

## WAVE POWER AROUND SOUTHERN COASTS OF INDIA DURING SEPTEMBER - OCTOBER, 1977

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### ABSTRACT

Waves were recorded at 34 stations along the southern coasts of India between Visakhapatnam and Mormugao by a shipborne wave recorder. Wave power at these stations was computed from the significant wave height and zero-crossing period, with a view to study the power potential along the coasts of India. Although September/October is the period of comparatively low wave activity, the computed power per metre of wave crest width was found to exceed 5 kW at some stations off Circars coast, southern tip of India and north Malabar coast. A station south-east of the Madras harbour recorded the lowest power of 1.3 kW.

### INTRODUCTION

The potential of wave power on India's long coastline could be quite substantial though it may vary from place to place and season to season. Wave power in terms of its utility has often been neglected partly due to lack of adequate information on the wave power potential. The only data on waves around Indian coasts are those published regularly by the India Meteorological Department based on visual estimates by sailors from merchant ships. These data are often treated with some reservations as the heights of the waves are estimated just by looking at the sea. However, waves were earlier recorded by bottom mounted wave recorders at a nearshore region off Mangalore for one year and the results have been reported (Dattatri, 1973; Sundara Ramam, Varkey, Vijayarajan, John and Joseph, 1974 and John, 1977). Reliable wave records were also obtained for a shorter duration in a nearshore area off Goa (Narayana Swamy, Kesava Das and Varkey, 1976). In this communication an attempt has been made to estimate the wave power available in southern regions of the Indian coastline during the months of September and October.

Data were collected from R.V. *Gaveshani* using a shipborne wave recorder designed and developed by the Institute of Oceanographic Sciences, U.K. This is a modified version of the shipborne wave recorder fabricated earlier (Tucker, 1956). The instrument has two sensors, mounted on port and starboard sides of the ship, each containing a pressure sensor and an accelerometer unit. The long waves over which the ship rides are measured almost entirely by accelerometer units and the short waves that do not cause appreciable heave are measured by the pressure sensors. The instrument converts the pressure and acceleration sensed into height of water above a reference level. The final record is a continuous tracing of the wave height against time. In all, 34 stations were worked covering the coastline from Visakhapatnam on

