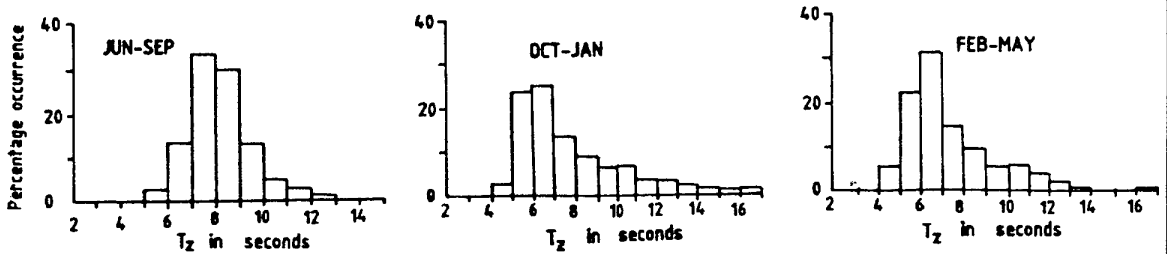


FIGURE 5  
PERCENTAGE DISTRIBUTION OF PERIOD OF MAXIMUM WAVE

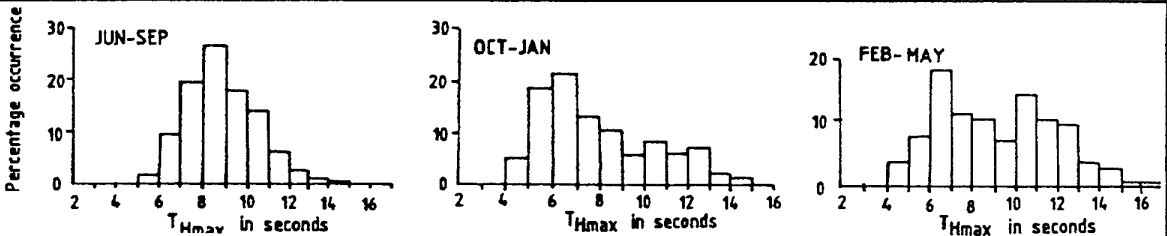
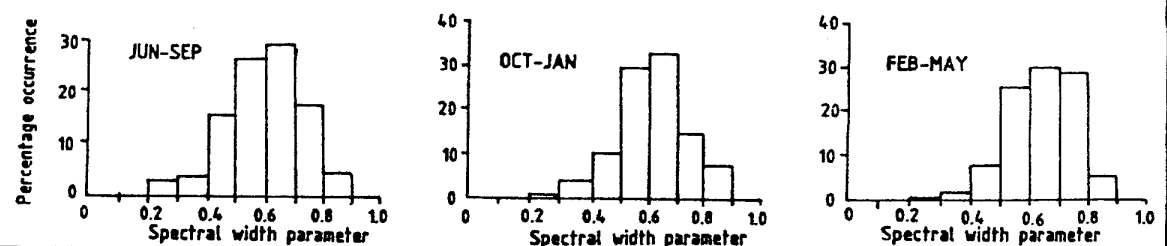
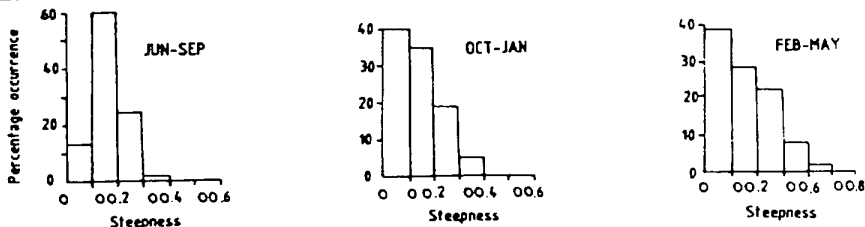


FIGURE 6  
PERCENTAGE DISTRIBUTION OF SPECTRAL WIDTH PARAMETER



**FIGURE 7**  
**PERCENTAGE DISTRIBUTION OF WAVE STEEPNESS**



west monsoon period as compared to that observed during the rest of the year in the absence of cyclones. The maximum wave height of 4.40 m was observed in June 83.

