THE BLACK SEA – GEOGRAPHICAL FEATURES

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The geographical position.

It is situated in the north emisphere , temperate zone, by its geographical coordinates (40˚55' and 46º32' north latitude, 27º27' and 41º42' east longitude), and by its limited connection with the Planetary Ocean, and lying within the European continent we can consider it a **continental sea**.

The Bosphorus Strait makes the connection with the Meditarranean Sea, the Marmara Sea, Dardanelles Strait and farther the Aegean Sea spotted with many isles.

Main morphometric elements.

The **area** of the sea waters is 413,490 km^2. If we include the area of 38,000 km^2 of the Azov Sea as we can find in a lot of papers, the area obviously increases correspondingly.

The **maximum depth** is 2,245 m, but other sources indicate 2,212 m and it can be found in the central-southern part on a profile that would link approximately the cities of Ialta in the Crimean Peninsula (Ukraine) and Sinop in the peninsula of Minor Asia (Turkey). The average depth is 1.288 m (other sources 1.278 m)

The **water volume** at normal level 529,955 km^2 , but other sources show 538,124 km^2 .

The **maximum length** from west to east is 1,148km, between the ports of Burgas (Bulgaria) and Batumi (Georgia); the **maximum width** between Odessa Gulf (Ukraine) and rivermouth Sakarya (Turkey) is 615 km, and the **minimum width** between the peninsula of Ialta and Burun Cape is 300 km. The Crimean Peninsula in the north and the Burun Cape in the south divide the basin of the Black Sea into two compartments – **western** and **eastern**, that influence and individualize the circulation of the sea currents.

The **shore length** (interface land-water) is 4,431 km (without the shore of the Azov Sea) and is divided among the riverside countries as follows: Ukraine 1,676 km; Russian Federation 475 km; Georgia 310 km (including the shore of the Autonomous Abhazian Republic); Turkey 1,350 km; Bulgaria 375 km; Romania 245 km (P.Gâştescu, 1996).

The **hydrographic basin** of the Black Sea (including the Azov Sea basin) is 2,863,119 km^2, containing the waters of both the Black Sea and Azov Sea. If the area of the two seas is excluded, the actual area drained by the Black and Azov seas is 2,405,000 km^2. Out of this actual drainage area (2,405,000 km^2) the Danube covers 34% with 817,000 km^2 (actual drainage area), then comes the Nipru (Dnieper) with 504,000Km^2 (21%), the Don with 422,000 km^2 (17,6%), the Kîzîl Irmak with 77,100km^2 (3.2%), the Nistru (Dniester) with 72,100km^2 (3.0%), the South Bug with 63,700 km^2 (2.6%), the most important affluents that make together 80.9% (Marea Neagră –monografie hidrologică, 1973).

Out of the 21 states the Russian Federation and Ukraine have almost 49% in the hydrographic basin of the Black Sea, then comes Turkey with 10.7% and Romania with 9.98%. As for the territory of the respective countries related with the same hydrographic basin we consider that Romania, the Republic of Moldavia and Hungary are entirely within its limits, being followed by Ukraine (98%), Austria (97.4%), Slovakia (96,3%), Bosnia-Herzegovina (91%), Yugoslavia (87.1%), etc (fig.1).

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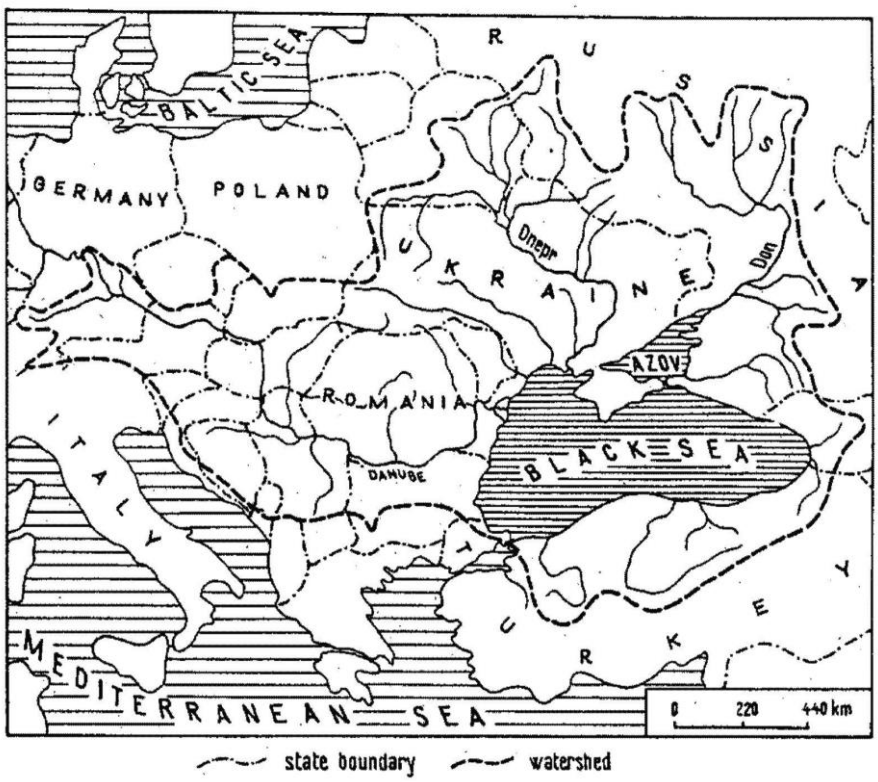


