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SHORELINE STABILITY IN THE VICINITY OF COCHIN HARBOUR

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ABSTRACT

A small stretch of barrier beach on either side of Cochin harbour along the west coast of India has been investigated for its stability through systematic surveys. The observed erosion of the beaches during the southwest monsoon is due to an order of magnitude increase in the wave energy. But the accretional tendency of the beaches along the Narakkal zone are due to the presence of static mud suspension in this region during monsoon season. Beaches of Anthakaranazhi exhibited a near-cyclic behaviour, showing stability over a period of one year. The growth of shoreline north of Cochin harbour channel takes place at the cost of sediment that should have otherwise by-passed the estuarine mouth. During the southwest monsoon the development of opposing circulation cells on either side of the harbour entrance channel favours siltation in the channel.

1. INTRODUCTION

Sandy beaches along most of the shorelines of the world, exhibit variations in their geometric form over different time scales in response to the prevailing dynamic forces due to waves, tides and associated currents. In the nearshore zone, these forces together with the available sedimentary material control the nature and extent of variability of the beach geometric form and decide the stability of the adjoining shoreline. The information about the shoreline stability, on a long term basis is a pre-requisite for the design and effective maintenance of navigable water ways, harbours and marine structures. The present study is an attempt to understand the shoreline stability in the vicinity of Cochin harbour which is exposed to the monsoonal wind and wave climate.

2. ENVIRONMENTAL SETTING OF THE STUDY AREA

Along the southern half of the west coast of India, the barrier beaches of Kerala are backed by extensive lagoonal systems. The sediments in the nearshore areas have been found to be mostly silty-clays or clayey-silts with marginal differences in their depth of occurrence. The beach material comprises of sand in the medium to very fine size limits. The tides in this area are of semi-diurnal

type and fall within the microtidal range (1.2 m). The area under study is about 57 km stretch of shoreline from Azhikode to Anthakaranazhi (Fig.1). The strip from Azhikode to Vypeen (26.5 km) and Fort Cochin to Anthakaranazhi (30 km) forms two barrier islands known as Vypeen and Chellanam islands respectively with widths varying from 1.6 to 2.4 km. The bordering beaches compose of fine sands and possess, in general, a low profile.

The Cochin harbour mouth is the major inlet connecting the backwaters to the Arabian Sea. The navigation channel of Cochin harbour consists of 6km long approach channel, 3 km long Ernakulam channel and 4km long Mattancheri channel inside the backwater system. The approach channel was constructed in 1928 by cutting the offshore sand bar about 1.6 km west of the coast. Silting is a severe problem in the outer channel which is being dredged every year to maintain the required depth.

3. DATA ACQUISITION AND ANALYSIS

In order to assess the shoreline stability, the study area has been divided into four zones - Narakkal and Malipuram along Vypeen island and Fort Cochin and Anthakaranazhi along Chellanam island. In all, 15 locations have been selected for field observations

(Fig.1). The beach profiles were monitored following the technique of Emergy (1961) for a period of 16 months from October 1980 to January 1982. These surveys were carried out at the time of low tide at fortnightly intervals along the Malipuram and Fort Cochin zones and at monthly intervals along the Narakkal and Anthakaranazhi zones, keeping a constant distance of 5 m between stations (Fig.2) along the profile. From the data collected during these surveys, the beach profiles were drawn using a HP 1000 computer. From these plots, changes in the volume of sediment ($m^3 m^{-1}$ of shoreline) were computed to examine the temporal variations.

The nearshore wave induced fields have been worked out based on the convergence and divergence patterns obtained from the refraction diagrams (Shenoi and Prasanna Kumar, 1982).

4. RESULTS

4.1. Zone - Narakkal

The observed beach profiles (Fig.3a) at the three locations in this zone show the presence of fully grown berm at locations N1 and N2 with varying distance of 5-15 m from the reference point (R.P.). At N3 such a feature is not observed.

The volume computations indicate the fact that beaches at Narakkal zone (Fig.4a), in general, gain material during the period of study through alternate cycles of accretion and erosion. During the period May to December, the response of the beaches at all the three locations is similar except for minor departures during times of accretion. However, during December (1980) to May (1981), the depositional or erosional trend indicates greater complexity at all the three locations.

4.2 Zone - Malipuram

In this zone, the beach profiles at each of the locations show the presence of a berm and a wider backshore (fig.3b). The location of the berm varies between 5 and 30 m from R.P.

Volume computations highlight the fact that, in the Malipuram zone, though there is a wide variation in the response of the beaches during January to June, the beaches on the northern part (M1 & M2) and southern part (M3 & M4) behave more or less in a similar pattern during July to December (fig.4b). Even though M1 & M2 are subjected to alternate accretion and erosion, the net change leads to a build up. At M3 & M4, the beaches do not show much of an accretional tendency.

4.3 Zone - Fort Cochin

The beach profiles along this zone indicate the presence of wide berm ranging 5 - 30 m from R.P., except at F4, where no permanent berm exists (fig.3c). The volume computations show that the beaches in this zone are subjected to accretional and erosional cycles with differential lags and leads (fig.4c). In general, the beaches undergo erosion over the period of study.

4.4 Zone - Anthakaranazhi

The beaches in this zone exhibit the presence of berm located between 5 and 20 m from R.P. (fig.3d). The volume changes show an accretional tendency during January to April and suddenly experience severe erosion from May to July (Fig.4d). Then onwards the beaches show depositional tendency.

4.5 Nearshore flow patterns

The nearshore flow patterns are presented in figs. 5a-e. The flow associated with waves of 6 sec period approaching from 220° TN, indicates large number of circulatory cells (fig.5a). With increasing wave period, the number of cells increases but their sizes decrease. For waves from 240° TN (fig.5b) the larger cells could be identified at the northern stretch of the coast when the periods are 6, 12 & 14 sec, while smaller cells appear along the southern stretch. Waves of 260° and 280° TN (fig.5c & d) give rise to large cells which are more conspicuous on the southern stretch for 10 & 12 sec period waves.

There exists a clockwise circulation off Vypeen and anti-clockwise circulation off Cochin associated with 6, 8 and 10 sec waves. Waves approaching the coast from 300° TN (fig.5e) produce large cells along the northern and southern stretches for 6 & 12 sec and 10 & 14 sec waves respectively.

