HYDROCHANGES AT GIBRALTAR

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Abstract
3-year T+S time series are now available at the sill (270 m) and on the Moroccan shelf (80 m). The outflow, observed at both places, displays a several-month non-seasonal variability; its denser part can clearly originate mainly from either the western or the eastern basin. The inflow encounters a huge salinification that could explain all changes observed within the sea. Results are detailed in papers published [1], submitted [2] and on hand [3].
Keywords : Strait Of Gibraltar, Hydrology, Monitoring.

Introduction
We first specify our basic understanding of the processes and our major feelings. For the outflow, we focused during the CIESM 2004 Barcelona HydroChanges Round Table on the fact that it originated, in 2003-2004 at least, mainly from the eastern basin with no recognisable western water, as was the case in the early 1980s and before. Because the early 1980s were intensively covered and the few data collected thereafter not analysed yet, it was generally assumed that the outflow's denser part was always composed of Western Mediterranean Deep Water (WMDW) from the western basin. Our feeling was that not enough attention was generally paid to the densest waters from the Aegean and Adriatic subbasins that form the Eastern Overflow Water (EOW) in the channel of Sicily. Indeed, EOW cascading down to 2000 m in the Tyrrhenian mixes with the resident waters (including WMDW) and forms the Tyrrhenian Dense Water (TDW). Depending on the amounts and characteristics of EOW vs. those of WMDW, TDW can be more or less different from WMDW, hence have an origin more eastern or western. And WMDW can be identifiable at Gibraltar only if produced in relatively large amounts; otherwise, it can outflow just as part of TDW! In any case, the outflow must be considered as composed of 3 different Mediterranean Waters (MWs): Levantine Intermediate Water (LIW) always outflowing on the strait's northern side, TDW always present with changing characteristics and WMDW that can be entirely included into TDW. For the inflow, the hypotheses published about the sea warming and salinification assume that the water of Atlantic origin (AW) has constant characteristics. Our feeling was that this should be checked at first, furthermore worldwide long-term changes are now specified.

Two moorings have been set on a small plateau at $\sim$ 270 m and on the outer continental shelf at $\sim$ 80 m near Tangiers to monitor the MWs and AW. They were initially deployed in mid-Jan. 2003 and serviced in early Apr. 2004 and in mid-Oct. 2005 (actually providing 30-month time series).

The results
About the outflow, we have first compared the 270-m time series in 2003-2004 with other time series in the mid-1990s and with all available CTD casts [1]. It is clear that the densest outflowing MWs have been continuously changing from the mid-1990s at least; T and S have been increasing, being in the early 2000s much warmer ($\sim$ 0.3°C) and saltier ($\sim$ 0.06) than $\sim$ 20 years ago, a feature possibly related to the Eastern Mediterranean Transient. This period is roughly period #1 in fig. 1 [2]. Points are very different from those representative of WMDW and very few characterise the MWs at 80 m. During period #2 (fig.1b), WMDW is still absent but more numerous values are retained at 80 m, and they are denser than at 270 m, an easily explainable feature [3]. In fig.1c, the outflow there is clearly of western origin, in particular at 80 m, while it comes to be composed mainly of TDW in fig.1d. There is clearly no seasonal variability in the composition of the outflow [3]. Various quantifications of the salinification at 80 m lead to $\sim$ 0.05/year during these 30 months (fig. 2) [2] which could explain alone both the salinification and the warming in the whole sea. In addition to homogenisation of the AW layer [2], such changes reduce the mixing with the MWs, hence leading to an outflow less and less mixed with the inflow [3].

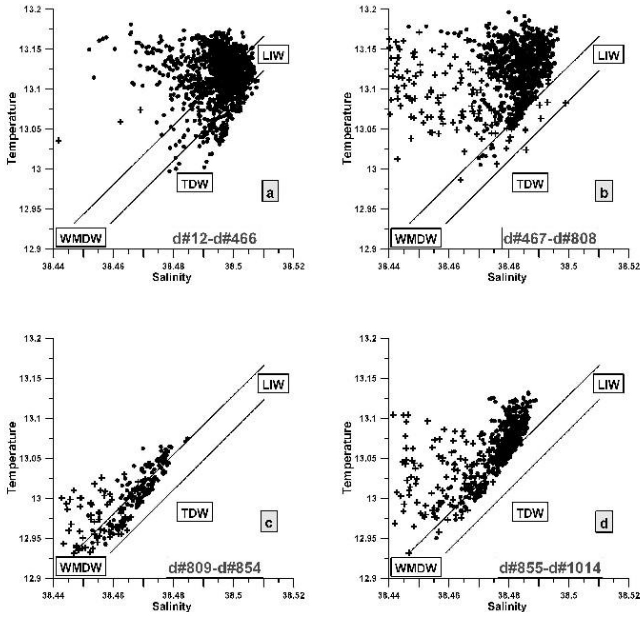

Fig. 1. θ-S diagrams from a selection of data aimed to represent relatively unmixed MWs at 270 m (.) and 80 m (+), separated in 4 periods (d#1 is Jan. 1, 2003), with 29.08 and 29.09 isolines.

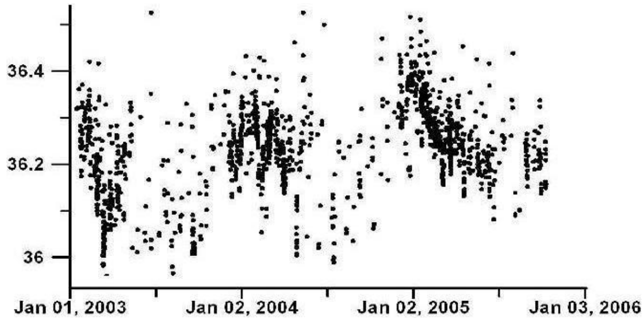

Fig. 2. Variation with time at 80 m of S values aimed to represent relatively unmixed AW.

References
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