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# ON SOME PHENOMENA ASSOCIATED WITH WAVES NEAR COCHIN COAST*

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ABSTRACT

Predominant deep water wave characteristics off Cochin have been assessed on seasonal basis from the Indian Daily Weather Reports for the period 1960-64. Refraction and direction functions at five points along the Cochin Coast have been evaluated from the refraction diagrams drawn for the above wave parameters. Shallow water wave energy spectra and possible littoral currents have been presented and discussed. Conclusions are drawn regarding the distribution of wave energy along the coast and possible zones of erosion and accretion.

## INTRODUCTION

MANY phenomena take place as the waves approach the coast. Mention may be made of a few examples such as 1. Wave refraction; 2. Wave breaking; 3. Transfer of energy to the shore and shore structures; 4. Development of a long shore current and consequent transport of beach material and 5. Erosion and accretion. Studies have been made regarding wave refraction along some parts of east and west coasts of India (Sivaramasastry, 1956; Das, *et al.*, 1966). The problems of long shore currents and erosion and accretion have been discussed in relation to wave propagation near the shore. A speciality of the Kerala Coast is the presence of mud banks. These mud banks modify the wave pattern to some extent and a somewhat preliminary examination of the mud banks along with the probable causes of their formation has been made by Varma (1969); one such mud bank is found off Cochin. Some waves may break around this mud bank while some of them may reach the coast. The waves that reach the coast import energy to the shore resulting in erosion and accretion and littoral transport. In this paper a detailed study has been presented concentrating over a relatively small area around Cochin. The problem of erosion is of direct importance to shore establishments such as Coast Battery and Sea wall construction. It is intended in this report to understand the nature of deep water waves, refraction, development of littoral current, etc. From this study, it became possible to delineate the points of convergence and divergence along the coastal strip, and also most probable deep water directions for which the energy is high at the shore have been established.

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## METHOD OF STUDY

Wave parameters like wave height, period and direction of deep water waves off Cochin during various seasons over a period of five years (1960-64) have

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been obtained from Daily weather reports of India meteorological department. Frequency analysis (Fig. 1) and wave energy spectra (Fig. 2) for deep water waves were worked out for different seasons namely March-April, May-September, October and November-February from the collected data. Thea clssification of the seasons is based on the investigations made by Vijayarajan *et al.*, (1970). From the period,

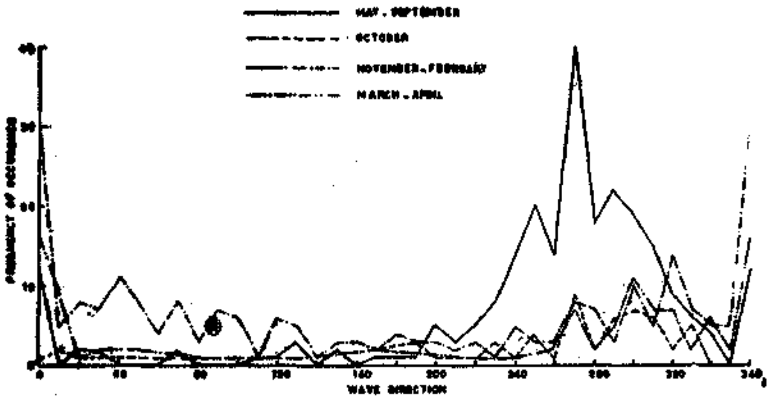

Fig. 1. Seasonal distribution of deep water wave direction off Cochin (1960-64).

direction frequency and energy distribution selection has been made regarding most probable prevailing directions and periods. Using the latest bathymetric chart around Cochin (No. 2004) wave refraction diagrams have been drawn for selected periods and directions following the method of Arthur *et al.* (1948) at few selected points along Cochin Coast. The selected periods and directions are 4,5,6 and 7 secs and 240° to 300° at an interval of 15° respectively. A sample chart showing the refracted rays is shown in Fig. 3. Refraction and direction functions and directions at the coast (Pierson, W.J. Jr. *et al.*, 1955) have been evaluated at the selected points along the coast from the refraction diagram. The equation used for the evaluation of refraction function at any point is given by

$$R = [K(f,\theta)]^2 = \frac{b_d/b}{\left(c/c_d\right) + \frac{4\pi d}{L}\,\frac{1}{\sinh\frac{4\pi d}{L}\left(\frac{c_d}{c}\right)}}$$

where L is the wave length, *d* is the depth at the point of interest, *Cd* and *C* are the wave velocities in deep water and at depth of interest respectively.

