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GEOMORPHOLOGY OF THE COASTAL ZONE AROUND KRISTNA RIVER CONFLUENCE

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ABSTRACT

A critical examination of the relief chart off the region around Kristna river confluence indicated the presence of typical topographic features in the shelf zone consisting of an extensive bank in the Nizampatnam bay and Masulipatnam bay respectively towards west southwest and northeast of Kristna delta. The shoreline indicated growth towards west at False Divi point which is an unusual phenomenon along the East coast of India when compared to the shoreline development in the neighbourhood of Mahanadi & Godavari deltas, where the marine environment is influenced by the similar wave climate.

An analysis of the deep sea wave data off the Kristna delta indicated the occurrance of frequent waves from South and Southwest during Southwest monsoon and northeast and east during winter season. However, an annual frequency distribution of deep sea waves indicated south as predominant direction in the sector between south and west through southwest while east happened to be the most frequent direction in the sector between north and east through north-east. The directions of the current near the shore indicated presence of severe zones of diverging and converging currents. The observed currents in the shallow water of Nizampatnam bay have been discussed. Sedimentary tracks in the Nizampatnam bay have been explained as related to the typical circulation leading to weak currents allowing suspended sediment to settle and form banks.

Key-words : Geomorpholcgy, Coastal zone, Kristna River.

INTRODUCTION

The understanding of the shoreline development is the basic requirement for the coastal management and planning. The physical and dynamical proccesses along different parts of the coast line boardering the sea with continents and islands widely vary depending upon the combined influence of various factors contributing to the shaping of the coast. Among the various types of coasts, the river deltas and their formation could be separately dealt because of the vast differences in the terrestrial sediment influx compared to the other shorelines away from the influence of the river discharges. The scientific efforts during the past half a century made it possible to explain the behaviour of shorelines and sedimentory tracks in their neighbourhood. However, the characteristics cannot be generalised for all the delta shorelines due to the differences observed in the causative factors influencing the nearshore dynamics. While discussing the geomorphology of the coastal zone, one should also take shoals, banks, sand-spits, sand bars etc, into account. The geomorphological features of the coastal zone have been explained by Jhonson (1919), Evans (1942), Price (1968), King (1970), Shepard (1950), Kueleguan (1948), Mikhailov (1966), Mc Kee and Sterrett (1961), Inman (1954), Inman, Komar & Bowen (1969), Shepard & Inman (1950), Shepard & Lafond (1940) and Komar (1976) from extensive field and laboratory investigations. However, the understanding of the coastal circulation is very important to explain the unique sedimentary features of the individual regions.

The present investigation attempts to find a physical reasoning to explain the shoreline development and shallow water topography in the neighbourhood of the Kristna river confluence in relation to the marine environmental factors such as circulation, wave climate and tides. Typical geomorphological feactures of the region under investigation have been compared with the shorelines around a few other major and minor streams under similar marine environment on the East coast of India.

Description of the area

The Kristna river delta (Fig. 1) is the seaward extended land mass situated approximately between the latitudes 15° 45′ N and 16° 5′ N and longitudes 80° 40′ E and 81° 10′ E. The seaward growth of the delta resulted in the formation of an extenstve Nizampatnam bay towards west-southwest of

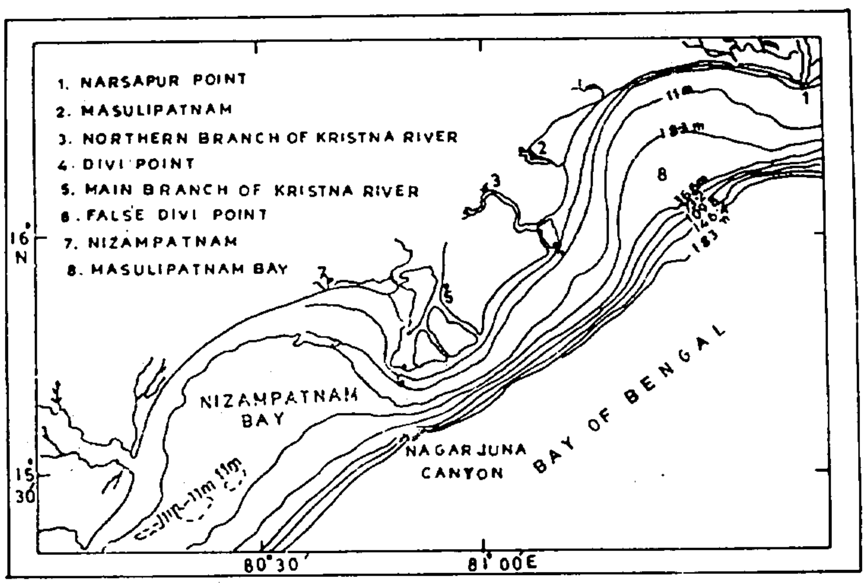

Fig. 1. Relief chart around Kristna River confluence.

