Bull. Inst. Oceanogr. & Fish. ARE, 12, 1986: 291 - 299.

ON THE PECULIAR HYDROGRAPHIC CHARACTER OF THE EASTERN MEDITERRANEAN SEA IN WARM AND COLD WINTERS.

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ABSTRACT

The variations of the water masses were investigated on monthly basis for each year (between 1955 - 1978), with particular attention given to the distinct warm and cold years.

The water temperature, salinity and density (σ-t) varied from one year to another in the same month and position, on the sea surface and at deeper levels.

The vertical convection in the cold winters was stronger than that in the warm ones, especially in the upper 300 m.

The water salinity in the warm years was higher than that in the cold years (up to 0.2 ‰). This is explained as due to evaporation.

The Aegean Sea may be considered as a secondary source of the intermediate water mass.

In the east of Crete Island, in the northern Levantine basin, forms the deep water mass. This conclusion agrees and resolves the contrast between the results of Nielsen (1912), Pollak (1951) and Wust (1961).

INTRODUCTION

Scientific interest and practical importance of the Eastern Mediterranean Sea, which is today one of the most poorly studied regions of the world ocean, arise from two major reasons: i) the obvious regional importance of new scientific knowledge of that sea to the nations which border it, ii) the profound interest in the general physical processes which occur there, and can be studied relatively easily and efficiently. In the far eastern part of the Mediterranean Sea (Levantine Sea, Fig. 1), as the result of a strong vertical convection in winter, the Levantic Intermediate water mass is formed (Nielsen, 1912; Wust, 1959, 1960 and 1961; Lacombe and Tchernia, 1960). These waters are exchanged

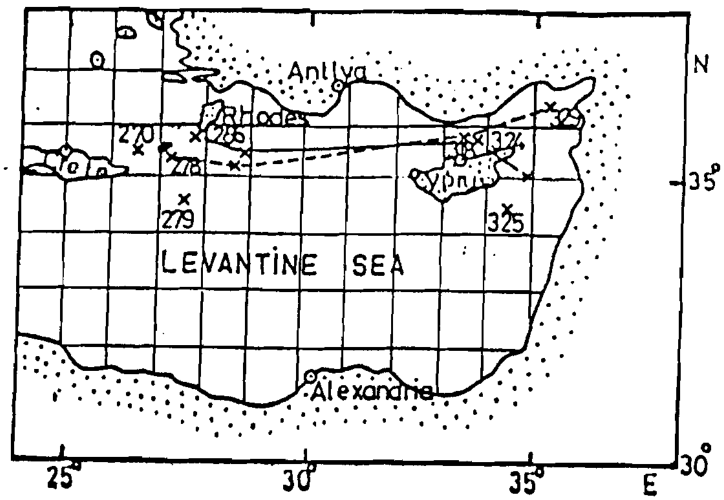

Fig. (1)
Map showing the location of the sections and hydrographic stations in the warm (---) and cold (---) winters in the far eastern part of the Mediterranean Sea (Levantine Sea), X : hydrographic stations; O : meteorological station.

through the straits of Sicily and Gibraltar whence they importantly affect the general circulation of the Atlantic Ocean.

The source of formation of deep and bottom waters in the Eastern Mediterranean Sea was suggested by Nielsen (1912) to be in the southern parts of the Adriatic and Aegean Seas, but the suggestion of Pollak (1951) was only the Adriatic and that the deep outflow through the Strait of Otranto was far from continuous. Wust (1961) noted the maximum value of dissolved oxygen content (> 4.4 ml/1) and minimum water temperature at the deep levels (<13.2°C) to the south of the islands separating the Aegean Sea from Levantic Sea (as shown in Fig. 2).

The aim of the present work is to study the peculiar hydrographic character of the extreme Eastern Mediterranean Sea, (Fig. 1) as the main source of the intermediate waters and try to prove the evidence of formation of the deep waters in the area to the east of Crete Island (where Wust, 1961 put two question marks, Fig 2) using the differences in hydrographic parameters between the distinct warm and cold winters.

