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# HYDROGRAPHIC STUDY OF THE EASTERN COAST OF QATAR.

HASSAN M. HASSAN* AND M. A. MAHMOUD

Marine Sciences Department, Faculty of Science,
The University of Qatar, Doha, Qatar.

## ABSTRACT

The hydrographic conditions of the eastern coast of Qatar were studied in the two main seasons, winter and summer 1984. Two cruises representing the two seasons were made in the area which lies between Umm Said in the south to Ras Laffan in the north and extends 90-100 Kilometers, offshore. The temperature and salinity data are analysed; the thermal structure of the water masses and their seasonal variations are discussed. The density of the sea water was calculated. Temperature salinity relationship for the two seasons shows different characteristics. Some direct current measurements were made at shallow levels. The results of the studies show that during winter and summer two different water masses are observed. The tidal movement in the Gulf clearly affects the current speed and direction in the area.

## INTRODUCTION

Qatar as a peninsula in the Arabian Gulf is bounded manily by two long coasts. The eastern coast, which is the subject of this study, is about 180 kliometer long. The two main ports of Qatar, Doha and Umm Said lie along this coast. The western coast of Qatar lies along the Bay of Salwa, at the entrance of which is the island of Al Bahrain. The bay has not been completely surveyed from the oceanographic point of view. The water in the bay is isolated and of high salinity ( Sugden, 1963; Beltagy, 1983). The depths in the bay are very shallow and it is encombered with reefs and shoals, (Persian Gulf Piolt, 1967). The water circulation in the bay is mainly through its entrance around Al Bahrian. A proposed plan is suggested to study this bay in the near future.

The present study represents a part of the research programme of the Marine Science Department of the University of Qatar. The programme aims to study the marine environment of the Arabian Gulf region with special emphasis on the Gulf waters around Qatar peninsula. In brief it is planned to obtain the first systematic oceanographic data base in the area from the physical, chemical, biological and geological point of view. This paper deals with the detailed hydrographic studies of a part

*Future adress : Dr. Hassan M. Hassan ( Lecturer of Physical Oceanography), Institute of Oceanography and Fisheries, Alexandria, A.R. of Egypt.

of the western half of the Arbian Gulf. The area concerned occupies the coastal water East of Qatar (Fig. 1). It extends from 25° 00 N to 26° 51 N Latitude and 52° 10 to 52° 50 E Longitude, and covers an area of about 28,000 km sq. Depths are generally shallow and range between 10 and 60 meters.

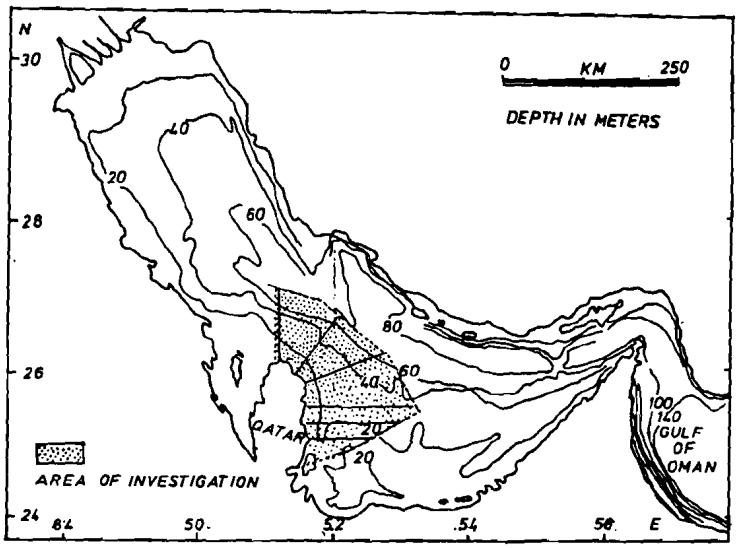


Fig. (1)
Area of Investigation.

## MATERIALS AND METHODS

Using the R/V Mukhtabar Al Bihar, the University of Qatar Research Vessel, the hydrographic survey was fulfilled to cover the area mainly in the winter and the summer of 1984 represented by February and July respectively. Sixteen hydrographic stations covering four hydrographic sections from the south at Umm Said and Doha to the north at Ras Laffan and Ras Rakan were occupied (fig.2). Water temperature, salinity, oxygen, pH and pressure data were collected mainly using Guildline CTD system. Samples for salinity and other chemical parameters determinations were collected using Nansen reversing bottles with two protected reversing thermometers. Samples were taken at 0,5,10,15,20,30,40 and 50 meters where depths allowed. Salinity determinations were made using an inductive salinometer. Sigma T was calculated using a prepared program on the

computer of Qatar University. Current measurements were directly taken by a Savonius type current meter. Currents were measured hourly at different depths in some selected coastal stations.

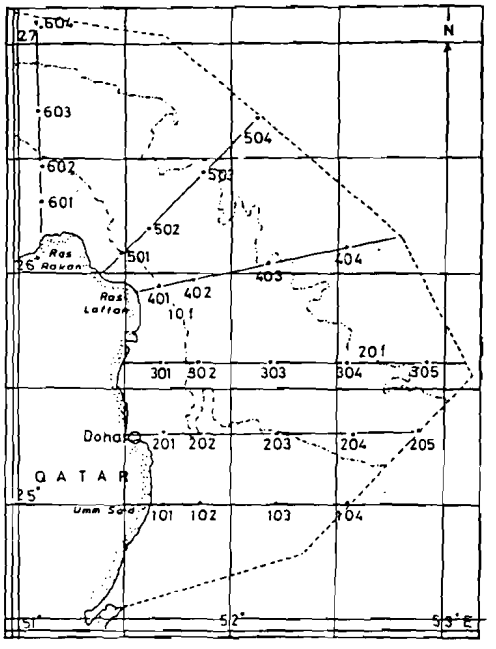


Fig. (2)
Position of Stations.

