

NOTES

MICRO-FLUCTUATIONS OF TEMPERATURE AND SALINITY IN THE GULF OF KUTCH

M. J. VARKEY, R. V. N. SARMA and R. NAGARAJAN

National Institute of Oceanography, Dona Paula - 403 004, Goa

ABSTRACT

Vertical distributions of temperature and salinity in the Gulf of Kutch show nearly homogeneous conditions in the water column. Though, variations in the vertical distributions with tide are very small, wind and insolation coupled with the phase of the tide cause transient features in the general mean patterns. The large tidal amplitude in the Gulf effects flooding of extensive low lying areas especially during spring tides and this results in numerous water pools trapped in the intertidal zone. The subsequent exposure of these individual water pools results in intense evaporation and formation of high saline water parcels. These parcels, when they are flushed into the Gulf during ebb tides, cause microfluctuations in salinity and temperature.

The Gulf of Kutch opens into the north-east Arabian Sea and is located between the peninsula of Kathiawar on the south and the coast of Kutch on the north. The Gulf is oriented in a nearly east-west direction and lies between $69^{\circ}00'$ and $70^{\circ}30'E$. At its entrance it is about 50 km wide and further eastward the width decreases gently over most of its length. It narrows abruptly at about $70^{\circ}20'E$. The southern coast is indented by numerous reefs and islands interspersed by several inlets. All along, this coast is fringed by extensive intertidal flats which get dried up during the low tide. These flats, at places, extend as much as 8 km. Fig. 1 shows a typical section of the southern coastline. In contrast, the northern coast of the Gulf is fronted by numerous sandy shoals.

The Gulf is comparatively shallow with a maximum depth of about 55 m. The tidal range increases upstream; from the mouth of the Gulf (Okha) to its head (Kandla) with a range increase of more than 200%. The associated tidal currents are fairly strong reaching 3-4 knots in the

open Gulf. In some of the creeks especially at the head of the Gulf (Hansthal Creek) the currents are known to exceed 7 knots. The rainfall over the hinterland is scanty throughout the year and consequently the fresh water discharge into the Gulf is negligible.

During the course of a survey in the Gulf from January through April, 1976, observations of temperature, salinity, silt charge, transparency and pH were carried out at surface, mid-depth and bottom at five stations located along a transect off Narara Bet (Fig-1). These data revealed a nearly homogeneous water column in the Gulf (National Institute of Oceanography Report, 1976). Clearly this homogeneity is brought about by mixing associated with strong tidal currents, uneven bottom topography and lack of fresh water discharges. However, on a few occasions, comparatively large fluctuations in temperature (about $1^{\circ}C$) and salinity (about 1%) were observed.