Direction function ( $\theta$ $(f,\theta)$ ) is expressed in terms of the angle between a line perpendicular to the depth contour at the point of interest and the line of approach of wave.

Distribution of refraction function and final direction are presented in Fig. 4. Wave heights at the points of interest were calculated using the refraction function and deepwater wave height. Energy spectra (Pierson W.J.Jr. *et al.*, 1955) was drawn from the wave height and the corresponding wave period at the shore. A qualitative assessment of the longshore currents based on the refraction and direction functions and shallow water/wave energy has been attempted.

## DISCUSSION OF RESULTS

### *A. Frequency and spectral analysis of deepwater waves:*

Frequency analysis of the direction of deepwater waves off Cochin during various seasons (Fig.1) indicates that waves are very prominent within 240°-300° especially during May/September. Direction of waves during November-February is evenly distributed with a high frequency of occurrence in 260-120 through 000°. However, waves within 360°-120°. move away from the coast and hence do not have any significant contribution to the generation of longshore currents. Directions 300°-360° were not considered because of the plotting errors involved.

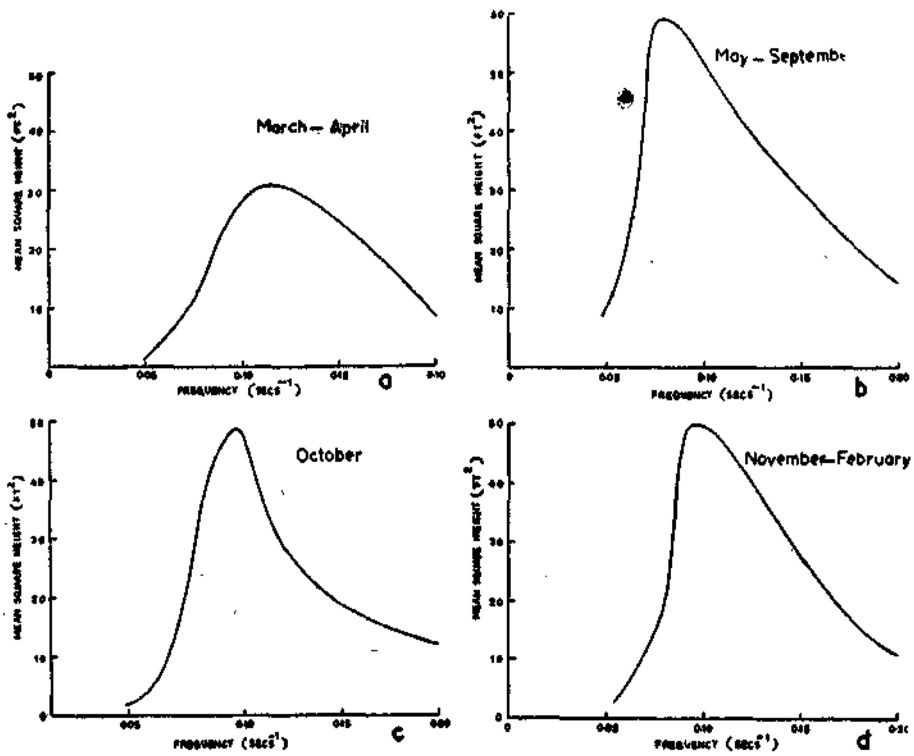


Fig. 2. Deep water energy spectrum for the period 1960-64: a March-April; b. May - September; c. October; and d. November -February.

