SAND MOVEMENT ON THE WALTAIR BEACH, VISAKHAPATNAM, INDIA

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Abstract

The paper presents the results of the analysis of the profile data of the Waltair beach which is subject to three distinct influences: (*a*) rhythmic short period tide cycles, (*b*) random 'Cataclysmic' events like rain storms and (*c*) beach erosion induced by the construction of a break-water. The marked changes in the profile area in November 1958 are correlated to the unprecedented floods in the Visakhapatnam area and the consequent prevalence of erosion conditions. The construction of a break-water near the entrance to the Visakhapatnam Port impeded the movement of littoral drift in the N.E. direction, resulting in beach erosion in the Waltair area. This erosion process seems to follow a negative exponential trend. It is found that the net mean rates of change for the foreshore, backshore and the beach during 1958 are +0·24, −16·44 and −15·35 sq. ft./day respectively.

Introduction

The Waltair-Visakhapatnam beach is a stretch of sand four miles long running in the N.E.-S.W. direction from the Visakhapatnam Harbour channel in the south to the Waltair Point (a sandy promontory studded with rocks) in the north (Fig. 1). At the entrance of the Harbour channel and adjacent to the prominent hill on the sea shore, called Dolphin's nose, a break-water has been erected in 1933 by sinking two rock-filled ships. The break-water has been so oriented that the direction of approach of the waves is roughly normal to it, at least during the S.W. monsoon when the major movement of sand towards north-east takes place. The construction of the break-water has resulted in the deposition of sand in the shadow region behind the break-water. The beach north of the break-water has thus been deprived of its usual supply of sand while the sand movement in the N.E. direction continued apace. This has resulted in beach erosion all along the Visakhapatnam-Waltair beach, shortening the beach at places by as much as 350 ft., as is evident from the analysis of the beach profile data obtained by the Visakhapatnam Port Authorities during the period 1934–1953 at the Light House, at the Piroj Mansion and at the Anchor Light (Prasadarao and Mahadevan 1956).

The site chosen for an intensive study of the beach is near the Andhra University, Waltair (17° 43′ 15″; 83° 20′). It is away from any major stream confluence and there are no rocky promontories in the vicinity. Sand drift

