J. mar. biol. Ass. India, 1973, **15** (2) : 728-734

NEARSHORE CIRCULATION AT TARAPUR ON THE WEST COAST OF INDIA*

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ABSTRACT

Hydrographic data from a cruise in the nearshore areas of Tarapur (March 20-28, 1966) on the west coast of India are presented. Temperature data indicate that the waters closer to the shore are warmer than those offshore. Salinity data also showed higher salinities closer to the shore compared to offshore areas. Sigma-t data suggests sinking conditions near the coast. Current measurements have shown oscillatory tidal currents at the four stations occupied. The current component normal to the shore (East) was very much weaker than the one parallel to the shore (North). The flood currents were slightly stronger than the ebb and the residual current data suggested a net movement of water towards the north at most of the stations. Current velocities were found to be higher towards offshore areas.

INTRODUCTION

A HYDROGRAPHIC survey was undertaken in the coastal waters off the Atomic Power Station at Tarapur during the period 20th to 28th March, 1966. The survey had as its prime object a detailed study of the nearshore circulation in view of its importance in the operation of the power station which uses seawater as a secondary coolant for its two reactors. Earlier observations by Cartwright and Spanne (1964) had indicated the possibility of recirculation of heated effluents due to the reversing tidal currents off the Tarapur Coast. The problem is particularly acute owing to the relatively high water temperatures (about 28°C), shallowness of the waterbody, and the gentle slope of the coast.

I am indebted to the authorities of the Fisheries Department, State of Maharashtra for providing facilities at Tarapur. I wish to acknowledge the help of Ss. G. R. Doshi, C. D. Mulay and M. C. Balani in the collection of data. Thanks are also due to Dr. A. K. Ganguly, Head, Health Physics Division for going through the manuscript and offering helpful suggestions.

The observations were carried out from M. F. V. Janjiria, a 42 foot wooden-hulled fishing trawler. A hydrographic section consisting of four stations (Fig. 1) was occupied perpendicular to the coastline off the Atomic power station. At each station measurement of temperature and collection of samples for salinity analysis were carried out at selected depths. Two current stations were occupied and measurements were made for over fourteen hours using an Ekman current meter. At these stations measurements of surface temperatures were also carried out at hourly intervals.

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*Presented at the 'Symposium on Indian Ocean and Adjacent Seas — Their Origin, Science and Resources' held by the Marine Biological Association of India at Cochin from January 12 to 18, 1971.

Temperature

Vertical distribution of temperature at Stations 18-21 is given in Fig. 2 a. The isotherms indicate that the waters closer to the shore are warmer than those off-shore. The temperatures below 5 m depth decreases progressively offshore. At stations 18, 19, 20 and 21 (five, ten, fifteen and twenty miles respectively away from the coast) the bottom water was cooler than the surface water by 0.28, 0.39, 0.90 and 0.89° C. These observations were repeated in October and the values at stations 18 and 19 were 1.9 and 2.4°C respectively.

Hourly readings of surface temperature taken at two stations (current stations I and II) have shown that the temperature at station I ranged from 27.3 to 27.9° C, the maximum and minimum being at 1522 hrs and 0418 hrs respectively. At station II the surface temperature ranged from 26.8 to 27.8°C. These differences between the maximum and minimum temperatures are considerably smaller than those reported by Cartwright and Spanne (1964) who noticed a temperature difference of 5.5°C between the maximum and minimum in a day during October 1964. They

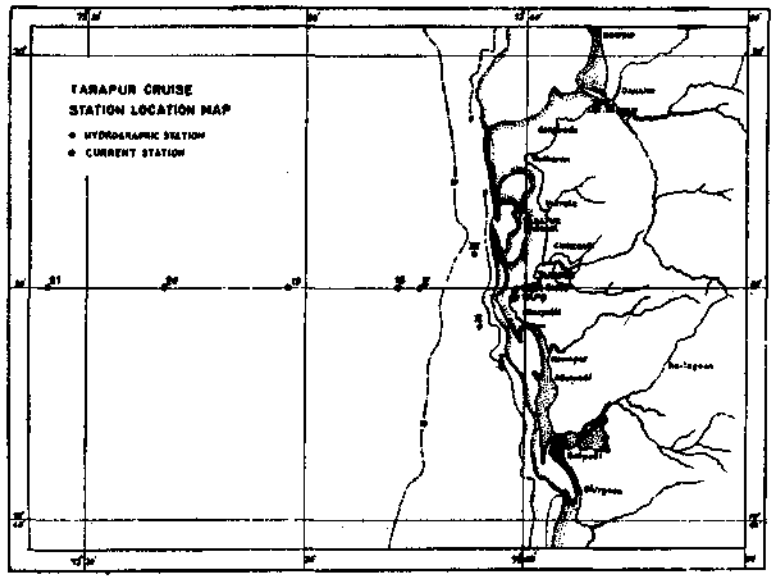

Fig. 1. Map showing Tarapur cruise station locations.

