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Pressures, threats and impacts on life in the Black Sea

Greenpeace CEE

Pressures, threats and impacts on life in the Black Sea

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1 EXECUTIVE SUMMARY

Introduction

The Black Sea serves as a vital connection between six countries, namely Bulgaria, Georgia, Romania, Russia, Türkiye and Ukraine, offering diverse opportunities for environmental protection efforts. The sea is a unifying factor, therefore the ecological issues faced by the countries necessitate collaborative actions.

Numerous projects have shown that eutrophication, pollution, microplastics, overfishing and invasive species are major environmental challenges. Moreover, the ongoing Russian invasion poses major threats to marine habitats due to increased exposure to noise pollution, presence of sea mines, increased vulnerability to oil spills, lack of practical protection in the northern part of the Black Sea, and other war-related challenges.

This situation combined with numerous other effects of human activities led to the need to identify the pressures and threats to the marine environment of the Black Sea.

In light of the initiated Greenpeace work on different aspects united around the common theme of the Black Sea, the necessity of the elaboration of this report about the existing major pressures for the marine environment has been identified.

This report relies on information from various sources, such as the Permanent Secretariat of the Black Sea Commission Against Pollution. It should not be viewed as an exhaustive analysis reflecting the consensus of all stakeholders, but rather as a framework guiding the establishment of further monitoring networks and programs necessary in the Black Sea.

Main findings of the report

- Among the most frequent offshore generated pressures to the marine biodiversity identified in our database, transportation, fishing and fisheries were found.
- The most frequent onshore generated pressures found in the analyzed sources, with effects and subsequent impacts to the marine biodiversity, are industrial activities, agriculture and military activities.
- The countries with the most generated effects to the marine environment are Türkiye, Russia and Romania.
- The future estimates for climate variables as temperature, sea level rise and wind speed show that all the Black Sea is vulnerable, Russia's waters being the most exposed, followed by Georgia and Türkiye.
- All the countries included in the analysis contribute to habitat alteration for all taxonomic groups, especially Russia.
- The western part of the Black Sea is the most exposed to oil & gas exploration and exploitation fields, considering their overlapping with IMMAs and MPAs.
- Transportation routes are also overlapping certain protected areas, especially in the western region of the sea, which may cause impacts to marine mammals.

- According to additional sources cited in this report, military activities in Ukraine may generate unprecedented impacts to the marine biodiversity, requiring relevant ecological reconstruction measures.
- Pressures as wastewater treatment plants, port activities, waste disposal, nuclear accidents, agriculture, tourism, industrial activities, shipping accidents, illegal dumping of oil products, transportation can generate increased level of pollution and inevitably can lead to habitat alteration for the Black Sea marine species.
- Underwater infrastructure can cause habitat loss to invertebrate species or to other benthic taxonomic groups (e.g. fish, crustaceans etc.). In addition, this type of impact and habitat alteration can result as well in the case of sand extraction, dredging or fishing by trawling.
- Invasive species and climate change are indirect effects of transportation and industrial activities, which can spread without limits and can compete for food with native species, making the latter to migrate to other areas where they can find resources or even die of starvation.
- The most exposed species to the presented pressures remain the marine mammals, as their population numbers are at risk due to the potential significant cumulative impact of the war with other impacts posed by improperly assessed projects in the lack of legislative requirements.

Conclusions and recommendations

In light of the findings of this report, we shall conclude and recommend the following:

- Hydropower energy generation facilities should take into account the assessment of cumulative impacts before their implementation, as the subsequent dams may lead to habitat fragmentation for migratory fish species.
- Oil & gas extraction should be done after the completion of rigorous Environmental Assessments as it presents the potential to show significant impacts to certain sensitive receptors such as cetaceans.
- Future wind energy generation projects (especially offshore ones) may act as a potential significant threat in the lack of relevant avoidance and mitigation measures, particularly related to bird and bats collision.
- In concern to new developments in the Black Sea region, it is essential for the countries bordering the sea to establish explicit regulations outlining the evaluation of cumulative impact on the Black Sea ecosystem. A comprehensive study of the Black Sea is required to enhance the identification of habitats and species, particularly those facing potential threats.
- Recommended legal actions involve addressing the intentional introduction of alien species into the Black Sea. National authorities are urged to adopt these measures and integrate them into international conventions such as the Convention on the Protection of the Black Sea Against Pollution (the Bucharest Convention) and the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention). Additionally, careful consideration should be given to the significant impacts of both climate change and the Mediterranean influence on the Black Sea.

- Establishing Marine Protected Areas (MPAs) is a crucial strategy for marine ecosystem recovery, as outlined by the Convention on Biological Diversity (CBD). These areas are settled for their ecological or biological significance and aim to preserve biodiversity, maintain vital ecological processes, promote sustainable use of species and ecosystems, and safeguard environmental quality, protecting at the same time the health and safety of coastal communities and resource users.
- While reducing negative interactions between marine mammals and fishing activities remains challenging, awareness campaigns aimed at fishers and stakeholders engaged in fishery activities are vital. These could emphasize the importance of marine mammals in natural cycles, biodiversity conservation, ecotourism, and various other aspects.
- Establishing an updated Red Book detailing the habitats, flora, and fauna of the Black Sea is feasible and would serve as a valuable resource for conservation management at the regional level.
- We identified the necessity for further examination of the repercussions of the war in Ukraine, including potential ecological reconstruction efforts. Currently, there is a significant lack of information regarding the impacts on biodiversity in the war zones, primarily due to the dangers posed to civilians. Nonetheless, the analysis suggests that the ongoing conflict in Ukraine could be exerting the highest pressure on biodiversity in the Black Sea, despite insufficient data. Supporting evidence includes numerous reports of dolphin deaths, satellite images depicting fires or floods resulting from dam destruction, and the likelihood of other unprecedented effects yet to be identified.

2 BASELINE ANALYSIS ON WATER QUALITY FOR THE BLACK SEA

The Black Sea is a nearly enclosed basin with a narrow connection with the Aegean Sea through the Turkish Straits Dardanelles and Bosphorus. Its unique features make it vulnerable to many pressures and disturbances (ANEMONE Deliverable 2.3, Lazăr et al., 2021).

The only source of salty water to the basin is represented by the water flowing out of the Bosphorus Strait, maintaining constant deep-water salinity. On the other hand, the freshwater inflow from European rivers Danube, Dniester, Dnieper, Don and Kuban keeps a lower level of salinity in the surface layer. Therefore, the water column is stratified regarding salinity and density. As a consequence of the stratification, the surface layer is oxygenated, while the deep layer is anoxic. However, considering the strong vertical stratification, the deep water is not replaced rapid enough to refill the oxygen already consumed through respiration by the organic matter (Stewart et al., 2006). This situation results in the incapacity of diluting the entered contaminants or to ecologically self-counterbalance (ANEMONE Deliverable 2.3, Lazăr et al., 2021).

The tools (BEAST and CHASE) resulted after the implementation of the ANEMONE project facilitated the identification of a high risk of eutrophication (BEAST) and chemical contamination (CHASE) in the rivers neighbouring areas of the Black Sea. This risk was decreasing from N-NW (southern Bug, Dnieper, Dniester, Danube) to W (Kamchia) and slightly increased in S (Sakarya and Yesilirmak). This risk was highly correlated with the basin's area and activities (ANEMONE Deliverable 2.3, Lazăr et al., 2021).

According to MODIS Land cover (Friedl & Sulla-Menashe, NASA, 2022), the dominant land use in the basin is agricultural with 65% of coverage. Therefore, the main sources of pollution are agricultural and inappropriate wastewater management. Having these considered, the introduction of nutrients from the upstream watershed represents an important issue in the study area, especially in the N-NW and S Black Sea.

Eutrophication represents the enrichment of a waterbody with minerals and nutrients, in particular nitrogen and phosphorus (ANEMONE Deliverable 2.1, Lazăr et al., 2021). The enrichment of nutrients caused by human activity results in excessive phytoplankton[1] growth and may also lead to the development of macrophytes[2].

Human activities that introduce nutrients into the marine environment lead to an overall increase in phytoplankton density. The composition of phytoplankton species adjusts to the altered nitrogen, phosphorus, and silica ratios. Conditions of high nutrients and low light favor smaller species with significant surface chlorophyll. Phytoplankton, being short-lived, either dies or is consumed by zooplankton, sinking below the euphotic zone where sufficient light for photosynthesis is unavailable. The resulting accumulation of phytoplankton and zooplankton fecal material undergoes bacterial decay, consuming oxygen. In extreme cases, insufficient diffusion and mixing can lead to oxygen

[1] Phytoplankton is represented by microscopic free-floating aquatic plants (ICPDR - ICPBS, 1999).

[2] Macrophytes are vascular plants in which specialized cells (tracheids) transport water and minerals from true roots (Bowden et al., 2007).

depletion, creating a "dead zone" where no marine animals can survive. Eutrophication is characterized by an increase in jellyfish abundance, which adapts more easily to altered environmental conditions than other predators. This phenomenon is linked to toxic species' blooms, posing risks to human health. Eutrophication also has direct economic impacts, diminishing the aesthetic appeal of seawater, making it appear "dirty" and unattractive to bathers. Some affected areas may experience blooms of phytoplankton species producing foams in a similar manner to detergents. Beaches near "dead zones" may be littered with dead animals, underscoring the environmental and economic consequences of eutrophication (ICPDR - ICPBS, 1999).

Nutrients can get to freshwater before reaching the sea by various manners: runoff from agricultural land, animal feeding operations, urban areas and discharge from wastewater treatment plants and atmospheric deposition of compounds resulted from the fossil fuel combustion (ANEMONE Deliverable 2.1, Lazăr et al., 2021).

In what regards the input of other substances, such as synthetic substances, non-synthetic substances, radionuclides etc., the integrated hazardous substances assessment tool CHASE (utilised in the ANEMONE project for the assessment of the water quality in the Black Sea for three countries: Romania, Ukraine, Türkiye) concluded that the Black Sea water chemical status is better in the Southern part, where the status was moderate in general, while the other areas were found to have a bad status (ANEMONE Deliverable 2.1, Lazăr et al., 2021).

Moreover, the near-complete lack of tidal action hinders the dilution of contaminants and obstructs natural depuration processes typically observed in larger water bodies, such as oceans. The Black Sea exhibits limited movement of deep-water masses and surface currents, which tend to circulate within this nearly enclosed basin. As a result of these distinctive characteristics, this basin responds more promptly to environmental disruptions caused by anthropogenic pressures compared to larger oceans (ANEMONE Deliverable 2.3, Lazăr et al., 2021).

3 MAIN PRESSURES IDENTIFIED FOR THE BLACK SEA

The Black Sea is mainly landlocked, with a very limited connection with the ocean and restrained capacity for the of exchange marine waters with the World Ocean. These conditions render the region highly vulnerable and responsive to various natural and economic pressures. Observations of the coastal zone's natural state in the Black Sea reveal widespread anthropogenic impact stemming from diverse economic sectors, affecting both terrestrial and marine ecosystems. In this context, the shelf area in the North-Western part of the sea stands out as an area of considerable impact (BSC, 2019).

The key sectors directly tied to the Black Sea's economic activities encompass shipping and ports, fishery, tourism, and oil and gas-related operations. Across all Black Sea countries, there is a notable and substantial expansion of urbanized areas and associated infrastructures. Consequently, the built-up areas nearly doubled within the 10 km buffer zone along the Black Sea coastline between 1992 and 2014. The urban expansion toward and along the coast, particularly around major cities, accounts for 4% of the coastal area in Georgia and up to 12% in Türkiye. This urbanization trend emerges as a significant pressure on the coastal zone (BSC, 2019).

The severe degradation of the marine ecosystem began in the 1980s and persists despite concerted efforts by the Black Sea countries and the global community. The fundamental factors that negatively impact the marine environment in the region, prevalent in the latter decades of the 20th century, remain unchanged. These factors include, but are not limited to, the extensive utilization of terrestrial and marine resources. Across the Black Sea catchment, land and water face intense utilisation for agriculture, forests are exploited for the paper industry and construction, rivers and the sea are employed for navigation and commercial fishing, while coastal resources are utilized for tourism, energy generation, transport infrastructure, construction, and various industries. Pipelines are constructed in coastal and marine areas to meet the growing demands for oil and gas. Consequently, natural landscapes are deteriorating, progressively giving way to anthropogenic landscapes (ANEMONE Deliverable 2.2, Lazăr et al., 2021).

An important aspect for this report is the differentiation between causes (pressures), effects and impacts, as effects will always appear as a result of a cause (pressure), while impacts result only when the zone of influence of the effect interacts with receptors (e.g.: Natura 2000 habitats, birds included in IBAs, mammals that move outside their habitat included in MPAs etc.). Having these considered, the analysis of the most obvious pressures to the Black Sea is presented as follows.

3.1 WASTEWATER TREATMENT PLANTS, INAPPROPRIATE WASTEWATER MANAGEMENT

Introduction
Wastewater treatment is a process which removes and eliminates contaminants from wastewater and converts this into an effluent that can be returned to the water cycle. The treatment process takes place in a **wastewater treatment plant.** After that, wastewater treatment plants (WWTPs) discharge water containing nutrients and micropollutants, which can lead to aquatic eutrophication and ecosystem dysfunction in receiving streams, rivers, and lakes (Wang et al., 2020).
Inappropriate wastewater management can generate untreated wastewater which generally finds its way into rivers, the sea and other surface water bodies. In addition, it can contaminate underground water reserves. Some of the types of inappropriate wastewater management include: exceedances of the effluent limitations, discharge of unauthorized substances, lack of wastewater treatment, improper treatment.

Lazăr et al. (2021) have concluded in the ANEMONE Deliverable 2.2 that the wastewater discharge volume from the WWTP "South" into the Black Sea surpasses that from the WWTP in the city and port of Chernomorsk, Ukraine, by a factor of 8.5. Consequently, the quantity of chemicals introduced into the marine environment is more substantial at the discharge point of the WWTP "South." However, this discrepancy is applicable only to certain parameters. The WWTP "South" significantly contributes to pollution in the marine environment, particularly in terms of nutrient levels (ANEMONE Deliverable 2.2, Lazăr et al., 2021).

Turkish coastal areas along the Black Sea experience significant enrichment of nutrients and organic matter. The main contributors to this enrichment are inadequate wastewater treatment and inputs from rivers (ANEMONE Deliverable 2.2, Lazăr et al., 2021).

The Lazar et al., 2020 article emphasized that the Romanian coast impacts the Black Sea through human activities, one of them being the wastewater treatment plants. Moreover, a study completed in 2023 by Baboş et al. (2023) shows that plastic particles with local origins usually come from sewage systems or wastewater treatment plants.

Summary

Pressure	**Wastewater treatment plants; inappropriate wastewater management**	
Location	Onshore	Offshore
Main effects	• Eutrophication (increased nutrient load); • Pollution; • Changes in water quality; • Microplastics; • Fauna mortality; • Heavy metals pollution.	

3.2 PORT ACTIVITIES

Introduction
Port activities refer to such as activities as cargo handling operations, anchoring or construction, which may determine several harmful effects to the marine biodiversity.

Pokazeev et al. (2021) showed that the highest oil products concentration in sea bottom sediments are found in the main ports of Ukraine and in Crimea, most probably because of the port activities.

In the Samsun area, Türkiye, maritime activities, including port and harbour facilities, serve as another pollution source. Substances like Petroleum Hydrocarbons and other chemicals, when accidentally released or during handling operations, pose a risk to the aquatic environment (ANEMONE Deliverable 2.2, Lazăr et al., 2021).

According to the *EMBLAS Final Scientific Report* (2021), the greatest concentrations of floating marine macro litter was observed in 2017 and 2019 in the Russian sector of the Black Sea. Some of the main sources might be the ships that wait to enter the harbour, the fishing activities or the riverine litter discharge into the sea. However, the mentioned report also concluded that the Don river had a maximum value of litter flux of 32 items/hour, which was the lowest amount, compared with the other rivers which provide maximum values of litter flux of 150 items/hour.

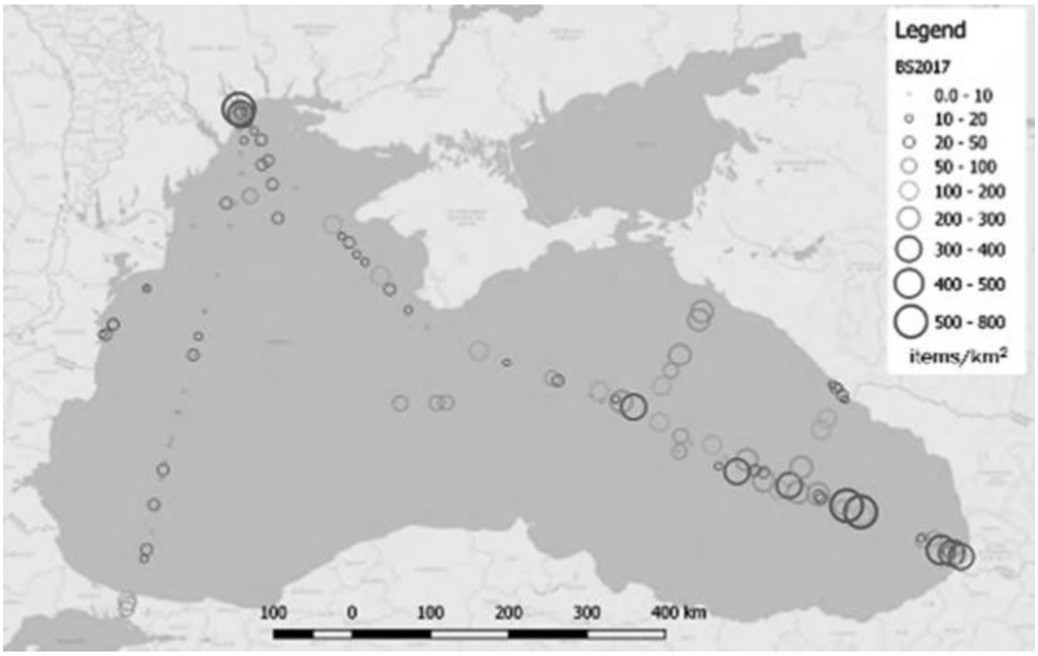


Figure no. 3-1 Floating Marine Macro Litter during the observations made in 2017 (Source: *EMBLAS Final Scientific Report*, 2021)

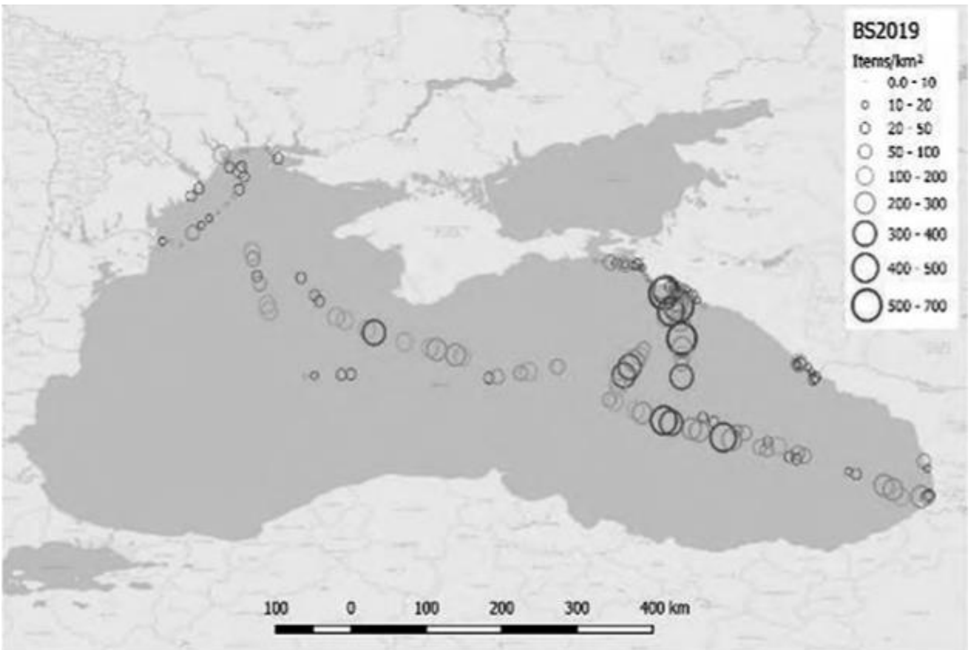


Figure no. 3-2 Floating Marine Macro Litter during the observations made in 2019 (Source: *EMBLAS Final Scientific Report*, 2021)

Nonetheless, the southeastern coast of the Black Sea has also been analysed for microplastics and it has been concluded that the activities carried in the fishing port contribute to the microplastic pollution of the sea (Eryaşar et al., 2021b).

Summary

Pressure	**Port activities**	
Location	Onshore	Offshore
Main effects	• Pollution; • Microplastics; • Marine litter; • Heavy metals pollution.	

3.3 NUCLEAR POWER GENERATION

Introduction

Nuclear power is the use of nuclear reactions between radioactive chemical elements for energy production. Nuclear accidents can, for example, be caused by the failure of technical components, by human error or by natural disasters. As a result of a nuclear accident a significant level of radioactive substances is released. This can seriously affect human health and environment. In addition, nuclear power plants operation can also result in the production of large amounts of radioactive materials, which consequently may lead to radioactive pollution.

Radioactive substances or radionuclides exist naturally in seawater and sediments, and these occurrences, being of natural origin, are not considered pollution by definition. However, numerous instances demonstrate that technical processes have introduced radioactive substances into the ocean. Man-made radionuclides are introduced into the marine environment through various artificial sources. The primary sources include: global worldwide fallout, authorised discharges from nuclear reprocessing plants, authorised discharges from nuclear power reactors or research establishments, accidental releases to the atmosphere and subsequent contamination of the marine surface, accidental releases from other radioactive sources like re-entering of satellites with radioactive power sources, accidental losses of nuclear driven ships and submarines or dumping of nuclear wastes in the marine environment (Nies, 2017).

The operation of nuclear power plants results in the production of significant amounts of radioactive materials, leading to radiation pollution. While regulatory authorities permit the discharge of liquid wastes from these plants, it must be closely monitored, controlled, and reported. Radionuclides commonly reported in the liquid waste include fission and activation gases like xenon, krypton, and argon; halogens/iodines such as bromine and iodine; particulates including cobalt, cesium, chromium, manganese, and niobium; and tritium in the form of hydrogen. Standards and regulations, as outlined by control authorities, govern the handling of these radioactive substances from nuclear power plants. However, operating risks such as nuclear accidents may cause higher levels of radiation pollution than usual operation (Iqbal et al., 2021).

According to Pokazeev et al. (2021), the Black Sea is one of the most radioactively contaminated basins of the World Oceans. The world's biggest nuclear accident at Chernobyl nuclear power plant still leaves traces in the form of ^{137}Cs and ^{90}Sr radionuclides. A few results of the determination of these elements concentrations in the surface water layer of the Black Sea in 2011-2013 concluded that the levels are continuing to be notably high, reaching 56 Bq m^{-3} for ^{137}Cs and 32 Bq m^{-3} for ^{90}Sr, comparable or even exceeding levels recorded before the accident, near the Dnieper-Bugskiy estuary in Ukraine.

Other notable nuclear incidents, such as the Windscale fire in 1957 and the Fukushima accident in 2011, have led to significant radioactive contamination of ocean waters. Despite the initial high contamination, the vast dilution capacity through the dispersion of marine waters resulted in rapid reduction. This contamination can be transported over long distances by ocean currents, potentially causing widespread contamination of marine waters. In most cases, the contamination of marine organisms does not pose harm to humans and biota. Legal limits for contamination in fish or shellfish ultimately constrain the marine exposure pathway, ensuring consumption remains below accepted thresholds for the general population (Nies, 2017).

From 1991 to 1995, a survey assessed over 3000 water bodies in regions impacted by the Chernobyl accident, including Zhytomyr, Kiev, Rovno, and Chernihiv (Ukraine). This screening resulted in the development of a 'contamination cadastre', pinpointing lakes, ponds, and small reservoirs with heightened contamination levels. The survey found elevated risks from the use of water in various regions, including 40 water bodies in Rovno, 87 in Zhytomyr, 27 in Kiev, and 28 in Volinsky (Ukraine). Increased risks were anticipated in activities like irrigation, fishing, raising water birds, and game hunting. The risk analysis employed conservative approaches, utilizing worst-case scenarios with maximum concentrations and sporadic measurements for dose calculations. Despite the conservative approach in the analyses, the study revealed that around 2% of the surveyed water bodies in Rovno and Zhytomyr districts exceeded the provisional permissible level of 2 Bq/L for ^{137}Cs and ^{90}Sr. Data on radionuclides in fish and birds indicated significant bio-enhancement compared to water. For instance, in Lake Bile, ^{137}Cs concentration in water was 1.5 Bq/L, while in fish, it reached 450 Bq/kg, and in aquatic birds, it ranged from 50 to 75 Bq/kg. In some smaller ponds, the ^{137}Cs contamination in fish surpassed the permissible levels for Ukraine (150 Bq/kg) (IAEA, 2006).

Presently, there are several Nuclear Power Plants in the Black Sea countries which might generate a great damage to the Black Sea in case of accidents, these being detailed in what follows.

In the first place, as it can be observed from the figure below (IEA – International Energy Agency, 2023), the countries with the greatest share of nuclear energy supply are Russia and Ukraine, followed by Bulgaria and Romania with lower shares.

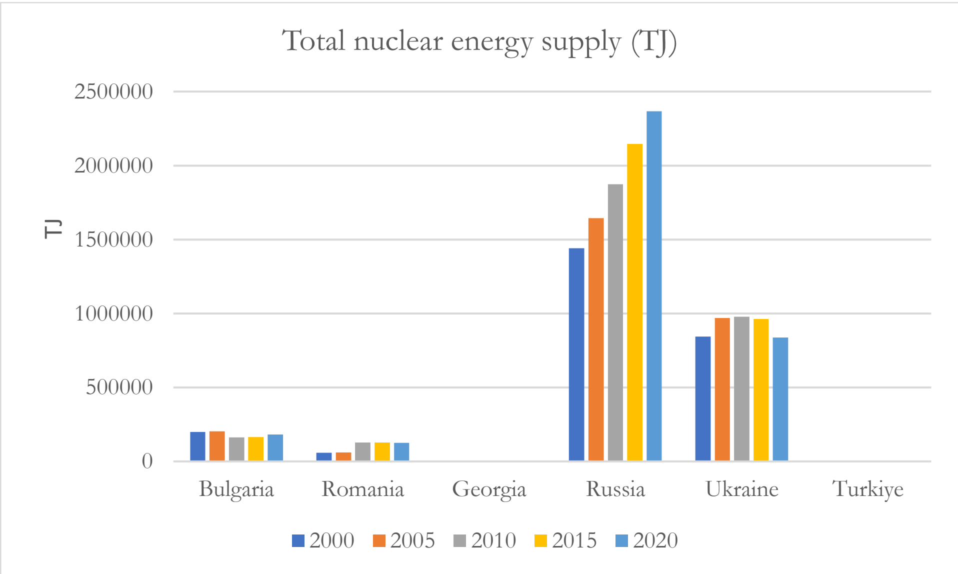


Figure no. 3-3 Total nuclear energy supply in the Black Sea countries (Source: IEA – International Energy Agency, 2023)

The Black Sea countries with nuclear power reactors currently in operation are the following:

Table no. 3-1 Operating nuclear reactors in the Black Sea countries (Source: *Information Library - World Nuclear Association*, 2023)

Country	In operation		Under construction (number)	
	Number	Name / Location	Number	Name / Location
Bulgaria	2	Kozloduy 5	0	-
		Kozloduy 6		
Georgia	0	-	0	-
Romania	2	Cernavoda 1	0	-
		Cernavoda 2		
Russia	37	*Novovoronezh 4	3	BREST-OD-300
		*Novovoronezh 5		
		*Novovoronezh 6		Kursk II-1
		*Novovoronezh 7		
		*Rostov 1		Kursk II-2
		*Rostov 1		
		*Rostov 3		
		*Rostov 4		
Ukraine	15	[$]South Ukraine 1	[#]2	Khmelnitski 3
		[$]South Ukraine 2		
		[$]South Ukraine 3		
		[$]Zaporizhzhia 1		Khmelnitski 4
		[$]Zaporizhzhia 2		
		[$]Zaporizhzhia 3		
		[$]Zaporizhzhia 4		
		[$]Zaporizhzhia 5		
		[$]Zaporizhzhia 6		
Türkiye	0	-	4	Unknown

*: *Nuclear reactors in operation in Russia that have connections with the Black Sea through Don River and implicitly, through the Azov Sea.*

[#]: *construction currently suspended.*

[$]: *Nuclear reactors in operation in Ukraine that have connections with the Black Sea through Bug and Dnieper Rivers.*

It can be observed in Figure no. 3-3 and in Table no. 3-1 that there is a high correlation between the number of reactors and the energy supply of each country.

Moreover, in Figure no. 3-4 to Figure no. 3-7 the locations of the nuclear power plants are shown. Some of the NPPs[3] are located close to rivers that flow into the Black Sea (i.e.: Kozloduy NPP – Bulgaria, cca. 3.7 km from Danube river).

[3] NPP = Nuclear powerplant

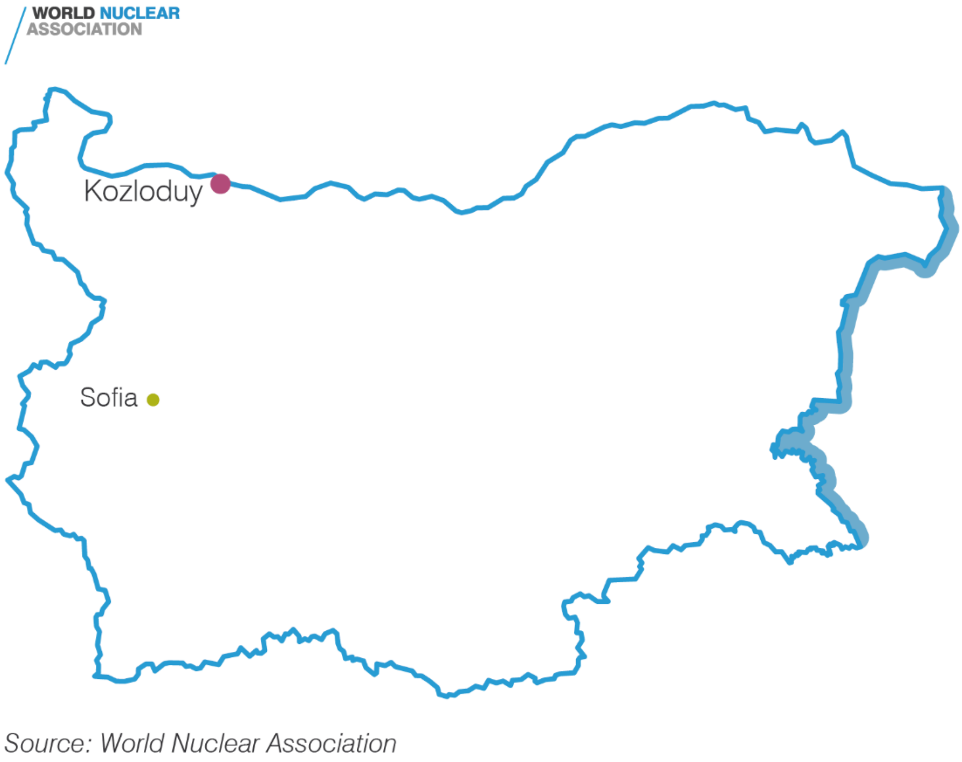


Figure no. 3-4 Location of the Kozloduy nuclear power plant in Bulgaria (Source: Information Library - World Nuclear Association, 2023)

Figure no. 3-5 Location of the Cernavoda nuclear power plant in Romania (Source: *Information Library - World Nuclear Association*, 2023)

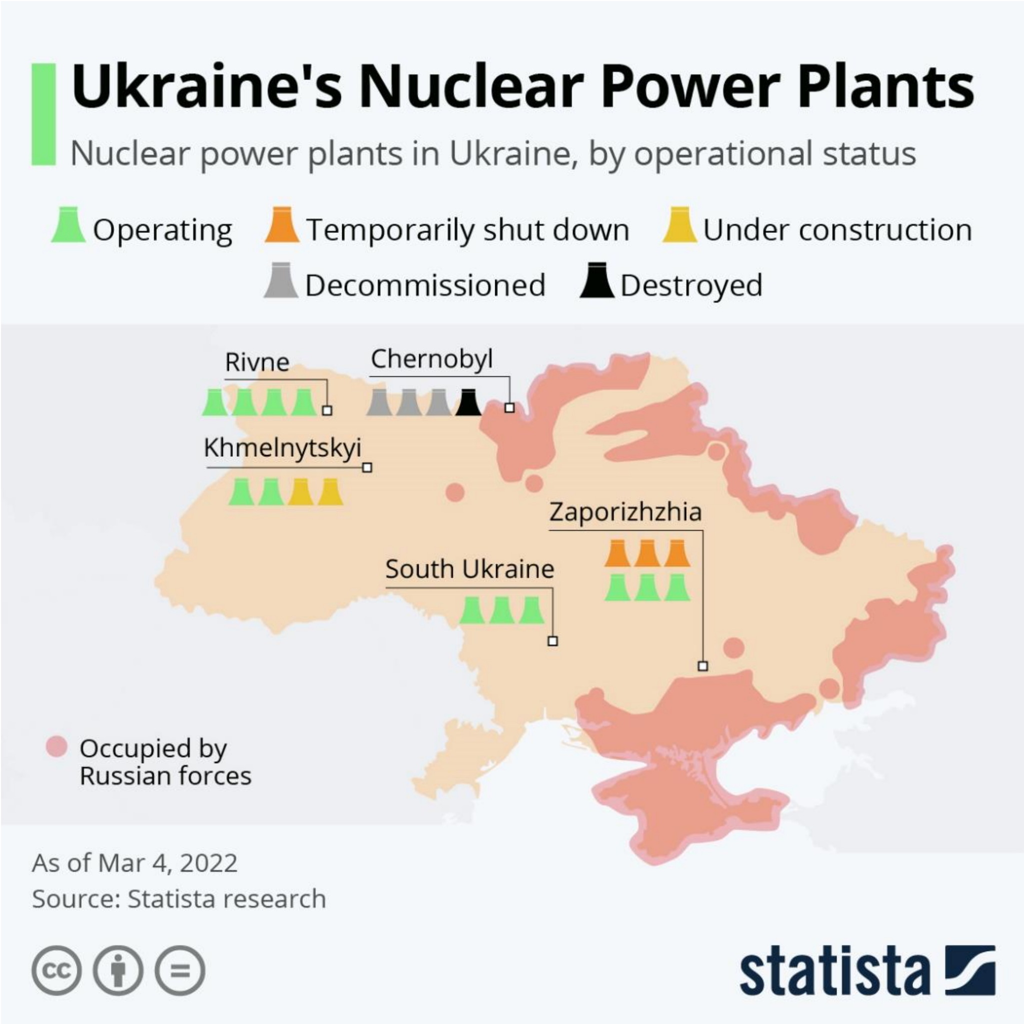


Figure no. 3-6 Location of the Ukrainian nuclear power reactors (Source: Armstrong, *Statista Daily Data*, 2022)

Figure no. 3-7 Nuclear power plants in Russia (Source: *Information Library - World Nuclear Association*, 2023)

While the likelihood of a major accident at a nuclear power plant is deemed low due to continuous enhancements in facilities in the Russian Federation and Ukraine, the potential consequences of a significant release would be substantial, particularly if the incident occurred in the southern regions of Ukraine, such as at the Zaporozhe nuclear power plant. Transboundary impacts, especially in the Black Sea, could be significant in such a scenario. In the hypothetical scenario, a portion of the deposited ^{137}Cs is absorbed by sediments in the Kakhovka reservoir and the Dnieper–Bug estuary. However, the majority (14 PBq) is carried to the Black Sea, with a maximum influx of 1.5 GBq/s. In comparison, the total ^{137}Cs release during the Chernobyl accident was 85 PBq, but only 1 TBq reached the Black Sea. This highlights that in the event of a major accident at the Zaporozhe nuclear power plant, proximity to the Black Sea, along with adverse weather conditions, could result in significant transboundary contamination. The analysis focuses solely on the water pathway, measuring impact through concentrations and fluxes of ^{137}Cs, without attempting to estimate radiation doses (IAEA, 2006).

In addition, the NPP from Kozloduy, Bulgaria and the NPP from Cernavoda, Romania are also potential contamination sources of the Black Sea, through the Danube river (Borcia et al., 2017).

Summary

Pressure	**Nuclear power generation**	
Location	Onshore	Offshore
Main effects	• Radioactive pollution.	

3.4 Waste disposal

Introduction
Waste disposal is the collection, processing and recycling or deposition of the waste materials of human society. The term "waste" is usually applied to solid waste, sewage, hazardous waste and electronic waste. Improper waste disposal means that waste is not correctly disposed and causes negative consequences for the environment. These include: littering, hazardous waste dumped into the ground, lack of recycling etc. Waste that does not get to landfills or any other disposal areas, usually finds its way into any bodies of water and finally, into the seas and oceans.

The observations of the *EMBLAS Final Scientific Report*, 2021 on the Ukrainian side of the Danube River emphasized that the highest values of litter flux was of 350 items/hour, which makes it the river with the greatest input of litter into the sea.

Furthermore, the presence of solid waste in storage areas near the Turkish coast poses challenges for coastal regions (ANEMONE Deliverable 2.2, Lazăr et al., 2021). Bat et al. (2018) have also addressed the fact that the deficient disposal of waste represents a serious problem for the Black Sea region.

The discharge of hazardous substances from the polluted dredged material exerts a significant impact on the marine environment as well (ANEMONE Deliverable 2.2, Lazăr et al., 2021).

During the ANEMONE Project, in *ANEMONE Deliverable 4.2*, Gheorghe et al. (2021) it can be found that from an abundance point of view, Türkiye generated the highest amount of marine litter (2.81 items/m^2), followed by Romania (0.95 items/m^2), Bulgaria (0.57 items/m^2) and Ukraine (0.22 items/m^2).

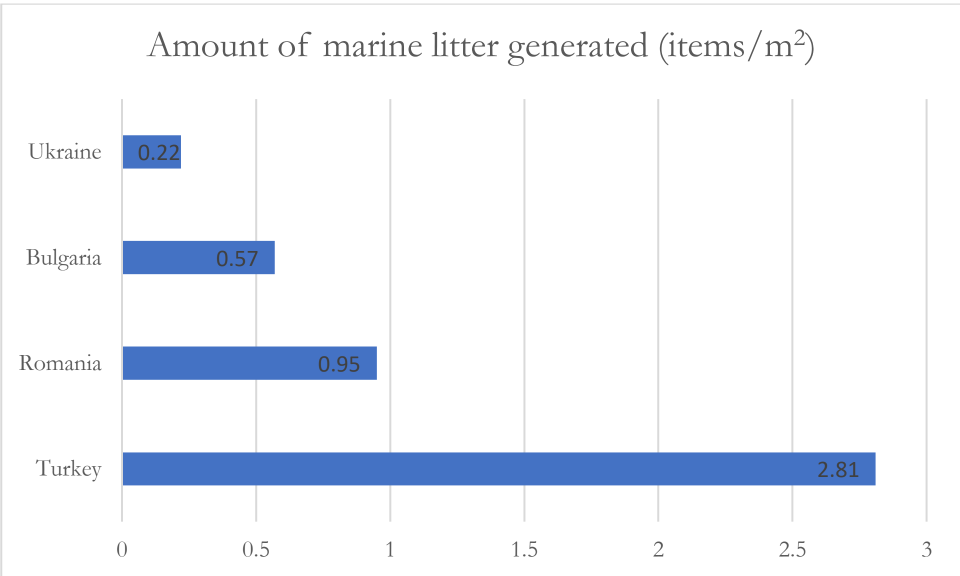


Figure no. 3-8 Amount of marine litter generated (Source: *ANEMONE Deliverable 4.2*, Gheorghe et al., 2021)

Four rivers from Georgia were monitored for riverine litter within the EMBLAS project. However, those rivers provided maximum values of litter fluxes of 150 items/hour (*EMBLAS Final Scientific Report*, 2021).

Bekova & Prodanov (2023c) emphasize the fact that the land-based litter on the Bulgarian coast originates from poor waste management among other sources. Moreover, rivers are responsible for transporting over 90% of the poorly managed plastic waste in Bulgaria. Moreover, rivers were up to 21.96% accountable for transporting the land-based litter in the southeastern Turkish Black Sea coast.

Winterstetter et al. (2023) show that most of the Black Sea countries (Türkiye, Ukraine, Romania) presented a very high or high level of mismanaged PPSI (plastic packaging and small non-packaging plastic items) waste in 2018 (Figure no. 3-9). It should be noted that there is no data for Georgia or Russia in this article. Moreover, it is shown that the countries with the highest level of mismanaged PPSI in coastal areas are Romania, Türkiye and Bulgaria (>2500 t/y).

However, according to *Plastic Overshoot Day – Report 2023*, EA-Environmental Action 2023, Russia was responsible for more than 3000 kt/year of mismanaged plastic waste.

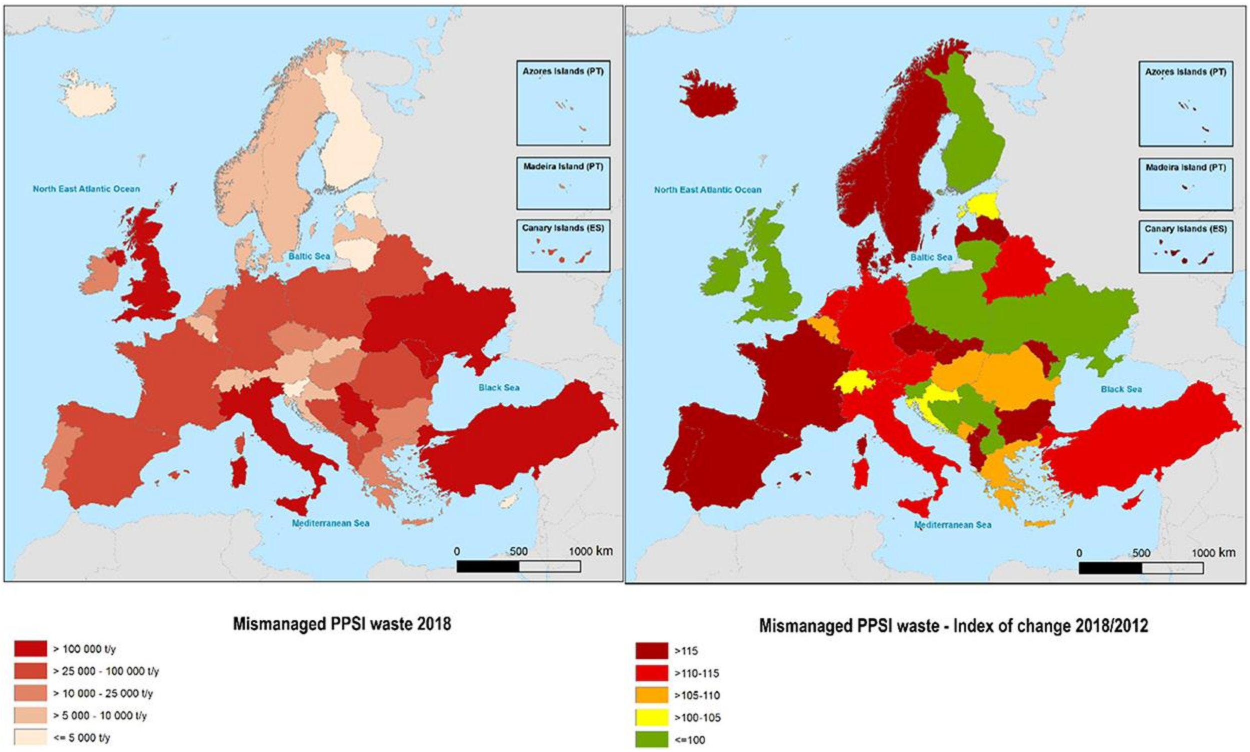


Figure no. 3-9 Total estimated amounts of mismanaged PPSI waste in 2018 (tons per year, t/y) (left) and index of change 2018/2012 (right) (Source: Winterstetter et al., 2023)

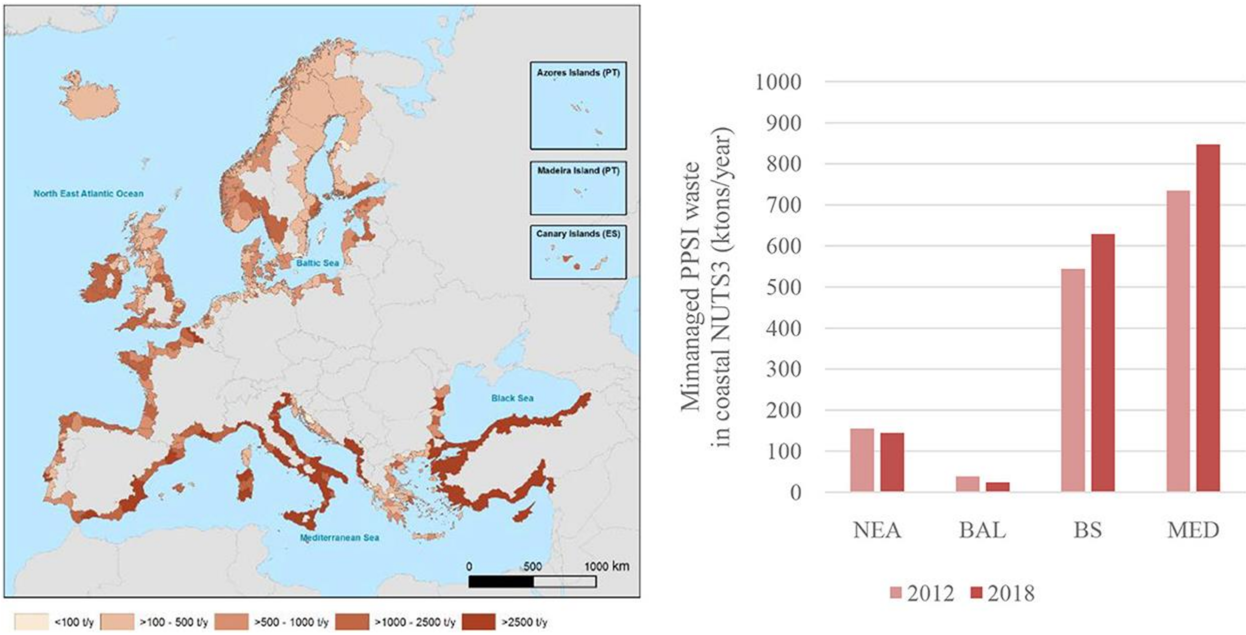


Figure no. 3-10 Amounts of mismanaged PPSI waste in 2018 in coastal NUTS 3 (tons per year, t/y) (left); and total amounts in NUTS 3 (thousand tons per year, ktons/year) aggregated by European regional sea in 2012 and 2018 (right) (Source: Winterstetter et al., 2023)

Summary

Pressure	**Waste disposal**	
Location	Onshore	Offshore
Main effects	• Eutrophication (increased nutrient load); • Pollution; • Marine litter; • Riverine litter discharge into the sea; • Health impairment of fauna; • Heavy metals pollution.	

3.5 TOURISM, FISHING, FISHERIES

Introduction
Tourism is the act and process of spending time away from home in pursuit of recreation, relaxation and pleasure, while making use of the commercial provision of services. The most obvious environmental effect is waste production and improper disposal.
Fishing refers to the activity of catching fish, often in the wild, for various purposes such as for food, sport, or commerce. Several issues such as litter, overfishing, bycatch of vulnerable species, discards, pollution, Illegal, Unreported and Unregulated (IUU) fishing can lead to disastrous impacts to the environment.
Fisheries can mean either the enterprise of raising or harvesting fish and other aquatic life or, more commonly, the site where such enterprise takes place. Challenges such as declining fish populations, overfishing, marine pollution, seabed habitats disturbance because of trawling and destruction of coastal ecosystems raise concerns regarding ocean health and water quality.

A study conducted in 2021 on the public beaches of the Marmara Sea (connected with the Black Sea through the Bosphorus Strait) concluded that the majority of litter found on public beaches resulted from tourism activities, with plastic being the predominant type. Plastic constituted 48.07% of the total weight and 76% in terms of the overall number of items (Artüz et al., 2021).

Marine debris densities varied between 304 and 20,000 items/km^2, with an average density of around 6,359 items/km^2. The quantity of items decreased from north to south, reaching its peak off the Romanian coast. The quantity was smaller in front of Bulgaria (9,598 items/km^2) and Türkiye (7,956 items/km^2). In coastal areas (where the depth is <40m), the prevalence of marine litter mostly exceeded that on the continental shelf, excluding Bulgaria. Across all samples, it was evident that fishing and tourism-related activities significantly contributed to seafloor litter. Plastic debris was the most prevalent and abundant, constituting approximately 68% of the total. The nature of the marine litter suggested a predominant origin from shipping and fishing activities (ANEMONE Deliverable 2.3, Lazăr et al., 2021). In addition, another study completed on the Romanian coast by Baboş et al., 2023 showed that many analysed samples originated from fishing.

Lazăr et al. (2020) have discussed the fact that the high demography during summer season is one of the pressures of the Romanian coast of the Black Sea.

Moreover, Simeonova et al. (2017) concluded that the Bulgarian coast is very polluted with marine litter, most of the items originating from recreational activities, wild camping and increased tourist flow. It was also emphasized by Eryaşar et al. (2021b) that the SE coast of the Black Sea in Türkiye was mainly polluted with microplastic coming from fishing and tourism.

Bekova & Prodanov (2023) state that fishing is one of the main sea-based sources of pollution on the Bulgarian coast and mainly generates items such as fishing nets and cords. However, land-based sources generate the majority (70%) of marine litter, tourism and recreational activities representing a significant source.

However, high population densities living on the Black Sea coastal areas and tourism might be two of the most significant pressures related to human presence, which are causing changes in marine ecosystems (European Environment Agency, 2017).

According to Shaw et al. (2013), the percentage of people residing in administrative regions along the Black Sea coast varies significantly across national populations: 0.6% in Russia, 4.5% in Romania, 10.5% in Türkiye (excluding Istanbul), 14.4% in Ukraine, 26.5% in Bulgaria, 37.1% in Türkiye (including Istanbul), and 38.6% in Georgia (the proportion is considered as number of persons/km^2 compared to national averages).

In addition, according to Liyanage & Yamada (2017), water quality of surface waterbodies is worst in highly populated areas. Furthermore, population density has been identified as a major factor of degradation of the water ecosystem, mainly due to untreated sewage, discharge of municipal wastewater or to disposal of various items (organic materials, nutrients etc.).

Thus, a recent mapped analysis of Wong (2022) shows that the highest population densities in 2023 within the coastal areas of the Black Sea can be found in the main port cities: Istanbul, Samsun (Türkiye), Varna (Bulgaria), Constanta (Romania), Poti, Batumi, Sukhumi (Georgia), Sevastopol (Crimea), Odessa (Ukraine).

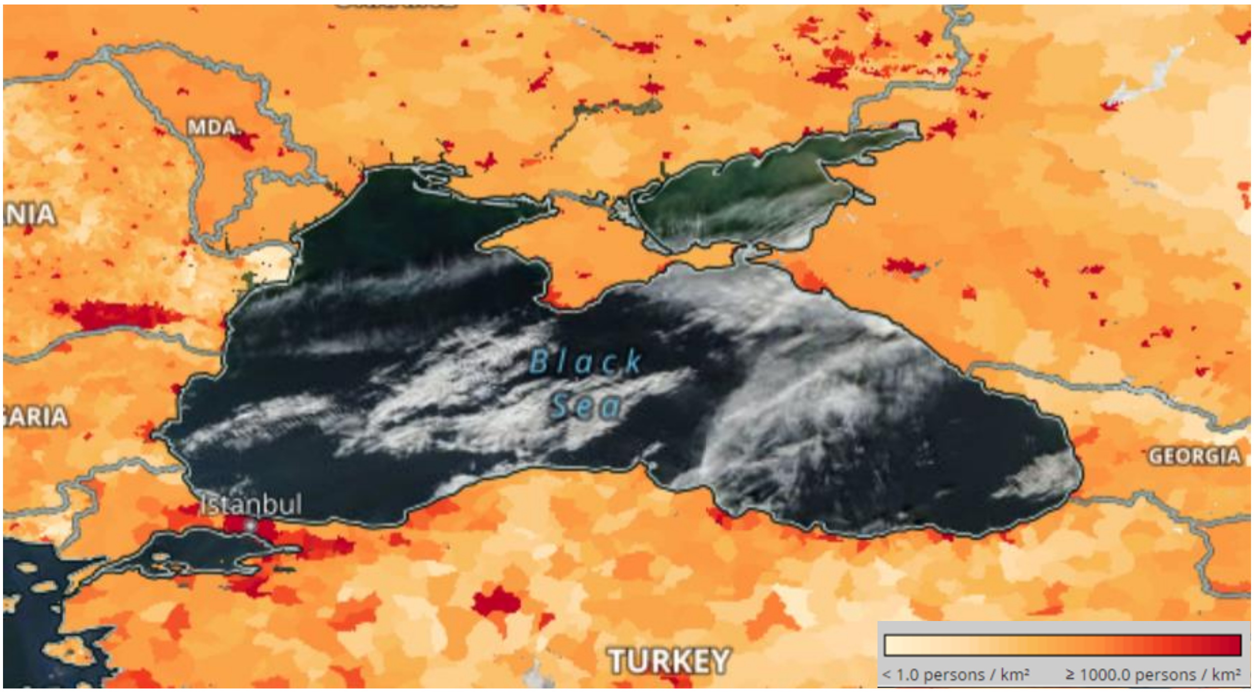


Figure no. 3-11 Population densities in the coastal areas of the Black Sea (Source: Wong, NASA Worldview, 2022)

In what regards the current state of fishery, Oğuz (2017) states that predatory fish (sturgeons, tuna, turbot) species are deficient in the Black Sea, with approximately 85% of the overall fish catch consisting of the economically viable anchovy, predominantly found in the southeastern region. This situation globally stands out as one of the most severe instances of mismanagement, leading to a significant collapse. The issue is exacerbated by fleet overcapacity, primarily from Turkish fleets, resulting in the capture of fish exceeding sustainable levels and surpassing quotas through illegal or unreported means. Political and social pressures have historically influenced the enforcement of quotas to favour short-term fishing gains, neglecting long-term sustainability. Subsidies in the fisheries sector contribute to overcapacity and the overexploitation of fish stocks (Oğuz, 2017).