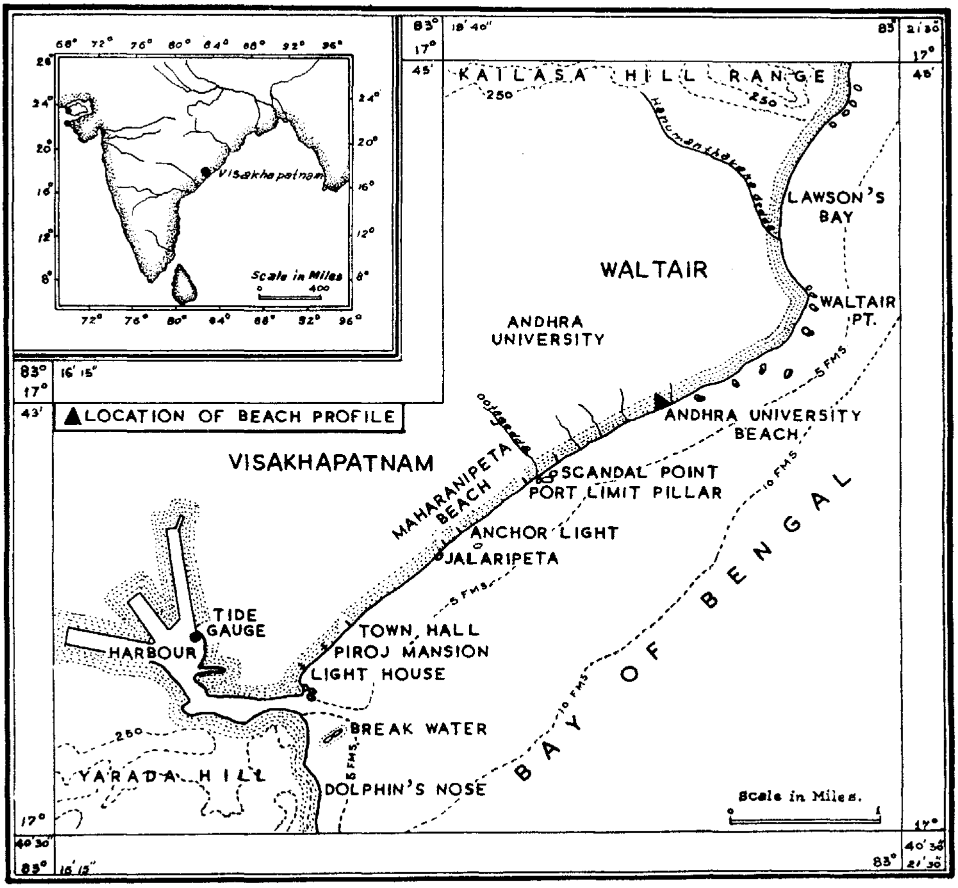

FIG. 1. Sketch map of Waltair-Visakhapatnam beach.

due to wind is considered negligible. The beach erosion cycles operating at this point have already been studied (La Fond and Prasadarao 1954; Prasadarao 1956). This report presents, for the first time, some quantitative data on the sand movement on the Waltair beach.

METHOD OF STUDY

For a period of one year (March 1958 to March 1959), the Andhra University beach profile has been measured 66 times. Strict periodicity in the profile measurement could not be maintained due to certain difficulties like rain, non-availability of personnel, etc.

The technique of measurement is substantially the same as the one reported earlier (Fig. 2) (La Fond and Prasadarao 1954). A reference point is established by half-burying a large rock (called reference rock) on the backshore sand dune and aligning it to a face of a permanent building nearby. The beach profile is measured along this alignment (Fig. 2). This job requires two persons: One to hold the graduated 8 ft. pole at fixed intervals of 8 ft. and the other to sight on the vertical staff from the top of the reference rock and note the reading of the horizon. 'Since the line of vision to the horizon is nearly horizontal, the reading on the pole which is graduated from the bottom, gives the difference in the height of the stations below the reference level' (La Fond and Prasadarao 1954). It is often necessary to use additional reference points, since the length of the staff is usually not adequate to cover the entire drop along the beach profile. Such points can be easily tied up to the reference point.

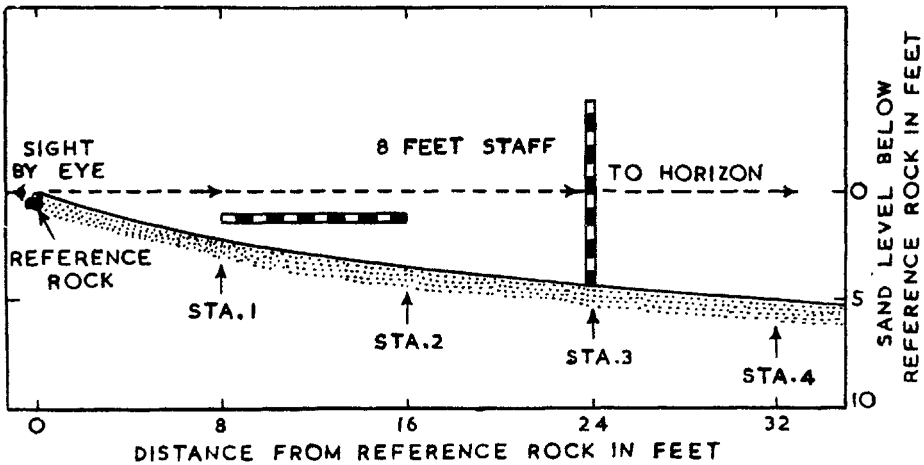

Fig. 2. Method of measuring beach profile.

The profiles are plotted on linear graph paper using suitable scales and the area and 'width' of the backshore and foreshore are computed (Fig. 3). The height of the reference rock above M.S.L. has been arbitrarily fixed at 20 ft. to allow the maximum profile area of the maximum number of profiles to be counted.

