

# THE IMPACT OF A FULL-SCALE WAR ON THE BLACK SEA ECOSYSTEMS OF UKRAINE AND THE ENTIRE SEA IN GENERAL

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**Abstract.** *The Russian full-scale invasion of Ukraine in February 2022 and the ongoing Russian-Ukrainian war have a significant impact on the Black Sea ecosystems, especially on their biotic component. About 87 % volume of the Black Sea are heavily anoxic. The northwestern part of the sea has the best conditions for the development of biota. This water area is well warmed by the sun's rays in the warm period of the year and rivers saturate seawater with dissolved oxygen and nutrients. This part of the sea is of decisive importance for the biota of the entire Black Sea. The impact of war on marine ecosystems is divided into two types: (i) the direct impact of the war – on the biota of the sea; (ii) the indirect impact of the war – on the ecosystems of the Black Sea. As direct impacts in this article are considered the effects of weapons, ammunition explosions (the shock waves, the sound of explosions), the use of powerful sonars – primarily on marine mammals (dolphins and porpoises – probably up to 50 000 cetaceans have already died). The consequences of oil spills due to the flooding and damage of warships and other military equipment, water pollution by toxic components of ammunition (heavy metals, polychlorinated biphenyls etc.), pathogens (as a bacteriological weapon or due to damage to the city sewer or an agricultural complexes), and possible radioactive contamination are considered as indirect impacts. The possibilities of spreading the indirect consequences of the war to non-Black Sea – Mediterranean – ecosystems are highlighted.*

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**Introduction.** The Black Sea is a marginal mediterranean sea of the Atlantic Ocean between Europe and Asia – the water border between Southern Europe and Asia Minor passes along it. It is bounded by Ukraine, Bulgaria, Romania, Turkey, Georgia and Russia. About 16 million people inhabit the coastal area (Black Sea Scene, 2023).

The Black Sea covers 422 000  $km^2$ . Its length (the greatest distance from west to east) is 1 175  $km$ , and its width (the greatest distance from north to south) is 580  $km$ . The Black Sea has a maximum depth of 2 245  $m$ , a volume of 547 000  $km^3$ , a water salinity of 17-18 ‰ (it is the lowest in the northwest – about 13 ‰); the composition of salts is identical to that in the oceans (Black Sea, 2001). It drains into the Mediterranean Sea: the Bosphorus Strait – a 31-kilometer belt with a minimum width of 704  $m$ , the depth varies from 12,8 to 110,0  $m$  (Güngör, 1999) – connects it to the Sea of Marmara which is connected to the Aegean Sea (north-eastern embayment of the Mediterranean Sea) via the Strait of the Dardanelles. The Kerch Strait in the north provides the connection with the Sea of Azov – the shallowest sea on the planet (Troianovski, 2018).

The Black Sea is a unique macroecosystem in the world. It is an almost fully enclosed basin, with only a limited water exchange with the Mediterranean Sea through a counter-current straits system wherein lighter, less saline water flows in a surface current from the Black Sea into the Aegean Sea; while a counter-current of denser, saltier water flows underneath that layer, towards the Black Sea (Ulman et al., 2015).

The marked density difference between the two layers inhibits mixing, leaving only depths shallower than about 150-200 *m* capable of supporting multicellular life. Indeed, the deeper waters – about 87 % volume of the Black Sea – are heavily anoxic, causing the Black Sea to be the largest anoxic body of water in the world with its unique hydrological characteristics (Black Sea Scene, 2023).

In the entire Black Sea at a depth greater than 150-200 *m* there is a permanent *hydrogen sulphide* ( $H_2S$ ) zone devoid of life. Oxygen is completely absent at this deepwater level. Oxygenated surface waters supporting life in the sea constitute only about 13 % of the sea volume. These features influence the condition of the marine environment and the biodiversity depending on it. They are the key to the character and the problems of the Black Sea's environmental health (Black Sea Scene, 2023).

