THE HYDROLOGICAL CHARACTERISTICS OF THE WATERS EXCHANGED BETWEEN THE EASTERN AND THE WESTERN BASINS OF THE MEDITERRANEAN

by

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ABSTRACT

An analysis is done of hydrographic data obtained in 1965 and 1966 in the region of Tunis-Sicily-Malta. Vertical sections permit to follow the opposite spreadings of the surface water of Atlantic origin and the levantine intermediate water; the evolution of the characteristics are studied on T/S diagrams. The Atlantic water with low salinity is strongly influenced by evaporation, especially in the vicinity of the 15th East meridian. The levantine water, characterized by the maximum of salinity, goes over the Malta sill, the deep Ionian water however does not. Between this eastern sill and the western sills, opening on the western Mediterranean, there is an intermediate basin filled right to the bottom (1600m) by this levantine water. On the deeper western sill, the characteristics of this outgoing flow are around: S ‰ = 38.74 - 38.75 and T°_{p} = 14.00 - 14.10°C. These values are modified by sinking and mixing processes after the flow has passed the sill.

The levantine water filling the intermediate basin is supposed to be renewed rapidly because of a low vertical stability combined with an important undercurrent over the Sicilian Strait. An attempt to establish the water budget of the eastern Mediterranean permits to estimate the order of magnitude of the opposite flows (Atlantic and levantine). These estimates emphasize the close similarity between the Strait of Sicily and the Strait of Gibraltar.

INTRODUCTION

Some preliminary remarks on the Bathymetry of the Strait of Sicily*

The most significant fact revealed by an analysis of Frassetto's bathymetric chart of the Strait of Sicily is the existence of a long-shaped basin, with a SE-NW orientation, cutting deep into the Sicilian-Tunisian shelf, (R. Frassetto, 1964).

Consequently the water exchanged between the Eastern and Western Basins does not pass, as in the Strait of Gibraltar, over a single sill but takes place in the so-called Intermediate Basin, that is over at least two sills (or systems of sills), an eastern one and a western one.

All the main features of the rugged bottom of the Intermediate Basin have a SE/NW orientation. The average depth is greater than 400/500m. Steep troughs, with a perfectly flat bottom, and filled with sediments (see sections), cut into the bottom of the basin down to depths considerably greater than its average depth. For instance: 1100 to 1200 m off Pantelleria (stations 6606-6632 and 6627); 1300 m off Linosa (station 6622) and about 1650 m in the central part of the basin (station 6614).

Water exchanges between the Eastern and Western Basins are confined to depths not greater than 558 m (Frassetto) and take place on the Eastern Sill, almost exactly along the 15° E meridian, in the shallows between the area South of Malta and the Medina Bank. All the area between Malta and Sicily is shallow and it is highly probable that there are no passages of significant depth, that is deeper than 400 m, further to the south, between the Medina Bank and the Libyan coast.

*In this text, the "Strait of Sicily" should be taken in the broadest meaning to include all the area between the meridian of Malta (or rather that of Medina Bank) and a line joining Cape Bon to the Aegates Islands (Marittimo). There is a general consensus to give the name of "Sicilian Channel" (or "Pantelleria Channel") to a more restricted area.

Only one of the two western sills, by which the Intermediate Basin and the Western Basin communicate, used to be known; it is located at 11°35'E - 37°30'N and has a depth of approximately 350 m. However, the major part of the water exchange probably happens in a second passage, which Frassetto was the first to mention, it is a narrow and deep trough, 430 m deep at the sill, and with an approximately north-south orientation along the 11°35'W meridian, a few nautical miles east off Talbot Bank.

1. LOCATION OF THE STATIONS

The results of the hydrological measurements in the zone, in 1965 and above all in 1966, have already been published (Equipe du Laboratoire d'Océanographie physique de la Faculté des Sciences de Paris, 1969) with indications of the way the measurements were made and of the techniques and instrumentation used. We wish however to make a few additonal remarks.

Figure 1 shows the positions of the stations on a map, which is a reproduction of part of Frassetto's bathymetric chart. Only the 100,200 and 300 fathom contours have been reproduced. However, incomplete section of the Straits while keeping south of the shallows of Adventure Bank. After completion of the bathymetric survey it became clear that the location and orientation of this section had not been the best choice it was nevertheless repeated to obtain confirmation and also to study the possible variations in another season of the year. The locations of the remaining stations were selected in such a way as to cover the whole Intermediate Basin, from the Eastern Sill (Station 6616) to the outer approaches to the Western Sill (Station 6637, later repeated as Station 6643); two lines of stations were made, (6635-6639 and 6640-6642), one on each side of the "active" sill while Station 6636 was above the shallower sill, which anyhow had already been recognized before. The surveys along the sections were performed in two phases: first without stopping, so as to minimize the uncertainty about the path really followed and in order to achieve a continuous survey of the bottom, during the second phase stations were made at locations suggested by a study of the (first) survey. On the other hand no stations were taken above the sill itself, because this would have required too much preliminary research work as well as, considering the navigational instrumentation available, a too precise positioning of the ship.

2. HYDROLOGICAL CHARACTERISTICS OF THE WATER MASSES IN THE STRAIT OF SICILY – THEIR VARIABILITY

The main trends of the water circulation in this area are well known, (see, e.g. H. Lacombe and P. Tchernia, 1960; or G. Wüst, 1961). They include the following features: absence of exchange between the deeper waters due to the shallowness of the sills, hydrological separation of the deeper parts of the Western Basin from those of the Eastern Basin, restriction of water circulation to opposite flows involving only the surface and the intermediate layers. The Levantine Water, with high salinity and temperature, originate, on the surface near Rhodes during winter, it then spreads downwards to the intermediate layers of the Eastern Basin and, passes the Strait of Sicily, to form the intermediate layers of the Western Mediterranean. Inversely, starting from Gibraltar, the flow of low-salinity Atlantic water moves eastwards along the North African coast round Cape Bon, to the Eastern Basin.

We shall now proceed to discuss successively the changes both flows undergo as they pass the Strait of Sicily, and, for the Levantine Water, when it passes the sills.

2.1 THE LEVANTINE WATER

2.1.1 Above the Eastern Sill

Station 6616 is located approximately above the Eastern Sill, between station 6615 to the north and 6617 to the south, (see Fig. 1 and the stations on Fig. 9). Since the Levantine Water follows generally a westward direction, it can be useful to compare the θ – S diagrams (where θ is the symbol for potential temperature) of station 6616 with those of stations located before the sill, such as stations 6620 and MOP 123, 13, 14, 15, (H. Lacombe and P. Tchernia, 1959). Figure 2 shows the diagrams for the stations east of the sill (these are enlarged diagrams in which the areas corresponding to the surface layer have been left out).

All of these curves show a strongly marked maximum salinity which is a typical feature of Levantine Water: the higher the salinity peak the higher the temperature associated with it. The influence of this intermediate water of Levantine origin is most strongly felt at those depths that correspond to potential densities near 29.10. The value of the highest salinity increases from north to south down the line of stations MOP 23, 6520, MOP 13; this maximum exceeds 38.80 at the stations nearest to the sill or that are approximately on the same parallel, MOP 14 and 15. It should be noted that the water with the highest salinity was found between 600 m and 800 m depth, at station 6520 during May, which is much deeper than the 200 - 400 m depths measured at the MOP stations taken in July or September.

Beyond this more or less marked peak, all curves have the same shape in the area that corresponds to the deeper parts of the Eastern Mediterranean. The main features of this area are: a slow and simultaneous decrease in temperature and salinity together with a slight increase in potential density, which attains 29.18 - 29.20 at 2000 m depth, (H. Lacombe and P. Tchernia, 1958).

Figure 3 allows a comparison to be made between the θ - S diagram of MOP 15, (this diagram is identical to that in Fig. 2, MOP 15 was preferred because it is on the same parallel as the sill, 110 n.mi. to the east of it), with the diagrams at station 6616, above the sill, and at the more westward stations beyond the sill (6618, 6619).

A number of effects caused by the crossing of the sill are worth recording:

a. Before the sill, the θ - S diagram is obviously truncated since water with a potential density higher than 29.13 apparently does not cross the sill, leaving out almost completely the area of the diagram where temperature and salinity decrease in parallel. As a result, the water filling the Intermediate Basin* has the same characteristics as Levantine Water, including high salinity.

b. To be more precise we must add that the extreme values of the characteristics were not found in the water passing close to the sill: the highest salinity (above 38.75‰), for instance, was found at a higher level. It should however not be inferred from this remark that it depicts a permanent feature, as could have been the case had the measurements been taken at smaller intervals or had a continuous profile been made**.

Anyhow these slightly less saline and colder waters that cross the sill at sill depth undoubtedly fill all the lower part of the Intermediate Basin. A reflection of this fact can be seen in the sharp "hook" in the θ - S diagrams present in their terminal areas. (See later).

c. Immediately after passing the sill the characteristics of the flow of Levantine Water are slightly changed; owing to mixing with overlaying layers, the extreme values are attenuated and the θ - S diagram becomes smoother. Although the effects of this intrusion are most strongly felt at $\sigma = 29.10$, they can already be detected at $\sigma = 29.00$.

d. Finally, the geostrophic character of this water is clearly indicated by the way in which the flow's core hugs the right edge of the stream (see the section in Fig. 9).

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*In our opinion "intermediate" is not suitable here, since in this basin the water is also bottom water. On the other hand "Levantine Water" is unequivocal.

**For identical reasons one cannot be absolutely sure that there is no water at all with a salinity above 38.75‰ at station 6615.

