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Physics and biogeochemistry along the MedSHIP high frequency transects in the Western Mediterranean Sea (cruise TALPRO2016)

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Abstract

In the past, the Mediterranean has been sampled sporadically in time and space, mostly by national expeditions in regional waters. An outcome of a CIESM Workshop (2012) was a recommendation for repeated oceanographic surveys of the Mediterranean in a programme called MedSHIP, to observe the changing circulation in a manner similar to the international GO-SHIP programme for the global ocean. Mediterranean marine scientists have designed a network of hydrographic sections on which comprehensive physical and biogeochemical properties will be measured to highest international standards on a regular basis. In 2016 the first cycle of repeat surveys along the MedSHIP network has been completed. Here the physics and biogeochemistry of the two meridional transects in the Western Mediterranean Sea are shown and discussed.

MedSHIP at a glance

Changes observed in the properties of the oceanic water masses around the globe can answer important questions about the sensitivity of the MOC to anthropogenic climate changes and the potential feedbacks on climate, ocean biogeochemistry and ecosystem functioning. As a response to this, the Global Ocean Ship-based Hydrographic Investigations Program, GO-SHIP, was initiated in 2007 (Sloyan et al., 2019). The program aims for promoting and coordinating repeat hydrographic investigations on the global scale in order to provide approximately decadal resolution of the changes in the budgets of heat, freshwater, carbon, oxygen, nutrients and transient tracers, covering the ocean basins from coast to coast and full depth, with measurements of the highest required accuracy to detect these changes.

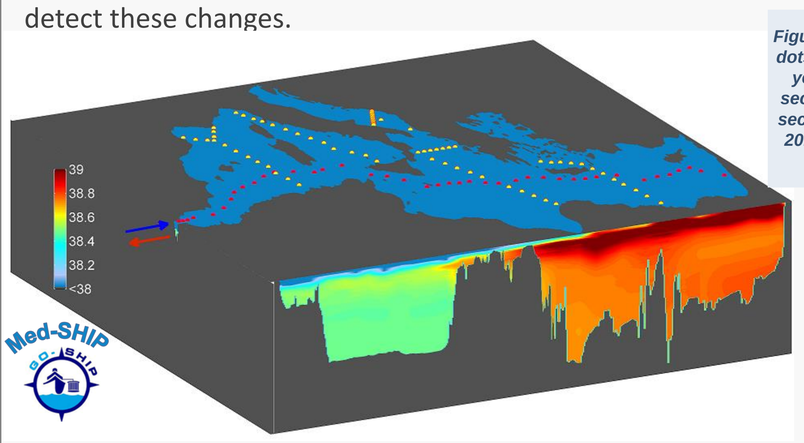

Figure 1: MedSHIP hydrographic sections. Red dots indicate the low-frequency zonal section, yellow dots the high-frequency meridional sections. The interior salinity along the zonal section is shown in color. Salinity data from a 2011 R/V Meteor cruise (Tanhua et al., 2013). From Schroeder et al. (2015).

GO-SHIP observations have clearly shown that the ocean, also below 2000 m, is variable and plays a significant role in the Earth energy and freshwater balance. So does the Mediterranean Sea. Marginal seas were originally not considered in the GO-SHIP program or in global data synthesis efforts as GLODAP. But the Mediterranean Sea can be regarded as a miniature ocean where processes occur faster and on smaller scales than in the open ocean. The Mediterranean ocean observing community is thus committed to making regular surveys of the Mediterranean, and have developed the MedSHIP initiative (Schroeder et al., 2015) to observe the changing circulation in a manner similar to the international GO-SHIP programme: on 5 hydrographic sections (Fig. 1) comprehensive physical and biogeochemical variables following the GO-SHIP guidelines should be measured to the highest international standards on a regular basis. The MedSHIP program consists of 2 north-south sections in each of the eastern and western Mediterranean and a zonal section from the Strait of Gibraltar to the easternmost Mediterranean.