its confluence and Masulipatnam bay towards Northeast of the Northern distributory of the river. The Northern and the Northeastern parts of the Nizampatnam bay are sheltered by the delta itself extending towards south into the sea. The Kristna river divides into a number of branches among which the western one forms the major river and the northern branch has its confluence at Divi point. The southern branch subdivided before joining the sea forming three islands and extending the estuarine regime in the river upto about 30 km. upstream (Ramanadham and Varadarajulu, 1973). The delta has predominantly grown towards west parts of which submerge at the time of high tide and elevated parts appear as off shore bar and it is called as False Divi point. Thus, the shoreline around the main branch of the river is quiet anamolous compared to the surrounding of the other eastern and northern branches.

The shelf break of the Kristna river confluence is profoundly influenced by the seaward advancement of the shoreline due to the growth of the delta. The width of the shelf break off the Kristna river confluence has an average about 15 km. While the corresponding width off the Nizampatnam bay is about 50 km. The shelf width off the Kristna river confluence appears to be reduced by the advancement of the delta shoreline on one side and the presence of Nagarjuna canyon (Subba Rao, Venkataratnam and Chandra, 1967) cutting accross the continental shelf and slope upto a depth of about 45 meters on the seaward side. However. none of the river branches extended upto the head of the canyon.

The northern part of the bay adjacent to the False Divi point is quiet shallow upto 11 meters depth while the bottom of the western bay is gently sloping or considered as flat between 11 and 18.3 meters depth. The southern parts of the bay consists of quite a larger number of banks between 11 and 18.3 meters depth. The masulipatnam bay is relatively deeper than the Nizampatnam bay with more gently sloping bottom between 18.3 and 36.6 meter depth.

Material and Methods

The wave characteristics in the deep sea of the Kristna delta between the latitudes 14°N to 19° N and longitudes 80° E to 85° E reported by the ships and published in the Indian daily weather reports were collected for a period of five years (1976–1980) and analysed to study the annual and seasonal frequency distribution of wave heights and wave periods. Analyses were made grouping wave heights (0–1.750, 1.751–2.750, 2.751–3.750 and > 3.75 m) and periods (0–7, 8–11, 12–17 and > 17 sec) and for sixteen directions (N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, NNW) and mean seasonal and annual percentages were obtained by grouping and averaging the data. Frequency distributions of wave heights and periods are presented in figs. 2A and 2B respectively.

Results and Discussion

During winter (Nov.–Feb.) the waves are primarily between NE and E with predominant direction of NE while during Pre monsoon months (March–May), the waves are generally from S and SW with predominant direction of SSW and during monsoon season (June–August) waves are frequent from SW