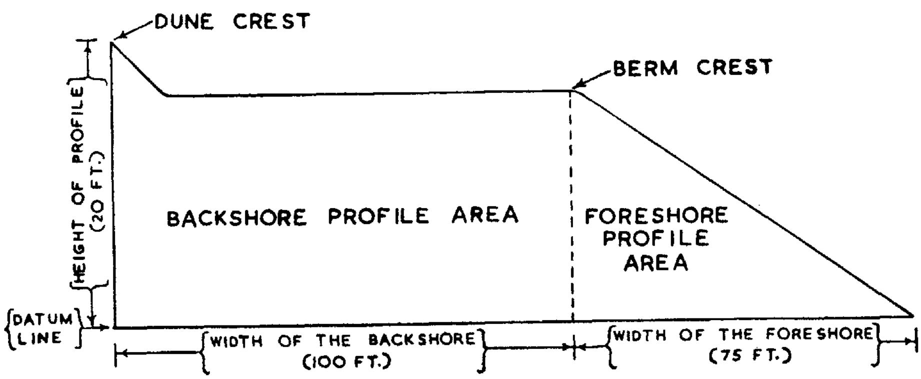

Fig. 3. Idealized cross-section of beach profile.

TABLE I

S. No.	Date on which profile was measured	Time interval between successive measurements (in days)	Backshore			Foreshore			Beach		
			Width (in ft.)	Profile area (in sq. ft.)	Change in the profile area (in sq. ft.)	Width (in ft.)	Profile area (in sq. ft.)	Change in the profile area (in sq. ft.)	Width (in ft.)	Profile area (in sq. ft.)	Change in the profile area (in sq. ft.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	27-3-58	—	136	13,124	—	72	2,176	—	208	15,300	—
2	28-3-58	1	136	12,606	− 518	69	2,124	− 52	205	14,730	− 570
3	1-4-58	4	136	13,572	+ 966	62	1,812	− 312	198	15,384	+ 654
4	2-4-58	1	136	13,804	+ 232	86	2,296	+ 484	222	16,100	+ 716
5	5-4-58	3	136	14,533	+ 729	83	2,107	− 189	219	16,640	+ 540
6	7-4-58	2	136	13,740	− 793	86	2,030	− 77	222	15,770	− 870
7	9-4-58	2	136	13,785	+ 45	77	2,245	+ 215	213	16,030	+ 260
8	11-4-58	2	136	13,440	− 345	69	2,119	− 126	205	15,559	− 471
9	15-4-58	4	136	13,759	+ 319	77	2,201	+ 82	213	15,960	+ 401
10	18-4-58	3	136	13,797	+ 38	67	1,923	− 278	203	15,720	− 240
11	21-4-58	3	144	14,621	+ 824	136	3,259	+1,336	280	17,880	+2,160
12	23-4-58	2	136	14,122	− 499	70	1,948	−1,311	206	16,070	−1,810
13	24-4-58	1	128	13,211	− 911	74	2,249	+ 351	202	15,510	− 560
14	26-4-58	2	128	12,968	− 243	58	2,022	− 277	186	14,990	− 520
15	26-5-58	30	128	12,269	− 699	56	1,741	− 281	184	14,010	− 980
16	28-5-58	2	136	13,522	+1,253	107	4,178	+2,437	243	17,700	+3,690
17	2-6-58	5	128	13,561	+ 39	76	2,289	−1,889	204	15,850	−1,850
18	6-6-58	4	128	13,561	0	83	2,729	+ 440	211	16,290	+ 440
19	7-6-58	1	128	13,323	− 238	80	2,557	− 172	208	15,880	− 410
20	16-6-58	9	128	13,103	− 220	61	2,517	− 40	189	15,620	− 260
21	21-6-58	5	112	11,547	+1,556	82	3,493	+ 976	194	15,040	− 580
22	24-6-58	3	112	11,573	+ 26	93	3,827	+ 334	205	15,400	+ 360
23	26-6-58	2	112	11,657	+ 84	104	4,313	+ 486	216	15,970	+ 570
24	27-6-58	1	112	11,278	− 379	109	3,722	− 591	221	15,000	− 970
25	2-7-58	5	104	11,025	− 253	88	3,765	+ 43	192	14,790	− 210
26	12-7-58	10	104	11,142	+ 117	88	3,968	+ 203	192	15,110	+ 320
27	14-7-58	2	104	11,118	− 24	69	4,032	+ 64	173	15,150	+ 40
28	22-7-58	8	104	11,456	+ 338	80	3,174	− 858	184	14,630	− 520