## RESULTS

### Horizontal Distribution of The Water Temperature, Salinity and Sigma T In Winter (February, 1984).

During February the surface water temperature of the area under investigation ranged between 18.62°C in the inshore part of the northern area to more than 20.30°C in the offshore eastern part of the area (Fig. 3A). The near bottom water temperature showed no significiant difference from the surface. An increasig temperature trend in the offshore direction was indicated. The near bottom water temperature (Fig. 3B) changed from 18.68 to 20.11 C.

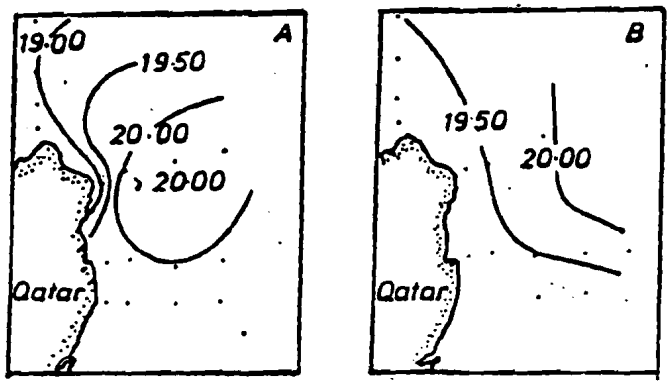


Fig. (3)
Horizontal Distribution of water temperature in February, 1984.
( A, surface ; B, near bottom )

The surface salinity in February (Fig. 4A) showed small variations where it changed from 40.00 ‰ in the offshore eastern part of the area and 41.50 ‰ in the southern part to more than 42.00 ‰ in the inshore northern part of the area. The near bottom salinities generally showed no changes from the surface ones except of some lower values of salinity in the northern inshore part of the area where salinity is about 40.50 ‰ near the bottom (Figure. 4B) compared with 42.00 ‰ at the surface.

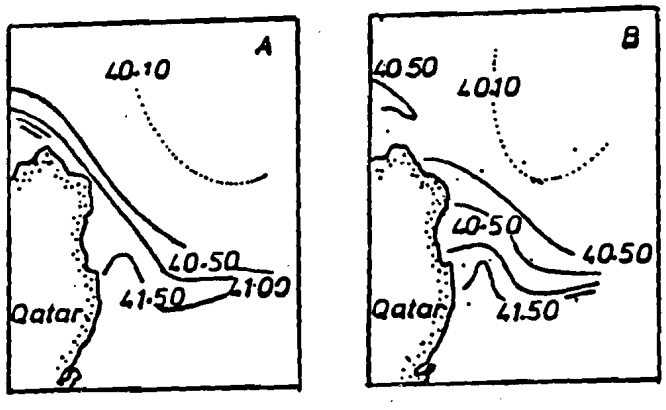


Fig. (4)
Horizontal distribution of salinity in February, 1984.
( A, surface ; B, near bottom )

The horizontal distribution of Sigma T at the surface (Fig. 5A) showed changes from 30.50 at the most northern part of the area to less than 28.00 in the eastern offshore part of it. A similar sigma T distribution in the near bottom layer was indicated (Fig. 5B).

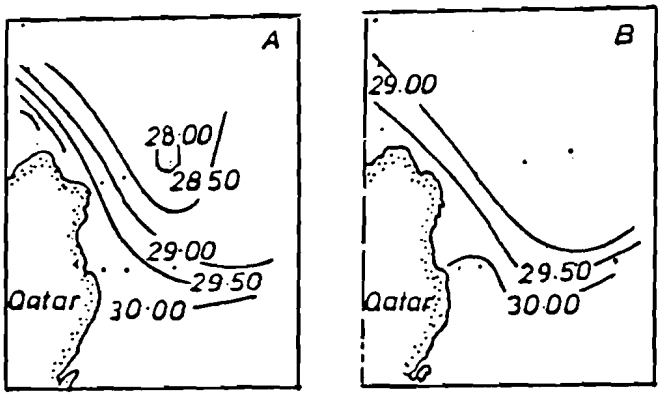


Fig. (5)
Horizontal distribution of sigma T in February, 1984.
( A, surface ; B, near bottom )

**Vertical Distribution of the Water Temperature, Salinity and Sigma T in the Water (February, 1984)**

F.g. 6A to Fig. 6D, show the vertical distribution of water temperature in Umm Said, Doha, Ras Rakan and Ras Laffan (Sections 1,2,4 and 6). A vertical homogeneity in the water temperature is evident indicating good mixing conditions due to decrease in the water temperature reinforced by higher salinity. The vertical water temperature gradient is about 0.2°C within 40 meters depth. The water temperature showed relatively lower temperaure in the inshore water than in the offshore one. Generally the water temperature changes vertically from 15.00 to 20.00°C in winter.

The vertical salinity distribution confirms the vertical mixing conditions, where salinity is vertically homogeneous. The inshore watres are of higher salinity due to the relatively slow moving inshore water, as compared with the off shore moving water. The offshore water is of lower salinity (Fig. 7A to Fig. 7D). Sigma T ranges between 28.50 in winter in the offshore to 30.50 in the inshore water; also the vertical distribution (Fig. 8A to Fig. 8D) show the vertical homogeneity in sigma T.

