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SHORTER CONTRIBUTIONS

On the temperature and salinity structure of the Mediterranean water in the Northeast Atlantic

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Abstract—Typical results of continuous temperature–salinity measurements from stations west of Gibraltar are presented. Special features of the structure of the Mediterranean Water in this area in relation to the corresponding turbulent mixing and salt-fingering processes are discussed: the two maxima in the vertical profiles, the variation in time of small-scale phenomena, and the step-like structure at the lower boundary of the Mediterranean Water.

INTRODUCTION

As part of a long-time plan of studies of oceanic variability (DIETRICH, 1966), an investigation of the temperature–salinity structure west of Gibraltar was carried out on R.V. *Meteor* Cruise No. 8 in winter 1967. Continuous profiles of temperature, electrical conductivity, and pressure were obtained by instruments of the Bathysonde type (SIEDLER, 1968a). The positions of hydrographic stations are given in Fig. 1. Station 65 was a ten-day anchor station. Typical results from a few of these stations will be presented here.

TYPICAL VERTICAL PROFILES AND T–S-RELATIONS

The position of the core layer of the Mediterranean Water in the North Atlantic has been studied extensively on the basis of Nansen bottle data by numerous authors (WÜST, 1936; COOPER, 1967; MADELAIN, 1967). An attempt was made in this investigation to study the vertical fine structure of temperature and salinity by continuously recording instruments.

Four examples from stations following the Mediterranean Water from Gibraltar to Cape Finisterre are given in Fig. 2. It can be seen that in the depth range of the Mediterranean Water a strong fine structure with small vertical scales is found similar to former investigations in areas with equivalent hydrographic conditions (SIEDLER, 1969; PINGREE, 1969). This fine structure decreases in amplitude with increasing distance from the strait. The divergence of the main temperature and salinity maxima is a result of the different boundary conditions for the mixing of the two properties near the source (BUBNOV, 1967).

Another characteristic feature is the frequent existence of two main maxima in the temperature and salinity profiles. This type of profile was already shown earlier for a greater distance from Gibraltar by narrowly-spaced Nansen bottle measurements (COOPER *et al.*, 1962, Fig. 90). The mean depths of these two main peaks were found at 750 and 1170 meters from repeated measurements at Sta. 65. It has been shown that these two maxima are a consequence of the tidal mixing processes in the Strait of Gibraltar where a frequency distribution of water types with two preferred temperature and salinity values is generated (SIEDLER, 1968b). These two types of water are denoted by MW 1 and MW 2 in Fig. 3. This water moves down the slope while mixing with the Deep Atlantic Water. At the depth where it has the same density as the surrounding water it leaves the bottom and spreads more or less horizontally. Figure 3 additionally gives the distribution at *Meteor* station no. 8–68 in the Gulf of Cadiz and at *Crawford* Sta. 231 in the Sargasso Sea as examples for areas with Mediterranean Water having a small influence. NACW denotes the North Atlantic Central Water (SVERDRUP, 1941), at approximately 500 m in such an area, and the dotted line is obtained from a mean of all

