

UPWELLING ALONG THE EAST COAST OF INDIA

by C. S. MURTY and V. V. R. VARADACHARI

Physical Oceanography Division of National Institute of Oceanography, Ernakulam

An examination of the physical characteristics of the shelf waters off Karaikal in the premonsoon period and off Madras and Waltair in the premonsoon and monsoon periods reveals the presence of upwelling along the East Coast of India but with the following differences:

1. Off Madras and Karaikal, weak upwelling is indicated. Water from shallow depths reach the surface nearshore and there is no marked lowering of the surface temperature near the coast.
 2. Upwelling is prominent off Waltair during the premonsoon and monsoon periods. Waters from deeper layers of the shelf appear to reach the surface causing considerable fall of surface temperature near the coast.
- The probable causes for these differences in upwelling along the coast are discussed.

INTRODUCTION

The speed of the mean vertical motion in the sea is several orders of magnitude smaller than that of the horizontal currents, but this motion is essential for the maintenance of life in the sea since it is the most important process by which the sunlit regions near the surface are refertilized with the essential plant nutrients.

Upwelling is the process in the sea whereby the subsurface layers move up towards the surface (LaFond 1954). The seasonal occurrence of upwelling and sinking off the East Coast of India has been reported by LaFond and co-workers at the Andhra University, Waltair (LaFond 1957; LaFond and Rao 1955). Theoretical and physical aspects of the upwelling phenomenon off Waltair, have been studied by Varadachari (1958). Most of these studies are confined mainly to the coastal region off Waltair. A few reports on upwelling are also available for the coastal waters off Madras (LaFond 1954; Rama Sastry 1954; Varma and Gangadhara Reddy 1959). A critical survey of the biological and Oceanographic differences between the Arabian Sea and the Bay of Bengal appeared recently (Panikkar and Jayaraman 1966). A comparative study of upwelling in different parts of the East Coast of India has not been made so far. The data obtained under India's Programme of International Indian Ocean Expedition enables a qualitative comparison of upwelling at three different places along the East Coast of India, namely Karaikal, Madras and Waltair.

MATERIAL AND METHODS

The hydrographic data collected during the monsoon period of 1964 and the premonsoon period of 1965, on board I.N.S. KISTNA during her 15th, 16th and 26th cruises under the Indian Programme of International Indian Ocean Expedition,

off Waltair, Madras and Karaikal, has been used for the comparative study. The data collected off Waltair during the premonsoon period, under the programme of Andhra University cruises and studied previously (Varadachari 1958) has also been used.

The investigations are made along sections perpendicular to the coast at all the places except Waltair, where the data is available only along a section in a south-north direction for the monsoon period. Vertical space sections of temperature and density (σ_t) are prepared and the intensities of upwelling inferred qualitatively from the sections.

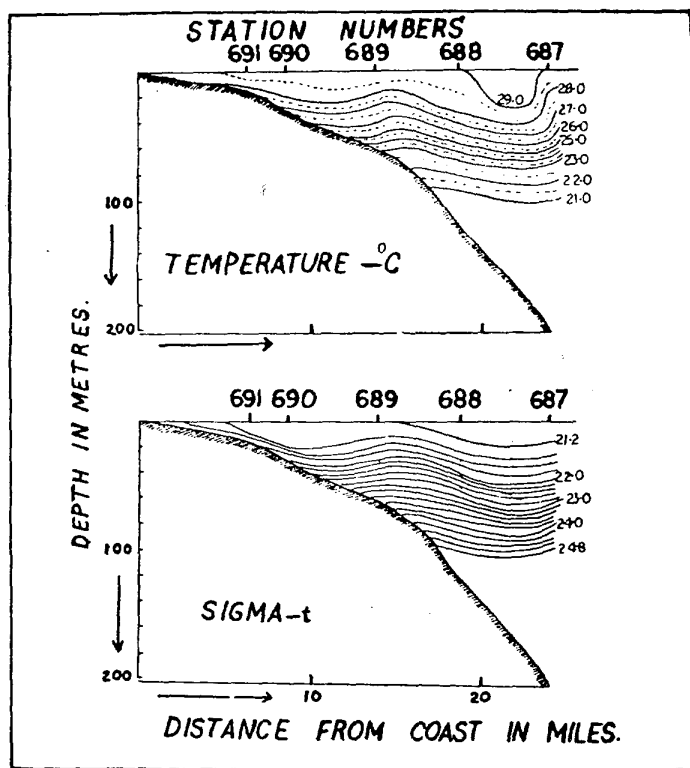


FIG. 1. Vertical sections of temperature and σ_t , of the shelf waters off Karaikal, for the premonsoon period.

RESULTS

The vertical space sections of temperature and σ_t for the premonsoon period off Karaikal, Madras and Waltair are shown in Figures 1, 2 and 3. They represent the conditions in April. The sections for the monsoon period for Madras

and Waltair are shown in Figures 4 and 5. They represent the conditions during June-July.

