THE STUDY OF THE SEA STATE DATA COLLECTED FROM BAY OF BENGAL DURING 1964-65

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The wave data collected on board *INS KISTNA* from Bay of Bengal during July to August, 1964 and January, February and April, 1965 are presented. The wave parameters are analysed and given in a form most suitable for model testing of ships. The variation of wave height with Beaufort number is remarkable. Wave periods from 2 to 10 seconds are observed with maximum frequency in the range of 2 to 5 seconds. The heights and period obtained are compared with those obtained by previous workers for the North Atlantic region and Bay of Bengal. The influence of the wave period 2 to 5 seconds on the rolling, pitching and heaving periods of medium size vessels is also discussed.

INTRODUCTION

A knowledge of prevailing sea condition is essential for design of sea-worthy ships and also for carrying out realistic model tests in waves. As a matter of fact fishing vessels are influenced more by the sea conditions because of their relatively smaller size. At the same time these vessels have to provide a stable platform for carrying out fishing operations and as such the reduction of motions in seaway are of importance. Thus it is neeessary to have detailed information about the sea state condition around the Indian coast, to estimate the limitations imposed by these factors on the sizes of the fishing vessels. Venkataraman (1956) and Chakravorthy *et al.* (1957) published some wave data from Arabian Sea and Bay of Bengal respectively. These were based on the visual observations made by merchant ship skippers and show only the wave heights, period and wind speed. In this paper the wave data collected on board *INS Kistna* during her oceanographic voyages in Bay of Bengal under the Indian Ocean expedition programme are presented and discussed. The data were collected during 17th, 18th, 22nd, 26th (observations in Arabian Sea excluded) and 27th cruises during July, August, 1964, January, February and April 1965 respectively. The presentation of the data is according to the method suggested by Ewing and

Hogben (1964) which is convenient from the point of view of model experiments and ship motion calculations.

Materials and methods

Wave parameters viz. height, period, length and direction were observed along with wind velocity and direction. The procedure adopted was as described by Pierson *et al.* (1955). A system of floats tied at every fifty feet of a 400 ft. long line was employed for the estimation of wave length. The successive floats were coloured differently for ease of observation. The height was estimated from a graduated floating pillar. The stability of the pillar under dynamic condition was maintained by attaching a buoyant float at about 2/3 depth from the upper end and a base plate and an anchor kept at about 80 ft. below water surface attached to the lower end by a rope. Since the base plate was kept at about 80 ft. below water surface the vertical oscillation at that depth due to surface wave was practically negligible (Trochoidal theory) and the floating pillar assumed to be stationary and a satisfactory reference for measuring the wave heights as the wavecrests moved past the pillar.

The floats and the pillar were dropped into the sea from the stern of the ship after the ship was stopped and they were allowed to drift for about fifteen minutes. The floats adjusted themselves perpendicular to the crest in a direction opposite to the wave direction. The length of the wave was observed by sighting one of the floats on the crest of a wave and estimating the distance of the next crest with respect to the system of floats. The height of the wave was estimated from the different colour graduations of the pillar as the waves passed across it. Wave period was observed by noting the time of passage of successive wave crests at a distant float with the help of a stop watch. The direction of the wave was read from the Mariners' compass whereas the velocity and direction of the wind were taken from the Anemometer. Fifteen observations each of which was the average of another ten continuous observations were taken from each station. The fifteen observations were distributed over the one to one and half hour duration of each station. The data were entered in a log sheet following the system of Ewing and Hogben (1964). All data were collected by the same person using the same instruments.

Presentation of data

Fig. 1 shows the locations of the 93 stations. The numbers in the 2° squares indicate the number of stations. Tables I, II, III & IV show the relations wave height–wave period, wave height–wave direction, wave period– wave direction and wind direction–Beaufort number. Table V shows the relation wave height–Beaufort number. Table VI shows the relation wave period–wave length. Table VI also shows the ratio between the mean observed wave length to the wave length calculated from the corresponding mean period by the expression $\lambda_2 = \frac{gT^2}{2\pi}$, where λ_2 is wave length and 'T' mean period. The relation between mean wave height and Beaufort number derived from Table V is shown in Fig. 2. The number adjacent to each point in this figure gives the number of observations for the particular Beaufort number.