2.1.2 In the central part

The series of sections, (Fig. 10 to 14), as well as the combined section (Fig. 16a) show that there is a considerable volume of Levantine water in the Intermediate Basin; the 38.74‰ isohaline can be adequately used to delineate it, (although some doubtful third decimal digits cause irregularities in the 38.75 isohaline, such irregularities are probably insignificant as long as only punctual measurements by sampling are made).

The surface of the isohaline presents a slight slope, the isohaline surface being found at greater depth on the eastern side, while for each section it is also at greater depth in the south than in the north (250-300 m against 250-150 m); the effects of the geostrophic features of the flow are in some cases accentuated by the influence of the topography of the sea-bottom (e.g. Adventure Bank).

This large quantity of Levantine water probably accounts for the steady character of the hydrology of this area. After a little "smoothing" above the Eastern Sill, the θ - S diagrams practically do not undergo any further changes during the water exchange (Figs. 5 and 6).

Furthermore, it is noteworthy that these hydrological features do not depict a single type of water but a water mass, the presence of which is represented by the hook in the end section of each diagram; the highest salinity (38.76, and even 38.78) is generally associated with a potential temperature of 14.20° to 14.40°C. With depth, both salinity and temperature decrease slowly but steadily: for 20 measurements of samples at 500 m depth or deeper, the mean salinity is 38.748‰, the corresponding potential temperatures range from 14.03°C to 13.85°C (with a mean value of 29.114 and a standard deviation of 0.013).

Although this is not a typical water, the variability within the water mass is insignificant both in potential temperature and salinity. The resulting stability of the layers is nevertheless rather precarious.

A comparison of the θ - S diagram (Fig. 4) at the stations made in May and July 1965 along this same section calls for the following remarks:

a. The difference regarding the interface layer between the surface water and the Levantine Water should be pointed out. Owing to the winter cooling of the surface water, which by May is felt down to the base of this layer (with observed temperature minimum of 13.95° to 20.15°), a relative maximum of 14.8° - 14.9°C appears in the upper layer of the Levantine water so that the depth of maximum salinity is then greater than the depth of maximum temperature, (the order of magnitude of difference is 100 to 150 metres). This can be important when using techniques like those recommended by J. Le Floch and by V. Romanovsky (1966), which are based on this very dissociation of the maxima due to mixing, all these maxima being assumed to have been at the same depth. In summer, the situation changes the relative temperature minimum fades out and, apart from some slight deviations temperature decreases continuously, with only salinity showing a maximum.

b. On the other hand no systematic difference appeared when measurements were made more than a year later. This stability of the characteristics of Levantine water is clearly shown in the enlarged (Fig. 5).

2.1.3. On the Western Sill

Figure 6 displays the θ - S diagrams of stations located on either side of the deepest sill. The scarcity of the measurements and the lack of continuity of the surveys on which the curves are based do not allow definitive conclusions to be drawn; however, it is probably safe to state that water in the Intermediate Basin with a potential density above 29.10 does not cross the sill (if so, it would be denser than the deep waters of the Western Basin - Lacombe H., Tchernia P., 1958).

The curves can be subdivided into two well defined groups with some overlapping (see inset of Fig. 6) due to the water that crosses close to the sill, at levels which correspond to 29.08 - 29.10 potential density. This water that was intermediate water when it entered the Strait of Sicily, is characterized by 14.00° - 14.10°C potential temperature and 38.73 - 38.75‰ salinity.

The hydrologic features of the bottom layers have not changed, but the typical hook of Levantine waters has faded out. The logical explanation for the disappearance of the warmest and most saline waters, is that they very likely partake in an active mixing process with the water from higher layers. This mixing is very likely since it is made easier by the abrupt fall when the sill is passed. Most significant in this is the increase of the thickness of the transition layer with increasing depth of the intermediate water layer, the difference in depth between the 38.50 and 38.74 isohalines is less than 80 m before the sill, (120 and 200 m respectively), it is greater than 250 m after the sill (450 and 250 m respectively), (see the sections taken before and after the sill and the combined section, Figs. 14, 15, 16a). Let us observe here that, at station 6616, that is above what used to be considered the only sill, the θ - S diagram puts this station in the same category as those beyond the sill; this is yet another indication that only the deeper sill that Frassetto discovered directly affects the water exchange.

The absence, west of the sill, of water with a potential density higher than 29.10, as well as the alteration the curves undergo when the sill is passed, was entirely confirmed by the measurements made in the same area during the Hydromède II crùise, in February-March 1968*.

*This cruise was directed by the Laboratoire d'Océanographie Physique du Muséum d'Histoire Naturelle ; we wish to express our acknowledgements especially to Prof. H. Lacombe and Prof. P. Tchernia for kindly allowing us to use their unpublished data both for this illustration and in the conclusions to this paper.

The similarity of the diagrams is striking indeed. Almost no changes in temperature and salinity were observed for different seasons and after a time lapse of more than one an a half years. This stability points to a source of intermediate western water with stable characteristics. This is shown on the diagrams in Fig. 8, based on the stations taken, west of the sill, by the ORIGNY, (i.e. curves without a hook), during September-October 1963, (M. Henrotte-Dubois, 1969).

As the characteristics of the Levantine water are such that they confer to the Intermediate water of the Western Mediterranean, which it forms, a potential density scarcely lower than that of the deeper layers of the basin, it is striking to note that the Intermediate water will keep its specific features over considerable distances, where, from a theoretical point of view, one might expect mixing to be quite easy.

3. THE ATLANTIC WATER

As the general trend shows, part of this surface water turns round Cape Bon and passes through the Strait of Sicily; the geostrophic character of the flow is strongly marked at least in the channel of Pantelleria. The flow is thicker and less saline on its Tunisian than on its Sicilian side. In both sections (Fig. 13a and 13b), and after a fifteen months interval, the slope of the isohalines is well marked; on the other hand the depth and slope gradient of the corresponding isohalines differ. Between Tunisia and Pantelleria, isohaline 37.50‰, which was found at 150 m depth in May 1965, was observed below 100 m during July 1966. But the isohalines coincide at the surface, above Adventure Bank, and almost exactly at the same place, (Stations 6516 and 6610).

At first sight the current appeared to be stronger and there seemed to be a larger mass of water transported in May 1965 than in July 1966. A possible evidence of this was the existence, northeast of Pantelleria, of water with a salinity lower than 37.10‰, which had not been observed in July. As far as water transport is concerned, the intensity of evaporation tends to render this indication less convincing than the slope of the isohalines.

On the Sicilian side of the flow, salinity is always higher than 37.40‰. The 37.50‰ isohaline is formed at about 50 m depth; however it does come closer to the surface* in the vicinity of the shallows of Adventure Bank (above Terrible Bank, to be more precise, at stations 6515, 6517 and 6610, 6611).

The θ - S diagrams for these two sections (Fig. 4) show that the curves formed in 1965, two well defined sets; those belonging to the stations south of the Adventure Bank (6510-6514), and the other ones. This indicates that the flow of Atlantic Water is well delineated to the North; this limit was more diffuse during the observations made in July 1966; on the other hand owing to evaporation, the lowest salinity was now found lower than the surface layers (approximately at 50 m depth, on either side of Pantelleria island.

The successive sections, as well as the combined section, clearly show how the minimum below-the-surface salinity decreases as one travels eastwards. The Atlantic water actually hugs the right edge of the stream in the first section, while in the next section it spreads out with a structure that becomes rather confused owing to patches of higher salinity, (or rather less low salinity), appearing in the middle of the section (stations 6626,6623, Fig. 11 and 10).

Beyond the 14°E meridian, salinity increases rapidly. Whereas at station 6620, water with less than 37.50 salinity still forms a layer 10 metres thick, 30 n.mi. further to the east (at station 6619) salinity is never less than 37.80 (except at 50 m depth, where salinity is 37.60‰); similar conditions were observed at stations 6616, 1617 and 1618.

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* This very localised feature is probably strengthened by drift currents; horizontal stratification of salinity was observed on 21 May 1965 while waters less saline than 37.40‰ were found at the surface (see insert); four days later, after a violent gale from the northeast the diverging structure caused waters of considerably higher salinity to appear at the surface.

In the eastern part, to the contrary, low salinities are found only at the most northerly station (6615). The stations were too far apart to allow any firm explanation, but it seems clear that the Atlantic flow branches off in two arms, as the presence in the centre of the north-south sections of water with relatively higher salinity (Fig. 10 and 11), seems to indicate; one arm flows southwards off station 6610, the other one seems to move further to the east, past the southern coast of Malta. This would explain the existence of salinities less than 38.50 ‰ at station 6615. The evidence of a discontinuity between stations 6620 and 6619 is more positive. It is hardly conceivable that, over such a short distance, evaporation could account for the discontinuity. Therefore a more satisfactory explanation would be to assume that the surface water observed at stations 6616, 6617, 6618, 6619 is transformed Atlantic water flowing back from the south where, due to heavy evaporation, its salinity has been driven up by 0.3 to 0.4‰.

The topography of the 28.0 isohaline-surface pleads in favour of a southward deviation of the surface water that overlays it. The 28.0 density was chosen because it is associated with salinities close to 37.5‰ - 37.6‰, which is an acceptable lower limit of the Atlantic water. The contours of this surface first follow a direction dilineated by the middle-line of the channel, and by the shallows of Adventure Bank (i.e. the lowest part of station 6630), turn sharply in a north-south direction east of Linosa.

