European Environment Agency

Europe's biodiversity
- biogeographical regions and seas

Seas around Europe

The Black Sea
- an oxygen-poor sea

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CONTENTS

Summary

- Nearly 87 % of the Black Sea is entirely anoxic (without oxygen) and contains high levels of hydrogen sulphide. This is the result of past geological events, its shape and its specific water balance (high degree of isolation from the world ocean, deep water depression with a maximum depth of 2 212 metres (m) in the centre of the sea, the extensive drainage basin and the large number of incoming rivers).
- Deep pelagic and benthic organisms are largely absent.
- The wide diversity of biotopes provides favourable conditions for invasion of alien species to the Black Sea.
- The composition and structure of the marine communities is constantly changing with the decline of certain species and the expansion of others.
- Generally, in undisturbed natural conditions species diversity in Black Sea fauna is approximately three times less than that in the Mediterranean.
- Increasing salinity due to inappropriate water management and regulation, and pollution of brackish coastal lakes and estuaries represents a threat to relics and endemic species, especially in the Sea of Azov.
- As a result of eutrophication, primary production has increased and the number of species has declined. These changes, as well as inappropriate fishing practices, have affected the fish stocks. A change towards small pelagic fish, i.e. anchovy and sprat, has been observed.
- Deterioration of some marine habitats and a lack of laws and technology for regulating the introduction of alien species, for example via ballast waters, have allowed the invasion of such species. These have produced mass populations, which have changed the equilibrium of the native marine ecosystems. Growing concern for the fate of the Azov-Black Sea basin is stimulating a search for efficient countermeasures to combat unwanted alien settlers, since they are now the dominant species across the food web.
- Overexploitation of fish stocks in combination with the invasion of the comb jellyfish *Mnemiopsis leidyi* has caused the collapse of the anchovy fish stocks in the Black Sea and the disappearance of the most valuable fish species. No overall management of fish stocks in the Black Sea is in place.

1. What are the characteristics of the Black Sea?

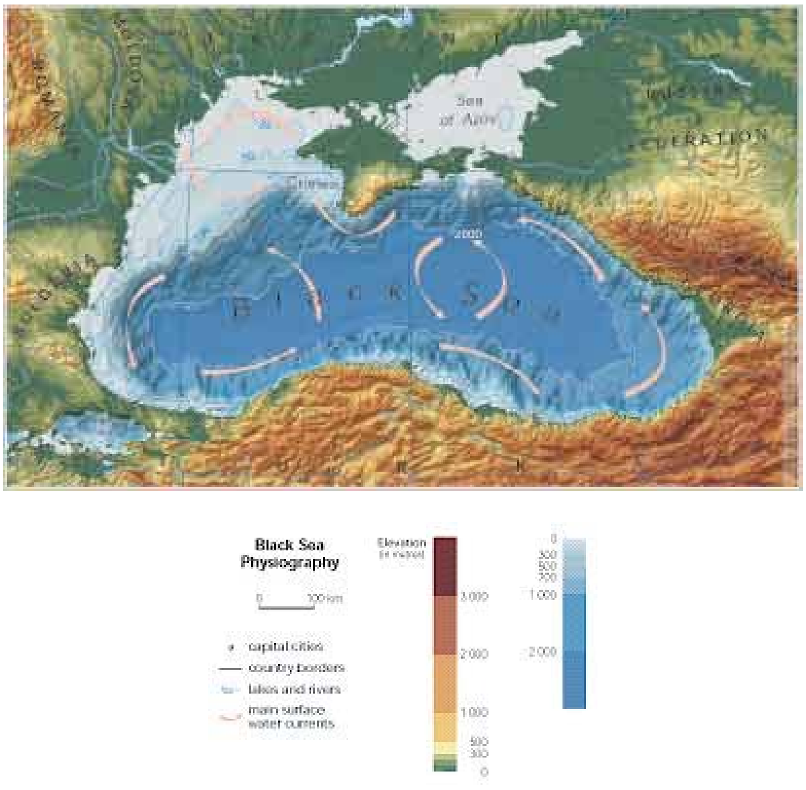
1.1 General characteristics

Table 1: Statistics for the Black Sea

Surface km²	Volume km³	Coastal length km	Depth m average (max)	Temperature ºC average (max)	Salinity ‰ Average (max)
		The Black Sea proper (excluding the Sea of Azov)			
423 000	547 000	4 740	1 315 (2 212)	11.0 (27)	17.5 (24)
		The Sea of Azov			
37 860	324		14	11.5 (31)	11.65 (14)

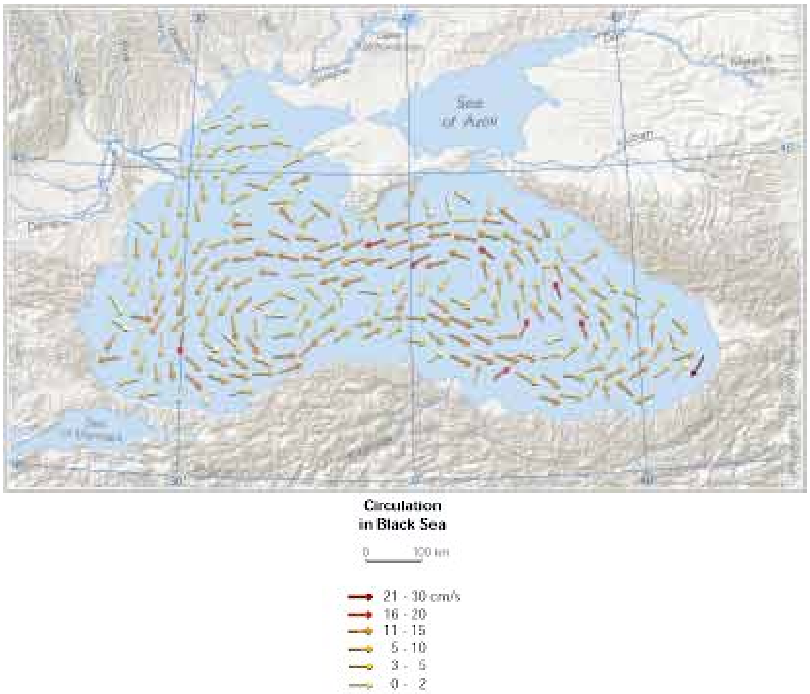
Once a lake connected to the Caspian Sea, the Black Sea became connected to the Mediterranean after the opening of the Dardanelles in the interglacial period (100 000-150 000 years ago). It was then again isolated and only about 6 000 years ago reconnected to the Sea of Marmara and Mediterranean Sea (Zaitsev and Mamaev, 1997). The Turkish straits system - the Dardanelles, Bosporus and Marmara Sea - forms a transitional zone between the Mediterranean and the Black Sea. The special characteristics of this zone make it a barrier, a corridor or an acclimatisation zone for different organisms. To the north, the Kerch Strait, a shallow channel about 45 kilometres (km) long, connects the Black Sea to the Sea of Azov.