Todorova et al. (2021) emphasized that, in 2017, around 60% of the Bulgarian Black Sea shelf experienced physical disturbance from MBCG (Mobile Bottom Contact Gears). Nonetheless, only 12% of the seabed at depths below 200 meters faced high physical disturbance pressure from fisheries. The circalittoral mud and mixed sediments were the predominant benthic habitat types subjected to extensive trawling pressure, followed by offshore circalittoral mixed sediments. The circalittoral zone habitats bore the highest pressure intensity. It was noted that the physical disturbance on infralittoral sands might be considerably underestimated due to the absence of tracking systems on boats under 12 meters in length, which form the predominant fleet segment.

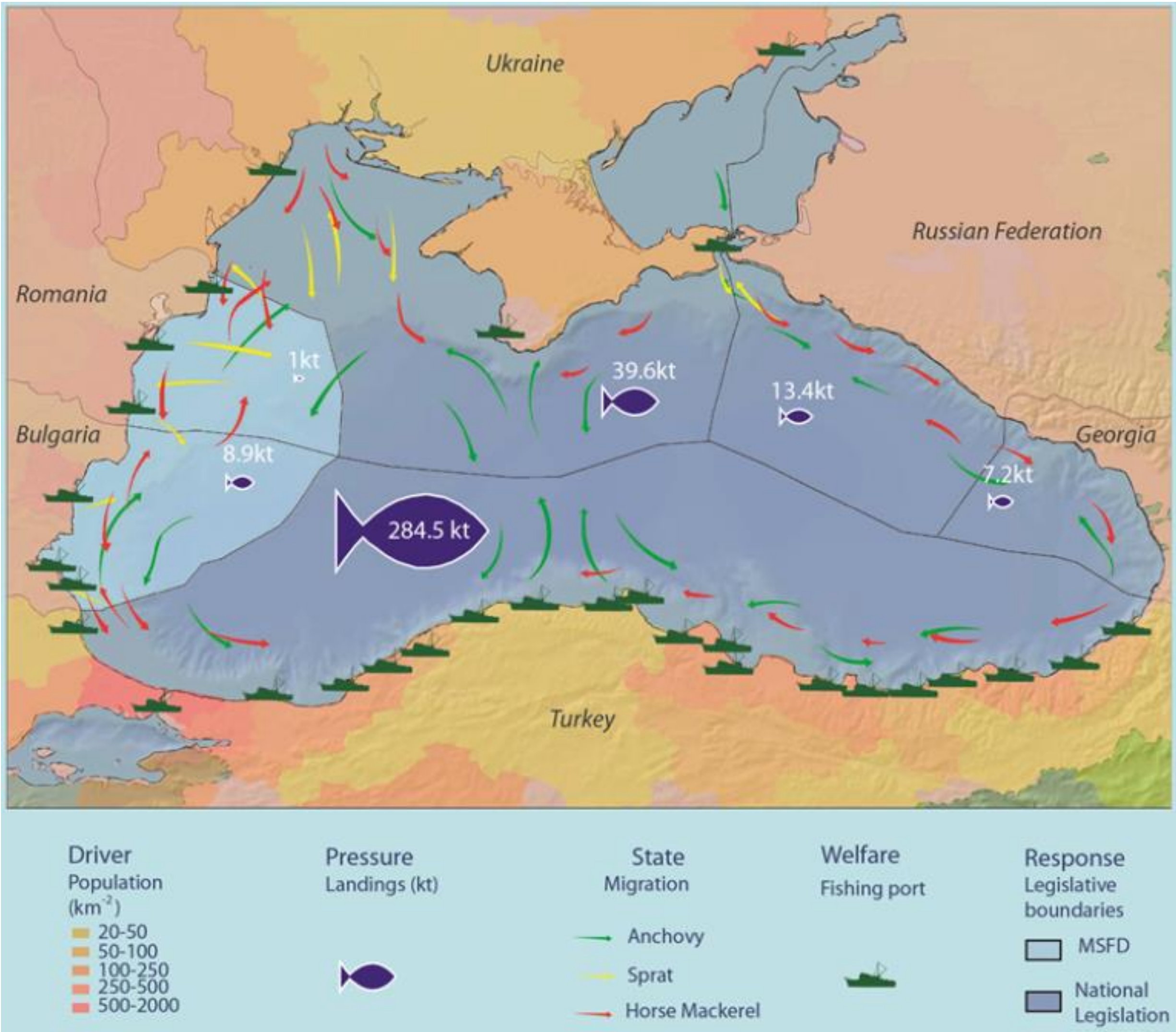


Figure no. 3-12 Space analysis map for small pelagic fisheries in the Black Sea (Source: O'Higgins et al., 2014)

Figure no. 3-12 demonstrates the significance of the Turkish fishery in the Black Sea, evident in both the number of fishing ports and the volume of fish landings. The primary driving force behind Black Sea small pelagic fisheries is the demand for fish protein in Türkiye (O'Higgins et al., 2014).

Another issue emerged from fishing is bycatch of vulnerable species. Carpentieri (2021) presents a comprehensive review of the literature and shows that the Black Sea countries with the highest rates of incidental catches of various vulnerable species are Russia, Ukraine, Türkiye, Romania and Bulgaria.

According to FAO (2024), FAO major fishing areas for statistical purposes are arbitrary areas, the boundaries of which were determined in consultation with international fishery agencies on various considerations. For statistical purposes, the major fishing areas are referred to as statistical areas and each area may be divided into smaller areas as needed. The internationally accepted standard practice is to divide a statistical area into one of more statistical subareas, then divide a subarea into one of more statistical divisions and finally divide a division into one or more statistical sub-divisions. A total of 27 major fishing areas have been internationally established to date. Mediterranean And Black Sea (Major Fishing Area 37) is divided as follows: Western Mediterranean (Subarea 37.1), Central Mediterranean (Subarea 37.2), Eastern Mediterranean (Subarea 37.3), Black Sea (Subarea 37.4). In 1989 the Black Sea Subarea 37.4 was subdivided into three divisions on the basis of the following considerations:

- The species found in the Sea of Marmara are not found in the Black Sea proper. It is misleading for scientific analysis to mix fauna of the Marmara Sea with the Black Sea.
- Because of the damming of the rivers flowing into the Sea of Azov, salinity had increased markedly. Species composition of the fauna had changed and it was deemed important to monitor the changes in the Sea of Azov.

Thus, subarea 37.4 is divided as follows: Marmara Sea (Division 37.4.1), Black Sea (Division 37.4.2), Azov Sea (Division 37.4.3) (FAO, 2024) (Figure no. 3-13).

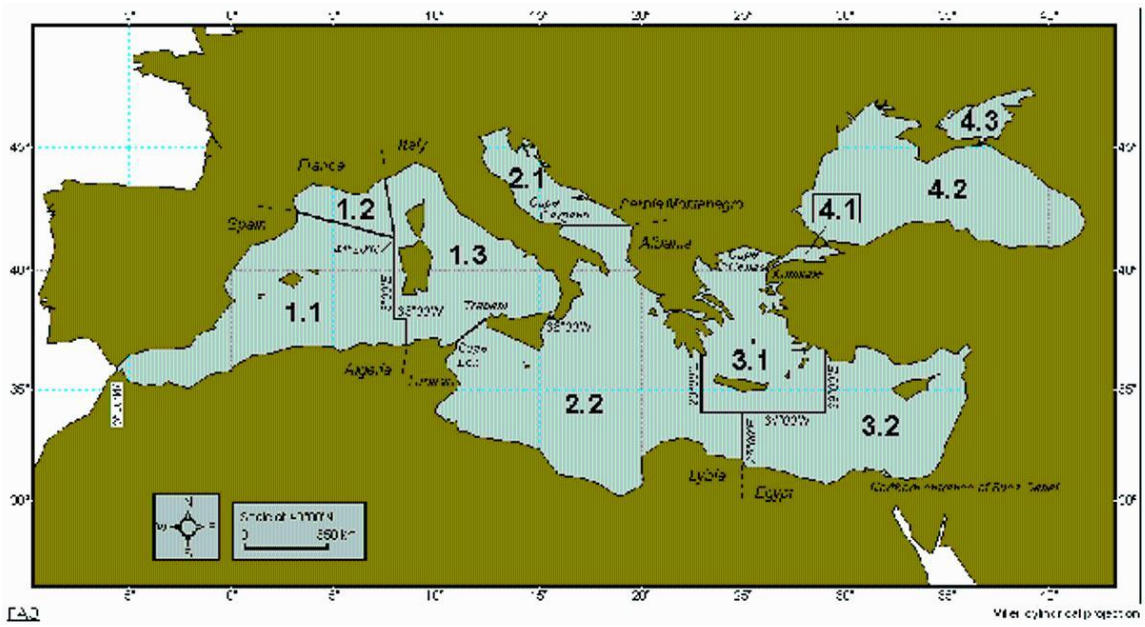


Figure no. 3-13 Boundaries of the Mediterranean and Black Sea (Major Fishing Area 37), subareas and divisions (Source: FAO, 2023)

Furthermore, bycatch of non-target species, such as vulnerable fish, mammals, sea turtles, and seabirds, results in adverse effects on the population sizes of these species. Additionally, the physical impact inflicted by trawling and other active fishing gear harms the benthic flora and fauna within the fishing area. Consequently, the catch of both target and non-target species may contribute to diminished biodiversity and other alterations in marine ecosystems (European Environment Agency, 2017). For instance, the bycatch rate for harbour porpoises was calculated by Popov et al. (2023) to be between 4.6% and 21.3% of the total Black Sea abundance estimation (approx. 258 900 porpoises), which is by far higher than the limit (1.7% of best population estimate) of unnaceptable interaction defined by ASCOBANS (2015). In addition, considering the results of Lewison et al. (2014), the bycatch intensity of marine mammals (cetaceans) is medium-high in the western and southern parts of the Black Sea, mostly by the use of gillnets.

Intensive fishing activities, such as trawling, generate the primary environmental pressures on fisheries by causing physical damage to the marine ecosystems in the seafloor, more specifically by abrasion or siltation. However, the extent of these impacts varies depending on the scale of fishing and the unique biological characteristics of sea. The quantity of fish caught predominantly influences the population size of the targeted species, potentially altering the age distribution as larger specimens are often the focus of fishing efforts. This shift may contribute to changes in the genetic makeup of the population, impacting food-web dynamics, stock resilience, and overall stock levels (European Environment Agency, 2017).

However, the European Environment Agency (2017) analysed the impact generated by fishing for the European seas by estimating fishing effort. The analysis shows five categories of fishing based on fishing technique and gear type. Each of these impacts the seafloor differently and the list is presented in descending order of impact on the seafloor relative to the most impacting gear: mobile gears with high (beam trawl and dredge); medium/low (bottom trawl and seine); and no impact (pelagic trawl) on the seafloor; passive gears with low (gillnets, pots and traps) or no impact on the seafloor (longlines). The analysis found that the most used fishing techniques were done by passive gears, with a low impact on the seafloor. The second frequently used fishing technique was bottom trawling with medium/low impact.

Marine fisheries represent an important economic sector in the Black Sea countries. Popescu (2010) has shown that Türkiye was the most important fishery nation in the Black Sea in 2010, both in terms of volume and of value of catches. Furthermore, according to *Sea Around Us* database, Türkiye remains the country with the highest volume of catches (Figure no. 3-14). For example, according to Goulding et al. (2014), the European anchovy (*Engraulis encrasicolus*) catch (in tonnes) between 2006-2010 of Türkiye represents 85,78% of all Black Sea countries total anchovies catch.

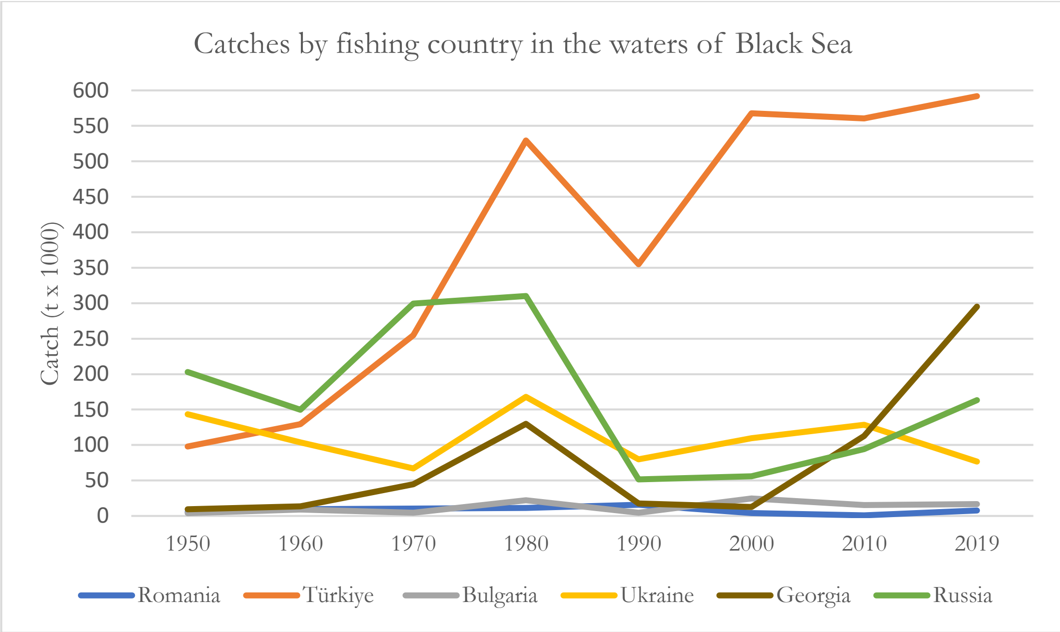


Figure no. 3-14 Volume of the landings in the Black Sea countries between 1950-2019 (Source: https://www.seaaroundus.org)

The Turkish fisheries exert the primary influence on fish stocks, accounting for approximately 80% of the Black Sea catch by weight (BSC, 2008 apud. O'Higgins et al., 2014). Anchovy represents the most substantial portion of this fishery, followed by sprat (Daskalov and Ratz, 2011 apud. O'Higgins et al., 2014). Legitimate fishing operations are predominantly confined to territorial waters, although a notable portion, ranging from 10 to 50%, of the anchovy catch in Turkish ports originates from Georgian waters (Özturk 2013; S. Knudsen, *personal communication* apud. O'Higgins et al., 2014).

However, IUU fishing remains one of the most concerning pressures to biodiversity at global scale, not only in the Black Sea. There have been several initiatives to measure and estimate the IUU caught fish at global and regional scales. Such studies estimated that IUU caught fish in 2003 ranged from 11% to 19% of officially reported catches. This accounted for a total of 10 to 26 million tonnes of fish, with a corresponding market value of US $10 to $23 billion (Agnew et al., 2009). Nevertheless, Macfadyen, Caillart & Agnew (2016) concluded that a global estimate of IUU catches can lose accuracy due to the insufficient transparency of the reviewed studies.

Considering the lack of data not only at global level, but also at regional level, we will present the conclusions of *The Illegal, Unreported and Unregulated Fishing Index* (2021) for the Black Sea countries. Nonetheless, it should be noted that countries as Russia or Türkiye have access to other seas as well and the index does not provide data only for the Black Sea.

The overall IUU score ranking across all state responsibilities and indicator types shows that Russia is the 2nd country, Ukraine the 7th, while the other Black Sea countries (Georgia – 44, Türkiye – 103, Bulgaria – 140, Romania – 146) have much lower scores (Figure no. 3-15). The *The Illegal, Unreported and Unregulated Fishing Index* (2021) Report shows that the countries with the lowest rank are the ones with the poorest performance in terms of vulnerability, prevalence and response across different state responsibilities. In addition, the scores constitute a standardized performance rating associated with the 40 indicators incorporated in the Index. All in all, as long as Russia and Ukraine are included in the top 10 worst performance ranking, we may conclude that these are the countries with the greatest contribution to IUU fishing. However, it should not be excluded that the reporting of such cases in the other Black Sea countries is data deficient.

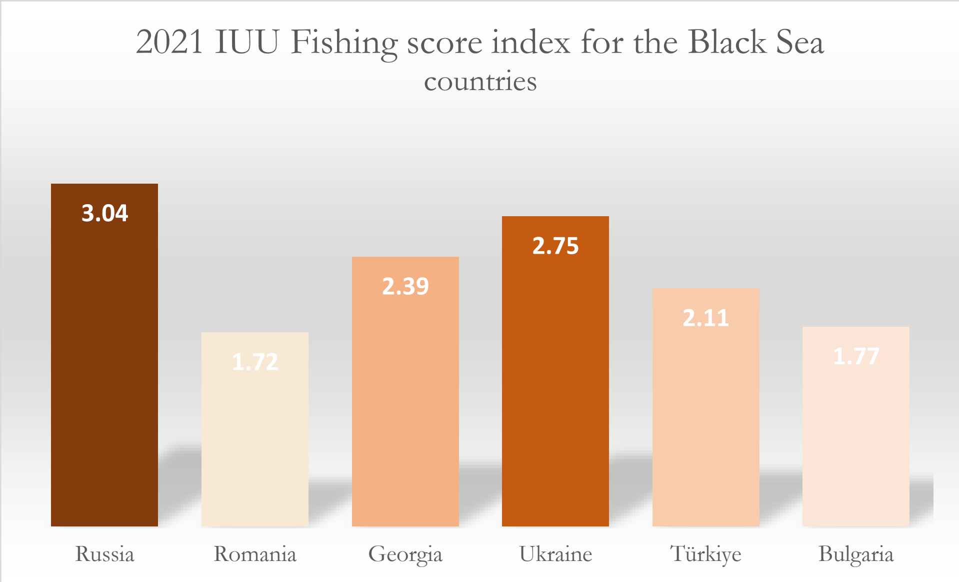


Figure no. 3-15 IUU Fishing score index for the Black Sea countries (Source: Macfadyen, G. and Hosch, G. (2021). The IUU Fishing Index Dataset (2019:2021))

Öztürk (2013) presented 65 cases of illegal fishing that occurred between 1992-2012 in different exclusive economic zones of the Black Sea. In most of these cases, Turkish fishermen were involved.

Summary

Pressure	Tourism; fishing; fisheries	
Location	Onshore	Offshore
Main effects	• Microplastics; • Marine litter; • Eutrophication (increased nutrient load); • Overexploitation of fish stocks; • Fauna mortality; • Changes in the structure/dynamics of populations; • Habitat degradation; • Heavy metals pollution.	

3.6 Agriculture, Aquaculture

Introduction
Agriculture, encompassing livestock farming, stands as the primary contributor to water pollution. The major culprits include leaching of fertilizers, runoff from agricultural fields, discharge from concentrated livestock operations, and nutrient sources from aquaculture.
Aquaculture involves the breeding, maintenance, and cultivation of fish, along with other aquatic animals, plants, and algae. This activity is conducted under complete or partial human supervision with the aim of producing marketable products, restoring commercial stocks of aquatic biological resources, and safeguarding biodiversity and recreational opportunities. The cultivation of marine fish and shrimp results in the concentrated release of nitrogen and phosphorus derived from excrement, unconsumed food, and organic waste. On average, for each ton of fish, aquaculture operations generate approximately 42 to 66 kg of nitrogen waste and 7.2 to 10.5 kg of phosphorus waste.

According to Lazăr et al. (2020), agriculture is one of the main pressures of the Romanian coast of the Black Sea. Another study completed in 2023 by Baboş et al. (2023) in Romania shows within its findings that many water samples were containing microplastic originating from agriculture.

Additionally, localized activities such as agriculture, which includes associated erosion, sand/gravel extraction, industrial processes, and aquaculture, also play a role in contributing to eutrophication along the Black Sea coast (ANEMONE Deliverable 2.2, Lazăr et al., 2021).

Although not many recent studies on the impact of aquaculture on the marine environment in the Black Sea can be found, we can draw a few conclusions from the information presented in the *Aquaculture market in the Black Sea: country profiles*, FAO, 2022.

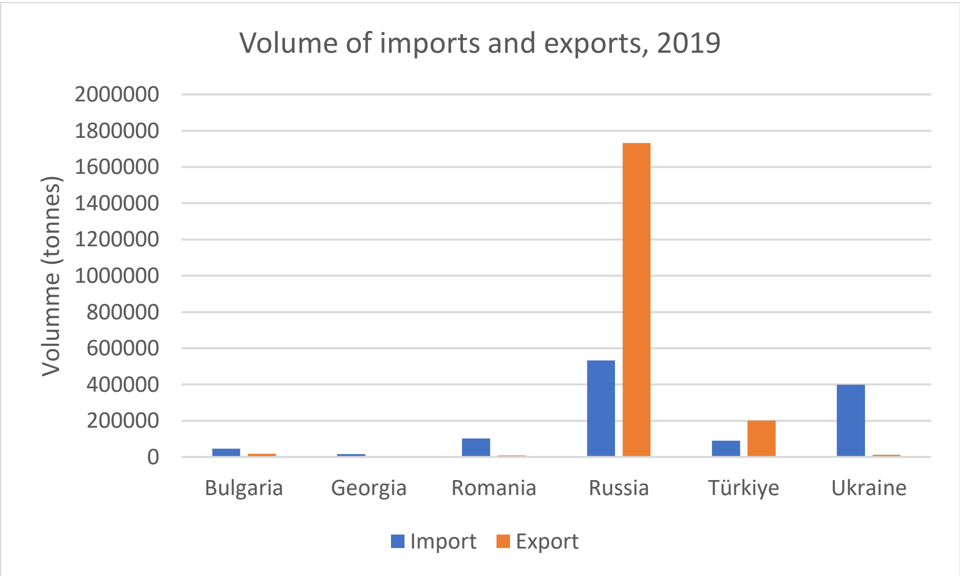


Figure no. 3-16 Volume of imports and exports of farmed species of the Black Sea countries, 2019 (Source: FAO. 2022. *Aquaculture market in the Black Sea: country profiles*)

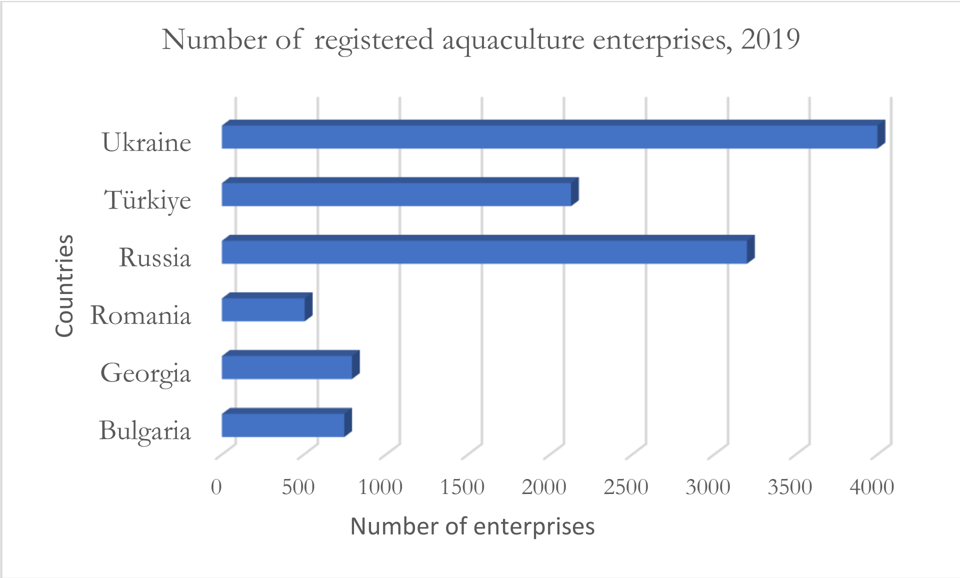


Figure no. 3-17 Number of registered aquaculture enterprises in the Black Sea countries, 2019 (Source: FAO. 2022. *Aquaculture market in the Black Sea: country profiles*)

According to the *Aquaculture market in the Black Sea: country profiles*, FAO (2022), in Russia aquaculture is seen as a priority sector of the fishery industry. In consequence, farmed fish for human consumption reaches, on average, over 85% of the total volume. Therefore, as it can be noticed from the figures above, Russia was in 2019 the only substantial exporter of farmed seafood of the Black Sea countries.

In regards to the number of aquaculture enterprises, Ukraine had in 2019 approximately 4000 enterprises involved in aquaculture and Russia had 3200 in 2017. In correlation with Massa et al. (2017), we can emphasize that aquaculture generates several effects such as: release of nutrients, particulate material and chemicals.

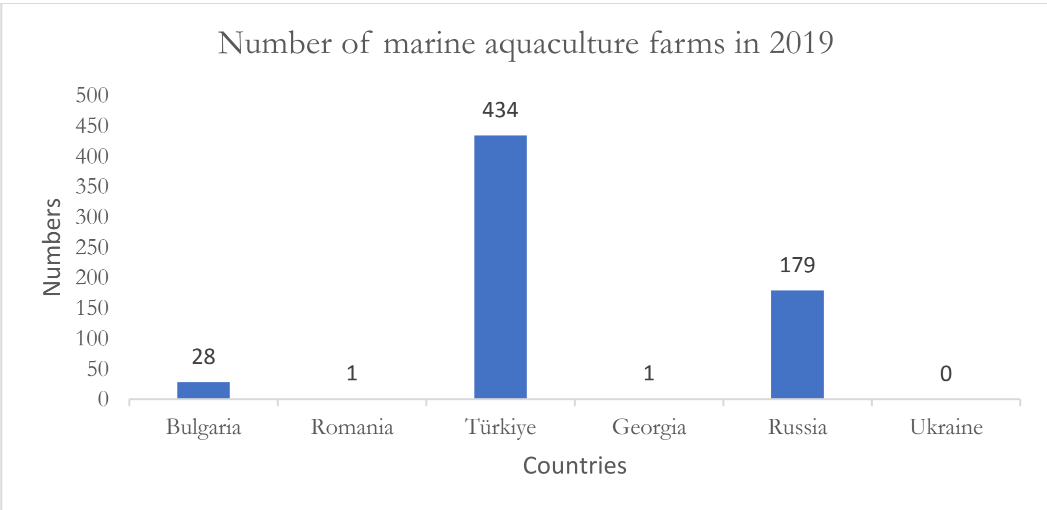


Figure no. 3-18 Number of marine aquaculture farms in 2019 (Source: FAO. 2022. *Aquaculture market in the Black Sea: country profiles;* Massa et al., 2021)

As it can be concluded from Figure no. 3-18, in most countries, mariculture remains underdeveloped. It should be noted that Russia holds most of its marine farms in the Far East (Primorsky Krai region)

(Adamowski, 2023). Thus, Türkiye remains the country with the highest number of marine farms, which consequently leads to bigger concerns regarding the unwanted effects.

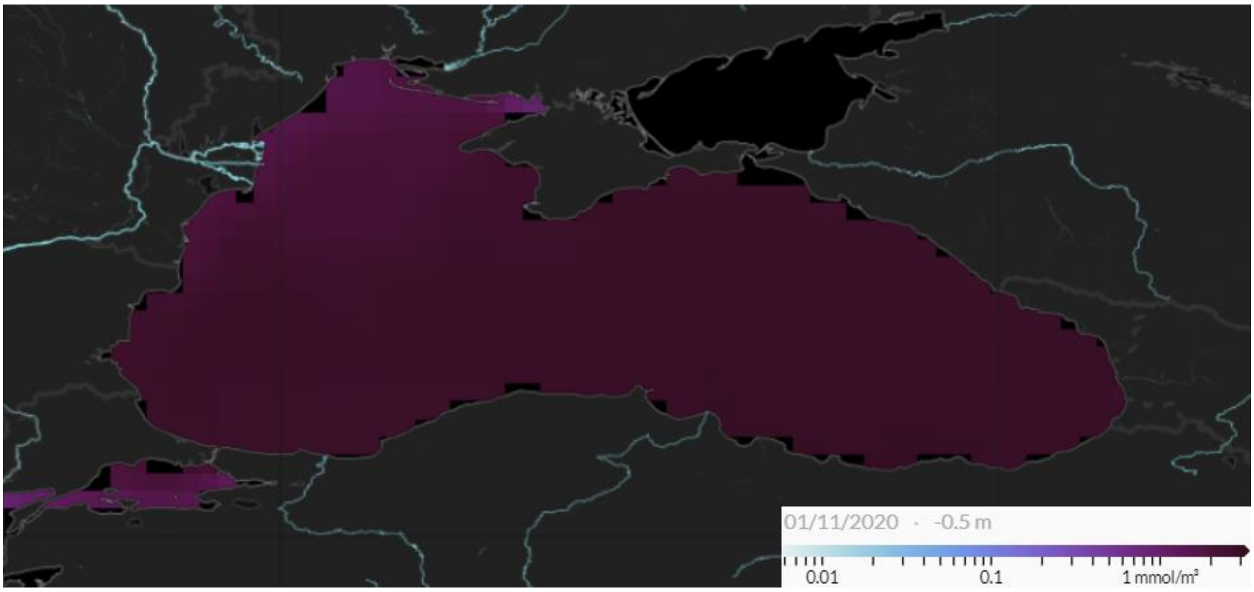


Figure no. 3-19 Mole concentration of phosphate in Black Sea water (Source: Global Ocean Biogeochemistry Hindcast. *E.U. Copernicus Marine Service Information*)

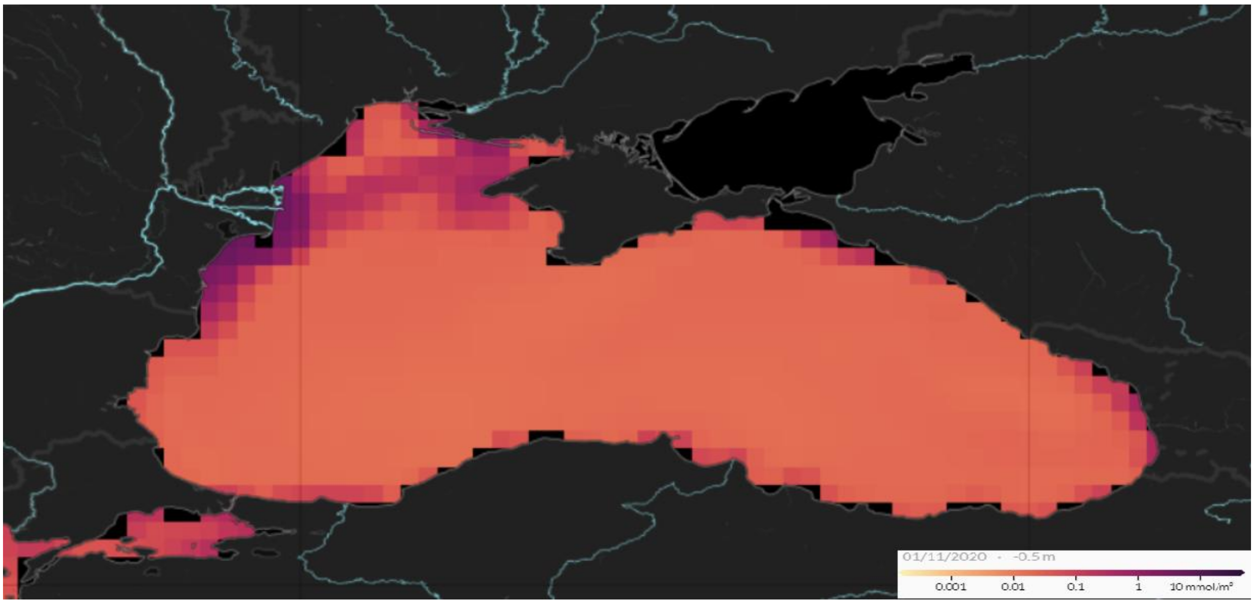


Figure no. 3-20 Mole concentration of nitrate in Black Sea water (Source: Global Ocean Biogeochemistry Hindcast. *E.U. Copernicus Marine Service Information*)

Moreover, after analysing Figure no. 3-19 and Figure no. 3-20, we can conclude that in 2020 phosphate could be found in high concentrations in the EEZ and coastal waters of Bulgaria, Türkiye, Georgia, Russia and near the Crimean Peninsula (Figure no. 3-19). On the other hand, nitrate concentrations could be found in the highest concentrations near the Romanian coast, while lower levels can be observed near the Ukrainian, Georgian and Russian coasts (Figure no. 3-20).

The high levels of nitrate and phosphate[4] can be correlated with the land use in the Black Sea area, which is dominated by croplands and dense short vegetation (FAO and IWMI, Mateo-Sagasta et al., 2017)(Figure no. 3-21).

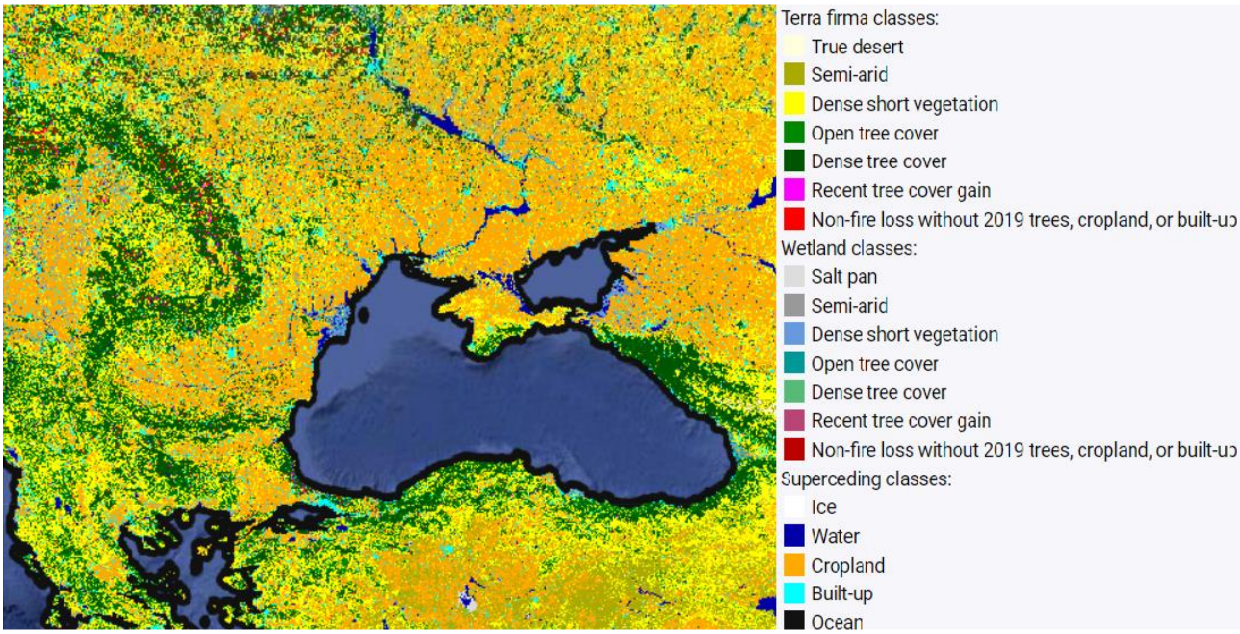


Figure no. 3-21 Land use in the Black Sea region (Source: Hansen et al., 2022)

According to Eryaşar et al. (2021b) the intensive agricultural activities in the summer in the southeastern part of the Black Sea (Türkiye) coast represents a source of microplastic found in the seawater analysed samples.

As it can be observed in Figure no. 3-22, the countries with the most use of their land in agriculture are Ukraine, Romania, Türkiye and Bulgaria which can be correlated with the high levels of phosphate and nitrate remarked in Figure no. 3-19 and Figure no. 3-20.

[4] Nitrogen and phosphorus present in chemical and organic fertilizers as well as animal excreta and normally found in water as nitrate, ammonia or phosphate are also reffered to as ”nutrients” (FAO and IWMI, 2017).

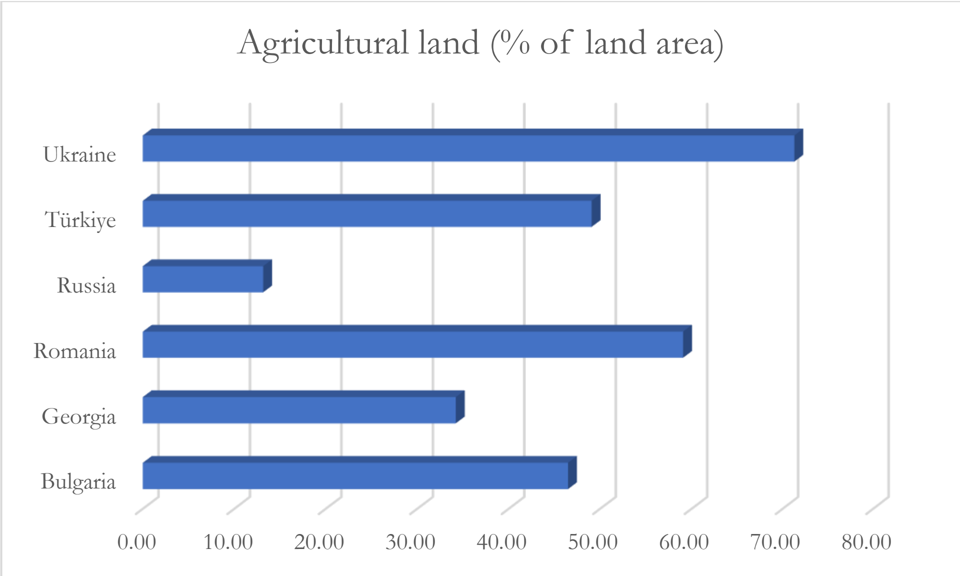


Figure no. 3-22 Share of land area used for agriculture, 2020 (Source: Hannah Ritchie and Max Roser (2019) - "Land Use" Published online at OurWorldInData.org)

In the past two decades, new agricultural pollutants, including antibiotics, vaccines, growth promoters, and hormones, have emerged. These pollutants can enter water sources through leaching and runoff from livestock and aquaculture farms, as well as the application of manure and slurries to agricultural land. Additionally, residues of heavy metals in agricultural inputs, such as pesticides and animal feed, pose emerging concerns (FAO and IWMI, Mateo-Sagasta et al., 2017).

Summary

Pressure	**Agriculture; aquaculture**	
Location	**Onshore**	**Offshore**
Main effects	• Eutrophication (increased nutrient load); • Heavy metals pollution; • Marine litter; • Pollution; • Microplastics; • Health impairment of fauna; • Riverine litter discharge into the sea.	

3.7 THERMAL POWER PLANTS

Introduction
Thermal power plants are large-scale facilities that convert heat energy into electricity. They have traditionally comprised the bulk of global electricity generation, providing around 60% of the world's power. However, their reliance on burning fossil fuels raises environmental concerns. Heat energy is typically generated by burning fossil fuels, such as coal, oil, or natural gas.

Contamination stemming from thermal power plant byproducts, such as ashes and slag, poses a significant concern for the marine environment. The use of lignite at Çatalağzı Thermal Power Plant or the nitrogen plant in Samsun, Türkiye contribute to deposition in environmental matrices like sediment, soil, and water (ANEMONE Deliverable 2.2, Lazăr et al., 2021). Bat et al. (2018) have also described the thermal power plants at Karabük, Eregli, Samsun, Çatalagzı in the northern part of the country, on the coast of the Black Sea, as marine environmental problems due to the accumulations of sludge and ashes on soil.

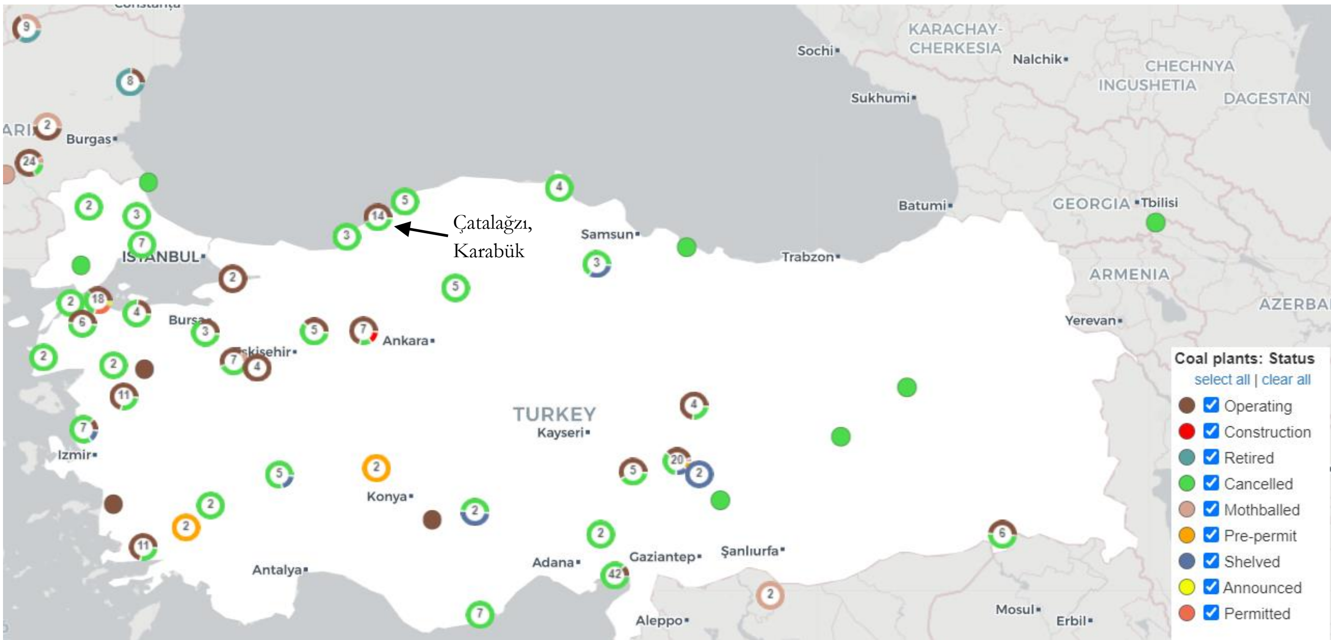


Figure no. 3-23 Coal Plants in Türkiye (Source: Global Energy Monitor, 2022)

The dispersion of coal dust in seawater has the potential to impact benthic plants and organisms in close proximity to coal terminals, making them particularly vulnerable to coal dust and potential hypoxia. Moreover, the presence of coal particles in water substantially diminishes light penetration, ranging from 44% to 99%, depending on the coal concentration (ranging from 38 to 278 mg/L), in comparison to unpolluted seawater (Tretyakova et al., 2021).

Rocha et al. (2015) observed that zooplankton exposed to coal ash showed that the zooplankton community had been exposed to extensive restructuring over 30 years. Only 12 species of 35 species that lived in the studied lake in 1985, remained by the year 2015.

Furthermore, coal deposition on the surface of marine plants reduces the efficiency of photosynthesis by 17-39% (Naidoo & Chirkoot, 2004).

Summary

Pressure	**Thermal power plants**	
Location	Onshore	Offshore
Main effects	• Pollution.	

3.8 INDUSTRIAL ACTIVITIES

Introduction

Industrial activities mean the manufacturing, production, assembling, altering, formulating, repairing, renovating, ornamenting, finishing, cleaning, washing, dismantling, transforming, processing, recycling, adapting or servicing of, or the research and development of, any goods, substances, food, products or articles for commercial purposes, and includes any storage or transportation associated with any such activity. These can generate several problems such as pollution, resource depletion, species extinction, and climate change.

One of the *EMBLAS II Joint Black Sea Surveys 2016*, 2017 report main findings is that the Georgian waters presented exceedances for various toxic substances from industrial and agricultural provenience.

Bat et al. (2018) have indicated that industrial activities represent a pressure in the Turkish side of the Black Sea by the discharge of industrial waste into the sea or rivers. In addition, the atmospheric deposition of heavy metals in the marine environment is another issue posed by this source.

Industrial facilities are low in number in the Black Sea coast of Türkiye and concentrated in Zonguldak and Samsun. Copper (in Murgul and Samsun) and iron/steel production (Samsun) are essential in the eastern Black Sea region. Zonguldak and Samsun harbours are important transportation centres for these industries and the fertiliser industry in Samsun. The main industrial sectors located in the Sakarya and Yesilırmak River Basins are plastics, rubber and synthetic resins, mineral products other than metals, food processing, metal products, chemicals and chemical products. Direct discharges, spills of contaminants leaching from land, atmospheric deposition of compounds as black carbon (Figure no. 3-24), large quantities of contaminants are thus, carried to the Black Sea through Sakarya and Yesilırmak rivers (ANEMONE Deliverable 2.1, Lazăr et al., 2021).

Bekova & Prodanov (2023) show that industrial and manufacturing facilities significantly contribute to the generation of land-based litter on the Bulgarian coast.

The chemical, food, and pulp and paper industries are prominent industrial polluters, and wastewaters from these plants raise the levels of nutrients, heavy metals, and organic micropollutants in the Danube river network, finally getting into the Black Sea (ANEMONE Deliverable 2.1, Lazăr et al., 2021).

The exceedances of toxic substances in Georgian waters, discharge of industrial waste in Turkish waters, and the contribution of industrial facilities to land-based litter in Bulgaria and Romania collectively pose a threat to the aquatic environment of the rivers that flow into the Black Sea. Collectively, the above mentioned studies highlight the environmental challenges posed by industrial activities around the Black Sea, emphasizing the need for comprehensive measures to address and mitigate the impact of pollutants to the marine ecosystem in the region.

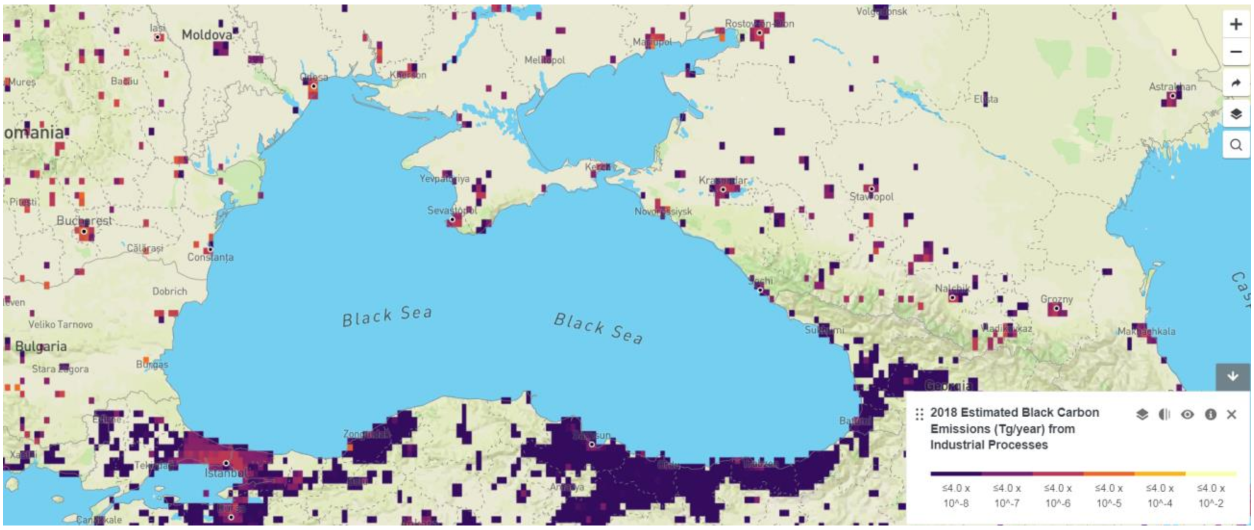


Figure no. 3-24 Estimated black carbon emissions from industrial processes (Source: Granier et al., 2019)

Summary

Pressure	**Industrial activities**	
Location	Onshore	Offshore
Main effects	• Pollution; • Heavy metals pollution; • Eutrophication (increased nutrient load); • Coastal erosion; • Marine litter; • Habitat degradation.	

3.9 OIL & GAS EXTRACTION, OIL & GAS PROCESSING, SHIPPING ACCIDENTS, ILLEGAL DUMPING OF OIL PRODUCTS

Introduction
Oil & gas extraction is a process that refers to the exploration and production of petroleum and natural gas from wells. Oil and gas extraction companies may operate oil and gas wells based on their own initiatives or act as a service provider on a contract or fee basis. Oil & gas exploration and development causes disruption of migratory pathways, degradation of important species habitats, and oil spills—which can be devastating to the animals and humans who depend on these ecosystems.

The purpose of **oil & gas processing** is to separate, remove, or transform these various components to make the hydrocarbons ready for sale.
Shipping accidents are unexpected events that result in financial loss and properties, damages and either loss of people. Several reasons as human errors, technical failures, natural conditions, shipping factors, route conditions and cargo related factors play role in these accidents. The consequences of such incidents on the marine environment are particularly noteworthy, particularly with regard to oil spills. Oil spills can result in a variety of effects within the marine ecosystem.
Illegal dumping of oil products Routine tanker operations contribute to oil pollution through the discharge of ballast water, residues from tank washing, and various oil mixtures originating from the engine room and bilge waters. This type of pollution is commonly referred to as *slops*. When older tankers unload cargo and prepare for empty travel, they need to take on significant amounts of ballast water to ensure the ship's proper balance. However, upon discharging the ballast water, oil residues are also released. While the recommended practice is to release ballast water in specialized receiving facilities at ports, it is often carried out at sea to circumvent additional costs. Oil poses a threat to the marine environment through three distinct mechanisms: poisoning upon ingestion, direct contact, and habitat destruction.

3.9.1 Oil & gas extraction infrastructure

The increase in oil and gas exploitation in deep waters, facilitated by advances in technology and diminishing onshore resources, involves routine drilling below 200 meters in various regions. Notably, in well-explored areas such as the Gulf of Mexico, there is a growing trend in ultra-deep water drilling activities (>1000 meters depth), extending up to 3000 meters depth. The impacts of oil and gas exploitation in offshore development encompass various activities, with major direct effects being localized and including physical damage to the benthic habitat and community caused by drilling infrastructure installation (within approximately a 100-meter radius). The discharge of drilling muds and produced water can affect benthic communities at distances of about 300 meters from the source. These activities result in changes in density, biomass, and diversity across all size classes of the benthic community (meio-, macro-, and megafauna), while effects on the microbial community remain less understood. Accidental oil spills, as the Deepwater Horizon blowout accident in the Gulf of Mexico in 2010, can lead to significant environmental impacts (i.e.: reduction of health condition of dolphins, making them more susceptible to disease, reduced growth, impaired reproduction, mortality (Beyer et al., 2016)). Detected impacts to deep benthic fauna covered an area of 300 km^2, with notable repercussions for cold-water coral communities located 22 km away from the well and at depths of 1950 meters (Ramírez-Llodra, 2020).

Although there are many companies that perform drilling operations in the Black Sea, there is not enough data on this pressure and its effects to biodiversity of the Black Sea. There is information on the exploration of oil and gas fields in Romania, Bulgaria and Turkyie in *State of the Environment of the*

Black Sea, (2009-2014/5) released by BSC in 2019. However, some effects of this pressure might include underwater noise, pollution, metal pollution, fauna mortality or health impairment of fauna.

After an analysis on the deep-sea biodiversity of the Mediterranean Sea, IUCN (2019) mentions that the potential impacts on deep-sea ecosystems of oil and gas exploration have not yet been studied, although oil and gas exploration and exploitation takes place in many parts of the sea, such as: Israel (depth below 1,500 m), Italy and Spain.

Nevertheless, ERM (2022) predicted various impacts due to the drilling of the wells in Romanian MIDIA block, most of them generated by the drill cuttings discharged during drilling: habitat alteration by smothering, changes to sediment composition or trace metals; habitat loss, reduction in population numbers and species activity disturbance. Other effects and impacts are detailed in section **Error! Reference source not found.**.

In what follows, the extraction infrastructure in each Black Sea country is detailed.

Bulgaria

In 2007 in the Black Sea shelf, Bulgaria discovered a new gas field, Kaliakra and in 2008 the Kavarna field 15 km from Galata. In 2010 the natural gas extraction was started in these fields. Accordingly, the forecasted reserves of gas in the Bulgarian shelf were evaluated at 200 bcm (Zonn & Zhiltsov, 2015b).

Oct 2016: Total (operator, 40%), OMV (30%) and Repsol (30%) have made an oil discovery with the Polshkov-1 exploration well, 128 kms offshore in the Khan Asparuh license, Black Sea. The commitment is to drill 2 exploration wells (Smith, 2024).

Block "Khan Asparuh" is located about 80 km from the coast near Varna. The area for exploration of block "Khan Asparuh" is 14,220 square kilometers. The block "Silistar" is located in the continental shelf of the southern Black Sea coast and has an area of 6893 square kilometres. The first drilling discovered the deposit "Galata", which is already empty Another 2-3 smaller deposits are being exploited - Kaliakra Kavarna, Galata East. (BSC, 2019).

Figure no. 3-25 Black Sea and inland exploration, development and exploitation perimeters in Bulgaria (Source: https://www.24chasa.bg/biznes/article/1568127)

Georgia

After becoming independent, Georgia invited the US oil company Anadarko to explore the Georgian shelf area. In 2000 Anadarko sent its special vessel "Western Wave" to the Georgian shelf to study areas near Adjara, Poti, Lanchkhuti, and Zugdidi (Zonn & Zhiltsov, 2015b).

