

STUDIES ON COASTAL PROCESSES IN THE VICINITY OF GANGAVARAM BAY, EAST COAST OF INDIA

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A B S T R A C T

The coast in between Yarada Konda and Kutu Konda is about 11 km in length. This part of the coast has assumed significant importance because of the proposed construction of a steel plant here. Also there is a great potential for the development of the Gangavaram tidal inlet to serve as a small harbour. This paper presents the studies made on beach changes, littoral drift, longshore currents and wave characteristics in this area. The study revealed that the net longshore transport along this coast is $0.65 \times 10^6 \text{ m}^3$ in the northeasterly direction and this part of the coast is found to be in stable and dynamic equilibrium condition.

INTRODUCTION

The Gangavaram Bay is situated about 10 km south of Visakhapatnam along the east coast of India. It possesses the possibilities of developing as a small harbour. The coastline in this vicinity between Yarada Konda and Kutu Konda (Fig. 1) comprises of promontories, pocket beaches as well as open sandy beaches. Gangavaram and Appikonda are the two small villages situated respectively at northern and southern parts of the beach (Fig. 1). The alignment of the coast lies approximately in a northeast and southwest direction. The understanding of the coastal processes in this region would be much value for any coastal developments in this region.

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CLIMATE AND OCEANOGRAPHY

The climate in this region is controlled by reversing monsoons which can be divided into premonsoon (March-May), south-west monsoon (June-September) and northeast monsoon (December-February). The average yearly rainfall is about 975 mm. The cyclonic storms occurring in Bay of Bengal are generally associated with heavy rains, rough seas and considerable rise in sea levels due to storm surges. The air temperature varies from about 19°C to 33°C, during the year. The sea is rough during May to September with wave heights ranging from 1 to 3 m. During October to December, the sea is calm except during cyclonic period. For the remaining period of the year, sea is generally calm with light swells. The wave periods range between 8 and 10 secs during the greater part of the year. The width of the continental shelf in this region varies between 35 to 40 km (Rao, Machado and Moorthy, 1980). The shelf edge is narrow and occurs at about 130 m depth.

METHOD OF STUDY

Seven stations were established along this stretch (Fig. 1) and monthly observations on beach level changes and longshore currents were measured for a period of 13 months from December 1978 to December 1979. The wave height, period and direction were visually observed every month at 80 m water depth off the study area using a boat. The trapezoidal rule was used for computing the beach volumes. The longshore energy flux formula was used for computing longshore transport along this region (Shore Protection Manual, 1975).

$$Q = 7500 \times \frac{\rho g^2 H_o^2 T K_r^2 \sin 2\alpha_b}{64 \pi}$$

where,

- Q = annual sediment transport in cubic yards
- ρ = sea water density in lb/ft³
- g = acceleration due to gravity in ft/sec²
- H_o = deep water wave height in ft.
- T = wave period in sec.
- K_r = refraction coefficient = $(\cos \alpha_o / \cos \alpha_b)^{1/2}$
- α_o = deepwater wave angle
- α_b = breaker angle

RESULTS AND DISCUSSION

Wave Characteristics

Monthly average wave heights, periods and direction as

observed at 80 m depth are presented in Table 1. The wave height varied between 0.5 m and 3.0 m during June to September, 0.5 m to 2.0 m during November to January and 0.3 m to 3.0 m during remaining period. The wave period varied between 5 and 12 sec during the period of study. Waves were approaching from the direction between SE and S during March to September and between NE and SE during October to February.

Longshore Currents

The distribution of observed longshore currents is shown in Fig. 2. In general, the longshore current direction was towards northeast during April to September, towards southwest during November to February and the direction was variable in March and October. It was observed that the longshore current was comparatively stronger with speeds 0.30 - 0.60 m/sec in January, May and September and weaker with speeds 0.05 to 0.20 m/sec in August, November and December. Strong longshore currents even in the order of 1.0 m/sec were observed most of the time along the beach near stations 5, 6 and 7. This is quite understandable due to the fact that this particular stretch of the coast is exposed to direct wave action. At station 3 which is flanked and partly protected between two promontories, weak currents of the order 0.5 to 0.25 m/sec were observed during the study period.

