CHAPTER 39

LONGSHORE CURRENTS AND WAVES AT BURULLUS COAST

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ABSTRACT : Littoral currents within the breaker zone and currents other than those induced by waves beyond the breaker zone exist with considerable magnitude along the Nile Delta coast. Analysis of the littoral currents within the breaker zone by four semi-empirical formulae involving energy, momentum and radiation stress principles indicates good correlation between predicted and observed velocities. Galvin-Eagleson approach gives the best fit. Current data are statistically analysed enabling the determination of the magnitude, direction and percentage of occurrence of any particular littoral current for any particular period.

More comprehensive studies of the currents climate within the breaker zone and beyond the breaker zone for the entire Nile Delta coast covering a large number of years are under way.

INTRODUCTION : The complex offshore and nearshore processes which change continually are mainly due to two sources of energy, namely due to waves and due to currents other than those induced by waves. In the very shallow water zone and especially the breaker zone when waves break at an angle with the beach, the momentum of the breaking waves generates a longshore current along the beach and thus inside the breaker zone, such wave-induced currents predominate over other currents, though the situation may be reversed beyond the breaker zone and other currents such as tidal or wind driven currents may predominate.

Though there has been many attempts for a theoretical solution of the longshore currents, they have not been highly successful. The main defects are in the assumptions made in regard to the variables which simplify the complexity too drastically. Moreover, rip currents, types of breakers, underwater topography and interdependence of some of the variables further complicate the analysis. Similarly empirical analysis can be only as good as the data on which it is based and data even with sophisticated instrumentation are very difficult to get especially in the breaker zone.

THEORY : There are at least three different methods of analysis of longshore currents namely (i) use of semi-empirical formulae based on theory and field data which require obtaining the best fit between actual field data and predicted velocities for each particular location; (ii) combining the

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individual variables linearly through a method known as multiple linear regression (6), and (iii) attempting a non-linear approximation using a product form of optimum powers of individual variables. However, only the first approach was attempted in this paper due to the type of available field data.

There are at least 15 different equations proposed by different investigators (1,2,3,5,7,8,9,10,11,12,13,14,15) but they can be divided into four classes namely: the momentum balance, energy balance, conservation of mass and empirical correlation of data. All of them are based on simplified bottom topography, and a steady state of equilibrium either in terms of momentum exchange, energy and conservation of mass, or continuity. Some are based on rip currents also though they have not been used in this study due to the absence of rip currents in the area of field study.

The following four formulae were used.

1. Brebner and Kamphuis (2), 1963.

(a) Energy Balance

$$V_{\ell Be} = \frac{8H_o}{T^{1/3}} \left| \sin 1.65\theta_o + 0.1 \sin 3.30\theta_o \right| \sin\alpha^{1/3} \quad \text{in ft/sec} \quad (1)$$

(b) Momentum Balance

$$V_{\ell Bm} = \frac{14H_o^{\frac{3}{4}}}{T^{\frac{1}{2}}} \left| \sin 1.65\theta_o + 0.1 \sin 3.30\theta_o \right| \sin\alpha^{1/3} \quad \text{in ft/sec} \quad (2)$$

In these V_ℓ= longshore component of current in the breaker zone, H_o = deep water wave height, T = period, θ= angle between the wave crest and the bottom contours, and $\tan\alpha$ = beach slope.

They have the advantage that they contain deep water equivalents of wave characteristics which are the fundamental variables available from wave forecasting techniques. In the energy balance principle, the total energy of an incoming wave is assumed to be dissipated in the breaking wave, in the frictional resistance of the bottom and in generating the longshore current. The momentum approach considers the momentum given to a volume of water put into motion in the direction of wave propagation when the wave breaks. The alongshore component of this momentum provides energy of the longshore component.

2. Galvin-Eagleson (5), 1965. The Galvin-Eagleson formula, namely:

$$V_{\ell G} = KgT \tan\alpha \sin 2\theta_b \quad \text{(m/sec)} \quad (3)$$

is based on both field and laboratory data and on the momentum balance principle. K, a coefficient, has been assumed to be unity though it varies from 0.6 to 1.1 .

