CIRCULATION OF THE MARMARA SEA

Aysin Yilmaz *, Şükrü Besiktepe and Erdem Sayin

METU, IMS (Institute of Marine Sciences), Erdemli/İçel, Turkey - sukru@ims.metu.edu.tr

Abstract

The circulation of the Marmara Sea is studied using data-driven primitive equation simulations. The data are drawn from basin wide cruises carried out during 1991-1995 by R/V Bilim of the Institute of Marine Sciences of Middle East Technical University.

Keywords : Aegean Sea, Black Sea, Circulation, Hydrology, Marmara Sea.

The general water movement characteristics are given by Killworth's Ocean General Circulation Model (OGCM) based on the primitive equations as described by [1] and [2]. The main modification is to explicitly include a free surface. The horizontal resolution is about 1 km with 89 and 261 grid points in the latitudinal and longitudinal directions, respectively. The vertical is discretized with 13 levels. The grid spacing in the upper layers is finer than in the layers below.

The BSW (Black Sea Water) enters to the Marmara Sea from north through the Bosporus as a surface water, due to the sea level difference between the Black Sea and the Marmara Sea. The ASW (Aegean Sea Water) enters to the Marmara Sea from west through the Dardanelles strait as an intermediate water, due to the density difference between the Aegean Sea and the Marmara Sea [3] (Figure 1 and Figure 2).
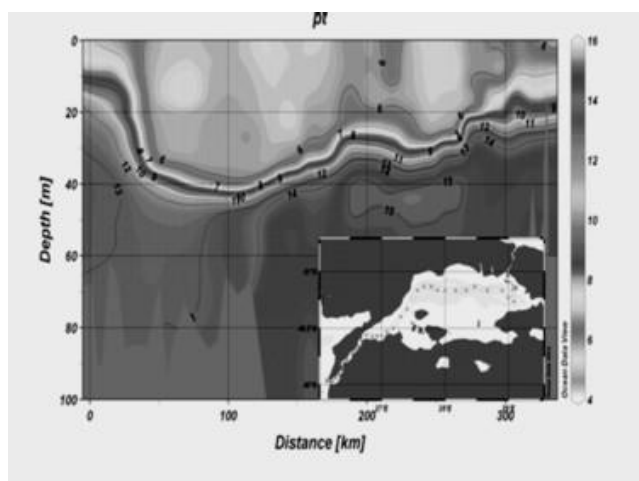

Fig. 1. Dardanelles - Bosporus potential temperature cross section for February 1993

During high discharge from the Bosphorus (e.g. March 1992), the currents at the surface were predominantly directed southward and concentrated on the left of the downstream flow. At the exit section of the Strait into the Sea of Marmara, current velocities reached 300 cm/s, due to the small extent of the upper layer. Away from the Bosphorus-Marmara junction region, the velocities were of the order of 20 cm/sec. These measurements also reveal the presence of the anti-cyclonic circulation of the Bosphorus outflow in the Marmara Basin.
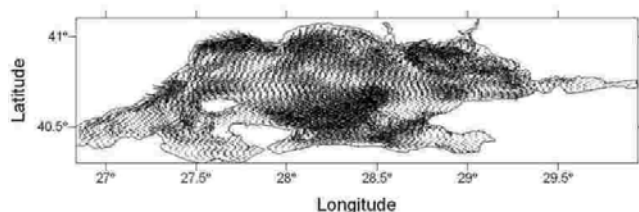

Fig. 2. Barotropic circulation pattern for February 1993

During the low discharge periods (e.g. October 1991), the upper layer flow exiting from the Bosphorus is not as well defined and contrary to the direct southward flow. A right-hand attachment of the outflow, i.e., to follow the Thracian coast was observed. Outflow velocities were measured to be about 30 cm/s even in the exit region of the Bosphorus. The mean flow was the basin scale anti-cyclonic circulation. The model sensitivity studies show that the upper layer circulation patterns are set up by the sea-level differences between the Black Sea and the Aegean and modified by the winds.

Mediterranean water coming through the Dardanelles sinks to the deeper layers of the Marmara Sea and moves to the east. The sinking depth of the Mediterranean water is controlled by buoyancy.

Modelled circulation patterns of the Marmara Sea are found to be consistent with ADCP measured currents.

References

1 - Bryan K., 1969. A numerical method for the study of the circulation of the world ocean. *Jour. Comp. Physics,* 4: 347-376.
2 - Cox M.D., 1984. A primitive equation, 3-dimensional model of the ocean, *GFDL Ocean Group Tech. Rep.*, 1.
3 - Besiktepe S.T., Sur H.I., Ozsoy E., Latif M.A., Oguz T. and Unlüata U., 1994. The circulation and hydrography of Marmara Sea. *Prog. in Oceanogr.,* 34: 285-334.