Littoral Drift

The computed quantity and direction of the longshore transport along this region is shown in Fig. 3. The longshore sediment transport was about $0.89 \times 10^6 \text{ m}^3$ towards northeast during March to September and $0.24 \times 10^6 \text{ m}^3$ towards southwest during October to February. The net transport was towards northeast and it was estimated to be $0.65 \times 10^6 \text{ m}^3$. For the coast along Visakhapatnam region, Saxena, Vaidyaramanan and Srinivasan (1976) reported that a northerly drift of $0.88 \times 10^6 \text{ m}^3$ during southwest monsoon and calm weather period and a southerly drift of $0.18 \times 10^6 \text{ m}^3$ during northeast monsoon. Chandramohan (1982) reported for Visakhapatnam region that a northerly drift of $0.94 \times 10^6 \text{ m}^3$ during March to September and a southerly drift of $0.28 \times 10^6 \text{ m}^3$ during October to February. The quantity of sediment transport computed for the study area is in close agreement with the quantity reported for the Visakhapatnam region.

Beach Changes

Monthly variation of beach levels at station 3 and 6 representing a pocket beach and an open beach respectively are

shown in Figs. 4 and 5. The width and height of the beach subjected to annual changes are shown in Table 2. The beach near station 4 is subjected to maximum vertical level changes of about 4.3 m whereas the beach near station 3 is subjected to maximum width changes of about 135 m. The values of maximum and minimum foreshore slope changes during the period of study at different stations and their time of occurrence are presented in Table 3. It is observed that the variation in the foreshore slope during an annual cycle at station 4 is not very significant.

The variation in the quantity of sediment deposited per unit length of the beach with reference to the lowest beach level is shown in Fig. 6. It shows that during the study period, the sediment volume fluctuation per unit length of the beach on an annual basis is only upto a maximum of about 407 m³ near station 3 and minimum of about 83 m³ near station 6. These sediment volume fluctuation were 176, 239, 105, 116 and 336 m³ near stations 1, 2, 4, 5 and 7 respectively. The beach level variations near stations 1, 5 and 6 are similar in nature and they experienced erosion during March to September and accretion during October to February. Station 2 is situated just south of Gangavaram inlet and experienced erosion during December to March and accretion during April to November. During the study period the beach was observed to be in erosional phase at station 3. A part of the beach near station 4 underwent erosion during September to December and accretion during January to August. The beach near station 7 experienced erosion during January to April and deposition takes place around December and January.

The net volume changes of beach sediments along this stretch stretch of the beach in an annual cycle shows that the beach is stable and there is no net addition or removal of sand. Also, the beach profiles at all seven stations regained their original level after the completion of an annual cycle.

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TABLE 1

Wave Characteristics by Visual Observation

Month	Height (m)	Period (sec)	*Direction (deg)
January	0.5 - 0.8	6 - 8	- 15
February	0.3 - 1.0	5 - 8	- 5
March	1.0 - 1.5	6 - 8	5
April	1.0 - 3.0	8 -10	45
May	1.0 - 2.5	6 - 9	60
June	1.5 - 3.0	6 -10	75
July	0.5 - 2.0	6 -10	75
August	0.5 - 2.5	8 -10	75
September	0.5 - 2.0	6 -10	55
October	0.5 - 2.0	8 -12	- 15
November	0.5 - 2.0	6 -10	- 65
December	1.0 - 1.5	6 - 9	- 15

*(+) sign = angle clockwise to the coast
 (-) sign = angle anticlockwise to the coast.

TABLE 2

Height and Width of Beach Changes

Station No.	Changes in beach elevation (m)	Changes in beach width (m)
1	2.5	60
2	3.0	95
3	3.0	135
4	4.3	25
5	3.5	65
6	2.5	65
7	3.5	35

TABLE 3

Changes in Foreshore Slope

Station No	Maximum Slope	Minimum Slope
1	0.080 (June)	0.011 (February)
2	0.033 (April)	0.015 (November)
3	0.120 (December)	0.015 (June)
4	0.020 (September)	0.018 (February)
5	0.048 (June)	0.012 (December)
6	0.055 (August)	0.024 (May)
7	0.150 (September)	0.018 (January)