3. Komar-Inman (1,10,11), 1970. The Komar-Inman formula, namely:

$$V_{\ell K} = 2.45\, U_m \sin\theta_b \quad \text{(m/sec)} \quad (4)$$

is based on both field and laboratory data and assumes that the longshore currents are generated from the longshore component of the radiation stress. U_m = maximum horizontal component of the orbital velocity of the breaking wave = $\frac{1}{2}\gamma_b C_b$ where $\gamma_b = \frac{H_b}{d_b}$ and $C_b = \sqrt{gd_b} = g(\frac{H_b}{\gamma_b})^{\frac{1}{2}}$ (5)

FIELD MEASUREMENTS AND ANALYSIS : Measurements of currents were made at Burullus and Ras el Bar, of the Nile Delta coast (figs.1,2) both inside and outside the breaker zone by means of simple floats whose movements were observed with time between two stations marked by poles. However, only Burullus data have been reported in this paper. Within the breaker zone, only surface currents were measured whereas beyond the breaker zone, measurements were made in three depths, namely, the bottom, mid depth, and surface at each station.

Simultaneously with the current measurements, wave measurements were also made in 6-8 m depths by means of OSPOS wave recorders. With the wave characteristics known in 6-8 m depths, values of $\frac{d}{L_o}$, shoaling coefficient, refraction coefficient (assuming parallel contours) and subsequently deep water wave height, breaker depth, breaker height and breaker angle were obtained by standard procedures (4). The bottom slopes up to 6 m depths were obtained from the monthly hydrographic surveys of the coast. Thus with all the necessary data, longshore current velocities were calculated. Fig. 3 shows comparison between predicted and measured velocities at Burullus. Though the predicted velocities differ from the observed velocities, the deviations are systematic and can be approximated by a constant factor in each case. Galvin-Eagleson formula gives the best fit, a conclusion previously reached by others (9) also.

Typical statistical analysis of the currents is indicated in figs. 4,5, and 6. Fig. 4 shows the percentage of occurrence of currents for each month whereas fig. 5 is another schematic representation of percentage distribution. Fig. 6 represents a form of cumulative frequency distribution curve with percentage of occurrence (percent equal to or less than) against the velocity range. From these, it is possible to determine the directional changes in velocities, percentage of occurrences of any magnitude of velocity and its direction. Since the direction of wind generating the waves and wave energy govern the magnitude and direction of littoral currents, percentages of wave energy and of wind causing the currents are shown in figs. 7 and 8. Fig. 8 shows the existence of a linear relationship between percentages of wave energy and current. Fig. 9 represents some typical data of currents beyond the breaker zone. Preliminary studies indicate that currents beyond the breaker zone generated by forces other than those due to waves play a predominant role in the movement of sediment along the Nile Delta coast. Since the study is incomplete, it is not described here.