TABLE I—*contd.*

S. No.	Date on which profile was measured	Time interval between successive measurements (in days)	Backshore			Foreshore			Beach		
			Width (in ft.)	Profile area (in sq. ft.)	Change in the profile area (in sq. ft.)	Width (in ft.)	Profile area (in sq. ft.)	Change in the profile area (in sq. ft.)	Width (in ft.)	Profile area (in sq. ft.)	Change in the profile area (in sq. ft.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
29	29-7-58	7	88	9,911	—1,545	94	3,149	— 25	182	13,060	—1,570
30	11-8-58	13	96	10,664	+ 753	107	4,736	+1,587	203	15,400	+2,340
31	13-8-58	2	96	10,182	— 482	104	4,218	— 518	200	14,400	—1,000
32	18-8-58	5	96	10,053	— 129	67	2,687	—1,531	163	12,740	—1,660
33	13-9-58	26	96	10,106	+ 53	77	3,154	+ 467	173	13,260	+ 520
34	17-9-58	4	88	9,263	— 843	83	3,827	+ 673	171	13,090	— 170
35	24-9-58	7	88	9,264	+ 1	96	4,086	+ 259	184	13,350	+ 260
36	30-9-58	6	99	10,250	+ 986	93	3,520	— 566	192	13,770	+ 420
37	10-10-58	10	95	10,015	— 235	99	4,265	+ 745	195	14,280	+ 510
38	1-11-58	22	96	9,887	— 128	108	4,723	+ 458	204	14,610	+ 330
39	6-11-58	5	96	9,757	— 130	88	3,853	— 870	184	13,610	—1,000
40	17-11-58	11	80	8,590	—1,167	67	2,775	—1,078	147	11,365	—2,245
41	18-11-58	1	80	8,582	— 8	69	2,818	+ 43	149	11,400	+ 35
42	19-11-58	1	80	9,120	+ 538	58	2,342	— 576	138	11,462	+ 62
43	24-11-58	5	72	7,893	—1,227	50	1,707	— 635	122	9,600	—1,862
44	25-11-58	1	72	7,980	+ 87	56	1,984	+ 277	128	9,964	+ 364
45	26-11-58	1	72	7,973	— 7	61	1,876	— 108	133	9,849	— 115
46	28-11-58	2	64	7,181	— 792	58	2,641	+ 765	122	9,822	— 27
47	29-11-58	1	64	7,033	— 148	64	3,070	+ 429	128	10,103	+ 281
48	5-12-58	6	64	7,324	+ 291	56	2,732	— 338	120	10,056	— 47
49	18-12-58	13	64	7,168	— 156	61	2,514	— 218	125	9,682	— 374
50	26-12-58	8	56	6,455	— 713	69	3,267	+ 753	125	9,722	+ 40
51	29-12-58	3	64	7,285	+ 830	67	2,720	— 547	131	10,005	+ 283
52	30-12-58	1	56	6,563	— 722	56	3,192	+ 472	112	9,755	— 250
53	31-12-58	1	56	6,524	— 39	67	3,285	+ 93	123	9,809	+ 54
54	3-1-59	3	56	6,537	+ 13	67	3,582	+ 297	123	10,119	+ 310
55	5-1-59	2	56	6,549	+ 12	69	3,681	+ 99	125	10,230	+ 111
56	12-1-59	7	56	6,540	— 9	67	3,332	— 349	123	9,872	— 358

TABLE I—*concld.*

S. No.	Date on which profile was measured	Time interval between successive measurements (in days)	Backshore			Foreshore			Beach		
			Width (in ft.)	Profile area (in sq. ft.)	Change in the profile area (in sq. ft.)	Width (in ft.)	Profile area (in sq. ft.)	Change in the profile area (in sq. ft.)	Width (in ft.)	Profile area (in sq. ft.)	Change in the profile area (in sq. ft.)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
57	17-1-59	5	56	6,489	−51	58	2,806	−526	114	9,295	−577
58	21-1-59	4	56	6,421	−68	56	2,736	−70	112	9,157	−138
59	24-1-59	3	56	6,530	+109	58	2,788	+52	114	9,318	+161
60	3-2-59	10	64	7,298	+768	50	2,037	−751	114	9,335	+17
61	9-2-59	6	64	7,341	+43	53	2,227	+190	117	9,568	+233
62	11-2-59	2	64	7,318	−23	51	2,142	−85	115	9,460	−108
63	27-2-59	16	56	6,643	−675	58	3,016	+874	114	9,659	+199
64	10-3-59	11	64	7,331	+688	50	2,112	−904	114	9,443	−216
65	13-3-59	3	72	8,200	+869	51	2,197	+85	123	10,397	+954
66	17-3-59	4	64	7,487	−713	56	2,362	+165	120	9,849	−548

Results

Complete data are recorded in Table I. The changes in the profile area of backshore/foreshore/beach between successive profile measurements are added up, taking into consideration the sign of the change (positive or negative), and the net change per year and per day are calculated. Table II gives some important data in an abstract form.

