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HYDROGRAPHY OF THE WESTERN PART OF THE ARABIAN GULF

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ABSTRACT

The hydrographic conditions in the western part of the Gulf, from Kuwait to UAE, were studied. Water temperature, salinity, sigma T and water masses were determined for two cruises. The first cruise was carried out from 25° N to 30° N and from 48° 30' E to 52° E during November 1984; the second one was nearly along 25° N and from 52° E to 55° E in September 1985. The results showed that the the inshore shallow water of the Gulf was vertically almost homogenous in winter (November). A weak stratification appeared in early autumn (September). The winter vertical convection is clearer in the inshore than the offshore waters. Water masses in the Gulf show different characteristics in the different seasons.

INTRODUCTION

Little work has been published on the Gulf after the report of R / V "Meteor" cruise 1965 (Grasshoff 1975). During that cruise the hydrographical conditions of the eastern part of the Gulf waters were studied. The present work aims to study the hydrography of the western part of the Gulf, during the winter and the autumn of 1984 & 1985. The study covered the area from 25° N to 30° N and from 48° 30' E to 52 °E during November 1984, and along 25° N and from 52° E to 55° E in September 1985. The present investigation may shed some additional light on the presently available informations in the Gulf area. The area of investigation covers a large part of the western half of the Gulf. It includes the regional waters of Kuwait, Saudi Arabia, Qatar and United Arab Emirates. Station depths in the area range between 8 and 70 meters with the bottom gently sloping towords the east.

METHODS

The area of investigation was surveyed along two longitudinal hydrographical sections using the R / V Mukhtabar Albihar of the University of Qatar. The first section extends from Doha to Kuwait along which 11 hydrographic stations were occupied. The second section was from Doha to Sharjah and covers 26 hydrogrphic stations (Fig. 1). Water samples for salinity determinations were collected using the reversing Nansen bottles, water temperatures were measured using the reversing protected thermometers at the standard depths **(depth permitting)** Salinity was determined by inductive salinometer. Due to the abnormal high temperature and high salinity, sigma T was computed using an inhouse programme in the Qatar University Computer Center. The water volume estimation of the different areas and hence of the Gulf was based on the mean depths – picked from the **Admiralty** chart – and the areas of one degree square grided into nine squares.

RESULTS

Vertical and Horizontal Distributions of Temperature, Salinity and Sigma T in Winter 1984 (Fig. 2)

Fig. 2a shows the vertical distribution of water temperature along section A – B (extending from Doha to Kuwait) during November 1984 (Fig. 1). Generally the water temperature in the upper 30 meters was vertically homogeneous due to the weak winter convection. A thermocline layer appeared between 30 and 50 meters mainly in the relatively deeper stations. Along this section water temperature ranged between 22.5 C in its northern part to 26.5 C in the southern part. The homogeneous vertical distribution of salinity (Fig. 2b) confirms the vertical mixing conditions of the waters. The salinity of the northern coastal waters was higher than that of the other offshore waters. Salinity ranged from 41.60 ‰ in the northern area to 40.40 ‰ in the central offshore waters of the Gulf. The homogeneous vertical distribution of sigma T (Fig. 2c) indicated that the upper meters of the water column were well mixed.

In September the vertical distributions of the temperature and salinity along the Doha – Sharjah section, section C – D, (Fig. 3a and 3b) indicated that the water column was homogeneous (Fig. 3c). The conditions were similar to those in section A – B except for the absence of the thermocline layer which may be attributed to the shallowness of the area. The water temperature ranged between 32.5 °C and 35.5 °C.

The vertical salinity distribution (fig 3b) also reflected homogenous conditions. Salinity varied from 39.5 ‰ at the southern part of the section, due to the inflow of low salinity water form the Gulf of Oman through the Srait of Hormuz, to 40.5 ‰ in the northern part of the section.