**Horizontal Distribution of the Water Temperature, Salinity and Sigma T in Summer (July, 1984)**

Generally the surface water temperature during July 1984 range between 29.00 C at the northern part of the area and 32.00 C at the southern part

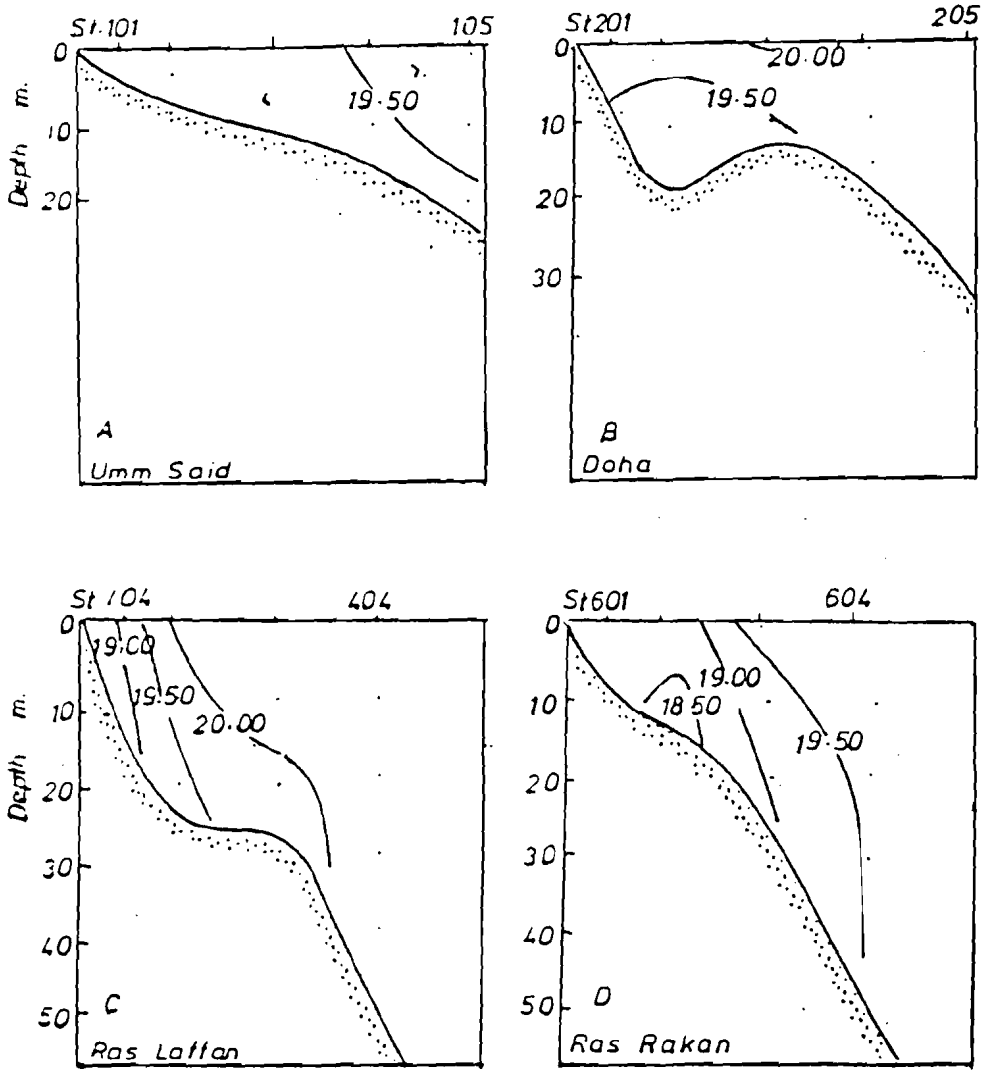


Fig. (6)
Vertical distribution of water temperature in February, 1984.
( in the four sections )