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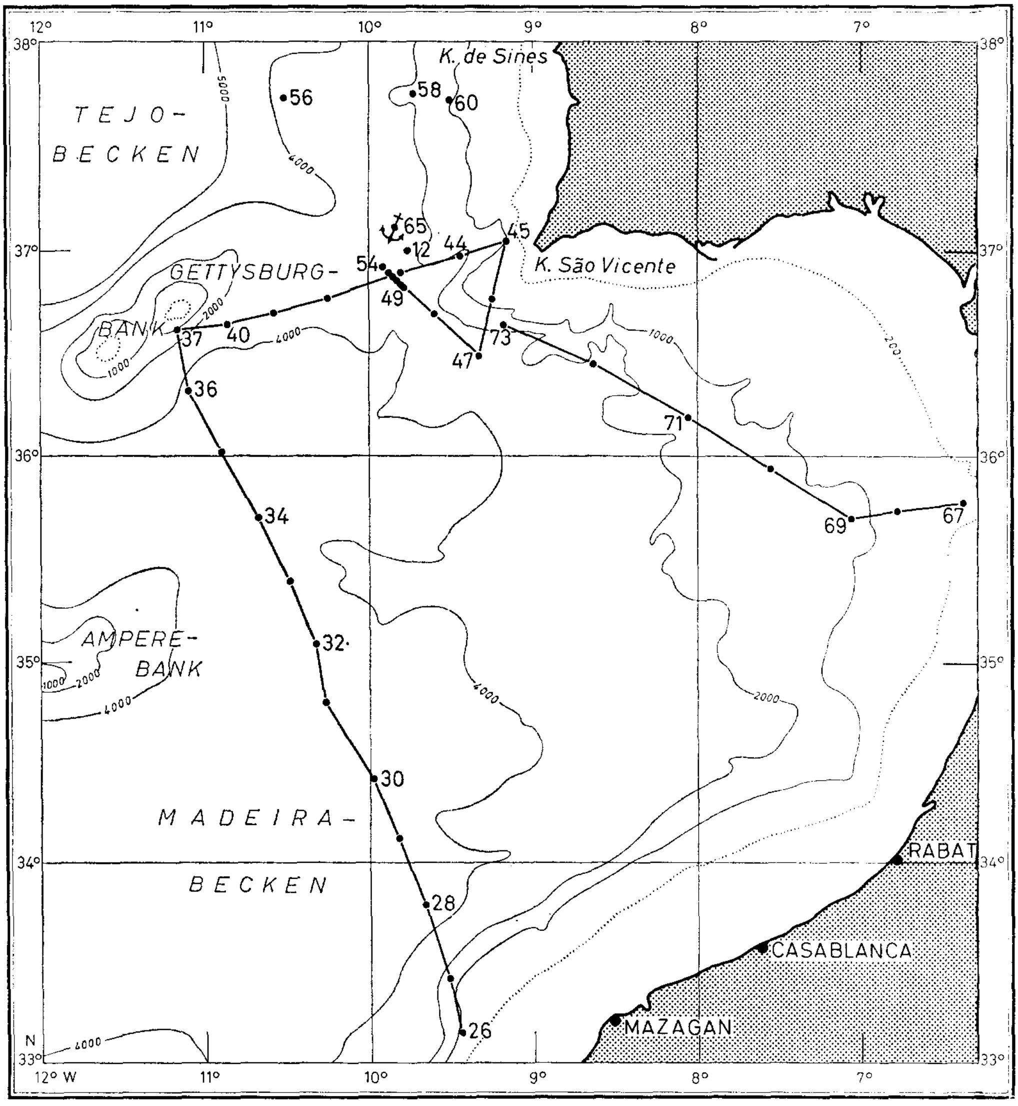


Fig. 1. Chart of the area west of Gibraltar with the location of the Bathysonde stations of R.V. *Meteor* Cruise No. 8. Depths are given in meters.