Having emerged as the successful bidder in an open international tender, OMV Petrom, in March 2021, entered into a Production Sharing Contract (PSC) for Block II in the exclusive economic zone of the Georgian Black Sea. The PSC grants permission for exploration, development, and production activities of hydrocarbon resources within Block II, covering a total area of 5,282 square kilometers with varying water depths between 400 and 2,000 meters. As the operator, OMV Petrom established an operational entity in Georgia and initiated geoscientific and environmental studies in 2021. However, as of 2023, seismic acquisition activities remain temporarily on hold (OMV Petrom).

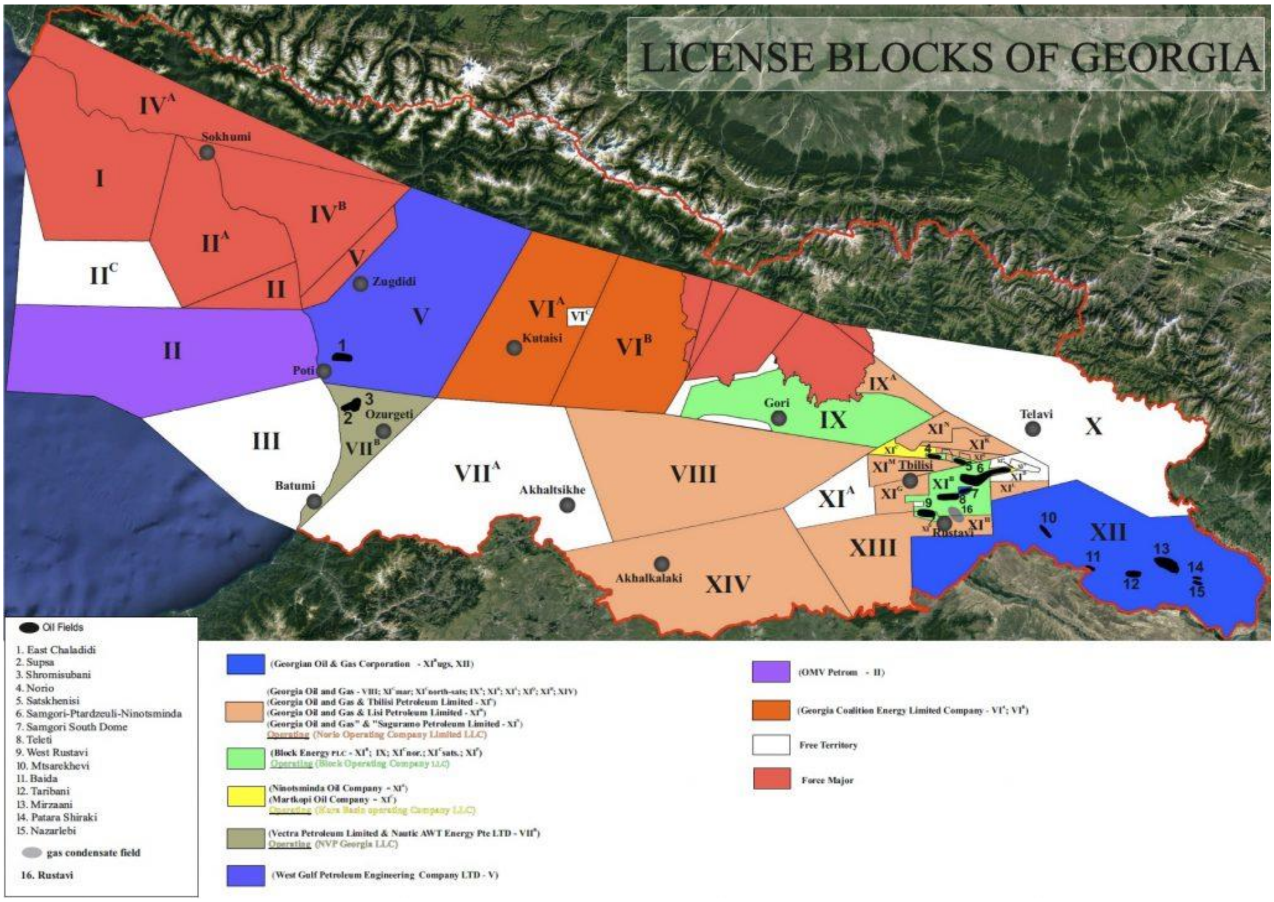


Figure no. 3-26 Black Sea and inland exploration perimeters in Georgia (Source: https://georgiaoilandgas.ge/georgian-oil-gas-industry-history-and-highlights/)

Romania

In Romania, there are 9 exploration perimeters, which are detailed as follows.

Lebada East (commenced production in 1987), Lebada West (commenced production in 1993), Sinoe (commenced production in 1999), Pescarus (commenced production in 2003), and Delta (commenced production in 2009) fields within the XVIII ISTRIA block are the earliest discoveries. Collectively, they contributed to 185 million barrels of oil, 8 million barrels of condensate, and 48 bcm of gas. Given their extensive exploitation history, oil and condensate reserves are nearly depleted, while the remaining gas resources are approximately 6 bcm (Deloitte, 2018).

In the XV MIDIA A block, two significant discoveries were made: Doina (in 1995) and Ana (in 2008), holding recoverable resources of 9.5 bcm of gas. Exploitation started before 2020. In EX-27 MURIDAVA, exploration has revealed potential quantities of 4.85 bcm of gas and 11.7 million barrels of oil (Deloitte, 2018).

Explorations in EX-28 EST COBALCESCU, EX-29 EST RAPSODIA, XV MIDIA B blocks have not yielded commercially viable quantities thus far (Deloitte, 2018).

In 2014, a minor discovery was announced in ISTRIA XVIII block, Marina field, with a production potential of 1,500-2,000 boe/day. In March 2012, OMV Petrom S.A. and Exxon Mobil Exploration

& Production Romania Ltd. revealed, through the Domino 1 well in the XIX 2 NEPTUN (DEEP) block, estimated recoverable resources between 42 and 84 bcm of gas (Deloitte, 2018).

In 2022, S.N.G.N Romgaz S.A announced the completion of the transaction to acquire and the transfer of all shares issued by ExxonMobil Exploration and Production Romania Limited which holds 50% of the acquired rights and obligations under the Petroleum Agreement for the Deep Water Zone of Neptun XIX offshore Block in the Black Sea. The other 50% is held by OMV Petrom.

The Neptun Deep project is situated within the Neptun Block, covering an expansive area of about 7,500 km² in the deep-water region of the Black Sea. The Neptun Deep natural gas perimeter encompasses 9,900 km² in the Black Sea. The Neptun Deep gas field project encompasses the development of the Domino and Pelican South fields, both of which will be connected to the Neptun unmanned shallow water platform. First production from the field is expected in 2027 (*Neptun Deep Gas Field Project, Black Sea, Romania*, 2023).

In October 2015, Lukoil, PanAtlantic, and Romgaz announced the discovery of a field in EX-30 TRIDENT block. Preliminary results, based on seismic data and drilling analysis, indicate reserves exceeding 30 bcm of natural gas (Deloitte, 2018).

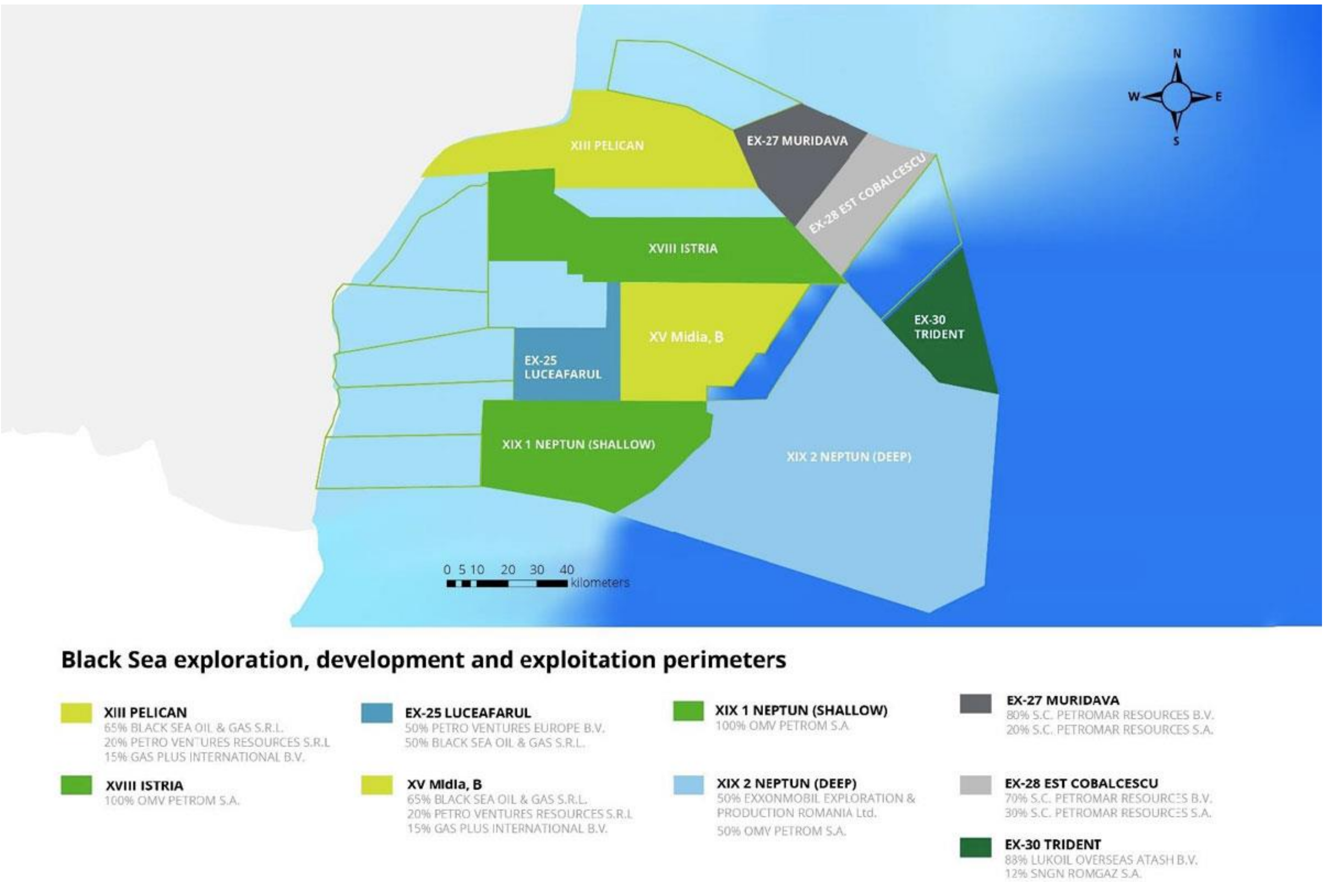


Figure no. 3-27 Black Sea exploration, development and exploitation perimeters in Romania (Source: Deloitte, 2018)

Russia

Commercial natural gas production commenced in the Azov Sea in 1981 and in the northwestern part of the Black Sea near the Crimean coast from 1983 onwards. In 2002, SAO "Chernomorneftegaz" was established in Russia, initiating the development of oil and natural gas fields in the shelf of the Azov and Black Seas, particularly focusing on the Paleozoisky and Vysokosny deposits and the southwestern and northwestern deposits within the Pallas field. In 2003, "Rosneft" and "Total" entered into an agreement for the joint exploration and development of fields in the Tuapse sag area. Seismic surveys were conducted in 2004, and in 2007, preparations for drilling began (Zonn & Zhiltsov, 2015b).

In 2009, the Russian company Rosneft and the Ministry of Economy of the partially recognized Republic of Abkhazia signed a five-year agreement for geological surveys to explore and evaluate hydrocarbon deposits in the Gudauta area of the Black seabed, covering a total area of 3.85 thousand km^2. In January 2011, Rosneft signed an agreement with US Exxon Mobile for the joint development of the Tuapse shelf. Under this agreement, drilling works in the Abrau South structure of the Tuapse sag were anticipated to start after 2014. After Crimea's annexation, Rusia reviewed the issue of the Black Sea shelf development (Zonn & Zhiltsov, 2015b).

Figure no. 3-28 Black Sea exploration, development and exploitation perimeters in Russia (Source: *Illegal extraction of natural resources in Crimea. Part 1. Development of the stolen shelf*, 2018)

Türkiye

In 2006, Türkiye entered signed a contract with the Brazilian corporation Petrobras. Opting for the accelerated development of fields in the Black Sea shelf, Turkey emerged as a key player in investigating the Black Sea region's shelf (Zonn & Zhiltsov, 2015b).

In the beginning of 2009, Exxon Mobil finalized an agreement with the state company TPAO for further surveys in the Samsun block, situated 100 km from the southern border of Ukraine's Prikerchensky block. In 2009 the operation of the Brazilian deepwater platform Leiv Eiriksson was started. In January 2010, Exxon Mobil and Petrobras, the oil companies, entered into an agreement with TPAO for the exploration of hydrocarbons in the deepwater Turkish shelf of the Black Sea (Zonn & Zhiltsov, 2015b).

In 2011, an agreement for prospecting works in the Black Sea oil deposits was signed between Türkiye and Brazil. During the same year, Türkiye conducted drilling in two wells, with promising results indicating significant hydrocarbon volumes. In February 2013, the Turkish oil and gas company TPAO and Shell entered into an agreement for oil surveys in the Black Sea (Zonn & Zhiltsov, 2015b).

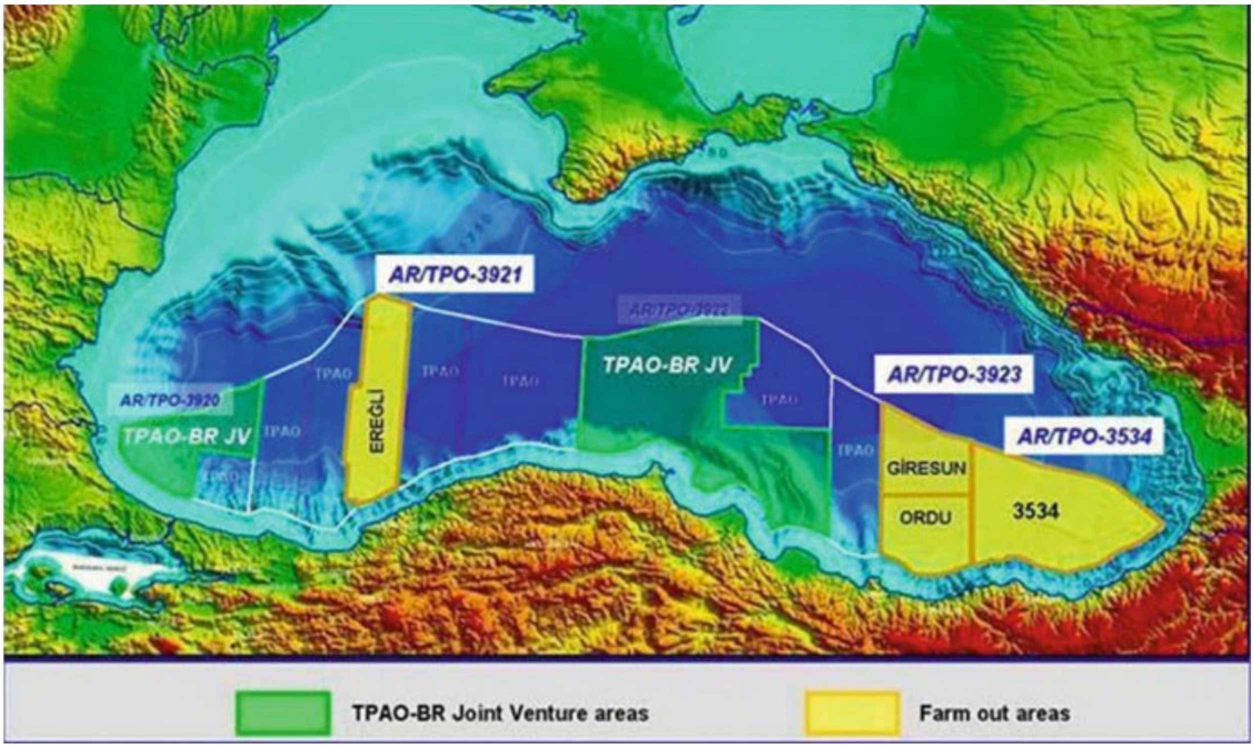


Figure no. 3-29 Black Sea exploration perimeters in Türkiye (Source: Zonn & Zhiltsov, 2015)

Ukraine

At the end of 2020 the Cabinet of ministers of Ukraine issued granted Naftogaz exclusive rights for exploration, appraisal and development in North-Western part of the Black Sea, with close proximity to major gas discoveries. The depth of water in the exploration perimeters varies between <150 m in shallow water, <1000 m in slope and <2000 m in deep water. The perimeters, Dolphin and Skifska (Figure no. 3-30) are planned to start production in 2026 and have a total number of 117 wells to be drilled, with a total production estimated at 44.0 bcm gas (*Ukraine Oil & Gas Industry Guide 2021*, 2021).

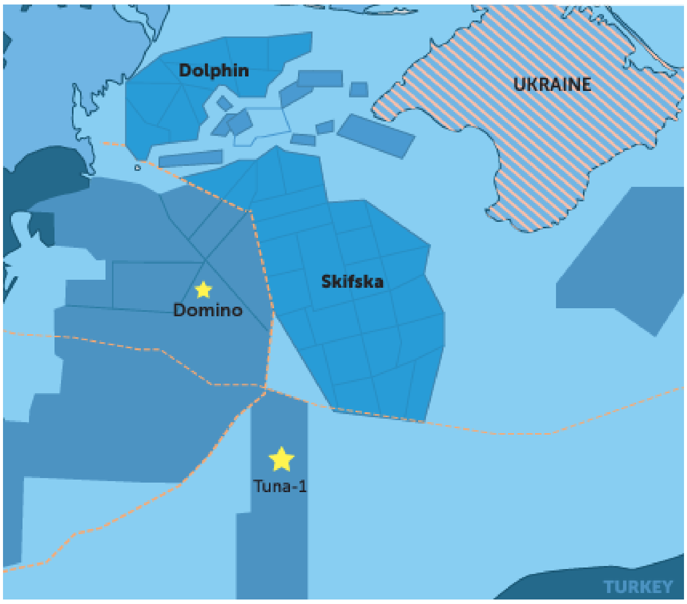


Figure no. 3-30 Black Sea oil and gas exploration perimeters in Ukraine in 2021 (Source: *Ukraine Oil & Gas Industry Guide 2021*, 2021)

Moreover, the political events in Ukraine in January–March 2014 affected the development of the Black Sea shelf and consequently, the foreign oil and gas companies Shell and Exxon Mobil announced their withdrawal from negociations for the Scythian natural gas area (Zonn & Zhiltsov, 2015b).

Oil and gas exploration fields and perimeters before the start of the full-scale invasion and war in Ukraine in 2022 can be observed in Figure no. 3-31.

By comparing Figure no. 3-31 and Figure no. 3-32, it can be noticed that most of the Black Sea exploration perimeters of Ukraine are now occupied by Russia.

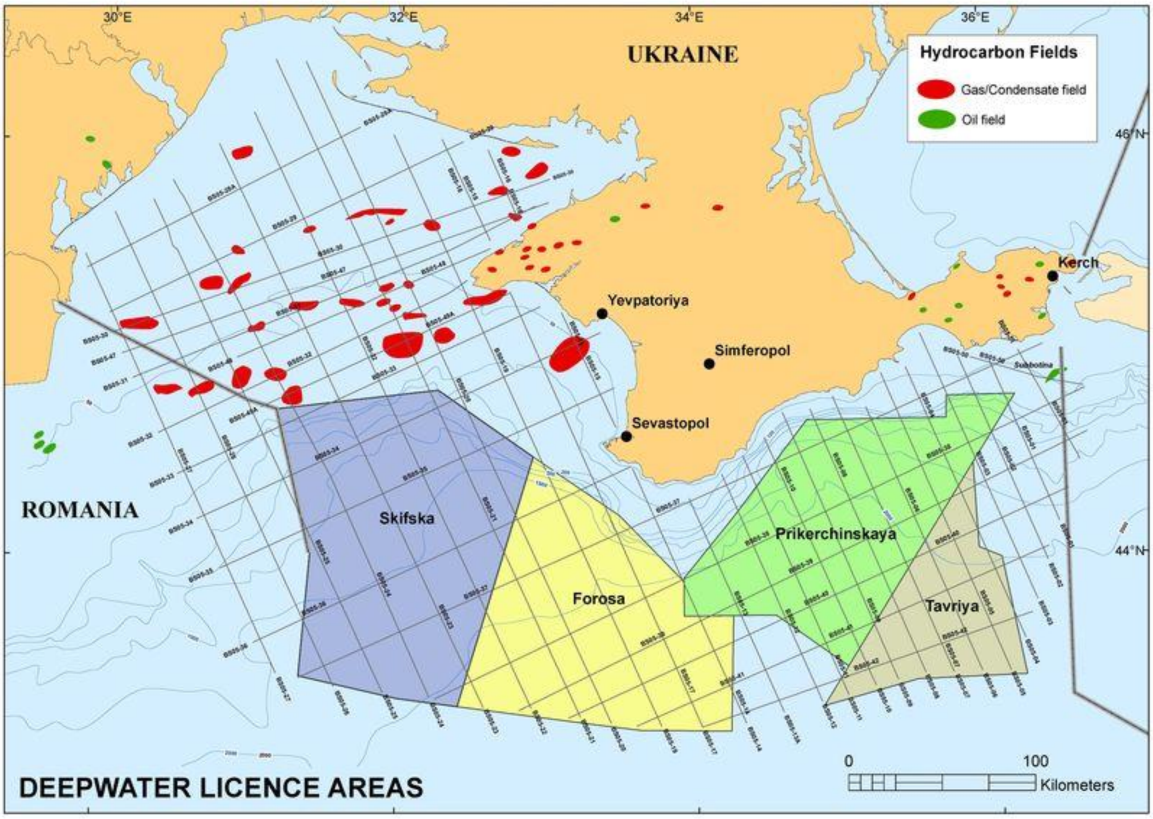


Figure no. 3-31 Oil and gas exploration perimeters in Ukraine (Source: https://euromaidanpress.com/2018/10/10/black-sea-gas-deposits-an-overlooked-reason-for-russias-occupation-of-crimea/)

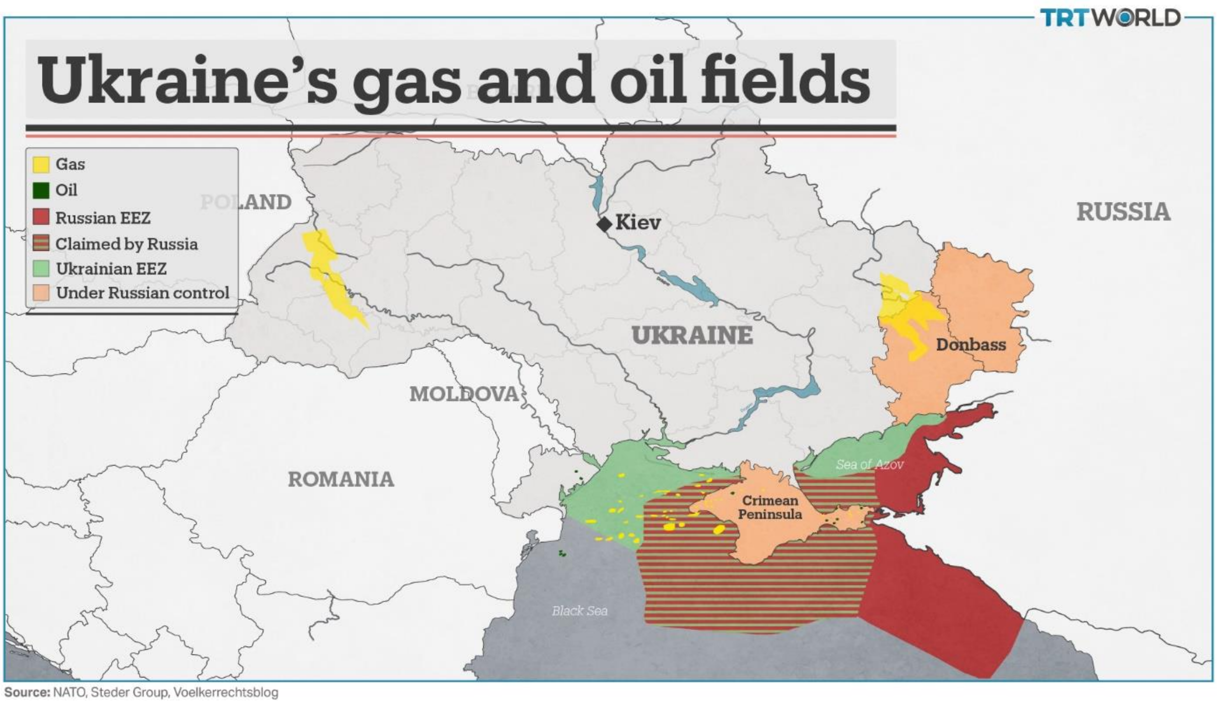


Figure no. 3-32 Oil and gas exploration fields in Ukraine, partly claimed by Russia (Source: TRT World)

3.9.2 Oil & gas processing

It was recently concluded that two major Russian oil ports can play a major role in the Black Sea oil pollution. This was said to happen due to accidental spills during pipeline transportation, shipping accidents, illegal dumping of oil products or even due to the soil pollution caused by the refineries located close to the ports (e.g.: the refinery complex in Tuapse) (Pokazeev et al., 2021).

Petrol mining and chemical industries (e.g., oil refining) cause water pollution by phenols and oil products. Their key sources are in the basin's upper part, where petroleum mining occurs, and oil refineries are located. Due to the high migration ability of phenols and oil products, elevated concentrations are also found in the Middle Dniester (ANEMONE Deliverable 2.1, Lazăr et al., 2021).

Moreover, according to the BSC (2019), higher annual average concentration of Total Petroleum Hydrocarbons (TPHs) in coastal Black Sea waters of Russia in 2014 could have been explained by small-scale oil discharges from the refinery factory in Tuapse, oil transportation and ships activity in Tuapse port. The waters in the vicinity of Tuapse were more polluted than other monitored northern sites, such as Novorossiysk, the TPHs concentration reaching 410 μg/dm^3. Furthermore, in December 2014 a leak on the major pipeline from the Tuapse oil refinery sent nine cubic metres of oil into the sea, requiring a state of emergency and a 300-person cleanup operation.

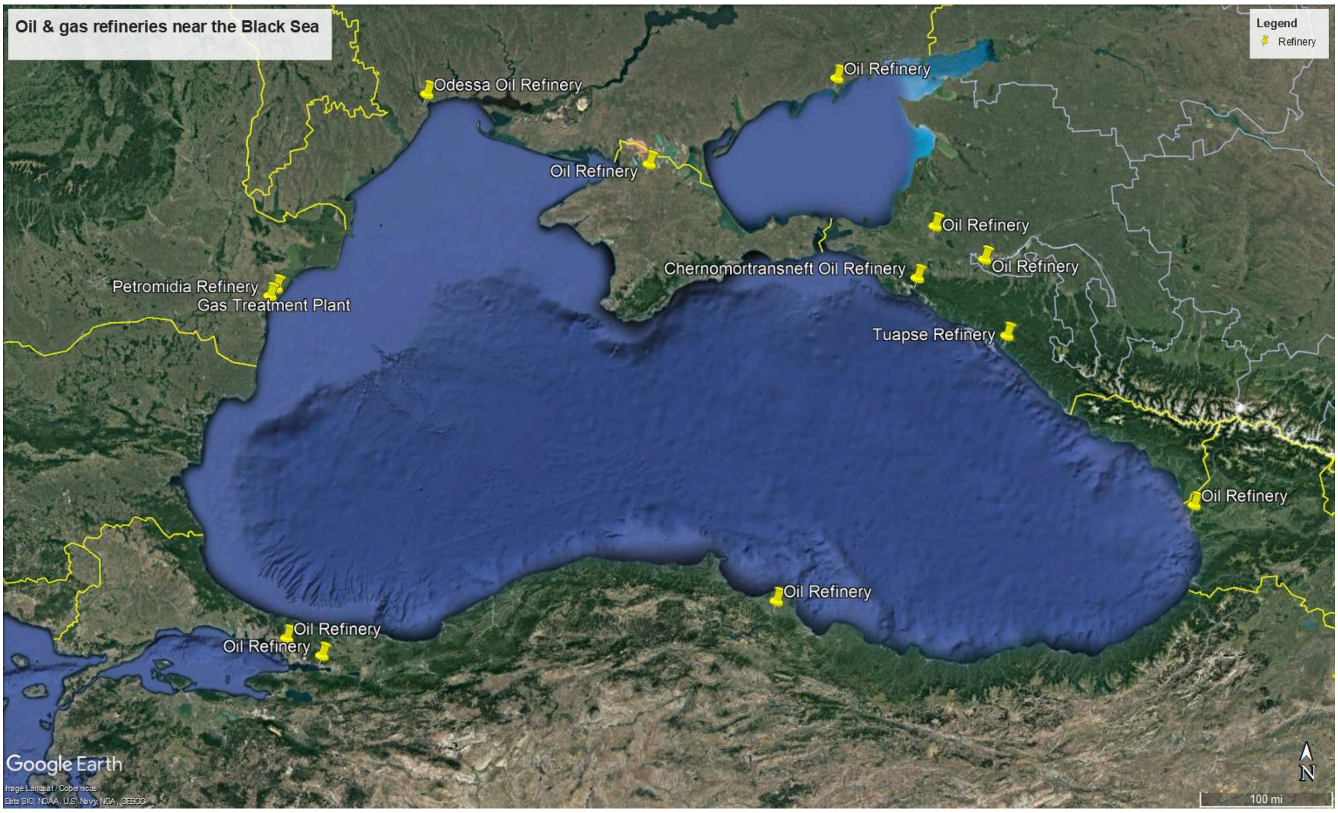


Figure no. 3-33 Oil & gas refineries near the Black Sea

3.9.3 Shipping accidents

In terms of shipping accidents, there have been several serious disasters which happened on the Black Sea. Those include: World Harmony, Independenta, Unirea, Nassia, TPAO and Volganeft. There were numerous additional accidents and collisions in Turkish sea waters that had adverse effects on the marine environment, such as: mortality in plankton and small organisms, smothering, chemical toxicity, reduction in population numbers, loss of habitats. In the past, a considerable number of incidents, including oil spills, occurred in this region, causing substantial damage to both the marine environment and human life (Ceyhun, 2014).

According to Nedelcu & Rusu (2022), 37 very serious and serious accidents (22.05%) accidents and 114 less serious accidents (75.47%) happened on Romania's navigable national waters in 2021, most of them being collisions or groundings.

Case study: the Kerch Strait accident in 2007 followed by an oil spill

A severe storm on November 11, 2007, in the Kerch Strait, connecting the Sea of Azov with the Black Sea and serving as the boundary between Ukraine and the Russian Federation, featured winds reaching up to 35 m/s and waves up to five meters high. Thirteen vessels were either sunk, stranded, or damaged during the storm, leading to casualties, property loss, and environmental damage (European Commission & United Nations Environment Programme, 2008).

The oil products volume discharged into the strait water area reached an estimated quantity of 1300–1800 tons of heavy fuel oil. A spill over 700 tones is considered large. The polluted area affected the migration route of red-throated and black-throated Siberian diver birds traveling from Central Siberia to the Black Sea. The coastal wetlands, essential migratory breeding grounds for various seabirds and waders, witnessed significant oil pollution in the Kerch Strait coastal area following the November 2007 accident, leading to adverse effects on the bird population. Cormorants, gulls, pochards, and other water birds along the coast suffered the most from the oil spill. The fuel oil adhered to the birds' feathers, impeding their mobility, and a substantial number of seabirds died during the acute phase of the oil spill. Initial Ukrainian reports indicated 150 birds killed, while other estimates suggested that up to 30,000 seabirds perished due to the oil spill in November-December 2007 (Korshenko et al., 2011).

Bodies of dead dolphins were found along the shore, but their deaths could potentially be attributed to collisions with vessels or storm waves. Additionally, a considerable number of shellfish were discovered on the coastal strip, although the exact cause of their death was not determined. After the accident, in August 2009, phytoplankton biomass was determined critically high, evidencing a poor water quality (Korshenko et al., 2011).

16 days after the oil spill, the first completed survey was carried out. It concluded that eggs of sprat (*Sprattus sprattus phalericus*) and shore rockling (*Gaidropsarus mediterraneus*), along with sprat and sand lance larvae (*Gymnammodytes cicerelus*), were discovered in the water column, constituting 74% of sprat eggs. Despite favorable temperature conditions, ichthyoplankton abundance was low. Horizontal surface catches revealed no eggs and only two larvae, while vertical catches showed an average of 6.6 ind/m^2 for eggs and 0.3 ind/m^2 for larvae. Over 75% of sampled pelagic eggs were

found to be dead, exhibiting abnormalities such as bubble formation, yolk compression, and deformation, indicating unfavorable conditions for their survival two weeks after the oil spill (Korshenko et al., 2011).

3.9.4 Illegal dumping of oil products

CleanSeaNet is a satellite-based pan-European oil spill and vessel monitoring service and is provided by the European Maritime Safety Agency. The main role of the service is to give information regarding oil spills and pollution alerts to national authorities as soon as the situation occurs (Sheppard, 2019). However, in the image below (Figure no. 3-34) it can be noticed that in the Black Sea, most oil spills are concentrated in the western part, near the coasts of Romania, Bulgaria and Türkiye and near the Crimean peninsula.

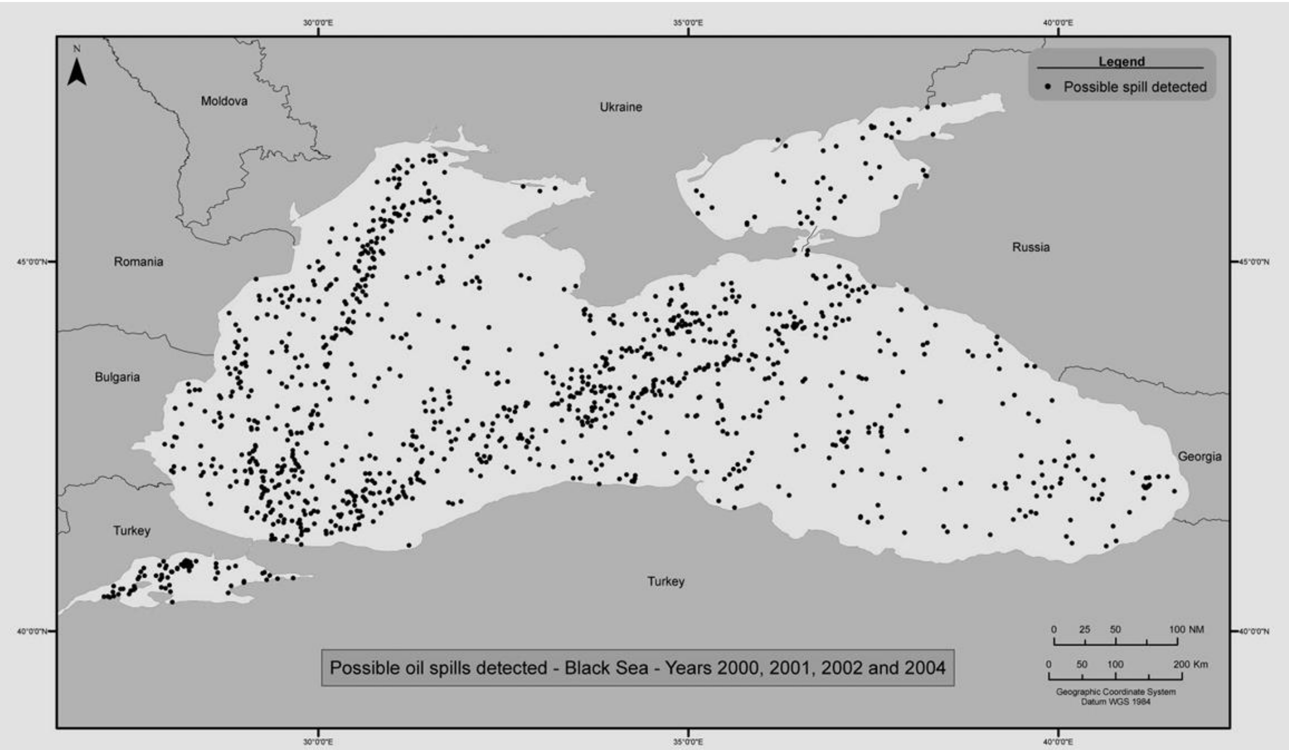


Figure no. 3-34 Possible oil spills detected in the Black Sea during 2000, 2001, 2002 and 2004 (Source: Joint Research Centre of the European Commission, 2010)

Bat et al. (2018) emphasize that the map of the Joint Research Centre shows that the greatest concentration of oil spills is along the main shipping routes: Odessa – Istanbul and Novorossiysk – Istanbul.

According to Bat et al. (2018), the countries that contributed the most to oil pollution of the Black Sea before 1996 are Ukraine, Romania and Bulgaria, many of the sources being domestic, industrial, land-based or rivers. However, accidental spills were reported as 136 t/year, while illegal discharges could not be assessed.

Furthermore, the total amount of oil spilt into the Black Sea was overall less than 50 t during 1996-2004, except 260 t in 1997 and 530 t in 2003 (Büyükgüngör et al., 2014).

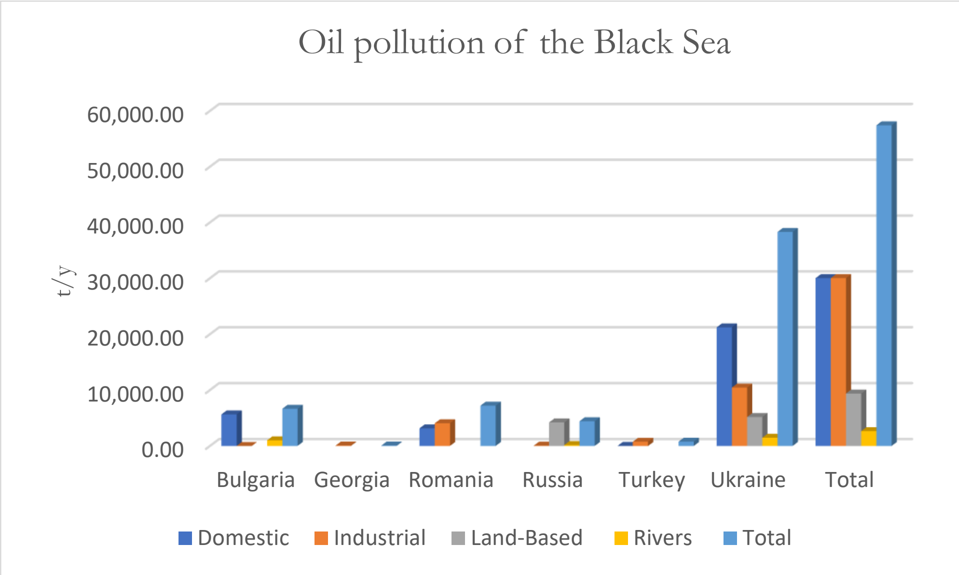


Figure no. 3-35 Oil pollution of the Black Sea before 1996 (Source: Bat et al., 2018)

Summary

Pressure	**Oil & gas extraction; oil & gas processing; shipping accidents; illegal dumping of oil products**	
Location	Onshore	Offshore
Main effects	• Pollution; • Fauna mortality; • Health impairment of fauna; • Heavy metals pollution.	

3.10 Transportation

Introduction
Transportation represents the movement of goods and persons from place to place and the various means by which such movement is accomplished. Marine transportation can generate various effects on the marine environment, including air pollution, greenhouse gas emissions, discharges of ballast water carrying aquatic invasive species, spills of oil and chemicals, releases of dry bulk cargo, improper disposal of garbage, underwater noise pollution, collisions with marine megafauna, the potential for ship grounding or sinkings, and extensive sediment contamination of ports during transshipment or ship-breaking activities.

Since 1949, the shipping sector has been responsible for introducing the largest proportion of non-indigenous species (NIS) into EU seas, accounting for nearly 50% of all species, with the highest concentration found in the Mediterranean. Among these, 51 species are classified as high impact, posing threats to ecosystems and native species. Organisms are primarily transported through ballast water (up to 25.5%) and ship hull fouling (up to 21.2%), while other sources like dredging or fishing equipment contribute to a smaller percentage (2.3%). Ballast water plays a crucial role in providing stability and manoeuvrability during navigation, particularly when ships are not carrying a sufficiently heavy cargo or no cargo at all. However, the discharge of ballast water introduces non-native organisms, bio-invaders, and exotic species into the environment (Nedelcu & Rusu, 2022).

Furthermore, according to Pokazeev et al. (2021), there has been an assessment of the composition, abundance, origin, and primary distribution vector of invasive species, along with the assessment of the risk level for coastal ecosystems in the Azov-Black Sea basin. As a result of the sample studies, the concluding stage of the port survey was focused on formulating legislation and regulations aimed at preventing the introduction of pathogenic and potentially hazardous biological organisms.

The intense traffic reported in 2021 in Romanian waters undoubtedly has numerous adverse consequences for the biodiversity of the Black Sea, such as: discharge of nutrients, the production of underwater noise, loss of oil products (Nedelcu & Rusu, 2022).

Bekova & Prodanov (2023) have found that sea-based sources, one of them being shipping (transportation) contributes with a notable amount of macrolitter (23%) on the Bulgarian coast.

In *Shipping and underwater noise – a growing risk to marine life worldwide* (2021), there is more information related to the generation of underwater noise of the shipping activities. For instance, in the Istanbul Strait, underwater noise has been associated with altered behaviour in harbour porpoises, which spend less time feeding at the water's surface in the presence of ships. Furthermore, bottlenose dolphins are visibly disturbed by the ships and spend little time resting or socialising. In the Baltic Sea, underwater noise from ships interrupts foraging, causes behaviour changes and reduces their ability to use echolocation.

Bat et al. (2018) are emphasizing that the Black Sea stands as one of the globe's most bustling maritime routes. In 2005, more than 55,000 vessels, nearly 6,000 of which were oil tankers, navigated through the Bosporus Strait, predominantly transporting Russian oil.

Yankova et al. (2013) have addressed the fact that the increase of commercial trades led to the spread of non-native fish species in the Black Sea. The article shows that all the Black Sea countries have several recordings of invasive fish species in their national sea waters. More recently, Alexandrov, Minicheva and Zaitzev (2017) emphasized that 261 non-indigenous marine species were registered in the database of the Permanent Secretariat of the Black Sea Commission in 2013, of which 148 were recorded in Ukraine, 94 in Turkey, 82 in Romania, 80 in Bulgaria, 51 in the Russian Federation and 34 in Georgia, the greatest driver being transportation (Alexandrov, Minicheva & Zaitzev, 2017 apud. Öztürk, 2021). Shipping activities are intense in the Black Sea, mainly due to the transport of Caspian oil from Novorossiysk, in the Russian Federation, to Mediterranean countries via the Turkish Straits (Wonham et al., 2000 apud. Öztürk, 2021). In Figure no. 3-36 the main shipping routes in the Black Sea can be observed.

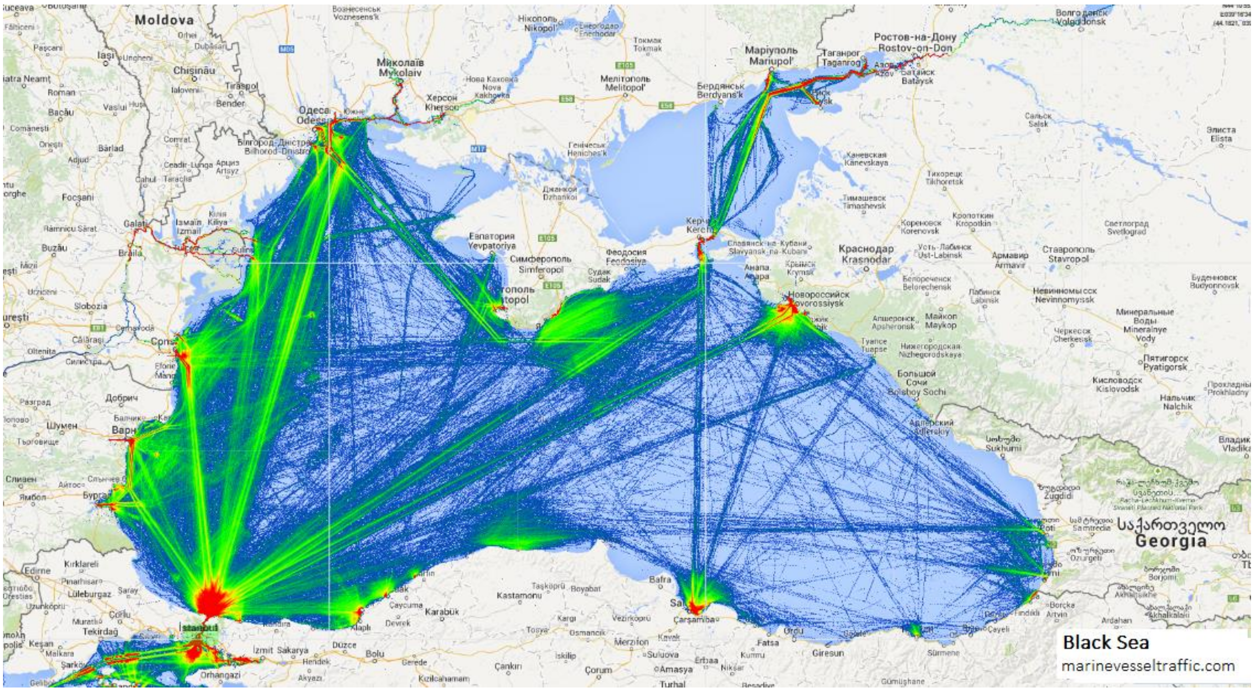


Figure no. 3-36 Ship Traffic Density Map of the Black Sea (Source: *BLACK SEA Ship Traffic Live Map | Marine Vessel Traffic*, 2024)

Summary

<table>
<tr><td>Pressure</td><td colspan="2">Transportation</td></tr>
<tr><td>Location</td><td>Onshore</td><td>Offshore</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Main effects</td><td colspan="2">• Marine litter;
• Pollution;
• Introduction and spread of IAS (invasive alien species);
• Habitat degradation;
• Underwater noise;
• Heavy metals pollution.</td></tr>
</table>

3.11 UNDERWATER INFRASTRUCTURE

Introduction

Underwater infrastructure refers to equipment and technology placed on or anchored to the ocean floor. This infrastructure includes cables for telecommunication, cables for power transmission, and other stationary equipment for scientific research, underwater pipelines transporting liquids, gases, loose solids. Effects include habitat disruption, contamination from oil spills, several species' death and disturbance.

Existing and proposed infrastructure

Although many pipelines transporting oil and gas exist and are projected, their effects are not sufficiently studied. Some of the current underwater oil & gas pipelines from each country of the

Black Sea are presented below. However, Russia was the main oil and gas exporter, at least before the war in Ukraine (BSC, 2019).

- **BlueStream:** the foundation of Blue Stream natural gas pipeline, the largest energy project ever between Turkey and Russia, was laid by the Intergovernmental Agreement on Russian Gas Supply to Turkey via Black Sea as signed on 15 December 1997. The gas deliveries through the Pipeline started in February 2003 and the official inauguration ceremony was held on 17 November 2005. The BlueStream has a total length of 1,213 kilometers, with 396 kilometers situated in the offshore section of the Black Sea. This pipeline facilitates the direct supply of Russian gas to Turkey (BSC, 2019).
- **TurkStream 1 and 2:** the two parallel pipelines enter the water near Anapa, on the Russian coast, and come ashore on the Turkish coast almost 100 kilometers west of Istanbul, near the village of Kiyikoy. Each has the ability to deliver up to 15.75 bcm/year. The first pipeline supplies natural gas to Turkey, and the second pipeline extends into southeastern Europe (Global Energy Monitor, 2023a).
- **Midia Gas Pipeline:** the pipeline runs from the Ana and Doina fields in the Black Sea to Corbu commune, Constanta county, Romania. Construction of the pipeline began in September 2020. The pipeline would provide 10% of Romania's total gas supply. According to Black Sea Oil & Gas, the laying of the pipeline was finalized in January 2021. In June 2022, Romania received the first shipments of natural gas extracted from the Midia Gas Development through this pipeline (Global Energy Monitor, 2022c).

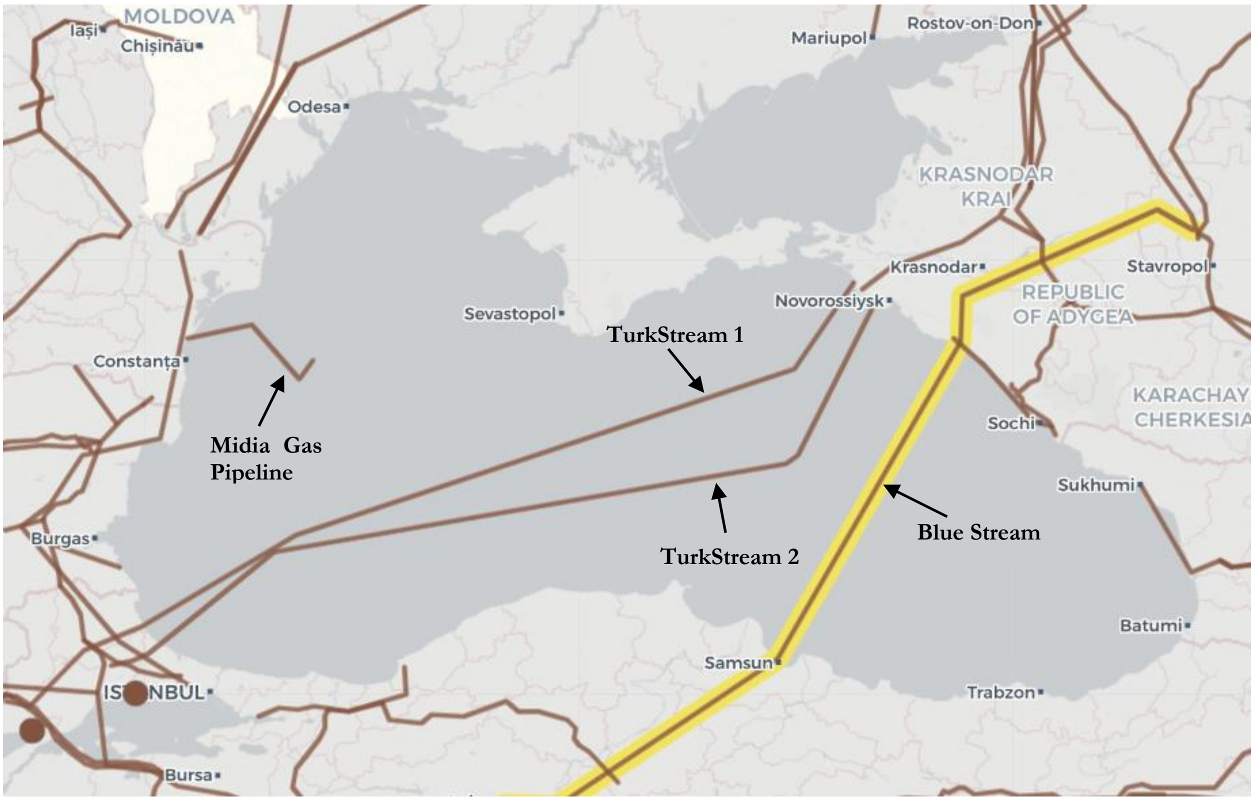


Figure no. 3-37 Black Sea Gas Operating Pipeline Infrastructure (Source: Global Energy Monitor, 2022b)

- **White Stream Gas Pipeline** is a proposed natural gas pipeline which is planned to cross the Black Sea from Georgia to Romania. The White Stream pipeline would branch-off from the existing South Caucasus Gas Pipeline (SCP) at a location south-west of Borjomi in Georgia. From there the pipeline would run west to a new compressor station on the Georgian Black Sea coast where the gas would be taken across the Black Sea to Constanta in Romania. As of August 2023, there have not been any developments in the implementation of the project. The project seems to be shelved because of an array of political, economic, and technical problems (Global Energy Monitor, 2023c).