Map 1: Black Sea physiography (depth distribution and main currents)



Source: EEA, UNEP/GRID Warsaw final map production

Map 2: Water circulation in the Black Sea



Source: Compiled by ETC/MCE.

1.1.1 Hydrography

Average temperature and salinity fall from west to east (Table 2).

Table 2: Average surface temperature and salinity values in the surface layer of the Black Sea (BS)

	Turkish straits	SE BS	Centre BS	NW BS	Azov Sea
Temperature °C	Dardanelles: 20.0 Bosporus: 19.4	16	14–15	11–13	11.5
Salinity ‰	Dardanelles: 38.7 Bosporus: 36.7	18.4–20.6	Surface 17–18 Deep 22–24	< 10	11.7

1.1.2 Climate

The Black Sea is situated in the temperate zone. Its climate is subtropical, of the Mediterranean type (summer sea temperatures exceed 25 ºC, in winter the open sea temperatures are 6-8 ºC). Only two areas, the south Crimea and Caucasian coasts, belong to the subtropical zone. The Sea of Azov has a continental climate (Bronfman, 1995); in winter the sea is covered by ice for two to three months.

1.1.3 Population

The total population in the catchment area of the Black Sea is about 160 million, almost half of which is from non-coastal countries of the catchment area of the Danube (Mee, 1992). The Black Sea coastal zone is densely populated. It has a permanent population of about 6 million and another 4 million visitors during the summer tourist season. The longest and most densely populated zones are in Turkey and the Ukraine. The Bulgarian coastal zone is characterised by a large number of resorts (GEF-BSEP/UN, 1997). The Azov basin is highly developed economically, and has a population of 35 million.

1.2 Main influences

- Eutrophication through agriculture, industrial activity and inputs of insufficiently treated sewage;
- Contamination through input of harmful substances, and especially oil products;
- Introduction of alien species;
- Fisheries.

1.3 Main political instruments

In addition to the establishment of wetlands of international importance, especially waterfowl habitats, under the Ramsar Convention and the Convention on Biological Diversity (Rio de Janeiro, 1992), international legal documents concerning the protection of the Black Sea are:

- Bucharest Convention on the Protection of the Black Sea against Pollution, adopted at the Conference on the Protection of the Black Sea (Bucharest, 21-22 April 1992). According to Article XIII, the Contracting Parties shall undertake all necessary measures in order to protect the biodiversity of the sea and the landscape bordering it.
- Odessa Ministerial Declaration on the Protection of the Black Sea (Odessa, 6-7 April 1993). An agreement between ministries of the six Black Sea countries (Bulgaria, Georgia, Romania, Turkey, the Russian Federation and Ukraine) to set the policies, goals and priorities for environmental actions. The document is based largely on Agenda 21 adopted at the United Nations Conference on Environment and Development in 1992.
- The Strategic Action Plan for Rehabilitation and Protection of the Black Sea (Istanbul, October 31, 1996) defined policy measures, actions and timetable for setting up and achieving the environmental objectives of the Convention on the Protection of the Black Sea Against Pollution.
- Ministerial Declaration on Protection of the Black Sea Ecosystem (Varna, June 14, 2002) and Black Sea Biological and Landscape Diversity Conservation Protocol (Varna, June 14, 2002 signed by four coastal states) reinforces the regional cooperation for the protection and rehabilitation of biodiversity of the Black Sea.
- Black Sea Environmental Programme (1993-1996), TACIS Black Sea Funds (1995-2000), Black Sea Ecosystem Recovery Project (2002-2004) delivered the international assistance for protection and rehabilitation of the Black Sea ecosystem including its biodiversity components and institutional capacity building.

1.4 Biodiversity status

The Black Sea biota - the historically established combination of flora and fauna - reflects the general processes that have influenced the ecosystem of the sea. According to the origins of the species, it is divided into five groups:

- Pontian relics: The most ancient inhabitants are found in waters with low salinity. (Pontos in ancient Greek is an old name for the Black Sea.).
- Boreal-Atlantic relics: Marine species originating from cold seas and living in deep layers of the sea.

- Mediterranean species: These constitute the most numerous element in the Black Sea fauna, comprising up to 80 % of the total fauna. Most prefer warm, saline waters, and are found in the upper layers of the sea.
- Freshwater species: Introduced by river discharges and usually found in the sea water during the maximum river run-off.
- Alien species: Established populations of alien species introduced by various routes.

The number of species in the Black Sea is around one third of that in the Mediterranean. Despite recent changes in absolute numbers, the ratio remains close to three: 10 000 species in the Mediterranean versus 3 700 species in the Black Sea.

1.4.1 Ecosystems and habitat types

The main biotopes are sandy-bottom shallow-water areas, especially in the north-western part of the Black Sea and the Sea of Azov. The coasts of the southern Crimea, the Caucasus, Anatolia, some capes in the south-western part of the Black Sea (Kaliakra, Emine, Maslen Nos, Galata) and Zmeiny Island are mostly rocky. The sea beds are mostly mud in the zone between 10 to 20 m and 150 to 200 m depth. The total area of Black Sea coastal wetlands is about 10 000 km2. There are sites of reproduction and feeding and wintering grounds of many rare and commercially valuable fish species, including the sturgeon family, and are therefore biotopes of special importance.

Anoxic conditions occurring below 70 to 200 m delimit the vertical distribution of planktonic and nektonic organisms as well as of deep sea-bottom organisms.

The structure of marine ecosystems differs from that of the neighbouring Mediterranean Sea in that species variety is lower and the dominant groups are different. However, the abundance, total biomass and productivity of the Black Sea are much higher than in the Mediterranean Sea. (Alexandrov & Zaitsev, 1998; Zaitsev & Alexandrov, 2000).