Results and discussion

The relation obtained between the Beaufort number and the average wave height (Fig. 2) is quite interesting. Though there are several wave heights associated with each Beaufort number, the variation in the average wave height with Beaufort number is quite constant as shown in Fig. 2. In Table VI the 'K' value is

TABLE I. WAVE PERIOD (SECONDS).

Wave Height (Ft.)	0–2	2–4	5	6	7	8	9	10	Totals
1	50	288	45	8	4	2	5	1	403
3	47	323	151	52	11	4	.	.	588
5	5	100	114	48	4	.	.	.	271
7	.	50	30	9	2	.	.	.	91
9	.	29	5	.	2	.	.	.	36
11	.	.	6	.	.	.	.	.	6
TOTALS	102	790	351	117	23	6	5	1	1395

TABLE II WAVE DIRECTION FROM NORTH

Wave Height (Ft.)	000	030	060	120	150	180	210	240	270	300	330	Totals
1	16	57	7	53	22	47	63	70	18	36	14	403
3	26	107	26	21	10	63	46	159	87	43	...	588
5	10	39	18	...	2	28	37	99	25	13	...	271
7	...	2	...	...	...	9	38	42	...	...	...	91
9	...	...	...	...	...	...	16	20	...	...	...	36
11	...	...	...	...	...	...	6	...	...	...	...	6
TOTALS	52	205	51	74	34	147	206	390	130	92	14	1395

TABLE III PERIOD (SECONDS)

Wave Direction from North	0–2	2–4	5	6	7	8	9	10	Totals
000	12	21	19	...	...	...	...	...	52
030	6	95	79	17	8	...	...	...	205
060	...	31	16	4	...	...	...	...	51
120	...	64	10	...	...	...	...	...	74
150		14	2	7	2	4	4	1	34
180	15	119	6	7	...	...	...	...	147
210	24	100	47	27	6	1	1	...	206
240	27	236	85	37	5	..	...	...	390
270	1	46	69	13	...	1	...	...	130
300	3	64	18	5	2	...	...	...	92
330	14	...	...	...	...	...	...	...	14
TOTALS	102	790	351	117	23	6	5	1	1395

TABLE IV BEAUFORT NUMBER

Wind direction from North Deg.	1	2	3	4	5	6	Totals
000	...	...	...	52	...	...	52
030	...	...	14	149	28	14	205
060	...	...	28	23	...	...	51
120	28	32	14	...	...	...	74
150	14	...	...	...	...	...	14
180	...	50	131	...	...	...	181
210	28	14	50	100	...	...	192
240	14	78	100	100	25	125	442
270	...	39	14	25	...	...	78
300	28	...	14	50	...	...	92
330	14	...	...	...	...	...	14
TOTALS	126	213	365	499	53	139	1395

TABLE V BEAUFORT NUMBER

Wave Height (Ft.)	1	2	3	4	5	6	Totals
1	126	93	116	64	4	...	403
3	...	110	185	263	13	17	588
5	...	10	57	119	26	59	271
7	...	...	7	35	8	41	91
9	...	...	...	16	2	18	36
11	...	...	...	2	...	4	6
TOTALS	126	213	365	499	53	139	1395
Mean wave height	1	2.21	2.78	3.75	4.70	6.00	

TABLE VI PERIOD (SECONDS).