5. DISCUSSION

The beaches investigated for their stability, along all the four zones experienced erosion and accretion of varying magnitude at all locations. The beaches within the Narakkal and Anthakaranazhi zones, in general, indicate similar patterns of accretion and erosion within each of the zones. However, the response of the Narakkal zone differed from that of Anthakaranazhi zone. In the Narakkal zone, all the beaches accrete over the period of study whereas, the beaches of Anthakaranazhi exhibited a near-cyclic behaviour, showing stability over a period of one year. Beaches of Malipuram and Fort Cochin zones showed wide range of variation with varying lags and leads in the times of occurrence

of accretion and erosion.

In order to understand the observed intra and inter-variability of the beaches, by way of accretion and erosion, the near-shore wave climate and the flows prevailing close to the shore have been detailed.

An examination of the wave climate of this coast shows that the waves approaching the coast with deep water directions of 220°TN to 300°TN and with periods varying from 6 to 14 sec contribute significantly in the littoral movement of sediment along this coast. These waves, as they propagate over the shelf, and after experiencing refraction to variable degrees, indicate divergence of wave energy followed on either side by convergence along the coast. These converging and diverging zones have been found to shift along the shore with changes in the wave period (Prasanna Kumar, 1985). Under the influence of the alternating converging and diverging zones, the observed erosion and deposition of sediments on these beaches are not continuous over sufficiently longer time scales but are likely to exhibit greater variability. This is more pronounced in the Malipuram and Fort Cochin zones, as the refraction functions show greater variation in the convergence and divergence pattern. This may be the reason for the observed differential response of the beaches, especially within Malipuram and Fort Cochin zones.

The wave energies computed along this coast are of the order of $10^4 \text{ gm m.m}^{-1} \text{ day}^{-1}$ at the onset of the southwest monsoon (Prasanna Kumar et al., 1983). Under the influence of this increased wave energy, the beaches should experience erosion. But the accretional tendency of the beaches along the Narakkal zone are due to the presence of static mud suspension (mud bank) present close to the shore during the southwest monsoon season. These mud suspensions attenuate the wave energy thereby helping in the accretion of the adjoining beaches.

Detailed examination of the bathymetric charts (fig.1) shows a progression of shoreline north of Cochin with flat inshore bottom contour while south of Cochin recession is noticed where the depth contours are very steep. This growth of shoreline near Vypeen takes place at the expense of the sediment that should have by-passed the estuarine mouth in the absence of the channel. This results in inadequate supply of sediments from the north to the southern beaches and leads to the erosion of the beaches affecting their stability. During

the monsoon season, when the predominant wave direction is 260° - 280°TN , the wave induced near shore circulation shows an anti-clockwise cell north of Cochin harbour and a clockwise cell south of it. Under the influence of these cells, sediment from either side of the channel gets transported into the channel thereby causing high siltation in the outer channel.

6. CONCLUSIONS

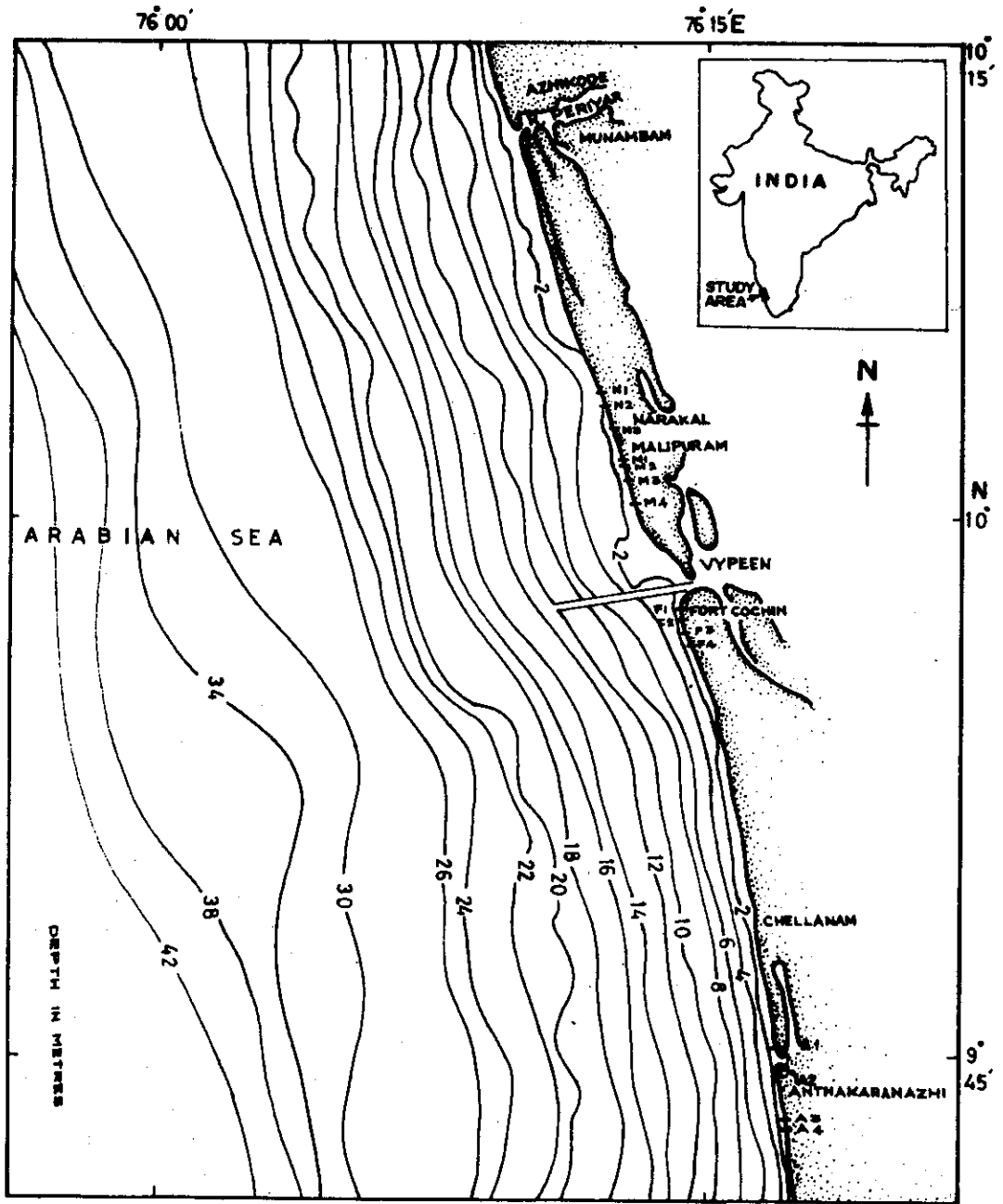
In general, the beaches along the Kerala coast are subjected to high rate of erosion for a short period (southwest monsoon), while the rest of the period they are exposed to low wave energy, congenial for beach build-up. This indicates the dynamic equilibrium of the barrier beaches of Kerala, except those in the vicinity of mudbanks. The region where mudbank exists, the beaches adjacent to build-up even during monsoon season, due to the protection offered by the static mud suspension. But this growth of the shoreline takes place at the cost of the sediments that would have otherwise by-passed to the southern stretches under the prevailing southerly flows.