The frequency associated with maximum energy in the deepwater is 0.08 (Fig.2) during May-September and it shifts to higher frequency side *i.e.,* 0.10 during October to February. The peak in the energy curve becomes flat during March-April indicating that the energy is uniformly distributed over a wide band of frequencies namely from 0.1 to 0.14 corresponding to 10 and 7 seconds respectively (Fig. 3 a - d). During the southwest monsoon energy associated with long period waves is high and hence their height may become such that they break before reaching the coast. But, it is seen, however, from the shallow water energy that 10 seconds period waves reach one fathom line without breaking.

*B. Refraction and Direction functions:*

A sample chart of refraction diagram is shown in Fig. 3. Distribution of refraction function and final wave directions at the shore in polar diagrams is shown in Fig. 4 for all stations at 1 fathom contour. It can be seen from the graphs that the refraction function is much higher for waves of periods 6 and 7 seconds at stations B, C and D, for directions from 240° to 285° while at stations A and E the function is one or less than one except for direction 255° at station A and 240° and 270° at station E.

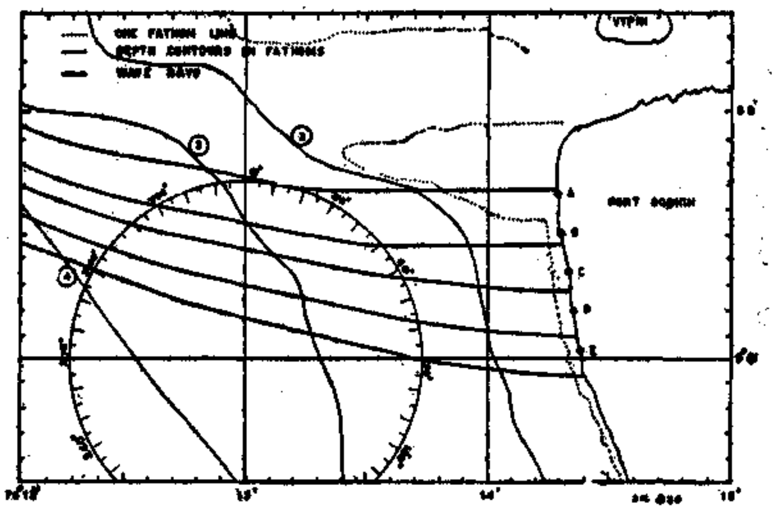

Fig. 3. Refraction diagram for the period 5 Secs and deep water wave direction 300° N.

Direction of the waves at the coast changes from 236° to 270° corresponding to deepwater directions of 240° to 300° respectively. Waves in the direction 240° in deepwater do not change considerably in direction after reaching the shore. Waves between 270° to 300° change their directions to about 250° to 270° at the shore.

The distribution of direction function is shown in Table 1, from which it can be seen that the direction function has both +ve and —ve values. In case of +ve values, the direction of long shore current is northerly while southerly current is indicated with —ve values of direction function. At station A, the direction function is—ve and high for all deep water directions while at all other stations this function has both +ve and —ve values for various directions.

From the stt dy of the refraction function and direction at the shore together with the direction function at five stations, it may be infered that the changes which are significant from station to station and direction to direction for waves of periods 6 and 7 seconds may be attributed to the shoaling effect of the mud bank off Cochin. It is noteworthy that the refraction function abruptly reduces at all stations for wave direction 300°.