also observed a temperature difference of 0.22°C between the surface and bottom water (23′ depth) at a station 30′ deep. While this small difference does not suggest thermal stratification, the seasonal variation reflected in the 2.4°C difference in October is noteworthy. Such differences were also observed during October 1964 by Nair *et al.* (1964) off Bombay. Stratification will limit the absorption of heat to the upper layers resulting in an increase in the surface temperature (Parr, 1933).

Salinity and sigma-t

The salinity distribution at stations 18-21 is given in Fig. 2 b. The salinities ranged from 36.15 to 37.29‰ with the higher values being observed nearer shore. The isohalines upto 15 miles away from the coast reach from surface to bottom, decreasing

in value progressively offshore. The area between stations 20 and 21 would appear to demarcate the low saline offshore waters from the more saline coastal water. At station 21 depthwise variations were somewhat significant with a high salinity cell at a depth of 10 m.

In October when the observations were repeated at stations 18 and 19 salinities were found to be considerably lower ranging from 35.68‰ to 35.95‰. Such postmonsoon lowering of salinities were also observed by Jayaraman *et al.* (1961) off Bombay and Ramamirtham and Jayaraman (1963) near Cochin.

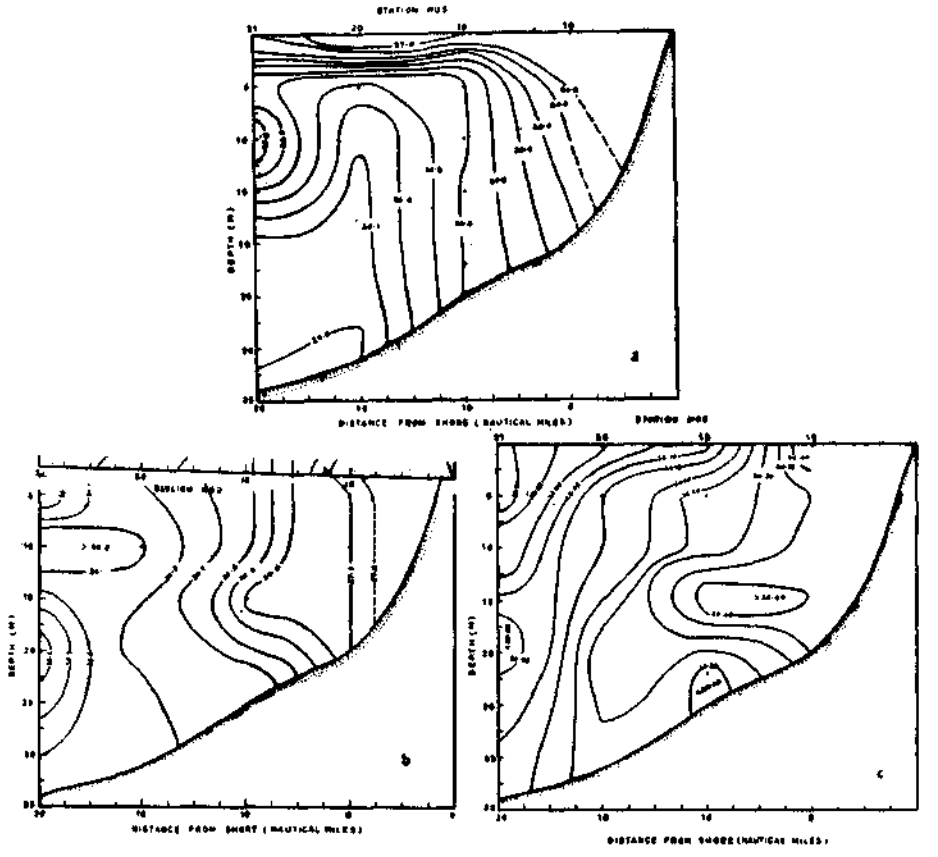

Fig. 2. Vertical distribution of - a. temperature (°C), b. salinity (‰) and c. density (σt) in a section off Tarapur on 23. 3. 1966.