The horizontal distribution of the surface water temperature measured during the two cruises of R / V Mukhtabar Albihar in 1984 & 1985, in the wstern part of the Gulf (denoted by A & B respectively) together with that of the cruise carried out by R / V Meteor in 1965 in the eastern part of the Gulf (denoted by C) are shown in Fig. 4a. Due to the geographic position the surface water temperature decreases generally toward the north. During November 1984 temperature decreased from 26.0 °C north of Qatar to 22.5 °C near Kuwait. The same trend is also observed during march 1965 along the eastern coast, where temperature decreased from 25.0 °C near the Strait of Hormoz to 19.0 °C to the most northern part of the Gulf. During September 1985 the water temperature, in the south western part of the Gulf, shows no significant differnces : between 33.0 °C and 34.0 °C.

Fig. 4b shows the horizontal salinity distribution of the above mentioned cruises. High salinity values (42.5 ‰) exsisted near the embayment area between Qatar and UAE due to its shallowness, slow water movement and high rate of evaporation. Salinity increased in the northward and westward directions from 39.5 ‰ near the eastern part of UAE coast to 41.5 ‰ near Kuwait.

This increase is consistant with the work done by R / V "Meteor" March in 1965 in the eastern part of the Gulf where salinity increased from 37.0 ‰ near Hormoz Strait to 40.5 ‰ in the most northern part of the Gulf. Salinity distribution reflects well the known counter clockwise water circulation in the Gulf (Pickett *et al* 1984).

Temperature Salinity Relationship and Water Masses

Fig. 5 shows the different water masses of the Qatari waters during the winter season (February 1984 represented by filled circles) and during the summer season (July 1984 represented by crosses) (Hassan *et al,* 1984), together with water masses of both section AB (November 1984 represented by open circles) and section CD (September 1985 represeted by x signs). The Qatari waters are homogenous in winter, where the the water masses extend within a narrow range of density (sigma T 28.50 to 30.50). In the summer season the water masses of the Qatari waters cover a wider ragne of density (sigma T 24.00 to 28.00). The water masses across section CD (Sept. 1985), except for the lower density due to the higher temperature, show similarity in density variation to that of Qatari waters in summer. The homogeneous character is clear in the water masses in section AB (Nov. 1984) where density variations are limited to sigma T between 27.00 and 28.00. Fig. 6a shows a schematic representation of the water temperature with the corresponding water volume in km^3 for the three different areas. The temperature variation in both the Iranian and the Kuwaiti – Saudi waters is clear which may reflect either the effect of the geographic position or the character of the moving water bodies. That is not observed in the Emirates waters. Fig. 6b shows the relationship between salinity variation and the corresponding water volume in km^3. As can be seen the Iranian waters show a wider range of salinity 37.00 – 40.50 ‰ where the typical Gulf water (salinity 40.50 – 41.50 ‰) appears along the Kuwait Saudi coast and there, no effect was observed in the Gulf of Oman waters. Along the Emirates Coast, traces of lower salinity waters (39.00 – 39.50 ‰) appear indicating the intrusion of some water masses from the adjacent Iranian side.

Fig. 7 shows a representation of the percentage of the volume of the water of different salinity and temperature – extending along the line of the corresponding sigma T – to the total water volume of the three mentioned areas (the estimated total Gulf water was 7151 km^3). The difference in characteristcs is very clear indicating the presence of different water types in every water mass; the figure shows that at the Iranian side water masses show mainly three water types. The first one is of temperature 23.0°C, salinity 37 ‰ and sigma T 25.00 representing the highest percentage of the water volume, 17 ‰(712 km^3 to 4237 km^3) in the area.

The second water type is of temperature 21.5 C, salinity 38.5 ‰and sigma T 27 occupynig 11 ‰of the water volume in the area. The third water type, with a volume of 11 %, also shows a water temperatrure of 19 C, salinity of 40.5 ‰ and sigma T 27.00.

In the case of the water masses along Kuwait Saudi coast three water types are also clear. The first one is of temperature 26.5°C, salinity 40.50 ‰and 27.00 sigma T representing highest percentage (29 %) to the total water volume (457 km^3 out of 1600 km^3). The second water type – 18 % by volume of the area – of temperature 25.0, salinity 41.0 ‰ and sigma T 28.00. The third water type (6 %) of temperature 23.0 C salinity 41.5 ‰ and sigma T 29.00. Along the coast of the

Emirates mainly two water types are clear. the first one represents the highest percentage (28 %) of the water volum in the area (357 km^3 out of 1314 km^3) with temperature 34.0 °C, salinity 40.0 ‰ and sigma T 24.00. The second water type (6 % by volume) is of temperature 33.5 °C, salinity 42.5 ‰ and sigma T 26.00.