The northwestern part of the Black Sea is the territorial waters of Ukraine. This part has a very important ecosystem value. The water area between the coast of Odesa region and the Crimea is a shelf. Moreover, a significant part of this shelf has a depth of less than 50 *m*. The largest rivers of the Black Sea basin flow into this water area: Danube, Dnipro, Dniester and Pivdennyi (Southern) Buh.

Thus, the northwestern part of the Black Sea is well warmed by the sun's rays in the warm period of the year. And rivers saturate seawater with dissolved oxygen and nutrients (particularly the phosphorus and nitrogen compounds). Therefore, this water area is of decisive importance for the biota of the entire sea.

Russia is currently waging a naval war against Ukraine in the mentioned water areas. Such a war kills Ukrainians, and also causes irreparable damage to the environment, in particular to all Black Sea ecosystems. The entire biotic pyramid is collapsing: from the base (plankton) to the top (marine mammals). This is real ecocide.

**The direct impact of the war on the biota of the Black Sea.** Naval mines, surface and underwater explosions, power sonar from Russian warships and submarines have caused an environmental catastrophe for marine wildlife. The submarines and warships have fired at Ukraine – an additional source of acoustic disturbance, along with helicopter motors. Any of hundreds of Russian missiles that fell in the sea would have killed fish and cetaceans.

Surface and underwater explosions cause a shock wave that can travel long distances underwater, stunning fish and killing other organisms. This is primarily a result of the anatomical structure of bony fishes, which have a gas-filled swim bladder that bursts readily in the event of large pressure drops. Explosions can also pose a serious threat to Black Sea marine mammals (Sadogurskaya, 2022).

The Black Sea mammal fauna has cetaceans from 3 different species; all of them are endemic subspecies:

- Black Sea bottlenose dolphin (or afalina);
- B. S. short-beaked common dolphin;
- B. S. harbour porpoise (or phocene).

Until the 1960s, populations were in decline. Scientists estimated there were probably between 1 million and 2 million dolphins and porpoises in the Black Sea in 1900. By 1945 had dropped to about 100 000. Hunting was the biggest threat. Cetaceans were caught for the sake of raw materials used for the manufacture of oils, paints, adhesives, varnishes, food, medicines, soaps, cosmetics, leather, and fertilizers. But in 1966 it was banned in Ukraine and Georgia (which were then occupied

by the Soviet Union), Bulgaria, Romania and Russia. In 1983 dolphin hunting was banned in Turkey too (Kroeger, 2023).

The most authoritative study of the number of dolphins to date was carried out by *the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)* in 2019-2020 – in Ukraine, Bulgaria, Romania and Turkey – and in 2021 (data was collected only in Bulgarian waters). It estimated there were about 250 000 cetaceans in the Black Sea (Gol'din et al., 2021). The total quantity of such marine mammals from 3 different species is shown in Table 1.

The survey covered nearly all of the Black Sea, except for an area around Crimea, which is temporarily occupied by Russia. All 3 species remain on the red list of threatened species maintained by the International Union for the Conservation of Nature (*IUCN*), are listed in the Black Sea Red Data Book, are protected by the Bern Convention on the Conservation of Wild Flora and Fauna and the Natural Convention and the Bonn Convention on the Conservation of Migratory Species of Wild Animals, the *ACCOBAMS* (Polyanska et al., 2020).

Table 1

**The total number of cetaceans, were recorded in the Black Sea (in 2019-2021)  
(Gol'din et al., 2021)**

Species		Number of individuals	%
Common name	Scientific name		
Black Sea short-beaked common dolphin	<i>Delphinus delphis ponticus</i> <i>Barabash, 1935</i>	118 328	46,5
Black Sea bottlenose dolphin	<i>Tursiops truncatus ponticus</i> <i>Abel, 1905</i>	42 169	16,5
Black Sea harbour porpoise	<i>Phocoena phocoena relicta</i> <i>Barabash, 1940</i>	94 219	37,0
<b>Total</b>		<b>254 716</b>	<b>100,0</b>