CONCLUSIONS

As already shown, the Intermediate Basin, from 200 - 300 m downwards, is completely filled with Levantine water which constitutes a sort of reserve of this type of water. Using Frassetto's bathymetric chart, its volume can be assessed by planimetry; the estimated value is 15.2×10^3 km^3 for water below 200 fathoms (365 metres) and 28.2×10^3 km^3 for water below 100 fathoms (183 metres); the figure for water with a salinity of at least 38.74‰ would be somewhere between those two values, probably closer to the latter.

Attempts have been made to determine the rate at which this Levantine water is renewed, assuming that the low stability of its stratification, which gives it the features of a typical water, would enable vertical translations thus involving the whole water mass. In order to assess this rate of replacement, more should be known about the flux of Levantine water passing the Strait of Sicily. In other words, one should first make up the hydrological balance of the Eastern Basin of the Mediterranean.

The Eastern Basin is with regard to the Western Basin a concentration basin, exactly as the whole Mediterranean Sea is in relation to the Atlantic Ocean. Off Cape Bon, and above the Western Sill, the salinity of the outgoing Levantine water (38.74‰) is higher by 4.5% than the incoming Atlantic water (averaging 37‰); thus to keep the salt balance the outgoing flux should be inferior to the incoming flux by 4.5%, the difference in volume ΔV is because evaporation is more intense above the less saline water of the Eastern Basin. Data furnished by J. Tixeront (1970) allow us, after making the necessary assumption, to obtain a gross estimation of ΔV. According to this reference, the total amount of river water flowing into the Mediterranean is about $16 \times 10^3 m^3/s$ ($9 \times 10^3 m^3/s$ for the Eastern Basin; by planimetry of the rain chart, the precipitation for the Eastern Basin alone can be estimated at approximately $13 \times 10^3 m^3/s$. Finally, the uncertainty rests mostly in the assessing evaporation for lack of information, the only reasonable way is to assume that evaporation is proportional to the areas*, this would mean 2/3 for the Eastern Basin and 1/3 for the Western Basin. J. Tixeront has estimated the global evaporation for the Mediterranean at $95 \times 10^3 m^3/s$ ($115 \times 10^3 m^3/s$ according to Sverdrup, Johnson, Fleming, in "The Oceans", p. 648). Making the necessary reserves, we shall use $70 \times 10^3 m^3/s$ for the Eastern Basin.

*It is probably safe to assume that evaporation is actually more important above the Eastern Basin because of a more continental and drier climate, so that the share of the Eastern Basin in the global evaporation is probably underrated. However, the correction would be anyhow very empirical.

The hydrological balance of the Eastern Basin could then be:

River water	$9 \times 10^3 m^3/s$	
Precipitation	13	
Water from the Black Sea	6	[Sverdrup et al.]
Total Gain	28	
Loss by evaporation	70	
Δ V : the difference due to the excess of the incoming flux over the outgoing flux	42	

The difference Δ V represents 4.5% of either fluxes, this means that the order of magnitude for both figures is $10^6 m^3/s$, or $31.5 \times 10^3 m^3$/ year.

Were all the Levantine water (20 to $25 \times 10^3 km^3$) to participate in this westward move (and not merely the uppermost layers), the total mass of Levantine water would theoretically be replaced in less than one year (and all the more rapidly because evaporation is more intense in the Eastern Basin).

The flux of Intermediate water could not be estimated by calculating the geostrphic current. The data from the 1966 stations, did not allow such an estimation, becuase of the inadequate position of the stations with regard to the topography of the bottom. On the other hand, two stations made by the Laboratoire d'Océanographie Phsique du Muséum d'Histoire Naturelle, (Stations 101, 102, Hydromède II Campaign, see Fig. 1) permit a calculation since they are located on a line that crosses the underwater valley following the sill, and is some 50 n.mi. to the north. Although part of the Intermediate water probably escapes westward along this "outlet" and fails to pass the line of stations, some confirmation of the estimated flux can be obtained by assuming total absence of movement below 800 m depth and since, under those conditions, inversion takes place at 150 m depth; the flow will be at its maximum (6 cm/s) between 300 and 500 m depth, a depth at which the specific features of the Intermediate water are indeed strongly marked. This means that the flux of outgoing water in this channel would be about 06-08 x $10^6 m^3/s$, accepting a margin to allow for the uncertain data about the precise positions of the (near) stations as well as for the lack of accuracy with which the profile of the current was extrapolated to extend it down to 800m depth.

From the section shown in Fig. 13a, it is possible to assess the thickness of the layer of Atlantic water, immediately after it has passed Cape Bon. By planimetry of that section, and assuming the value of the flux to be $10^6 m^3/s$, one can deduce that the speed of the eastward flow, calculated along the normal to the section, if of the order of magnitude of 0.2 knots, which is by all means acceptable.

The conclusion is that, although lack of reliable information regarding some factors of the flux balance and the exact volume of Levantine water present in the Intermediate Basin prevented us from obtaining a more accurate estimation of the speed with which the replacement takes place, the order of magnitude is undoubtedly significant. On the other hand the equivalence of the volumes of water exchanged further emphasizes the similarity between the conditions in the Strait of Gibraltar and the Strait of Sicily.

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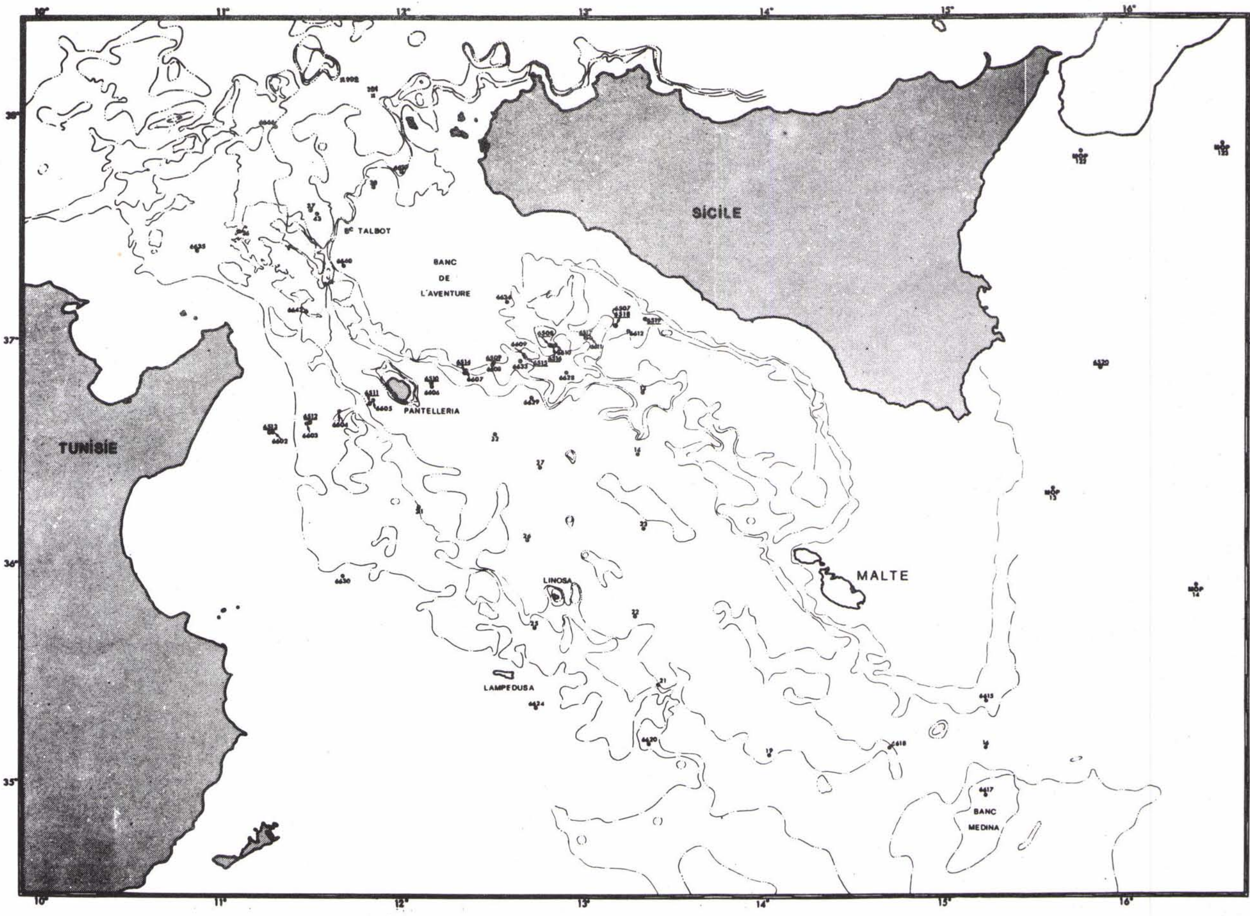
CAPTIONS TO FIGURES 5, 6, 7, and 17

Figure 5 is an enlargement of part of Fig. 4 with the addition of the measurement performed during 1966 outside the section but nevertheless within the central area. (The measurements on and beyond the sills, both eastwards and westwards have been left out).

Figure 6 θ-S diagram of stations on either side of the Eastern Sill (6605-06-07-41-42 to the east, 6636-37-43-44-45-56 to the west); the three circles are for representing the deep water of the western Mediterranean (mean characteristics H. Lacombe and P. Tchernia, 1958).