During the premonsoon period the isolines of temperature in vertical sections, tilt upward towards the coast at all the three places (Karaikal, Madras and Waltair) indicating upwelling. But the upward tilt of isolines is quite pronounced for the Waltair section (Fig. 3) while it is weak for the other two places (Figs. 1, 2). In

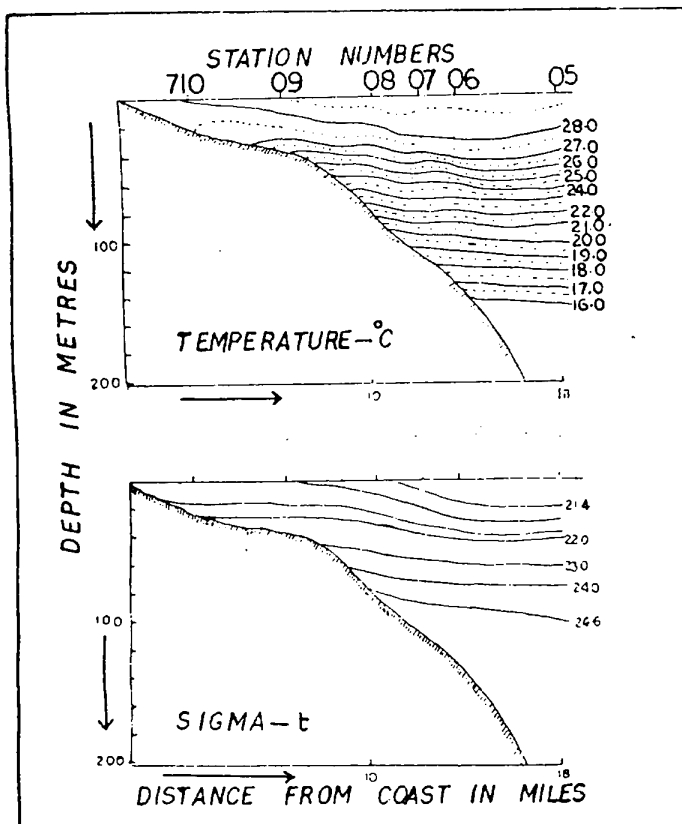


FIG. 2. Vertical sections of temperature and sigma-t, of the shelf waters off Madras, for the premonsoon period.

the monsoon period, the upward tilt of the isolines towards the coast, is noticed, in the sections for Madras and Waltair (Figs. 4, 5) but the sloping of the isolines is more prominent at Waltair than at Madras. In both the cases the thermocline moves up towards the surface from the premonsoon to the monsoon period. From the sections, it could be inferred that waters from a depth of hundred metres or more reach the surface at Waltair during the monsoon period (Fig. 5) while at Madras,

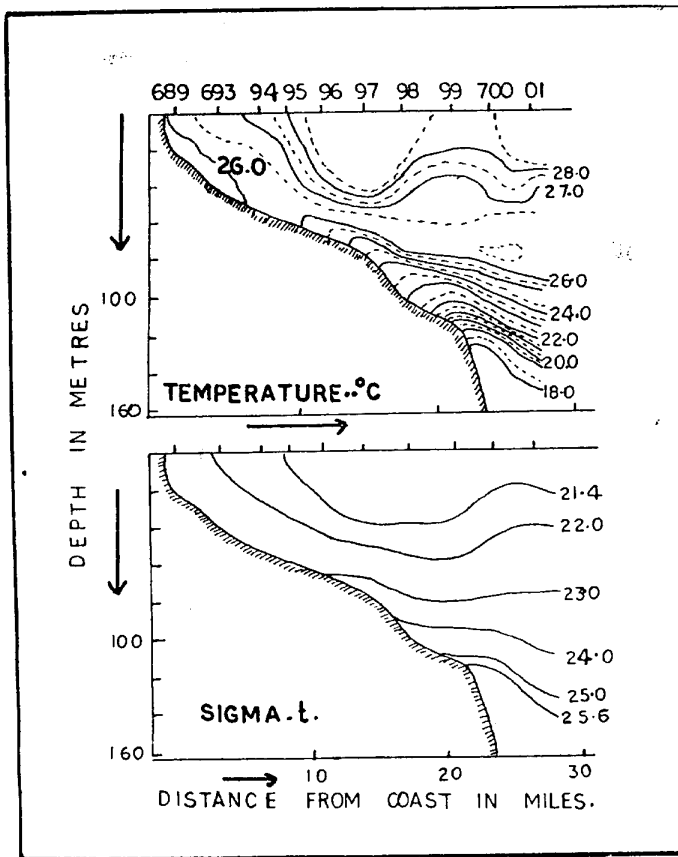


FIG. 3. Vertical sections of temperature and sigma-t, of the shelf waters off Waltair for the monsoon period.

waters from a depth not exceeding 30 metres seem to reach the surface (Fig. 4). During the premonsoon period, waters from a depth of 60 metres reach the surface at Waltair, while at Karaikal and Madras upwelled waters seem to reach the surface only from a depth of twenty or thirty metres.

The studies on the vertical sections of temperature and density (sigma-t) therefore reveal that upwelling is present at all the three places during the premonsoon period but with higher intensity at Waltair. In the monsoon period also the intensity of upwelling (as revealed by the tilting of the isolines) is more along the Waltair coast than along the Madras coast.