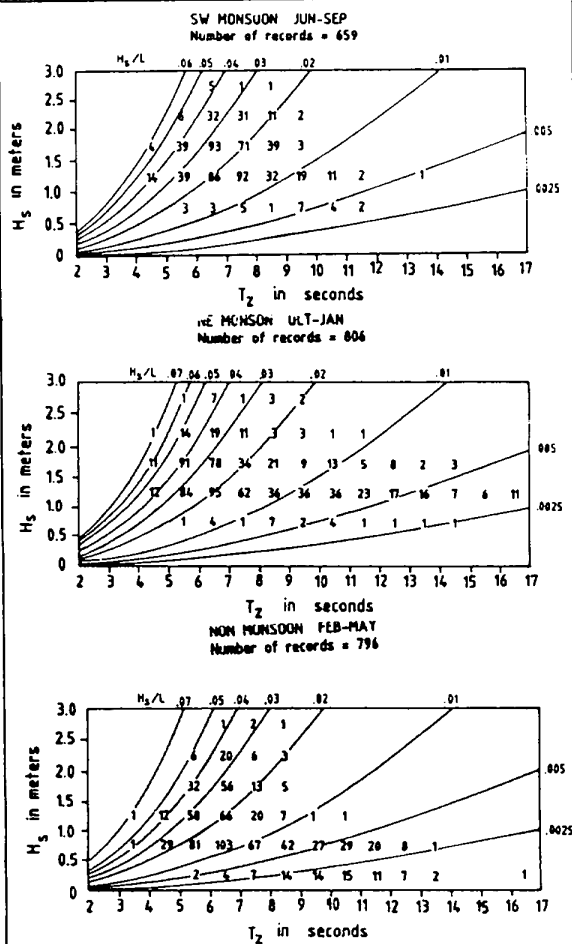
Distribution of zero-crossing wave periods and the periods corresponding to the maximum wave height are presented in Figs 4 and 5. In general, the zero-crossing wave period varied between 7 and 9 s during the southwest monsoon period, 5 and 9 s in the northeast monsoon and non-monsoon period. Seasonal distribution of spectral width parameter and wave steepness are presented in Fig 6 and 7. Spectral width parameter varied mostly between 0.5 and 0.8

during the year. Wave steepness was less in the southwest monsoon varying between 0.1 and 0.2 compared to that observed during the rest of the year.

Joint distribution of significant wave height and the corresponding zero-crossing wave period for the southwest monsoon, northeast monsoon and the non-monsoon periods are presented in the form of scatter diagrams in Fig 8. The constant wave steepness lines superimposed on the scatter diagrams indicate that the monsoon waves were steeper with steepness ( $H_s/L$ ) mostly between 0.01 and 0.03 and during the northeast monsoon, it varied between 0.005 and 0.04. During the non-monsoon months, the wave steepness mostly varied between 0.0025 and 0.03.

Typical example of the wave spectra computed for a few selected records during the study period are presented in Figs 9 and 10. It may be observed that the wave spectra are mostly single peaked with peak periods varying from 7 to 15 s. Occasionally, second peak can be observed due to the sea or second train of swell waves occurring at the site.

**FIGURE 8**  
**SEASON-WISE JOINT DISTRIBUTION OF SIGNIFICANT WAVE HEIGHT AND ZERO CROSSING WAVE PERIOD**



**Inter-comparison of Results**

For a selected 200 wave records, an intercomparison study was carried out. Figs 11, 12 and 13 clearly show good correlation existing between the significant wave heights computed by the three methods. The best-fit line was obtained by the method of least squares.

A regression coefficient ( $r^2$ ) of 0.93 indicates that there is a good correlation between the significant wave heights obtained by the three methods.