The sigma-t data for station Nos. 18-21 are given in Fig. 2. The isolines of sigma-t indicate instability in the area leading to sinking conditions near the coast. Also significant is the presence of a picket of high density water (sigma-t 24.40) between stations 18 and 19.

Currents

Most studies on currents are generally confined to the open seas. Oceanic currents are far off the Tarapur Coast and recent studies (Cartwright and Spanne,

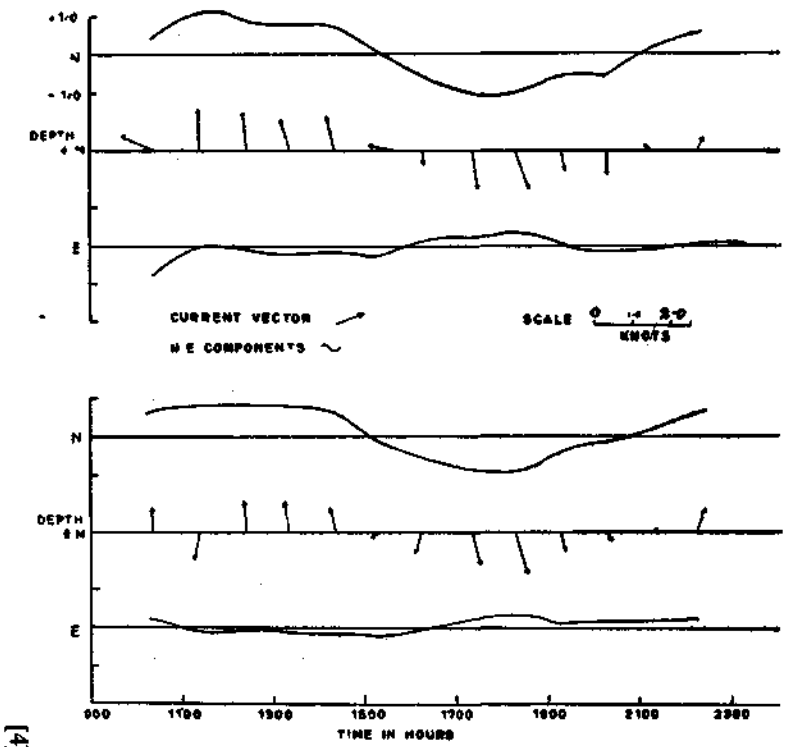

Fig. 3. Tarapur cruise—24.3.1966. Current vectors and north and east velocity components at station I.

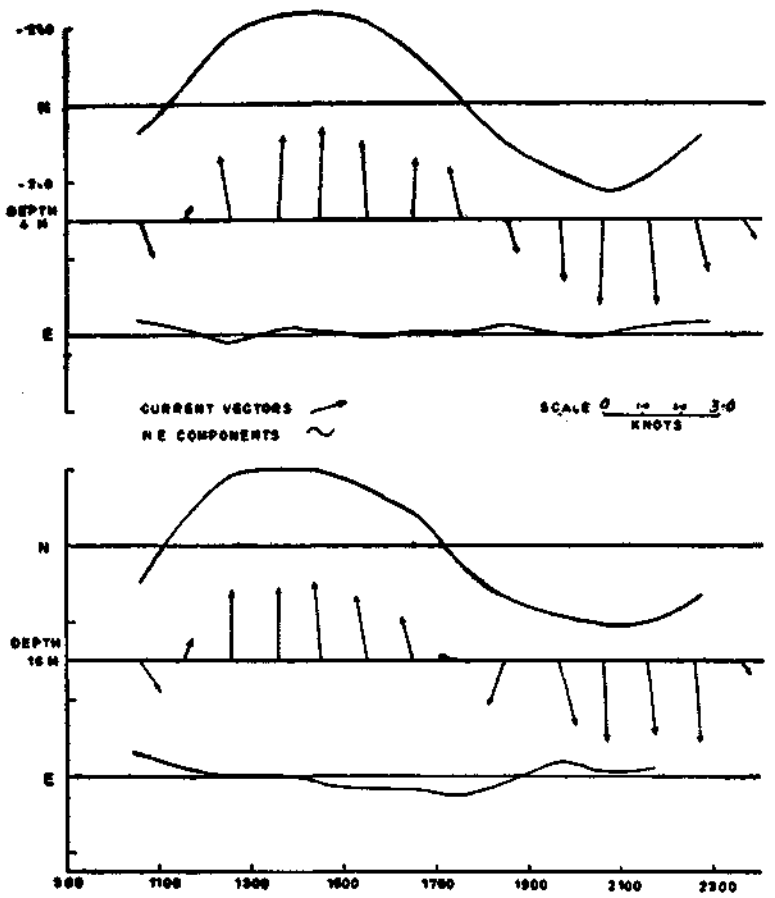

Fig. 4. Tarapur cruise — 26.3.1966. Current Vectors and north and east velocity components at station II.

