DISTRIBUTION OF THE SURFACE AND INTERMEDIATE WATER MASSES INFERRED FROM THE XBT-THETIS 2 TRANSECTS ACROSS THE WESTERN MEDITERRANEAN SEA

Jean-Luc FUDA and Claude MILLOT

Centre d'Océanologie de Marseille, Antenne COM, BP 330, La Seyne/mer, France

The THETIS 2 experiment is conducted by IFM-Kiel, IACM-Heraklion, IFREMER-Brest and COM-La Seyne/mer within the framework of MAST 2 (SEND, 1995). Its aim is to check the capability of tomographic measurements to evidence large scale temperature variations in the western Mediterranean Sea. Among the 7 tomography moorings set in place for ~10 months in 1994 in the whole Algero-Provençal Basin, 2 have been positionned on the route closely followed by a tanker navigating between Fos/mer (~5°E, France) and Skikda (~7°E, Algeria). During that time, 24 calibrated XBT-T7 probes (accuracy of 0.05°C instead of 0.1°C; nominal depth ~760 m) have been launched, twice a month, every ~25 km between these two moorings. Beside the forthcoming tomography results, new valuable information about the distribution and variability of the Modified Atlantic Water (MAW), the Winter Intermediate Water (WIW) and the Levantine Intermediate water (LIW) has been collected which closely agrees with our schematic circulation diagrams (MILLOT, 1987) and analyses performed up to now. In the Gulf of Lions, the February sections were typical of the preconditionning phase of the Western Mediterranean Dense Water (WMDW) formation. A relatively cool (12.5-13.0°C) and thick (200-400 m) mixed layer was separated from below by a relatively thin (~100 m) thermocline (~0.5°C). Thereafter, due to exceptionally mild weather conditions, this whole surface layer was found, in mid-March, with a larger temperature (~13.1°C) before being entirely caped, in late March (fig.1), by an unusually warm (~13.5°C) superficial layer. Then, worse weather conditions occurred which led, in mid-April (fig.2), to a stratification similar to that encountered one month ago (mean temperature of ~13.1°C down to ~200 m). Even if the 25-km space scale is not sufficiently small to provide definitive information about mesoscale features, it is interesting to note that, during the whole experiment, the most homogeneous profile has been collected in mid-April. The North Balearic Front, which delimits the northward spreading of MAW in the Algerian Basin, is clearly evidenced near 40°30'N, mainly contrasting with the generally low stratification in the zone of dense water formation. From the beginning of May, the seasonal thermocline sets up, as usual.

According to our most recent analyses, WIW is cooled and homogeneized MAW which has been covered by less modified MAW advected from neighbouring places. Even if mainly formed in the northern part of the basin, it has been recognized by its temperature minimum in two specific places. One is just south of the North Balearic Front (~12.9°C at ~250 m) and often associated with an underlying lens of LIW, as if both water masses were entrained by a cyclonic rim current surrounding the zone of dense water formation. The other is in the Algerian Basin, where WIW appears as lenses with less low temperatures (~13.1-13.2°C). These lenses are supposed to have been entrained first from the Spanish continental slope to the Algerian one by the flow of recent MAW, and then in the interior of the Algerian Basin by mesoscale eddies.

Some of the LIW is distributed in a roughly similar way. In addition to its association with WIW south of the North-Balearic Front, LIW is found along the French continental slope clearly flowing westwards as a quasi-permanent vein (~13.4-13.5°C). The LIW having the less large temperatures, and thus expected to be the oldest and more mixed water, is generally found close to the Algerian continental slope. This clearly supports our recent hypothesis suggesting that, as WIW, LIW can be entrained too from Spain to Algeria, and then eastwards. Of major interest is the fact that the less-mixed LIW (up to ~13.9°C) is distributed in the interior of the Algerian Basin in the form of mesoscale accumulations (width sometimes greater than ~50 km, thickness up to ~200 m at 300-400 m). This distribution dramatically changes from one transect to the other (see fig.1 and 2). This LIW is relatively unmixed so that, according to our 1987 schematic diagrams, it is expected to have been entrained away from the Sardinian continental slope and then trapped by mesoscale eddies. In order to get more precise information about these accumulations, we presently take advantage of the return trip and launch, at a space scale as small as possible, standard XBT's.

