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Estimated monthly mean wave heights in Indian seas

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सार — भारतीय समुद्रों के तरंग सम्बंधी आंकड़े दुर्लभ हैं। तटीय और अपतटीय संस्थापनाओं की योजना बनाने और महासागर में जाने वाले वेसल के मार्ग निर्धारण के लिए माध्य तरंग की उच्चता महत्वपूर्ण होती है। इस अध्ययन में, अर्द्ध आनुभविक पवन तरंग समीकरण का प्रयोग करके वायुमंडलीय माध्य पवनों पर आधारित तरंग उच्चता के आकलन का प्रयास किया गया है। ISMEX-73 और MONEX-79 के दौरान एकत्रित वास्तविक तरंग प्रेक्षकों के साथ आकलित तरंग उच्चता की तुलना की गई है और इन्हें परस्पर तुलनीय पाया गया है। बाम्बे हाई तेल रिगो से लिए गए तरंग प्रेक्षक भी इन आकलित मूल्यों के समान पाए गए हैं।

ABSTRACT. Wave data over Indian seas are rare. For ocean going vessels' routing and planning of coastal and offshore installations, mean wave heights are important. An attempt has been made in this study to estimate the wave heights based on climatological mean winds using a semi-empirical wind-wave equation. Computed wave heights have been compared with actual wave observations collected during ISMEX-73 and MONEX-79 and have been found comparable. Wave observations from Bombay High oil rigs also have been found comparable with computed values.

1. Introduction

Transportation of bulk cargo, at cheaper rates, is done globally through shipping only. The needs of modern shipping industry are mainly safety of navigation, reliable weather routing and pre-estimation of extreme values of wave heights. The knowledge of wave heights in different months and seasons is also important for planning of coastal and offshore installations. Monthly average values of wave heights are also helpful for weather routing as a guide to the forecaster for predicting wave heights based on prevailing conditions and a knowledge of normal situations.

Mukherjee and Sivaramakrishnan (1982) studied the wave patterns over the Arabian Sea based on Bombay High wave data for the monsoons of 1976 to 1978. They have studied and projected the weekly variations of wave patterns over the region. Ray (1988), with the help of a semi-empirical model, simulated waves generated by cyclonic storm in the region.

As the main governing force for generation, growth and movement of waves is the surface wind, many empirical formulations are available in oceanographic literature for the computation of waves. WMO (1976) *Manual on Handbook of wave analysis and forecasting* presents some simple graphical methods of predicting ocean waves based on wind speed and fetch. U.S. Army (1981) publication, *shore protection manual* (wave and water level predictions) deals in detail simple operational models for use in wave forecasting.

2. Data

For computation of waves monthly mean wind speed over the Indian Ocean, the Arabian Sea and the Bay of Bengal have been used from Hastenrath and Lamb (1979). For verification of the computed values, observations collected during ISMEX-73 and MONEX-79 have been used. Besides, wind and wave data available from oil rigs in Bombay High region have been used.