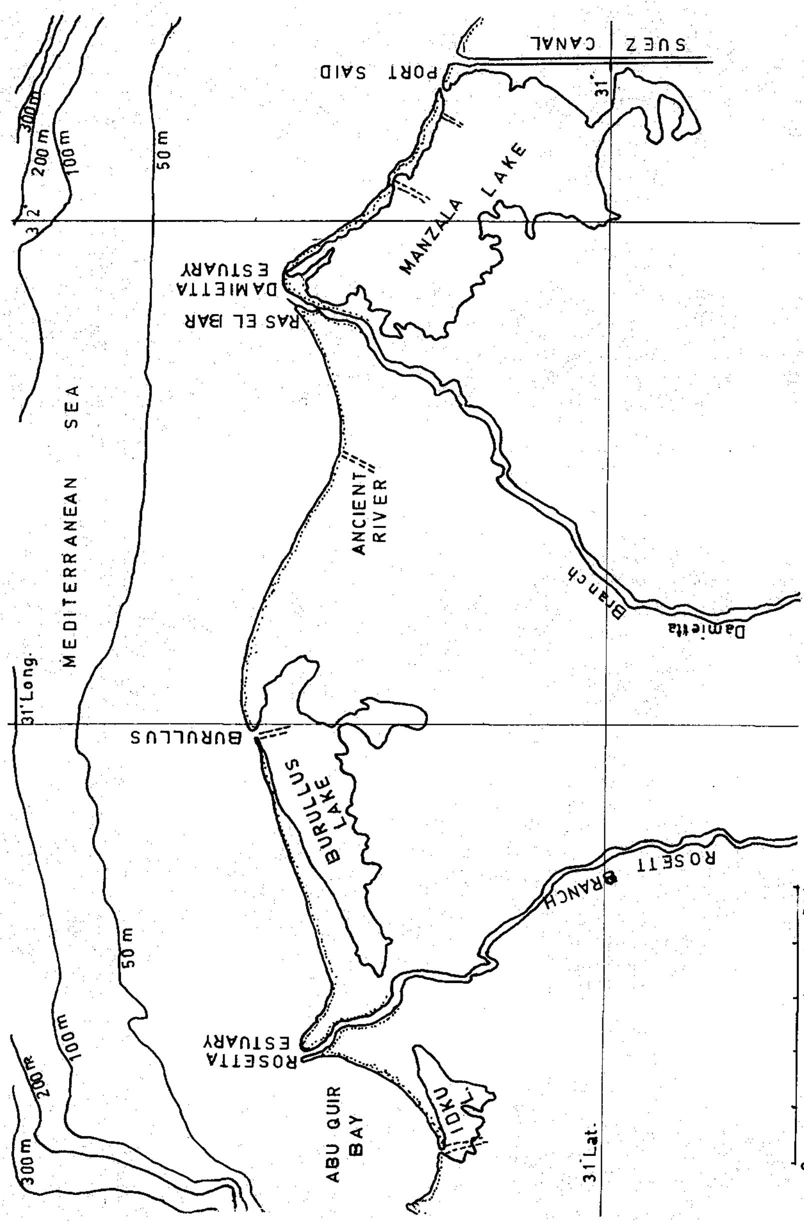

Fig.1: Nile Delta Coast

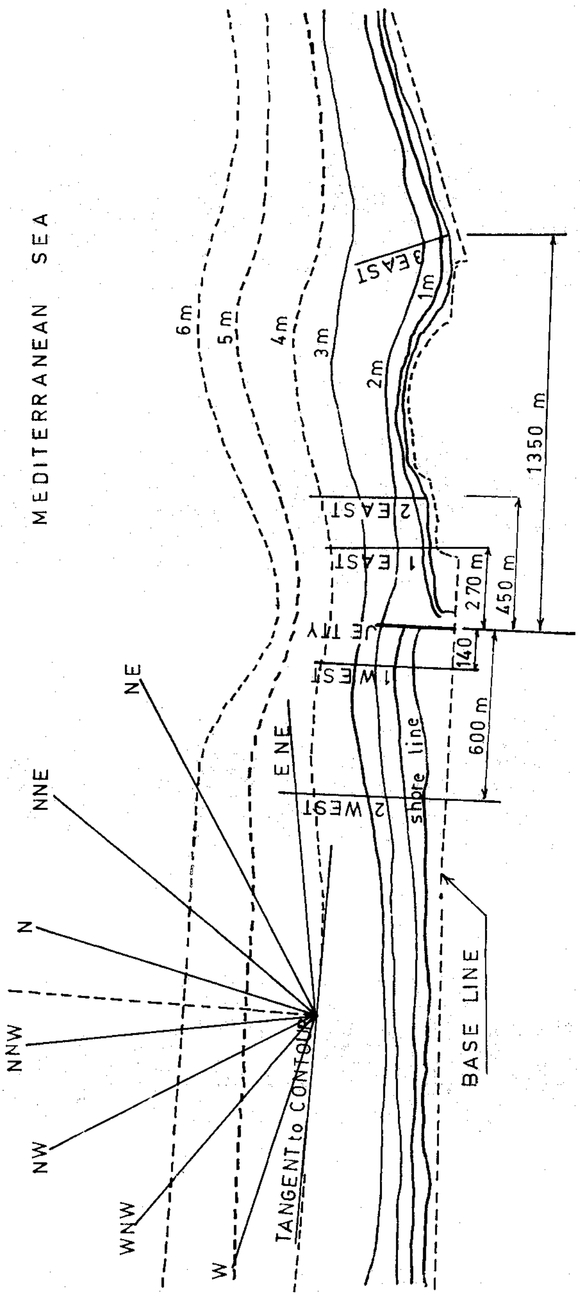

Fig.2: Map Showing Burullus and Measuring Stations

