

Currents & Temperature Structure Off Godavari (East Coast of India) during September 1980

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Currents and temperature structures and their short term variation at a station (water depth ≈ 250 m) off Godavari were studied from time series data collected during 24-28 Sept. 1980. The surface drift was of the order of 2 to 3 knot and was directed towards NE to E. Currents recorded at different depths (15, 115 and 240) had speeds < 1 knot showed variation in direction with time and exhibited a velocity shear. They do not seem to be influenced much by the tides. Temperature of the surface waters was about 30°C and that of the near bottom waters was about 11.5°C . There was no well defined mixed layer and the temperature gradually decreased with depth during most of the period.

Observations on currents in the waters adjoining the Indian coastline are relatively few¹ and are limited to tide dominated zones. Along the east coast of India, current measurements are practically non-existent. In this paper, analyses of short time variability of currents and temperature structures off river Godavari in the continental slope region (Fig.1) along with eddy kinetic energy are presented. This work is intended to delineate the meso-scale features of currents and temperature structures in the study area.

Methods

During 79 cruise of *R V Gaveshani*, a mooring of 3 Aanderaa recording current meters was laid in the study area on 24 Sept. 1980 and retrieved on 28 Sept. 1980. During this period, the ship's drift in the area was monitored with the help of miniranger system and ship's radar. Temperature-depth profiles from surface to bottom were obtained at hourly intervals by operating a mechanical bathythermograph from the ship.

The moored current meters recorded data on current direction and speed, temperature and conductivity for every 15 min at 15 m (near-surface), 115 m (mid-depth) and 240 m (near-bottom) depths. About 1030 observations were made for each depth. The raw data obtained from the current meters on $\frac{1}{4}$ in. magnetic tapes were read through Aanderaa Tape Reader and transferred onto $\frac{1}{2}$ in. magnetic tapes and processed². The zonal and meridional components of the currents were computed from the processed current meter data and the values of salinity were calculated from the conductivity data. Hourly averages of the different parameters were also computed.

The data on ship's drift could be obtained at 5 min intervals with the miniranger. Whenever this was not possible, the ship's drift was monitored at 15/30 min intervals through position fixing by the ship's radar and the trajectories of ship's drift were drawn.

From the observed current data, the following parameters were derived using the formulae suggested by Webster³:

$$u = \bar{u} + u' \quad \dots (1)$$

$$v = \bar{v} + v' \quad \dots (2)$$

where, u and v are the zonal and meridional components, \bar{u} and \bar{v} are their means and the primed quantities are the departures from the mean.

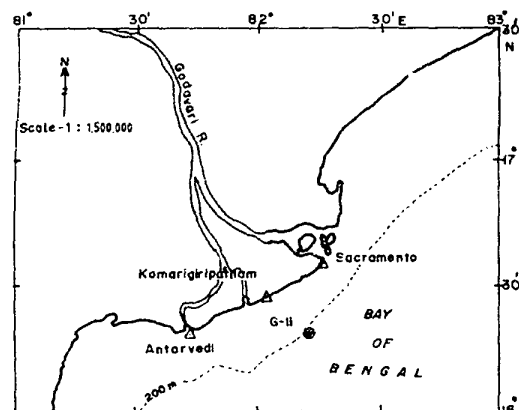


Fig. 1— Station location

$$\text{Variance } u = \overline{(u')^2} = \frac{1}{N} \sum_{j=1}^N (u_j - \bar{u})^2 \quad \dots (3)$$

$$\text{Variance } v = \overline{(v')^2} = \frac{1}{N} \sum_{j=1}^N (v_j - \bar{v})^2 \quad \dots (4)$$

The kinetic energy (KE) of time dependent motion was computed from the formula,

$$KE = \frac{1}{2} \rho (u'^2 + v'^2) \quad \dots (5)$$

where, ρ is the density of water and taken as unity and u'^2 and v'^2 represent the variances of eddy components of current.

Another parameter, stability of the current (S_e) defined as the ratio of kinetic energy of mean flow (K_m) to that of the fluctuations (K_f) was computed⁴ for all 3 layers.

$$S_e = \frac{K_m}{K_f} = \frac{\frac{1}{2} (\bar{u}^2 + \bar{v}^2)}{\frac{1}{2N} \sum_{i=1}^N (u_i^2 + v_i^2)} \quad \dots (6)$$

Results and Discussion

Currents— The surface drift varied between 1 and 4 knot. The drift was directed towards NE to E reflecting the influence of surface winds.

Currents at 15 m depth generally had speeds between 20 and 30 cm. sec⁻¹. Occasionally, current speeds were higher (45 cm.sec⁻¹). The current direction, in general, was towards SW on 24 Sept. towards SE on 25 Sept., oscillating on 26 Sept. and towards NE during 27 to 28 Sept. (Fig.2a).