3. Methodology

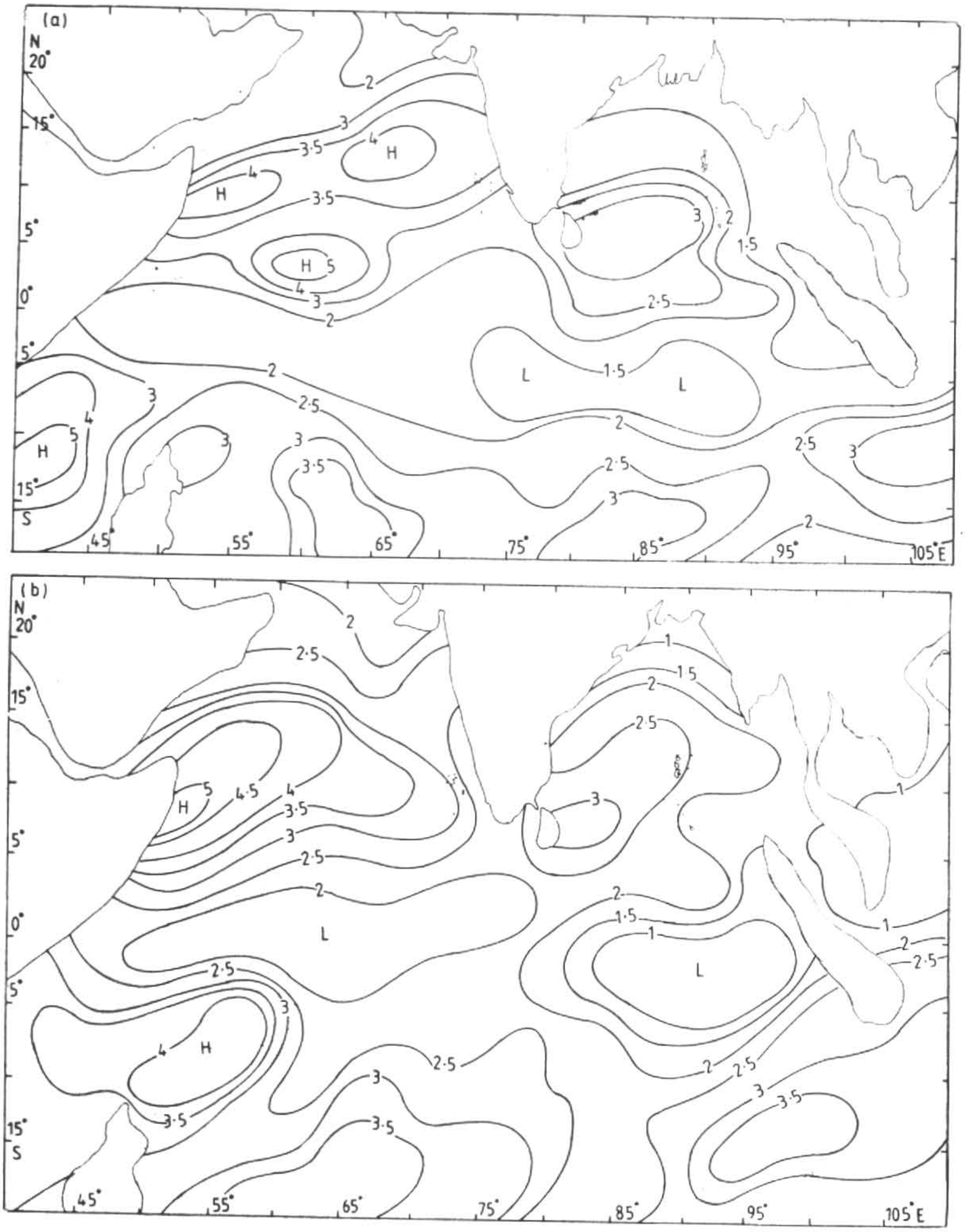
The area bounded by 20°S-25°N and 40°E-110°E have been divided into 5-degree Lat./Long. square. Mean wind speed in each of these squares is used. As per convention, wave growth formulae and nomograms are expressed in terms of wind stress factor U_A (adjusted wind speed) the mean wind speed at each square is converted to a wind stress factor by the following formula :

$$U_A = 0.71\ U^{1.23} \tag{1}$$

where U is the mean wind speed in mps. Significant wave height is calculated at each 5-degree square with the help of following empirical relation :

$$\frac{gH}{U_A^2} = 1.6 \times 10^{-3} \sqrt{\frac{gF}{U_A^2}} \tag{2}$$

where, H is the significant wave height, g is the acceleration due to gravity, F is the fetch and U_A is the wind stress factor.



