A "NATURAL" TRACER RELEASE EVENT IN THE WESTERN MEDITERRANEAN SEA

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Abstract

Oceanography is mainly an observational science where direct controlled experiments are hardly feasible. In the past some tracer release experiments have been carried out, that allowed to keep track of water parcels using stable compounds, in a classical lagrangian approach. Recently, intense deep water formation events in the western Mediterranean have produced high volumes of a new deep water, significantly warmer, saltier and denser than previously. These peculiar characteristics are mixing very slowly with the surrounding water and are still detectable in the whole basin. Thus, there has been a natural tracer release event where the tracer is temperature, or salinity, and for the first time we can track the evolution of the new deep water with standard CTD profiles, along its route from its formation region toward Gibraltar.

Keywords: Deep Waters, Western Mediterranean, Circulation

Since 2005 the deep waters of the western Mediterranean Sea (WMED) have experienced significant physical changes, which are likely to be caused partially by the Eastern Mediterranean Transient (EMT). This connection between the two basins, where one anomaly induced the other one decade later, may be a considered as a Mediterranean Sea Transient, MST [1].

The major change involved a change in the deep stratification, with an abrupt increase of temperature, salinity and density in the deep layers of the whole western basin [2]. The sharp signature (Fig. 1) provides for the first time the possibility to unequivocally identify the deep water formed during one specific winter throughout the basin, using only CTD data.

Repeat stations measured from 2005 to 2009 in wide regions of the WMED give the chronology of the new deep water spreading from its formation region towards Gibraltar and towards the Tyrrhenian Sea. Each year, the signature became evident in wider and wider regions, allowing a time-scale estimate of the spreading, which could only have been possible otherwise with a designed tracer release experiment. This time, the tracers are the sharp temperature, salinity and density increases in the bottom layer (Fig. 1).

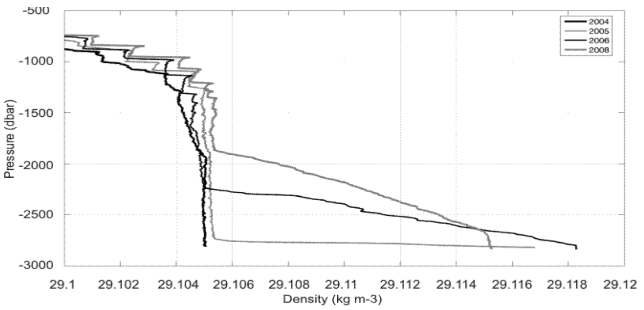

Fig. 1. Temporal evolution of the "tracer" signature (here density) south of the Balearic Islands.

For more than 25 years the scientific community is aware of the fact that the Mediterranean outflow is composed either by Levantine Intermediate Water (LIW), originating in the Eastern Mediterranean Sea (EMED), and by Western Mediterranean Deep Water (WMDW), which is aspired through the Strait of Gibraltar by Bernoulli suction [3, 4]. The direct outflow of the deep waters may affect the abyssal circulation of the Mediterranean Sea as well as the circulation of the adjacent ocean. In 2005 the new WMDW was found in a wide areas of the WMED, along its spreading pathway, even in the northern part of the Algerian subbasin and in stations near the entrance of the Alboran subbasin. In 2006 the new WMDW was present in almost the entire WMED, excluding the Tyrrhenian and the western Alboran subbasins. More recent data, collected in 2008, clearly show that the only subbasin that has not yet been reached by the new WMDW is the Tyrrhenian Sea. In 2008 the new deep water signature was found at the entrance of the shallower Alboran Sea (Fig. 2a), where its interface with the overlying water was at 950 m depth. Here the unequivocal identification of the winter-04/05 formed deep water near Gibraltar was possible thanks to the particular shape in the TS diagram. Therefore, its detection at about 100-150 km from the Strait of Gibraltar, allows an estimate of the temporal scales of its spreading: a deep water mass formed in February-March 2005 in the NW-MED has almost reached Gibraltar in 33 months.The fraction of new WMDW still seems to be very low and no signature could be found at stations west of Gibraltar. Nevertheless, the route of the WMDW hypothesized by [3] is confirmed. Indeed also the anomalous WMDW is flowing westward along the Moroccan continental slope, which is an indication of the anticyclonic Alboran gyre extending throughout the water column.

Most recent data (Nov. 2009) seem to detect an increase presence of the "tracer" along the axis of the canyon in the Sardinia Channel, on the way to the Tyrrhenian Sea (Fig. 2b). Fig. 2c evidences that the new WMDW has just got over the sill (1930 m) dividing the Algerian basin from the Tyrrhenian Sea.

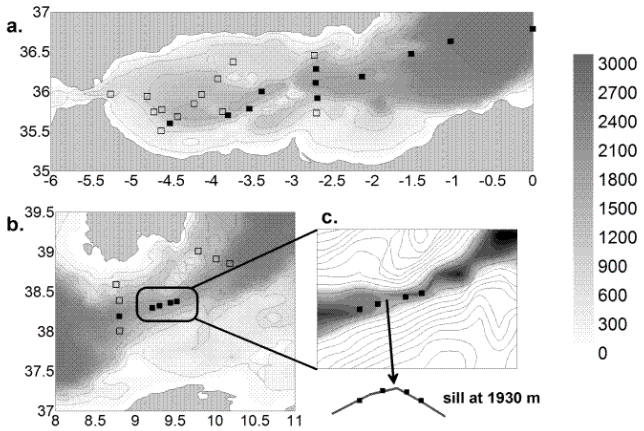

Fig. 2. CTD stations in (a) 2008 in the Alboran Sea and (b) 2009 in the Sardinian Channel, evidencing the spreading of the new WMDW (black squares = presence of new WMDW, empty squares = absence). (c) Zoom of the sill region in the Sardinian Channel (the bathymetric grey scale is for (a) and (b) only).

References

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