

PHYSICAL CHARACTERISTICS OF THE COASTAL WATERS BETWEEN NAVAPUR AND UMBHARAT, WEST COAST OF INDIA : PART II. VERTICAL HOMOGENEITY OF TEMPERATURE AND SALINITY

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ABSTRACT

Vertical distribution of temperature and salinity at five stations in the coastal waters off Navapur-Umbharat (Maharashtra-Gujarat coast) was studied over different seasons during 1978. The results showed that inspite of large tidal and seasonal changes in these parameters, the vertical distribution was remarkably uniform on a seasonal basis at these stations having strong tidal currents during most part of the year, suggesting efficient mixing of the water layers. However, the vertical distribution of the salinity at some of the stations in the vicinity of big rivers was influenced by the seasonal influx of freshwater.

Key words: Physical characteristics, coastal water, vertical distribution, seasonal changes.

INTRODUCTION

The properties of the coastal waters north of Maharashtra have not hitherto been studied systematically despite the fact that this water body is being increasingly utilized for industrial purposes in recent years. This paper summarises the tidal and seasonal distribution of temperature and salinity at five stations between Navapur and Umbharat observed during 1978 (NIO, 1979). A description of the current regime and the tidal characteristics of this region has been given by Swamy, Sarma and Suryanarayana (1982).

METHOD OF STUDY

Observations on temperature and salinity were made at five stations viz., Navapur, Umbergaon, Daman, Tithal and Umbharat, situated along the Maharashtra-Gujarat coast (vide Fig. 1 in Swamy, Sarma and Suryanarayana, 1982). The temperature of the surface waters was measured by ordinary thermometer whereas subsurface values were measured using reversing thermometers. The seasonal and typical diurnal variations of temperature are given in Table I and Figs. 1-5. Salinity of the water samples collected during the course of the survey was estimated by titration. The NIO T-S meter was also made use of. The seasonal and tidal variations are shown in Table II and Figs. 1-5.

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RESULTS AND DISCUSSION

Temperature

(a) *Navapur*: During February and March the surface water temperature varied between 23.0 and 26.4°C. The bottom water temperature was close to the surface temperature. The average temperatures of the surface, mid-depth and bottom waters were 25.0, 25.7 and 24.9°C respectively, during this season. Diurnal changes in water temperature were noticeable. Isothermal conditions prevailed in the late evening hours (Fig. 1).

During the southwest monsoon months the minimum surface temperature was lower than the minimum sub-surface temperature but the average temperature was the same at all the three depths. Diurnal variation was not pronounced (Fig. 1).

During post-monsoon season an increase in the temperature range was observed – increase in maximum temperature and decrease in minimum temperature, at all the depths. The temperature fluctuations were more at the surface than at the sub-surface waters over a diurnal cycle (Fig. 1).

(b) *Daman*: The maximum surface water temperature (29.6°C) was observed in April and minimum (20.5°C) in January (Table I). The minimum close to 20°C was observed in the bottom waters when strong cold winds were blowing from the north in January. During the winter months the average temperature of