Fig. 1 Drainage area of the Black Sea

The genesis and evolution of the sea depression

There have been issued more hypotheses about the age of the Black Sea depression, among which more interesting are those of Melanovski (1967) who assumes that it was formed in the Precambrian era, of Neprochnov and his collaborators (1967) who take it back to the Paleozoic era, of Brinkmann (1974) who affirms that it was formed in the medium-upper Mesozoic era, of Biju-Duval and his collaborators (1977) who place it in the Berriasan (upper Mesozoic), of Muratov and Neprochnov (1967) who reconsider it taking it back to the Paleocene - Neocene (inferior and medium Neozoic) and finally, that of Nelivkin (1960) who assumes that it was formed in the Quaternary era (Y.P. Neprochnov, D.A. Ross, 1975).

The evolution of the sea basin in the Quaternary era – for 600,000 years was characterized by periods when it could communicate with the Mediterranean Sea and periods when the connection was interrupted. In those circumstances the sea waters were either salted, saltish or sweet, thus influencing the fauna.

Morphobathymetric configuration

From morphostructural point of view allows the identification the following units from the shore to the center of the Black Sea stand out (fig. 2):

- the **shelf** (continental platform), delimited by the –100m isobath as far as the –200m isobath, depending on its interference with the continental slope; the shelf develops most in the north-west reaching a width of 200km in the Odessa Gulf and it is very limited on the south shore; the entire area of the shelf covers about 30%;
- the **continental slope** covers almost evenly the central zone, but the slope values vary between 8-10º and sometimes between 20-22º in the south-east.

- the **marginal depression** (the continental base) represents the passage to the abysmal zone;
- the **abysmal zone** (the abysmal field) situated in the centre of the Black Sea and being extended most in the eastern part, can be 2,000m deep, having a surface of about 12% (Geografia României, 1983).