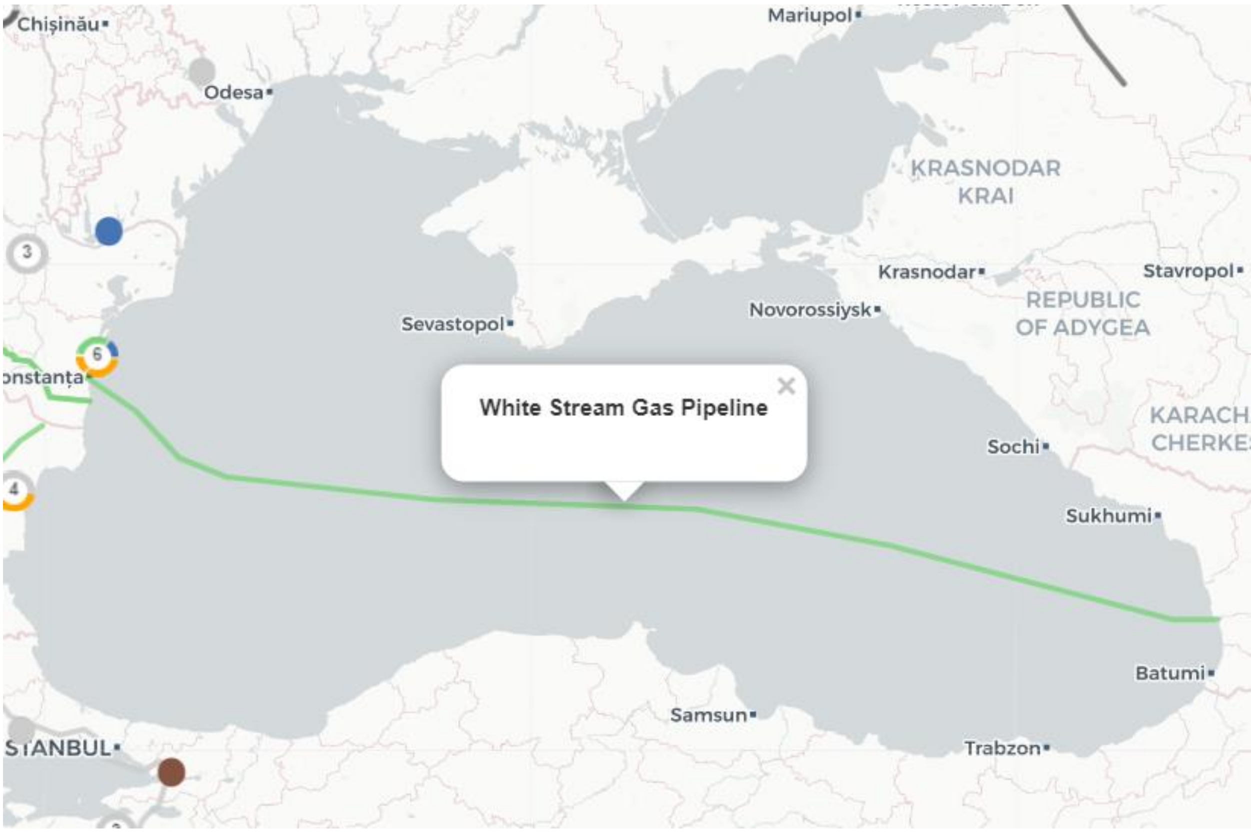


Figure no. 3-38 Black Sea Gas Proposed Pipeline Infrastructure (Source: Global Energy Monitor, 2022b)

Other oil & gas pipelines might be planned, but currently there is insufficient information on the subject.

Besides the underwater pipeline infrastructure, on the seabed we can find submerged optic fiber or electrical cables, which are essential for various communication and connectivity purposes, enabling the transmission of data, telecommunications signals, and, in some cases, electrical power across the Black Sea region. The installation and maintenance of these underwater cables play a crucial role in supporting international communication networks and facilitating connectivity between countries bordering the Black Sea. In the figure below, the Black Sea submarine cables can be observed.

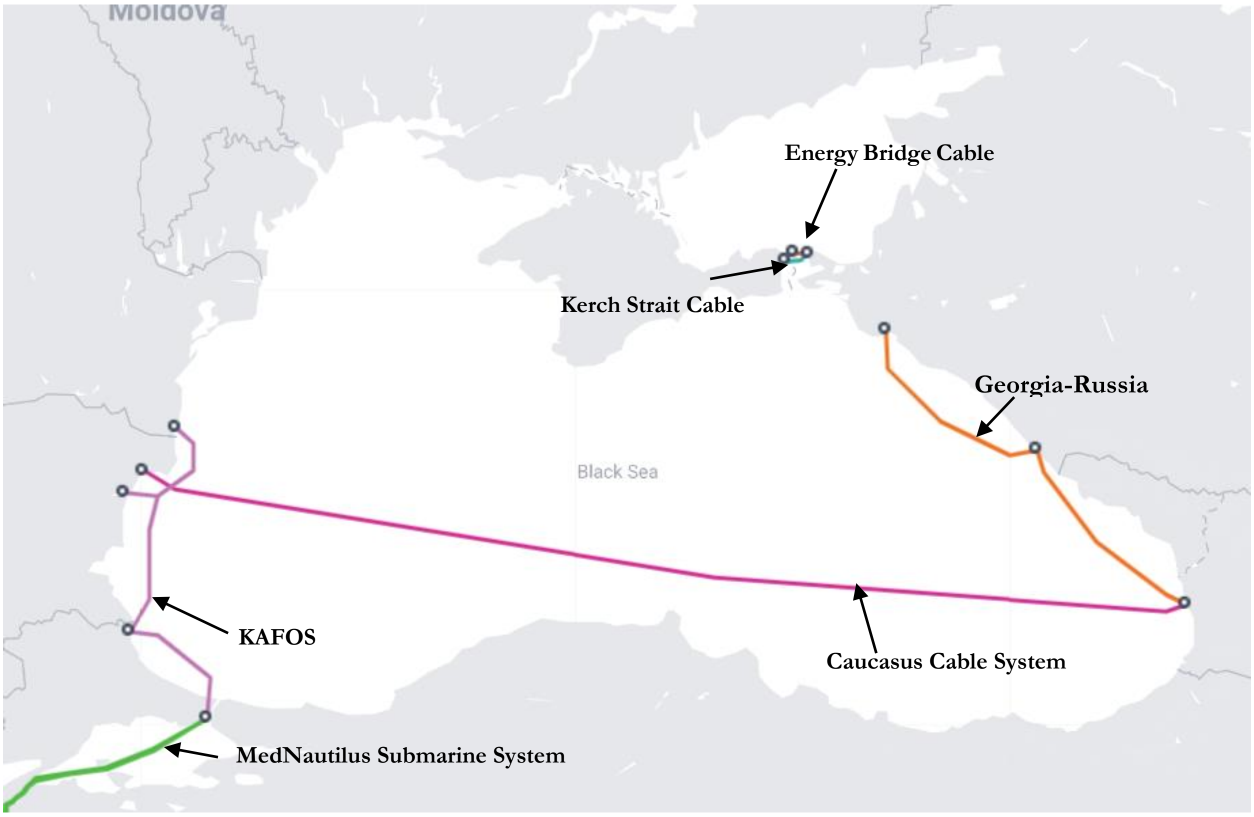


Figure no. 3-39 Black Sea Existing Submarine Cables (Source: Submarine Cable Map, 2023, CC BY-SA 4.0 DEED, https://creativecommons.org/licenses/by-sa/4.0/, adapted from https://www.submarinecablemap.com/)

Other planned submarine cables include High-Voltage Direct Current Line (HVDC), which is planned to be installed between Constanta, Romania and Istanbul, Türkiye, but the installation of the line or its route are not clear yet (EIA Report, TurkStream Gas Pipeline Project, 2017).

Summary

Pressure	**Underwater infrastructure**	
Location	Onshore	Offshore
Main effects	• Habitat degradation.	

3.12 Other resource extraction, Sand/gravel extraction

Introduction
Other resource extraction refers to the withdrawing of materials from the environment for human use, including coal, rocks and minerals. Effects include: loss of species, fragmentation or habitat loss, noise pollution, light pollution, oil spills. **Sand/gravel extraction** offshore entails removing sediments from a seabed that is consistently submerged in seawater.

Frequent dredging activities, necessitated by high sedimentation rates at various fishing ports, lead to the release of nutrients previously trapped in sediments back into the water column (ANEMONE Deliverable 2.2, Lazăr et al., 2021).

In Istanbul, the demand for sand is around 10 million m^3, with half of this amount dredged from the Black Sea, particularly from the western part of the entrance to the Istanbul Strait. Sand dredging can have both direct and indirect effects on beaches (BSC, 2019).

In terms of direct effects, if a dredge hole is situated in an area with significant sediment movement, the hole will eventually fill, trapping sediment and disrupting the littoral cycle. This can lead to shoreline erosion. Conversely, in cases where the dredge hole is not filled, it disrupts the littoral cycle in the opposite way, affecting the shoreline indirectly by altering wave patterns. This results in long-term gains and losses along different sections of the beach (BSC, 2019).

There is not much information at this time regarding the effects of other resource extraction in the Black Sea and according to ANEMONE Deliverable 1.3 (2021) more detailed data on the location of aggregate extraction (within a site) from electronic monitoring system (EMS) on board or AIS (automatic identification system) are currently not available for the Black Sea. However, information on mining activities in the Turkish Black Sea region is the most present in the literature. There are also sources detailing mainly the extraction of sand and gravel from the shores of the Black Sea, especially in Türkiye and Romania (BSC, 2019).

Summary

Pressure	**Other resource extraction; sand/gravel extraction**	
Location	Onshore	Offshore
Main effects	• Pollution; • Heavy metals pollution; • Eutrophication (increased nutrient load); • Habitat degradation.	

3.13 Renewables

Introduction
Renewables, including solar, wind, hydropower, biofuels and others, are at the centre of the transition to less carbon-intensive and more sustainable energy systems. The impacts can span both onshore and offshore components, ranging from loss of habitats to mortality of individuals in onshore and offshore bird species, marine mammals, fish and invertebrates.

At the level of the countries surrounding the Black Sea, statistics show that Georgia is the country with the highest share of electricity production from renewables, while Ukraine presents the lowest share. However, it should be noted that this graph also includes hydropower.

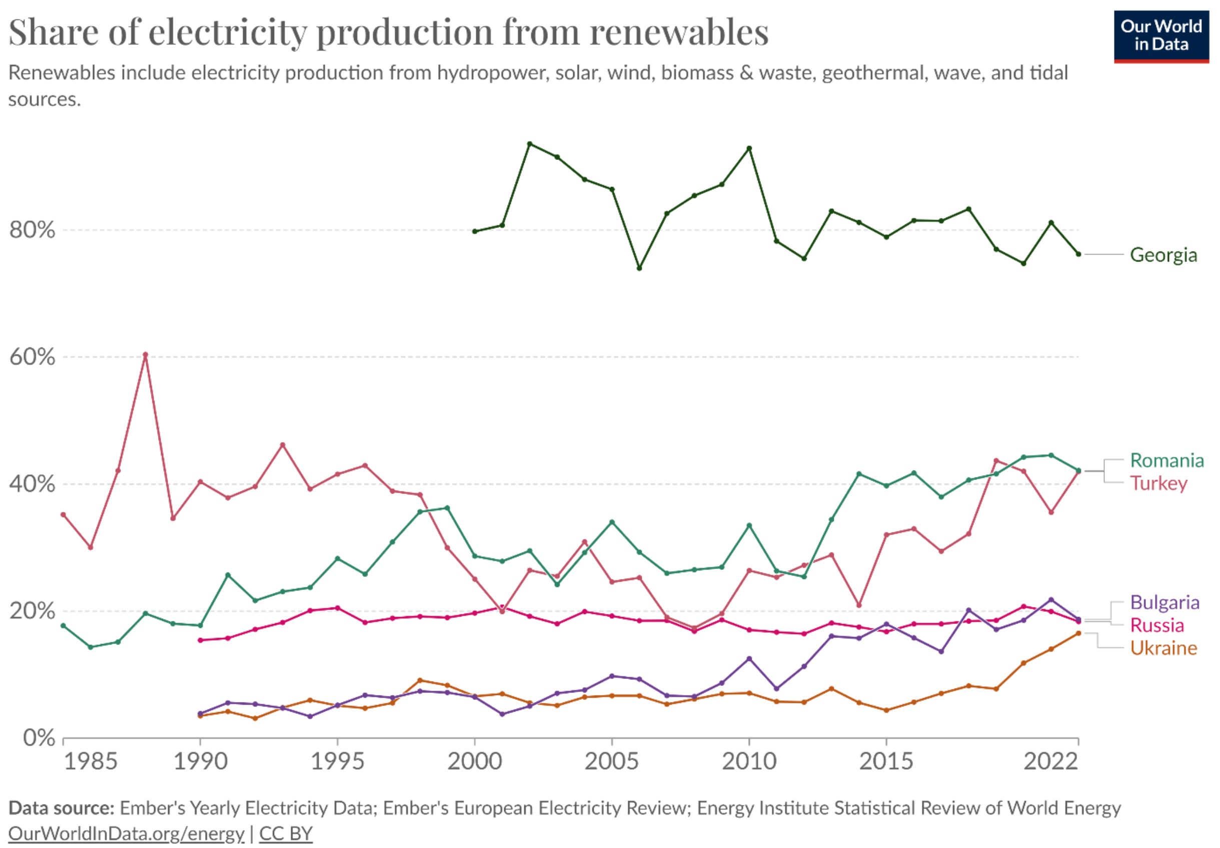


Figure no. 3-40 Electricity production from renewables by Black Sea countries (Source: OurWorldInData.org)

Wind energy

In the context of the Black Sea, the most relevant types of renewable energy production are onshore wind farms. It should be noted that the Black Sea does not yet have any operating offshore wind farms or other offshore energy production facilities. Romania aims to become the first country in the Black Sea area with such projects, as an offshore wind power plant in the sea is planned by Hidroelectrica, with a capacity between 300 MW and 500 MW by 2026, but the process is still in its beginning stages, as the Ministry of Energy has published in 2023 a draft law on the requirements for the development and procurement of offshore wind energy projects. Furthermore, last year, Skyborn Renewables stated that it had applied to the Romanian government for two offshore wind farms in the Romanian sector of the Black Sea. It the published "Statement of reasons", the Romanian Ministry of Energy cited a figure (Figure no. 3-41) from the World Bank regarding Romania's technical offshore wind potential, which estimates it to be 22 GW for fixed-bottom wind turbines and 54 GW for floating ones (Buljan, 2023). Another company, Eolink, announced that plans to install a 5 MW floating offshore wind turbine off the Bulgarian coast in the Black Sea. The unit will be connected to an existing gas platform operated by Petroceltic (Vujasin, 2023). According to The World Bank (2020) the offshore wind technical potential in the Black Sea would be of 435 GW, comprising 269 GW from fixed turbines and 166 GW from floating turbines (Figure no. 3-42).

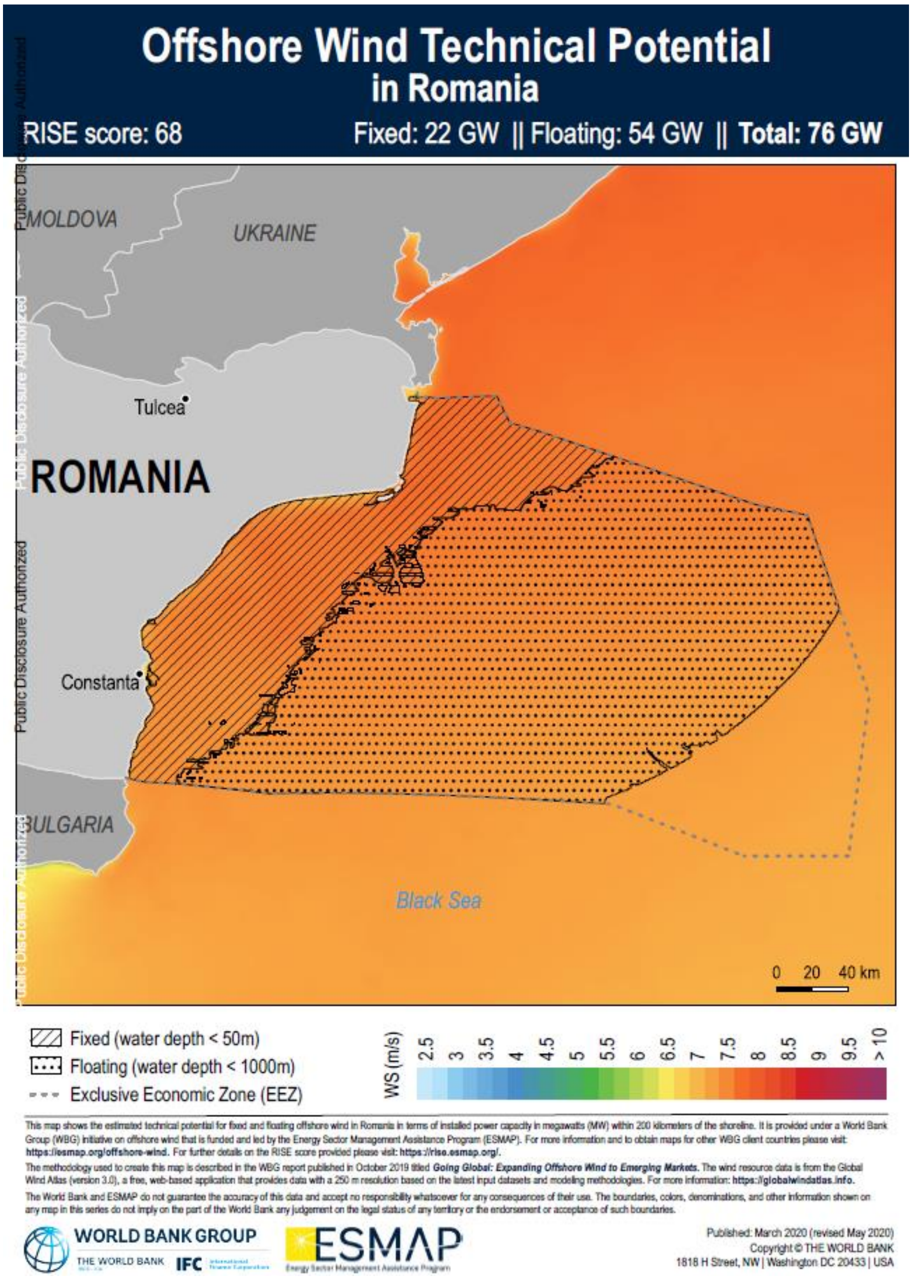


Figure no. 3-41 Romania's offshore wind potential (Source: The World Bank, 2020)

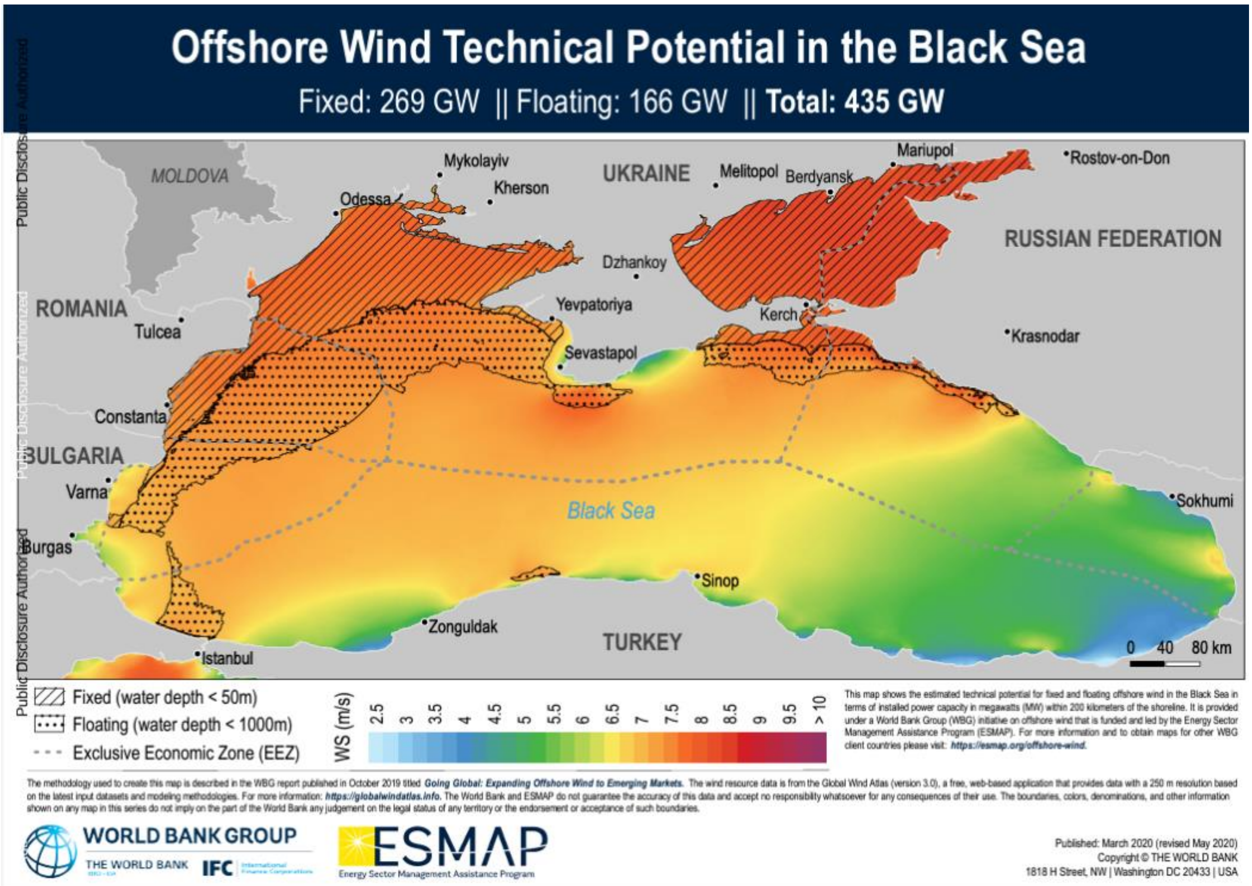


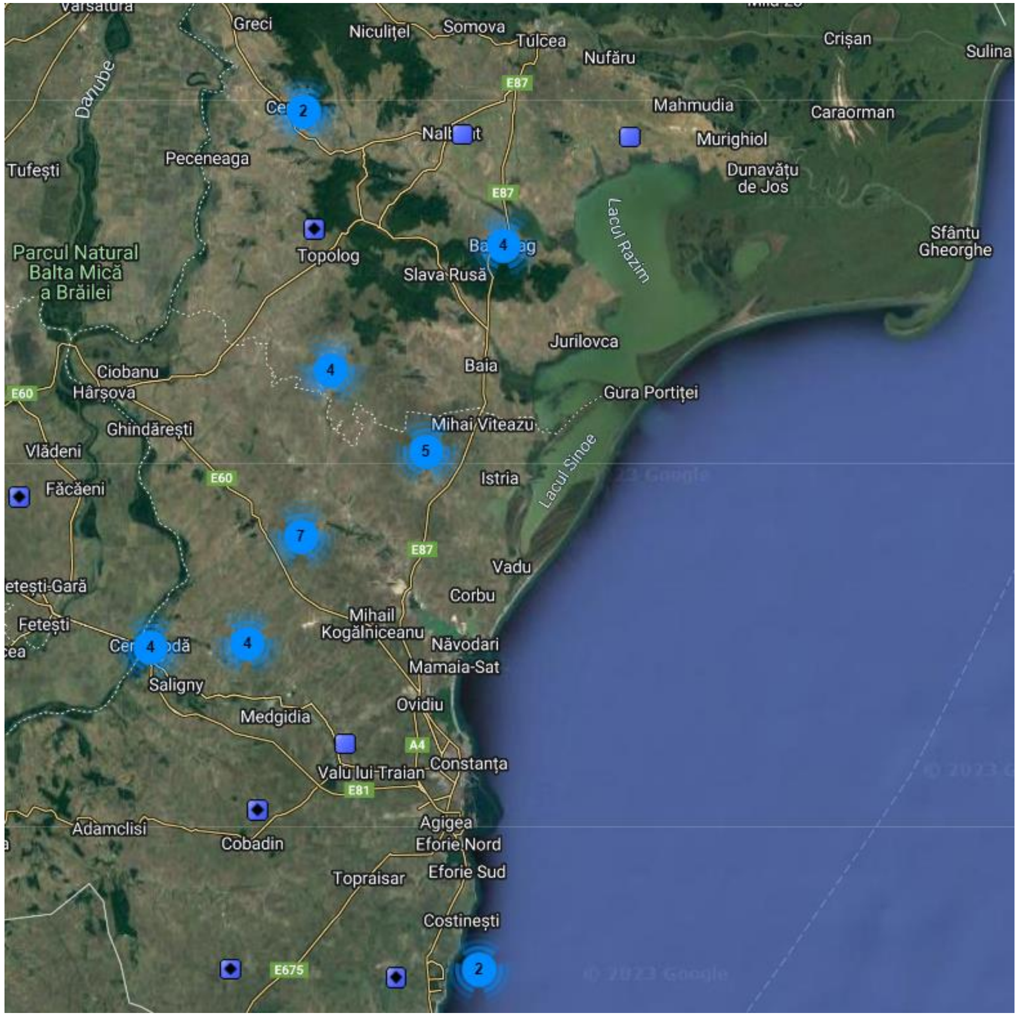
Figure no. 3-42 Offshore wind technical potential in the Black Sea (Source: The World Bank, 2020)

All in all, according to the World Bank (2019) methodology for identifying offshore wind technical potential, fixed offshore wind farms are suitable for water depths of less than 50 m, while floating wind farms are suitable for water depths between 50 to 1000 m. In the mentioned methodology, only regions less than 200 km from shore were considered.

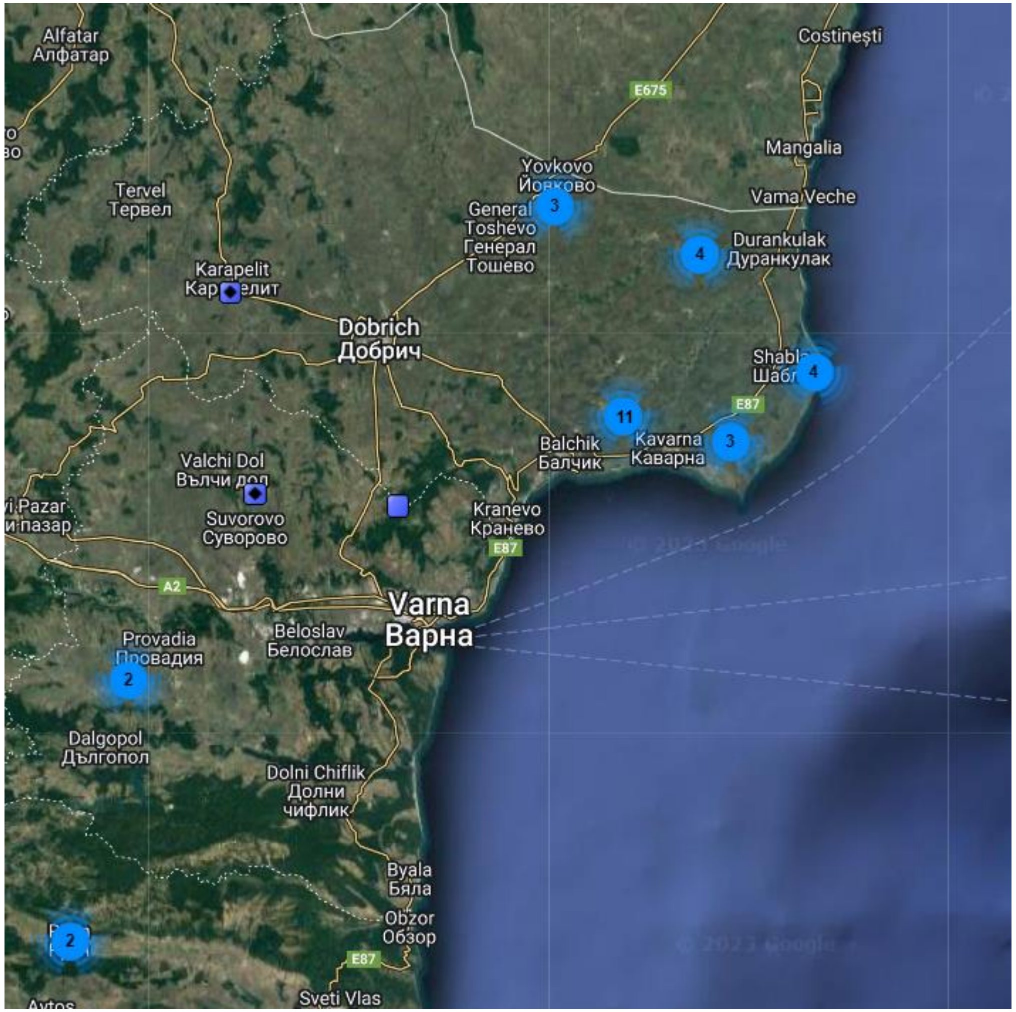
However, onshore wind farms are surrounding the Black Sea. In Romania, most wind farms are located in Dobrogea, close to the Black Sea. A similar situation exists for Bulgaria. In the case of Türkiye, there are wind farms located in its Northern side, close to the Black Sea. Georgia only has one wind park, located in the centre of the country, close to Tbilisi. Russia has a wind park close to Rostov-on-Don, but mostly their parks are located more inshore, east of Krasnodar. Ukraine also has several wind farms near the shore of the Black Sea, near Odesa, Mykolaiv and Kherson. It should also be noted that several parks are located in Crimea, also on the shores of the Black Sea. This spatial information is provided by TheWindPower.net, an online database for wind power development[5].

The maps below show the locations of onshore wind parks in countries surrounding the Black Sea.

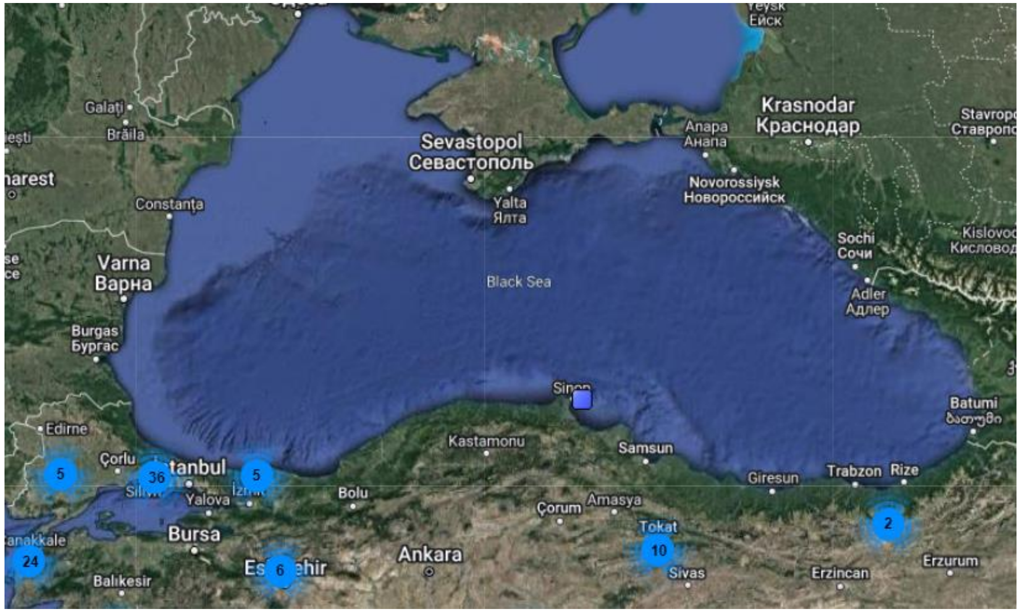
[5] https://www.thewindpower.net/about_en.php



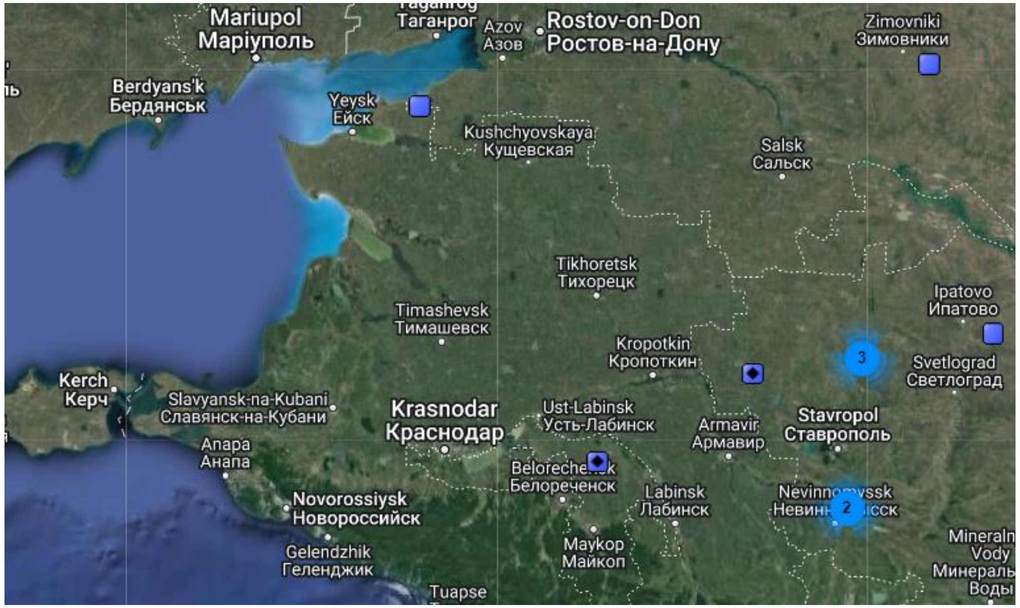
Wind farms near the Black Sea shore in Romania



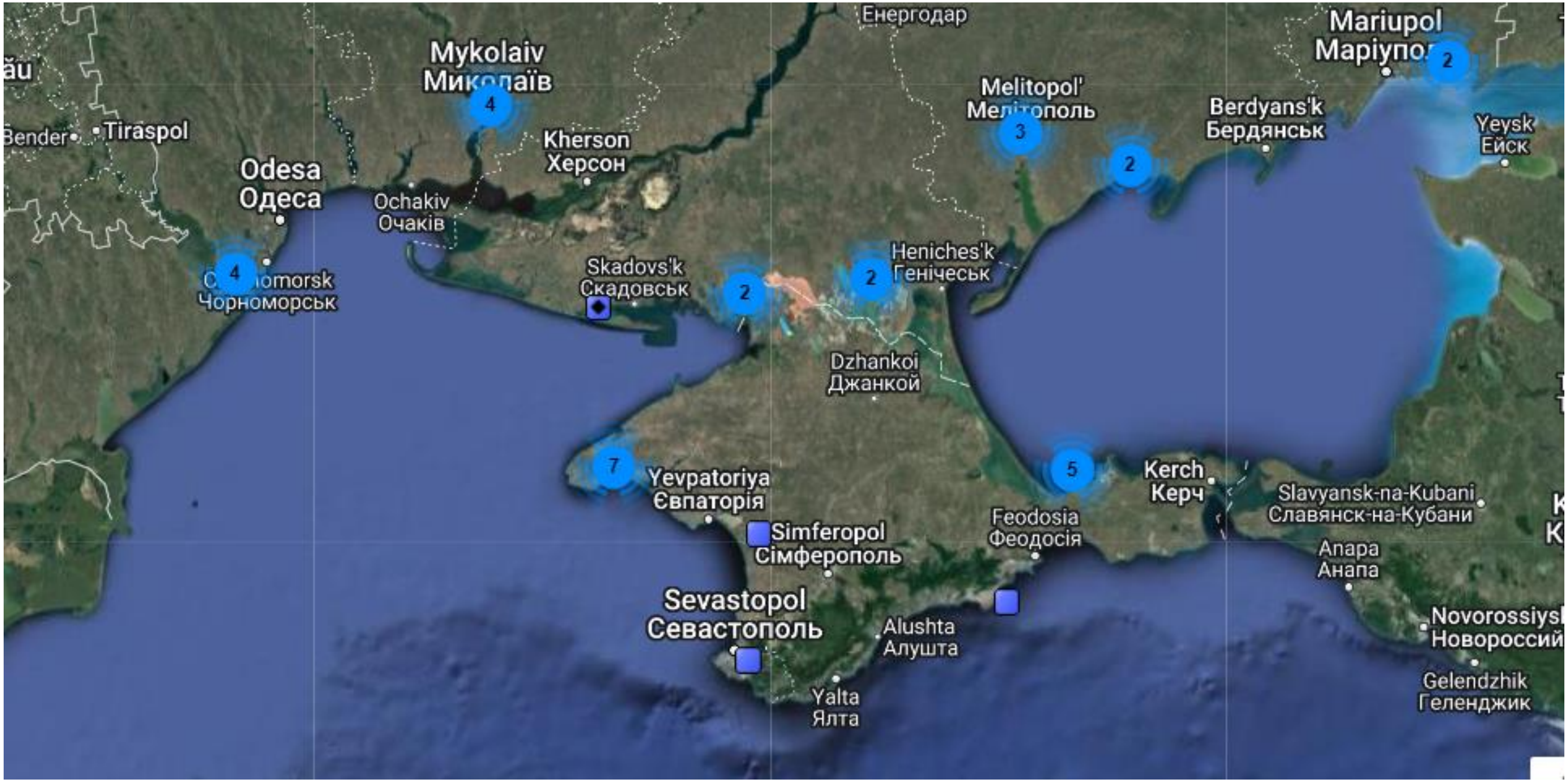
Wind farms near the Black Sea shore in Bulgaria



Wind farms near the Black Sea shore in Türkiye



Wind farms near the Black Sea shore in Russia



Wind farms near the Black Sea shore in Ukraine

Table no. 3-2 Onshore wind farms located near the Black Sea in the different countries (Source: TheWindPower.net)

Wind farms, both onshore and offshore, can pose threats to biodiversity during operation, especially flying fauna such as birds and bats (Biodiversity Impacts Associated to Onshore Wind Power Projects, 2021). The most important and often impact is related to fauna mortality, due to collision of birds and bats with turbines (Thaxter et al., 2017).

In the context of the Black Sea, the existing coastal wind farms and the onshore and offshore intended further developments in this sector can pose a serious threat to the marine bird and mammal species under protection in the Natura 2000 sites designated in Romania and Bulgaria and in the Emerald sites from Ukraine, Russia and Georgia in the absence of environmental studies that analyze all the potential impacts of such projects. The key potential impacts generated by offshore windfarms have been identified by Perrow (2019) apud. Bennun et al. (2021) as: risk of collision mortality for birds and bats, displacement due to disturbance (including noise impacts), barrier effects (also including noise), habitat loss and indirect ecosystem-level effects (e.g. changes in the abundance of populations due to a decrease in feeding sources). These key impacts should be considered in all stages of an offshore wind project planning and development and the comprehensive approach adopted in impact assessment of onshore windfarms projects is applicable to offshore ones as well. However, these potential impacts are detailed in section 4.2 Analysis of main forms of impacts.

According to BirdLife International (2009), during seasonal migrations, large numbers of passerines fly across European seas at night and low altitudes, making collisions with wind turbines likely, especially in adverse weather conditions with poor visibility. Moreover, offshore wind farms can act as barriers for travelling seabirds, leading to displacement from their preferred routes. This may increase travel distances, causing higher energy expenditure and potentially affecting the survival of nestlings by reducing provisioning rates (Fox et al., 2006 apud. BirdLife International, 2009).

In the table below, the total number of onshore windfarms near the Black Sea coast is presented for each country, while currently, there is no offshore operating windfarm in the Black Sea.

Table no. 3-3 Approximate number of onshore windfarms near the Black Sea coast (Source: *Countries - Online Access - the Wind Power - Wind Energy Market Intelligence*, 2024)

Bulgaria	Georgia	Romania	Russia	Türkiye	Ukraine
32	0	37	9	89	35

In what regards offshore wind farms, it has been observed (Degraer et al., 2020) that turbines with a larger distance between the sea surface and the lower tip of the rotor to result in lower collision risk for seabirds and a high turbine density to result in a higher collision risk.

Movement of equipment, people or components may facilitate the introduction of invasive alien species (IAS), for example via movement of vessels on hulls and in ballast water and other equipment during construction stage of offshore wind projects. The hard substrate used for foundations can provide habitat for invasive species, allowing newly introduced species to become established in the area, or existing populations of invasive species to expand (Bennun et al., 2021). This situation can be prevented by implementing mitigation measures listed by Bennun et al. (2021), such as washing vehicles before they enter the construction site or by ensuring good waste management practices are established in the construction phase, and carried through to the operational phase.

Hydropower energy

Weirs and dams can cause notable environmental impacts, including river fragmentation, substantial alterations to river flow and temperature regimes, significant reductions in sediment transport, and hydromorphological degradation of downstream river sections. These factors contribute to habitat loss, biodiversity loss, and the impairment of ecological integrity in river ecosystems, leading to the loss of ecological functions, ecosystem services, and overall system resilience (Hudek & Schwarz, 2021).

It is important to mention that there are several rivers connected to the Black Sea, where hydropower dams exist (Figure no. 3-43), impeding the migration of fish species upstream for reproduction (Costea et al., 2021; Hydroeconex, 2019). Examples of these are the Dubăsari dam in Moldova (with the Dniester Hydroelectric Station further upstream on the Dniester river, in Ukraine) and the Porțile de Fier dam in Romania and Bulgaria.

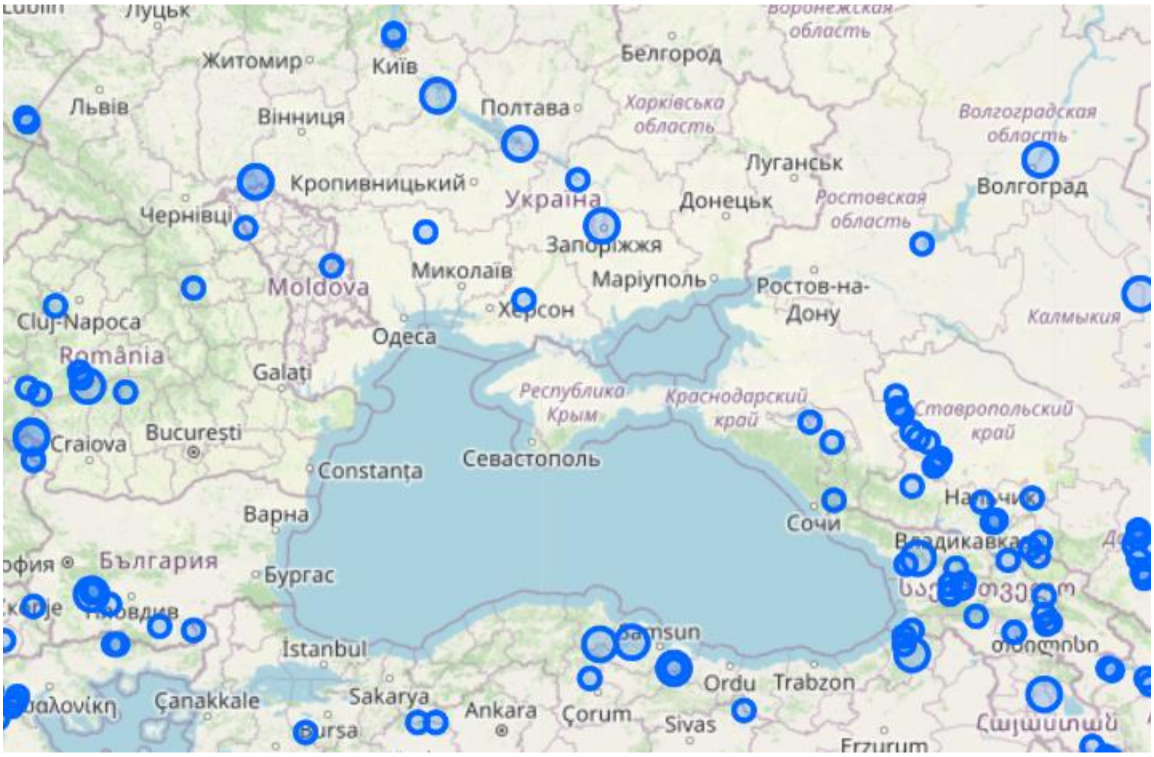


Figure no. 3-43 Hydropowerplants in the Black Sea countries (Source: Power plants across the globe (World Map))

An important mention would be the fact that Figure no. 3-43 presents the HPPs which have an increased capacity to produce energy and have the potential to generate impacts.

Case study I – Dniester river fragmentation by Dniester and Dubăsari hydropowerplants

The interruption of longitudinal connectivity on the Dniester River represents one of the most significant direct effects caused by the Dniester Hydropower Plant (Dniester HPP). This is being attributed to HPP-1 and HPP-2.

Transverse blocking represents an obstacle to the movement of fish (downstream - upstream or upstream - downstream) on the Dniester River. Neither of the two dams is equipped with fish passage structures, causing complete interruption of longitudinal connectivity, especially for fish moving downstream to upstream. Due to Dubăsari dam, approximately 49% of the total length of the Dniester in the Republic of Moldova (Naslavcea – Dubăsari sector) is lost habitat for migratory fish species from the Lower Dniester or marine fish species migrating into freshwater.

During the period from 1996 to 2000, between Naslavcea and Camenca (Median Sector of Dniester), a total of 42 fish species were identified, compared to previous years (49-75 species) (Hydroeconex, 2019). In the post-HPP period, studies indicate a general decrease in fish abundance, characterized by a trend of replacing native species with allochthonous and/or invasive species (Bulat et al., 2014; ACVAGENRESURS, 2020).

The pressures occurred after 1950 (primarily the construction of the Dubăsari hydropower plant, followed by the completion of the Dniester HPP) have led to a decrease in diversity in the Dniester River's ichthyofauna (Bulat et al., 2014, Zubcov, 2012). The literature indicates that over time, the number of fish species in the Dniester River has decreased (Moşu & Trombiţki, 2013). In the Median Sector of the Dniester (Naslavcea-Dubăsari), after the construction of the Dubăsari hydropower plant, the population of Acipenseridae has significantly declined. Species such as *Huso huso*, *Acipenser stellatus*, *Acipenser gueldenstaedtii* and *Acipenser nudiventris* were no longer identified in fish catches during the period 1993-2017 (Bulat, 2017). In the Median Sector, according to literature data (Usatii, 2004; Moşu, 2013; Bulat et al., 2017), the only species from the Acipenseridae family present in fish catches in the last two decades has been *Acipenser ruthenus*, while in the Lower Sector of the Dniester, all species were present in the years 1993 and 2013. Additionally, the species *Anguilla anguilla* and those of the Atheridae and Umbridae families have disappeared from the Median Sector of the Dniester River after the completion of the Dniester HPP.

Most of the species that disappeared from the Median Sector of the river are either anadromous (regularly migrating from the sea to rivers for reproduction) or catadromous (migrating from rivers to the sea for reproduction), or occasionally amphidromous species (undertaking occasional movements from brackish areas of river mouths upstream, not necessarily for reproduction). This indicates that a pressure that played a crucial role in the disappearance of these species is the dam at Dubăsari, due to the interruption of longitudinal connectivity and the prevention of characteristic reproductive cycles of species (migrations between marine habitats and freshwater habitats).

The fish species that can be considered extinct from the Middle Sector of the Dniester river due to the Dniester HPP are *Mylopharyngodon piceus*, *Romanogobio uranoscopus* and *Umbra krameri*.

The species *Mylopharyngodon piceus* is an allogeneic species, originating from Southeast Asia (Usatîi et al., 2014). This species requires movements to the upstream area for reproduction. It can be considered that this species was affected by the reduction of the longitudinal connectivity of the

Dniester river by the construction of the Dniester HPP dams. Other effects of Dniester HPP that can cause significant impacts are the rate of water level rise and fall, changes in water velocity, alterations in sediment transport, changes in water temperature and reduced lateral connectivity (Greimel et al., 2018).

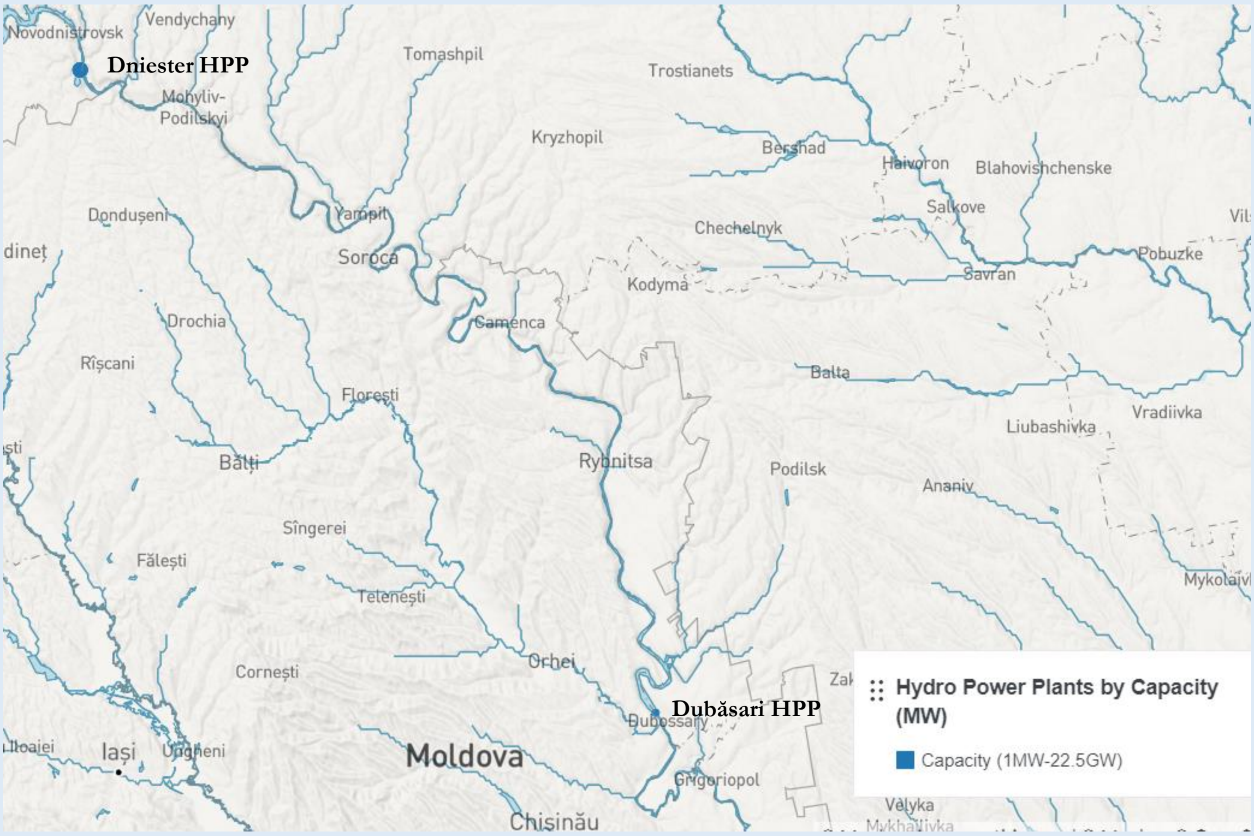


Figure no. 3-44 Location of Dniester and Dubăsari HPPs (Source: Global Power Plant Database v1.2.0, 2019)

As previously mentioned, other examples of river fragmentation are Porțile de Fier I and II HPPs, detailed in the Case study below in terms of effects and impacts for anadromous fish.

Case study II – Danube river fragmentation by Iron Gates I and II hydropowerplants

The first obstruction for anadromous fish species on their spawning migration from the Black Sea and the Danube Delta is the Iron Gate II hydroelectric power plant, completed in 1984 at river km 863. The second barrier is Iron Gate I, operational since 1970, located at river km 943. These structures serve as dams and barriers in the Danube River, hindering the migration of anadromous fish species, as there are no fish passes (Lenhardt & Pekárik, 2021).

Thus, the spawning area of the Pontic shad (*Alosa immaculata*), the Azov Shad (*Alosa tanaica*), and three anadromous sturgeon species, the Beluga Sturgeon (*Huso huso*), the Russian Sturgeon (*Acipenser gueldenstaedti*) and the Stellate Sturgeon (*Acipenser stellatus*) has been reduced due to the interruption of longitudinal connectivity by the Iron Gates I and II hydropowerplants which also lead to prevention of characteristic reproductive cycles of species (migrations between marine habitats and freshwater habitats) (Honţ, Paraschiv & Iani, 2022).

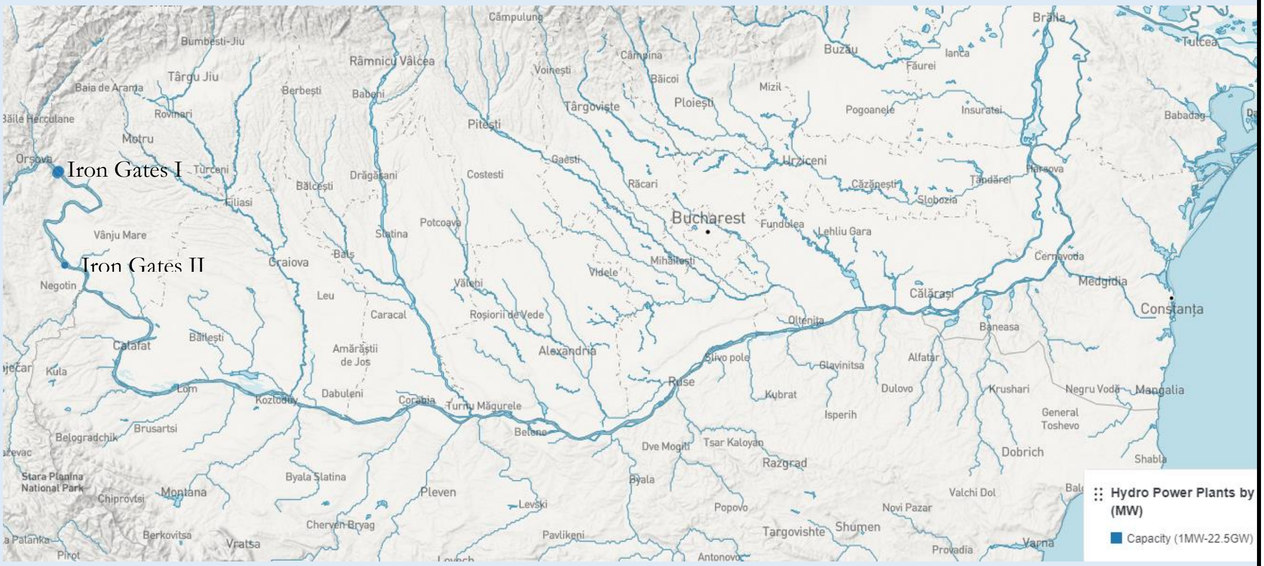


Figure no. 3-45 Iron Gates I and II HPPs (Source: Global Power Plant Database v1.2.0, 2019)

Wave and tidal energy

In what regrads **wave energy**, Türkiye plans to develop the first in the Black Sea and Türkiye and world's largest wave energy power station in the southern part of the Black Sea, in the city of Ordu (*Türkiye to Step in Wave Energy With Largest Ever Plant off Black Sea*, 2022).

