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Dynamics of surf phytoplankton in relation to cross-shore and long-shore wind components

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The paper deals with the influence of cross-shore and long-shore component of the wind on surf-phytoplankton concentration. The peaks in the cell number coincide with the peaks of positive cross-shore component (onshore drift) which confirms the earlier findings that the surf diatom 'blooms' are not due to cell division, but are also due to advective forces. While the water column is exchanged between surf-zone and nearshore, the surf phytoplankton and foam were found to be trapped within the surf-zone. It was observed that during the strong long-shore component, the cell number decreased indicating the removal of cells to the lateral boundaries of surf-zone.

The physical condition of surf-zone and phytoplankton variability have been the subject of study mainly along the South African coast since 1980. McLachlan[1] suggested that wind controls both wave action and surf circulation and that these factors create a condition for surf-diatom patch development. Talbot[2] used onshore/offshore flux of cells to demonstrate that the accumulation is not the result of cell division (blooming) but rather the response to physical conditions in the surf-zone which concentrate the cells into surf-foam.

Phytoplankton patches are known to occur during the strong onshore wind. Campbell & Bate[3] observed that these patches move from one end of the surf-zone to the other in the direction of prevailing long-shore currents. Immediate and complete removal of *Anaulus australis* from surf-zone to the seaward of the breaker line have been reported[4,5] for offshore winds in excess of 22 m s^{-1}. The magnitude of primary productivity of coastal waters is strongly influenced by the wind. The present study is aimed to correlate the changes in surf phytoplankton density with cross-shore and long-shore components of the wind.

Materials and Methods

The station location is situated along 15°28'N and 78°48'E and is adjacent to Miramar-Caranzalem beach along Mandovi estuary (Fig. 1). Weekly water samples were collected in clean bucket for 24 months (1989-1990) during high tide. Three litres of sample was passed through 10 μm nybolt and preserved in Lugol's solution for the analysis of net phytoplankton number and diversity. Three subsamples were then drawn carefully and transferred to Sedgewick Rafter counting chamber. The counts have been averaged and presented. Each cell in colonial and chained forms was counted as one unit. The counts refer only to net phytoplankton (> 10 μm). The data on wind velocity, collected every day by the India Meteorological Department, Panaji, was used for this study.

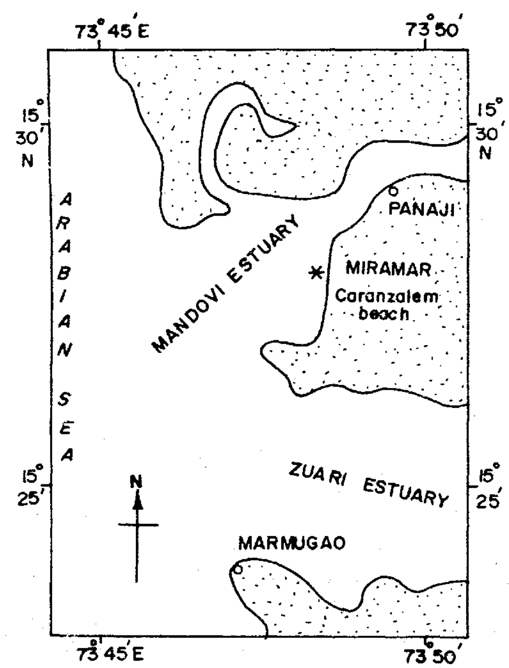

Fig. 1—Location of study area (*)

It is often convenient to express the influence of the wind in terms of long-shore and cross-shore components. The cross-shore component moves across the shore and the long-shore component moves along the shore. A cross-shore component with a positive value (pointing towards east) brings about shoreward movement of watermass (onshore drift), and that with a negative value (pointing towards west) brings about seaward movement of water (offshore drift). A positive long-shore component (pointing towards north) is conducive for upwelling. The wind data was resolved into cross-shore and long-shore components using vector analysis. The coastline was approximated by a straight line, making an angle of 24° with the north.

Results

The results of vector analysis of wind velocity data are presented in Figs 2 and 3. The cross-shore component was positive during the major part of the study period with pronounced negative values from November-January. It increased gradually from January to July and then decreased. This component was very weak during October-February. The values of positive cross-shore component (indicative of onshore drift) varied between 0.00025-27.36 km/h and that of negative (indicative of offshore drift) varied between 0.0062-7.13 km/h.