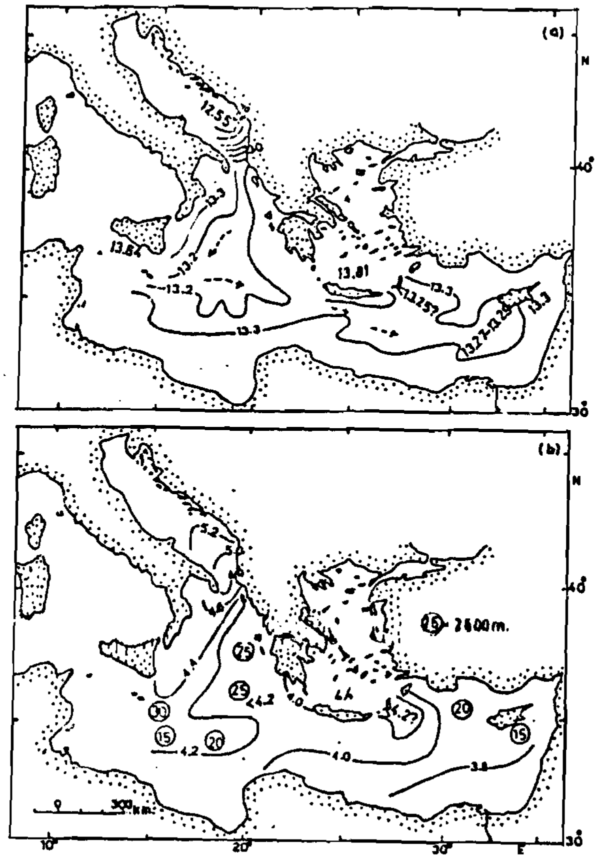

Fig. (2)
Distribution of water temperature (a) and Oxygen (b) within the core layers of the deep waters (Wust, 1961).

MATERIALS

Using international hydrographic data for about 7000 stations collected in the Eastern Mediterranean during a period of 24 years (1955 - 1978), combined with data from 13 meteorological stations surrounding the area, and complemented with daily charts covering the same period, a study was made of the regularity of variation of the thermal air and water characteristics of the region. Thus, the variations of the water masses were investigated on monthly basis for each year, with particular attention given to the distinctly warm and cold years.

RESULTS AND DISCUSSION

Maiyza, (1984) considered 1969 and 1970 as warm years and 1968 and 1972 cold years. Table (1) shows the air and surface water temperatures. Air temperature of the nearest meteorological stations from four representative squares. The squares numbers were taken from the Russian book "The hydrography of the Mediterranean Sea ", 1976. The locations of these squares are shown in Fig. (1). It is important to mention that the temperature anomaly, usually, does not cover all the area of the Eastern Mediterranean Sea but may, in some cases, cover one or more of the basins of the Eastern Mediterranean Sea (Maiyza, 1984). These squares which we used here, had mainly the general trend of temperature anomaly of the Eastern part of the Mediterranean Sea.

From Table (1), it is clear that the surface water temperature and air temperature varied from one year to another in the same month and in the same degree square. Fig. (3) shows the vertical distribution of temperature and salinity in the warm 1970 and cold 1972 winters for a latitudinal section along the northern part of the Levantine Sea. From this figure, the variation in the water temperature was observed not only on the surface but also to a deep layers. Also, those differences were observed not only for temperature, but also for salinity and consequently for density.

Table (1)
The air water temperature in the warm (1969 and 1970) and cold (1968 and 1972) winters in February in Levantine Sea.

Sq. No. / Meteo. St.	YEARS			
	1968 (cold)	1969 (warm)	1970 (warm)	1972 (cold)
270 / Crete	15.3 / 13.0	-----	17.3 / 13.7	-----
279 / Crete	-----	-----	16.5 / 13.7	15.0 / 10.3
286 / Antalia	-----	-----	15.6 / 12.0	14.5 / 10.3
318 / Cyprus	-----	16.8 / 10.4	-----	16.0 / 8.6
/ Alex.	/ 14.2	/ 16.2	/17.3	/ 15.2

From Fig. (3), it is clear that in February 1970 (warm winter) and 1972 (cold winter) there was an area of convergence to the east of Crete Island. The vertical temperature gradient in the warm winters is larger than that in the cold ones.