Wave Length (Ft.)	0–2	2–4	5	6	7	8	9	10	Totals	Mean Period	Wave length calculated (ft)	K*
25	98	335	54	4	...	...	...	...	491	2.85	41 61	0.60
50	4	246	98	22	...	...	...	...	370	3.69	69.76	0 72
75	...	145	103	35	...	4	...	...	287	4.15	88.25	0.85
100	...	46	70	27	6	...	...	...	149	4.64	110.32	0 91
125	...	17	12	12	5	2	...	...	48	4.88	122 02	1 02
150	...	1	13	6	...	...	1	...	21	5.38	148.31	1 01
175	...	...	1	3	2	...	...	...	6	6.17	195.07	0 89
200	...	...	...	8	10	...	...	...	18	6.56	220.00	0.91
225	...	...	...	...	...	...	...	...	...	...		
250	...	...	...	...	...	...	4	...	4	9.00	415.00	0 60
275	...	...	...	...	...	...	...	1	1	10.00	512.00	0.54
TOTALS	102	790	351	117	23	6	5	1	1395	...		

$$*K = \frac{\text{Wave length observed } (\lambda_1)}{\text{Wave length calculated from mean period } (\lambda_2)}$$

FIG. 1

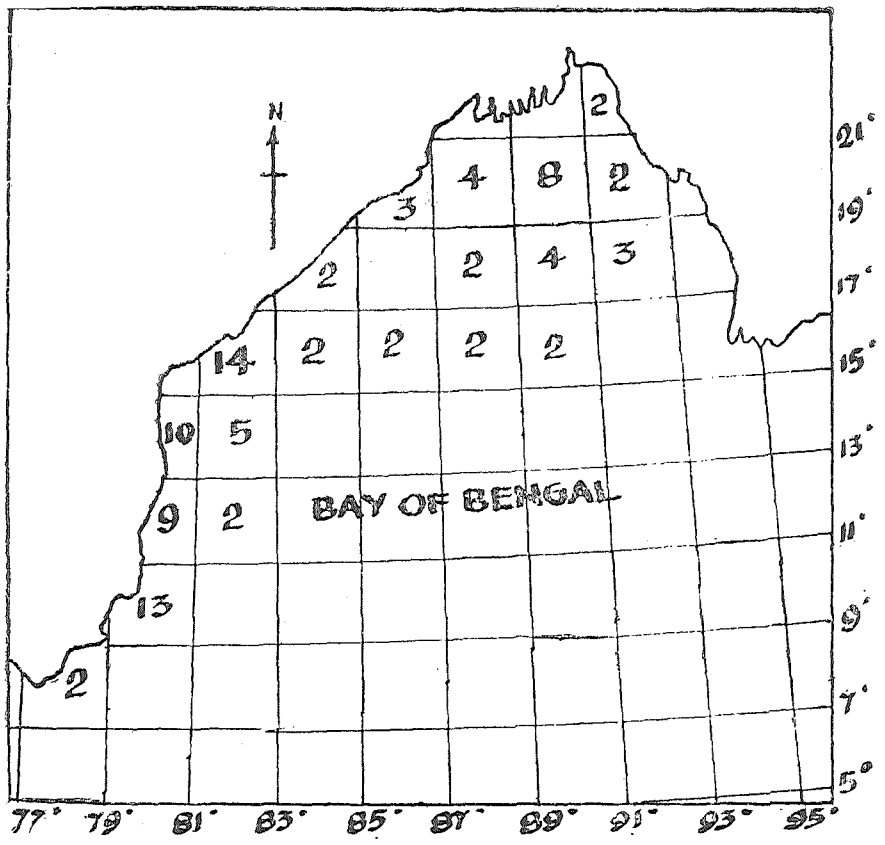
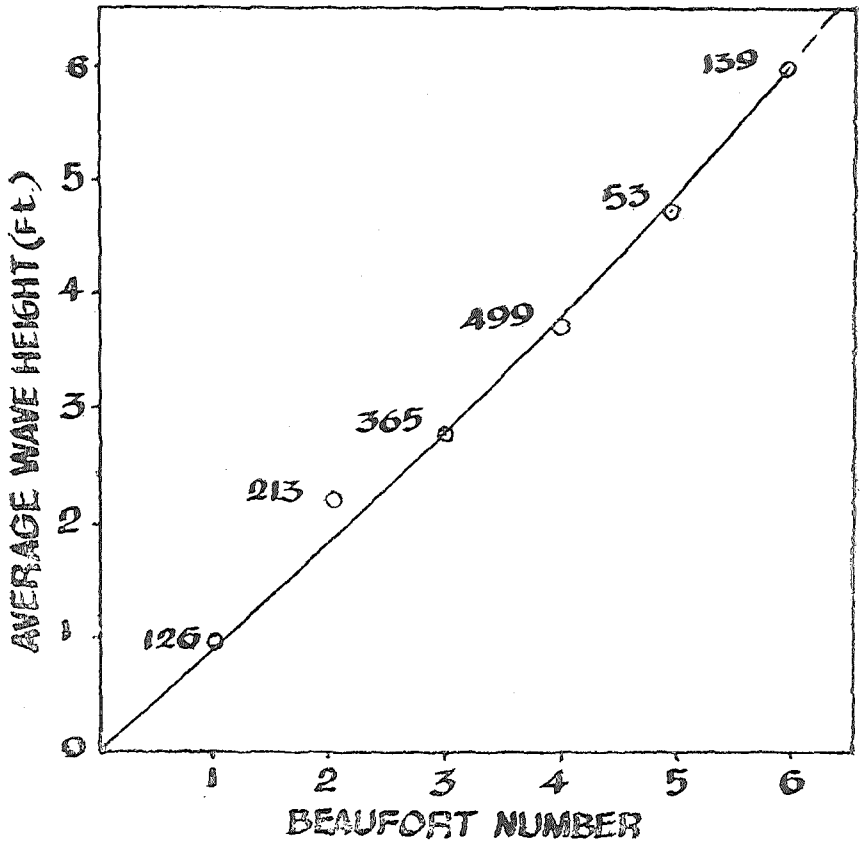