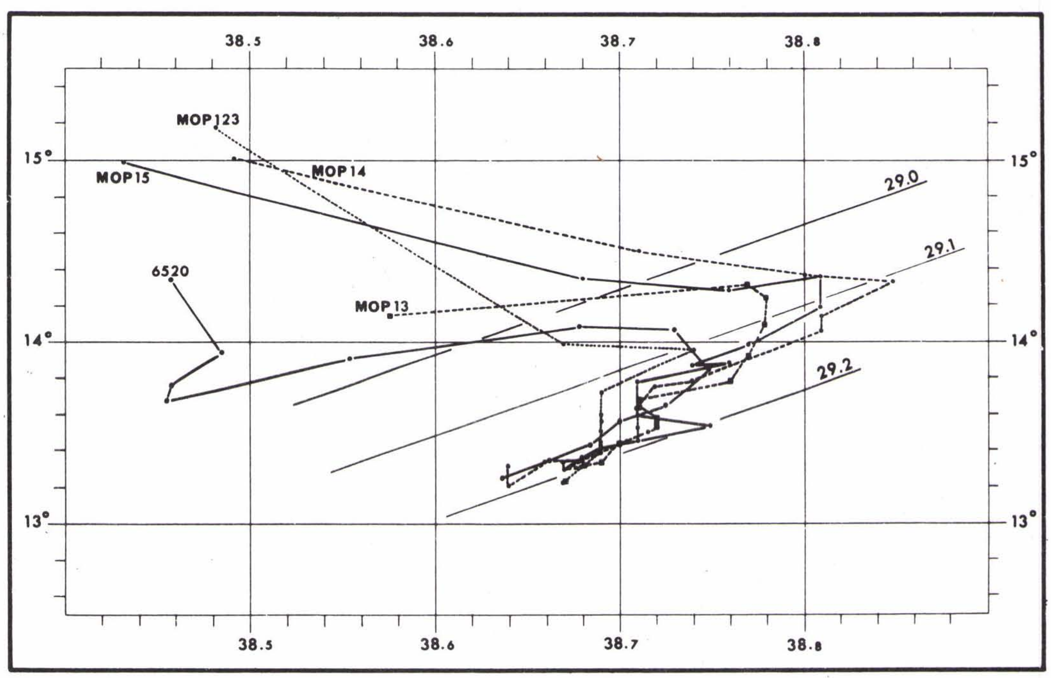
Figure 7 θ-S diagrams at stations on either side of the Western Sill, made during the "Hydromède II Campaign by the Laboratoire d'Oceanographie Physique du Muséum d'Histoire Naturelle".

Figure 17 for every middle station (i.e. located between the Eastern and Western Sills) mean values of saturation (percentage of oxygen) as a function of depth; the horizontal line segments show the standard deviation about the mean value; the figure to the right of the segment gives the value of the standard deviation; to calculate the actual depths were approximated to the nearest standard value. Saturation was determined from F.Varlet and C. Leroy's table of extrapolated values, and starting from Carpenter's results.



SICILE
TUNISIE
MALTE
PANTELLERIA
LINOSA
LAMPEDUSA
BANC DE L'AVENTURE
Bc TALBOT
BANC MEDINA

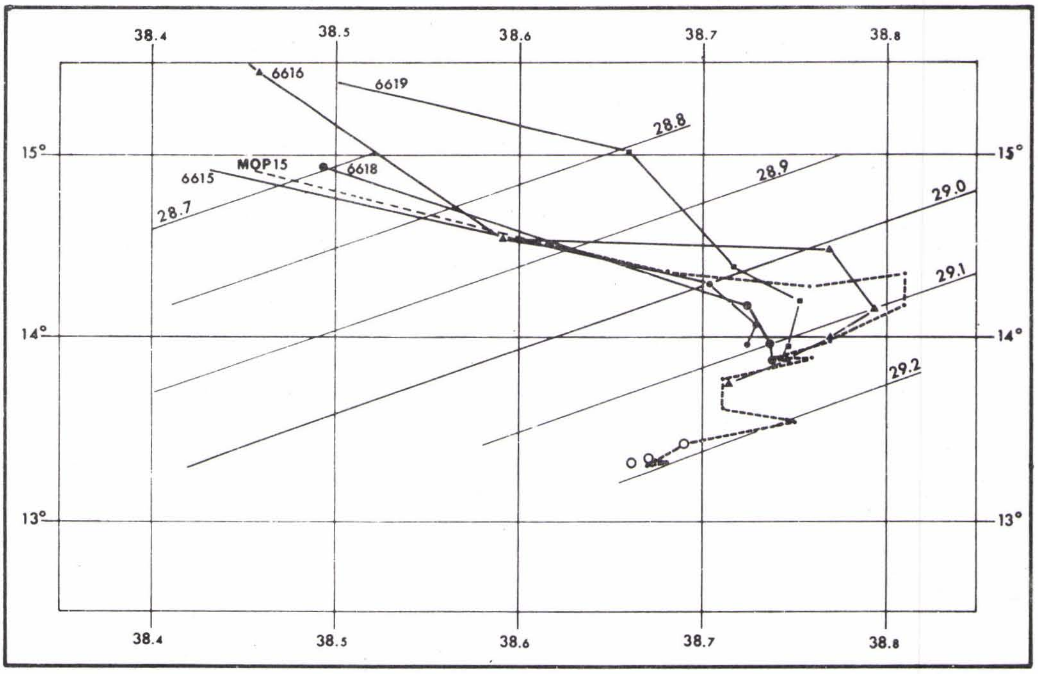
FIG. 1



MOP123
MOP15
MOP14
MOP13
6520
29.0
29.1
29.2
38.5
38.6
38.7
38.8
15°
14°
13°

FIG. 2

FIG. 3


38.4
38.5
38.6
38.7
38.8
6616
6619
6615
MOP15
6618
28.7
28.8
28.9
29.0
29.1
29.2
15°
14°
13°

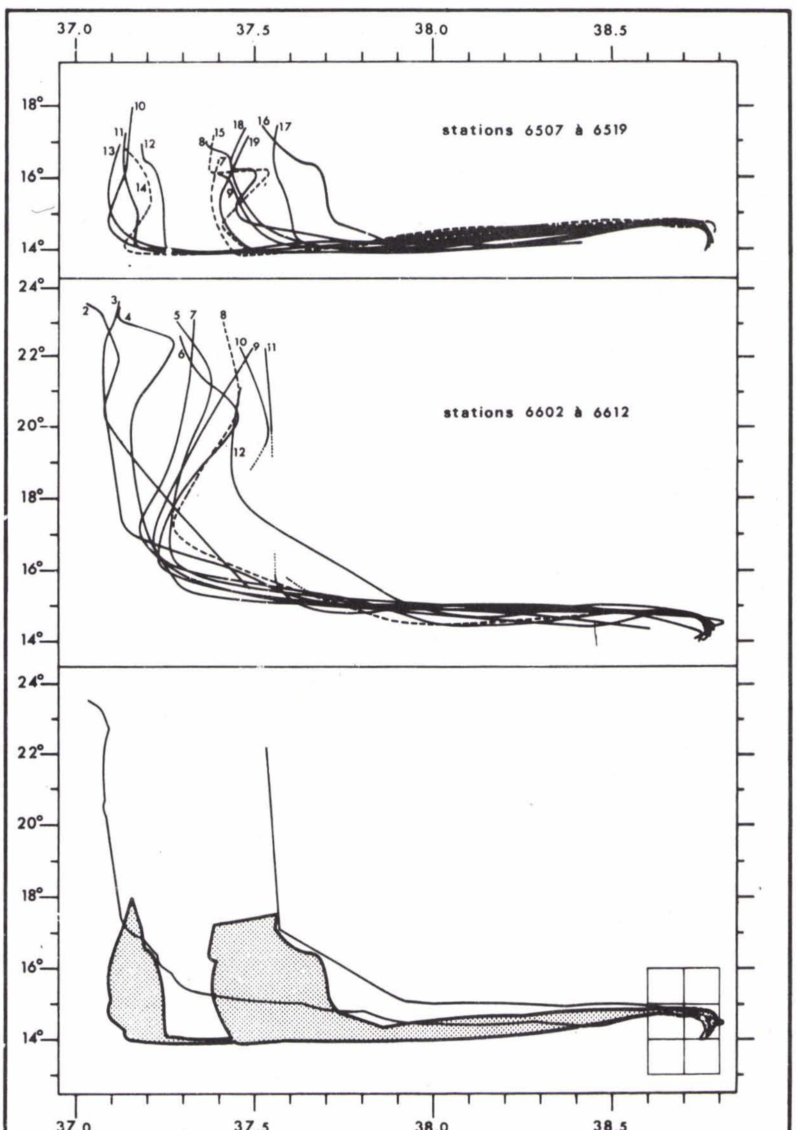

37.0
37.5
38.0
38.5
18°
16°
14°
24°
22°
20°
stations 6507 à 6519
stations 6602 à 6612