However, as there is no information regarding other such planned projects in the Black Sea waters, the wave power potential in the Black Sea can be observed in Figure no. 3-46. According to Rusu et al. (2017), the highest mean wave power values are found in the southwest, with a maximum value of 4.4 kW/m (first image, right). Furthermore, in winter the highest mean wave power values can be reached, with a value of 8.1 kW/m, the most valuable areas being located in the southwestern side of the basin (offshore of Istanbul) and in the northeast, along the coast of Russia. In autumn, the mean wave power levels are almost as high as those for the entire period, while during summer, the wave energy levels are weak over the entire basin (maximum value reaching only 2 kW/m). It is important to mention that there are no significant differences between the seasons for the southeastern part of the basin. Thus, in what regards the wave power, the western side appears to have more potential than the other areas of the basin.

Rusu et al. (2017) also show in Figure no. 3-46 that the mean wave heights (first image, left side) for the entire analyzed period reach 1 m in the centre and southwest of the basin, while the values in the eastern part do not exceed 0.9 m in any offshore area. Additionally, the seasonal maps show that the maximum values are reached in the winter (1.44 m), while the distribution of the values for spring and autumn have similar patterns. The smallest values of all the seasons are reached in the summer, with a highest value of 0.8 m in the southwest of the Black Sea.

As global energy demand increases, so does the demand for wave energy generation devices, which are said (Frid et al., 2012) to provide a significant source of energy.

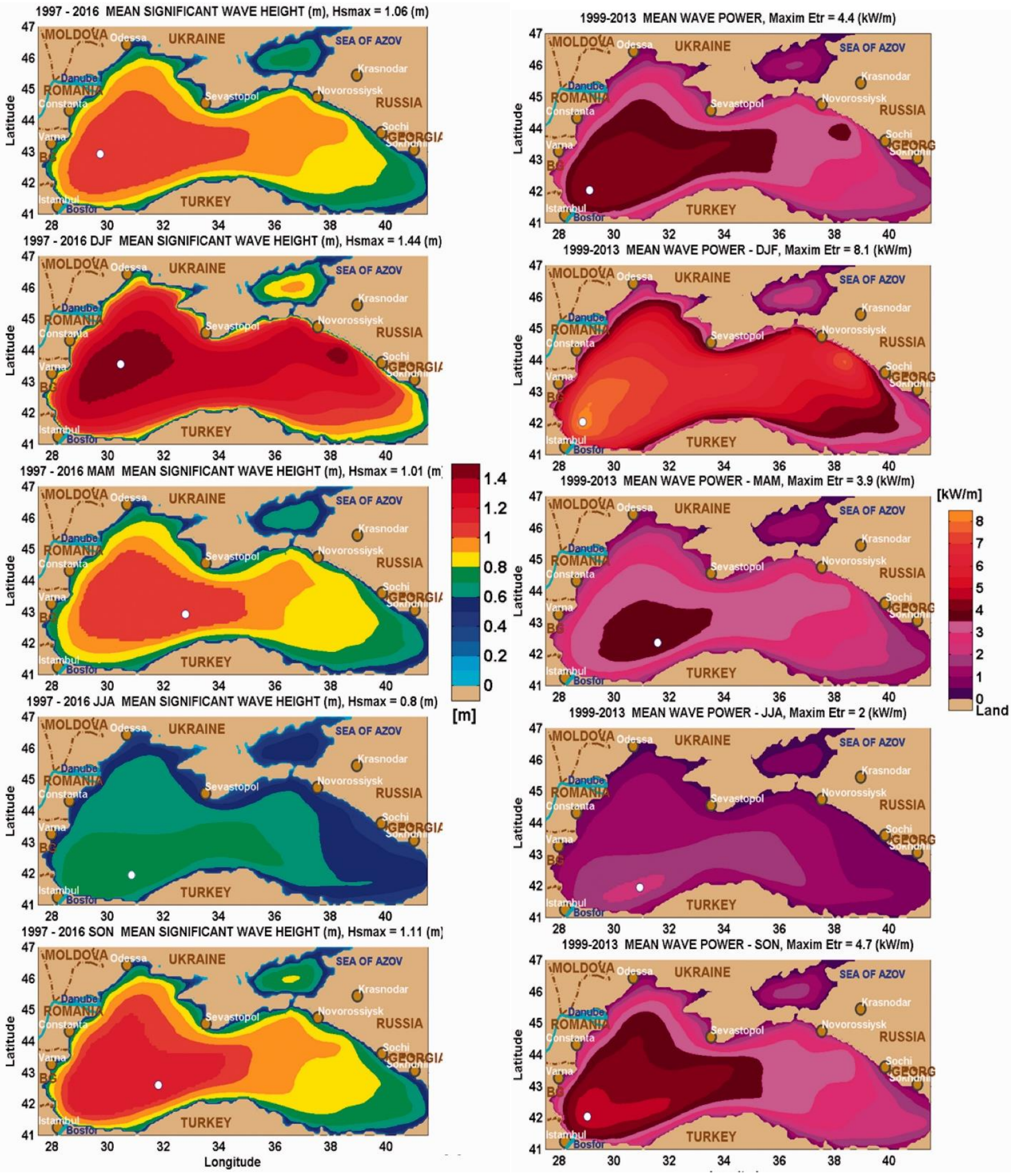


Figure no. 3-46 The mean wave power fields (right panels) and the mean significant wave height fields (left panels) for the entire 20-year period 1997–2016 (fist line), and for each season: winter (DJF) – second line, spring (MAM) – third line, summer (JJA) – fourth line, autumn (SON) – last line (Source: adapted from Rusu et al., 2017).

According to Frid et al. (2012) and Pelc and Fujita (2002) wave energy farms act as wave breakers, which might result in impacts on the marine life and fisheries. However, demersal fish are likely not to be directly affected, but changes in surface productivity due to reduced mixing may potentially decrease the food supply for benthic populations. Species that spend their lives nearer the surface would be most directly impacted by changes in waves and currents. Fish species relying on currents to transport larvae may face harm from wave energy devices altering the currents between spawning grounds and feeding grounds, which could potentially affect fish populations.

Wave energy promoters suggest that devices could improve marine life by serving as artificial reefs, providing structure. However, the validity of this claim needs careful evaluation for individual projects, as the impact of artificial structures seems to depend heavily on the specific site. In locations where a lack of hard substrate restricts production, these structures may indeed enhance marine life. On the other hand, in areas where other factors limit marine life, artificial structures might divert organisms from natural habitats, potentially making them more susceptible to harvesting (Pelc & Fujita, 2002). It was also found that invertebrate and fish assemblages around the anchored artificial structures exhibit higher abundance in comparison to surrounding areas (Langhamer, 2010b).

In what concerns **tidal energy**, there are two types of exploitation: tidal barrage/fence and tidal stream farms. According to Frid et al. (2012), tidal energy power generation devices can pose different effects depending on the used instalation.

Tidal barrages/fences can change the phytoplankton dynamics upstream as the water in the basin would be static, while constrainted flows can result in highly turbid conditions and low primary productivity. Moreover, construction of a barrage on or near a nursery or spawning area will clearly lead to adverse effects at the population level, as they act as barriers and block access to reproduction. Tidal fences can also restrict fish and marine mammal passage through physical blockage, impeding migrations of anadromous and catadromous species (Frid et al., 2012).

The extraction of kinetic energy from tides, both in the near field and far field, is expected to reduce tidal amplitude, current velocities, and water exchange. The extent of these changes is proportional to the number of installed units in **tidal stream farms**, which could potentially alter hydrography and sediment transport in the affected region. Additionally, the presence of moving rotors and foils has demonstrated an increase in mixing, particularly in systems with well-defined salinity or temperature gradients. Tidal energy turbines may also have an impact on wave heights by extracting energy from the underlying current. In order to avoid affecting species reproduction, the devices should not be closely located (Frid et al., 2012).

Installation and decommissioning of tidal barrages, tidal stream farms and wave energy farms are said to include considerable noise levels, damaging to marine life. Activities such as pile driving, explosive or seismic work have the potential to impact cetaceans due to high-level impulsive sounds by damaging sensory or sensitive tissues (direct impacts) or by changing behaviours (indirect impacts - short-term reduction of echolocation activity up to 15 km from the source). However, there is little information on the noise produced and generated impacts by these installations during operation (Madsen et al., 2006; Henriksen et al., 2004; Tougaard et al. 2003; DFO, 2009 apud. Frid et al., 2012).

Summary

Pressure		
Location	Onshore	Offshore
Main effects	• Habitat loss • Fauna mortality • Increased noise • Introduction and spread of IAS (invasive alien species)	

3.14 Military activities

Introduction

Military activities are defined as something rather different and more practical, namely the activities that (usually) the nation-state requires for its defence and security, or for military offensives and interventions beyond its borders. They can also be defined as actions and movements, as well as corresponding impacts pertaining to or conducted by armed forces. The effects include: habitat alterations, environmental pollution, species disturbance, underwater noise, species mortality.

The full-scale Russian invasion in February 2022 made it far more difficult to monitor the state of industrial facilities across Ukraine and their impact on the environment. Targeted attacks on energy infrastructure increasingly threaten the failure of facilities processing or storing hazardous materials, whose operation is dependent on a steady power supply. Industrial accidents can bring significant long-term consequences to the environment and public health and increase the risk of transboundary water and air pollution (*Risks and impacts from attacks on energy infrastructure in Ukraine,* 2022).

An additional crucial safety issue is the power plants' cooling process, dependent on the availability of power supply. This is especially dangerous in the case of nuclear power plants (NPPs), as conflict-related damage to power lines supplying NPPs can risk a nuclear accident. When the cooling system stops functioning, the fuel rods of the reactors begin to melt (*Risks and impacts from attacks on energy infrastructure in Ukraine,* 2022).

In 2022, constant shelling of energy infrastructure in Ukraine is increasing the risk of power cuts to crucial drainage systems, leading to the possible release of mine water into rivers and groundwater (*Risks and impacts from attacks on energy infrastructure in Ukraine,* 2022).

It has been stated that the Russian military activities performed in Ukraine since the beginning of the war generated many damaging effects to the Black Sea. Some of the military activities involved: bombing of large ammonia producers located near the Dnieper and Donets rivers; attacks on reservoirs with gasoline, diesel and liquefied petroleum gas; damage to the cities' infrastructure, leading to malfunctioning or nonoperating and leakage of untreated wastewater into the rivers; destruction of several producers and processing plants (Algan & Aydoğan, 2023).

Various ports along the Black Sea and Azov Sea coast at Mykolayiv, Odessa and Mariupol were brutally attacked. The damage to regional biodiversity can only be estimated at the moment. It was mentioned that 14 Ramsar wetland habitats encompassing 400,000 hectares along the Dnieper River's lower reaches are under threat, including: the vast shallow marine lagoons and the largest island in the Black Sea in Karkinitska and Dzharylgatska Bays, the Dnipro river delta, and the bogs, meanders and natural meadowsof the Desna river floodplains (Cundy, 2022 apud. Tahmid et al., 2023).

Toxins released into the environment as a result of the bombings can spread transboundary as 98% of Ukrainian river catchment area flows to the Black Sea and Azov Sea and the other 2% flows to the Baltic Sea. Many protected sites have also been affected by fire since the beginning of 2022, the total area of burned forests being a hundred times higher than the same period last year. Reserves in Mykolaiv and Kherson have been affected by these fires: Biloberezhia Sviatoslava National Park, Kinburn Spit Park, Black Sea Biosphere Reserve and Lower Dnipro National Nature Park (uwecworkgroup.info, 2023).

Water pollution and biodiversity loss can have an influence on coastal and marine protected areas. For instance, many protected areas on the coasts of the Azov Sea, Odessa and the Danube Delta are vital habitats for migrating birds, which can suffer from direct or indirect impacts (Pereira et al., 2022 apud. Tahmid et al., 2023).

The adverse impacts of armed conflicts on coastal and marine ecosystems include harm to underwater habitats caused by sunken ships, missiles, and anchor usage, as well as the negative effects of ammunition blasts. Key consequences encompass chemical and acoustic pollution, physical damage to habitats, and a decrease in conservation activities, as outlined in a report by CEOBS (2023).

The resulted environmental changes in the Black Sea may have affected dolphins, with reports indicating 80 dolphin deaths based on complaints about stranded mammals since late February 2022. Turkish Marine Research Foundation specialists suggest that disrupted echolocation due to polluted environments may have contributed to the majority of these dolphin deaths. Additionally, sources report nearly 3,000 dead dolphins found with marks from water mines or bombs, highlighting the severe consequences on the Black Sea's dolphin population (Renolafitri and Yolandika, 2022; Andreikovets, 2022 apud. Tahmid et al., 2023).

Summary

Pressure	**Military activities**	
Location	Onshore	Offshore
Main effects	• Pollution • Changes in water quality • Underwater noise • Riverine litter discharge into the sea • Fauna mortality • Changes in the structure/dynamics of populations • Habitat degradation • Health impairment of fauna	

3.15 Anti-erosional works, Coastal protection works

Introduction
Anti-erosional works refers to preventing or controlling wind or water erosion in agriculture, land development, coastal areas, river banks and construction.
To address coastal erosion, **coastal protection works** are generally categorized as either soft or hard solutions, or a combination of both. Soft solutions encompass measures such as vegetation, beach nourishment, sand bypassing, flood proofing, sand dune formation, zoning, and retreat. On the other hand, hard solutions involve structures like seawalls, revetments, groynes, offshore reefs, and detached seawalls. Innovative methods include the use of sand-filled geotextile tubes, containers, bags, mats, stone-filled gabions, and artificial reef balls.

Coastal erosion presents a shared challenge for all the countries bordering the Black Sea. In Bulgaria, beach erosion surveys conducted between 1983 and 2003 revealed that landslides and erosion terraces encompass approximately 13% of the country's coastline. The average annual erosion of beach surface along the Bulgarian Black Sea coast is reported at 17,527 m^2/year, with an estimated coastal erosion rate of 0.08 m/year (BSC, 2019).

In the northern sector of Romania's coast, approximately 50 ha experienced accumulation, while around 80 ha underwent erosion processes. The shoreline exhibited advancement by more than 10 m on 10% of the total coastline length and recession by more than 10 m on 53% of the coastline. Roughly 38% of the coastline is considered stable (having retreated or advanced by less than 10 m). To address erosion, five priority coastline protection projects were initiated under the Coastal Zone Master Plan, aiming to mitigate erosion and rehabilitate the coastal zone. Ongoing projects, such as "COASTAL EROSION REDUCTION PHASE II (2014-2020)," are actively working to reduce coastal erosion in the Romanian Black Sea coast (BSC, 2019).

Along the Russian coast, the average annual variation does not exceed 1 m. In the northern part, where erodible rocks prevail, the average coastal recession is 0.7 m/year. Conversely, in the south, a 50 km sand bay-bar system with dunes and beaches is followed by a flysch zone featuring abrasion cliffs and a mountainous coastline with gravel/pebble beaches. A longshore transport stream interrupted by groins and breakwaters, intercepting pebble and gravel material migration, is established along the coast, preventing natural beach restoration. The average rate of beach surface erosion is reported as 0.5 m (BSC, 2019).

Summary

Pressure	**Anti-erosional works; coastal protection works**	
Location	Onshore	Offshore
Main effects	• Hydromorphological changes; • Coastal erosion; • Habitat degradation; • Eutrophication (increased nutrient load).	

3.16 Effects generated by identified pressures

3.16.1 Direct effects

In the sense used by the present study, the effects refer to the changes caused to the physical environment as a direct consequence of the pressures (interventions) generated by humans. The identified effects mainly include: eutrophication, pollution, heavy metals pollution, marine litter etc. A summary table with the identified effects can be found in the table below, which represents the result of an original database containing literature entries regarding Black Sea pressures correlated with their effects. The numbers represent the total entries introduced in the database for each effect. In the list of effects may appear certain overlaps, as we chose to utilise them in the form presented by the authors of the different studies.

Table no. 3-4 Summary of the identified direct effects based on database entries

Effects of pressure	Country						
	Ukraine	Romania	Moldova	Turkiye	Russia	Bulgaria	Georgia
Eutrophication (increased nutrient load)	5	9	2	9	8	1	1
Pollution	7	12	0	20	13	4	3
Microplastics	0	1	0	5	1	0	0
Changes in water quality	2	2	1	3	5	1	1
Hydromorphological changes	0	1	0	0	0	0	0
Marine litter	3	10	1	6	5	12	1
Underwater noise	0	1	0	0	2	0	0
Heavy metals pollution	0	6	0	12	5	0	0
Radioactive pollution	1	0	0	0	0	0	0
Riverine litter discharge into the sea	3	3	2	1	6	2	1
Overexploitation of fish stocks	3	0	0	4	3	0	0
Coastal erosion	0	2	0	0	0	0	0
Changes in the structure/dynamics of populations	1	1	0	2	2	1	1
Health impairment of fauna	4	1	0	1	2	0	1

3.16.2 Indirect effects

During the literature analysis for the current study, we have identified climate change and introduction and spread of invasive alien species (IAS) as indirect effects of human activities, such as transportation and industrial activities.

Table no. 3-5 Summary of the identified indirect effects based on database entries

Effects of pressure	Country						
	Ukraine	Romania	Moldova	Turkiye	Russia	Bulgaria	Georgia
Climate change	0	0	0	2	5	0	2
Introduction and spread of IAS	2	2	0	2	3	2	2

Thus, we have described them in detail, considering the complex mechanisms of propagation and their far-reaching consequences.

3.16.2.1 *Climate change*

The marine environment is expected to undergo changes in eutrophication due to climate change, characterized by rising water temperatures and shifts in rainfall patterns. In Europe, there has been an observed increase in sea surface temperature (EEA, 2014d). Elevated water temperatures influence the growth of phytoplankton and the rates of organic material mineralization, both of which tend to rise with temperature. The decrease in the solubility of oxygen in warmer water exacerbates the impact of high nutrient inputs on the occurrence of hypoxia. For instance, in the case of the Baltic Sea, in certain parts, a temperature increase of approximately 2 °C over the last century has contributed to the expansion of sea floor areas experiencing hypoxia (Carstensen et al., 2014 apud. EEA, 2017).

The heightened frequency of extreme floods may lead to the release of old contaminants and contaminated sediments into the aquatic environment. Moreover, the impact of climate change is expected to worsen coastal erosion, already evident in the exposure of landfill sites in Europe. This poses a clear risk of contaminating coastal waters (EEA, 2017).

Marine organisms are sensitive to temperature variations as their life cycles are adapted to specific temperature ranges. Changes in temperature determine organisms to either migrate, perish, or adapt to sub-optimal conditions. Adaptations in the marine environment occur more rapidly than on land, although the nature of these adjustments varies among different species (EEA, 2017).

For example, the invasion of the Black Sea by Mediterranean-originated species is a relatively recent phenomenon attributed to the rise in water temperature resulting from climate change. Despite the ecological barrier posed by the Turkish straits (Istanbul and Çanakkale Straits), which have distinct oceanographic characteristics compared to the Black Sea and the Mediterranean Sea, certain phytoplankton and zooplankton species manage to penetrate into the Black Sea. Additionally, due to climate-induced temperature increases, Mediterranean fish species like sardine, bouge, and wrasse have entered the Black Sea in recent years. The overall trend suggests the establishment of a miniature Mediterranean Sea within the Black Sea, as various species infiltrate through different vectors (BSC, 2019).

However, below we have presented the most relevant climate change variables for the Black Sea and their evolution trend over certain periods of time.

Surface Temperature

Current exposure

According to Black Sea Surface Temperature Cumulative Trend Map From Observations Reprocessing | CMEMS (2023), it has been noticed that there is a general ascending trend in the Black Sea surface temperature with a range between 1.5-2.3°C for the analysed period 1993-2022. The highest increase (2.3-2.1°C) has been observed around the coast of Russia, near Novorossiysk and around the Turkish coast, near Sinop. A medium increase (ranging between 2.0 and 1.8°C) has been found near the shore of Romania and Bulgaria and in the South of Crimea. Lastly, the lowest increase (1.7-1.5°C) was observed near the western part of Crimea.

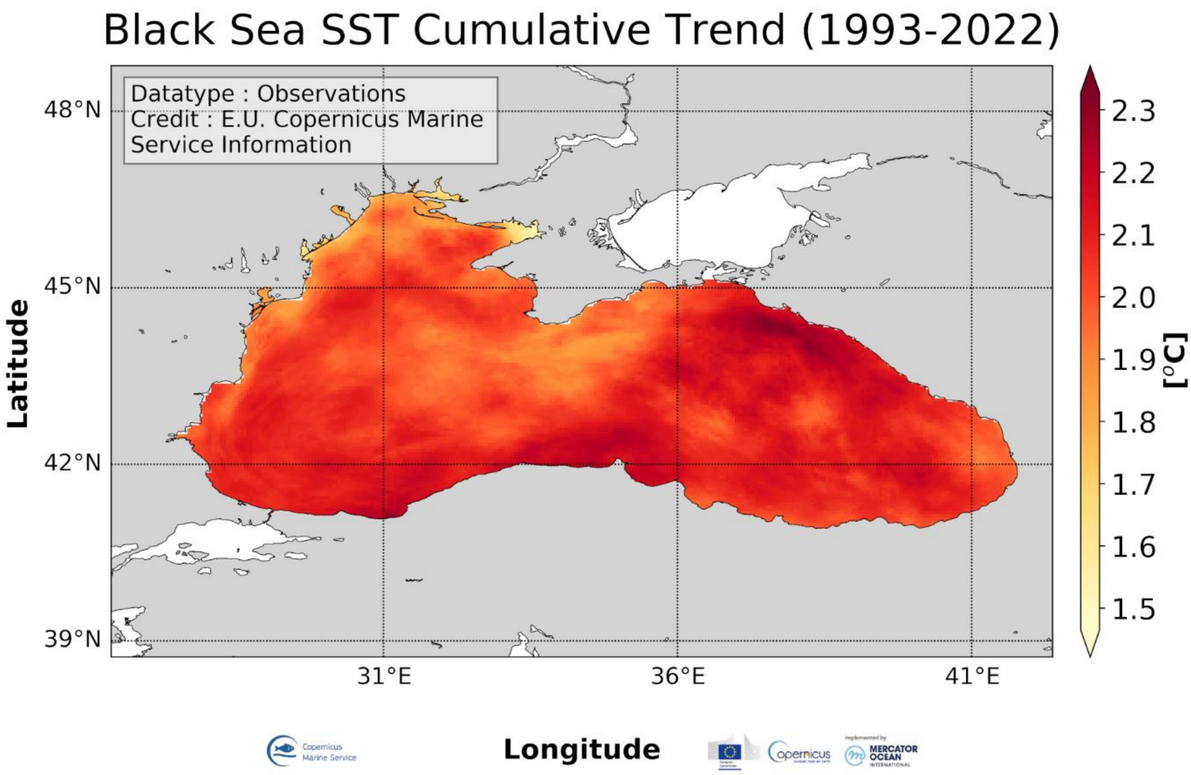


Figure no. 3-47 Black Sea Surface Temperature cumulative trend map from Observations Reprocessing (Source: Black Sea Surface Temperature Cumulative Trend Map From Observations Reprocessing | CMEMS, 2023)

Between the mid-1990s and 2010, the average annual Sea Surface Temperature (SST) experienced an upward trend. In the open sea, the increase was approximately 0.05°C per year, while in the bay, it rose by about 0.04°C per year. However, after 2010, a slight decline was observed, continuing until 2015. Notably, the highest average annual SST on record occurred in 1982 (Ginzburg et al., 2021).

Future exposure

For the future scenario, according to EEA (2023), sea temperatures at the surface are expected to increase further in the 21st century (by 2100), between 1.3 °C and 3.5°C, under SSP2-4.5 (the intermediary scenario).

In Figure no. 3-48 by Sakallı and Başusta (2018), we can see that the comparison between historical (1986–2015) and future (Future 1: 2031–2060 and Future 2: 2071–2100) sea surface temperatures (SSTs) in the Black Sea reveals similar trends between the Future 1 and historical periods, with SST ranging from 13.4 to 19.8 °C in the Future 1 period. The warming of the Black Sea occurred in an east–west direction. The difference (increase) between the Future 1 and historical periods showed variations ranging from 1 to 3.5 °C, with the highest increase (approximately 3.5 °C) and the lowest increases (around 1.0 °C) observed in the north and northeastern Black Sea and the Sea of Azov, respectively.

In addition, in the Future 2 period, the Black Sea continued to experience continuous warming, with SST reaching up to 22.2 °C in the northeast. The largest simulated increase (6.6 °C) occurred in the northeast, between Ukraine and Russia. Across most regions of the sea in the Future 2 period, the increase in SST was approximately 5.5 °C (Sakallı & Başusta, 2018).

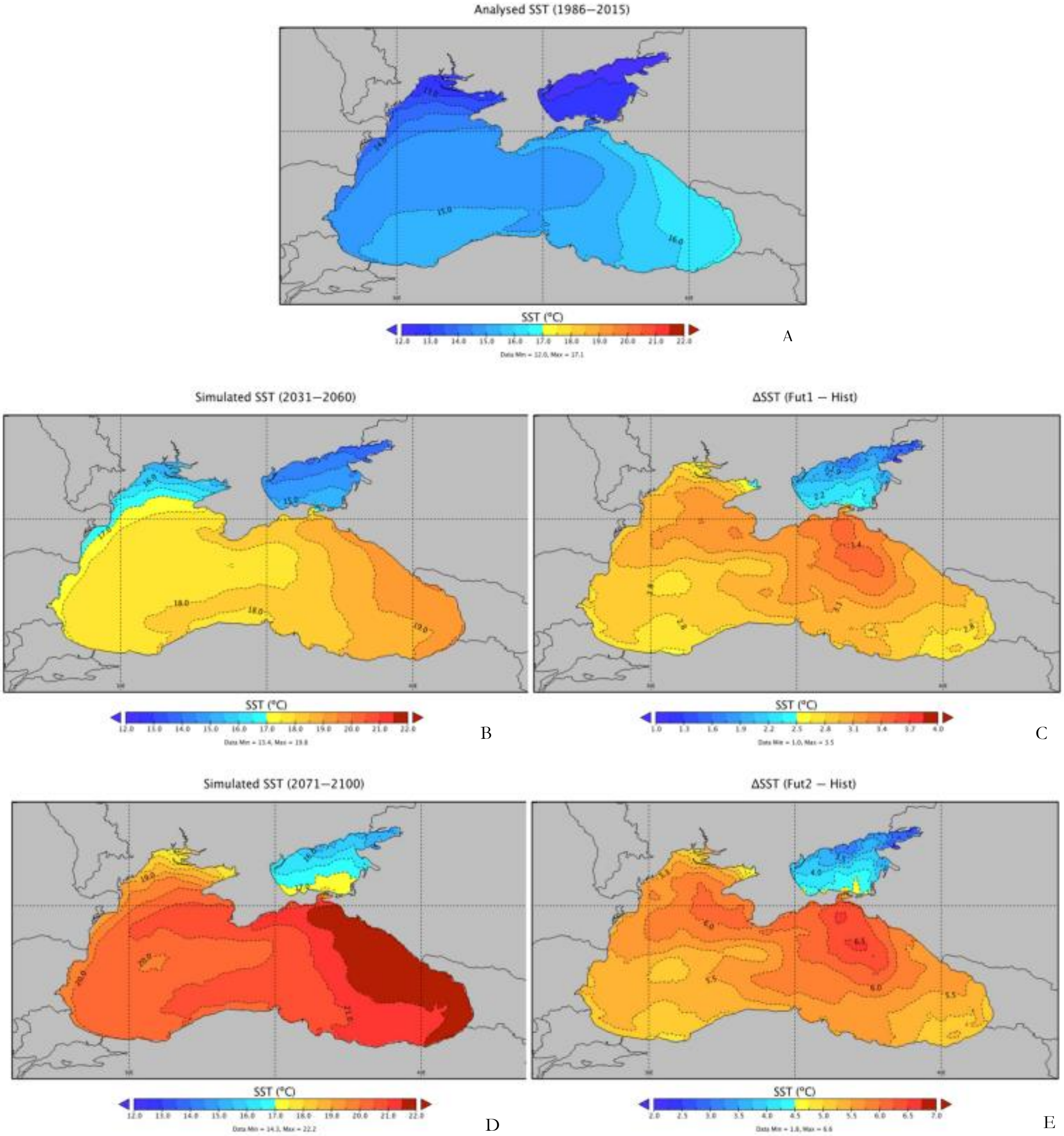


Figure no. 3-48 Sea surface temperature change in the Black Sea in the Future 1 and Future 2 periods (Source: Sakallı & Başusta, 2018)

Sea surface salinity

Current exposure

The Black Sea exhibits a clear negative trend in sea surface salinity near the Danube River delta. However, in its immediate vicinity, as well as to the southwest and off the coast of Crimea, positive salinity values are observed. These variations may suggest that the freshwater runoff from the Danube River is confined closer to the coasts.

Additionally, slightly negative salinity values are also found in the Black Sea Eastern gyre. On average across the entire area, there is a small increase in salinity within the upper 250 meters of the basin, with a trend of 0.0064 parts/million per year. Interestingly, during the period from 2002 to 2011, the upper 100 meters experienced lower salinity than the long-term average. However, this trend becomes less significant in deeper layers (Von Schuckmann et al., 2018).

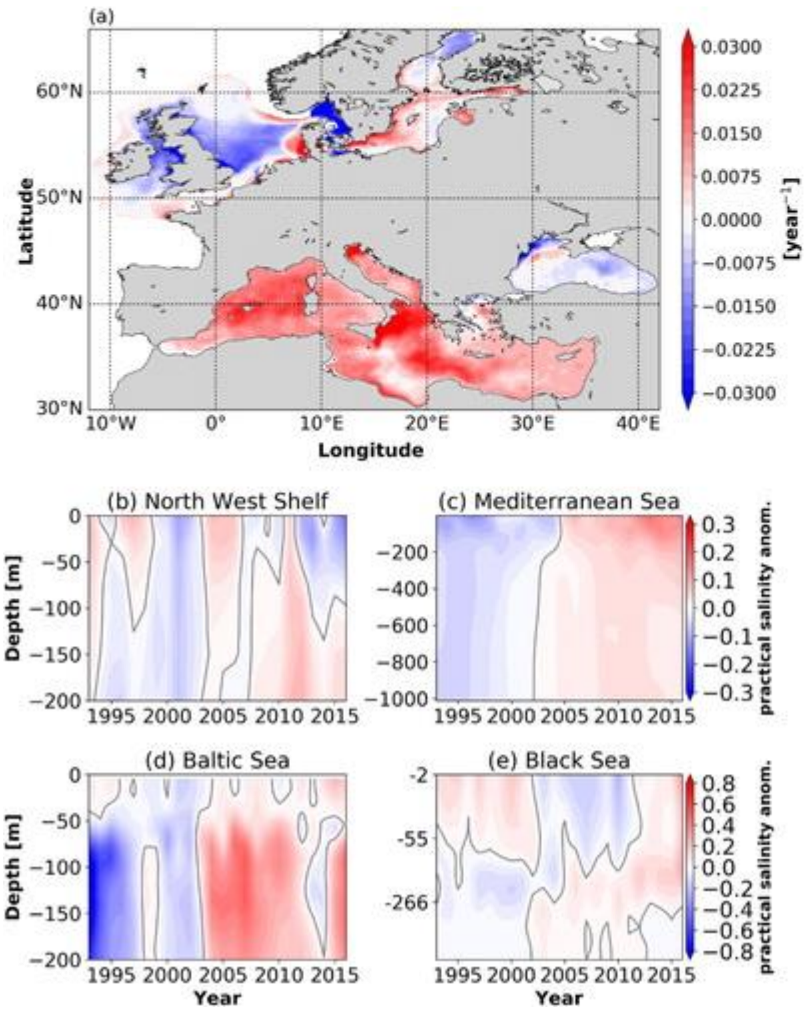


Figure no. 3-49 Salinity trend for the Black Sea for the range 1995-2015 (Source: Von Schuckmann et al., 2018)

Future exposure

As we could not find relevant future predictions for this parameter, we will precautionary consider that the present estimates will be maintained, meaning that it is possible that the salinity decrease will be enhanced.

Sea level rise

Current exposure

According to IPCC AR6 Sea Level Projection Tool (2021), in the chosen scenario 2-4.5, the sea level for decade 2010-2020 ranges between 0.05 near the the coast of Romania, Bulgaria, Crimea and Russia and 0.12 m near the coast of Georgia.

The north-western part of the Black Sea features a substantial shelf, exceeding 200 km in width with depths ranging from 0 to 160 m. In certain areas, the shelf is narrow and intermittent near the Anatolian and Caucasian coasts. Additionally, Figure no. 3-50 highlights the spatial distribution of land below the 20 m line, indicating high vulnerability to sea level rise. Hazardous areas are identified along the Black Sea coast in all countries. To assess vulnerability, factors like soil type, land use, population, and income should be considered. Notably, the geographical distribution of sea level trends reveals the maximum rate (~5 mm/year) between 38º–40º northern latitudes and 41º–42º eastern longitudes in the Black Sea, requiring attention despite the absence of low-lying areas in that section (Avsar et al., 2015).

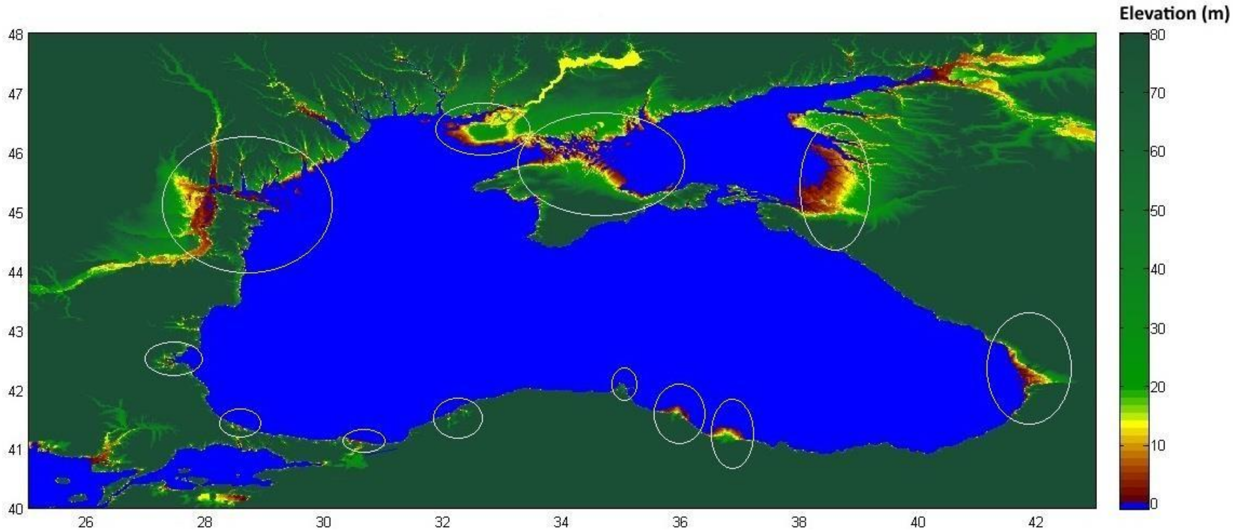


Figure no. 3-50 Coastal areas below 20 m elevation along the Black Sea shore (Avsar et al., 2015)

Future exposure

According to IPCC AR6 Sea Level Projection Tool (2021), in the chosen scenario 2-4.5, the evolution prognosis of the sea level until 2050 ranges between 0.16 m near the coast of Bulgaria and 0.41 m near the coast of Georgia.

Figure no. 3-51 Median projections of global and regional sea level rise, relative to a 1995-2014 baseline (Source: IPCC AR6 Sea Level Projection Tool, 2021)

Wind

Current exposure

From 1979 to 2019, the rise in wind speed from the northeastern quadrant to the western Black Sea during June to September can be attributed to a notable surge in the occurrence of wind events originating from this direction. These changes are due to changes in the atmospheric circulation, represented by the northward and northeastward shift of the North Atlantic Anticyclone maximum in June, August and September. This has an impact on the western sector of the Black Sea. Furthermore, the baric gradient is intensified due to the pressure contrast between the southern (lower) and northern (higher) regions of the Black Sea. As a result, more robust winds are expected to occur from the northeast. As the increase in air temperature, an effect of global warming, is the main cause of these changes in atmospheric circulation, episodes of high wind speed are expected to intensify over the Black Sea (Nojarov, 2021).

Future exposure

During the upcoming period from 2021 to 2060, the average wind speed in the western and northwestern Black Sea is slightly lower (up to -0.12 m/s) under the RCP8.5 scenario, while it is slightly higher (up to +0.10 m/s) in the eastern Black Sea compared to the RCP4.5 scenario (refer to Figure no. 3-52 a, c). Across the remaining areas of the basin, there are no notable differences in mean wind speeds between the RCP4.5 and RCP8.5 scenarios (refer to Figure no. 3-52 a,c).

In the subsequent mid-term period from 2061 to 2100, significant variations in mean wind speeds between the RCP4.5 and RCP8.5 scenarios are only evident in the northeastern part, where the

RCP4.5 scenario indicates higher wind speed estimates, reaching up to 0.19 m/s (see Figure no. 3-52 b, d).

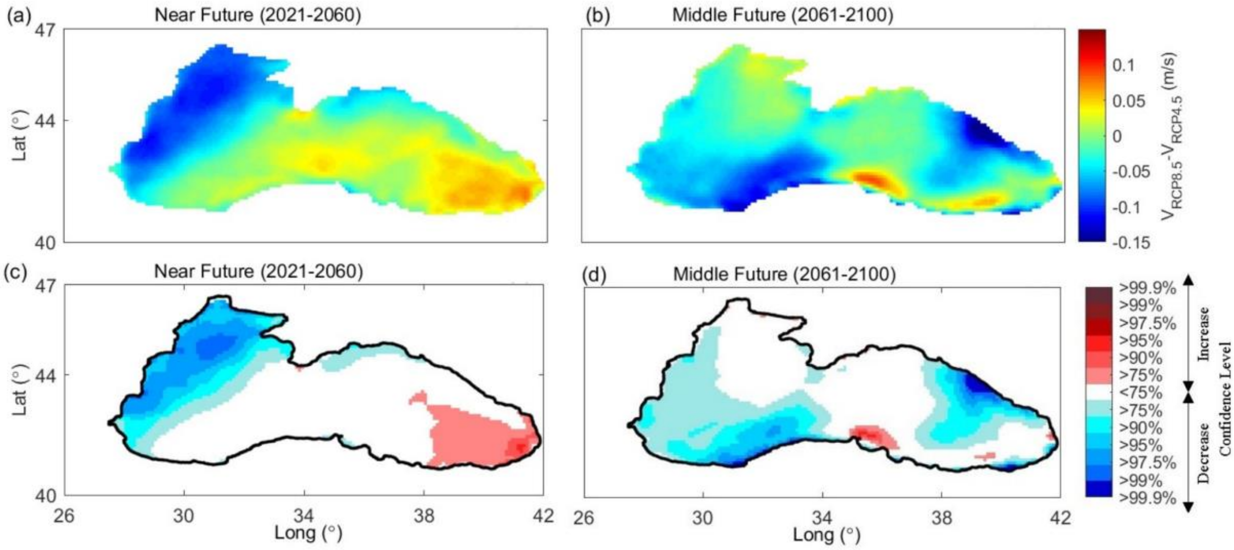


Figure no. 3-52 Variations in the average wind speeds under the RCP4.5 and RCP8.5 scenarios for the (a) near future and (b) mid-term future are examined. The significance of these differences in means is assessed using Student's t-test at various confidence levels for the (c) near future and (d) mid-term future (Source: Islek et al., 2021)

Coastal erosion

Current exposure

Particularly, areas experiencing the most significant erosion are located in Romania (constituting 37% of the national coastline), Ukraine (29%), and Georgia (26%). The highest rates of erosion are observed in specific locations along sandy, low-lying beaches characteristic of deltas (such as the Danube, Kizilirmak, Yesilirmak, Sakarya, and Rioni) or coastal barriers and spits predominantly in the northwest part of the basin. Notably, at the mouth of the Ochakov Arm (Chilia Lobe) in the Danube Delta, maximum shoreline retreat values surpass 30 m/yr, reaching an extreme value of −43.2 m/yr. Additionally, areas with retreat values ranging from −10 to −30 m/yr are identified, including near the mouths of the Yesilirmak and Kizilirmak Rivers, as well as on the receding Sacalin spit. Bulgaria and Russia exhibit the most stable coastlines, with 84% and 82% of their respective national coastlines characterized by stability. Following closely are Turkey (68%), Ukraine (63%), and Georgia (63%) (Tătui et al., 2019).

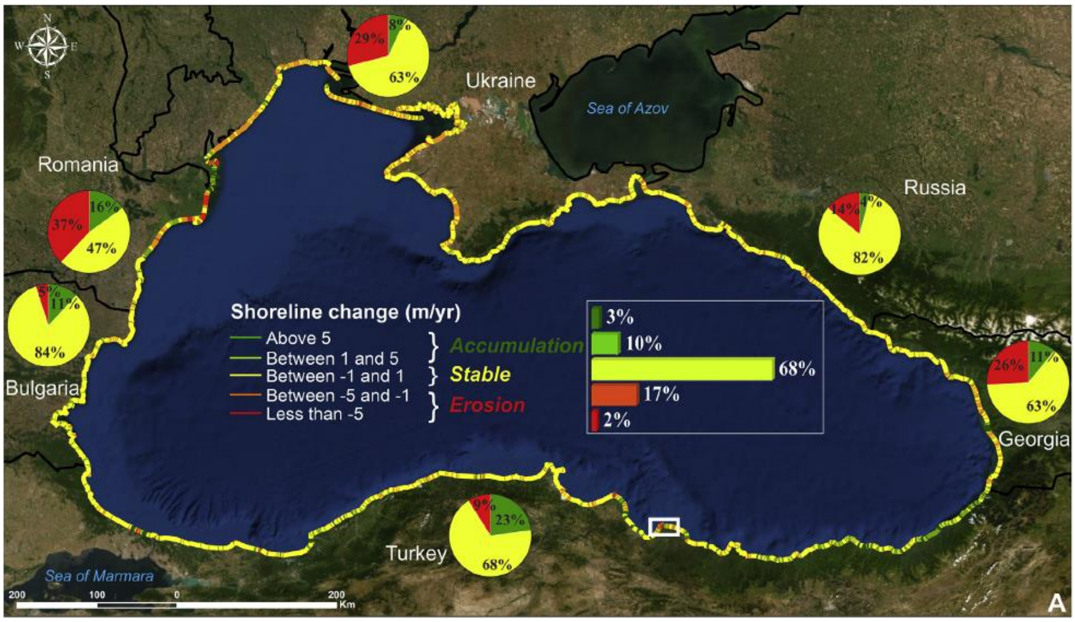


Figure no. 3-53 The relative ranking distribution and frequency of the shoreline change variable for the Black Sea coasts (Source: Tătui et al., 2019)

Future exposure

The key factor contributing to uncertainty is in the forecast of coastal erosion, presenting challenges on a continental scale. This complexity is underscored by limitations arising from insufficient data, predictive tools, and the accessibility of computational resources (Paprotny et al., 2021).

3.16.2.2 *Introduction and spread of IAS*

In recent times, the Black Sea has experienced a notable influx of non-indigenous plants and animals. The primary vectors for the introduction of these species into the Black Sea include: a) shipping activities, being the most prevalent vector; b) intentional or unintentional introduction by humans; and c) Mediterranization, a process where species from the Mediterranean overcome ecological barriers in the Turkish Straits and enter the Black Sea (Öztürk, 2021).

Leppäkoski and Mihnea (1996) apud. Öztürk (2021) observed that the Black Sea, characterized by low salinity, diminished species diversity, and coastal ecosystems heavily affected by eutrophication, along with elevated shipping activity, has created contributive conditions to the establishment of non-indigenous species with considerable ecological adaptability.

Hundreds of algal and animal species, including microorganisms and smaller organisms, often travel by being attached on ships' hulls. These organisms, such as algae, clams, barnacles, as well as more active non-sessile forms like amphipods, shrimps, crabs, and fish, can attach themselves to ships' surfaces and survive during transit. Ballast water, used to stabilize ships when not carrying cargo, is a common vector for the transfer of suspended matter and various planktonic organisms. These organisms, along with their spores and eggs, may survive the journey in ballast water or sediment. Upon reaching the ship's destination, the ballast water is discharged into the sea, introducing these organisms into a new environment. If conditions are favorable, these introduced species may thrive and become naturalized. The substantial number of ocean-going ships continually introduces new species into diverse environments. For instance, in the Romanian part of the Black Sea, approximately 60% of non-indigenous species were introduced via ballast water, while only about 6% were intentionally introduced for economic purposes. The geographic origin analysis of marine non-indigenous species in Romanian waters reveals that 43% are cosmopolitan planktonic species, 12% have an Atlantic-Mediterranean origin, 27% are North Atlantic species, and 18% have an Indo-Pacific origin. In total, 102 non-indigenous aquatic species, including 44 freshwater and 58 marine species, have been reported in the Romanian waters of the Black Sea (Skolka and Preda, 2010; Anastasiu et al., 2016 apud. Öztürk, 2021).

Several non-indigenous species have been intentionally introduced into the Black Sea, primarily for aquaculture or other specific purposes. An illustrative example is the mosquitofish, *Gambusia affinis*, introduced to combat malaria by feeding on neuston larvae and mosquito eggs. Originally introduced in the wetlands surrounding the entire Black Sea basin, the mosquitofish has demonstrated rapid adaptation, transforming into a euryhaline species. As a result, it is now widely distributed in the Black Sea basin, thriving in a broad salinity range from 0 to 17 per mille (Kosarev, ed., 2007 apud. Öztürk, 2021).

Boltachev and Karpova (2013, 2014) apud. Öztürk (2021) noted a change in 2013, marking the first occurrence of the dogtooth grouper (*Epinephelus caninus*) along the southwestern Crimean Peninsula. This occurrence is attributed to the impacts of Mediterranization on the Black Sea, as the dogtooth grouper, a subtropical species widely distributed in the eastern Atlantic Ocean and the Mediterranean Sea, had never been recorded in the Black Sea before. The finding aligns with the observed trends in increasing temperatures in the region generated by climate change.

In recent decades, numerous non-indigenous invasive species, such as the sea snail *Rapana venosa*, bivalve species *Mya arenaria* and *Anadara inaequivalvis*, and carnivorous comb jelly species *Mnemiopsis leidyi* and *Beroe ovata*, have proliferated, forming large populations in the Black Sea. These invasions have resulted in significant ecosystem transformations, with notable impacts on both pelagic and benthic food webs in the region (Öztürk, 2021).

4 IMPACTS ON THE BLACK SEA ECOSYSTEM

4.1 BIODIVERSITY IN THE AREA OF THE BLACK SEA

4.1.1 Protected areas

The following categories of Natural Protected Areas can be found in the Black Sea area:

1. Natural protected areas of national interest:
   - Scientific reserves, natural monuments, nature reserves – protected natural areas whose elements are protected and the conservation of natural terrestrial and/or aquatic habitats, including scientific interest from a floristic, faunal, geological, speleological, paleontological, pedological or other nature.
   - National Parks – protected natural areas whose purposes are the protection and conservation of representative samples for the national biogeographic space, including natural elements of particular value in terms of physical-geographical, floristic, faunal, hydrological, geological, paleontological, speleological, pedological or other nature, offering the possibility of visiting for scientific, educational, recreational and touristic purposes.
   - Natural parks – natural protected areas whose purposes are the protection and conservation of landscape ensembles where the interaction of human activities with nature over time has created a distinct area with significant landscape and/or cultural value, often with great biological diversity.
2. Natural protected areas of international interest:
   - Natural sites of the world natural and cultural heritage - Paris Convention - protected natural areas whose purposes are the protection and conservation of natural habitat areas within which there are natural elements whose value is recognized as being of universal importance.
   - Geopark – territory that includes elements of special geological interest, along with elements of ecological, archaeological, historical and cultural interest.
   - Wetlands of international importance - Ramsar Convention - protected natural areas whose purpose is to ensure the protection and conservation of natural sites with biological diversity specific to wetlands.
   - Biosphere Reserves - MAB/UNESCO Committee - natural protected areas whose goals are the protection and conservation of natural habitat areas and specific biological diversity.
3. Natural protected areas of community interest – Natura 2000 sites:
   - Special Areas of Conservation - SAC - Site designated according to the Habitats Directive. Special area of conservation means a site of Community importance designated by the Member States through a statutory, administrative and/or contractual act where the necessary conservation measures are applied for the maintenance or restoration, at a favourable conservation status, of the natural habitats and/or the populations of the species for which the site is designated.

- Sites of Community Importance - SCI - natural areas that, in the region or in the biogeographical regions where they exist, have a significant contribution to maintaining or restoring the favourable conservation status of natural habitats or species of Community interest, and which can significantly contribute to the coherence of the "Natura 2000" network and/or contributes significantly to the maintenance of biological diversity in the respective biogeographic region or regions.
- Special Protection Areas - SPA - protected natural areas whose purposes are the conservation, maintenance, and where appropriate bringing bird species and specific habitats to a state of favourable conservation.

4. Areas of special conservation interest – Emerald sites:

- Areas of special conservation interest – ASCI – natural areas whose purposes are the conservation and protection of habitats and species defined in the Bern convention.

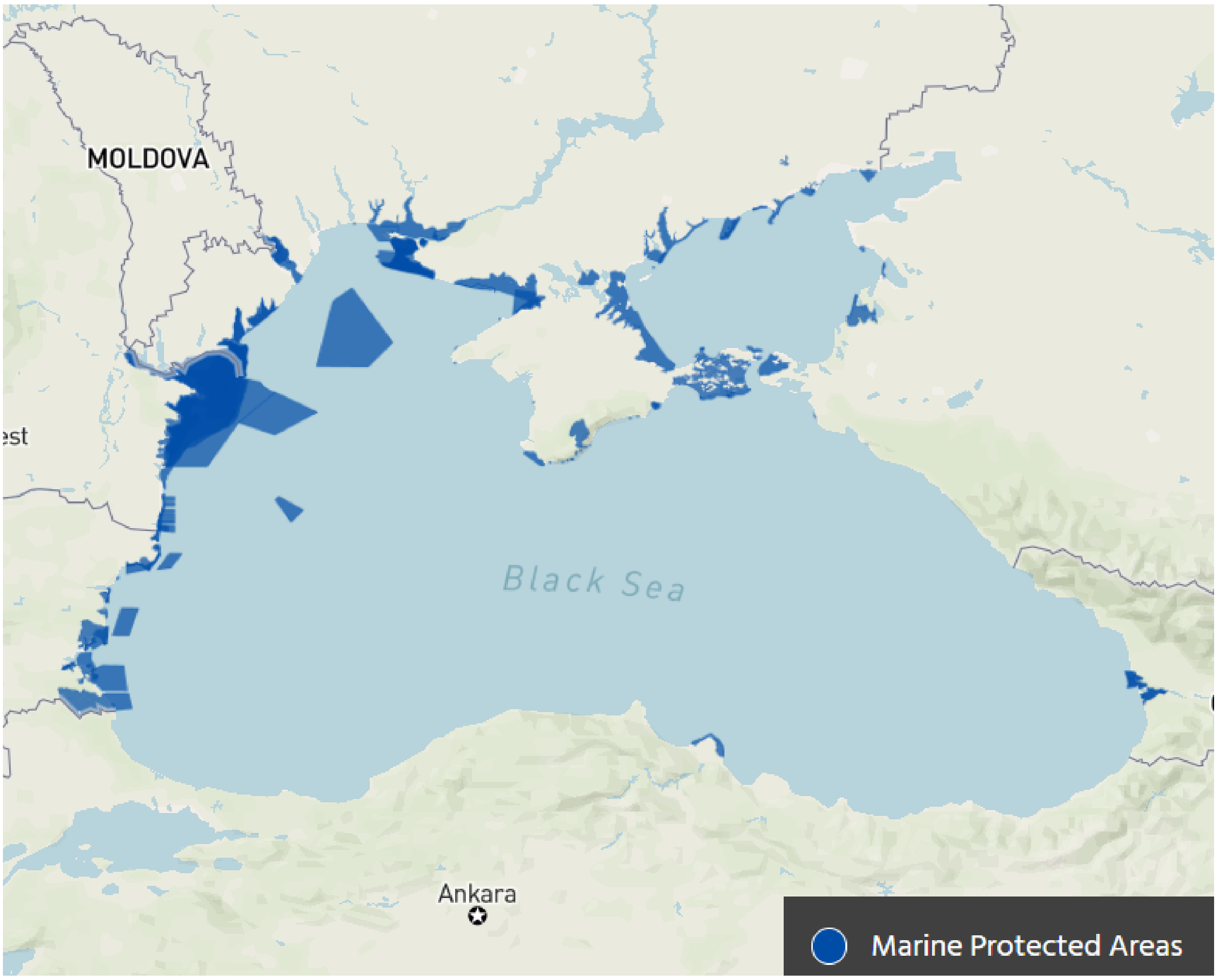


Figure 4-1 Distribution of marine protected areas in the Black Sea (Source: Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM), 2023)

The Natura 2000 sites that can be found in the Black Sea marine area are presented in the table below.