Discussion and Conclusions

An analysis of the profile data leads to the following conclusions:—

1. Though the mean 'width' of the backshore is only $1\frac{1}{4}$ times larger than the corresponding figure for the foreshore, the profile area of the former is about 4 times that of the foreshore. This is so due to the relatively higher elevation of the backshore with reference to the datum line.

2. During the period of study, the beach was subjected to three distinct influences: (*a*) rhythmic short period tide cycle which is indicated by oscillations around the mean (*vide* Figs. 4, 5, 6), (*b*) random 'Cataclysmic' events like the rain storms and (*c*) erosion brought about by the construction of the break-water.

Table II

S. No.	Item	'Width' (in ft.) of			Profile area (in sq. ft.) of		
		Back-shore	Fore-shore	Beach	Back-shore	Fore-shore	Beach
1	Maximum ..	136	107	280	14,621	4,736	17,880
2	Minimum ..	56	50	112	6,421	1,707	9,157
3	Mean ..	95	74	169	10,105	2,894	12,999
4	Mean deviation	26	15	52	2,387	686	2,513
5	Per cent of mean deviation to mean	27·4	20·3	30·8	23·6	23·7	19·3

3. The marked reduction in the dimensions of the beach in November 1958, both in terms of the width of the beach and profile area, are correlated to the unprecedented rain storms and cyclones in the Visakhapatnam area during the period. During a short period of 5 days (Nov. 21 to Nov. 25), there was as much as 19 cm. (about 8″) of rainfall which is roughly 1/5th of the average annual rainfall in the Visakhapatnam area. The resultant floods were so severe that part of Visakhapatnam town was flooded and the rail and road communications to Visakhapatnam were cut off. The relevant rainfall data, drawn from the records of the Indian Meteorological Department, are given below.