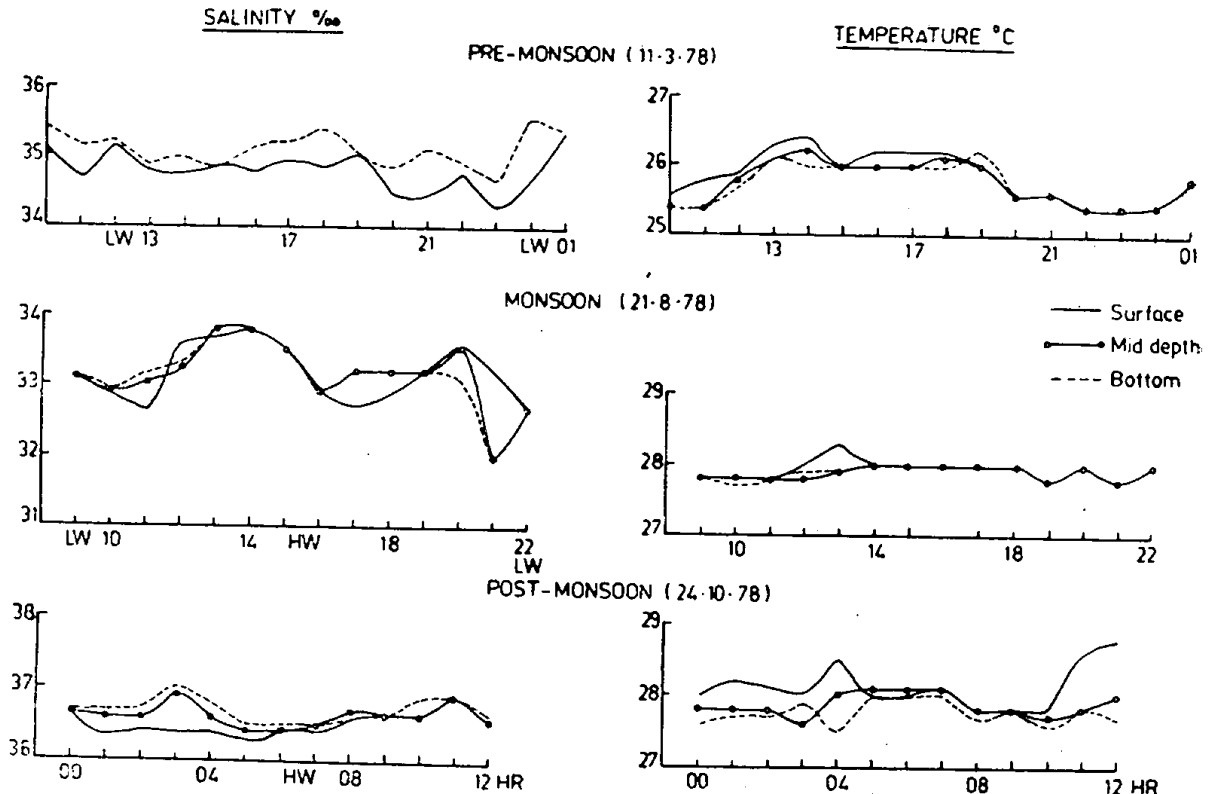


Fig. 1. Tidal distribution of salinity and temperature (Navapur)