Figs. 1 (a & b). Wave heights (m) : (a) Observed and (b) Computed

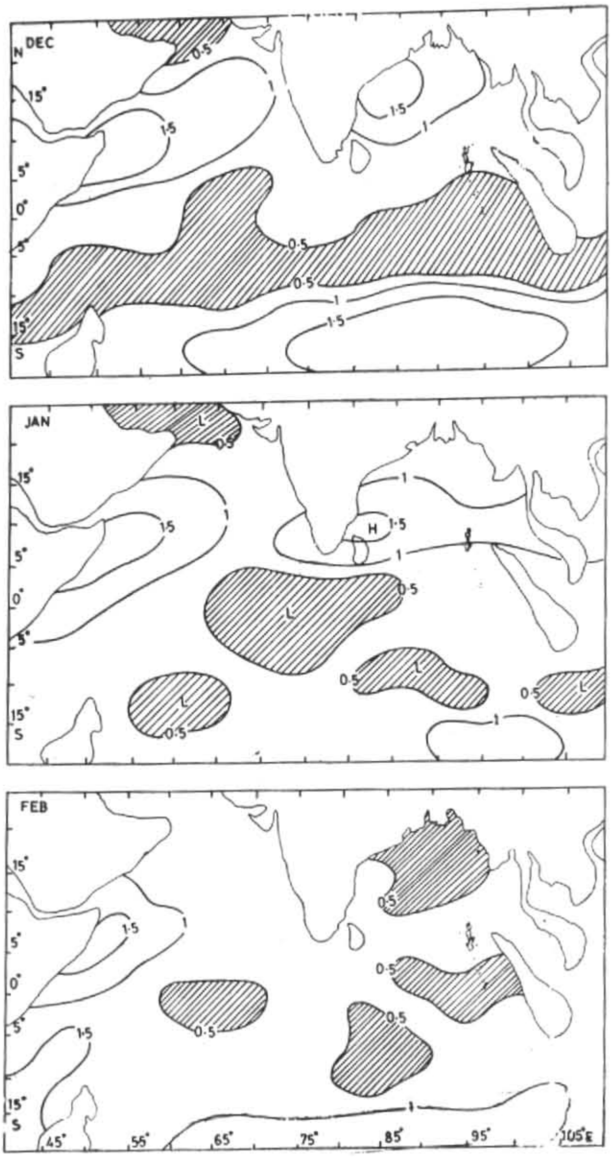


Fig. 2. Mean wave heights (m) : Winter (Dec-Feb)