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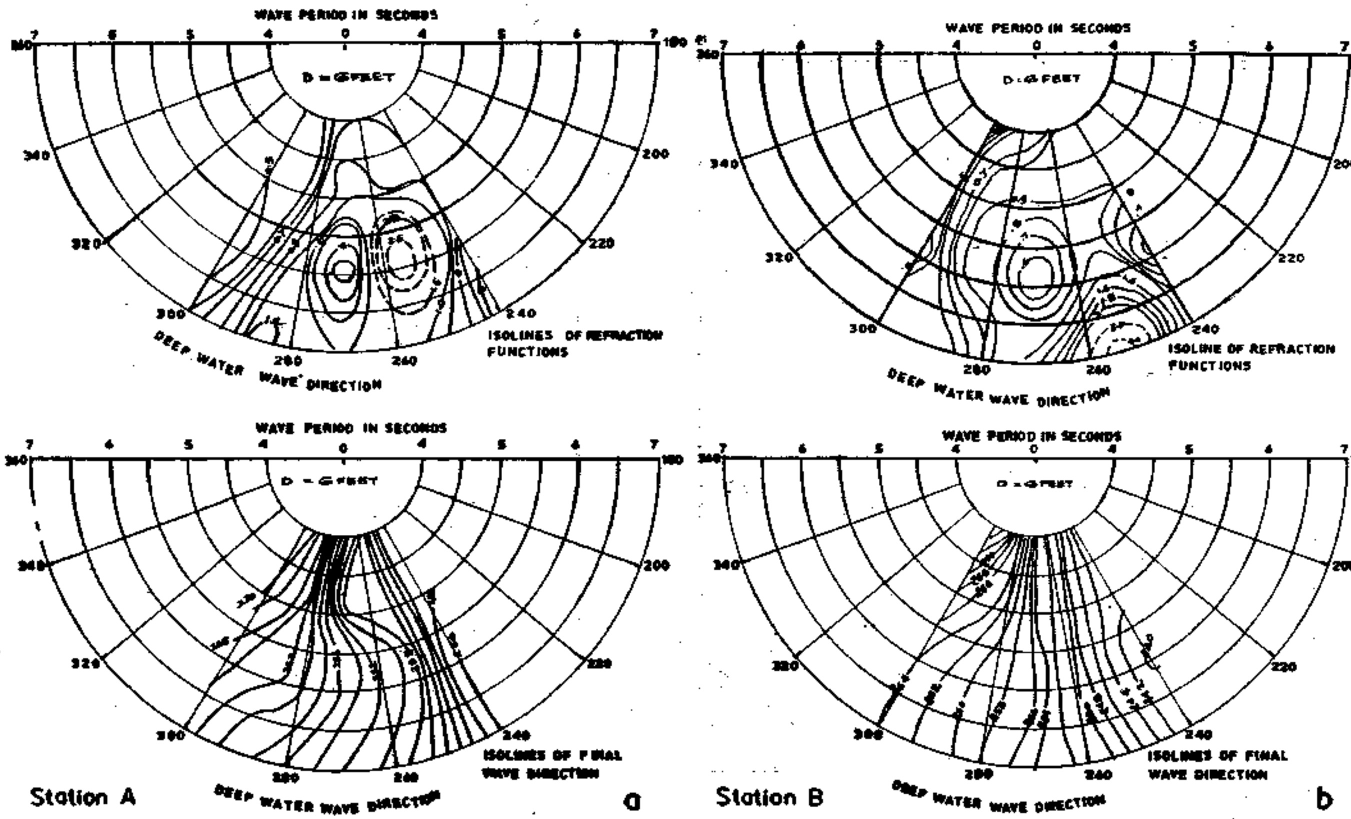


Fig. 4 – a and b: Stations A and B.