In 2016 the meridional sections have been carried out in both the WMED and EMED, thanks to ship time offered by the Eurofleets2 call “Regional3”. The western cruise was TAlPro2016 (Jullion, 2016, station map in Fig. 2), while the zonal section, as part of the GO-SHIP program, has been repeated in 2011 and 2018. The western component of MedSHIP is now in the process of being recognized by GO-SHIP as “associated lines”, while the zonal component is now officially part of GO-SHIP, where it has been named MED01 line. Primary objectives for the MedSHIP repeat hydrography are to observe long-term changes in physical and biogeochemical properties and to observe changes in the thermohaline circulation. The deep Mediterranean has low DIC/TA ratio and low Revelle factor, being prone to accumulate more anthropogenic carbon than any other basin (Álvarez et al., 2014), and we want to know how fast and where this carbon is being taken up and transferred by circulation and the biological pump. The salinity and temperature of the deep Mediterranean have been increasing with time (Schroeder et al., 2016, 2017), and we want to document the changes and understand the processes that led to these increases. In the same context, the weakness of vertical mixing during the last winter convection episodes in the WMED revealed a decrease of dissolved oxygen concentrations in the intermediate waters. This change could impact carbon export and the mesopelagic marine ecosystems (Coppola et al., 2019).

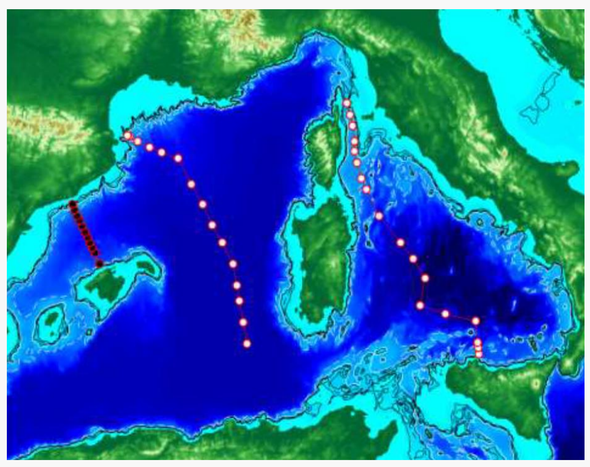

Figure 2: Station map of the TAlPro2016 expedition

TAlPro2016 findings

The TAlPro2016 cruise occupied two hydrographic transects across the Tyrrhenian Sea and the Algero-Provencal, plus an additional transect in the Catalan Sea. A total of 43 stations were occupied during which physical (temperature, salinity, pressure, velocity), biogeochemical (oxygen, nutrients, carbonate system, dissolved Barium, oxygen and nitrogen isotopes) and anthropic (CFCs, SF6) parameters were measured in order to monitor the physical and biogeochemical state of the Mediterranean. All data are available on PANGAEA (Tanhua, 2019a, 2019b).

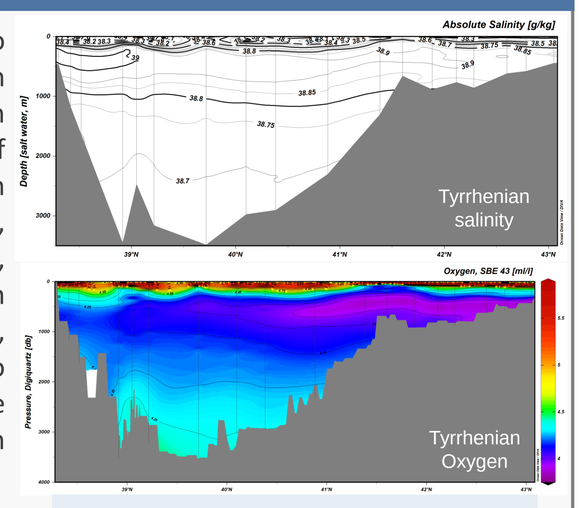

Figure 3: Vertical sections of Absolute Salinity (above) and dissolved oxygen (below) along the Tyrrhenian.

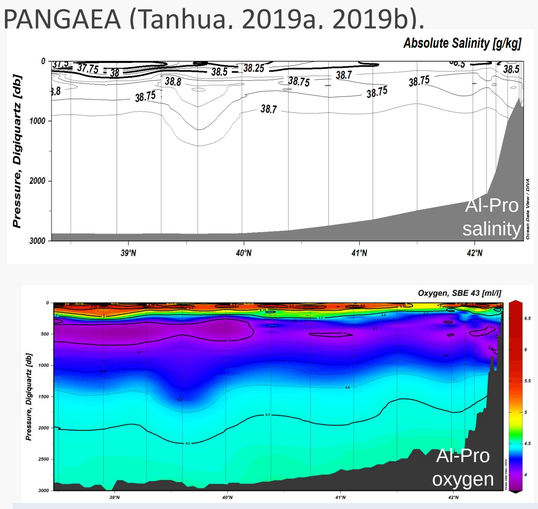

Figure 4: Vertical sections of Absolute Salinity (above) and dissolved oxygen (below) along the Algero-Provencal basin.