In this note, the authors present the nature of these fluctuations and plausible

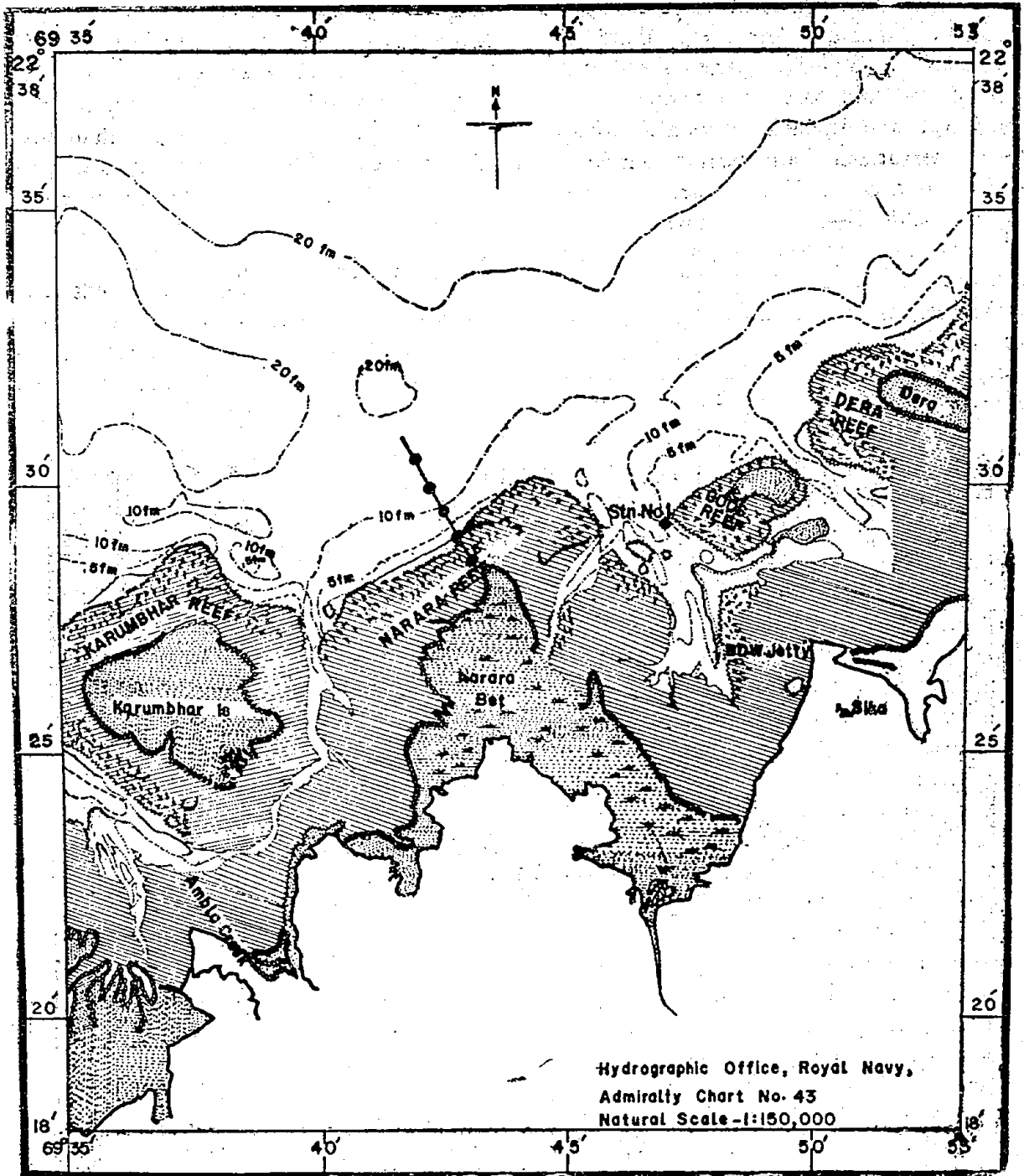


Fig. 1. Station location map.

reasons for the occurrence of these features.

In order to study the microstructure of the temperature and salinity distributions and their probable relations to tide and

atmospheric parameters hourly observations of temperature and salinity at 2 m depth intervals, under different tidal conditions were carried out at a station located near

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the Goose Reef (Fig. 1) at the opening of the Sikka Channel. The mean depth at this station is 18 m. Simultaneous observations of dry and wet bulb temperatures, wind speed and direction were also noted. These observations were carried out from 0800 hr. to about 1800 hr. Observations on 1st and 29th February represent spring tide conditions and those on 7th and 23rd represent neap tide conditions.

The vertical distributions of temperature and salinity are shown in Figs. 2 and 3 respectively. An examination of these figures suggest considerable fluctuations in

temperature and salinity from the mean pattern during the spring tide. These fluctuations are not quite evident during neap tide conditions. Further, the fluctuations in salinity are more conspicuous than that of temperature. Fig. 4 is a typical plot showing the variations of temperature and salinity at surface, mid-depth and bottom with tide.

Table I shows the wind speeds and directions during the period of observations. On 1st and 29th February, the wind speeds were considerable, averaging to about 5 m/sec. The wind direction varied between