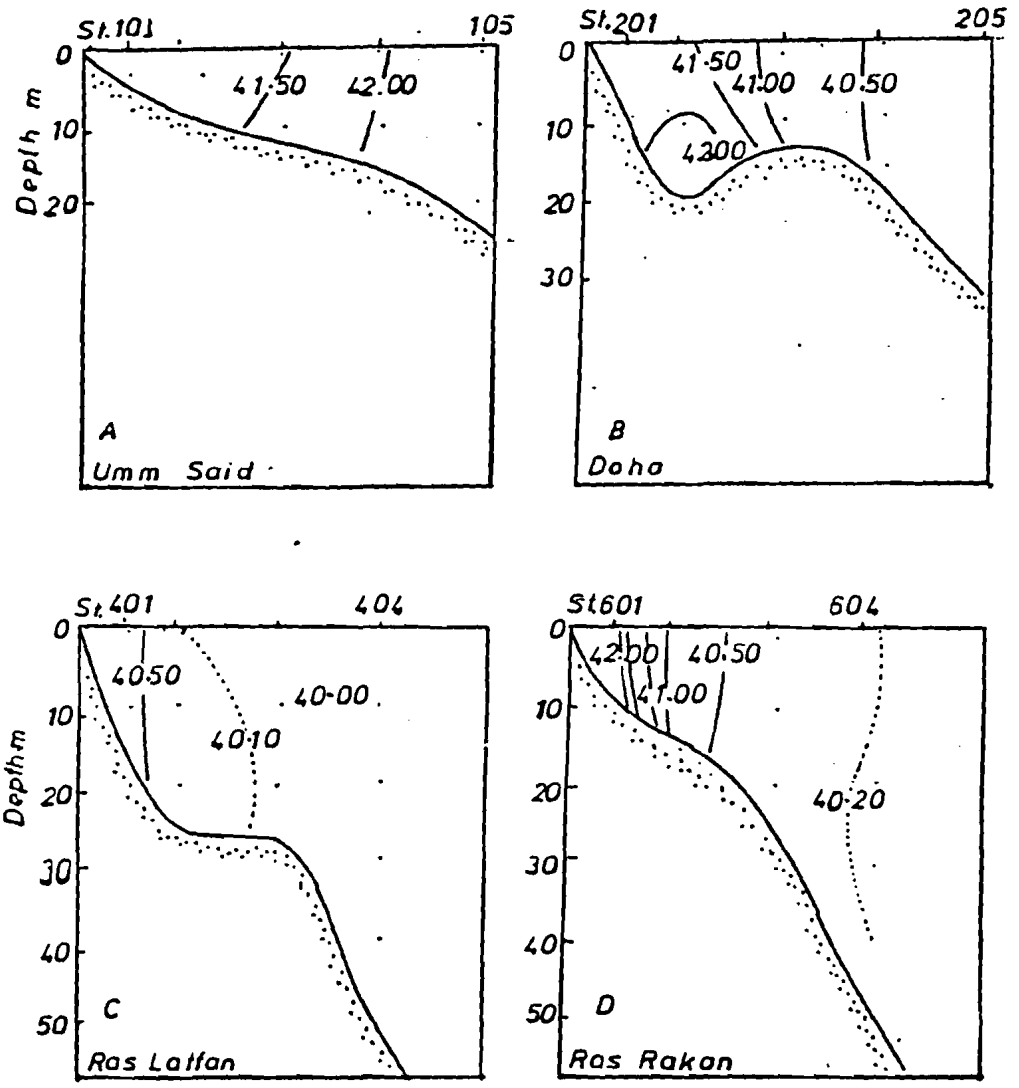


Fig. (7)
Vertical distribution of salinity in February, 1984.
( in the four sections )

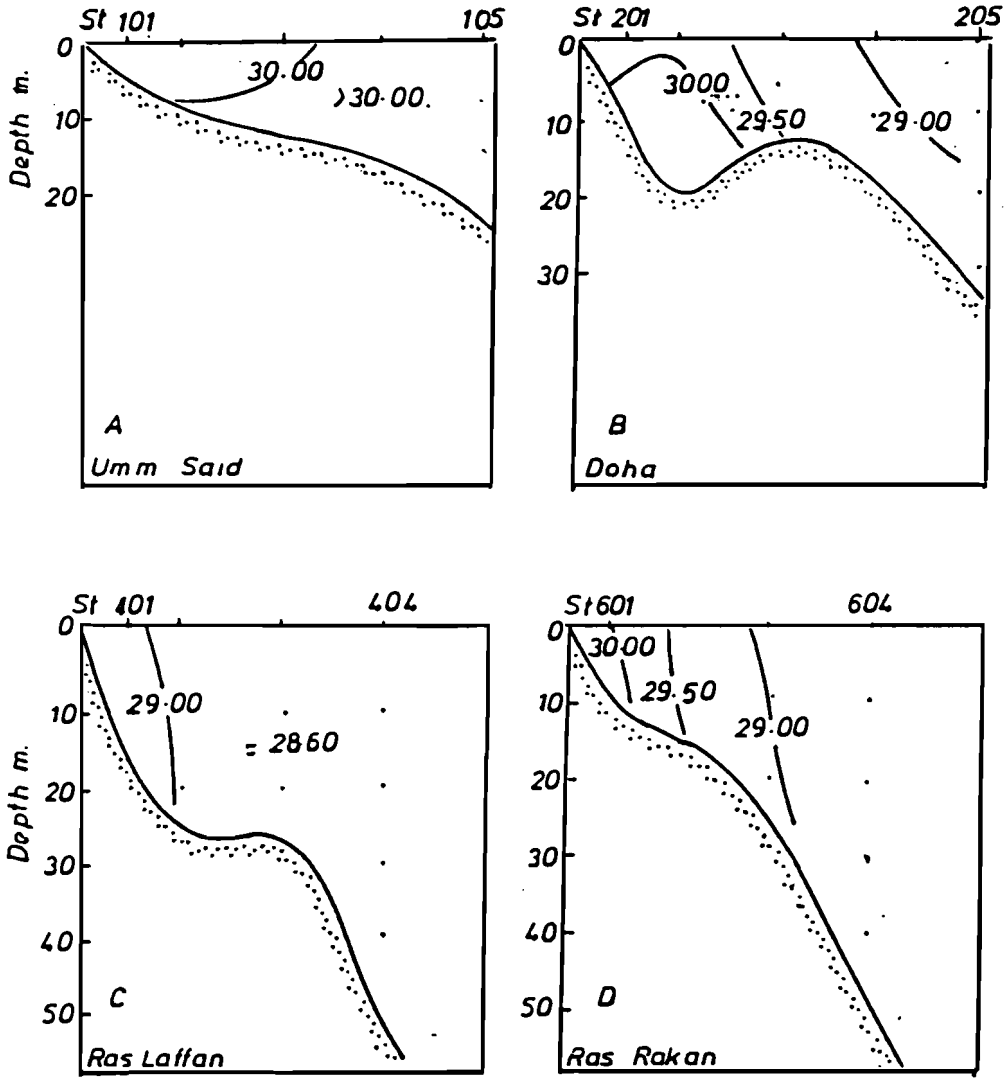


Fig. (8)
Vertical distribution of sigma T in February, 1984.
( in the four sections )

of it (Fig. 9A). The near bottom water temperature distribution (Fig. 9B) shows a decrease from 31.50° C in the inshore part to less than 28.00°C in the offshore part of the area. The surface salinity distribution (Fig. 10A) shows a decreasing trend in the seaward direction, where salinity changes from 43.00‰ in the inshore waters northern part of the area to less than 38.50 ‰ in the offshore, eastern part.