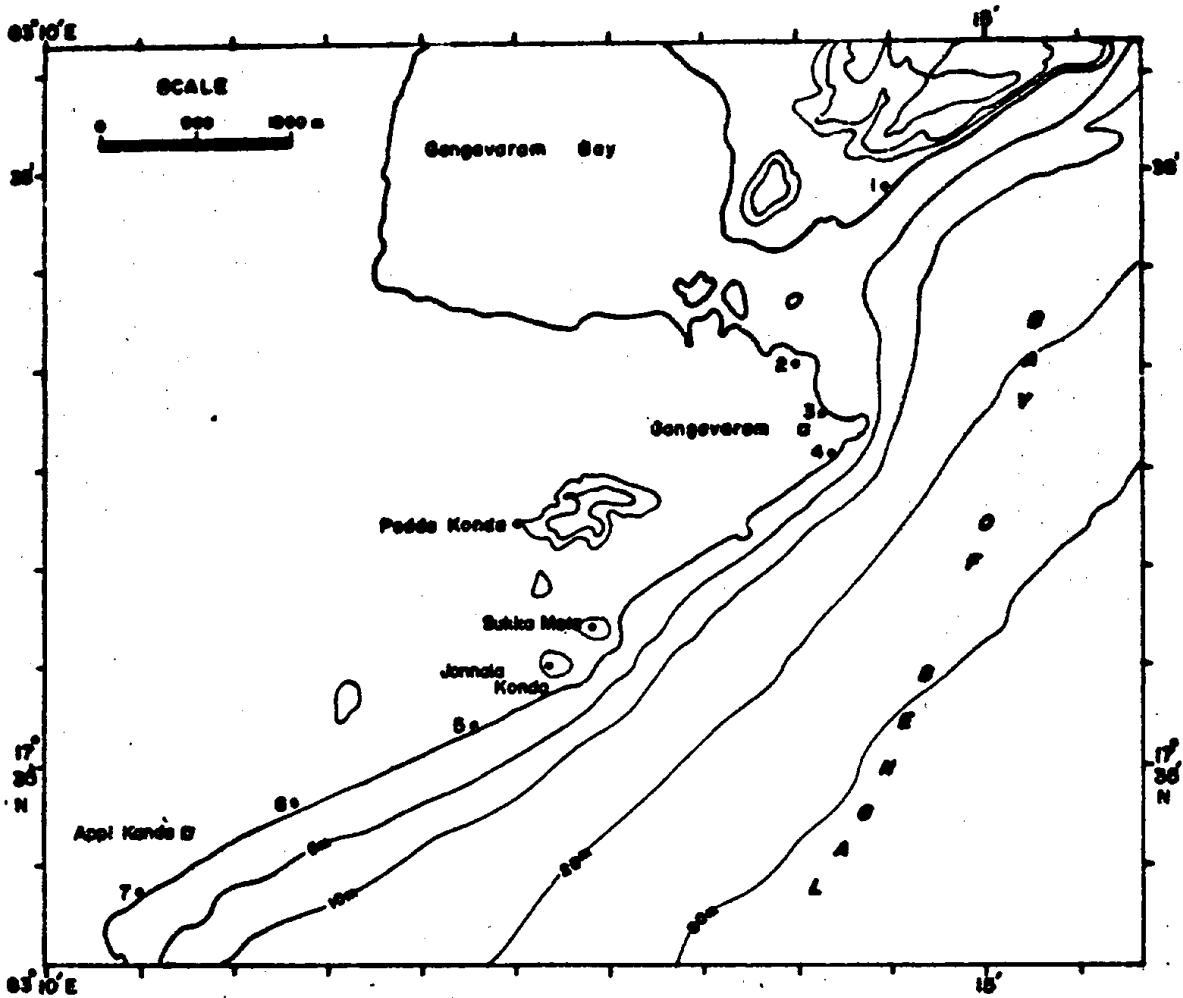


Fig.1 Location map

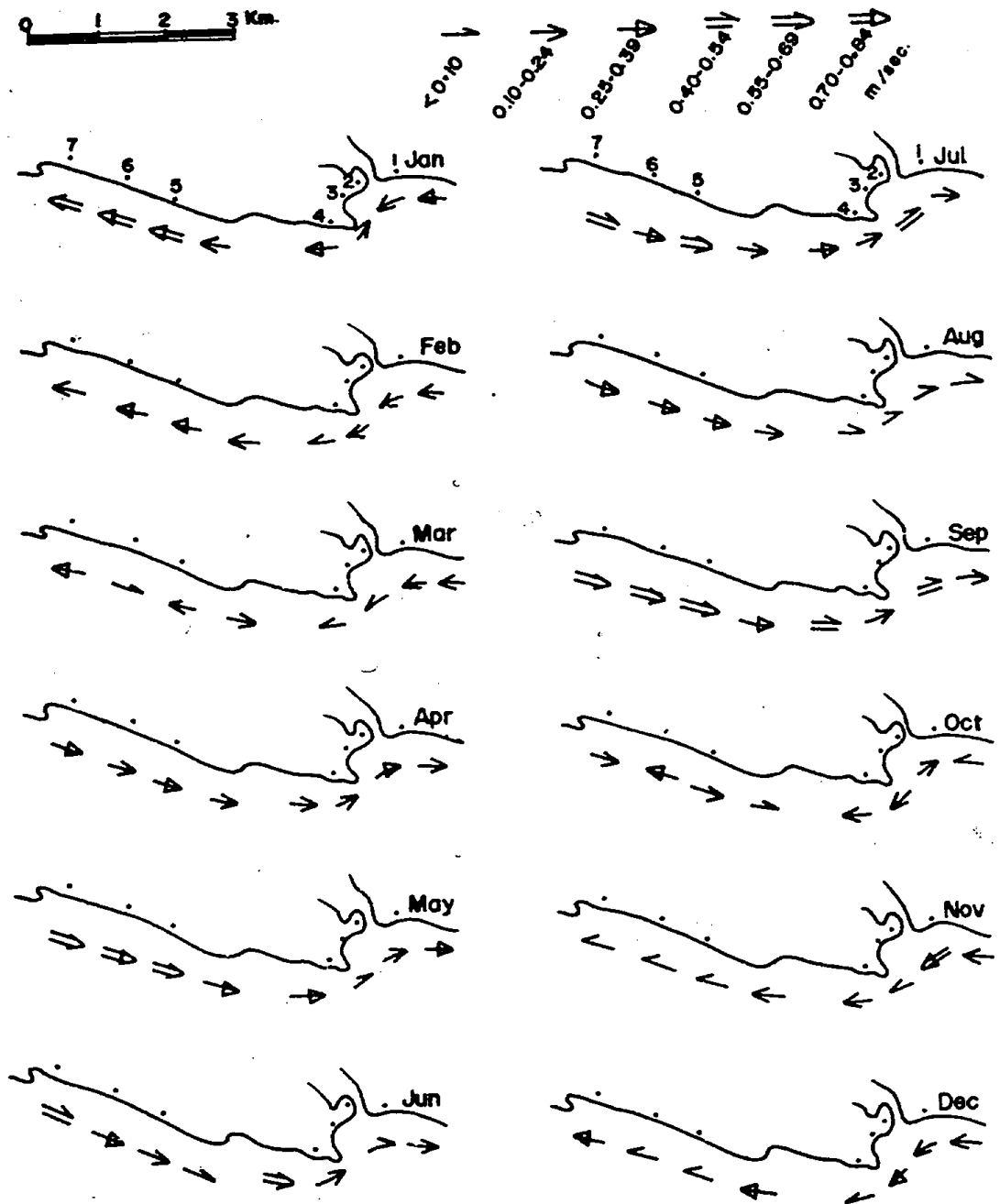


Fig.2. Distribution of speed and direction of longshore currents.

