FLUXES OF ^{137}CS IN THE SYSTEM BLACK – MARMARA - NORTH AEGEAN SEAS

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Abstract
The inventory of ^{137}Cs in the Western Black Sea at 2000 m water depth is presently 3.4 kBq m^{-2}, not significantly different from that measured in 1988, but about 1 kBq m^{-2} was transferred from the surface layer to the depth interval 100-400 m. 12 TBq y^{-1} of ^{137}Cs leave the Black Sea in the surface layer through the Bosphorous and only 2 TBq y^{-1} are brought back in association with the Mediterranean water from the Marmara Sea. The most important mechanism transferring ^{137}Cs and dissolved contaminants from surface Black Sea to the sub-picnoclyne layer is mixing on the southwestern shelf, at the exit from Bosphorous, between Mediterranean Water and surface water, producing an extra export of some10 TBq y^{-1} of ^{137}Cs from the surface layer.
Keywords: Black Sea, Marmara Sea, Radionuclides

Introduction and objectives
Due to the intense direct Chernobyl fallout and to the delayed input from rivers, the Black Sea has become a point source of radionuclides to the Mediterranean Sea. Some of these, like the long lived ^{137}Cs, are still easily detectable in the Black Sea and traceable along their pathway in the North Aegean Sea. The determination of the spatial distribution of ^{137}Cs in the system Black – Marmara – N. Aegean Sea can greatly help in elucidating the exchanges of dissolved contaminants among the basins and the role of the Turkish Straits System (TSS) in the contaminants budget of the Black Sea.

Study area
In the Black Sea freshwater input from large rivers (Danube, Dniepr, Dniestr and Don) and precipitation largely exceed loss by evaporation.The density-driven two-layer exchange flow through the Straits carries the excess of Black Sea Water to the Mediterranean and the saline Mediterranean water first to the Marmara Sea and then to Black Sea. This hydrological balance supports a stable environment, with two main components: colder, fresher, surface waters overlying warmer, more saline deep waters, separated by a permanent pycnocline [1, 2]. In May 2007 seawater samples were collected by IMS-METU in the different water masses of two of the three deep basins of the Marmara and in the Western Black Sea for the characterization of present ^{137}Cs vertical profiles and for a first estimate of the fluxes of the radionuclide in the TSS. We also present here the ^{137}Cs vertical profiles measured in 2001 in the N. Aegean Sea, to characterize the input of the radionuclide to the TSS in the Mediterranean Water flow (Fig. 1).

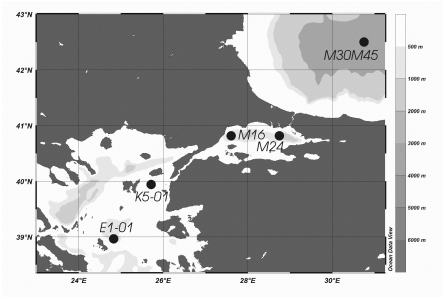

Fig. 1. Study area and sampling sites.

Results
In the Black Sea, surface concentrations are about 20 Bq m^{-3} and, decreasing almost exponentially, reach a constant value of 0.7 Bq m^{-3} at a depth of 600 m. Comparing this profile with that obtained in 1988 in a nearby station [3], ^{137}Cs concentration below the halocline has significantly increased, while the levels in surface water are less than a half of what expected from physical decay only. The inventories have not significantly changed: 2.9 kBq m^{-2} in 1988 (decay corrected to 2007) and 3,4 kBq m^{-2} in 2007. The increase at depth below the halocline, in this deep-sea area, compensates the loss at the surface. In the Marmara Sea surface concentrations are about 15 Bq m^{-3}, decreasing to about 4 Bq m^{-3} in the underlying Mediterranean water. The ^{137}Cs concentration in the Mediterranean Water entering the Dardanelles was assumed to be 3.5 Bq m^{-3}, mean value of the ^{137}Cs concentrations in the depth interval 50-300 of the N. Aegean Sea, corrected for physical decay to 2007. Based on ^{137}Cs concentrations in the different water masses and on volume fluxes estimated by Besiktepe et al. [2] we have estimated the fluxes of the radionuclide in the Turkish Straits System (Fig. 2).

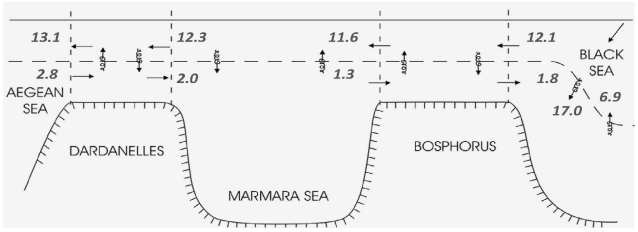

Fig. 2. Mean annual fluxes of ^{137}Cs (10^{12} Bq y^{-1}) in the TSS.

Conclusions
In the Western Black Sea, at 2000 m water depth, about 1 kBq m^{-2} of ^{137}Cs was transferred from the surface layer to 100-400 m in the period 1988 - 2007. Presently about 12 TBq y^{-1} of ^{137}Cs leave the Black Sea in the surface layer through the Bosphorous and only 2 TBq y^{-1} are brought back with the Mediterranean water from the Marmara Sea, resulting in a net annual loss of 10 TBq y^{-1}. The inflow of Mediterranean water alone does not explain the increase of ^{137}Cs concentration and inventory at intermediate depth in the Western Black Sea. The most important mechanism transferring ^{137}Cs and dissolved contaminants from surface water to the sub-picnoclyne layer appears to be the mixing on the southwestern shelf, at the exit from Bosphorous, between inflowing Mediterranean Water and Black Sea surface water. This process produces an extra export of some10 TBq y^{-1} of ^{137}Cs from the surface layer. It is the advection of this water towards the Black Sea deeper layer (200-600 m) that maintained the inventory constant with time.

Aknowledgements
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References
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