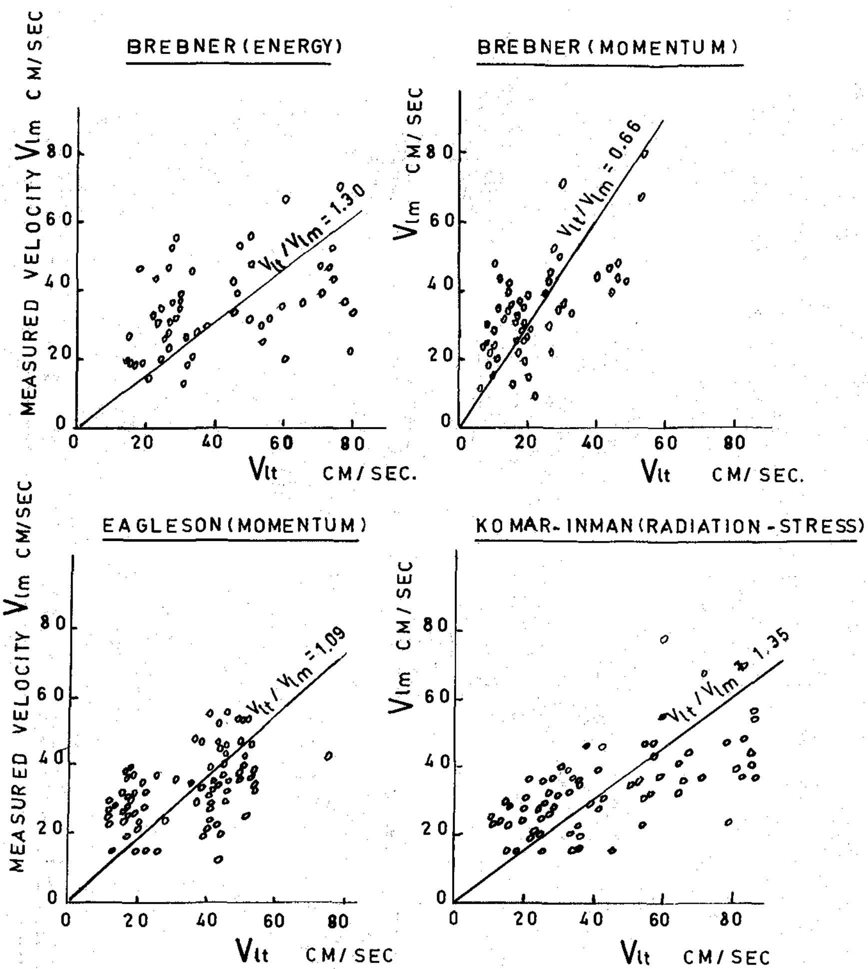

Fig 3: Correlation Curves Between Predicted and Observed Currents in the Breaker Zone at Burullus Area