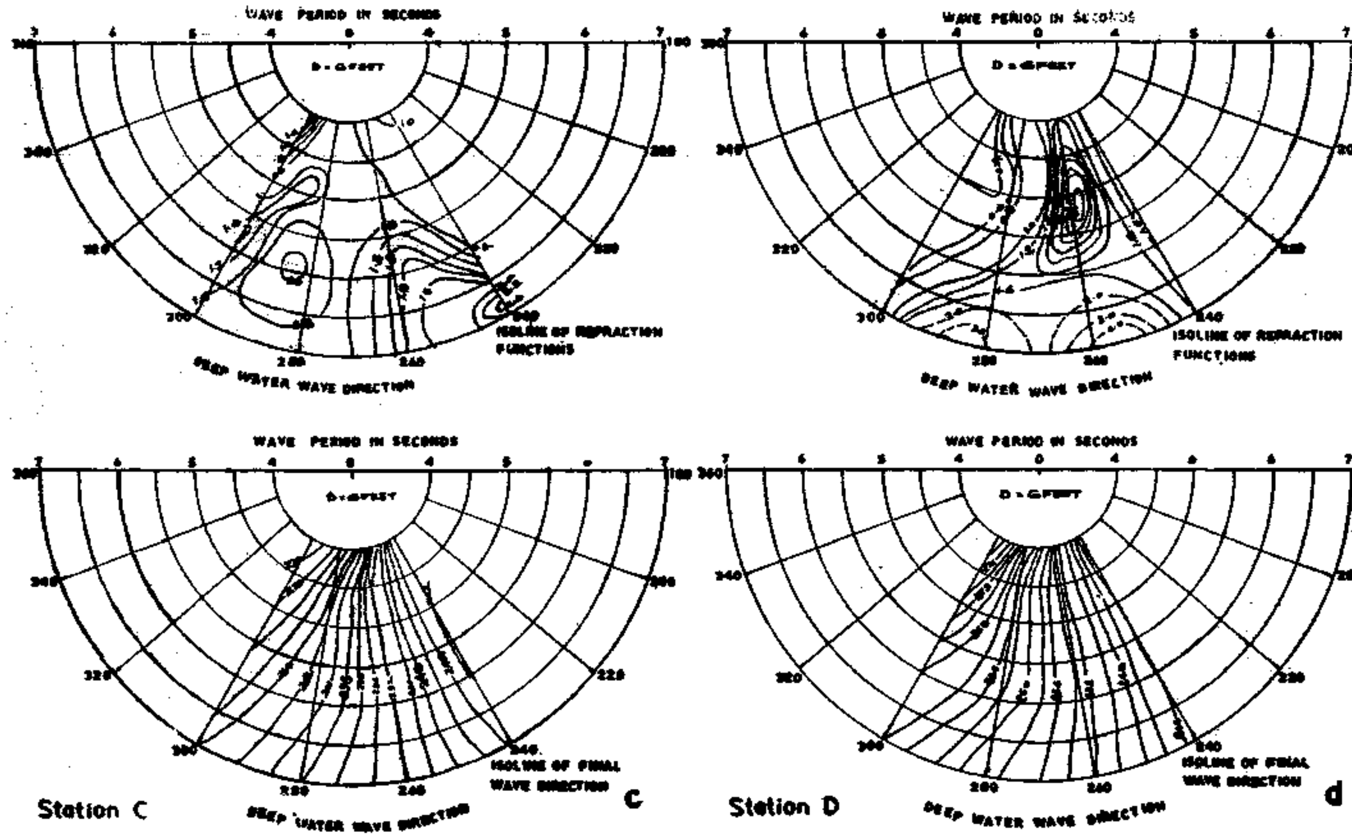


Fig. 4 - c and d: Stations C and D.

*C. Shallow water energy and direction:*

Energy distribution (Fig. 5) for four seasons shows that in general the energy of the shallow water waves is less than that of corresponding deepwater waves. During May to September the energy is high for waves, having a deepwater wave direction 270°. For waves of frequency 0.18 maximum energy is found for direction 240° in deep water.