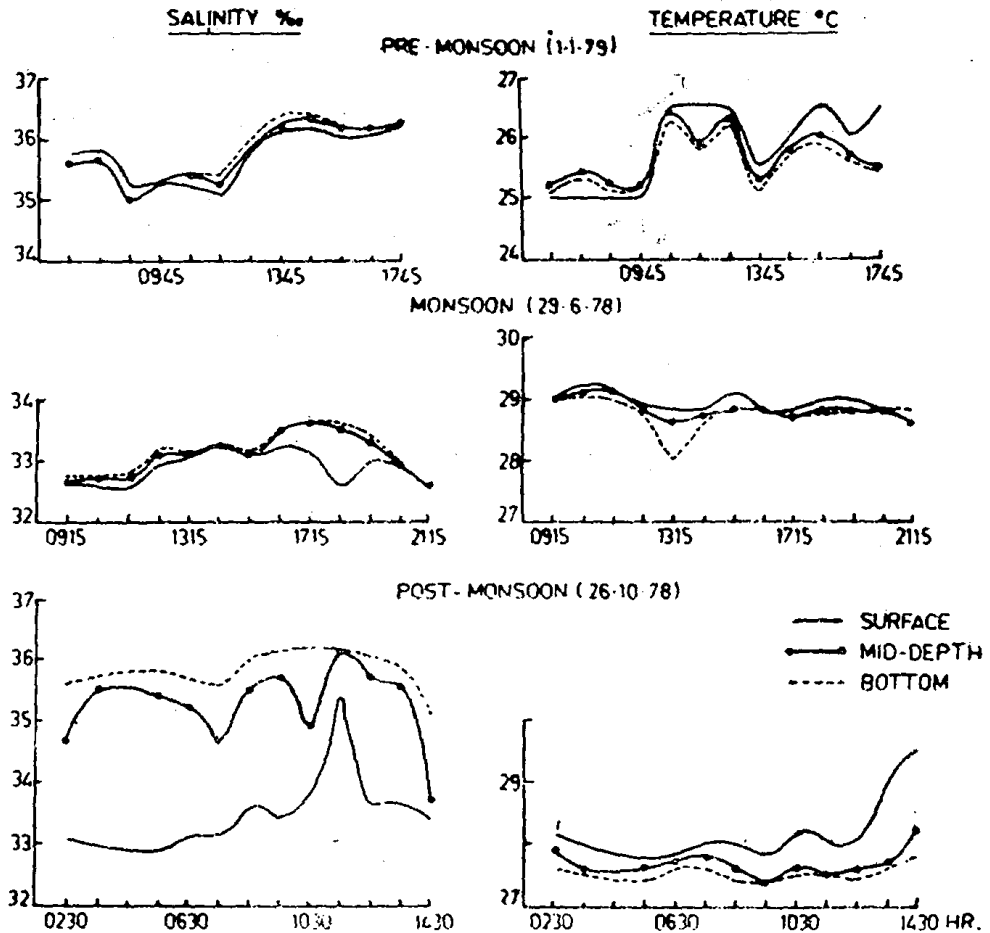


Fig. 2. Tidal distribution of salinity and temperature (Daman)

the surface, mid-depth and near-bottom layers was 24.0, 23.6 and 23.1°C respectively. Lower water temperatures were found, in general, to be associated with high tides, and vice versa (Fig. 2).

The range of water temperatures narrowed down during the monsoon months. The average surface, mid-depth and near-bottom temperature values were 28.4, 28.3 and 28.3°C respectively.

The range of water temperature widened at each level during the post-monsoon season with the average values of 27.2, 27.0 and 26.9°C at the surface, mid-depth and near-bottom layers.

(c) *Umbharat*: Of all the stations the maximum temperature (31.8°C) was noticed at Umbharat (Table I). During the pre-monsoon period the average temperature at the surface was found to be 28.1°C. In a typical diurnal cycle, it was seen that the water column was thermally mixed in the late evening hours of the day (Fig. 3).