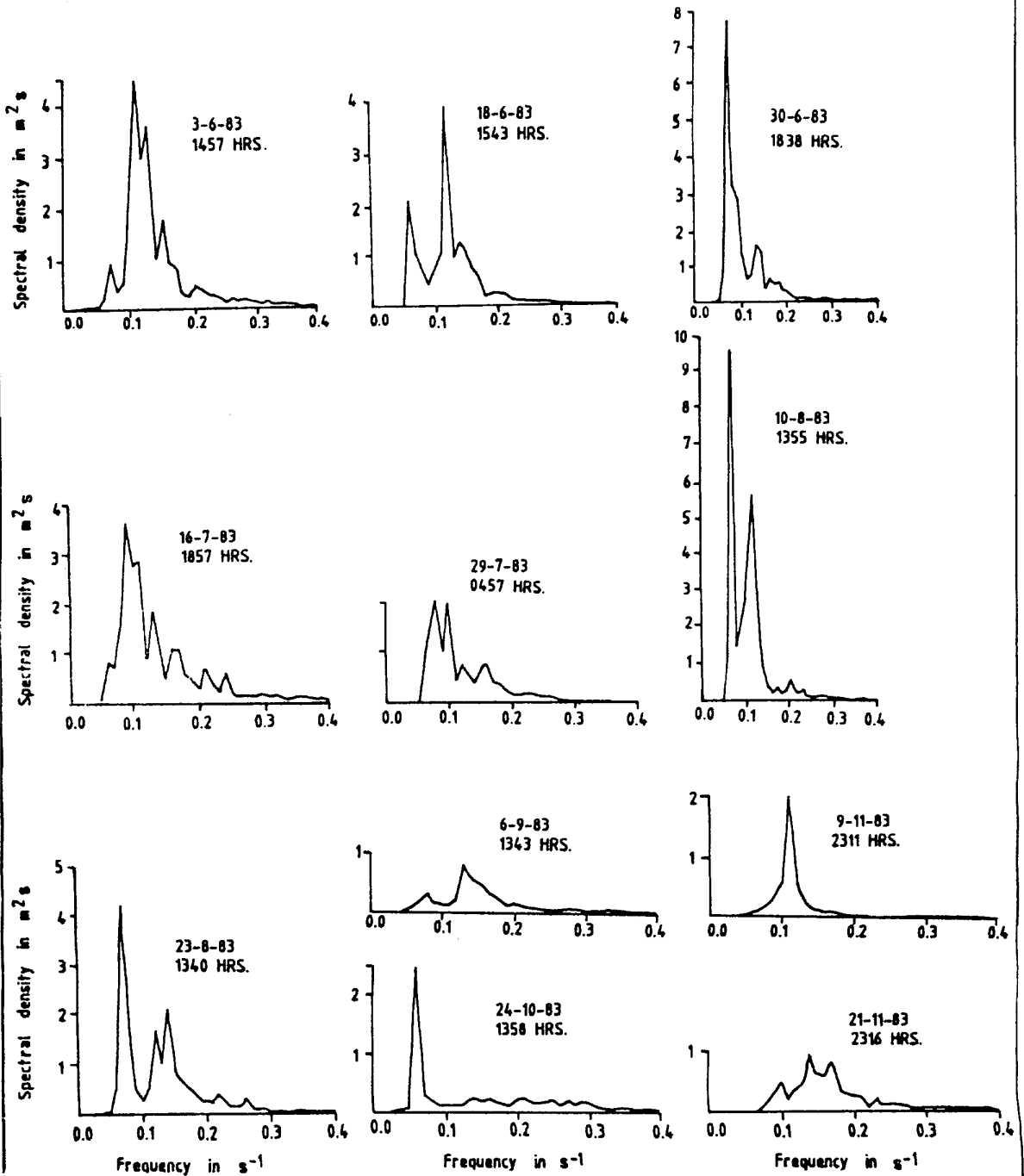
Fig 14 presents a plot of zero crossing wave periods ( $T_z$ ) computed by the Tucker's method against that estimated by the spectral method ( $T_{m02}$ ). There is a considerable scatter of data on either side of the line of best fit with a fairly low regression coefficient ( $= 0.47$ ). The linear regression line obtained by the method of least squares indicates that the zero crossing wave periods obtained by the Tucker's method are considerably higher than those obtained by the spectral method. Interestingly, somewhat good correlation was found between the zero crossing wave periods computed by the statistical ( $T_{zs}$ ) and the spectral ( $T_{m02}$ ) methods as shown in Fig 15.