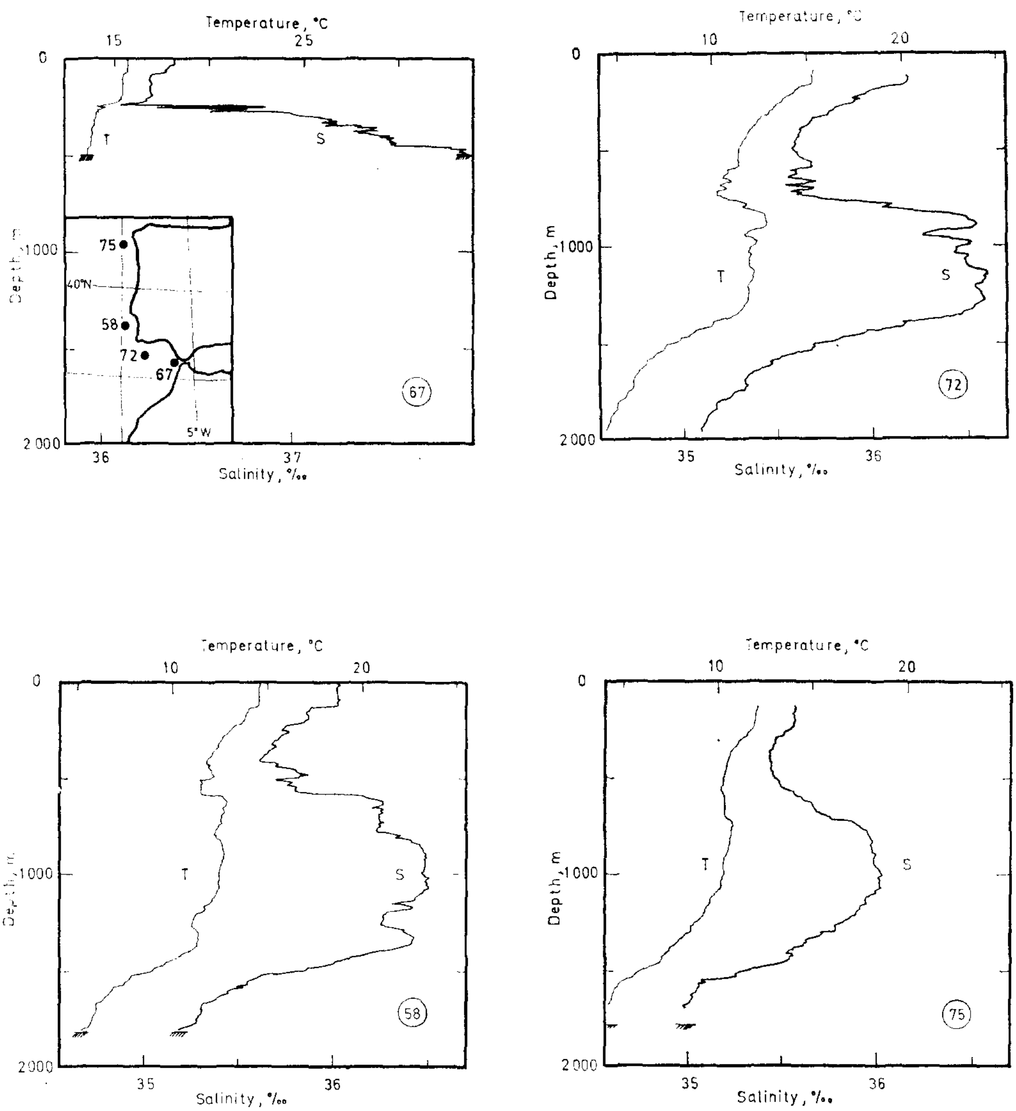


Fig. 2. Vertical temperature and salinity distribution at *Meteor* Stas. 67, 72, 58 and 75.

profiles of *Meteor* Sta. 65. This *T–S*-diagram displays the fact that the two observed main maxima have their origin in the water types Max 1 and Max 2 which are a mixture of NACW with MW 1 and MW 2 respectively with the same mixing ratio.

Variability in time

On the anchor station a total number of 61 profiles of temperature and salinity were obtained in 4-hr-intervals. Samples of these data for the depth range of the core layer are shown in Fig. 4. Great variations are observed in the total heat and salt content of this layer as well as in its vertical structure. The double-maximum feature is found during certain time intervals only. Other measurements in the neighbourhood of this station displayed a corresponding horizontal lens-like structure of the water.

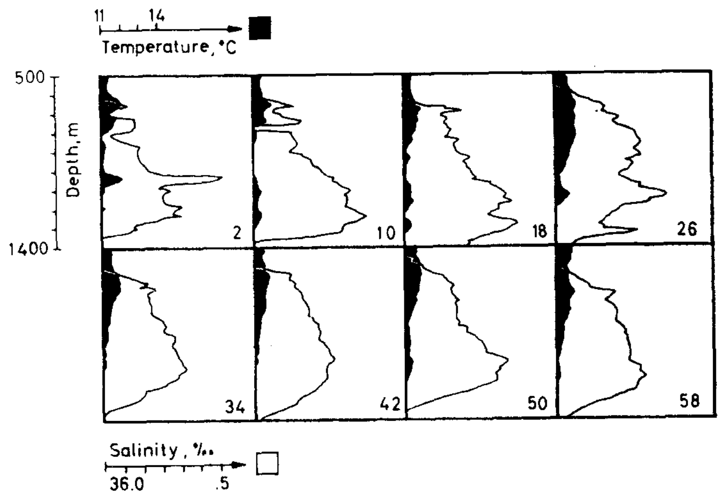


Fig. 4. Vertical temperature and salinity distributions in the depth range influenced by the Mediterranean outflow 40 nautical miles* west of Cape S. Vicente. Profiles are given for 32-hr intervals.