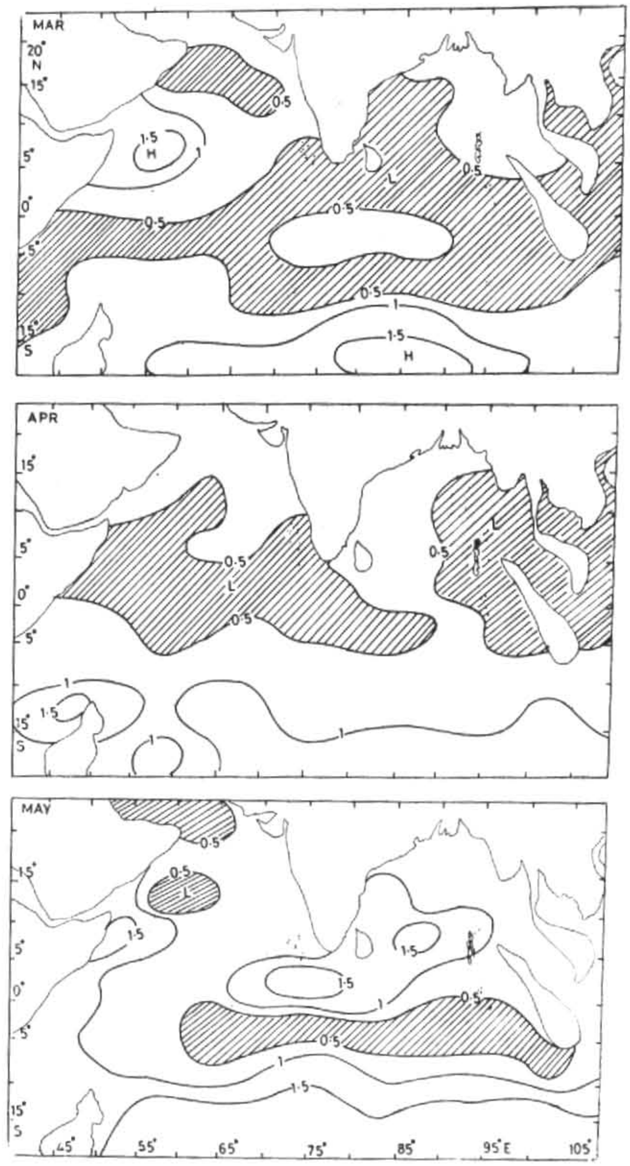


Fig. 3. Mean wave height (m) : Pre-monsoon (Mar-May)

For our use in present study where wind speeds are mean monthly values we have used a fixed fetch length of 200 km. The wave heights thus computed at each 5-degree square constitute monthly wave data charts. These charts are analysed and the isopleths of wave heights drawn for use by operational forecasters and planners.

4. Discussion of results

For the purpose of verification of the results we have presented in Figs. 1 (a & b) the actual and computed wave charts respectively for one representative week in June 1979. This has been done as weekly average wind speeds at 5-degree Lat./Long. areas are available for the period in 1979. It may be seen from the figures that areas of high and low wave heights are more or less coincident. Actual values of wave heights, however, are at variance at places. This is due to the fact that some of the wave observations are not consistent with the prevailing wind speeds.

In what we present in Figs. 2-5 are the computed normal wave heights for four seasons: winter (December-February) in Fig. 2, pre-monsoon (March-May) in Fig. 3, monsoon (June-September) in Fig. 4 and post-monsoon (October-November) in Fig. 5.

From Fig. 2 we note that areas of high amplitude waves are restricted only to the coast of east Africa. High amplitude waves are also seen over south Indian Ocean around Mascarene High.