FIG. 4

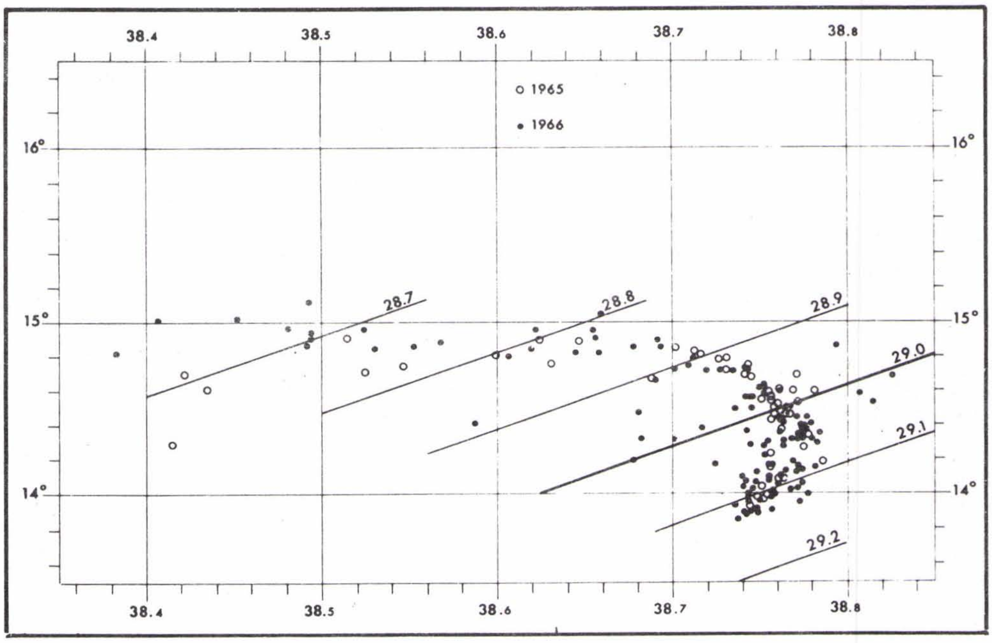


FIG. 5

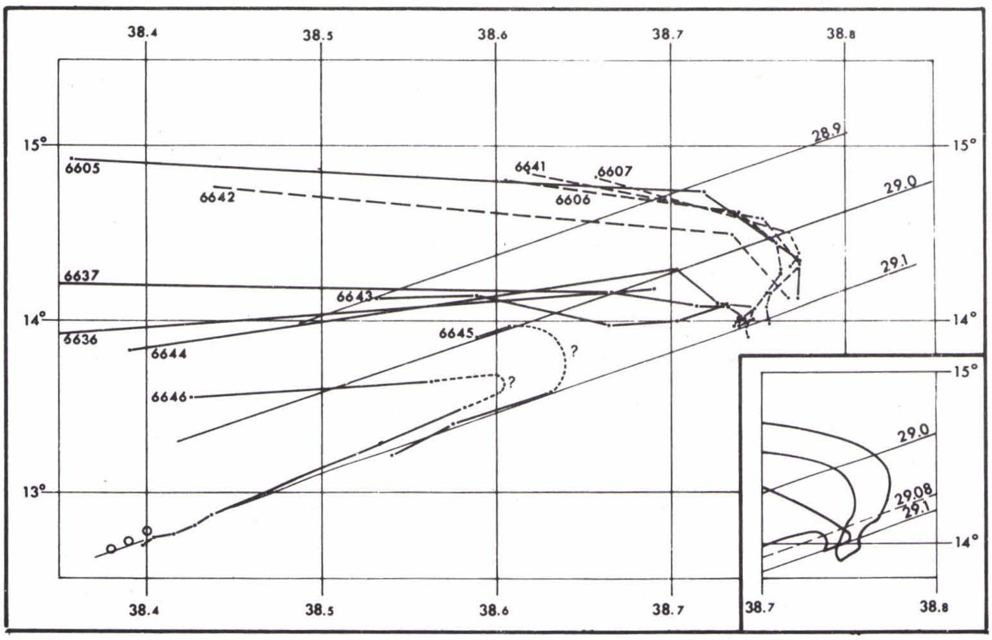


FIG. 6

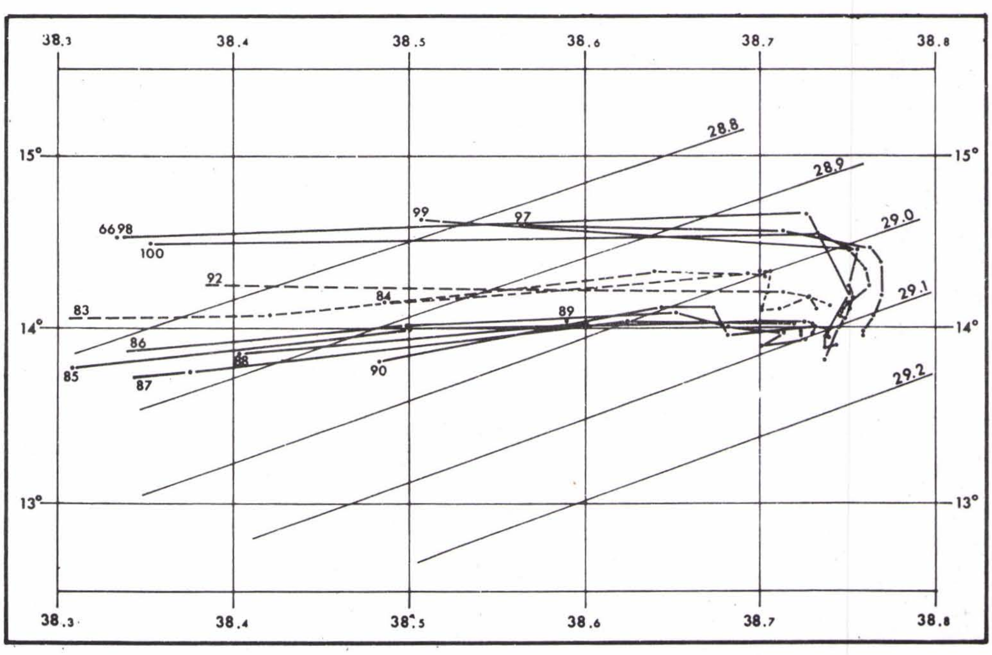


FIG. 7

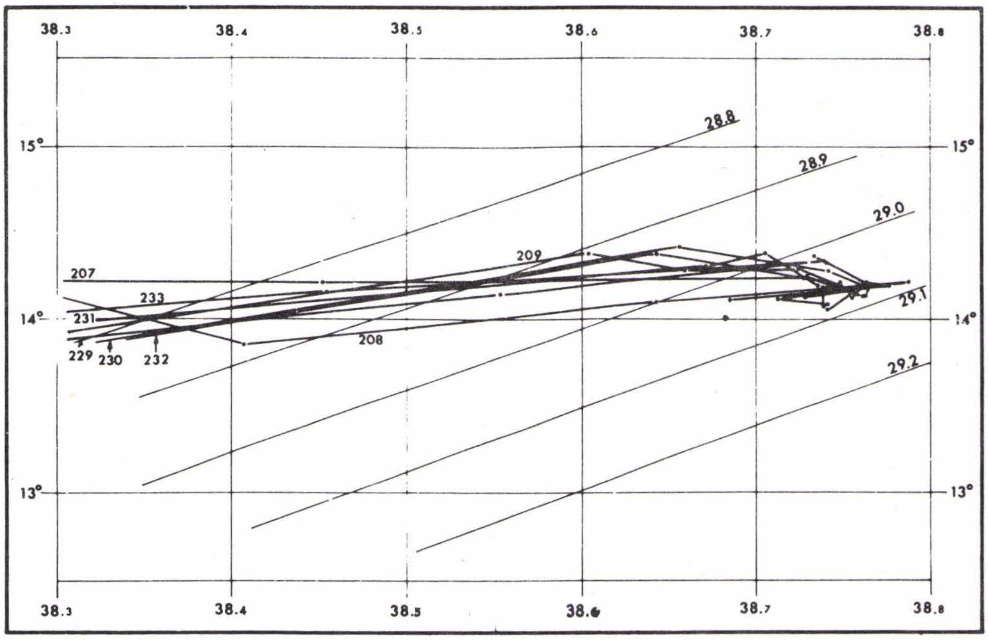

38.3
38.4
38.5
38.6
38.7
38.8
15°
14°
13°
28.8
28.9
29.0
29.1
29.2
207
209
233
231
229
230
232
208