1.4.2 Plankton and Benthos

- **Plankton**

The greatest part of the Black Sea coastal waters and continental shelf is eutrophic (rich in nutrients), the central part is mesotrophic (medium level of nutrients) in character, and significant parts are hypertrophic (high level of nutrients). The largest hypertrophic areas are located in the Sea of Azov and in the north-western part of the Black Sea in the zone influenced by inflow from the Danube, Dniester and Dnieper rivers which have high levels of chlorophyll (see satellite image, Map 3 in the chapter on the Mediterranean Sea). Primary production ranges from 570 to 1 200 micrograms (mg) Carbon/m^2 of sea area per day at the north-west shelf, from 320 to 500 in the regions of continental slope, and from 100 to 370 in the central deep-sea regions (Bologa *et al.*, 1999). Mean biomass of phytoplankton reached 4 105 mg/m^3 in the north-west shelf in 1983-90 (Petranu *et al.*, 1999).

Phytoplankton reacts to anthropogenic impacts by alterations in species composition and abundance and the timing and duration of blooming events. The taxonomic composition and number of bloom-producing species differ between the Black Sea coastal area (44 species) and the Mediterranean Aegean Sea (30 species) (Moncheva *et al.*, 1999). Abundance is on annual average around 7 million individuals/litre (l) but in cases of phytoplankton blooms may reach extreme values of 800 million individuals/l (Sukhanova *et al.*, 1998). An important plankton component is the protozoan *Noctiluca scintillans* in the surface layer (0-5 centimetres (cm)), which dominated the planktonic ecosystem in the 1980s, affecting the abundance of all zooplankton components. *Noctiluca* density has reached extreme values exceeding 6.8 million individuals/l and wet biomass of 500 kg/m^3 (Zaitsev and Alexandrov, 1998).

Among zooplankton organisms, medusae and ctenophores dominated the planktonic communities in the 1980s and 1990s respectively, affecting the abundance of copepods and small pelagic fish. The Black Sea copepods are represented by about 36 species compared to the 120 copepod species known in the Aegean Sea. Certain groups such as the Radiolaria are absent while the dominant groups are brackish water ones. Maximal concentrations of zooplankton are found in the coastal waters of the north-western part of the Black Sea in desalinated areas near river mouths on the north from the line Cape Tarchankut to Danube Delta. Average zooplankton biomass falls from west to east. The average biomass of the zooplankton in the period 1959-88 was 580 mg/m^3 for the north-western part, 422 mg/m^3 for the eastern part of the Black Sea and 325 mg/m^3 for the southern Crimea coastal zone (Simonov et *al*., 1992).

• **Benthos**

Seaweeds are represented by more than 200 species. The most diverse group is red algae. They are widespread in shallow waters up to depths of 60 to 80 m. Large algae are confined to a narrow zone in the periphery of the sea down to depths of 5 to 6 m. During the last two decades, the areas covered by eelgrass (*Zostera*) have decreased tenfold in shallow waters. The typical 'Zernov's *Phyllophora* field', in the centre of the north-west shelf, at 20-50 m depth, is an example of a habitat destruction due to human activity. The red algae *Phyllophora* was not only an important generator of oxygen and the nucleus of a benthic community, which included 118 species of invertebrates and 47 species of fish, but was also commercially harvested for the extraction of gelatine used as an ingredient for microbiological cultures, medicine, food industry and other purposes. *Phyllophora* dominated an area of the north-west shelf with the combined size of Belgium and the Netherlands. During the 1970s and 1980s, the north-west shelf ecosystem collapsed rather suddenly and catastrophically due to eutrophication, silting and other factors. Eutrophication has led to an increase of some algae such as the link frond (*Enteromorpha*) and red algae (*Ceramium*).

Although the coastal area is free of hydrogen sulphide, concentrations increase rapidly under the thermocline due to the restricted ventilation of deeper shelf water. Consequently, the number of macrobenthic species decreases rapidly with increasing depth - only the polychaete worm *Notomastus profundus* is found below about 120 m.

The Black Sea macrozoobenthos is represented by approximately 800 species. The Sea of Azov zoobenthos includes about 190 species. A comparative analysis of the benthic biodiversity of the Mediterranean Sea and the Black Sea (Table 3) shows that the ratio of Mediterranean to Black Sea bottom fauna varies between 5 and 33 for different groups of animals and is thus considerably higher than the ratio of three averaged for all species as mentioned above. The compositions of bottom fauna in the Aegean Sea and Black Sea are more similar. Some groups, such as the Sipuncula and Anthozoa, which cannot survive under the extremely low oxygen conditions of the Black Sea, are very poorly represented or absent.

Table 3: Number of species of some zoobenthic groups in the Black Sea (BS), Aegean Sea (AS) and whole Mediterranean Sea (MS)

	Mediterranean Sea	Aegean Sea	Black Sea	MS/BS ratio	AS/BS ratio
Polychaeta	1 000	570	192	5	3
Mollusca	2 000	937	210	10	4
Echinodermata	154	107	14	11	8
Arthropoda	1 935	612	193	10	3
Sipuncula	33	17	1	33	17
Bryozoa	500	200	18	28	11
Porifera	622	132	28	22	5

Source: Compiled by Zenetos for ETC/MCE from various sources.

1.4.3 Large fauna

• **Fish and shellfish**

The Far-Eastern haarder *Mugil soiuy* and the carp *Oryzias latipes* were introduced accidentally to the Black Sea after escaping from fish farms, which increased the total fish fauna in the Black Sea to 171 species.

Bottom trawling for the shellfish *Rapana thomasiana* has become widespread along the Bulgarian Black Sea coast during the past decade, and has raised significant environmental concerns. Assessment of its impact on benthic communities reveals disruption of mussel bed and transformation of the bottom community from epifauna (mussels and crustaceans) dominated to infauna (clams and polychaetes) dominated, which is generally less diverse (Konsulova *et al*., in press).