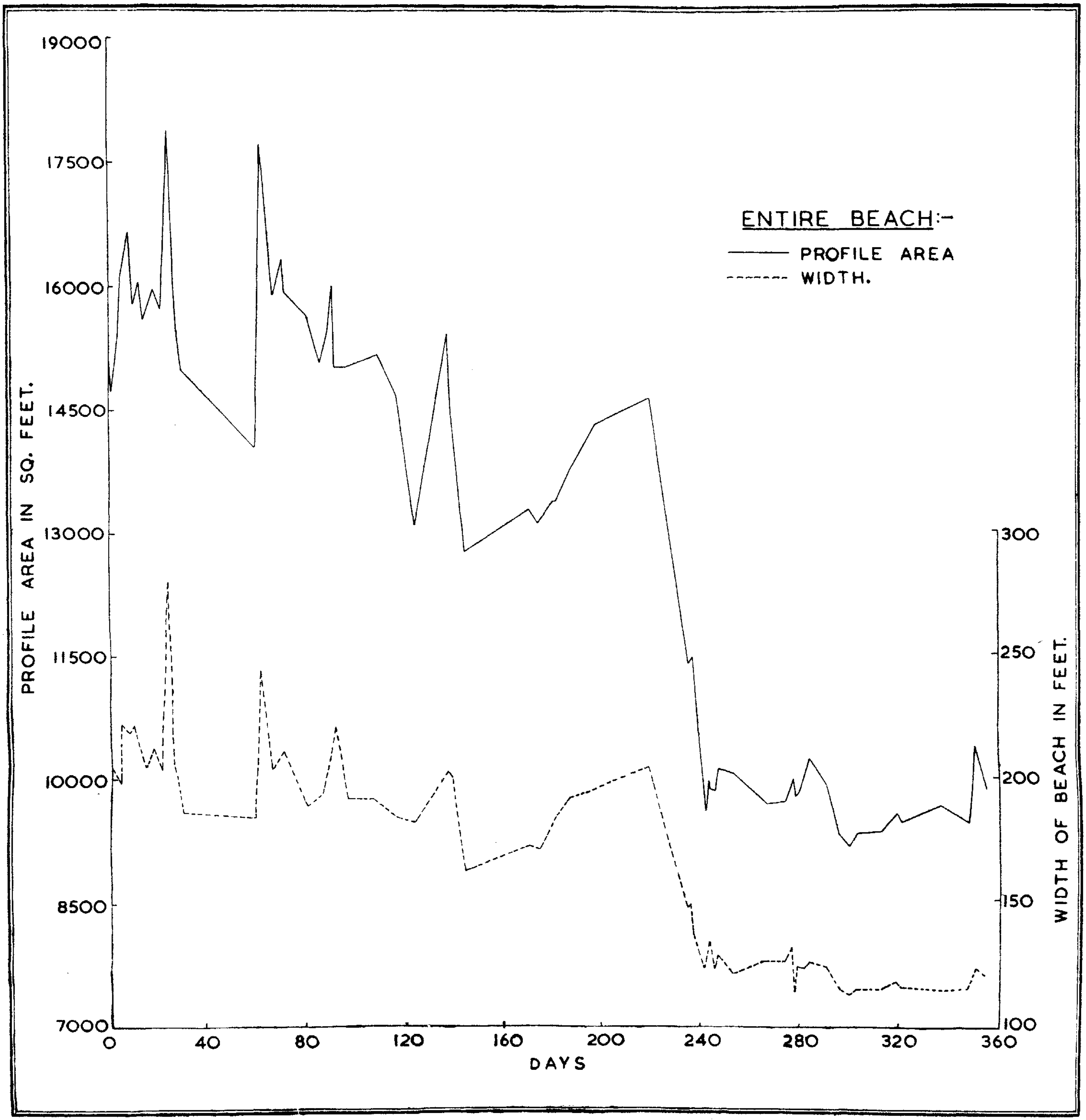

FIG. 4. Width and profile area of the beach.