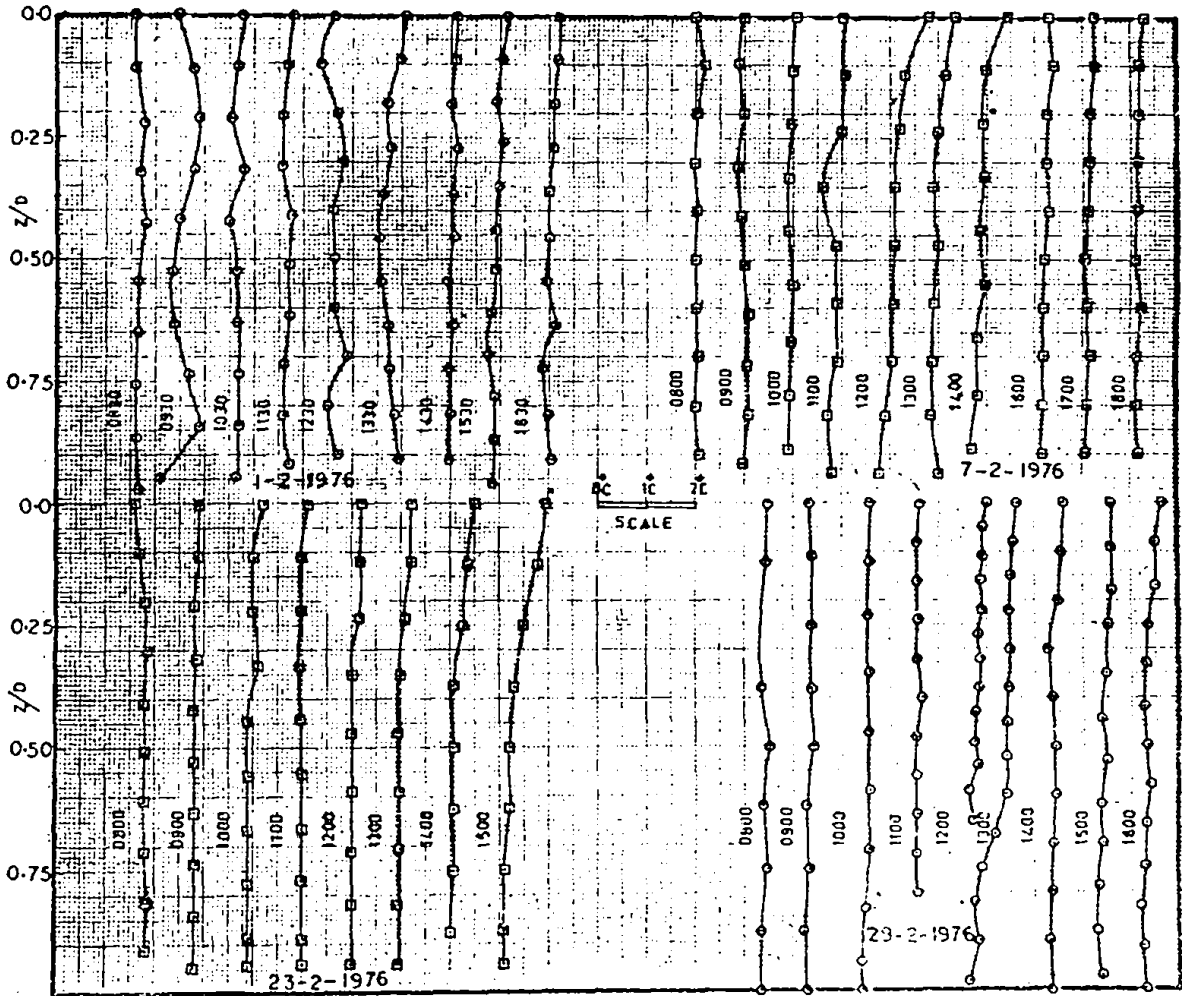


Fig. 2. Vertical distribution of temperature at Station 1, showing the relative vertical fluctuations only.