• **Birds**

The wetlands of the Black Sea basin are vital links in the network of wetlands that stretch from the Arctic Ocean to South Africa, providing refuge for 25 million migrating waterfowl (Chernichko, pers. comm.) every year. There are about 160 000 pairs of nesting waterfowl and 480 000 individual wintering birds in the Black Sea wetlands (Chernichko *et al*., 1993). The most significant habitats are situated in the coastal area of Romania (Danube Delta), Ukraine and the Russian Federation from the Danube Delta to the Tamansky Peninsula in the Kerch Strait. More than 75 % of the Black Sea birds concentrate here, and one third of their number inhabit the Danube Delta. There are 320 bird species in the Danube Delta. Of great importance in the Danube Delta are the pygmy cormorant *Phalacrocorax pygmeus*; the red-breasted goose *Branta ruficollis* - 275 000 - of this bird winter here, which is over one tenth of the world population; the white pelican Pelecanus onocrotalus; the Dalmatian pelican *Pelecanus crispus*; and the white-tailed eagle *Haliacetus albicilla* (eight pairs of this species in the Romanian part (Green, 1992) and three in the Ukrainian part of the delta) (Zhmud, pers. comm.). The region's sea birds include gulls (*Larus*) and terns (*Sterna*). During migration seasons, the bird fauna is diversified by numerous species of sandpipers and ducks.

• **Mammals**

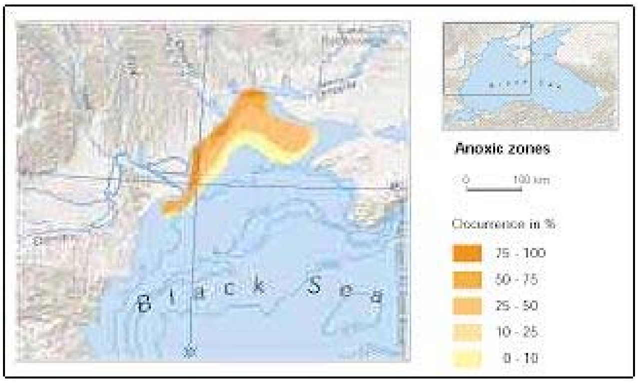
Four species of mammal occur: the monk seal (*Monachus monachus*), which is on the verge of extinction, and three species of dolphins, the bottlenose dolphin (*Tursiops truncatus ponticus*), the common dolphin (*Delphinus delphis ponticus*) and the harbour porpoise (*Phocaena phocaena relicta*). In the beginning of 1950s the Black Sea was home to about 1 million dolphins. Although hunting for dolphins has been banned since 1966 their population by the end of 1980s was less than 50 000 to 100 000.

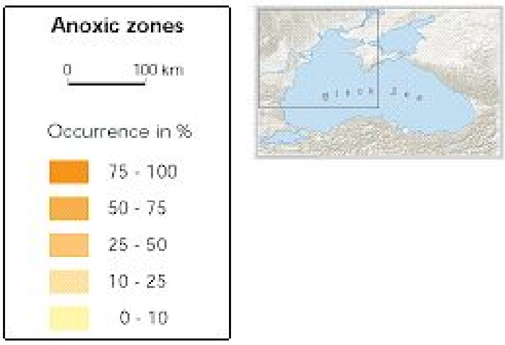
2. What is happening to biodiversity in the Black Sea?

2.1 Eutrophication

The main cause of the increasing eutrophication in the sea is nutrient inputs from the rivers. The catchment area of the Black Sea is over 2 million km^2, five times the size of the sea itself. The drainage basin entirely or partially covers 22 countries in Europe and Asia Minor. The largest volume of river flow entering the sea comes from the north-western part of the basin. Depending on meteorological, hydrothermal, and hydrobiological conditions during summer and autumn, oxygen deficiency (hypoxia or anoxia) and mass mortality caused by eutrophication have become an annual event in the north-western shelf area where anoxic zones expanded from covering 3 500 km^2 in 1973 to 40 000 km2 in 1990 (Zaitsev, 1993), see Map 3. This level of eutrophication also puts the 13 % of water volume of the shelf area that is not anoxic under severe stress.

Map 3: Areas of seasonal hypoxia (oxygen deficiency) and anoxia (no oxygen) in the bottom layer of water and mass mortality of benthic organisms on the north-western Black Sea shelf in 1973-2000



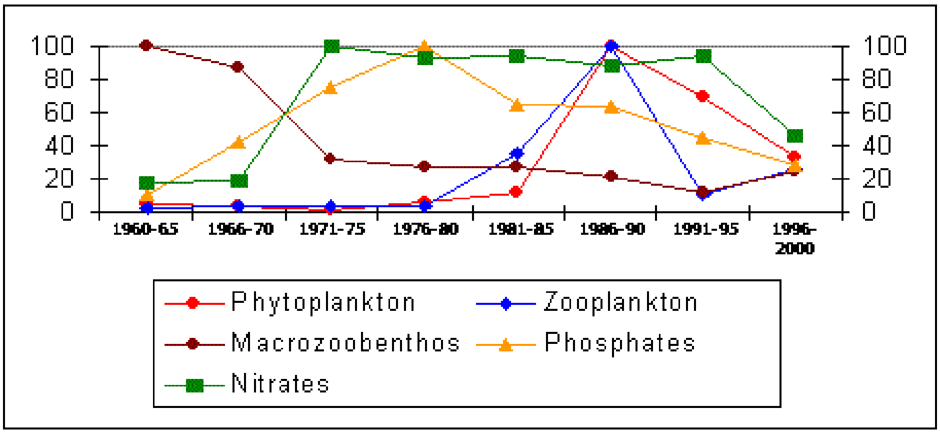


Source: Compiled by ETC/MCE.

There have been dramatic changes in the species diversity, particularly in the north-west part, caused by seasonal hypoxia and anoxia. A sharp decrease has been observed in crabs and other macrozoobenthic species. For example, between 1961 and 1994 the number of macrozoobenthic species on the Romanian shelf fell from 70 to 14 (Zaitsev and Mamaev, 1997) and there was mass mortality of bottom animals - between 100 and 200 tonnes of organisms per km^2 of shelf died because of depletion of oxygen. Between 1973 and 1990, 60 million tonnes of bottom-living animals died, including 5 000 tonnes of fish (Zaitsev, 1992).

Recently, there has been some relaxation of the pressure of eutrophication on the Black Sea ecosystem. The first signs of recovery have been seen in the pelagic communities, but the zoobenthic communities are responding more slowly with still uncertain signs of rehabilitation (Todorova and Konsulova, 2000).