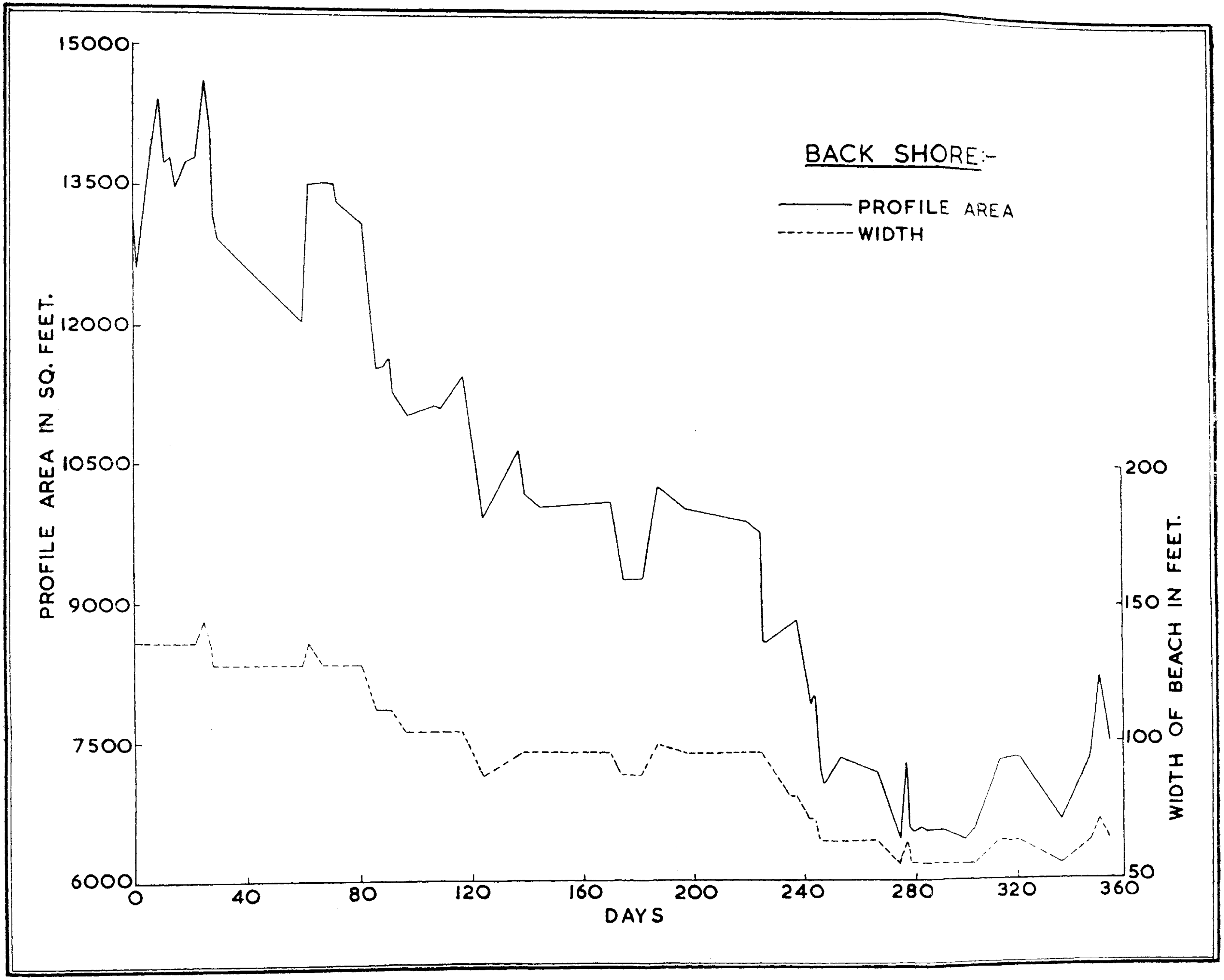

FIG. 5. Width and profile area of the backshore.