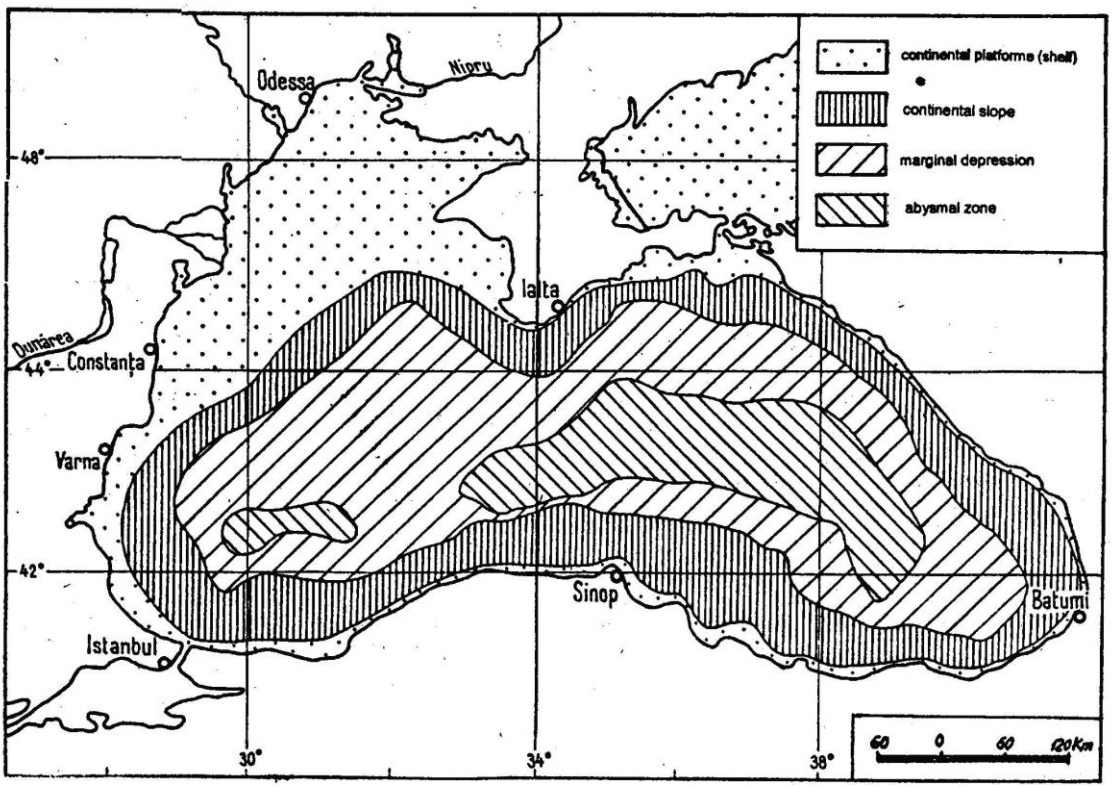


Fig. 2 Black Sea – the main structural units

Inside the sea waters there is a single island in the western part – **Snakes Island**, situated at 45km far from the town of Sulina (45º15′53″ north latitude and 30º14′41″ east longitude), covering an area of 17 ha (28 ha), and being of maximum 40 m high. It is made of chalks, gritstones and conglomerates, the same as in North Dobrudja, proving its genetic belonging to this continental part (V. Cucu, Gh. Vlăsceanu, 1991).

Climate conditions

The average annual **temperature** rises from north-west (10, 11ºC) to south-east (15,5ºC) and in the same way in January (from -2ºC to 8ºC) and in July, less clear (from 23ºC to 24ºC).

The rainfalls also increase from the north-west (365 mm/year at Sulina) to the south-east (2,685 mm/year at Batumi). In the western part of most sea waters the rainfalls are below 500 mm/year, and in the north-west of the continental platform they are registered only with 200 mm/year.

The surface **water temperature** is similar to the air temperature: 11ºC in the north-west the Odessa Gulf) and16ºC in the south-east at Batumi; in February it goes down to 0ºC and in hard winters ice is to be found on shore in the north-west, and little above 8º in the south-east; in August it rises in the same way from 19-20ºC in the south-west.

The season variations of the deep water temperature reach by convective mixture up to 80m in the winter and diminish up to 20m in the summer. From the mentioned depths to the bottom the water temperature decreases very little within the limits 7-9ºC.

The hydric balance

The greatest share at entrances is determined by rivers (42.2%) and at going outs the water is lost by evaporation (49.4%). Among the river sources, the Danube covers 60.3% through its 204 km^3 , the Dnieper covers 15.6% (52.7 km^3), the Dniester covers 2.9% (9.8 km^3), Kîzîl Irmak covers 1.9% (6.3 km^3).

The balance structure does not affect the whole water volume of the Black Sea but only the superficial layer between 0 and 150 – 200 m (Prakticheskaja Ecologhia, 1992).

Long time variation of the water level

The secular and millenary variation has affected the climatic variations from Quaternary to the present, being a specific feature of the continental seas.

It is estimated that the level was about 80 – 100 m lower than the present one, about 18,000 years ago during glaciations. While the ice was melting after the last glaciation the level began to rise with 2 –3 m/100 years, alterning with short periods of stagnation or an easy decline, so that 8,000- 9,000 years ago the level was still 20 m lower than the present one (Y.D. Shuiski, 1999).

The establishing of the connection with the Mediteranean Sea 9,000 years ago led to the beginning of the marine level equalization process, reaching the "0" quota.

Refering to the present period, as a general tendence of rising of the Planetary Ocean level because of the greenhouse effect, it comes out that even the Black Sea level increases by 18 – 20 cm/100 years (1.8 – 2.0 mm/year) (fig. 3).