The currents at 115 m depth generally had speeds between 10 and 30 cm.sec⁻¹. Occasionally, the current speeds were higher (40 cm.sec⁻¹). The current direction, in general, was towards NE during 24 to 26 Sept. and towards S during 26 to 28 Sept. (Fig.2b). The current speeds were generally low (10 to 15 cm.sec⁻¹) during 27-28 Sept.

The currents at 240 m depth generally had the speeds <20 cm.sec⁻¹ and directions variable. During 24 to 26 Sept. the currents were very weak (<1.5 cm.sec⁻¹). Subsequently, the current speed increased and attained values of the order of 35 cm.sec⁻¹, occasionally (Fig.2c).

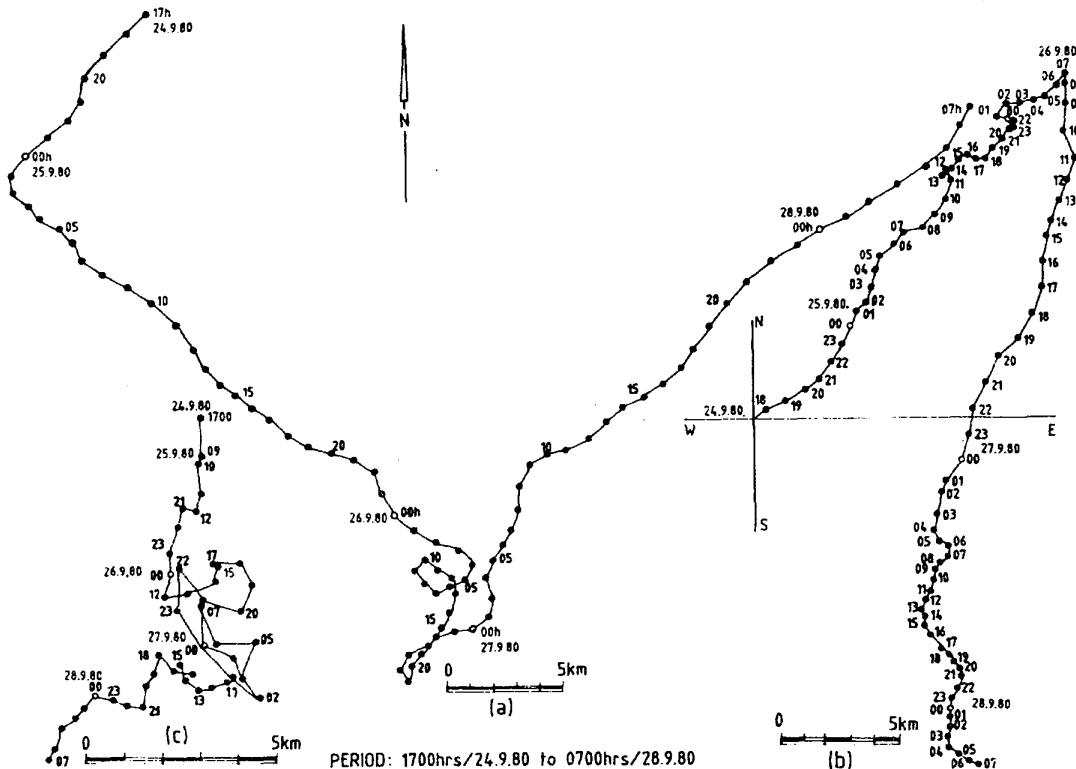


Fig. 2 - Progressive vector diagram of currents (hourly averages) at (a) 15, (b) 115 and (c) 240 m depth

Table 1—Some Mean Properties of Currents during 24 to 28 Sept. 1980

Depth m	Maximum current		Mean current		\bar{u} (cm.sec ⁻¹)	\bar{v} (cm.sec ⁻¹)	Kinetic energy		Stability (K_m/K_f)
	Speed (cm.sec ⁻¹)	Direction (Deg.)	Speed (cm.sec ⁻¹)	Direction (Deg.)			K_m (ergs)	K_f (ergs)	
15	45.7	135	27.2	128	11.04	-2.192	63.34	328.08	0.1961
115	40.7	210	18.4	143	0.597	-2.285	2.79	239.08	0.01167
240	34.0	230	18.2	222	-1.153	0.403	0.7463	137.20	0.005439