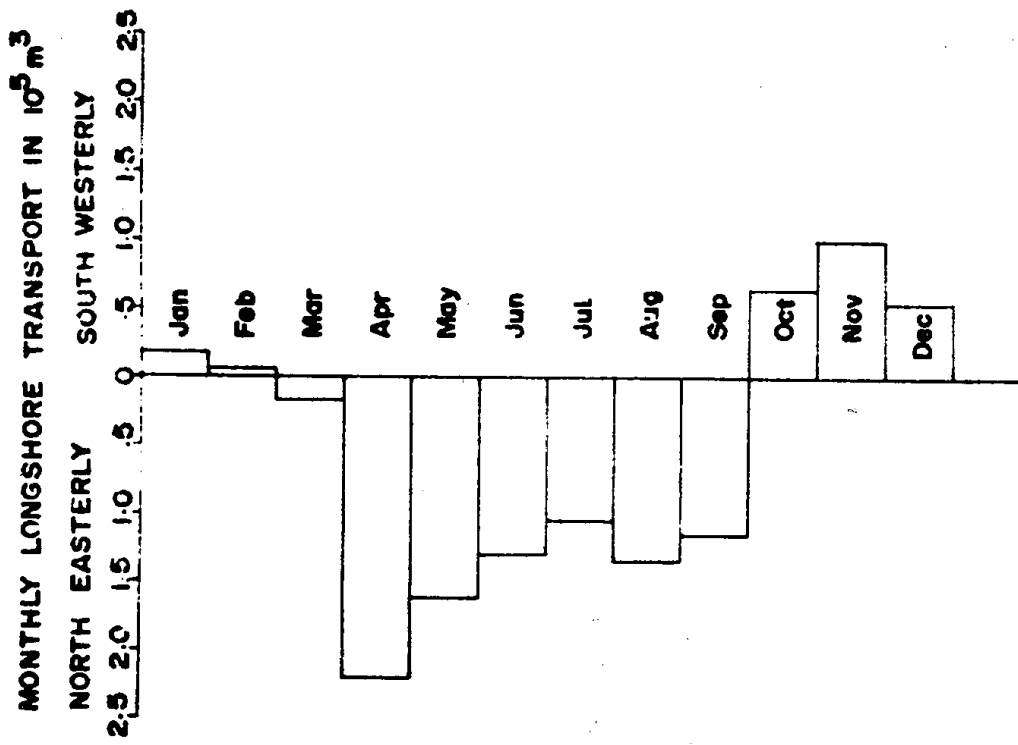


Fig. 3. Monthly distribution of longshore transport.