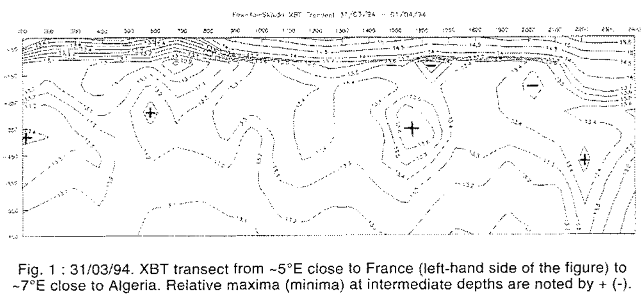


Fig. 1 : 31/03/94. XBT transect from ~5°E close to France (left-hand side of the figure) to ~7°E close to Algeria. Relative maxima (minima) at intermediate depths are noted by + (-).

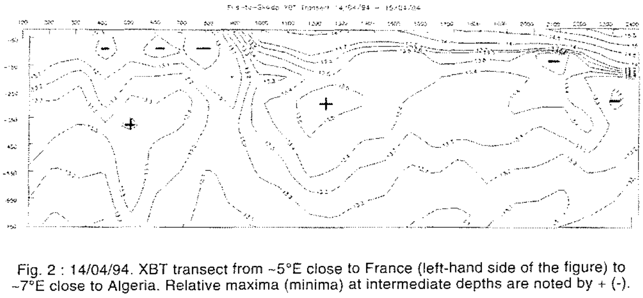


Fig. 2 : 14/04/94. XBT transect from ~5°E close to France (left-hand side of the figure) to ~7°E close to Algeria. Relative maxima (minima) at intermediate depths are noted by + (-).

REFERENCES

MILLOT C., 1987. *Oceanol. Acta*, 10, 2.

SEND U., 1995. *Rapp. Com. Int. mer Médit.*, 34.

SMALL SCALE FEATURES OF THE ALBORAN SEA CIRCULATION INFERRED FROM HYDROLOGICAL AND ICTHYOPLANCTONICAL DATA

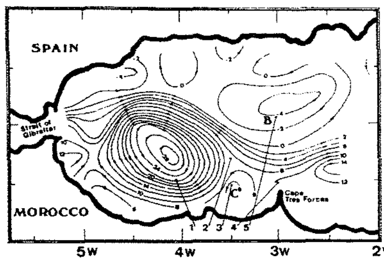
J. GARCIA LAFUENTE[1], N. CANO LUCAYA[2], J.P. RUBIN[2] and A. HERNANDEZ GUERRA[3]

[1] Department of Applied Physics II, University of Malaga, Spain

[2] Instituto Español de Oceanografia, Malaga, Spain

[3] Faculty of Marine Sciences, University of Las Palmas de Gran Canaria, Spain

In July 1993, the "Instituto Español de Oceanografia" carried out the ICTIOALBORAN-93 survey in the Alboran Sea, performing 65 hydrographic (CTD) and biological stations. Figure 1 shows the dynamic topography (cm-dyn) of the surface referred to 200 db. The western Alboran anticyclonic gyre appears well developed while the eastern gyre is notoriously smaller. West of Cape Tres Forcas, a reduced area of cyclonic circulation was observed (area C, fig. 1). The T-S characteristics of the surface waters here suggest that they have been drawn away from the northern part of the Atlantic Current (AC), (zone B, fig. 1) where warmer and saltier surface waters are found in summer. This is confirmed by the analysis of fish larvae distribution of three mesopelagic species whose adults live in open sea between 200 and 1000 m depth. Two of them, *Benthosema glaciale* and *Maurolicus muelleri,* are abundant north of 36°N in the Alboran Basin, where their maxima larvae concentrations were found. However, a noticeable abundance of them was also found in the core of this cyclonic area, south of 36°N, and negligible amounts in the stations around it. The simultaneous lack of larvae of *Ceratoscopelus maderensis* in the core confirms additionally the intrusive nature of this small-scale feature, since these larvae were found all over the southern portion of the western basin, that seems to be their adult's habitat. The presence of this surface water here could be explained by a significative north to south cross-stream ageostrophic circulation in the vicinity of Cape Tres Forcas or, alternately, by barotropic instability of the AC forced by the local topography. The second hypothesis seems more probable since this small-scale feature is not regularly observed, which would be the case under the first assumption. The variability of the Alboran Sea anticyclonic gyres and the inflowing AC has been (and still is) widely investigated by means of field studies (CANO & CASTILLEJO, 1972), satellite imagery (HEBURN & LaVIOLETTE, 1990), numerical (PRELLER, 1986) and laboratory (WHITEHEAD & MILLER, 1979) models. There is a general agreement on the key role played by topography in configuring the gyres. The small Alboran island and the prominent Cape Tres Forcas, near 3°W, must have influence not only in the size and location of the Western gyre but on the formation and size of the Eastern one, for the AC enters the eastern basin following a path which lies between both of them.