When full-scale war broke out the Black Sea dolphins generally got into terrible conditions. No one knows how many naval mines have been deployed or exploded in the sea since February 24. Large-scale explosions have also been plentiful around ports and strategic outposts. Oil rigs and civilian ships hit with heavy artillery and missiles. And the Ministry of Defence of Ukraine reports 18 (as of May 22, 2023) losses to the Russian Navy's Black Sea fleet. These include its flagship, the *Moskva* cruiser (was discovered and sunk on April 13-14, 2022), and a landing craft sunk under heavy bombardment near Zmiinyi (Snake) Island (Fitt, 2022). The bodies of dolphins and harbour porpoises found on the coast were burnt and injured (Hubareva, 2022).

Due to the use of power sonars on Russian warships and submarines, which affect the cetaceans, dolphins have lost their echolocation.

Echolocation is their main unique ability – a biological form of sonar. Cetaceans use echolocation to find their way around, communicate and find food. But many dolphins and porpoises came within the zone covered by ship's navigation devices. The latter disabled their navigation and dealt them powerful acoustic injuries, paralyzing this vital echolocation system. As a result, the animals cannot orient themselves in space, become blind.

Animals have no acoustic control over their surroundings. These dolphins experience stress and panic, are unable to navigate in space, encounter various obstacles, including naval mines and rocks. And most importantly, such blinded animals have trouble finding food and quickly get exhausted. The dolphins, blinded by the sonar impact, become susceptible to viruses and parasites due to weakened immune systems. They become the target of self-infection by pathogens, which constantly live inside them.

Before Russia's full-scale invasion biologists recorded traces of fishing gear on the bodies of dead dolphins with their fins cut off. Now they are found many animals untouched. Powerful underwater explosions trigger dolphins to swim rapidly to the surface of the water causing air embolism, or decompression sickness, that occurs when scuba divers surface too quickly and nitrogen bubbles form in the bloodstream (Datskevych, 2022). As a result, blood clots appear and dolphins or porpoises die.

Ivan Rusev, a doctor of ecology and scientific department head at *Tuzlovsky Limany National Park* (Ukraine), said: before February 24 (2022) he found three to four dead dolphins along the 27 miles of shoreline in the park annually. But when the full-scale war began, the military closed a large portion of shoreline. Between 24 February and the end of August 2022 doctor Rusev and his team discovered 35 dead marine mammals along the 5 km of shoreline still accessible (Kroeger, 2023).

Ecologists from Bulgaria, Romania and Turkey have all reported an extraordinary increase in the number of dead dolphins and porpoise washed ashore.

In the Bulgarian city of Burgas alone, about 60 dead dolphins have been found around since the beginning of the year (2022), according to ecological inspection expert Maria Andreeva (Datskevych, 2022).

Bogdan Bulete, regional head ranger at the *Danube Delta Biosphere Reserve* (Romania), received on May 9 2022 what he thought was yet another routine call to check out a possible dolphin stranding near the town of Sulina. But when he reached the beach this time, the sight that met his eyes was “overwhelming,” – up to 30 dolphins lay dead on the sand (Fitt, 2022). But Bulete estimated that more than 100 stranded cetaceans went unreported internationally in the Romanian Danube Delta region alone, including the dolphins in Sulina.

Bulete said: “Some of them looked burned, and all of them had marks of nets around their tail or their belly” (Fitt, 2022). Russian landing craft sunk May 7 (2022) under bombardment near Zmiinyi Island – 40 km away in Sulina, blowing open Bulete's office doors and windows. He said they felt like earthquakes. The mass mortality occurred two days (May 9) after the offensive that sank the landing craft. B. Bulete explained the dolphins could have swum into fishing nets in panic, while fleeing explosions, or sustained traumas that rendered them unable to detect the nets by echolocation (Fitt, 2022).

Rusev's team spoke to their counterparts in other Black Sea countries (except Russia and Georgia). Some of Ukraine's national parks are now in Russian occupied territory. His team couldn't reach any of their colleagues there. When they added up the numbers they learned at least 2 500 dead dolphins had washed up on shore between 24 February, when the war started, and May 2022 (Alund,

2023). But currently this number is much higher, because most dead dolphins simply sink and never to be seen or counted.