The long-shore component was negative (towards south) throughout the study period with only occasional positive values. It increased gradually from April to August during 1989 and reached a peak in August. During 1990 it gradually increased from February to April and reached the peak in June. This component was quite weak between October and February. The values of positive long-shore component varied between 0.0004 and 6.53 km/h and negative component between 0.018 and 14.55 km/h. The magnitude of the cross-shore component was generally greater than that of the long-shore component.

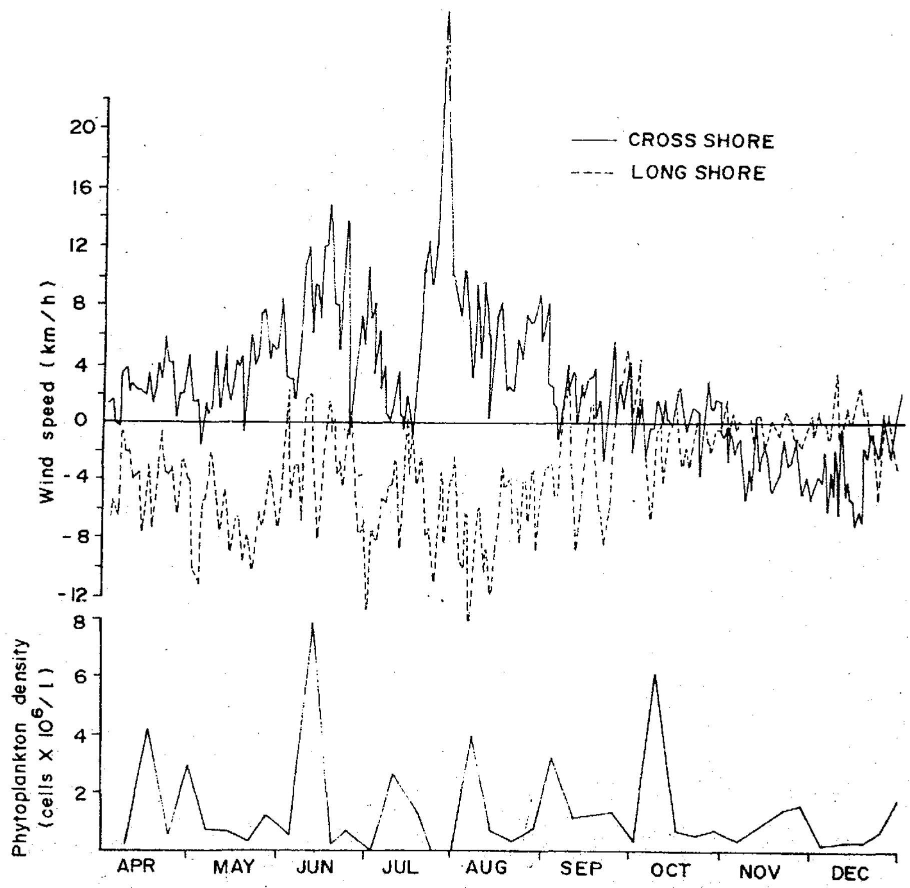

Fig. 2—Cross-shore, long-shore components and phytoplankton density during 1989

In general, the cell number peaks coincided with positive cross-shore component, indicative of the onshore drift which brings cells into the surf-zone. Where such a coincidence was not observed (May - July 1989, Fig. 2), an increase in long-shore component may have led to the removal of cells to the lateral boundaries of the surf-zone. October 1989 to April 1990 and June-July 1990 marked the period of lower cell concentrations.

Discussion

The northern Indian Ocean is one of the very few oceanic regimes which come under the influence of the monsoon and experiences a wind field which is energetic at times and possesses a well marked annual cycle. The long-shore component is pointed towards south throughout the year, reaches a peak around July with the cross-shore component larger than the long-shore component[6].