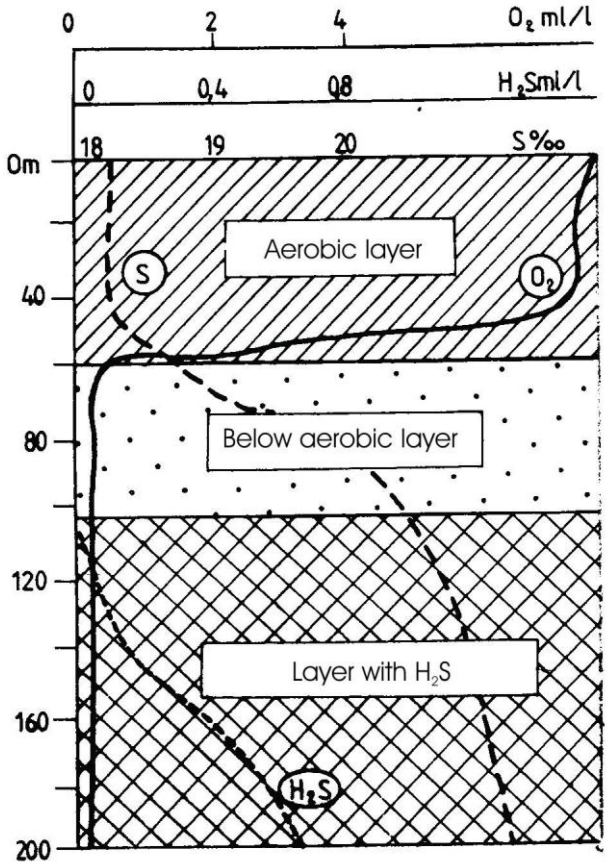


Fig. 3- The waters stratification in teh 0-200 m layer of the Central Black Sea: O_2- oxygen; S – salinity, H_2S – sulphuratted hydrogen.

Salinity

Because of the isolation from the Mediteranean Sea in the **holocene**, the Black Sea was oligosaline and the salinization process begins after establishing the connection with it. It is estimated that the salinization process up to the present concentration, which was achieved 1,000 years ago, lasted for about 6,000 years including the depth distribution.

The average salinity in the surface layer is 17.87‰ and the entire salinity of the water volume is 22‰.

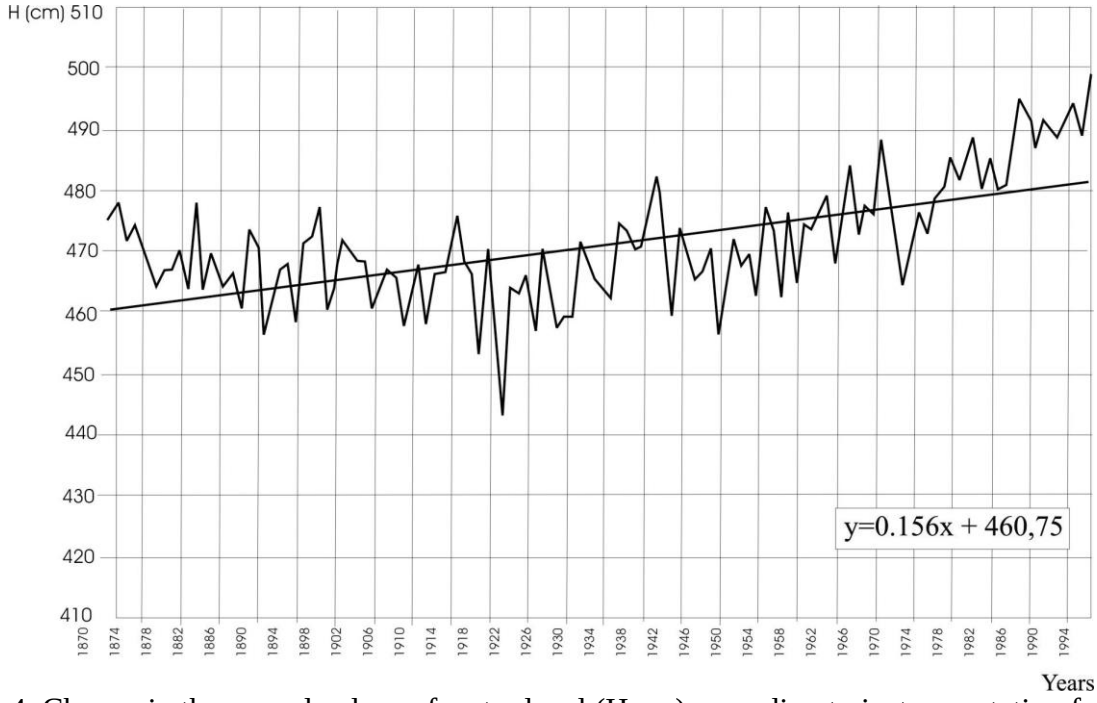
The salinity in the sea surface alters depending on the season, higher in the summer and lower in the winter with 0.5 – 0.6‰ because of the diminishing of the rivers flow and the more dynamic mixture of the water layer – as a waves effect. Also, the surface salinity is much lower in the coastal zones as a result of the rivers fresh water; the salinity reaches 4 - 7‰ (i.e. in front of the Danube Delta) compared to the central zone where it is 18‰.