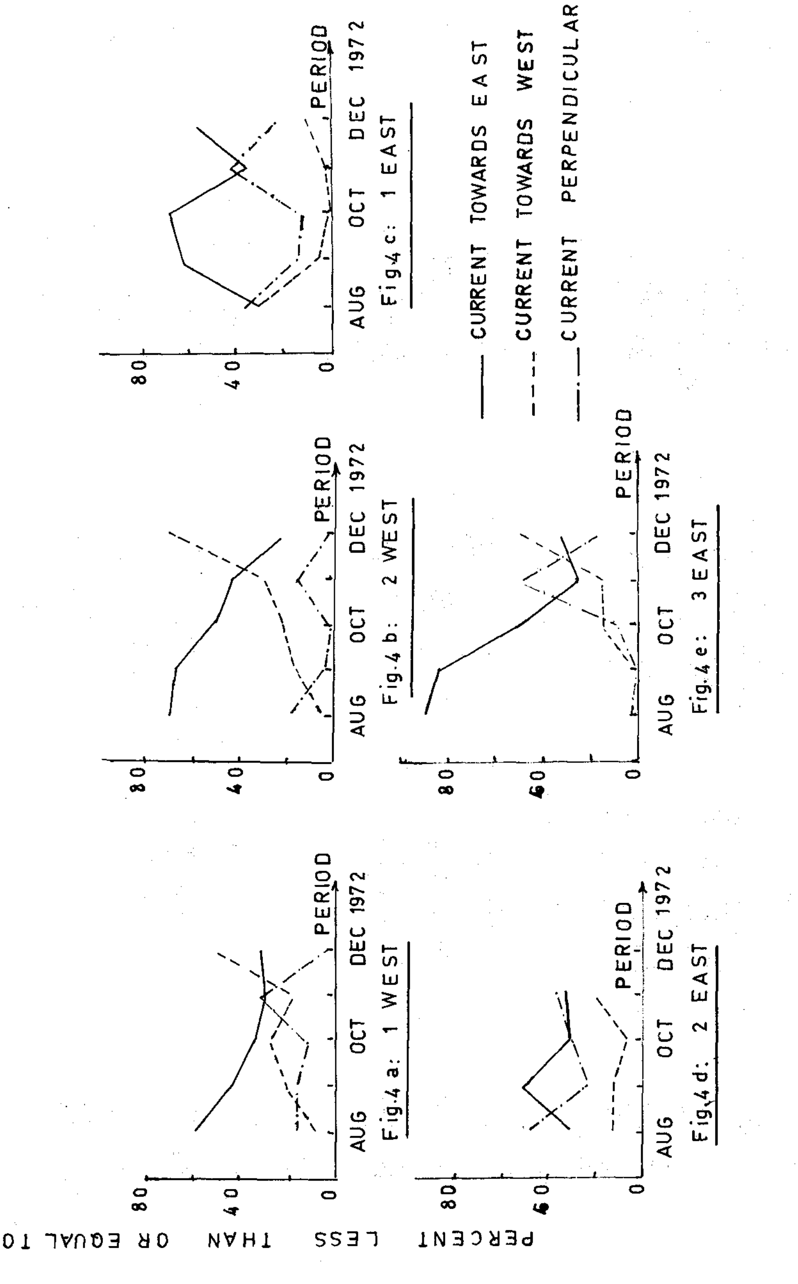

Fig. 4: Percentage of Occurrence of Currents for Each Month

(BURULLUS AREA)