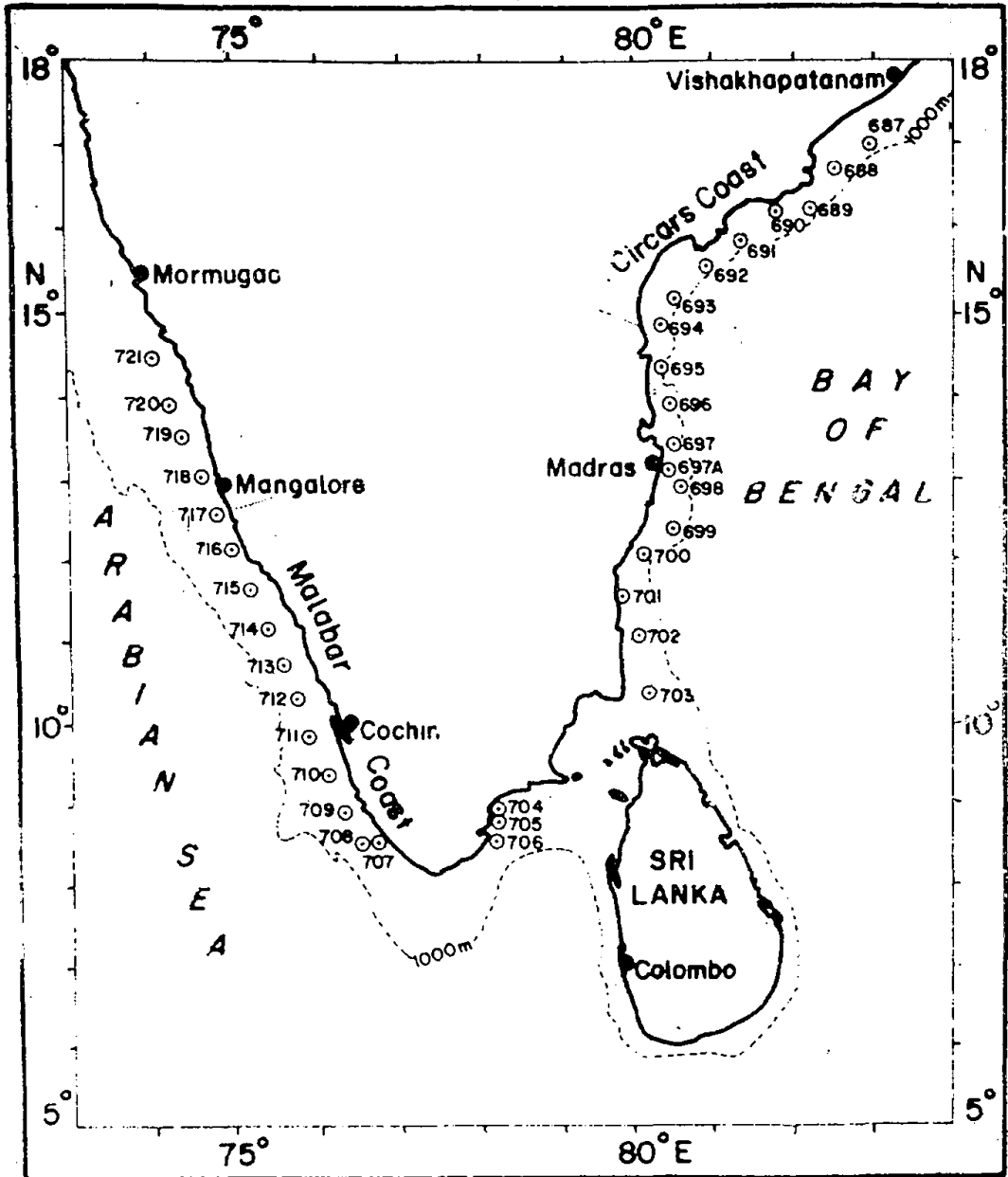


Fig. 1. The stations worked along the coasts of India. Stations are numbered along the track of R. V. Gaveshani, from Visakhapatnam to Mormugao. Stations 688 and 700 were not worked.

the east coast to Mormugao on the west coast, including the small coastline in the Gulf of Manaar off Tuticorin (Fig 1). The survey lasted for 13 days from September 23 to October 5, 1977. All the stations occupied were on the shelf. Recordings were made for a period of 15 minutes while the ship was at heave. A typical wave record obtained is presented in Fig. 2.

#### ANALYSIS OF DATA

The method of analysis followed was the one suggested by Draper (1966). The following parameters were determined for each station:

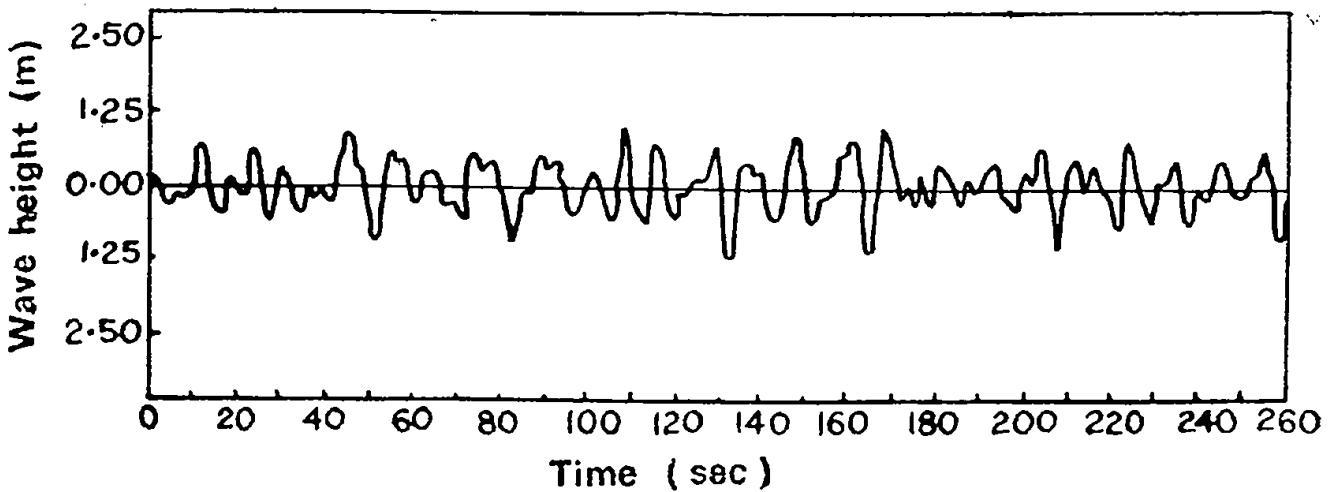


Fig. 2. A typical wave record of the ship borne wave recorder.

1. The height of the highest crest (A),
2. The depth of the lowest trough (C),
3. The total number of upward zero crossings ( $N_z$ ) and
4. Total number of crests ( $N_c$ ).

From the above values significant wave height ( $H_s$ ) and the zero crossing period ( $T_z$ ) were computed, assuming the wave train to represent nearly a sine wave. The power  $P$  per metre of crest width of such a wave is given by the expression

$$P = \frac{\gamma g}{64\pi} H_s^2 T_z \text{ Watts}$$

where  $\gamma$  is the specific weight of sea water which is taken to be  $10.05 \times 10^3$  Newtons/m<sup>3</sup>,  $g$  is the acceleration due to gravity in m/sec<sup>2</sup>,  $H_s$  is the significant wave height in metres and  $T_z$  is the zero crossing period in seconds (Panicker, 1976, 1977; Johnson, 1977). The power as calculated from the above expression is the rate of transmission of wave energy per unit area across a plane perpendicular to the wave front per unit width of a wave crest.

#### RESULTS AND DISCUSSION

Table I shows the station positions, water depth, computed significant wave height, zero crossing period and the wave power available. Fig. 3 shows the distribution of significant wave height, zero crossing period and the computed wave power at the stations.

The calculated wave periods were between 10 and 15 sec at most of the stations. Periods were between 8.3 and 10 sec at the stations 699, 704, 705, 706 and 714. The lowest period was 8.3 sec observed at the station 705, in the Gulf of Manaar. The highest period of 15 sec was observed at the station 713, along the Malabar Coast.

Significant wave heights were higher than 0.9 m at the stations 687, 689, 691, 699, 704, 705 and 706 along the east coast and at the stations 707, 708, 709, 714, 715, 716 and 717 along the west coast. The highest significant wave height computed was 1.15 m at the station 706, in the Gulf of Manaar. The lowest height observed was 0.45