FIG. 8

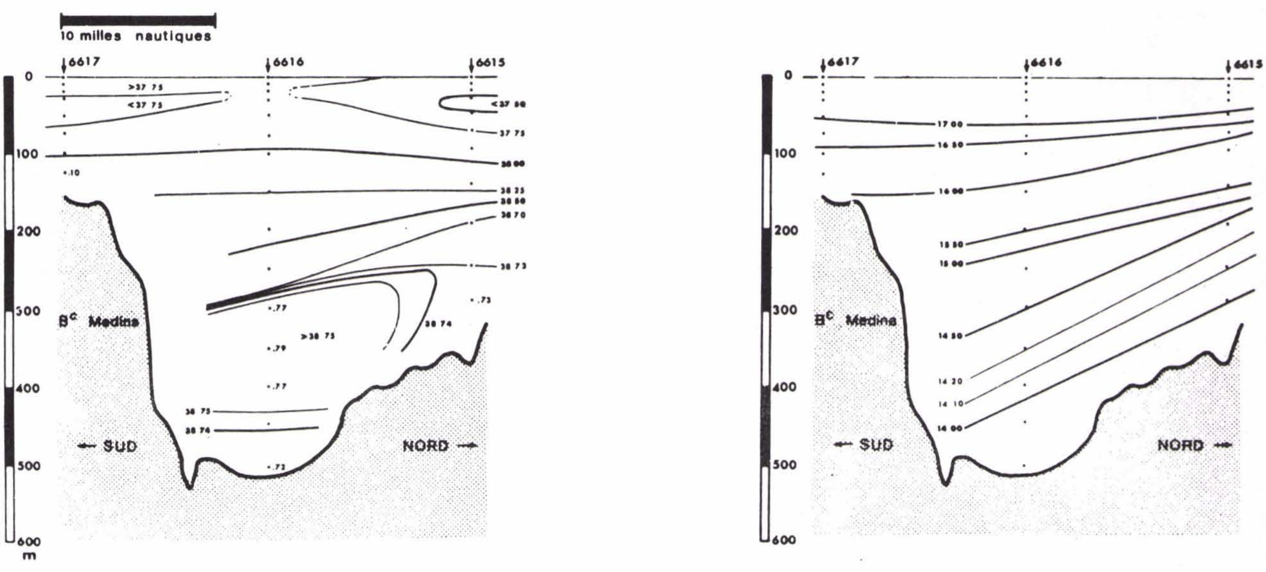
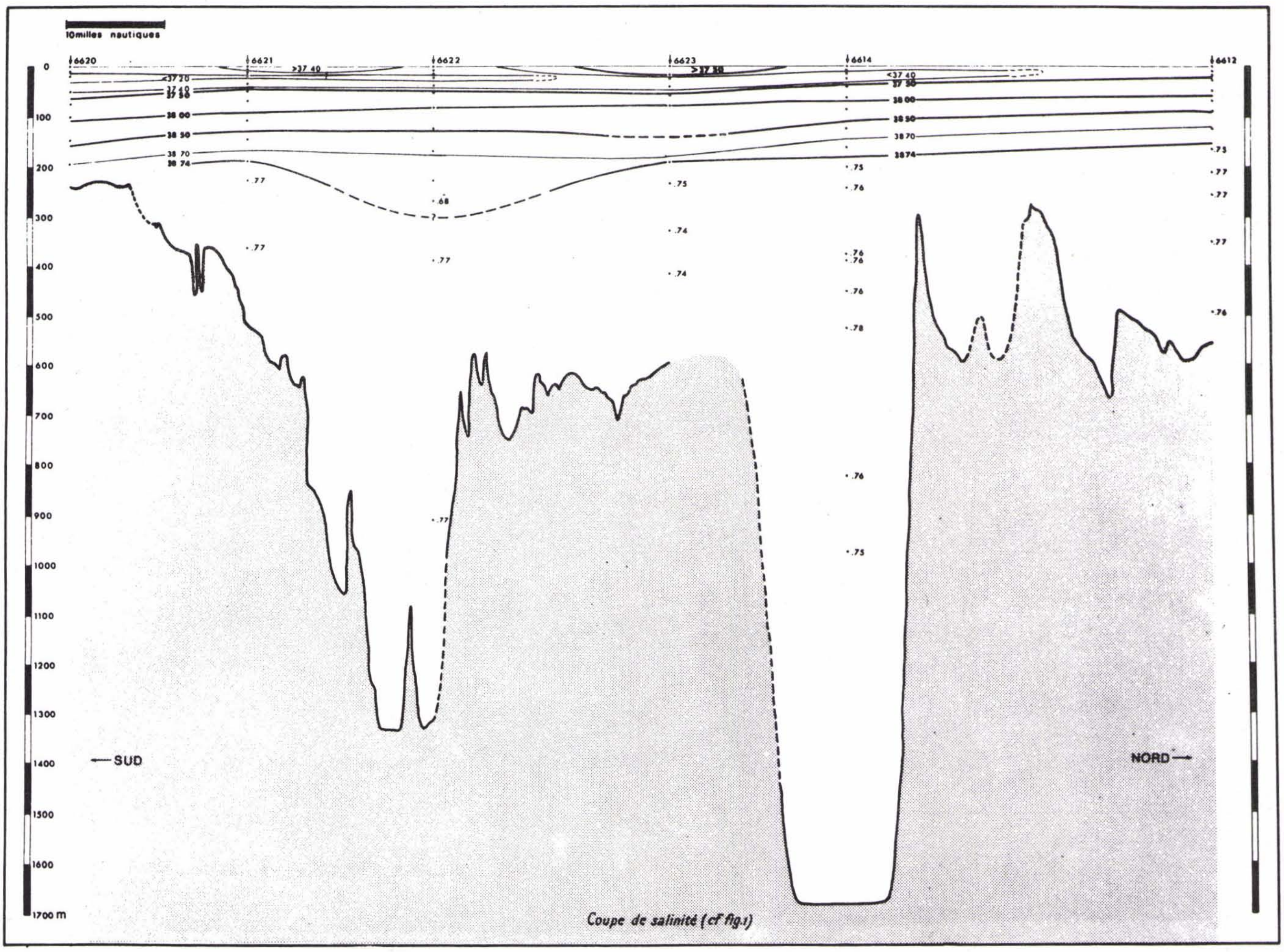

10 milles nautiques
6617
6616
6615
0
100
200
300
400
500
600
m
B^c Medina
SUD
NORD

FIG. 9



10milles nautiques
6620
6621
6622
6623
6614
6612
>37 40
>37 50
<37 20
37 40
37 50
38 00
38 50
38 70
38 74
<37 40
37 50
38 00
38 50
38 70
38 74
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700 m
SUD
NORD
Coupe de salinité (cf fig.1)

FIG. 10

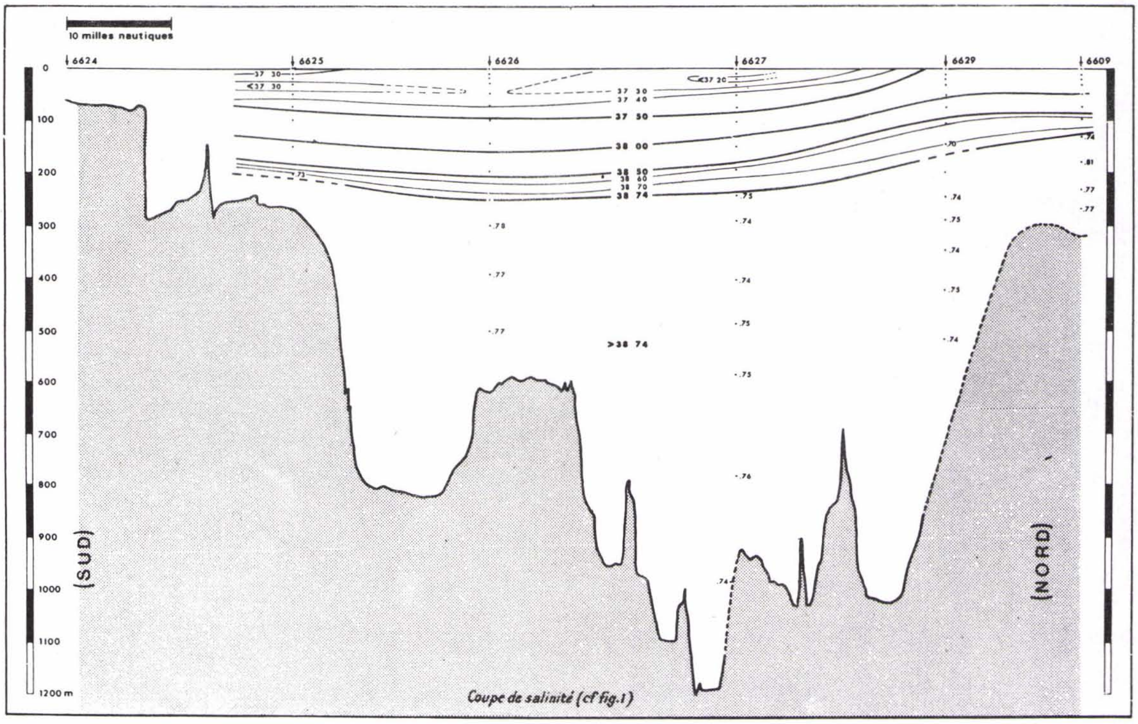

10 milles nautiques
6624
6625
6626
6627
6629
6609
(SUD)
(NORD)
37 50
38 00
>38 74
Coupe de salinité (cf fig.1)

FIG. 11

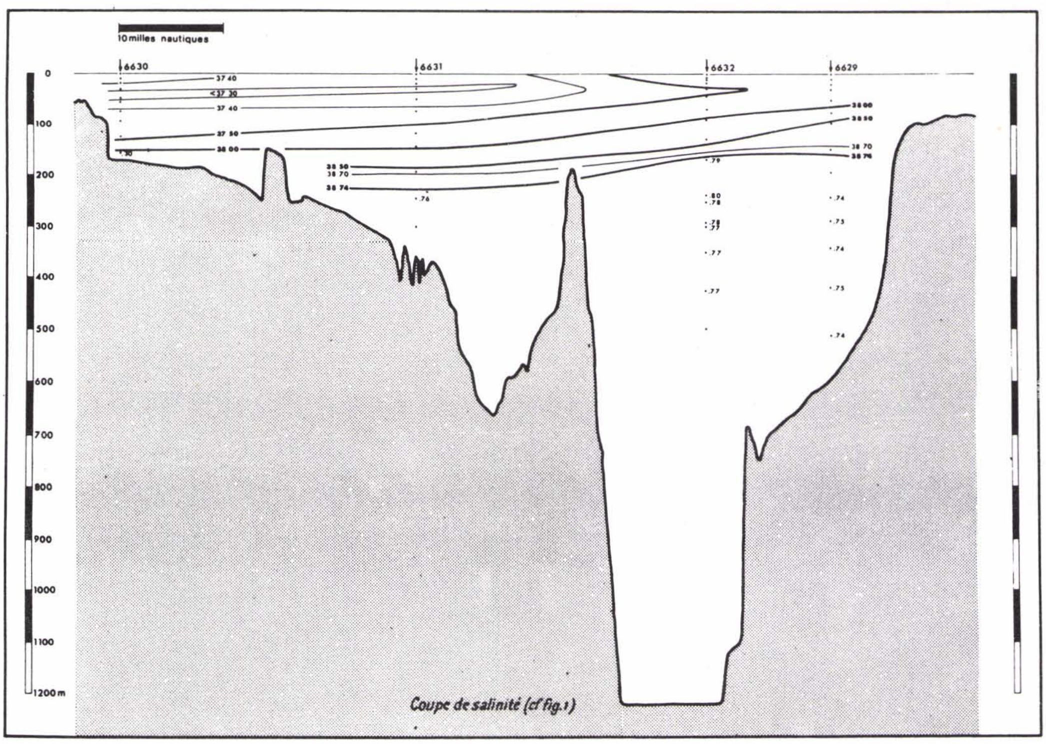

10 milles nautiques
6630
6631
6632
6629
Coupe de salinité (cf fig.1)