Fig 16 shows a relationship between the significant wave height ( $H_{ss}$ ) and the mean wave height ( $H_{ms}$ ) computed by the zero upcrossing (statistical method),

$$H_{ss} = 1.75 H_{ms}$$

The theoretical relationship based on the Rayleigh distribution is  $H_s = 1.6 H_m$  which is on the assumption that the ocean waves possess a narrow band spectrum<sup>3</sup>. Values computed by the Tucker's method were used to determine a

FIGURE 9  
A FEW SELECTED WAVE SPECTRA COMPUTED FOR THE WAVE MEASUREMENT PERIOD



relationship between maximum wave height and significant wave height as shown in Fig 17. The method of least squares gave a line of best fit with regression coefficient =

0.94 as,

$$H_{max} = 1.53 H_s$$

The significant wave period,  $T_{ss}$  (average period of the

FIGURE 10  
A FEW SELECTED WAVE SPECTRA COMPUTED  
FOR THE WAVE MEASUREMENT PERIOD

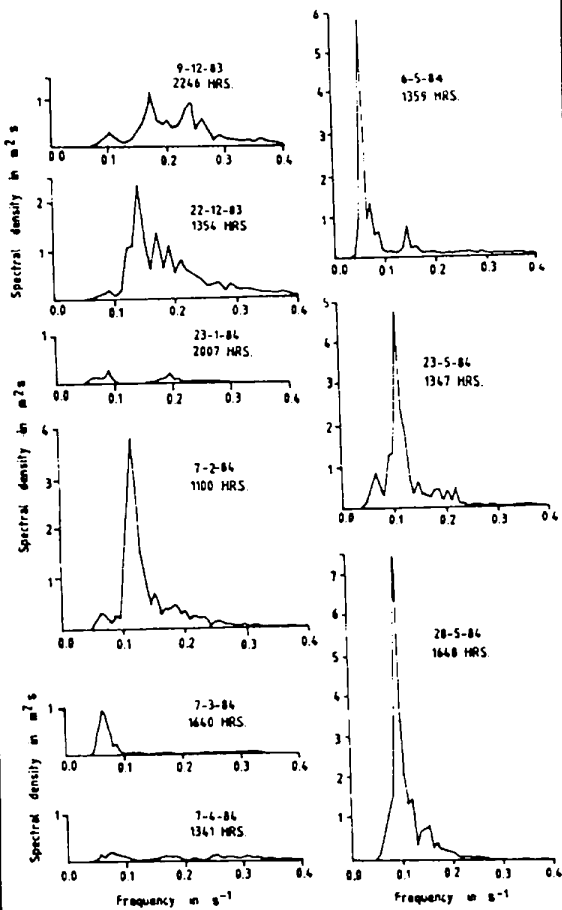
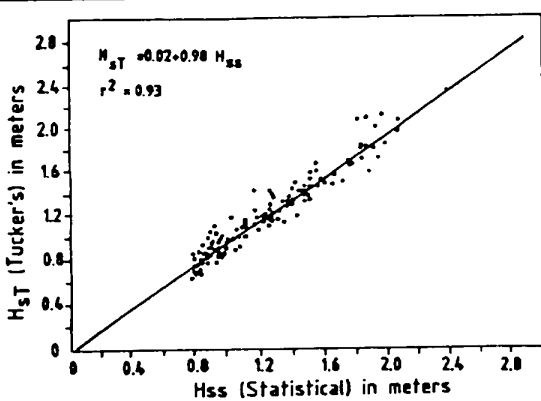