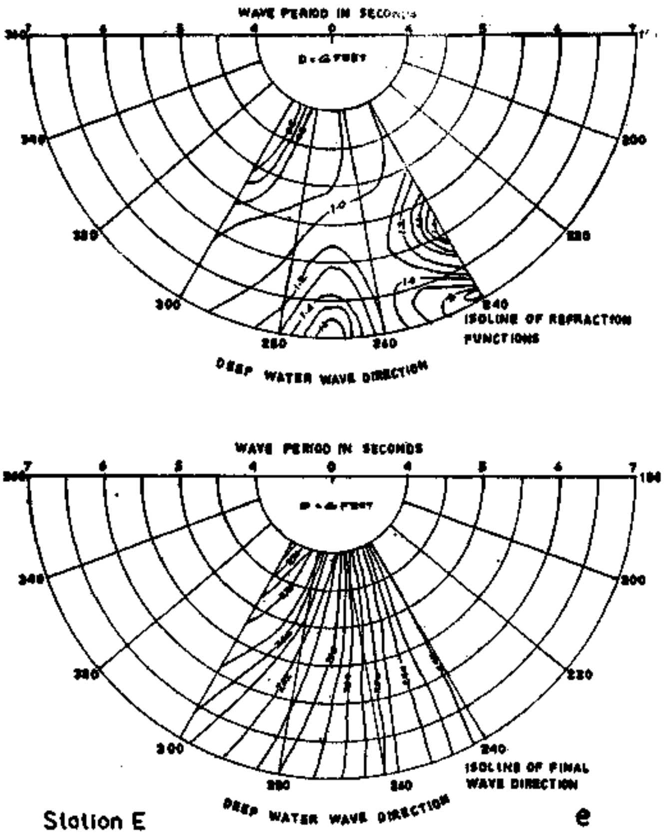


Fig. 4 e. Station E.

But, for deepwater direction 270° and 300° the maximum energy is found at frequency 0.12 corresponding to a shallow water direction 249°. During October, maximum energy is associated with waves of frequency 0.16 for deep water direction 270°. The maximum energy has been found with waves of frequency 0.16 and deep water direction 240° during November-April with 236° as the shallow water direction.

From these it may be mentioned that the energy is maximum with waves of frequency 0.16 for all seasons except May-September. The distribution of energy in shallow water clearly indicates that during the southwest monsoon, the maximum energy is due to long period waves having large heights without breaking at the 1 fathom contour. When such high energy waves impinge the coast, they give rise to severe erosion.