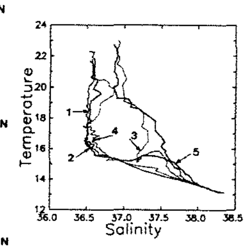


Fig. 1 (left). Dynamic topography of the sea surface referred to 200 db. Numbers 1 to 5 label hydrographic stations whose T-S diagrams are shown in fig.2.

Fig. 2 (right). T-S diagrams. The arrows identify the stations and indicate the depth of 50 m.

Satellite imagery is a powerful tool to study the time variability of the gyres, provided that the surface thermal structures reflect the underlying dynamics. HEBURN and LaVIOLETTE analyzed a considerable set of images from the years 1982 and 1986. All of the images belonged to one of the three situations sketched in figure 3, the simultaneous absence of both gyres never being observed. From the results of their analysis it is not possible to elucidate which is the most likely situation; the actual situation seems to evolve continuously. The path of the AC in the Alboran Sea can be modelled as a baroclinic Rossby wave strongly modified by topography, which reduces its "natural" length-scale to make it fit into the basin (PRELLER 1986, HEBURN & LaVIOLETTE, 1990). From this point of view, situation 3-a seems more unstable than either 3-b or 3-c, due to the strong curvature of the stream in the southern meander. For instance, what would happen if conditions in the inflowing Atlantic Water (AW) through the Strait of Gibraltar were changed and the size of A_1 increased ? Part of this AW should remain inside A_1 and, as it grows up, the curvature of the Jet near Cape Tres Forcas would be emphasized, favouring barotropic instability and cyclonic eddy shedding, which would remain trapped between A_1 and the African coast. Water parcels of the leftwards side of the stream (looking downstream) should be caught during the instability. After the eddy shedding, the AC would enter the eastern basin following a more eastward direction. Less AW is arriving at the eastern basin during the growth of A_1 and, probably, the size of A_2 would be reduced if part of the AW inside it is drained to feed the Algerian Current. All this would lead to situation 3-c from 3-a. In the frame of this highly simplified dynamics, the ICTIOALBORAN-93 survey would have been carried out shortly after the hypothetical shedding, as the water of its core is still distinguishable from the surrounding waters.

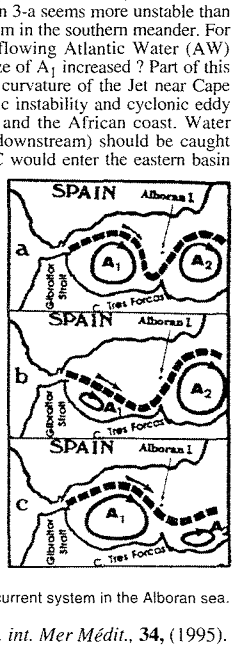


Fig. 3.Three possible situations of the gyres current system in the Alboran sea.

REFERENCES

CANO N. and CASTILLEJO, F., 1972. Contribucion al conocimiento del Mar de Alboran: variaciones del remolino anticiclonico. *Bol. Inst. Esp. Oceanogr.* ,157 : 3-21.

HEBURN, G.W., LA VIOLETTE,P., 1990. Variations in the structure of the anticyclonic gyres found in the Alboran Sea. *J. Geophys. Res.*, 95 : 1599-1613.

PRELLER R., 1986. A numerical model study of the Alboran Sea gyre. *Prog. Oceanogr.*, 16 : 113-146.

WHITEHEAD J.A., MILLER A.R., 1979. Laboratory simulation of the gyre in the Alboran Sea. *J. Geophys. Res.*, 84 : 3733-3742.