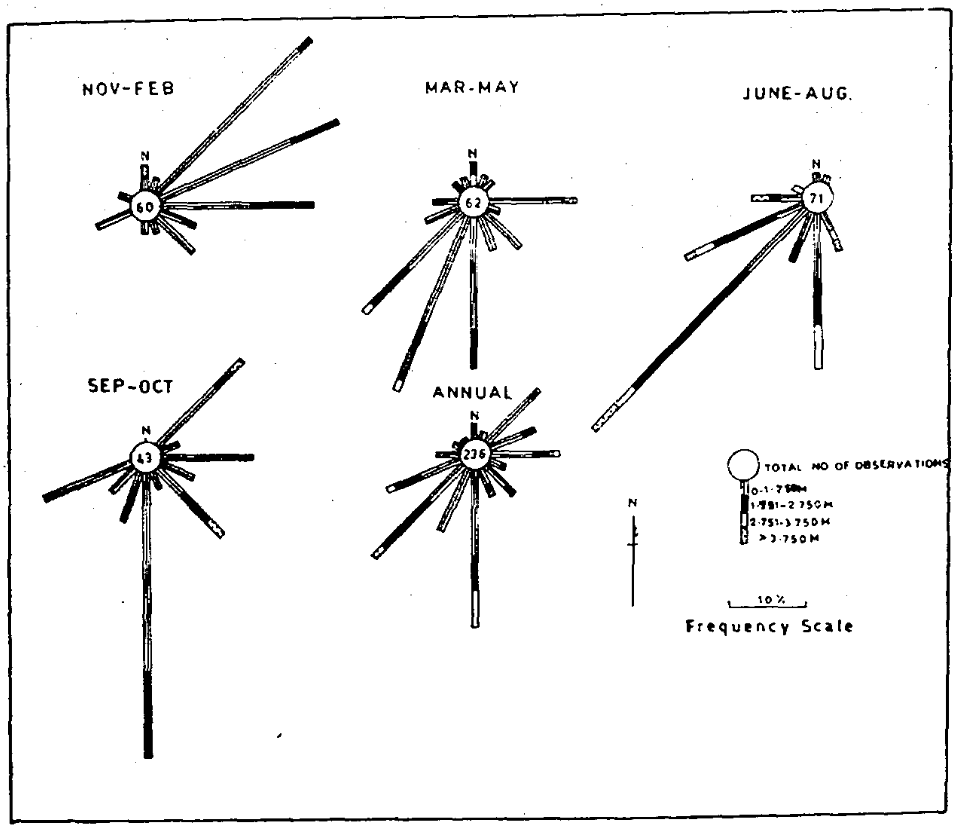

Fig. 2A. Frequency distribution of wave heights.

and S. In September and October, the months of post monsoon period, waves frequently propagate from S. Mean annual frequency distribution of wave heights indicate S and SW as predominant directions in order while the frequencies from NNE and SSW and WSW are also quite significant. On about sixty percent of the days wave heights are moderate ranging from 0 to 1.750 m and waves of heights ranging from 1.751 – 2.750 m occur on about 27% of the days while high waves are occasional. The frequency distribution of wave periods of different seasons also appear to be similar to those of wave heights. However, the predominant direction appears to be south in the sector between S and SW through SSW and E in the sector between NE and E through ENE while similar studies by Varadarajulu and Raju (1974) off the Visakhapatnam coast, Varadarajulu and Dhanalakshmi (1975) off the Madras Coast. Varadarajulu and Harikrishna (1979) off the Paradip Coast and off the Mahanadi delta and Varadarajulu, Harikrishna and Kumar (1982) along some regions in the Bay of Bengal indicated the predominance of SW and NE was not only during Monsoon and winter season respectively, but also in the annual distribution. About 84% of waves possess periods ranging from 8–17 sec. The waves with periods ranging from 12–17 secs. were slightly more than those of 1–11 sec. Thus the most frequent waves posses period of 12–13 sec.