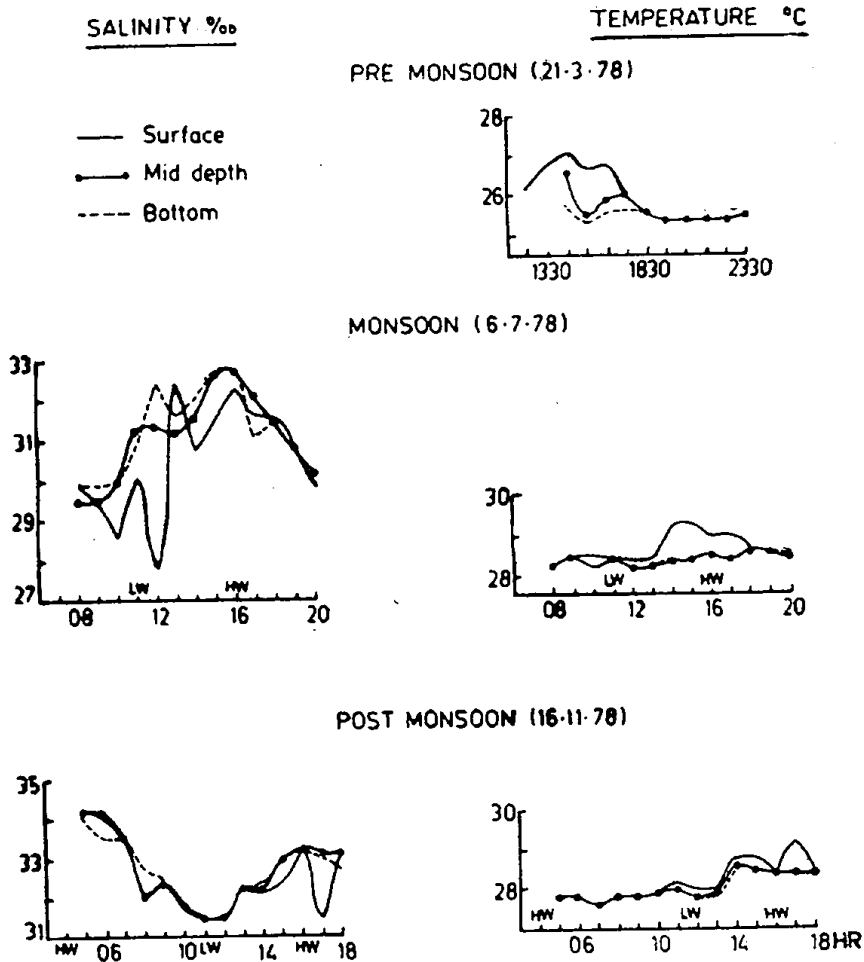


Fig. 3. Tidal distribution of salinity and temperature (Umbharat)

During the monsoon period, the temperature range was narrow as in the case of Daman. The seasonal average was 28.5 and 28.2°C at the surface and the sub-surface water respectively. The surface layers were found to have somewhat constant temperature (Fig. 3).

The temperature range increased again during the post-monsoon period (Table I). Increased insolation due to clear skies, warmed up the surface waters during the earlier part of the season and cold winds during the later part, contributed to the lowering of the surface temperature. On an average, 27.1, 27.0 and 27.0°C were noted at the surface, mid-depth and bottom water respectively. Occasional inversions were noticed during this season. Otherwise the water was well-mixed thermally. The diurnal variation of temperature was not appreciable in the bottom layers (Fig. 3).

(d) *Tidal*: Data collected in March and April indicated that the water temperature varied roughly between 24 and 30°C (Table I). The surface waters had an average temperature of 27.6°C while the mid-depth and bottom layers

exhibited average values of 27.5 and 27.4°C respectively. Diurnal fluctuations in water temperature in response to the insolation were observed (Fig. 4).

(e) *Umbergaon*: The data collected for Umbergaon during post-monsoon months indicated a considerable range of water temperature (25 to 31°C) (Table I). The similarity in the average values of the temperature for the surface, mid-depth and near-bottom waters showed the near-isothermal nature of the water column. The water temperature fluctuated marginally with varying atmospheric temperature (Fig. 5).

Salinity

(a) *Navapar*: While the surface salinity fluctuated within a considerable range, the near-bottom salinity was observed to vary in a comparatively narrow range during the pre-monsoon season (Table II). The average salinity at the surface and the

Table I. Observed seasonal changes in water temperature (°C).

		NAVAPUR		UMBERGAON		DAMAN		TITHAL*		UMBHARAT	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Pre-monsoon	S	26.4	23.0	—	—	29.6	20.5	29.8	24.0	30.9	25.4
	M	26.2	23.7	—	—	26.4	—	28.8	24.0	—	25.4
	B	26.2	23.0	—	—	26.3	20.0	28.8	24.0	29.5	25.2
Southwest monsoon	S	29.4	27.0	—	—	29.2	27.6	—	—	29.6	27.7
	M	29.4	27.8	—	—	29.1	27.6	—	—	28.9	27.7
	B	29.4	27.7	—	—	29.0	27.4	—	—	28.9	27.7
Post monsoon	S	30.3	25.4	29.4	25.1	29.5	25.0	—	—	31.8	23.9
	M	28.3	25.3	28.6	25.3	28.7	25.0	—	—	29.1	24.1
	B	28.3	24.7	28.2	24.7	28.7	25.0	—	—	29.1	24.1

Note: S — Surface, M — Mid-depth, B — Near Bottom. * Data inadequate

Table II. Observed seasonal changes in salinity (‰).