In Fig.(3), the isotherm 14°C in the west (to the south-east of the Aegean Sea) lies at a depth of 250 m. eastward this isotherm becomes deeper to 400m. This phenomenon can be observed, also, in the vertical distributions of salinity and density (the vertical distribution of density followed that of temperature). That led to a conclusion that, the Aegean Sea can be considered as a secondary source of the intermediate waters mass in the Eastern Mediterranean Sea especially in the cold winters.

The vertical distributions of water temperature, salinity and density (σ-t) in some warm and cold winters in the squares No. 318, 279, 270 and 325 are shown in Fig. (4). Generally, the water salinity in the warm years was higher than in the cold years (up to 0.2‰). This variation in salinity may be due to the variation in the rate of evaporation.

In the warm winters, over the Eastern Mediterranean Sea, the continental tropical air masses prevail (Fig. 5, a). Under the action of this dry and warm air masses intruding into the Mediterranean region from the Sahara in the south, the rate of evaporation increases and consequently the water salinity increases. In the cold winters, the Continental Arctic and Continental moderate air masses, from the north, prevail (Fig. 5, b). These latter air masses are cold and wet.

The density of the upper layer in the warm winters was lower than that in the cold winters, due to higher temperature. In the deeper layers the density was higher. The thickness of the upper layer varies from 100m. in sq. No. 318 to 200m. in sq. No 325 in the warm winters. In some cold winters the upper layer had a thickness of about 500m. (sq. No. 286). In sq. No. 270 (Fig. 4), there can be a distinct difference in the value of water temperature (2°C) and density (0.4), between the warm and cold winters, but the differences in salinity were little and only in the upper 200m.

To the east of Crete Island (sq. No 279, Fig. 4 and sq. No 286, Fig. 3) the salinity was higher in the warm winters than that in the cold ones, for all the water column (1100 and 600 m., respectively). This phenomenon agrees with the opinion of Moskalenko et al (1976). They suggested that, in the area of Crete-African Anticyclonic gyre the vertical convection may reach the bottom. The differences in the hydrographic conditions between the warm and cold winters (especially salinity) appear from the surface to the depth of maximum vertical convection.

As a conclusion, to the east of Crete Island not only the intermediate water but also the deep water are formed. This deep water mixed in the deep layers with the Adriatic deep water characterized by its lower

(1961), who observed, to the [illegible]
(Fig. 2), the existence of a water tongue of minimum temperature and maximum oxygen content. Thus, the results of Nielsen (1912), Pollak (1951) and Wust (1961) and results of the present work agree with each other when considering the area of formation of this water mass out of the Aegean basin, to the east of Crete Island.

CONCLUSIONS

The water and air temperatures vary from one year to another in the same month and the same degree square. This variation in temperature is observed from the surface to the deep levels in the Eastern

Mediterranean Sea. These variations in temperature affect the value of salinity and density.

The water temperature and salinity gradiant in the warm winters is larger than that in the cold ones and consequently the vertical convection in the cold winters is stronger.

The salinity in the warm winters was higher than in the cold ones (up to 0.2 %o). This is explaind as due to evaporation, the rate of which considerably increases under the action of the prevailing dry and warm continental tropical air masses intruding into the Mediterranean region from the Sahara in the south.

The Aegean Sea can be considered as a secondary source of the intermediate water mass in the Eastern Mediterranean Sea, especially in the cold winters.

To the east of Crete Island, in the northern Levantine basin, formed not only the intermediate waters, but also the deep water mass. This conclusion agrees and resolves the contrast between the results of Nielsen (1912), Pollak (1951) and Wust (1961).

ACKNOWLEDGEMENTS

This work was carried out while the author was at the Department of Oceanology, Fáculty of Geography, Moscow State University, U.S.S.R.

The author wishes to acknowledge his gratitude to Prf. Dr. A. D. Dobravolski and Dr. M. G. Deev for supervising the research and for their valuable suggestions and advice throughout the work. He also wishes to express his sincere thanks to the Senior Scientist and staff of the Department of Oceanology, Moscow University for all the facilities made available for his study.

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