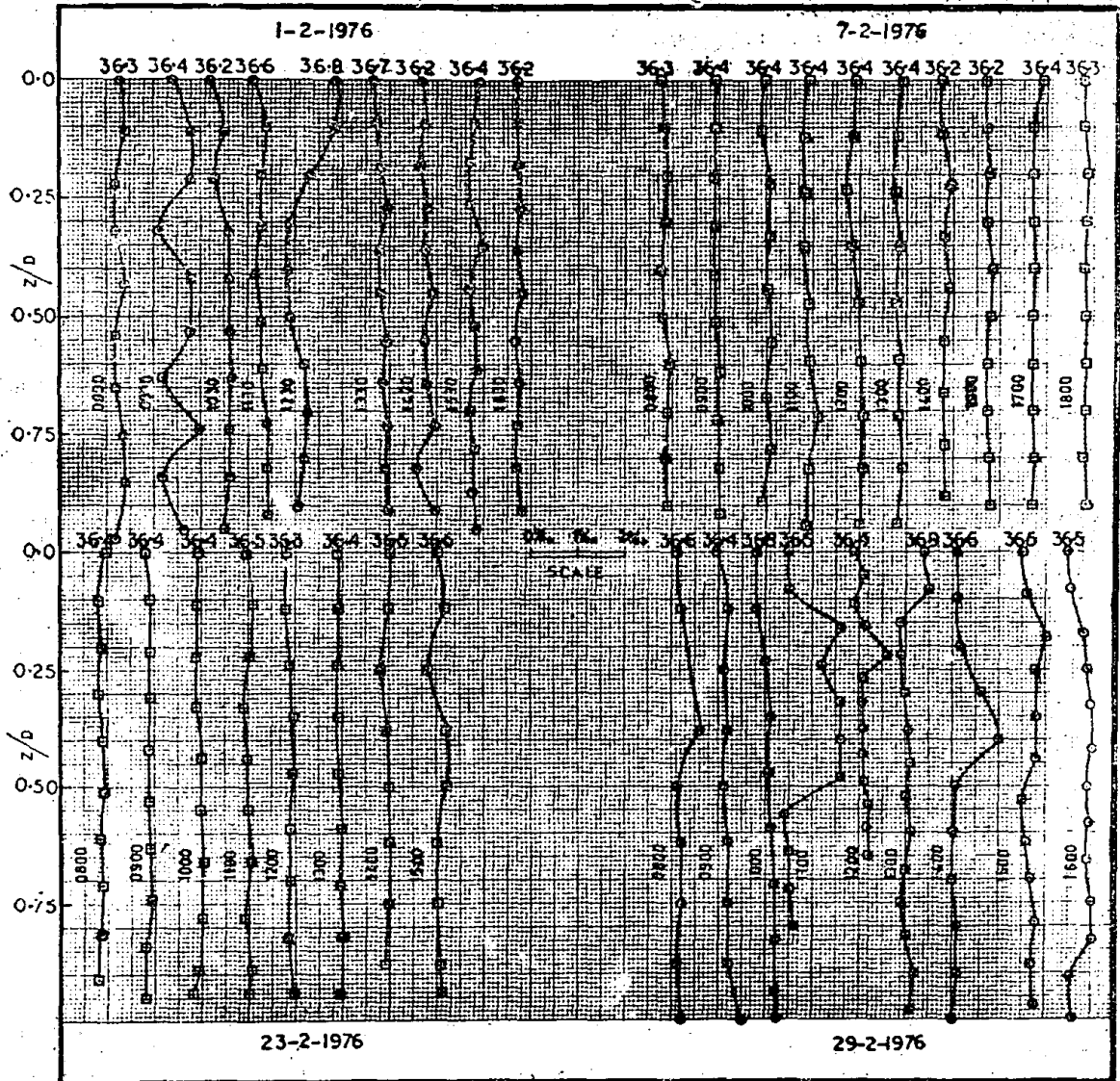


Fig. 3. Vertical distribution of salinity at Station 1.

southwest and north on 1st while it was predominantly northeast on 29th. On the other two days the winds were relatively calm and varied in direction.

Fig. 5 shows the variations of air temperature and sea surface temperature with time on the four days. During the early morning hours, the sea surface was warmer than the air and as the day progresses the air becomes progressively warmer.

On few occasions, the difference between air temperature and sea surface temperature was found to be as much as 10°C .

The evaporation rates for the observations' period were computed using the formula $E = (0.26 + 0.077W) (0.98 e_{\text{sat}} - e_a)$ (Bathen 1975). The evaporation rates are found to be $0.1 \text{ mm/cm}^2/\text{hr}$ or more during the morning hours and as the air temperature increased by noon the evaporation rates

