

WATER MASS SPREADING PATTERNS AND LARGE-SCALE CIRCULATION OF THE EASTERN MEDITERRANEAN SEA INFERRED FROM NEUTRAL SURFACE ANALYSIS

Athanasios J. THEODOROU

Department of Agriculture, Crop and Animal Production, University of Thessaly
Pedion Areos, Volos, 383 34, Greece

The general features of the water masses and their circulation patterns in the Eastern Mediterranean have been known for some time - see, *inter alia*, EL-GINDY and EL-DIN (1986), MALANOTTE-RIZZOLLI and HECHT (1988), OZSOY, HECHT and UNLUATA (1989). The aim of the present study is to infer the quantitative circulation patterns of the Levantine Intermediate Water (LIW) and of the Deep Water (DW) within the Eastern Mediterranean Sea via neutral surface analysis based techniques.

To this end, first the idea of a "perfect" neutral surface is re-explored and some possibilities for approximating the latter are comparatively examined, leading to the introduction of a new modified version of the "central-reference-pressure" (THEODOROU, 1991) approach; the latter in conjunction with CTD data collected within the framework of POEM experiments supported with historical hydrographic data is used to obtain a number of neutral surfaces on which the spreading of LIW and DW will be examined.

Neutral Surface Analysis. The salinity distribution on those neutral surfaces was qualitatively examined and detailed patterns of the spreading of LIW and of the DW within the eastern Mediterranean were inferred. The topographies of the neutral surfaces were found to follow closely the configuration of the bottom bathymetry. The isohalines on all neutral surfaces were approximately parallel to the depth contours of the respective topographies, and the salinity maxima persisted for hundred of km without being eroded. Vertical mixing was important in the source regions of the two main water masses, whilst all features of the three dimensional salinity distribution could be accounted for in terms of lateral mixing and flow.

Water Mass Analysis. Plots of oxygen versus salinity on the neutral surfaces enabled the identification of the characteristics of the source waters and also of the number of water types involved in the mixing. Within this framework a variant of the technique of "mixing triangles" was employed and quantitative spreading patterns of the unmodified LIW on a number of neutral surfaces were obtained; these results were coherent with the inferences from the analysis of the salinity distribution on the same neutral surfaces

Dynamic Inferences. Using "composite sectional diagrams" dynamic inferences were made: these inferences in conjunction with the associated thermohaline alternations provided a description of the modification patterns of the LIW and of DW along their respective courses. In the same context, occurrence and development of mesoscale "disturbances" and loci of possible cross-isopycnal mixing were identified.

Geostrophic Fluxes. The qualitative picture of the flow field, obtained from the configuration of the neutral surfaces, under the assumption of geostrophy, was quantitatively examined by the computation of geostrophic currents and transports. The latter were further analysed, in conjunction with the mixing triangles defined within the study area, and numerical estimates of the relative proportion of the main water masses were obtained.

Circulation Patterns. The results were combined within the constraint of mass balance and in conjunction with the spreading patterns deduced, produced detailed quantitative patterns of the large-scale time mean flow of the intermediate and deep waters of the Eastern Mediterranean.

REFERENCES

- EL-GINDY A. A. H and EL-DIN S. H., 1986. Water masses and circulation patterns in the deep layer of the Eastern Mediterranean. *Oceanologica Acta*, 9, (3): 239-248.
MALANOTTE-RIZZOLI P. and HECHT A., 1988. Large-scale properties of the Eastern Mediterranean: a review. *Oceanologica Acta*, 11, (4): 323-336.
OZSOY E., HECHT A. and UNLUATA U., 1989. Circulation and Hydrography of the Levantine Basin. Results of POEM coordinated experiments 1985-1986. *Prog. Oceanog.* 22: 125-170.
THEODOUROU A. J., 1991. Some considerations on neutral surface analysis. *Ocean. Acta*, 14(3): 205-222.