FIGURE 11  
RELATIONSHIP BETWEEN SIGNIFICANT WAVE  
HEIGHTS BY TUCKER'S AND STATISTICAL  
METHODS



one third highest waves) was plotted against the zero crossing wave period,  $T_{zs}$  obtained by the zero upcrossing statistical method as in Fig 18. Considerable scatter in the points on either side of the line of best fit can be seen giving a low

FIGURE 12  
RELATIONSHIP BETWEEN SIGNIFICANT WAVE  
HEIGHTS BY TUCKER'S AND SPECTRAL METHODS

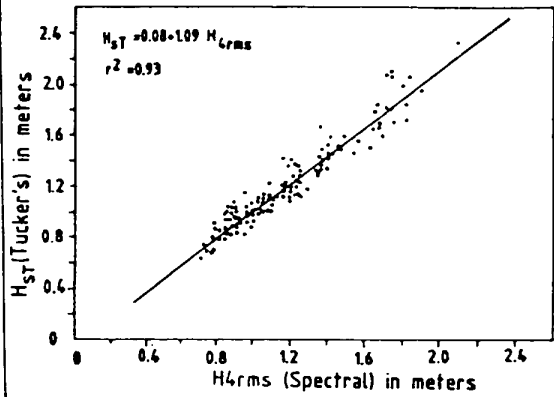


FIGURE 13  
RELATIONSHIP BETWEEN SIGNIFICANT WAVE  
HEIGHTS BY STATISTICAL AND SPECTRAL  
METHODS

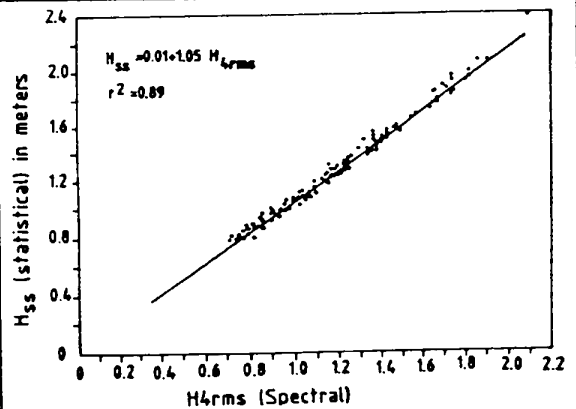
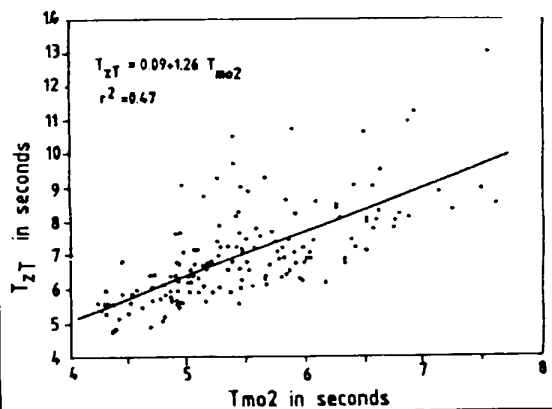


FIGURE 14  
RELATIONSHIP BETWEEN ZERO CROSSING WAVE  
PERIODS BY TUCKER'S AND SPECTRAL METHODS



regression coefficient. The relationship obtained with regression coefficient = 0.48 is,

$$T_{SS} = 0.38 + 1.29 T_{ZS}$$

The plots of Figs 19, 20, 21 and 22 show that there is hardly any correlation between significant wave heights,

FIGURE 15  
RELATIONSHIP BETWEEN ZERO CROSSING WAVE PERIODS BY STATISTICAL AND SPECTRAL METHODS

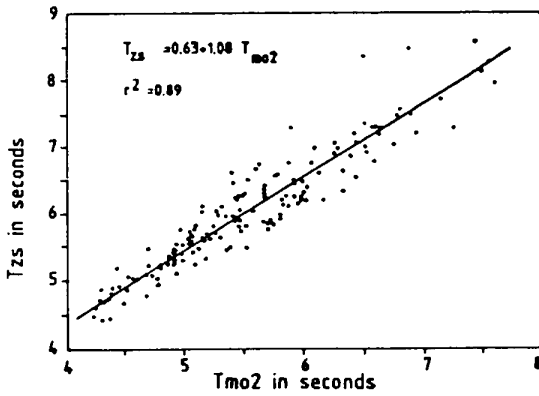


FIGURE 18  
RELATIONSHIP BETWEEN SIGNIFICANT AND ZERO CROSSING WAVE PERIODS (STATISTICAL)