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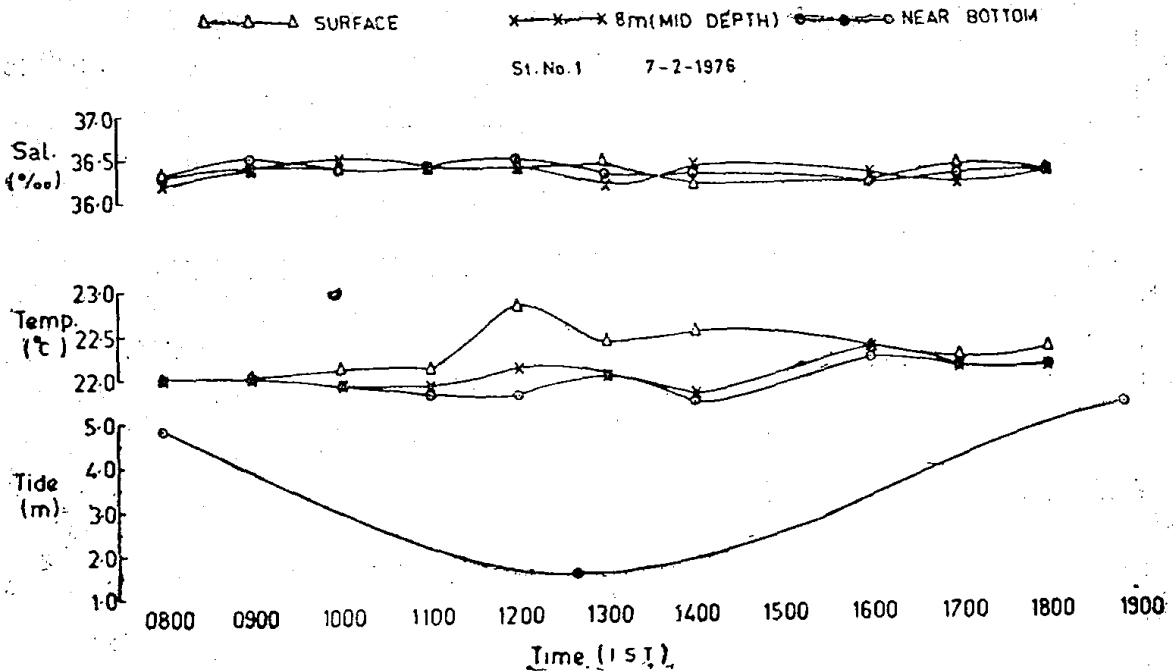


Fig. 4. Variations of temperature and salinity with tide at Station 1.

were found to decrease considerably. These results, it may be mentioned, are in accordance with the reasoning that maximum evaporation occurs when the sea surface is warmer (Sverdrup, et al., 1942).

The following points emerge from a close examination of the vertical distribution curves:

1. The sea surface temperature undergoes a ^{diurnal} variation,
2. The fluctuations in temperature and salinity during neap tides are small compared to those during springs,
3. The fluctuations in temperature are seen only on one spring tide condition (1-2-1976) whereas the salinity fluctuations are observed on both the spring tide days (1-2-1976 and 29-2-1976). Thus fluctuations in temperature and salinity need not be coincident.

These features suggest that the stage of the tide and the consequent exposure of the intertidal flats and the processes of

evaporation and heating determine the observed micro-structure in the vertical profiles of temperature and salinity. A plausible explanation is given below.

During high water springs the entire intertidal zone is flooded with water. The successive high water marks recede away from the coastline leaving some areas exposed. During the ebbs, while most of the water is withdrawn from the intertidal zones, some water is trapped in several pools. These water pools remain exposed depending upon the stage of the tide. These parcels of water are subjected to the processes of heating, cooling and evaporation. The period of observation being winter the night air temperatures are generally lower than the sea surface temperature and evaporation could be considerable. Thus, these waters isolated in numerous pools attain higher salinities. However, the temperature of these water parcels undergoes, a diurnal variation