1964) have shown that the nearshore waters are affected by the North and South tidal currents. These authors used floats for their studies and concluded that the current Velocity does not exceed 1.2 knots and that there is no evidence to indicate a significant net movement of water along the coast independent of the tidal cycle. In the present study measurements were carried out from an anchored boat using an Ekman current meter. At each station measurements were made at two depths, one close to the surface and another close to the bottom.

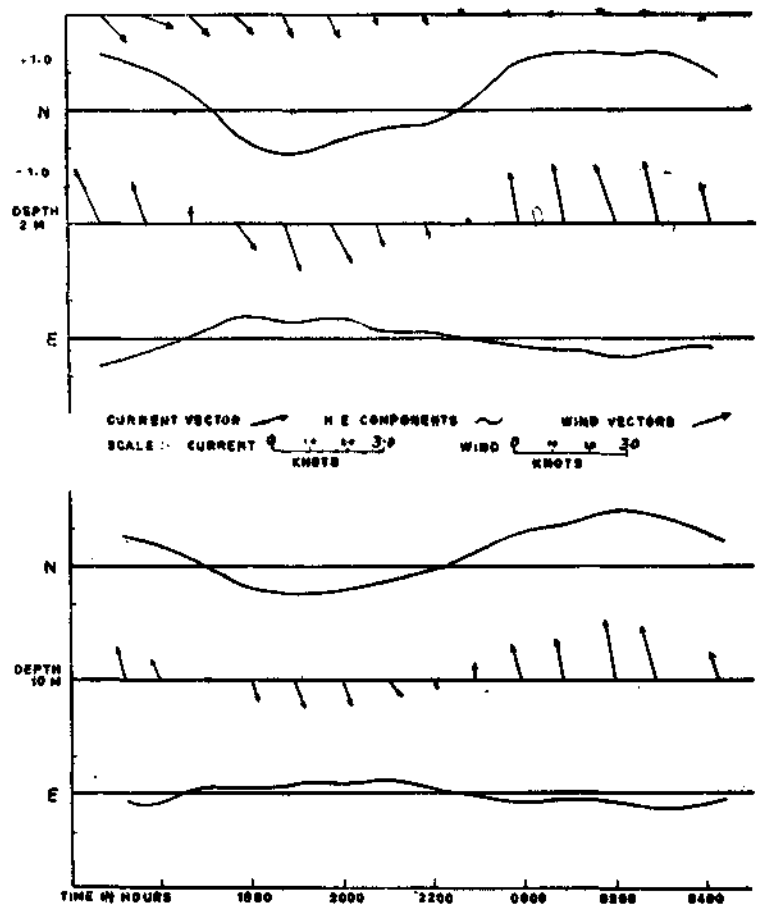

Fig. 5. Tarapur Cruise - 18.10.1966. Wind and current vectors and north and east velocity components at station III.

Current vectors along with the North and East Velocity components at the four stations are given in figures 3 to 6. Table 2 and 3 gives respectively the range of current velocities and the residual currents at the four stations. Currents at all the stations were oscillatory in character and the pattern during a tidal cycle presents a sinusoidal curve. This contrasts with the pattern of nearshore currents observed by the same author at Mormugao (Nair *et al.*, 1967) where the currents were northwesterly for the full tidal cycle at one station while slight indications of reversal of direction was noticed at two stations.

The maximum velocities were found at station II which is farther away from the coast than the other three stations. From an analysis of the North-South and

TABLE 1. *Current ranges at four stations off Tarapur*

Station No.	Depth (m)	Range (knots)
I	4	0.17 — 1.18
	8	0.14 — 1.15
II	4	0.58 — 2.35
	16	0.41 — 2.12
III	2	0.12 — 1.77
	12	0.12 — 1.52
IV	2	0.02 — 1.65
	10	0.37 — 1.71