		NAVAPUR		UMBERGAON		DAMAN		TITHAL*		UMBHARAT	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Pre-monsoon	S	36.71	33.79	—	—	36.20	34.28	35.25	—	34.61	32.34
	M	—	—	—	—	36.35	34.65	35.10	—	34.99	33.10
	B	36.38	34.35	—	—	36.43	34.65	35.10	—	35.17	32.34
Southwest monsoon	S	33.80	32.00	—	—	33.25	29.50	—	—	32.38	27.83
	M	33.80	32.00	—	—	33.60	29.50	—	—	32.76	29.00
	B	33.80	32.00	—	—	33.60	29.75	—	—	32.78	29.50
Post-monsoon	S	36.90	34.90	36.62	33.36	36.90	29.91	—	—	35.75	31.00
	M	36.90	35.10	—	33.30	36.90	30.31	—	—	35.75	31.20
	B	37.00	35.20	36.50	34.70	36.90	30.02	—	—	35.75	31.20

Note: S — Surface, M — Mid-depth, B — Near Bottom. * Data inadequate

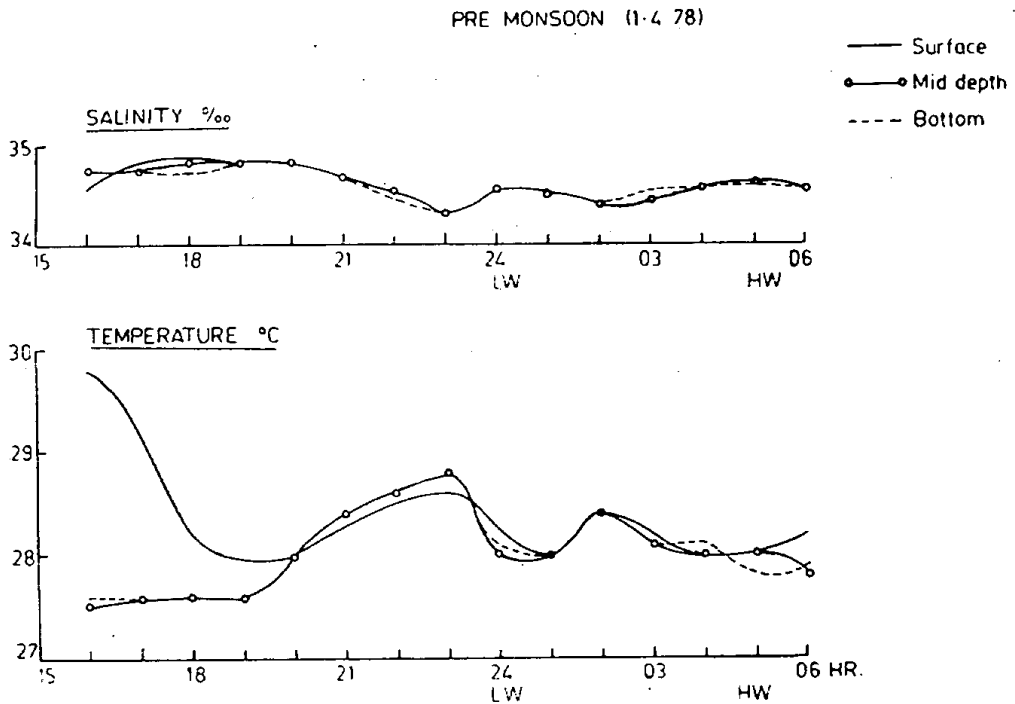


Fig. 4. Tidal distribution of salinity and temperature (Tithal)