Doctor Rusev said that the sea washes up only about 5 % of all dead animals. The remaining 95% go to the bottom and we cannot register them. They are not available for detection and counting from the shore. “Therefore, we estimate that during the war waged by Russian barbarians against Ukraine, probably up to 50 000 cetaceans have already died, which is absolutely terrible for the marine ecosystem”, wrote I. Rusev (Barsukova, 2022). 50 thousand dead dolphins, this is a fifth of their total number.

Russian Navy’s Black Sea fleet is stepping up security at the Sevastopol base by deploying trained dolphins. Many of the Russian ships anchored there are potentially vulnerable to undersea attacks (Aratani, 2022). The dolphins are kept at the entrance to the harbour to detect and counteract Ukrainian naval drones and military divers. Space satellite images show floating mammal pens in the bay (stretches for 7,5 km), which likely contain Black Sea bottlenose dolphins.

Living in a polluted military harbor is very harmful for animals. Russia catches and trains dolphins to perform various missions, including suicide ones. This treatment of animals is very cruel. Many dolphins are injured and die at a very young age. This practice will be stopped immediately after Ukraine's victory in the war.

If the dolphins and other cetaceans, who also act as sanitarians of the sea by eating sick fish, continue to disappear, life in the Black Sea will degrade, the expert fears. *Phocoena phocoena relicta*, *Tursiops truncatus ponticus* and *Delphinus delphis ponticus*, found only in the Black Sea, are keystone species – they balance the ecosystem by keeping prey populations in check (Fitt, 2022). “Many of the unique fish species we have today will disappear. We will lose a whole ecosystem,” said doctor Rusev (Datskevych, 2022).

The initiative launched by the Odesa Regional Prosecutor’s Office in July aims to hold Russia accountable for ecocide under Ukrainian law. Ecocide was legally defined as “*unlawful or wanton acts committed with knowledge that there is a substantial likelihood of severe and either widespread or long-term damage to the environment*” in 2021 by an international group of 12 lawyers (Fitt, 2022). But ecocide is not yet criminalized under international law.

The monk seal is believed has disappeared from the sea as a whole, because there is no scientific data on recent sightings for many years. Cetaceans of unique species we have today will also disappear from the Black Sea if the full-scale war continues.

**The indirect impact of the war on the ecosystems of the Black Sea.** Marine ecosystems are also indirectly affected by hostilities. Remains of sunken warships, submarines, bombs, naval mines and missiles, anchor usage can damage underwater communities on the seabed. The greatest biodiversity is usually concentrated in benthic algal communities, so damage to them may be a determining factor for the entire marine ecosystem.

Warships and submarines of the Russian Baltic, Pacific and Northern Fleets can also accidentally introduce non-native invasive species into the Black Sea where such species were not previously present. This, in particular, can happen through the discharge of ballast water, generally governed in peacetime by laws and regulations and overseen by relevant Ukrainian authorities. Sinking of warships, aircraft, helicopters, naval armed drones and other military equipment can lead to **oil spills** toxic to marine flora and fauna and can poison the marine environment for numerous decades (Sadogurskaya, 2022).

Warships are powered by vast diesel engines. Many Russian ships are powered by bunker fuel, which is diesel of such low quality that it is almost considered waste. Damaged or sunken Russian ships pollute the sea with such diesel fuel.

The *Moskva* cruiser, after it was struck by Ukrainian missiles, is thought to have sunk in the sea 45-50 m deep and wrecks can become persistent sources of pollutants. Oil slicks were used to pinpoint the location of the wreck.

On 25 February 2022, a Moldovan chemical tanker *Millennial Spirit* was carrying 600 tons of diesel fuel through the Black Sea. The tanker was shelled while underway 22 km south of the Ukrainian port of Yuzhne (Odesa region) by Russian warships. About 100 tons of diesel fuel probably spilled into the sea.