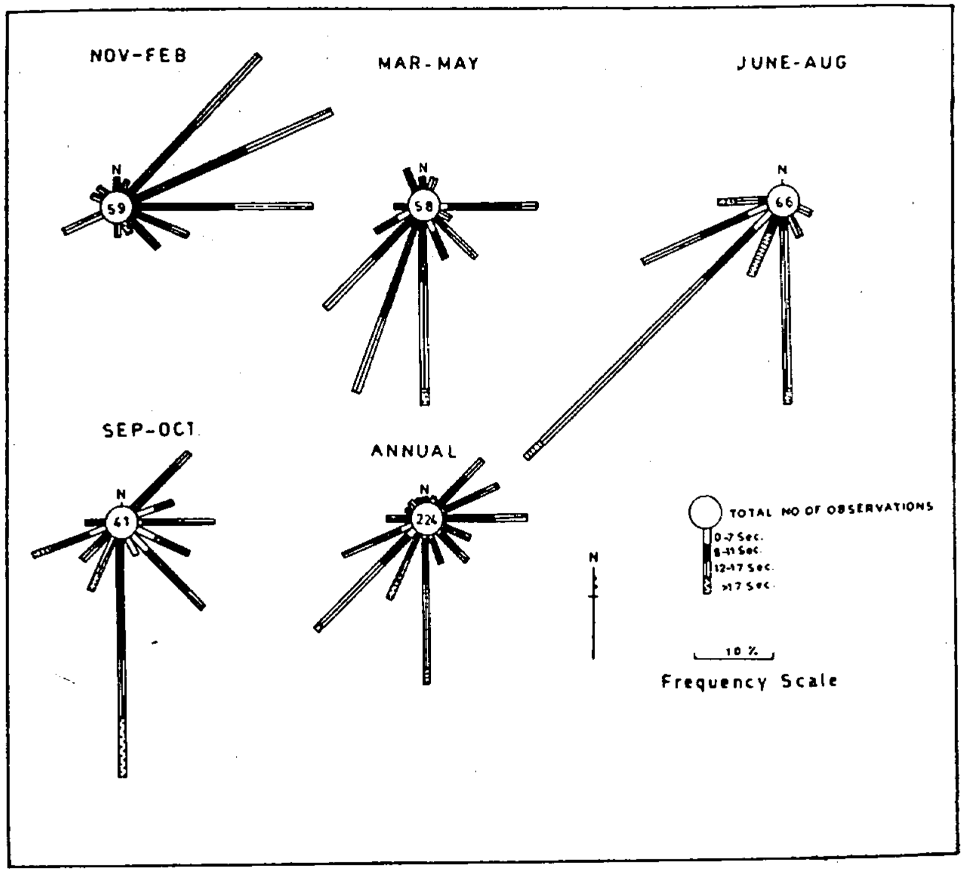

Fig. 2B. Frequency distribution of wave periods.

The directions of the nearshore currents shown in Fig. 3A (broken arrows) (Reddy 1962) estimated from the wave refraction diagrams for 12 secs. southerly waves prepared following the technique of Aurthur, Munk & Issacs (1952), clearly indicate a zone of divergence off the confluence of the major branch of Kristna river and an unusual westerly flow along the Nizampatnam coast. This phenomenon appears to be related to the divergence of the southerly deep sea waves over the Nagarjuna Canyon while propagating towards the coast. According to the estimated directions of the nearshore currents a strong zone of convergence appears at latitude 15° 53′. The observed currents (solid arrows) evaluated from the tracks of the surface floats indicate typical circulation in shallow waters of Nizampatnam bay during July. The currents are mostly westerly and northwesterly along the northern bay while northeasterly flow prevails in the southwestern bay. The magnitude of the current gradually decreases from Southwest to Northeast from about 1 to 0.5 km ph. Thus the reduction in the speeds towards False Divi Point appears to be related to the counteracting effect of the diverging wave induced currents around the Kristna river confluence. The diverging currents may be transport-

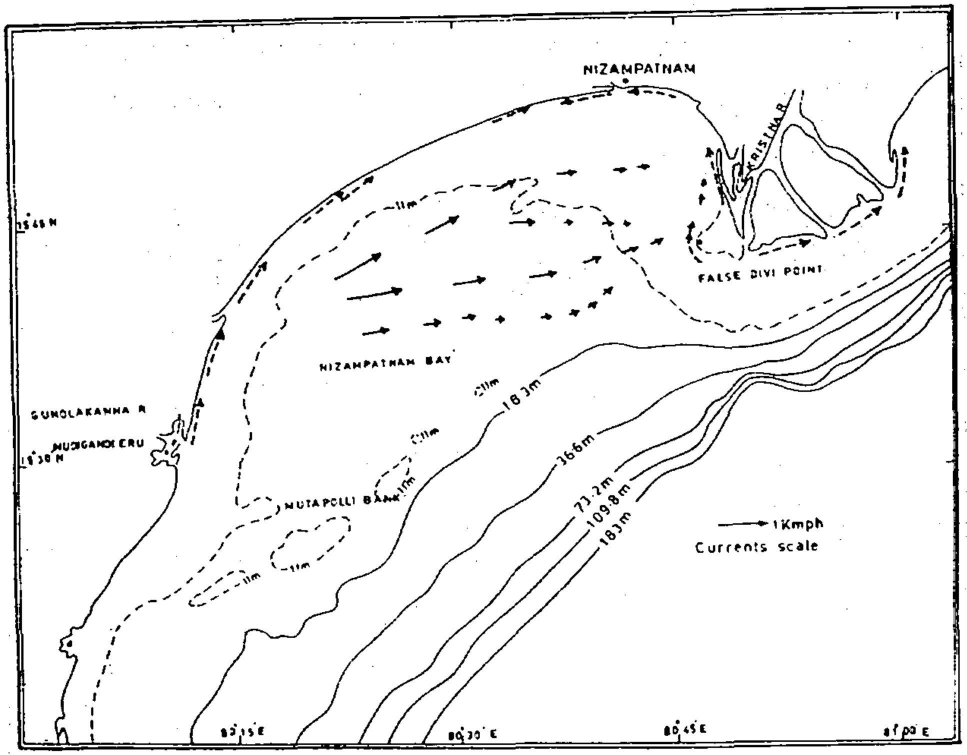

Fig. 3A. Currents in the Nizampatnam bay during July.