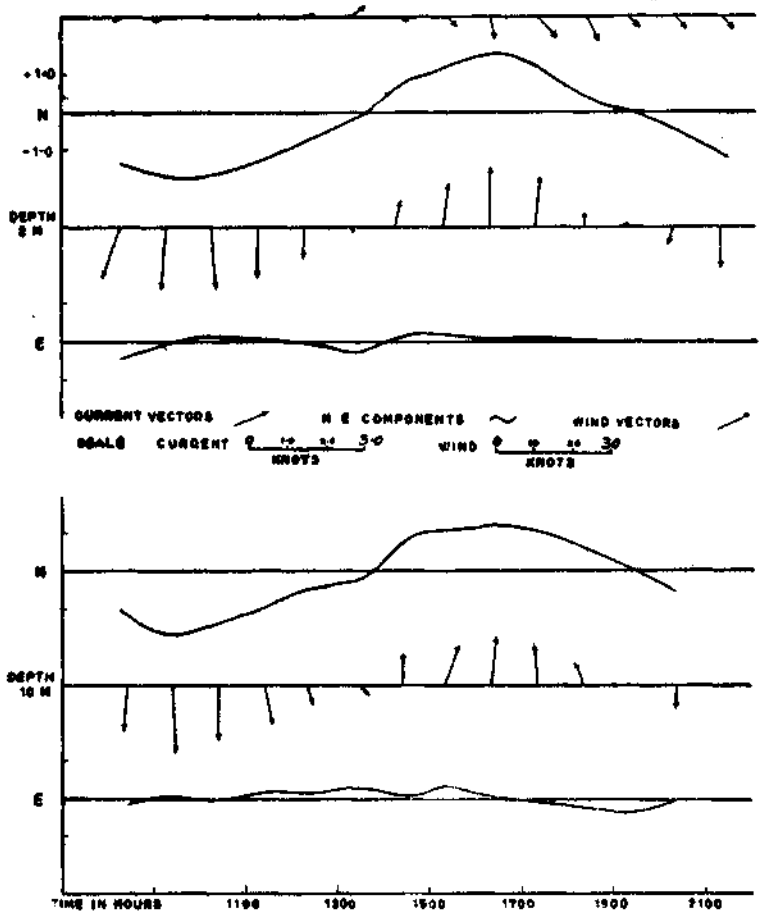

Fig. 6. Tarapur cruise - 20.10.1966. Wind and current vectors and north and east velocity components at station IV.

East-West velocity components it is seen that the North-South component is the more predominant. The data on residual currents indicate a net transport of water towards

the north at stations I, II, and III although earlier studies (Cartwright and Spanne, 1964) have shown no evidence of any such net flow towards the North).

TABLE 2. *Residual Currents at four stations off Tarapur*

Station No.	Depth (m)	Residual Current speed (knots)	Direction
I	4	0.085	N 70°W
	8	0.067	N 27°E
II	4	0.250	N 15°E
	16	0.020	E
III	2	0.270	N 10°W
	10	0.180	N 6°W
IV	2	0.240	S 7°W
	10	0.150	S 7°E

Data on thermohaline circulation as well as those due to nearshore currents are particularly important from areas like Tarapur. After the detailed studies on tidal currents, the single discharge system of the Tarapur Atomic Power Station was redesigned into a double discharge system, which makes use of the current direction in getting maximum dilution of heated effluents. The heated effluents are dischaged to the North during a flood tide and to the south during an ebb tide.

REFERENCES

CARTWRIGHT, P AND G. A. SPANNE 1964. Tarapur Atomic Power plant circulating water system, proposed double discharge system, Report to Govt. of India. (Restricted). Atomic Power equipment Department, General Electric, San Jose, California.

JAYARAMAN, R., R. VISWANATHAN AND S. S. GOGATE 1961. Characteristics of seawater near the Light House, Bombay. *J. mar. biol. Ass. India*, 3 (1 & 2): 1–5.

PARR, A. E. 1933. A geographic-ecological analysis of the seasonal changes in temperature conditions in shallow water along the Atlantic Coast of the United States. *Bull. Bingham oceanographic collection*, 4 : Art 3, Yale University, New Haven, Conn., U. S. A.

RAMAMIRTHAM, C. P. AND R. JAYARAMAN 1963. Some aspects of the hydrographical conditions of the backwaters around Willington Island (Cochin). *J. mar. biol. Ass. India*, 5 (2) : 170–177.

VIJAYAKRISHNAN NAIR, K., V. R. NERALLA AND A. K. GANGULY 1967. Current measurements off Mormagao. Paper presented at the NIO/NISI Symposium on Indian Ocean, New Delhi. *NISI Bulletin* No. 38 : 254-262.