CONCLUSION

The hydrographic conditions of the western part of the Gulf have been presented in some detail. The results have confirmed that the vertical distribution of water temperature, salinity and sigma T are homogenous in winter particularly in the inshore water. The analysis has also shown that salinity increases from south to north, which is in consistant with the work done, along the eastern part of the Gulf, by Grasshoff 1976. The isohalines distribution follows closely the outflow of the Gulf water to the Gulf of Oman. The waters in the Gulf show the different water masses of different water types dependig upon the geographical position in addition to the seasonal variations. We recommend in future the sampling network to be more adequate in order to cover larger area of the Gulf to obtain more sufficient data.

ACKNOWLEDGEMENT

The authors wish to express their hearty thanks to Prof. E. M. Hassan, head of the Marine Sciences Department, Qatar University, for his helpful encouragement and valuable suggesions and for his supervision and reading of the manuscript.

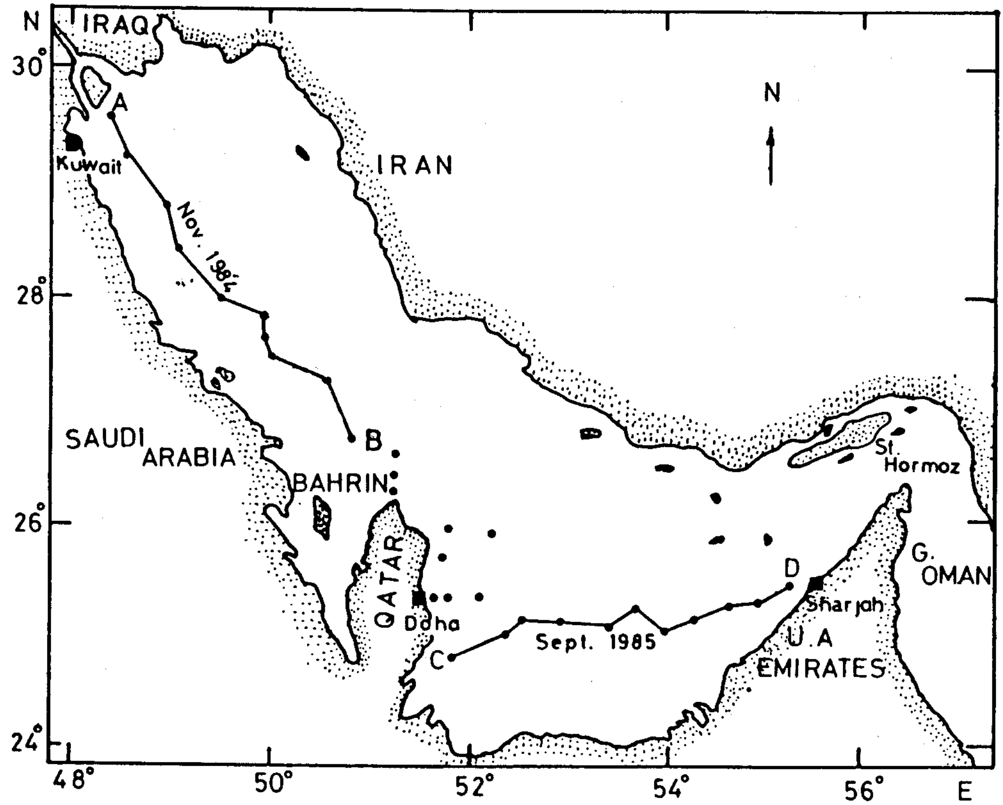


Fig. 1 Area of investigation

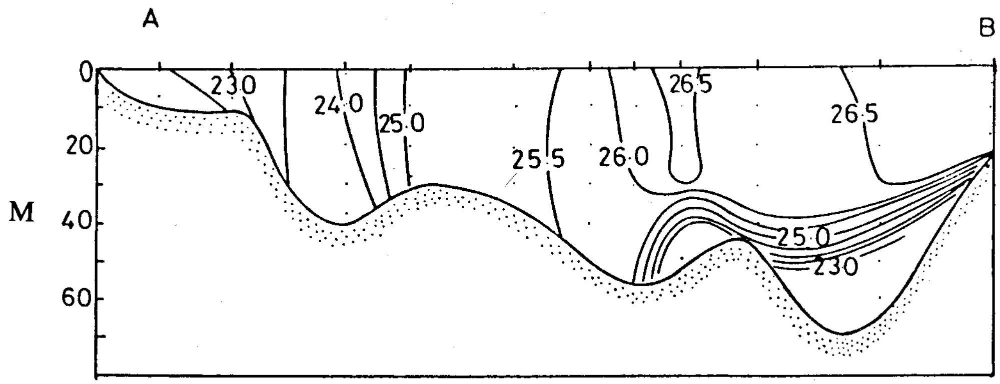


Fig. 2a Vertical distribution of water temperature

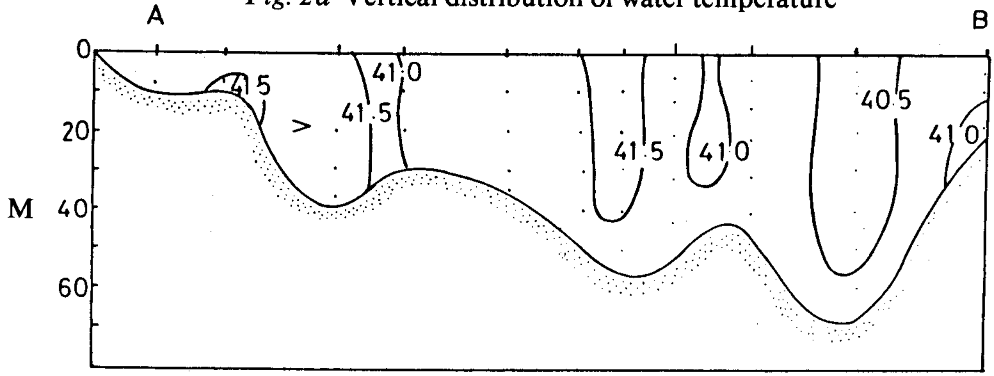


Fig. 2b Vertical distribution of salinity

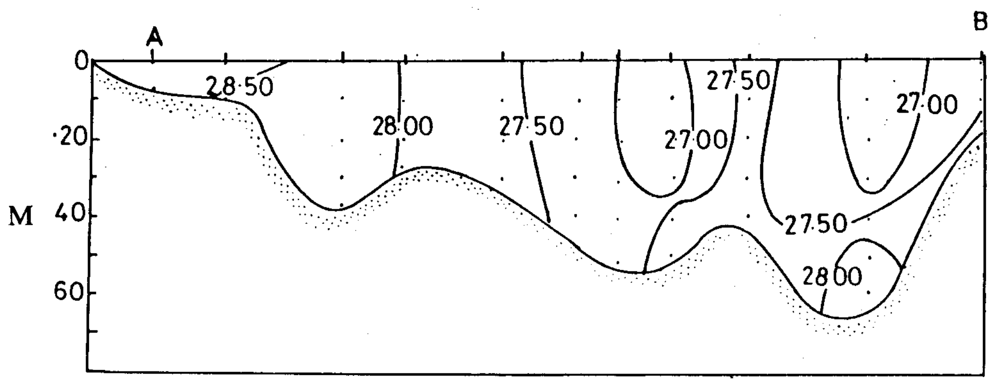


Fig. 2c Vertical distribution of sigma T

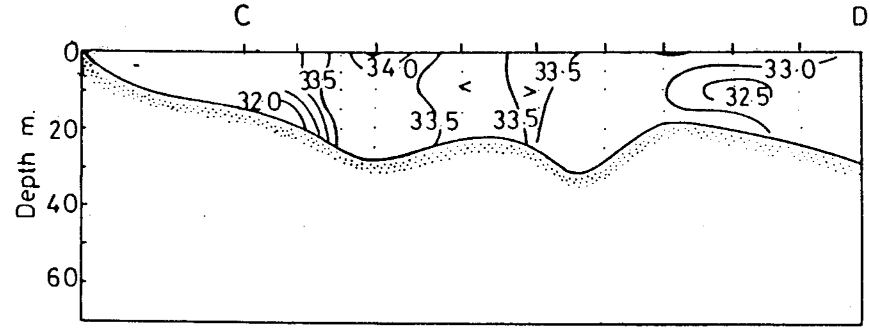


Fig. 3a Vertical distribution of water temperature

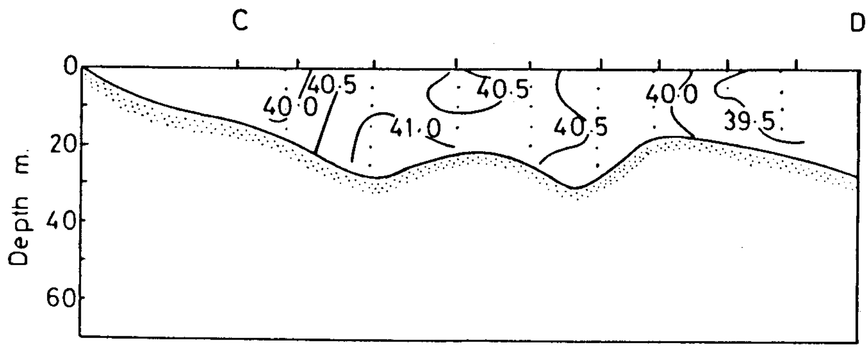