Figure 1: Dynamics of long-term changes in the north-western Black Sea area, Danube Delta area. Index of changeability for each parameter is the percentage of deviation from maximal value for the period 1960-2000



Source: Compiled by B. Alexandrov from unpublished data of D. Nesterova, L. Polyschuk and I. Sinegub for ETC/MCE.

2.2 Contamination and oil pollution

Oil spills cause serious deterioration of the coastal marine ecosystem through contamination of water and sediment, aesthetics quality, etc. Some 170 thousand tonnes of oil products are discharged into the Black Sea every year with sewage (Bayona *et al*., 1999). Pollutants and toxic agents are also carried to the sea in river waters. The highest concentrations of hydrocarbons (petroleum residuals) were detected in the Danube, Dnieper and Dniester river estuaries and other point sources of pollution located off the shores of Romania and Bulgaria where oil production and refining is carried out (i.e. Constanza, Varna) (Maldonado *et al*., 1999). The Danube River accounts for 48 % of the 111 000 tonnes of oil entering the Black Sea via rivers each year.

In addition, ports, oil terminals and their immediate surroundings, and straits are at risk from maritime accidents involving ships transporting crude oil. In Sevastopol Bay, the major port for the Black Sea navy, oil concentrations more than 100 times higher than background level were measured. Concentrations of oil products in the bottom layer of the water were two to six times higher than background levels in the Azov Sea region (Sebakh and Pankratova, 1995). In 1998 pollution by oil hydrocarbons in the Russian sector of the Azov Sea decreased compared to the 1997 level in all areas.

2.3 Water management/regulation

Large-scale construction of cascade dams on the Dnieper and Don and other rivers has led to the loss of spawning areas for the sturgeon and other valuable fish species due to their being cut off from the sea. Moreover the drastic decrease of annual river flow has resulted in apparent hydro-chemical and biochemical changes, with catastrophic effects in the low-salinity basins.

Significant damage to the productivity of sea areas is also caused by the intake of cooling water by various installations along the coast. Despite the fact that about 80 % of these have fish protection devices at their water intake, their efficiency remains rather low and several thousands tonnes of fish die each year. The Sea of Azov waters are used to a greater extent for cooling (18.9 million m^3 per year) than the Black Sea waters (1.59 million m^3 per year).

Implementation of a new technology to control the quality of coastal waters and increase biodiversity, the construction of artificial reefs, began in the 1970s. At present, special constructions have been built in Constanza port (Romania) and Odessa Bay (Ukraine). These artificial reef systems attract pelagic fish and are now characterised by increased biomass of the threatened seaweed species *Cystoseira* and *Phyllophora*, but the species diversity of the communities is still low.

2.4 Fisheries

Over-exploitation has affected fish stocks. Commercial fishing in the Dnieper and Dniester estuaries has been reduced. Some valuable species such as mackerel, bonito and horse mackerel in the Black Sea and pike, perch, roach and bream in the Sea of Azov have practically disappeared. Of the 26 commercial fish species found in the period 1960 to 1970, only five were left by 1980 (Zaitsev, 1992) (Table 4). By the mid-1980s, sturgeon catches had nearly reached the average annual amount for the 1930s of 1 000 tonnes, but farm-produced fish accounting for more than 90 % of the total catch. Stock replenishment of stellate sturgeon (*Acipenser stellatus*) and white sturgeon (*A. gueldenstaedtii*) was apparently insufficient. Fish farming in the coastal ecosystems is a relatively recent development and not yet very widespread. According to the Russian Federation national report, the seven Russian Black Sea/Azov Sea fish farms produced not less than 20–25 million fry. With the addition of 4 million fry from the Ukrainian fish farm in Kherson, the total should be about 25-30 million sturgeon fry per year (GEF-BSEP/UN, 1996b).

Commercial mussel farming (*Mytilus galloprovincialis*) is practised in all countries except Georgia and Turkey (GEF-BSEP/UN, 1996b). Importation of species for aquaculture has induced severe alterations at the ecosystem level.

Table 4: Status of stocks of key Black Sea fisheries

State of stock		Fisheries management measures
Sprat	High	Could allow moderate expansion of catches
Whiting	High	Could allow moderate expansion of catches
Anchovy	Stock recovery restricted by uncontrolled exploitation	Negotiate internationally and introduce catch limits
Horse mackerel	Some recovery	Allow only accidental catches
Turbot	Stocks declining seriously	Essential to decide on national fishing zones
Spiny dogfish	Slow decline	Fishing not to exceed current levels
Giant sturgeon	Endangered	Adopt strict national measures to reduce poaching
Other sturgeon	Depleted	Place fisheries for sturgeons under strict international law

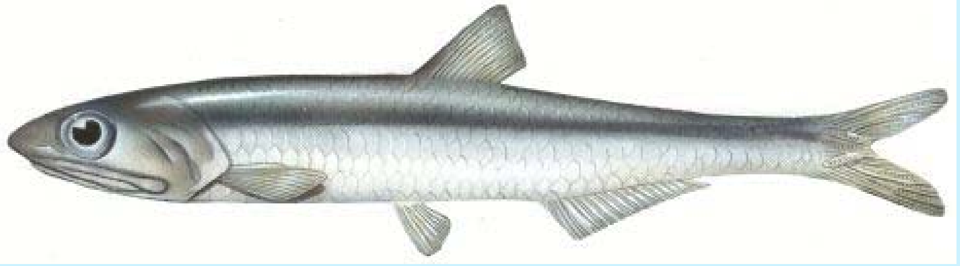
Source: www.fao.org/fil/publ/circular/

Case study - evolution of anchovy stocks in the Black Sea

The evolution of the Black Sea fisheries from the 1930s until the present is typical for inland seas subject to land-based pollution and other human influences. From the 1930s to the 1950s small fish, anchovy and sprat, made up 35 % of the total catch of about 100 000 tonnes. In the 1980s, only five of the 26 commercial fish species were left in commercial numbers and the catch of 400 000-500 000 tonnes was composed mainly of small forage fish, such as anchovy and sprat (75-80 %), whiting and horse mackerel. The catch of the Black Sea countries increased until 1985-86 (700 000 tonnes) after which there was a sharp decline, because of Mnemiopsis predatory activity. The anchovy catch on the north-western shelf declined at least tenfold, and after 1989 anchovy fishing in the Sea of Azov ceased entirely.

