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The Levantine intermediate water outflow from the Strait of Sicily

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The Levantine Intermediate Water (LIW) reaches the Western Mediterranean Basin through the Strait of Sicily flowing over two sills 430 and 365 metres deep. Past the sills it enters first into the large valley delimitated by the Sicily and the Tunisia continental slopes, and by the M. Elimi chain to the North.

The LIW has three possible ways out into the western basin: directly toward the sardinia Channel, between M. Aceste and M. Drepano, and along the Sicily continental slope.

Seasonal hydrological surveys of the above area were carried out in the framework of the POEM Project in October 1986, March and September 1987, March 1988. The first results obtained from the distribution of salinity maximum, which is a good tracer of the LIW, are reported.

The isolines representing the salinity maximum obtained from the observed data indicate at first sight the area occupied by the LIW, their weak diluition along the "core" which points out the flow direction, and the cross gradient which gives an idea of the flow intensity (Fig. 1).

The larger influence of the deepr sill is easily recognized (this however does not exclude the transit of LIW over the shallover sill, where less dense water is observed).

The "core" of the LIW tends to dispose itself along the Sicilian side of the valley up to our farthest cross section, south of Ustica Island.

In the vicinity of the sill near to seamounts Drepano and Aceste a secondary branch stems out of the main flow and moves counterclockwise toward NW. One remarks in the vertical section (Fig. 2) that the former flow transports the upper part of the LIW, namely water lying between the depths of 300 and 400 m; the water underneath feeds the East flow of the LIW.

The seasonal changes appear through the shape and size of the areas the LIW occupy rather than through the salinity variations. Indeed these variations, after the CTD accurate calibrations, resulted in the range of errors.

In wintertime the flow is observed to be generally compact in comparison with the widespread one observed in summertime. Its deeper part follows closey the Sicilian side of the valley and moves Eastward. The shallower flow appears as a water tongue of more saline water than the other.

In summertime a displacement of the flow away from the Sicily is noted as well as some prevalence of the shallower flow with its transport toward the Sardinia Channel.

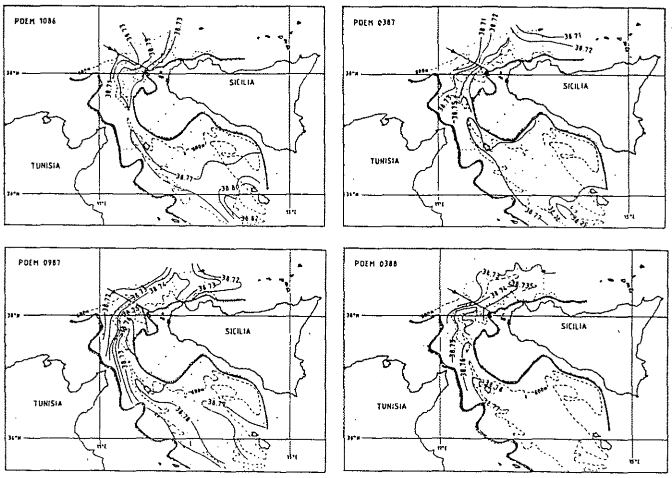

Fig. 1 - Salinity maximum distribution. The shaded line indicates the bottom boundary of LIW salinity maximum.

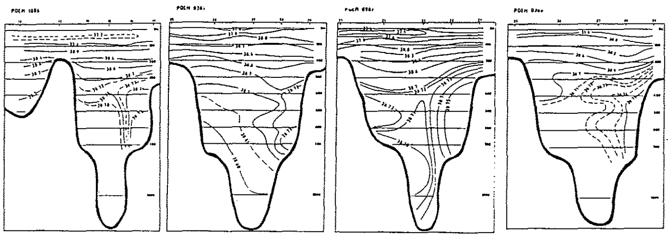

Fig. 2 - Vertical salinity distribution along cross section of Fig. 1.

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Mixing and internal hydraulic characteristics of Bosphorus exchange flow

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The main oceanographic features of the Bosphorus water exchange associated with its mixing and internal hydraulic characteristics are reported in the following using the findings from a total of 24 surveys of R/V Bilim comprising the period of November 1985-October 1987.

