

Nearshore Hydrography Off Visakhapatnam, East Coast of India, during Winter

B PRABHAKARA RAO & V RAMESH BABU*

Regional Centre of National Institute of Oceanography, Waltair 530003

Received 19 August 1985; revised received 20 June 1986

Based on hydrographic data and time series data of currents and temperature, the nearshore hydrographic structure during winter (November, 1981) has been studied to examine the possibility of discharging industrial effluents into the nearby sea. The near bottom region in the offshore area, rather than the nearshore area, seems to be promising dumping ground for industrial waste material during winter period when the thermal inversions in the water column are major mechanisms of vertical mixing.

Information on nearshore hydrography off Visakhapatnam is essential in the context of coastal pollution from the industries. Earlier studies on the coastal circulation off Visakhapatnam are mainly on longer time scales (seasonal and monthly)¹⁻⁸. Apart from the influence of seasonally varying winds and fresh water discharges from the rivers, the water circulation is also effected by short period internal waves which are due to the presence of strong density gradients in the upper layers of the sea⁹. However, no information on the nearshore circulation in relation to shorter time scales such as tidal periods is available for Visakhapatnam coast. In addition to the internal waves, strong thermal inversions especially during winter (January-March) period are also known to affect the hydrographic structure in the Bay of Bengal¹⁰.

In this paper, the winter (November) hydrographic structure off Pudimadaka, 25 km south of Visakhapatnam, is presented along with temporal variability of thermal structure and currents over a tidal cycle at a nearshore station located about 6 km off Pudimadaka.

Materials and Methods

A hydrographic section involving 3 stations at 22, 42 and 62 m depths respectively was covered (25-26 Nov. 1981) off Pudimadaka (Fig. 1). At each station, temperature data were obtained at every 5 m depth interval using a mechanical bathythermograph (Range: 0-60 m; accuracy: $\pm 0.1^\circ\text{C}$). Salinity, also obtained at 5 m interval, was measured at sts 1 and 2 using an *in situ* salinometer (Make: Hydro-Bios-Apparatebau GmbH, West Germany, Model: NC-5, accuracy: ± 0.1 ppt) while at st 3; salinity data were not available due to failure of the salinometer. The current data were taken

at st 2 employing a digital current meter (accuracy: ± 1 cm. sec⁻¹; $\pm 1^\circ$) designed by NIO, Goa. At this station, repeated lowerings of mechanical bathythermograph were also made at hourly intervals from 20.00 hrs (25-11-1981) to 09.00 hrs (26-11-1981) over a semi-diurnal tidal cycle comprising 2 high tides. The wind observations (wind speed and direction) were taken simultaneously using an air meter and a portable magnetic compass. Before taking the time series data at st 2, the transect was covered during 16.00 to 19.00 hrs (25 Nov. 1981).

Results and Discussion

Temperature and salinity structures along the transect (Fig. 2) reveal conspicuous absence of thermal gradients both in the upper and near bottom layers and further it is seen that the gradients are confined within 15-25 m depth range. In nearshore regions, the isotherms show some tendency of downward sloping.

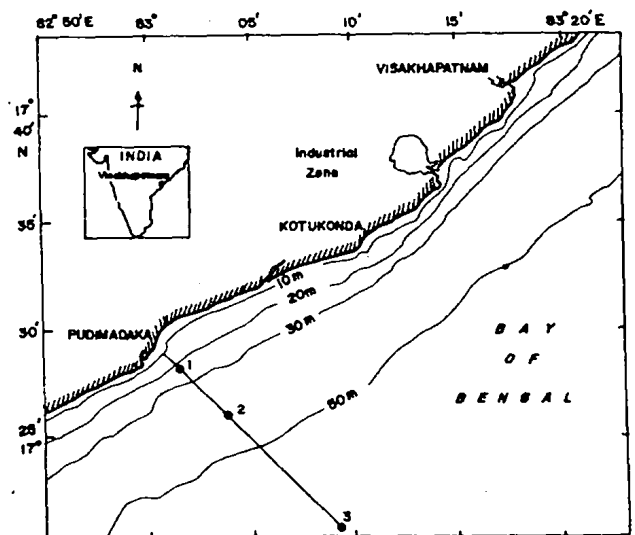


Fig. 1—Station locations

*Present address: National Institute of Oceanography, Dona Paula, Goa 403004.