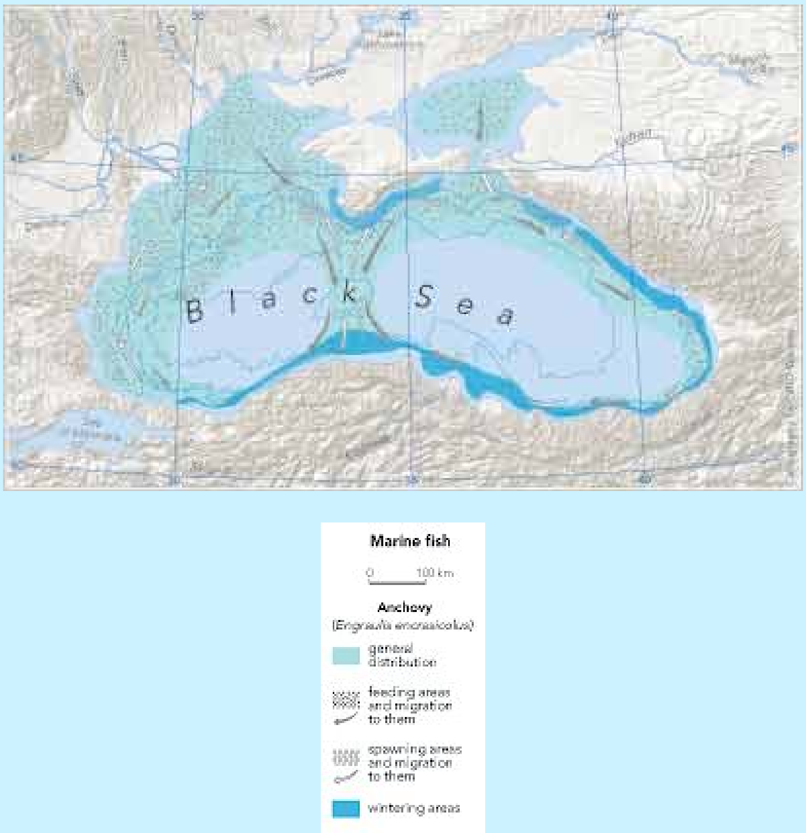
Source: Zaitsev, 1993.

Illustration: Anchovy (*Engraulis encrasicolus*)



Source: Tuvia Kurz

Map 4: Distribution of anchovy



Source: FAO

Effects of bottom trawling on biodiversity

• Bottom trawling for sprat during the 1970s-80s

- Direct impact: disturbance of the mussel Modiolus phaseolinus community, insufficient data about community response and recovery.
- Indirect impact: resuspension and redistribution of sediments caused silting of large areas in the north-west shelf, the alteration of sediment type resulted in loss of 70 % of species diversity.

• Bottom trawling for the snail *Rapana venosa* (whelk)

- Disruption of mussel beds.
- Transformation of bottom community from epifauna (mussels and crustaceans) to infauna (clams and polychaetes), the latter community is generally less diverse.

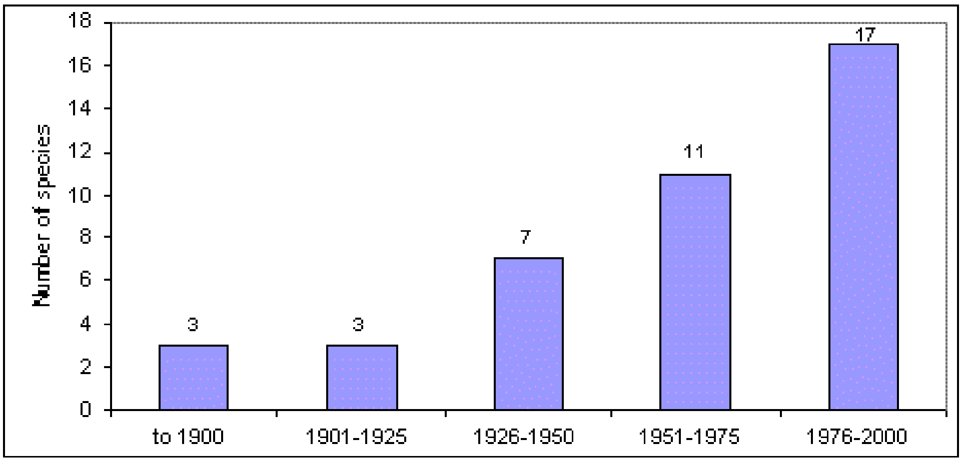
Source: After Zaitsev and Mamaev, 1997; Todorova, 2001

2.5 Alien species

Among the 41 introduced alien species, 34 % have been imported for aquaculture and 66 % have entered the Black Sea as pelagic larvae in ballast waters and/or fouling organisms on ship hulls. The number of introduced species continues to increase, as shown in Figure 2. About one fifth of these (eight species) have invaded the Black Sea during the past decade, all through ballast waters, due to insufficient measures to control such introductions. The ways of introduction are graphically illustrated in Map 5, along with the origins of the species in known cases. Most of the newcomers are fish imported for fish farming.