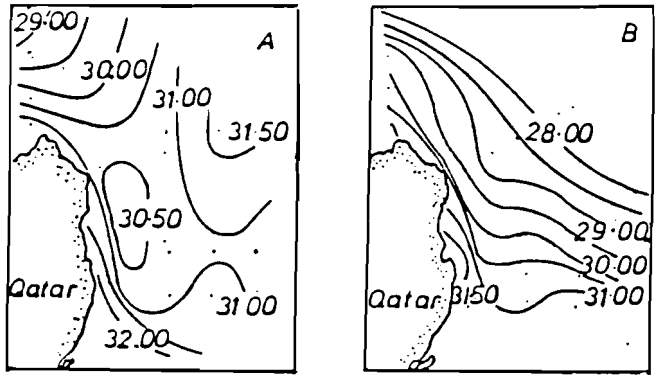


Fig. (9)
Horizontal distribution of water temberature in July, 1984.
( A, surface ; B, near bottom )

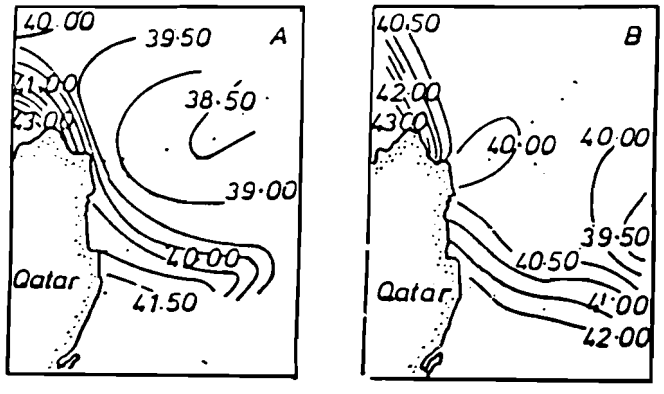


Fig. (10)
Horizontal distribution of salinity in July, 1984.
( A, surface ; B, near bottom )

In some parts of the area the surface salinity showed higher values than the near bottom layer (Fig. 10B) due to the wind factor and the evaporation effect. The near bottom layer showed the same seaward decreasing trend of salinity. The near bottom salinity changed from 43.00 ‰ in the inshore areas at the north to less than 39.50 ‰ in the offshore waters in the eastern part of the area.

Fig. 11A and Fig. 11B show the horizontal distribution of sigma T at the surface and near bottom layers. The surface sigma T changes between 24.00 at the eastern offshore waters to more than 27.00 in the waters inshore in the north. The near bottom sigma T changes between 25.50 in the offshore east of the area to more than 27.50 in the inshore part of the same area. The increase in sigma T is due to the decrease of the water temperature in the seaward direction.

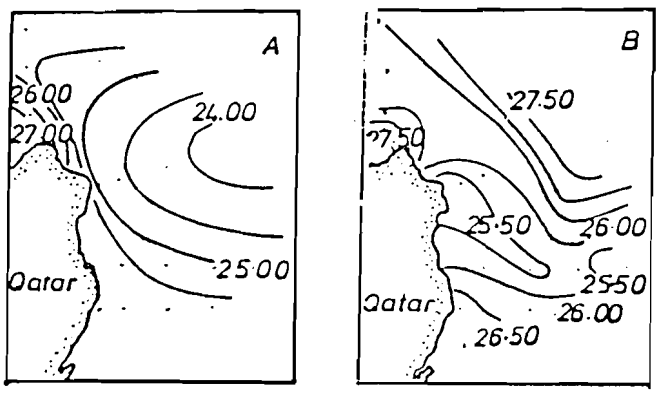


Fig. (11)
Horizontal distribution of sigma T in July, 1984.
A, surface ; b, near bottom )

**Vertical Distribution of the Water Temperature, Salinity and Sigma T in Summer (July, 1984).**

Fig. 12A to Fig. 12D show the vertical distribution of temperature in the four mentioned sections. The water temperature decreases from 32.0 C in the inshore water of Umm Said (Section 1) to less than 23.50 C in the offshore deeper water of Ras Laffan (Section 4). In this relatively deeper water a weak stratification is detected, compared with the mixed condition in winter.

Fig. 13A to Fig. 13D, show the vertical distribution of salinity in the four sections. The decrease in salinity in the offshore directions is clear.