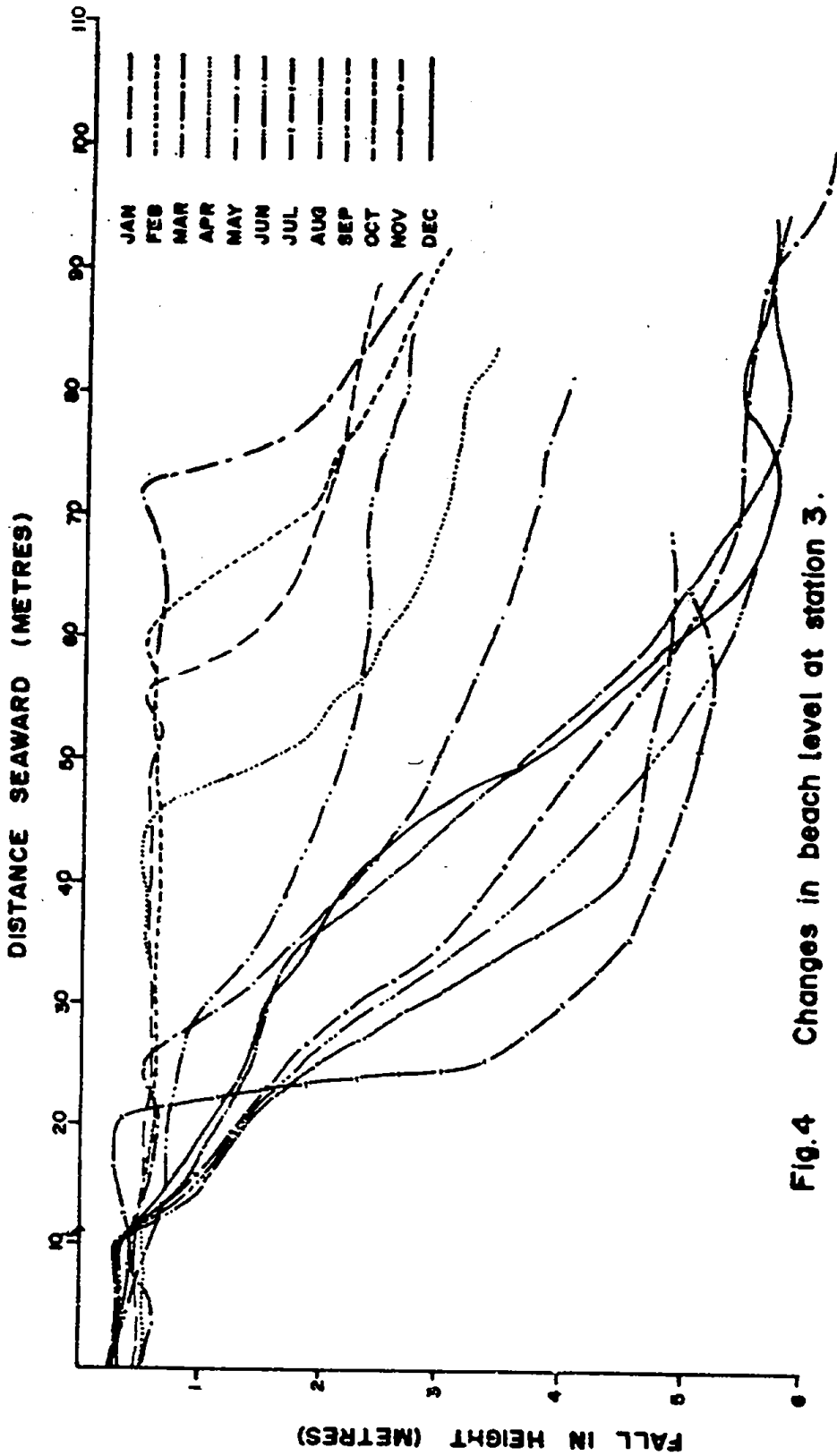


Fig. 4 Changes in beach level at station 3.