A persistent two-layer system of exchange normally takes place in the Bosphorus. The two-layer system attains marked seasonal variations depending particularly on the intensity of the Black Sea inflow at the surface layer as well as the shorter-term changes occuring in response to the prevailing wind conditions. The two-layer stable density stratification is dominated by the salinity, even though the temperature undergoes considerable seasonal variations. The salinity of the upper layer varies between 16.5-18.5ppt at the northern half of the Strait throughout the year, with the lower values indicating summer conditions corresponding to the peak Black Sea inflow (June-July). The salinity of the lower layer waters attains a maximum value of 38.5ppt near the Marmara exit region. The surface and bottom waters are separated by a sharp interfacial layer with an average thickness of 10m at the northern part of the Strait. The interface extends horizontally with a mild slope towards the constricted area and is situated close to the bottom (about 40-50m below the free surface). The transitional layer may be identified in the salinity transects by the zone located between the salinity limits of 16-22ppt and 33-38ppt. Towards the southern end of the Strait, significant changes take place with respect to the position of interface as well as the stratification, mixing and flow characteristics. This region is characterized by intense mixing of the bottom waters into the upper layer, a sharp upward tilt of the interface and the intensification of the upper layer currents. The vertical mixing results in a total increase of about 2-3ppt in the upper layer salinity between the two ends of the Bosphorus. The salinity of the northerly flowing bottom layer waters decreases accordingly by about 2-3ppt. The interfacial zone becomes much broader as compared with further upstream and has a thickness of 20-30m. The surface layer flow eventually exits from the southern entrance in the form of a turbulent buoyant jet.

Noteable changes encountered in the property fields and increased mixing observed in the southern Bosphorus are related with certain morphological features of the channel which effectively lead to hydraulic controls of the exchange flow. The contraction of the channel at the southern part of the Strait, the sills located to the south of the constricted region and immediately outside the northern entrance as well as the abrupt terminations of the channel at the exit regions of the adjoining seas evidently cause significant changes in the mixing and flow characteristics as the two distinct water masses traverse the Strait in opposite directions.

The observations generally indicate the presence of three internal hydraulic controls of the flow at the abruptly widening southern end of the Bosphorus, the constricted area and the crest of the northern sill. The internal hydraulic adjustment of the flow occuring within the constricted region near the Kandilli-Bebek section is observed in most of the surveys but no evidence for its existence could be observed in some cases corresponding to the periods of weak upper layer flows in the Strait. When the controlled flow condition exists at the constriction, the interface which is located at deeper levels to the north of the region is sharply elevated. In this way, the flow adjusts itself to the critical hydraulic condition, and the upper layer flow becomes supercritical immediately to the south of the constriction. Thereafter, the interface depth declines and the surface layer flow undergoes through an internal hydraulic jump so that it passes through another critical section at the southern exit region. The surface layer flow which becomes critical at the exit section enters into the adjoining Marmara region in a supercritical state. The supercritical flow is, eventually, matched to the subcritical flow of the Marmara Sea through an internal hydraulic jump taking place in the vicinity of the exit. The northern sill, on the other hand, exercises internal hydraulic control on the lower layer flow which almost permanently enters the Black Sea by flowing over the sill in the form of a thin plume. The blockage of the underflow can only take place temporally under extreme conditions of abnormally high Black Sea inflow into the Bosphorus. Under normal conditions, the effluent passing over the sill has a thickness of about 10m, and proceeds in the north-northwest direction towards the western Black Sea shelf in the form of gravity flow along the bottom slope.

As a result of these hydraulic controls, the two-layer water exchange between the Marmara and Black Seas will be determined by the conditions within the Bosphorus Strait, and not dictated by the conditions at the adjacent basins. In other words, depending on the average densities of the layers, the geometry and the magnitude of net southerly flowing barotropic flow, the critical controls will determine approximately the shape of interface established in the Bosphorus and the magnitudes of flows in the layers entering into the Strait from the upstream basins.