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Evidence of isopycnal mixing across a thermohaline front in the Strait of Otranto

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The region of Otranto strait was visited during POEM-02-86 cruise by R/V AEGAIO. Three CTD casts, over the eastern part of the sill, were taken on April 23rd (fig.1). The existence of a thermohaline front, at the point where Ionian and Adriatic waters meet, is revealed by the distribution of hydrological characteristics (fig.2). The spatial scale of the front was found to be of the order of 30-40 nautical miles. Temperature and salinity inversions are observed throughout the water column (Georgopoulos et al, 1986). Those vertical structures are more important at the northernmost station and become weaker as one moves to the south of the sill. Near the bottom of the sill, dense water (σ_θ = 29.17) was found to outflow towards the Ionian sea.

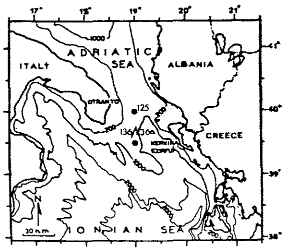

Fig.1. Bathymetric chart of Otranto strait (depth in meters). Location of hydrographic stations.

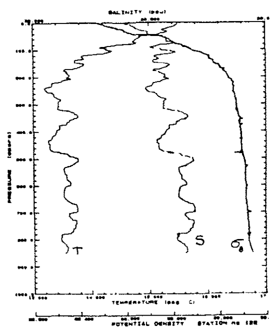

Fig.2. Vertical profiles of T, S, σ_θ at station 125.

The objective of this paper is to study mixing mechanisms occuring in the front. Finestructure theory techniques are used.

Data were filtered by a cosine-type filter. Subtraction of smoothed profiles from original ones provides zero-mean temperature and salinity fluctuations T' and S' (fig. 3). Spectral analysis of those fluctuations revealed important oscillations at wavelengths of 78m, 45m and 25m, throughout the water column. From ratios of vertical to horizontal dimensions of such structural elements (known to be between 10E-2 and 10E-3) it follows that the horizontal scale of the features observed are typical of mesoscale variability.

To separate vertical and horizontal mixing mechanisms, values of smoothed T-S diagram slope ($d\bar{T}/d\bar{S}$), ratios of expansion coefficients β/α and ratios of temperature and salinity anomalies T'/S' were computed along the vertical. Results for the northernmost station over the sill are shown in Table 1.

Table 1

Pressure range dbars	β/α °C/ppt	T'/S' °C/ppt	$d\bar{T}/d\bar{S}$ °C/ppt
250-345	3.66	3.48	2.78
346-437	3.66	3.22	4.04
438-514	3.64	3.42	3.14
515-561	3.64	3.42	4.71
562-585	3.64	3.61	2.25
586-624	3.64	3.54	4.11
625-704	3.63	3.38	3.17
705-800	3.63	3.47	4.08

From table 1 it is evident that T'/S' ratio values are closer to β/α than to $d\bar{T}/d\bar{S}$ (fig. 4) and hence that isopycnal mixing dominates in the 250-800 dbar range. Vertical mixing could also play a role in the ranges 438-514 and 625-704 dbars.

In depth study is needed to elucidate any eventual relation of the mixing processes described above to the formation of the dense water observed near the bottom of the sill.

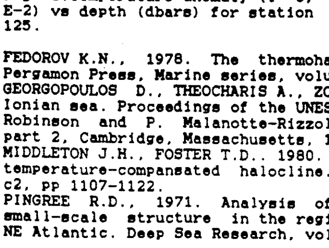

Fig. 3.Temperature anomaly (T'°C, E-2) vs depth (dbars) for station 125.

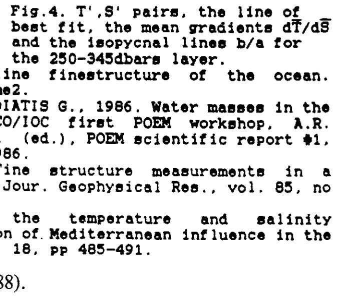

Fig.4. T',S' pairs, the line of best fit, the mean gradients $d\bar{T}/d\bar{S}$ and the isopycnal lines b/a for the 250-345dbars layer.

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O-I8

The outflow conditions of the Mediterranean effluent at the Black Sea exit of the Bosphorus Strait

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The outflow of the Bosphorus underflow into the Black Sea has been a puzzling subject since it was first investigated in 1940's. Many of the earliest studies have been based on the assumption that the underflow could be blocked at the northern end of the Bosphorus in the form of a salt wedge. While the earliest version of this hypothesis, i.e. the lower layer current being blocked for extended peroids (a few months) have become obscure at present, it has often been argued that the excessive cases of Black Sea outflows through the Bosphorus upper layer or strong northerly winds could cause temporary blocking at the northern end of the Strait. The earlier information on the bottom topography of the region has misplaced the sill depth of 45-50 m. Because of this misconception on the sill depth, observations showing interface depths of larger than 50 m within the northern Bosphorus were interpreted as corresponding to blocking conditions.

The exit conditions of the lower layer flow of the Mediterranean origin into the Black Sea has been investigated during recent surveys. The topography is found to be unique in many respects and play important roles on controlling and steering the bottom currents. A narrow bottom groove (the Bosphorus Canyon) extends from the northern exit towards offshore and directs the outflow across the continental shelf. About 3 km from the exit, a sill of 60 m depth exists within the Bosphorus Canyon. The Canyon is initially in the northeast direction and after passing the sill it gradually turns north and finally to the northwest. The presence of the Mediterranean waters to the northwest of the exit, as observed in the earlier studies, is therefore explained by the steering of topography and had earlier remained puzzling because of the expectations of easterly bending on the basis of Coriolis effect.

At the sill, the flow is hydraulically controlled and after overflowing the sill it reaches the continental shelf region in the form of a gravity current. However, the presence of another control section at the constriction of the Bosphorus within its southern half imposes modifications on the nature of single control at the sill. A maximal exchange occurs between the Marmara and Black Seas and is often controlled by the combination of the constriction and sill controls. The presence of a constriction control on the high density basin side of the sill reduces the influence of the sill on the exchange and the control by the constriction dominates. Becuse of the widths at the sill and the constriction are different (the sill is narrower) the blocking of the lower layer can occur at smaller values of net barotropic currents as compared to the single sill case.

In the reported set of observations, these controls are evident and the Bosphorus underflow is observed to reach the Black Sea in almost all of the cases. However, during periods of strong northerly winds and peak Black Sea outflows blocking of the lower layer was observed for short periods (1-2 days). In such cases, the ordinary controlled flow conditions resume shortly after the transient forcing ceases. The interface depth varies nonlinearly between the two controls and is often close to the bottom in this region.