The cell number peaks coincide (Figs 2, 3) with the positive cross-shore component (onshore drift) which confirms earlier findings that surf-diatom 'blooms' are not due to cell division, but are actually 'accumulations' or 'patches' formed due to advective forces. Talbot & Bate[7,8] showed that breaker line clearly forms a physical barrier to surf-zone cells during the day preventing their loss to the nearshore i.e. beyond surf-zone.

Campbell & Bate[3] observed that the patches move from one end of surf-zone to the other in the

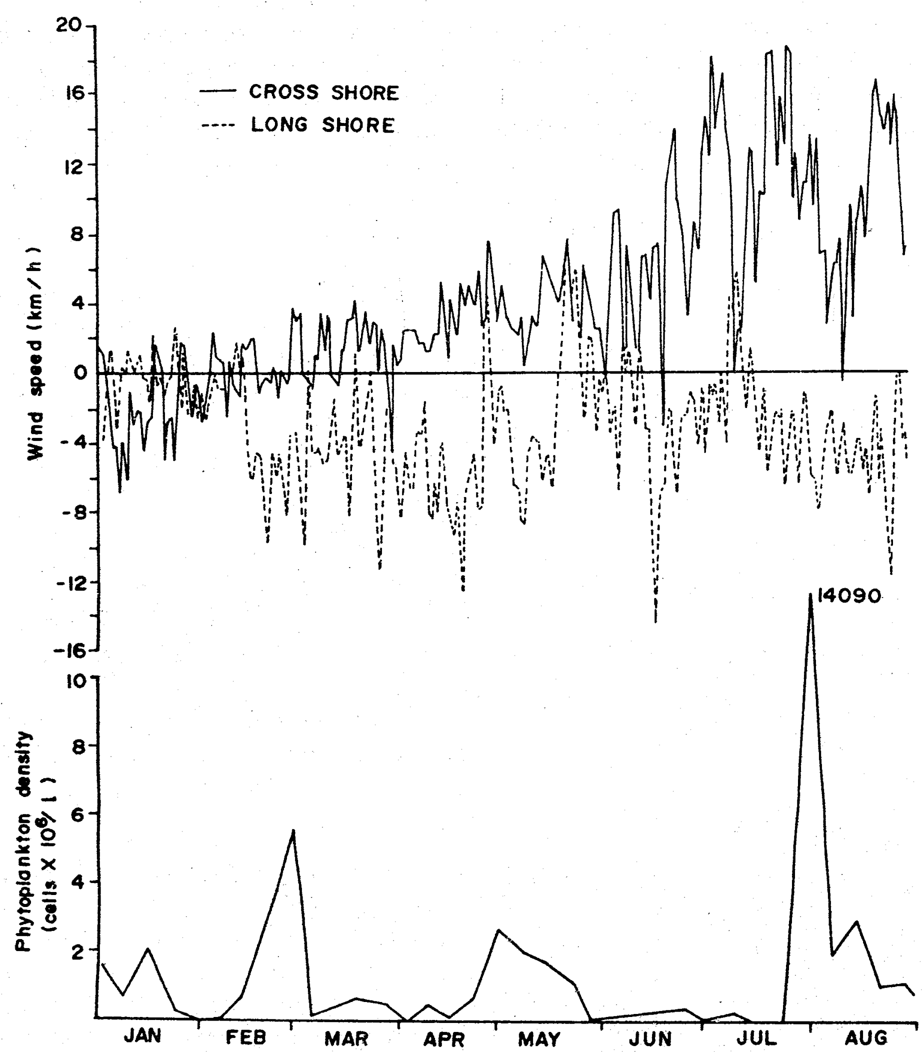

Fig. 3—Cross-shore, long-shore components and phytoplankton density during 1990

direction of prevailing long-shore current. The presence of strong long-shore component may be the cause for the low cell concentration observed during May-June 1989 and June-July 1990 (Figs 2, 3) inspite of onshore drift.

The cell concentration was low during October 1989 to February 1990, probably because the circulation during this period is not governed by wind but by thermohaline circulation. Thermohaline sinking is observed in this region of the west coast of India during this period[9].

The foregoing discussion corroborates well with the earlier findings[2,7] that the wind controls surf diatom patch development and the changes are brought by offshore/onshore drifts in watermass and that onshore winds provide an added means of concentrating cells into the surf-zone.

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