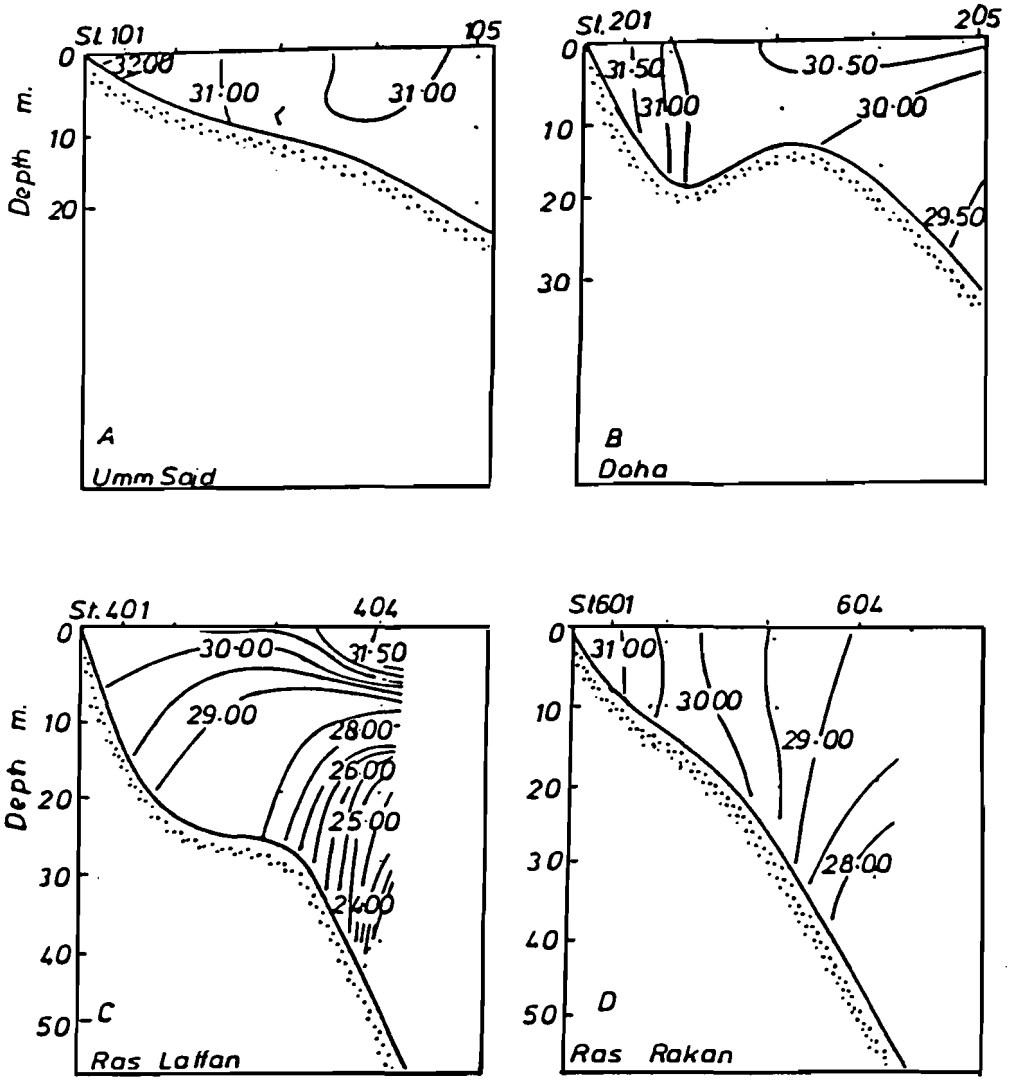


Fig. (12)
Vertical distribution of water temperature in July, 1984.
( in the four sections )

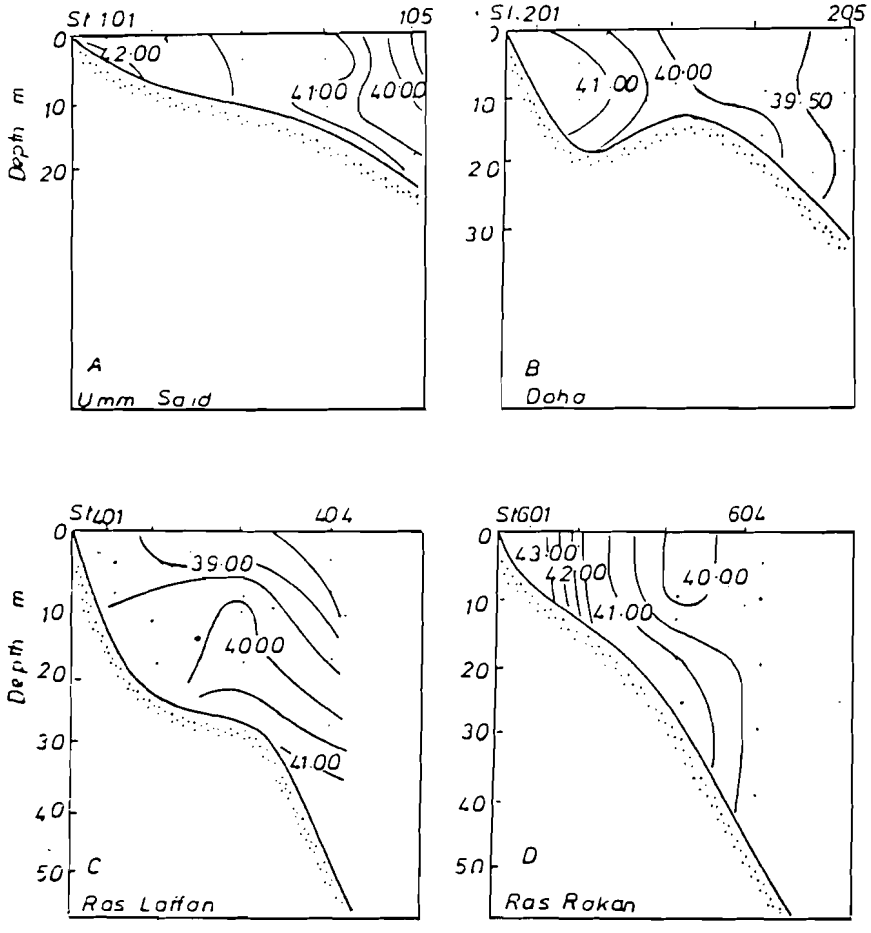


**Fig. (13)**
**Vertical distribution of salinity in July, 1984.**
**( in the four sections )**

In Umm Said and Doha sections salinity changes from 42.00 and 41.00 ‰ respectively to less than 39.50 ‰ in the offshore directions. The same trend is also clear in Ras Rakan to the north, where salinity changes from 43.00 ‰ in the inshore to less than 40.00 ‰ in the offshore waters. In Ras Laffan section the increase in salinity vertically with depth is clear where it increases from 38.50 ‰ on the surface to more than 41.00 ‰ at 40 meter depth. The coastal shallow water is homogeneous in sigma T in all the sections except in Ras Laffan one, where weak density stratification is clear (Fig. 14A to Fig. 14D). Generally sigma T decreases from the inshore water (26.00 - 27.00) to less than 25.00 in the offshore waters. Vertically sigma T changes from 25.50 on the surface to more than 27.50 at 50 meter depth.