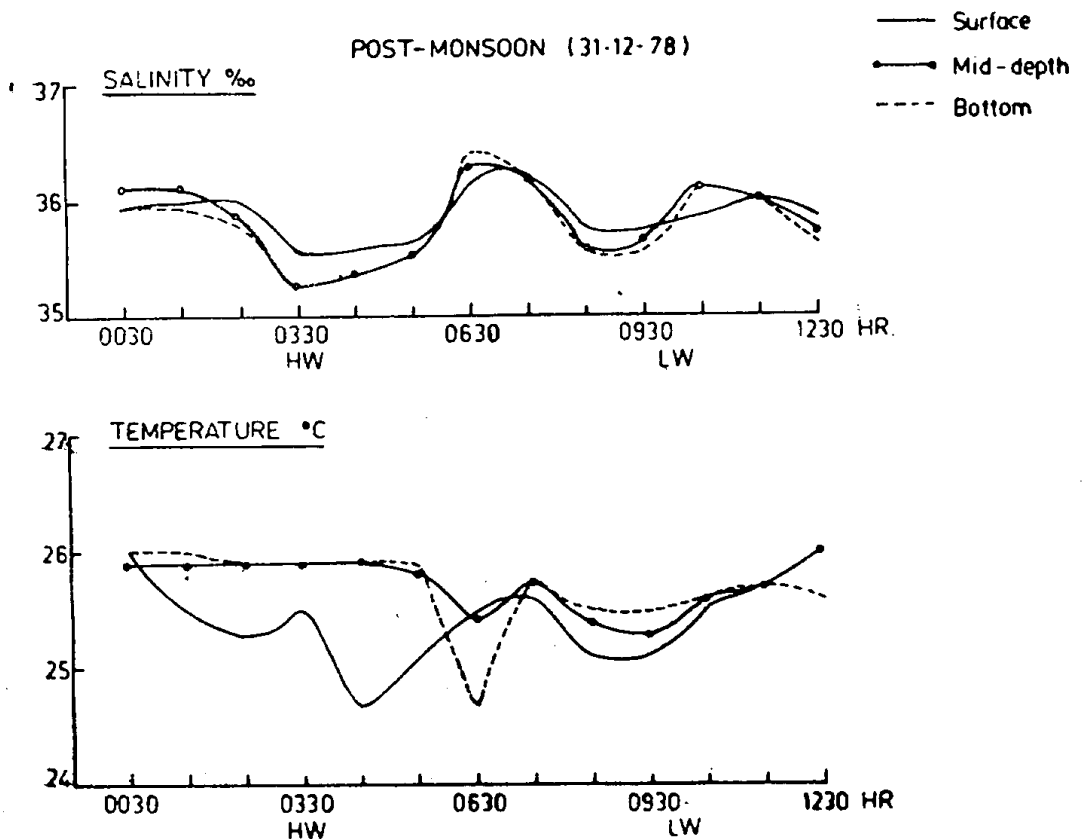


Fig. 5. Tidal distribution of salinity and temperature (Umbergaon)

bottom was 35.04 and 35.20‰ respectively. The changes in salinity with tide were more prominent at the surface and isohaline conditions prevailed over the entire water column occasionally.

Considerable decrease in salinity was observed owing to the freshwater runoff during the southwest monsoon months. However, the salinity values were slightly higher than that of Daman and Umbharat, where considerable amount of river discharge occurred. The surface salinity variation was narrow (32.00 to 33.80‰) and mostly tidal; low salinity was observed at low water.

The salinity was maximum at this station during the post-monsoon period. The salinity averages at the surface, mid-depth and bottom were 36.12, 36.10 and 36.22‰ respectively. The tidal ranges of salinity were small (36.25 to 36.90‰). The surface salinity closely followed the tidal rhythm and the bottom salinity had a lag of a quarter of tidal cycle (Fig. 1).

(b) *Daman*: The observed range was 34.28 to 36.20‰ at the surface waters off Daman during the premonsoon season (Table II). The average salinity values exhibited a marginal increase from surface to bottom. It was also noticed that the maximum salinity occurred during the spring high tide. The minimum was observed during the neap. The variation over a tidal cycle was small and smooth. However, the surface salinity was found to be slightly higher than the subsurface values a few hours after the high tide (Fig. 2).