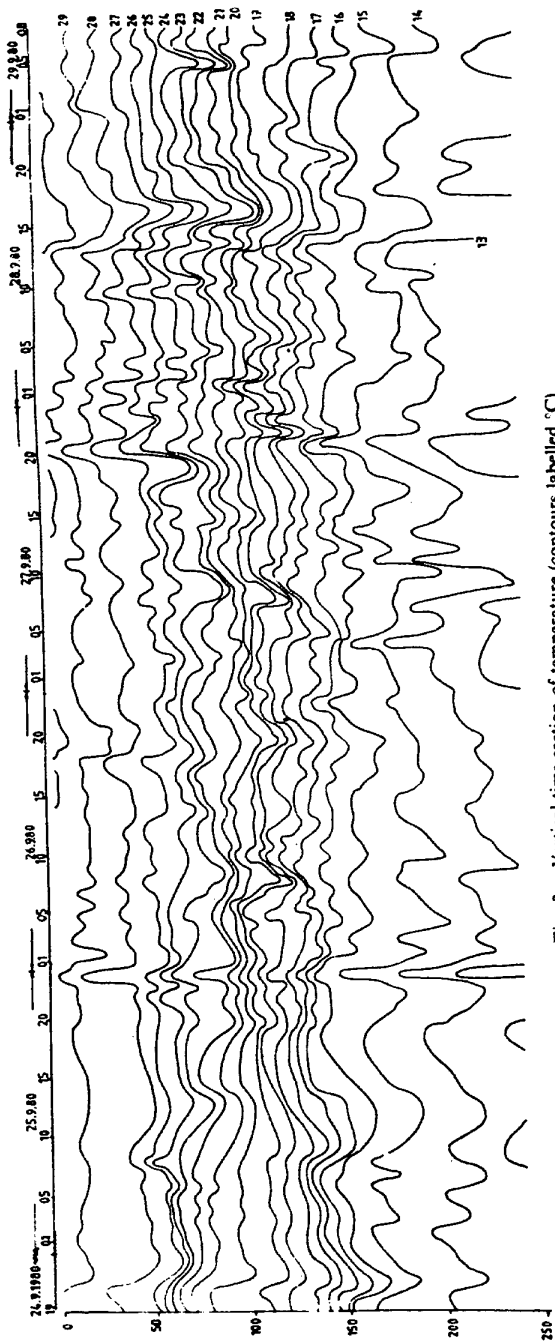


Fig. 3—Vertical time section of temperature (contours labelled °C)

Thus the currents recorded at different depths show variation in direction with time and exhibit a velocity shear. They do not seem to be influenced much by the tides. Near-surface currents show more stability than the currents at 115 and 240 m depths (Table 1).

Thermal structure— Sea surface temperature varied from 30.5° to 29°C and the thickness of the surface layer from 15 to 30 m showing little variation. The surface layer had shown a decrease in its thickness from the beginning of observations (24 Sept.) towards the end. From Fig.3, the 15° isotherm appears to be the bottom of thermocline and its depth lies around 150 m. The figure also indicates upslope of the isotherms towards the end of observational period. During the beginning of observations, the isotherms in the thermocline region showed weak gradients around 100 m compared to those towards the end. In general, the isotherms pattern shows fluctuation suggesting the probable effect of internal waves. The temperature at 250 m depth is about 12°C.

Mean vertical profiles of currents— Values of mean zonal component (\bar{u}) and mean meridional component (\bar{v}) are given in Table 1. At 15 and 115 m, \bar{u} was positive, indicating that the zonal flow was towards E, while at 240 m depth, it was negative indicating that the zonal flow was towards W. At 15 and 115 m depths \bar{v} was negative suggesting that the flow was towards S. However, at 240 m depth, \bar{v} indicates N flow. To summarise, the flow at 15 and 115 m depths was directed towards SE and at 240 m depth it was NW, in general.

Time dependent currents— Kinetic energy (K_f) with time (Fig.4) at 15, 115 and 240 m depths varied from 739 to 308, 496 to 243 and 268 to 46 ergs respectively. The kinetic energy decreased with depth. At all depths, it first decreased to a minimum and after 42 h increased and beyond 66 h showed little variation. The plot of E and N component variance shows that the variance at

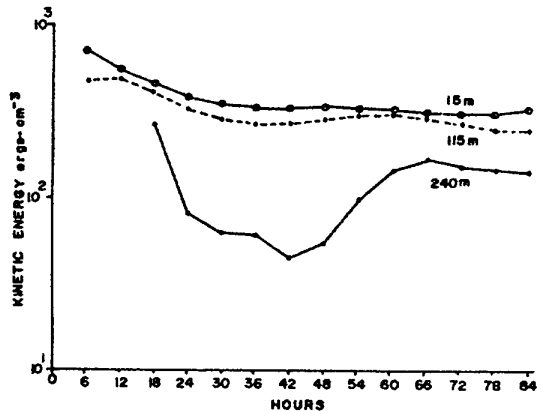


Fig. 4— Variation of kinetic energy with time

15 m depth was isotropic. The N component variance was always greater than the E component variance.

The analyses presented in this paper reveal the short term variability of currents and temperature at different depths in the study area and is of vital importance to offshore engineering activities.

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