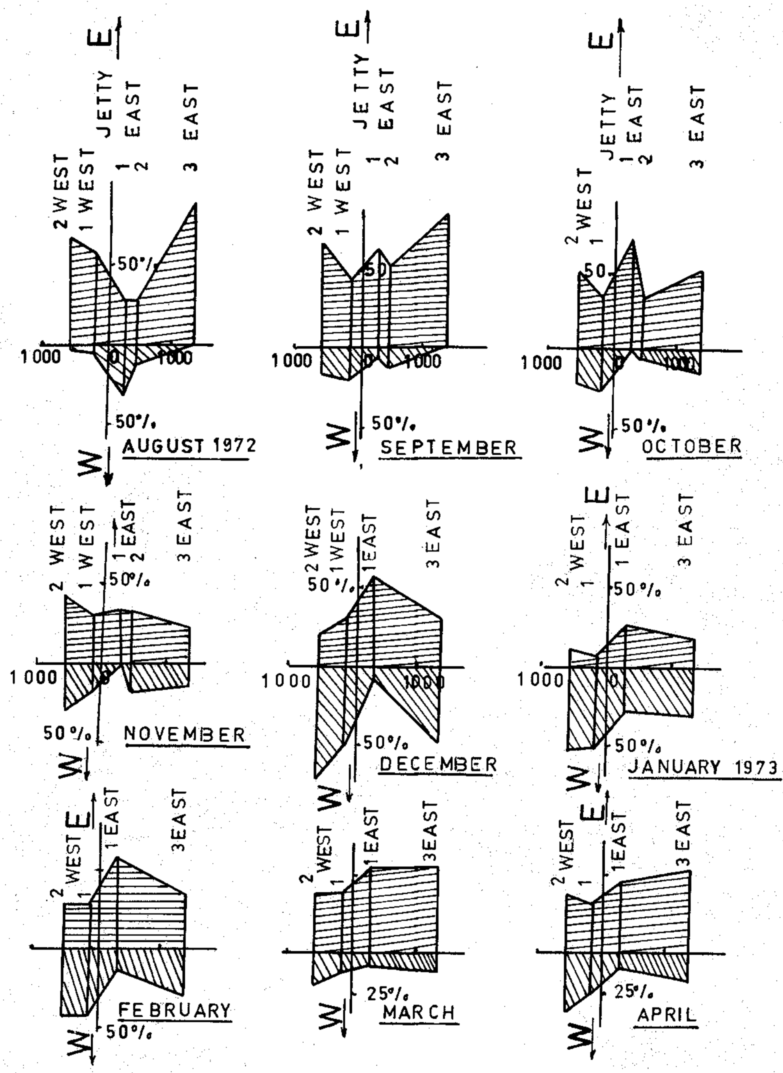

Fig.5: Percentages of Current Directions Against Measuring Stations at Burullus

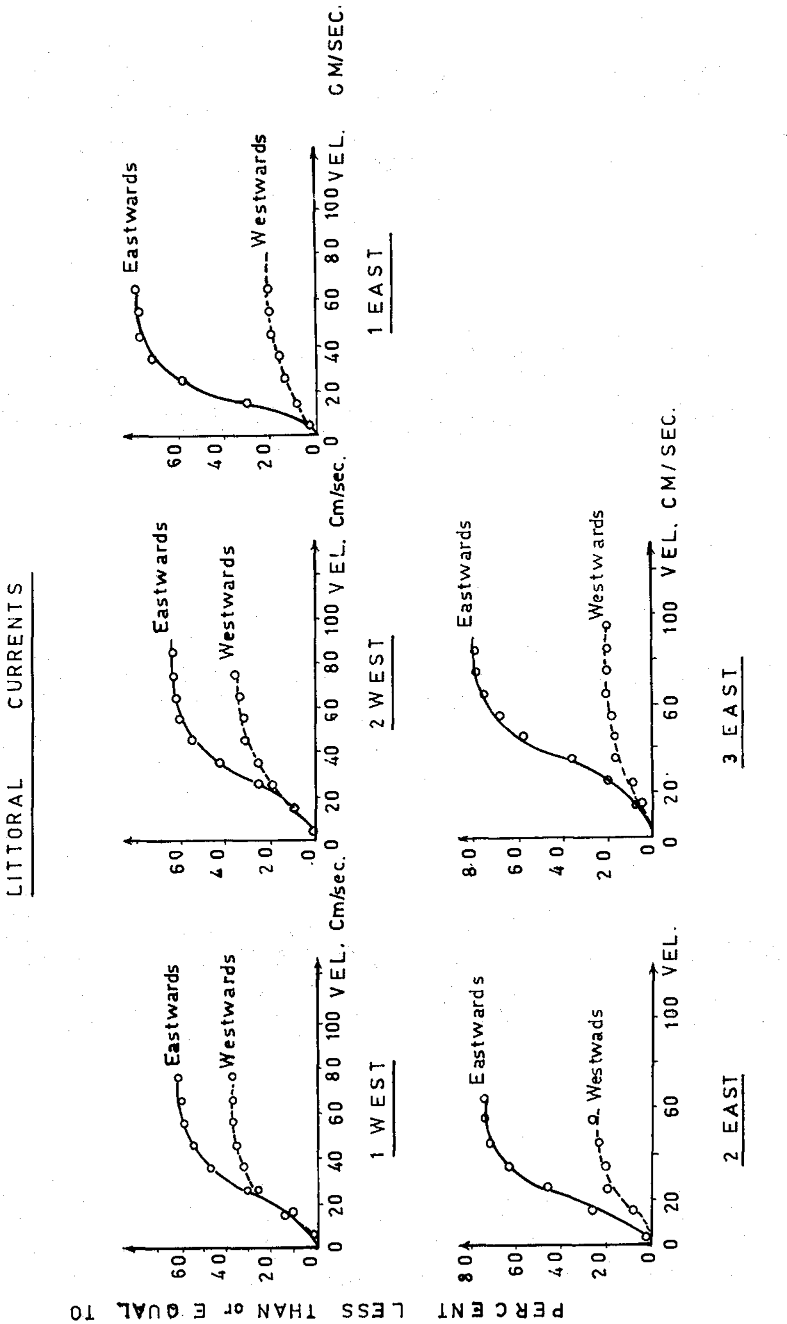

Fig. 6: Cumulative Frequecy Distribution Curves
(BURULLUS)