FIG. 12

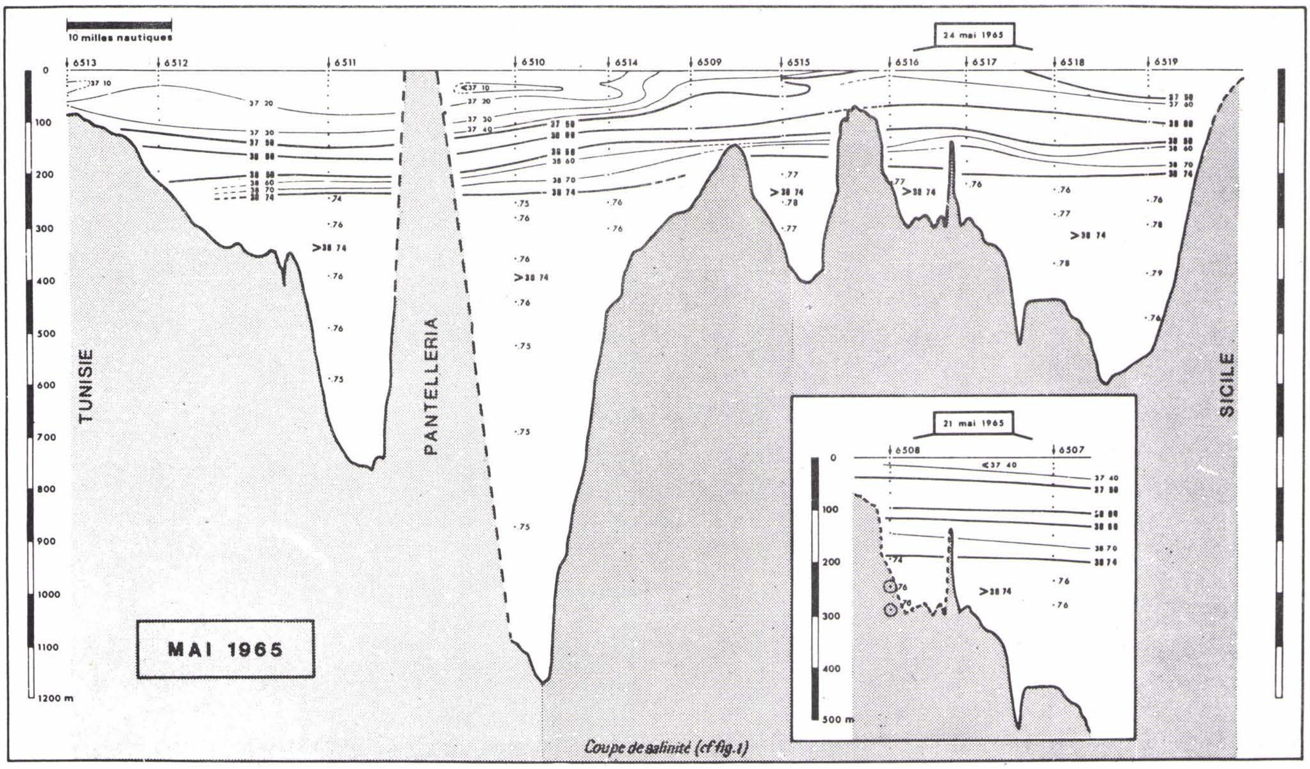


FIG. 13a

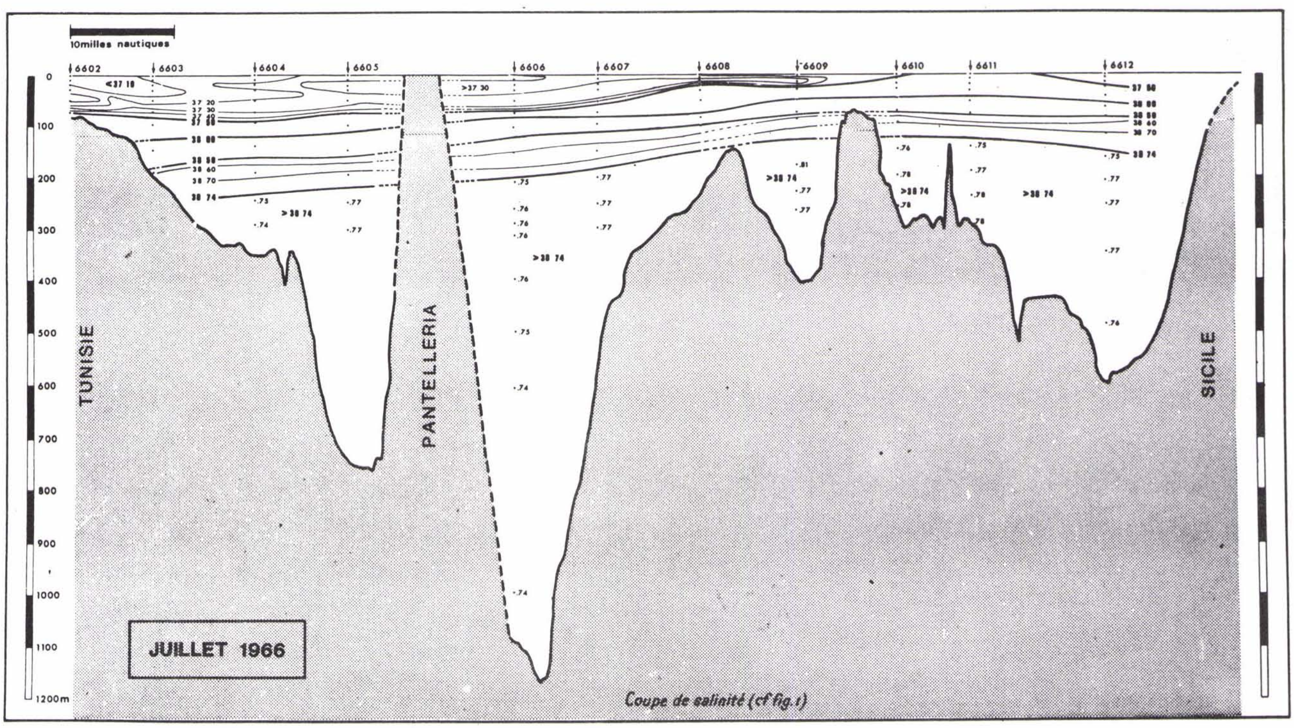


FIG. 13b

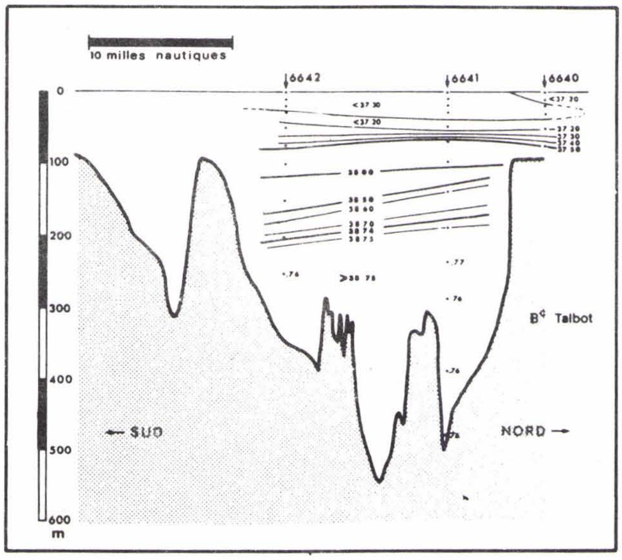

10 milles nautiques
6642
6641
6640
B^c Talbot
← SUD
NORD →
0
100
200
300
400
500
600
m

FIG. 14

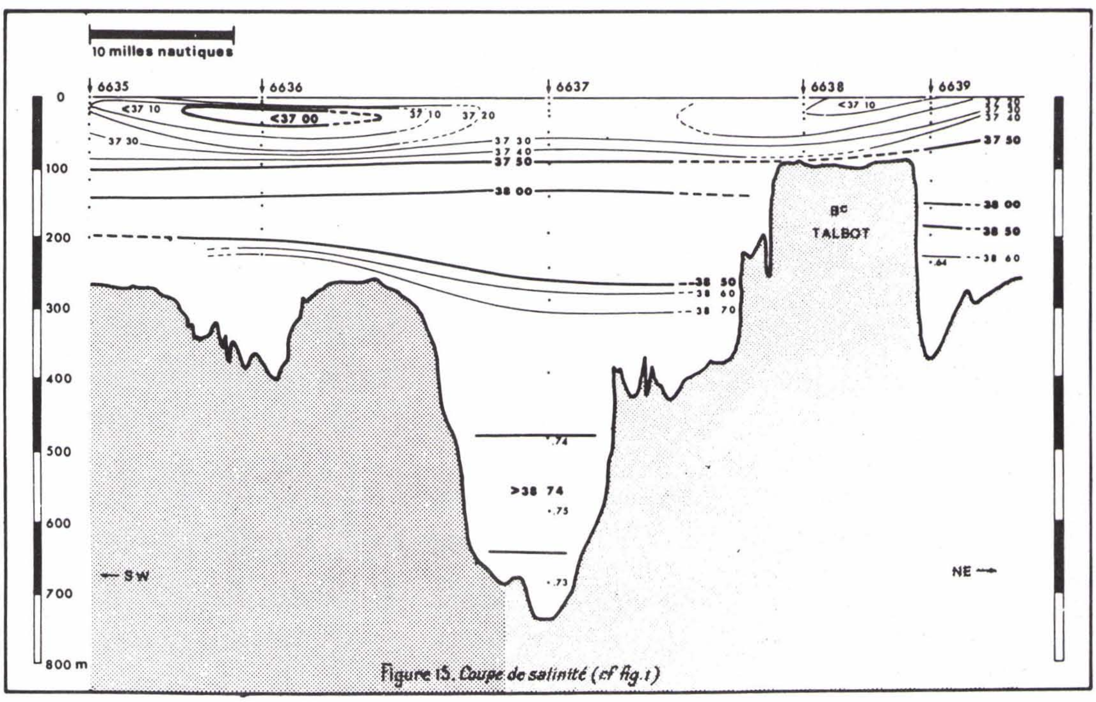

10 milles nautiques
6635
6636
6637
6638
6639
<37 10
<37 00
37 30
37 50
38 00
>38 74
B^c
TALBOT
← SW
NE →
0
100
200
300
400
500
600
700
800 m
Figure 15. Coupe de salinité (cf fig. 1)