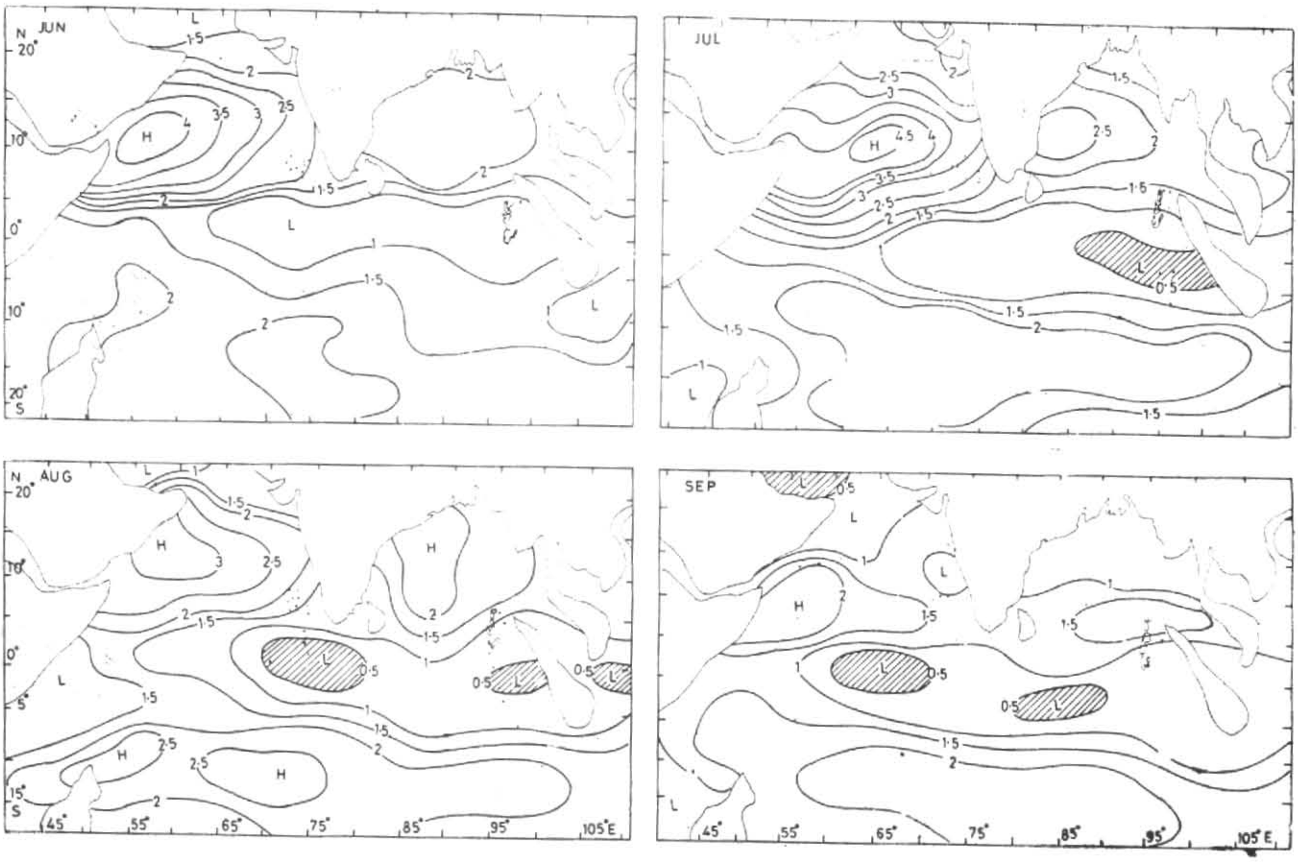


Fig. 4. Mean wave height (m) : Monsoon (Jun-Sep)

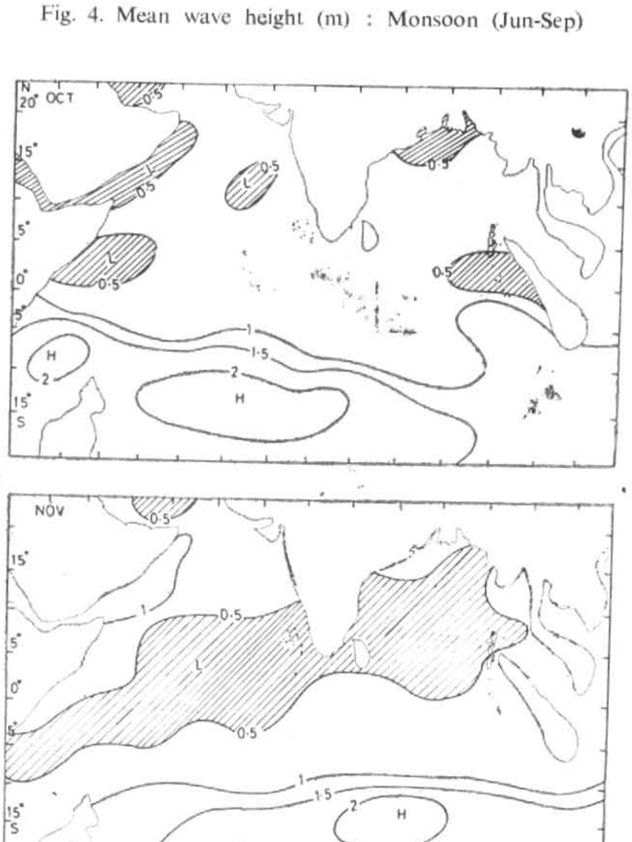


Fig. 5. Mean wave height (m) : Post-monsoon (Oct & Nov)