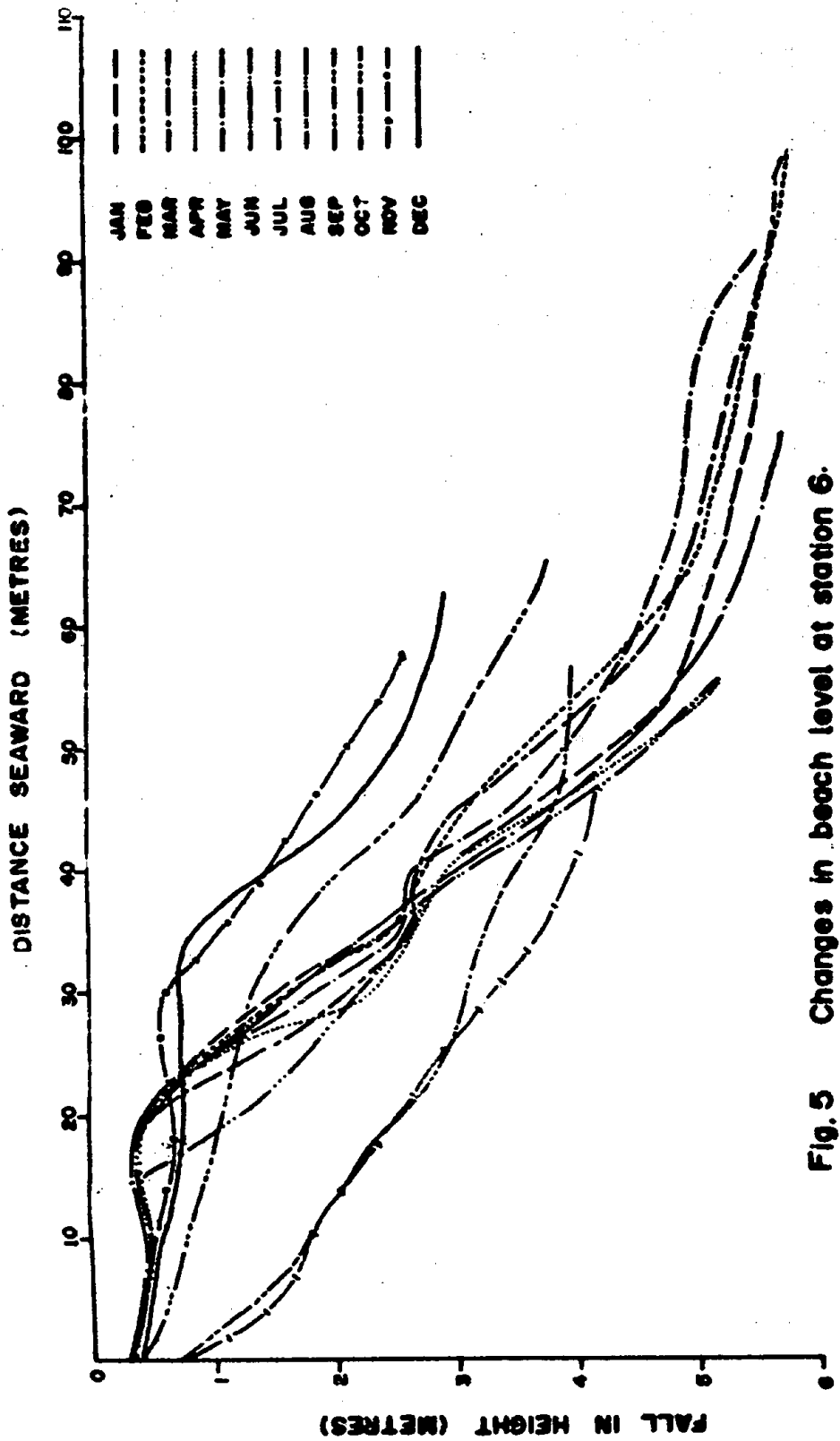


Fig. 5 Changes in beach level at station 6.

