Black Sea thermo-haline structure

Sukru Besiktepe (IMS)

The Black Sea has a specific hydrological structure of the water that is due to a restricted water exchange with the other parts of the World Ocean and an inflow of water masses of polar characteristics. River run-off contributes a main bulk of fresh water and is concentrated, basically, in the north-western part of the Black Sea. The water of the Sea of Azov has salinity of 10-14‰ and enters the north-western part of the sea through the Kerch Strait as a lower layer Bosphorus Straits flow.

The Black Sea basin has a volume of 550,000 km^3. The mean many-years water budget inflow comprises about 710 km^3/year that consist of river run-off (about 50%), precipitation (about 20%), inflow of Sea of Azov water (7%) and the Marmara Sea inflow (24%). The losses, at zero inflow/loss balance, comprise evaporation (46%), outflow of more or less fresh surface water to the Marmara Sea and, later, to the Aegean Sea (51%) and the outflow to the Sea of Azov (3.3%).

The most peculiar features of the vertical structure are: thin (20-100 m) less saline surface water layer with considerable seasonal temperature variations within 0-50 m and a much more thick (1,500-2,000 m) salt water layer with the inverse temperature distribution; existence of the permanent halocline in the upper layer or existence, partially and above it in the warm half of the year, of cold intermediate layer with absolute vertical minimum of temperature; and the initial input of salinity into the density stratification of the water.

On the whole, it is possible, using sometimes slightly different criteria, to single out about 6 types of water masses in the open part of the Black Sea: the shallow Black Seawater mass (SBSWM), the upper Black Seawater mass (UBSWM), the cold intermediate layer (CIL), the intermediate Black Seawater mass (IBSWM), the deep Black Seawater mass (DBSWM) and the bottom Black Seawater mass (BBSWM) (Table 2.5).

Some authors include CIL into the surface water mass and do not single out the IBSWM as an independent mass as they consider the permanent halocline zone to be an intermediate layer. The CIL water is formed by two basic winter sources: the north-western shelf (NWS) and the cyclonic whirl centres in the open sea. The coldest but relatively fresh water mass is formed in the north-western shelf wherefrom it extends southward losing a part of its coldness and gaining salinity. Gradually submerging into the convergence zone at the depth fall, they form the upper CIL core. Further extension of subsurface shelf water towards the open sea during winter and spring is not observed while in summer and autumn it is possible if the general cyclonic circulation system is ruined.

The lower and denser CIL water core in the convergence zone make the water that flows down from the central divergence zone domes. Of particular interest is the seawater mass that characteristics and a possible formation mechanism were specified in the first half of the 90s in the course of high-precision measurements performed during HydroBlack and CoMSBlack experiments. The boundary between the deep and bottom waters are easily defined by means of the vertical distribution of thermohaline characteristics: the bottom water indicates complete homogeneity of these characteristics. The top boundary of bottom water is located at about 1,750 m depth. Heat flow from the bottom creates a super adiabatic temperature rise that contributes to a development of convection in this bottom layer.

It is quite hard to interpret water masses of the NWS. First, it is due to a great volume of river water that comes from several sources of various capacities. Shallow shelf factor leads to a considerable impact of variable winds on surface currents, so the regime of drift re-distribution of water masses turns to be rather complicated.

Detailed hydrophysical survey data obtained in the NWS shelf in 1990-1994 during sea expeditions by UkrSCES research vessels made it possible to carry out a volume and statistical

analysis of water masses and determine the annual variability of the shelf water thermohaline condition. In total, three subtypes of water were distinguished in the SBSWM: near estuary water mass (NEWM), shelf water mass (SWM) and shelf water mass of Karkinit Bay (SWMKB). The central and south-eastern areas of the NWS have a relatively small volume of surface water mass in the open sea, which is a slightly transformed shelf version of the UBSWM) (Table 2.6).

A general view of the two-dimensional water mass distribution in the T,S = coordinate system that were obtained on the basis of the volume and statistical analysis of five surveys is shown in Fig. 2.2. In order to visualize the shelf water variability, the boundaries of thermohaline changes in the intermediate and deep water of the open sea are shown with dotted line.

Table 2.5 Main water masses of the Black Sea

Season	Volume (km^3)	Salinity (10^6t)	Enthalpy, (10^{15}J)	Average salinity (‰)	Average potential thermperature (°C)
SBSWM (salinity < 17‰)					
Winter	117	1904	1881	16.04	3.90
Spring	390	6346	20259	16.09	12.22
Summer	438	7164	35253	16.26	19.96
Autumn	233	3818	11901	16.20	11.68
UBSWM (17‰ < salinity < 18.6‰)					
Winter	20996	390231	666338	18.32	7.83
Spring	21013	389785	847413	18.30	9.95
Summer	20161	372989	1157398	18.26	14.19
Autumn	20177	373501	1002336	18.26	12.27
CIL (18.6‰ < salinity < 20‰)					
Winter	20518	401227	649176	19.26	7.81
Spring	20949	409833	661648	19.27	7.79
Summer	19597	382970	623946	19.25	7.86
Autumn	18884	368877	612453	19.24	8.00
IBSWM (20‰ < salinity < 22.2‰)					
Annual	232923	5154106	8287159	21.76	8.80
DBSWM (salinity ≥ 22.2‰)					
Annual	263581	5979068	9590970	22.30	9.00
BBSWM (depth > 1750 m)					
Annual	N/A	N/A	N/A	22.333	8.895

Note: DBSWM characteristics have been calculated together with the BBSWM.

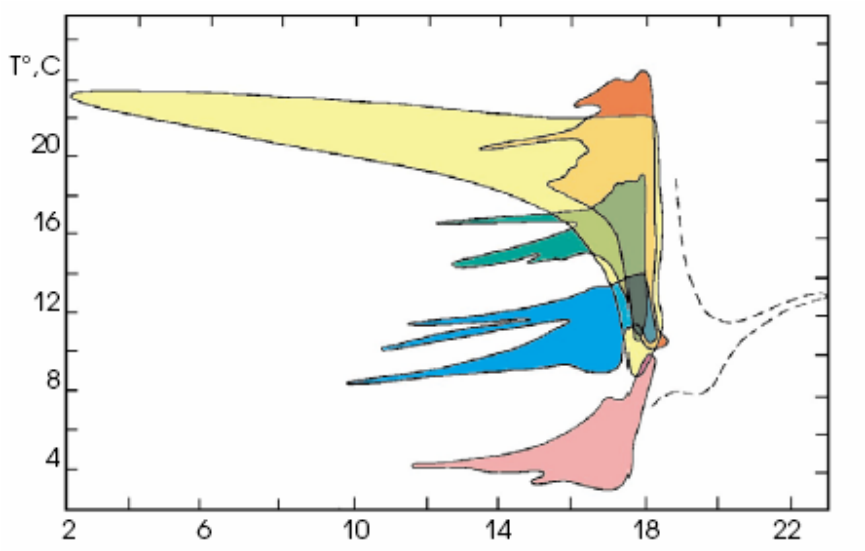

Fig. 2.2 Synthesized picture of water masses distribution

Additional information can be found on the web sites:

The Black Sea Region: Past, Present and Future -
http://www.biaa.ac.uk/blackseaconference

Black Sea Wikipedia
http://en.wikipedia.org/wiki/Black_Sea

Black Sea GOOS - Black Sea Global Ocean Observing System
http://www.ims.metu.edu.tr/Black_Sea_GOOS/

Black Sea –
http://www.lycos.com/info/black-sea.html

The Black Sea Journey –
http://www.ocean.udel.edu/blacksea/research/index.html