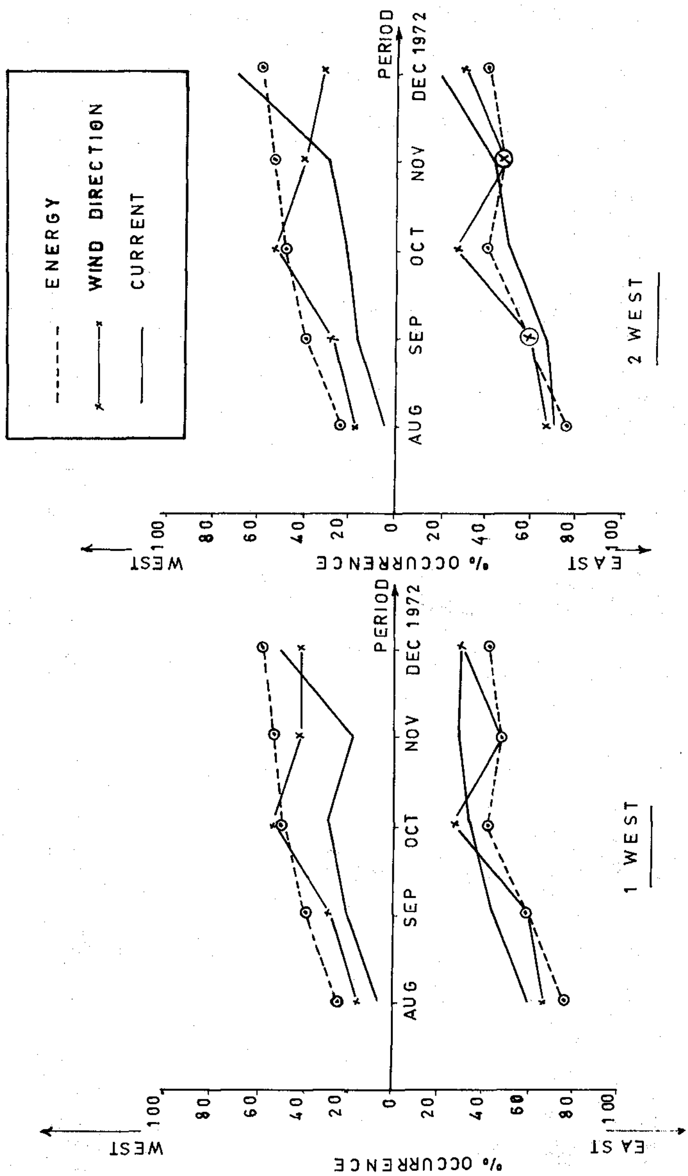

Fig. 7: Percentage Of Occurrence Of Currents, Wave Energy and Wind Directions Against Months at Burullus