Fig. 3b Vertical distribution of salinity

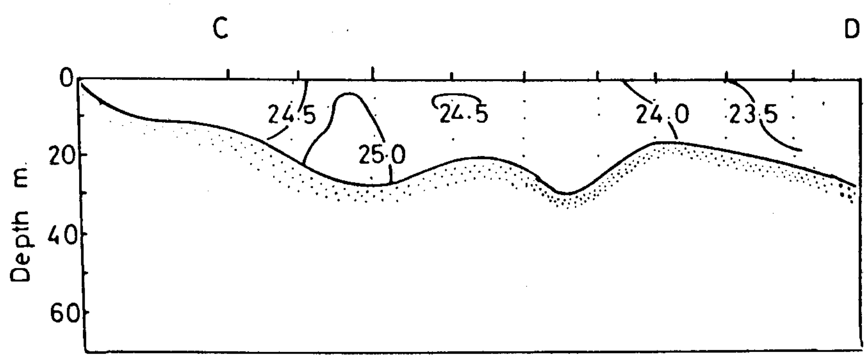


Fig. 3c Vertical distribution of sigma T

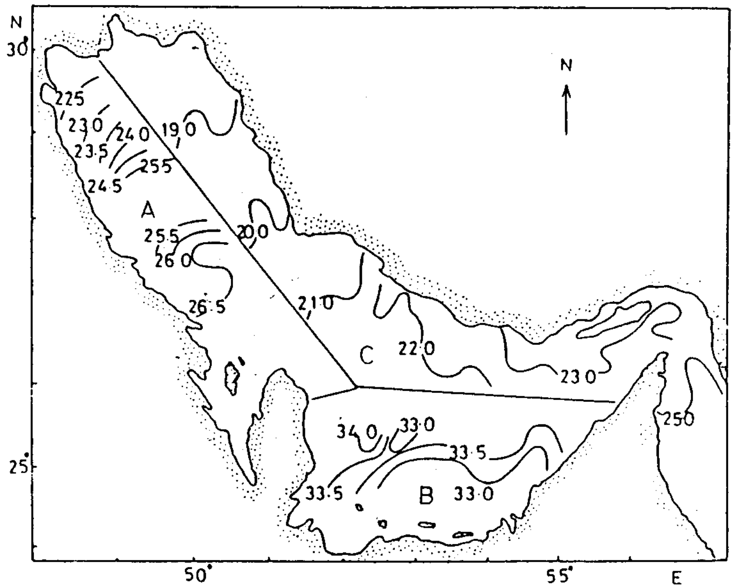


Fig. 4a Horizontal distribution of surface water temperature

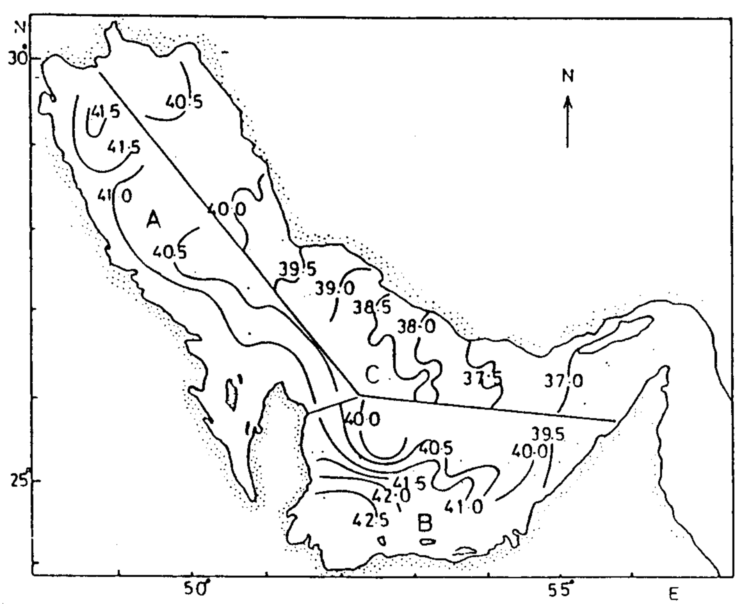
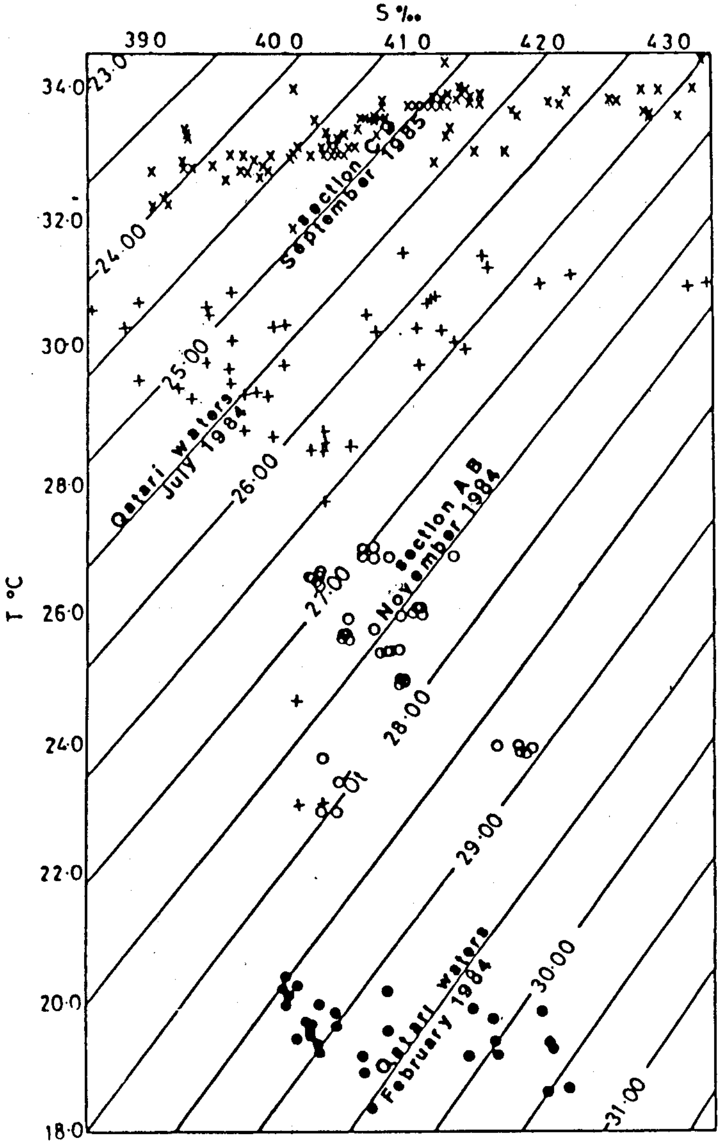


Fig. 4b Horizontal distribution of salinity



● February	1984	Qatari waters
+ July	1984	Qatari waters
○ November	1984	NW part of the Gulf
× September	1985	SW part of the Gulf