Table no. 4-1 Natura 2000 sites in the Black Sea marine area

Member State	Site code	Site name	Directive	Area SDF (ha)
Romania	ROSCI0066	Delta Dunării - zona marină	Habitats	336200.20
Romania	ROSCI0094	Izvoarele sulfuroase submarine de la Mangalia	Habitats	5784.90
Romania	ROSCI0197	Plaja submersă Eforie Nord - Eforie Sud	Habitats	5716.70
Romania	ROSCI0269	Vama Veche - 2 Mai	Habitats	12311.00
Romania	ROSCI0273	Zona marină de la Capul Tuzla	Habitats	4946.80
Romania	ROSCI0281	Cap Aurora	Habitats	13592.20
Romania	ROSCI0293	Costinesti - 23 August	Habitats	4883.60
Romania	ROSCI0311	Canionul Viteaz	Habitats	35376.70
Romania	ROSCI0413	Lobul sudic al Câmpului de Phyllophora al lui Zernov	Habitats	186815.30
Romania	ROSPA0076	Marea Neagră	Birds	149143.90
Bulgaria	BG0000100	Plazh Shkorpilovtsi	Habitats	6457.00
Bulgaria	BG0000103	Galata	Habitats	3853.57
Bulgaria	BG0000116	Kamchia	Habitats	12919.94
Bulgaria	BG0000146	Plazh Gradina - Zlatna ribka	Habitats	1245.85
Bulgaria	BG0000152	Pomoriysko ezero	Birds	921.53
Bulgaria	BG0000154	Ezero Durankulak	Habitats	5050.79
Bulgaria	BG0000156	Shablenski ezeren kompleks	Birds	3174.93
Bulgaria	BG0000242	Zaliv Chengene skele	Birds and Habitats	190.02
Bulgaria	BG0000271	Mandra - Poda	Birds and Habitats	6139.17
Bulgaria	BG0000573	Kompleks Kaliakra	Habitats	48336.28
Bulgaria	BG0000574	Aheloy - Ravda - Nesebar	Habitats	3926.78
Bulgaria	BG0000620	Pomorie	Habitats	2085.15
Bulgaria	BG0000621	Ezero Shabla - Ezerets	Habitats	2623.59
Bulgaria	BG0001001	Ropotamo	Habitats	98204.78
Bulgaria	BG0001004	Emine - Irakli	Habitats	16794.59
Bulgaria	BG0001007	Strandzha	Habitats	153529.61
Bulgaria	BG0001500	Aladzha banka	Habitats	669.64
Bulgaria	BG0001501	Emona	Habitats	55345.28
Bulgaria	BG0001502	Otmanli	Habitats	8.83
Bulgaria	BG0002041	Kompleks Ropotamo	Birds	3857.75
Bulgaria	BG0002043	Emine	Birds	66750.52
Bulgaria	BG0002044	Kamchiyska planina	Birds	88897.23
Bulgaria	BG0002045	Kompleks Kamchia	Birds	10300.56
Bulgaria	BG0002050	Durankulashko ezero	Birds	3355.98
Bulgaria	BG0002051	Kaliakra	Birds	16171.78
Bulgaria	BG0002060	Galata	Birds	8043.61
Bulgaria	BG0002077	Bakarlaka	Birds	33507.89
Bulgaria	BG0002082	Batova	Birds	38149.52
Bulgaria	BG0002097	Belite skali	Birds	4163.06

The total surface of Natura 2000 sites in the Black Sea is of 9188 km^2 and are found in Bulgaria and Romania. Romania has 16% of its marine total surface covered by Natura 2000 protected sites, while Bulgaria has almost 8% of its marine total surface protected within Natura 2000 network.

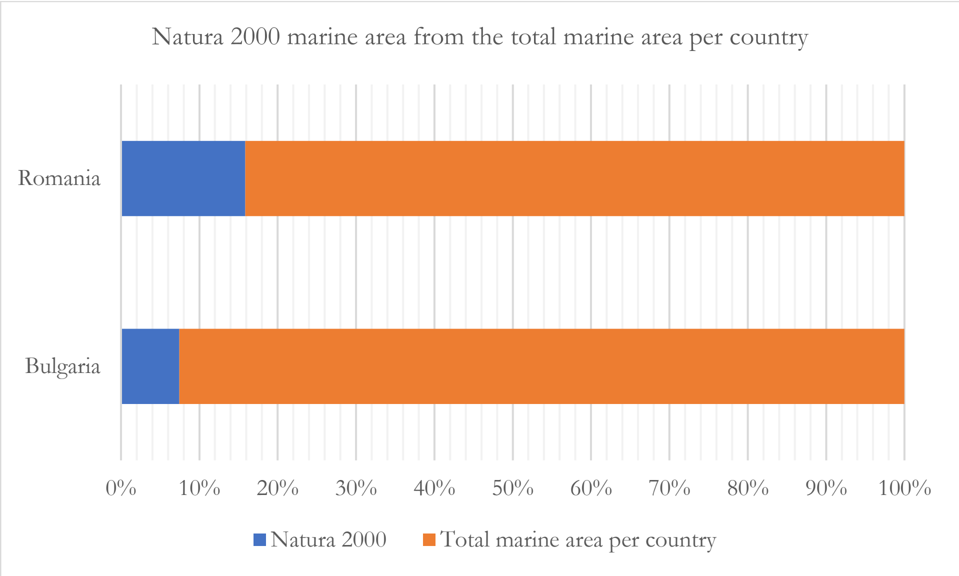


Figure no. 4-1 Natura 2000 marine area from the total marine area in the Black Sea countries (Source: Natura 2000 Barometer)

In regards to the Emerald coastal and marine sites in the Black Sea countries, as it can be seen in the table below, most of the adopted sites are found in Ukraine. In Russia, only candidate sites can be found, while in Georgia there are only few adopted. Türkiye does not have any information available on the Emerald sites.

Table no. 4-2 Marine and coastal Emerald sites in the Black Sea countries (Source: Emerald Network - General Viewer)

Country	Site code	Site Name	Status
Ukraine	UA0000018	Danube Biosphere Reserve	Adopted
Ukraine	UA0000151	Sasyk Lyman	Adopted
Ukraine	UA0000140	Tuzlovski Lymany National Nature Park	Adopted
Ukraine	UA0000141	Dnistrovskyi Lyman	Adopted
Ukraine	UA0000138	Tyligulskyi Lyman	Adopted
Ukraine	UA0000577	Khadzhider-Alkalia	Proposed
Ukraine	UA0000097	Biloberezhzhia Sviatoslava National Nature Park	Adopted
Ukraine	UA0000207	Berezanskyi	Adopted
Ukraine	UA0000017	Black Sea Biosphere Reserve	Adopted
Ukraine	UA0000206	Tuzly	Adopted
Ukraine	UA0000139	Zernov Phyllophora Field Zakaznyk	Adopted
Ukraine	UA0000108	Dzharylhatskyi National Nature Park	Adopted
Ukraine	UA0000214	Zatoky	Adopted
Ukraine	UA0000005	Crimean Nature Reserve	Adopted
Ukraine	UA0000398	The Karkinit Gulf and the Bakal Spit	Proposed
Ukraine	UA0000388	Marine area along the Tarkhankut Peninsula and Karadzha Lake	Proposed
Ukraine	UA0000130	Charivna Havan National Nature Park	Adopted
Ukraine	UA0000376	Tarkhankut	Adopted
Ukraine	UA0000379	Donuzlavskyi	Proposed

Country	Site code	Site Name	Status
Ukraine	UA0000390	Dzharylhach, Jarylhach and Pans'ke lakes	Proposed
Ukraine	UA0000378	Sakskyi	Proposed
Ukraine	UA0000380	Kyzyl-Yar	Proposed
Ukraine	UA0000431	Eski-Qislav and Buranchi-Echi	Proposed
Ukraine	UA0000462	Herakleyskyi	Proposed
Ukraine	UA0000392	Laspi and Sarych	Proposed
Ukraine	UA0000148	Black Sea Dolphins	Adopted
Ukraine	UA0000132	Baidarskyi Ta Mys Aia	Adopted
Ukraine	UA0000021	Yaltynskyi Hirsko-Lisovyi Nature Reserve	Adopted
Ukraine	UA0000397	Mount Kosh-Kaya, Swan Wing and Diva rocks	Proposed
Ukraine	UA0000391	Ai-Todor cape	Proposed
Ukraine	UA0000007	Mys Martian Nature Reserve	Adopted
Ukraine	UA0000200	Aiu-Dah	Adopted
Ukraine	UA0000395	Plaka cape	Proposed
Ukraine	UA0000604	Kuchuk-Lambatskyi stone chaos	Proposed
Ukraine	UA0000399	Soniachnohirs'ke and Malorichyns'ke	Proposed
Ukraine	UA0000603	Kanaka	Proposed
Ukraine	UA0000128	Bilogirskyi	Adopted
Ukraine	UA0000204	Mehanom	Adopted
Ukraine	UA0000008	Karadazkyi Nature Reserve	Adopted
Ukraine	UA0000155	Tepe-Oba	Adopted
Ukraine	UA0000377	Kerch peninsula	Adopted
Ukraine	UA0000022	Kazantypskyi Nature Reserve	Adopted
Ukraine	UA0000129	Karalarskyi	Adopted
Ukraine	UA0000131	Eastern Syvash	Adopted
Ukraine	UA0000201	Ak-Monaiskyi Steppe	Adopted
Ukraine	UA0000027	Azovo-Syvaskyi National Nature Park	Adopted
Ukraine	UA0000460	Western Azov	Proposed
Ukraine	UA0000150	Obytichna Kosa Ta Zatoka	Proposed
Ukraine	UA0000092	Pryazovskyi National Nature Park	Adopted
Ukraine	UA0000435	Preslavska luka	Proposed
Ukraine	UA0000065	Meotyda	Adopted
Ukraine	UA0000381	Kerch strait	Proposed
Russia	RU6100693	Bezlitskaya Kosa	Candidate
Russia	RU6101157	Delta Dona	Candidate
Russia	RU2301159	Ustie Ei	Candidate
Russia	RU2300559	Ozero Khanskoe	Candidate
Russia	RU2300083	Del'ta Kubani	Candidate
Russia	RU2301249	Tamano-Zaporozhskiy	Candidate
Russia	RU2300560	Karabetova Gora	Candidate
Russia	RU2300561	Solionoe ozero	Candidate
Russia	RU2300360	Tsokur-Kiziltash	Candidate
Russia	RU2300102	Poluostrov Abrau	Candidate
Russia	RU2300744	Markotkh	Candidate
Russia	RU2300052	Sochinskiy	Candidate

Country	Site code	Site Name	Status
Georgia	GE0000025	Bichvinta-Miusera	Adopted
Georgia	GE0000006	Kolkheti	Adopted
Georgia	GE0000060	Kobuleti	Adopted
Georgia	GE0000054	Chorokhi Delta	Adopted

According to the Ramsar Sites Information Service, the highest percent of marine or coastal Ramsar sites from the total surface of each Black Sea country can be found in Romania, with more than 2% of its surface, followed by Ukraine with 0.86%, while the other countries have percentages lower than 0.10% of their total surface.

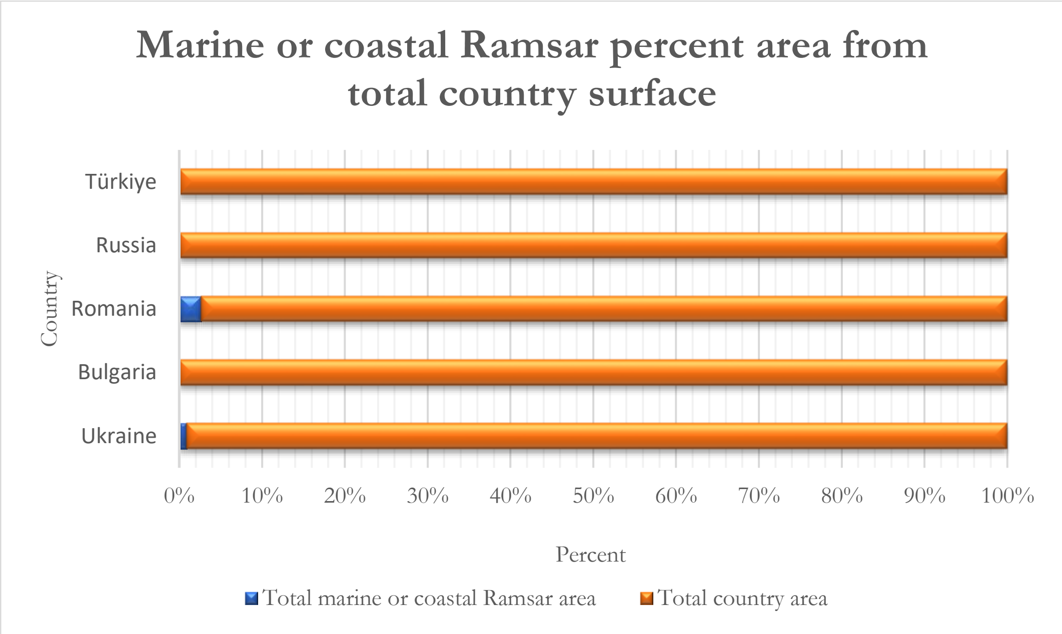


Figure no. 4-2 Marine or coastal Ramsar sites share of the total surface of each Black Sea country (Source: Ramsar Sites Information Service)

According to Marine Mammal Protected Areas Task Force (2020), Important Marine Mammal Areas (IMMAs) are defined as discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation. IMMAs consist of areas that may merit place-based protection and/or monitoring. 'Important' in the context of the IMMA classification refers to any perceivable value, which extends to the marine mammals within the IMMA, to improve the conservation status of those species or populations. The covered areas can be observed in Figure no. 4-3.

The establishment of a network of Important Marine Mammal Areas (IMMAs) is a cost-effective conservation approach, driven by several considerations. These include: the specific vulnerability of many marine mammals, their neglect in national efforts to create Marine Protected Areas (MPAs), their role as indicators facilitating MPA identification and spatial protection measures, their function as umbrella species ensuring proper conservation plans beneficial for the entire ecosystem, and their role as flagship species representing political and public support for the conservation of less popular organisms, communities, or habitats (Important Marine Mammal Areas - IMMAs - Marine Mammal Protected Areas Task Force, 2020).

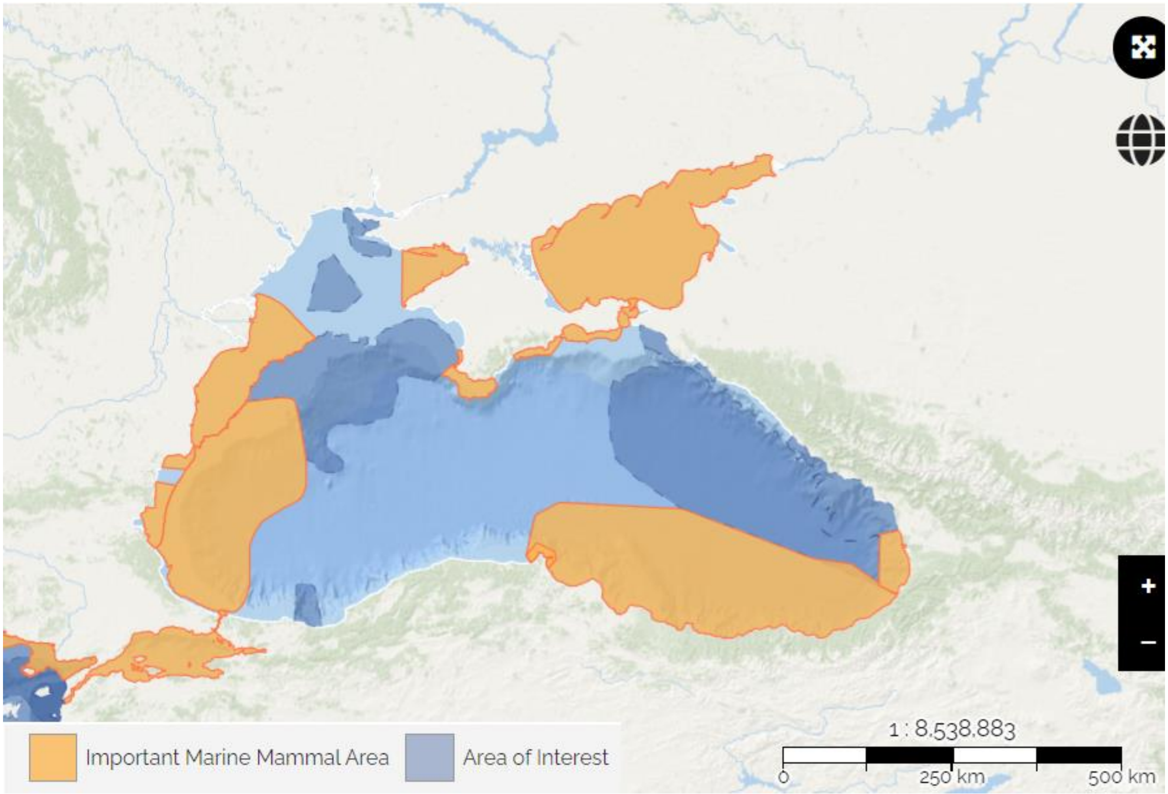


Figure no. 4-3 Important Marine Mammal Areas (IMMAs) in the Black Sea area (Source: IMMA e-Atlas - Marine Mammal Protected Areas Task Force, 2024)

4.1.2 Key species

According to Ohara (2020), 5680 species have been recorded in the Black Sea, mostly plant species, comprising phytobenthos and plankton (Figure no. 4-4).

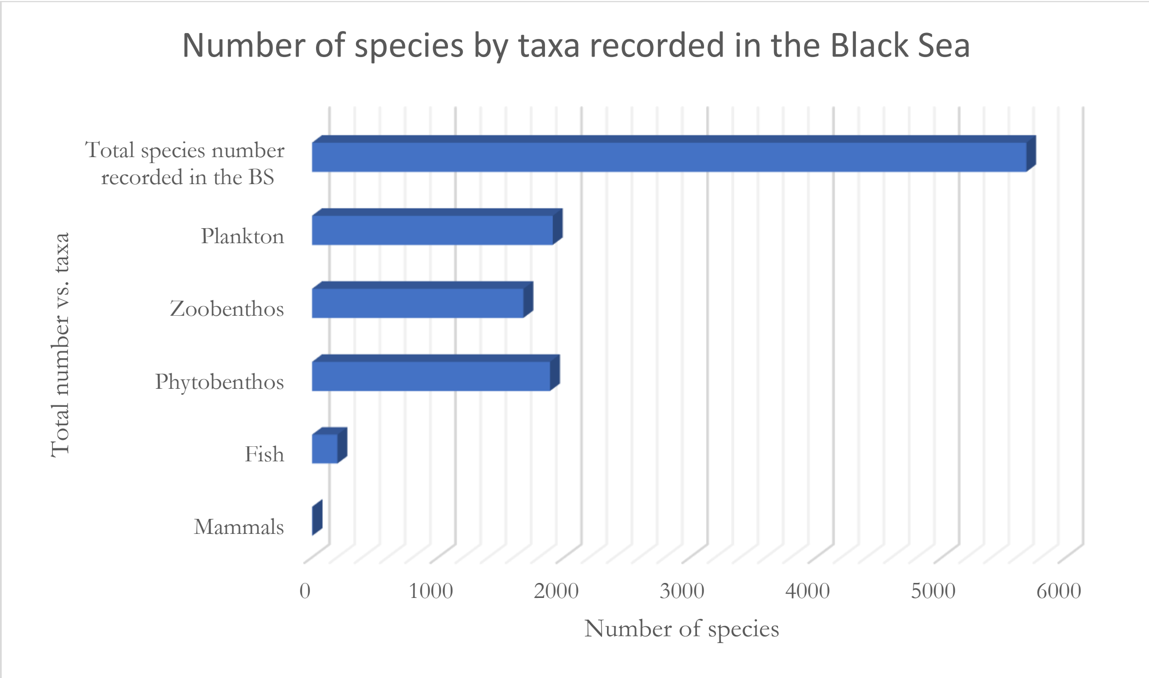


Figure no. 4-4 Number of species recorded in the Black Sea (Ohara, 2020)

4.1.2.1 *Mammals*

The mammal species of interest from the Black Sea include three species of cetaceans (bottlenose dolphins - *Tursiops truncatus ponticus*, common dolphins – *Delphinus delphis ponticus* and harbour porpoises – *Phocoena phocoena*) and a seal species – *Monachus monachus*, which is believed to be extinct in most of the regions of the Black Sea, except the Sea of Marmara (Fisheries, 2017; *SECRETS OF THE BLACK SEA – EMBLAS Project*, 2020).

Tursiops truncatus ponticus **(Black Sea bottlenose dolphin)**

The species is found in the Black Sea, Azov Sea and Turkish Straits System. Population size was estimated to be around 26,000 in 2014 and approximately 18,000 (excluding Russian waters) or 42,000 (including Russian waters) confirming that bottlenose dolphins are, in fact, the scarcest cetaceans in the Black Sea. Bottlenose dolphins in the Black Sea are frequently observed in both coastal and shelf waters, as well as in the deep offshore areas of the region. In the Danube Delta and the estuaries of the Dniester, Southern Buh, Dnieper, and Lake Donuzlav, bottlenose dolphins are commonly sighted. Their presence is less frequently noted in the Azov Sea. The main diet of the species consists of fish, with a preference for both benthic and pelagic species of various sizes, including: whiting (*Merlangius merlangus*), picarel (*Spicara flexuosa*) and horse mackerel (*Trachurus* spp.) as the dominant prey species. Presently, one of the primary pressures facing bottlenose dolphins is accidental mortality resulting from fishing gear, particularly in bottom-set nets (Notarbartolo Di Sciara & Tonay, 2021).

Bottlenose dolphins in the Black Sea are believed to exhibit fidelity to certain regions, forming local populations. They are also known to coexist with offshore populations, particularly during the summer when there is a high concentration of dolphins in pelagic waters. Typically, during autumn, winter, and spring, these dolphins gather in a relatively small area off southern Crimea between Cape Sarych and Cape Khersones. Hundreds of animals migrate to this area every autumn from the eastern and possibly other parts of the Black Sea (ANEMONE Deliverable 4.3, Paiu, et al., 2021).

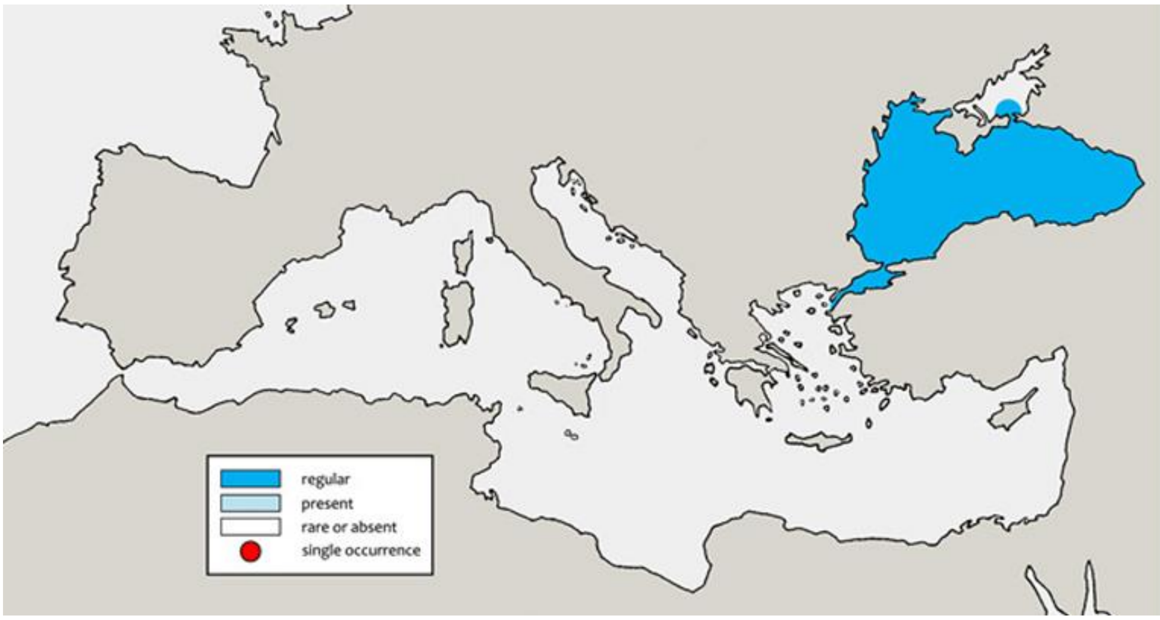


Figure no. 4-5 Distribution based on sightings of *Tursiops truncatus ponticus* (Source: Notarbartolo Di Sciara & Tonay, 2021)

Table no. 4-3 Short species description (Source: Accobams, 2018)

<table>
<tr><td rowspan="3">Tursiops truncatus ponticus</td><td>IUCN Status (EU)</td><td>EN</td></tr>
<tr><td>Habitat</td><td>While they are primarily associated with coastal environments, including lagoons, semi-enclosed bays, and estuaries, these species are also commonly encountered in deeper waters.</td></tr>
<tr><td>Colour</td><td>Dark grey back, at times bluish or brownish grey, with lighter sides, the belly white, light grey or pinkish. Body size and colouration in bottlenose dolphins vary greatly amongst different populations.</td></tr>
<tr><td rowspan="2">Adult male</td><td>Length</td><td>2.5-3.5 m</td></tr>
<tr><td>Weight</td><td>200-300 kg</td></tr>
<tr><td rowspan="2">Adult female</td><td>Length</td><td>2.2-3.2 m</td></tr>
<tr><td>Weight</td><td>approx. 10% less than males</td></tr>
<tr><td rowspan="2">Newborn</td><td>Length</td><td>1-1.2 m</td></tr>
<tr><td>Weight</td><td>15-20 kg</td></tr>
</table>

Delphinus delphis ponticus (Black Sea common dolphin)

The common dolphin in the Black Sea is exclusively located within the Black Sea and the Turkish Straits System. Common dolphins in the Black Sea favour depths ranging from a minimum of 50 meters to the basin's deepest points, with temperatures ranging between 5°C and 18°C. The total population of Black Sea common dolphins remained unknown until the summer of 2019 when basin-wide aerial line-transect surveys, covering 62% of the Black Sea, were carried out. The findings indicate that the present population size is estimated to be around 118,000, compared to previous estimates done in 2014 of around 60,000. Common dolphins in the Black Sea primarily inhabit offshore areas. They venture into shallow coastal waters during seasonal aggregations and regular migrations of their preferred prey, which include small pelagic fishes such as Black Sea anchovy (*Engraulis encrasicolus ponticus*), Black Sea sprat (*Sprattus sprattus phalericus*), sand smelt (*Atherina* sp.), and horse mackerel (*Trachurus* spp.). Currently, bycatch represents the main pressure of the species, followed by several threats: the changes in the climatic regime; changes in the trophic structure in ecosystem due to eutrophication, and malfunctioning of food web; deterioration of prey-predator relations due to overfishing; and introduction of invasive alien species (Notarbartolo Di Sciara & Tonay, 2021).

The ongoing war in Ukraine represents another major pressure for the species. However, there is still only few evidence in the literature and it needs to be substantiated by research.

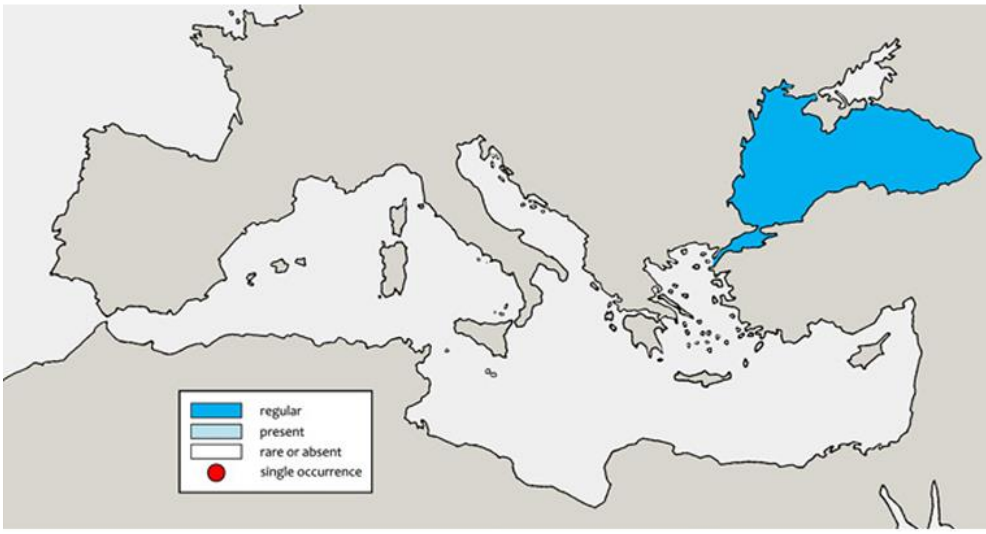


Figure no. 4-6 Distribution based on sightings of *Delphinus delphis ponticus* (Source: Notarbartolo Di Sciara & Tonay, 2021)

Table no. 4-4 Short species description (Source: Accobams, 2018b)

Delphinus delphis	IUCN Status (EU)	VU
	Habitat	Mainly offshore and visit shallow coastal waters following seasonal aggregations and regular migrations of their prey.
	Colour	Characteristic: a coloured hourglass pattern on the side, with black, grey, white and yellow colours. Colours and patterns vary considerably from one individual to another.
Adult male	Length	2.0-2.6 m
	Weight	60-130 kg
Adult female	Length	2.4 m
	Weight	60-130 kg
Newborn	Length	80-90 cm
	Weight	about 10 kg

Phocoena phocoena **ssp.** ***Relicta*** **(Black Sea harbour porpoise)**

The Black Sea Harbour Porpoise is endemic in the Black Sea and neighbouring waters. They inhabit mainly shallow waters over the continental shelf around the entire perimeter of the Black Sea. However, sometimes they also occur far offshore in deep waters. Harbour porpoises in the Black Sea are found in areas characterized by low salinity and high turbidity. In the warmer seasons, they may venture into brackish bays, lagoons, estuaries, and rivers, including those such as the Danube, Dnieper, Don, and Kuban. The total population of Black Sea harbour porpoises remained unknown until the summer of 2019, when basin-wide aerial line-transect surveys, covering 62% of the entire Black Sea, were carried out. The results indicate that the current population size is approximately 94,000 (Notarbartolo Di Sciara & Tonay, 2021).

In a prior study conducted in July 2013, a dedicated line-transect cetacean survey covered both inshore and offshore waters of the western Black Sea. This survey, which combined shipboard and aerial line transect methods, aimed to document the distribution and abundance of cetaceans in the waters under the jurisdiction of Bulgaria, Romania, and the waters of Ukraine to the west of the Crimean Peninsula. The estimated population size of harbour porpoises in the surveyed area at that time was around 29,000. The main pressures of the species are represented by accidental captures and overexploitation of marine resources (Notarbartolo Di Sciara & Tonay, 2021).

The species undergoes seasonal migration from the Black Sea to the Azov Sea through the Kerch Strait in the warm season, as documented by Kleinenberg (1956) apud. Notarbartolo Di Sciara & Tonay (2021). They leave the Azov Sea and the northwestern Black Sea before winter. The main wintering areas are located in the southeastern Black Sea, encompassing the southern Georgian territorial waters and the eastern Turkish territorial waters (Birkun, 2008 apud. Notarbartolo Di Sciara & Tonay, 2021).

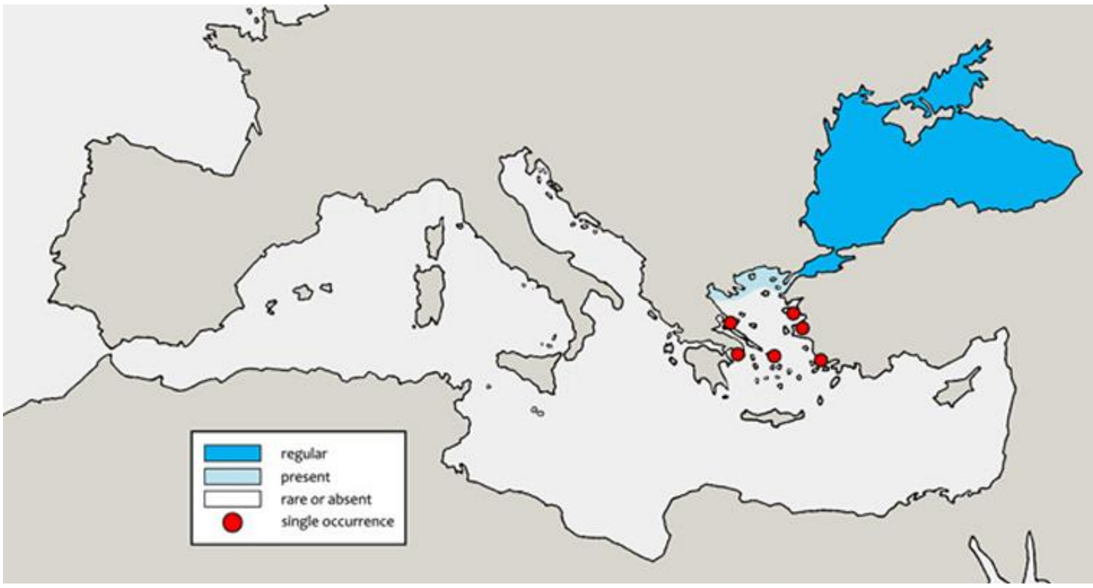


Figure no. 4-7 Distribution based on sightings of *Phocoena phocoena* ssp. *Relicta* (Source: Notarbartolo Di Sciara & Tonay, 2021)

Table no. 4-5 Short species description (Source: Accobams, 2018b; Notarbartolo Di Sciara & Tonay, 2021)

Phocoena phocoena	IUCN Status (EU)	VU
	Habitat	They are usually found in the waters of the continental shelf, although sometimes they move into deeper offshore waters. Black Sea harbour

		porpoises are distributed mostly over the continental shelf (at depths <200 m) and have a preference for lower sea surface temperatures (<18°C).
	Colour	Colouration: little contrast; the dorsal side is brownish-black, very dark grey (northern populations) or grey (Atlantic African coasts) and the flanks and belly are light-coloured with a spotted area in between.
Adult male	Length	1.4-2.4 m
	Weight	55-65 kg, max. 90 kg
Adult female	Length	1.5-2.8 m
	Weight	55-65 kg, max. 90 kg
Newborn	Length	70-80 cm
	Weight	4-5 kg

***Monachus monachus* (Mediterranean monk seal)**

The Mediterranean monk seal is one of the most endangered marine mammals, with approximately 350-450 individuals currently surviving. Mediterranean monk seals mostly seek refuge in inaccessible caves, often along remote, cliff-bound coasts. Such caves may have underwater entrances, not visible from the water line. Known to inhabit open sandy beaches and shoreline rocks in ancient times, the occupation of such marginal habitat is believed to be a relatively recent adaptation in response to human pressures – hunting, pest eradication by fishermen, coastal urbanisation, and tourism. The species was reduced to only two populations: one in the northeastern Mediterranean and the other in the northeast Atlantic (*Mediterranean Monk Seal Fact Files: Overview*, 2017).

The species is either extinct or possibly extinct across most of its historical range in the Mediterranean Basin. In some countries, only a few individuals are reported to survive, while in others, the status is uncertain. The classification varies, with the species considered vanishing or extinct in countries where no seal sightings have been documented. In cases where occasional seal sightings occur, but no births are recorded or the actual habitat use is not well-known, seals are labeled as 'vagrants' (Bundone et al., 2019). However, according to Inanmaz et al. (2014), two seals were sighted at four different occasions during the field surveys in the Marmara Sea. The individuals were a female adult and a juvenile not older than a year.

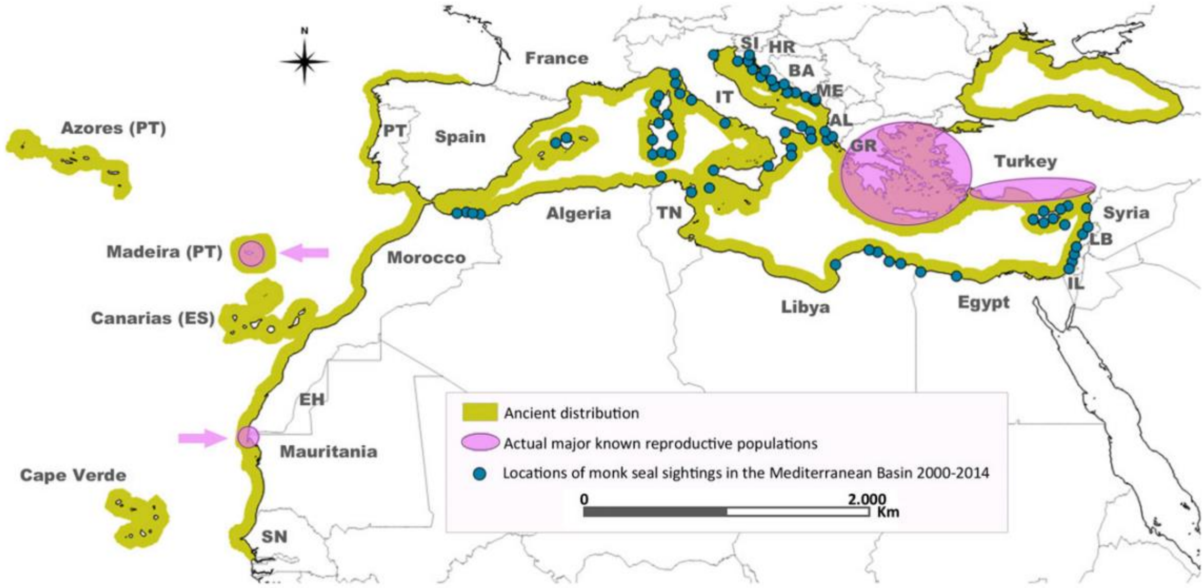


Figure no. 4-8 Ancient distribution of the Mediterranean monk seal, actual major known reproductive populations, and locations of monk seal sightings in the Mediterranean Basin excluding Greece and Turkey in 2000–2014 (the spots do not reflect numbers of sightings) (Source: Bundone et al., 2019)

Table no. 4-6 Short species description (Source: *Mediterranean Monk Seal Fact Files: Overview*, 2017)

***Monachus monachus* (Mediterranean monk seal)**	IUCN Status (EU)	VU
	Habitat	Sea caves along remote cliff-bound coasts for resting and giving birth; originally congregated on open beaches and shoreline rocks. Feeds in coastal waters.
Adult male	Length	2.4 meters (nose to tail)
	Weight	250-300 kg (estimate only)
	Colour	Predominantly black with a white belly patch, but several variations exist.
Adult female	Length	Slightly smaller than male (2.4 m).
	Weight	250-300 kg (estimate only)
	Colour	Predominantly greyish, with several variations.
Pup	Length	94 cm (nose to tail)
	Weight	15-20 kg
	Colour	Soft woolly hair, black to chocolate, with distinctive white belly patch.

4.1.2.2 *Fish*

According to Yankova et. Al. (2010), there are 185 native fish species in the Black Sea. Of these, 17 species so far have a „threatened” IUCN status. In what follows, we will present the description of the 9 Critically Endangered ones.

Table no. 4-7 Short species description (Source: Angel Shark *Squatina squatina* — Shark Research Institute; IUCN, 2019)

***Squatina squatina* (Angelshark)**	IUCN Status	CR
	Colour	Grey to reddish or greenish-brown on the back with scattered small white spots and blackish dots and spots. A white nuchal spot may be present, and no ocelli. Its young often have white reticulations and large dark blotches, while the adults are plainer.
	Size	The shark is born at a length of 24 to 30 cm. Females mature at 126 to 167 cm and males reach a maximum length of 183 to 224 cm.
	Habitat	The shark prefers mud and sand bottoms inshore 5 m on coasts and estuaries up to over 150 m on the continental shelf.
	Distribution	Northeast Atlantic: historically from Norway to Mauritania, Canary Islands, Mediterranean and Black Sea. They have now vanished from some of these areas, but can still be found in the Marmara Sea.  **Figure no. 4-9 Distribution of *Squatina squatina* (Source: IUCN, 2019).**
	Biology	Feeds mainly on flatfishes, skates, crustaceans, and mollusks. Reproduction – 7-25 pups per litter, increasing with female size. Their gestation is 8-10 months.
	Pressures	They are a very vulnerable target and bycatch species in bottom trawl, line gear and fixed bottom nets.
	Population	Decreasing. Information gathered from scientific trawl surveys in the Mediterranean, supports the fact that catch data series from 1985 reveal a remarkably low density of Angelshark in the northern Mediterranean, with only two individuals captured in 6,336 hauls between 1994 and 1999. Sightings of Angelsharks in Turkish waters have risen since the mid-1990s and continued into the 2010s. However, the numbers are still quite limited, and the perceived increase may be a result of heightened awareness and reporting of Angelshark catches.

Table no. 4-8 Short species description (Source: IUCN, 2010; FishBase; U.S. Fish and Wildlife Service, 2020)

***Acipenser gueldenstaedtii* (Russian Sturgeon)**	IUCN Status	CR
	Colour	Color of back olivaceous grey, flanks lighter, and belly white.
	Size	This fish can grow up to about 235 cm and weigh about 115 kg.
	Habitat	Marine habitat for this species includes shallow coastal and estuarine zones. In freshwater, it occurs in deep parts of large rivers with moderate to swift current.

	Distribution	Black Sea, Sea of Azov and Caspian Sea basins. The species is gone from the Southern Bug, Dniester, Kızılırmak, and Sakarya Rivers. In the Black Sea is very rare and remains in the Dnieper River as it is stocked with farmed fish. The species may still reproduce naturally in the lower Danube, the only suitable spawning sites remaining being downstream of the Iron Gates II Dam. The species may still reproduce in Georgia's Rioni river, but fishing is a great pressure there.
	Biology	Anadromous and freshwater populations (freshwater populations existed in the Danube and Volga – both are now extinct). A complicated pattern of spawning migrations includes spring and autumn runs. Individuals migrating in spring enter freshwater just before spawning; they tend to spawn in lower reaches of rivers (320-650 km in the unregulated Ural). Individuals migrating in autumn overwinter in rivers and spawn the following spring further upstream (900-1200 km in the Ural). The Russian Sturgeon feeds on a wide variety of benthic molluscs, crustaceans and small fish. Males reproduce for the first time at 8–13 years, females at 12–16 years of age. Females reproduce every 4–6 years and males every 2–3 years in April–June, when the temperature rises above 10 °C. Average generation length is 47.6 years; three generations is therefore estimated as approximately 143 years for this species.
	Pressures	Fishing, dams & water management/use, introduction of invasive species, industrial and military activities.
	Population	Decreasing. The Russian Sturgeon is currently highly uncommon in the Danube, with recent occurrences limited to individual specimens. There is no evidence of reproduction in the last decade. Romanian catch data from the Danube reveals a significant decline, with 3,726 kg caught in 2002, 1,499 kg in 2003, 440 kg in 2004, and only 37 kg in 2005, indicating a staggering 99% decrease in just four years. Russian Sturgeon is extremely rare in the Black Sea basin, with natural populations having been reduced by >90% over the last three generations.

Table no. 4-9 Short species description (Source: IUCN, 2010; FishBase)

***Acipenser nudiventris* (Ship Sturgeon)**	IUCN Status	CR
	Colour	Color of back grey, flanks lighter, belly white.
	Size	This fish can grow up to about 211 cm and weigh about 80 kg.
	Habitat	In marine habitats, this species is observed close to shores and estuaries. In freshwater, it inhabits deep stretches of large rivers, while juveniles inhabit shallow riverine habitats.
	Distribution	Black, Azov, Caspian and Aral Sea, ascending some rivers (Volga up to Kazan, Ural up to Chkalov), unknown or very rare in others. Extinct from the Black Sea and Danube.
	Biology	Anadromous (spending at least part of its life in salt water and returning to rivers to breed), with some non-migratory freshwater populations. The species feeds on a wide variety of benthic fishes, molluscs, and crustaceans. Spawning takes place in strong-current habitats in main course of large and deep rivers on stone or gravel bottom from end of April to June. Males reproduce for the first time at 9–15 years, females at 12–16. Across its global distribution, Ship Sturgeon has generation lengths within the range 28–54 years (best estimate 40–41 years); three generations for the species are somewhere between 84 and 162 years (best estimate 120–123 years).

***Acipenser nudiventris* (Ship Sturgeon)**	IUCN Status	CR
	Pressures	Fishing, dams & water management/use, introduction of invasive species, pollution.
	Population	Decreasing. Number of mature individuals: 100. In the Black Sea, the Ship Sturgeon ascended the Rioni River (Georgia), where the last adult individual was recorded in 1997 as a bycatch. In 2020, six juveniles were caught in the Rioni River. In the Danube River, 2 males were last caught in 2003 in Serbia and in 2005 in Hungary. In Romania, between 1996 and 2001, 15 individuals were caught and in the Hungarian Danube another individual was caught in 2009. In Ukraine, the species has not been caught in the past 30 years.

Table no. 4-10 Short species description (Source: IUCN, 2010; FishBase)

***Acipenser persicus* (Persian Sturgeon)**	IUCN Status	CR
	Size	Maximum length: 255 cm; maximum weight: 70 kg.
	Habitat	Inhabits coastal and estuarine zones at the sea. Breeds in strong-current habitats in main course of large and deep rivers on stone or gavel bottom.
	Distribution	Caspian basin, most abundant in the southern part. Also distributed along the eastern Black Sea.
	Biology	Anadromous (spending at least part of its life in salt water and returning to rivers to breed). Juveniles migrate to the sea during their first summer and remain there until maturity. The species feeds on a wide variety of invertebrates, including shrimps, crabs, fish. The sturgeon mainly reproduces in the Volga, Kura, Araks, and Ural rivers. This sexual reproduction occurs in waters that are 20-25 °C.
	Pressures	Fishing, dams & water management/use, waste water, industrial, military and agricultural effluents.
	Population	Decreasing. Number of mature individuals: 200. The species was once widespread in the Caspian Sea and Black Sea basin. However, it is now restricted to the Sefid River, where up to 50 individuals spawn below the first dam annually. Considering the wide historic distribution of this species, it is estimated that the global population has declined by more than 99% during the last 100 years (approximately three generations).

Table no. 4-11 Short species description (Source: IUCN, 2010; FishBase)

***Acipenser stellatus* (Stellate Sturgeon)**	IUCN Status	CR
	Colour	Back dark gray to almost black, flanks lighter, belly white.
	Size	Maximum length: 250 cm; maximum weight: 80 kg.
	Habitat	Found mainly near shore over sand and mud, stays at the bottom during the day and rises to the surface to feed at night.
	Distribution	Inhabits the Caspian, Black and Azov seas and was historically present in the northern Aegean Sea basin (Evros River). The Volga, Ural, Terek, Sulak, Kura, Sefid, Don, Danube, and Kuban Rivers were the major

		spawning rivers. The highest abundance and biomass of natural population remained in the Caspian Sea.
	Biology	This species is anadromous (spending at least part of its life in salt water and returning to rivers to breed). Feeds mainly on fish, also molluscs, crustaceans and worms. Spawns in strong-current habitats in main course of large and deep rivers, on stone or gravel bottom. Spawning also takes place on flooded river banks and if gravel bottom is not available, on sand or sandy clay. Juveniles stay in shallow riverine habitats during first summer. Caspian fish first mature at 6–8 years for males, and 8–12 years for females, with an average generation length of 28 years. Females reproduce every 3–4 years and males every 2–3 years in April-September. It spawns only under relatively constant hydrological conditions, as fluctuating hydrological conditions lead to high egg mortality.
	Pressures	Fishing, dams & water management/use, invasive species, industrial & military effluents.
	Population	Decreasing. The species has declined more than 95% in the last 40 years. Three generations correspond to about 75 years in this species. Currently, most spawners are first-time spawners with only few individuals surviving to participate in a second spawning period. Stellate sturgeon seems to have vanished from the Aegean Sea, where only single individuals are reported occasionally.

Table no. 4-12 Short species description (Source: IUCN, 2022; FishBase)

***Acipenser sturio* (European Sturgeon)**	IUCN Status	CR
	Colour	Dorsal side greenish-brown to blackish with golden tints, flanks light with silvery tints, belly white.
	Size	Maximum length: 600 cm; maximum weight: 400 kg.
	Habitat	It lives the major part of his life in sea but enters rivers for reproduction. Found on various substrates, from sand to rocks. At the sea, it occurs in coastal and estuarine zones. In freshwaters, it inhabits estuaries and large rivers.
	Distribution	This species was once known from the North and Baltic Seas, English Channel, European coasts of Atlantic, northern Mediterranean west of Rhodos in Greece. Considered to be extinct from the Black Sea and Danube. It was occasionally recorded in Algeria, Morocco and Tunisia. The last record from the Rioni (Georgia) was in 1991, and further surveys have failed to find the species. Today this species is restricted only to the Garonne River in France.

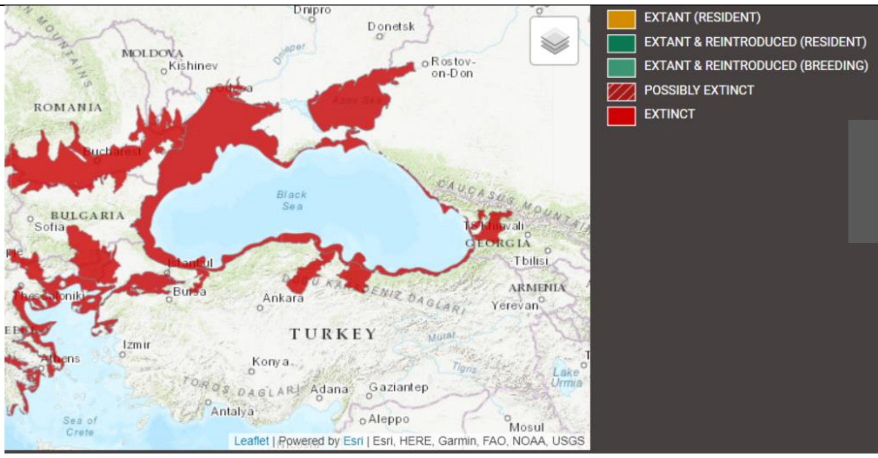
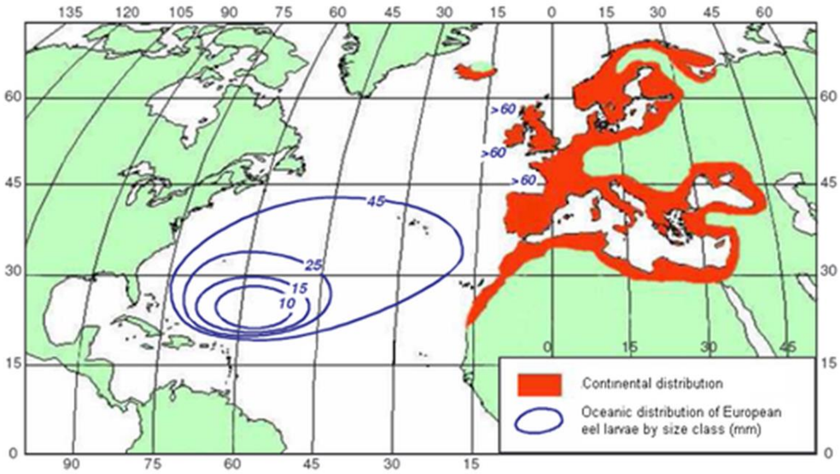
***Acipenser sturio* (European Sturgeon)**	IUCN Status	CR
		 **Figure no. 4-10 Distribution of *Acipenser sturio* (Source: IUCN, 2022)**
	Biology	This is an anadromous species (i.e., it spends at least part of its life in salt water and returns to rivers to breed). Feeds on crustaceans, molluscs, polychaete worms and small fish. Average generation length is 66 years; three generations is therefore estimated as approximately 198 years for this species. There are indications for a reproduction at two-year intervals for males and 3–4 years for females in April–July. Adults do not eat during migration and spawning. The distance of the spawning migration seems to be positively correlated with water level, and a distance of 1,000 km or more may be covered during years of high water. Spent fishes immediately return to the sea.
	Pressures	Mining & quarrying, shipping, fishing, dams & water management/use.
	Population	Decreasing. Number of mature individuals: 20-750.

Table no. 4-13 Short species description (Source: IUCN, 2010; FishBase)

***Huso huso* (Beluga)**	IUCN Status	CR
	Colour	Back ash-grey or greenish, flanks lighter, belly white.
	Size	Maximum length: 800 cm; maximum weight: 3.2 t.
	Habitat	At sea, this species is found in the pelagic zone, following food organisms. It spawns in the main course of large and deep rivers on stone or gravel bottom.
	Distribution	Caspian, Black, Azov and Adriatic Sea basins. Its current native wild distribution is restricted to the Black Sea (in the Danube only) and the Caspian Sea (in the Ural only).
	Biology	This species is anadromous (spending at least part of its life in salt water and returning to rivers to breed). Generation length is 60.8 years; three generations is therefore estimated as approximately 182 years for this species. It spawns every 3–4 years in April-June. Feeds mostly on sea fishes (Black Sea whiting, anchovies, flatfishes, gobies, fry of bottom-living fishes), also crustaceans, mollusks, mysids and amphipods.
	Pressures	Shipping, fishing, dams & water management use, invasive species, industrial & military effluents, agricultural effluents.
	Population	Decreasing. Global fisheries statistics show that there has been a 93% decline in catch from 1992 (520 tonnes) to 2007 (33 tonnes) and this decline is believed to have continued. The decline might even be much

***Huso huso* (Beluga)**	IUCN Status	CR
		larger, if only wild, self-sustaining populations would be considered, and 97–99% decline might have been reached by 2019.