7. ACKNOWLEDGEMENT

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8. REFERENCES

- EMERY, K.O. (1961). A simple method of measuring beach profiles. *Limnology and Oceanography*, vol. 6, 90-92.
- PRASANNA KUMAR, S. (1985). Studies on sediment transport in the surf zone along certain beaches of Kerala. Ph.D. thesis, Cochin University of Science and Technology, Cochin, 110.
- PRASANNA KUMAR, S., SHENOI, S.S.C. and KURUP, P.G. (1983). Littoral drift along shoreline between Munambam and Anthakaranazhi, Kerala coast. *Indian Journal of Marine Sciences*, vol. 12, 209-212.
- SHENOI, S.S.C. and PRASANNA KUMAR, S. (1982). Littoral processes along shoreline from Azhikode to Anthakaranazhi on the Kerala coast. *Indian Journal of Marine Sciences*, vol. 11, 201-207.



N1-N3; M1-M4; F1-F4; A1-A4- Locations for field observations.

FIG.1 MAP SHOWING BATHYMETRY AND ZONES UNDER STUDY.

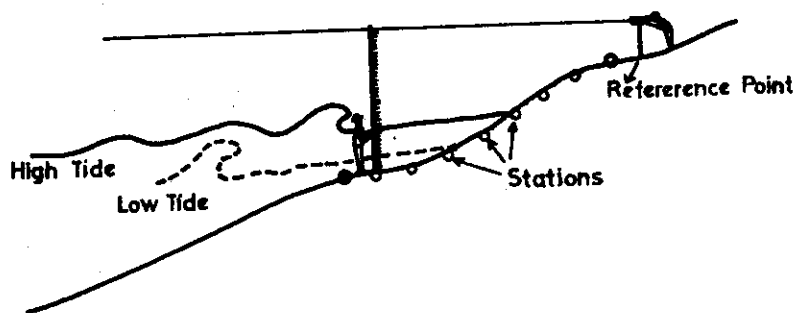


Fig. 2 Diagram showing methodology of beach Profiling (not to scale)

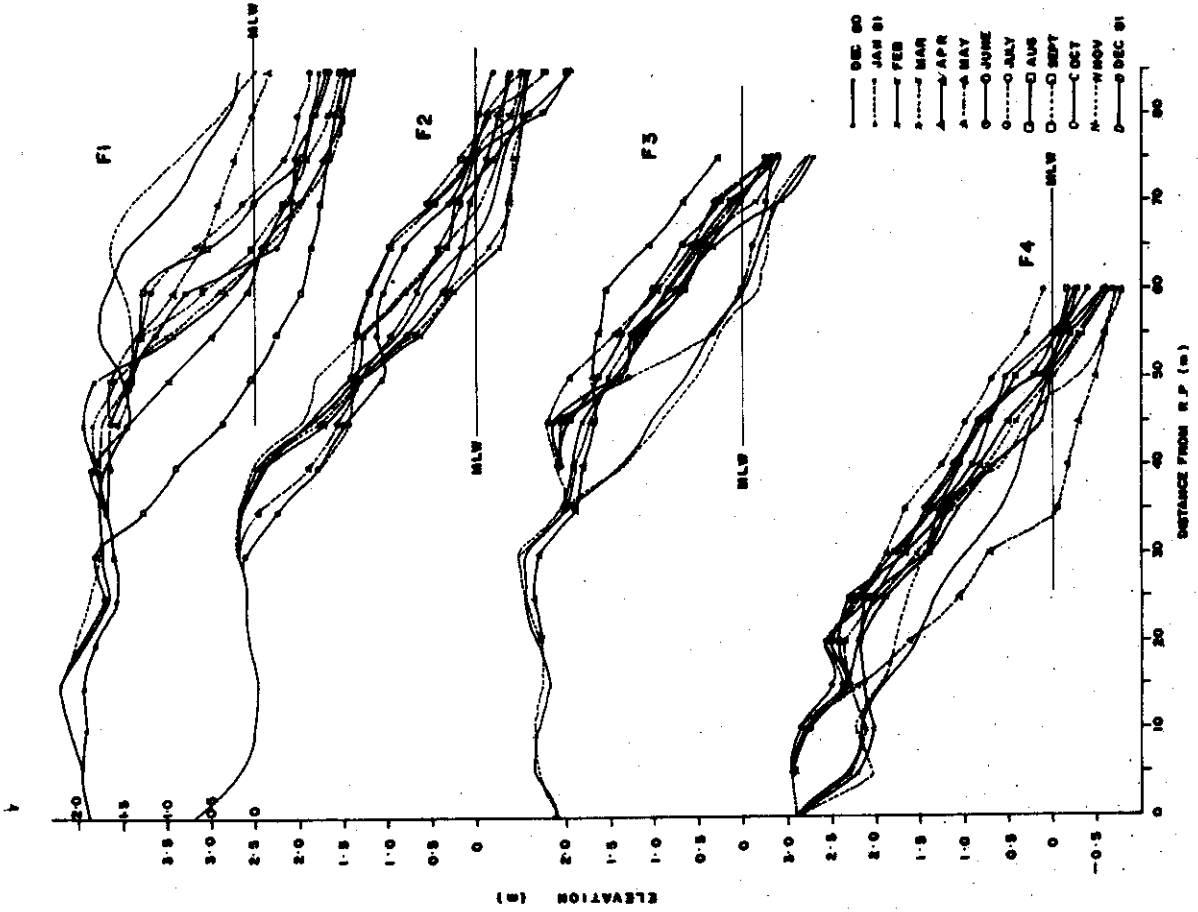


Fig.3c Beech profiles of Fort Cochin zone.