N
BAY OF BENGAL
2
4 8 2
3
2 4 3
2
14 2 2 2 2
10 5
9 2
13
2
21°
19°
17°
15°
13°
11°
9°
7°
5°
77° 79° 81° 83° 85° 87° 89° 91° 93° 95°

FIG. 2


AVERAGE WAVE HEIGHT (FT.)
BEAUFORT NUMBER
0
1
2
3
4
5
6
126
213
365
499
53
139

practically equal to 1 in most cases. This indicates the presence of a narrow band of wave frequencies in these cases. It may have been due to sea being limited either by fetch (offshore wind) or by duration.

Wave periods from 2 to 10 second are observed in the present study with the maximum occurrence in the region of 2 to 5 second (Table I). In the data presented by Chakravorthy and Bhattacharjee (1957) periods below 5 seconds are not referred except for the month of September during which the number of observations are few. The frequent occurrence of periods between 2 to 5 seconds observed during the present study is of importance, because the rolling, pitching and heaving periods of medium size trawlers fall in this region, increasing the chances of synchronous ship motions.

The heights reported by Chakravorthy and Battacharjee (1957) are unaided visual observations and so they are nearer to significant wave heights ($H\frac{1}{3}$). They are more than the average heights (H_{Ave}) presented here by a factor 1.2 to 1.35. The average heights presented here are the averages of all the heights including, the significant heights. Theoretically $H\frac{1}{3} = 1.6 \times H_{Ave}$. Considering that the data of the former are from unaided visual observations and that probably fully developed sea was not present (as seen from the value of K. mostly equal to one), the agreement between the two sets of wave heights is considered good. The heights presented here are less than those observed by Ewing and Hogben (1964) in North Atlantic around the British Isles. The difference increases as Beaufort number increases and it is found that the values at Beaufort number, 3 and 6 are 75% and 45% of the heights given by Ewing and Hogben (1964). The K values reported in the later cases are between $\frac{1}{3}$ and $\frac{2}{3}$ indicating fully aroused sea conditions (i. e. fetch and duration limitations virtually nil). For lower wind speeds the minimum fetch and duration required for the maximum wave heights to be reached are small and so they are not likely to affect the observations too much. But for the higher wind speeds these factors can cause sizeable differences in wave heights.

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