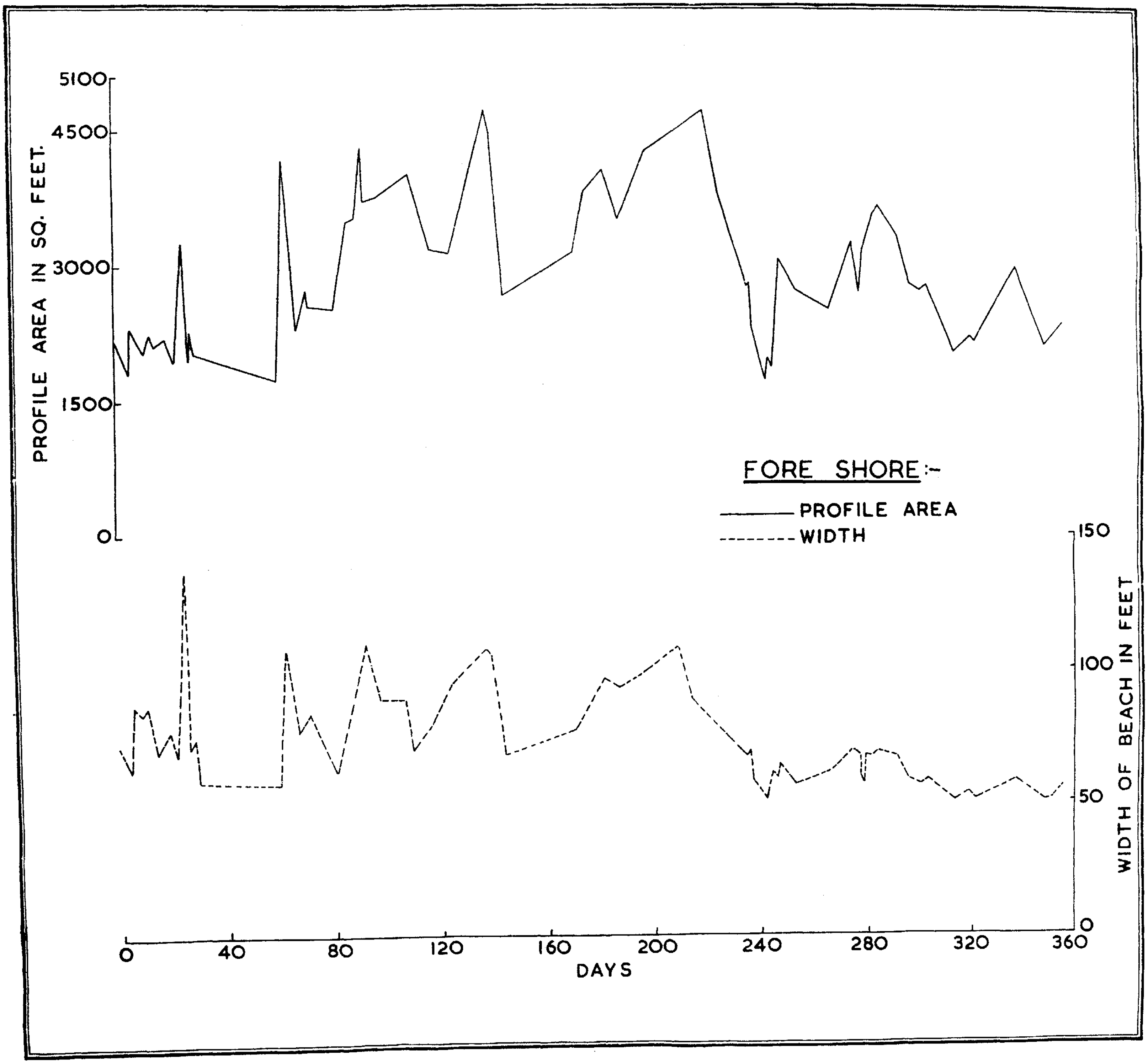

Fig. 6. Width and profile area of the foreshore.

Date		Rainfall (in mm.)
November	3	18·0
,,	4	2·7
,,	21	27·2
,,	22	81·3
,,	23	40·5
,,	24	41·0
,,	25	12·3
,,	27	1·8

4. An examination of the profile *vs.* time curve indicates that the beach as a whole follows a negative exponential trend. This is a direct consequence of the beach erosion which, as has been explained earlier, has been induced by the construction of the break-water at the entrance of the Harbour channel. In the particular period under study, it so happened that the negative exponential trend has been deeply accentuated in November 1958 by the unprecedented floods and the consequent prevalence of erosion conditions. In other words, the degradation tendency is there, independent of the superposition of random factors.

The beach and backshore follow a similar trend while the foreshore exhibits a series of oscillations with no delineable trend.

5. During the period of study, there has been a net reduction of 5,837 sq. ft. in the profile area of the backshore (which gives an average rate of −16·44 sq. ft./day). The total reduction corresponds to 57·8 per cent of the mean profile area (10,105 sq. ft.) of the backshore.

The profile area of the foreshore oscillated around a mean in a more or less steady fashion but ultimately showed an insignificant net increase of 86 sq. ft. (or at the rate of +0·24 sq. ft./day) which is about 3 per cent of the mean profile area (8,600 sq. ft.) of the foreshore. The beach taken as a whole has recorded a net reduction of profile area which corresponds to 41·9 per cent of the mean profile area (12,999 sq. ft.) of the beach.

6. The 'width' of the backshore has been reduced from 136 ft. in the beginning of the year to about half of this figure towards the end of it. The foreshore oscillated widely in its 'width' but without significant net annual change. The 'width' of the beach, as a whole, has been shortened from 208 ft. in the beginning of the year to about 120 ft. towards the end of it.

7. The beach changes that took place during the year 1958-59 are clearly atypical and it would hence be incorrect to project the rate of change in the width, profile area, etc., to the coming years. Meaningful conclusions can be drawn on the quantum of beach changes only after the data (of the type that have been collected) are accumulated for several years.

8. When the beach changes in response to the influence of any major

factor affecting it, the backshore tends to react to it slowly and steadily. The foreshore, which is the part of the beach most amenable to change, is markedly influenced by minor factors like tides but is not significantly affected by major long term factors like erosion due to the construction of the breakwater. Apparently the long term changes are obliterated by short period modifications.

9. What has been measured in the present study is the change in the external morphology of the beach. It is quite possible that there could be under surface movement of sand, without its effect being necessarily reflected in the external shape of the profile.

Further Work

The sand movement in the littoral region off Visakhapatnam-Waltair beach is proposed to be studied using Scandium-46 tracer (Putman and Smith 1956) since, as earlier explained, the beach erosion cycles and littoral drift are interrelated. It is also proposed to conduct flume experiments using radio-tracers, to study the movement of sand of various dimensions, under the impact of wave action of different magnitudes.

Acknowledgement

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