An examination of the wind field in the Bay of Bengal (Climatological Atlas for Airmen, 1943) shows that the winds are parallel to the coast and directed north-

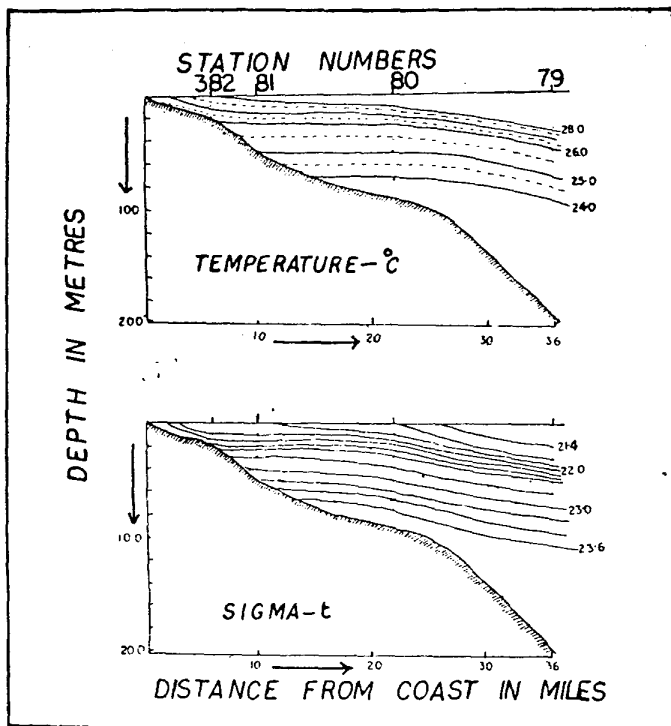


FIG. 4. Vertical sections of temperature and sigma-t of the shelf waters off Madras, for the monsoon period.

ward at Waltair in April while they are onshore along the Madras coast. The coastal currents are northerly along the entire coast during this period. Varadachari (1958), Stommel (1965), Ryther and Menzel (1965) and Panikkar and Jayaraman (1966) stressed the need for considering the coastal currents as a factor in inducing upwelling. Theoretical and physical studies by Varadachari (1958, 1961) show that a northerly current along the East Coast of India is favourable for upwelling and a southerly current for sinking along the coast. It is well known that a wind blowing parallel to a sea coast with the coastline to its left in the Northern Hemisphere, or an offshore wind, gives rise to upwelling near the coast (Sverdrup 1942). Thus, while the current and wind are favourable for upwelling along the Waltair coast, only the current is favourable for upwelling along the Madras coast while the wind is not. The relatively stronger upwelling at Waltair than at Madras could thus be explained. During the monsoon period both the wind and current are favourable for upwelling along the Waltair and Madras coasts. The difference in intensity during the monsoon period may therefore be attributed to the relatively stronger winds along the Waltair coast. Further, the currents along the Madras

coast are reported to be variable during the month of June (Bay of Bengal Pilot, 1953) and even southerly flow is sometimes reported. This may be an additional factor responsible for the weaker upwelling along the Madras coast.

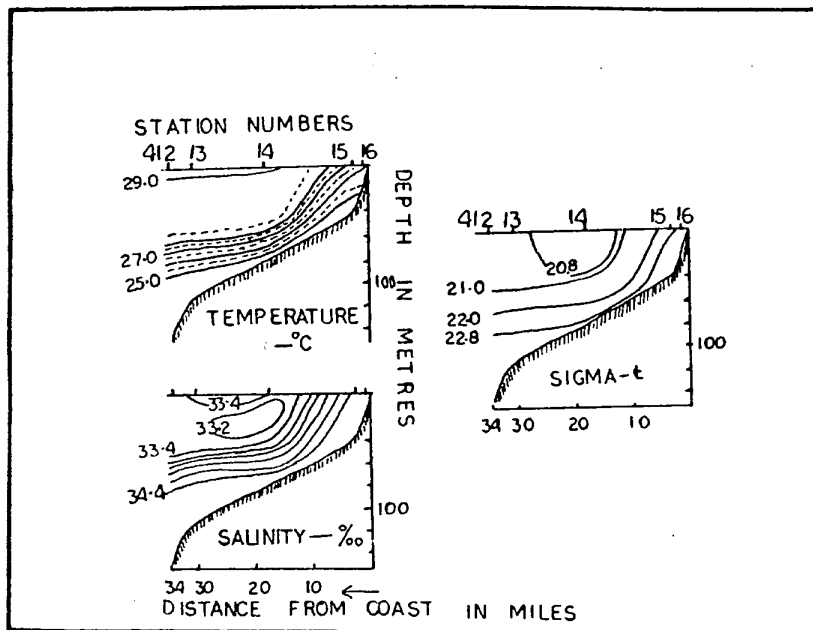


FIG. 5. Vertical sections of temperature, salinity and sigma-t, of the shelf waters off Waltair for the monsoon period.

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