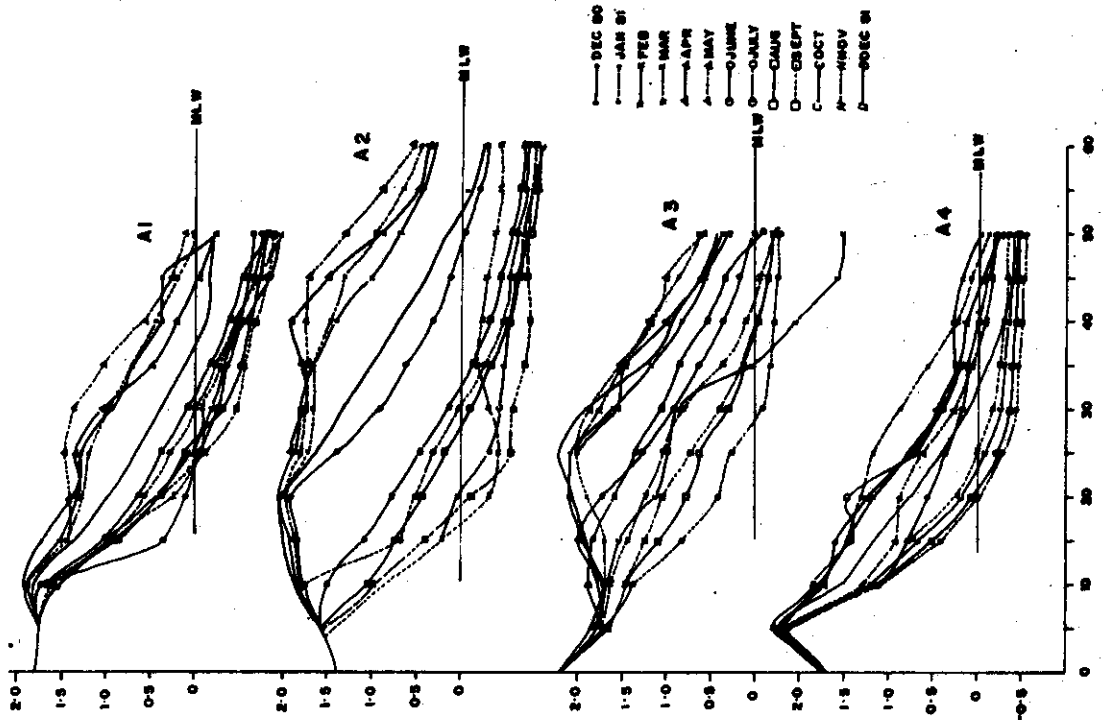


Fig.3d Beech profiles of Anthakaramzai zone.