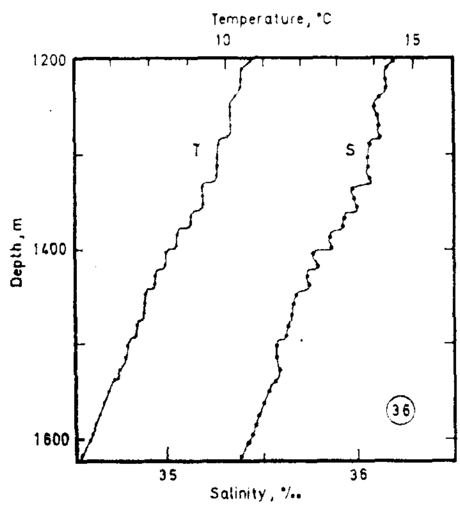


Fig 5. Step-like fine structure in the vertical temperature and salinity distribution at the lower boundary of the Mediterranean Water at Sta. 36.

* 1 nautical mile = 1·852 km.

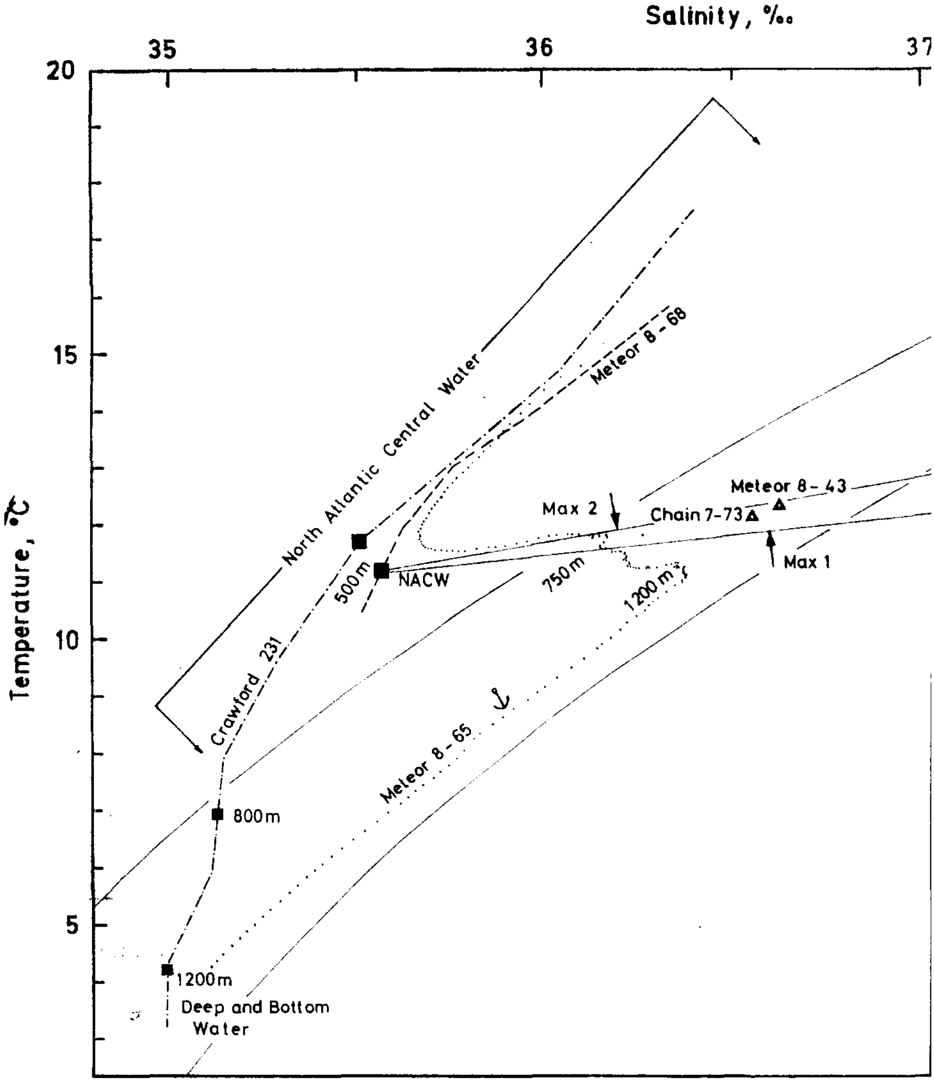
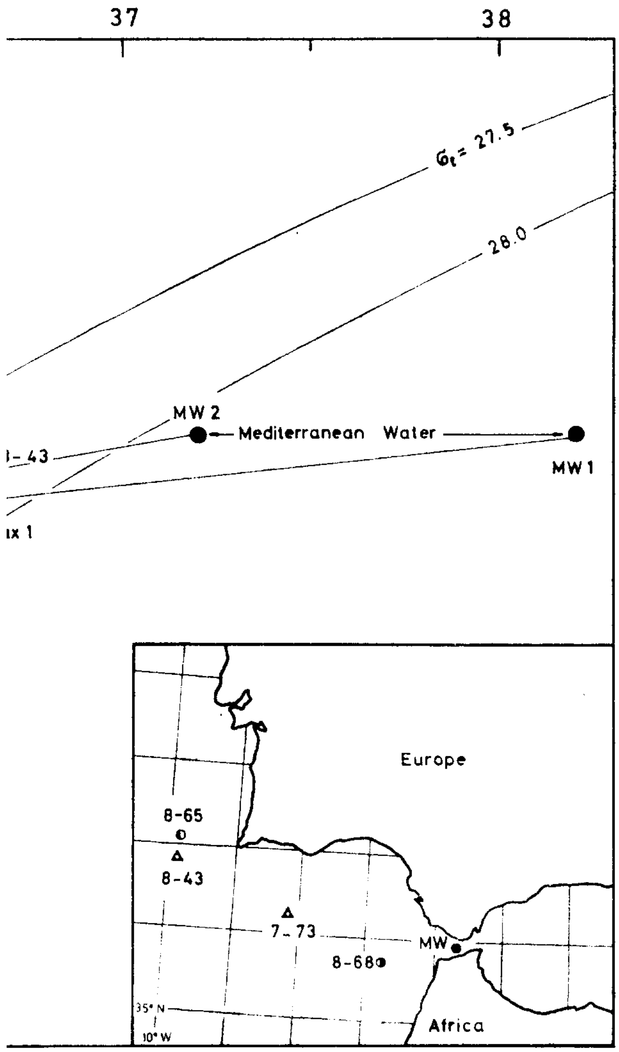