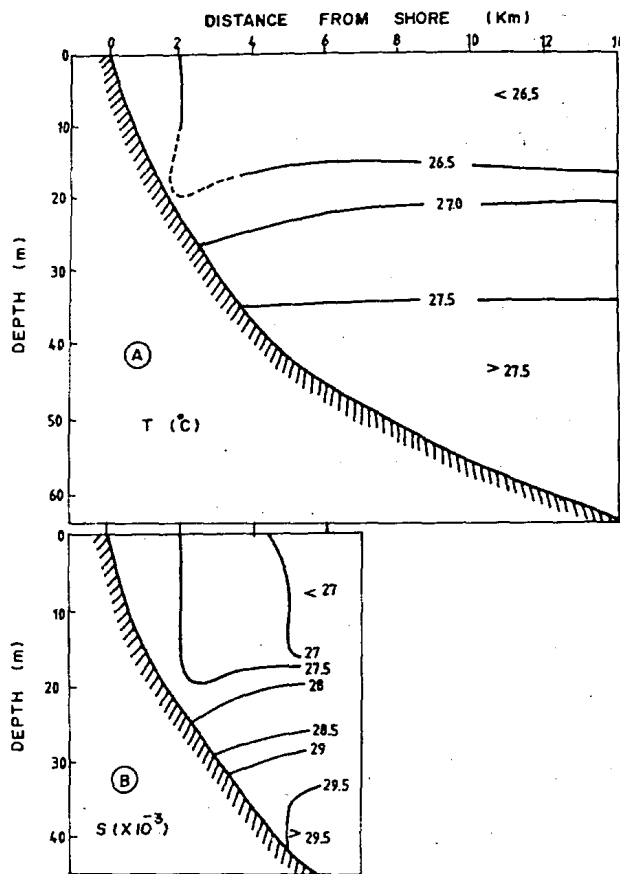


Fig. 2--Distribution of (A) temperature and (B) salinity off Pudimadaka, Visakhapatnam coast

Similar features are also observed in the salinity structure. The gradients in the upper layers are comparatively less at nearshore than those at offshore as seen from vertical nature of 26.5°C isotherm and 27.5×10^{-3} isohaline. The whole water column is encountered with thermal inversion which is due to cooling of surface layers by the winter cold dry winds. During this period, on average the surface air temperature is colder than sea surface temperature by 2.3°C.

Currents observed at st 2 over a tidal cycle show directional consistency in the upper layers while at deeper depths unsteadiness in current direction is noticed (Fig. 3). In general the current strength decreases with depth and an anti-clockwise rotation of currents with depth is seen. Longshore southwestward currents are encountered in the upper layers whereas an offshore tendency in the flow field is visualised near bottom layers (30-35 m). The presence of relatively strong and steady longshore surface currents as compared to weak and unsteady near bottom currents in association with northerly and north-northwesterly winds indicates that the wind induced currents play a dominant role in the observed surface and near surface flow field. The unsteadiness in the flow field near bottom layers can be related to the turbulent mixing, generated by bottom friction which is responsible for the absence of thermal and saline gradients. Internal waves can be inferred from wavy oscillations in the temporal variation of thermal structure (Fig. 4) as