Along the Tyrrhenian section the southern and northern part clearly display different distributions of thermohaline properties and dissolved oxygen (Fig. 3). In the south the inflow (coming from the EMED) of relatively young LIW is evident, exhibiting high salinity and temperatures with a core at about 400 m. Going northward the salinity and temperature, but also oxygen, decrease with increasing age of this water mass. The recent ventilation in the deep layers of the Tyrrhenian Sea is also well evident in TS properties as well from transient tracers (SF6/CFC-12, Fig. 5 left), south of 40.5°N and below 2000 m, due to the ingression through the Sardinian channel (sill at 1930m) of newly formed deep water. While until 2005 only the “classical” old WMDW was found at the sill, the new denser WMDW (which started to form during the Western Mediterranean Transition, or WMT, Schroeder et al., 2016) started to cross it since then. It has been reported that in 2012–2015 the thickness of the modified deep layer increased to almost 1000 m and the signature of the WMT in the Tyrrhenian Sea was clear in almost all stations in the interior.

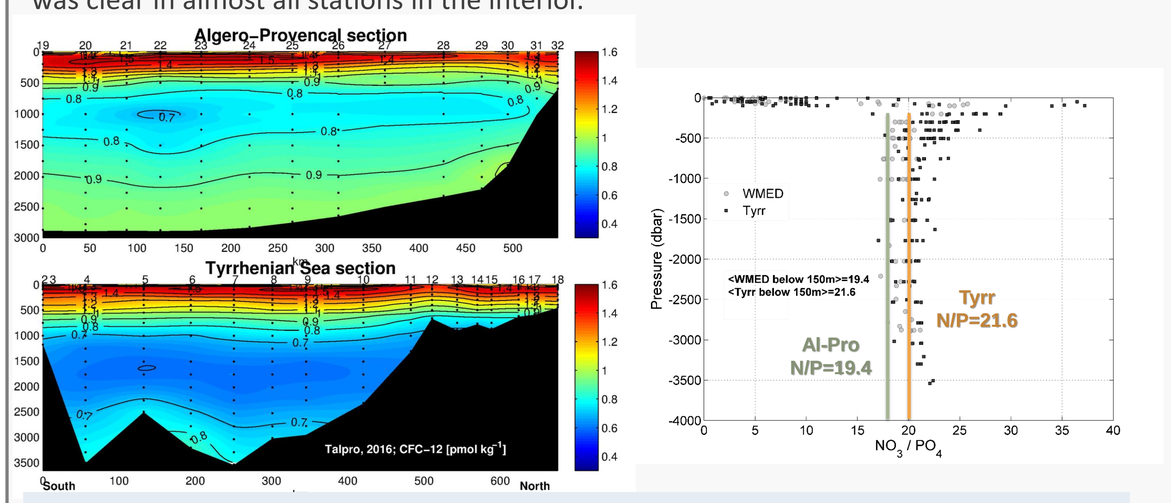

Figure 5: (left) Vertical section of CFC-12 along the two TalPro2016 sections, in the Algero-Provencal basin (above) and in the Tyrrhenian Sea (below), evidencing the recently ventilated bottom layer (data from Tanhua, 2019b). (right) Vertical profiles of NO3:PO4 ratios along the Tyrrhenian (black) and the Algero-Provencal (grey) sections

Along the section through the Algero-Provencal Basin (Fig. 4), the well-defined vein of AW flowing eastward, and coming directly from Gibraltar, is evident in the south, along the Algerian coast. It is essentially characterized by very low salinity and its signature involves the surface layer down to 250 m south of 39.5 °N. Recent ventilation can be identified at the bottom along the whole transect (Fig. 5 left, above), which in fact crosses the most active dense water formation site of the Mediterranean Sea. If compared to historical data, the whole water column appears to have warmed and become saltier, a tendency that is especially evident in the LIW layer, as already anticipated by Schroeder et al. (2017) who observed the acceleration of the T and S trends in the intermediate water crossing the Sicily Channel. The average NO3:PO4 ratios (Fig. 5, right) in the deep (>150 m) Tyrrhenian sea is slightly higher than along the Algero-Provencal section (21.6 vs 19.4), a feature that might be related to the higher oligotrophy (P-limited) in the Tyrrhenian if compared to the Algero-Provencal basin.

Outlook and future priorities

The second repetition of the western MedSHIP component has been recently proposed to use ship time offered by the EurofleetsPlus SEA call in summer 2021. The TAlPro2021 expedition will add some Level 2 and Level 3 parameters, with respect to TAlPro2016 (radionuclides, DOC, UVP, mooring and ARGO data).

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