For the second time, according to the report of a Ukrainian Ministry of Defence, a *Millennial Spirit* was attacked by Russian aircraft on July 7, 2022. Two *X-31* missiles were fired from a Russian *Su-30* aircraft. One of the missiles hit the tanker which was drifting in the territorial sea of Ukraine without a crew and with more than 500 tons of diesel fuel on board. A fire broke out on the ship. The tanker *Millennial Spirit* eventually sank off Odesa after drifting. A lot of diesel fuel got into the sea.

Oil enters the sea due to infrastructure destruction on land by Russian shelling. Oil rigs, which were bombed, still leak a lot of oil products. Ukraine's aerial and marine drone attacks on oil terminals at Sevastopol and Novorossiysk entailed varying risks to the environment.

A lot of fuel oil can get into the sea due to the destruction of hydroelectric power plants. According to Ukrainian military intelligence reports, more than 450 tons of fuel oil are stored at the mined Kakhovka HPP alone. Russian terrorists control it and can blow it up. In this case, Dnipro River will carry hundreds of tons of fuel oil into the sea.

The damage from diesel fuel or fuel oil entering water is no less than from crude oil spills. 1 ton of oil can cover an area of up to 12 km<sup>2</sup> with a 1 mm thick layer (Al Bayaty, 2020). This means that the oil products of only the Kakhovka HPP and the tanker *Millennial Spirit* can be enough to form a stains with an area of up to 12 600 km<sup>2</sup> with a 1 mm thick layer. For example, 12 600 km<sup>2</sup> is more than 1/3 of the territory of Belgium or 1/2 of the territory of Slovenia and almost 5 territories of Luxembourg.

Oil prevents sunlight and oxygen from reaching the lower water layers as it spreads through the surface first. As a result, algae don't receive enough light to do photosynthesis to produce oxygen, and fish and millions of fry die, which live and feed almost on the sea's surface. Oxygen-breathing animals die en masse. And eutrophication may begin. Oil spills can also lead to the death of birds, which suffer by falling into oil stains.

Even a small oil spill it is a huge biota loss. It harms tiny organisms – zooplankton and phytoplankton – that float around the surface of the water. Plankton is the basis of the biotic component of the sea. Destruction of this foundation leads to catastrophic consequences for marine ecosystems of the Black Sea.

During the explosions of bombs, missiles, military shells, naval mines and torpedoes, a vast amount of dangerous substances are released into the environment. Some munitions may use very **toxic chemical compounds**. For example, white phosphorus releases poisonous gas and causes burns when ignited, and poisons water if it gets into the environment. Phosphorus is practically insoluble and can be stored for decades in salty seawater under conditions of oxygen deficiency (Black Sea is the largest anoxic body of water in the world). Many compounds developed as chemical warfare agents used by the Russian invaders are highly toxic to humans. Such compounds are also harmful to

other vertebrates. They can accumulate and persist for decades in the natural environment and affect aquatic organisms (Hubareva, 2022).

Toxic substances enter the sea due to the destruction of industry and infrastructure on land by Russian shelling. For example, satellite imagery shows huge damage to 13 out of 14 warehouses of the *Olvia QTerminals* in Olvia seaport (Mykolaiv region). The warehouses were enclosed by berms (a raised barriers usually made of compacted soil) – this suggests storage of ammonium nitrate fertiliser, or potentially munitions (The coastal, 2023). Contaminants from toxic compounds are highly likely to have entered the Dnipro–Buh estuary and then to the sea.

There was a major offensive on Mykolaiv between February and May 2022, during which city has endured prolonged artillery and missile attacks. As a result, Mykolaiv and nearby towns have sustained significant physical damage generating large volumes of debris. Such debris contaminated with a broad range of pollutants, including heavy metals, polychlorinated biphenyls (*PCBs*) and asbestos. Some of these hazardous materials have been or will be transported into the Buh estuary and to the sea through surface run-off or via groundwater flow.