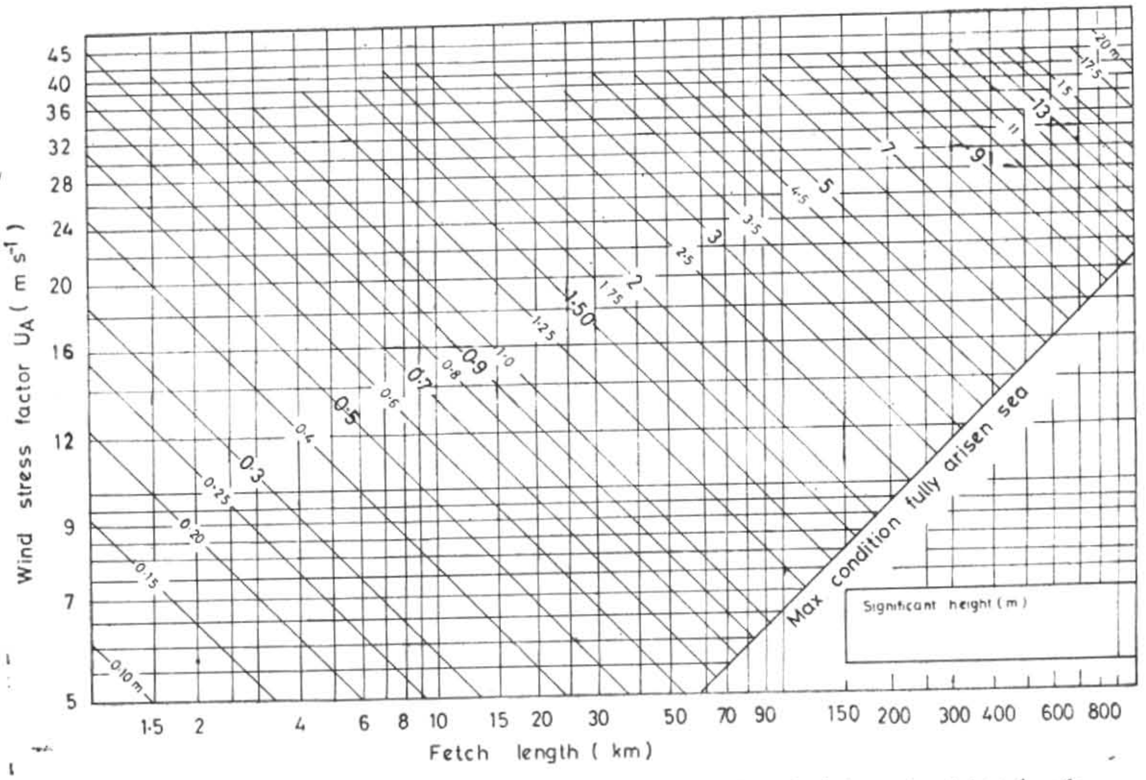


Fig. 6. Nomograms of deep water significant wave curves as function of wind speed and fetch length

During the pre-monsoon (Fig. 3) the southern hemispheric high amplitude waves start moving north west and cross the equator. This phenomenon is clearly visible from the normal wave charts for March, April and May. This diagram clearly indicates the transition from winter to summer (monsoon) in the same way the transition takes place in atmosphere.

Strong monsoon winds produce high amplitude waves as seen in Fig. 4. Here also one notices the transition from onset phase to active and later the withdrawing phases of the summer monsoon. During June, with the burst of strong cross-equatorial wind flow, the high amplitude waves mainly occupy the coast of east Africa and the central Arabian Sea. During July when the monsoon is established over the whole region we note that the high amplitude waves are well distributed over the region north of the equator. South of the equator is generally occupied by low amplitude waves. With the start of withdrawal of the monsoon from Indian subcontinent in September we note that the strength of the the waves also reduce and the high amplitude waves start migrating back to the southern hemisphere.

After the withdrawal of the southwest monsoon Indian seas are mostly free from high amplitude waves and the prevailing areas of bigger waves are mainly the southern Indian Ocean. The regime of low amplitude waves extends throughout the northern seas in November.

5. Spot wave computation

For spot computation of wave heights based on wind speeds and fetches a nomogram prepared from the Eqns. (1) and (2) is presented in Fig. 6. This nomogram can be used to suppliment the normal wave charts depending an actual day to day situations.

6. Conclusion

In the absence of adequate wave observations over the area the computed normal wave charts may be used as a guiding material for the operational forecasters, planners of bulk cargo carriers and coastal engineering industry. With the help the nomogram, a more accurate assessment of the wave heights can be made based on actual wind speed and fetch length.

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