**Temperature Salinity Relationship**

Using all the available temperature, salinity and sigma T data, a T-S diagram was plotted. Fig. 15 shows the difference in the characteristics of the water masses between winter and summer. The homogeneity of the water in the winter is obviously clear. This is mainly due to the low temperature (18.5 20.5 C) and the relatively higher salinity (40.0 - 42.5 ‰) and hence higher sigma T (28.50 - 31.00). While in summer the water shows higher temperature (28.00 - 32.00°C) and wider range of salinity (38.50 - 43.00 ‰) and sigma T ranges between 24.00 and 28.00.

**Currents**

From the figures (16A to 16C) it is clear that the tidal movement affects the current speed and direction. At Umm Said section (st.102) the current vectors show relatively higher speed where it reached more than 60.0 cm/sec. It was also found that the current speed generally decreases with depth, and decreases also as one goes north. The inshore and the offshore salinity distributions are mainly influenced by the current speed and direction, the low tide correlates well with high salinity, while at high tide low salinity is observed with little time lag (Fig. 16).

## CONCLUSION

In winter the water temperature changes horizontally from 18.6 C to 20.30 C. Temperature increases in the southward direction, as well as in the offshore direction. Vertically water temperature changes very little due to winter convection. The low air temperature (15°C) and the high wind speed (7-11 knots with maximum 53 K) in winter reinforce the mixing process. The changes in temperature are limited between about 20.30°C at the surface and 20.10°C at 40 meter depth (st. 404). During summer the maximum water temperature occurs. The surface water temperature ranges between 29.0 C in the north and 32.0°C in the south. Vertically the water temperature shows a weak stratification.

During winter the vertical homogenous salinity confirm the mixing winter conditions, while in summer the surface salinity changes from 38.50 to

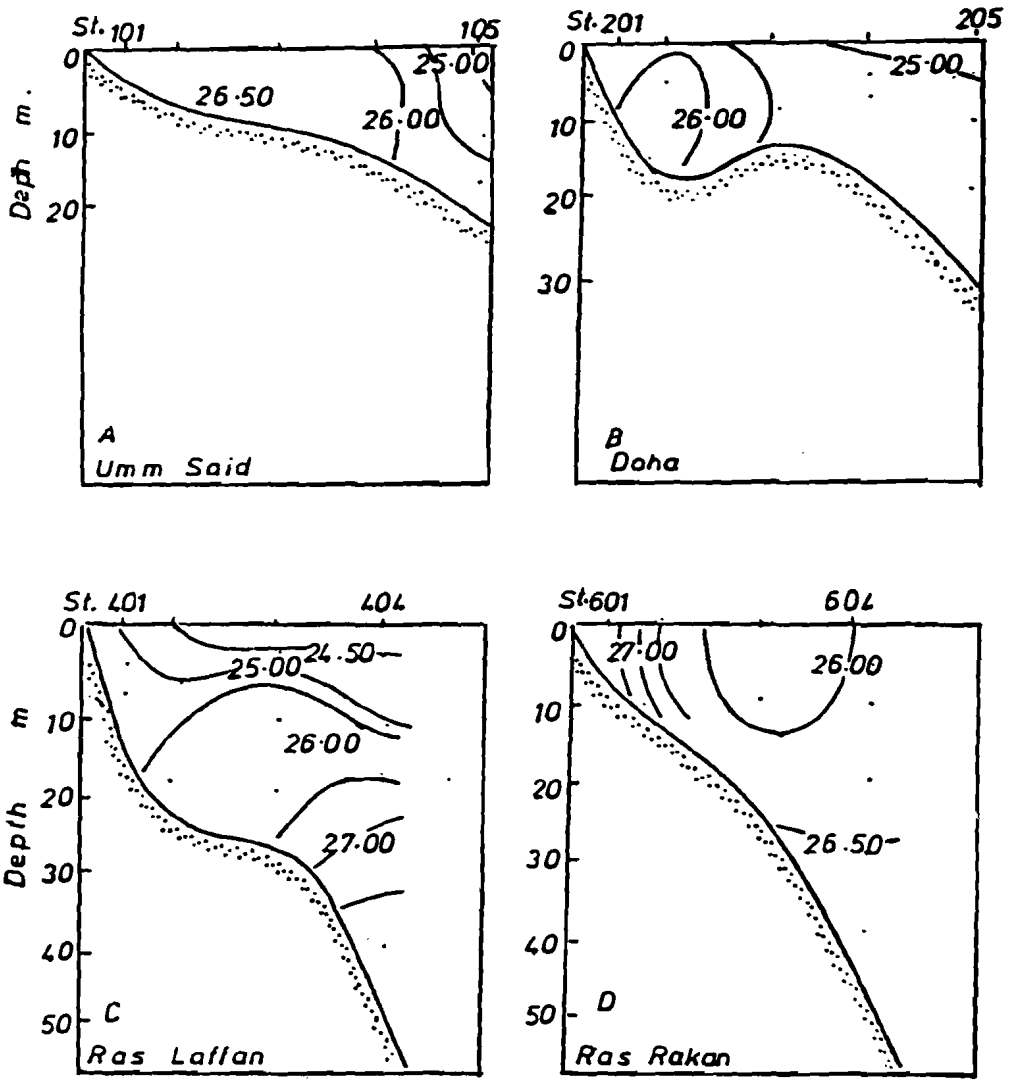


Fig. (14)
Vertical distribution of sigma T in July, 1984.
( in the four sections )