Table no. 4-14 Short species description (Source: IUCN, 2023; FishBase)

***Anguilla anguilla* (European Eel)**	IUCN Status	CR
	Colour	Greenbrown.
	Size	Maximum length: 122 cm; maximum weight: 6.6 kg.
	Habitat	The species is found in a range of habitats from small streams to large rivers and lakes, and in estuaries, lagoons and coastal waters. Under natural conditions, it only occurs in water bodies that are connected to the sea.
	Distribution	Atlantic Ocean: Atlantic coast from Scandinavia to Morocco; Baltic, Black and Mediterranean Seas; rivers of North Atlantic, Baltic and Mediterranean seas. The species occurs in low abundance in the Black Sea region. Eels undertake long migrations between the spawning areas and growth habitats. The latter extend to fresh, brackish and coastal waters of coastal countries in Europe, North Africa and Asian coasts of the Mediterranean and Black Sea.  **Figure no. 4-11 Distribution area for *Anguilla anguilla* (Source: Adam, 1997 apud. OSPAR Commission, 2022)**
	Biology	The species is facultatively catadromous, living in fresh, brackish and coastal waters but migrating to pelagic marine waters to breed. Its food includes virtually the whole aquatic fauna (freshwater as well as marine) occurring in the eel's area, augmented with animals living out of water, e.g., worms. Sensitive to weak magnetic fields. Migrates to the depths of the Sargasso Sea to spawn. Eel larvae (leptocephali) are transparent ribbon-like. At the end of their growth period, they become sexually mature, migrate to the sea and cover great distances during their spawning migration (5,000-6,000 km); with extensive daily vertical migrations between 200 m at night and 600 m during day time, possibly for predator avoidance.
	Pressures	Industrial activities, urban areas, tourism, agriculture, aquaculture, oil & gas drilling, renewable energy, transportation, fishing, dams & water management, invasive species, wastewater, industrial & military effluents.

	Population	Decreasing. Review of information supports the view that the European eel population as a whole has declined in most areas, the stock is outside safe biological limits and current fisheries not sustainable. Obvious decreasing of the stocks for all the continental native distribution area.

Table no. 4-15 Short species description (Source: IUCN, 2008; FishBase)

***Knipowitschia cameliae* (Danube Delta dwarf goby)**	IUCN Status	CR
	Colour	Both sexes are black dorsally, lighter towards the belly.
	Size	Maximum length: 3.2 cm.
	Habitat	A small and shallow lagoon behind coastal sand dunes with brackish water and mud bottom.
	Distribution	Romania: known from a single small lagoon near Portita, south of Danube delta in the Golovita-Sinoe-Razelm Lake complex.
	Biology	Unknown.
	Pressures	Unknown.
	Population	Unknown. Last recorded in 1994, when it was described. The site was visited the year later and none were found. Another survey in 1998 also failed to find the species.

4.1.2.3 *Invertebrates*

The main invertebrate species found in the marine and coastal protected sites can be found in the following tables.

Table no. 4-16 Main invertebrate species found in Natura 2000 sites of the Black Sea

Country	Natura 2000 Site code	Species
Bulgaria	BG0000154	*Lycaena dispar*
Bulgaria	BG0000154	*Vertigo moulinsiana*
Bulgaria	BG0000573	*Catopta thrips*
Bulgaria	BG0000573	*Cerambyx cerdo*
Bulgaria	BG0000573	*Euplagia quadripunctaria*
Bulgaria	BG0000573	*Lycaena dispar*
Bulgaria	BG0000573	*Probaticus subrugosus*
Bulgaria	BG0000573	*Lucanus cervus*
Bulgaria	BG0000573	*Vertigo angustior*
Bulgaria	BG0000573	*Vertigo moulinsiana*
Bulgaria	BG0001004	*Cerambyx cerdo*
Bulgaria	BG0001004	*Dioszeghyana schmidtii*
Bulgaria	BG0001004	*Lycaena dispar*
Bulgaria	BG0001004	*Morimus funereus*
Bulgaria	BG0001004	*Osmoderma eremita*
Bulgaria	BG0001004	*Rosalia alpina*
Bulgaria	BG0001004	*Lucanus cervus*
Bulgaria	BG0001004	*Unio crassus*
Bulgaria	BG0001004	*Vertigo angustior*

Country	Natura 2000 Site code	Species
Bulgaria	BG0001004	*Vertigo moulinsiana*
Bulgaria	BG0001001	*Bolbelasmus unicornis*
Bulgaria	BG0001001	*Cerambyx cerdo*
Bulgaria	BG0001001	*Dioszeghyana schmidtii*
Bulgaria	BG0001001	*Euphydryas aurinia*
Bulgaria	BG0001001	*Paracaloptenus caloptenoides*
Bulgaria	BG0001001	*Unio crassus*

Table no. 4-17 Main invertebrate species found in Emerald sites of the Black Sea

Country	Site code	Species
Ukraine	UA0000018	*Callimorpha quadripunctaria*
Ukraine	UA0000019	*Catopta thrips*
Ukraine	UA0000020	*Cerambyx cerdo*
Ukraine	UA0000021	*Probaticus subrugosus*
Ukraine	UA0000141	*Unio crassus*
Ukraine	UA0000138	*Callimorpha quadripunctaria*
Ukraine	UA0000206	*Catopta thrips*
Ukraine	UA0000109	*Unio crassus*
Ukraine	UA0000017	*Carabus hungaricus*
Ukraine	UA0000017	*Euplagia quadripunctaria*
Ukraine	UA0000005	*Gortyna borelii lunata*
Ukraine	UA0000005	*Mesosa myops*
Ukraine	UA0000005	*Rhysodes sulcatus*
Ukraine	UA0000388	*Carcinus aestuarii*
Ukraine	UA0000388	*Eriphia verrucosa*
Ukraine	UA0000388	*Hemimysis serrata*
Ukraine	UA0000388	*Lysmata seticaudata*
Ukraine	UA0000388	*Pachygrapsus marmoratus*
Ukraine	UA0000388	*Pilumnu shirtellus*
Ukraine	UA0000388	*Xantho poressa*
Ukraine	UA0000021	*Rhysodes sulcatus*
Ukraine	UA0000021	*Rosalia alpina*
Ukraine	UA0000008	*Pseudophilotes bavius*
Georgia	GE0000006	*Agriades glandon aquilo*
Georgia	GE0000006	*Leucorrhinia pectoralis*

4.1.2.4 *Birds*

The main bird species that are found in the marine and coastal protected areas of the Black Sea are presented in the following table.

Table no. 4-18 Main bird species found in the Black Sea deltas and marine areas (Source: BirdLife International, 2023)

IBA Name	Country	Species name	IUCN EU Status
Danube Delta	Romania	*Mergus merganser*	LC
Danube Delta	Romania	*Branta ruficollis*	VU
Danube Delta	Romania	*Bucephala clangula*	LC
Danube Delta	Romania	*Puffinus yelkouan*	VU
Danube Delta	Romania	*Oxyura leucocephala*	EN
Danube Delta	Romania	*Anser erythropus*	VU
Danube Delta	Romania	*Aythya ferina*	VU
Danube Delta	Romania	*Falco cherrug*	EN
Danube Delta	Romania	*Numenius tenuirostris*	CR
Danube Delta	Romania	*Pelecanus onocrotalus*	LC
Danube Delta	Romania	*Clanga clanga*	VU
Danube Delta	Romania	*Falco vespertinus*	VU
Danube Delta	Romania	*Ciconia ciconia*	LC
Danube Delta	Romania	*Phalacrocorax carbo*	LC
Danube Delta	Romania	*Phalaropus lobatus*	LC
Danube Delta	Romania	*Hydrocoloeus minutus*	LC
Danube Delta	Romania	*Larus genei*	VU
Danube Delta	Romania	*Larus ridibundus*	LC
Danube Delta	Romania	*Larus melanocephalus*	LC
Danube Delta	Romania	*Larus canus*	LC
Danube Delta	Romania	*Sternula albifrons*	LC
Danube Delta	Romania	*Gelochelidon nilotica*	LC
Danube Delta	Romania	*Hydroprogne caspia*	LC
Danube Delta	Romania	*Chlidonias niger*	LC
Danube Delta	Romania	*Sterna hirundo*	LC
Danube Delta	Romania	*Thalasseus sandvicensis*	LC
Black Sea	Romania	*Mergus merganser*	LC
Black Sea	Romania	*Branta ruficollis*	VU
Black Sea	Romania	*Bucephala clangula*	LC
Black Sea	Romania	*Aythya marila*	LC
Black Sea	Romania	*Aythya ferina*	VU
Black Sea	Romania	*Pelecanus crispus*	NT
Black Sea	Romania	*Podiceps grisegena*	VU
Black Sea	Romania	*Podiceps nigricollis*	VU
Black Sea	Romania	*Puffinus yelkouan*	VU
Black Sea	Romania	*Phalacrocorax carbo*	LC
Black Sea	Romania	*Phalaropus lobatus*	LC
Black Sea	Romania	*Hydrocoloeus minutus*	LC
Black Sea	Romania	*Larus genei*	VU
Black Sea	Romania	*Larus ridibundus*	LC
Black Sea	Romania	*Larus melanocephalus*	LC
Black Sea	Romania	*Larus canus*	LC
Black Sea	Romania	*Sternula albifrons*	LC
Black Sea	Romania	*Gelochelidon nilotica*	LC
Black Sea	Romania	*Hydroprogne caspia*	LC

IBA Name	Country	Species name	IUCN EU Status
Black Sea	Romania	*Sterna hirundo*	LC
Black Sea	Romania	*Thalasseus sandvicensis*	LC
Sakarya Delta	Turkiye	*Melanitta fusca*	VU
Kızılırmak Delta	Turkiye	*Melanitta fusca*	VU
Kızılırmak Delta	Turkiye	*Puffinus yelkouan*	VU
Kızılırmak Delta	Turkiye	*Hydrocoloeus minutus*	LC
Yeşilırmak Delta	Turkiye	*Melanitta fusca*	VU
Delta of the Kuban' river	Russia (European)	*Larus ichthyaetus*	LC
Delta of the Kuban' river	Russia (European)	*Hydroprogne caspia*	LC
Delta of the Kuban' river	Russia (European)	*Thalasseus sandvicensis*	LC
Delta of the River Don	Russia (European)	*Podiceps grisegena*	VU
Delta of the River Don	Russia (European)	*Podiceps cristatus*	LC
Delta of the River Don	Russia (European)	*Podiceps nigricollis*	VU
Delta of the River Don	Russia (European)	*Phalacrocorax carbo*	LC
Delta of the River Don	Russia (European)	*Hydrocoloeus minutus*	LC
Delta of the River Don	Russia (European)	*Larus cachinnans*	LC
Delta of the River Don	Russia (European)	*Larus ridibundus*	LC
Delta of the River Don	Russia (European)	*Larus genei*	VU
Delta of the River Don	Russia (European)	*Larus ichthyaetus*	LC
Delta of the River Don	Russia (European)	*Sternula albifrons*	LC
Delta of the River Don	Russia (European)	*Gelochelidon nilotica*	LC
Delta of the River Don	Russia (European)	*Hydroprogne caspia*	LC
Delta of the River Don	Russia (European)	*Chlidonias niger*	LC
Delta of the River Don	Russia (European)	*Sterna hirundo*	LC

The **Important Bird Areas** or **IBA**s, are areas that play a key role in the protection of birds and biodiversity, whose identification is part of a global project, curated by BirdLife International. The IBA project stems from the need to identify uniform and standardised criteria for the designation of SPAs. IBAs have been used to assess the adequacy of designated national SPA networks in the Member States (data.europa.eu, 2019).

An **Important Bird and Biodiversity Area (IBA)** is an area identified using an internationally agreed set of criteria as being globally important for the conservation of bird populations. As specified by BirdLife International (2020), these standardized criteria are designed to identify IBAs of global significance ("level A" criteria) and can be found listed below. There are also regional and subregional criteria, which can be found on the BirdLife International website[6]. There are no differences in the IBA criteria used in terrestrial and marine environments. The differences consist of the habitat, the data used to describe the sites and the methods for defining boundaries.

Table no. 4-19 The four global criteria for IBA identification (Source: BirdLife International, 2020)

[6] BirdLife International website: https://datazone.birdlife.org/site/ibacriteria

IBA Criterion Description	IBA Criterion Description
A1: Globally Threatened Species Criterion: the site is known or thought regularly to hold significant numbers of a Globally Threatened species.	The site qualifies if it is known, estimated or thought to hold a population of a species categorized on the IUCN Red List as globally threatened (Critically Endangered, Endangered and Vulnerable). Specific thresholds apply to species in the three threat categories. The list of globally threatened species is maintained and updated annually for IUCN by BirdLife International (www.birdlife.org/datazone/species).
A2: Restricted Range Species Criterion: the site is known or thought to hold a significant population of at least two range-restricted species.	Restricted-range bird species are those having a global range size less than or equal to 50,000 km^2. "Significant population": it is recommended that site-level populations of at least two restricted-range species should be equal to or exceed 1% of their global population. This criterion can be applied to species both within their breeding and nonbreeding ranges.
A3: Bioregion-restricted assemblages Criterion: the site is known or thought to hold a significant component of the group of species whose distributions are largely or wholly confined to one biome-realm.	Bioregion-restricted assemblages are groups of species with largely shared distributions which occur (breed) mostly or entirely within all or part of a particular bioregion. Networks of sites must be chosen to ensure, as far as possible, adequate representation of all relevant species. In data-poor areas, knowledge of the quality and representativeness of the habitat types within sites alongside incomplete knowledge of the presence of bioregion-restricted species can be used to inform site selection. Biome-realms require that the networks of sites take account of both the geographical spread of the biome-realm and the political boundaries that cross them, as appropriate. Under "significant component" it is recommended to use 30% of the number of bioregion-restricted species within a biomerealm within a country or five bioregion-restricted species, whichever is greatest.
A4: Congregations Criterion: the site is known or thought to hold congregations of ≥1% of the global population of one or more species on a regular or predictable basis.	Sites can qualify whether thresholds are exceeded simultaneously or cumulatively, within a limited period. In this way, the criterion covers situations where a rapid turnover of birds takes place (including, for example, for migratory land birds).

According to BirdLife International (2020), the aim of identifying IBAs has always been to secure viable populations of the qualifying species at each site. Simultaneously, IBAs are also forming a network where the survival of qualifying species´ populations at one site may depend on keeping other sites in good conservation status as well (e.g. for migratory birds within a flyway).

There are three stages of an IBA designation, which are described in the following lines.

Confirmed Important Bird and Biodiversity Areas (IBAs) have undergone a thorough quality-control process, involving a comprehensive assessment of qualifying species and populations, a site description, and associated boundaries. These have been reviewed and approved by both BirdLife Partners and the BirdLife Secretariat (BirdLife Data Zone, 2024).

Proposed sites, on the other hand, have not completed this entire cycle but are listed to indicate the number and range of sites in the identification and review process (BirdLife Data Zone, 2024).

Candidate sites are identified globally as potentially meeting IBA criteria, but further work is required to substantiate these claims. The boundaries and qualifying species for proposed and potential sites are preliminary and subject to change during the assessment process (BirdLife Data Zone, 2024).

In the image below (Figure no. 4-12) it can be observed that most of the marine IBAs are found in the N-W, N and N-E sides of the Black Sea, while in the Georgian side none can be found.

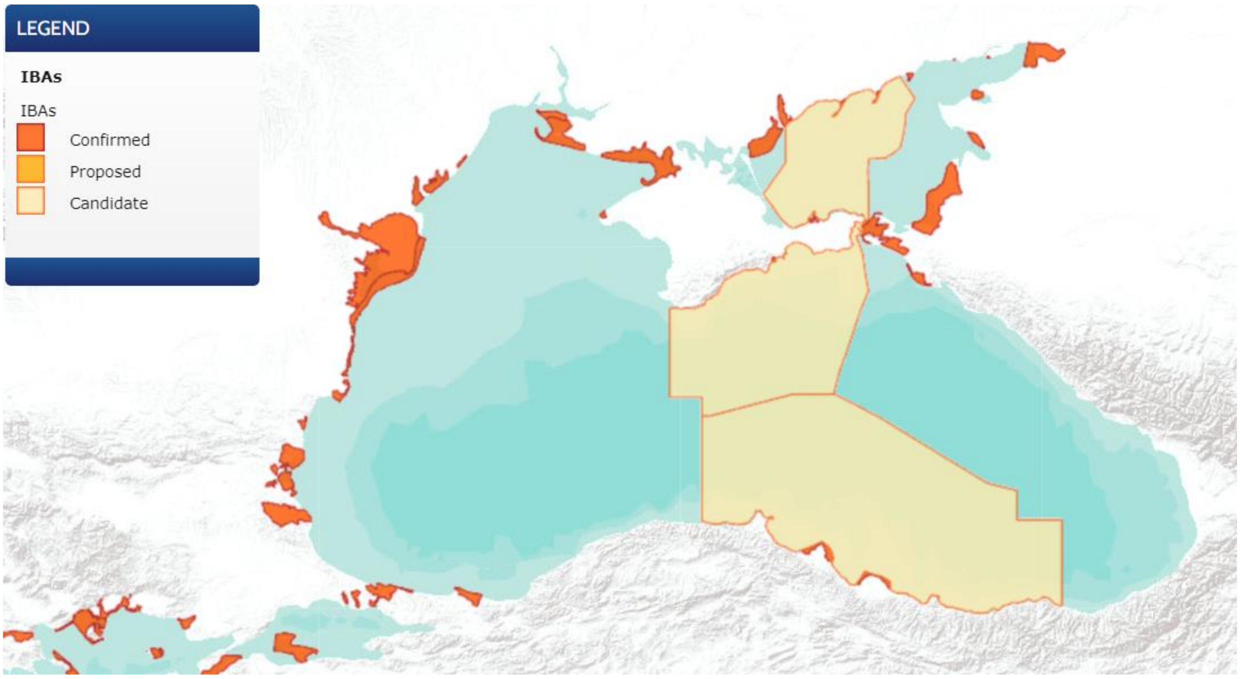


Figure no. 4-12 Marine IBAs in the Black Sea (Source: BirdLife Marine IBA Inventory. https://maps.birdlife.org/marineIBAs/)

Moreover, in Figure no. 4-13 it can be found that Romania has about 2.7% of its land covered by marine IBAs, followed by Bulgaria with about 2.4%, Türkiye with 1.31% and Ukraine with a smaller share, 0.55%. Figure no. 4-14 alternatively shows the proportion between marine IBAs and the total land area of each country. Data for Russia could not pe found, while Georgia does not have marine IBAs.

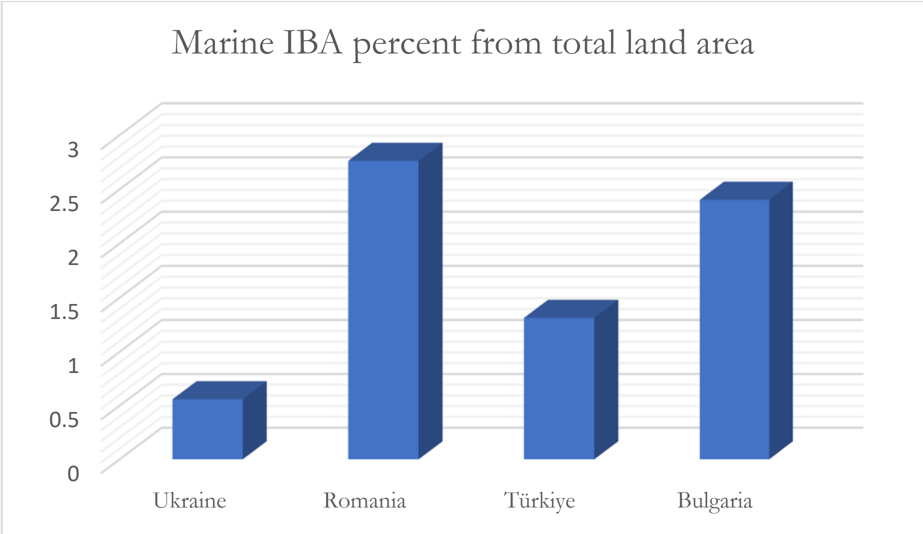


Figure no. 4-13 Marine IBA percent from total land area (Source: BirdLife International, 2024)

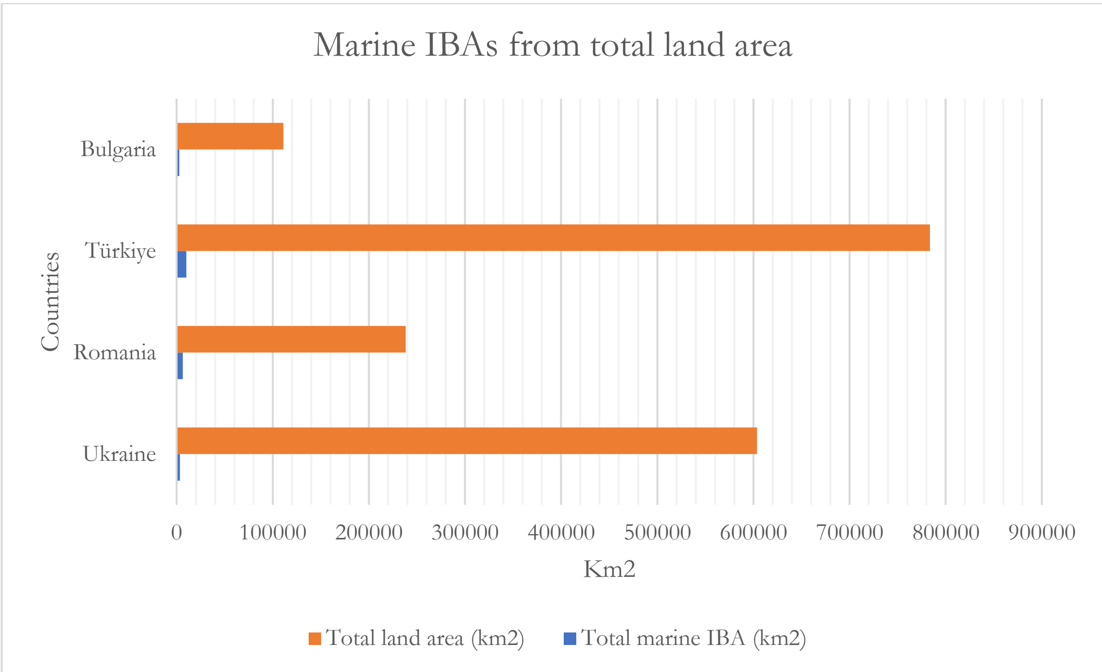


Figure no. 4-14 Marine IBAs from total land surface (Source: BirdLife International, 2024)

The Mediterranean/Black Sea Flyway is one of the three Palaearctic-African flyways that connect Europe with Africa, collectively forming the world's largest bird migration system. The magnitude of avian movement involves over 2 billion passerines and near-passerines, 2.5 million ducks, and two million raptors migrating from their breeding grounds in Europe, central, and western Asia to winter in tropical Africa. The primary route for those originating from Western Siberia, Central, and Eastern Europe is the Mediterranean/Black Sea Flyway, which extends southward from the Russian arctic. Birds such as *Branta ruficollis* from breeding grounds in Russia face the challenge of traversing the Ural

Mountains before continuing their journey south through western Russia towards Eastern Europe and finally reaching the Black Sea coast *(Mediterranean Black Sea Fact Sheet, 2010)*.

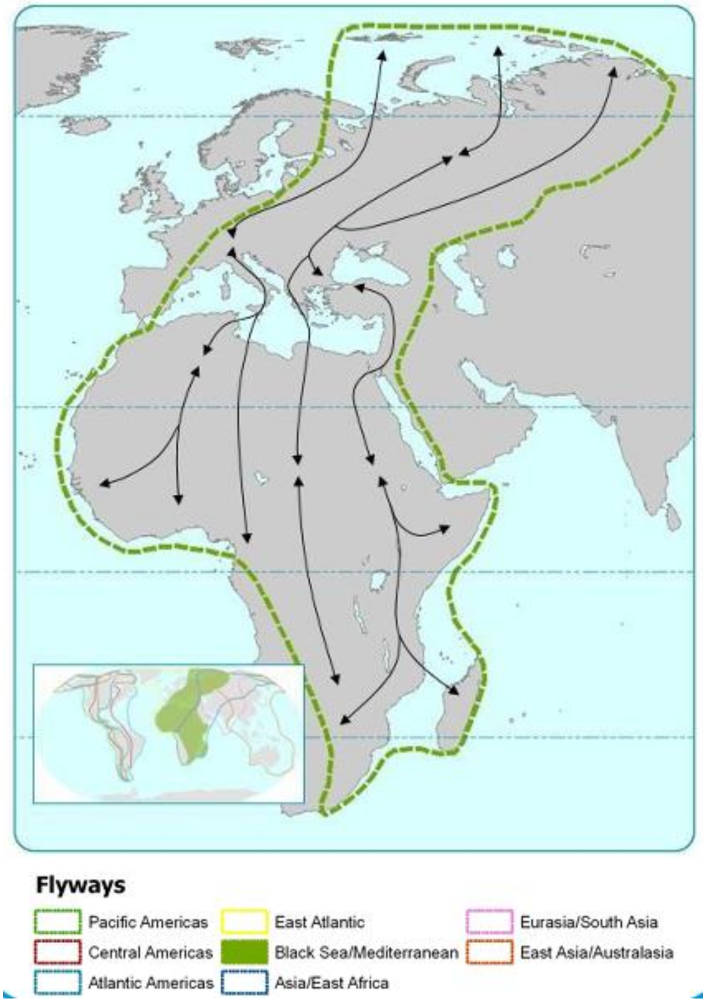


Figure no. 4-15 Flyways, with an emphasis on Mediterranean/ Black Sea Flyway (Source: *Mediterranean Black Sea Fact Sheet, 2010*)

However, Figure no. 4-15 is only orientative, as each migratory bird species' flyway might be slightly different than the presented routes. For instance, *Branta ruficollis* oftenly crosses the northern part of the Black Sea during her migration to the eastern sides of Romania and Bulgaria (as seen in Figure no. 4-16 and Figure no. 4-17).

The species *Branta ruficollis* breeds on the Taimyr, Gydan, and Yamal peninsulas in Russia. Historically, during winter, a significant portion of the population was found along the western coast of the Caspian Sea, primarily in Azerbaijan, Iran, and Iraq. However, the wintering area shifted to the western Black Sea coast, with 80-90% of birds congregating at roost sites, including Shabla Lakes and Durankulak Lake in Bulgaria, Razelm-Sinoe lagoons in Romania, and the coastal area between the rivers Danube and Dniester in Ukraine (Figure no. 4-18). Small numbers also winter in Azerbaijan, and the distribution varies based on weather severity. Migration follows a route south down the Ob to

Kazakhstan, with four main staging areas identified in Russia and Kazakhstan (BirdLife International, 2024).

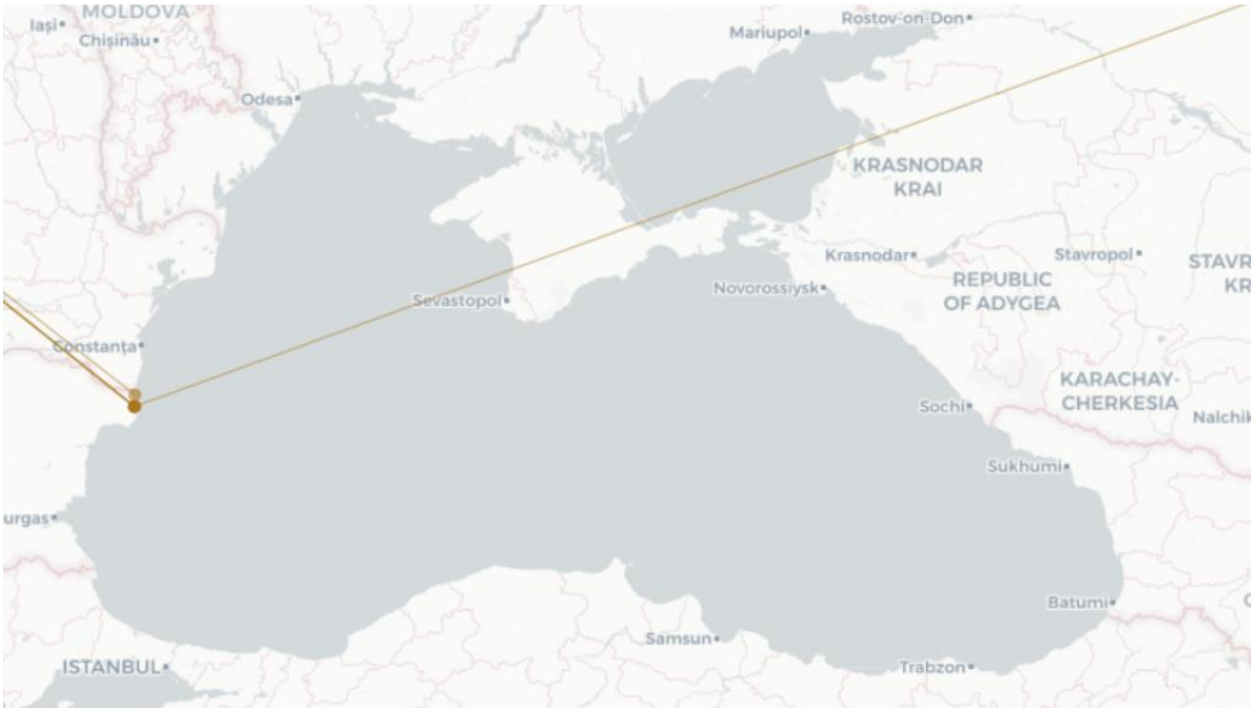


Figure no. 4-16 Migration route of *Branta ruficollis* (EURING/CMS, 2022)

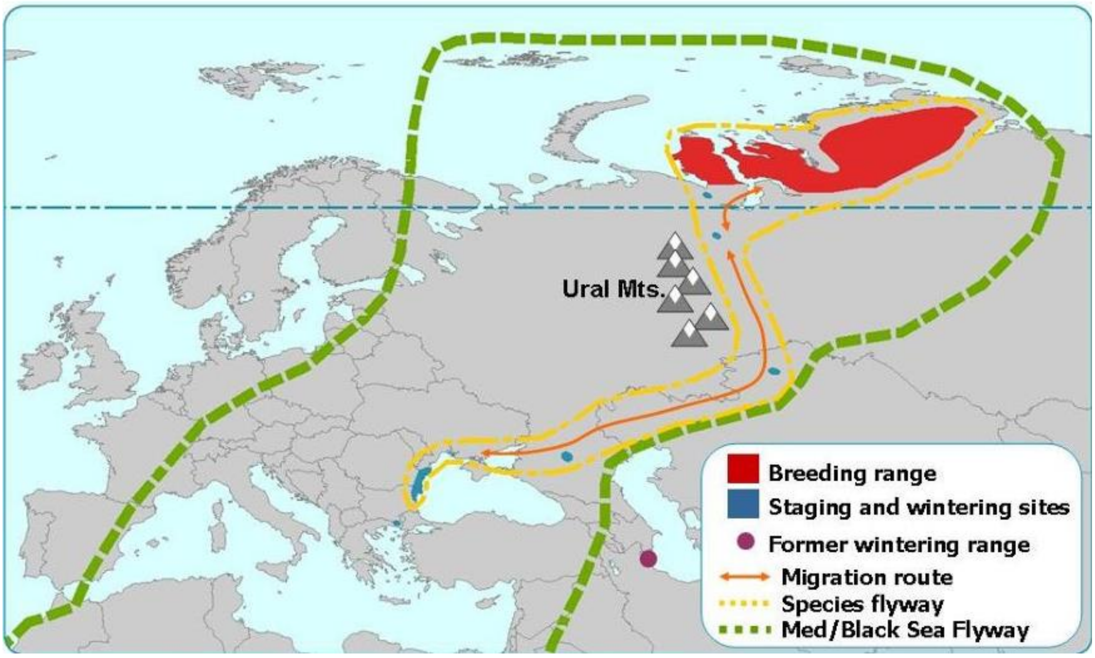


Figure no. 4-17 *Branta ruficollis* flyway, breeding range and wintering sites (Source: Mediterranean Black Sea Fact Sheet, 2010)

Figure no. 4-18 Distribution of *Branta ruficollis* (Source: BirdLife International, 2024)

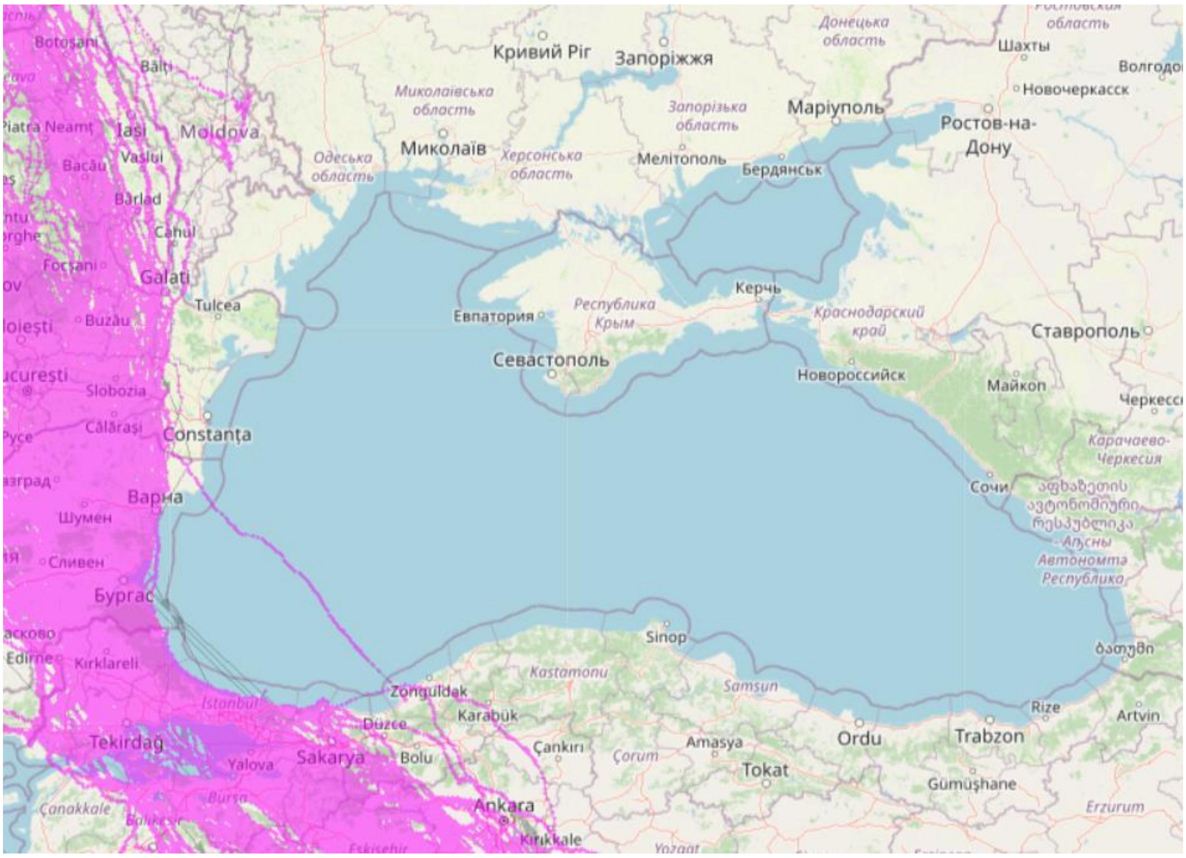


Figure no. 4-19 *Ciconia ciconia* flyway (Source: Wikelski, Davidson & Kays, 2024; Kays, Davidson et al. 2022)

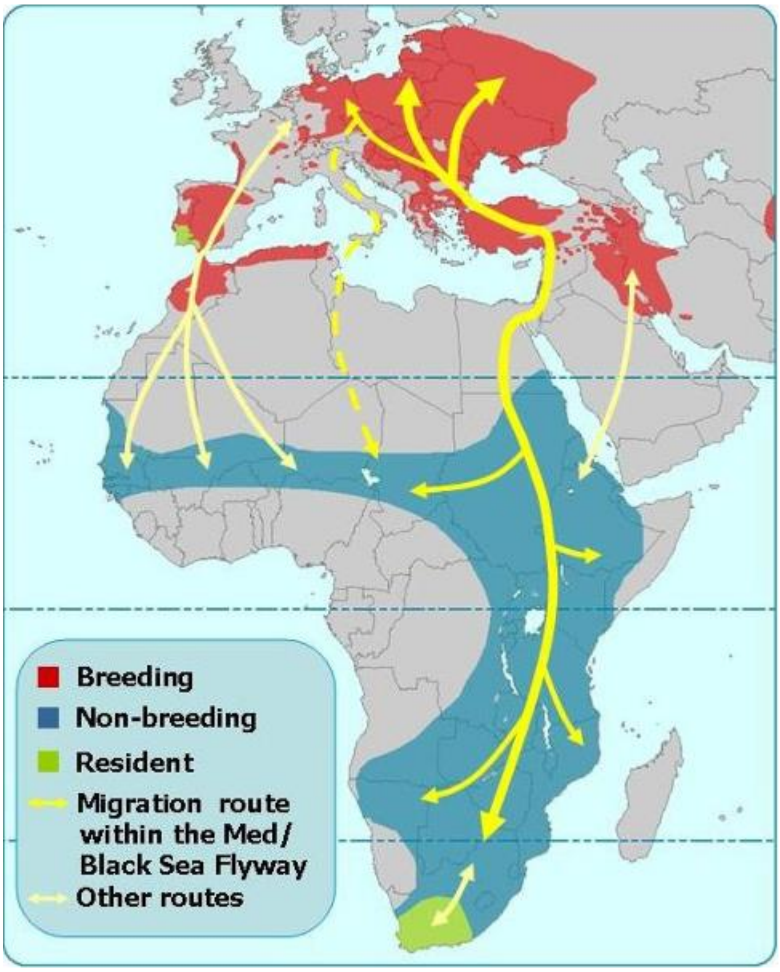


Figure no. 4-20 *Ciconia ciconia* flyway, breeding range and wintering sites (Source: Mediterranean Black Sea Fact Sheet, 2010)

The pictures above show the fact that the Black Sea is important for migratory birds as well (e.g. Figure no. 4-19, Figure no. 4-20), not only for resident birds. However, identified pressures might affect their migratory behaviour.

Moreover, there are also species identified as Vulnerable in the Black Sea area. One example would be *Puffinus yelkouan,* which in the non-breeding season disperses widely within the Mediterranean and Black Seas, often congregating in large flocks. This species is marine, frequenting mostly inshore waters. It breeds on rocky coastal and offshore islets, and on the mainland. It is a colonial breeder, nesting in rock crevices or ledges in caves, occasionally in old rabbit burrows, lined with sparse plant material. It sometimes nests on cliffs (*Detailed species account from European Red List of Birds*, 2015).

According to BirdLife International (2024), the species is known to breed in France (627-1044, Cadiou, 2015), Italy (9,000-20,000 pairs, 12,791-19,774 according to BirdLife International 2015), Malta (1,370-2,000 pairs, according to Barbara et al. 2015), Algeria (8-10 pairs), Tunisia (176-200 pairs), Croatia (300-500 pairs, 300-400 pairs according to BirdLife International 2015), Albania (1-10 pairs), Greece (4,000-7,000 pairs) and Bulgaria (0-10 pairs) giving a global estimate of 15,300-30,500 pairs according to Derhé (2012) and 19,400-31,200 pairs according to BirdLife International (2015).

Breeding is assumed in Turkey on offshore islands or mainland cliffs in the Aegean and Mediterranean, but so far no colonies have been identified and more surveys are required (D. Sahin in litt. 2015).

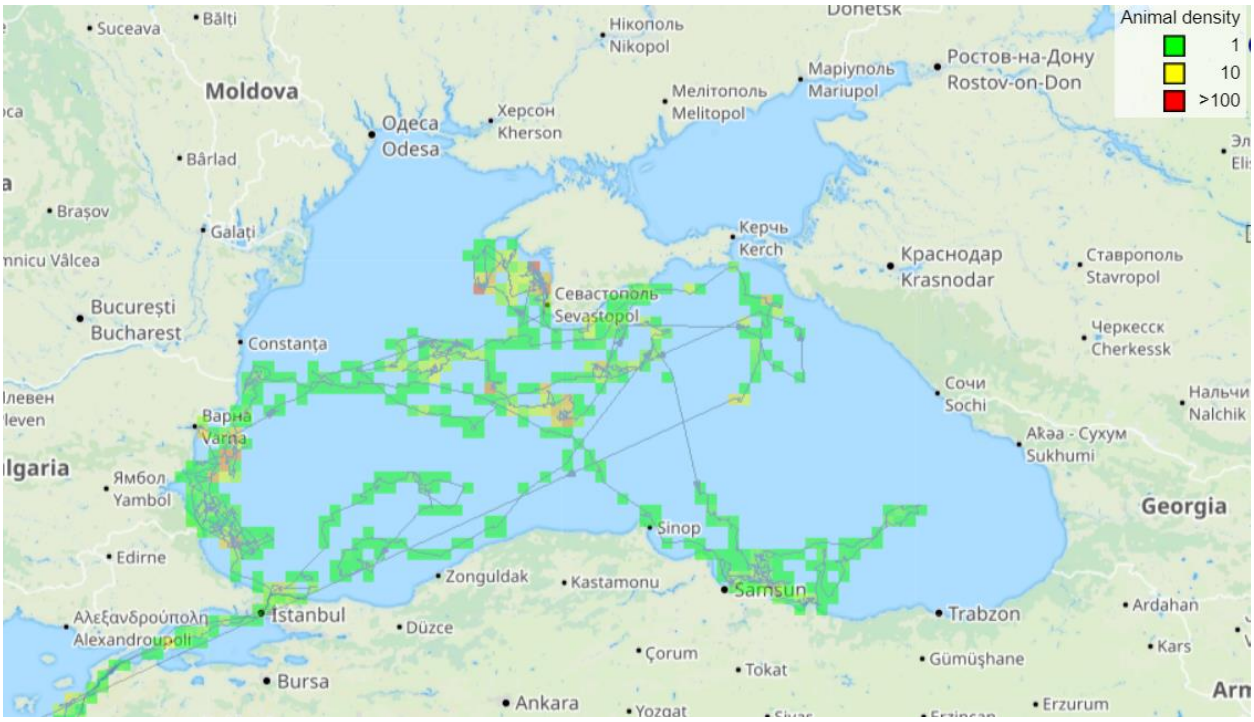


Figure no. 4-21 Movements of *Puffinus yelkouan* density (Source: Wikelski, Davidson & Kays, 2024; Kays, Davidson et al., 2022)

Another example of Vulnerable bird species that is present in the Black Sea would be *Larus genei*. Within Europe this species occurs along the south and east of the Iberian Peninsula, through the Mediterranean and Black Sea. The species breeds on sand-spits, beaches and islands with mudflats and marshes in shallow tidal waters and on saline inland seas. It may also frequent meadows and moist grassland by tidal inlets and brackish or freshwater lagoons or marshes near river deltas during this season. The species is almost entirely coastal outside of the breeding season, frequenting shallow inshore waters and salt-pans, although it generally avoids harbours (BirdLife International, 2021).

The species faces multiple threats, including pollution from oil and plastic waste, as well as exploitation by local communities engaging in subsistence egg collecting in the Mediterranean. Disturbance from both local residents and tourists visiting breeding colonies, along with habitat loss due to tourism development, also poses significant challenges for the species (BirdLife International, 2021).

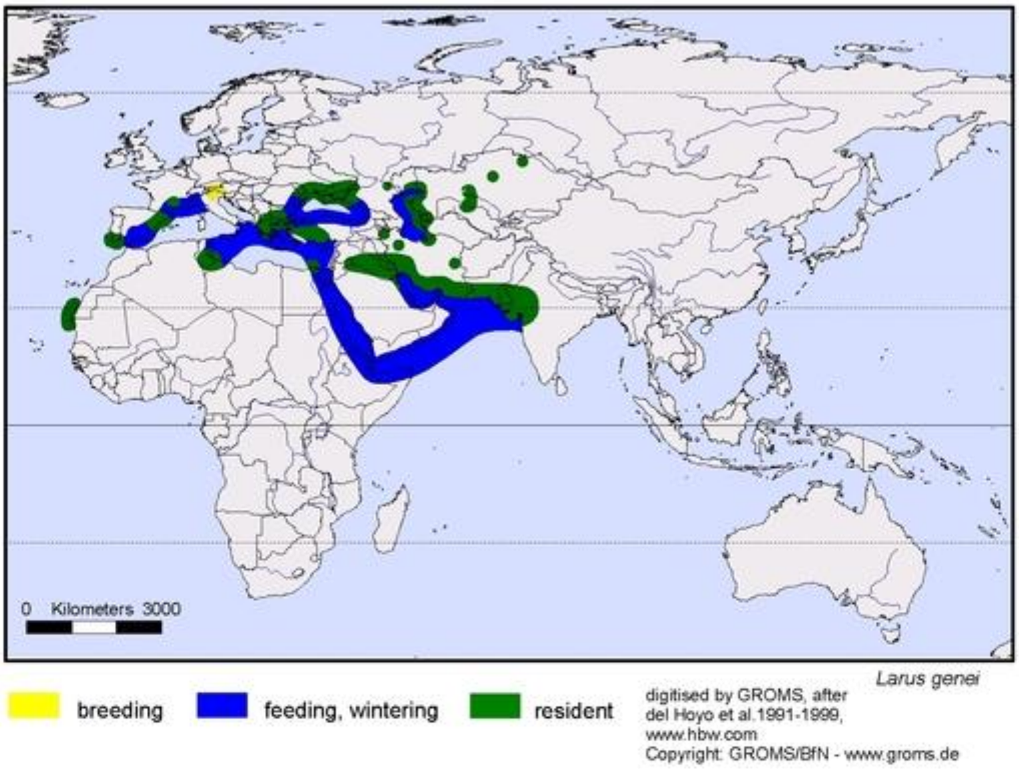


Figure no. 4-22 Presence areas for *Larus genei* (Species Fact Sheet by Global Register of Migratory Species, 2004)

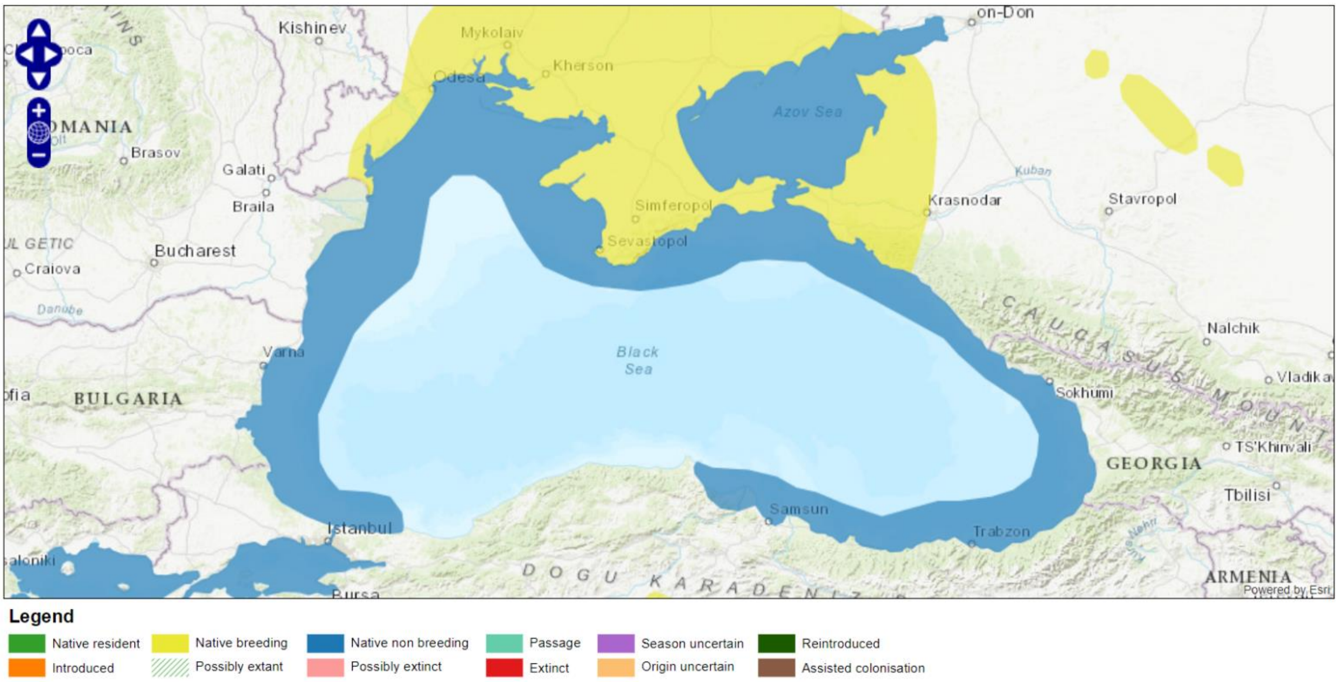


Figure no. 4-23 Presence areas for *Larus genei* (Source: BirdLife International, 2024)

4.1.2.5 *Herpetofauna*

The main herpetofauna species that can be found in the Black Sea are: *Emys orbicularis, Elaphe sauromates, Bombina bombina, Testudo graeca, Testudo hermanni, Triturus karelinii, Elaphe situla*.

Table no. 4-20 Main herpetofauna species found in the Black Sea

Species	Status (EU)
Emys orbicularis	NT
Elaphe sauromates	LC
Bombina bombina	LC
Testudo graeca	VU
Testudo hermanni	NT
Triturus karelinii	LC
Elaphe situla	LC

4.1.2.6 *Aquatic plants*

The key species of macrophytes are represented by large dominant species, which form an indicatory community - species from genus *Cystoseira*, *Zostera*, *Phyllophora*.

4.2 ANALYSIS OF MAIN FORMS OF IMPACTS

In the long term, there is a considerable possibility that certain species will be tremendously affected by the identified effects (Table no. 4-21 Summary of the identified impacts based on database entries), resulting the following forms of **impact**: habitat loss, habitat alteration, habitat fragmentation, species disturbance and species mortality.

Table no. 4-21 Summary of the identified impacts based on database entries

Impacts	Country						
	Ukraine	Romania	Moldova	Turkiye	Russia	Bulgaria	Georgia
Fauna mortality	2	3	0	2	4	0	1
Habitat loss	0	1	0	0	0	0	0
Habitat fragmentation	0	0	0	0	0	0	0
Habitat degradation	4	5	0	6	7	4	1

Figure no. 4-24 shows a summary of the most evident pressures, which can lead to the presented impacts. It should be noted that the data used for the cartographic material presented below were obtained based on the georeferencing of images found in several sources presented in section 3.9.1. Given this detail, the accuracy of the map is only indicative. The shapefiles for MPAs and IMMAs were obtained from the European Environment Agency Datahub[7] and from *the IUCN Global Dataset of Important Marine Mammal Areas*[8].

[7] EEA Datahub. (2024). https://www.eea.europa.eu/en/datahub
[8] IUCN MMPATF (2023). www.marinemammalhabitat.org/imma-eatlas

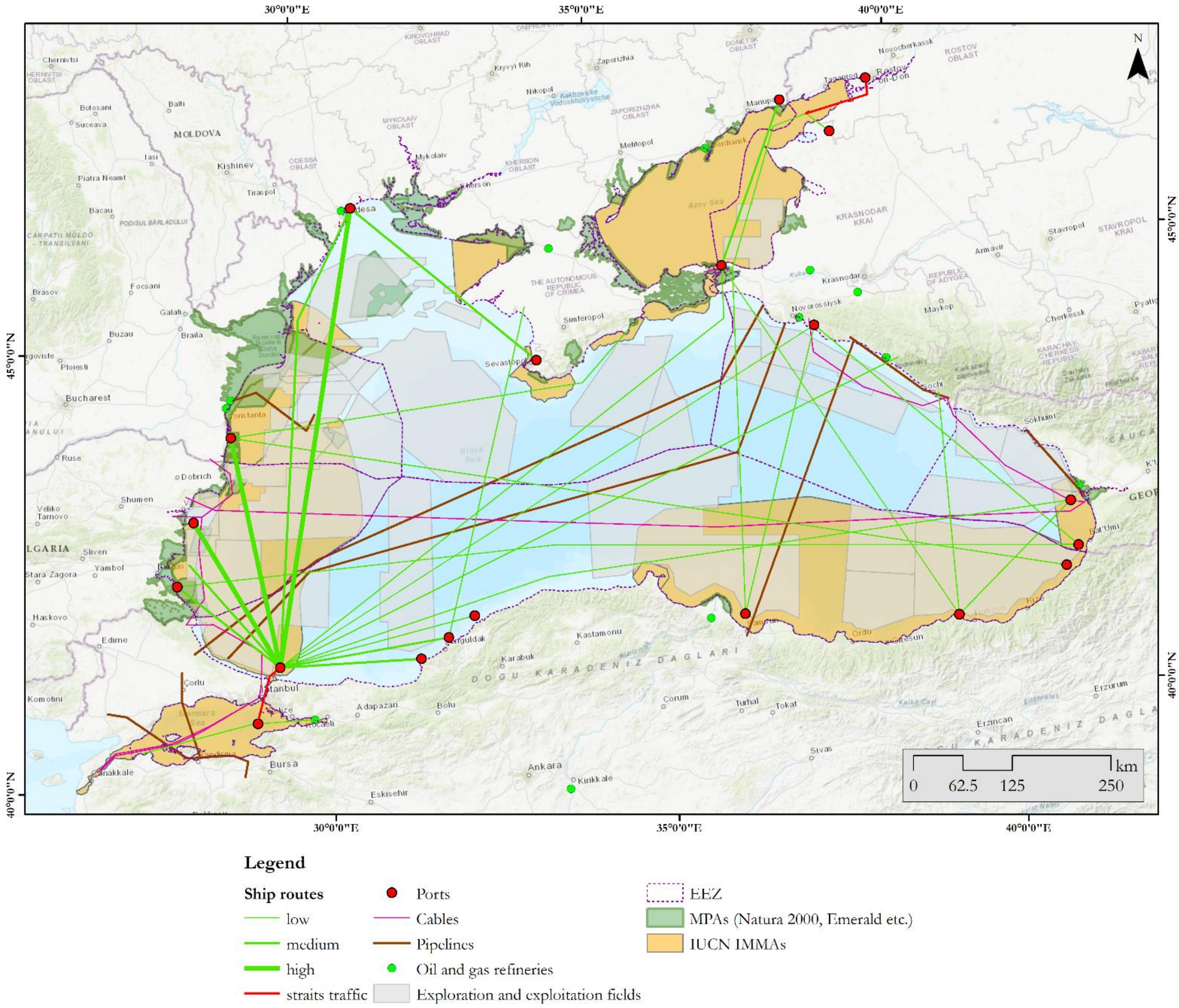


Figure no. 4-24 Summary of pressures and their relation with MPAs and IMMAs (Source for IMMAs: *IUCN MMPATF, 2023*[9])

4.2.1 Habitat loss

The most vulnerable species are currently, by far, the **mammal species** that inhabit or feed in coastal areas: *Tursiops truncatus ponticus, Delphinus delphis ponticus, Phocoena phocoena* which are dealing with coastal erosion in several areas of the Black Sea coast, such as the northern part of the Romanian coast, the Bulgarian or the Russian coast (BSC, 2019) or the potential destruction of their coastal habitats (such as: Sea of Azov IMMA, Karkinit and Dzharylhach Gulfs IMMA, Balaklava and the Southern Crimea

[9] *IUCN MMPATF (2023) The IUCN Global Dataset of Important Marine Mammal Areas (IUCN IMMA). September 2023. Made available under Agreement on Terms of Use by the IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force and made available at www.marinemammalhabitat.org/imma-eatlas*

IMMA, Karadag and Opuk IMMA and Kerch Strait and Taman Bay IMMA) due to the war in Ukraine (Figure no. 4-25).