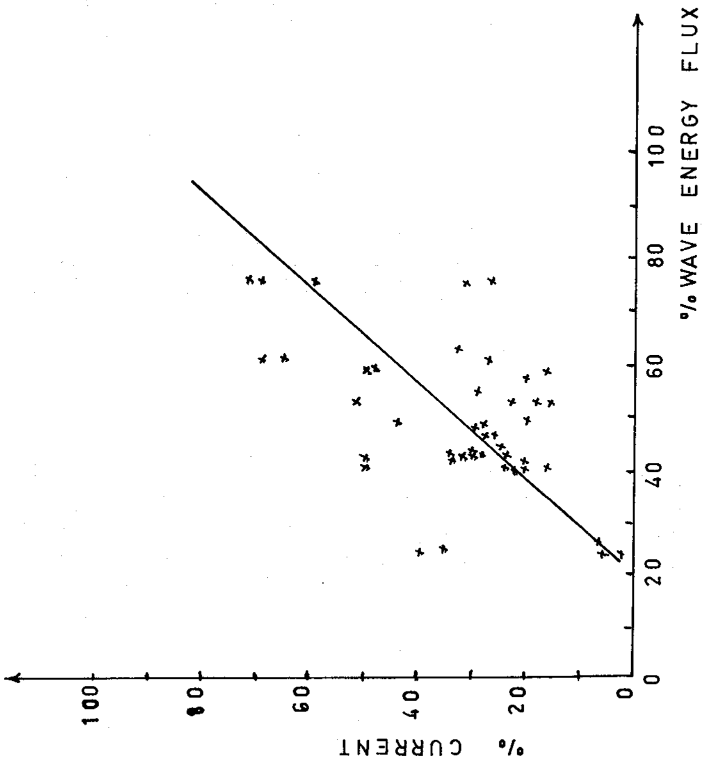

Fig.8: Percentage of Currents vs Percentage of Wave Energy Flux

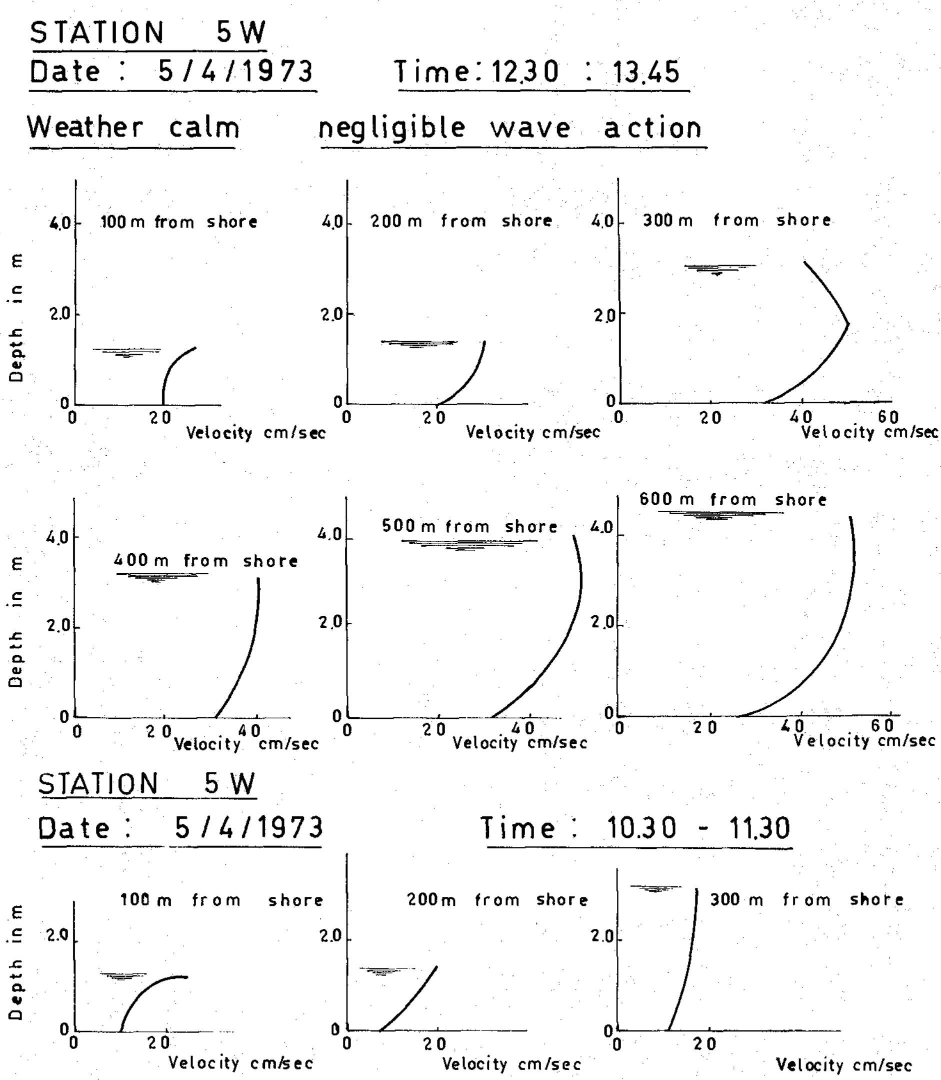

Fig. 9: Typical Current Distribution Beyond Breaker Zone

SUMMARY AND CONCLUSIONS : Analysis of littoral currents within the breaker zone measured during October-December 1972 at Burullus were checked with four semi-empirical methods involving energy and momentum balance and assuming steady state of equilibrium, constant underwater slopes and straight and parallel depth contours. The constant factor between the predicted and observed velocities in a particular direction is as follows:- Galvin-Eagleson : 1.09; Brebner-Kamphuis (energy) : 1.30; Brebner-Kamphuis (momentum) : 0.66 and Komar-Inman : 1.35 . Statistical analysis of the current data namely determination of percentage of occurrence of currents with respect to months, and cumulative frequency distribution curves for different velocity ranges enable the determination of magnitude, direction and percentage of occurrence of any particular littoral current for any particular period.

Currents other than those induced by waves exist beyond the breaker zone indicating their importance in the analysis of sediment movement along the coast.

The above analysis of littoral currents is only a forerunner of a comprehensive study of current climate (within the breaker zone and beyond the breaker zone) along the Nile Delta coast covering a large number of years.

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