ing terrestrial sediments advected into the sea during southwest monsoon season towards the Nizampatnam bay in suspension and the weak currents in the Nizampatnam bay allow the suspended sediments to settle leading to the formation of extensive shoals and banks, shifting 18.3 meter depth contour seawards. The transport of the sediments by the nearshore currents initially towards west of the Kristna river mouth and finally part of it towards north appears to be contributing to the formation and growth of the False Divi Point and widening of the shallow water zone off the Nizampatnam coast between the shoreline and 11 m depth contour while similar sandspits formed towards north of the Godavari and Mahanadi River confluences.

The direction of the nearshore currents for the 12 sec. period waves from E, according to Reddy (1962), shown in fig. 3B (broken arrows) clearly indicate a region of diverging currents off the confluence of the main branch (western branch) of the Kristna river, northerly flow in the north-eastern bay, westerly flow along Nizampatnam coast and Southwesterly flow along the coast of the Southwestern bay. The observed currents are uniformly weak posessing magnitudes less than 0.5 km ph. and very weak flow in the north-eastern bay north of False Divi Point. Easterly waves diverging on the Canyon also tend to transport sediment into the Nizampatnam bay during December from the Kristna river confluence but the discharge of the sediments into the sea by the river during this month is very much reduced due to the reduced

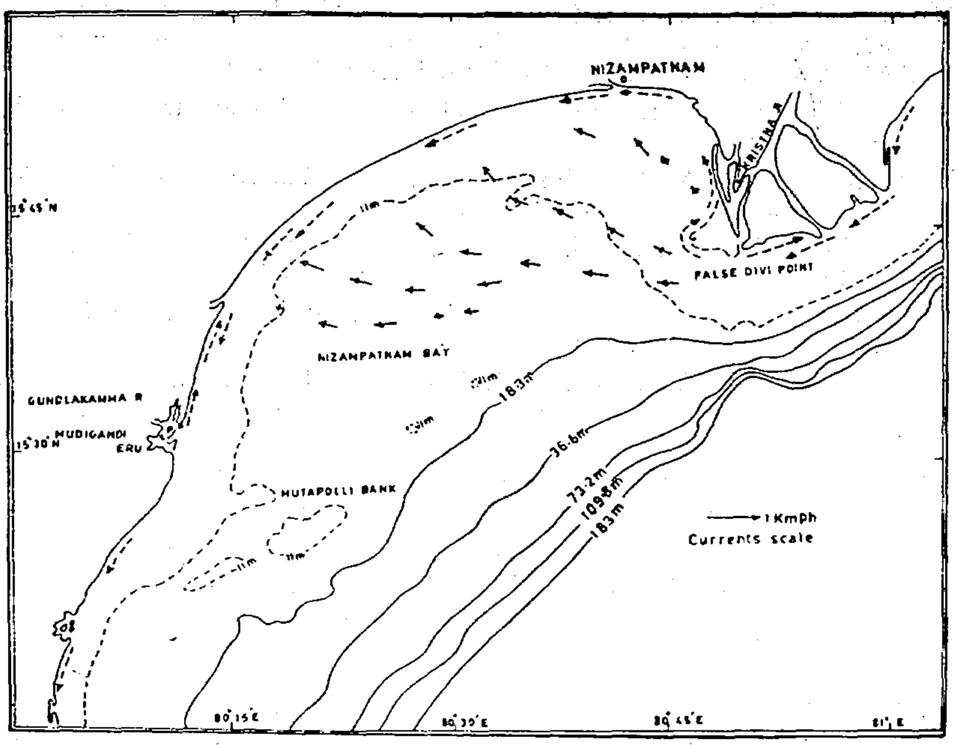

Fig. 3B. Currents in the Nizampatnam bay during December.

fresh water discharge by the river. The observed currents and the estimated directions of the nearshore currents using wave refraction diagrams clearly indicate that sediment discharged by the main branch of the Kristna river flows into the Nizampatnam bay throughout the year.