Fig. 3. Temperature–salinity diagram indicating the mixing of Me
North Atlantic Central Water. The following abbreviations are used:
NACW = North Atlantic Central Water at approximately 500 m dept
MW 1, MW 2 = main types of outflowing Mediterranean Water in th
Max 1, Max 2 = product of mixture of NACW with MW 1 and MW



ıixing of Mediterranean Water with
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ly 500 m depth;
ı Water in the Strait of Gibraltar;
/ 1 and MW 2, respectively.

STEP-LIKE STRUCTURE AND SALT-FINGERING

Characteristic step-like structures of temperature and salinity were found at the lower boundary of the Mediterranean Water in certain areas. Later after the measurements, information was obtained that similar steps had been observed by British oceanographers in 1966 in the Madeira area (TAIT and HOWE, 1968). An example of the Meteor-data is given in Fig. 5. The dots denote depth levels where salinity was computed from digitized data, the lines are drawn according to analog data. A step-structure was observed at 8 stations. The depth range with steps is found between 1300 and 1545 meters, with an average number of 7·6 steps per profile. The mean thickness of the homogeneous layers was 21·6 meters similar to the results of Tait and Howe. The mean temperature and salinity differences $\overline{\Delta T}$ and $\overline{\Delta S}$ across the interfaces and the corresponding standard deviations were found as: $\overline{\Delta T} = 0{\cdot}37 \pm 0{\cdot}19^{\circ}C$, $\overline{\Delta S} = 0{\cdot}069 \pm 0{\cdot}035‰$. It has been shown earlier (TURNER, 1967) that such a step-like structure should be expected if salt-fingering occurs at the lower boundary of the warm and haline Mediterranean Water. The vertical transport coefficients K_S (see TURNER, 1967) calculated from the *Meteor*-data yield values of $K_S \sim 7$ cm^2 sec^{-1} as compared with $K_S = 5$ cm^2 sec^{-1} obtained by Tait and Howe in the Madeira area. The lifetime T of the salt-fingers is found to be $T = 4$ days and is therefore shorter than in the Madeira area where $T = 6$ days was calculated.

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