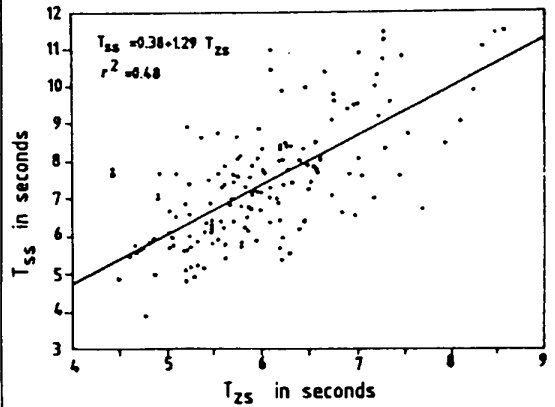


FIGURE 16  
RELATIONSHIP BETWEEN MEAN AND SIGNIFICANT WAVE HEIGHTS (STATISTICAL)

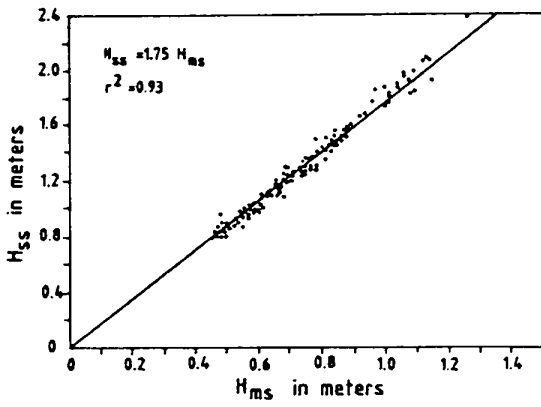


FIGURE 19  
RELATIONSHIP BETWEEN SIGNIFICANT WAVE HEIGHT AND ZERO CROSSING WAVE PERIOD (TUCKER'S)

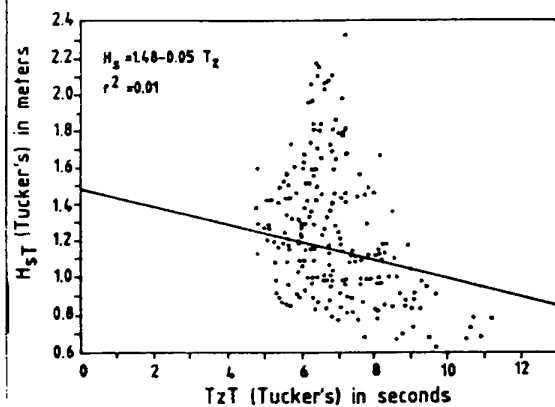


FIGURE 17  
RELATIONSHIP BETWEEN SIGNIFICANT AND MAXIMUM WAVE HEIGHTS (TUCKER'S)