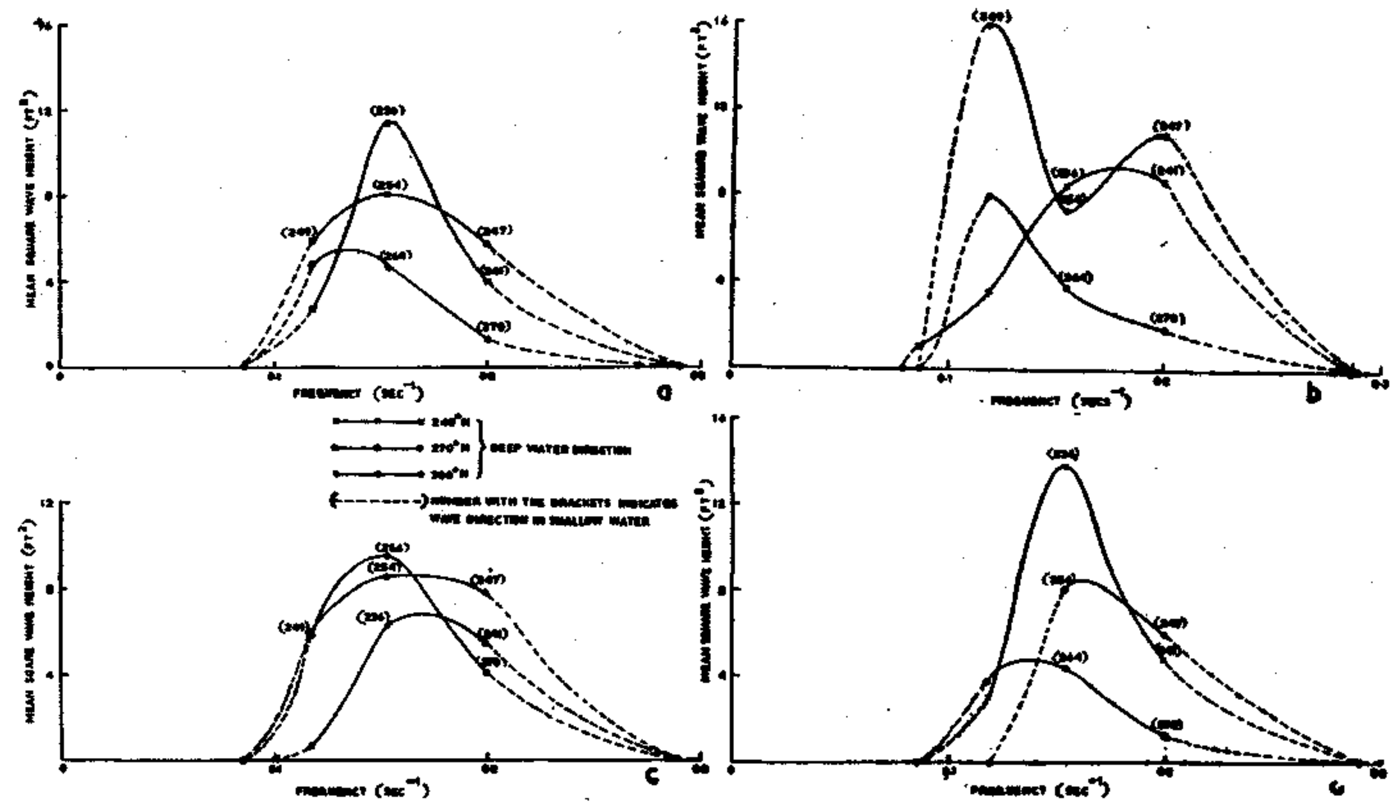

Fig. 5. Shallow water wave energy Vs frequency: a. March–April; b. May-September; c. October; and d. November-February.

*D. Littoral Currents:*

Directions of littoral currents were obtained from the direction functions at five stations along Cochin Coast for different deepwater directions (Fig. 6). From the figure it can be seen that the littoral currents due to waves having deepwater directions 240° to 285° are convergent between A and B indicating that accertion takes place at this place. For deep water directions 270° and 285°, which are prominent during May to Sept., erosion takes place between D and E, and C and E respectively. Again the refraction functions are very high around D for 7 seconds in these two directions. From these it can be seen that waves of period 7 seconds and directions around 270° to 285° cause severe erosion around D during May to September. Finally for direction 300°, the direction of littoral current is southerly.

TABLE 1. *Direction function in terms of Deep Water wave direction and period.*

| Station Number | Direction period | 240° | 255° | 270° | 285° | 300° |
|---|---|---|---|---|---|---|
| | 4 | -54 | -56 | -51 | -65 | -80 |
| | 5 | -56 | -59 | -49 | -55 | -71 |
| A | 6 | -41 | -55 | -55 | -57 | -66 |
| | 7 | -40 | -50 | -49 | -62 | -64 |
| | 4 | +18 | +12 | -2 | -7 | -14 |
| | 5 | +17 | +11 | +5 | +4 | -6 |
| B | 6 | +21 | +10 | +6 | +2 | -2 |
| | 7 | +20 | +19 | +7 | +3 | -2 |
| | 4 | +19 | +11 | -1 | -5 | -11 |
| | 5 | +24 | +10 | +3 | +1 | -8 |
| C | 6 | +24 | +16 | +4 | +2 | -5 |
| | 7 | +24 | +13 | +10 | +4 | -2 |
| | 4 | +14 | + 5 | -3 | -14 | -18 |
| D | 5 | +14 | + 9 | +4 | -6 | -11 |
| | 6 | +18 | +11 | +2 | -5 | -6 |
| | 7 | +14 | + 8 | +2 | -6 | -4 |
| | 4 | +12 | +2 | -8 | -16 | -15 |
| | 5 | +10 | +3 | -3 | -23 | -9 |
| E | 6 | + 4 | +8 | -1 | -9 | -6 |
| | 7 | +13 | +4 | -0 | -2 | -3 |

From actual observations, it has been found that beach is built up between A and B and is eroded around D. A few measurements have been made regarding littoral current using floats and theodolites at stations A and B and it has been found that the southerly current at A has a velocity of 11.7 cm / sec and a northerly current at B has a velocity of 16.5 cm/sec.