The maximum tide ranges (Ramanadham and Varadarajulu, 1973) observed near the Kristna river confluence are about 1.14 m and these cannot significantly influence the circulation in the Nizampatnam bay, since the shoreline of Nizampatnam bay is more a straight coast and tidal currents are only periodically oscillating currents without significantly altering the direction and magnitude of the mean currents. However, during short spells of periods less than one tidal cycle, tidal currents counteract weakening resultant flow of wave and wind induced currents enabling rapid siltation of the suspended sediments in the shallow waters which led to the formation of extensive banks in the Nizampatnam Bay.

REFERENCES

Arthur, R.S., W.H. Munk and J.D. Issaacs, 1952. A direct construction of wave rays. *Transactions of American Geophysical Union*, **33**: 855–866.

Evans, O.F., 1942. The origin of Spits, Bars and Related Structures, *Jounal of Geology*, **50**: 846–865.

Inman, D.L., 1954. Beach and Nearshore Processes along the Southern California Coast, *Bulletin of California Division of Mines*, **170**: 29–34.

Inman, D.L., P.D., Komar and A.J. Bowen, 1969. Longshore Transport of Sand, *Proceedings of the 11th Conference on Costal Engineering*, London, 1968. American Society of Civil Engineers: 298–309.

Jhonson, D.W., 1919. Shore Processes and Shoreline development, John Wiley & Sons, New York

Keulegan, G.H., 1948. An Experimental Study of Submarine Sand Bars. *Beach Erosion Board Technical report*, **3**: 1–40.

King, C.A.M., 1970. Changes in the Spit and Gibralter point, Lincolnshri, 1951 to 1969, *East Middle Geography*. **5**: 19–30.

Komar, P.D., 1976. Beach Processes and Sedimentation, Prentice Hall Inc., Eagilwood Criffs, New Jersy.

Mc Kee, E.D., and D.S. Sterret., 1961. Laboratory Experiments on Form and Structure of Long shore Bars and Beaches. *Geometry of Sandstone bodies*: 13–28.

Mikhailov, V.N., 1966. Hydrology and Formation of River Mouth Bars. Humid Tropic Research — *Proceedings of the Dacca Symposium*: 15–64.

Price, W.A., 1968. Bars. *Encyclopaedia of Geomorphology*, 55–58.

Ramanadham, R. and R. Varadarajulu., 1973. Hydrology and Hydrography of the Krishna Estuary. In: *Recent Researches in Estuarine Biology*, Edited by R. Natarajan, Hindustan Publishing Corporation (I), Delhi: 151–164.

Reddy, M.P.M., 1962. Limnological studies of the Chilka lake and wave refraction studies in relation to shoreline development, *Ph.D. thesis, Andhra University*. Waltair.

Shepard, F.P., 1950. Longshore Bars and Longshore Trough. *Beach Erosion Board Technical Memoirs*, **15**: 1–31.

Shepard,F.P. and E.C. La Fond, 1940. Sound Movement along Scripps Institution Pier, *American Journal of Sciences*, **238**: 272–285.

Shepard, F.D. and D.L. Inman., (1950). Nearshore water circulation related to Bottom topography and wave refraction, *Transactions of American Geophsical Union*, **31**: 196–212.

Subba Rao, M., K. Venkataratnam and P.R. Chandra., 1967. Submarine Canyons of the East coast of India. ***Proceedings of the Seminar on Geomorphological Studies in India***, Centre of Advanced Study in Geology, University of Saugar, (1965): 114–120.

Varadarajulu, R. and G.S.N. Raju., 1974. Wave characteristics along Visakhapatnam coast. *Indian Journal of Marine Sciences*, **3**: 120.

Varadarajulu, R. and M. Harikrishna, 1979. Wave characteristics of Paradip Port. *Indian Journal of Marine Sciences*, **8**: 68–72.

Varadarajulu, R., M. Harikrishna and A.R.S. Kumar., 1982. Wave Characteristics of some regions in the Bay of Bengal. *Indian Journal of Marine Sciences*, **11**: 247–248.

Varadarajulu, R. and S. Dhanalakshmi, 1975. Sealevels and waves along the Madras **Coast**. *Indian Journal of Marine Sciences*, **4**: 115–123.