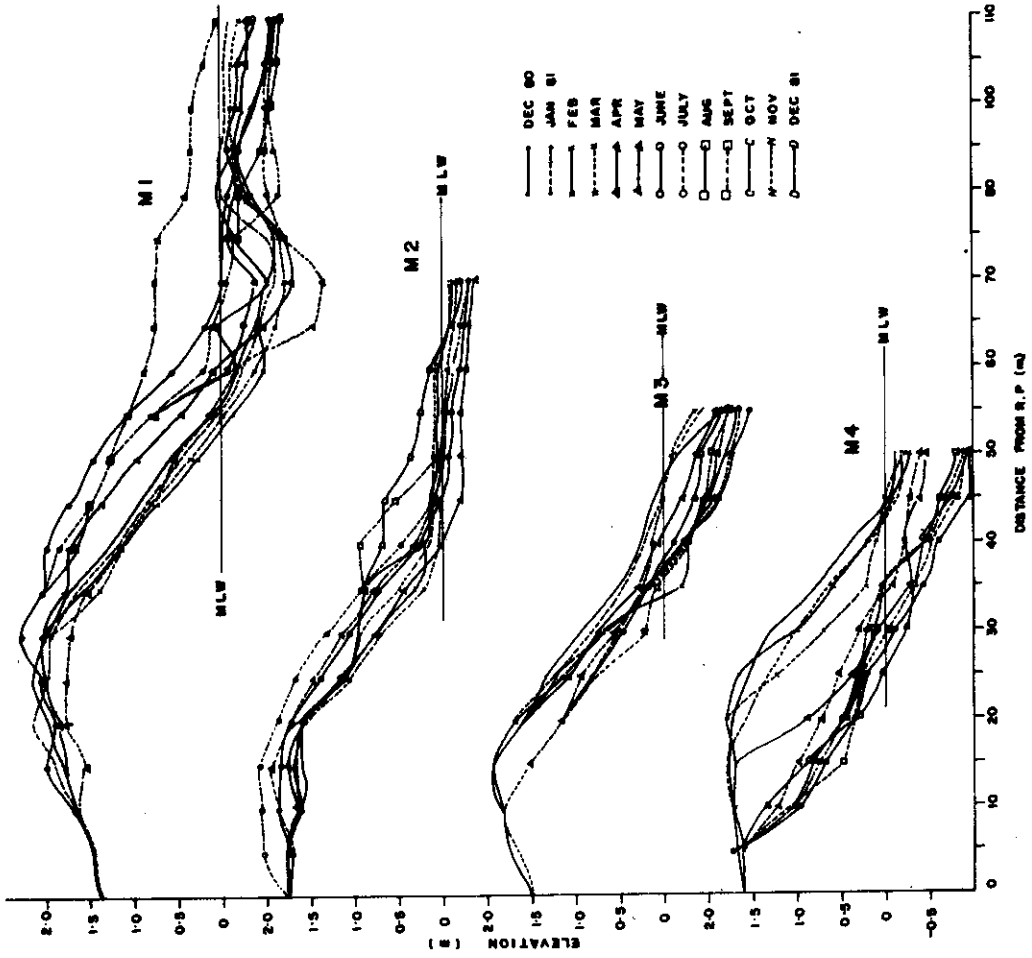


Fig. 3b Beach profiles of Malpapuram zone

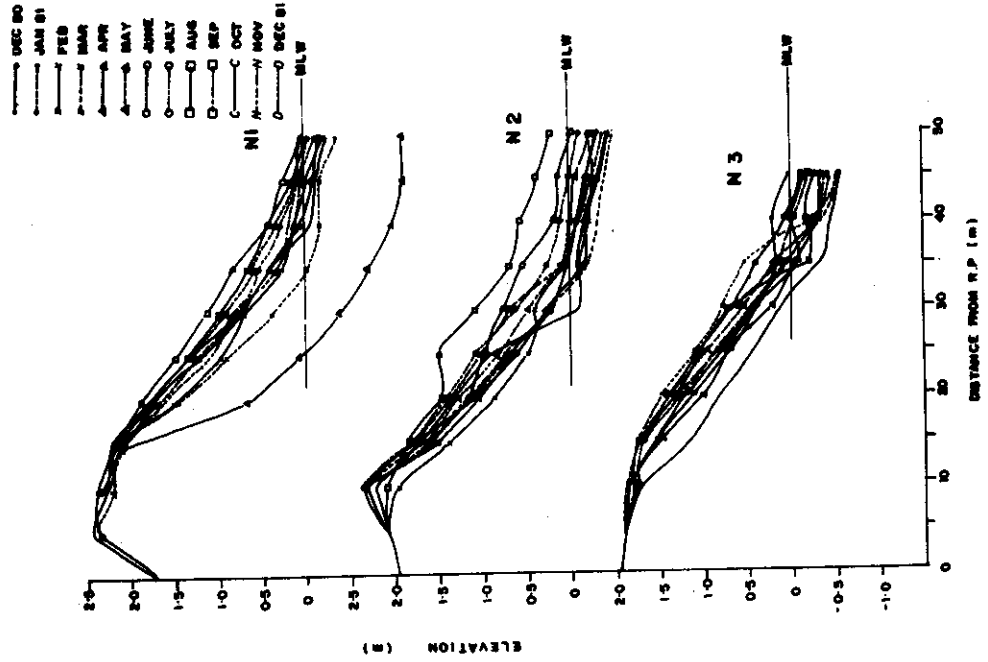


Fig. 3a: Beach profiles of Marakkal zone

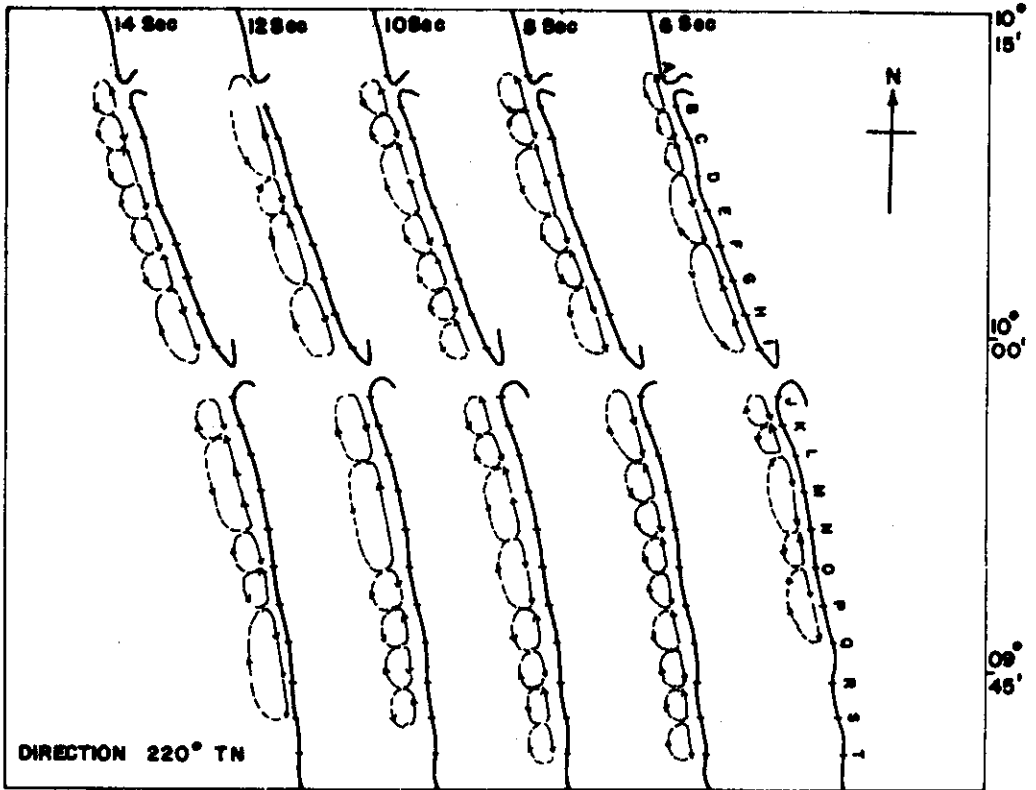


Fig. 4a Cellular circulation associated with wave convergence and divergence

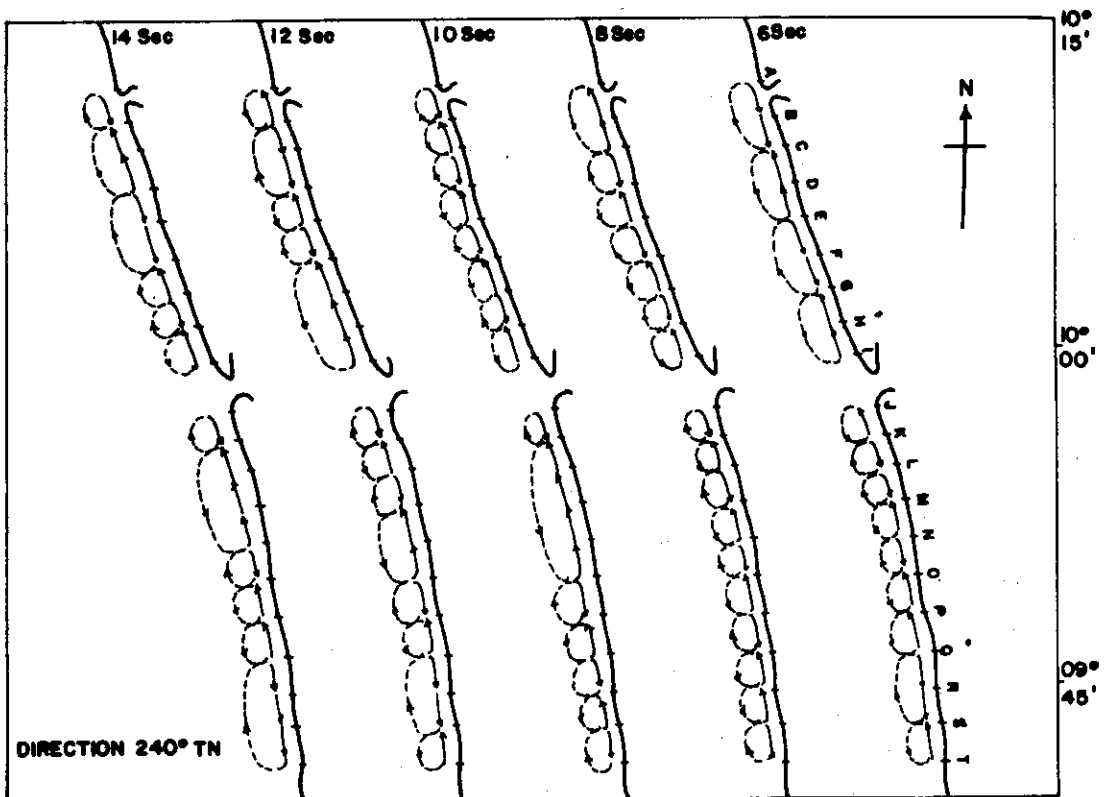