The salinity increases from the surface (10 - 18‰) to the depth, reaching 22.3‰ at 1,000 m and 25‰ at the bottom in the central zone; the abrupt rising of the salinity (haloslope) occurs within 25 – 50 m.

Oxygen and hydrogen sulphide

Because of the basin morphobatimetric configuration with respect to the Marmara Sea, the Mediterranean Sea and the Bosphorus Strait (is 27.5 m minimum deep and 750 m wide in a certain section) which allows the connection, the accumulation of the hydrogen sulphide in the Black Sea began 7,000 years ago. This harmful gas, formed on the bottom as a result of the decay of the organic substances, has increased in volume rising to the superior layers to the prejudice of the dissolved oxygen. It comes out that this rising of the hydrogen sulphide level has reached now 100 – 200 m on an average. It is estimated that 90% of the Black Sea water (484,000 km^3) is anoxic (overloaded with H_2S), being the biggest volume of this kind all over the Planetary Ocean. The yearly production of hydrogen sulphide is about 30 x 10^6 tons (V.S. Petrosian, 1992).

The ratio between the temperature, the dissolved oxygen, the salinity and the hydrogen sulphide on vertical line establishes a certain stratification of the sea waters from surface to bottom (fig. 4).



Fg.4. Change in the annual values of water level (H,cm) according to instrumentation from the Odessa station for 1870 – 1997 (atfer Y.D. Suisky, 1999)

Status of water quality from the biologic productive horizon

The hydrographic basin of the Black Sea consists of 21 countries, industrialized at different stages and inhabited by about 192 million people, out of which 81 million people are in the Danube basin, 86 million are adherent to the Dniester, South Bug, Dnieper basins, that is to Ukraine and Russian Federation, 12 million in the adherent part to Turkey to which are added other 9 million inhabitans of Istambul that lies on the both banks of the Bosphorus.

The polluted waters of the hydrographic basin as well as the intense navigation, the exploitation of good mineral substances and the offals discharges, the sanitary waters, the toxic substances resulted from all the socio-economic activities on the 5,141 km shore zone are leading to a very high polluting potential.

This present situation have caused some ecological change of balance which have drastically diminished the potential of natural resources adherent to the riverside states and, consequently, has lead to an ecological catastrophe of the entire Black Sea.

The eutrophication, chemical and microbiological pollution are among the numerous aspects that bring about ecological catastrophes of the euphotic (trophogen) horizon in the Black Sea.

The **eutrophication** registers alarming growth quota in the north-west of the Black Sea owing to the waters brought by rivers. It is estimated that the Danube annually brings 60.000 tons of phosphorus and 340,000 tons of anorganic nitrogen, that are increasing every year as a result of the use of fertilizers in agriculture and of detergents in housework.

Because of the eutrophication the transparence decreased from 50-60m in the 1960's to 35m and even under 10m in the coast waters. The diminishing of transparance and, consequently, of the light penetration has determined the diminution of macrophitae, an important part of the sea ecosystem and favoured the explosion of nanoplankton with a low value in the trophic chain (ex. *Noctiluca scintillans*, a zooplanktonic species), of the biomass of jelly-fish and polyps (*Aurelia aurita, Mnemiopsis leidyi*), reaching 1 kg/m^2 in the open sea and 5 kg/m^2 on the shelf.

The process chain by the growth of the decomposed biomass causes the disappearance of the benthic anoxic layer, which finally had a negative effect upon the piscicultural fauna. Out of the 26 commercial species in the 1960's remained only 6 species in non-significant quantities for exploitation.