Because of the presence and movement of mud bank, a bathymetric survey of the area off Cochin Coast will help to know the complicated refraction pattern within

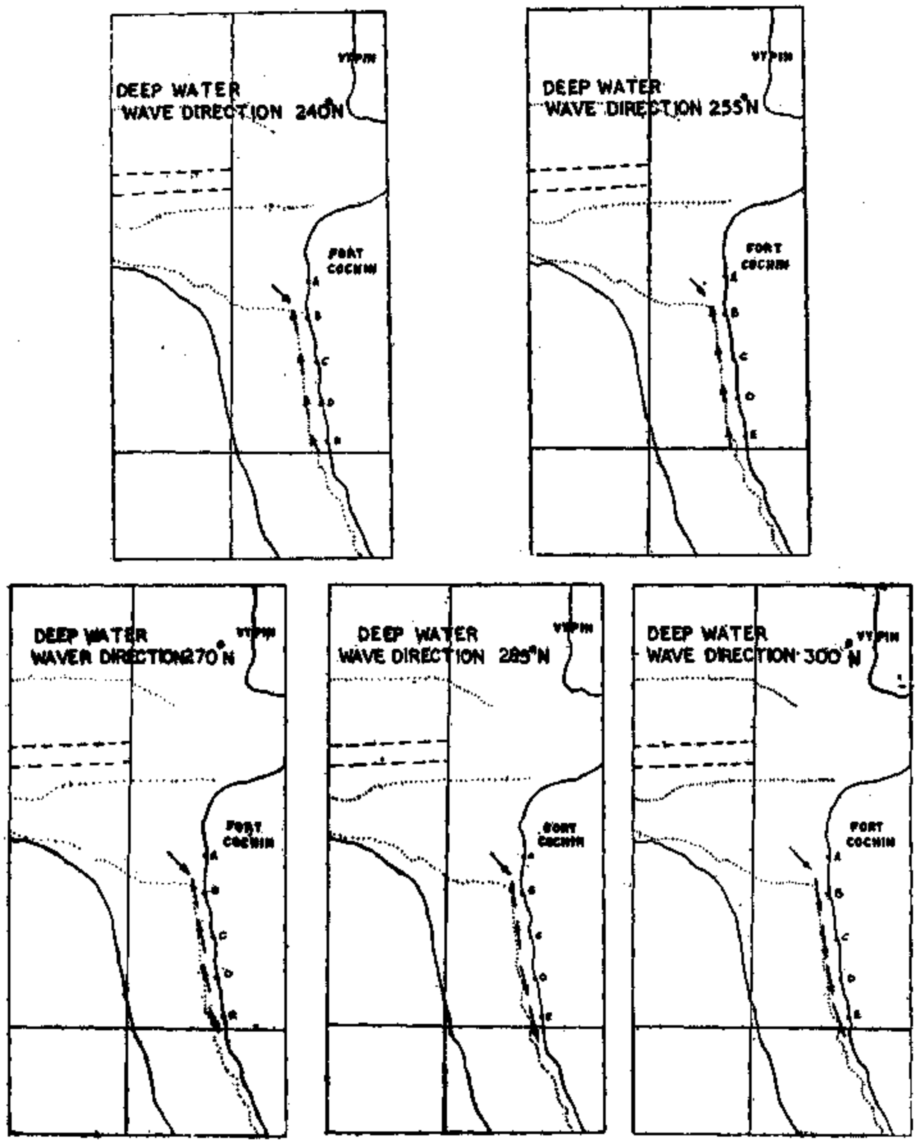


Fig. 6. Direction of littoral transport.

the area in detail. Also systematic direct observations of littoral transport along with the wave characteristics will help in understanding the phenomena more closely and in suggesting remedies for erosion.

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