Fig. 5 Water masses

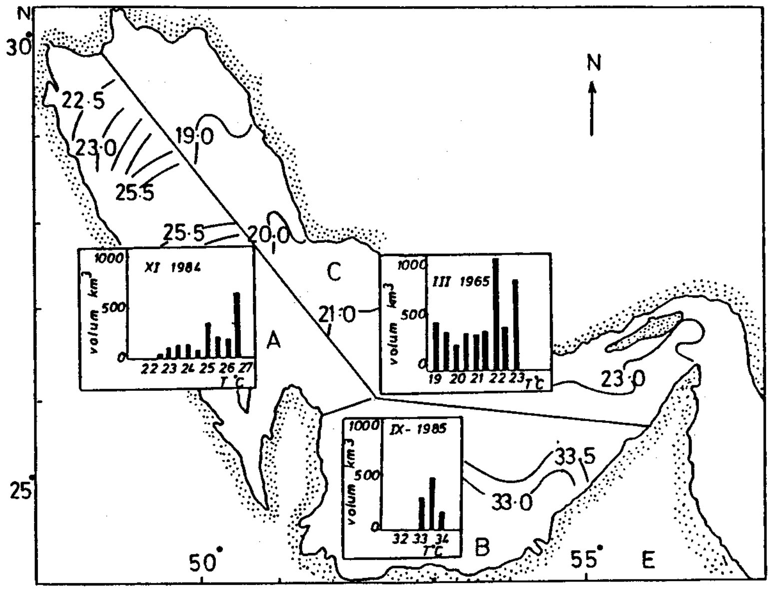


Fig. 6a Water temperature volume relationship

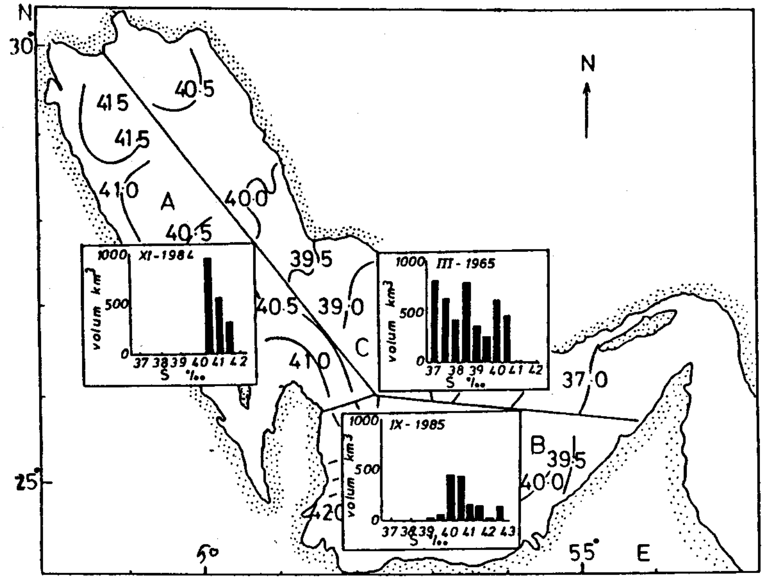


Fig. 6b Salinity volume relationship

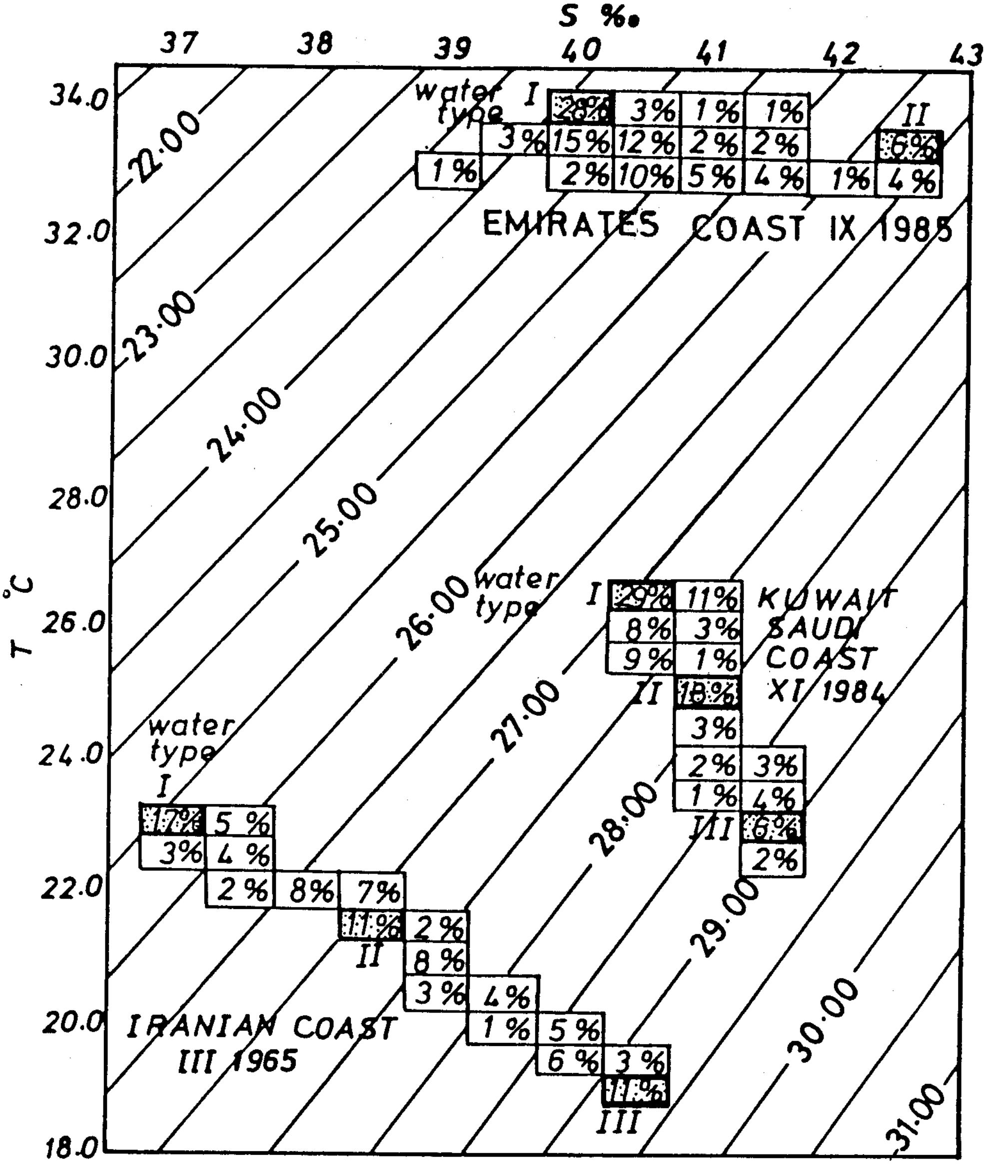


Fig. 7 Percentage of the volume of different water masses.

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هيدروجرافية الجزء الغربي من الخليج العربي

حسن مصطفى حسن و محمود آدم محمود

شمل هذا البحث بالتفصيل الظروف الهيدروجرافية للجزء الغربي من الخليج العربي ، نوقشت نتائج رحلتين هيدروجرافيتين من رحلات سفينة البحوث مختبر البحار التابعة لجامعة قطر ، الأولى في نوفمبر ١٩٨٤ شملت مياه كلٍ من دولة قطر والمملكة السعودية ومياه الكويت ، والثانية في سبتمبر ١٩٨٥ وشملت المياه القطرية ومياه دولة الإمارات العربية المتحدة ، شملت الدراسة توزيعات درجات الحرارة والملوحة والكثافة كما تم تحديد الكتل المائية المختلفة واستنتاج سريان المياه من الخليج ، تبين النتائج أن المياه الضحلة القريبة من الشاطئ متجانسة كليةً في فصل الشتاء ، وأنه في فصل الخريف تظهر طبقية ضعيفة لعمود المياه يتبين أيضاً من الدراسة أن المزج الرأسي للمياه يتم بوضوح في المناطق الساحلية عنه في المناطق البعيدة عن الساحل ، كما تختلف الكتل المائية باختلاف الموقع الجغرافي وباختلاف المواسم .