Moreover, marine **invertebrate species** might suffer from habitat loss due to sand extraction, underwater infrastructure implementation/operation, renewable energy project implementation/operation, oil and gas extraction or due to the military activities (explosion of the war mines) in Ukraine.

Having these considered, dredging, coastal, and offshore construction activities, including the construction of oil/gas facilities, pipelines, cables, coastal protection installations, offshore windfarms, and wave breakers, have harmful effects on benthic communities as areas of benthic habitats may be lost under the foundation/pipeline or degraded due to construction activity or to exploding mines (causing sediment plumes and smothering), displacing benthic organisms permanently or temporarily (Bennun et al., 2021; European Environment Agency, 2017). These activities directly and indirectly impact bottom landscapes, leading consequently to a decrease in phytoplankton and benthic macrophytes due to the disturbance of silty mud. Both dredging operations and certain fishing practices (e.g. trawling) can also lead to habitat loss for fish (e.g. turbot – *Psetta maxima*) and contribute to damage to benthic ecosystems which can have a substantial impact on the overall marine ecosystem (BSC, 2019).

Certain bird species that breed on beaches and search for food on the coast and in inshore waters outside their breeding season (e.g. *Larus genei*) can suffer from habitat loss due to coastal tourism development (BirdLife International, 2021).

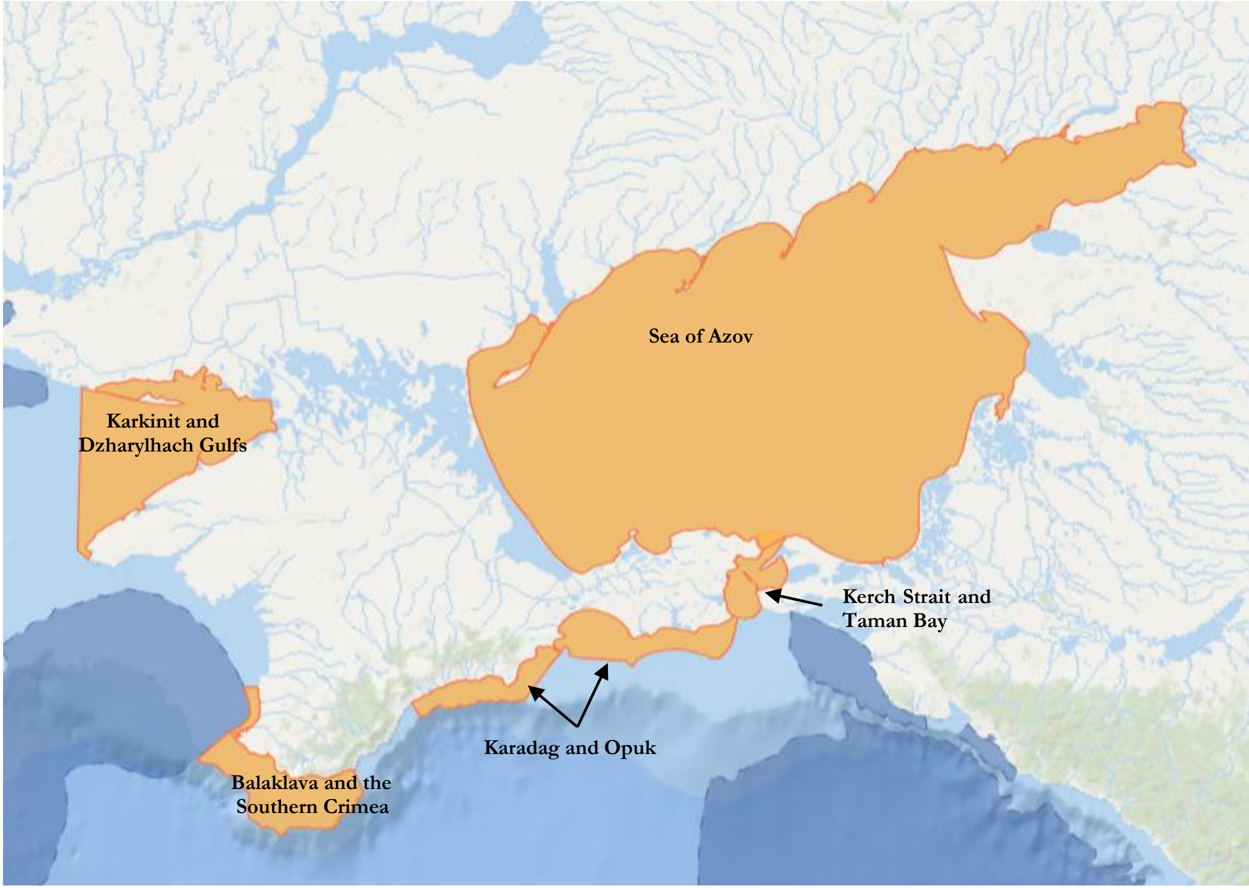


Figure no. 4-25 Important Marine Mammal Areas (IMMAs) potentially affected by the war in Ukraine (Source: IUCN Marine Mammal Protected Areas Task Force, 2024)

4.2.2 Habitat alteration

The species that are predicted to suffer the most from habitat alteration are the mammals, fish and invertebrate species found in the waters of the Black Sea. As the level of marine water pollution was found to be very high in Turkiye, Romania, Russia and Ukraine (BSC, 2019), it is likely that the species found in the waters of these countries to be highly affected if measures are not implemented soon. Some of the concerned species might be: *Tursiops truncatus poncticus, Delphinus delphis ponticus, Phocoena phocoena* ssp. *Relicta, Acipenser gueldenstaedtii, Acipenser nudiventris, Acipenser persicus, Acipenser stellatus, Acipenser sturio, Huso huso, Anguilla anguilla.* At the same time, benthic species (e.g. invertebrate – mollusks, crustaceans, polychaetes, fish – *Psetta maxima*, *Neogobius melanostomus*) might suffer from this type of impact due to the underwater infrastructure or due to the extraction of resources.

Habitat alteration in marine ecosystems is primarily attributed to three main mechanisms: abrasion, siltation, and the extraction of non-living material. Abrasion results from erosive interactions between human activities and the seafloor, such as trawling or the installation of infrastructure like electricity cables. Siltation refers to changes in the concentration and distribution of suspended sediments in the water column, induced by activities like dredging, trawling, and runoff from fertilizers. The extraction of non-living material involves the removal of sand, gravel (commonly used in construction aggregates), and surface substrates for seabed exploration and subsoil extraction. These activities collectively contribute to physical damage in marine environments (European Environment Agency, 2017).

The installation of foundations, scour protection, turbine towers as in offshore wind farms, and other seabed infrastructure can alter hydrodynamic conditions, potentially impacting benthic communities and fish species. These effects may be either negative, such as scouring around turbines, increased turbidity, and smothering, or positive, including the creation of new habitats (Bennun et al., 2021).

Introduction of invasive species is another effect that leads to habitat alteration. Shipping and intentional introduction are the primary mechanisms for introducing non-indigenous species into the Black Sea. Given the enclosed nature and low biodiversity of the Black Sea, these non-indigenous species pose threats to native biota. An example is the comb jelly *Mnemiopsis leidyi*, introduced via ship ballast water, causing significant ecological and economic damage by feeding on the larvae and eggs of small pelagic fishes (e.g. achovy *Engraulis encrasicolus*). Another invasive species, the sea snail *Rapana venosa*, has gained commercial status and been exported to Asian countries, impacting native fauna, particularly mussel and oyster beds, since the 1980s (Öztürk, 2021).

Pollution, particularly from heavy metals, oil, microplastics and other harmful substances, has direct (e.g. poisoning) and indirect impacts (e.g. changes in reproductive success) on the marine ecosystem in the Black Sea. Direct toxic effects on biota result from these pollutants (e.g. health impairment). Additionally, suspended solid particles reduce sunlight penetration, hindering the development of benthic biocenoses, pelagic algae, and other organisms. Agricultural runoff, containing mineral and organic fertilizers, leads to microflora blooms (eutrophication), causing destructive effects on coastal water biocoenosis. Coastal Black Sea water quality is significantly below the natural level due to poor management, particularly in bays, gulfs, and harbor areas of large cities such as Constanta, Odesa, Sebastopol, Novorossiysk, Poti, Batumi, Trabzon, Istanbul, Varna, making these regions the most polluted areas in the Black Sea (BSC, 2019).

Eutrophication, characterized by changes in oxygen concentration, triggers various alterations in the water environment. This includes shifts in algal populations and zooplankton dynamics. The excessive nutrient availability during eutrophication stimulates the overgrowth of macroalgae, phytoplankton (such as diatoms, dinoflagellates, and chlorophytes), and cyanobacteria. These organisms, influenced by factors like nutrients, light, temperature, and water movement, undergo substantial proliferation. More importantly, some of these organisms can release toxins or be inherently toxic, posing risks to public health. The impact of eutrophication is evident in changes observed in fish and shellfish populations, which are the first to demonstrate alterations. These species, particularly sensitive to oxygen levels, may experience mortality due to oxygen limitation or shifts in water chemical composition, such as excessive alkalinity resulting from intense photosynthesis. For instance, the toxicity of ammonia in fish is significantly higher in alkaline waters (Borysova et al., 2005). Further accelerating ongoing ecological changes presently occurring due to eutrophication. Öztürk (2021) mentions that, direct environmental impacts on pelagic and benthic systems (anoxia) are caused by mucus and dead comb jellies raining down in massive quantities to the floor of the shallow shelf.

4.2.3 Habitat fragmentation

In the Middle Sector of the Dniester (Naslavcea-Dubăsari), after the construction of the Dubăsari hydropower plant, the population of Acipenseridae decreased significantly. The species *Huso huso*, *Acipenser stellatus*, *Acipenser gueldenstaedtii* and *Acipenser nudiventris* were no longer identified in the fish catches from 1993-2017 (Bulat, 2017). In the Middle Sector, according to data from the literature (Usatii, 2004; Moşu & Trombiţki, 2013; Bulat et al., 2017), the only species from the Acipenseridae family present in fish catches in the last two decades was *Acipenser ruthenus*, while in the Lower Sector of the Dniester, all species were present in 1993 and 2013.

The Dubăsari dam also has a significant impact on fish species. Several species of fish that disappeared from the Middle Sector of the Dniester can no longer be found in this sector because of the Dubăsari dam. These are fish species that need to migrate from the sea to rivers or from rivers to the sea, or littoral species that occasionally go upstream on rivers. These species can no longer access the Middle Sector of the Dniester because of the transverse barrier caused by the Dubăsari dam. Among these species, we emphasize *Acipenser gueldenstaedtii, Acipenser nudiventris, Acipenser stellatus, Anguilla anguilla, Huso huso* and also*, Alosa immaculata, Alosa tanaica, Aspius aspius* etc.

Another example would be Portile de Fier hydropower plant. The reports regarding the sturgeon catch (*Acipenser gueldenstaedti, Huso huso*) have indicated significant decreases, even 10 times lower compared to the period right after the finalization of Portile de Fier I. The Portile de Fier reservoirs are not equipped with special technique that would act as side trips designed to facilitate the migration of fishes (Dorobăţ, 2019).

In what regards wind energy generation impacts, Fülöp et al. (2012) showed that migratory birds in Dobrogea, Romania, can suffer from a barrier effect in their passage across windfarms leading to feeding and breeding habitat loss. Other authors support similar findings in other areas: Bennun et al. (2021), Thaxter et al. (2017), Grover (2023), Petersen et al. (2003), Fox et al. (2006), Degraer et al. (2020).

4.2.4 Disturbance of species activity

The species that are the most likely to suffer from this type of impact are the ones sensitive to noise, vibrations and poor water quality: cetaceans, *Monachus monachus* (nowadays present in the Sea of Marmara, connected with the Black Sea), sturgeons and other fish species. However, birds might suffer as well from disturbance from noise or pollution, especially in the highly anthropized coastal areas in Romania, Bulgaria, Turkiye or in Ukraine, due to the war.

The influx of alien species into the Black Sea is also exerting pressure on indigenous Black Sea endemic species, causing them to retreat to brackish water areas, estuaries, and deltas. The impact of these alien species on native counterparts may result in a loss of ecological niches, particularly in the mouths of rivers such as the Danube, Dnieper, Dniester, Kizilirmak, Yesilirmak, and Sakarya. Due to the low salinity of brackish water in the Black Sea, species that are euryhaline (organisms are able to adapt to a wide range of salinities) and eurytherm (organism that tolerates a wide range of temperature) are more suitable for settlement (BSC, 2019).

Invasive invertebrates

The sea snail *Rapana venosa*, bivalve species *Mya arenaria* and *Anadara inaequivalvis*, and carnivorous comb jelly species *Mnemiopsis leidyi* and *Beroe ovata*, have proliferated during the last decades, forming large populations in the Black Sea. These invasive species may compete for food with fish species of commercial importance as European sprat (*Sprattus sprattus*), European anchovy (*Engraulis encrasicolus*) and Atlantic horse mackerel (*Trachurus trachurus*). For example, in the case of *Engraulis encrasicolus*, the damage inflicted by *Mnemiopsis leidyi* on the anchovy population is likely a result of food competition, evidenced by unusually low levels of zooplankton biomass in the top 50 meters of the water column during the summers of the early 1990s (Oğuz, Fach, and Salihoğlu, 2008 apud. Öztürk, 2021). The impact on anchovy larvae could be attributed to both food competition and predation by *M. leidyi*, as anchovy larvae numbers peak in July and August, coinciding with the seasonal peak in *M. leidyi* biomass (Grishin et al., 2007). Despite anchovy larvae primarily inhabiting narrow coastal zones and *M. leidyi* being distributed further offshore, there is some overlap between the two. Oğuz, Fach, and Salihoğlu (2008) apud. Öztürk (2021) suggest that a shift from a large marine ecosystem to a gelatinous invader-dominated state requires a substantial environmental perturbation, creating a suitable niche for a non-indigenous gelatinous invader to integrate into the food web structure and share resources with native small pelagic fish communities.

Underwater noise

Concerns about the impact of anthropogenically derived sound on marine mammals have grown in recent decades. Various activities, such as shipping, motorized vessels, explosives, drilling, dredging, construction, and deliberate sound sources like active sonars and seismic surveys, contribute to the wide range of anthropogenic noise in the marine environment. The impact of this noise can range from insignificant to severe, depending on factors like type, frequency, duration, and the species involved. Some cetaceans may tolerate noise to stay in preferred locations, even when the noise is strong enough to elicit reactions during other activities. Nowacek et al. (2007) apud. Hughes et al. (2013) categorized cetacean responses to anthropogenic noise into three main types: behavioral responses (deviation from normal activity, changes in swimming speed, breathing, and diving activity, and avoidance of an area), acoustic responses (changes in vocalizations in response to noise sources), and physiological responses (temporary or permanent reductions in hearing sensitivity, known as auditory threshold shifts).

Marine mammals, turtles, and fish face potential sub-lethal exposure to underwater noise from various activities associated with shipping, offshore wind farms, oil & gas extraction facilities, including site characterization, construction, operation, vessel activity, and decommissioning. These activities generate impulsive and continuous noise, impacting different zones: audibility, responsiveness, masking, and hearing loss. Marine mammals, particularly harbor porpoises and bottlenose dolphins, are well-studied, with evidence of disturbance and displacement during activities like piling. Fish species exhibit varying sensitivity to underwater noise, with some, like herrings, being highly sensitive, while others detect sound through particle motion. The understanding of the impact of anthropogenic underwater sounds on fish is limited, but evidence suggests that intense sounds can affect detection, behavior, and potentially cause injury or death (Bennun et al., 2021; Copping & Hemery, 2020; *Shipping and underwater noise – a growing risk to marine life worldwide*, 2021).

Changes in water quality

Presence of pollutants such as heavy metals, pesticides, and industrial chemicals can be toxic to aquatic organisms, leading to disturbances in their physiological functions and behaviors (Newman, 1998). Excessive sedimentation, often linked to activities like construction or deforestation, can degrade water quality and harm aquatic species by smothering habitats, reducing light penetration, and affecting feeding behaviors (Lalli, & Parsons, 1997). Furthermore, presence of endocrine-disrupting substances in water, such as certain chemicals or pharmaceuticals, can interfere with the endocrine systems of aquatic organisms, leading to reproductive and developmental disturbances (Jobling, et al. 1998).

4.2.5 Species mortality

This type of impact affects mostly the mammals or the fish species that are victims to bycatch (Carpentieri, 2021), to pollution or to marine litter resulted from fishing (fishing gear, nets, lines, pots and traps). Other causes might involve collision with ships, ingestion of litter, intoxication with various substances or even war explosions. The most affected species are cetaceans and the already assessed as Critically Endangered species of sturgeons in the Black Sea.

Case study: *Delphinus delphis ponticus* mortality

The common dolphin (*Delphinus delphis*) has experienced a significant decrease in both abundance and distribution in the Mediterranean and Black Sea basin during the past century. This decline is attributed to various human activities, including fisheries, pollution, and habitat loss, as documented in studies by Bearzi et al. (2003, 2005) apud. Carpentieri (2021).

Since the late 1980s, a persistent and significant threat to *Delphinus delphis ponticus* has been identified as reduced prey availability (Bushuyev 2000 apud. Notarbartolo Di Sciara & Tonay, 2021). Notably, four mass mortality events occurred in winter–spring 1990, summer–autumn 1994, summer 2009, and spring-summer 2017, with the second event attributed to a morbillivirus epizootic (Birkun et al. 1999, Krivokhizhin & Birkun 1999, Tonay et al. 2012, Gol'din et al. 2017a, Vishnyakova et al. 2017 apud. Notarbartolo Di Sciara & Tonay, 2021). The initial two die-offs coincided with a substantial decline in the abundance of the primary prey species, anchovy and sprat. The small pelagic fish stocks in the Black Sea have exhibited significant fluctuations, with the total annual landings of anchovies varying widely, ranging from 85kt to 500kt over the last 50 years (Gücü et al. 2017 apud. Notarbartolo Di Sciara & Tonay, 2021). These shifts are thought to be influenced by four primary factors: alterations in the climatic conditions, modifications in the trophic structure within the ecosystem due to eutrophication and disruptions in the food web, deterioration of prey-predator relationships due to overfishing, and the introduction of invasive alien species (such as the alien ctenophore *Mnemiopsis leidyi*) as documented by Zaitsev & Mamaev (1997) and Gücü (2012) apud. Notarbartolo Di Sciara & Tonay (2021). The observed correlation between significant die-offs of Black Sea common dolphins and a scarcity of prey suggests that a decrease in prey availability may compromise the dolphins' health and heighten their vulnerability to viral infections. This situation parallels the conditions observed in

Mediterranean striped dolphins, *Stenella coeruleoalba*, during the 1990-1992 morbillivirus epizootic outbreak as reported by Aguilar & Raga (1993) apud. Notarbartolo Di Sciara & Tonay (2021).

Recent findings from the Black Sea reveal ongoing cetacean bycatch, particularly in the context of Black Sea coastal turbot bottom net fisheries. The incidental catch predominantly affects the Black Sea harbour porpoise (*Phocoena phocoena relicta*), the smallest of the three cetacean species endemic to the region, which primarily inhabits coastal habitats. The significant impact on the harbour porpoise is attributed to factors such as the mesh size used in gillnets and trammel nets, emphasizing the technical aspects contributing to the differential impact on cetacean species in the Black Sea (Carpentieri, 2021).

The main impacts to diadromous species (anadromous and catadromous fish) include habitat loss due to dam construction, gravel extraction, pollution, river flow regulation, and discharge reduction. Overfishing in seas, estuaries, and rivers, along with the impacts of climate change, particularly global warming, are also significant challenges (Memiş et al., 2020).

One pressure which may be significant in relation to species mortality is the presence of wind farms in areas surrounding the Black Sea. This affects mainly flying species, such as shore birds, seabirds or bats. For instance, important results (Fülöp et al., 2012) showed that many migratory birds (e.g. *Ciconia ciconia, Pelecanus crispus, Falco cherrug*) that use the Black Sea and the land surrounding it as a flyway can be affected by windfarms by an increased risk of collision. Bennun et al. (2021) showed that offshore windfarms can also hold a major collision risk without appropriate mitigation measures, various examples being listed in the referenced study. For instance, during the operating phase of offshore windfarms, one of the most effective measure would be to shut down turbines temporarily when priority species are at risk. Birds flying within the rotor swept zone of offshore wind turbines are at potential risk of collision, leading to serious injury or death. This risk is particularly relevant for migratory birds passing through the wind farm area or birds in the vicinity for foraging or hunting prey (Bennun et al., 2021).

Studies suggest that bats forage within offshore wind farms, at sea, for example between 2.2 km and 21.9 km showing potential attraction to the turbines, possibly due to lighting (Sjollema et al., 2014; Rydell & Wickman, 2015 apud. Bennun et al., 2021). Bats may migrate offshore and use islands, ships, and other offshore structures as stopovers. Although there is limited information on bat migration altitudes and behavior at operational offshore wind farms, evidence suggests that many species migrate offshore (Hüppop et al., 2019 apud. Bennun et al., 2021). Bennun et al. (2021) mentions that among others, one effective measure to minimize this impact for bats is to raise the wind speed at which turbines begin operating (the 'cut-in speed'). Below this threshold, turbine blades are either halted from rotating or adjusted to spin very slowly, reducing energy output. However, the relationship between bat activity and weather parameters varies among species, sites, and years. Therefore, cut-in speed thresholds must be determined based on site-specific monitoring data, considering various parameters such as peak bat activity.

However, a solution for developing offshore windfarms in environmentally important areas could be the avoidance of sites with sensitive marine and seabird habitats and migratory bird routes (Boero et al., 2016). According to the same referenced study, no-go sites (as *Phyllophora* fields and *Posidonia*/sea grass meadows) and Natura 2000 sites are, generally, restricted areas for offshore windfarm development. In addition, it is crucial to undergo rational and appropriate assessments of the proposed project area to meet the principles of the Birds and Habitats Directives and make informed decisions. As a general rule, the restrictions related to the location of offshore windfarms are to be found in the Management Plans of the protected areas.

Introduction and spread of invasive alien species is another effect generating species mortality. The introduction of *Mnemiopsis leidyi* stands out as a significant example of a non-indigenous species exerting a negative impact on the Black Sea ecosystem. Following its invasion in the Black Sea, there was a substantial alteration in the structure of planktonic communities in both coastal waters and the open sea. The overall abundance of subsurface mesozooplankton decreased by an average factor of 2–2.5 or more compared to previous conditions. The biomass of specific species, such as small copepods including *Oithona* sp., *Paracalanus* sp., *Acartia* sp., and *Pseudocalanus* sp., witnessed a reduction by a factor of 3–10 or more. Additionally, there was a sharp decline (by a factor of approximately 2–10) in meroplankton during the summer, indicating the grazing impact of *M. leidyi* on the larvae of benthic animals. The subsequent decrease in zoobenthos biomass due to starvation has been estimated at about 30 percent. *Mnemiopsis leidyi* has been observed to engage in predation on fish eggs and larvae, particularly in shelf waters. Estimates indicate that *M. leidyi* is capable of grazing up to 70% of the total ichthyoplankton stock in these areas (Öztürk, 2021).

4.3 Effects and long-term potential consequences of the war-related activities due to the Russian invasion of Ukraine

Ukraine's marine ecosystems face imminent risk due to a diverse array of military activities on land and at sea. The ongoing conflict has directly impacted delicate and ecologically sensitive coastal habitats. To accurately gauge the conflict's real impact on the ecology of the Black Sea, the Sea of Azov, and surrounding estuaries and wetlands, additional research is essential. These water bodies were already contending with various human-induced pressures, such as pollution, overfishing, invasive alien species, and climate change. Consequently, the cumulative impacts of these stressors could be substantial (ConEnvObs, 2023a).

The conflict and occupation have led to the aggravation or initiation of damage and disturbance to various coastal and marine habitats, many of which are delicate or extremely sensitive. Nevertheless, determining the exact impact on the populations of certain species is challenging in most instances without on-site field research (ConEnvObs, 2023a).

The construction of trenches and fortifications not only damages flora but also intensifies soil erosion. Additionally, military refuse and waste contribute to soil and groundwater pollution. As frontlines shift, the line of physical damage to habitats moves accordingly, especially in areas heavily subjected to shelling. For instance, ecologically sensitive wetlands (Kinburn Spit, Dniprovsko-Buzkyi Lyman, Biloberezhzhia Sviatoslava National Nature Park, Black Sea Biosphere Reserve, Lower Dnipro National Nature Park) along the Dnieper estuary in south Kherson were fortified by Russia after withdrawing from Kherson city (ConEnvObs, 2023a; Ecoaction, 2022).

In May, a fire damaged the Kinburn Spit Park on the Black Sea coast, causing extensive harm to unique coastal habitats (e.g. Littoral mixed sediments, Coastal saltmarshes and saline reedbeds, Coastal stable dune grassland (grey dunes)). The fire was exacerbated by the inability to extinguish it due to Russian occupation and the presence of minefields. The affected area included nesting places for wild birds (e.g. *Larus genei*, *Lanius minor, Falco cherrug*) and the largest orchid (*Anacamptis palustris*) field in Europe. Preliminary estimates indicate that the fires impacted nearly 2,000 hectares of forest and coastal ecosystems, leading to the loss of rare species present in the Red Book of Ukraine (e.g. *Centaurea breviceps* and *Centaurea paczoskii*) and damage to the distinctive sand habitat flora of Kinburn Spit (Figure no. 4-26) (Тьоткіна, 2022; ConEnvObs, 2023b; GBIF Secretariat, 2023; BirdLife International, 2022).

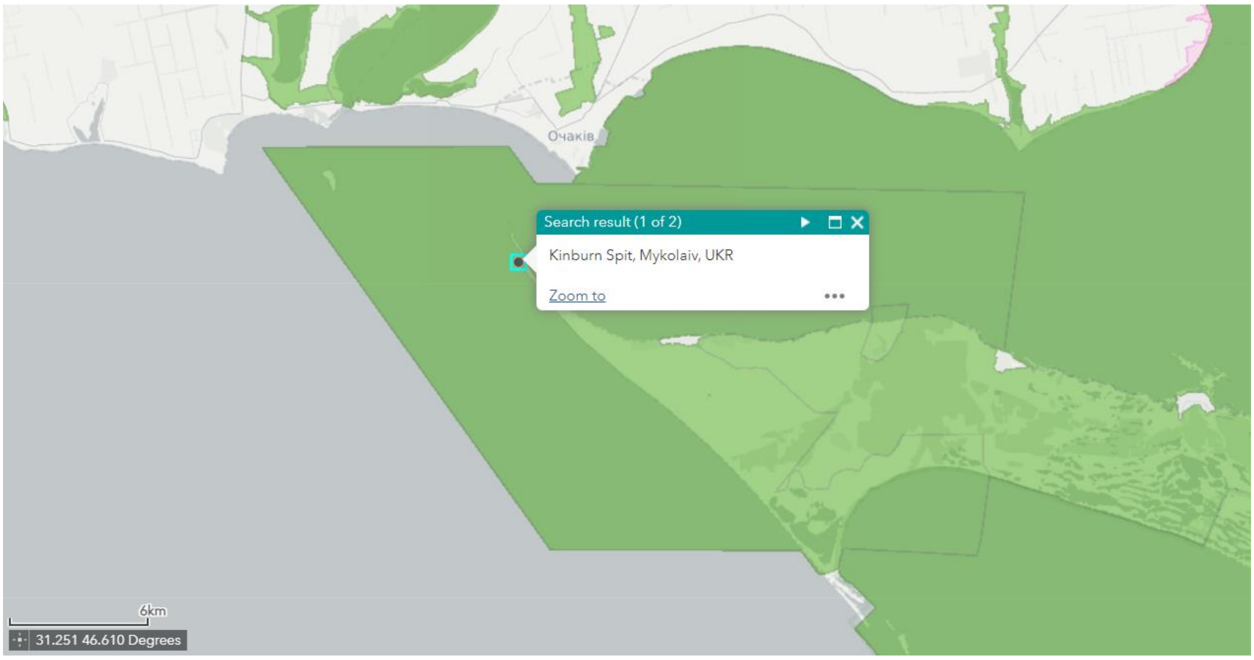


Figure no. 4-26 Location of Kinburn Spit in Biloberezhzhia Sviatoslava National Nature Park, Emerald site (Source: EEA, Emerald Network Viewer, 2023)

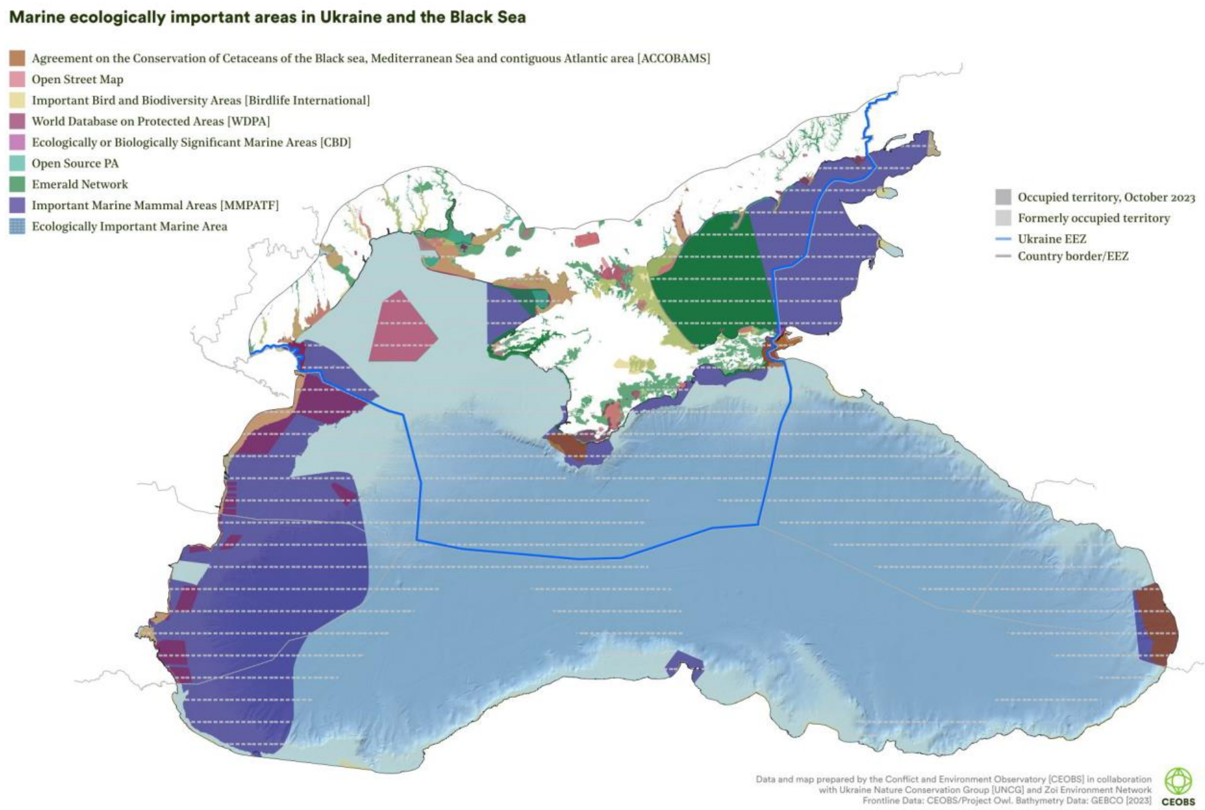


Figure no. 4-27 Marine ecologically important areas in Ukraine and the Black Sea (Source: ConEnvObs, 2023c)

In Crimea, crucial coastal habitats in Emerald sites Karalarskyi and Kerch peninsula (Figure no. 4-27) reportedly (uwecworkgroup.info, 2022) have been repurposed into military training grounds. Alongside physical disruption, noise disturbance is likely affecting bird and mammal species (ConEnvObs, 2023a).

Offshore habitats have also been affected by the conflict. Zmiinyi (Snake) Island witnessed intense fighting between February and July, involving heavy explosive and incendiary weapons. Part of the island and surrounding waters were designated as a state Marine Protected Area (MPA) in 1998 (ConEnvObs, 2023b), comprising 58 fish species (12 of which are included into the Red Book of Ukraine) (Snigirov, Goncharov & Sylantyev, 2012). While terrestrial biodiversity on the island is inevitably harmed, the impacts on its marine ecosystem are challenging to assess (ConEnvObs, 2023b).

The Bug estuary, a vital shipping port, has witnessed damage to numerous industrial facilities along its left bank. In March and October, the Alumina Refinery was deliberately targeted, as confirmed by satellite imagery displaying damage throughout the site, affecting structures and tanks holding fuel, caustic soda, and processed materials. Notably, satellite images from April 22nd reveal a substantial leak, presumably of bauxite residue, characterized by high alkalinity, heavy metals, and even trace radioactive elements (ConEnvObs, 2023a).

Figure no. 4-28 Locations and types of pollution incidents documented and verified by CEOBS in the Bug Estuary (Source: ConEnvObs, 2023a)

The shock waves generated by underwater explosions can travel significant distances, stunning fish and causing harm to various organisms. This has been observed in Ukraine's freshwater bodies during the ongoing conflict (Algan & Aydoğan, 2023; TUDAV, 2022), with the Irpin River near Kyiv facing an ecological disaster due to fish casualties resulting from airstrikes. The vulnerability of bony fishes, with easily ruptured gas-filled swim bladders, exacerbates the impact. Additionally, marine mammals (*Phocoena phocoena* ssp. *Relicta*, *Tursiops truncatus ponticus, Delphinus delphis ponticus)* particularly those already at risk and protected by international conventions, face serious threats from explosions (Ecoaction, 2022). According to (Ecoaction, 2023) from January to October 2022, experts from Ukraine, Romania, Bulgaria, Turkey, and Greece observed around 1,000 documented cases of dead Black Sea cetaceans, marking a significant increase compared to 2019-2021, with the actual number potentially much higher. Moreover, according to the same source, Ecoaction (2023), an unusually high number of cases involved live sea creatures washing up on the shore. In Ukraine, particularly in Crimea, notably Sevastopol where Russian military bases are situated, numerous instances of stranded and live sea creatures were reported. The surge in both dead and stranded cetaceans raises concerns about the health and conservation status of Black Sea marine life.

However, the onset of active sea-based hostilities in early March has led scientists in Black Sea countries to document a concerning surge in dolphin mass mortality. Notably, the coasts of Ukraine and Turkey have experienced an unprecedented number of White-sided dolphins washing ashore, an uncommon occurrence in these regions. Dolphins found on the coasts of Bulgaria and Romania displayed injuries and extensive burns, likely attributed to explosions (Ecoaction, 2022). While comprehensive research is necessary to fully understand the factors at play, preliminary data strongly suggest that Black Sea dolphins have become unintended casualties of the ongoing conflict (TUDAV, 2022).

Furthermore, the Black Sea witnessed a notable increase in mass stranding events of dolphins, coinciding with the Russian invasion of Ukraine. Many stranded dolphins exhibited marks indicative of bycatch in fishing gear. Dr. Pavel Goldin from the Schmalhausen Institute for Zoology in Kyiv highlighted the correlation between the mass strandings and the onset of the Russian attack. There is a serious consideration of the hypothesis of acoustic trauma, where sonar, though not directly causing dolphin mortality, leads to inner ear damage. This damage can impair the animals' ability to orient themselves and feed, potentially resulting in strandings or starvation. Efforts have been directed towards detecting and researching acoustic trauma as a potential cause of the observed strandings (The Guardian, 2022 apud. Zengin, 2022).

Beyond explosions, the continuous patrolling of warships and submarines in the Black Sea employing sonar technology poses an additional threat to dolphins. The acoustic frequency utilized by cetaceans aligns with marine sonar frequencies, potentially causing harm to their hearing. Given that dolphins heavily rely on echolocation for various biological functions, the use of sonar technologies has the potential to disrupt their behaviour and compromise their ability to thrive. These findings underscore the urgency of mitigating the impact of military activities on marine life in the Black Sea (Ecoaction, 2022).

Explosions from munitions and the activities of marine vessels result in the loss of dolphin lives, the destruction of distinctive steppe habitats, and harm to protected areas (Opuk Nature Reserve and Karalar Regional Landscape Park). The ongoing shelling poses a persistent risk of marine pollution, including the release of petroleum products and toxic chemicals (uwecworkgroup.info, 2023).

However, the war in Ukraine may influence other type of effects, such as the regeneration of population numbers in certain fish species, fact that can be concluded from an increase in the number of contacts (e.g. *Squalus acanthias* in the Romanian Black Sea coastal waters) (Trifu, 2024). This is an indirect result of the reduction of fishing activities in war-affected areas.

Environmental consequences of the Kakhovka dam collapse

Six ecologically significant areas were identified by now to have suffered the impact of floodwater: Zernov Phyllophora Field Zakaznyk, Kinburnska Kosa, Lower Inhulets river valley, Dniprovsko-Buzkyi Lyman, Black Sea Biosphere Reserve, Biloberezhzhia Sviatoslava National Nature Park. Among them, five are designated as adopted Emerald Network sites. The Lower Dnipro Delta, classified as a wetland of international importance under the RAMSAR Convention and a crucial component of Ukraine's Emerald Network, was the most severely affected. It was revealed that over 90% of its area was submerged. Despite being a wetland, the flood intensity surpassed that of typical seasonal events and carried a heightened load of sediment and pollutants. Seafloor habitats, such as the significant and vulnerable Zernov's Phyllophora Fields in the northwestern Black Sea, may have been affected (ConEnvObs, 2023).

The abrupt influx of freshwater led to a decrease in the salinity of the northern Black Sea. On June 10th, it was reported (Team, 2023) that samples near Odesa had salinity levels three times lower than normal conditions. Although temporary, the phenomenon's volume surpassed typical summer freshwater flows into the basin, potentially influencing currents, water mixing, and productivity in the northern Black Sea (ConEnvObs, 2023).

The influx of freshwater, along with its substantial nutrient load, heightened the probability of plankton blooms. Specialists from the Odesa-based Ukrainian Scientific Centre for Marine Ecology suggested that 40-50% of these blooms were potentially hazardous due to toxin production (ConEnvObs, 2023).

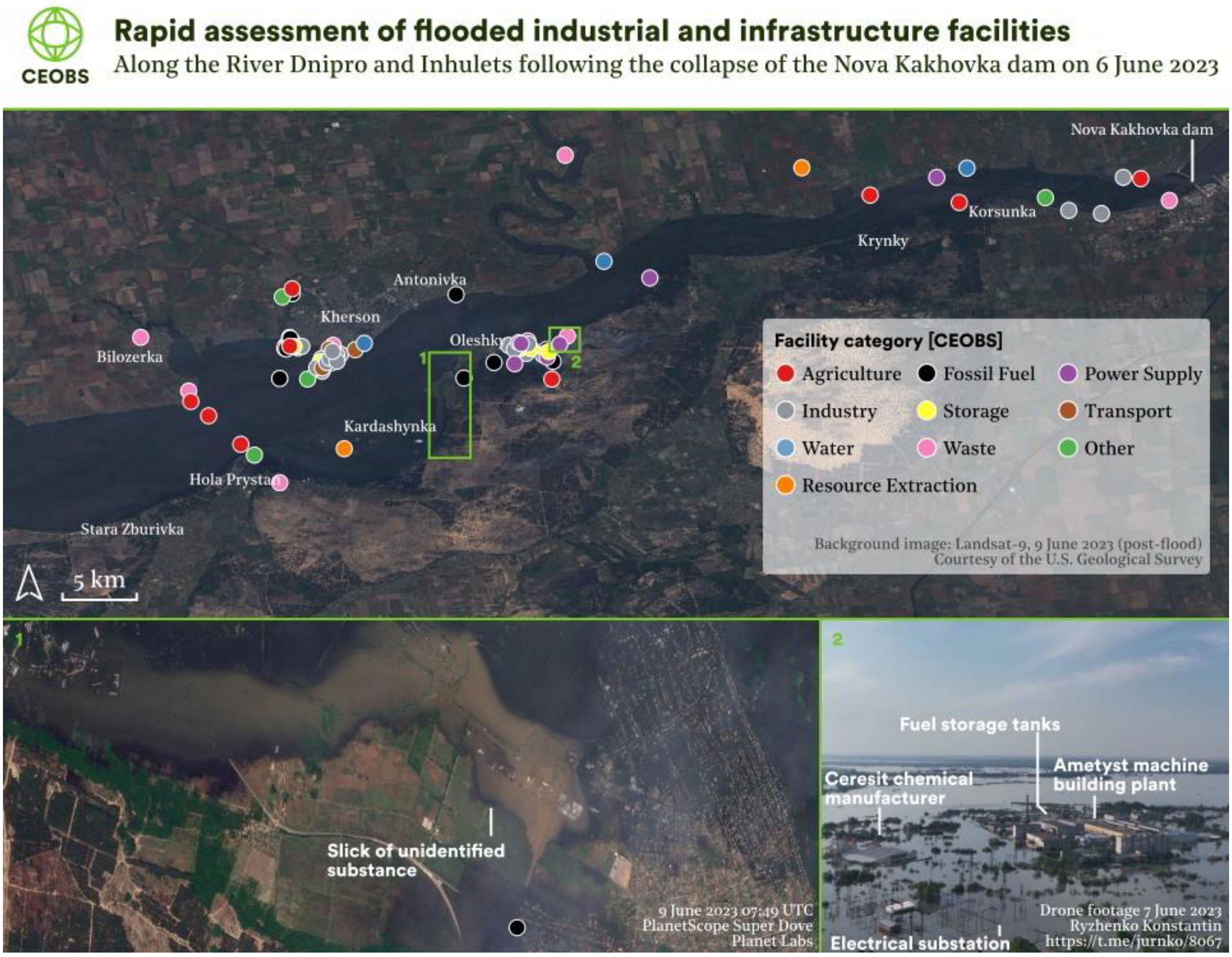


Figure no. 4-29 Assessment of the flooded facilities due to the Nova Kakhovka dam collapse (Source: ConEnvObs, 2023)

5 METHODOLOGY FOR DEVELOPING THE REPORT

The roughly oval-shaped Black Sea occupies a large basin strategically situated at the southeastern extremity of Europe. The Black Sea is very vulnerable to pressures from land based human activity and its health is strongly dependent on the coastal and non-coastal states of its basin, as it is almost entirely landlocked and surrounded on all sides by developed, urbanised areas.

Starting from this idea, various projects have found that eutrophication, pollution, microplastics, overfishing and invasive species are major environmental challenges. However, there still are many gaps in the knowledge regarding the Black Sea.

The purpose of this study was to create an overall summary of the existing international data and collaborative projects about the existing major pressures for the marine environment.

In light of the established purpose, the following objectives were established:

- The elaboration of a database with the existing data on the Black Sea onshore and offshore pressures;
- Identification of the effects on the marine environment resulted from the studied pressures;
- Identification of the main form of impacts to biodiversity of the Black Sea;
- Distinguish the least studied pressures;
- Draw conclusions and make recommendations based on the already studied pressures, effects and the generated impacts.

In the elaboration process of this study, various sources in the literature were consulted, starting from reports resulted from international collaborative projects and ending with studies by independent authors.

From the point of view of the consulted time period, the newest sources, from the last 5 years were first taken into account. Secondly, the last appearance on a certain topic was consulted. Lastly, previous data, that most probably was out-of-date, was analysed, even though this was not generally taken into consideration.

The focus was mostly on the most recent status of a topic and trends in order to gain a bigger picture of the Black Sea state of the marine environment and its pressures.

With many of the identified bibliographical resources, a database was constructed, showcasing the main pressures, their location (onshore/offshore), their country of origin and the main effects associated with these pressures, as well as the generated impacts. Additional blibliographic resources were found for the development of the present report.

Our approach in this report is based on the relationship between PRESSURES (CAUSES) – EFFECTS – IMPACTS, in a similar manner proposed in the recently adopted Romanian Order no. 1679/2023 on the approval of The specific methodological guidelines regarding the appropriate assessment of the potential effects of the plans/projects in the fields of interest. According to the guidelines, the difference between effects and impacts is that effects will always occur as a result of a cause (pressure).

6 GAP ANALYSIS

The gap analysis refers to data and information identified in the literature and open-access sources.

In the research process for the current study, it has been noticed that many topics were not sufficiently or not at all explored for the Black Sea. These topics include:

- renewables onshore/offshore;
- oil & gas extraction;
- other resource extraction;
- underwater infrastructure;
- nuclear power generation.

There are also several topics for which information could not be found in relation to countries such as Russia, Georgia or Türkiye (countries that are not included in the EU). These topics include:

- anti-erosional works: all the countries, except Romania;
- oil & gas extraction and processing: Russia, Georgia;
- thermal power plants: Russia, Ukraine, Romania, Bulgaria;
- underwater infrastructure: Georgia, Ukraine;
- illegal dumping of oil products: Ukraine, Georgia;
- nuclear power generation: all the countries, except Ukraine.

There are also topics for which the timeframe of the data is limited:

- oil & gas extraction;
- fisheries;
- shipping accidents;
- illegal dumping of oil products.

There are many implemented projects for which there is little clear data on their effects on biodiversity. These projects cover the following topics:

- underwater infrastructure;
- renewables;
- oil & gas extraction and processing.

Furthermore, we have found that for the Black Sea, there is a lack of recent spatial data regarding the most important pressures (oil and gas extraction perimeters, oil and gas extraction fields, future offshore renewable energy projects).

Another issue was related to the fact that countries as Türkiye or Russia present little information regarding their protected areas, which leads to an improper and incomplete assessment of the effects generated by the ongoing pressures.

Insufficient information was found regarding the impacts of climate change to biodiversity of the Black Sea. Although we found some sources mentioning a potential impact to certain fish species, clear evidence was not yet substantiated.

In addition, the countries that are not included in the European Union (all the Black Sea countries, except Romania and Bulgaria) do not have legislative requirements in accordance with the Marine Strategy Framework Directive (MSFD), which is EU’s main tool to protect and conserve the health of our coasts, seas and oceans. Its aim is to achieve a good environmental status of the EU's marine waters and sustainably protect the resource base upon which marine-related economic and social activities depend. Through the MSFD, the ecosystem-based approach became a legally-binding and operational principle for managing the EU’s entire marine environment (EEA, Marine Environment, 2024). However, data provided by European Union (EU) Member States (Romania and Bulgaria) in fulfillment of essential legal obligations outlined in directives like the Marine Strategy Framework Directive, the Habitats Directive, and the Common Fisheries Policy has been very useful. Thus, the other countries that are not legally bound to report such data, may continuously generate harmful effects to the Black Sea environment, with an improper assessment of the impacts.

7 CONCLUSIONS AND RECOMMENDATIONS

The present study gathers data provided by the European Union Member States, along with data reported by the member countries of the Black Sea Commission. Moreover, it incorporates information from various sources, including EU indicators and reports, regional assessments, peer-reviewed scientific papers, and other relevant literature.

Environmental impacts related to biodiversity change encompass frequent and intense algal blooms, water quality impairment, modification of community structure and changes in food webs, depletion of fish stocks, loss of migratory species using the habitat (e.g. sturgeons) as well as altered migration patterns, increased mortality of aquatic organisms and avian mortality, decreased native species diversity, an increased proportion of threatened species, changes in ecosystem stability, alien species establishment and increased vulnerability to opportunistic invaders, and ecosystem degradation (Pernetta & Bewers, 2012).

The Black Sea, characterized by its enclosed system and the largest anoxic basin globally, faces vulnerability due to limited water renewal and exchange primarily through the Istanbul (Bosphorous) Strait. This unique ecosystem requires special protection for biodiversity in response to anthropogenic pressures. A key strategy for marine ecosystem recovery involves establishing Marine Protected Areas (MPAs) in ecologically or biologically significant regions, guided by the Convention on Biological Diversity (CBD). The primary aims of these protected areas are to preserve biological diversity, safeguard essential ecological processes, ensure sustainable use of species and ecosystems, and protect environmental quality, as well as the health and safety of coastal communities and resource users (BSC, 2019).

Comprehensive and periodic assessments of major marine systematic groups are essential in all Black Sea countries, utilizing the latest IUCN criteria and regional application guidelines. These evaluations should rely on current data regarding distribution, population levels, and structure. Adequate funding and capacity building are crucial requirements across all Black Sea countries to facilitate this process (Pernetta & Bewers, 2012).

This study has determined the need for additional efforts to analyze the effects of the war in Ukraine, as well as the potential need for ecological reconstruction measures. Currently, there is a considerable lack of information regarding the impacts suffered by the biodiversity in the war zones, mostly due to the great danger that the war poses to civilians.

During the analysis for this study we have determined the fact that the ongoing war in Ukraine may be the highest pressure to biodiversity in the Black Sea, in spite of the lack of sufficient gathered data. Supporting arguments for this would be the great number of reported dolphin deaths, the satellite images of fires or floods caused by dam destruction. Other unprecedented effects may not even be detected yet.

In regard to the projects developing in the Black Sea, it is necessary for the bordering countries to have clear requirements in the form of regulations regarding the assessment of cumulative impact at the level of the Black Sea ecosystem. There is a need for a thorough research on the Black Sea for a better localization of habitats and species, especially the threatened ones.

The second great pressure to the biodiversity of the Black Sea would be the impacts and risks associated to the oil and gas extraction projects. We have noticed that most of the western part of the Black Sea is occupied by exploration perimeters which concerningly overlap with Important Marine Mammal Areas (IMMAs).

Among concerning threats, the future wind farm projects (especially offshore ones) may lead to significant impacts to migratory birds and even resident birds if the interested stakeholders do not implement active collision mitigation measures.

We have also found the fact that fishing represents another important pressure to the biodiversity of the Black Sea, which is why the bordering countries should develop relevant legislative requirements.

Specifically, for endangered diadromous fish (live most of their lives in salt water but are born in fresh water and return to fresh water to spawn), there is a need for revising rules, legislation, bans, and methods of stock enhancement through aquaculture. It is necessary to make clear and realistic decisions on priority rivers, crucial fish migration routes, target species, and fishing quotas (Memiş et al., 2020).

Reducing interactions between marine mammals and fishing activities remains challenging, but recent positive signs include decreases in bycatch and lethal interactions. These improvements are attributed to increased awareness among fishers, reductions in fishing effort (especially the number of boats in some areas), and the implementation of protection and mitigation measures. These measures, tailored to different fishing gear types and strategies, aim to minimize harm to marine mammals. To further mitigate cetacean and monk seal (seen in the Marmara Sea and the Bosphorus Strait) bycatch and economic damage to fishers, controls such as fishing effort limitations (e.g., closures at specific times and areas) and modifications to fishing gear and strategies (e.g., gear designed to minimize bycatch, introduction of prevention devices like grids for trawlers, and changes in fishing behavior) could be implemented. Additionally, awareness campaigns targeting fishers and stakeholders involved in fishery activities are crucial, emphasizing the importance of marine mammals in natural cycles, biodiversity conservation, ecotourism, and other aspects (Carpentieri, 2021).

It would be recommended that following the compilation of national Red Lists for habitats and biota, it would become feasible to establish a Red Book documenting the Habitats, Flora, and Fauna of the Black Sea. This Red Book can subsequently function as a resource for conservation management at the regional level (Pernetta & Bewers, 2012).

Additionally, legal measures concerning the deliberate introduction of alien species into the Black Sea are recommended. These measures should be implemented by national authorities and incorporated into international conventions, including the Convention on the Protection of the Black Sea Against Pollution (the Bucharest Convention) and the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention). Consideration should also be given to the substantial effects of both climate change and the Mediterranean influence on the Black Sea (BSC, 2019). To address these challenges, there is a need for specialized studies to genetically identify non-indigenous species, evaluate economic losses caused by them on individual countries, and enhance the reliability of catch statistics, particularly for species like the rapa whelk (*Rapana venosa*). The report suggests the establishment of a regional database and the ongoing development of networks to strengthen regional cooperation and enhance early detection of various non-indigenous species, including the invasive alga *Alexandrium monilatum*.

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8 BIBLIOGRAPHY

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