One more visible indirect impact was the discharge of sewage between 28 June and 15 July, 2022, from the Halytsynove wastewater treatment plant (plant near the village of Halytsynove treat 83 % of Mykolaiv's wastewater). This was likely associated with an attack on the facility in March. Such releases of untreated wastewater can harm ecosystems through the release of toxic substances (The coastal, 2023).

Croplands turned into battlefields. Therefore, agricultural runoff – pesticides, mineral and organic fertilizers, fuel, battery acids and other liquid components of damaged and destroyed agricultural machinery – enters rivers and then the sea. Most of their components poison water. Mineral and organic fertilizers cause eutrophication.

The Dnieper River is being used as a front line during the war. It is impossible for this source not to be polluted by the toxic chemicals released from the use of ammunition. Almost all of these toxic substances will be carried by the Dnipro River into the Black Sea.

**Pathogens** are also a factor in the indirect effect of war on the death of marine biota. They can get into the sea as a bacteriological weapon or accidentally due to damage to the city sewer or, say, an agricultural complexes. Scientists discovered this pollution mechanism even before the start of a full-scale war – the Russians deliberately, in a brutal way, polluted their water areas and international waters, dumping sewage from agricultural farms in the Krasnodar Territory into the sea, which caused dolphins to become infected with toxoplasmosis (Hubareva, 2022).

Unfortunately, **radioactive contamination** is not excluded. According to unconfirmed data, there could be missiles with nuclear warheads on the sunken *Moskva*. The warheads could have been damaged when Ukrainian missiles hit the cruiser. This can cause radioactive contamination of biota-rich waters (its wreckage is at a depth of up to 50 m).

Russian terrorists also control the Zaporizhzhia nuclear power plant. This is the largest nuclear power plant in Europe. It is located near the shores of the Kakhovka Reservoir. Ukrainian intelligence warns that Russian is probably preparing to commit a terrorist attack at the power plant. The consequence of a terrorist attack can be a terrible radioactive contamination of both the land and the Black Sea.

After the Chernobyl disaster, at least 6 000 Ci of *cesium-137* and 5 000 Ci of *strontium-90* entered the Dnipro reservoir cascade with aerosol fallout and river runoff. Ecosystems retained about 99 % of  $^{137}\text{Cs}$  and 70% of  $^{90}\text{Sr}$ . The main part of retained radionuclides – up to 70% – is deposited in

the bottom sediments of the Kyiv Reservoir. Russian missiles can destroy the dam of the Kyiv Reservoir. In this case, the concentration of radioactive pollution in the cascade will increase tens and hundreds of times. Now radionuclides are absorbed by mineral and organic components of bottom soils and therefore do not pose a significant danger. Most of the radionuclides deposited at the bottom will enter the water masses and pollute all other reservoirs – and the Black Sea.

**Possibilities of the spread of indirect effects of war on non-Black Sea ecosystems.** Russia's full-scale war against Ukraine caused great damage to marine ecosystems. But, unfortunately, not only Black Sea ecosystems will suffer.

The Black Sea has positive freshwater balance – it receives more fresh water from the rivers and rainfall than it loses from evaporation. Every year the Black Sea receives about  $350 \text{ km}^3$  of river water (more than  $283 \text{ km}^3$  (81 %) – from the rivers flowing through Ukraine; Table 2), about  $25,5 \text{ km}^3$  of sea water from the Sea of Azov and about  $230 \text{ km}^3$  of precipitation (totaling  $605,5 \text{ km}^3$ ) while evaporation takes away approximately  $354 \text{ km}^3$  of water.