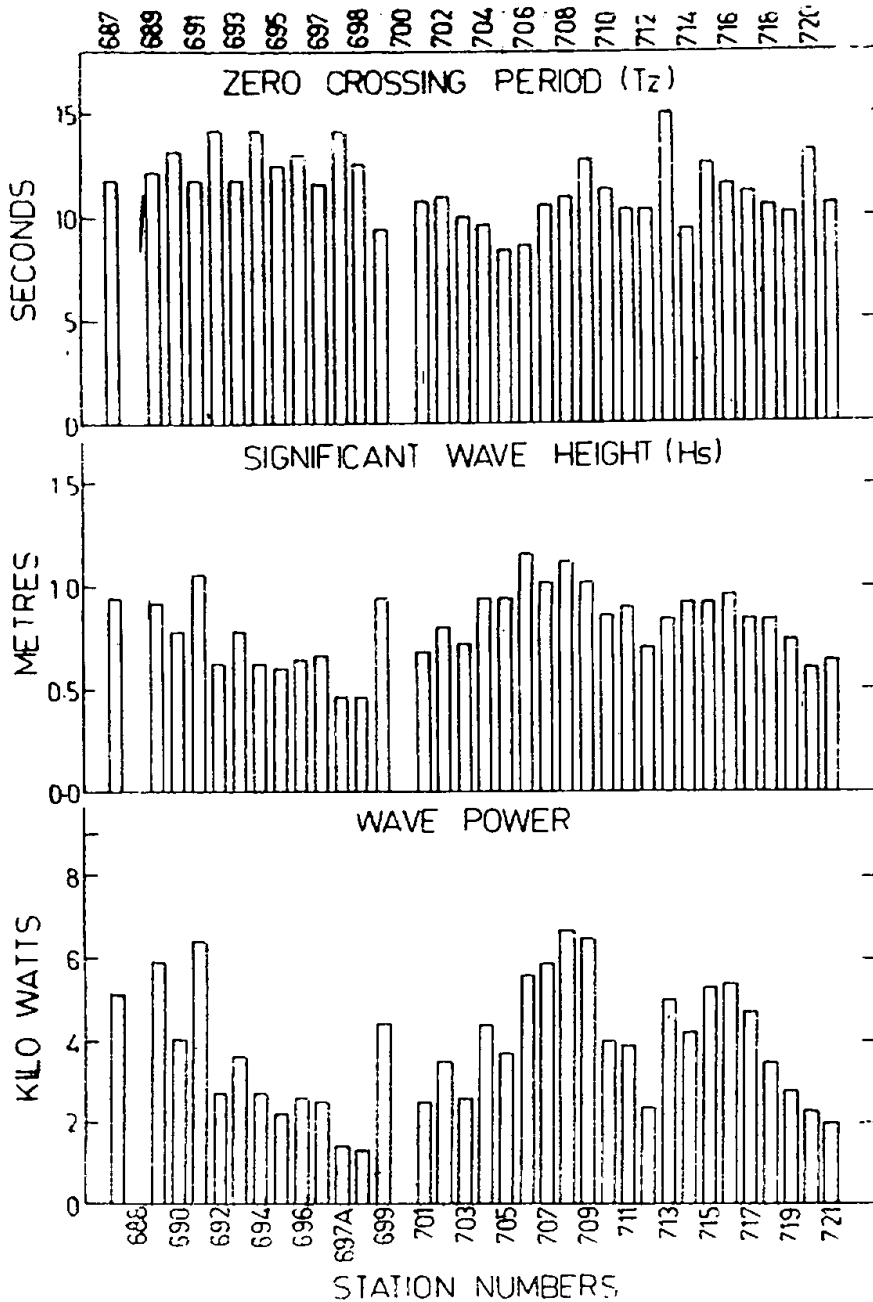


Fig. 3. Bar diagrams of zero-crossing period, significant wave height and computed wave power plotted against stations. The gaps correspond to stations 688 and 700.

m at 697A on the east coast. Wave heights were comparatively low, about 0.7 m at the station 712, and were still lower at the stations 720 and 721 on the west coast.

The computed power exceeds 5 kW at the stations 687, 689 and 691 which are along the Cricars coast, the stations 706, 707, 708 and 709 along the tip of Indian peninsula, and the stations 713, 715 and 716 along the north Malabar coast. The computed wave power was lowest, 1.3 kW at the station 698 on the east coast. The other station which had comparatively low wave power, 1.4 kW on the east coast was 697A. On the west coast the wave power had its lowest value of 2.0 kW at the station 721.

Table I. Showing the station positions, water depth and computed period, height and power of waves at the stations.