Fig. 4b Cellular circulation associated with wave convergence and divergence

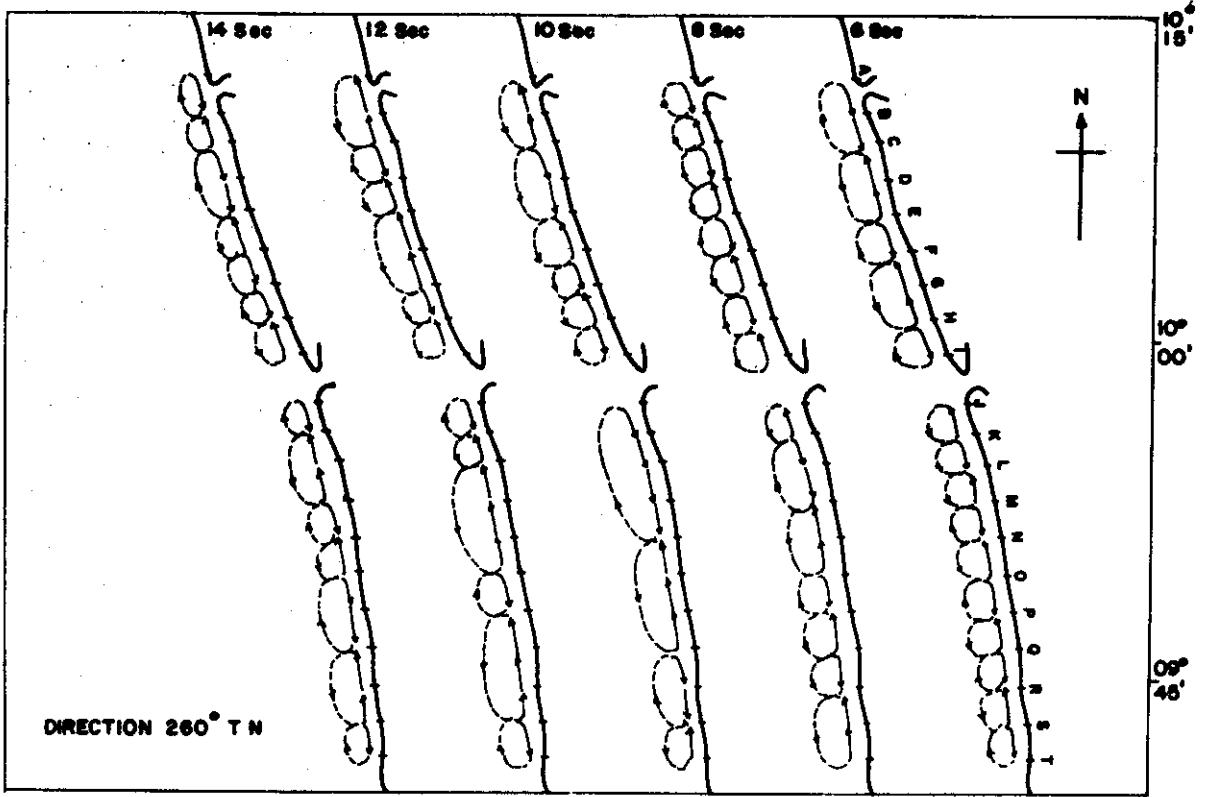


Fig. 4c Cellular circulation associated with wave convergence and divergence

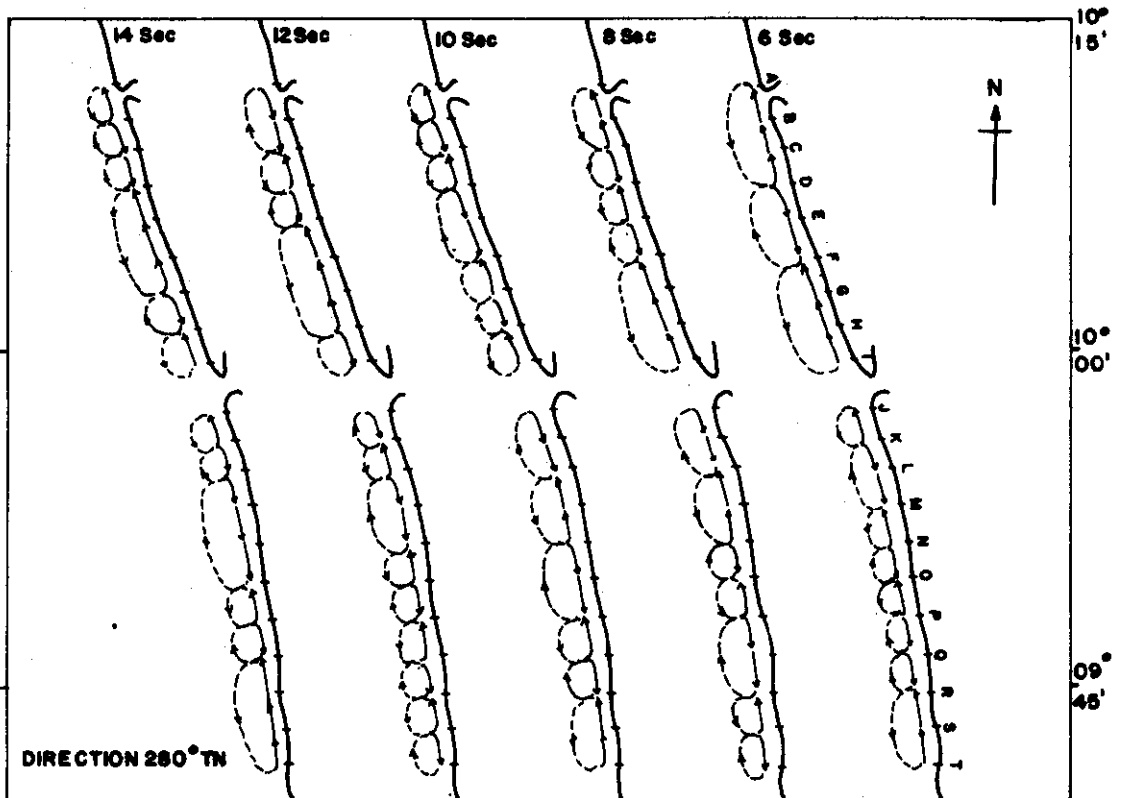


Fig. 4d Cellular circulation associated with wave convergence and divergence