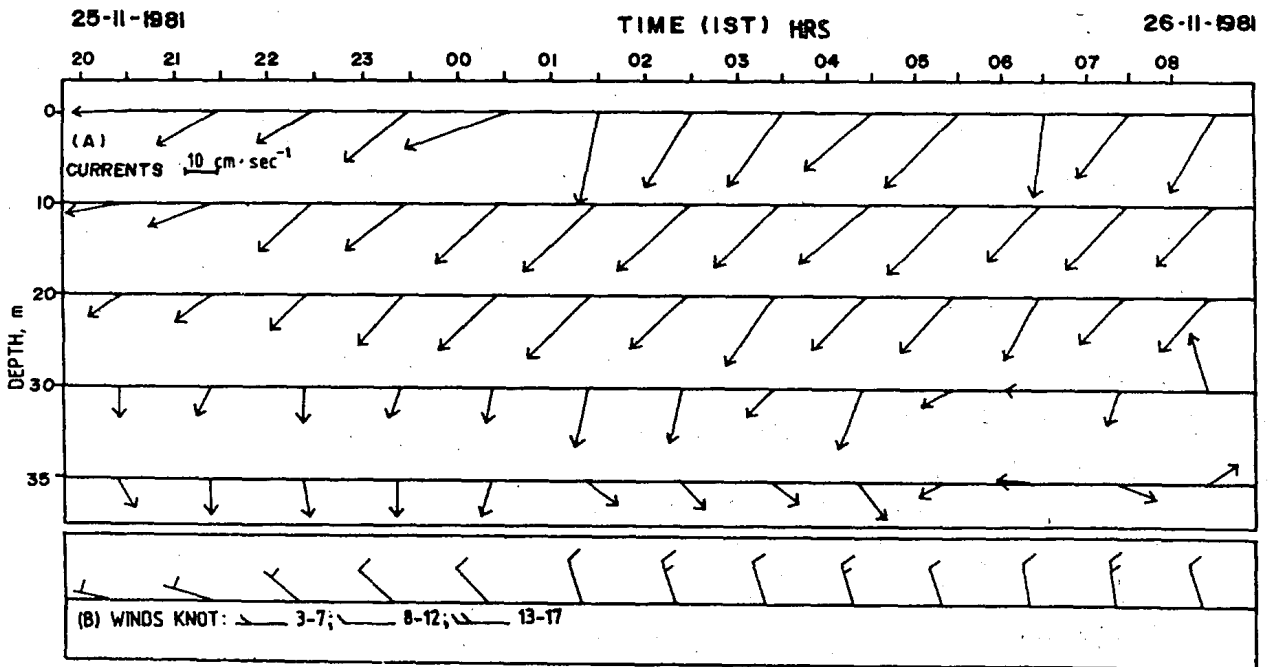


Fig. 3—Hourly variation of (A) currents and (B) winds at st 2

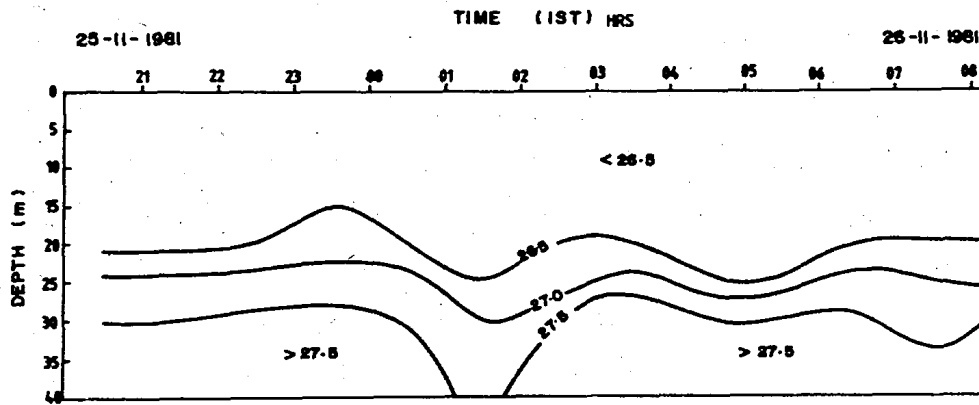


Fig. 4—Hourly variation of temperature at st 2

LaFond and Rao¹¹ have earlier attributed the fluctuations in temperature field to the propagation of internal waves. However, the influence of these internal waves on the flow field is not felt since the currents around 25 m are steady.

The convective mixing in the upper layers of the water column due to thermal inversions together with piling of coastal waters under the influence of southwest longshore currents enhances the mixing rates at nearshore regions. This will result in the increase of vertical homogeneous nature in temperature and salinity fields as seen at st 1. Further, the higher vertical mixing rates in the nearshore regions cause to produce relatively warm and saline waters compared to those in the offshore regions. LaFond¹ has also mentioned about the presence of high salinity waters in the vicinity of Visakhapatnam beach during winter.

The present study indicates that the surface waters off Visakhapatnam coast in winter are likely to be affected little if non-buoyant waste material is dumped near the bottom in the offshore regions where the currents with components of offshore tendency will carry the material away from the coast. Further, the surface layers in the offshore areas will also likely to be less contaminated due to low mixing rates.

Acknowledgement

Thanks are due to Dr H N Siddiquie, Director, and to Dr V V R Varadachari, former Director, for their keen interest. Thanks are also due to Dr T C S Rao for his encouragement.

References

- 1 LaFond E C, *Andhra Univ Mem Oceanogr*, 1 (1954) 117.
- 2 Ganapati P N & Sriramachandra Murthy V, *Andhra Univ Mem Oceanogr*, 1 (1954) 125.
- 3 LaFond E C & Bhavanarayana P V, *Indian J Meteor Geophys*, 8 (1957) 183.
- 4 Murthy C B & Ramasastry A A, *Indian J Meteor Geophys*, 8 (1956) 377.
- 5 Rao C P, *Indian J Meteor Geophys*, 7 (1956) 377.
- 6 Ramasastry A A & Murthy C B, *Proc Indian Acad Sci*, 46B(1957) 293.
- 7 Varadachari V V R, *On some meteorological and oceanographic studies on the coastal waters of Waltair in relation to upwelling and sinking*, D.Sc. thesis, Andhra University, 1958.
- 8 LaFond E C, *Andhra Univ Mem Oceanogr*, 2 (1958) 9.
- 9 LaFond E C & LaFond K G, *Bull Natn Inst Sci India*, 38 (1968) 164.
- 10 Rao D P & Sastry J S, *Mahasagar-Bull Natn Inst Oceanogr India*, 14 (1981) 1.
- 11 LaFond E C & Rao C P, *Andhra Univ Mem Oceanogr*, 1 (1954) 109.