Stn. No.	Lat. (°N)	Long. (°E)	Depth (m)	Zero-crossing period (sec)	Significant wave height (m)	Wave power (watts)
687	17°00'	82°58'	230	11.8	0.9380	5092
689	16°22'	82°14'	95	14.3	0.9143	5863
690	16°22'	81°49'	28	13.3	0.7858	4028
691	15°54'	81°22'	105	11.8	1.0506	6388
692	15°36'	80°57'	101	14.3	0.6217	2711
693	15°19'	80°31'	95	11.8	0.7879	3593
694	14°51'	80°19'	108	14.3	0.6217	2711
695	15°19'	80°32'	103	12.5	0.5984	2195
696	13°52'	80°26'	83	13.0	0.6435	2640
697	13°22'	80°31'	103	11.7	0.6597	2498
697A	Madras Anchorage	—	—	14.3	0.4535	1443
698	12°52'	80°38'	86	12.5	0.4638	1319
699	12°22'	80°31'	75	9.5	0.9584	4370
701	11°35'	79°55'	8	10.7	0.6931	2521
702	11°08'	80°05'	82	11.0	0.8026	3476
703	10°34'	80°11'	83	10.1	0.7200	2568
704	08°58'	78°25'	12	9.6	0.9614	4352
705	08°48'	78°25'	33	8.3	0.9504	3677
706	08°38'	78°25'	35	8.6	1.1530	5608
707	08°30'	76°53'	—	10.6	1.0614	5857
708	08°30'	76°35'	75	11.0	1.1172	6734
709	08°57'	76°23'	40	12.7	1.0230	6519
710	09°25'	76°11'	27	11.3	0.8539	4041
711	09°52'	75°59'	37	10.3	0.8770	3886
712	10°20'	75°46'	61	10.3	0.6948	2439
713	10°47'	75°34'	49	15.0	0.8250	5008
714	11°17'	75°21'	48	9.5	0.9536	4237
715	11°43'	75°08'	46	12.7	0.9229	5306
716	12°13'	74°55'	99	11.7	0.9700	5400
717	12°36'	74°44'	39	11.1	0.9337	4747
718	13°03'	74°32'	42	10.5	0.8259	3513
719	13°30'	74°16'	44	10.1	0.7560	2831
720	13°58'	74°07'	52	13.3	0.5980	2333
721	14°25'	73°54'	53	10.5	0.6287	2036

From the point of commercial exploitation, the power potential reported here may appear to be relatively low. But it is important to note that these values refer only to one metre of wave crest width and hence a device that taps the power can always optimise production by covering a wider stretch of wave crest as envisaged in many prototype models (Salter, 1974).

An important aspect of the present study is the period of observation. These observations were made during a period when the weather was relatively calm. So the available power will possibly be much greater in other seasons because of monsoons and depressions.

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## REFERENCES

- Dattatri, J., 1973. Waves off Mangalore - west coast of India. *Journal of Waterways, Harbours and Coastal Engineering Division ASCE*, 99: 39-58.
- Draper, L., 1966. The analysis and presentation of wave data - a plea for uniformity. *Proceedings of 10th Conference on Coastal Engineering, Tokyo*, 1: 1-11.
- John, V.C., 1977. Distributions and relationships of height and period of ocean waves off Mangalore. *Indian Journal of Marine Sciences*, 6: 49-54.
- Johnson, I.G., 1977. Power resource estimate of ocean surface waves. *Ocean Engineering*, 4: 211-212.
- Narayana Swamy, G., V. Kesava Das and M.J. Varkey, 1976. Wave characteristics off Goa for the period, November to May. *Mahasagar - Bulletin of the National Institute of Oceanography*, 9: 63-66.
- Panicker, N.N., 1976. Power resource estimate of ocean surface waves. *Ocean Engineering*, 3: 429-439.
- Panicker, N.N., 1977. Power resource estimate of ocean surface waves - closure. *Ocean Engineering*, 4: 213.
- Salter, S. R., 1974. Wave power. *Nature*, 249: 710-724.
- Sundara Ramam, K.V., M.J., Varkey, P.K. Vijayarajan, V.C. John and M.X. Joseph, 1974. Waves in coastal waters off Mangalore. Part I: Distribution of wave characteristics. *Indian Journal of Meteorology and Geophysics*, 25: 453-460.
- Tucker, M.J., 1956. A shipborne wave recorder. *Transactions of the Institution of Naval Architects*, 9: 236-250.