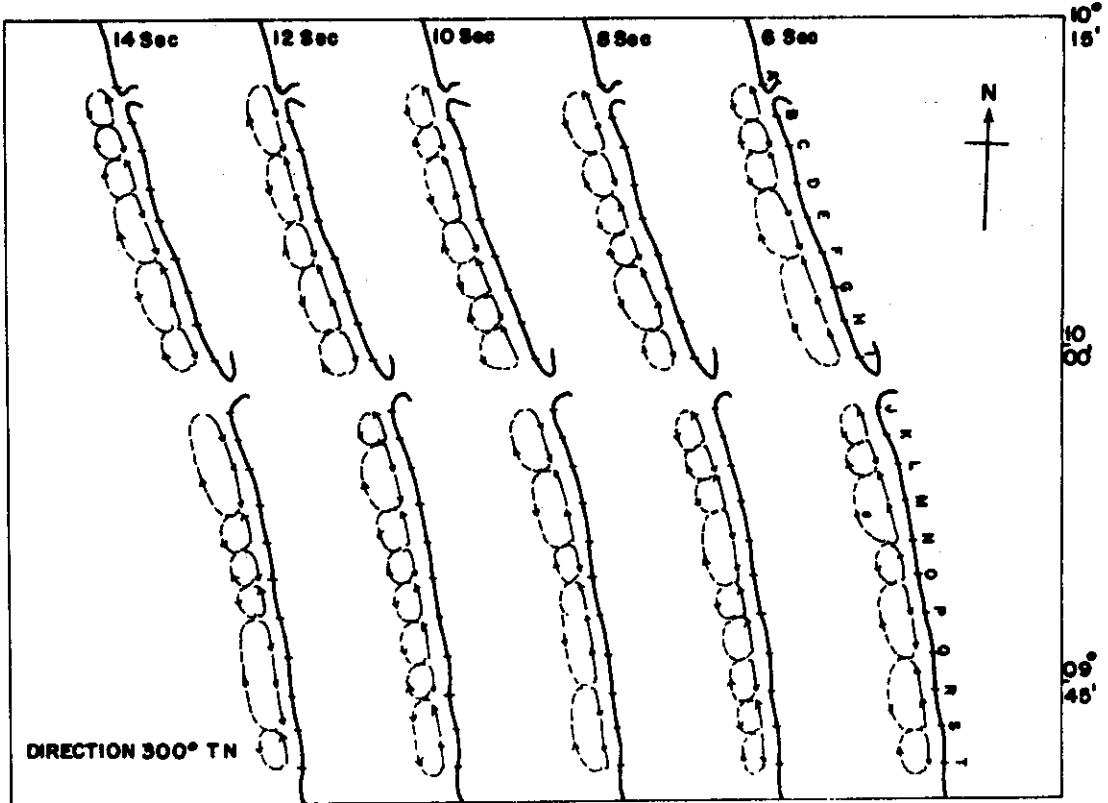


Fig. 4a Cellular circulation associated with wave convergence and divergence

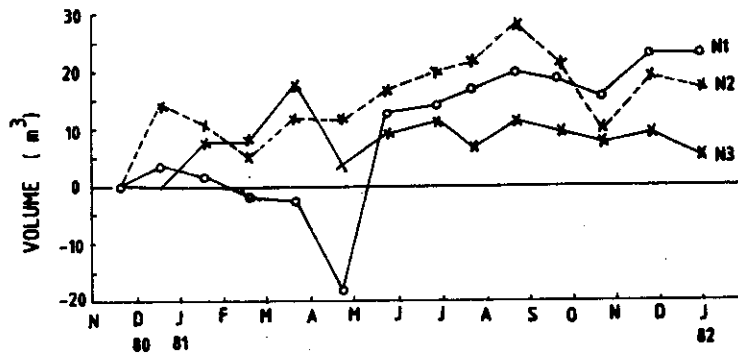


Fig. 5a Monthly changes in beach volume at Narakal zone.

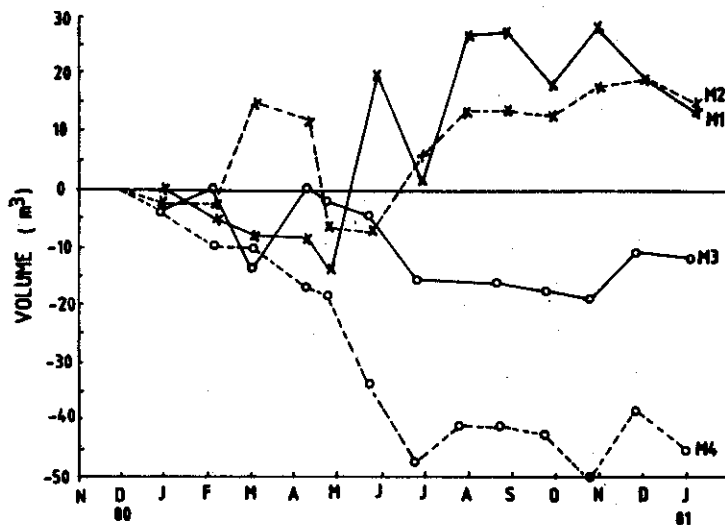


Fig. 5b Monthly changes in beach volume at Malipuram zone.