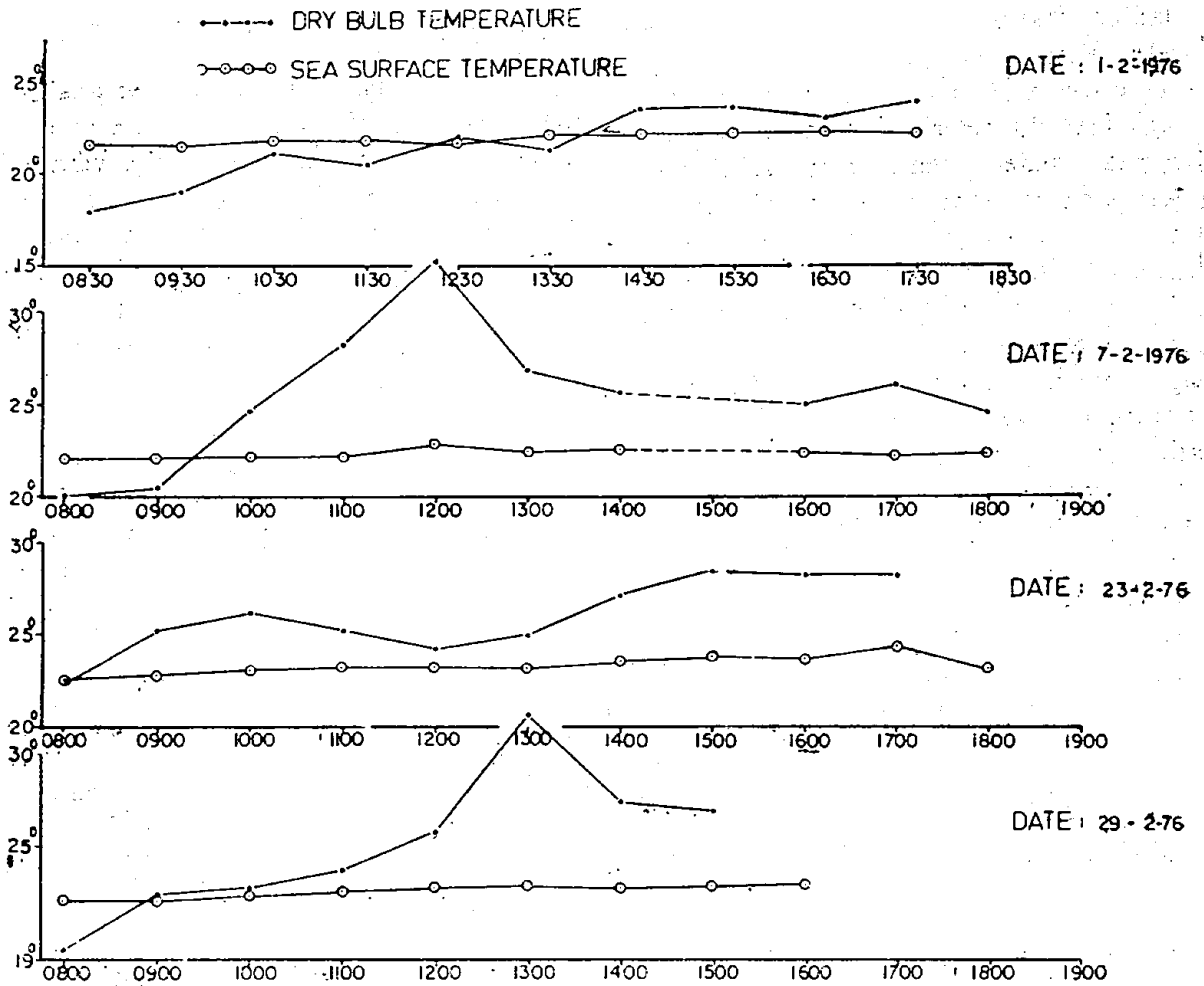


Fig. 5. Variations of dry bulb temperature and sea surface temperature during the observations' period.

Table 1. Wind speeds and directions for the observations' period.

Sl. No.	Date	Wind Speed (cm/ sec) and Direction											
		0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	
1	7-2-1976	3.0	2.7	3.0	3.8	0.9	3.0	3.0	..	6.0	3.8	2.8	
		320°	310°	310°	310°	325°	350°	320°	..	330°	330°	280°	
2	23-2-1976	2.5	Calm	Calm	1.5	2.6	1.8	Calm	Calm	Calm	1.1	1.2	
		145°	..	..	240°	180°	180°	..	..	..	120°	120°
3	29-2-1976	2.7	5.3	7.3	6.9	7.0	1.7	5.9	5.0	5.0	..	..
		40°	60°	60°	60°	60°	20°	360°	10°	60°	
4	1-2-1976	5.0	4.6	5.0	4.3	5.3	4.6	3.2	3.6	3.8	2.2	..	
		245°	305°	225°	220°	350°	220°	205°	220°	40°	260°	..	

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similar to that of air temperature. These parcels when they get entrained during the successive tides proceeding from neap to spring—the characteristic feature of the entrained water being high salinity—appear as fluctuations in the vertical salinity profile. The temperature of the entrained water being a function of the time of the day, the vertical temperature profile depends upon the time of the entrainment. During neap tides the quantum of water getting entrained is comparatively small and the vertical profiles of temperature and salinity do not show fluctuations from the mean distributions. The larger fluctuations in temperature and salinity on 1st and 29th February are explained thus as the combined effect of tidal conditions, evaporation and

entrainment.

The results of this study emphasize the importance of the processes of evaporation from the intertidal zone in the vertical structure of the water column of the Gulf of Kutch. However, the results cannot be generalised extensively due to the scanty nature of the data limited to a single station for only short periods.

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