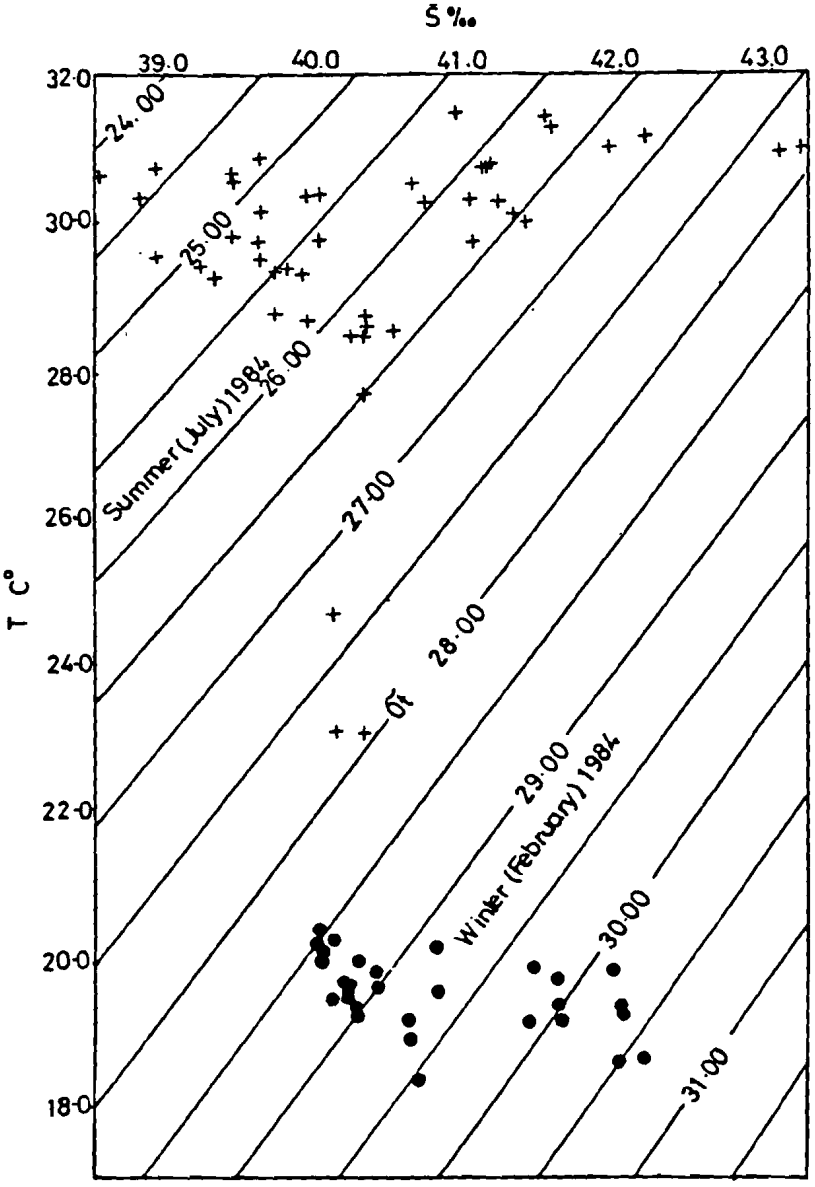


Fig. (15)
Temperature / salinity relationship.

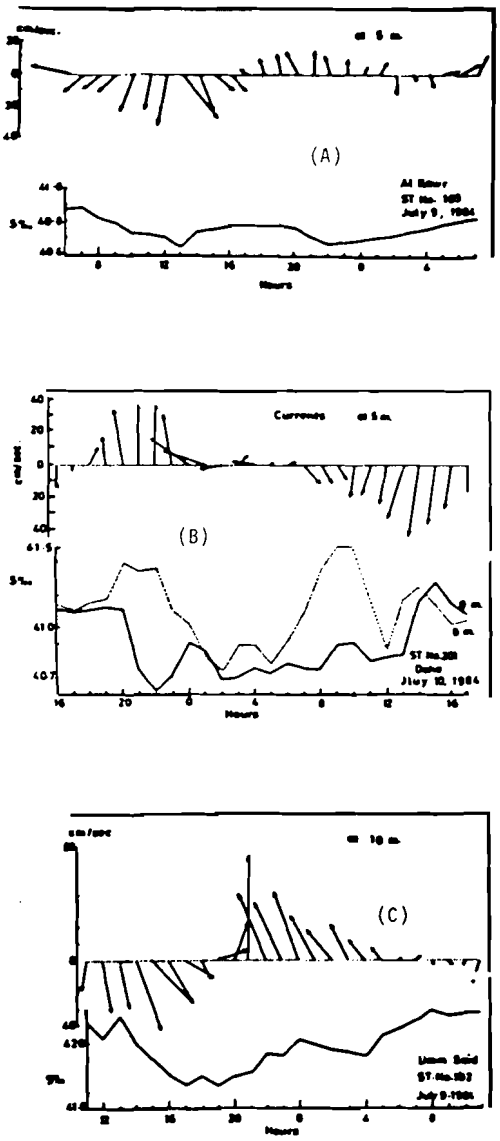


Fig. (16)
Vector representation of the currents observed
at different areas.

43.00‰. Generally salinity decreases in the offshore direction and somewhat vertically.

The highest values of sigma T (28.00 at the surface & 30.60 near the bottom) occur in winter as a result of the temperature decrease. Vertical sigma T gradient is very small due to the homohaline homothermal conditions. During summer sigma T shows the lowest values especially on the surface, where it varies from 24.00 to 27.00. The vertical sigma T shows a weak stratification where it changes during July between 25.00 at the surface to about 27.00 at 50 meter depth. A clear difference is observed in the character of the water masses between winter and summer. In winter the water is of low temperature high density and reflects vertical homogeneity. In summer the high temperature, lower density give the water different characteristics than the homogeneous winter one.

The current speed and direction in the area is affected mainly by the tidal movement in the Gulf, where the current changes mainly in a north south dirction parallel to the tidal amplitude in the Gulf. The current speed changes from 3 cm/sec to 65 cm/sec. Salinity changes in the area correlates with current speed and direction.

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