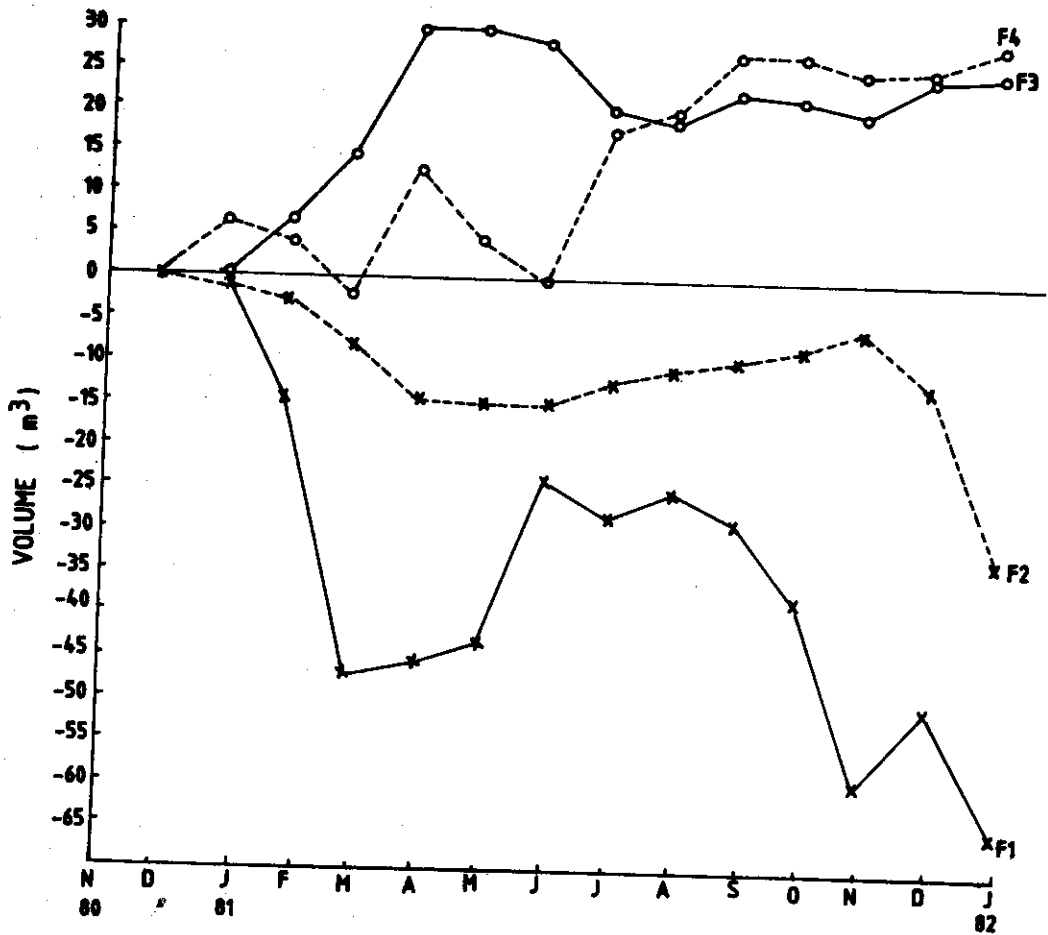


Fig. 5c Monthly changes in beach volume at Fort Cochin zone.

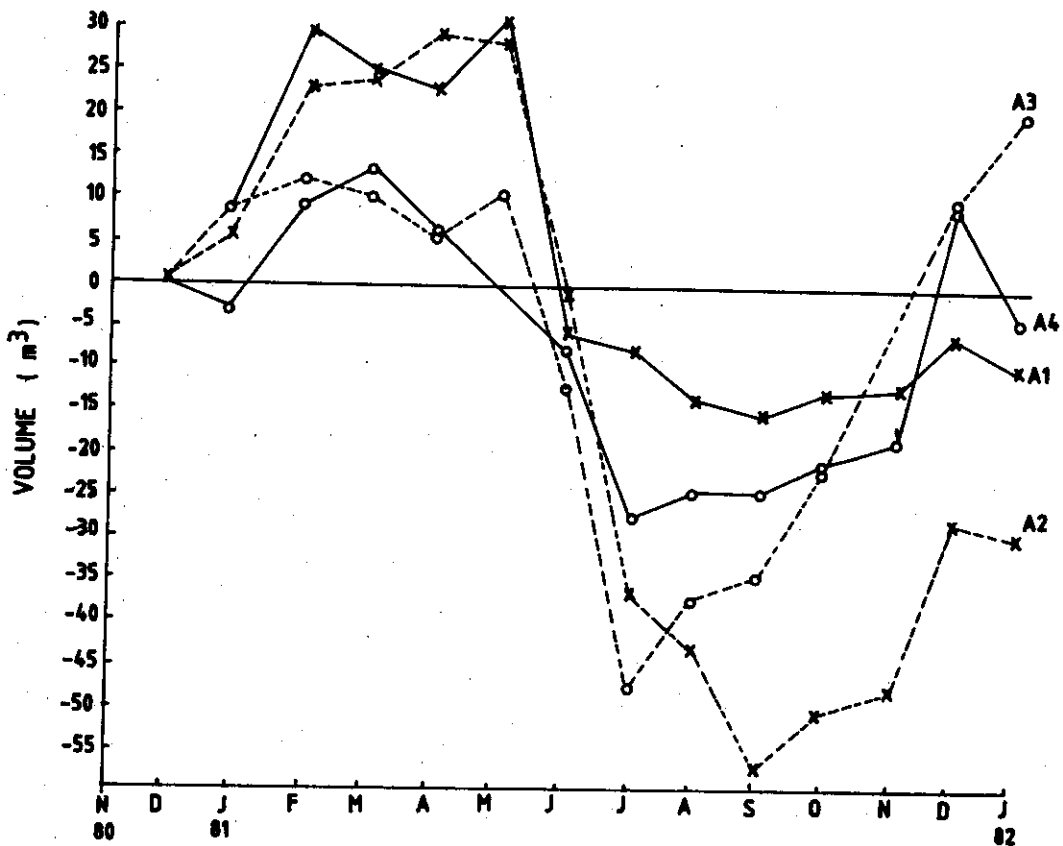


Fig. 5d Monthly changes in beach volume at Anthakaranazhi zone.