The disappearance of some ecologically and economically valuable autochtonous species owed to some opportunistic predators brought into the ballast waters of ships, that found proper conditions for extending. The most relevant example is the gastropode *Rapana thomasiana* brought in 1940 from the Japanese waters, which destroyed the oysters population. In the last 4-5 years the demand for rapanas in Japan contributed to its diminution (Black Sea Biological Diversity, 1997).

The **chemical pollution** represents the consequence of metal discharges into the rivers in the north-west part and particularly into the Danube. Quality measurements have been made and they showed that it pours into the Black Sea 1,000 tons chromium, 900 tons copper, more than 60 tons mercury, 4,500 tons lead, 6,000 tons zinc and 50,000 tons oil (L.D. Mee, 1994).

Other ways of polluting the marine waters are represented by the toxic offals discharges, the dragged muds and other industrial and domestic factors on the continental platform that inflence the benthic layer. The oil offals pollution appears in the neighbourhood of ports, on the maritime navigation routes, in the oil exploitation regions or in the Bosphorus Strait.

The eutrophication, chemical and oil pollution encourage the growth of the anoxic layer charged with hydrogen sulphide. The investigations in the north-west part of the

Black Sea, though contradictory, showed the fact that, compared to the year 1970, the limit between the oxic and anoxic horizons sometimes reaches 30m related to the sea level.

Policies for the management of the Black Sea environment

Owing to the critical situation of this marine basin from the ecological and political points of view (the changes appeared after 1990 in the riverside countries, especially in the former socialist countries), more programmes have been implemented aiming at a better data basis, a coordination of the reconstruction policy and ecological management. To this effect , are worth mentioning the Convention for the Black Sea Protection, modelled after the Convention from Barcelona for the Meditarranean Sea(1985). In April 1992 the Convention for the Black Sea Protection was signed and ratified by the governments of the 6 riverside countries and was put in application in February 1994. This convention focuses on establishing the Black Sea Commission and a series of protocols regarding the protection from the polluting sources in the hydrographic basin, adjusting the oil offals and toxic substances discharges. The commission with the headquarters at Istambul is responsible, on the one hand, with the ellaboration of criteria regarding the prevention, diminution and control of pollution, and,on the other hand, with their implementation.

After 1990 a lot of conventions have been signed and a lot programmes have been implemented, among which Global Environment Facility (GEF) is the most important, all the riverside countries participating in it. The GEF programme for the Black Sea is correlated with other regional programmes in the hydrographic basin, such as EROS 2000 Black Sea (European River Ocean System), NATO's Science for Stability, respectively Ecosystem Modelling as a Management Tool for the Black Sea., Cooperative Marine Science Programme for the Black Sea, The Application of Tracer Techniques in for the Study of Processes and Pollution in the Black Sea, under the auspices of IAEA (International Atomic Energy Agency) and many others in which are implied institutions belonging to UNO (UNDP, UNEP, UNESCO-IOC, WMO, FAO), World Bank, European Community, etc.

References

Cucu, V., Vlăsceanu, Gh., (1991) Insula Şerpilor, Casa de Editură şi Presă "Viaţa Românească", Bucureşti.

Gâştescu, P., (1996) Marea Neagră – trăsături geografice de bază, stare actuală, preocupări de monitoring şi management, Rev. Terra, anul XXVI-XXVII (1994-1995).

Mee, L.D., (1994) Management and protection of the Black Sea environment; an international approach, Background document an Environmental Economics Expert group, 13-15, june, Istambul.

Neprochnov, Y.P., Ross, D.A., (1975) Black Sea geophysical Frammework, D.S.D.P., XLII, part 2, Washington.

Petrosian, V.S., (1992) Can we save Black Sea ?, Metionom 4-5/19-29, Moskow.

Suisky, Y.D. (1999) Impact of sea level rise on the morphology and dynamics of the Black Sea coasts, The Delta`s: State-of-the-art protection and management, Conference Proceedings, July, Tulcea-Romania.

Vespremeanu, E., (2004) Geografia Mării Negre, Edit. Universităţii Bucureşti.

***(1973)Marea Neagră în zona litoralului românesc, Monografie hidrologică, IMH, Bucureşti.

***(1983) Geografia României I, geografie fizică, Edit. Academiei, Bucureşti.

***(1990) Prakticheskaja Ecologhia Marskih Reghinov Cernoe Mare, kiev Naukova Dumka.

***(1997) Black Sea Biological Diversity Romania, United Nations Publications, New York.