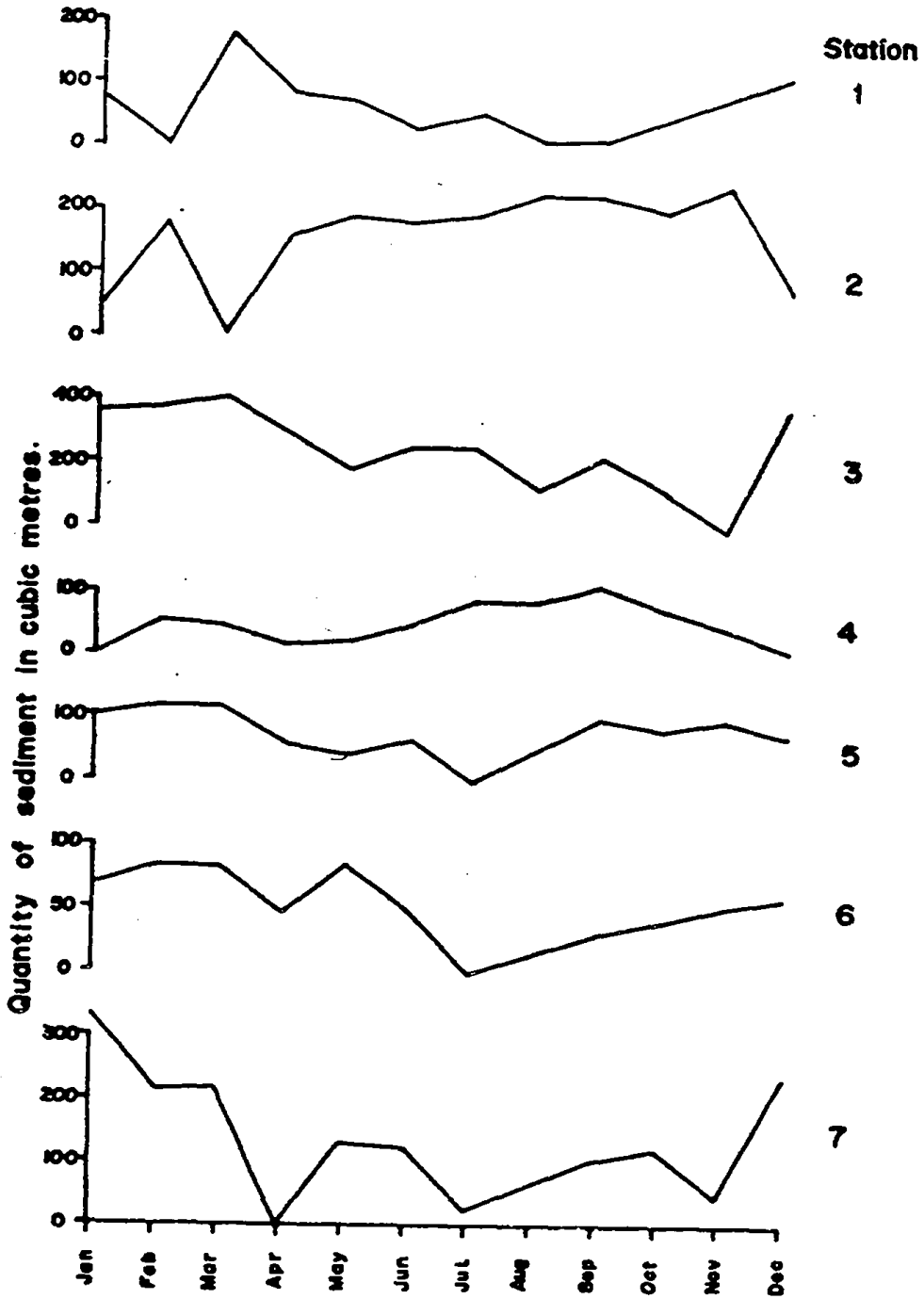


Fig.6 Quantity of sediment deposited /Unit length of Beach