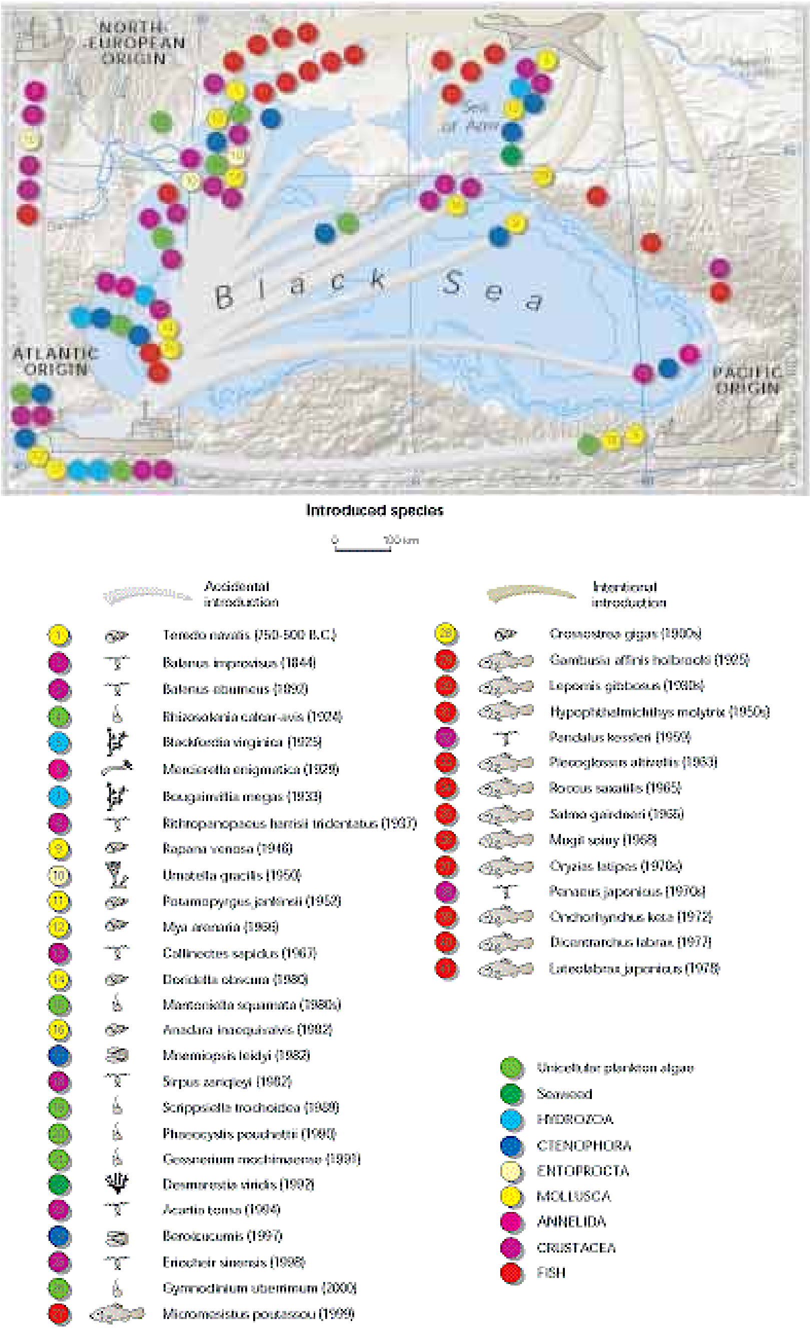
The Turkish straits system, once major biological corridors for pelagic fish migrating between the Mediterranean and the Black Sea, has ceased to be so due to the destabilisation of the pelagic and benthic ecosystems. On the other hand the straits allow the acclimatisation of certain species of Mediterranean origin, such as decapod crustaceans, anthozoans and sponges, penetrating to the Marmara Sea and Black Sea. Alien species, such as *Rapana venosa=R. thomasiana, Mnemiopsis leidyi* and *Anadara inaequivalvis=Scapharca*, have also become resident there. Major sources of pollution, overfishing, ship accidents and heavy marine traffic constitute major threats for the biological diversity of the Turkish straits system and hence for the ecological balance of adjacent seas. This might have caused the disappearance of resident populations of marine mammals from the straits (Ozturk and Ozturk, 1996).

Figure 2: Trend in the introduction of alien species into the Black Sea



Source: Compiled by ETC/MCE

Map 5: Introduced species and their ways of introduction into the Black Sea



Source: Compiled by ETC/MCE

Case study - Introduction of the comb jellyfish *Mnemiopsis leidyi*

The most prominent example of the impact of alien species in the Black Sea environment is that of the comb jellyfish *Mnemiopsis leidyi*. This alien carnivorous animal, introduced in 1982 to the Black Sea, has attained a gigantic biomass in the Sea of Azov and in the Black Sea. It feeds on zooplankton and fish larvae and is itself a top predator at the end of the food chain. The decomposition of the large number of individuals is increasing the problem of hypoxia, especially in the shallow waters of the Sea of Azov and the north-western Black Sea area, although it is also affecting the entire Black Sea area.

Source: Zaitsev and Mamaev, 1997

Photo: Comb jellyfish (*Mnemiopsis leidyi*)

Source: Tamara Shiganova

3. Policies at work in the Black Sea

The Convention on Biological Diversity has been signed and ratified by all Black Sea countries. In addition, specific conventions such as MARPOL (Prevention of Marine Pollution from Ships) have already come into force but are only slowly being implemented while others, such as the Convention on Fishing in the Black Sea have not been signed by Turkey. The creation of better legal arrangements for land tenure elsewhere around the Black Sea are part of the process of economic transition and remain to be resolved in some countries (GEF-BSEP/UN, 1996b).

The aim of the Black Sea Strategic Action Plan for the Rehabilitation and Protection of the Black Sea (Istanbul, 31 October 1996) (GEF-BSEP/UN, 1996a) is to commit the six surrounding countries to prioritise actions towards protection of the environment, to be implemented by a thematic regional activity centre (RAC) in each country. In January 1998 a consortium led by the International Centre for Water Studies (ICWS) was awarded a project to assist in implementation of the plan in Georgia, the Russian Federation and Ukraine.