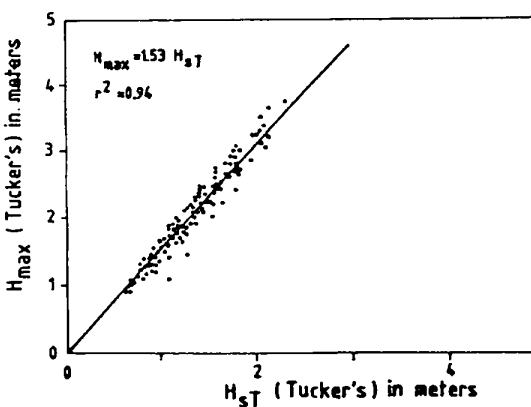
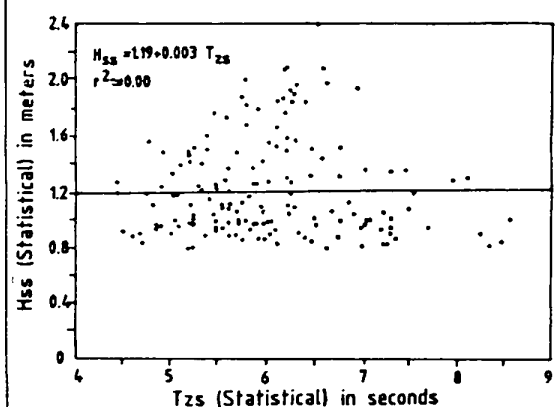
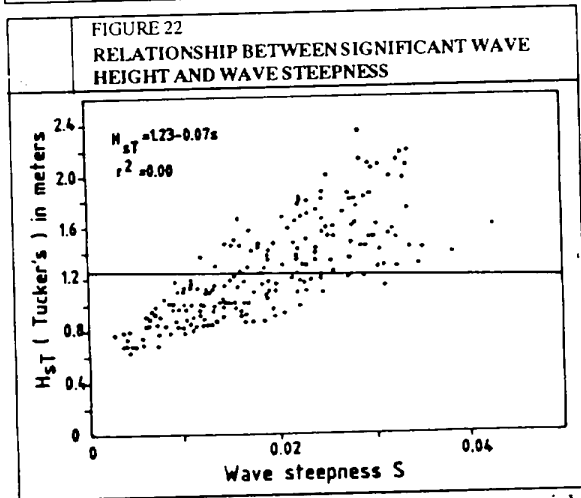
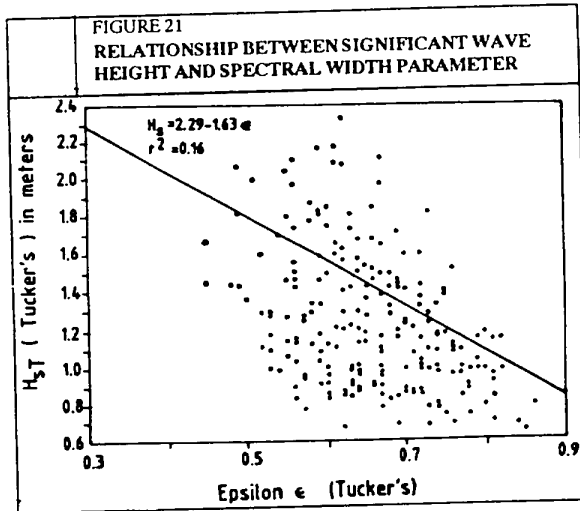


FIGURE 20  
RELATIONSHIP BETWEEN SIGNIFICANT WAVE HEIGHT AND ZERO CROSSING WAVE PERIOD (STATISTICAL)



zero crossing wave periods; spectral width parameters, and wave steepnesses. Fig 20 does indicate, however, that higher waves are not associated with longer periods as observed by many other investigators<sup>4-6</sup>. Some correlation between  $H_s$  and  $\epsilon$  is observed in Fig 21 indicating that the

higher waves are associated with lower values of the spectral width parameter and vice versa. This may be explained here as follows. The wave energy is distributed in a wide frequency band in the case of the sea with



predominantly smaller waves. The heigher waves mainly representing the swell would have smaller spectral width parameter indicating that the wave energy here is distributed

in a comparatively narrow frequency band.

## CONCLUSION

The present study of one year duration shows that the wave heights are steeper and heigher during the southwest monsoon period from June to September. The spectra are mostly single peaked indicating that the waves mostly arrive from one generating area in this region. Good correlation has been observed between the significant wave heights obtained by the three methods. Similarly, good correlation has been obtained between the significant wave height, mean wave height and maximum wave height computed from each record. The inter-relationship between other wave para- meters could not be well established due to considerable scatter of the points in the plots.

## ACKNOWLEDGMENTS

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