During the monsoon period, the salinity was comparatively less, and the subsurface salinity varied between 29.50 and 33.25‰. The subsurface salinities were higher on an average. Unlike previous season, the maximum salinity was observed during the neap tide and the minimum during spring tide. The lower surface salinity and the variation of vertical salinity distribution over a tidal cycle indicated the effect of fresh water influx from the nearby river (Damanganga) (Fig. 2).

The average salinity for the post-monsoon season was found to increase from surface to bottom (34.55, 34.88 and 35.06‰ for the surface, mid-depth and bottom, respectively). However, the maximum salinity was almost same throughout the water column whereas the minimum value varied with depth. The salinity ranges over this season were larger than the previous seasons (Table II). The maximum salinity was observed during spring high water. The tidal influence was quite pronounced in the salinity distribution during the post-monsoon period too (Fig. 2).

(c) *Umbharat*: The average salinities at the surface, mid-depth and near-bottom were 33.30, 34.14 and 33.43‰ respectively during the pre-monsoon season. Marginally higher salinity values were noticed in the mid-depth layers. The pre-monsoon salinity was found to be the maximum of the year, partly due to the fact that there was no appreciable precipitation.

During the monsoon period the depthwise variation of the maximum salinity was not prominent whereas the minimum values exhibited an increasing trend with depth. On an average the salinity of the water increased from surface to bottom. Over a tidal cycle the salinity varied appreciably with maximum values at high water and minimum values at low water (Fig. 3). The surface salinity minimum was

associated with the spring low tide. The proximity of a fresh water source (Purna river) was clearly reflected on the salinity pattern. The high and low values of salinity were lower than those of the other seasons (Table II).

During the post-monsoon period, the average salinity of the water off Umbharat was higher than that during the other seasons. The average salinity values indicated a prominent increase with depth. However, the maximum values were similar from surface to bottom. Variation of salinity with tide was comparatively small (Fig. 3).

(d) *Tithal*: The pre-monsoon data collected off Tithal indicated that the salinity varied in a very narrow range over a tidal cycle. The water column was fairly homogeneous and the low and high salinities coincided with the low and high tides (Fig. 4).

(e) *Umbergaon*: The data collected for this area during the post-monsoon period showed that generally higher salinity prevailed over this area (Table II & Fig. 5). The extreme salinities were observed during spring tide.

Vertical Homogeneity

The vertical distribution of the seasonal averages of temperature and salinity were found to be remarkably uniform at Navapur. This condition prevailed at Daman too. At Umbharat though vertical homogeneity was noticed in the temperature distribution, marked salinity gradient was present, presumably due to the surficial spreading of water from the large Purna river. The pre-monsoon and post-monsoon data obtained at Tithal and Umbergaon respectively, also exhibited vertical homogeneity in salinity and temperature.

Apart from the seasonal averages, the instantaneous vertical distribution of salinity and temperature was nearly uniform at most of the stations over majority of the tidal cycle during most part of the year. During the pre-monsoon months isothermal conditions prevailed at Navapur in the late evening hours (Fig. 1) and the changes in salinity were associated with the tidal fluctuation. During the monsoon months, the water temperature was concurrent at all the depths over most part of the day. But during the post-monsoon months, no appreciable vertical uniformity in the diurnal distribution of temperature or salinity was noticed. Daman waters exhibited vertical uniformity in temperature and salinity during the pre-monsoon and monsoon periods (Fig. 2). Though fairly isothermal condition prevailed at Umbharat most of the time the tidal distribution of salinity was conspicuously modified presumably by the runoff from the river nearby (Fig. 3). Tithal and Umbergaon were characterised by homogeneous salinity profile during the pre-monsoon and post-monsoon seasons, respectively (Figs. 4 & 5). Vertical temperature distribution was also uniform at these stations during most part of the tidal cycle.

The vertical homogeneity of these parameters in this region could largely be the result of strong tidal currents favoured by the nearshore geometry. It is also noteworthy that the stratification prevails in the places and in the seasons having substantial river water influx. Analysis of the vertical stability of the different water layers in combination with prevailing oceanographic and meteorological processes would throw more light into this characteristic phenomenon.

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