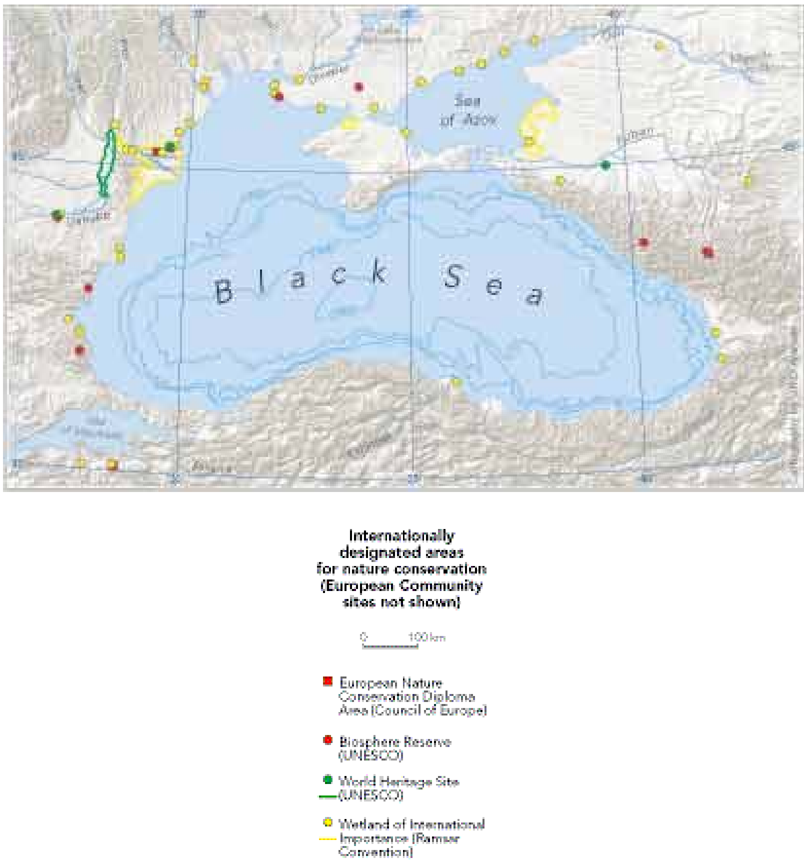
A decree was signed by the International Coordination Committee of UNESCO in the framework of the programme Man and Biosphere for the creation of the International Bilateral Biosphere Reserve Danube Delta (Romania-Ukraine) in 1999.

3.1 Nature protection

3.1.1 Protected areas

There are more than 20 nature reserves in the Black Sea and eight in the Sea of Azov; these are of different status, at local, national and international levels. Many reserves still lack effective management plans and infrastructure. The four UNESCO biosphere reserves of international status protected by identical legislation are Kamchia (Bulgaria), Chernomorsky (Ukraine), Danube Delta (Romania) and Dunaisky (Ukraine). All Black Sea countries have ratified the Ramsar Convention (between 24 January 1976 (Bulgaria) and 7 June 1997 (Georgia)). The maximal area of this kind of protected area in the coastal zone of the sea is found in Ukraine (22 wetlands with a total area 716 250 km^2).

Map 6: International nature protection areas in the Black Sea



Source: compiled by EEA

3.1.2 Red List species

A total of 157 species are on Red Lists, comprising 4 % of total Black Sea species. Among these are 10 aquatic plants, 5 molluscs, 28 crustaceans and 40 fish (GEF-BSEP/UN, 1999).

3.2 Protection of marine resources by restrictions on fishing and hunting

Nature protection for species under international conventions and programmes

- Among the most threatened habitats is that of the red algae *Phyllophora* community. Creation of a protected area east of 33º 10 E and prohibition of bottom trawling in that area are included in the measures proposed in the Transboundary Diagnostic Analysis (GEF-BSEP/UN, 1997).

Resource protection

- At the national level there are regulations for the protection of red listed species.
- At the international level, however, there are no universal agreements among all Black Sea countries extending protection to Red Listed species except mammals. Measures to conserve the dolphin population include the tripartite agreement concluded in 1966 between Bulgaria, Romania and the Russian Federation to stop dolphin catches. Recently all countries have signed the Agreement on Cetaceans of the Black and Mediterranean Seas and Contiguous Atlantic Area (ACCOBAMS).

The sturgeons (*Acipenser nudiventris, A. ruthenus, A. sturio, Huso huso*) and the Black Sea salmon (*Salmo trutta labrax*) are listed in the Red Data Book and Red Data Lists of Ukraine but, despite their significance, they are not universally protected. The implementation of reproduction proposals for sturgeon, which has been repeatedly suggested by the Azov Fisheries Science Research Institute, would allow an increase of annual sturgeon catches (Makarov *et al*., 1998; Gorbachova and Rekov, 1996).

3.3 Research and monitoring programmes

In 1993, at the urgent request of the governments of Bulgaria, Georgia, Romania, the Russian Federation, Turkey and Ukraine, the United Nations Global Environment Facility (GEF) and its affiliated organisations decided to fund the Black Sea Environmental Programme (BSEP) to provide a sustainable basis for managing the Black Sea. Six national biodiversity reports were completed in the late 90s (Komakhidze, 1998; Konsulov, 1998; Mamaev, 1998; Ozturk and Turkish Marine Research Foundation, 1998; Zaitsev and Alexandrov, 1998; Petranu, 1997).

The information collected for the national reports was fully utilised during the preparation of the Transboundary Diagnostic Analysis of the Black Sea (GEF-BSEP/UN, 1997). This is a technical document which, in a highly analytical manner, examines the root causes of Black Sea degradation and options for actions to address them.

The results of ecological monitoring, as habitat for aquatic organisms, have been published in Black Sea pollution assessment (Mee and Topping, 1999) and Black Sea Studies (GEF-BSEP/UN, 1998a and 1998b).

The most prominent activity in the region is the former Soviet sturgeon-release programme, which has continued to operate since the 1950s. The programme was initiated following the depletion of stocks caused by overfishing, damming activities and/or other environmental degradation ruining the spawning grounds in the rivers.

A database of Turkish marine biodiversity was published by the Environmental Problems Foundation of Turkey in 1987, where a total of 1 787 species (including invertebrates and vertebrates) were listed. The database may still be of interest, but several hundred marine species have been added during the past decade.

One of the considerable results of BSEP was the publication of the first regional Black Sea Red Data Book (GEF-BSEP/UN, 1999).

At the national level, some countries are more active than others in investigating the effects of short- and long-term factors on the fluctuation of biodiversity in the sea. For example, a national programme in Ukraine aims at the protection and recovery of the resources of the Azov and Black Seas. Two stages of the programme are planned: the first in 2001-05 and the second in 2006-10. Moreover, within the framework of the European Network for Marine Research Stations (MARS), the near-shore area of Crimea has been offered as a base site for biodiversity monitoring for the Black Sea.

Under the Bathing Waters Directive there is regular monitoring of indicators of sewage pollution at 13 500 beaches in the EU Member States. Unfortunately, there is currently no regular monitoring of beaches in the Black Sea. Measurements of water quality are made but the standards applied are different in each country and the frequency of sampling is often insufficient to protect human health. Results are rarely published but health authorities try to close beaches when sewage pollution reaches dangerous levels. These warnings are often ignored, especially by visitors who have paid a high price for their vacations. Without open access to public health data, visitors lack the information needed to make a choice.

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MARS: http://www.biomareweb.org/