Table 2

**The largest rivers of the Black Sea basin (flowing through Ukraine) (Drainage Basin of The Black Sea, 2020; Dnister River, 2001; River Basin Management Plan for Pivdenny Bug, 2014)**

<b>Name</b>	<b>Annual drainage volume, <math>\text{km}^3</math></b>	<b>Drainage basin, <math>\text{km}^2</math></b>	<b>Passes through or touches the borders of</b>
Danube	216,3	801 400	Ukraine, Romania, Moldova, Bulgaria, Serbia, Croatia, Hungary, Slovakia, Austria, Germany
Dnipro	52,7	504 000	Ukraine, Belarus, Russia
Dnister	11,0	72 100	Ukraine, Moldova
Southern Buh	3,4	63 700	Ukraine
<b>Total</b>	<b>283,4</b>	<b>1 441 200</b>	

Due to its positive balance the level of the Black Sea is higher than that of the Marmara Sea by an average of  $0,43 \text{ m}$ . The surplus of water – about  $251,5 \text{ km}^3$  – therefore flows through the Bosphorus Strait into the Sea of Marmara and then through the Dardanelles into the Mediterranean Sea. But there is another factor. Two flows through the straits are formed. The upper flow leaves the Black Sea and carries surface water out of it. Meanwhile a bottom flow carries salt water from the Mediterranean to the Black Sea. The volume of the bottom flow is about 300 cubic kilometers (Black Sea Scene, 2023).

Thus, not  $251,5 \text{ km}^3$  of surface water flows into the Mediterranean Sea from the Black Sea annually, but about  $551,5 \text{ km}^3$ . For example, it is almost twice the volume of the Sea of Azov. There are two surface currents in the Black Sea. They caused by the cyclonic pattern of the winds and move counterclockwise parallel to the coastline along closed circuits.

The surface currents form two closed circles. The width of the western circle, opposite the Danube Delta, reaches  $100 \text{ km}$  and decreases towards the south. The velocity of the current is about  $0,5 \text{ km}$  per hour. This current carries polluted waters from the war zone south along the coasts of

Romania and Bulgaria to the Bosphorus. The lighter waters of the Black Sea flow as a surface current into the Sea of Marmara at a velocity of 1-2 *m* per second (Black Sea, 2001), or 3,6-7,2 *km* per hour.

**Conclusions.** The Black Sea is a unique macroecosystem in the world. Oxygenated surface waters supporting life in the sea constitute only about 13 % of the sea volume. Oxygen is completely absent at a depth greater than 150-200 *m*. But the Black Sea biota is well adapted to such natural conditions. 500 years ago Black Sea sturgeon were so numerous that caviar was thought of as a food for the poor among coastal peoples.

The northwestern part of the Black Sea – the territorial waters of Ukraine – has a very important ecosystem value. A significant part of this shelf has a depth of less than 50 *m*. The largest rivers of the Black Sea basin flow into this water area. They saturate seawater with dissolved oxygen and nutrients. Therefore, this region is of decisive importance for the biota of the entire sea. But Russia has been waging war against Ukraine for 9 years.

Active hostilities cause great damage to the territorial waters of Ukraine, and the entire ecosystem of the Black Sea and even the Mediterranean ecosystems. Probably up to 50 000 cetaceans have already died. The oil products of only the Kakhovka HPP and the tanker *Millennial Spirit* sunk by the russians can be enough to form a stains with an area of up to 12 600 *km*<sup>2</sup> with a 1 *mm* thick layer. During the explosions of bombs, missiles, military shells, naval mines and torpedoes, a vast amount of dangerous substances are released into the environment. Toxic substances (heavy metals, polychlorinated biphenyls, asbestos etc.) enter the sea due to the destruction of industry and infrastructure on land by Russian shelling. Agricultural runoff – pesticides, mineral and organic fertilizers, fuel, battery acids and other liquid components of damaged and destroyed agricultural machinery – enters rivers and then the sea, because croplands are turning into battlefields. On the sunken *Moskva* could be missiles with nuclear warheads. The warheads could have been damaged when Ukrainian missiles hit the cruiser. This can cause radioactive contamination of biota-rich waters. Russians also control the Zaporizhzhia nuclear power plant. The consequence of a terrorist attack can be a terrible radioactive contamination of both the land and the Black Sea.

The destructive war must stop with Ukraine's victory. After that, the Black Sea will become *Εὔξεινος Πόντος* (“*Hospitable Sea*”) again. But if the war continues for a long time, the Black Sea may become dead not by 87 – but by 100 % of its volume.

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