TWO DECADES OF MONITORING AND FORECASTING OF THE CIRCULATION IN THE LEVANTINE (1995-2016)

G. Zodiatis [1]*, I. Gertman [2], . Poulain [3], M. Menna [3] and S. Sofianos [4]
[1] Oceanography Centre, University of Cyprus - gzodiac@ucy.ac.cy
[2] Israel Oceanographic and Limnological Research, Haifa, Israel
[3] Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Trieste, Italy
[4] University of Athens, Athens, Greece

Abstract
The in-situ data gathered the last two decades in the Levantine Basin from several hydrographic campaigns (CYBO, CYCLOPS, MSM/14, Haifa-Sec), the Argo floats, the drifter deployments (NEMED project) and several gliders missions, along with data provided by the well established operational numerical modeling systems of ALERMO, CYCOFOS and SELIP, nested in MFS (nowadays in Copernicus marine service), have all provided insight on the dominating meso-scale coherent circulation features of the basin and their variability. The above long term in-situ monitoring and forecasting provides also extend of the main waters masses characterizing the area and demonstrates the increase of the temperature and salinity not only at the surface and subsurface layers, but also in deep waters, through these twenty years.

Keywords: Levantine Basin, Mesoscale phenomena, Salinity, Temperature

Preface. In the 1980s, during the mutli-national POEM cruises [1], a detailed pattern of the meso-scale circulation in the Levantine Basin was defined, and consisted of several alternative cyclonic and anticyclonic eddies and gyres, an offshore cross basin jet, the Mid Mediterranean-MMJ, as well as the anticlockwise current along the coasts of the basin. The dominant flow feature in the open part of the Levantine was identified to be a non-permanent multi-pole gyre, the Shikmona that consisted of few eddies, of which the most northern one, the Cyprus warm eddy is the most well pronounced. The present work aims to provide an overview of the meso-scale hydrodynamical features of the Eastern Mediterranean - Levantine Basin, based on synoptic in-situ data obtained the last 20 years, after the POEM cruises, from various observing platforms, as well as from the well established operational numerical models in the basin, assimilating satellite and in-situ data.

Discussion and Results. The new data sets obtained from in-situ investigations in the Levantine Basin, in the frame of CYBO, CYCLOPS, MSM/14, Haifa-Sec (Figure 1) and NEMED research projects made possible to provide, after some years of scientific disputes on the circulation pattern of the basin, as presented in [2], strong evidences about the seasonal and inter-annual variability of the main hydrodynamical features of the basin, such as the MMJ, the Cyprus warm eddy, the Shikmona eddy generation and the periodical re-establishment of the Shikmona gyre [3,4]. Based on these new in-situ data sets, it is evident that the Cyprus warm core eddy is the dominant feature in the area, with significant fluctuations in time and space. The generation of the Shikmona gyre as a non permanent eddy, was observed as a result of the fluctuation of the northward current along the eastern coastline of the Mediterranean. The latter is also evident in the drifter trajectories, gathered by the NEMED project that showed that this eddy is detached from the northward current towards the area of the secondary eddy, as observed by CYBO cruises and the CYCOFOS forecasts. Initially, the secondary warm eddy observed at the SE end of the Levantine was found during periods when the Cyprus warm eddy became weaker and shifted westward or southward from Eratosthenes SM. During theses long term observing campaigns it was found periodically the re-establishment of the Shikmona gyre, when the co-existence of the Cyprus and Shikmona warm eddies were observed. With the development of the ocean predictions-hindcasts and the possibility of assimilation of in-situ and satellite data, the Mediterranean Forecasting System-MFS depicted an improved pattern of the circulation in the Eastern Mediterranean Levantine, showing the co-existence of the anticlockwise along shore and the offshore cross basin currents [5]. Similarly, the higher resolution numerical datasets from ALERMO, CYCOFOS and SELIPS forecasting systems, all nested in MFS, reveal that the dominant flow features in the SE Levantine is the Cyprus warm core eddy. The Shikmona eddy, which is generated during periods when the Cyprus eddy becomes weaker and/or shifted westward or southward from Eratosthenes SM, and when the strong northward current flowing along the Israel-Lebanese coast becomes unstable. The latter is also evidently in drifter trajectories, deployed during the NEMED project. The drifter trajectories show an anticyclonic eddy to be detached from the prevailed northward current along the coast. Synthesis of circulation patterns derived from the in-situ and numerical data sets obtained in the Levantine during 1995-2016, provide a typical picture of the meso-scale circulation, where: a)the Cyprus and Shikmona eddies, as well as the MMJ are the dominant flow features; b)the Cyprus warm eddy presents strong spatial and temporal variability; c)the variability of the displacement of the Cyprus warm eddy affects the MMJ and the eastward transfer of the AW; d)The Shikmona eddy was found to be established for certain periods, when the Cyprus eddy shifts to the west, south-west; e) the MMJ flows along the northern periphery of the Cyprus eddy and is the major current transferring the AW in the area.

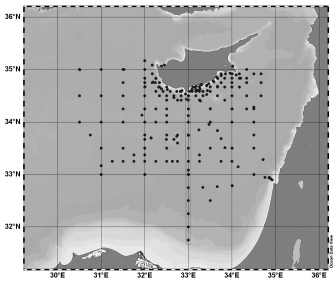

Fig. 1. Figure 1 : Maps with CTD stations in the Levantine during CYBO cruises from 1995-2010, CYCLOPS, MSM/14, Haifa-Sec and during the PERSEUS project, in the frame of the CYBO-HaiSec cruises in October and December 2012 and March 2013.

References
1 - POEM group, (1992). General circulation of the eastern Mediterranean, Earth Sci. Rev., 32: 285-309.
2 - The Climate of the Mediterranean Region, from the past to the future (2012) . P. Lionello Editor, 590 p. ISBN 9780124160422. Elsevier. Circulation of the Mediterranean Sea and its variability, 187-256.
3 - Zodiatis G., Drakopoulos P., Brenner S., Groom S., (2005). Variability of the Cyprus warm core Eddy during the CYCLOPS project, DSR- II, 52, 2897–2910.
4 - Menna, M., P.M. Poulain, G. Zodiatis, I. Gertman, 2012, On the surface circulation of the Levantine sub-basin derived from Lagrangian drifters and satellite altimetry data, DSR- I, 65, 46-58.
5 - Pinardi Nadia, et. al.(2015). Mediterranean Sea large-scale low-frequency ocean variability and water mass formation rates from 1987 to 2007: A retrospective analysis. Progress in Oceanography Volume 132, 318–332.