FIG. 15

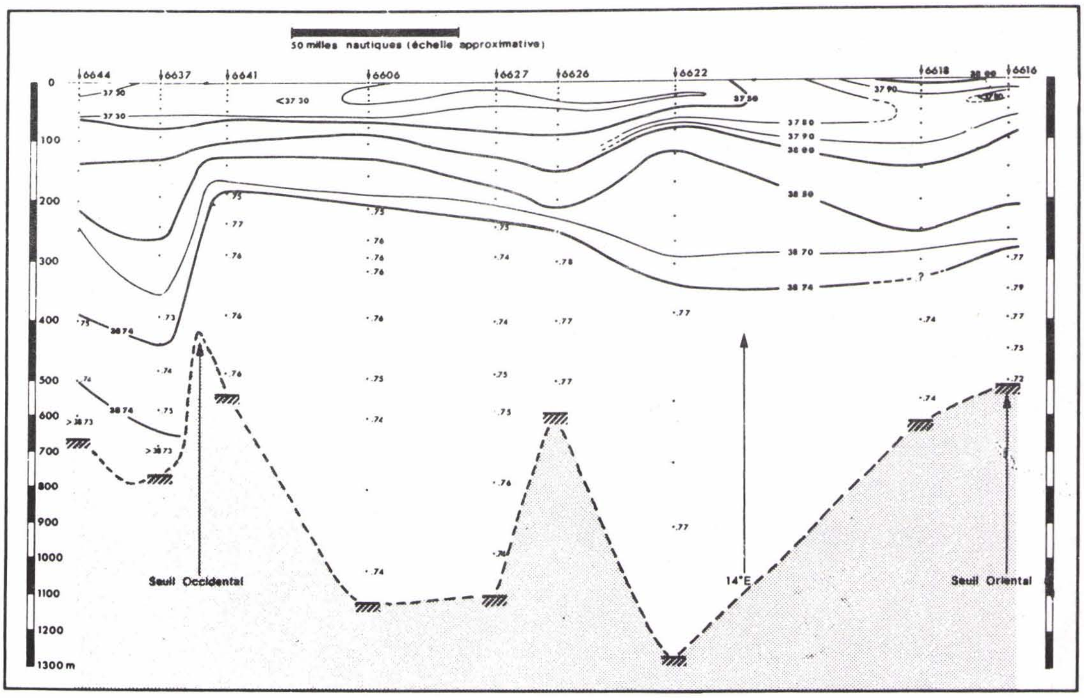


FIG. 16a

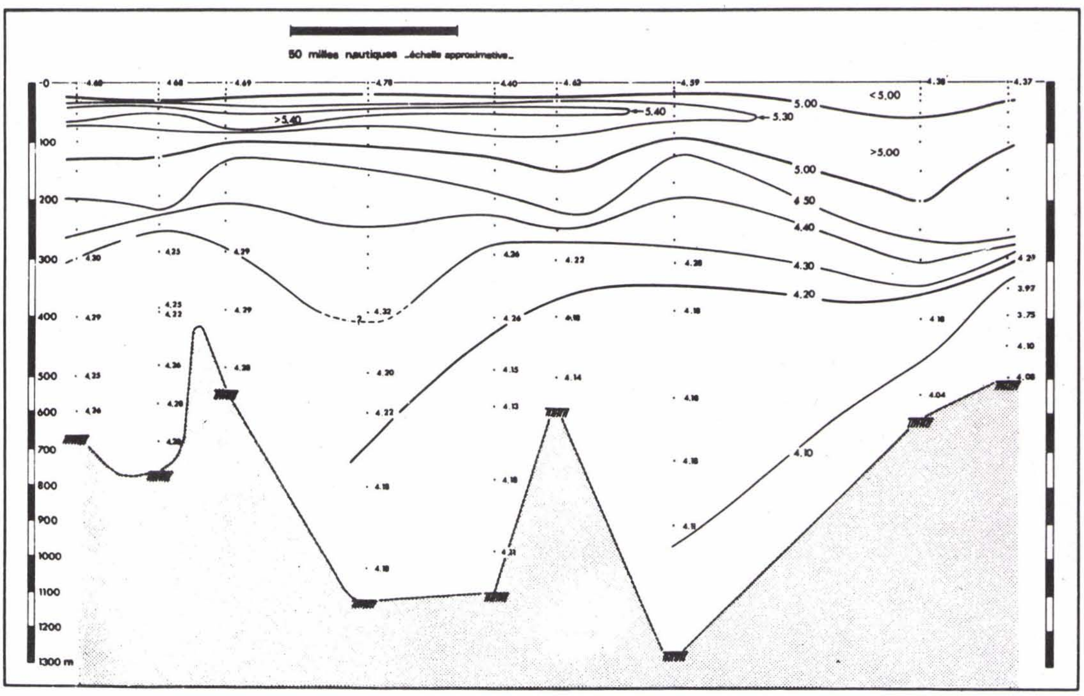
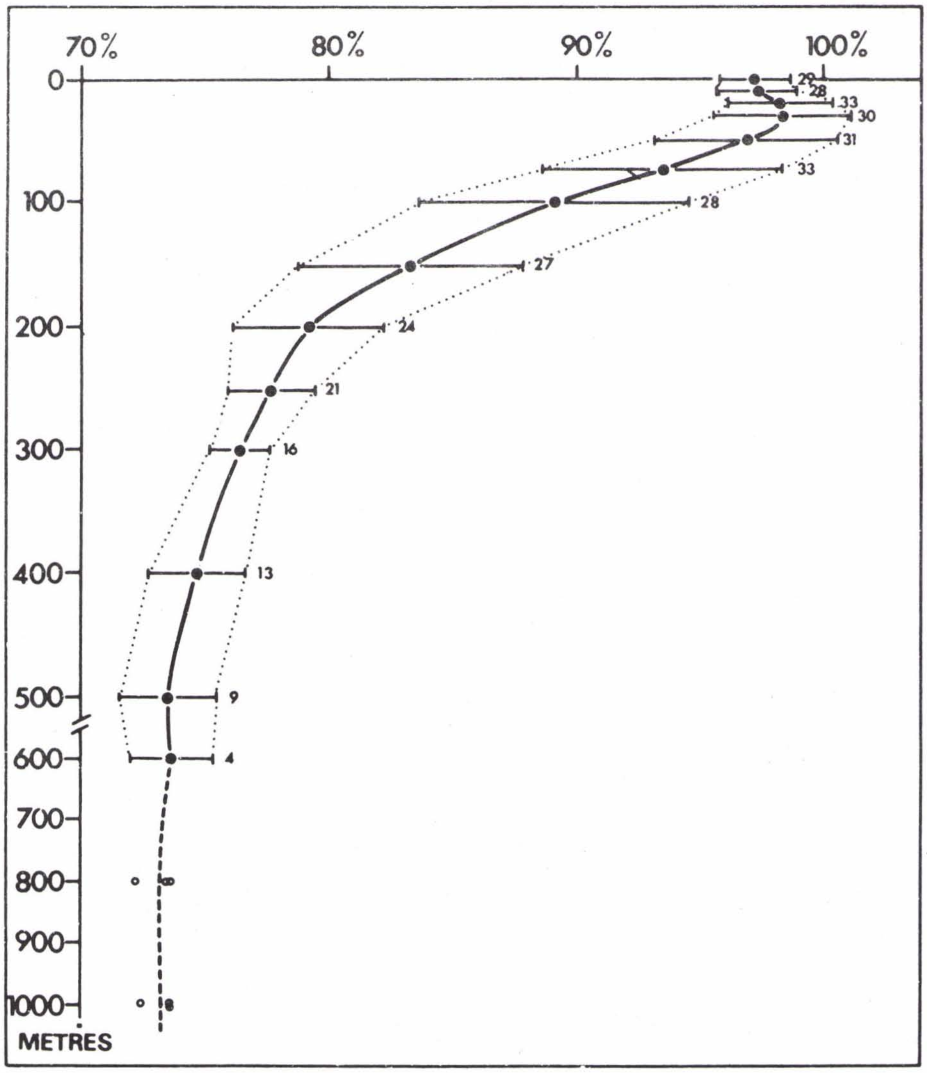


FIG. 16b



70%
80%
90%
100%
0
100
200
300
400
500
600
700
800
900
1000
METRES
29
28
33
30
31
33
28
27
24
21
16
13
9
4

FIG. 17